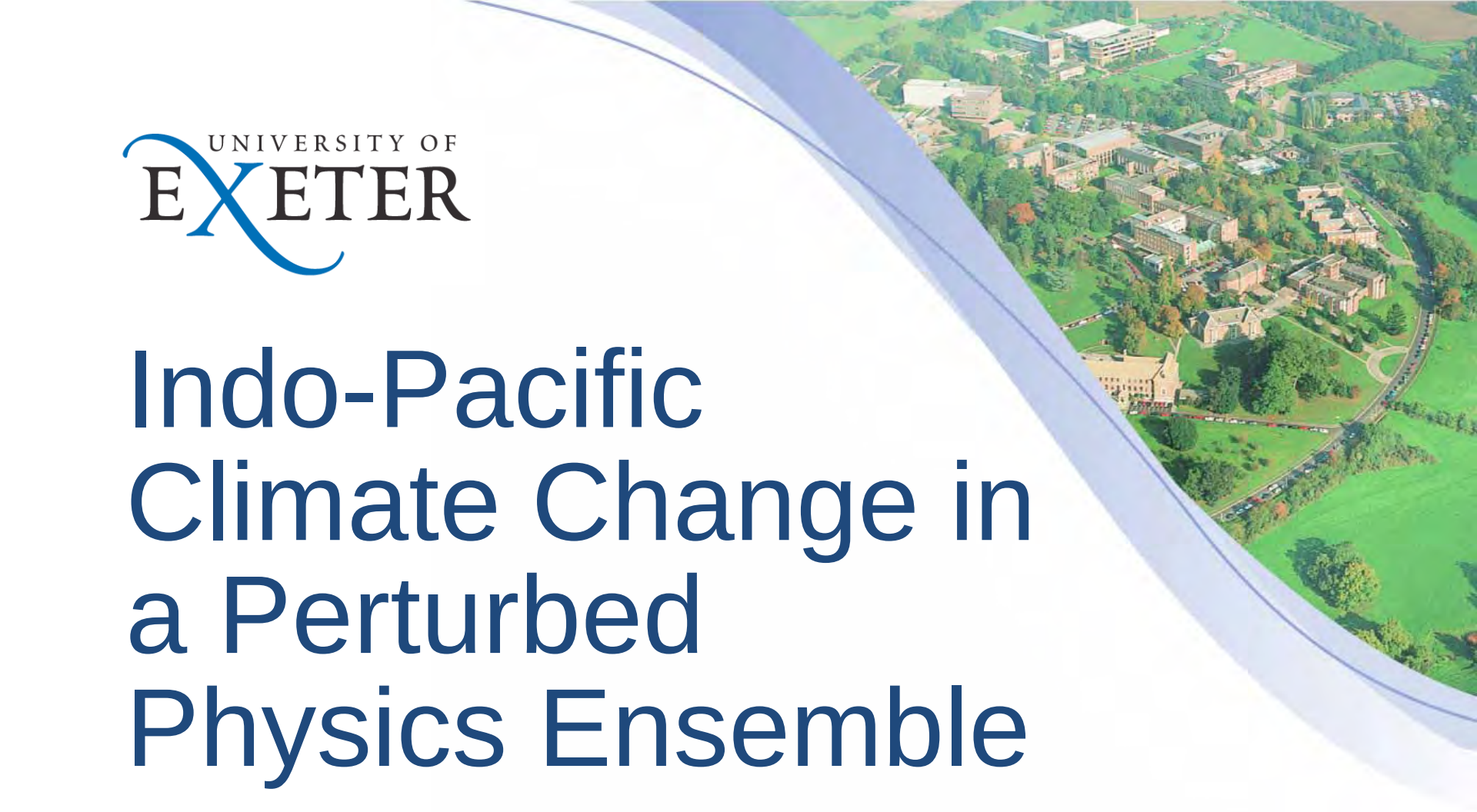


Indo-Pacific Climate Change in a Perturbed Physics Ensemble

Mat Collins, Exeter Climate Systems, College of Engineering, Mathematics and Physical Sciences, University of Exeter

Perturbed Physics Experiments

- HadCM3 experiments with flux adjustments used to prevent drift
- Standard model parameters
- 16 members with perturbations to atmosphere parameters
- 16 members with perturbations to ocean parameters
- 33 in total
- Scenarios: 1xCO_2 control, 1%/year CO_2 increase, historical forcing, SRES A1B
- Also, multi-century unforced 1xCO_2 run with non-flux-adjusted HadCM3

Perturbed Physics Experiments

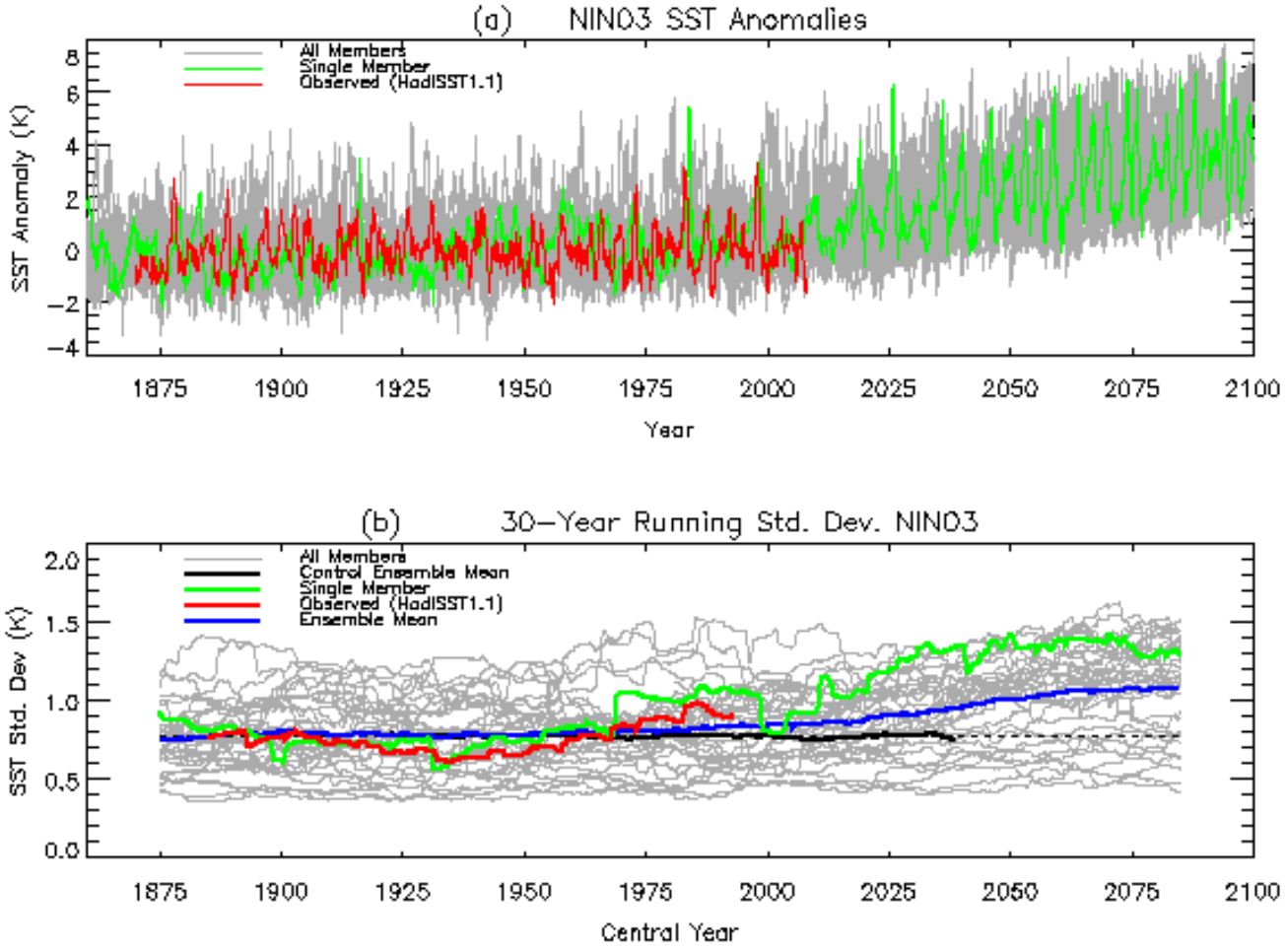
Advantages:

- Systematic investigation of uncertainties
- Can increase signal-to-noise for some problems

Disadvantages:

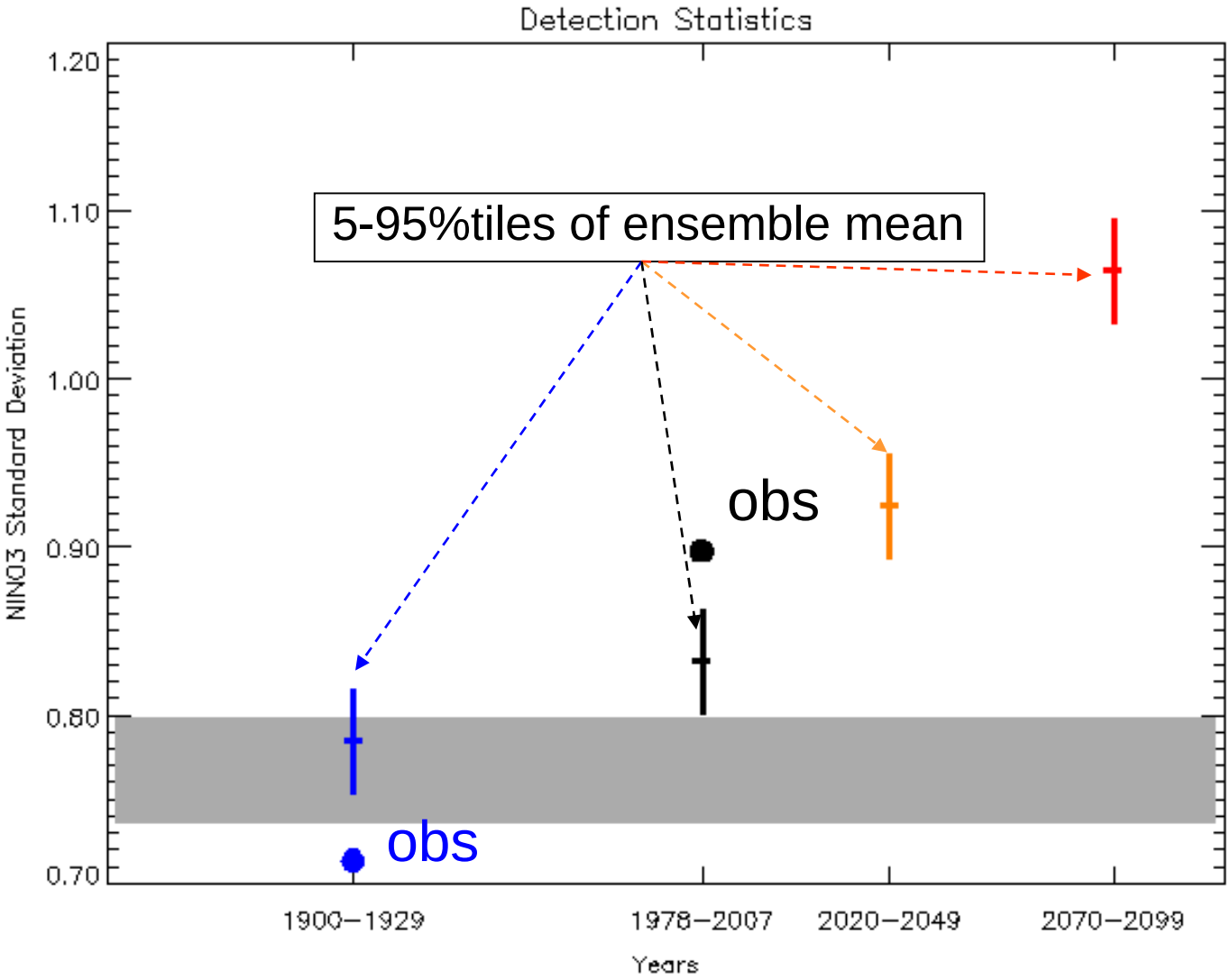
- Cannot sample “structural” uncertainties
- Not enough ensemble members for full Bayesian statistical treatment

ENSO and Climate Change



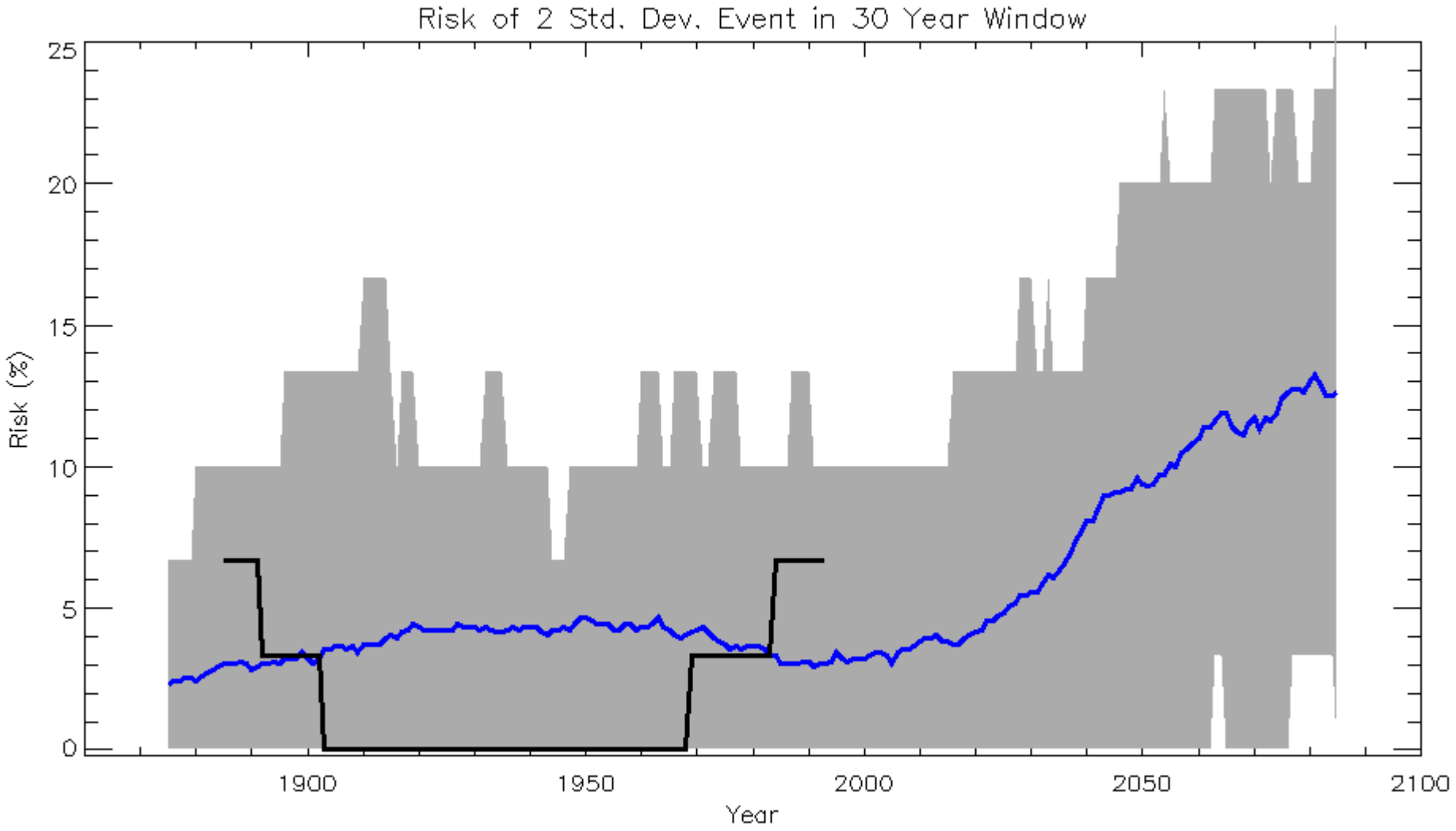
- 33 ensemble members
- Anthro and natural forcings
- SRES A1B
- Mean ENSO strength and frequency is sensitive to forcing in 20th and 21st centuries

Detection: Ensemble Mean Std. Dev. 30-year NINO3

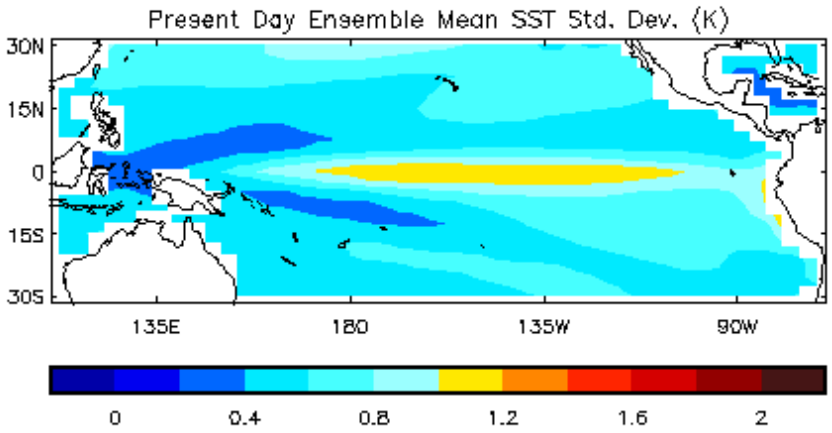


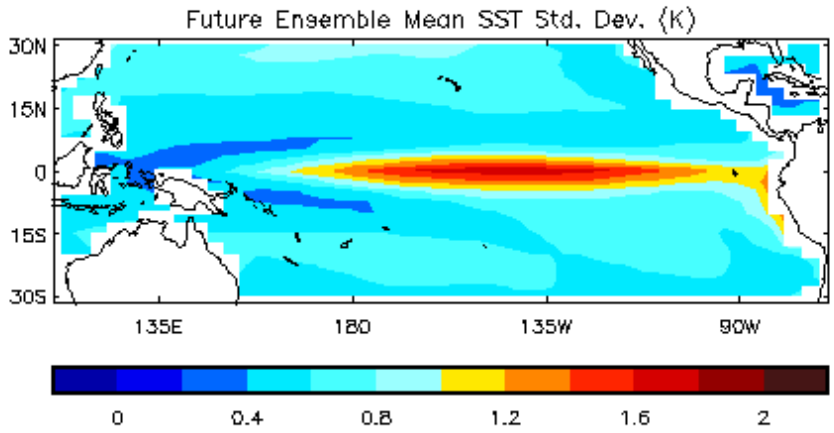
Natural variability
5-95%tiles

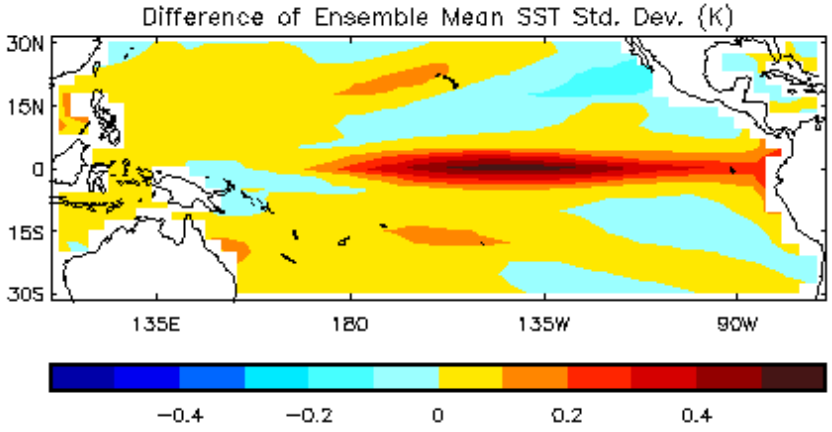
Risk of Large El Nino Event

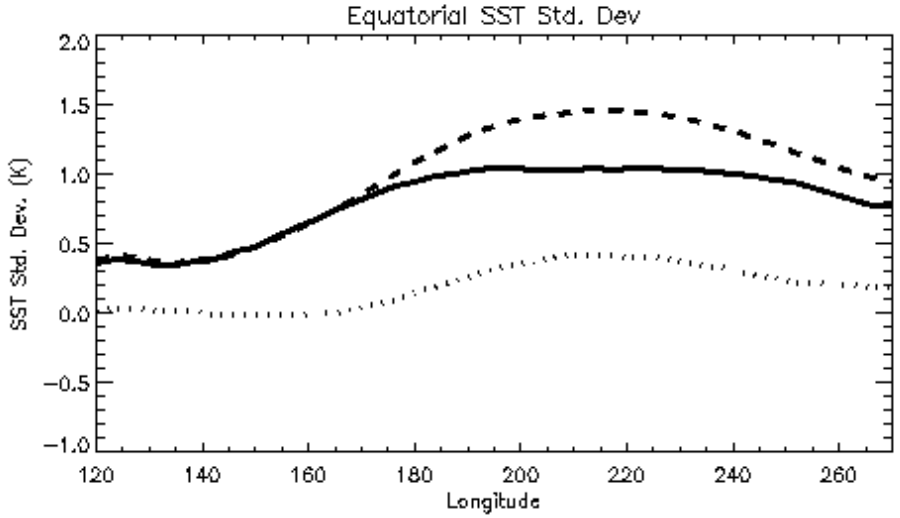


Switch to Modoki/Central Pacific ENSO?

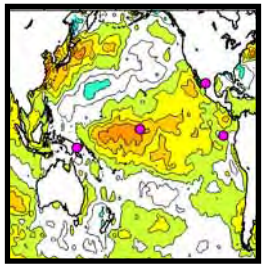






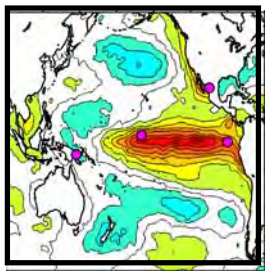


Unforced variability in ENSO ‘modes’

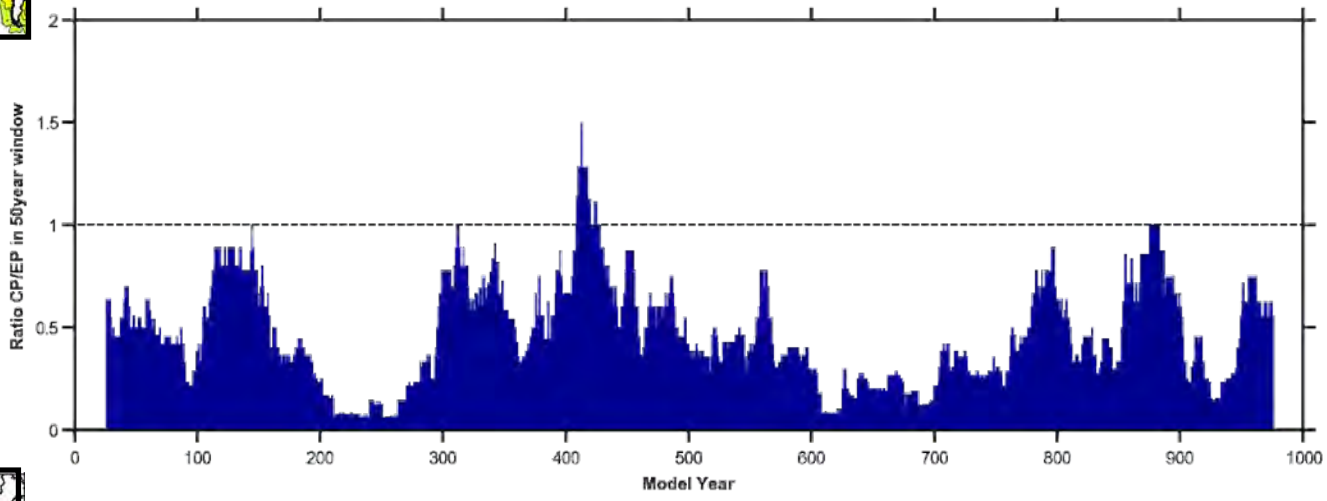


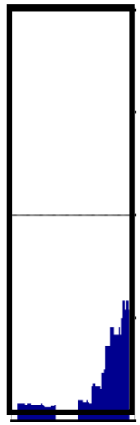
‘CP’

‘EP’



Ratio of El-Niño event types in moving 50yr window



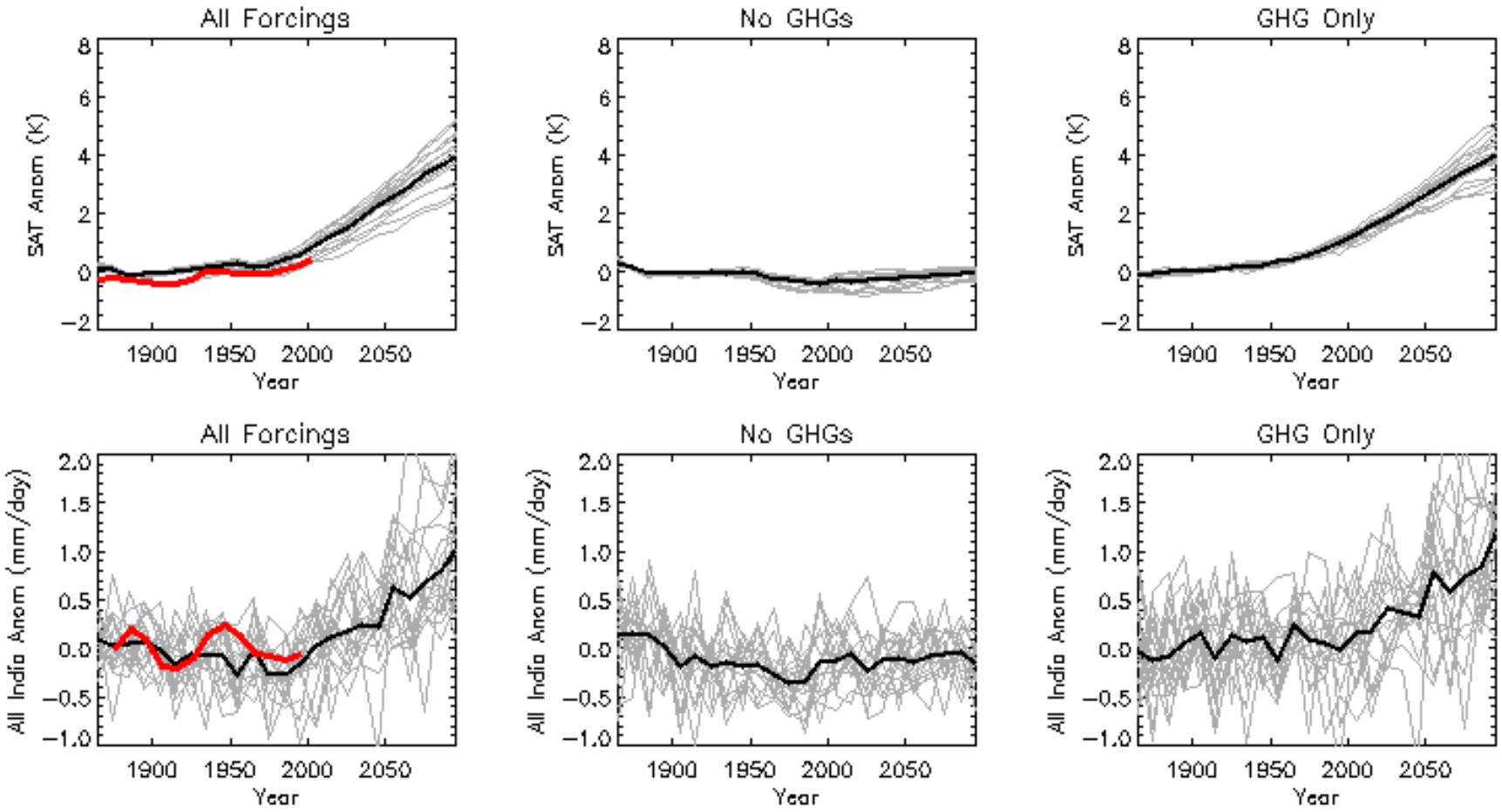


HadCM3
Control run

HadISST

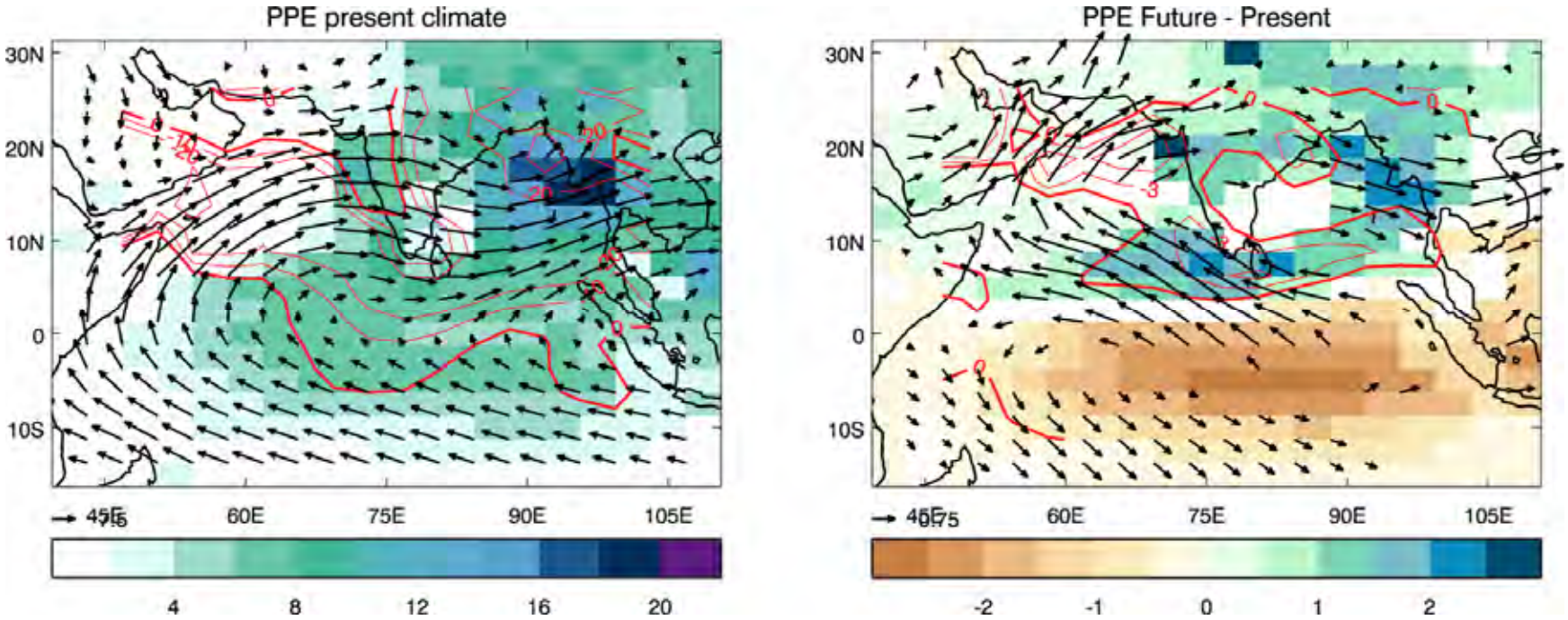
Tom Russon et al.

Indian Monsoon Changes



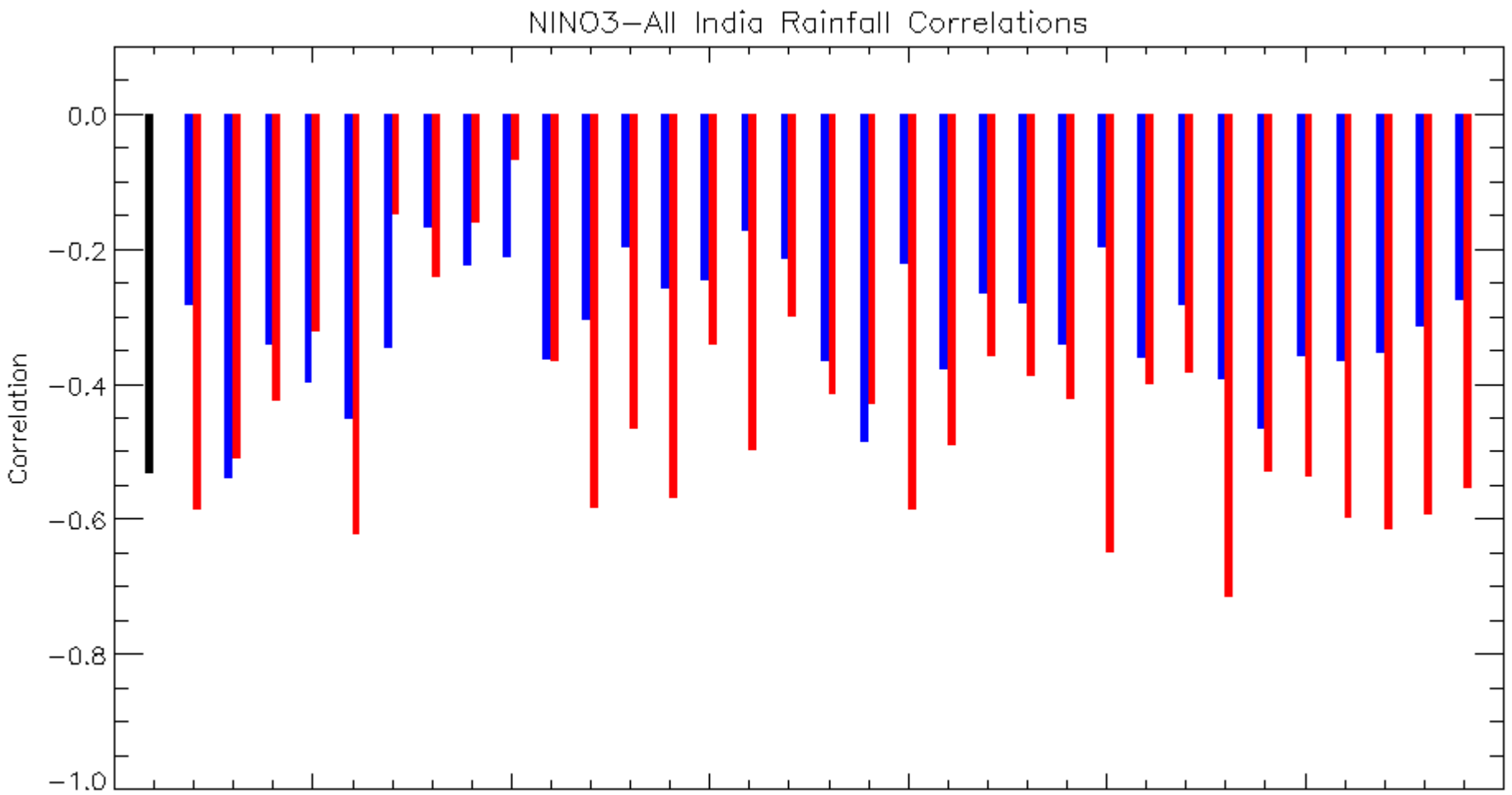
JJAS global mean temperature and All-India rainfall anomalies

Indian Monsoon Changes



B. Bhaskaran et al. Spatial distribution of PPE mean precipitation (shading), 850hPa winds and convergence (contours) for present day (left panel) and future change (right panel. The change values that are not significant at 95% are omitted. Precipitation is in mm/day, winds are m/s and convergence is in units of 10^{-6}/s.

ENSO-Monsoon Teleconnection



JJAS NINO3 All-India rainfall correlations for past (blue) and future (red)

Summary

- PPE experiments show increasing risk of large El Niño events
- However no clear shift to Modoki/Central Pacific mode
- Long HadCM3 control experiment suggest recent Modoki trends may be natural
- Increases in Indian Monsoon rainfall have been ‘held back’ by aerosol forcing but are now ready to be ‘released’
- Northward shift in monsoon flow pattern and increase in ENSO-monsoon teleconnection

Notation

$$c = M(p, R)$$

M = model/function
c = climate variable
p = model parameters/inputs
R = radiative forcing
Subscript h=historical, f=future
o = observations

$$c_h = M(p, R_h)$$

$$c_f = M(p, R_f)$$

General Algorithm:

- Run model/evaluate function at many different input parameters for historical radiative forcing
- Compute metric of fit between model output and observations
- Weight future projections according to the value of the metric

$$m = (c_h - o)^T (c_h - o) = \sum (c_h - o)^2$$

$$w = \exp\left(-\frac{1}{2}\sum (c_h - o)^2\right)$$