Deltares
Enabling Delta Life

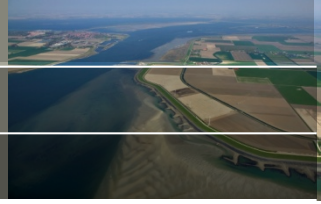
Impact-Based Forecasting and Risk-Based Warnings

Stakeholders Workshop, Maldives

Reimer de Graaff

6 oktober 2016

Flood (hydrodynamic) modelling



The modelling of water levels, currents, waves and flooding during severe weather conditions or tsunamis.

… is very powerful as it:

- integrates data from various sources (global models, measurements)
- can give timely forecasts or assess risk maps
- can help to better understand / teach the physics
- can be updated with new models, bathymetric surveys, computer capacity, etc.
- can be extended to include e.g. sediment transport, water quality, spills, etc.
- can be used to assess worst-case or what-if scenarios

… but, as part of impact-based forecasting:

- should be in place before integrated in forecasting
- should be able to give quick and accurate predictions
- should be robust
- should be easy to use / hand-over

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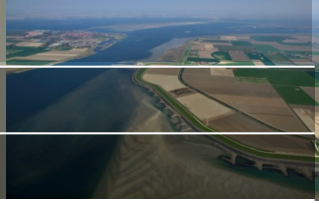

- Brief Introduction Deltares
- Hydrodynamic modelling software
  - Delft3D / DFLOW-FM
  - SWAN / XBeach
  - Delft-FEWS
- Examples Flood Forecasting systems
  - North Sea
  - Arabian Gulf
  - Singapore
- Options for modelling in the Maldives

Deltares

Brief introduction to Deltares

Deltares is an independent institute for applied research in the field of water, subsurface and infrastructure.

- applied research & specialist consultancy

- main focus on deltas, coastal regions and river basins
- extensive hydraulic/geotechnical laboratories and computer modeling facilities
- open-source policy: “dare to share”

- > 800 academic staff
- main office in Delft, The Netherlands
- branch offices in Singapore, USA, Jakarta, Abu Dhabi, Rio de Janeiro

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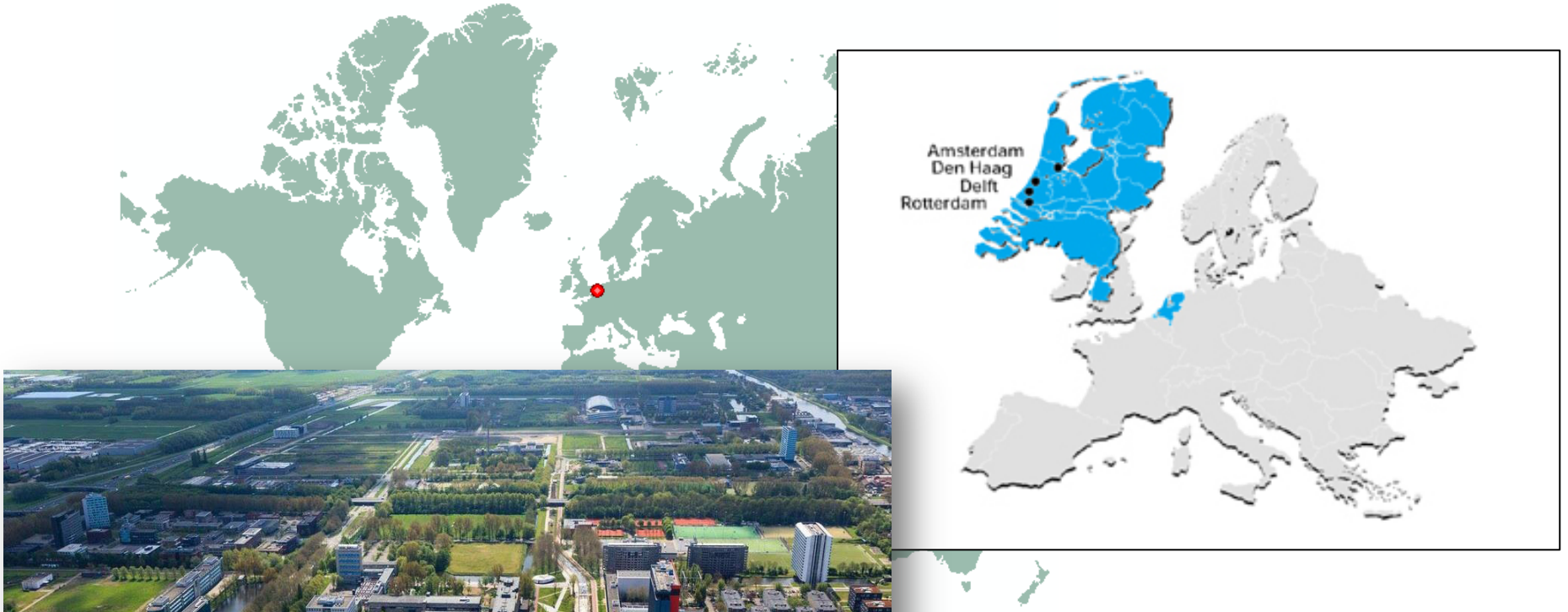
Delft, The Netherlands



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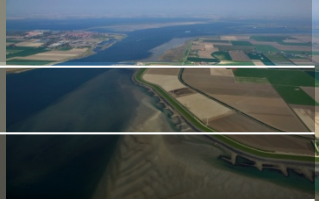
Deltares software programmes



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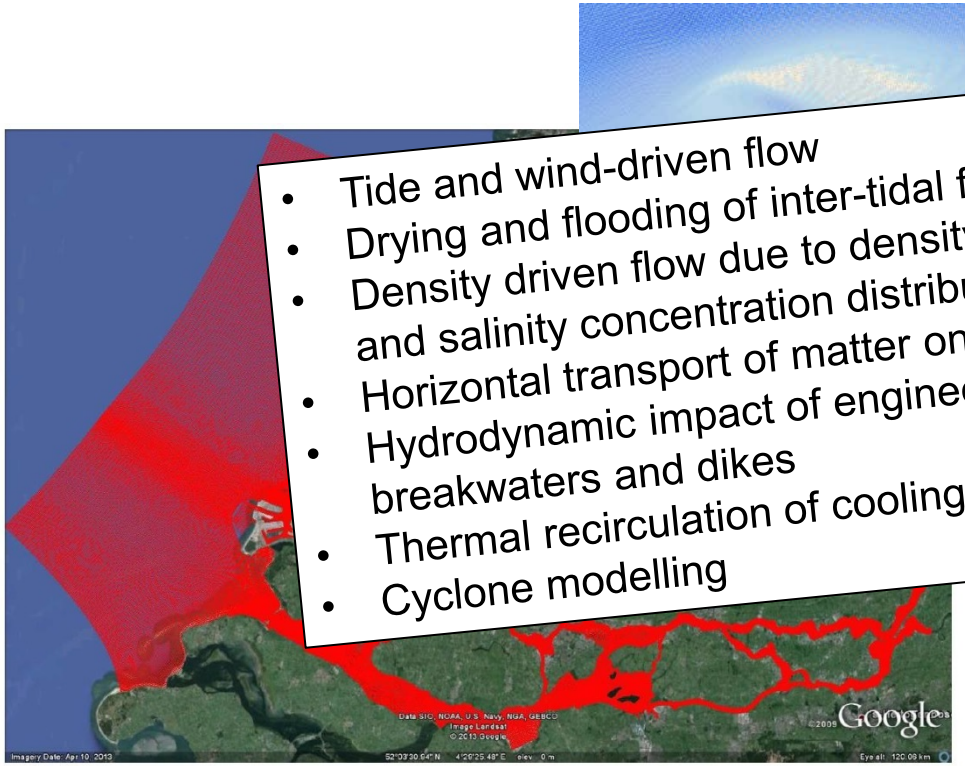
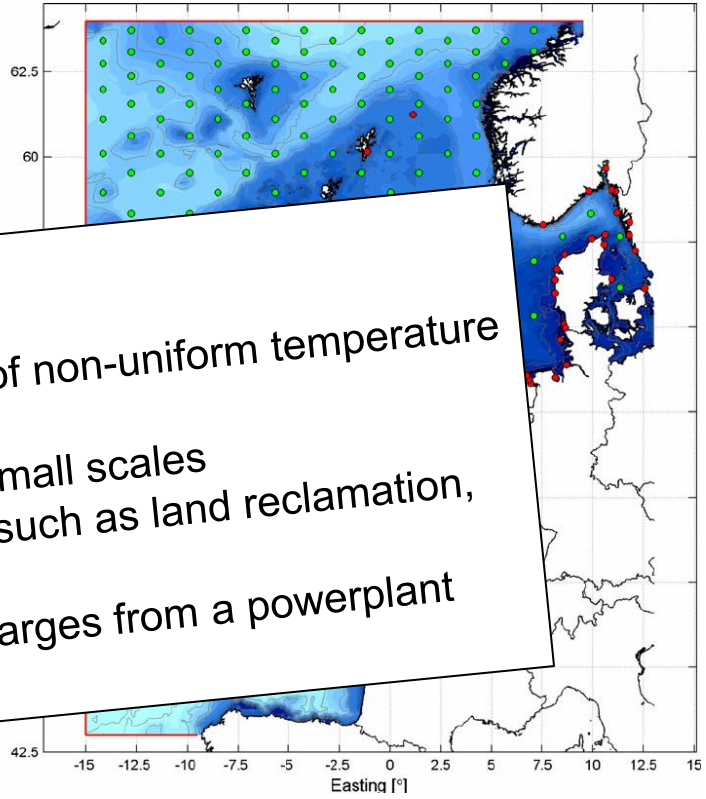
Delft3D – hydrodynamic model

- Integrated 2D and 3D modelling of water levels, currents, waves, sediment transport, seabed changes, water quality and ecology
- Areas of application: marginal seas, estuaries, rivers, lakes
- Recti- and curvilinear grids
- Open Source software



- Tide and wind-driven flow
- Drying and flooding of inter-tidal flats
- Density driven flow due to density gradients of non-uniform temperature and salinity concentration distributions
- Horizontal transport of matter on large and small scales
- Hydrodynamic impact of engineering works such as land reclamation, breakwaters and dikes
- Thermal recirculation of cooling water discharges from a powerplant
- Cyclone modelling



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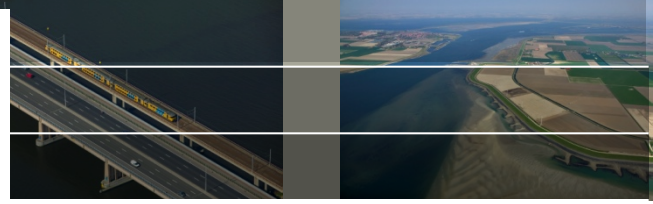
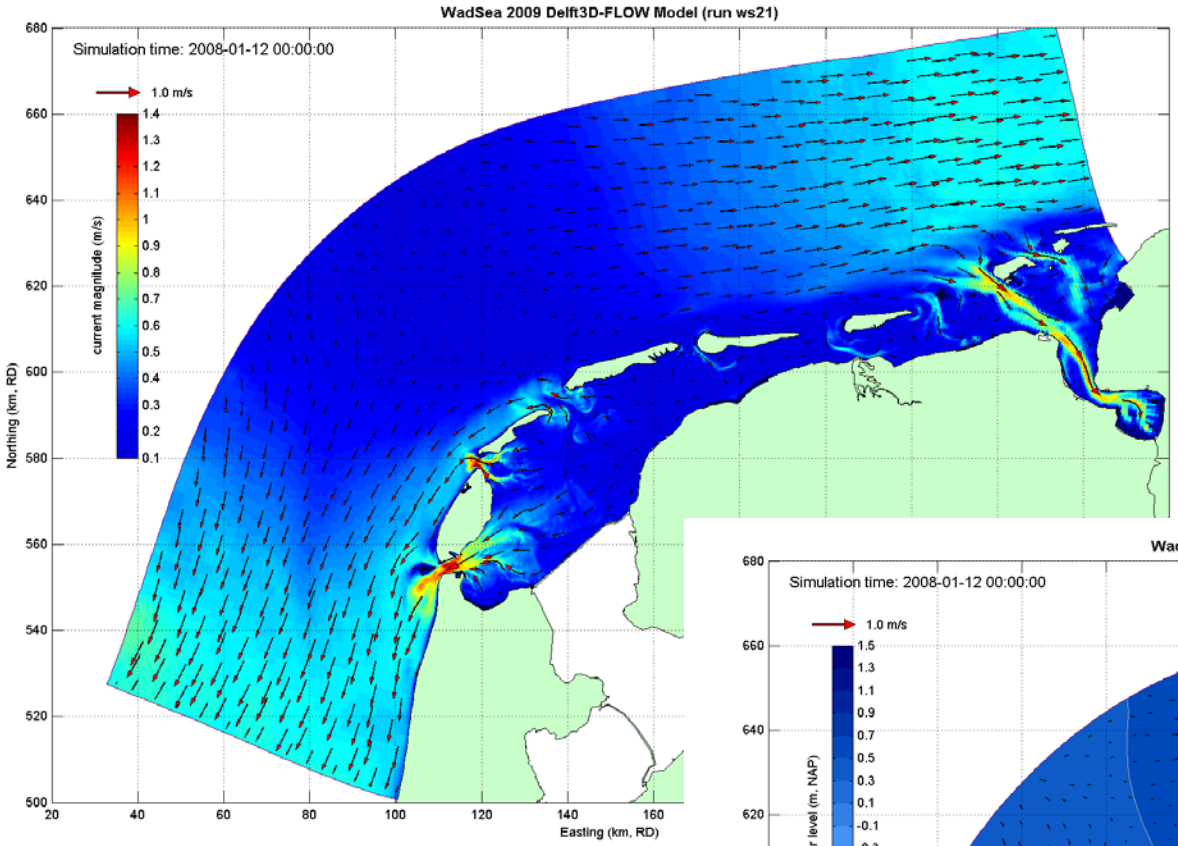
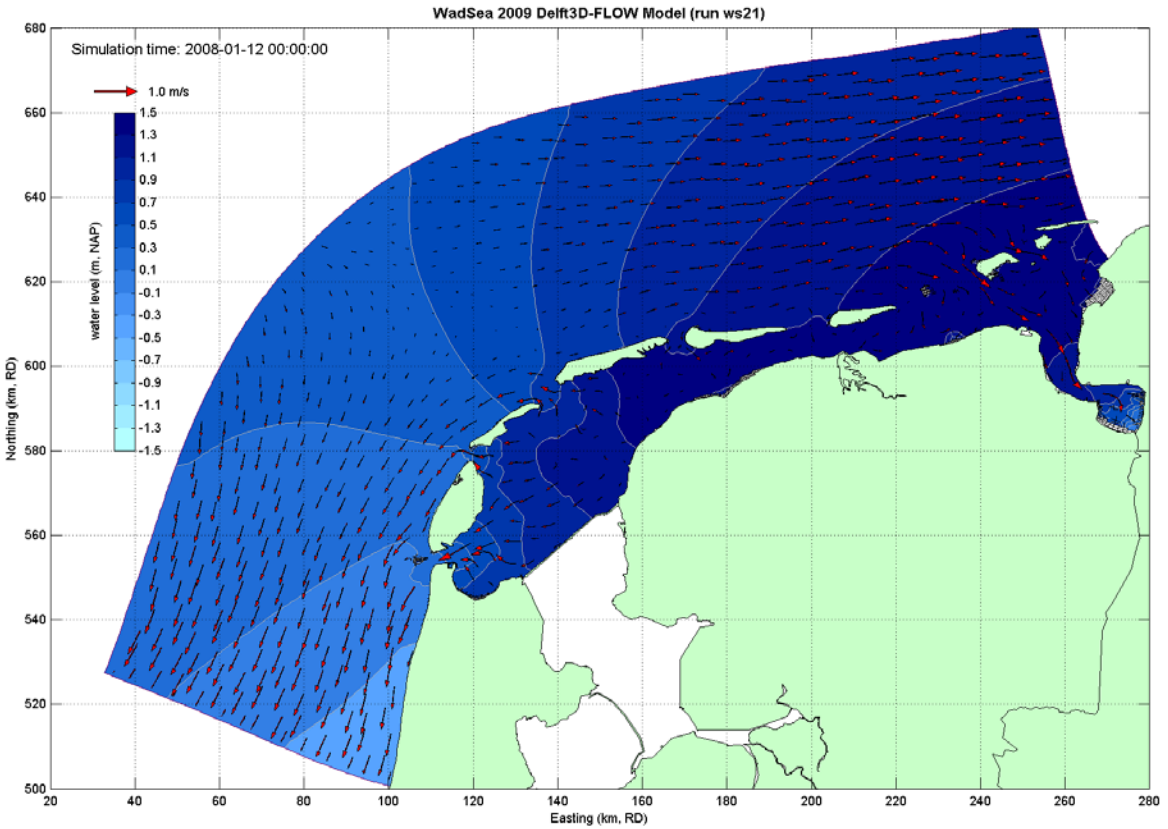



WadSea 2009 Delft3D-FLOW Model (run ws21)
Simulation time: 2008-01-12 00:00:00
1.0 m/s
current magnitude (m/s)
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Northing (km, RD)
Easting (km, RD)
680
660
640
620
600
580
560
540
520
500
20
40
60
80
100
120
140
160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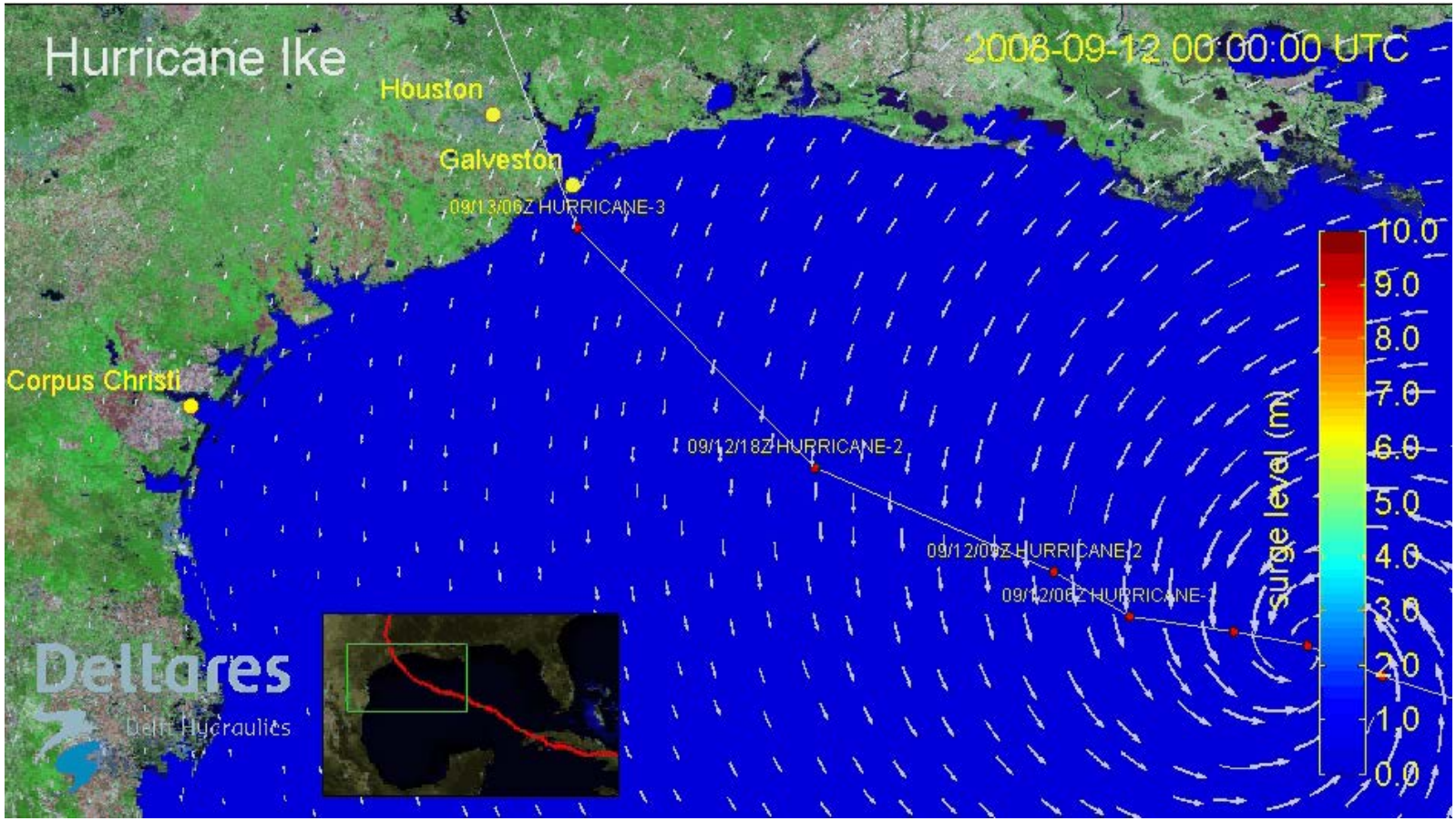
260
280

Cyclone modelling (incl. inundation)



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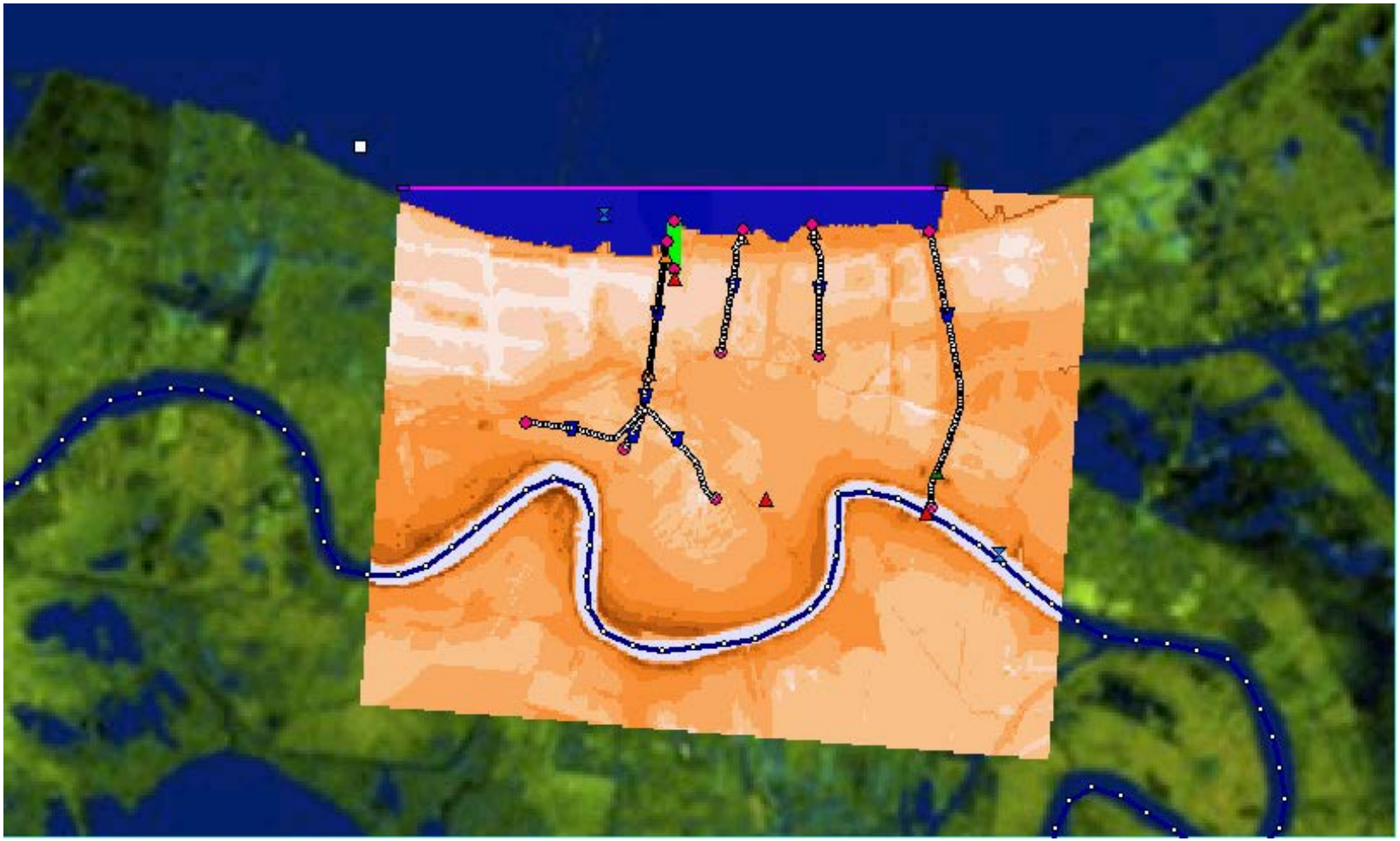

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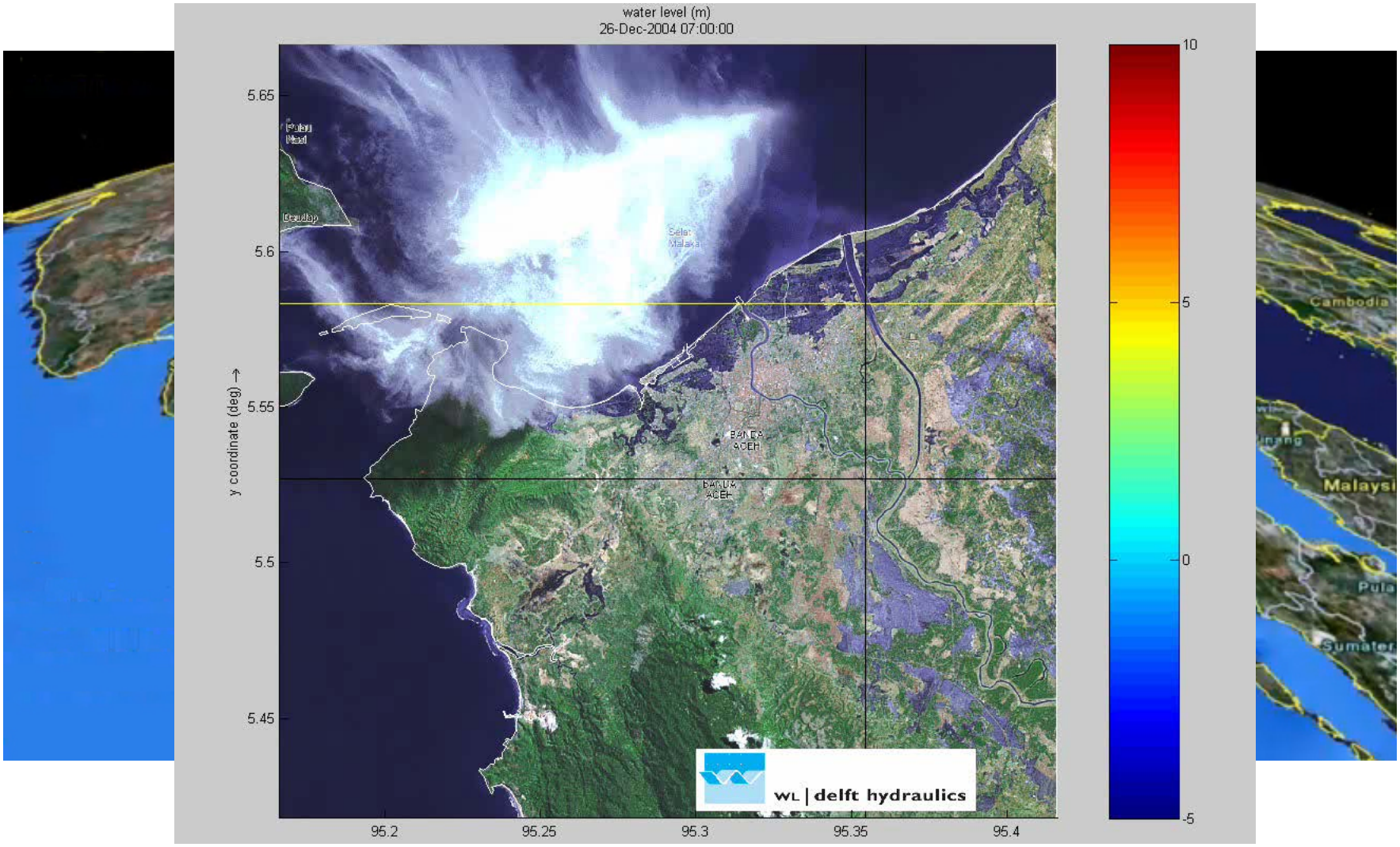
Tsunami modelling (incl. inundation)



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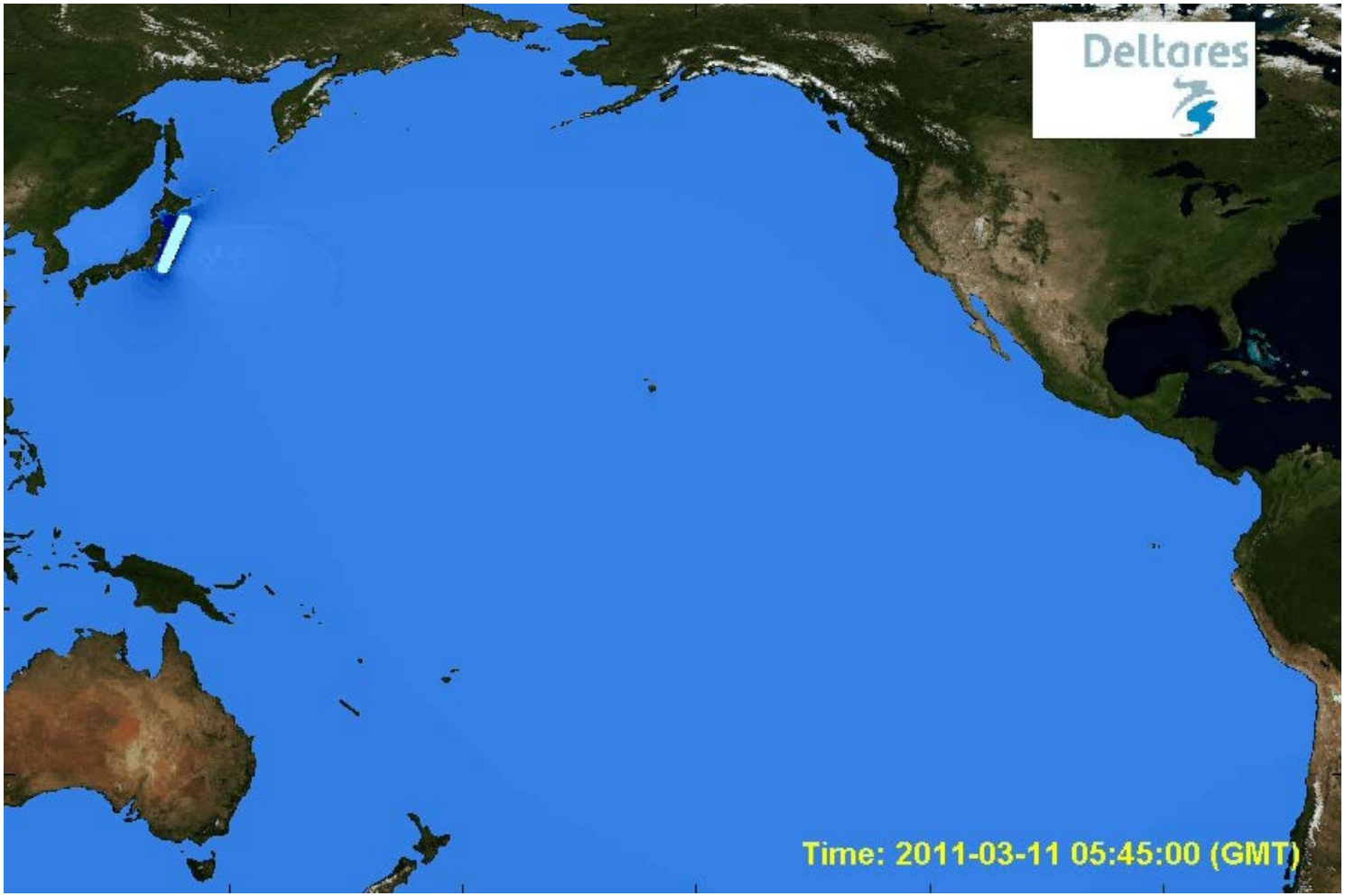

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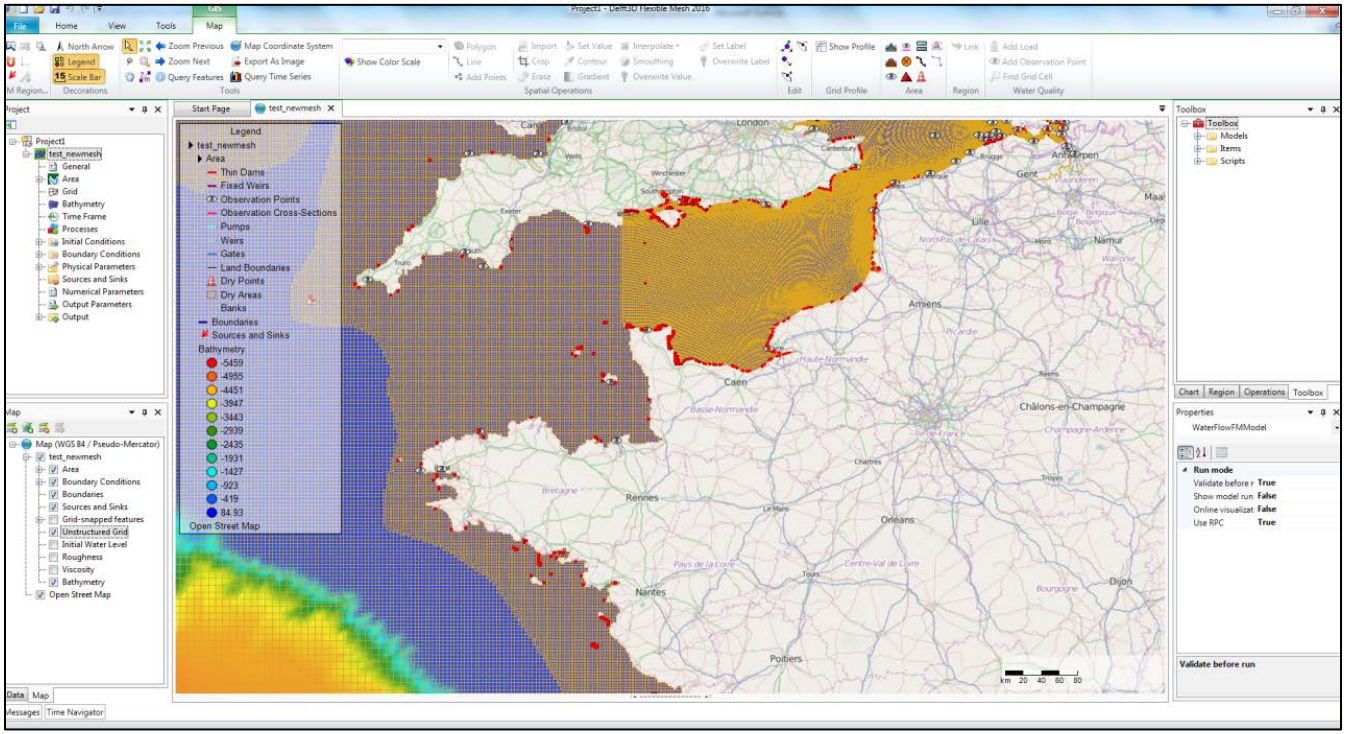
Deltares software – Delft3D-Flexible Mesh

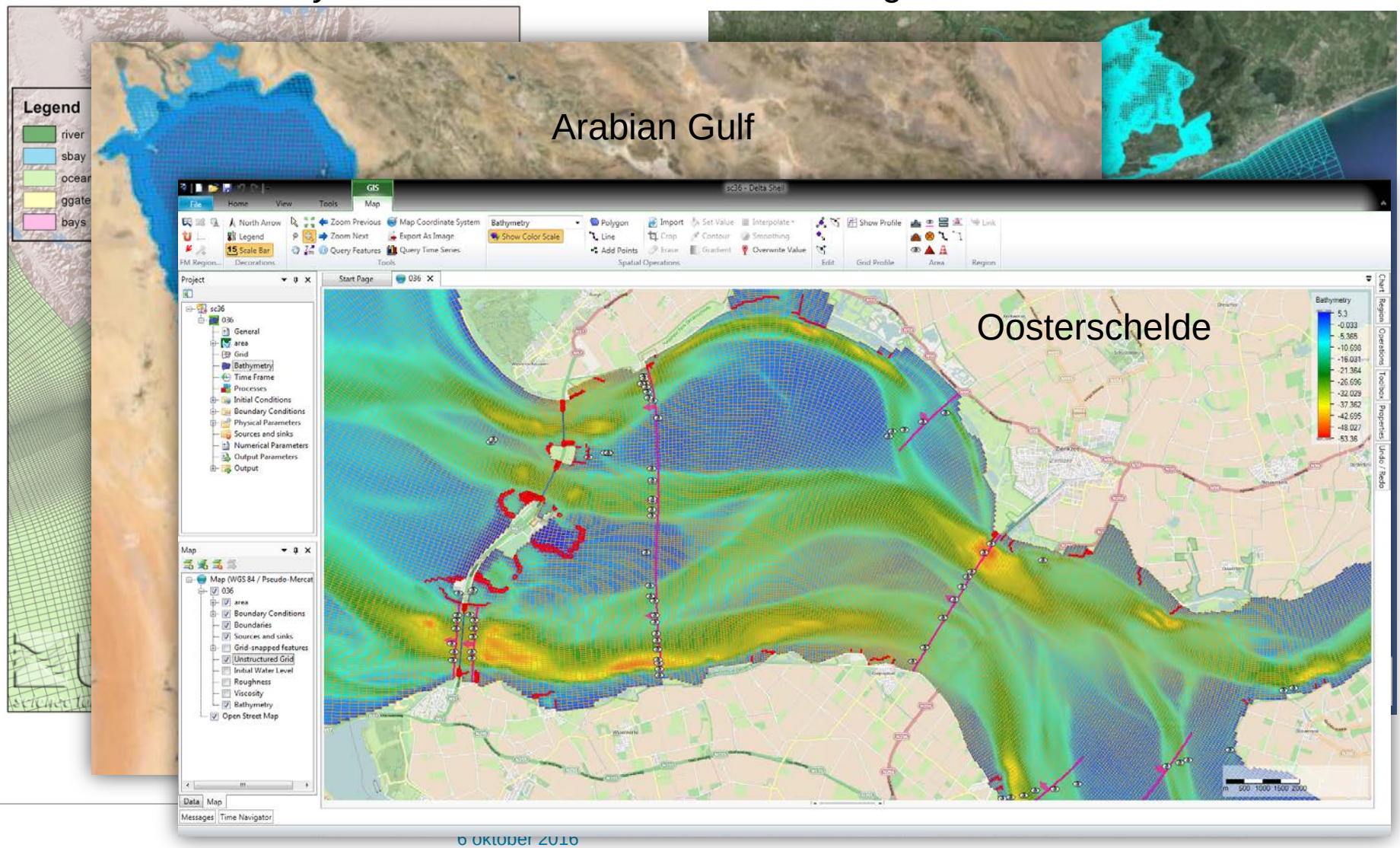
- Delft3D Flexible Mesh (FM) is the new software engine
- successor of Delft3D 4.01, launched in Nov 2015
- for hydrodynamic, sediment transport, morphodynamic, water quality and ecology simulations on unstructured grids in 1D-2D-3D
- optimal modelling flexibility and parallel computing



FM model examples

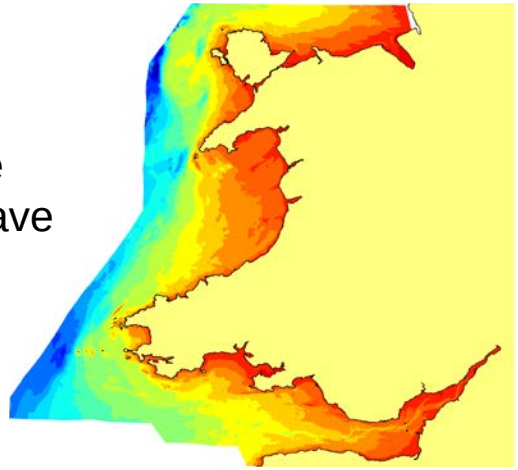
San Francisco Bay

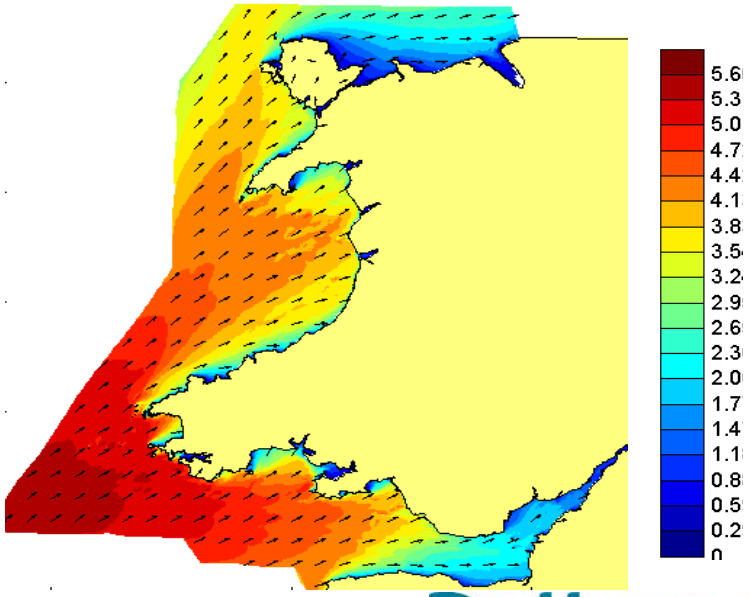
Venice Lagoon



SWAN wave model

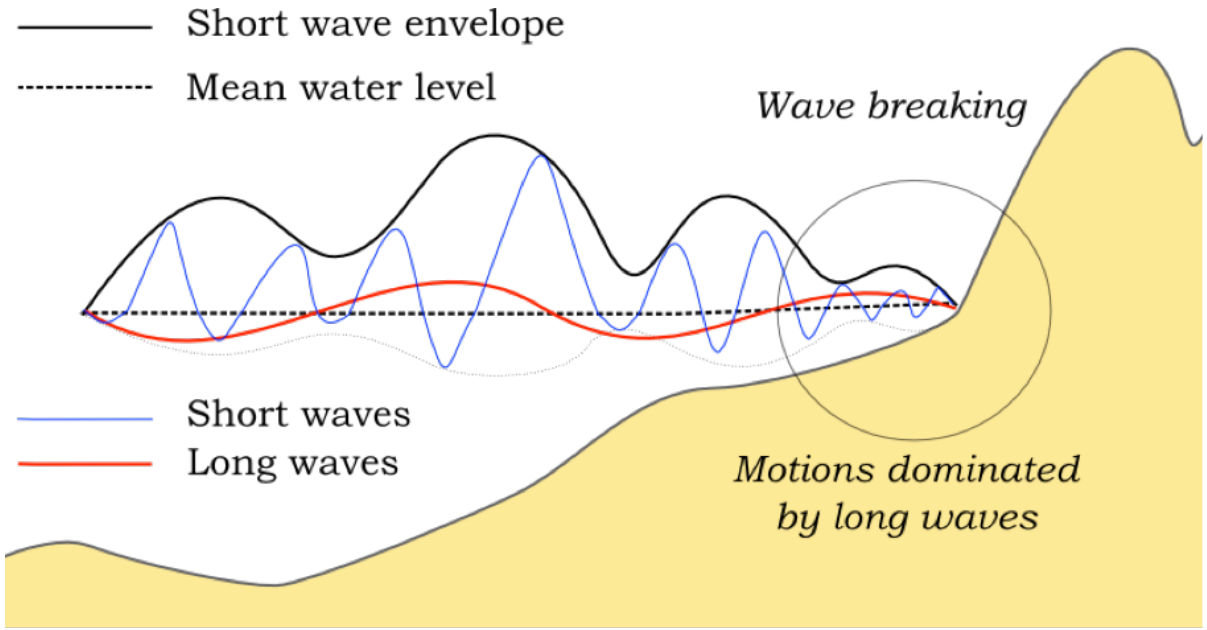
- Shallow-water wave modelling
- SWAN: developed by TU Delft, in cooperation with Deltares
- Wave propagation, wave growth, refraction, breaking, wave-wave interaction, dissipation (e.g. mud, vegetation) wave set-up and wave reflection
- Stationary and non-stationary simulations
- Generation, propagation and dissipation of waves
- Combined sea and swell waves
- Dynamic coupling with Delft3D modules

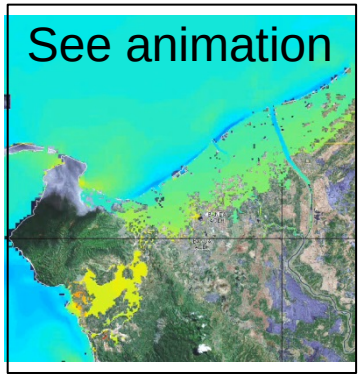




XBeach model

- New open-source numerical model
- for wave propagation, long (infragravity) waves and mean flow, sediment transport and morphological changes of the nearshore area, beaches and dunes during storms
- developed by Deltares, UNESCO-IHE, TU Delft and University of Miami
- Very effective model for combined sea + swell wave propagation, and flooding of atoll islands





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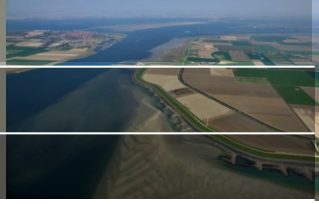

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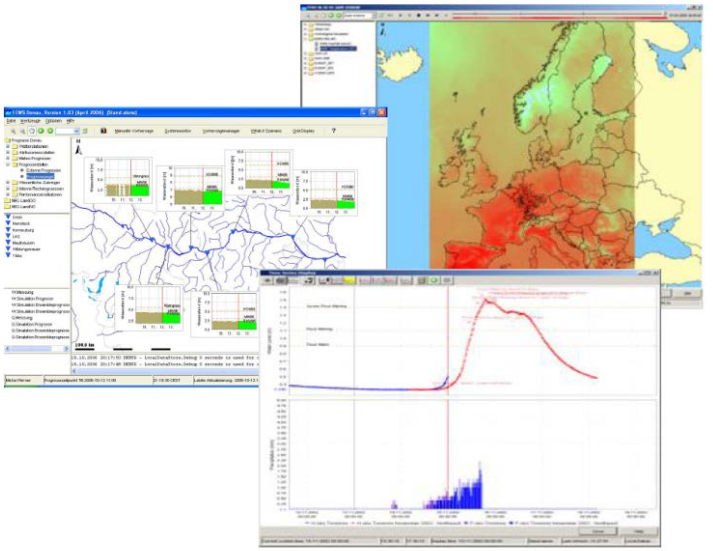
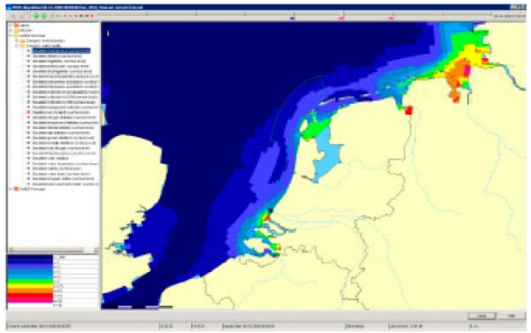


- open shell system for managing the forecasting process
- handles all data flows, modelling, archiving and dissemination
- interface to external data sources and models
- modular and highly configurable
- runs stand-alone, or in in a fully automated distributed client-server environment
- forecasting of hydrodynamics, but also water quality parameters, dredging plumes, spills, etc.
- what-if scenarios
- designed for robustness with advanced back-up/shadow functionalities
- worldwide applications by governments and local/regional institutes (NL, UK, US, AUS, UAE, Brazil, Singapore, etc.)
- active user community with yearly user meetings



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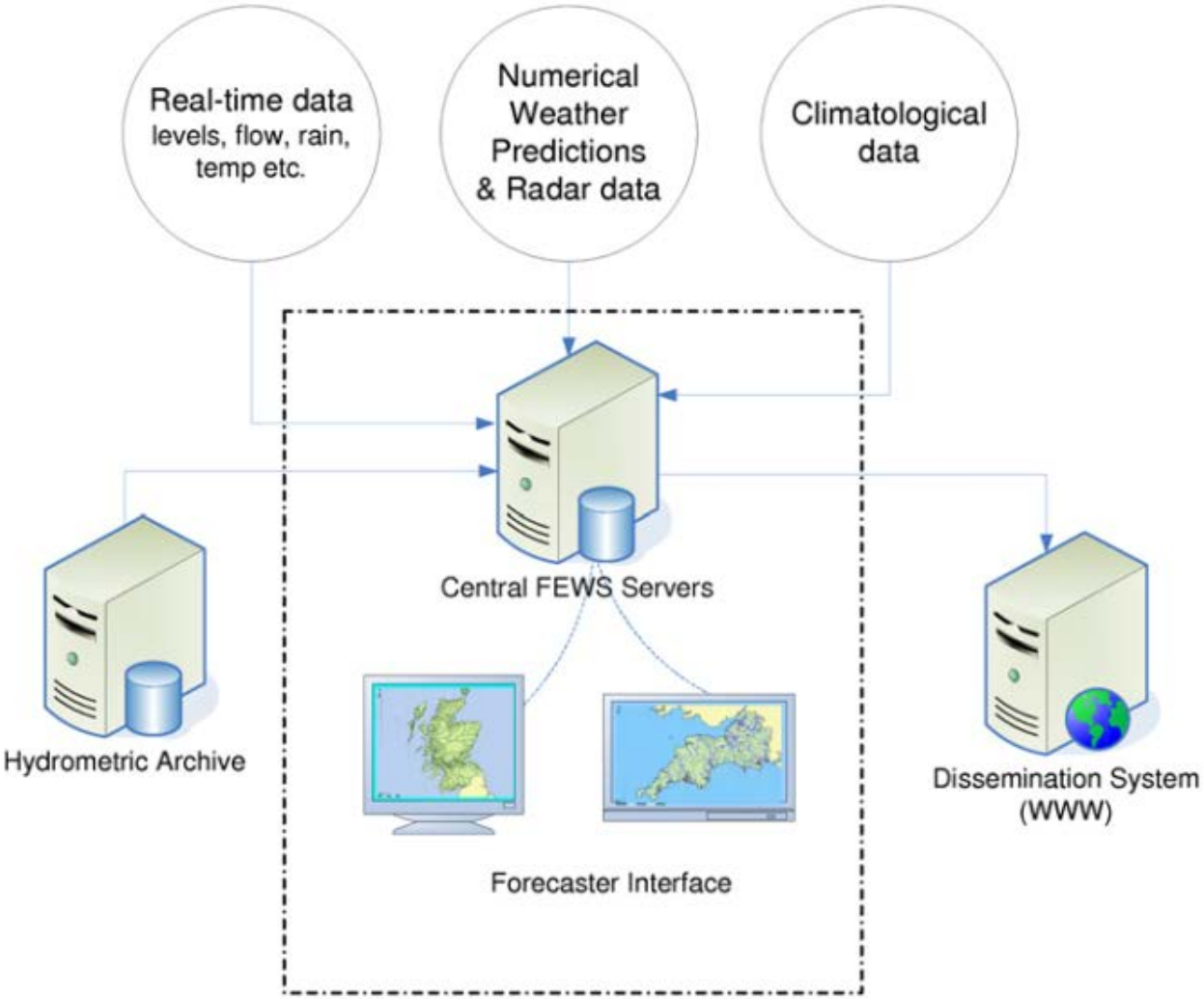
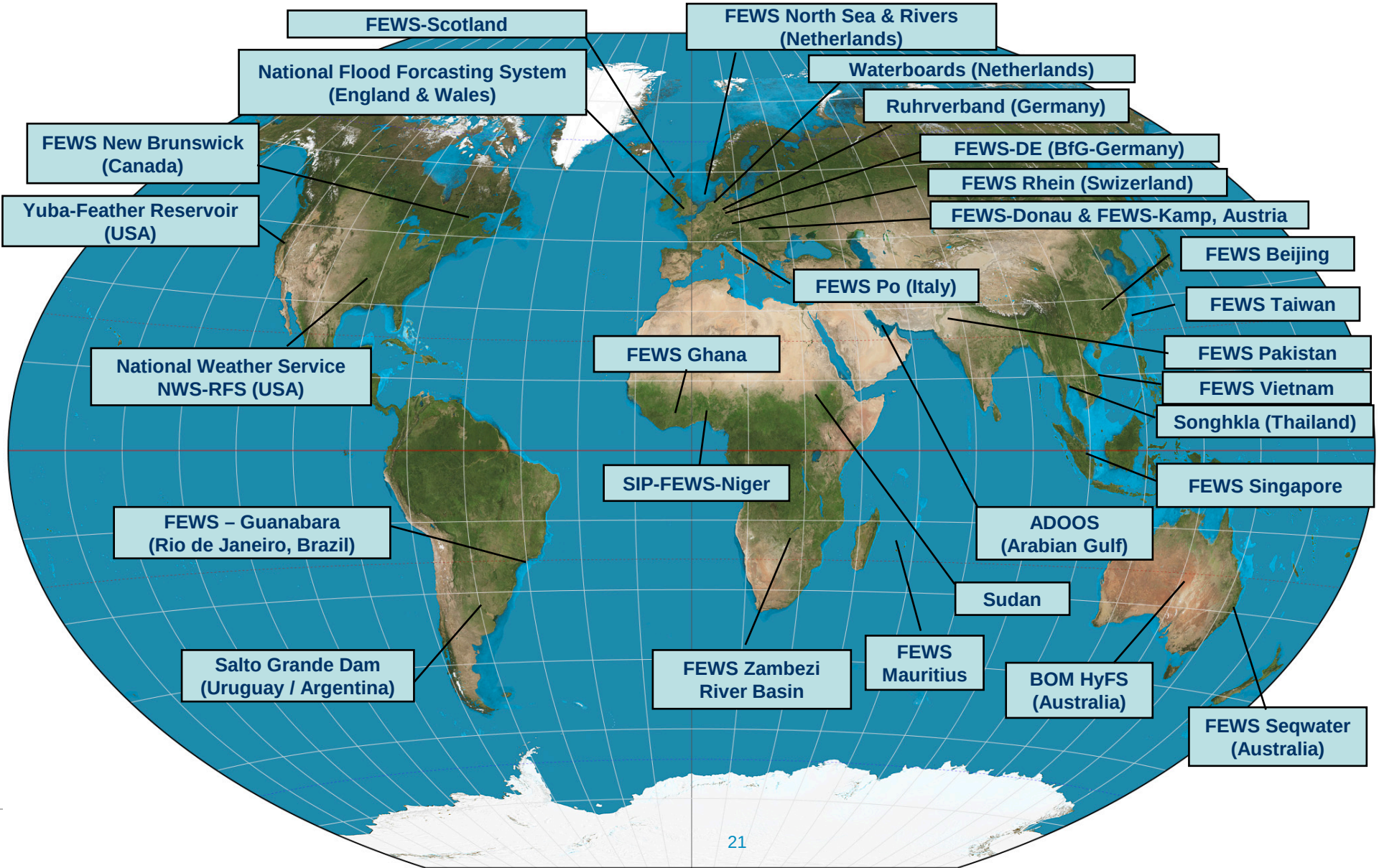
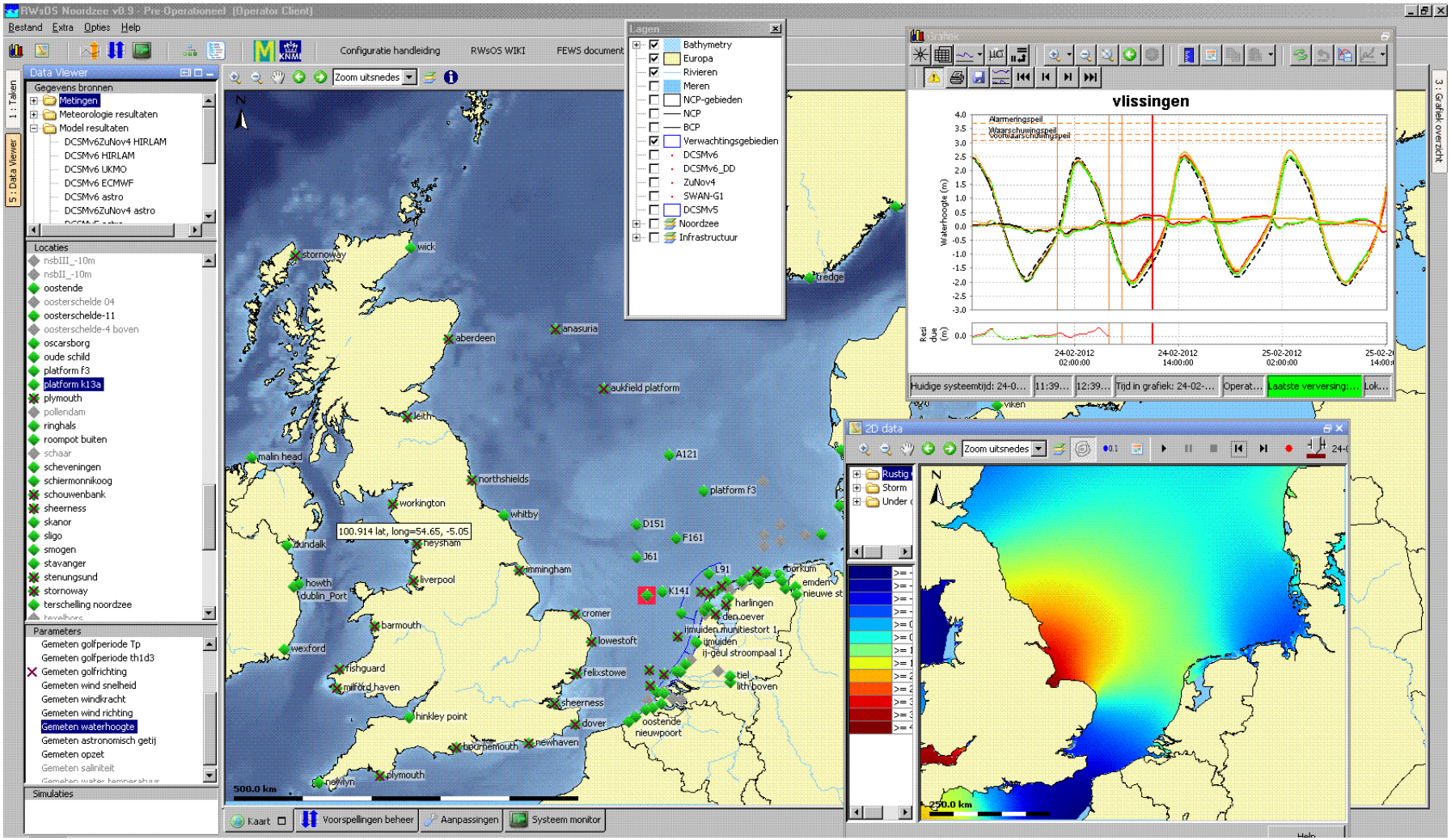


Delft-FEWS Forecasting Systems



FEWS North Sea – Flood Forecasting System



Water-level forecasts at stations along the Dutch coast are provided every 6 h, with a 48-hour lead time. Developed for Rijkswaterstaat.

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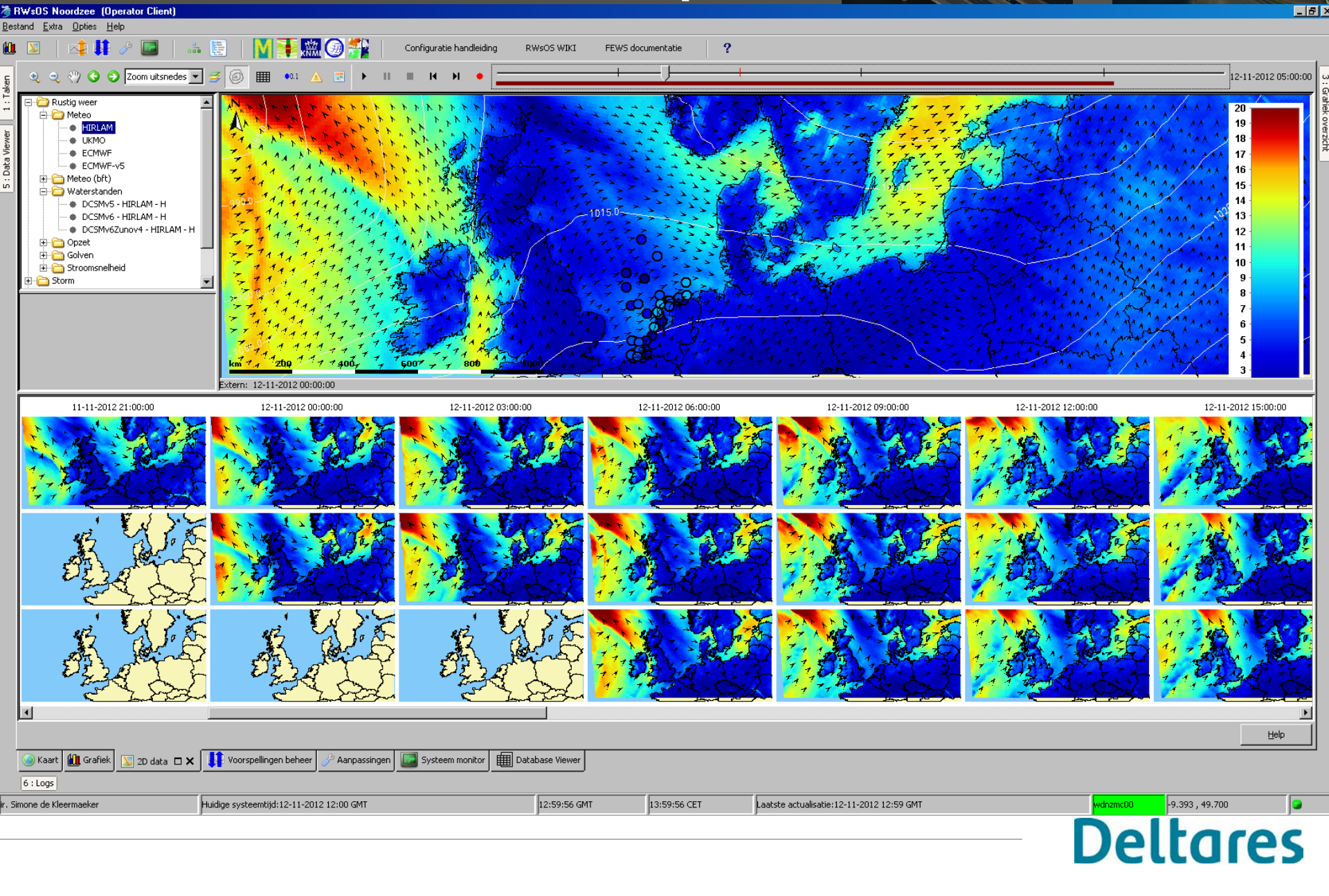
FEWS North Sea - multiple meteo forecasts



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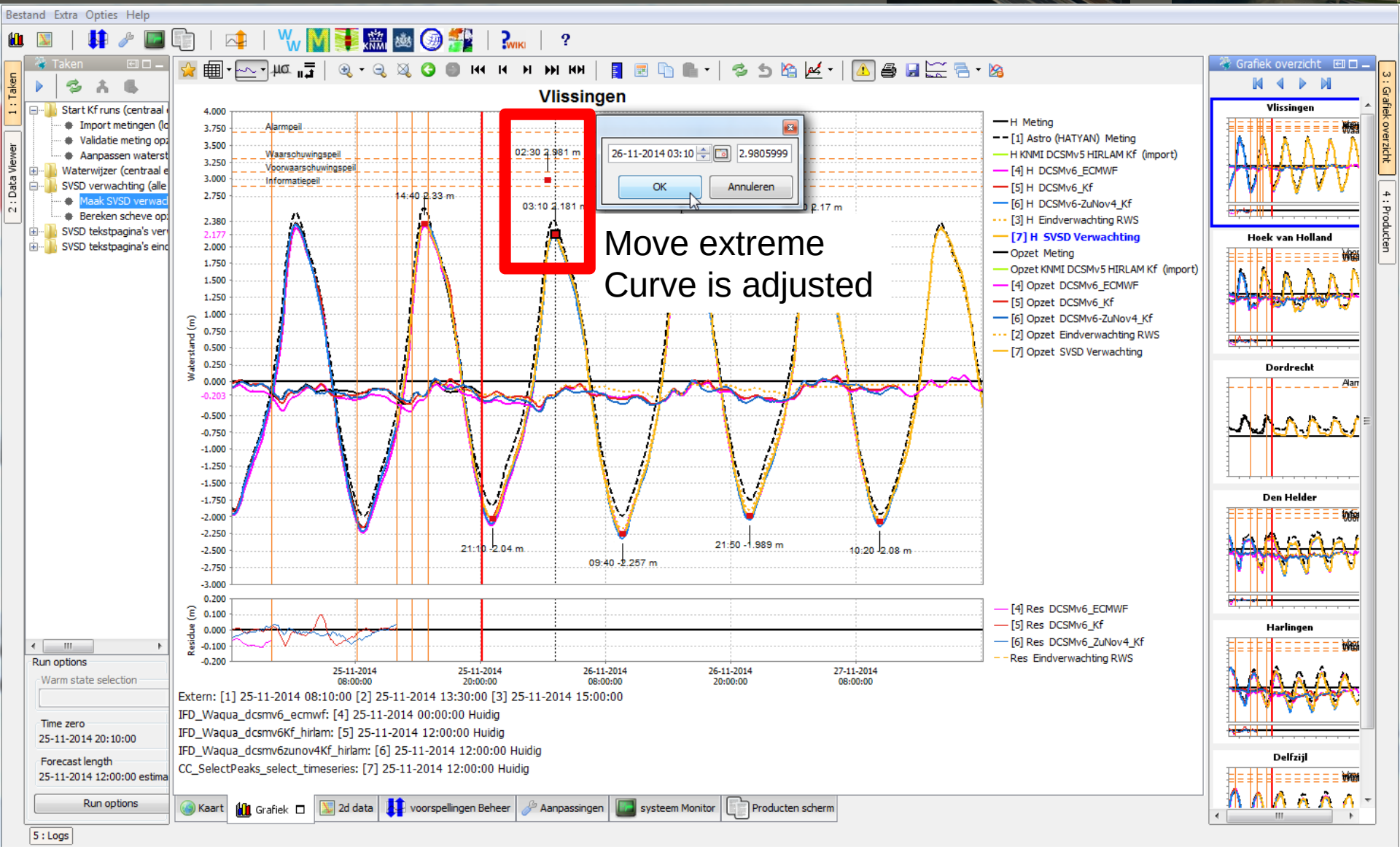
Fews Horth Sea – Forecast optimisation



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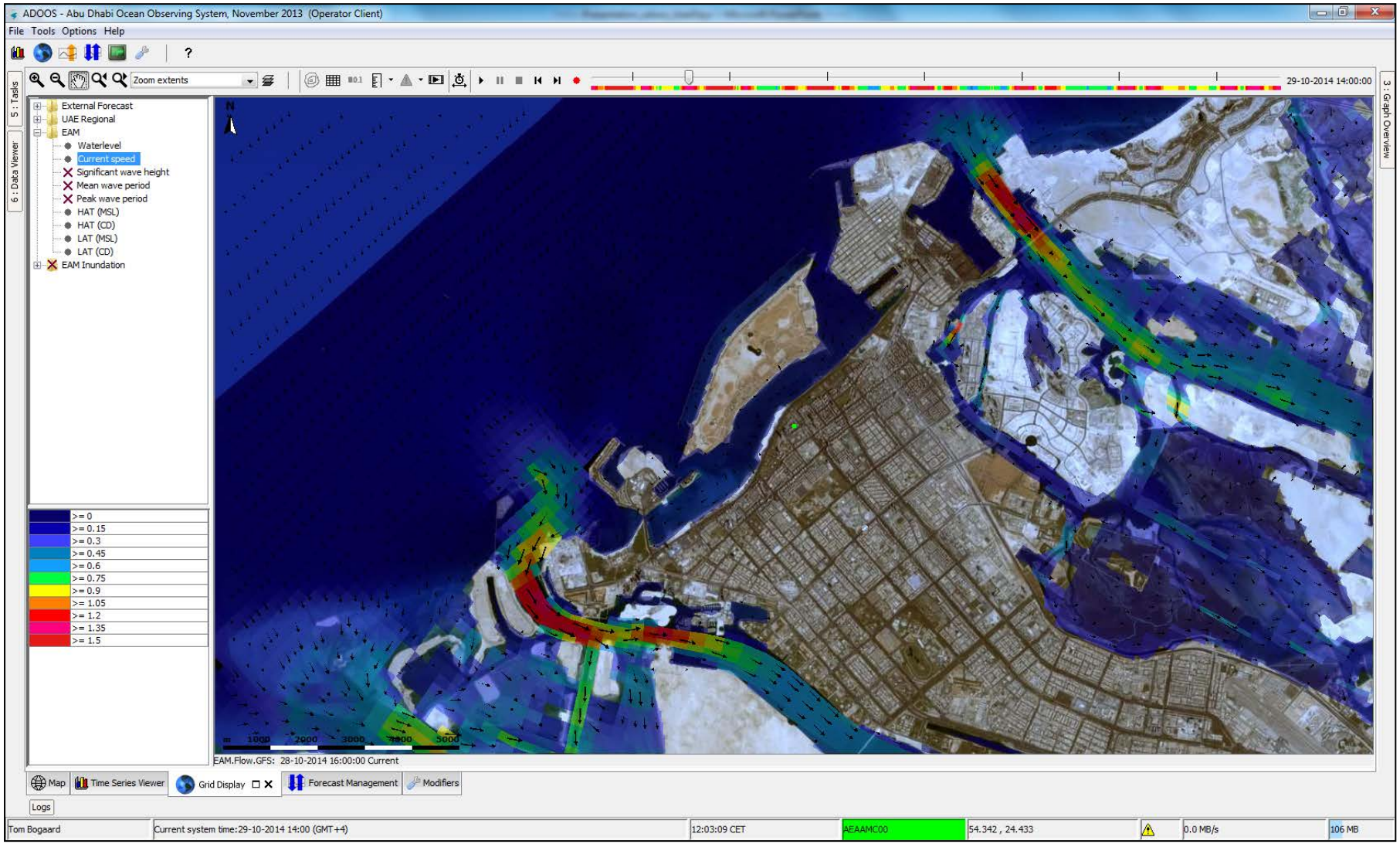
Abu Dhabi Ocean Observing System



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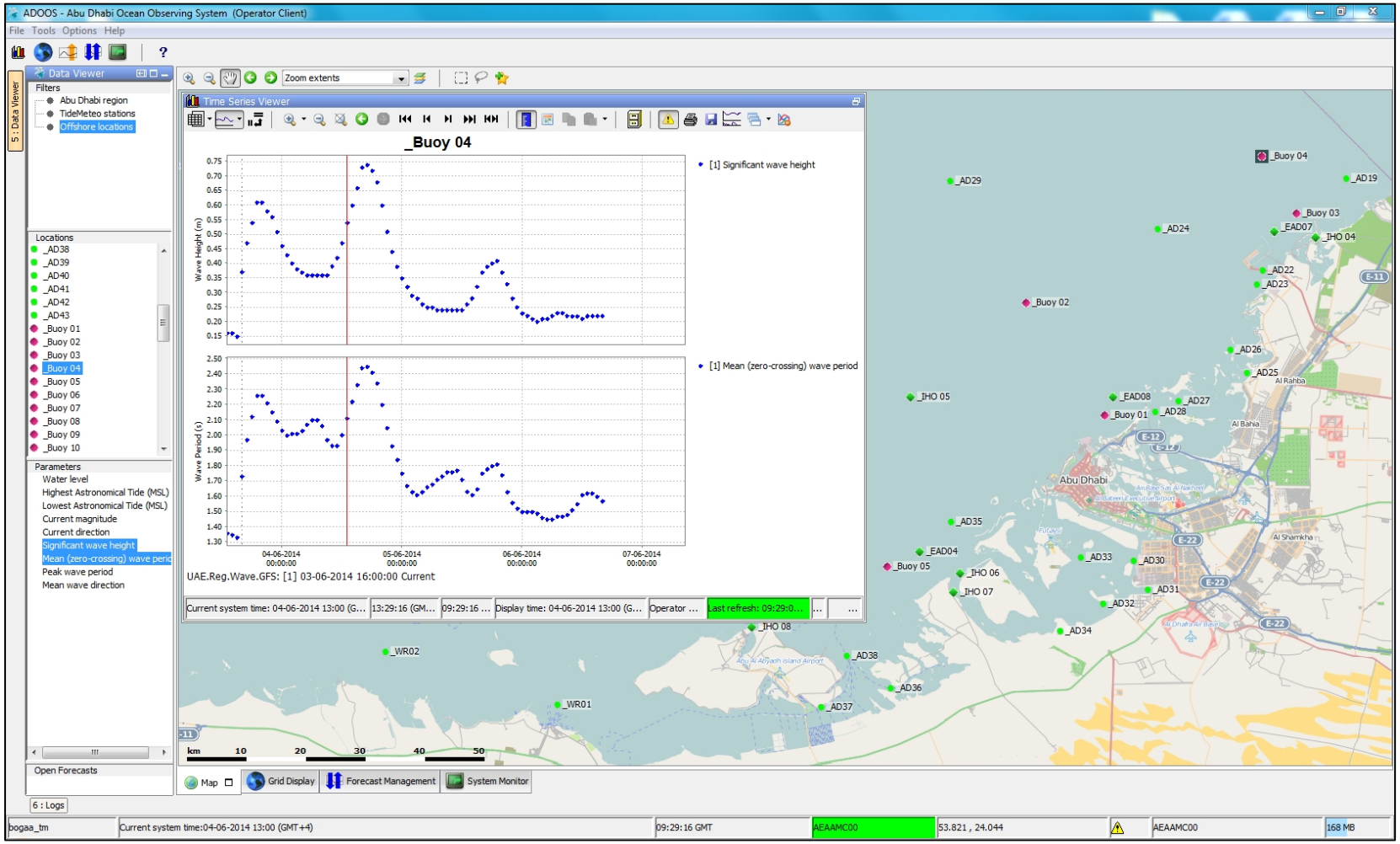
FEWS Client



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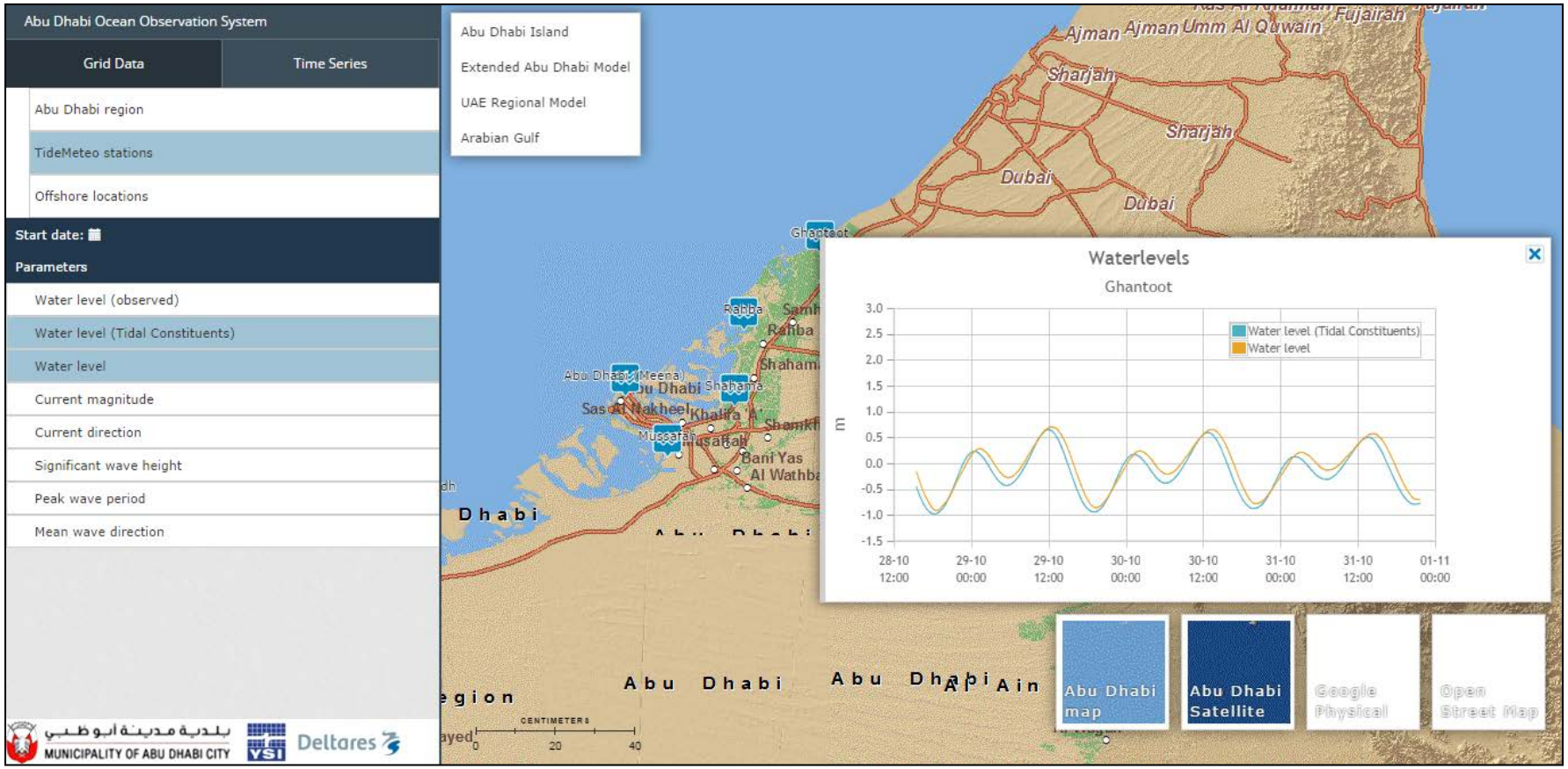
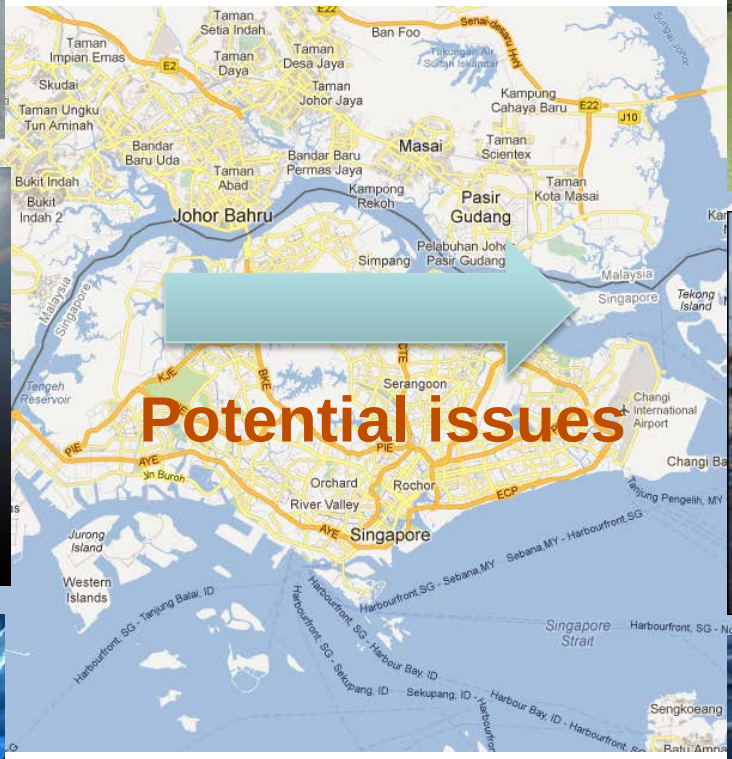
Webviewer



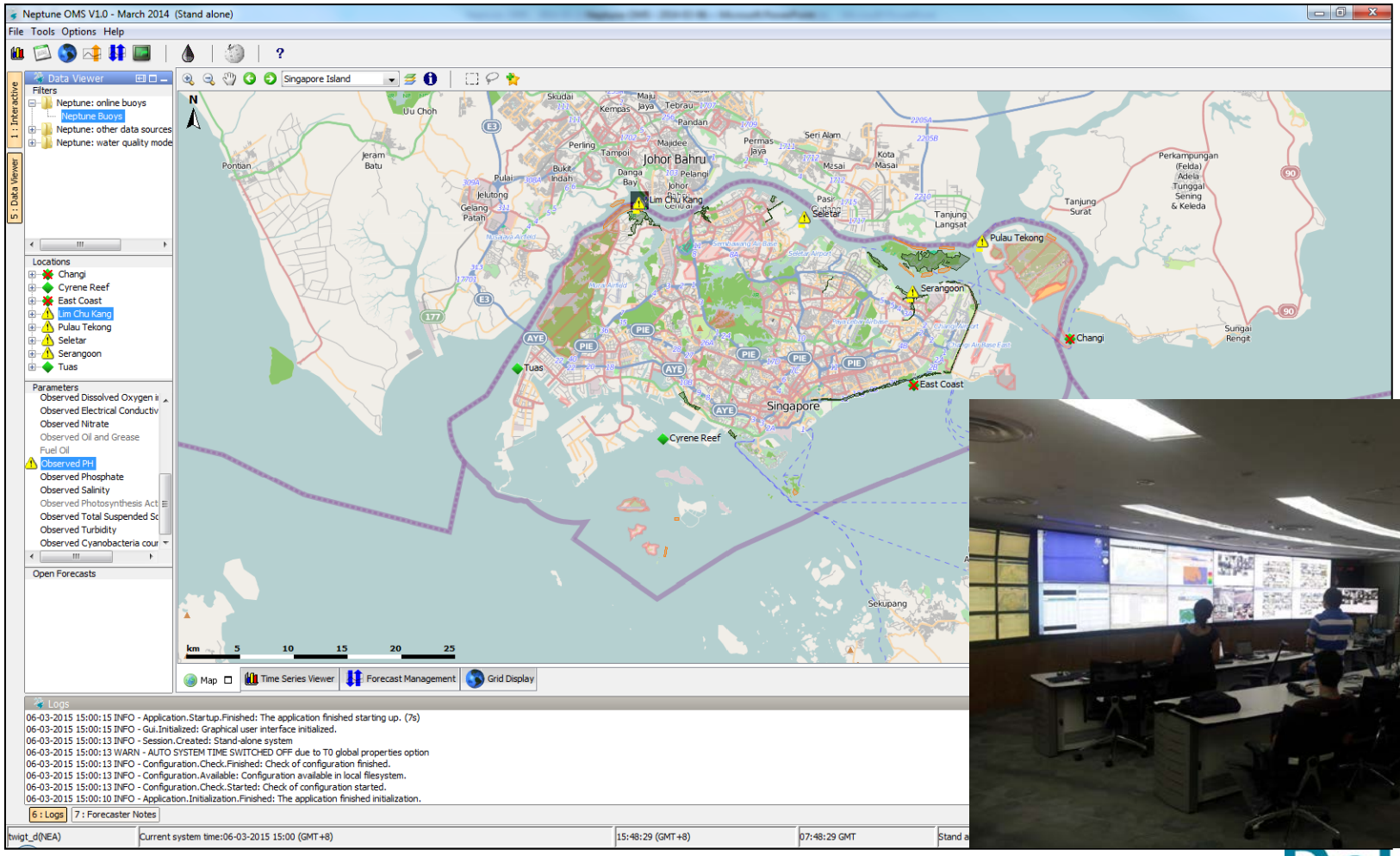
Singapore – FEWS Water Quality



ADAPTATION FUND

Singapore – FEWS Water Quality

Runs operationally (24x7) at National University of Singapore (NUS) for daily usage by NEA through a client application.



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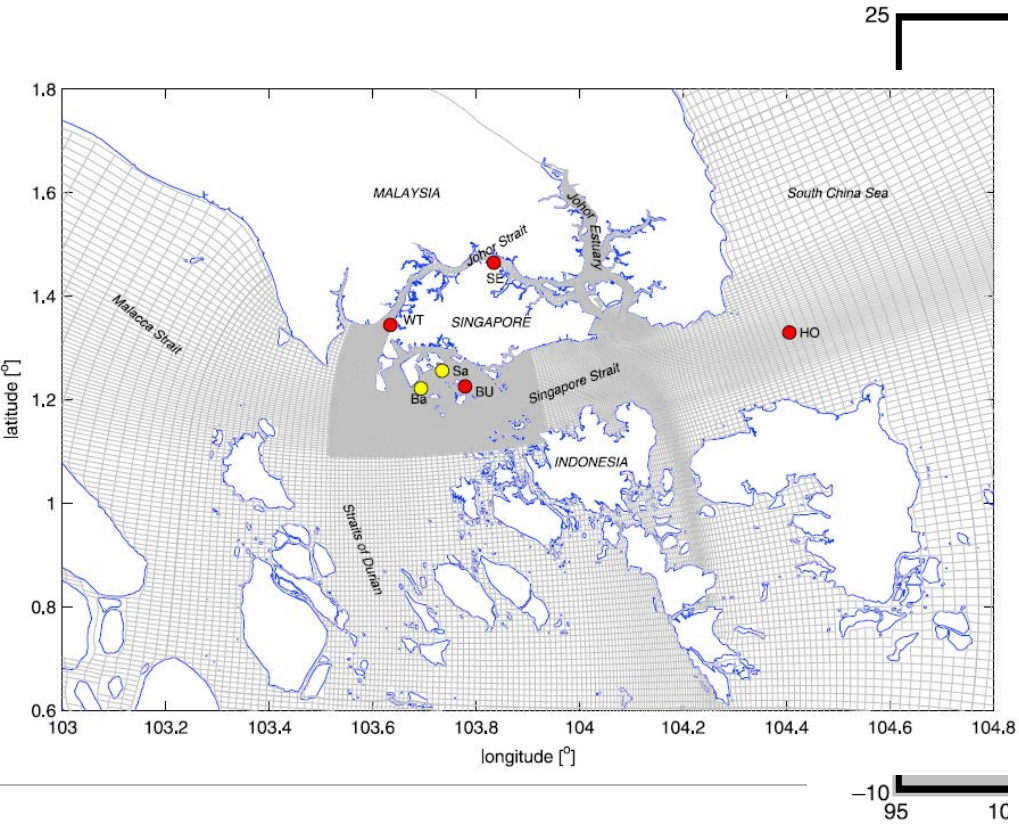
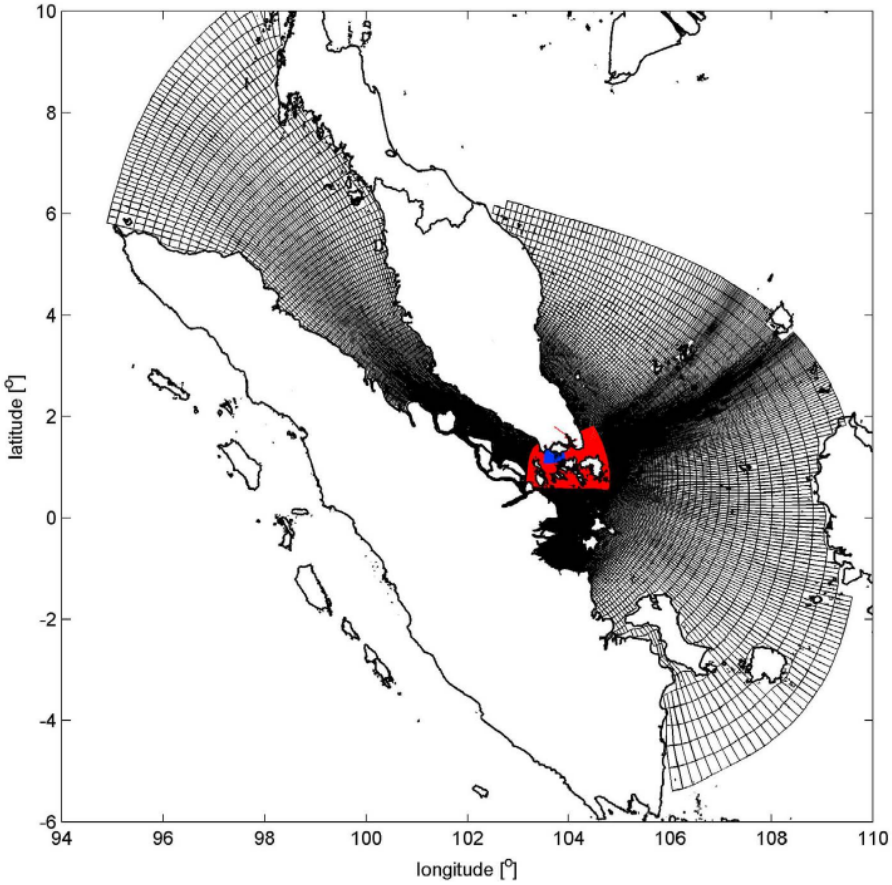
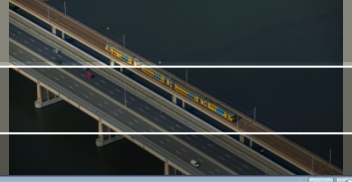
Hydrodynamics around Singapore

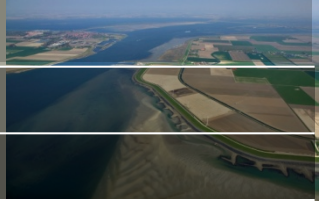
- The Singapore Strait connects the semi-diurnal Malacca Strait with the diurnal South China Sea
- Three domains for better compromise (accuracy, performance)

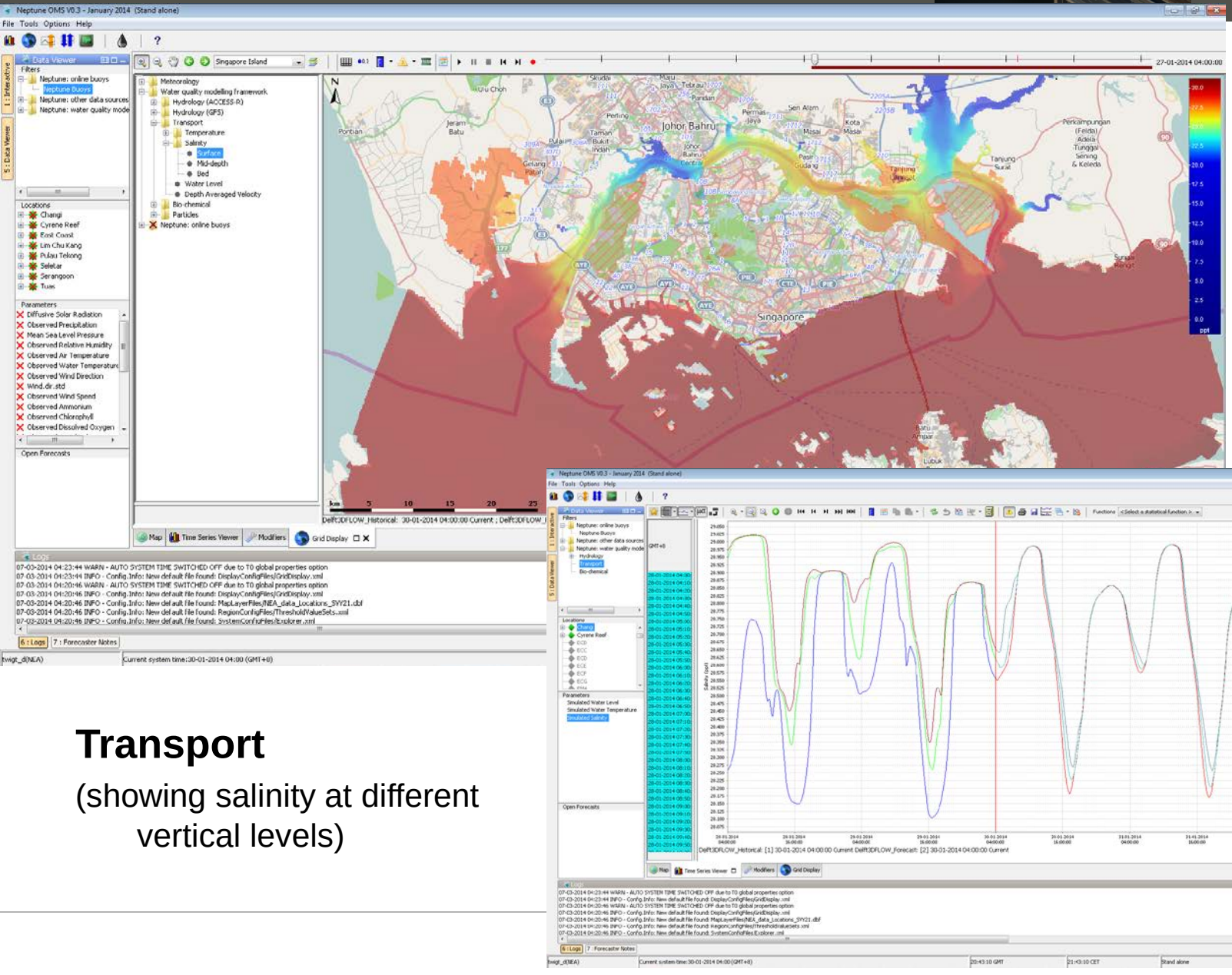




Several desired components



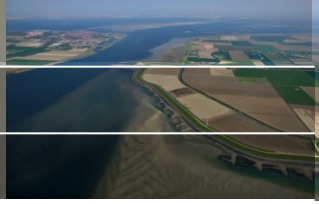




Transport

(showing salinity at different vertical levels)

Options for modelling in the Maldives



Hydrometeorological conditions

- Tropical climate
- Distinct dry (NE) and wet (SW) monsoon
- Average tide (HAT-LAT range 1.2 m)
- Strong tidal currents (~ 1 m/s) between atoll islands
- No severe cyclones, tropical storms (North Maldives)

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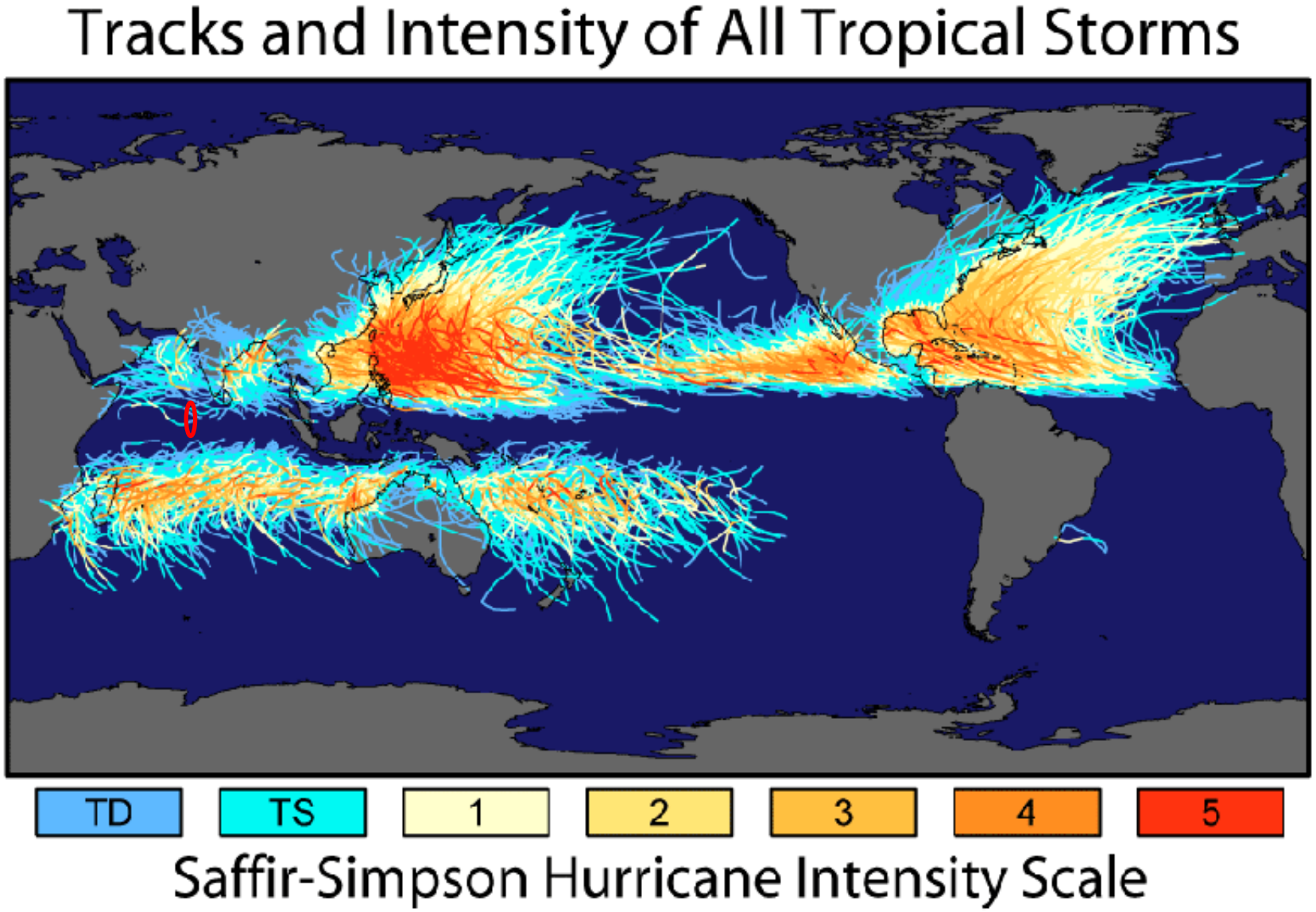

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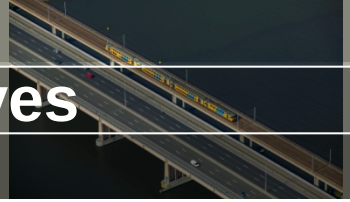

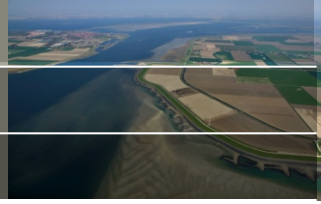

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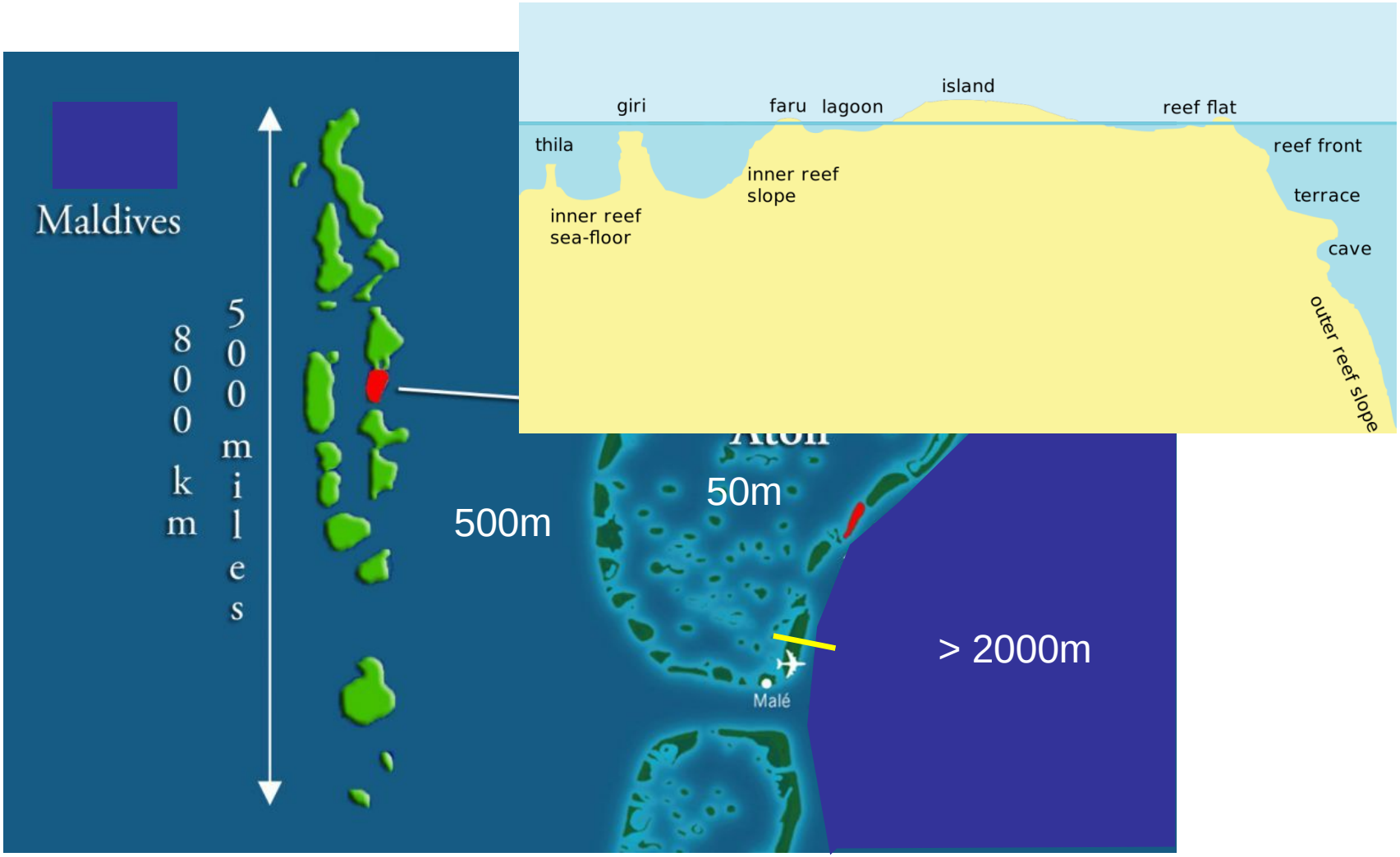
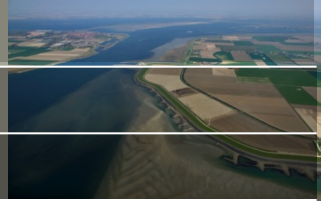
Options for modelling in the Maldives



Deltares

Options for modelling in the Maldives



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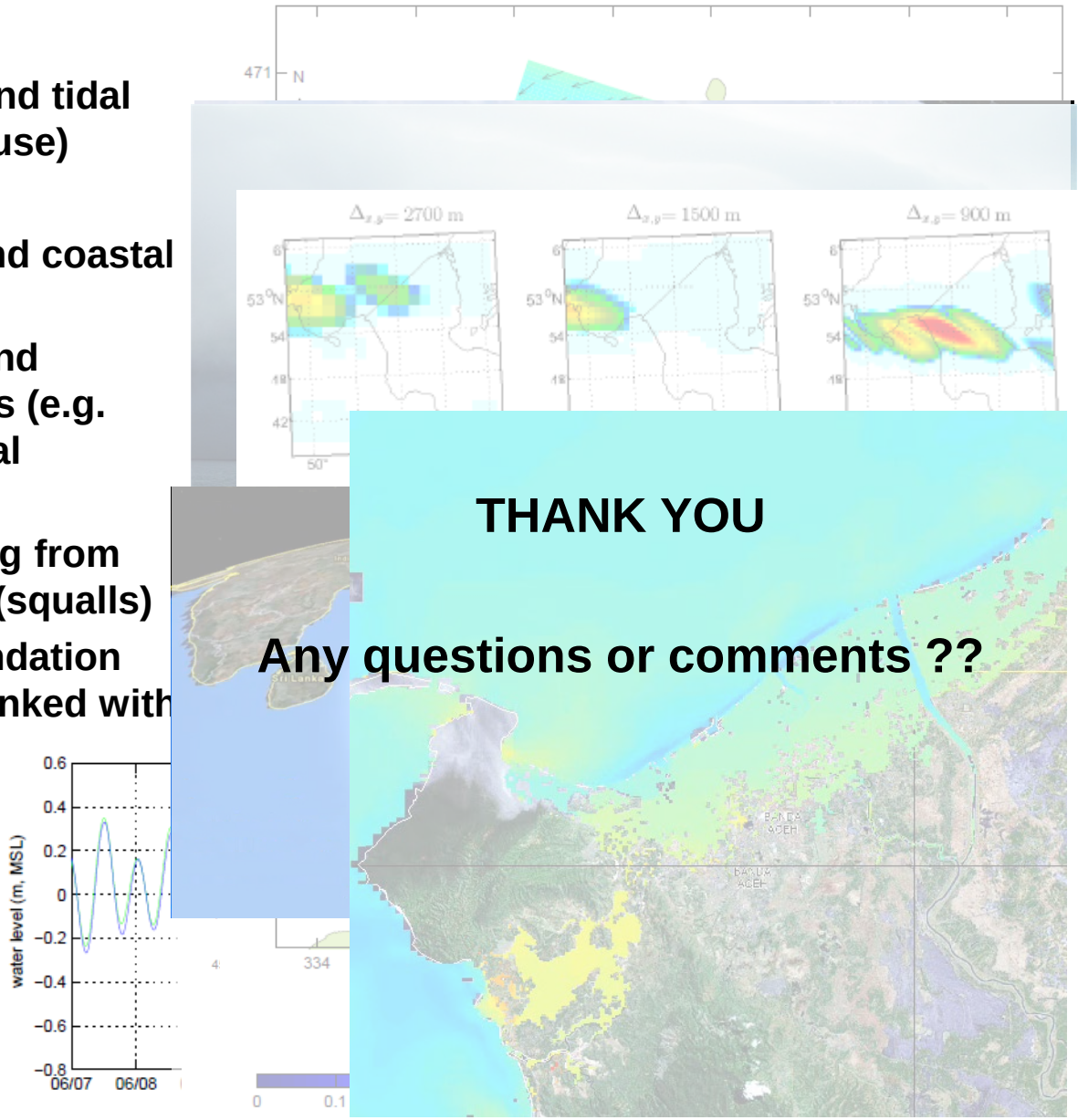
- El Nino effects
- Climate change:
  - sea level rise (25 cm in 50 years? 1m in 100 years?)
  - changing weather patterns??

Deltares

Options for modelling in the Maldives

- **Tide: water level predictions and tidal currents (also for operational use)**
- **Waves:**
  - **swell wave propagation and coastal flooding**
  - **generation, propagation and overtopping of wind-waves (e.g. during monsoon or tropical storms/cyclones)**
- **Wave and inundation modelling from rainfall during thunderstorms (squalls)**
- **Tsunami propagation and inundation modelling (look-up database linked with published seismic warnings)**