

# Does ENSO Dominate Global Warming?

Maaneli (Max) Derakhshani

Rutgers University

Department of Mathematics

[maanelid@yahoo.com](mailto:maanelid@yahoo.com)

# ENSO? I

- ENSO = **El Niño** / **Southern Oscillation**. Coupled ocean-atmosphere phenomenon occurring across the tropical Pacific Ocean.
- [“El Niño” \(Christ’s child\)](#) the name Spanish fishermen gave a periodic (warm) ocean current around tropics – they observed it usually right after Christmas.
- [Southern Oscillation](#) = changes in sea level air pressure patterns in Southern Pacific Ocean between Tahiti and Darwin, Australia (both in Tropics). El Niño *one* part of this.



Image source: <https://www.noaa.gov/jetstream/tropical/enso>

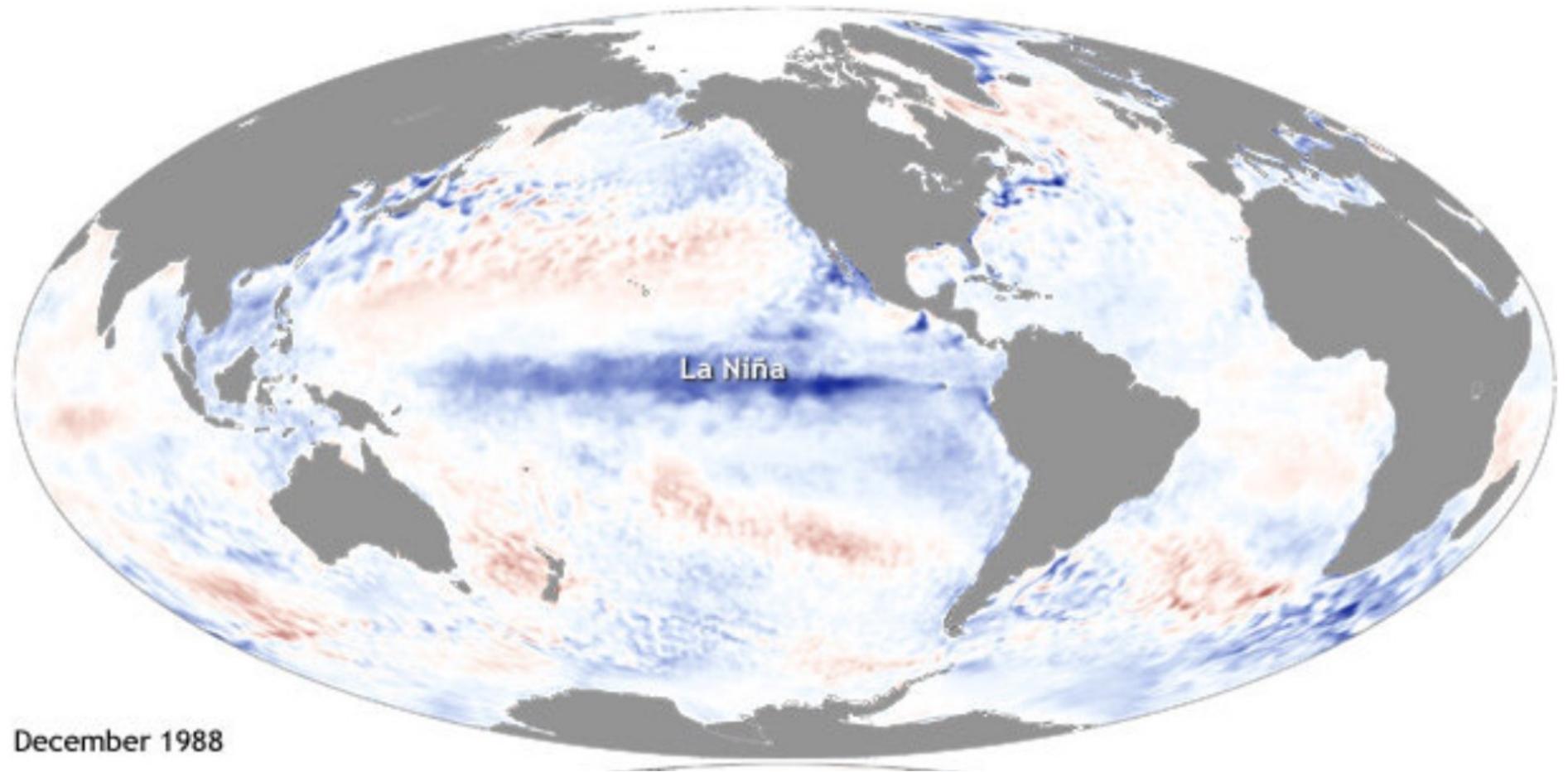
# ENSO? II

- During El Niño period, avg air pressure **higher** in Darwin than Tahiti. Causes changes in water surface temperatures in Central and East Pacific Ocean. Get **warmer** water surface temps.
- During *La Niña* period, avg air pressure **lower** in Darwin than Tahiti. Causes cooler water surface temps.
- **El Niño = warming episode** of ENSO, and **La Niña = cooling episode** of ENSO. Periods in between, “ENSO-neutral”.
- EL Niño or La Niña episode typically lasts 9-12 months.

# ENSO? III

- During La Niña, avg air pressure **lower** in Darwin than Tahiti, hence trade winds (which blow from east to west across tropical Pacific Ocean) get stronger than normal.
- Stronger winds push more surface water to the western half of Pacific basin. Pool of warm water there grows deeper, storing excess heat at depth. Allows for colder, deeper water to rise to the surface in eastern half of Pacific basin.
- This creates large region along equator where ocean surface temps are below normal.
- Over several months, heat from atmosphere then goes **into** the ocean. Leads to **cooler** air temps over region large enough to cool the global avg temp.

# ENSO? IV

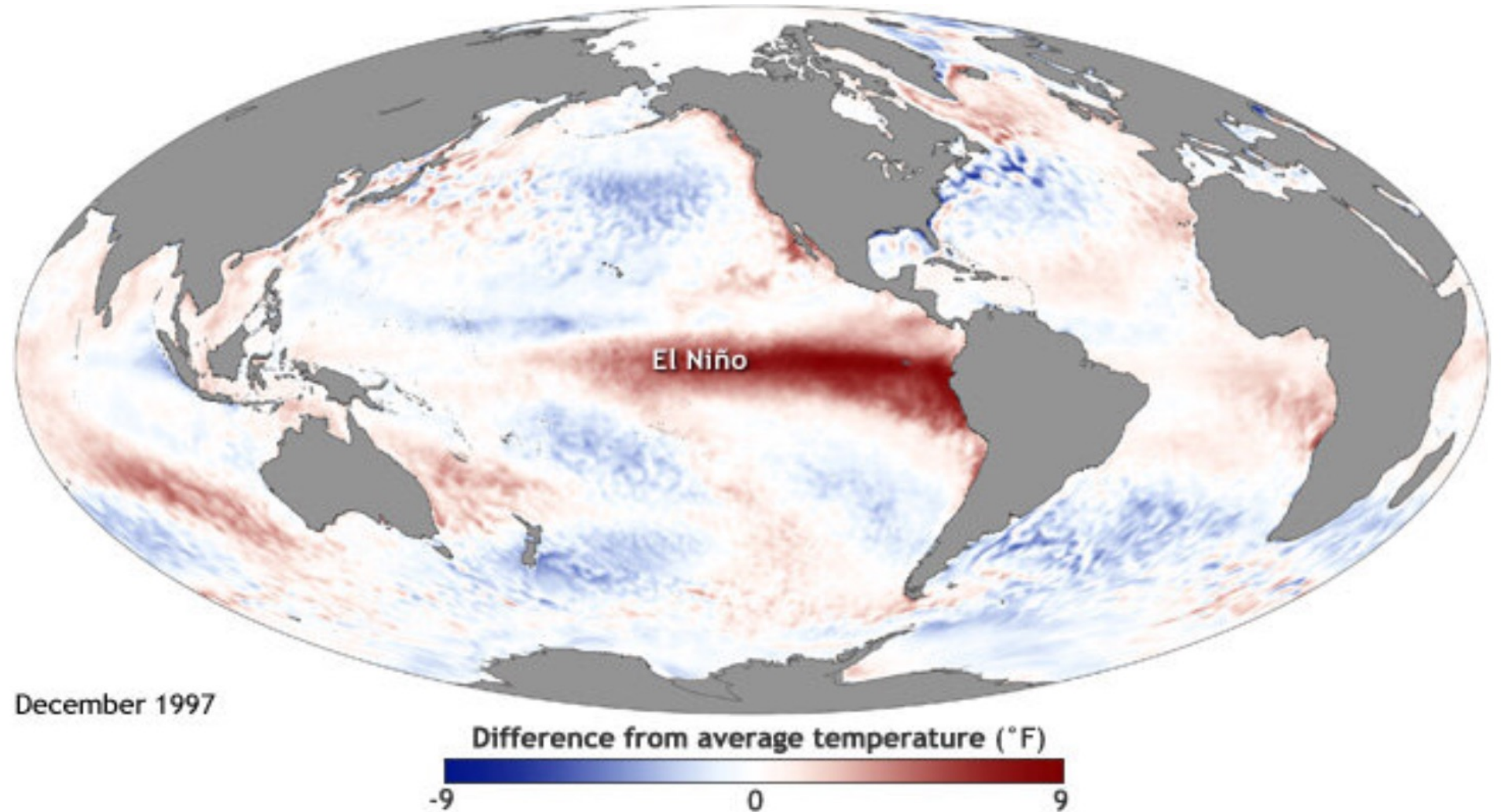


**Source:** <https://www.climate.gov/news-features/understanding-climate/el-niño-and-la-niña-frequently-asked-questions>

# ENSO? V

- During El Niño, avg air pressure **higher** in Darwin than Tahiti, hence trade winds weaken or reverse.
- Hence amount of cold water that comes to the surface in eastern Pacific Basin gets reduced. Warm waters in west Pacific Ocean slosh east, creating large region along equator where ocean temps above normal.
- Heat from ocean then goes **out** into atmosphere, leading to warmer air temps in the Pacific and hence warmer global avg air temps.

# ENSO? VI



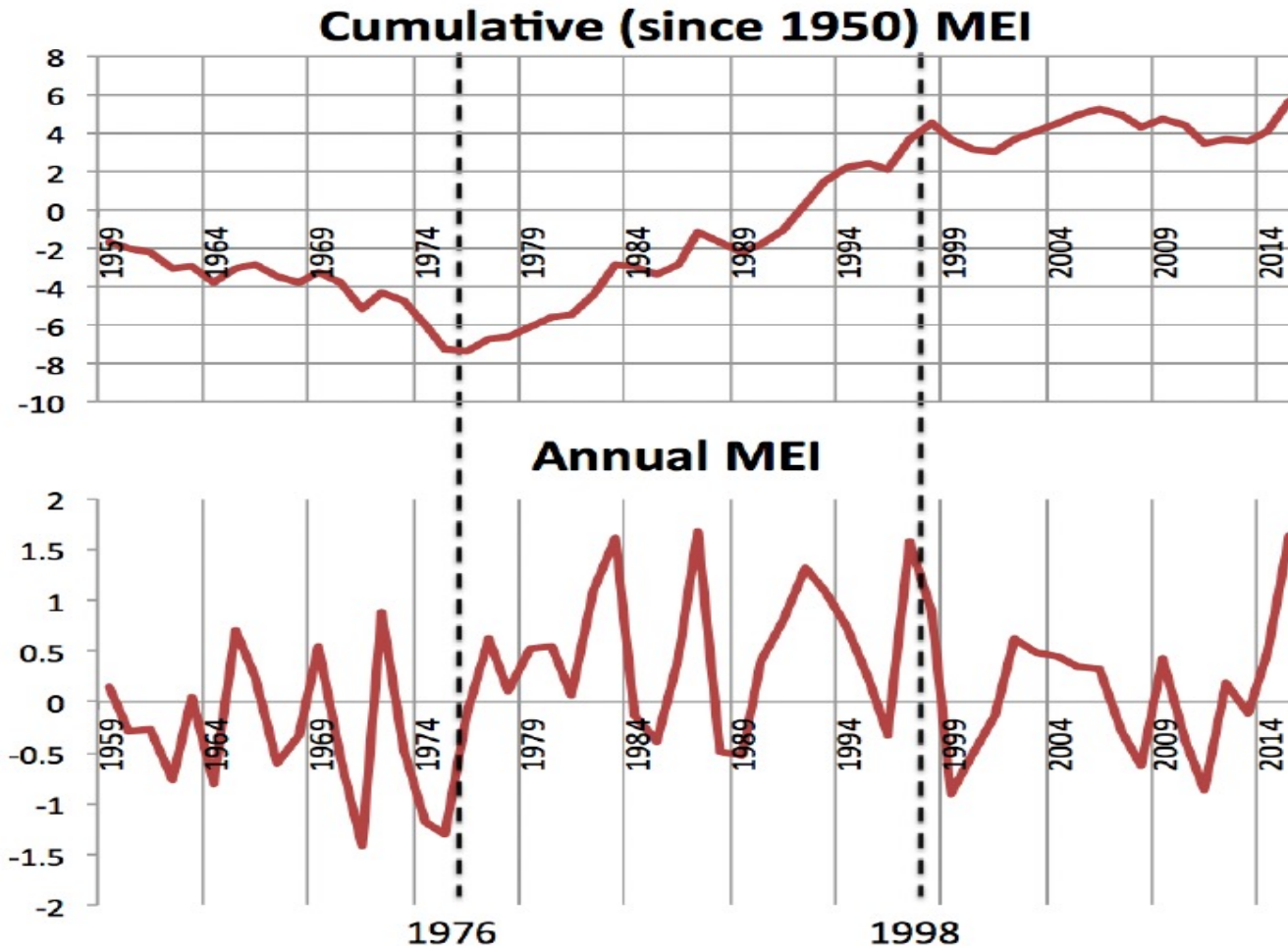
**Source:** <https://www.climate.gov/news-features/understanding-climate/el-niño-and-la-niña-frequently-asked-questions>



# ENSO? VII

- **Key**: ENSO shuffles heat from ocean to atmosphere (vice versa). Phases of ENSO don't create or remove energy from climate system (at least not directly).
- Climate scientists thusly call ENSO a form of **internal** climate variability.
- Nevertheless: El Niños cause global scale warming of atmosphere, La Niñas global scale cooling, other things equal. Magnitudes related to ENSO strengths.
- Multi-decadal cycles happen where tropical Pacific Basin takes physical state favoring El Niños alternating with multi-decadal periods favoring La Niñas.

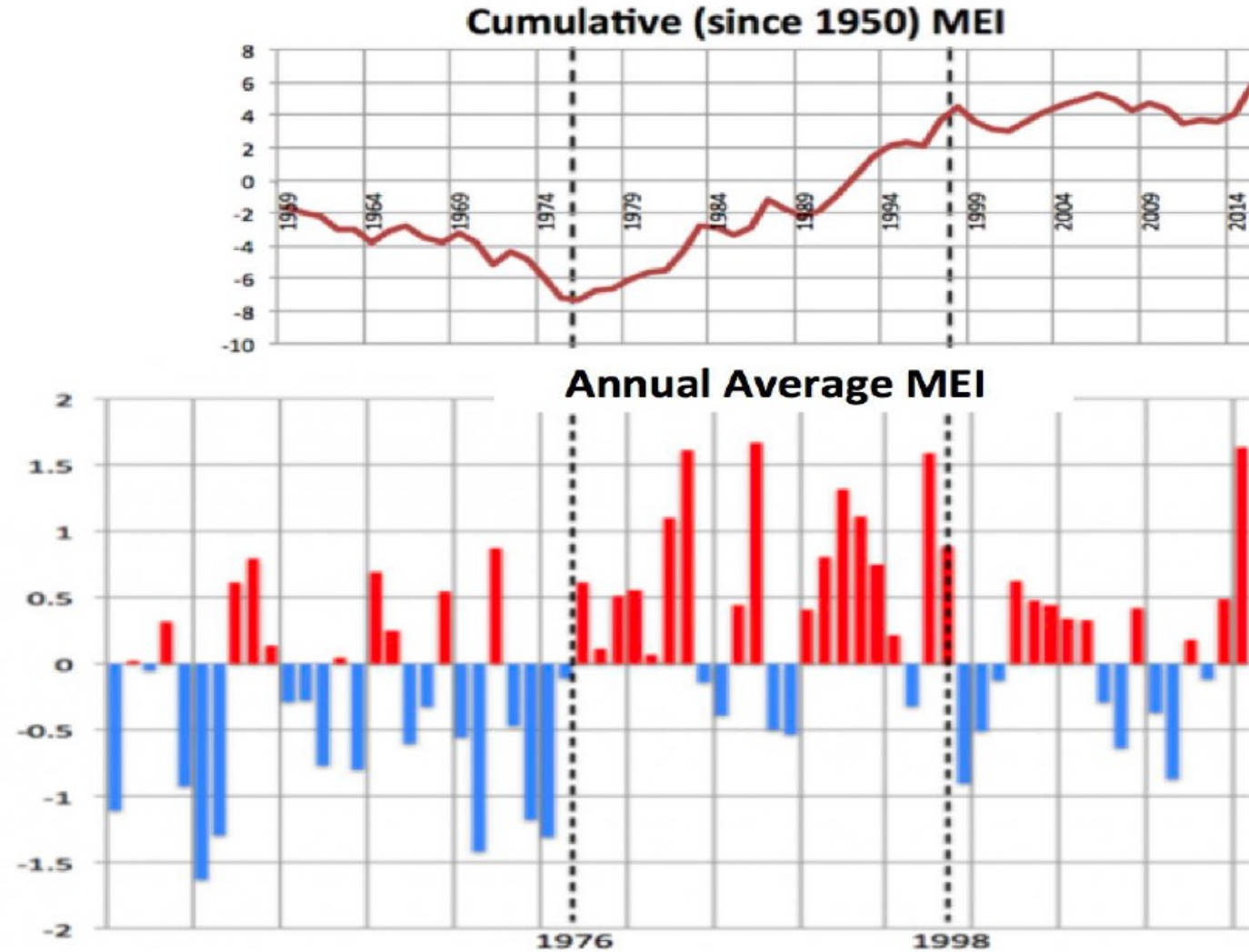
**Figure VI-1**



Source: <http://www.esrl.noaa.gov/psd/enso/mei/table.html>

Source: <https://thsresearch.wordpress.com/2016/09/17/ths-exec-sum/>

Figure VI-2



Source: <http://www.esrl.noaa.gov/psd/enso/mei/table.html>

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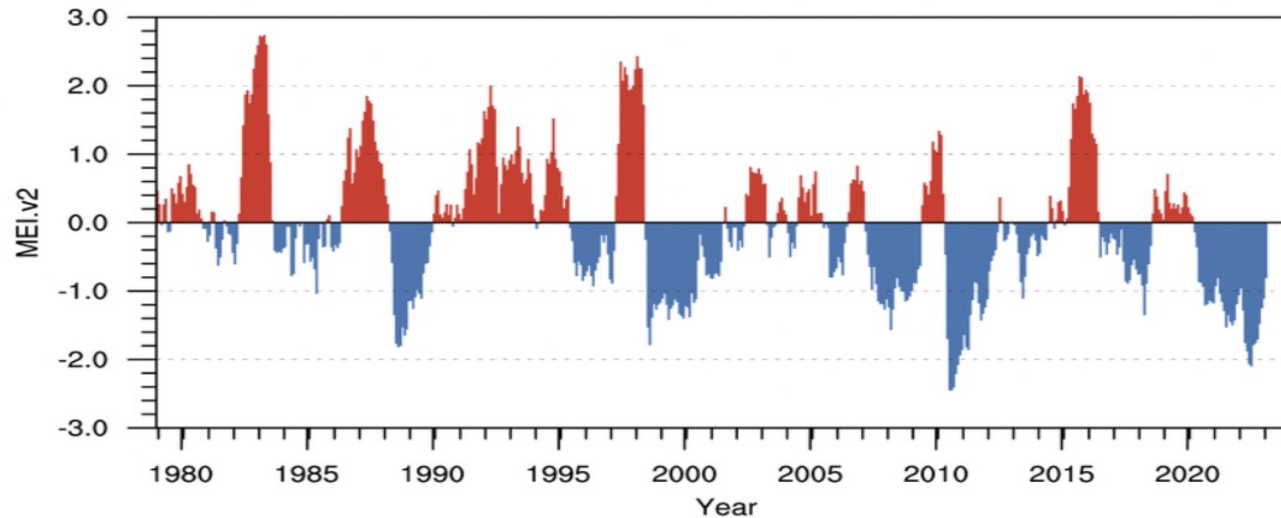
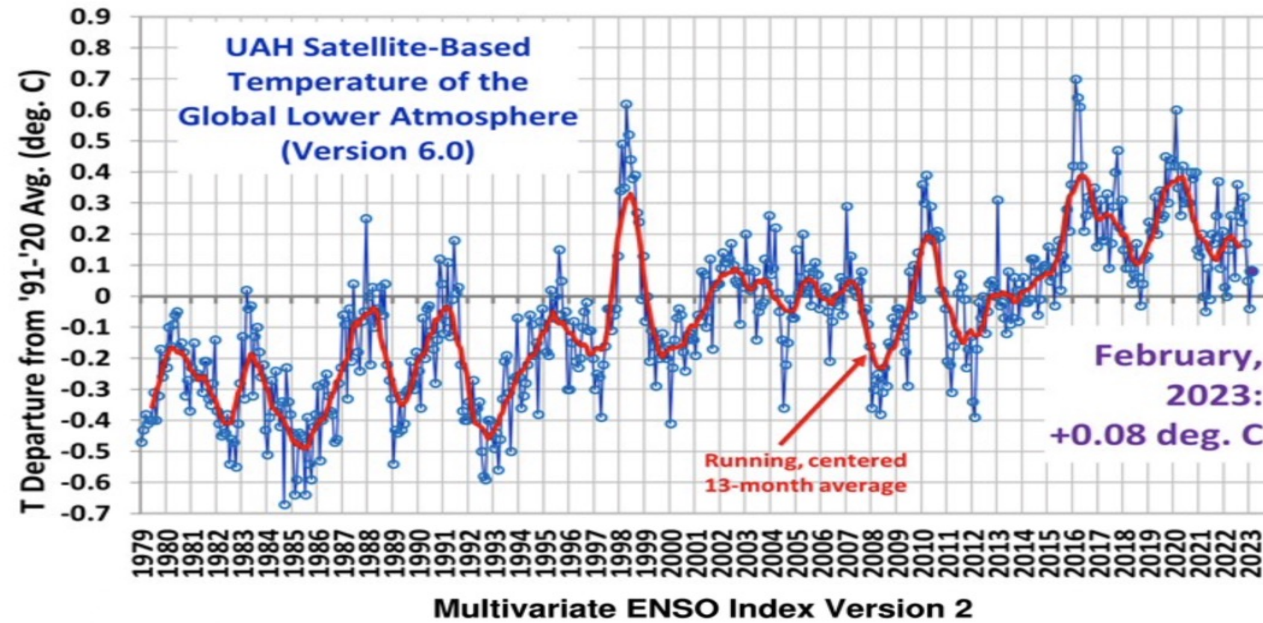
# ENSO? VIII

- MEI is one of many measures of the frequency and magnitude of ENSO phases.
- Other measures of ENSO exist, e.g., [Southern Oscillation Index \(SOI\)](#), and [Oceanic Nino Index \(ONI\)](#).
- [NOAA](#): "We attempt to monitor ENSO by basing the Multivariate ENSO Index (MEI) on the six main observed variables over the tropical Pacific. These six variables are: sea-level pressure (P), zonal (U) and meridional (V) components of the surface wind, **sea surface temperature (S)**, **surface air temperature (A)**, and total cloudiness fraction of the sky (C)."
- MEI, at given point in time, is linear f'cn of 6 variables, all measured in the Tropics.

# Global warming dominated by ENSO?

- We've seen that El Niños leads to warming of air temperatures globally, and La Niñas to cooling.
- Also seen that multi-decadal cycles of ENSO led to net cooling from 1949-1977, significant net warming from 1977-1998, not much trend from 1999-2015.
- So it's natural to ask: how strongly do global avg atmospheric temp anomalies correlate with ENSO phases?
- Can ENSO explain most of the warming and cooling periods in the temperature anomaly records?

# ENSO dominance: visual evidence



Sources: <https://www.drroyspencer.com/latest-global-temperatures/>  
<https://psl.noaa.gov/enso/mei/>

# ENSO dominance: visual evidence II

- Can see clear correlation between monthly variations in ENSO around 6 months prior to monthly variations in temperature, except for major volcanic eruptions occurring during El-Niños.
- Largest volcanic eruption events since 1979 that coincided with El Niño events (temporarily negating some or all the warming from them) were: Mt. St. Helens (May 1980), El Chichon (April 1982), Mt. Pinatubo (June 1991), and Mt. Hudson (August 1991).
- The other largest volcanic eruption events, Caulle (June 2011) and Ha'apai (January 2022), coincided with La Niñas.

# ENSO dominance: McLean et al. (I)

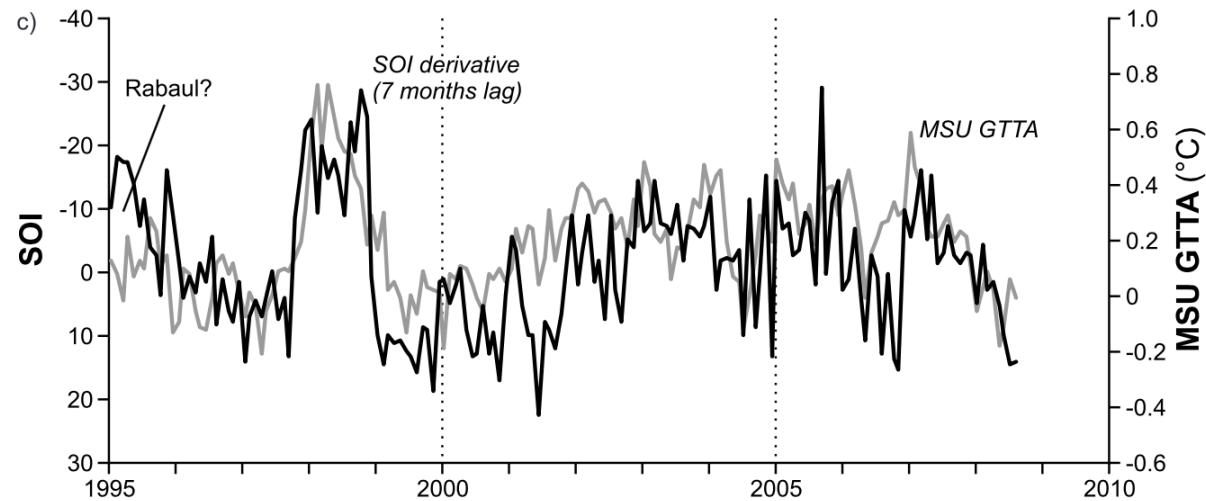
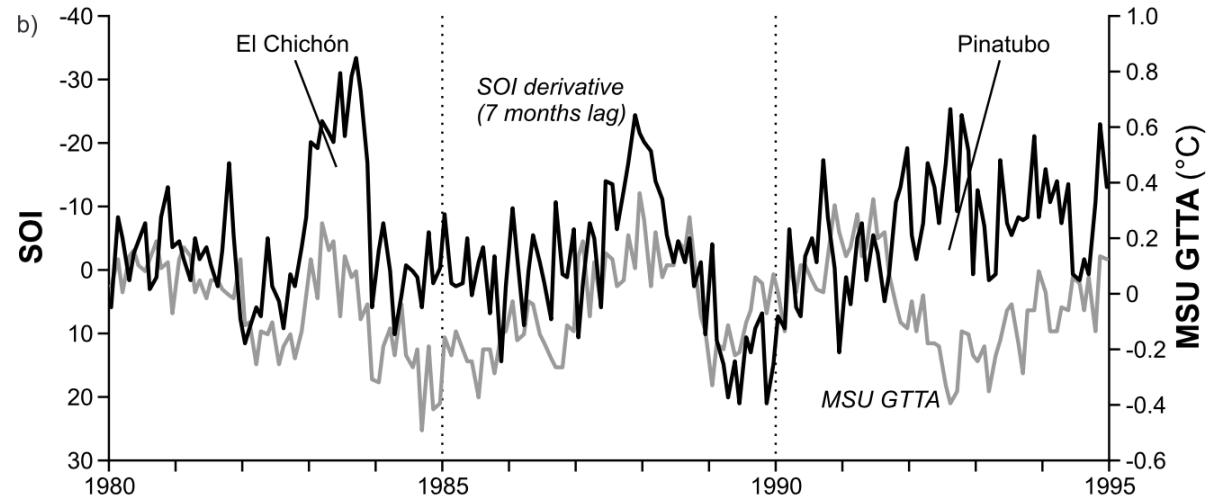
- 2009 paper in Journal of Geophysical Research by J. D. McLean, C. R. de Freitas, and R. M. Carter, [“Influence of the Southern Oscillation on tropospheric temperature”](#).
- Quantifies extent of correlations between monthly variance in the Southern Oscillation Index (SOI) and monthly variance in both UAH temp record and “RATPAC” weather balloon temp record.
- SOI based on sea level pressure diff btwn Tahiti and Darwin, Australia.
- [NOAA](#): “In general, smoothed time series of the SOI correspond very well with changes in ocean temperatures across the eastern tropical Pacific.”  
<https://www.ncei.noaa.gov/access/monitoring/enso/soi>



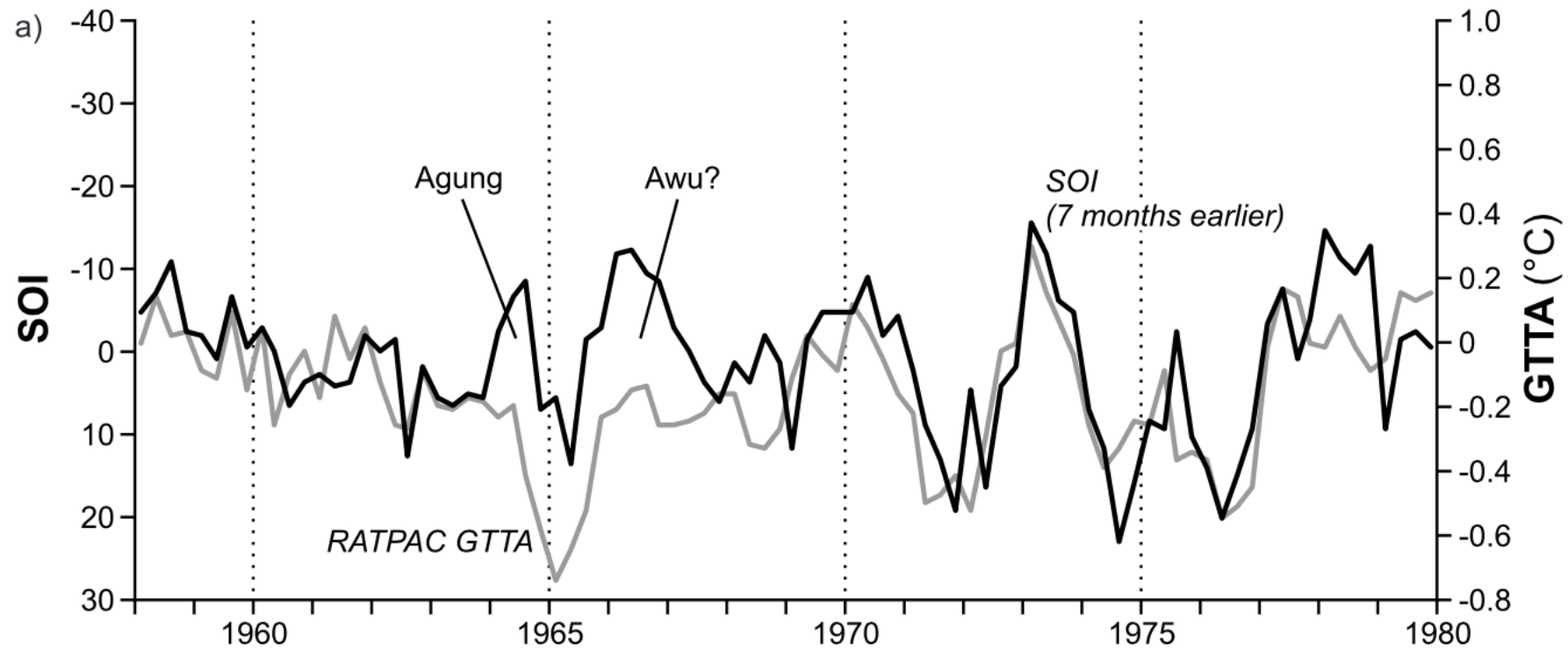
# ENSO dominance: McLean et al. (II)

- **From abstract**: ...Change in SOI accounts for 72% of the variance in GTTA [global tropospheric temperature anomalies] for the 29-year-long MSU [UAH satellite] record and 68% of the variance in GTTA for the longer 50-year RATPAC [weather balloon] record. Because El Niño–Southern Oscillation is known to exercise a particularly strong influence in the tropics, we also compared the SOI with tropical temperature anomalies between 20°S and 20°N. The results showed that SOI accounted for 81% of the variance in tropospheric temperature anomalies in the tropics. Overall the results suggest that the Southern Oscillation exercises a consistently dominant influence on mean global temperature, with a maximum effect in the tropics, except for periods when equatorial volcanism causes ad hoc cooling. **That mean global tropospheric temperature has for the last 50 years fallen and risen in close accord with the SOI of 5–7 months earlier shows the potential of natural forcing mechanisms to account for most of the temperature variation.**

# ENSO dominance: McLean et al. (III)



# ENSO dominance: McLean et al. (IV)

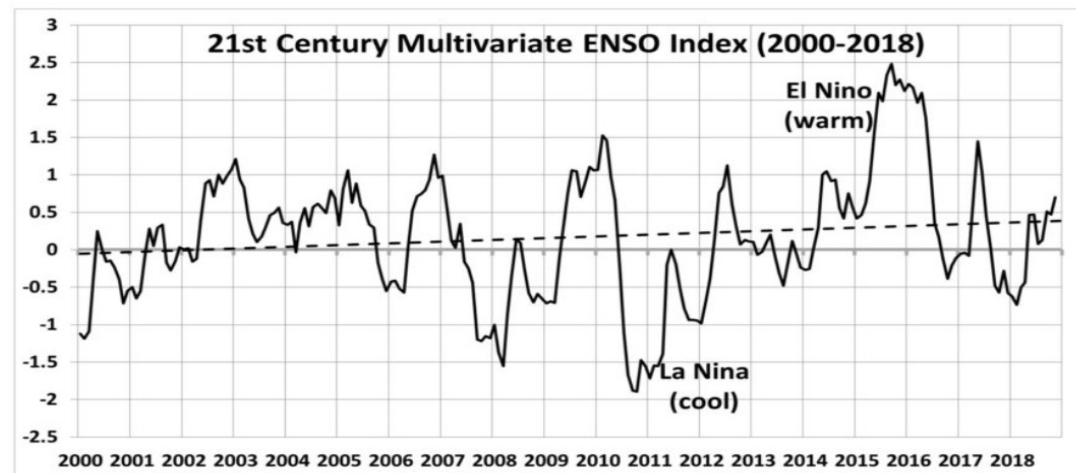
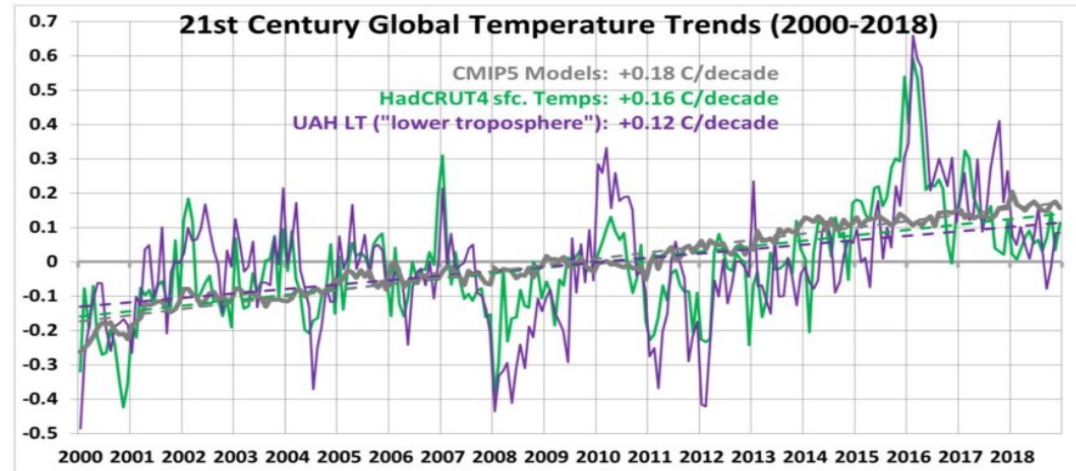


Source: <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2008JD011637>

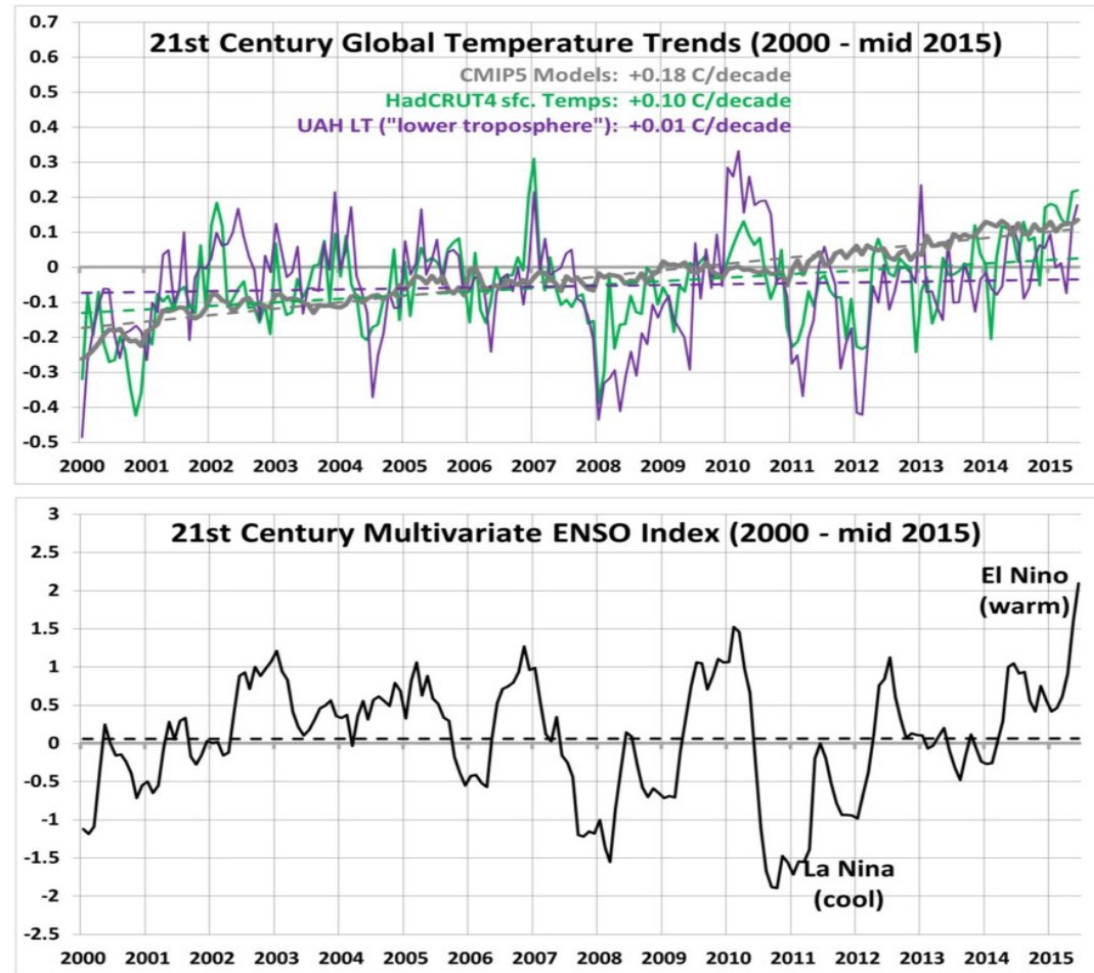
# ENSO dominance: Dr. Roy Spencer (I)

- What about ENSO impacts accounting for long-term temperature trends?
- In 2019 blog post, [“Half of 21<sup>st</sup> Century Warming Due to El Nino”](#), Spencer shows how UAH tropospheric temp trend and HadCRUT4 surface temp trend each change in 21<sup>st</sup> century, upon removing big El-Nino event in 2015-2016 (net zero impact of El-Niños and La-Niñas before then).
- UAH trend +0.12 C/decade from 2000--2018 drops to **+0.01 C/dec** from 2000--June 2015 (15.5 years). RSS halves to +0.10 C/dec.
- HadCRUT4 drops from +0.16 C/dec to +0.10 C/dec over same span.

# ENSO dominance: Dr. Roy Spencer (II)



# ENSO dominance: Dr. Roy Spencer (III)



# ENSO dominance: Wallace-Christy-D'Aleo (I)

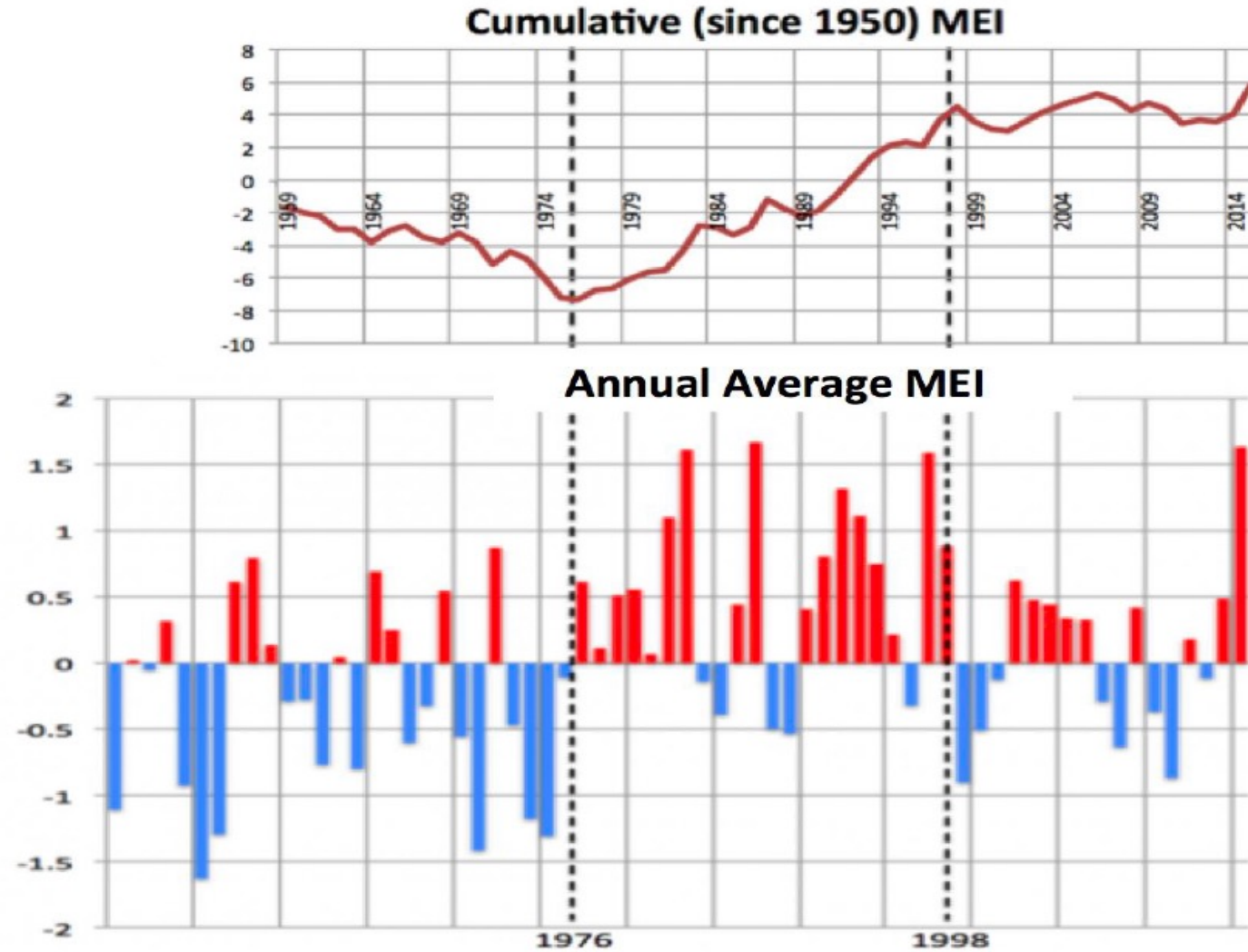
- Spencer's finding suggestive that global warming trend in lower troposphere due almost entirely to overall warming impacts of ENSO.
- Does this finding hold up over complete record of UAH? What about for the other temp datasets?
- 2016 report by Wallace, Christy, and D'Aleo – [“On the Existence of a ‘Tropical Hot Spot’ & The Validity of EPA’s CO<sub>2</sub> Endangerment Finding”](#) – addresses this.

# ENSO dominance: Wallace-Christy-D'Aleo (II)

- Report does standard econometric modeling – multivariate regression analysis – of 13 different temperature time series (9 Tropics, 1 for U.S., and 3 Global).
- Asks: does adjusting a temperature time series *only* for the impact of ENSO – via MEI, cumulative MEI, and “1977 Pacific shift” MEI variable – account for all of the positive and statistically significant warming trend?
- In each of the 13 cases analyzed, **yes**.
- Two striking examples.



Figure VI-2



Source: <http://www.esrl.noaa.gov/psd/enso/mei/table.html>

Source: <https://thsresearch.wordpress.com/2016/09/17/ths-exec-sum/>

Figure XX-3

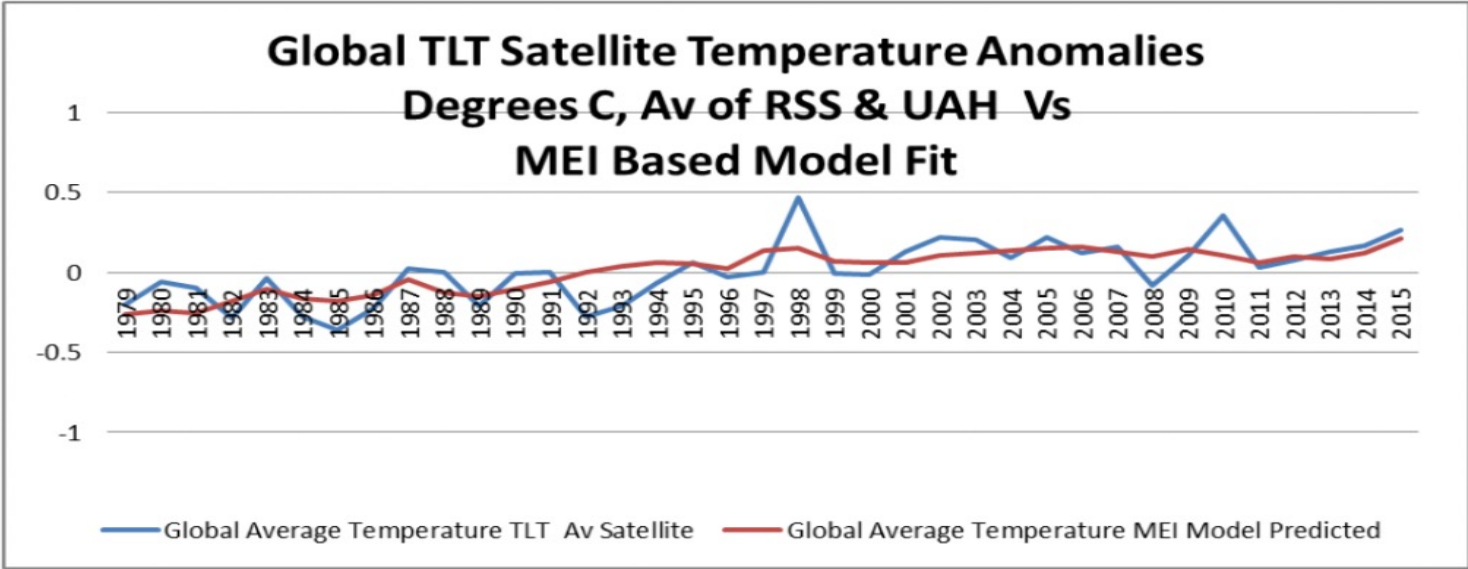
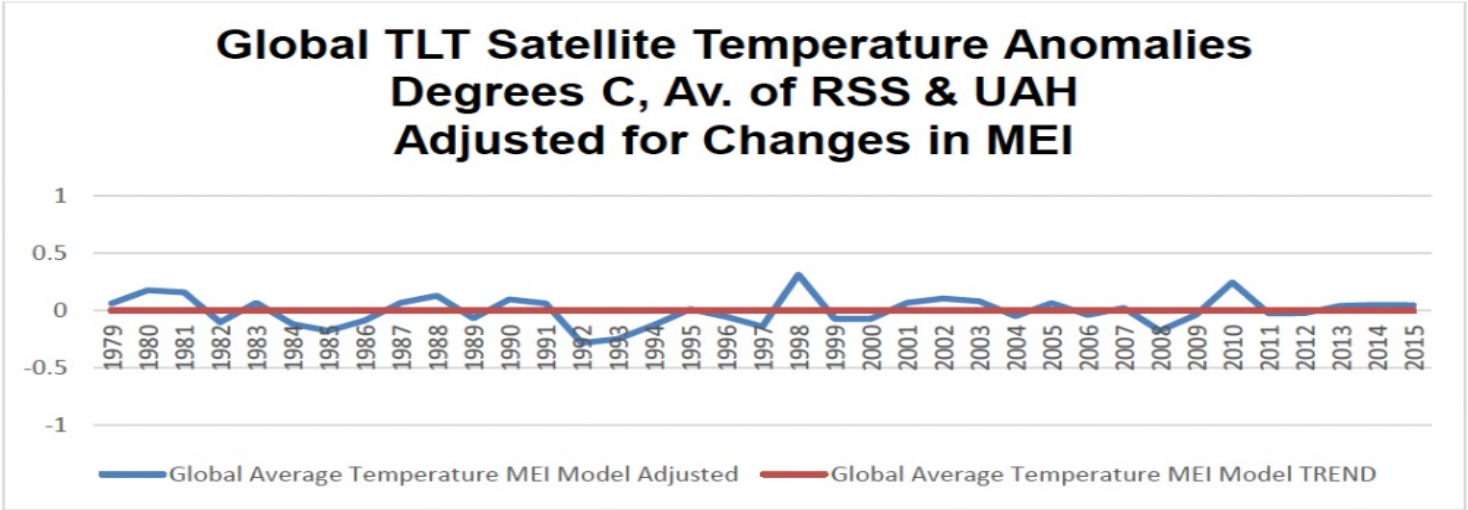


Figure XX-4



Source: <https://thsresearch.wordpress.com/2016/09/17/ths-exec-sum/>

Figure XXI-2

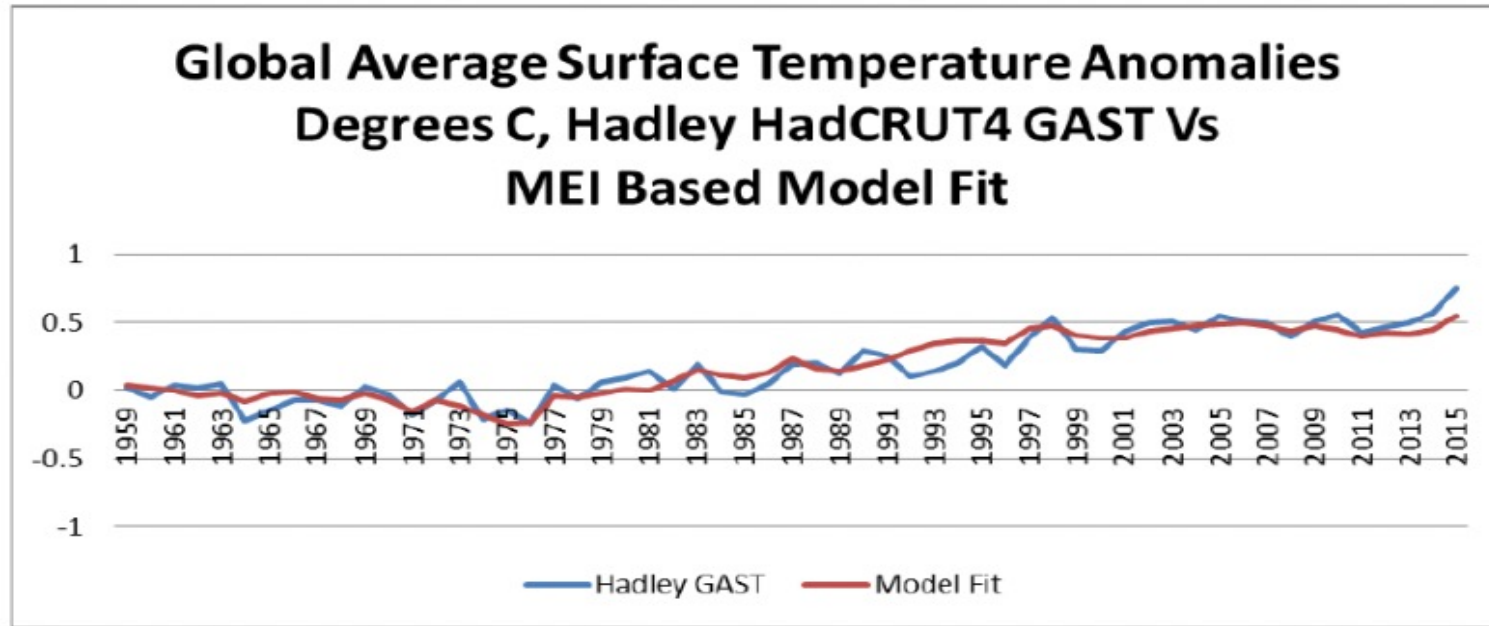
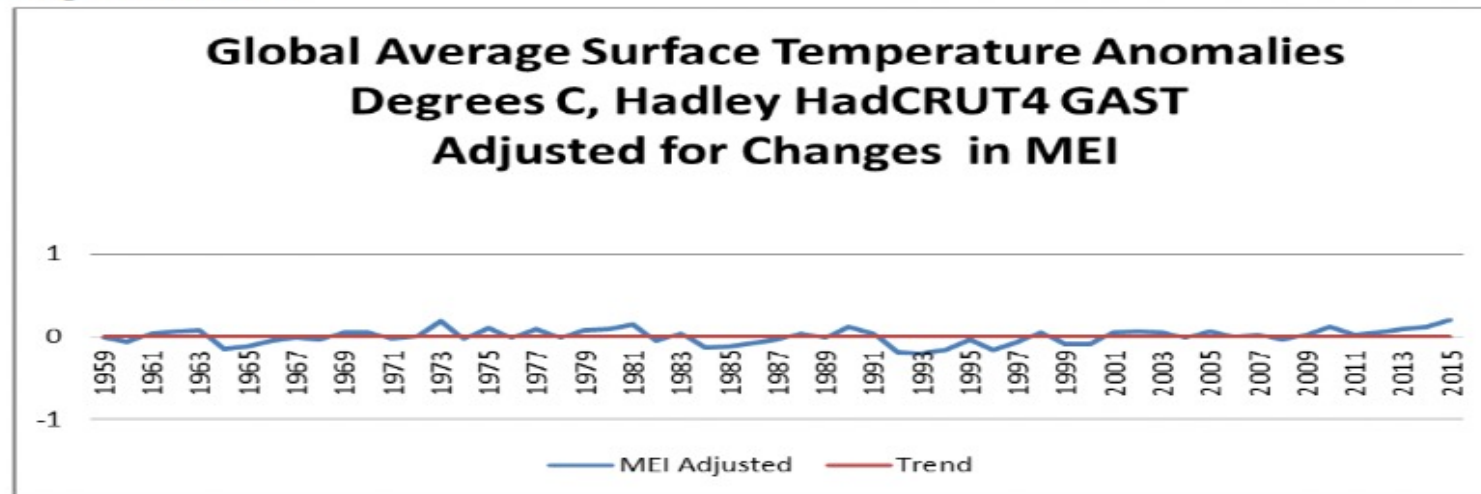


Figure XXI-4



Source: <https://thsresearch.wordpress.com/2016/09/17/ths-exec-sum/>

# Wrapping up

- Four lines of evidence strongly suggest ENSO is dominant (proximate) driver of global warming trends in the atmosphere.
- Proximate b/c ENSO also significantly influenced by other natural climate variables: Pacific Decadal Oscillation, planetary albedo, solar activity, and (?) submarine volcanoes, among others.
- But still not well understood what causes PDO or how exactly the other natural climate variables influence ENSO variations.
- ENSO variations are highly chaotic, unpredictable. More research needed!

Thanks for your attention  
Comments welcome!

[maanelid@yahoo.com](mailto:maanelid@yahoo.com)

<https://www.researchgate.net/profile/Maaneli-Derakhshani>