

# The Weather Noise C202 Core Project: Progress and Prospects

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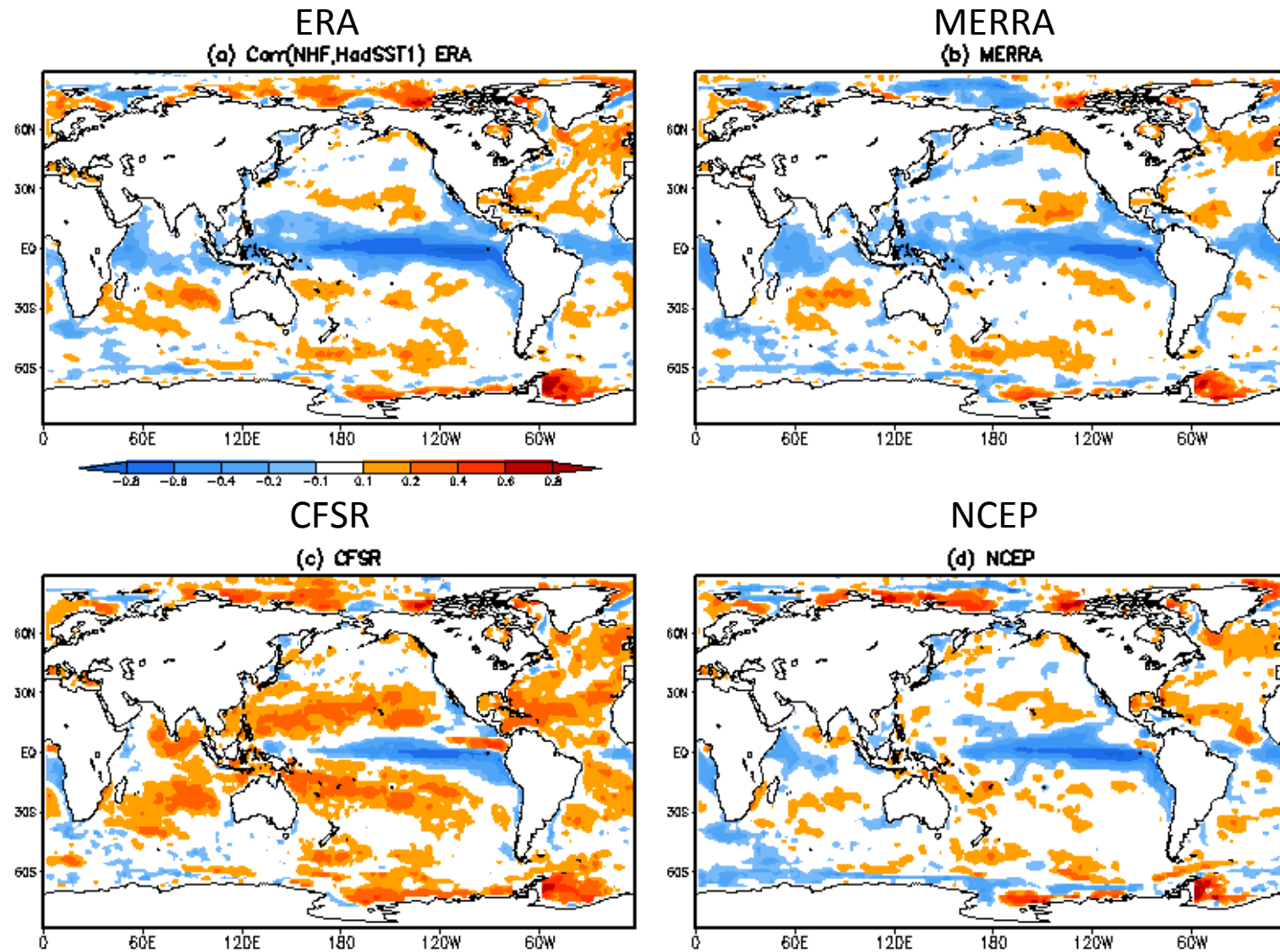
<sup>3</sup>*Nanjing Institute of Information Science and Technology*

**International CLIVAR Climate of the 20<sup>th</sup> Century (C20C) Project Sixth  
Workshop, Melbourne, Australia, 2013**

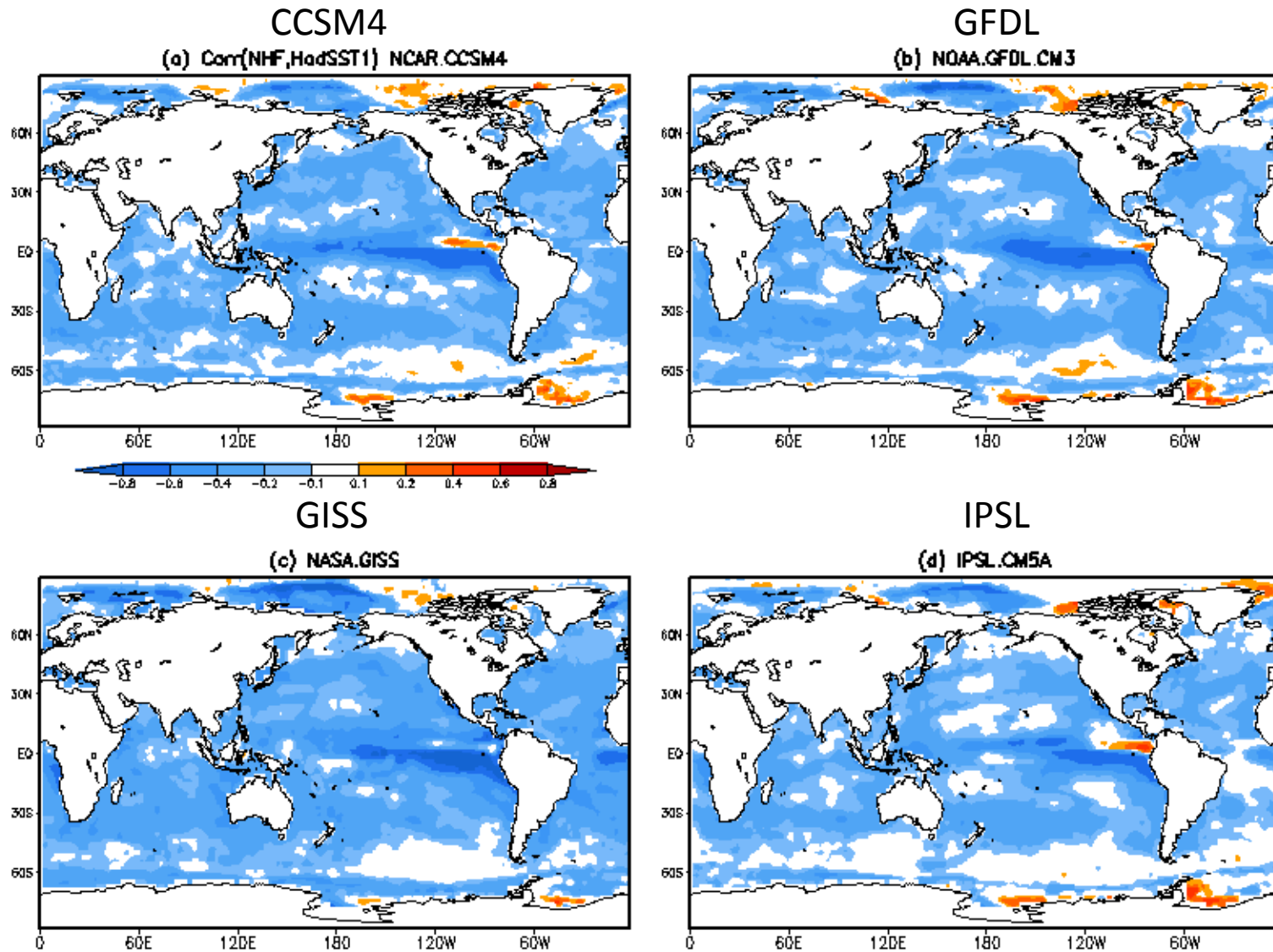
# Project Description

- Infer the atmospheric weather noise and its uncertainty in the observed 20<sup>th</sup>/21<sup>st</sup> century atmosphere.

# Simultaneous Correlation NHF and SST in Reanalyses



# Simultaneous Correlation NHF and SST in Four CMIP5 Models' AMIP Simulations



# Working Hypothesis

- Atmospheric models forced by observed SST and external forcing produce estimates of the atmospheric response to those forcings.
- Reanalyses include estimates of both the atmospheric response and the weather noise that is forcing the SST.
- The information contained in reanalyses and models can be better understood by comparing the forced responses and the weather noise.

# Procedure

- The procedure to estimate the weather noise ( $N$ ) of a variable is to subtract the time-varying response to the observed SST and external forcing as given by an AGCM ( $F$ ) from an observational analysis ( $O$ ).

$$N = O - F$$

- The weather noise estimate will then depend on the choices of atmospheric model and observational analysis.

# Progress

- Initial inquiries revealed that the required diagnostics were not saved from a sufficient number of models in the earlier set of C20C HadISST-forced historical AGCM simulations to provide useful uncertainty estimates.
- However ... saved by CMIP5.
  - Currently, we are developing weather noise estimates and related diagnostics of the response of the atmosphere to SST forcing for the latter part of 20<sup>th</sup> century using various reanalyses and results from AMIP-type simulations forced by the CMIP5 SST and ice. This SST product uses HadISST1 merged with NOAA OI SST. Examples of the sensitivity of these estimates to reanalysis and model will be described here.

# Data Used

- 4 atmospheric reanalyses
- CMIP5 AMIP ensembles from 5 models
- Chosen from COLA data archives



# Reanalyses

1. ERA-Interim (ECMWF)
2. MERRA (NASA)
3. CFSR (NCEP)
  - Coupled atmosphere/ocean analysis
4. NCEP

✧ 1979-2008

✧ Monthly data

# CMIP5 AMIP Ensembles

1. CSIRO-QCCCE.CSIRO-Mk3-6-0 10 members
2. IPSL.IPSL-CM5A-LR 10 members
3. NASA-GISS.GISS-E2-R 6 members
4. NCAR.CCSM4 (CAM4) 6 members
5. NOAA-GFDL.GFDL-CM3 5 members

# Products

- Ratios of standard deviations Analysis:AGCM
- Ratio of noise standard deviations

# Results: Net Heat Flux (NHF) Ratios

- Ratio of total NHF for Analysis:AGCM
- Ratio of noise NHF for Analysis:AGCM
  - Noise estimates for the analyses are found by subtracting the SST/externally forced response from the different models from the analysis.
  - Noise for an AGCM simulation is found by subtracting the SST/externally forced response of that model from the simulation.

# CMIP5 Noise Estimates

- Each model  $m$  has produced data from an AMIP ensemble of  $n$  simulations, with each member forced by the same SST and external forcing over the historical period.
- The SST forced solution from model  $m$ ,  $F_m$  is the ensemble mean of the  $n$  members.
- $m$  noise estimates  $N$  for reanalysis  $i$  are found by subtracting the SST forced solution of model  $m$  from reanalysis  $i$  ( $O_i$ ).

$$N_{i,m} = O_i - F_m$$

- $n$  noise estimates  $\mathcal{N}$  for model  $m$  are found by subtracting the SST forced solution of model  $m$  from model  $m$  simulation  $i$  ( $O_{m,i}$ )

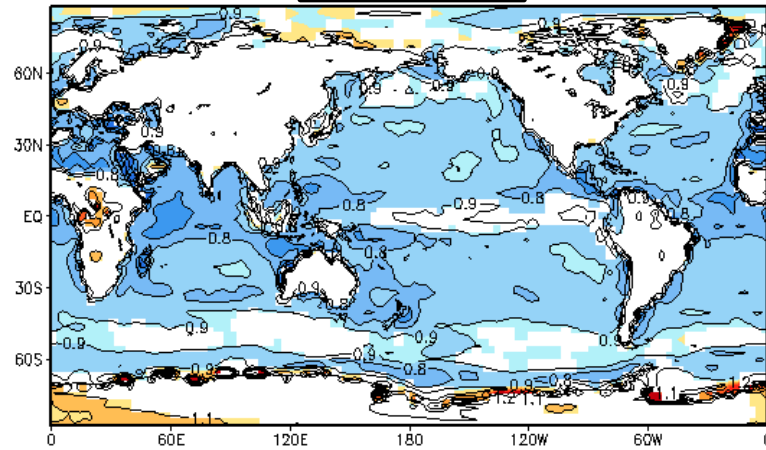
- $\mathcal{N}_{i,m} = O_{m,i} - F_m$

Reminder: NHF CGCM:AGCM Ratios in  
Perfect Model Simulations

# Ratio of Standard Deviation of Monthly Mean Net Surface Heat Flux Variance CONTROL:AGCM; Heat Flux Variance CONTROL:AGCM;

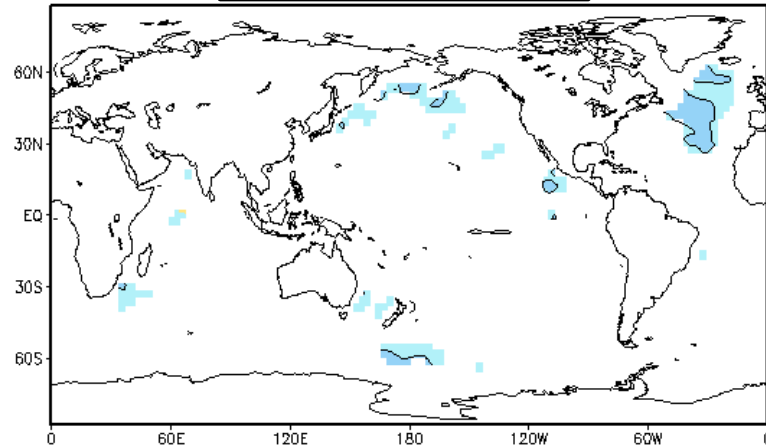
$< 1$

Total



$\approx 1$

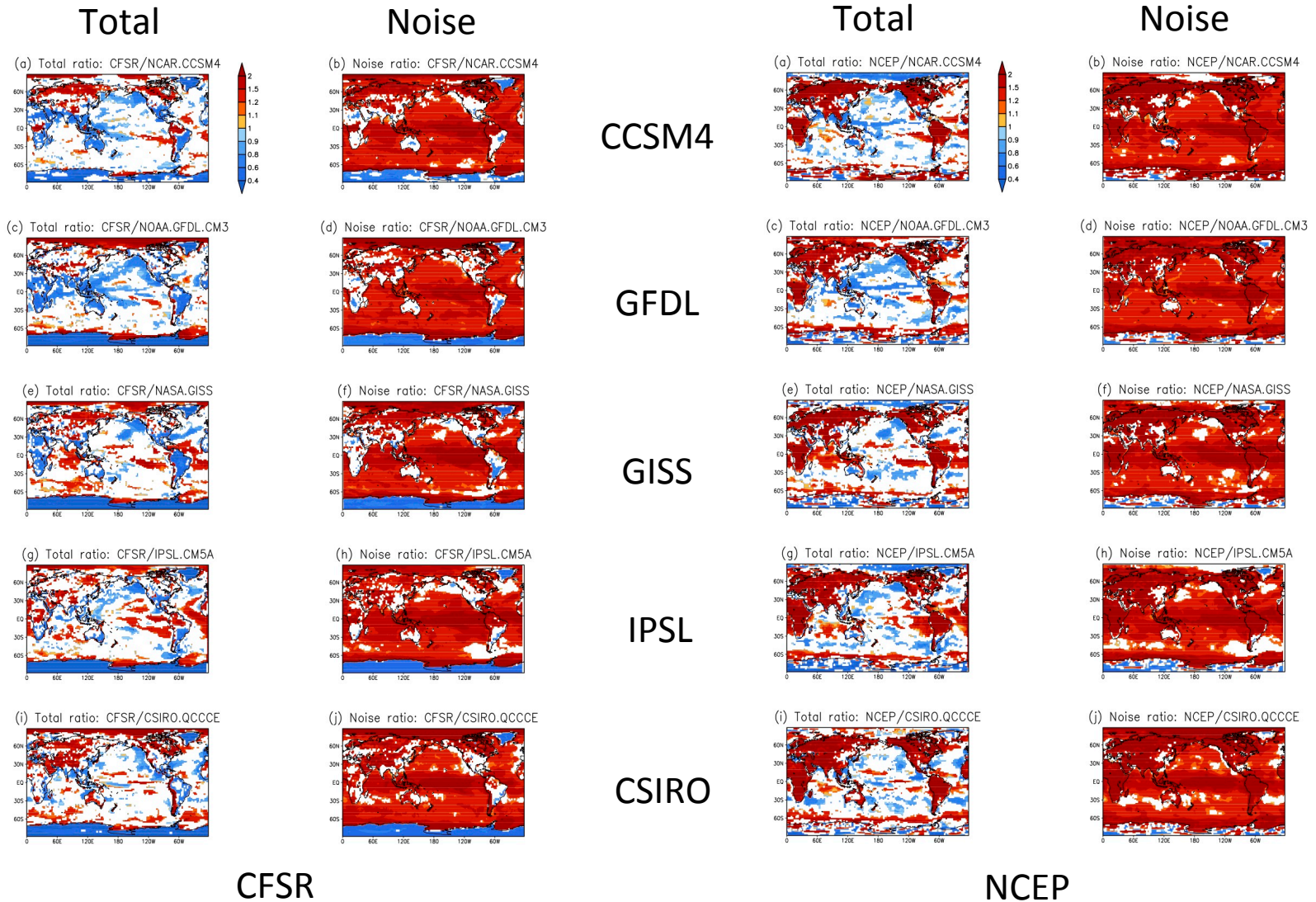
Weather Noise



Significance test:  
In shaded regions the ratio is different from 1 at the 1% significance level

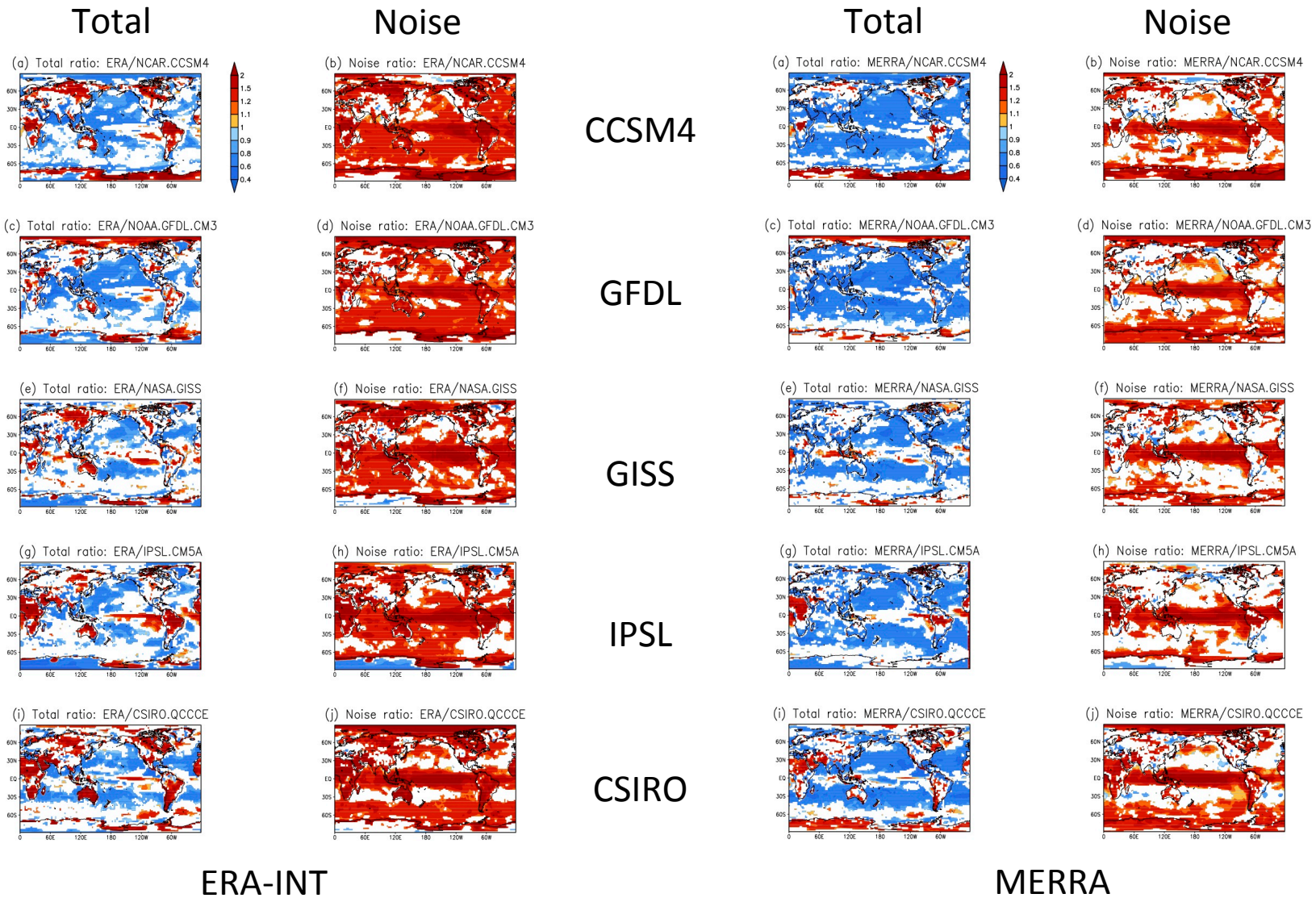


# NHF Ratios Analysis:AGCM





# NHF Ratios Analysis: AGCM



# Lag Regressions Against SST Indices

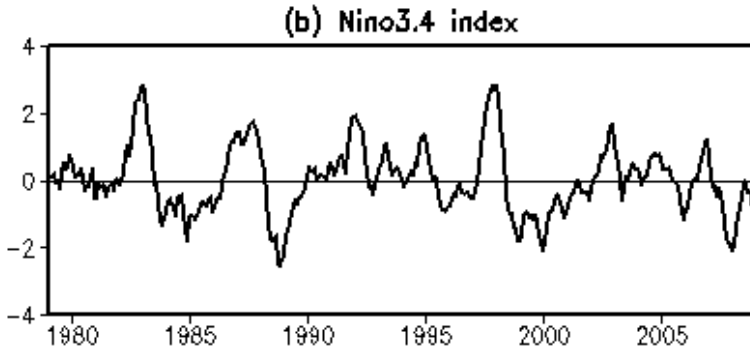
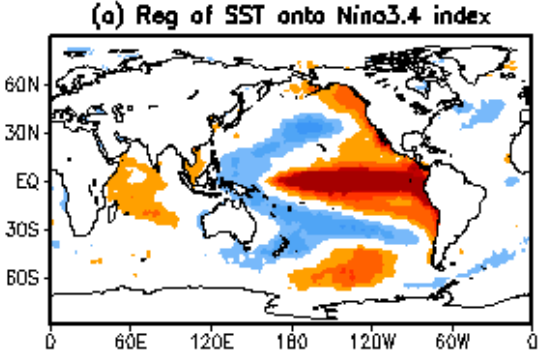
- Lag regressions with SST leading test if SST forced response is the same or different between two realizations, A and B, with the same SST:
  - Same forced response: Difference of lag regressions of A and B with SST leading zero (statistically)
  - Different forced response: Difference of lag regressions is not zero.
  - Can compare analysis with analysis, analysis with model, or model with model.

# Forcing of SST by Noise

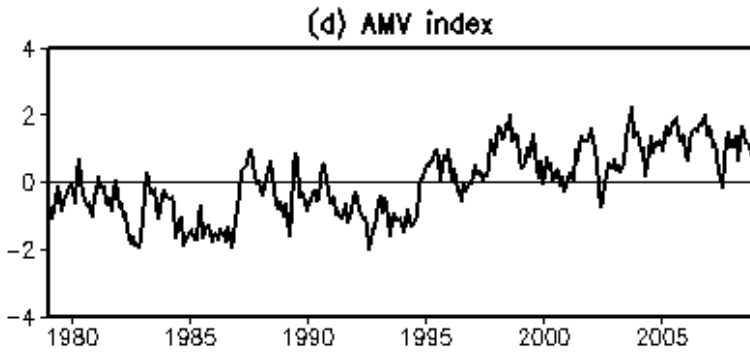
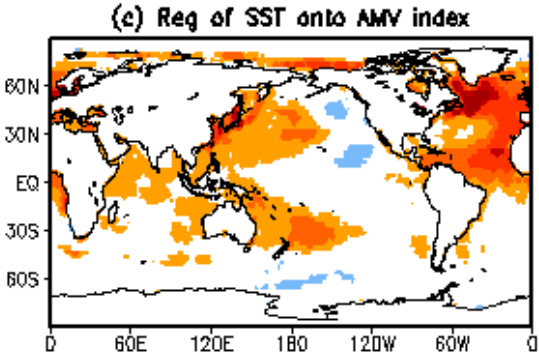
- For simultaneous regressions or when SST is lagging, forcing of the observed SST by weather noise is possibly important if the lag regressions of analysis A and model B are different.

# SST Indices

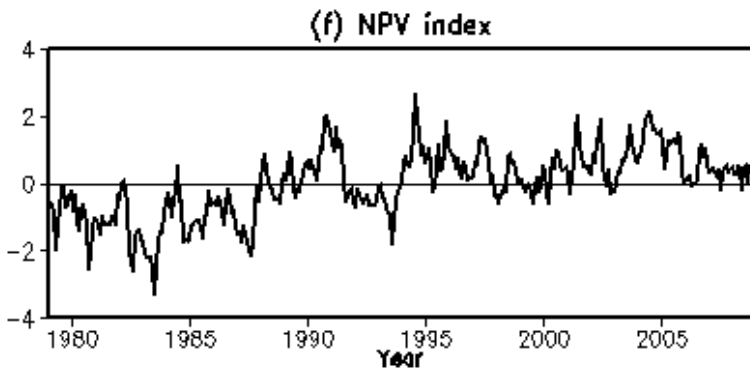
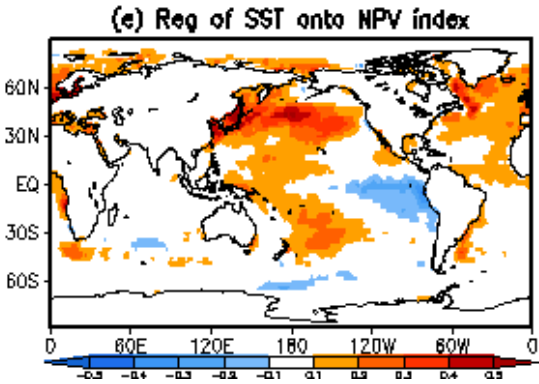
NINO3.4



AMV



NPV



# AMV-NHF Lag Regressions

AMV leads

Simultaneous

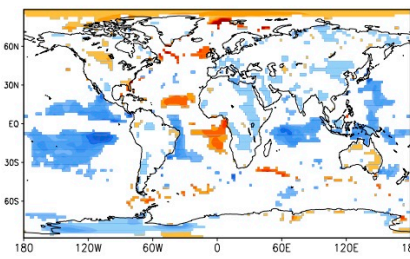
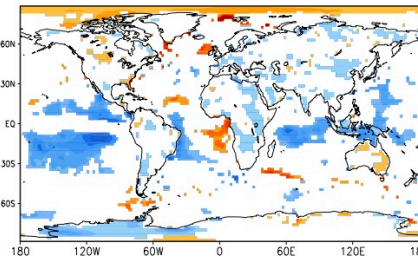
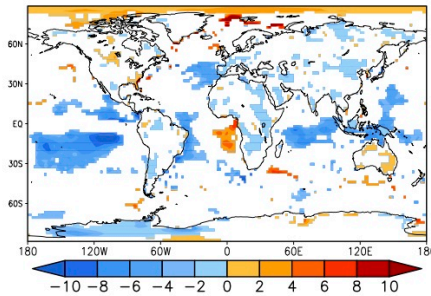
AMV lags

(a) SST leads, ERA

(b) Simultaneous, ERA

(c) SST lags, ERA

ERA

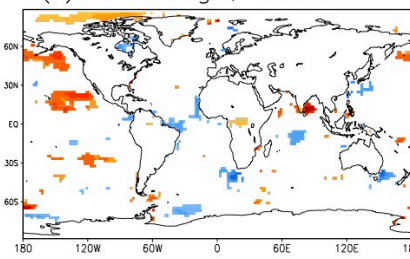
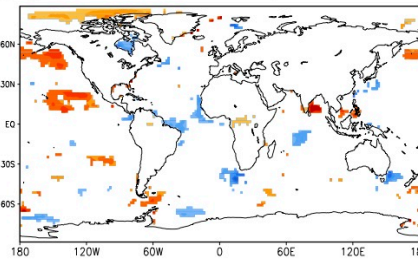
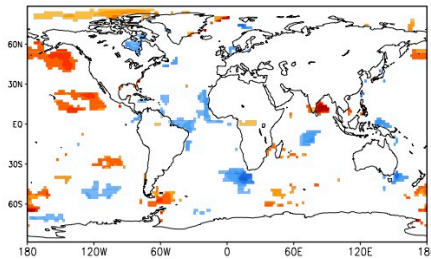


(d) SST leads, CCSM4

(e) Simultaneous, CCSM4

(f) SST lags, CCSM4

CCSM4

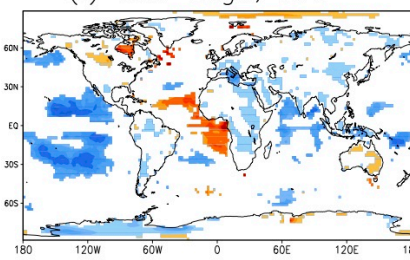
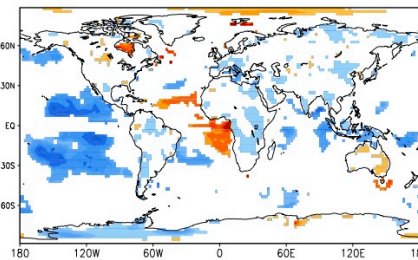
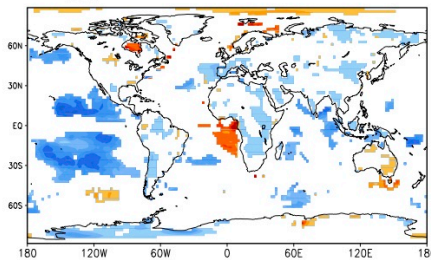


(g) SST leads, Diff

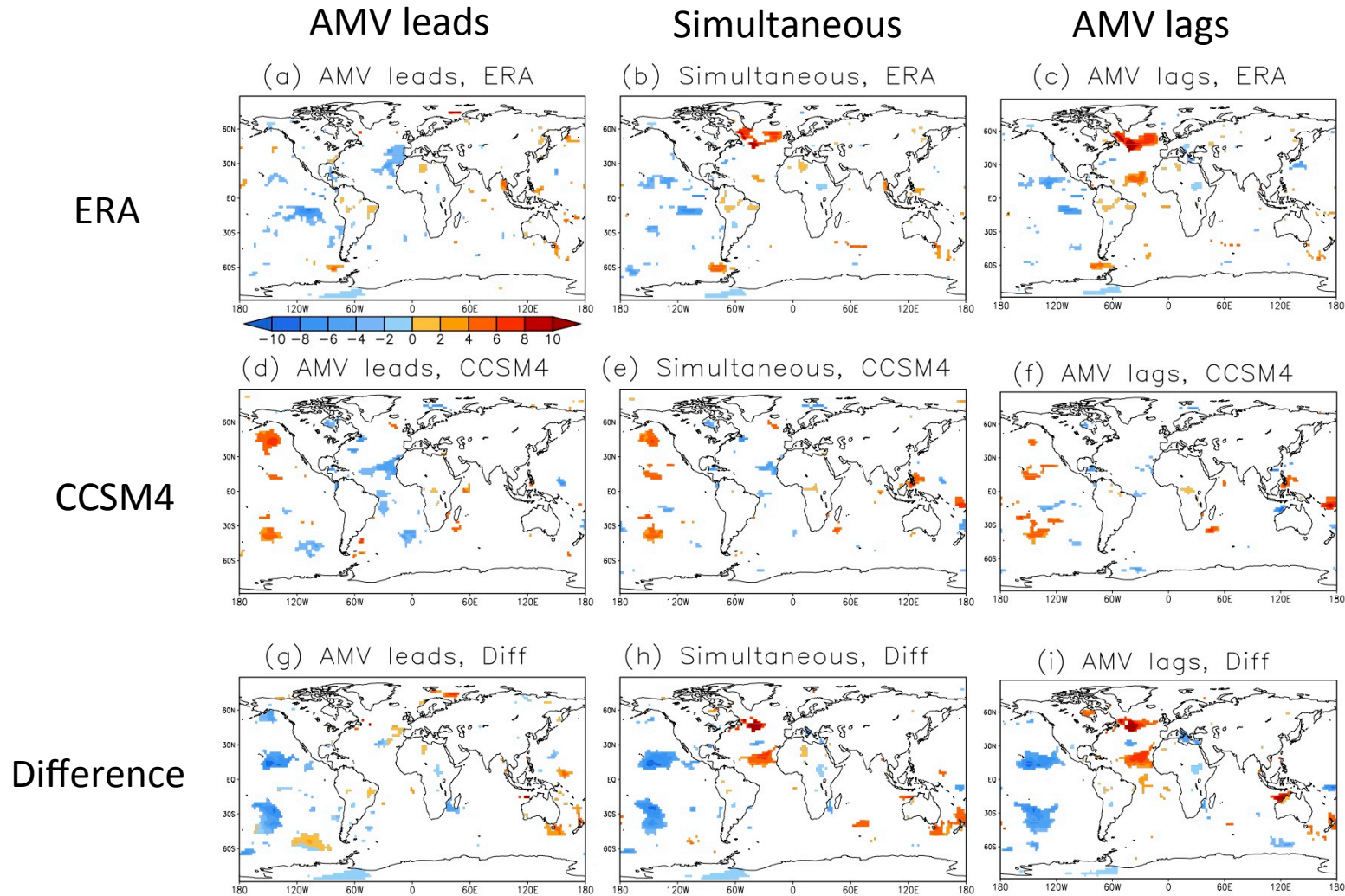
(h) Simultaneous, Diff

(i) SST lags, Diff

Difference



# Detrended AMV-NHF Lag Regressions

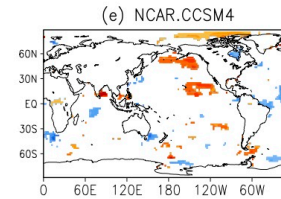
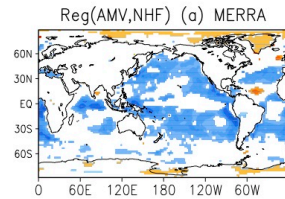


# Simultaneous Regression AMV-NHF

Reanalysis

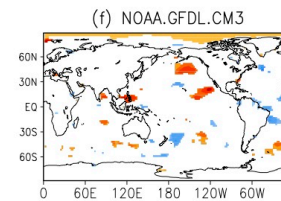
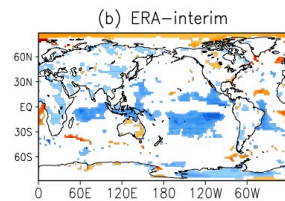
Model

MERRA



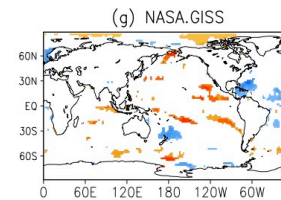
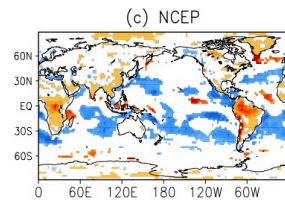
CCSM4

ERA



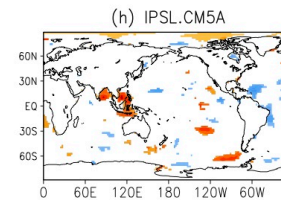
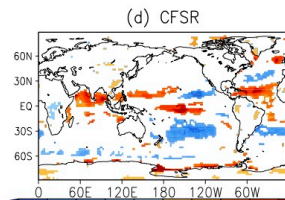
GFDL

NCEP

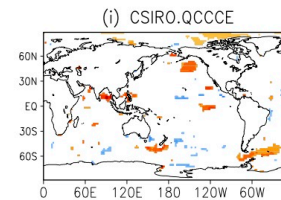
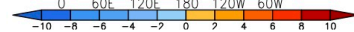


GISS

CFSR



IPSL

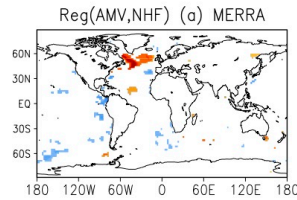


CSIRO

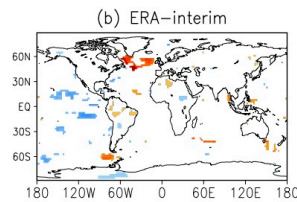
# Simultaneous Regression Detrended AMV-NHF

Reanalysis

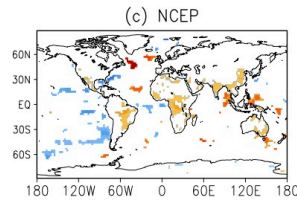
MERRA



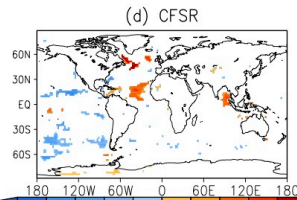
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NCEP

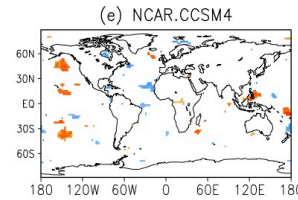


CFSR

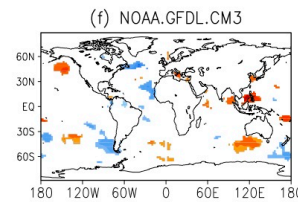


Model

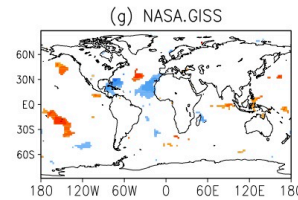
CCSM4



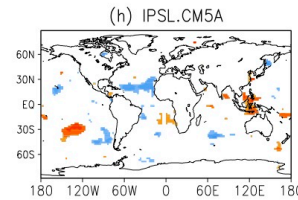
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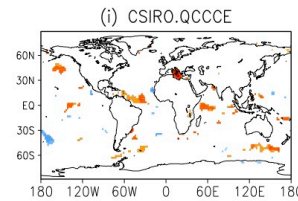
GISS



IPSL



CSIRO



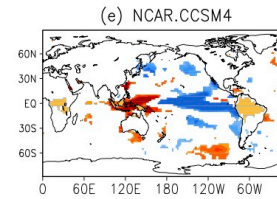
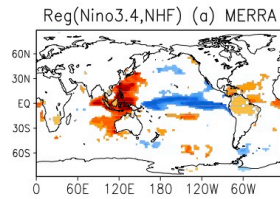


# Simultaneous Regression NINO3.4-NHF

Reanalysis

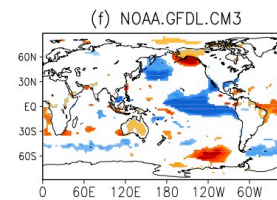
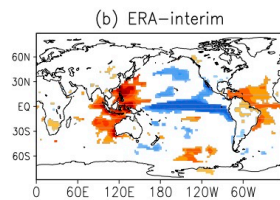
Model

MERRA



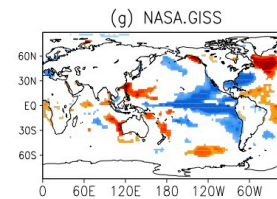
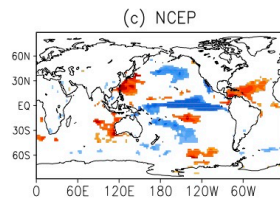
CCSM4

ERA



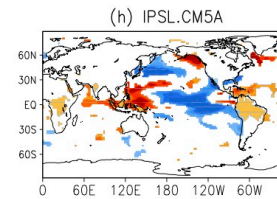
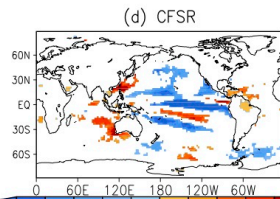
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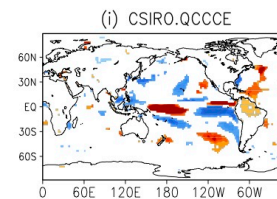
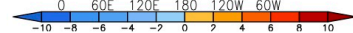


GISS

CFSR



IPSL

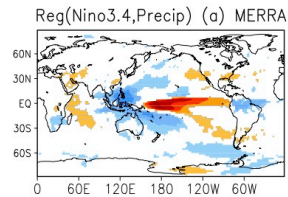


CSIRO

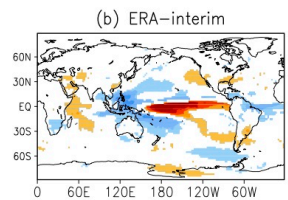
# Simultaneous Regression NINO3.4-Precip

Reanalysis

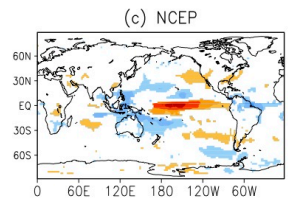
MERRA



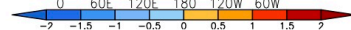
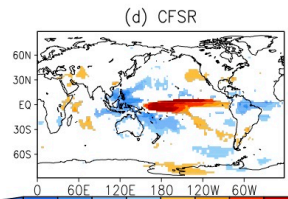
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NCEP

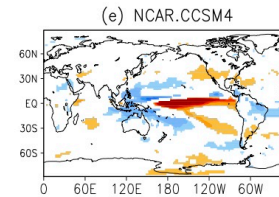


CFSR

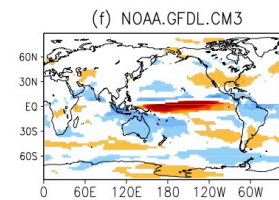


Model

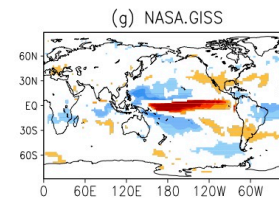
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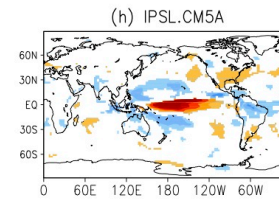
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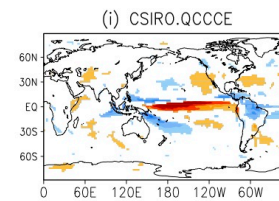
GISS



IPSL



CSIRO



# Summary

- Reanalyses and CMIP5 AMIP models provide an opportunity to proceed with the C20C weather noise project of estimating the of the weather noise in the observed 20<sup>th</sup>/21<sup>st</sup> century atmosphere and its uncertainty.
- According to our understanding of the properties of the weather noise in coupled and uncoupled systems, ERA-Int and MERRA reanalyses are most consistent with the CMIP5 models.
- Lag regressions indicate that weather noise forcing is an important forcing of the (detrended) AMV, but not of ENSO.