El Nino / Southern Oscillation (ENSO)

Coupled Ocean-Atmosphere Eigenmodes
Phenomenology: El Nino

- Strong warming of Equatorial and South Pacific every 2-7 years

- Correlated with:
  - Strong Precipitation at otherwise dry west coast of South America
  - Drought in otherwise very humid Southeast Asia
ENSO: El Nino / Southern Oscillation

- Southern Oscillation is surface pressure variation correlated with El Nino Events
- Quantified by Southern Oscillation Index

\[ SOI = \frac{p_{\text{Tahiti}} - p_{\text{Jakarta}}}{\Delta \bar{p}} \]

Correlation of SOI and SST suggests coupling of ocean and atmosphere
Delayed Action Oscillator
Southern Oscillation Index
El Nino as Oscillation

- With respect to a Background state:
  - El Nino is warm anomaly
  - La Nina is cold anomaly

- The period varies between 2-7 years, on average 3.5 Jahre
Background State

- Warm ocean in the west, cold in the East
- Easterly Trade Wind
- High humidity and convection in West, subsidence of dry air in East
Important Terms

- SOI (Southern Oscillation Index)
- SST (Sea Surface Temperature)
- Walker Zirkulation
- Thermocline
Walker Circulation

- Walker Circulation like Hadley Cell
- Walker Cell amplifies temperature gradient
Die Thermocline

- Thermally mixed layer of ocean
- Divides warm surface water from deep water
- Depth of thermocline is a proxy for heat content of ocean
The two Extremes

El Nino

- Warm water anomaly in Eastern Pacific
- Westerly Wind
- Sinking of thermocline in east, rise in west

La Nina

- Cold water anomaly in Eastern Pacific
- Strong Trade Winds
- Rise of Thermocline in Eastern Pacific
ENSO Cycle

El Nino

La Nina

Equator

Thermocline
El Nino & La Nina – Unstable Extrema

- Convection over warm water
- Convergence of winds (Walker Cell)
- Wind stress causes convergence of water
- Accumulation of warm surface water

Positive (coupled) Feedback