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NATURAL ENVIRONMENT RESEARCH COUNCIL

Irreducible uncertainty in near-term climate predictions

Ed Hawkins

National Centre for Atmospheric Science, University of Reading

Thanks to: Rowan Sutton, Emma Suckling, Robin Smith, Jonathan Gregory, David Stainforth

University of Reading

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ISSUED DECEMBER 27, 1933

IS OUR CLIMATE CHANGING? A STUDY OF LONG-TIME TEMPERATURE TRENDS

By J. B. KINCER

[Weather Bureau, Washington, D.C., Sept. 29, 1933]

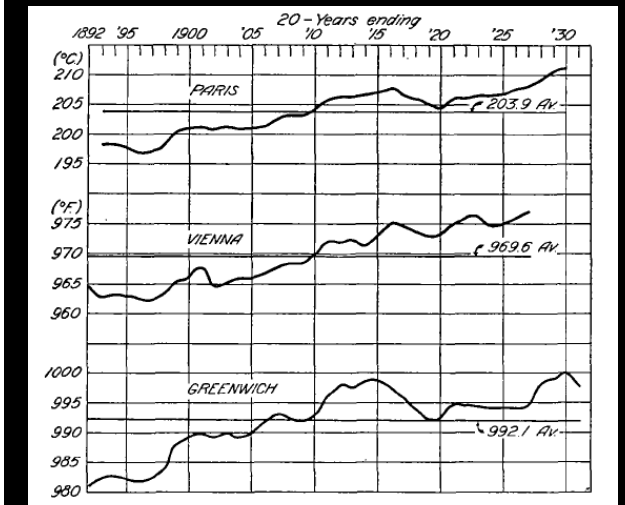

FIGURE 7.—20-year moving temperature summations, representing Europe (Paris, Vienna, and Greenwich). Data in table 1.

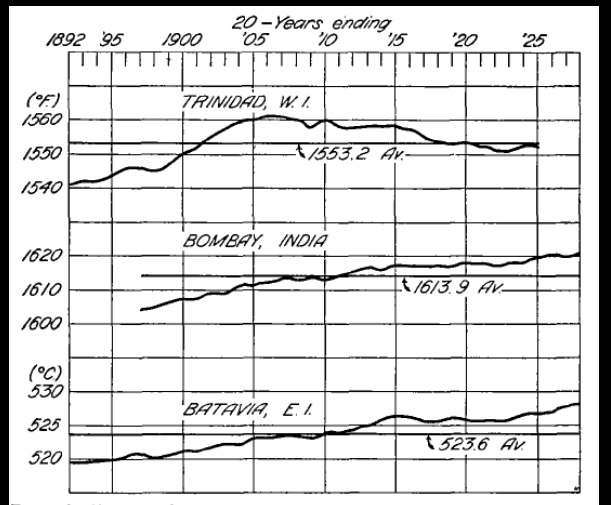

FIGURE 9.—20-year moving temperature summations, representing low latitudes (Trinidad, West Indies; Bombay, India; and Batavia, East Indies). Data in table 1.

Kincer (1933)

Simulating climate variability

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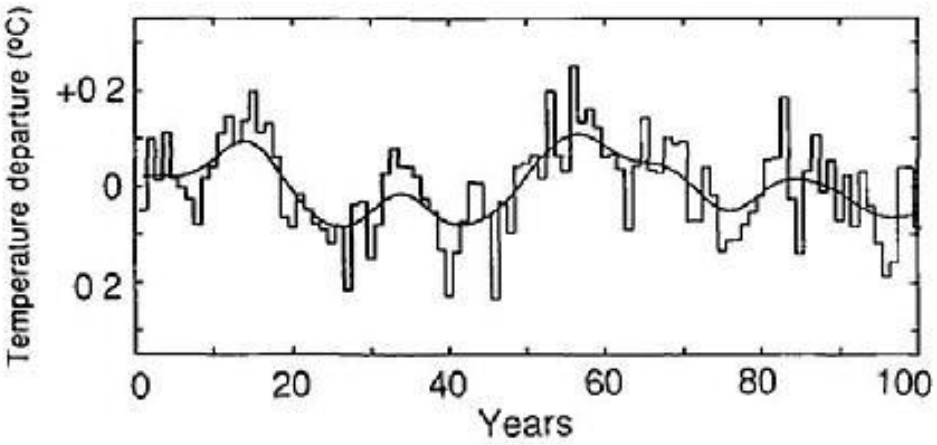

Figure 6.2: The temporal variation of the deviation of global mean surface air temperature (°C) of the coupled ocean atmosphere model from its long term average From Manabe (1990), personal communication

IPCC 1st Assessment Report, 1990

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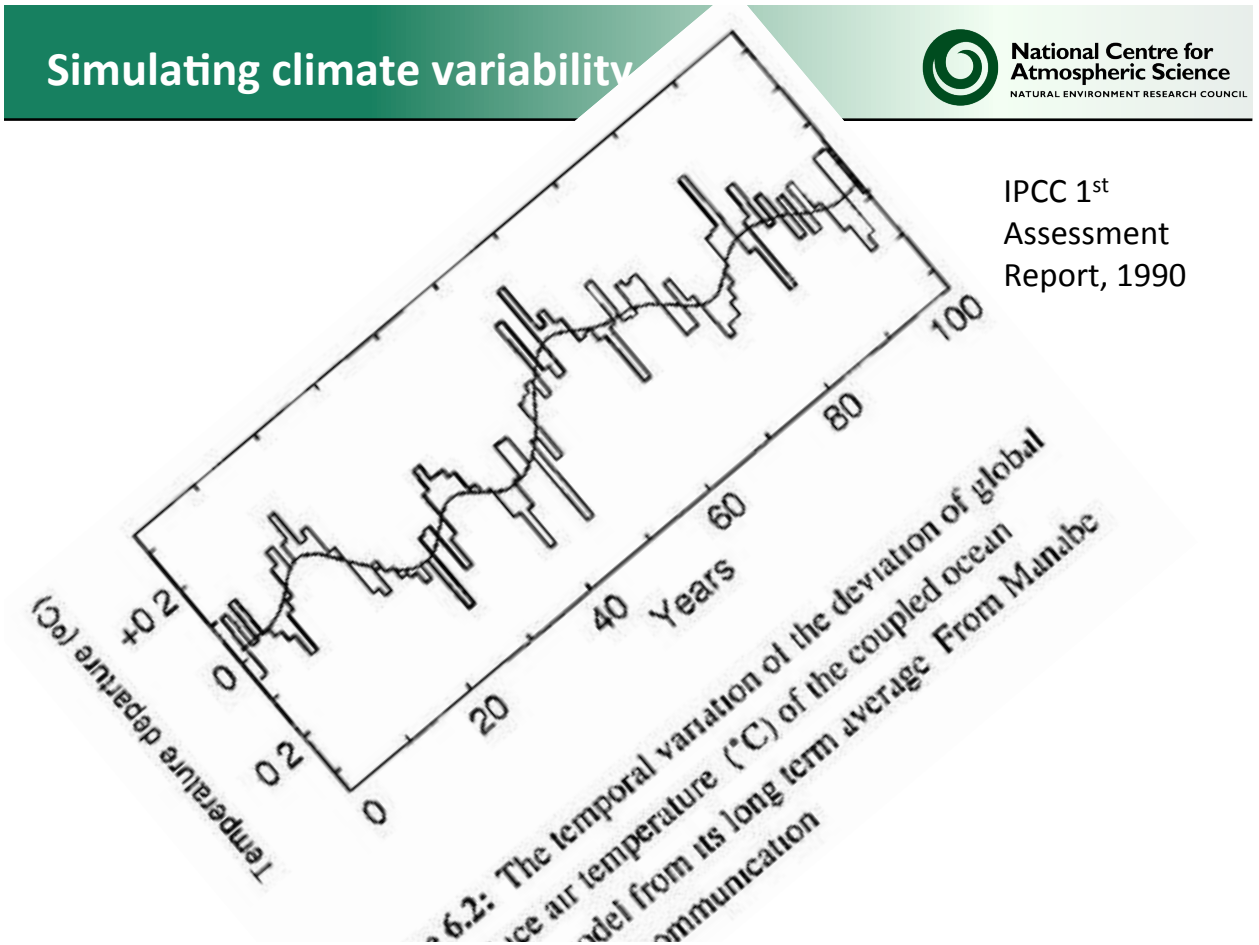

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IPCC 1st Assessment Report, 1990

Comparing global and UK change

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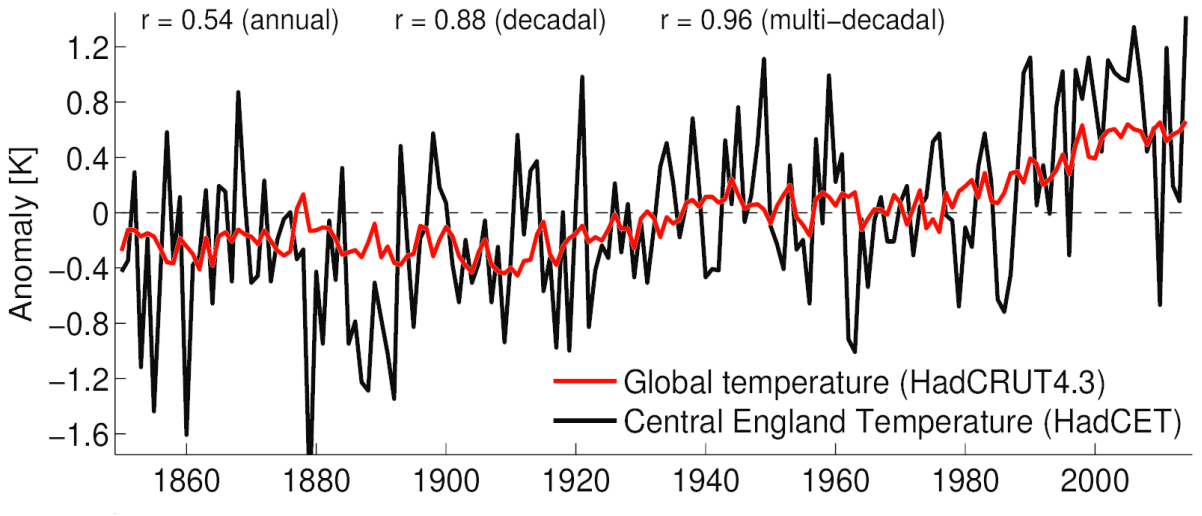
Global temperature and Central England temperature



Sutton, Suckling & Hawkins, 2015, Phil Trans A

Comparing global and UK change

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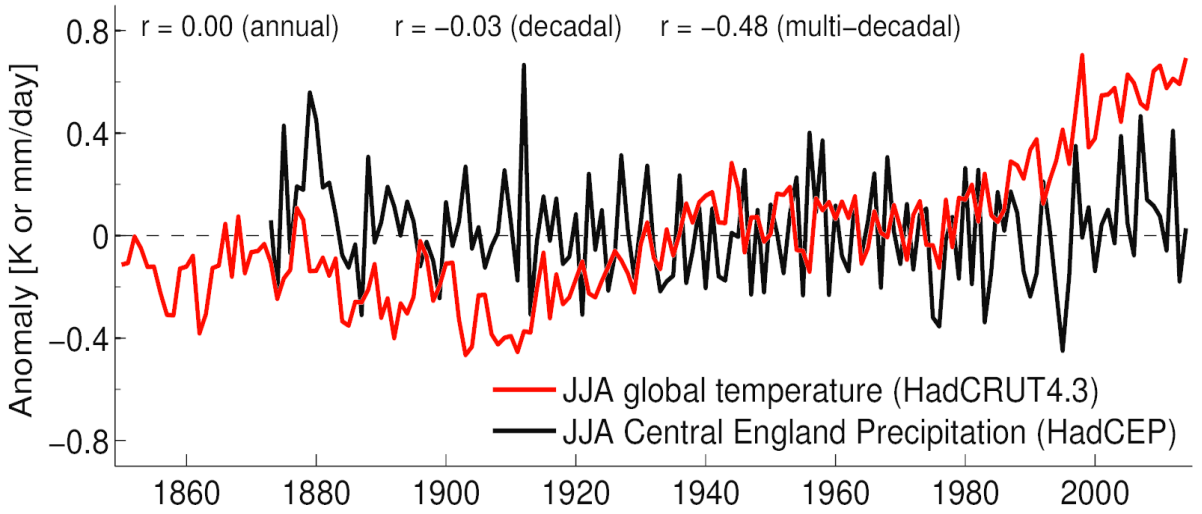
Global temperature and Central England rainfall



Sutton, Suckling & Hawkins, 2015, Phil Trans A

Discussing role of variability

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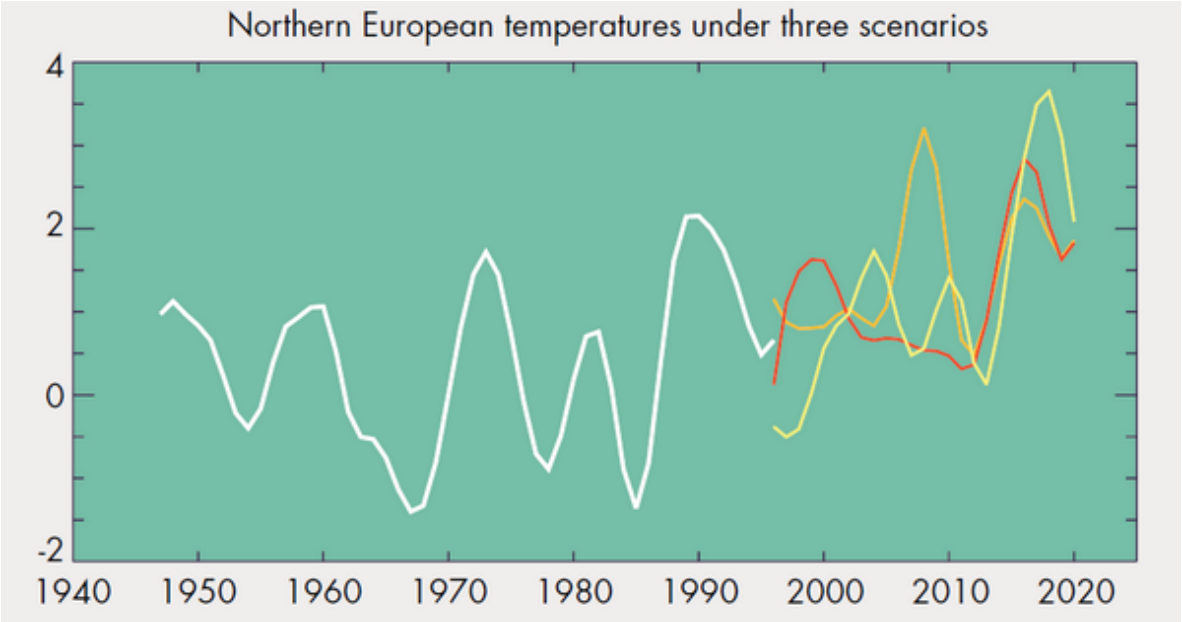

Sutton et al., 2001, CLIVAR Exchanges

Possible future regional trends

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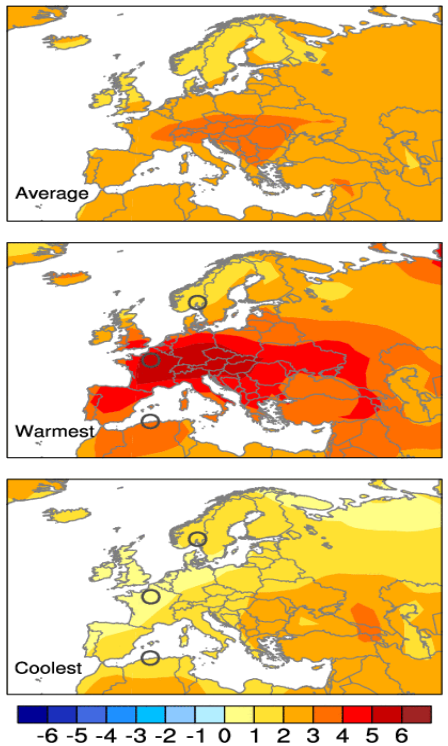

CCSM large ensemble

Clara Deser & Laurent Terray

Large ensembles to explore variability

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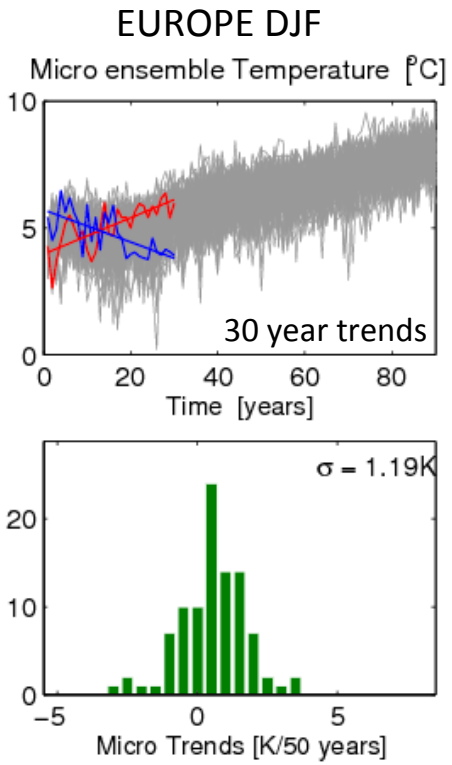
- FAMOUS GCM
- Atmosphere: 5x7.5° Ocean: 2.5x3.75°
- 1%/year increase in CO_2 for 140 years
- 'MICRO' ensemble:
  - 100 members initialised with a tiny random perturbation to identical initial conditions
- 'MACRO' ensemble:
  - 30 members initialised from different coupled initial conditions

http://tiny.cc/famous-ensembles

Hawkins et al., in press, Climate Dynamics



Large ensembles to explore variability

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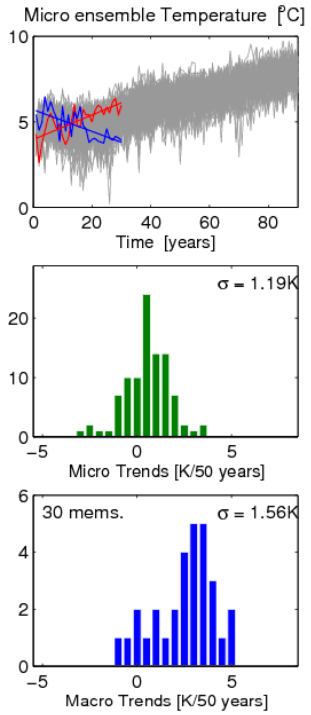
EUROPE – DJF – 30 YEAR TRENDS



Large ensembles to explore variability

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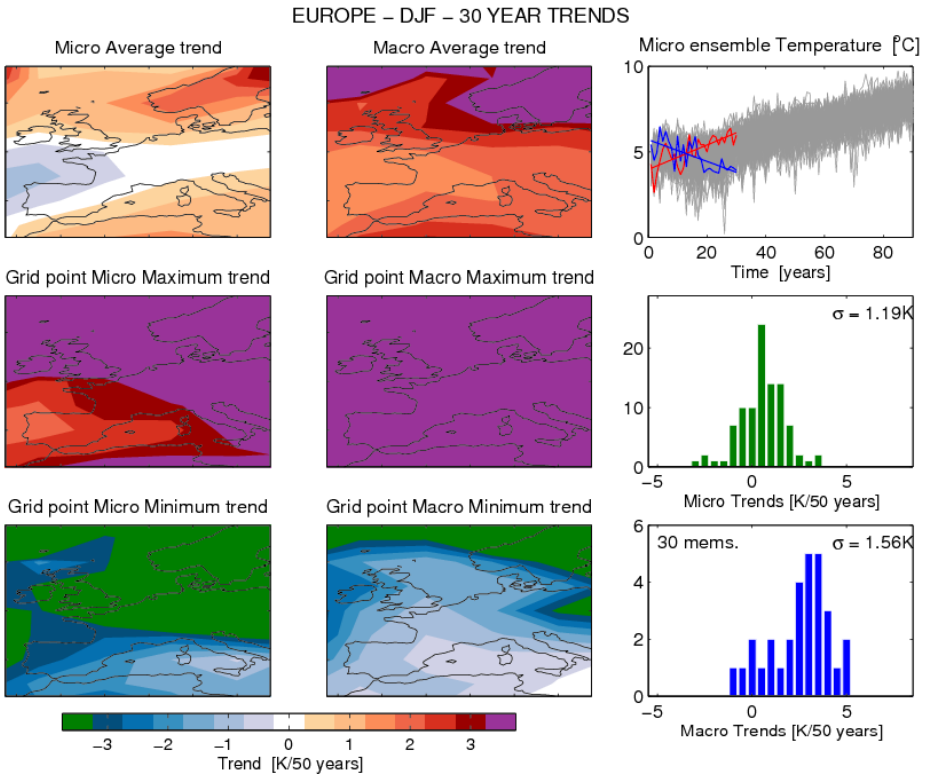

Large ensembles to explore variability

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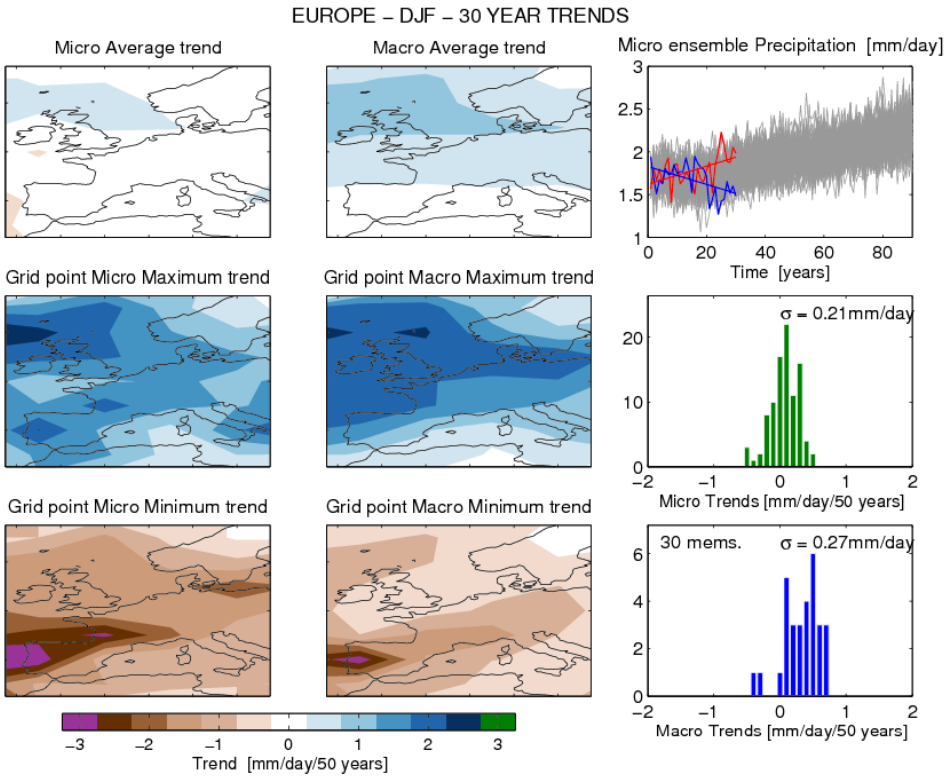

Why the differences between MICRO & MACRO?

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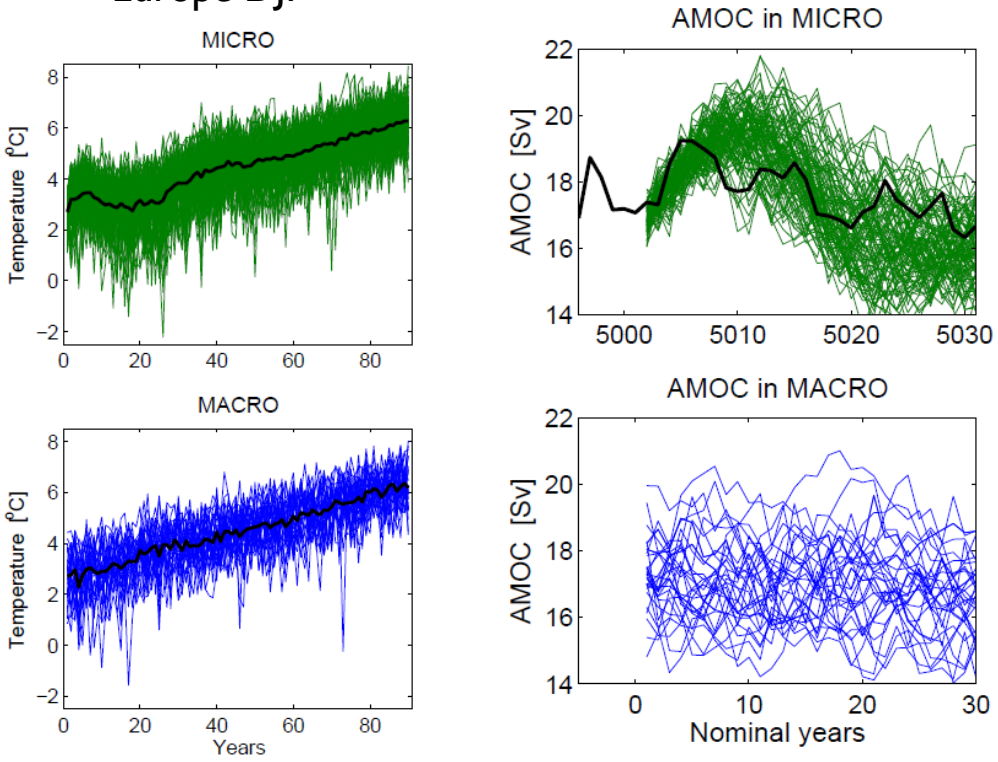
Europe DJF



Probabilistic projections

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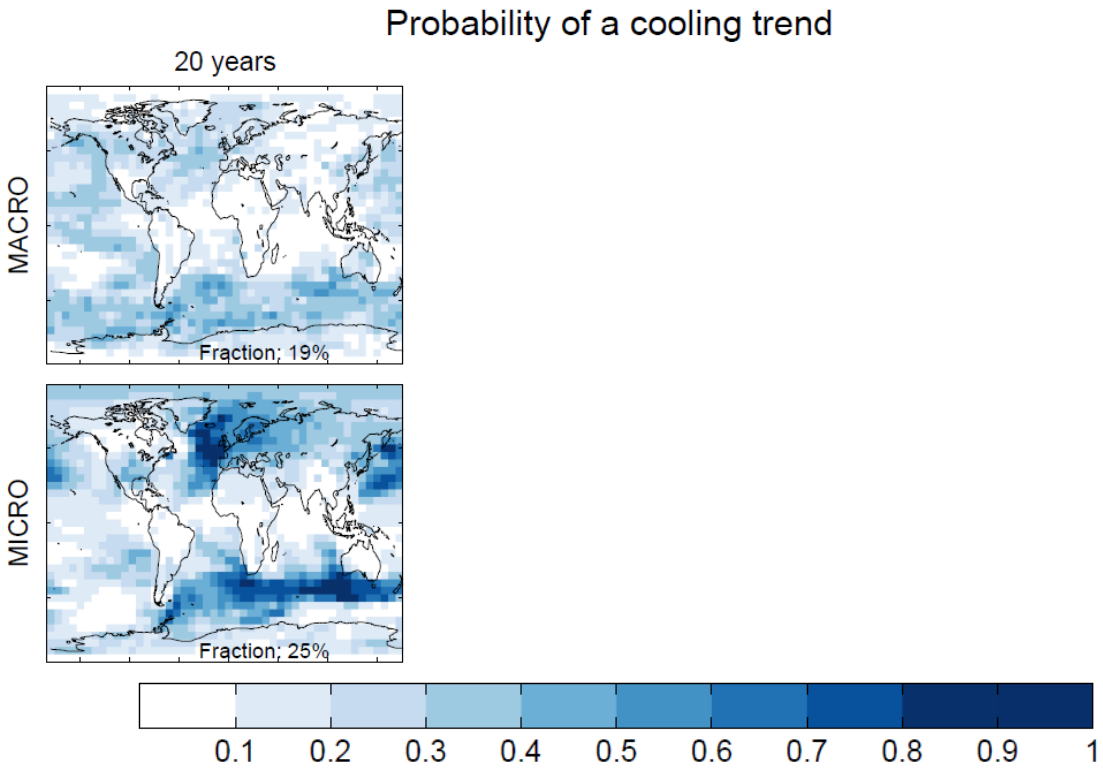

The slowdown ‘zoo’

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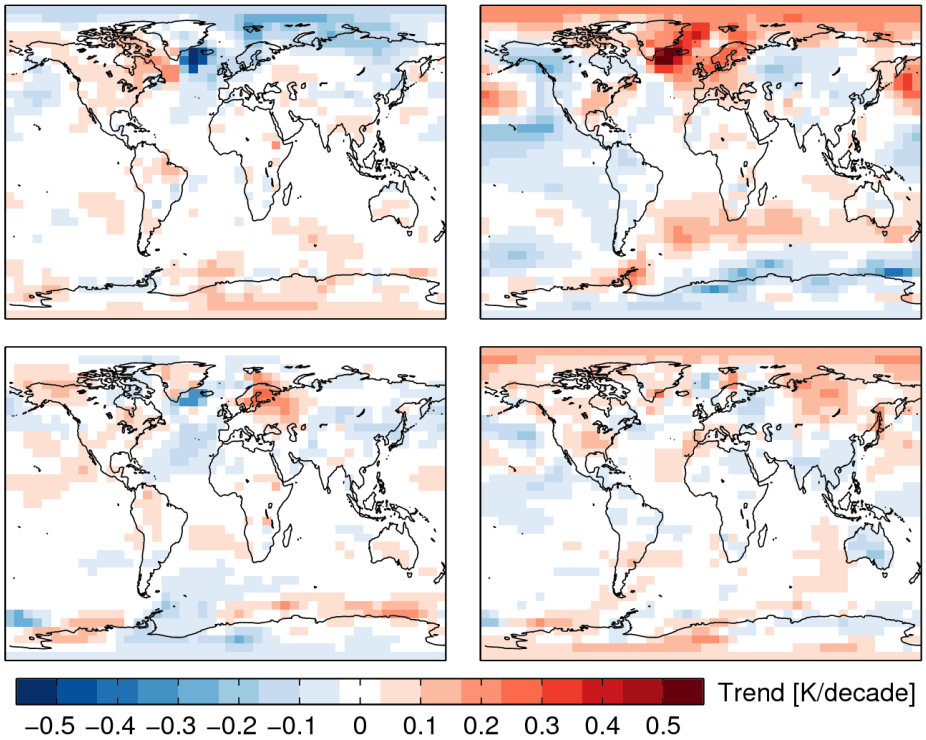
Example regional trends during 15–year periods of 0.00K/decade global warming



Trends in global temperature

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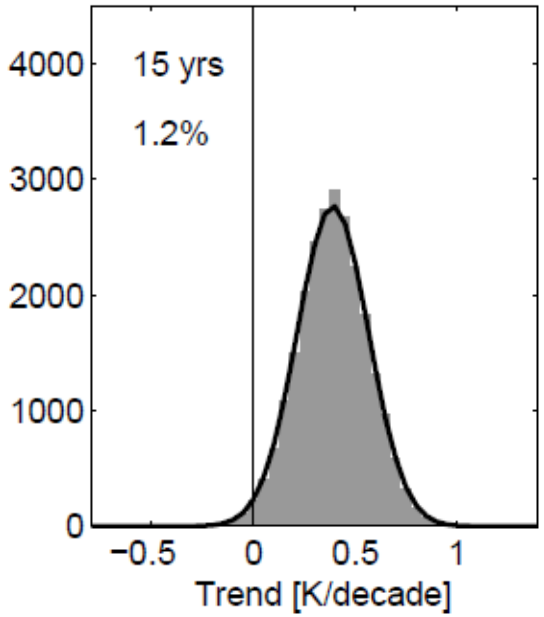

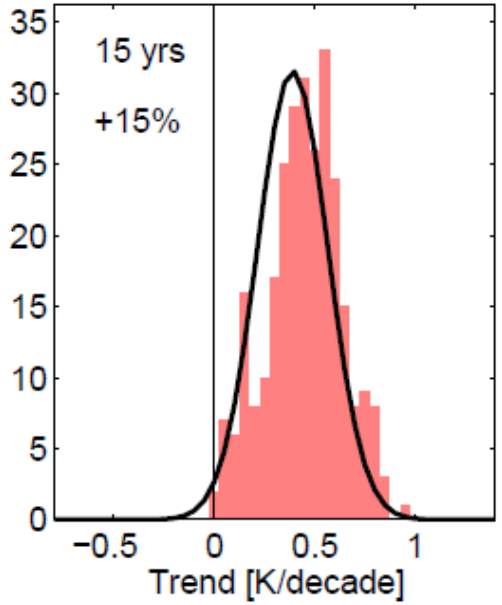

All 15 year trends

15 year trends after pauses

Hawkins, Smith, Gregory & Stainforth, in press, Climate Dynamics

Comparing apples with apples

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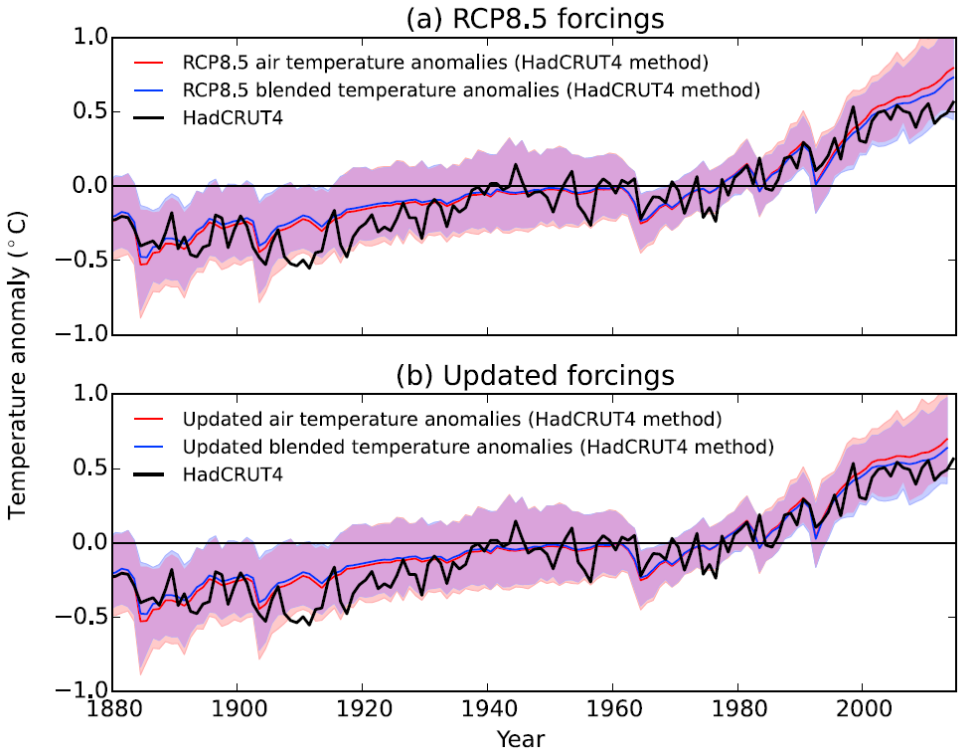

Cowtan et al. 2015, GRL

Summary

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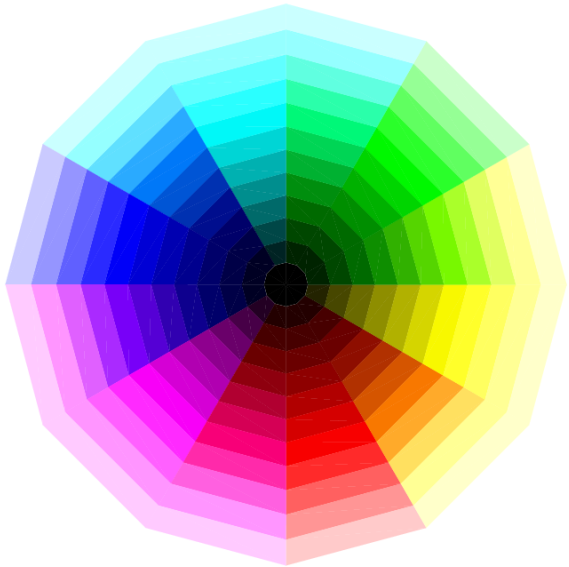
- The climate exhibits substantial natural variability in temperature, precipitation, sea-ice… etc
- GCMs show large diversity in variability characteristics. Need to better understand these differences
- Large ensembles are valuable tools to explore possible outcomes on regional scales
- Appropriate communication & visualisation of regional variability is essential
- A like-with-like approach is essential when comparing models and observations

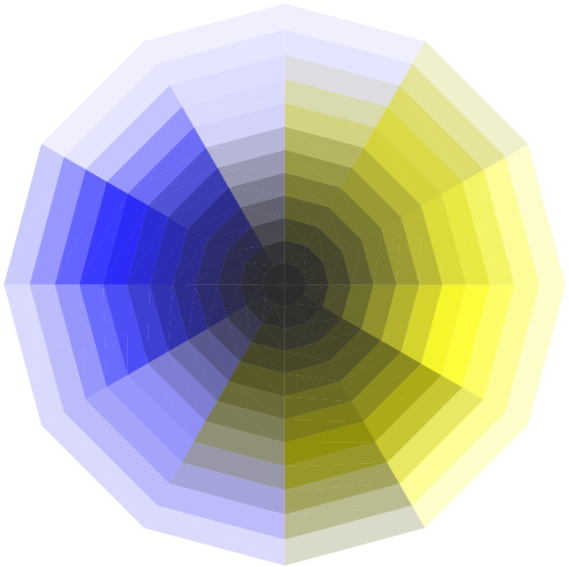
(also see poster discussing sensitivity to reference periods)

@ed_hawkins

Scrap ‘rainbow’ colour scales



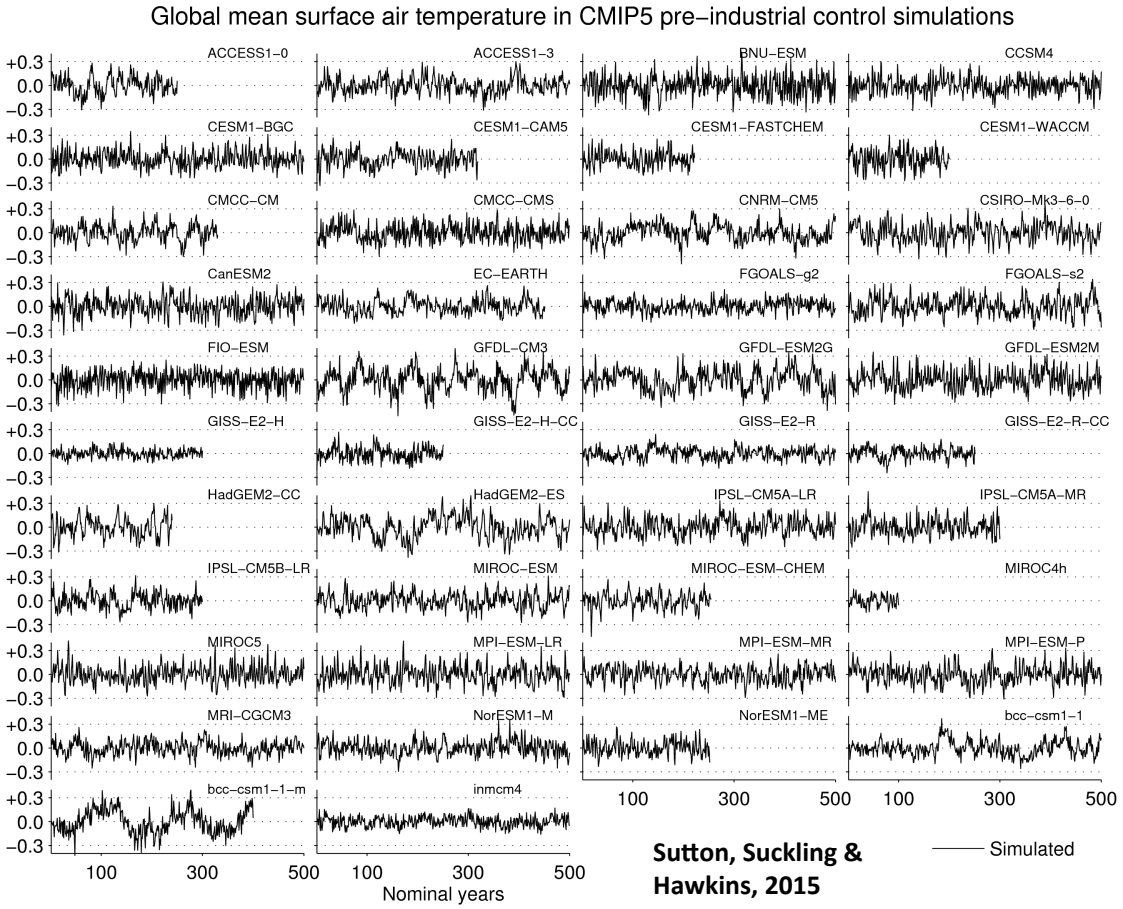
Normal colour vision



Simulation of severe deuteranopia

tiny.cc/endrainbow

#endrainbow


Global mean surface air temperature in CMIP5 pre−industrial control simulations
ACCESS1−0
ACCESS1−3
BNU−ESM
CCSM4
CESM1−BGC
CESM1−CAM5
CESM1−FASTCHEM
CESM1−WACCM
CMCC−CM
CMCC−CMS
CNRM−CM5
CSIRO−Mk3−6−0
CanESM2
EC−EARTH
FGOALS−g2
FGOALS−s2
FIO−ESM
GFDL−CM3
GFDL−ESM2G
GFDL−ESM2M
GISS−E2−H
GISS−E2−H−CC
GISS−E2−R
GISS−E2−R−CC
HadGEM2−CC
HadGEM2−ES
IPSL−CM5A−LR
IPSL−CM5A−MR
IPSL−CM5B−LR
MIROC−ESM
MIROC−ESM−CHEM
MIROC4h
MIROC5
MPI−ESM−LR
MPI−ESM−MR
MPI−ESM−P
MRI−CGCM3
NorESM1−M
NorESM1−ME
bcc−csm1−1
bcc−csm1−1−m
inmcm4
+0.3
0.0
−0.3
100
300
500
Nominal years
Sutton, Suckling & Hawkins, 2015
Simulated

Example warming trends in FAMOUS

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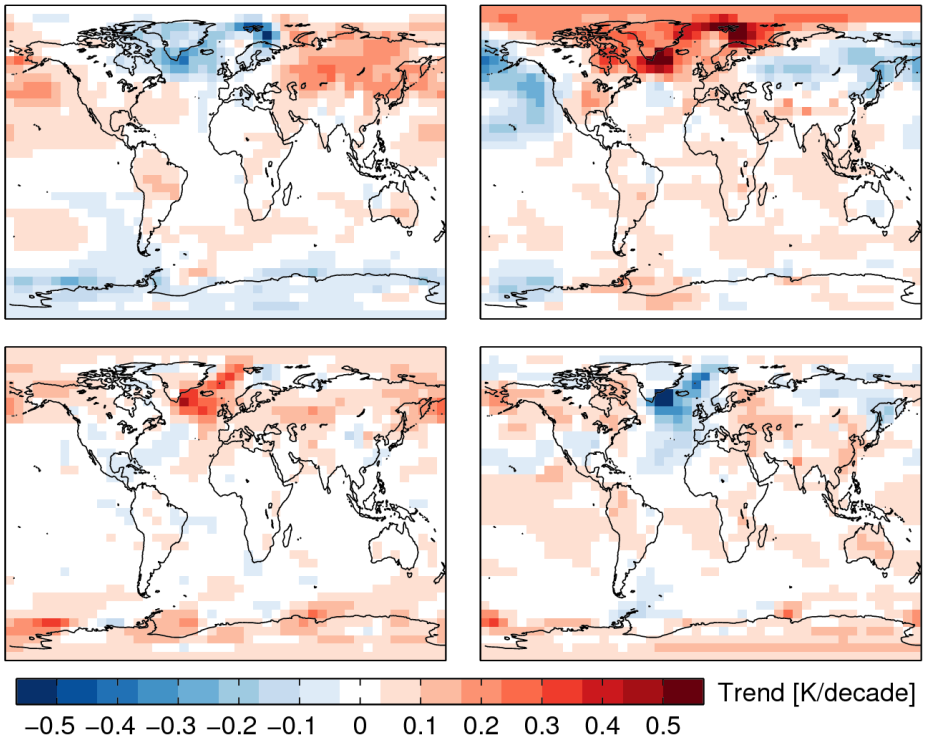
Example regional trends during 15–year periods of 0.20K/decade global warming



Communicating variability

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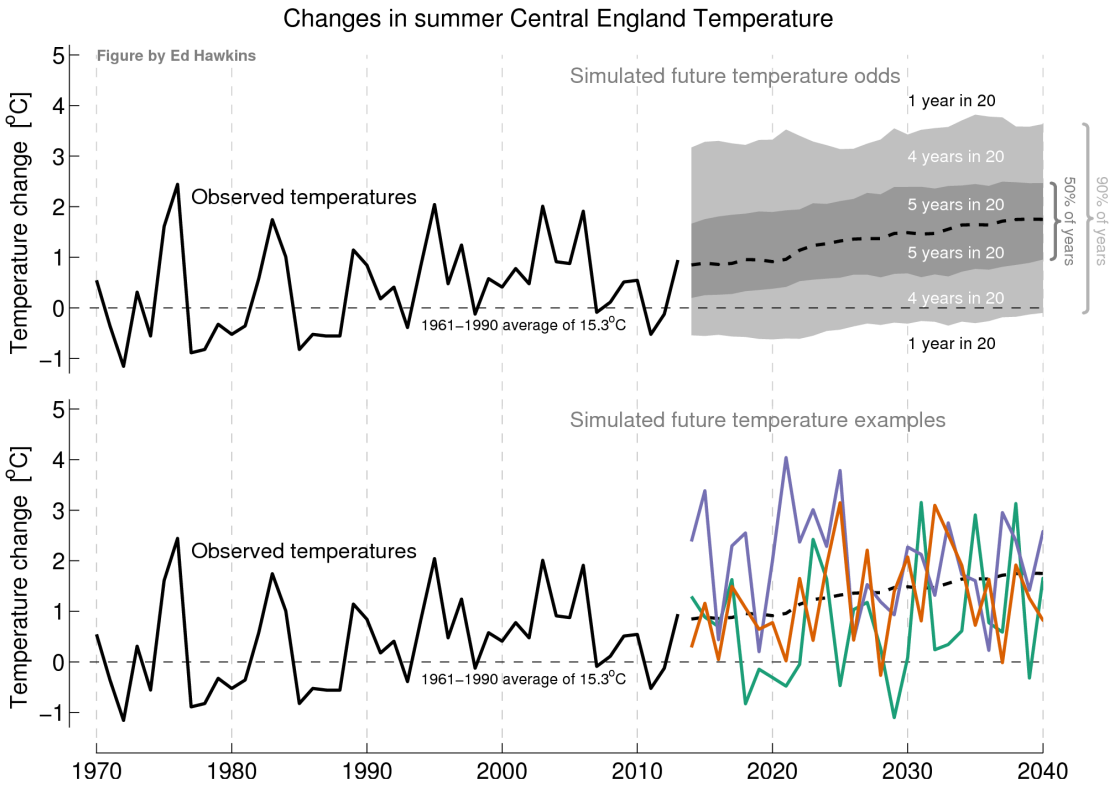

Observed Arctic sea ice trends

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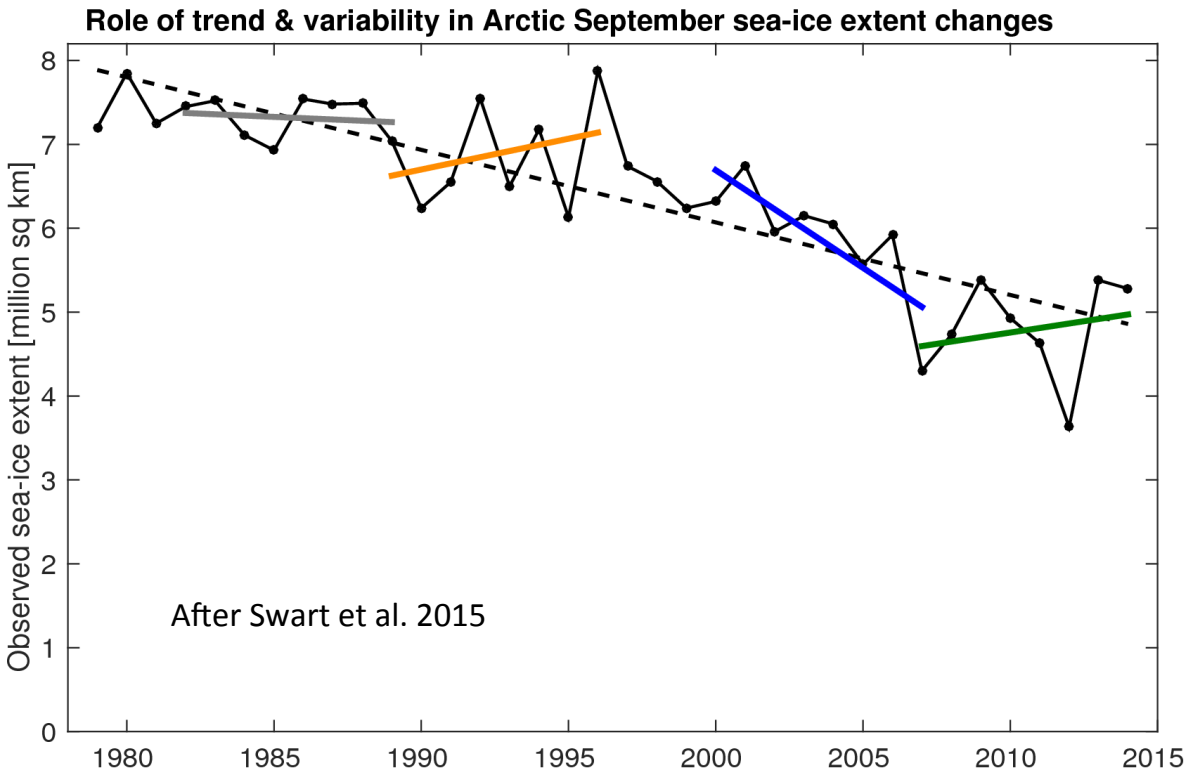

The cascade of uncertainty

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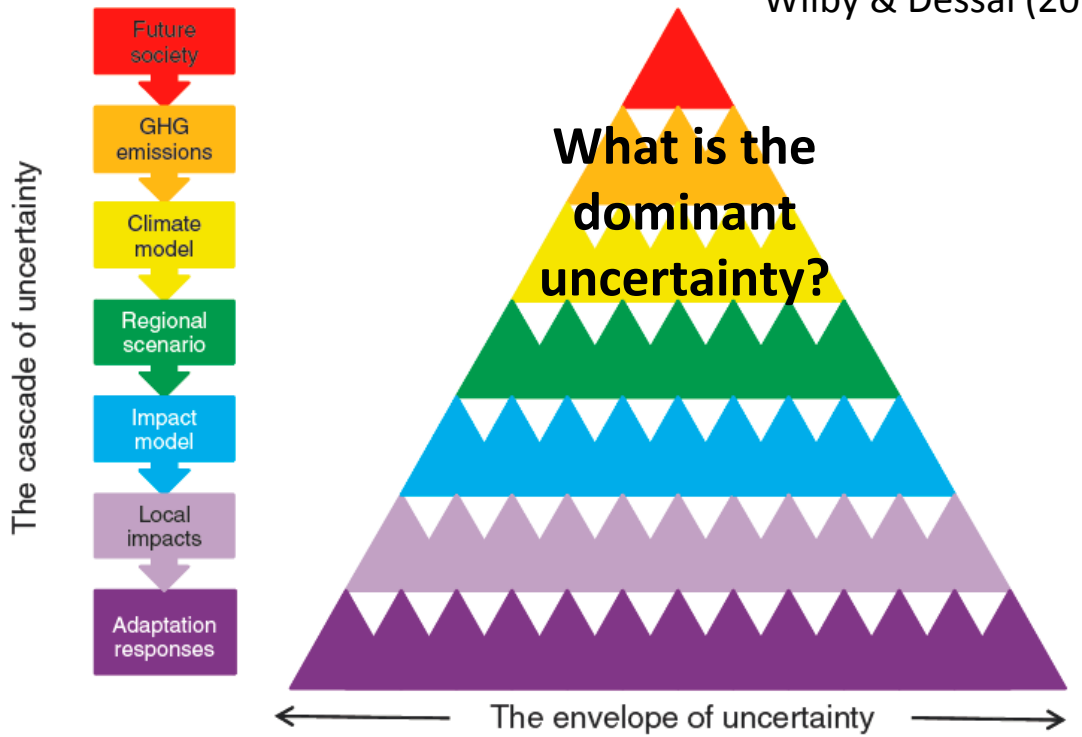
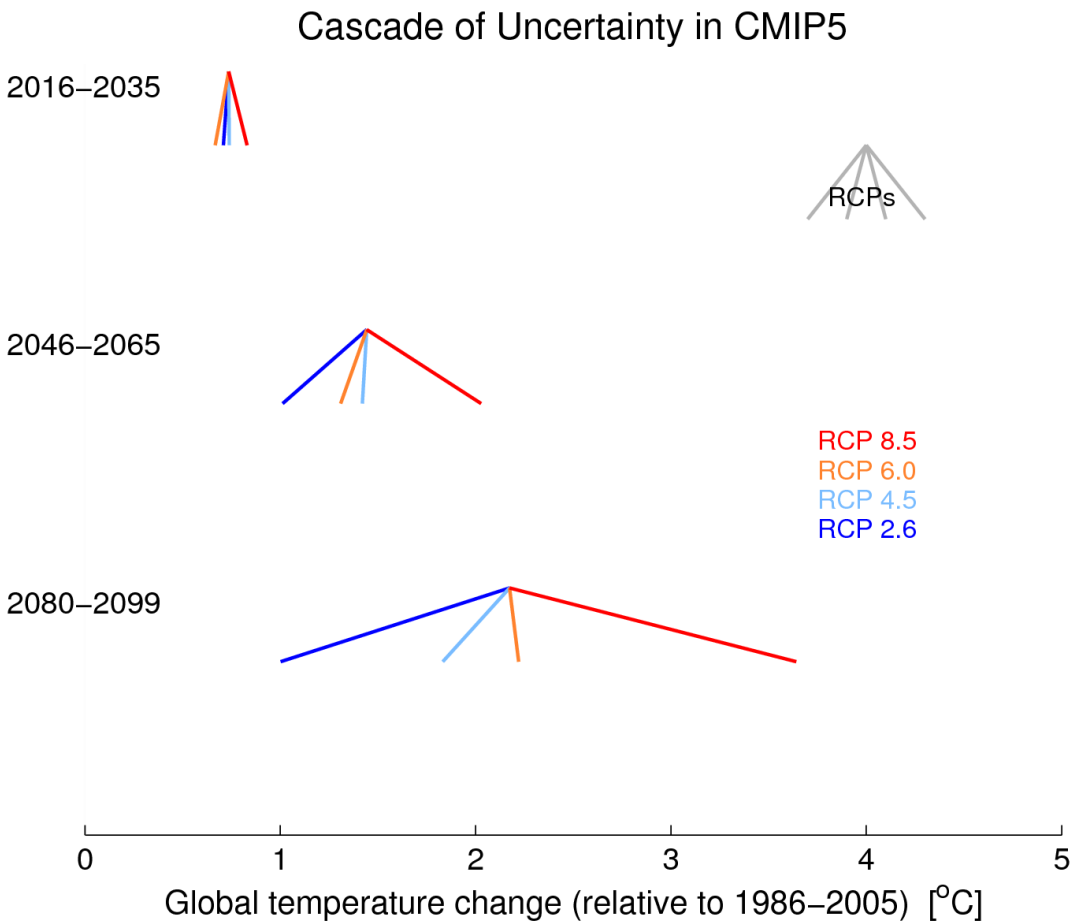
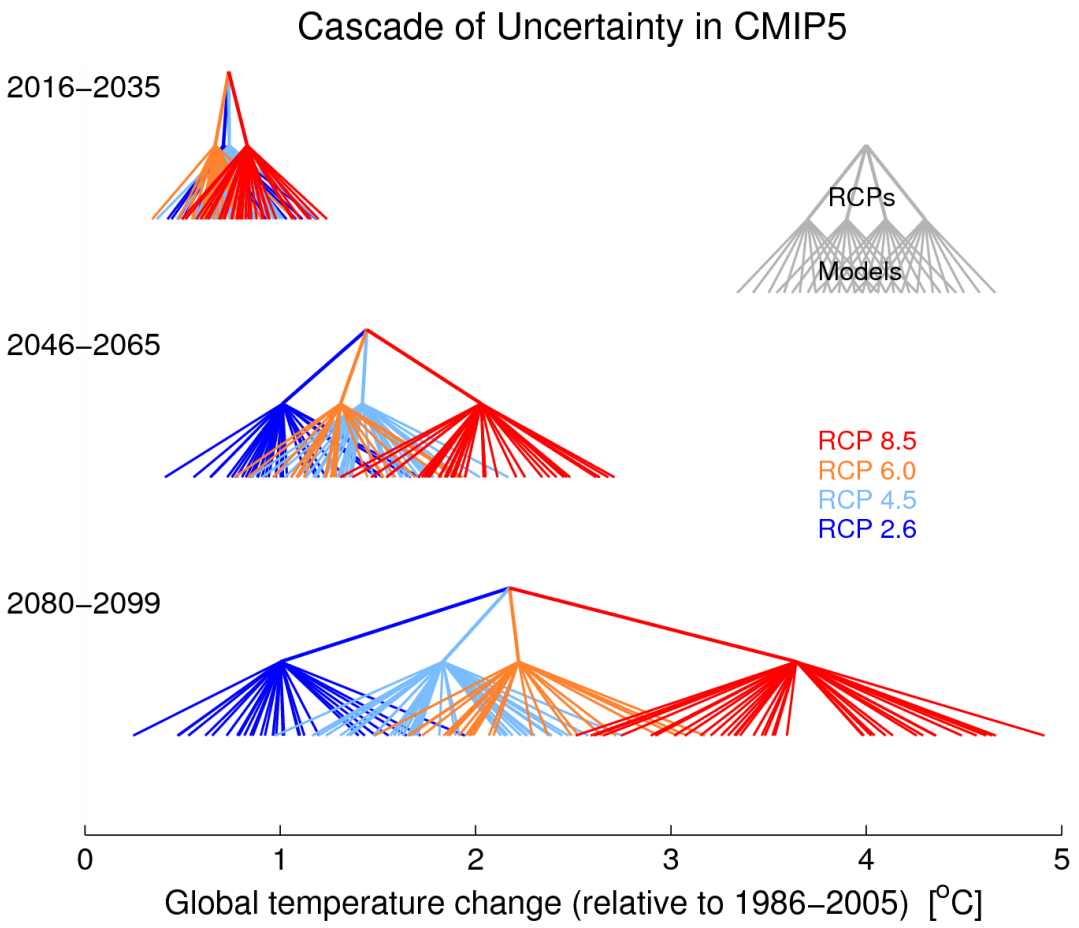
Wilby & Dessai (2010)




Cascade of Uncertainty in CMIP5
2016–2035
RCPs
2046–2065
RCP 8.5
RCP 6.0
RCP 4.5
RCP 2.6
2080–2099
0
1
2
3
4
5
Global temperature change (relative to 1986–2005) [°C]


Cascade of Uncertainty in CMIP5
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2046–2065
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RCPs
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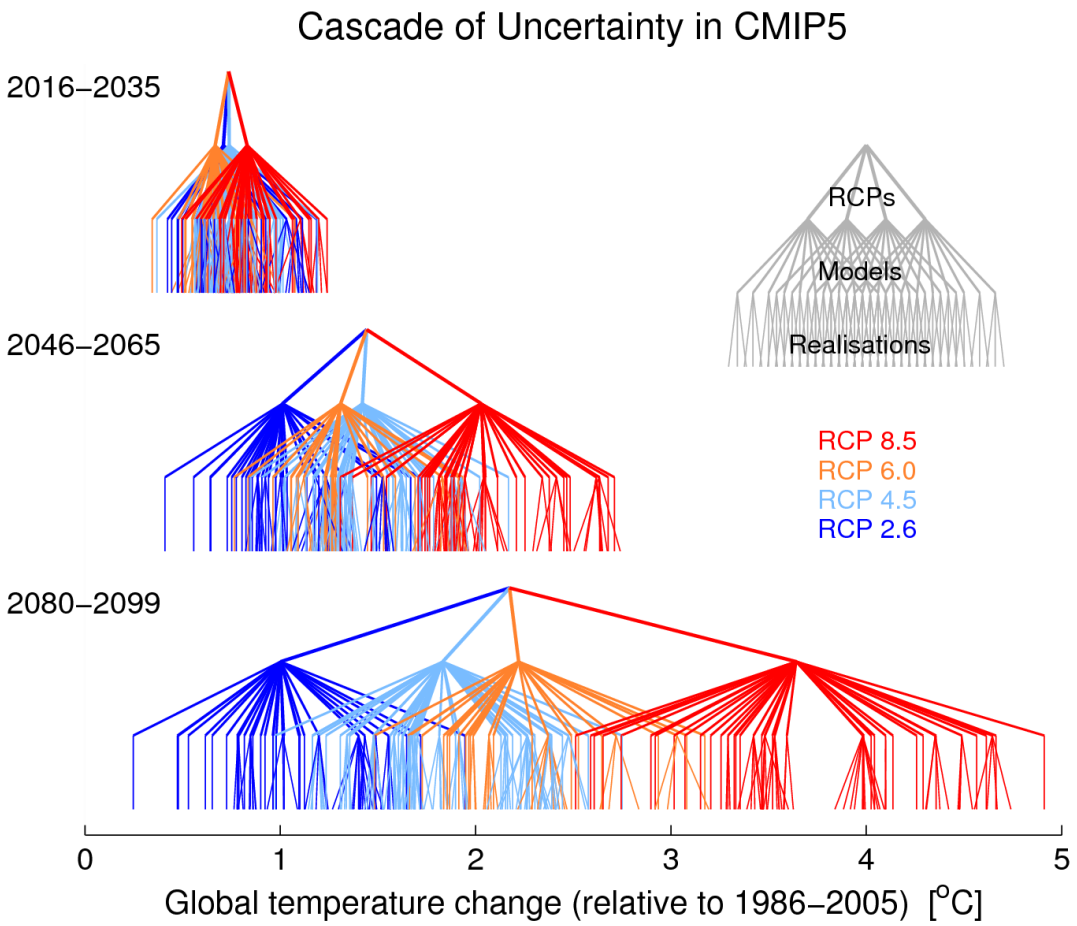
Cascade of Uncertainty in CMIP5
2016–2035
2046–2065
2080–2099
RCPs
Models
Realisations
RCP 8.5
RCP 6.0
RCP 4.5
RCP 2.6
0
1
2
3
4
5
Global temperature change (relative to 1986–2005) [°C]

THE ARTIFICIAL PRODUCTION OF CARBON DIOXIDE AND ITS INFLUENCE ON TEMPERATURE

By G. S. CALLENDAR

(Steam technologist to the British Electrical and Allied Industries Research Association.)

(Communicated by Dr. G. M. B. Dobson, F.R.S.)

[Manuscript received May 19, 1937—read February 16, 1938.]

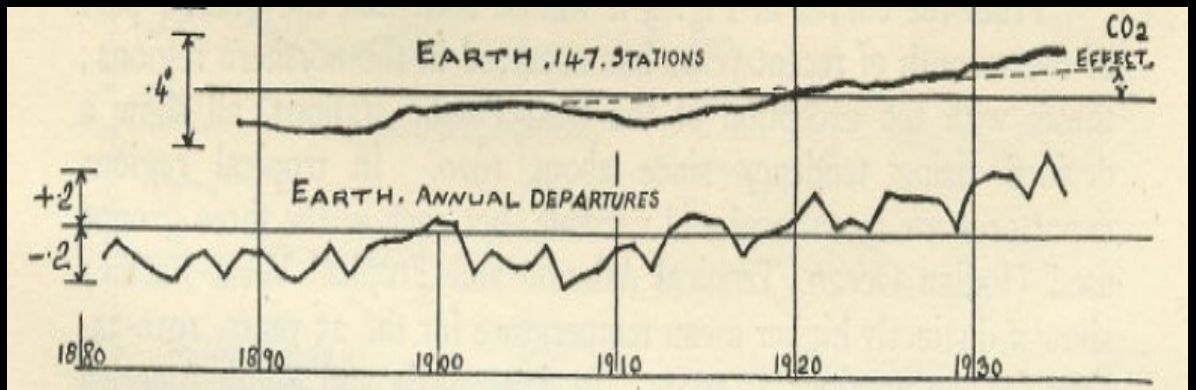

FIG. 4.—Temperature variations of the zones and of the earth. Ten-year moving departures from the mean, 1901-1930, °C.

@GuyCallendar

Callendar (1938)