A Reanalysis of the Extended Multivariate ENSO Index (MEI.ext) and Comparison of the 1877-78 and 2015-16 El Nino Events

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Introduction and Motivation

- **Mission:** Create an observationally and ensemble-based Extended Multivariate ENSO index that's as long and reliable as possible.
- Awareness of the history of the El Nino Southern Oscillation (ENSO) increases our knowledge of the mechanisms and behavior that drive and characterize it. Grasping these mechanisms and previous behavior are key to understanding ENSO's future
- A longer observational record allows the natural and anthroprogenic contributions to ENSO to be attained more easily
- Using pre-1950 data more than doubles the sample size of analyzed ENSO events!
- ENSO is the dominant mode of variability that skews the probability of weather phenomena over specific regions of the globe beyond a few weeks to a month and up to a year or two.
- The 2014-16 El Nino event is very likely the first multi-year "Super" El Nino since at least 1876-78, hence little-no modern precedent for this event currently exists
- What is the significance of the rapid succession of "Super" El Nino events near the turn of the 21st century and what implications does this have on the future of ENSO?
- Each SST reconstruction and reanalysis dataset are often fraught with spurious data and widely varying interpretations of individual ENSO event timing, amplitude, and progression, especially before 1950
- Popular geographically fixed indices, including the NINO 3.4 and the SOI fail to account for variability beyond their analyzed regions and are not allowed to vary with the seasonal cycle
- Due to the non-linearity and irregularity of ENSO, any index measuring this phenomena needs to be "reduced" in order to boil it down into its most basic components. Hence, Principal Component Analysis (PCA) is applicable for ENSO monitoring
- The integration of an ensemble of quality controlled datasets is anticipated to increase the confidence, stability, and coherence of the Ensemble Extended Multivariate ENSO Index (ENS MEI.ext) compared to the original MEI.ext
- Using a suite of statistically independent datasets provides first-guess uncertainty estimates of ENSO thru the mid 19th century
- A recent barrage of new 19th and 20th century SST reconstructions and reanalyses makes an ensemble-based approach to estimating ENSO more feasible

Data and Methodology

Gather Data from 25 SST and 18 SLP datasets

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Calculate Monthly Nino 3.4 SSTs and Tahiti/Darwin SLP

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Construct a confidence interval to remove spurious data

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Remove data that falls outside this confidence interval

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Calculate 30-year sliding base periods

↙ ENS ONI ↓ ENS SOI ↘

Calculate Tropical Pacific Bi-Monthly SST and SLP EOFs

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Remove EOF Data that failed monthly NINO 3.4 and SOI QC

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Combine Remaining EOFs

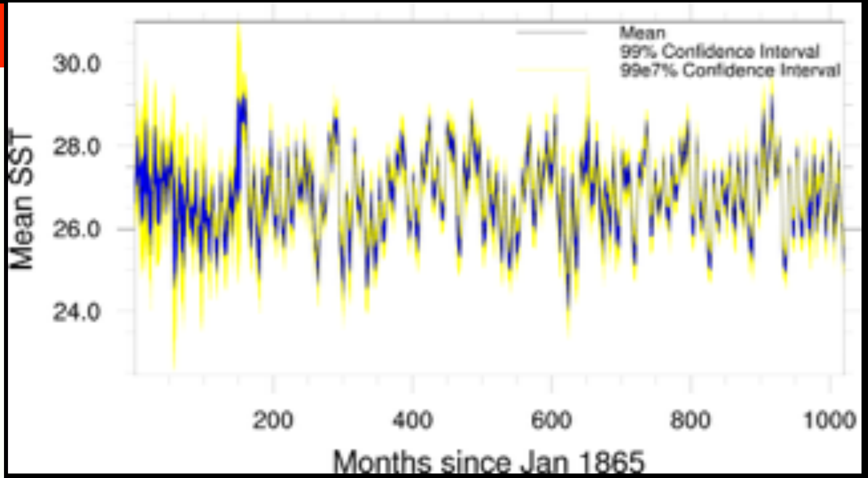

Figure 1: ENS ONI Monthly NINO 3.4 SSTs (black), 99% confidence interval (blue), 99.9e7% Confidence Interval (yellow) (1865-1949)

Results and Conclusions

- The ENS MEI.ext…
- Likely provides the most realistic, up-to-date, significant, and longest running observationally-based measure of ENSO
- Increases the amplitude of most pre-1950 El Ninos
- Depicts 1876-78 as a very close analog to 2014-16
- Is capable of resolving the 1865-66 and 1867-68 El Ninos also noted in the Quinn reconstruction
- Confirms previous findings that ENSO underwent a period of relatively high activity near the turn of the 19th century
- Captures the rapid succession of at least 4 moderate-strong El Nino events from 1896-1906. This exceptionally high frequency of significant El Ninos is virtualy unprecedented in the observational record.
- Shows that the amplitude of the 1877-78 El Nino is more comparable to 1982-83 and 1997-98 as compared to the original MEI.ext
- Trends in inter-dataset variance mirror HADSST3 uncertainties
- COBE SST2 and NOAA's 20th Century Reanalysis Version 2c performed relatively poor in the NINO 3.4 QC, ERSSTv4 was flagged a lot in the past few years of data
- Japanese 55-year Reanalysis (JRA-55) performed the best in the SOI QC

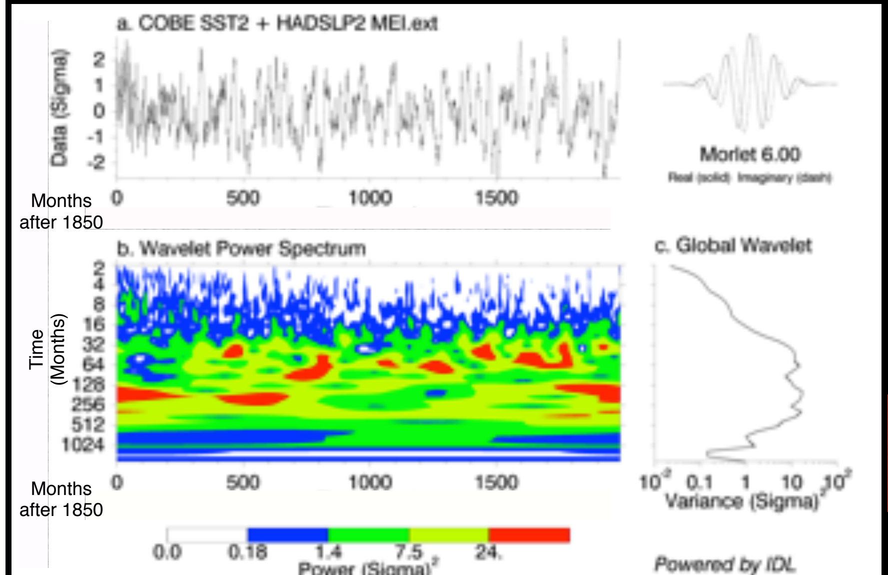

Figure 2: COBE SST2 + HADSLP2 MEI.ext wavelet analysis (1850-2015)

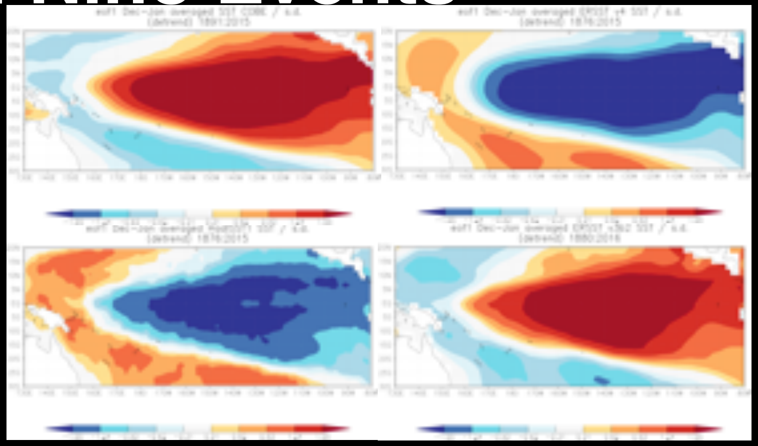

Figure 3: From top left to bottom right: COBE SST, ERSSTv4, HADISST, and ERSSTv3b Dec-Jan Tropical Pacific (20N-30S, 130-280E) SST 1st EOF (30S-20N, 130-280E).
Note the minor discrepancies in EOF structure amongst these datasets, especially ERSSTv4

Future Work

- Change the latitudinal extent of the analyzed EOF region to account for the seasonal migration in the EOF poles
- Contrast the relative uncertainties in the SLP and SST observations
- Regular updates and revisions to the ENS MEI are expected as new sources of data are discovered and a new generation of SST reconstructions and coupled ocean-atmosphere reanalyses emerge.
- ICOADS Release 3.0 unveiled in 2016, has added thousands of new observations in the Tropical Pacific. For example, this release includes ~ 600% more SST observations over the equatorial Pacific in the 1950s!

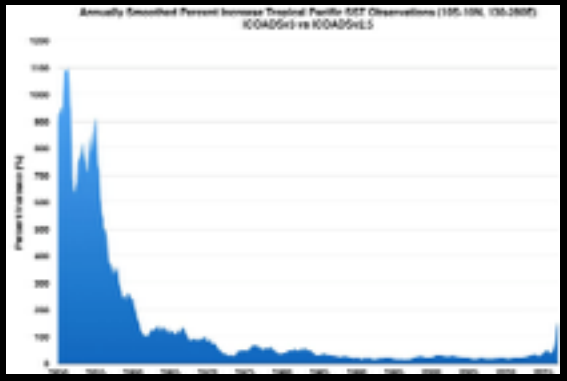

Figure 4:
Annually Smoothed Tropical Pacific Percent Change (%) in Marine Observations
ICOADS Release 3.0 versus ICOADS Release 2.5 (1950-Present)

References

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Acknowledgements:
Special Thanks to Dr. Anantha Aiyyer, Dr. Nicholas Meskhidze, Dr. Michael Ventrice, Anthony Masiello, Dr. Ryan Maue, Eric Blake, Philip Klotzbach, Tyrrell Wade, James Russell, and Dylan White for feedback, guidance, and encouragement.

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