R – Advance Programming

Lecture 8

- Moving Scripts to function
- Using arguments -- the smart way
- Advanced Programming
- Coding tips

Presentation Potential Titles

- Regression modeling of monthly temperature and rainfall for Prince George.
- Soil organic carbon content and how it correlates to climatic factors and elevation
- Correlations between ENSO and Kootenay River discharge.
- Correlation analysis of sea ice and global warming.

What We Know So Far

- Read data
- Create objects, array, matrix
- Print, paste, dump and sink
- Plots (scatter, line, slope and bar)
- Functions (built-in and new)
- Mean, sum, rmse, corr, trends
- For, if, while loops for code automation

Basic Metrics for Time series Analysis

Mean

$$\mu_x = \frac{1}{N}\sum_{i=1}^{N} x_i$$

Variance

$$\sigma_x^2 = \frac{1}{N}\sum_{i=1}^{N} (x_i - \mu_x)^2$$

Correlation

$$r = \frac{1}{n-1}\sum_{i=1}^{n}\left(\frac{x_i - \bar{x}}{s_x}\right)\left(\frac{y_i - \bar{y}}{s_y}\right)$$

Normalization

$$x_s = (x - \bar{x}) / \sigma$$

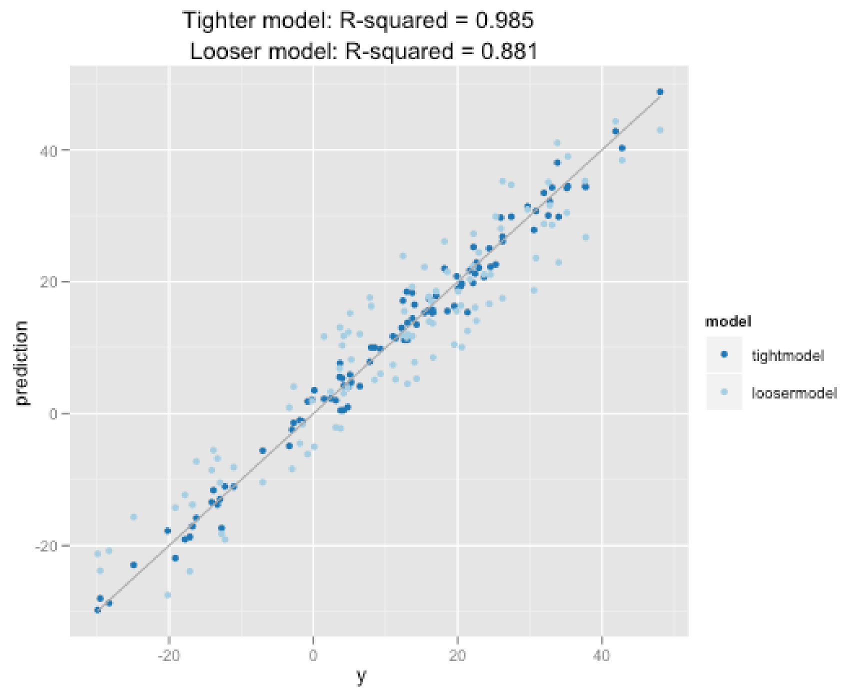
Anomaly

$$x_s = (x - \bar{x})$$

R-squared (R^2)

It represents the proportion of the variance for a dependent variable that's explained by an independent variable or variables in a regression model.

Example: if the $\mathbf{R}^2$ is 0.50, then approximately half of the observed variation can be explained by the model's inputs



$$R^2 = 1 - \frac{\Sigma(y_i - \hat{y})^2}{\Sigma(y_i - \bar{y})^2}$$

$$R^2 = 1 - \frac{\text{Explained Variation}}{\text{Total Variation}}$$

Where,

$\hat{y}$ − *predicted value of y*

$\bar{y}$ − *mean value of y*

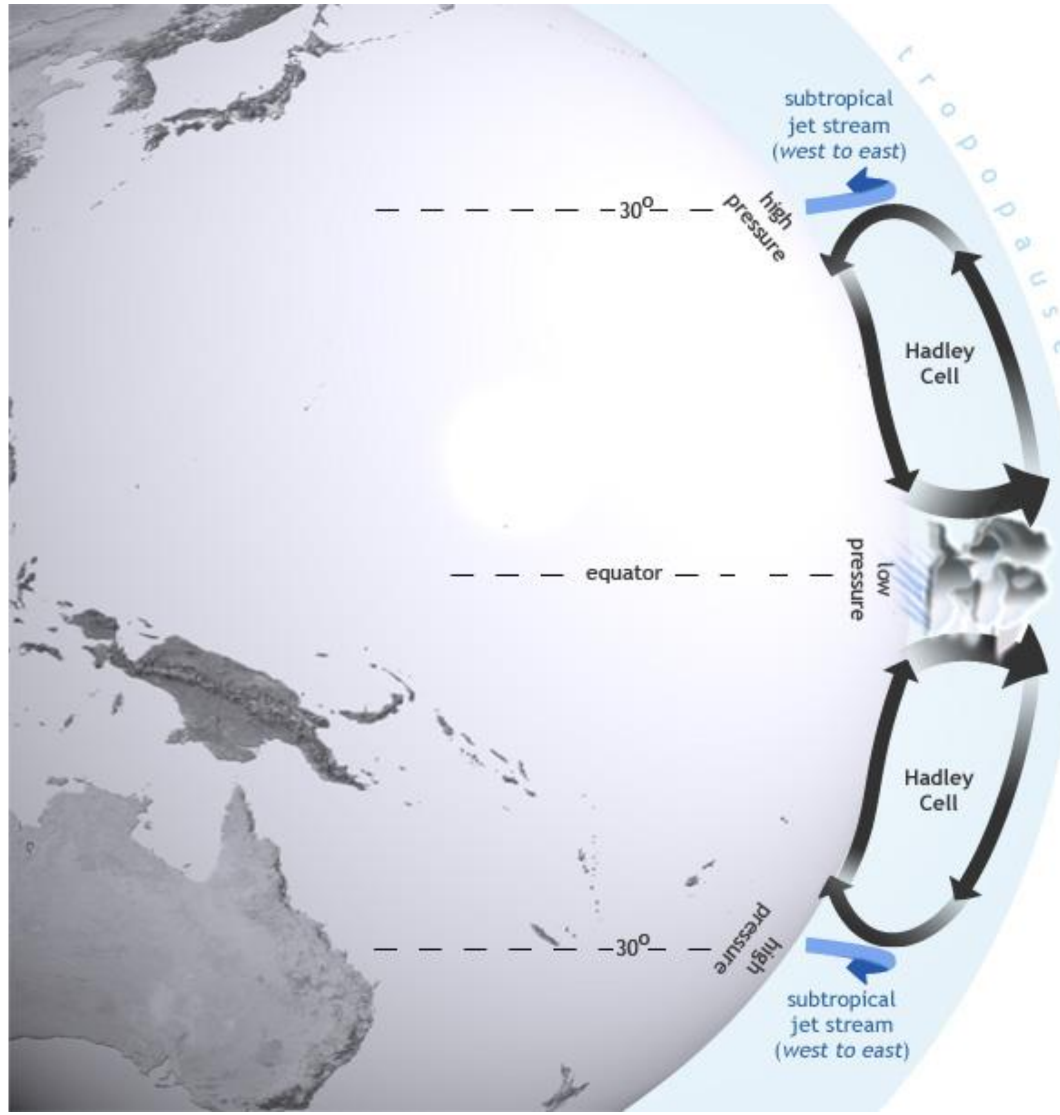
Source: investopedia

El Nino – Southern Oscillation (ENSO)

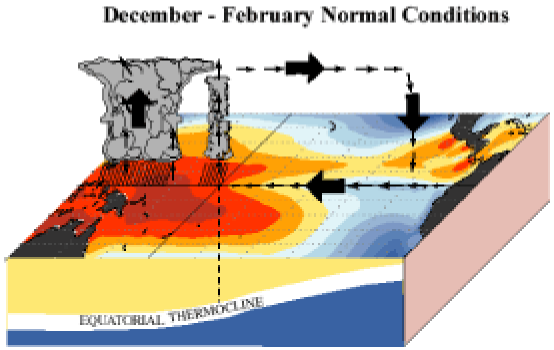
ENSO" refers to the interaction between the atmosphere and ocean in the tropical Pacific that results in a somewhat periodic variation between below-normal and above-normal sea surface temperatures and dry and wet conditions over the course of a few years. While the tropical ocean affects the atmosphere above it, so too does the atmosphere influence the ocean below it.

ENSO influences global atmospheric circulation by intensifying the Hadley circulation, in which heat is transferred from the Earth's surface to the upper atmosphere through convection and latent heating.

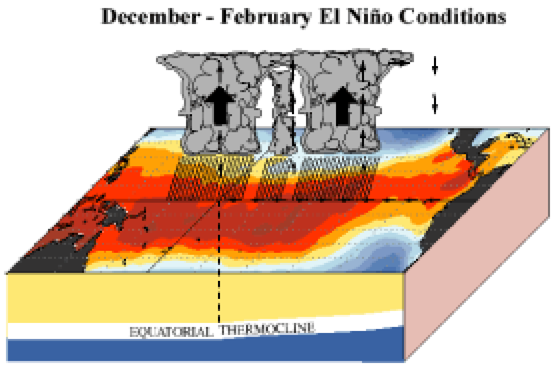
Map by NOAA Climate.gov.



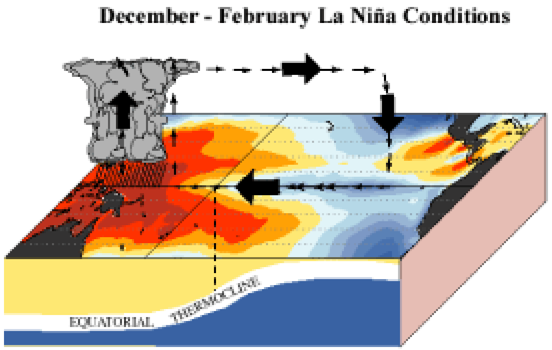
ENSO Dynamics



During ENSO neutral conditions, surface trade winds blow westward across the equatorial Pacific Ocean. Blowing against the ocean's surface, these winds result in a westward current.



During El Niño conditions, the usually present east to west winds weaken and an anomalous west to east flow develops. The west to east flow drives warm equatorial waters from the western Pacific towards the eastern Pacific and northern South America.



During La Nina conditions, the east to west flow present during neutral conditions is intensified.

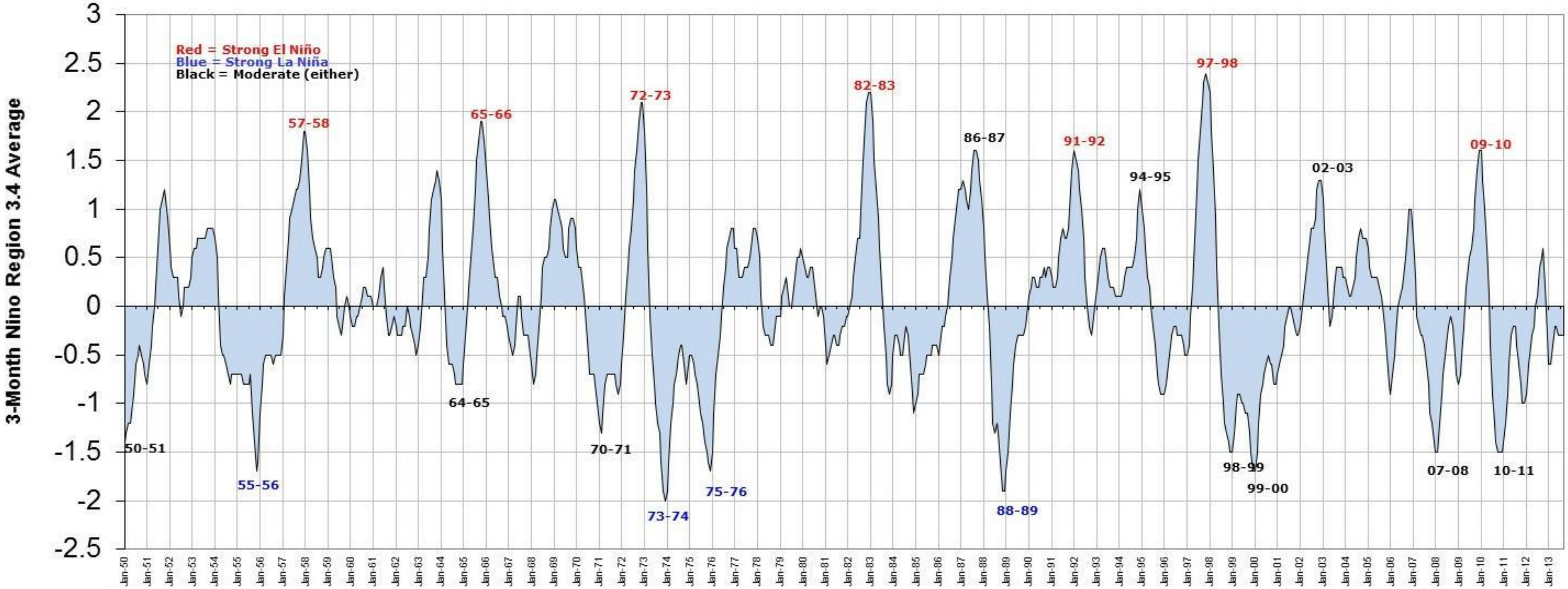
iridl.ldeo.columbia.edu

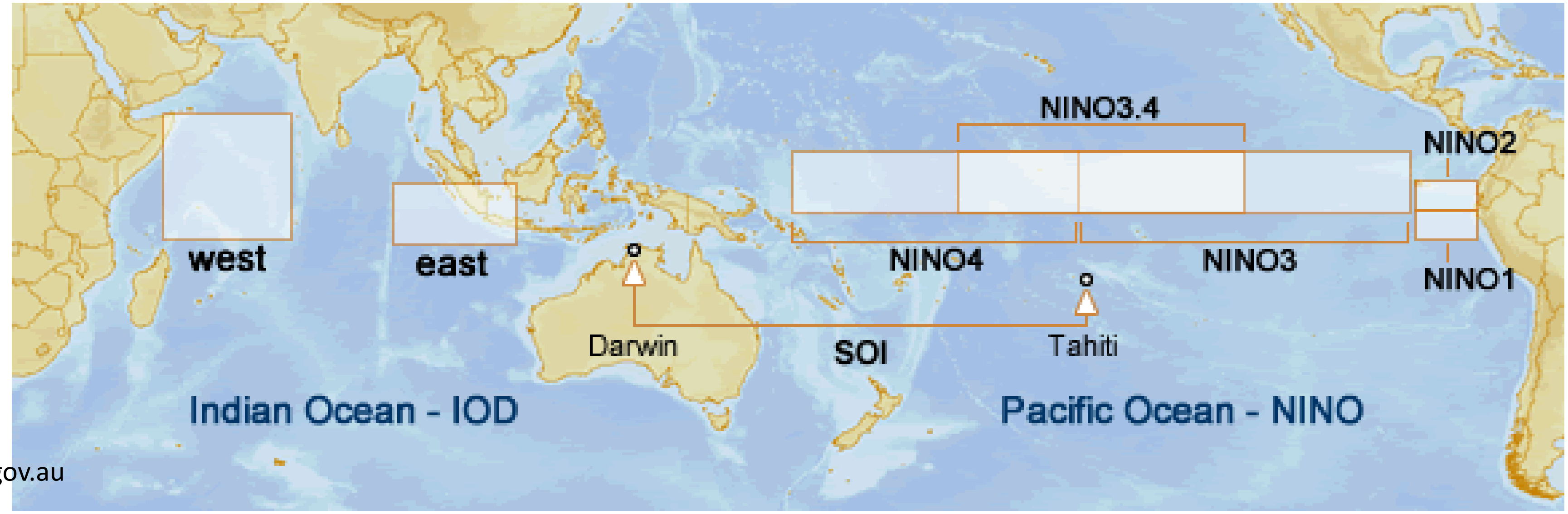
A Scientific Definition of ENSO Events

When the three-month running mean of the SST anomalies in the Nino 3.4 region are greater than or equal to 0.5°C, there is a good chance of an El Niño event taking place. When the anomalies are smaller than or equal to -0.5°C, there is a good chance of a La Niña event taking place.

Oceanic Niño Index (ONI)

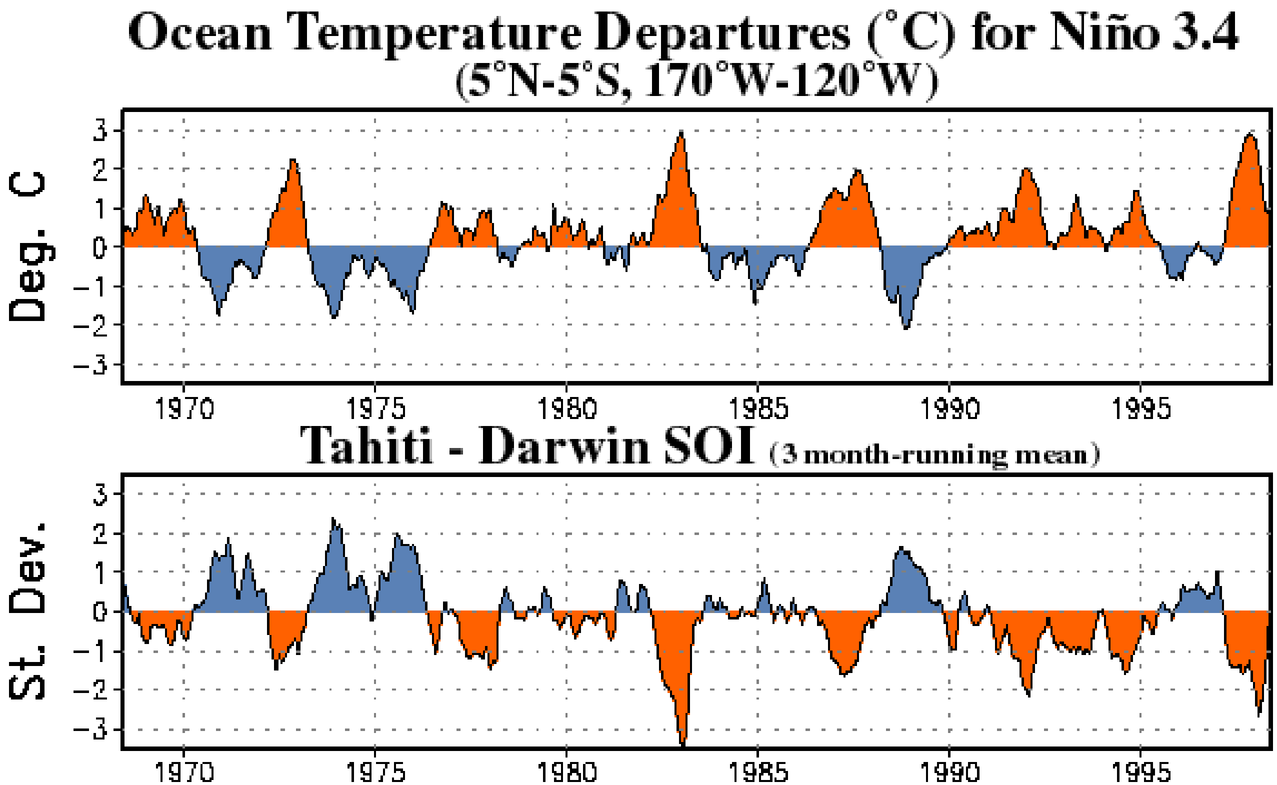
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml





bmo.gov.au

Southern Oscillation Index vs Nino3.4



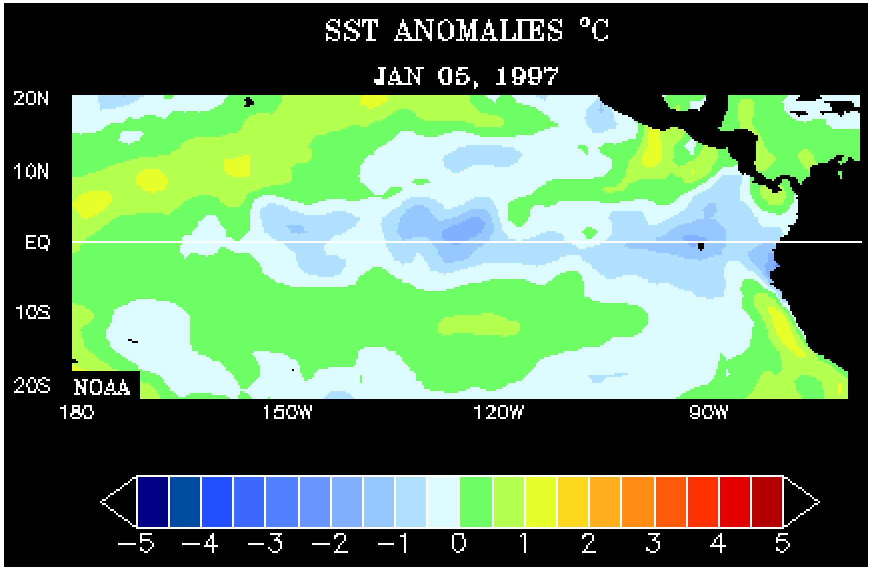
SOI is one measure of the large-scale fluctuations in air pressure occurring between the western and eastern tropical Pacific (i.e., the state of the Southern Oscillation) during El Niño and La Niña episodes. This index has been calculated based on the differences in air pressure anomaly between Tahiti and Darwin stations. The negative phase of the SOI represents below-normal air pressure at Tahiti and above-normal air pressure at Darwin. Prolonged periods of negative SOI values coincide with abnormally warm ocean waters across the eastern tropical Pacific typical of El Niño episodes. Prolonged periods of positive SOI values coincide with abnormally cold ocean waters across the eastern tropical Pacific typical of La Niña episodes.

www.cpc.ncep.noaa.gov

El Niño Years

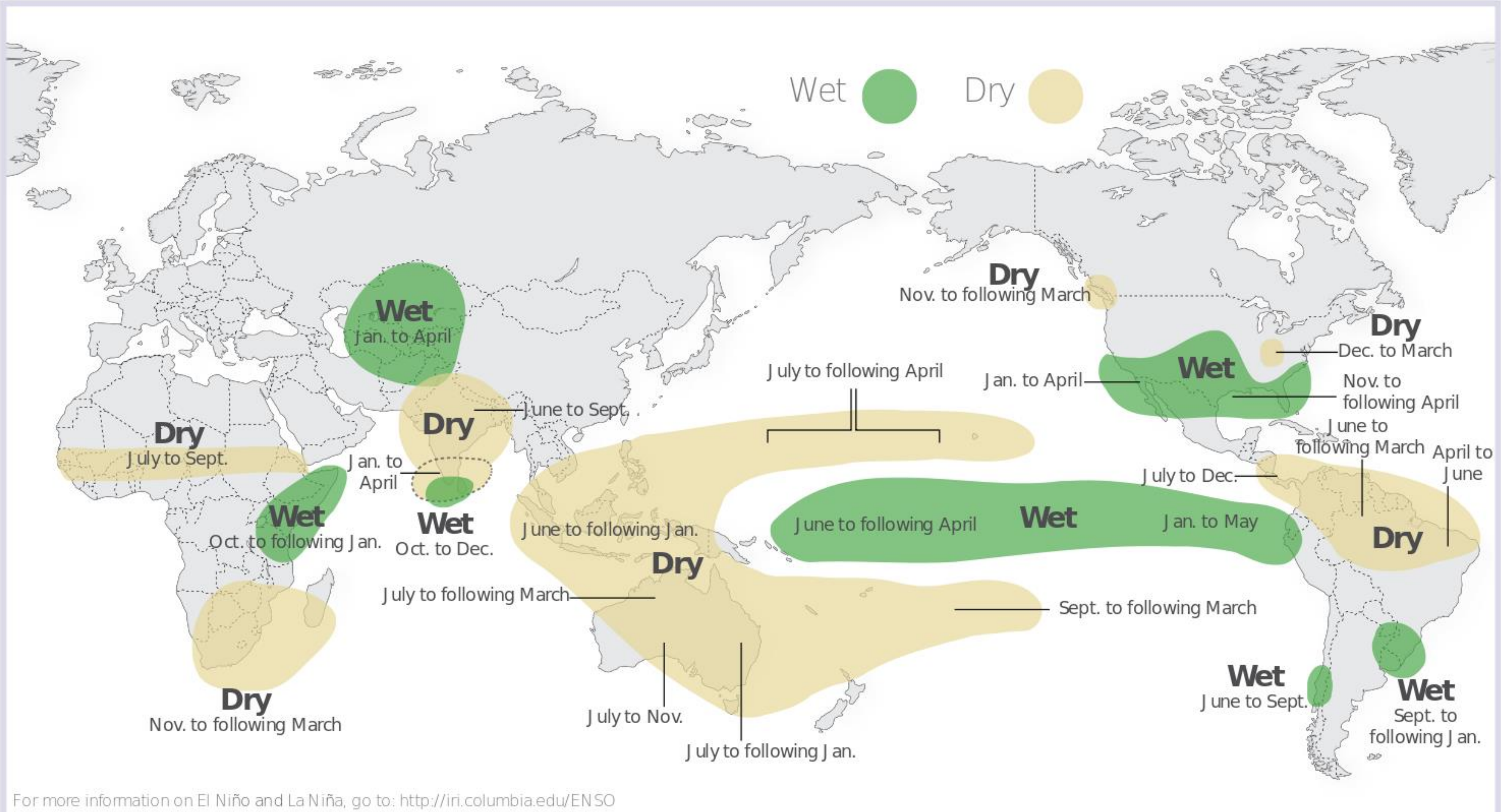
1902-1903 1905-1906 1911-1912 1914-1915 1918-1919 1923-1924 1925-1926 1930-1931 1932-1933 1939-1940 1941-1942 1951-1952 1953-1954 1957-1958 1965-1966 1969-1970 1972-1973 1976-1977 1982-1983 1986-1987 1991-1992 1994-1995 1997-1998 2002-2003

2006-2007 2009



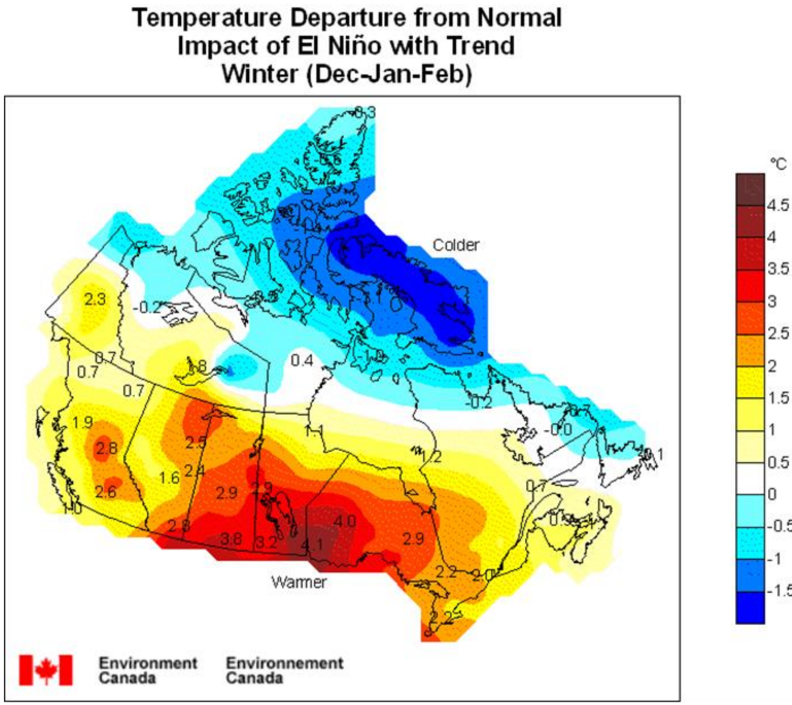
El-Nino and Rainfall

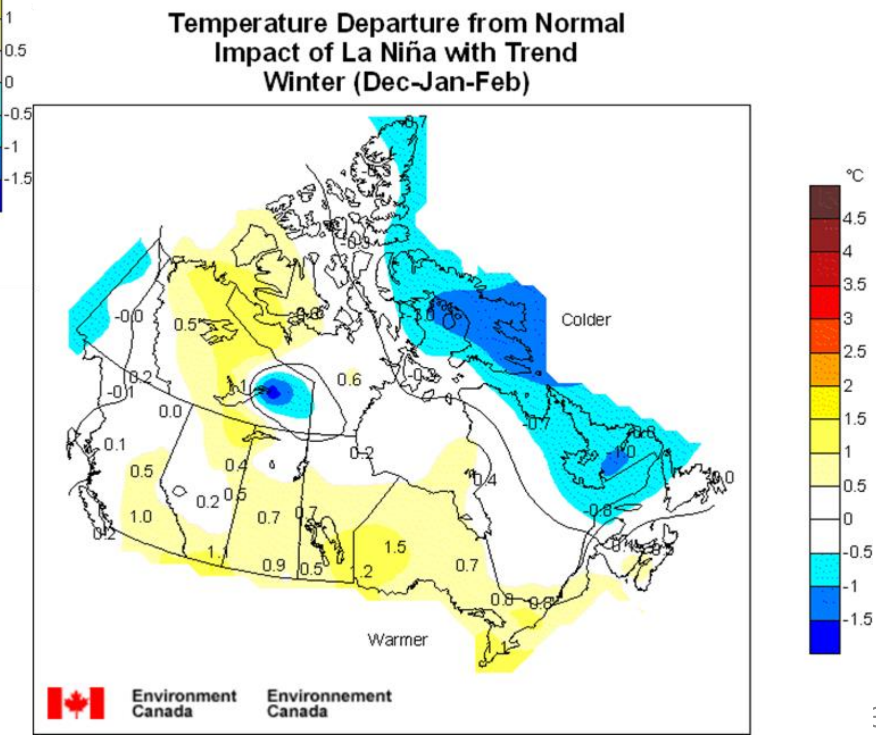
El Niño conditions in the tropical Pacific are known to shift rainfall patterns in many different parts of the world. Although they vary somewhat from one El Niño to the next, the strongest shifts remain fairly consistent in the regions and seasons shown on the map below.



Typical rainfall patterns during El Niño events. Such teleconnections are likely during El Niño events, but not certain. Map by IRI.

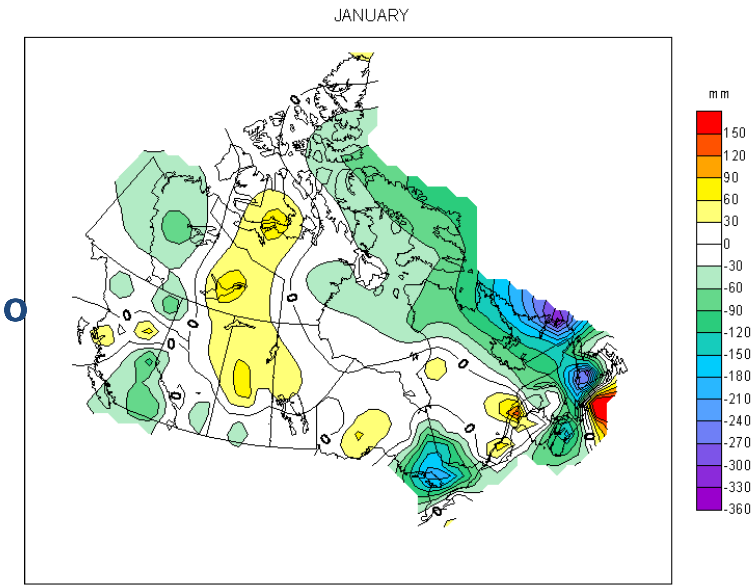
ENSO effects for North America



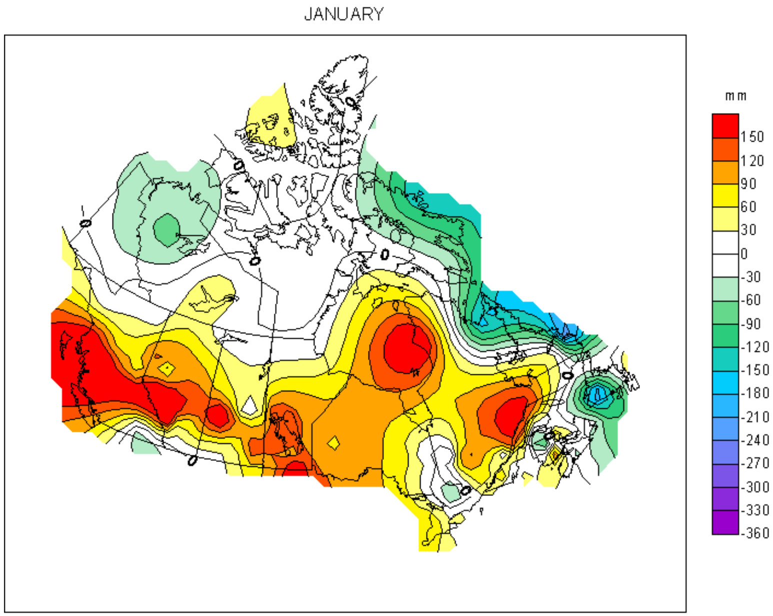


Difference in maximum Snow depth in millimeters between El Niño and La Nina and Neutral years

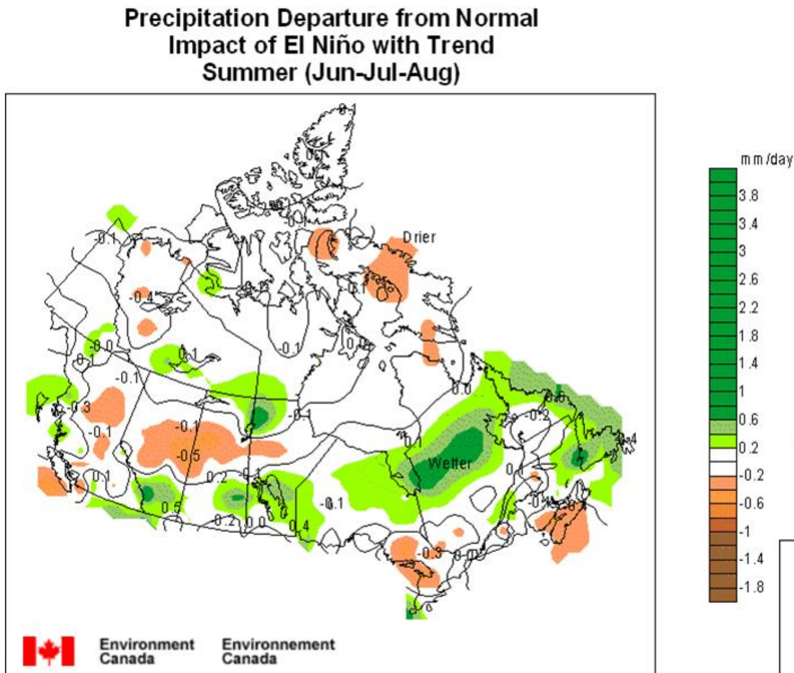
EL Niño

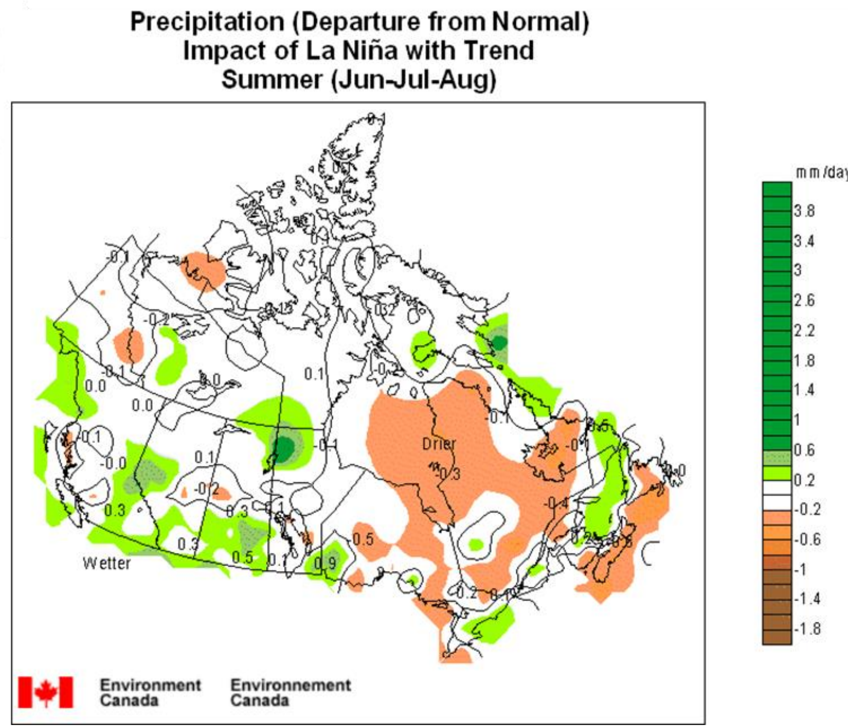


La Niña



The map shows typical summer precipitation response following the onset of El Niño. The numbers indicate the rate of precipitation (mm/day) by which the precipitation departs from the seasonal normal.



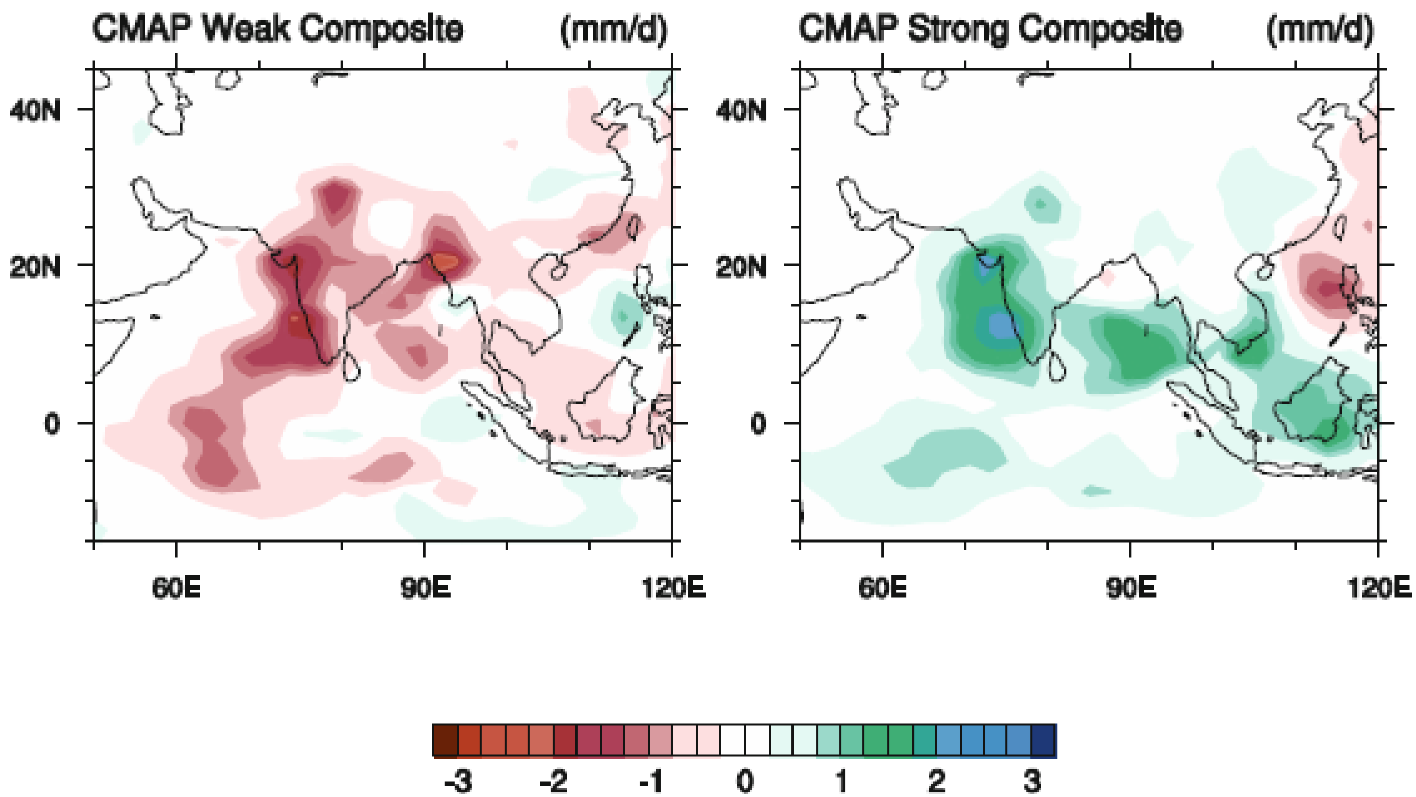


Composite Analysis

It is a technique to determine basic structural characteristics of a phenomenon which occur over time (e.g., the weather/climate over a given geographic area). In studying climate, composites can be quite useful for exploring the large scale impacts of teleconnections from modes of atmospheric variability.

- Composite analysis involves collecting large numbers of cases of a given meteorological phenomenon.
- Standardize the data.
- And then composite the weather over a large area over a period of many years e.g. ENSO index to study how precipitation or temperature vary due to ENSO.

Example: Composite Analysis



June–September (JJAS) anomaly precipitation composites of weak (1982, 1984, 1986, 1987, 1989 and 2002) and strong (1980, 1981, 1983, 1988, 1994, 1996, 1998 and 2007) monsoon years for a, b observation (CMAP). Units are in mm/day

Islam et al., 2013

Composite Analysis SST

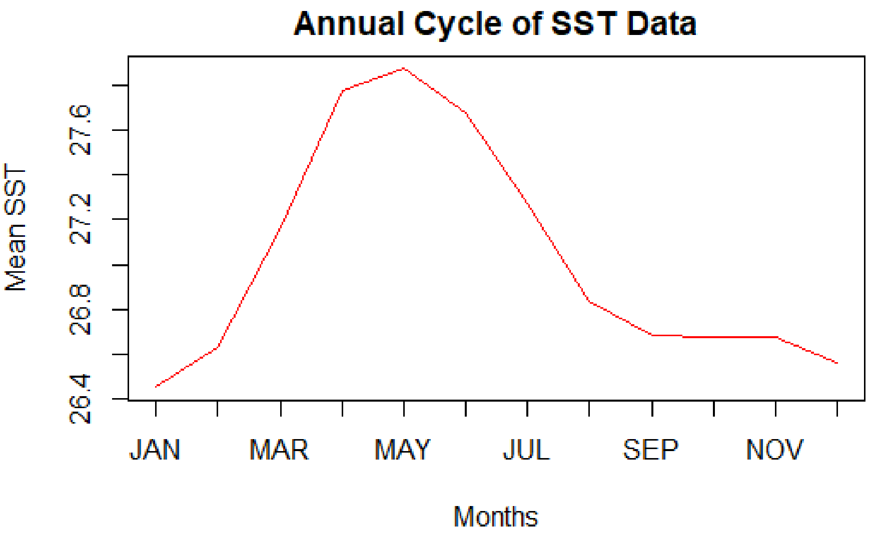
"The mean anomaly temperature for strong warm months is 1.92"
"The mean anomaly temperature for warm months is 0.861"
"The mean anomaly temperature for cold months is -0.866"
"The mean anomaly temperature for strong cold months is -1.67"

Lab Exercise 1

- Lets make the function to calculate climatology of any monthly data stored in a matrix.

- Make new R files and save it as mon_clim.R in your working directly. Copy the part of the code into this file using function()

- Make function that can compute the all values > 0.5 in anomaly time series.



Lab Exercise 2

- Download the daily weather station data http://web.unbc.ca/~islam/ENSC250/sample_daily_data_pr_tmax_tmin.txt
- Load the text file into R and do quick check of columns.
- Convert daily data in to monthly and then to yealy.
- Plot the yearly data with trend line and report your findings.