Some Societal Impacts of ENSO

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(See WP by Bond, Goddard, Harrison, Martinez, Yamagata)
Tropical Pacific Observing System-2020
SIO
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Lots of Reasons to Observe, Study & Forecast Tropical Pacific

• Variability in the region impacts local and remote areas in many ways, and strongly in some.
• ENSO is a primary mode of regional variability with impacts around the globe.
• Will offer only a big picture view of a few ENSO impacts here. Details elsewhere.
• Also, please see Zebiak et al (2014) for more background and other impacts.
Outline

• Identifying El Nino and La Nina Events
• **Seasonal Weather**
• Tropical Cyclones
• **Marine ecosystems**
• Central American examples
• **Atmospheric CO2 uptake**
Identifying El Nino and La Nina Events

• Nino SSTA indices, SOI, MEI, BEI, and OLR criteria have all been used to define events.
• Depending upon region and season and impact of interest, different indices will have tighter/different ENSO associations.
• Will illustrate with one example for North American DJF El Nino weather anomalies
• Research on best approaches to optimize relationships for each region and each impact is needed and ongoing.
Multi-decadal Variability in ENSO

• An often-insufficiently acknowledged aspect of ENSO/impacts relationships is that ENSO has strong low frequency variability.

• Any random 20 year period is unlikely to have similar ENSO characteristics to another.

• It may not be ok to extrapolate behavior from one period to the coming period, esp trends.

• Implications for e.g., fisheries mgmt., global change
ENSO Seasonal Weather: The Big Picture

• Familiar since at least Ropelewski and Halpert’s works (’87, ’89, ’92)
• **Approach is to composite weather anomalies over many El Nino and La Nina events**
• How to identify El Nino and La Nina events is an issue for studies of details of effects
• **But Big Picture story is not affected by choice of criterion to identify events, and is widely familiar.**
Big Picture El Nino Seasonal Weather

Warm Episode Relationships
December - February

Warm Episode Relationships
June - August

High Resolution Images can be found at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ENSO/ENSO-Global-Impacts/
Big Picture La Nina Seasonal Weather

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Event to Event Variability

• A major limit on the utility of the big picture perspective for seasonal weather forecasting is the large event to event variability of seasonal weather anomalies.

• Using the now-familiar NINO3.4 SSTA criterion, many El Nino and La Nina years do not exhibit the big picture anomalies.

• Turns out we can do better, at least in the satellite era.
OLR Perspective on El Nino N. Am Seasonal Weather Anomalies

• Since 1975 (when OLR became available), using an OLR index to identify distinctive conditions as El Nino events leads to fewer events but with much more useful weather associations than using NINO3.4 SSTA.

• The average associations for the non-OLR El Nino years are not robust from event to event and have almost no areas of strong stat. significance. Not explained by amplitude, either

• Tho’ not shown here, the OLR approach also helps in many areas and seasons, globally.
OLR approach to identifying El Nino events was motivated by our familiar ENSO Cartoons, in which deep convection shifts eastward.
Eastern Central Pacific OLR and El Niño

Monthly OLR Anom. 160°W:110°W and 5°S-5°N

Figure from Chiodi and Harrison (J. Climate, 2013)
OLR from NOAA Interpolated data set (Liebmann and Smith, 1996)
DJF Temperature Anomalies

OLR El Niño

masking at 95% local statistical significance
period 1974-2011

95% statistical significance colored

data: CRU Temp

non-OLR El Niño
DJF Precipitation Anomalies

OLR El Niño

non-OLR El Niño

masking at 95% local statistical significance
period 1974-2011

data: GPCC Global Precip
ENSO and Tropical Cyclones

- Tropical cyclones do severe damage when landfalling, potentially affect many millions of people, and can involve $\text{billion}$ in damage.
- There are significant relationships between ENSO and tropical cyclone genesis areas, frequency and intensity.
- But the story varies with region around the planet.
- And the relationships are not tight.
- Nino3.4 widely used for studies.
- See White Paper and refs for more details.
Aggregate of Tropical Cyclone Tracks
Difference between El Niña and La Niña in terms of genesis potential (based on a combination of vorticity, vertical wind shear, potential intensity, and humidity) during August-October (Adapted from Camargo et al. 2007).
Atlantic Tropical Cyclone Damage Estimates vs ENSO State (Pielke and Landsea, 1999)
**ENSO and some Ecosystem Impacts**

- As we have seen with the other impacts, ecosystem impacts can depend upon the region of interest and the ENSO index examined.
- **Will present some results from Trop Pac and California Current**
- Please see other White Papers for more on fisheries and biology and biogeochemistry.
Satellite Mon. Mean Chlorophyll Estimates

- **December 1997**: Major El Niño
- **August 1998**: Major La Niña

Chlorophyll Concentration
- Contour = 29°C isotherm

Notes: Snapshots of monthly average chlorophyll conditions during the 1997-1998 transition from a strong El Niño (upper panel) to La Niña (lower panel) state. The 29°C isotherm is overlaid for reference.
Displacement of tagged skipjack tuna with ENSO events from a program carried out by the Secretariat of the Pacific Community (SPC) organization (Adapted from Lehodey et al. 1997)
Species change substantially during Warm conditions. Cold water species provide better nutrition for sea birds and fish. Warm conditions can be remotely or locally forced.
ENS0 Impacts, Central America, ‘05–’12

• An overview of recent impacts is provided in the White Paper, event by event.
• Only a big picture perspective can be included here, and it is substantially the picture from Ropelewski and Halpert’s composite work.
Hurricanes frequency Reduction

Below normal rainfall in Venezuela,

Warmer and drier Central America

Drought in the N. E. Brazil

Equatorial Pacific for several months with positive SST anomalies.

Heavy rainfall and above normal temperature in Ecuador, Peru and Bolivia

Heavy rainfall and increased temperature in Rio de Janeiro, Sao Paulo, Paraguay.
Increased hurricanes

Abundant rain in N. Venezuela

Rainfall deficit along NW and central coast

Abundant rain in NE Brazil

Deficit rainfall and Low temperature in Chile and Argentina

Wet conditions in Central America and the Caribbean

TYPICAL LA NINA CONDITIONS
Typical La Nina Conditions, Central and South America, 2005-2012

- Wet conditions in Central America and the Caribbean
- Abundant rains in northern Venezuela
- Abundant rainfall and warm atmosphere in northern Venezuela
- Deficit rainfall and low temperature in Chile and Argentina
- Equatorial Pacific for several months has negative SST anomalies.
- SST below normal
- Rainfall deficit
**ENSO and Atmospheric Carbon Concentration Changes**

- After the seasonal cycle and trend, ENSO is the largest contributor to atmospheric CO2 changes.
- Concentration increases more rapidly than normal during El Nino and less rapidly than normal during La Nina.
- Changes are not ‘inverse’ to each other, so changes in ENSO statistics will alter decadal rate of increase.
Annual CO2 concentration change vs ENSO

El Nino/La Nina defined by NINO3 SSTA >1C or <-1C
El Niño

El Nino ave change is ~2/3 of long term trend

La Niña

La Nina ave change is ~1/3 of long term trend
Wrap-up

• ENSO has, on average, important consequences for various societies around the globe in different seasons and different regions.

• Event to event variability sometimes can be minimized by the choice of ENSO index. Present practice has not optimized utility.

• For ENSO prediction and understanding, sustained climate quality observing of the upper ocean and lower atmosphere of the tropical Pacific is essential.

• Others will speak to the many scientific questions and predictability issues that remain to be worked out.
Conclusion

• There will be substantial societal benefit from improved prediction of ENSO, arising out of improved understanding of the physics and the statistical properties of ENSO, and of the impacts associated with ENSO events.
THANK YOU