Statistical Approaches for Simple Measurements of Surface Temperature and Cloud Forcing Trends and Extrema

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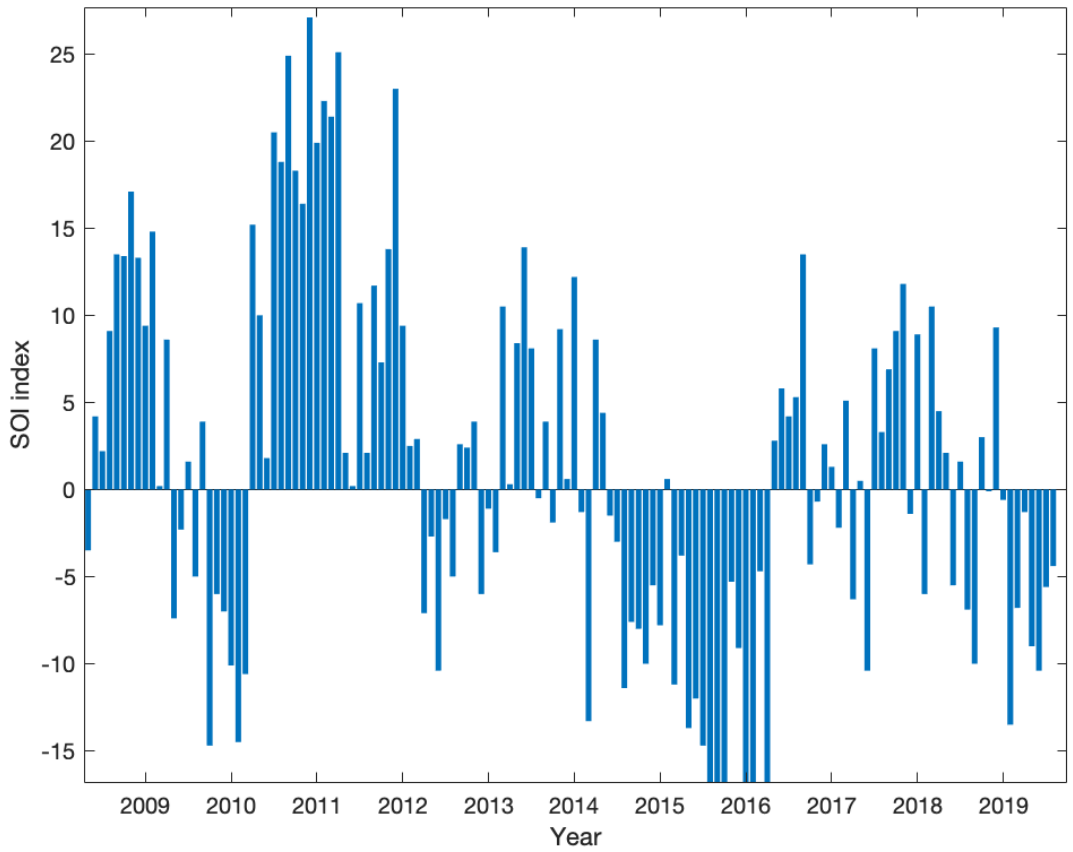
Overview

- AIRS has made nearly 17 years of high quality TOA radiance measurements
- We have previously shown that the instrument stability is sufficient to determine linear rates surface temp., column CO_2, temp. and wv profiles
- We have also shown that probability density functions (PDFs) of clear sky PDFs can provide insight into non-Gaussian climate variability and stochastic forcing of the atmosphere
- We want to learn whether the 16+ years is long enough to start to see climate signals in surface temperature and cloud forcing.
- The primary issue to resolve is whether the rates we calculate have a significant contribution from the ENSO cycle.

The ENSO cycle during the past 10 years

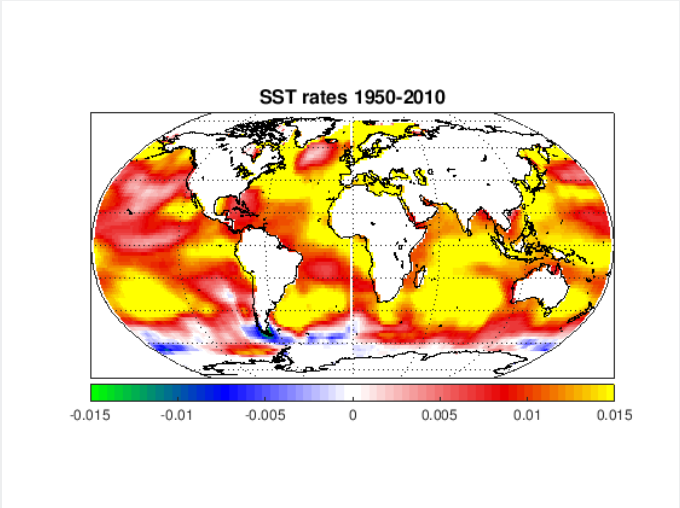
The SOI is a measure of the pressure difference between Tahiti and Darwin:

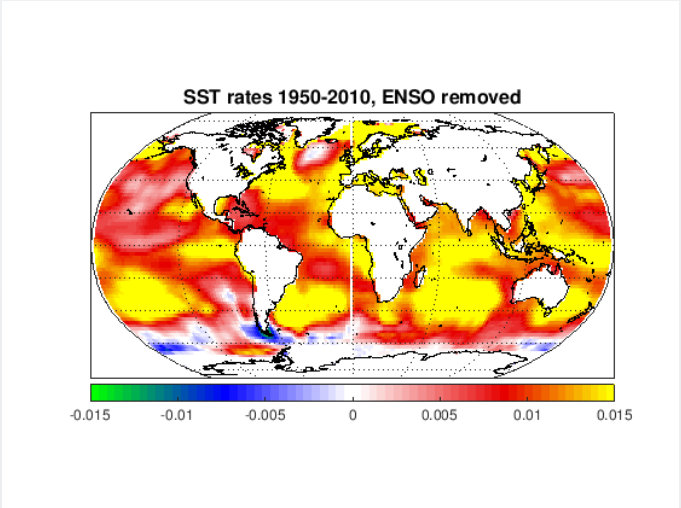
$$SOI = \frac{\Delta P - \Delta P_{average}}{\sigma_{\Delta P}}$$

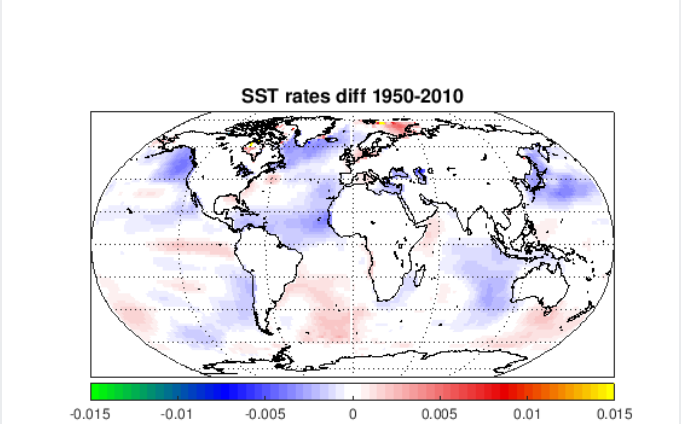


Can we quantify how much ENSO is affecting linear rates in SST and CF?

- Consider the linear SST rate from the NOAA Extended Reconstructed SST V5 - 60 years
- Time period for the rate calculation is 1950-2010

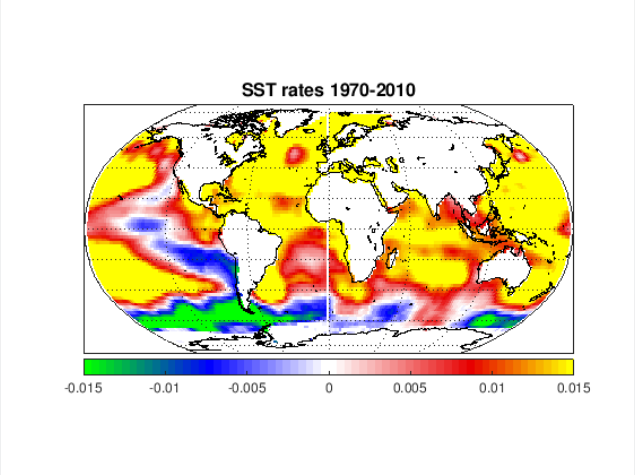


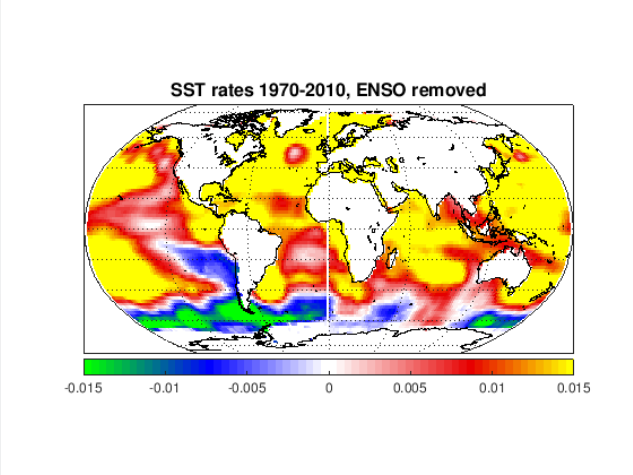


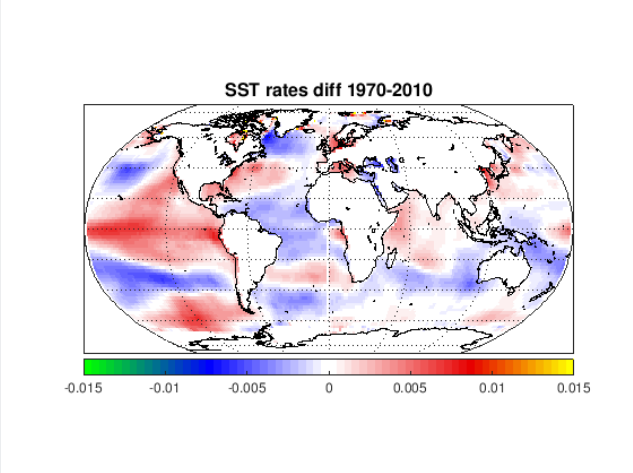


Impact of ENSO on 40 year SST rates

- Impact of of ENSO is noticeably larger.

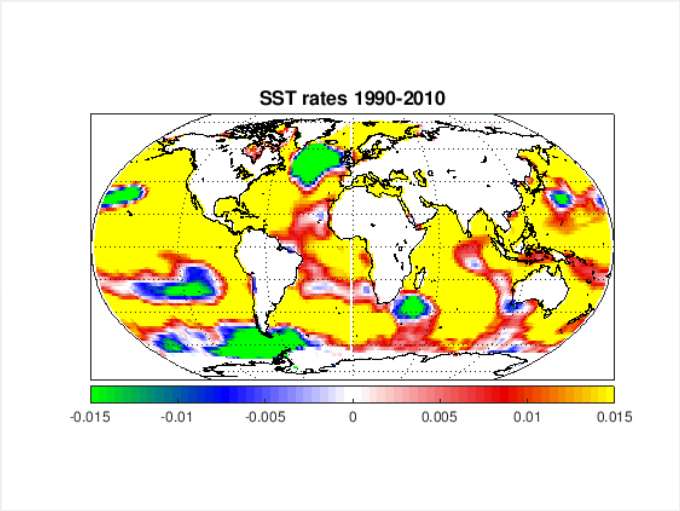


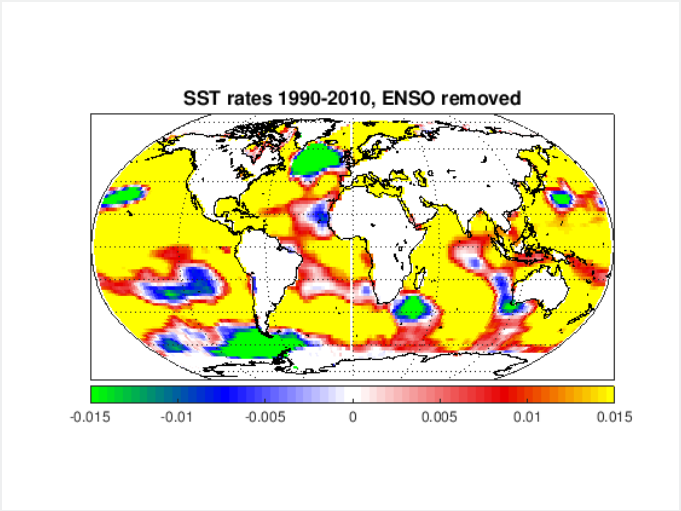


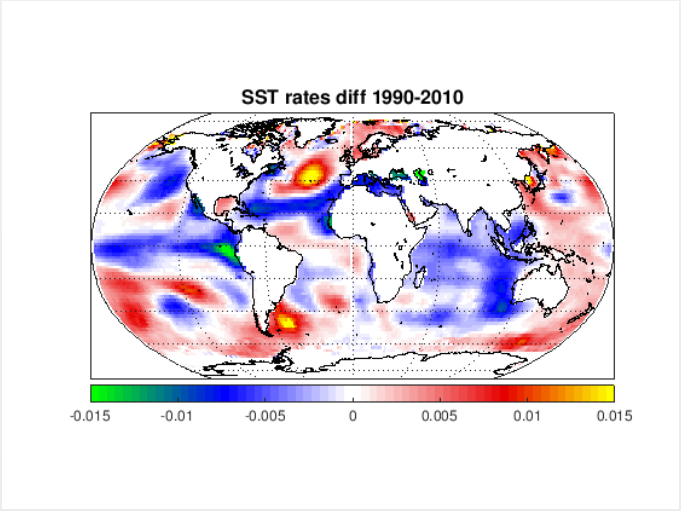


Impact of ENSO on 20 year SST rates

- Maximum difference off the west coast of S. America.

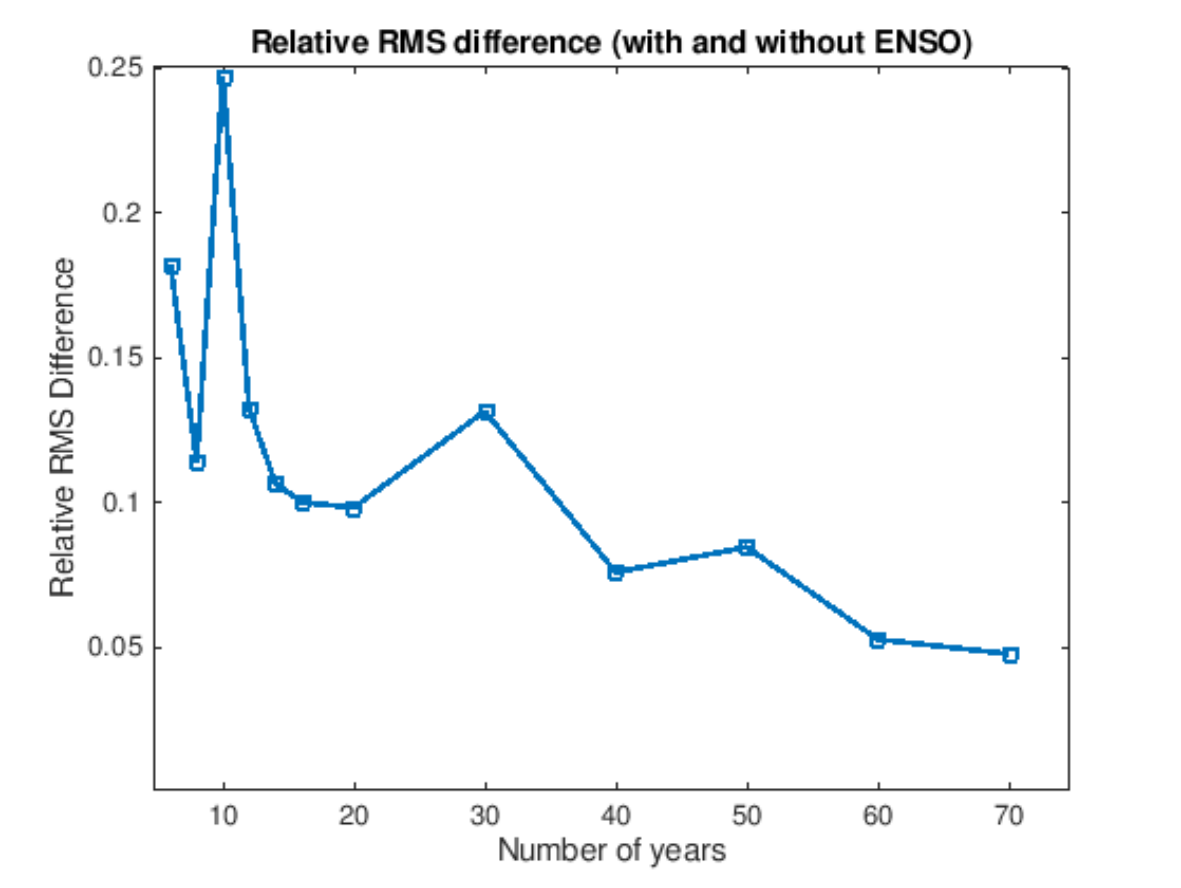






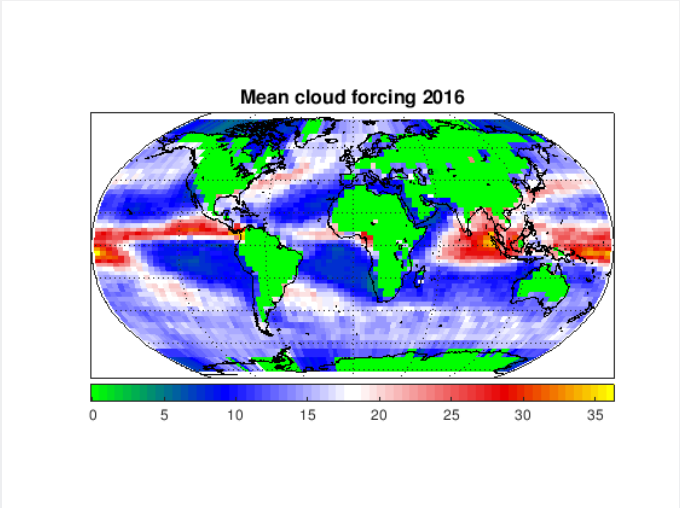
Relative RMS difference vs. number of years

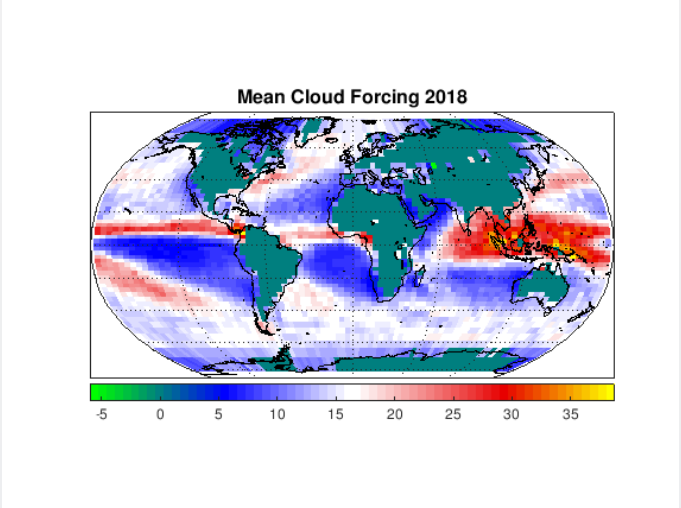
- Global differences depend on how many El Nino/La Nina events are included.
- 16 year rates have a 10% impact of ENSO.

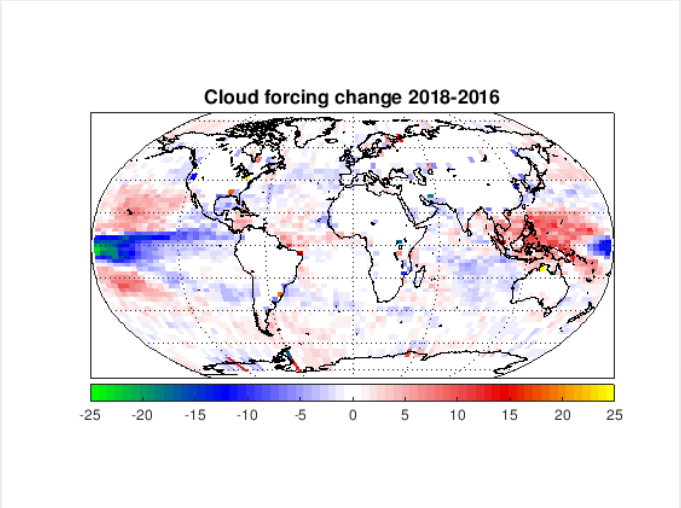


Cloud Forcing: Surface Temperature - BT for WN $917.3 cm^{-1}$

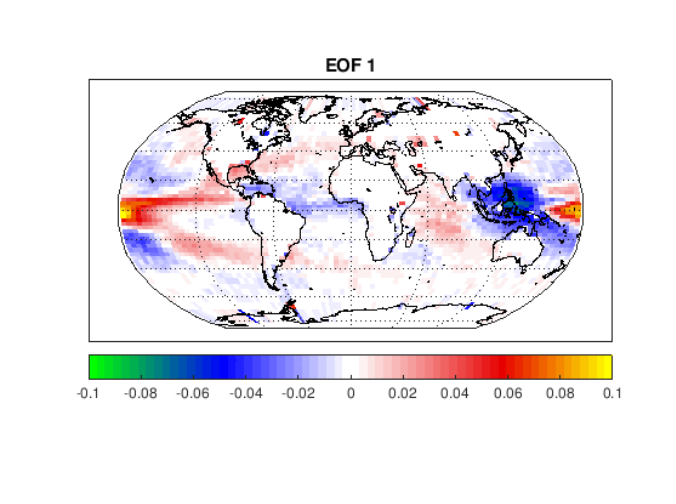
- Mean CF in 2016 and 2018.
- Is there a signature of ENSO in the change of CF?

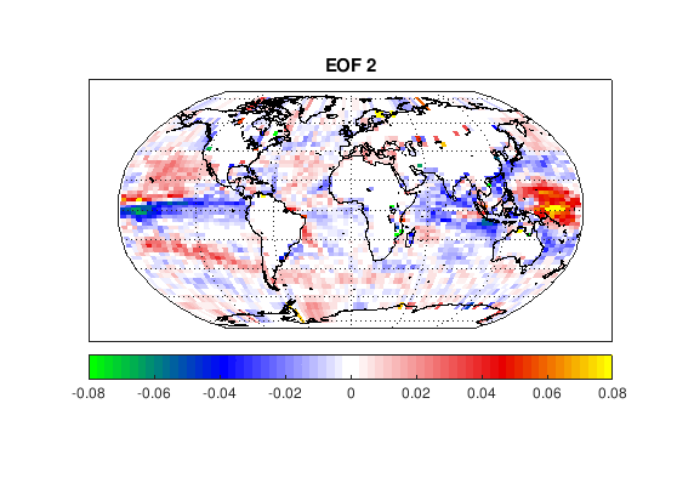




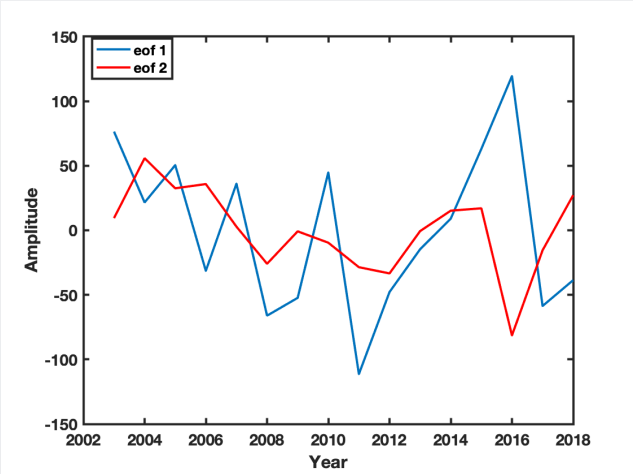


EOFs of CF





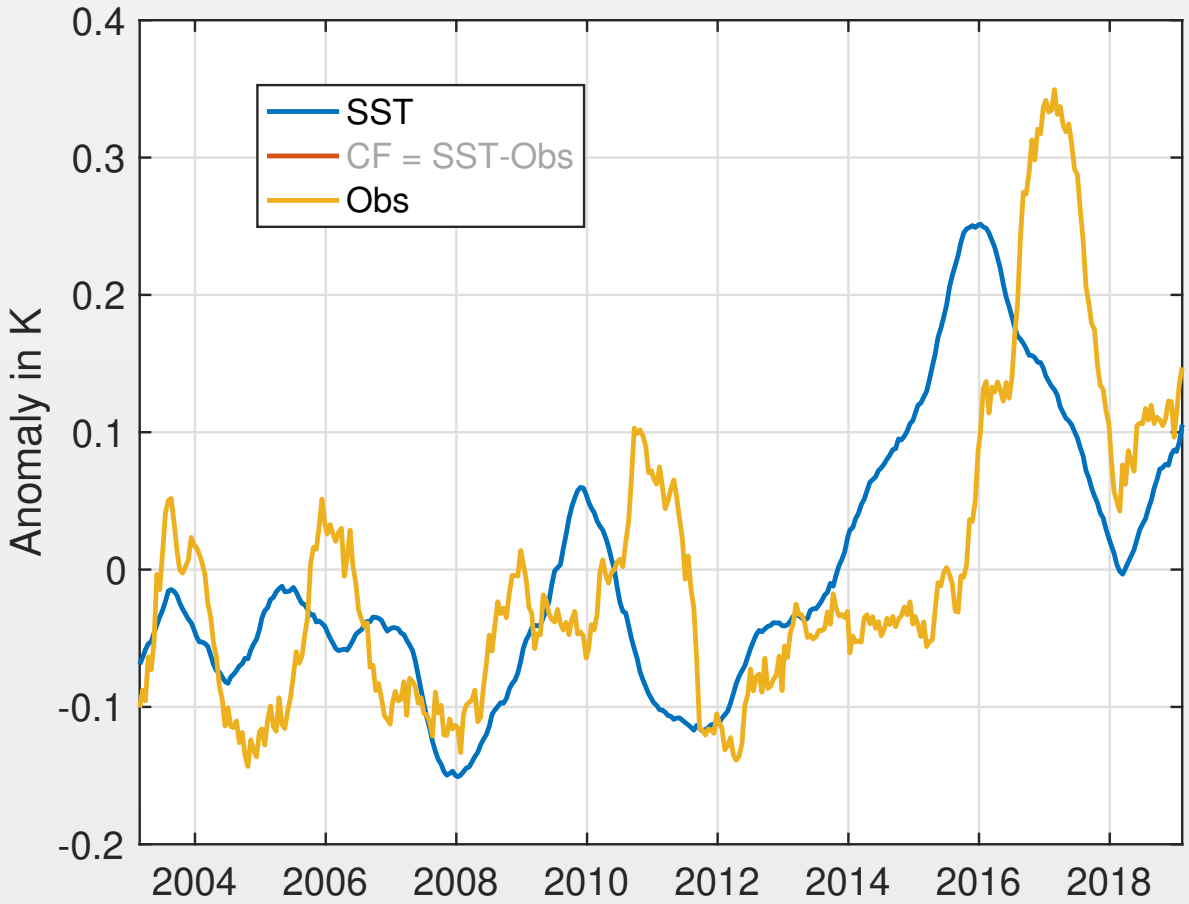
- EOF coefficients in time. First 2 peak in 2016.
- Can we use EOFs to get a handle on how much ENSO is impacting CF?



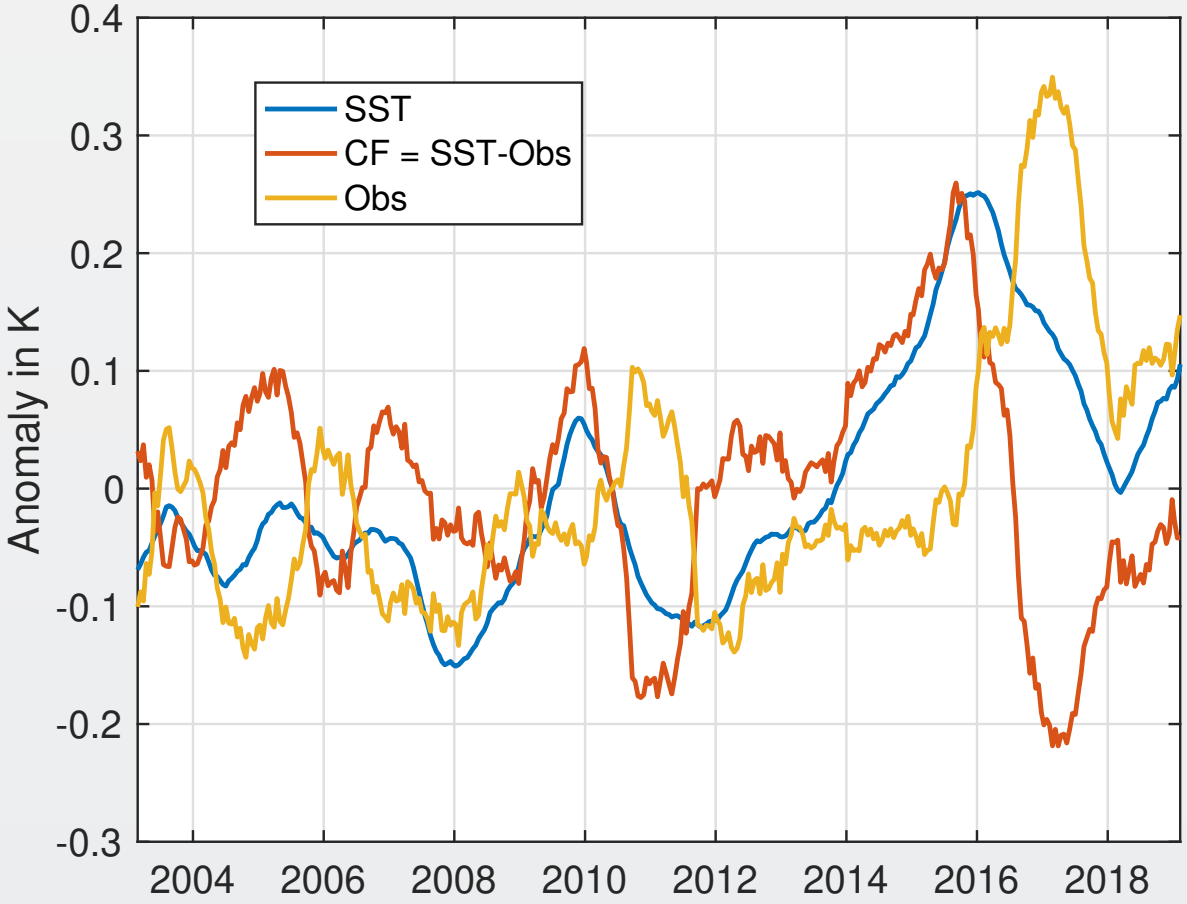
Cloud Forcing Global Behavior

- Something for which AIRS may have a unique contribution
- Define CF = SST - BTobs. (more cloud means positive)
- Global: maybe interesting, what does AIRS stability tell us?
- ENSO: how does cloud forcing respond to an ENSO kick?
- We know SST very well, we know BTobs very well.
- Of course, global dominated by tropics

Global SST and BTobs Anomalies

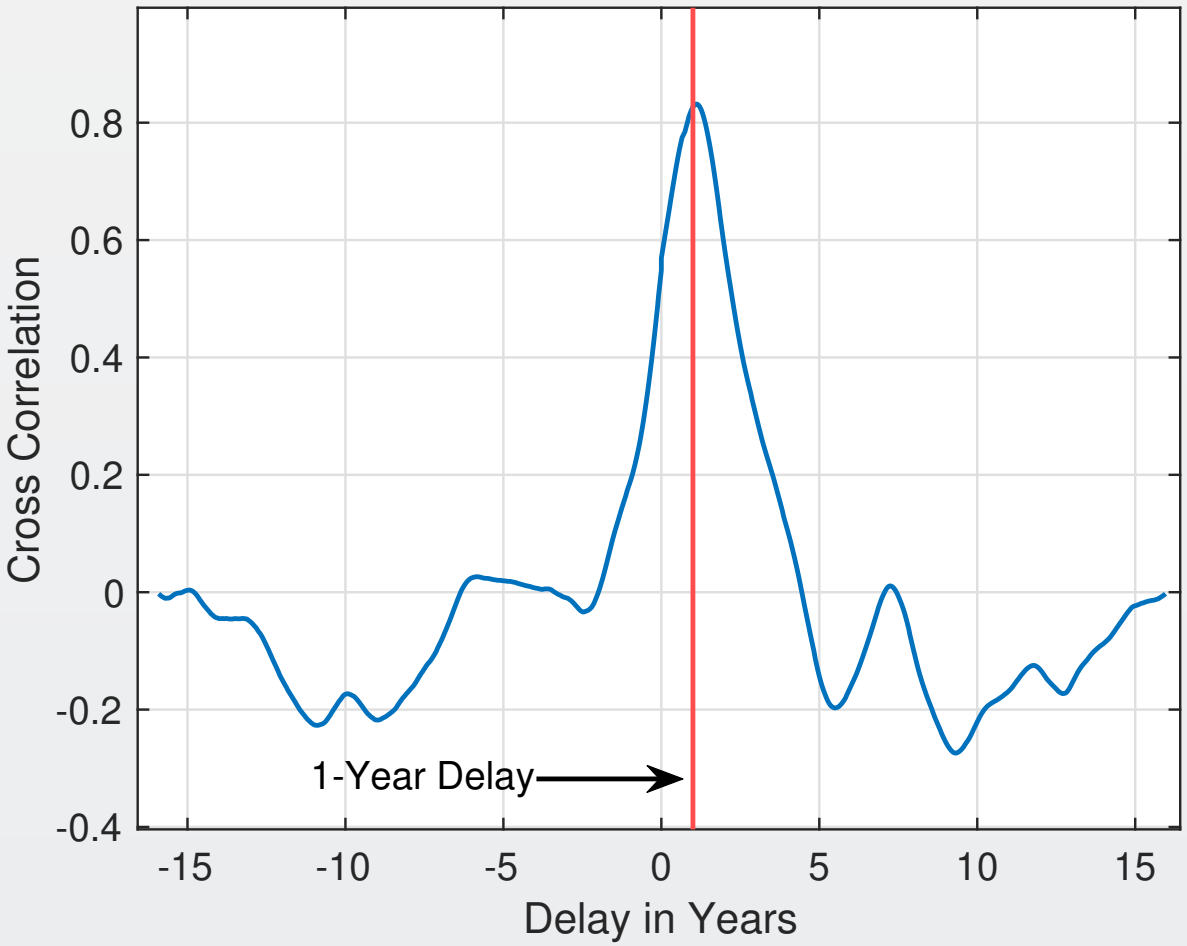


Now Add Longwave Cloud Forcing



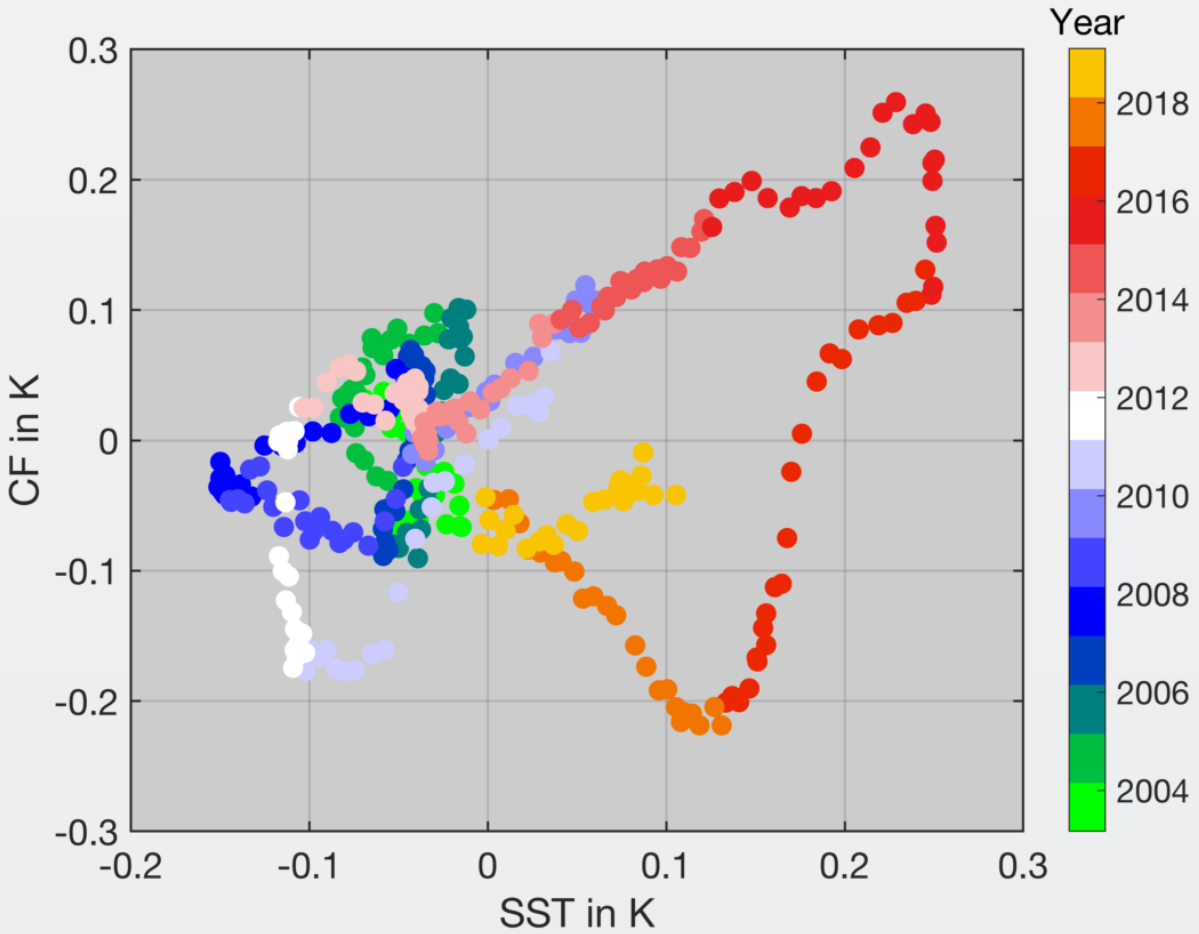
- Note sharp CF drop at SST peak anomaly

Delay of BTobs Anomaly to SST Anomaly



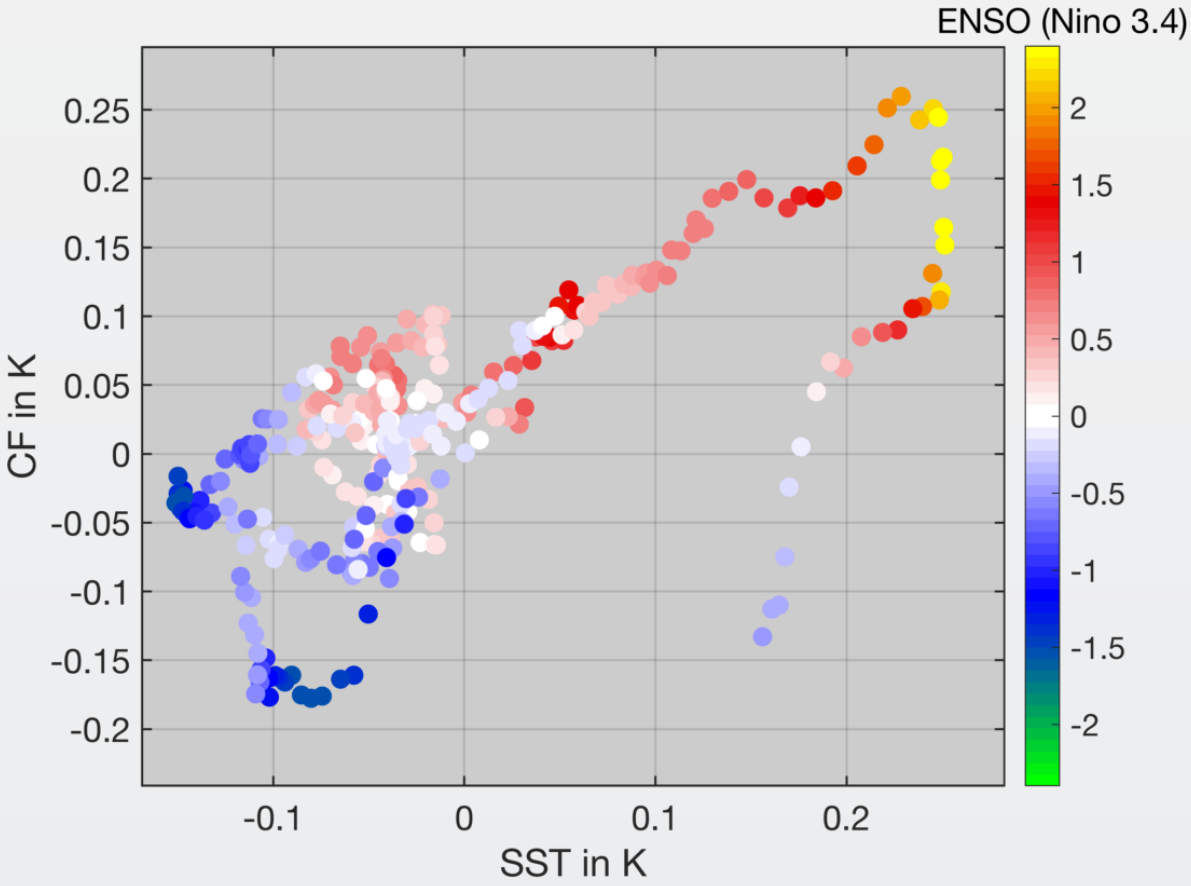
- Almost exactly a 1-year delay in BTobs (clear trend) from SST

Examine Time Dependence of CF vs SST Anomaly



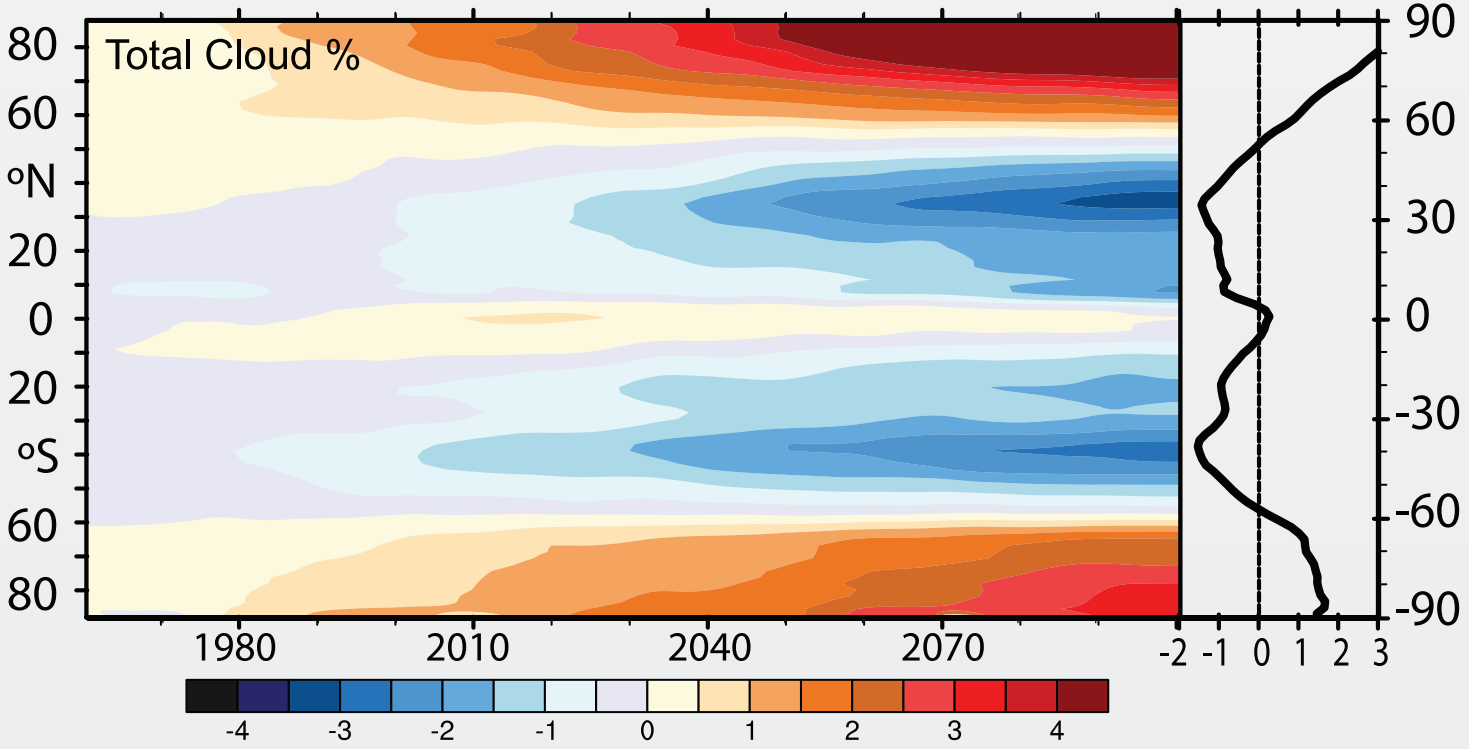
- At peak of ENSO CF drops very quickly
- Overshoots
- Then back to normal, BUT, of course, SST has gone up by a tremendous amount in a short time: 0.15K

CF vs ENSO Index

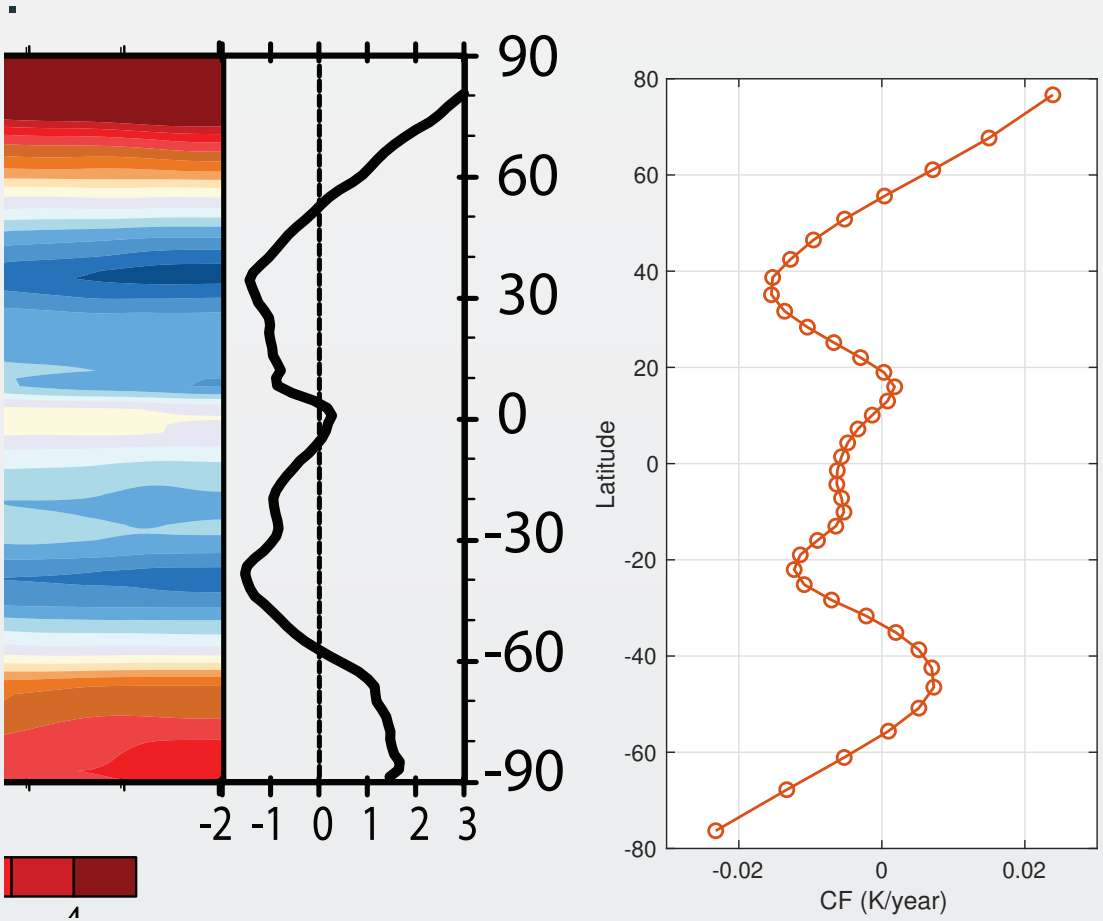


- ENSO returns to normal, CF returns

Climate Model Cloud Trends (Trenberth, 2009)

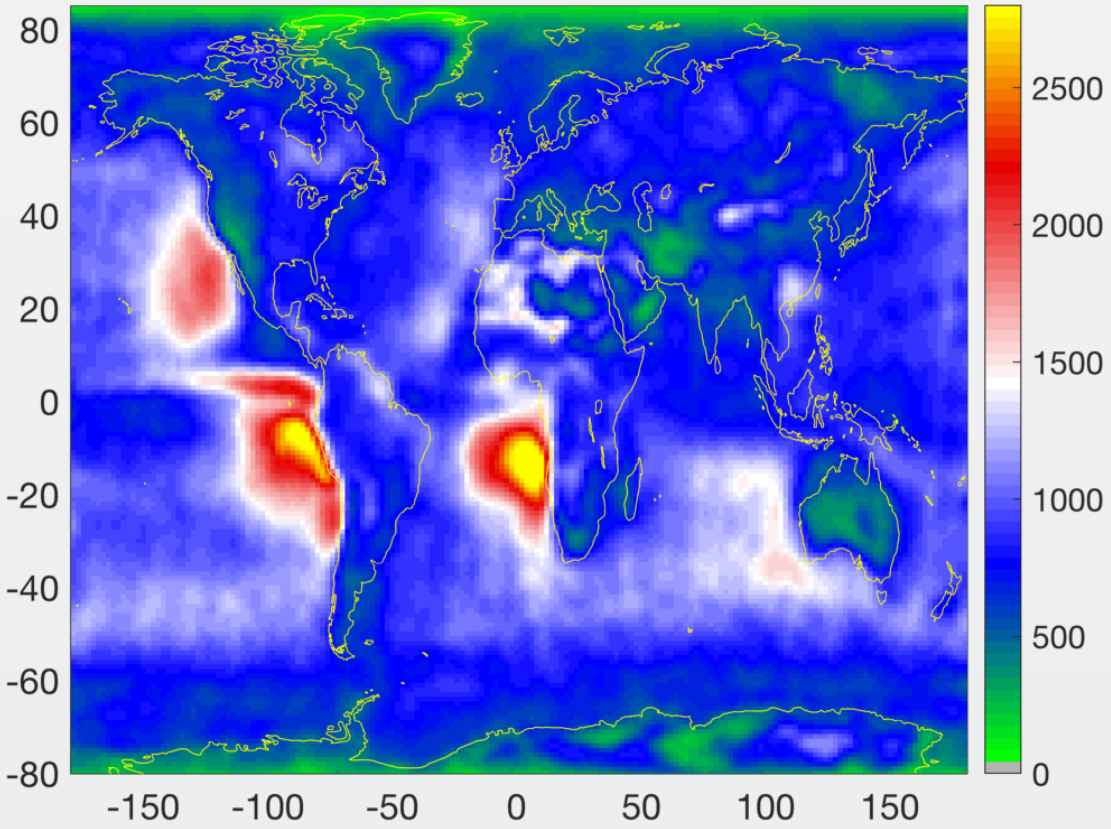


CF Trends: Left: Trenberth (2009) %/150 years, Right: AIRS



- AIRS cloud forcing fractional change ~5X higher than models
- Clearly we may just be observing fragments from ENSO, need time
- But, climate model uncertainty large
- AIRS stability likely 3x better than obs

AIRS Connection with Shortwave Cloud Forcing



- With a good surface T, marine boundary layer (MBL) clouds easy to detect (BTobs 4-10K lower than surface T)
- They represent one of the largest contributors to cloud radiative effect in climate models increasing MBL clouds greatly affect reflected solar with little change to longwave forcing
- We can very precisely monitor changes in MBL clouds using BTsurface - BTobs