

# Towards detection and attribution of changes in extremes

Gabriele Hegerl,  
Nicholas School of the  
Environment, Duke University

Nikos Christidis, Xuebin Zhang, Francis  
Zwiers, Peter Stott, Slava Kharin, and  
Jesse Kenyon.

# Detection and attribution of climate change

- “detection”: significantly different from internal climate variability (usually estimated from model ctls)?
- “attribution”: can this change be attributed to a combination of external forcings (eg greenhouse gas and aerosol) ruling out other explanations (eg natural only?)
- **Fingerprint methods, determine amplitude of model fingerprints in observations (scaling factors)**
- **Fingerprints: large-scale changes in statistics of extremes**

# Temperature extremes

- “Perfect model study” using HadCM3 and CGCM2 data (Hegerl et al. 04):
- **Study using gridded observed daily data (John Caesar): Christidis, Stott, Brown, and Hegerl submitted**

# Detection of changes in temperature extremes

Type of Index	Index
Warm Days	JJA/Tmax, 30ex, 10ex, 05 ex, 01ex
Warm Nights	JJA/Tmin, 30ex, 10ex, 05 ex, 01ex
Cold Days	DJF/Tmax, 30ex, 10ex, 05ex, 01ex
Cold Nights	DJF/Tmin, 30ex, 10ex, 05 ex, 01ex

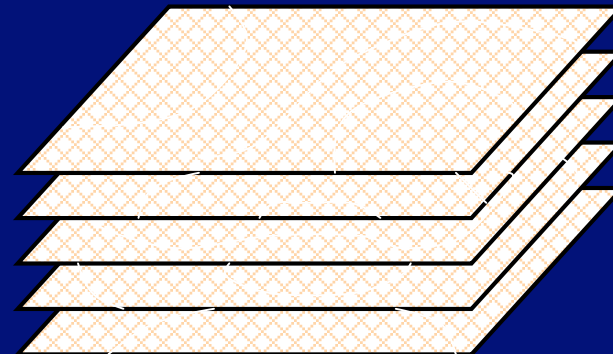
## 2-D Signal Patterns

Index mean difference between periods (obs: 1980-99 and 1950-69; perfect model: 2040-60 minus 1975-95)



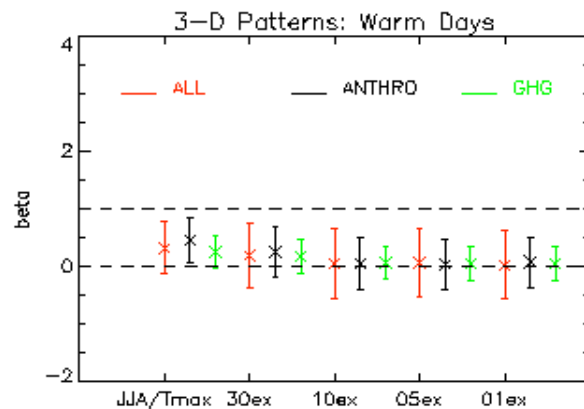
## 3-D Signal Patterns

Index mean anomalies in the 50s, 60s, 70s, 80s and 90s relative to the segment mean

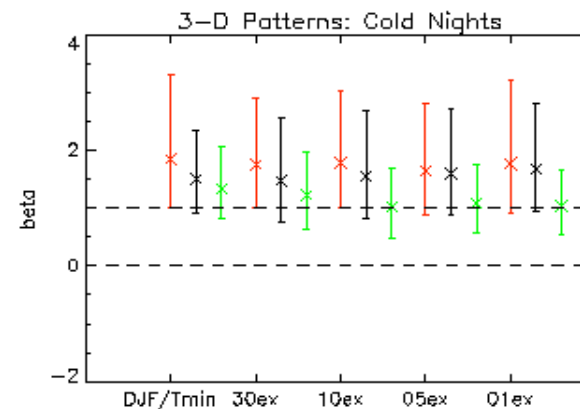
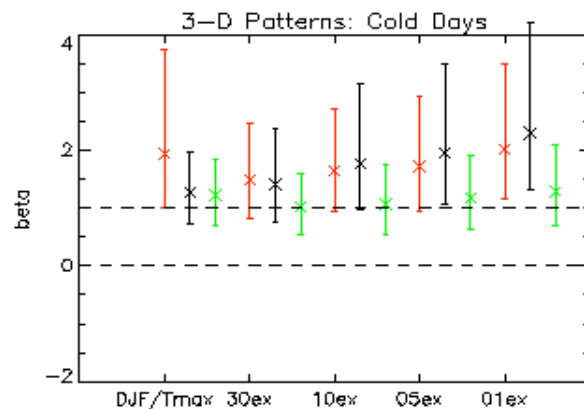
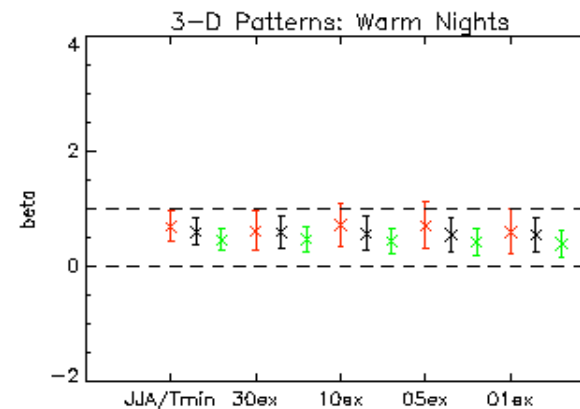


# Results for time-space pattern

No Detection (in most cases)



Detection



ALL

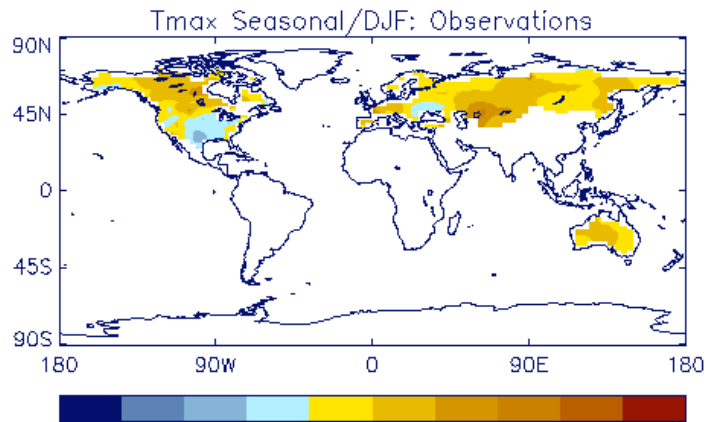
ANTHRO

GHG

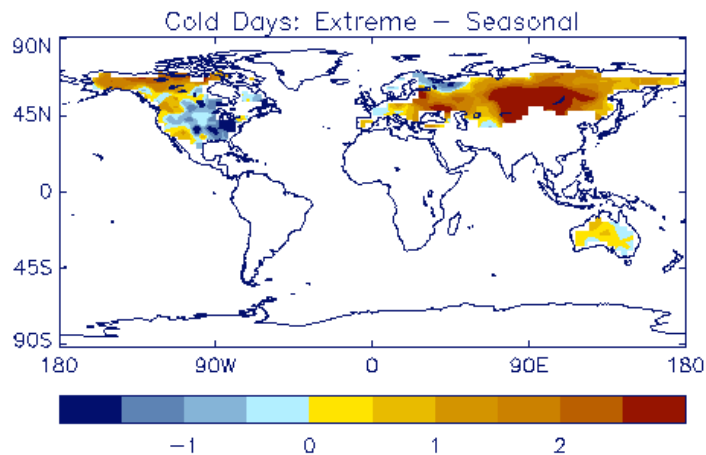
Model overestimates changes in warm extremes, underestimates cold extremes. Change in warm nights can be separated from natural forcing

# Is this just a shift?

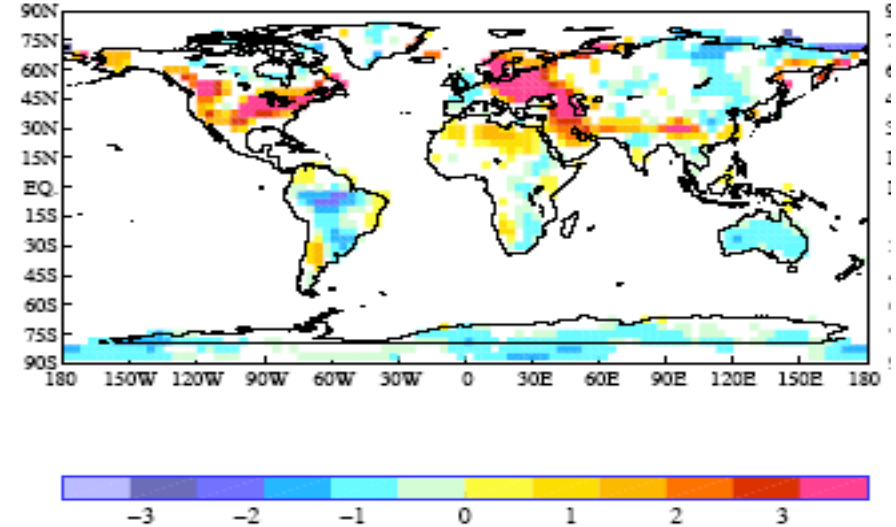
## Coldest day-DJF mean change (SH JJA mean)



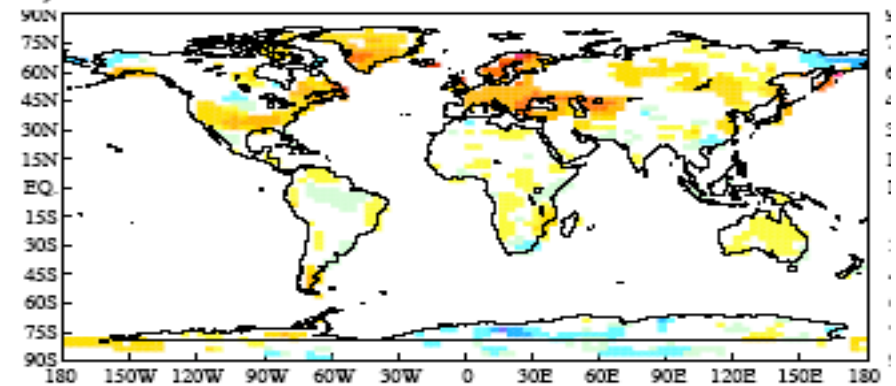
Obs extremes - DJF mean



a) CGCM2



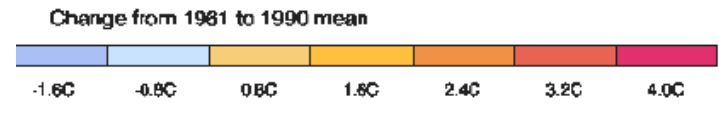
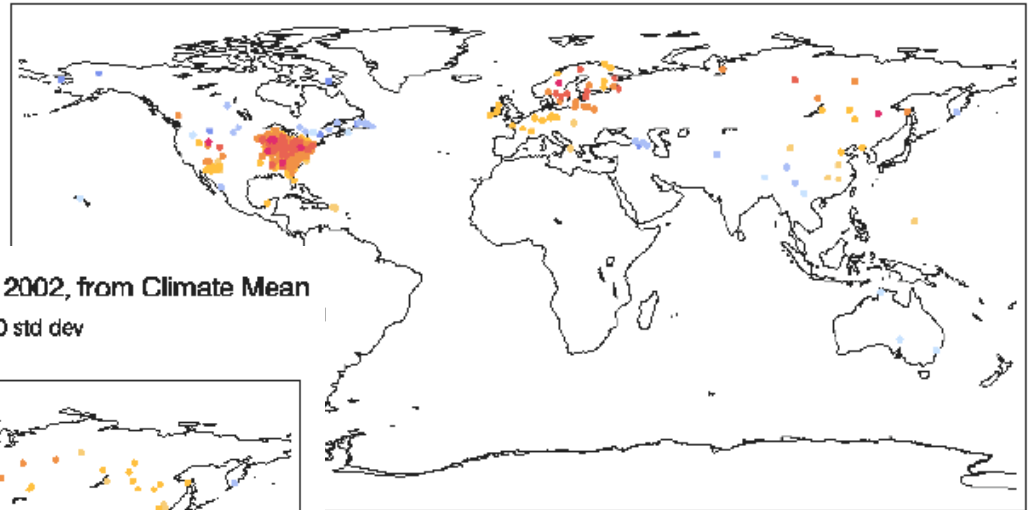
b) HadCM3



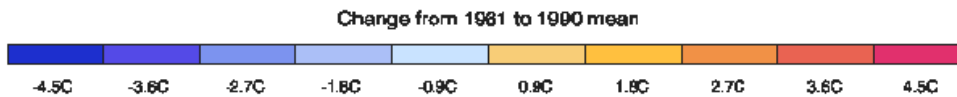
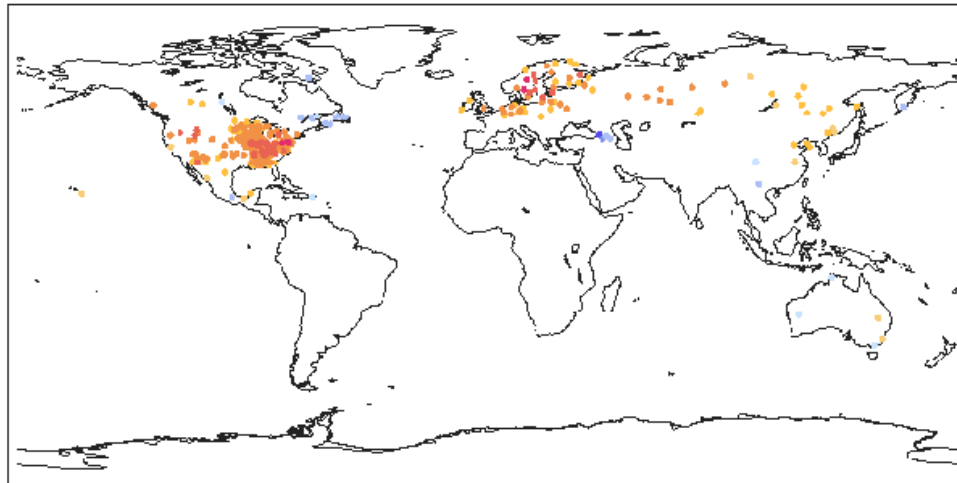
# Circulation matters! NAO+

## Tmax

TMAX Extrm Ann Low: Difference Pos NAO yrs, 1948 to 2002, from Climate Mean  
Determined by detrended NAO index > 0.300 std dev



TMIN Extrm Ann Low: Difference Pos NAO yrs, 1948 to 2002, from Climate Mean  
Determined by detrended NAO index > 0.300 std dev

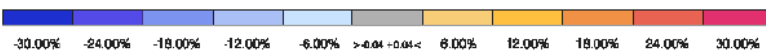
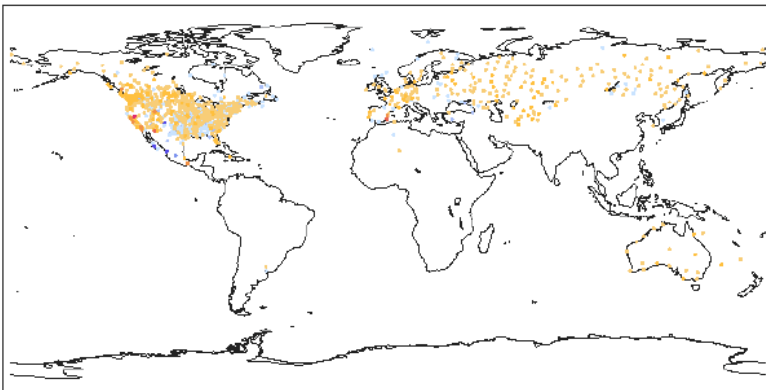


## Tmin

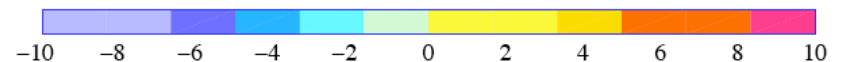
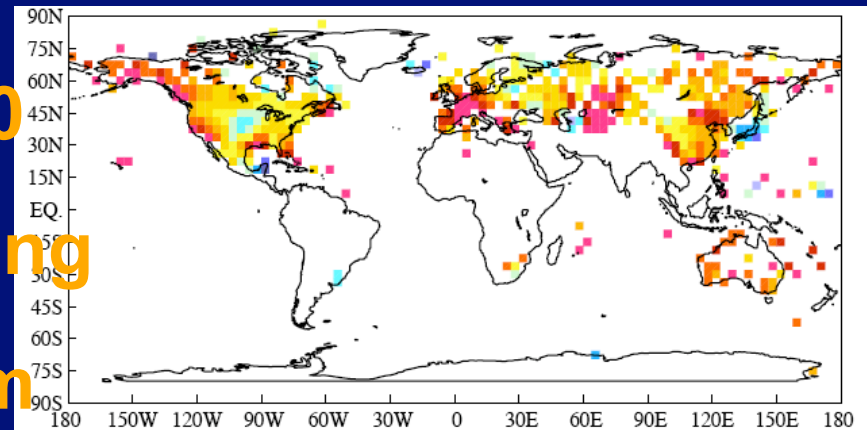
# Towards detection of changes in percentile based indices

- Tn90, Tn50, Tn10, Tx90, Tx50, Tx10 exceedance of nth percentile
- Processed using Zhang et al. method
- Data for detection in place, observations gridded based on median in gridbox

Xuebin's Temperature Index TN90  
Trend over years 1946 to 1995  
Each decade has at least 7 non-fill years

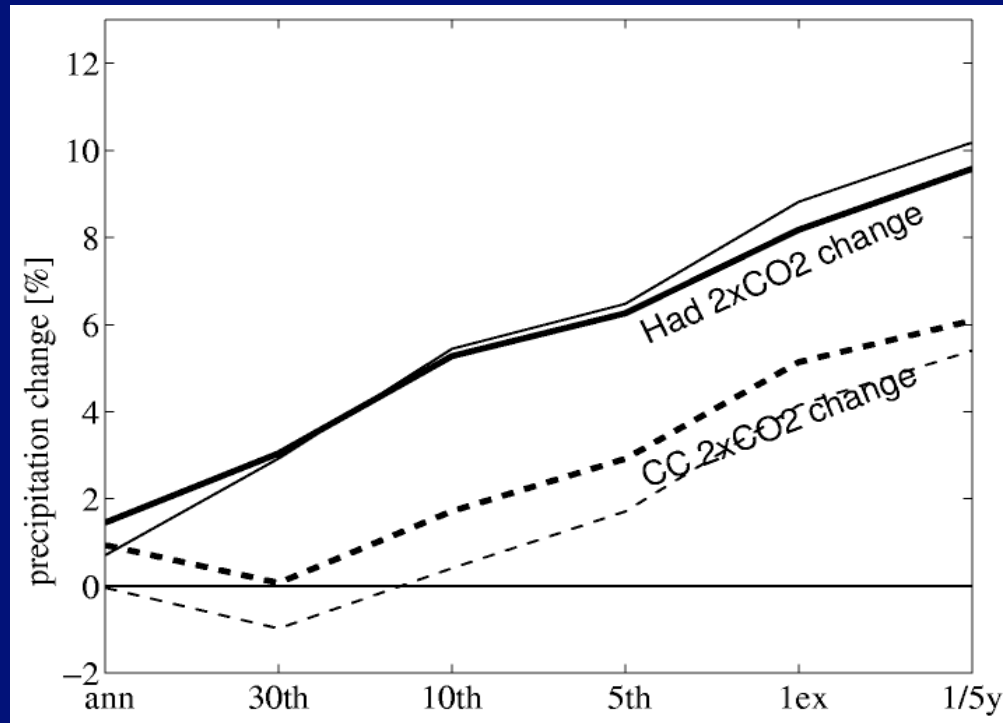


Tn90  
Gridding  
warm  
season





# Rainfall extremes



**% change  
stronger for  
extreme rainfall in  
both models**

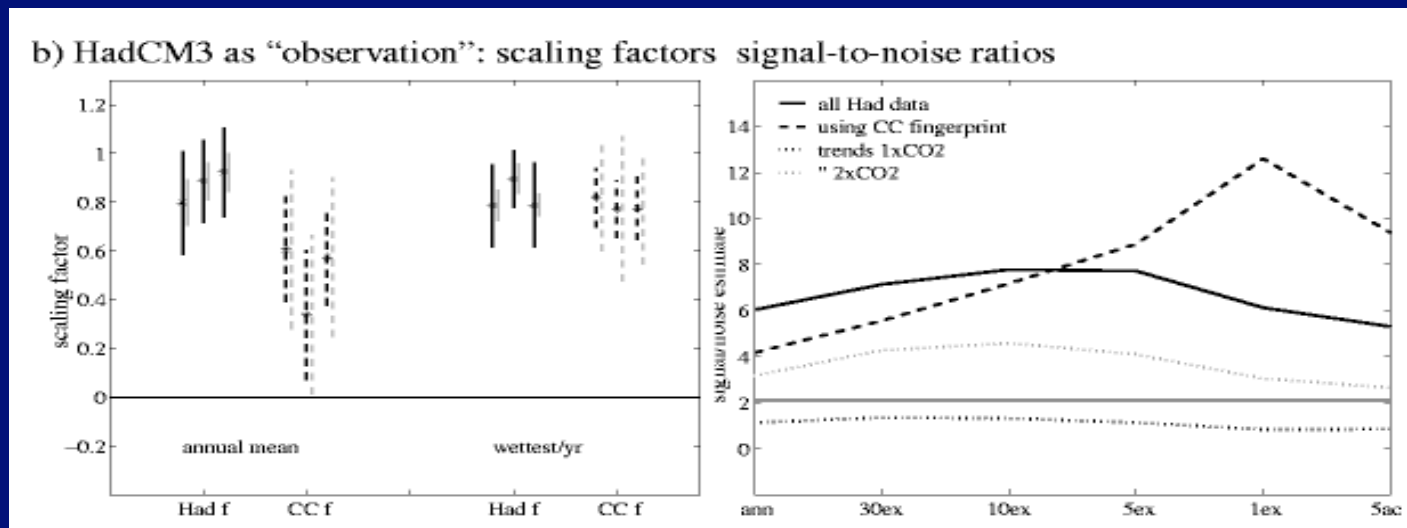
# HadCM3 vs Observed changes (caution: decorrelation scale)

Response Patterns for the Warmest Night of the Year

# Perfect model detection results for precipitation

⇒ Signal-to-noise ratio low for annual rainfall (even with ~80-yr trend) and sensitive to model uncertainty

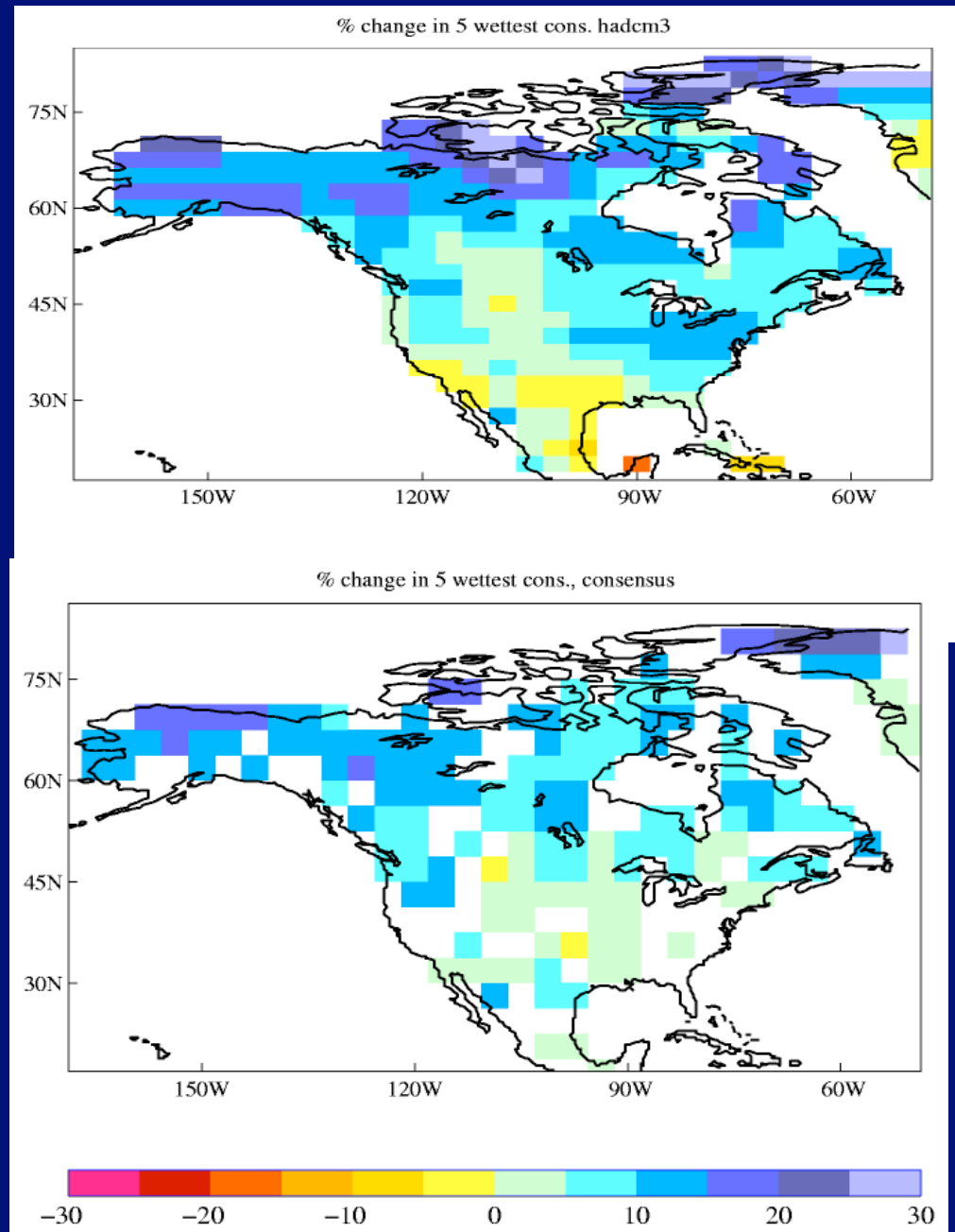
⇒ Change in extreme rainfall may be more robustly detectable



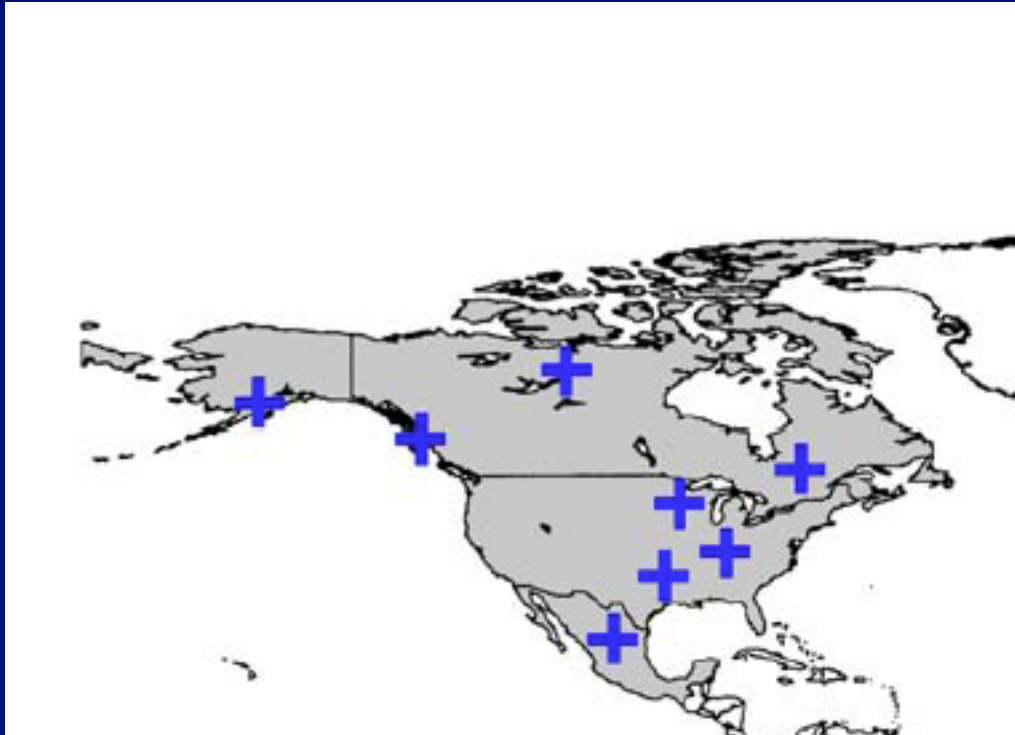
# Change in wettest 5-day event/yr

HadCm3

Consist with  
CGCM1

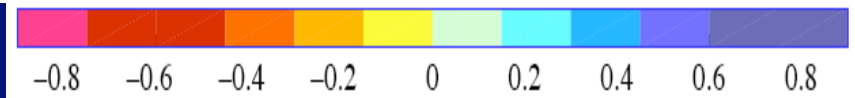
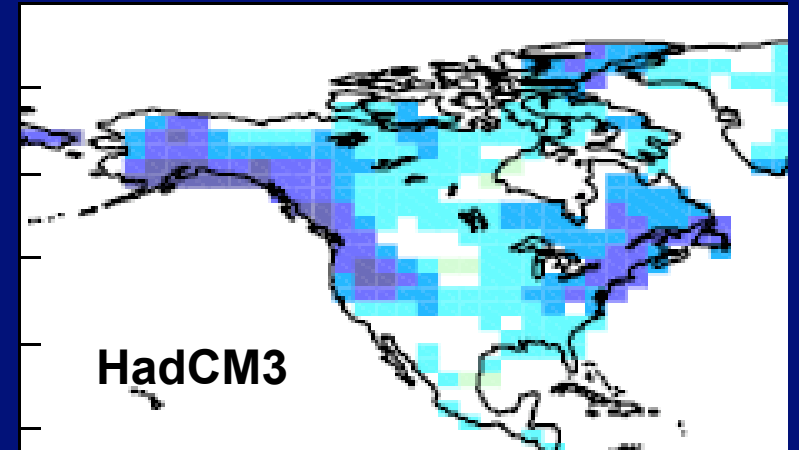
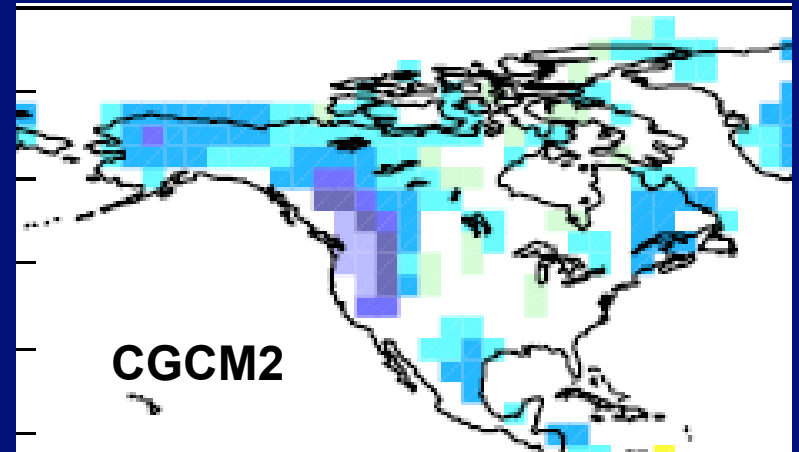


# Change in 99.7% percentile



Observed trends

Groisman et al. 2005



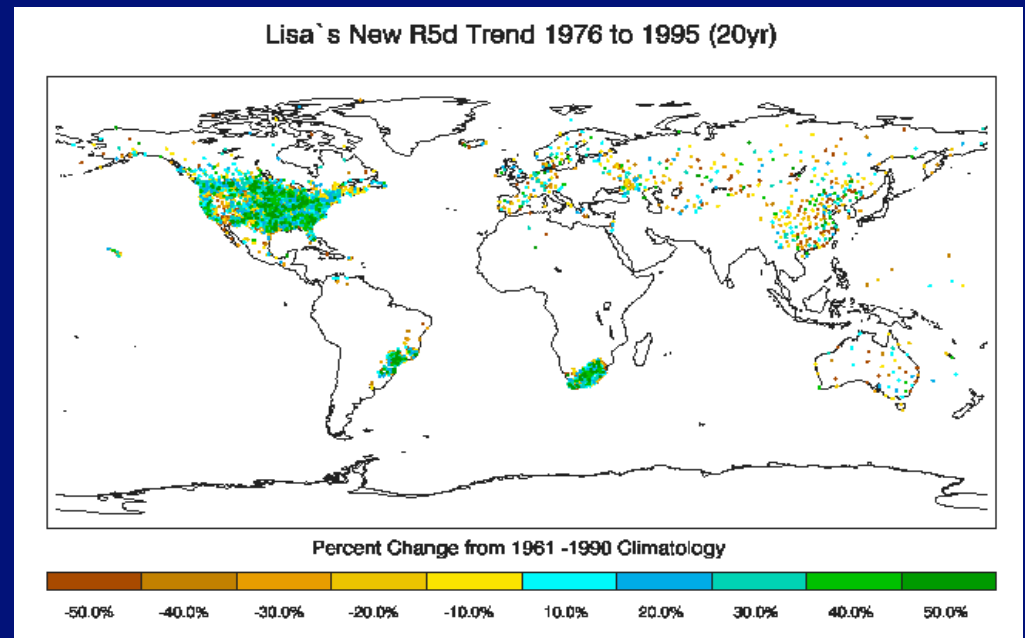
Change in #exceedances  
at 2xCO<sub>2</sub>

# Why rainfall changes are difficult to deal with

⇒ Large uncertainty

⇒ Spatial decorrelation scale

⇒ AGCM model has little skill simulating changes in rainfall (Kiktev et al.)



# Conclusions

- Changes in observed temperature extremes detectable for warm nights and cold days and nights
- Model appears to underestimate change in cold and overestimate change in warm extremes
- Changes in rainfall extremes may be more robustly detectable than changes in annual total rainfall
- Detection of in extreme rainfall in observations remains difficult (scale)
- **Indices for extremes need to be carefully selected for homogeneity in time and statistical properties**

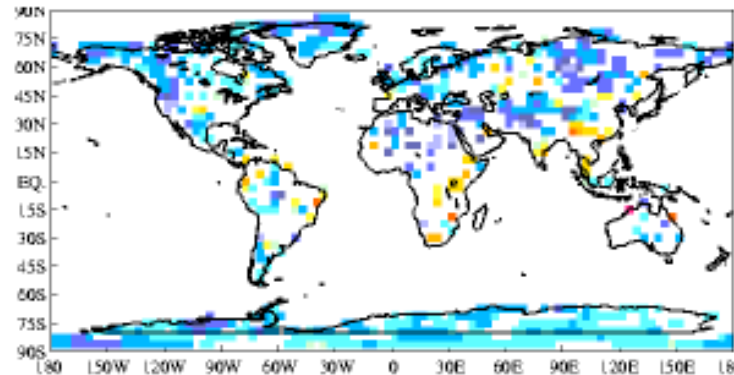




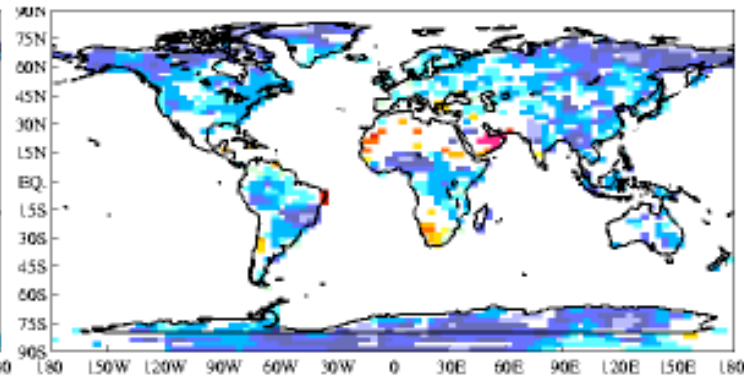
# Change in extreme rainfall

Change in wettest day/yr [%]

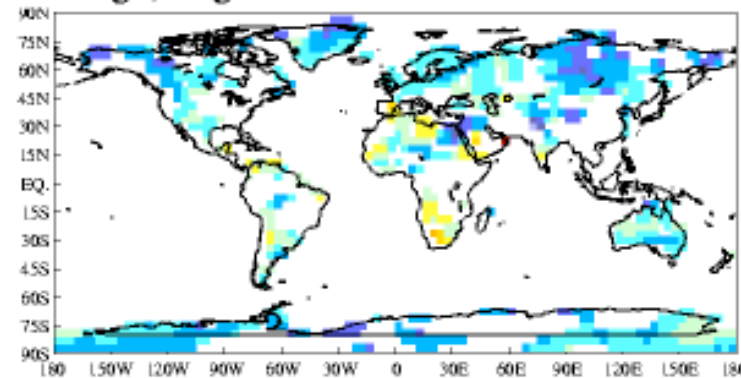
CCCma



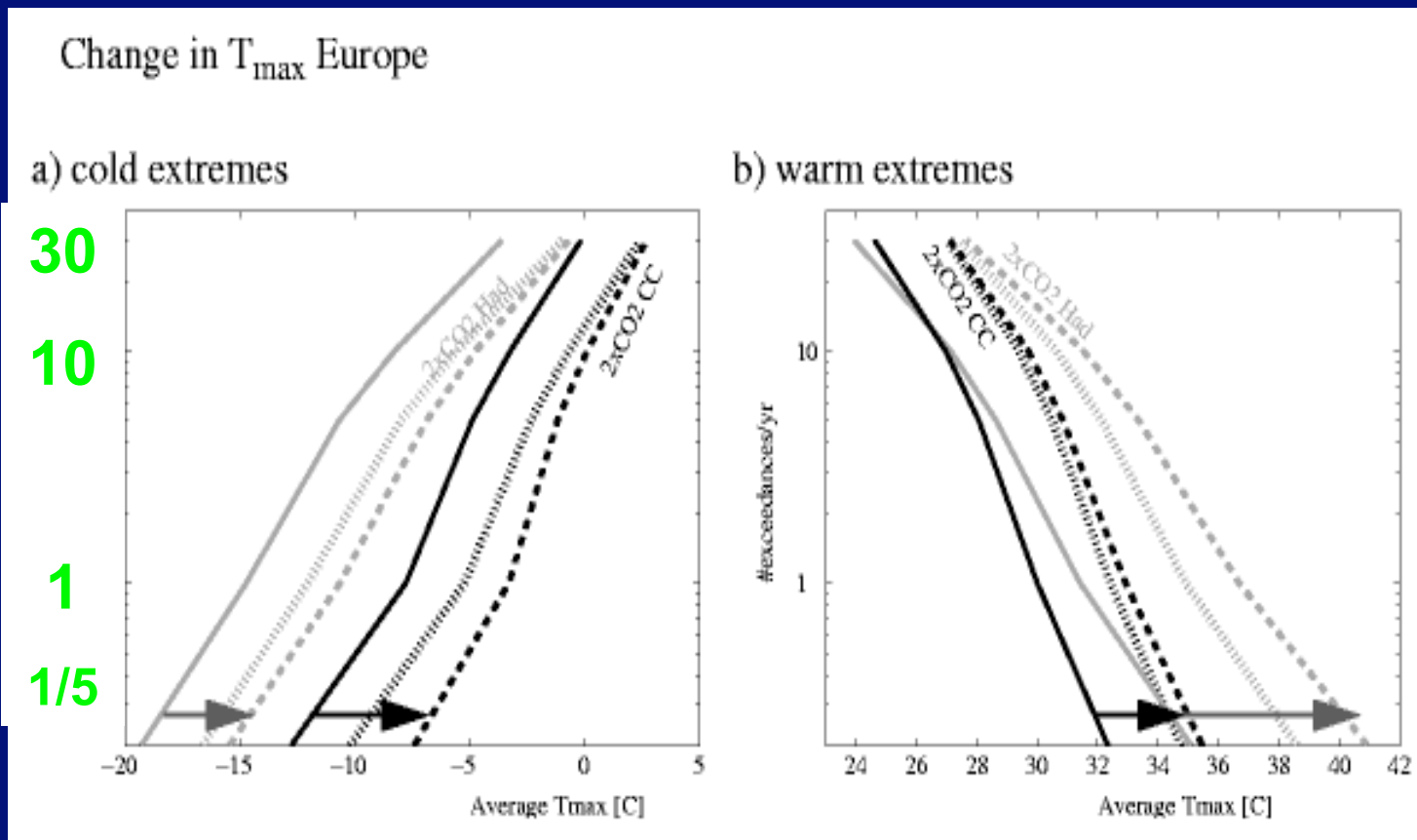
HadCM3



Average, large-scale consistent



# More than just a shift in mean T



Model at time of CO2 doubling

# Results for Warm Nights

