



Climate change, sea level, islands and coastal areas

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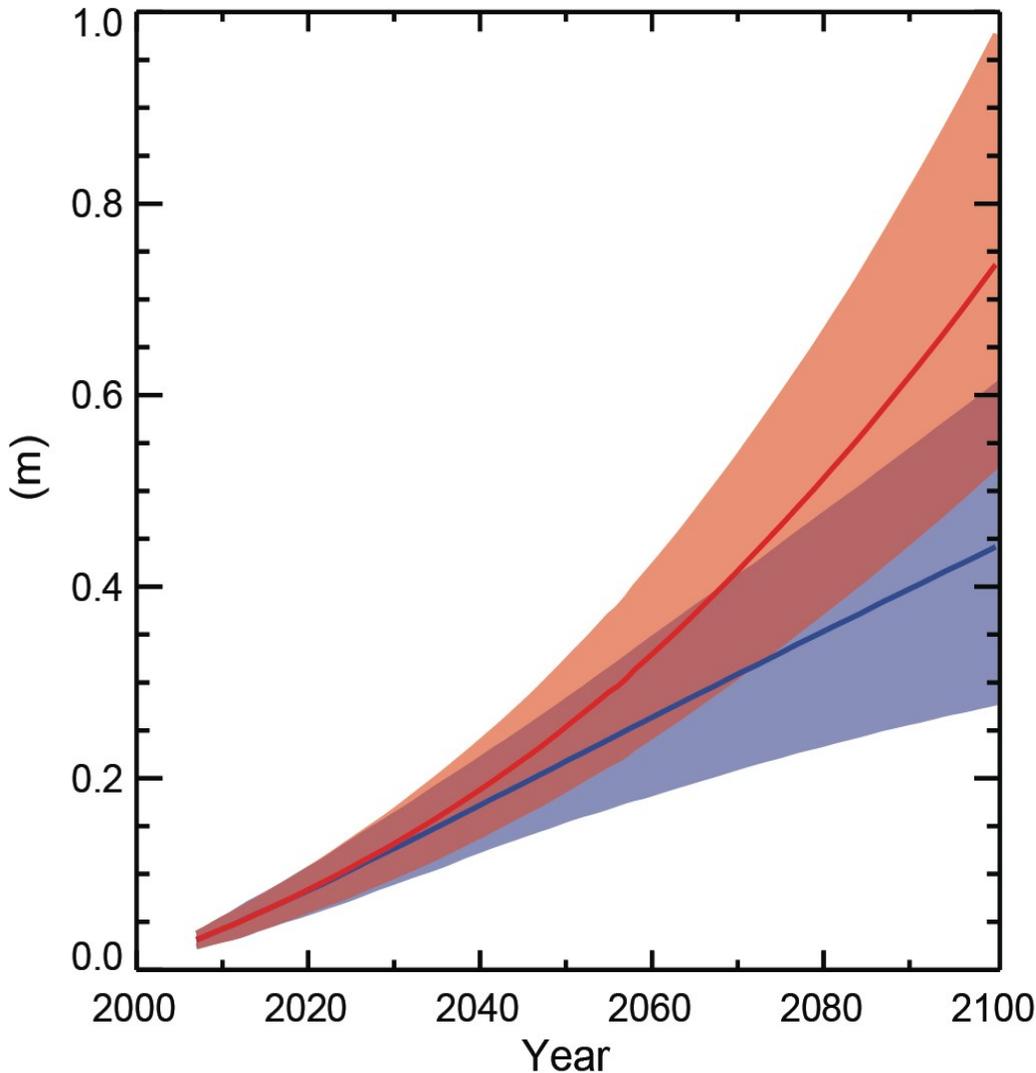
Climate change and sea level

- Warming raises averages sea levels from the oceans expanding as they warm and melting of land-ice
- These effects are modulated by other atmospheric processes leading to storm surges and extreme wave heights interacting with natural tidal processes
- Surges and waves may be affected by climate change (e.g. If typhoons become more extreme, wind patterns change)
- Local sea levels are affected by local land height which may change for other reasons (e.g. water abstraction)



Global sea-level rise projections

Global mean sea level rise



Mean over
2081–2100

RCP2.6

RCP4.5

RCP6.0

RCP8.5

With large increases in global greenhouse gas emissions sea-levels will continue to rise exponentially

Even if global emissions peak within next few years then decline sea levels will continue to rise (for centuries)

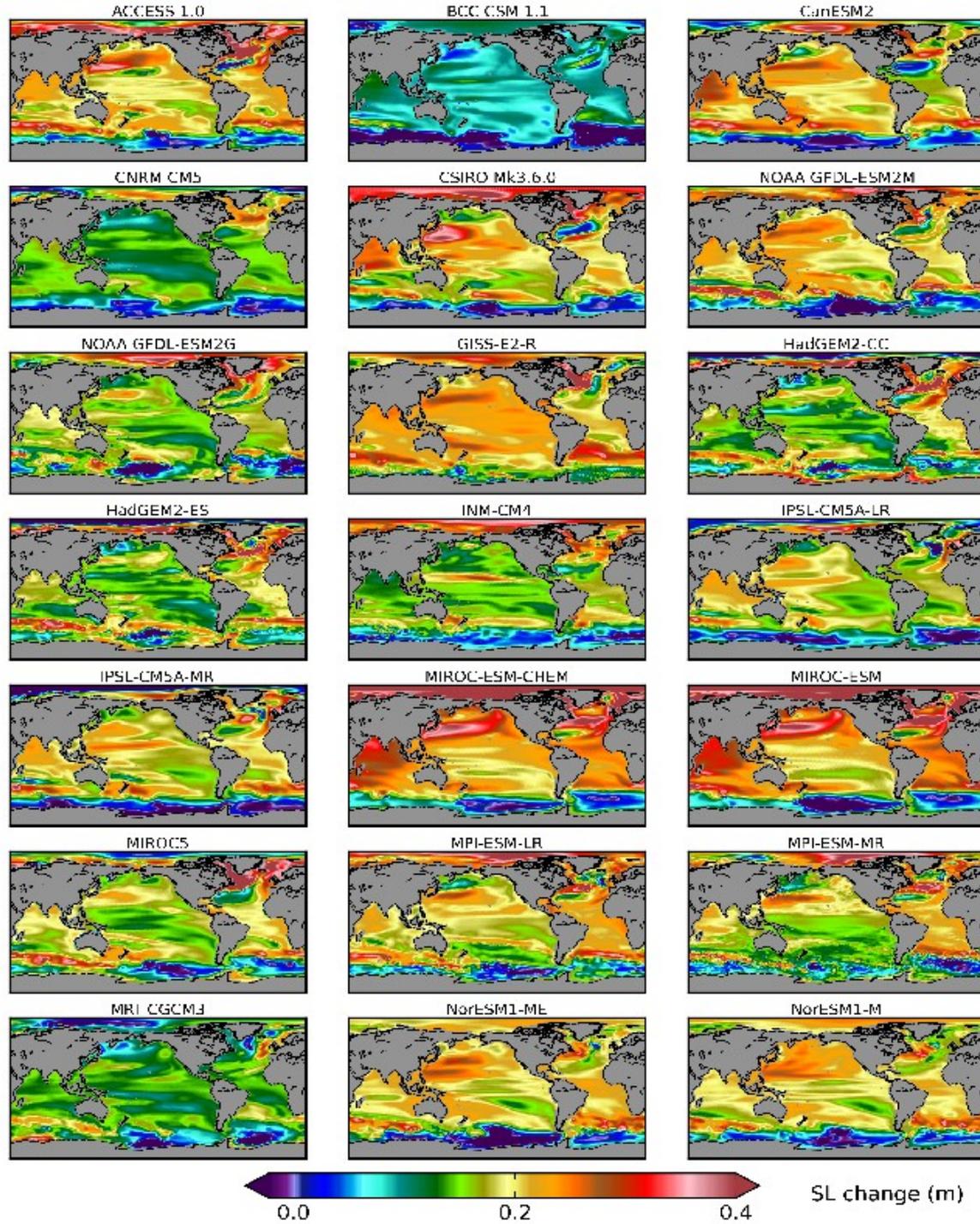
Projections from multiple global climate models assessed in the IPCC AR5 using four Representative greenhouse gas Concentrations Pathways (RCPs)



Ranges in sea level rise estimates from global climate models are from different magnitudes of projected change

Also, spatial patterns of change vary so regional sea level rise will have different ranges

No guidance available on which patterns are more reliable

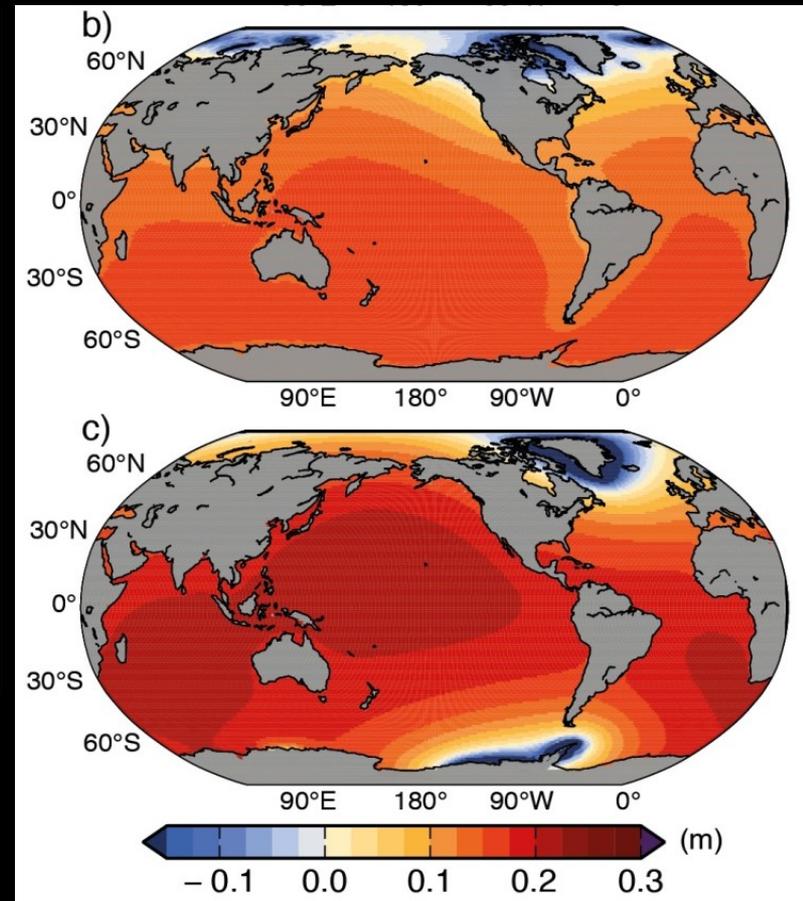
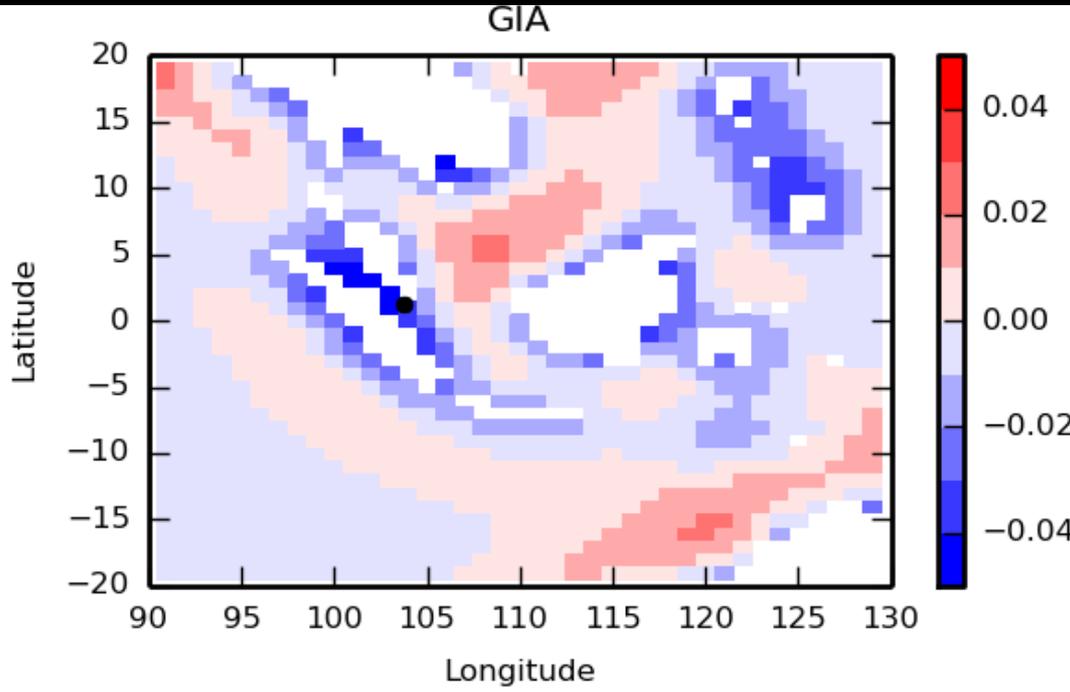




Other contributing factors

Glacial Isostatic Adjustment

Glacial melting (b) Ice-sheet melting (c)

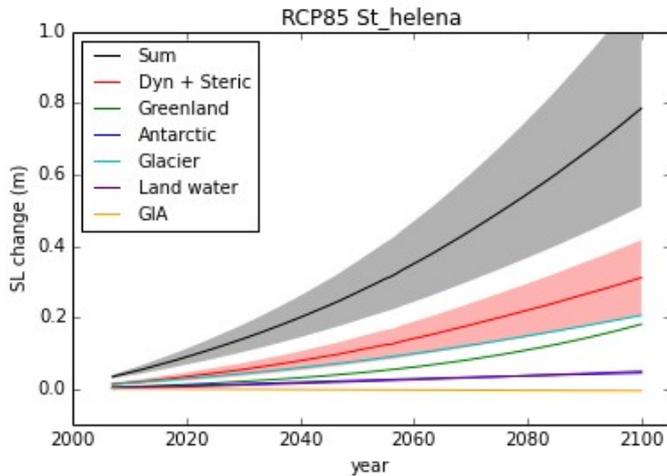


Also:

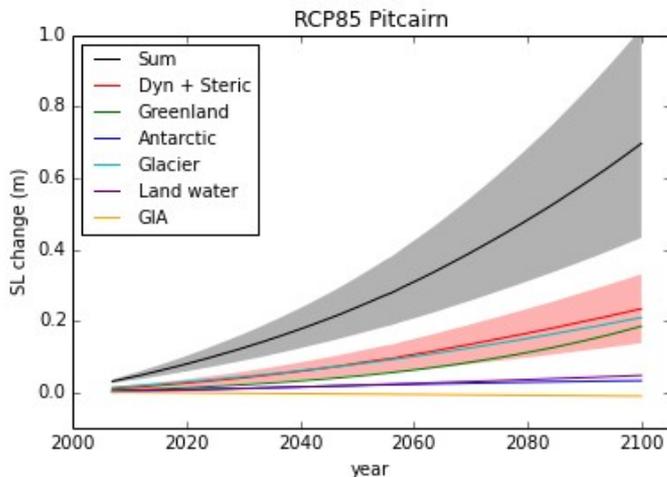
- Land water storage (reservoirs, groundwater)
- Rapid ice-sheet dynamics



Regional sea level rise: Island examples – St. Helena, Pitcairn



These different processes and the different levels of confidence in their magnitudes lead to different ranges of local sea level rise

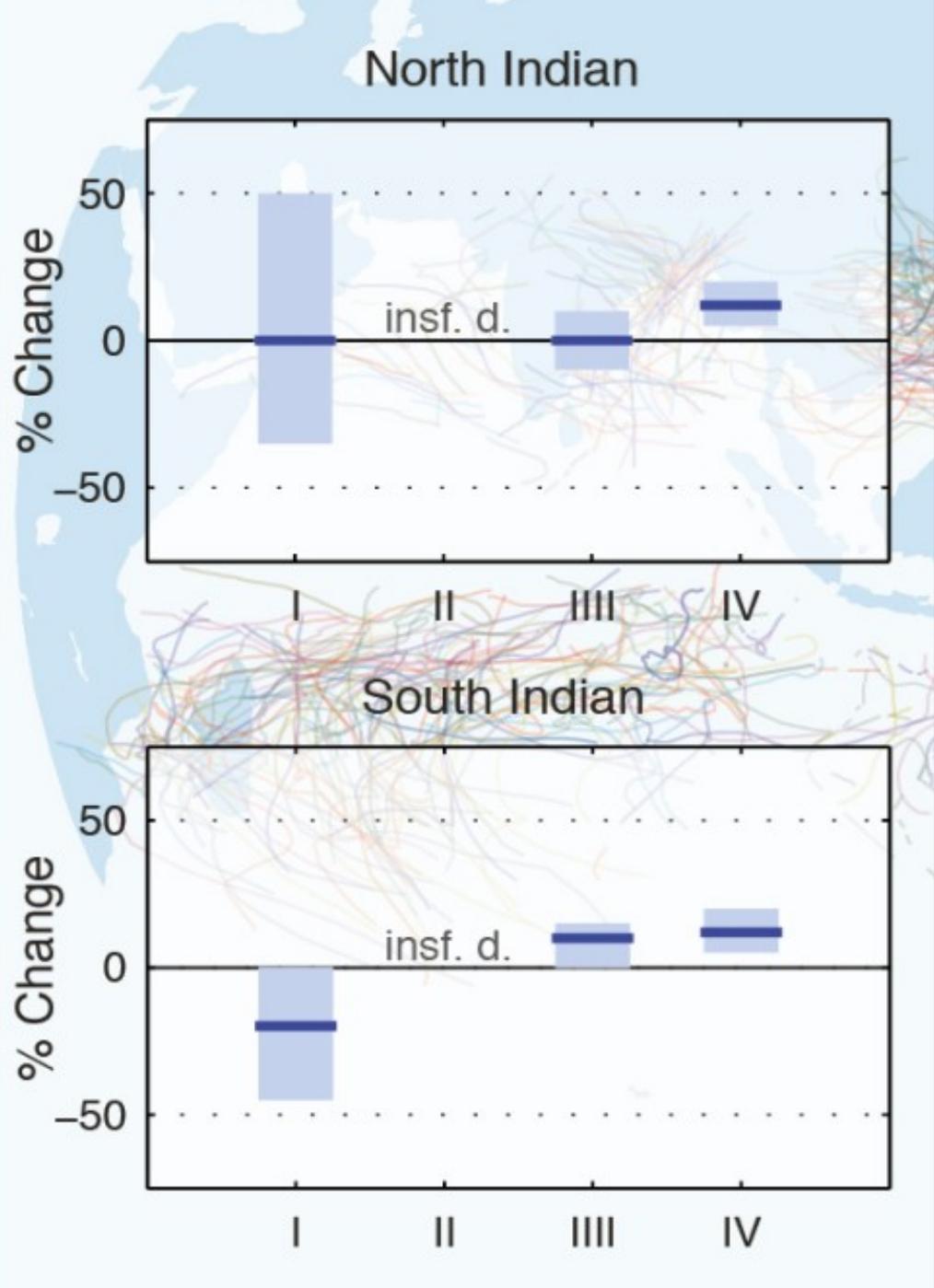


- Sum
- Thermal expansion
- Glaciers
- Greenland ice sheet
- Antarctic ice sheet
- Greenland ice-sheet rapid dynamics
- Antarctic ice-sheet rapid dynamics
- Land water storage

Projected changes in tropical cyclones

Climate models suggest:

- increases in intensity
- this would lead to an increase in associated storm surge heights

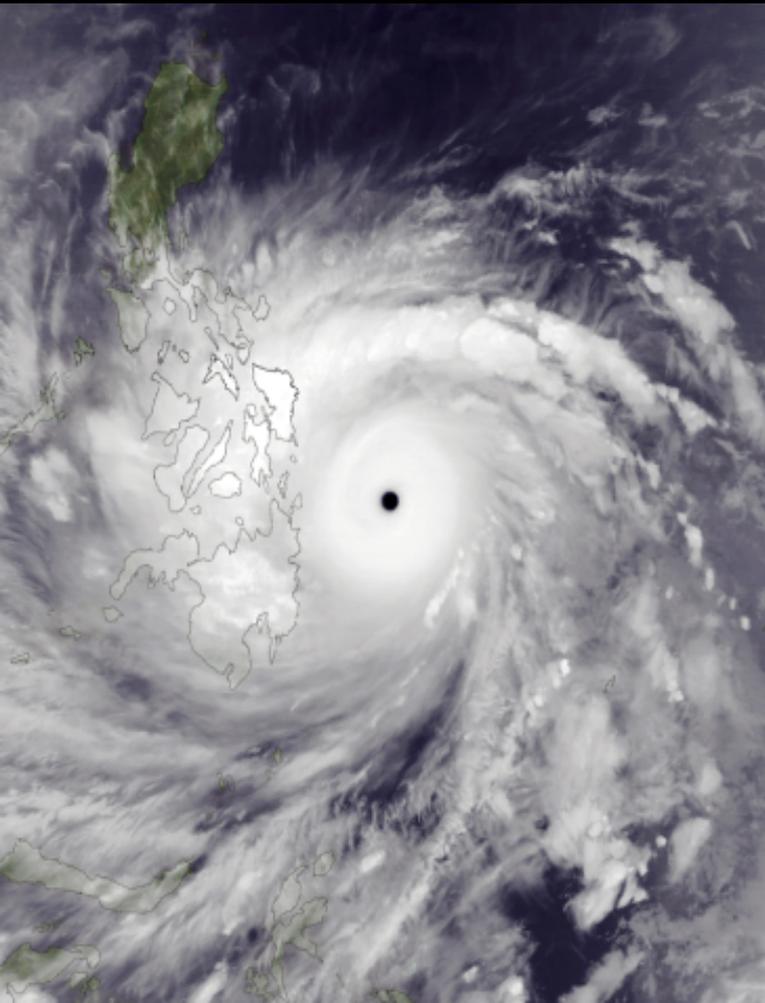


Tropical Cyclone (TC) Metrics:

- I All TC frequency
- II Category 4-5 TC frequency
- III Lifetime Maximum Intensity
- IV Precipitation rate

Typhoon Haiyan (Yolanda)

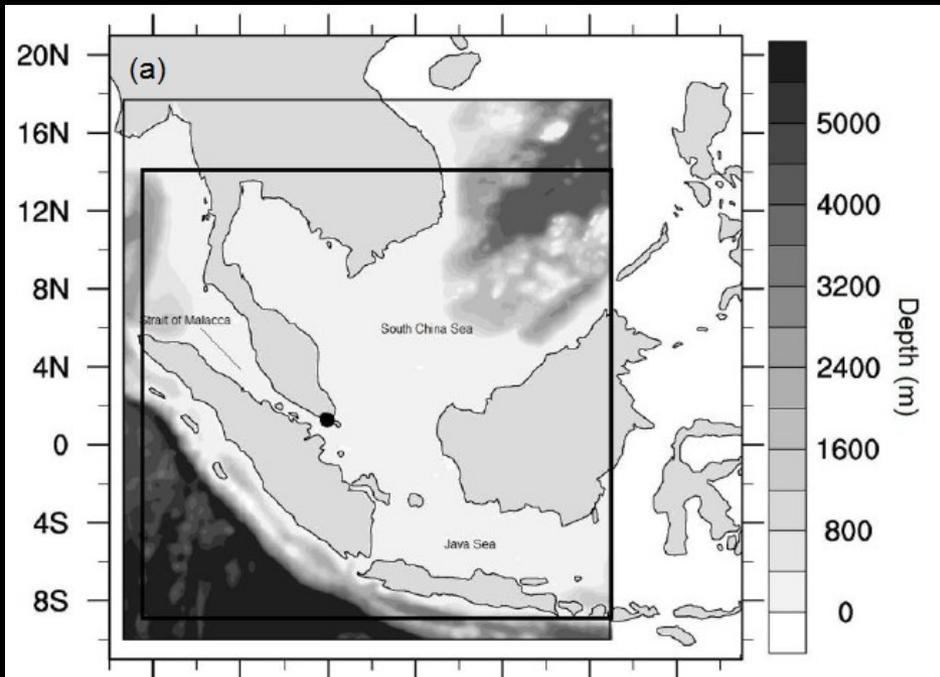
November 2013



- Most severe land-falling typhoon on record
- Winds reaching 197mph
- 5-6m storm surge
- Over 6300 people killed and four million people displaced
- Even if climate change was not a factor in the intensity then sea-level rise was in the surge height and storms of this size clearly need to be planned for in the future

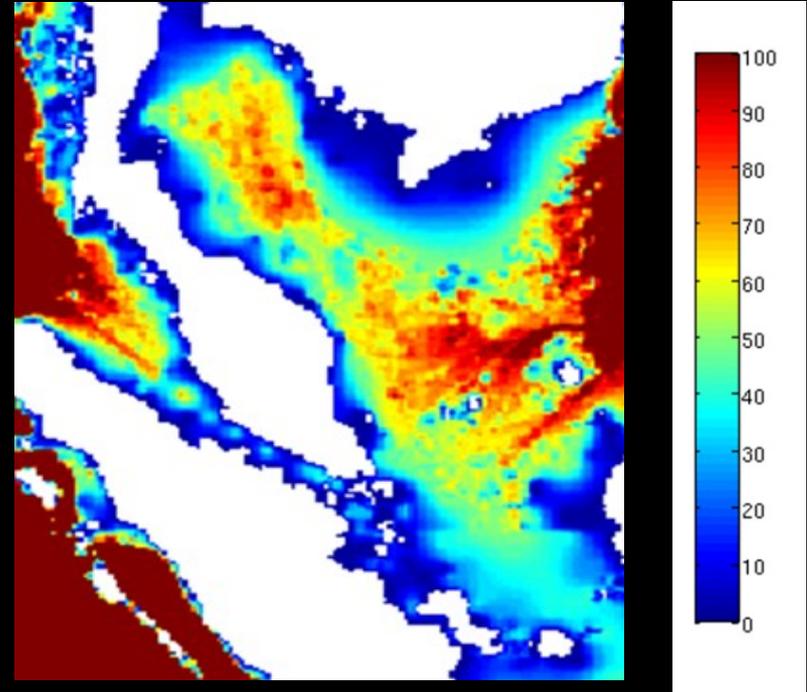


Providing information on storm surges and waves requires detailed local models



Surge model

- 1/12th degree resolution, constant density, 9 vertical levels
- Forced by tides at lateral boundaries
- Forced by atmospheric pressure and winds at sea surface



Wave model

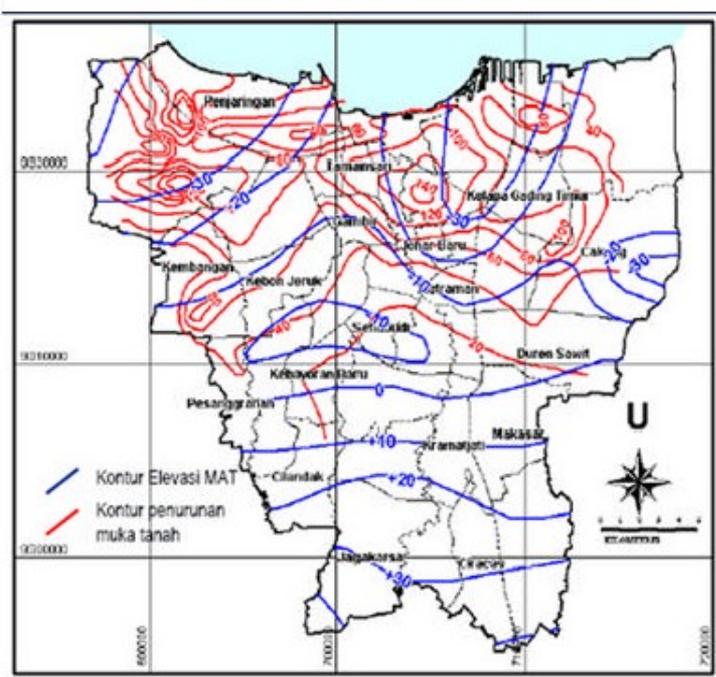
- 1/12th degree resolution
- Forced by 50km global wave model at lateral boundaries
- Forced by winds at sea surface



Vertical land movement - An example for Jakarta

Jakarta is subsiding due to groundwater extraction

Sea levels **relative to coastal land** are increasing



Elevation of ground water (cm)

Land subsidence contour (cm)

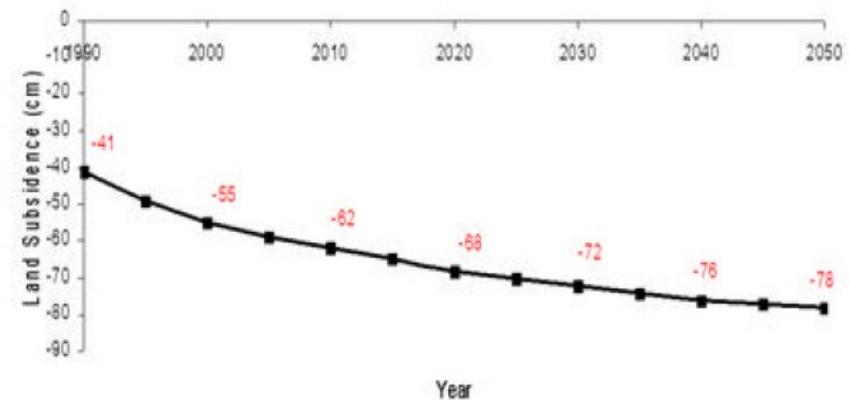


Figure 3.9 Projected land subsidence in the vicinity of Jakarta (Priyambodo, 2005)

Figure 3.8 Groundwater extraction in Jakarta and the resulting land subsidence

Further subsidence will contribute an additional component to **local** sea level rise



The Sea Level Rise “Jigsaw Puzzle”

Global Mean Sea Level

Thermal Expansion

Glaciers

Ice Sheets

- Surface Mass Balance
- Ice Dynamics (v. uncertain)

+ other

- Reservoirs
- Ground water storage

TOTAL

Large-Scale Sea Level (> 100km)

Ocean

- Local density changes
- Ocean circulation

**Land Ice
Mass Loss**

- Geoid response
- Lithosphere response

**Glacial Isostatic
Adjustment**

Inverse Barometer

Time-Mean Sea Level

Regional + Extreme SL

Extreme Sea Level:

- Tides
- Surges
- Waves + Swell

**Basin
resonance?**

Vertical Land Movement

- Tectonic movements
- Ground water extraction
- Sediment compaction
- Channel dredging



Met Office

Conclusions

Temperature increases raise sea levels by expanding the oceans and melting land ice

The magnitude of sea level rise from these processes differs regionally and in the accuracy of the estimated changes

This gives rise to different estimates of the range of future sea-level rise at different island and coastal locations

Storm surges, waves and other non-climate factors such as local subsidence also affect local sea-levels – and extremes of the climate-related factors can cause very large (and damaging) local sea-level rise

Providing comprehensive local information on future sea-levels is a complex process