

# The Impact of Anthropogenic Forcing on ENSO Amplitude

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Ben Goldman

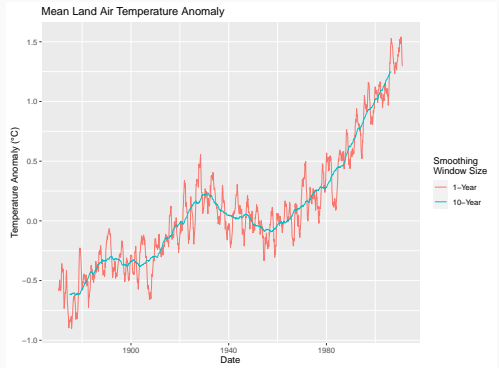
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# Introduction

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# Climate Change

- The earth is getting warmer. (Pachauri et al., 2014)
- Climate varies on different scales.
- Long-term trends and short-term noise.

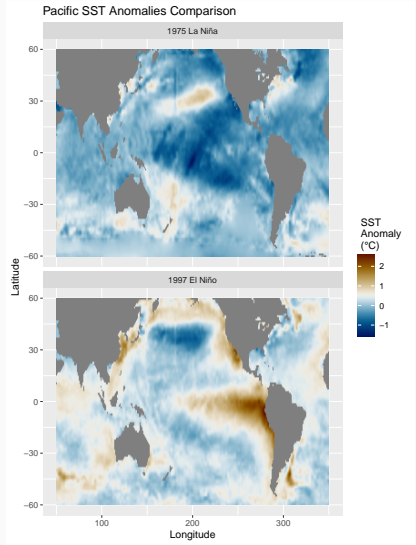


**Figure 1:** Global mean land air temperature in GISSTEMP 4 dataset. (Team et al., 2019) and (Lenssen et al., 2019)

# El Niño

- 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)





# ENSO in the Future

# Gap and Goal

# Research Questions



## **Data and Methods**

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## Ensembles: CESM1 and CESM2

# Analysis Tools

## R:

- ncdcf4
- zoo
- dplyr
- ggplot2
- WaveletComp
- reshape2

## Python:

- numpy
- pandas
- scipy
- matplotlib
- netCDF4

## Other:

- nco

# 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

# Measuring ENSO

# Measuring ENSO Intensity



## ENSO is Becoming Stronger



# It's not That Simple

# Single Forcing Ensembles

# Influence of Aerosols and Greenhouse Gasses

## Correlation With Ocean Temperature



## Stratification in Other Ensembles

## Conclusion

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# Conclusions





# Acknowledgments

# References

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