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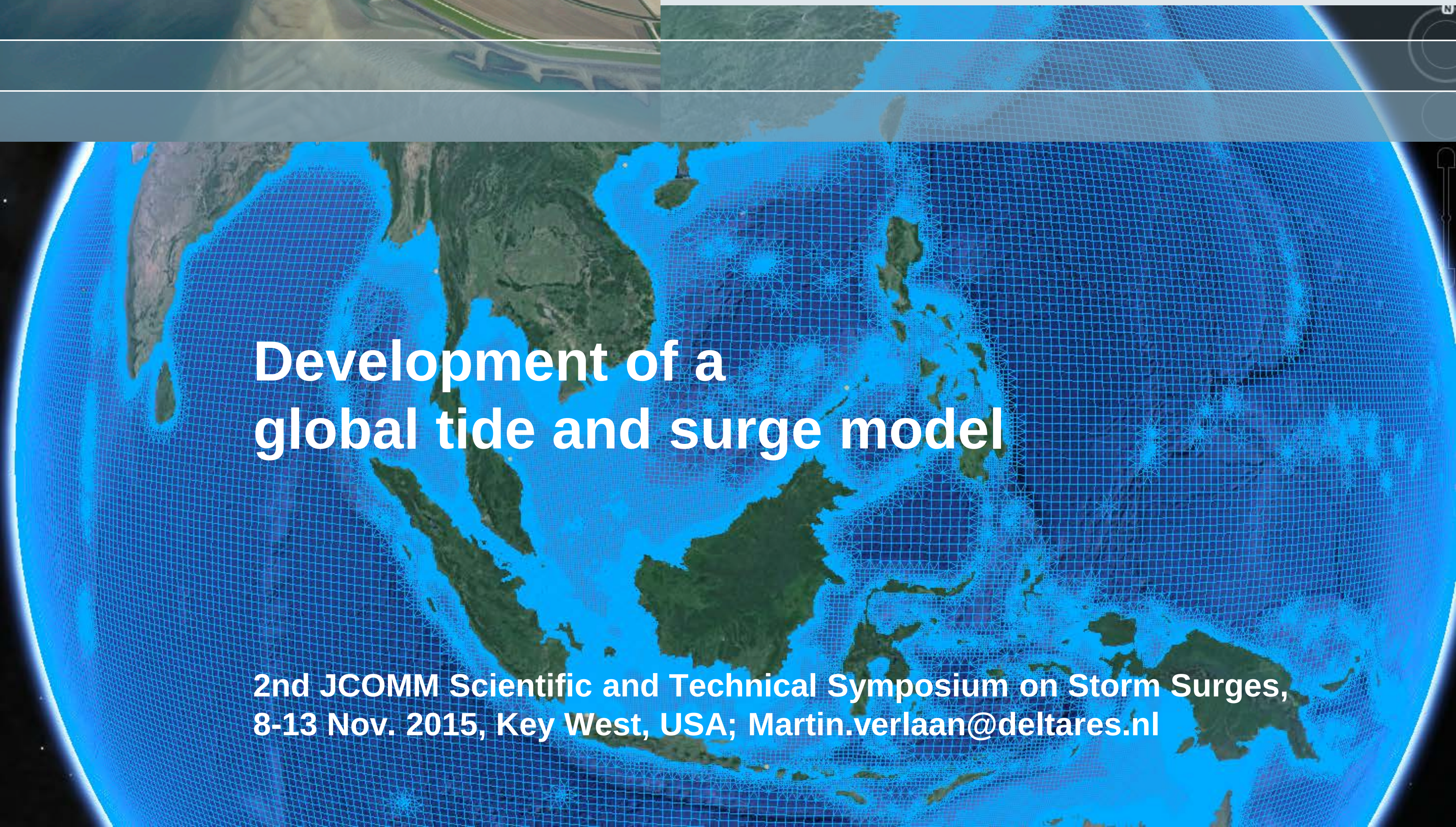
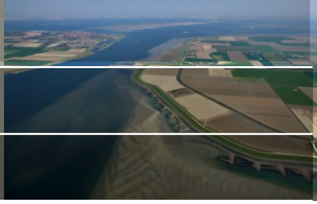
Enabling Delta Life



Development of a global tide and surge model

2nd JCOMM Scientific and Technical Symposium on Storm Surges, 8-13 Nov. 2015, Key West, USA; Martin.verlaan@deltares.nl

Outline

- Introduction
- Development of GTSM version 1
- Reanalysis of extreme sea levels
- GLOSSIS operational forecasting
- Tropical cyclones
- Model improvements – towards GTSM version 2

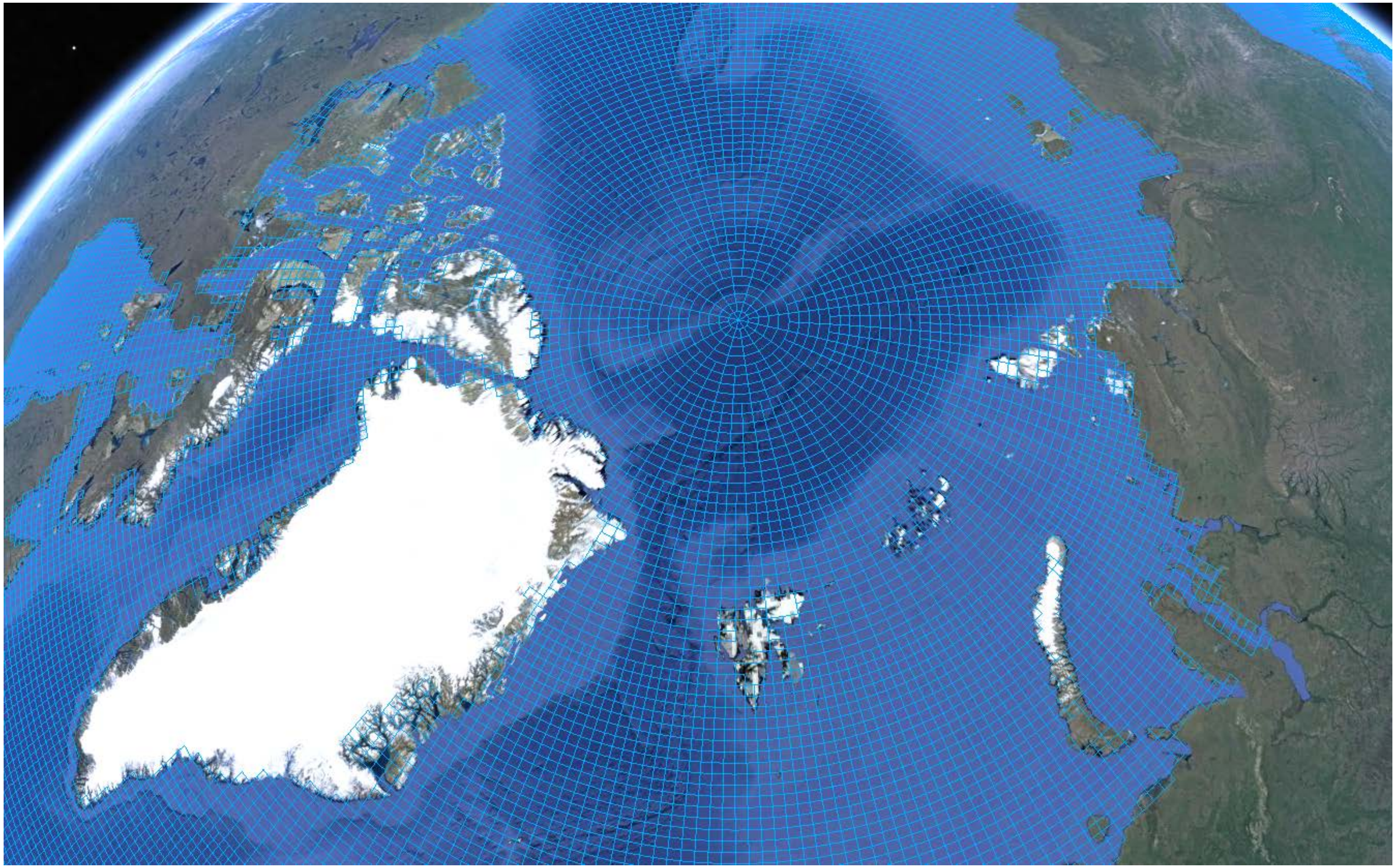
Introduction & Development of GTSM v1.0

for:

Computing water levels dynamically (surge, tide etc. combined) during any significant events but also to for statistic analysis
Study the effect of MSL on tide and water level globally

Grid in Dflow-FM

Unstructured approach - step 1: grid thinning at high latitudes



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Grid in Dflow-FM

Unstructured approach - step 2: grid refinement in shallow areas

This Dflow-FM grid uses triangles and rectangles
for local grid refinement. Resolution is based on Courant number.

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Grid North America

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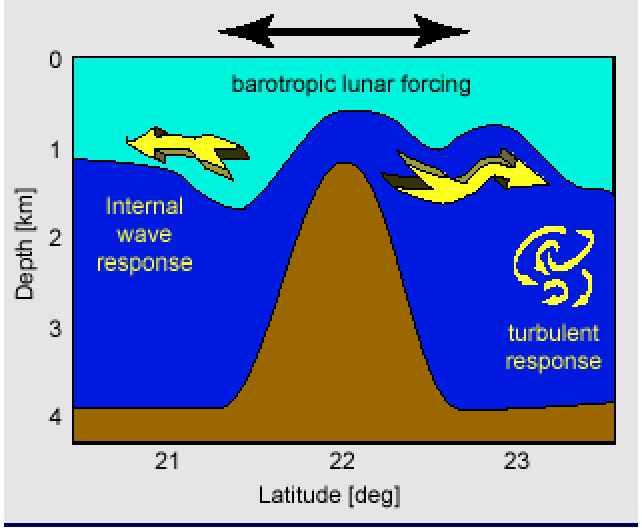
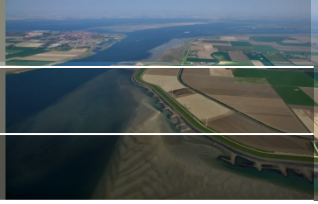
Necessary terms:

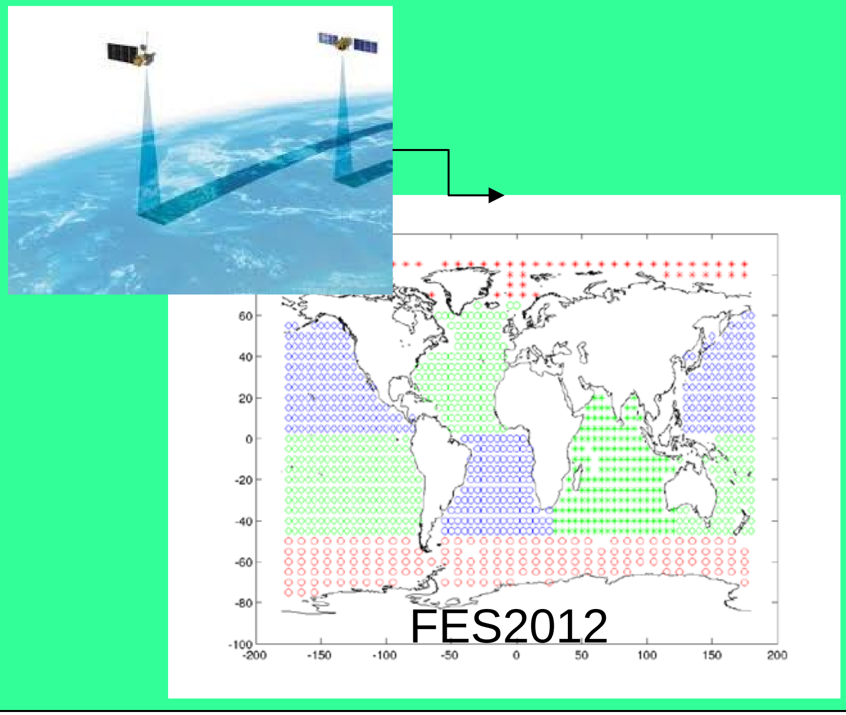
1. Self attraction and loading
   - Tides modify the gravity potential
   - Computationally expensive so we use simple approximation

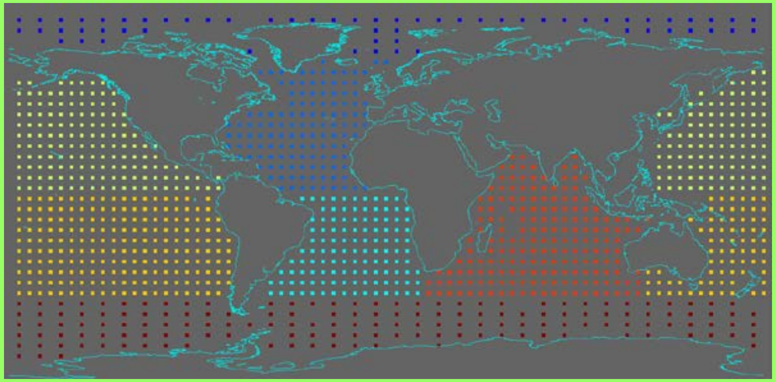
2. Internal tides
   - Tides create internal tide where there is stratification and steep bathymetry
   - introduce dissipation (roughly ¼ of total tidal dissipation on global scale)



Calibration of the Model







Altimeter observations:
- assimilated FES2012 gridded data
- very accurate on deep water

Automated calibration:
- 21 parameters
- deep water series Jan2007

OpenDA

Calibration parameters:
- Depth & Friction
- 7 regions

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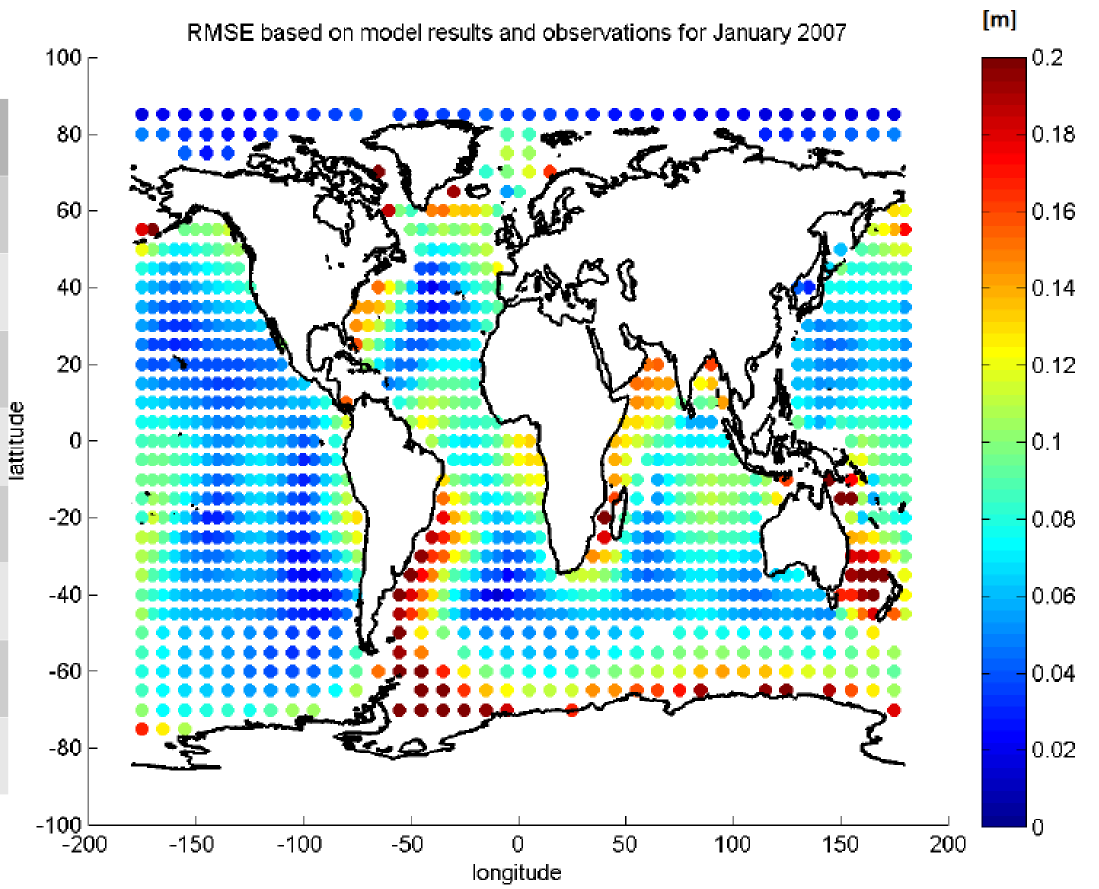
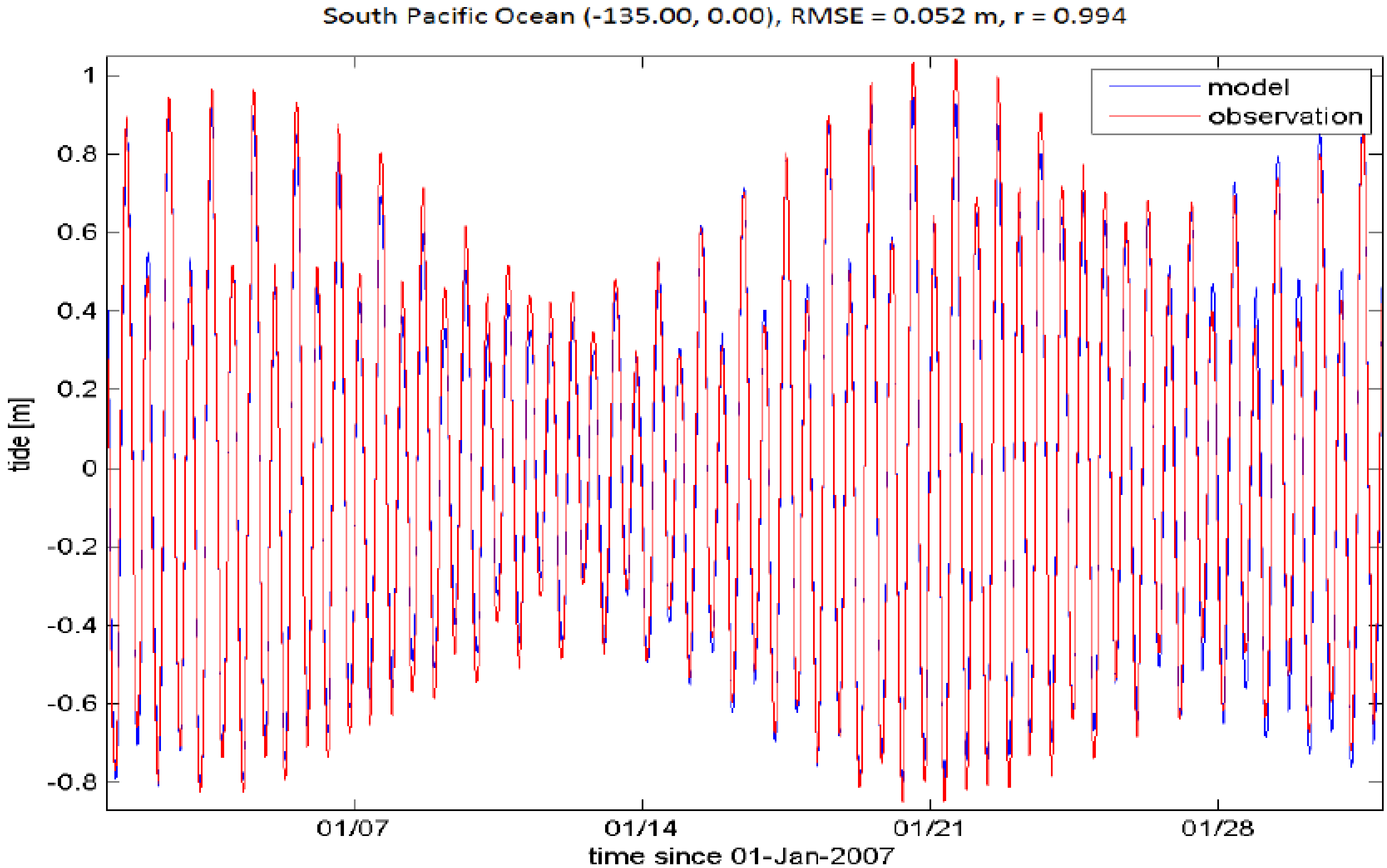
Calibration results for deep water

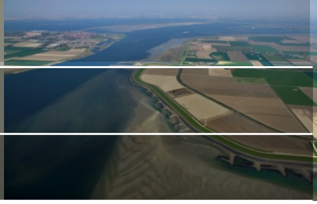
Region	Before	After
Arctic	5.1 cm	3.2 cm
N. Atlantic	9.4	7.4
S. Atlantic	12.1	8.4
N. Pacific	8.1	6.2
S. Pacific	11.2	7.3
Indian Ocean	11.7	8.2
S. Ocean	12.4	10.2
Total	**10.2**	**7.4**



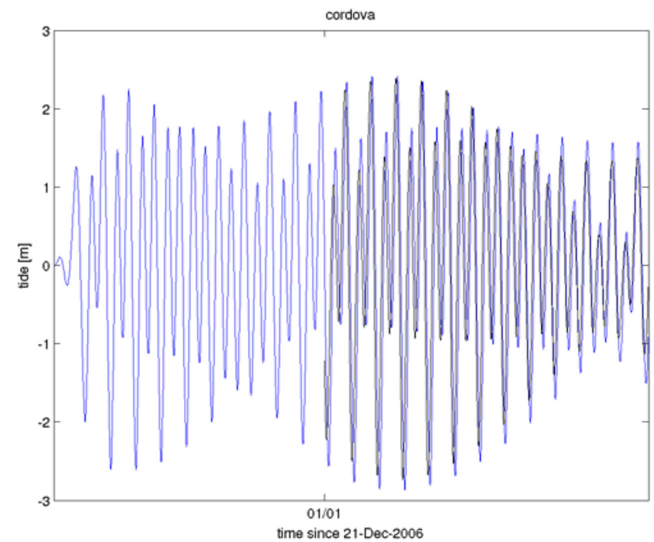
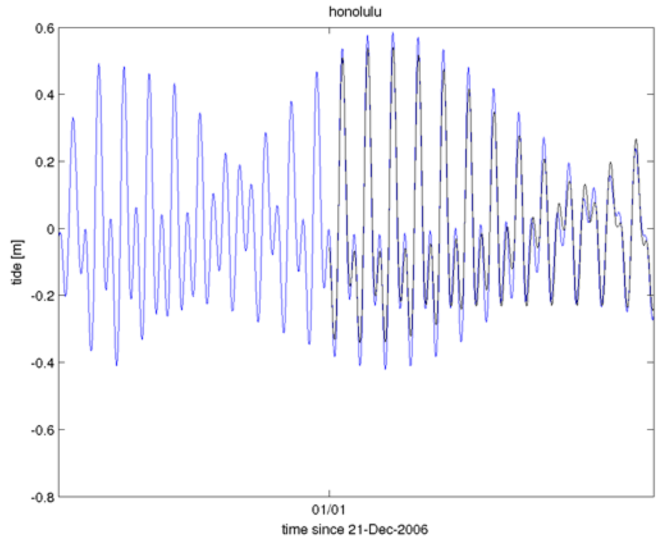
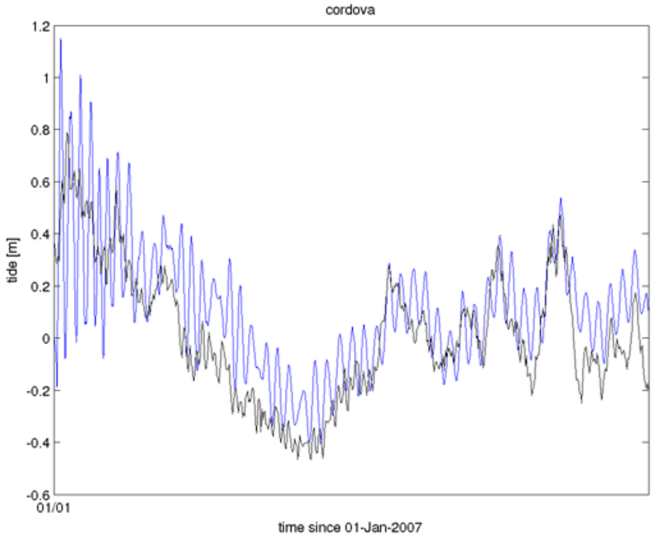
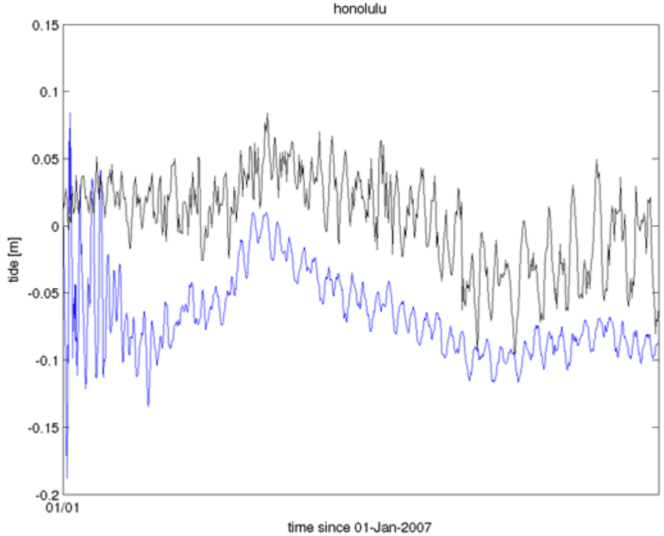
Sample deep water station

After calibration

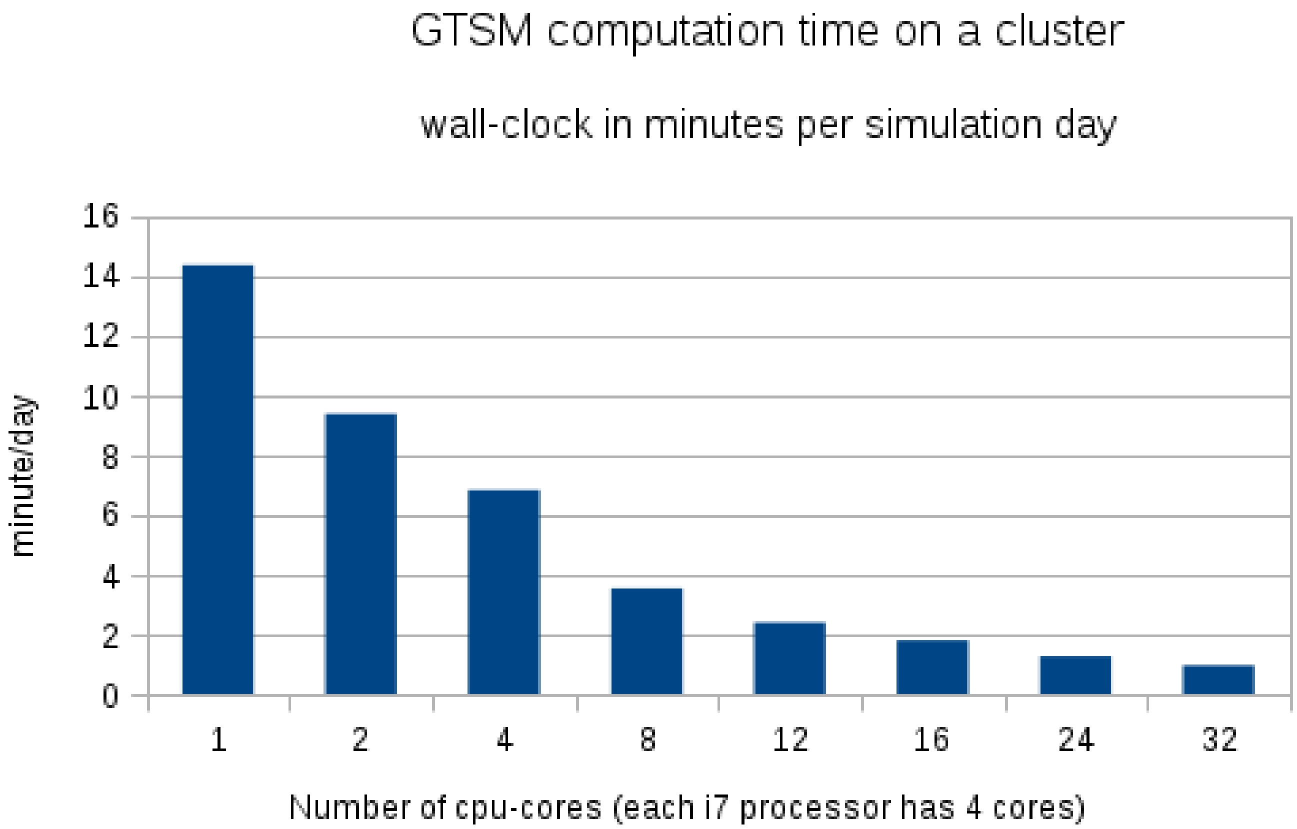




Sample coastal time-series

Cordova		Honolulu
	Tide	
	Surge	

Computational performance



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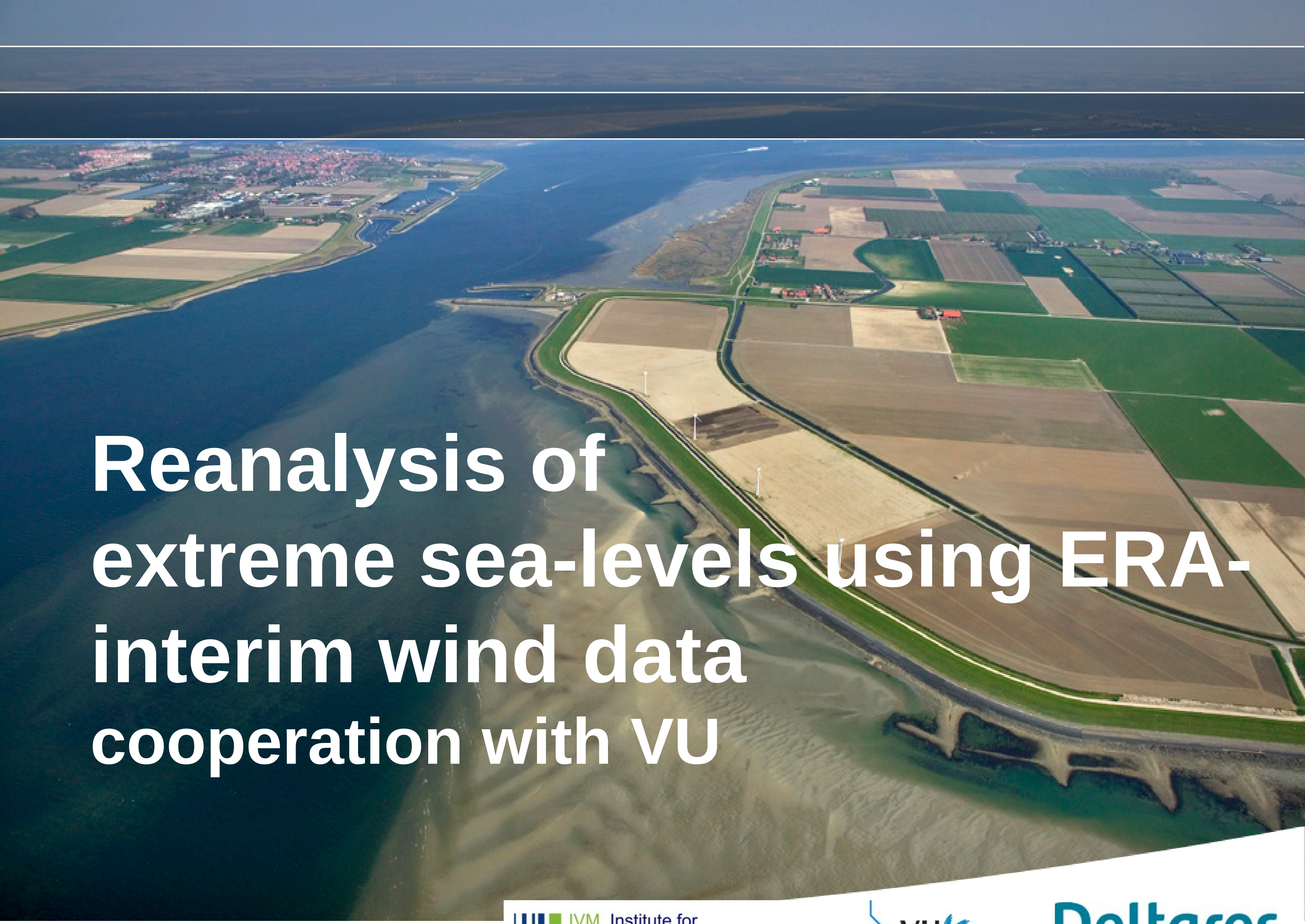

Reanalysis of extreme sea-levels using ERA-interim wind data

cooperation with VU

IVM Institute for Environmental Studies

VU University Amsterdam

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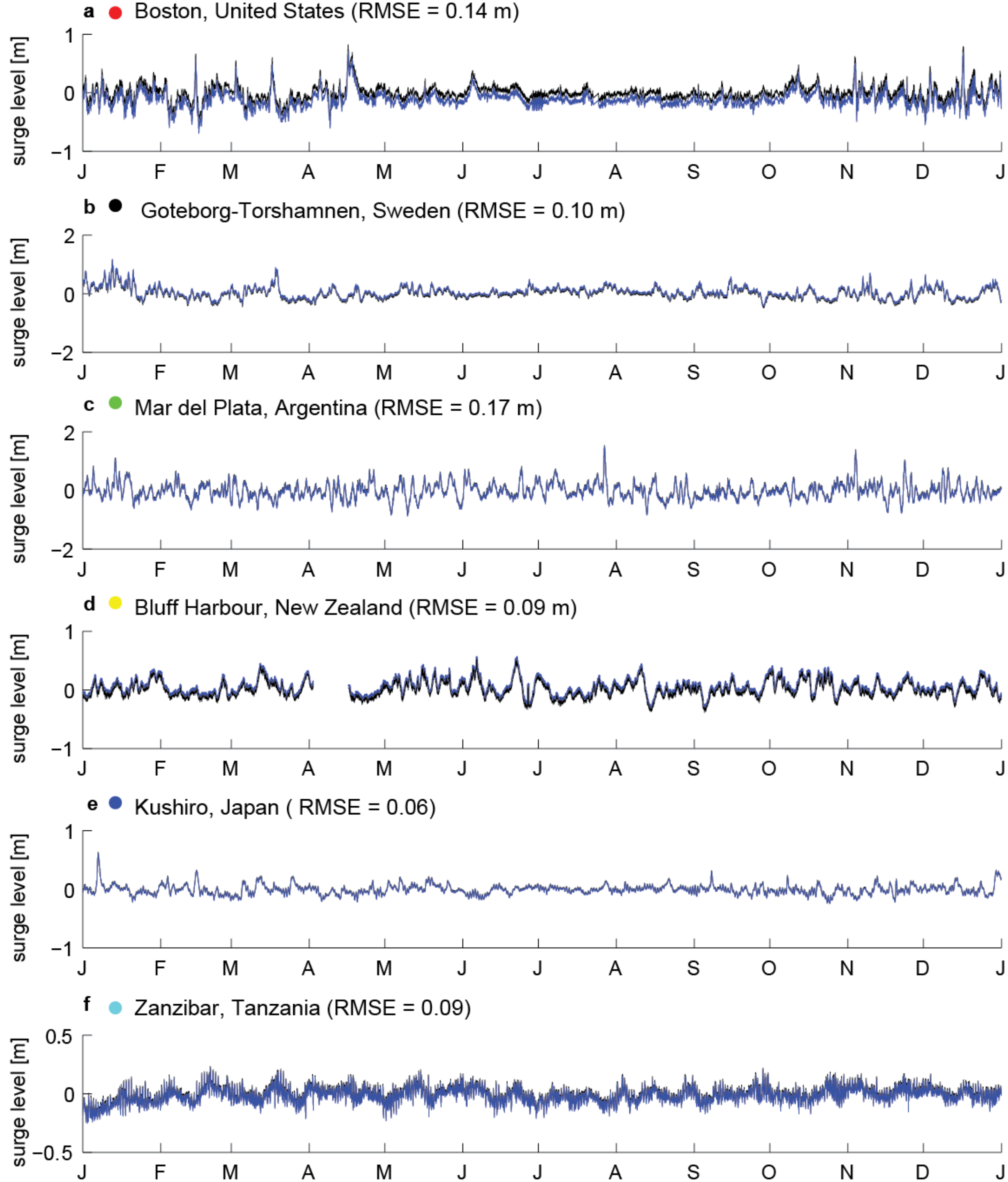
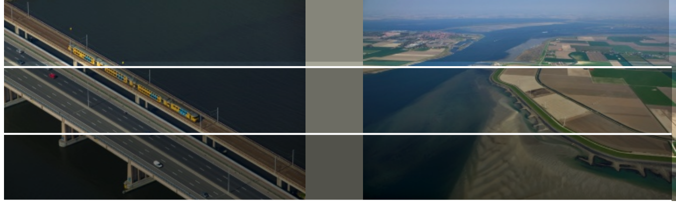
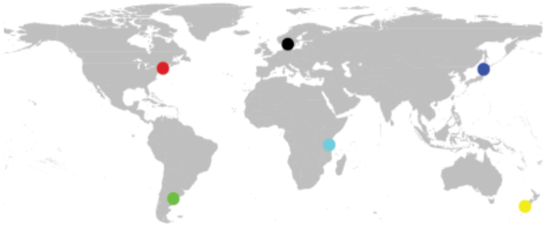




2007

modelled surge levels
observed surge levels



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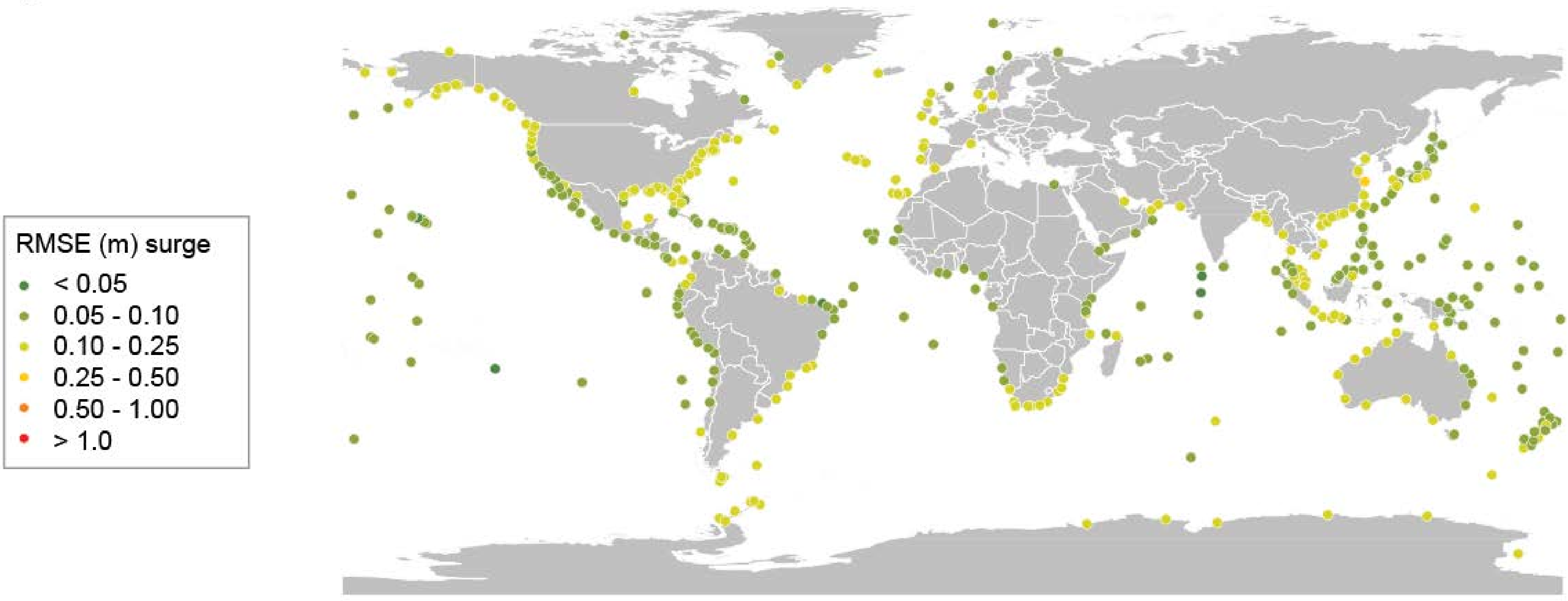
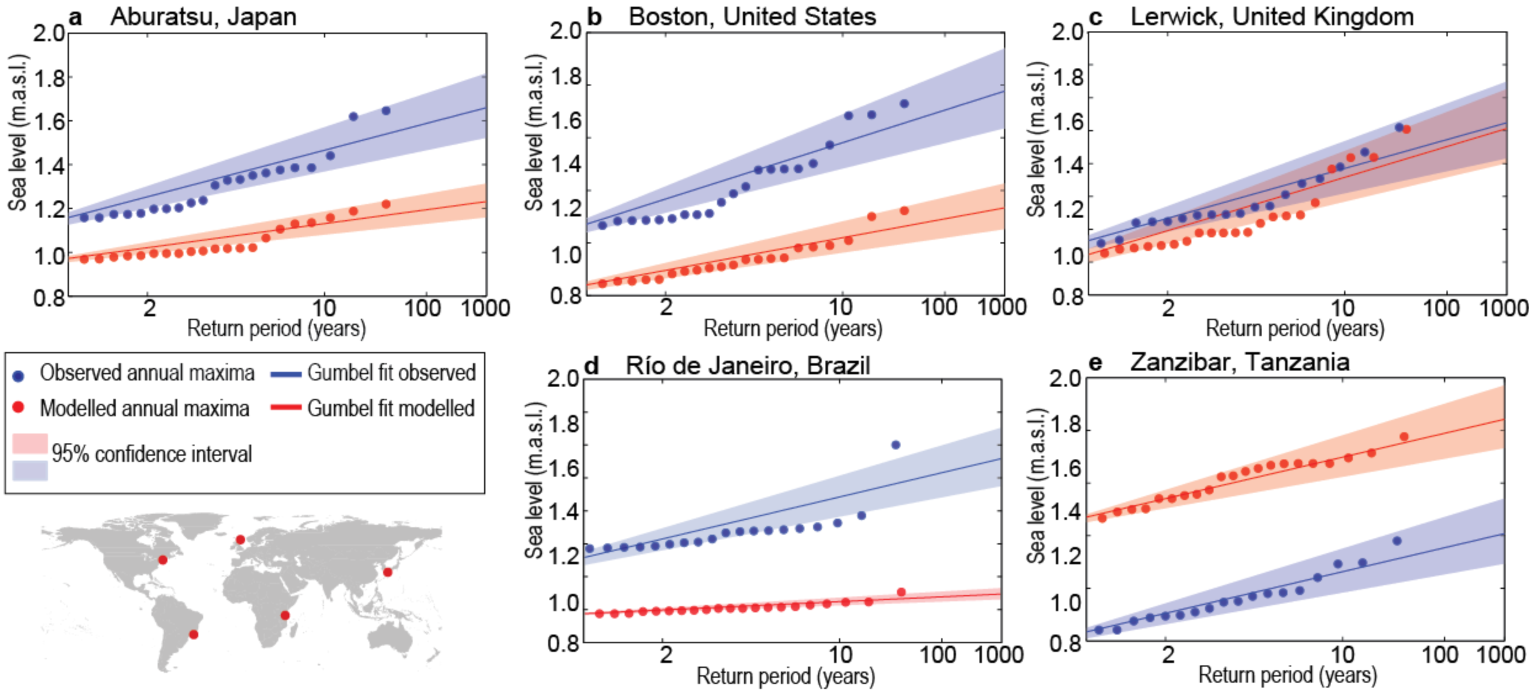
Validation ERA-interim (1980-2011)

Surge errors

a



Validation of return periods



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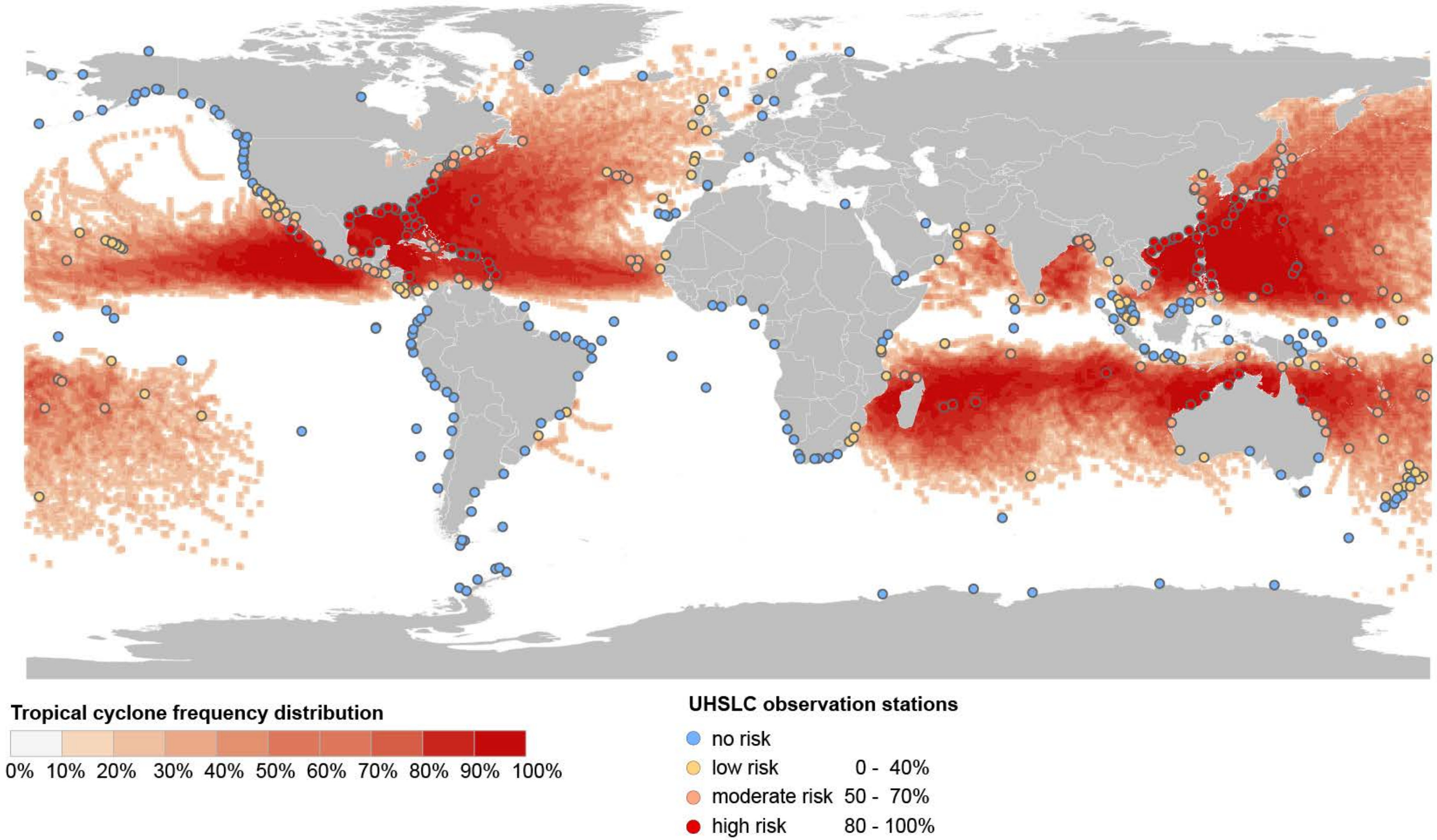
Tropical Cyclones – work is under way

Distribution of cyclones



Model improvements towards GTSM v2.0

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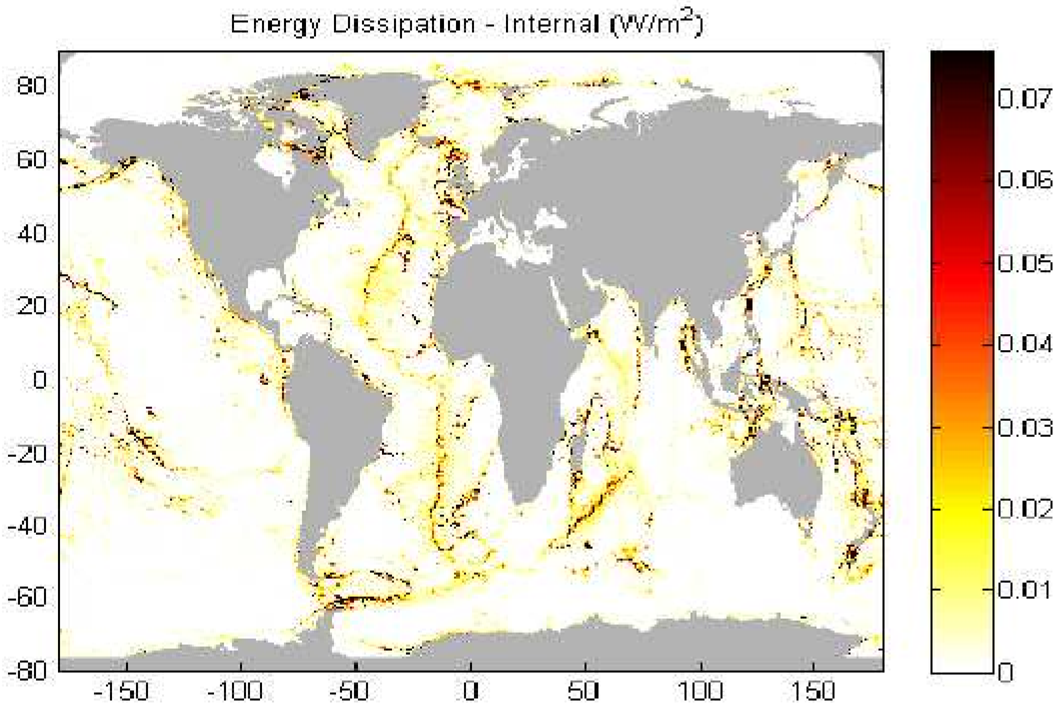
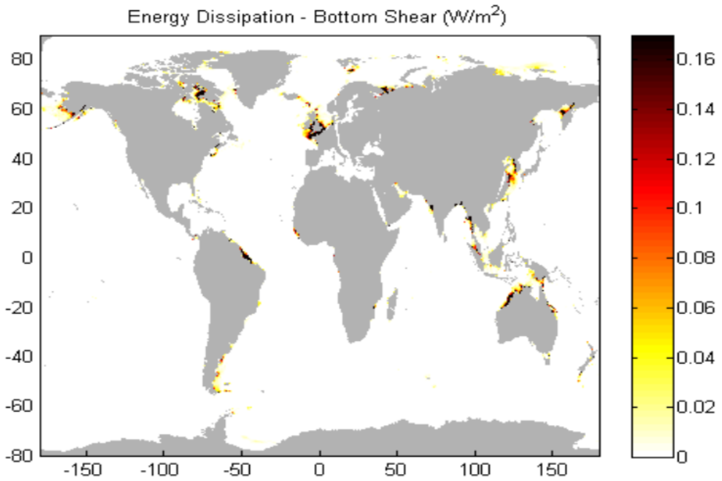
Dissipation by internal tides



Simplified formulation

Dissipation type	Sum [TeraWatts]
Bottom drag	0.95
Internal tides	2.30
Total	3.26

Work of: Shobhit Jain



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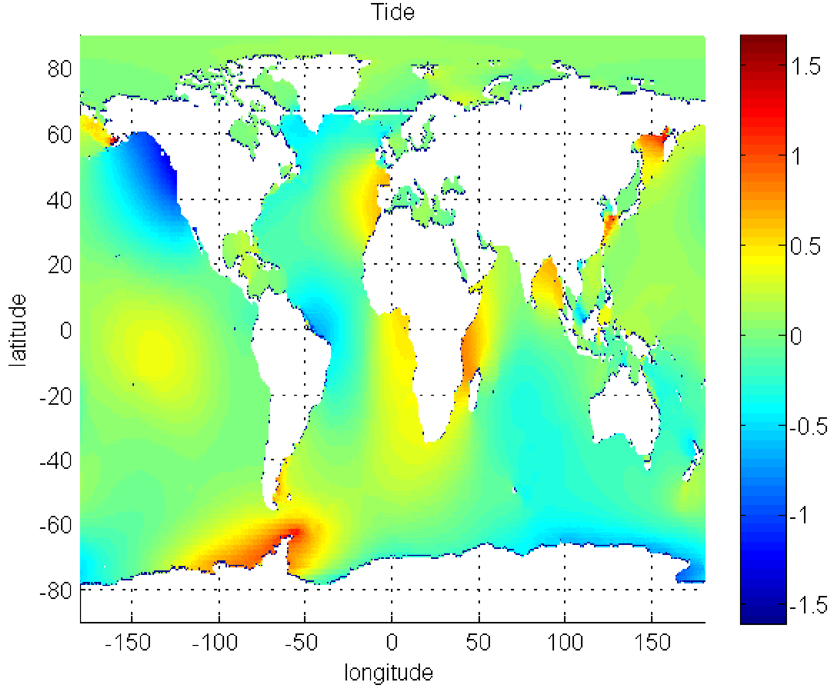
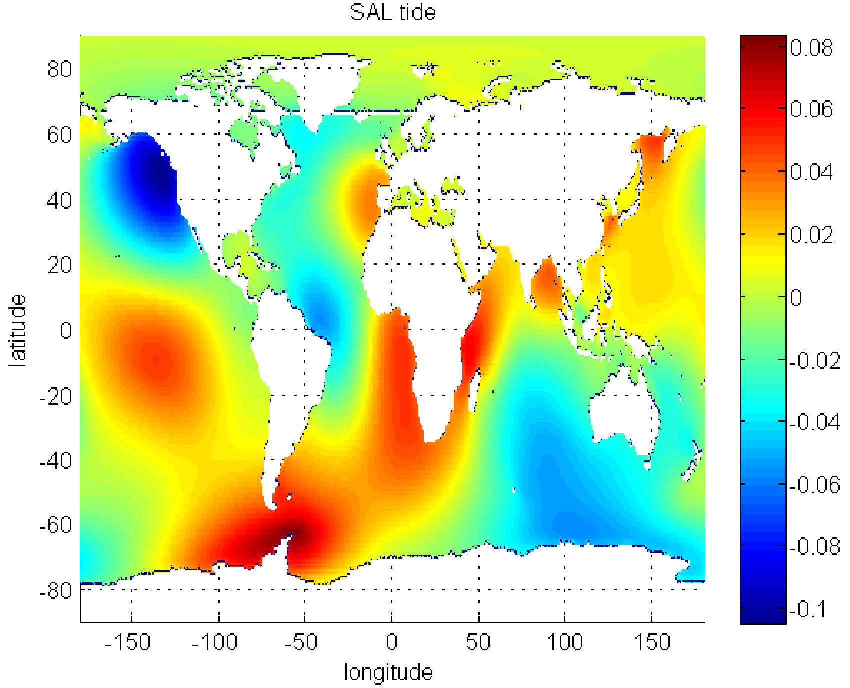
SAL-term

Tide



SAL tide



Work of: Camille le Coz

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GLOSSIS operational forecasting

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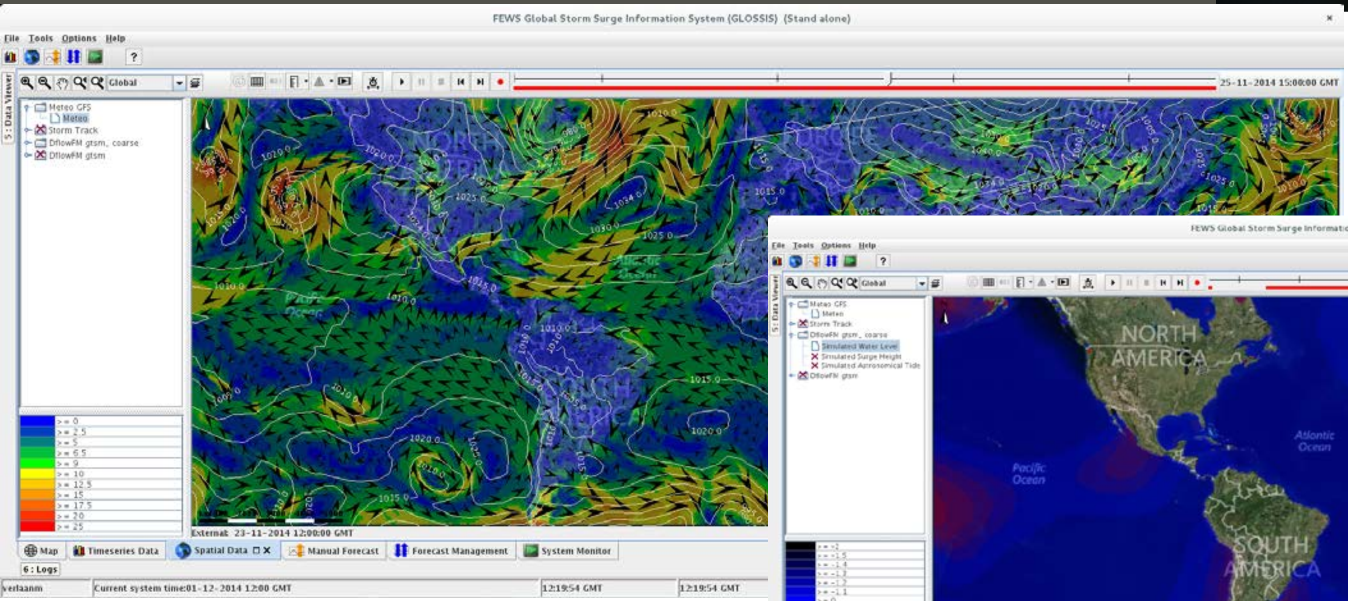
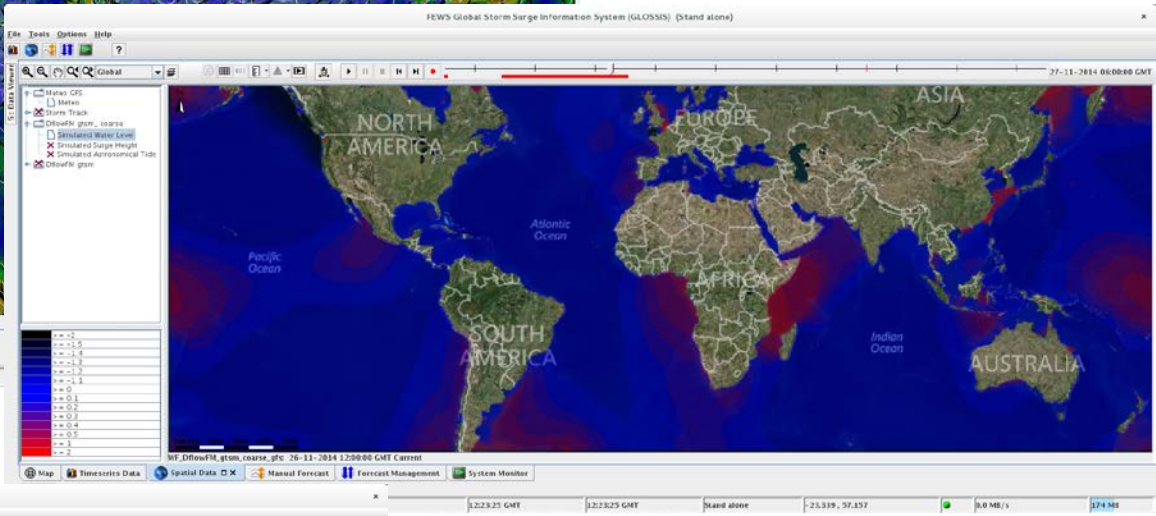
GLOSSIS – global operational storm surges

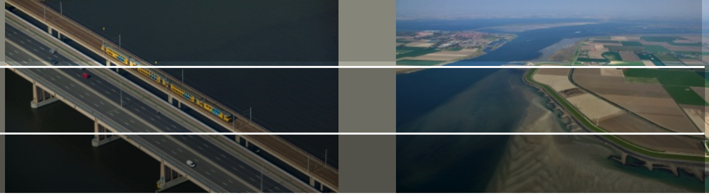


Running in ID-Lab

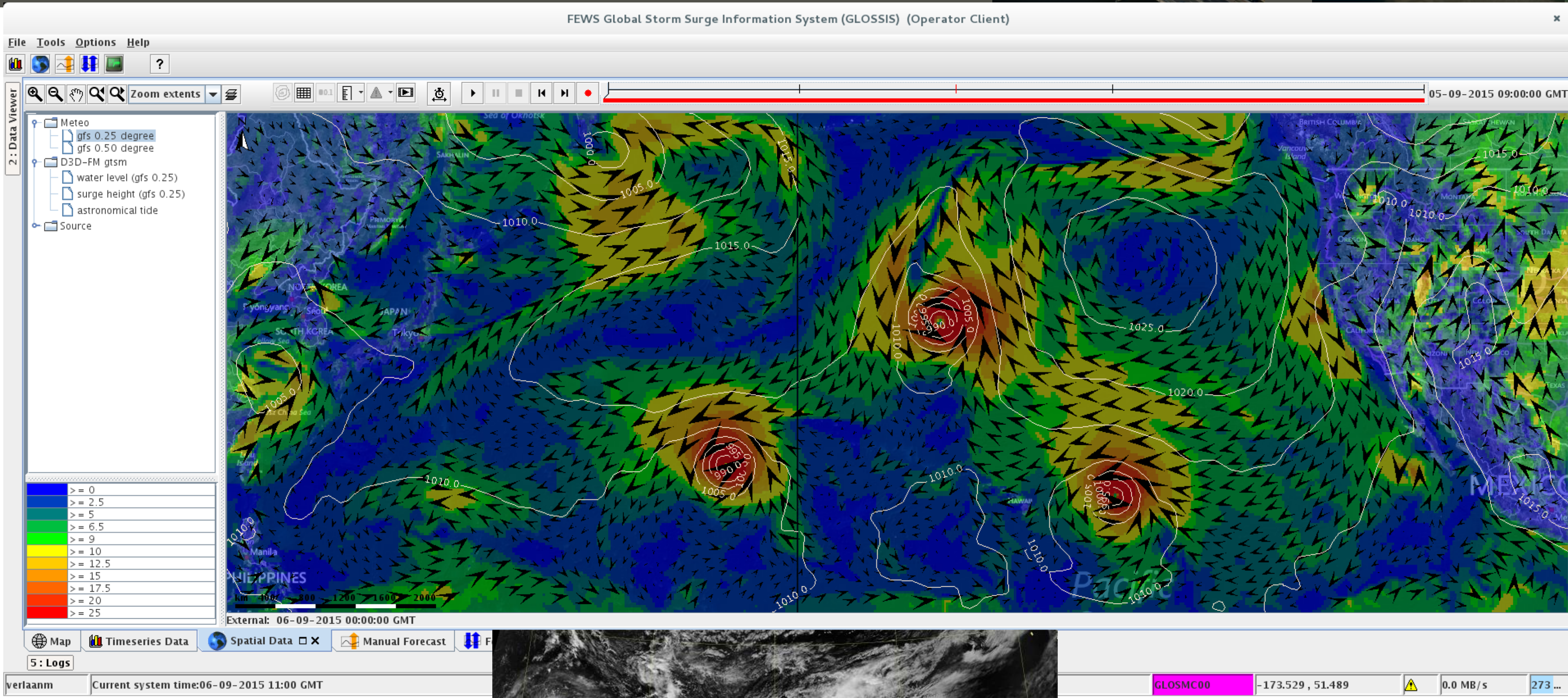


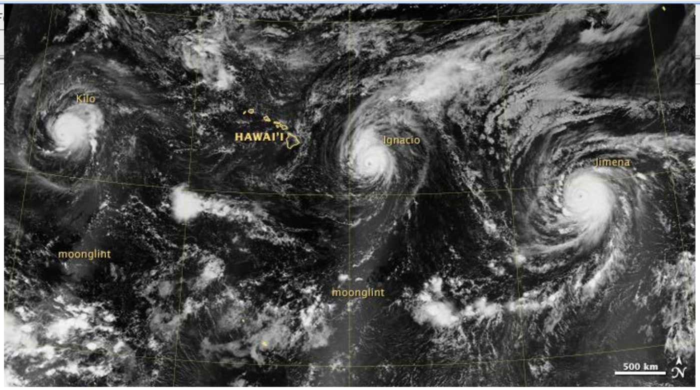
Real-time observations from IOC

Work of: Lora Buckman



Pacific start Sept 2015





Nasa: aug 30

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Thanks and Questions?

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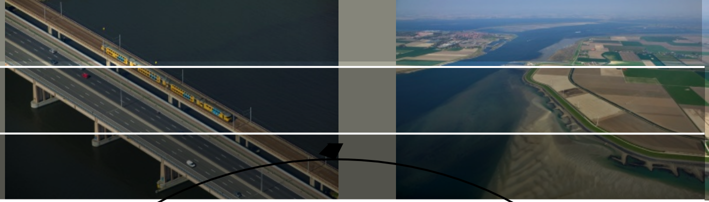
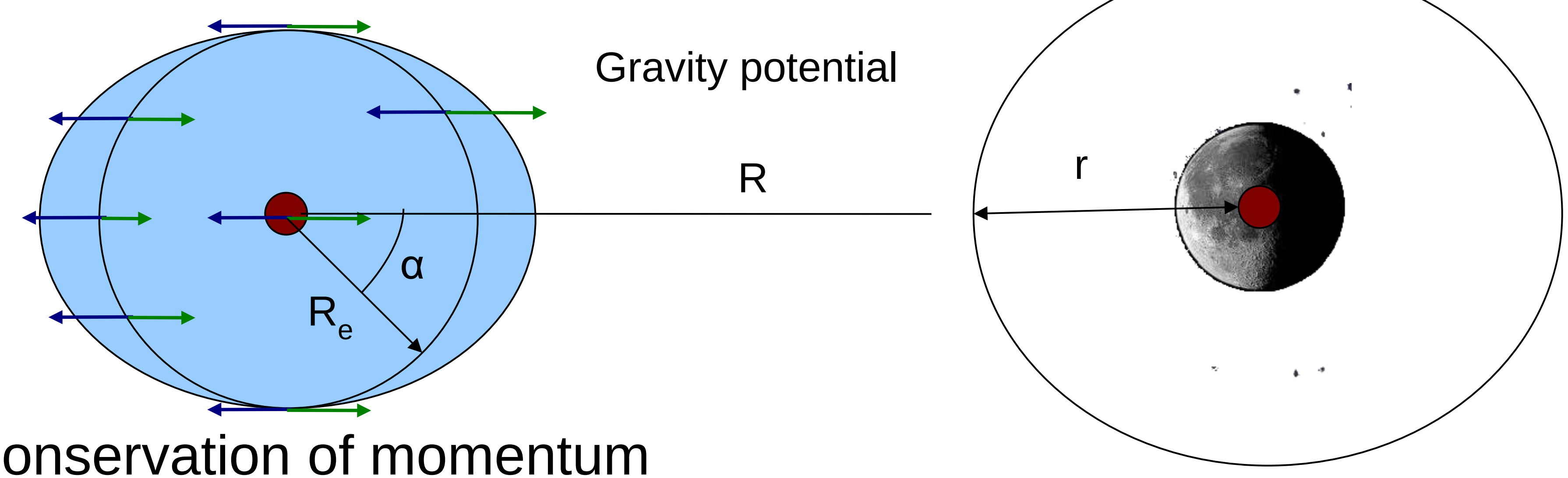


Modified equations



Conservation of momentum

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+g\frac{\partial h-\zeta-\beta h}{\partial x}-fv+\frac{gu\sqrt{u^2+v^2}}{C^2H}+\frac{\alpha\kappa Nd^2\sqrt{\omega^2-f^2}}{2\omega H}u=0$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+g\frac{\partial h-\zeta-\beta h}{\partial y}+fu+\frac{gv\sqrt{u^2+v^2}}{C^2H}+\frac{\alpha\kappa Nd^2\sqrt{\omega^2-f^2}}{2\omega H}v=0$$

1. tidal forcing
2. SAL
3. dissipation by internal tides