



**Proudman
Oceanographic Laboratory**
NATURAL ENVIRONMENT RESEARCH COUNCIL

Sea Level Changes Past and Future

Philip L. Woodworth

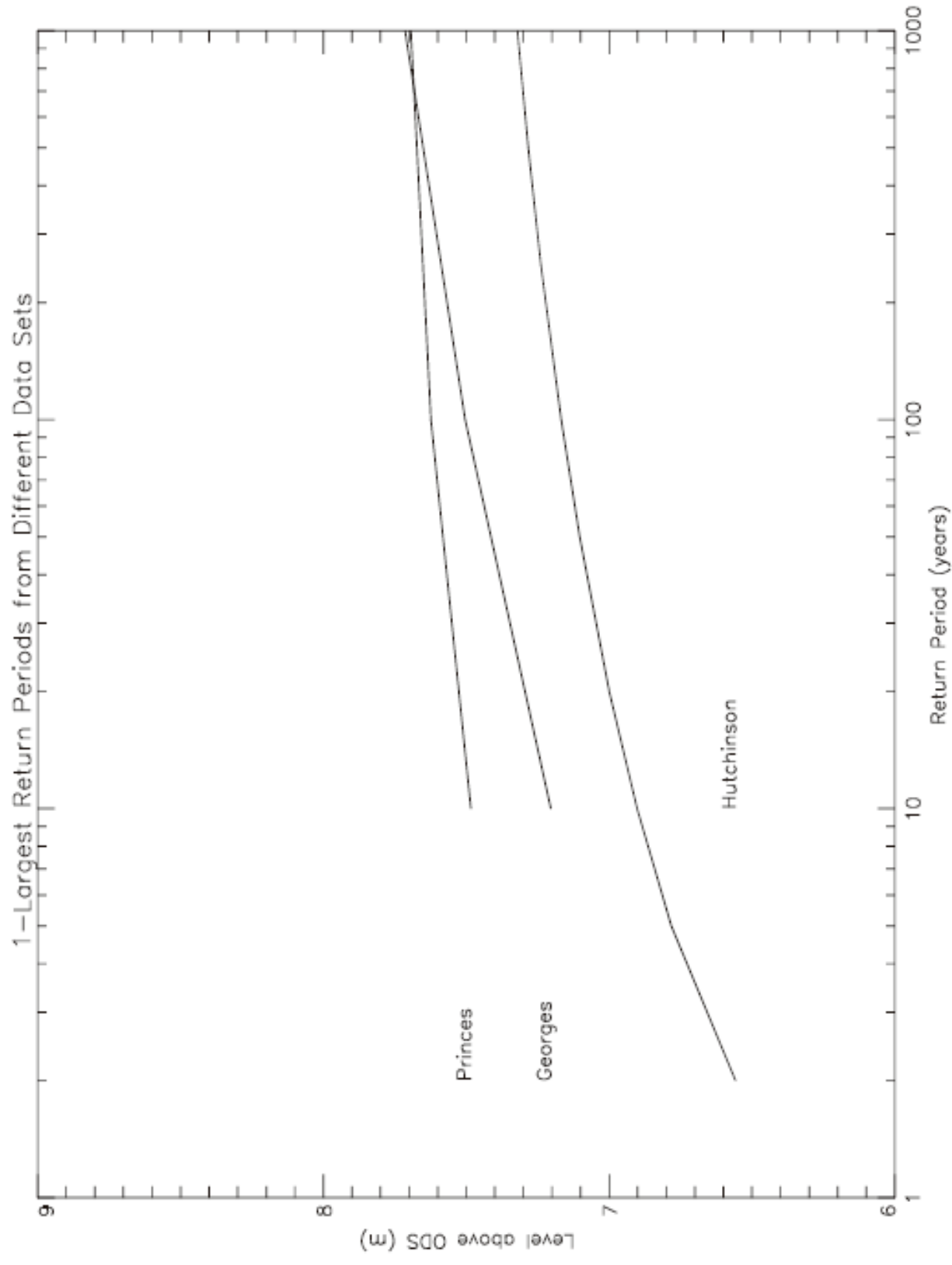
Proudman Oceanographic Laboratory, Liverpool

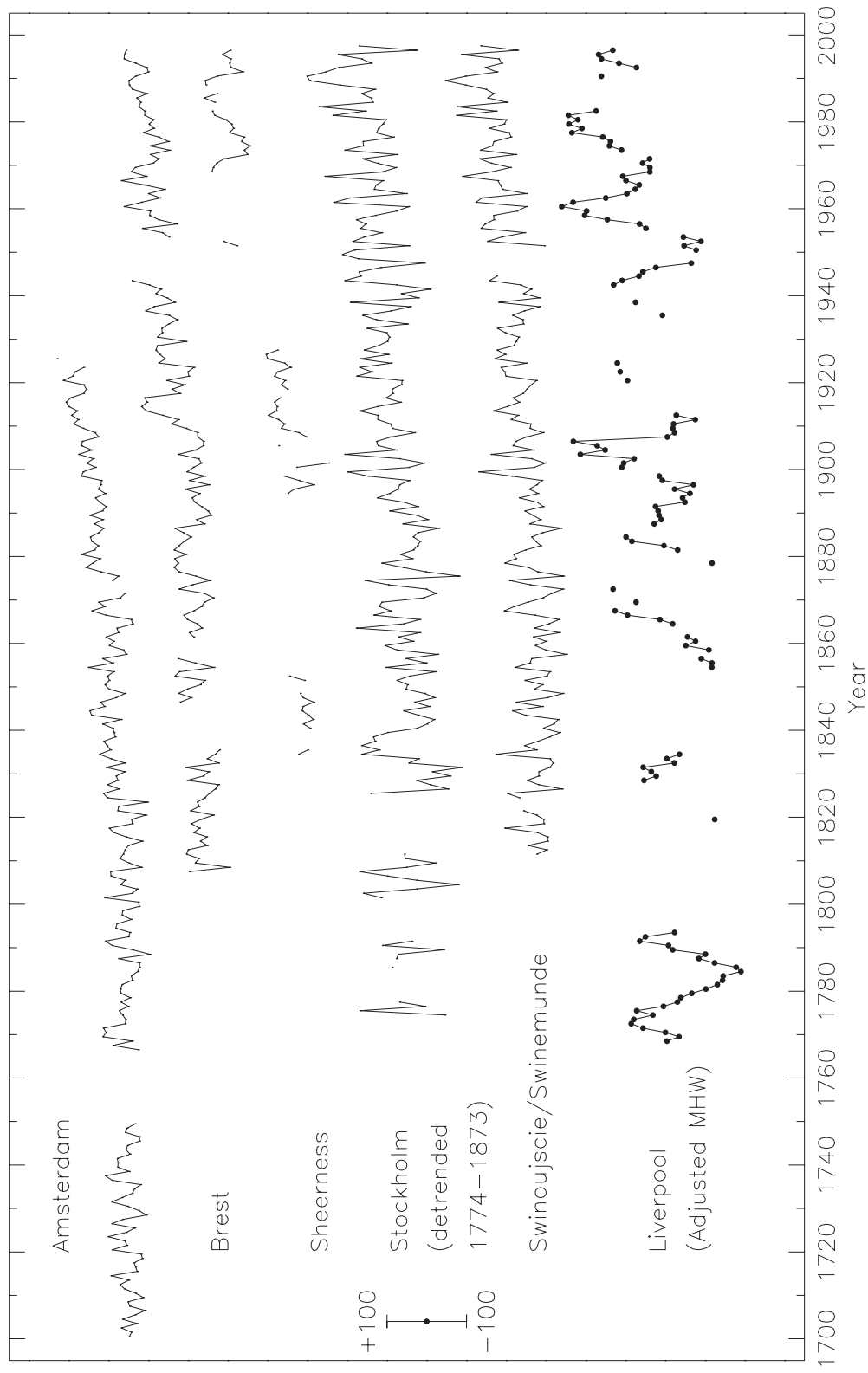
Liverpool Marine Science Symposium 8 January 2008

- Global Sea Level Trends
- Changes in UK Sea Level
- Projections for 21st century sea level

All with a local Liverpool emphasis!





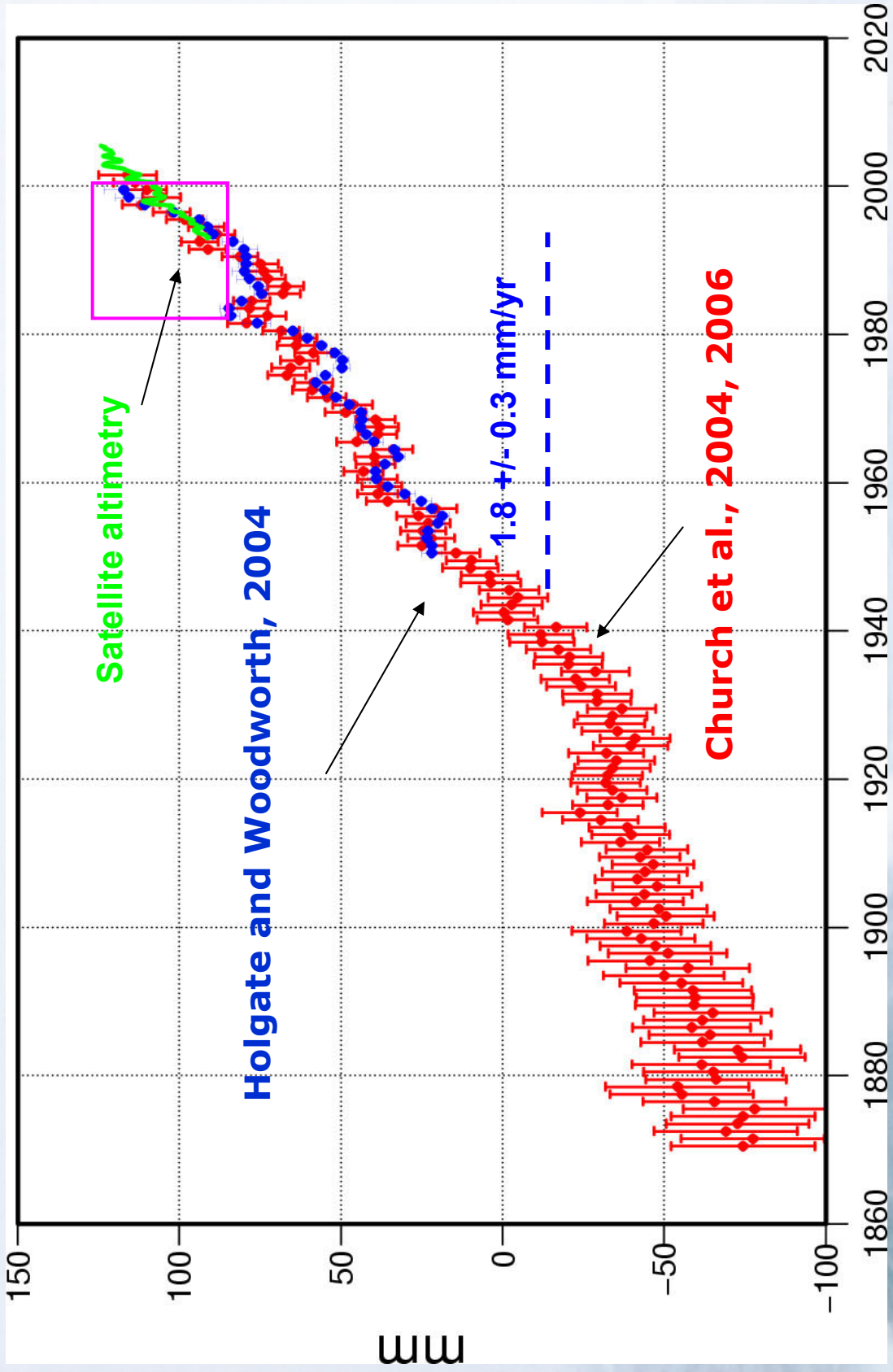


Sea level change contains an acceleration of sea level rise from the 19th to the 20th centuries probably due to climate change 5

Global Sea Level Rise

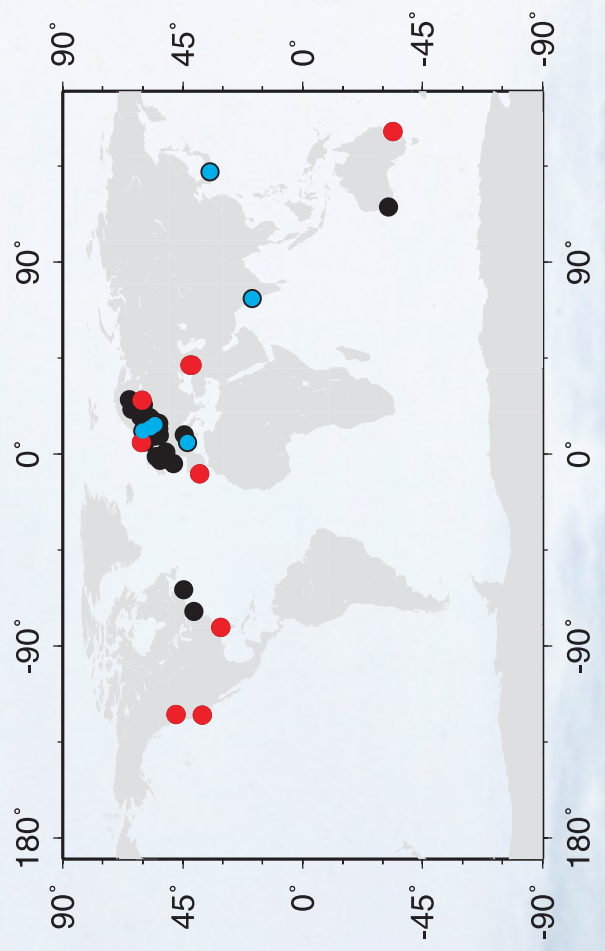


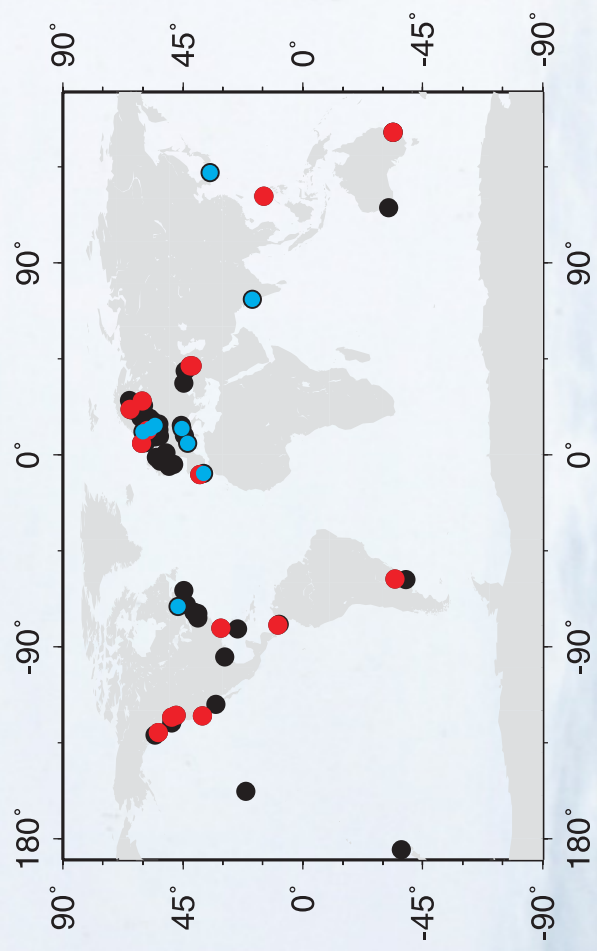
19th - 20th century sea level rise

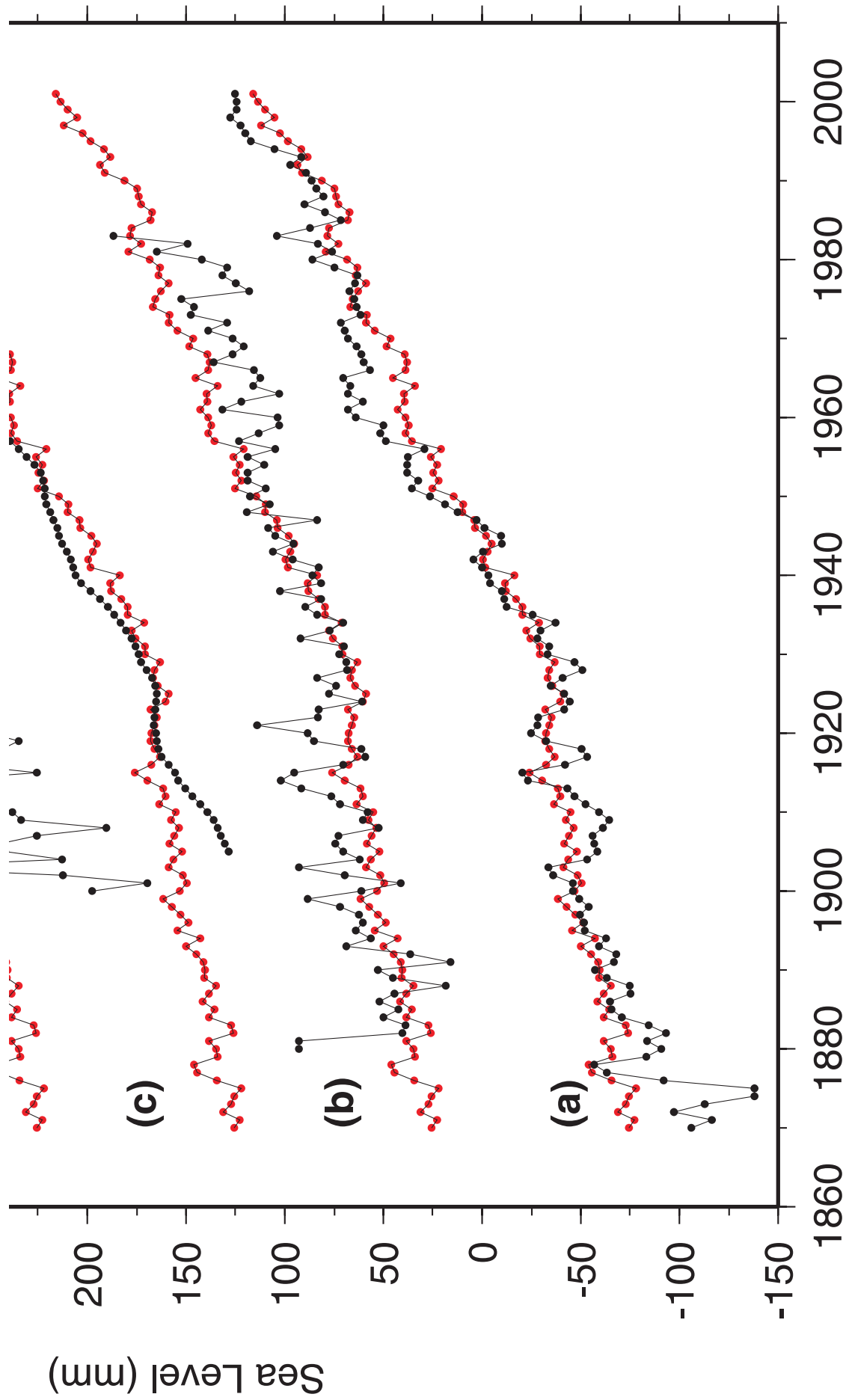


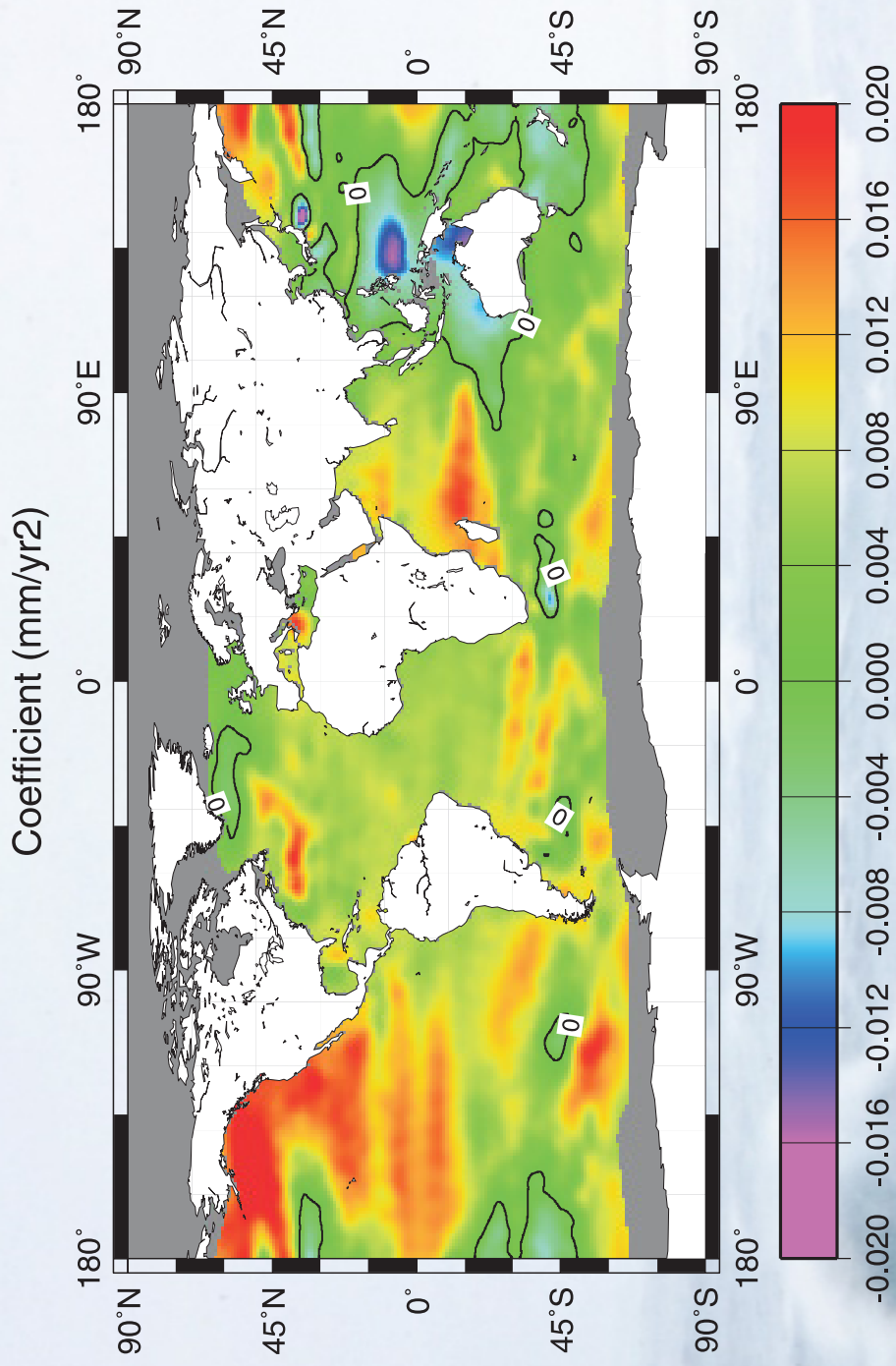
Has the Rise been the same throughout the 20th century?

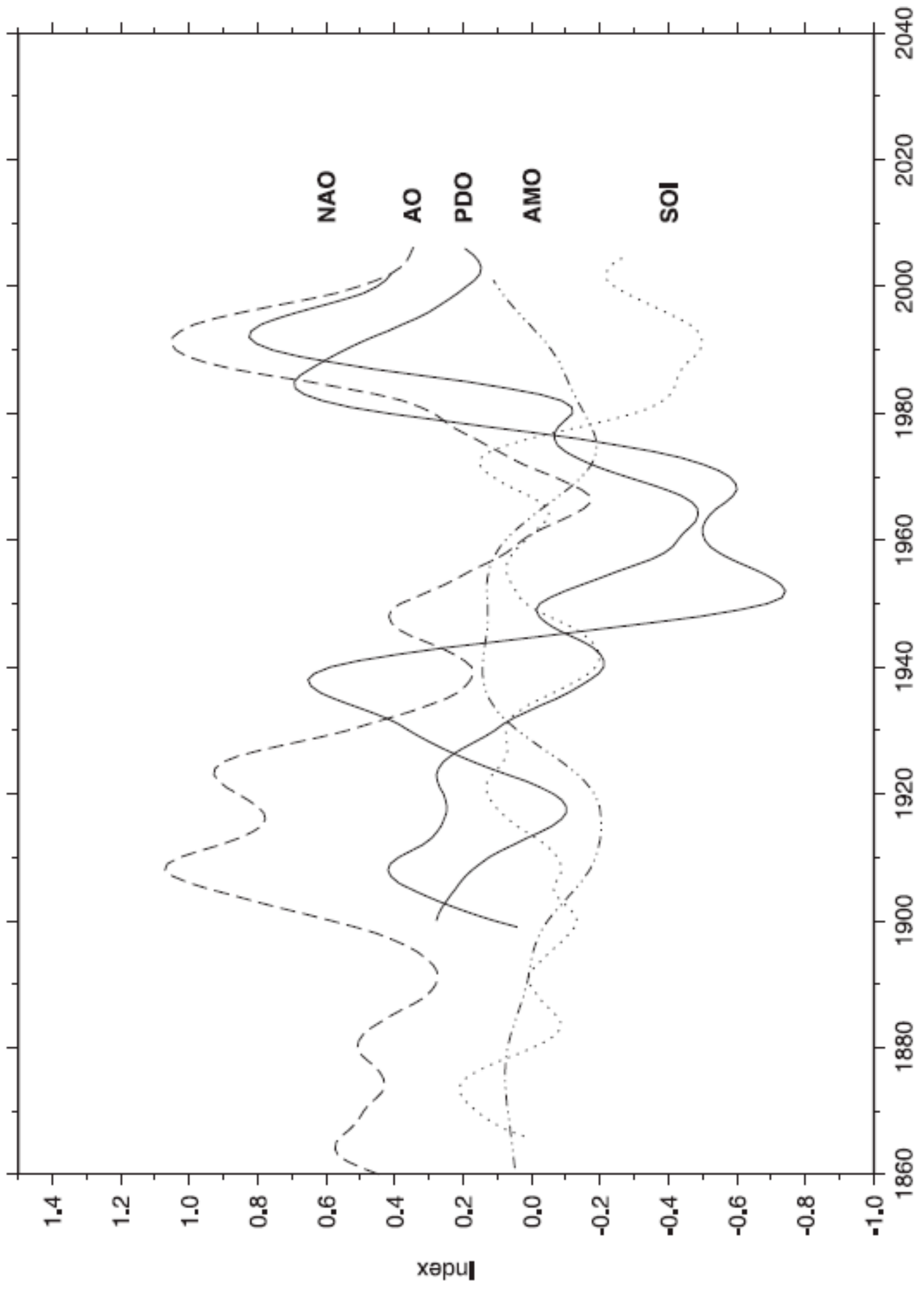
- **No.**
- **There have been both positive and negative long term accelerations depending on the region.**
- **Within the long term accelerations there have been short-term accelerations and decelerations.**



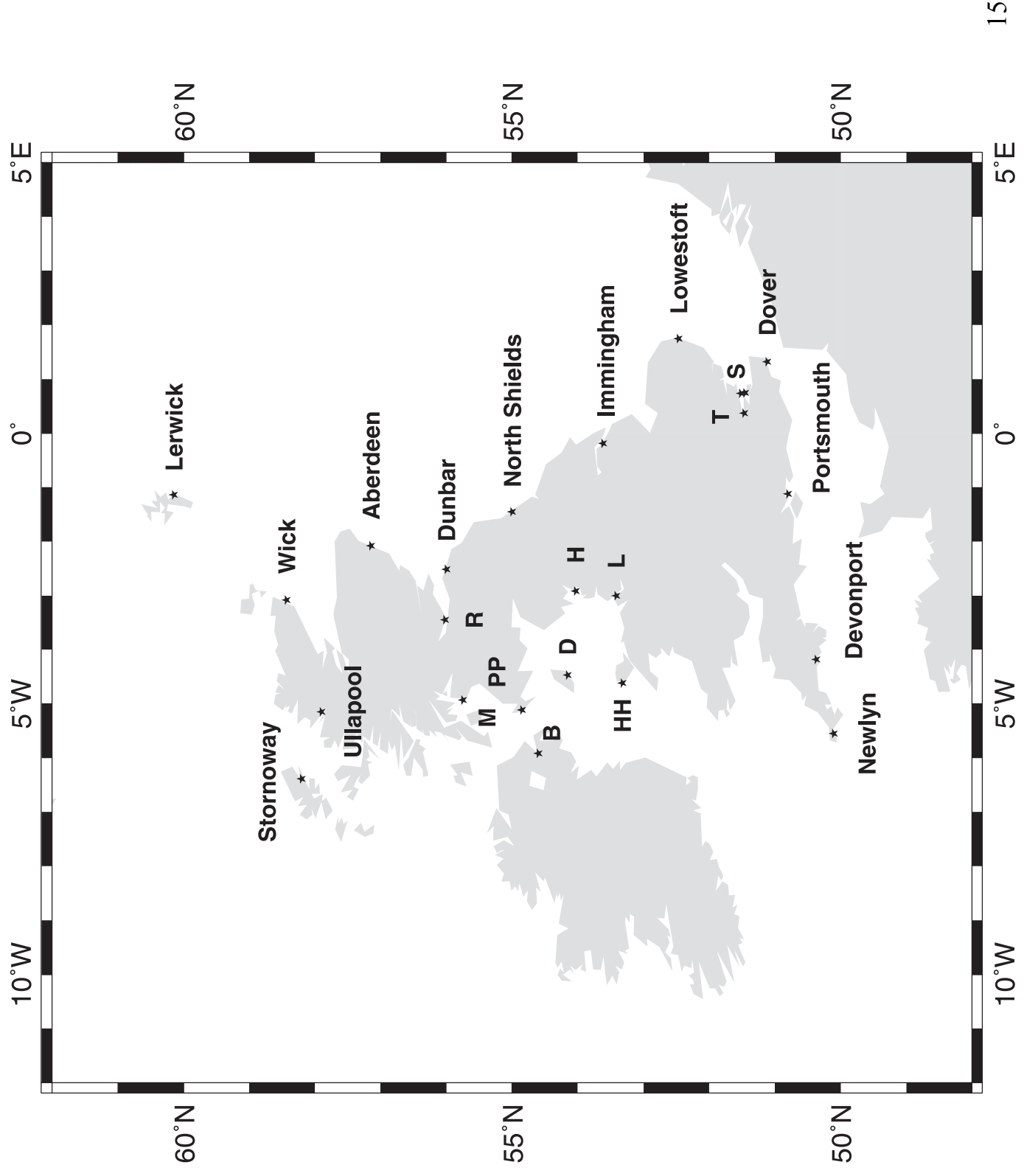


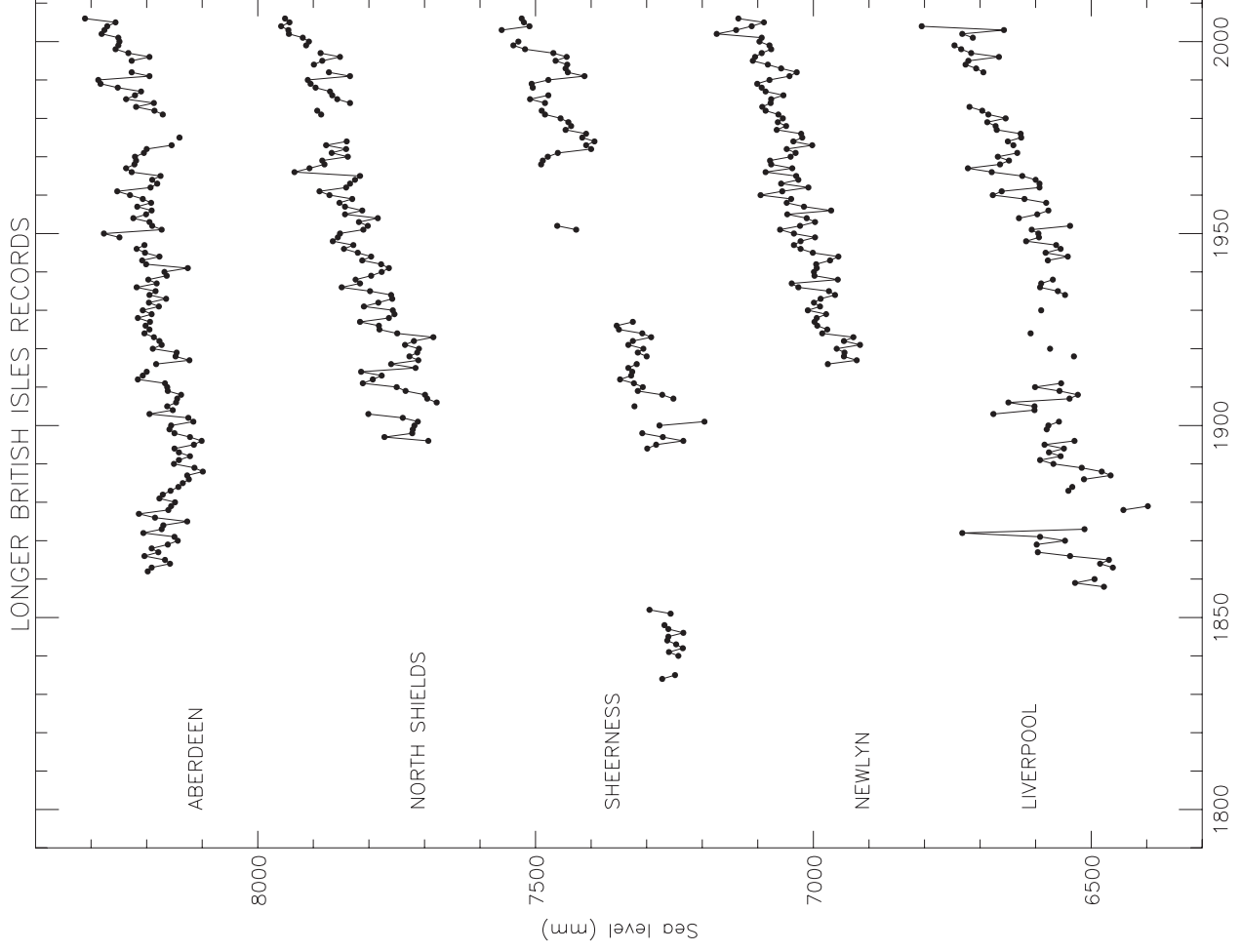


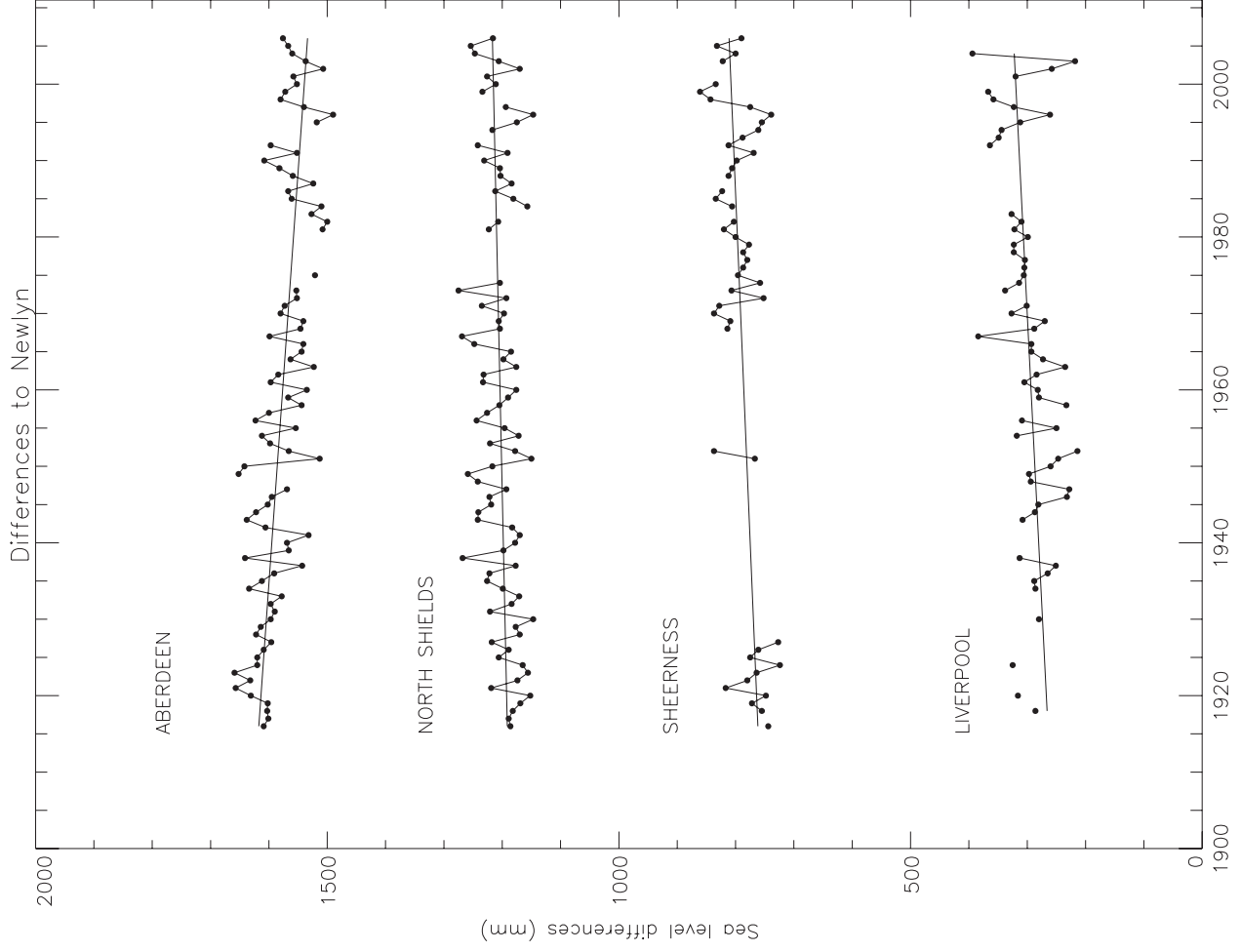


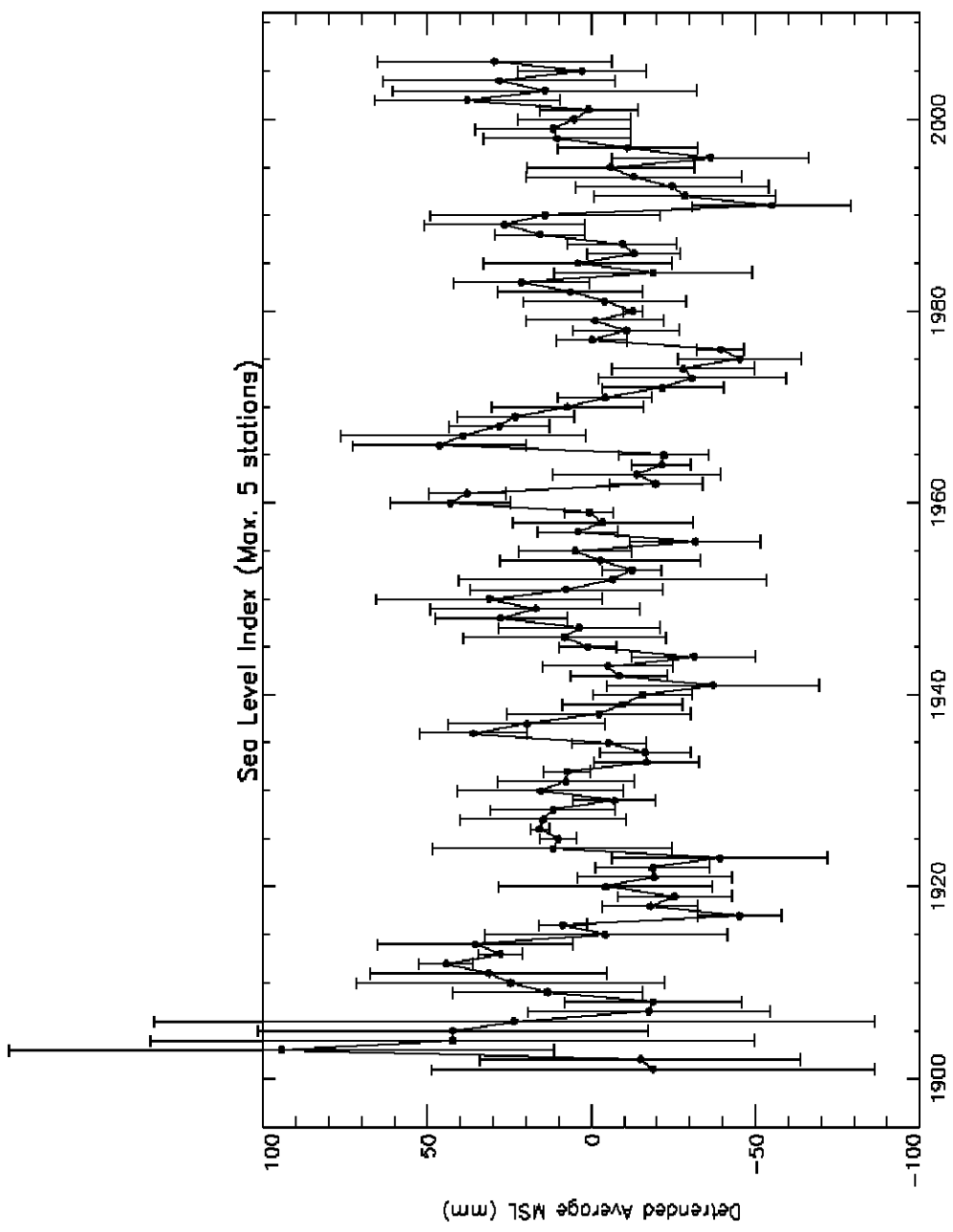


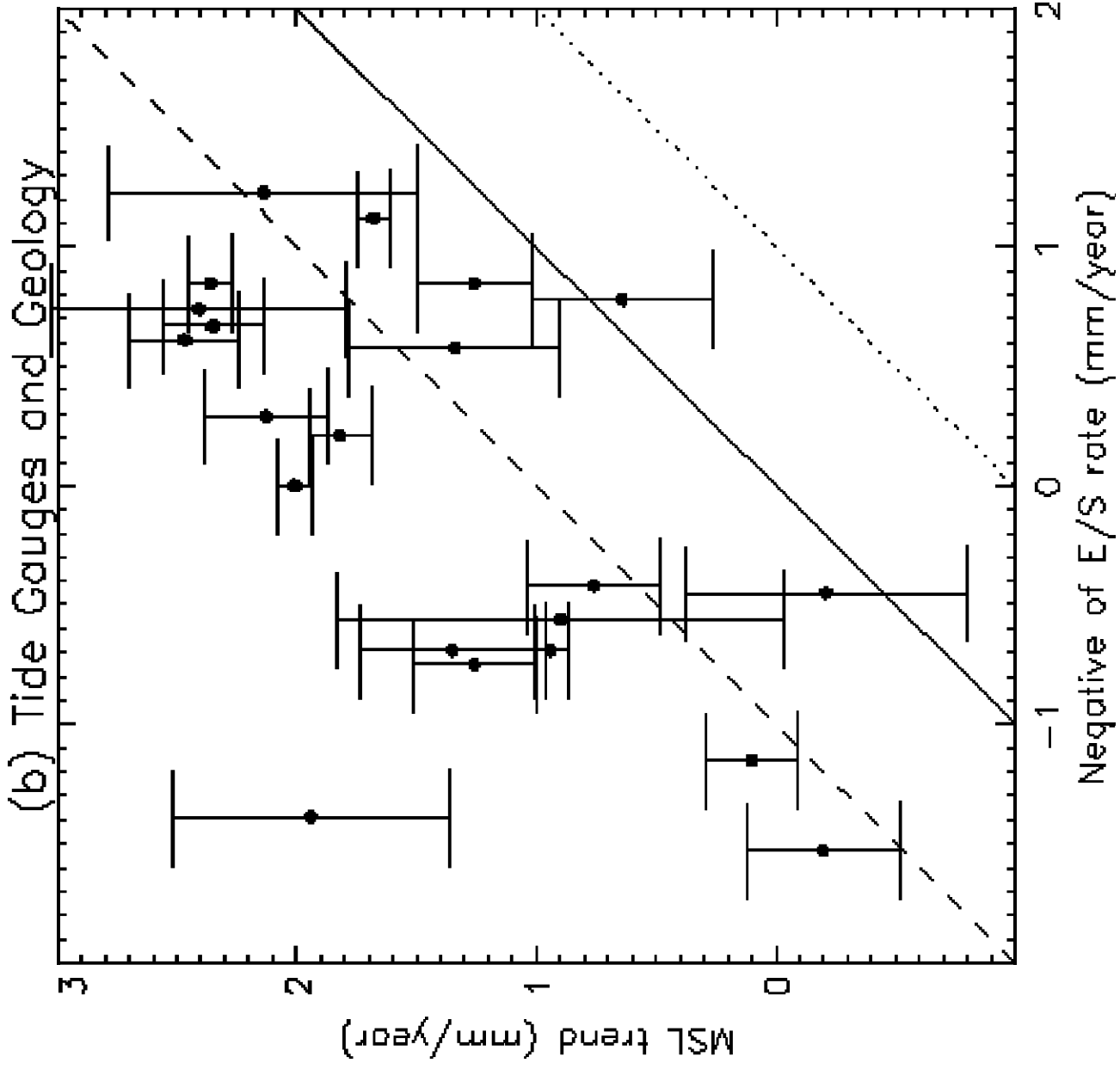
UK Sea Level Rise

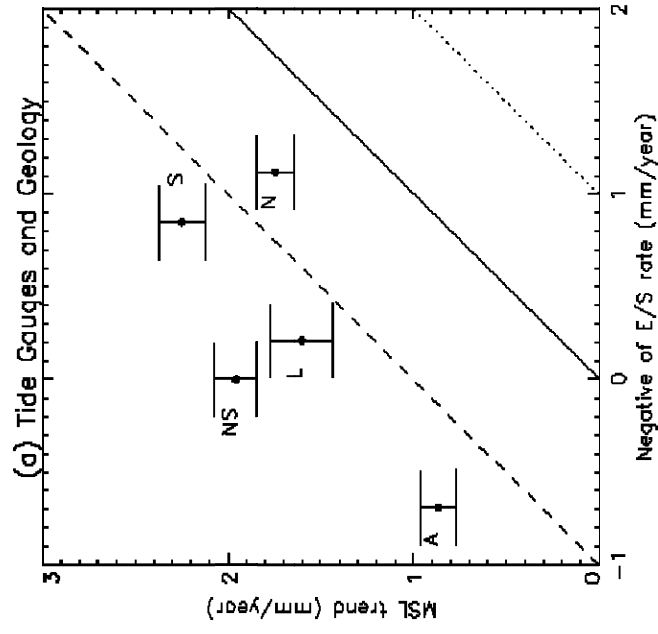
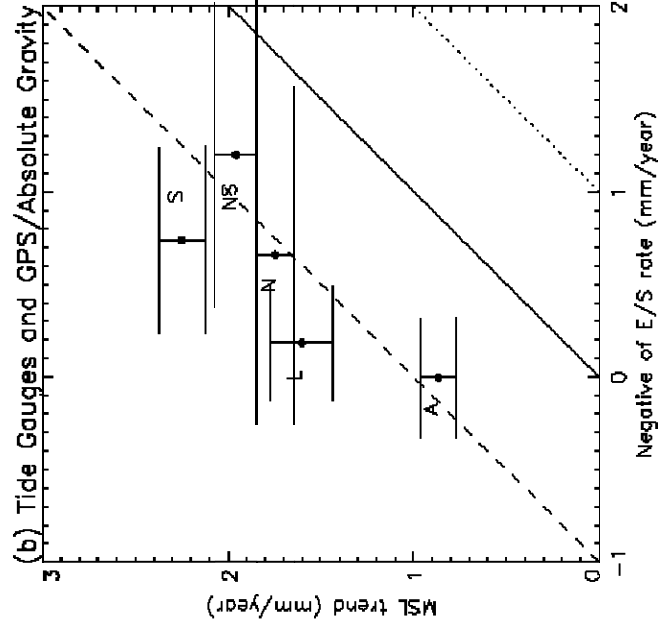


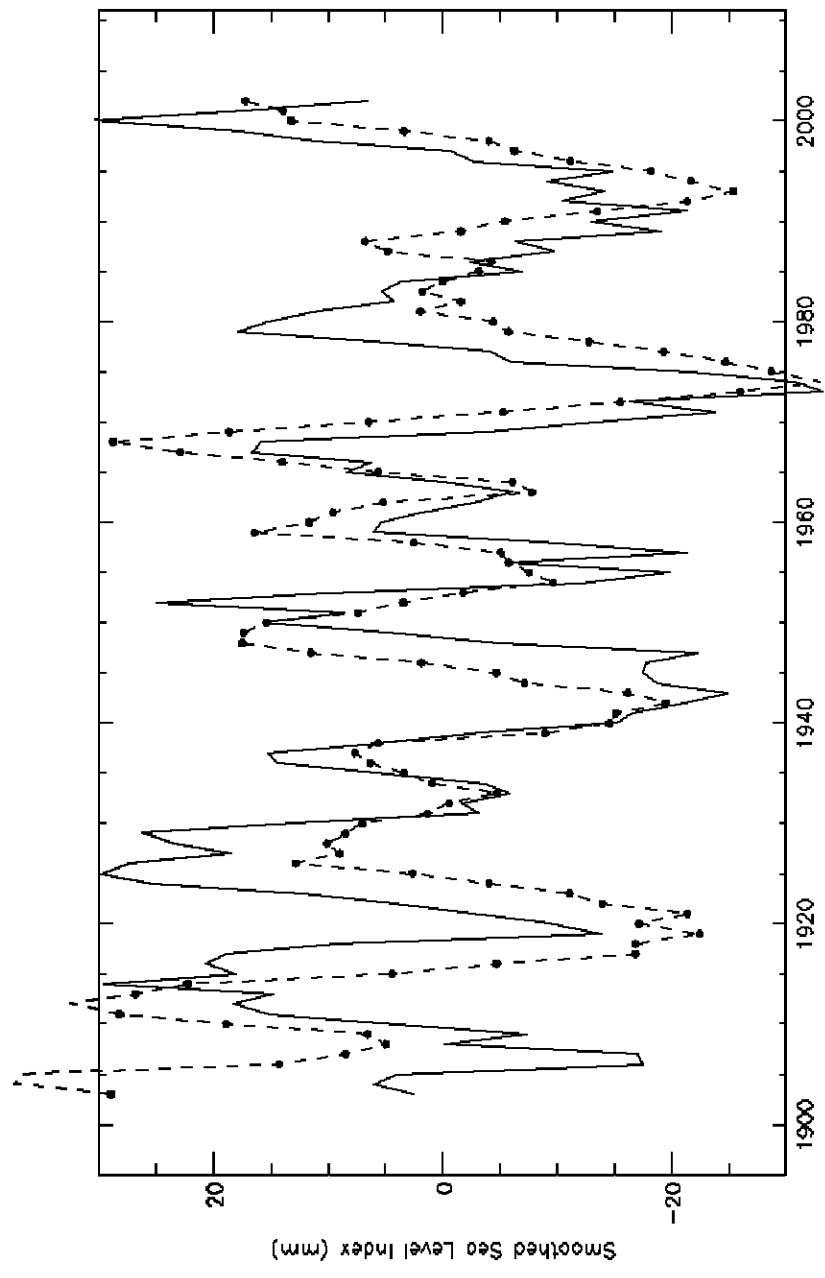




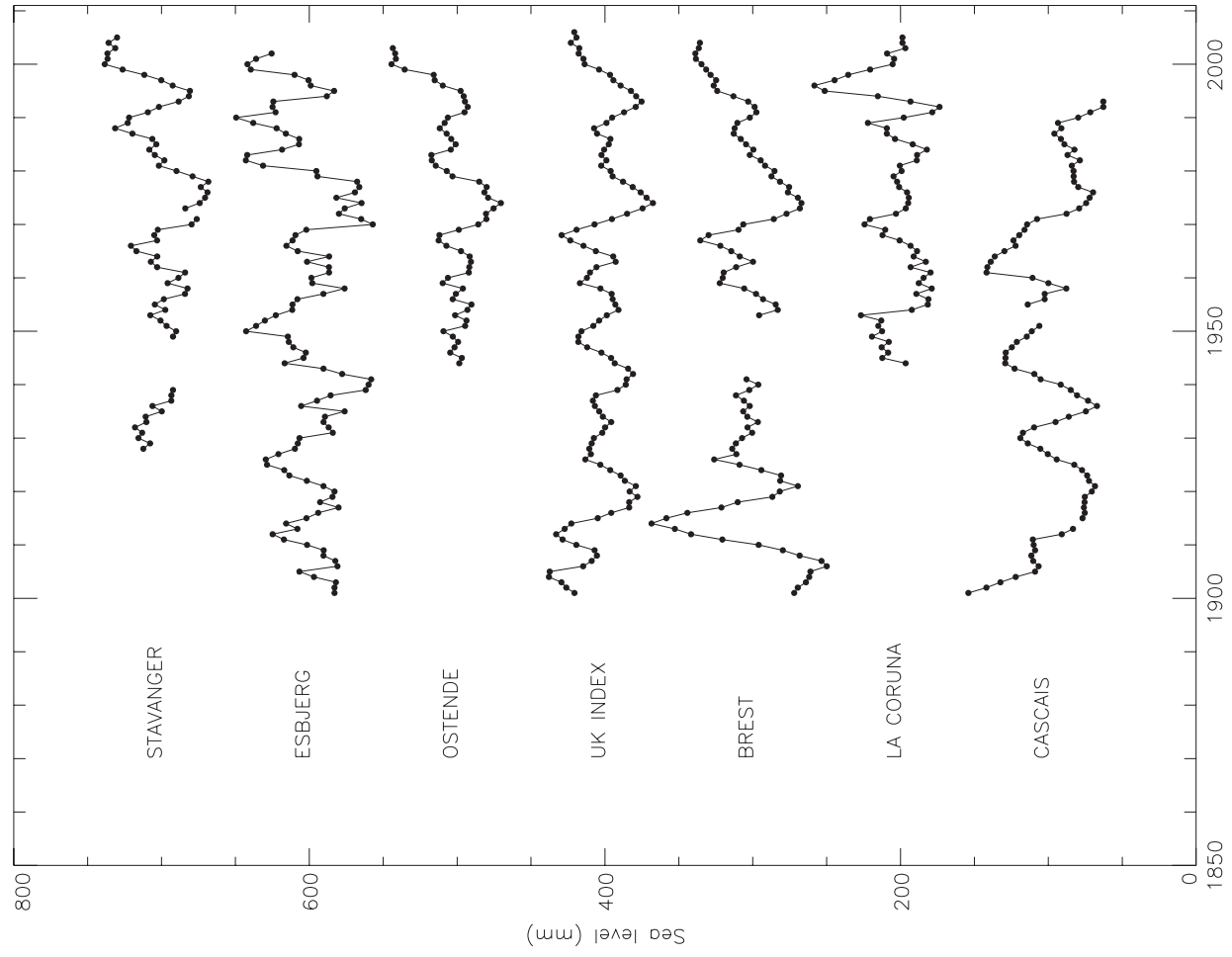


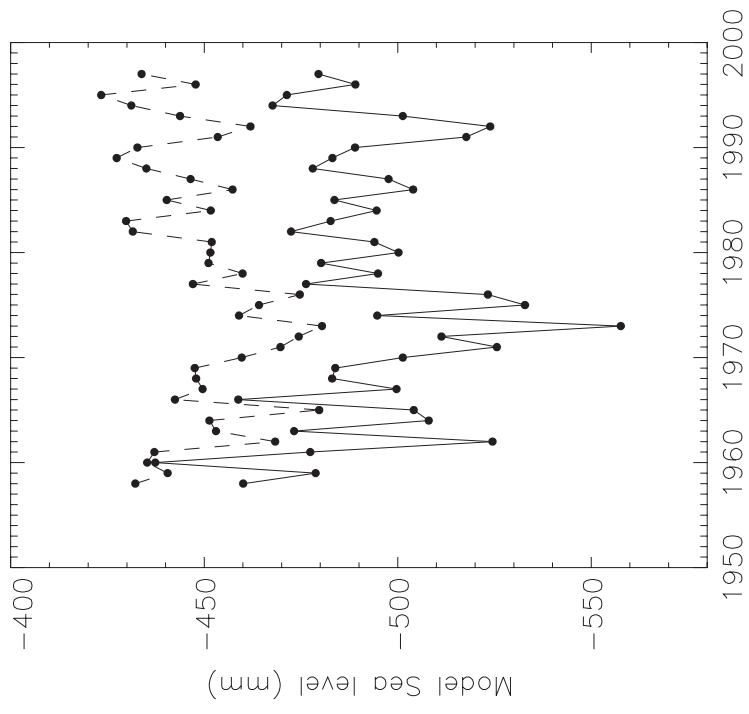






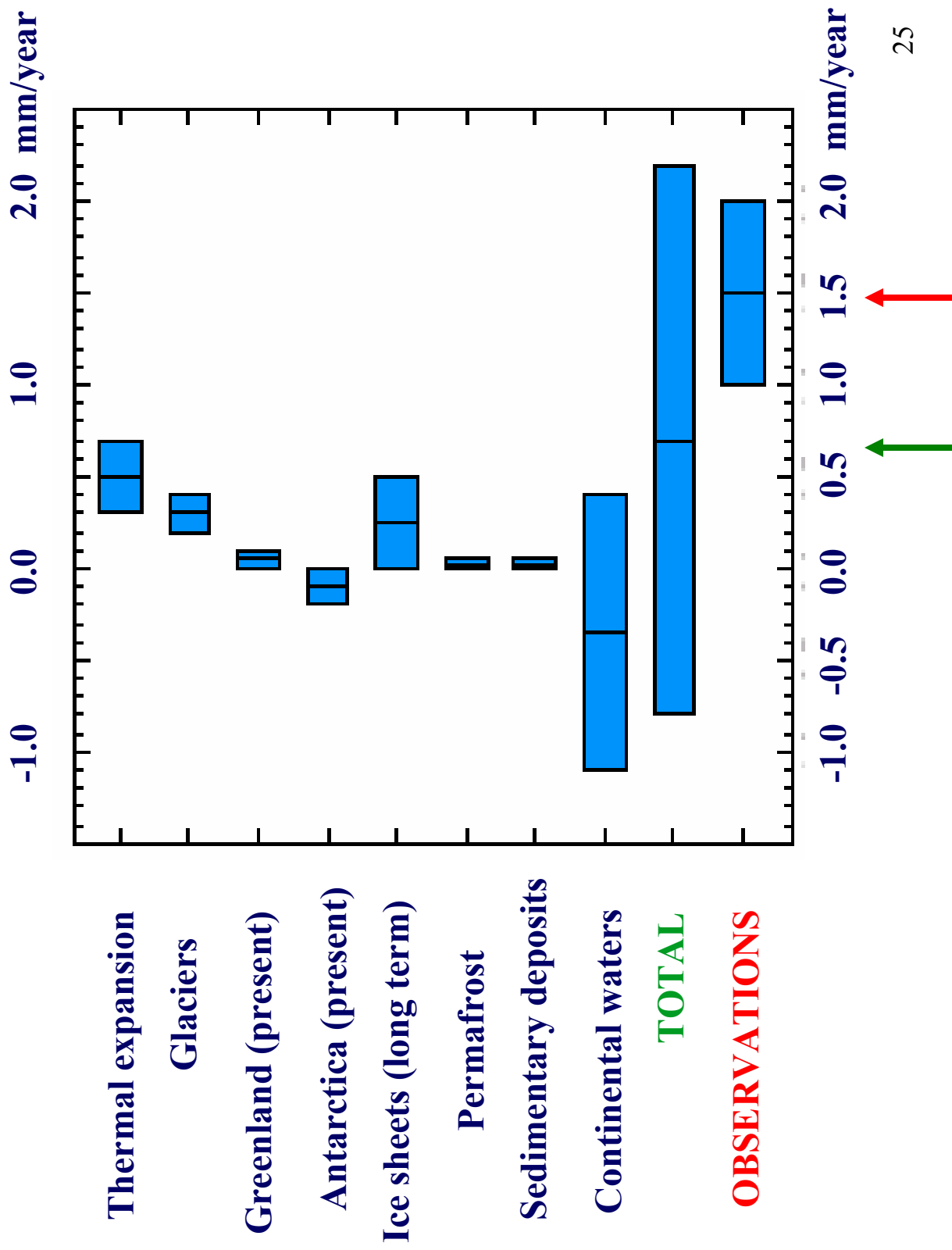
Smoothed Sea Level Index (dashed) and Scaled Negative Air Pressure (solid)

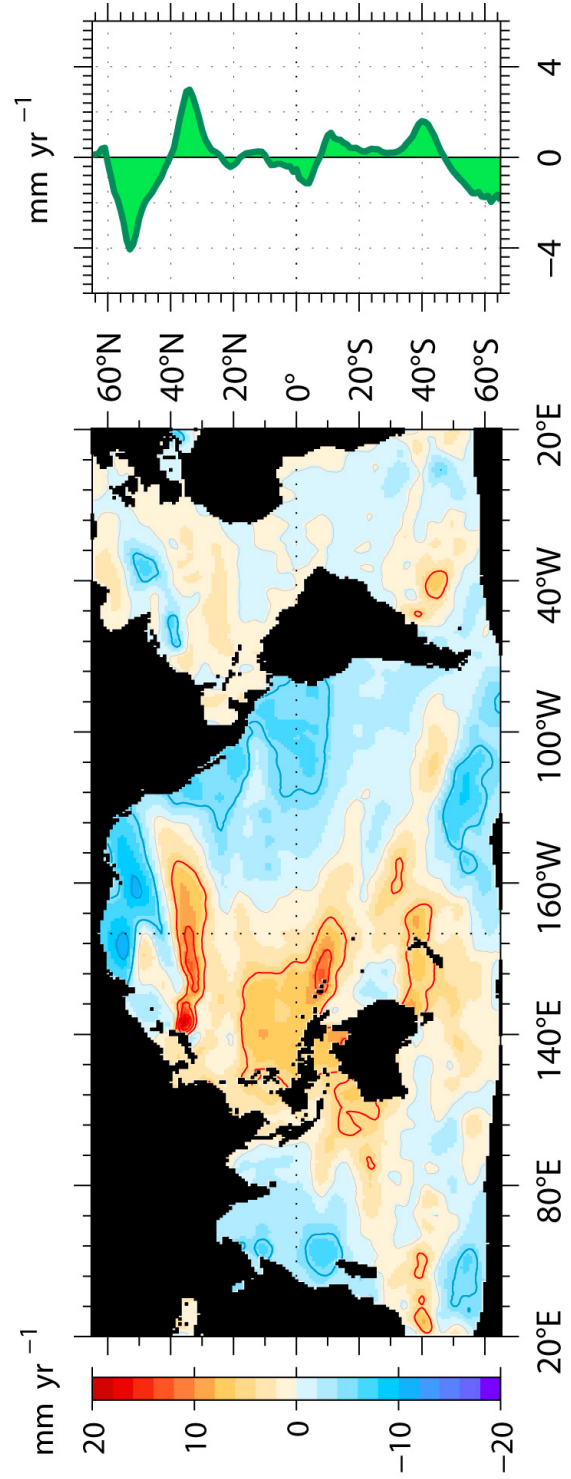
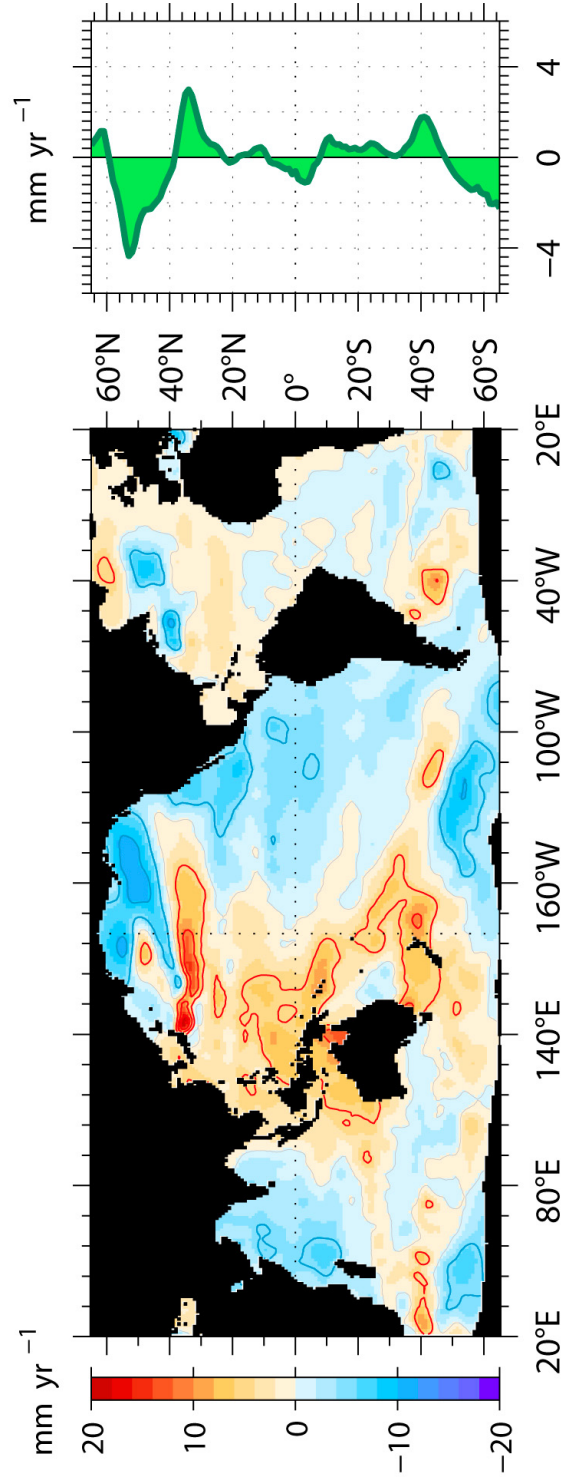




How Much will it Rise in the Near Future ?

Budget of 20th Century Sea Level Rise (IPCC 2001)



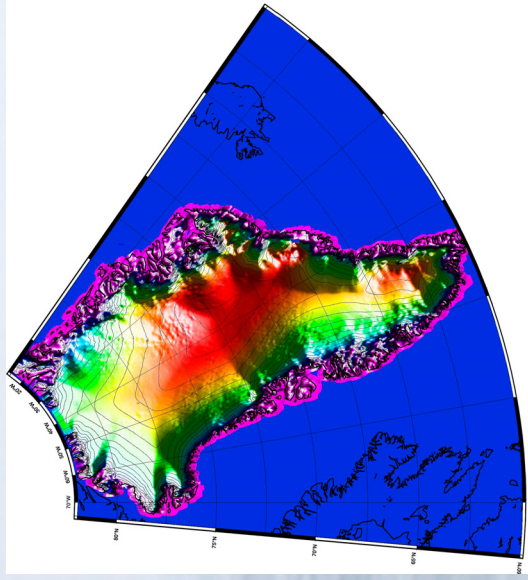


Land Ice Contribution (past few years)

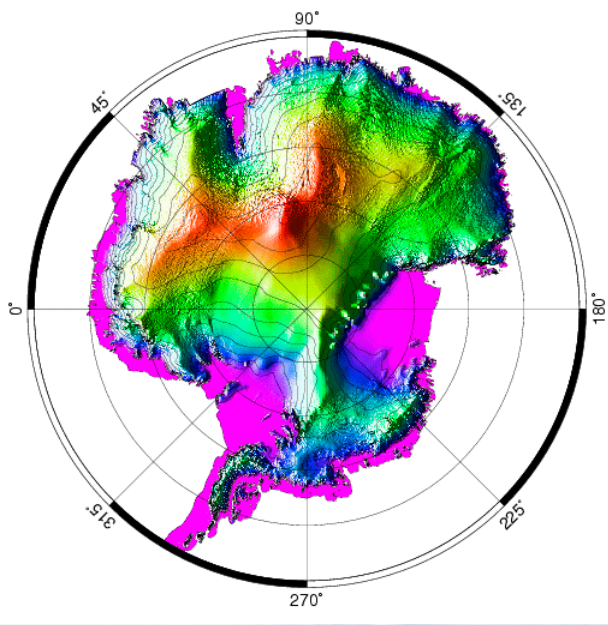
Dyurgerov and Meier, 2005

Cogley, 2005

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Rignot & Thomas, 2002
Thomas et al., 2004
Krabill et al., 2004
Zwally et al., 2005
Johanessen et al., 2005
Davis et al., 2005
Rignot & Kanagaratnam, 2006
Rignot et al., 2006
Velicogna & Wahr (2005, 2006)
Ramillien et al. (2006)
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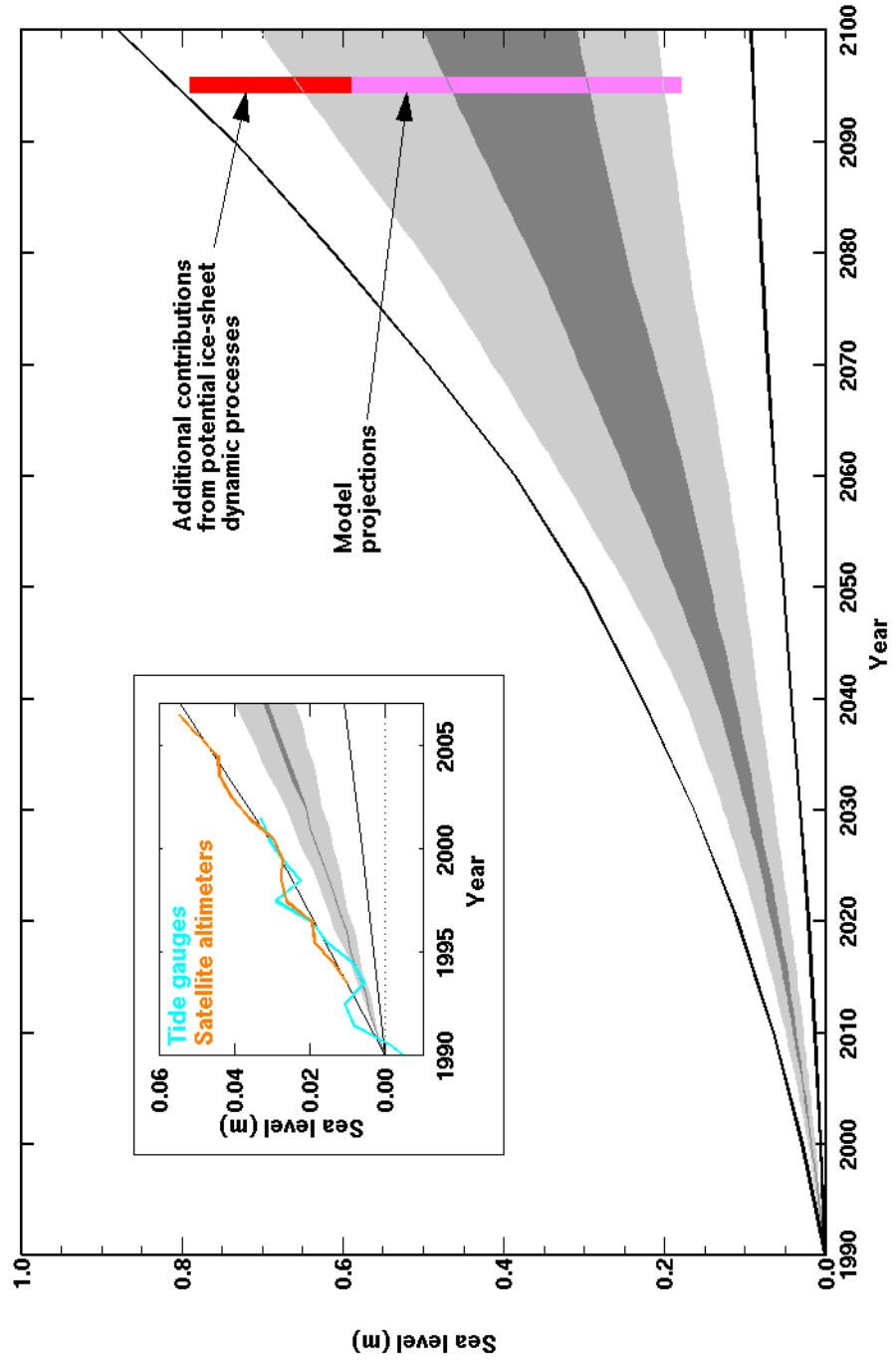
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

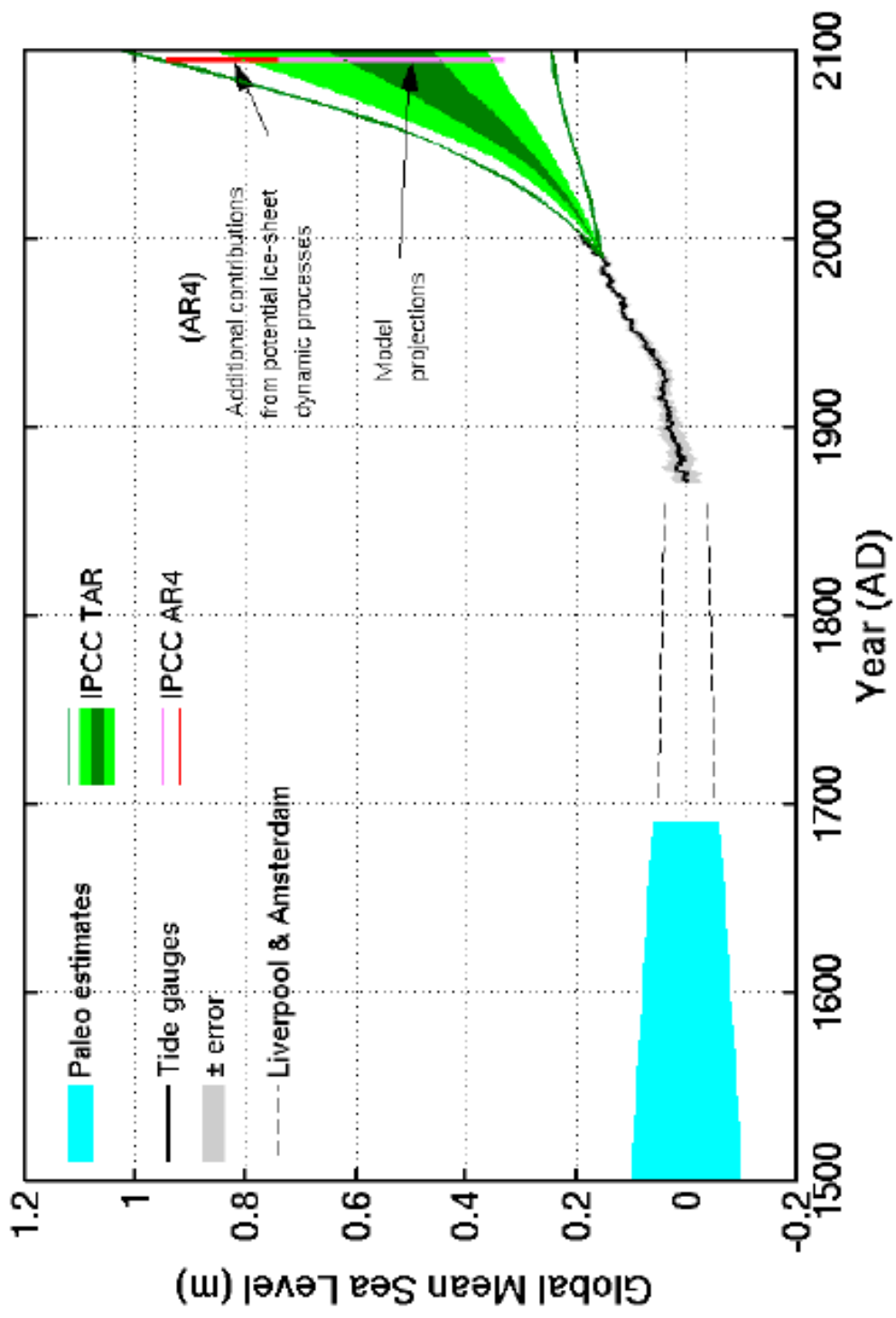
**Increasing concern
about ice-sheet
stability and a
substantially larger
rise in sea level**

- **Surface melting**

For sustained warmings above 4.5 ± 0.9 K in Greenland (3.1 ± 0.8 K in global average), it is likely that the ice sheet would eventually be eliminated. [Gregory, Huybrechts and Raper, Nature, 2004]

- **Dynamic instability**





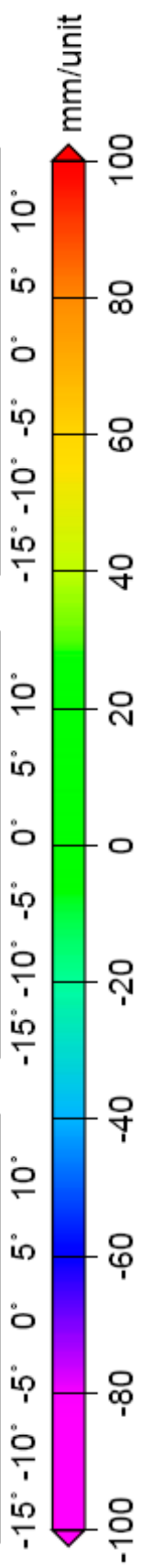
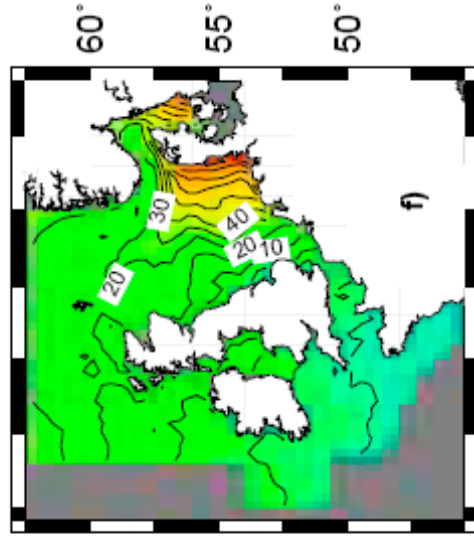
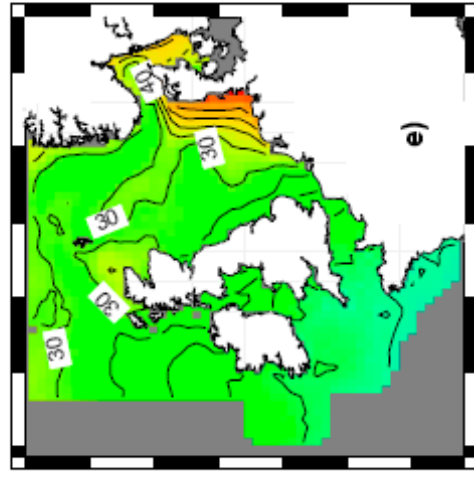
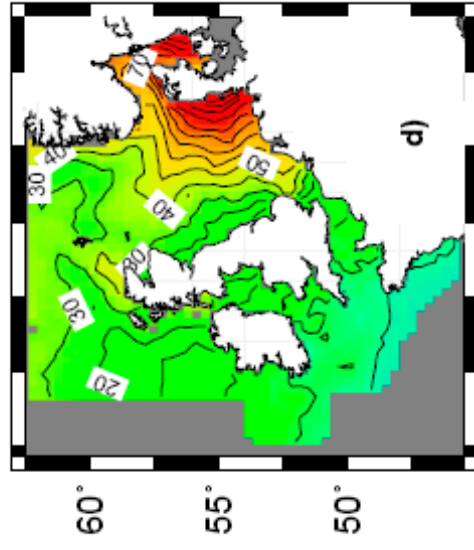
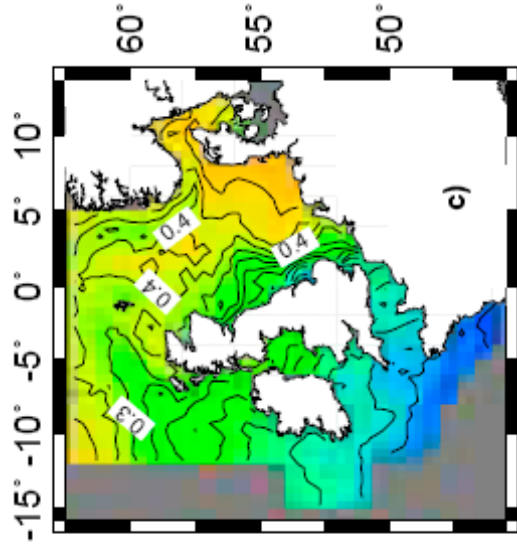
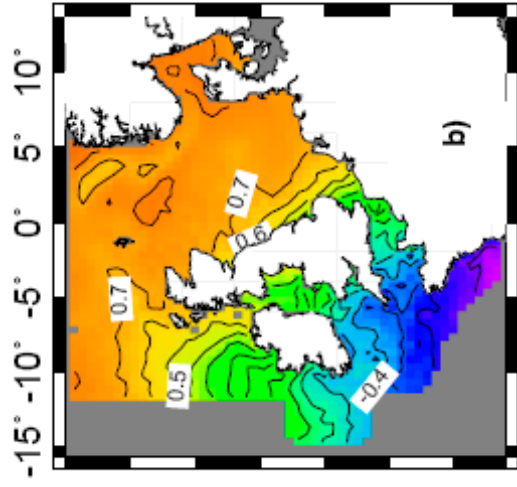
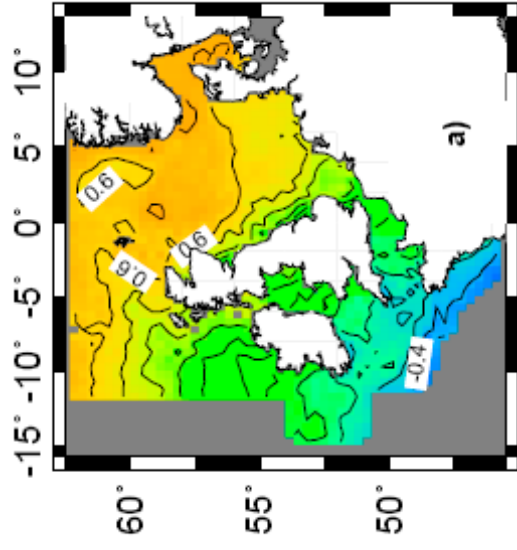
Sea Level Rise will not be the Same Everywhere

- Ocean circulation readjusts in response to changing climate → changes in the ‘ocean topography’
- There are vertical land movements as well as sea level changes e.g. submergence due to mining, uplift due to post glacial rebound

It is important to keep in mind that these rising Sea Levels sooner or later lead to changes in Extreme Levels and often to local flooding. So this is not only a ‘Scientific’ exercise.

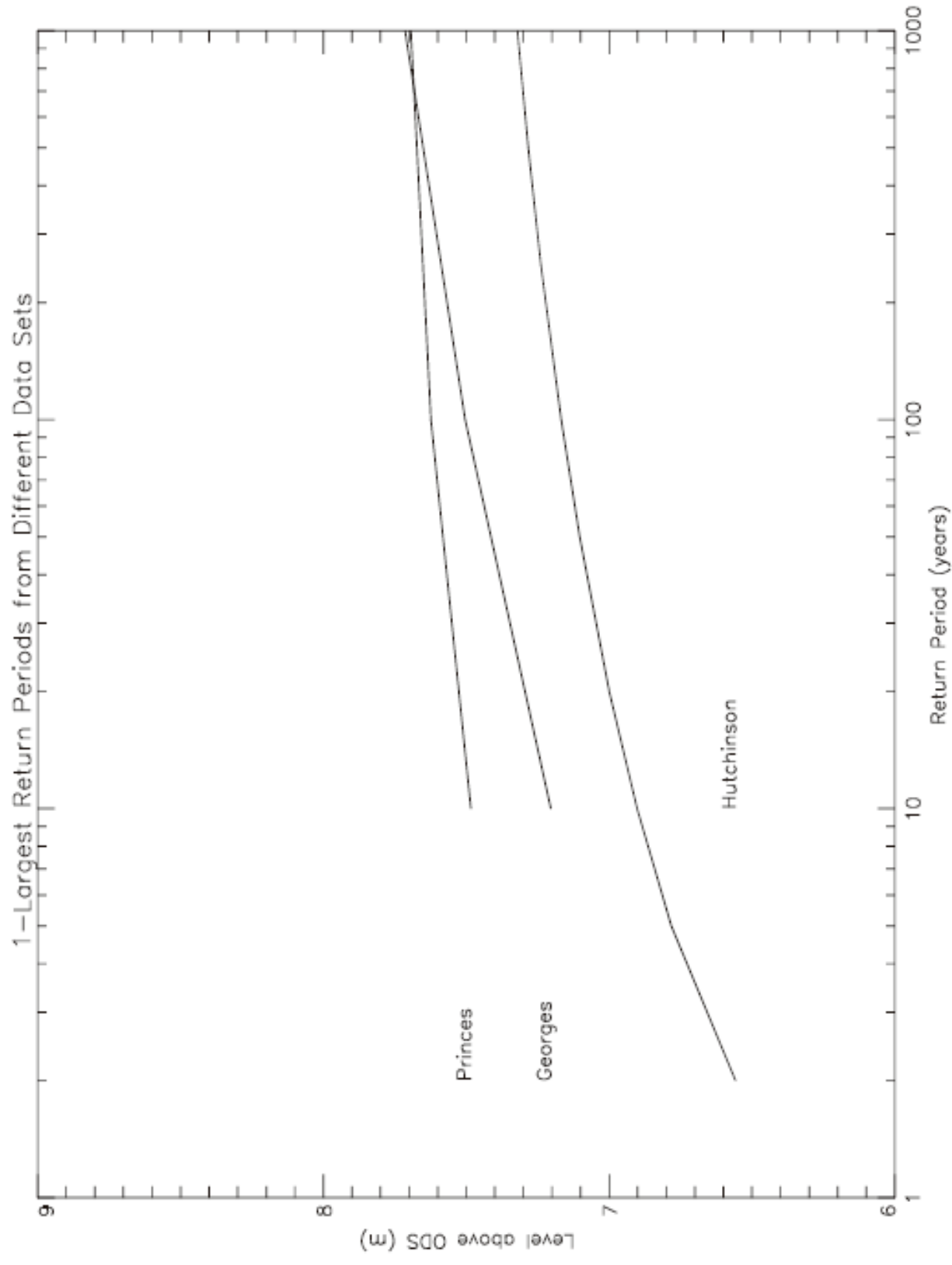
Will Floods Become More Frequent ?

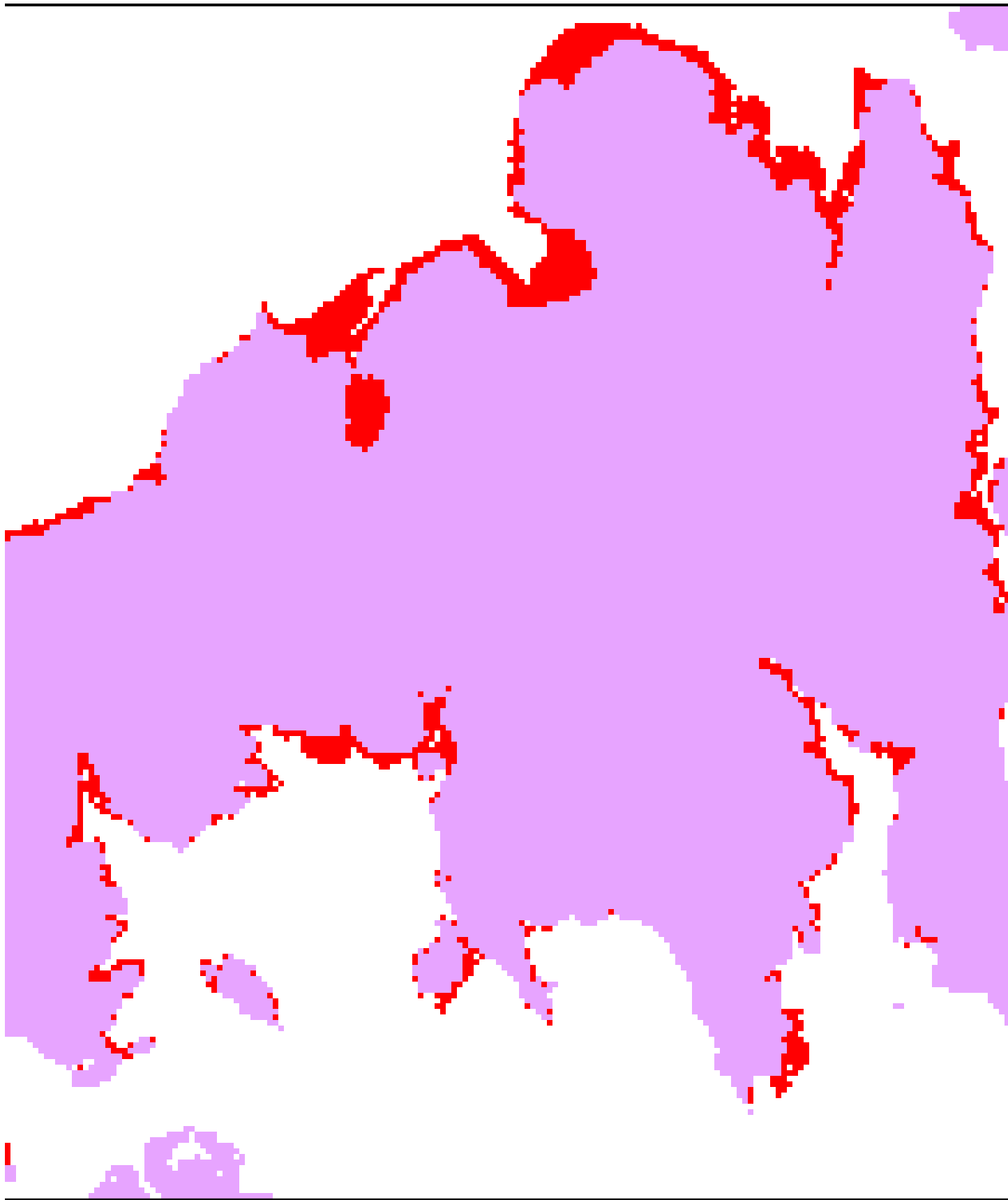
- Not necessarily around the UK, other than via sea level rise itself.
- Westerly winds may increase (North Atlantic Oscillation may intensify) but that will lead to more storm surges in German Bight (North Sea) rather than in the UK.



Will Floods Become More Frequent at Liverpool ?

- Liverpool is more or less on 'UK geological hinge line'.
- Westerly wind sensitivity not large.
- So impact around Liverpool should be primarily due to global (or at least regional) sea level rise





Local Emphasis – Liverpool, the Home of Sea Level Science

- Sea Level Science is an exciting interdisciplinary topic
- Sea Level Science is a very practical and important topic
- Much of the history of Sea Level Science, and we hope much of the future (!?), is connected with Liverpool

To mark this we have a special sea level session at the Liverpool British Association 2008 Science Festival



And a special CD