El Niño Tele-Connections and Their Role in Drought

David Sauchyn, Mauricio Bedoya, Álvaro González-Reyes, Ariel Muñoz, Jorge Julian Velez Upegui

ENSO Alert System Status: **El Niño Advisory**

Synopsis: El Niño is expected to remain strong through the Northern Hemisphere winter 2015-16, with a transition to ENSO-neutral anticipated during late spring or early summer.

Source: US National Weather Service, Climate Prediction Center
Ocean-Atmosphere Oscillations (O) / Modes (M)

- ENSO
- PDO
- AO / NAM
- AMO
- IOD
- SAM
Sir Gilbert Walker
- Arrived in India shortly after the failure of the monsoon in 1877 and the worst famine in the India’s history
- As director of the meteorological service he discovered that the monsoon rains, and other global weather phenomena, were correlated with the Southern Oscillation; the atmospheric component now bears his name

Jacob Bjerknes
- Norwegian-American meteorologist and professor at the University of California,
- In the 1960s, he hypothesized that small perturbations in the Walker circulation and Southern Oscillation leads to an El Niño and the ENSO teleconnections
The three phases of El Niño – Southern Oscillation (ENSO)

Neutral

La Niña

El Niño

ENSO Indices

Source: NOAA <www.climate.gov>
Southern Oscillation Index (SOI), 1950-2015

La Niña

* - 1.7 (Oct 2015)

El Niño

Source: http://www.cpc.ncep.noaa.gov/data/indices/soi
Teleconnections – El Niño

Source: NOAA Climate Prediction Center

December to February

June to August
Streams and Trees Respond to the Same Hydroclimatic Processes

The Hydrologic Cycle

- Precipitation
- Snowmelt and Runoff
- Infiltration
- Condensation
- Evaporation
- Evapotranspiration
- Plant Uptake
South Saskatchewan River Basin, western Canada
Mean Water Year Flow ($m^3/s$) South Saskatchewan River at Medicine Hat, 1108-2010
Spectral (Continuous Wavelet) Analysis of River Flow

2-8 years: ENSO
Climate signals in high elevation tree-rings from the semiarid Andes of north-central Chile: Responses to regional and large-scale variability
Tree Rings and Winter Precipitation
Snow cover and sea surface temperature and in the southern Andes (Masiokas, et al. 2013)
Water-year flow of the Biobío River, 1500-2003

Muñoz et al. (In review)
# River basins and tree-ring reconstructions of annual stream flow – western Canada and central Chile

<table>
<thead>
<tr>
<th>River Basin</th>
<th>Bio-Climatic Zone¹</th>
<th>Reconstruction (Years)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHILE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BioBio</td>
<td>Temperate Rainforest</td>
<td>1500-2003</td>
<td>Munoz et al., In review</td>
</tr>
<tr>
<td>Maule</td>
<td>Mediterranean (Semiarid)</td>
<td>1590-2000</td>
<td>Urrutia et al., 2011</td>
</tr>
<tr>
<td><strong>CANADA</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Athabasca</td>
<td>Temperate Boreal Forest</td>
<td>1111-2010</td>
<td>Sauchyn et al., 2015</td>
</tr>
<tr>
<td>South Saskatchewan</td>
<td>Grassland (Semiarid)</td>
<td>1108-2010</td>
<td>Axelson et al., 2009²</td>
</tr>
</tbody>
</table>
Correlations between tree-ring reconstructions of annual river flow and ENSO (from Li et al., 2013)
Correlations of ENSO with river levels (first empirical orthogonal function) at each gauge, 1972-2008

Source: M Bedoya
Chinchiná River Basin, Colombia – Modeled monthly streamflow for **La Niña**, **El Niño** and **Neutral** weather conditions, 1981-2010

Source: J J Velez Upegui
Modeled* past and future flows of the Chinchiná River

* Climate Model: CNRM-CM5 RCP 8.5

Source: J J Velez Upegui
Vulnerability and Adaptation to Climate Extremes in the Americas (VACEA)

Vulnerabilidad y Adaptación a los Extremos Climáticos en las Américas

Principal Investigators:

Dr. Dave Sauchyn, University of Regina, Canada
Dr. Fernando Santibañez, Universidad de Chile, Santiago

www.parc.ca/vacea/
106 municipalities with water supply deficits

minimum historical water levels in the Magdalena-Cauca Rivers Basin

40 % (orange) rainfall anomalies over large area

Cauca River gauges:

- Buenos Aires - Valle: 1.98
- Candelaria - Valle: 2.17
- La Victoria - Valle: 3.32
- La Virginia - Risaralda: 2.00
- Venecia - Antioquia: 2.04
- Antioquia - Caucasia: 1.96
- Achi - Bolivar: 3.08
NOT JUST EL NIÑO
Global Temps on the Rise

1°

0°

-0.5°

1950

2015

Average Annual Global Temp Anomaly Relative to 1961-1990. 2015 Data through August. Source: NASA (GISTEMP Analysis), NCEI-NOAA (MLOST), and Hadley (HadCRUT)
OCEANS HEATING UP
Change in Sea Surface Temperature (°F) Since 1901:

Data through 2014. Gray indicates insufficient data
“*” indicates statistically significant trend
Source: IPCC, NOAA: Merged Land-Ocean Surface Temp Analysis