Under the Weather

A History of Health, Weather, Climate and Environment

Ronald Hes

Master Thesis

History and Philosophy of Science

Utrecht University

Supervision: Prof. dr. Frank G. Huisman

Second reader: Dr. David M. Baneke

September 2020

Contents

Introduction

While I am writing this text, faint rumours pass through my garden door: shouts and horns from protestors on the 'Malieveld' in The Hague. Yet another manifestation of the protest group 'Virus Truth', formerly known as 'Virus Madness'. The protesters rally against the government measures to tackle the ongoing Covid-19 crisis.

The protests represent the extreme end of a wider dissent with the role of medical science during the Covid-19 crisis. While they are expected to rely on the advice from medical specialists as how to deal with the virus, increasing numbers of citizens doubt or ignore these guidelines. Several ambiguous signals were sent by the government about the best line of action, backed by the 'National Institute for Public Health and the Environment'.[1] Initially 'group immunity' was presented as the solution to the crisis, an idea that was soon abandoned. It was communicated that the evidence for wearing mouth masks is unconvincing, yet it became obligatory to wear masks at several locations. The government announced an application for use on the mobile phone as a crucial tool to follow the spread of the disease, but withdrew it soon because of technical and privacy issues. In the meantime, elderly people were dying in nursing homes without any relative in their vicinity. The main reason for asking people to stay at home for months appeared to be the requirement to keep the number of patients at intensive care units below a certain value.

The public starts to question why decisions about what is a good quality of life are left to a small elite of medical specialists who approach the question only from their own narrow perspective. Why is specialized medical knowledge judged more important than other forms of knowledge? And even if one respects the authority of these experts, is the medical knowledge in this crisis presented to the public in an unbiased way?

The current situation is handled by experts in the first place as an outbreak of infectious disease. The continuously changing course of their advice and their actions is justified by an appeal to ignorance: massive outbreaks of corona viruses simply have not occurred so far. In view of this, the instruments to tackle the crisis are the same remedies that were used against earlier epidemics: isolation, hygiene, quarantine, vaccination. This standard approach fits the model that medical historian Charles Rosenberg called the contamination

[1] Rijksinstituut voor Volksgezondheid en Milieu

view.[2] In this view, the transmission of some material from one person to another is held responsible for spreading disease. Epidemics are the result of a contamination of a collective of people at a given place and time. The emphasis lies on one single cause, i.e. the material that causes the collective imbalance in health. The contamination view, however, is just one possible way to look at epidemics from a medical perspective.

In the contrasting alternative model, the 'configuration view', the surroundings of a person are thought to be responsible for disease. Health is situational in this world view: it is a result of the external factors that uniquely apply to the individual under consideration in combination with the properties of that person. Perhaps surprisingly, this has been the dominant mode of thinking in Western medicine for centuries. Even epidemics were once seen as the consequence of a unique constellation of environmental circumstances. They represented an unusual arrangement of climate, environment, and social circumstances.

What happened to this environmental view on human health, centred around the notion that health is influenced by the weather and the environment? Medical historians tend to agree that this idea was dominant until approximately 150 years ago. New developments in scientific medicine by that time changed the view of physicians on the human body. They started to see it as a mechanism based on the laws of physics and chemistry, virtually independent from its environment. The importance of the environment, so the conventional history of medicine tells, was also overthrown by the new germ theory that explained many diseases in terms of a single cause, micro-organisms. The present thesis investigates what happened to the belief in the influence of the environment on health after approximately 1870 when this revolution took place.

When I came across some material about contemporary scientists who still investigate the role of the weather and the climate on health, I wondered what they represent. Are these scientists working inside the medical establishment and still carrying on an old tradition that has never really vanished? Or are they eccentrics that dwell outside the borders of medicine in search for old mythical wisdom? Why do they still study the relation man-environment at all?

[2] Rosenberg, C.E., *Explaining Epidemics*, 293-304

Central question

This thesis addresses the question how the thinking about the causal relation between health and the weather, climate and the environment of man developed during the last 150 years. It also addresses the question why the current thinking about this relation, although less prominent than alternative explanations, appears to undergo a certain revival.

None of the terms *health, weather, climate and environment* have meanings that are fixed or stable in time. In the course of 150 years these terms obtained variable and interdependent meanings. Concerning 'health', this thesis is about the influence of environmental factors on 'disease', which broadly speaking is the subjective 'absence of health'. Concerning weather and climate, a plethora of definitions can be found, but the essence appears to be that weather refers to a constellation of atmospheric condition of the 'here and now', whereas climate implies some averaging of the conditions over time. Admittedly, the timescale that defines a 'climate' is not fixed. Environment, finally, is understood in this thesis as the 'natural environment' of man, in contrast to the use of the term in epidemiology where it is may refer to the 'social environment'. The concept of 'natural environment', however, underwent changes in time, as it became more and more seen something that is mutable by man.

Structure of this thesis

Chapter 1 concerns the time period from 1870-1950. In this chapter I investigate what happened in this time frame to the idea that health is related to the weather, climate and the environment. When around 1870 germs were identified as the cause of diseases, this led to the belief that most diseases are caused by a single cause. I show how the older environmental thinking, in the tradition of Hippocrates persisted among three groups. Practitioners (e.g. soldiers, farmers, physicians), generally in the context of colonial activities, continued to believe in the relation between health and environment and used this knowledge for therapeutic purposes. Proponents of holistic ideas appropriated these ideas in a worldview that opposed mainstream medicine and endorsed the healing capacities of nature. Small groups of scientists in the meantime started to study the relation between health and climate in a methodical way.

Chapter 2 focuses on the period after 1950 and describes the remarkable role of the Dutch geologist Solco Tromp (1909-1983) in the development of the scientific discipline 'biometeorology'. This chapter is a mini-biography of his life and work. Driven by curiosity, a desire to work at the borders of mainstream science and gifted with perseverance and unusual social skills, Tromp successfully managed to co-create a new scientific discipline, biometeorology. His personality and unconventional thinking led to conflicts about the future of the field. I argue that Tromp's personality and his questionable scientific status contributed to these conflicts. Nevertheless, he is still remembered as a pioneer, partly because he secured his memory in the form of an award that bears his name.

Chapter 3 analyses in some detail how the scientific discipline of biometeorology was formed. I show how Solco Tromp and his colleagues performed 'boundary work' to enhance the credibility of biometeorology as a 'true' science and to secure its position in the spectrum of other scientific disciplines. From documents that were published during this process, I have identified six elements that characterize the formation of this discipline: common ideas and language, knowledge platforms, social binding and awards, internationalism, education and the formation of legends. The interdisciplinary nature of the new discipline proved to be its strength, as it could adapt to the demands of the outside world. While initially it hosted a wide range of topics, the field narrowed down and focussed on ecological topics in the 1960s, with a further emphasis on climate change related health issues since the 1990s.

In chapter 4, I summarize the previous chapters and present some conclusions for discussion. These conclusions address the question why environmentalism did not disappear after 1870, despite the emergence of the germ theory. I speculate that there are several reasons. First, the germ theory proved to be inadequate for explaining a number of the most frequent chronical disease. Second, the causal model behind the germ theory proved to be unsuitable to explain the cause of many diseases. Third, the germ theory introduced a view on the human body that was not acceptable to those, within or outside medicine, who kept interest in the role of the environment. Fourth, I note that the importance attributed to the weather, climate and environment in medicine is also culturally determined: locally, especially in Germany, it has never ceased to be of importance. Finally, the growing attention for ecological issues, and recently for climate change and its effects, has boosted environmentalism, now with an emphasis on the influence of man on his environment.

Historiography and method

Although medical historians have studied the ideas about health and the environment extensively for the period up to the middle of the 19th century, the historiography on this topic is very limited for the subsequent period. To my knowledge, the only work that is also dedicated to later developments is '*Hippocratic Heritage*' (1981) by the physiologist Frederick Sargent. The book is a valuable reference, but written from a point of view internal to science: its emphasis is on the achievements of important scientists rather than on a wider historical context. In the present thesis I attempt to interpret the development of the 'Hippocratic' environmental thinking within medicine in a broader sense.

The period 1870-1950 is the topic of the first chapter. In as far as the history of the health-environment has been documented for this time frame, this was in papers that address specific contexts. The first context is the colonial history of Britain and France. The second context is the intellectual history of the first decades of the 20th century with emphasis on a wider holistic movement that also influenced medicine. A third context is found outside medical history. I included some recent scholarship on environmental history, works in which historical narratives about environmental issues are extended to include the consequences for human health.[3]

In the second chapter I trace the development of the scientific discipline of biometeorology by means of the biography of one of its initiators, Solco Tromp. This chapter is primarily based on publications from the International Society of Biometeorology, the organisation co-founded by Tromp. To my knowledge, the only articles dedicated to the person Solco Tromp appeared in its journal, the International Journal of Biometeorology. My description of Tromp's involvement in parapsychological research is based on the PhD thesis of Inge Kloosterman about parapsychology in the Netherlands. Information about his public activities was derived from newspaper clippings in the Delpher database of the Royal Library of the Netherlands. In addition to these written sources, I held interviews with two veteran scientists who shared their recollections of Tromp and of the International Society of Biometeorology.[4] Unfortunately, my attempts to obtain archival material about Tromp and the early years of the International Society of Biometeorology remained unsuccessful.

[3] E.g. Coen, *Climate in Motion* (2018) and Nash, *Inescapable Ecologies* (2006)
[4] Prof. Dr. W. Rietveld. Interview in Wassenaar on 25-11-2019.
Prof. Dr. P. Hoeppe. Telephone interview on 16-12-2019.

In the third chapter I analyse the process of the formation of the scientific discipline of biometeorology. As theoretical framework for this chapter, I used the work of historians of science about discipline formation. The concept of 'boundary work', developed by Thomas Gieryn, serves as the central idea.[5] I applied this to the development of the field of biometeorology while doing close reading of the internal documents from the International Society of Biometeorology. Some of these documents were provided by the interviewed persons. Other information was taken from the International Journal of Biometeorology, in which up to 1980 internal material about the organization appeared. For the later period, I analysed some historical overviews of the organization's history, which appeared regularly in the journal in the last few decades.

In the fourth chapter I discuss why environmentalism did not disappear, despite the emergence of the germ theory. For a discussion on the concept of causality I used the work on disease etiology of K. Codell Carter as starting point.[6] Some recent work on causality in medicine by authors from the field of philosophy of medicine was also consulted for this chapter.

[5] Gieryn, T., *Cultural Boundaries of Science*

[6] Codell Carter, K., *The Rise of Causal Concepts*

Chapter 1: Health and the environment (1870-1950), the legacy of Hippocrates

Up to the middle of the 19th century it was common in Western medicine to think that diseases find their origin in the environment. In the 18th and 19th century this concept was studied empirically by collecting meteorological data and by searching for associations of these data with the occurrence of diseases. The idea was also widely employed in campaigns to prevent disease by modifications of the living environment, e.g. by improving ventilation in houses to decrease the influence of bad air and by applying drainage to fight against harmful humidity. The credibility of this environmental thinking was probably supported by the decrease in mortality where these measures were applied. In addition, there were social and economic reasons for favouring the idea of a pathogenic environment over the competing contagionist world view that held a living disease germ responsible for contagious diseases.[7] Most importantly, the theory explained more of the available evidence than any alternative explanation at the time: there was simply no better theory available.[8]

Where did the idea that the weather makes us sick or healthy come from? Medical history conventionally teaches that the ideas of the Greek sage Hippocrates dominated western modern medical thinking until well into the nineteenth century. Hippocrates of Kos, who lived around 400 BC, was a Greek physician who founded a medical school that had a profound impact on Greek medicine. Around eighty works about medicine are attributed to him, almost certainly not all written by himself. One of many ideas in this 'Hippocratic Corpus', is the notion that climate is intimately related to health and disease. It is developed in 'Airs, Waters and Places', one of the texts that has guided western thinking about health and the environment since the Renaissance. Up to the 16th century the ideas of Hippocrates reached the western intellectuals mostly through the adaptations made by the Roman physician and writer Galen, whose status as the prime source of medicine was virtually absolute. Although Hippocrates' work was retranslated from Latin in the twelfth century, the Greek version of 'Airs, Waters and Places' in 1512 triggered the appreciation of his original

[7] This was argued by Ackerknecht in 1948 in his seminal paper 'Anticontagionism between 1821 and 1867'.
[8] See e.g.. Riley, *The eighteenth-century campaign to avoid disease*, Chapters 1 &2, and: Jankovic, V., *Confronting the Climate, British Airs and the Making of Environmental Medicine*

thoughts. This was not an overnight process: it took another century until the original Hippocratic texts on the role of the environment overtook the work of Galen.[9]

The central concept of 'Airs, Waters and Places' is the influence of *variations* in weather and seasons on the health and diseases of man. Different ratios of heat, cold, wetness and dryness translate into different health conditions because they influence the balance of the essential fluids, or 'humours', in the body. Abnormal seasons, like a dry winter, disturb the balance of these humors and provoke disease. A further effect on health derives from the quality of external influences, like the winds, which are seen as being composed of a mix of heat, cold, wetness and dryness. A strong link also exists with geography: the health status and the characteristics of people in a town depend on the orientation of the town with respect to the prevailing winds in the various seasons. Likewise, the prevalence of several diseases also depends on the direction into which the water that supplies a town is flowing.[10]

The standard view in medical history is, that around 1870 two developments rendered the teachings of 'Airs, Waters and Places' obsolete.[11] Firstly, physiologists like Claude Bernard advocated a new approach to the study of disease. They started to analyse the functions of individual organs in meticulous detail with the help of experiments in the laboratory. These physiologists saw the human body as a mechanism based on the laws of physics and chemistry, abandoned the notion of humors and considered the body mostly independent from its environment. Secondly, Hippocratic thinking was overthrown by the new the germ theory that explained many diseases in terms of micro-organisms.[12]

[9] Miller claims that the first English translation appeared in 1734 and the last edition for purely medical purposes in 1874 (p. 136-139) See also Cantor, Reinventing Hippocrates, p. 5, where it is claimed that the first complete Greek edition was published in 1526.
[10] The Airs, Waters and Places, translation by Francis Adams. http://classics.mit.edu/Hippocrates/airwatpl.html
[11] Miller, 139
[12] Ibid. See also Bynum, Science and the Practice, 105-109 and 128-132

FIGURE 1 HIPPOCRATES IN SAD SURROUNDINGS (LEIDEN, 2020). PHOTOGRAPH BY R. HES.

The standard account in the history of medicine teaches that after the germ revolution in the 1870s medicine increasingly saw man as a system in isolation that could be studied in a reductionist fashion. In such a system there was no place left for the Hippocratic ideas. In other words, this period was the end of, as medical historian Charles Rosenberg labelled it, the 'Hippocratic era'. About the fate of the Hippocratic idea that a given place with its local climate is a determinant of health, he wrote:

> By the mid-twentieth century this accustomed epidemiology of place had become decreasingly central in Western medicine, not so much forgotten as moved from center stage. It had become a supporting player in a little-questioned narrative of progress toward an increasingly inward and ultimately biochemical and biophysical understanding of the body.[13]

Likewise, medical historian Genevieve Miller noted in 1962:

> While the attempt to correlate disease with climatic and weather conditions is still made by some investigators, this approach is no longer in the mainstream of medical thought. Modern research workers might admit that meteorological and climatological phenomena are probably indirect causes in a complicated causal nexus; for example, as determining the conditions favorable for the generation and multiplication of pathogenic organisms which are the immediate cause of disease, or they might relate

[13] Rosenberg, 2012, 664

> specific meteorological episodes and the onset of illness in terms of the stress to which they subject the organism, but the philosophical ideas embodied in "Airs, Waters, and Places" are meaningless for contemporary research.[14]

The present chapter investigates whether this standard account, the relentless march of bacteriology, tells the whole story. What happened to the Hippocratic ideas after 1870? This chapter aims to answer this question for the period up to approximately 1950.

While historians studied extensively how the relation between health and the environment developed up to the middle of the 19th century, little has been published about later developments. The monograph '*Hippocratic Heritage*' (1982) by William Sargent, a physician who played a significant role in the revival of this mode of thinking himself, is, to my knowledge, the only attempt to provide a synthetic overview of the later period. Besides, several case studies were published about specific periods, such as the interbellum, or about specific contexts, such as medicine in the colonies of Great Britain.[15] In the following section, I will provide a synthesis of the current knowledge on the development of the health-environment relation in the period up to 1950. The mentioned sources indicate that pronounced differences existed between countries in how the health-climate relation was expressed. Overall, three different groups kept the interest in this relation alive: firstly practitioners who worked in colonial or imperial settings, secondly followers of diverse 'holistic movements and thirdly, the first cohort of 'biometeorologists' who began to study the relation in a scientific way.

Practical Hippocratism: colonial and imperial health

In Great Britain the interest in relations between health, climate and place persisted in the second half of the 19th century because of its relevance for the country's colonial activities. The quality of local climates was seen as crucial for the success or failure of the white colonizers in remote parts of the world. Some climates were judged to be suitable for European settlers and their crops, while other climates, especially humid and hot tropical climates like those of West Africa and New Guinea, were labelled the 'white man's grave'.

---

[14] Miller, 139-140

[15] David Cantor discussed the appropriation and transformation of the ideas of Hippocrates throughout history, including the first half of the twentieth century in '*Reinventing Hippocrates'* (2002). The connection of Hippocratic thinking with holism in the interwar period was mentioned in his 'Greater than the Parts' (1998). The study '*Climate in Motion*' (2018) by Deborah Coen, an investigation of the origin of the concept 'climate' discusses the association of climate and human health in the Habsburg empire after the middle of the 19th century.

Colonial authorities sustained their belief in the Hippocratic notions with systematic collection of facts about the health of individuals in order to clarify the relations between health, weather and other factors such as diet. To mitigate the harmful effects of bad climates, they also identified colonies or regions within colonies with beneficial health qualities. These places, often cool and at high altitude, were used to provide 'climatotherapy' to victims of poor climates, either from the colonies or from Great Britain. Some of the colonial health destinations were used as retreat for tuberculosis patients whose stay in the overcrowded European cities was considered damaging to their health.

An offspring of this colonial attitude towards health was the treatment of rheumatism in Great Britain after World War I. In the post-war years a great concern existed about the poor health situation of the population and the military in particular. Rheumatism, a frequent disease among recruits, was seen as a sign of degeneration and as a major threat to the economy. By analogy to the way tropical diseases were seen as a mismatch between racial properties and the climate in the colonies, rheumatism was interpreted as a sign of poor adaptation to the British climate. The remedy for rheumatism, physiotherapy, involved a (re-)adaptation to the northern climates. Just like a return to northern climates was suggested as cure for sufferers of tropical diseases, a stay in a warmer, more wholesome, climate was suggested to restore the balance in rheumatoid patients. Obviously, such climatic travel was not feasible for the masses. To help patients nevertheless, physiotherapists created artificial conditions, using local spas and ultraviolet light to emulate the characteristics of more wholesome climates.[16]

In similar ways, the colonial empire of France struggled with diseases that were particular to the different localities and climates where its soldiers and officials were stationed. Knowledge and control over environmental health issues was important for maintaining the quality of the imperial troops. While physicians in France generally respected the bacteriological revolution of Pasteur, they did not all abandon the traditional Hippocratic teachings on the effect of climate on health. In fact, they continued a long colonial tradition that valued the role of 'place' and 'climate', a tradition that also existed in other colonial nations like Great Britain and the Netherlands.[17] In particular, military physicians who knew from their experience the effects of extreme climatological conditions on soldiers continued to appreciate 'place' as a factor in disease causation. This explains why Lyon, a city with many

[16] Cantor, Cortisone, 465-466
[17] See the contributions in: Medical History in Geographical Perspective, 2000

colonial and military institutions, became the centre of neo-Hippocratic medicine in the interwar period, most notable in the person of Marius Piéry.

Having had war experiences himself, the Lyonnese physician Piéry must have been influenced by the Hippocratic tendencies among the military circles in Lyon. His interest was centred on curing diseases by spa treatments and by the wholesome radioactive emanations at these locations. He objected to the dangerous procedure of inducing 'pneumothorax', a surgical procedure to produce a collapse of lung tissue for treating tuberculosis. Instead Piéry favoured a more subtle 'Hippocratic' approach in which the patient was subjected to a change of place. Where Hippocrates had indicated that a mere change of place was enough to cure tuberculosis, Piéry disagreed. He sought out favourable climatic conditions at spas and resorts at high altitude. According to him, bringing the patients to these places did not only decrease the symptoms of tuberculosis but even had a curative effect on some form of tuberculosis.

Likewise, in imperial Austria the belief in the relation between weather and health remained even after the rise of the germ theory. Environmentalism was endorsed in this country by the imperial and military institutions. Military professionals in particular continued to blame poor health and poor performance of soldiers on unwholesome surroundings.[18] They clung to the ancient Hippocratic notion that climatic variability causes disease: 'Klimawechsel' was thought to be harmful to the soldier's health. To put these ideas on a firmer basis, the royal-imperial Central Institute for Meteorology and Geomagnetism charted the climatological and medical properties of all areas of the Habsburg empire. This central research institute installed measurement devices all over the country to determine whether the local climatic conditions were wholesome or not. This stimulated the practical implementation of 'climatotherapy'. Many spas, resorts and other places with beneficial health properties were established and became popular tourist destinations for the well-to-do by the end of the 19th century.

Climatology in the Habsburg empire was concerned with precise measurements and at the same time with the meaning of these measurements for the human condition. The gathered data were also intended to help the public, ordinary people who relied on this knowledge for their existence, to cope with 'fluctuations in health, hunger and prosperity'.[19] Among the beneficiaries were doctors and their patients. Around the turn of the century middle class citizens became interested in the possibility to control their health by means of the new

[18] Coen, Climate in Motion, 61
[19] Coen, Climate in Motion, 155

climatological knowledge. At this time, the central meteorological institute presented evidence for the impact of changes of air pressure on health of students, workers and patients. The importance of such climatic variabilities was discussed in several journals aimed at professionals and the public.

In terms of therapy, Habsburg doctors emphasized the positive effect of relocating patients from one climate inside the empire to another. Just as climatic variability was associated with the emergence of diseases, it was also applied as a remedy to improve health. The great diversity of landscapes and climates within the Habsburg empire provided ample opportunity for such cures. A variety of diseases were targeted by exposing patients to a change of climate: diabetes, arthritis, heart diseases and diseases of the sexual organs. As had been the case earlier in Great Britain, this approach was also politically and economically motivated.[20] Outbreaks of diseases like cholera were common in those days. While other countries applied contagionist remedies, such as quarantine, Austria choose a different policy. By resorting to environmentalist instead of a contagionist explanations of disease, the Habsburg government gave in to lobbying from the commercial class against quarantine measures that could harm the economy.[21]

The nineteenth century Hippocratic view on the health-environment relation also persisted in the USA in the context of colonial expansion by European settlers. In her study '*Inescapable Ecologies'*, Linda Nash investigated the situation in the USA after the rise of the germ theory. She found that settlers in California regarded the different landscapes within the area in terms of traditional Hippocratic concepts. They praised Southern California for its therapeutic qualities, good air and wholesome temperatures, whereas settlers in the Central Valley worried about miasmas, poisonous winds and climate-related fevers and diseases. These pioneers and their local physicians saw a direct relationship between health and the environment and expressed concerns about their own role in changing the environment. Although the germ theory became more and more accepted as standard in the USA around 1900, environmentalism was never completely abandoned:

> At the level of practice, understandings of bodies and places remained deeply intertwined. The uneven distribution of disease and the recurrence of epidemics indicated that certain places still seemed to harbor illness while others did not. In other words, germ theory could not and did not completely disconnect the body from its environment. Any attempt to contain disease and health within a simple modernist narrative was bound to fail. Consequently, the rhetoric of germ theory existed alongside the environmentally oriented practices of sanitary engineers and marginalized subfields of biomedicine that still took the

[20] See Ackerknecht's paper 'Anticontagionism between 1821 and 1867' (1948, reprinted in 2009)
[21] Coen, Climate in Motion , 181-183

broader environment into account. In fact, engineers and others would invoke germ theory as their rationale for a much more widespread effort to reorganize landscapes along "sanitary" lines.[22]

Whether the case of California is representative for a wider movement in the USA remains to be studied. Nevertheless, the example shows that men of practice outside mainstream medicine, in this case settlers, farmers and their local physicians, continued older medical traditions.

In summary, even after the turn in medicine in the 1870s, the belief in the relation between health and environment persisted in the context of imperial and colonial expansion. The involved practitioners, soldiers, farmers, local physicians, spa owners, dealt with situations in which the importance of climatic situations for everyday health was manifest. Their assessment of the relation between health and the environment may have been experiential rather than scientific, yet they played in role in carrying over the pre-existing Hippocratic environmentalism.

Holism and Hippocratic health

In the first decades of the twentieth century environmental thinking was incorporated as an element in a wider 'holistic' world view**.** Holism was an intellectual movement that blended scientific and cultural elements into various systemic world models. Medical holism is one of its many manifestations. Diverse forms of medical holism had an anti-reductionistic stance in common. The holists favoured to view the human body as a system in its totality. There were many ramifications of medical holism, some of which originated outside mainstream medicine. In this section, I limit myself to holistic physicians that expressed holism within the boundaries of medicine. Some of them took a special interest in the effects of the external environment on the human organism, transforming ideas from the 'Hippocratic' tradition into new forms of medical environmentalism.

In France, medical holism generally did not stray far from mainstream medicine. One of the key figures in French holism was the earlier mentioned Marius Piéry. In his massive *Traité de climatologie biologique et médicale* (1934), he combined medical climatology with results from other fields such as meteorology, geography and astronomy. All in all, he favoured the idea of the diverse climates as 'active and therapeutic agents', without renouncing the results of other medical orientations. As Osborne stated, 'his Neo-

[22] Nash, Inescapable ecologies, 84

Hippocratism, far from being a recalcitrant refusal of medical modernity, was part of a vibrant and developing world view'.[23]

The work of Piéry with its synthesis of Hippocratic elements and modern medicine can be seen as a precursor to the modern biometeorology that, as will be shown later, developed from the 1950s onwards. Frederick Sargent, who was to become one of the initiators of the new field, credited Piéry for his role in connecting old traditions with contemporary medicine.[24] This is not to say that the approach of Piéry and followers was the dominant alternative to mainstream medicine. During a revival of interest in Hippocrates in France in the 1920s and 1930s, a plethora of holistic medical doctrines flourished, like naturopathy, homoeopathy and vitalism. These doctrines called upon both the Hippocratic tradition and modern medicine, with a variable degree of confidence in either of these.

Whereas most holistic movements in France favoured 'natural' healing without surgical interventions and agreed that a more complete view of the patient was needed, they disagreed about the implementation of these ideas. Some, like Piéry, believed in the healing role of environmental changes, exploiting the therapeutic options that nature provides: sunshine, waters and mountainous air. Others believed that the role of environment was less important because they saw in disease a manifestation of constitutional imbalances within the body; they stressed the Hippocratic notion that the body was its own healer. The neo-Hippocratics embraced the ambiguities in the Corpus. This allowed the proponents of widely different medical approaches to appropriate Hippocrates for their own means.[25]

In Great Britain some forms of natural healing were practiced that originated from colonial medicine. The Hippocratic nature of these treatments resonated with the promotors of 'neo-Hippocratism' or neo-humoralism, who argued that the body cannot be healed without attention to its environment. In a similar vein, these holists held that the treatment of individual parts of the body could not be done without attention to the organism as a whole. Like in France, these holistic tendencies were most prominent in the 1930s. The movement was a reaction to modernization in medicine and in society at large. Its proponents objected to the increasing mechanization, bureaucratization and changes of scale within medicine, and the corresponding marginalization of the role of the patient. At the same time, it was a reaction in medicine and science in general against reductionism, the idea that phenomena could be

[23] Osborne, 558
[24] Osborne, 545
[25] Weisz, Hippocrates, Holism and Humanism, 269-274

explained in atomist fashion by studying its basic constituents. In particular, criticism was voiced against the idea that disease could be understood in terms of a single cause, such as bacteria.[26] In Britain, more than in other countries, holistic medicine was confined to a small elite. Holistic physicians, such as the neo-Hippocratist Alexander Cawadias, served a wealthy clientele in their private practices in London and used the holistic notions to defend their freedom to act as a clinician.[27]

In Germany the interest in weather and climate-related disease causation remained alive, despite the status of Robert Koch and others as fathers of modern medicine. Part of this can be explained by a pre-existing intellectual tradition in the 19th century in which holistic ideas were already deeply rooted.[28] Like in France and England, a revival of environmental thinking was seen in the 1920s and 1930s, although in Germany it was associated with neo-Hippocratism, and holism in a different, and overall more political way. Responding to a general feeling of crisis in medicine and society at large, diverse political streams reverted to historical figures like Paracelsus and Hippocrates, whose ideas were appropriated to fit into the desired political framework. In this, Hippocrates served as 'ideological toolkit, a miscellaneous collection of beliefs and ideas associated with the ideal doctor'.[29] Some Hippocratic ideas, such as the notion of 'complete medicine' were presented as a release from the predominant mechanic-materialist medicine by proponents of national socialism. Nazi physician Karl Kötscha, for instance, incorporated the Hippocratic notion that 'nature heals' in a total package, 'New German Art of Healing', which also included abstinence from alcohol and folk therapies like fasting and herbal cures. [30] Throughout the national socialist era, Hippocratic thinking was incorporated as a political tool.

In sum, holism in provided a shelter for a great diversity of ideas about medicine, including environmental thinking. Some holistic concepts were new and experimental, others referred to medical history in search for more humane and nature-oriented forms of treatment. In Great Britain, neo-Hippocratic doctors picked up the pre-existing tradition that saw a relation between health and climate. In practice, its application was confined to a small elite group of physicians and their patients.[31] British Hippocratic medicine was essentially a conservative form of holism that did not spur new investigations about this relation, unlike in

[26] See e.g. Lawrence, Continuity in Crisis, 267-269
[27] Lawrence & Weisz, Greater than the Parts, 12, 82-38; Cantor, Reinventing Hippocrates, 283
[28] Ibid., 8
[29] Timmermann, 303
[30] Harrington, Reenchanted Science, 186-187
[31] Cantor, Reinventing Hippocrates, 283

France, and more so the USA and the German speaking countries where a new synthesis between Hippocratism and modern medicine inspired the new field of biometeorology.

Hippocratic science in the USA: 'The Patient and the Weather'

In the first decades of the 20th century the relation between man and climate became the subject of scientific research in the United States. Pioneering work on the relation between human behaviour and the weather was performed by Edwin Grant Dexter (1868–1938), who correlated events like suicide, murder and drunkenness with parameters such as temperature, wind, humidity and cloud cover.[32] His work influenced Ellsworth Huntington (1876-1947), who used large amounts of mortality data to search for the most healthy geographical locations.

Perhaps one of the last explicitly Hippocratic medical works was '*The patient and the Weather'* by the American pathologist William F. Petersen (1887-1950). The book was published around 1935 and covers some four thousand pages of material, combining modern medicine with the doctrines of 'Airs, Waters and Places' and other Hippocratic writings. As starting point, Petersen acknowledged the success of modern medicine in fighting infectious diseases, but criticized the emphasis on infections in medical teaching. Given the decrease in infectious diseases, the emphasis of medicine should lie elsewhere:

> But we still stress the infectious diseases in the schoolroom, while the major infections are rapidly disappearing from practice. Many physicians never see a case of typhoid fever. But we still devote much time to a careful study of the typhoid-dysentery group. We are rapidly eliminating diphtheria by preventative measures. Tuberculosis mortality has been reduced by two-third. In their stead we deal with colitis. Hay fever makes multitudes miserable; so do migraine and arthritis. Chronic ailments make up an ever-increasing percentage of the practice. The psychoses increase year by year. But with his training fundamentally centered about the infections, the young physician is not equipped to evaluate, is seldom curious to study, rarely competent to treat properly the types of diseases that now make up the backwash.[33]

Being a pathologist himself, Petersen, attacked the preoccupations of his own profession. Pathology, according to him, drives the physician towards an understanding of disease 'in terms of the deadhouse', while the origin of disease should be traced to inflammations and alterations that appear long before. And, so Petersen argued, it is a serious neglect that the environment is hardly taken into consideration for understanding the origin of diseases. He writes about the main idea of his book:

---

[32] See Stewart, A. E., 2015 about Dexter

[33] Petersen, Patient and the Weather, Part 1, ix

> The thesis concerns the effect of the environment on the patient, but chiefly the immediate environment, namely, the weather and the season. I have made use of the meteorological changes to support my main objective for several reasons. In the first place, this environmental factor can be measured with considerable accuracy. In the second place, it is the most environmental factor from the time we are conceived to the time we die. In the third place, it is thoroughly ignored in medical teaching and medical practice…..We will have to ignore much of the older literature of the subject for the very simple reason that, as will become evident in this volume, the recognition of the importance of the meteorological environment is already completely developed in the Hippocratic texts.[34]

Throughout the first part of the book, Petersen combines statistical data on the geographical distribution of diseases throughout the United States with corresponding climatic data. These observations are mirrored with elements of the Hippocratic corpus. First, with the notion that all diseases are related to the supply of air to the tissues and that diseases occur mostly when the air is disturbed, especially when the seasons change. Meteorological disturbances affect the tissues and these only regenerate after a certain period. Second, with the notion that the development of the unborn child is affected by atmospheric changes, which, together with the climatic situation after birth, determine the differentiation between human races.

Starting from these Hippocratic premises, Petersen created maps of the degree of climatic variation within the USA, based on storm tracks, cyclonic movements of the air and barometric variability. These are signs of variability, and therefore related to the causation of diseases according to the Hippocratic view. If these variabilities are projected on a map of United States, three 'regions of greatest meteorological demand on the organism' appear. Next, Petersen drew the geographic prevalence of many diseases across the country, on the basis of data from the US Draft and mortality statistics. Indeed, the regions identified as having the highest climatic variabilities stand out as the regions with highest disease loads for many diseases. Figure 2 shows in the upper panel the three areas in the USA with the highest weather-induced demand on health. The lower panel is one of Petersen's many geographical disease maps, displaying the prevalence of diabetes as determined from the US military draft records. The areas with the densest shadings are the most affected by diabetes, in this case showing a correspondence with the three areas identified in the upper panel.

[34] Petersen, Patient and the Weather, Part 1, xii

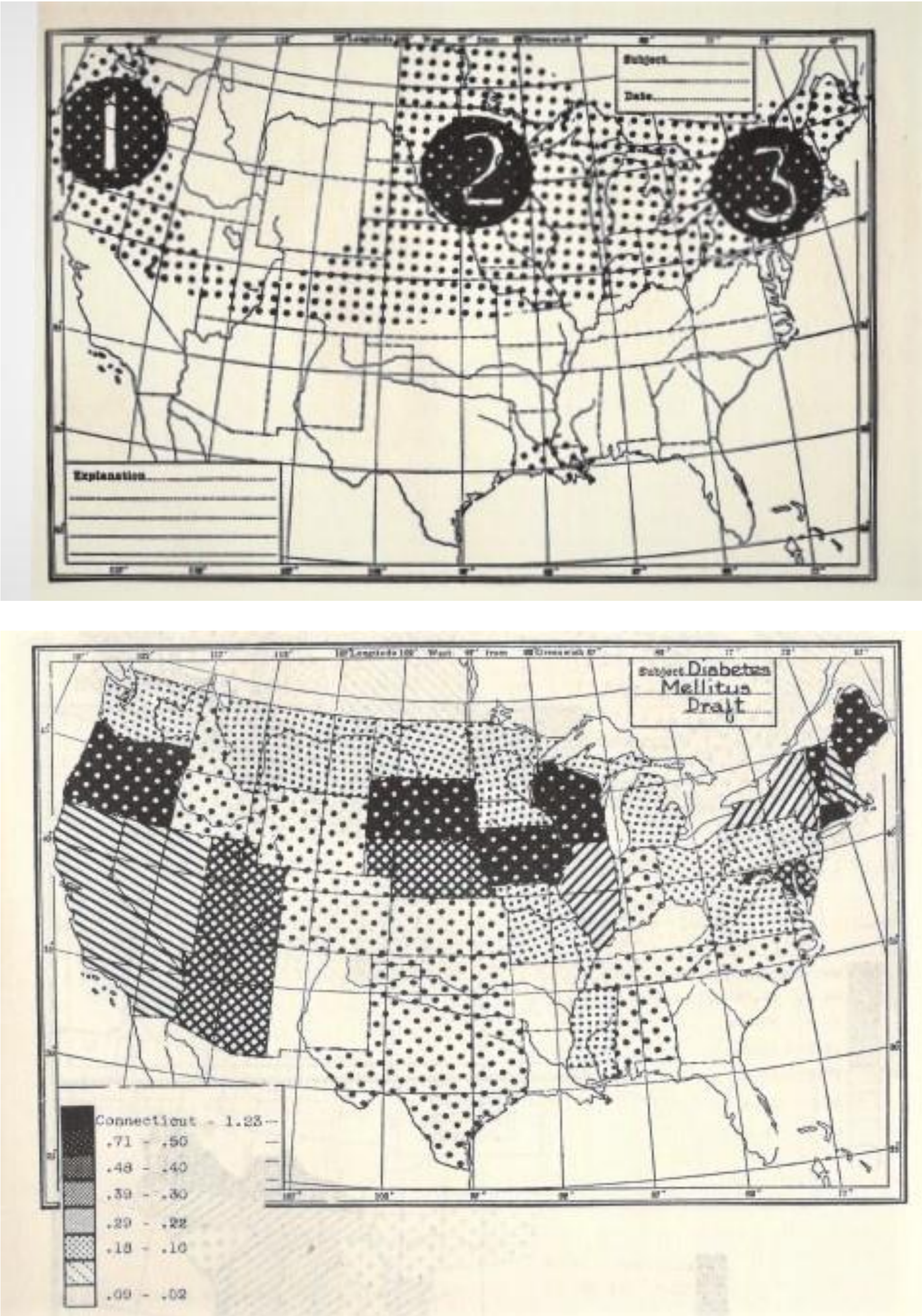

FIGURE 2 REGIONS WITH THE GREATEST DEMAND ON HEALTH AS DETERMINED FROM ATMOSPHERIC PHENOMENA (ABOVE) AND THE MEASURED GEOGRAPHICAL DISTRIBUTION OF DIABETES IN THE USA (BELOW). REPRODUCED FROM: W. F. PETERSEN, THE PATIENT AND THE WEATHER, PART I

A second Hippocratic element, the role of the *constitution*, is another pillar of Peterson's interpretation of the geographical variation of diseases. A person's constitution is, amongst other factors, affected by the climatic situation before birth, whereas his later development is meteorologically, and geographically, conditioned. Petersen elaborates on the combination of environment and constitution for numerous individual patients suffering physical or mental diseases. Each case study in '*The Patient and the Weather'* comprises a detailed history of a patient together with detailed logs that show how physiological values develop in time along with the weather conditions.

Coupled to the Hippocratic thesis, Petersen developed a physiological model to explain the causal relationship between health and environment. The essence of the model is a rhythmic response of organic processes of the vegetative system to meteorological variations. The phases of the rhythm include a phase of increasing blood pressure with spasms of the vessels and a phase of decreasing blood pressure in which vessels dilate and oxidize. These phases are sensitive to shifting airmasses, the passage of cold fronts or warm fronts. While in a healthy person these rhythms are in tune and cause no problem, sick persons suffer from unbalances in the rhythm. Petersen used the metaphor of man as a 'cosmic resonator' for these phenomena.[35]

A shortcoming of Petersen's approach is that it is difficult to assess the strength of the correlations between climatological factors and diseases from his complex set of geographic maps and other charts. Petersen failed to show how meteorological events, such as the passage of cold or warm fronts, correlate in time with the onset of diseases. In the absence of such proof, the claimed correlations between climatic factors and diseases are not entirely convincing. At the time he wrote '*The Patient and the Weather*', moreover, statistical methods were lacking that could put the claims on a firmer footing. Petersen attempted to overcome these deficiencies in later work by using new statistical techniques, such as those developed by Bernhard de Rudder in Germany. The results, however, indicated that the reality of many of the correlations inferred from visual inspection of his maps could not be proven statistically.[36]

The Patient and the Weather, in summary, stands out because it attempts to combine environmental, Hippocratic, concepts with the results of mainstream modern medicine. To integrate his results with modern medicine, Petersen developed a physiological model to explain how environment affects health. Albeit rudimentary, he correlated statistical data on disease and weather to prove that their relationship was not only intuitive but supported by data. Not surprisingly, Petersen's linking of ancient Greek concepts with 20th-century

[35] See Sargent, 'Hippocratic Heritage' for a summary on this so called ARS/COD rhythms.
[36] Ibid., 361-362, 390

scientific medicine was criticized for the way in which writings attributed to Hippocrates wer used to anticipate modern theories.[37] From the current perspective, this criticism appears justified, and it is clear that Petersen overstretched the correspondence between ideas from the Hippocrates Corpus and concepts from modern medicine. Despite this, Petersen's combination of holistic neo-Hippocratism with modern science marks a transition towards a scientifically oriented 'human biometeorology', the subject of the following chapters. One of his pupils, Frederick Sargent, would after World War II play a significant role in promoting this new science.

Germany: the birth of biometeorology

The relation between health and environment remained a subject of study in the interwar period in the German speaking countries. Parallel to the holistic movement, some German meteorologists and physicians studied the Hippocratic ideas on the relation between health and weather in a neutral and highly analytic way. Two new focal points were the study of the effect of alpine climate by Czech scientists and the study of man-made urban climates by Austrian scientists. During a congress on balneology in 1928 in Baden, the conference organizers coined the term 'bioclimatology' for their work, a name under which the field became known later.

The meteorologist Franz Linke (1878-1944) introduced a new concept into medical meteorology. Instead of studying separate weather elements, he investigated the relation between complexes of weather factors (so called 'Luftkörper', e.g. frontal passages and air mass changes) with biological events. To obtain the necessary measurements, Linke erected bioclimatological stations throughout Germany and began to provide medical meteorological forecasts based on statistical studies. To communicate the results, he founded, together with Austrian colleagues, the first journal dedicated to bioclimatology, the '*Bioklimatische Beiblätter'* as a supplement to the Austrian '*Meteorologische Zeitschrift*'. The topics of the journal carried the field beyond the Hippocratic theme of atmospheric variation. Processes in and above the soil, within the 'biosphere' of humans, were also taken into account, including those in man-made urban environments. The journal united several branches, such as physics, medicine, botany, and geography that were relevant for the interdisciplinary study of biology and the climate. The journal existed for ten years, during which some of the earliest papers

[37] Edelstein, 1946, 477-482

appeared on topics such as urban pollution, urban 'heat-islands' and the adaptation of city planning to the climate.[38]

The transition towards a scientific 'bioclimatology' was further marked in 1931 by the publication of '*Wetter und Jahreszeit als Krankheitsfaktoren: Grundriss einer Meteoropathologie des Menschen*' by Bernhard de Rudder.[39] Originally a pediatrician, de Rudder had noticed in the 1920s in his practice that goiter, an enlargement of the thyroid gland, and eclampsia, a pregnancy disorder accompanied with high blood pressure, preferentially occurred when certain weather conditions prevailed. Based on Linke's concept that movements of air masses are correlated with health, de Rudder compiled a synthesis of the knowledge on weather and health in his '*Grundriss*'.

De Rudder examined in detail how relations between man and the atmosphere can be demonstrated in a methodologically correct way and with statistical support. He claimed that correlations between diseases and descriptive categories like cold, warm, sultry, gloomy, and stormy were not meaningful. Attempts to find such correlations had generally remained inconclusive. Instead, de Rudder attempted to correlate episodes in which diseases were clustered with atmospheric processes that occurred at or around the same time. Such processes were defined as the collective actions of measurable weather elements: air masses, fronts, foehns, turbulences, etc. Using these large scale phenomena, he hoped to achieve objective descriptions of weather processes and to obtain reliable correlations of these with diseases and other life events. For this purpose, he developed a statistical measure, the 'meteorotropy index'. The index allowed to classify diseases according to the likeliness that they were 'meteorotropic', i.e. caused by weather phenomena.

[38] Coen, Climate in Motion, 353

[39] Later editions in 1938 and 1952 would be called 'Grundriss einer Meteorobiologie des Menschen'.

„Wetterkrankheiten" („meteorotrope Krankheiten"), im Sinne einer Auslösbarkeit durch atmosphärische Unstetigkeitsschichten.

Ein Zusammenhang zwischen Krankheitsschüben und dem Durchzuge atmosphärischer Unstetigkeitsschichten ist:

gesichert oder fast gesichert	sehr wahrscheinlich	möglich aber noch eingehend zu untersuchen
Akuter Kehlkopfcroup (jeder Ätiologie). *Spasmophilie beim Säugling* in allen akuten Manifestationen (tetanische und eklamptische Anfälle). *Eclampsia gravidarum* *Schmerzattacken* (Wetterempfindlichkeit an allen *chronisch entzündeten Geweben*; rheumatisch, an *Narben*, an arthritisch veränderten *Gelenken*, an tuberkulösen Narben im Lungengewebe usw., *lanzierende Schmerzen bei Tabes)*. *Neuritische* Schmerzen. *Haemoptoe*. Akute „*Erkältungskrankheiten*" der oberen Luftwege. Akuter *Glaukomanfall*. *Apoplexie und Thrombose*.	*Croup. Pneumonie*. *Asthma-bronchiale-Anfälle* (gewisse Formen). *Epileptische Anfälle*. *Appendicitis* (gewisse Formen). *Migräneanfälle* (gewisse Formen). *Malariaanfall* bei chronischer Malaria. *Plötzliche Todesfälle* beim Säugling *(„Ekzemtod")*. *Lungenembolie*. Tod an *Coronarsklerose*. *Anginen* (genuine und postoperative).	Beginn von *Diphtherie* (auch septischen Formen) und von *Scharlach* Gewisse Schmerzattacken bei *Koliken* verschiedenster Art.

FIGURE 3 THE CONFIDENCE LEVELS OF CORRELATIONS BETWEEN DISEASE CLUSTERING AND ATMOSPHERIC VARIABILITY TELL WHETHER A DISEASE IS METEOROTROPIC. REPRODUCED FROM: DE RUDDER (1931)

As to the mechanisms behind meteorotropic diseases, de Rudder pointed to irritability of the vegetative system. Interestingly, he found that in some people certain complaints started before the related atmospheric conditions actually occurred. The persons in question were labelled as 'Wetterfühlig' (weather hyper-sensitive), a concept that has been accepted as a reality in Germany until today. De Rudder accounted for this phenomenon by the function of the central nervous system.

All this left the question open which atmospheric phenomenon precisely caused the effects. Attempts to understand the causation in terms of single factors, like temperature, pressure of humidity proved to be unconvincing.[40] Something had to be identified that could account for weather sensitivity. It had to be a cause that can influence the patient before the corresponding atmospheric condition is apparent. In addition, it also should be able to affect

[40] De Rudder, Grundriss (1931), 68

patients indoors, sheltered from the atmospheric influences. Small pressure oscillation, atmospheric ions and other forms of air electricity were proposed as candidates, but de Rudder hastened to say that this was far from certain.[41]

Bernhard de Rudder, moreover, emphasized the fundamental problem that a mere correlation between certain atmospheric phenomena and the presence of diseases is insufficient to establish a causal connection. He pointed out that the relation should also be proven to be congruent, i.e. the degrees of increase of decrease of the atmospheric phenomena and the strength of diseases should match. And even so, a correlation might emerge because of a correlation with a confounding third factor.[42] The same reasoning would be repeated a few decades later when Bradford Hill constructed new criteria for causality in medicine (see chapter 4 of this thesis). Frederick Sargent would comment on de Rudder's contribution to the changing views on causality as follows:

> Only indirectly did de Rudder ever address what was becoming a central question for biometeorology in the twentieth century. In the hierarchy of known causal factors of human illness and disease, just where did weather, season, and climate rank? De Rudder went all around this question and seemed to have had it in mind when he wrote about unraveling the enigma of life. Thus, we find that it was generally realized at midcentury that weather was but one of an array of environmental circumstances that might precipitate or even cause disease. Human biometeorologists were reacting just as other health professionals to changing concepts of causality of human disease. The simplistic idea of one cause/one effect that had dominated medical thinking since the discovery of bacteria was losing ground, and a new idea of multiple causation was emerging.[43]

The 'Grundriss' was published in the same period as Petersen's 'Patient and the Weather'. While both may be seen as a precursor to modern scientific biometeorology, there is a marked difference between the books: the 'Grundriss', despite its emphasis on the effect of atmospheric variability, no longer contains any references to Hippocrates or other historical figures. In addition, it attempts to prove the alleged correlations between climatic events and the onset of diseases with statistical means. As Sargent would later remark about the 1952 edition of the 'Grundriss':

> It is reasonable to infer that with the appearance of his textbook, biometeorology had come of age, and from its contents we can learn something of the state of the art and the principal unanswered questions at midcentury.[44]

[41] De Rudder, Grundriss (1931), 72-73
[42] De Rudder, Grundriss (1931), 108-109
[43] Sargent, Hippocratic Heritage, 436
[44] Sargent, Hippocratic Heritage, 422-423

Conclusions

Despite the revolution in medicine that resulted in the germ theory, bacteriology and parasitology as central concepts in medicine, older Hippocratic beliefs about the environmental causes of disease persisted. These ideas were expressed in different forms, dependent on the local context and the intentions of those who adopted them.

For the colonial empires of France and Great Britain it was crucial to sustain a sufficient number of troops and officials in their remote territories. To achieve this, they needed to control the damage resulting from unwholesome climates, as well as to exploit the beneficial qualities of wholesome climates. Climatic treatments (spas, mountain stays, light therapy) became highly popular in the colonies for convalescence of soldiers and officials, while in the home countries they served as cure for chronic ailments, such as rheumatism and tuberculosis. Similar development took place within the Habsburg empire. The peak period of these 'Hippocratic' treatments occurred in the first decades of the twentieth century.

The rise of climatotherapy corresponded with a wider intellectual movement in which a variety of Hippocratic elements were incorporated in 'holistic' world views. In France and Great Britain, these holistic movements reacted against modernity in medicine, opposing mechanistic and reductionistic tendencies in scientific medicine, in particular the emphasis on reductionistic bacteriology. Holistic values emphasized an organistic view of man as a patient, thereby creating a place for forms of 'natural healing' such as climatotherapy. Holism in England and France also hosted various forms of fringe medicine, like homoeopathy and naturopathy. At the same time, Hippocratic thinking was appropriated for political purposes in Germany and used as a tool to restore social unity, culminating in its inclusion in sinister national socialist folk healing.

In parallel to the 'holistic' attention for the relation between man and environment, physicians in the USA and Germany initiated an empirical and analytical approach to the problem. The abstract classical Hippocratic notion that climatic variability caused disease was adopted in the scientifically oriented approaches of Petersen, de Rudder and others, which became known as 'bioclimatology' or 'biometeorology'. In view of the desire to unravel the link between man and his environment, it is not surprising that this idea was selected from the plethora of Hippocratic concepts. To trace the onset of disease, which is a digression from the healthy state, it was logical to search for related variabilities in the environment, the weather or the climate. It was fortuitous that in the 1920s meteorologists made breakthroughs in their understanding of changes in the atmosphere. As a result, physicians such as de Rudder and Petersen started to study how the onset of diseases is related to large scale atmospheric movements.

By the middle of the 20th century, the belief in the relation between health and climate still persisted. In some countries, like France and Great Britain, it lived on in therapeutic interventions, such as spa treatments and high altitude cures. In other places, notably Germany, Austria and the United States, it was also subject to scientific study by a small group of medical professionals. Although much effort had already been invested in charting and correlating diseases with climatological phenomena, it was still unsettled which atmospheric properties were really related to disease. Even less understood was the causal relation between these 'meteorotropic' parameters and the resulting disease processes within the human body.

While some of the Hippocratic thinking on health and environment in the interwar period had been embedded in a wider 'holistic' movement, such an overarching framework practically vanished after the second World War. By the 1950s, holism in medicine had declined, due to the perceived success of biomedicine and the increasing American influence in medicine after World War II. [45] Those who wanted to pursue ideas the Hippocratic tradition needed to do so within the scientific arena. The remaining scientists who investigated the health-environment relation, however, were scattered across different countries and used a diversity of approaches. How they, nevertheless, succeeded in boosting their ideas, is the subject of the next two chapters, which concern the genesis of the modern scientific discipline of 'bioclimatology' or 'biometeorology'.

[45] Cantor, in: Reinventing Hippocrates, 294; see also, Greater than the Parts, 16-18, 85-87

Chapter 2: Charmer, charlatan or champion? Solco Tromp and human biometeorology

It is beyond doubt that a person's health is influenced by his environment. Conditions like extreme cold or heat obviously affect our well-being. It is less clear whether and how more subtle environmental factors play a role in the origin of diseases. Biometeorology is the field that studies such relations between living organisms and their surroundings, with its sub-branch of human biometeorology dedicated to issues concerning human health. These fields are multidisciplinary, combining biology or medicine with meteorology and climatology.

Around 1950 biometeorological topics were studied by dispersed and isolated individual scientists with various backgrounds. A need was felt to organize these efforts into a new discipline with its own institutions in the form of a society, a journal and dedicated conferences and study groups. The next chapter will analyse in more detail how this process took place.

This chapter especially highlights the remarkable part played a Dutch geologist, Solco Walle Tromp (1909-1983) in the first stages of discipline formation. I will show that Tromp played a key role during the first phase, due to his extraordinary capacity to mobilize and motivate scientists and others that were instrumental for his goals. Despite his successes, Tromp, initially trained as a geologist, remained during his entire lifetime an outsider with respect to the medical establishment and the scientific community at large. His involvement with fringe sciences, his unconventional ideas about what should be covered by the field of biometeorology and his allegedly poor attention to methodology gradually alienated him from the scientific community. Although his influence had waned in the final years of his life, the memory of Tromp was consolidated after his death by a foundation named after him which provides awards to young scientists. As a consequence, the history of the discipline, as written by its insiders, has tended to describe Tromp as a legendary initiator of modern biometeorology.

In the present chapter I provide a biographical sketch of Solco Tromp in order to understand how and why he became one of the key persons in modern biometeorology.

Early years: from geology to border science

Adventurous years

Solco Walle Tromp was born in Batavia in 1909, as member of a colonial family that claimed to descent from Maarten Tromp, a 17th century Dutch naval hero. After spending his childhood in the Dutch East Indies, where his father worked for the Bataafsche Petroleum Maatschappij, a predecessor of the Shell company, Solco migrated to the Netherlands in 1926 to study geology at Leiden University. In 1932 he obtained a Ph. D. based on a thesis about the geology of the Bitto Valley in northern Italy. This heralded an adventurous period during which Tromp exploited his geological knowledge in the worldwide oil business. He worked until 1940 in Egypt, China and Korea and in Indonesia, where he supervised oil wells in the jungle of Sumatra. During World War II he served as advisor for the government of Turkey and wrote two books that exposed his ideas about the desirable world order after the war. With a certain bravado he communicated these ideas to the Dutch government in exile in London. Somehow he managed to obtain a function as Head of Economic Warfare for the Netherlands Forces Information Service, where he informed in 1945 and 1946 the Allied Forces about the situation in the Dutch East Indies.

A worldview unfolds: neo-materialism

During the war, Tromp began to express his ideas on the desirable world order in the future. A first book on this topic, '*World peace through federation*', appeared in 1944 in Cairo under the pseudonym 'William P. Mort'.[46] This book deals with the material conditions for world peace. In the same period Tromp wrote a sequel that finally appeared in 1947 at the publishing house Sijthoff in the Netherlands. This second book entitled '*The religion of the modern scientist (Neo-materialism)*' concerns the mental conditions for world peace. In this massive volume, Tromp assembles material from thousands of sources to support the eclectic argument that all processes in nature can be understood with two simple concepts, 'the original creative force' and 'energy'. Based on an analysis of matter, forces and energy, he developed a theory of the entire living world, with crystallization acting as the core process.

This 'neo-materialism', based on laws of nature and the idea of strict causality, is presented as the new religion, the religion of the scientist, ready to replace the old religions. As Tromp puts it, neo-materialism 'gives support to man in his mental sufferings and is still

[46] This book is exceedingly rare. It was published by Costa Tsoumas in Cairo in 1944.

complying with the laws of nature, which cannot be said neither of Christianity, nor of the Moslim or any other religion. It seems to be the highest conceivable form of religion which in future will be able to support man in his relentless struggle with the surrounding forces of nature'.[47]

Tromp indicates that the concept of neo-materialism 'originated vaguely after the author completed his geological studies in Leiden in 1930', after which he elaborated on it for some fifteen years.[48] He positions his philosophy as the opposite of the popular vitalist world conceptions, such as that of Hans Driesch (1867-1941), whose theory stipulates the existence of entelechy, an immaterial entity that determines all living processes. Tromp argues that it is impossible to prove observed material phenomena, such as heredity or the properties of cells, on the basis of such an immaterial ordering principle. A similar criticism is voiced against the concept of 'elan vital' of Bergson.

As inspiration for his ideas, Tromp refers to monistic hypotheses that were popular in the interbellum. These came in different flavours: 'psychic monism' advocated by the philosopher Gerard Heymans, 'energetic monism' by the neurologist Vladimir Bechterew and the 'pneumat-energetic monism' by Felix Louis Orrt. All of these had proposed a unitary energetic principle that governs the living and the non-living world. This appealed to Tromp, who tipped the scale towards a materialistic view in which a single principle governs all phenomena, both living and non-living: 'Neo-materialism could be described therefore as an improved energetic monism'.[49]

Perhaps the most unusual part of the '*The religion of the scientist*' is its last chapter which extrapolates the consequences of neo-materialism to the realm of human morality. It declares the 'Ten commandments for the modern scientist', the 'basic moral laws for a new world order'. I highlight a few of these commandments, because they shed a light on Tromps convictions.[50]

Commandment II: *One should help to build up state- and international socialism, based on the principles of real democracy.* This commandment implies that democracy can only be fruitful through international organizations, since these coordinate forces that originally move in different directions. The result is the creation of 'a form of energy of

[47] Tromp, Neo-materialism, 411
[48] Tromp, Neo-materialism, Preface, IX
[49] Tromp, Neo-materialism, 8-11
[50] Based on 'Neo-materialism', 411-421

higher order'. This requires 'social discipline', 'respect for one's neighbour' and 'respect for the superior'. All in all, the result is a form of 'international socialism'.

Commandment VI: *One should develop the adaptational capacities of men.* A complete socialization of mankind could lead to the death of mankind when 'an equilibrium in energy is reached'. Although stability in energy creates happiness, too much stability could lead to self-destruction. This will, however, be avoided through 'the necessary internal social reforms in the life of man in the post-war world', the type of reforms implied by the second commandment. Evolution of mankind benefits from activities that stimulate the adaptive qualities of people, ranging from sports, compulsory labour service, travelling to other cultures, changing jobs frequently and propaganda stimulating women to 'return to more purely feminine professions'.

Commandment VII: *One should never deprive a person of his illusions and hopes*. Helping the adaptational capacities of people requires that hopes and illusions are kept wherever possible.

Altogether, '*The religion of the scientist*' expresses a strong belief in the power of causal and materialistic thinking, in the role of international cooperation for the future of mankind and in the adaptability of man. The thesis of the book based on 'energy' and 'creative power' may sound rather eclectic, its tone of societal re-design based on international principles was not uncommon during the period of post-war reconstruction.[51]

The psychic period

The neo-materialistic world view of Tromp encompassed phenomena that could not easily be attributed to known scientific laws. Like some of the monists, such as Heymans and Ortt, who had inspired him, Tromp emphasized the importance of parapsychological phenomena.[52] These should be studied more systematically to understand the 'physico-chemical processes in the brain' with the ultimate aim to cure mental diseases and to further develop the psychic capacity of people.[53]

After his return to the Netherlands in the course of 1946, Tromp took up the study of such psychic phenomena: a decision that would, as we will see, have effects on his reputation as a scientist. Partly based on experiments performed in Delft and Leiden during the years

[51] See e.g. Somsen, A History of Universalism
[52] See Kloosterman, 64, 106-110 about the involvement in parapsychology of Heymans and Ortt
[53] Tromp, Neo-materialism, 236-237.

1946 and 1947, he delivered an extensive study entitled ‘*Psychical physics*’ that was published in 1949. The subtitle of the book reads: ‘*A scientific analysis of dowsing, radiesthesia and kindred divining phenomena*’. Dowsing is the practice of determining certain conditions of an area by detecting movements of a handheld rod or a similar device. Examples are the detection of water, oil, ores, metals, gemstones or graves. Radiesthesia is defined as the same activity, with a pendulum being used instead of a rod.

In the introduction to his book, Tromp states that he intends to explain these divining phenomena in terms of the influence of external electro-magnetic fields on psychic and physiological phenomena in living organisms. He is aware of the resistance against the study of such phenomena, but argues that this should be overcome. In his words:

> Even amongst the more broad-visioned scientists, however, it is difficult to find one who is willing to make a careful study of divining phenomena. This is not surprising and there are several reasons to explain their attitude : 1 There are obviously a great number of charlatans amongst professional and non-professional diviners; these are unhappily apt to discredit their genuine counterparts. 2. It is very easy to devise certain experiments to test diviners and obtain negative results.[54]

Tromp aims to establish whether the different divining phenomena are real or only based on suggestion, to determine what factors are disturbing such phenomena, and to find out how diviners’ reactions can be used to indicate external physical conditions. The book is primarily a summary of material from some 1500 documents, but also contains a small section on Tromp’s own experiments on dowsing and radiesthesia, performed in physical and physiological laboratories in Delft and Leiden in 1946 and 1947. According to Tromp, his experiments confirm that these phenomena are real and that they are probably caused by the interactions of nerves and muscles of the dowser or pendulum swinger with external magnetic and electric fields.

The result of these experiments, as he summarizes is ‘that divining phenomena are not due to charlatanry and suggestion but really exist and that the number of people sensitive to these phenomena is greater than is usually assumed.’ Moreover, failures to record such phenomena are due to the large number of disturbing factors that might influence how human nerves and muscles pick up such phenomena. These phenomena are governed by normal physical and physiological laws and therefore belong to the domain of medical science instead of the parapsychological domain. Careful study of these promises to be of ‘great value to future medical science’.

[54] Psychical Physics, 1-2

Tromp gives three examples of the claimed medical importance of 'pallomancy', the use of the pendulum. Firstly, it might help a doctor to determine more accurately the required dosage of drugs for each individual patient. Secondly, the study of the individual's electrical field may cause the detection of diseases in a very early stage and also indicate electromagnetic treatments. Thirdly, changes in electric fields of the body of women might give an early clue for determination of pregnancy, enable a doctor to predict the sex of the foetus and indicate the most favourable periods for conception.[55]

Tromp gives a hint of his preferred approach, characteristic of much of his later activities: 'A complete treatment of the subject would probably require several thousand pages, each chapter written by its own specialist.' Moreover, he states: 'Should this summary stimulate cooperative work in the field of "psychical physics" and remove scientifically unjustified prejudices the author will feel sufficiently rewarded for his work.' Two characteristics of Tromp are apparent from these statements, his belief that science should be unprejudiced as to what is included within its borders and his belief in cooperation between scientists from multiple disciplines.[56]

The last passage of the book summarizes Tromp's mode of thinking and contains a plea to create facilities for the research into psychic phenomena:

> We have reached the end of chapter III and of this publication on the science of divining phenomena. We have endeavoured to demonstrate that an enormous number of fundamentally unknown phenomena occurs in the living world which should be united into an independent science, *the science of divining phenomena*. This should be the sphere of interest of the *Laboratories of Psychical Physics* all over the world. It requires coordinative work of a great number of scientists who would combine great intelligence with a highly critical mind and an unprejudiced conception. For the first time in the history of mankind we would have at our disposal the gigantic strength of science to solve these most fundamental philosophical problems of life. Let us prove worthy of the task that lies ahead.[57]

Tromp put these words into practice. On 30 June 1948 he sent a plan to the Dutch Ministry of Education, Arts and Sciences to request financing for a 'Laboratory of Psychical Physics'. Although the minister refused to finance such an office, he did ask the Royal Dutch Academy of Sciences to investigate the relevance of research into dowsing and earth rays. An advisory

[55] Psychical Physics, 378

[56] Apparently Tromp was inspired in this respect by his mother, since the dedication of 'Psychical Physics' reads: 'To my mother who always stressed the point not to reject facts which do not seem to fit into the frame of our minds and which appear to be inexplicable by current theories'

[57] Psychical Physics, 405-406

committee was established in August 1948, which was headed by the brain researcher Brouwer and had among its members, the physicist and philosopher Jacob Clay.[58]

One of the first reviews on 'Psychical Physics' in 1950 in the 'Nederlands Tijdschrift voor Geneeskunde' happened to be by this very Jacob Clay. This review was extremely negative, criticized potential medical applications of the pendulum, and ended with the statement:

> Wij betreuren het dat Prof. Tromp gelegenheid heeft gekregen deze resultaten van zijn vlijt en grote energie onder de vlag de Uitgeversmaatschappij Elsevier de wereld in te sturen; het publiceren van boeken als deze dient ten sterkste te worden bestreden.[59]

Less outspoken, but similarly negative was a review in *The Lancet*. It labelled Tromp as 'candid' and 'industrious' but argued that the medical reader 'is content to remain a sceptic as long as the data about divining and its necessary conditions and relevance to medicine are in a state which the reports assembled here disclose'.[60]

A battle for recognition

In 1947 Tromp obtained a professorship in geology at the Fouad I University in Cairo, a position that he would occupy for three years. Probably he owed this position to his contacts with the local oil industry or to his father, who had lived in Egypt in the 1930s. Perhaps it was the unstable political situation in Egypt that caused Tromp's return to the Netherlands in 1950. There he found that the prospects for his proposed 'Laboratory of Psychic Physics' were dim. He persisted, however, and initiated the foundation of the 'Stichting ter Bevordering van de Psychische Physica'. For this purpose, he managed to gather a group of professors in psychology, notably Duijker, De Groot and van Lennep and the experimental physicist Heyn. The mission of the foundation bears the stamp of Tromp:

> 'to examine without prejudice or prepossession, with a preferably international scientific team, the different aspects of psycho-physics, which was defined in 1947 as the science which studies all physical and physico-chemical aspects of living phenomena in general, but in particular the physical and physico-chemical aspects of the fundamental problem of life studied by embryological science (especially physical embryology) and also the psychic-physiological aspects of psychical phenomena.'[61]

[58] Kloosterman, Thesis, 215-217
[59] NTvG, 1950, 1662. 'We regret that Prof. Tromp was given the opportunity to publish these results of his zeal and strong energy under the flag of the Elsevier publishing house: the publication of books of this kind should be strongly opposed'. (Translation R. Hes)
[60] Lancet, 1950
[61] Cited from Kloosterman, Thesis, 225

Tromp was controversial even within the foundation. The physicist Heyn did not hold him in high esteem, as he wrote to the American parapsychologist Rhine that Tromp is 'exactly like his book: many words but no contents. His experiments are 100% worthless'.[62] Circles around the established parapsychologist Tenhaeff also tried to counteract Tromp and the other members of the 'Stichting'.[63] When the opportunity arose to obtain funding for this type of research from the USA, allegedly because of its potential use in the fight against communism, Tenhaeff and his circle saw Tromp and his foundation as a threat to their own activities. This marked a period of conflicts between the established qualitative parapsychologists centred around Tenhaeff and the proponents of quantitative experimental work typified by the 'Stichting'. These conflicts would last throughout the nineteen-fifties.

In the meantime, the verdict of the advisory committee Royal Dutch Academy of Sciences was still pending, partly because of disagreements within the community of experts on parapsychology. It took until 1954 for the committee to present its report, concluding in strong terms that dowsing was an inadequate method to detect any phenomena and that the existence of earth rays could not be demonstrated.[64] Tromp reacted bitterly to this report and complained in Dutch newspapers that the presidency of Clay, who earlier wrote critically about him, proved that the committee had been biased from the start.[65]

Tromp stood alone in the scientific arena: neither experimental physicists, medical experts nor the 'established' parapsychologists treated Tromp favourably at this moment in time. Resuming his role as geologist, Tromp spent the early 1950s as a consultant for the United Nations in Central America and the Middle East and for the government of Afghanistan. This wandering employment appears to have been profitable, since he could commission the famous Dutch architect Dudok in 1951 to build a villa for him. This house in Oegstgeest would soon become Tromp's residence and the site of his own private research centre.

Founder of a new discipline: biometeorology

Biometeorology lifts off

[62] Cited from Kloosterman, Thesis, 224

[63] Tenhaeff held a chair in parapsychology in Utrecht. Although a controversial figure himself, his academic status enabled him to dominate parapsychology in the Netherlands.

[64] Kloosterman, Thesis, 219

[65] E.g. 'Wichelroedephenomeen een realiteit? In: 'De Telegraaf' of 18-05-1954

Frustrated by the unproductive atmosphere within the Dutch parapsychological community, Tromp gave up his plan for a laboratory for psychic physics. His own research had taken a somewhat different direction in the meantime. Together with retired army physician Johan Carel Diehl (1874-1963) he determined the geographical distribution of cancer in the Netherlands in relation to the properties of the soil and the composition of drinking water.[66] Driven by his interest in such influences of external factors on health, Tromp decided to search for new allies with whom he could establish a scientific movement. For this purpose, he founded in 1955 the 'Biometeorological Research Centre', located at his residence in Oegstgeest. Despite its grand name, it was staffed by Tromp himself as Director and, from some moment onwards, Janneke Bouma as Assistant Director. As far as I know, the research centre never had other members of personnel.

Working on his own and without funds, Tromp was advised by three physicians of the Leiden University Medical Centre to gather support for his research centre.[67] In September 1955 he visited Hans Ungeheuer at Bad Tölz in Bavaria, head of the Medical-Meteorological research station of the German Weather Service. Both men agreed that research on effects of the physical environment on living creatures could only prosper if the dispersed individual scientists in this field would unite in an international organization. To that end, they sent a questionnaire form to about 50 scientists, asking them to indicate their interest and provide names of other individuals with potential interest. This questionnaire went 'viral' and more than 100 people had joined by the end of the year.[68] In the meantime, Tromp visited some key American scientists in Washington to gain their support.

Acting quickly on the positive responses, Tromp started the 'International Society of bioclimatology and biometeorology' (ISBB) on 1st of January 1956, declaring himself as Secretary-Treasurer. Making use of his contacts at the United Nations, he managed to convene the first symposium of the new organisation at the UNESCO Head Quarters in Paris from 29-31 August of that year. Tromp made use his social skills and his large international network to collect money from friends like Major David Russell, a Scottish saw-mill owner, war-hero and philanthropist.[69] At the symposium an executive board was established, which included the physiologist Frederick Sargent II, who would act as President until 1966 and

[66] Tromp, 1954; Tromp & Diehl, 1954
[67] These were Prof. Mulder, Prof. van Dishoeck and Dr. Haex. See Sargent & Tromp, 1966, p. 207
[68] Tromp, 1975, 71
[69] During the first three years about 10% of the income of the ISBB came from such donors. Russell was continuing his support thereafter, for which he received a honorary membership in 1969. See Tromp, 1975, 78

became the main driver of the young organization together with Tromp, who would remain Secretary-Treasurer for twenty years.

To avoid political issues, the ISBB decided that members could join the society as individuals instead of representatives of countries. This proved to be unproblematic, except for the USSR, where the government did not allow such personal memberships.[70] The attendants of the Paris symposium were from widely different backgrounds, including human, animal and plant biology and meteorology.[71] This made the society different from most existing professional and scientific organizations at the time: its multi-disciplinary character was, as Haufe stated 'avant-garde'.[72] Not surprisingly, this led to discussions on principles, such as the name of the society. The name 'International Society of bioclimatology and biometeorology' (ISBB) was a compromise between the term 'bioclimatology' preferred by most German and French speakers and the term 'biometeorology' preferred by others. In 1961 the name was changed into 'International Society of Biometeorology' (ISB), under which name it is known today.[73] Ten years later, Sargent end Tromp would point out that they had met quite some resistance in this period from local organizations in different countries and from individual scientists who saw a new world-wide society as a threat to their own work.[74] Nevertheless, the member list of September 1957 already counted some 450 members.[75]

After the Paris symposium the president drafted statutes, which were voted upon at the first congress of the organization in 1957. These statutes sketched the outlines of the process of discipline formation that the founders of the society envisaged, as will be discussed in more detail in the next chapter of this thesis. The statutes foresaw, for instance, that every three years a scientific congress be held, each time in a different country. Another cornerstone was the establishment of a dedicated journal.

A new journal

One of the principal goals that the ISBB board set in 1956 was to study the possibility of issuing an international journal about biometeorology. In 1957 the first issue, in loose-leaf

[70] Tromp, 1975, 74
[71] Weihe, 1997, 11. The decision to allow a wide variety of specialists was preferred by the meteorologists, who feared that otherwise the focus would be too much on human biology.
[72] Haufe, 1991, 131
[73] Weihe, 1997, 11; Tromp, 1975. 74
[74] Sargent & Tromp, 1966, 213
[75] ISBB, 1957

form, of a new journal, the 'International Journal of Bioclimatology and Biometeorology' appeared, later renamed to 'International Journal of Biometeorology'. Solco Tromp acted as 'scientific and managing editor' until 1961. Some thousand pages appeared as loose sheets, including scientific papers but also communications about the ISB, such as reports and membership lists. According to Tromp, several libraries complained that the loose sheets were reported stolen. In 1961 the first bound edition therefore appeared. In the meantime, Tromp managed to find a scientific publisher for the journal: from 1964 onwards, the publishing house Swets & Zeitlinger in the Netherlands was in charge of the journal and paid for its expenses[76]. The link of the ISB and JSB with this publishing house and its editor Klaus Plasterk would become stronger and lasted until 1989, when changes in the publishing landscape led to the choice of Springer as the new editor.[77]

Biometeorology: growth and internationalization

The 1960s may be called successful years for the ISB and the IJB. The symposium of 1960 in London was well attended with 172 attending members from 26 countries. By this time the society had grown beyond 500 members. During this meeting Tromp delivered a report that emphasizes the international character of the organization at the backdrop of the cold war:

> It has been refreshing and most encouraging to realize that despite the increasing political unrest in the whole world and the apparently increased deterioration in relationships and understanding between the different nations, in our Society a truly international friendship has grown between scientists of different disciplines, of different countries, different religions and different political background.[78]

The principle of individual membership was presented as one of the reasons for this success, as Tromp stated:

> Not their nationality, religion or political background is taken into consideration, only their scientific ability and human qualities are considered in our mutual relationships. Therefore it does not seem exaggerated to state that the International Society of Bioclimatology and Biometeorology belongs to the very few truly international organizations.[79]

As indicated by Tromp in London, the early 1960s saw a growing recognition of the field within established international organisations. Already at the London symposium, official delegates of UNESCO, World Meteorological Organization (WMO) and the Food and Agricultural Organization (FAO) were present. Further recognition came when the WMO requested the ISB to prepare a special overview of the status of human biometeorology. The

[76] Sargent F., Tromp, S.W., 1966, 213
[77] Lieth, 1989: also Weihe 1997, 12
[78] I.J.B.B., vol IV, 1960, part VII, section D, Report of the Secretary-Treasurer
[79] Ibid.

result was published as WMO Technical Note in 1964, edited by F. Sargent II and Tromp and including material from sixteen other contributors.[80] This WMO report and Tromp's monograph '*Medical Biometeorology*' (1963) and can both be seen as defining documents for the field of human biometeorology. A closer look at their programs reveals a difference in orientation that would gradually alienate Tromp from that rest of the field.

Tromp's tour de force: *Medical biometeorology* (1963)

Tromp's 'Medical biometeorology' is a review of 4400 titles from the literature. The book counts some thousand pages with only its table contents taking a staggering 25 pages. Its starting point is the definition of biometeorology adapted when the ISBB was founded in 1956:

> *Biometeorology comprises the study of the direct and indirect interrelations between the geophysical and geochemical environment of the atmosphere and living organisms, plants, animals and man.*[81]

The first part of the book explains various meteorological factors such as temperature, humidity, pressure, wind, condensation, radiations, electric properties of the atmosphere, chemical substances in the air, aerosols, pollutants and extra-terrestrial influences. After this follows a part about 'biometeorological methods'. Next some 300 pages describe the 'biometeorological effect on healthy man', followed by some 200 pages on 'biometeorological effect on diseases (pathological biometeorology)'. The last part lists an countless number of correlations found between infectious, non-infectious and mental diseases with various meteorological and seasonal parameters, generally without indications of the possible underlying causal relationships. The book closes with various topics, such as urban biometeorology, space vehicle medicine and graduate training in human biometeorology.

In the part on methods, Tromp acknowledges that hitherto the progress in the field had slow, for several reasons: (1) The poor cooperation between meteorologists or geophysicists and medical practitioners due to the tendency of representatives of each discipline to believe that they were the only with competence to study certain problems. (2) Lack of sufficient statistical experience, leading to publication of results that are not statistically significant. (3) Claims based on dubious or limited clinical material. (4) Widespread use of meteorological

[80] Sargent, F., Tromp, S. W., WMO Report XXV
[81] WMO report, 1

averages, thereby overlooking relevant fluctuations.[82] Tromp argues that weather sensitivity, formerly often seen as mere psychological phenomenon, is a physiological phenomenon and should be described with the laws of physics and chemistry.[83] To this end, he presents some material about the proper use of methods in biometeorology. Despite this, Tromp himself would be criticized throughout his career for applying poor methodology.

Although impressive in size and scope, the book makes difficult reading. This is primarily because the presentation of material is factual rather than critical. The book therefore does not facilitate the reader to judge the level of confidence that should be attached to the presented relationships between health and environment.

The 1964 WMO Report: the ecological perspective

The WMO report, on the other hand, written by Sargent and Tromp, has a less ambitious but more focussed scope. It starts with the observation that the definition of biometeorology has been in flux since the foundation of the ISB. In 1960 a task force of biologists and meteorologist convened in Boston and came up with a new definition:

> *Biometeorology is a branch of ecology which studies the interrelations between chemical and physical factors of the atmospheric environment and living organisms. This environment ranges from the bottom of the root zone in the soil to the highest atmospheric levels involved in the dissemination of pollen and spores. Not only does biometeorology investigate in the natural atmosphere but also in man-made atmospheres such as those found in buildings, shelters and in the close ecological systems of submarines and satellites.*[84]

This new definition explicitly defines biometeorology as a branch of ecology. Moreover, it stretches the scope to atmospheres created by man. The newly introduced elements ‘shelters’, ‘submarines’ and ‘satellites’ reflect some of the preoccupations during the peak of the cold war period.

The goals of *human biometeorology* are defined twofold in the report:

[82] Tromp, Human Biometeorology, 157-158

[83] Tromp, Human Biometeorology, 4

[84] Ibid.

Human biometeorology thus has two central tasks. The first is to explain the causes of biological variability. The second is to understand how man's ability to modify his atmospheric environment may affect his biological fitness.

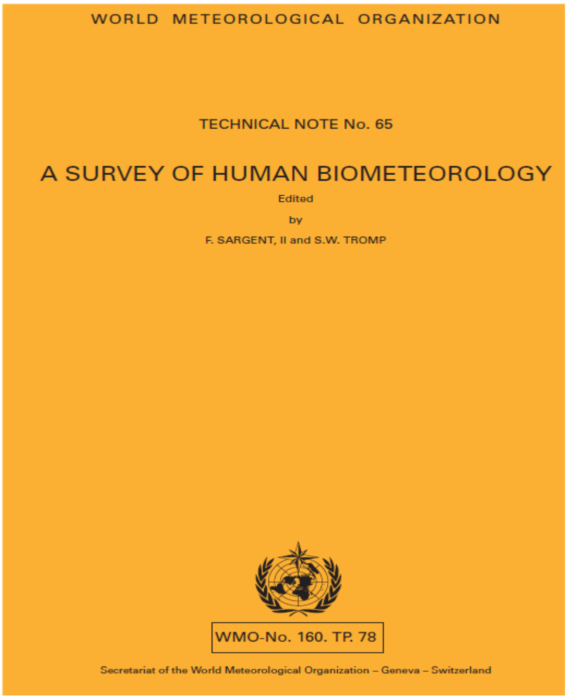

FIGURE 4 THE WMO REPORT OF 1964

The first goal is to be interpreted as a focus on the interaction between man's internal physiological regulation mechanism and the (periodic) changes in the environment. The second goal concerns the adaptivity of man's physiological regulation to cultural, i.e. self-created, changes of his physical environment. These two goals signify a somewhat different agenda for human biometeorology as compared with the broad scope of Tromps 'Medical biometeorology'.

The WMO report contains a summary on pathological biometeorology taken from Tromp's material, although significantly pruned. The focus of the report is rather on understanding the physiological reaction with man's ecology, including natural and man-made environments, and the problem how to cope with challenges such as air pollution. Looking back from our vantage point, the report is an early expression of concerns about health effects of man's deteriorating environment. This shift of attention towards an ecological perspective was the contribution of Sargent, who, in contrast with Tromp, had a strong interest in understanding the physiological effects of the environment, and in the mid-60s increasingly expressed his concerns about this issue, including one of the earliest notions that man-made carbon dioxide emission causes increased atmospheric heating.[85]

Biometeorology: the Tromp period, 1960-1975

Despite the successes of the ISB and JSB, two problems surfaced. The first concerns the financial situation of the ISB and the IJB, the second concerns the collaboration of Tromp with the other leaders of the organization.

[85] Sargent, Presidential Address, 1966, 221

Throughout the years Tromp drew attention to the critical financial situation of the ISB and the IJB. After the initial financial support from Major Russell and a certain Mr. Hicks, the financial well was running dry. At the 1960 symposium, Tromp stressed that the society had no external funds to support its work. In a letter of 10 August 1961 concerning the publication of a dictionary of biometeorology, he complained: 'apart from moral support little financial aid can be obtained from International organizations like W.H.O. or UNESCO. We have tried this several times in the past'.[86]

Tromp did not get tired of asking for money, directly or indirectly. In his contribution to the book 'Science and the Future of Man', on the occasion of the foundation of the 'World Academy of Art and Science', he presented the suggestion to establish a 'Universal Academy of Border Sciences'.[87] His agenda is clear:

> Of the various Border Sciences the international team spirit seems to be most strongly developed in the field of Bioclimatology. Therefore, if funds could be raised for a Universal Academy of Border Sciences, a Universal Centre for the Study of Bioclimatology and Biometeorology it its various aspects should first be created as a *Faculty of bioclimatology and biometeorology* in the future Academy. The experience obtained in such a truly International Centre could be applied to the creation of other Universal Centres for the Study of Border Sciences.[88]

However, the Universal Academy never materialized. Still in 1975 Tromp repeated, on the occasion of the twentieth anniversary of the ISB, that the financial position had been a concern since the beginning. He warned that this problem will never be solved unless the society grows strongly.[89]

Another problem is revealed in the personal recollections about this period by one of the organization's pioneers, Wolf Weihe (1923-2016), who recounts that conflicts arose between Tromp and the presidents of the ISB, Sargent (until 1966) and Lee (1966-1972) respectively. Both presidents were trained as physiologists. For them it was crucial to understand the physiological response of organism to atmospheric and meteorological factors. Without this, research in biometeorology would remain vulnerable to 'folklore, sectarianism, or utopian dreams about disturbing effects of unidentified atmospheric factors'.[90]

---

[86] Letter from Tromp to W.H. Weihe, 10 August 1961

[87] Along with Solco Tromp, among the founding members of the 'World Academy of Art and Science' are such luminaries as Bertrand Russell, Joseph Needham, Robert Oppenheimer and Harold Urey. See Boyko, 1961.

[88] Tromp, S. W, Science and the Future of Man, 119. The last sentence suggests that Tromp still aspired the creation of a study centre for other border sciences including the study of paragnostic phenomena, in this article presented as 'supersensorics'.

[89] Tromp, 1975, 79

[90] Weihe, 1997, 14

Tromps superficial way of working, endorsing questionable theories without sufficient empirical support, conflicted with the more rigorous approach advocated by both presidents. In addition, Tromp was gifted with a degree of self-confidence that made it difficult for his collaborators to persuade him. This became particularly apparent during the drafting by Tromp and Sargent of the WMO report. If one compares the content of the report to that of 'Human biometeorology', it is striking that the report focusses on physiology, whereas more speculative fringe topics are left out. Sargent complained that it was hard to convince Tromp about the central importance of some key physiological concepts. As shown above, the final WMO report is a mixture of material from Tromp with Sargent's work on physiology and the environment. But while Sargent was willing to compromise with Tromp, conflicts between Lee and Tromp apparently were never settled.[91]

When Tromp retired from his role as Secretary-Treasurer in 1976, this marked, according to Weihe, the end of the 'romantic period' of the ISB. Weihe recalls going home after the 1976 symposium 'leaving a lone Tromp behind' at the airport and realizing that the pioneering period of the organization was over. Since then, he felt, the ISB has become more realistic about biometeorology than during the first twenty years of its existence.[92]

Tromp as a scientist

While busy with the ISB, at home in the Netherlands Tromp continued to work on topics in biometeorology at his private research institute.[93] Although not a member of an established institute, Tromp managed to publish many journal papers on human biometeorology in the IJB and other journals, including *Nature* and the *Lancet*. Almost all of them single-handed, or co-authored by Janneke Bouma, the 'assistant director' of his research centre.

What was the nature of these publications? An example is the research by Tromp about the influence of weather on the amount and the chemical composition of urine. The first paper on this topic presents measurements of the urine of 'a healthy 50 year old male' during the period 1959-1963.[94] Close reading reveals that the male must have been Solco Tromp himself, who collected his urine on daily basis at a certain hour of the day. He was meticulous in doing so that 'if the subject had to go out, he took a bottle with him in his car'. The urine

[91] Ibid.
[92] Weihe, 1997, 10
[93] Folk, 1994, 4
[94] Tromp, 1964

samples were analysed at the clinical laboratory of the clinical lab of the department of Internal Diseases of Leiden University. Meteorological records were gathered at Tromps own meteorological station at the Leiden University hospital. The paper showed that urinary volume and composition correlate with periods of cooling. His conclusion was that this pattern was highly characteristic of normal thermoregulation. Consequently, deviations from this pattern could be used as a clinical indicator for potential disturbances of a person's thermoregulation mechanism. A paper based on this n=1 urine analysis, in which Tromp proposed to use such measurements as a measure of 'meteorological cooling' of healthy persons was accepted for publication in '*Nature*' in 1966: it is striking that Tromp affiliated himself this time with the department of Internal Diseases of Leiden University.[95]

Tromp suggested to use a 'water bath' test to determine to what extent the thermal regulation was malfunctioning. The 'water bath test' was a simple test that measured the rate of warming up of a person's hand after immersion in a cold water bath.[96] Different warming curves were claimed for healthy people and diseased people. Asthmatic people, or sufferers from cancer, were shown to have a markedly slower warming curves compared to healthy people.[97] Fig. 6 demonstrates two such warming curves, for a healthy and a diseased person.

The theme of poorly functioning thermoregulation recurred in many papers of Tromp. For instance, he inferred malfunctioning of this mechanism from the onset of asthmatic attacks in periods of cooling and from a correlation of blood sedimentation rates with such periods.[98] For these studies Tromp made use of observations from a children's asthma centre and a blood bank respectively. As for the causality of the relation between cooling periods and the occurrence of diseases, the papers are quite uninformative. A key role is given to the hypothalamus as control centre for thermoregulation. Disturbed thermoregulation, so is the speculation, influences other glands connected to the hypothalamus, thereby playing a role in the pathogenesis of diseases such as cancer, but how this works remains unclear.[99]

[95] Tromp, Nature, 1966
[96] Tromp, 1964
[97] Pathological Biometeorology, 32-33
[98] Tromp, 1965; Tromp, 1967
[99] See e.g. Tromp, 1974 and Tromp 1977, 32

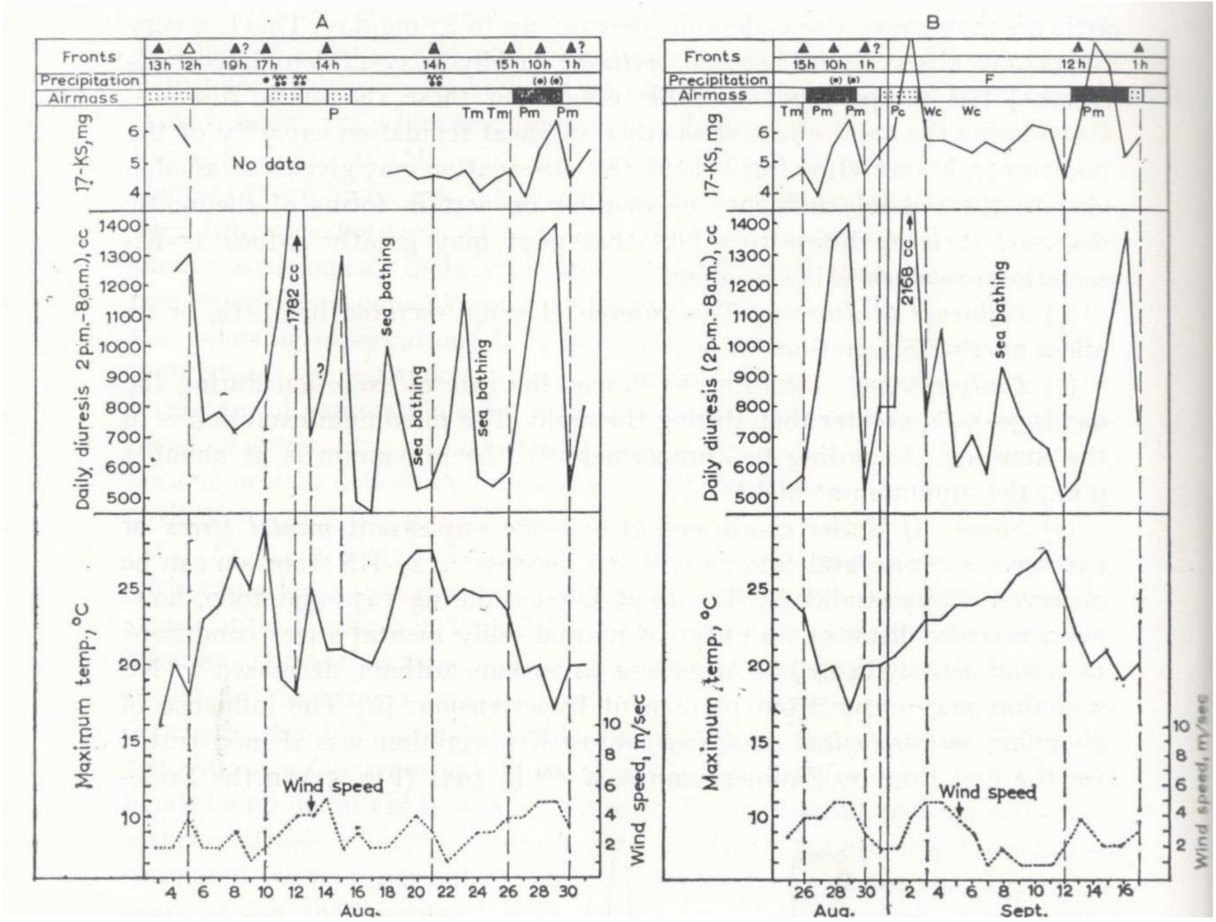

FIGURE 5 DAILY AMOUNT OF URINE AND 17-KETOSTEROID SECRETION IN A 'HEALTHY MALE SUBJECT' AT LEYDEN IN AUGUST AND SEPTEMBER 1959, AS A FUNCTION OF TEMPERATURE, AIRMASSES AND WEATHER FRONTS. THE MALE SUBJECT IN QUESTION APPEARS TO BE SOLCO TROMP HIMSELF. REPRODUCED FROM TROMP, MEDICAL BIOMETEOROLOGY (1963).

Overall, the quality of Tromps own research work was questionable. He was certainly unconventional in his choice of topics, but methodologically his work was often poor, often based on small samples with little statistical analysis.[100] His papers, like many papers in the field of biometeorology at that time, did not pass beyond the search for correlations between external factors and human diseases. The provided indications about the underlying causal connections are weak; thus the explanatory value of these papers is low and their implications for medical practice vague or unspecified.

In his later years, Tromp would drift away from the main stream within biometeorology and increasingly publish about fringe topics. In particular, he took interest in the discovery of rhythms and periodicity in all kinds of phenomena. To host papers about this topic, he convinced Swets & Zeitlinger to start a new journal. As editor-in-chief he aimed to

[100] See also Weihe 1997, 14

bring together papers on 'cycle research' from all disciplines.[101] The journal was aptly called 'Journal of Interdisciplinary Cycle Research'. This time Tromp found a partner in the person of the American scientist Edward Russell Dewey (1895-1978), who also provided funds from his 'Foundation for the Study of Cycles' in Pittsburgh. Apart from the aim of uniting methods across different disciplines, ranging from astronomy to poultry science, there was another motivation for the journal: 'the increasing conviction of many scientists, that apart from the direct mechanisms involved in cyclic phenomena, other still unknown exogeneous forces, partly of an extra-terrestrial origin seem to be responsible for long-term endogenous rhythms in the living organisms: plants, animals and man.'[102] With this mission, it is not surprising that the journal also came to host papers from authors with questionable scientific status.[103]

In a review of his work on fluctuations in blood pressure, blood sedimentation and blood chemistry from 1970, Tromp suggested that extra-terrestrial factors may be involved in the long term changes of these variables.[104] This suggestion refers to the work of George Piccardi from Italy and Carmen Capel-Boute from Brussels, who claimed jointly to have found periodic changes of the precipitation of certain colloidal solutions and attributed these to extra-terrestrial factors, such as solar activity or cosmic rays. The similarity of such colloids with body fluids such as blood would argue for a similar sensitivity of the human body for these effects. Although this 'Piccardi effect' was highly contested, Tromp continued to provide the Journal of Interdisciplinary Cycle Research, as well as the ISB conferences, as platforms for this type of research.[105]

Although he was creative in the choice of topics, methodological flaws in his research and the tendency towards fringe science alienated Tromp in his final years from the biometeorological community. In retrospect, it appears that his scientific work had no lasting effect. Sheridan (2017) recently presented an analysis of the citation totals of the 10 most highly cited articles from the IJB per decade. Tromp is notoriously absent from this list.

[101] In 1975 the editorial board of the journal had more than hundred members across 28 disciplines.
[102] Text from inner sleeve of 'Journal of Interdisciplinary Cycle Research', vol. 5,1974
[103] An example is the controversial French psychologist Marcel Gauqelin, known for his work on astrology.
[104] Tromp, 1970
[105] E.g. Tromp, 1976

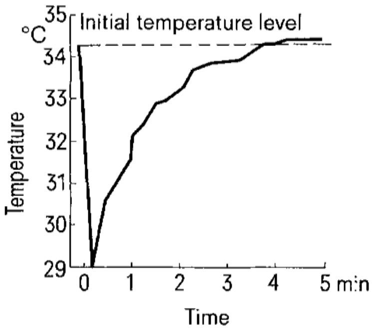

Fig. 1. Thermoregulation curve of a normal, well thermoregulated subject.

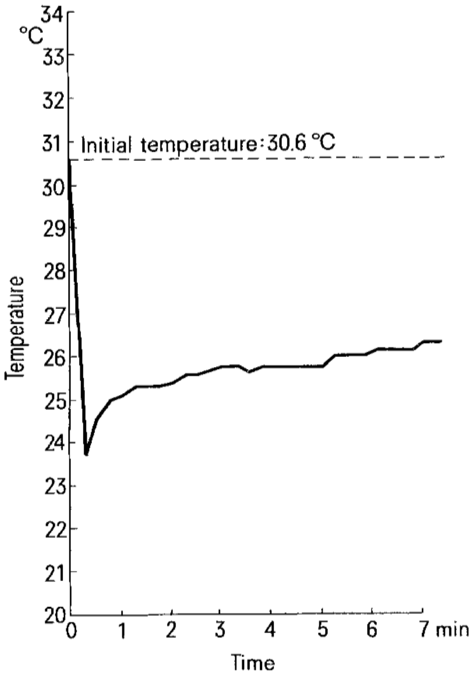

Fig. 2. Rewarming curve of a male subject of 23 years, suffering from inoperable rectum carcinoma.

FIGURE 6 EXAMPLES OF REWARMING CURVES FROM THE HEAT BATH TEST. REPRODUCED FROM TROMP (1974).

A loner in the Dutch medical landscape

It is unclear how Tromp managed to perform and finance his studies, since his 'laboratory' was a residential place without laboratory facilities. Although Tromp reports that his data were obtained with the help of Department of Internal Diseases, University Medical Centre, Leiden and other institutions, like asthma clinics, blood banks and a centre for blind people, none of the resulting publications lists authors from those institutions. Tromp was known for his ability to involve people in all his projects. Yet, it remains an open question how he convinced others to do all this work without any compensation in the form of money or authorship of publications.

Attempts to find collaborations in the medical community of the Netherlands during the 60s and 70s were often unsuccessful. Dr. Wop Rietveld, who was a young physiologist at Leiden University involved in biorhythm research at that time, remembers to have received several telephone calls from Tromp that were strongly persuasive, similar to modern-day sales calls. Tromp proposed collaboration with him as an opportunity not to be missed.[106] Within established medical circles, however, as Rietveld recalls, Tromp was not considered a respectable party to work with, and young medical professionals were discouraged from working with this outsider.[107]

Tromp’s association with border science and the alleged lack of proper methodology of his work did not help to strengthen his reputation. After 1970 his contacts with other scientific institutes appear to have petered out. A newspaper interview from 1971 attests Tromp’s status as a ‘loner’ within Dutch scientific circles where there was little interest in human biometeorology (Fig. 7). A further indication of his marginal support within the Netherlands is that only four of the 95 contributors to the review volume ‘Pathological Biometeorology’ (1977) are physicians from the Netherlands.

The legacy of Tromp

Tromp died unexpectedly in 1983, and might have been forgotten, if he had not bequeathed a part of his considerable wealth to his ‘Foundation for Biometeorological Research’. This money was dedicated to be transferred to the Foundation after the death of his wife, which occurred in 1996. The Foundation was governed by an independent board that renamed it to ‘Tromp Foundation’ and decided to spend the money for a triannual ‘Tromp Award’ for young scientists and a ‘Tromp Travel Fund’ to facilitate travel to meetings for ISB members.

[106] Tromps rash style of using the telephone was also mentioned by Weihe, 1997, 13
[107] Interview with W. Rietveld, Wassenaar, 5 Nov 2019

deVolkskrant van DONDERDAG 25 NOVEMBER 1971

WEINIG INTERESSE IN NEDERLAND

Effect van klimaat op mens in studie

Symposium stelt vandaag eisen aan stedebouw

(Van onze redactie wetenschappen)

AMSTERDAM, 25 november

WELKE invloed hebben weer en klimaat op de gezondheid van mensen en welke eisen moeten in verband hiermee aan de huizen- en stedebouw worden gesteld? Deze en andere vragen komen aan de orde op een symposium, getiteld „Ons physisch leefklimaat in 1980", dat vandaag en morgen in Den Haag wordt gehouden door de Algemene Vereniging voor de Centrale Verwarmings- en Luchtbehandelings-

Dr S. W. TROMP
... eenling ...

wat weerspiegeld wordt in zijn func
tie van secretaris-generaal van de In
ternational Society of Biometeorolo
gy, waarin zo'n 50 landen vertegen
woordigd zijn. Volgend jaar septem
ber houdt het genootschap zijn drie
jaarlijkse congres in Nederland.

Een van de belangrijkste onderzoe
ken in het instituut van dr Tromp
betreft een behandelingsmethode
van astmapatiënten zonder gebruik
van medicamenten. Volgens de Ne
derlandse biometeoroloog is de
weersgevoeligheid van niet-infec
tueuze astmatici (patiënten die nie
tevens aan bronchitis lijden) te wij
ten aan een slechte warmteregulati
van hun lichaam. Het was al lang be
kend dat een verblijf op grote hoogt
verbetering in de toestand van dez
patiënten brengt.

Door talrijke proeven in een lage
druk-klimaatkamer, waarin een
hoogte van 1500 tot 2500 meter word
nagebootst, is dr Tromp tot de over
tuiging gekomen dat de lage lucht
druk de warmteregulatie van het or
ganisme stimuleert. Herhaald verblij
in de lagedruk-kamer, waarbij de
functies voor de warmteregulati
steeds opnieuw worden geprikkeld
kan volgens hem vooral bij jonge pa
tiënten tot blijvende genezing leiden

FIGURE 7 THIS NEWSPAPER ITEM FROM 1971 DEPICTS SOLCO TROMP AS A 'LONER' WITHIN THE DUTCH SCIENTIFIC LANDSCAPE. (SOURCE: DELPHER)

As we speak, after 65 years, the ISB is still thriving and the IJB is still being published. The journal features a steady number of some 45 articles per year up to 2005, after which online electronic publishing was introduced. This led to an increase to a level of more than 200 publications in 2014.[108] The latest complete issue (2019) counts 195 publications. Currently the journal impact factor, as indicated by the editor, is 2.37.[109] This value is hard to compare with other journals because of the position of IJB between different scientific fields, but appears to indicate that the journal is successful.[110] There is a notable trend towards a more globalized authorship, which twice as many countries represented now as compared to the first decade, although USA and Europe still dominate. Some of the main topics in the field of human biometeorology are currently: heat stress related to mortality, heat stress in the

[108] Sheridan & Allen, 2017
[109] Springer website, 8 Jan 2020
[110] A medical journal with this factor would currently rank around place 100.

urban environment, migration of tropical disease, and control of indoor environments.[111] These topics show that issues related to global warming are nowadays the most important.

Solco Tromp is remembered in several memorials in the IJB as socially refined, courteous, self-confident, inquisitive, creative, quick, superficial, business-like, no-nonsense, taking strong positions and measures, highly persuasive, a stimulating personality, and an excellent organizer.[112] With these properties, he epitomizes the type of heroic male known from adventure stories: a man of means, yet complaining about his finances, at ease in the jungle and in the laboratory, who moved swiftly in different social environments and cultures, travelled the world to visit his many contacts, loved the good life, was eloquent and gifted with charm and ample self-confidence.

Solco Tromp was a man with a peculiar set of personal qualities, an international spirit and audacity to investigate matters beyond the established disciplinary borders. He happened to do this at a time when international and cross disciplinary collaboration between scientists was welcomed as a tool to ease international political tensions. Catching these waves, Tromp managed to initiate a scientific movement that exists up to date. Tromp represent a rare example of someone who operated on the fringes of established science, yet managed to play a decisive role in the development of a new scientific discipline.

[111] Interview with Prof. Peter Hoeppe, 16 Dec 2019
[112] Krasnow, 1984; Haufe, 1991; Folk, 1994; Weihe 1997: Green & Rietveld 2017

Chapter 3: Biometeorology, a case of double ‘boundary work’

Biometeorology is the scientific field concerned with the influence of the environment on living organisms in general. Environment is to be understood in a broad sense, including weather, climate, air pollution, radiation and other external influences. How environment affects man in particular is the subject of ‘human biometeorology’. This field covers physiological processes in healthy persons but also phenomena in diseased persons.[113] Human biometeorology is the branch that searches for causal relationships between environmental conditions and health.

Although the attribution of man’s condition to such external factors goes back to antiquity and has been dominant for a long time, this mode of thinking was no longer part of the mainstream medical science in the middle of the 20th century. When in the previous century micro-organisms were discovered as causal agents for many diseases, a fundamental change occurred in the understanding of disease causation. Since then an etiological model dominated in which diseases were expected to be reducible to single identifiable causes, particularly micro-organisms. However, while effective treatments had diminished the death toll of many diseases caused by such germs, other diseases that were more difficult to understand started to take centre stage. Diabetes, cardiovascular diseases, asthma, cancers are some of the frequent diseases that resisted a reduction to microbiological or other unitary causes. The failure to associate these diseases wuth a single cause created, as Le Fanu (1999) called it, ‘an ocean of ignorance’ that would in the 1970s make some people think that the progress of medicine had come to an end.[114]

Contrary to the dominant etiological model in medical science, a minority of physicians and scientists with other backgrounds continued to investigate the role of environmental factors in disease causation and the relation between health and the environment in general. Their interest also covered the application of this type of knowledge for preventing and treating diseases. Light therapy, sessions in pressure chambers and balneotherapy are some examples of these curative concepts. The prediction of harmful events, such as certain types of winds or

---

[113] Based on Tromp, ‘Medical biometeorology’ , 7-8. This reflects the definition of the field at the first meeting of the ISB in 1956.
[114] Le Fanu, The Rise and Fall, 178, 271

a high count of infectious agents in the atmosphere (pollen, viruses), could be used in a preventative fashion. Likewise, correlations of disease occurrence with place and time of conception or birth could theoretically be used to decrease the prevalence of some illnesses.

Uniting the dispersed group of physicians that worked along these lines and bringing them into contact with experts on environmental topics, especially meteorologists, was the intention of the founders of the International Society for Biometeorology (ISB), established in 1956 by Solco Tromp, Frederick Sargent and others.[115]

In this chapter I will analyse, from documents of these founders and documents issued by the organization they established, how they set out to organize dispersed groups of professionals into a new discipline, biometeorology. I will show that their activities were twofold. Firstly, the new scientific discipline was defended against and demarcated from 'non-science'. I will demonstrate that this was done by stressing the use of proper scientific methodology. Secondly, the new discipline needed to be demarcated in some way from other sciences, notably medicine and environmental sciences. I will show that this was done initially by emphasizing the special interdisciplinary and international character of the new discipline. After some twenty years, the nature of the discipline changed in such a way that its scope was gradually narrowed and adapted to growing societal concerns about the quality of the environment. The ability of biometeorology to adapt to changing circumstances and to involve new generations of researchers safeguarded the continuity of the discipline.

First, I present a concise review of the question why historians of science consider it important to study the formation of scientific disciplines and how they have approached this question. After that, I will apply this background to the development of biometeorology in the last sixty-five years. The formation of the field biometeorology as a discipline will be traced by using sources from insiders that were involved in actively shaping the discipline. In other words, I follow only these historical actors themselves in their attempt to demarcate their activities. Despite the one-sidedness of the source material, a close inspection of the documents from these insiders within the biometeorological community can be expected to reveal how the discipline was shaped, both in terms of its institutions and in terms of its intellectual development.

Boundary work: demarcating science

[115] Sargent & Tromp, 1966, 207

What qualifies an activity as science rather than as 'pseudo-science' or 'non-science' is a matter of long-standing debate amongst philosophers, sociologists, historians and others. Roughly speaking, the approaches to this question either refer to criteria that are internal to science or to criteria that lie outside the scientific arena.

The first, internal, type of demarcations can be based on philosophical criteria. Philosophers of science in the first half of the 20th century laid down criteria for comparing bona fide science with other types of knowledge generation. For them the keys to demarcating science were criteria like verification (Wittgenstein, Vienna Circle) or falsification (Karl Popper). Perhaps closer to scientific practice is Thomas Kuhn's pragmatic demarcation of science as the activity that contributes to 'puzzle solving' within an accepted paradigm in a period of stable or 'normal' science. A second type of internal demarcation is based on criteria that characterize science by its institutionalized norms. Such a sociological approach by Robert Merton proposed communism, i.e. proper sharing of knowledge, universalism, disinterestedness and 'organized skepticism' as idealized properties of science (summarized in the acronym KUDOS). These principles relate to scientists' behaviours and judgements. Merton's criteria therefore appear to be based on sociological considerations rather than on the logical and empirical criteria traditionally proposed by philosophers of science. Nevertheless, they also position the demarcation criteria internally, i.e. within the scientific realm.

A second and different approach to the question what is science positions the demarcation criteria outside the scientific realm. Thomas F. Gieryn asserted in '*Cultural boundaries of science*' (1999) that analytical and ideological attempts to define 'true' science, such as those proposed by many philosophers of science, are flawed. To him, the credibility of science is 'not decided in tinkerings at the lab bench or in the refereeing of a manuscript or in the machinations of instruments, statistics or logic'.[116] Instead, 'epistemic authority', the credibility attributed to science, is decided 'downstream from all that'. He calls the process of interpretative transformation that creates such authority: 'boundary work'. The arena where the transformation takes place lies elsewhere, in the places were science meets society at large.

The transformation activity, moreover, involves work: boundary work is like the action of a piston that pushes the boundary between two gases. The scientists involved actively contribute to the boundary work. By pushing the boundary, they include themselves within the domain of science, thereby excluding others. As Gieryn pointed out, boundary work is

[116] Gieryn, Cultural Boundaries, 27

rewarded. Epistemic authority is obtained, autonomy to perform research more independently is achieved and new career opportunities emerge, while resources are denied to the excluded 'pseudoscientists'.[117] The concept of boundary work was conceived by Gieryn to study the process of demarcating science from other types of non-scientific knowledge. Others, most notably Julie Thompson Klein, showed that the concept can also be applied to the mutual demarcation of scientific disciplines.[118]

Demarcating a discipline

It is pertinent to ask what history of science benefits from studying scientific disciplines. Among historians of science the study of scientific disciplines started in the context of the debate on internalistic versus externalistic approaches.[119] Early studies saw the process of discipline formation as a resultant of the intellectual dynamics within science. Studies about the emergence of physics as an independent discipline, for instance, interpreted it as a development internal to science, based on the merging of mathematical and experimental traditions.[120] Since the 1960s many historians no longer regard *ideas* as the core of disciplines but rather emphasize the role of *institutions* instead. Charles E. Rosenberg and Russell McCormmach were among the first who argued that disciplines have a dual role as conduit for intellectual as well as institutional development.[121]

Rosenberg (1964) argued that it is crucial to study the interrelation of science with the society, to account for the specific time and place in which the scientist (or physician) operates. The preferred level of study is, according to him, that of a discipline. It is not so much the question how an individual solves a scientific problem, but how a particular discipline 'defines, approaches and solves' the problem. In his paper, he shows how a group of chemists discovered that the absence of certain nutrients in food can cause disease. Physicians involved with the problem of explaining certain diseases, on the other hand, were not ready to think in this way because their frame of thinking was formed by the fashionable etiological theories that sought to explain diseases in terms of micro-organisms. This made it difficult for them to think that,

[117] See also: Gieryn, 1983
[118] E.g. Klein, 2015
[119] Shapin (1992) critically assessed the internalism/externalism debate and its relation to boundaries in science.
[120] Wegener, 2011, 21
[121] Rosenberg, 1964: McCormmach, 1971

instead, diseases might be caused by the absence of small amounts of certain nutrients.[122] Essentially, Rosenberg explains how the solution of a major scientific problem was dependent on the disciplinary framework in which scientists were operating. Cultural authority was granted to the science or scientist who succeeded in framing both the problem and its solution in the most convincing way.

McCormmach (1971) also favoured history of science at the level of disciplines. According to him, the main aspects of scientific activity, both intellectually and socially, are tied up with the discipline in which the scientist operates. He is explicit about the benefits of the study of disciplines:

> I will mention some advantages I think historians of science may derive from a discipline perspective. The biographical historian of science may deepen his understanding of his subject's motivations by studying his subject's discipline; the values held by the members of a discipline define the immediate psychological world of the individual scientist and constitute a major source of his identity qua scientist. The intellectual historian of science and the social historian of science will jointly profit by recognizing that arguments over theories, methods, and worldviews define intradisciplinary groupings; once identified the groupings may be examined for their members' extra scientific associations, enhancing our understanding of the total context and meaning of scientific arguments. The historian of science who is dissatisfied with the traditional disjunctions of his specialty, social vs. intellectual history, external versus internal history, will find the discipline a natural unit of study for relating the scientific to the non-scientific world; the prevailing institutions and culture affect the scientist's thought and career largely through the mediation of the discipline.[123]

An exemplary study that builds on the institutional premise is '*From medical chemistry to biochemistry'* (1982*)*, by Robert E. Kohler. In the genesis of biochemistry as a scientific discipline, the role of scientific ideas is considered relatively unimportant:

> It may be that in some cases particular discoveries were indispensable resources for discipline building. But I do not believe, as I once did, that particular theories have, in general, a causal role in the creation of disciplinary institutions. Some minimal level of intellectual achievement is, of course, a necessary condition for institution building. But intellectual achievement or the lack of it is not the reason why biochemists failed to build a discipline in nineteenth century Germany or why they succeeded in America, a provincial backwater if judged by research output. Differences in achievement cannot explain why the timing, location, and character of discipline building differed so markedly in the United States, Britain, and Germany. These patterns have to do with the political and economic support system of science: movements for reform of universities and medical schools, changing hospital practice, expanding markets for scientific professionals, and evolving division of labor among disciplines.[124]

This picture is somewhat nuanced by Daan Wegener (2011). According to him, Kohler tends to overemphasize the role of institutions. Institutions are important, but sometimes theories or ideas may be the binding substance of a discipline. Disciplines, often have an intrinsic flexibility to adapt to circumstances. While a discipline is flexible in principle, so Wegener argues, it needs a mechanism to carry its core values from one generation of scientists to the next. Some degree

---

[122] Rosenberg, 370-375
[123] McCormmach, 1971, ix-x
[124] Kohler, From Medical Chemistry to Biochemistry, 3-4

of institutionalization is therefore needed, at least in the organization of education. The long-time history of a discipline is determined by its educational structures. The dependence on the quality of education, however, entails at the same time a vulnerability of disciplines.

In summary, disciplinary boundary work along the lines proposed by Gierin in '*Cultural boundaries of science*', i.e. the actual work performed to demarcate a discipline, can be traced in two ways: either by following how its central ideas developed or by retracing how the discipline managed to organize itself institutionally. Below I will analyse how boundary work was instrumental in the creation of the discipline of biometeorology.

Demarcating biometeorology as a science

In the previous chapter of this thesis, I sketched the origin of biometeorology as a modern scientific discipline. The start of this development goes back to the mid-1950s when Solco Tromp, Frederick Sargent and others initiated the International Society of Biometeorology (ISB). In the preceding decade Tromp had attempted in vain to create an infrastructure for the study of psychic phenomena, trying to shift this topic into the scientific mainstream and out of the realm of pseudoscience. Frustrated by the failure to do so, he took up the topic of the relation of living beings with their environment, most notably the weather and the climate. Again, the challenge was to position this activity, biometeorology, within the boundaries of what the outside world accepted as science.

Biometeorology was at that time, at least in Europe, detached from the scientific mainstream, for several reasons. Firstly, the study of the relationships between man or animal and the environment had lost centre stage since the second half of the 19^{th} century because of the shift towards germ theory as etiological model for the causation of diseases. Environmental approaches to medicine did not disappear, but had become a niche activity in most countries, with the exception of Germany and Austria. Secondly, the topic carried with it a legacy of traditional or folk knowledge that had been preserved by groups of people in their everyday professional practice. In addition, environmentalism had been adopted in the preceding decades by the holistic movement that included alternative forms of medicine that bordered on 'pseudo-science' or quackery.

Against this backdrop, the founders of the ISB faced the task to represent or frame the 'new' biometeorology as a true science. In particular Solco Tromp emphasized this, not surprising because he had been fighting for a decade to obtain recognition for a new ‘scientific’ parapsychology. While he had attempted to shift parapsychology into the arena of proper science, the outcome was that his own scientific respectability had been questioned. It seems that he was anxious to avoid a repetition of this situation. Shaking off the feathers of folklore and ‘pseudo-science’ was therefore part of the rhetoric that Tromp and the other founders applied in the early days of the field.

During its first years the ISB built relations with established international organisations. A letter to the World Meteorological Organization contains the suggestion to make the long range goals of the ISB the focus of a mutual collaboration. The first of the goals was ‘to achieve a critical synthesis of what actually is solid fact and what is fancy speculation and assumption in the area of bioclimatology’.[125] The entry ticket to the world of international organizations, it seems, required clearing the field of biometeorology of ‘non-science’, thereby actively placing it within the boundaries of bona fide science.

A further measure to demarcate the ISB as a legitimate scientific organization was its membership policy. At the ISB conference in London in 1960 a report was given on the first three years of the organization. The report explicitly mentions the objective of barring entry for pseudo-scientists:

> Because of its wide scope, in the past certain authors, lacking scientific qualifications, have done harm to the scientific development of Bioclimatology and Biometeorology and this explains the rigid rule of our Society that nobody can become a member of our Society unless his application sponsored by two members in good standing is approved by the three members of our Membership Committee.[126]

The barring of prospective members is based on their scientific status, which is guaranteed by members ‘in good standing’. Unfortunately, there are no records of the criteria for admitting members, nor do we know who were excluded or meant to be excluded. The statement, however, shows how the society was fenced off from the outside by the designation ‘our Society’ and ‘our Membership Committee’, effectively separating the community of biometeorological scientists from practitioners of poor science.

In 1963 Tromp, then Secretary-Treasurer of the ISB, published a comprehensive work ‘*Medical biometeorology’*, which described on the status of the subfield concerned with human health. Again, he stressed the difference between biometeorology and ‘non-science’. This time the demarcation with ‘non-science’ was based on contrasting methodologically correct science

[125] Letter of ISBB to WMO, 23-6-1959, (published in ISB, 3,1959, 340)
[126] IJBB, IV, 1960, Part VII, section D (Tromp, 1960)

with methodologically flawed science. In particular, the traditional study of 'weather sensitivity' is mentioned as an activity beset with bad examples:

> Unfortunately, many unscientific papers have been published in the past on this subject, both by laymen and scientists, which have done a lot of harm to this new science and undoubtedly hampered its progress during the 20th century.[127]

To put biometeorology more firmly into the domain of 'real science', the book presents a chapter on proper observational, experimental and statistical methods. The fact that these guidelines for the 'new' science were laid down and published explicitly in this textbook signals to outsiders that biometeorology be regarded as a serious scientific discipline.

In sum, the initiators of the new discipline employed a rhetoric of scientific cleansing. To increase its credibility, they freed biometeorology from non-scientific elements, in terms of its canonical knowledge, its membership and its methods. Gieryn (1999) characterized this type of process as the essence of 'boundary work'. Epistemic authority, he observes, exists only to the extent that it is claimed by some people in the name of science, in this case the members of the society, but denied to others such as rejected candidates for membership. Inclusion of biometeorology within science was at stake, and with that the future of the new discipline.

Part of these activities appear to have been directed to convince the members of the new biometeorological community of their own scientific standing. Perhaps Solco Tromp, who had been fighting allegations of being a pseudo-scientist himself, projected his own experiences on the membership of the newly forming community. After the first few years, however, the 'new' biometeorology was no longer actively justifying itself as a legitimate scientific activity. The 'boundary work' of the pioneers shifted towards securing a position *within* the scientific arena.

Demarcating biometeorology as a discipline

When the International Society of Biometeorology was established, the members came from a wide variety of scientific backgrounds. The first member list of 1 January 1957 illustrates the original disciplines of the organization's first cohort of members. The 427 members indicated more than fifty different professions. In fact, only *one* member had explicitly entered 'biometeorologist' as profession. The most frequently occurring professions are listed below.

Profession	**Percentage**
Physician	22%

[127] Tromp, Human Biometeorology, 4

Meteorologist	13%
Physiologist	13%
Biologist	4%
Physicist	4%
Botanist	3%
Geographer	3%

The key challenge of the initiators was to accommodate this diversity of backgrounds within the new discipline. At the time of founding of the ISB, existing biometeorological initiatives were fragmented. Conferences, research institutes, journals and training institutes covered particular fields of interests, such as alpine climatology, and mostly had a regional or national scope. A need was felt to approach complex biometeorological topics in an integrated and synthetic manner with the involvement of diverse disciplinary input.[128] Such an intentional bottom-up call for interdisciplinary research was a relative novelty at the time: as later ISB president Weihe called it, 'avant garde'.[129] Counter to the trend of fragmentation of disciplines into subdisciplines, thereby creating an increasing specialization, the case of biometeorology asked for the unification of specialists into a more general interdisciplinary form a science. This provokes the question how this was achieved. In other words, how was an interdisciplinary activity positioned as a new discipline?

Source material to investigate this question is mostly provided by The International Journal of Biometeorology. During its first five years this journal served as publication board for internal documents from the ISB. Moreover, presidential addresses that document and comment on the course of the ISB regularly appeared until 1980. Every ten years, with the exception of the 1980s, a review was presented on the status of the organization. From the 1990s onwards several articles appeared about the history of the ISB and its key persons.

From these documents and related sources I derived six elements that contribute to the formation of biometeorology as a discipline: common ideas and language, knowledge sharing platforms, social bonding and rewards, internationalism, education, and the creation of legends.

Common ideas and language

[128] Tromp, 1966, 71; Haufe, 1976, 92-93
[129] Weihe, 1995

What exactly is biometeorology? The ability to answer this question could be seen as central to the new field, as it had to define and demarcate itself in a wider scientific ecology. In practice, however, it turned out that the definition of biometeorology was in a constant flux.

From the 1956 statute of the ISB followed the first official definition:

> *Biometeorology comprises the study of the direct and indirect interrelations between the geophysical and geochemical environment of the atmosphere and living organisms, plants, animals and man.*[130]

This definition was changed in 1960 into:

> *Biometeorology is a branch of ecology which studies the interrelations between chemical and physical factors of the atmospheric environment and living organisms. This environment ranges from the bottom of the root zone in the soil to the highest atmospheric levels involved in the dissemination of pollen and spores. Not only does biometeorology investigate in the natural atmosphere but also in man-made atmospheres such as those found in buildings, shelters and in the close ecological systems of submarines and satellites.*[131]

In 1970 biometeorology was defined as:

> *Biometeorology is the study of the direct and indirect effects of the physical, chemical, and physicochemical micro- and macroenvironments, of both the earth's atmosphere and of similar extra-terrestrial environments, on physico-chemical systems in general and living organisms (plants, animals and man) in particular.*[132]

A current definition is as follows:

> *Biometeorology is an interdisciplinary science studying the interactions between atmospheric processes and living organisms – plants, animals and humans.*[133]

These definitions reflect the changing societal background against which the biometeorology evolved. The earliest definition speaks about geophysics and geochemistry, reflecting the emphasis of one of the founders, the geologist Solco Tromp. It also signifies the widespread interest for geophysics that accompanied the International Geophysical Year in 1957, the breakthrough project that revived the scientific interchange between the East and the West after a period of interruption. Cold war preoccupations also explain the inclusion of submarines and satellites in the definition in 1960. The notion of 'ecology' appears first in that definition, reflecting the emerging awareness of global environmental issues. In 1970, the idea that the 'space-age' was imminent is mirrored by the inclusion of the effects of extra-terrestrial

130 WMO report, 1
131 Ibid.
132 Weihe, 1997, 12
133 https://uwm.edu/biometeorology/what-is-biometeorology/

environments. The modern definition is more pragmatic and neutral, emphasizing that biochemistry is a science, and an interdisciplinary science to boot.

For the discipline to persist, the boundaries of its common idea apparently did not need to be fixed. In fact, as I will argue later, the field probably survived until the present day just because of its readiness to adapt to new circumstances. This is in line with Wegener's stipulation that a certain flexibility as to the fundamentals of a discipline is a condition for survival.

Knowledge sharing platforms

In 1956, the principal goals of the society were established. Among these was the printing of an international journal devoted to biometeorology and the organization of biannual conferences where ideas could be exchanged.[134] Journals and conferences had by that time become the hallmark of the scientific profession, and it is not surprising that this model for scientific communication was copied. As described in the previous chapter, these platforms were quickly established: the first conference was held in 1957 and a dedicated journal started in the same year. These platforms gradually attained higher professional standards and still form the backbone of the discipline as it stands.

Social bonding and awards

The founders of the ISB faced the formidable task of bonding members who initially identified themselves with more than fifty professions. Such diverse professionals as physicians, meteorologists, geographers and physicists had applied for membership. The challenge was to provoke an identification with biometeorology instead of their original backgrounds. To de-emphasize the national origin of the members, the ISB decided to welcome them as personal members based on scientific merit and 'human qualities'. In addressing the members, terms like 'friendship' and 'mutual relationships' and 'our Society' were used. These terms stressed the unique character of the community in a time of Cold War political tensions.[135] When reflecting back on the first twenty years of the organization, the departing Secretary-Treasurer Solco Tromp memorized that early resistance against the foundation of the ISB from national societies and individual scientists who saw the internationalization as a threat to their activities had been resolved 'due to our individual memberships' and that a 'true international friendship has developed amongst all the members of the ISB'.[136] Elsewhere, Tromp even argued that a border science, like biometeorology, demanded an atmosphere of intellectual freedom, and therefore,

[134] Tromp, 1966, 75-76
[135] See e.g. Tromp, 1960
[136] Tromp, 1976, 79

more than regular science, had the potential to unite people globally, irrespective of their backgrounds.[137] This rhetoric of comradery fulfilled a symbolic role in tightening the social fabric of the organization.

A further mechanism to bond the members of a discipline is the awarding of prizes to exemplary representatives. Although this was mentioned in the principal goals of the ISB from the beginning, the financial situation of the organization did not allow to issue such awards. It was the initiative of a number of individual member to establish in 1963 the William F. Petersen Foundation in order to grant triannual awards for biometeorological research. Until the death of Tromp in 1983, these awards were being granted, a token of his commitment because he largely financed them from his personal funds.[138] Part of his legacy was also dedicated to a foundation, later renamed as 'Tromp Foundation', which would dedicate the money from 1999 onwards for a triannual 'Tromp Award'. The award was for young scientists under the age of 35 in the field of biometeorology who had produced the most meaningful peer reviewed manuscript over the preceding three years.[139] A further part of the money was granted to support a community of young members of the organisation, united in the Student and New Professionals (SNP) group. With these instruments of social bonding and award-giving, the young discipline successfully managed to safeguard the continuity of its community after some sixty years.

Internationalism

During the first decade of the ISB, its founders stressed the international nature of the new biometeorological community. In an address at the 1960 conference, when the political tension of the cold war was at its peak, this was expressed as follows:

> It has been refreshing and most encouraging to realize that despite the increasing political unrest in the whole world and the apparently increased deterioration in relationship and understanding between the different nations, in our Society a truly international friendship has grown between scientists of different disciplines, of different countries, different religions and different political background.[140]

Internationalism, it was claimed, was at the heart of the organization. Membership of the ISB, unlike that of many other scientific organisations, was on personal title and only based on scientific and human merits. Members from the East and West were joined in the organisation, with the only exception being scientists from the USSR, a country that did not allow personal

[137] Tromp, Significance, 118
[138] Haufe, 1991, 92
[139] Scott Greene, 2017, S20
[140] Tromp, 1960

memberships. Consequently, Tromp claimed that the ISB belonged to the 'very few truly international organizations'.[141]

To further demarcate biometeorology as a truly international scientific effort, the ISB built relationships with established international organizations from the start. Already in 1960, the ISB had a consulting status with the World Meteorological Organization. The timing happened to be fortuitous, since the WMO also went through a period of rapid internationalization in this time frame.[142] Members of the ISB became active in committees of this organization and, most importantly, the opportunity arose to issue a special review publication 'A Survey of Human Biometeorology' as Technical Note of the WMO in 1964. This report served as an endorsement of biometeorology as a proper scientific discipline by the established meteorological discipline.

The ISB established official relations with UNESCO and the Food and Agricultural Organization in the early 1960s. In 1967 the World Health Organization followed, thereby providing endorsement from the medical discipline. Admittedly, there was some work to do, as the first representative of the ISB, Wolf Weihe, noted after talking with contacts at the WHO that 'biometeorological awareness rarely exists among health professionals'. He expressed high hopes about this international collaboration:

> Biometeorology will thrive on the world wide investigations which can be developed in co-operation with specialized United Nations agencies such as WHO and WMO. In such agencies the biometeorological problems arise from an ecological background with a wide scope, permitting multilateral investigation programs'[143]

Formal relationship with international organizations would remain an important asset for the ISB. Up to the present time, the ties with especially the WMO would be kept. To ascertain this, a Memorandum of Understanding between the ISB and the WMO was signed in the year 2000.[144] On the other hand, the relationship with the WHO never seems to have flourished. The institutions of medical science posed a high threshold for entry posed as compared to those of meteorology. Medicine, being highly institutionalized as a discipline, tends to have a centripetal effect in the sense that its workers accumulate around central mainstream topics. It is therefore likely that a single liaison with the fringe topic of biometeorology held little attraction.

Internationalism has remained a binding factor of the ISB up to the present. This was made explicit again in 2014 when the members of the organization decided to increase the

---

[141] Ibid.
[142] Edwards, 2006, 240
[143] Weihe, 1967, 240
[144] Keatley, 2017, 12-13

representation of hitherto unrepresented parts of the world in the Executive Board.[145] Likewise, the authors who contribute to its journal nowadays are from all continents.

Education

The principle goals of the ISB, defined in 1956, included educational measures, specifically the creation of postgraduate training facilities at the larger universities of the world. Frederick Sargent, the first president of the ISB, stressed this point throughout the years. He noticed the growing importance of interdisciplinary approaches in science and urged universities to adapt their teaching programmes accordingly. For him, the ideal background of a student in biometeorology would be physiology and psychology, while the student should understand the basics of meteorology and climatology. But first and foremost, the principles of biometeorology should become part of the medical curriculum. This was to be done in the context of human ecology, which by then had become 'a major concern to many medical educators'. At this moment in time, 1963, Sargent foresaw that the ecological perspective, addressing the immanent environmental issues of mankind, would become the most suitable framework for biometeorology.[146]

Graduate training in biometeorology took off at universities in the USA and by 1976 some ten universities in that country also had established a post-graduate program.[147] Elsewhere, academic interest in teaching biometeorology was less. What happened to the programmes in the following decades is not entirely clear, but by 2017 little appears to have been left of these dedicated curricula.[148] A potential explanation might be that young scientists studying or working in interdisciplinary topics reported a worsening of their career prospects as compared to their peers who stick to established mono-disciplines.[149] It also possible that biometeorological topics found a place in competing curricula such as environmental studies.

Nevertheless, the need to involve younger generations of researchers remained on the agenda of the ISB: a Student and New Professionals (SNP) group was established for scientists who are within five years from leaving education (such as study for a Ph.D.) or under 35 years of age. The group first met in 2008 and has been active since. A selection of the group members met in 2015 to discuss 'how to effectively integrate biometeorological concepts, learning modules, and pedagogical techniques into undergraduate and graduate

[145] Keatley, 2017, 13
[146] Sargent, F., Part VII, 'Graduate Training in Human Biometeorology' in Tromp, Medical Biometeorology
[147] Tromp, 1976, 76. It is unclear which universities this refers to.
[148] See Allen, 2017
[149] Jacobs, Interdisciplinarity, 52-55

courses and curricula worldwide'. Reminiscent of the original goals of the ISB, the group aimed at 'understanding the true interdisciplinary nature of the actors within the biometeorology community and combining areas of expertise (e.g., climate concepts with human health) into varying forms of higher-education integration are a high priority for advancing the field of biometeorology.'[150]

A group of ISB members, including several young SNP members, reflected in 2017 on the status of education and training in biometeorology. They noticed that members of the organization reported diverse and somewhat improvised pathways into the field. Dedicated courses on biometeorology had become rare at both the graduate and undergraduate level. Their observations indicate the importance of education for preserving a discipline while at the same time it is its Achilles heel:

> While variability and improvisation may be assets in promoting flexibility, adaptation, and interdisciplinarity, the lack of formal training in biometeorology raises concerns about the extent to which continuing generations of scholars will identify and engage with the community of scholarship that the ISB has developed over its 60-year history.[151]

Not surprisingly, it was argued that the important challenges of this time, as codified in the Sustainable Development Goals of the UN, require students that were educated in an interdisciplinary framework, as exemplified by the field of biometeorology. It was proposed to integrate biometeorology into post-secondary curricula as a way to guarantee its future and to cope with the upcoming global sustainability challenges.[152]

Altogether, the importance of educating a new generation of scientists in biometeorology remained high on the agenda ever since the start of the foundation of the ISB. Its role as preserver of the discipline's continuity was on the discipline's mental map.

Legend creation

A discipline that gains self-confidence generally starts to write its own history. Biometeorology is no exception to this rule and, as de Wilde (1992) pointed out, such a disciplinary history provokes the creation of legends. Often these legends take the form of stories about the pioneers of the field who 'started from scratch'. For biometeorology, the story of Solco Tromp appears to fulfil this function. Although not the most likely role model for several reasons, his story has an element of scientific heroism: after his death

[150] Perkins, 2017, 239-240
[151] Allen, 2017, S93-S94. As contemporary topics of relevance to the UN SDG goals were identified: thermal comfort and exposure, agricultural productivity, air quality and urbanization.
[152] Allen, 2017, S103.

the story of his decisive role in adverse conditions was told repeatedly in the IJB.[153] When Wolf Weihe, a former president of the ISB, reviewed the history of the organization in 1995, he included some critical notes about Tromp and his controversy with other leaders about the direction of the organization. Weihe's critical stance upset some colleagues who were in charge of the 'Tromp Award'.[154] Perhaps the naming of this award after Tromp, and the resulting connection of his name to the newer generations of biometeorologists who receive the reward, is the most significant token of legend creation.

The ecological turn: new opportunities for biometeorology

Boundary work, in the sense of demarcating biometeorology as a true science and demarcating biometeorology as a discipline within the broader field of science, was successfully applied during the first two decades after the establishment of the ISB. In this section, I will argue that these activities were necessary for establishing the discipline, but not sufficient to explain its survival.

While the ISB was becoming more mature, establishing itself institutionally, the context in which its members worked presented new challenges. Two of the leaders of the organization, the first two presidents Sargent and Lee became acutely aware of the emerging environmental crises the world was facing. As early as 1957, Sargent noted that biometeorology could be understood only in the broader ecological perspective. He would repeat this during several presidential addresses in the 1960s, expressing his concerns about the environment, including one of the earliest realizations that man-made carbon dioxide emission causes increased atmospheric heating.[155] This would imply an ecological turn in the study of human biometeorology. Health, according to Sargent, is a concept that should be newly defined as the adaptive capacity of the organism towards environmental circumstances and hazards.[156] This definition was conceptually different from the canonical definition of health that the WHO had adopted two decades before, when health was defined as 'the state of complete physical, mental and social wellbeing and not merely the absence of diseases or infirmity'. In retrospect,

[153] E.g. Haufe, 1991; Weihe, 1997 and other publications (see previous chapter)
[154] W. Rietveld, private communication
[155] Sargent, Presidential Address, 1966, 221
[156] Sargent, 1966

Sargent's definition is close to recent definitions that define health in terms of human adaptability to external circumstances.[157]

Sargent's successor, Lee, was similarly concerned with environmental issues and pleaded in 1970 that the ISB should have a more notable influence on these. The failure to address this challenge, he stated, 'would seriously reduce the image of the Society that we would like to see emerge'.[158] As mentioned in the previous chapter, the ecological emphasis advocated by Sargent and Lee in the 1960s led to conflicts with Solco Tromp, who preferred to include a wide scope of topics, including fringe topics, under the umbrella of biometeorology. When the influence of Tromp waned in the 1970s, the emphasis of the ISB shifted towards ecological topics. The retirement of Tromp in 1976 marked, according to former ISB-president Weihe, the end of the 'romantic period' of the ISB and carried the organisation into a more mature state.[159] This is also the message of the presidential address of that year, in which the president Haufe evaluates the status:

> The first 4 congresses since the founding of the International Society of Biometeorology in 1956 were devoted to the developments of an organized multidisciplinary border science with facilities for interdisciplinary study, communication, international cooperation, and establishment of credible media for the publication of knowledge and for the synthesis and integration of scientifically relevant facts. As these objectives have been gradually achieved, more recent congresses, especially the 7th in August 1975, have become more concerned with identifiable impacts of the Society on the world of science and on scientific problems. It is evident that with time suddenly running out for the solution of many critical environmental problems implicating biometeorology, the Society must meet the test of its newly found maturity in providing technology transfer for practical applications of knowledge.[160]

The thematic shift towards environmental changes induced by man has persisted since the 1970s and obtained new impetus after the first explicitly mention in the IJB of 'climate change' in 1992. Since then, the term 'climate change' has been the most common two-word term in the journal. Also common in the last three decades were the terms 'heat stress' and 'air temperature', reflecting the importance of the effects of rising temperatures on man and other living beings. Human thermal comfort, heat balance and the definition of appropriate thermal indices are among the most cited topics in the journal in the last decades.[161]

Ten most recent articles about human biometeorology in IJB (April 2020)

Changing human-sensible temperature in Korea under a warmer monsoon climate over the last 100 years

[157] See e.g. Huber et al., 2011
[158] Quoted in Weihe, 1997, 15
[159] Weihe, 1997, 10
[160] Haufe, 1976, 95
[161] Sheridan & Allen, 2017, S5-S8

Mathematical model to estimate the increase in firefighters' core temperature during firefighting activity with a portable calorimeter
The spatial distribution of the normal reference values of the activated partial thromboplastin time based on ArcGIS and GeoDA
Relationship between heat stress exposure and some immunological parameters among foundry workers
Spatial patterns of health vulnerability to heatwaves in Vietnam
Improving street walkability: Biometeorological assessment of artificial-partial shade structures in summer sunny conditions
Weather factors, PCV intervention and childhood pneumonia in rural Bangladesh
The acute effects of ultraviolet radiation exposure on solar dermatitis in Shanghai, China
Perceived impact of meteorological conditions on the use of public space in winter settlements
Regional differences in exertional heat illness rates among Georgia USA high school football players

Likewise, the focus themes of the ISB currently are thermal comfort and exposure, agricultural productivity, air quality and urbanization. [162] At recent ISB congresses, the sessions on human biometeorology are mostly dedicated to heat stress and issues related to climate change.[163] With its focus on climate in the Anthropocene, biometeorology appears to have affirmed its wider relevance.

The creation of an interdiscipline

Biometeorology, as it now stands, deals with a considerably narrower range of topics than in its early years, when the response of the human organism to a wide range of external factors was on the agenda, including factors like the influence of ions, electromagnetic radiation, cosmic influences, time cycles, and soil properties. These speculative elements of biometeorology have been replaced by a more pragmatic list of topics addressing current environmental issues.

During this transition from a border science towards maturity, the concepts of the discipline have always been in flux. In this light it must be understood that the field in its early days endorsed topics that, from our perspective, appear side lines, aberrations or 'non-science'. These 'mistakes' were part of a dynamic process that created what is now seen as the

[162] Allen et al., 2017, S9
[163] See e.g. the program of the ISB Conference 2014 in Ohio. https://ams.confex.com/ams/ICB2014/webprogram/start.html

mainstream of the discipline. At any given moment in time, the discipline of biometeorology provided a locus for new ideas and for their evaluation. As such the creation of a discipline did not lead, as sometimes argued, to a fossilisation of knowledge, but rather act as safe haven for creative activity.[164] Some topics faded out because they proved to be scientifically unfruitful, other topics because the interest of the community shifted, as was argued in this chapter, to new subjects demanded by changes in society.

The story of the evolution of biometeorology as a discipline contains an apparent contradiction. By its very nature biometeorology is an interdisciplinary activity. Yet the logic of interdisciplinarity created a new discipline. The boundary work managed to cross boundaries, yet it also created new disciplinary boundaries. This obviously prompts the question what makes an 'interdisciplinary discipline' any different from other new disciplines. Somehow, the newly created knowledge is valued higher by its proponents than the knowledge of existing disciplines. Often this is explained by reference to the increasing complexity of problems which creates the need for a novel type of science. This type of argument is seen repeatedly in the first years of the formation of the biometeorology discipline.

Yet, there is more to it, as argued by Julie Klein, Mathias Friman and others.[165] The transgression or crossing of boundaries also implies that there is a value in the variety of knowledge and in the combination of knowledge that would otherwise remain confined within the enclosure of the traditional disciplines. Friman studied the corpus of scientific literature on interdisciplinarity and concluded that an interdisciplinary field is characterized by permeable or porous boundaries. He stated that it is 'striving for plurality of knowledge and consistently for the empowerment of alternate knowledge claims differing from those of established traditions'.[166] In the case of biometeorology this is seen in the liberal absorption of topics in this 'border science' as advocated by Tromp. Later, the permeable boundaries allowed for the influx of ideas from environmental sciences with the objective of creating new knowledge in the context of the world's ecological problems. An emerging interdisciplinary field like biometeorology is caught between two counteracting movements: interdisciplinarity opens it up to new influences, disciplinarity tends to narrow its scope.

[164] See e.g. Jonker (2011) for different views on the role of disciplines in the dynamics of science
[165] Klein (2018) and Friman (2010)
[166] Friman, 9

Conclusions

In this chapter I have shown how the new discipline of biometeorology was constructed. In the first phase, the activities of its founders aimed at grounding and demarcating the field as a science. This ‘boundary work’ did not only solve an analytical problem as to what constitutes science, but it also had practical consequences: being recognized as a science means entering the part of the cultural map that is associated with material and professional advantages available to the scientist. It also involves drawing a social boundary: within the contours of science, statements about the world have a higher truth value. In other words, epistemic authority is granted to the representatives of the new discipline once it has entered the territory of science.

Textual analysis of documents from the leaders of the ISB showed that the first phase of ‘boundary work’, in which the field was demarcated as real science with respect to pseudo-science, lasted around a decade. Simultaneously a second type of boundary work was ongoing, a demarcation activity to distinguish biometeorology from other scientific fields. This meant in the first place that the newly created community had to be provided with instruments to develop internal coherence, i.e. to demarcate their own boundaries. Knowledge sharing platforms, a dedicated journal and congresses, facilitation of social bonding and the granting of awards contributed to this required social structure.

Secondly, a legitimation and demand for biometeorological knowledge and expertise had to be created. This was done by creating alliances with other international organizations. The unstable international political situation around 1960 spawned the creation of international scientific cooperation, which was seen as a mechanism that could contribute to the improvement of relations between countries in the tense cold war period. The new discipline of biometeorology adopted internationalism as one of its core principles and used the opportunities to enter alliances with international organizations, such as the WMO, FAO and the WHO.

Demarcation of the field of biometeorology occurred mostly along these institutional lines. Nevertheless, there was also an internal scientific driver behind the formation of the discipline, since its proponents needed to agree to some extent on what their discipline *is* in terms of subject matter and methods. The history of the biometeorological movement reveals that the definition of biometeorology was not fixed during the first two decades of the ISB. Depending on internal and external circumstances, the definition was adapted every few years to the prevailing interests of the moment. This reflected the changes in the outside world as well as the interests of the leaders of its organization. The realization that the field could play a more significant role by associating itself with the issue of global environmental degradation emerged as early as the 1960s and changed the course of the discipline from the mid-1970s onwards. In a similar way, climate change issues further narrowed the field in the last two decades.

In summary, two phases can be traced in the emergence of the discipline of biometeorology. In the first phase, 'boundary work' involved demarcation as a bona-fide science, setting it apart from pseudo- or non-science. In the second phase, 'boundary work' involved demarcation as an autonomous scientific discipline, differentiating it from other (recognized) sciences. The creation of new institutions significantly contributed to the discipline formation. The continuity of the discipline over a long period, however, was also safeguarded by adapting the ideas that defined the field according to the needs of the outside world.

Chapter 4: From germ theory to a new environmentalism

The previous chapters traced the development of ideas about the dependence of human health on the environment. The 'Hippocratic' belief in the reality of this relationship, while the standard up to roughly 1850, eroded in the century that followed. When medicine adopted during the second half of the nineteenth century a model in which disease was attributed to a single microbial or parasitical cause, environmental thinking dis not entirely disappear. It persisted with local differences and flavours and within restricted segments of the medical profession. In the colonial and imperial context of e.g. France, Great Britain and Austria patients were still treated by exposing them to beneficial climatic conditions. Neo-Hippocratic thinkers incorporated man's relation to nature in a wider holistic worldview that expressed a critical stance towards what they perceived as reductionistic and dehumanizing tendencies modern medicine. A scattered group of physicians and meteorologists initiated in the meantime an objective scientific approach, emphasizing the need for empirical and experimental studies of the relation between climate and health. When after the second World War the holistic movement faded, dispersed groups of scientists continued this research in biometeorology.

A resurgence of biometeorological thinking occurred in the 1950s. As I have shown, the Dutch geologist Solco Tromp (1909-1983) played an important role in this movement. Tromp and his associates managed to establish the field of biometeorology as a separate scientific discipline. This discipline has a strongly interdisciplinary nature, combining medicine with meteorology and other sciences. Tromp and co-workers built an institutional framework for biometeorology, with a dedicated professional society, a scientific journal, conferences, awards and educational programmes. This infrastructure still exists and testifies to the success of the newly created discipline. As to its central ideas, the field of biometeorology underwent a major shift. Initially the research agenda included a wide range of natural environmental factors on health, but from the 1960s onwards the emphasis was rather on the health effects of man-made changes to the environment. This 'ecological turn' was initiated by Frederick Sargent in the early 1960s. Ecological aspects became more prominent research topics after the retirement, in the mid-1970s, of Tromp, who had been advocating a wider scope of the field. In the early 1990s, the topic of global warming became a new focus of human biometeorology.

When one overlooks the period from 1870 to now, it appears that the germ theory did not signal the end of environmental thinking. A certain continuity is observed instead. This triggers the question as to the meaning it has acquired after it ceased to be the dominant paradigm. Why was the environmental understanding of health not completely abandoned? In this chapter I tentatively explore this question and its relevance for contemporary medicine.

No single solution for all diseases

Firstly, it is undeniable that the discovery of germs, bacteria, parasites and viruses contributed to the understanding of, in the long term, to the prevention and eradication of some of the most common and serious infectious diseases. It was soon apparent, however, that the germ theory could not provide a one-size-fits-all solution. The initial hope that all major diseases could be reduced to single causes proved to be too optimistic. Several widespread diseases did not, or only partly, obey the new paradigm. Some appeared to be more complex than originally thought. The proof that a bacillus was involved in causing tuberculosis, for instance, did not explain why some people exposed to the bacillus contracted the disease and others did not, or why some people recovered while others died. It was long known that the prevalence of tuberculosis was associated with class, profession, economic status and physical living conditions. Apparently other factors than germs were involved in causing tuberculosis, such as a person's hereditary setup, his personal constitution and environmental factors.[167] For other diseases the responsible germs could not be identified. Some diseases were found to be due to food deficiencies instead, like beri-beri or rickets, or appeared to have other different types of causes, like cancer and mental diseases.

The limits of the success of the germ theory came in view in the 1930s, when the awareness grew that infectious diseases no longer were the main source of mortality. Chronic diseases that defied an explanation in terms of microbes became more prominent, even more so after the subsequent discovery and use of antibiotics. In the following decades other advances in surgery and pharmaceutics further reduced the burden of some major diseases, such as diabetes and cardiovascular condition. Arguably, though, the golden age of modern

[167] Bynum, Western Medical Tradition, 176

medicine inspired by the germ theory came to end by the 1970s.[168] As a consequence, the search for alternative disease factors, including environmental factors and lifestyle factors was back on the agenda.

Incompatible models of disease causation

A second reason why medicine modelled after the germ theory was not fully embraced concerns conflicting visions on how reliable knowledge is obtained for deciding what causes disease. As I will show here, the causal model that accompanied germ theory became dominant in medicine for almost a century. This model, however, was not suitable for explaining the connection of diseases with environment, weather or climate.

When it became possible to identify and isolate micro-organisms as causal agent for diseases, this changed the model for demonstrating the cause of a disease. As I will argue below, the new 'etiological model' that accompanied the germ theory made it difficult to explain diseases in terms of environmental causes such as the weather conditions. Since the 'etiological model' became more and more accepted around 1900, the case for environmental causes became weaker.

Before the middle of the 19th century, often two type of causes were invoked to explain diseases, proximate causes and remote causes. Proximate causes were the actual manifestations or anatomical abnormalities that accompanied a disease. Initially this was also described in as the changed constellation of body fluids. When more and more diseases were identified with specific lesions in the body, the proximate causes essentially became the disease itself. Remote causes were mostly causes outside the body that explained the start of a disease. These could be either 'predisposing' or 'exciting', i.e. they could either cause the body to become susceptible for a diseases (predisposing cause) or trigger the disease (exciting cause).[169]

Importantly, remote causes were not considered necessary for the disease episode of a given patient: if the patient would not get the disease from one cause, he might get it from another cause. As several causes might combine to bring about the disease episode, no single cause was necessary for the diseases to which it could contribute. In addition, an individual

[168] Le Fanu, The Rise and Fall of Modern Medicine
[169] Codell Carter, 10-23

remote cause was not considered sufficient either, because the same cause could be responsible for many different diseases. This being the case, an individual cause may be part of a combination of causes that was considered sufficient, for instance because the combination forms a predisposing cause together with an exciting cause. In fact, disease accounts in the eighteenth and nineteenth century often contained lists of predisposing and exciting causes. With regard to environmental causes, such as typically all kinds of weather conditions, these were usually seen as causes in a complex of factors that together was seen as sufficient cause for the given case of the patient. Weather was therefore causally connected to diseases in *a complex of multiple factors*.[170]

After the advent of the germ theory, causal thinking in medicine became dominated by a different causal theory, the so called 'etiological standpoint'. This term refers back to Robert Koch and signifies that diseases are best understood and treated if their *causes are known*. In the etiology according to Koch, causes are *natural*, i.e. they are governed by the laws of nature and not due to the transgression of the individual of some more or social boundaries, as was often thought in earlier medicine. They are *universal*, i.e. the same cause exists for all occurrences of a disease, and they are *necessary*, i.e. a disease does not occur without its cause. The primary instrument of the etiological standpoint, were Koch's postulates, a set of simple guidelines to ascertain the fulfilment of the standpoint.[171] Initially the etiological standpoint was very fruitful and Koch and his contemporaries foresaw the application of his postulates for other diseases agents than bacteria.[172] However, for environmental agents, such as climatic factors, the model failed because the criteria universality and necessary are normally not fulfilled. Climate, weather and environment interact with health in a more complex fashion: no single necessary cause was found sufficient to cause a disease, while the presence of an alleged cause usually affected some people but not others.

Early biometeorological studies came at a time when explanations of disease causation were still dictated by the etiological standpoint. Petersen in the USA and Linke and De Rudder in Germany were among the first to attempt, in the 1930s, a rigorous scientific

---

[170] Ibid.

[171] A modern version of the postulates may read: '1. The microorganism must be abundant in those suffering from the disease but absent in healthy people. 2. The microorganism can be isolated from a diseased organism and grown in pure culture. 3. The cultured microorganism should cause disease when introduced into a healthy organism. 4. The microorganism must be re-isolated from the inoculated, diseased experimental host and be identical to the specific causative agent.'
This version of the postulates is taken from Michael B. Bracken, *Risk, change and Causation* , p. 243-244

[172] Codell Carter, *The Rise of Causal Concepts of Disease*, 129-146

approach to the issue. Because of advances in meteorology in the preceding decade, they were able to correlate health data with the occurrence of meteorologically meaningful weather complexes. In addition, they could describe health conditions more precisely through chemical and physical measurements of body functions. By charting such physiological data of patients along with climatic data, they hoped to find direct correlations between health and the climate. De Rudder developed elementary statistical methods the ascertain whether the correlations were due to chance or whether they were potentially causal. Nevertheless, he cautioned that a correlation between quantities is not the same as a causal relation.

These precursors of modern biometeorology struggled with the problem how to prove causality. They faced the lack of good tools to establish the causal nature of relations between health and environment. It was only from the 1950s onwards that a better understanding developed of relations that could not fit into the prevalent etiological model. As Petersen had already noted two decades before, the dominant diseases that the physician encountered where no longer infectious diseases caused by micro-organism. Instead, chronic and non-communicable diseases now became the prime source of morbidity and mortality. The understanding of the causation of these diseases was boosted by the convincing proof that smoking caused cancer the 1950s. The rising incidence of lung cancer was proven to have a strong correlation with the increase of cigarette smoking. Although indications for this correlation were found in the 1930s, Sir Bradford Hill deserves the credit for arguing that it is a causal relation. Obviously, this clashed with the 'etiological' standpoint, because the relation does not involve a natural cause, and because the cause is not universal nor necessary: there are smokers without lung cancer as well as are lung cancer patients who never smoked. Additionally, the application of Koch's postulates fails in this case because there is no single disease-causing agent that can be isolated. In a seminal paper from 1965, '*The Environment and Disease: Association or Causation?*', Bradford Hill posed the question as follows:

> 'Our observations reveal an association between two variables, perfectly clearcut and beyond what we would care to attribute to the play of chance. What aspects of that association should we especially consider before deciding that the most likely interpretation of it is causation?'[173]

Realizing the limitations of the Koch's postulates for judging causation, Bradford Hill provided a new set of causal criteria for judging whether some of the most common diseases are caused by environmental factors.[174] His criteria teach that the strength and consistency of

[173] Hill, 1965, 295

[174] The Bradford Hill criteria are 1. Strength 2. Consistency 3. Specificity 4. Temporality 5. Biological Gradient 6. Plausibility 7. Coherence 8. Experiment 9. Analogy.

a correlation are important, but also its plausibility and the presence of an experimental verification of the underlying hypothesis. Importantly, these criteria help to determine the 'risk' that a disease is caused by an environmental factor. They no longer refer to individual patients, but rather to the disease risk for a population of patients if a certain causal factor is present. This epidemiological approach is a fundamental break with the 'etiological standpoint' in medicine.[175]

The problem of proving causality has been troubling scientific biometeorology, and in fact, any study relying on epidemiological relations.[176] The biometeorological literature abounds with studies that claim correlations between the occurrence of disease and environmental factors. Demonstrating causality is a persistent problem for all types of epidemiological studies that aim to reveal the root cause of diseases. Le Fanu (1999) argued that epidemiology had hitherto failed to produce convincing results, perhaps with the exception of the smoking-cancer relation, and that this failure was partly due to the fact that Bradford Hill's basic rules for establishing causation were ignored. Epidemiologists have claimed numerous relations between diseases and behavioural, lifestyle and environmental elements without, according to Le Fanu, advancing the progress of medicine at all. [177]

The solution to the problem may partly reside in a better model for establishing causal connection between chronic, non-communicable diseases and environmental factors. Essentially, this model has to account for the fact that explanations in terms of a single cause are unlikely to be found for such diseases: they have *multiple causes* which are usually not universal and not sufficient. In terms of environmental influences, causation involves a constellation of exposures, none of which is sufficient in itself to cause the disease. Vineis pointed out that the sceptical stance towards mono-causality is criticized by the pharmaceutical industry which has a vested interest in promoting causal claims.[178]

The consideration of multiple causes seriously complicates the identification of environmental causes such as required in biometeorology. In particular, as always in causal reasoning, correlations may be found that are wholly or partially explained by a relation with another, third factor, or 'confounder'. Bracken (2013) pointed out that this is even more problematic in multifactorial reasoning:

> Multifactorial models of disease causation are widely held to be the appropriate paradigm for studying the causes of complex, chronic disease. All the potential biases that jeopardize research using the simpler

[175] A more elaborate version of the Bradford-Hill criteria was worked out by Evans.[175] Evans also lists the deficiencies of Koch's postulates in the light of new developments in medicine.
[176] See e.g. Russo, 2018
[177] Le Fanu, 59
[178] Vineis, 356

> constructs of single risk factor etiology apply with even greater force when multiple factors are considered. For example, confounding factors that are linked to both the disease and the exposure of interest now must be associated with several environmental agents. Control of multifactorial confounding poses great challenges in observational research studies.[179]

Given the problem of validating multifactorial causal claims, is it possible to obtain convincing proof that some diseases are caused by the environment at all? Epidemiological work in the context of exposomics is the latest attempt to establish such proof. This approach exploits large data sets and computing power to reveal associations between environmental factors, genetics and diseases. The hope is to find combinations of factors that, coupled with genetic variation, relate to diseases. The factors may individually be insufficient to cause a disease, but their confluence may cause the passage of a threshold for the onset of disease. The epigenetic properties of a patient, the propensity of genes to express themselves under certain conditions, may be one of the determinants for the start of disease. This idea appears conceptually similar to the long standing idea that disease is caused by the combination of environment and constitution.

Exposomics is the newest form of environmental thinking, and its proponents are successfully attracting funds for their projects. It remains to be seen whether this will provide a more convincing scientific case for the relation between health and environment. But even if so, it is the question whether this will bring us any nearer to the roots of Hippocratic medicine in which man himself is understood to be in direct contact with airs, waters, places.[180] In one respect exposomics appears fundamentally different: instead of putting the individual patient back in the centre, it reduces the patient to a data point within an immense data set.

Discrepant images of the human body

Thirdly, several groups did not conform to the way in which the germ theory interpreted the fundamental relation between the human body and his environment. Overall, medicine developed from the second half of the nineteenth century onwards into a more scientific clinical direction through the use of medical instruments, laboratories and advances in pharmaceutics. As a consequence, medicine became almost exclusively practiced in hospital and clinics instead of the home of the patients. This move towards ‘place neutrality’ caused, along with an empowerment of the physician within the confines if his clinic, also the

179 Bracken, 258

180 A stark contrast exists with the conception of man in the 18th century, when e.g. the body itself was seen as an indicator of barometric pressure. See Knoeff et al., chapter 2 therein.

disappearance of the environment from his medical gaze. Without knowledge of the living conditions of the patients, the causes of illness were no longer searched in the domains of 'airs, waters, places'. Sellers (2018) provides in a recent review on environmental medicine a poignant example how neurological deficits in small children in El Paso were diagnosed as a very rare disease of the immune system. If the doctors would have inquired about the environment of the children, they would probably have arrived at a different diagnosis. They would have observed that the children lived in a neighbourhood adjacent to a smelter and that lead poisoning would have been a likelier cause. [181]

The germ theory, as Nash pointed out in '*Unescapable Ecologies*' marked the institutionalization of a concept of both the body and the environment. In earlier 'Hippocratic' medicine, the body was thought to be in constant contact with the outside world, while, in turn, this interaction affected the internal equilibrium and health of a person. In modern medicine the causes of disease were primarily sought in the body itself, not in the environment. Whereas the body was 'porous' or 'permeable' in Hippocratic medicine, modern medicine regarded it as virtually closed to the environment. In fact, this separation between the body and the environment also limited the view on causation of diseases, which was now confined to the body itself. This has also become part of the standard narrative of medical history in which the human and the non-human nature as seen as separated entities. As Nash puts it 'in all histories, the actors are assumed to be human: the rest of the world is a set of constraints that human actors must work within'.[182]

While the idea that environment did no longer matter became leading within main stream medicine, a different view was taken by some people who dealt in daily practice with disease and with the effects of the environment. For these practitioners the older 'Hippocratic' ways of thinking were still vital. Especially in colonial environments people often had a close relation with the weather, the climate and other properties of the local environment. Early settlers in the USA, for example, sensed in their everyday experience that the climate of certain regions could be harmful to their health. They selected the places to colonize with due care for the local environment and its health implications.[183] Colonial officers in British and French colonies investigated the damaging or wholesome characteristics of various places. Military officers in Austria preferred stable climatic conditions to keep the health of their

[181] Sellers, 1-2
[182] Nash, 8
[183] Nash, 212

troops intact.[184] These are some examples of how the idea that man and his environment are inextricably linked persisted outside medicine.

Apart from this, there was in the first decades of the twentieth century a revival of Hippocrates' ideas which was more intellectually oriented. Proponents of a 'holistic' worldview opposed what they perceived as the decentralization of the patient and the detachment from nature in 'modern medicine'. For them, a return to the environmental thinking of Hippocrates provided a convenient frame for alternative forms of medicine, ranging from a synthesis of traditional concepts with modern clinical medicine to an outright abandonment of mainstream medicine. The various neo-Hippocratic streams were united in their discomfort with the clinical and reductionistic turn that medicine had taken. Hippocratic thinking provided a different and preferred concept of the human body as a vulnerable, yet self-regulating, entity that was in a constant and changeable relationship with its environment. Healing involved the restoration of natural balance. Therapy consequently demanded a focus on the patient and a recourse to the options for natural healing, such as exploiting the healing effects of 'airs, waters and places'. Obviously this concept contrasted with the perceptions of the highly specialized, laboratory oriented and bureaucratic modern physicians.[185] In essence, the holistic movement was a reaction to the new vision on the patient and the body that had emerged after the rise of the germ theory.

In addition, a minority of medical practitioners within 'mainstream medicine' remained or became committed to environmental medicine. As for the persistence of the role of environment within medicine, Nash worded it as follows:

> In the rhetoric of public health, local environments were no longer understood as active components in the production of health and disease; instead, they were recast as homogeneous spaces that were traversed by pathogenic agents. In this formulation, the environment itself (aside from pathogenic bacteria) had no agency of its own in the production of disease. But that narrowed focus was always belied by actual public health practices and by the persistence of other, more environmentally oriented medical subspecialties.[186]

A similar point was made by Sellers, who showed how the interest in the relation between health and the environment shifted from mainstream medicine to specialty disciplines. Examples of these are tropical medicine concerned with the presence of white people in warm climates, and industrial medicine focused on health of workers in factories and mines.[187] Another of the 'medical subspecialties' was the early 'biometeorology', a field that attempted

[184] Coen, Climate in Motion, 61
[185] Cantor, 283-284 and Weisz, 270-273 in *Reinventing Hippocrates*
[186] Nash, 13
[187] Sellers, 2-3 & 24-33

to combine accepted medicine with the concept that the environmental influences our health. This could take the form of a representation of the body as an equilibrium state, as embodied in the concept of homoeostasis advocated by Cannon.[188] More explicitly Hippocratic was William Petersen's research on the correlations between non-infectious and mental diseases o the one hand and the climate on the other. The analytic approach of Bernard de Rudder no longer explicitly referred to Hippocrates, but also started from the Hippocratic premise that mankind is in constant exchange with its environment.

The institutionalized biometeorology that emerged from the 1950s onwards may have positioned itself as a proper science with the corresponding methodologies, its central premise was that of man as part of its natural environment and subject to its influences. Solco Tromp, whose interest in biometeorology found its roots in holistic theories, worded this in 1963 as follows in the final passage of his '*Medical biometeorology'*:

> At the present stage of medical science the physician is apt to forget that the human body and its physiological processes are closely integrated in the physical and chemical environment in which man happens to live. Although clinical treatment with drugs may bring temporary relief to the patient, it may not remove the actual primary cause of the disease. The observations to date suggest that a deeper understanding of biometeorological processes in general and of climatotherapy in particular might well remove at least some of the actual causes of a great number of diseases, thereby eliminating that recourse to innumerable drugs, which has become such a common practice in modern society. In its wider implications, moreover, biometeorology shows, more clearly than most other sciences, how closely the animate and inanimate worlds are integrated.[189]

This passages tells that Tromp was motivated by a desire to respect the traditional vision about man and his environment. Although committed to an analytic scientific approach, the underlying worldview of some of the biometeorologists ran counter to that of mainstream medicine.

Local culture matters

A further aspect of the persistence of environmentalism is that it was in some countries embedded in the local culture. Such cultural differences in attitudes towards health and disease might have been underestimated because of the anglo-centric nature of medical history. As shown earlier, the interest in the health aspects of weather and climate in the German speaking countries to some extent resisted the fundamental changes in medicine that took place in the second half of 19th century. Health was widely seen as a product of

[188] See: Greater than the Parts, 238-243
[189] Tromp, Medical biometeorology, 745-746

constitution and environment and this view persisted into the next century. This resonated with the typological categorization of people within the popular personality theory during the first decades of the 20th century. A classification of people, from Hellpach in 1911, as either 'weather-reactive', 'weather-sensitive' or the more extreme 'weather-hypersensitive' is still in use.[190] The last group, showing 'Wetterfühligkeit' is thought to be highly sensitive ('vegetativ stigmatisiert'), with health problems starting before the onset of an adverse weather situation. Whereas these persons might be labelled hypochondriacs in other cultures, their sensitivity was, and is, taken more seriously in German medicine.

The study of the relation between man and the weather remained a well-accepted academic topic and the literature about it in German is growing up to the present day. Not only the scientific but also the popular appreciation of the weather as health agent is still higher in the German speaking world than elsewhere. The German Weather Service issued in 2013 a large survey to investigate the prevalence of weather sensitivity, motivated by the suspicion that it was more common than known because weather sufferers would often not visit their practitioner. No less than 50% of the respondents considered themselves to a certain extent weather-sensitive, i.e. they confirmed that the weather had an influence on their health. The highest degree of weather-sensitivity was observed in persons who suffered from chronic diseases. The researchers from the German Weather Service had some reservations about how the form of the questions could have influenced the answers. Also the particular weather during the survey period might have distorted the results, so they stipulated. It is clear, though, that they interpreted weather-sensitivity as a real phenomenon.[191]

Everyday practice shows that the official weather services of Germany, Switzerland and Austria take weather sensitivity seriously. Along with the regular weather forecast, they issue daily 'bioweather' forecasts, specifying the health effects of the predicted weather for people suffering from a wide range of complaints. As of May 2020 the German Weather Service even launched a mobile application for weather sensitive people.

---

[190] De Rudder (1931) explains these categories (after Hellpach): *Wetterreagierend* ist jeder Mensch, es ist sozusagen das physiologische Antworten auf atmosphärische Umweltreize. *Wetterempfindlich* kann im Laufe des Lebens der Mensch werden, bei dem durch irgendeine Krankheit oder ein Leiden eine irreparable Gewebsschädigung an einer Körperstelle bzw. an einem Organ entsteht; diese Stelle neigt dann offenbar zu erhöhter Reizbeantwortung. Ob letztere dann empfunden wird, hängt vielleicht mit dem gleich zu besprechenden Reagieren zusammen, worüber indes kaum Genaueres bekannt ist. *Wetterfühlig* erweisen sich ganz besonders Menschen mit einer erhöhten Ansprechbarkeit, einer erniedrigten Reizschwelle ihres vegetativen Nervensystems, sog. "vegetativ Stigmatisierte", welche zu raschen Änderungen ihrer Hautdurchblutung (Farbwechsel), zu Dermographiomus und Schweißen und mannigfachen subjektiven Störungen neigen. From: De Rudder, Grundriss (1931).

[191] Repräsentativbefragung zur Wetterfühligkeit in Deutschland, Deutscher Wetterdienst, 2013

FIGURE 8 POPULAR INTEREST IN THE HEALTH EFFECTS OF THE WEATHER IS STILL HIGH IN GERMANY. THIS BOOK WAS PUBLISHED IN

In the German speaking countries less tension seems to exist than elsewhere between the layman's experience of weather and climate as health factors and the rational scientific assessment of this relation. In these countries environmental thinking and modern medicine were not seen as antagonistic as they were seen elsewhere. Perhaps this reflects a the deep-rooted feeling in the culture of the German 'Sprachraum' that human well-being is related to nature and connected to the home area or nation of a person. [192] These 'back to nature'-sentiments date back to the romantic movement, and formed the undercurrent of the holistic movement and early scientific biometeorology.

New interest in health and environment: the ecological factor

Finally, the interest in biometeorology persisted also because of the 'ecological factor'. This refers to the effect of man himself on the environment and the climate, and as a consequence on his heath situation. Due to this interest, the field of biometeorology became more relevant to society at large. This, however, caused a deviation from the Hippocratic way of looking at man and his environment. In 'Airs, waters, places', man's fate is determined by his environment. The climate and the properties of places are presented as inescapable determinants of health as well the characteristics of communities. The seasons, the air, the winds, the soil and their variability were thought to act upon the humoral balance within the human body. The human condition was seen as dependent on these externalities.

[192] See e.g. Lawrence & Weiss, Greater than the Parts, 8

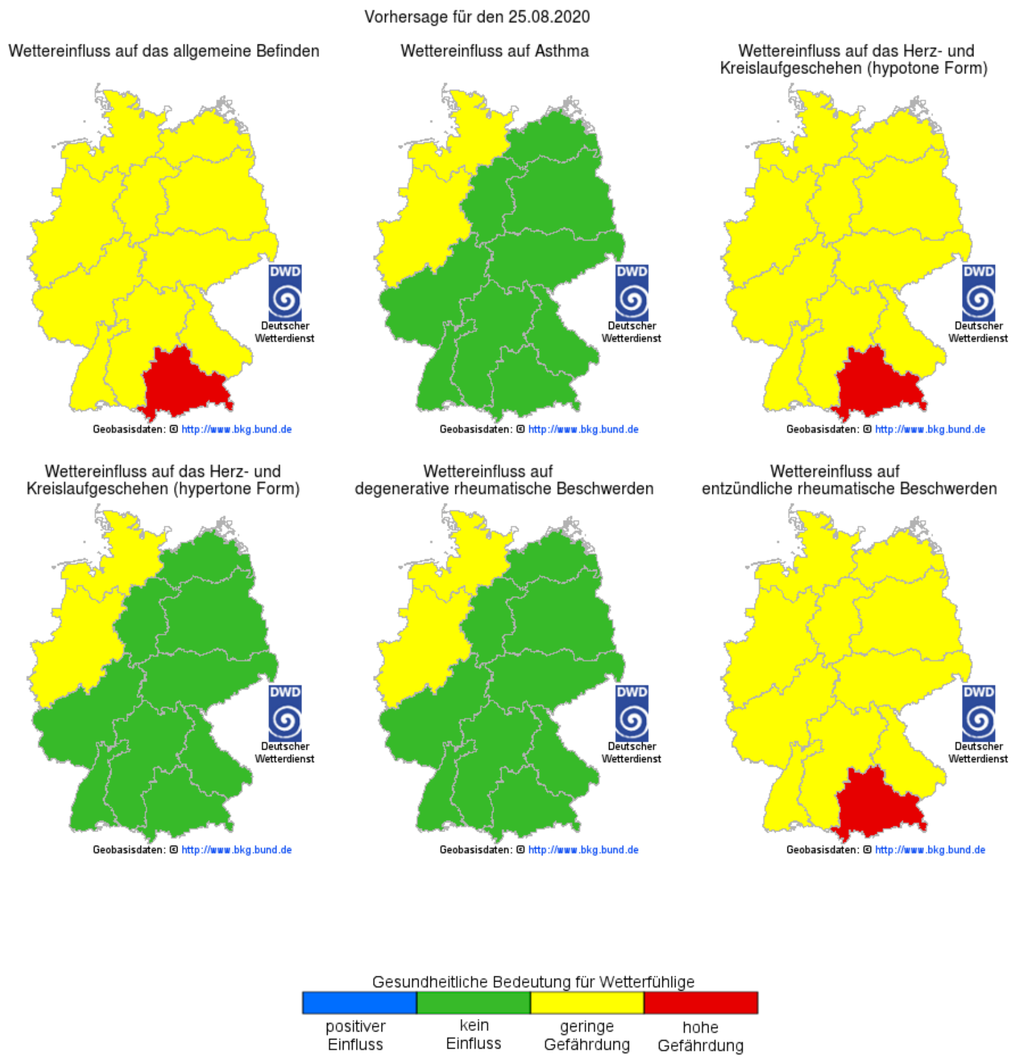

FIGURE 9 THE GERMAN WEATHER SERVICE PROVIDES WEATHER WARNINGS FOR WEATHER SENSITIVE PERSONS.

Quite different is the modern idea of environmentalism, in which the relation between man and his environment is seen as interdependent. The environment that was seen as the determinant of man’s health has now become highly dependent on man instead: airs, waters and places have become malleable through human action. The relation of dependence between man and environment in the Hippocratic medicine has changed such the medicine now also has to acknowledge the influence of man himself on his environment.

The shift towards the idea of an ecological symbiosis between man and his environment is sometimes presented as a new framework that emerged in the 1960s. Recent scholarship, such as Rebecca Coen’s ‘*Climate in Motion*’ and Linda Nash’ ‘*Inescapable Ecologies*’, however, shows that a more intimate relationship between Hippocratic ideas and ecological perspectives already developed earlier. This happened in situations where practical problems led to the creation of new knowledge about the relationship of man’s activities and the environment. Coen, for instance described the protests against proposed cutting of forests in Austria in the late nineteenth century. It was believed that the forests had a strong cooling effect and therefore provided an environment that had beneficial effects human health. Concerns were raised about the expected health effects of the human interventions with the forest. Linda Nash demonstrated in depth how agricultural workers in California's Central Valley raised concerns about the health effects of environmental changes caused by the massive exploitation of the natural resources of the area. Another example of disquiet about human-induced climatic health effects is seen in early studies on urban biometeorology in the interwar period in Austria and Germany.[193]

Despite these precursors, it took until the 1960s until ecological thinking gained wide public visibility. The publication of Rachel Carson's *Silent Spring* in 1962 is often seen as the main accelerator of this public awareness.[194] Whether the book was as influential as the standard narrative suggests is questionable, but, as Nash pointed out, it did articulate long-standing 'ecological' understandings in a novel way.

As I showed earlier, the leadership of the young International Society of Biometeorology showed in the same period a growing awareness of the ecological perspective and the health effects of human modifications of the climate. This ecological turn in human biometeorology led the president of the International Society of Biometeorology, Frederick Sargent, to redefine health as 'the adaptive capacity of the organism towards environmental circumstances and hazards'.[195] This definition was conceptually different from the canonical definition of health – adopted by Wealth Health Organization two decades before - in which health was defined as 'the state of complete physical, mental and social wellbeing and not merely the absence of diseases or infirmity'. Partly due to internal differences of opinion, it took another decade before ecology started to dominate the research agenda of the organization.

Although the ecological turn changed the vision on the mutual relationship between man and his environment, it also signifies *continuity* because it boosted the old Hippocratic notion that man is dependent on his environment. The fact that the effect of global warming is now the focus of human biometeorology signifies that man has become an agent in the creation of new climate-related health issues.

---

[193] See for example Brezina in: Klima, Wetter, Mensch, 347-349
[194] Rosenberg, Epilogue, 666
[195] Sargent, 1966.

Conclusions: experience, world view, science

In this chapter I addressed the question why the belief in the health effects of weather, climate and the environment continued to find followers after the rise of the germ theory.

In the first place, the germ theory failed to provide an explanation for many diseases, in particular non-infectious and chronic diseases. In addition, the model of disease causality that accompanied the germ theory proved inadequate to explain many common diseases. For an explanation of these, multiple factors must be invoked, as is typically also the case for any explanation in terms of environmental influences.

Second, the germ theory and the accompanying new medicine conflicted with ideas about the role of environment that were common within several groups of practitioners. Military and colonial officers, settlers and farmers, are some of these groups that were confronted with the influence of environmental factors in their daily life. Their 'Hippocratic' world view conflicted with the new concept of the human body as an isolated mechanical device, explainable by its inner workings and governed by chemical and physical laws. Disagreement with reductionistic tendencies in modern medicine and with the corresponding view on the human body as an isolated entity was also manifest in the holistic movement during the interbellum period. I noted that the degree to which environmental thinking was overtaken by modern medicine was also influenced by cultural factors. In the German speaking countries the belief in the relation between health and weather was rooted more deeply than in other countries, leading to a co-existence of these ancient ideas with the concepts of modern medicine.

Finally, it was widely realised from the 1960s onwards that mankind was causing fundamental changes in his own natural environment. This, and the related climate change issues in the last few decades, led to a new awareness of the importance of the environment and climate for human health.

The work by Tromp and others to gain recognition for a scientific approach to these issues resulted in the formation of a new scientific discipline. In the previous chapters I showed the boundaries of the discipline were negotiated. While initially a wide range of influences on health was studied, the field started to narrow its scope in the 1960s. This was triggered by the growing awareness of ecological issues, which boosted the idea of ‘environmentalism’ and thereby provided a new legitimation for biometeorology. Global warming issues, and their health implications, further pushed the discipline into this ecological direction since the 1990s. This emergence of environmental issues increased the practical relevance of biometeorology. The new direction of the discipline also implied some losses. The range of ideas covered within the boundaries of the discipline has become significantly narrower as compared to the founding days of Tromp. The idea of man as an integral part of inanimate nature in the widest sense is no longer prominent within scientific biometeorology. With its pragmatic research agenda, the field lost some of its original creativity: perhaps the boundaries of biometeorology have become too tight.

Biometeorology, moreover, represents just one aspect of the knowledge on the relationship between man and his surroundings. Although it is the result of a battle for recognition as a science, through the ‘boundary work’ described in the previous chapter, scientific knowledge is not the only relevant form of knowledge on man’s relation to the natural world. Experiential knowledge shaped by personal experiences in daily practice has been instrumental in the continuation of these ideas after the rise of the germ theory. Equally important is the underlying world view that shapes environmental knowledge. In the case of biometeorology, reservations about some aspects of modern medicine helped to keep environmental thinking alive and created a motivation for its growth as a science.

Epilogue: Covid-19, environmental causes in times of contagion?

At the time of writing, the SARS-Covid19 epidemic is in full swing. The course of the epidemic is unpredictable because of the many unknowns surrounding the virus that causes the disease. Although the disease shows many characteristics that resemble other viral respiratory diseases, the knowledge about the patterns of contagion and the effects of the disease is developing day by day. When the virus spread from Wuhan in China to other areas, in particular Iran, Northern Italy and the south-eastern part of the Netherlands, the question arose why these areas showed so many infected patients. It was suggested that the spread of the situation is not merely dependent on the interpersonal contagion but also on environmental factors.

Building on the observation that the SARS outbreak in China in 2003 was correlated with the amount of fine dust in the air, it was noted that the first areas with Covid-19 outbreaks were also areas with poor air quality. At the moment, the causal mechanism between these associations is not proven and it is unknown which type of fine particles or pollutants (fine dust, ultrafine dust, ozone) is involved.[196] A further pointer to the environmental factors in the Covid-19 epidemic was the reported concurrent increase in Paris, Bergamo and New York of Kawasaki disease, an epidemic systemic inflammation affecting young children, which happens to be one of most likely candidate 'meteorotropic' disease induced by seasonal atmospheric conditions.[197]

Yet another suggestion pointed at climatic factors: the transport of viral material might benefit from dry air, such as found in wintertime (in Northern Europe) and inside office buildings. Avoiding such environments may help to prevent 'superspreading' events in which one person infects many others. These suggestions are related to the issue of seasonality of infectious diseases such as influenza and measles, a topic that has been studied widely within biometeorology. Speculations are that the coming winter season will inevitably lead to a seasonal resurgence of the virus.

[196] in 't Veen, NTVG, D5153
[197] See e.g. Oumdali et al., 2020, Rypdal et al., 2018 and Esper et al., 2005

A more general concern is raised about the relation of the sudden outbreak of a viral pandemic with the disturbance of the natural environments of the original hosts of the viruses. The release of new and dangerous germs might be triggered the increasing destruction of ecosystems for agricultural purposes coupled with the shifting of habitats due the changing climate. Zoonotic transmissions and vector-borne diseases may affect the human habitat as a consequence. Indirectly, climate change may thus be responsible for this pandemic and the ones to follow.[198]

Regardless their truth value, these ideas attribute a role to the environment in a health crisis that is clearly caused by a contagious diseases. Professionals and lay persons alike revert to environmental thinking in their efforts to make sense of the events that cannot be explained by a straightforward model of contagion. This seems at odds with the long held conception of public health that the local environment is not a factor in health and disease but merely a neutral space that acts as a conduit for pathogens. It also contradicts the notion from medical history that the environmental 'configuration view' and contagionism are two antagonistic concepts of disease.[199]

Ultimately, the absence of sound evidence to answer questions such as the source of viruses and why some people get sick while others remain healthy, provokes questions about causes, which could reside in the environment. When scientific medicine with its monopoly on explaining diseases fails to satisfy such basic questions, one becomes aware that much may have been gained, yet something has been on the way. What has been lost is the capacity to provide explanations that patients can relate to their personal experiences and their deep rooted world views. Thinking about health in terms of the weather, climate or the environment has never disappeared because it connects us to the undeniable truth that man is a part of nature.

---

[198] Whitmee, Rockefeller-Lancet Report, p. 1992-2003
[199] Rosenberg, 'Explaining Epidemics', 295

Bibliography

<u>Primary sources</u>

Boyko, H. ed., *World Academy of Art and Science: Science and the future of mankind*, (Bloomington, Indiana University Press), 1961

Brezina, E., et al., *Klima*, *Wetter*, *Mensch*, (Quelle & Meyer, Leipzig), 1938

De Rudder, B., *Wetter und Jahreszeit als Krankheitsfaktoren: Grundriss einer Meteoropathologie des Menschen*', (Springer, Berlin), 1931

De Rudder, B., *Grundriss einer Biometeorologie des Menschen: Wetter- und Jahreszeiteinflüssen*, (Springer, Berlin), 1952

Hippocrates, *On Airs, Waters and Places*, Translation by Francis Adams. http://classics.mit.edu/Hippocrates/airwatpl.html

International Society of Biometeorology and Bioclimatology, *Int. J. Biometeorology and Bioclimatology*, 1, 1957, 449-479

Letter of ISBB to WMO, 23-6-1959, *Int. J. Biometeorology*, 3, 1959, 340

Lieth, H., Starting a new term for the International Journal of Biometeorology, *Int. J. Biometeorology*, 32, 1989, 1-10

Petersen, W. F., *The Patient and the Weather*, Edwards Brothers, Chicago, 1935

Sargent, F., Tromp, S. W., *A Survey of Human Biometeorology*, WMO Technical Note, 65, TP 78, 1964

Sargent, F., Tromp, S.W., The first Decade of the International Society of Biometeorology (1956-1966) , *Int. J. Biometeorology*, 10, 1966, 207-214

Sargent, F., Alternatives amid Crises, A Presidential Address, *Int. J. Biometeorology*, 10 1966, 217-222

Tromp, S. W., *The religion of the modern scientist (Neo-Materialism)*, (Leiden, Sijthoff), 1947

Tromp, S. W., *Psychical physics*, (New York, Elsevier), 1949

Tromp, S. W., Diehl, J.C, A Statistical Study on the Possible Influence on Soil and Other Geological Conditions on Cancer, *Experientia*, 10(12), 1954, 510-518

Tromp, S. W., Statistical study of the possible relationship between mineral constituents in drinking-water and cancer mortality in the Netherlands (Period 1900-1940), *Brit. J. Cancer*, 8, 1954, 585-593

Tromp S.W., Report of the Secretary-Treasurer, *Int. J. Biometeorology*, 4, 1960, 213-214

Tromp, S. W. (ed.), *Biometeorology. Proceedings of the Second International Bioclimatological Congress held at the Royal Society of Medicine, London, 4-10 September 1960*, (Oxford, Pergamom), 1962

Tromp, S. W., 'The Significance of Border Sciences for the Future of Mankind' in: *Science and the future of mankind*, ed. H. Boyko, (Bloomington, Indiana University Press), 1961, 83-120

Tromp, S. W. (ed.), *Medical biometeorology*, (Amsterdam, Elsevier), 1963

Tromp, S. W., A sample water bath test for estimating the thermoregulation efficiency of man, *Int. J. Biometeorology*, 7, 1964, 291-296

Tromp S. W., A Physiological Method for Determining the Degree of Meteorological Cooling, *Nature*, 210, 1966, 486

Tromp, S.W., Blood sedimentation rate patterns in the Netherlands 1955-1965, *Int. J. Biometeorology*, 11, 1967, 105-117

Tromp, S. W, Short and Long Periodical Fluctuations in the Diastolic Blood Pressure and Physico-Chemical State of Male Blood Donors at Leiden The Netherlands (Period 1955-1969), *Int. J. Biometeorology*, 14, 1970, 103-107

Tromp, S.W., The Possible Effect of Meteorological Stress on Cancer and its Importance for Psychosomatic Cancer Research, *Experientia*, 1974, 1475-1478

Tromp, S. W., Yearly Fluctuations of an Unknown Environmental Physical Factor at Leiden, The Netherlands (Period 1969-1974), A Brief Review of the Piccardi Effect, *J. Interdiscipl. Cycle Res*., 6, 1975, 9-14

Tromp, S. W., The Twentieth Anniversary of the International Society of Biometeorology 1 January 1956- 1 January 1976, *Int. J. Biometeorology*, 20(2), 1976, 71-91

Tromp, S. W. (ed.*), Progress in Biometeorology. The Effect of Weather and Climate on Man and his Living Environment, Vol 1, Part II, Period 1963-1975 Pathological Biometeorology,* (Amsterdam, Swets & Zeitlinger) , 1977

Weihe, W. H., Cooperation between the WHO and ISB, *Int. J. Biometeorology*, 11(3), 1967, 239-240

Secondary sources

Ackerknecht, E. H., Anticontagionism between 1821 and 1867, *Int. Journal of Epidemiology*, 38, 2009, 7–21; (Reprint of original paper from 1948)

Allen, M. J. et al., Supporting sustainability initiatives through biometeorology education and training, *Int. J. Biometeorology*, 61 (Suppl), 2017, S93-S106

Bracken, M. B., *Risk, Chance and Causation, Investigating the Origins and Treatment of Disease*, Yale, 2013

Bradford Hill, Sir A., The Environment and Disease: Association or Causation?, *Journal of the Royal Society of Medicine*, 58, 1965, 295-300

Bynum, W. F., *Science and the Practice of Medicine in the Nineteenth Century*, (Cambrdge), 1994

Cantor, C., Cortisone and the Politics of Empire: Imperialism and British Medicine, 1918-1955, *Bull. Hist. Med*., 67 (3), 1993, 463-493

Cantor, C. ed., *Reinventing Hippocrates,* (Aldershot, Ashgate), 2002

Clay, J., van der Tweel, H., Arts en samenleving. Besprekingen: Psychische Physica, *Nederlands Tijdschrift voor Geneeskunde*, 94(2), 1950, 1661

Codell Carter, K., *The Rise of Causal Concepts of Disease: Case Histories*, (Aldershot, Ashgate), 2003

Coen, D. R, *Climate in Motion, Science, Empire and the Problem of Scale, (*Chicago Univ. Press, Chicago), 2018

de Wilde, R., *Discipline en legende de identiteit van de sociologie in Duitsland en de Verenigde Staten 1870-1930*, Ph. D. Thesis, Rijksuniversiteit Limburg, 1992

Edelstein, L., Book Review: Hippocratic Wisdom, *Bull. Hist. Med.*, 20, 1946, 475-482

Edwards, P.N., Meteorology as Infrastructural Globalism, *Osiris*, 21, 2006, 229-250

Esper, F. et al., Association between a Novel Human Coronavirus and Kawasaki Disease, *The Journal of Infectious Diseases*, 191(4), 2005, 15

Evans, A. S., *Causation and disease. A chronological journey*, (New York, Plenum), 1993

Folk, G. E. Jr., The professional lifetime of Solco W. Tromp – a primary advocate of environmental influences, *Int. J. Biometeorology*, 38, 1994, 3-4

Friman, M., Understanding Boundary Work through Discourse Theory: Inter/disciplines and interdisciplinarity, *Science Studies*, 23(2), 2010, 5-19

Gieryn, T. F., Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests, *American Sociological Review*, 48(6), 1983, 781-795

Gieryn, T. F., *Cultural Boundaries of Science,* (Chicago, 1999)

Harrington, A., *Reenchanted Science, Holism in German Culture from Wilhelm II to Hitler,* Princeton, 1996

Haufe, W. O., Development and Application of Biometeorology, *Int. J. Biometeorology* , 20(2), 1976, 92-94

Haufe, W.O., Solco Tromp- promoter and developer of biometeorology, *Int. J. Biometeorology*, 35, 1991, 131-132

Huber, M., et al., How should we define health?, *Brit. Med. J*., 2011, 343, d4163

in ’t Veen, J, Kappen, J, van Schayck, O., Luchtverontreiniging: een determinant voor COVID-19?, *Nederlands Tijdschrift voor Geneeskunde,* 2020, 164, D5153

Jacobs, J.A., Frickel, S., Interdisciplinarity: a Critical Assessment, *Ann. Rev. Sociol.*, 35, 2009, 43–65

Jankovic, V., *Confronting the Climate, British Airs and the Making of Environmental Medicine,* (Palgrave MacMillan, New York), 2010

Jonker, E., Van relativisme naar oordeelsvorming. Recente tendensen in de wetenschaps-geschiedschrijving, *Studium*, 1, 2011, 2-15

Keatley, M. R., Developments in the International Society of Biometeorology over the decade 2007-2016, *Int. J. Biometeorology*, 61 (Suppl 1), 2017, S11-S18

Klein, J.T., *Interdisciplining Digital Humanities. Boundary Work in an Emerging Field,* (Ann Arbor, 2015)

Kloosterman, I. E, *Wetenschap van gene zijde, Geschiedenis van de Nederlandse Parapsychologie in de twintigste eeuw*, Ph. D. Thesis, Leiden, 2015

Knoeff, R., The body is a barometer. Dutch doctors on healthy weather and strong constitutions, in: *Lifestyle and Medicine in the Enlightenment The Six Non-Naturals in the Long Eighteenth Century,* (Routledge), 2020, 19-42

Kohler, R. E., *From medical chemistry to biochemistry: the making of a biomedical discipline* (Cambridge, 1982)

Koppe, C., Zacharias, S., Bernhard, D., Repräsentativbefragung zur Wetterfühligkeit in Deutschland, Deutscher Wetterdienst, 2013 (Bericht vom Umweltbundesamt UBA-FB 00)

Krasnow, S., In Memoriam Dr. Solco W. Tromp, *Int. J. Biometeorology,* 28, 1984, 257-260

Lawrence, C., Continuity in crisis: medicine, 1914-1945, in: *The Western Medical Tradition 1800 to 2000,* eds. W. F. Bynum et al., Cambridge, 2006, 247-406

Lawrence, C., Weisz, G. eds., *Greater than its Parts, Holism in Biomedicine 1920-1950*, Oxford, 1998

Le Fanu, J., *The Rise and Fall of Modern Medicine*, (London, Little, Brown and Company), 1999

Mahony, M., Endfield, G., Climate and Colonialism, *Wiley Interdisciplinary Reviews Climate Change*, 9(2), 2018, e510

Mc Cormmach, R., Editor's Foreword, *Historical Studies in the Physical Sciences*, 3, 1971, ix-xxiv

Medical History in Geographical Perspective, *Medical History*, 44 (20), 2000

Miller, G., "Airs, Waters and Places" in History, *J. History of Medicine and Allied Sciences*, 17 (1), 1962, 129-140

Nash, L., *Inescapable ecologies: a history of Environment, Disease and Knowledge*, (UCP: Berkeley), 2006

Osborne, M. A., Fogarty, R. S., Medical Climatology in France: The Persistence of Neo-Hippocratic Ideas in the First Half of the Twentieth Century, *Bull. Hist. Med.*, 86(4), 2012, 543-563

Oumdali M. D. et al., Emergence of Kawasaki disease related to SARS-CoV-2 infection in an epicentre of the French COVID-19 epidemic: a time-series analysis, *Lancet,* July 02, 2020

Perkins, D. R. et al., Enhancing the teaching and learning of biometeorology in higher education, *Bull. Am. Met. Soc*, 2017, 239-242

Review of Books, *Lancet*, 1950, 626

Riley, J. C., *The eighteenth-century campaign to avoid disease*, (MacMillan, Basingstoke), 1987

Rosenberg, C. E., On the study of American biology and medicine, *Bulletin Hist. Medicine*, 38, 4, 1964, 364-376

Rosenberg, C.E., *Explaining Epidemics and Other Studies in the History of Medicine*, (Cambridge, 1992), 293-304

Rosenberg, C. E., Epilogue: Airs, Waters, Places: A status report, *Bull. Hist. Med*., 86 (4), 2012, 661-670

Russo, F., *'Causation and Correlation in Medical Science: Theoretical Problems'*, in: Handbook of the Philosophy of Medicine, (Springer: Dordrecht). 2017, 839-849

Rypdal, M. et al., Clustering and climate associations of Kawasaki Disease in San Diego County suggest environmental triggers, *Scientific Reports*, 2018, 8 (1)

Sargent, F., *Hippocratic Heritage, A History of Ideas About Weather and Human Health*, (Pergamon, New York), 1982

Scott Greene, J., Rietveld, W. J., Dr. Solco Tromp and the Tromp Award, *Int. J. Biometeorology*, 40, (1997), 9-15

Sellers, C., To Place or Not to Place: Toward an Environmental History of Modern Medicine *Bull. Hist. Med.*, 92 (1), 2018, 1-45

Shapin, S., Discipline and bounding: The history and sociology of science as seen through the externalism-internalism debate, *History of Science*, 30, 1992 333-369

Sheridan, S. C., Allen, M. J., Sixty years of the International Journal of Biometeorology, *Int. J. Biometeorology*, 61 (Suppl 1), 2017, S3-S10

Somsen, G. J., A History of Universalism: Conceptions of the Internationality of Science from the Enlightenment to the Cold War, *Minerva*, 46, 2008, 361-379

Stewart, A. E., Edwin Grant Dexter: an early researcher in human behavioral biometeorology, *Int. J. Biometeorology, 59, 2015,745–758*

Vineis, P., From John Snow to omics: the long journey of environmental epidemiology, *European Journal of Epidemiology*, 2018, 33, 355–363

Wegener, D., Wetenschapsgeschiedenis op lange termijn: flexibiliteit en fragiliteit van disciplines, *Studium*, 1, 2011, 16-30

Weihe, W. H., Review of the history of the International Society of Biometeorology, *Int. J. Biometeorology*, 40, 1997, 9-15

Weisz, G., A Moment of Synthesis, Medical Holism in France between the Wars, in: *Greater than the Parts, Holism in Biomedicine*, eds. Lawrence, C., Weisz, G., Oxford, 1998

Weisz, G., Hippocrates, Holism and Humanism in Interwar France, in: *Reinventing Hippocrates*, ed. Cantor, G., Ashgate, 2002

Whitmee, S., et al., Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–*Lancet* Commission on planetary health, *Lancet*, 386, 2015, 1973-2028

Interviews

Prof. dr. Wop Rietveld, Wassenaar, 25-10-2019
Prof. dr. Peter Höppe, Munich, telephone interview, 15-12-2019

Acknowledgements

This thesis was written under conditions that were far from ideal. An unexpected pandemic brought many activities to a standstill: libraries and archives closed and ‘real’ personal interactions with university students and staff were no longer possible. Despite this, my supervisors Frank Huisman and David Baneke kept up the good spirits and carried on supporting me. First and foremost, I would like to thank them for their efforts.

A word of thanks goes out to all my fellow students who started their Master History and Philosophy of Science in 2018. They created a very pleasant atmosphere, both academically and personally, for which I am grateful. I would like to thank especially Martijn van der Meer, Valentine Delrue and Elske de Waal for their help.

It was not easy to find people who have met Solco Tromp in person. I thank professors Wop Rietveld and Peter Höppe for sharing their recollections of Tromp and their knowledge about the early days of biometeorology.

The critical gaze of Jan van Gijn, whose suggestions improved the content and style of my writing, is highly appreciated. I would also like to thank Mart van Lieburg for his suggestion to investigate the relation between medicine and meteorology.

Most important of all, Marlies Wopereis deserves more thanks than words can express.

Ronald Hes

September 2020