Prepared for:

WL | Delft Hydraulics

Schematisation of boundary conditions for morphological simulations

R&D Kustwaterbouw

Research Report

December 2007

WL | delft hydraulics

H4959.10

Prepared for:

WL | Delft Hydraulics

Schematisation of boundary conditions for morphological simulations

R&D Kustwaterbouw

A.C.S. Mol

Research Report

December 2007

wl | delft hydraulics

WL | delft hydraulics

Client:	WL | Delft Hydraulics
Title:	Schematisation of boundary conditions for morphological simulations

Abstract:

In morphological studies with Delft3D it is a common approach to take into account the year averaged wave climate. This climate, usually the result of a preceding wave study, often consists of a large number of wave conditions with varying wave height, period and direction. In order to reduce the run time of the morphological simulations, it is advisable to reduce the number of wave conditions to a limited set of conditions for the morphological modelling. However, the simulation with the limited set of conditions should of course lead to the same outcome as a simulation with the full set of wave conditions.

To facilitate the process of reducing the number of conditions, a program called ‘Opti’ was written. Opti performs the reduction of conditions (wave or tidal) for morphological simulations. Input for Opti is the outcome of a series of short simulations of all conditions to compare the reduced set against. The reduced set can then be used in long-term morphological simulations, while the outcome of these simulations is sufficiently accurate compared to the simulation with the full set of conditions. During this study, the process of reducing boundary conditions for morphological simulations that is performed by Opti, has been investigated and improvements have been made. Furthermore, the approach of applying sets of reduced conditions in morphological simulations has been tested and validated against simulations with the full set of wave conditions.

References:	

Ver	Author		Date	Remarks	Review		Approved by	
1.0	A.C.S. Mol		December 2007	Preliminary				
2.0	A.C.S. Mol		December 2007	Final	R. Morelissen		K. Bos	

Project number:	H4959.10
Keywords:	Morphological modelling, wave climate, condition reduction
Number of pages:	18
Classification:	None
Status:	Final

Contents

1 **Introduction 1–3**
- 1.1 Background 1–3
- 1.2 Study objective 1–3
- 1.3 Approach 1–3

2 **The Opti program 2–4**
- 2.1 Introduction 2–4
- 2.2 Morphological modelling with Delft3D 2–4
- 2.3 Improvements to the condition reduction method 2–4
- 2.4 Process overview 2–5

3 **Application of the condition reduction method 3–7**
- 3.1 Introduction 3–7
- 3.2 Procedure 3–7

4 **Description of the optimization process 4–9**
- 4.1 Introduction 4–9
- 4.2 Optimisation for one data group 4–9
- 4.3 Optimisation for multiple data groups 4–10

5 **Validation 5–12**
- 5.1 Validation case 5–12
- 5.2 Applying the optimization process 5–13
- 5.3 Simulation settings 5–14
- 5.4 Results 5–15
- 5.5 Conclusions and discussion 5–16

6 **References 6–18**

1 Introduction

1.1 Background

In morphological studies with Delft3D it is a common approach to take into account the year averaged wave climate. This climate often consists of a large number of wave conditions with varying wave height, period and direction. In order to reduce the run time of the morphological simulations, it is advisable to reduce the number of wave conditions to a limited set of conditions for the morphological modelling. However, the simulation with the limited set of conditions should lead to the same outcome as a simulation with the full set of wave conditions.

In order to reduce the number of wave conditions, two approaches are available. The first one is to perform a series of Unibest calculations with all conditions and manually select a set with a reduced number of conditions that approaches the mean yearly transport. This method will not be discussed in the present study. The second method is to use the program called 'Opti'. The aim of the Opti program is to reduce a certain set of (wave or tidal) conditions for morphological simulations. Input for Opti is the outcome of a series of short simulations with all conditions. The reduced set can then be used in morphological simulations, while the outcome of these simulations is sufficiently accuracy compared to the simulation with the full set of conditions.

The program Opti was written by D. Roelvink, but it was until now only available as user-unfriendly FORTRAN and MATLAB scripts. Furthermore, the program was never tested and validated very well.

1.2 Study objective

The objective of this study is to investigate, improve and validate the method of reducing boundary conditions for morphological simulations. To support the study, the Opti program will be used.

1.3 Approach

The study objective was approached in the following steps, presented below:

1. The traditional method of performing Delft3D morphology studies was investigated to inventory the possible improvements in efficiency;
2. Then, the existing procedures to reduce the number of wave conditions were studied, by studying the first version of the Opti program;
3. The method of reducing boundary conditions for morphological simulations was improved and important features were added. The improvements and additional features have also been included in Opti;
4. The resulting approach was validated with and against Delft3D Online Morphology simulations;

2 The Opti program

2.1 Introduction

This chapter describes the concepts of Opti. Section 2.2 explains some details about the background of the program. It describes how morphological modelling with Delft3D is usually carried out and what the motives are for condition reduction. Section 2.3 presents an overview of the functionalities and features of Opti.

2.2 Morphological modelling with Delft3D

In morphological studies with Delft3D it is a common approach to take into account tidal flow conditions, but also the year averaged wave climate. This climate, usually the result of a preceding wave study, often consists of a large number of wave. The long-term morphological simulations are usually carried out using the mormerge approach, which enables parallel simulations of all wave conditions (for more detail on this parallel online approach, see Roelvink 2005). Taking into account the duration of each wave condition, an averaged bottom change is calculated after every time step, which is used for the next time step. The total simulation, with all wave conditions, results in the expected morphological changes per year. However, due to the large number of wave conditions, running these long-term morphological simulations is very time consuming. In order to reduce the run time of the long-term morphological simulations, the number of wave conditions should be reduced. However, the results of the simulation should not be affected significantly. To facilitate this procedure, the program Opti was created.

2.3 Improvements to the condition reduction method

The program Opti was originally written in FORTRAN (D. Roelvink), but it has been programmed in MATLAB in 2006 (A.C.S Mol). In 2007, G. Lesser made some adjustments in the main routine of Opti (the optimizing routine), which resulted in a faster Opti computation and better results. During the usage of these initial versions of Opti and its condition reduction approach, some shortcomings were revealed:

1. the reduction of conditions could take a lot of time;
2. it was not possible to use interpolated data, for instance transport through transects;
3. it was not possible to reduce data points, so that the condition reduction was based on the entire model area and not only on the particular area of interest;
4. it was only possible to base the reduction of conditions on bed level changes, while the use of other parameters like sediment transport or a combination of parameters is sometimes desirable;
5. it was not possible to set a user-defined target (for example measurements).

As part of the current study, the condition reduction method in Opti has been improved and features were added to solve these shortcomings. First Opti was re-programmed (R.

Morelissen) to make it more generic, modular and easier to use. Also some extra features were added. During this project, the optimizing routine has been re-programmed again, resulting in a much shorter run times.

2.4 Process overview

The Opti program can be used to reduce a number of conditions, in order to speed up morphological simulations with Delft3D-FLOW. It can be applied to reduce a number of wave conditions, but also to determine a morphological representative tide which is a tidal cycle that has a similar effect on the morphology as the total spring-neap tidal cycle. In general, a set of conditions is reduced in such a way that the simulation results resemble well the outcome of the simulation with the full set of conditions. However, it is also possible to specify a user-defined calibration target, e.g. measurements. In that case, the reduced set of conditions is optimized to resemble the user-defined target.

The ‘outcome’, as mentioned above, can be any parameter specified by the user (e.g., sediment transports or bed level changes). In addition, multiple parameters can be used in combination for the optimisation process (denoted below as multiple data groups). It is possible to indicate a certain area (or arbitrary transects) in the model area for which the reduction of conditions should be optimized for.

The diagram in Figure 2.1 shows the Opti process and its input and output. The input consists of the results of a series of short morphological simulations, setting the optimisation target. For each wave/tide condition in the year averaged climate such a simulation has to be carried out. Also a set of weight factors is required, representing the duration of the conditions. Within the Opti process some steps need to be taken, depending on user-defined settings. Opti determines, based on the contribution of the separate conditions, which conditions contributes the least to the end result and drops this condition. Subsequently, the weights for the remaining conditions are redistributed to match the target as good as possible. This iteration continues until differences (root mean squared errors) compared to the target are too significant. Output of the Opti program is a reduced set of wave conditions and their adjusted weight factors.

As a result of the current study, the following features are now available within the program:

- Reduce wave or tidal conditions to morphological representative climates.
- Use multiple input formats (one trim, multiple trim, mormerge results).
- Use of bed level changes or sediment transports or both.
- Use of only a part of the model area, by specifying polygonal regions.
- Apply Opti on interpolated transports through transects.
- Specify a user-defined target for the reduction.
- Provide statistical output to support the user’s decision to select the optimum number of conditions to use.

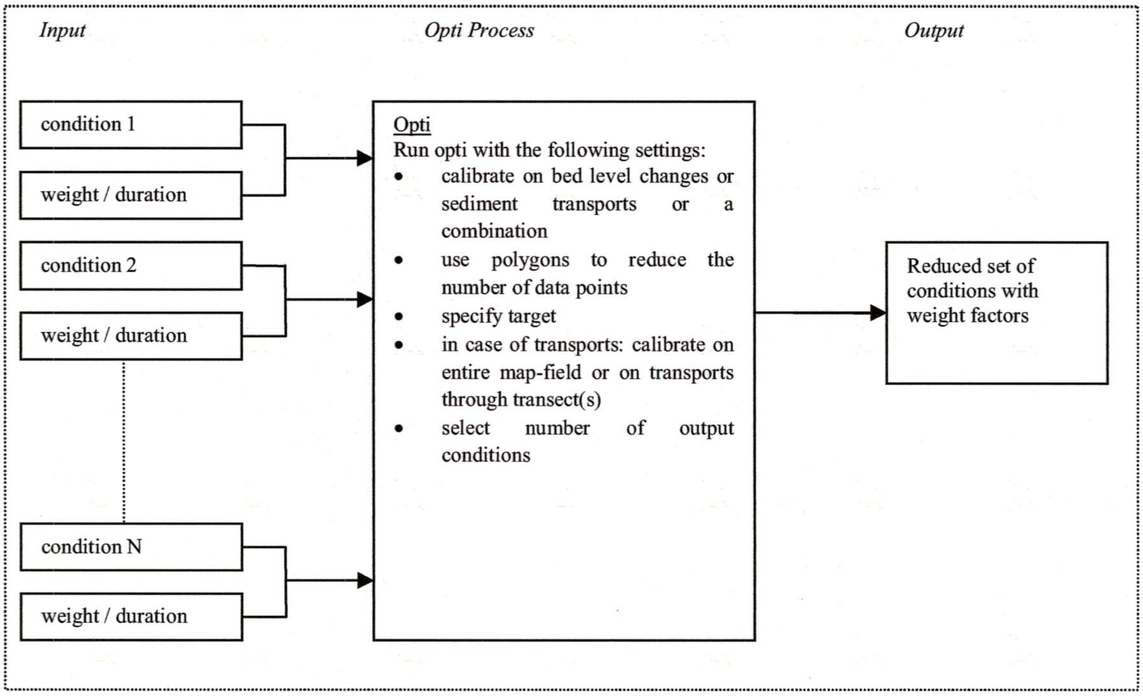


Figure 2.1 Overview of the Opti process

3 Application of the condition reduction method

3.1 Introduction

In morphological studies with Delft3D it is a common approach to take into account the year averaged wave climate. This climate, usually the result of a preceding wave study, often consists of a large number of wave conditions with varying wave height, period and direction. The number of conditions is usually in the order of 100-200. In order to reduce the run time, the number of conditions should be reduced. This chapter describes how to apply the method of condition reduction for morphological simulations. It provides the basic steps that should be followed to obtain a reduced set of (wave) conditions that can used for the long-term morphological simulations.

3.2 Procedure

Below, all steps of the procedure of preparing a reduced set of wave conditions for long-term morphological simulations are summed up:

1. First of all, a wave climate study should be carried out, resulting in a large number of wave conditions which together represent the year averaged wave climate.
2. Before the reduction of conditions can be started, short morphological simulations should have been carried out for each wave condition of the year averaged climate. The length of the input simulations can be in the order of a couple of hours to one day, but if the model is (also) driven by tidal forcing, it is recommended to let the simulation length be equal to or a multiple of the tidal cycle period.
3. Next, a target should be chosen, which will be used in the optimization process. Mostly, this is the weighted average of all conditions. However, it is also possible to use measurements as a target. The target can be any parameter, for example bed level changes or sediment transports.
4. After setting the target, the condition reduction can start. The main process of the condition reduction approach is the optimization process. This optimization process, which is described in more detail in Chapter 4, will drop conditions until only one condition is left.
5. After the optimization process is finished, it has to be decided how many conditions will be used for the long-term morphological simulation. To support this decision, statistical output of the optimization process should be studied. The statistical output indicates for a certain number of conditions if the morphological results with the reduced set of conditions are sufficiently accurate compared to a simulation with the full set of conditions. During recent projects in which the condition reduction method is used, it turned out that in some cases the number of conditions can be reduced by factor 10 without significant losses of accuracy.
6. The last step is to start the long-term morphological simulation with the reduced set of conditions.

Since the optimization process investigated in this study was built into the Opti program, a good approach to apply the condition reduction is to use this program. The program offers an extensive toolbox, but also a more user-friendly graphical user interface. For more details reference is made to the Opti user manual (Mol, 2007).

4 Description of the optimization process

4.1 Introduction

This chapter describes the optimization process, which is the main part of the condition reduction approach. *SmarterOpti* is the routine within Opti that takes care of the reduction of the number of conditions (a so-called 'optimizer'). In short, *SmarterOpti* carries out an elimination race of conditions. It starts with all conditions and their original weights. In each step, it will perform multiple tests in which it applies random variations to the weights of the remaining condition. Next, it determines which set of weights gives the best results, and then it eliminates one condition by setting its weight to zero. This procedure continues until only one condition is left.

Section 4.2 first describes the procedure with only one data group in use. At the end of this section, the procedure with multiple data groups will be explained.

4.2 Optimisation for one data group

During the first step, with all conditions still participating, it computes which condition contributes the least to the target. The target is the weighted mean (with the initial weights and all conditions) of *optiStruct.data*, which can be bottom changes, transports, measurements or a combination of those. For each data point (e.g. location) j, the target is computed as:

$$target_j = \sum_{i=1}^{N} \left(w_i \cdot optistruct.input.data(j,i) \right)$$

with w_i the initial weight of condition i, *optistruct.input.data*(j,i) the data point j (transports or bed level changes) for condition i and N the number of conditions.

The contribution of each condition is determined as follows:
Let QM_i be the quadratic mean of the data for condition i (in MATLAB: *optiStruct.input.data*(:,i)), then the contribution of condition i to the target is indicated well by:
$w_i \cdot QM_i$ with:

$$QM_i = \sqrt{\frac{1}{D} \sum_{j=1}^{D} \left(optiStruct.input.data(j,i) \right)^2}$$

with D the number of data points.

The condition which has the lowest contribution is eliminated by setting its weight to zero. In the next step, with one condition eliminated, an iteration is started. The number of iterations can be set by the user (in *optiStruct.optiSettings.maxIter*). During the first step of this iteration, the resulting weights from the first step are used, thus with the weight of the eliminated condition set to zero. During the following iteration steps, the weights are adjusted by random factors. After each iteration step, the program calculates how the weighted average of the data, computed with the new (random) weight factors during this iteration (*id*), compare to the target. This will be done on the basis of the relative root mean square error ($rmsRel_{id}$) for iteration *id*:

$$rmsRel_{id} = \frac{\sqrt{\frac{1}{D}\sum_{j=1}^{D}(wad_{id,j} - target_j)^2}}{\sqrt{\frac{1}{D}\sum_{j=1}^{D}(target_j)^2}} = \sqrt{\frac{\sum_{j=1}^{D}(wad_{id,j} - target_j)^2}{\sum_{j=1}^{D}(target_j)^2}}$$

with D the number of data points, $wad_{id,j}$ the weighted average of data point j using the weights of iteration *id*, $target_j$ the target of data point j.

During the remainder of the iteration steps, the weights of the conditions are randomly changed each step as follows:

$$w_{i,id} = w_{i,orig} \cdot ranScaled$$

in which $w_{i,id}$ is the weight of condition i of the nth iteration, $w_{i,orig}$ is the weight of condition i as it resulted from the previous elimination step and *ran* a random number within a predefined range. By default this range is set to [0.5 1.5]. Modifying this range should be done by changing the parameter *scaleTol* within the *optiSettings*. The range is calculated as follows:

$scaleRange = [1 - scaleTol ... 1 + scaleTol]$, and $ranScaled$ becomes:

$$ranScaled \;= ran \cdot \left(scaleRange(2) - scaleRange(1) \right) + scaleRange(1)$$

with *ran* a random number between 0 and 1.

The $rmsRel_{id}$ is calculated for each iteration step to determine how well each set of weights resembles the target. After all iterations, it is determined with which set of weights the target is resembled best by finding the iteration (*id*) with the lowest *rmsRel*.

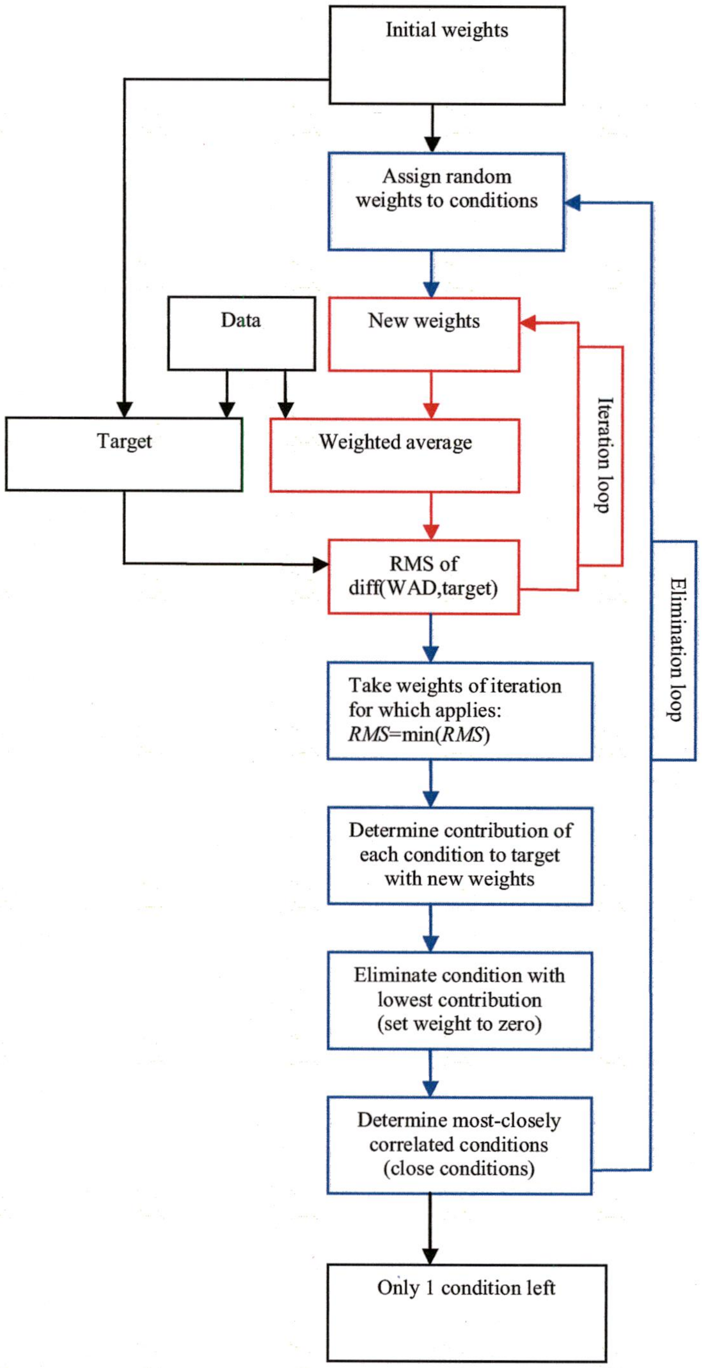
Next, these weights are used in the new elimination round, in which the next condition will be dropped. This process continues until one condition is left. The entire process is schematized in the diagram in Figure 4.1. Note that the sum of the weights during the elimination race will not remain constant.

4.3 Optimisation for multiple data groups

In case of multiple data groups (i.e. parameters, for example bed changes and transport), the process of finding the best set of (random) weights during each elimination round is more complicated. *SmarterOpti* will determine a $rmsRel_{id}$ for each data group, after each iteration *id*. After that it will determine the weighted sum of the $rmsRel_{id}$ of all data groups, using the weights as specified in *optiStruct.dataGroupWeights*, resulting in a weighted relative root mean square value:

$$rmsRelWeighted_{id} = \sum_{dataGroup=1}^{dg} \left(gw_{dataGroup} \cdot rmsRel_{id,dataGroup} \right) ,$$

with dg the number of data groups, $gw_{dataGroup}$ the weight for each data group and $rmsRel_{id,dataGroup}$ the relative root mean square error for iteration *id* and data group *dataGroup*. Subsequently this value is being used to evaluate the performance of each iteration is doing.



The diagram shows that during each elimination step, the iteration loop is performed, also for the first elimination step, with all conditions participating. During this step no conditions are eliminated yet, there are no most-closely correlated conditions to assign random weight to, so in fact nothing happens during this iteration loop. The weights from the iteration loop during the first step of the elimination loop are equal to the initial weights.

Figure 4.1 Schematization of the optimization process

5 Validation

5.1 Validation case

The approach of reducing conditions for morphological simulations has been validated in order to justify its use and to test the different ways of applying this method. The test case concerns a coastal area, with a shore-parallel breakwater at a depth of about 8m. The model consists of a rectangular flow and wave grid. The latter completely covers the flow grid. The bathymetry consists of a coastal profile, with the beach at the east side of the model domain. In north-south direction, the bathymetry is uniform. Figure 6.1 shows the model layout.

The flow model is not driven by any boundary conditions; the only currents are wave induced currents. The wave model itself is initially driven by 30 wave conditions, see Table 5.1. The climate has been presented graphically in Figure 6.2.

Condition	Hs [m]	Dir [° N]	Tp [s]	ms [-]	duration [%]	days/yr
1	0.40	188	2.85	4	1.0%	3.65
2	0.40	203	2.85	4	1.5%	5.48
3	0.60	203	3.49	4	1.0%	3.65
4	0.40	218	2.85	4	6.0%	21.90
5	0.60	218	3.49	4	3.0%	10.95
6	1.20	218	4.93	4	3.0%	10.95
7	1.80	233	6.04	4	1.0%	3.65
8	1.40	233	5.32	4	2.0%	7.30
9	1.00	233	4.50	4	3.0%	10.95
10	0.80	233	4.02	4	4.0%	14.60
11	0.60	233	3.49	4	6.0%	21.90
12	0.40	233	2.85	4	8.0%	29.20
13	0.40	248	2.85	4	7.0%	25.55
14	0.80	248	4.02	4	5.0%	18.25
15	1.20	248	4.93	4	4.0%	14.60
16	1.60	248	5.69	4	1.0%	3.65
17	1.60	263	5.69	4	1.0%	3.65
18	0.80	263	4.02	4	3.0%	10.95
19	0.40	263	2.85	4	4.0%	14.60
20	0.80	278	4.02	4	4.0%	14.60
21	0.40	278	2.85	4	4.0%	14.60
22	0.40	293	2.85	4	3.0%	10.95
23	0.60	293	3.49	4	2.5%	9.13
24	0.80	308	4.02	4	3.0%	10.95
25	0.60	308	3.49	4	3.0%	10.95
26	0.40	308	2.85	4	3.0%	10.95
27	0.60	323	3.49	4	3.5%	12.78
28	0.40	323	2.85	4	4.0%	14.60
29	0.40	338	2.85	4	3.0%	10.95
30	0.80	338	4.02	4	2.5%	9.13
				Total	**100.0%**	**365.00**

Table 5.1 Wave conditions for validation case

5.2 Applying the optimization process

With these wave conditions an initial simulation has been carried out, to determine the initial bed level changes and transports during each wave condition. The simulation has been carried out as a mormerge simulation, but the actual merging of bed level changes was turned off. In this way, each condition runs independently (with respect to the other conditions). The morfac was set to 30 for this simulation. After the simulation, the program Opti has been used to perform the condition reduction.

Opti has been applied in four different ways:

- opti_1: optimisation based on bed level changes (within a limited area, see red line Figure 6.1);
- opti_2: optimisation based on sediment transports (within a limited area, see red line Figure 6.1);
- opti_3: optimisation based on sediment transports through transects (see black lines Figure 6.1);
- opti_4: optimisation based on a combination of opti_1 and opti_3, with equal weights.

All optimizations are based on trim time step 97, which is after 5 days of morphological simulation (with a morFac of 30). The aim of the optimizations was to retain sufficient wave conditions to keep the *rmsRel* (formulation in Chapter 4) below 8%. The output of the optimizations is presented below.

Opti_1

	Condition	**Weight**	**days/yr**
1	4	0.1828	66.72
2	5	0.0956	34.89
3	6	0.0601	21.94
4	7	0.0118	4.31
5	13	0.0800	29.20
6	14	0.1475	53.84
7	15	0.0404	14.75
8	16	0.0208	7.59
9	20	0.0510	18.62
10	21	0.0760	27.74
11	24	0.0729	26.61
12	28	0.1397	50.99
	totaal	**0.9786**	**357.19**

Opti_2

	Condition	**Weight**	**days/yr**
1	6	0.0377	13.76
2	7	0.0076	2.77
3	8	0.0291	10.62
4	10	0.1742	63.58
5	15	0.0630	23.00
6	24	0.1465	53.47
	totaal	**0.4581**	**167.21**

Opti_3

	Condition	**Weight**	**days/yr**
1	7	0.0147	5.37
2	9	0.2182	79.64
3	18	0.3867	141.15
	totaal	**0.6196**	**226.15**

Opti_4

	Condition	**Weight**	**days/yr**
1	6	0.0147	5.37
2	7	0.0193	7.04
3	9	0.0277	10.11
4	12	0.4497	164.14
5	14	0.1669	60.92
6	15	0.0375	13.69
7	16	0.0155	5.66
8	20	0.1257	45.88
9	27	0.1731	63.18
	totaal	**1.0301**	**375.99**

Table 5.2 Results of optimization process for the four Opti runs

Table 5.3 presents the relative root mean square (rms) values for the four Opti runs. The rms values are not only presented for the optimization parameter of each Opti run itself, but also for the optimization parameters of the other Opti runs.

run	num. of cond.	sedero	transport	transport transect	sedero / transport transects (50/50)
opti_1	12	**7.5%**	7.9%	4.8%	6.2%
opti_2	6	50.4%	**7.0%**	4.5%	27.5%
opti_3	3	66.2%	19.1%	**4.3%**	35.3%
opti_4	9	11.2%	14.7%	3.2%	**7.2%**

Table 5.3 Relative rms values for opti conditions (values in bold are those parameters that are used as optimization of each Opti run).

From Table 5.3 it follows that the option within Opti to optimize for a specific parameter (like bed level changes or transport) functions very well. For opti_1, in which the optimization was carried out on the basis of bed level changes (sedero), the lowest rms-value (7.5%) for sedero is achieved in comparison to the other opti-runs. However, the number of conditions that is required for a rms-value lower than 8% is the highest for opti_1.

For opti_2, only 6 conditions are required. From Table 5.3 it follows that the rms-value for transport is the lowest (7.0%) compared to the other Opti runs, while the rms for sedero is very high (50.4%).

Opti_3, with a optimization based on the transports through transects, results in a rms-value of 4.3% for transport transect. This is not very low compared to the other Opti runs, but is achieved with only three conditions, which is much lower than the other Opti runs.
The last Opti run, based on a combination of bed level changes and transports through transects, results in 9 conditions, with a rms-value of 11.2% for sedero (which is the second lowest value) and 3.2% for transports through transects (which is the lowest value). The combined rms-value (7.2%) is not lower than with opti_1, but the number of conditions is lower.

5.3 Simulation settings

With above optimized climates simulations have been carried out with a morphological duration of 0.5 year (180 days). Besides that, a simulation with the full set of 30 wave conditions has been carried out to validate the outcome of the optimized climates with. The following settings were applied to this simulation:

- Start simulation: 1-8-2007 00:00:00
- Stop simulation: 4-8-2007 12:00:00
- Morphological spin-up interval: 12 hours
- Morphological scale factor: 60

For the simulations with the optimized climates, the morphological scale factor (morfac) has been adjusted to compensate for the change in total duration (due to changes weights). Note that another possibility to compensate the changed total durations of the optimized climates is to decrease or increase the hydrodynamic simulation time in stead of using an adjusted morfac. However, in order to guaranty a good comparability between all simulations it was chosen to change the morfac.

5.4 Results

The four optimized climates have been verified in three different ways:
1. by looking at the sedimentation/erosion pattern after 1 year (entire grid)
2. by looking at average sediment transport during 1 year (entire grid)
3. by looking at instantaneous transports through transects at the beginning and the end of the simulation and to the average transport through transects during 1 year.

Ad 1

For all four Opti simulations, the sedimentation/erosion pattern at the end of the simulations (t_{trim}=505) haven been compared to that of run07 (with the full wave climate). Figures 6.3a-6.3d show the patterns. To quantify the differences, the root mean square errors have been determined for each optimized climate. Opti_1 and opti_4 perform better than opti_2 and opti_3 concerning bed level changes. This is logical because the optimization was based on bed level changes.

opti_1	8.89%
opti_2	15.83%
opti_3	29.06%
opti_4	11.17%

Table 5.4 Relative rms values of the differences between bed level changes of the Opti simulations and run07 for data points within polygonal area (with all conditions)

Ad 2

A similar approach has been followed, only now based on the averaged sediment transports. Figures 6.4a-6.4d show the patterns. From Table 5.5 it follows that opti_2, with the optimization based on sediment transports, does not give the best results. Apparently the large number of conditions of run opti_1 makes this run the best one when it comes to sediment transport patterns. Nevertheless, the second best results have been achieved with run opti_2.

	x-direction	y-direction
opti_1	4.93%	7.00%
opti_2	9.20%	8.50%
opti_3	25.62%	30.10%
opti_4	9.27%	13.49%

Table 5.5 relative rms values of the differences between mean yearly transports (x,y-components) of the Opti simulations and run07 for data points within polygonal area (with all conditions)

Ad 3

Figures 6.5a, 6.5b and 6.5c show respectively the instantaneous transport of the simulation with all wave conditions (run07) at the beginning of the simulation through the transects, the instantaneous transport at the end of the simulation and the average transports throughout the entire simulation. In Table 5.6 the value of the simulations with the optimized climates have been compared to these results. The last column of the table presents the sum of the deviances over all transects. Looking at the instantaneous initial transport, it follows that opti_4 gives the best results. Obviously, opti_4 was optimized on bed level changes but also on transports through transects and it uses relatively many conditions (9). Opti_3, especially optimized for transport through transects, does not perform very well. The reason for this is that the aim of the optimization was to reduce the climate until a *rmsRel* of max. 8% was achieved. Looking at the results, it becomes clear that the error of opti_3 with respect to the results with the full wave climate indeed does not exceed 8% (on average).

Apparently, more conditions are required for the optimization of bed level changes to get *rmsRel* of max. 8%. As a consequence, the opti_4, with more conditions than opti_3, does predict the transports through transects very well.

Also for the instantaneous transport at the end of the simulation and the averaged transport throughout the simulation, opti_4 gives the best results. Opti_3 gives the second best results for these transports. Remarkable are the results of opti_1; despite of the large number of conditions, the transports through transects does not compare very well to the target values.

	transect 1	**transect 2**	**transect 3**	**transect 4**	**Sum of deviances**
instantaneous t_{ini}					
all conditions	30	97	188	181	
opti_1	38	110	199	195	**46**
opti_2	25	98	177	182	**-14**
opti_3	42	103	192	176	**17**
opti_4	32	95	186	174	**-9**
instantaneous t_{end}					
all conditions	-11	85	138	144	
opti_1	-7	93	145	153	**28**
opti_2	-7	81	127	138	**-17**
opti_3	13	80	134	141	**12**
opti_4	-5	83	135	135	**-8**
averaged					
all conditions	-1	85	145	147	
opti_1	4	94	151	156	**29**
opti_2	-1	82	135	144	**-16**
opti_3	17	80	140	143	**4**
opti_4	4	84	145	144	**1**

Table 5.6 Comparison sediment transports through transects (from northern transect in left column to southern transect in right column) for simulations with optimized climates in 1000m^3/yr, positive to the north

5.5 Conclusions and discussion

From the experiences with the test case described above, the following conclusions can be drawn:

- From the results from Table 5.3 it follows that the possibility to optimize for a specific parameter (bed level changes, transports, etc.) works well.
- A low relative root mean square value is more easily achieved (i.e. less conditions are required) for transports through transects than for bed level changes or transport patterns (map fields).
- During the study, long-term morphological simulations have been carried out with optimized wave climates and compared to the long-term simulation with all conditions. It turns out that the results of the long-term morphological simulation with the opti_4 climate (for which a optimization was carried out for both bed level changes as transports through transects) performs best on all fields.
- If the only interest is bed level changes, the long-term morphological results will be better when the optimisation is based on bed level changes only. This follows from Table 5.4.
- Usually each Opti run gives good results for the parameter that is was optimized for. However, also the number of conditions contributes to better results.

Some points of discussion are:

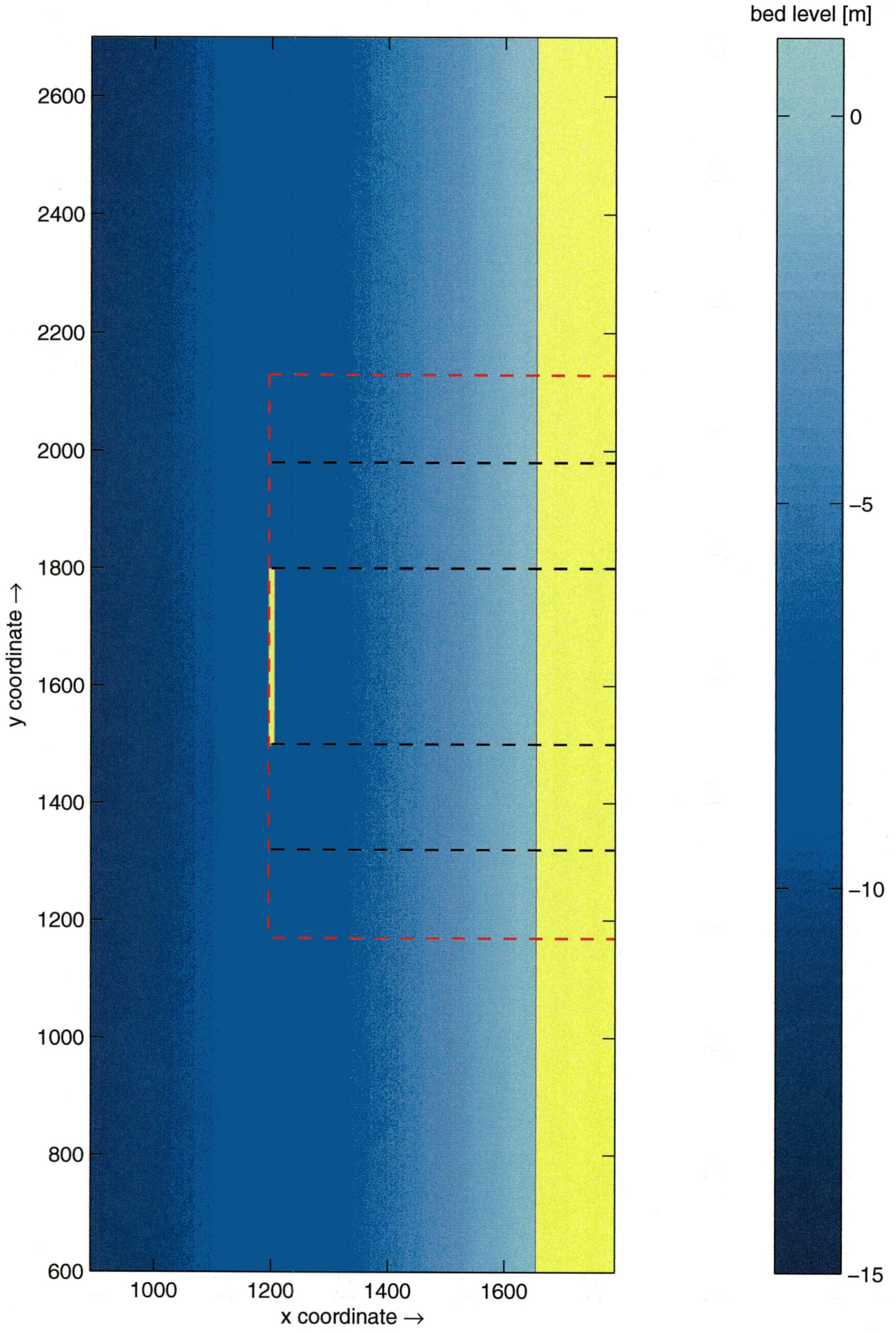
- More test cases are necessary to find out if above findings are generic.
- For simplicity reasons, in the opti_3 run only 4 transects were used. In real engineering cases, it is recommended to use more transects, which are also directed shore-parallel, in order to optimize the cross-shore transports.
- A recommended future development is to build in a functionality to optimize not only for net transports through transects, but also on gross transports. This would result in a reduced climate that is more realistic.

6 References

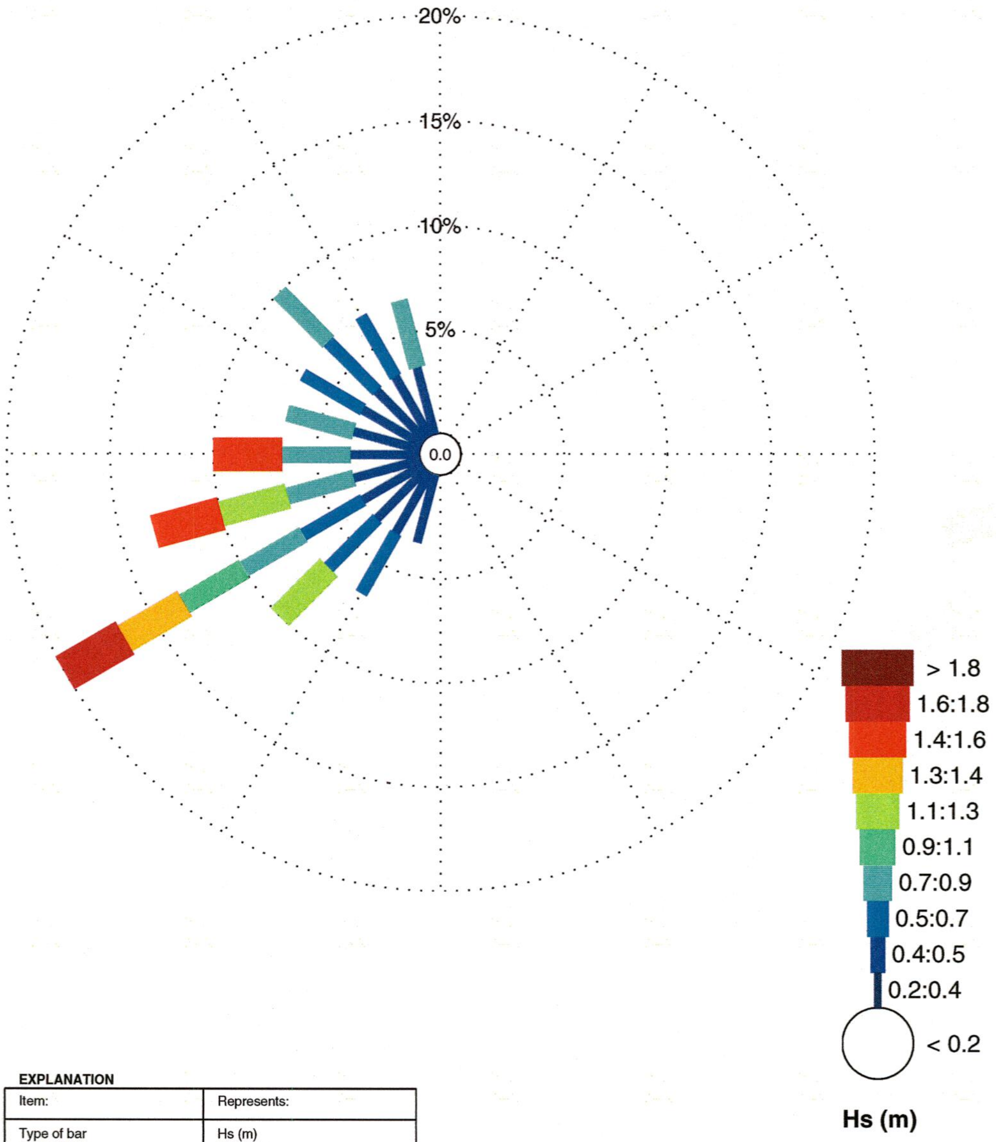
December 2007, A.C.S. Mol, Reduction of Boundary Conditions with Opti, User Manual.

November 2005, J.A. Roelvink, Coastal morphodynamic evolution techniques, Coastal Engineering

Figures



Model layout for validation case opti
Black dashed lines: transects used for opti_3 & 4
Red dashed lines: area used for opti_1 & 2



EXPLANATION

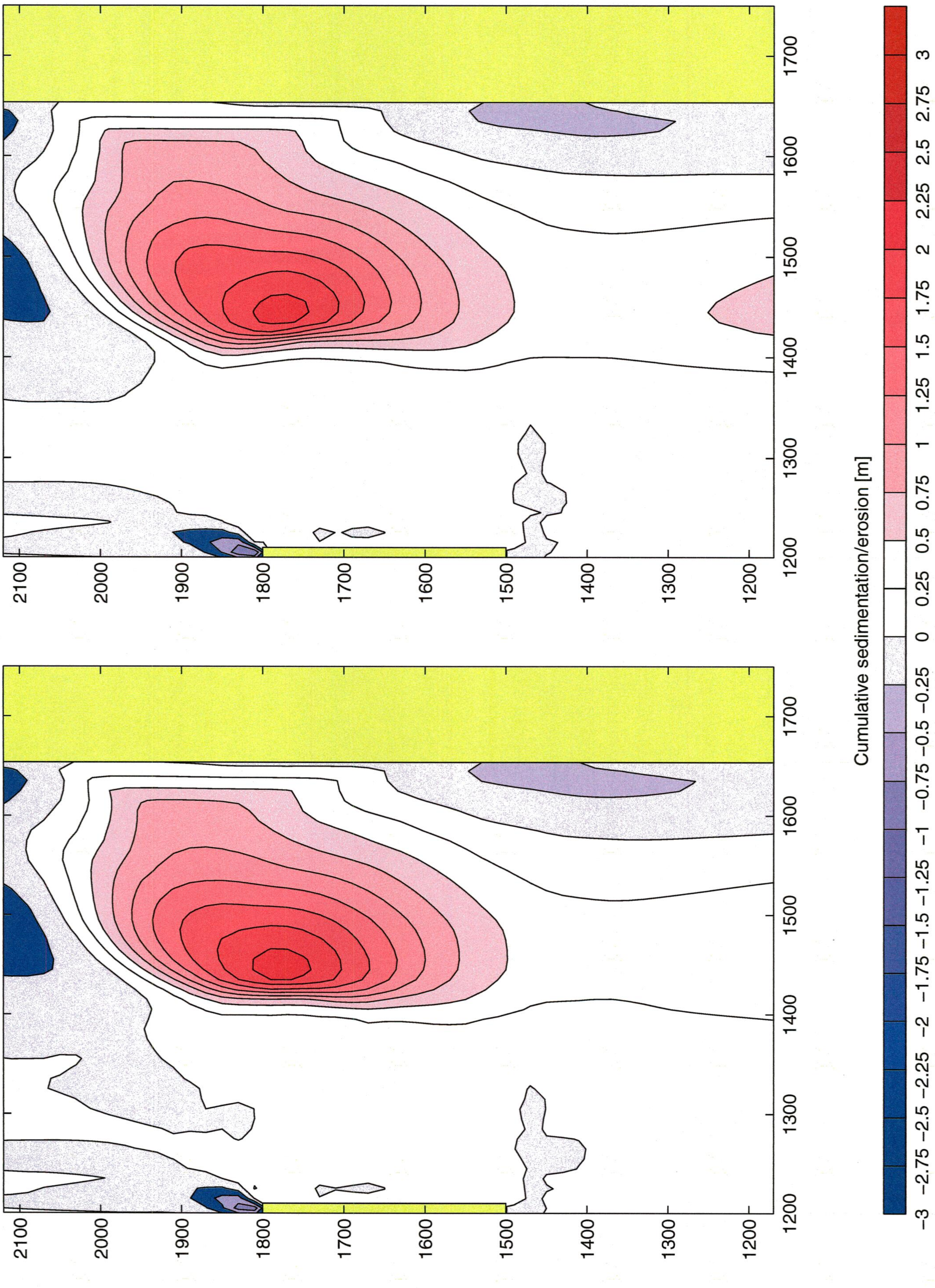
Item:	Represents:
Type of bar	Hs (m)
Direction of bar (to centre of rose)	Direction
Length of bar	Occurence (%)
Number in centre of rose	Occurence (%) in lowest class
Undetermined data	0.00 %

Wave climate for validation case presented as wave rose

WL | DELFT HYDRAULICS

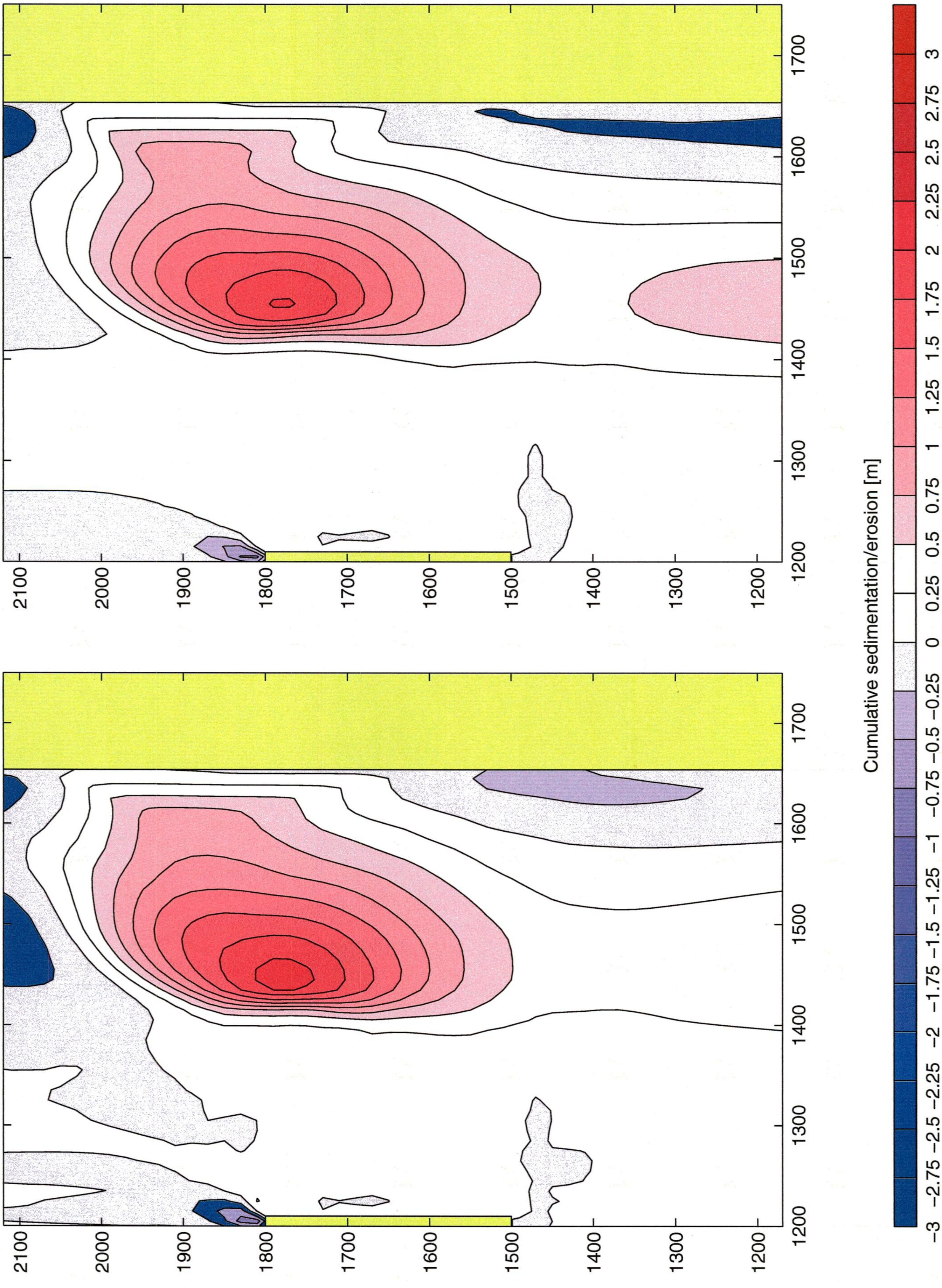
H4959

Fig. 5.2



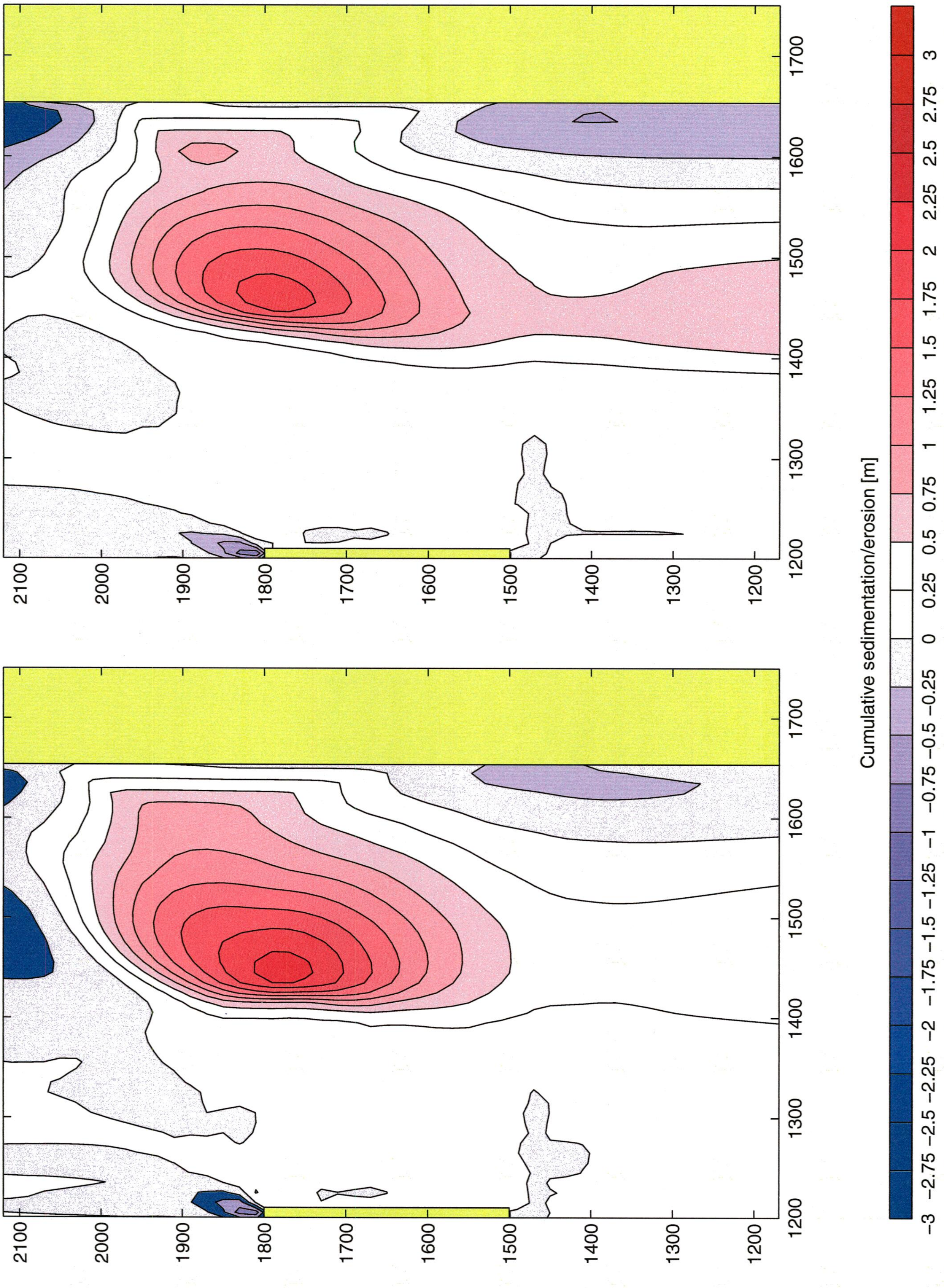
Comparison of bed level changes
Left plot: run07 (all conditions)
Right plot: opti_1

Fig. 5.3a



Comparison of bed level changes
Left plot: run07 (all conditions)
Right plot: opti_2

WL | DELFT HYDRAULICS	H4959	Fig. 5.3b

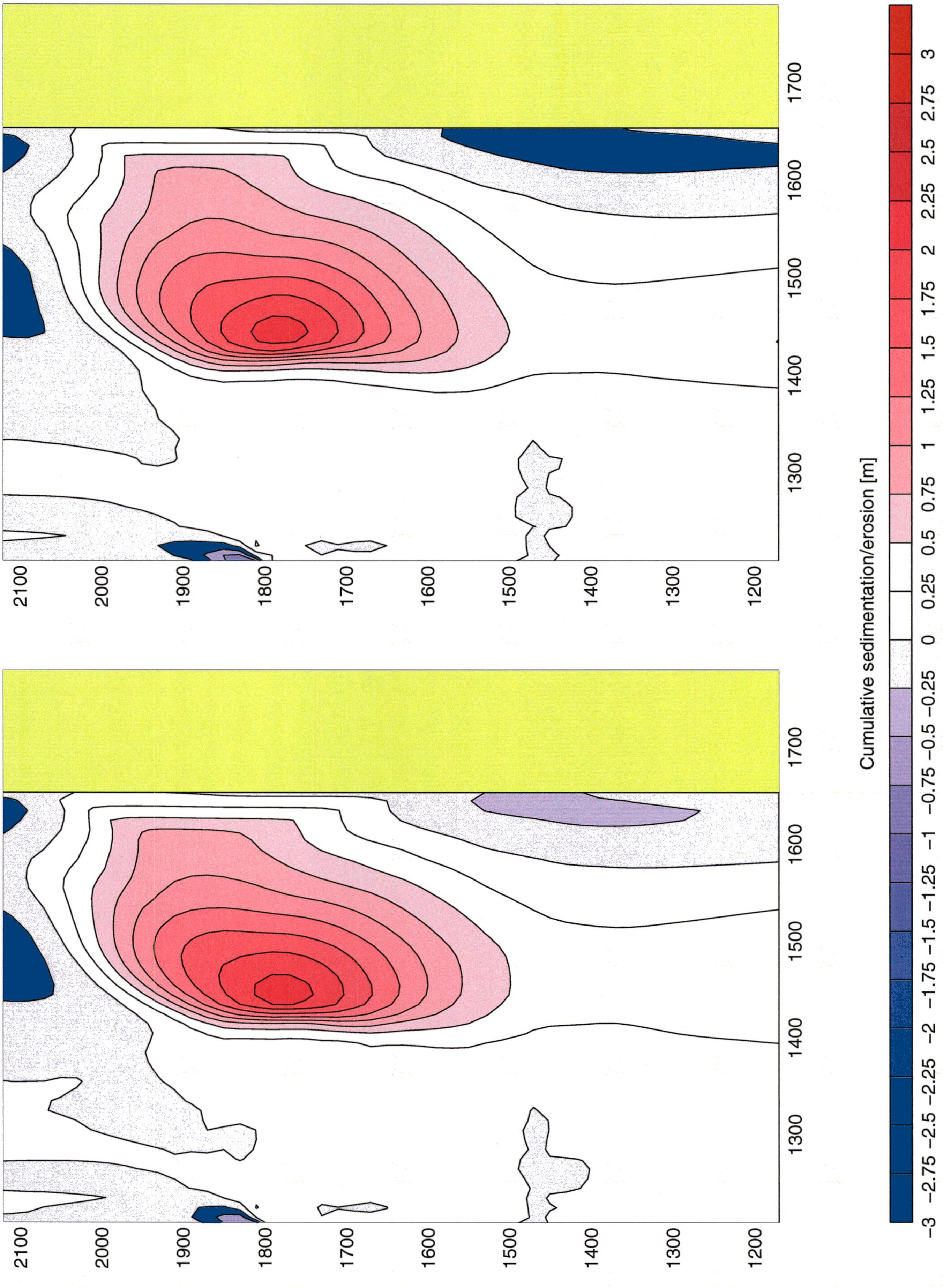


Comparison of bed level changes
Left plot: run07 (all conditions)
Right plot: opti_3

WL | DELFT HYDRAULICS

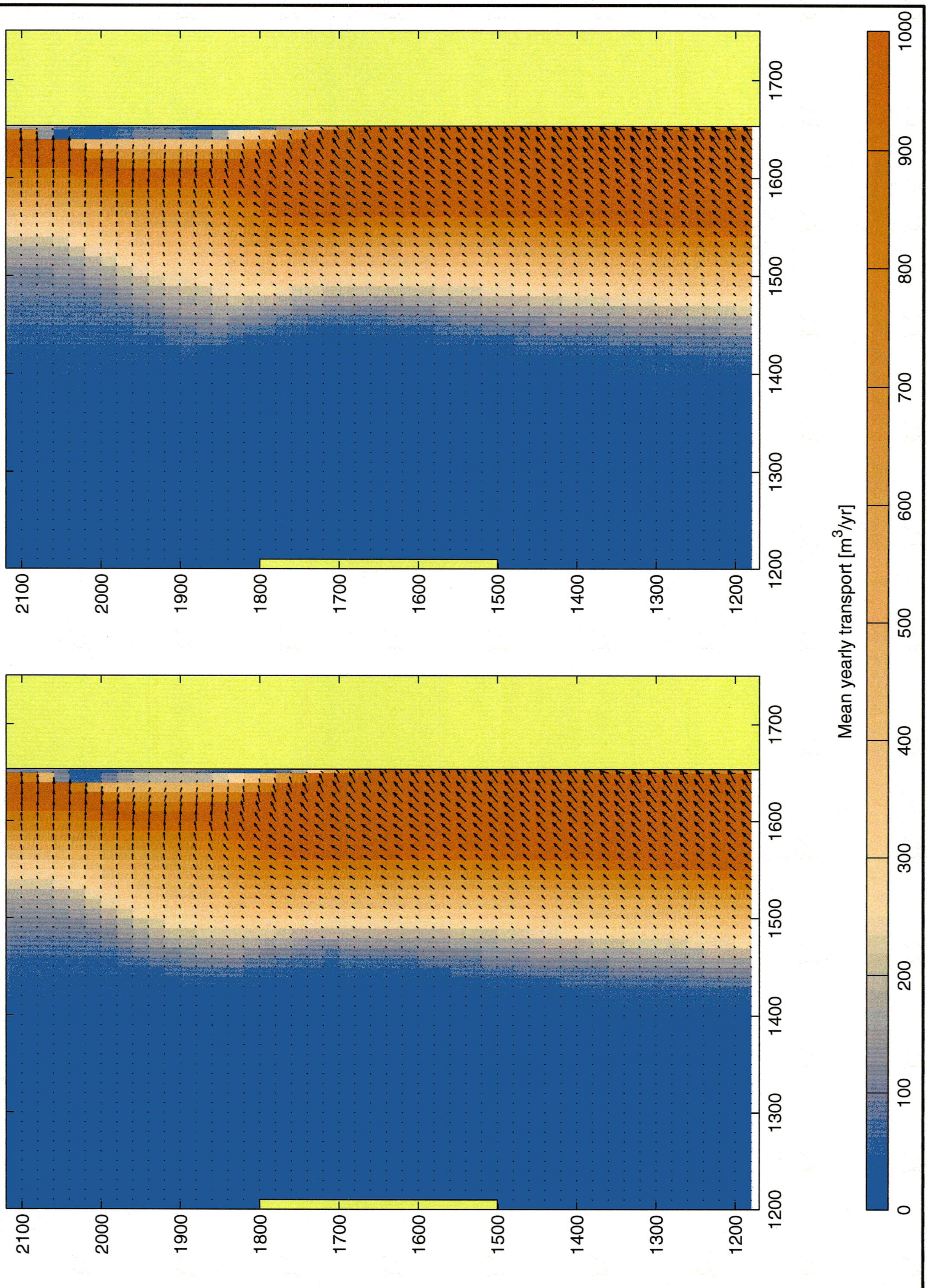
H4959

Fig. 5.3c



Comparison of bed level changes
Left plot: run07 (all conditions)
Right plot: opti_4

WL | DELFT HYDRAULICS	H4959	Fig. 5.3d

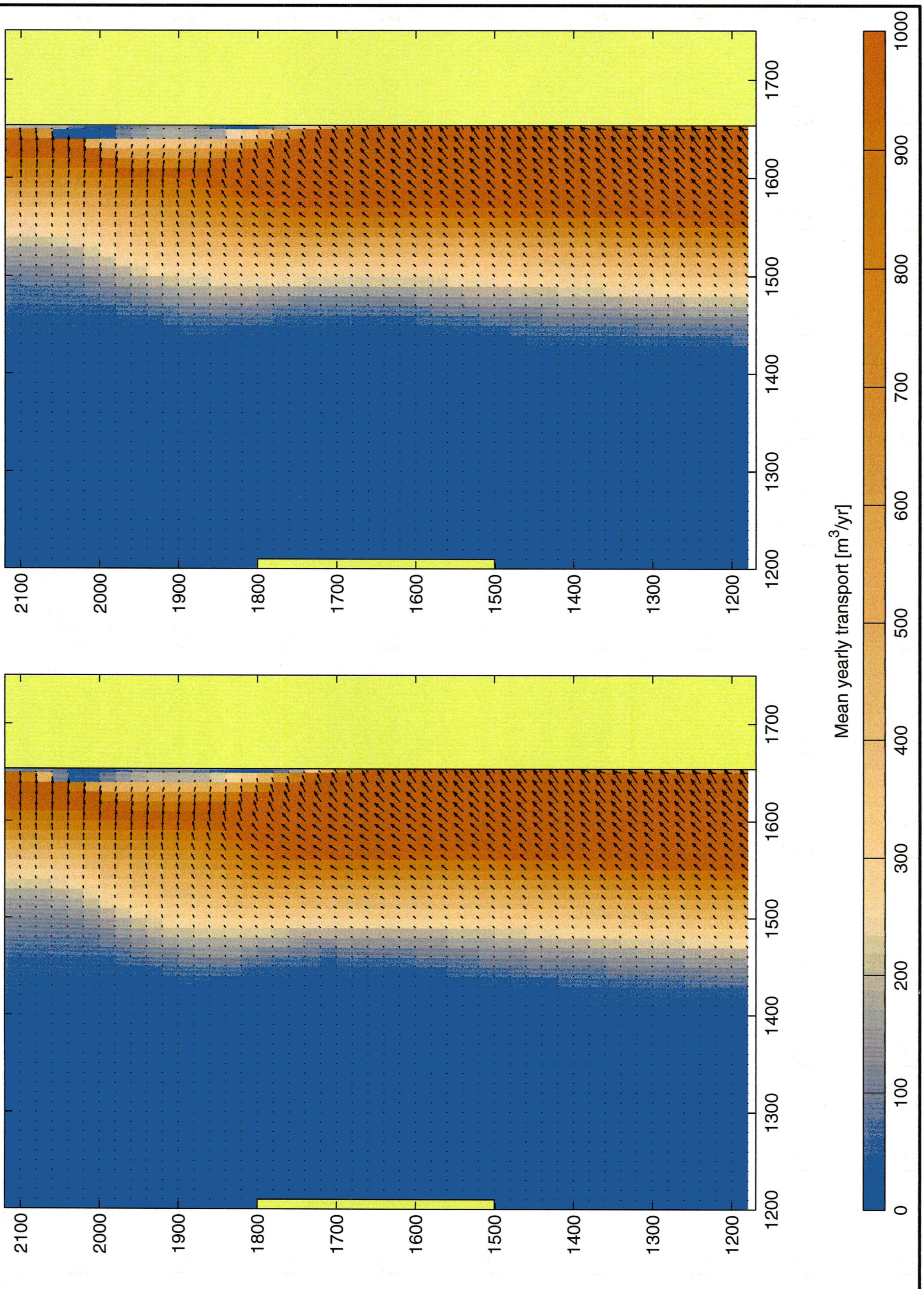


Comparison of mean yearly transport
Left plot: run07 (all conditions)
Right plot: opti_1

WL | DELFT HYDRAULICS

H4959

Fig. 5.4a

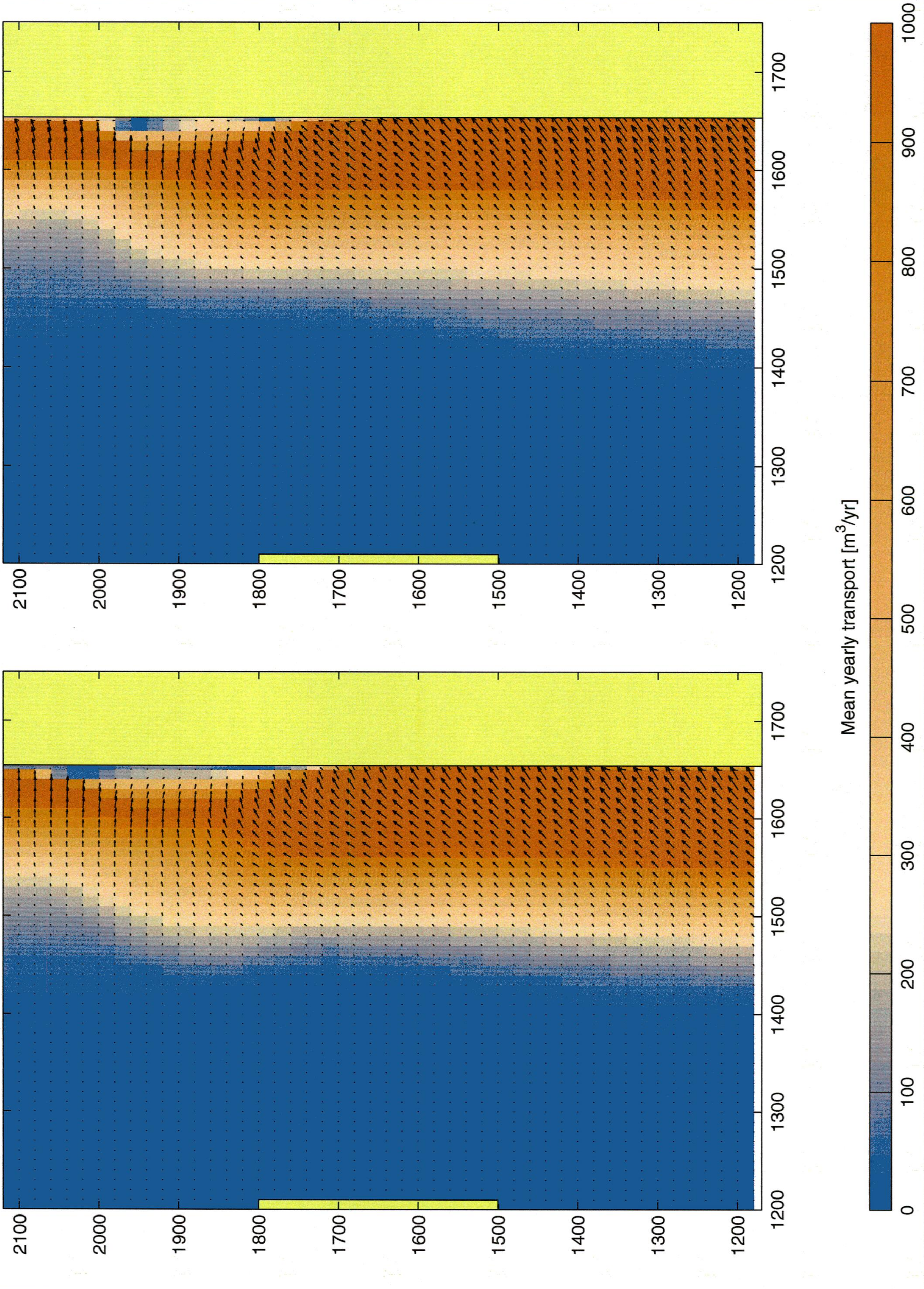


Comparison of mean yearly transport
Left plot: run07 (all conditions)
Right plot: opti_2

WL | DELFT HYDRAULICS

H4959

Fig. 5.4b

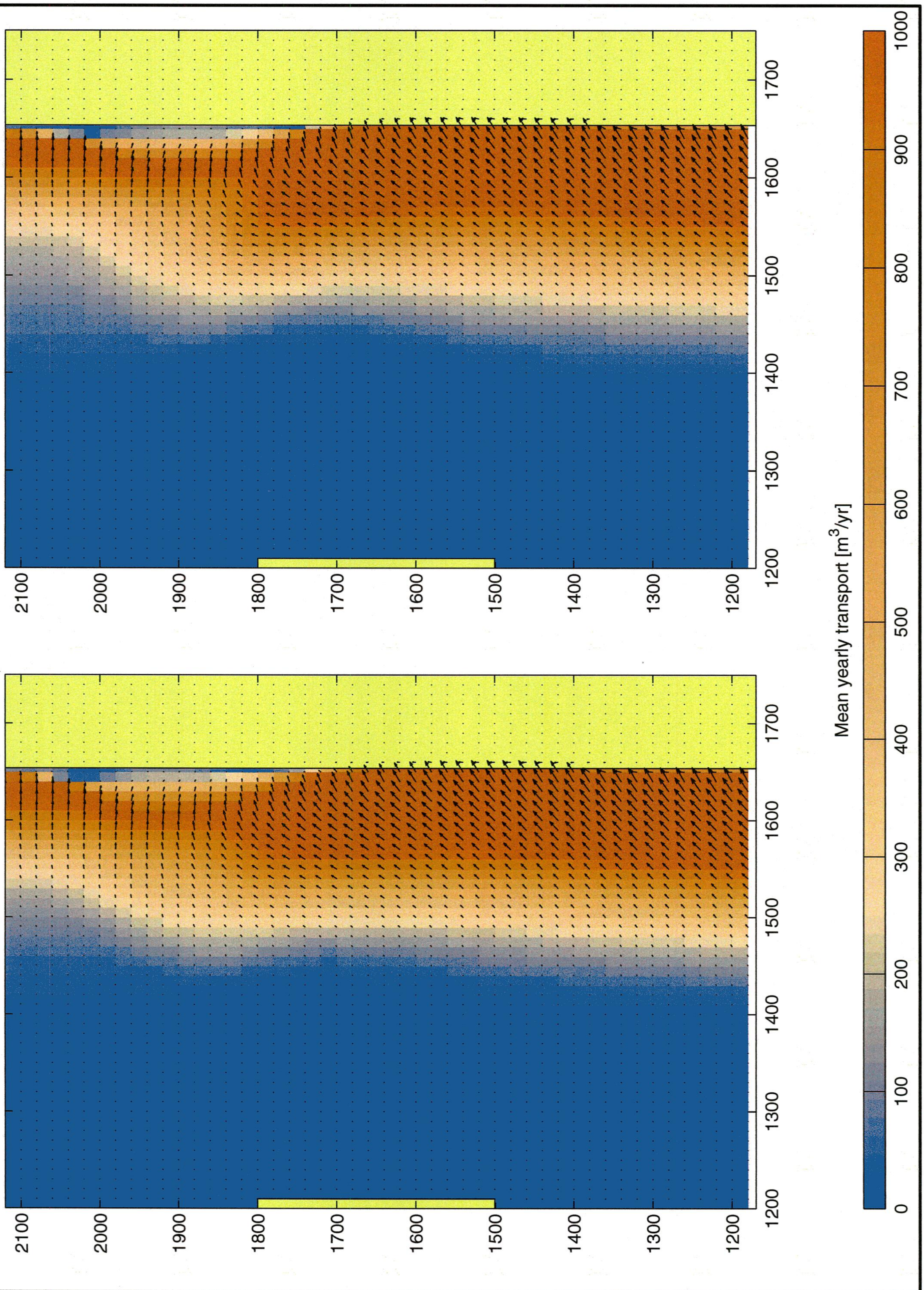


Comparison of mean yearly transport
Left plot: run07 (all conditions)
Right plot: opti_3

WL | DELFT HYDRAULICS

H4959

Fig. 5.4c

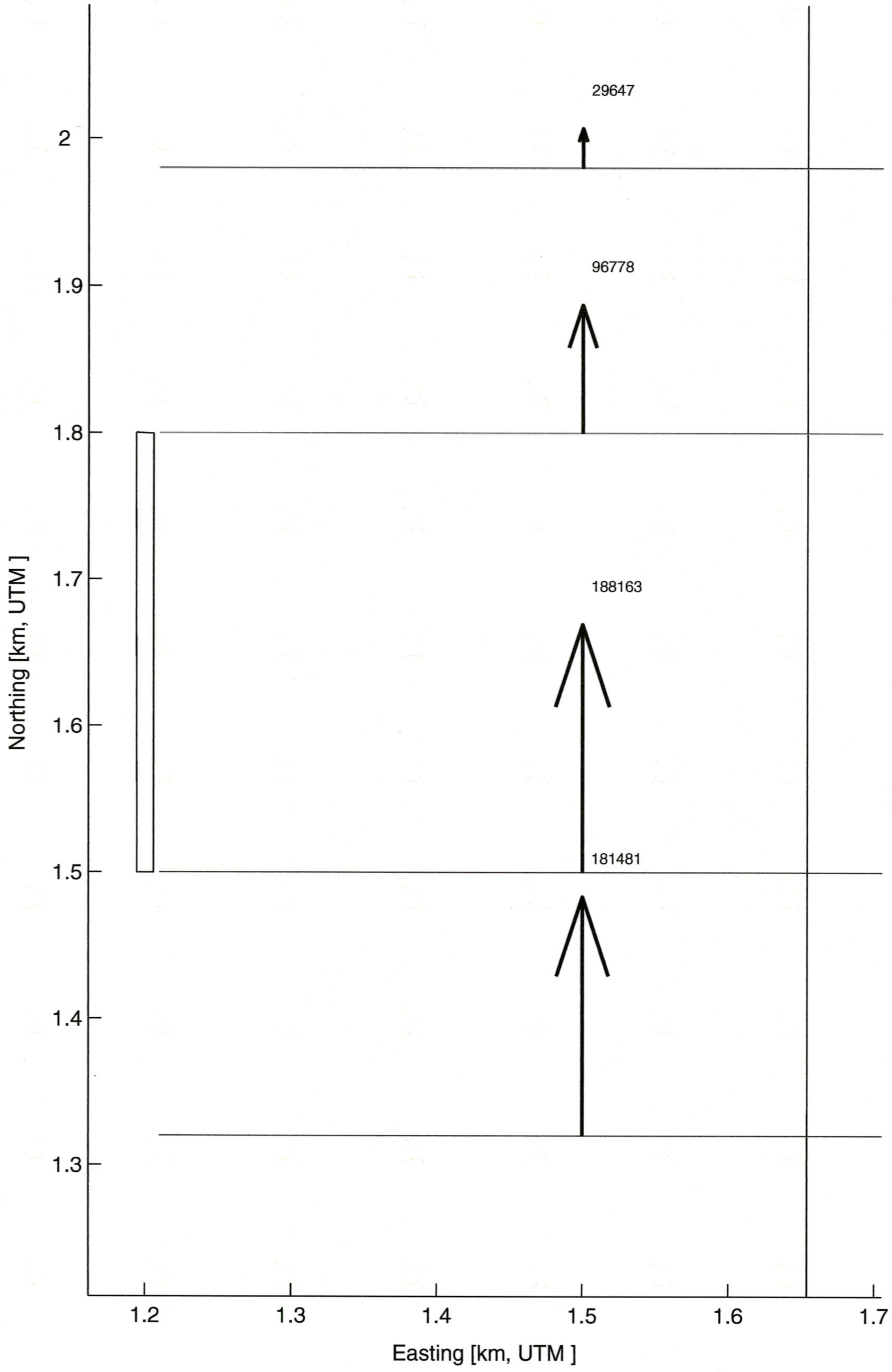


Comparison of mean yearly transport
Left plot: run07 (all conditions)
Right plot: opti_4

WL | DELFT HYDRAULICS

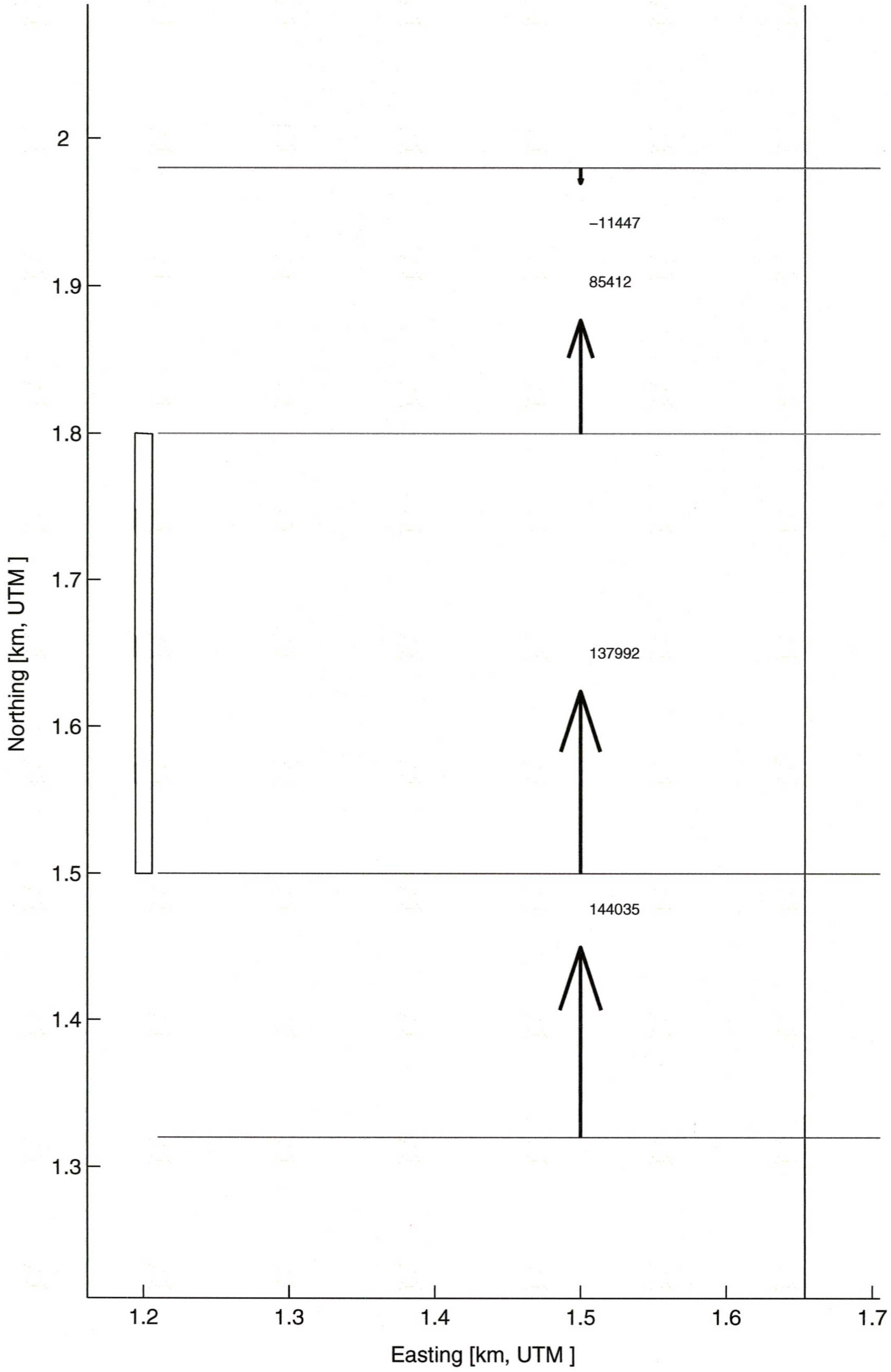
H4959

Fig. 5.4d

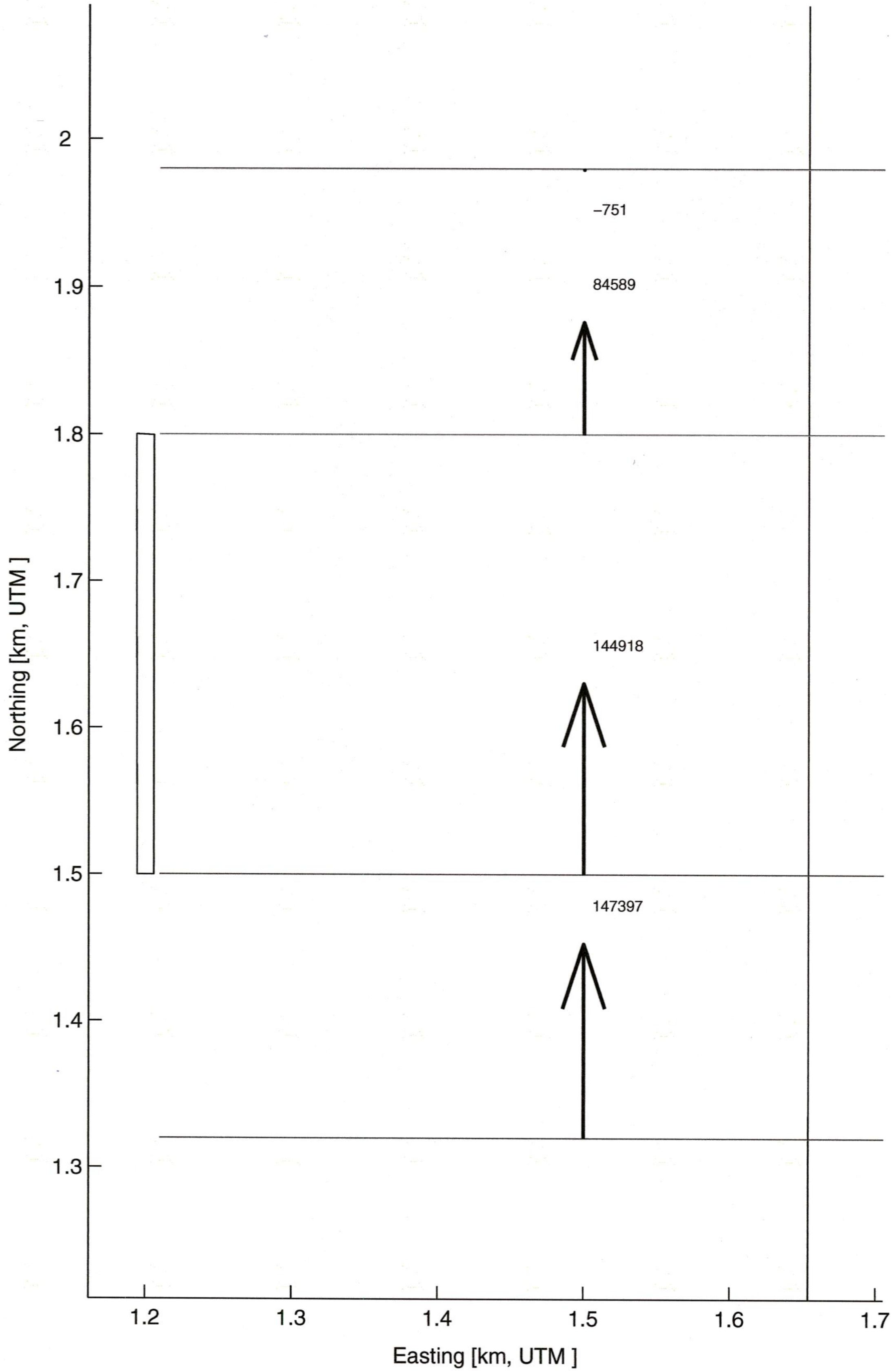


Instantaneous total sediment transport [m^3/year] for Run07
t–trim=73

	RunID: Run07	
WL | DELFT HYDRAULICS	H4959	Fig. 5.5a



Instantaneous total sediment transport [m^3/year] for Run07 t−trim=505	RunID: Run07	
WL | DELFT HYDRAULICS	H4959	Fig. 5.5b



Averaged total sediment transport [m^3/year] for Run07
t−trim=505

RunID: Run07

WL | DELFT HYDRAULICS

H4959

Fig. 5.5c

WL | Delft Hydraulics

Rotterdamseweg 185
postbus 177
2600 MH Delft
telefoon 015 285 85 85
telefax 015 285 85 82
e-mail info@wldelft.nl
internet www.wldelft.nl

Rotterdamseweg 185
p.o. box 177
2600 MH Delft
The Netherlands
telephone +31 15 285 85 85
telefax +31 15 285 85 82
e-mail info@wldelft.nl
internet www.wldelft.nl