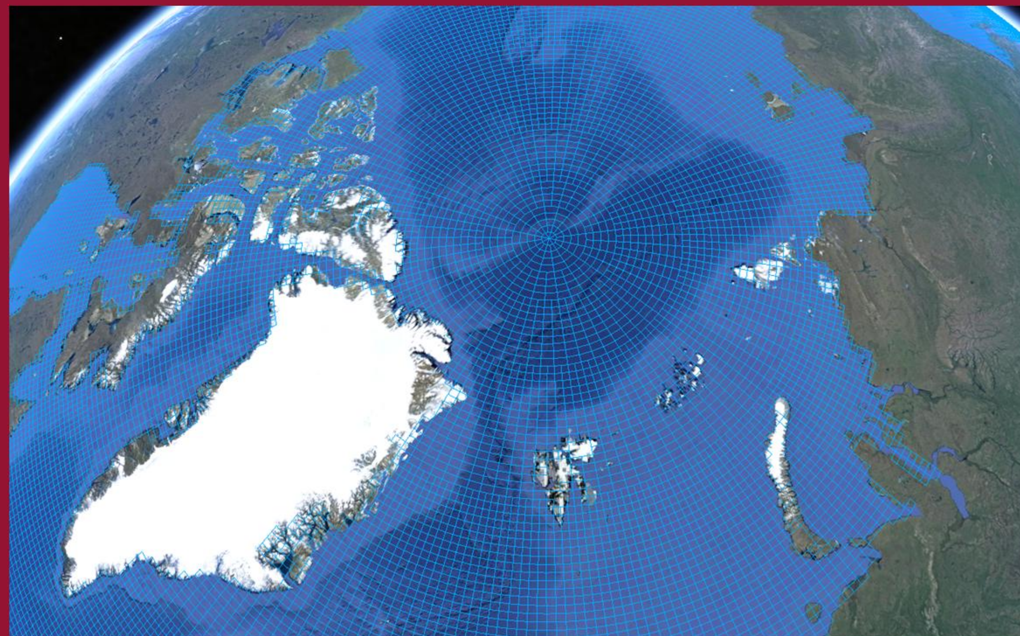


Global modelling of future extreme sea-levels using a high-resolution Global Tide and Surge Model

Climate Change

Maialen Irazoqui Apecechea
Deltares

Climate Change

Objective – CoDEC project

- Coastal Dataset for Evaluation of Climate impact (CoDEC) aims to provide:
  - A climate change data service for a European-wide coastal area
  - “Consistent” European dataset for tide, storm surge and wave conditions
  - EU wide Climate Impact Indicators (Tier 1 indicators)
  - Five local use cases through “user interaction” (Tier 2 indicators)
  - Data and indicators will be made available in CDS
  - Connect to a web service for data browse and download

•JBA Consulting Industrial Cases
•ISMAR with Venice Case
•DMI with Copenhagen Case
•UCC leading Atlantic Case
•Deltares/Rijkswaterstaat with North Sea Case

Deltares

Copernicus Europe's eyes on Earth

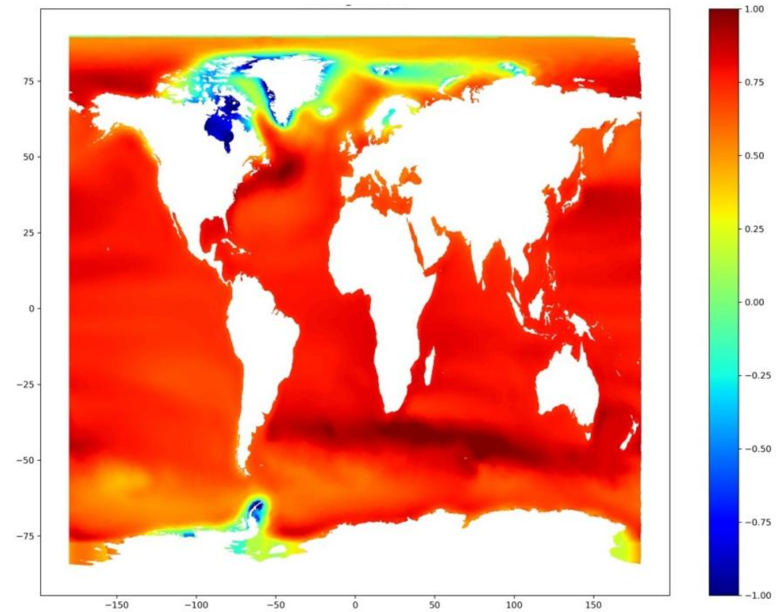
European Commission

Methodology - models

Climate Change

- Reanalysis meteorological forcing (wind stress, atmospheric pressure):
  - ERA5 (0.25 °, 1h)
  - ERA-Interim (0.75 °, 3h)
- Climate meteorological forcing:
  - EC-Earth (GCM): 1°, 3h
  - Euro CORDEX (RCM):~12km, 1h
- Relative Sea level rise: CMIP5 ensemble mean (current MSL 1985-2005) 0.5°
- Wave: ECMWF WAM model
- Tide and surge: GTSMv3.0

High spatial and temporal resolution hydro/meteo models, dynamic SLR-tide-surge interaction



Source RSLR: T. Frederikse Univ. Utrecht

Deltares

Copernicus Europe's eyes on Earth

European Commission

Climate Change

GTSM v3.0

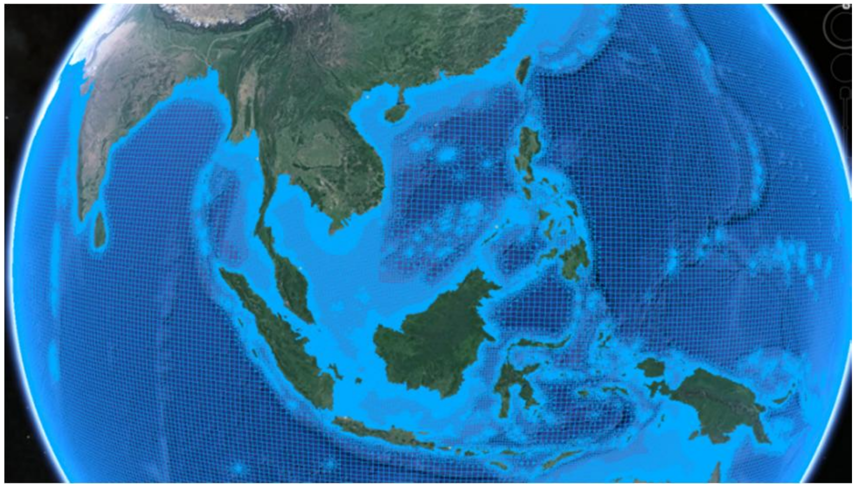
- 2D barotropic model
- Unstructured global grid

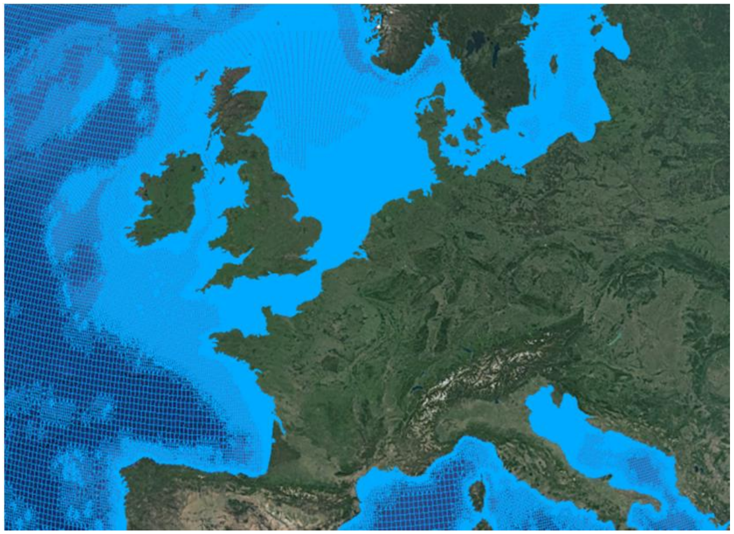
(25 km ocean - 2.5km coastal/1.25km EU)

- Bathymetry:
  - EMODnet (250m) for EU
  - Bedmap2 below lat 60S
  - GEBCO 2014 bathymetry(~1km)
- TGF driven, <u>no assimilation</u>

Runtimes in 8 cores ~3.6hour/week

- Two physical processes that are not negligible at a global scale:
  - Self attraction and loading (SAL)
  - Tidal dissipation through generation of internal tides





Deltares

Copernicus Europe's eyes on Earth

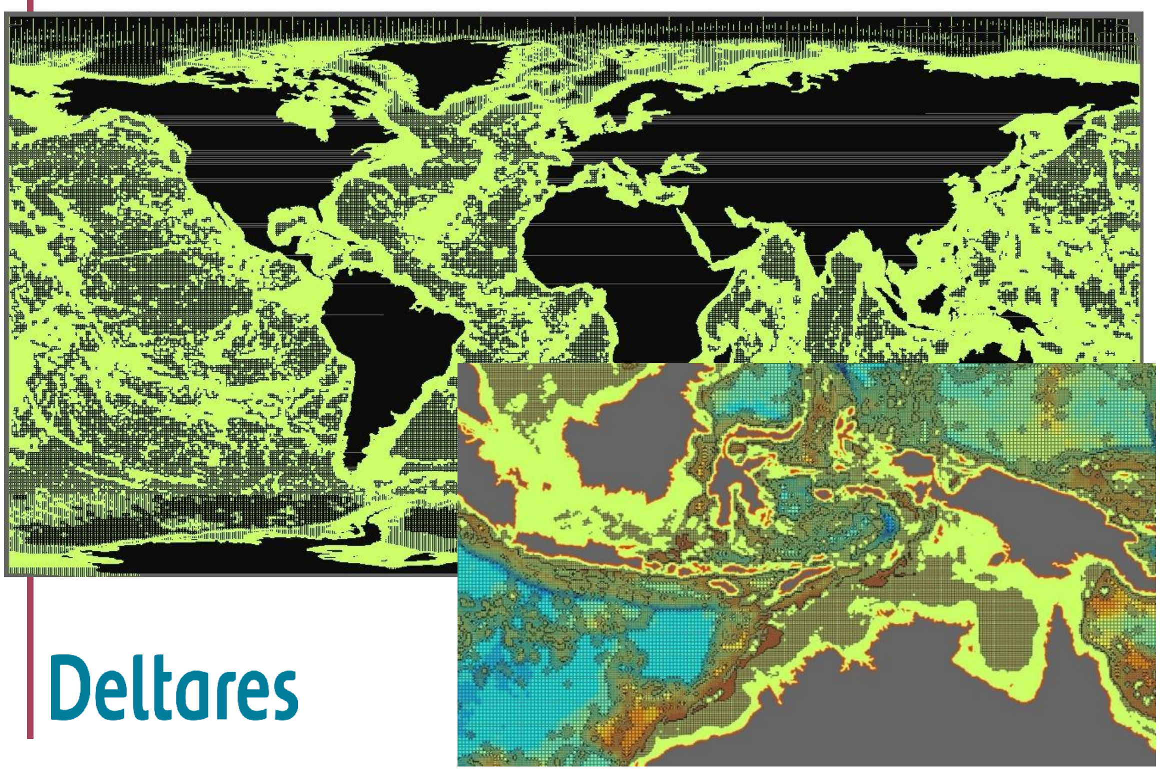
European Commission

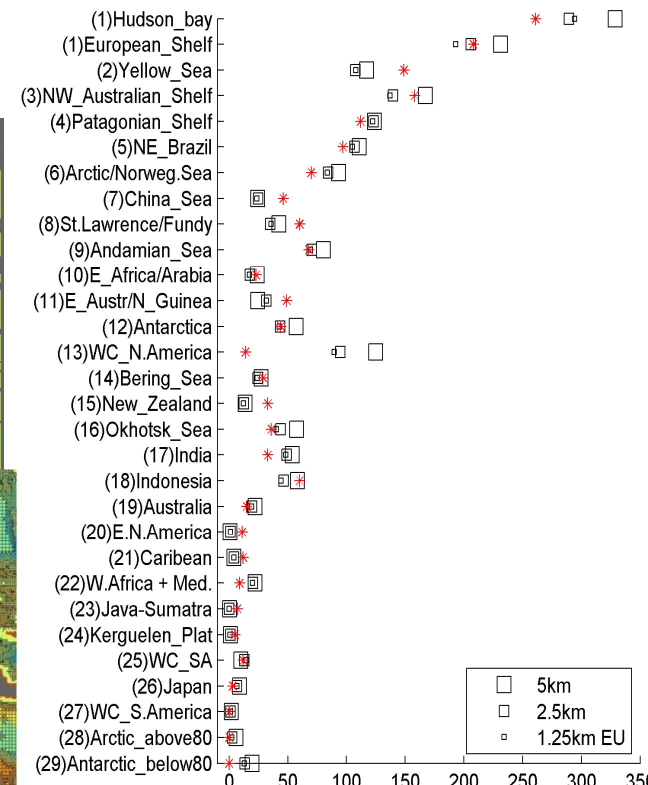
Climate Change

GTSM v3.0

Area	no. st	5km	2.5/ 1.25km EU
Deep ocean (FES2012)	347	7,6cm	6,3cm
Coast global (UHSLC)	292	20,2cm	16,4cm
Coast Europe (CMEMS)	324	20,4cm	15,0cm
Number of net nodes		2 million (~1h/week)	4,9 million (~3.6h/week)

- Considerable added value of higher resolution (mainly on tide)
- Some impact observed on dissipation in main areas





Deltares

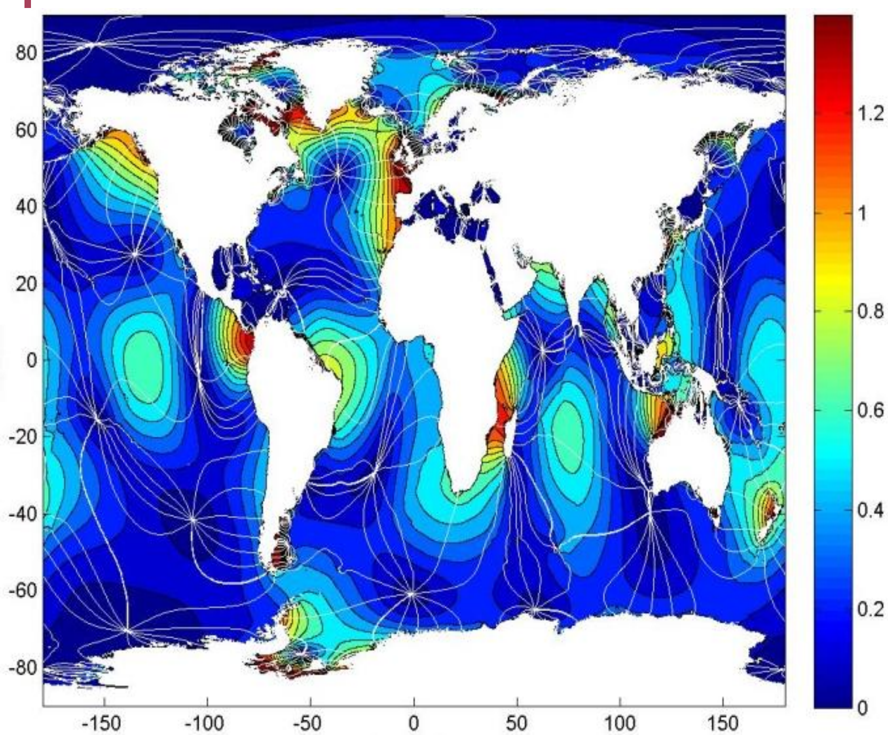
Copernicus Europe's eyes on Earth

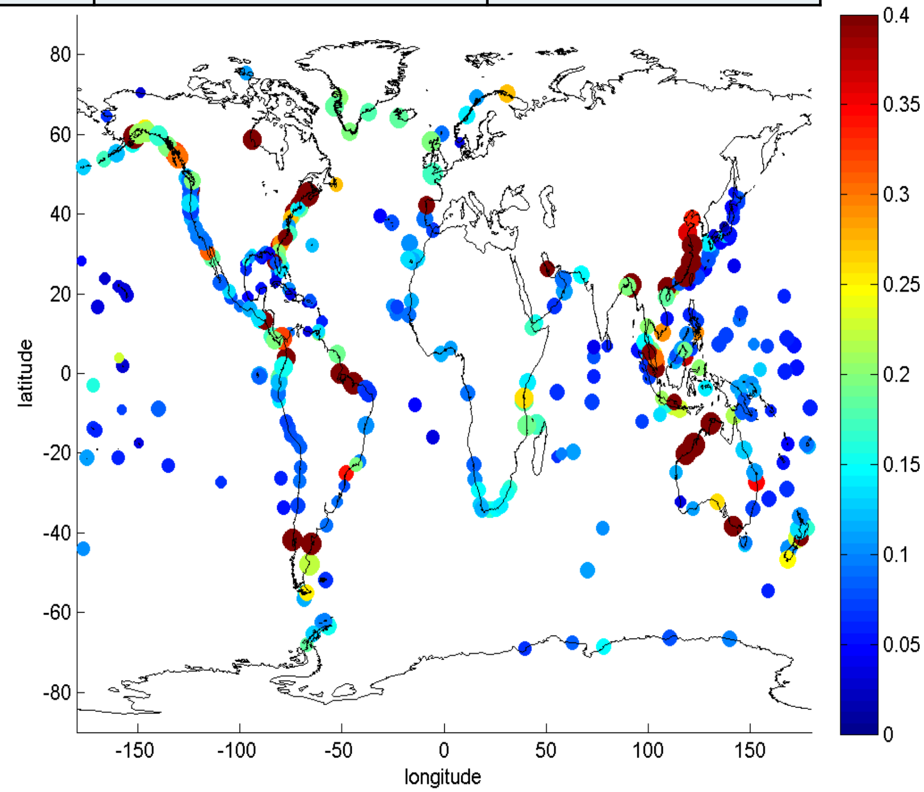
European Commission

Climate Change

G T S M v 3 . 0 - t i d e s

Model	Type	deep ocean M2	Coast M2
GTSMv3.0	Non-assimilative	3,5cm	10,5cm
FES2012	Assimilative(satellite)	--	4,5cm
Av. assimilative	Assimilative(satellite)	--	10,41cm
Best. Non-assimilative	Non-Assimilative	5,63cm	21.1cm

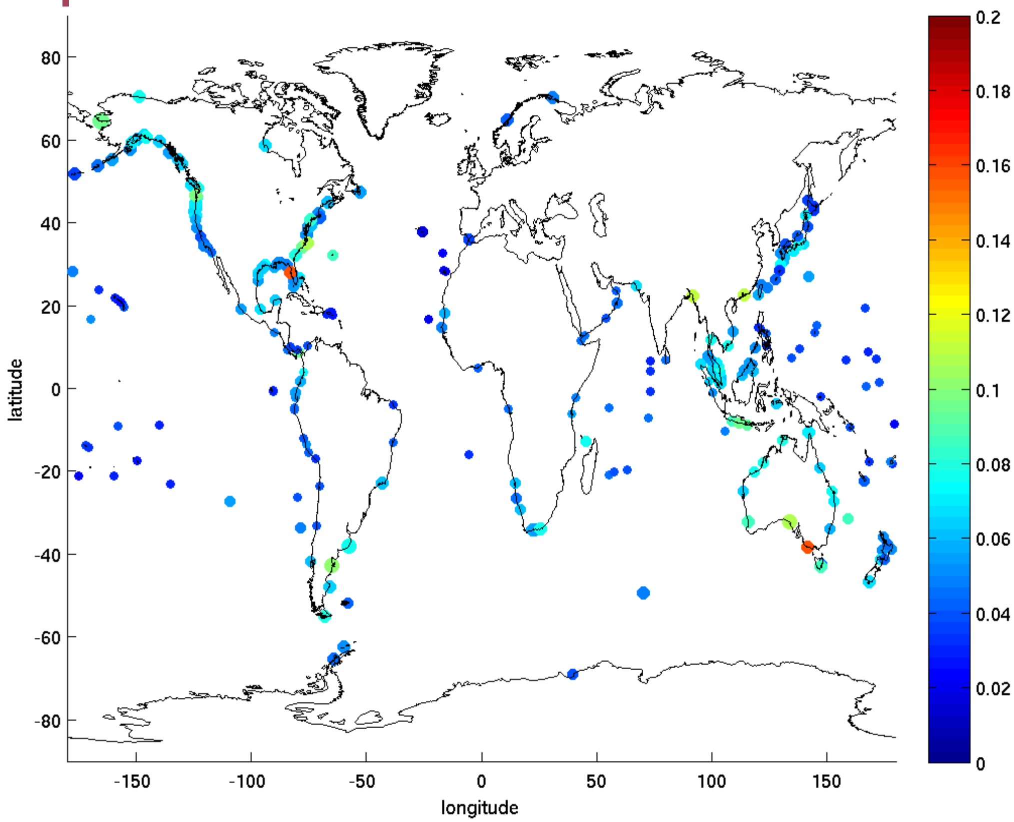


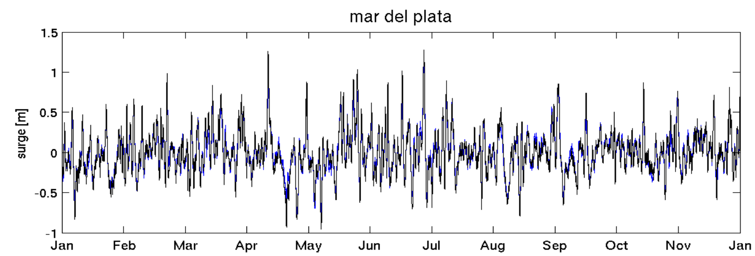


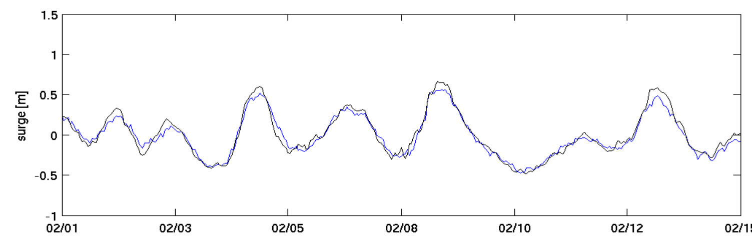
Climate Change

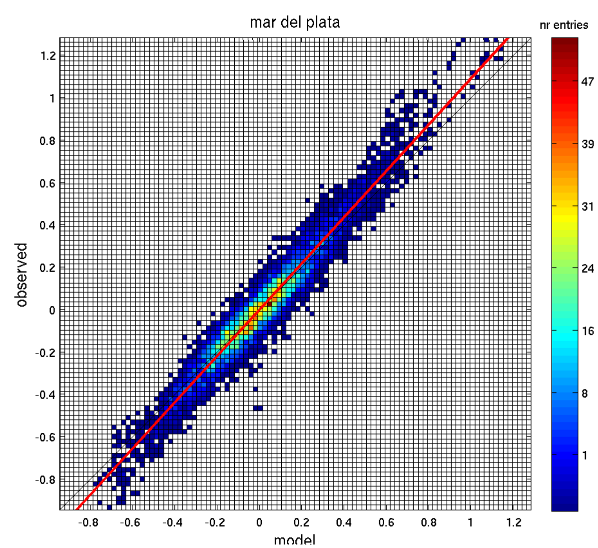
GTSM v3.0 – surge 2012

- Average error 5,5cm(8,8cm) and correlation 0.62 (0.85)







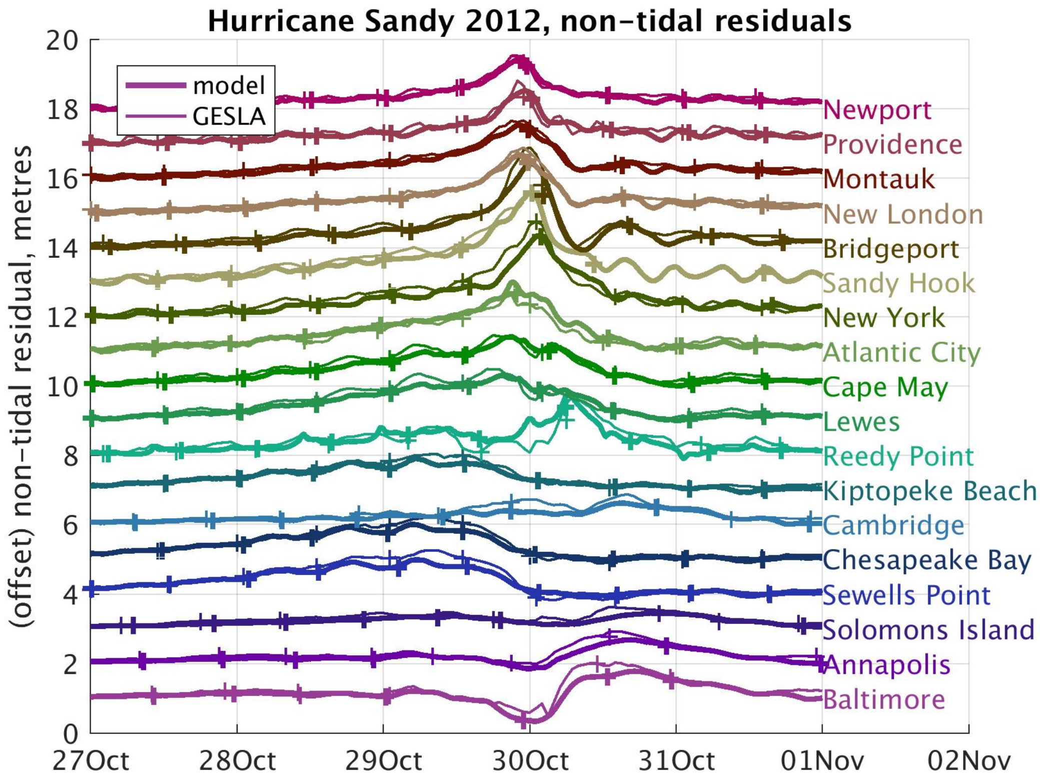


Deltares

Climate
Change

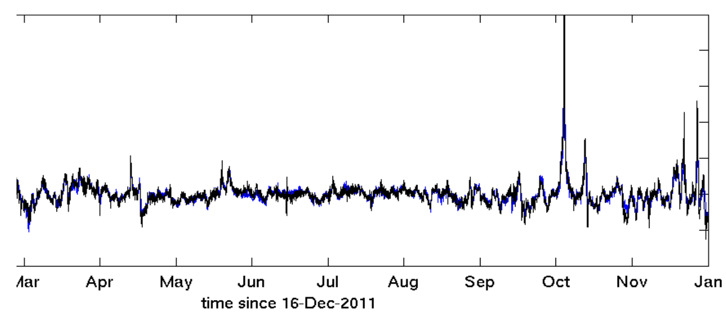
G T S M v 3 . 0 – s u r g e 2 0 1 2

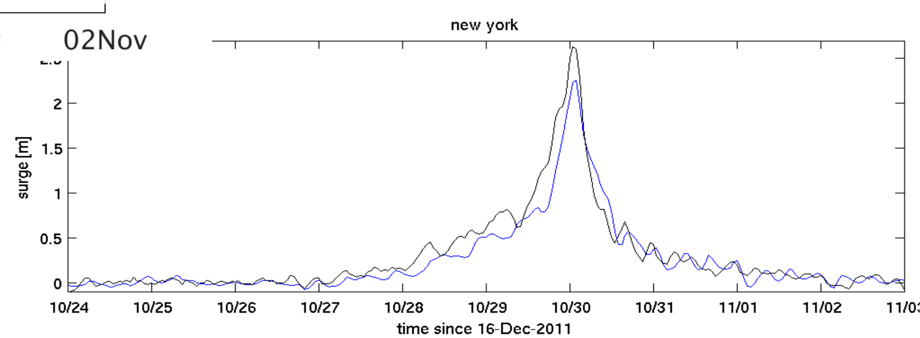
Hurricane Sandy



Source : J.Williams NOC

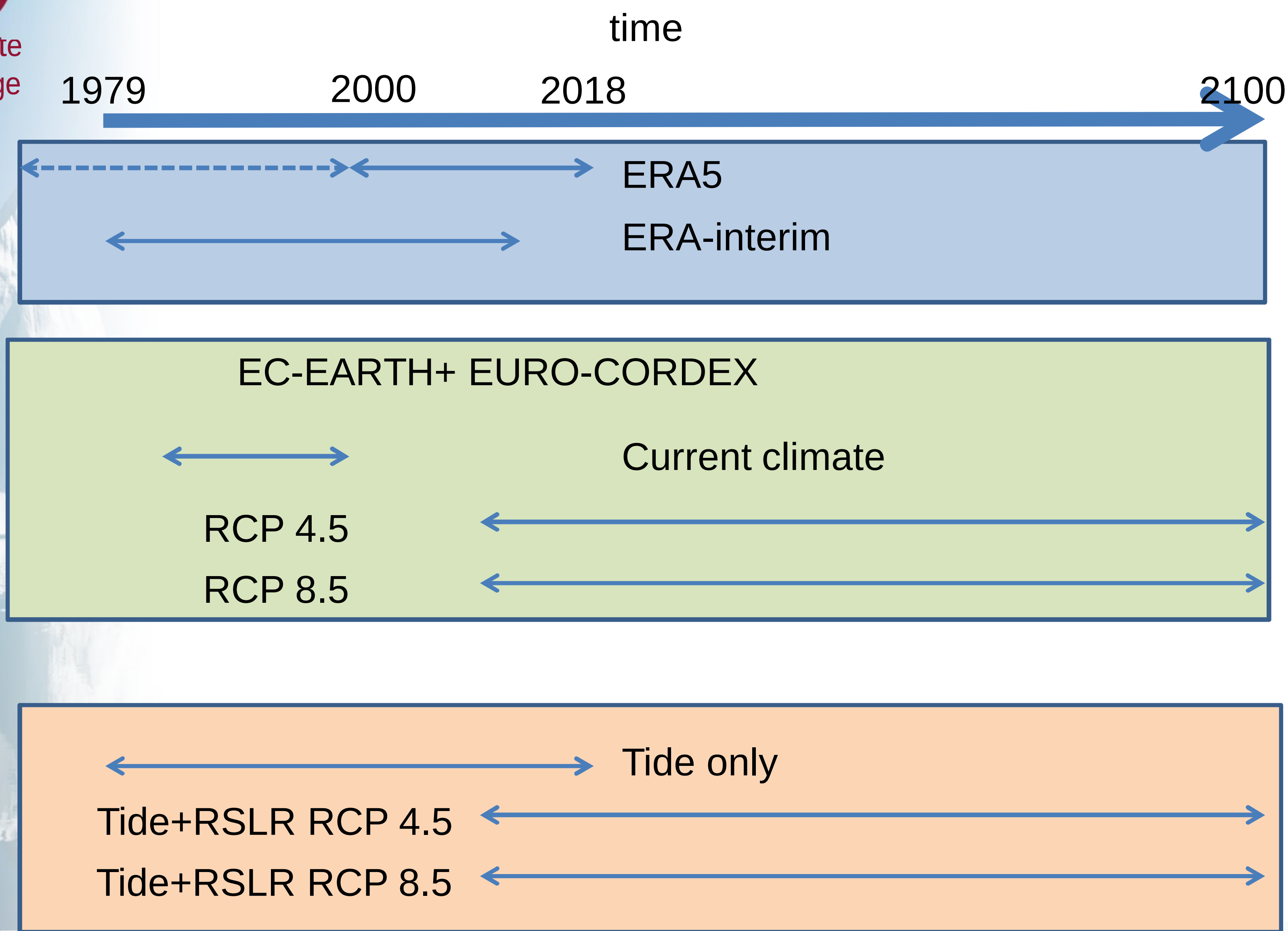
Irazoqui Apecechea et.al. (2018) "GTSM v3.0: A next generation Global Tide and Surge Model", Submitted.





Deltares

Overview of runs



Climate Change

Deltares

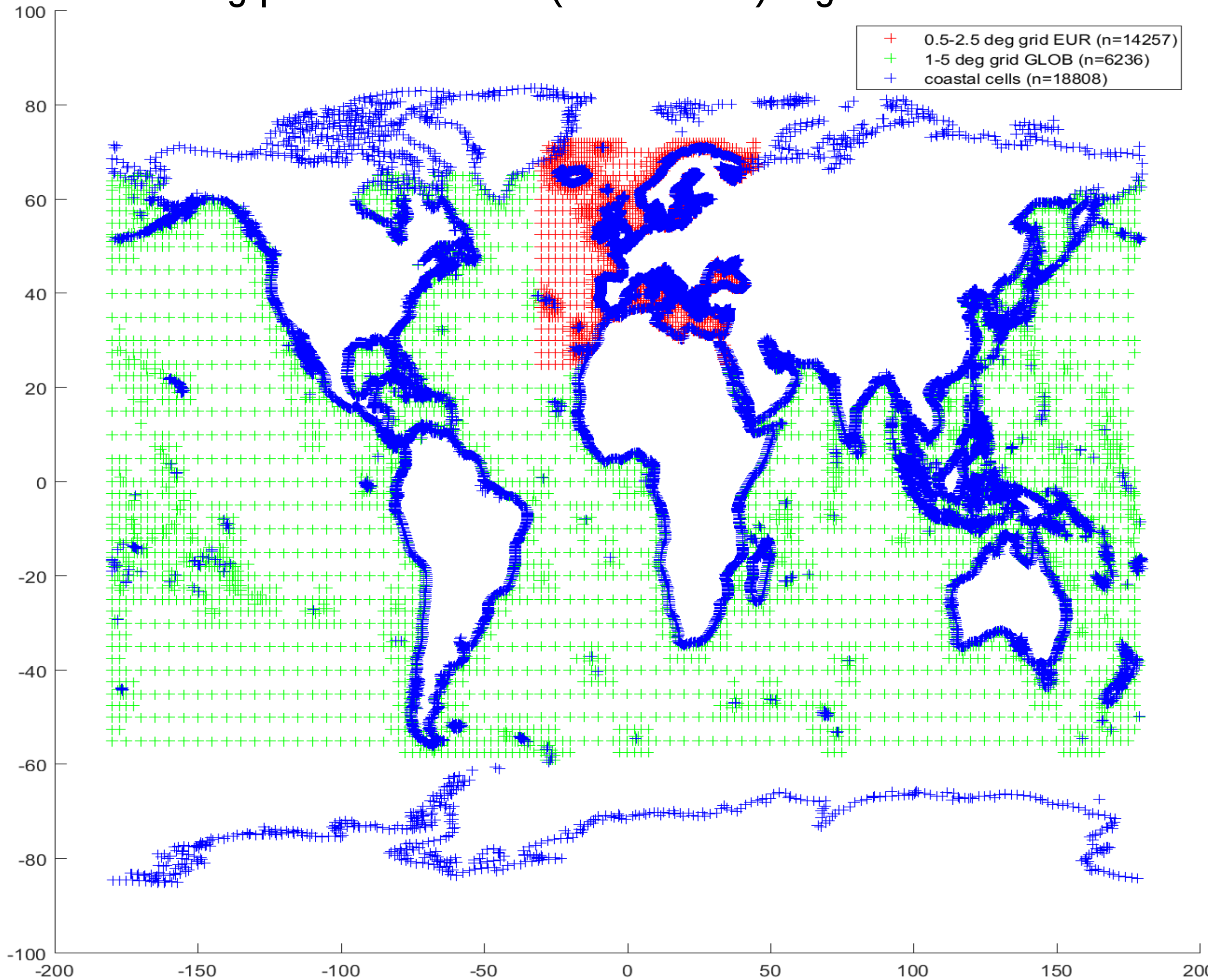
Copernicus Europe's eyes on Earth

European Commission

Climate Change

Output locations

- Observation points (UHSLC,CMEMS,GESLA)
- Coastal points worldwide (10km EU, 50km rest)
- Nesting points 1/ 2.5 /5 (0.25/0.5/1)degrees within 100/500/further km from land

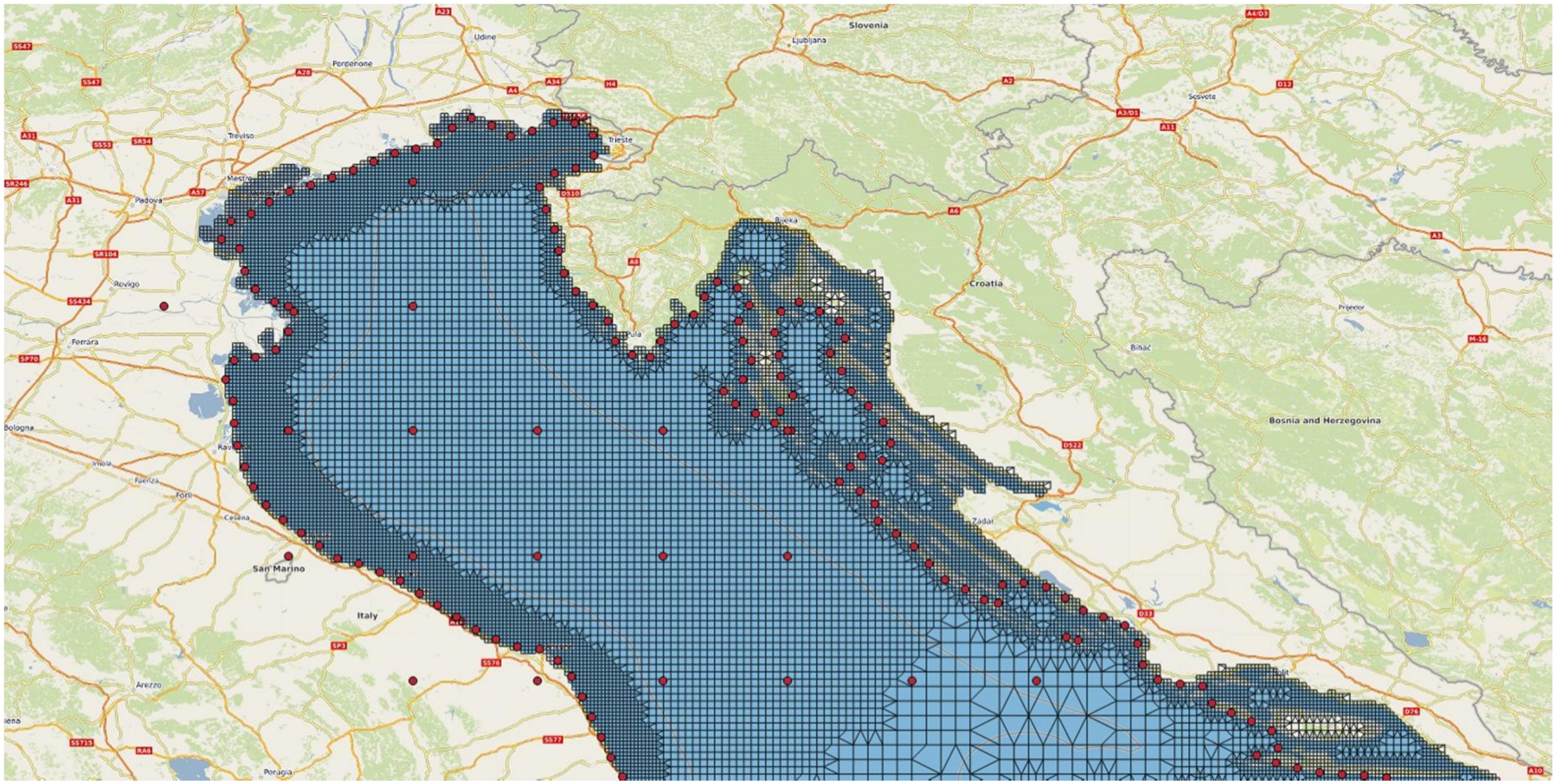


~40000 output locations, 10 min timestep

Climate Change

Output locations

Zoom in Adriatic Sea



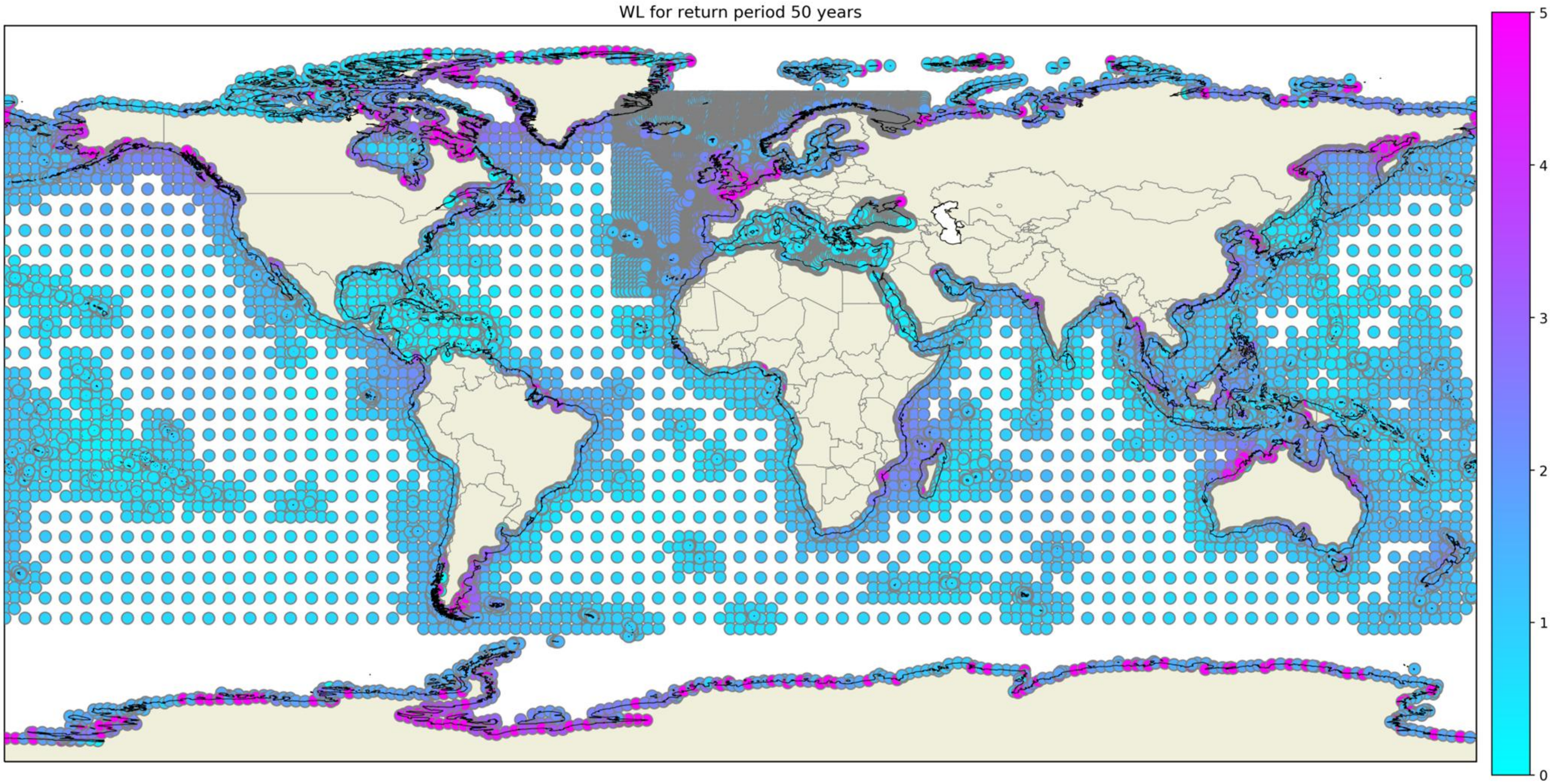
Deltares

Copernicus Europe's eyes on Earth

European Commission

Historical climate 100 year RP

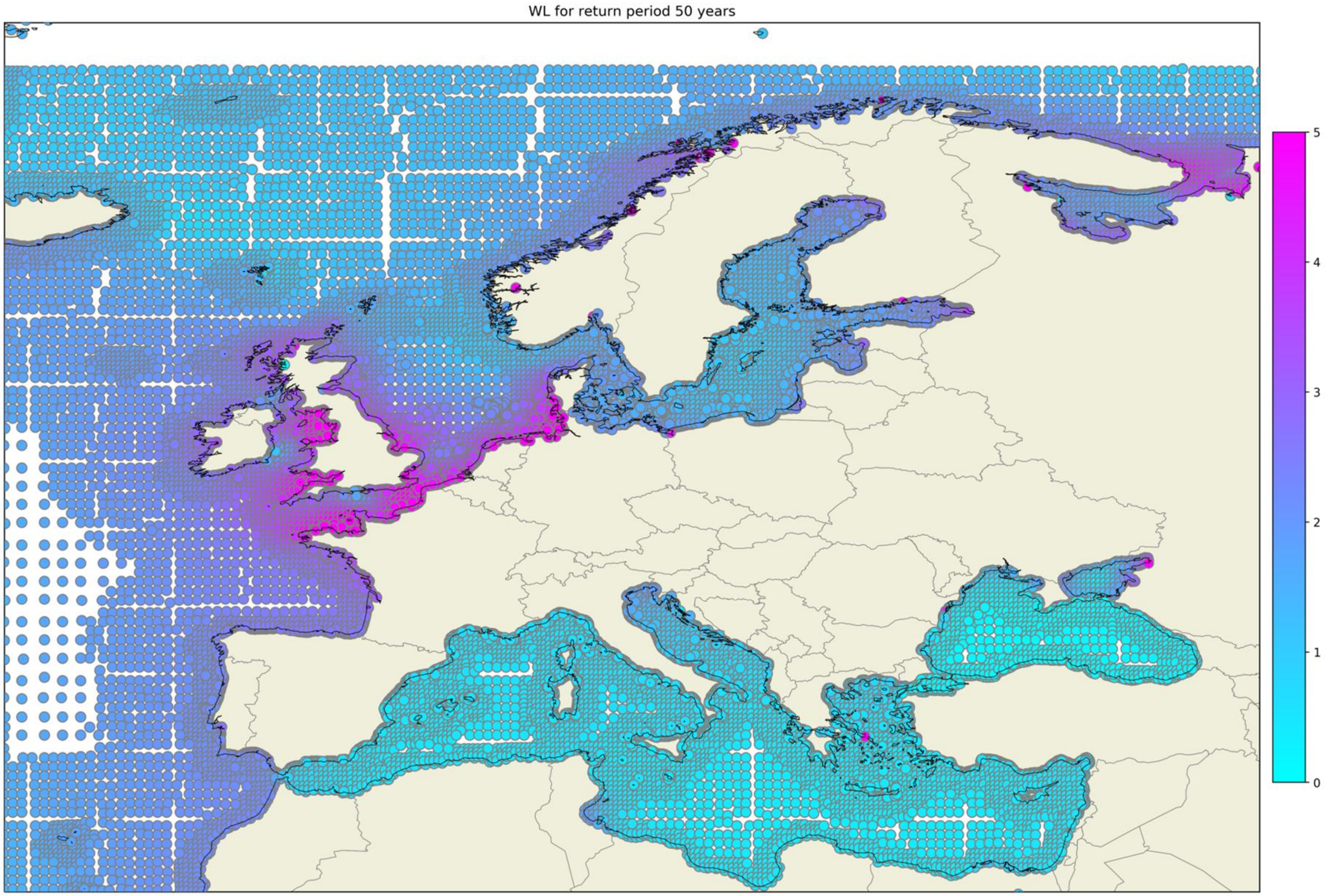
Climate
Change



Deltares

Historical climate 100 year RP

Climate Change



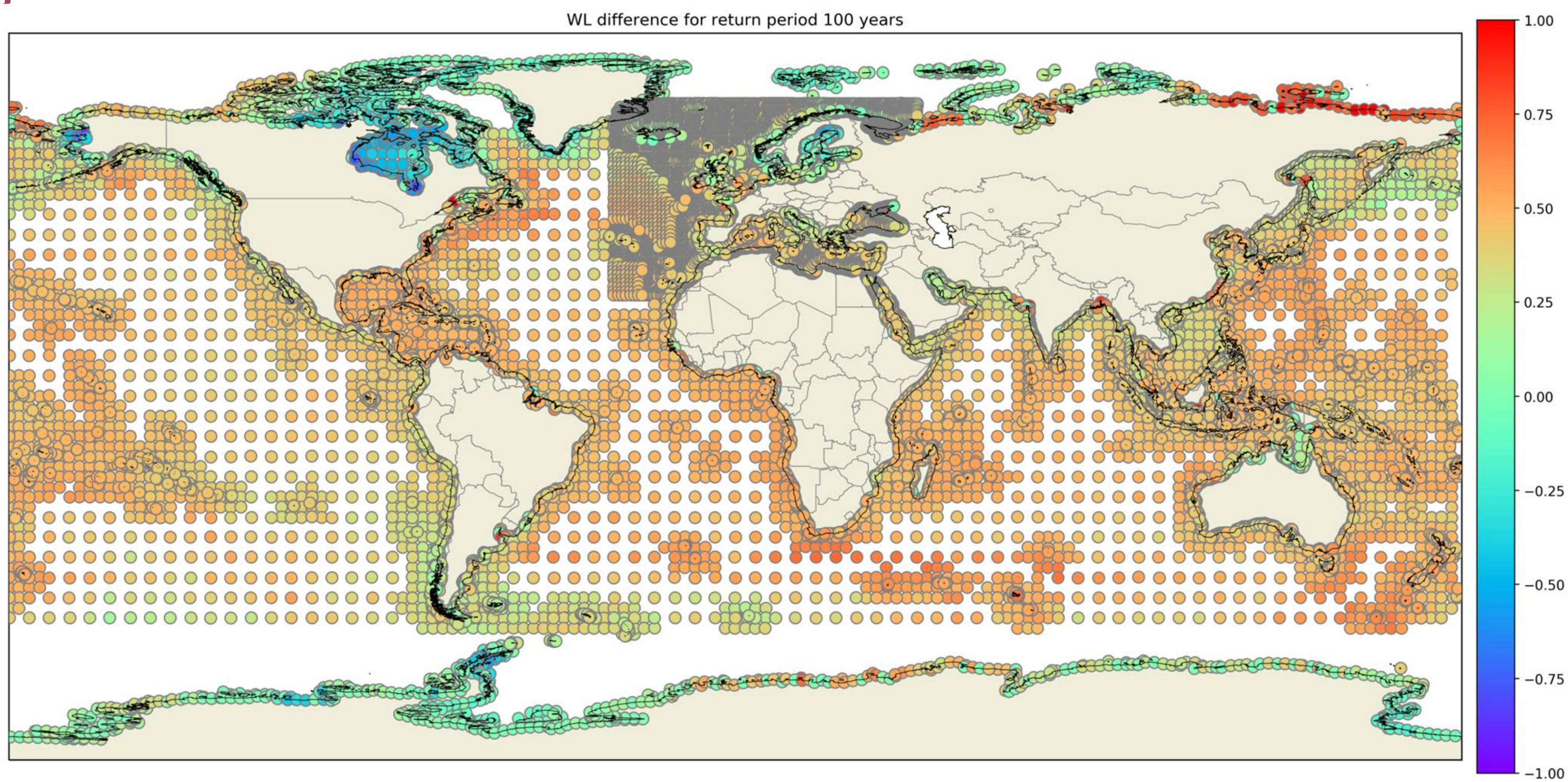
Deltares

Copernicus Europe's eyes on Earth

European Commission

Difference in return WL

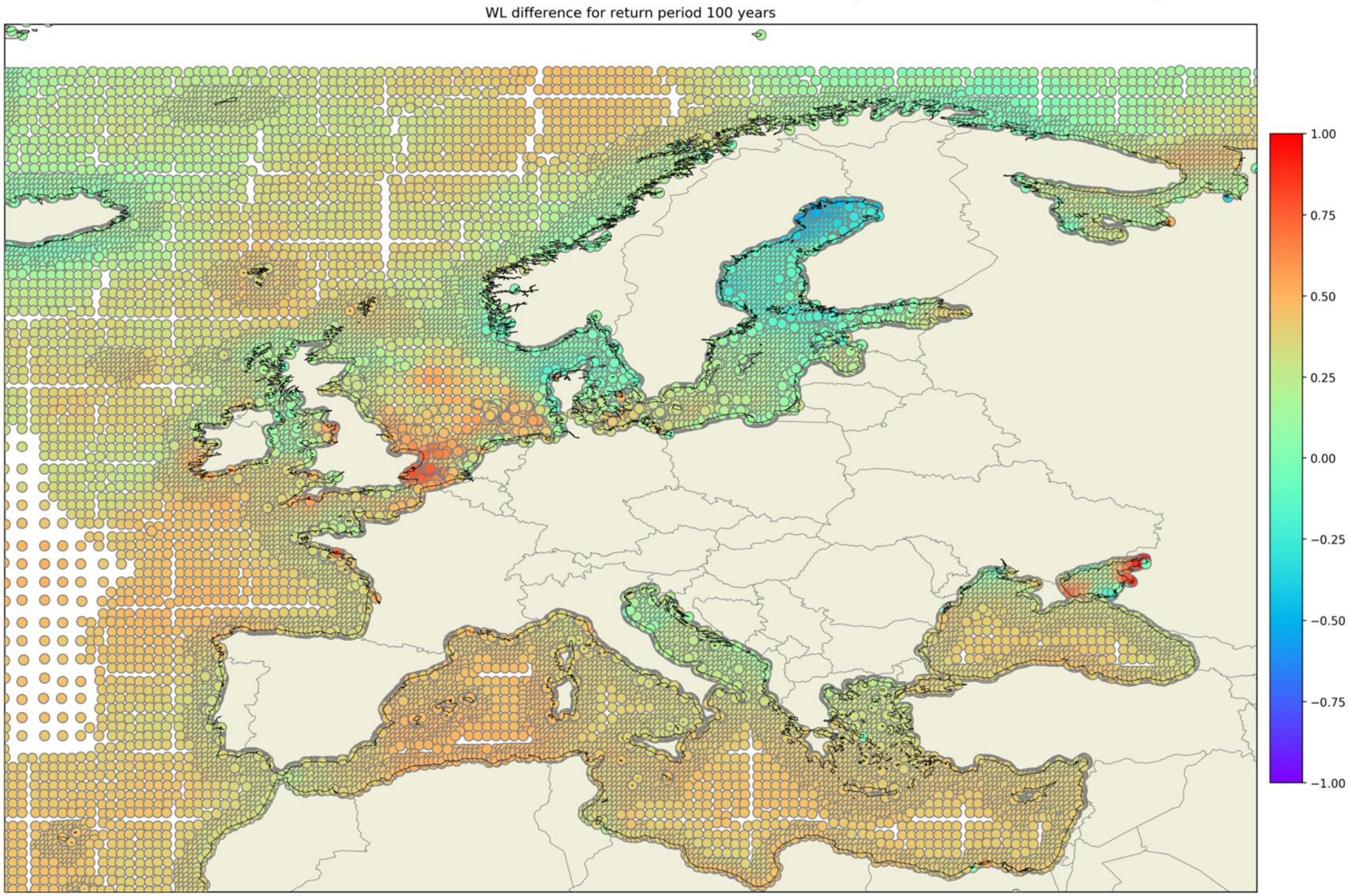
- RCP8.5 mid-century, RP= 100 years



Difference in return WL

Climate Change

- RCP8.5 mid-century, RP= 100 years - Europe



Deltares

Copernicus Europe's eyes on Earth

European Commission

Current status & outlook

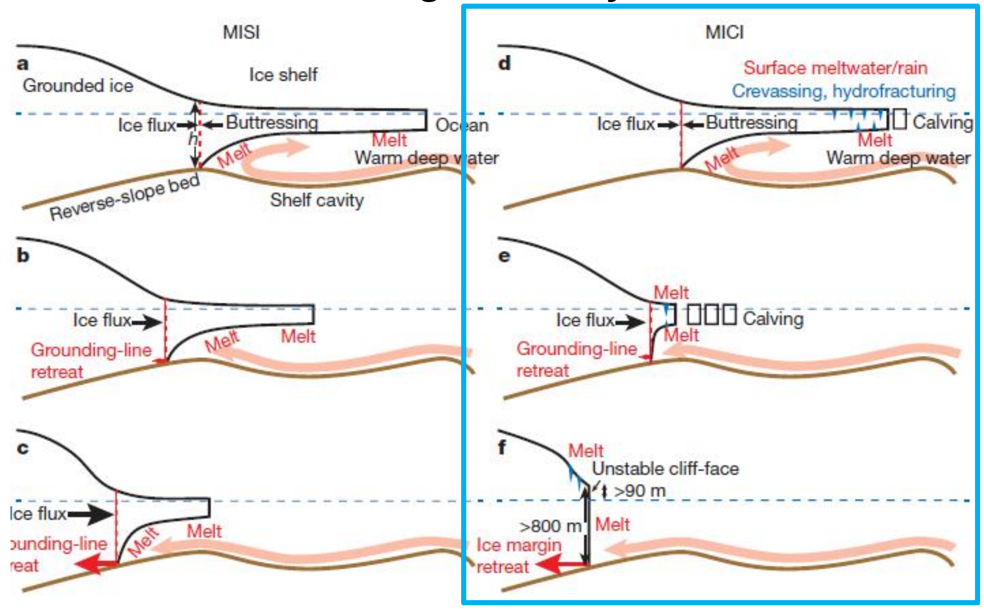
Climate Change

- ERA5 period 2000-2017
- Historical Climate 1976-2006
- RCP8.5 mid-century 2040-2070
- This will generate more than 30Tb of time-series data
- End of this year all time-series for Europe and the derived statistics/indicators will become available in Climate Data Store (CDS) at https://climate.copernicus.eu/

Extreme 2100 SLR scenarios – Tidal Changes

DeConto and Pollard (2016) : Antarctica could contribute significantly more to SLR

- Marine Ice Sheet Instability(MISI)
- Marine Ice Cliff Instability (MICI)



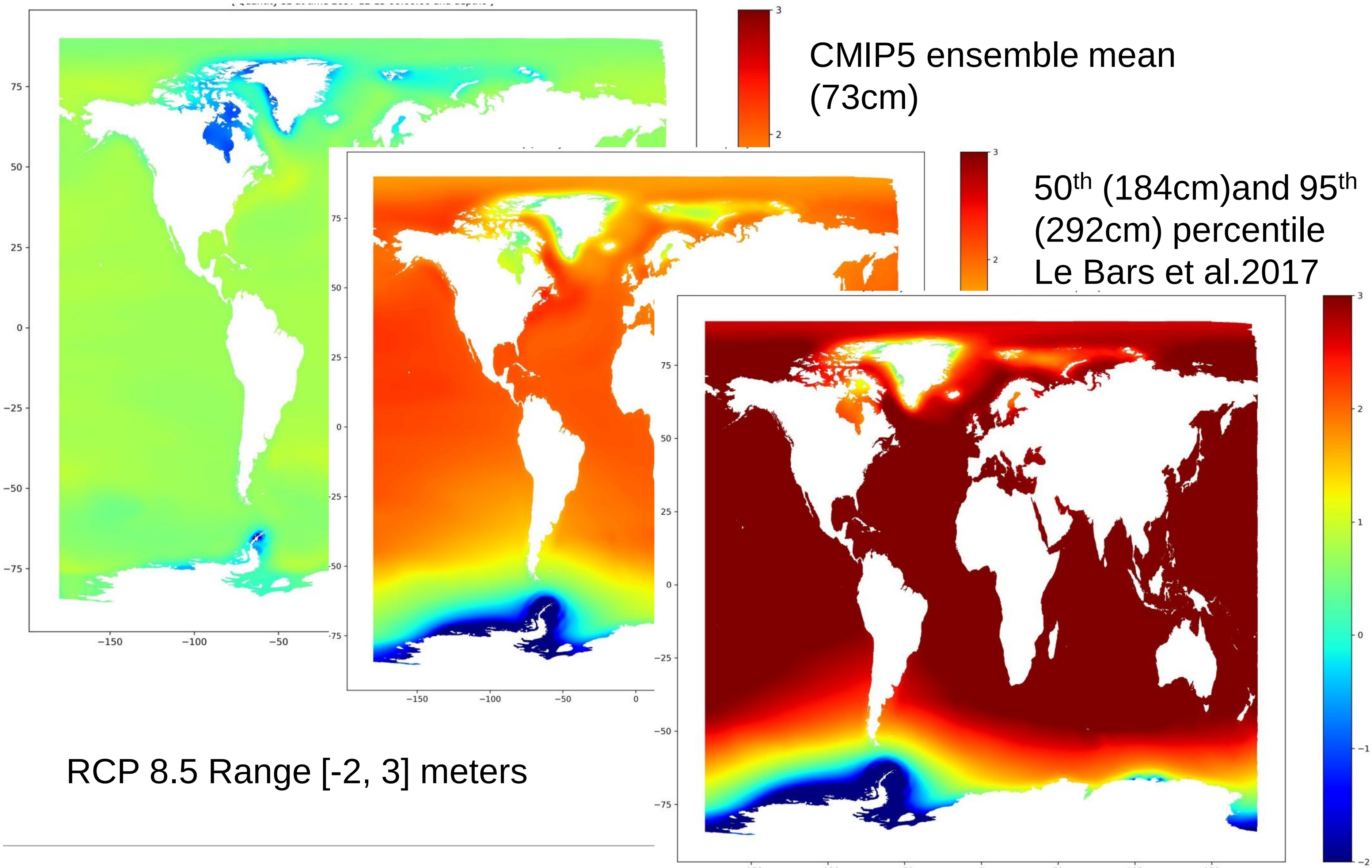
Potential contribution >1m by 2100 (IPCC AR5 was 14cm!)

+most uncertain contribution to SLR
+dependency in scenario (atmospheric warming)

This can increase global average SLC significantly, and dramatically regionally, especially for high percentiles (=high risk & low probability events, **commonly used for safety standards, flood risk assessments, policy requirements**)

➔Here we use high-end probabilistically computed scenarios (Le Bars et al. 2017) + regional fingerprints

RCP 8.5 SLR fields for 2100

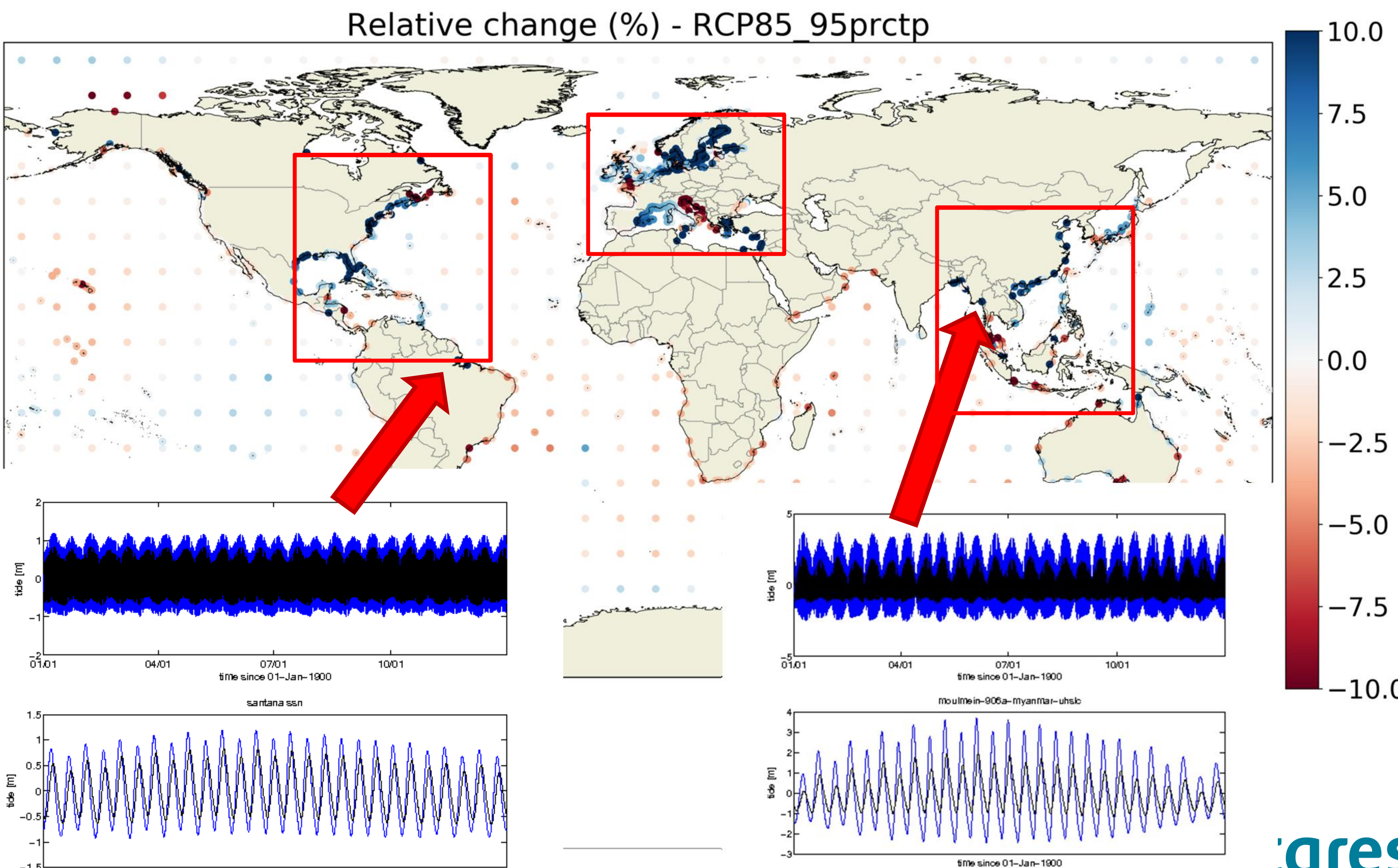


CMIP5 ensemble mean (73cm)

50th (184cm)and 95th (292cm) percentile
Le Bars et al.2017

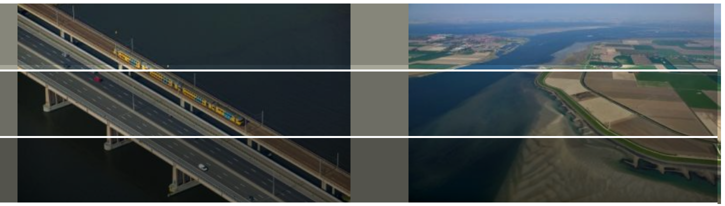
RCP 8.5 Range [-2, 3] meters

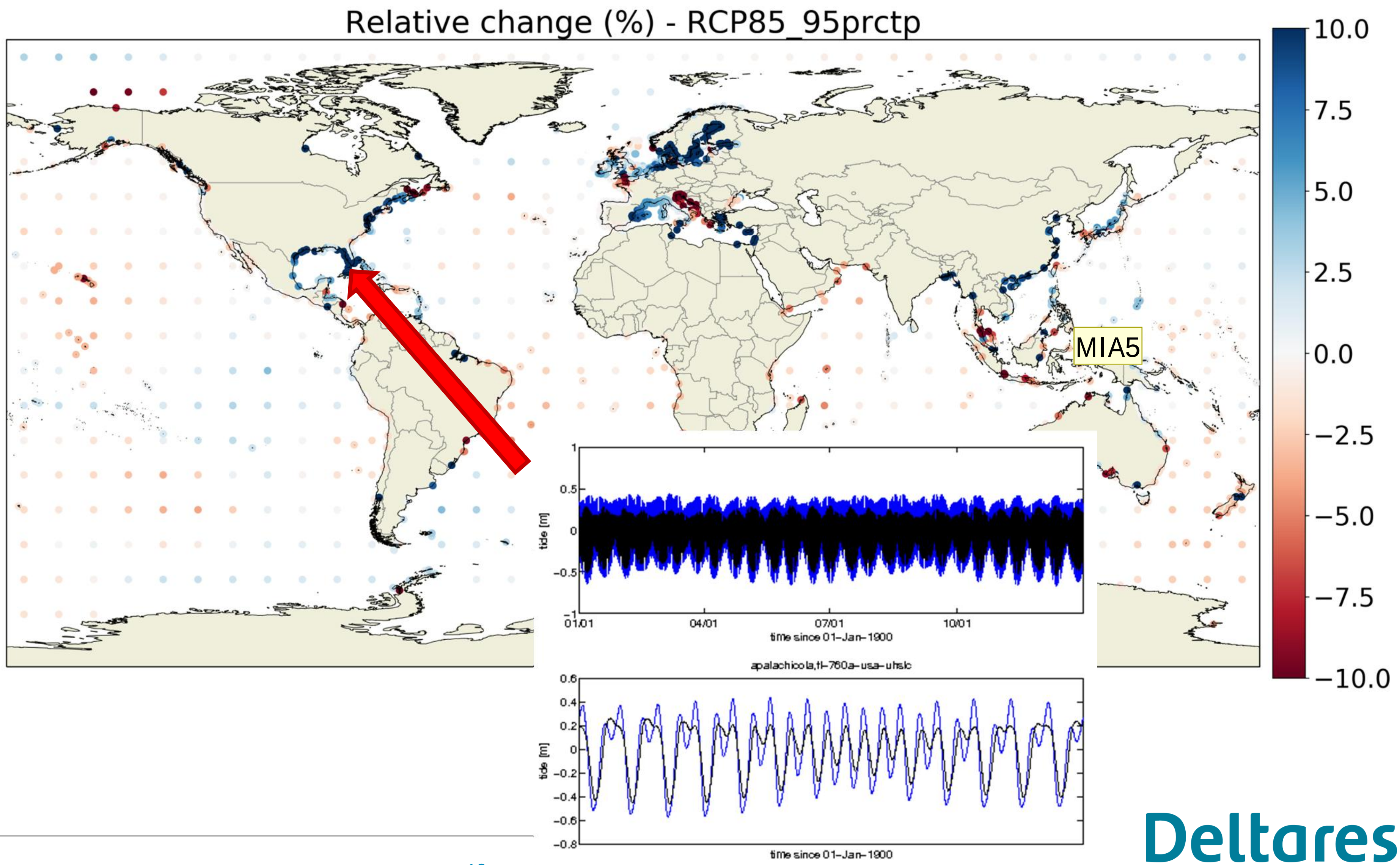
Changes can be comparable to SLR



ares

Changes can be asymmetric



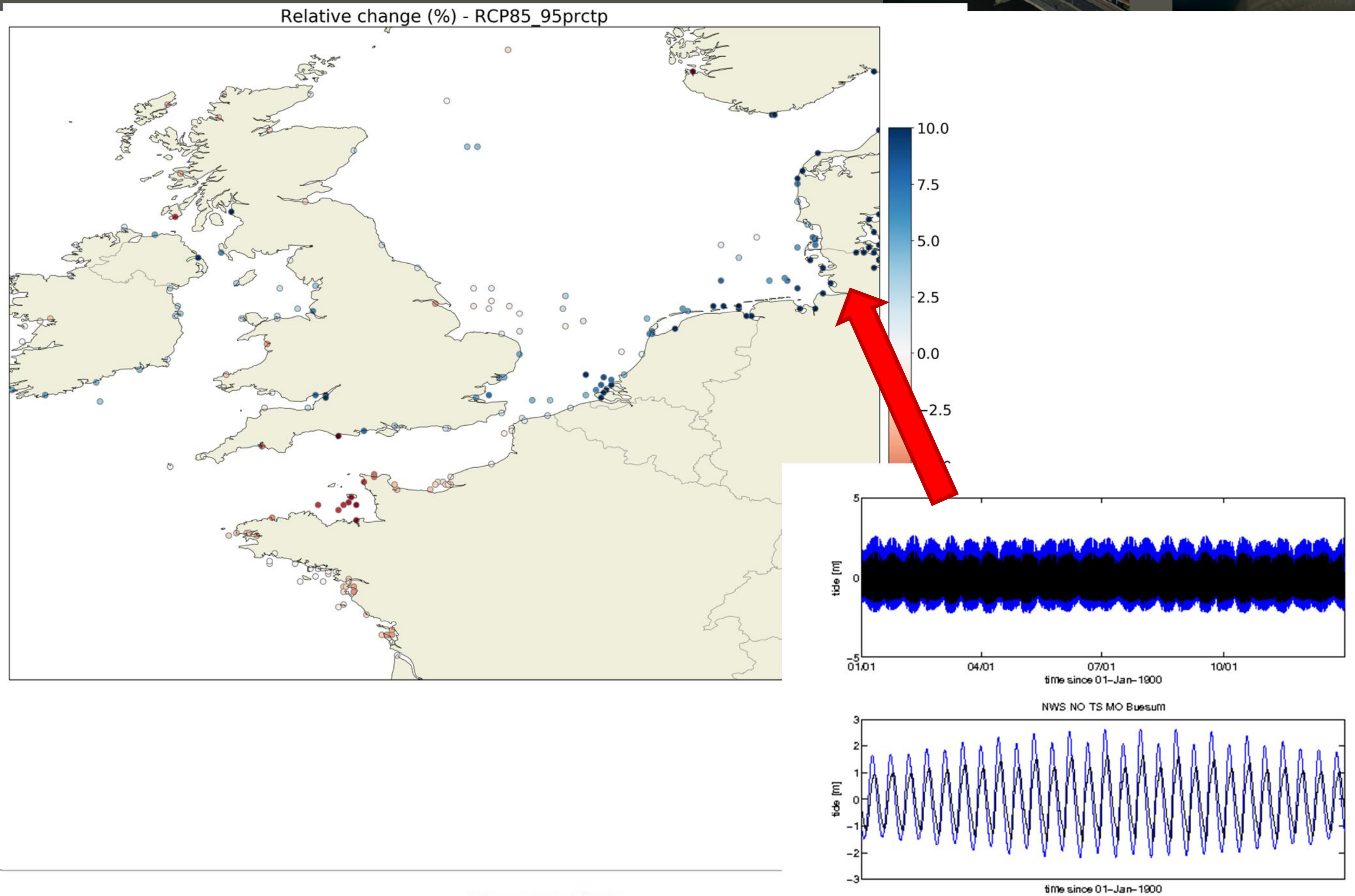


Deltares

MIA5 change for a new one

Maialen Irazoqui Apecechea; 16-Oct-18

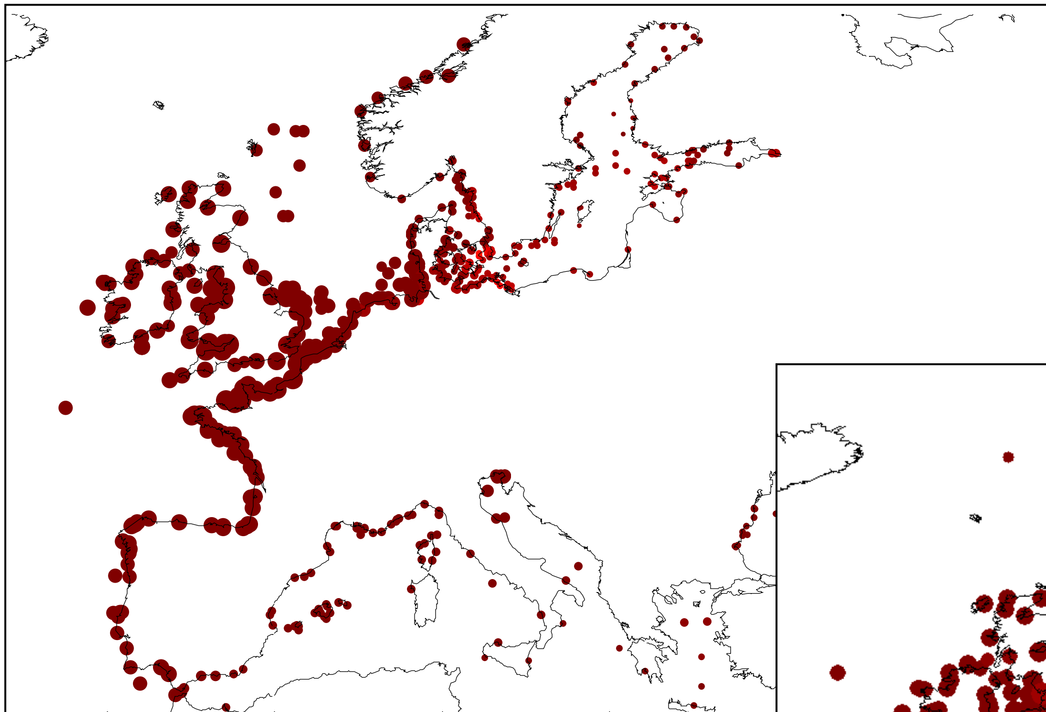
North Sea



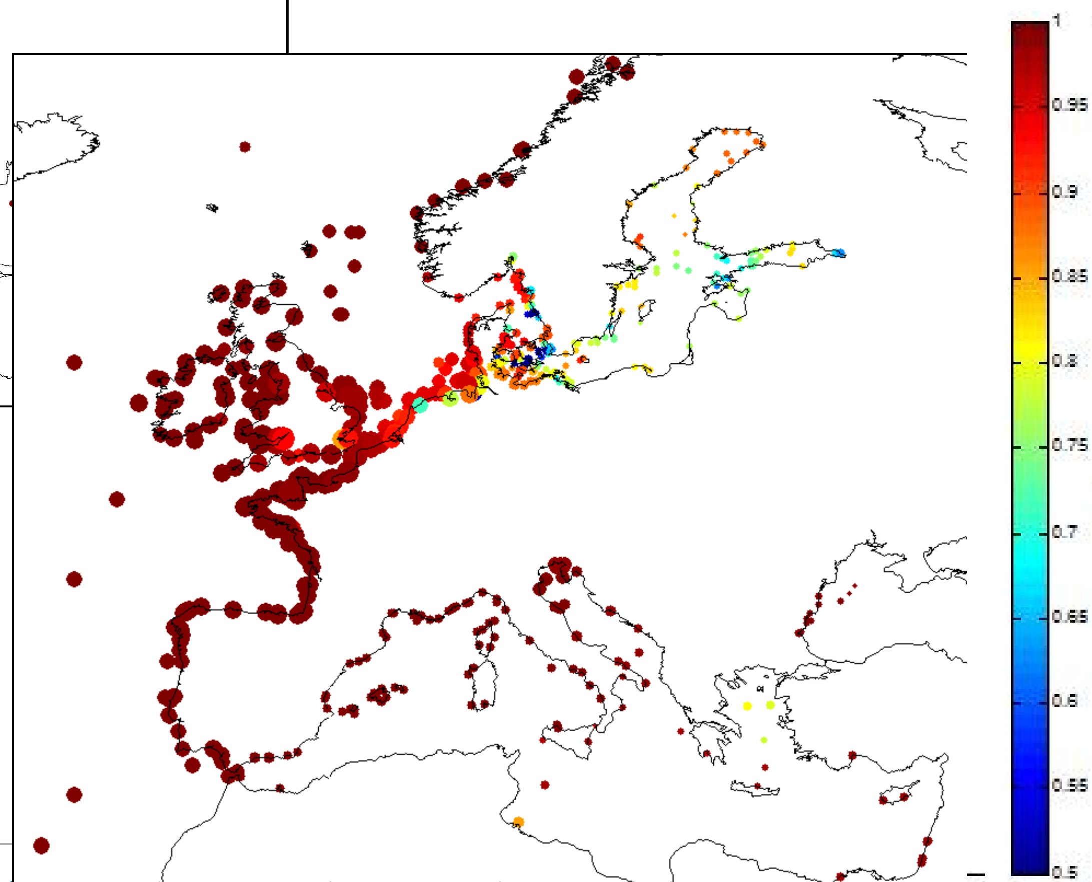
Relative change (%) - RCP85_95prctp
10.0
7.5
5.0
2.5
0.0
-2.5
tide [m]
01/01
04/01
07/01
10/01
time since 01-Jan-1900
NWS NO TS MO Buesum
tide [m]
time since 01-Jan-1900

Correlation – changes to tidal shape

- Low correlation: Strong local effects e.g. estuaries, bays
- Tipping points at certain SLR?

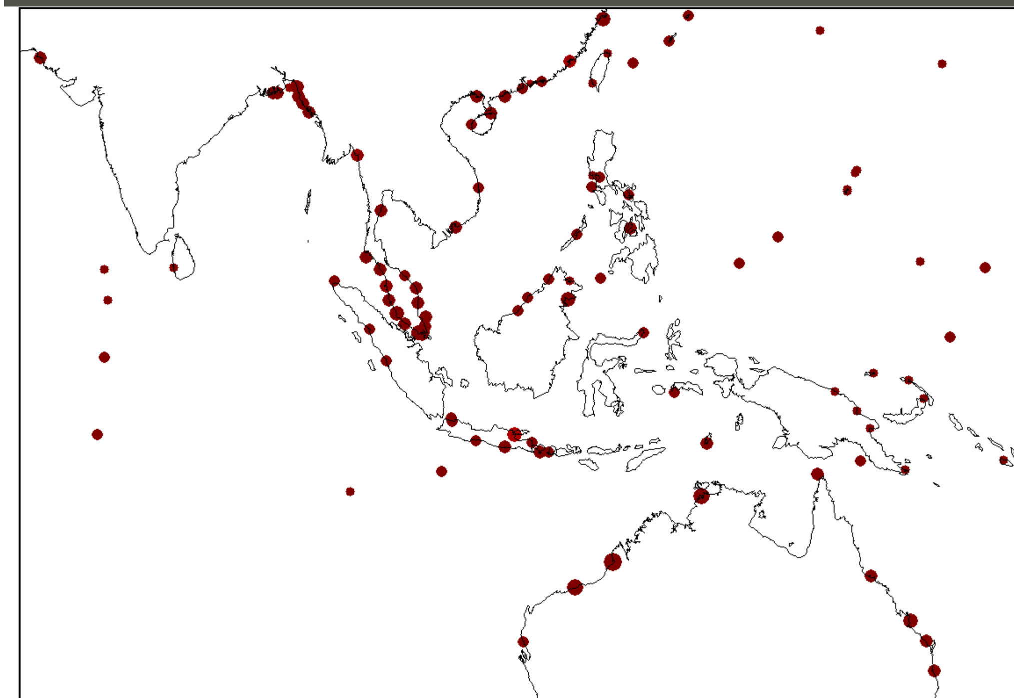


CMIP5 8.5RCP



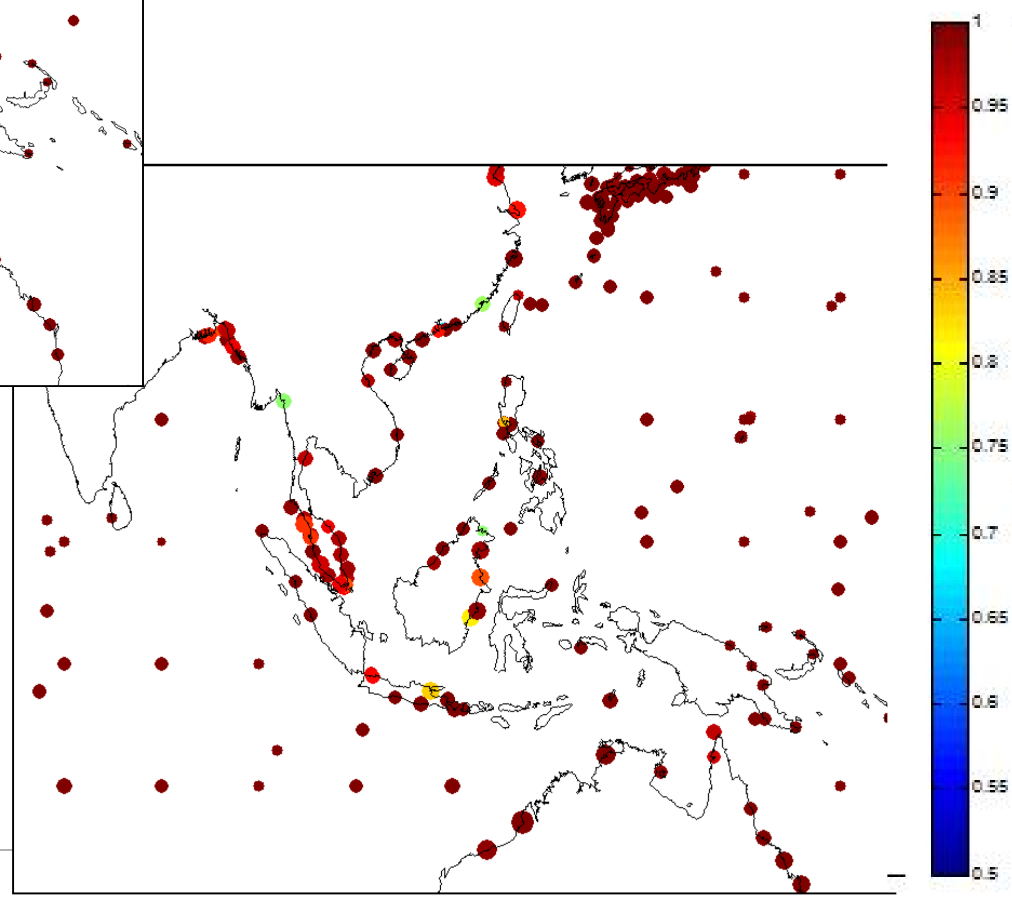
High end 95th prct 8.5RCP

Correlation – changes to tidal shape



- South East Asia: Interaction of several diurnal and semi-diurnal components

CMIP5 8.5RCP



High end 95th prct 8.5RCP

Future work

- Global climate runs (CoDEC and beyond):
  - Finalize dataset and investigate non-linear SLR/surge/tide interactions
  - Foreseen/ambitioned follow up: Ensemble of climate runs using CMIP6, assessment of uncertainty

- Tidal changes under high-end SLR projections:
  - Explore impacts on different functions: Storm surge barrier operations, navigability, intertidal zone ecology, tidal mixing-biodiversity, sediment transport…
  - Proportionality of changes to SLR (local vs remote/system effects), explore tipping points.
  - Impacts of coastline changes, grounding line retreat…

Climate Change

Questions?

Copernicus
Europe's eyes on Earth

European Commission