# Current Hiatus of Global Warming

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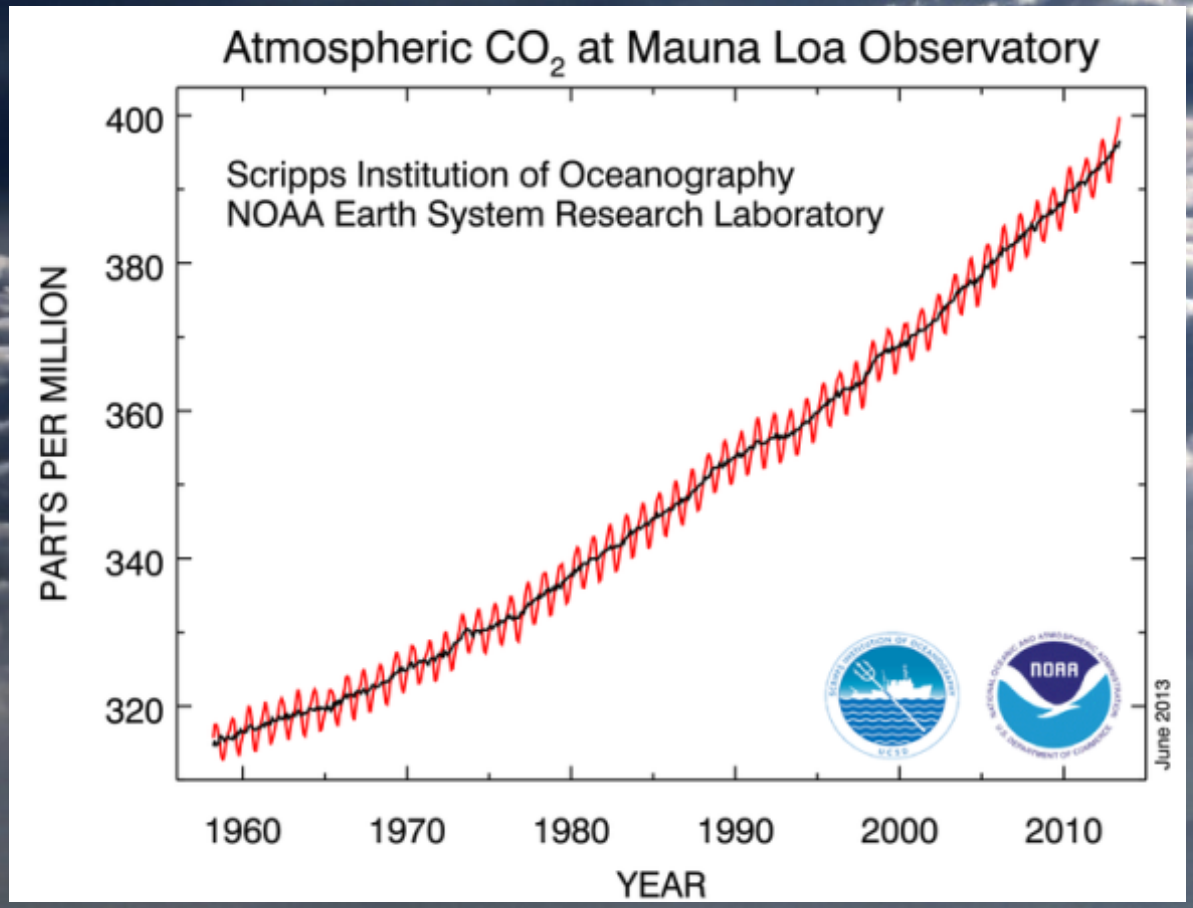
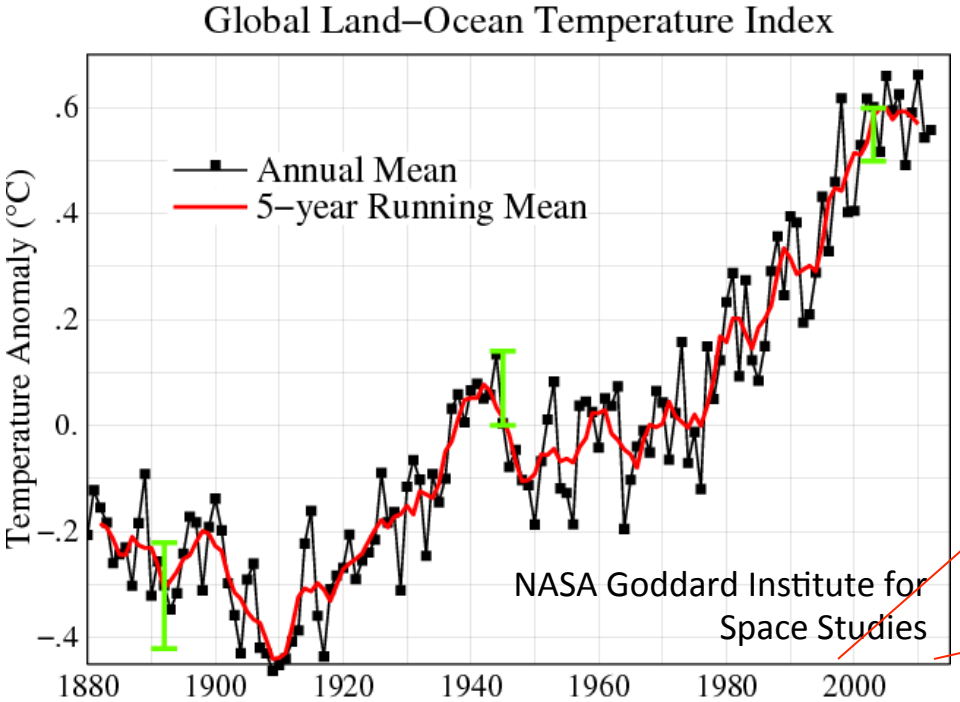
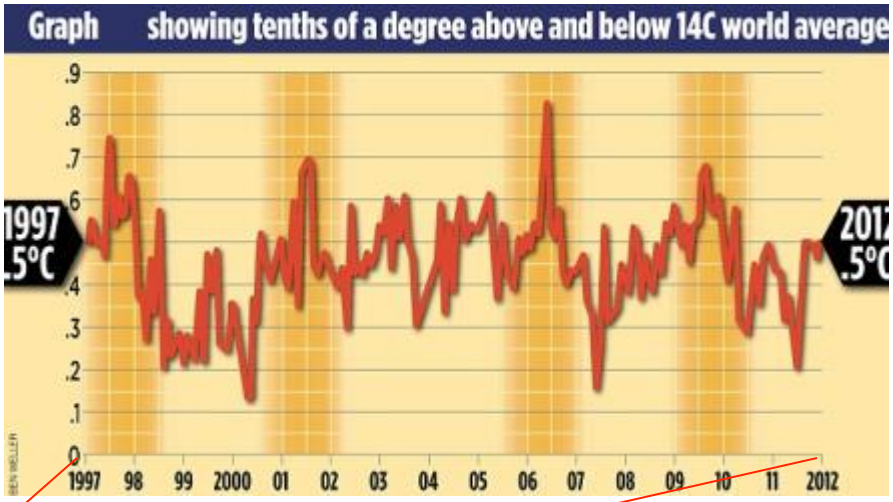



steephill.tv




*The Mail*, UK

**Hiatus of global warming**

The New York Times

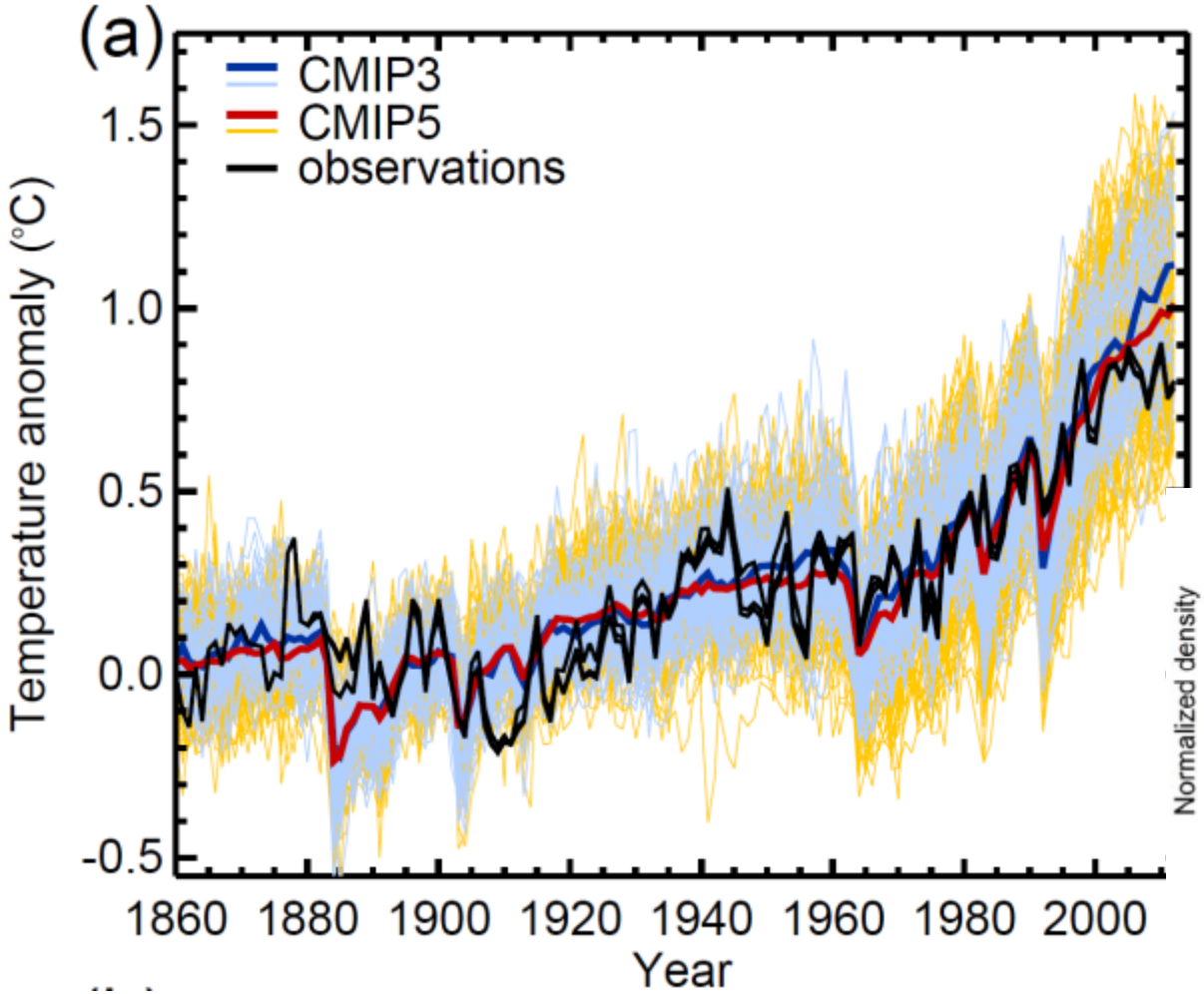
**July Set Mark as U.S.'s Hottest Month**, August 8, 2012

Record heat waves in Europe 2003, Russia 2010, US 2012, China 2013; Record Arctic sea ice loss in 2007 & 2012.

Daily-mean Maua Loa CO2 exceeded 400 ppm for the first time in May 2013.

Also in the news, global temperature has not risen for the past 15 years.

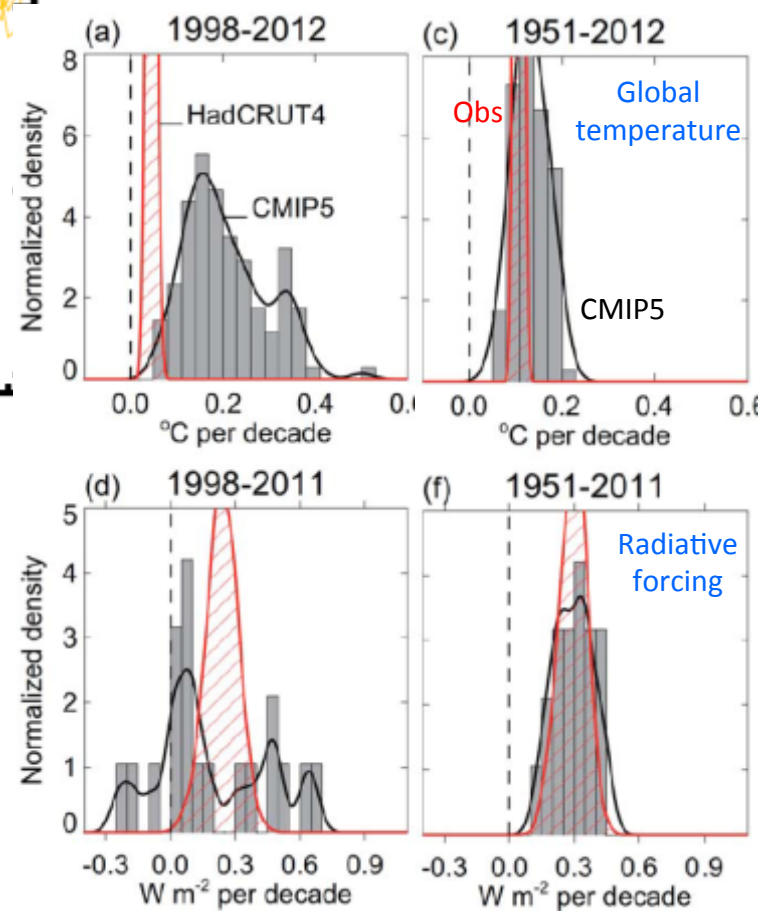
→ What causes the hiatus.



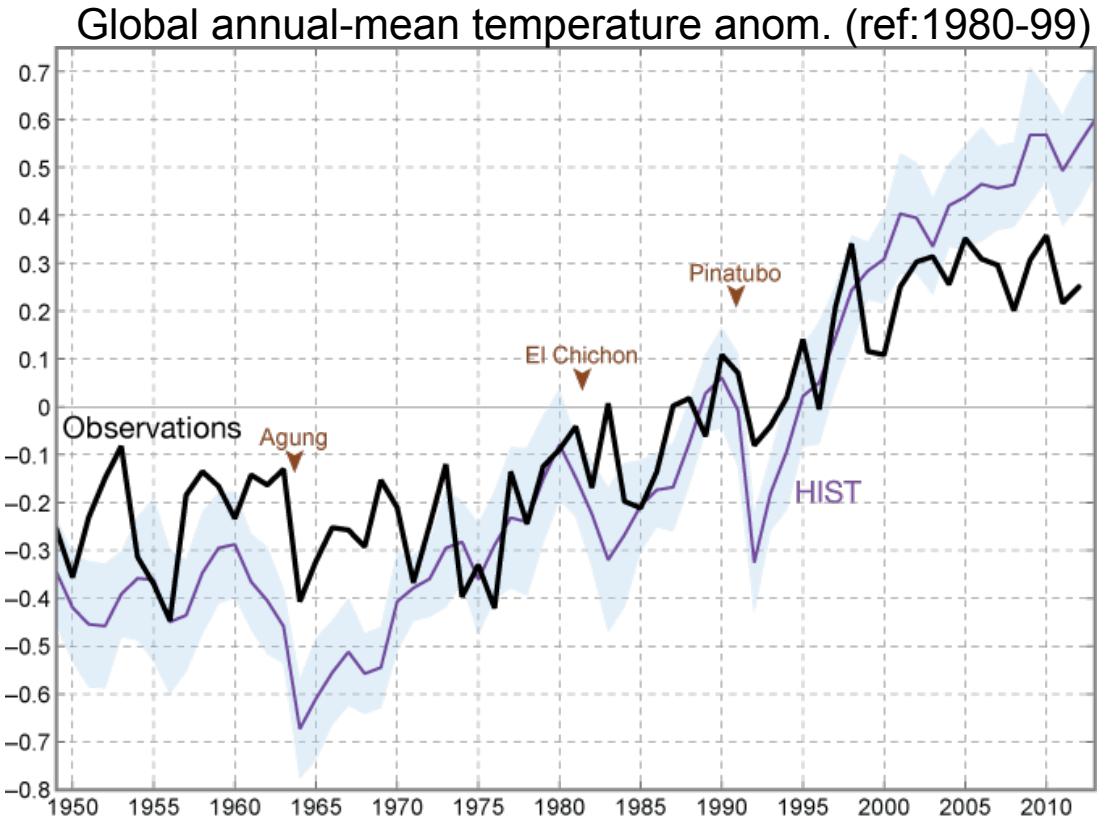

Bindoff et al. (2013, IPCC AR5 Ch 10)

Few of the 114 CMIP5 runs reproduce the hiatus

→ Too high radiaitve forcing (RCP4.5 for 2006-)




Flato et al. (2013, IPCC AR5 Ch 9)



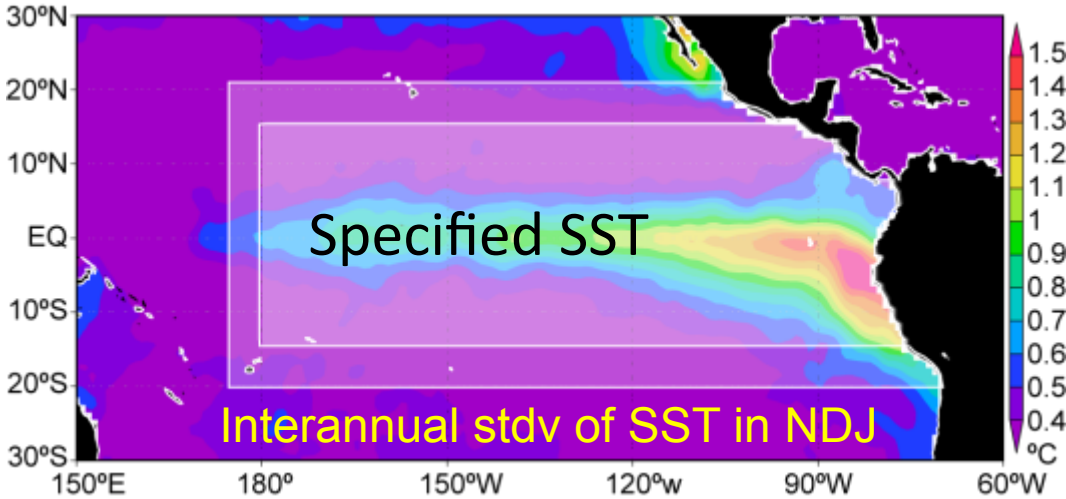

# Model: GFDL CM2.1

**HIST**: Radiative forcing only

**POGA-H**: Radiative forcing + tropical Pacific SST (8.2% of the Earth surface)

## POGA Experiments

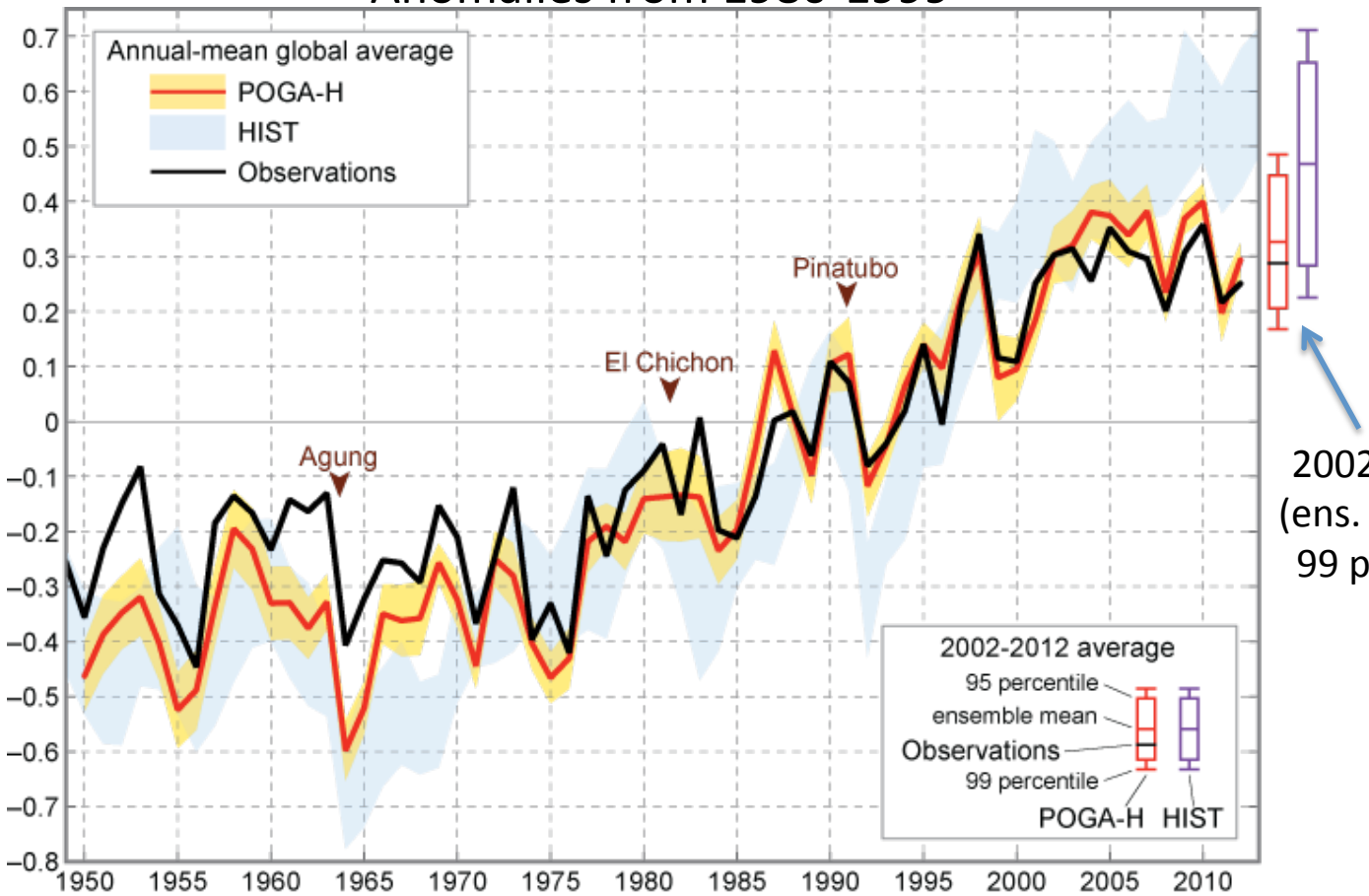
Pacific Ocean Global Atmosphere




Kosaka & Xie (2013, Nature)

# Global annual-mean sfc temperature

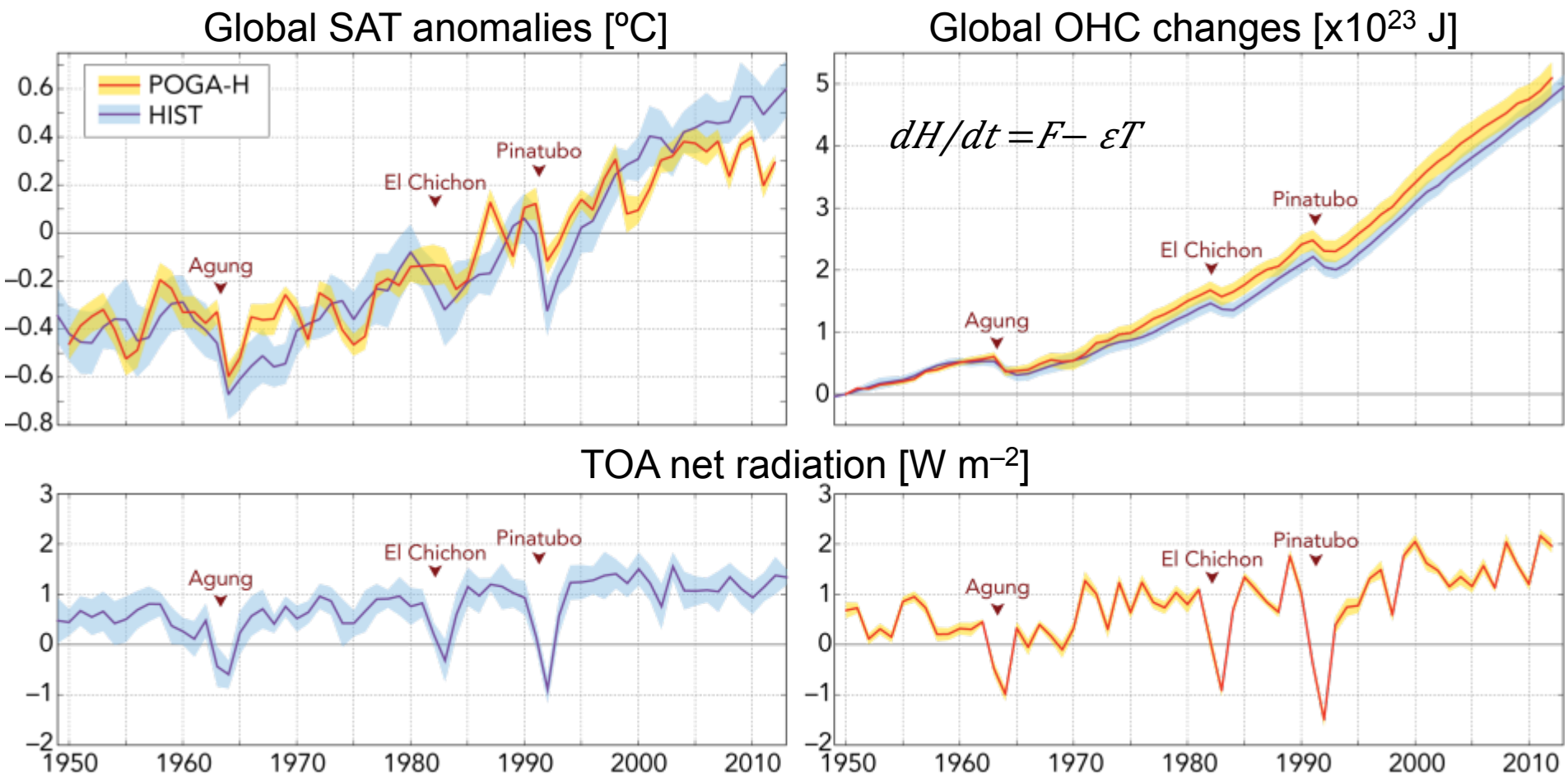
Anomalies from 1980-1999



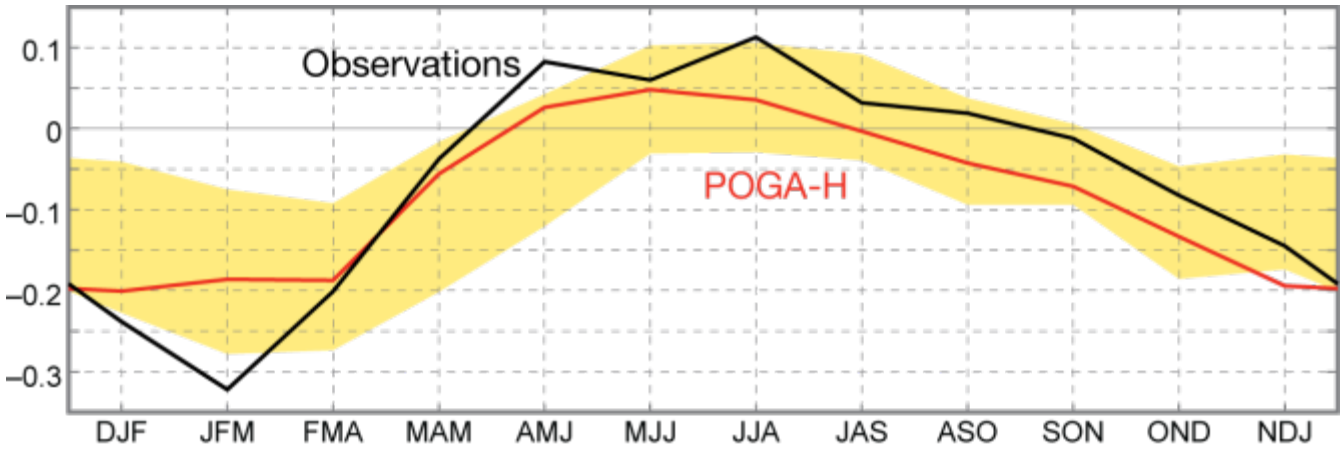

2002-2012 ave. (ens. mean, 95 & 99 percentiles)

Correlations with HadCRUT4 (1970-2012)

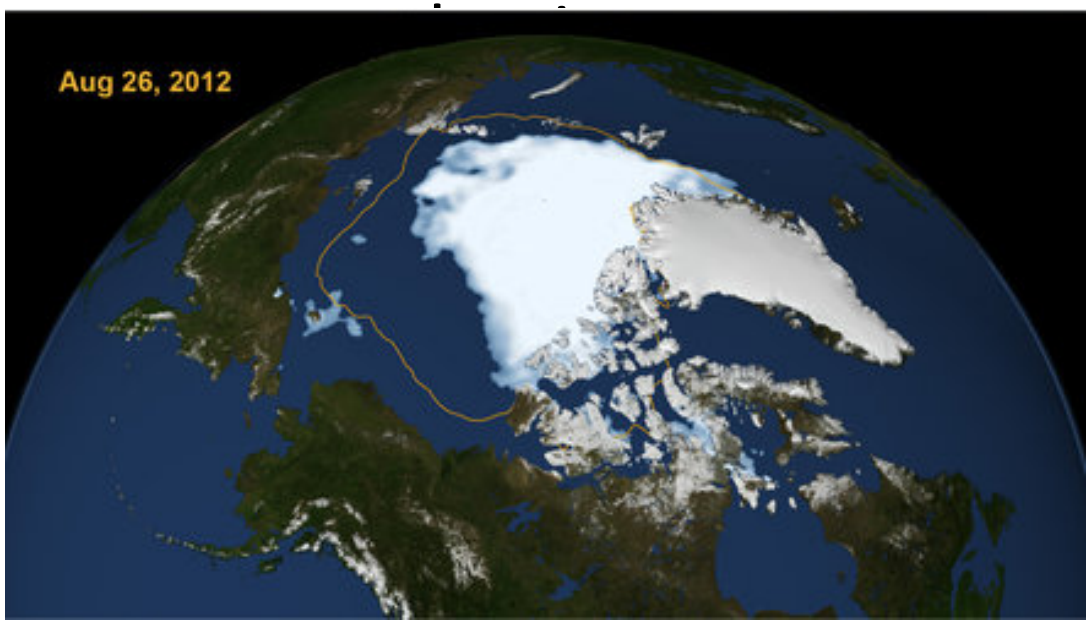
| | POGA-H | HIST |
|---|---|---|
| raw | 0.97 | 0.90 |
| detrend | 0.70 | 0.26 |


Global SAT anomalies [ºC]
POGA-H
HIST
Agung
El Chichon
Pinatubo
Global OHC changes [x10^23 J]
dH/dt = F − εT
Agung
El Chichon
Pinatubo
TOA net radiation [W m^−2]
Agung
El Chichon
Pinatubo
Agung
El Chichon
Pinatubo
1950
1960
1970
1980
1990
2000
2010

Seasonal trends for 2002-2011

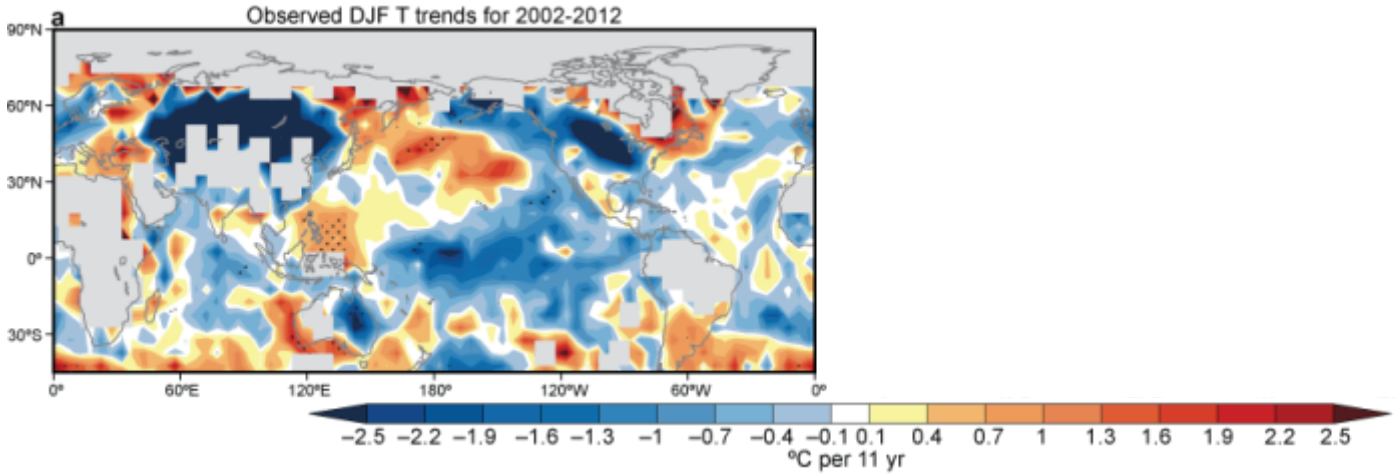



In summer, tropical effect on the northern extratropics is weak, and radiative warming

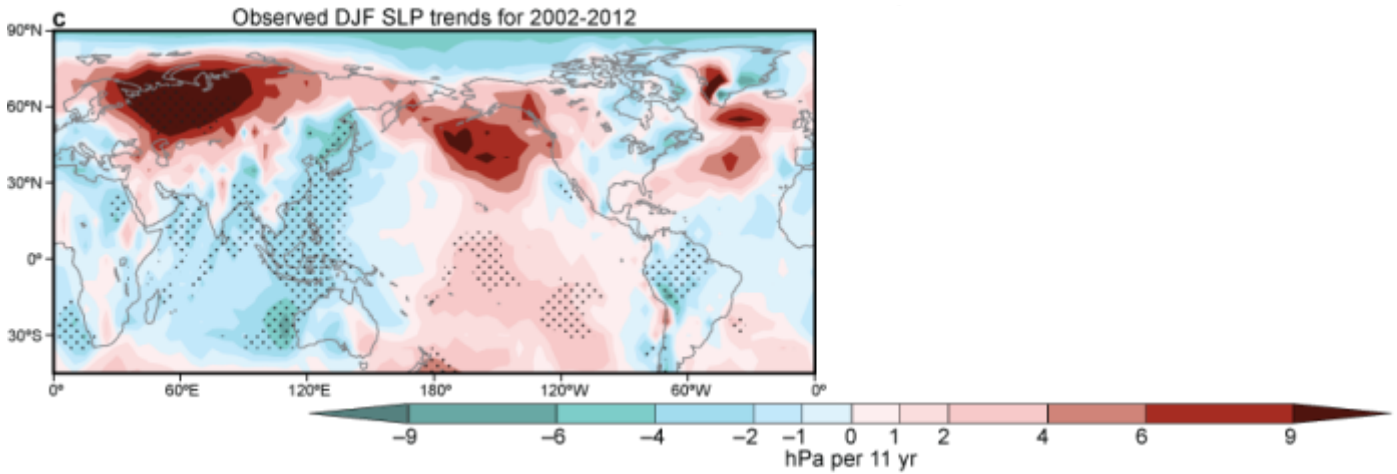


# DJF trend pattern for the current hiatus

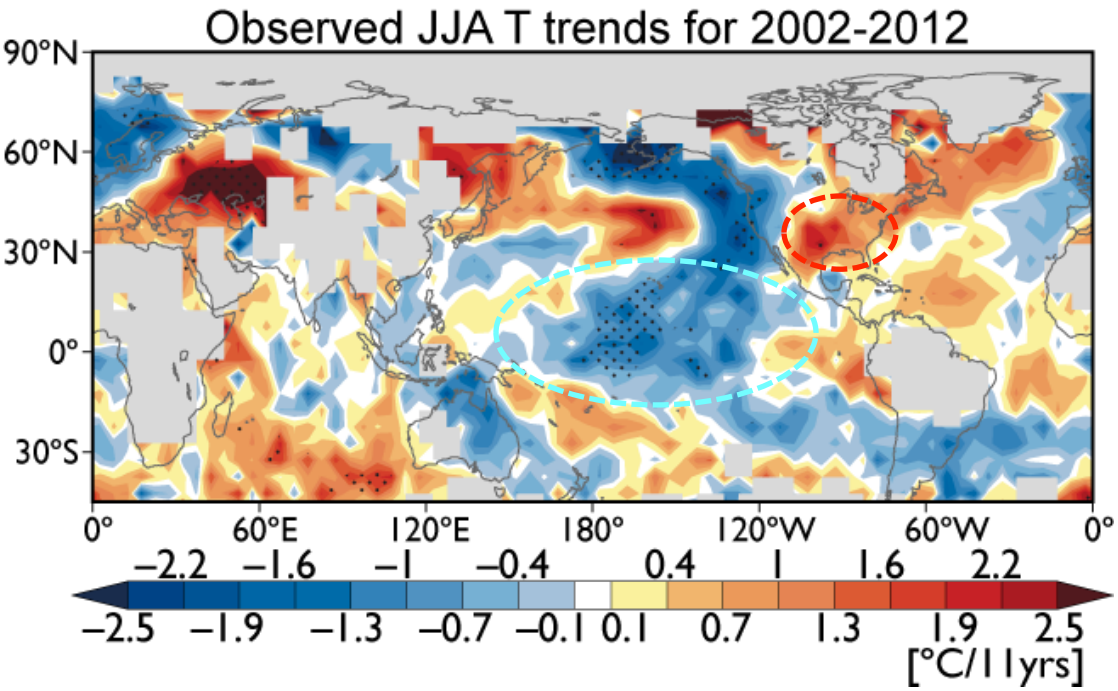
T




SLP

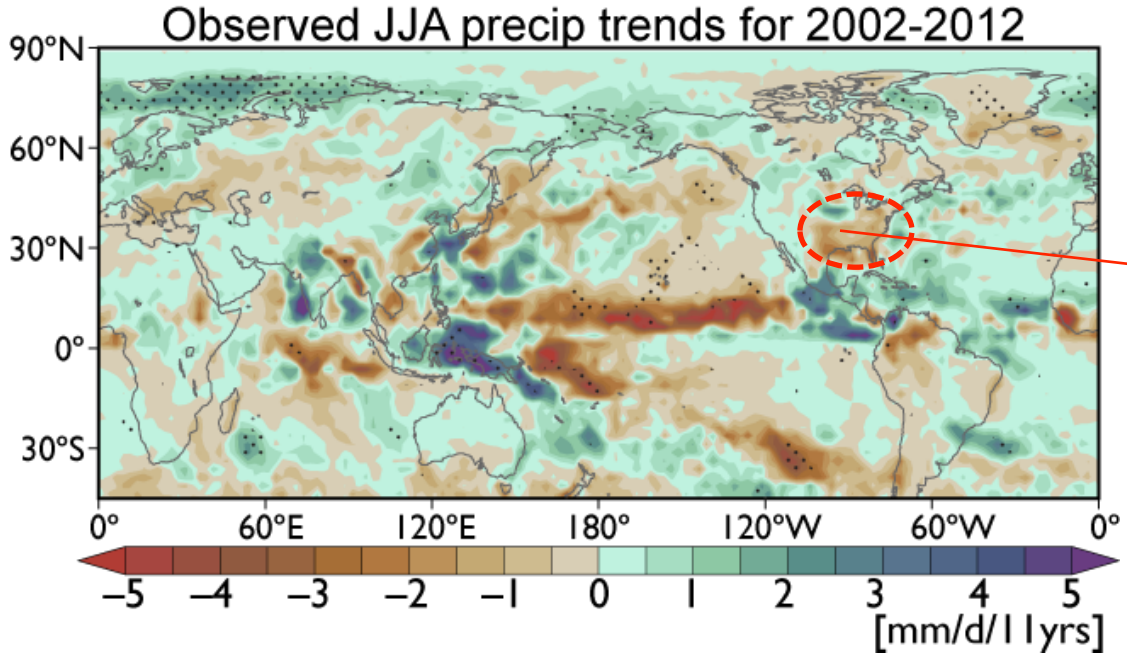



- Strengthening of Walker circulation (cf. projected weakening by GW)
- Weakening of Aleutian low and cooling over northwest N. America
- Eurasian trends are unrelated to tropical variability




## Ocean regulation of climate warming

- The global warming hiatus is due to the tropical Pacific cooling, the latter likely part of natural variability;
- Texas drought happened because of the hiatus (Pacific cooling).

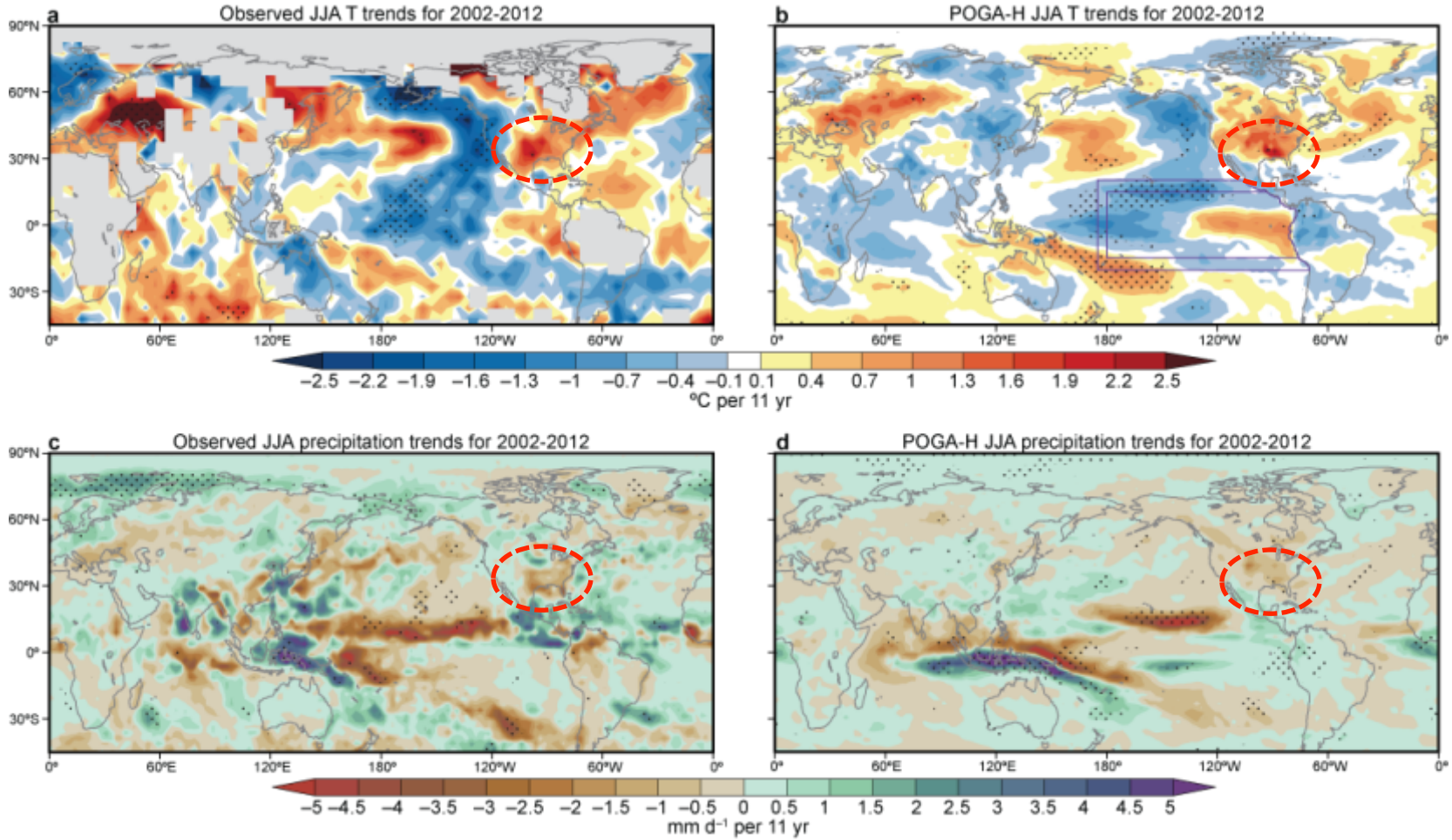


Yu Kosaka

# JJA trend pattern for the current hiatus

T

precip




- Weak changes in the extratropics
- Warming and drought over the southern US because of the hiatus

# Summary

- Decadal cooling of the Pacific causes hiatus.

  Regional anomalies

- Strengthened of Walker circulation
- Weakened Aleutian low and cooling over NW America in winter
- Summer extratropics is shielded from tropical influence

  → radiative warming dominates

  – Arctic sea ice shrinks in summer
  – Allows heat waves in extratropics (e.g. 2010 Russia)

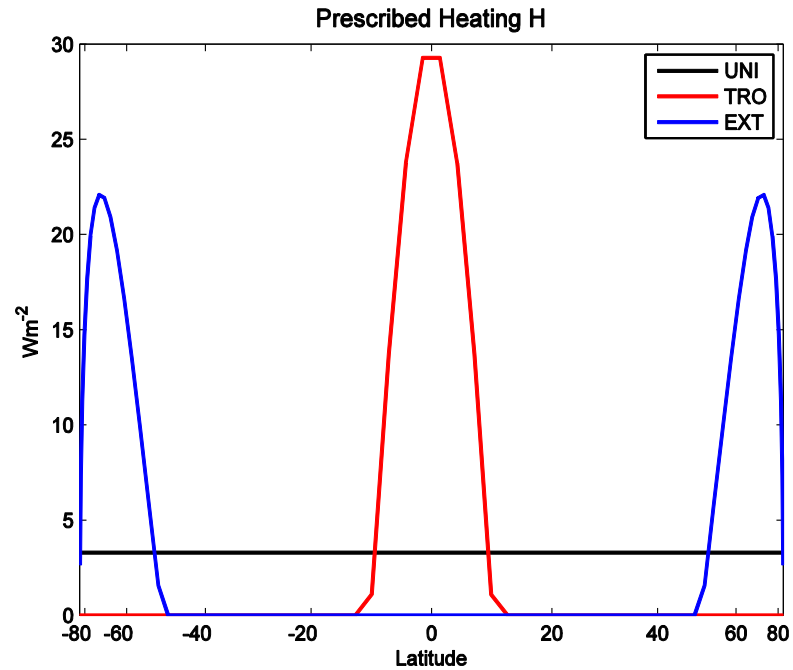
- Warming and droughts over the southern US in summer is due to the hiatus.

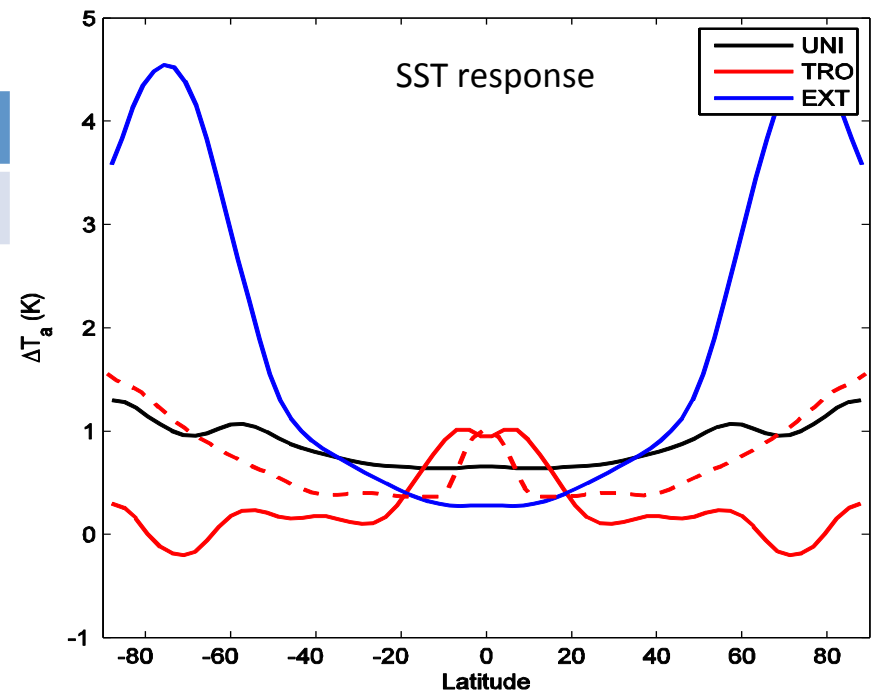
# **Radiative feedback**: The dependency on SST pattern (El Nino vs. CO2)

- Gray atmosphere
- Aqua-planet, slab ocean
- Prescribed ocean heat flux

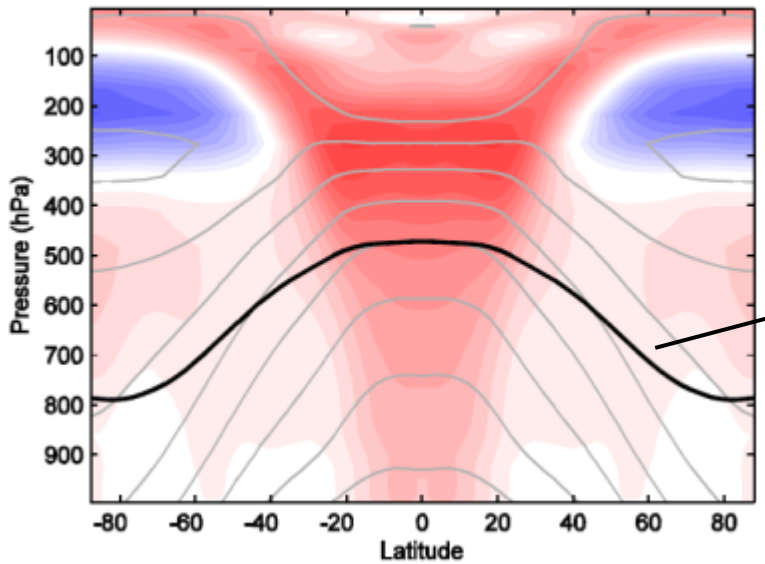
| Forcing | Tropical | Polar | Uniform |
|---|---|---|---|
| Global ΔT (K) | 0.36 | 1.19 | 0.78 |

Kang & Xie (2013, JC, submitted)



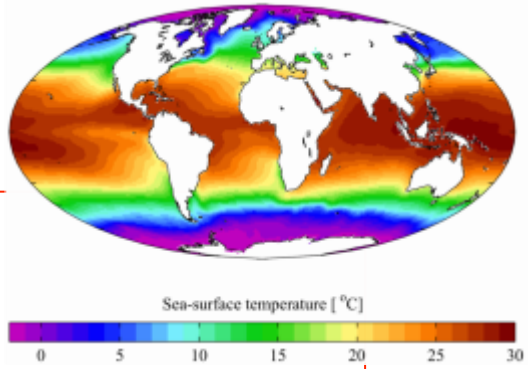



Tropical forcing




Radiation level, $T(z_R)=(OLR/\sigma)^{1/4}$

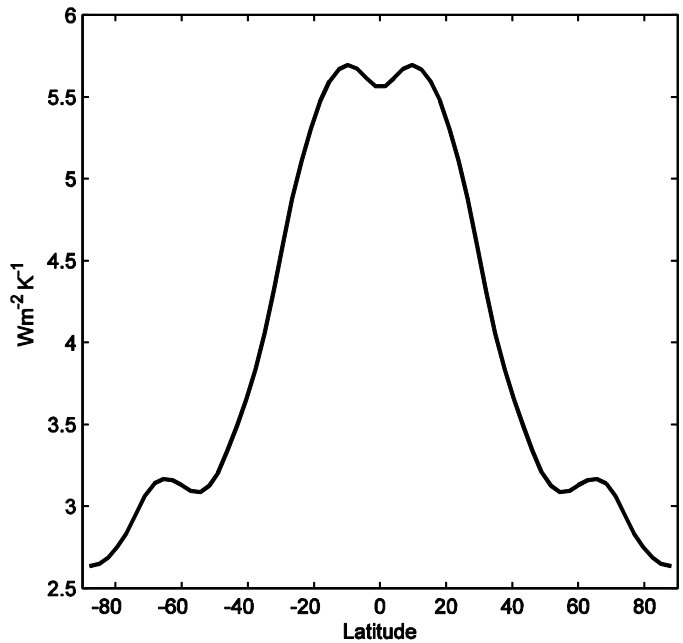
- Temperature response to tropical heating is vertically amplified (following moist adiabat), hence strongly damped.
- Temperature response to polar heating is surface trapped below the radiation level, hence only weakly damped.

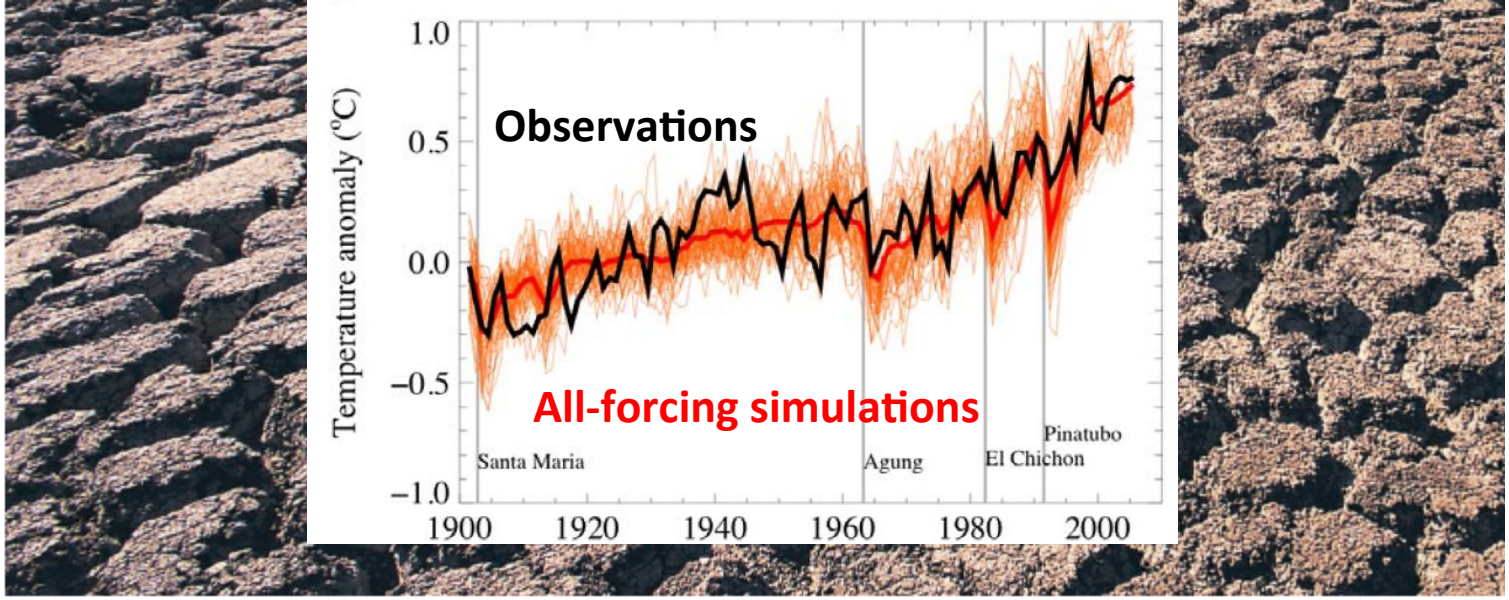



Tropical variability (ENSO) is

- strongly damped radiatively;
- still dominant and of global influence despite the damping;
- due to strong ocean-atmosphere interaction over the equatorial cold tongue.

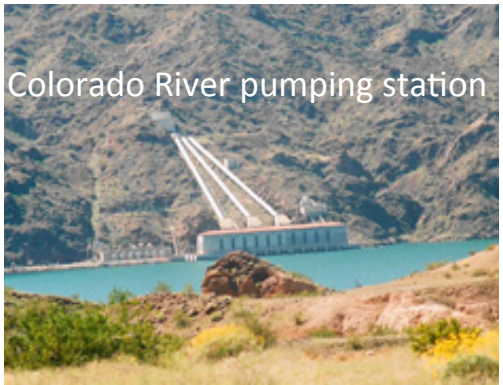
Local radiative damping rate: ΔOLR/ΔSAT from uniform heating run





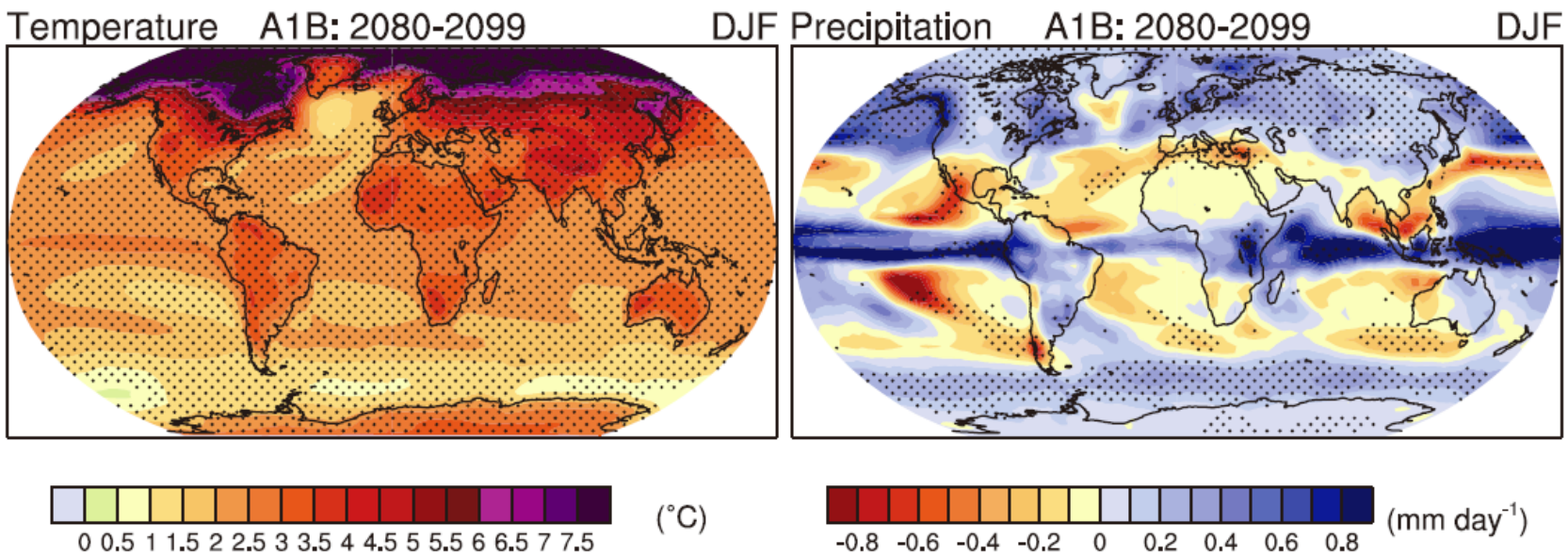

www.sciencemag.org SCIENCE VOL 334 25 NOVEMBER 2011

# Time to Adapt to a Warming World, But Where's the Science?



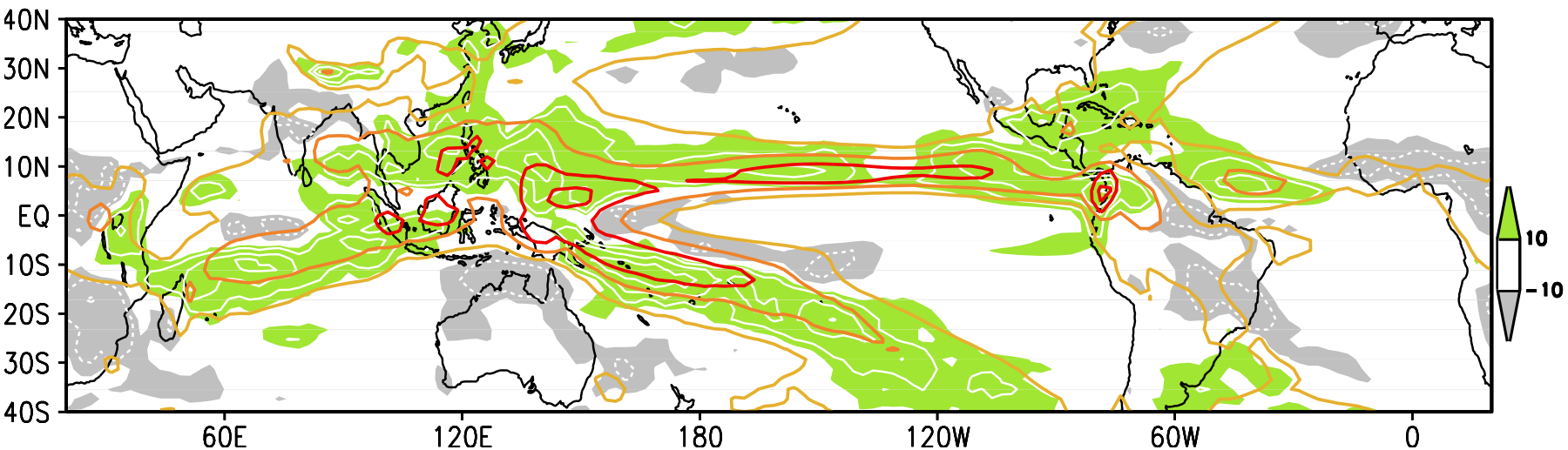
# Precipitation change is to first order spatially variable.

- Where it increases, and where it decreases?
- What determines patterns of rainfall change?
- Can we predict the pattern?




A1B multi-model ensemble mean (IPCC, 2007)

# Ocean warming pattern is important for rainfall change.




2K uniform ocean warming: mean (contour) and change of precipitation

→ Wet-get-wetter pattern

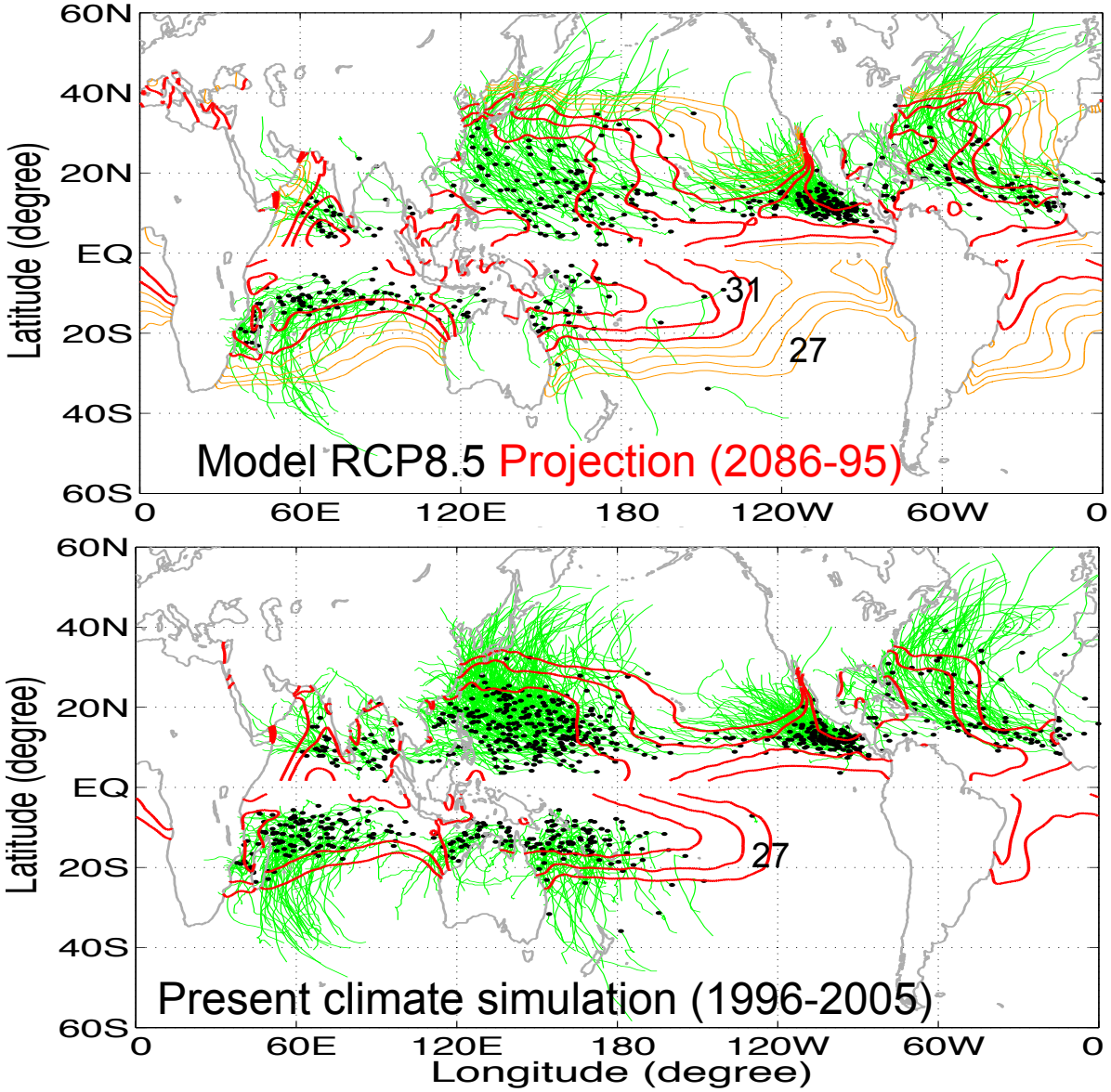
Upper air temperature increase = tropical mean ocean warming

Atmospheric instability = surface – upper air warming

Ocean warming pattern

Surface temperature threshold for atmospheric convection is dynamic, increasing with the tropical mean warming (Johnson & Xie 2010)

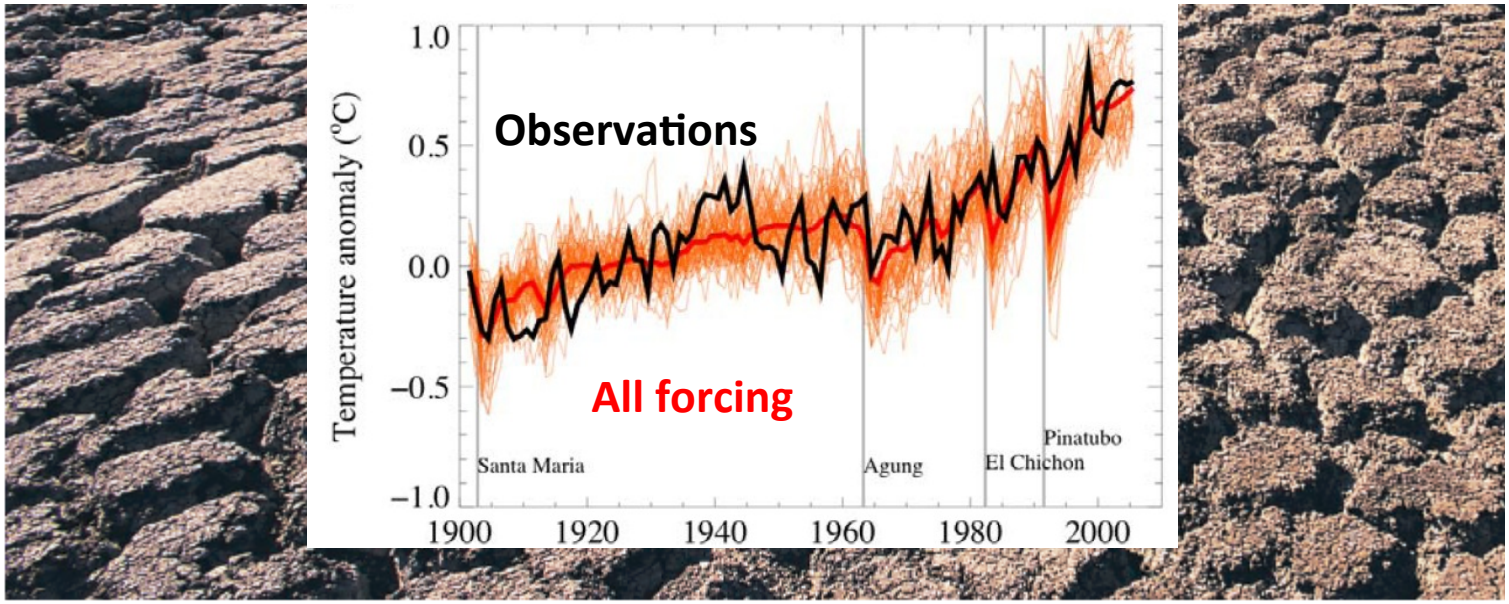
# Dynamic SST threshold for tropical cyclogenesis



- Current TC genesis confined to SST> 27°C.
- The SST threshold increases with the tropical mean.
- Global TC occurrence decreases in warmer climate but the regional change depends on SST warming pattern.

Courtesy of Wei Mei

Sea surface temperature & tropical cyclone genesis/tracks

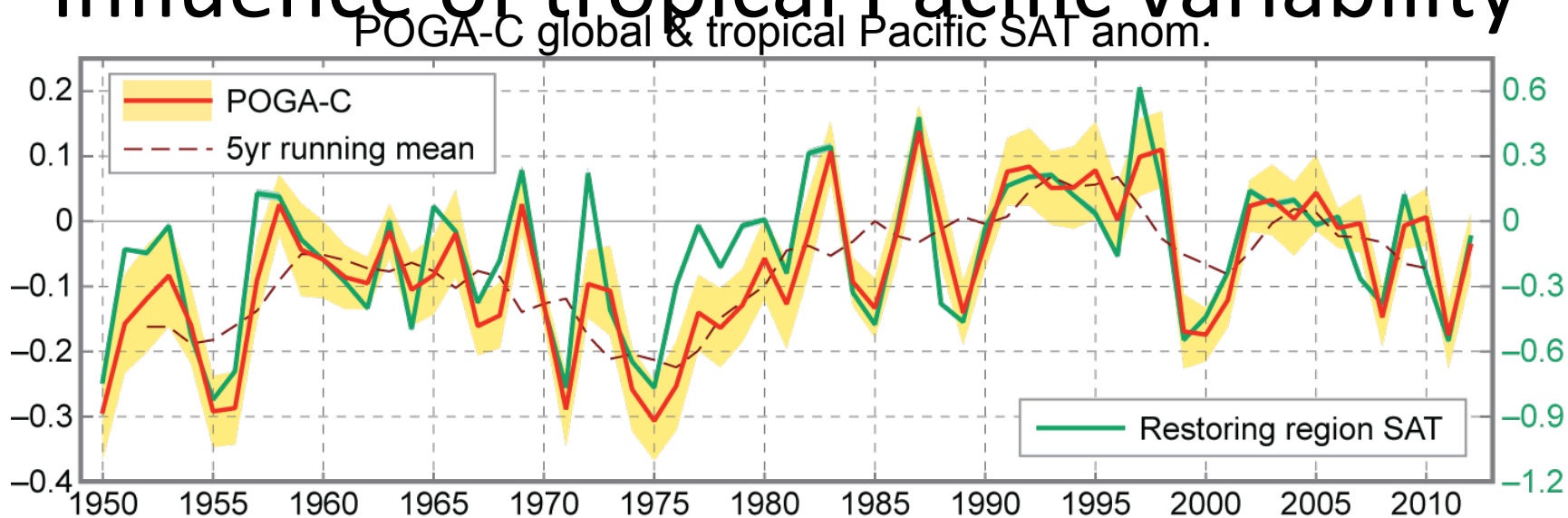



# Predictive dynamics of regional climate change:

## A grand challenge

Processes, model experiments/hypothesis development, observational constraints

# Influence of tropical Pacific variability




- Global-mean temperature follows tropical Pacific variability (0.29°C global-mean SAT anom. for 1°C tropical Pacific anom.)
- Cooling for the recent decade opposes the radiative warming

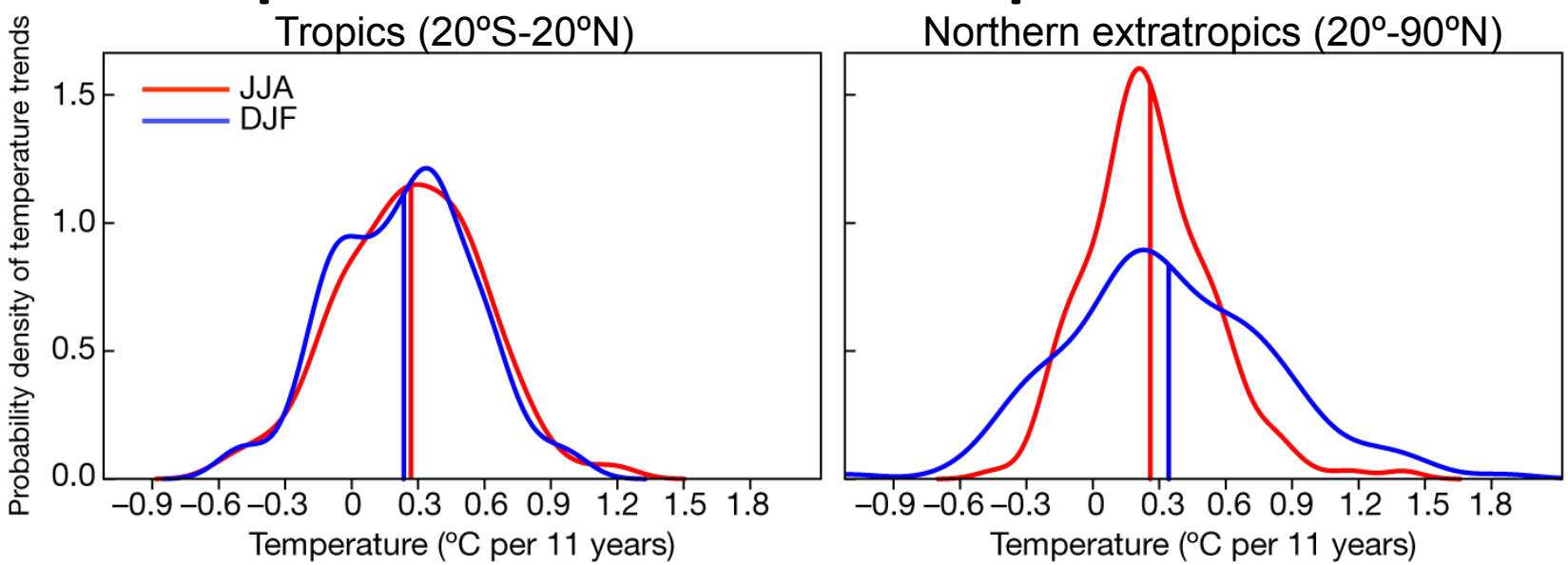
  → the current hiatus
- POGA enables direct year-by-year comparison with observations, not just statistically obtained hiatus events from usual CGCM simulations

# Linear trends

| | 2002-2012 (°C per 11 yr) | 1971-1997 (°C per 27 yr) |
|---|---|---|
| POGA-H | –0.01 | 0.55 |
| HIST | 0.19 | 0.41 |

- Linear trends of global annual-mean temperature
- Tropical Pacific Decadal variability accounts for ~25% of the warming from the 1970s to the late 1990s (the accelerated global warming)

# Tropical vs. extratropical trends




- Similar PDFs in the tropics
- Larger spread in winter than summer in the NH extratropics
- Smaller spread in summer in the NH extratropics than the tropics
  - Summer extratropics is shielded from tropical influence
  - Summer Arctic sea ice has kept reducing despite hiatus

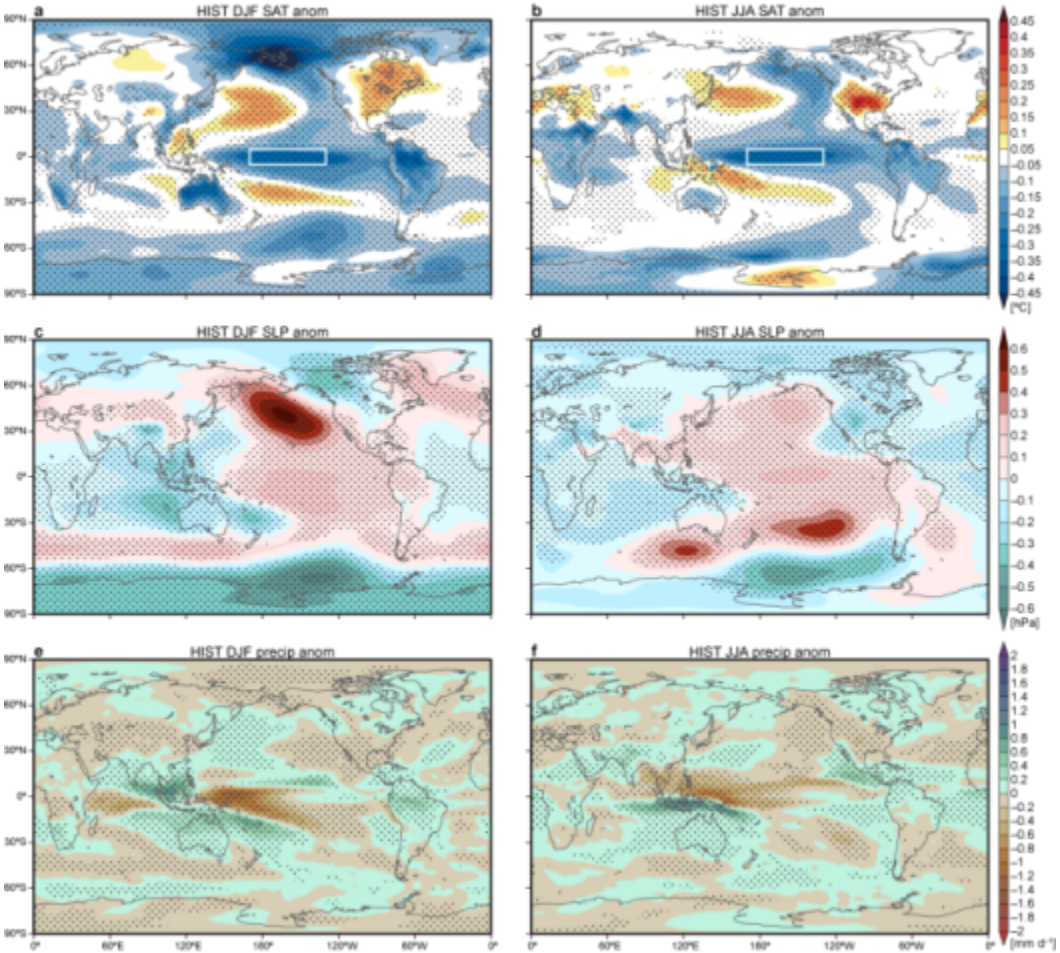
# Statistical influence of tropical PDO in HIST

DJF JJA

T

SLP

precip




Regressions against equatorial central Pacific SST
Inter-member anomalies, 8-yr low-pass filtered

# JJA trend pattern for the accelerated p

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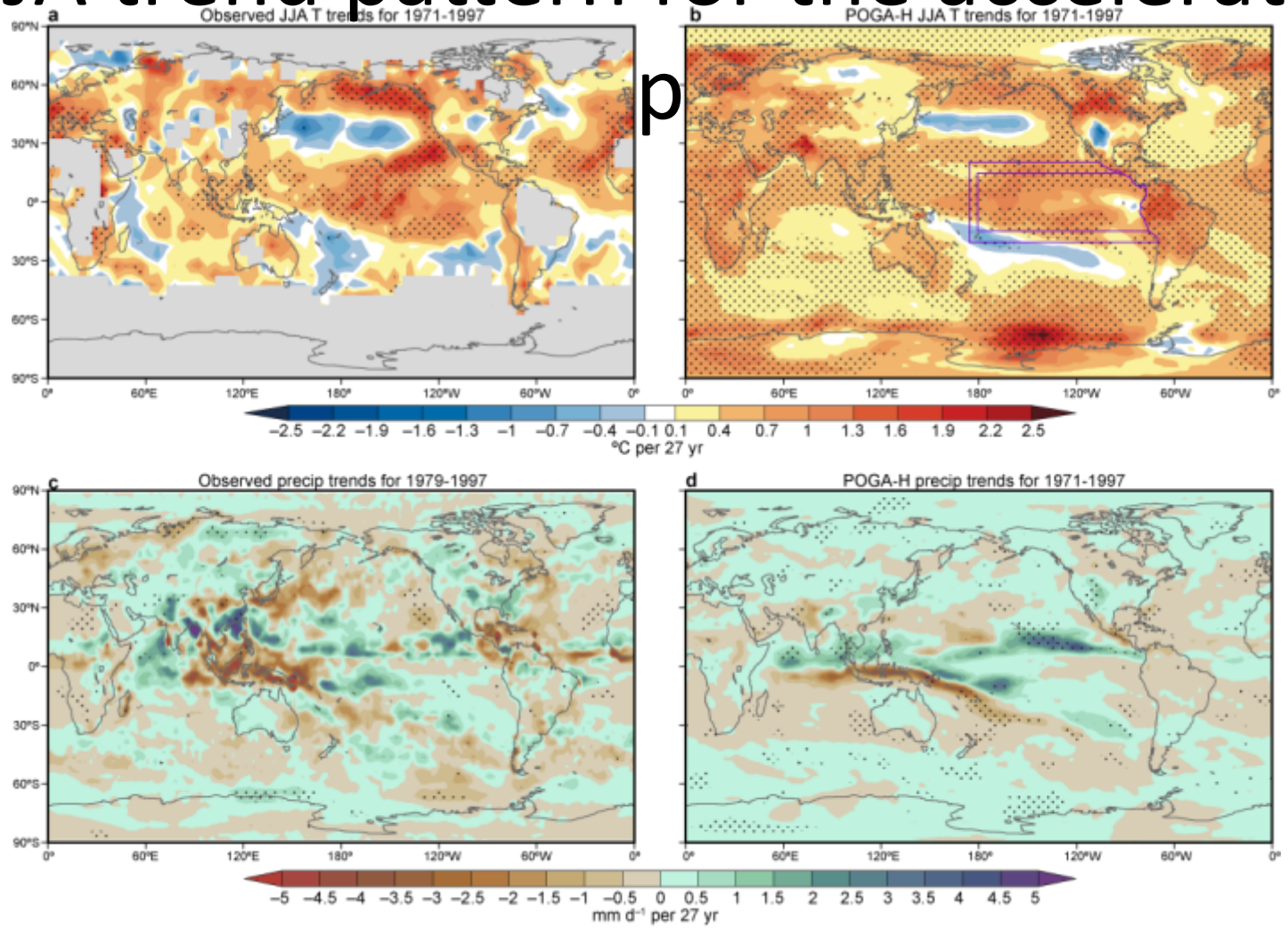
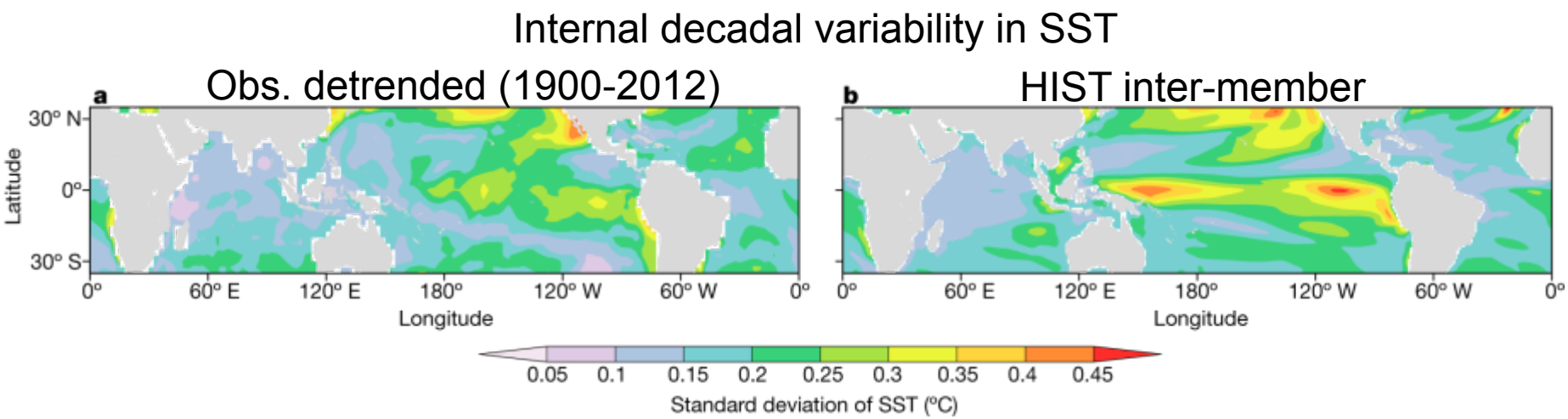
precip




- Accelerated global warming (~30%) for the 1970s - late 1990s due to El Niño-like trend
- Warming hole in the southern US

# Discussion: Is La Niña-like trend internal or forced?

- POGA cannot answer
- No CMIP models project tropical Pacific cooling in global warming (with the El Niño-like pattern)
- Tropical decadal internal variability maximizes in the Pacific




- It is suggested that the La Niña-like trend is internal

# Conclusions

- The current hiatus is part of natural climate variability

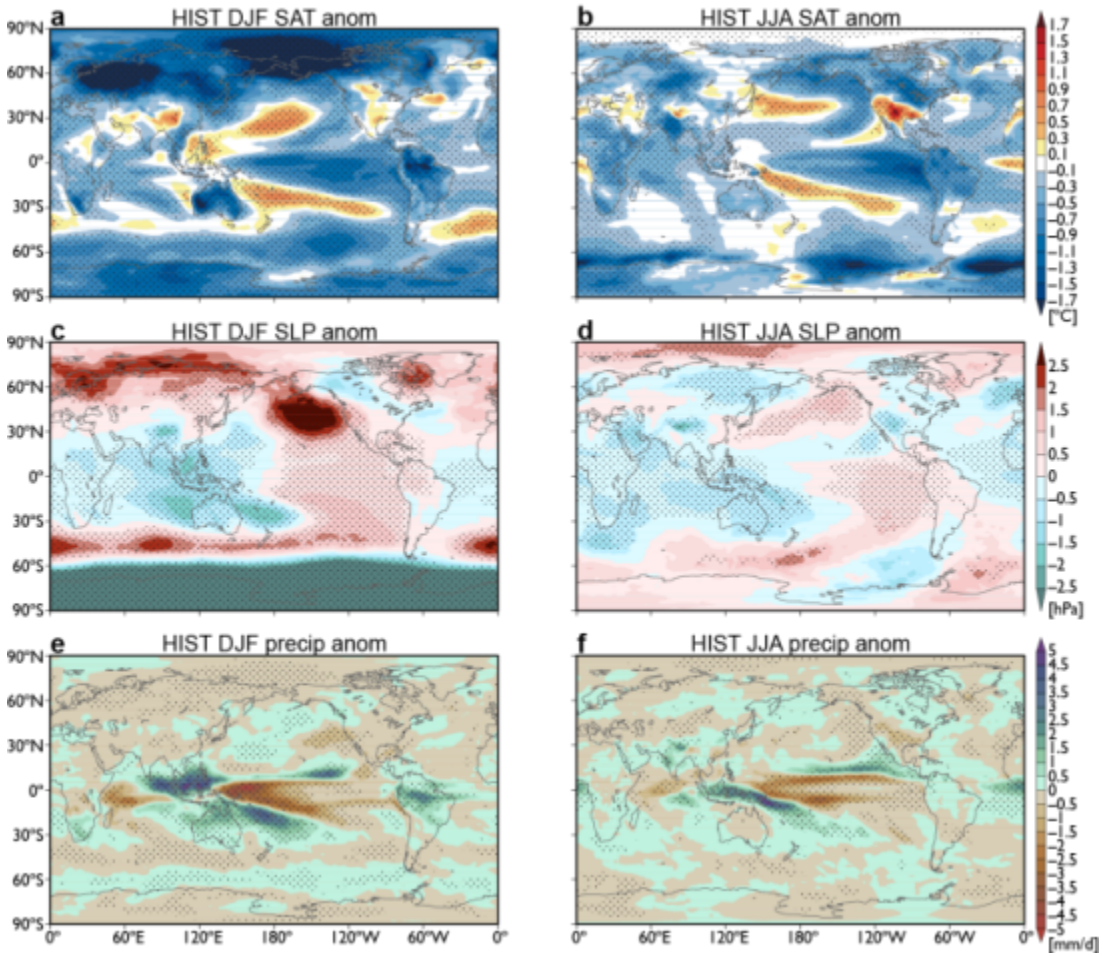
- When the tropical Pacific swings back to neutral or warming state, the global warming will resume

- The current hiatus may continue for additional years

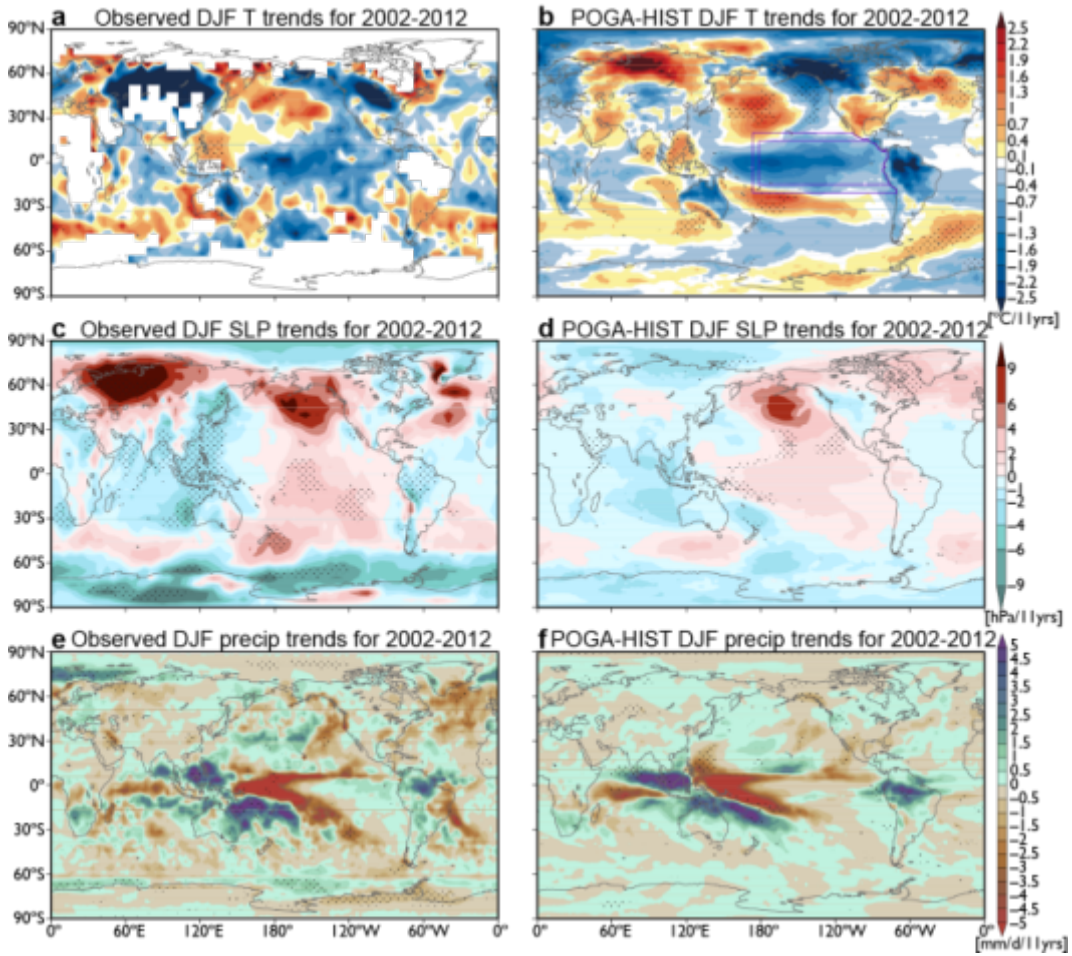
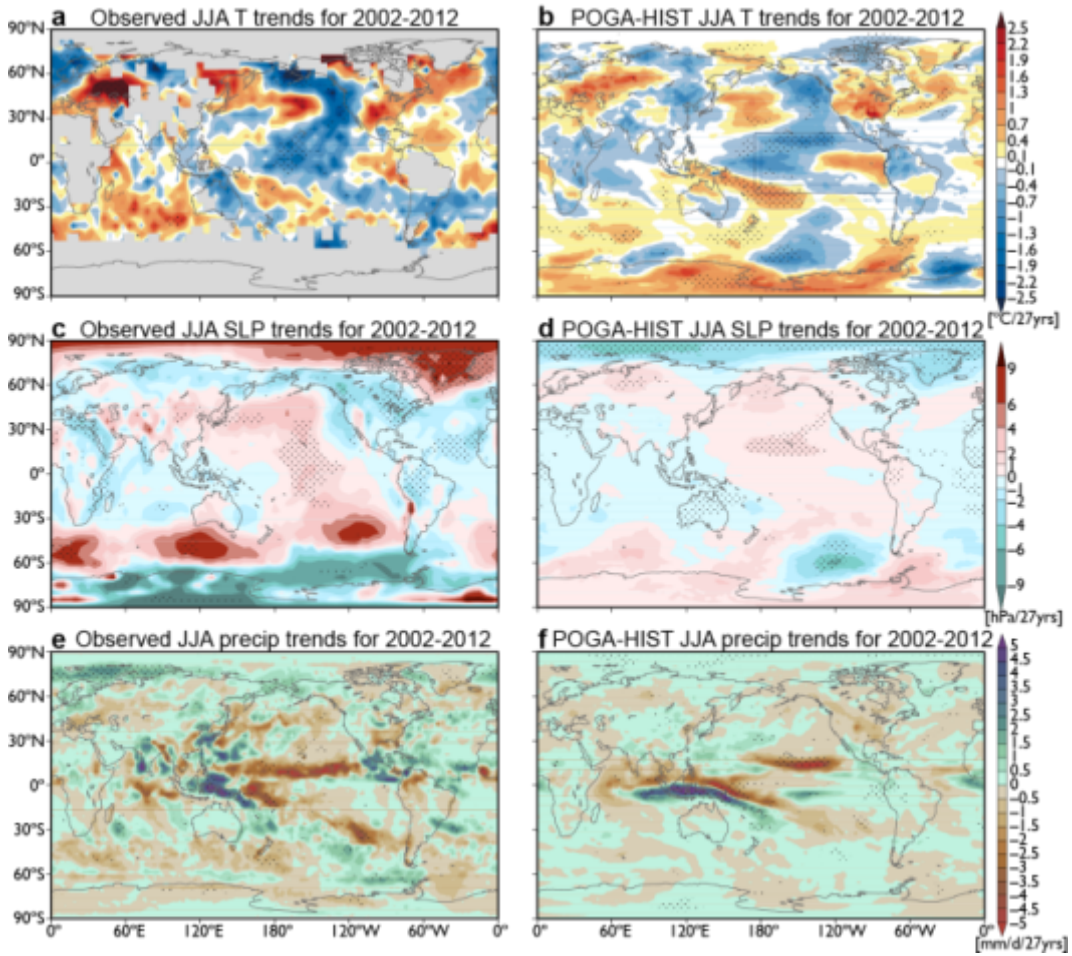
  (the previous hiatus event was from the 1940s to the early 1970s)

- Predicting end of the hiatus is difficult, limited by tropical Pacific predictability

# Composited hiatus events in historical exp



# DJF trend pattern for the current hiatus



# JJA trend pattern for the current hiatus