Sea Level and Climate Research Team

Mediterranean coastal sea level reconstruction based on tide gauge observations

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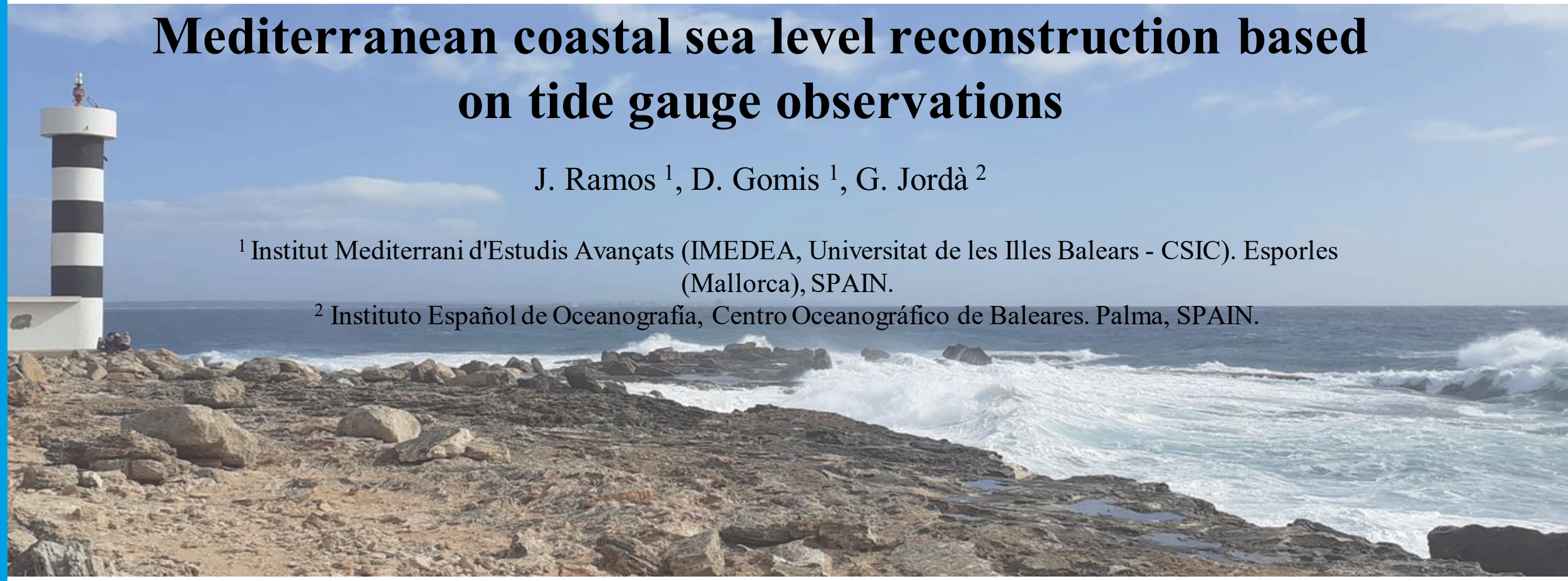

VENOM

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The need for coastal oceanographic databases

- It is necessary to study the variability of sea level on a regional scale.
- Various processes introduce short-scale variability in sea level records.

The need for coastal oceanographic databases

Tide gauges

- ✓ Accurate series
- ✗ Point-wise measurements
- ✗ Heterogeneous distribution

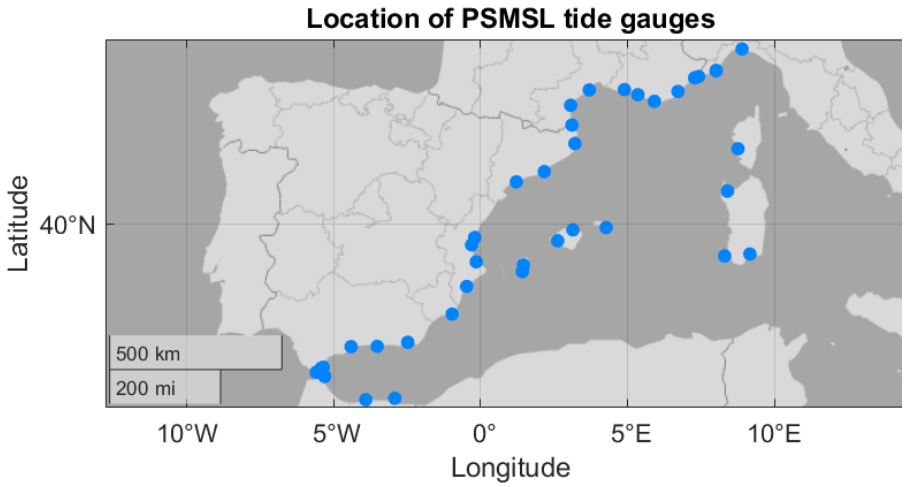
Satellite altimetry

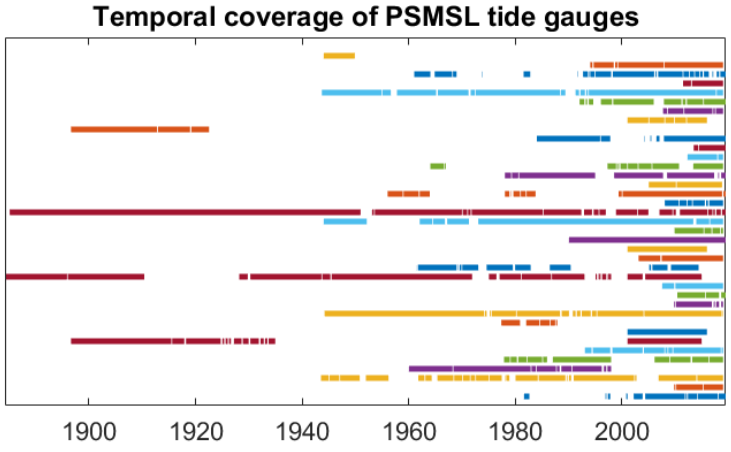
- ✓ Quasi-global coverage
- ✗ Problems near coastlines
- ✗ Tracks widely separated and revisiting time

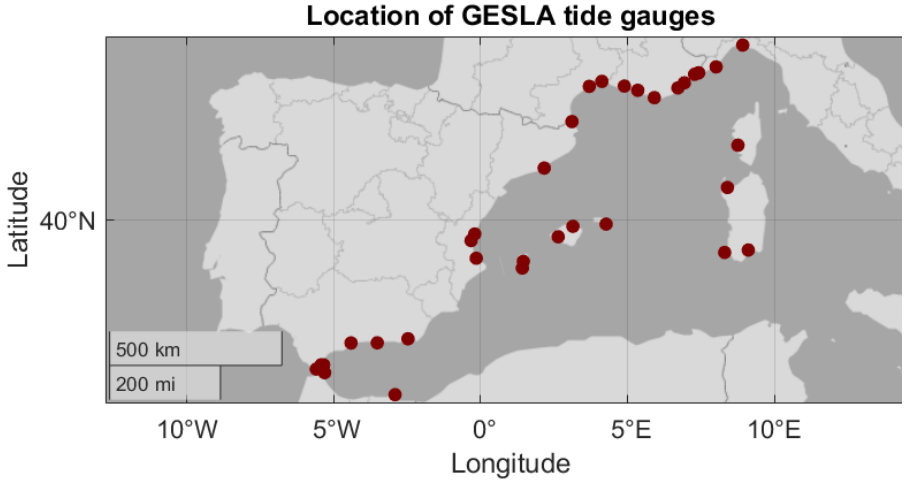
Objectives

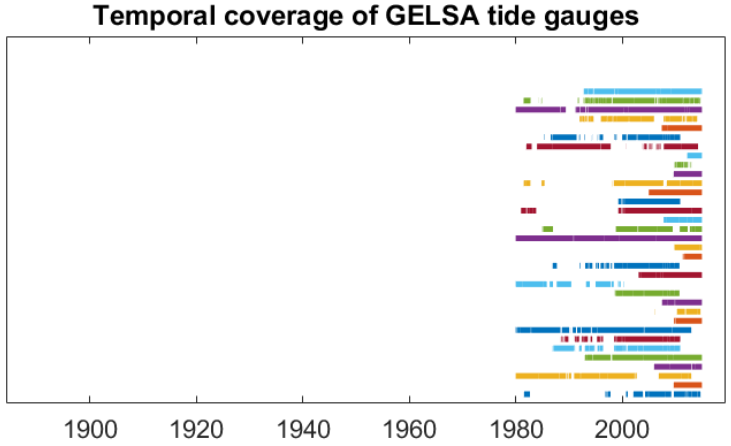
- To develop sea level series along the entire western Mediterranean coastline (i.e. also at locations where no observations are available) from existing tide gauge observations for several decades.
- To quantify the error of the estimated series.
- To compare the accuracy of the reconstructed series with that of last generation coastal altimetry data.
- To explore the applicability and limitations of the coastal sea level reconstruction method

Data and methods









- 38 tide gauges with monthly data from PSMSL.

- 34 tide gauges with hourly data from GESLA-2

Data and methods

Optimal interpolation

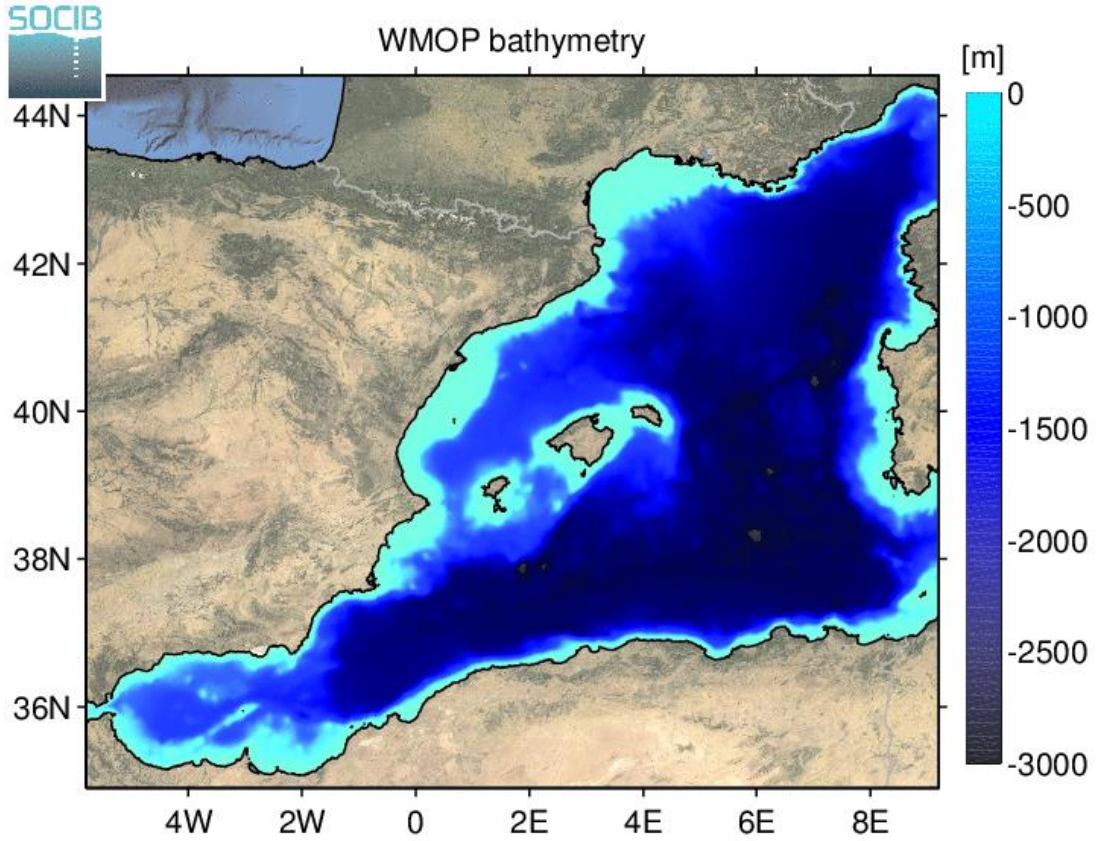
- Reconstruction in coastal points:

$$\widehat{\emptyset_g} = \tilde{\theta}_g{}^T \bar{\bar{T}}^{-1} \emptyset^{obs}$$

- Analysis error:

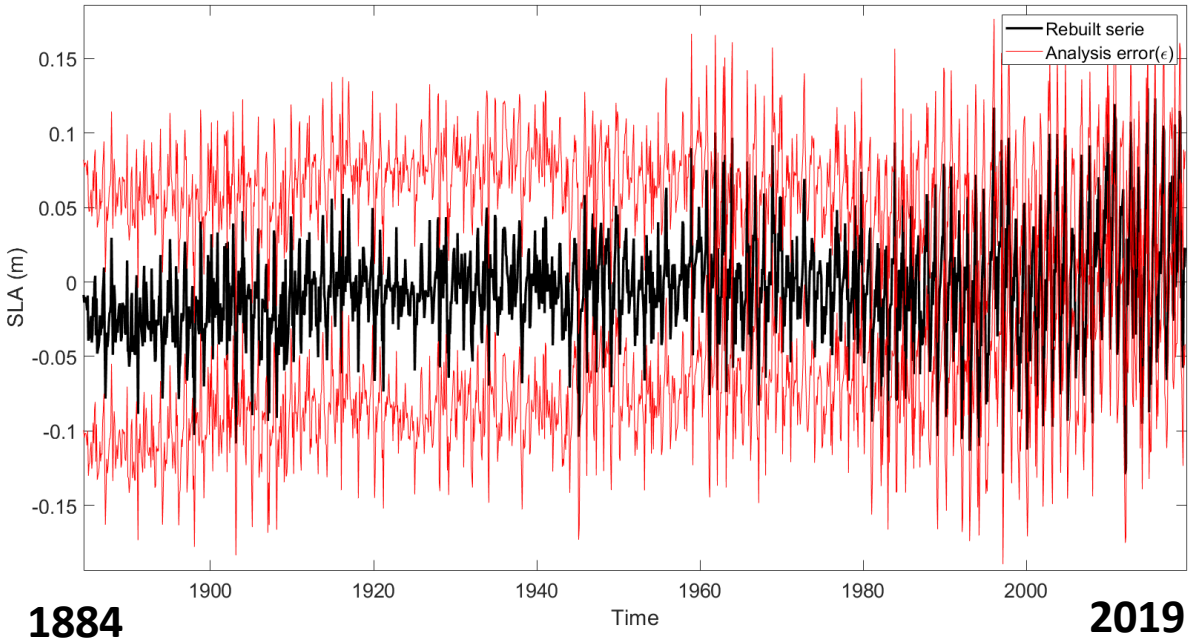
$${\varepsilon_g}^2 = {\sigma_g}^2 \left(1 - \tilde{\theta}_g{}^T \bar{\bar{T}}^{-1} \tilde{\theta}_g\right)$$

- The SOCIB WMOP numerical model was used to determine the elements of the station-station and station-grid correlation matrices

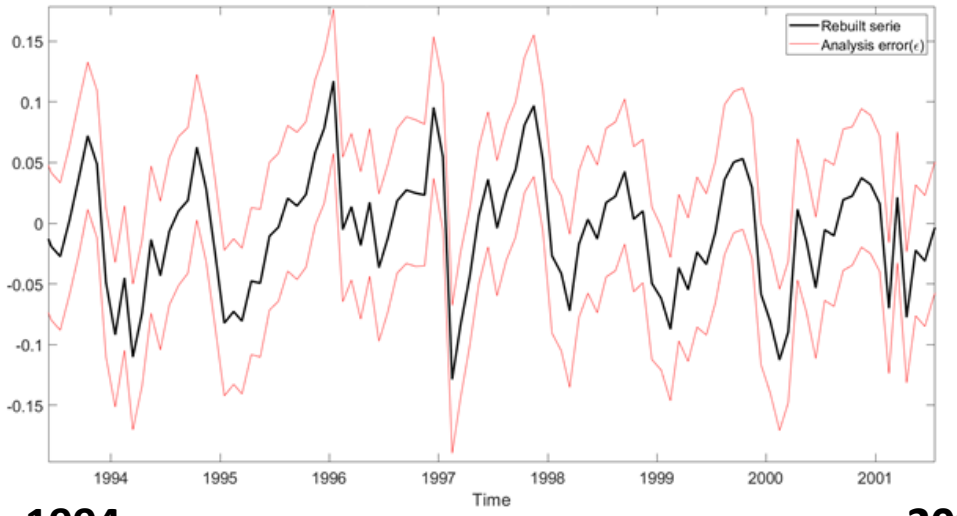


Monthly reconstructions with PSMSL data in Palma

Rebuilt SLA serie and analysis error intervals for a point close to Palma de Mallorca



1884 2019

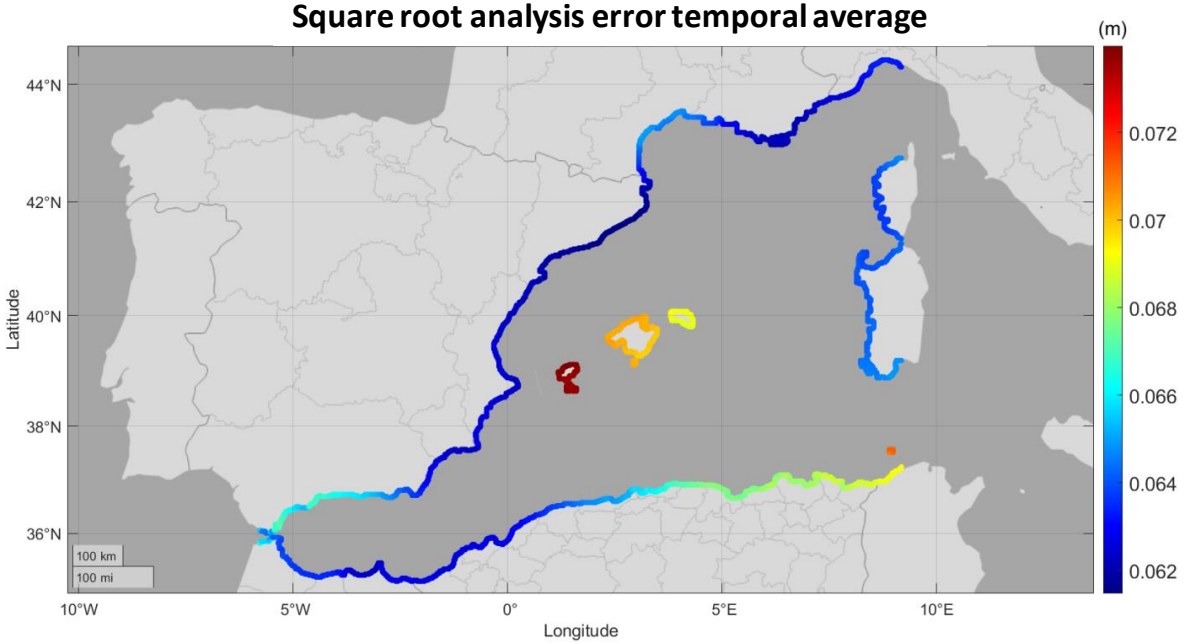


1994 2001

Monthly case

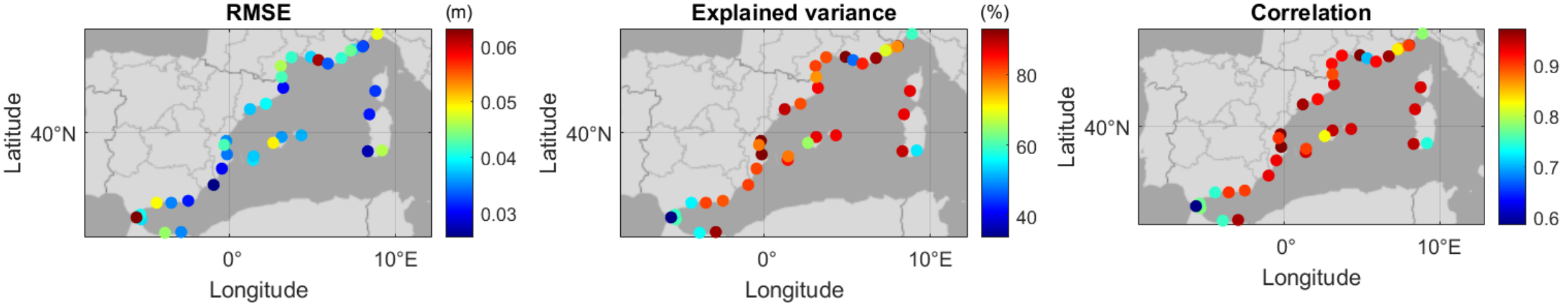
Theoretical estimate of errors:

Square root analysis error temporal average



Cross-validation test

Monthly case

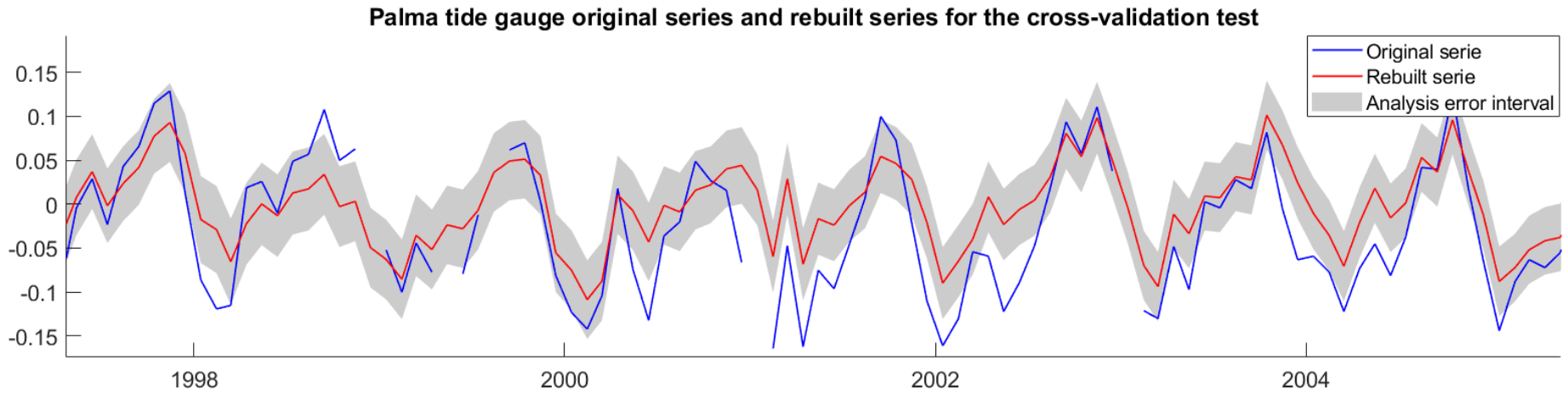


- Series reconstructed at each tide gauge location using only the other series for the interpolation (i.e. without considering the co-located series).
- Maximum RMSE values of 6.6 cm.
- Explained variances between 34 and 90%
- Correlations between 0.57 and 0.92.

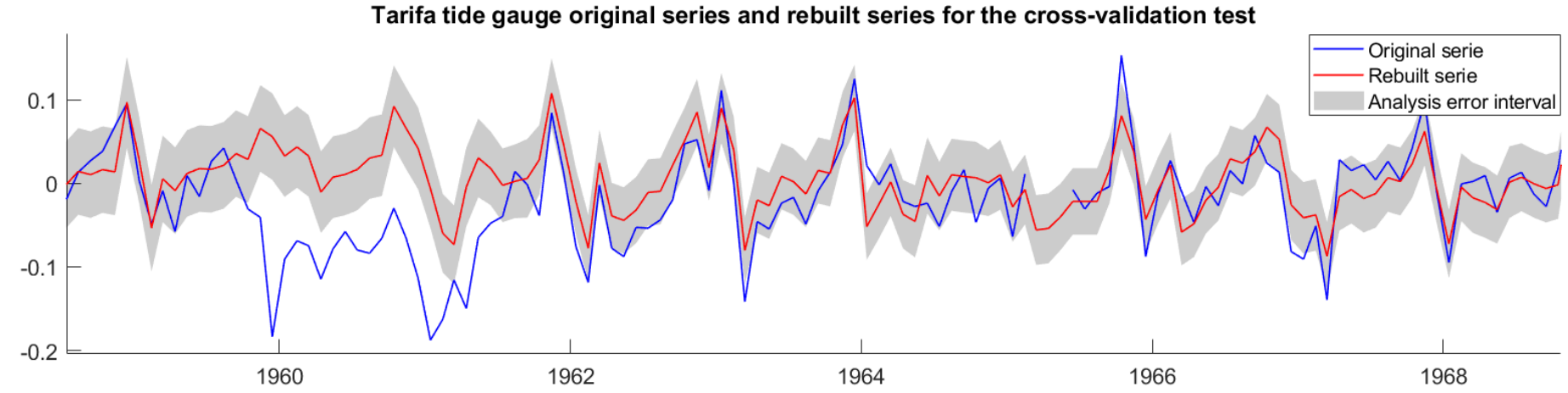
Cross-validation test

Monthly case

Example of good skills

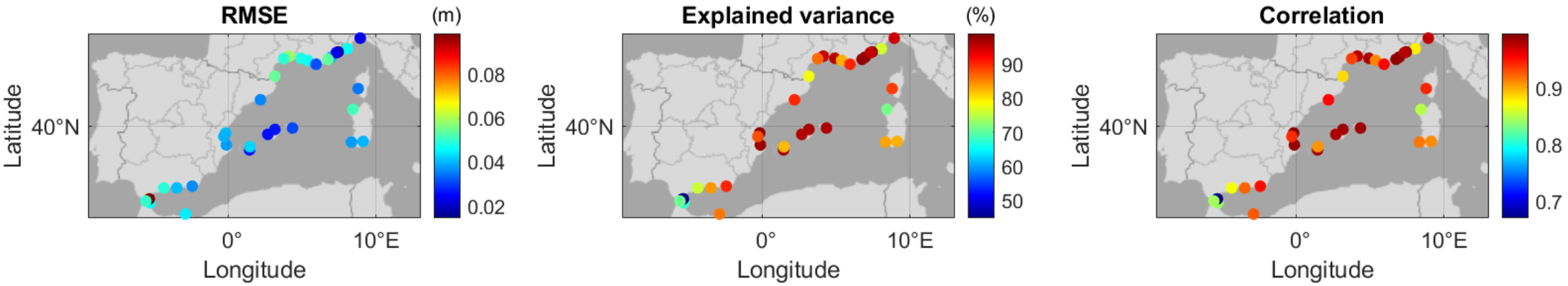


Example of low skills



Cross-validation test

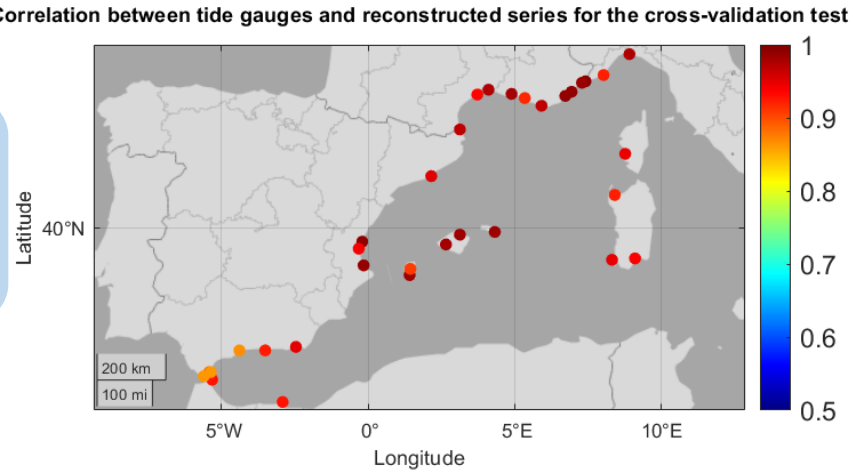
Daily case

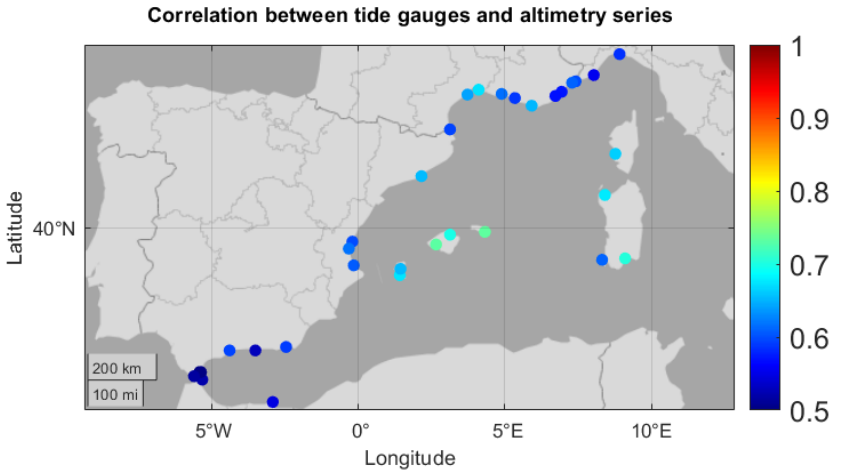


- Maximum analysis error values of 7 cm
- Maximum RMSE values of 10 cm.
- Explained variances between 40 and 90%
- Minimum correlations of 0.7.

Comparison of the reconstructions with the altimetry series

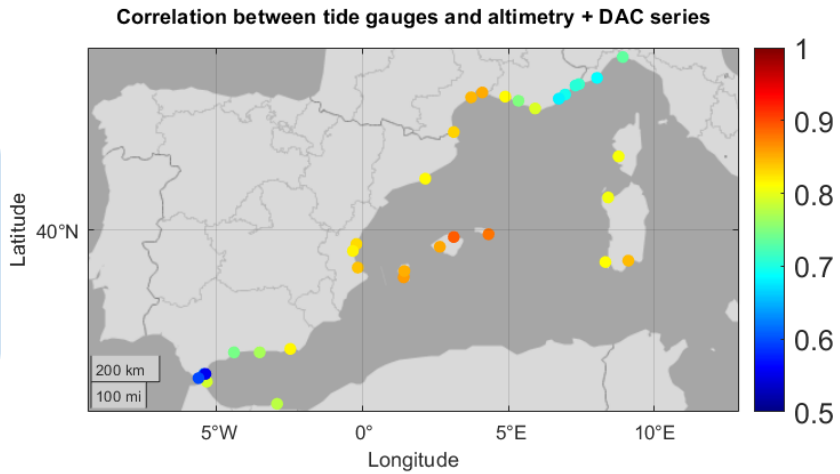
Cross-validation reconstructions VS tide gauges

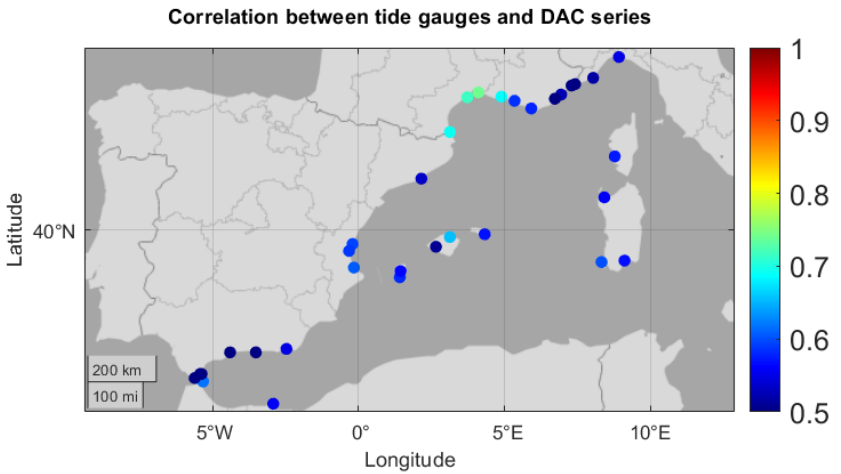




Altimetry VS tide gauges

Altimetry + atmospheric corrections VS tide gauges





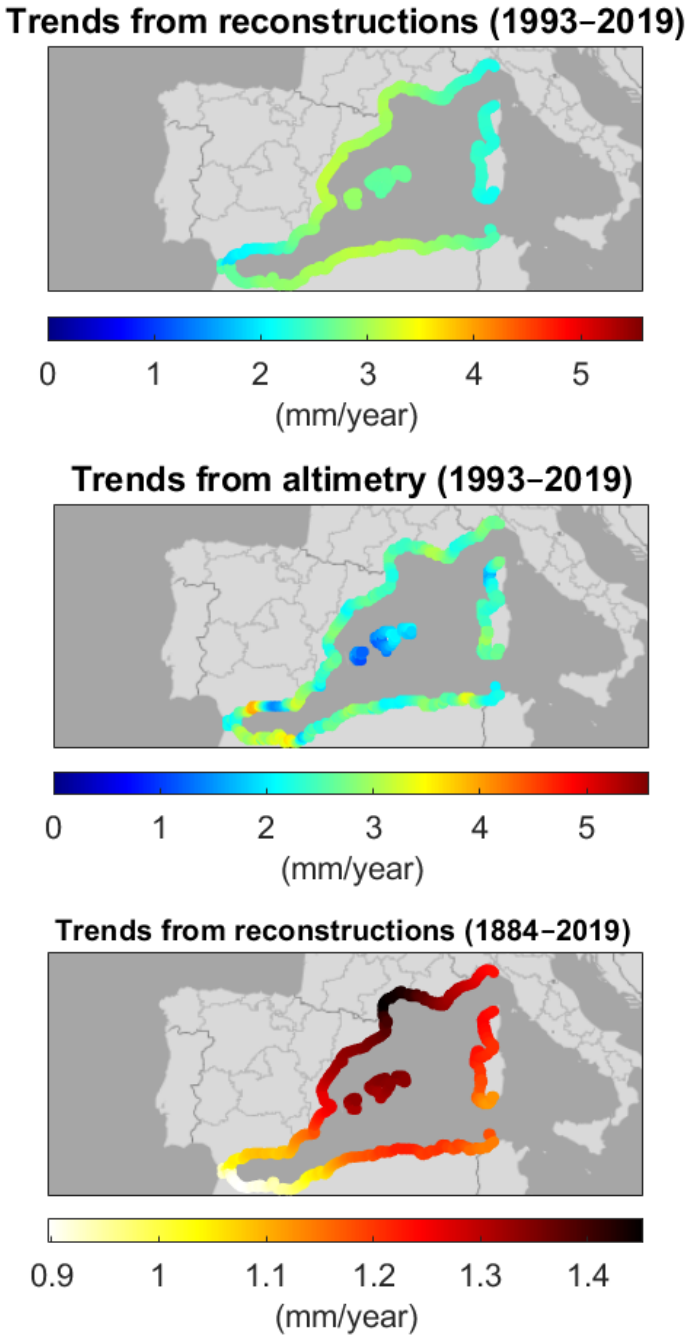
Atmospheric Corrections VS tide gauges

Examples of application

Coastal sea level trends

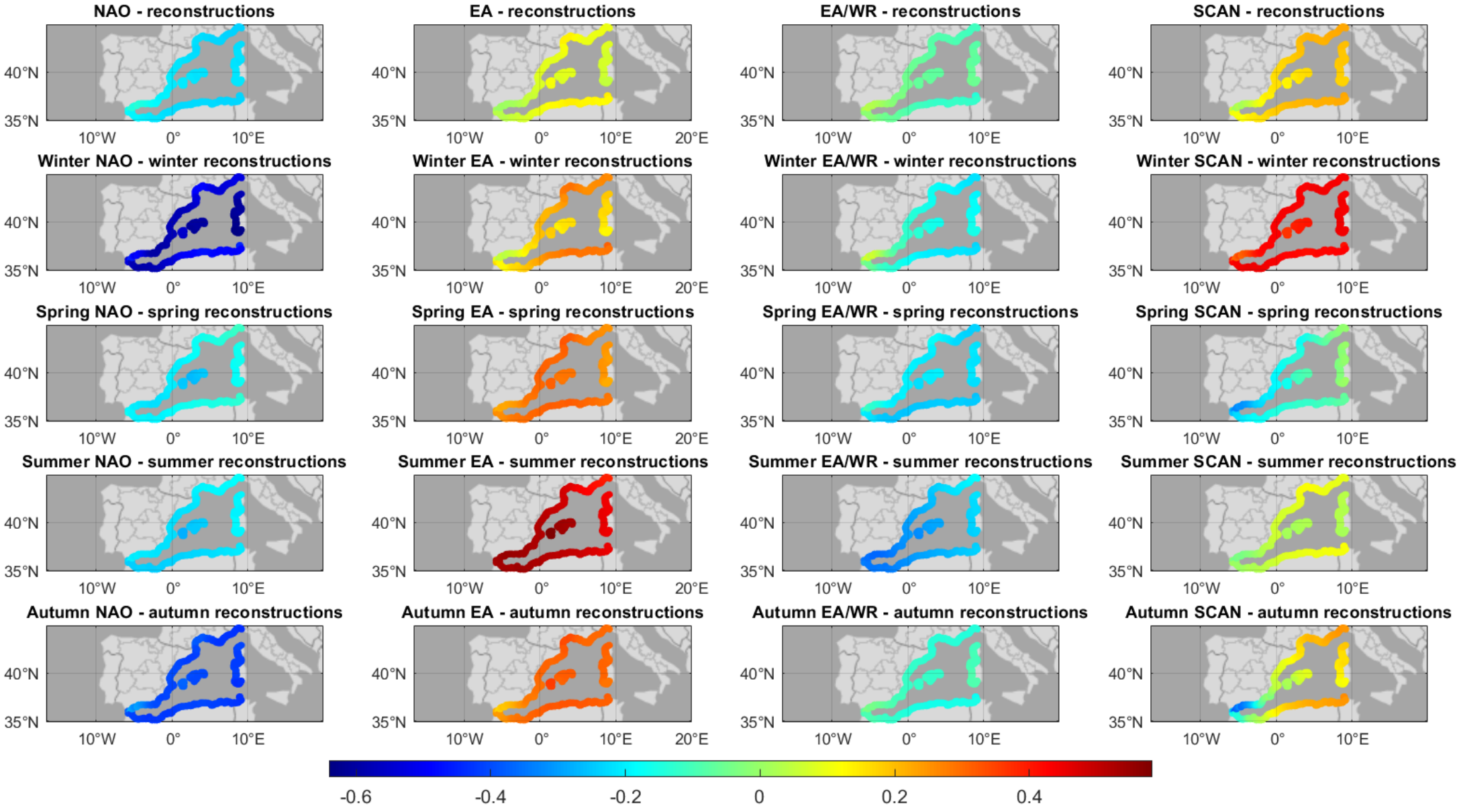
- For the period covered by the altimetry, trends of similar magnitude, but with smoother continuity along the coast for the reconstructions.

- For the total reconstruction period, the trends range from less than 1 mm/year in the African coasts close to Gibraltar, to about 1.5 mm/year in the Gulf of Lions, with a regional mean value of 1.20±0.14 mm/year.



Examples of application

Atmospheric climate modes



Limitations and applicability

Two main limitations

- The correlation elements of the Optimal Interpolation matrices should be reliable.

- The spatial distribution of tide gauge observations influences the quality of the reconstructions.

The applicability of the method to other coastal regions is conditioned by the availability of a good number of observations with long enough series, as well as by their spatial distribution.

Some conclusions

- The **developed method successfully reconstructs sea level all along the coast**, as far as several tide gauge observations are available in the region.
- Compared to observations, **the reconstruction provides better results than altimetry** at different time scales.
- Cross-validation tests have provided complementary measures of the error and have therefore helped to verify the goodness of the reconstructions.
- The method can be extrapolated to other coastal regions where tide gauge measurements are available. **The dataset represents valuable source of information**, which can be used to study various coastal processes.

More details?

Check out our preprint currently under discussion in Egusphere!

https://doi.org/10.5194/egusphere-2022-169
Preprint. Discussion started: 20 April 2022

Reconstruction of Mediterranean coastal sea level at different timescales based on tide gauge records

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Thanks for your attention!

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