On the computation of LAT grids

Martin Verlaan, Maialen Irazoqui Apecechea, Cornelis Slobbe, Sandra Gaytan Aguilar, Firmijn Zijl,

JONSMOD Oct 16-19 2018

Bathymetry

EMODnet bathymetry 2018 release (LAT version)

EMODnet
European Marine Observation and Data Network

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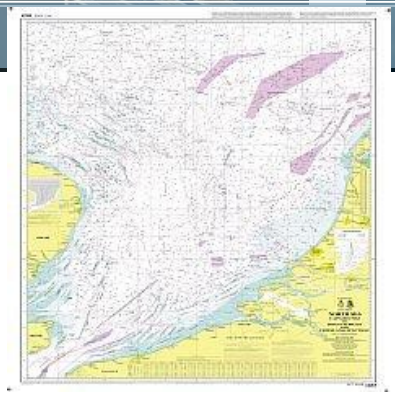
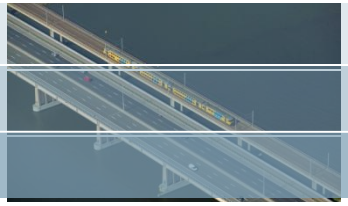
Lowest Astronomical Tide

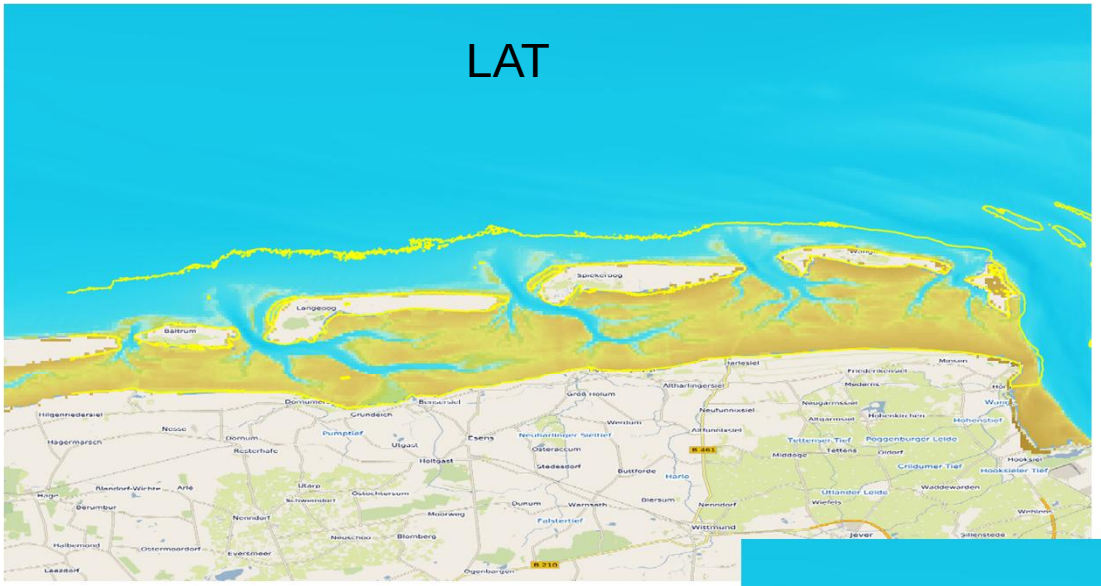


- IHO Resolution 3/1919 :
- “2a: ... It is further resolved that the Lowest Astronomical Tide (LAT), or as closely equivalent to this level as is practically acceptable to Hydrographic Offices, be adopted as chart datum where tides have an appreciable effect on the water level. ...
- Note i: LAT (...) is defined as the lowest (...) tide level which can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions. ...
- Note ii: In non-tidal waters, in order to allow the development of regional solutions, it is recommended that an appropriate long term range of low (...) water definitions of the lower (...) 94-100 percentile be adopted.”

LAT vs MSL in Wadden



LAT



MSL

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Outline

- Introduction LAT
- LAT computation for Netherlands (NEVREF)
  - DCSMv6 tidal computation with Kalman filter
  - Intertidal areas
- LAT computation for Europe (EMODnet-bathymetry)
  - GTSM tidal computations
  - Some modelling aspects

LAT for Netherlands and North Sea

TU Delft

STW
Nieuwe technologie mogelijk maken

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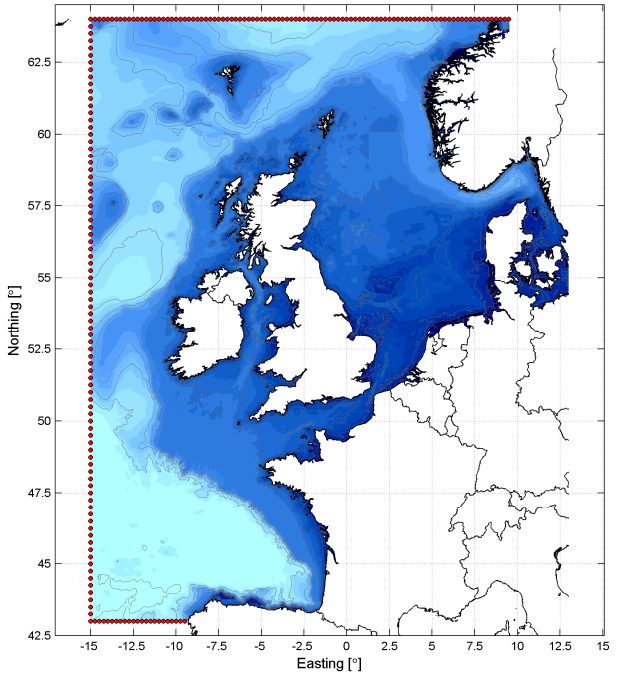
LAT computations: model setup

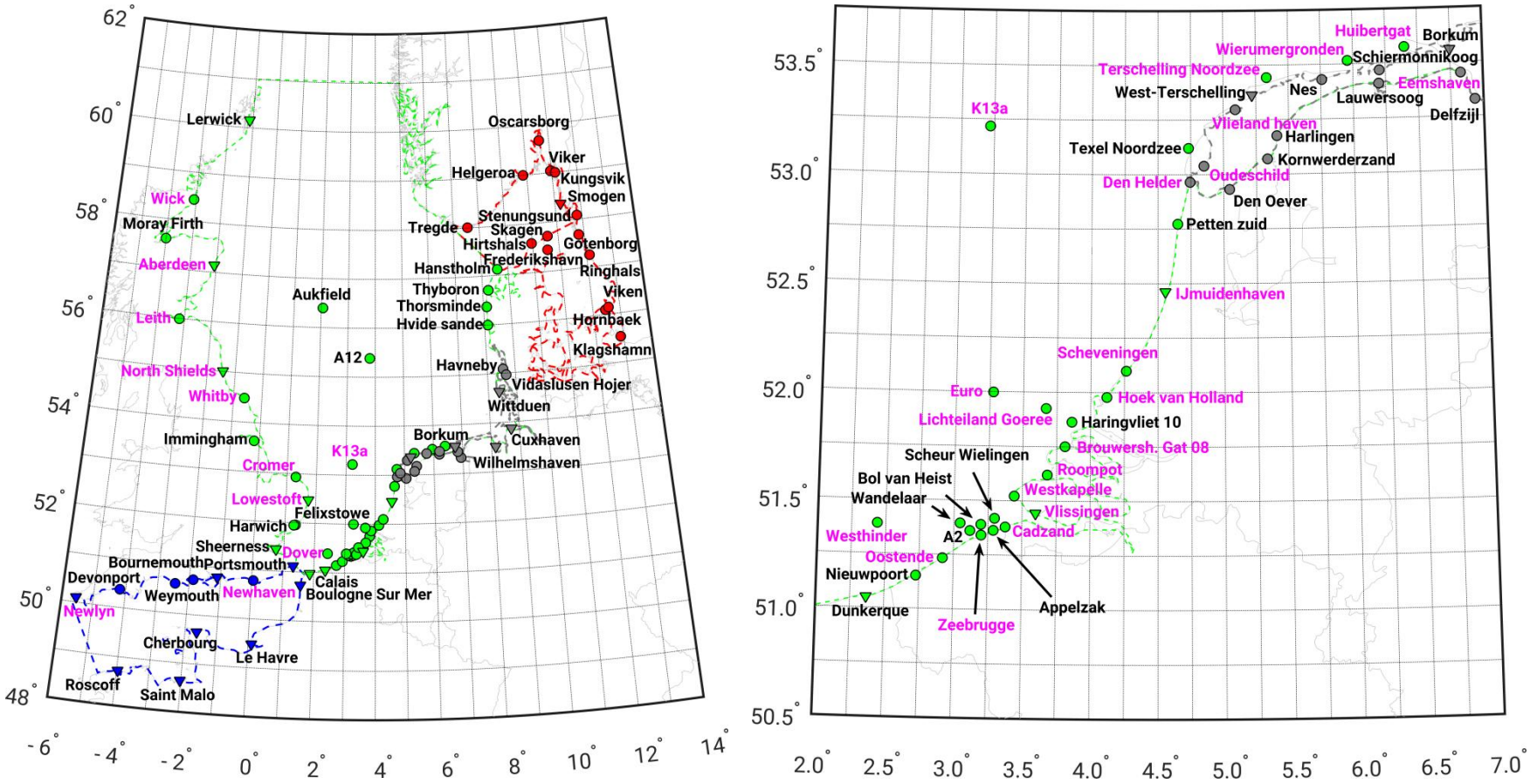
- DCSMv6 tide-only computations
- Simulation period: Jan 1993 - Jan 2012;
- Multi-year average monthly mean wind/ atmospheric + barocl. forcing included;
  - Wind/atmospheric pressure fields: ERA-Interim;
  - 4D Salinity/temperature fields: “Atlantic-European North West Shelf- Ocean Physics Reanalysis (1985-2014);



- Open boundary conditions:
  1. Tide, defined in frequency domain
     - ✓ 8 main + 5 long-term constituents taken from global ocean tide models;
     - ✓ 13 smaller (semi-)diurnal const.;
  2. Surge: MOG2D Dynamic Atmospheric Correction.
  3. Baroclinic contr. : computed from daily mean modeled water levels provided along with S/T fields:

Data assimilation

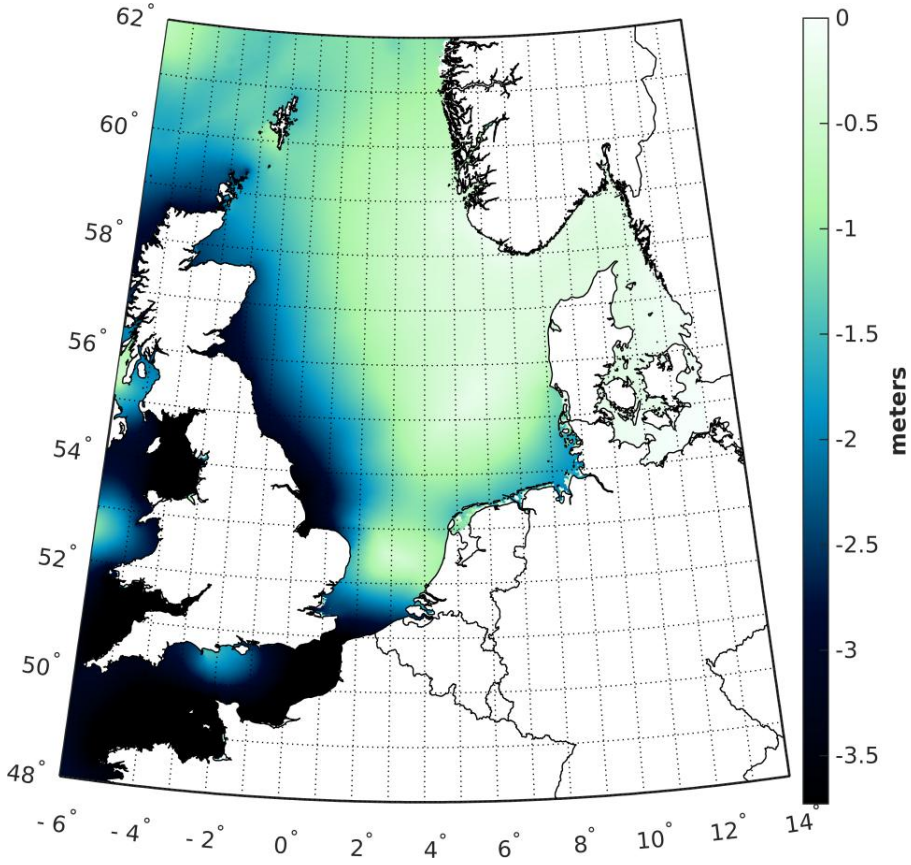
- *Kalman filtered* LAT solution obtained by assimilating tidal water levels @ 31 tide gauges;



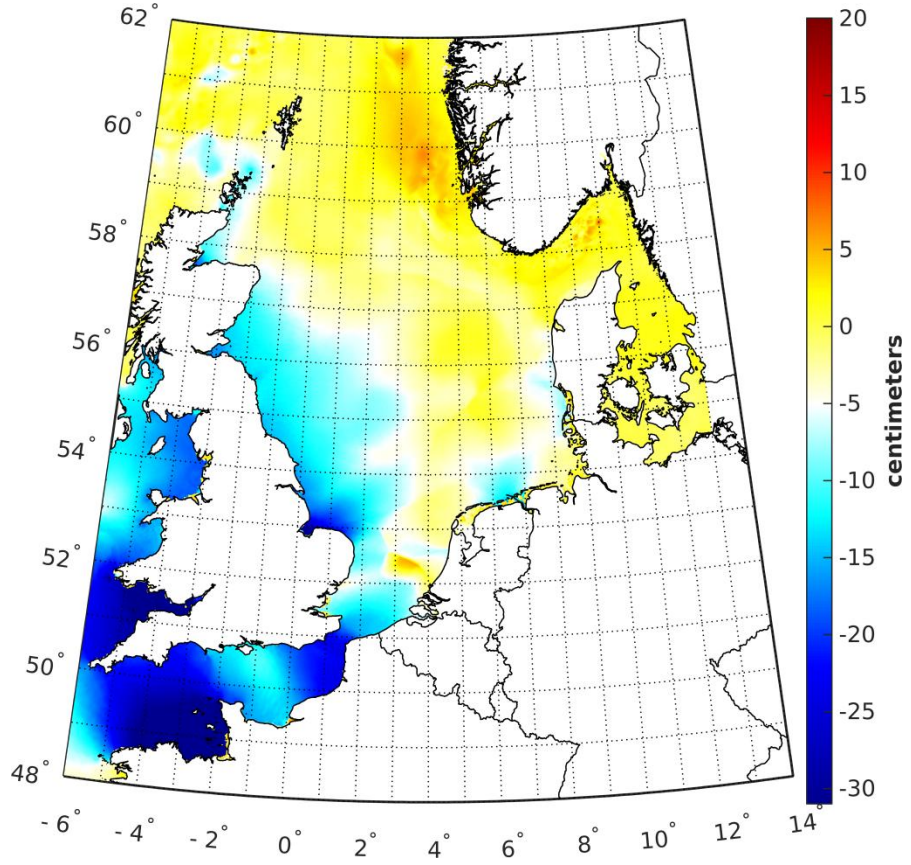
- Validation conducted using all TGs (Set A) & TGs <u>not assimilated (Set B)</u>

LAT w.r.t. geoid

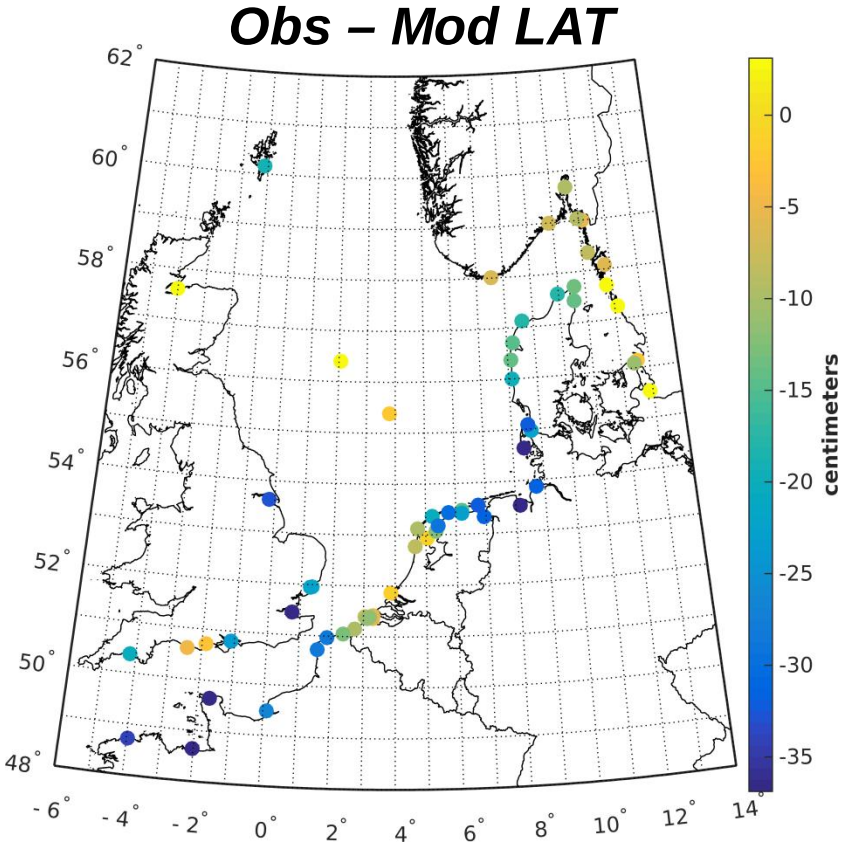
Kalman filtered LAT

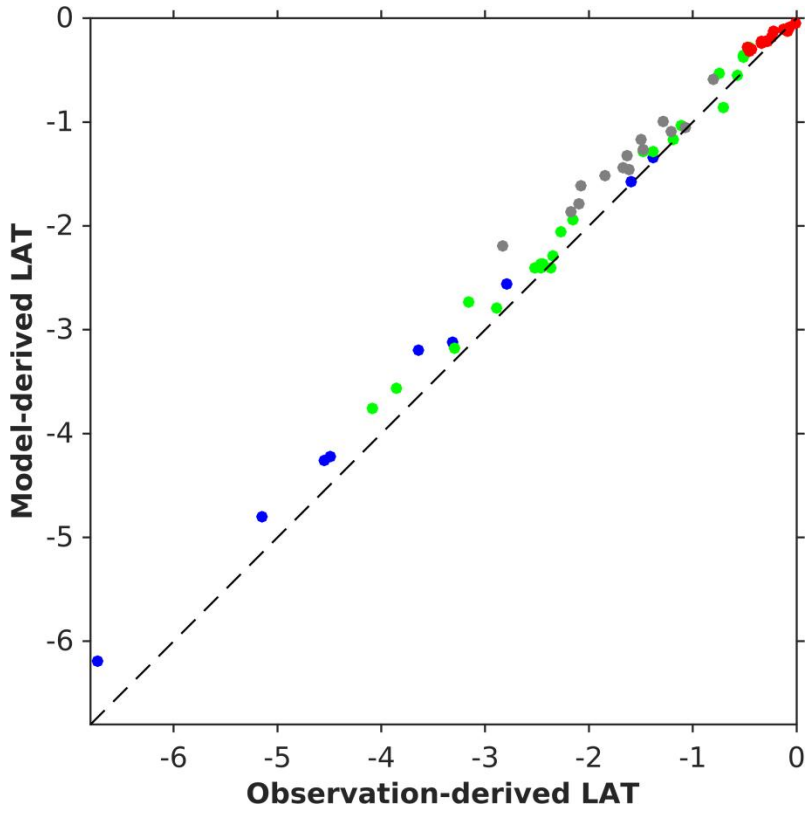


Kalman filtered LAT – model-only LAT



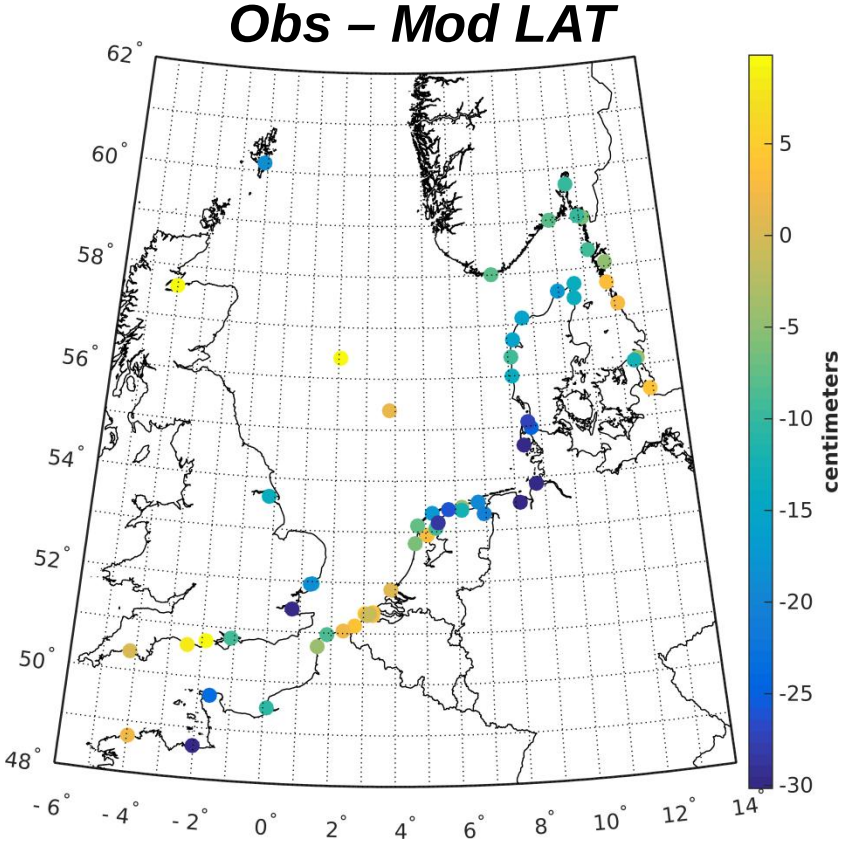
Model-only LAT - validation

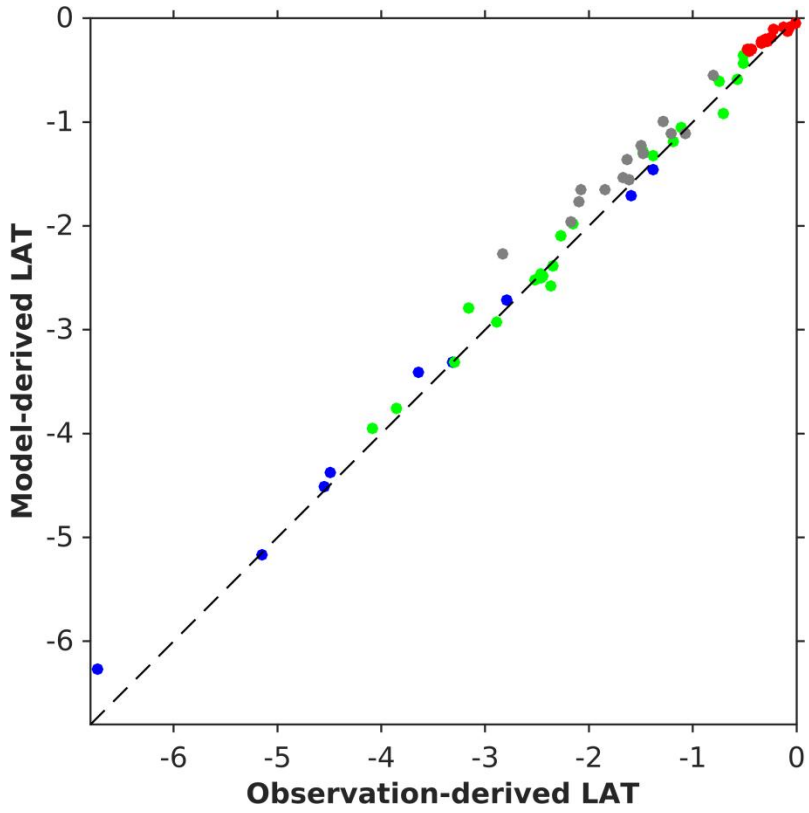




Set	Region	Nr	Rms (cm)	Range (cm)	Mean (cm)	Std (cm)
B	NS	23	17.6	58.3	-13.0	12.2
	WS	14	31.6	62.8	-28.0	15.2
	All	61	22.5	79.3	-16.9	15.1

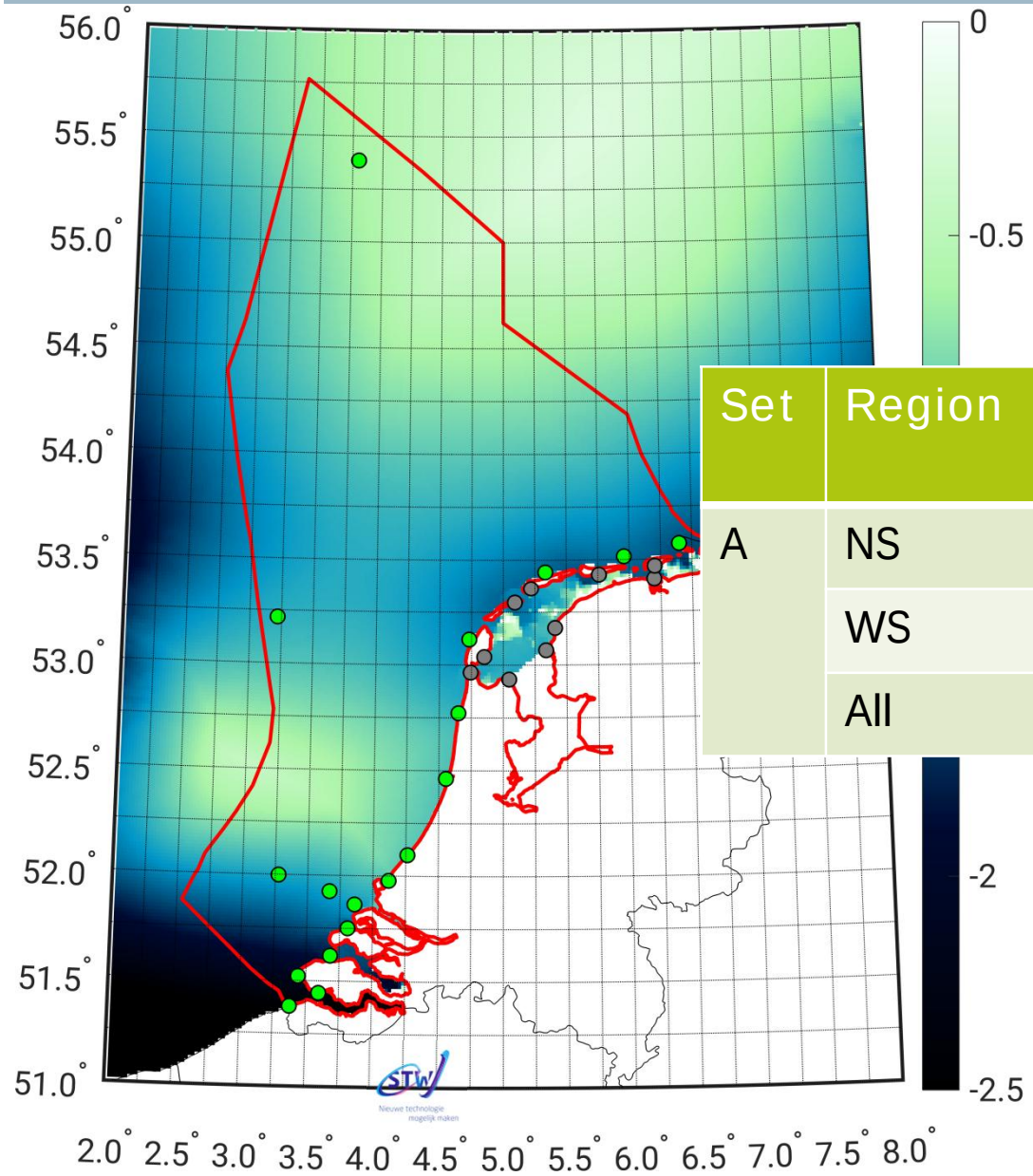
Kalman filtered LAT - validation





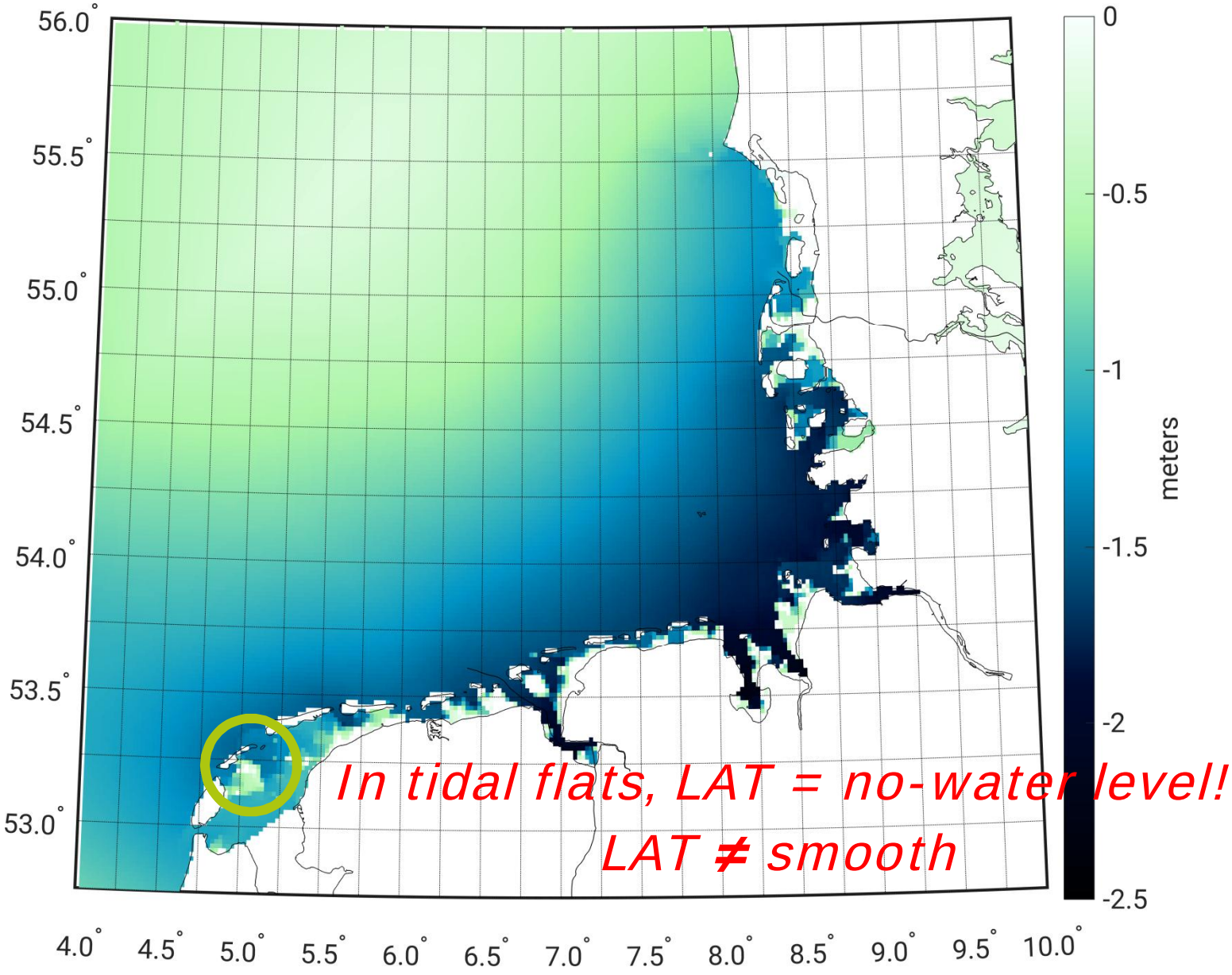
Set	Region	Nr	Rms (cm)	Range (cm)	Mean (cm)	Std (cm)
B	NS	23	13.7	57.6	-5.2	13.0
	WS	14	27.1	59.5	-22.8	15.3
	All	61	17.7	77.6	-10.2	14.6

Validation – Dutch waters

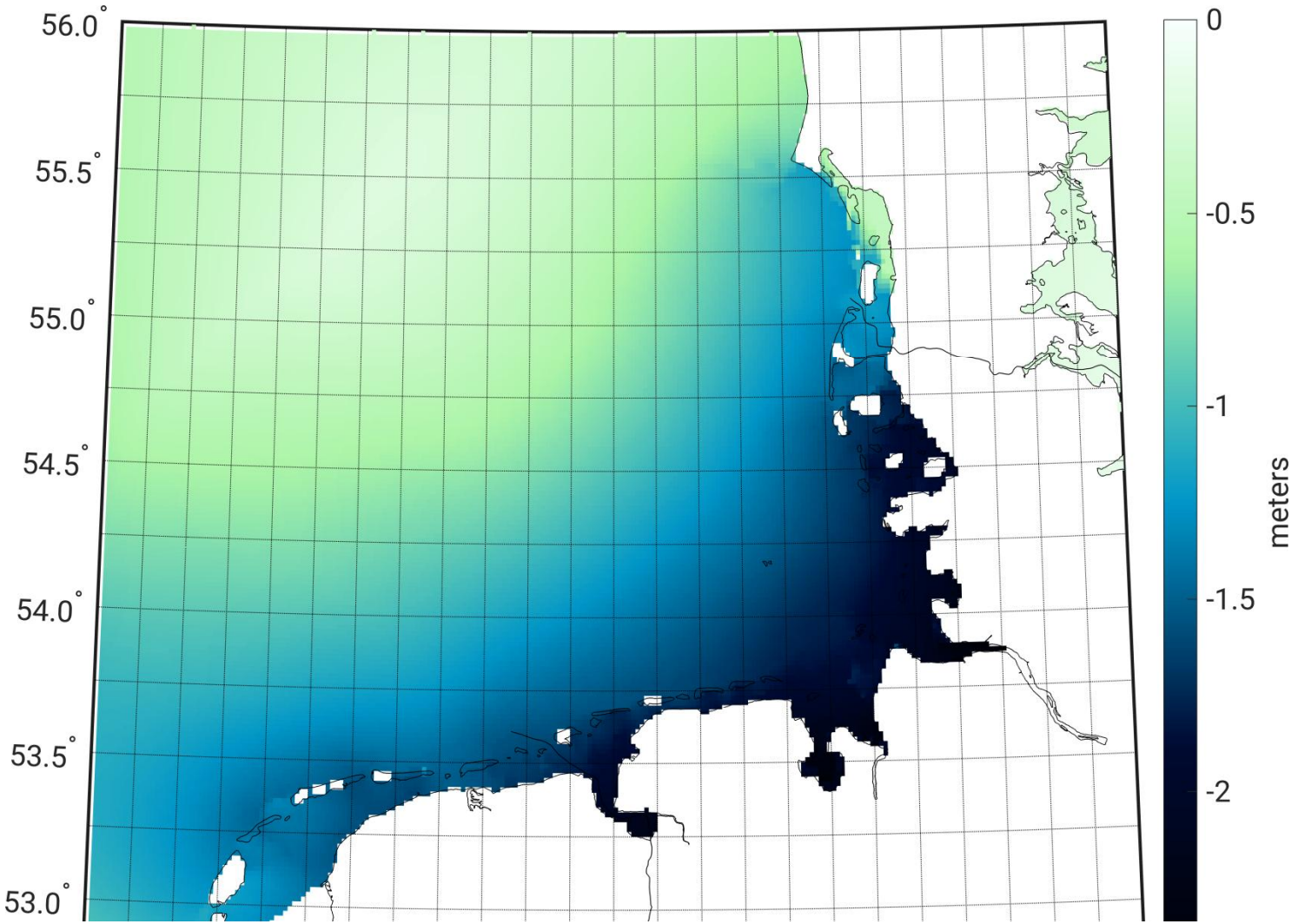


Set	Region	Nr	Mod-only LAT rms (cm)	KF LAT – rms (cm)
A	NS	19	8.0	6.6
	WS	12	19.6	14.8
	All	31	13.7	10.5

LAT in the Wadden Sea?



In the Wadden Sea LAT → pseudo LAT



To obtain pseudo-LAT we added 2 m of water to open boundary conditions & assimilated tidal water levels

Conclusions NL-LAT

- Kalman-filter approach allows to realize LAT in Dutch North Sea with decimeter accuracy (rms);
- Consistency is the key!
- In part of the Wadden Sea, LAT is not defined!
- Pseudo-LAT provides smooth transition at the North Sea/Wadden Sea boundary but has no physical meaning...

LAT for Europe

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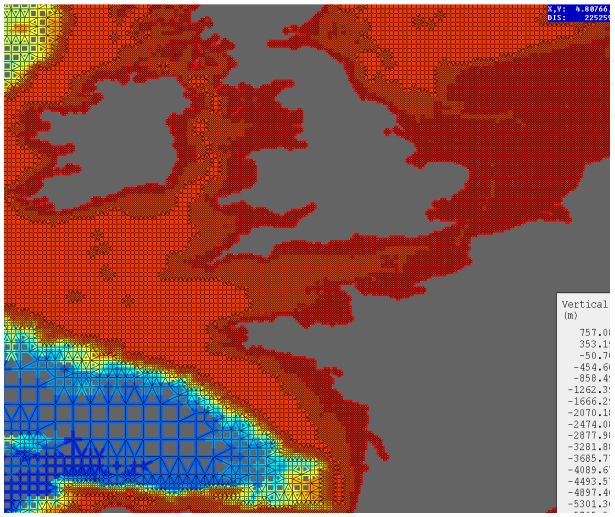
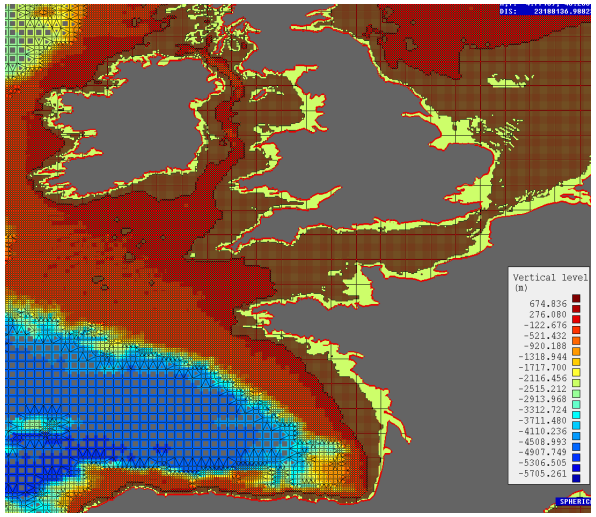
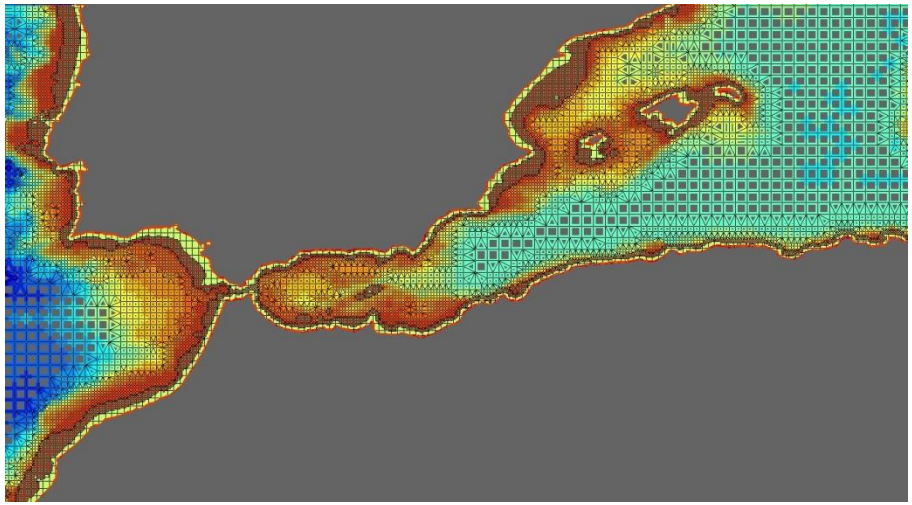
GTSM version3 grid

- Deep water 50km→25km
- Coast: 5km→2.5km globally, 1.25km Europe
- Smoothing at 2.5km resolution
- Larger coverage of refinement at steep bathymetry (5km)







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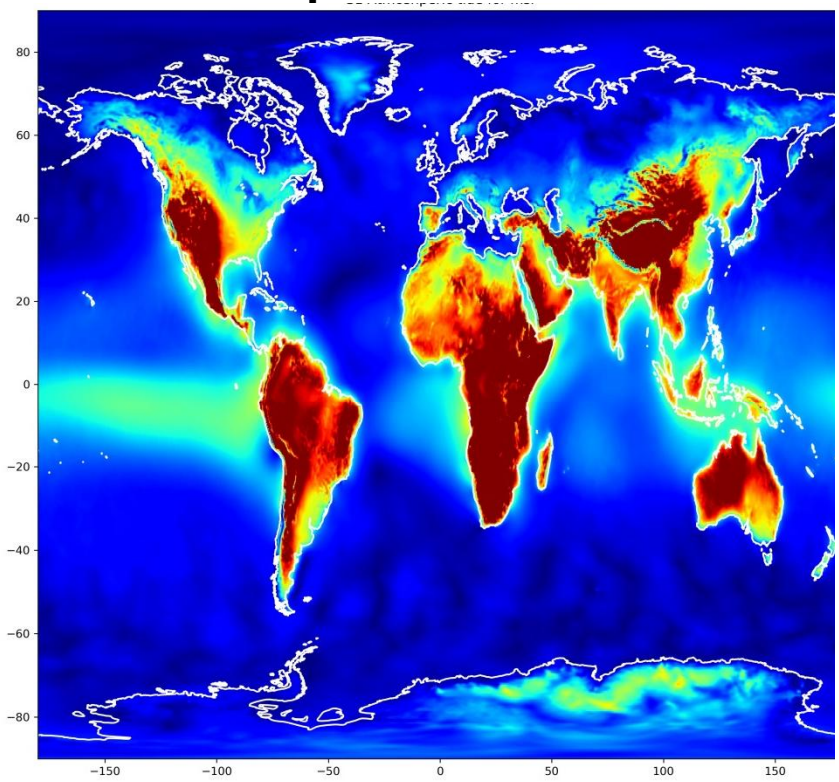
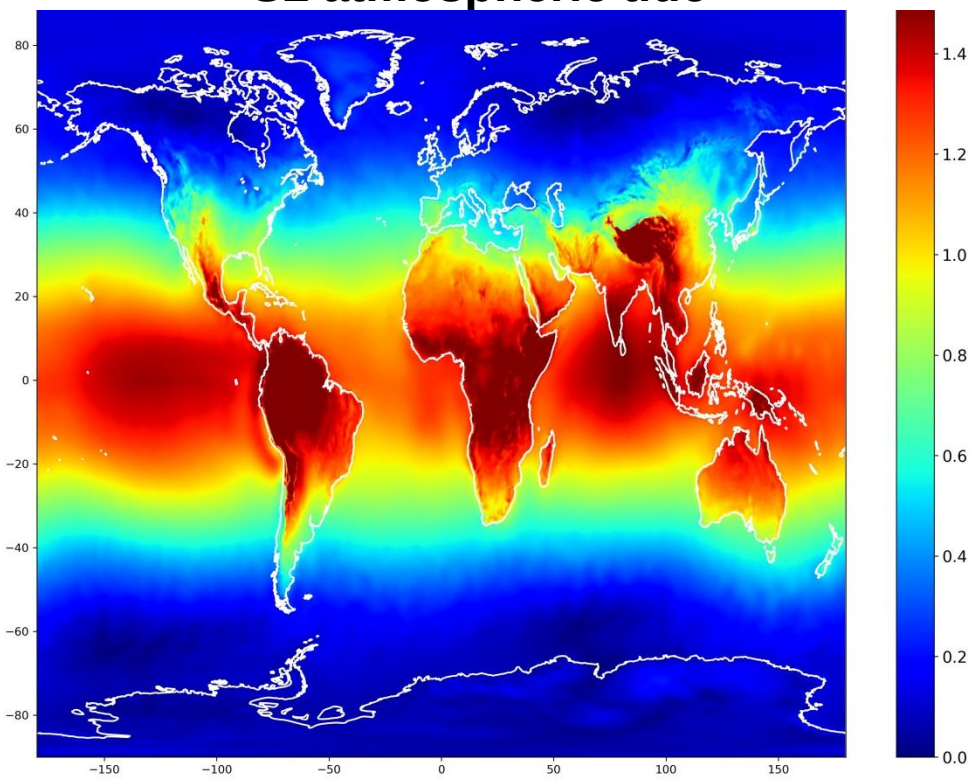
Radiational tides

S1 atmospheric tide



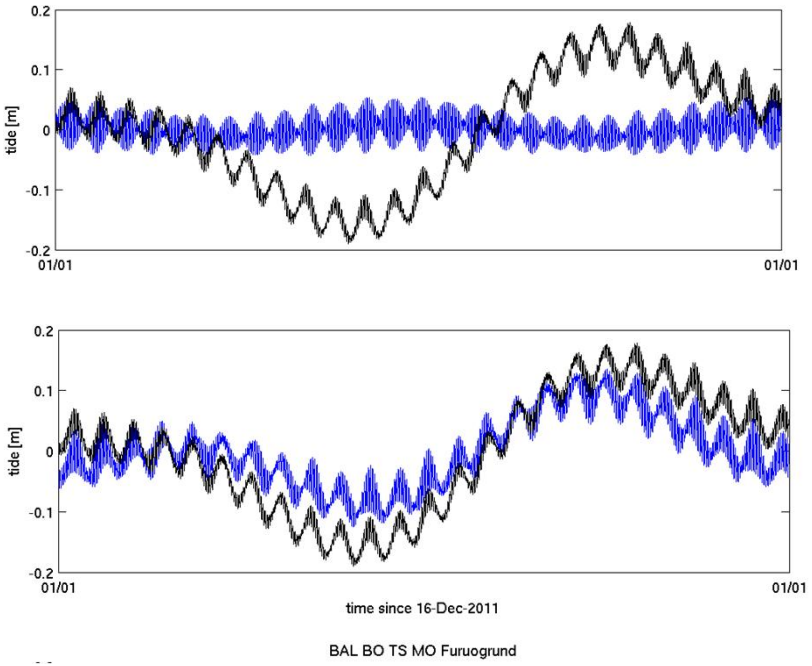
S2 atmospheric tide



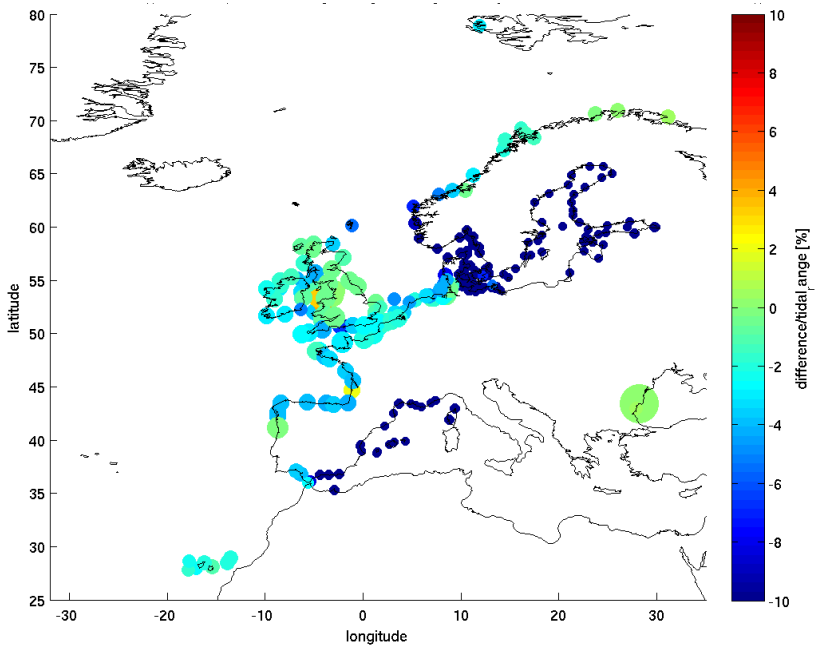
- Oceanic response to the atmospheric tides (“air tides”), resulting from solar radiation.
- Mainly pressure loading, wind stress considered negligible
- S1,S2,SSA,SA

-Harmonic analysis of surface pressure and wind stress maps from 7 years of ERA5 (0.25deg, 1hour)

Radiational tides



Modelled tide at Furuogrund (Baltic) without (upper) and with(bottom) radiational tides. Radiational seasonal signal is remarkable.



Tidal error change relative to tidal range. Mediterranean and Baltic significantly improved

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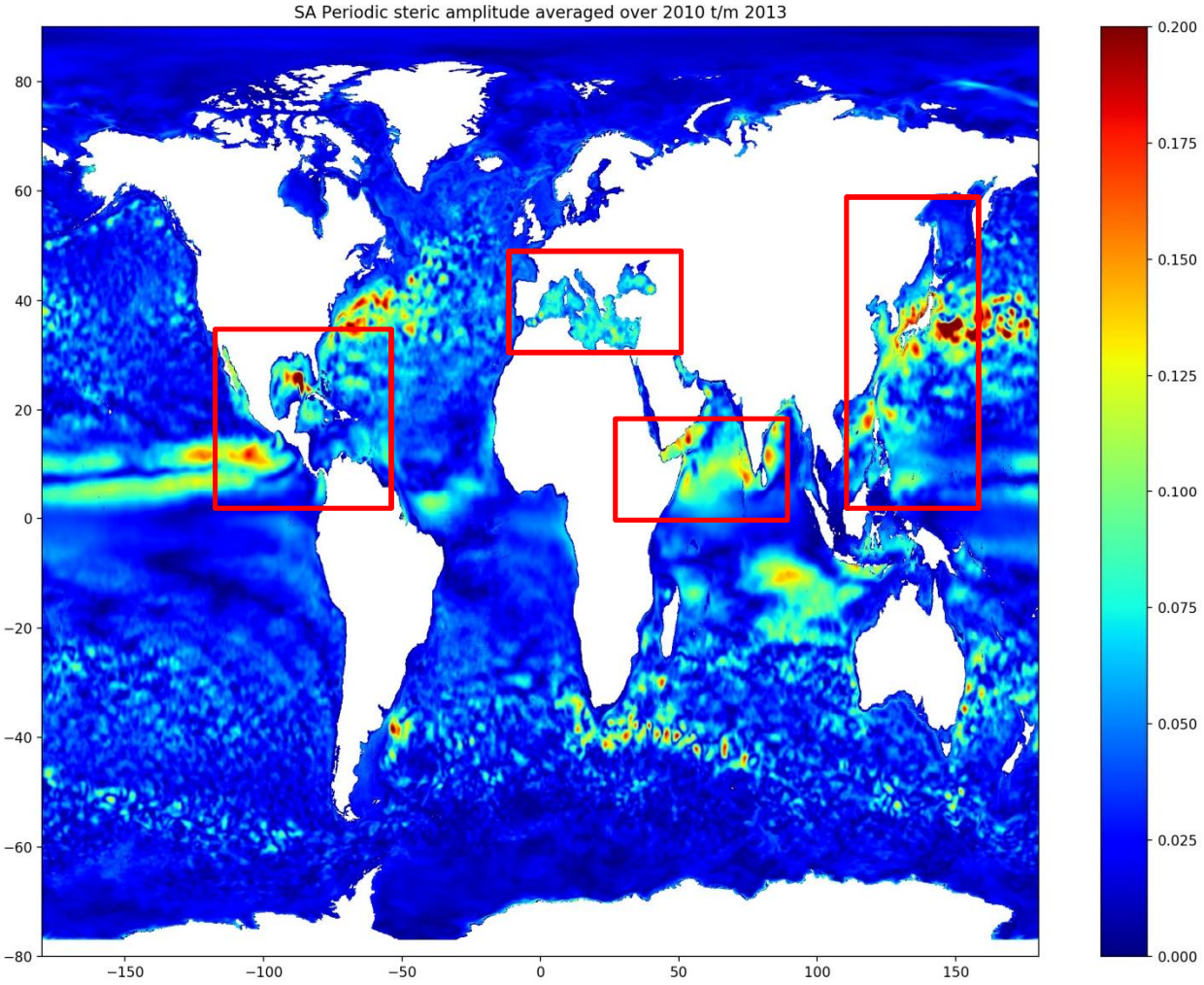
Steric tides

- SA: Mix of radiational + **steric effects** + water mass exchange
  Derivation of **average** seasonal steric anomaly from MERCATOR T&S 3D



- High values in many places close to the coast (10-20cm)
- High values close to islands in deep ocean
- Strong inter-annual variability
- E.g. Mediterranean: Main seasonal tidal signal is due to steric effects
- Recurring eddies visible in the field
- Interaction with radiational SA to produce the total SA signal.

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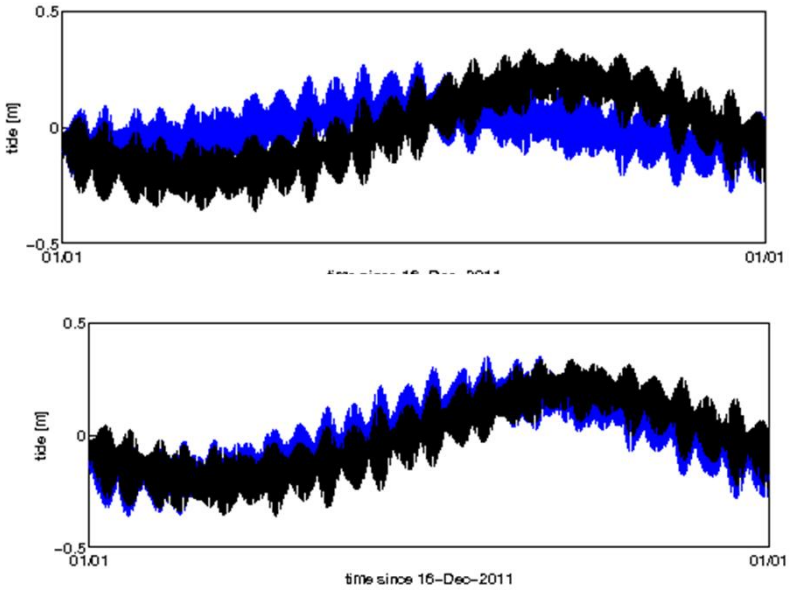
Steric tides

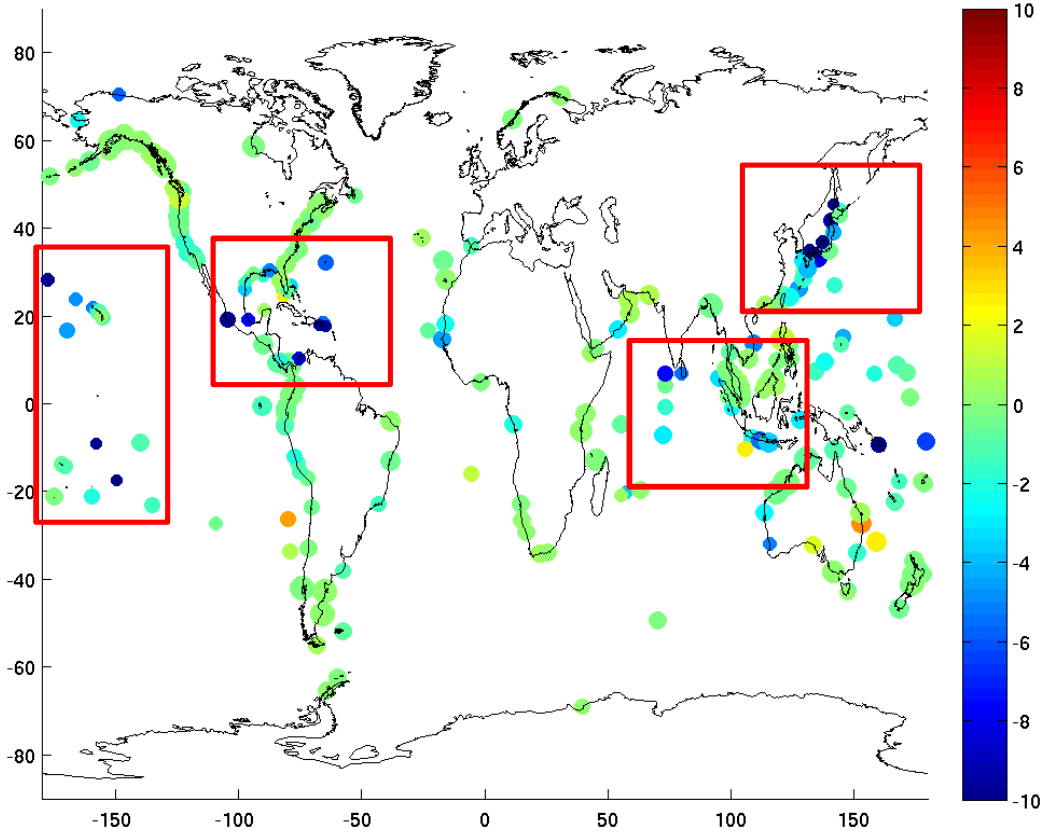
Methodology: Dynamic introduction of “steric tides” (SA,SSA) in form of pressure field.

- UHSLC stations



Blue: modelled, black: observed

Modelled tide at Toyama(Japan) without (upper) and with(bottom) steric tide



Tidal error change relative to tidal range (%)

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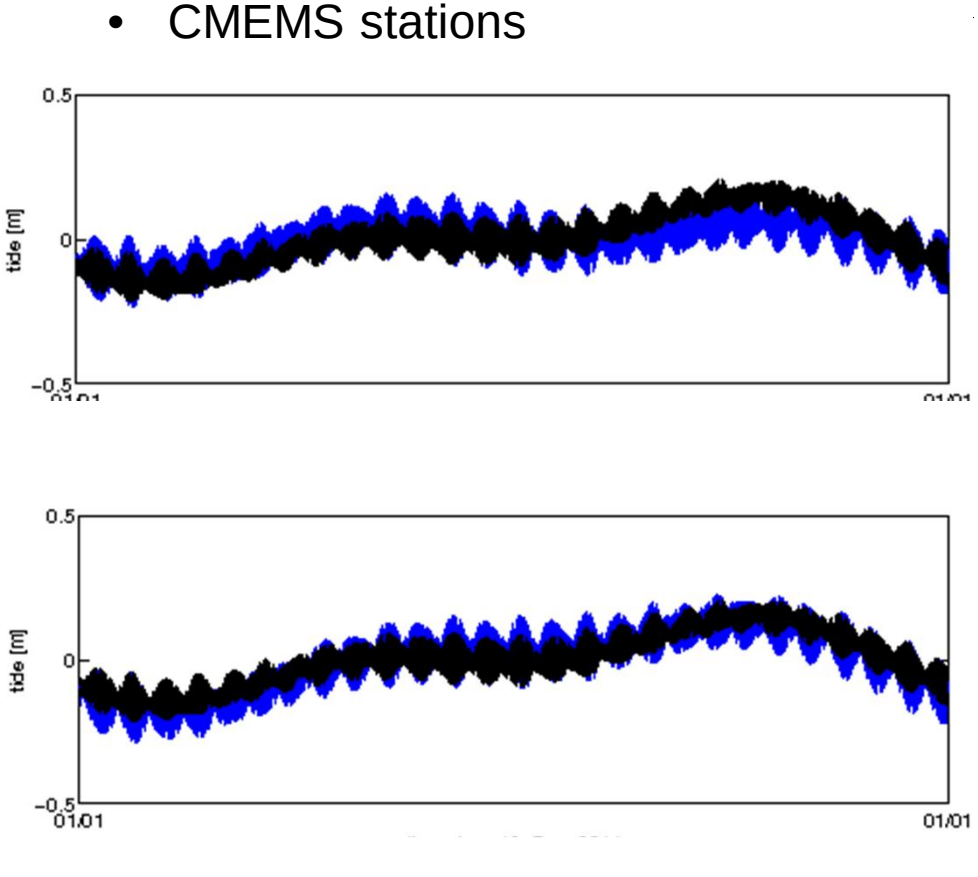
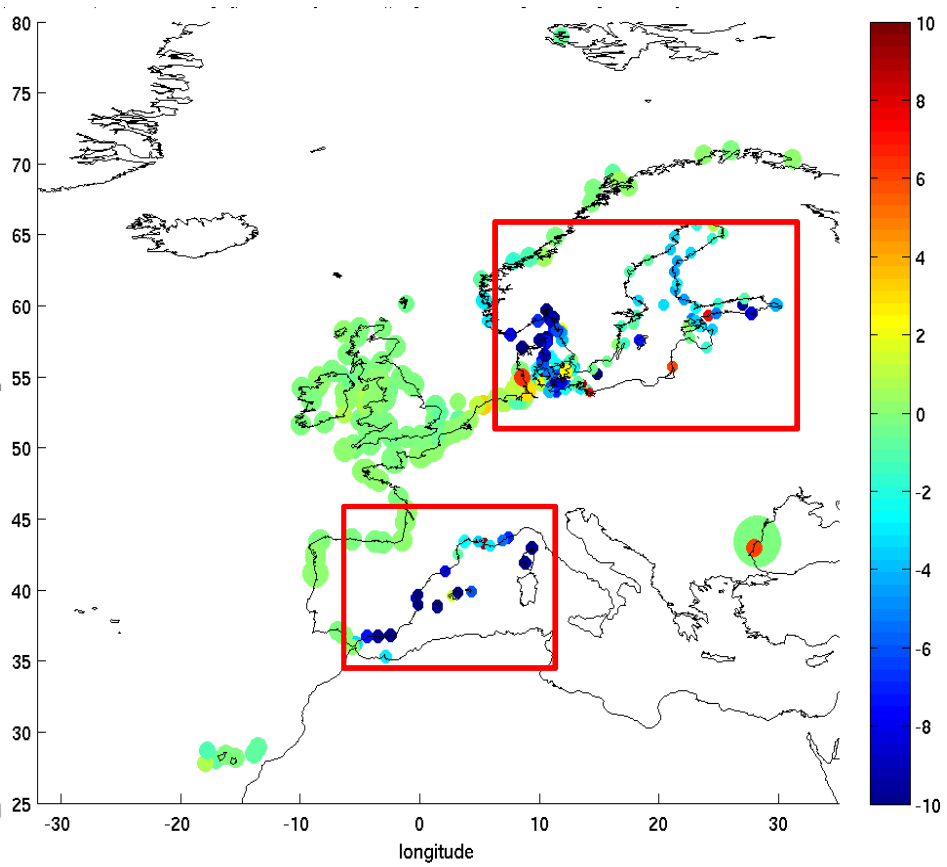
Steric tides

- CMEMS stations





Blue: modelled, black: observed

Modelled tide at Ibiza(Spain) without (upper) and with(bottom) steric tide

Tidal error change relative to tidal range (%)

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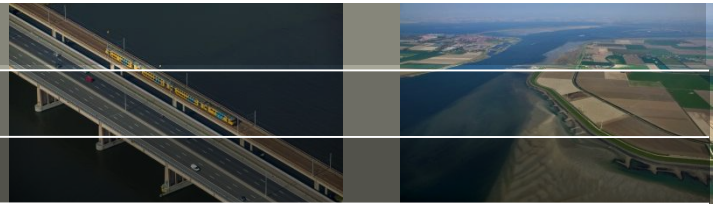
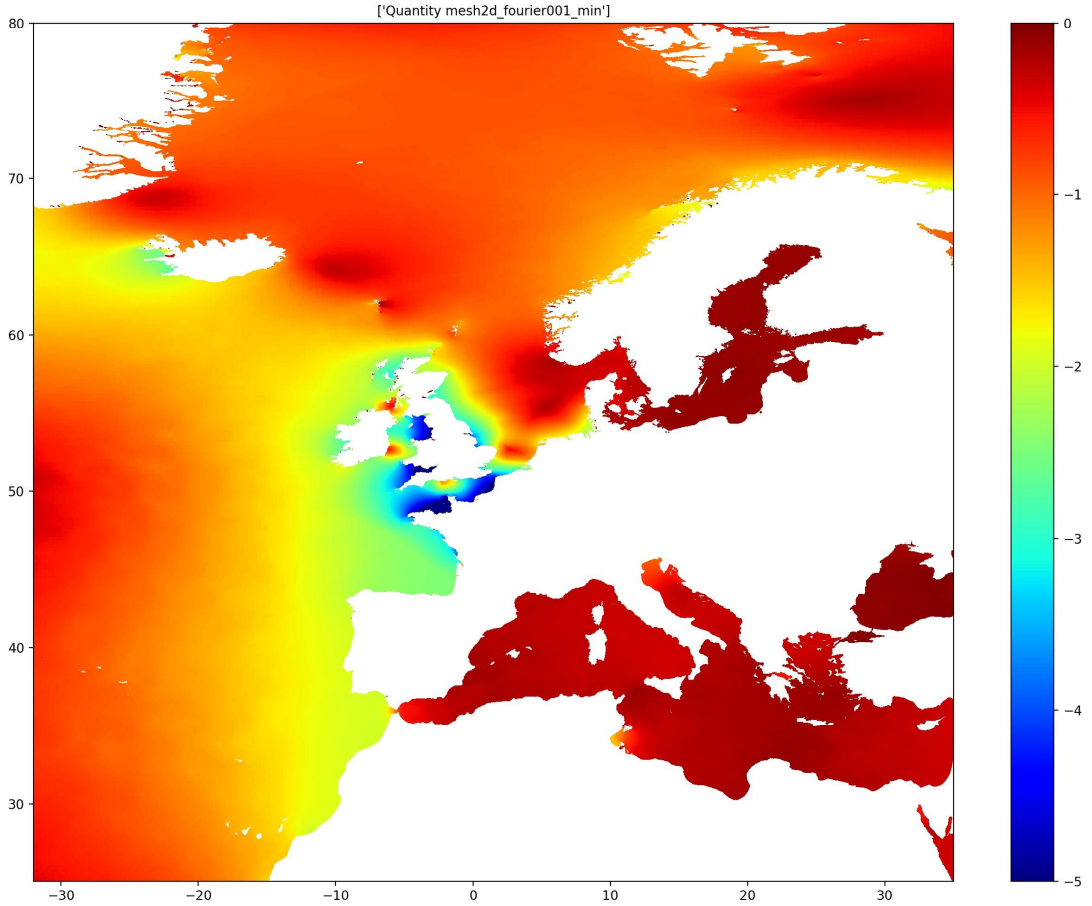
LAT worldwide





Preliminary GTSM LAT version 2018

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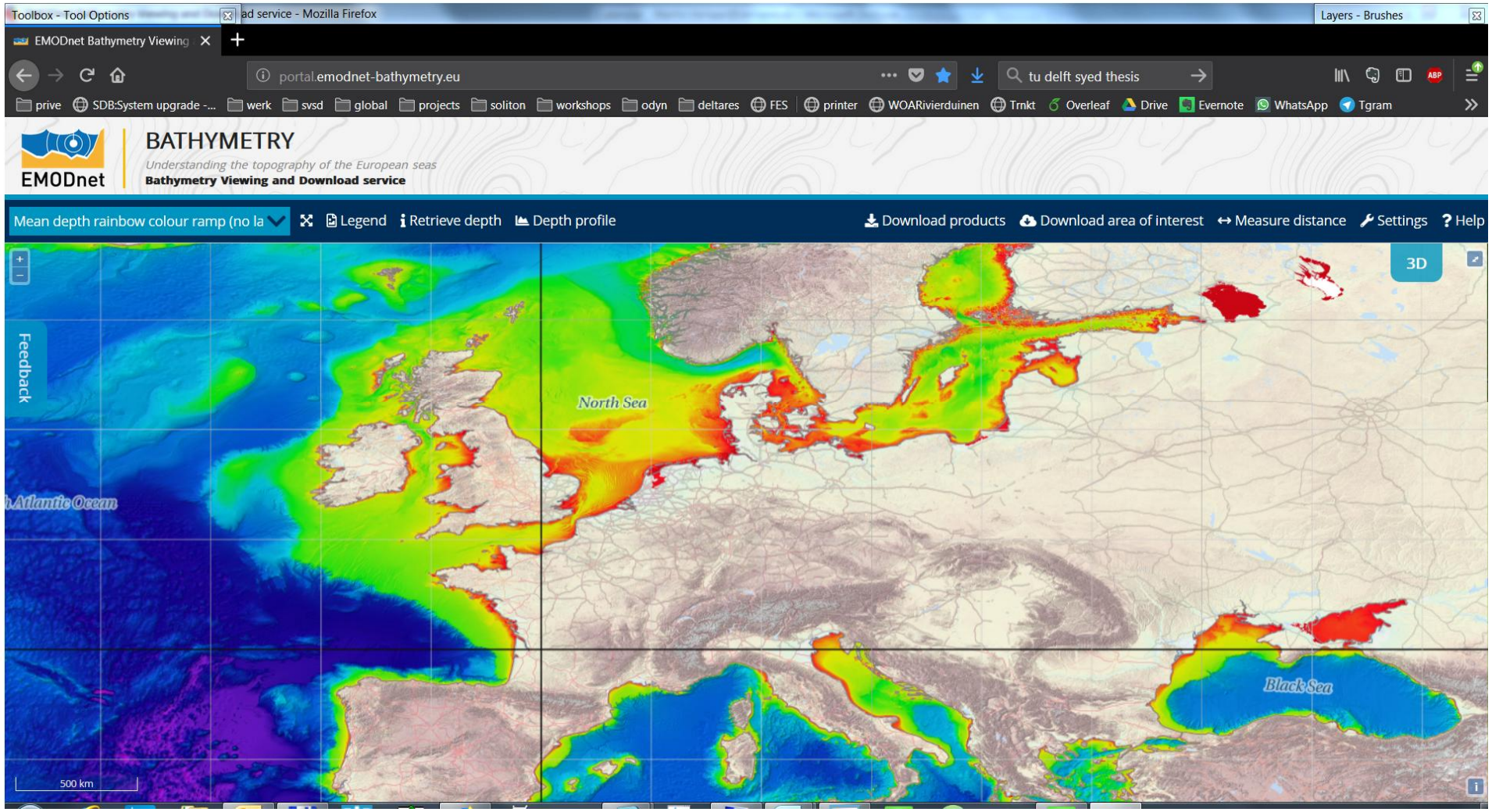
Upcoming bathymetry wrt MSL



http://portal.emodnet-bathymetry.eu

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Conclusions EU-LAT

- In several parts of Europe, radiational tides and steric tides are a significant part of the tide.
- A single tidal model covering all European seas can provide a consistent correction of LAT-MSL differences, thus avoiding jumps between regions.
- In a few months the EMODnet2018 bathymetry will be available relative to MSL too. This will simplify use of the data for model applications.

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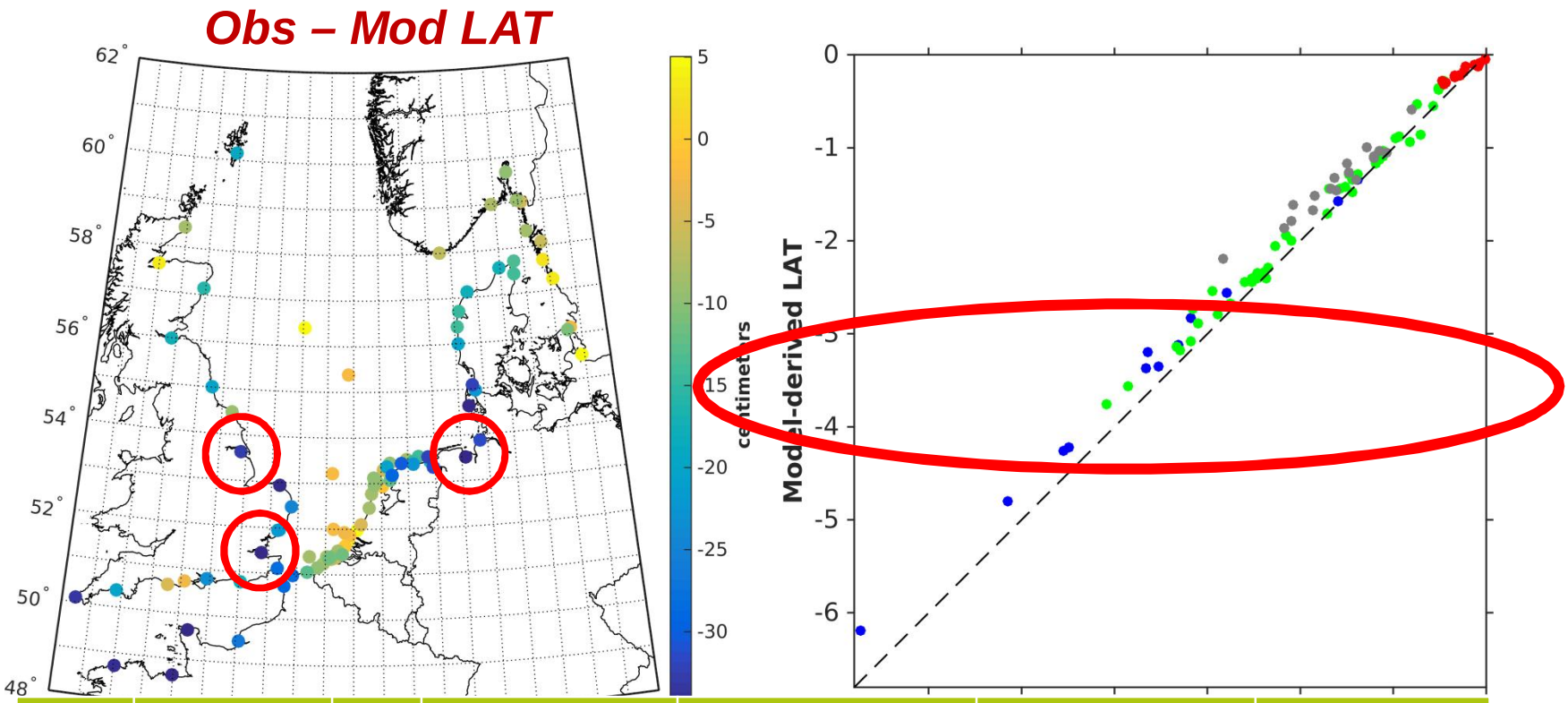
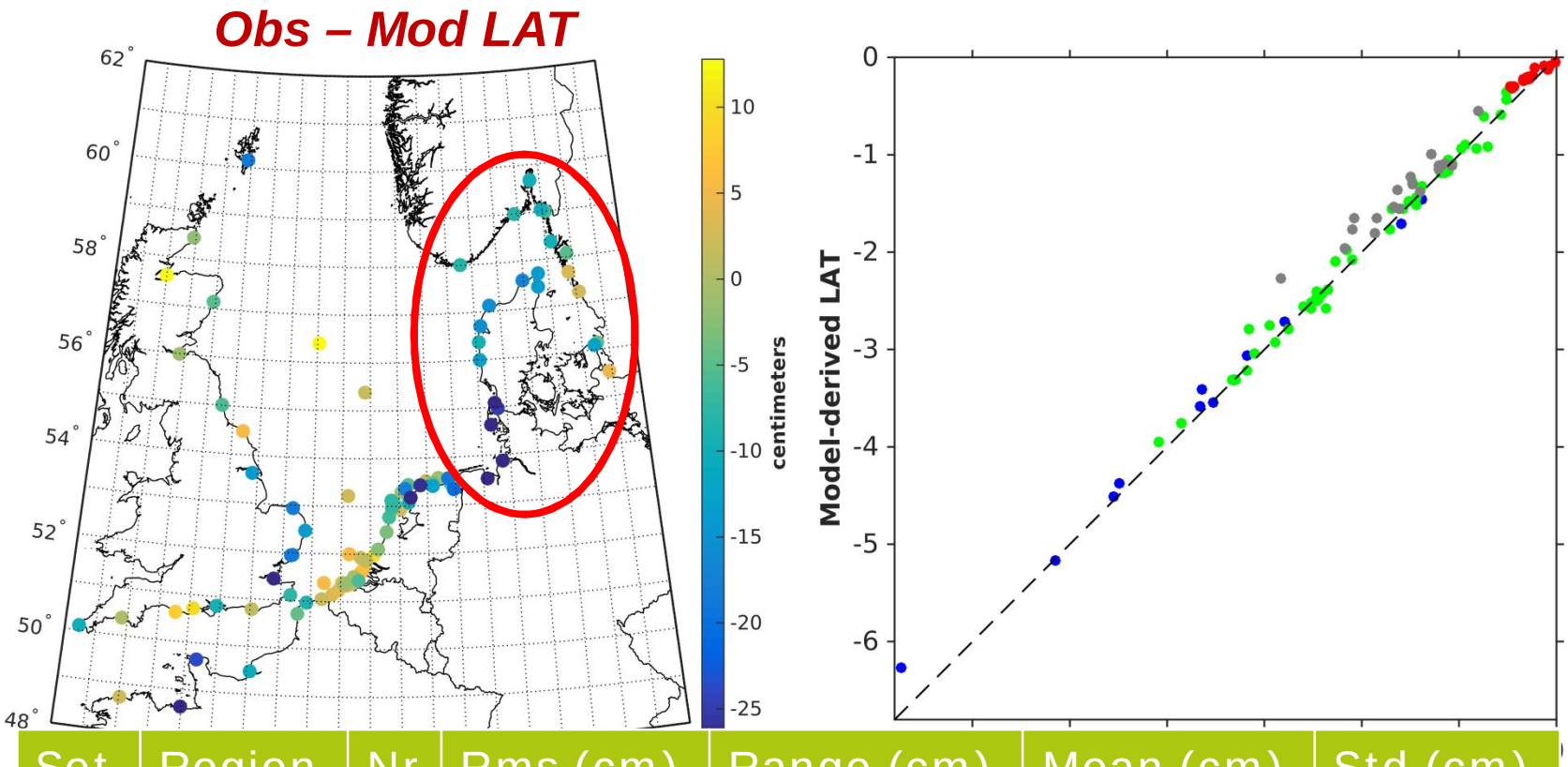
Model-only LAT - validation



Set	Region	Nr	Rms (cm)	Range (cm)	Mean (cm)	Std (cm)
A	NS	47	15.7	58.3	-11.2	11.2
	WS	18	28.4	62.8	-24.1	15.4
	All	92	20.4	79.3	-15.0	13.9

Kalman filtered LAT - validation



Set	Region	Nr	Rms (cm)	Range (cm)	Mean (cm)	Std (cm)
A	NS	47	10.6	57.6	-2.7	10.4
	WS	18	24.0	59.5	-18.7	15.4
	All	92	14.9	77.6	-7.2	13.1