What Is El Niño and La Niña

A general description of ENSO and their global impacts
General Location of Major Climate Variability System

PDO: 210712: -0.18, 199710: +1.63, 199810: -1.4

**El Niño/La Niña -Southern Oscillation (ENSO)**

(Develops in JAS, strengthen through OND, and weakens in JFM)

- **El Nino**—*major warming* of the equatorial waters in the Pacific Ocean
  - The anomaly of the SST in the tropical Pacific increases (+0.5 to +1.5 deg. C in NINO 3.4 area) from its long-term average;
  - A high pressure region is formed in the western Pacific and low-pressure region is formed in the eastern Pacific—this produces a negative ENSO index (SOI negative).

- **La Nina**—*major cooling* of the equatorial waters in the Pacific Ocean
  - The anomaly of the SST in the tropical Pacific decreases (-0.5 to -1.5 deg. C in NINO 3.4 area) from its long-term average;
  - A high pressure region is formed in the eastern Pacific and low-pressure region is formed in the western Pacific—this produces a positive ENSO index (SOI positive).
El Niño and La Niña

Weaker trade winds

(Cold SST) low pressure system

Normal

(Cold SST) high pressure system

Stronger trade winds

(Warm SST) low pressure system

La Niña

El Niño

Weaker trade winds
6 out of the 8 El Niño events since 1979 have transitioned to La Niña conditions.
La Niña-Rainfall

DJF: Wet over northern South America and Southern Africa/ and Dry along coastal Ecuador, northwestern Peru and equatorial eastern Africa

JJA: Wet over southeastern Australia /Dry over southern Brazil and central Argentina.

Rainfall is enhanced across the western equatorial Pacific—Indonesia and the Philippines.
ENSO and Tropical Cyclones

El Niño shifts TC genesis Eastward over the North and South Western Pacific

- Less TC activity
  - Australia
  - Philippines
- More TC activity
  - Tropical Pacific
  - Hawaii
  - American Samoa

From the Royal Netherlands Meteorological Institute
http://www.knmi.nl/research/global_climate/enso/effects/
Summary of historical global impact of La Niña and El Niño

<table>
<thead>
<tr>
<th></th>
<th>Jun-Aug</th>
<th>Dec-Feb</th>
<th>Jun-Aug</th>
<th>Dec-Feb</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>La Niña</strong></td>
<td><img src="image-url" alt="Image of table showing impacts of La Niña" /></td>
<td><img src="image-url" alt="Image of table showing impacts of La Niña" /></td>
<td><img src="image-url" alt="Image of table showing impacts of La Niña" /></td>
<td><img src="image-url" alt="Image of table showing impacts of La Niña" /></td>
</tr>
<tr>
<td>Wetter</td>
<td>India, Malaysia, Indonesia, Central America, Sahel, southern Australia</td>
<td>Indonesia, Malaysia, Australia, northern South America</td>
<td>central Pacific, central Chile, western United States (US)</td>
<td>South America (Ecuador, northwestern Peru, southern Brazil, central Argentina, Uruguay), equatorial East Africa, northern Mexico/southern Africa</td>
</tr>
<tr>
<td>Drier</td>
<td>central Pacific, Uruguay, eastern Argentina, central Chile</td>
<td>central Pacific, Ecuador, East Africa, southern India</td>
<td>India, Indonesia, Malaysia, eastern Australia, Sahel, southern Africa, northern South America</td>
<td>Australia, Indonesia, the Philippines, northern South America</td>
</tr>
<tr>
<td>Warmer</td>
<td>Papua New Guinea, eastern Indonesia</td>
<td>southern US</td>
<td>west coast of South America, southern Brazil, Central America</td>
<td>South East Asia, southern Africa, Japan, southern Alaska and western/central Canada, southeastern Brazil and southeastern Australia</td>
</tr>
<tr>
<td>Colder</td>
<td>West Africa, southeast Asia, western South America</td>
<td>West Africa, Japan, eastern Brazil, southern Alaska and western/central Canada</td>
<td>southern Pacific, New Zealand</td>
<td>Gulf coast of US</td>
</tr>
</tbody>
</table>
CURRENT CONDITIONS

General State of the Ocean and Atmosphere

Weak La Niña conditions are present in the tropical Pacific.

Sea Surface Temperatures are below average in the central and eastern equatorial Pacific.

Atmospheric La Niña signals have weakened in December 2017, and the Southern Oscillation Index (SOI) is slightly negative with -0.2 for December 2017.
During January and February 2017, above-average SSTs expanded in the eastern Pacific Ocean.

From mid April to July 2017, near-to-above average SSTs spanned most of the equatorial Pacific.

During August 2017, above-average SSTs dissipated east of the date line.

Since September 2017, negative SST anomalies have generally persisted in the central and eastern equatorial Pacific.
Niño Region SST Departures (°C) Recent Evolution

The latest weekly SST departures are:

- Niño 4: -0.1°C
- Niño 3.4: -0.8°C
- Niño 3: -1.4°C
- Niño 1+2: -0.8°C
Current State of ENSO (SST)

- A weak La Niña event continues, along with its climate impacts around the world. SST at NINO3.4 region is $-0.8^\circ$ C
- La Niña is likely (~85-95% by CPC-IRI) (72% by NIWA) through Northern Hemisphere winter, with a transition to ENSO-neutral expected during the spring.
CPC/IRI ENSO Forecast

CPC/IRI EL NIÑO/SOUTHERN OSCILLATION (ENSO) DIAGNOSTIC DISCUSSION

Expected Conditions

- The forecaster consensus favors La Niña continuing through the December-February season

- Rapidly returning to neutral

Climate Prediction Center
NOAA/National Weather Service
College Park, MD 20740

http://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/
CPC/IRI EL NIÑO/SOUTHERN OSCILLATION (ENSO) DIAGNOSTIC DISCUSSION

Expected Conditions

• Models favor weak La Niña conditions continuing through winter 2017-2018
• Quickly returning to neutral
• Predictions are for a weak event throughout

CPC/IRI EL NIÑO/SOUTHERN OSCILLATION (ENSO) FORECAST

Average Niño 3.4 SST Anomaly Forecast

<table>
<thead>
<tr>
<th></th>
<th>JFM</th>
<th>FMA</th>
<th>MAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamical</td>
<td>-0.7</td>
<td>-0.6</td>
<td>-0.4</td>
</tr>
<tr>
<td>Statistical</td>
<td>-0.6</td>
<td>-0.5</td>
<td>-0.4</td>
</tr>
<tr>
<td>All Models</td>
<td>-0.7</td>
<td>-0.5</td>
<td>-0.4</td>
</tr>
</tbody>
</table>

CPC/IRI ENSO Forecast

Mid-Dec 2017 Plume of Model ENSO Predictions

http://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/?enso_tab=enso-sst_table
http://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/?enso_tab=enso-sst_table
Atmospheric La Niña signals have weakened in December 2017, and SOI is slightly negative with -0.2 for December 2017;

La Niña conditions are likely (72% chance) to persist over JFM of 2018;

La Niña is likely to decay rapidly during AMJ of 2018;

ENSO-neutral conditions is most likely (74% chance) over AMJ of 2018 period.
https://www.facebook.com/climatesociety/videos/1098793830256505/

Impacts

• Quick recap of the 2017/2018 La Niña
• Current conditions for
  • Rainfall
  • Sea Level
  • Tropical Cyclones
  • Societal Impacts
Global impacts of La Niña

La Niña years have clearly shown greater average annual losses in comparison to El Niño and Neutral phases.

- La Niña USD77 billion
- El Niño USD45 billion

Much of the increase in losses during a La Niña year surrounds:

- Increased frequency of costly landfilling tropical cyclone events in the Atlantic Ocean basin
- Increased flooding events across Asia Pacific

Source: Aon Benfield 2015 Annual Climate and Catastrophe report.
Because of La Niña, 2017 fall and winter weather pattern may turn out to be “drier fall and snowier winter across the NORTH, and drier winter across the SOUTH”.

Cold: Montana, Wyoming, N Dakota, S Dakota, Nebraska
Wet: WC Washington, Oregon /EC New York, Michigan
Drier: California, Nevada, Texas, Louisiana, Mississippi, Florida
America battles EXTREME cold and ice in January 2018:
Bomb cyclone then bitter cold

- La Niña and shift of Arctic Circulation are the reason for this freezing weather.

Bomb cyclone is beginning of a 100 year GLOBAL COOLING period???
What is the Polar Vortex?

- Large area of low pressure and cold air near the poles—weakens in summer and **strengthen and expands** in winter sending cold air southward with the jet stream;
- "vortex" refers to the counter-clockwise flow of air that helps keep the colder air near the Poles;
- Since 2000, the Jet stream is **WEAKENING**/began slowing down—its waves meandering more;
- When this happens, Arctic air drops south, and sometimes very far south.

Global Monthly Precipitation Anomaly
Drought Condition

Drought now covers 26% of 48 contiguous states, easing in Arkansas but expanding in Texas Panhandle, Southwestern states and Illinois.

Dec 20-21: very heavy rains (4-10 inches) in western Maui, Lihue, eastern Molokai)

U.S. Drought Monitor

January 9, 2018
(Released Thursday, Jan. 11, 2018)
Valid 7 a.m. EST

Drought Impact Types:

- Delineates dominant impacts
- S = Short-Term, typically less than 6 months (e.g., agriculture, grasslands)
- L = Long-Term, typically greater than 6 months (e.g., hydrology, ecology)

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author: Brian Fuchs
National Drought Mitigation Center

http://droughtmonitor.unl.edu/
Drought impacts to the USAPIs

- Hydrological drought conditions have ended in the last couple of months
- Water supply no longer a concern
- Food security will take more time to recuperate
Sea Level Observation

Sea Levels have been
- Above average over Western Pacific Basin since March 2017
Synopsis of 2-years of SLV and Forecasts

- Rise from JAS-2015 and continued up to JAS 2016
- Fall from OND-2016 and stayed marginally below average in JFM-2017
- Rise again from June-2017 and currently staying above average
- Likely to stay 5-8 inches above normal up to JFM of 2018

*Observed monthly value; Note that Pago Pago values are adjusted by -5 inches;
**NDJ-2017 values are PEAC-CCA forecasts
High-Tides and Inundation pictures in Pohnpei & Kosrae on December 4 - 5 (PC: Wallace Jacob, WSO-Pohnpei)

High-tides in Kosrae

High-tides in Pohnpei

Damaged roads in Kosrae
### 2017 Northern Hemisphere Tropical Cyclone Activity (through October), by basin and with hemisphere totals

<table>
<thead>
<tr>
<th>Basin</th>
<th>Named Storms</th>
<th>Days</th>
<th>Hurri/Typh</th>
<th>Days</th>
<th>Major Hurri</th>
<th>Days</th>
<th>ACE**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natl</td>
<td>16 (11)</td>
<td>89 (55)</td>
<td>10 (6)</td>
<td>51 (22)</td>
<td>6 (3)</td>
<td>19 (6)</td>
<td>224 (99)</td>
</tr>
<tr>
<td>ENP</td>
<td>18 (16)</td>
<td>66 (72)</td>
<td>9 (8)</td>
<td>20 (29)</td>
<td>4 (4)</td>
<td>5 (9)</td>
<td>98 (130)</td>
</tr>
<tr>
<td>WNP</td>
<td>22 (23)</td>
<td>85 (119)</td>
<td>11 (15)</td>
<td>36 (58)</td>
<td>4 (8)</td>
<td>6 (20)</td>
<td>144 (259)</td>
</tr>
<tr>
<td>NIO</td>
<td>2 (3)</td>
<td>4 (8)</td>
<td>1 (1)</td>
<td>0.3 (2)</td>
<td>0 (0.5)</td>
<td>0 (0.7)</td>
<td>4 (11)</td>
</tr>
<tr>
<td>NHem</td>
<td>58 (54)</td>
<td>244 (255)</td>
<td>31(31)</td>
<td>107(112)</td>
<td>14 (15)</td>
<td>30 (35)</td>
<td>469 (500)</td>
</tr>
</tbody>
</table>

**ACE is proportional to the square of the wind speed.**

Throughout 2017, there was a **westward & northward** displacement of the TC activity, *which is consistent with the development of La Niña*. 
2017 Atlantic hurricane season
(Preliminary damage is over $369.86 billion)

- The 2017 Atlantic hurricane season was a **hyperactive**, deadly, and extremely destructive season, featuring 16/17 named storms, ranking alongside 1936 as the fifth-most active season since records began in 1851.

- The season also featured both the highest total accumulated cyclone energy (ACE) and the highest number of major hurricanes since 2005 with major hurricanes — Harvey, Irma, and Maria.

- This season is also one of only six years on record to feature multiple Category 5 hurricanes, and only the second after 2007 to feature two hurricanes making landfall at that intensity.

- This season is the only season on record in which three hurricanes each had an ACE of over 40: Irma, Jose, and Maria.
Hurricane Harvey

- Harvey was the first **major hurricane** (Cat 4: 134 mph) to make **landfall** in Texas on Aug 29-30 since **Wilma** (‘05)

- Harvey was the costliest **tropical cyclone** on record, inflicting nearly $200 billion (2017 USD) in damage;

- As of September 14, 2017, at least 82 people have died.
Hurricane Irma

- Irma was another **major hurricane** (Cat 5: 185 mph) to make **landfall** in Florida on Sep 10-11.

Hurricane Irma is the **strongest Atlantic basin hurricane ever recorded** outside the Gulf of Mexico and the Caribbean Sea. **Damage:** US $ 67 Billion
Hurricane Maria (Cat 5: 175 mph) was regarded as the worst natural disaster on record in **Dominica** and **Puerto Rico**. It made landfall in Dominica on Sep 18.

Damage: $103.45 billion (2017 USD);
Fatalities: 547

- **Hurricane Jose**: was a powerful longest-lived **Atlantic hurricane**
- **Hurricane Katia** struck the east coast of Mexico as a Category 1 storm
Why Hurricane Season was so Intense?

- Atmosphere was Hurricane friendly
- ENSO neutral—improving Atlantic Hurricane prospects
- Tropical Atlantic was exhibiting high “thermal potential”—meaning water can rapidly evaporate to atmosphere
- SST was warmer than average
- As the world warms, evaporation speeds up. So on average there's more water vapor for a storm to sweep up and dump now, compared to 70 years ago
- —global warming is making a bad situation worse???
Global warming is making a bad situation worse

- Harvey benefited from unusually toasty waters in the Gulf of Mexico
- As the storm roared toward Houston, sea-surface waters near Texas rose to **between 2.7 - 7.2 °F above average**.
- The tropical storm, feeding off this unusual warmth, was able to progress from a tropical depression to a category-four hurricane in roughly 48 hours.

Harvey intensified rapidly amid sea surface temperatures in the Gulf of Mexico up to 2.7 - 7.2°F (1.5 - 4°C) above average, relative to a 1961-1990 baseline.
2017: The year of hurricanes, wildfires and floods

Forecast

ENSO forecasts
Rainfall, Sea level, Tropical Cyclones and Coral Bleaching
Rainfall Forecasts (Typical effects of La Niña)

- Above-avg rains in Philippines, Indonesia and in southern America
- **Below-avg rains in Greater Horn due to weak response of IOD (+ more rains)**
- Above-avg rains in northern Europe, Asia, parts of the interior U.S. and Alaska
- **Strong drier-than-normal in the southern U.S and central to northern Mexico**
- Drier-than-normal in parts of South America, south Africa, central and eastern Asia, as well as smaller, scattered areas around the world….
<table>
<thead>
<tr>
<th>Location</th>
<th>UKMO</th>
<th>ECMWF</th>
<th>CA</th>
<th>NASA</th>
<th>NCEP</th>
<th>IRI</th>
<th>APCC</th>
<th>PEAC CCA</th>
<th>Rainfall Outlook</th>
<th>Final Probs</th>
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<tbody>
<tr>
<td>Palau</td>
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<td>Koror 7º</td>
<td>Above</td>
<td>Above</td>
<td>Avg-above</td>
<td>Avg.</td>
<td>Avg-above</td>
<td>Above</td>
<td>Above</td>
<td>Above</td>
<td>Avg-Abv</td>
<td>30:35:35</td>
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<tr>
<td>FSM</td>
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<tr>
<td>Yap 9º</td>
<td>Above</td>
<td>Above</td>
<td>Above</td>
<td>Avg.</td>
<td>Above</td>
<td>Above</td>
<td>Above</td>
<td>Above</td>
<td>Average</td>
<td>30:40:30</td>
</tr>
<tr>
<td>Chuuk 7º</td>
<td>Above</td>
<td>Above</td>
<td>Above</td>
<td>Avg-below</td>
<td>Above</td>
<td>Avg.</td>
<td>Avg.</td>
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<td>Avg-Abv</td>
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<tr>
<td>RMI</td>
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<tr>
<td>Kwajalein</td>
<td>Avg.</td>
<td>Above</td>
<td>Above</td>
<td>Below</td>
<td>Above</td>
<td>Avg.</td>
<td>Below</td>
<td>Above</td>
<td>Average</td>
<td>30:40:30</td>
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<tr>
<td>Majuro 7º</td>
<td>Avg-above</td>
<td>Above</td>
<td>Avg-above</td>
<td>Below</td>
<td>Avg-above</td>
<td>Below</td>
<td>Below</td>
<td>Above</td>
<td>Avg-above</td>
<td>30:35:35</td>
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<tr>
<td>Guam and CNMI</td>
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<tr>
<td>Guam 13</td>
<td>Above</td>
<td>Above</td>
<td>Avg-above</td>
<td>Avg-above</td>
<td>Avg-above</td>
<td>Above</td>
<td>Above</td>
<td>Above</td>
<td>Average</td>
<td>30:40:30</td>
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<tr>
<td>Saipan 1</td>
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<td>Above</td>
<td>Avg-above</td>
<td>Avg-above</td>
<td>Avg-above</td>
<td>Above</td>
<td>Above</td>
<td>Above</td>
<td>Average</td>
<td>30:40:30</td>
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<tr>
<td>American Samoa</td>
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<tr>
<td>State of Hawaii</td>
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<td></td>
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<tr>
<td>19.7º - 21.0'N, 155.0º - 159.5'W</td>
<td></td>
<td></td>
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</tbody>
</table>
# Seasonal Sea level forecasts: USAPI

## Observed and Forecasts of MEAN anomaly for JFM/2018 Season (in INCHES)

<table>
<thead>
<tr>
<th>Tide-gauge</th>
<th>Observed Dec-17</th>
<th>JFM-18 Mean Forecasts</th>
<th>JFM-18 Std Dev</th>
<th>JFM-18 Outlook</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guam,</td>
<td>+7</td>
<td>+5</td>
<td>+4.1</td>
<td>Above-Stable</td>
</tr>
<tr>
<td>Malakal, Palau</td>
<td>+4</td>
<td>+5</td>
<td>+4.3</td>
<td>Above-Stable</td>
</tr>
<tr>
<td>Yap, FSM</td>
<td>+9</td>
<td>+6</td>
<td>+4.6</td>
<td>Above-Stable</td>
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<tr>
<td>Chuuk</td>
<td>+9</td>
<td>+6</td>
<td>+4.4</td>
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</tr>
<tr>
<td>Pohnpei</td>
<td>+9</td>
<td>+7</td>
<td>+4.7</td>
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<tr>
<td>Kapingamarangi</td>
<td>+7</td>
<td>+6</td>
<td>+4.5</td>
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<tr>
<td>Majuro, RMI</td>
<td>+8</td>
<td>+7</td>
<td>+3.5</td>
<td>Above-Stable</td>
</tr>
<tr>
<td>Kwajalein</td>
<td>+6</td>
<td>+6</td>
<td>+3.6</td>
<td>Above-Stable</td>
</tr>
<tr>
<td>Pago Pago, AS</td>
<td>+7</td>
<td>+6</td>
<td>+3.1</td>
<td>Above-Stable</td>
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<tr>
<td>Honolulu</td>
<td>+5</td>
<td>+4</td>
<td>+1.7</td>
<td>Above-Falling</td>
</tr>
<tr>
<td>Hilo</td>
<td>+6</td>
<td>+5</td>
<td>+1.8</td>
<td>Above-Stable</td>
</tr>
</tbody>
</table>

**MEAN is the difference between the mean sea level for the given month and the 1983 through 2001 monthly mean sea level value at each station (seasonal cycle removed);**
Seasonal SL Forecasts in the Western Pacific (Feb-Apr 2018)

- Sea Level across the Western Pacific Basin will be above average during FMA 2018

Sea Level Forecasts

Model forecast (CFSv2: initialized 20171202–20171231)
Lead = 2.5 months (201802)

Model forecast (CFSv2: initialized 20171202–20171231)
Lead = 4.5 months (201804)
Tropical Cyclone Forecast

- US Affiliated Pacific Islands
  - Tropical cyclone activity will be near average with a westward displacement (Philippine Sea and South China Sea to remain the focus)
- Below average in the western North Pacific basin
- From climatology, enhanced activity in the Bay of Bengal during La Niña
Tropical Cyclone Forecast

- American Samoa TC (PEAC Center Issued November 28th)
  - November to April TC season
  - American Samoa will be near average to slightly below average
- Australia (Australian BOM Forecast issued October 10th)
  - BoM is calling for near-average to slightly above average
  - NIWA is calling for a slightly above average
  - higher around the Coral Sea and west of the DL, and lower further east
Coral Bleaching Outlook

- High probability of Coral Bleaching across the Pacific Islands
- Western South Pacific Islands may see bleaching in the coming months
- Australia at risk of bleaching events
La Niña and Flu Pandemics


- A new study examining weather patterns around the time of these pandemics finds that each of them was preceded by La Niña conditions in the equatorial Pacific.

- La Niña alters the stopover time, fitness and interspecies mixing of migratory birds, which are thought to be a primary reservoir of human influenza.

- The scientists theorize that altered migration patterns promote the development of influenza.
Summary

• A weak La Niña event continues up to JFM of 2018, and then likely to decay rapidly in AMJ of 2018;
• Above-average rain in USAPIs and Philippines, Indonesia and in southern America, and parts of the interior U.S. and Alaska;
• Below-average rain in Greater Horn, South America, and eastern Asia;
• High sea Level across the Western Pacific FMA 2018;
• TC activity will be near average over the WNP;
• Flu Pandemics in next 3-6 months.
The PEAC Center

The Pacific ENSO Applications Climate Center

Photo courtesy of Lt. Charlene Felkley