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**CLIMATE
COMMISSION**
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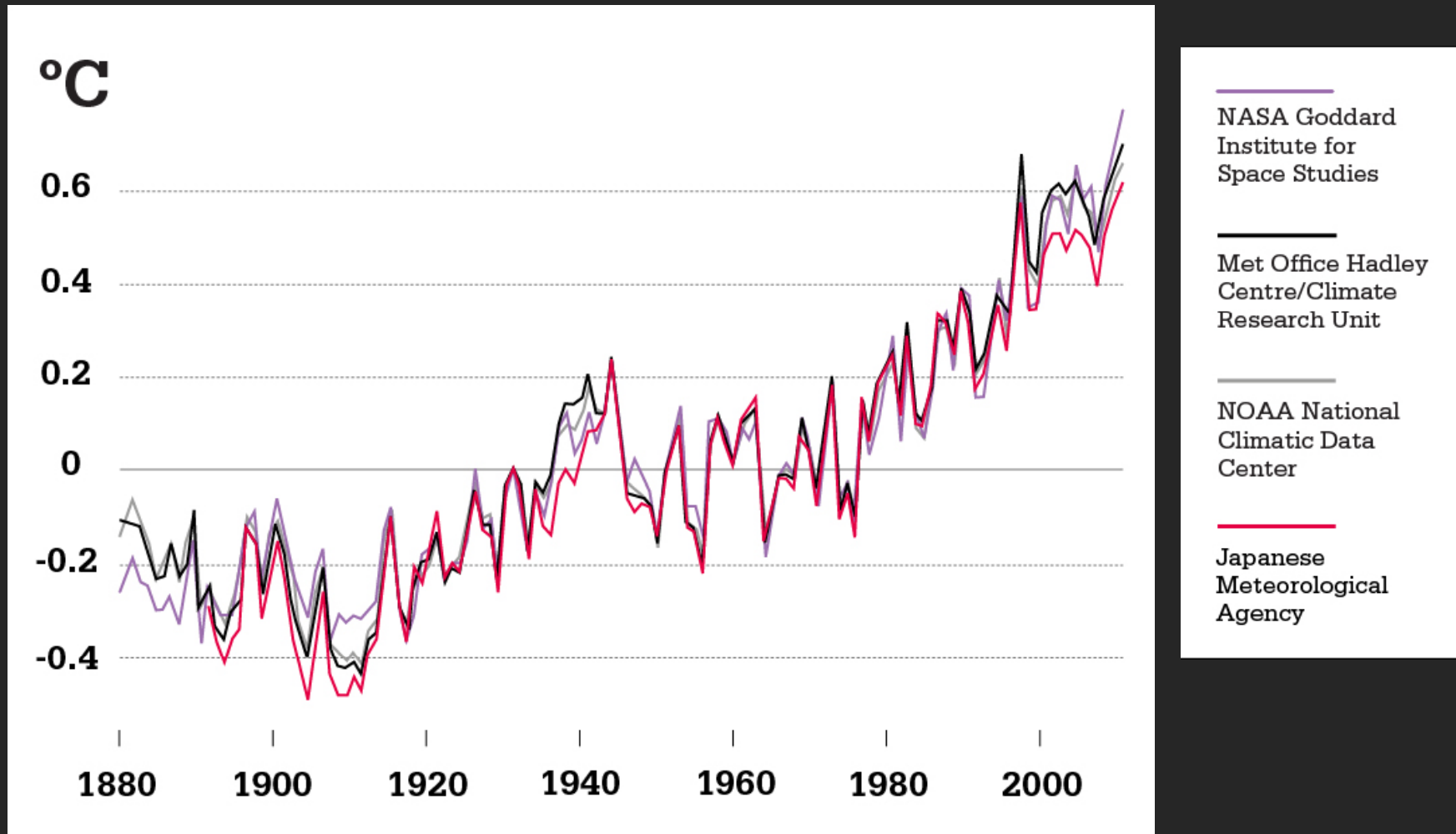
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Extreme Weather

The influence of climate change

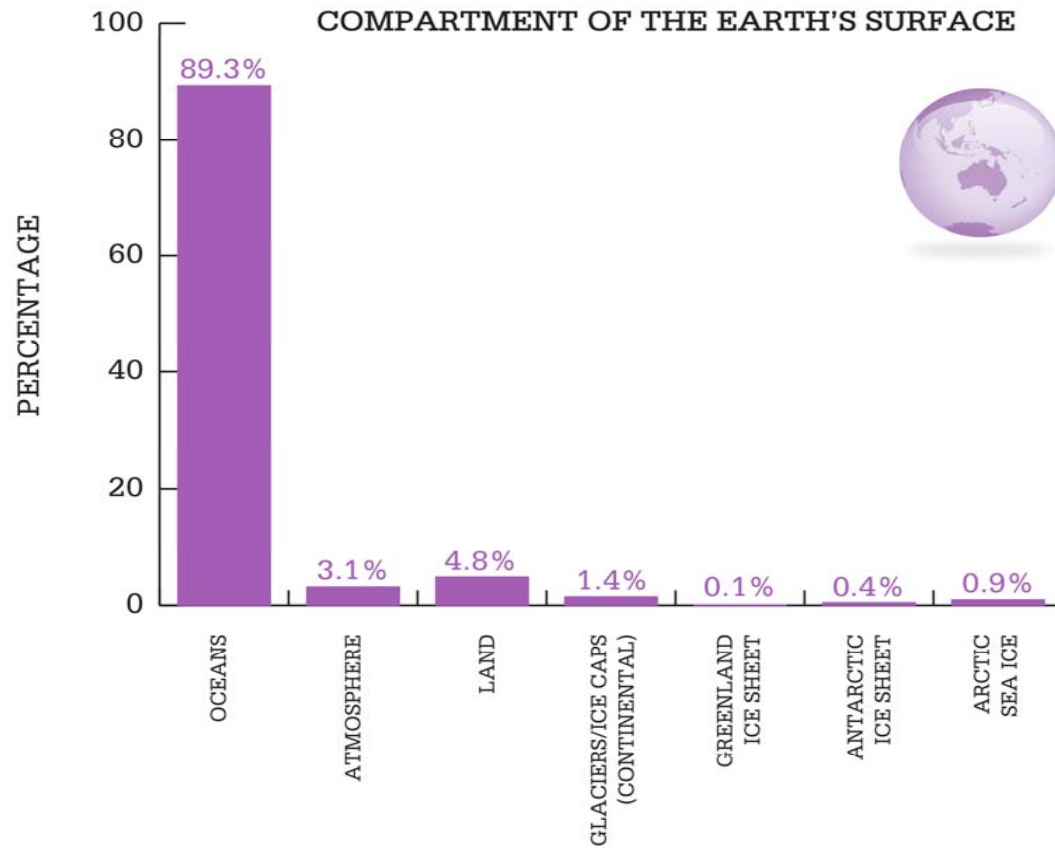
Professor Will Steffen

www.climatecommission.gov.au
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There is no doubt the climate is changing – the atmosphere is warming...



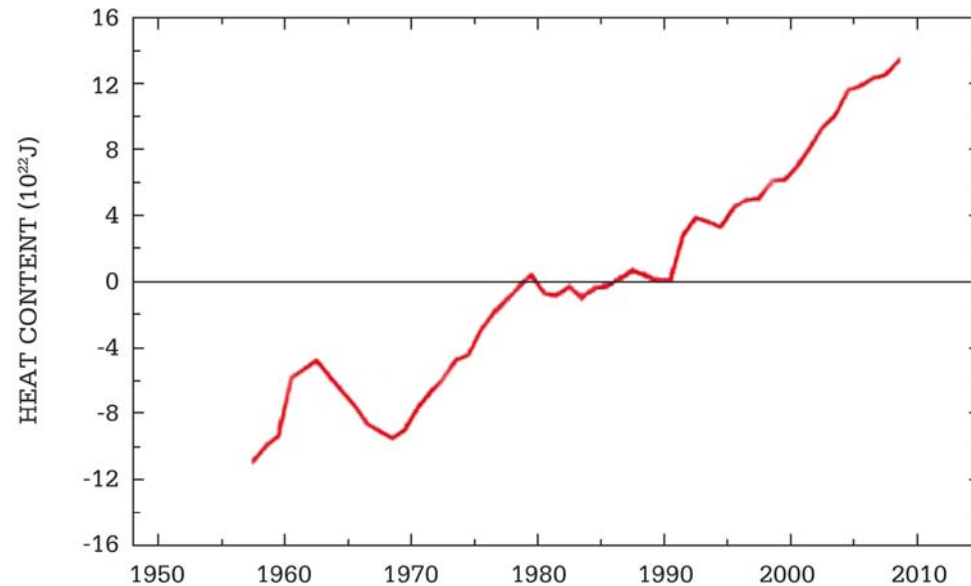
Where does the excess heat go?



Source: IPCC AR4

Climate change and ocean heat content

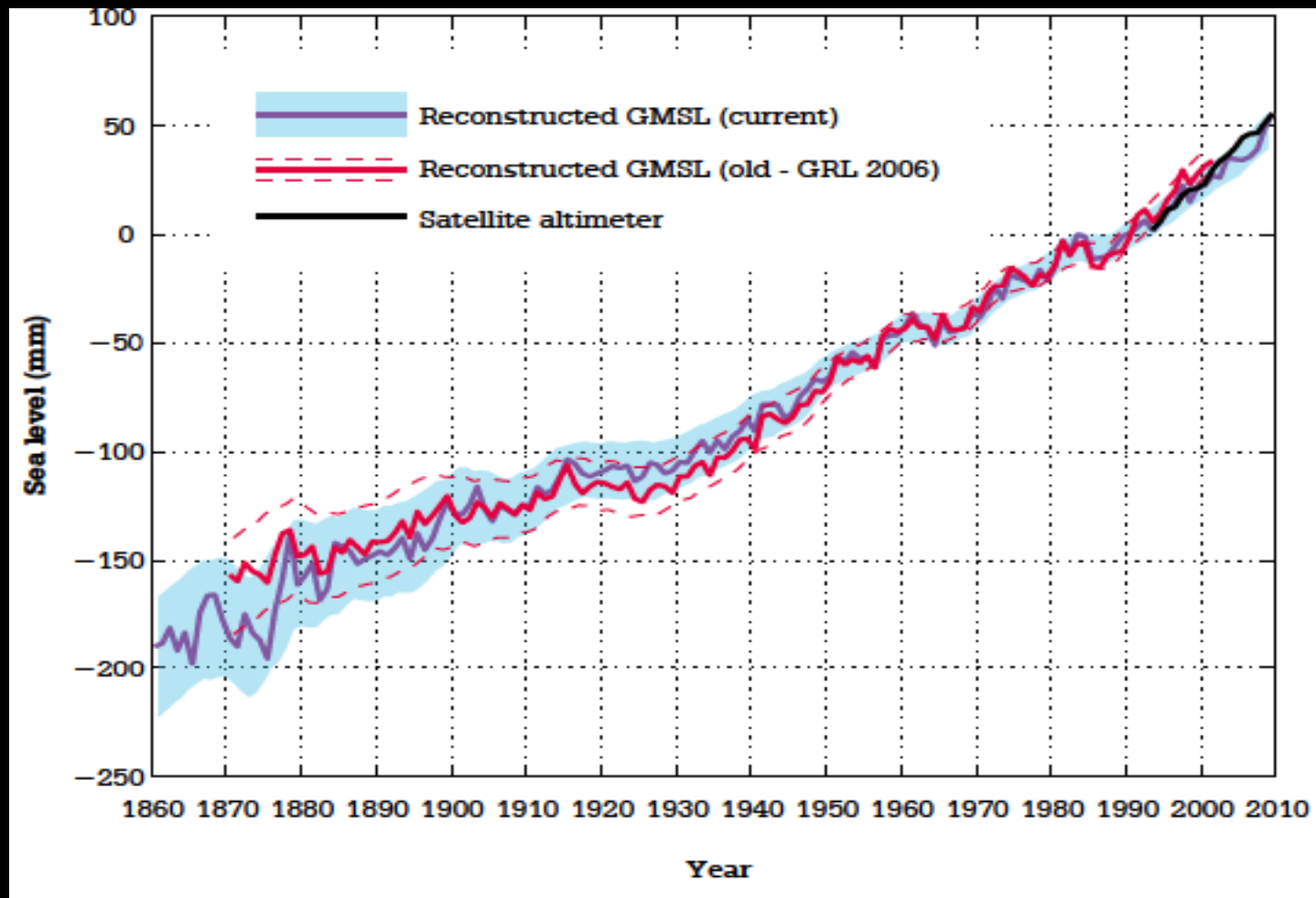
Change in Ocean Heat Content from the surface to 2000 m
(relative to 1955-2006)



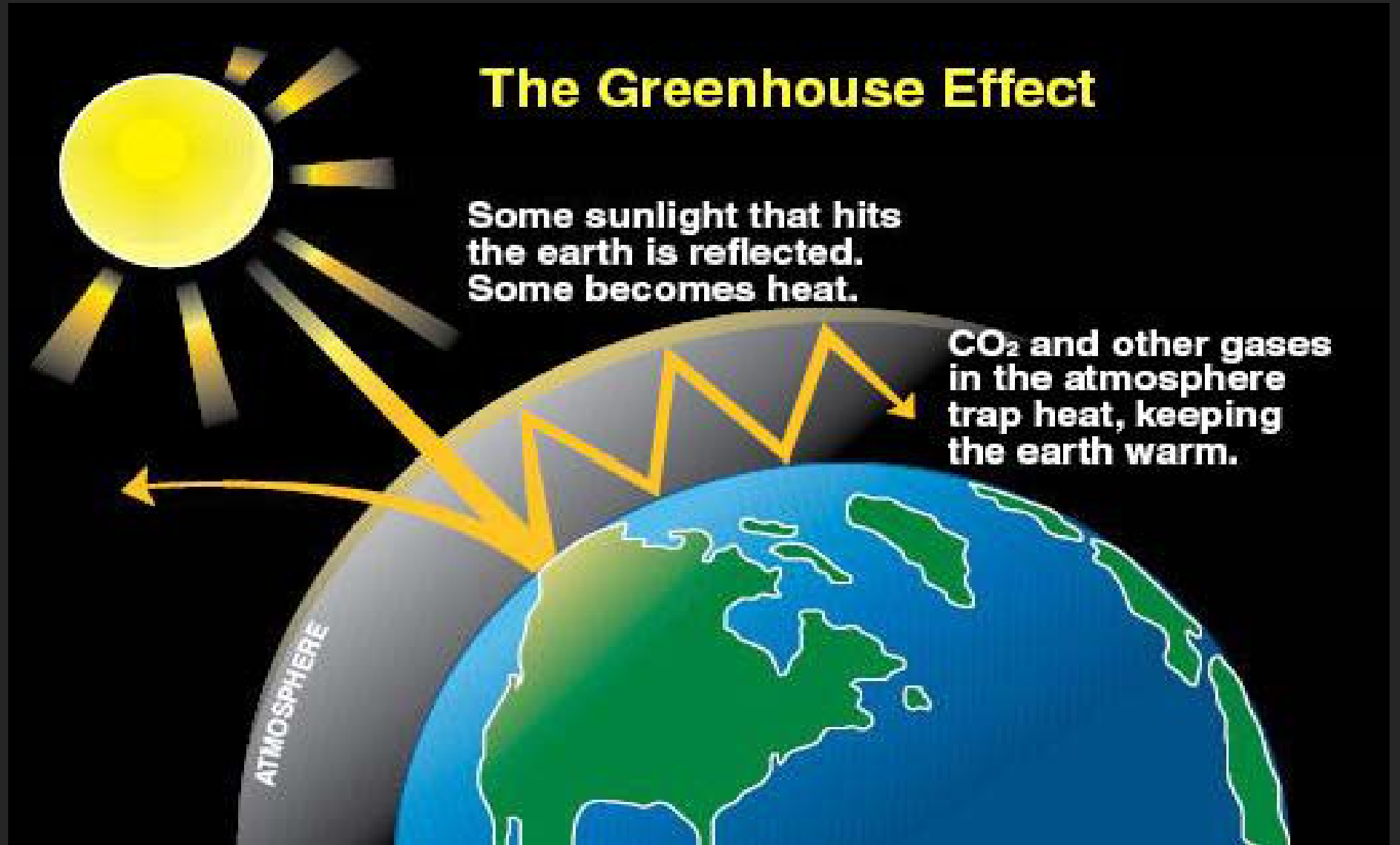
Levitus et al. 2012

Observed changes in global sea-level

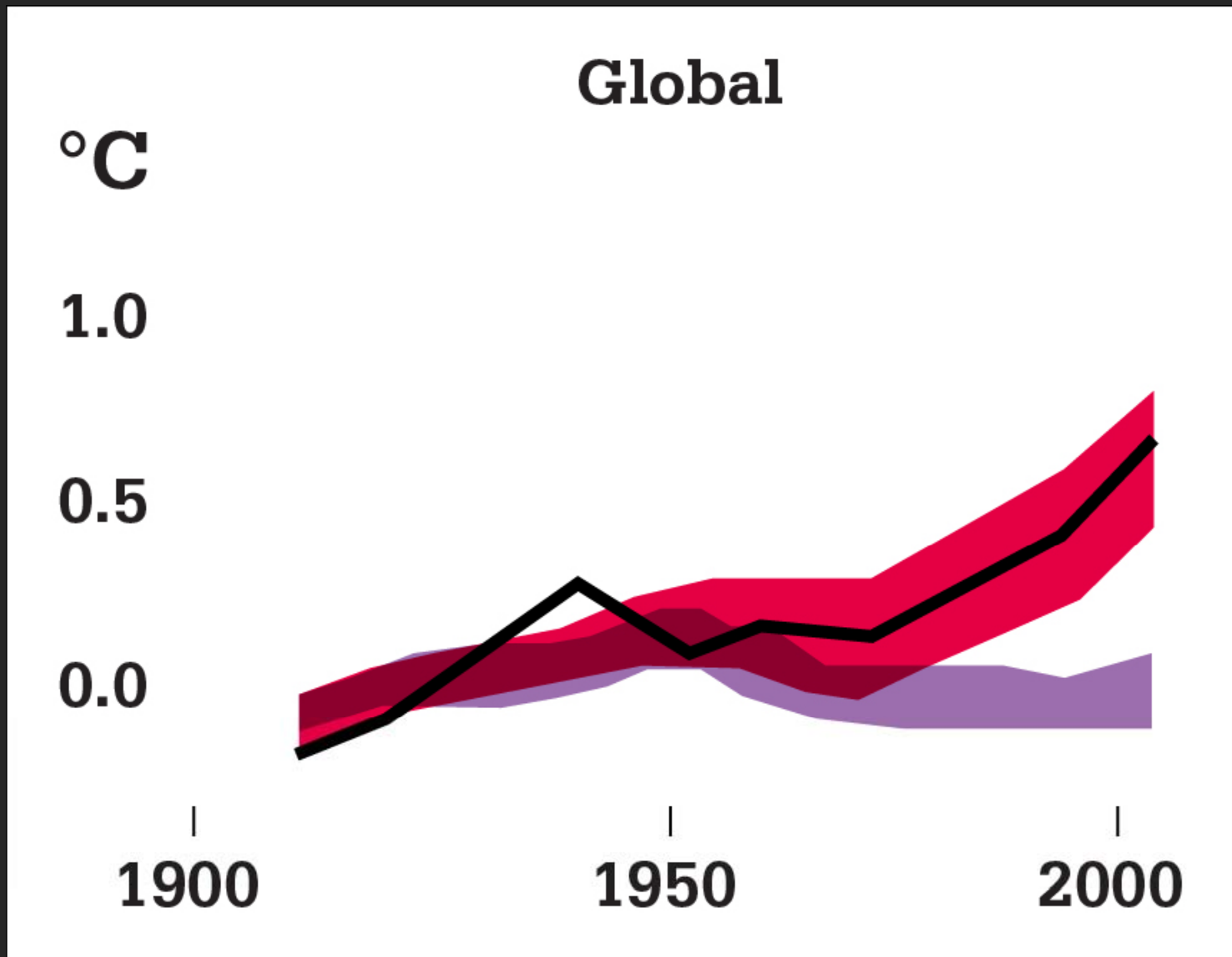
Global average sea level from 1860 to 2009



Greenhouse gases naturally warm the Earth...



But human activities are making it warmer.



Source: IPCC AR4

Photo: Bruno & Ligia Rodriguez

Climate change and extreme weather

Extreme weather has always occurred. But due to additional **greenhouse gases** in the atmosphere, the **climate system** now contains significantly **more heat** compared to 50 years ago.

This means that **all extreme weather events** are **influenced** by **climate change**.


The **severity** and **frequency** of many **extreme weather** events are increasing due to **climate change**.


 **Heatwaves** have become longer and hotter. The number of record hot days in Australia has doubled since the 1980s. Australians will face **extreme heatwaves** and **hot days** far more often.

A hotter, moister global climate provides more energy for **tropical cyclones**. Cyclones are likely to become **more intense** but less frequent. 

Heavy rainfall events are increasing. Record sea surface temperatures fuelled recent very heavy rainfall events on the east coast, with damaging flooding. 
Across much of Australia, when rain comes there is a **higher risk** of heavy rainfall.

 Global **sea level** has risen 0.2 m over the last century. Coastal flooding happens more often when storm surges occur on higher sea levels. Further rises in sea level will drive **major impacts** to coastal cities.

 Southwest and southeast Australia have become drier. In these regions **droughts** are likely to happen even **more often**.

Hotter and drier conditions have contributed to increased **bushfire** weather risk in southeast Australia. Continued increases in hot and dry weather will likely **increase** the frequency of **extreme fire danger** days. 

Extreme events have major impacts

-  environmental
-  social
-  economic

How quickly and deeply we reduce greenhouse gas emissions will greatly influence the severity of extreme events our children and grandchildren experience.

Find out more: www.climatecommission.gov.au

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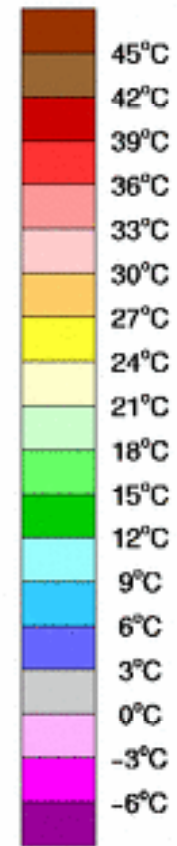
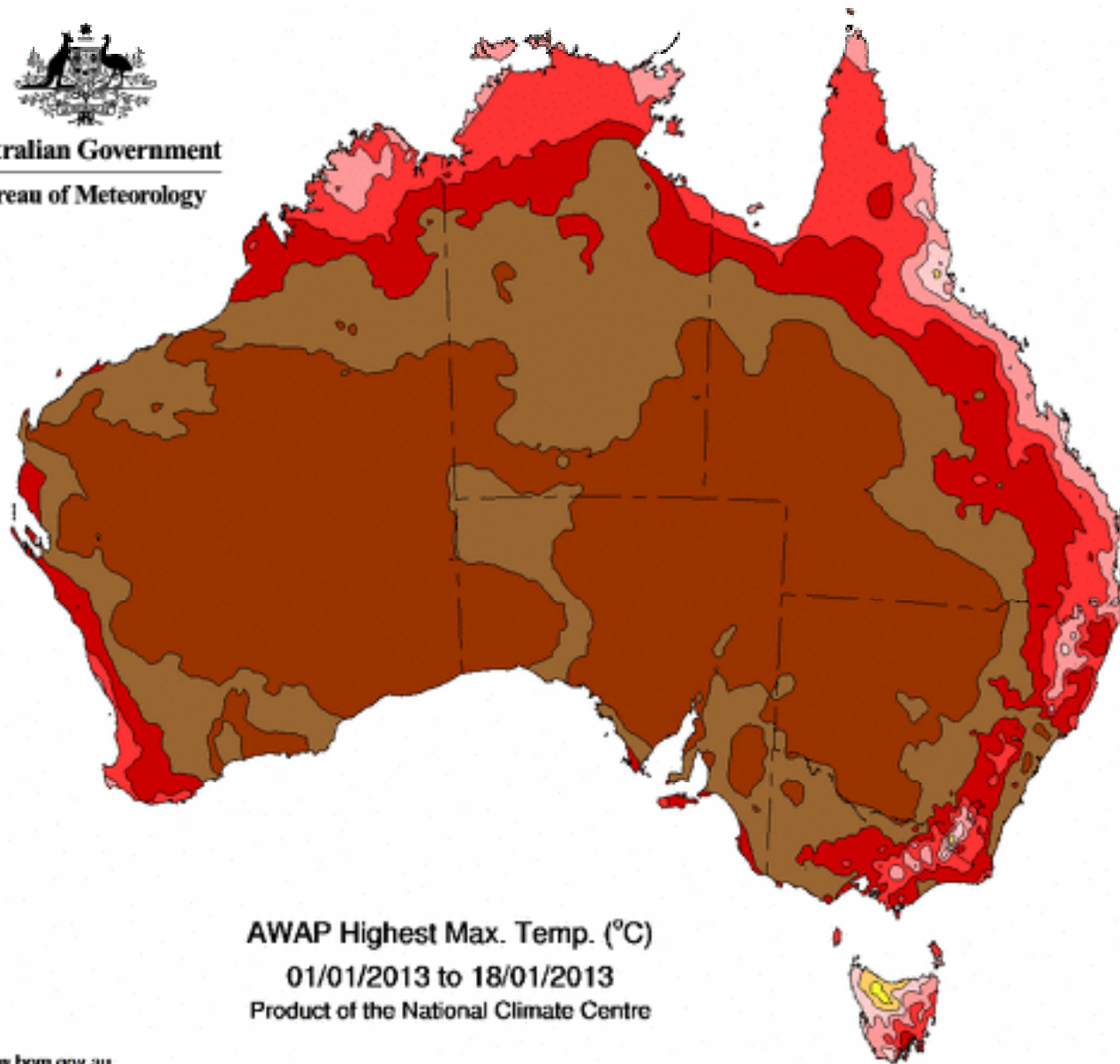
Sources: Hot days and Heatwaves: CSIRO and BoM, 2012; Perkins and Alexander, 2013; Alexander and Arblaster, 2009. Cyclones: Emanuel, 2000; Wing et al., 2007. Rainfall: Donat et al., 2013a; IPCC, 2012. Bushfires: Lucas et al., 2007; Clarke et al., 2011. Drought: BoM, 2013h; IPCC, 2012. Sea Level: Church and White, 2011; Church et al., 2006; Hunter, 2012.

Full references available in **The Critical Decade: Extreme Weather** www.climatecommission.gov.au/report/extreme-weather

Heatwaves



Australian Government
Bureau of Meteorology



AWAP Highest Max. Temp. (°C)
01/01/2013 to 18/01/2013
Product of the National Climate Centre

<http://www.bom.gov.au>

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ID code: IGMMapAWAPDailyTemps

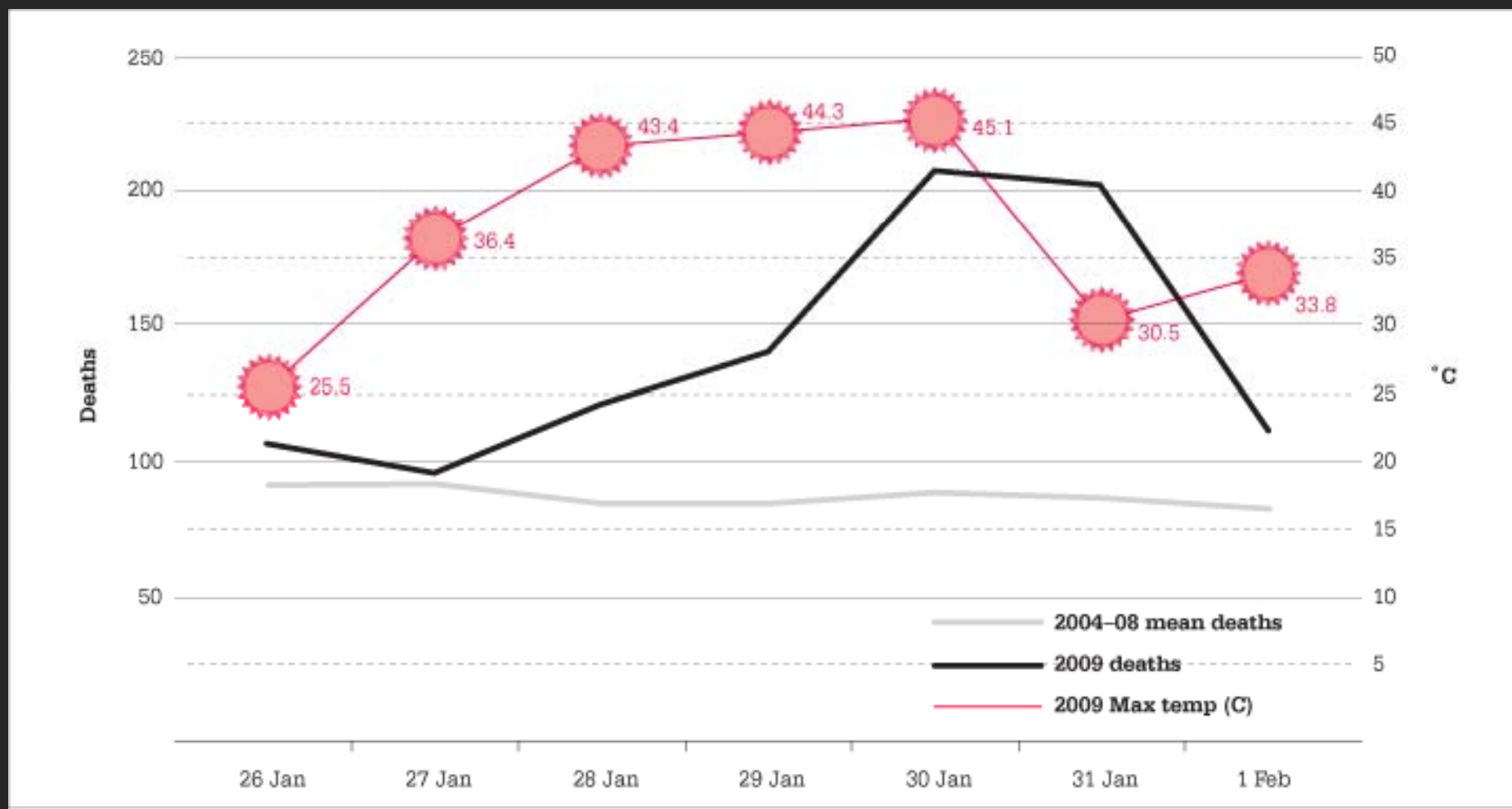
Issued: 23/01/2013

Source: Bureau of Meteorology

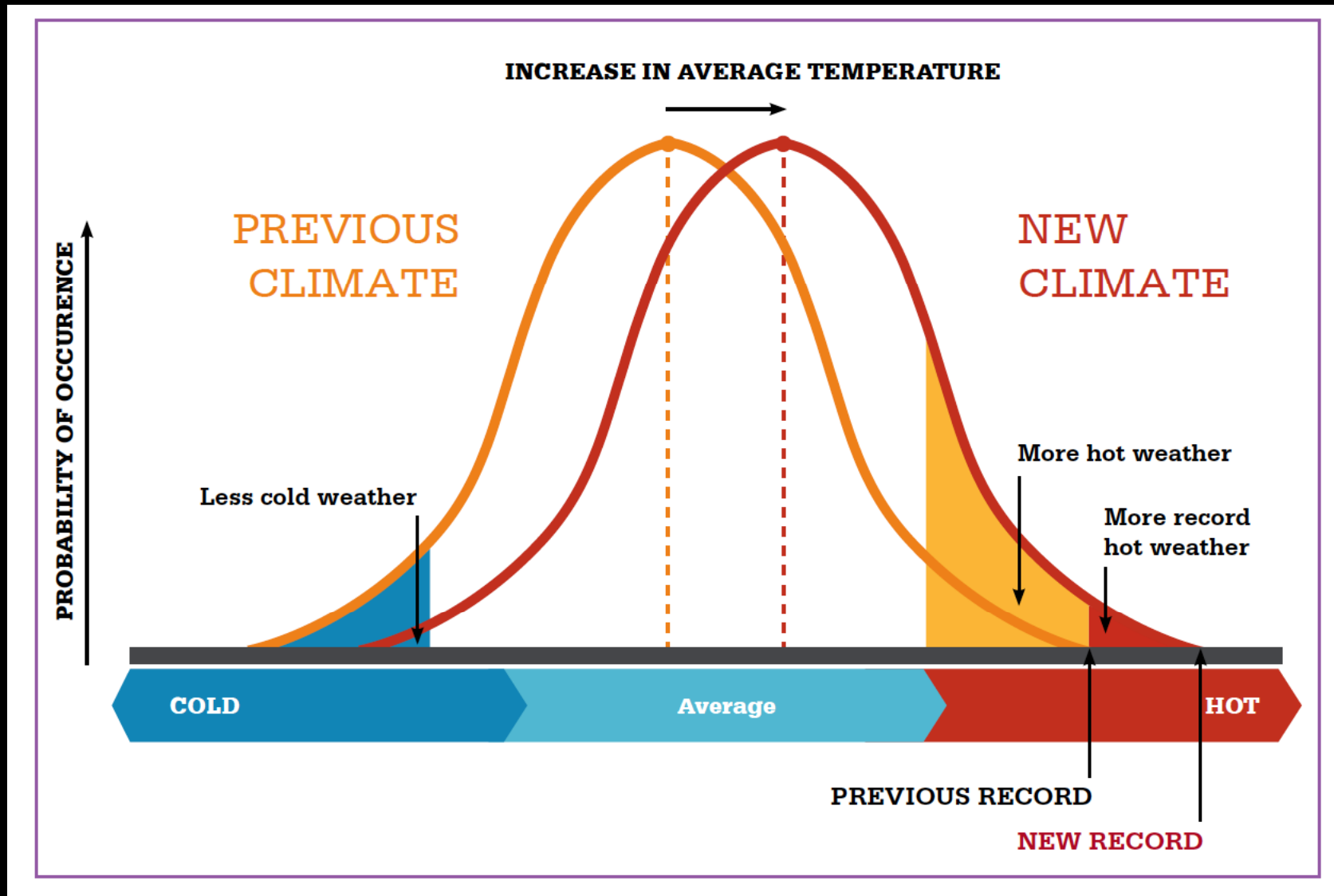


- Severe heatwave across 70% of Australia late Dec 2012 /early Jan 2013. Temperature records set in every state and territory
- Hottest ever area-averaged Australian maximum temperature, 7 January 2013: 40.30 C
- Hottest month on record for Australia – January 2013
- All-time high maximum temperatures at 44 weather stations
- Average daily maximum temperature for the whole of Australia was over 39 C for seven consecutive days (2-8 January)

Melbourne 2009 heatwave



Even a small increase in average temperature can cause a big change in hot weather.

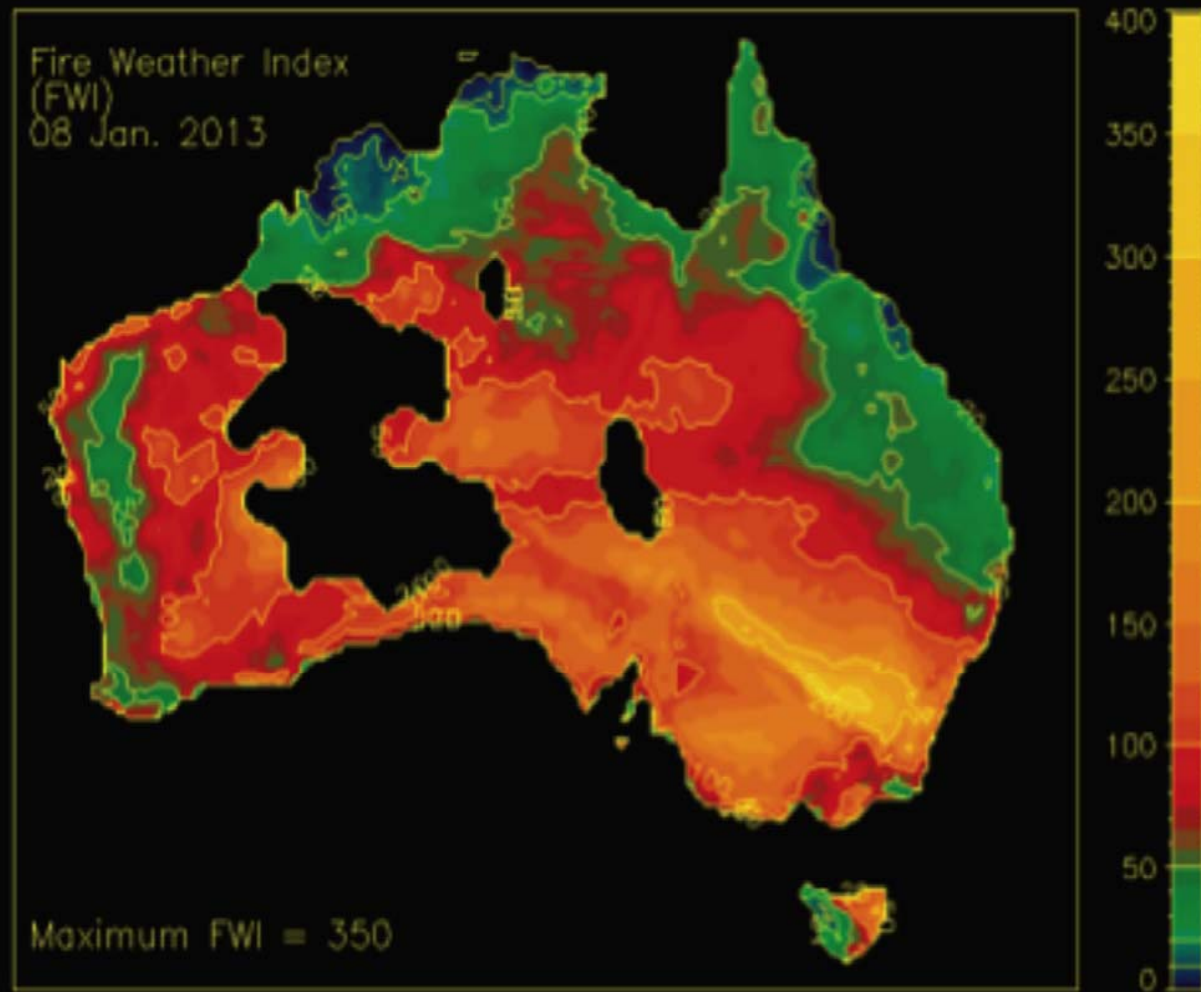


Bushfires





Source: CAWCR



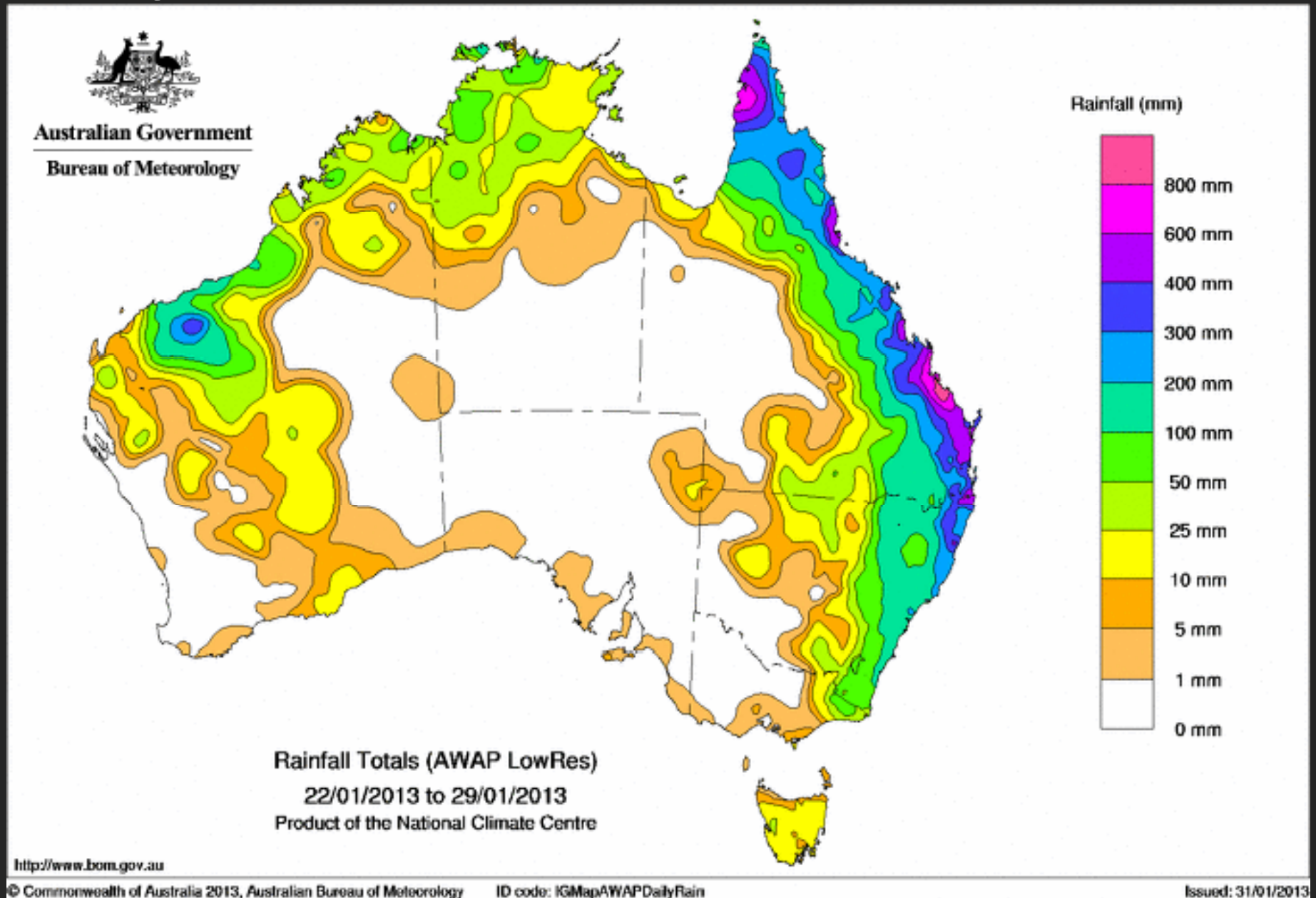


- Australia has a long history of bushfires – Black Friday 1939; Ash Wednesday 1983
- In 2003 large and uncontrollable bushfires devastated several suburbs in Canberra
- In 2009 the Black Saturday fires took 173 lives and destroyed over 2,000 houses in Victoria
- In 2013 large bushfires in Tasmania swept into the town of Denalloy, destroying nearly 200 properties and forcing the evacuation of hundreds of people from the Tasman Peninsula.



- Climate change exacerbates bushfire conditions by increasing the frequency of very hot days.
- Between 1973 and 2010 the Forest Fire Danger Index increased significantly at 16 of 38 weather stations across Australia, mostly in the southeast. None of the stations showed a significant decrease.
- Projected increases in hot days across Australia, and in dry conditions in the southwest and southeast, will very likely lead to more days with extreme fire danger in those regions.

Heavy rainfall

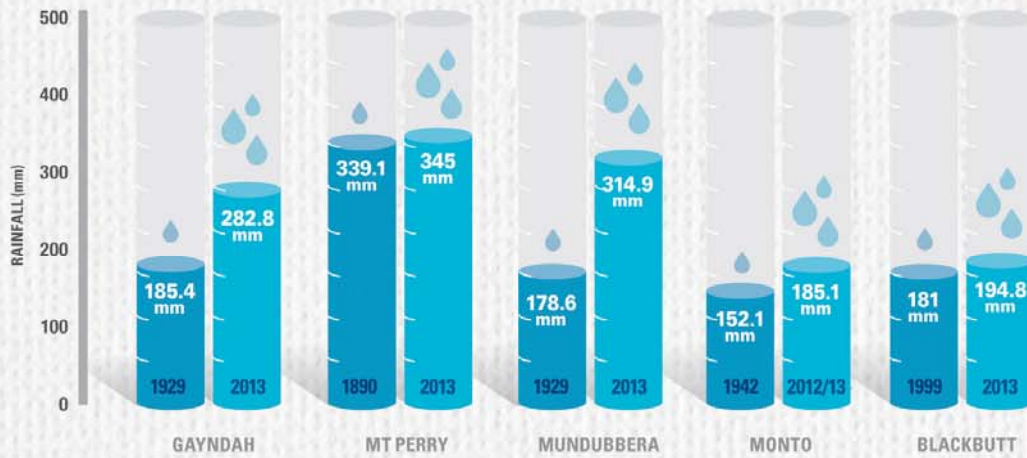


Heavy rainfall

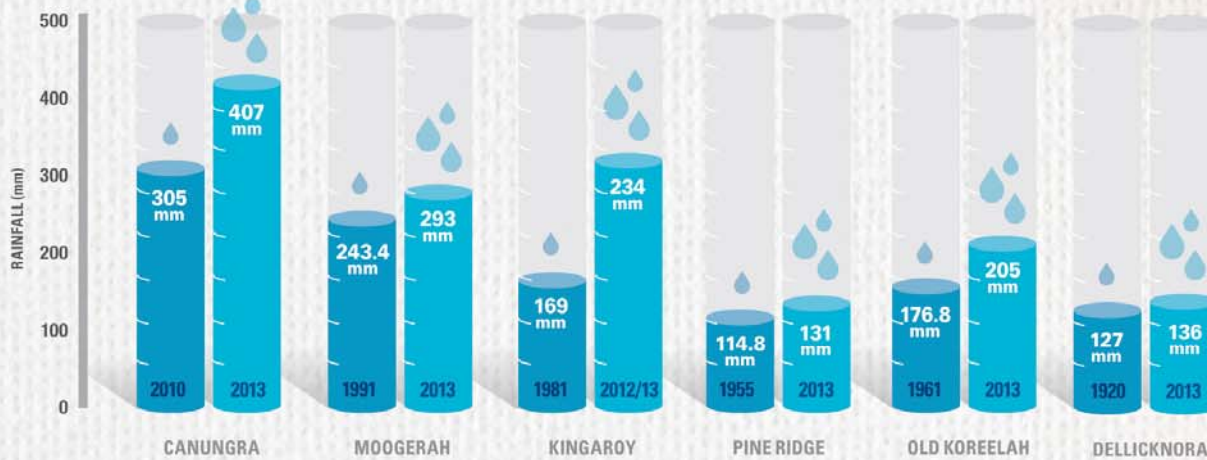
ANGRY SUMMER: EXTREME RAINFALL

THE ANGRY SUMMER

ALL-TIME DAILY RAINFALL RECORDS FOR JANUARY



ALL-TIME DAILY RAINFALL RECORDS FOR JANUARY



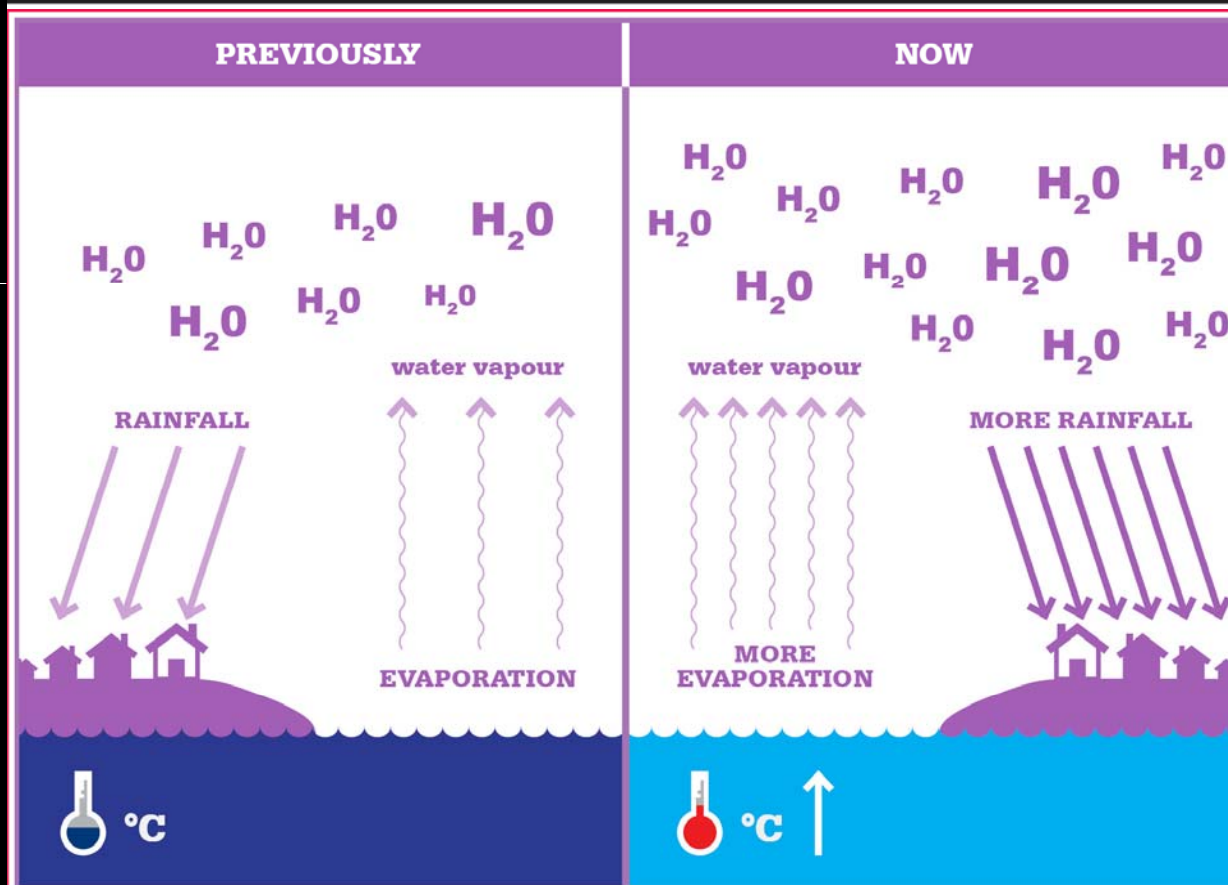
- Gayndah QLD
- Mount Perry QLD
- Mundubbera QLD
- Monto QLD
- Blackbutt QLD
- Canungra QLD
- Moogerah QLD
- Kingaroy QLD
- Pine Ridge NSW
- Old Koreelah NSW
- Dellicknora VIC

DATA SOURCE: BoM (2013b). Special Climate Statement 44 – extreme rainfall and flooding in coastal Queensland and New South Wales.



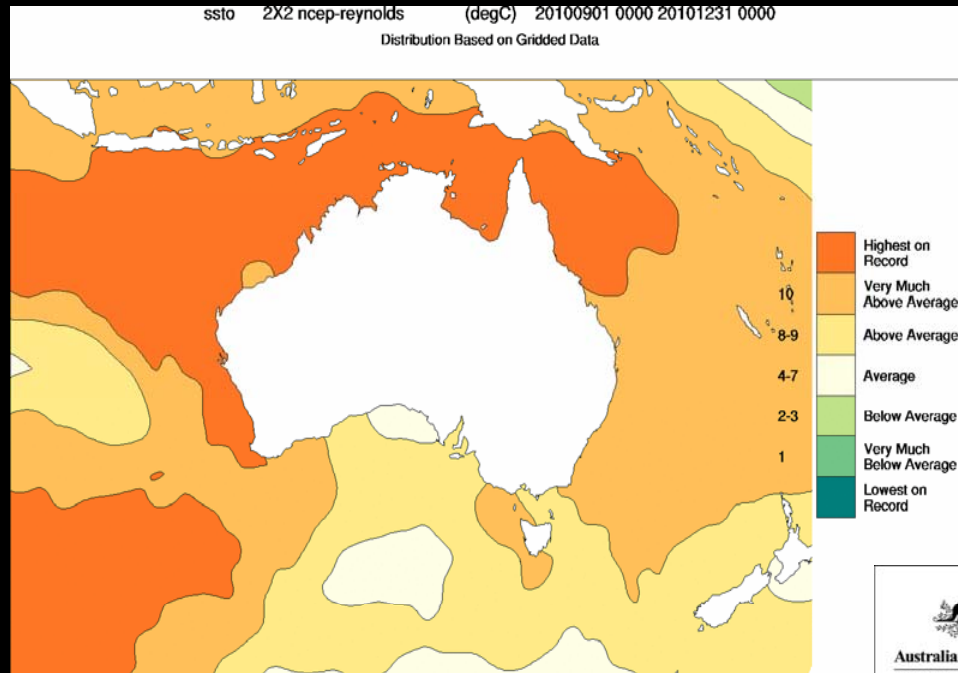


- December 2010 was Queensland's wettest December on record
- Floods broke river height records at over 100 observation stations
- 78% of the state was declared a disaster zone
- Economic cost estimated to be in excess of \$5 billion
- 300,000 homes and businesses lost power in Brisbane and Ipswich



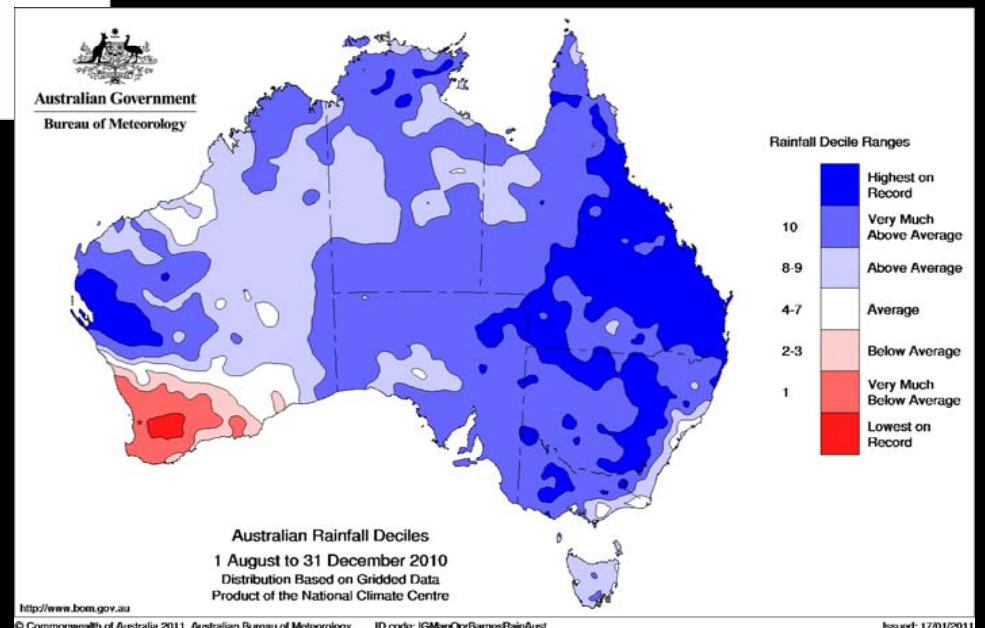
The influence of climate change on the water cycle. LEFT: The pre-climate change water cycle. RIGHT: The water cycle operating under higher surface ocean and air temperatures. The symbol H₂O represents water vapour.

SST and Rainfall Extremes



SST anomalies
1 Aug - 31 Dec 2010

Rainfall deciles
1 Aug - 31 Dec 2010



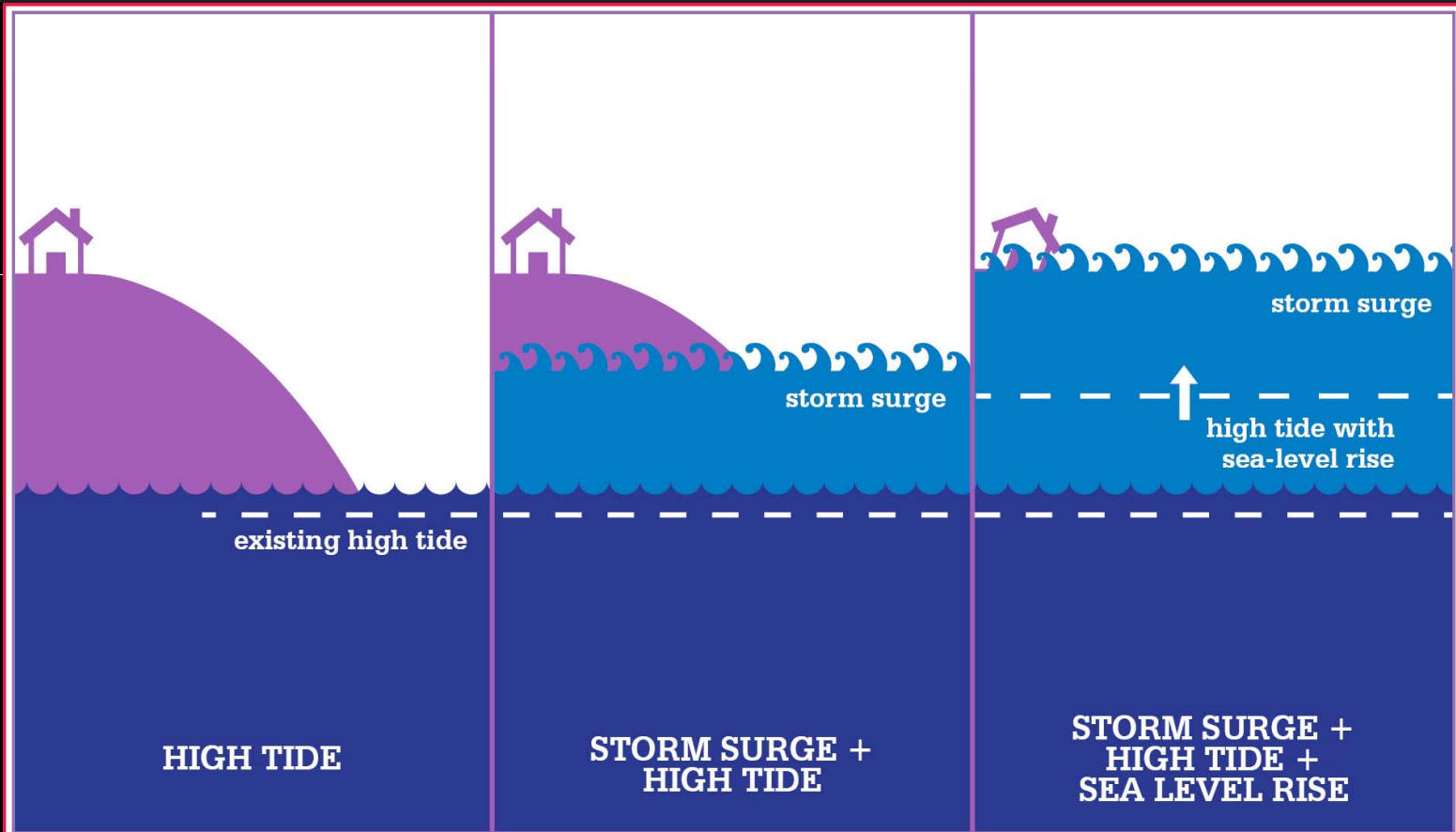
Consequences of sea-level rise



**Western Australia –
Perth region**

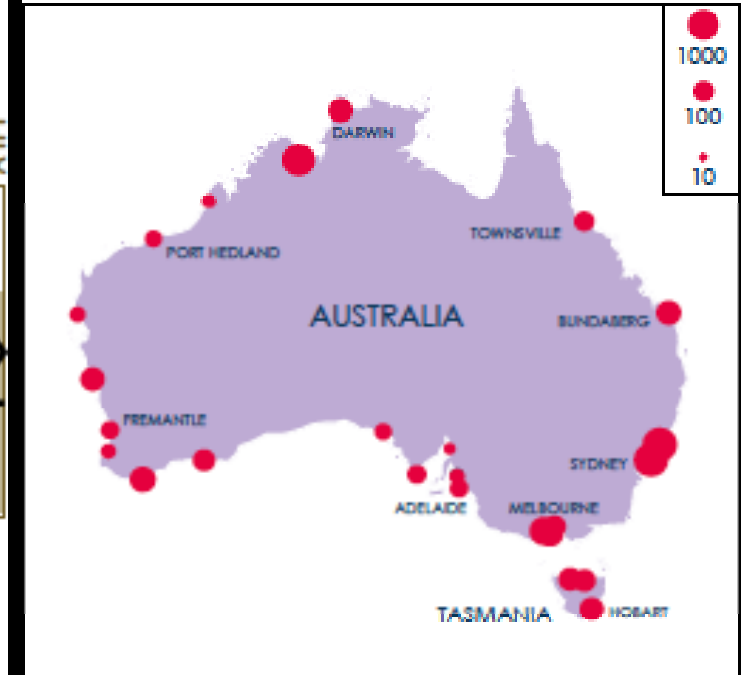
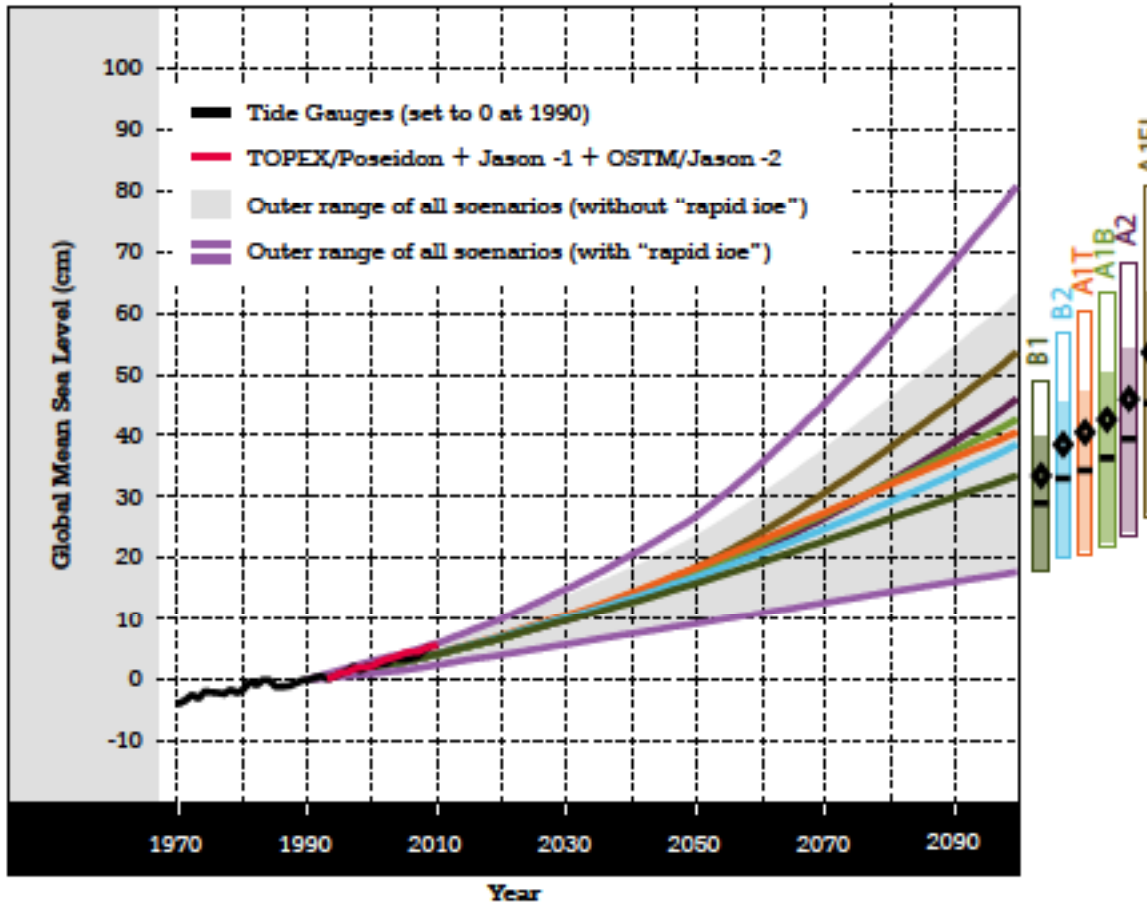
Torres Strait Islands





Sea-level rise increases the base sea level and thus exacerbates the effects of a storm surge.

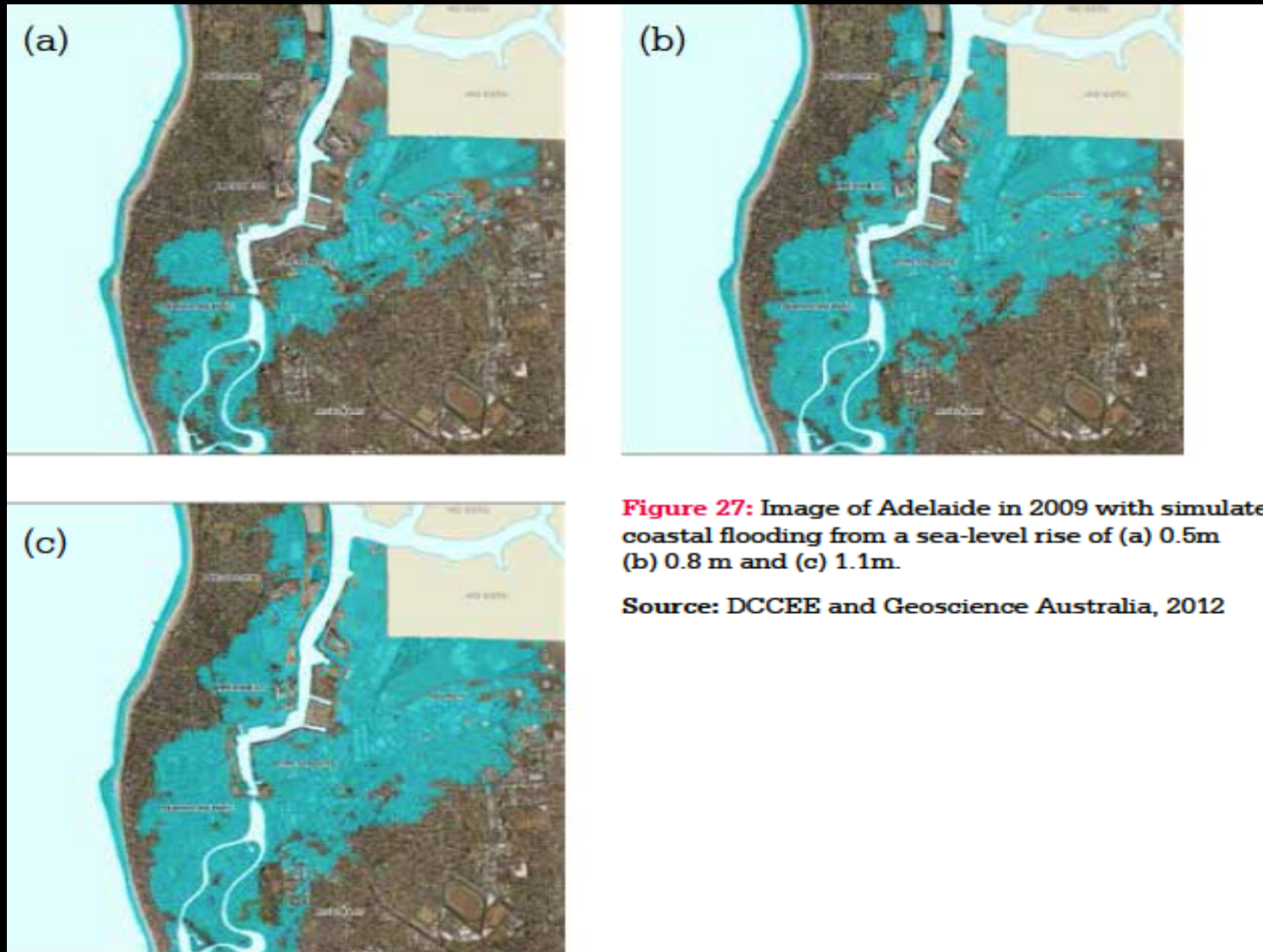
Projected rises in sea level



Projected increase in frequency of flooding for a sea-level rise of 0.5 m. Source: Hunter 2012

Global averaged projections of sea-level rise to 2100. Source: Church et al. 2011

Projected impacts of sea-level rise



Polar ice sheets and sea-level rise

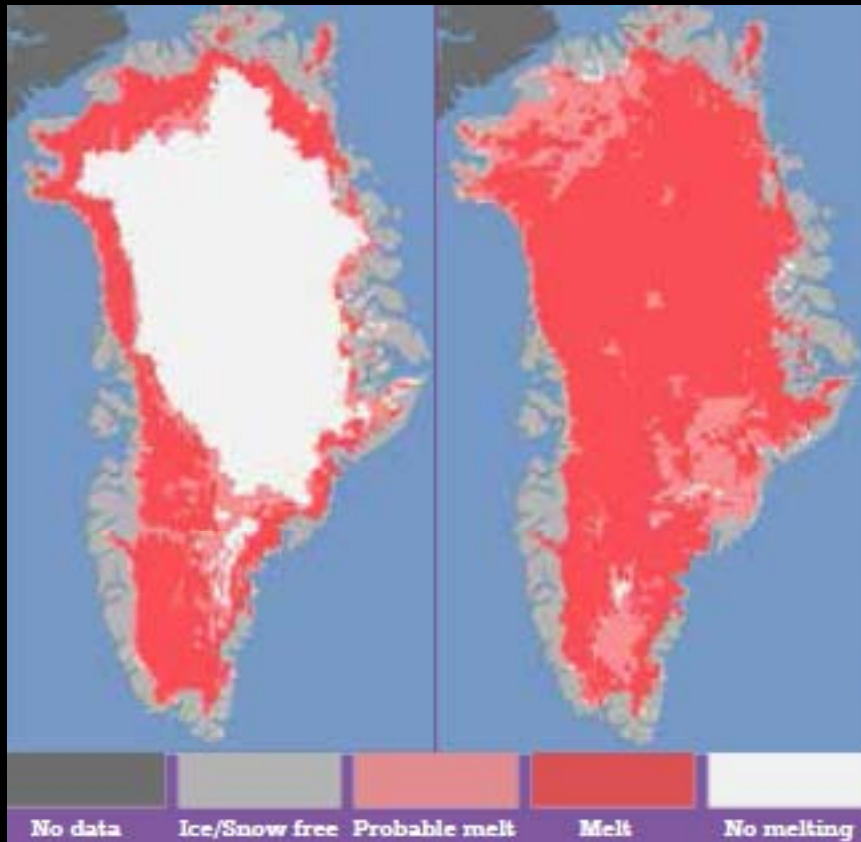
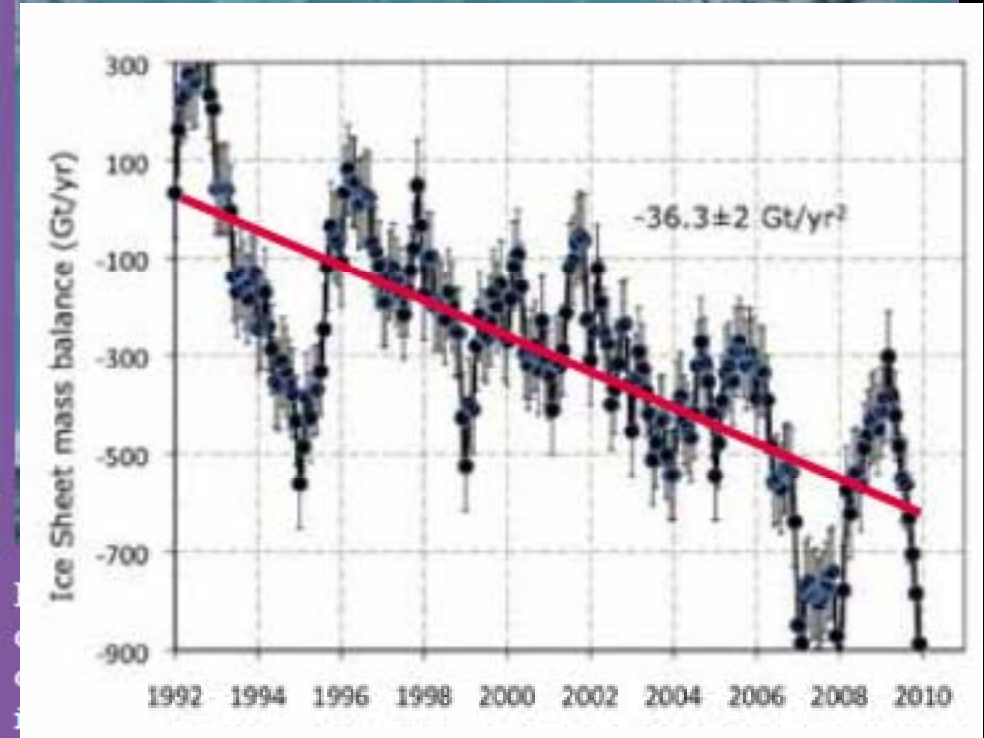


Figure 33: NASA satellite image of the extent of surface melt over Greenland's ice sheet on 8 July (left) 2012 and 12 July 2012 (right)

Source: NASA, 2012

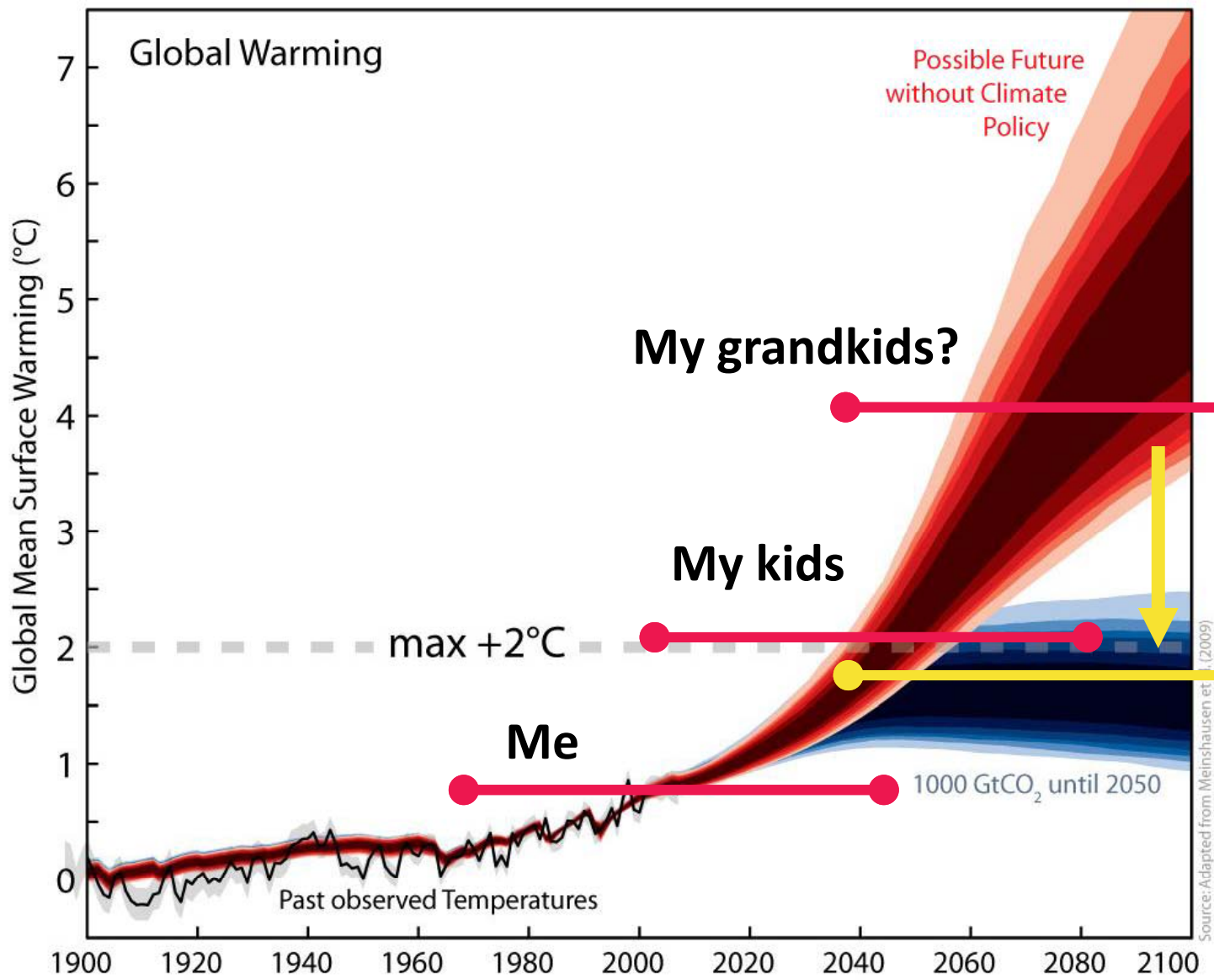


Norway pictured.

Rignot et al. 2011

Source: Flickr/Yukon White Light

This is the critical decade for action.



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