Summary of climate regulation and timescales - 1

1,000,000+ years
• Sun is becoming brighter
• Plate tectonics & continental drift
• GHG composition - silicate weathering

1,000 - 100,000
• GHG composition - biological pump, peat bogs
• Orbital configuration
• Ice sheet dynamics
• Thermohaline circulation
Summary of climate regulation and timescales - 2

10 to 1,000
• Sunspot cycles
• Volcano frequency
• GHG composition - humans and short term cycles
• Deforestation, land use changes

1 to 10
• Volcanoes
• El Nino - Southern Oscillation (ENSO)

... with some things left out
Hockey Stick Controversy

Note that

- Most other analysis are similar, Esper is the outlier
- Mann uncertainty spans the most of the others

Global averages of reconstructed proxy and instrumental data

Various curves from different analysis methods and different data
Hockey Stick Controversy

Where is the Little Ice Age and the Medieval Warm Period?

Lesson - They aren’t very visible in global average, indicating lack of global forcing (ie not by sunspots)

Ruins skeptics arguments that 20th century warming is due to sunspots cycles, if the Maunder minimum doesn’t show up here
Two ways we identify conditions:

1) Sea surface temperature (SST) in eastern Pacific defines “El Nino”

2) East-west pressure difference (roughly) on equator defines “Southern Oscillation”
Tropical Pacific - Normal conditions

Easterly trade winds
• pile up warm water in west
• cause coastal upwelling of colder water in east
Walker circulation

\[ \text{Warm SST} \quad \text{Cold SST} \]

\[ \text{west} \quad \text{east} \]

\[ \text{atmosphere} \quad \text{ocean} \]
Involves positive feedback

- Western Pacific sea-surface temperature
- Western Pacific atmospheric convection
- Easterly surface ocean currents
- Easterly surface winds

(+)
Far reaching influence

Sea surface temperature changes with positive ENSO
El Nino + Southern Oscillation = ENSO

La Nina = nonENSO?

Preferred is positive/negative ENSO
(less preferred is warm/cool ENSO)
**Positive ENSO**

**Negative ENSO**
Measure Wind speed and direction, air temperature, relative humidity, rainfall, radiation, pressure, sea surface salinity and temperature, ocean current
Data from last week

Hard to tell from upper panel if the present is normal

Easier with “Anomalies” or departures from the mean (nothing much this year)
Are positive ENSOs more frequent lately? IPCC 2001 says possibly in past and in future.
Forecasts of ENSO are made with climate models and/or statistics

Too soon to tell for next winter (wait till ~July)
Pacific Decadal Oscillation - PDO

Sea surface temperature changes with positive PDO and ENSO

Figures from Hare and Mantua, UW climate impacts
The PDO has at least as big an influence on PNW climate as ENSO, but there is no theory yet that gives useful predictions of its future.

PDO and Cascades snowpack

[Graph showing snowpack data for Paradise Ranger Station, Mt Rainier, and Snoqualmie Pass, with lines representing warm and cool PDO conditions over the months from November to April.]