

Monitoring El Niño/Southern Oscillation Behaviour with an Improved Multivariate ENSO Index (MEI)

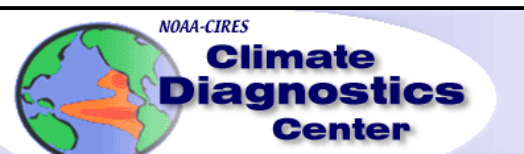
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<http://www.cdc.noaa.gov/people/klaus.wolter/MEI/>

<http://www.mei.noaa.gov/>



*Gdynia, Poland, CLIMAR-III
8 May 08*



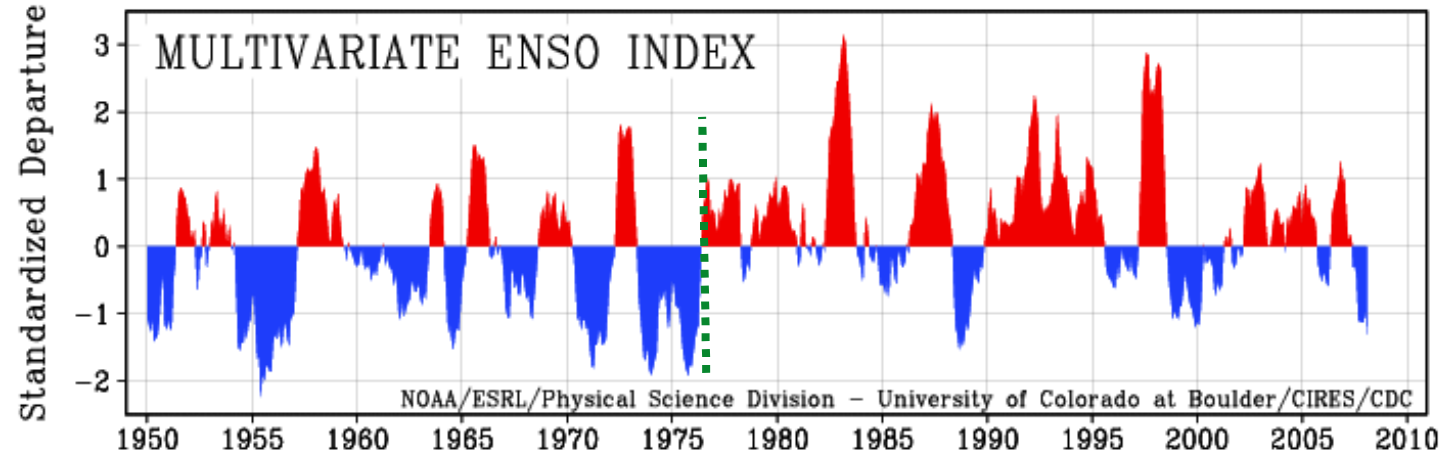
Monitoring El Niño/Southern Oscillation Behaviour with an Improved Multivariate ENSO Index (MEI)

- **We already have Niño 3.4 SST to monitor ENSO - Why bother with something more complicated?**
30 years ago, the SOI seemed entrenched, too
- **Variations on the MEI theme - How robust is it?**
- **‘Bare-bones’ MEI based on Hadley Center SLP and SST**
- **How to pick the best ENSO index & Where to go from here?**

MEI Background

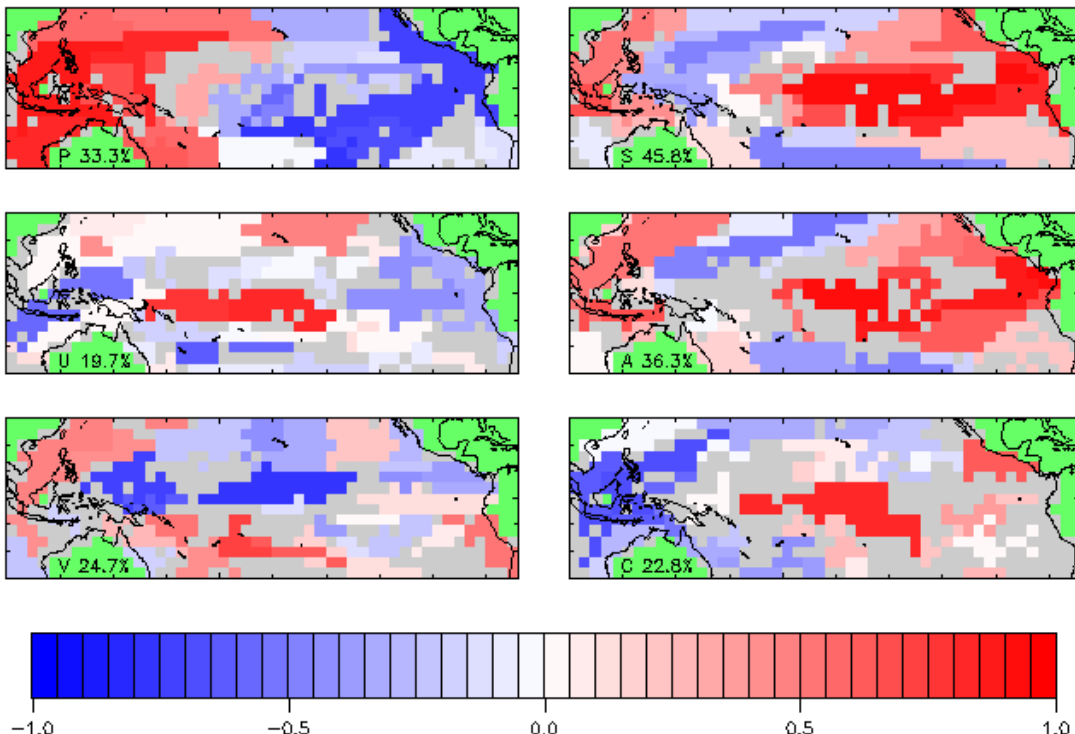
- The Multivariate ENSO Index (**MEI**) is an outgrowth of my dissertation work more than two decades ago. It was inspired by the original definition of the ‘**Southern Oscillation**’ by **Walker and Bliss** (1932) that includes much more than the familiar sea level pressure seesaw between the western and eastern Pacific, but also temperature and precipitation fields, stratified by season, an early multi-variate approach to this phenomenon.
- The **MEI** was engineered in its present form with support from Michael Timlin who is also helping with the MEI revisions. It is computed from surface marine data (COADS) - filtered through spatial cluster analysis and based on six different observational fields: sea level pressure (**P**), zonal- and meridional wind component (**U, V**), sea surface temperatures (**S**), near-surface air temperatures (**A**), and total cloudiness (**C**). Separately diagnosed for twelve sliding bi-monthly seasons, the MEI is the first Principal Component (EOF) of all six observational variables analyzed jointly for the tropical Pacific basin (normalized variance for each field).
- The MEI was launched on the internet in mid-1997. Monthly updates include an assessment of recent and evolving ENSO conditions.

MEI Time Series & Loading Maps



Sliding bimonthly averaging takes out much if not all of the intra-seasonal 'noise'. Step-change in 1976 parallels PDO.

Jan/Feb Index Loadings 1950–2005
Variance Explained = 30.4%



'Loadings' refer to the correlations of local time series with the MEI time series. The MEI is designed to reflect both the dynamic (PUV) and thermodynamic (SAC) aspects of this coupled phenomenon, but is effectively anchored by SLP and SST (A is too co-linear with SST to contribute much additional information, while C is inherently noisy).

MEI - Why Bother?

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- While it can be argued that Niño 3.4 SST anomalies are the fundamental ‘engine’ that drives ENSO, one can also argue that the tropical **‘atmospheric bridge’** to the Maritime Continent is an integral part of ENSO - *if such first order impacts don’t work, how can you expect to see reliable teleconnections with the extratropics?*

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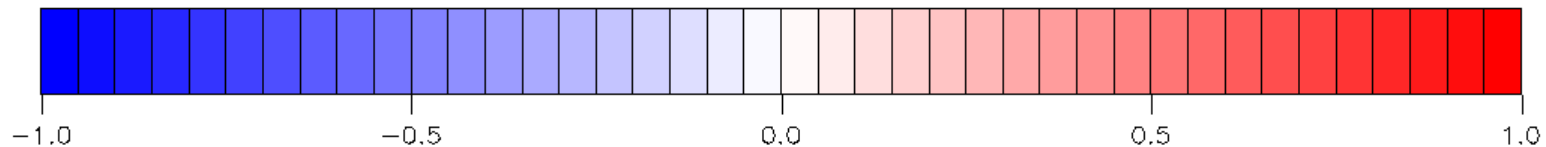
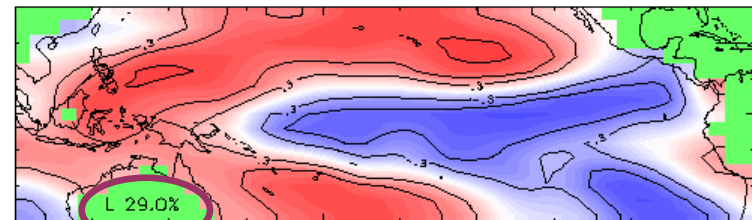
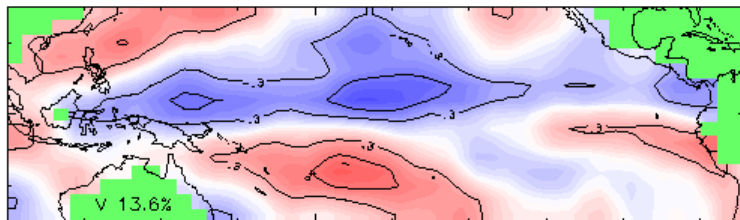
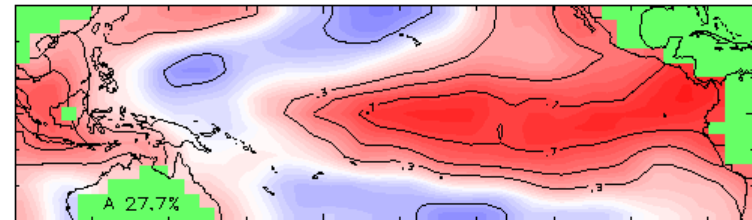
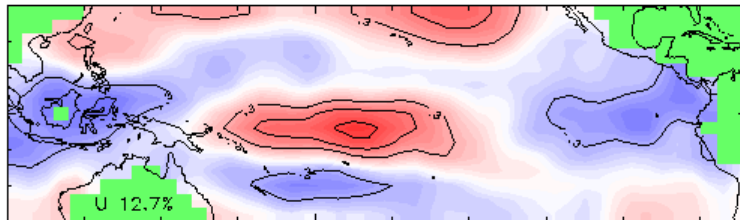
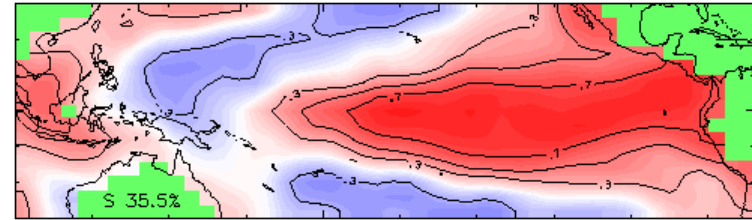
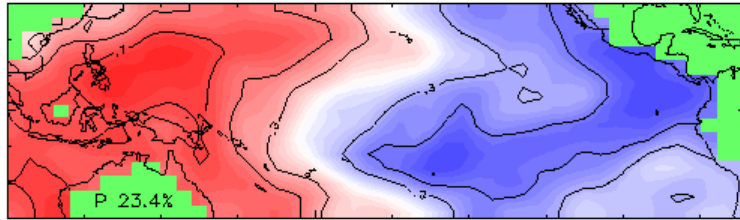
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- Despite all this, the MEI correlates highly with all other ENSO indices, so there is no question that they all monitor the same phenomenon - *in boreal winter.*

Currently Tested Changes to MEI

- ✓ **Switch from clustered to gridded data input (not shown here)**
- ✓ **Explore impact of change in base period (not shown here)**
- ✓ **Replace cloudiness with Outgoing Longwave Radiation (OLR)**
- ✓ **Explore NOAA-NCAR Reanalysis data (reanalysis-OLR looks reasonable pre-'79)**
- *Use reconstructed Hadley Center SST & SLP - a 'bare-bones' MEI to extend the record back to 1871!*
- * *Explore alternative reconstructed SST (Kaplan & ERSST)*

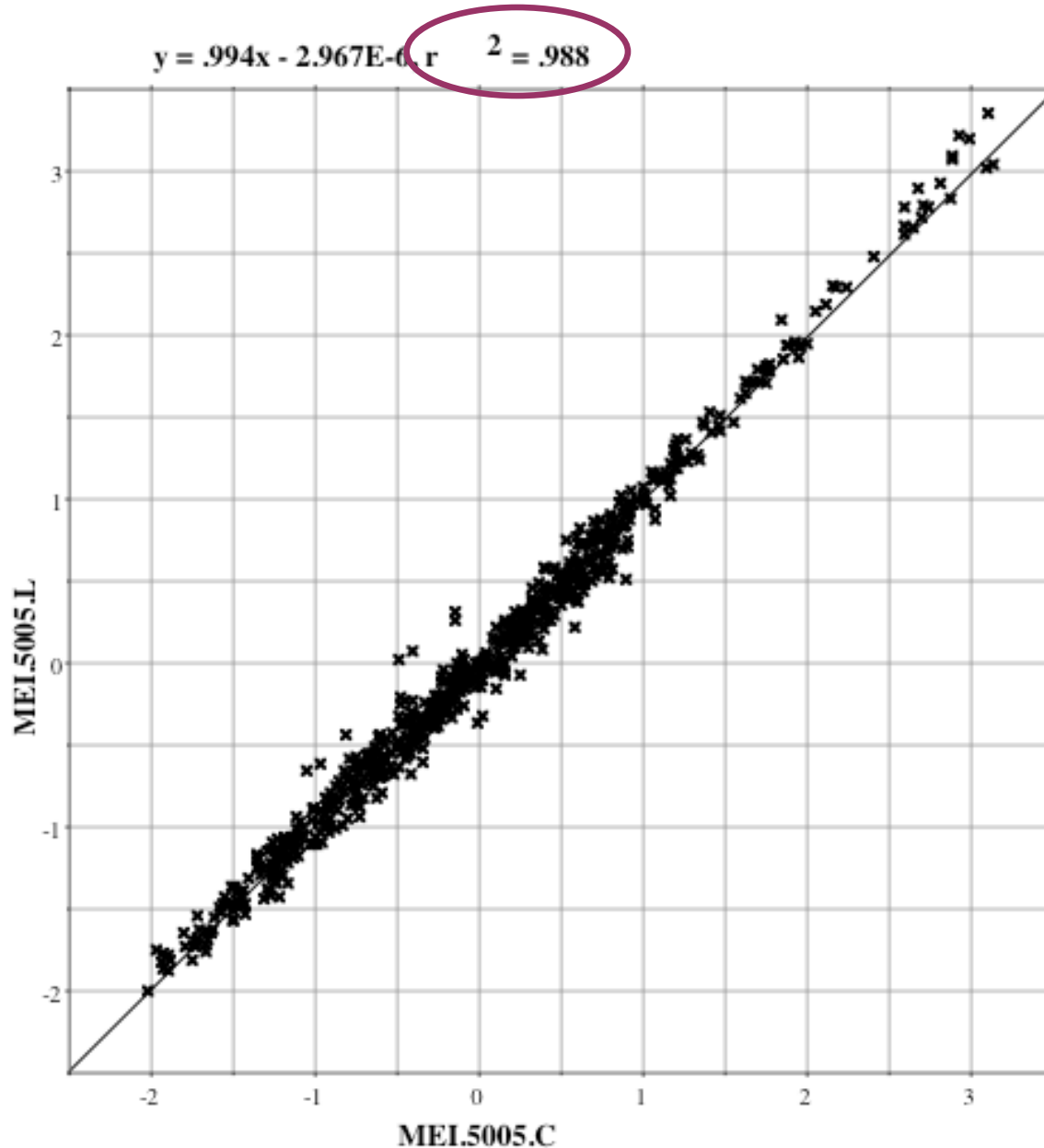
MEI Loading Maps, OLR (1950-2005; no clusters)

Jan/Feb Index Loadings 1950–2005
Variance Explained = 23.2%



Unclustered MEI explains 7-13% less variance than original clustered version, although loading patterns remain similar. Replacing cloudiness with OLR triples explained variance for that field!

PUVSAC MEI vs. OLR MEI - 5005

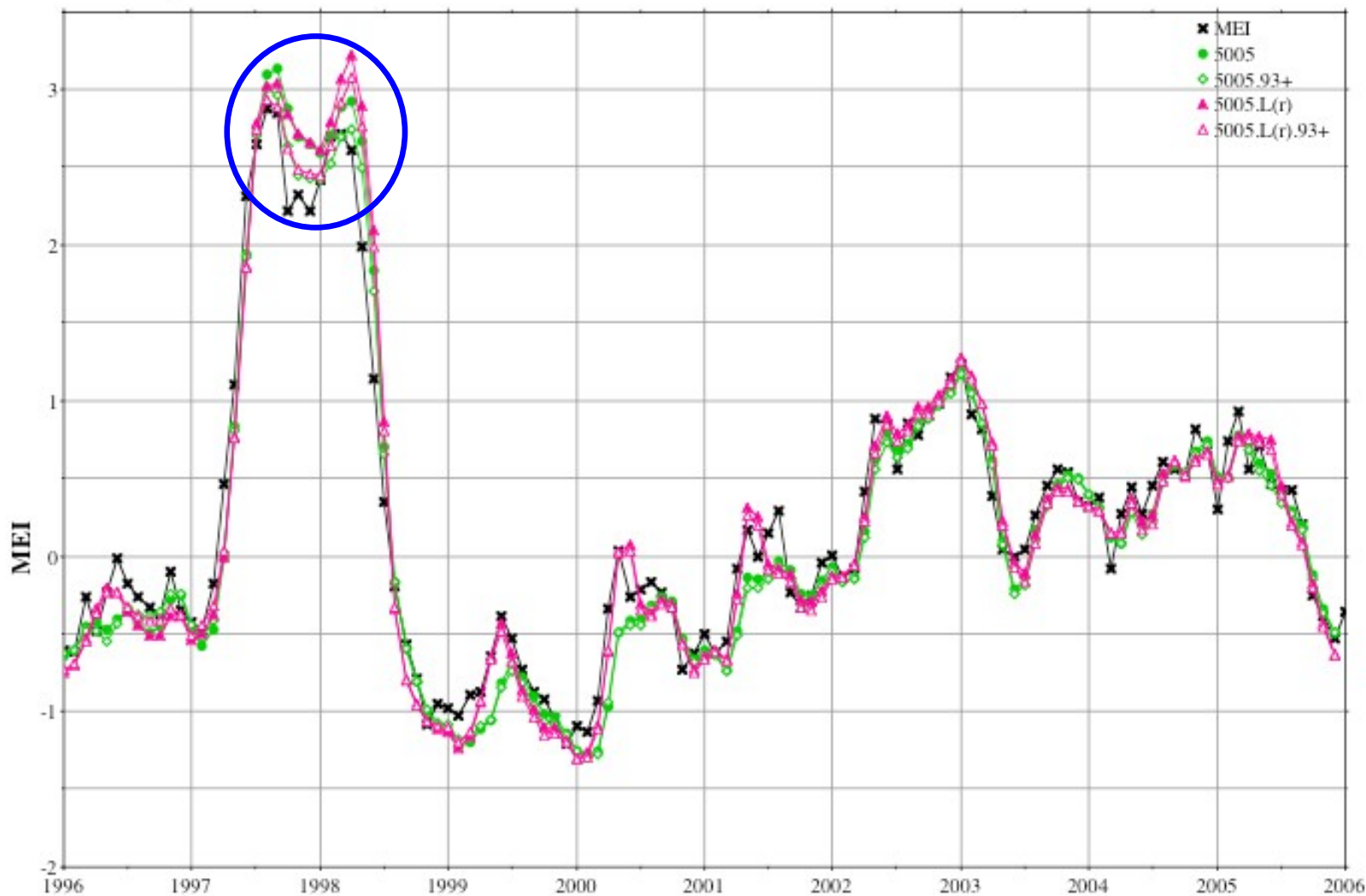


Match between original mix of unclustered variables (PUVSAC) & new mix of variables (PUVSA&OLR) MEI is very good, despite big change in explained variance for cloudiness vs. OLR and “reanalyzed” OLR before 1974.

Match between 1950-05 vs. other base period versions is also very good, ditto for clustered vs. unclustered (not shown here).

1996-2005 OLR- vs. Cloudiness-based MEIs

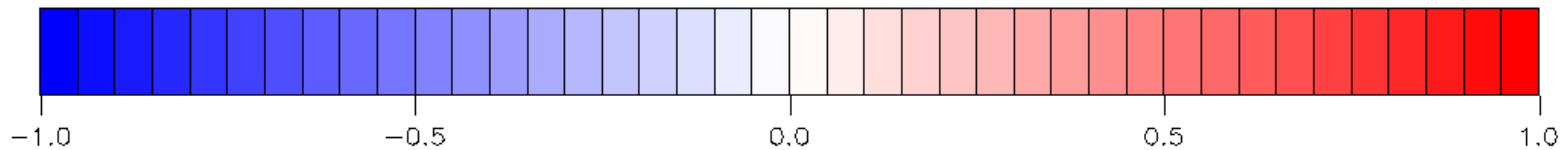
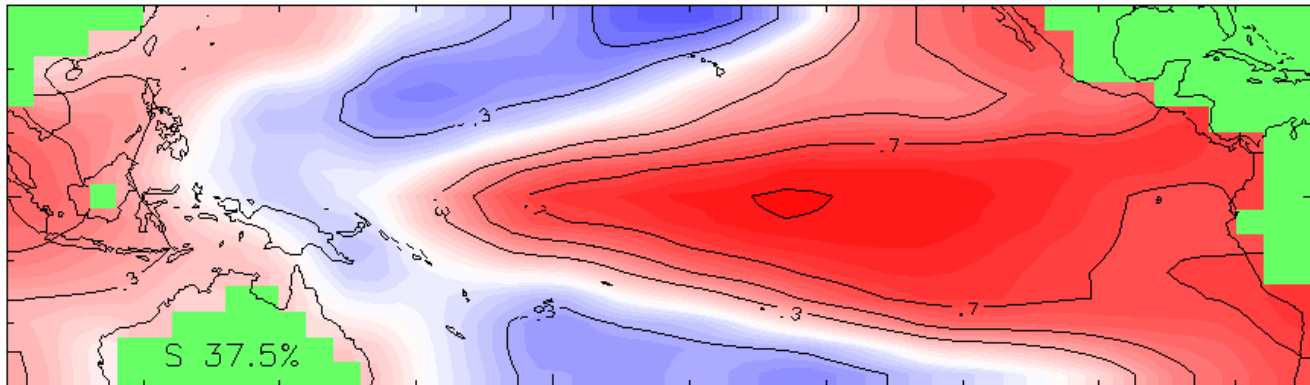
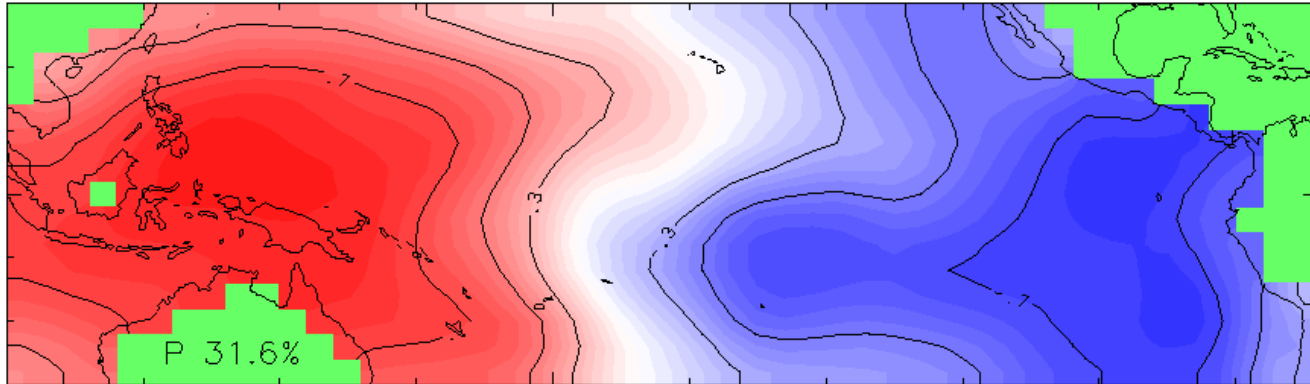
Original MEI (x) vs. New MEI (PUVSAC) vs. New MEI (PUVSAL)



Biggest Δ between original and new MEI appears due to shift from clusters to gridded data, 2nd biggest Δ due to OLR instead of cloudiness, and remaining Δ due to differences between near-realtime (GTS) and COADS data (1997-98!).

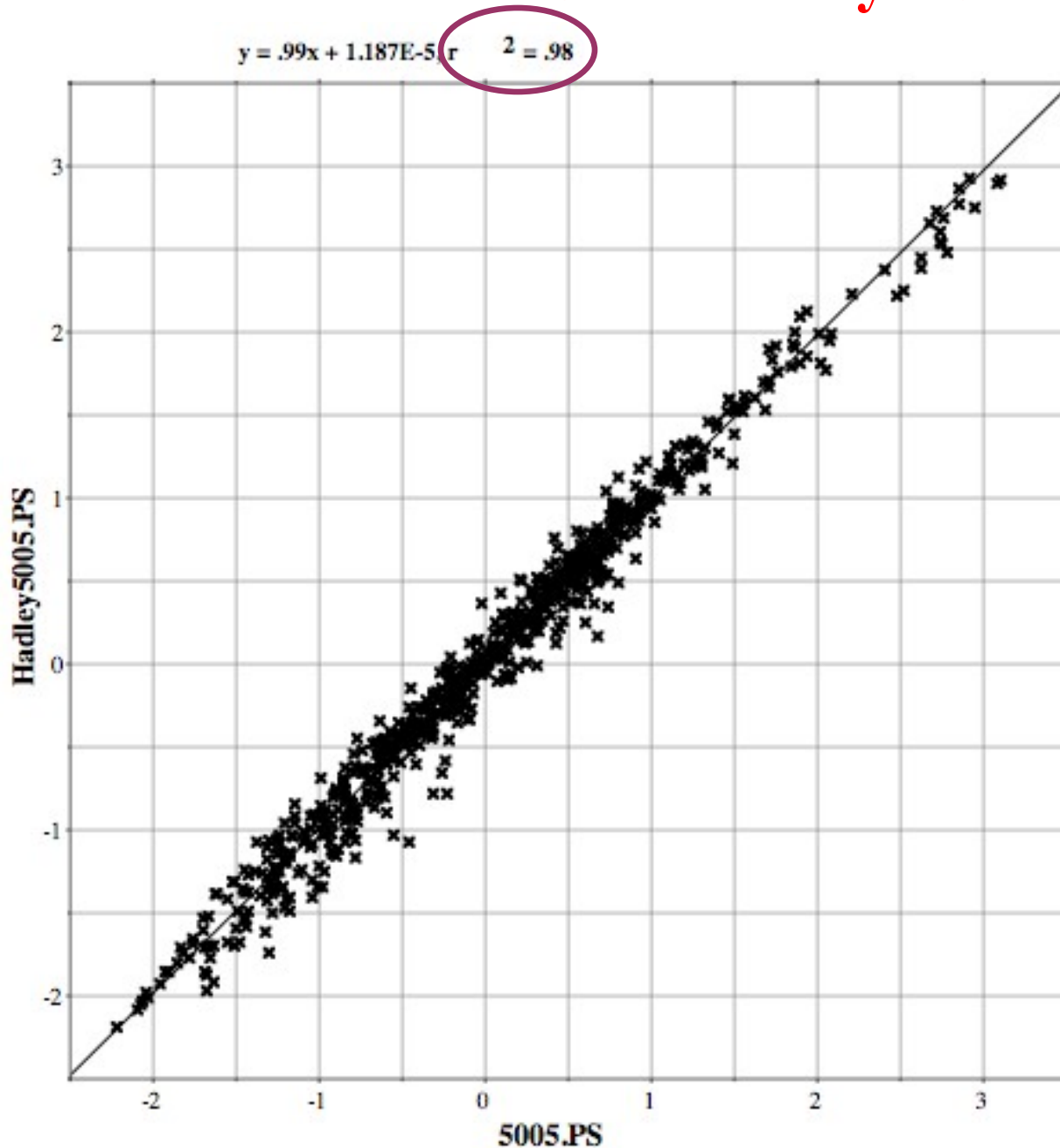
Hadley PS version

Apr/May Index Loadings 1950–2005
Variance Explained = 34.1%



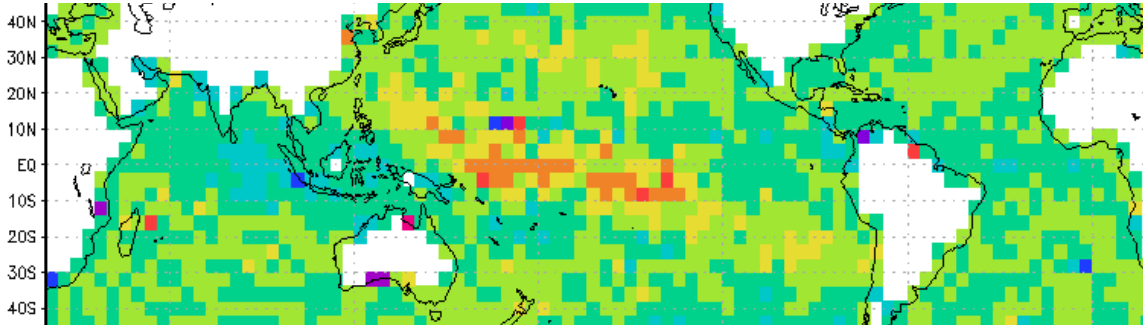
Loading map for Hadley PS in 50-05 shows higher loadings than COADS PS due to pre-filtering of data (especially in P).

COADS vs. Hadley PS version

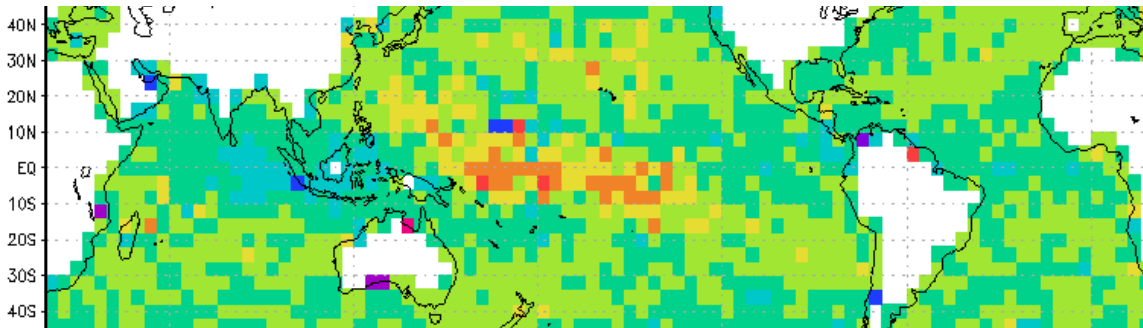


Match between Hadley and COADS PS is very good (98% shared variance). Even PUVSAL MEI shares almost 94% of its variance (not shown). Hadley PS does not get the full seasonal cycle/range that the COADS MEI versions displays (not shown).

Comparison 1876-1915 COADS U vs. PS, Niño 3.4 & SOI

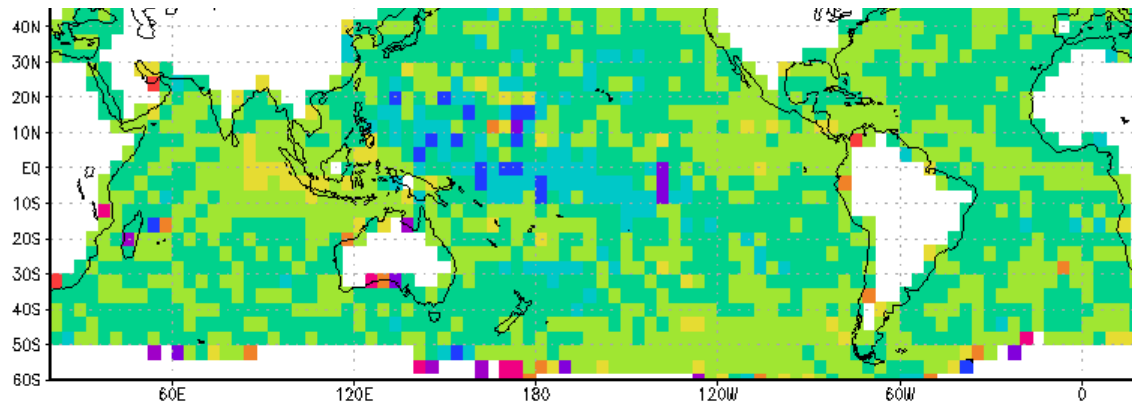


Hadley P&S 1871-2005 (slight edge over Niño 3.4)

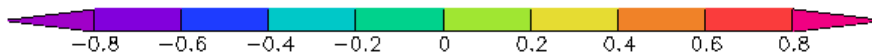


Hadley Niño 3.4

JAN/FEB

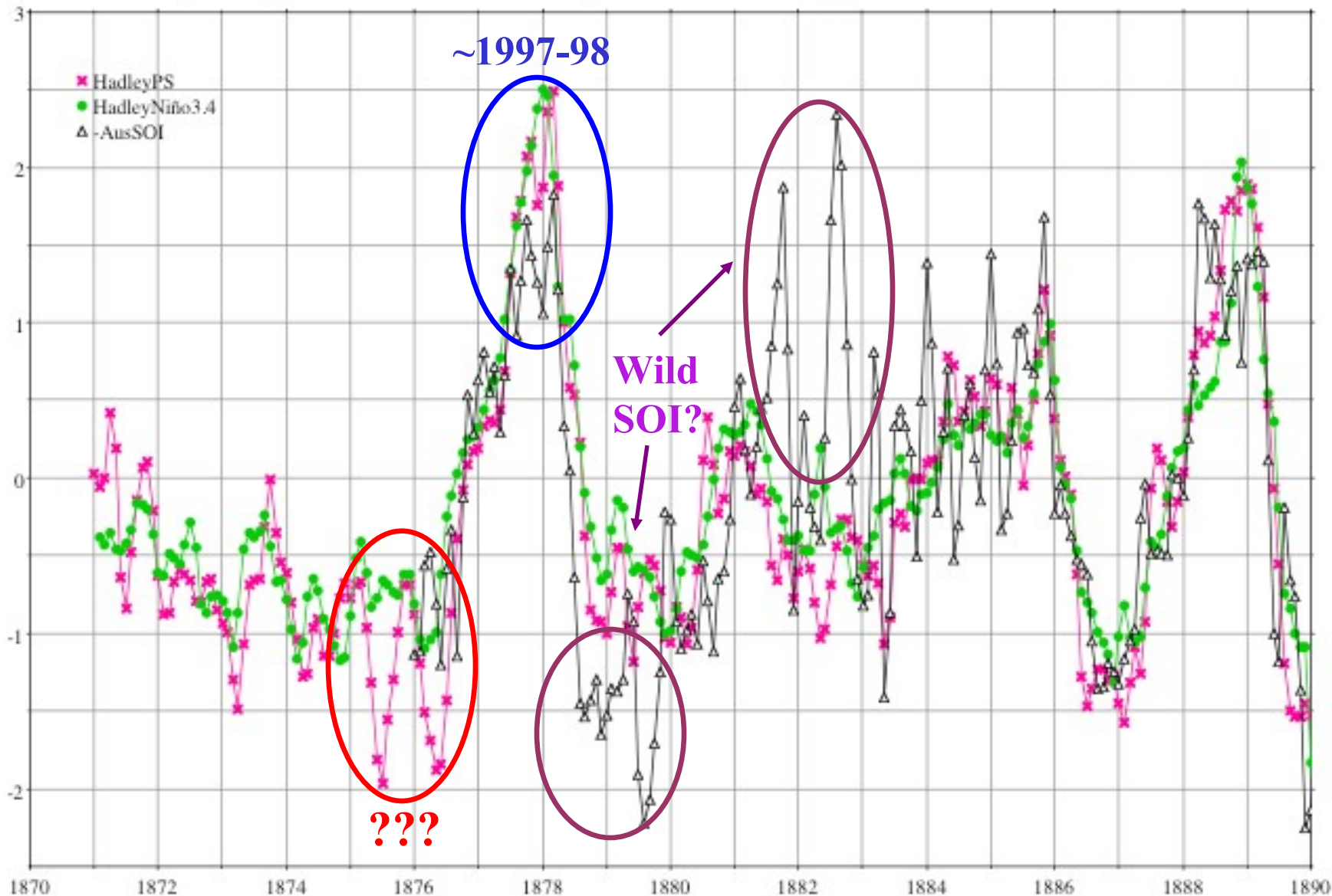


Australian SOI - inverted corr's are weaker than either of the above

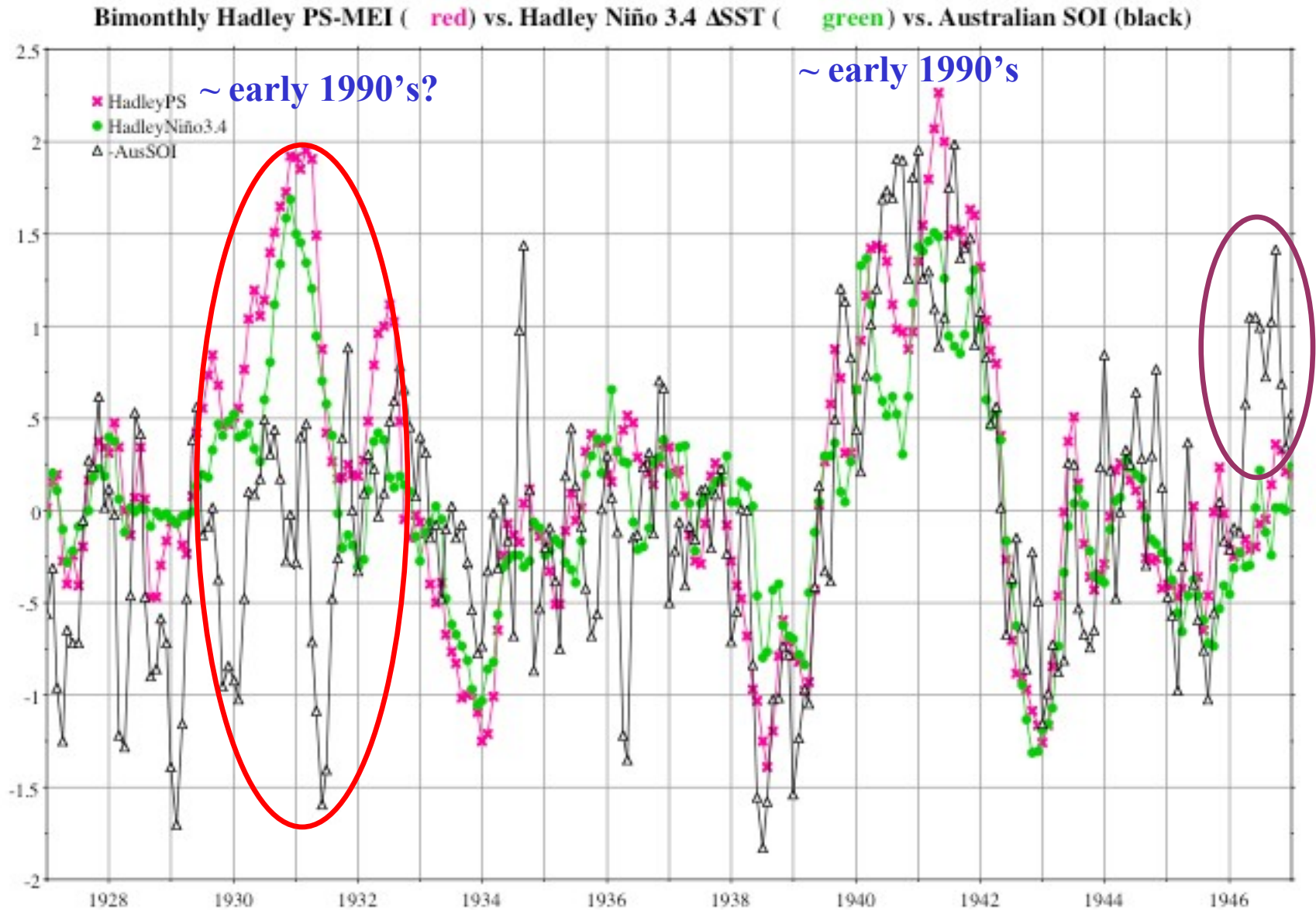


Hadley SLP/SST MEI vs. Niño 3.4 vs. SOI 1871-89

Bimonthly Hadley PS-MEI (red) vs. Hadley Niño 3.4 ΔSST (green) vs. Australian SOI (black)



Hadley SLP/SST MEI vs. Niño 3.4 vs. SOI 1927-1946



What can be said about pre-1950?

- **Australian SOI clearly inferior to Niño 3.4/bare bones MEI in terms of getting primary surface winds right;**
- **Hadley PS only slightly better than Hadley Niño 3.4 for same era** (as best as I know Hadley SLP was NOT used to adjust Hadley SST (and vice versa)) - need to explore more;
- **Not all of the remaining discrepancies can be blamed on data issues** (WW II appears fixed, WW I not) - the period from about 1920-50 was when ENSO 'lost its groove' (Tahiti SLP more or less uncorrelated with Darwin SLP);
- **Quite a few 'unique' aspects of late 20th century ENSO events were already observed in earlier instrumental record, such as multi-year El Niño and La Niña events, late onset events, and central vs. eastern Pacific 'flavors';** need to be careful when claiming any linkage to anthropogenic forcing if similar behavior was already observed a century ago.

Σ : What is the best ENSO index?

- **Philosophically**, the **MEI** has intuitive appeal, since it at least tries to address the multivariate ‘nature of the beast’ - still unclear **what is the optimum mix** of variables to include (for monitoring, predicting, **analyses**); **Niño 3.4 SST** was only introduced a decade ago, but has become current standard ENSO index (replacing **SOI**);

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- From an **impact** perspective, one could compare the **explained variance** of, say, global temperature and precipitation fields based on various ENSO indices to decide which index is best (MEI ‘beats’ Niño 3.4 and SOI in Western U.S. - at least since 1950); **need to explore for pre-1950!**

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- From an **operational** perspective, there is a need for an ENSO index that is most **reliable** in flagging the onset and demise of ENSO conditions (lowest False Alarm Rate, etc.) - initial results from Australia also favor MEI over Niño 3.4 and SOI;

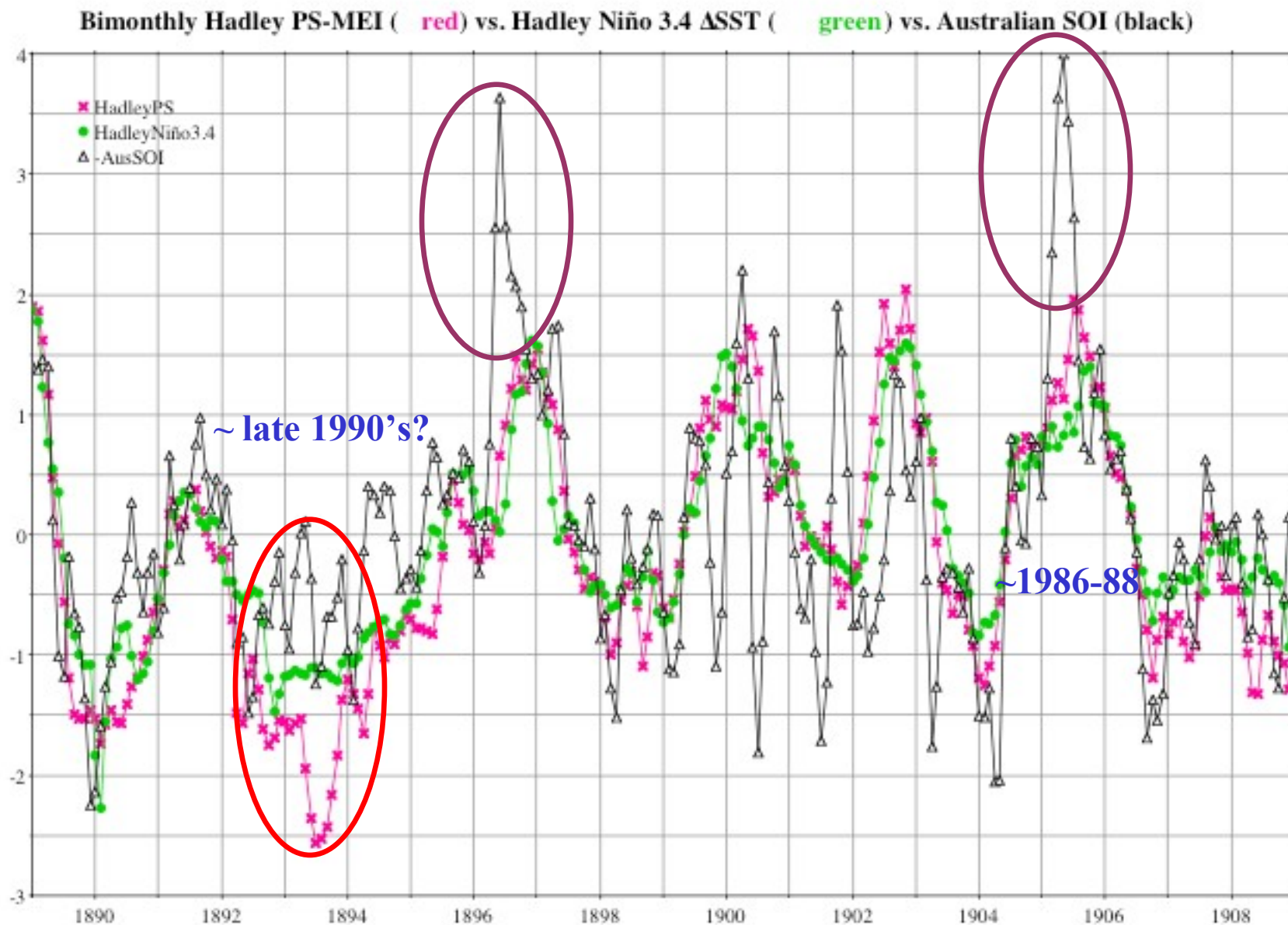
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- From a **modeling** perspective, dozens of coupled ocean-atmosphere models have been ‘trained’ to make Niño 3.4 SST forecasts, with a recent ‘plateau’ in skill. ***Could it be that modeling and predicting the key features of the MEI is a more rewarding target?!***

Quo Vadis, MEI?

- *New website (“mei.noaa.gov”) will be updated with more background information, user tutorials, alternative MEI indices, and analysis tools;*
- *Tools will include compositing and correlation options, possibly risk analysis, with user input options (similar to CDC “Map Room”);*
- * *Explore subsurface ocean data (‘GODAS’ upper-ocean heat content) - there may be more useful information for predictive than for diagnostic purposes;*
- * *Explore domain changes (currently mostly tropical Pacific) - possibility of regionalized versions of the MEI to highlight ‘flavors of ENSO’;*
- * *Deal with ‘Climate Change’ - are the characteristics of ENSO events changing?*

Hadley SLP/SST MEI vs. Niño 3.4 vs. SOI 1889-1908



Hadley SLP/SSST MEI vs. Niño 3.4 vs. SOI 1908-1927

