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Appendix A: List of abbreviations and formulations

Unit	Description
cm	centimeter
h	hour
kg	kilogram
km	kilometer
L	Liter
m	meter
mm	millimeter
s	second
y	year

Abbreviation	Description
b1	backbarrier location number 1
d1	Ebb-tidal delta location number 1
DEM	Demographic elevation model
HW	high water or flood
i1	inlet location number 1
LW	low water or ebb
MSL	mean sea level
nr	number
R^2	Coefficient of determination
x	longitudinal direction
y	longitudinal direction
z	vertical direction

Abbreviation	unit	Description	Formulation
a	m	tidal amplitude	
Ac	m^2	Channel area	$Ac = a P^m$
A_e	m^2	Area of estuary	
B	cm	Inlet width	
C	$m^{0.5}/s$	Chézy coefficient	
D	m	depth	
d_{10}	m	10th percentile grain size	
d_{50}	m	median grain size	
d_{90}	m	90th percentile grain size	
ESV	m^3	Ebb-tidal delta sand volume	
Fr	(-)	Froude number	$Fr = u/ (gh)^{0.5}$
g	m/s^2	gravitation accelaration	
h	m	mean channel depth	
L_e	m	Length of estuary	
m	(-)	coeffient	
P	m^3	tidal prims	
Q	m^3/s	discharge	
Re	(-)	Reynolds number	$Re = (\rho_w h u) / \mu$
S	(-)	slope	
T	s	tidal period	
u	m/s	flow velocity	
Vc	m^3	Volume of water stored in channels	
Vs	m^3	Volume of water stored on shoals	
W/D	(-)	width to depth ratio	
W	m	width	
θ	(-)	Shields number	$\theta = \tau_b / ((\rho_s - \rho_w)\, gD50)$
θ_{cr}	(-)	critical Shields number	$\theta_{cr} = \tau_{b,cr} / ((\rho_s - \rho_w)\, gD50)$
τ_b		bed shear stress	$\tau_b = \rho_w g h S = \rho g u^2/C^2$
$\tau_{b,cr}$		critical bed shear stress	
ρ_w	kg/m^3	density of water	
ρ_s	kg/m^3	density of sediment	
μ	Kg/m/s	dynamic viscosity	

Appendix B: Experiments on long estuaries

This study aimed to investigate the emerging morphology in case of plane sand bed. Does an equilibrium form attain since there is no additional sediment source? What is the effect of the boundary conditions water level, tidal amplitude, basin length, slope of the sediment bed and inlet width? What is the effect of interaction of tidal flow and river flow? In addition to a series of tests with small perturbations, six runs were conducted to study the evolution of an inlet in case of initial long channel configuration. The initial long channels resemble estuaries as in van der Wegen et al. [2008a] and Seminara and Tubino [2001]. Their configuration of the model consists of a rectangular box that has an open boundary at the seaward end.

This study includes a systematic account of the dependent variables water level at MSL, amplitude and speed of tilting, length of the rectangular basin, slope of the sediment bed, inlet width and river input. The experimental settings are provided in table 1.

Table 1 Experimental settings of experiments with initial configuration to simulate estuaries.

Nr.	Sedi-ment	Initial con-figuration	Ampli-tude of tilting	Speed of tilting	Delay	Tidal period	Total cycles	Back-barrier	Sand level	Equilibrium state	Inlet width
	type		cm	mm/min	s	s	nr		cm		cm
30	poly	estuary	6	50	20	65	185	sloping	4.5	dynamic	23
31	poly	estuary	6	50	20	65	203	sloping	4.5	dynamic	23
32	poly	estuary	2 – 6	6-12	20	44 – 48	*3400*	sloping	4.5	dynamic	23
33	poly	estuary	3	30	20	60	1440	plane	4.1	static	23
34	poly	estuary	3 – 3.8	40	*25*	65 - 70	5926	plane	4.1	dynamic	35
36	poly	estuary	3.8	30	20	63	4114	plane	4.1	dynamic	44

In summary:

30 as experiment 28 but lower amplitude of tilting and sloping sediment bed
31 lower water than in 30
32 low settings regarding water level, amplitude and speed of tilting
33 longer sediment basin and no sediment slope
34 Most settings slightly higher than in 33
36 Additional river input and small adjustments

Experiment 30: as experiment 28 but lower amplitude of tilting and sloping sediment bed
The initial long channel showed separation of flow for the ebb and flood flow in figure 1. Channel curvature was promoted by separation of flow. The channel in the backbarrier retreated within 100 tidal cycles to the length in lower figure 1. Then the backbarrier flow area widened by channels that eroded their outer banks. The number of channels in the backbarrier remained unchanged, being four. Channel migration speed was low. There was one main channel through the inlet. Alongside this channel there were two banks. Further into the sea basin the channel widened. Hereby a symmetrical ebb-tidal delta with respect to the inlet emerged.

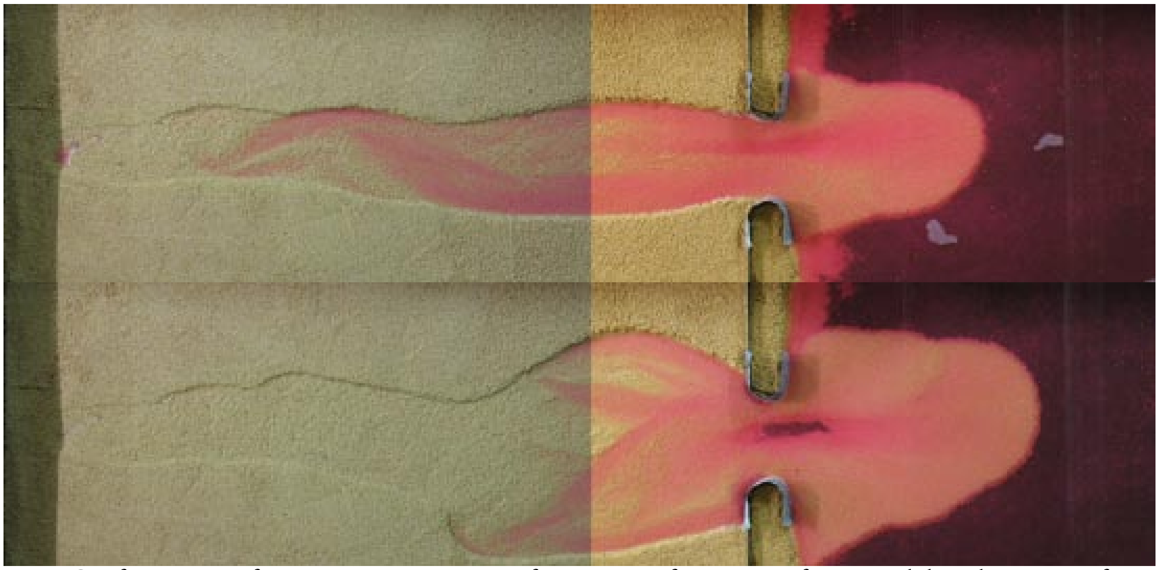


Figure 1 Configuration of **experiment 30**. Upper figure is configuration after 28 tidal cycles. Lower figure is configuration after 175 tidal cycles.

Experiment 31: lower mean water level

Experiment 31 was identical to experiment 30 apart from the water level at MSL. The water level at MSL in experiment 31 was 0.7 cm lower which was a decrease of 20%. Similar to experiment 30 was the emergence of curvature due to different flow paths of ebb- and flood in figure 2. The channel in the backbarrier retreated within 35 tidal cycles to the length in lower figure 2. Then the backbarrier flow area widened by channel migration. The number of channels in the backbarrier was three whereas the middle channel migrated slowly. The inlet described one main channel with two smaller side channels. The main channel was separated from the small channels by small banks. The channels through the inlet widened over the ebb tidal delta. The ebb-tidal delta was symmetrical with respect to the inlet. The major difference between experiment 30 and experiment 31 was that the channels in experiment 31 were less wide and less deep. At the same time the backbarrier flow area was smaller and the entire system was almost symmetric through the inlet.

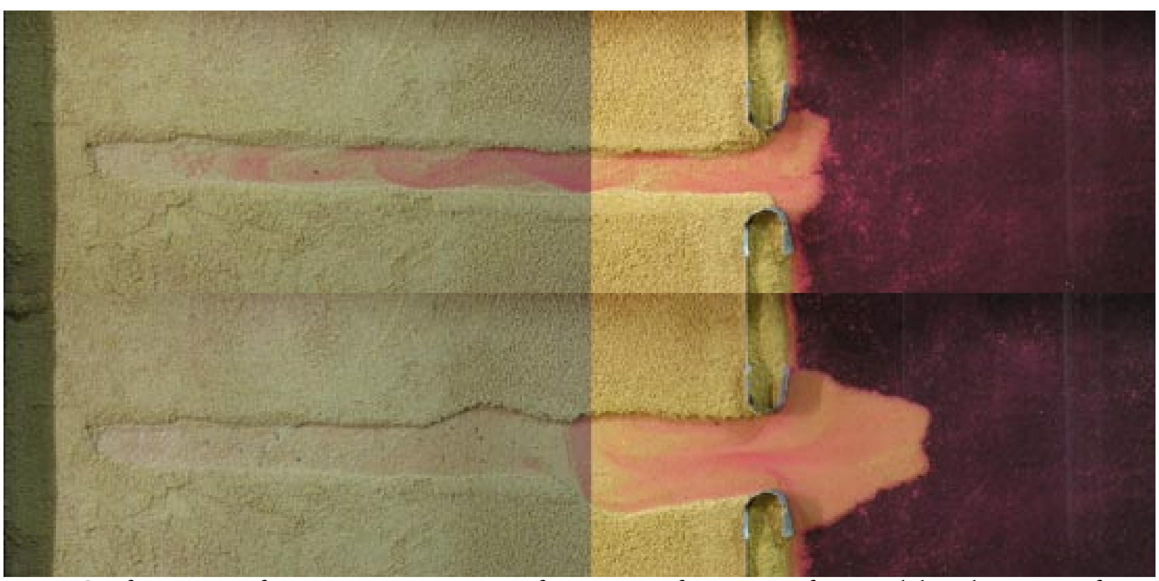


Figure 2 Configuration of **experiment 31**. Upper figure is configuration after 9 tidal cycles. Lower figure is configuration after 203 tidal cycles.

Experiment 32: low settings regarding water level, amplitude and speed of tilting
Experiment 32 resembles low settings regarding water level, amplitude and speed of tilting. The initial channel is deep. The evolution shows that the flow through the initial long channel confines into a narrow straight channel in upper figure 3. The channel needs about 2800 tidal cycles to retreat and become middle figure3. Then the channel erodes the banks at its outer bends and hereby widens the backbarrier area. The backbarrier first consists of one main channel. Sediment is depostited to one side of the ebb-tidal delta. In time a second channels emerges in the backbarrier. The two channels congregrate near the inlet. The inlet channel now deflects to the lower side of the ebb-tidal delta. The net effect is an ebb-tidal delta that is almost symmetric with respect to the inlet and a bank in front of the inlet. The ebb-tidal delta is small compared to other tests. Likely it is a result of less sediment being available because the initial channel was deep and from low transport capacity from low settings.

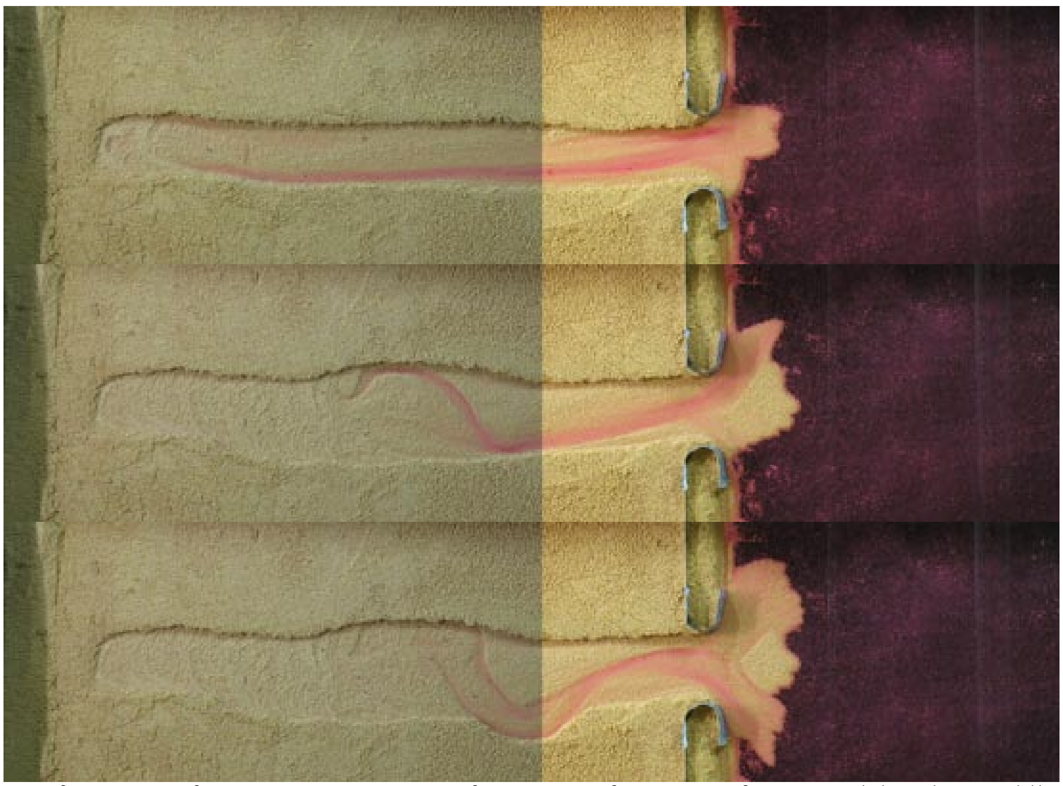


Figure 3 Configuration of **experiment 32**. Upper figure is configuration after 505 tidal cycles. Middle figure is configuration after 885 tidal cycles. Lower figure is configuration after 1435 tidal cycles.

Experiment 33: longer sediment basin and no sediment slope
In order to create a longer estuary the sediment basin is about 30 centimeters longer in experiment 33 as in the previous experiments. Also the sediment slope was absent.

The flow through the initial channel in the backbarrier confined into two smaller channels in figure 4. These channels retreated within 700 tidal cycles to the length of lower figure 4. The backbarrier flow area did not widen as for the previous experiments and channel migration was insignificant. The channel tip may migrate slightly in association with ebb-tidal delta expansion. The equilibrium state was near static. Some sediment transport was still observed. The estuary was about 1.40 meter in length and 20 centimeters wide.

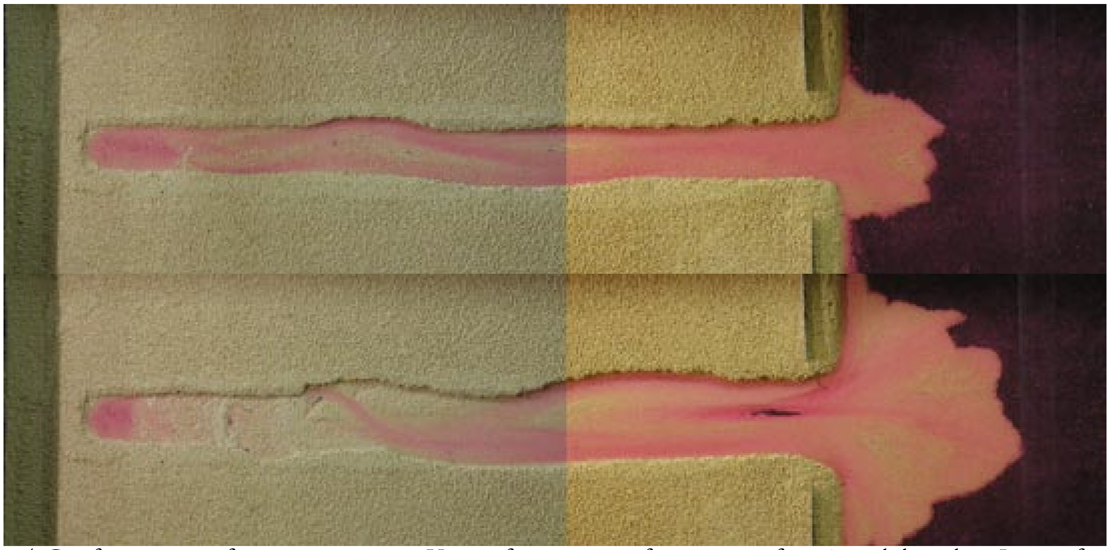


Figure 4 Configuration of **experiment 33**. Upper figure is configuration after 50 tidal cycles. Lower figure is configuration after 635 tidal cycles.

Experiment 34: settings slightly higher than in experiment 33

Experiment 34 described settings that ware slightly higher than for experiment 33. The amplitude of tilting, speed of tilting, water depth at MSL and sediment basin length were slightly higher.

The channel in the backbarrier were wider and longer than for experiment 33. Also the ebb-tidal delta grew bigger in figure 5. The entire width of the fixed inlet was used. After more or less 5000 tidal cycles the channels in the backbarrier of upper figure 5 retreated to the length as of lower figure 5. At the same time the channel tips migrated slowly. After retreatment (in the lower figure 5) channel migration ceased. The estuary was about 1.60 meter in length and 45 centimeters wide.

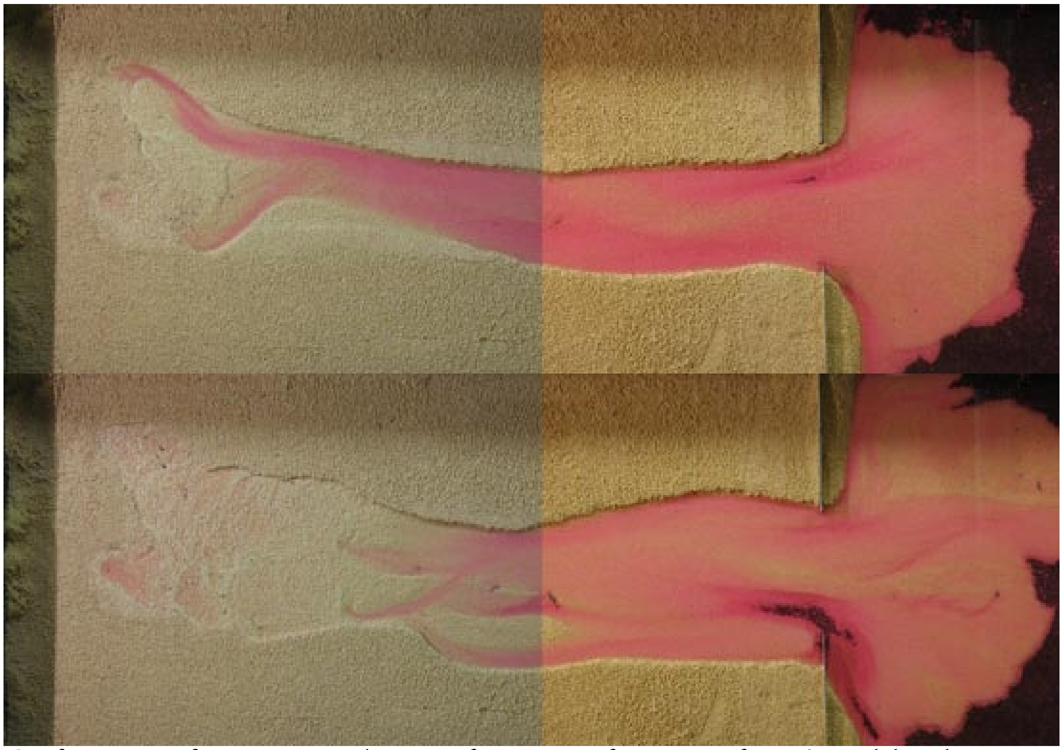


Figure 5 Configuration of **experiment 34**. Upper figure is configuration after 1695 tidal cycles. Lower figure is configuration after 5000 tidal cycles.

Experiment 36: additional river input and small adjustments

Experiment 36 resembled experiment 34 as in settings although speed of tilting was slightly lower, water level at MSL higher and the fixed inlet was improved and slightly wider. Additional was the river input in the backbarrier. The input was 0.2-0.5L per tidal cycle. The discharge was not constant. It decreased in time which was a deficiency of the experiment.

The channel curvature was high in the backbarrier in upper and second figure 6. At the same time ebb- and flood flow paths were distinguished by the appearance of sills (following chapter). After approximately 1000 tidal cycles the river input ceased. The channels retreated from the back part of the backbarrier. At the same time the channel tips migrated by sweeping tips (third figure 6). The channel tips may blend and diverge. In third figure 6 a bank was seen in the middle of the estuary. The estuary was close to a two inlet channel system with long straight channels. After about 3900 tidal cycles the river input was present again. An immediate response was the curvature of the channels in the backbarrier in lower figure 6. The channels migrated fast by sweeping over the floodplain area. The ebb-tidal delta built out as a response. It indicated an increase in transport capacity with the ebb-flow. Also the deepest channel through the inlet that formerly deflected to the south migrated northward. It resulted in a main channel through the middle of the inlet that extended far into the ebb-tidal delta. This channel was distinguished to be an ebb-channel. Near the inlet two smaller channels were observed which resembled flood-channels. The ebb- and flood channels were schematized in figure 7. The existence of separate ebb-and flood channels indicated that the system was still a tide dominated estuary. Estuary length was about 2.20 long and 50 cm wide.

Major observations and comparison to literature

This section provides a summary of observations from experiment 30 to 36 on estuaries. Comparison to literature is described for.

The inlet width was an important condition for the state of the estuary. When the width was too high the channels in the backbarrier lost their migrating character. The water level at zero tilt correlated to the width of the main inlet channel. In case of higher water levels the tendency of the system to widen its inlet was stronger. It is a logical result of the tidal prism P relation to channel area Ac [Powell et al. 2006].

The sediment bed had a major control over the length of the estuary. It is observed that a plane sediment bed resulted in a longer estuary than a sloping sediment basin. Deep initial channels resuled in a longer estuary despite of lower flow capacity in experiment 32. In experiment 30 to 34 the drowned basin retreated indication sedimentation in the back part of the basin. At the same time the flow depth near the inlet, displayed in emergence of scour holes and more intense color of the water, indicated that the bed profile changed to a landward up sloping bed. Modeling of profile adjustment of a horizontal flat bed shows evolution to a landward sloping bed [van der Wegen and Roelvink 2008]. Net sedimentation occurred to the right of the intersection of bed profile. Net erosion occurred in the part left of the intersection of bed profile. Resemblance is seen between results from 1D-modelling by van der Wegen et al. [2008a] and observed experimental profile adjustment. An additional river flow had strong effects on the estuarine morphology. The channels in the back part of the sediment basin showed a high curvature and were highly dynamic with migrating bars and meanders.

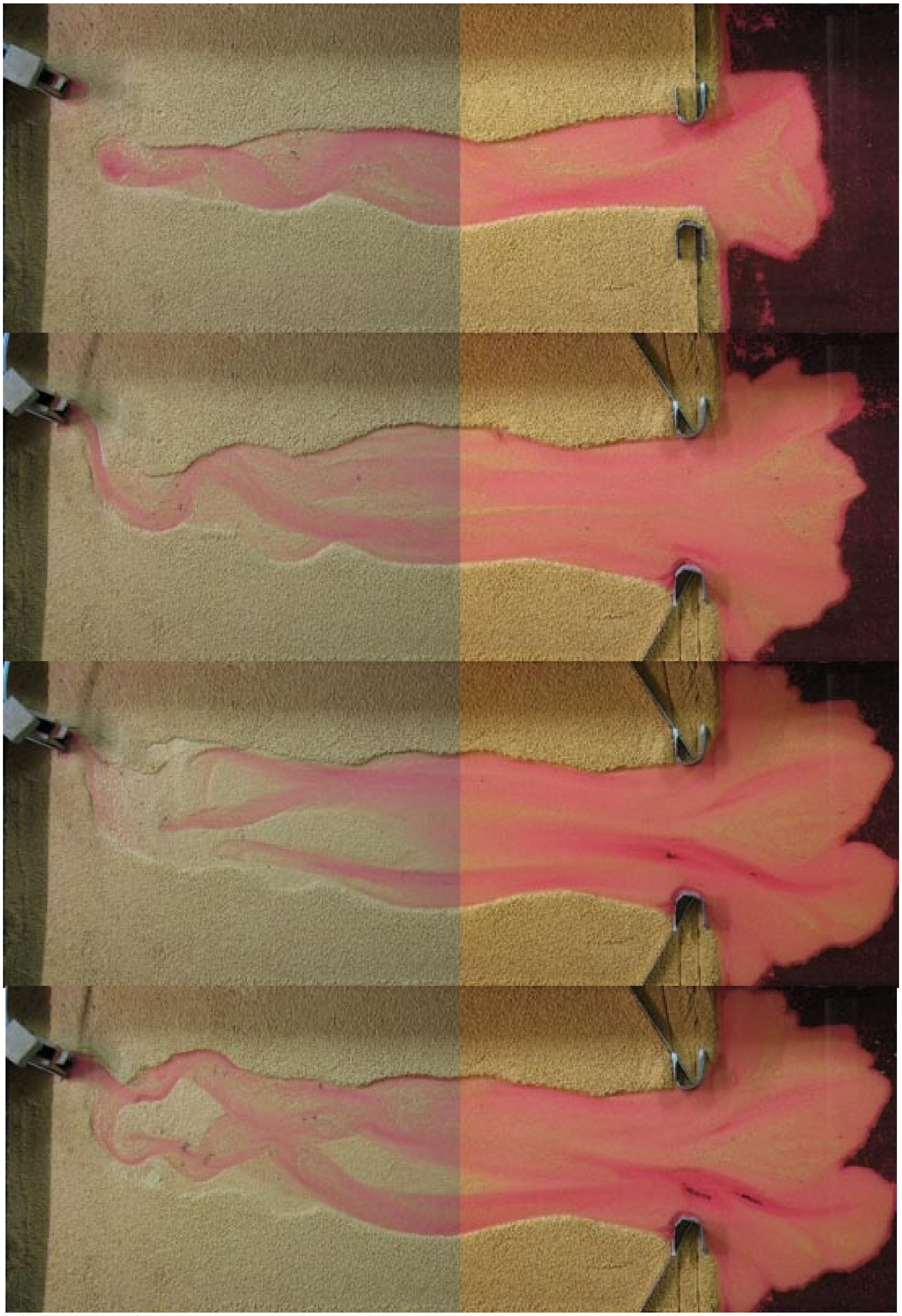


Figure 6 Configuration of **experiment 36 with additional river input**. Upper figure is configuration after 115 tidal cycles. Second figure is configuration after 375 tidal cycles. Then river input slowly decreases and ultimatiely ceases around 1000 tidal cycles. Third figure is configuration after 2800 tidal cyles. River input is present again 3900 tidal cycles. Lower figure is configuration after 4100 tidal cycles.

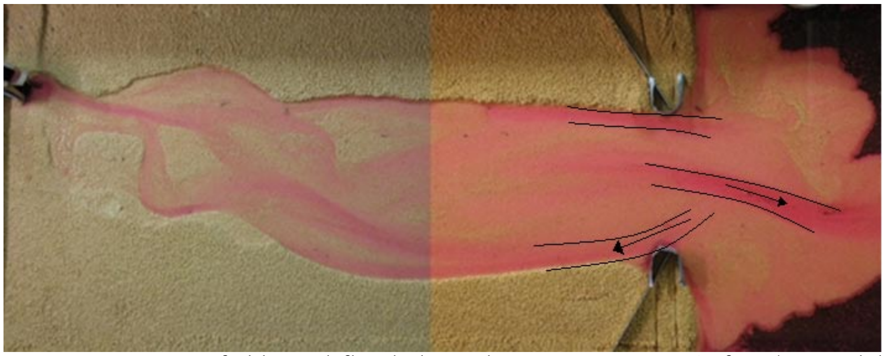


Figure 7 Representation of ebb- and flood channels in experiment 36 after 4150 tidal cycles.

Appendix C: List of materials

Mechanical jack – specifically manufactured by Henk Markies for this purpose.

Rectangular plastic tub of 3.5 x 1.2 x 0.25 m on metal frame with pivot point over short side in the middle. The inner bottom and sides of the tub are covered with 'afdekvilt met absorberend vermogen voorzien van anti-slip folie'.

Sediment – poorly sorted sand (rivierzand / metselzand of Utrecht University)
Sediment – light weight ethylpropyleen (Utrecht University)
Approximately 1.2 m^3 sediment is needed for a sediment bed of 4 centimeters.

Tap water
Rhodamine B – pink color additive
$C_{28}H_{31}ClN_2O_3$
479,0 g/mol
Mogelijk kankerverwekkend gebleken bij dierproeven.

Metal (Pb) frames to construct a fixed inlet

Clock and stopwatch

Two photo camera's
Canon PowerShot A640

StarCam™ 3D camera

Computer with software:

- VX studio 3D
- Photoboot
- PSRemote
- Matlab with image processing toolbox

Sufficient data storage
Per day (releasing every 15 minutes at LW, MSL 2x and HW, good quality)

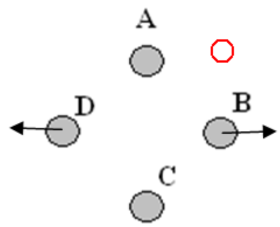
4	GB	original data
8	GB	rectified photos
5.5	GB	stitched photos
20	MB	movie of LW photos

---------------------Total ----------------------------------

18	GB	one day of experimental time
123	GB	per week (7 days)
500	GB	per month

Appendix D: mechanical jack user guide

The mechanical jack is specifically manufactured by ing. Henk Markies of Utrecht University to tilt the basin with specific settings. The settings are listed according to mode 0 to 12. The modes and their settings are described below. With the control buttons you can switch between modes (A and C) and changes the settings of the modes (B and D).



A previous mode
C next mode
B next value of setting
D previous value of setting
○ photo release sign --> light on

Mode		Description	unit
0	start and exit	press AC for 2 seconds	
1	speed up	set speed of upward movement	mm/s
2	speed down	set speed of downward movement	mm/s
3	direction ↑↓	first direction after start	up or down
4	Delay	wait time at lowest and highest point	seconds
5	Distance up	upward distance from zero tilt	mm
6	Distance down	downward distance from zero tilt	mm
7	photo	photo release options - see table below	0 to 4 photos
8	Photo divider	periods between next series of photos	number
9	Home down ↓		on/off
10	Home up ↑		on/off
11	Level 0 ↓↑	Finds zero level, searches in direction 'mode 3'.	Press AC
12	Manual	move leg manually by A (up) and C (down)	up/down

Photo release options
Whether taking a photo at a certain phase is selected is listed in the table below. There are 16 possible combinations. You can select or deselect by searching number 0 - 15. Description 0 is take no photos while 15 is take a photo at all four phases.

OFF	ON	Description	
l	L	low	taken half way the delay period
m ↓	M ↓	at zero tilt	downward movement
m ↑	M ↑	at zero tilt	upward movement
h	H	high	taken half way the delay period

Appendix E: user guide stereo system for rapid automated DEM production StarCam™ 3D

The Starcam™ 3D-camera is fixed to the ceiling with a small angle to capture a larger area. The capture area is about 70 x 50 cm. The camera manual suggests not to place the camera at an angle but the results are good enough for this purpose. The manual strongly discourages to use the striped projection pattern when the camera is placed at an angle. The software does not provide a tool to correct for the camera angle.

Test pattern settings: fine, …
The lens of the projector should be properly focused when the test patterns are projected on the sediment bed. For these experiments the test pattern fine is used at all times.

Projection patterns: Stripes and dots
Dots is the best pattern for standard scans and for objects that are not moving.
Stripes is a quick scan and better suited when objects do not remain still for a long enough period of time. For these experiments the projection pattern dots is used at all times.

Resolution: 1-20
The scan resolution adjusts the shifting of the scan pattern. A higher resolution results in more shifts of the pattern. The outcome is an image with more detail. Although the image might also include more noise. Also the scan takes longer and data storage is significantly higher.
For these experiments the resolution 4 – 12 is tested. Optimum results in available time (10 seconds) is a resolution of 10.

Saving the output
To save the output image from the VX Studio 3D to a text file with 3 columns (level z at location x and y) you need to select the thumbnail of the 3D-image in the preview mode. Press Ctrl + Alt + o to save the selected image in a particular directory. Save the file as .txt (ascii).

Processing of the 3d-images is described for in appendix working with DEM images.

Appendix F: light-weight sediment size and density

Sediment size

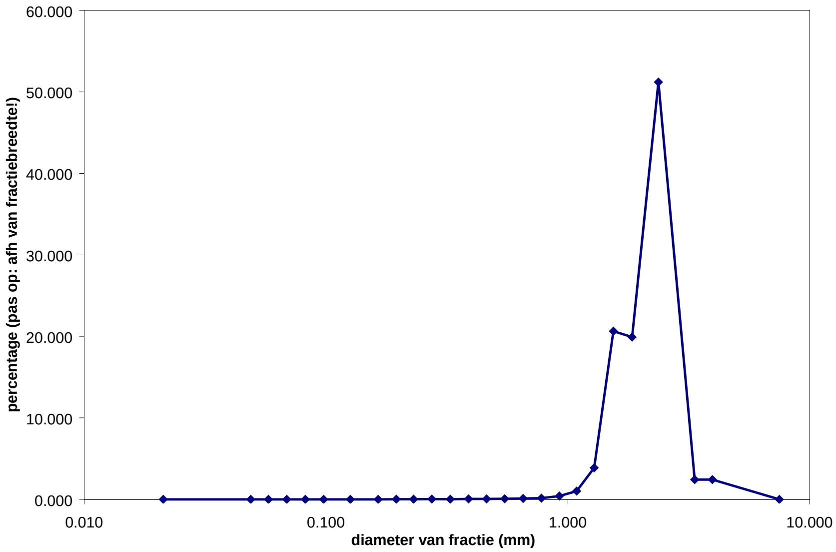
The fractions of the sediment grains of the light-weight polystyrene sediment are determined by the sieving method provided at Utrecht University, department of Physical Geography in the Zonneveldvleugel.

Baknummer:	tilting tub	
Omschrijving:	Licht-gewicht polystyreen	
Herkomst:	Wageningen --> Utrecht	
Filenaam:	U:\lichtgewichtpolystyreen.xls	
Datum:	25-1-2012	Renske Terwisscha van Scheltinga

The average over two samples gives:

Diameter	leeg gewicht	vol gewicht	netto gewicht
monster	785.28	1069.38	284.1
5.6	808.12	808.12	0
4	700	700	0
2.8	722.08	728.97	6.89
2	675.92	821.08	145.16
1.7	660.26	716.72	56.46
1.4	699.92	758.43	58.51
1.18	665.5	676.45	10.95
1	579.34	582.23	2.89
0.85	533.72	534.85	1.13
0.71	530.16	530.57	0.41
0.6	523.32	523.65	0.33
0.5	493.74	493.95	0.21
0.425	507.14	507.29	0.15
0.355	466.38	466.54	0.16
0.3	441.64	441.71	0.07
0.25	445.1	445.21	0.11
0.212	408.96	408.99	0.03
0.18	406.48	406.52	0.04
0.15	397.8	397.8	0
0.106	380.66	380.66	0
0.09	366.48	366.48	0
0.075	374.3	374.3	0
0.063	349.42	349.42	0
0.053	452.36	452.36	0
0.045	344.84	344.84	0
0	593.32	593.32	0
		Totaal gewicht	283.5

Diameter zeef mm	percentage van %
5.6	0
4	0
2.8	2.43
2	51.203
1.7	19.915
1.4	20.638
1.18	3.862
1	1.019
0.85	0.399
0.71	0.145
0.6	0.116
0.5	0.074
0.425	0.053
0.355	0.056
0.3	0.025
0.25	0.039
0.212	0.011
0.18	0.014
0.15	0
0.106	0
0.09	0
0.075	0
0.063	0
0.053	0
0.045	0



Baknummer: 4 Filenaam: C:\Documents and Settings\markies\My Documents\Goot\Zeefanalyse\rivierzand.xls Datum: 8-3-2007
Omschrijving: Rivierzand Herkomst: Zandhandel Theo Pouw

Density and porosity

It was provided that the density of the sediment is 1055 kg/m^3. Since multiple experiments are done with the (in Wageningen, Delft and Utrecht) the sediment density may have changed. The density and porosity of the light-weight polystyrene sediment are determined according to method described by Maarten G. Kleinhans. The method is elaborated and performed by Renske Terwisscha van Scheltinga (author). It is likely that the method slightly underestimates the density and overestimates the porosity. For this research two samples are measured separately. The sample giving the highest outcome of density (1041 kg/m^3 versus 1033 kg/m^3) is incorporated in the research thesis.

Bepalen van dichtheid en porositeit van sediment

type	lichtgewicht sediment
datum	22-12-2011
locatie	Zonneveldvleugel, Utrecht
door	Renske Terwisscha van Scheltinga, MSc
file	LightWporositydensity.xls

Benodigdheden		**volume noteren**		**diameter noteren**	
2 cilinders	inhoud 1L	1	(L)	6.15	(cm)
water	0.5L per monster				
sediment	0.5L per monster				
weegschaal	op gram nauwkeurig; tot 2 kilo voor lichtgewicht; tot 3 kilo voor zand				

Werkwijze			**waarde**	**eenheid**
1)	leeg gewicht bepalen van cilinder		199.24	g
2)	vullen met water tot bepaald volume (halfvol)		500	ml
3)	het gewicht meten van cilinder met water		698.36	g
4)	gewicht meten van tweede cilinder		199.24	g
5)	tweede cilinder vullen met sediment (halfvol)		500	ml
6)	gewicht bepalen van cilinder + sediment		543.1	g
7)	sediment toevoegen aan eerste cilinder met water			
8)	schudden en laten settlen	1		
9)	totaalgewicht noteren		1041.6	g
10)	volume aflezen van sedimenthoogte		480	ml
11)	volume aflezen waterhoogte		828	ml
12)	nogmaals schudden	2		
13)	wederom volume aflezen van sedimenthoogte		475	ml
14)	wederom volume aflezen van waterhoogte		828	ml
15)	nogmaals schudden	3	1041.55	g
16)	wederom volume aflezen van sedimenthoogte		480	ml
17)	wederom volume aflezen van waterhoogte		829	ml

Rekensheet

dichtheid	kraanwater (koud)	kg/m3	998

	cilinder 1	gewicht	g	199
	cilinder 2	gewicht	g	199
	water	volume	ml	500
	water	gewicht	g	499
	water	volume uit gewicht	ml	**498**
	sediment	volume	ml	500
	sediment	gewicht	g	**344**
gemiddele van schudden 1-3	sed+water	volume	ml	828
gemiddele van schudden 1-3	sediment	volume met porien	ml	478
	sediment	volume zonder porien	ml	330
	porie	volume	ml	148
	porositeit	fractie	(-)	0.31

sed+water	gewicht	g	842
sediment	gewicht	g	344
water	gewicht	g	499
check	gewicht	g	843

sediment	nat volume	ml	**478**
sediment	droog volume	ml	500

(oranje)	check 1	geen verliezen
(geel)	check 2	de cilinder leest niet heel nauwkeurig af, watervolume wordt berekend uit gewicht en dichtheid
(roze)	check 3	het natte sediment vult zijn porien iets meer op en wordt gebruikt voor de berekening

dichtheid	water	998.2	kg/m3	
dichtheid	droog sediment incl. porien	*687.7*	kg/m3	droog sediment is minder nauwkeurig dan nat sediment
dichtheid	nat sediment incl. porien	*718.9*	kg/m3	ter vergelijking met droog sediment
dichtheid	sediment	1041.8	kg/m3	

Appendix G: processing of images

To process images from Canon PowerShot A640 use is made of the computer language and software provided in Matlab R2009b and R2011b. The Matlab image processing toolbox is essential. This section provides Matlab scripts to:

- select data and camera type
- rectify photos (lens correction)
- Stitch two photos to one
- Make a movie of stitched and rectified photos
- Rename images in directory

Select data and camera

Matlab script: DoPhotos.m

```
% This script is used to rectify photos, stitch them and make a
% movie of it. Only used for the images from the Zonneveldvleugel.

clear all
close all
clc

%% Give the initial settings for Rectification, Stitchen and Movie making
experiment = '25'; %Set the number of the experiment
camera = 'CanonA640_f=7.3mm_1'; % Choose the camera which took the photos
Canon A640, or CanonEOS 550D

addpath('U:\Matlab_codes\');
workdir = 'U:\Experimenten Tidal Inlets\';
sourcedir = ['Experiment_',num2str(experiment),'\'];
% Change this parameter for the data you want to open

cd([workdir sourcedir])
```

Rectify photos

The photos show a deflection towards the corners. The deflection is dependent of the particular lens (photo camera) and on the zoom level. The following script corrects photos from the Canon A640 with f=7.3 mm (no zoom). The script is written by Wout Van Dijk, PHd candidate at Department of Physical Geography (U.U). He provided the Microsoft Access files ind.mat, a#.mat and ind_new.mat and the matlab script undcol.m. These files are camera specific data files which he collected with PHd candidate Wietse van de Lageweg.

```
%% Rectification of the Photos

I2=rectified(sourcedir,workdir);
clear I2
```

Matlab script: rectified.m

```
function I2=rectified(sourcedir,workdir)

addpath('U:\Matlab_codes\CanonA640_f=7.3mm_1\');
cd('U:\Matlab_codes\CanonA640_f=7.3mm_1\');
```

```
load ind.mat
load a#.mat
load ind_new.mat

cd([workdir sourcedir])

% list jpg files in folder where the images are located
pics=dir('*.jpg');

for pic=1:size(pics)
    tic

    %% OPEN THE ORIGINAL IMAGE:
    nameonly=char([pics(pic).name]);
    I=single(imread(nameonly));

    %% UNDISTORT THE IMAGE:
    threeD = (ndims(I)==3);
    if threeD % Transform red, green, blue components separately
    newimage(:,:,1) = undcol(I(:,:,1), a1, a2, a3, a4, ind_lu, ind_ld,
ind_ru, ind_rd, ind_new);
    newimage(:,:,2) = undcol(I(:,:,2), a1, a2, a3, a4, ind_lu, ind_ld,
ind_ru, ind_rd, ind_new);
    newimage(:,:,3) = undcol(I(:,:,3), a1, a2, a3, a4, ind_lu, ind_ld,
ind_ru, ind_rd, ind_new);
    I2=newimage;
    else % greyscale image
    newimage = undcol(I, k1, k2,P1,P2, fmw, ppx, ppy );
    end

    %% SAVE THE IMAGE IN FILE:
    namenew=[pics(pic).name ];
    imwrite(I2, namenew ,'Quality', 100);
    toc
end
```

Stitch two photos to one

The experimental apparatus made use of alternately one and two photo cameras. Whether one of two photo cameras where used depended on the size of the scale model. The use of a single photo does not require stitching of the photos. When using the two photo cameras, this script allows to stitch the two photos made at a time certain time step together. The script is written by Wout Van Dijk, PHd candidate at Department of Physical Geography (U.U).

```
%% Stitching of the Photos

fig = plakken(workdir,sourcedir,experiment);
clear fig
```

Matlab script: plakken.m

```
function [fig] = plakken(workdir,sourcedir,experiment)
cd([workdir sourcedir])

pics=dir('*.jpg');
j=length(pics)./2;
```

```
originalName = pics

% Read images, stitch them together and save them in a new map
for i= 1:1:j
    tic

    % Load images
    nameonly=char([pics(i).name]);
    foto1 = (imread(nameonly));
    nameonly=char([pics(i+j).name]);
    foto2 = (imread(nameonly));

    % Put the images together till one image
     Fotos = [foto2(:,1:2910,:) foto1(:,433:end,:)];

    clear foto1 foto2

    % Saving the new photo with name New_number.jpg
        if i < 10;
        namenew=[workdir sourcedir, 'New\',
num2str(experiment),'_000',num2str(pics),'.jpg'];
    elseif i < 100;
        namenew=[workdir sourcedir, 'New\',
num2str(experiment),'_00',num2str(i),'.jpg'];
    elseif i < 1000;
        namenew=[workdir sourcedir, 'New\',
num2str(experiment),'_0',num2str(i),'.jpg'];
    else
        namenew=[workdir sourcedir, 'New\',
num2str(experiment),'_',num2str(i),'.jpg'];
    end

    imwrite(Fotos, namenew ,'Quality', 100);
    toc
end

fig=1;
```

Make a movie of the stitched and rectified photos

In order to visualize the set of photos from the experiments it is useful to make a movie of the set of photos. This scripts adds the images (frames) together in a movie (avi). One should change the fps (frames per second) accordingly. Ten frames per seconds generally gives a subtle transition in which the morphological change is easy to follow. In order to reduce the size of the movie, one can set the imresize of 0.1 to 100 % of the original quality of the photo. The setting of 0.2 (20%) produces a sufficient quality for the purpose. The script is written by Wout Van Dijk, PHd candidate at Department of Physical Geography (U.U).

Movie without text: MovieMaking28.m

```
tic
cd([workdir sourcedir,'New\'])
pics=dir('*.jpg');
```

```
aviobj =
avifile([num2str(experiment),'_tides.avi'],'fps',20,'compression','cinepak')
;
% Opening the images and put write these in the movie
for pic = 1:size(pics)
    nameonly=char([pics(pic).name]);
    I=(imread(nameonly));
    K= imresize(I,0.25);
    M = im2frame(K);
    aviobj = addframe(aviobj, M);
end
aviobj = close(aviobj);
toc
```

Movie with text: text29.m

```
clear all
close all
clc
experiment = '29'; %Set the number of the experiment
addpath('U:\Matlab_codes\');
workdir = 'U:\Experimenten tidal inlets\Experiment_29\corrected\LW';

tic
cd([workdir])
pics=dir('*.jpg');
i=1;

aviobj =
avifile([num2str(experiment),'_3SeaRise10fps.avi'],'fps',10,'compression','c
inepak');
% Opening the images and put write these in the movie
for pic = 1:size(pics)
    nameonly=char([pics(pic).name]);
    I=(imread(nameonly));
    S=I(1:2400,1:3000,:);
    K= imresize(S,0.2);

       % write text to specified image in series
    if i < 89;
        Name = 'dynamic equilibrium (exp28)';
    elseif i < 178;
        Name = 'Sea level rise, STEP 1';
    elseif i < 268;
        Name = 'Sea level rise, STEP 2';
    elseif i < 304;
        Name = 'Sea level rise, STEP 3';
    elseif i < 363;
        Name = 'Sea level rise, STEP 4';
    else
        Name = 'Sea level rise, STEP 5';
    end
    % add text to image
    textImage=cell(1);
    textImage{1}=repmat(text2im(Name), [1 1 3]);
    sx=1;
    sy=1;
```

```
        alpha=0.75;
        for t=1:numel(textImage)
            textImage{t}(textImage{t}==1)=alpha;
            K(sx:sx+size(textImage{t},1)-1,sy:sy+size(textImage{t},2)-
    1,:)=uint8((double(K(sx:sx+size(textImage{t},1)-
    1,sy:sy+size(textImage{t},2)-1,:)).*alpha+double(intmax('uint8'))*alpha) .*
    ...
                textImage{t});
            sx=sx+size(textImage{t},1);
        end

        M = im2frame(K);
        aviobj = addframe(aviobj, M);
        i= i+1;
    end

    aviobj = close(aviobj);
    toc
```

Change name of files

It might be useful to rename your files for a better overview of the edits you performed and the follow-up numbering within the experiments. One can change the name preferably, by modifying the sentence: name = `[(experiment),'_',(newNr),'.jpg'].` The particular numbering of the images can be quantified in the for loop. This script is written by the author.

newname.m

```
cd([workdir])
photo = dir('*_*.jpg');
i = 1

for totalphoto=1:size(photo)
     I=photo(i)
     photoNr = I.name(4:7);
     number = str2num(photoNr);
     if i<10;
         newNr = ['00',num2str(i)];
     elseif i < 100;
         newNr = ['0',num2str(i)];
%      elseif i<1000;
%          newNr = ['0',num2str(i)];
     end
     name = [(experiment),'_',(newNr),'.jpg']
     a = photo(i).name
     b = name
     eval(['!rename ' a ' ' b]);
     i = i+1
end
```

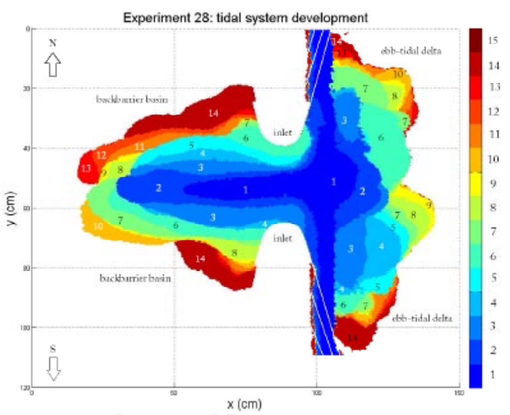
Appendix G: visualization of results

The results presented in the MSc thesis are realized by editing the images from the photo cameras and editing the profiles from the stereo system for rapid automated DEM production. Different matlab files follow which enable fast processing of experimental results.

- evolution in color indeces
- flow depth maps
- load data for making figures of change in time at certain location
- Resize images and cut off corners to insert photos in thesis
- Functions for making specific color bars (redblue.m makeColorMap.m owncolor.m)

deltagrowth.m

```
%% this script makes color indices of change in time of a series of images
%% (delta growth) and erosion of initial bed.
```




```
    clear all
    close all
    clc

    cd('U:\Experimenten Tidal Inlets\Experiment_28\deltagrowth\')
    fig = dir('*.jpg');
    p=1;

    for i=[1:length(fig)]

        I =(imread(char([fig(i).name])));
        I = I(600:2300,80:2330,:);
        I = imresize(I,0.2);
        if i==1
            Q = single(zeros.*I(:,:,1));
        else
            Q=Q;
        end
        class=makecform('srgb2lab');
        Il=applycform(I,class);

        Ir=double(Il(:,:,2));

        bw=im2bw(Ir./255,0.6);
```

```
        hm=zeros.*bw;
        boundaries = bwboundaries(bw);
        lengte1 = repmat(NaN,length(boundaries),1);
        e2 = lengte1;
        for k=1:length(boundaries)
            b = boundaries{k};
            tussen = size(b);
            lengte2(k,1) = tussen(1);
        end
        temp = -sortrows(-lengte2);
        i1 = find(lengte2==temp(1)); %(largest)
        bw2 = single(boundaries{i1});
        clear g hm1 ok boundaries lengte1 lengte2 temp b tussen i1 k Ir Il I

        J=single(roipoly(hm,bw2(:,2),bw2(:,1)));
        a=find(J>0 & Q==0);
        Q(a) = J(a).*p;
        clear hm
        p=p+1;
    end

    Q(find(Q==0))=NaN;
    [height, width] = size(Q);
    [XS,YS]=meshgrid(1:1:width,1:1:height);
    Q=double(Q);

    XS = XS.*0.32;
    YS = YS.*0.32;
    figure,
    surf(XS,YS,Q)
    shading flat

    view([0,270])
    colormap(jet(15)) %%colormap(flipud(jet(15)))
    % Colorss = ['Lb','Dg','Yl','Rd','Sn'];
    % colormap(owncolor(Colorss)

    caxis([1 16]) %%
    title('Experiment 28: tidal system
    development','FontSize',20,'FontName','Arial');
    c2=colorbar;
    xlabel('x (cm)','FontSize',16,'FontName','Arial');
    ylabel('y (cm)','FontSize',16,'FontName','Arial');
```

wdratio28.m

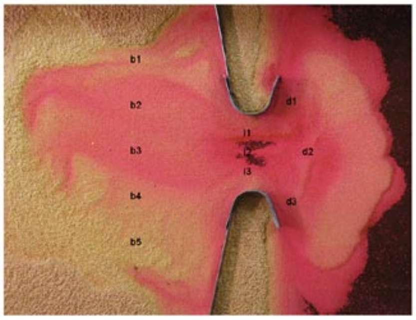
This script makes a flow depth map of selected image. Note that the flow depth scale needs to be adjusted according to the water depth conditions of the experiment. Best is to use the image of phase in tide MSL HW to LW.

Experiment 28: `Ic(a) = (Ir(a)-155)*1.5./17;`
Experiment 29, step 5: `Ic(a) = (Ir(a)-155)*1.5./14;`
Further
One photo: `I= laden(600:2300,80:2330,:);`
`X and Y scale` `XS = XS./19.565.*2; %% *2 ivm resize 0.5`

```
clear all
close all
clc

cd('U:\Experimenten Tidal Inlets\Experiment_29\wdratio\')

fig = dir('*.jpg');

    laden =(imread(char([fig(1).name])));
    I= laden(600:2300,80:2330,:); %% from resize 28
    class=makecform('srgb2lab');
    I = imresize(I,0.5);
    Il=applycform(I,class);
    Ir=double(Il(:,:,2));

    a = find(Ir>155);
    Ic = zeros.*Ir;
    Ic(a) = (Ir(a)-155)*1.5./14;

    Ic(Ic==0)=NaN;
    [height, width] = size(Ic);
    [XS,YS]=meshgrid(1:1:width,1:1:height);
    Ic=double(Ic);

    XS = XS./19.565.*2; %% *2 ivm resize 0.5
    YS = YS./19.565.*2; %%
    figure,
    surf(XS,YS,Ic)
    shading flat
    view([0,270])
    colormap(jet) %%colormap(flipud(jet(15)))
    colorbar('EastOutside')
    xlabel('x (cm)','FontSize',16,'FontName','Arial'); ylabel('y
(cm)','FontSize',16,'FontName','Arial');
    text(88,2,'flow depth(cm)','FontSize',13,'FontName','Arial');
    %% in klein scherm opslaan
```

channeldyn.m

This scripts selects the value of 2 pixels at location and averages over the value of the two pixels. Eleven data points are selected as presented in figure below. After having run the script, the parameter ‘ opslaan’ provides 11 columns and many rows according to the number of images. An excel file is made (dynamics28.xls) that makes figures from the value of data points. The figures show the change in the value of the pixel over time. The time scale is taken from excel file (nummeringExpFotos1.xls).




```
clear all
close all
clc

cd('U:\Experimenten Tidal Inlets\Experiment_29\dynamics\')
fig = dir('*.jpg');
opslaan = zeros(length(fig),11);

for i=[1:length(fig)]     %%  i=[1:length(fig)]
    laden =(imread(char([fig(i).name])));
    I= laden(600:2300,80:2330,:); %% from resize 28

    class=makecform('srgb2lab');
%   I = imresize(I,0.5);
    Il=applycform(I,class);
    Ir=double(Il(:,:,2));
    a = find(Ir>155);
    Ic = zeros.*Ir;
    Ic(a) = (Ir(a)-155)*1.5./14;

 %     inlet

    slct = Ic(705:706,1350);
    slct = (slct(1) + slct(2)) ./2;
    opslaan(i,1) = slct;

    slct = Ic(810:811,1350);
    slct = (slct(1) + slct(2)) ./2;
    opslaan(i,2) = slct;

    slct = Ic(915:916,1350);
    slct = (slct(1) + slct(2)) ./2;
    opslaan(i,3) = slct;

%     backbarrier

    slct = Ic(300:301,700);
    slct = (slct(1) + slct(2)) ./2;
    opslaan(i,4) = slct;

    slct = Ic(550:551,700);
    slct = (slct(1) + slct(2)) ./2;
    opslaan(i,5) = slct;

    slct = Ic(800:801,700);
```

```
    slct = (slct(1) + slct(2)) ./2;
    opslaan(i,6) = slct;

    slct = Ic(1050:1051,700);
    slct = (slct(1) + slct(2)) ./2;
    opslaan(i,7) = slct;

    slct = Ic(1300:1301,700);
    slct = (slct(1) + slct(2)) ./2;
    opslaan(i,8) = slct;

%     ebb-tidal delta

    slct = Ic(530:531,1560);
    slct = (slct(1) + slct(2)) ./2;
    opslaan(i,9) = slct;

    slct = Ic(805:806,1650);
    slct = (slct(1) + slct(2)) ./2;
    opslaan(i,10) = slct;

    slct = Ic(1080:1081,1560);
    slct = (slct(1) + slct(2)) ./2;
    opslaan(i,11) = slct;

    i=i+1;
end
```

The following is useful to visualize where the data points are in the image.

```
% % % locations of points
imshow(I)
text(700,300,'b1','FontSize',13,'FontName','Arial');
text(700,550,'b2','FontSize',13,'FontName','Arial');
text(700,800,'b3','FontSize',13,'FontName','Arial');
text(700,1050,'b4','FontSize',13,'FontName','Arial');
text(700,1300,'b5','FontSize',13,'FontName','Arial');

text(1560,530,'d1','FontSize',13,'FontName','Arial');
text(1650,805,'d2','FontSize',13,'FontName','Arial');
text(1560,1080,'d3','FontSize',13,'FontName','Arial');

text(1350,705,'i1','FontSize',13,'FontName','Arial');
text(1350,810,'i2','FontSize',13,'FontName','Arial');
text(1350,915,'i3','FontSize',13,'FontName','Arial');
```

It is calculated whether to average over 1 point, 2 points, 4 points or 9 points. Example:

```
slct = Ic(710:711,1355);
slct = (slct(1) + slct(2)) ./2;

 slct = Ic(710:711,1355:1356);
 slct = (slct(2,1) + slct(2,2) + slct(1,1) + slct(1,2)) ./4;


slct = Ic(710:712,1255:1257);
```

```
slct = (slct(1,1) + slct(1,2) + slct(1,3) + slct(2,1) + slct(2,2) +
slct(2,3) + slct(3,1)+ slct(3,2) + slct(3,3)) ./9;
```

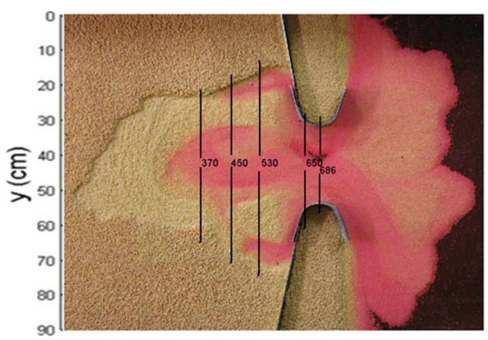
It gives

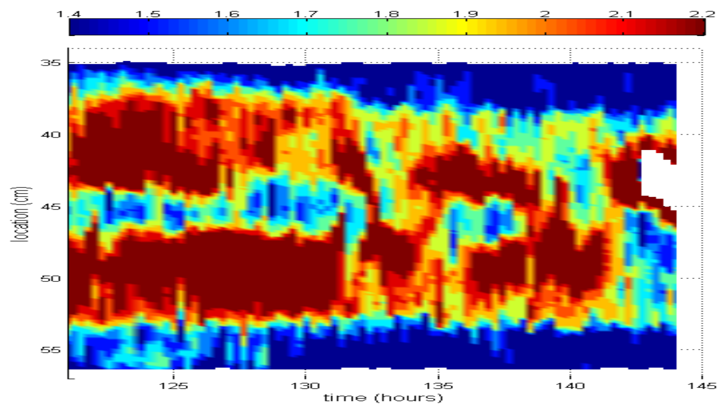
	Value	random sample 2	random sample 3
1 data point	1.85	2.12	0.97
2 data points	1.85	2.12	1.06
4 data points	1.85	2.12	1.06
9 data points	1.89	2.19	1.16

It is concluded that two to four data points give the same value for flow depth. Possibly, the use of nine data points incorporates an experimental change in flow depth. Therefore taking the average over nine data points is not necessarily more accurate than the average over two to four data points. Since two or four data points give the same value, incorporation of 2 data points to calculate flow depth is considered to be sufficiently accurate.

timestack.m

This scripts selects values of water depth along a cross-section at location (`ordfilt2(Ic(:,`**`686`**`))`as presented in figure below. The script provides the waterdepth in time (selected images). The time scale is taken from excel file (`timestackaxis`.xls).



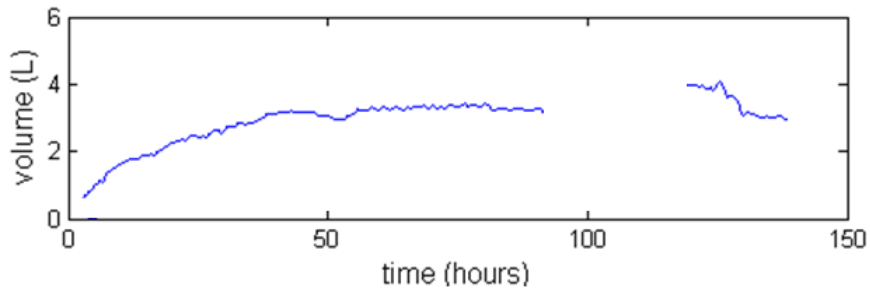



```
clear all
close all
clc

cd('U:\Experimenten Tidal Inlets\Experiment_29\corrected\MSLebb')
fig = dir('*.jpg');

for i=[1:length(fig)]
      laden =(imread(char([fig(i).name])));
      I= laden(600:2300,80:2330,:); %% from resize 28
      I = imresize(I,0.5);
      class=makecform('srgb2lab');
      Il=applycform(I,class);
      Ir=double(Il(:,:,2));

      a = find(Ir>155);
      Ic = zeros.*Ir;
      Ic(a) = (Ir(a)-155)*1.5./14;
```

```
            Ic(Ic==0)=NaN;
            [height, width] = size(Ic);
            [XS,YS]=meshgrid(1:1:width,1:1:height);
            Ic=double(Ic);

            XS = XS./17.76.*2; %% *2 ivm resize 0.5
            YS = YS./17.76.*2;

    profile29op686= ordfilt2(Ic(:,686),ceil(15/2),ones(15,1),'symmetric');
    g686.profile(:,i) = profile29op686;
%     profiles = profiles(profile,i);

    profile29op230= ordfilt2(Ic(:,230),ceil(15/2),ones(15,1),'symmetric');
    g230.profile(:,i) = profile29op230;

end
 save('U:\Experimenten Tidal Inlets\Experiment_29\profile29op686','g686')

[height, width] = size(g.profile);
[TS,YS]=meshgrid(1:1:width,1:1:height);
timeaxis = xlsread('U:\workdirectory\timestackaxis','Sheet1','d1:d439'); %%
check rij in excelsheet
% TS= timeaxis;
% TSa = TS;
TS = timeaxis';
YS = YS./17.76.*2; %%

figure(2);
surf(TS,YS,g.profile)
ylim([34 57]);
xlim([0 150])
view([0,270])
shading interp;

caxis ([1.4 2.2]);

colormap(flipud(pink));
% colormap(hsv);
% colormap(jet);
lighting none;

xlabel('time (hours)','FontSize',12,'FontName','Arial');
ylabel('location (cm)','FontSize',12,'FontName','Arial');

colorbar('NorthOutside')
text(70,28,'depth (cm)','FontSize',12,'FontName','Arial');


%%   Display where cross-sections are made in time
imshow(I)
text(230,418,'230','FontSize',13,'FontName','Arial');
text(370,418,'370','FontSize',13,'FontName','Arial');
text(530,418,'530','FontSize',13,'FontName','Arial');
text(650,448,'650','FontSize',13,'FontName','Arial');
text(686,418,'686','FontSize',13,'FontName','Arial');
```

areaCalc.m

This scripts calculates the volume of water that is in the backbarrier area at high water. The backbarrier area is defined at `IcSum1 = sum` () and defined at `IcSum2`. Next the moving averages is calculated to obtain a smooth figure as below.

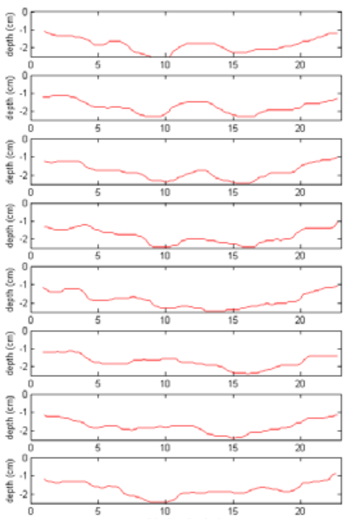



```
clear all
close all
clc

cd('U:\Experimenten Tidal Inlets\Experiment_29\corrected\HW')
% cd('U:\Experimenten Tidal Inlets\Experiment_28\HW')

fig = dir('*.jpg');
volumes = zeros(length(fig));
for i = 1:length(fig)

    laden = imread(char([fig(i).name]));
    I = laden(500:2400,1:2330,:); %% aangepast (600:2300,80:2330,:) anders
passen zijgeulen in exp29 er niet op
    I = imresize(I,0.5);
    class=makecform('srgb2lab');
    Il=applycform(I,class);
    Ir=double(Il(:,:,2));

    a = find(Ir>155);
    Ic = zeros.*Ir;
    Ic(a) = (Ir(a)-155)*1.5./14;

    IcSum1= sum (Ic(:,1:675)); %% 0.68/1.20 * 1126 --> 635 naar 675 ivm nieuwe
grid...
    IcSum2= sum(IcSum1,2);
    IcSum2m = IcSum2./100;

    oppervlakteVakje = 126.8018./100./1126 .* 95.8333./100./851;
    volumeM3 = IcSum2m .* oppervlakteVakje;
    volumeL = volumeM3 .* 1000;
%     gemGetalHokje = IcSum2./100./(635.*851);
%     oppHokjeM = 0.112613.*0.112613/10000;
    volumes(i) = volumeL;
end

% timeaxis = xlsread('U:\workdirectory\timestackaxis','Sheet1','a1:a436');
timeaxis = xlsread('U:\workdirectory\timestackaxis','Sheet1','h86:h547');
```

```
TS = timeaxis';
volume = volumes(:,1);

%% volumeS = smooth(volume); %% smooths the data in the column vector y using
a moving average filter (5) = curve fitting toolbox
%% smooth / moving average calculation (from internet)
wndwSize = 15;
h = ones(1,wndwSize)/wndwSize;      % equiv to a moving average window
subplot(413), plot( filter(h, 1, volume) );
h = pdf('Normal',-floor(wndwSize/2):floor(wndwSize/2),0,1);   % gaussian
subplot(414),
% plot ( filter(h, 1, volume) );
volumeS = filter(h, 1, volume);

figure(3),
plot(TS, volumeS)

xlabel('time (hours)','FontSize',12,'FontName','Arial');
ylabel('volume (L)','FontSize',12,'FontName','Arial');
axis([5 225 0 10])

figure(2),
plot(TS,volume)
```

doorsnedes.m

This scripts makes a cross-section of water depth data stored from timestack.m.




```
clear all
close all
clc

f = open('U:\Experimenten Tidal Inlets\Experiment_28\inlet686.mat');
doorsnedes = zeros(195,10);
j=1;
for i = ([20 60 100 150 200 250 300 350 390 430])
    doorsnee = f.g.profile(308:502,i);
    doorsneeNeg = doorsnee.*-1;
    wndwSize = 4;
```

```
    h = ones(1,wndwSize)/wndwSize;      % equiv to a moving average window
    subplot(413), plot( filter(h, 1, doorsneeNeg) );
    h = pdf('Normal',-floor(wndwSize/2):floor(wndwSize/2),0,1);   % gaussian
subplot(414),
    % plot ( filter(h, 1, volume) );
    doorsneeSmooth = filter(h, 1, doorsneeNeg);
    doorsnedes(:,j) = doorsneeSmooth;
    j = j + 1
end

[height, width] = size(doorsnedes);
[LS,XS]=meshgrid(1:1:width,1:1:height);
XS = XS./17.*2;

figure (1),
%plot(doorsneeNeg) %% de smoothed vershuift stukje over de x-as maar is wel
goede gemiddelde

l = 5
subplot(l,1,1)
plot(XS,doorsnedes(:,1),'r')
title('profile after 9 hours')
axis ([0 23 -3.0 0])

ylabel ('depth (cm)')

subplot(l,1,2)
plot(XS,doorsnedes(:,2),'r')
title('profile after 19.5 hours')
axis ([0 23 -3.0 0])

ylabel ('depth (cm)')

subplot(l,1,3)
plot(XS,doorsnedes(:,3),'r')
title('profile during 100')
axis ([0 23 -3.0 0])

ylabel ('depth (cm)')

subplot(l,1,4)
plot(XS,doorsnedes(:,4),'r')
title('profile during 150')
axis ([0 23 -3.0 0])

ylabel ('depth (cm)')

subplot(l,1,5)
plot(XS,doorsnedes(:,5),'r')
title('profile during 200')
axis ([0 23 -3.0 0])
xlabel ('inlet location (cm)')
ylabel ('depth (cm)')
```

resize.m

In order to obtain the evolution in a series of images over time a script is written to resize the images in directory to 30-150KB storage. It also focuses on the location where morphological change occurs.

```
clear all
close all
clc

cd('U:\Experimenten Tidal Inlets\Experiment_29\resize\')

fig = dir('*.jpg');
p=1;

%% this script cuts off the corners and resizes the picture.

for i=[1:length(fig)]
    I =(imread(char([fig(i).name])));

    I = I(500:2450,1:2400,:); % defines x and y reach = 1photo
%   I = I(1:2500,100:5600,:); % defines x and y reach = 2photos/stitched
    I = imresize(I,0.1); % quality reduction

    namenew=[fig(i).name];
    imwrite(I, namenew ,'Quality', 100);
end
```

Functions to save

```
function c = redblue(m)
addpath('E:\Matlabdata\')

%SEDEROS   red to white to blue color map.
%   See also HSV, GRAY, HOT, BONE, COPPER, PINK, FLAG,
%   COLORMAP, RGBPLOT.
%
%   M. Kleinhans Universiteit Utrecht 3 Nov 2006

if nargin < 1, m = size(get(gcf,'colormap'),1); end

c = makeColorMap([1 0 0], [1 1 1], [0 0 1],m);



function cMap = makeColorMap(varargin)
defaultNum = 100;
errorMessage = 'See help MAKECOLORMAP for correct input arguments';

if nargin == 2 %endPoints of colormap only
    color.start  = varargin{1};
    color.middle = [];
    color.end    = varargin{2};
    color.num    = defaultNum;
elseif nargin == 4 %endPoints, midPoint, and N defined
    color.start  = varargin{1};
    color.middle = varargin{2};
```

```
    color.end    = varargin{3};
    color.num    = varargin{4};
elseif nargin == 3 %endPoints and num OR endpoints and Mid
    if numel(varargin{3}) == 3 %color
        color.start  = varargin{1};
        color.middle = varargin{2};
        color.end    = varargin{3};
        color.num    = defaultNum;
    elseif numel(varargin{3}) == 1 %numPoints
        color.start  = varargin{1};
        color.middle = [];
        color.end    = varargin{2};
        color.num    = varargin{3};
    else
        error(errorMessage)
    end
else
    error(errorMessage)
end

if color.num <= 1
    error(errorMessage)
end

if isempty(color.middle) %no midPoint
    cMap = interpMap(color.start, color.end, color.num);
else %midpointDefined
    [topN, botN] = sizePartialMaps(color.num);
    cMapTop = interpMap(color.start, color.middle, topN);
    cMapBot = interpMap(color.middle, color.end, botN);
    cMap = [cMapTop(1:end-1,:); cMapBot];
end


function cMap = interpMap(colorStart, colorEnd, n)

for i = 1:3
    cMap(1:n,i) = linspace(colorStart(i), colorEnd(i), n);
end

function [topN, botN] = sizePartialMaps(n)
n = n + 1;

topN =  ceil(n/2);
botN = floor(n/2);
% Copyright 2008 - 2009 The MathWorks, Inc.


function c = owncolor(Coloring,m)
% giscolor is the color that is from brownish to white.
%   See also HSV, GRAY, HOT, BONE, COPPER, PINK, FLAG,
%   COLORMAP, RGBPLOT.
%
%   W.van Dijk Universiteit Utrecht 15 apr 2010

addpath('E:\Matlabdata\')
```

```
if nargin < 2; m = 640; end %  size(get(gcf,'colormap'),1); end

colorbands = 255; % Normal colorbands values of 255. Used to make nummers of 
0-1.

for i = 1:(length(Coloring)/2)
    name(i,:) = (Coloring((i*2-1):(i*2)));
    if name(i,:) == 'Rd'
        cc(i,:) = [255 0 0]/colorbands(1); %Red
    elseif name(i,:) == 'Ge'
        cc(i,:) = [0 255 0]/colorbands(1); %Green
    elseif name(i,:) == 'Bl'
        cc(i,:) = [0 0 255]/colorbands(1); %Blue
    elseif name(i,:) == 'Lb'
        cc(i,:) = [20 190 255]/colorbands(1); %Lightblue
    elseif name(i,:) == 'Db'
        cc(i,:) = [0 0 125]/colorbands(1); %Darkblue
    elseif name(i,:) == 'Lg'
        cc(i,:) = [55 255 55]/colorbands(1); %Lightgreen
    elseif name(i,:) == 'Dg'
        cc(i,:) = [0 100 10]/colorbands(1); %Darkgreen
    elseif name(i,:) == 'Br'
        cc(i,:) = [120 50 0]/colorbands(1); %Brown
    elseif name(i,:) == 'Bw'
        cc(i,:) = [175 30 30]/colorbands(1); %Light Brown
    elseif name(i,:) == 'Bk'
        cc(i,:) = [0 0 0]/colorbands(1); %Black
    elseif name(i,:) == 'Yl'
        cc(i,:) = [255 255 0]/colorbands(1); %Yellow
    elseif name(i,:) == 'Pi'
        cc(i,:) = [255 150 200]/colorbands(1); %Pink
    elseif name(i,:) == 'Pu'
        cc(i,:) =[220 70 255]/colorbands(1); %Purple
    elseif name(i,:) == 'Gr'
        cc(i,:) =[220 217 217]/colorbands(1); %Grey
    elseif name(i,:) == 'Wh'
        cc(i,:) =[255 255 255]/colorbands(1); %White
    elseif name(i,:) == 'Sn'
        cc(i,:) =[255 250 250]/colorbands(1); %Snow
    elseif name(i,:) == 'Or'
        cc(i,:) =[255 125 0]/colorbands(1); %Orange
    end
end

for j = 1:(length(cc(:,1))-1)
    a(:,:,j) = makeColorMap(cc(j,:),cc(j+1,:),(m/(length(cc(:,1))-1)));
end

for k = 1:length(a(1,1,:))
    c(((k-1)*length(a(:,1,1))+1:(k*length(a(:,1,1)))),:) = a(:,:,k);
end
```

Appendix H: Working with DEM images

The apparatus also consists of a stereo system for rapid automated DEM production (300mm resolution). The DEM-scan measures the sediment level over a plot of approximately 70 x 50 centimeters. The software VX Studio results a 3-dimensional image of the morphology from the scan.

Settings that were used in VX studio are:

Resolution	10
	Fine
	Dots

The 3d-image is taken of a fixed location in the scale model.

In the software program the scans are named according to the experiment number and the elapsed time. For instance, 28-96h is a scan of experiment 28 at the time that 96 hours elapsed. Then the 3d-image is saved from the software VX 3D Studio by pressing ctrl+alt+o in the preview mode. A save window appears and the scan should be saved as .txt file in a particular direction. The files are named according to the experiment number, nth image at elapsed time. For instance, 28.10at96h is the tenth DEM-image for experiment 28 and was taken when 96 hours of experimental time had elapsed.

Other abbreviations that are arbitrarily used are:

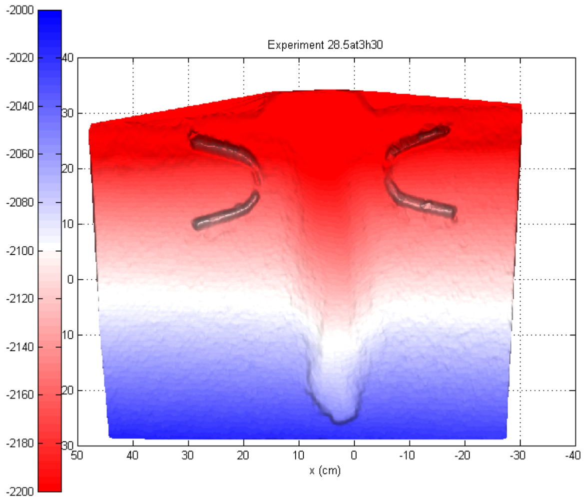
flat	flat bed
ini	initial digged channel, experimental time 0 hours.
R8	resolution 8
d	dots
s	stripes
H	hours
m	minutes
L0	level zero implies that the set-up was not tilted when the scan was made
LW	low water implies that the scan was made when the set-up was tilted at the maximum of the experimental amplitude. At this mode, it is ebb in the scale model.

The 3d-images are saved as .txt files. The .txt files contain three rows. The following matlab script, starcam.m, produces a 3d-image of the change over two 3d-images.

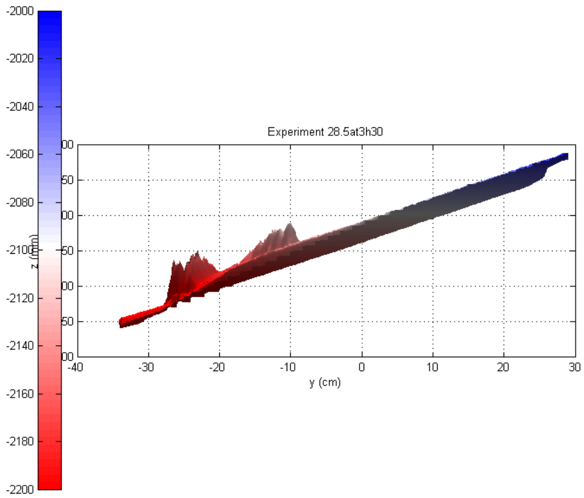
Starcam3d.m

The 3D-image of a scan can be visualized by this script. Since there is no flow at low tide, 3d images where taken at low tide. As a result morphology in the 3D-images is insignificant compared to difference in bed level do to the tilting bottom. The effect is seen in figures below by the color shift of red to blue and the slope in the lower figure.

You cannot make a scan at zero tilt while the experiment is running because the set-up moves. If you would pause the mechanical jack you can manually bring the set-up to zero tilt. But this is not appropriate because it might affect the morphology.

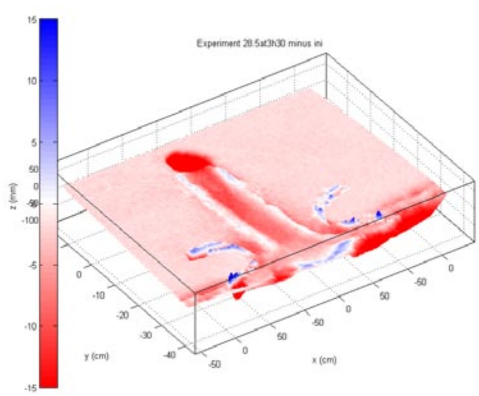


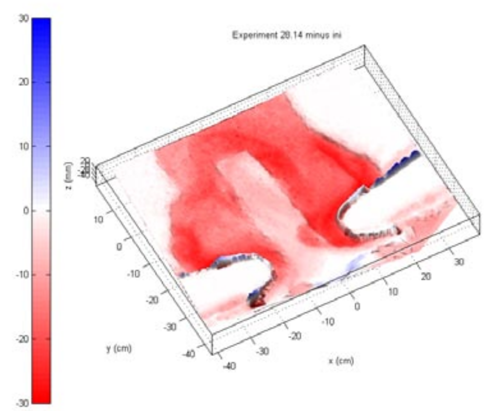
view [90,90]



[view 90,0]

By subtracting 28.3iniLW (a0) from 28.5 (a1) in **starcam3dminusini.m** you obtain a better representation, as seen below.





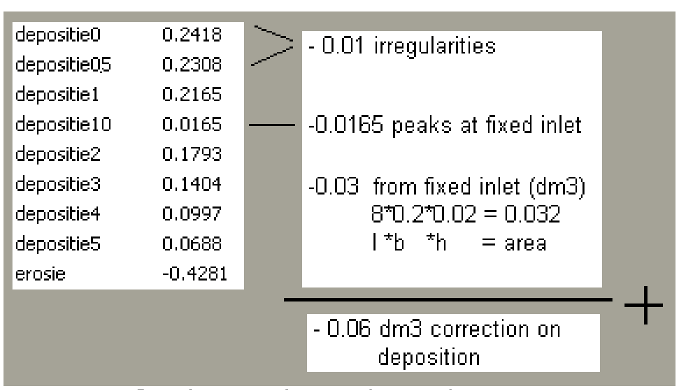
starcam28m.m

The script starcam28.m calculates and visualizes the change in time over two 3D-images.

```
% Load, interpolate and manipulate x y z data
clear all
close all
clc

%% load
%cd 'E:\Matlabdata\Heightmodels';
cd 'U:\RenskeDEM'\experiment_28;

a0 = load('28initial.txt');
a1 = load('28.2at1h20');

% a1 = load('28.1flatL0.txt');
% a2 = load('28.2flatLW.txt');
% a3 = load('28.3iniLW.txt');
% a4 = load('28.4ini25minLW.txt');
% a5 = load('28.5at3h30.txt');
% a6 = load('28.6at5h30.txt');
% a7 = load('28.7at8h10.txt');
% a8 = load('28.8at24h.txt');
% a9 = load('28.9at31h.txt');
% a10 = load('28.10at96h35.txt');
% a11 = load('28.11at99h45.txt');
% a12 = load('28.12at103h.txt');
% a13 = load('28.13at121h40.txt');
% a14 = load('28.14at124h10.txt');
% a15 = load('28.15at126h20.txt');
% a16 = load('28.16at145h15.txt');

files = dir('*.txt');

%% 3D plot

%% prepare grid 2 minus 1
xa2 = a2(:,1); ya2 = a2(:,2); za2 = a2(:,3);
xa1 = a1(:,1); ya1 = a1(:,2); za1 = a1(:,3);

%specify:
spacing = 1; %grid cell size
Xax = [min(xa2):spacing:max(xa2)];
Yax = [min(ya2):spacing:max(ya2)];
[X,Y] = meshgrid(Xax,Yax);

%% interpolate on regular grid
Za2 = griddata(xa2,ya2,za2,X,Y,'linear'); %original data
Za1 = griddata(xa1,ya1,za1,X,Y,'linear'); %original data

Zad12 = Za2-Za1;
 [ga2x,ga2y] = gradient(Zad12,X,Y);

addpath('U:\Matlab_codes\');
%optional lines for fixing figure size:
```

```
figure
set(gcf,'units','centimeters','position',[2 2 22
18],'papertype','A4',...
   'papertype','A4','paperunits','centimeters','paperposition',[2
2 22 18]);
set(gca,'dataaspectratio',[2 2 1])

surf(X,Y,Zad12);
shading flat %flat: no grid lines
colorbar('WestOutside') %West, SouthOutside, etc
set(gca,'view',[20,60],'dataaspectratio',[5 5 1]); %height
exaggerated % vanaf delta
view(160,75); %view(2);
xlabel('x (cm)'); ylabel('y (cm)'); zlabel('z (mm)')
set(gca,'XtickLabel',get(gca,'Xtick')./10,'YtickLabel',get(gca,'Y
tick')./10)

set(gca,'clim',[-20 20],'box','on'); % vanaf delta
camlight headlight
lighting phong
material dull
colormap(redblue)
title ('Experiment 28: evolution 6')
pname = ['Experiment 28: evolution from initial small channel'];
hold off

erosie= nansum(Zad12(Zad12<0)).*1./1000./1000;
depositie10= nansum(Zad12(Zad12>10)).*1./1000./1000;
% depositie5= nansum(Zad12(Zad12>5)).*1./1000./1000;
% depositie2= nansum(Zad12(Zad12>2)).*1./1000./1000;
depositie0= nansum(Zad12(Zad12>0)).*1./1000./1000;
```

erosie and depositie0 calculate net erosion or net deposition between the two images. The deposition involves a scatter from the fixed barriers, therefore the value > has to be chosen carefully. The inaccuracy is calculated in figure below. The first box presents the deposition over two 3d-image for levels higher than 0, 0.5 mm, 1.0 mm, 2 mm etc. to 10 mm. The second box gives the value that is expected to cover the inaccuracy within that level. The summation gives a correction of – 0.06 dm3 on total deposition (deposition is change > 0).



Over evolution 7 in 28dems.doc

Appendix I: experimentele aanbevelingen

Huidige beperkingen

- De krikpaal verschuift ongemerkt na een aantal experimenten. De paal schuift immers omhoog en omlaag en moet aan de bak zijn hoogte doorgeven. Op dat punt zit een rubbertje, bij dat rubbertje gaat het mis. Als de paal verschuift bij het rubbertje heeft dit tot gevolg dat de bak asymmetrisch gaat kantelen. Ik heb dit nu opgelost door plankjes onder de krikpaal te schuiven totdat de waterdieptes voorin en achterin de bak weer overeen kwamen.
- De bodem is niet geheel waterpas, met name langs de randen bolt hij omhoog. Bij de huidige – relatief kleine – getijdesystemen was dit niet zo van invloed. Maar bij de estuaria-experimenten, die veel groter in oppervlak zijn, wel. De opbolling kan ongewilde effecten hebben voor de ‘ebb-tidal delta’. De waterdiepte dichtbij de randen is dan namelijk lager. En een zee hoort zeewaarts niet ondieper te worden! Ook bij het uitrekenen van prisma’s en volumes geeft dit een onnauwkeurigheid. Het vorige probleem (verschuiven van de krikpaal) is hierdor ook moeilijker om op tijd te tackelen.
- De drainagepijp gaat nogal stroef als je de waterspiegel omhoog wilt hebben. Ik kon hem niet meer hoger krijgen dan een bepaalde stand. Smeren en dergelijke helpt wel maar als een experiment een tijdje gelopen heeft komt er sediment tussen en wordt het mechanisme stroef. Het is immers constant in aanraking met water, en water gaat ook waar het niet gaan mag…

Foto’s

In een vervolgstudie zou ik aanraden om de foto’s met een overgang aanelkaar te plakken. Want er zit een duidelijk kleurverschil tussen de twee camera’s. Ik heb de methode’s van Wouter Marra en Wout van Dijk getest op de foto’s maar daarmee verander je de RGB-waardes. Dit werkt dan weer door op je waterdiepte-kaarten. Daarom heb ik ervoor gekozen om de foto’s niet dusdanig te bewerken.
Ook zo het beter zijn om ‘world coordinates’ te definieren. Dit heb ik nu niet gedaan. De reden hiervoor was dat ik de bak kantel en daardoor veranderen je ‘world coordinates’ per amplitude en moment in je getijdecyclus. Ik ben nog niet kundig genoeg met matlab om de kanteling van de bak en moment in de getijdecyclus mee te nemen in het definieren van de ‘world coordinates’. Wat ik nu gedaan heb is het assenstelsel definieren aan de hand van de breedte tussen de vaste barriers. Deze weet je voor elk experiment. Voor een experiment zonder vaste barriere kan je de breedte van de bak als referentie gebruiken.

DEM

De kwaliteit van de DEM was het hoogst als deze tijdens laag water werd genomen. Dan was de bathymetry het best zichtbaar (al komt dit ook doordat de bathymetryverschillen het hoogst zijn nadat het getijdebasin is leeggelopen). Ik zou de DEM-camera dusdanig ophangen zodat je loodrecht op de laag water richting het beeld maakt. Het beste zou zijn als je deze ook nog eens in zou kunnen stellen afhankelijk van de amplitude van kantelen Dit zou eventueel met een draaiknop kunnen die is afgesteld op de hoogte van de amplitude.

Waterdiepte

Ik heb nog geen nauwkeurige formule kunnen schrijven die gebaseerd is op de roze-intensiteit. De intensiteit zou een maat moeten zijn voor waterdiepte. Ik heb hier wel pogingen toe gedaan maar ik stuitte op teveel beperkingen. Wat ik gedaan heb is een schaal definiëren per experiment aan de hand van maximale waterdiepte bij MSLebb (voor experiment 28 delen door 17, voor experiment 29 delen door 14). Beperkingen die een zelfde waarde voor alle foto's onmogelijk maakte en onnauwkeurig toevoegden waren als volgt:

- De korrels van het lichtgewicht sediment – welke relatief groot zijn - hebben een schaduweffect op pixelniveau. Er is dus teveel ruis om een eenduidige formule te schrijven. Je zou dan een formule kunnen schrijven die met de pixels eromheen middelt. Maar de ruis was nu nog dusdanig hoog dat deze methode ook niet nauwkeurig was.
- Je neemt foto's op momenten dat de bak gekanteld is op verschillende standen. Het RGB-signaal verandert per stand en is ook afhankelijk van de amplitude van kantelen. Dit komt met name door iets andere lichtinval. Je zou dus voor elke amplitude en LW, MSL en HW een (iets) aangepast script moeten schrijven.
- Een deel van de kleurstof slaat neer op het sediment. Dus gedurende een proef verandert het RGB-signaal.
- Er zit een schaduwrand in de bak. Het RGB-signaal verschilt hier van de rest van de bak.
- De twee camera's maken foto's op een verschillende plek waartussen de lichtinval verschilt. Dit uit zich meteen wanneer je de twee foto's aanelkaar plakt. Maar dit betekent dus ook dat het RGB-signaal verschilt per camera.

De waterdiepte kaartjes in deze thesis zijn gebaseerd op het signal groen uit RGB. Dit geeft een prima beeld maar de nauwkeurigheid schat ik zo rond de +/- 0.5 centimeter. Als je shear stresses/snelheden nauwkeurig wil bepalen bij 1.0-3.0 centimeter waterdiepte dan zal dit leiden tot beperkt resultaat.

Experiment 36: riviertoevoer

De riviertoevoer zat gekoppeld aan de hoofdpomp. Maar binnen een uur was de afvoer steeds significant afgenomen. Uiteindelijk stopt deze er helemaal mee. Ik moest dus ieder uur de afvoer iets hoger zetten. Een *constant head* pomp zal dit probleem waarschijnlijk oplossen.