Setting the scene - The Changing Ocean Climate and Madagascar Observations and projections of marine climate change: Sea Level and Storminess

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With thanks to Angela Hibbert, Phil Woodworth and Francisco Calafat, NOC

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Observed and Future changes - IPCC reports

- Fifth Assessment Report (AR5, 2013)
- Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) - update on AR5
- Sixth Assessment Report (AR6) in progress - expected 2021
- Observations and projections for
  - Sea Level (mean sea level and extreme events)
  - Waves
  - Tropical Storms
  - Also Sea Surface Temperature, acidification and oxygen content, salinity

IPCC AR5 / SROCC - Global Mean Sea Level

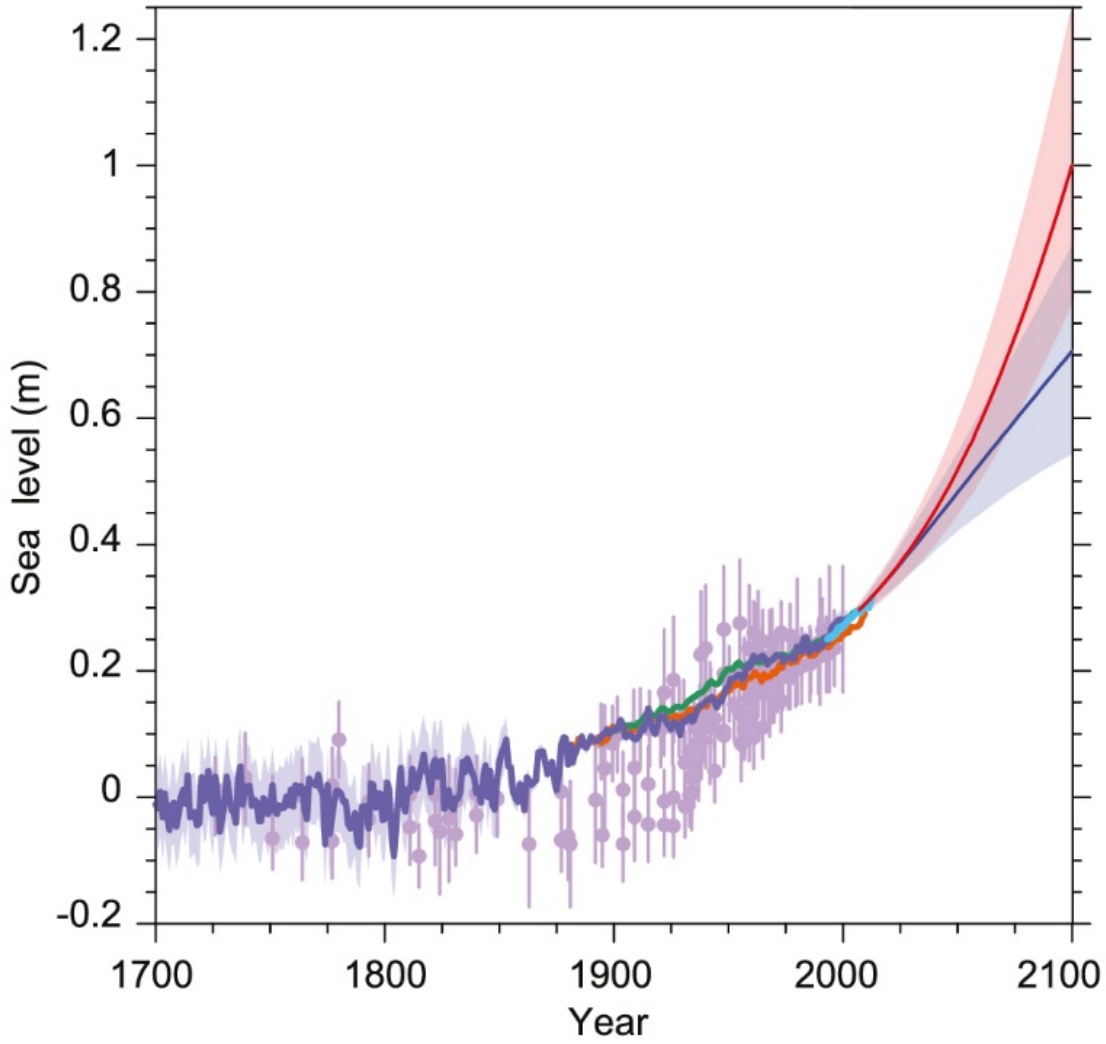
- It is ***very likely*** that:
  - Between 1901 and 2010, GMSL rose by 1.7 mm/y
  - Between 1993 and 2010, GMSL rate nearer to 3.2 mm/y

- Thermal expansion and melting of land-based ice explain 75% of this change 1901-2010. Higher rate post-1993 due to radiative forcing and increased meltwater.

- Future Sea Level Rise
  - Low emissions scenario: **4 mm / y -> 0.43m increase by 2100** (on 1986-2005)
  - High emissions scenario: **15 mm/y -> 0.85m increase by 2100**

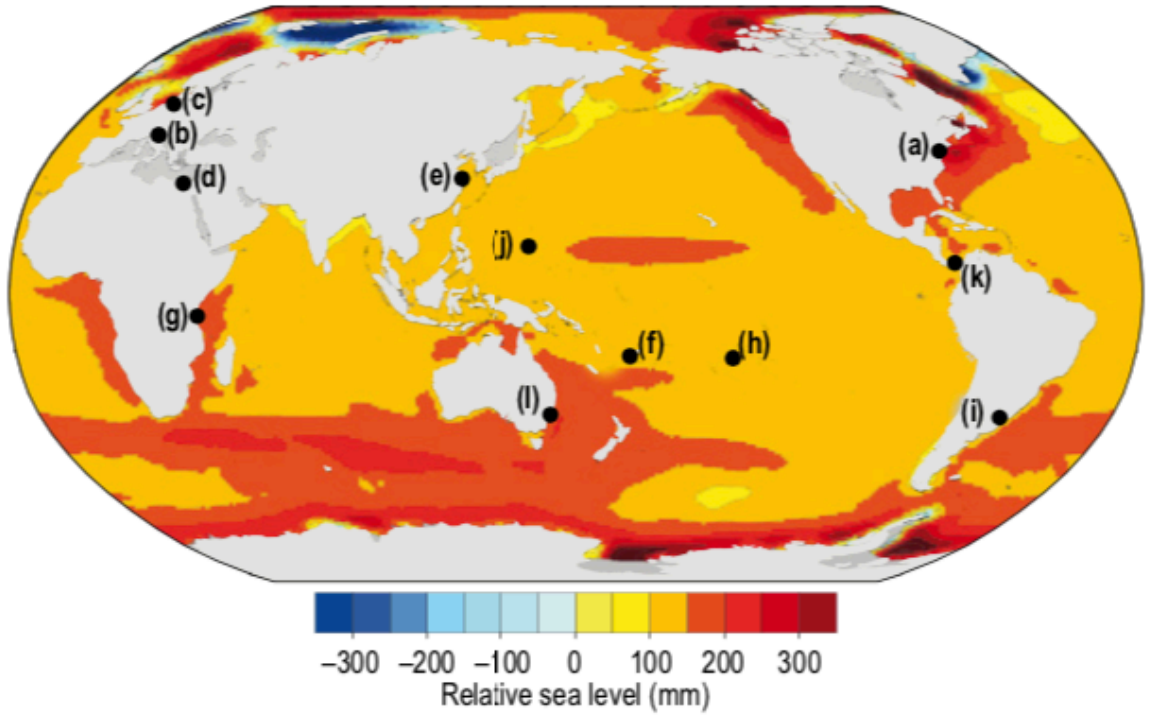
IPCC AR5 - Global Mean Sea Level

Compilation of paleo, tide gauge and altimeter data, plus RCP2.6 and RCP8.5model scenarios

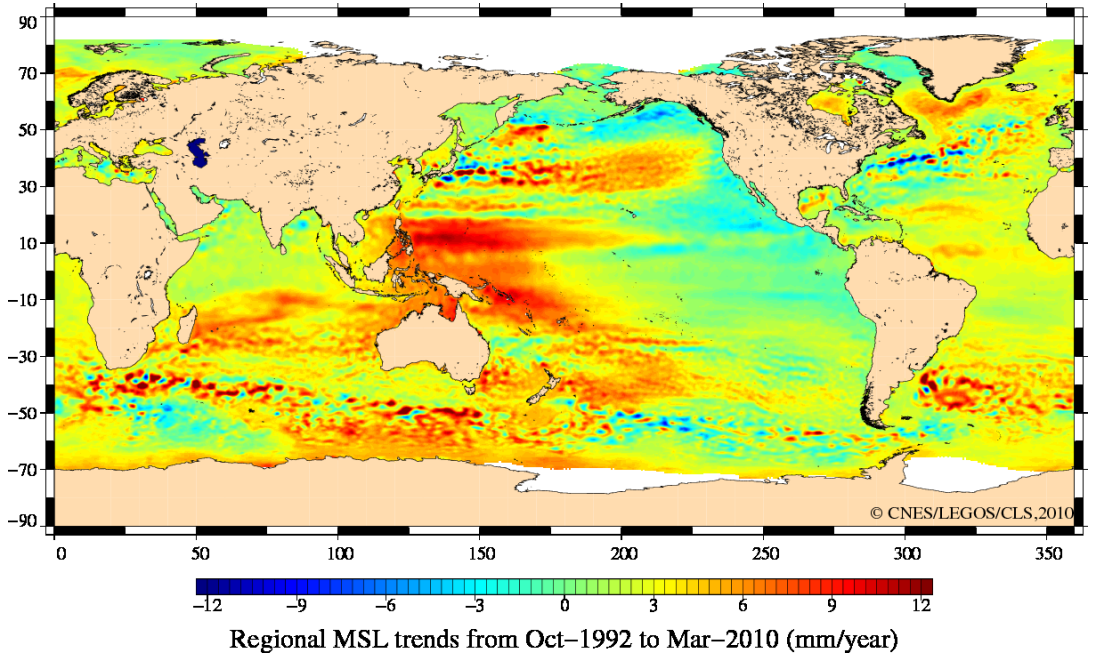


- High emissions : **15 mm/y -> 0.85m increase by 2100**
- Low emissions : **4 mm / y -> 0.43m increase by 2100**

SW Indian Ocean Regional Effects – Sea Level



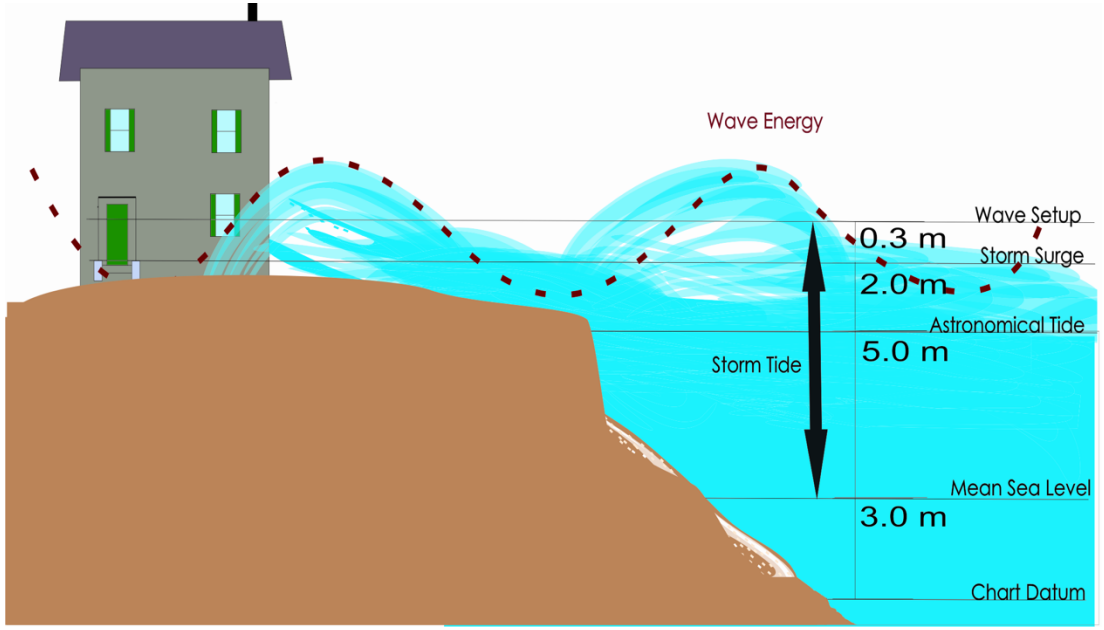
Simulated Sea Level Rise 1901-1920 to 1996-2015 estimated from climate models



Altimeter measure Sea Level Rise 1992-2010

IPCC AR5 / SROCC – Extreme Events

IPCC AR5 / SROCC - Extremes



- Global mean sea level rise will cause the frequency of extreme sea level events at most locations to increase.
- Local sea levels that historically occurred once per century are projected to occur at least annually at most locations by 2100.

IPCC AR5 / SROCC – Waves, Tides

- Wave height ***likely*** to increase in Southern Ocean due to greater wind speed
- Wave height and duration of wave season ***very likely*** to increase in Arctic due to reduced sea ice
- Elsewhere, is ***low confidence*** in projections due to ***low confidence*** in storminess projections and use of coarse resolution models
- Coastal tidal amplitudes and patterns are projected to change due to sea level rise and coastal adaptation measures (**very likely**).

IPCC AR5 / SROCC – Tropical Storms

- The average **intensity** of tropical cyclones, the proportion of Category **4 and 5** tropical cyclones and the associated average **precipitation rates** are projected to **increase** (***medium confidence***).
- Rising mean sea levels will contribute to **higher extreme sea levels** associated with tropical cyclones (***very high confidence***).
- There is ***low confidence*** in projected changes in the future frequency of tropical cyclones at the global scale

SW Indian Ocean Regional Effects – Tropical Cyclones

- Observed **poleward migration** of location of highest tropical cyclone intensity in the S Indian Ocean

- Number of **intense tropical cyclones** (in the South West Indian Ocean) **increased** from 36 during 1980-1993 to 56 during 1994-2007, parallel to a simultaneous but smaller decrease in the number of tropical storms. Evidence of a longer-term decrease from 1952-2007.

- Landfall in Madagascar and Mozambique is more common in La Niña years (1983-86, 1988-89, 1995-96, 1998-2001, 2005-06). Slightly more Intense Tropical Cyclones in these years

- 2018-19 season “Most active, costliest and deadliest on record”.

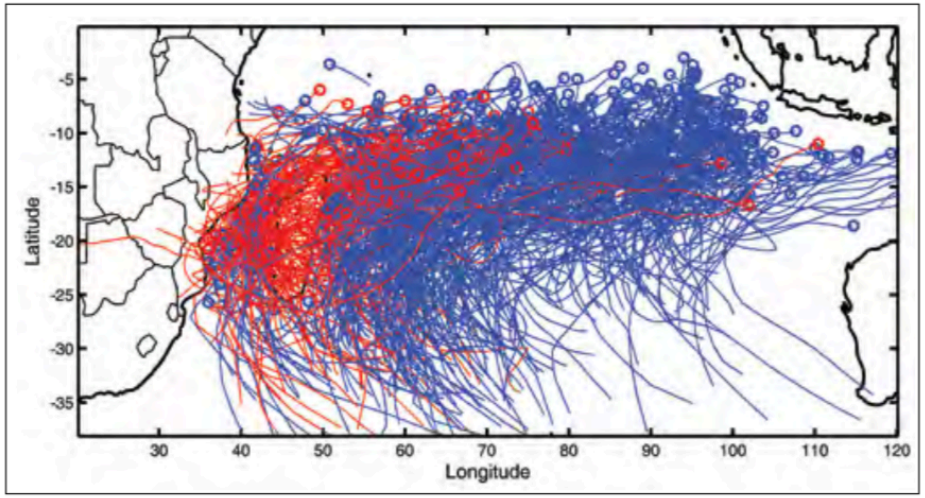
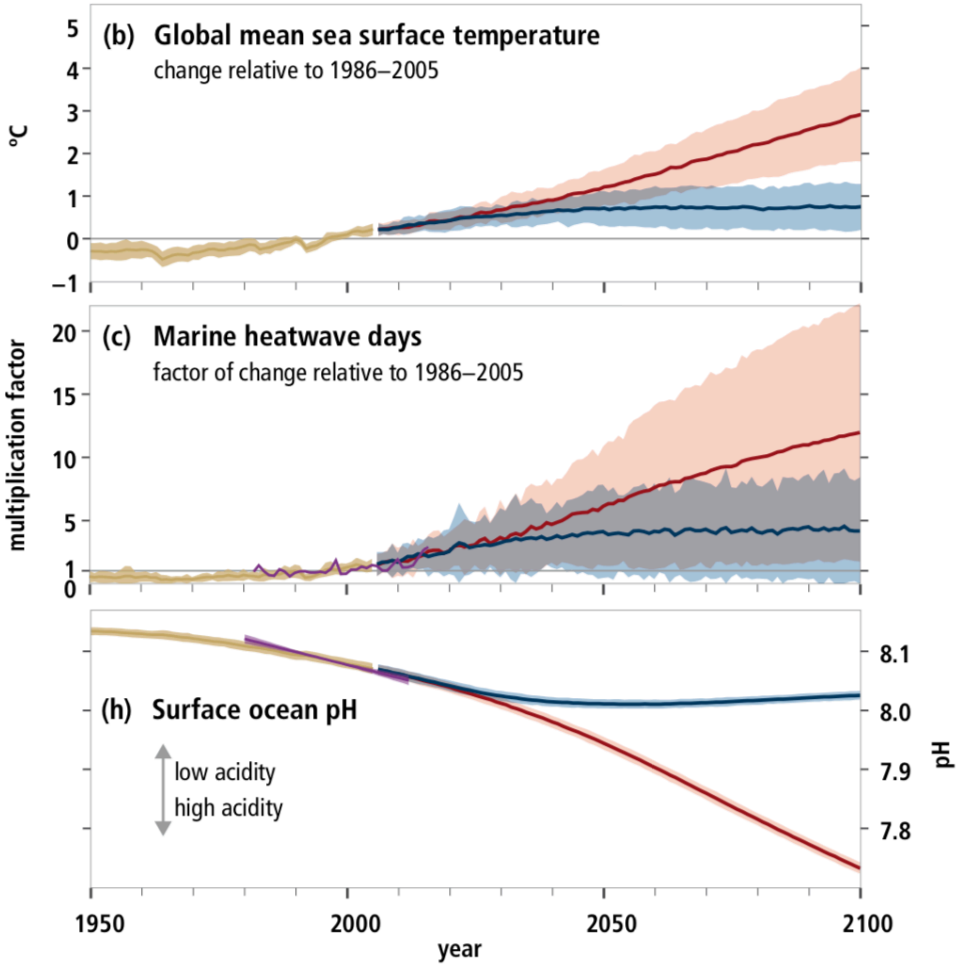


Fig. 18. Cyclone tracks (November-April) 1952-2007. Land-falling cyclone tracks are red-marked

IPCC AR5 / SROCC – SST, Acidification, Oxygen Content, Salinity

- *Virtually certain* that the global ocean has warmed unabated since 1970 and has taken up more than 90% of the excess heat in the climate system.
- Since 1993, the rate of ocean warming has more than doubled.
- The Tropical Indian Ocean SST has warmed by 1.4°C from 1950-2015, global average was 0.65°C.
- Marine heatwaves have doubled in frequency since 1982 and are increasing in intensity (*very high confidence*).
- By absorbing more CO2, the ocean has undergone increasing surface acidification (*virtually certain*).
- A loss of oxygen has occurred from the surface to 1000 m (*medium confidence*).
- Enhancements in geographical contrasts in salinity: saline surface waters have become more saline (increased evaporation); fresh surface waters in rainfall dominated regions have become less saline (more rainfall).



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Thank you!

Any Questions?

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