ENSO precursors and building an operational ENSO monitoring system

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Laying the Groundwork

• **Validation Time**
  – Extended Boreal Winter (~Nov.-Mar.)
  – Robust ENSO signal
  – Relatively high impact (particularly on North America)

• **Initialization Time**
  – “Quantitative ENSO Forecast” (QEF): 0-6 Months prior to event
    • Post-Spring Predictability Barrier
    • First-order feedbacks are predominantly positive
    • **Can still be substantial “unforced” ENSO development during this time**
    • Monitoring region is “relatively” well constrained
  – “Medium Range ENSO Forecast” (MREF): 6+ Months prior to event
    • Pre-Spring Predictability Barrier
    • Substantially more potential initiation mechanisms
    • Need to discern which processes and metrics are worth monitoring

• **Target**
  – Magnitude *and* Structure
    • Both characteristics modulate local and far-field climate responses to ENSO
    • Both have “preferred” precursors, suggestive of different initiation mechanisms
Precursor Nonpareil: Subsurface Heat Content
Subsidiary Precursors

W.Eq Wind Stress (WEWSI)
Subsidiary Precursors

Hawaiian SLP (HSLPI)
Subsidiary Precursors

West. North Pac. (WNP)

Meridional Mode (MM)
Subsidiary Precursors

Tradewind Charging (TWC)
Subsidiary Precursors

30-year Correlation: Index/NINO3.4(\(yr+1\))

- HSLPI
- WEWSI
- MM(SST)
- WNP

Year(centered)

Correlation

Latitude

US CLIVAR
Climate Variability & Predictability

2015 US CLIVAR Summit        August 4-6    Tucson, Arizona
Subsidiary Precursors

Multivariate Regression w/NINO3.4(yr+1)

- HSLPI
- WESI
- MM(SST)
- WNP

Median Regression Coeff. vs.
ALL   w/o WNP   w/o MM   w/o HSLPI
Subsidiary Precursors

Multivariate Regression w/NINO3.4(yr+1)

Median Regression Coeff.

-0.2  -0.1  0  0.1  0.2  0.3  0.4  0.5  0.6

ALL  w/o WNP  w/o MM  w/o HSLPI

HSLPI  WEWSI  MM(SST)  WNP(unadj.)
Operational Monitoring System Requirements

**“MREF” Precursors: > 6 months**
- Subsurface ocean temperatures
  - Vertically integrated
  - Horizontal and vertical gradients
- Western equatorial wind stress
  - Events
  - Accumulated Influence
- Meridional mass transport
  - ENSO v. Non-ENSO
  - Directly measured
  - Derived: Wind-stress gradients and thermocline depth changes
- Air-sea interactions (?)
  - N. Pacific Meridional mode
  - Western North Pac. Mode
  - [Indian and Atlantic SSTs](see Dayan et al., 2014, 2015 for good review)

**“QEF” Precursors: 0-6 Months**
- Subsurface ocean temperatures
- Equatorial wind stress
  - Westerly wind burst events
  - MJO
  - Basin-wide modification of trades
- Air-sea Interactions
  - Convection
  - Surface heat budgets
- Tropical ocean circulation
  - Equatorial Currents & Upwelling
  - Temperature, Salinity, and Density Gradients
  - Mixing/Diffusion/Entrainment
- Remote atmospheric circulations
  - Seasonal footprinting SSTs
  - North Pacific Oscillation
  - S. Pacific Meridional Mode
  - Southern Hemisphere “Booster”
  - Tropical Atlantic Variability
Building an Operational Monitoring System

• **“MREF” Precursors: > 6 months**
  – Subsurface ocean temperatures
    • Direct measurements
    • Satellites
    • Reanalyses
  – Western equatorial wind stress
    • Direct measurements
    • Satellites
    • Reanalyses
  – Meridional mass transport
    • Direct measurements
    • Satellites
    • Reanalyses
  – Air-sea interactions (?)
    • Direct measurements
    • Satellites
    • Reanalyses

• **“QEF” Precursors: 0-6 Months**
  – Subsurface ocean temperatures
  – Equatorial wind stress
  – Air-sea Interactions
    • Direct measurements
    • Satellites
  – Tropical ocean circulation
    • Direct measurements
    • Satellites
    • Reanalyses
  – Remote atmospheric circulations
    • Direct measurements
    • Satellites
    • Reanalyses
Panel Science Strategies and Goals

Monitoring and predicting the evolution of ENSO cuts across the Science Strategies and Goals of all three panels:

- **POS:** Advocate and leverage long-term climate monitoring strategies to better document, understand, model and **predict climate variability**
  - What are the most robust monitoring products
  - What monitoring strategy best balances the skill/parsimony trade-off

- **PSMI:** Promote process studies to gain a quantitative understanding of the mechanisms controlling climate variability and change, and to provide observational data to evaluate and improve models; **Improve climate models, including their representation of processes**, data assimilation approaches, and evaluation
  - What monitoring products are needed to evaluate processes within models
  - What monitoring products are needed to be better initialize models

- **PPAI:** Develop and employ techniques to critically assess improvements in predictions and projections in order to build the confidence of users and to **identify the most likely targets for future improvements**; **Apply fundamental lessons from research on climate to facilitate knowledge transfer** between the various scientific communities that generate and use information on climate variability and change
  - What processes should be monitored when?
  - Which potential sources of improved ENSO prediction are “Data limited” v. “Science limited”
  - What monitoring products can be used to “condition” skill/uncertainty of ENSO predictions?
Unperturbed ENSO Growth
(Larson & Kirtman, 2015)
Proposed Remote SST Precursors (Dayan et al., 2015)