OpenDA

Deltares

Enabling Delta Life

www.openda.org

Delft3D numerical model calibration with OpenDA

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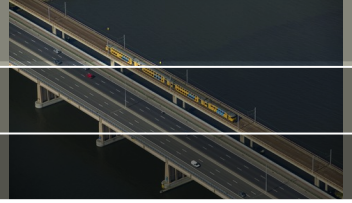
Deltares

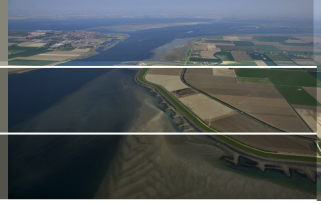
&

Nils van Velzen, Alja Vrieling, Jeroen Gerrits, ...

Vortech

Outline





Installation of OpenDA

- Installation of OpenDA binaries
- Automated calibration concepts
- A simple calibration example

Calibration for Delft3D-Flow

- Black-box model wrappers
- Installation of Delft3D wrapper
- Calibration example with Delft3D-Flow for a simplified estuary
- Next steps...

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Installation of Windows binaries

1. Locate zip-file on sourceforge (use link on http://www.openda.org)
2. Download openda v2.0 windows binaries
3. Unpack zip-file (use a path without spaces)
4. Make a shortcut for run_openda_gui.bat
5. Test by starting the batch script

Known issues:

- A 32bit java environment is included to avoid issues with incompatible java versions.
- Sometimes existing directories in the PATH environment variable cause trouble.

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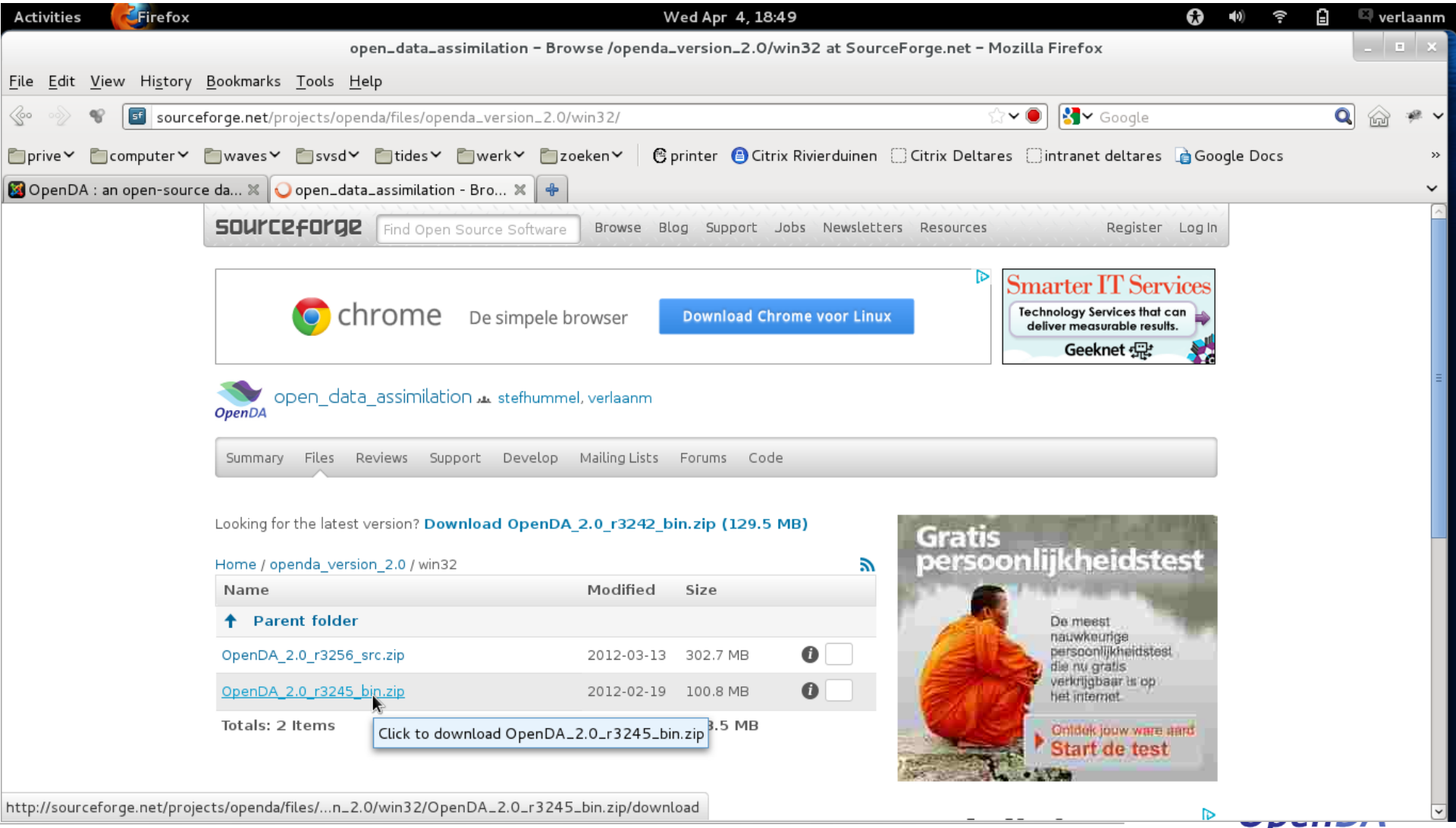
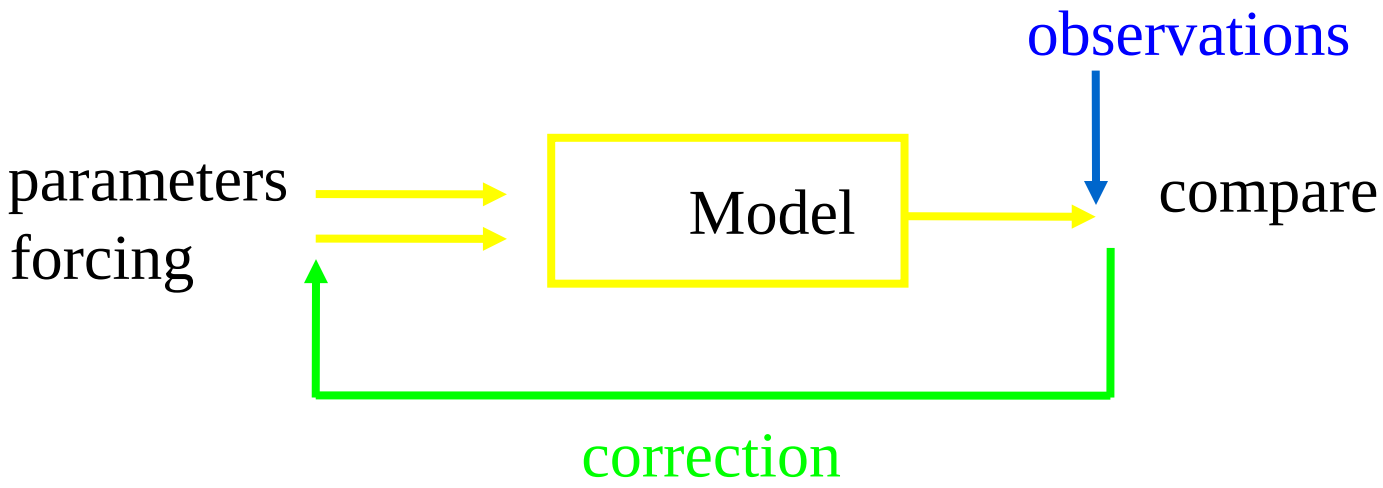
Download OpenDA



Automated calibration concepts

- **Many models contain uncertain parameters, often related to friction, boundary conditions or sub-soil material properties**
- **Model output can be validated against observations.**



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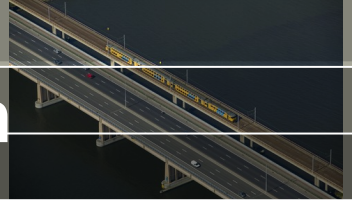
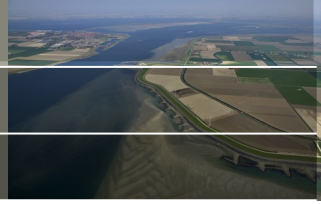
Optimization of a costfunction





- Calibration is defined as an optimization problem
- Elaborate background in statistics: log-likelihood function
- Measure distance or misfit of model to observations
- Depends on uncertainty of observations

$$J_p = \sum_t \frac{(y_o(t) - y_m(t))^2}{\sigma_o^2}$$

- May be ill posed!
- Additional background term

$$J_p = \frac{(p - p_0)^2}{\sigma_p^2}$$

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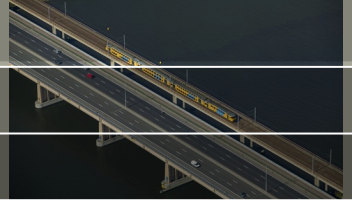
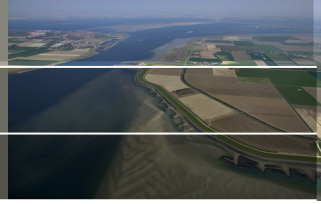
DUD algorithm





DUD (efficient for nearly linear models)

- **Start with running:**
  - **first guess**
  - **& modified run for each parameter**
- **Linearize the model around these values**
- **Solve linear problem**
- **If this is an improvement update linearization with new point**
- **Else do a line-search (only until there is improvement)**

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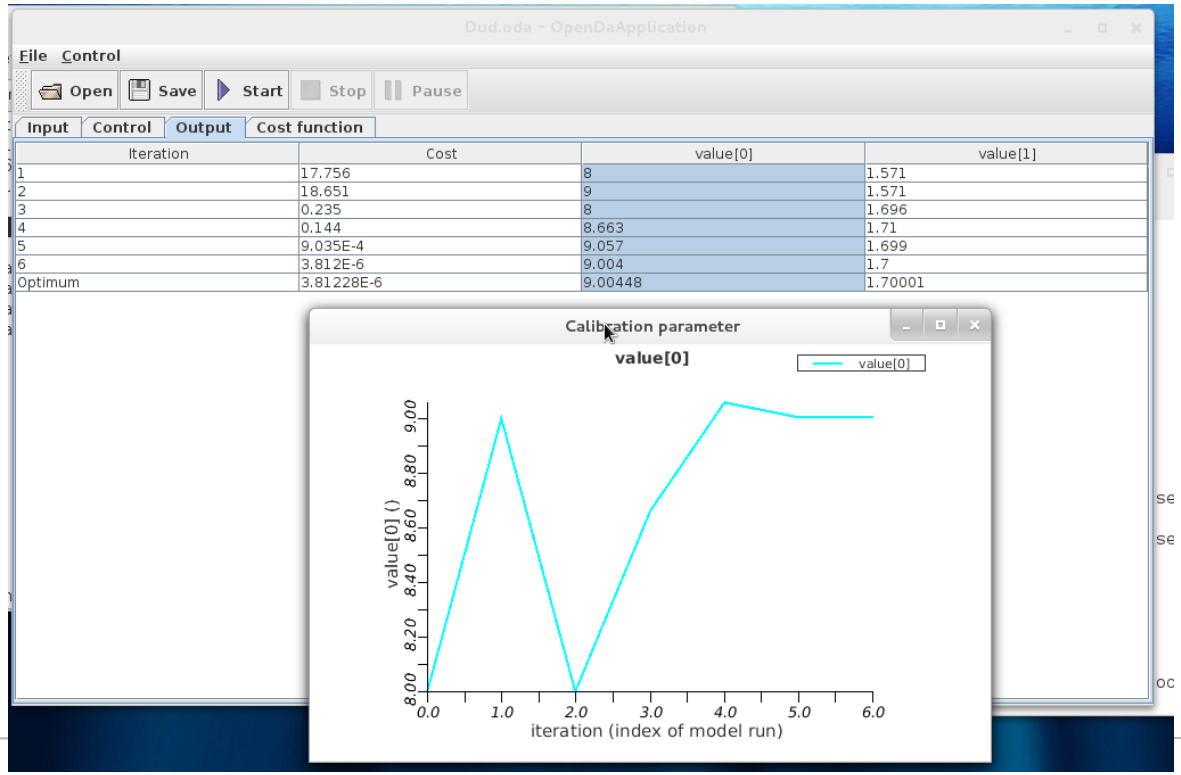
A simple calibration example

- Run DUD calibration for linear oscillator
  - Start OpenDA gui
  - Open examples/simple_oscillator/Dud.oda
  - Start computations



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Black-box model wrappers

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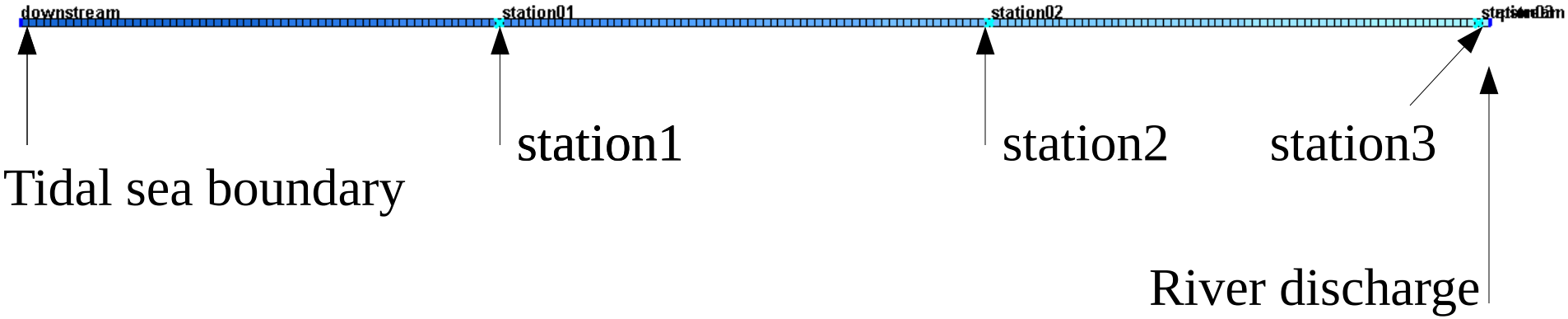
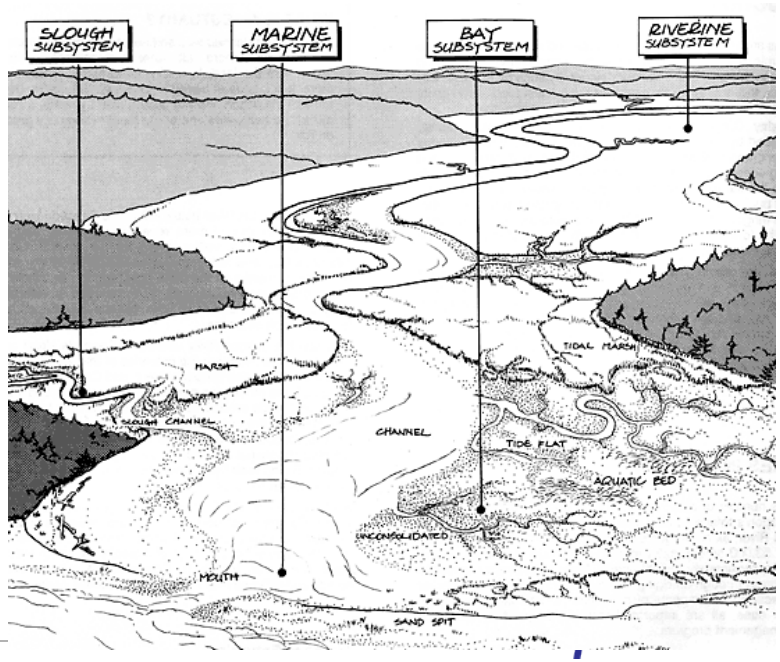
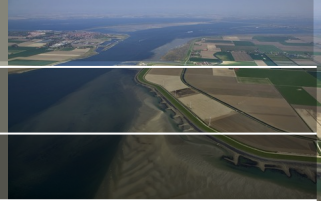
Simplified model of an estuary



- **One dimensional model**
- **Tidal boundary**
  M2 (12h25min) and S2 (12h)
- **Constant slope depth**
- **Constant river inflow**
- **3 Observation locations**
- **Observations are not real but generated with 'truth' model.**



Exercise



- Download openda_d3d_plugin.zip from http://www.openda.org/course and unpack to openda/bin
- Download estuary.zip from http://www.openda.org/course and unpack
- Run the simulation with OpenDA, using the main OpenDA file simulate.oda
- Prepare some time-series plots with quickplot
  - Start matlab in direcory src/tools_lgpl/matlab/quickplot/progsrc and run d3d_qp
  - the observations are available as tekal file, for including them in the plots (use add to plot and change the color)
  - Output can be found in estuary/work/work0
- What are the most likely causes of differences between observations and model?

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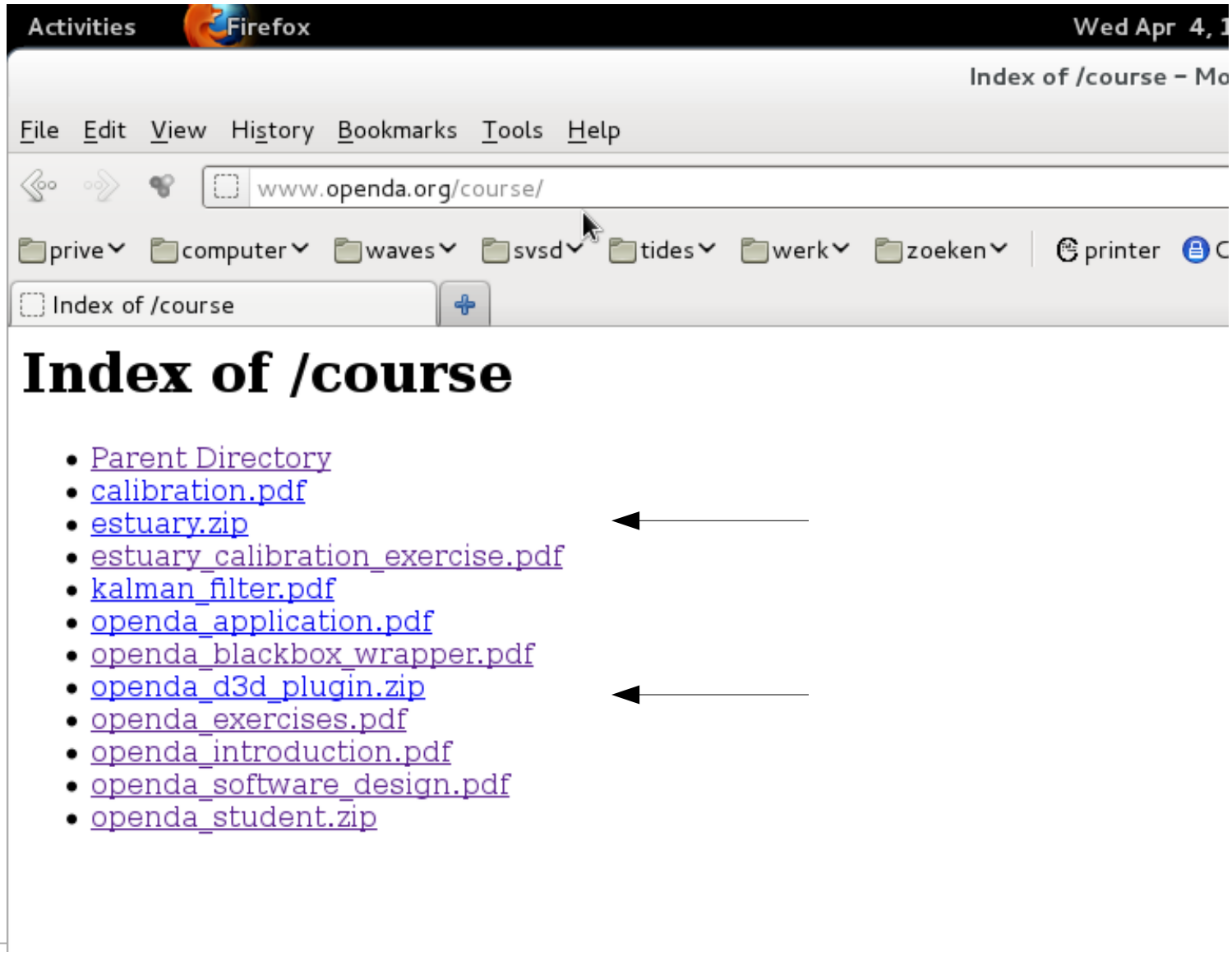
Estuary example Delft3D



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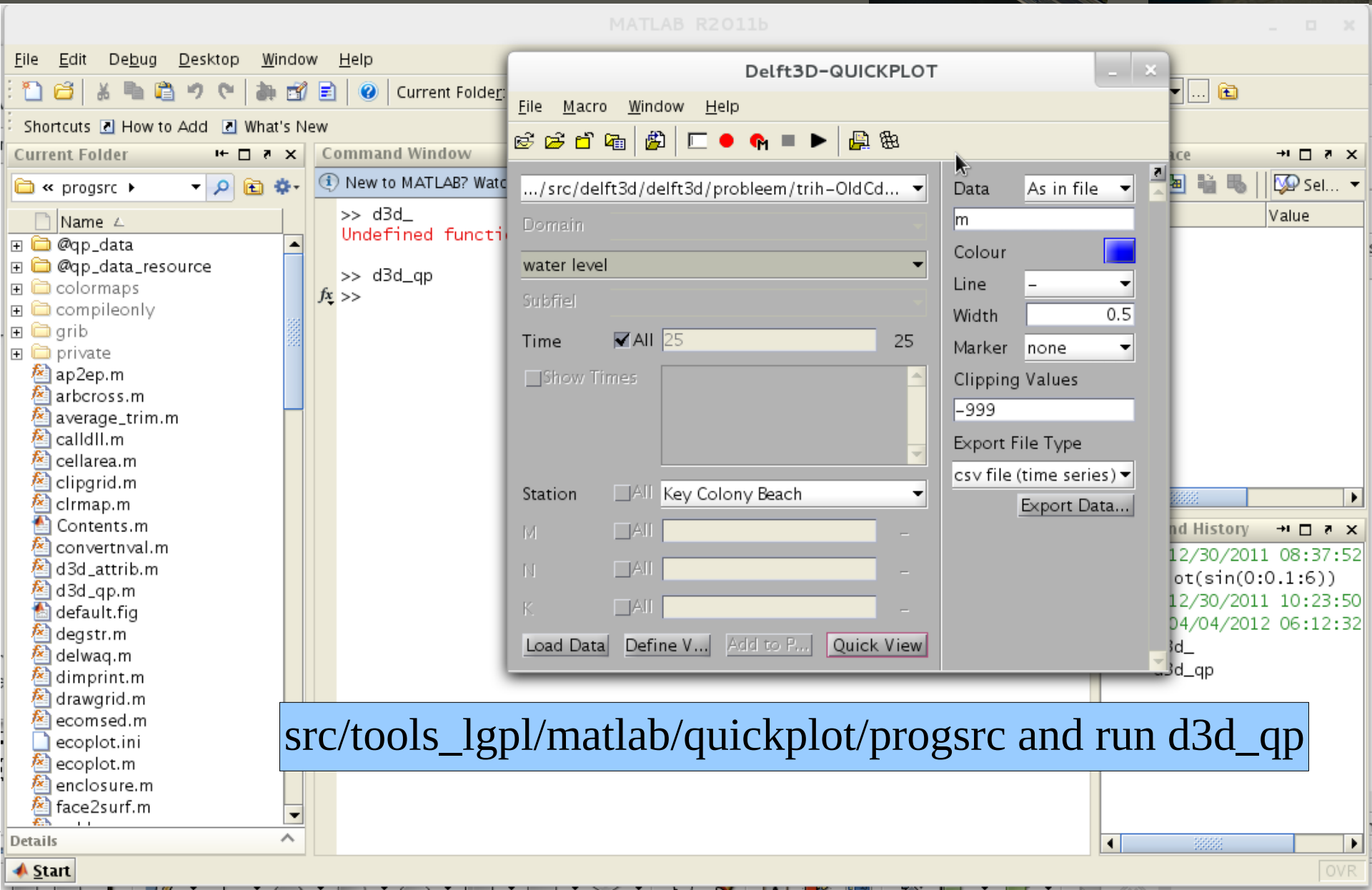
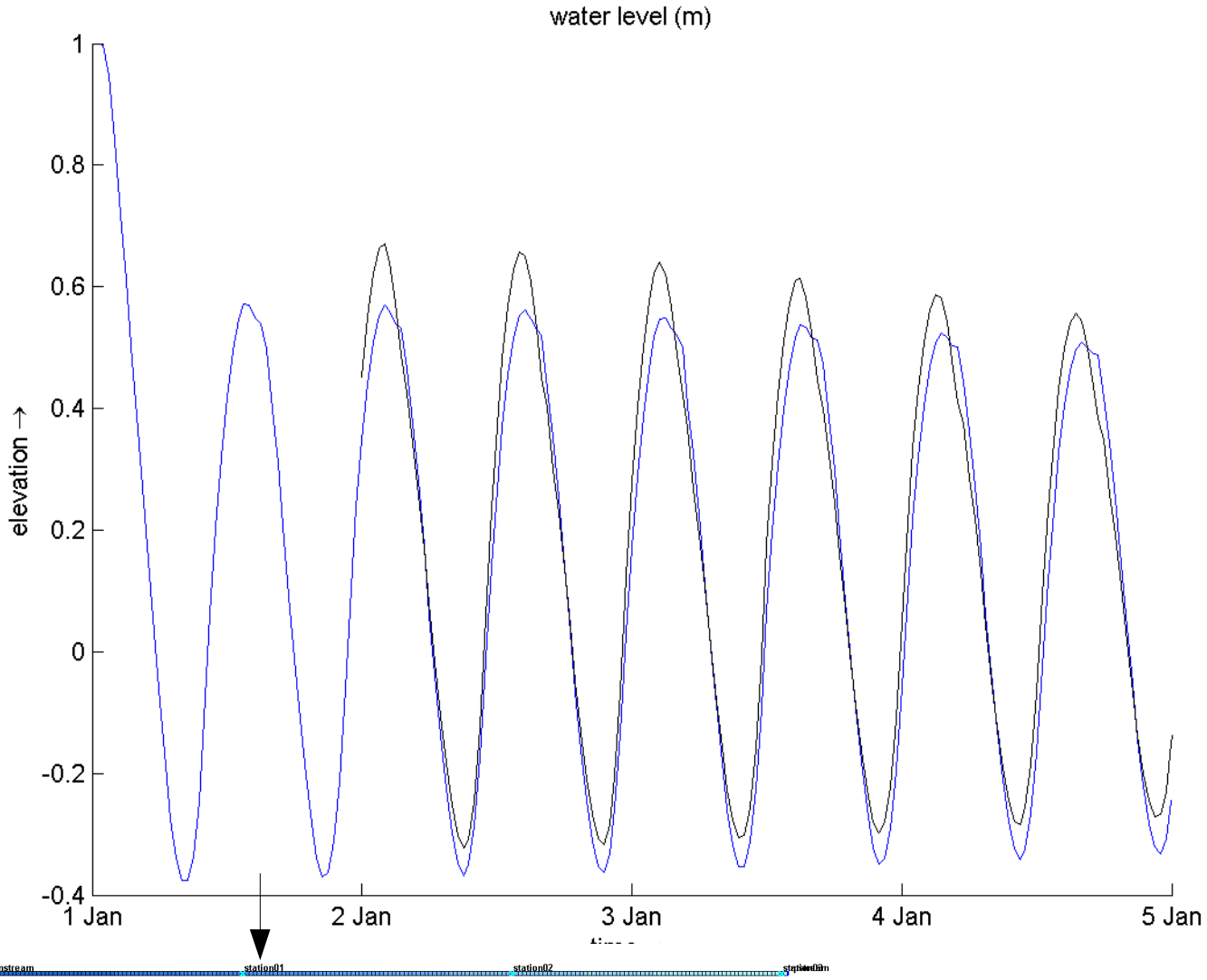
Quickplot



src/tools_lgpl/matlab/quickplot/progsrc and run d3d_qp

Initial performance



RMSE=9cm

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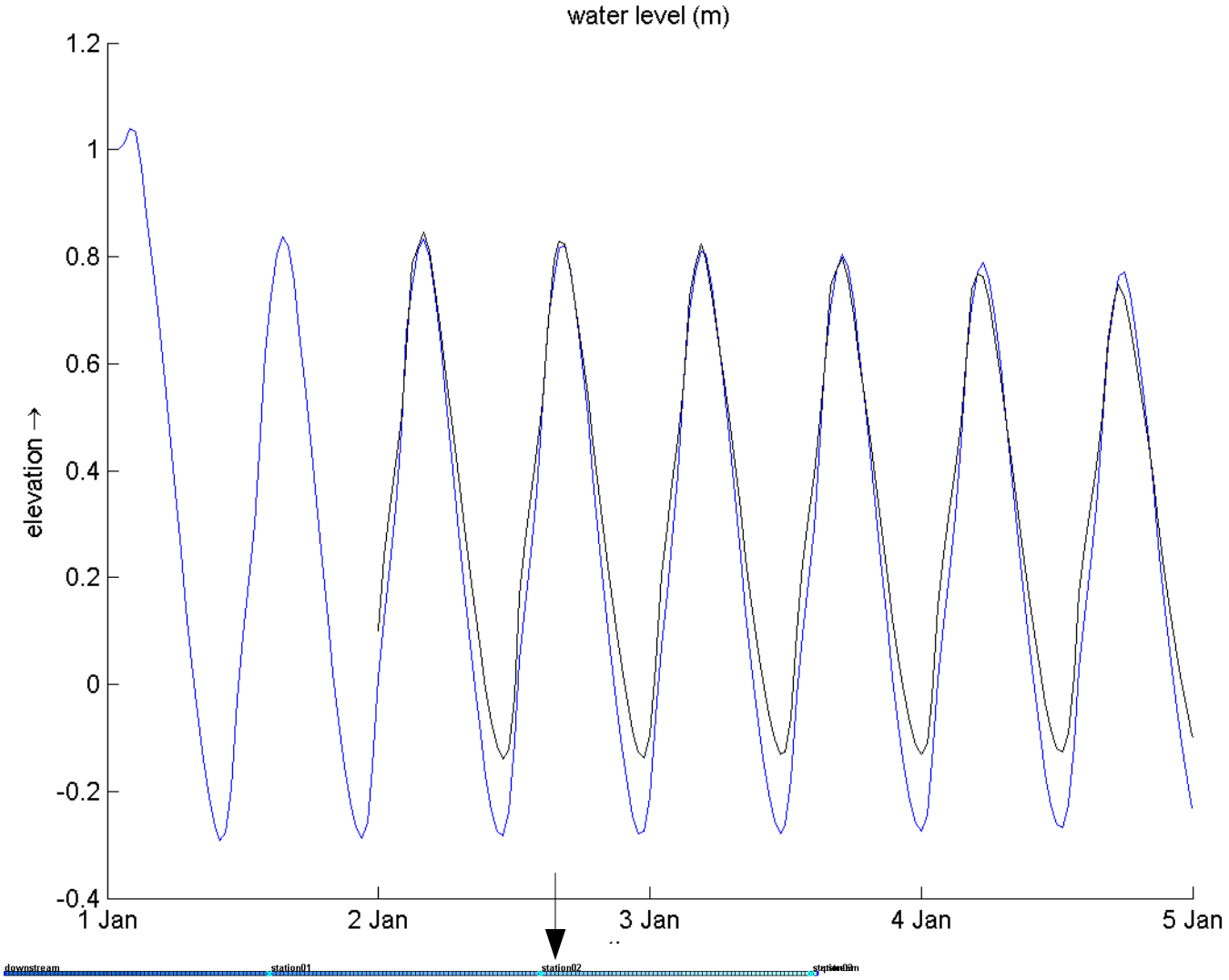
Initial performance



RMSE=12cm

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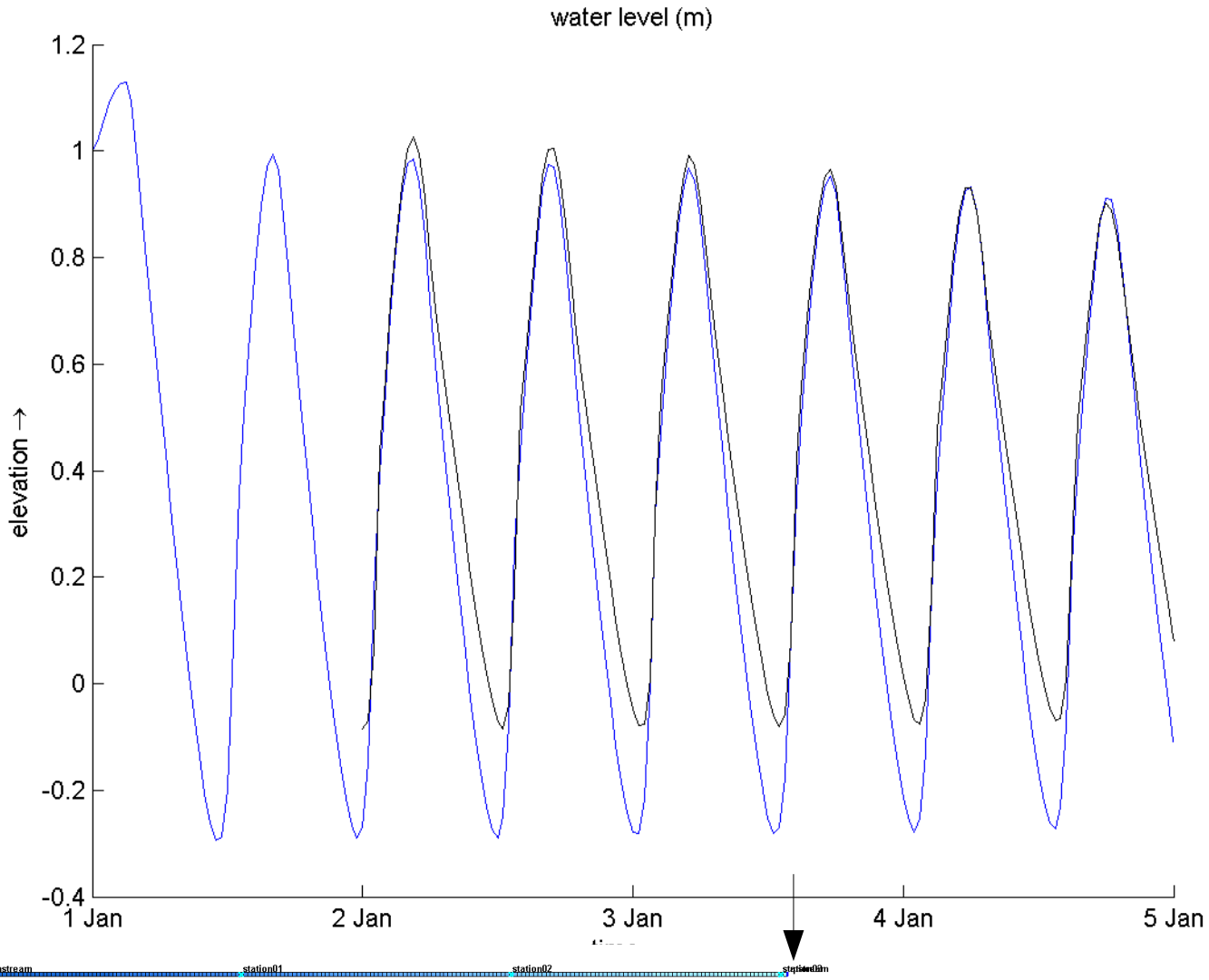
Initial performance



RMSE=7cm

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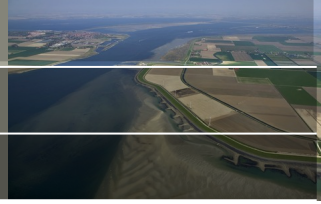
Exercise



- Run the calibration for a globally constant change to the bathymetry (experiment DEP)
  - Start OpenDA with estuary/calibration.oda
  - Look at the output in the control tab and output tab
  - The output of each of the runs can be found in work/work<number>
  - Plot the time-series with quickplot.
- Is this what you expected?

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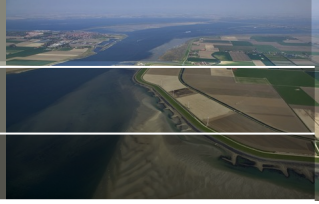
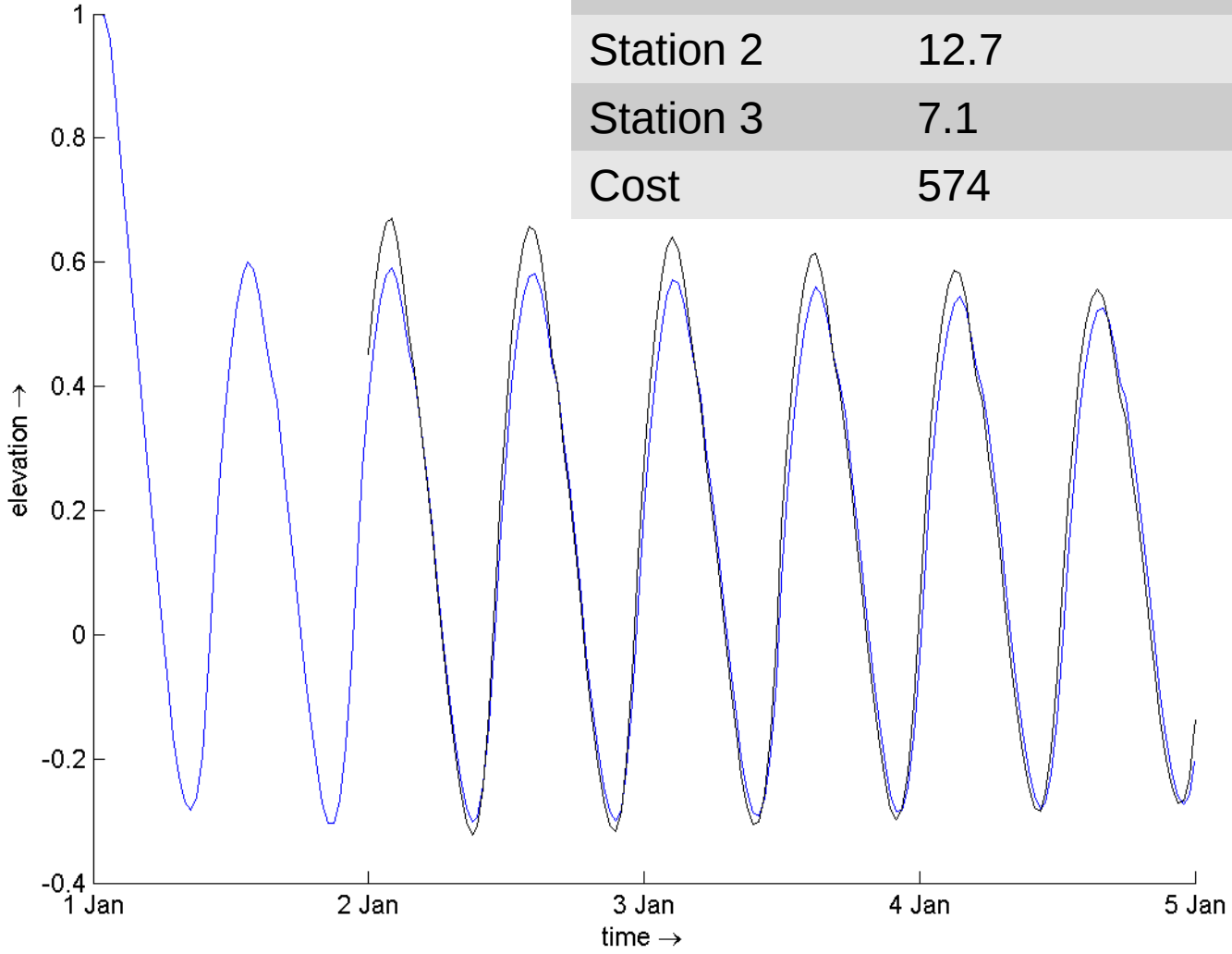
Calibration Depth



Name	First guess	DEP calib.
Station 1	9.2 cm	4.5
Station 2	12.7	5.0
Station 3	7.1	4.9
Cost	574	134

Station 1



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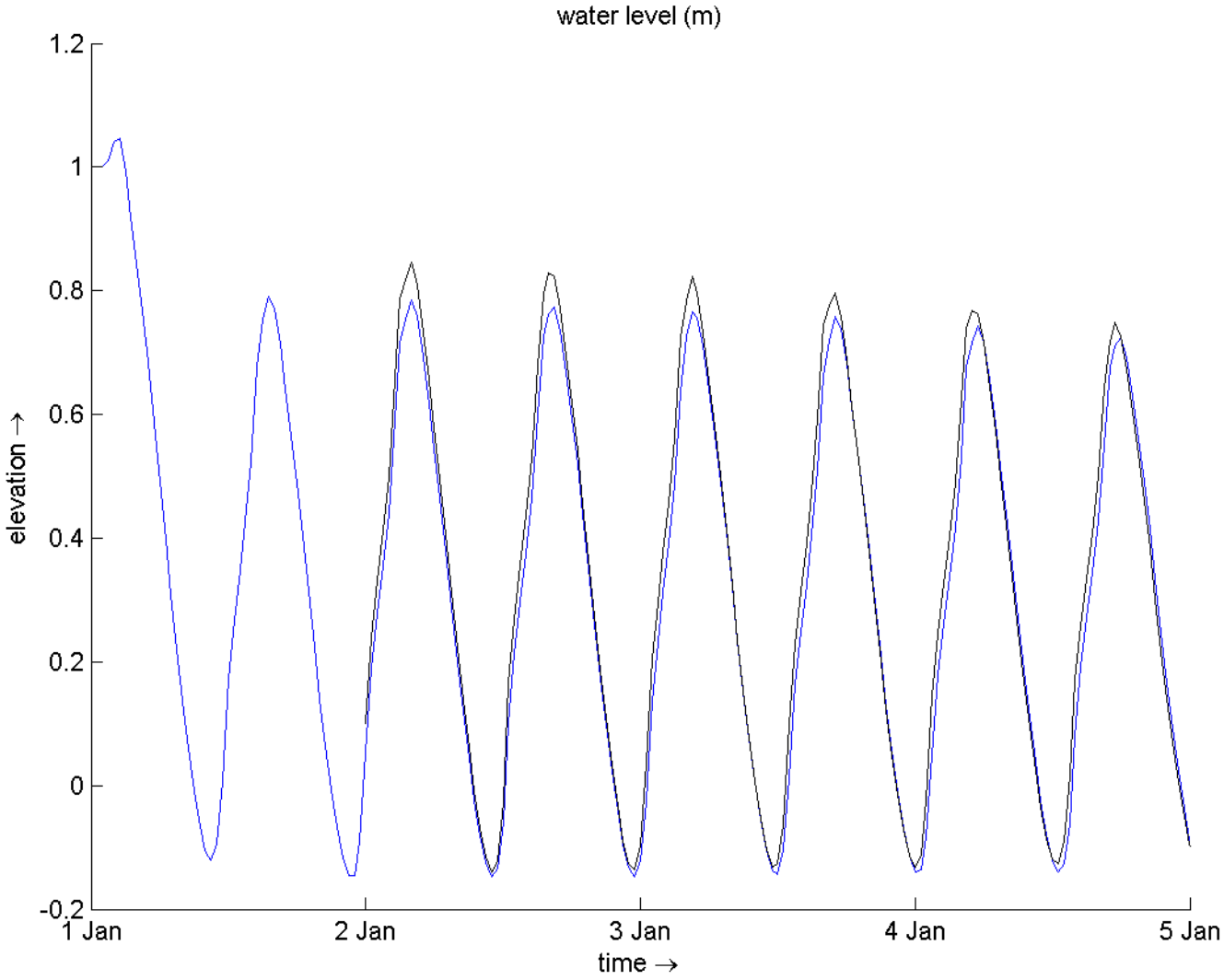
DEP output Station 2



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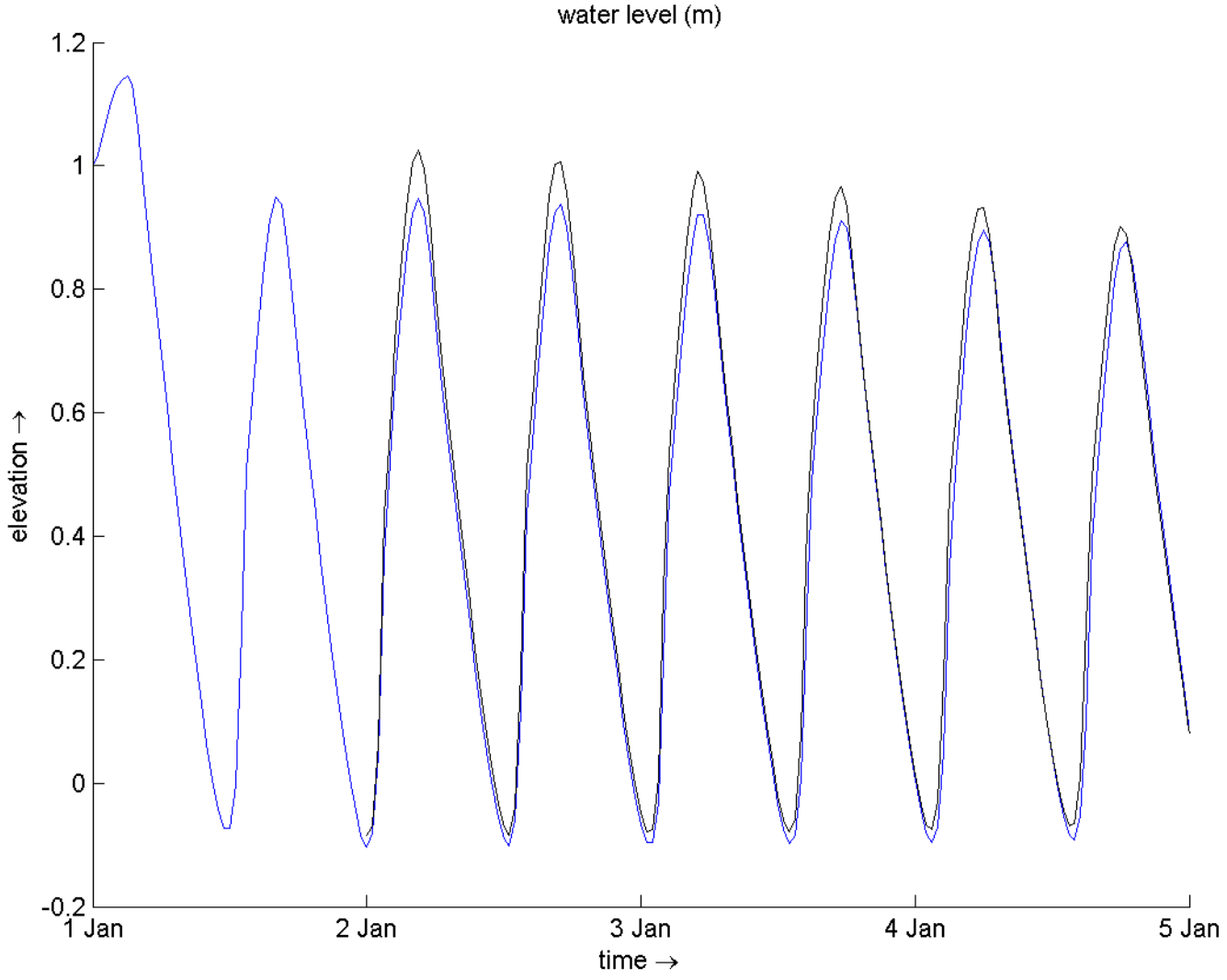
DEP output Station 3



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Exercise

Since the amplitude shows a similar deviation from observations in the whole domain we add calibration of M2 tides at boundary.

- Add the calibration (experiment DEP+M2)
  - Uncomment M2 section in stochModel/D3DStochModel.xml
  - Run calibration
  - Look at the output and plot the time-series.
  - Is this what you expected?

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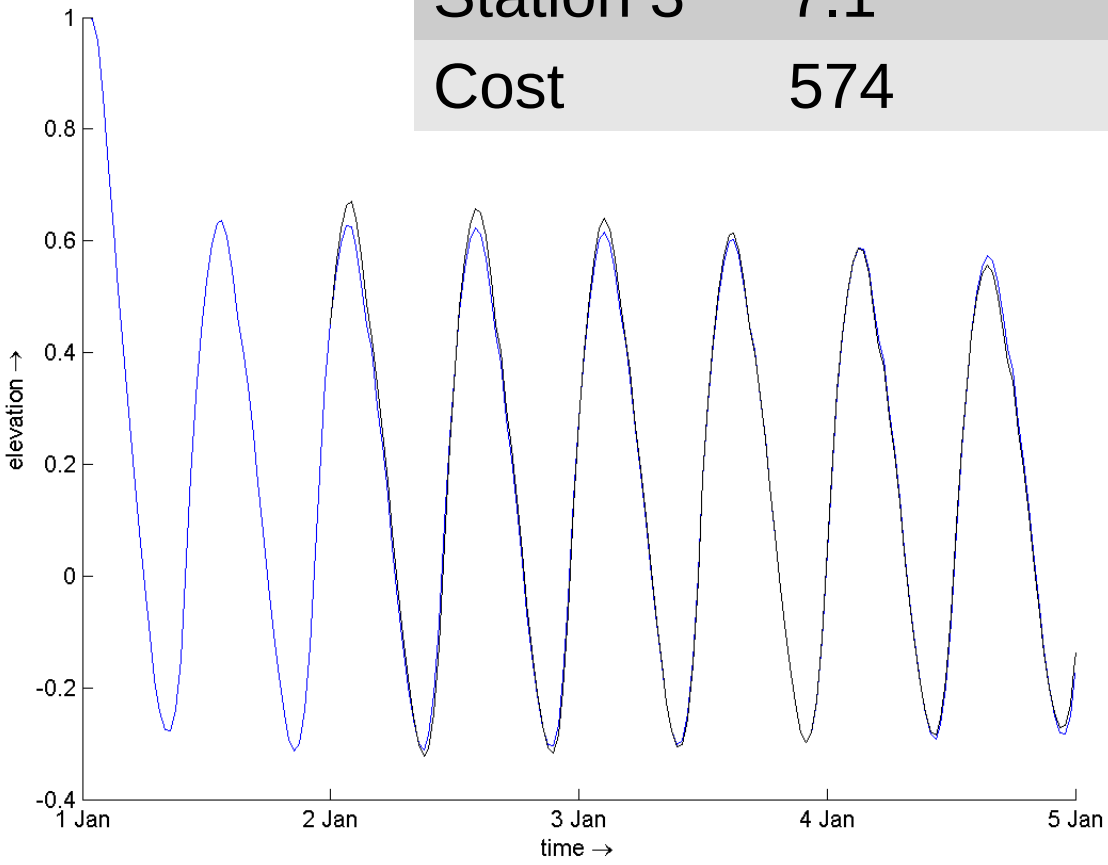
Calibration Depth+M2

Station 1

Name	First guess	DEP	DEP+M2
Station 1	9.2 cm	4.5	1.1
Station 2	12.7	5.0	1.4
Station 3	7.1	4.9	1.1
Cost	574	134	8.4



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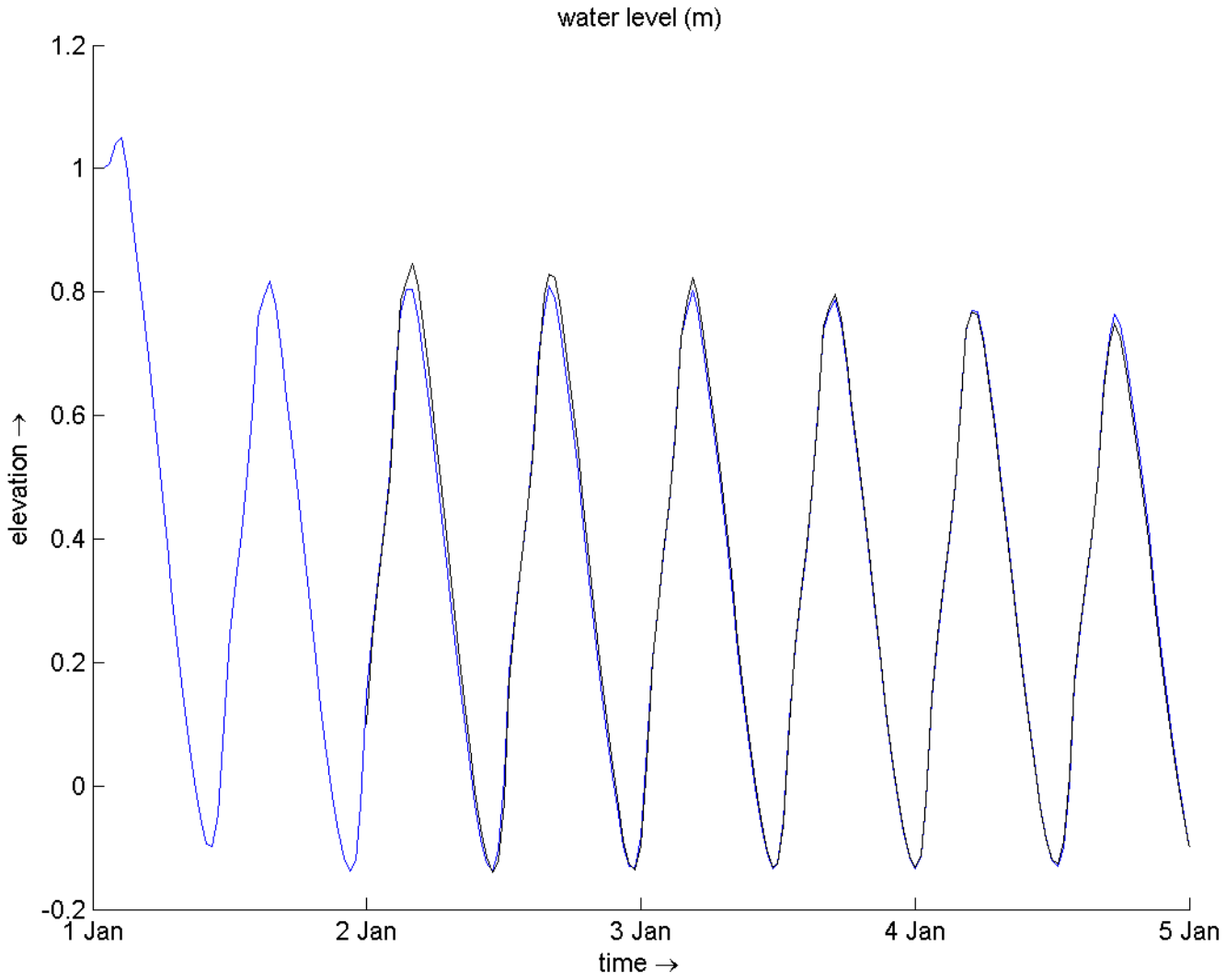
DEP+M2 output Station 2



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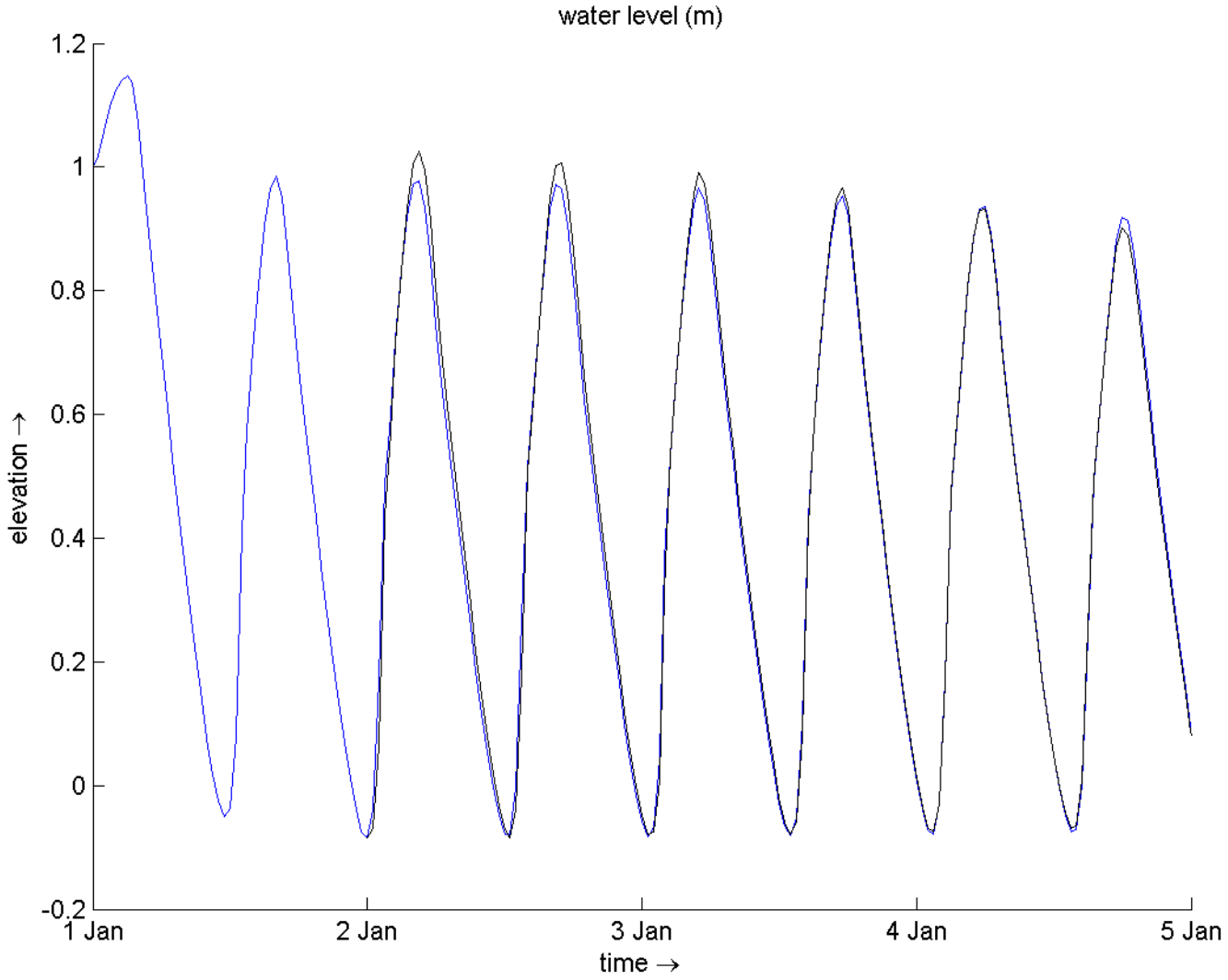
DEP+M2 output Station 3



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Exercise

The output looks nice. The cost-function is much lower, but there is still a problem...

- Make a longer run with the final run of experiment DEP+M2
  - Modify work/work<last_number>/estuary.mdf and change the Tstop = 2.3040000e+004 which is 17-1-1991 0:00h; alternatively use the gui.
  - Run deltares_hydro.exe for this case
  - Make time-series plots
  - What is wrong?

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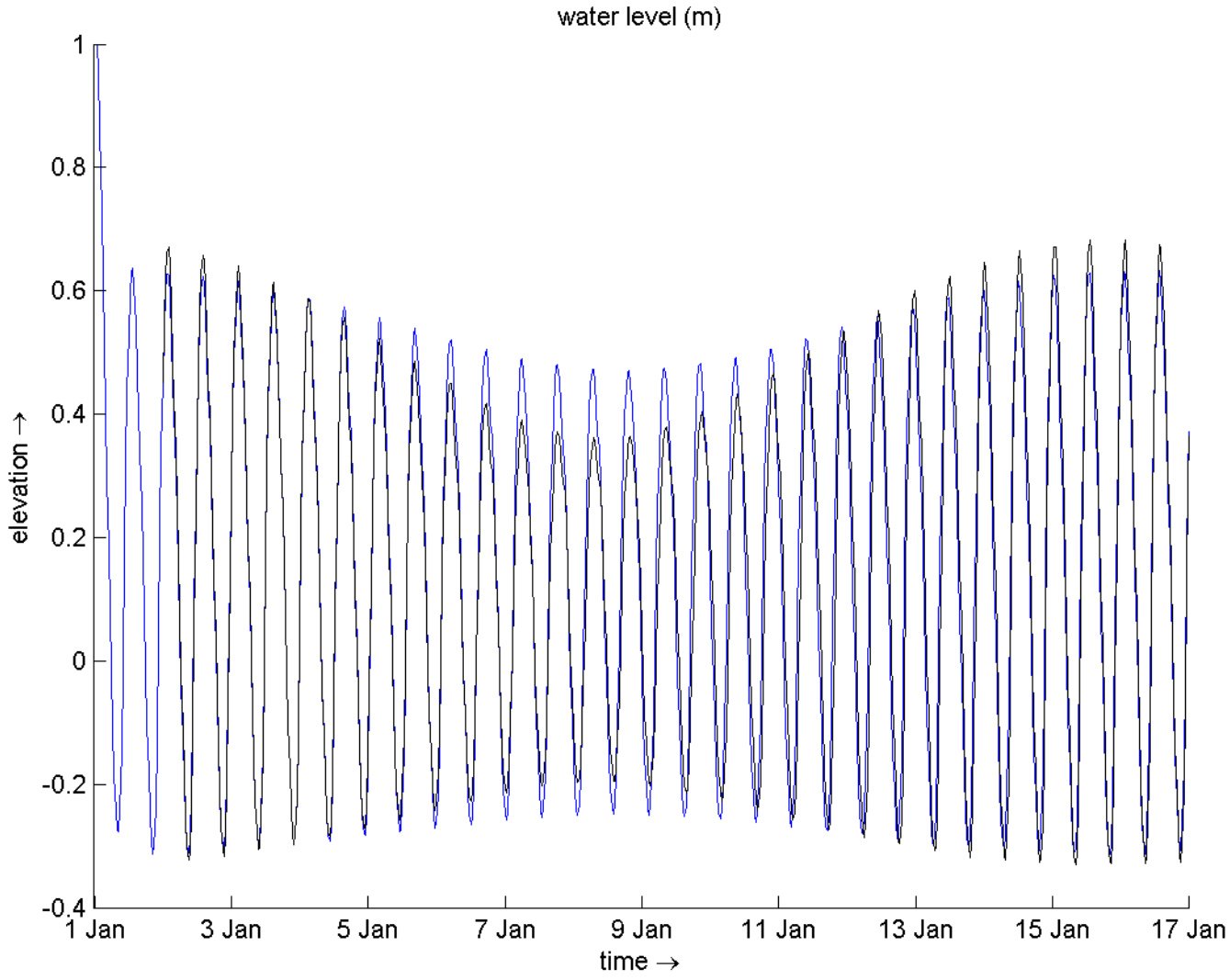
Long run for DEP+M2 result



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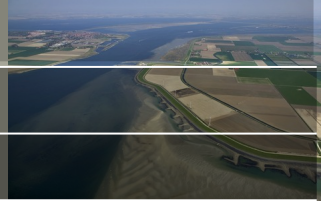
Exercise



The error in S2 was attributed to M2. Let's make fix this with a longer simulation and adding S2 to the calibration

- Add S2 to calibration and lengthen simulation experiment DEP+M2
  - Modify input_d3d/estuary.mdf and change the Tstop = 2.3040000e+004 which is 17-1-1991 0:00h; see also estuary_long.mdf
  - Lengthen the observations in stochobserver/noosObservations.xml to 17-1-1009 0:00h; see noosObservations_long.xml
  - Uncomment S2 section in stochModel/D3DStochModel.xml
  - Run calibration with OpenDA
- What would go wrong if we would use only 3 days of observations for calibration of S2 and M2?

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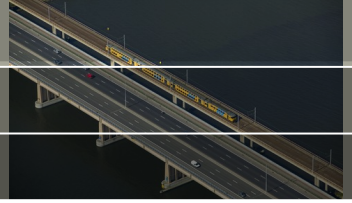
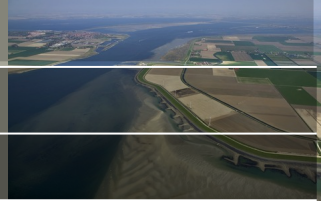
Calibration DEP+M2+S2





Name	First guess	DEP+M2+S2
Station 1		0.9cm
Station 2		0.7
Station 3		0.2
Cost	5281	1.5

Parameter	Final value (change)	True values
M2.Amplitude	0.1 cm	0.0 cm
M2.Phase	0.4 degr	0.0 degr
S2.Amplitude	10.1 cm	10.0 cm
S2.Phase	0.3 degr	0.0 degr
Depth	-92cm	-100cm

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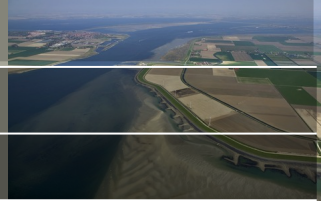
And much more



- Calibration of roughness
- Calibrate blocks of the grid for depth or roughness
- Proportional instead of additive modification of parameters
- Make subselections of observations
- Restarts
- Parallel computing
- Output formats and selection
- Try other algorithms
- Calibration of other models, such as sobek, swan or waqua
- ….

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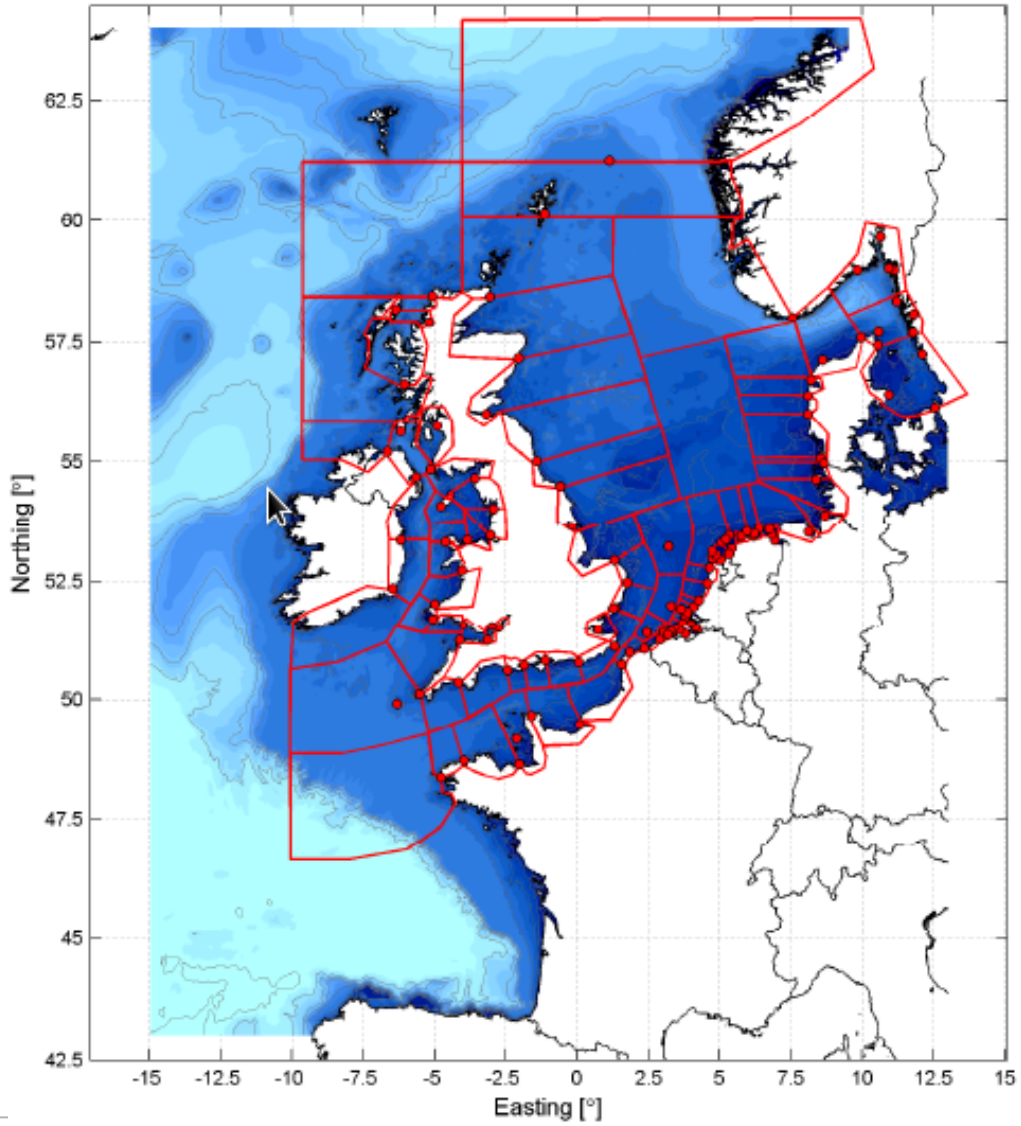
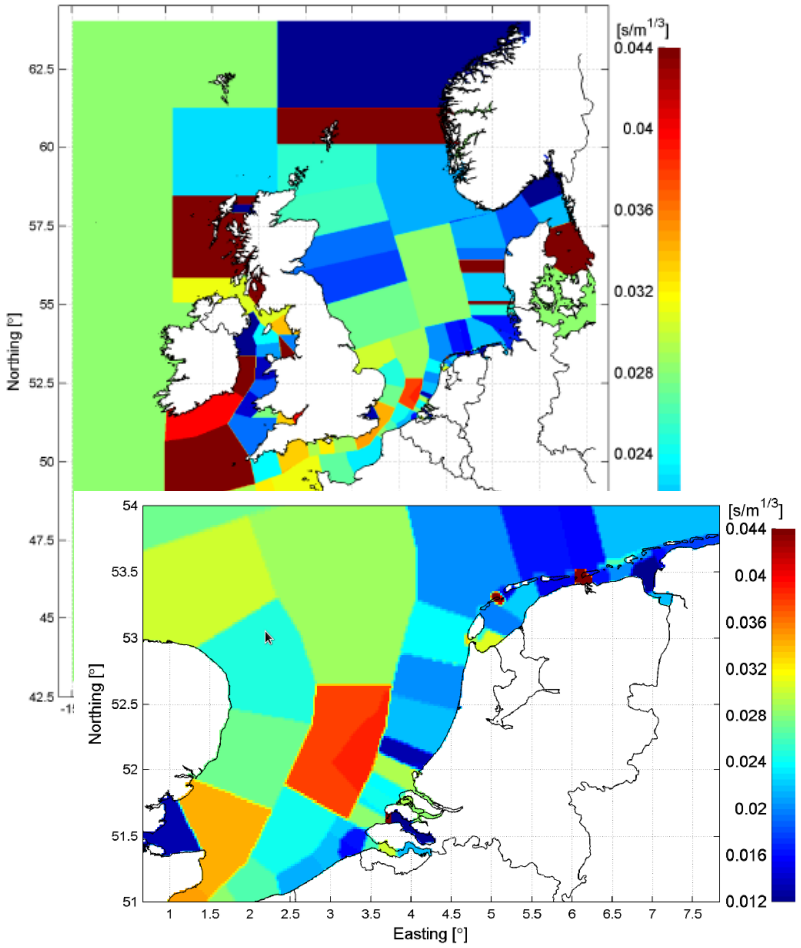
Calibration of a storm surge model





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