Sediment fluxes in the Belgian coastal zone

& influence of global change scenarios on siltation of fair channels

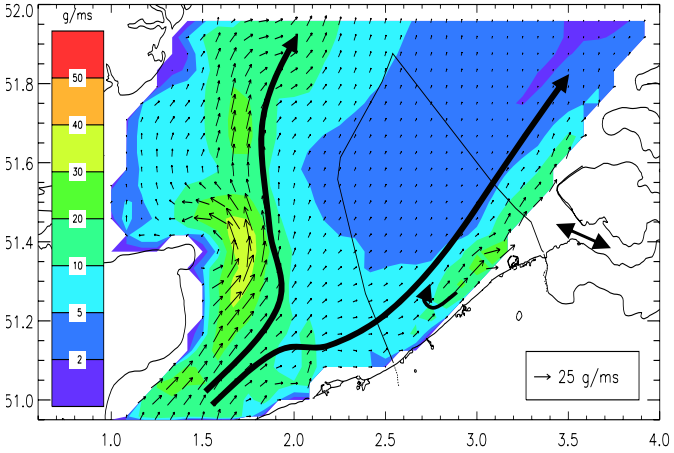
Overview

- Sediment fluxes in the Belgian coastal zone
  - Satellite images
  - Numerical models
    - Model for advection-diffusion of mud
    - Model for total (sand) transport
- Setting up new model for mixed sediments and bed model

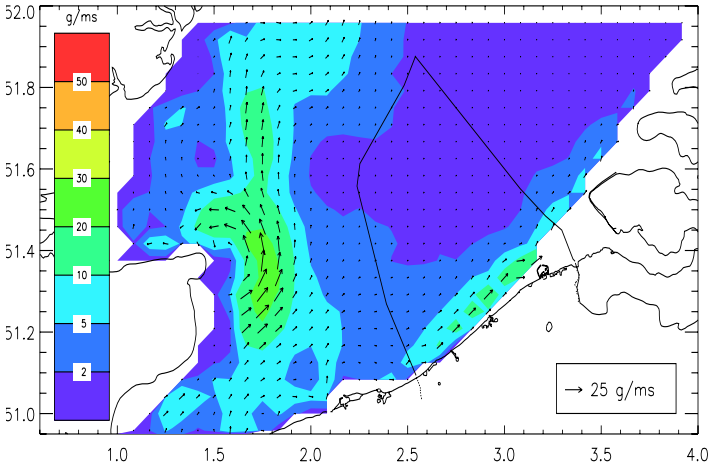
- Influence of sea level rise and increased storminess on siltation of fair channels (CLIMAR + Quest4D)
    - Climate change scenario's
    - Changes to currents and waves
    - Changes tot siltation

SPM transport from SeaWiFS images and 2D HD model

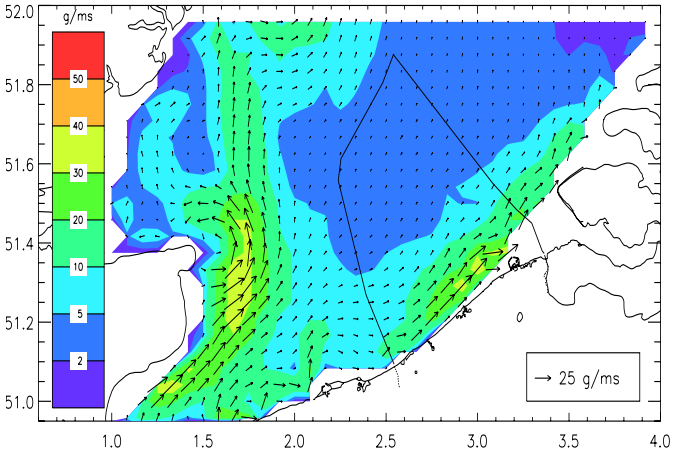
Spring



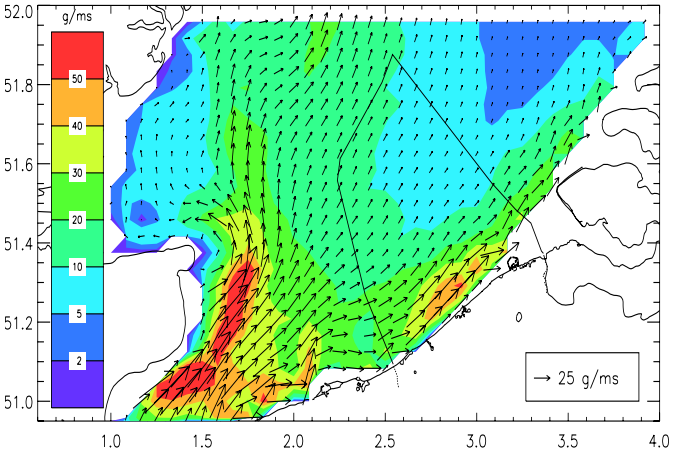
Summer



Autumn



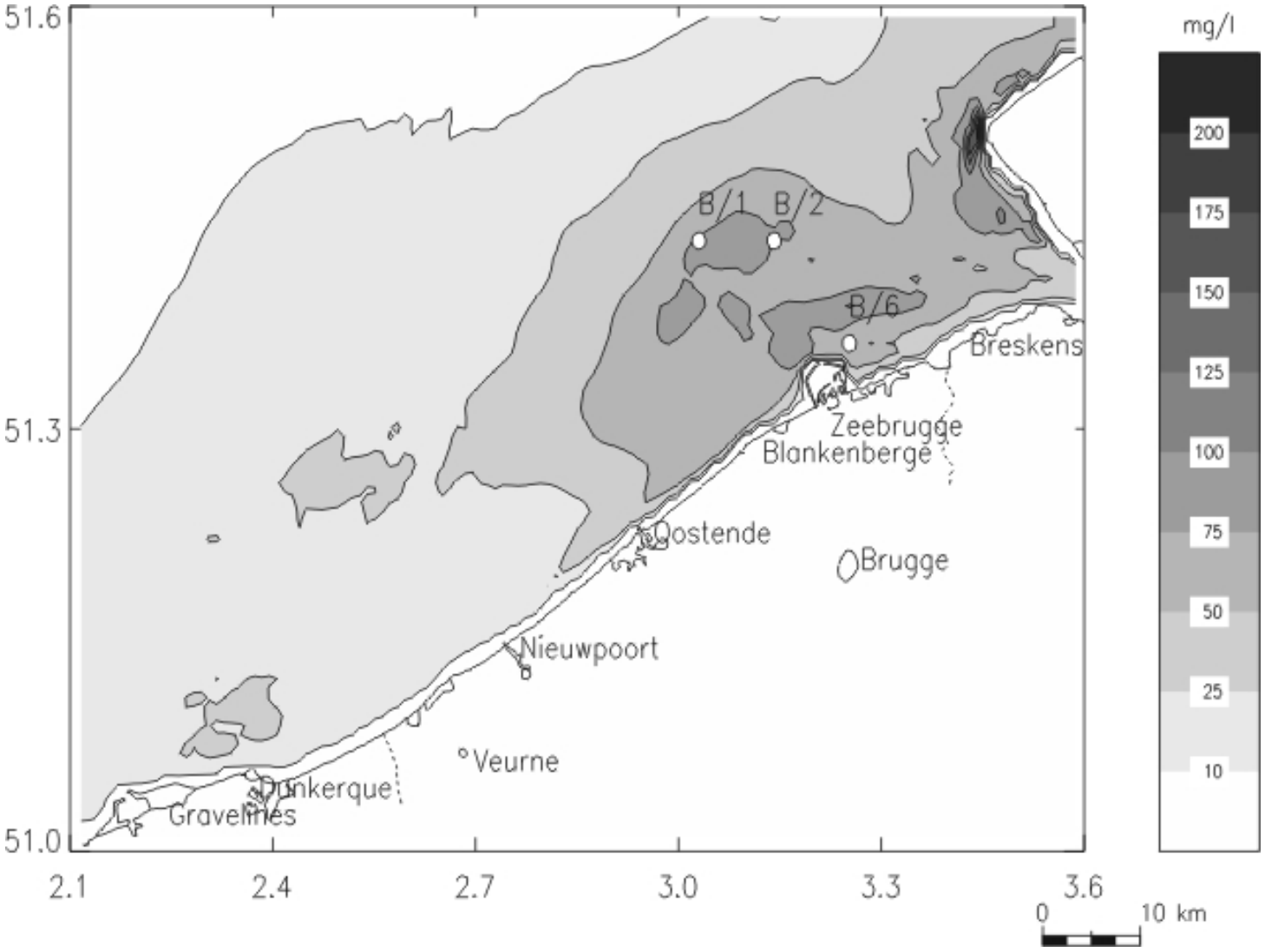
Winter



Sediment transport model mu-STM

- Advection-diffusion model for cohesive sediments, transported in the water column
- Semi-Lagrangian model – based on Second Moment Method
- Bottom stress under influence of currents and waves
- Erosion and sedimentation
- Consolidation model with different layers in the bottom
- Boundary conditions

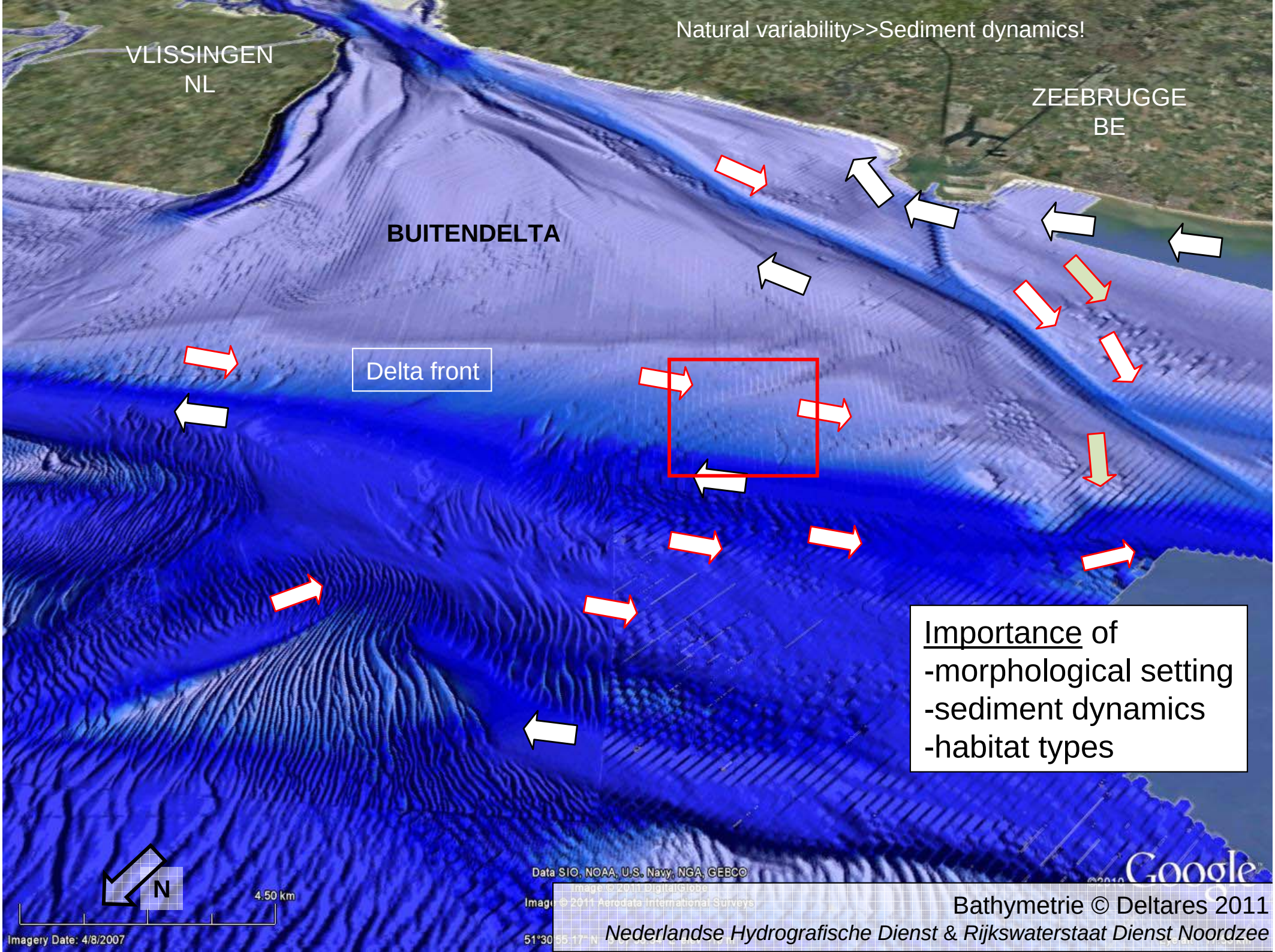
SPM distribution from mu-STM



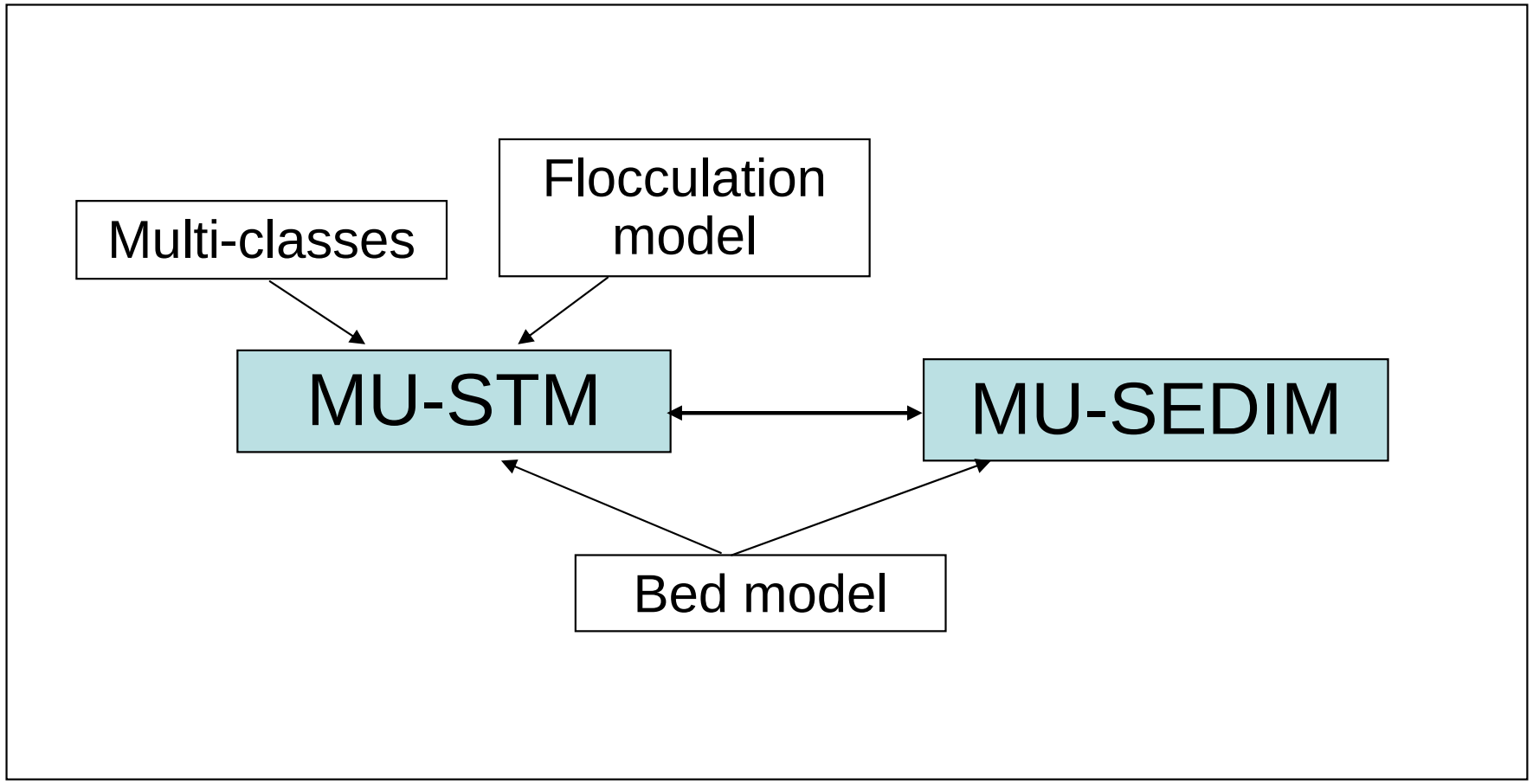
Tidally averaged SPM during spring tide

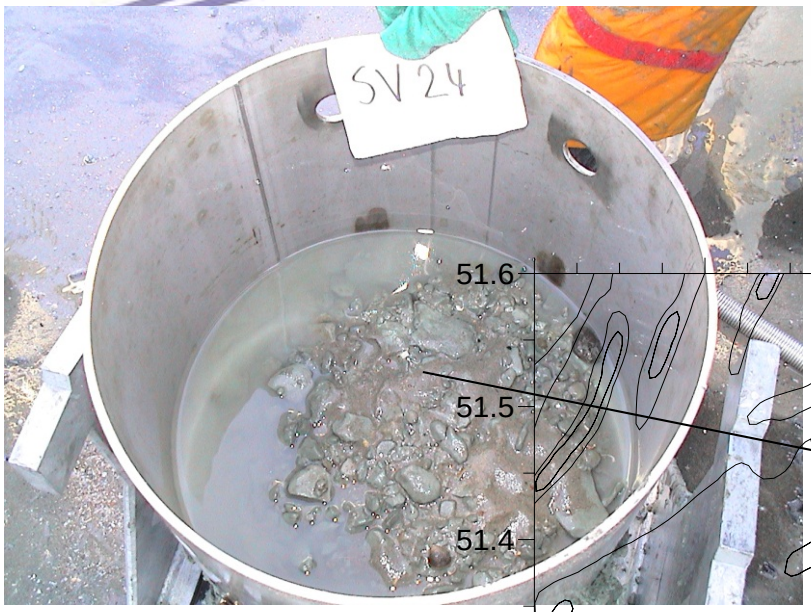
Sediment transport model mu-SEDIM

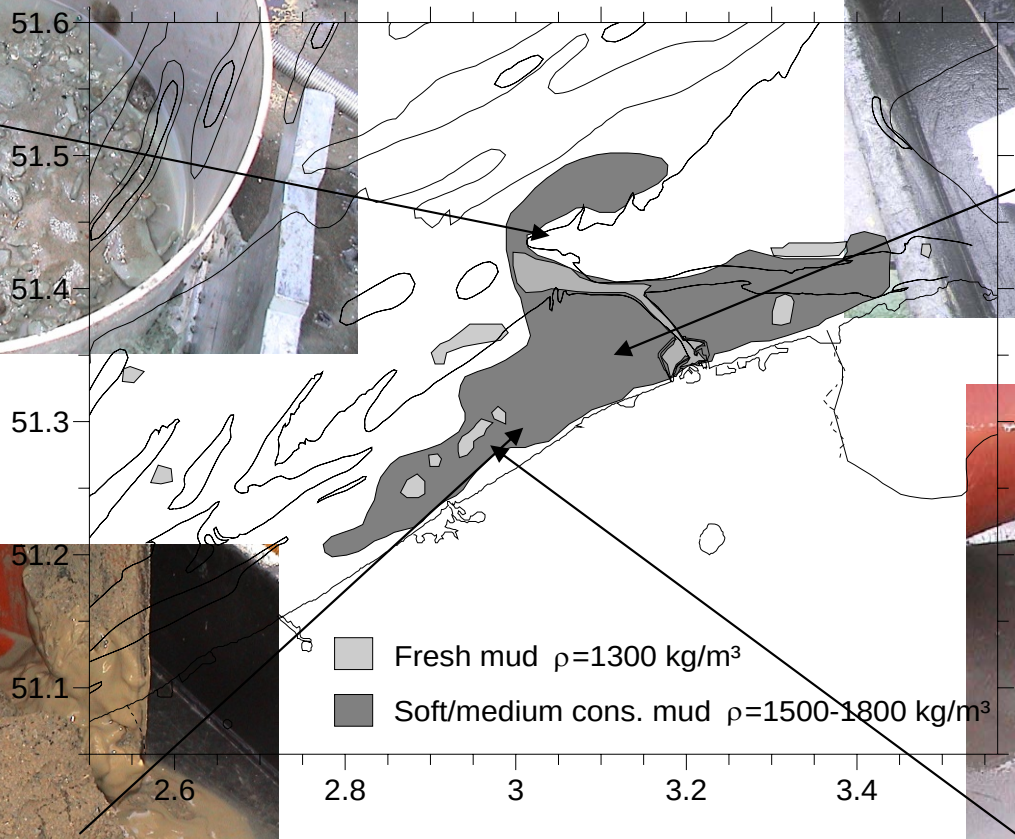
- Model for bedload or total load for calculation of sand transport
- Bottom stress as function of currents and waves: Bijker formula
- Bottom roughness
    - Skin-friction: function of grain size: Engelund-Hansen (1967), roughness by bottom load: Grant & Madsen (1982), roughness by bottom ripples: Grant & Madsen (1982), bottom ripples: Grant & Madsen (1982)
- Shields-criterium for start of sediment transport
- Different formulae for local total load
  – Ackers-White (1973) with adaptations of Swart (1976, 1977)
  – ➔ many different formulae available, results vary of orders of magnitude!
- Continuity for bottom: erosion and sedimentation

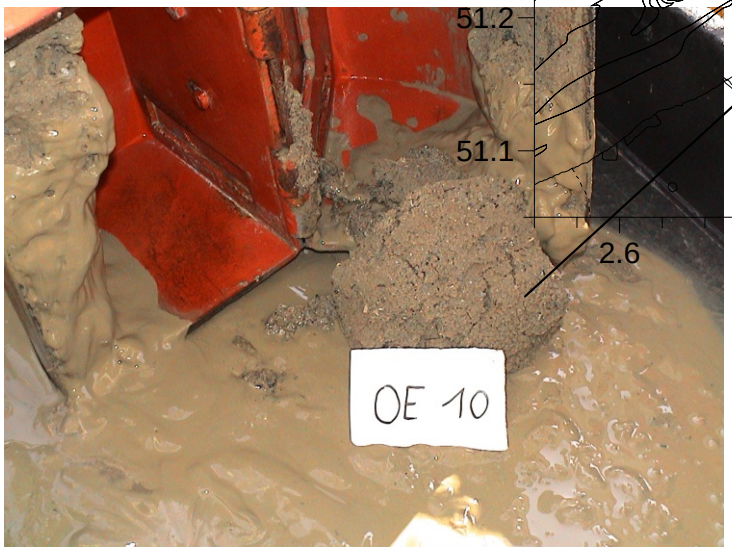

Natural variability>>Sediment dynamics!
VLISSINGEN
NL
ZEEBRUGGE
BE
BUITENDELTA
Delta front
Importance of
-morphological setting
-sediment dynamics
-habitat types
N
4.50 km
Imagery Date: 4/8/2007
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2011 DigitalGlobe
Image © 2011 Aerodata International Surveys
Google
Bathymetrie © Deltares 2011
Nederlandse Hydrografische Dienst & Rijkswaterstaat Dienst Noordzee

Q4D Sediment transport model



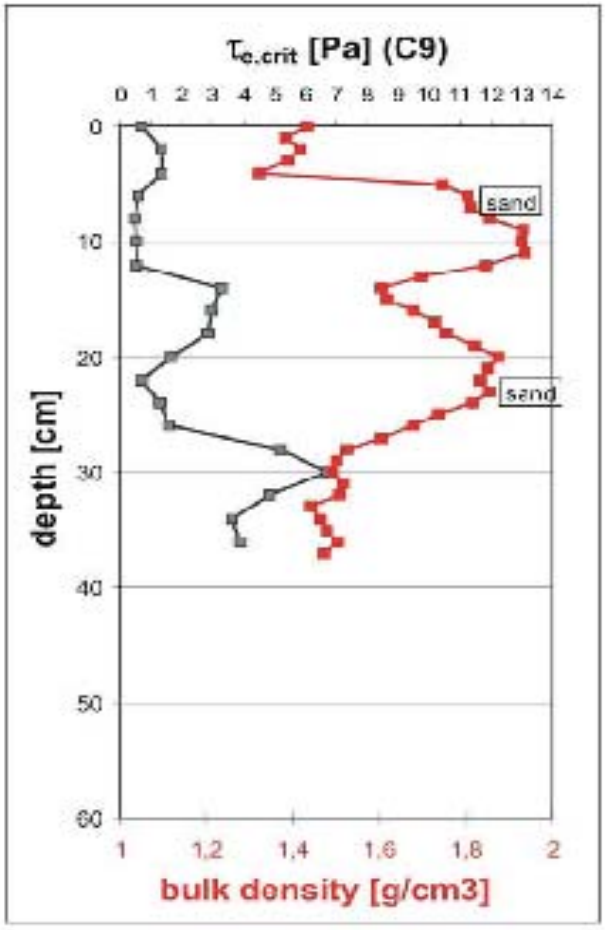

SV 24


51.6
51.5
51.4
51.3
51.2
51.1
2.6
2.8
3
3.2
3.4
Fresh mud ρ=1300 kg/m³
Soft/medium cons. mud ρ=1500-1800 kg/m³


OE 10

Critical erosion shear stress measurements
Very soft consolidated mud & mixed sediments

Very soft mud with intercalation of sand layers



- Critical shear stress: 0.5-6 Pa
- Critical shear stress decreases with increasing sand content

(carried out by Westrich & Jancke, Stuttgart Univ.)

Bed model: parent bed – active bed

In order to incorporate erosion of old sediments the bed is split in active & parent part

Active layer: consist of different sub-layers to allow consolidation of mud, washing out of mud and armouring, and segregation between sand/mud layers

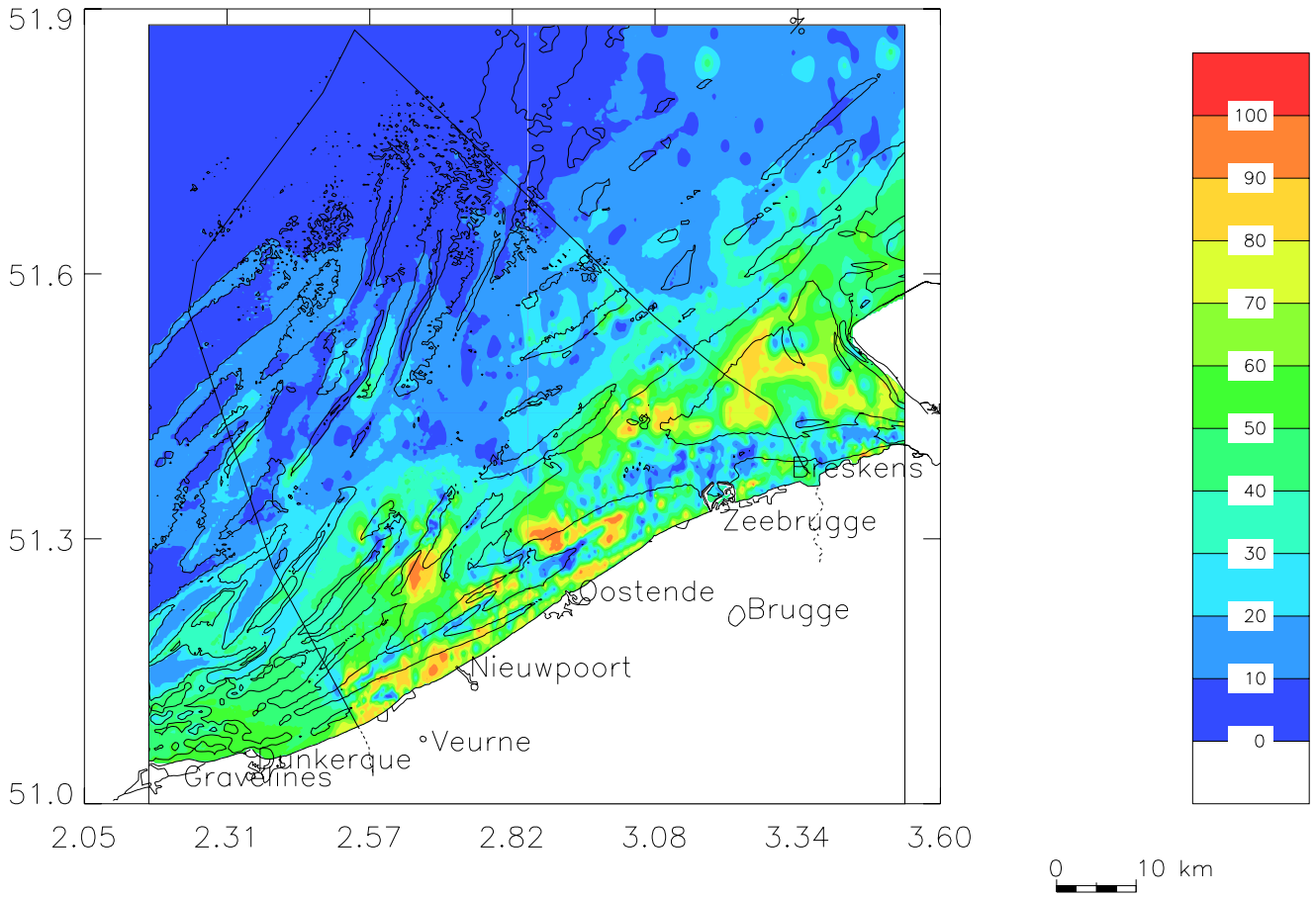
- Change sand total load to sand transport in suspension (Waeles et al., 2007)
- Deposition – indepent for each fraction
- Erosion – function of mix of sediments
- Bed model: sometimes mixing, sometimes new layer
- New consolidation/fluidisation model (A. Roels)

Parent bed: only erosion, corresponds to old sediments (Holocene, tertiary clays near surface)

- different grain size classes and critical bottom stress for erosion

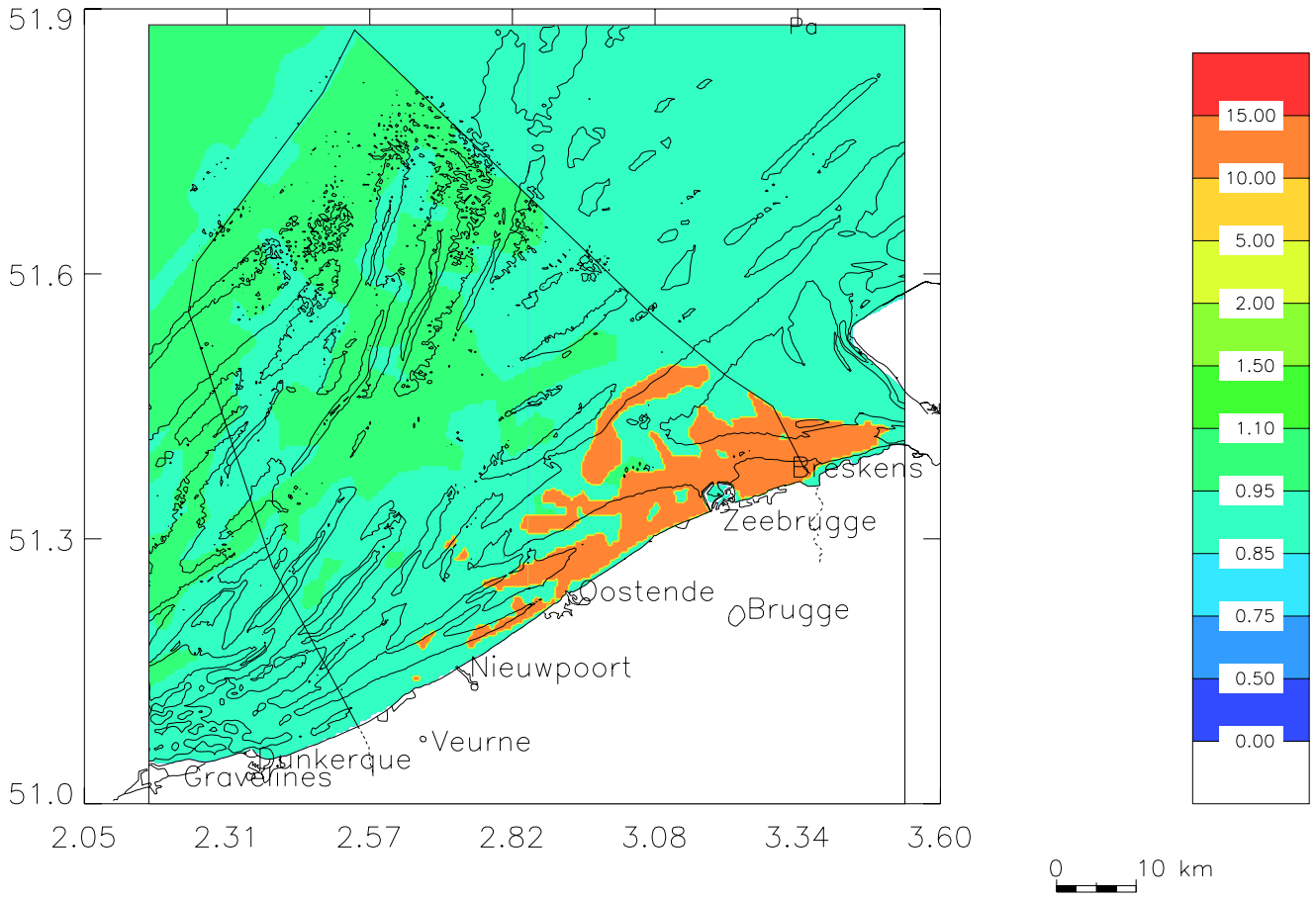
Model is set up but calibration/validation still necessary

Parent bed model: fine and coarse sand, silt and clay content



fsand_250m

Parent bed model: critical stress for erosion

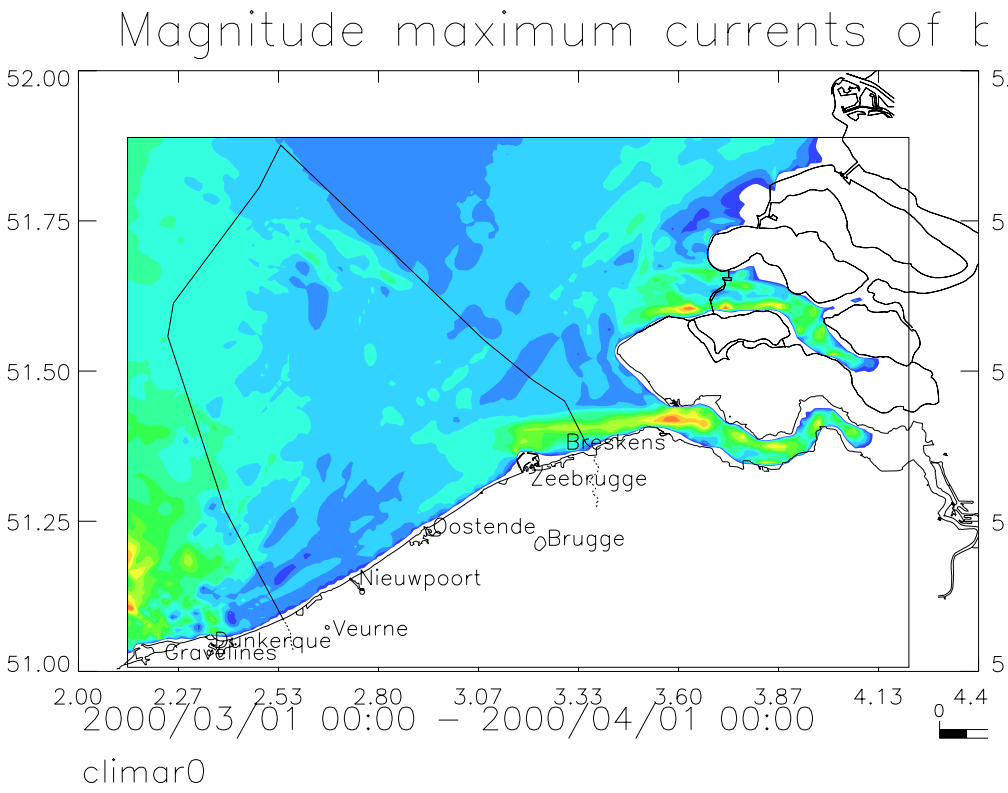


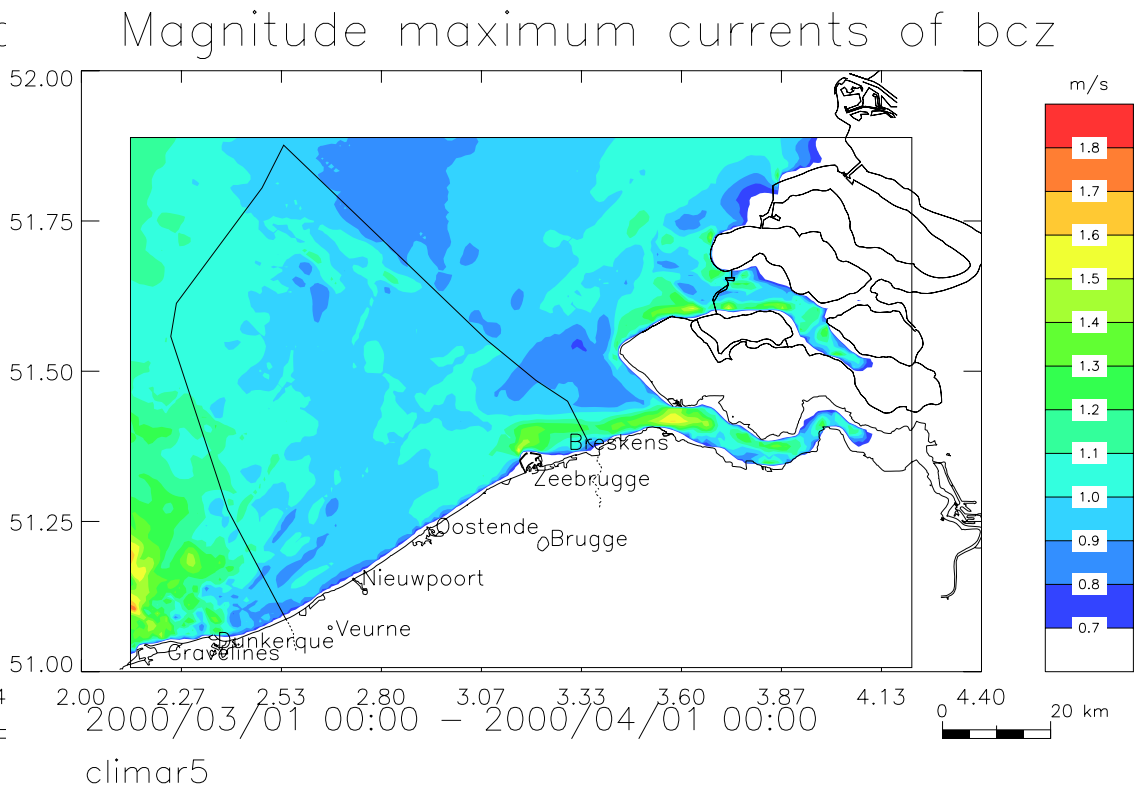
tau_ero

Scenarios 2100

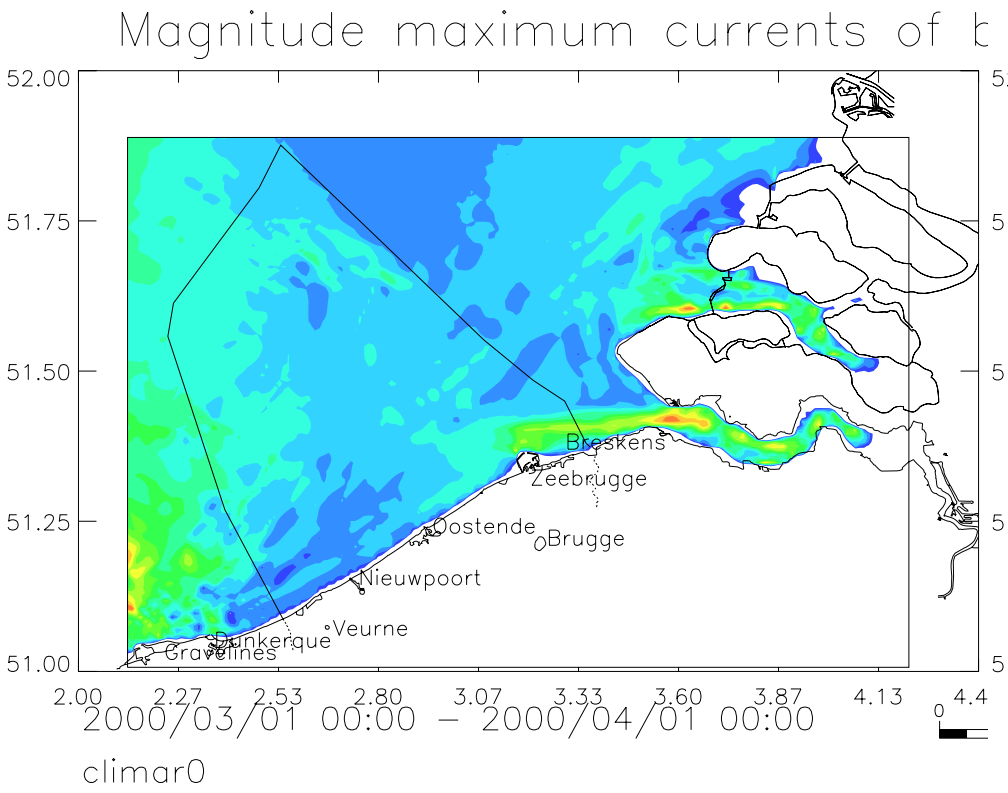
	M	M+	W	W+	Worst
Air temperature	+2 °C	+2 °C	+4 °C	+4 °C	+4 °C
Changing air circulation	No	Yes	No	Yes	Yes
Winter precipitation	+8 %	+14 %	+16 %	+28 %	+28 %
Summer precipitation	+6 %	-20 %	+12 %	-40 %	-40 %
Wind speed	+0 %	+4 %	-2 %	+8 %	+8 %
Sea water temperature	+2,5 °C	+2,5 °C	+3,5 °C	+3,5 °C	+3,5 °C
Sea level	+60 cm	+60 cm	+93 cm	+93 cm	+200 cm

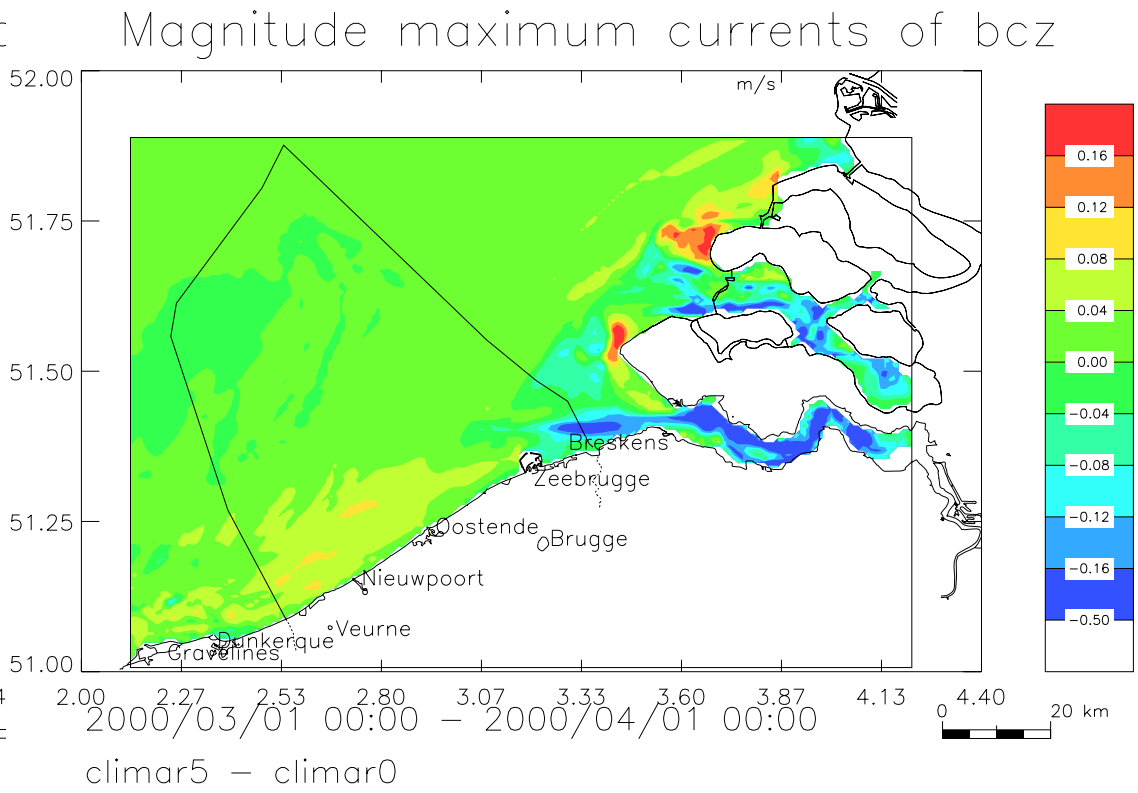
Impact on currents



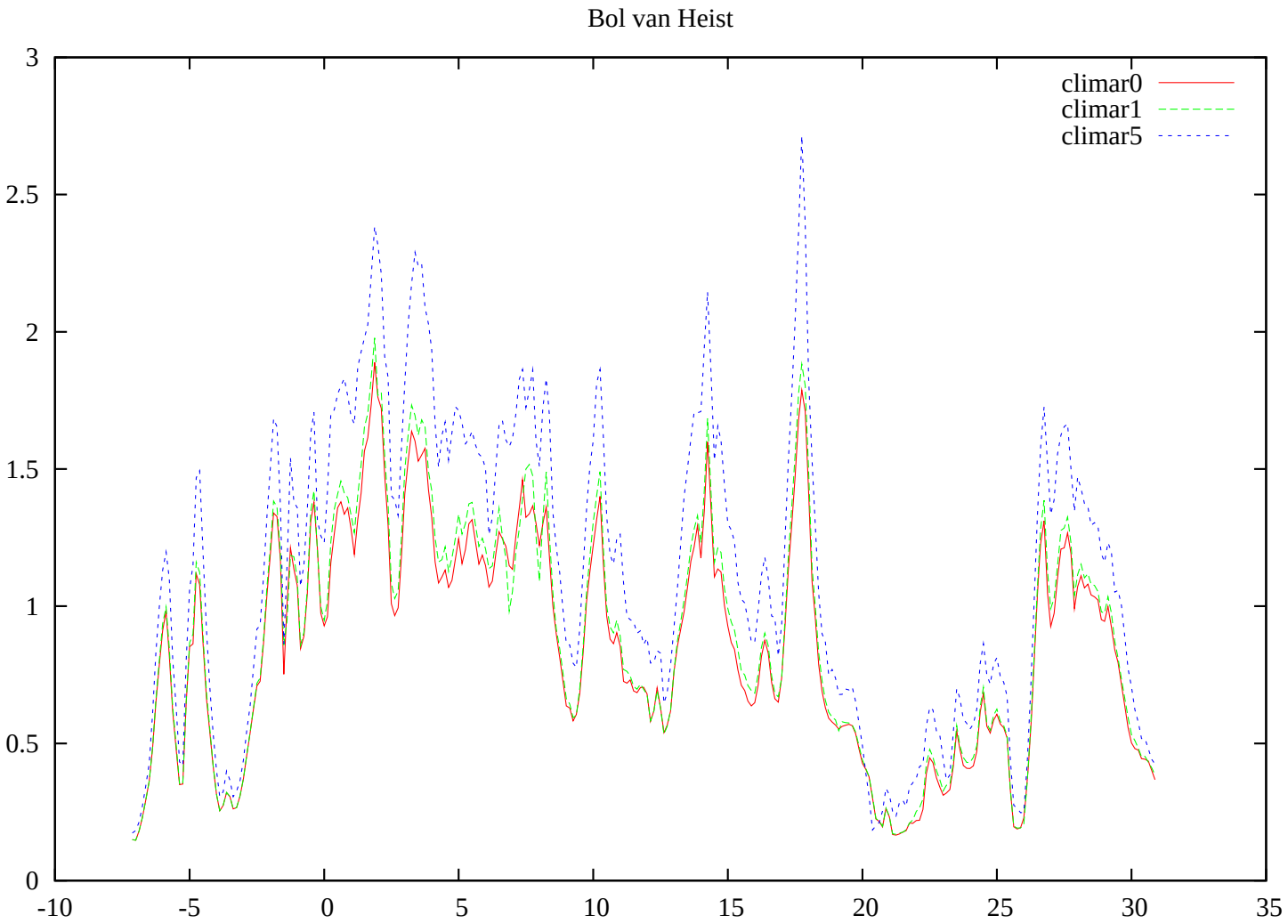


Impact on currents



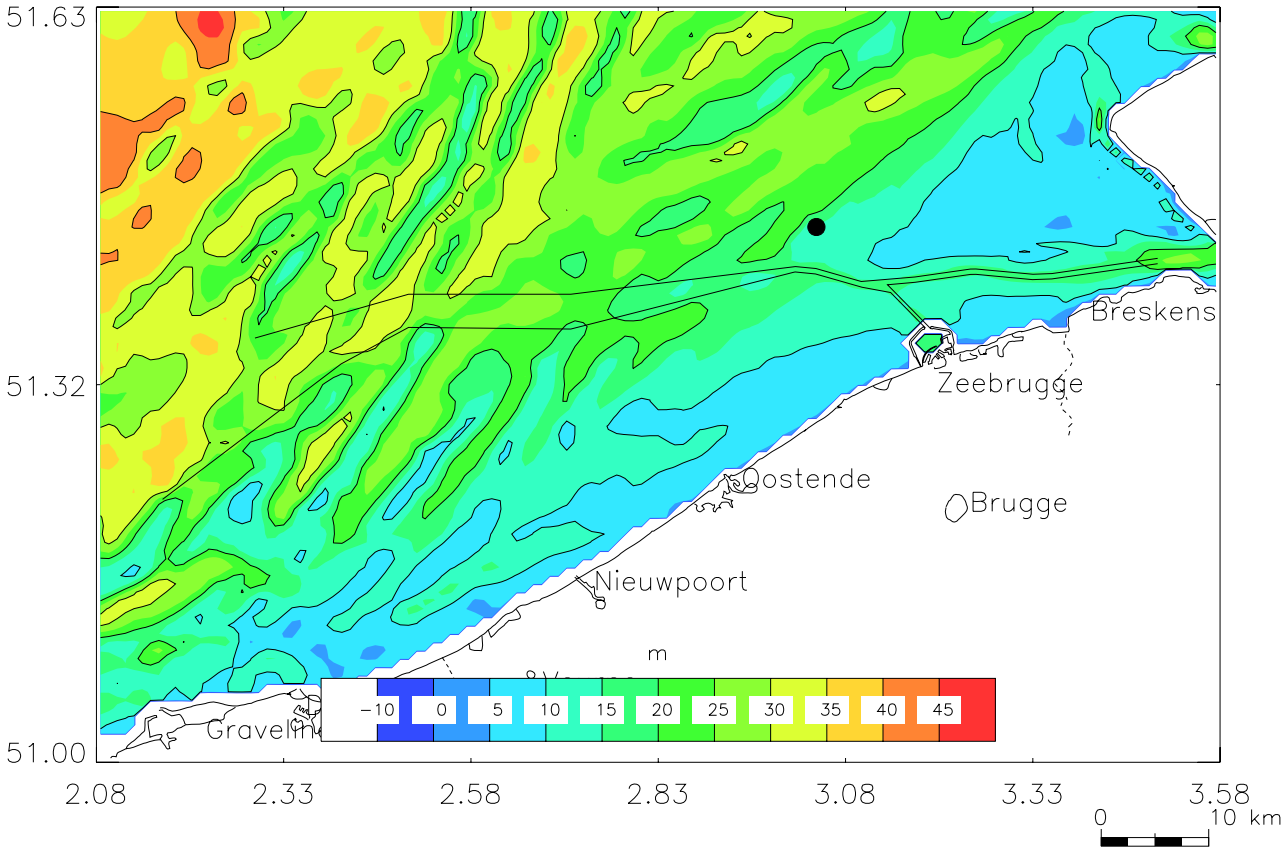


Impact on waves



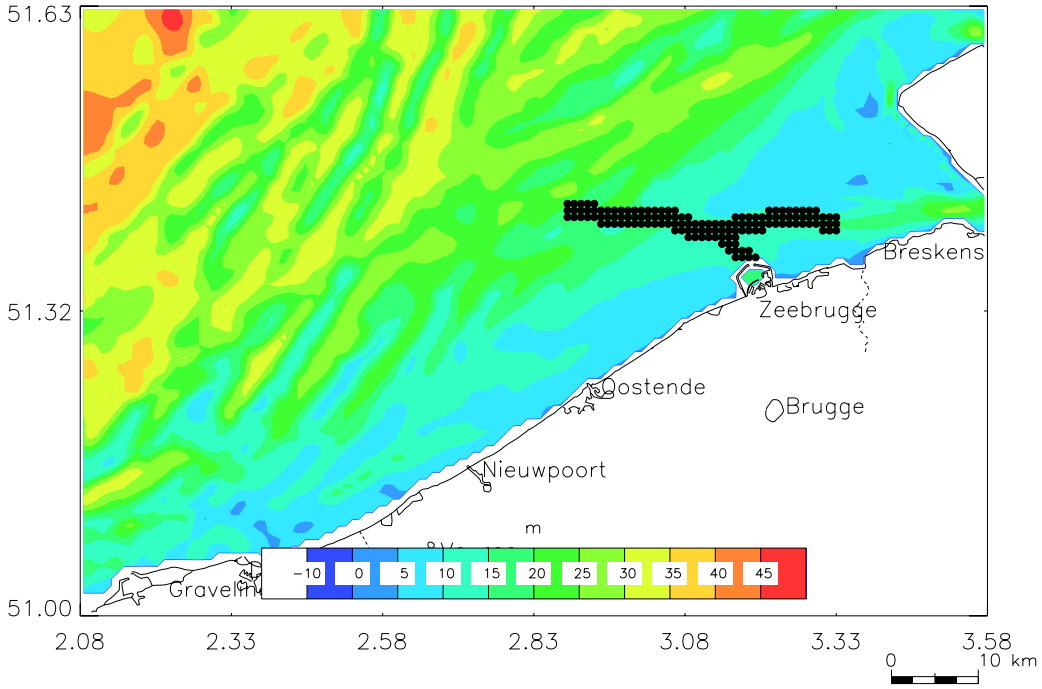
Bol van Heist + 82 cm

Impact on siltation

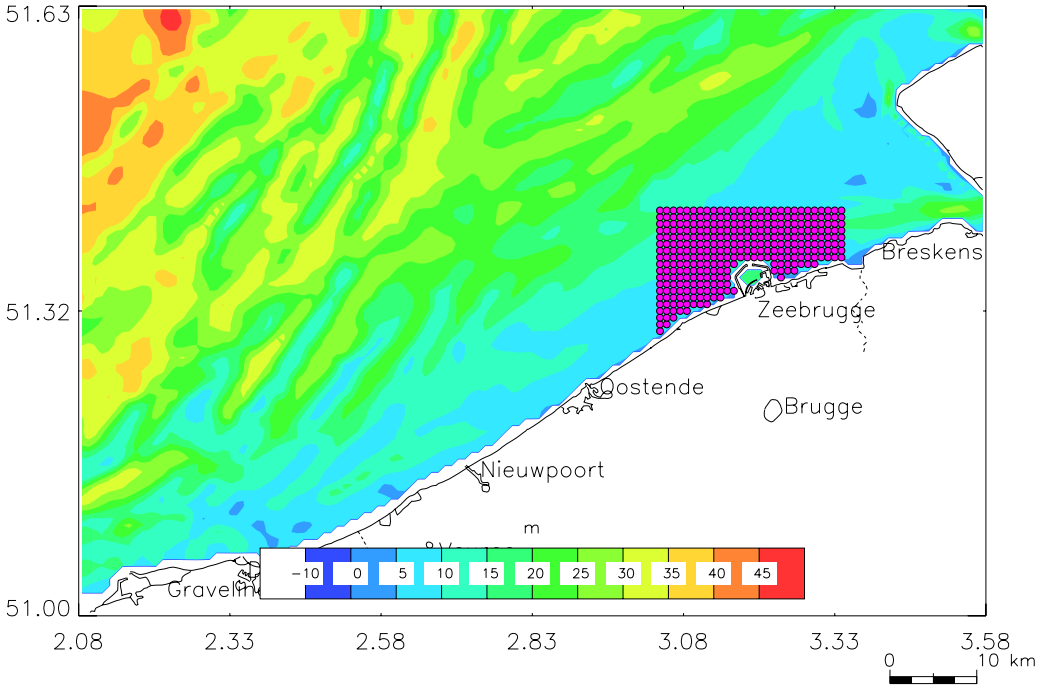


- Run 1: hourly dumping of material during one month
- Run 2: one big dumping
- Run 3: no dumping, but boundary conditions at open sea boundaries

Impact on siltation

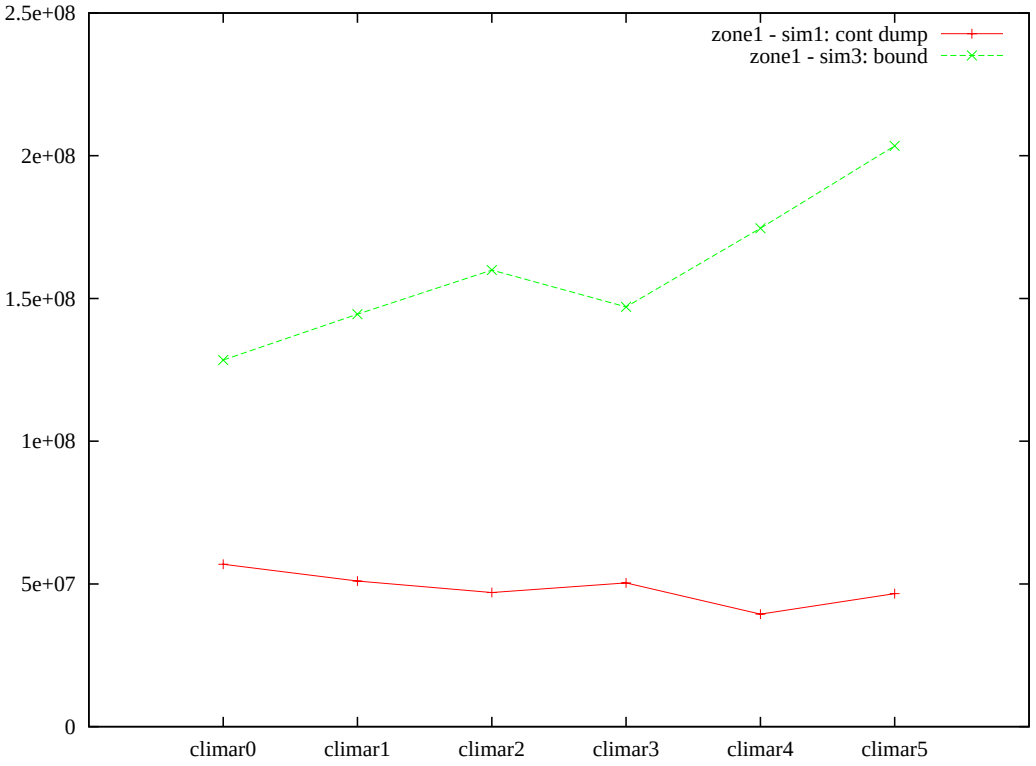


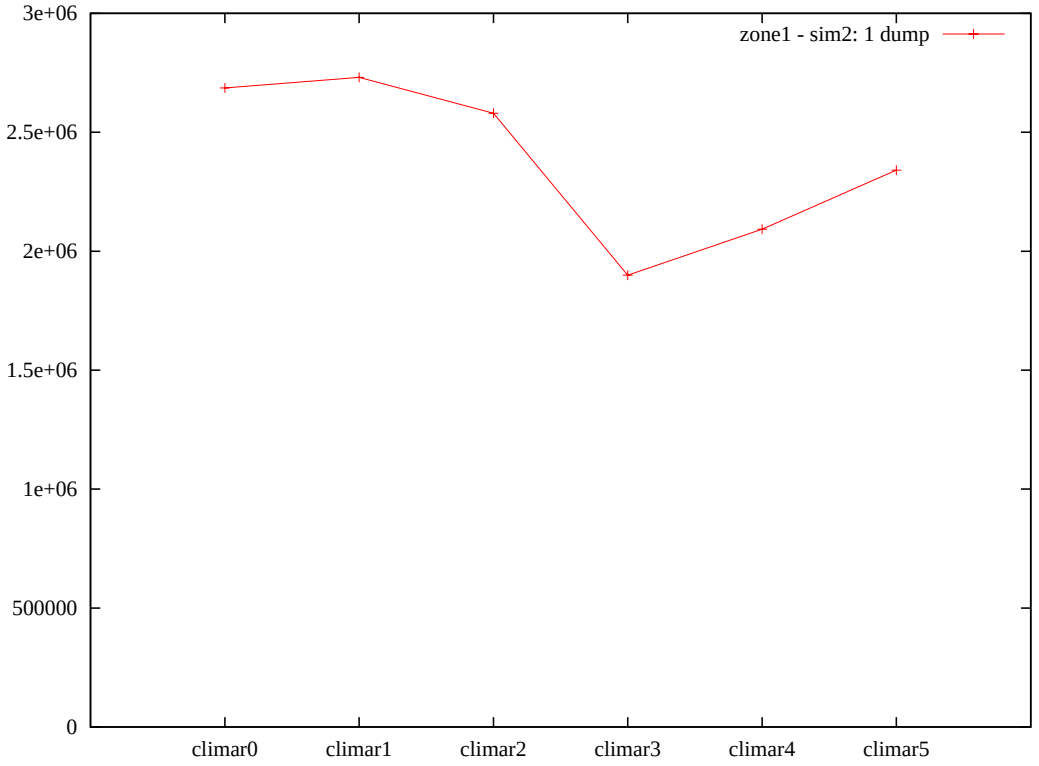
Zone 1: fair channels



Zone 2: area around Zeebrugge

Impact on siltation in fair channels





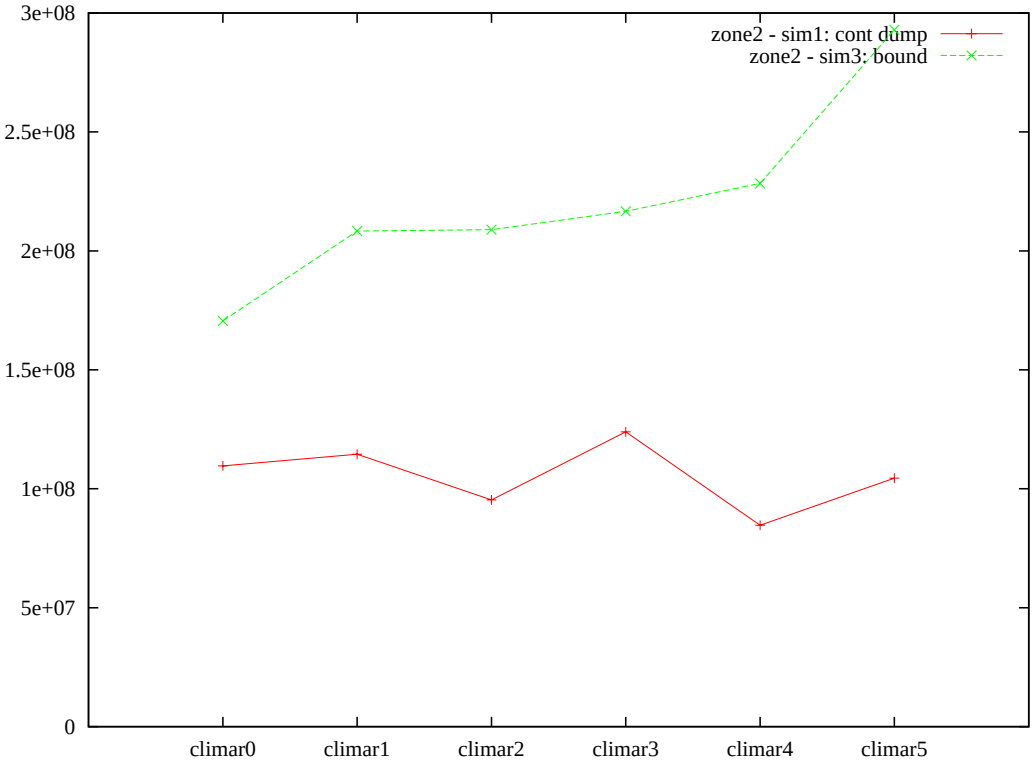
Zone 1: Fair channels

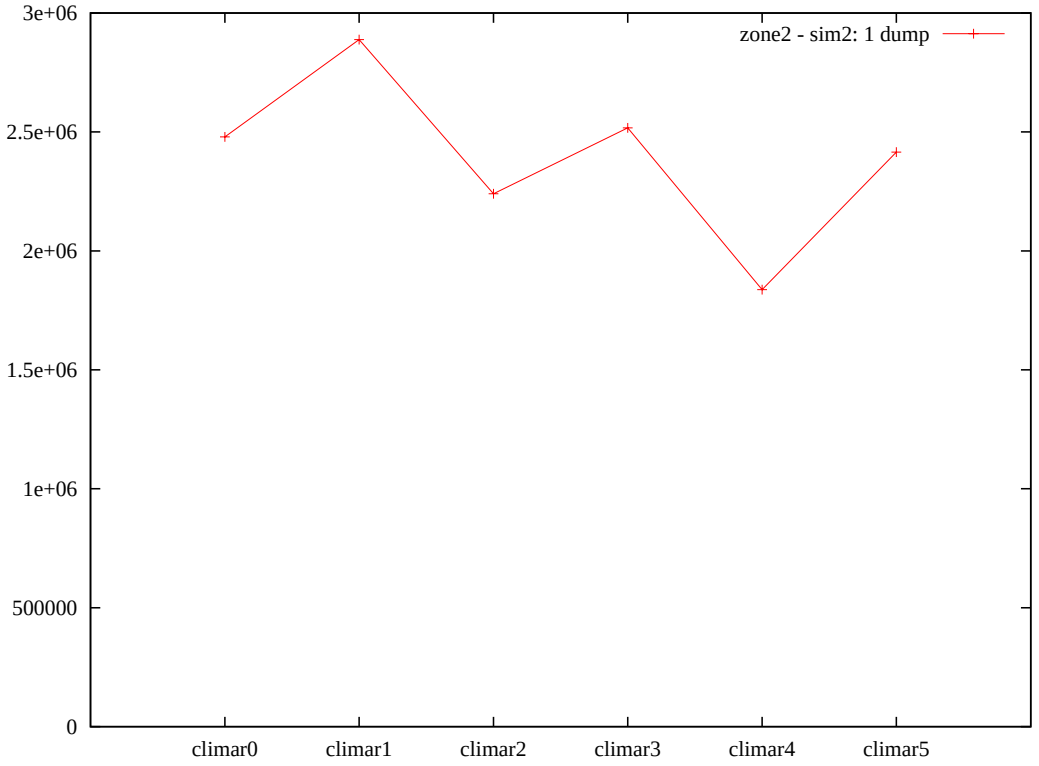
Red: continuous dumping

Yellow: boundaries

Red: one dumping

Impact on siltation in area around Zeebrugge





Zone 2: area round Zeebrugge

Red: continuous dumping

Yellow: boundaries

Red: one dumping