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Is There Evidence of 'Fingerprints' in North Atlantic Tide Gauge Records?

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Abstract

Sea level is rising but clear evidence of an increase in the rate of rise has proved elusive. Recent observations have suggested that there has been a marked increase in the rate of Greenland melting. Increased melting from high latitudes should produce an identifiable pattern of sea level change ('fingerprints') that may provide evidence of an acceleration in the rate of sea level rise.

Here we show evidence of recent changes in the latitudinal pattern of sea level change from global and North Atlantic tide gauges. These gauges show a latitudinal pattern of sea level change over the past 60 years which is indicative of an acceleration in the rate of sea level rise but is inconsistent with a dominant role for either melting ice or steric changes.

Introduction

Sea level does not change the same everywhere, for a variety of reasons.

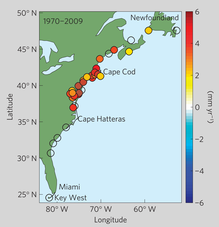
In the open ocean, most variability on inter-annual timescales is driven by variations in temperature and salinity, that is, steric sea level. Adding mass to the ocean has no effect on dynamics.

Melting of large ice masses produces a spatial pattern of sea level change due to the alteration of the Earth's gravitational field - the geoid (e.g. Mitrovica et al., 2001; 2011). This pattern of sea level change has been dubbed "fingerprints".

"Hotspots"

Sallenger et al (2012) recently identified a "hotspot" on the east coast of the US where the rate of sea level change has increased over the past 60 years.

- Is this "hotspot" related to the gravitational effect of mass increase?
- Or is it due to steric changes?
- Is there an identifiable pattern of sea level change related to mass changes?

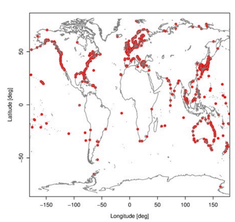


Data

Satellite altimetry only covers the past 19 years.

Tide gauges provide the only multi-decadal measurements of change.

Tide gauge data obtained from Permanent Service for Mean Sea Level (Holgate et al, 2012, *in press*).



- 178 tide gauges with global coverage selected from PSMSL's Revised Local Reference set
- At least 70% complete in every decade from 1948 to 2009.
- The North Atlantic has 68 gauges.

Steric data is based on Smith and Murphy (2007) updated to 2009.

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Method

Difference in rate calculated between 1st and 2nd halves of record (1979:2009-1948:1978) constrained by intersection of rates at mid-point

- True acceleration can be obtained

Spatially averaged in 20 zonal bands (c.f. Merrifield et al, 2009)

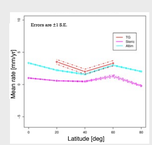
Comparison made of altimetry period to long term rate

North Atlantic region compared with global results

Results I

North Atlantic

Altimetry period (1992-2009)



Mean rate:

Altimetry and tide gauges are similar

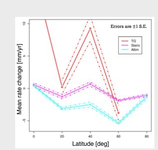
Steric change is lower rate but similar in form

Change in rate (2001:2009-1993:2001):

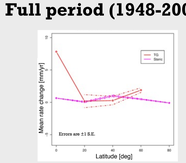
Altimetry has negative change in rate

Varies with latitude

Tide gauges more variable than altimetry or steric



Full period (1948-2009)



Change in rate (1979:2009-1948:1978):

Tide gauges show increase in rate with latitude

No evidence of latitudinal variation in steric rate

Results II

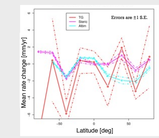
Global

Altimetry period (1992-2009)

Change in rate (2001:2009-1993:2001):

Patterns of change similar between variables

Magnitude of tide gauges larger than altimetry or steric



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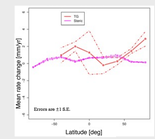

Change in rate (1979:2009-1948:1978):

As in North Atlantic tide gauges increase in rate with latitude

No evidence of significant latitudinal variation in steric rate

Discussion

Gravitational models (e.g. Mitrovica et al., 2001; 2011) predict decreasing rate change with increasing northward latitude.

In contrast, the tide gauge analysis here shows an increase in rate (acceleration) since 1948 which increases with increasing northward latitude.

Reconstructions of steric change since 1950 show no significant change in rate with latitude.

Suggests pattern of rate increase is due to changes in circulation related to wind stress (e.g. Lozier et al, 2008; Merrifield et al, 2011)

"Hotspot" of sea level change consistent with Sallenger et al (2012) but appears to be part of broader pattern.

Summary and Conclusions

- Tide gauges show increase in rate over past 60 years globally and in North Atlantic.
- Rate increase has latitudinal pattern which increases northwards from the equator.
- Increasing ice melt should lead to decreasing rate with increasing latitude
- No evidence of increase in steric rate with latitude
- Suggests tide gauges are not detecting "fingerprints"
  - Increase due to ocean circulation changes.

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