Effects of volcanism on tropical variability

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Introduction

Volcanic eruptions

- SAT cools rapidly over 1-3 years post eruption, then recovers over 6-7 years

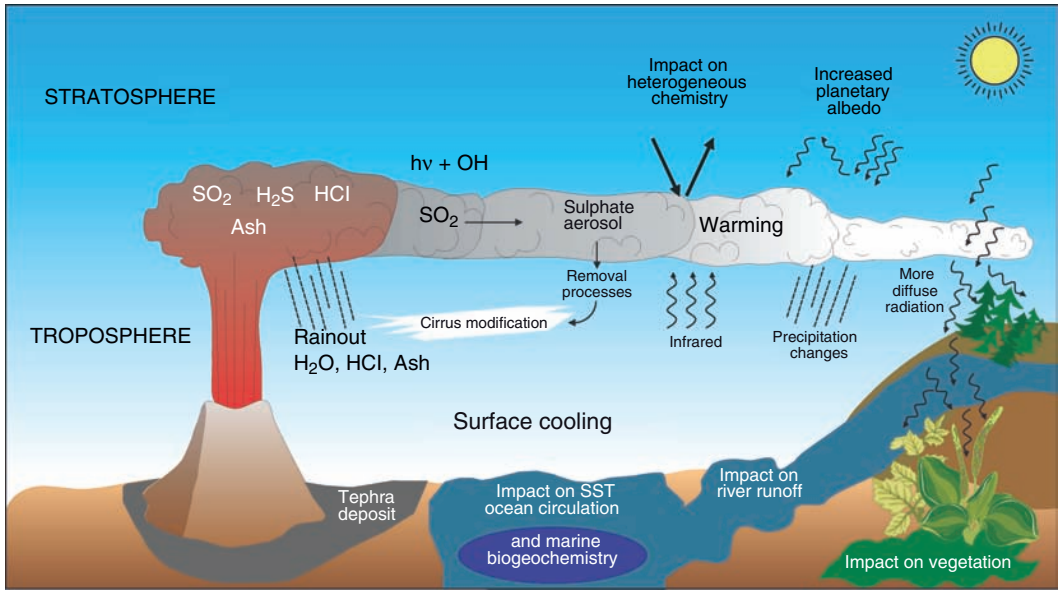

Figure: Timmreck, 2012

Volcanic eruptions and Pacific variability

- Many studies have investigated link to Pacific Ocean variability
  - El Niño response, hypothesised due to a dynamical thermostat (*Adams et al 2003; Seager et al 1988, Clement et al 1996; Cane 1997, Mann et al 2005, Ohba et al 2013*)
  - El Niño followed by La Niña (*McGregor et al 2010*)
  - El Niño response only with Pinatubo or larger eruptions (*Emile-Geay et al 2008*)
  - No response (*Hirono 1988; Nicholls 1990; Self et al 1997; Robock 2000; Ding et al 2014*)
- Influences on the Pacific may then influence SST (El Niño/La Niña associated with warm/cool SST)

Motivation

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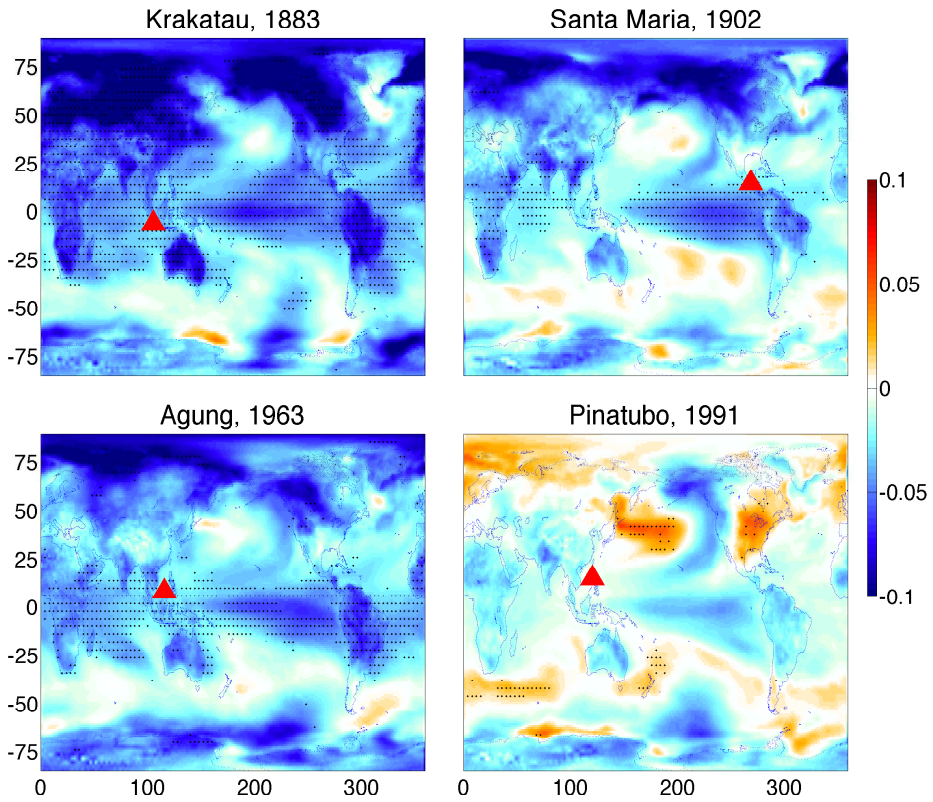
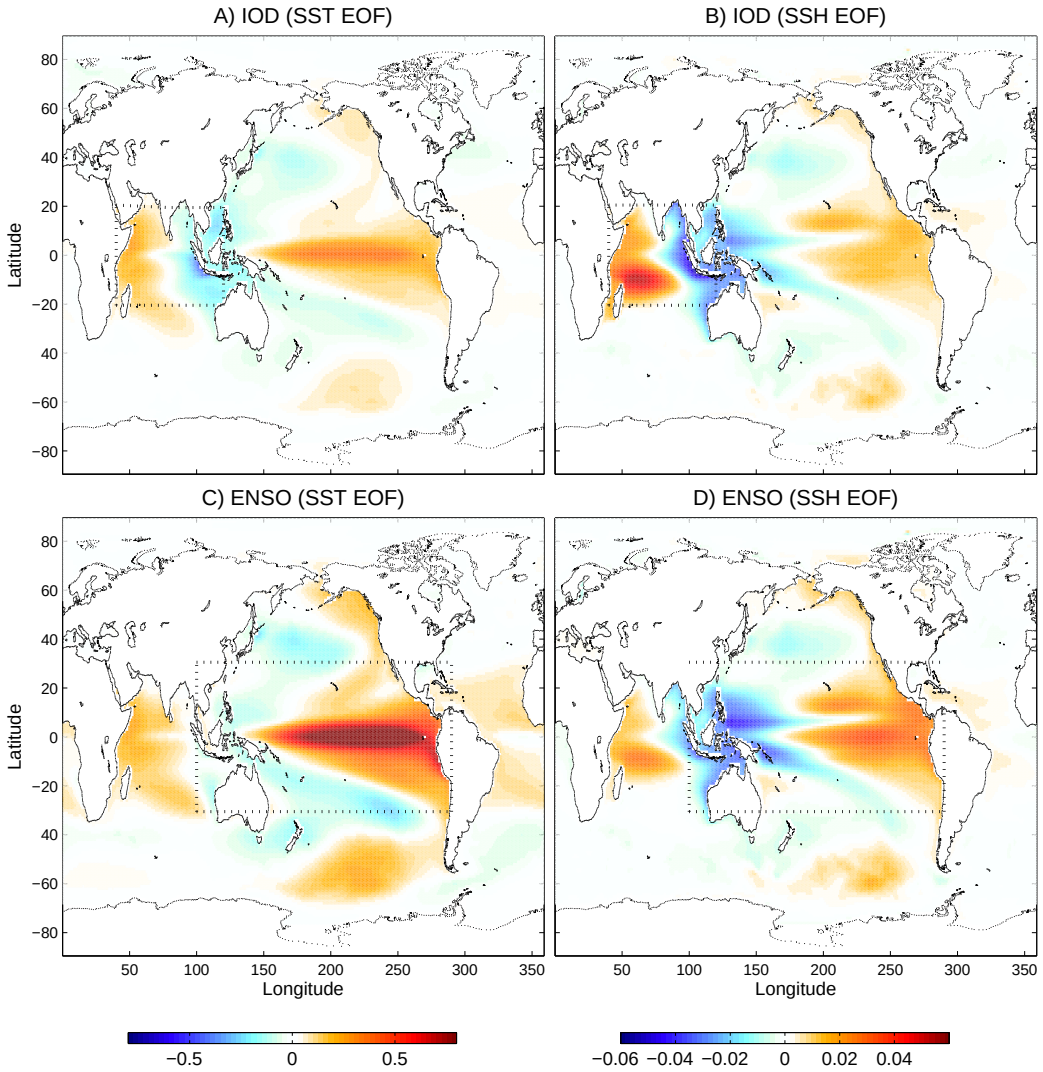


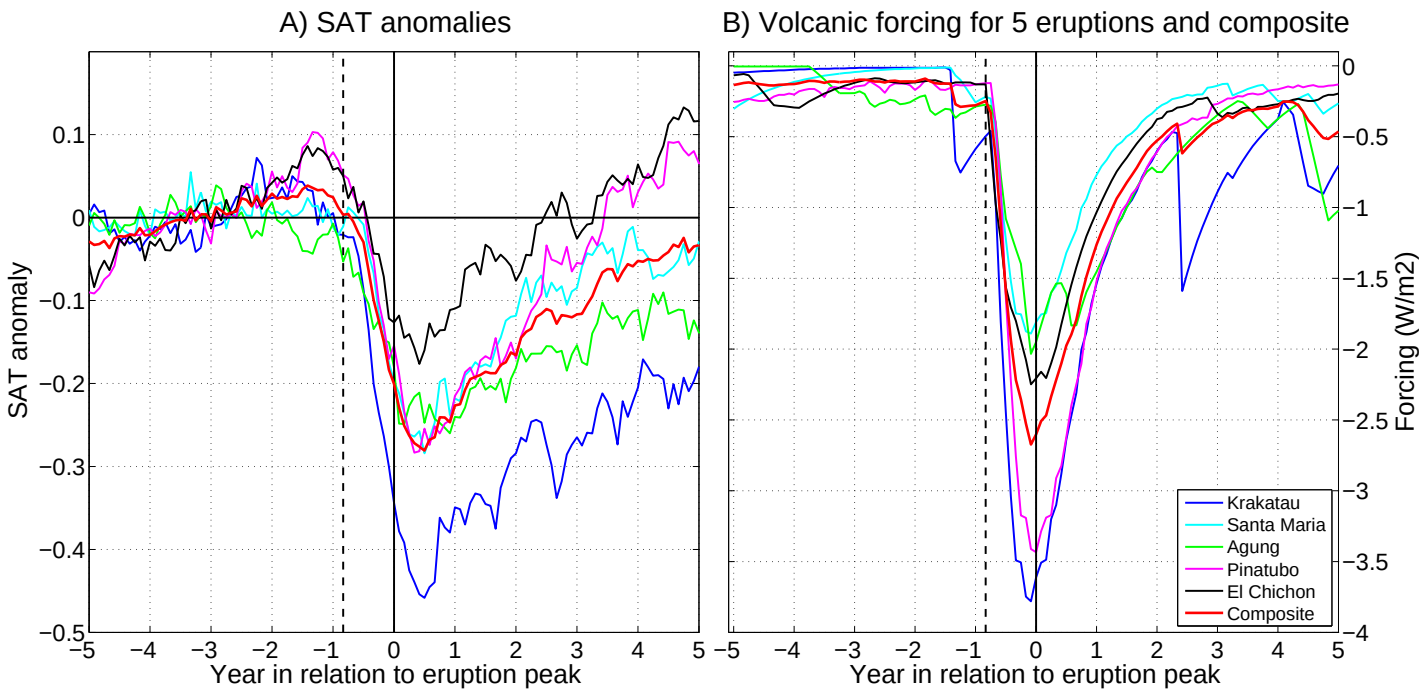
Maher, N., Sen Gupta, A. and England , M. H. (2014), Drivers of decadal hiatus periods in the 20th and 21st centuries, Geophys. Res. Lett., 41, 5978-5986

Results

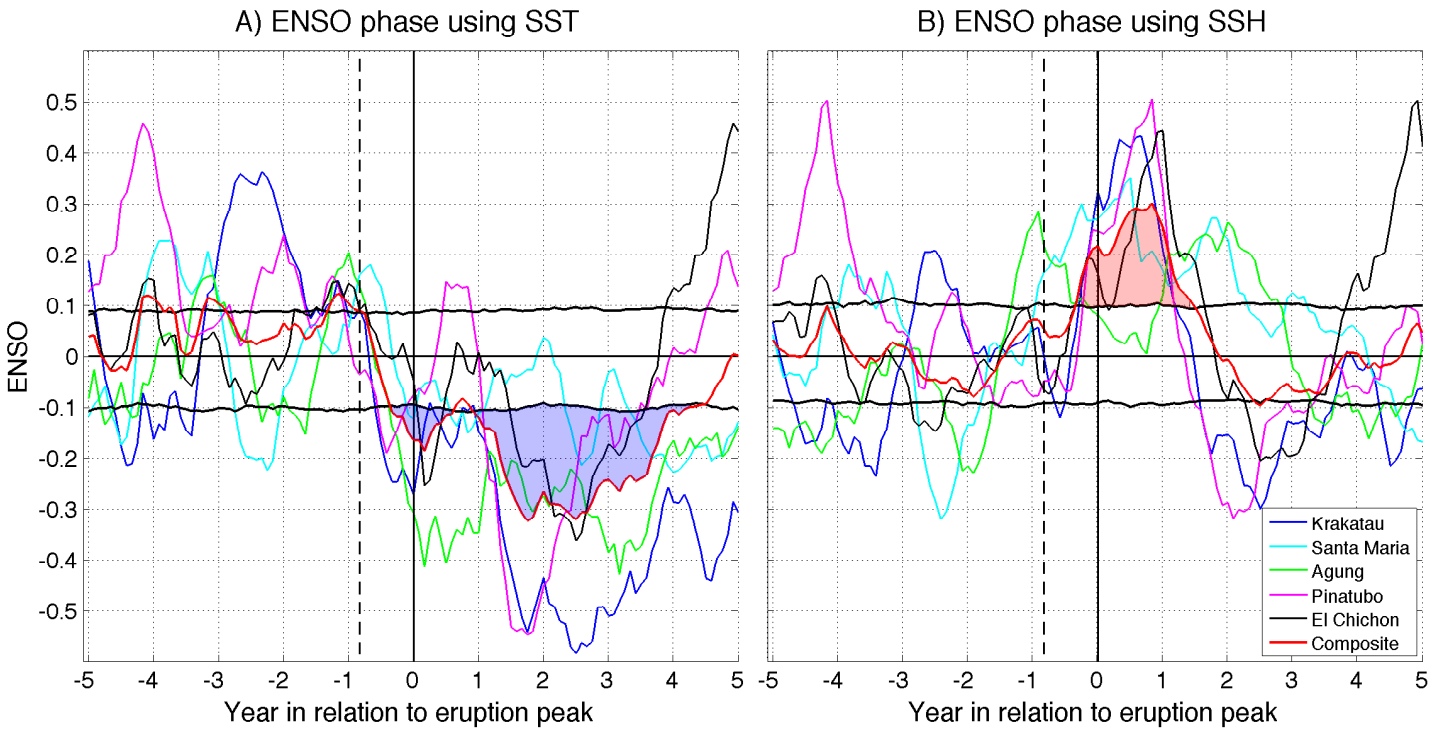
Tropical modes of variability



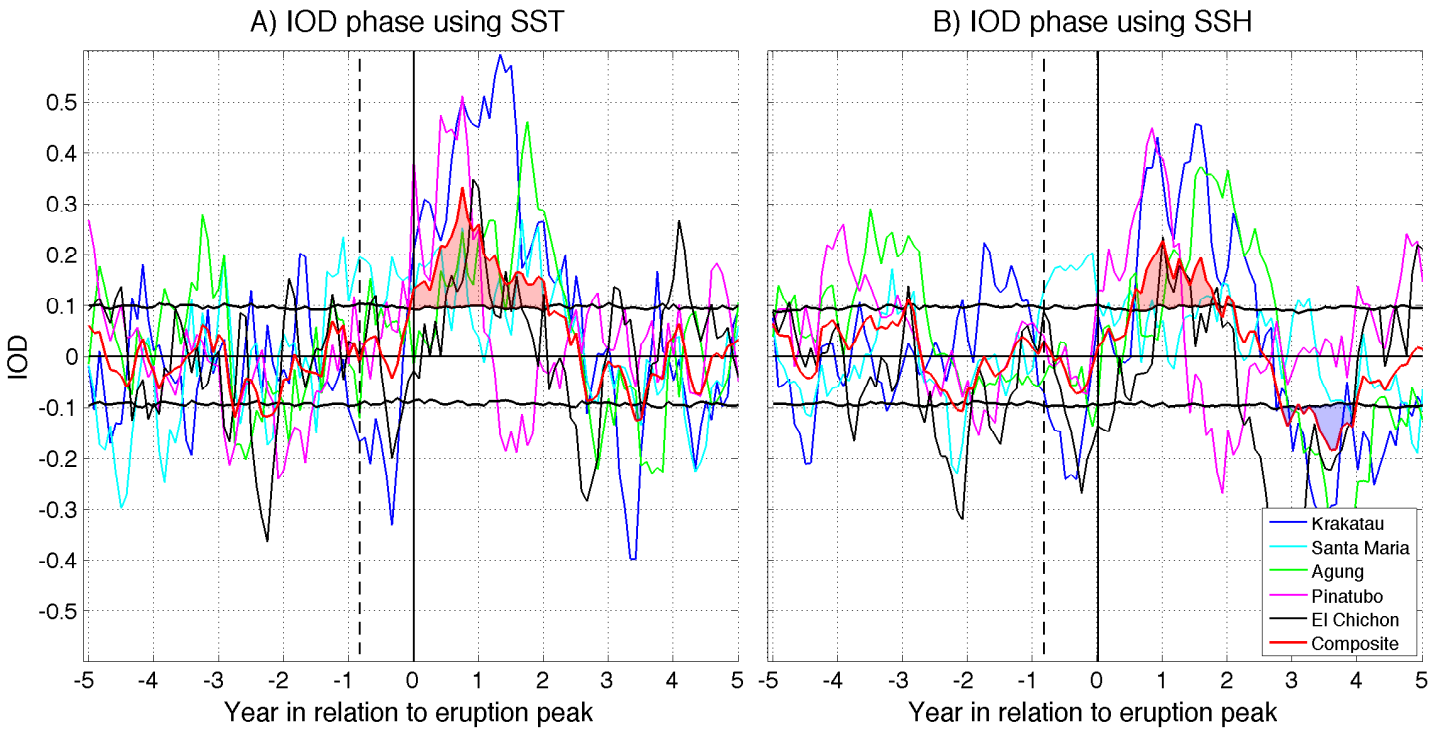
Volcanic forcing and SST response



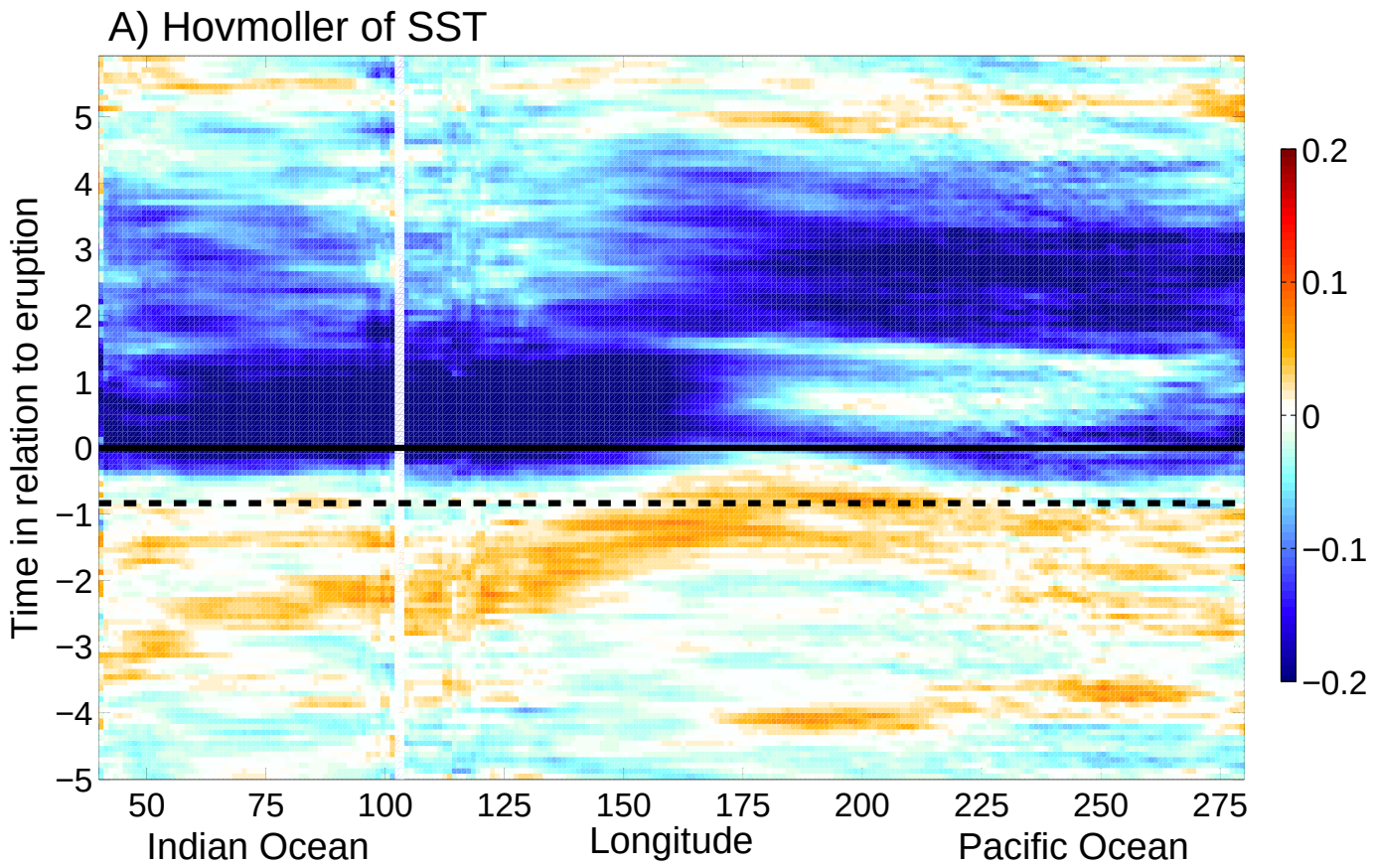
ENSO phase relative to volcanic eruption



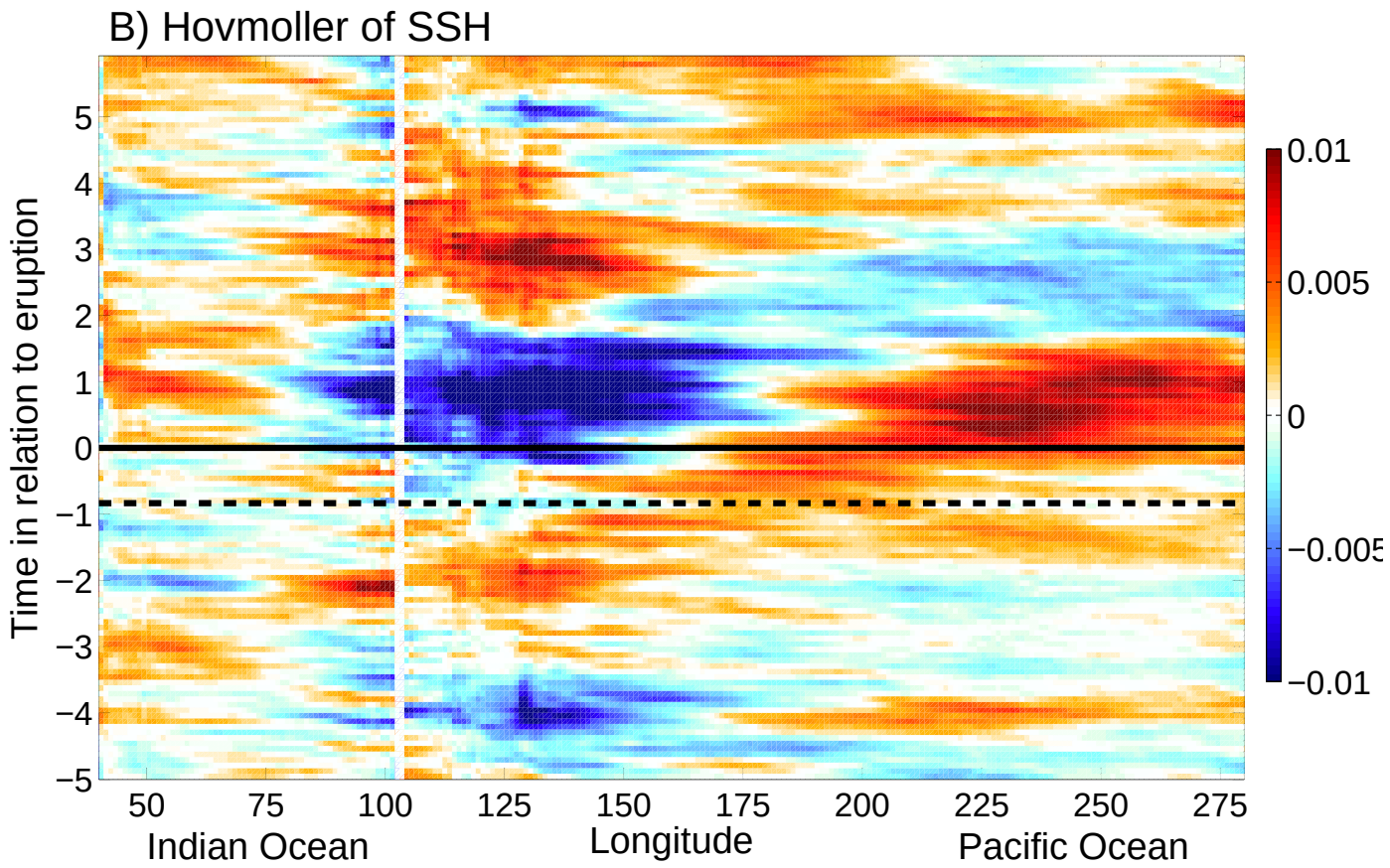
IOD phase relative to volcanic eruption



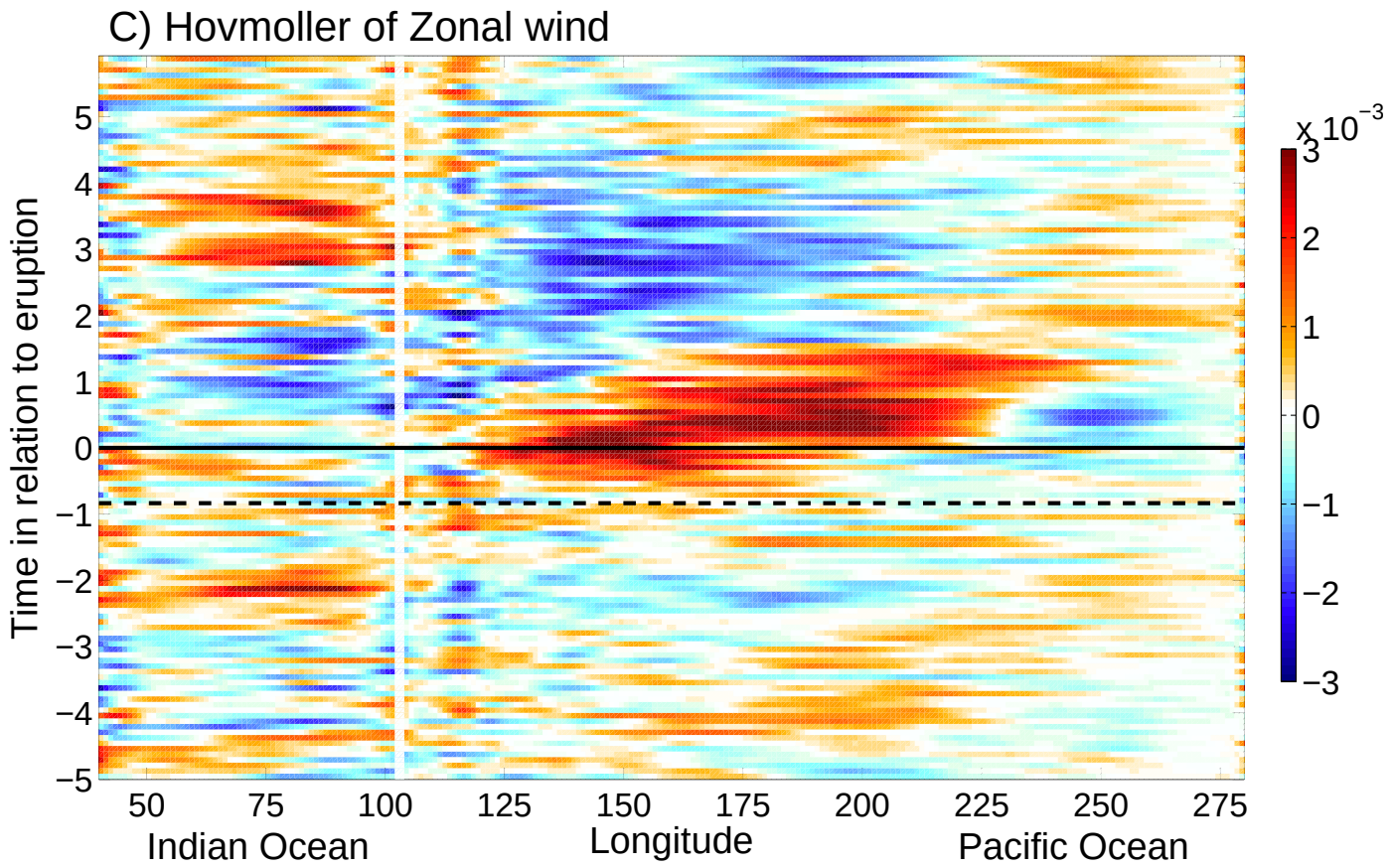
Hovmoller of SST



Hovmoller of SSH



Hovmoller of zonal wind



Change in probability of ENSO phase

At 95% significance level in the multi-volcano mean there is:

- 20-25% increase in probability of a positive IOD in 6-18 months after eruption
- 30% chance of El Niño- like response at same time (seen in SSH field)
- 50% increase in chance of La Niña 18months - 3.5 years after the eruption (in SST field)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Thermocline
Deep cold water
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Tahiti
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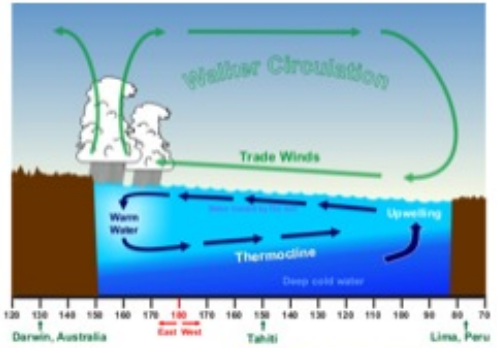
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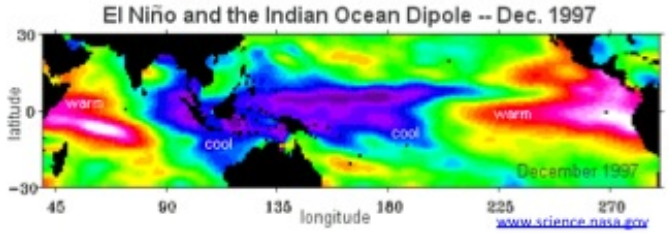
El Niño and the Indian Ocean Dipole -- Dec. 1997
warm
cool
cool
warm
December 1997
latitude
longitude
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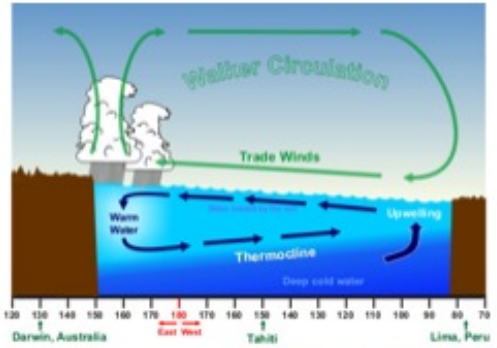
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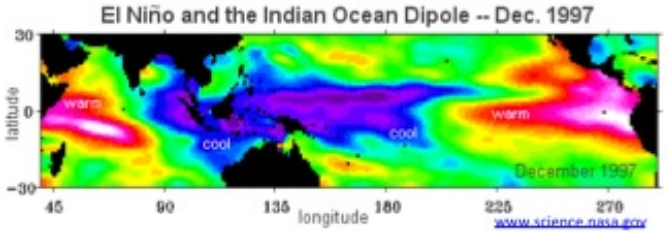
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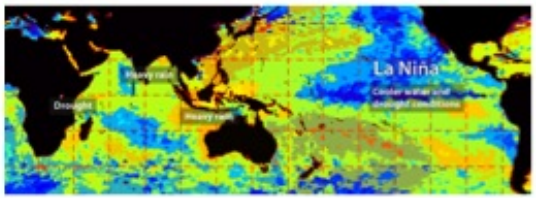
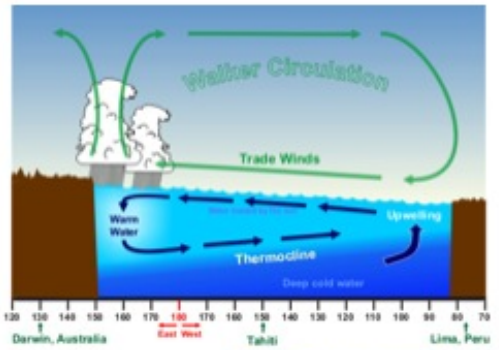
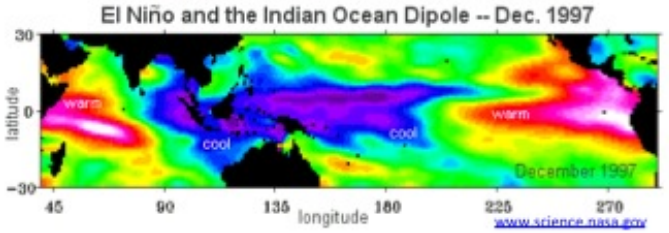
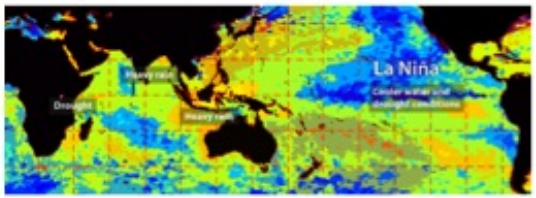

La Niña
www.whoi.edu



Persistent cooling





Conclusions

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1. Large tropical eruptions consistently result in cooling in the CMIP5 models
2. Large tropical eruptions cause a increase in probability of the following sequence of events
   - Positive IOD and El Niño-like event in the austral spring/summer post eruption
   - La Niña in the third austral summer after the eruption
   - Increased persistence of volcanic cooling due to La Niña state of the ocean

Questions?

Thank you for your attention!

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- *Maher, N., McGregor, S., England, M. H, and Sen Gupta, A. (2015), Effects of volcanism on tropical variability, Geophys. Res. Lett., 42, 6024 - 6033*

Key questions

- Do the results differ if we subset for models that represent ENSO well?
  - Kim et al. [2014] have used ENSO magnitude to subset the best 9 CMIP5 models
  - These models have a noticeably reduced cold tongue bias when compared to the remaining models
  - We find no difference in result when subsetting for the best 7 models
- Does it matter which forcing dataset is used?
  - Each model uses one of the following volcanic forcing datasets: Sato et al. [1993], Ammann et al. [2003], Ammann et al. [2007], Stenchikov et al. [1998] or Andres and Kasgnoc [1998]
  - Different models also treat volcanic aerosols differently