Climate Variability

November 11, 2019

Variability

Forced vs **Internal**

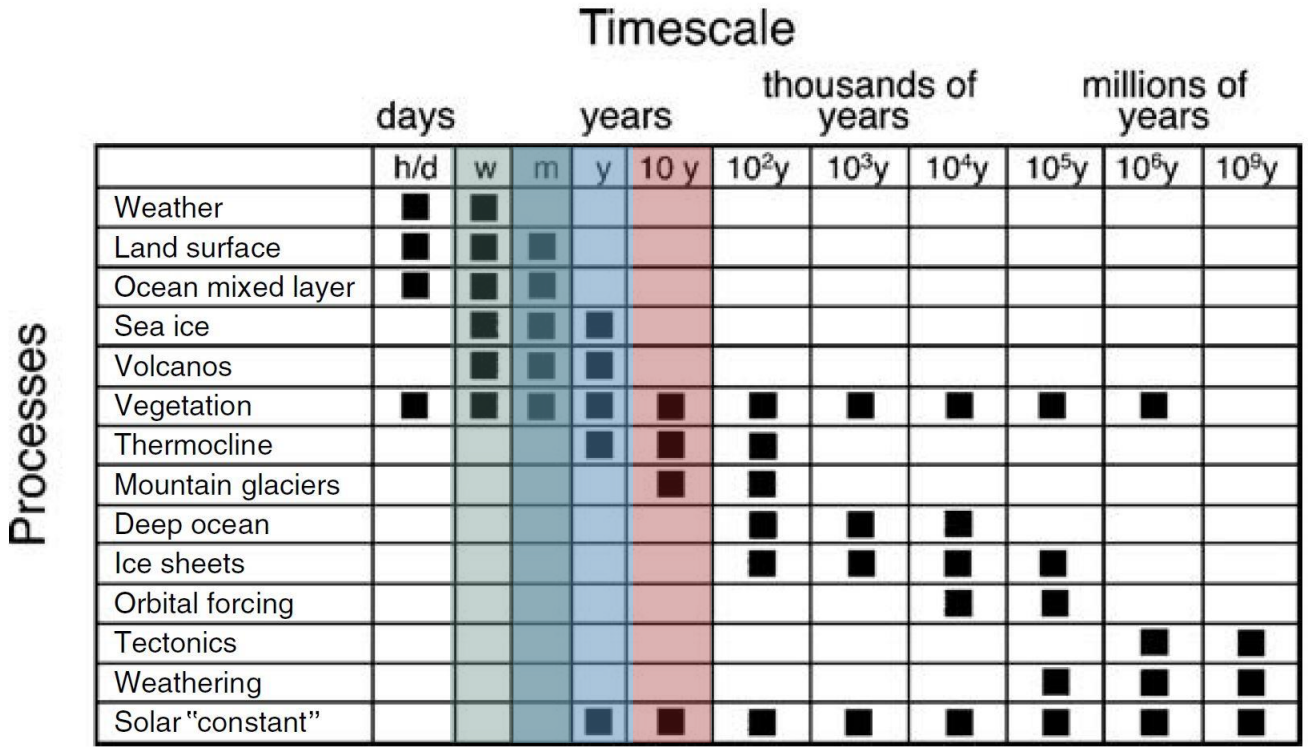
external factors

interactions between elements of climate system

Climate **modes:** internal variability that manifests in patterns and structures, typically defined by an **index**

Teleconnections: variability correlations between remote regions

Variability Timescales



Marshall and Plumb 2008

MJO: Madden-Julien Oscillation

ENSO: El Nino Southern Oscillation

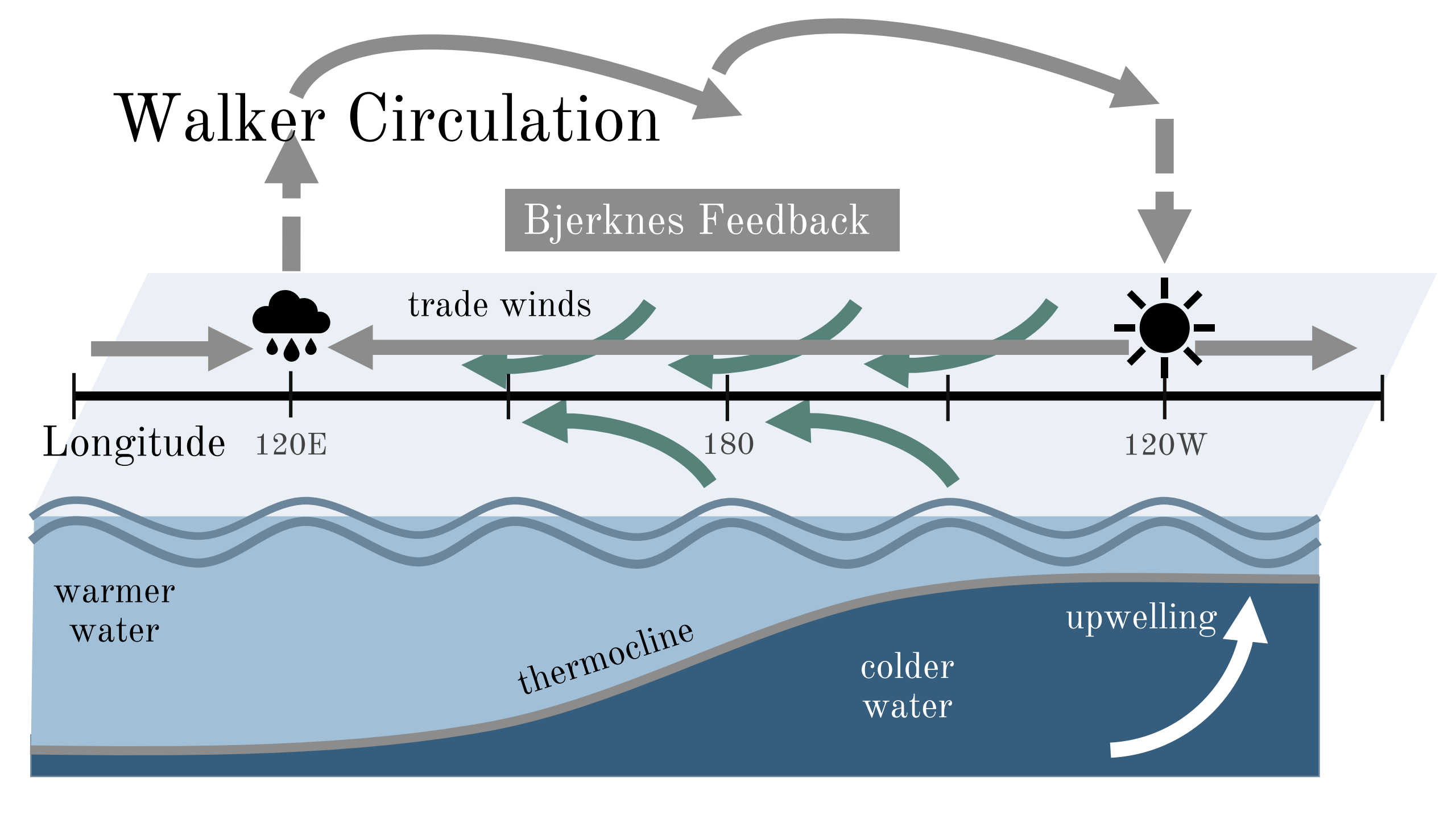
NAO: North Atlantic Oscillation

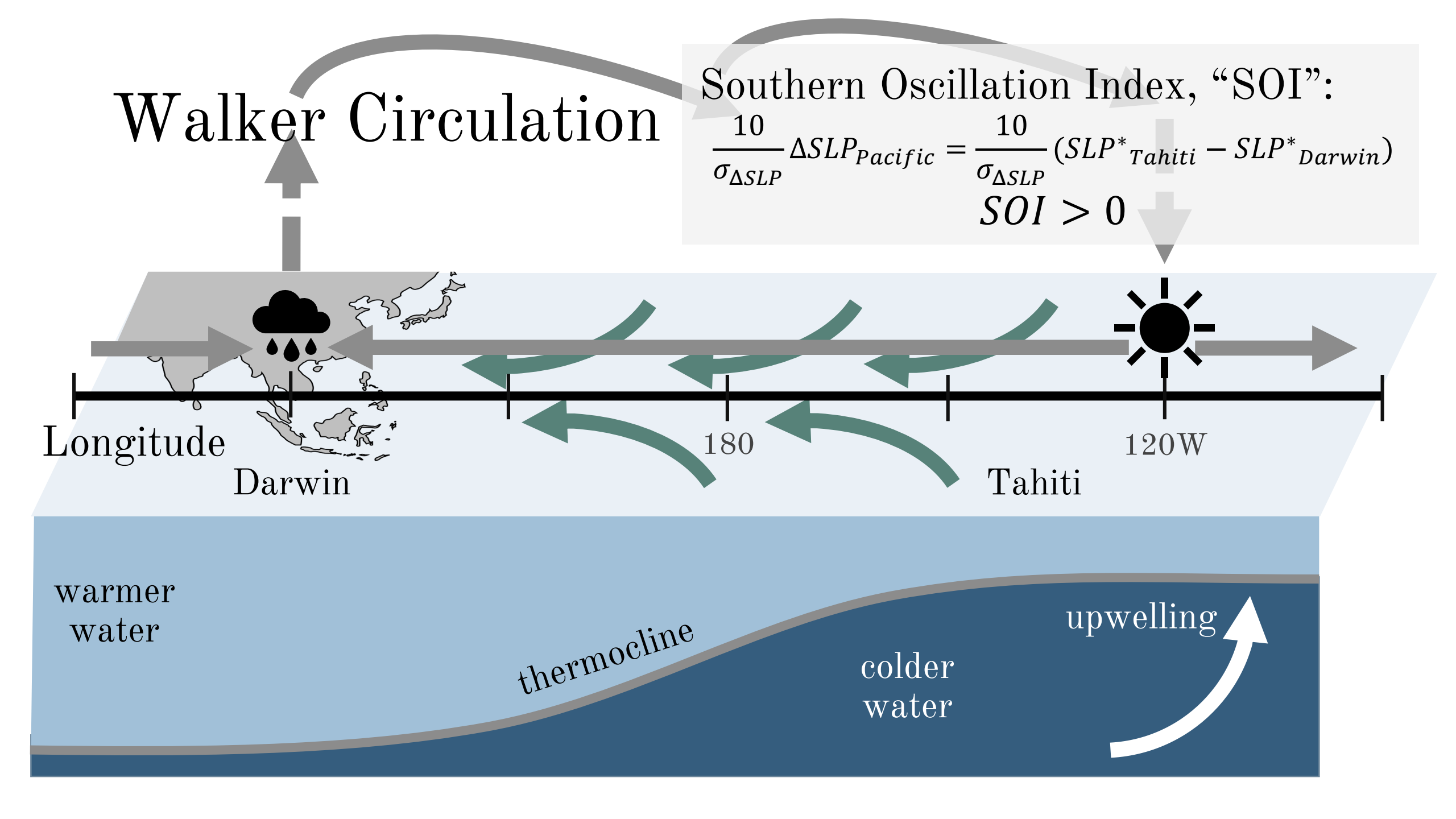
SAM: Southern Annular Mode

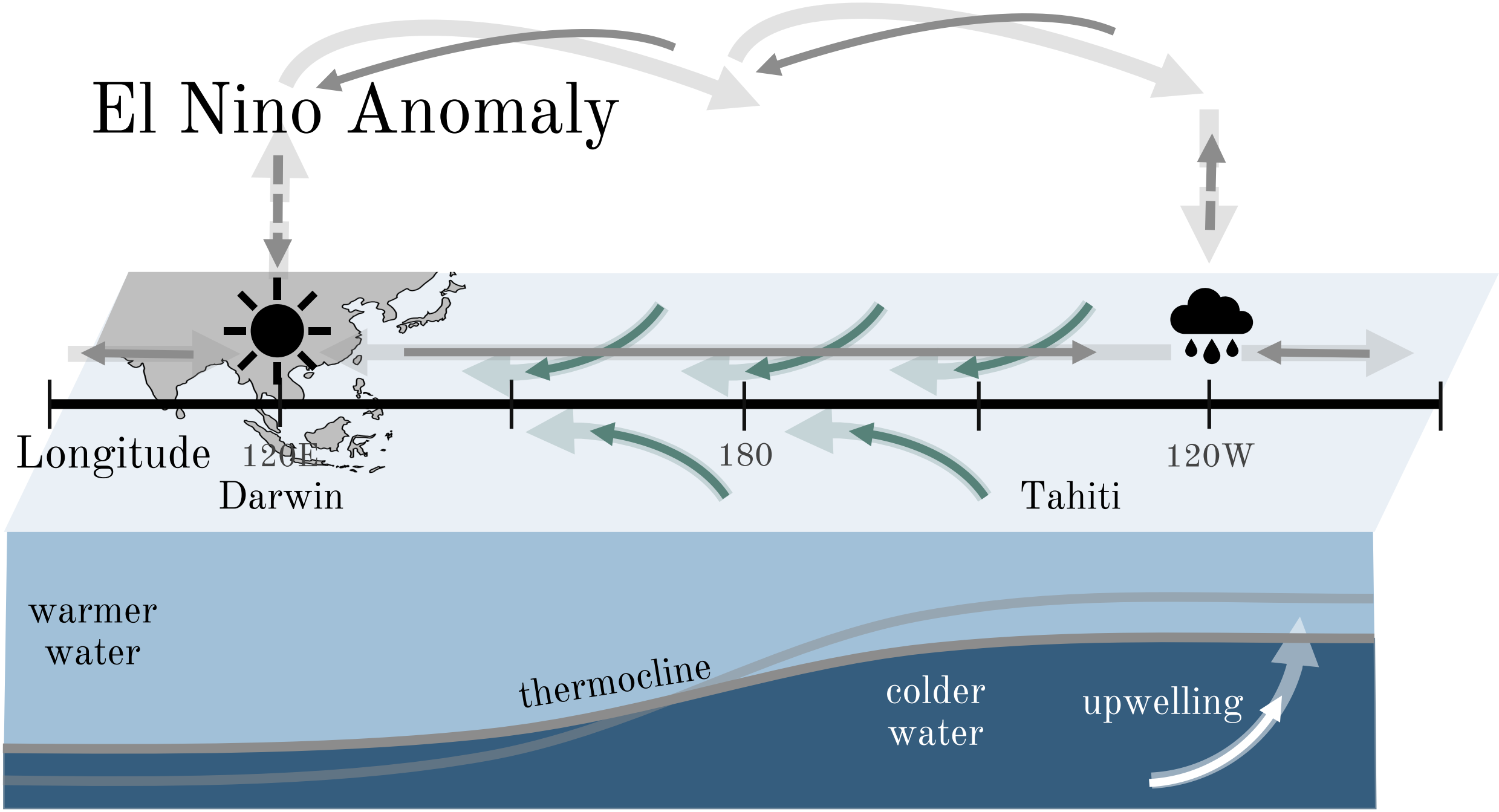
PDO: Pacific Decadal Oscillation

AMO: Atlantic Meridional Oscillation

Variability Modes


Walker Circulation
Bjerknes Feedback
trade winds
Longitude
120E
180
120W
warmer
water
thermocline
colder
water
upwelling


Walker Circulation
Southern Oscillation Index, "SOI":
$\frac{10}{\sigma_{\Delta SLP}} \Delta SLP_{Pacific} = \frac{10}{\sigma_{\Delta SLP}} (SLP^*_{Tahiti} - SLP^*_{Darwin})$
$SOI > 0$
Longitude
Darwin
180
120W
Tahiti
warmer water
thermocline
colder water
upwelling


El Nino Anomaly
Longitude
120E
Darwin
180
120W
Tahiti
warmer
water
thermocline
colder
water
upwelling

El Nino Anomaly

Southern Oscillation Index, “SOI”:

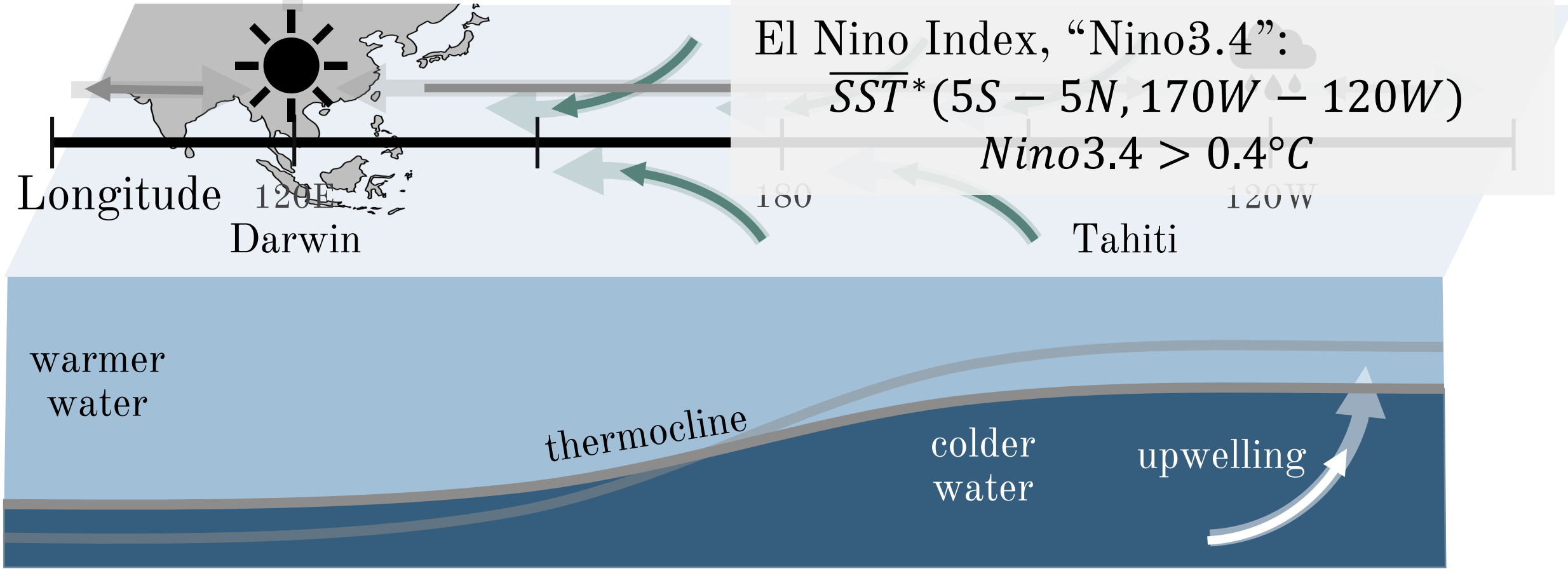
$$\frac{10}{\sigma_{\Delta SLP}}\Delta SLP_{Pacific} = \frac{10}{\sigma_{\Delta SLP}}(SLP^*_{Tahiti} - SLP^*_{Darwin})$$

$$SOI < 0$$

El Nino Index, “Nino3.4”:

$$\overline{SST}^*(5S - 5N, 170W - 120W)$$

$$Nino3.4 > 0.4°C$$



El Nino Southern Oscillation (ENSO)

El Nino Anomaly

Southern Oscillation Index, “SOI”:

$$\frac{10}{\sigma_{\Delta SLP}}\Delta SLP_{Pacific} = \frac{10}{\sigma_{\Delta SLP}}(SLP^*_{Tahiti} - SLP^*_{Darwin})$$

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El Nino Index, “Nino3.4”:

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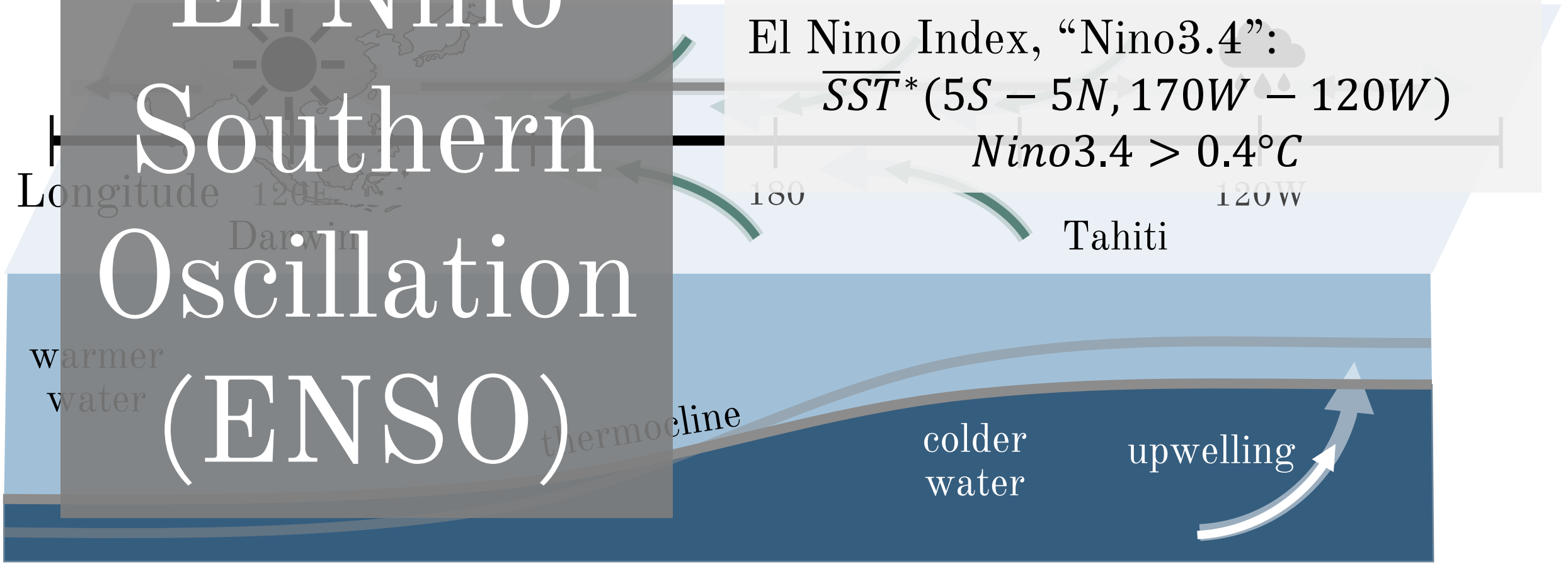


ENSO Indices

Nino 1+2 (0-10S, 90W-80W)

Nino 3 (5S-5N, 150W-90W)

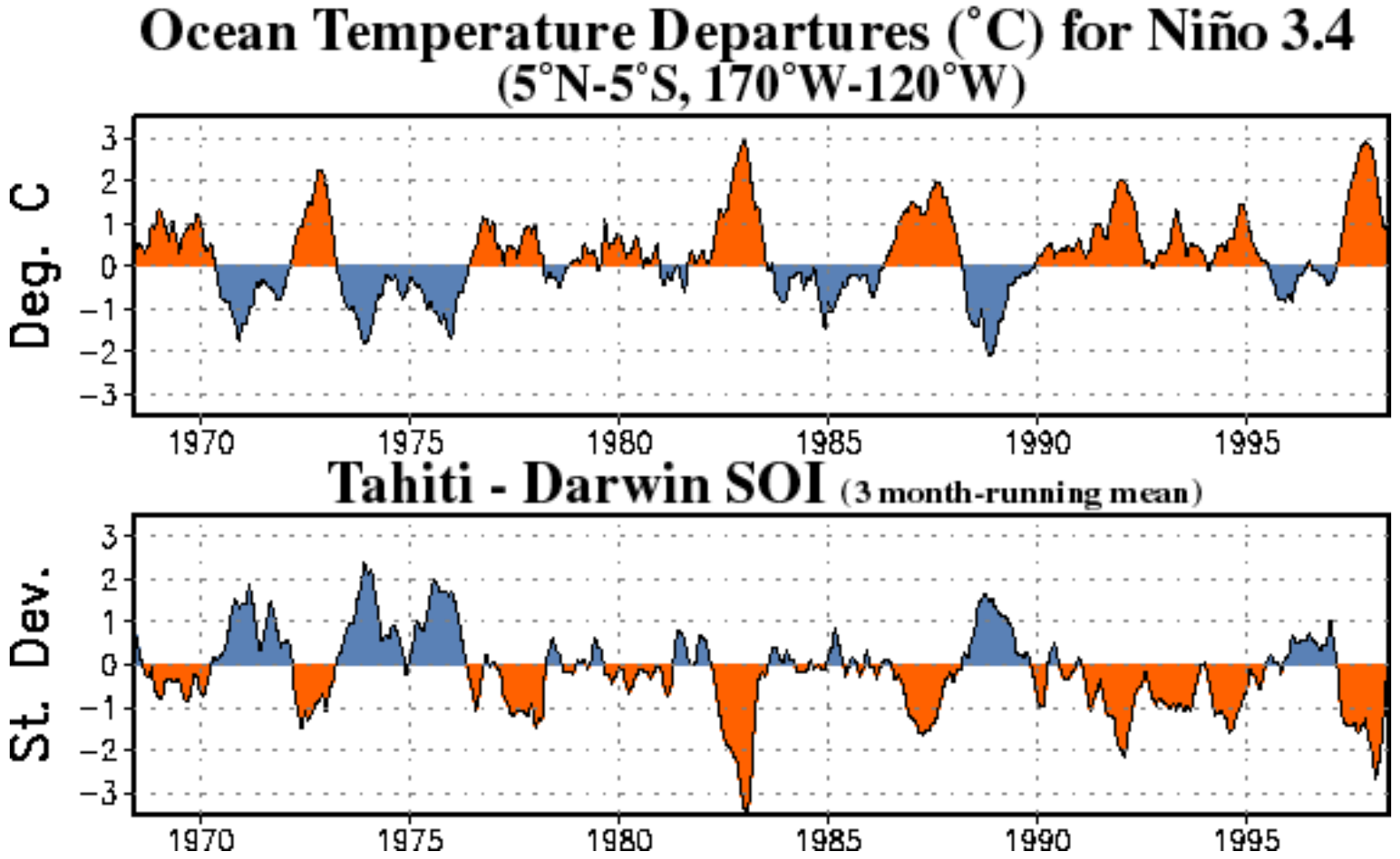
Nino 4 (5S-5N, 160E-150W)

Nino 3.4 (5S-5N, 170W-120W), 5-month running mean, +/-0.4C

ONI (5S-5N, 160E-150W), 3-month running mean, +/-0.5C

Extra info: https://www.climate.gov/news-features/blogs/enso/why-are-there-so-many-enso-indexes-instead-just-one

ENSO Time Series



NOAA Climate Prediction Center

ENSO Animations

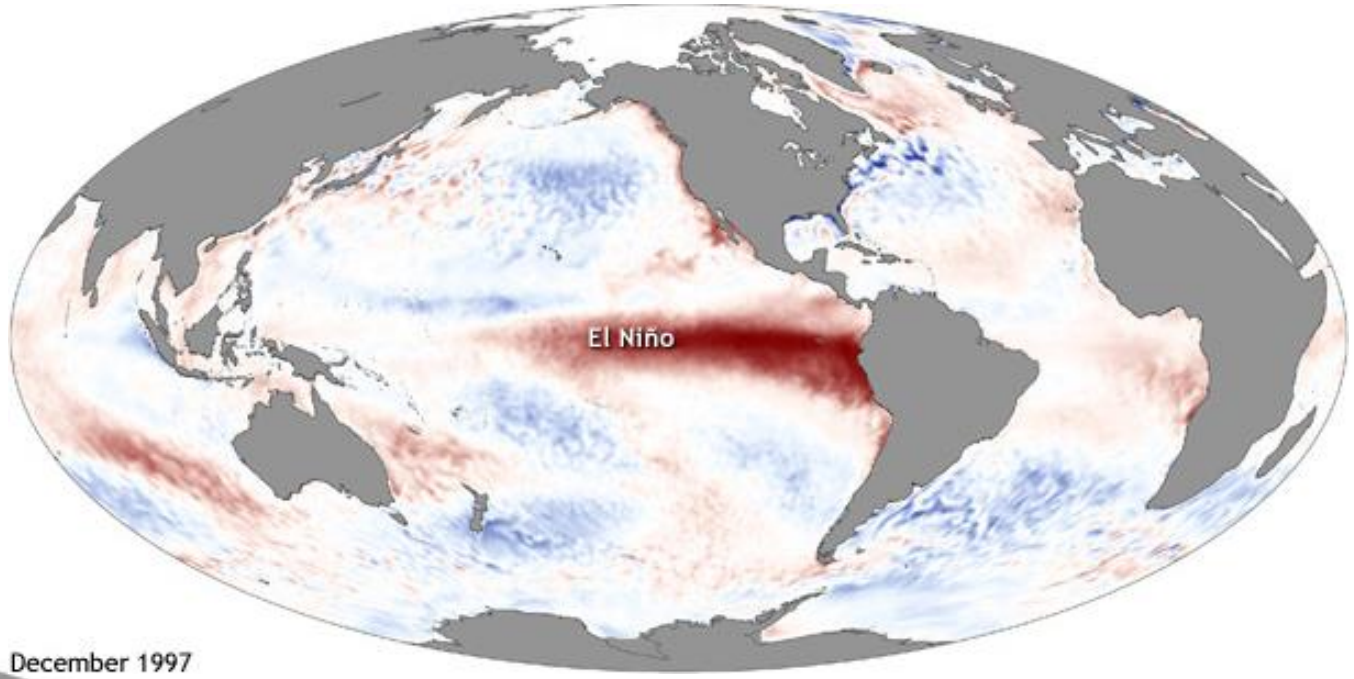
El Nino

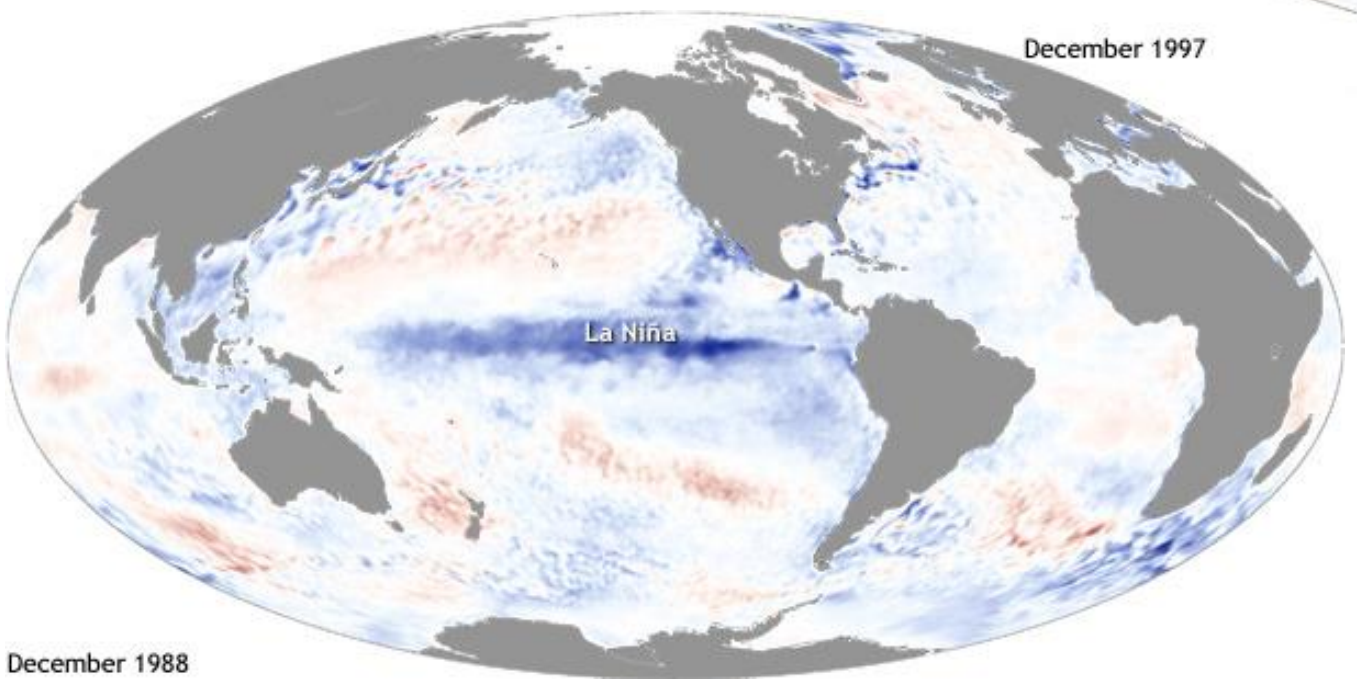
https://www.esrl.noaa.gov/psd/map/clim/sst_olr/old_sst/sst_8283_anim.shtml

La Nina

https://www.esrl.noaa.gov/psd/map/clim/sst_olr/old_sst/sst_8889_anim.shtml

ENSO Signal



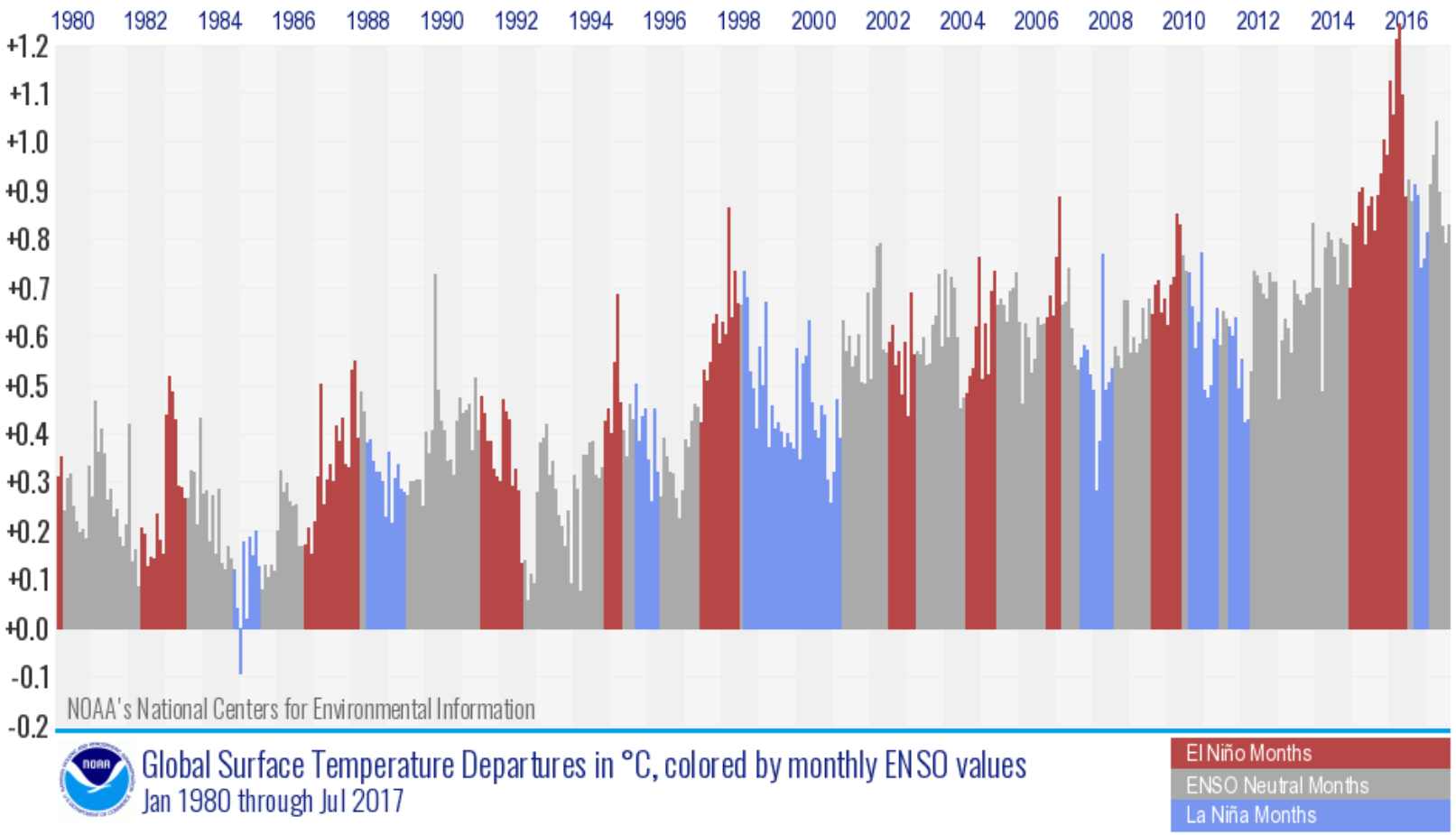


Difference from average temperature (°F)

-9 0 9

NOAA Climate

ENSO Signal



Global Climate Report 2017

North Atlantic Oscillation

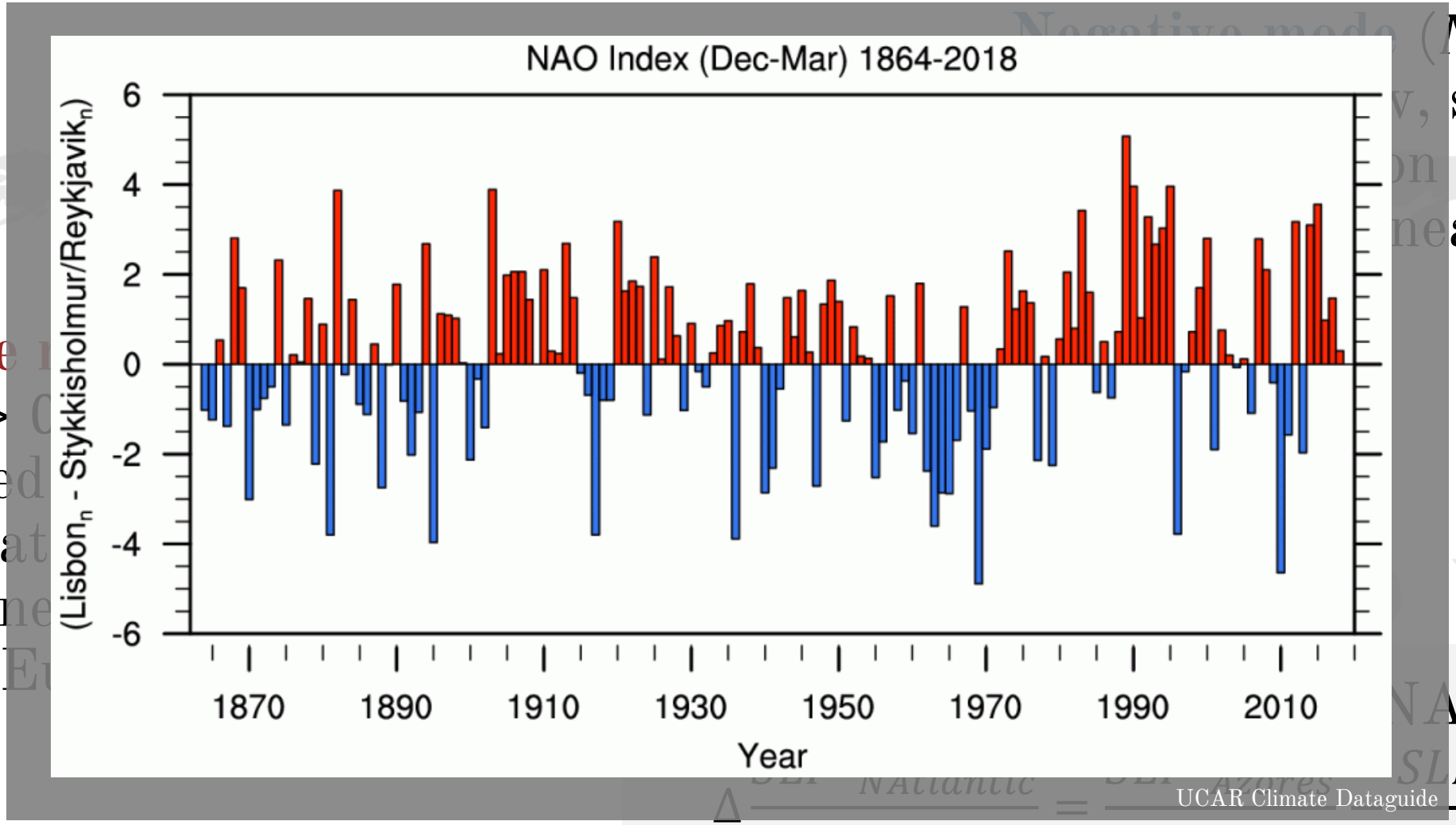
Negative mode ($NAO < 0$): more zonal flow, cold air brougth across Mediterranean region

Positive mode ($NAO > 0$): increased precipitation and "storminess" over central Europe

North Atlantic Oscillation, "NAO":

$$\Delta \frac{SLP^*_{NAtlantic}}{\sigma} = \frac{SLP^*_{Azores}}{\sigma} - \frac{SLP^*_{Iceland}}{\sigma}$$

North Atlantic Oscillation



UCAR Climate Dataguide

Positive
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($NAO < 0$):
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AO":

$$\frac{\Delta}{\sigma} = \frac{P^*_{Iceland}}{\sigma}$$

Southern Annular Mode

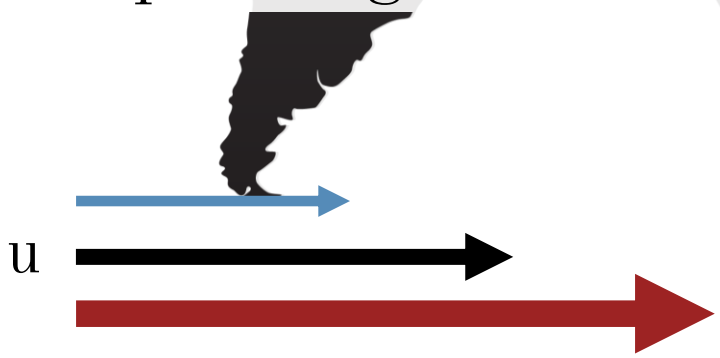
Positive mode ($SAM > 0$): poleward shift and strengthening of surface winds, enhanced divergence and upwelling

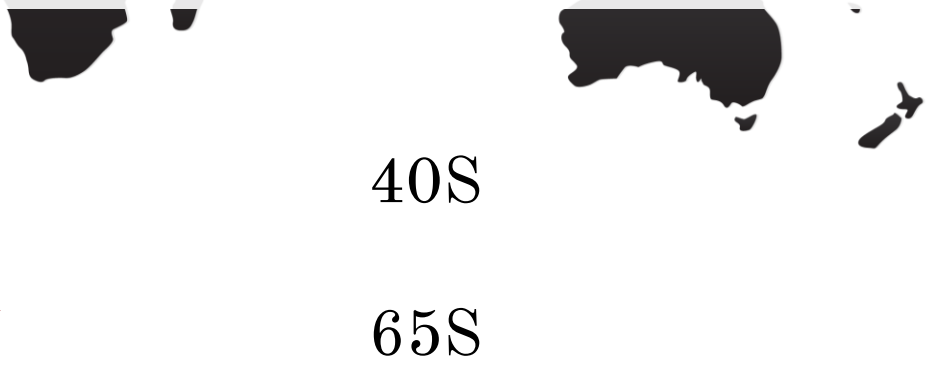
Negative mode ($SAM < 0$): equatorward shift and weakening of surface winds, reduced divergence and upwelling

Southern Annular Mode, "SAM":

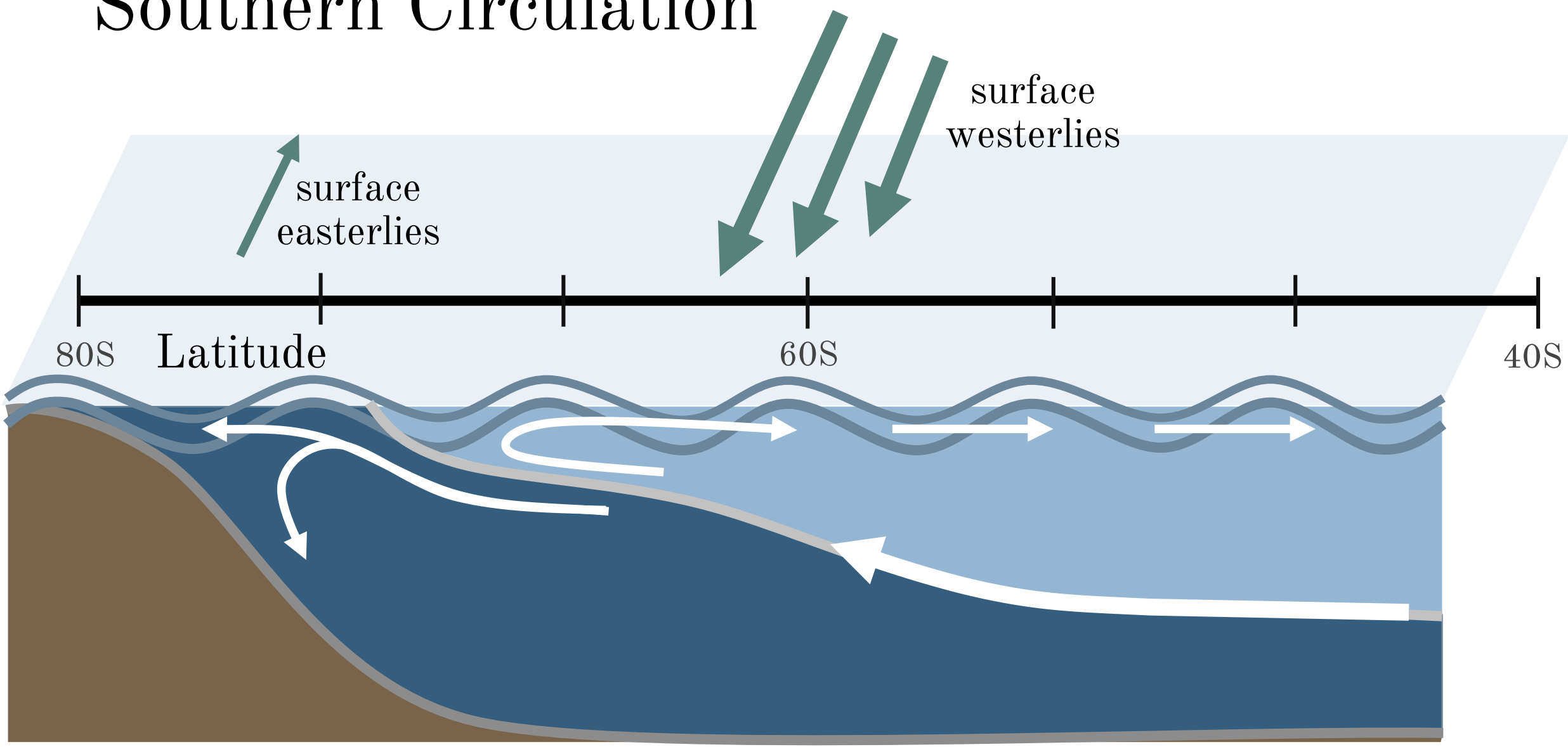
$$\Delta SLP_{S\,Ocean} = SLP^*_{40S} - SLP^*_{65S}$$

Changes in Southern Ocean Circulation!





Southern Circulation



Southern Annular Mode

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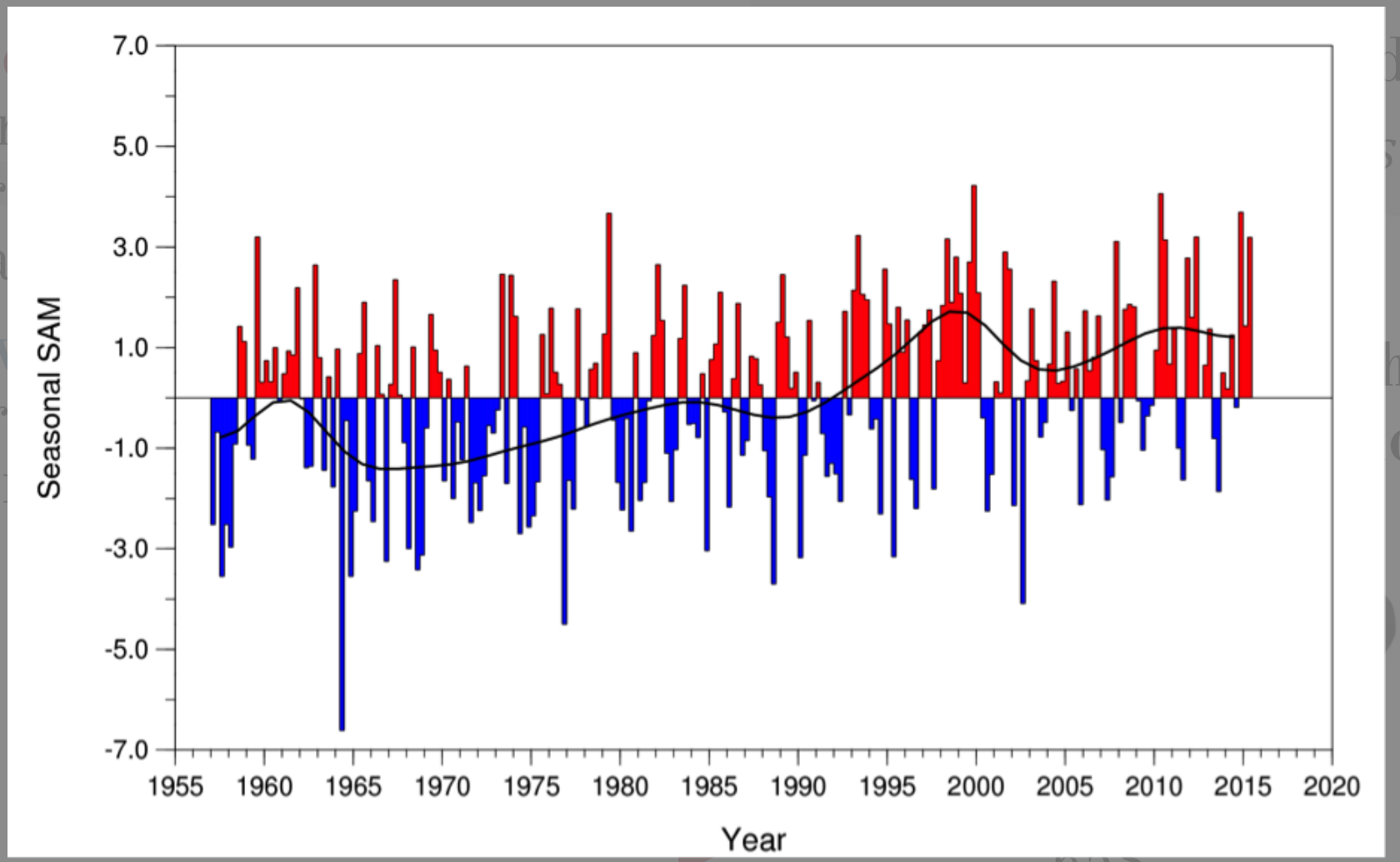


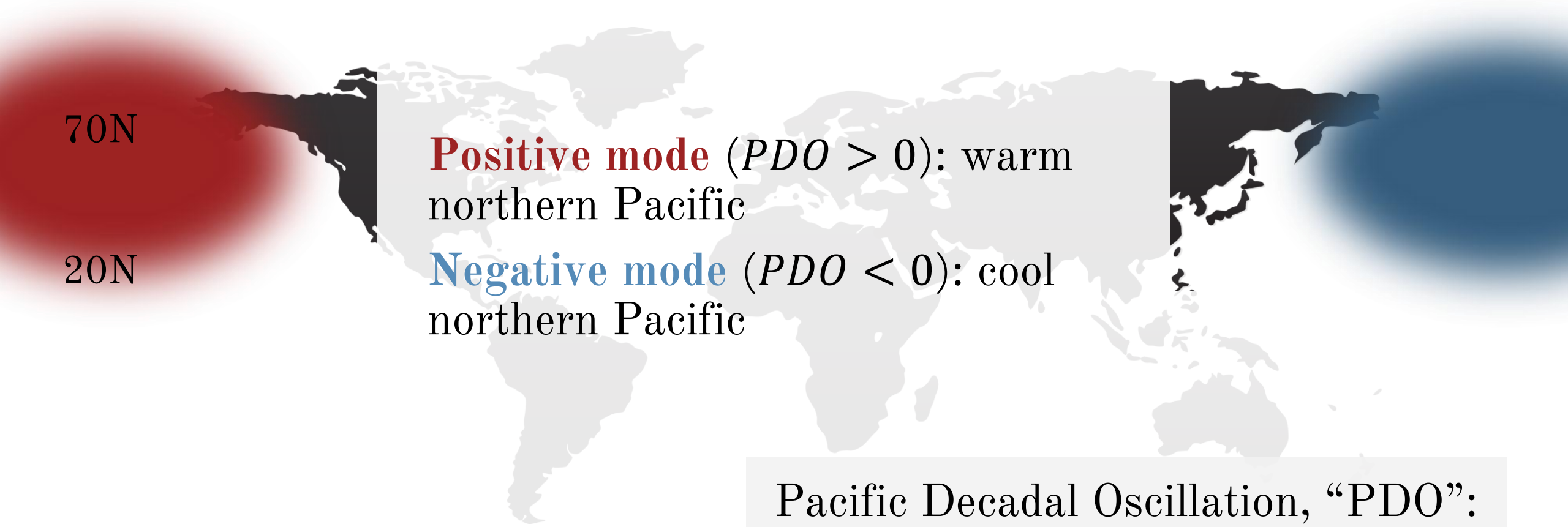
UCAR Climate Dataguide

"SAM": SLP^*_{65S}

rn

on!

Pacific Decadal Oscillation

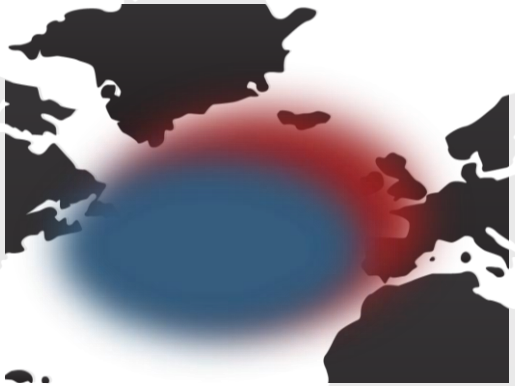


Positive mode ($PDO > 0$): warm northern Pacific

Negative mode ($PDO < 0$): cool northern Pacific

Pacific Decadal Oscillation, "PDO":
$\overline{SST}^{*}(20-70N, Pacific)$

Atlantic Meridional Oscillation



Positive mode ($PDO > 0$): warm northern Atlantic

Negative mode ($PDO < 0$): cool northern Atlantic

Atlantic Meridional Oscillation, "AMO":
$\overline{SST}^{*}(0-60N, Atlantic)$