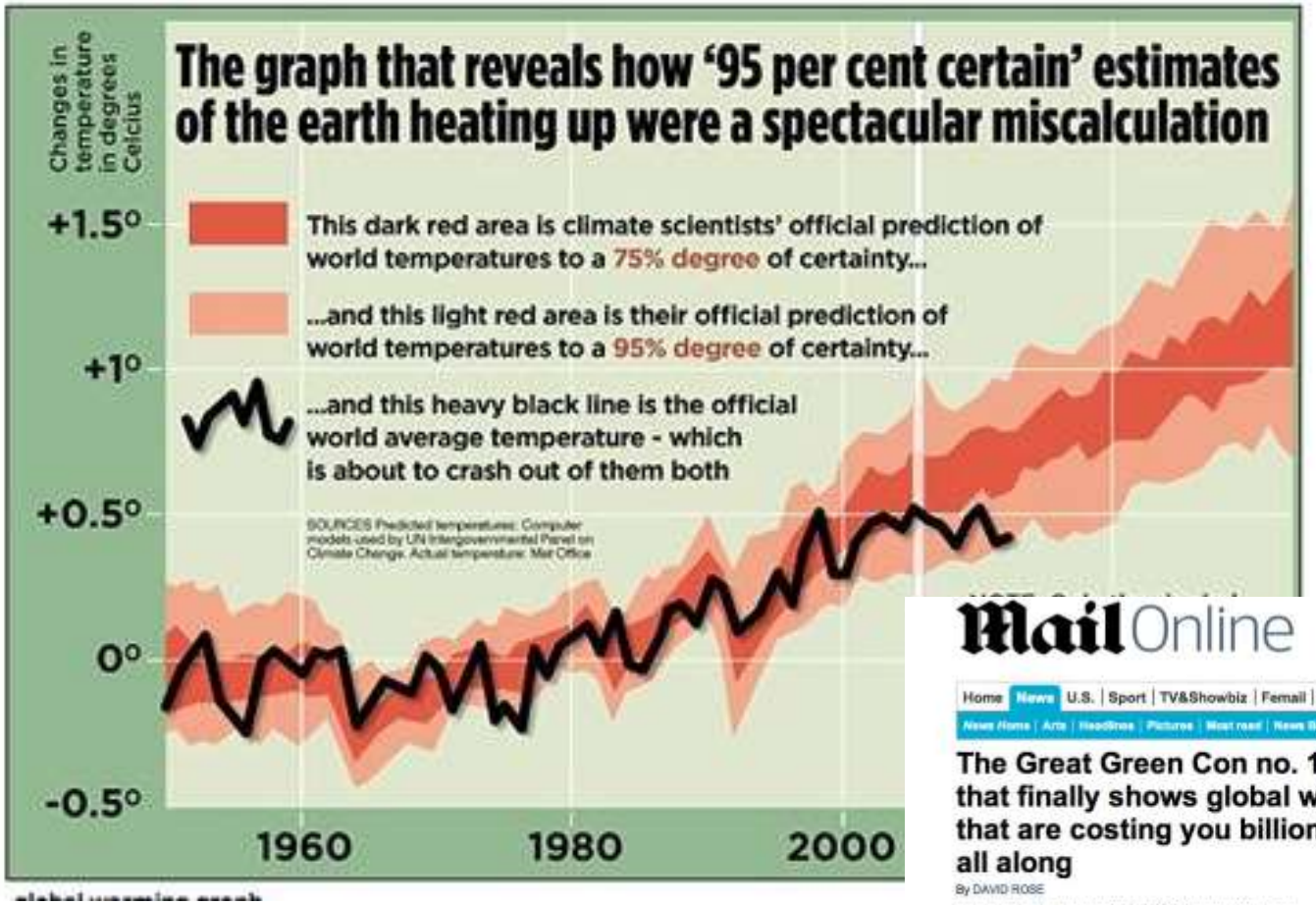
An update on the hiatus in global warming at Earth's surface

Richard Allan

WCD, Friday 13th March 2015

Has global warming stopped?

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The Great Green Con no. 1: The hard proof that finally shows global warming forecasts that are costing you billions were WRONG all along

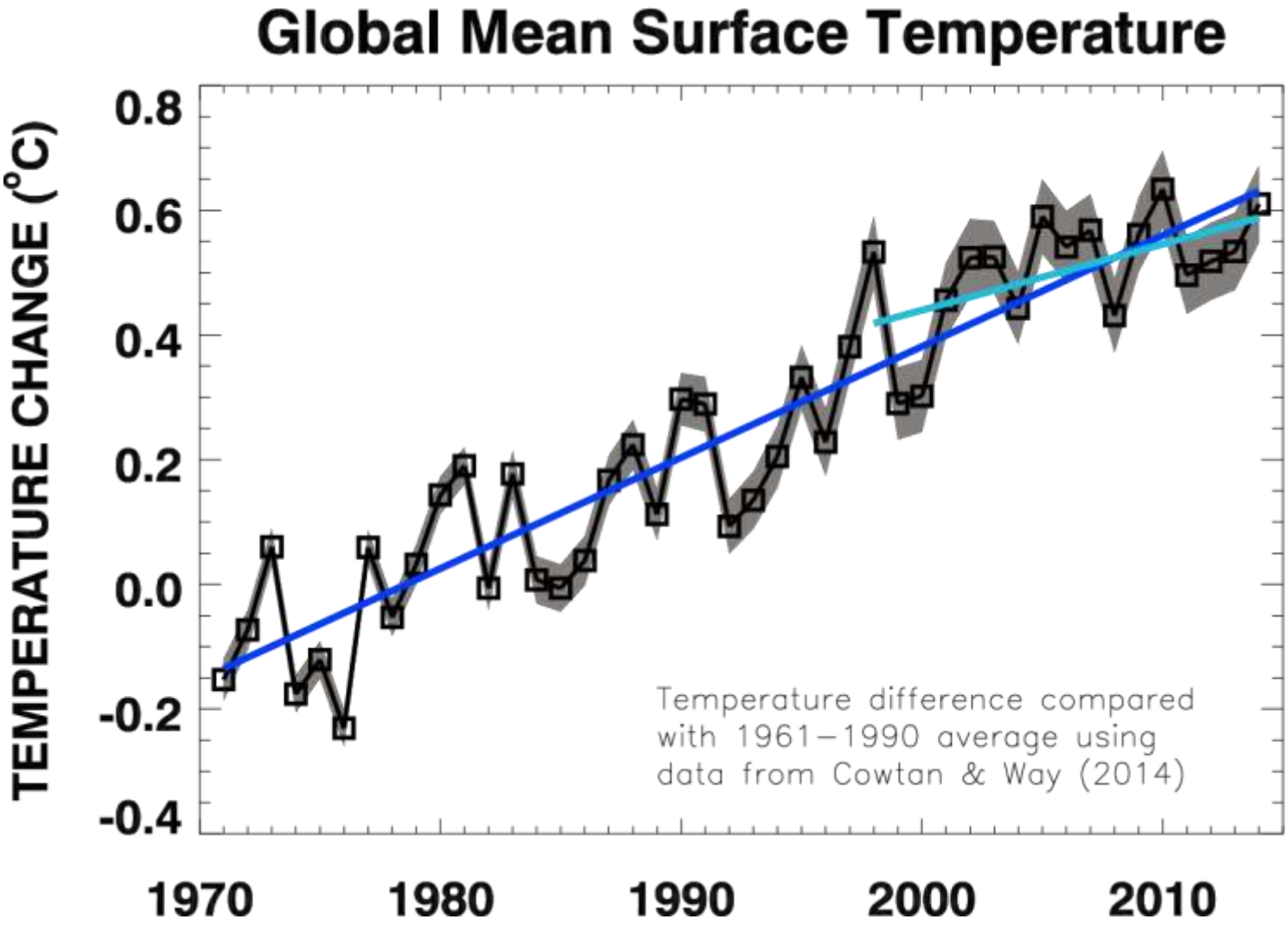
By DAVID ROSE

PUBLISHED: 23:37, 16 March 2013 | UPDATED: 13:41, 18 March 2013

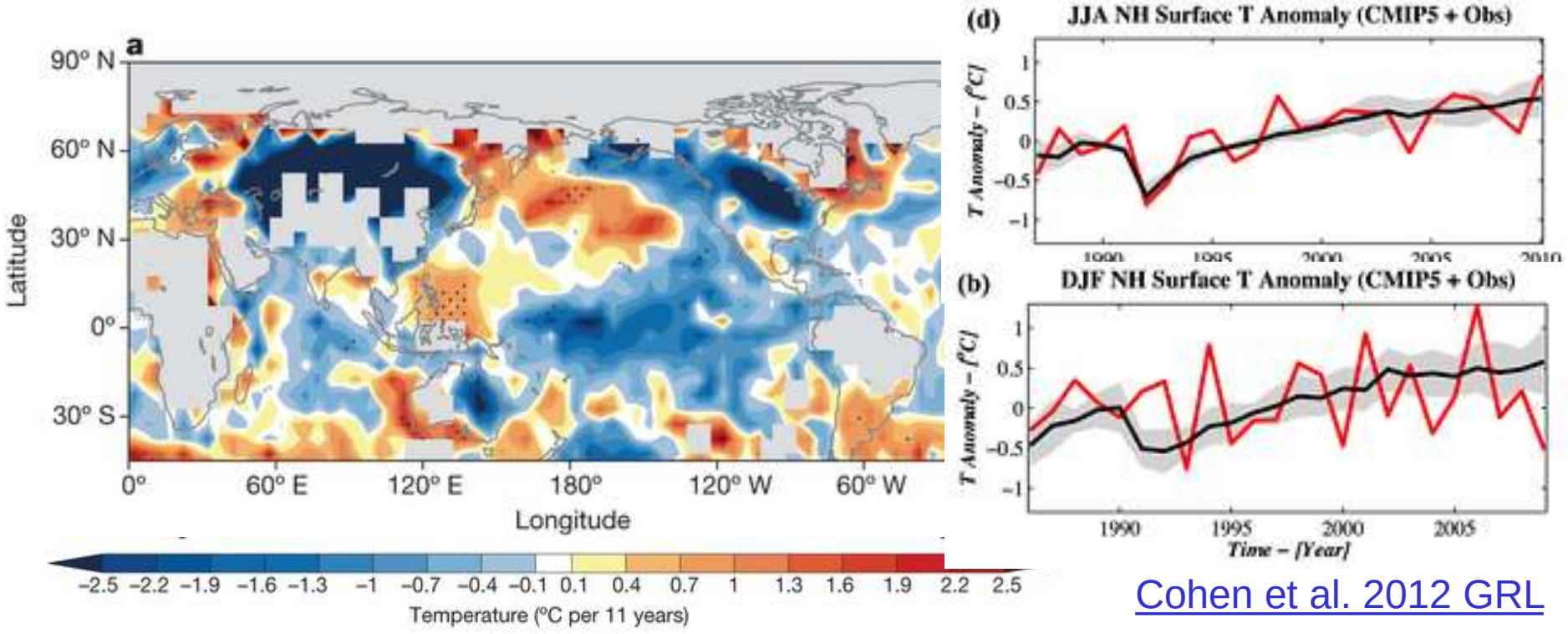
No, the world ISN'T getting warmer (as you may have noticed). Now we reveal the official data that's making scientists suddenly change their minds about climate doom. So will eco-funded MPs stop waging a green crusade with your money? Well... what do YOU think?

[Mail on Sunday 16th March 2013]

What hiatus?

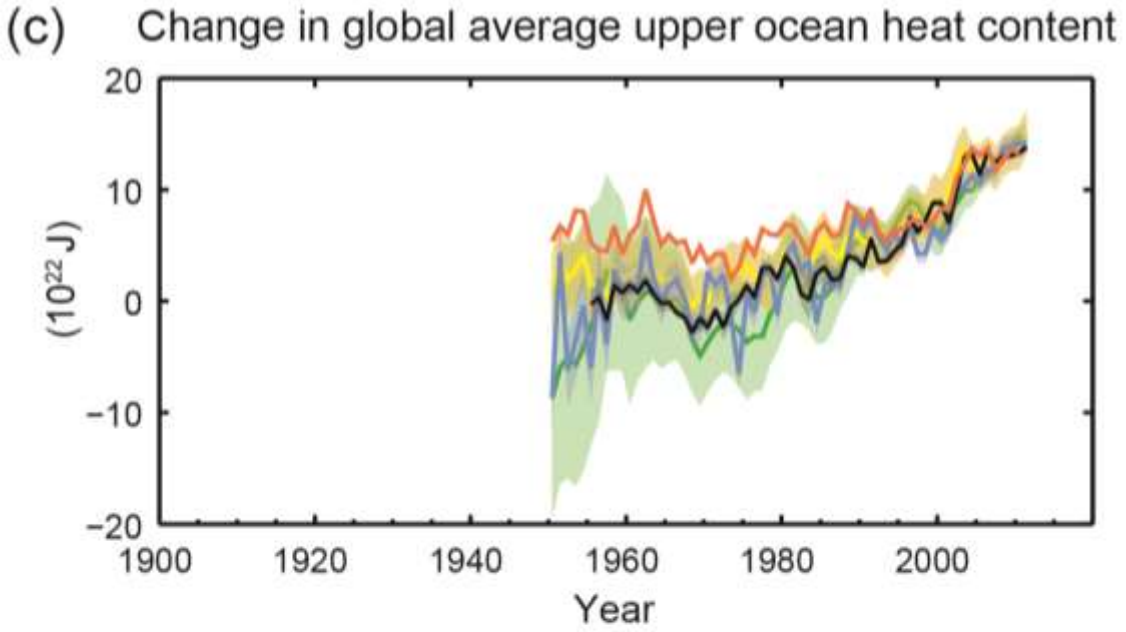

Global Mean Surface Temperature
TEMPERATURE CHANGE (°C)
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
1970
1980
1990
2000
2010
Temperature difference compared with 1961–1990 average using data from Cowtan & Way (2014)

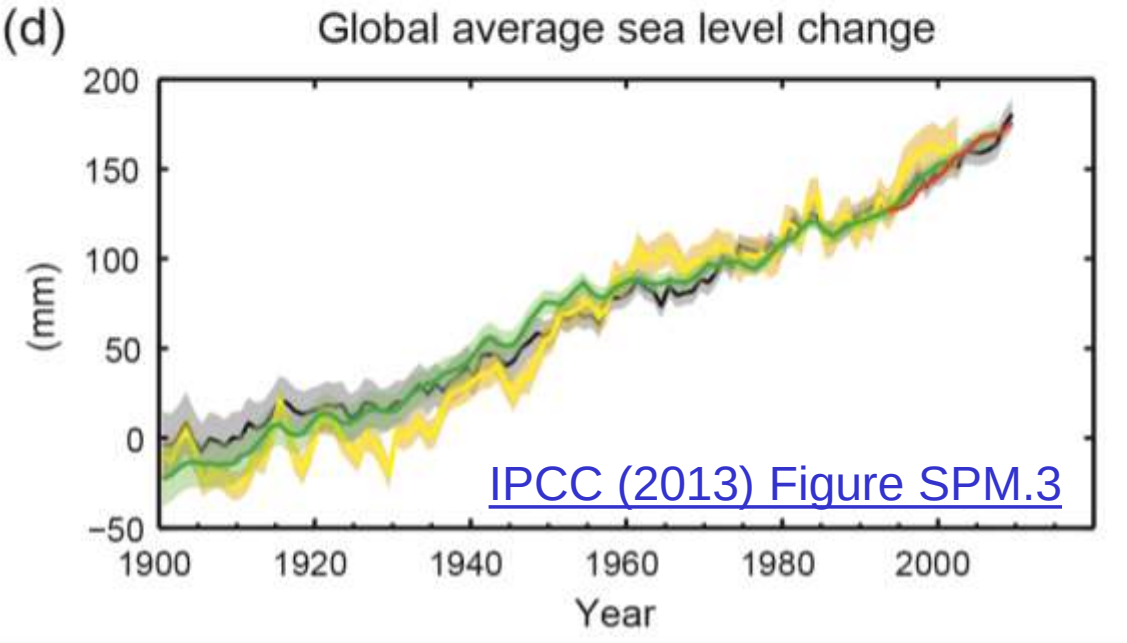
Morphology: The hiatus has a low latitude signal (Gleisner et al. 2015 GRL) but also in northern winter over land (Cohen et al. 2012 GRL) although data gaps are important (Cowtan and Way 2013 QJRMetS; Saffioti et al. 2015 GRL)



Cohen et al. 2012 GRL

Observed trends in DJF near surface temperature, 2002-2012: **Kosaka and Xie (2013) Nature**



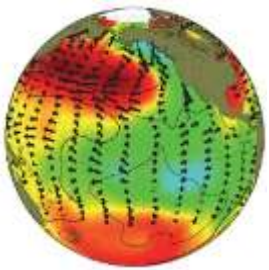


The oceans are continuing to heat up and sea-levels continue to rise

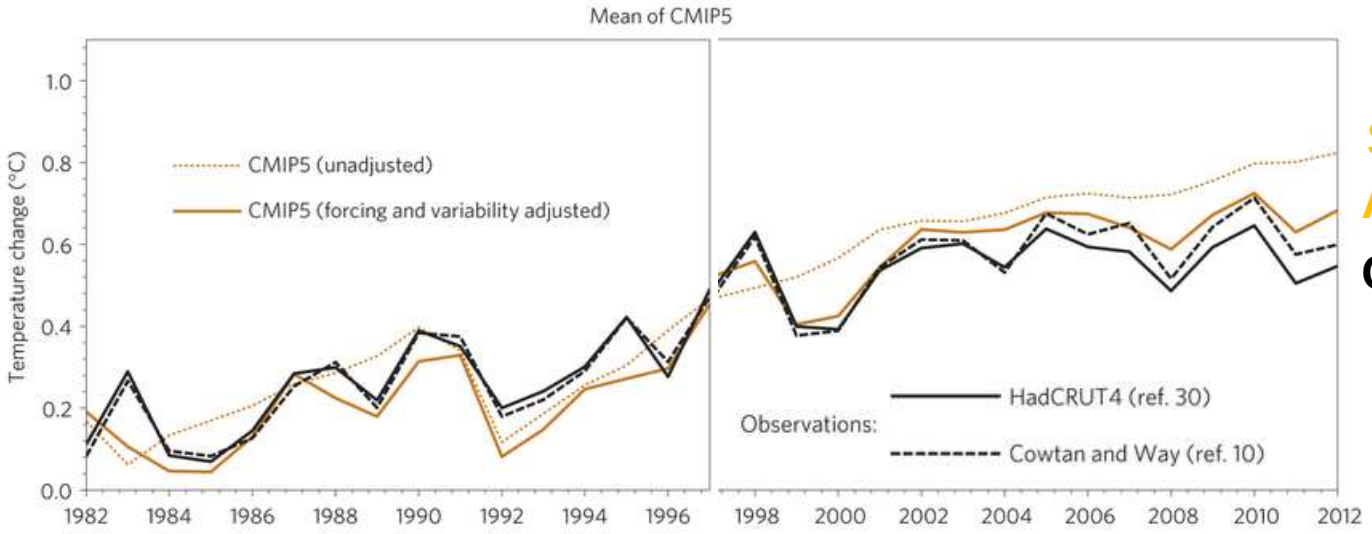
The Earth continues to gain heat (e.g. Loeb et al. (2012) Nat. Geosci.; Allan et al. (2014) GRL ; Roemmich et al. (2015) Nature Climate Change)

So why has rise in surface temperature rise slowed?

What explains the hiatus



- Declining solar forcing (e.g. Hansen et al. 2013 PLOSONE) , more small volcanos (e.g. Ridley et al. 2014 GRL) & more La Niñas/cold NH land in winter vs late 1990s appear to explain:
  - Slowing in surface warming (e.g. Foster & Rahmstorf 2012)
  - Slower surface warming compared with coupled simulations (e.g. Risbey et al. 2014 ; Huber & Knutti 2014)



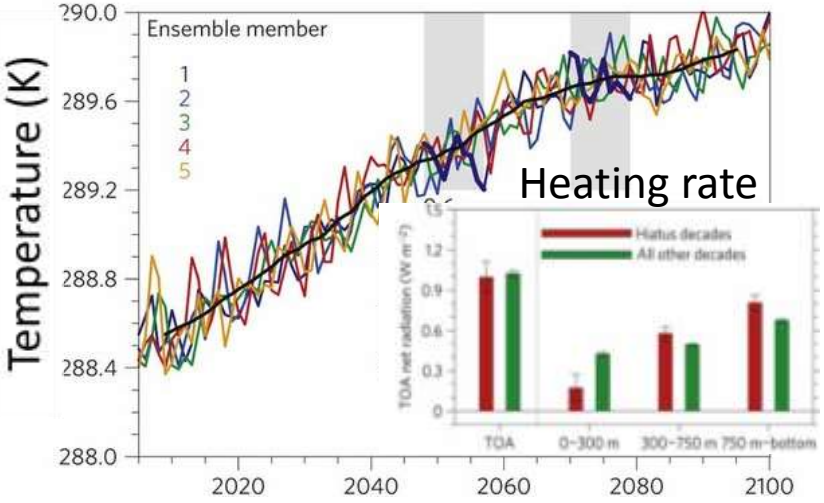
Simulations

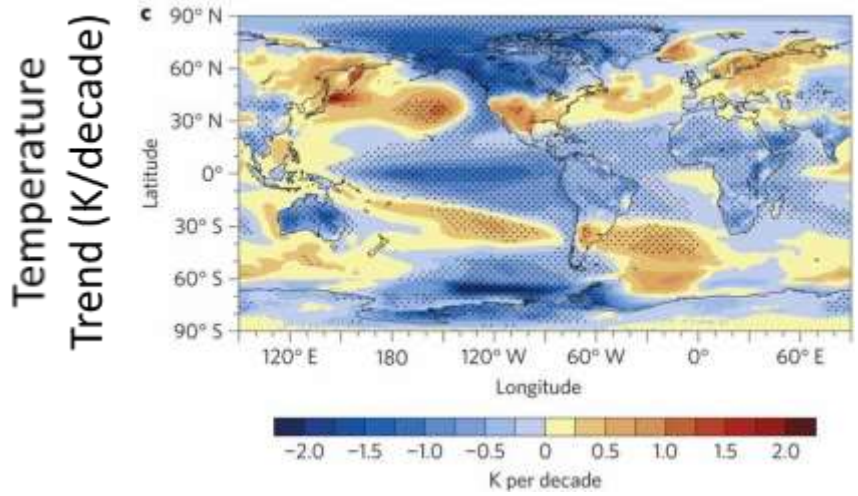
Adjusted Simulations

Observations

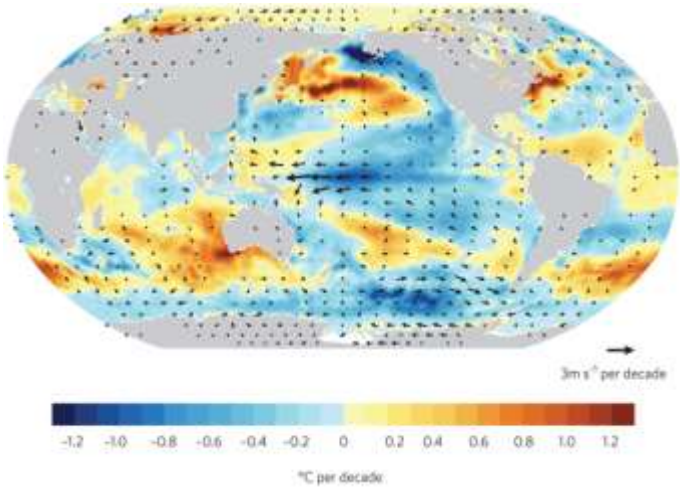
Huber & Knutti 2014

Climate models simulate decades with little surface warming despite CO_2 increases





- Ocean variability causes heat to mix to deeper levels in some decades
- Associated pattern of sea surface temperature trends match current observations

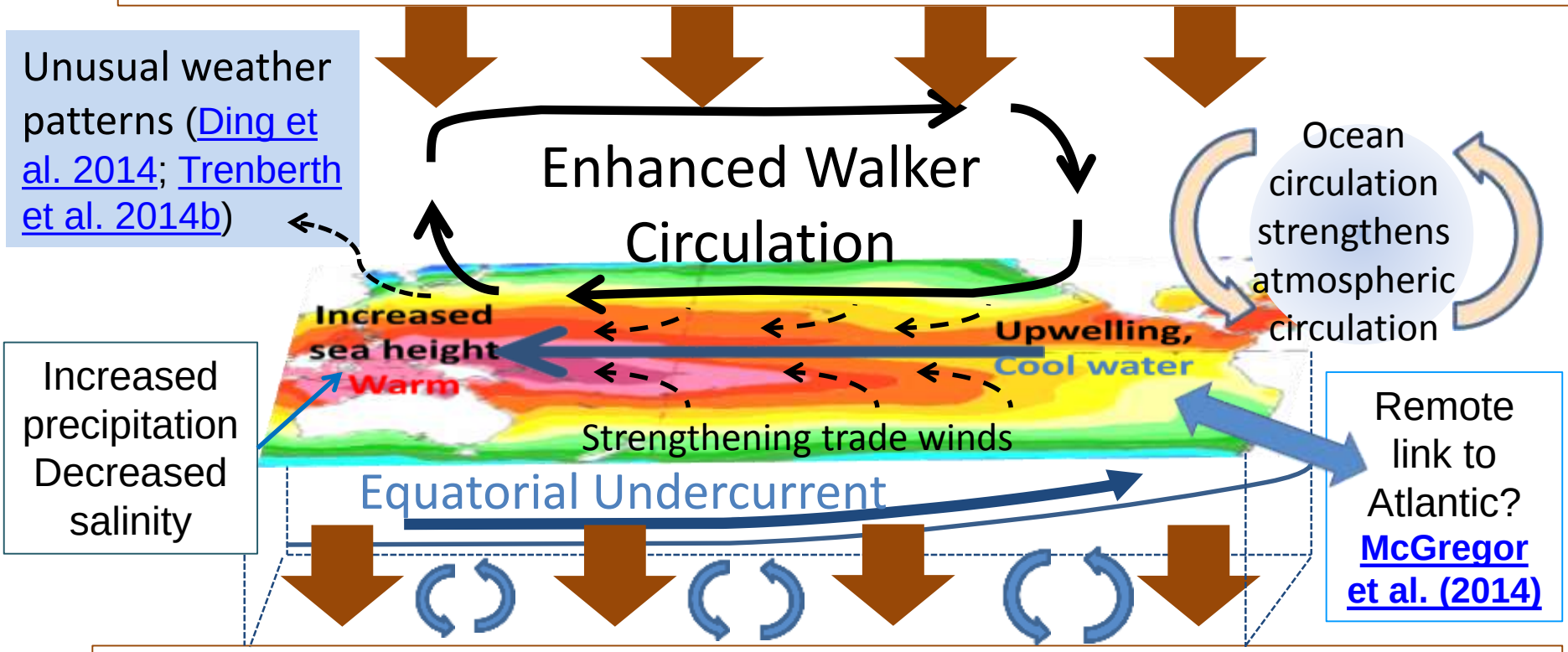


Model (Meehl et al. 2011, 2013)

Observations 2001-2013 (Kosaka 2014)

Role of Pacific Ocean Variability

Continued heating from rising greenhouse gas concentrations



Enhanced mixing of heat below 100 metres depth by accelerating shallow overturning cells and equatorial undercurrent

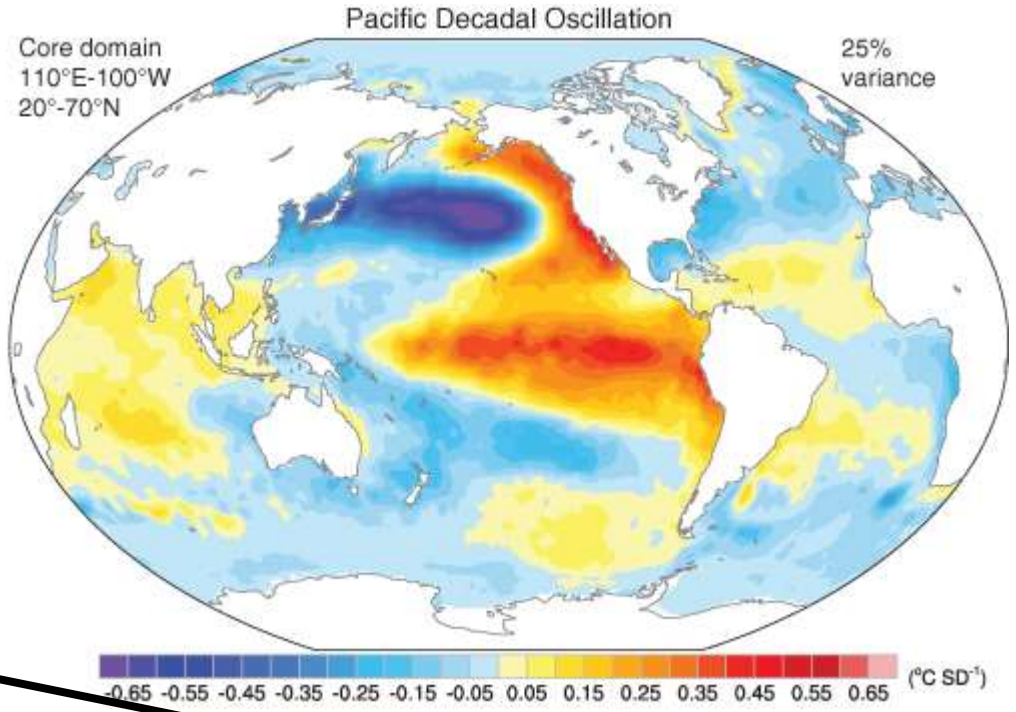
See: Merrifield (2010) J. Clim.; Sohn et al. (2013) Clim. Dyn.; L'Heureux et al. (2013) Nature Clim. Change; Kosaka and Xie (2013) Nature; England et al. (2014) Nature Clim. Change; Watanabe et al. 2014 Nature Clim. Change; Balmaseda et al. (2013) GRL; Trenberth et al. (2014) J. Clim.

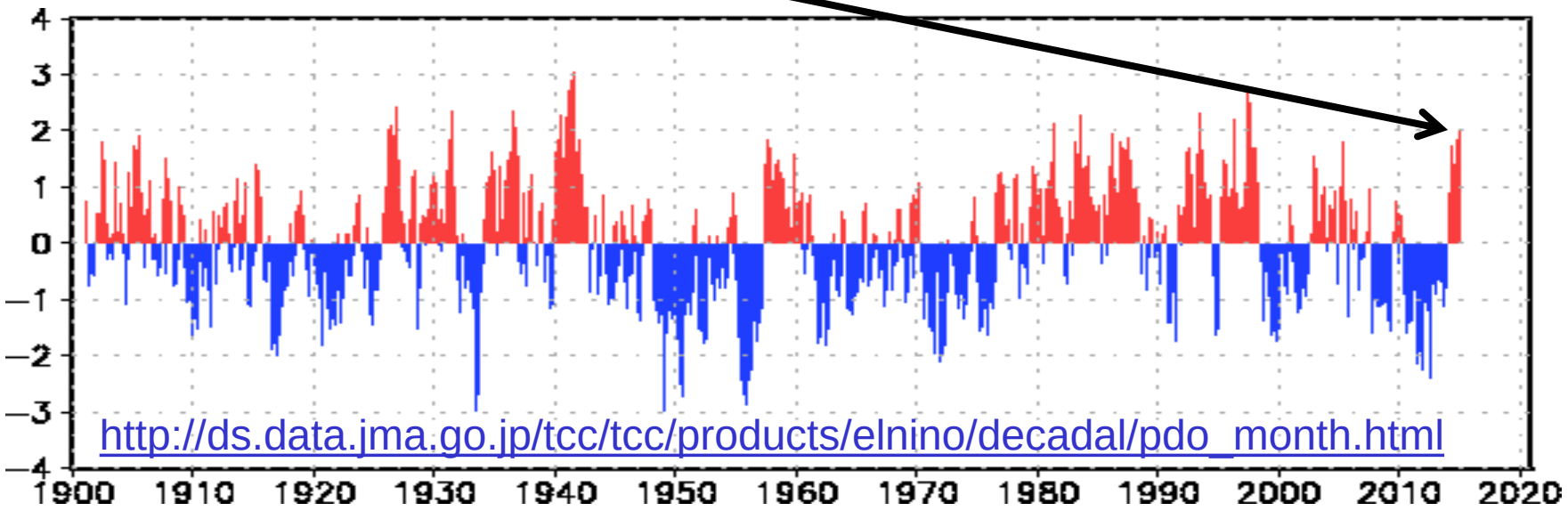
What next?

Trenberth and Fasullo (2013) Earth Futures

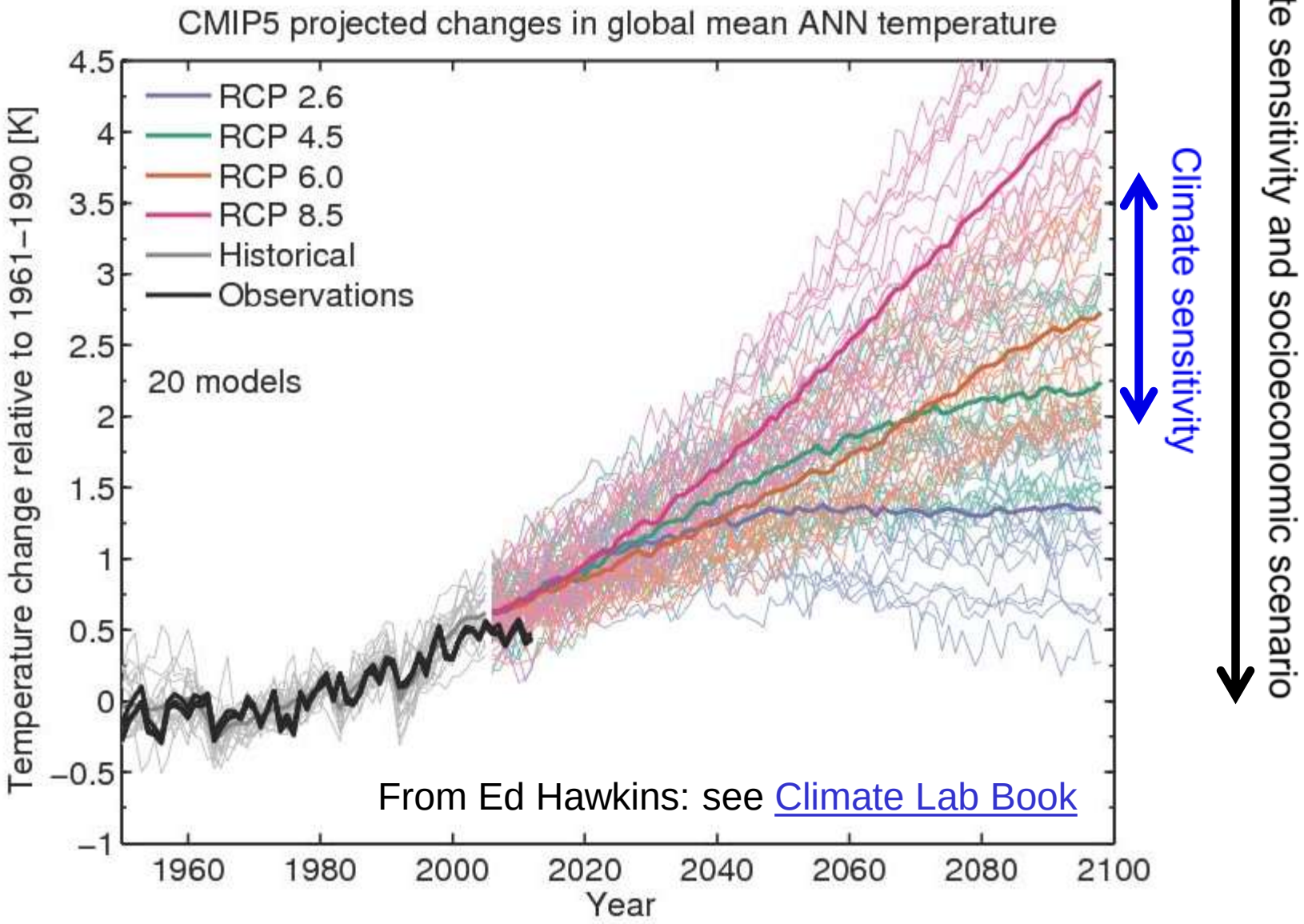
- **Modelling:** 1 in 6 chance of the current surface warming hiatus continuing for another 5 years - Roberts et al. (2015) Nature Climate Change

- **Observations**: Is Pacific Decadal Oscilation (PDO) shifting out of negative phase?





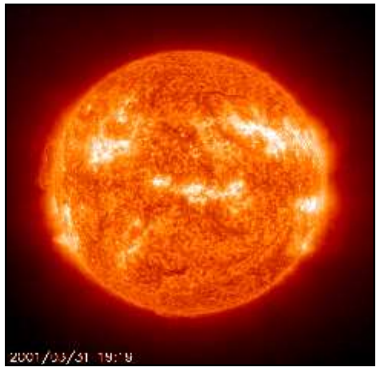
Implications for projections

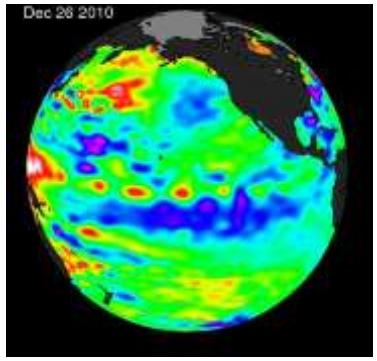


Conclusions

- Heating of Earth continues mainly from rising greenhouse gas concentrations
- A mixture of factors (mostly natural) have offset some of this heating since 2000 (weaker sun, small volcanoes, …)
- More heat currently being mixed below surface ocean layers explaining lack of surface warming. Pacific appears key, but likely also Atlantic/Southern Ocean role.

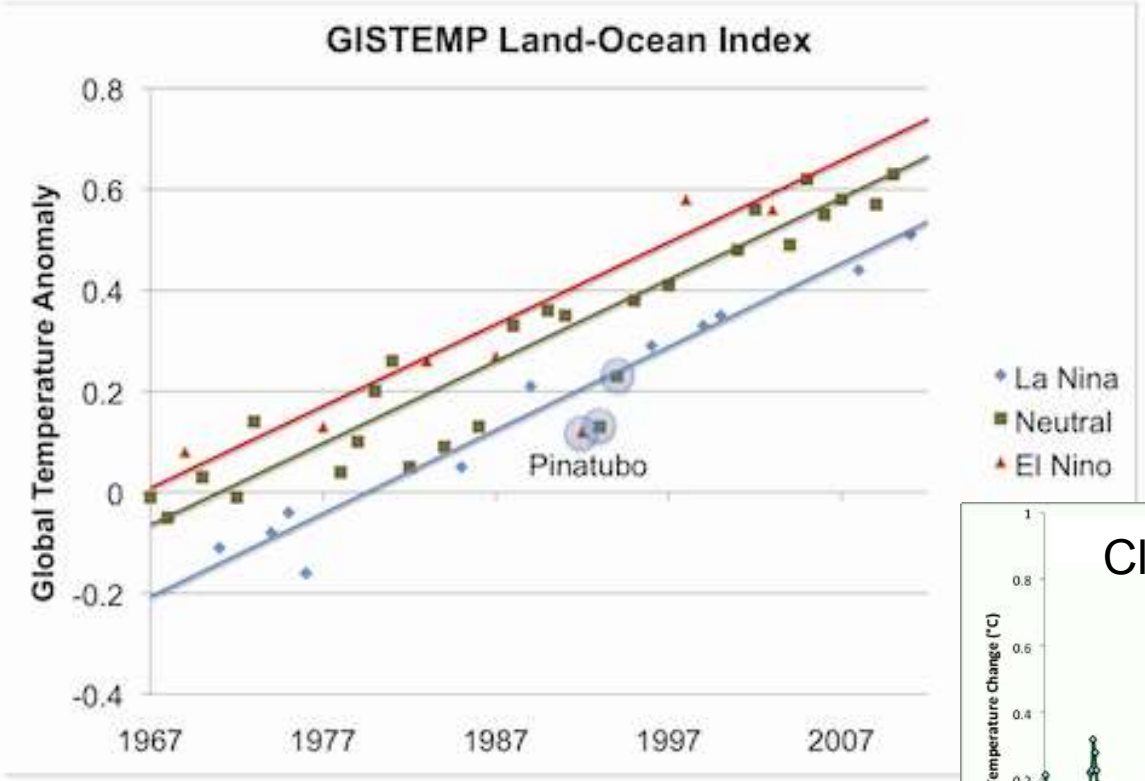
The climate system is complex and will continue to surprise us but the implications of burning fossil fuels are clear… More links on DEEP-C website





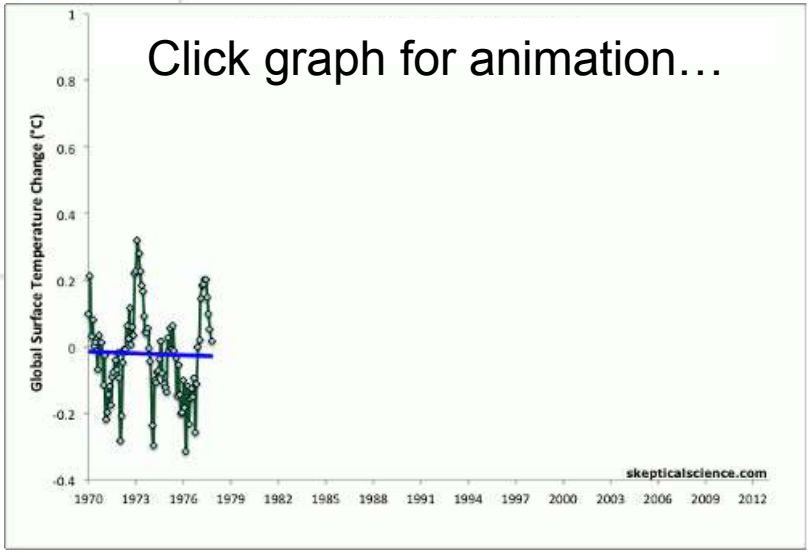
Extra slides

Influence of El Niño and Volcanoes on Surface Temperature Trends

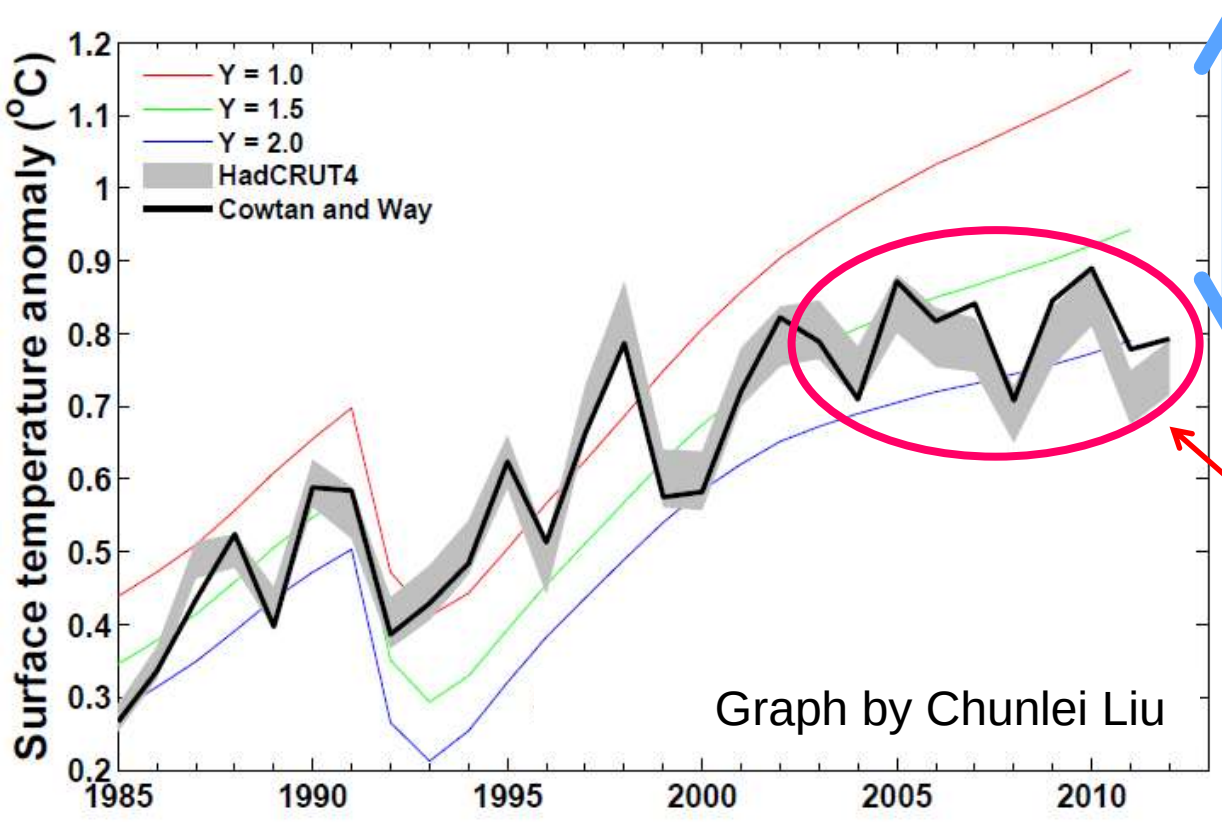


But why have there been more La Niñas recently and hasn't the slowdown in surface warming lasted a long time?

John Nielsen-Gammon, Texas A&M University
see [Foster & Rahmstorf (2012) Environ. Res. Lett.](#).



Is the temperature record wrong or are computer models inaccurate?



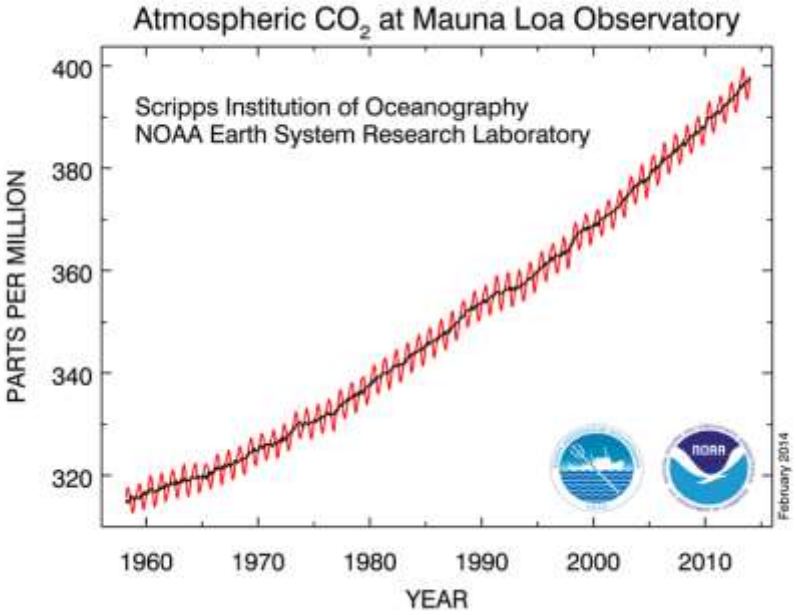
Research in DEEP-C project
(Reading, NOC-Southampton & Met Office)

Can comparisons tell us about how sensitive climate is to radiative forcing? e.g. Otto et al. (2013) Nature Geosci

Spatial infilling of data gaps influences trends in surface temperature (Cowtan & Way, 2013 QJRMS) and ocean heat content (Lyman & Johnson 2014 J. Clim.)

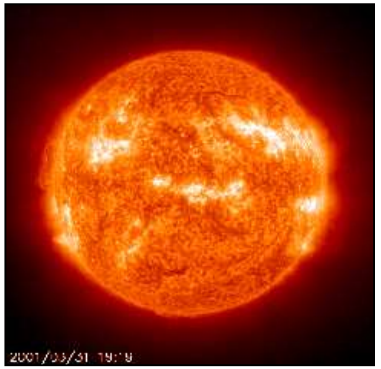
“Radiative forcing” of climate

- Increased concentrations of greenhouse gases heat planet by reducing the efficiency at which Earth can cool to space
- More small pollutant particles (aerosols) can cool the planet by reflecting sunlight
- If more energy is arriving than is leaving the planet should heat up…

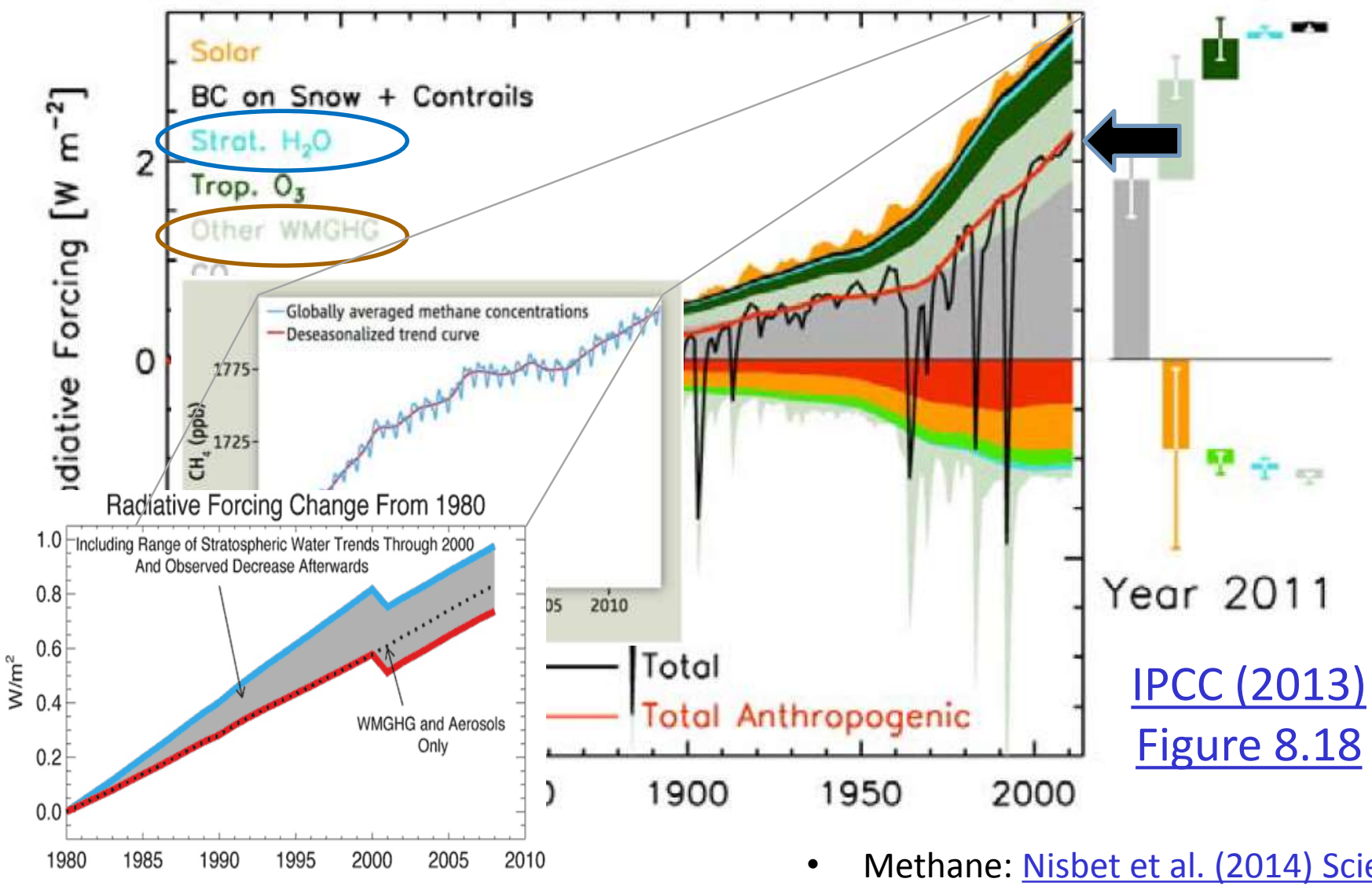


Have other factors offset warming from greenhouse gases?

- The sun has weakened in the 2000s
- There were a series of small volcanic eruptions causing reflection of sunlight
- Particle pollution from Asia, changes in stratosphere water vapour, changes in Methane and sampling of temperature observations may also be important
- Natural chaotic fluctuations in the ocean appear to play an important role



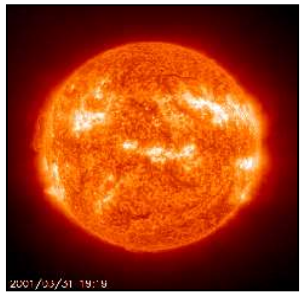
Changes in radiative forcing since 1750



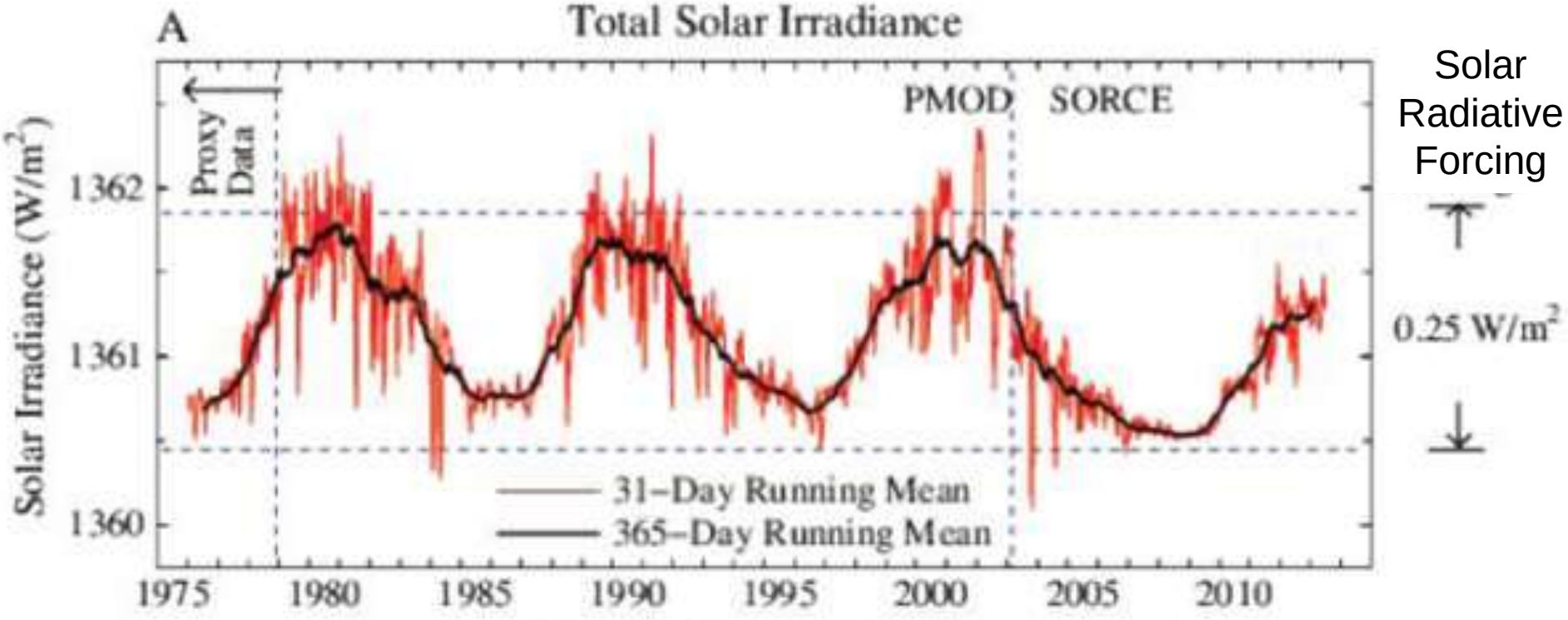
[IPCC (2013) Figure 8.18]

- Methane: [Nisbet et al. (2014) Science]
- Strat. Water Vapour: [Solomon et al. (2010) Science] ; [Hegglin et al. (2014) Nature Geosci.]:

Weaker Solar Output?

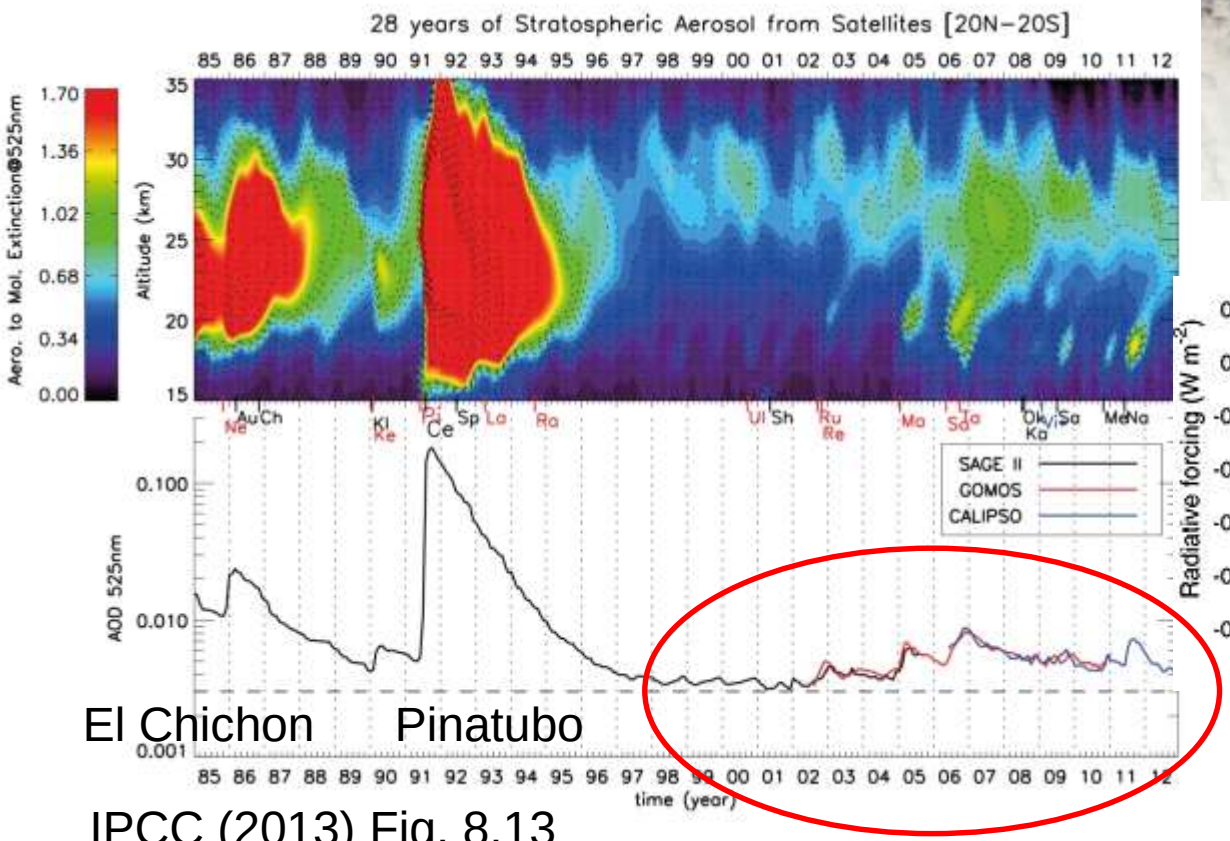


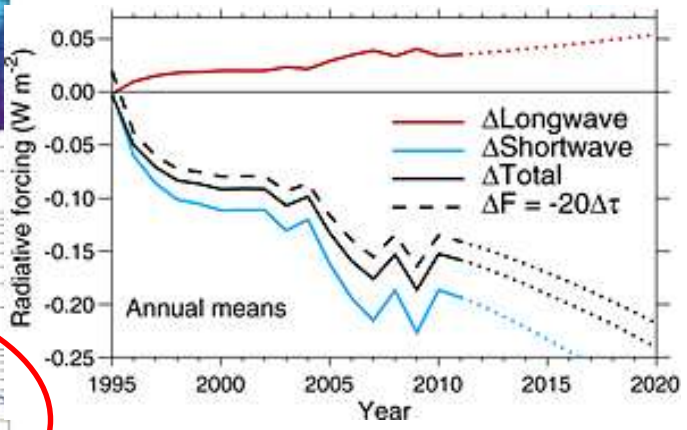
IPCC: Solar Radiative Forcing change of –0.04 Wm^{-2} from 1986 to 2008



Hansen et al. (2013) PLOSONE; see also Kaufmann et al. (2011) PNAS

Cooling from small volcanos?



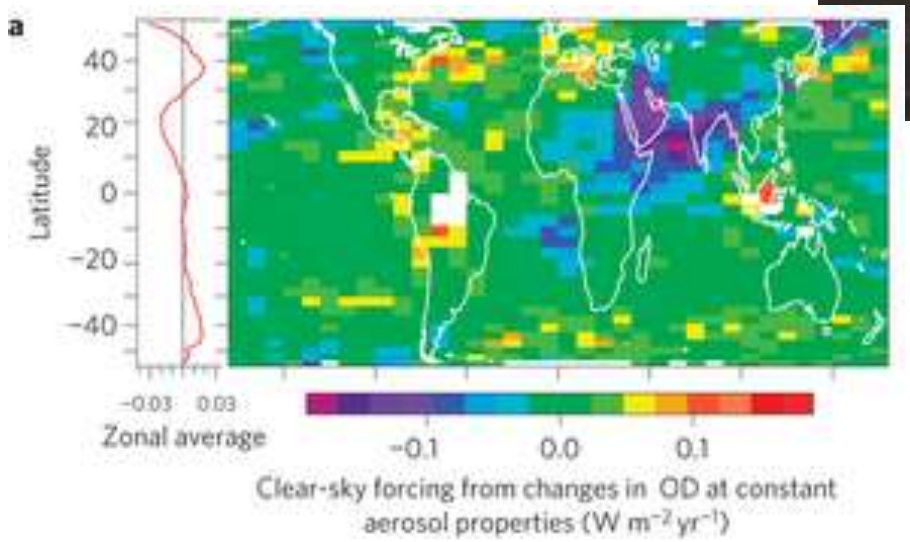


IPCC (2013) Fig. 8.13

Work by Solomon et al. (2011) Science; Vernier et al. (2011) GRL; Fyfe et al. (2013) GRL; Schmidt et al. (2014) Nature Geosci; Santer et al. (2014) Nature Geosci.; Ridley et al. (2014) GRL

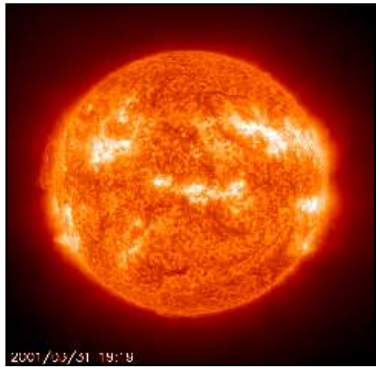
Has increased aerosol pollution refelected more sunlight back to space ?

Increased Asian aerosol offset by decreases elsewhere – little change in 2000s: Murphy (2013) Nature Geosci (below)

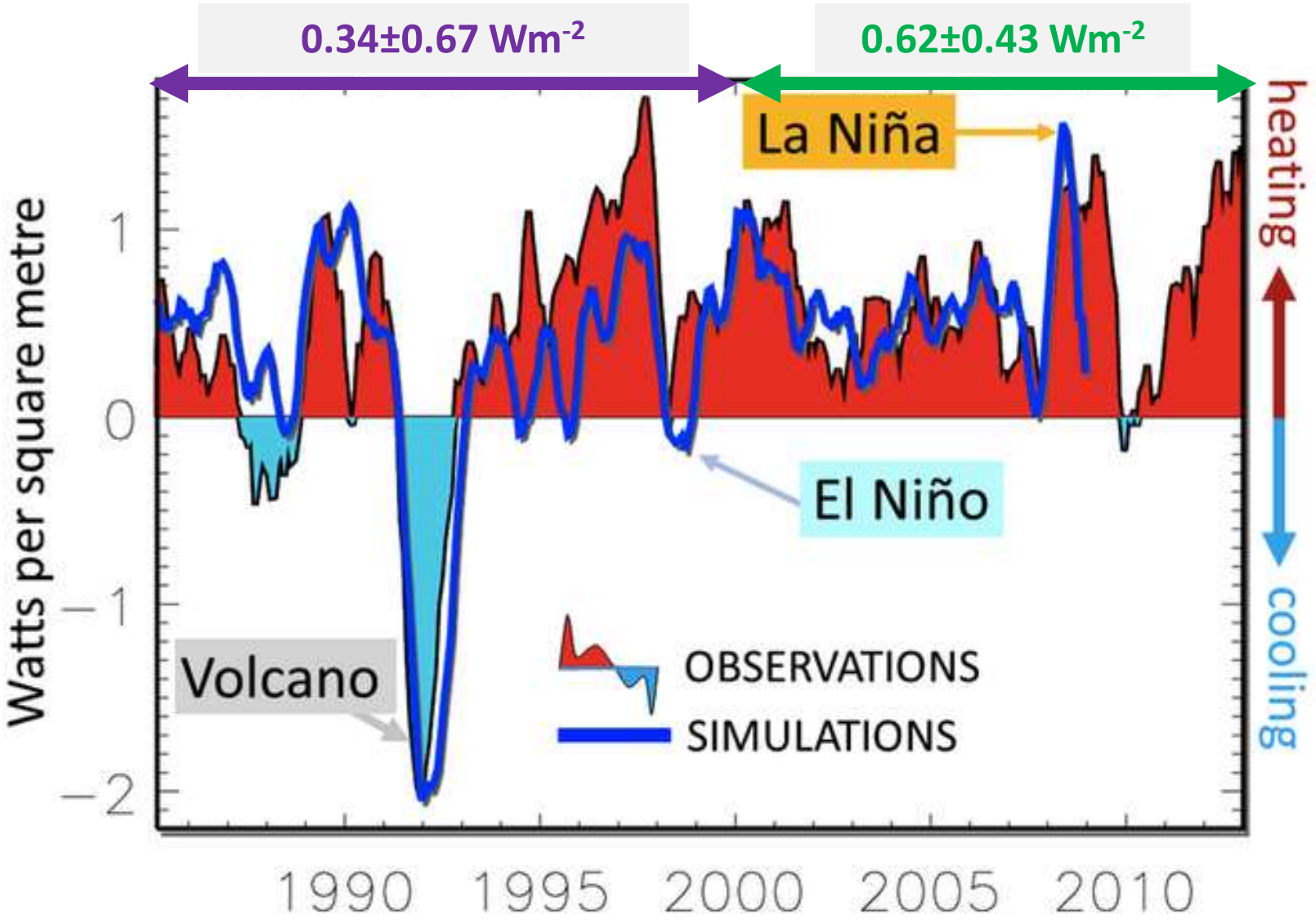


What explains the hiatus?

- The sun weakened in the 2000s
- There were a series of small volcanic eruptions causing reflection of sunlight
- Particle pollution from Asia, changes in stratosphere water vapour, changes in Methane and sampling of temperature observations may also contribute
- Natural chaotic fluctuations in the ocean appear to play an important role

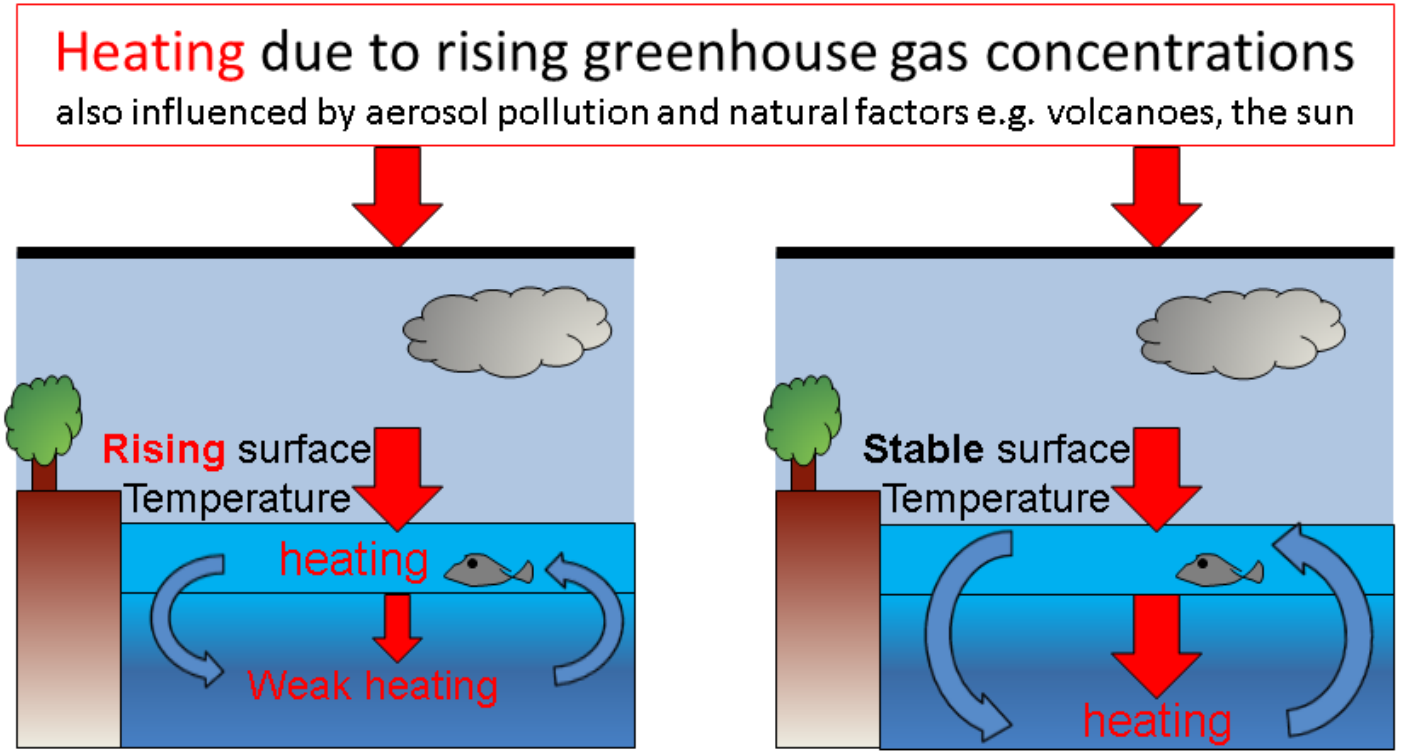


Heating of Earth continues…



Loeb et al. (2012) Nat. Geosci. ; Allan et al. (2014) GRL

Chaotic ocean fluctuations have contributed to the hiatus

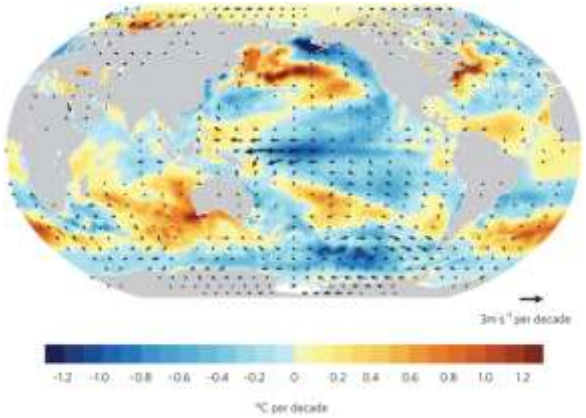


1980s-1990s: heating of upper layers of the ocean – rising surface temperature

2000s: heating of deeper layers of the ocean – slow rises in surface temperature

Increased heat flux to deeper layers of the ocean: Watanabe et al. (2013) GRL; Balmaseda et al. (2013) GRL; Trenberth et al. (2014) J. Climate ; Merrifield (2010) J. Climate; Sohn et al. (2013) Clim. Dyn.; L'Heureux et al. (2013) Nature Climate Change; Kosaka and Xie (2013) Nature; England et al. (2014) Nature Climate Change

Mechanisms of ocean variability

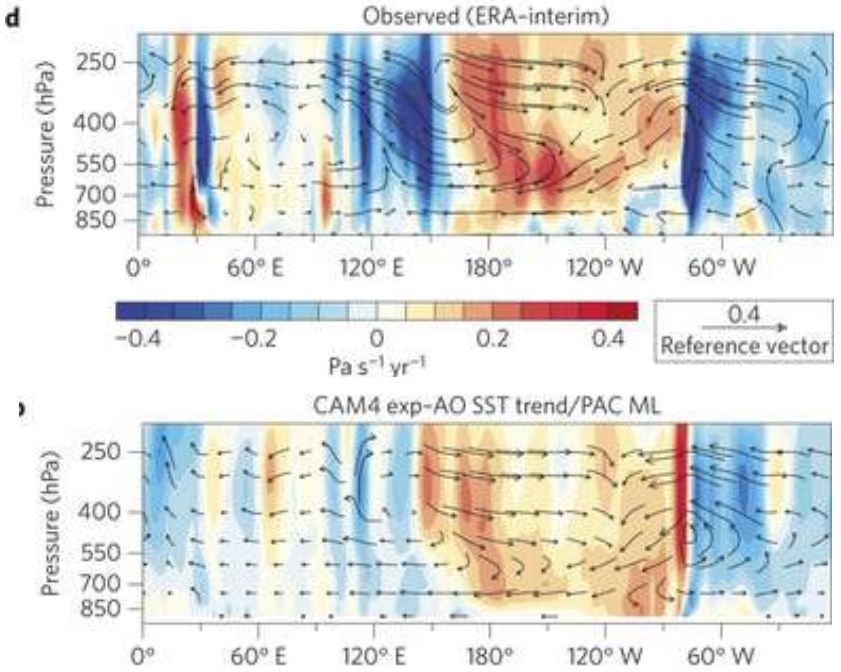


(Kosaka 2014)

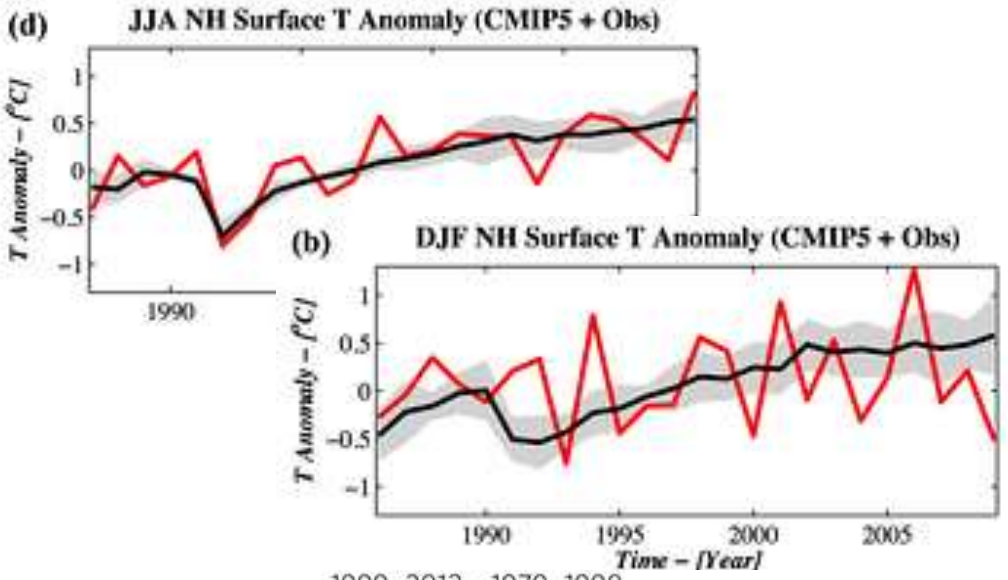
- Pacific Decadal Variability Pattern
- Is Atlantic driving Pacific changes?
- Atlantic circulation salinity feedback? (Chen & Tung 2014)

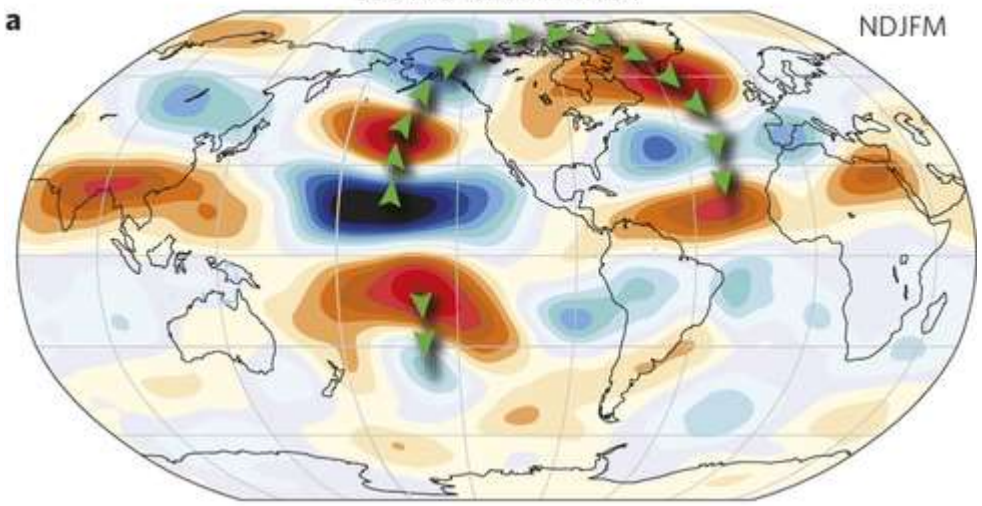
Model simulates stronger Pacific trades when apply Atlantic SSTs + Pacific SST allowed to respond →

McGregor et al. (2014)



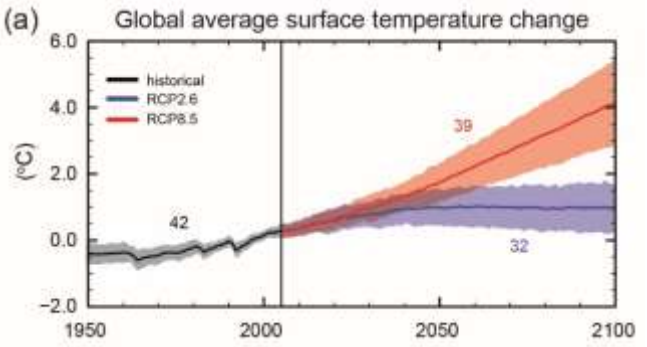
Remote influences on weather patterns

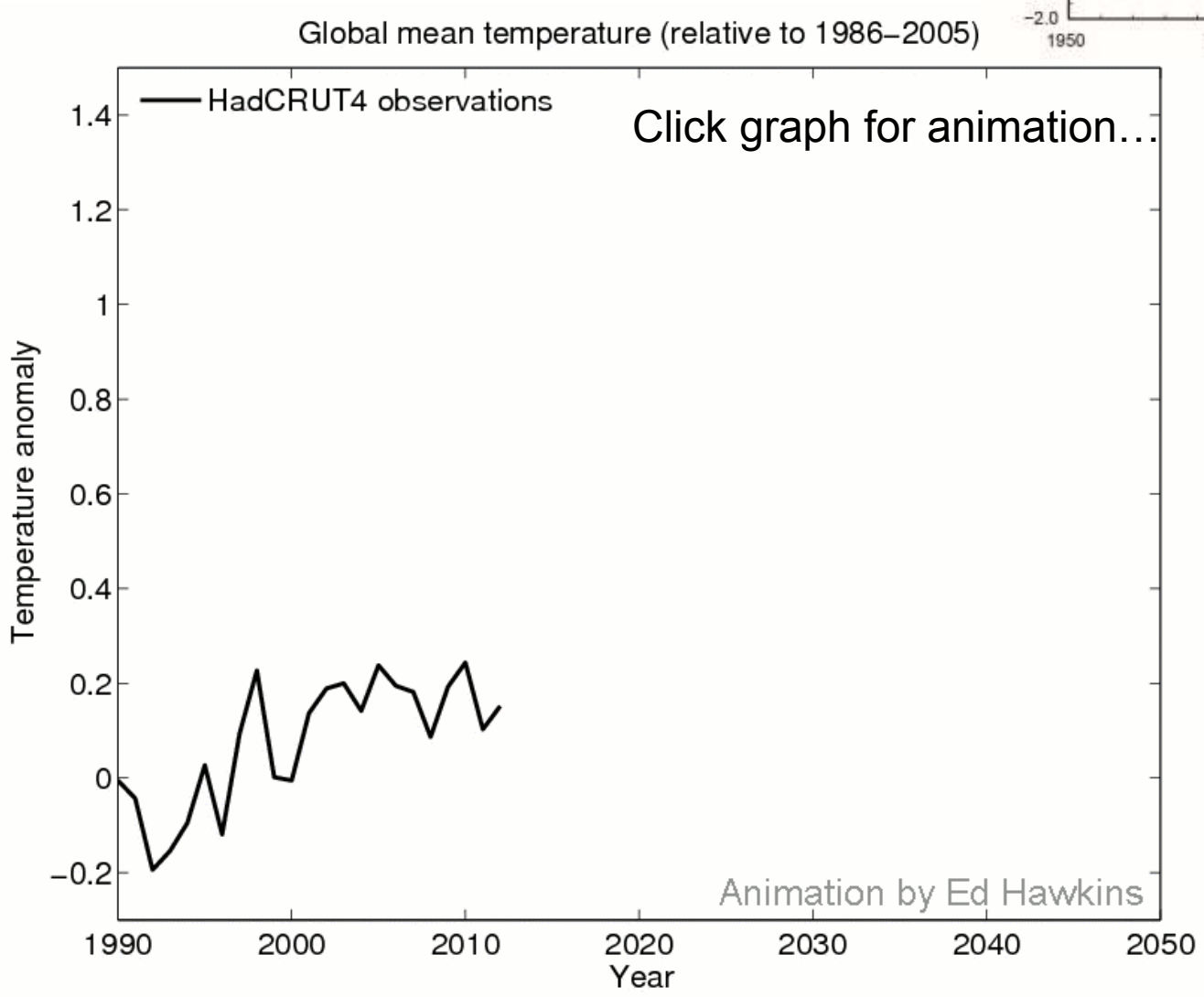




- Hiatus dominated by northern winter (e.g. Cohen et al. 2012)
- Cooling in east Pacific explains reduced heat export during northern winter (Kosaka & Xie 2013)
- Rapid Arctic warming linked to tropical changes (Ding et al. 2014)
- Atmospheric bridges link tropical anomalies & mid latitude weather patterns (e.g. Trenberth et al. 2014b)

Implications for future





From [Climate Lab Book] blog (Ed Hawkins)

1) There has been a slowing (rather than a pause) in the rate of surface warming
2) Heating from greenhouse gases continue to warm upper oceans
3) Currently more heat is reaching deeper ocean levels rather than warming the mixed layer which influences surface temperature