

# Climate Change and Variability

- Global warming
- Long-term trends vs short-term randomness

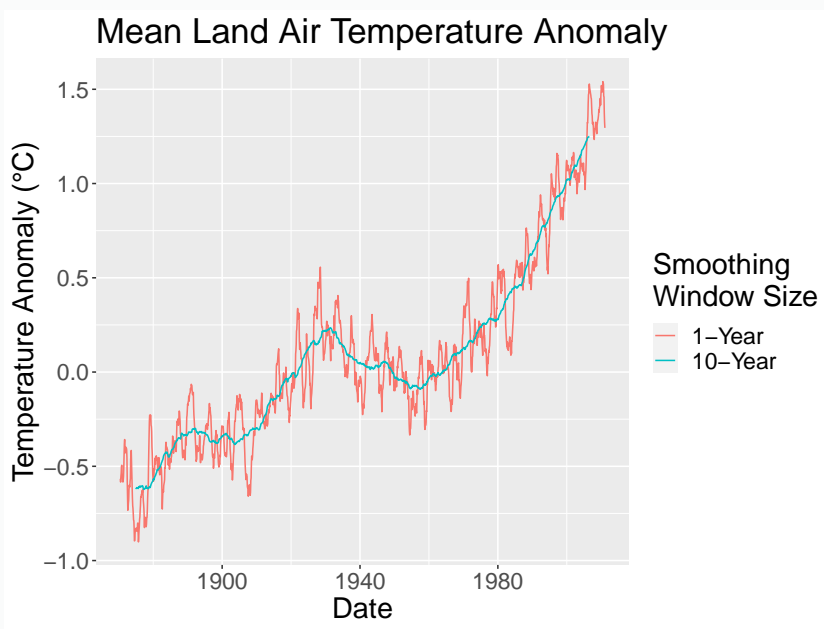


Figure 1: Global mean land air temperature in GISSTEMP 4 dataset. (Team et al., 2019) and (Lenssen et al., 2019)

# Climate Forcing

**Forcing:** any external factor that affects climate.

**GHG** Greenhouse gasses

**AER** Aerosols (natural: volcanic ash, artificial: smoke)

**BMB** Biomass burning

**LULC** Land use/cover (deforestation, desertification)

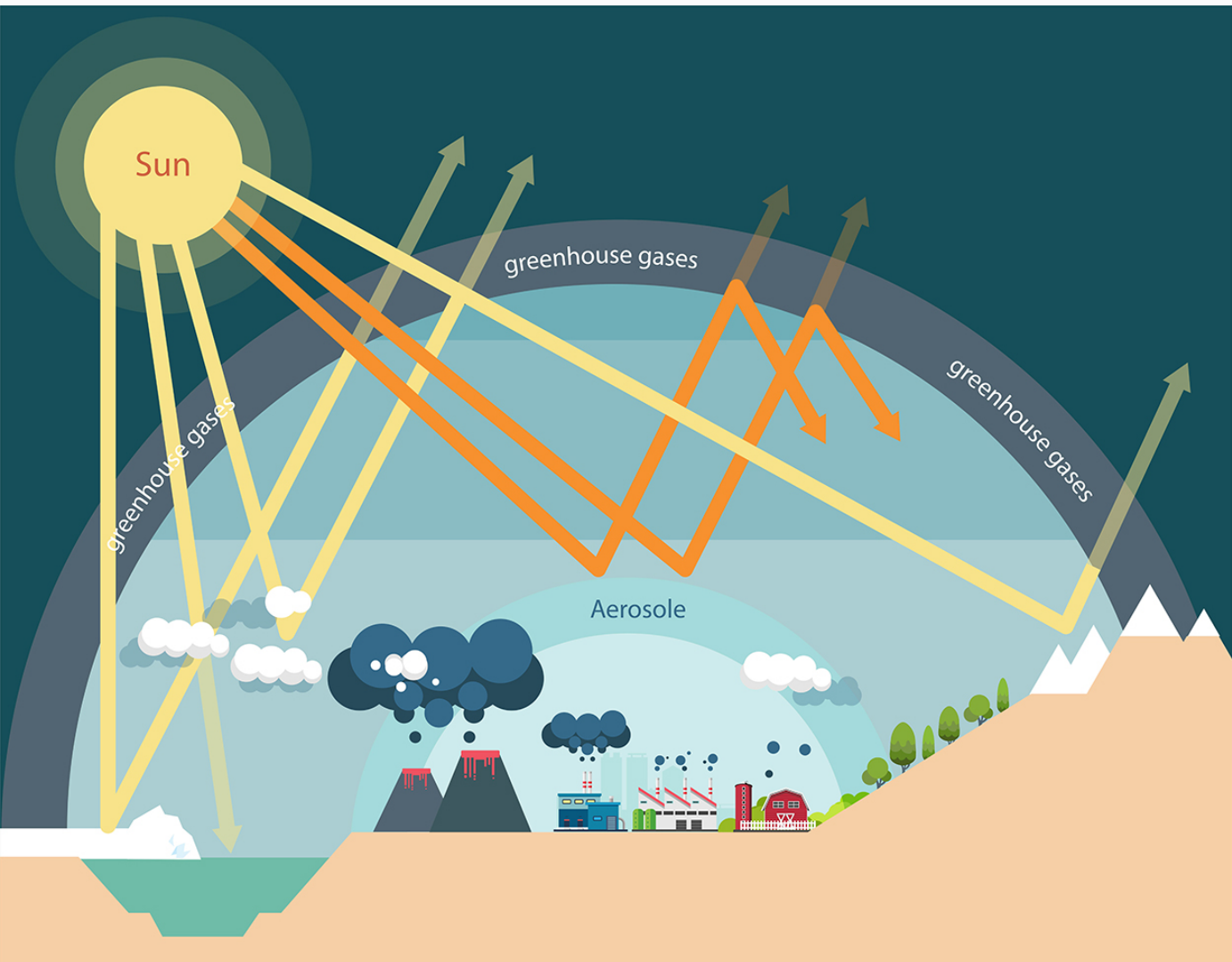
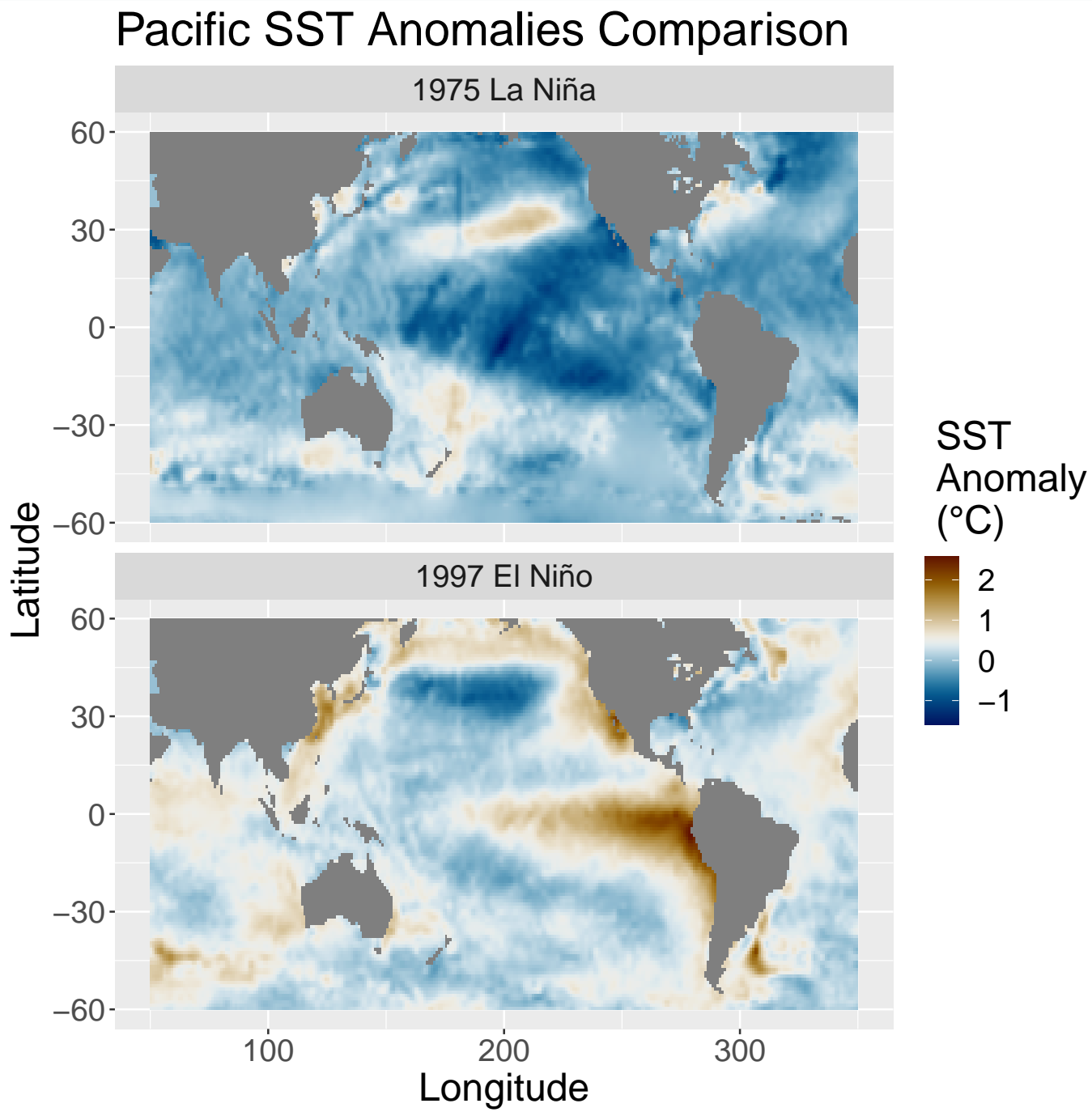


Figure 2: Factors that contribute to the greenhouse effect. <https://www.coolaustralia.org/the-greenhouse-effect-secondary>

# 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 3: Comparison of SST anomaly between 1975 La Niña event and 1997 El Niño event in HadISST 1 dataset. (Rayner et al., 2003)



# Review of Literature

- ENSO’s properties observed vary across different decades. (Lübbecke and McPhaden, 2014).
- ENSO responds to external forcing.
- Weakened ENSO during the Ice Age due to reduced CO<sub>2</sub> levels (Zhu et al., 2017).
- Models show possible increasing ENSO activity in the future (Zheng et al., 2017) and (Maher et al., 2018).

# 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

# Questions

What? Do the CESM1 and CESM2 predict increased or decreased ENSO intensity in the future?

Why? Is the predicted increase (or decrease) due to human activities?

How? What processes are causing greenhouse gasses and aerosols to affect ENSO?

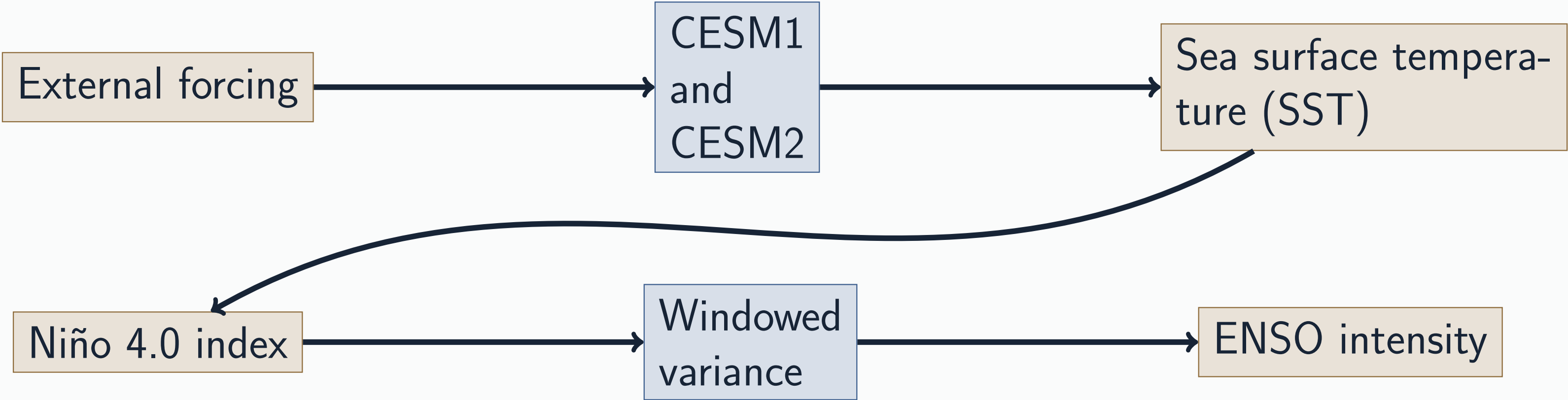
# Methods Overview

- Precollected predictions of sea surface temperature from climate models.
- Calculate ENSO intensity in model output.
- Use single forcing ensembles to estimate contributions each forcing item.
- Plot correlation between ENSO intensity and ocean temperature to examine relationship between heat transfer, forcing, and ENSO.
- Use wavelet analysis to analyze changes to ENSO at different frequencies.

# Model Setup (Data)

- CESM1 (Kay et al., 2015) and CESM2 (Danabasoglu et al., 2020)
- Predicts climate over 21st century with global warming.
- 40-50 simulations per ensemble.
- Control simulation with pre-1850 forcing levels.
- Single forcing ensembles that represent influence of single factor.

# Measuring ENSO Intensity





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