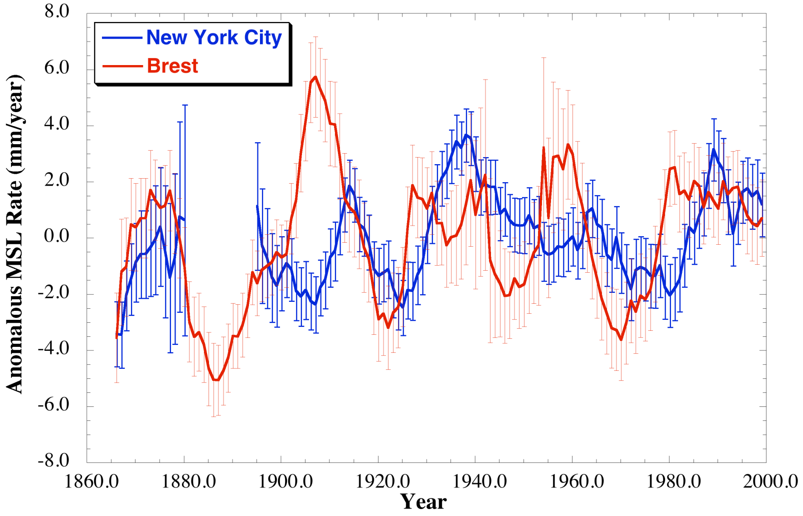
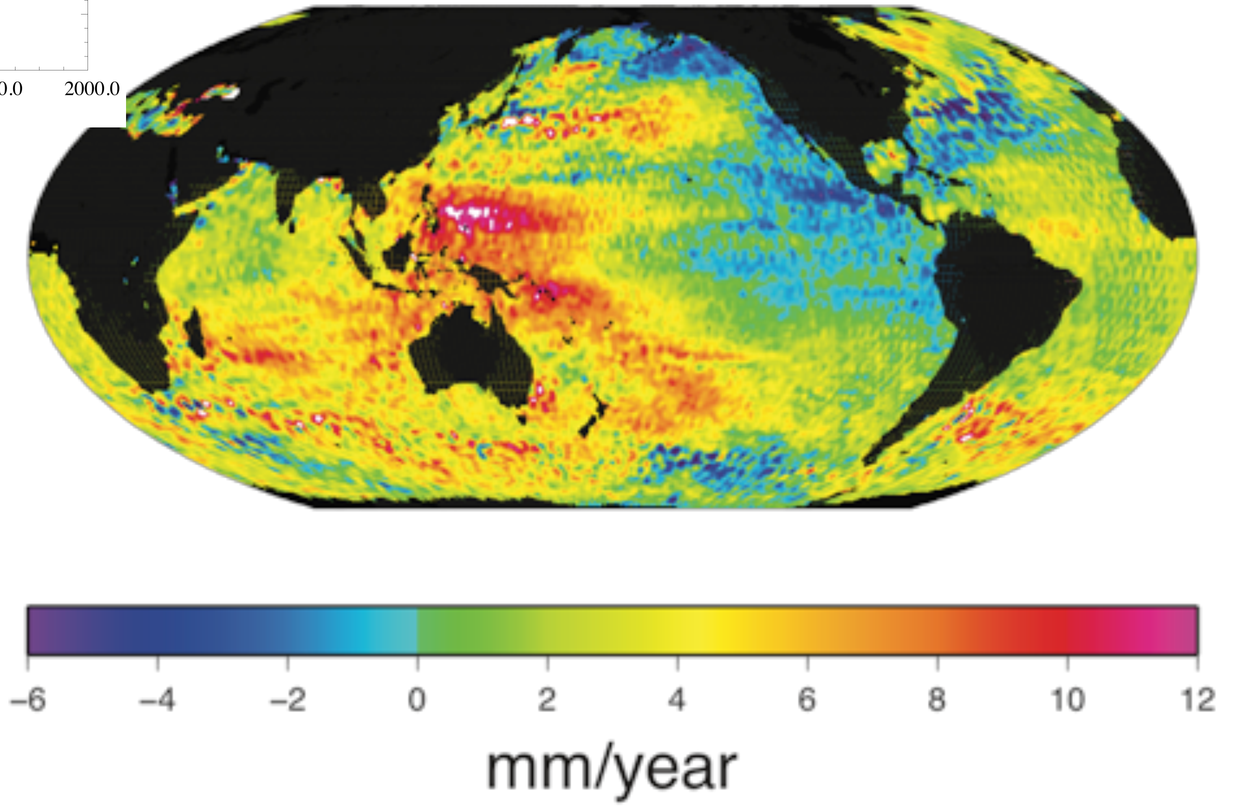
SEA LEVEL & REVIEW OF WCRP/ INTERNATIONAL CLIVAR GRAND CHALLENGE WHITE PAPER

Don Chambers
The University of South Florida
College of Marine Science

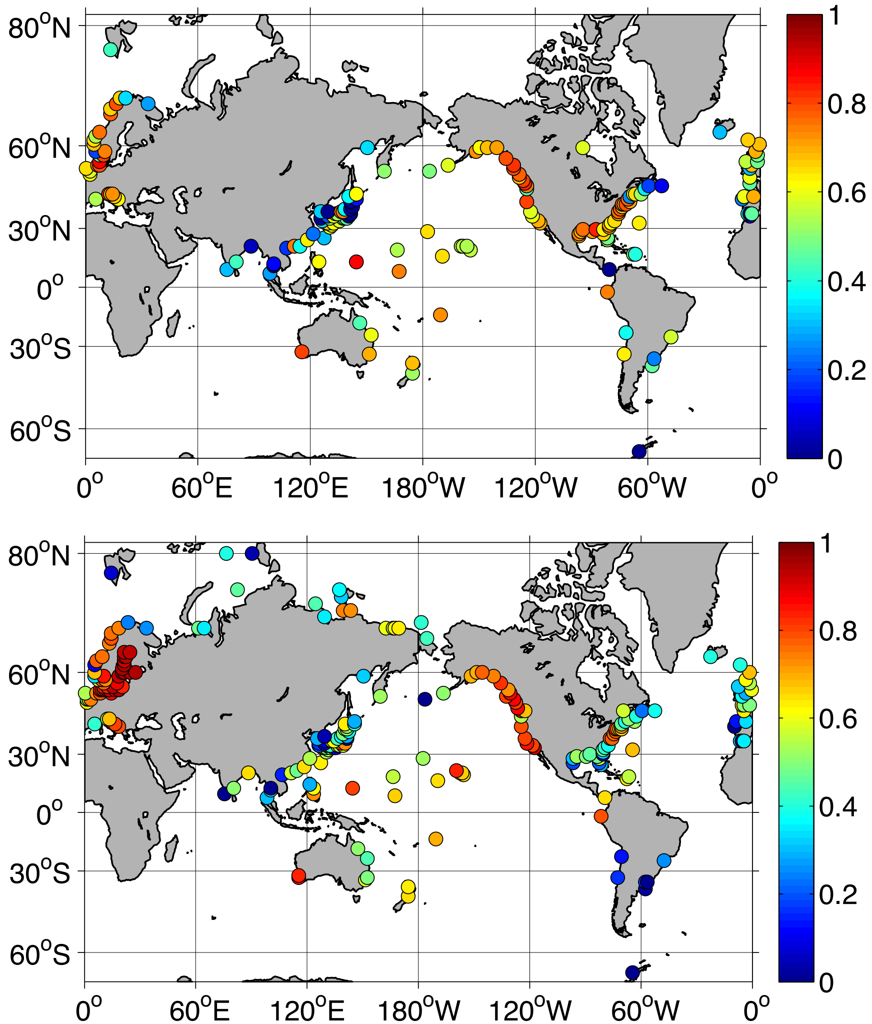
Anomalous rates of sea level rise (with long term mean removed) for two long tide gauge records – New York City and Brest – that border the North Atlantic.



- White Paper based on a WCRP Workshop held in Paris in February, 2011
  - http://www.wcrp-climate.org/documents/Regional_SeaLevel_workshop.pdf

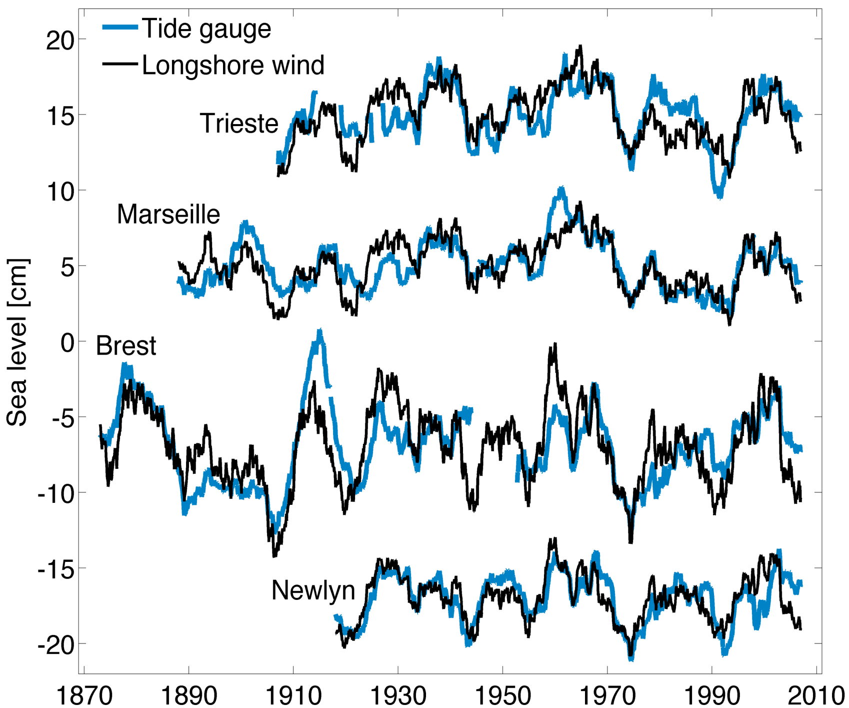


Map of local SL rates determined from T/P, Jason-1, and OSTM/ Jason-2 data from January 1993 to December 2011. Global mean is 3.1 mm/year.

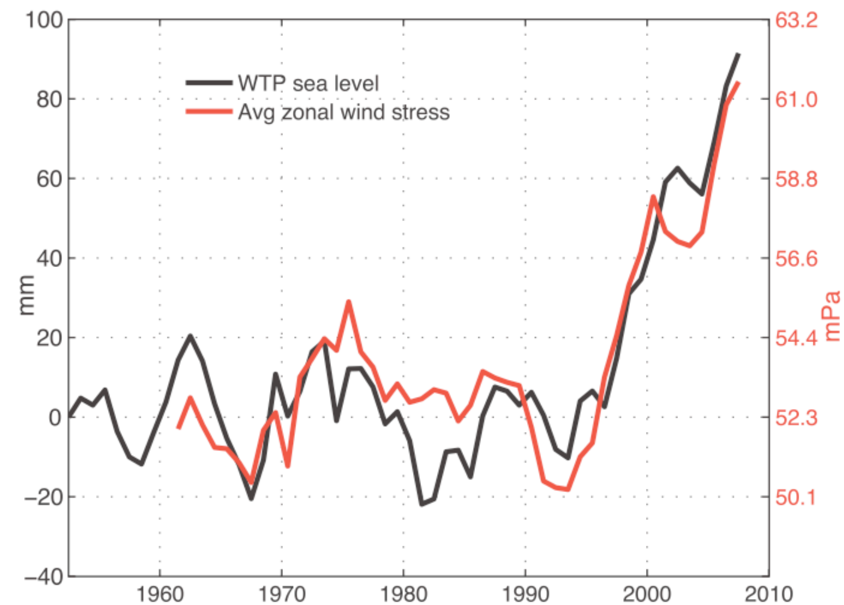


Correlation between sea level measured by tide gauges and sea level from two different models: (top) GECCO, 1962-2001 (bottom) SODA, 1958-2008. All data have had the seasonal variation and trends removed, and have been low-pass filtered with a 1-year running mean. From *Calafat and Chambers* (JGR, in review, 2013)

- Predicting regional sea level change is difficult
- Climate models and even higher resolution general circulation models disagree substantially with measurements and each other
- Numerous studies have shown the changes are driven by winds, but different mechanisms are responsible for different regions
- Climate model projections are not sufficient to predict regional sea level rise



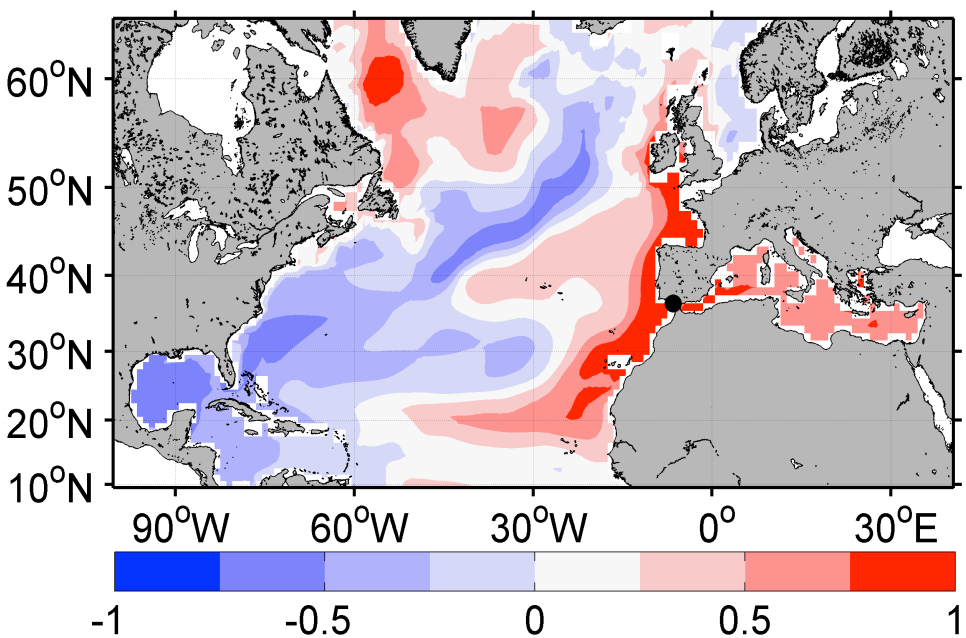
From *Calafat et al*. (JGR, 2012). Comparison between the (scaled) integrated longshore wind and the sea level from the tide gauge records at Trieste, Marseille, Brest, and Newlyn. All time series have been detrended and smoothed using a 4-years running mean.



From *Merrifield* (GRL, 2011). Comparison of average western tropical Pacific (WTP) sea level and the amplitude of zonal wind stress averaged across the Pacific between 20°S and 20°N and from 150°E to the eastern boundary. The WTP sea level is the average from 11 island tide gauges with a 5-year running mean filter applied.

- Observed regional changes are steric in nature, to a large degree being caused by redistribution in temperature and salinity in response to changing winds.

- Local effects (e.g., shelf dynamics, tectonics) may complicate the relationship between coastal and offshore sea level change
  - One reason that climate models and GOCMs likely do not explain a significant fraction of sea level variance at coastal tide gauges in some regions



Map showing the correlation between the sea level from GECCO at the Atlantic side of Gibraltar (black dot) and the sea level at each grid point. All time series have been detrended and smoothed using a 4-years running mean prior to the computation of the correlation. From *Calafat et al*. (JGR, 2012).

- While it is obvious that wind stress impacts regional sea level on all time scales, it is not obvious why the wind is changing during the last one or two decades as it does.

SOME OPEN ISSUES

- While consensus exists that a major fraction of the observed sea level changes during the last decade are caused by internal climate variability, it is not known what the relative contribution of specific climate modes (ENSO, PDO, NAO, AMO) is to sea level variability.

- It is not obvious how realistically climate modes are being simulated by climate models. This calls for a comparison of climate modes in observations and climate models.

- We have indications that climate modes will change in a warming climate. Given the clear role of climate modes for regional sea level, it is important to know how climate modes will change in the future.

- Regional sea level observed during the last 1-2 decades is strongly influenced by climate modes. It is important to better understand how to separate long-term trends from natural climate variability in observations and models.

- Similar to long-term trends we also need to better understand and quantify the amount of decadal internal variability in existing observations and in forecasts and projections. Even projections of regional sea level changes over 100 years will be influenced by internal decadal variability.

- While it is obvious that changes in wind forcing are a primary driver for sea level changes observed during the last decades, it is not obvious what the relative contribution of changes in wind forcing and buoyancy forcing is in long-term climate projections.

- It is recommended to enhance our data base of deep hydrographic observations (below 2000m depth).

- Enhanced freshwater input will lead to a dynamical adjustment of the ocean. We need to better understand the dynamical response of sea level to polar ice sheet melting and analyze this adjustment in coupled climate models.

  - Most "hosing" experiments assume unrealistically large fresh water fluxes and place these all along the northern boundary. More work needed to use realistic forcing

- The workshop participants acknowledge large remaining uncertainties in surface forcing fields. It is recommended to use ocean (sea level) information to decipher those uncertainties by comparing resulting sea level changes against observations and thereby learn more about the accuracy of the forcing, a strategy that is being pursued in ocean syntheses efforts.