

Climate Change 2013: The Physical Science Basis

Working Group I contribution to the IPCC Fifth Assessment Report

Ocean Observations of Climate Change: Overview of the IPCC 5th Assessment Report

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For the Chapter 3 Writing Team

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Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased.

from the Summary for Policymakers, approved 27 September 2013

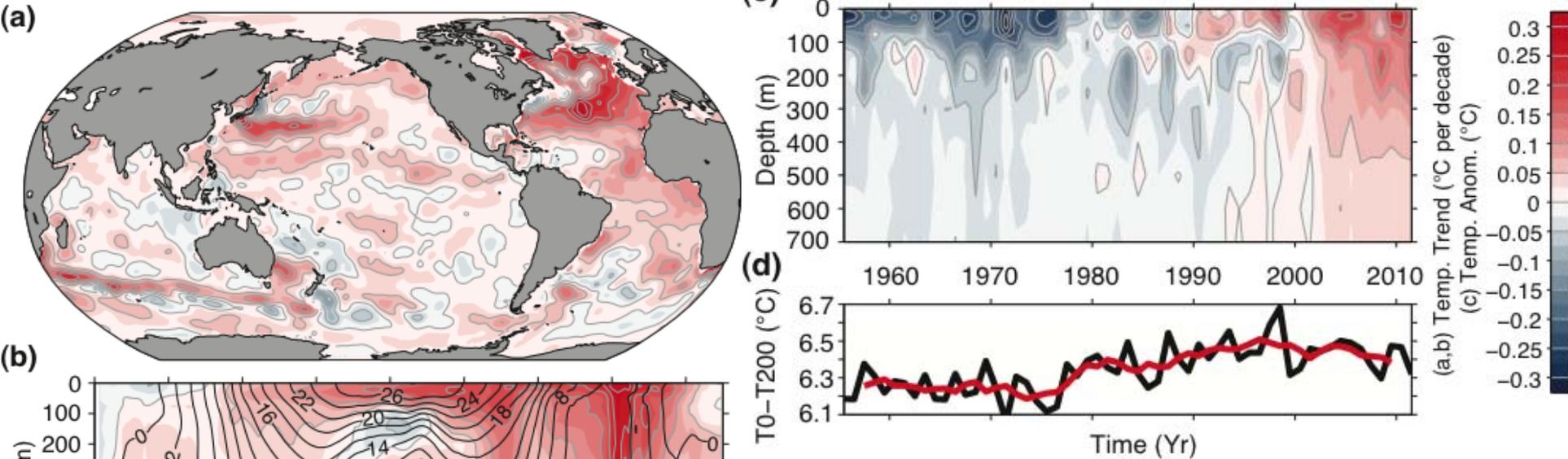


Figure 3.01

a) Depth-averaged 0–700 m temperature trend for 1971–2010 (in °C per decade). **b)** Zonally-averaged temperature trends (in °C per decade) for 1971–2010 **c)** Globally-averaged temperature anomaly. **d)** Globally-averaged temperature difference between the ocean surface and 200-m depth.

On a global scale, the ocean warming is largest near the surface, and the upper 75 m warmed by 0.11 [0.09 to 0.13]¹ °C per decade over the period 1971–2010.

¹ uncertainty range in brackets is 90% confidence interval

(a)

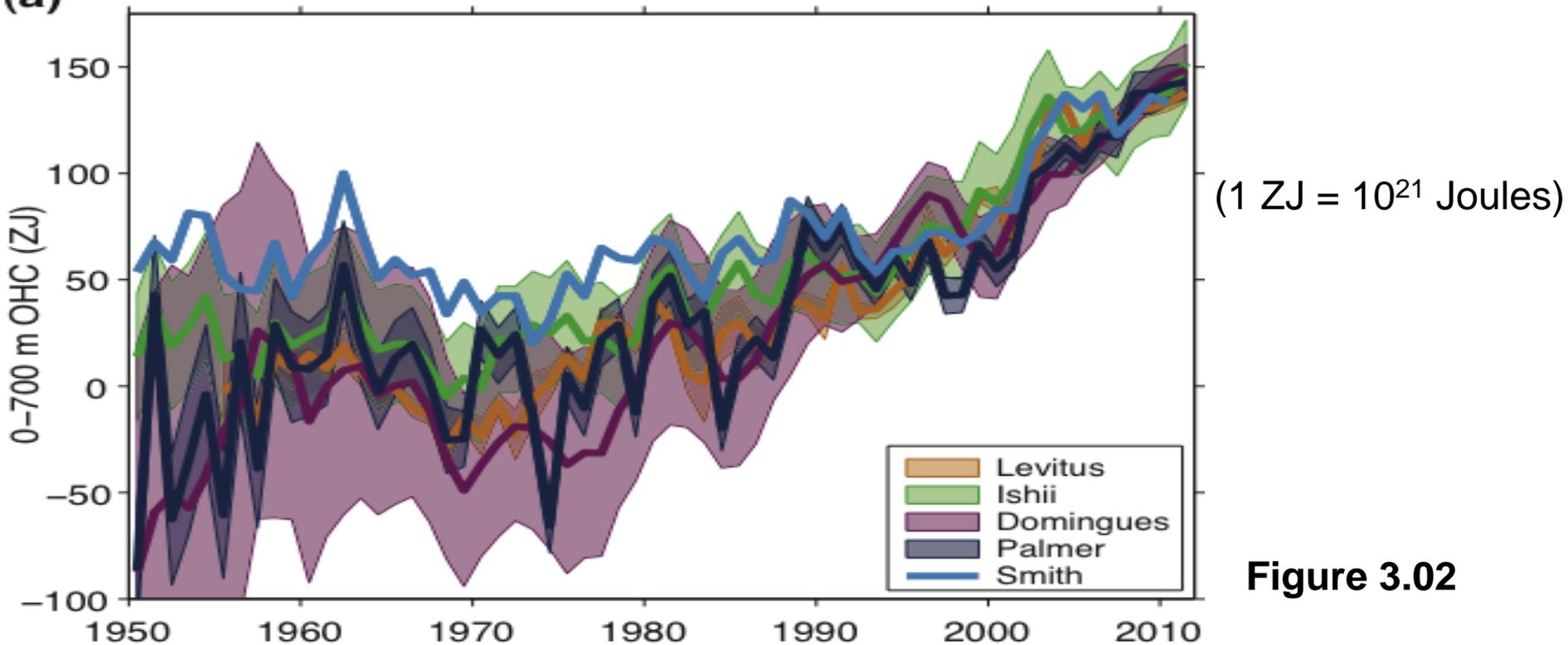


Figure 3.02

It is *virtually certain*¹ that the upper ocean (above 700 m) has warmed from 1971 to 2010, and *likely* that it has warmed from the 1870s to 1971.

¹ Virtually certain 99-100% probability, Very likely 90-100%, Likely 66-100%,

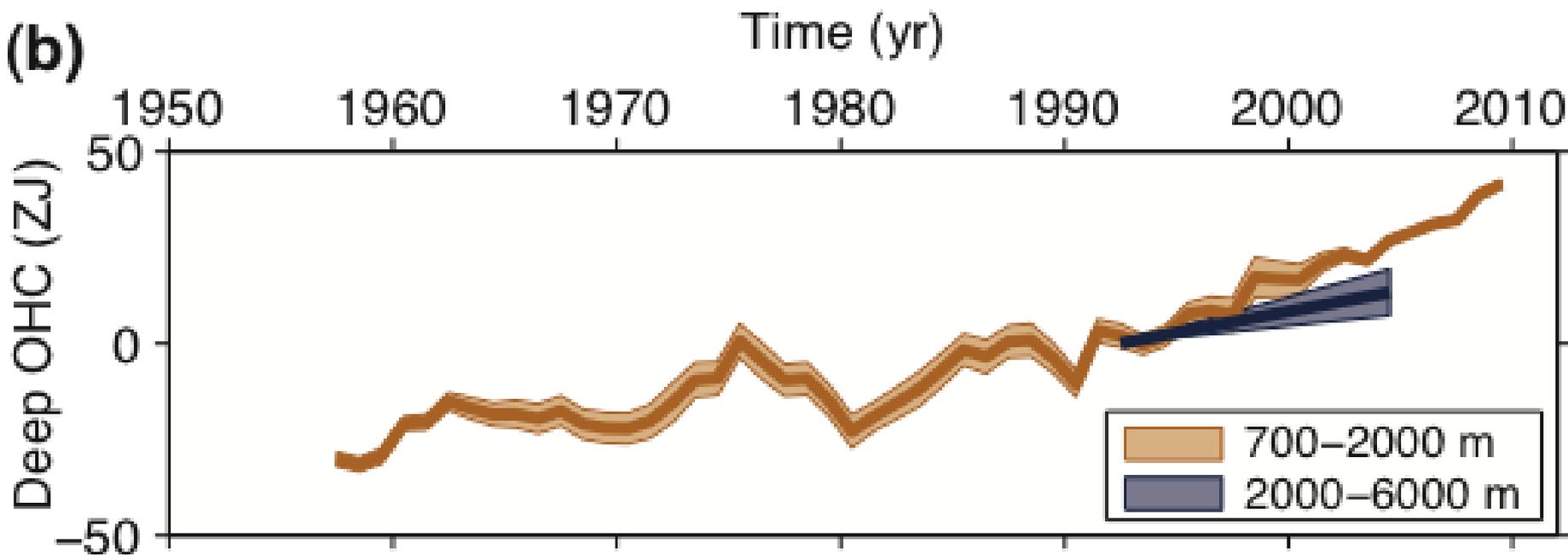
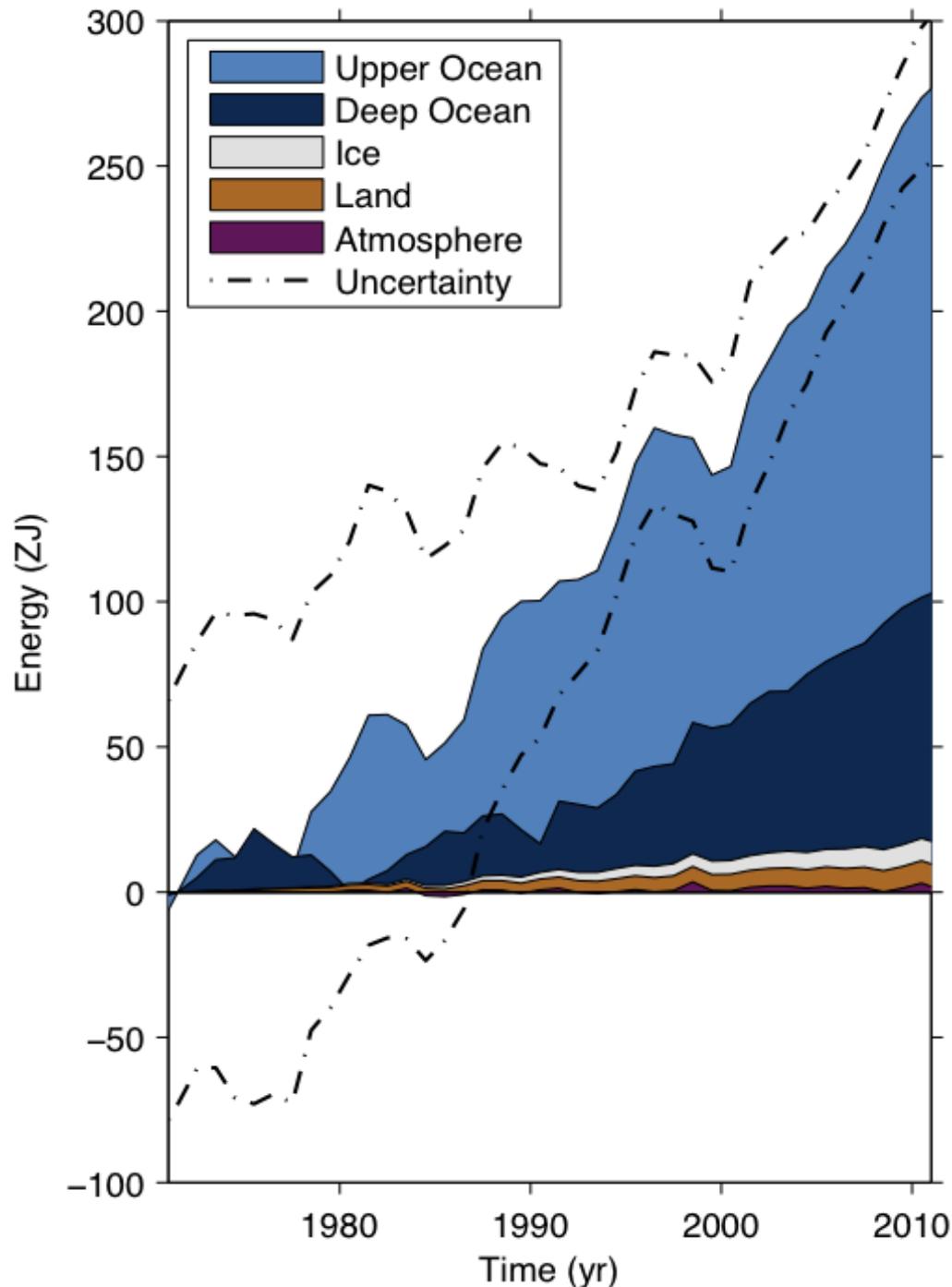


Figure 3.02

It is *likely* that the ocean warmed between 700 and 2000 m from 1957 to 2009. Sufficient observations are available for the period 1992 to 2005 for a global assessment of temperature change below 2000 m. It is *likely* that the ocean warmed from 3000 m to the bottom for this period.



Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2010 (*high confidence*).

Box 3.1

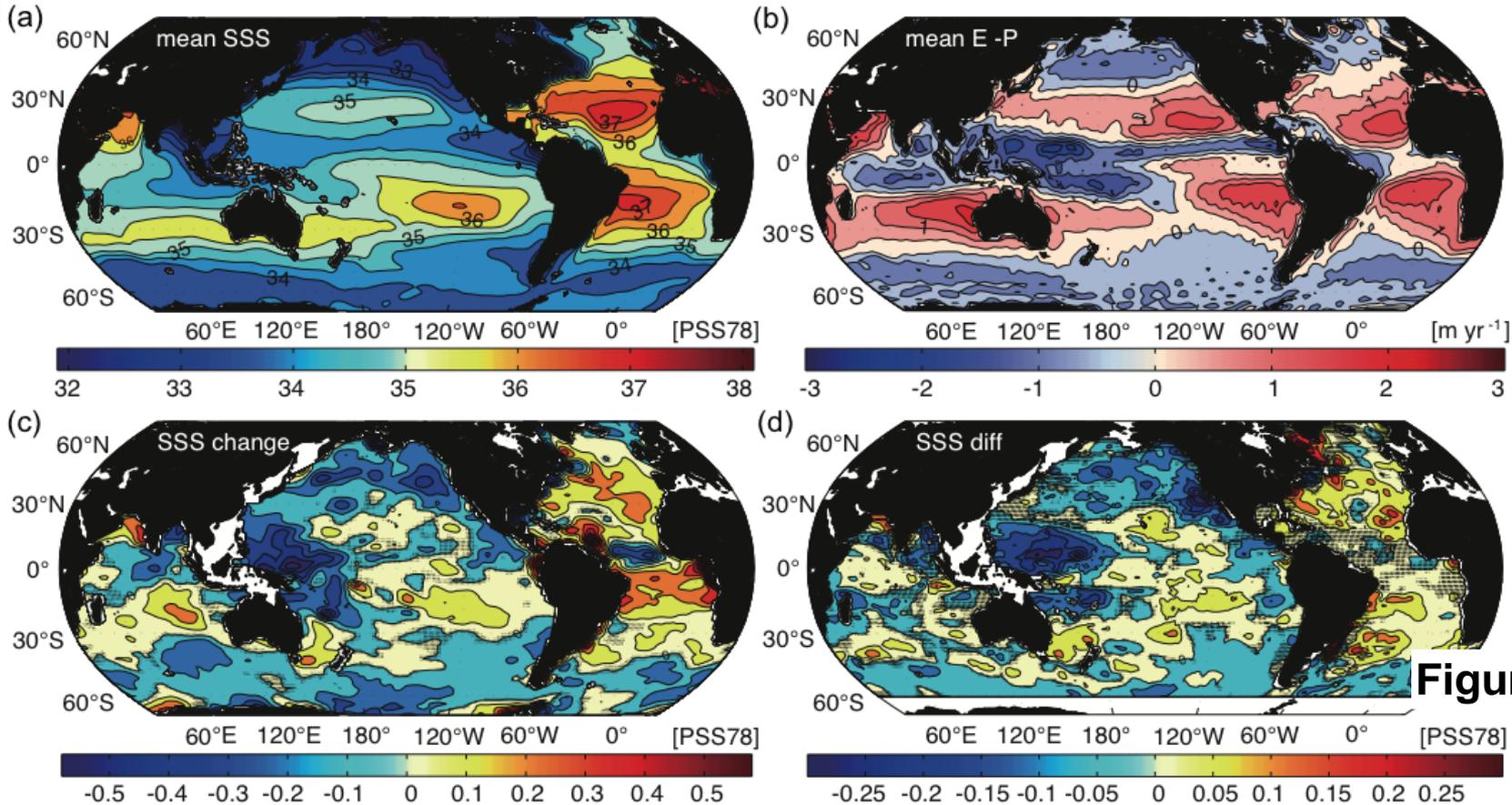


Figure 3.04

From 58-year trend of Durack and Wijffels (2010)

2003-2007 minus 1960-1989 averages (Hosoda et al., 2009)

It is *very likely* that regions of high salinity where evaporation dominates have become more saline, while regions of low salinity where precipitation dominates have become fresher since the 1950s. These regional trends in ocean salinity provide indirect evidence that evaporation and precipitation over the oceans have changed (*medium confidence*).

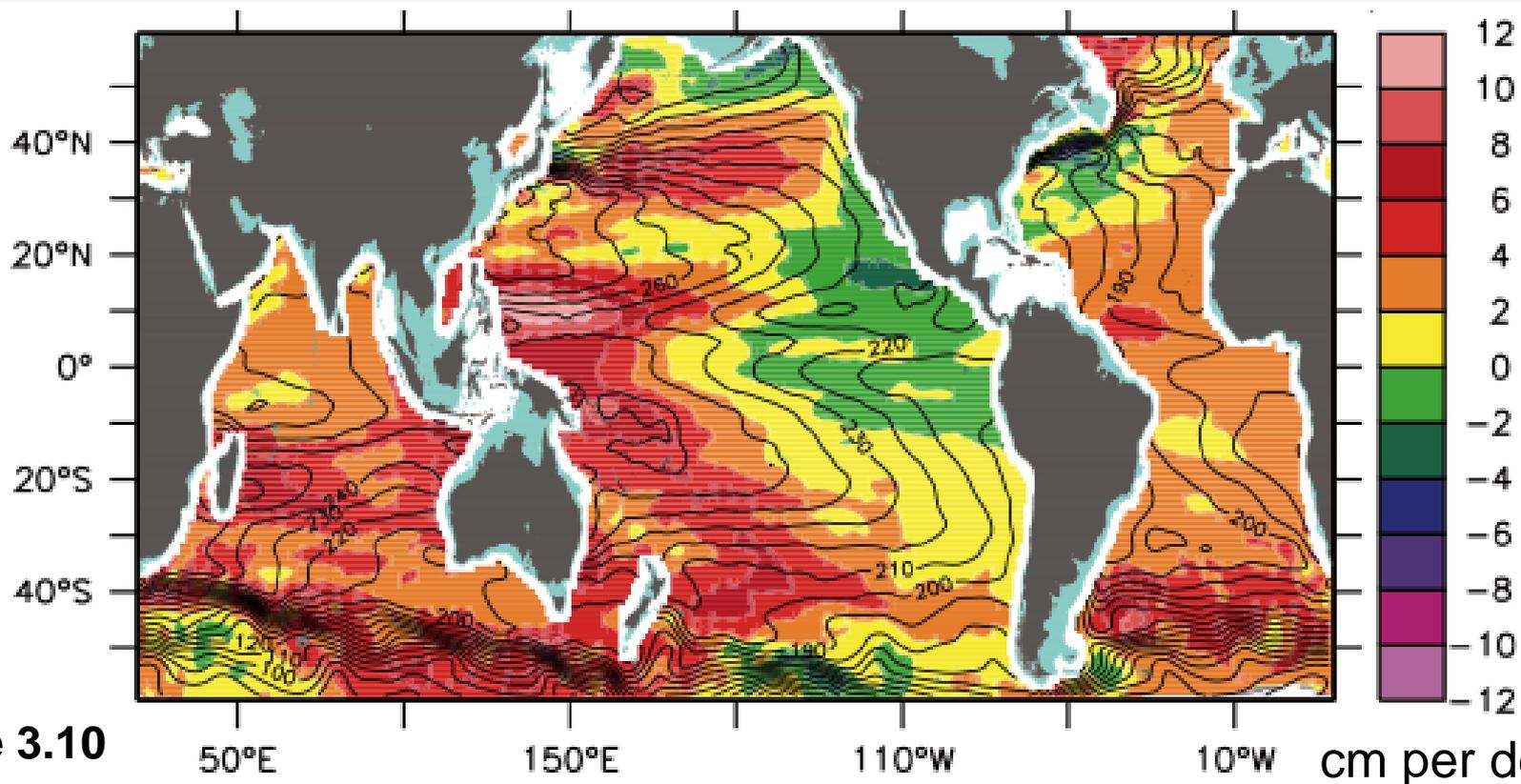
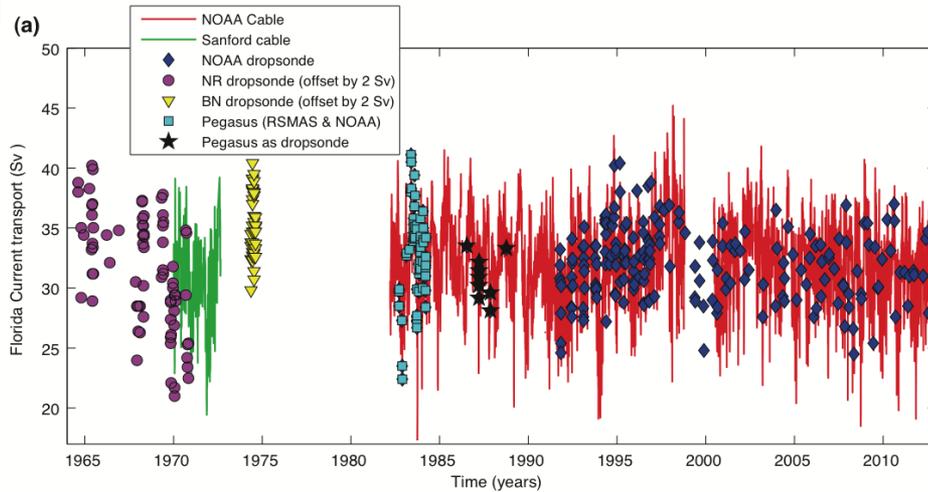


Figure 3.10

cm per decade

Recent observations have strengthened evidence for variability in major ocean circulation systems on time scales from years to decades. It is *very likely* that the subtropical gyres in the North and South Pacific have expanded and strengthened since 1993.



$$1 \text{ Sv} = 10^6 \text{ m}^3 \text{ s}^{-1}$$

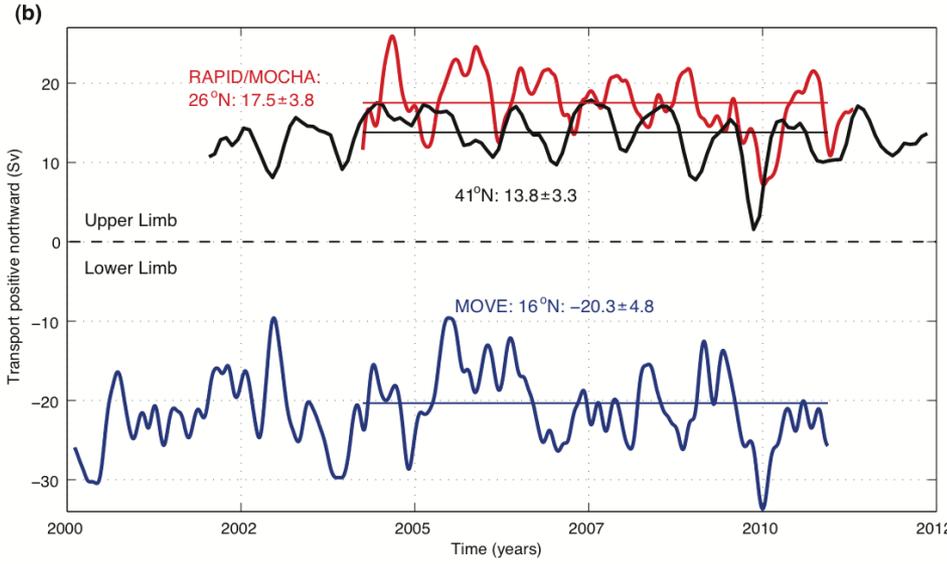


Figure 3.11

There is no observational evidence of a trend in the Atlantic Meridional Overturning Circulation (AMOC), based on the decade-long record of the complete AMOC and longer records of individual AMOC components.

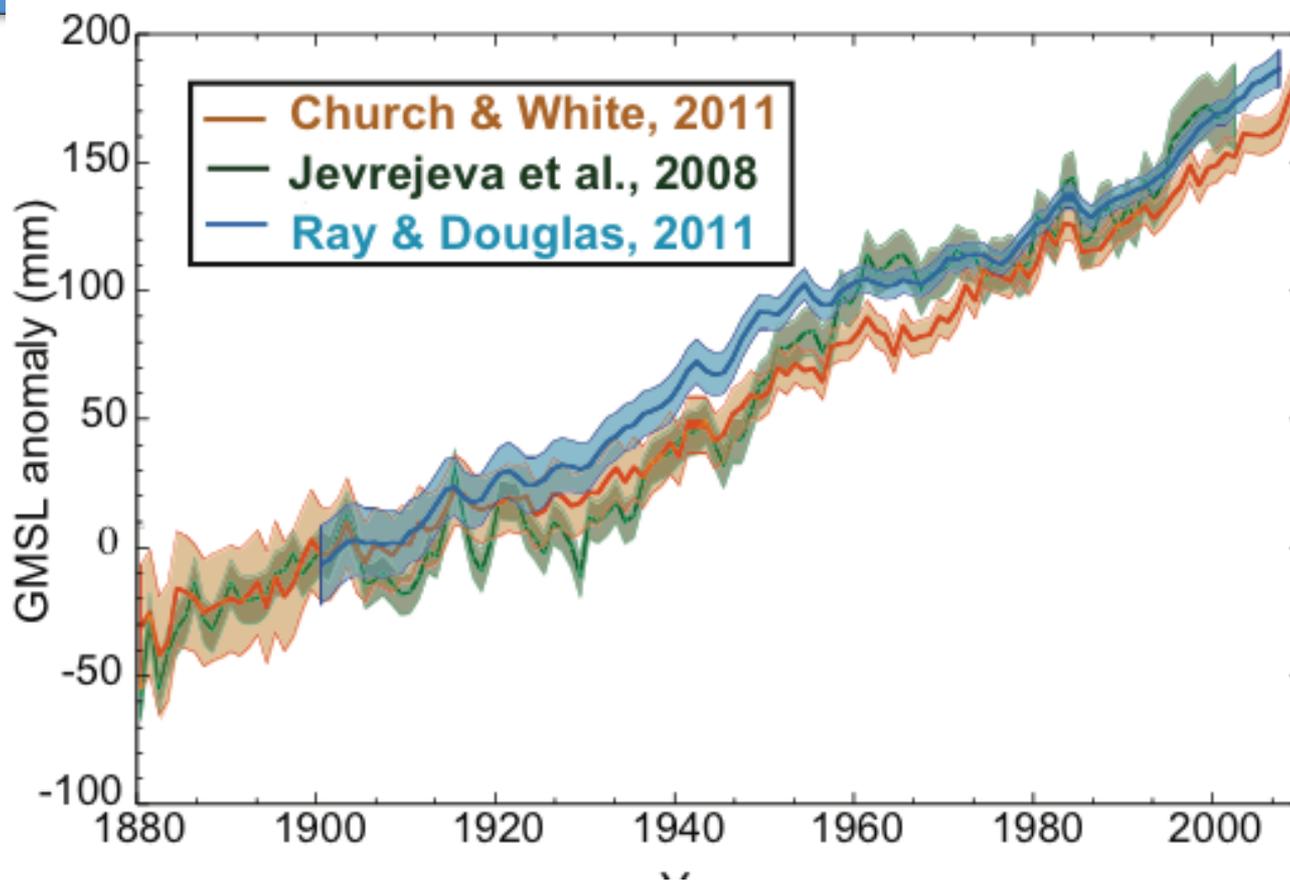


Figure 3.13

Global mean sea level (GMSL) has risen by 0.19 [0.17-0.21] m over the period 1901-2010. It is *very likely* that the mean rate was 1.7 [1.5 to 1.9] mm yr⁻¹ between 1901 and 2010 and increased to 3.2 [2.8 to 3.6] mm yr⁻¹ between 1993 and 2010.

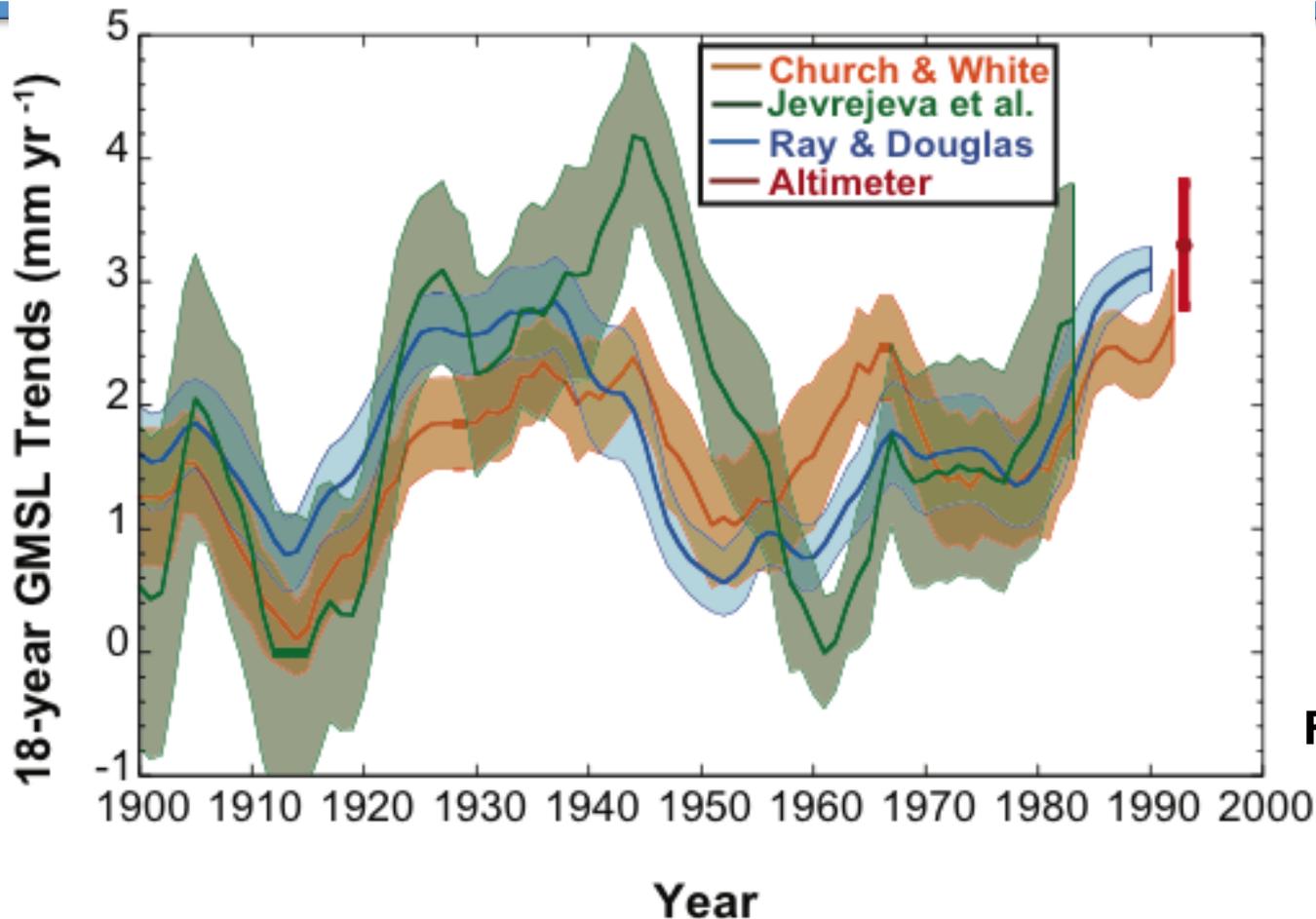


Figure 3.14

It is *likely* that GMST rose between 1920 and 1950 at a rate comparable to that observed between 1993 and 2010, as individual tide gauges around the world and reconstructions of GMST show increased rates of sea level rise during this period.

Figure 3.18

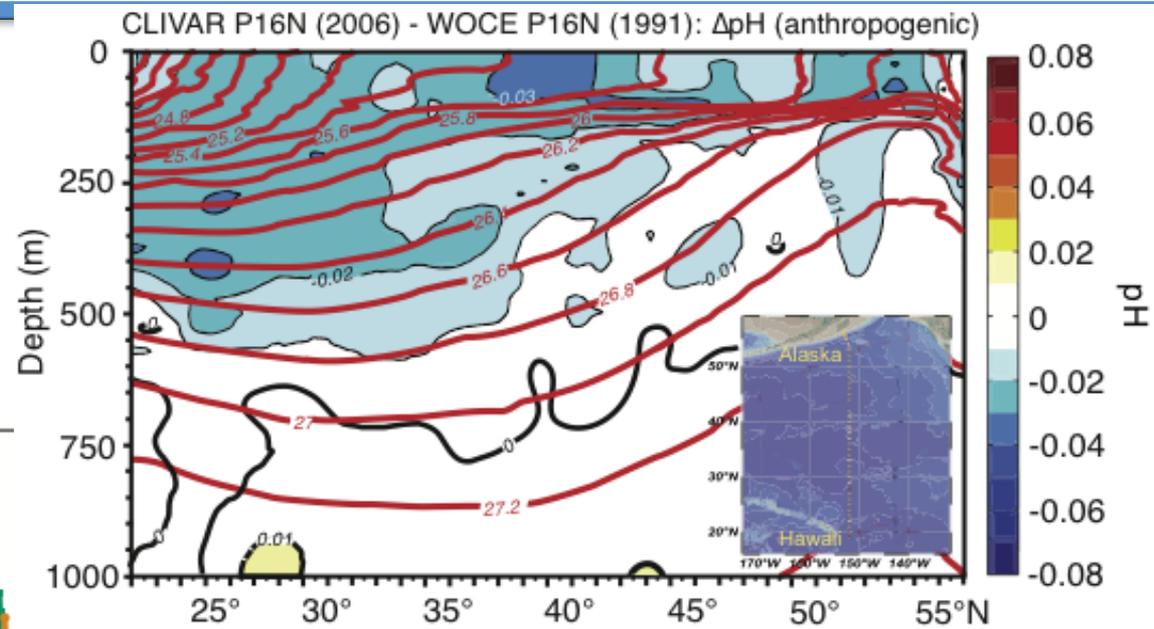
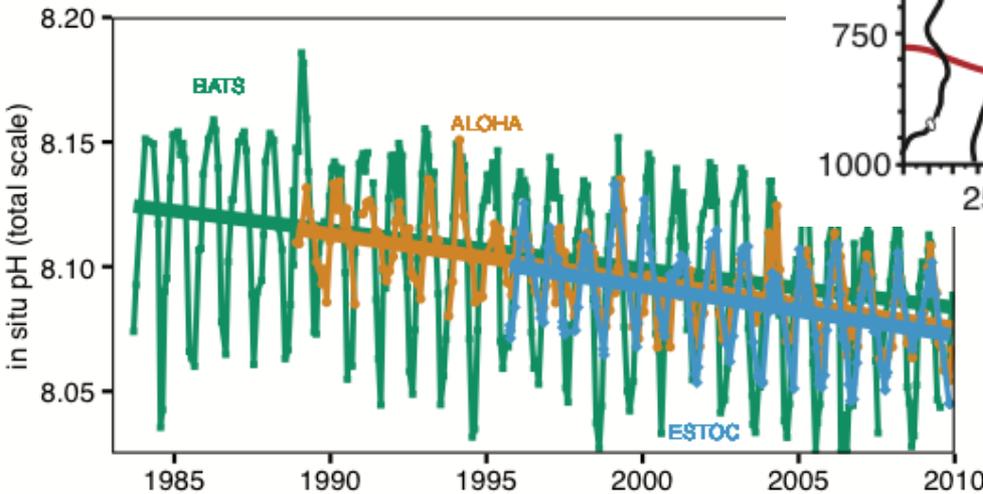


Figure 3.19

The ocean has absorbed about 30% of the emitted anthropogenic carbon dioxide, causing ocean acidification. Ocean acidification is quantified by decreases in pH. The pH of ocean surface water has decreased by 0.1 since the beginning of the industrial era (*high confidence*).

Abyss warms, coasts flood
Air moistens – salt patterns shift
Carbon sours oceans

Gregory C. Johnson

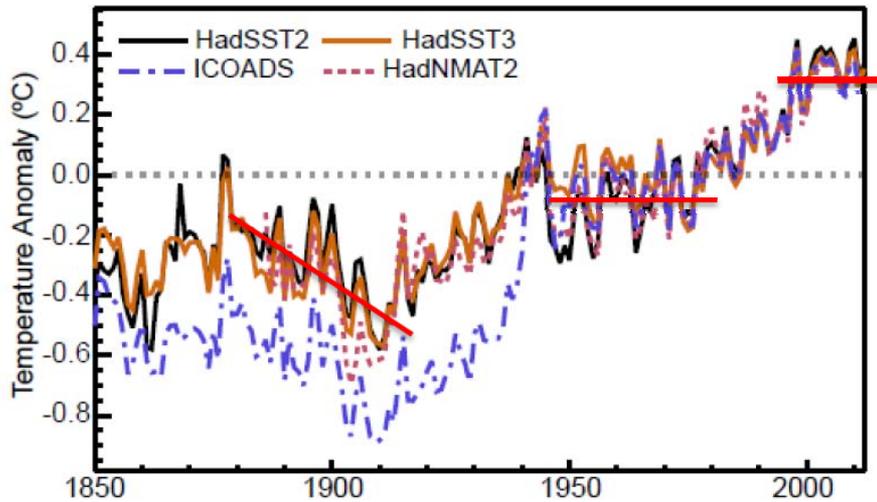
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Further Information
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SST



Heat Storage

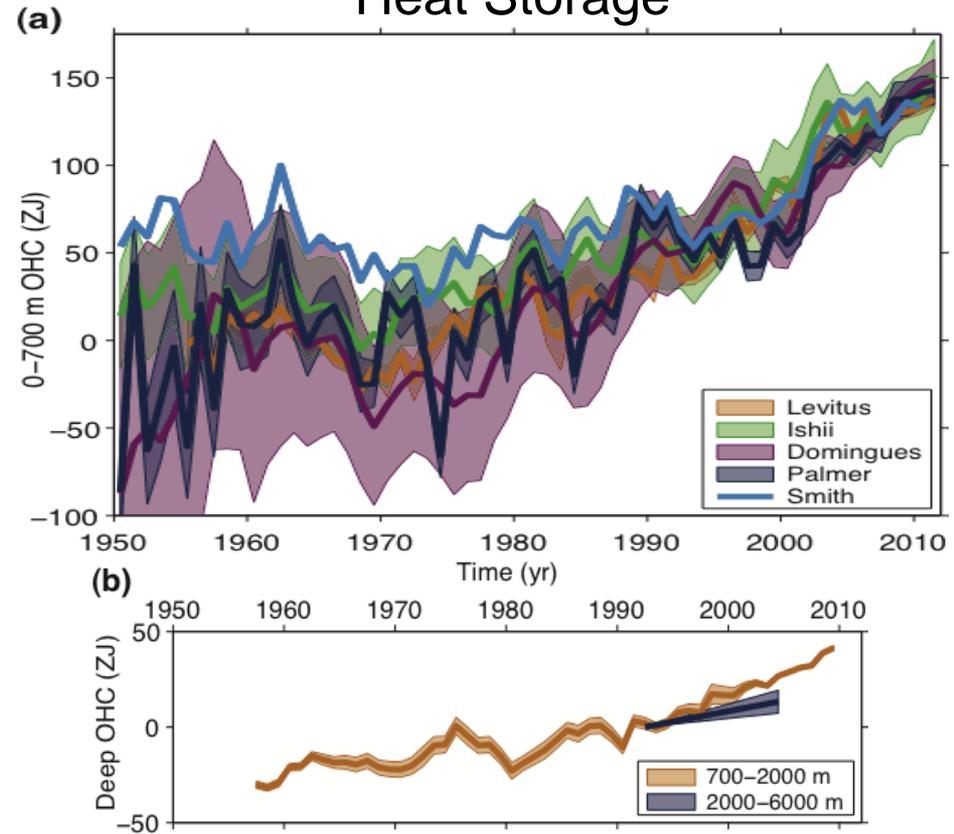


Figure 2.16

Has been considerable discussion in the blogosphere recently about the so-called hiatus in warming for the last 15 years.

Only observed robustly in SST and it's not unprecedented in the record.

From the Summary for Policymakers

In addition to robust multi-decadal warming, global mean surface temperature exhibits substantial decadal and interannual variability (see Figure SPM.1). Due to natural variability, trends based on short records are very sensitive to the beginning and end dates and do not in general reflect long-term climate trends.

And later:

The observed reduction in surface warming trend over the period 1998–2012 as compared to the period 1951–2012, is due in roughly equal measure to a reduced trend in radiative forcing and a cooling contribution from internal variability, which includes a possible redistribution of heat within the ocean (medium confidence). The reduced trend in radiative forcing is primarily due to volcanic eruptions and the timing of the downward phase of the 11-year solar cycle.