

Bayesian approaches to the spatial interpolation of sea-level time-series

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Funding

NERC studentship, fully funded.

Background

Sea-level rise is one of the most pressing societal consequences of climate change with 200 million people already vulnerable to flooding from extreme levels and this population expected to grow to around 800 million by the 2080s. Sea-level not only affects coastal populations through increased flood risk, inundation and storm damage, but also through the contamination of fresh water aquifers, wetland loss, erosion and impeded drainage as the water table rises.

Our understanding of sea-level change over the twentieth century is primarily based on a sparse array of tide gauge measurements which are distributed unevenly in time and space. Long tide gauge records are predominantly located in the northern hemisphere, in Europe and North America and they are almost exclusively at the ocean margin with only very few island measurements of the ocean interior.

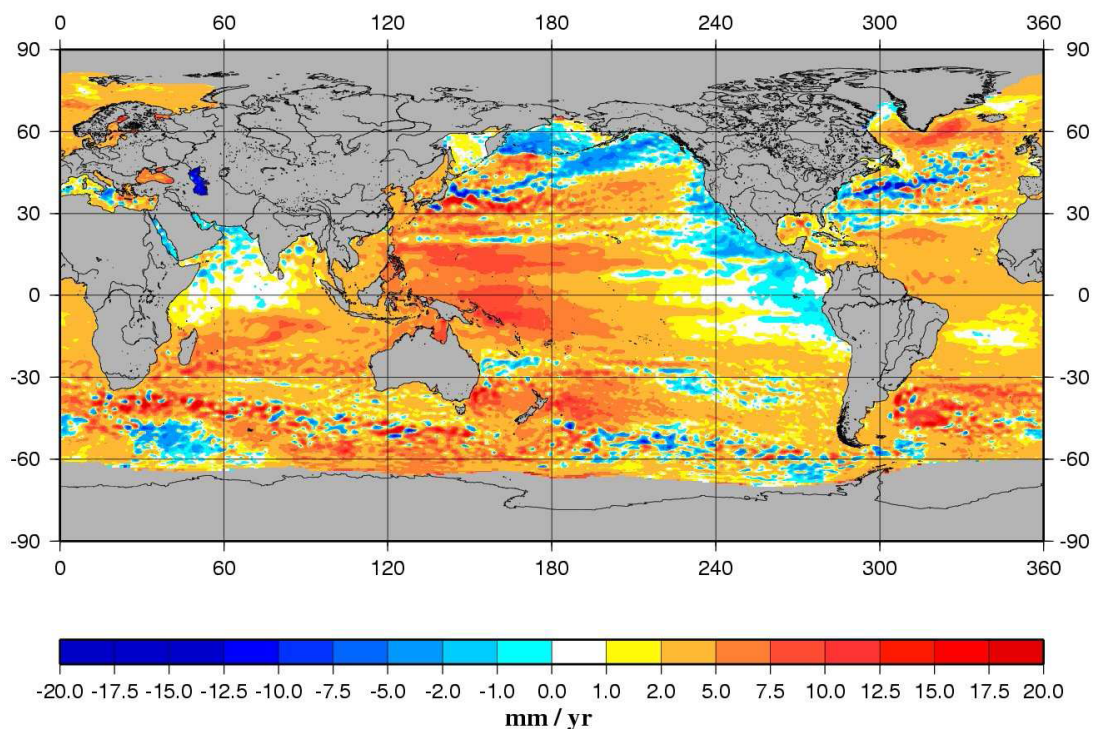


Figure 1: Map of spatial trend patterns of observed sea level between January 1993 and December 2008. (From Cazenave and Llovel, 2010).

Estimates of sea level change made on the basis on these tide gauges,

which are weighted in different ways depending on the particular approach employed, give a global mean rate of sea-level change of approximately $+1.8 \text{ mm yr}^{-1}$ over the last 100 years or so.

In the past couple of decades, satellite measurements of sea-level have provided a new, global, view of the spatial variability in sea level change (Figure 1). Satellite altimetry has provided estimates of global mean sea-level rise 1992-2010 of around $+3.2 \text{ mm yr}^{-1}$ depending on various assumptions and processing methods. The near doubling of the rate in comparison with the long term tide gauge rate has led some researchers to assert that there has been a recent acceleration in the rate. However, this view is complicated by the switch in measurement systems and by land level changes resulting from, for example, post-glacial rebound and tectonics. In addition, the tide gauge record shows considerable decadal variability in the rate (Figure 2) meaning that it is unclear that the recent rate is unusual. Importantly though, the global mean rate tells us nothing about the spatial variability of sea-level which is key to the assessment of risk for coastal populations.

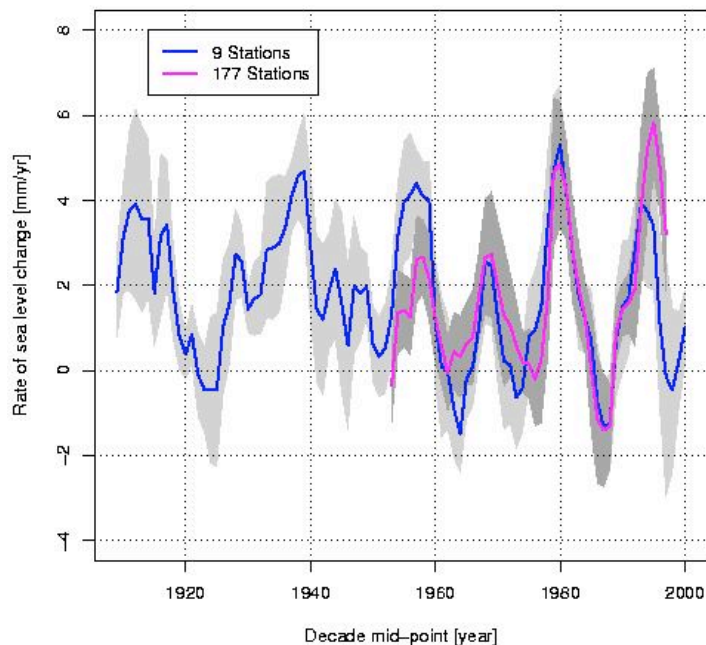


Figure 2: Decadal variability in the rate of global mean sea level change from long sea level records. (From Holgate, 2007).

The aim of this project is to use Bayesian methods to produce probability density functions (PDF) for global and regional sea-level change to reflect the uncertainty in the sea-level estimates. The student will also develop spatial interpolation methods based on Kriging with time dependence that will allow improved statistical interpretation in comparison with existing Empirical Orthogonal Function (EOF) based estimates of sea-level change.

It is envisaged that the studentship will be primarily based in Oxford and funding is provided for 3.5 years. One of the three years may be based at NOC in Liverpool, dependent upon how the project evolves.

Scientific questions to be addressed:

What are our best estimates of the PDFs of sea-level change, global and regional, over the past 100-150 years?

How do these confidence estimates affect our interpretation of sea level change over this time period and ideas regarding a recent acceleration in the rate of global sea level rise?

Workplan

Year 1:

- Develop familiarity with the issues surrounding sea-level change and the datasets involved
- Summarise the datasets
- Start with simple spatial interpolation using Briggs method

Year 2:

- Generalise the method to Kriging to give a statistical interpretation
- Produce correlations with spatial information
- Interpolation with directional Bayesian control

Year 3:

- Add time dependent interpolation, which will require new methods to be developed
- Finish writing up

Training provided

The student will participate in the training programme of Oxford University, as well as any appropriate courses offered at the National Oceanography Centre.

The Doctoral Training Grant includes funds that can be used for visits to other supervisors and it is expected that the student will attend at least one national and one international conference during the course of their study. It is also possible that the student will attend an international summer school (such as the geophysical fluid dynamics program at Woods Hole Oceanographic Institution), depending on the student's needs and interests.

Computing facilities will be provided as required at Oxford University and the National Oceanography Centre. It is not envisaged that high performance computing facilities will be needed for this project but the NOC cluster is available should it be required.

Applicants should possess, or expect to graduate with a first class or upper second degree in mathematics or physics, or be able to demonstrate a high level of relevant mathematical competency in order to undertake this project. Experience of programming would be useful but not essential.

Funding for this studentship is restricted to UK and EU nationals who fulfil NERC's eligibility requirements. More information is available from the NERC website at: <http://www.nerc.ac.uk/funding/available/postgrad/eligibility.asp>

Recent publications relevant to the research area

Cazenave, A. and Llovel, W. (2010), "Contemporary Sea Level Rise.", *Annual Review of Marine Science*, 2 (1), pp. 145-173, doi: 10.1146/annurev-marine-120308-081105

Church, J. A., and White, N. J. (2006), "A 20th century acceleration in global sea-level rise.", *Geophys. Res. Lett.*, 33, L01602, doi:10.1029/2005GL024826.

Farmer, C. L. (2007) "Bayesian Field Theory Applied to Scattered Data Interpolation and Inverse Problems". In, '*Algorithms for Approximation*'. Ed. A. Iske and J. Levesley, Springer-Verlag, Heidelberg, pp. 147-166.

Holgate, S. J., and Woodworth, P. L. (2004), "Evidence for enhanced coastal sea level rise during the 1990s.", *Geophys. Res. Lett.*, 31, L07305, doi: 10.1029/2004GL019626.

Holgate, S. J. (2007), "On the decadal rates of sea level change during the twentieth century.", *Geophys. Res. Lett.*, 34, L01602, doi:10.1029/2006GL028492.

Potsepaev, R. V., Farmer, C. L. and Azi, M. (2010), "Stochastic partial differential equations as priors in ensemble methods for solving inverse problems", *Inverse Problems* (submitted)