Earth System Research Laboratory
Physical Sciences Division

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CIRES
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ENSO Variability Since 1980 Reconsidered

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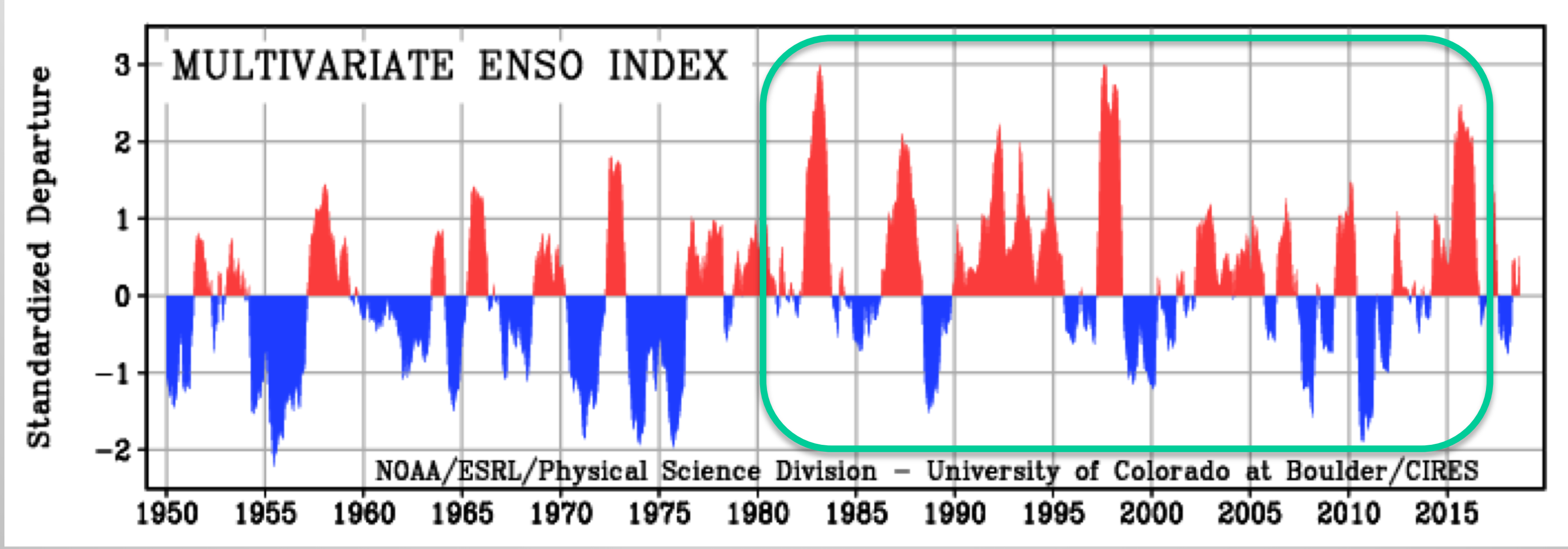


Online since 1997: https://www.esrl.noaa.gov/psd/enso/mei/

Contains three "Super Niños" and strongest La Niña since mid-70s

Outline

- ***Background for Multivariate ENSO Index (MEI.o)***
- ***First new MEI: Reanalysis MEI (MEI.r)***
- ***Second new MEI: GFSv2 MEI (MEI.g)***
- ***ENSO events since 1980 reconsidered***
- ***Summary***

Motivation & Background of the Multivariate ENSO Index (MEI)

- **Walker and Bliss (1932) used THREE observed fields (SLP, air temperature, and rainfall) to define original 'Southern Oscillation'**

- **Before TOGA-TAO, spatial coverage of equatorial Pacific was sparse, thus a need for judicious filtering - Wolter (1987, 1989; both J. Climate) used spatial clusters**

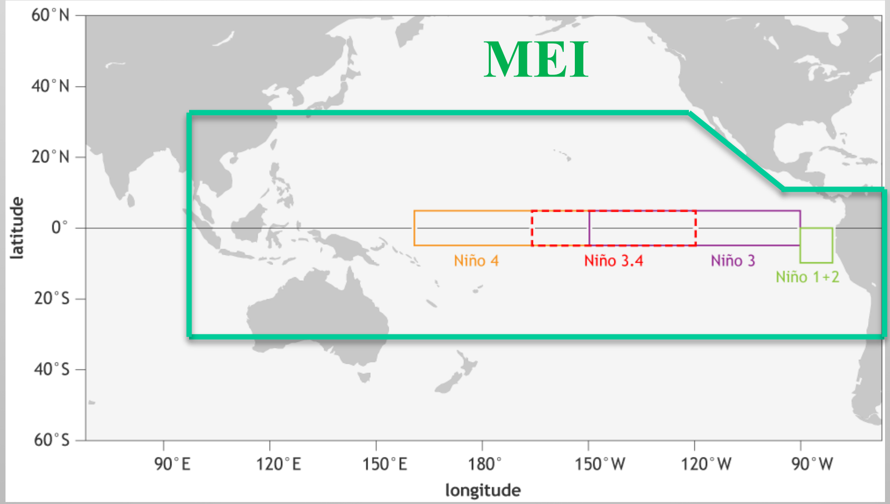
- **Wolter and Timlin (1993, 1998) created operational version of the MEI (next slide)**

- **While the MEI is more 'holistic' than single variable indices (Niño 3.4 SST, SOI) in describing the coupled ENSO phenomenon, it does not explicitly address the degree of coupling between atmosphere and ocean**

- **Our team has developed two new versions of the MEI that reproduce most of the original MEI features, while also addressing the last bullet**

Key Steps in the creation of Multivariate ENSO Index (MEI.o)

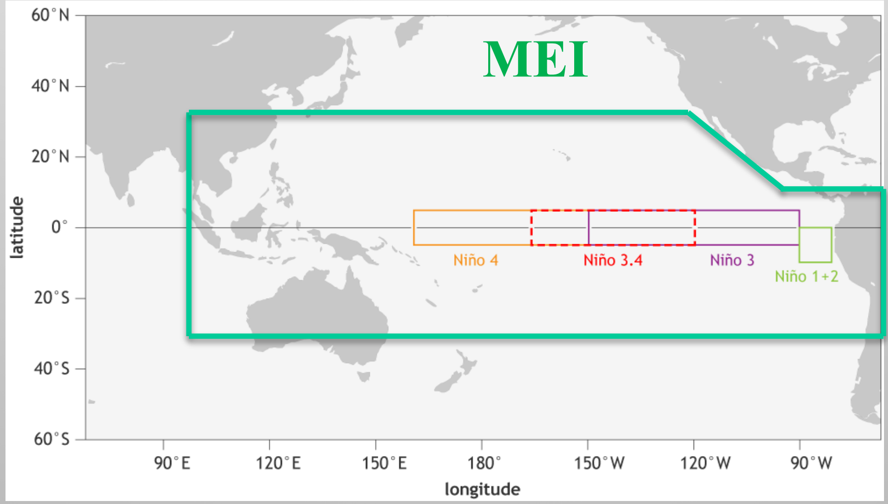
- **Original MEI uses six ship-board observations (SLP, U, V, SST, Tair, Cloudiness), new ones swap OLR for cloudiness – built-in redundancy to make it more robust**
- **Domain includes main features of ENSO phenomenon over tropical Pacific (100°E to 70°W, 30°N to 30°S)**
- ***Given poor sampling of original COADS data, there was a spatial filtering step to create viable (clustered) time series; this is not necessary with reanalysis data***
- ***After creating normalized time series for each spatial cluster (now 2.5x2.5 degree box) and each bimonthly season, we combined all fields and subjected them to a Principal Component (EOF) analysis (equal weights for each field)***



First new MEI: Reanalysis MEI (MEI.r)

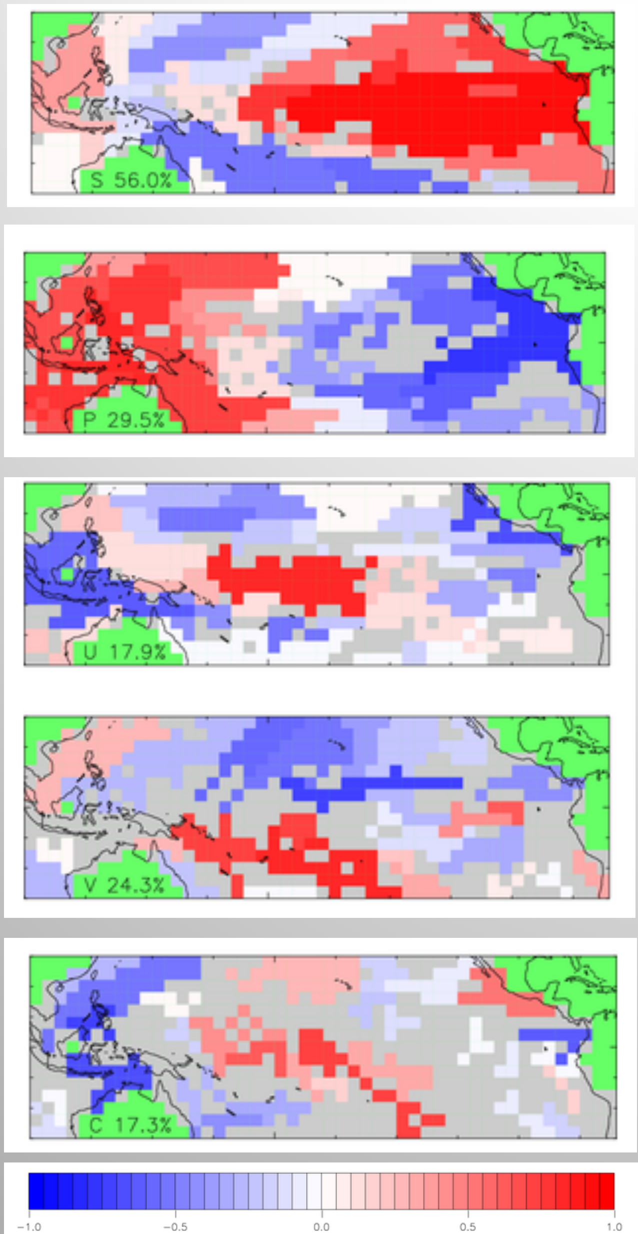
- **ERA-interim reanalysis MEI.r, available from 1980-2016, domain the same as for original MEI, winds and SLP derived from reanalysis, Hurrell SST (=OI SST since ‘81), OLR;** ***all data interpolated to 2.5°x2.5° (OLR resolution)***

- **MEI.r is 1st Principal Component of all five fields combined, computed separately for 12 sliding bimonthly seasons, and normalized with respect to 1981-2010**



Loading maps of original MEI vs Reanalysis-MEI during Nov-Dec

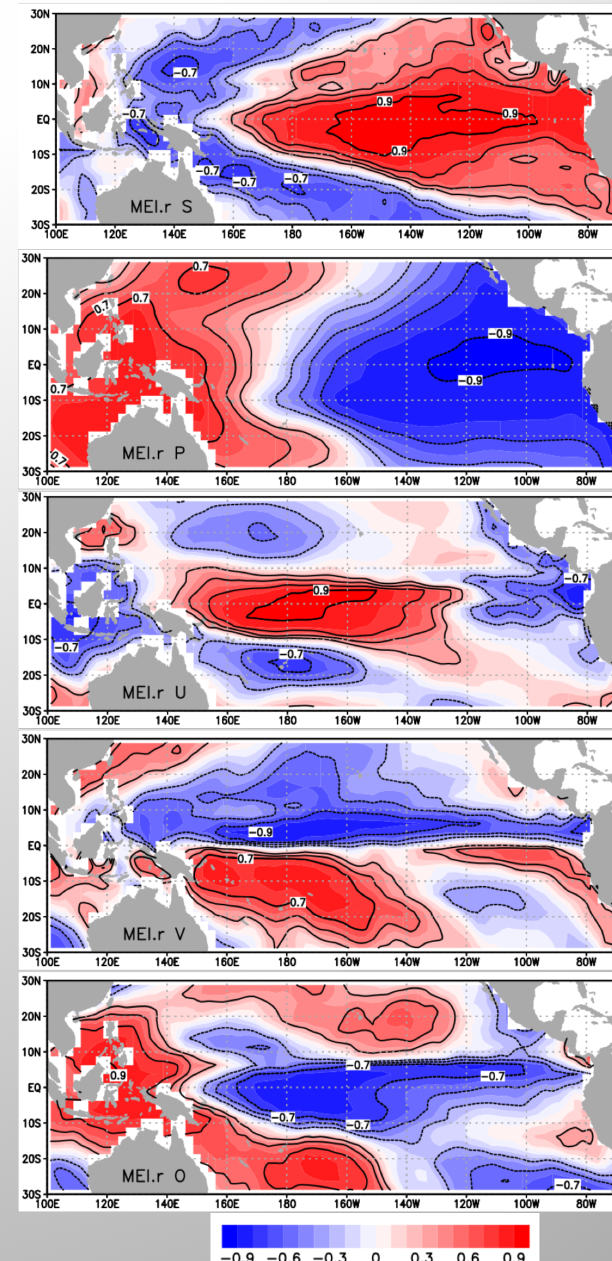
MEI.o (1950-2016)



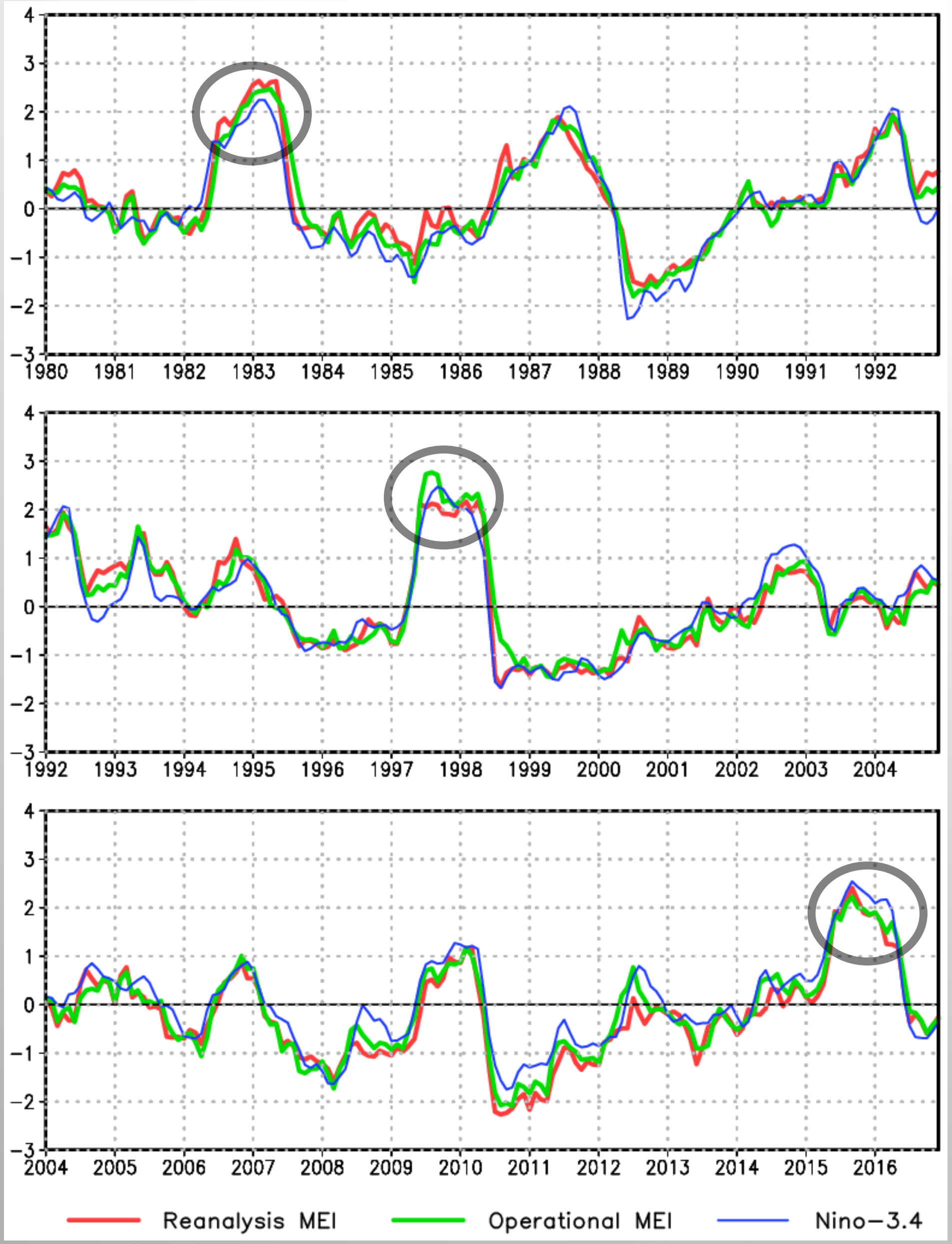
High positive correlations in red, negative in blue (El Niño is positive case)

Increased cloudiness during El Niño shows up in red for MEI.o (left bottom), vs blue for MEI.r OLR (negative anomalies; right bottom)

MEI.r (1981-2010)



Comparisons of MEI.o and MEI.r vs Niño 3.4 SST



All timeseries are normalized with respect to 1981-2010 (for each season)

r(MEI.o, Niño 3.4):
0.98 jan-feb
0.89 june-july

r(MEI.r, Niño 3.4):
0.96 jan-feb
0.88 june-july

Niño 3.4 was weaker than both MEI's in 82-83, about equal in 97-98, & stronger in 15-16.

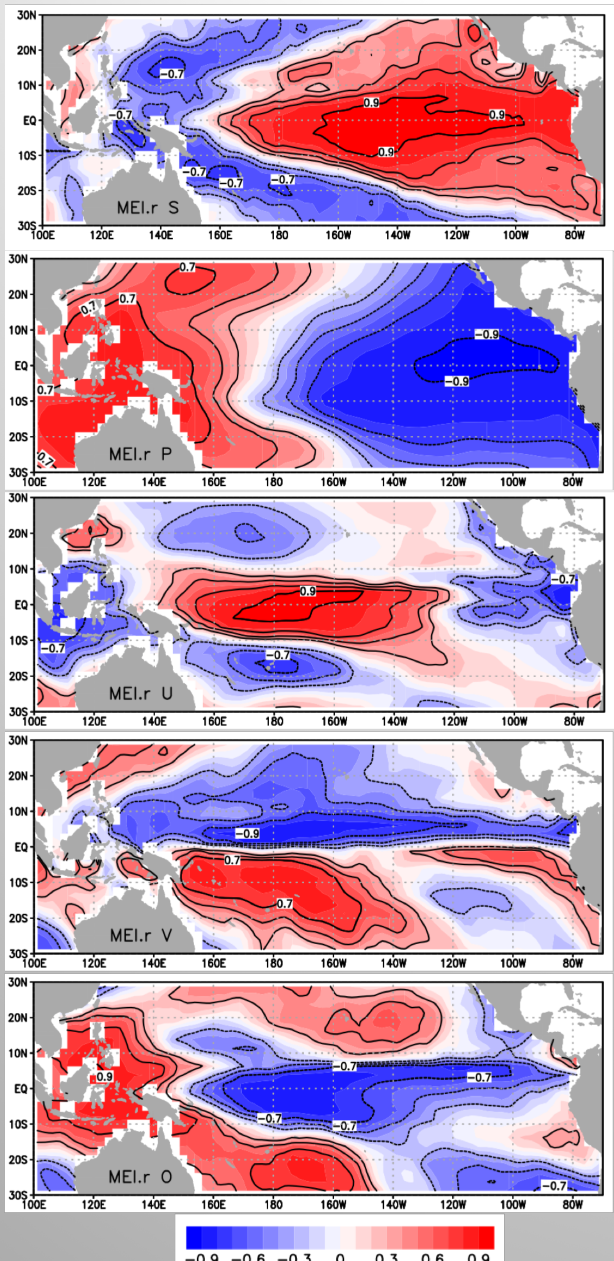
Second new MEI: GFSv2 MEI (MEI.g)

- **50 AMIP runs of the GFSv2 (atmospheric portion of CFSv2) to create model version of MEI, using same Hurrell SST since 1980, but with the other four variables model-generated, including OLR**

- **The MEI.g is the 1st Principal Component of the same five variables combined as for the MEI.r. We use the concatenation all 50 realizations to get a robust estimate of the MEI.g, as well as ensemble clouds around it, normalized with respect to 1981-2010**

Loading Maps of MEI.r vs MEI.g

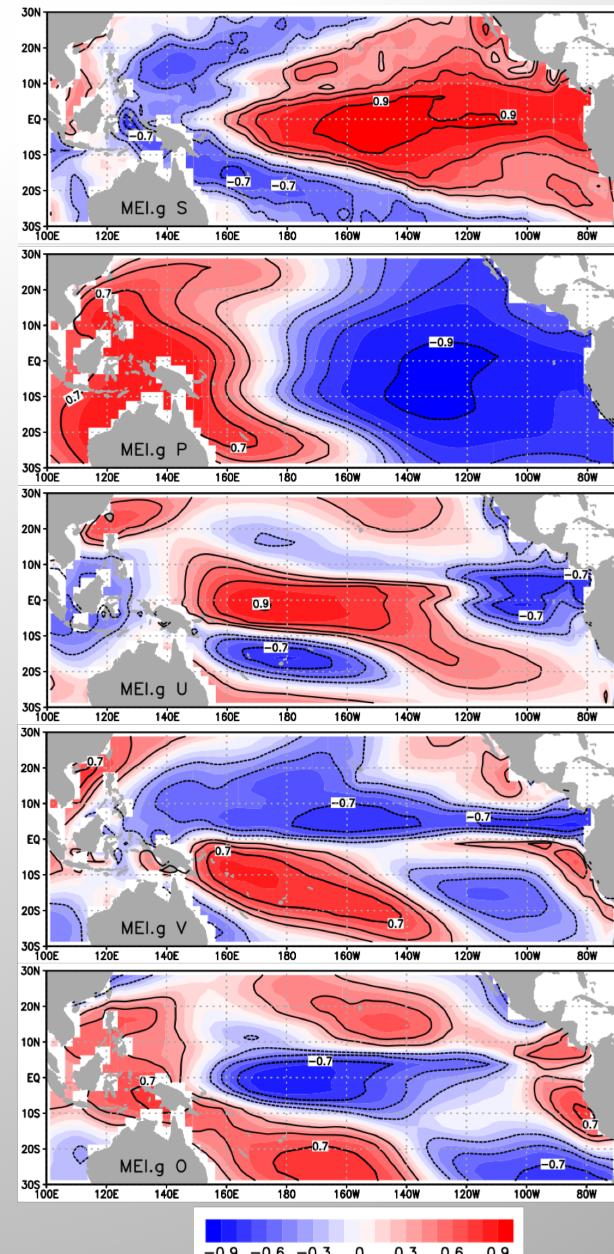
MEI.r (1981-2010)



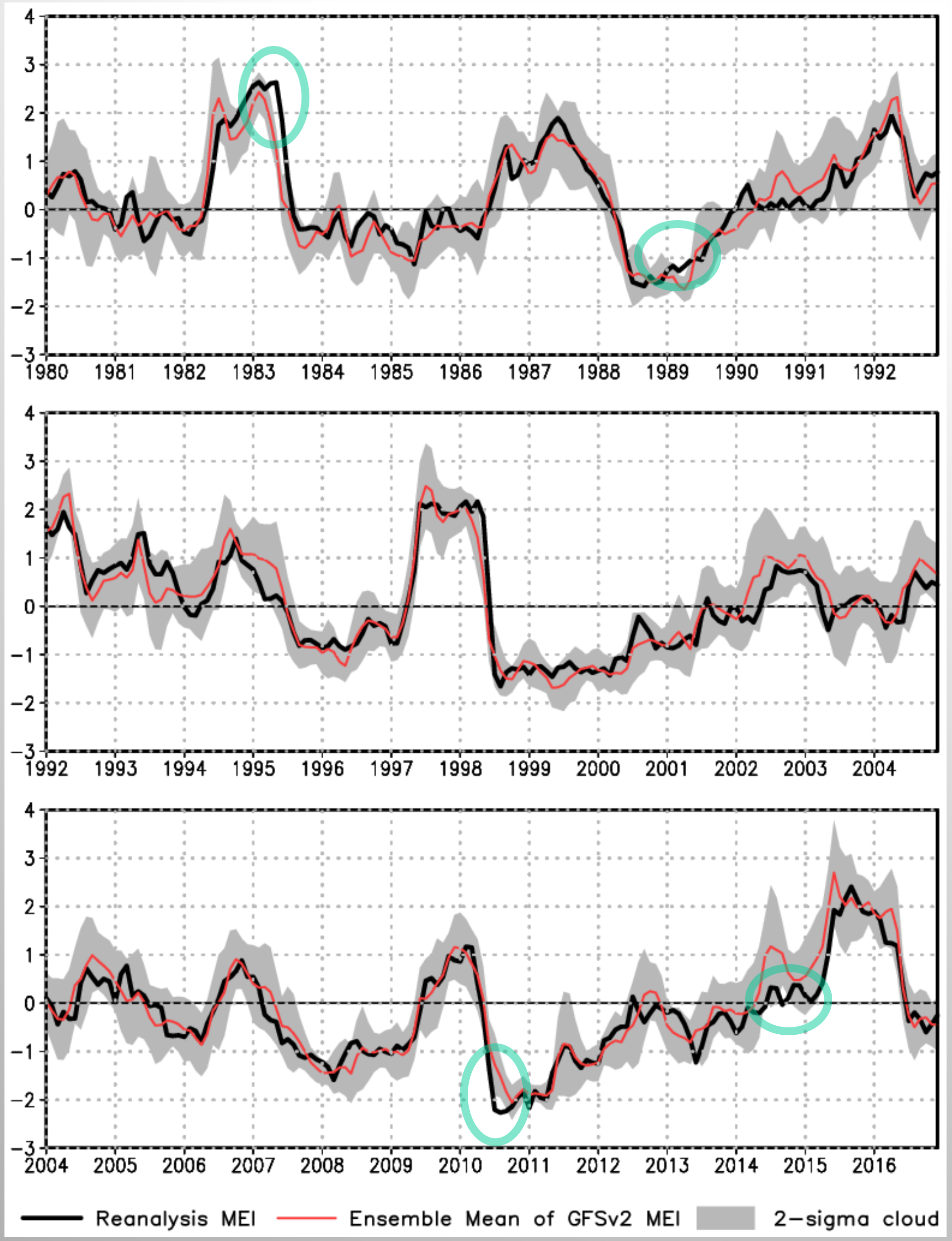
High positive correlations in red, negative in blue (El Niño is positive case)

Overall differences are small, biggest perhaps for North Pacific zonal wind (U), and easternmost equatorial Pacific OLR (O).

MEI.g (1981-2010)



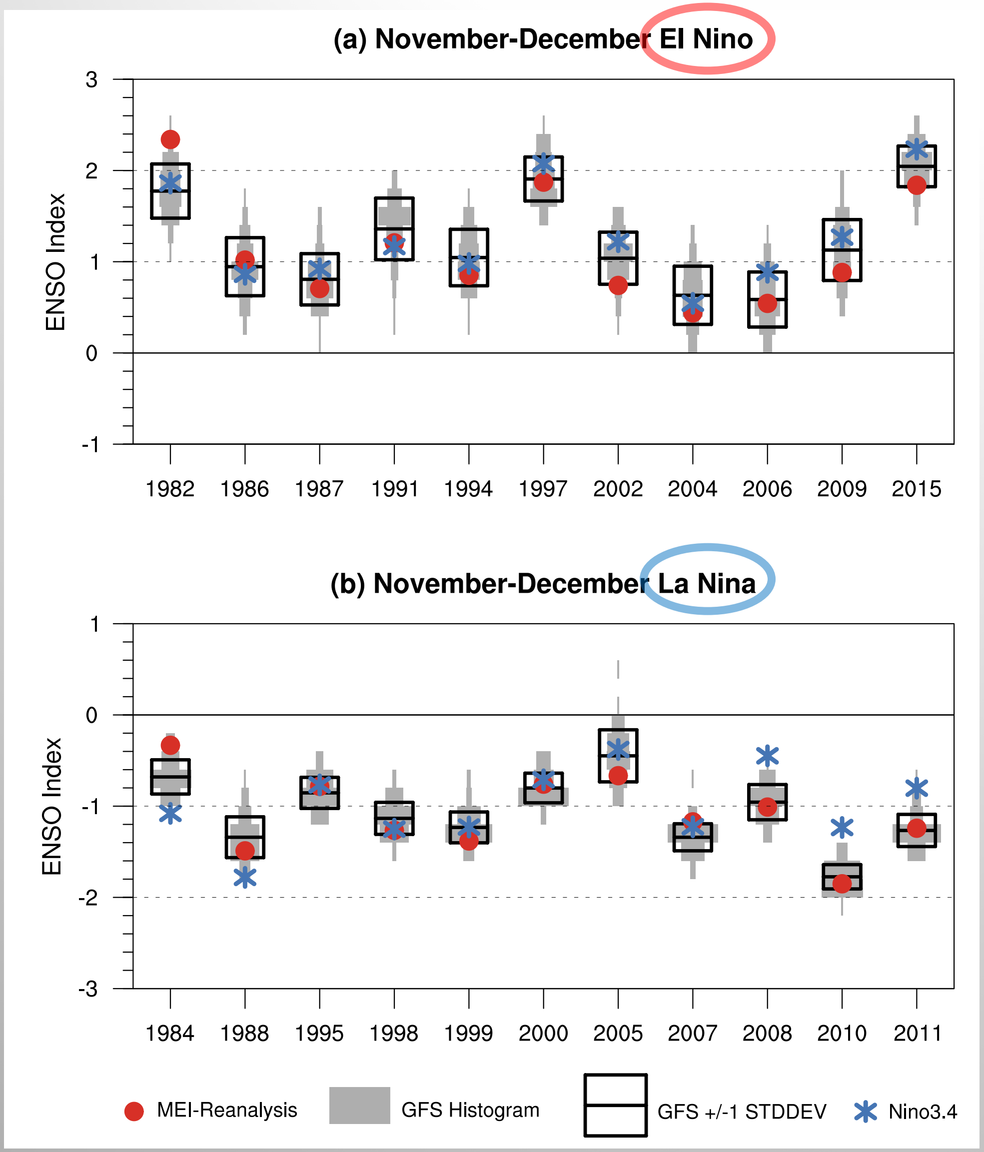
Comparisons of MEI.r and MEI.g against each other



Time series for the full ensemble mean *(50 members)* from 1980 through 2016 for GFSv2 AMIP runs, the 'Two-sigma cloud', plus MEI.r

There were occasions when observations (MEI.r) 'escaped' the two-sigma envelope, such as in the late Niño spring of 1983 and onset of 2010 La Niña, but also during the prolonged 2014 Niño onset (a 'slacker'?) and premature weakening of 1989 La Niña (ready to give up before model).

ENSO events since 1980 reconsidered



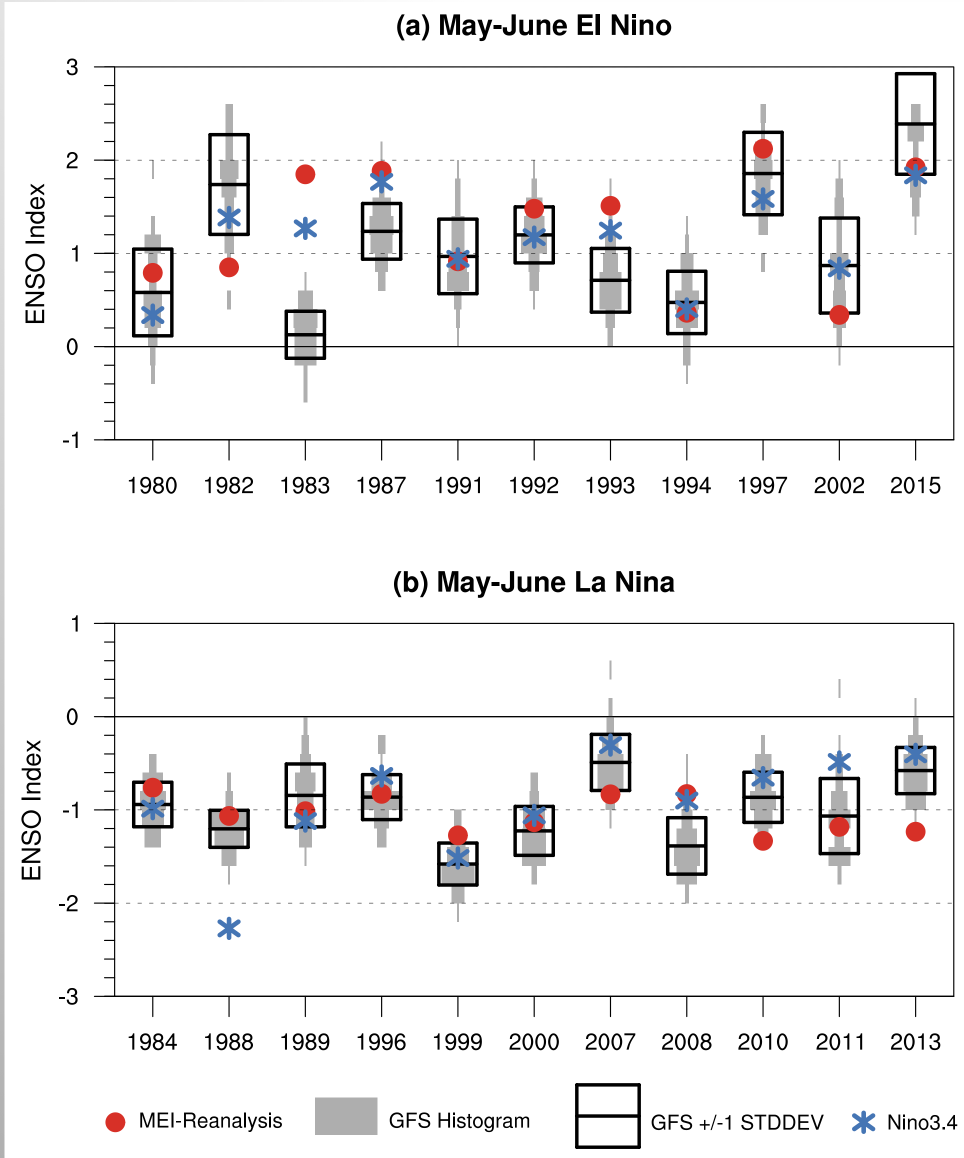
11 Niño and Niña cases since 1980 (30%ile cutoff) – a comparison of Niño 3.4 SST vs MEI.r vs MEI.g

Smaller MEI.g scatter (boxes) for La Niña than El Niño

For El Niño, MEI.r 'overachieves' in 1982 compared to MEI.g and Niño 3.4, while '02 and '15 ended up weak compared to SST-based potential.

For La Niña, Niño 3.4 used to be strongest of all indices in the 1980s, in contrast to last decade. MEI.r dovetailed MEI.g during that period.

ENSO events since 1980 reconsidered – which ones 'clicked', and which ones were 'slackers' in May-Jun?



11 Niño and Niña cases since 1980

For El Niño, MEI.r dramatically 'overachieves' in 1983 compared to MEI.g and Niño 3.4, in 1987 only compared to MEI.g (also in '93), while 2002 was the 'slacker' for MEI.r, and 2015 both in Niño 3.4 and MEI.r compared to MEI.g.

For La Niña, Niño 3.4 was clearly much stronger than the MEIs in 1988, while more recently it has been the weakest (2008 was weak in both MEI.r and Niño 3.4 compared to MEI.g).

Both El Niño and La Niña show more scatter than in Nov-Dec.

Summary

- **MEI concept is portable to reanalysis and GFSv2 AMIP model data.**
- **A comparison of MEI.r with MEI.g and its ensemble-cloud shows when ENSO events were better coupled or weaker compared to their strength based on SST alone.**
- **A comparison of MEI.g with Niño 3.4 SST similarly indicates when the full tropical Pacific contributed to or reduced the impact of Niño 3.4 SST alone – this is particular noticeable during recent La Niña events.**
- **There has been a tendency for recent El Niño events to be less well coupled than before (as measured by MEI.r), while La Niña events have looked stronger if compared to Niño 3.4, but close to expectations if compared to MEI.g. It is unclear what is causing this apparently trend.**

Questions?

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Second new MEI: GFSv2 MEI (MEI.g) <Extra slide>

- Scatter of 50 ensemble members from 1980-2016 shows that Niños are less well constrained than Niñas, with a tendency for weak Niños to be least constrained for most seasons.