Sea level change caused by mass loss of the major ice sheets[1]

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Introduction

Recently a major contributor to relative sea level change is the change of temperature of the ocean. Furthermore, there are also changes in sea level caused by the mass loss of major ice sheets in Greenland and the West Antarctic.

Also land movements take place which causes regional sea level to change. These originate from global isostatic adjustment, mostly from past loss of ice sheets. However a significant contribution is due to present day mass redistribution and associated change in geoid and uplift of the solid Earth.

During this project, we study sea level change caused by the mass loss of the major ice sheets and of the glaciers in Alaska. The oceanic response is modelled with the finite element sea-ice ocean model. Furthermore, the regional changes caused by the viscous Earth response to past glacial loading are taken into account. We apply melt rates lying in the range of different studies and compare our results to time series from tide gauges in the North Atlantic.

FESOM

- The finite element sea-ice ocean model (FESOM)[5] is used to simulate variations in sea level for a period of 50 years.
- Anomalous fresh water inflow due to mass loss of the
  - Greenland Ice Sheet 200 Gt/yr,
  - West Antarctic Ice Sheet 100 Gt/yr, and
  - Glaciers in Alaska 50 Gt/yr
- The fresh water inflow is modelled as flux of volume and mass, but not of salinity (nonlinear free surface model)
- Modelled sea level change is computed by taking the sea surface height difference between a reference simulation and a simulation including the additional fresh water inflow.
- The gravitational sea level response to the surface loading and the effect of the uplift of the ocean bottom are computed using Green's functions[2,3].

Modelled sea level change after 50 years

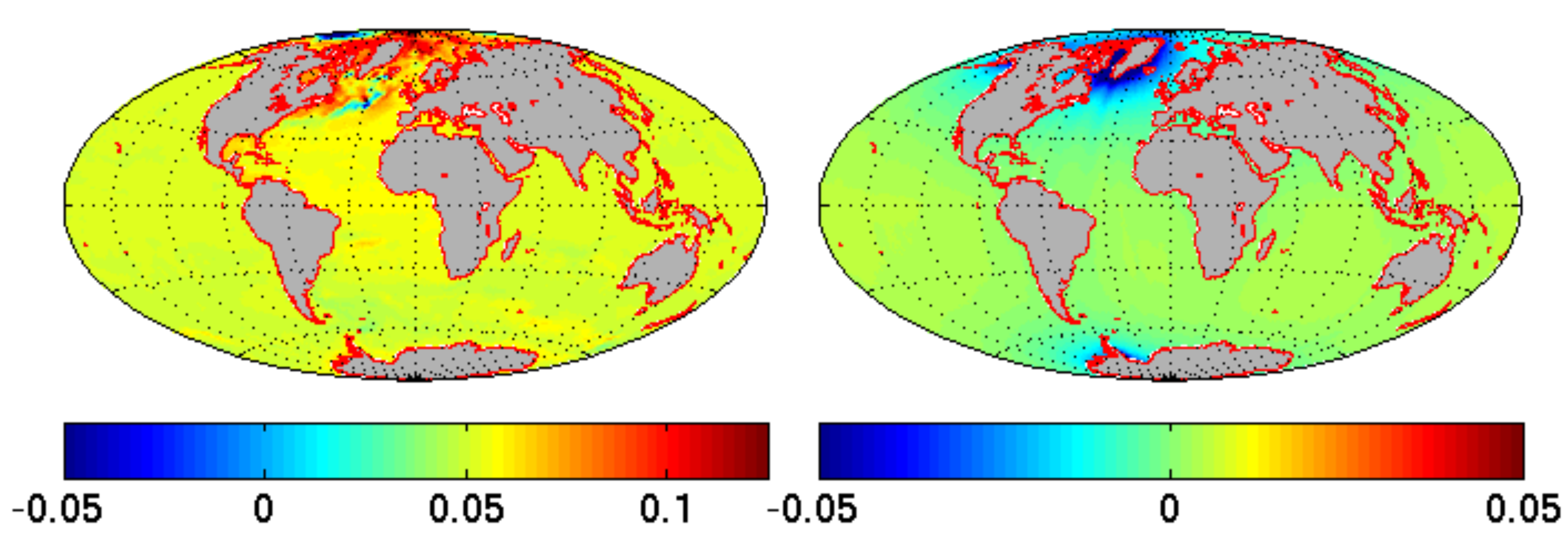

Fig.1: Modelled sea surface height change in meter (left) and sea level change due to changes in gravitational attraction and the uplift of the land surfqace and ocean bottom (right) [1]

- After 50 years modelled sea surface height mainly changes in the North Atlantic
- Sea level change caused by the gravitational response and uplift of the ocean bottom shows a decrease near the source of the mass loss and slight increases at greater distances

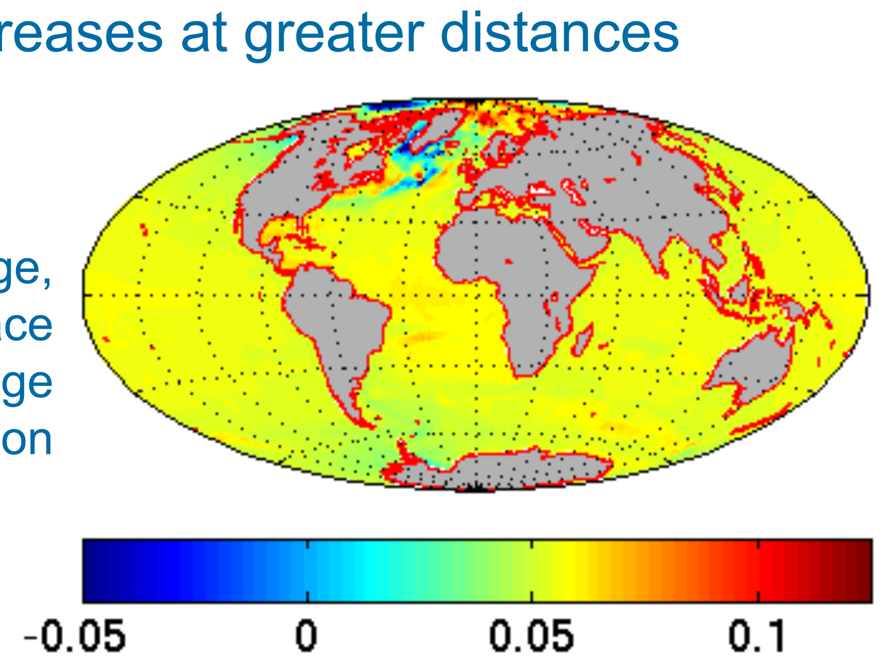

Fig.2: Full relative sea surface change, i.e. the sum of modelled sea surface height change and sea level change due to changed gravitational attraction and uplift [1]. The unit is meters.

Comparison with Tide Gauges

- The comparison of the estimated relative sea level change with tide gauge measurements show good agreement in the structure and the amplitude of yearly mean variations
- The GIA component[4] is added to the FESOM time series
- The correlation between the two time series is further increased to around 0.8 when including the components corresponding to ice mass loss of the three regions into the model simulations.

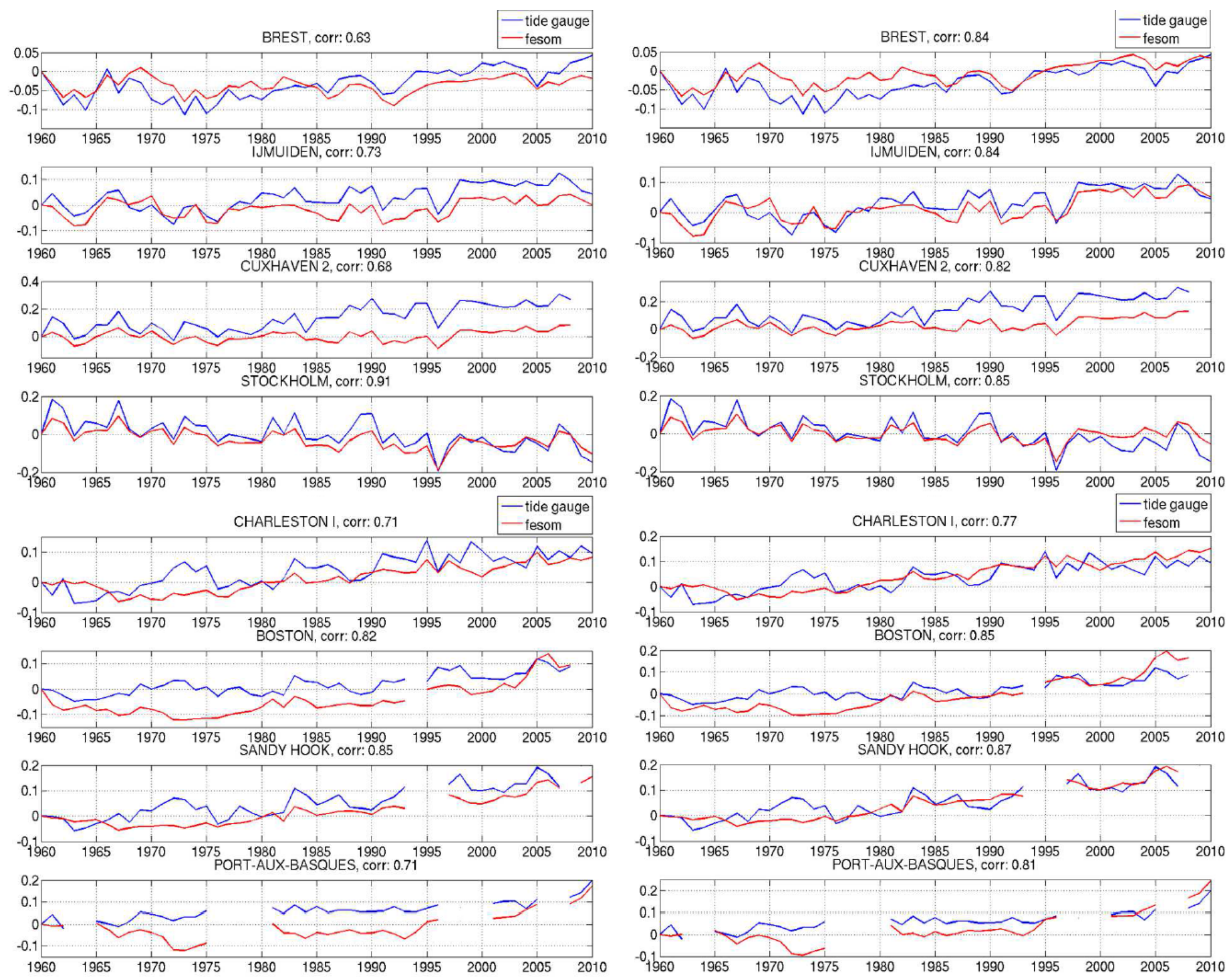

Fig.3: Time series of tide gauges and modeled sea level change in meter without ice mass loss of the major ice sheet (upper left: European coast, lower left: North American coast) and with fresh water inflow due to ice mass loss of the three region (upper right: European coast, lower right: North American coast) [1]

Conclusions

- The reduced gravitational attraction of the remaining ice sheets together with the uplift of the ocean bottom results in a decrease in sea level near the source of the mass loss and a slight increase at regions further away.
- Estimated sea level change shows good agreement with tide gauge records at different locations coasts in the North Atlantic (expected as the short term variations are mainly caused by wind and atmospheric pressure, derived from observations) .
- Introducing fresh water inflow at coastal regions, where land ice mass is lost, further increases the correlation of modelled sea level change and tide gauge measurements.

References

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