The Impact of Anthropogenic Forcing on ENSO Amplitude

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- The earth is getting warmer. (Pachauri et al., 2014)
- Climate varies on different scales.
- Long-term trends and short-term noise.
- Forcing: any external factor that affects climate.
    - Greenhouse gasses
    - Aerosols (natural: volcanic ash, artificial: smoke)
    - Biomass burning
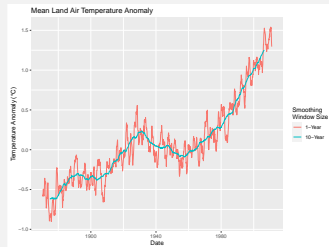   - Land use/cover (deforestation, desertification)

Figure 1: Global mean land air temperature in GISSTEMP 4 dataset. (Team et al., 2019) and (Lenssen et al., 2019)

El Niño (ENSO)

- Warming and cooling of the Pacific Ocean.
- Affects human societies through temperature and rainfall. (Ropelewski and Halpert, 1987)
- May be affected by climate change.

Figure 2: Comparison of SST anomaly between 1975 La Niña event and 1997 El Niño event in HadISST 1 dataset. (Rayner et al., 2003)
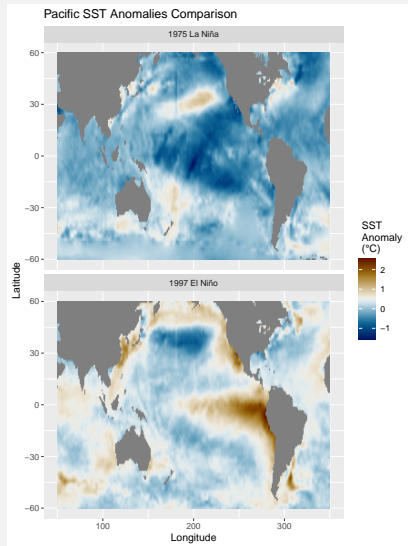
- Run climate simulation with predicted forcing levels as input.
- Ensemble: set of repeated simulations.

ENSO and Climate Change
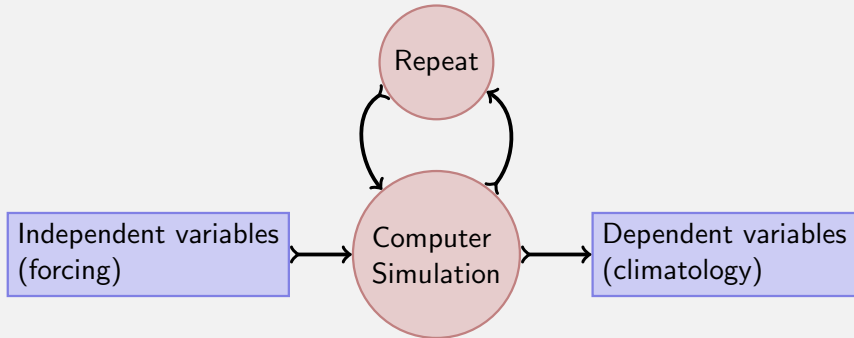
- ENSO changes over time (Lübbecke and McPhaden, 2014).
- ENSO responds to external forcing.
    - Correlation between ENSO strength and sunspot activity (Emile-Geay et al., 2007).
    - Weakened ENSO during the Ice Age due to reduced CO_2 levels (Zhu et al., 2017).
- Models show possible increasing ENSO activity in the future (Zheng et al., 2017) and (Maher et al., 2018).
- Factors other than CO_2 can affect ENSO.
    - Ozone emission may reduce ENSO activity (Nowack et al., 2017)
    - Aerosol emission may reduce ENSO activity (Stevenson et al., 2017)

Gap:

- Little research using a large ensemble to examine the effect of individual factors on ENSO.

- Considerable disagreement between studies on whether ENSO will strengthen or weaken due to global warming

Role of Mentor and Student

Mentor:

- Suggest future methods
- Conduct parallel analysis to complement student work
- Provide raw precollected data
- Interpret data produced by student
- Review student writing

Student:

- Analyze data on computer
- Produce graphics for analysis and publication
- Write documentation
- Suggest interpretations of data

- CESM1 (Kay et al., 2015)
- CESM2 (Danabasoglu et al., 2020)
- Observed forcing levels from 1850-2005
- Predicted forcing levels from 2005-2100
- Ensembles have 40 and 50 simulations respectively
- Control simulation with pre-1850 forcing levels
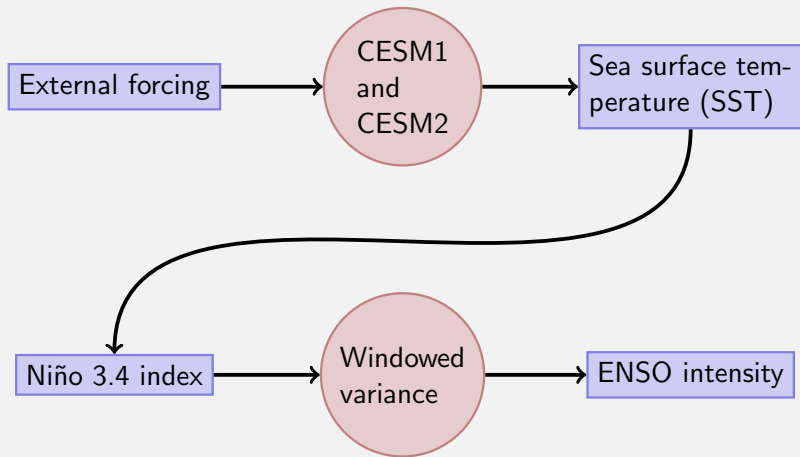
- Butterfly effect
- Use ensemble mean to remove noise.
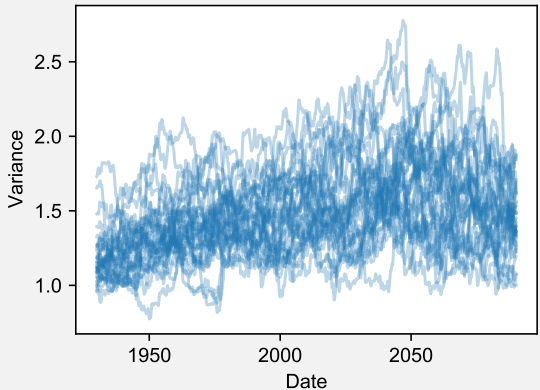- The larger the ensemble, the less noise there is.

Figure 3: ENSO intensity for each run of the CESM1 Large Ensemble

ENSO is Becoming Stronger

- Increase in ENSO intensity
  in both ensembles.
- Increase slows down in
  CESM1 and decreases in
  CESM2 after around 2050.
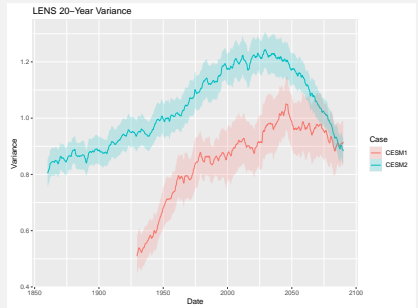   - May be caused by aerosol
      emissions.

Figure 4: ENSO intensity ensemble
mean and standard error for CESM1
and CESM2

Single Forcing Ensembles

Acknowledgments

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