Climate of the Ocean

Lecture 4: Atmospheric Circulation and Variability

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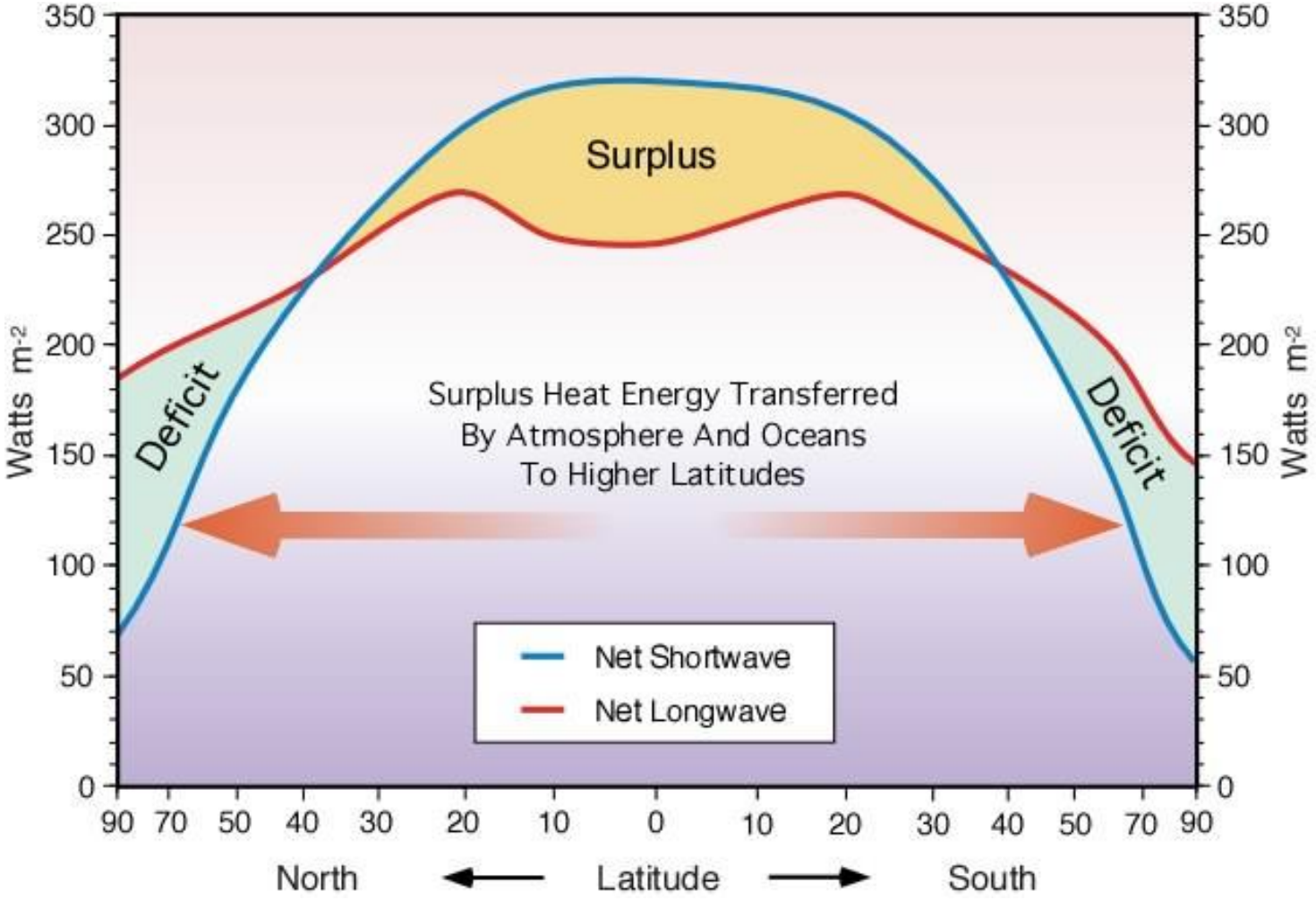
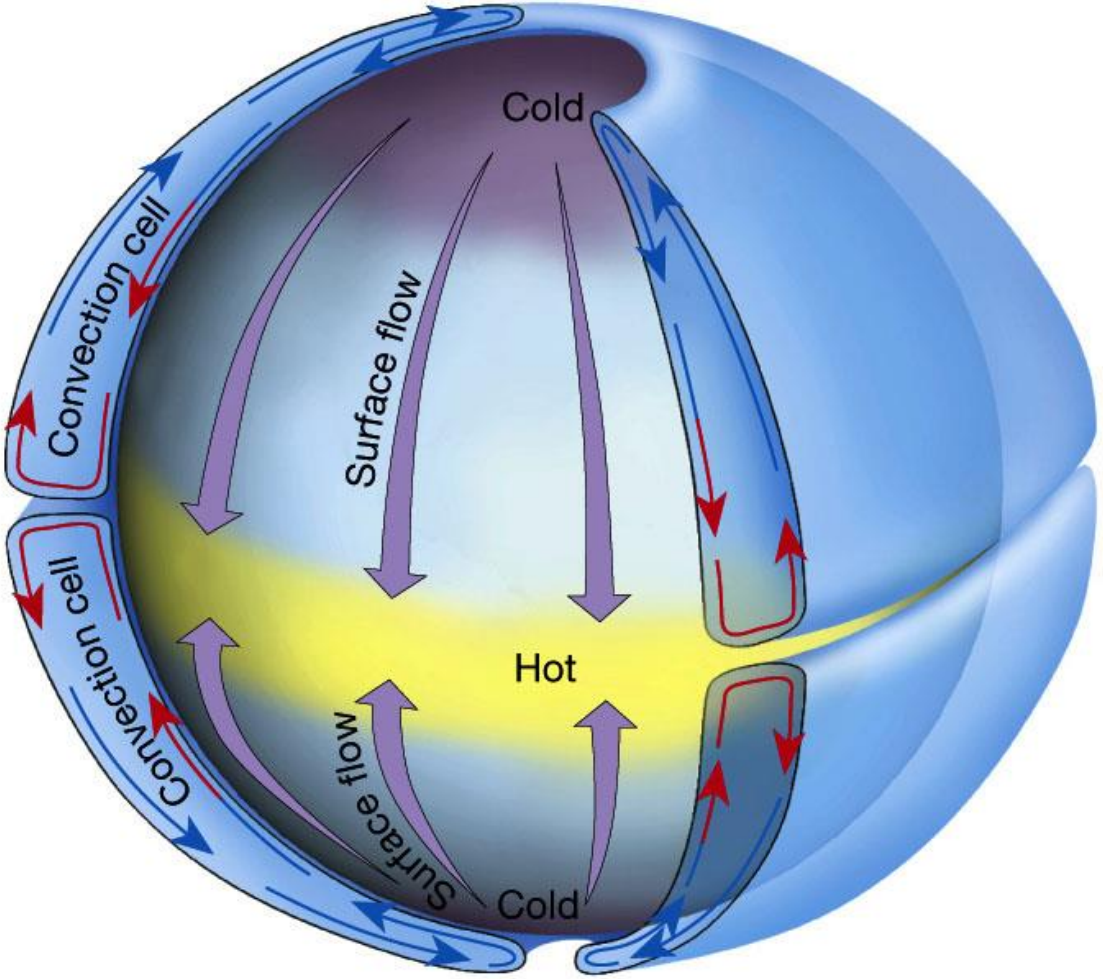
The General Atmospheric Circulation

Annual radiation budget of the earth



http://www.physicalgeography.net

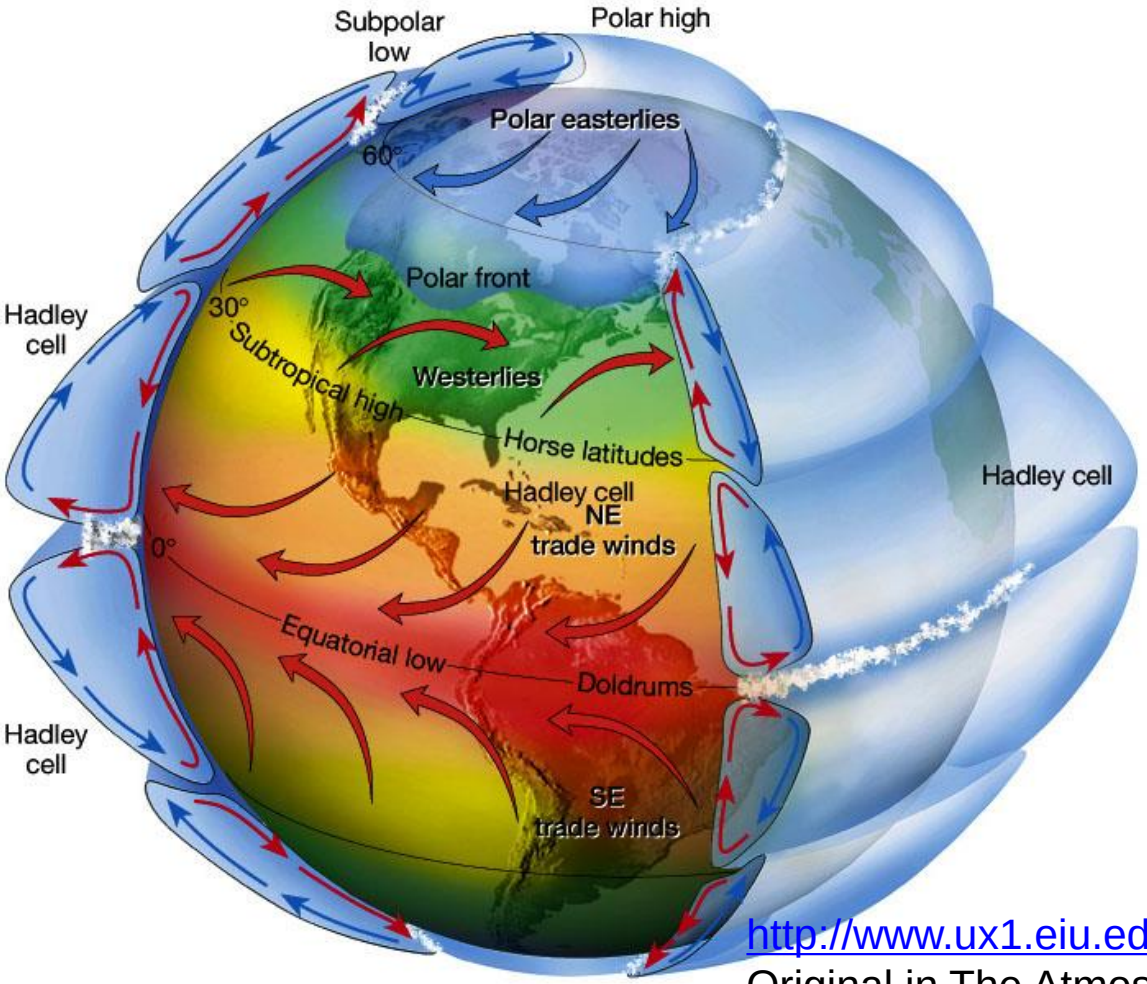
Simple sketch of the direct atmospheric circulation (non-rotating earth)



http://www.ux1.eiu.edu/~cfjps/1400/circulation.html

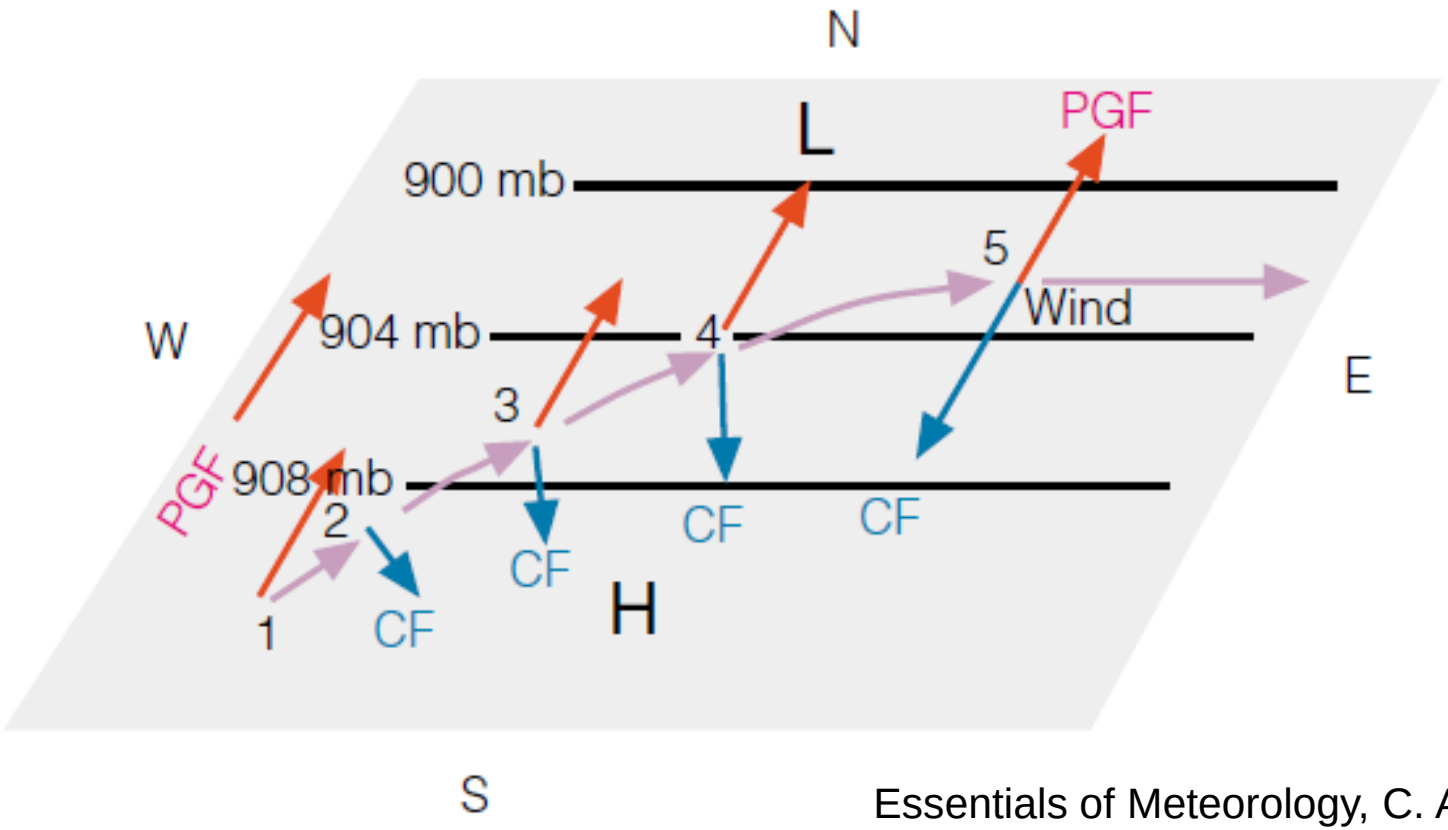
Original in The Atmosphere, 8th edition, Lutgens and Tarbuck

Sketch of the main cells of the general atmospheric circulation



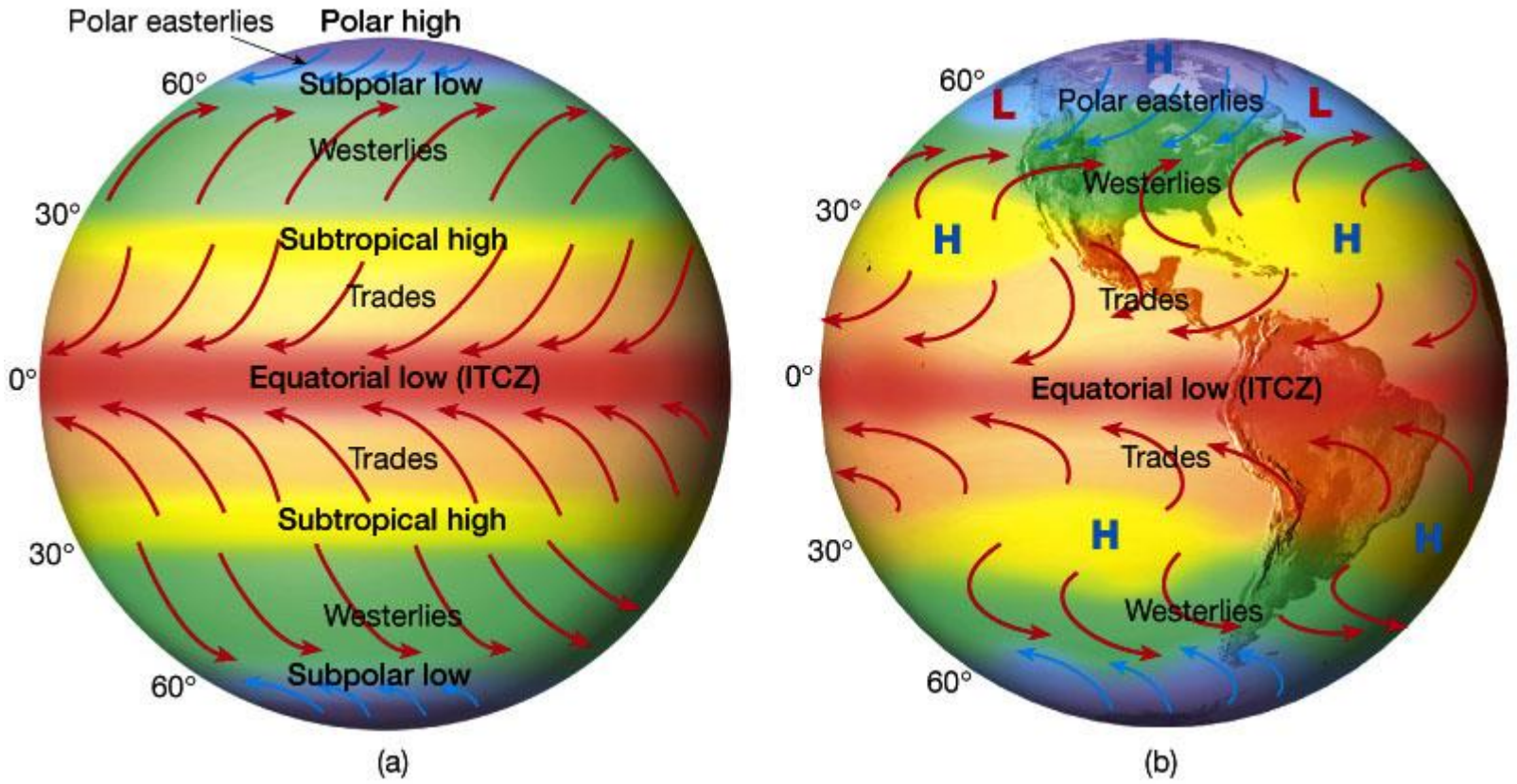
http://www.ux1.eiu.edu/~cfjps/1400/circulation.html
Original in The Atmosphere, 8th edition, Lutgens and Tarbuck

Geostrophic Wind Balance



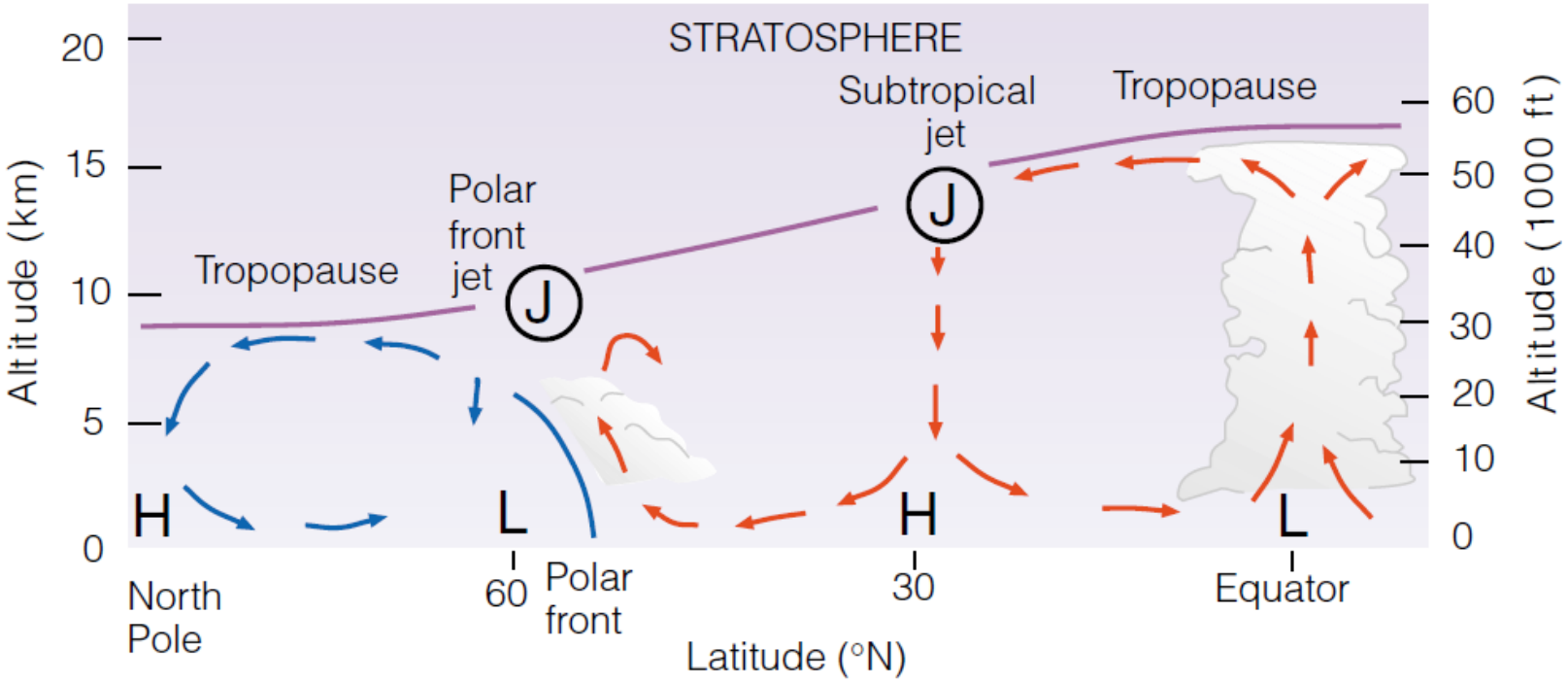
Essentials of Meteorology, C. Ahrens

Idealized winds generated by pressure gradient and Coriolis Force and actual wind patterns owing to land mass distribution



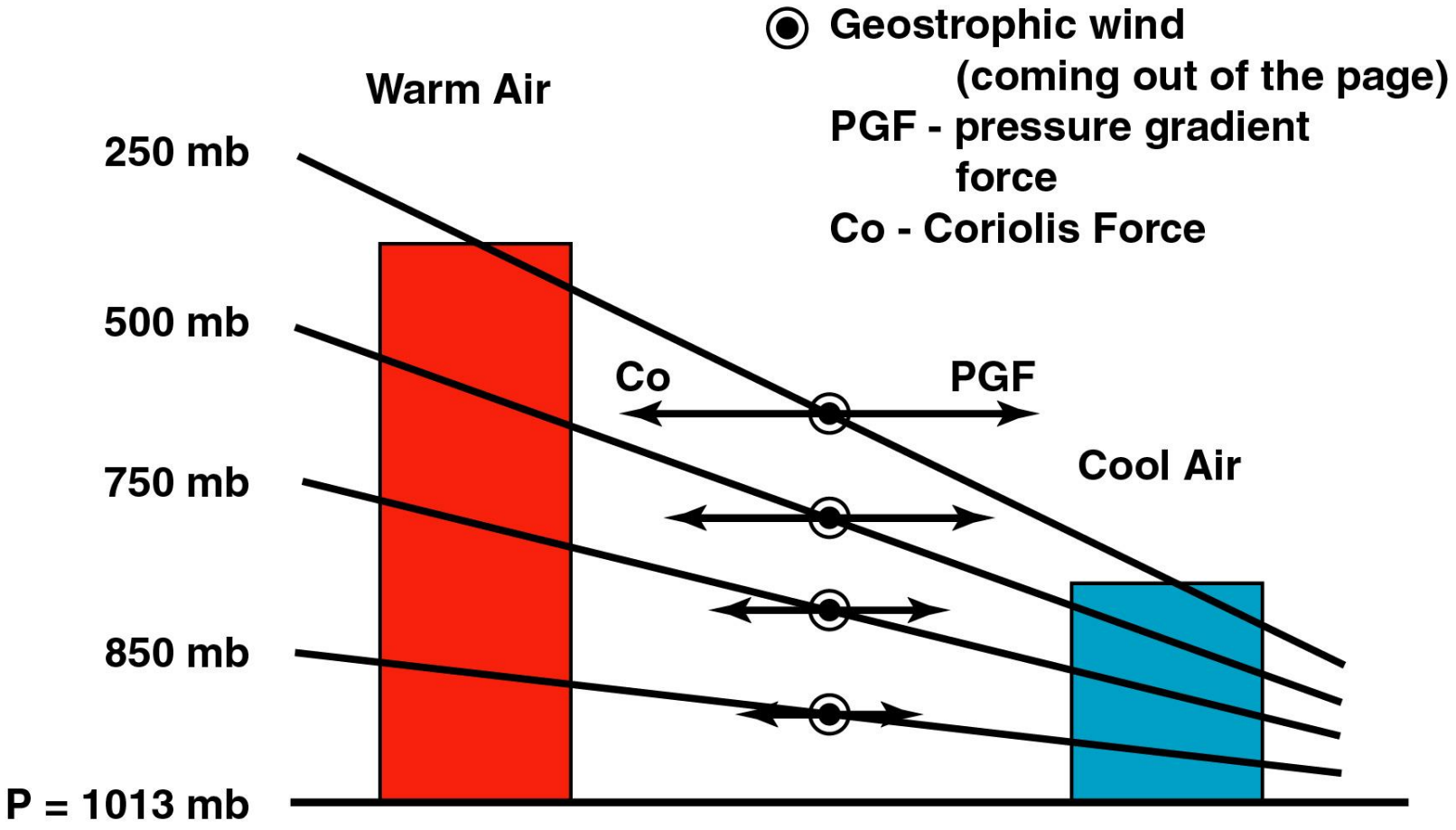
http://www.ux1.eiu.edu/~cfjps/1400/circulation.html
Original in The Atmosphere, 8th edition, Lutgens and Tarbuck

Meridional cross section of the main cells of the general atmospheric circulation



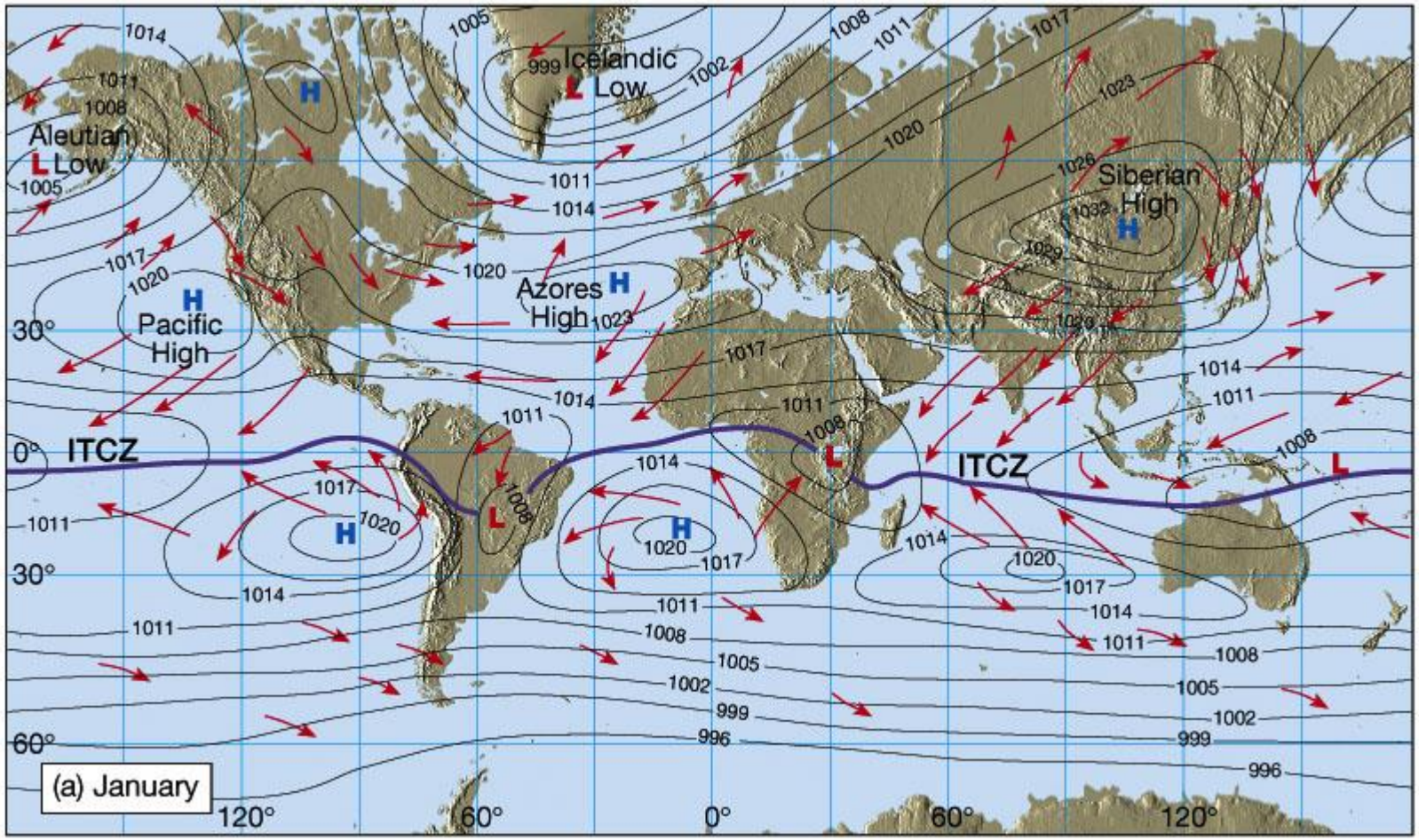
Essentials of Meteorology, C. Ahrens

How jet streams form: Thermal Wind Balance



http://www.ux1.eiu.edu/~cfjps/1400/pressure_wind.html

Climatological mean surface pressure and position of the ITCZ in January



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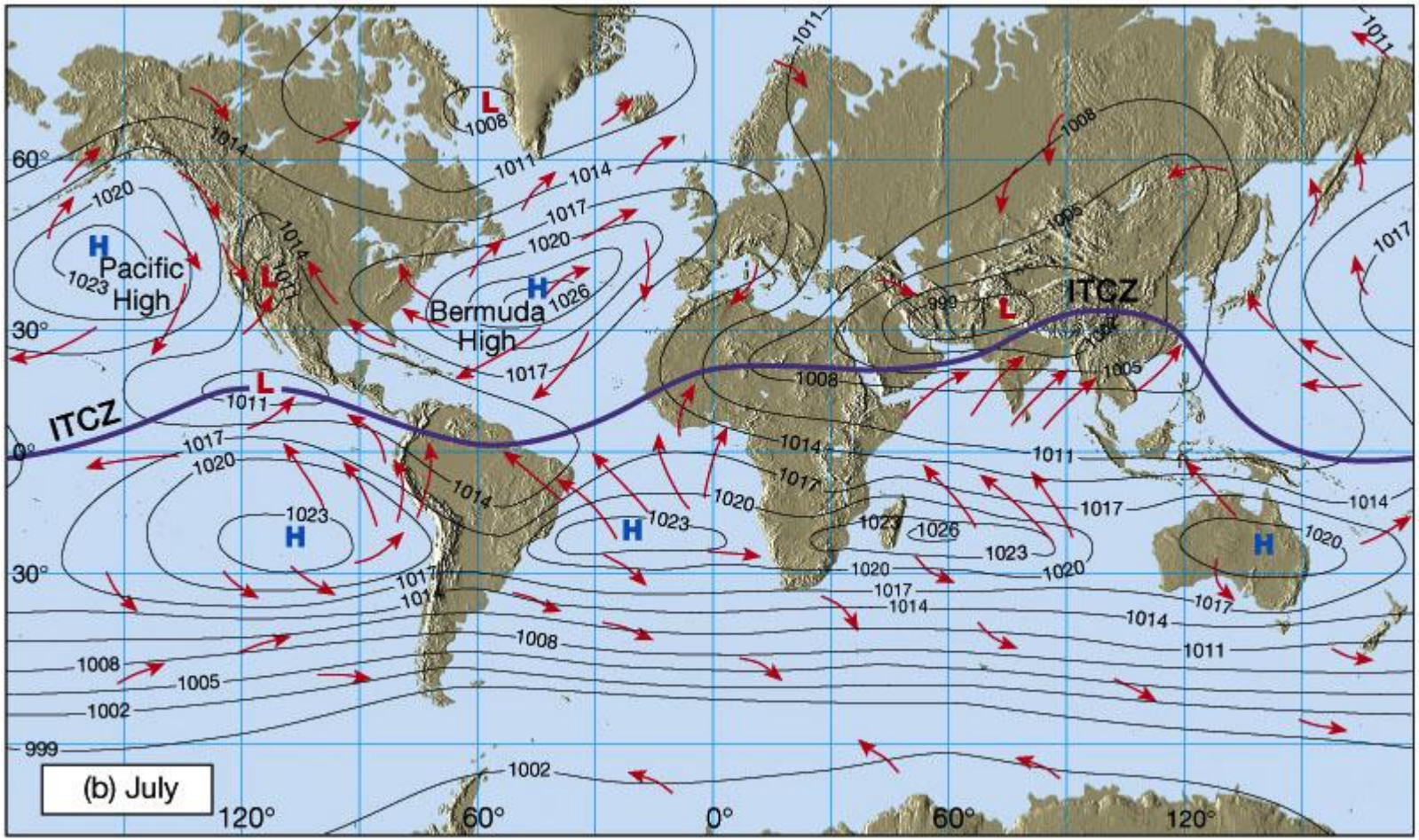
Original in The Atmosphere, 8th edition, Lutgens and Tarbuck

Climatological mean surface pressure and position of the ITCZ in July



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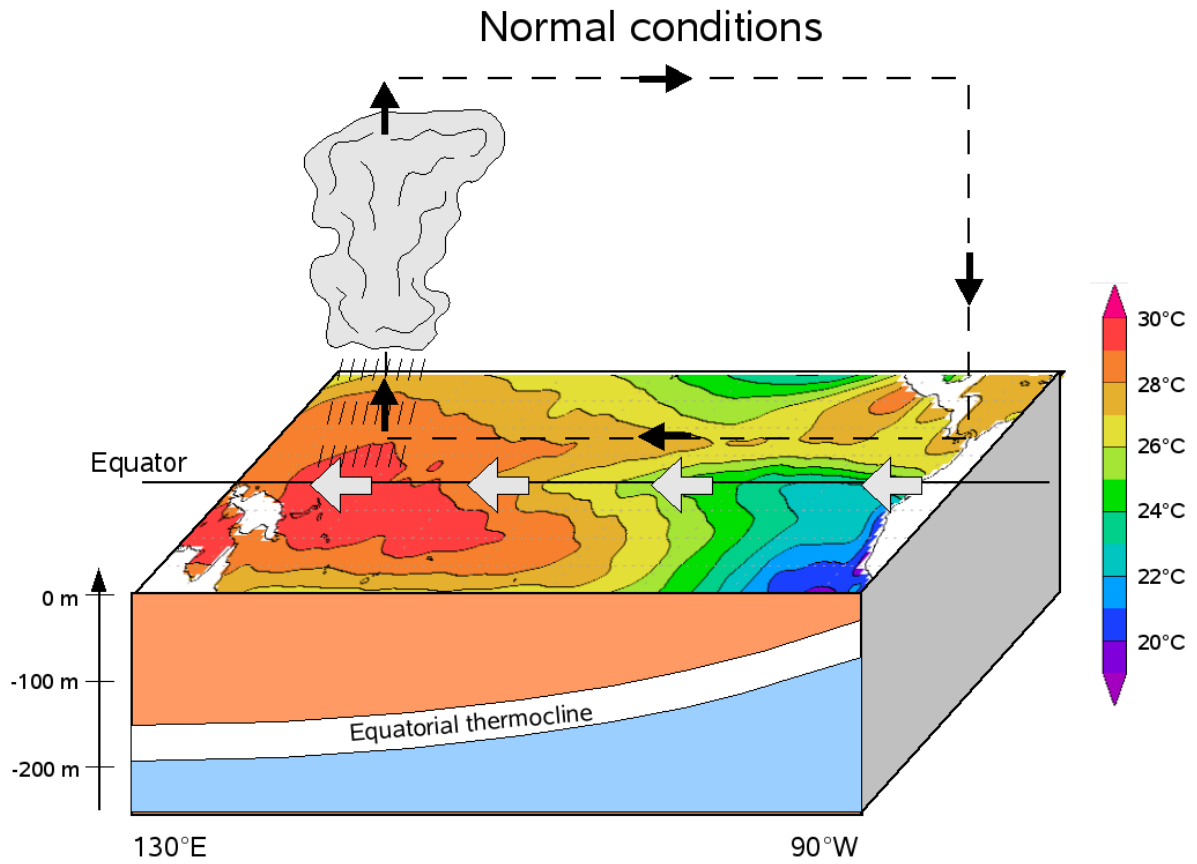
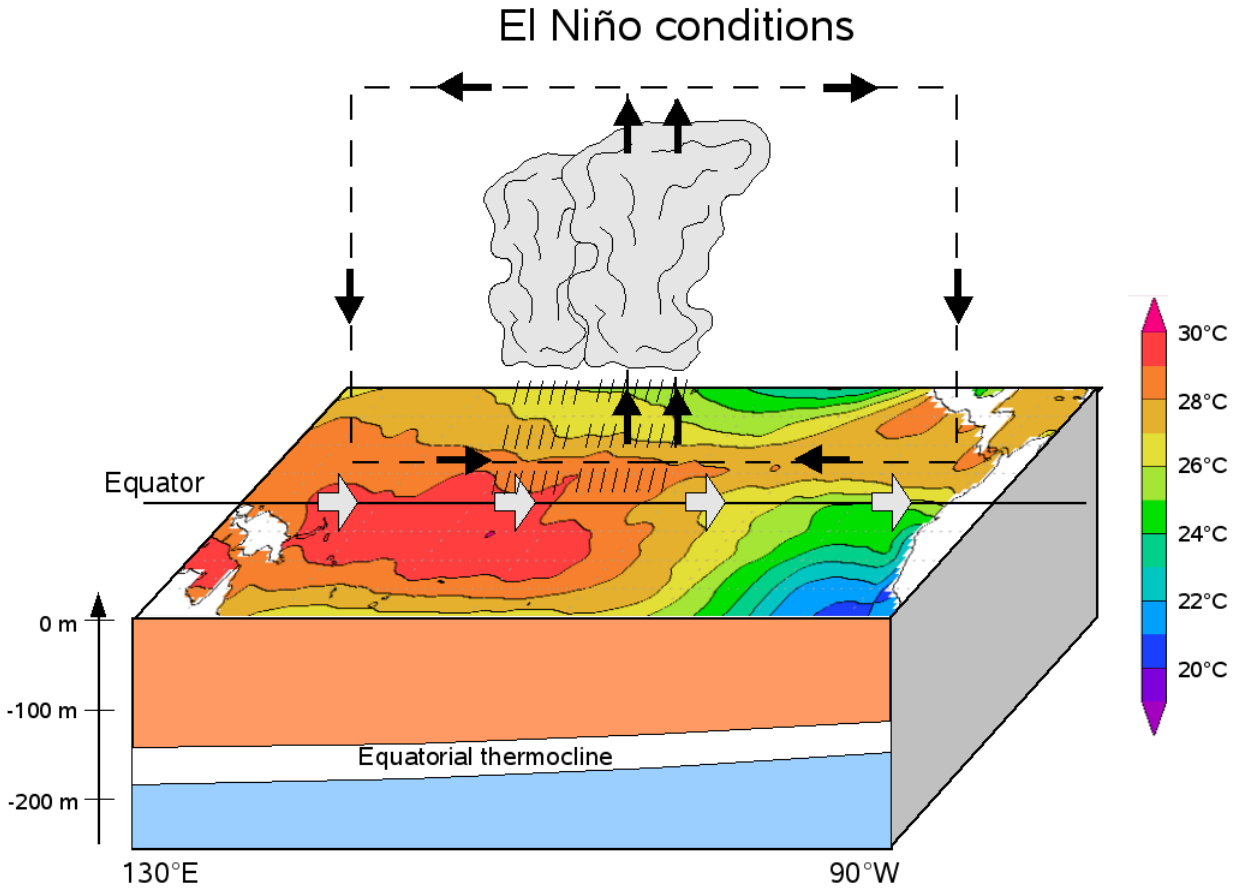
Original in The Atmosphere, 8th edition, Lutgens and Tarbuck

The Equatorial Walker Circulation in the Pacific

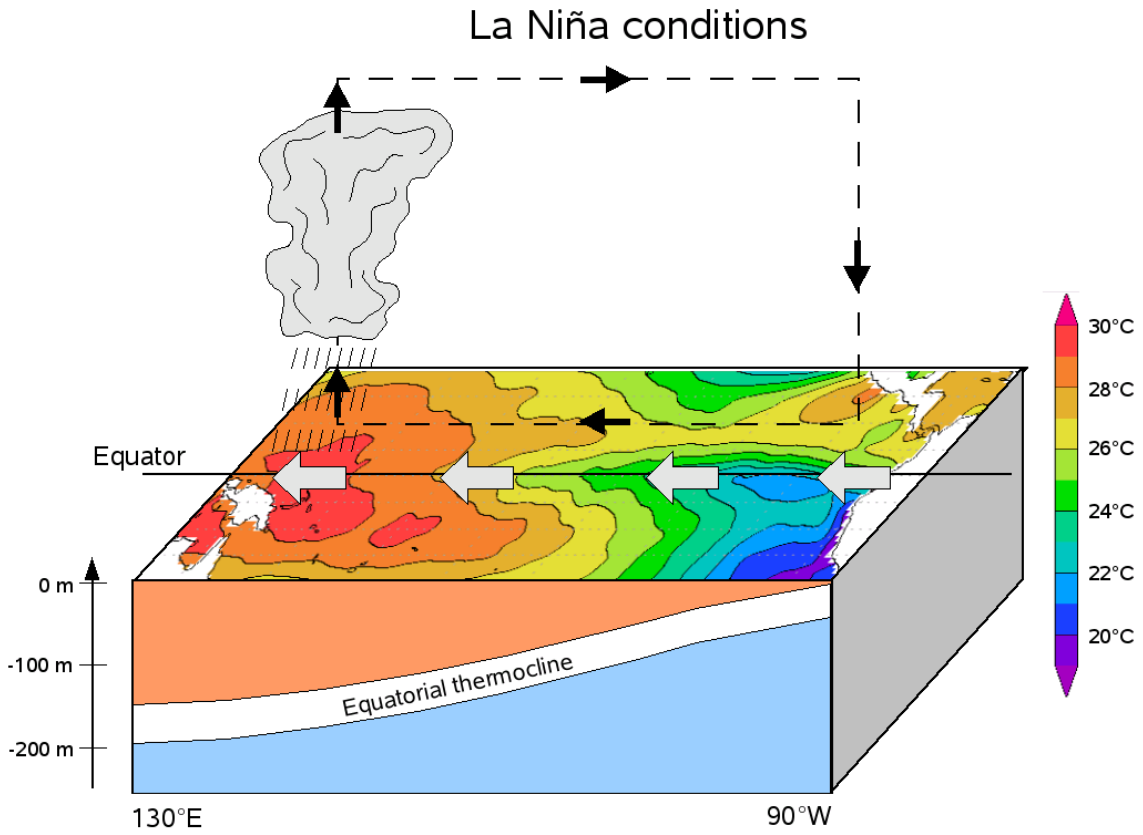


Climate Variability: The El Niño Southern Oscillation (ENSO)

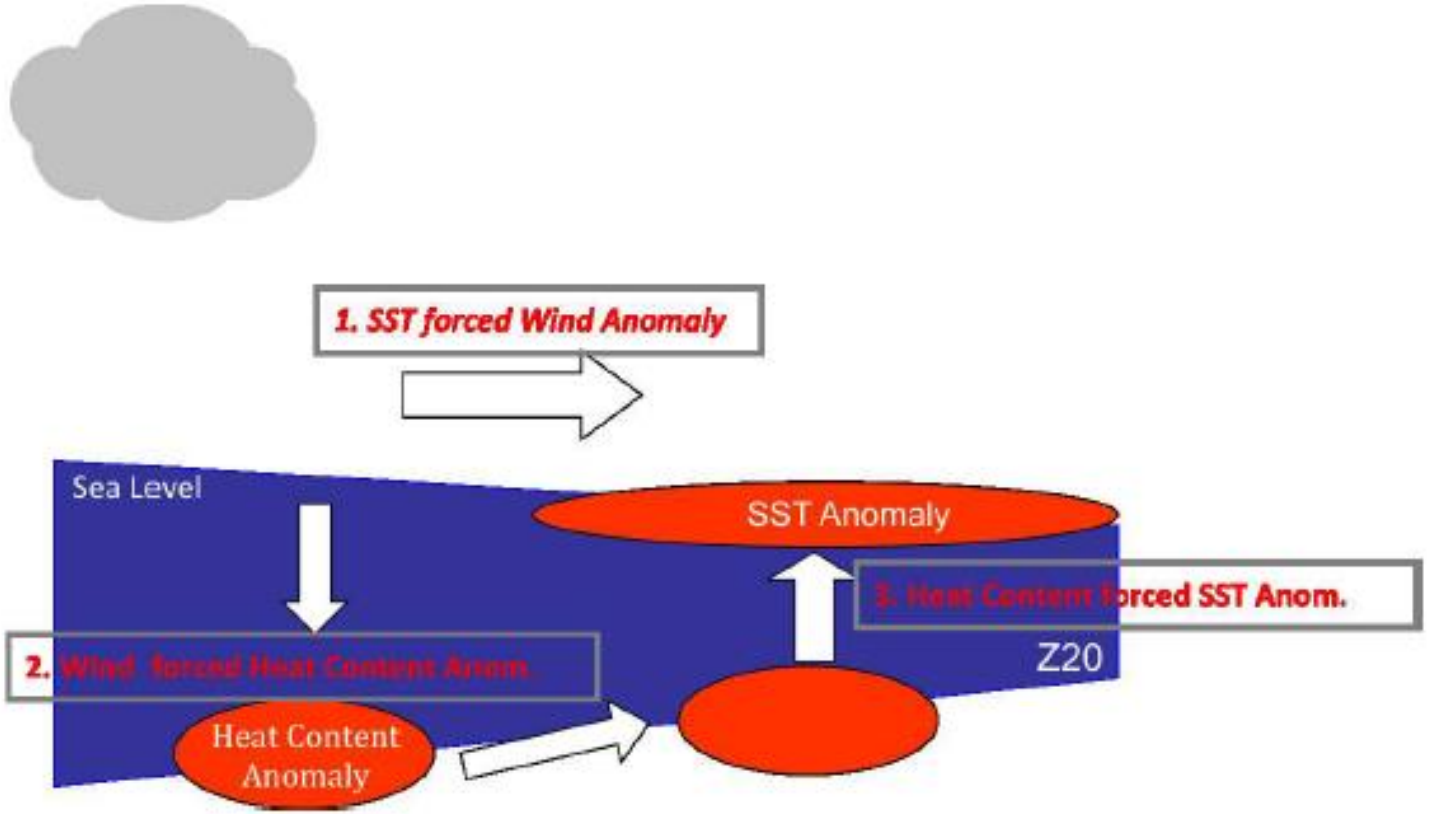
Changes in the Atmosphere and Ocean during El Niño Events



Changes in the Atmosphere and Ocean during La Niña Events

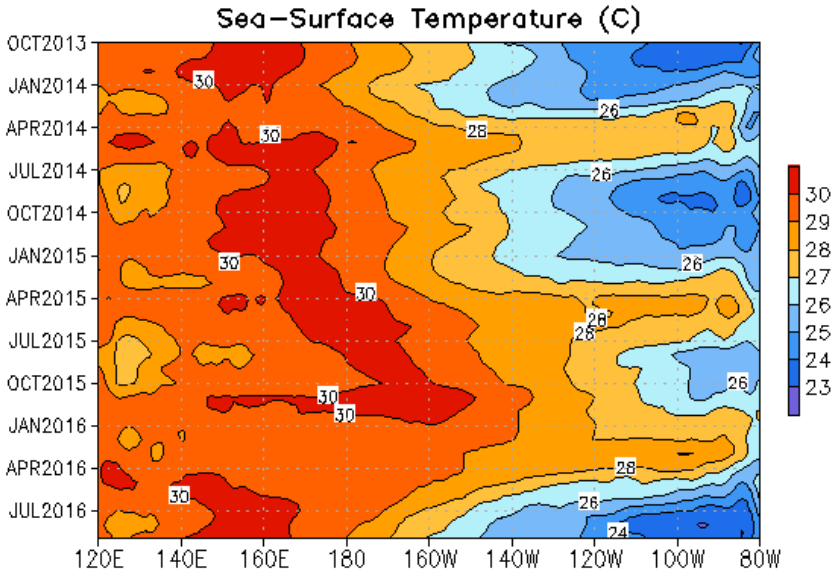


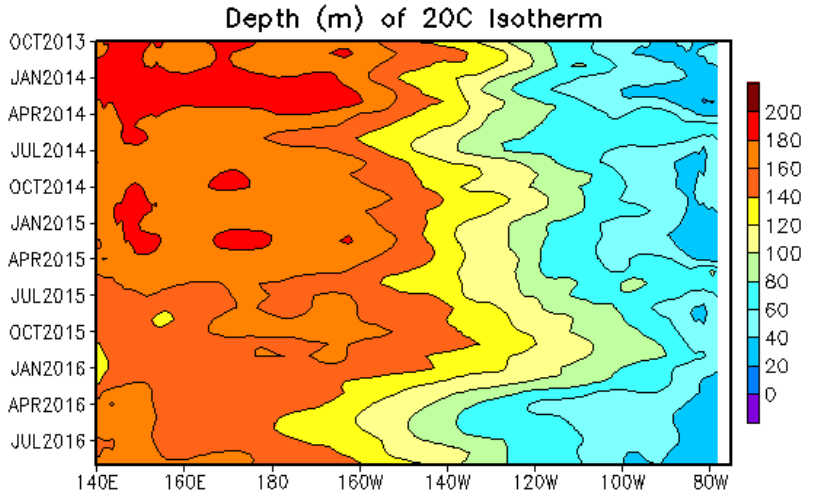
The Bjerknes Feedbacks

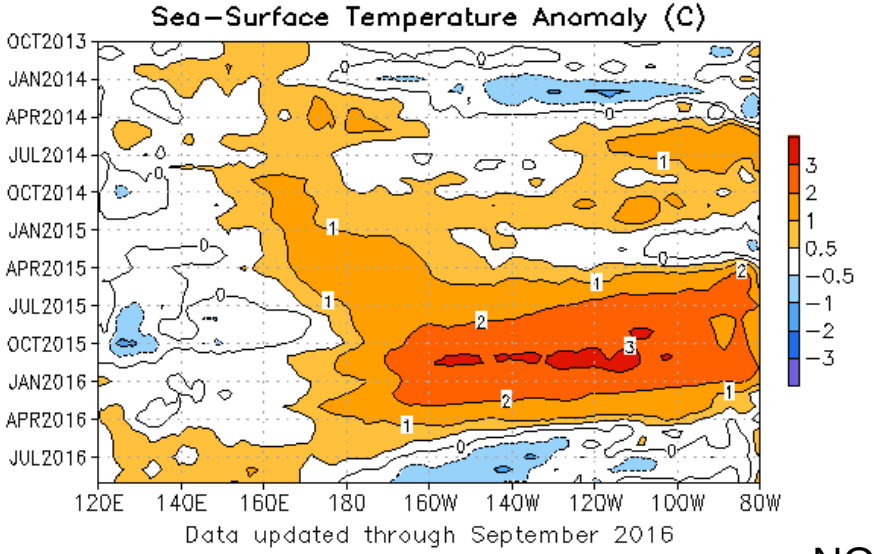


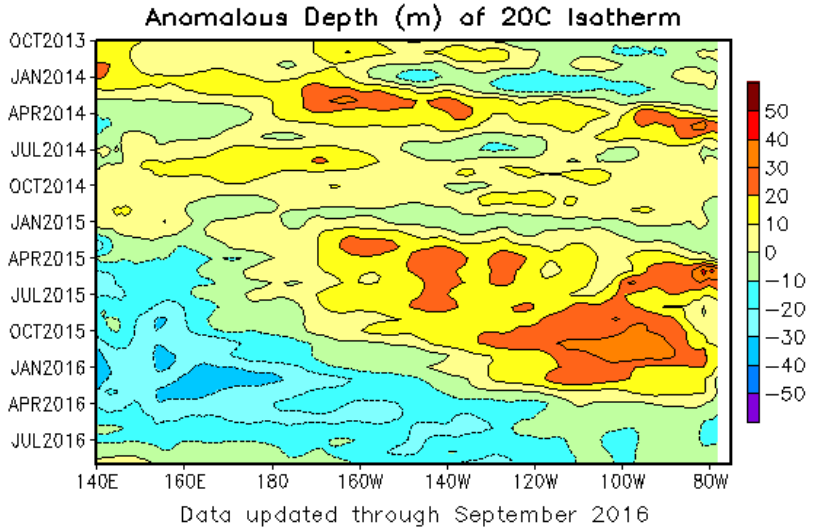
D. Dommenget

The 2015 El Niño



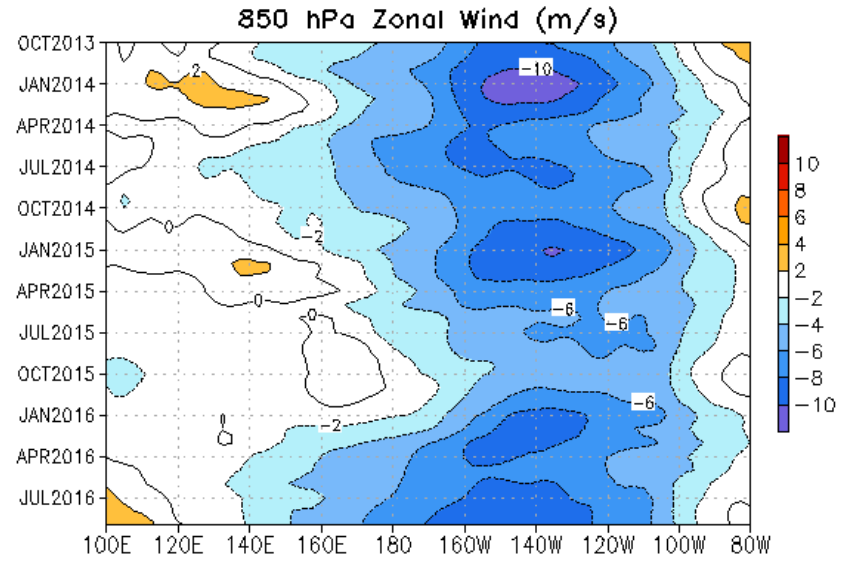


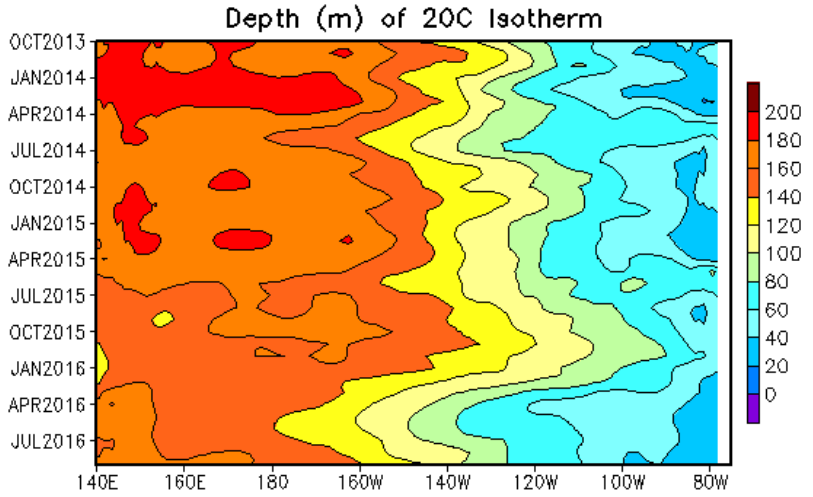


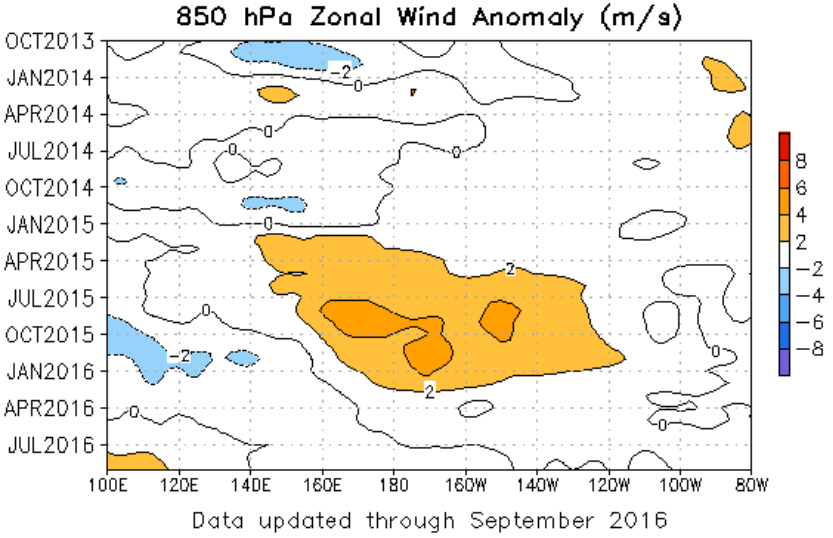


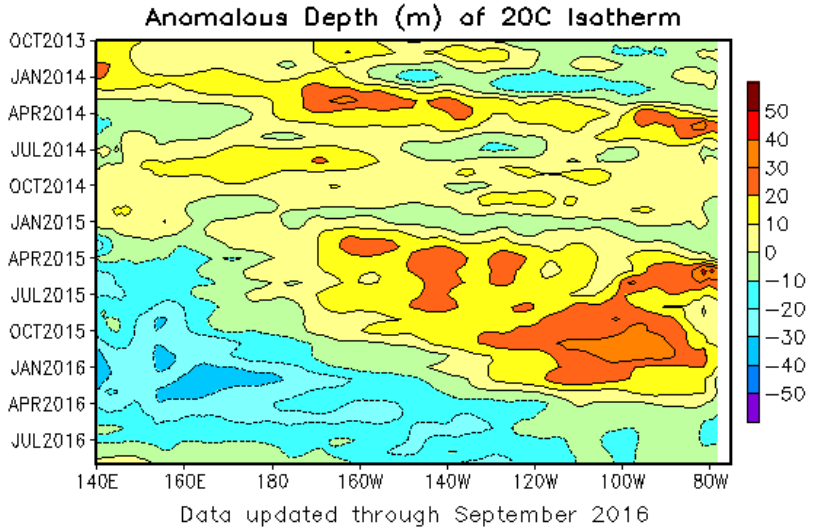
NOAA CPC Climate Diagnostics Bulletin 09/2016

The 2015 El Niño









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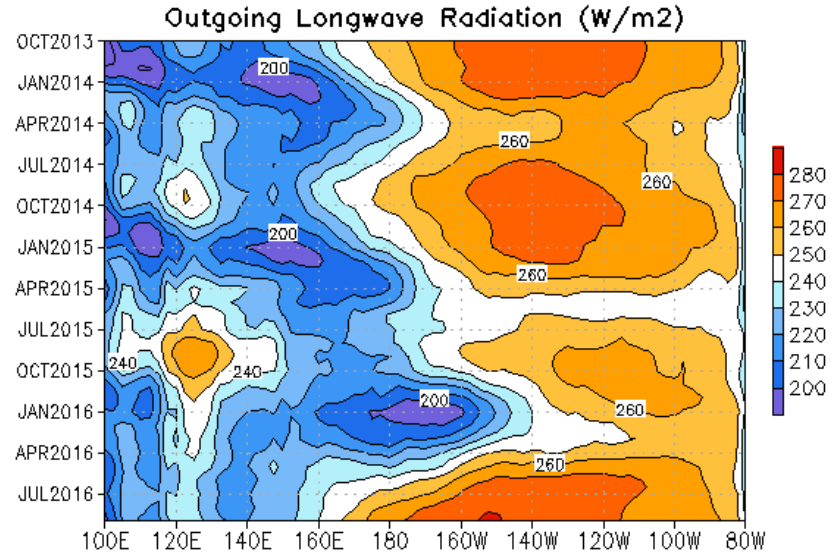

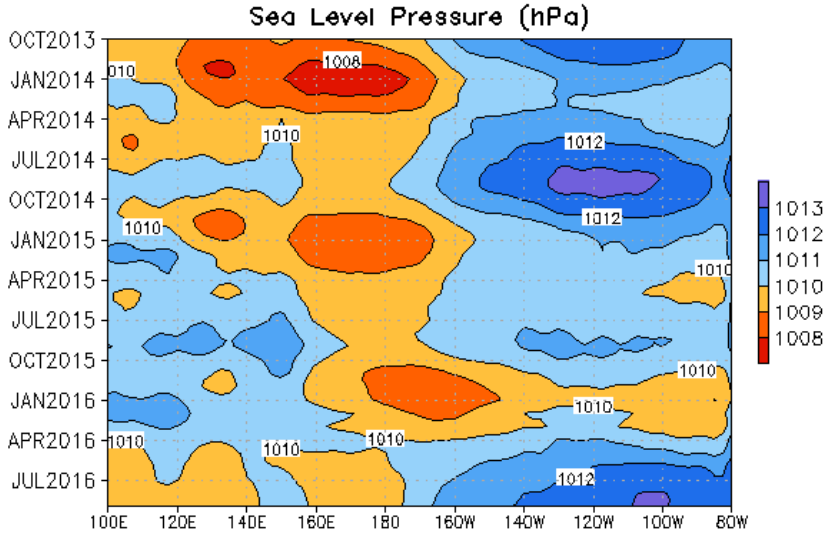

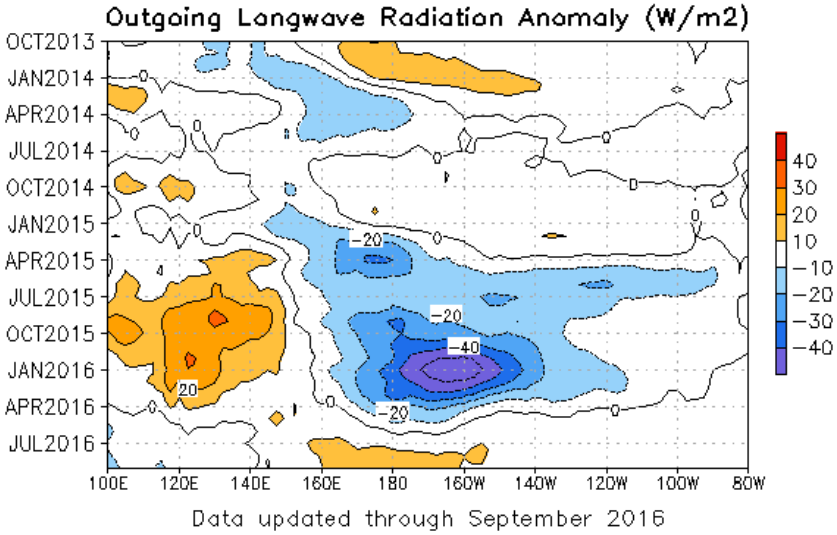

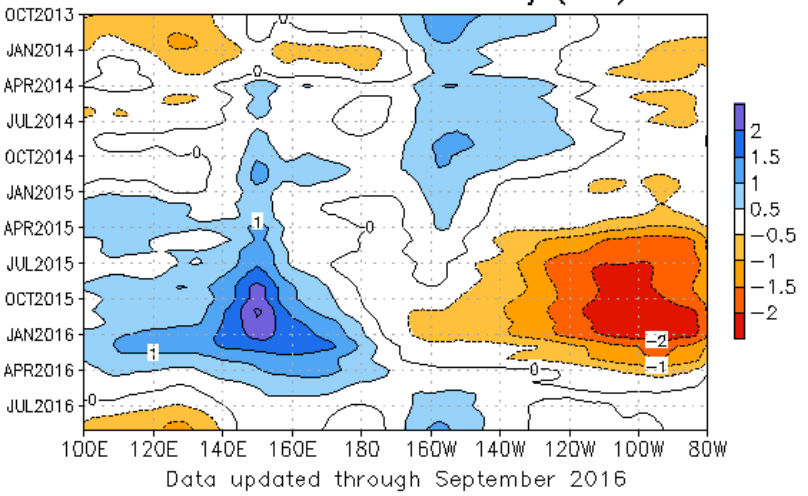

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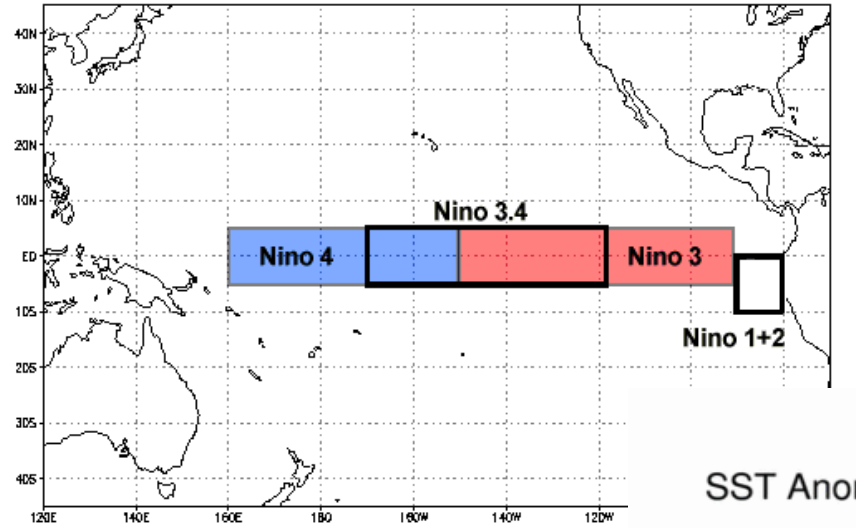
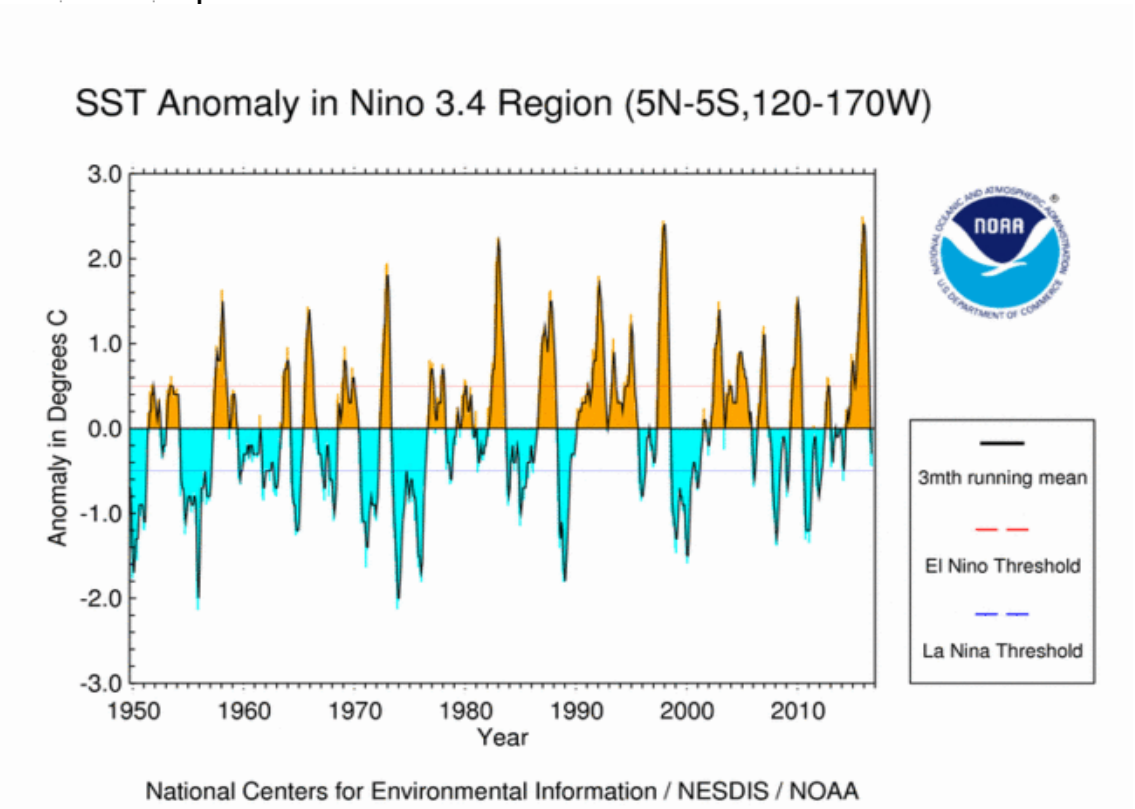
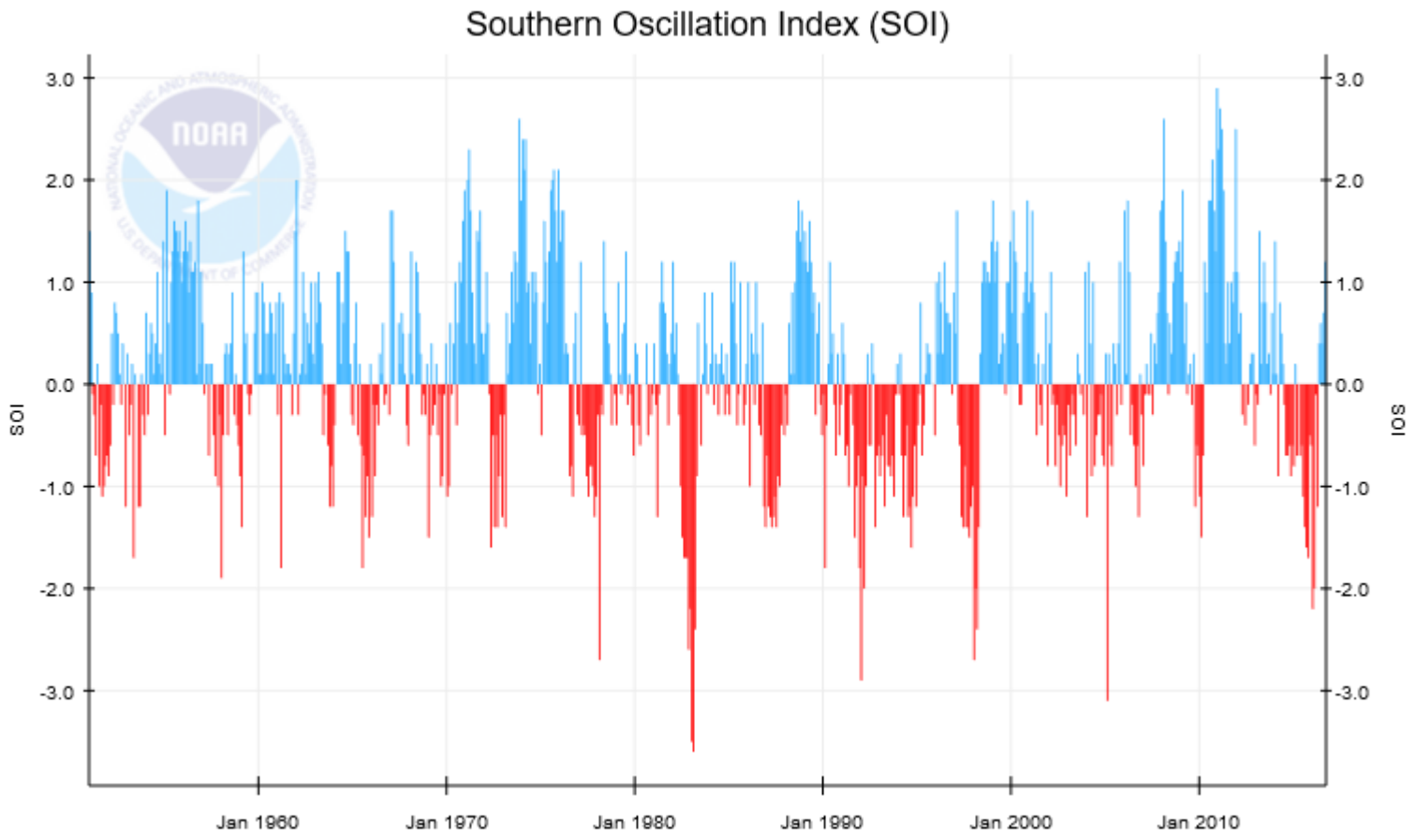
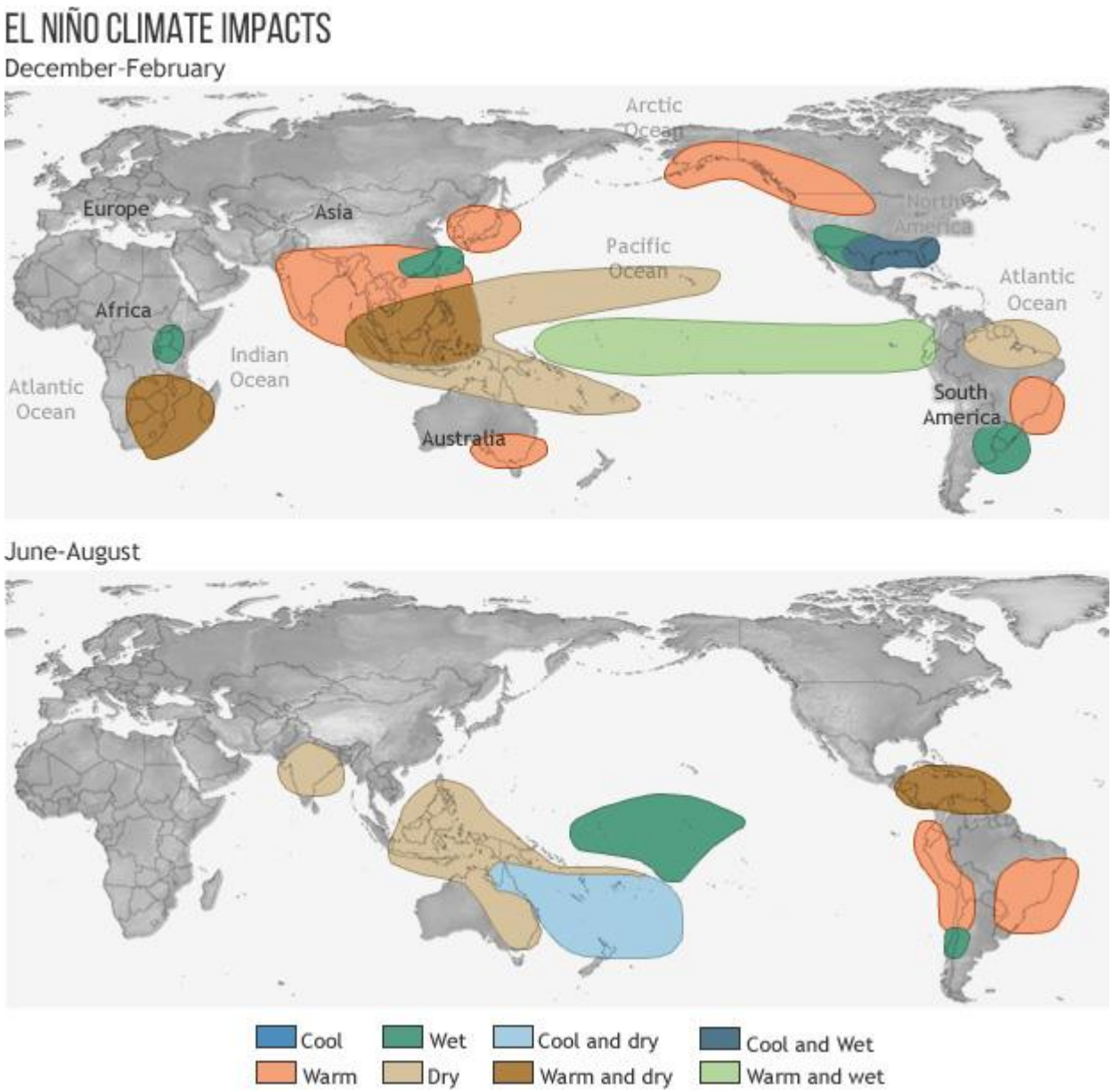


How to measure ENSO: The NINO3.4 SST Index



The Southern Oscillation Index: Pressure difference between Tahiti and Darwin





www.climate.gov

Indonesian fires sending haze across south-east Asia could become worst on record, NASA warns

Updated 3 Oct 2015, 7:08am

PHOTO: Satellite image from September 24, 2015 shows smoke from fires in Indonesia over the coasts of Borneo and Sumatra. (NASA Earth Observatory)

www.abc.net.au

El Niño Paints the World's Driest Place with Color

Unusually strong rains earlier this year set the stage for a widespread flower bloom across the Chilean desert.

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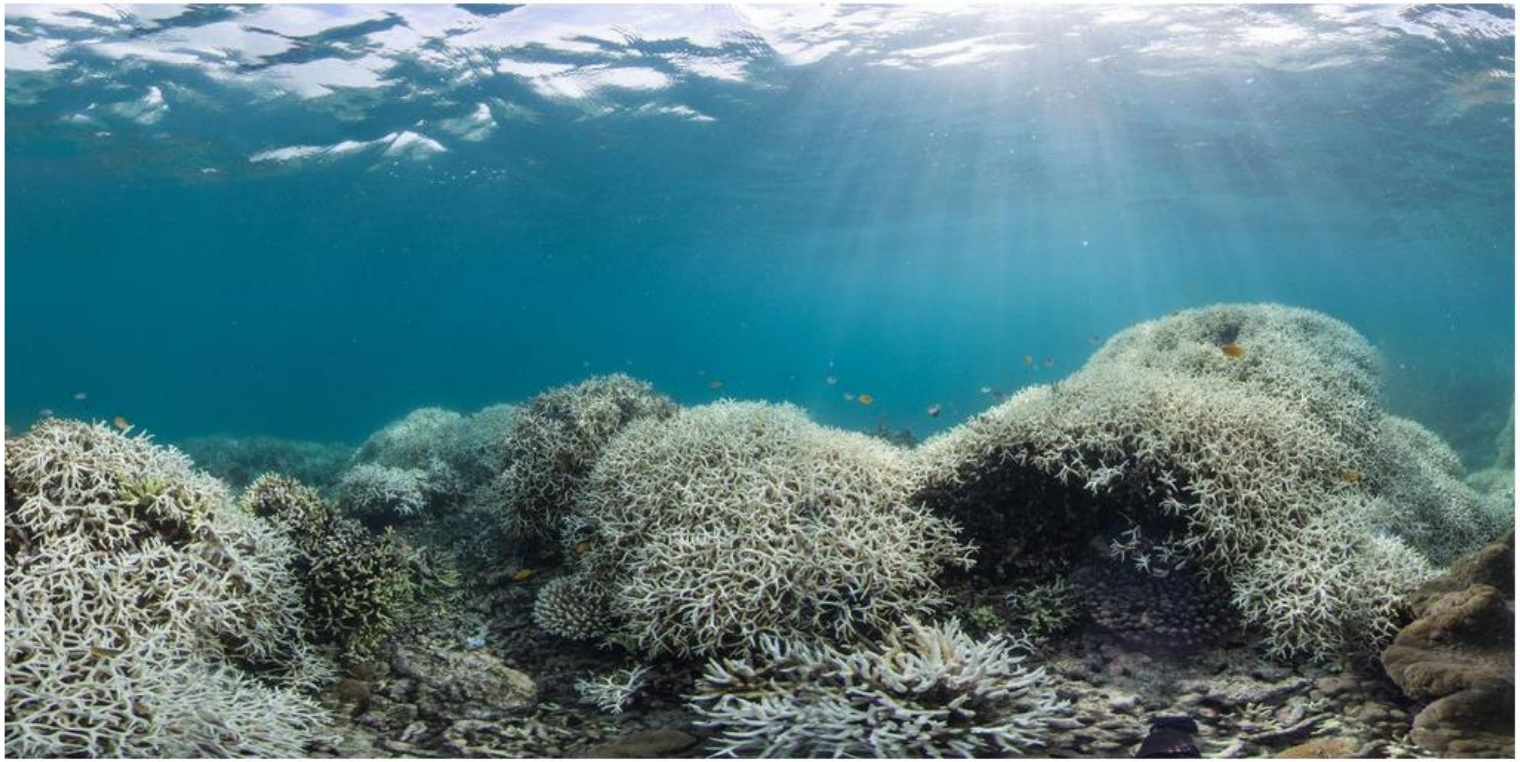
A Rare Sight A mallow field in full bloom in the Atacama region, some 750 kilometers north of Santiago, Chile. The *desierto florido* (desert in bloom) occurs every five to seven years, though this year's is more vibrant than most.

PHOTOGRAPH BY MARIO RUIZ, EPA

news.nationalgeographic.com

Corals Are Dying on the Great Barrier Reef

Australian government issues emergency response level and warns that bleaching may be linked to climate change.

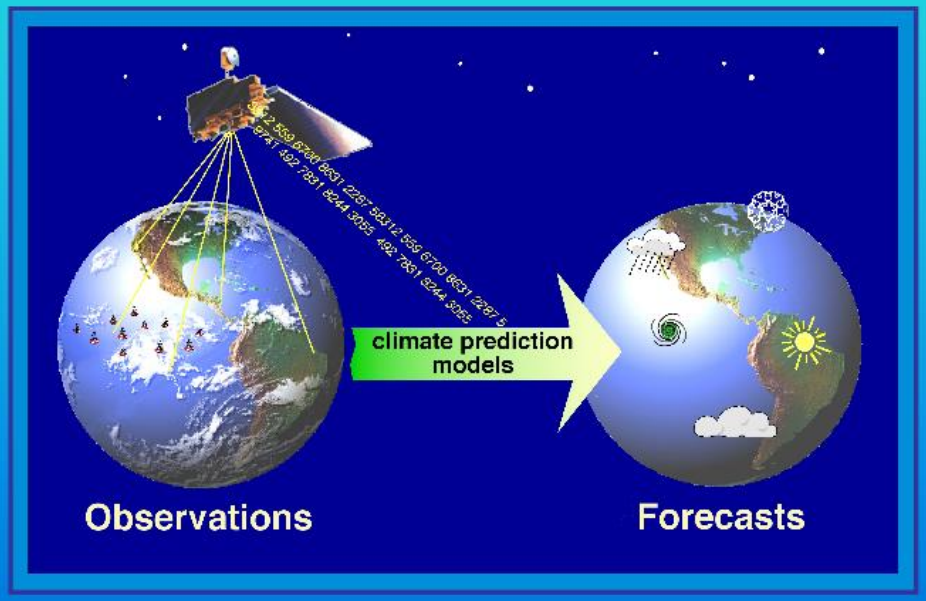


This panoramic image reveals coral bleaching at Lizard Island on the Great Barrier Reef in March 2016.

PHOTOGRAPH BY XL CATLIN SEAVIEW SURVEY

news.nationalgeographic.com

El Niño and La Niña are Predictable

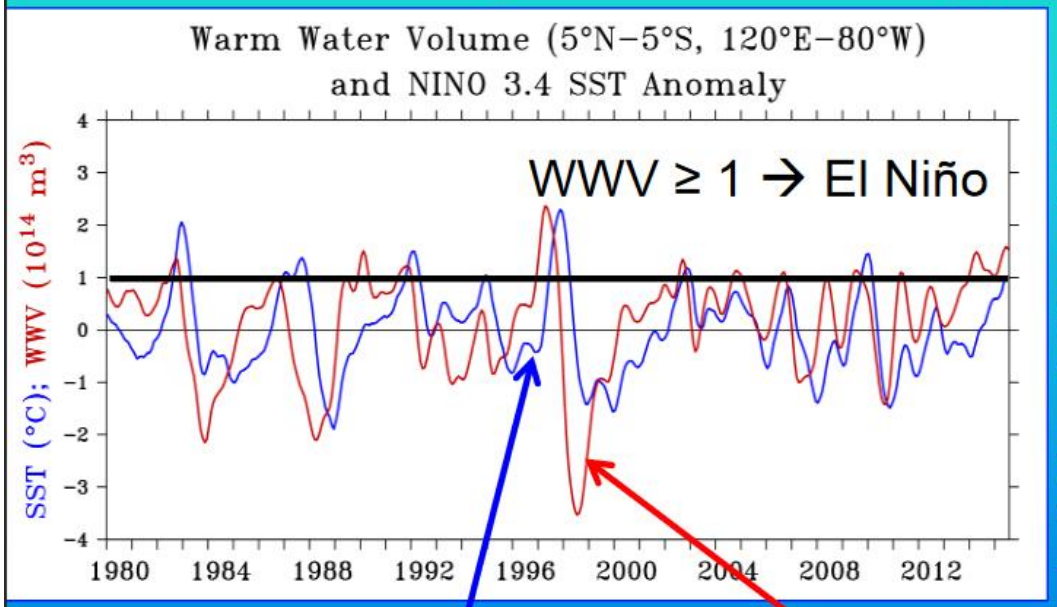


- *First successful El Niño prediction in 1986*
- *Forecast models are reasonably skillful at up to 6-9 month lead times*
- *Predictability based on slow evolution of upper ocean heat content*

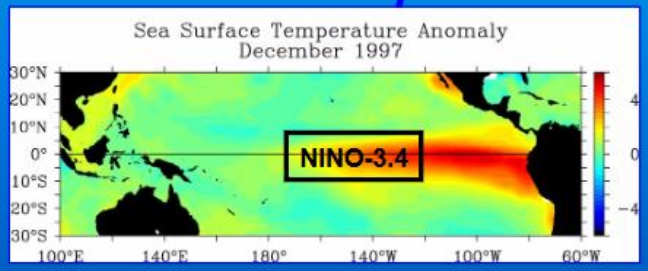
M. McPhaden, US Clivar ENSO Workshop 08/2015

Upper Ocean Heat Content as ENSO Predictor

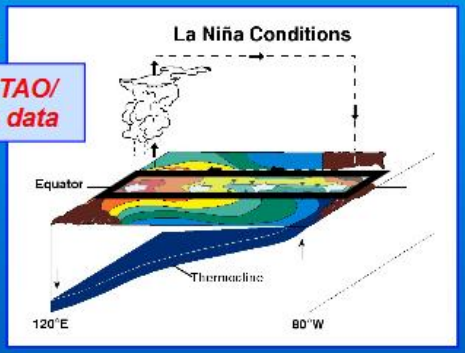
Recharge Oscillator Theory (Jin, 1997)



- Build up of excess heat content along equator is a necessary precondition for El Niño to occur.
- El Niño purges excess heat to higher latitudes, which terminates the event.
- The time between El Niños is determined by the time to recharge.



Heat content based on TAO/ TRITON, XBT, and Argo data



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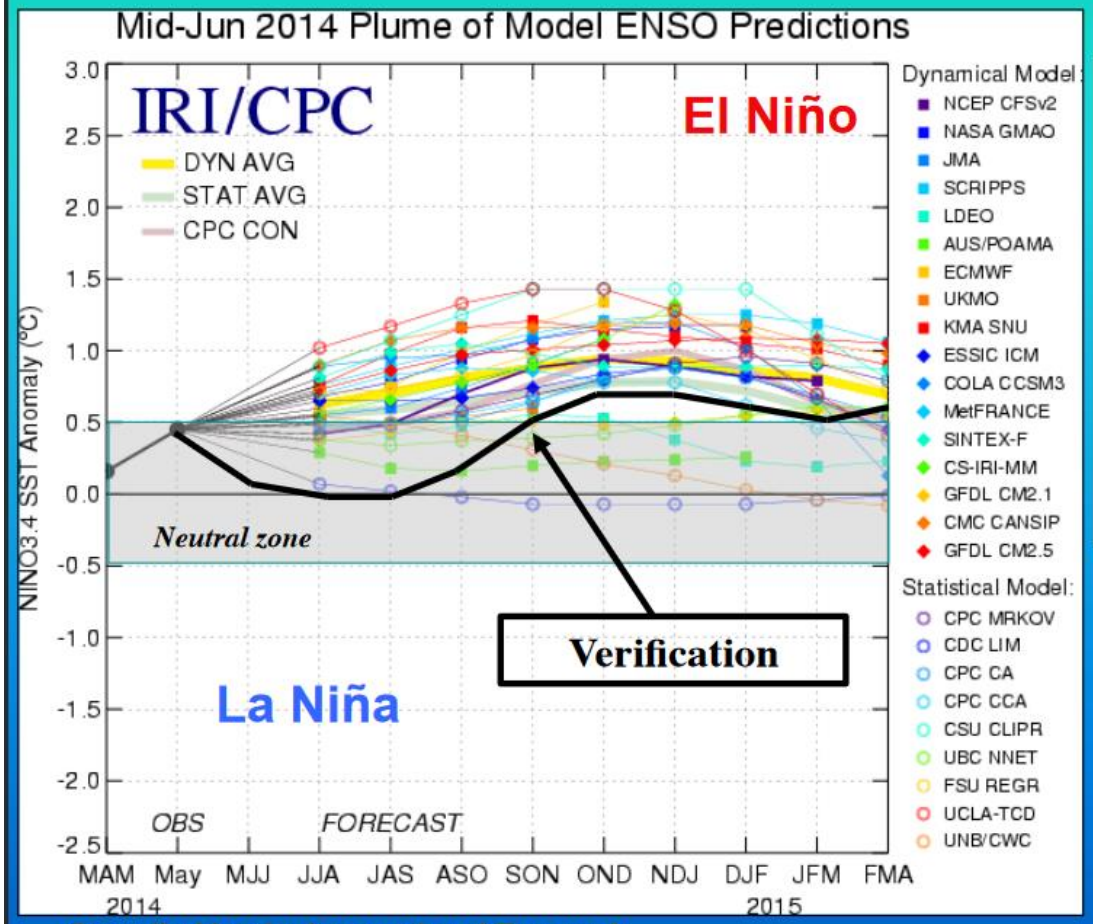
Niño-3.4 Predictions From June 2014



Compiled by the International Research Institute for Climate and Society (IRI)

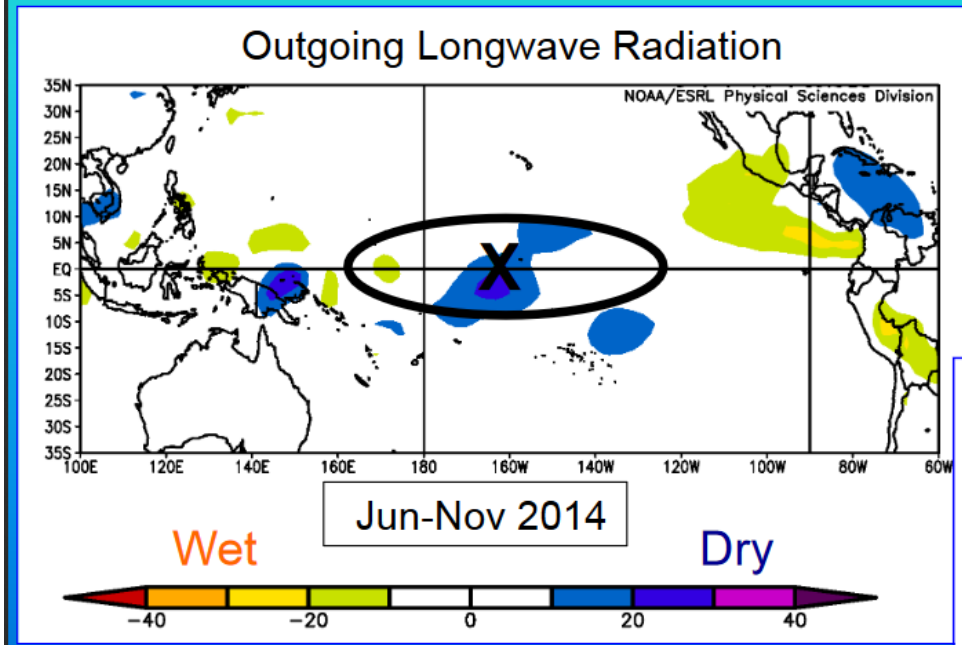
"The chance of El Niño is about 70% during the Northern Hemisphere summer and is close to 80% during the fall and early winter."

NOAA/NCEP
10 July 2014

M. McPhaden, US Clivar ENSO Workshop 08/2015

Atmosphere is not Engaged!

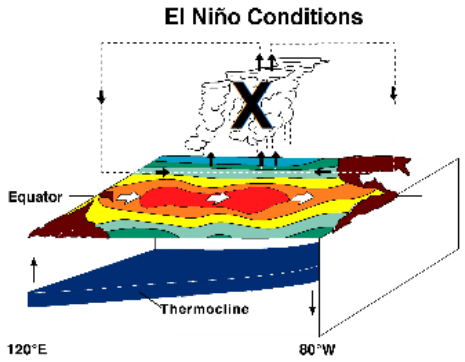
No Organized Persistent Deep Convection Near Dateline



Outgoing Longwave Radiation: An indicator of deep convection and heavy rainfall

"…rainfall continued to be below average near the Date Line…and near average east of the Date Line."

NOAA El Niño Watch 4 Dec 2014



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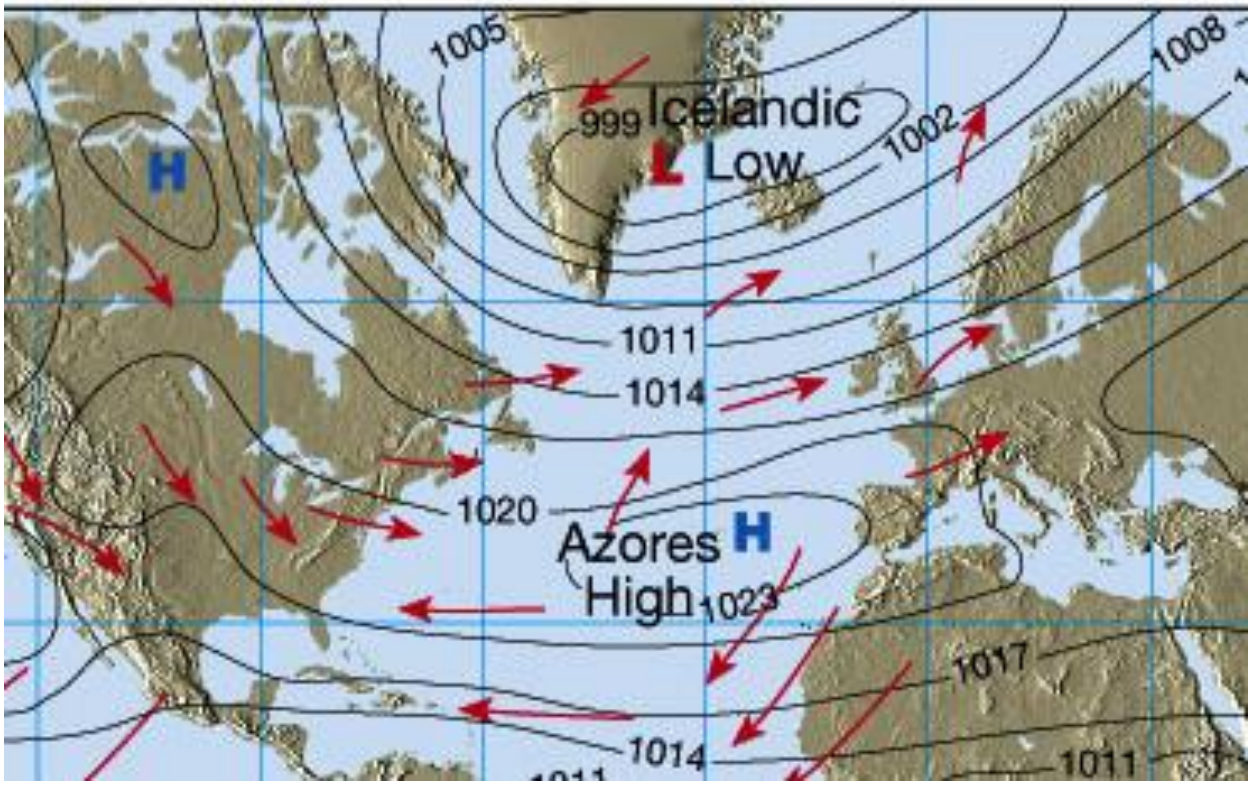
- ENSO is the most important mode of climate variability on interannual time scales
- It has its origins in the interactions of the tropical Pacific Ocean and the atmosphere, but its impacts reach far beyond the tropical Pacific region
- Over the past 20 years there has been huge progress in the understanding of the processes leading to ENSO events and models are in general able to predict ENSO events up to 6-9 months in advance
- However, the failed El Niño prediction in 2014 shows that it is still not fully understood

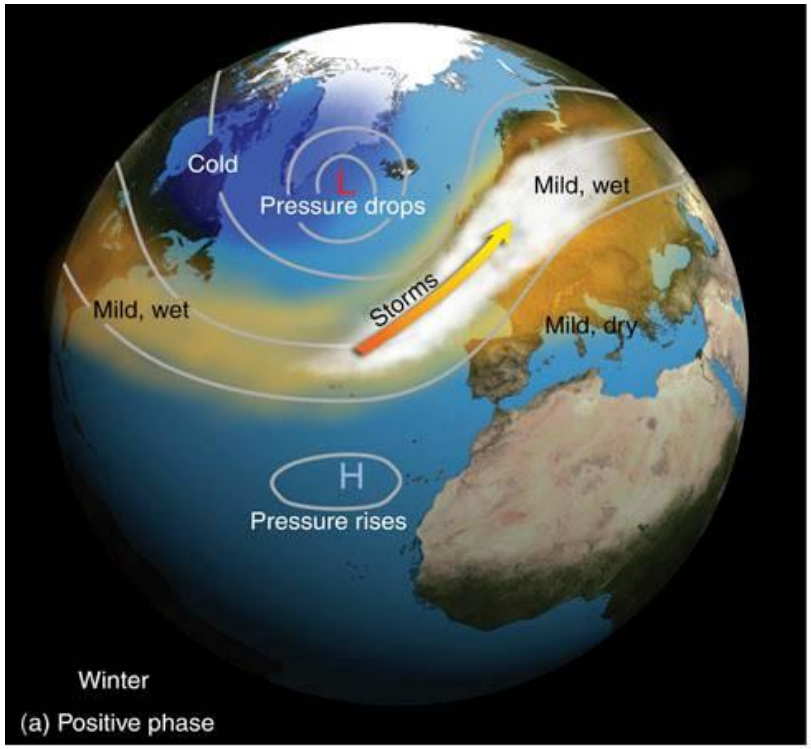
Climate Variability: The North Atlantic Oscillation (NAO)

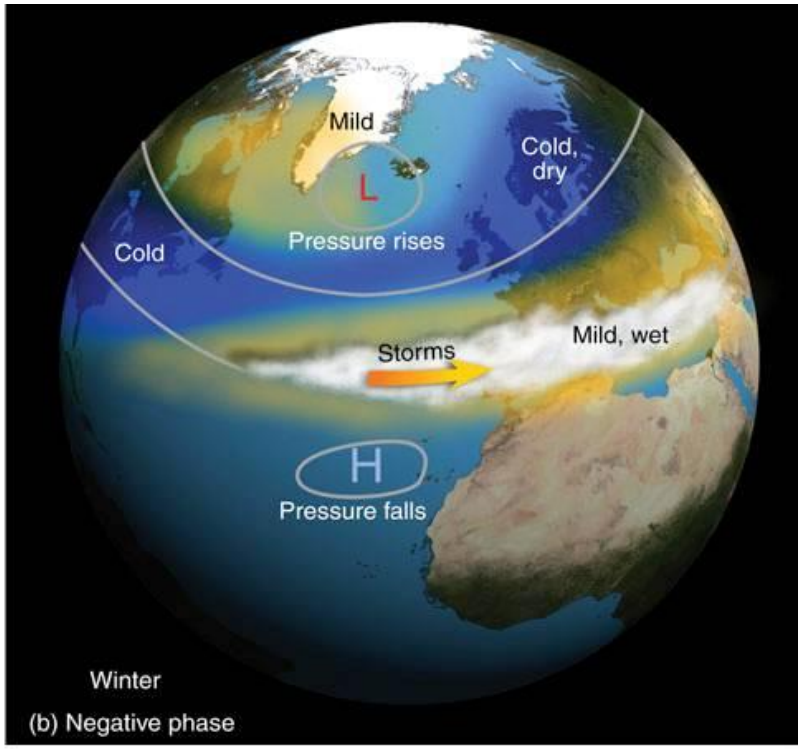
Icelandic Low, Azores High and mean Storm Tracks in January



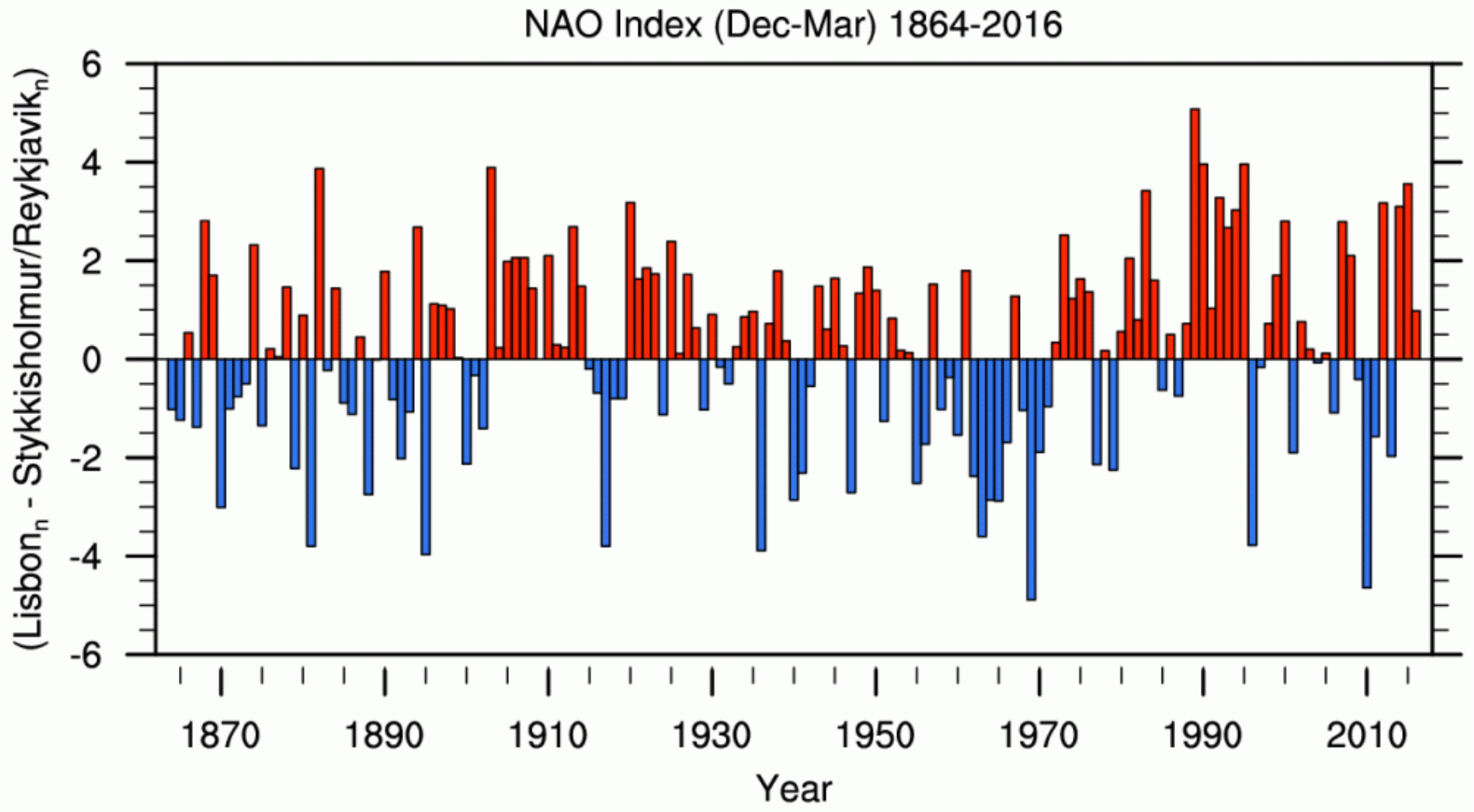
http://www.ux1.eiu.edu/~cfjps/1400/circulation.html
Original in The Atmosphere, 8th edition, Lutgens and Tarbuck

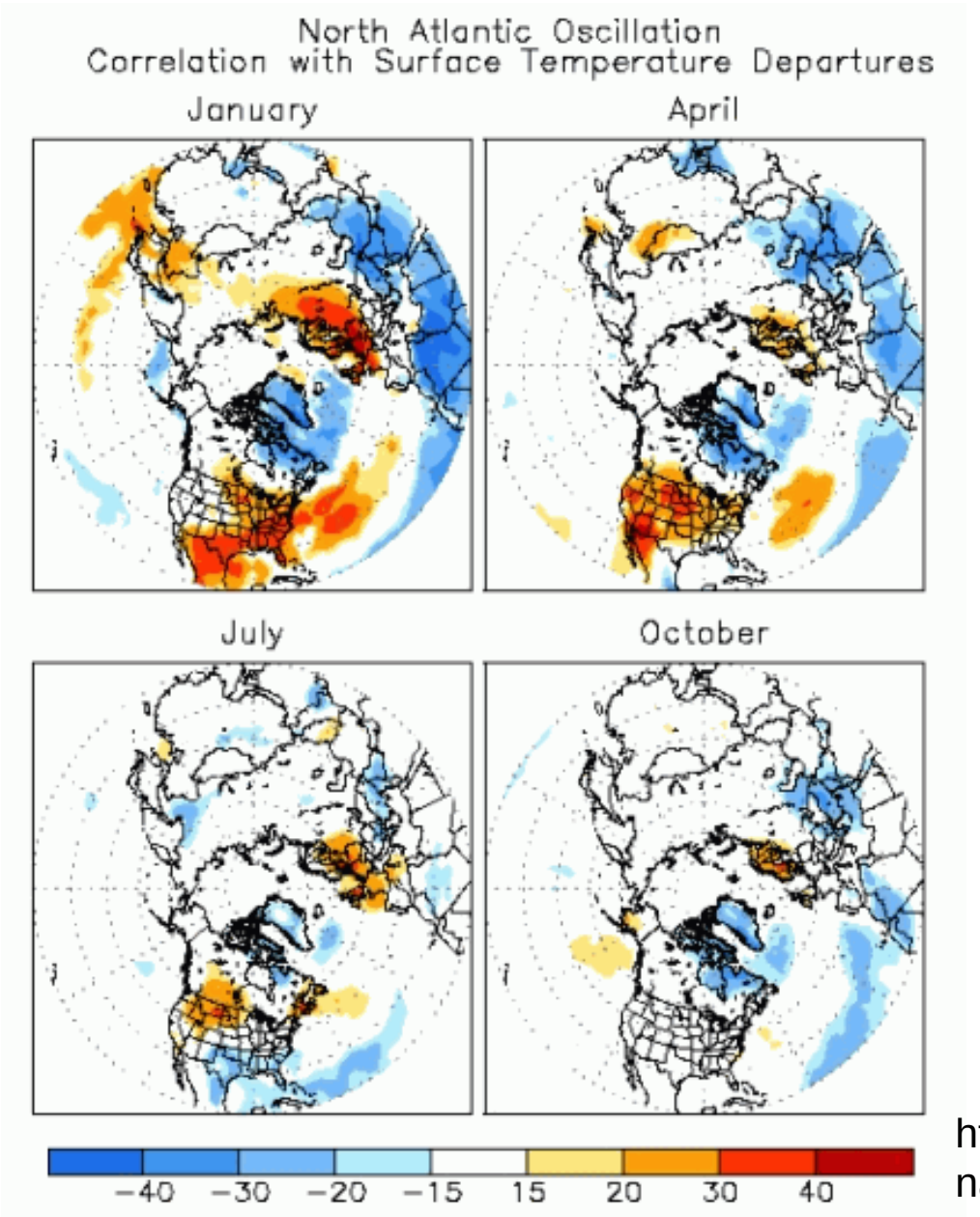
Positive and Negative Phases of the NAO



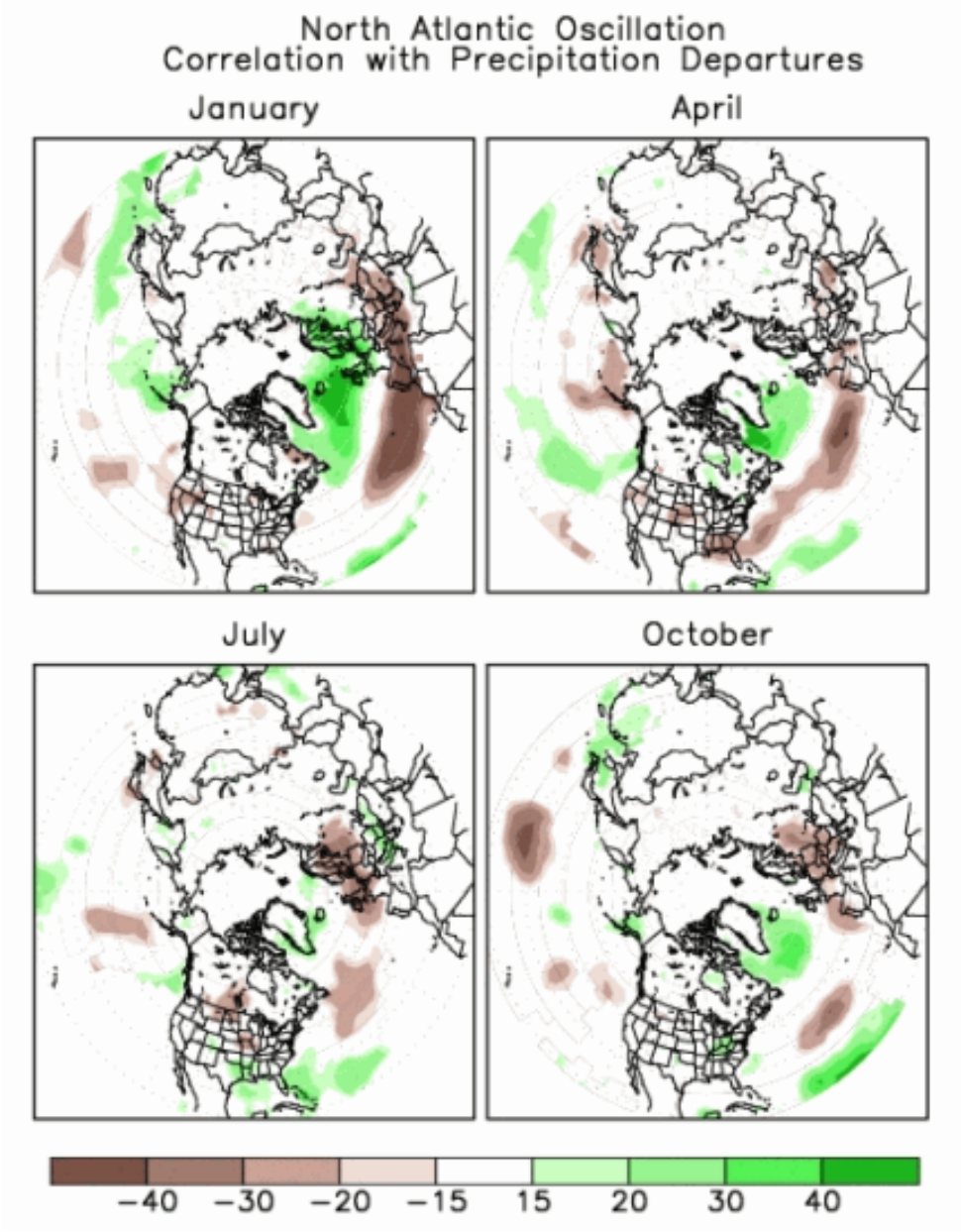


The NAO index: Pressure Difference between Lisbon and Reykjavik





http://www.cpc.noaa.gov/data/teledoc/nao_tmap.shtml



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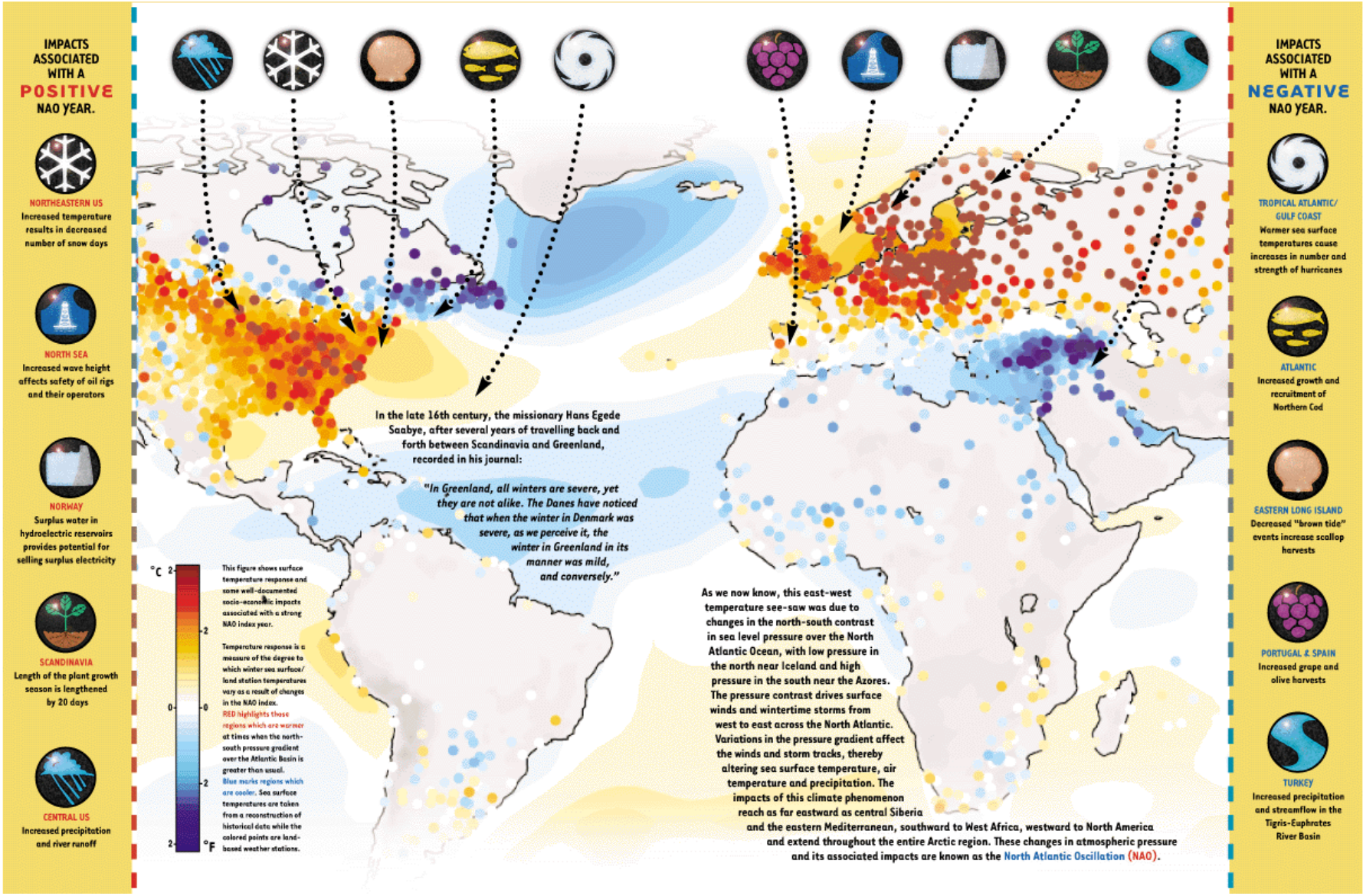

http://www.ldeo.columbia.edu/res/pi/NAO/pamphlet.html

- The NAO is the most important mode of atmospheric variability in the northern hemisphere
- It impacts not only the North Atlantic but the whole northern hemisphere
- It is one of the main sources of predictability for European winter conditions
- However, models still have problems to predict the NAO