Regional Climate Changes From a 0.5C Increase in Global Mean Temperature

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Environmental Defense Fund

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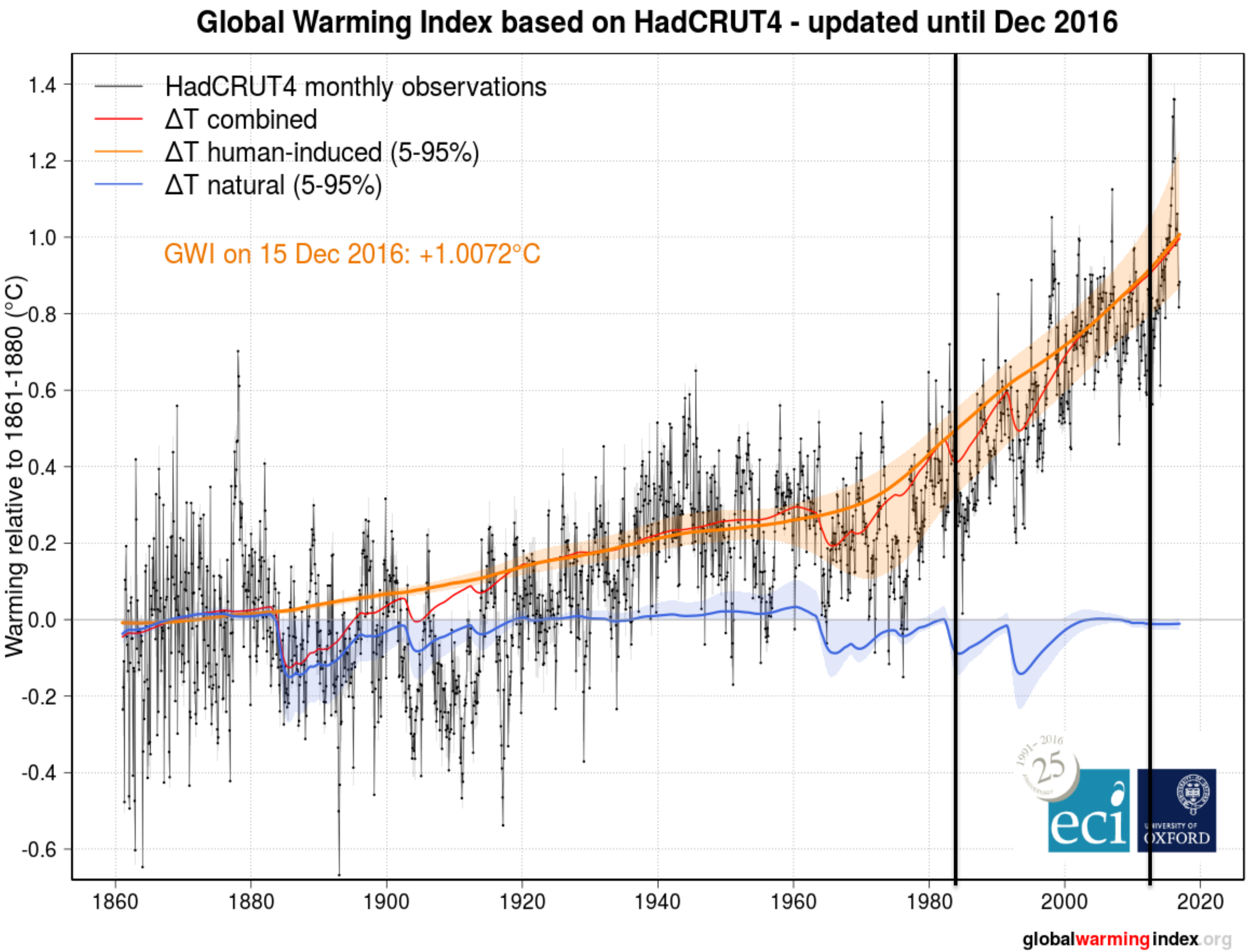
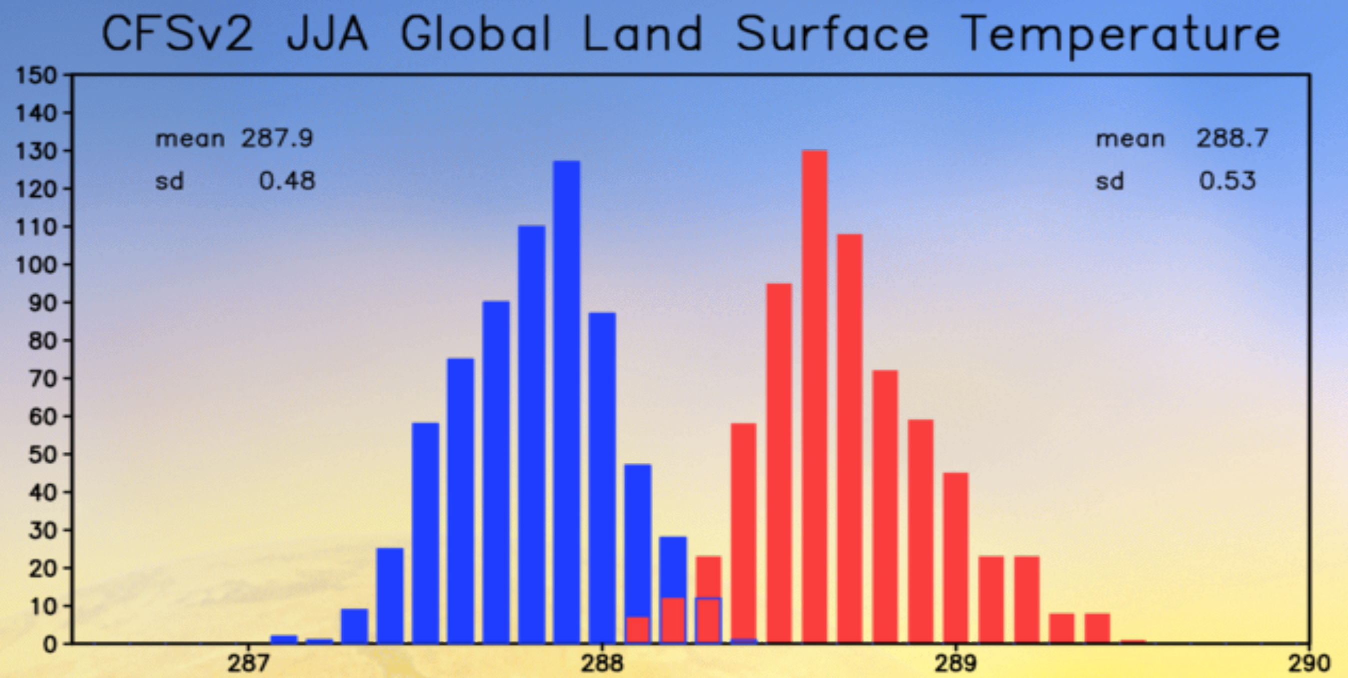
Finding the ways that work

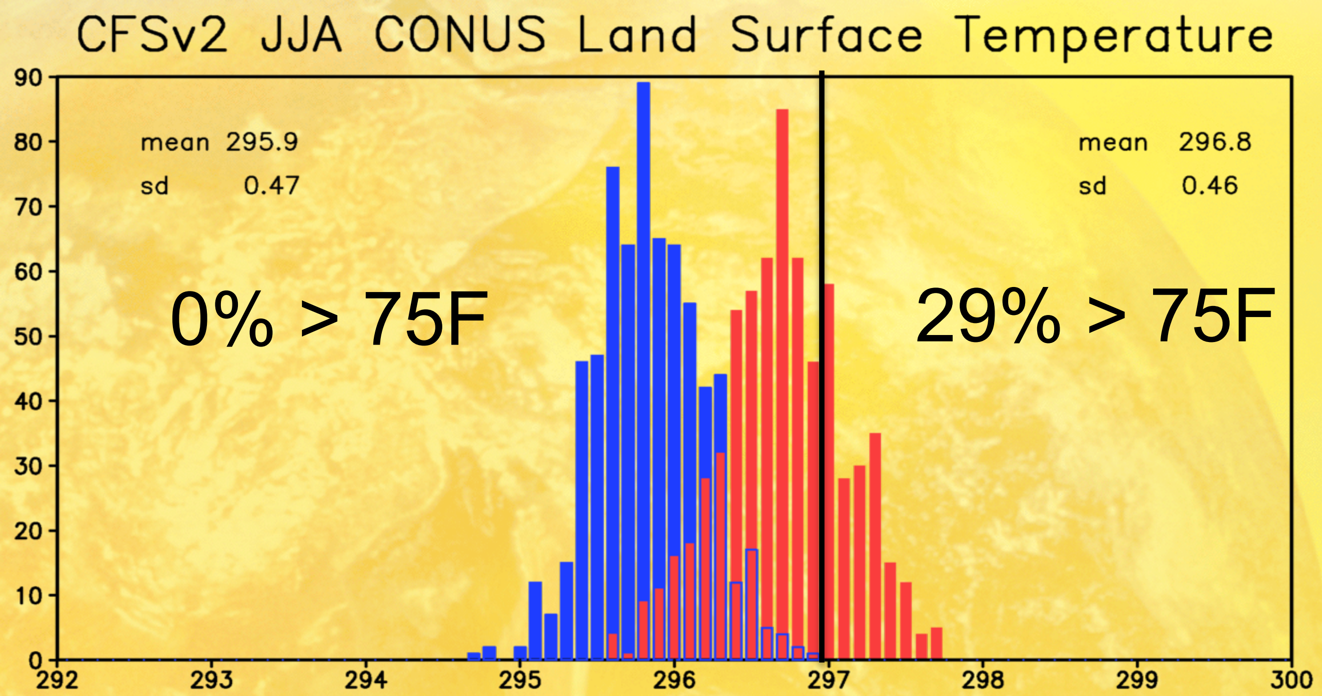


Global Warming Index based on HadCRUT4 - updated until Dec 2016
HadCRUT4 monthly observations
ΔT combined
ΔT human-induced (5-95%)
ΔT natural (5-95%)
GWI on 15 Dec 2016: +1.0072°C
Warming relative to 1861-1880 (°C)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
1860
1880
1900
1920
1940
1960
1980
2000
2020
eci
UNIVERSITY OF OXFORD
globalwarmingindex.org

672 simulated seasons/period

1983-1986
2009-2012

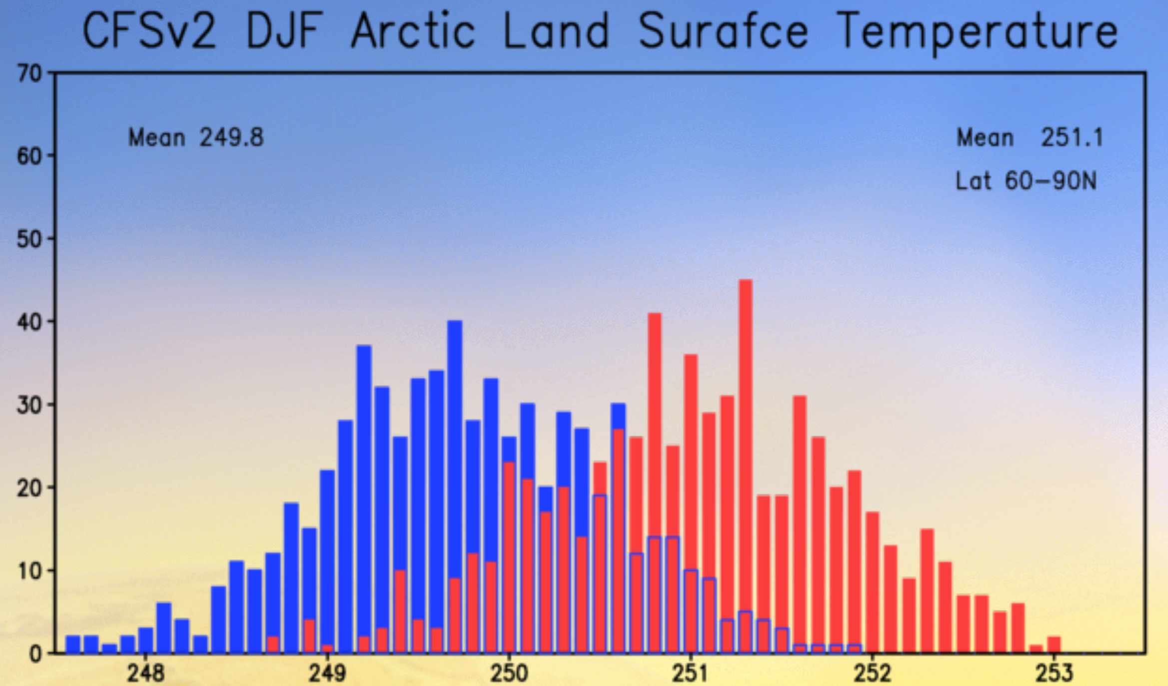


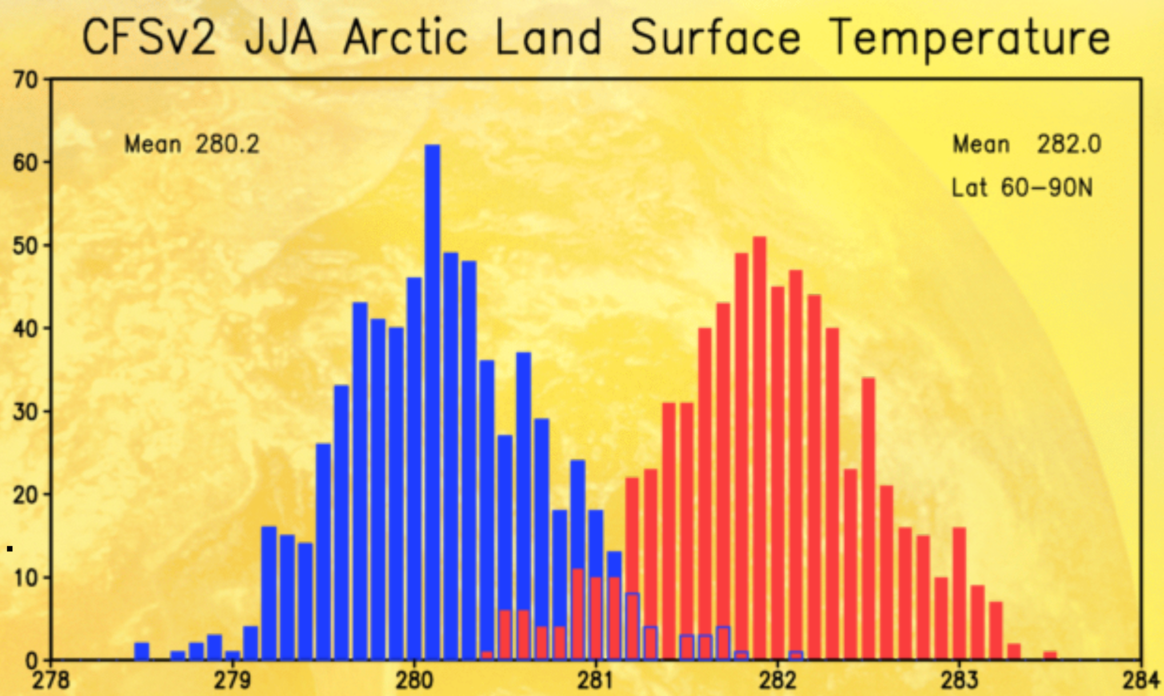


672 simulated seasons/period

1983-1986
2009-2012

- Mean shift exceeds 0.5C global temperature rise in both winter and summer.
- Implications for summer glacier melt.
- Greenland glacial melt contributes directly to sea level rise.
- Glacier melt also leads to enhanced ice sheet advance.





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Geoscientific Model Development
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Half a degree additional warming, prognosis and projected impacts (HAPPI): background and experimental design

Daniel Mitchell[1,a], Krishna AchutaRao[2], Myles Allen[1,3], Ingo Bethke[4], Urs Beyerle[5], Andrew Ciavarella[6], Piers M. Forster[7], Jan Fuglestvedt[8], Nathan Gillett[9], Karsten Haustein[1], William Ingram[3,6], Trond Iversen[10], Viatcheslav Kharin[9], Nicholas Klingaman[11], Neil Massey[1], Erich Fischer[5], Carl-Friedrich Schleussner[12,13], John Scinocca[9], Øyvind Seland[10], Hideo Shiogama[14], Emily Shuckburgh[15], Sarah Sparrow[16], Dáithí Stone[17], Peter Uhe[16,1], David Wallom[16], Michael Wehner[17], and Rashyd Zaaboul[18]

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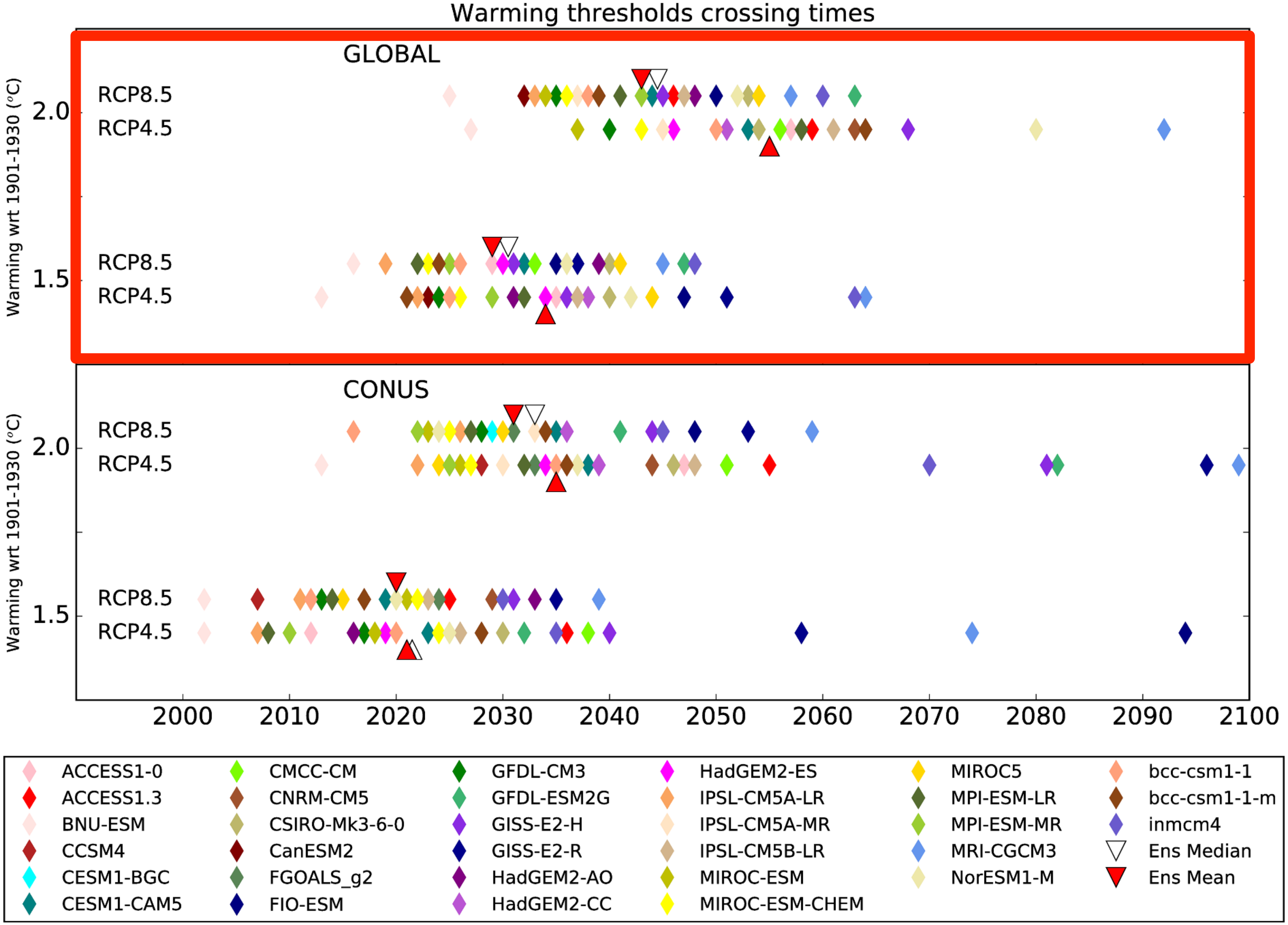
“Pursuing Efforts at 1.5C?”

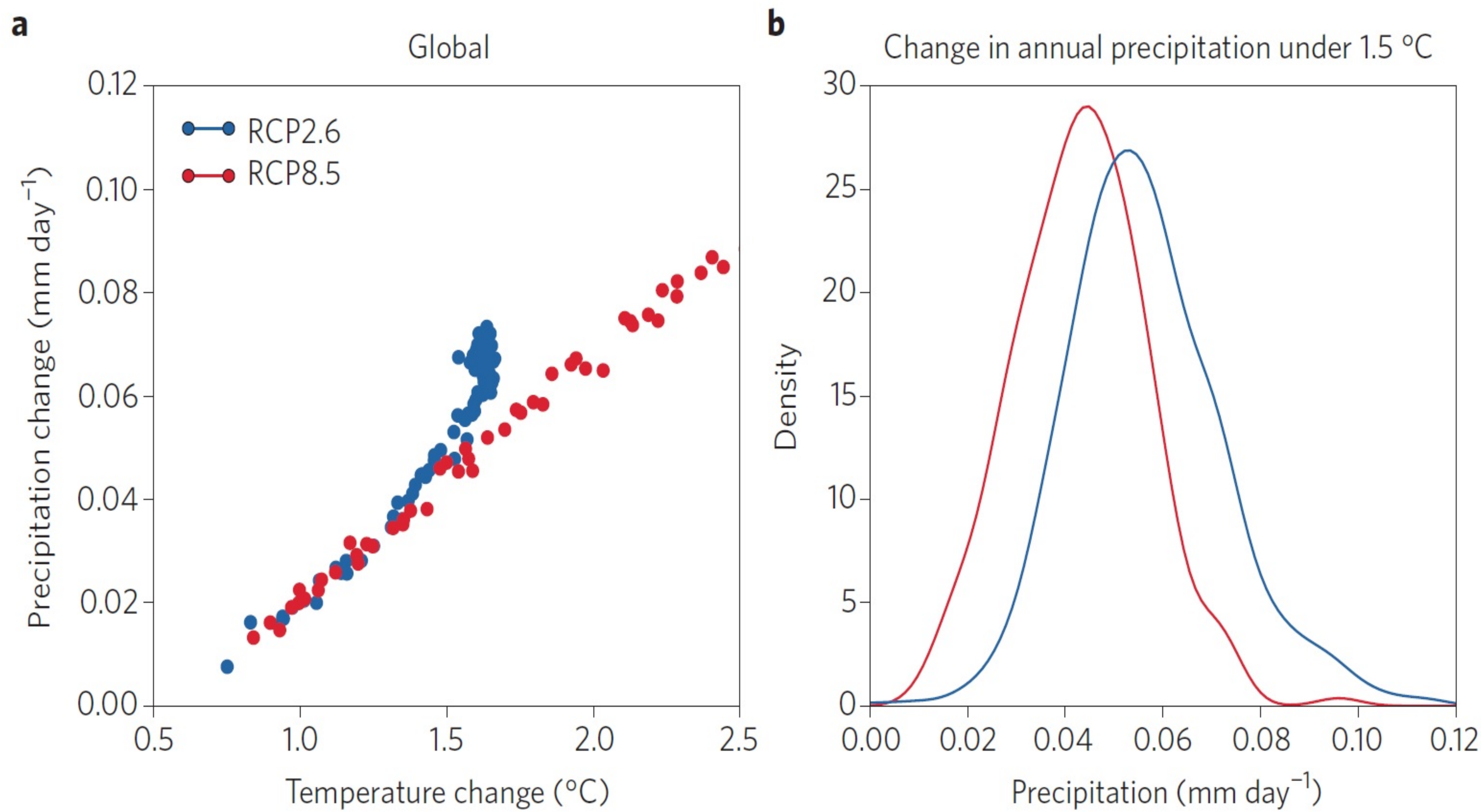
- UNFCC asked IPCC to develop SR 1.5 to evaluate issues around the 1.5C/2C temperature targets. Climate extremes only one component of the report.
- Limited body of research assessing 1.5C/2C extremes compared to higher emission scenarios.
- Calls for a framework to assess 1.5C/2C impacts and those avoided from higher degree worlds.
- RCP scenarios may not be the best option to answer the 1.5C/2C question.
- Requires large sets of simulations to adequately sample the extreme weather.

RCP Model Scenarios May Not be the Best Option to Answer the 1.5/2C Question



Karmalkar & Bradley 2017

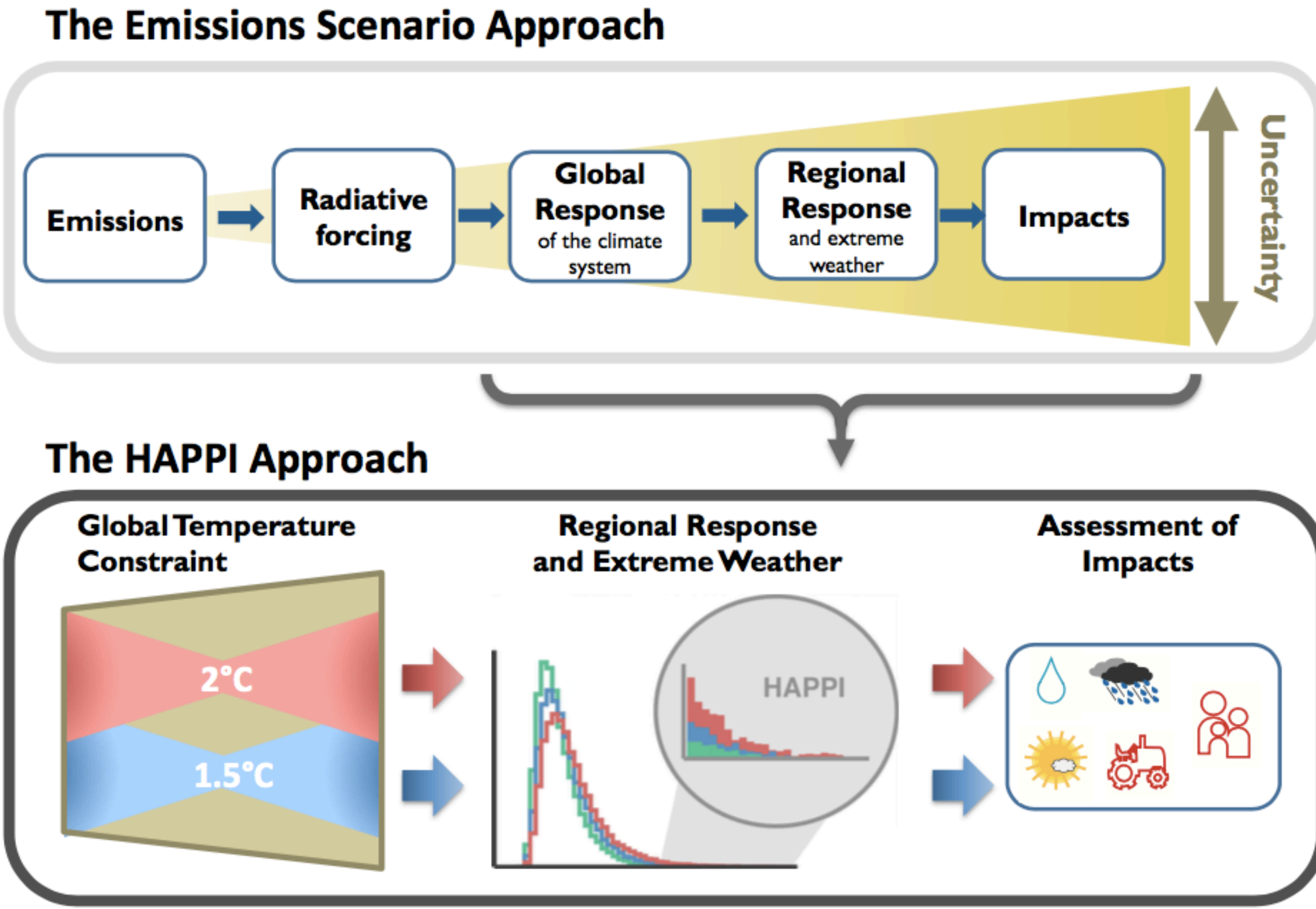
RCP Model Scenarios May Not be the Best Option to Answer the 1.5/2C Question



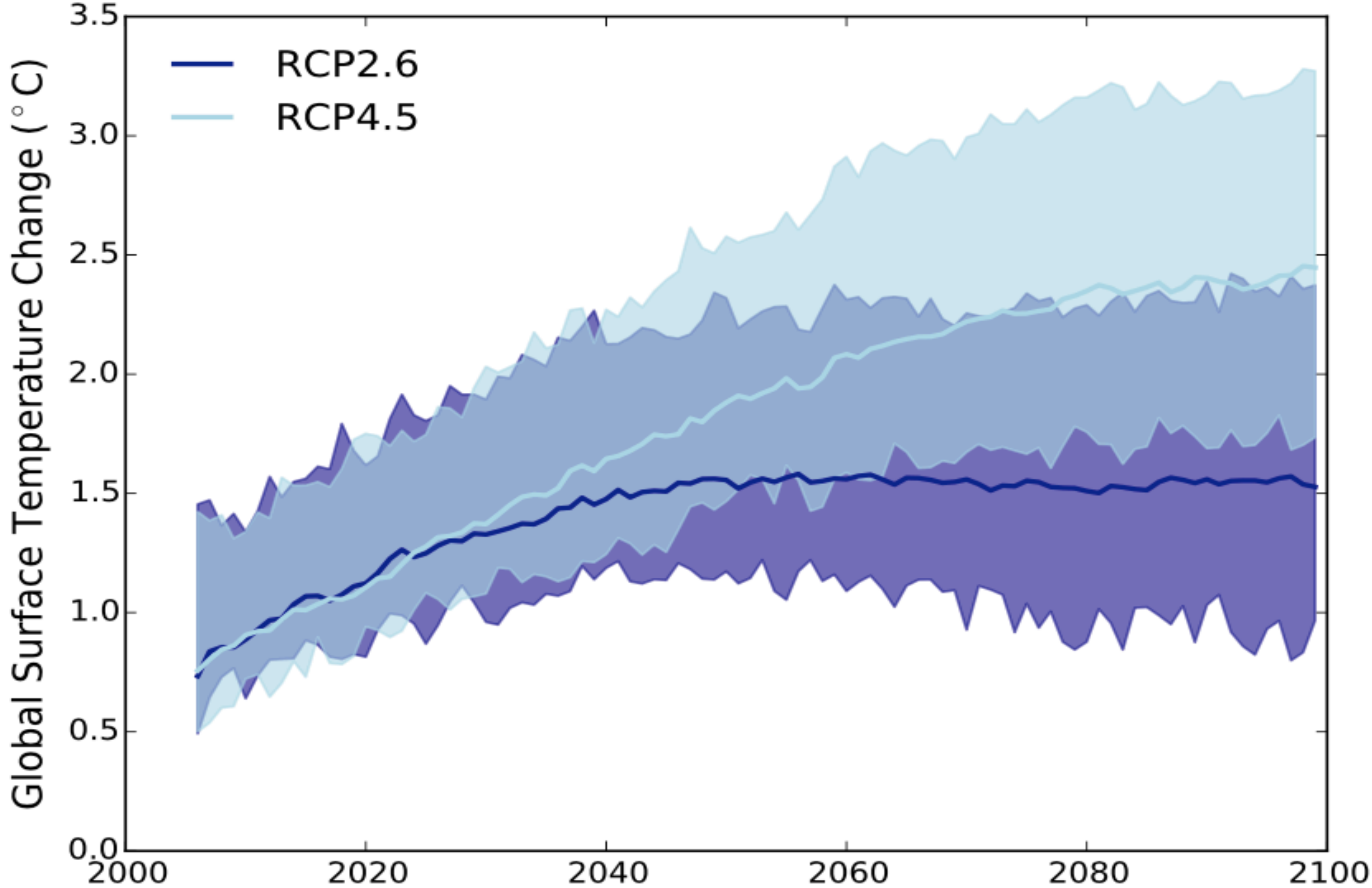
Mitchell et al. 2016

HAPPI

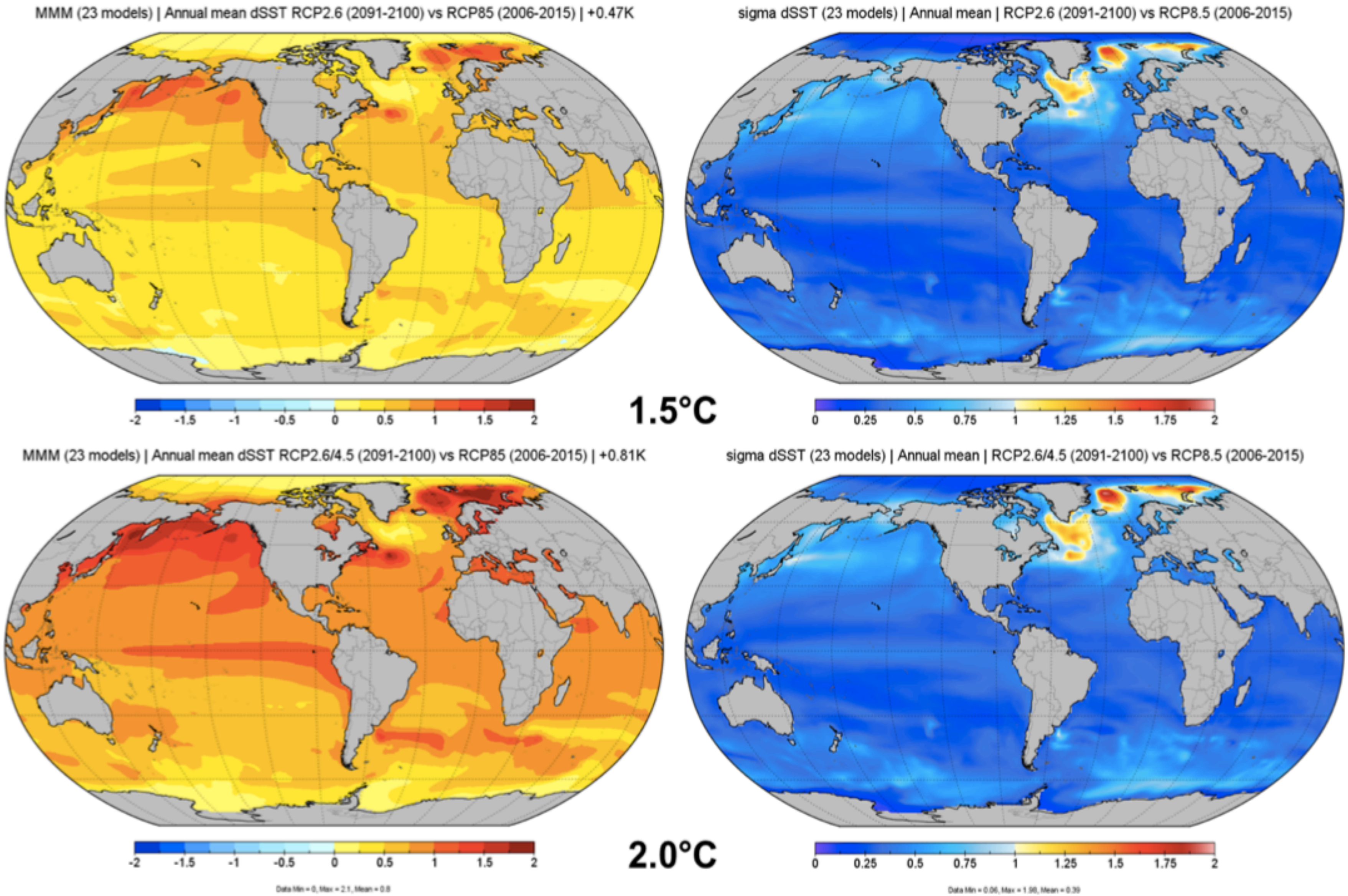
- **H**alf a degree of **A**dditional warming, **P**rojections, **P**rognosis, and **I**mpacts.
- Assess the shift in extreme events or other climate change impacts as a function of climate policy targets.
- 50-100 member ensemble of AMIP simulations conditioned on 2006-2015 natural variability for 1.5C and 2.0C above preindustrial.
- Models Include: CAM4, **CAM5.1.2 (25x25km)**, CAM5.1-1degree, CAN, HadAM3P, HADGEM3, MetUM-GOML2, MIROC5, MPI-ECHAM6.3, NorESM1_Happi
- Results may be used to Inform the Special IPCC Report on 1.5C.

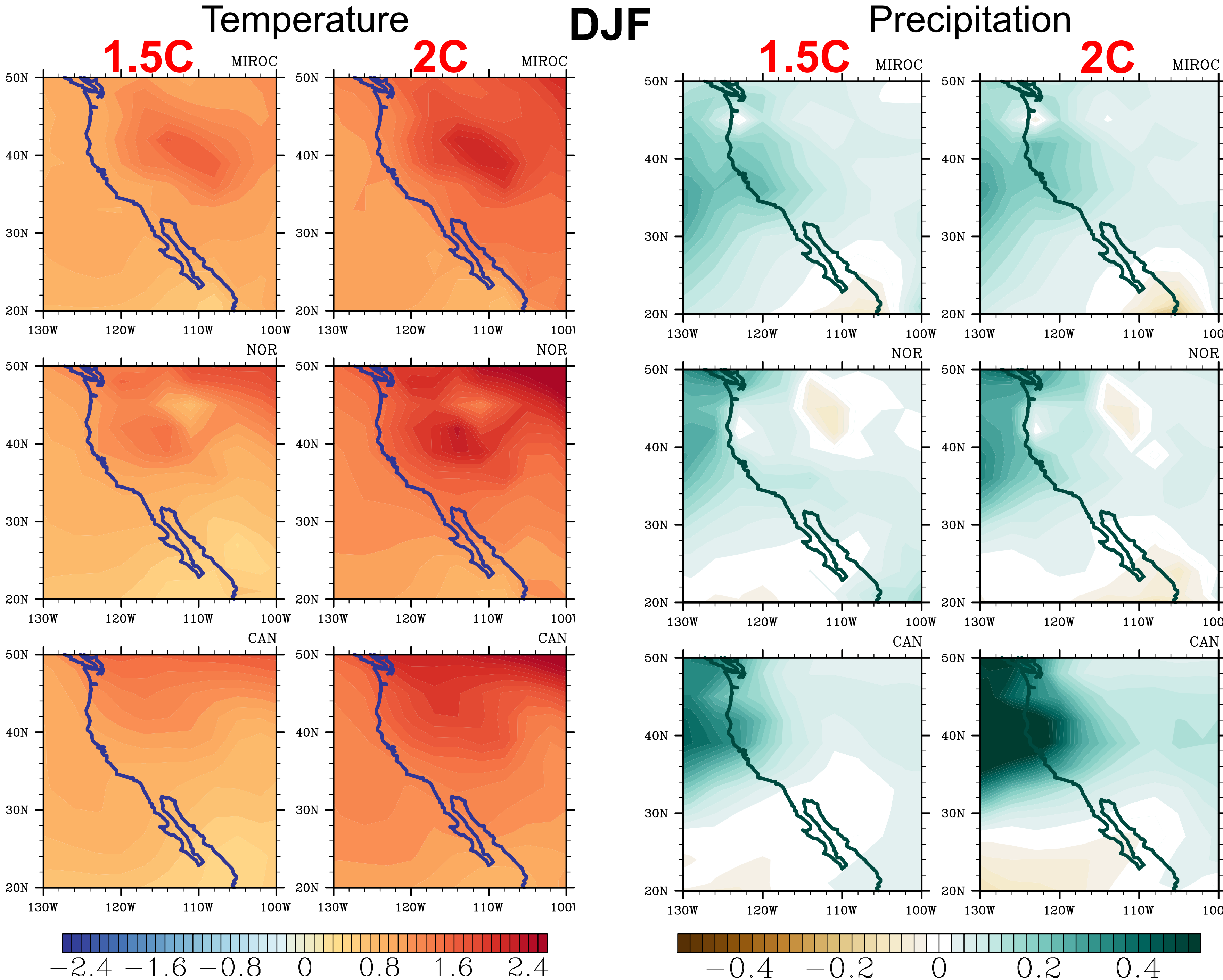

The Emissions Scenario Approach
Emissions
Radiative forcing
Global Response of the climate system
Regional Response and extreme weather
Impacts
Uncertainty
The HAPPI Approach
Global Temperature Constraint
2°C
1.5°C
Regional Response and Extreme Weather
HAPPI
Assessment of Impacts

Where Do The Forcing Patterns Come From?

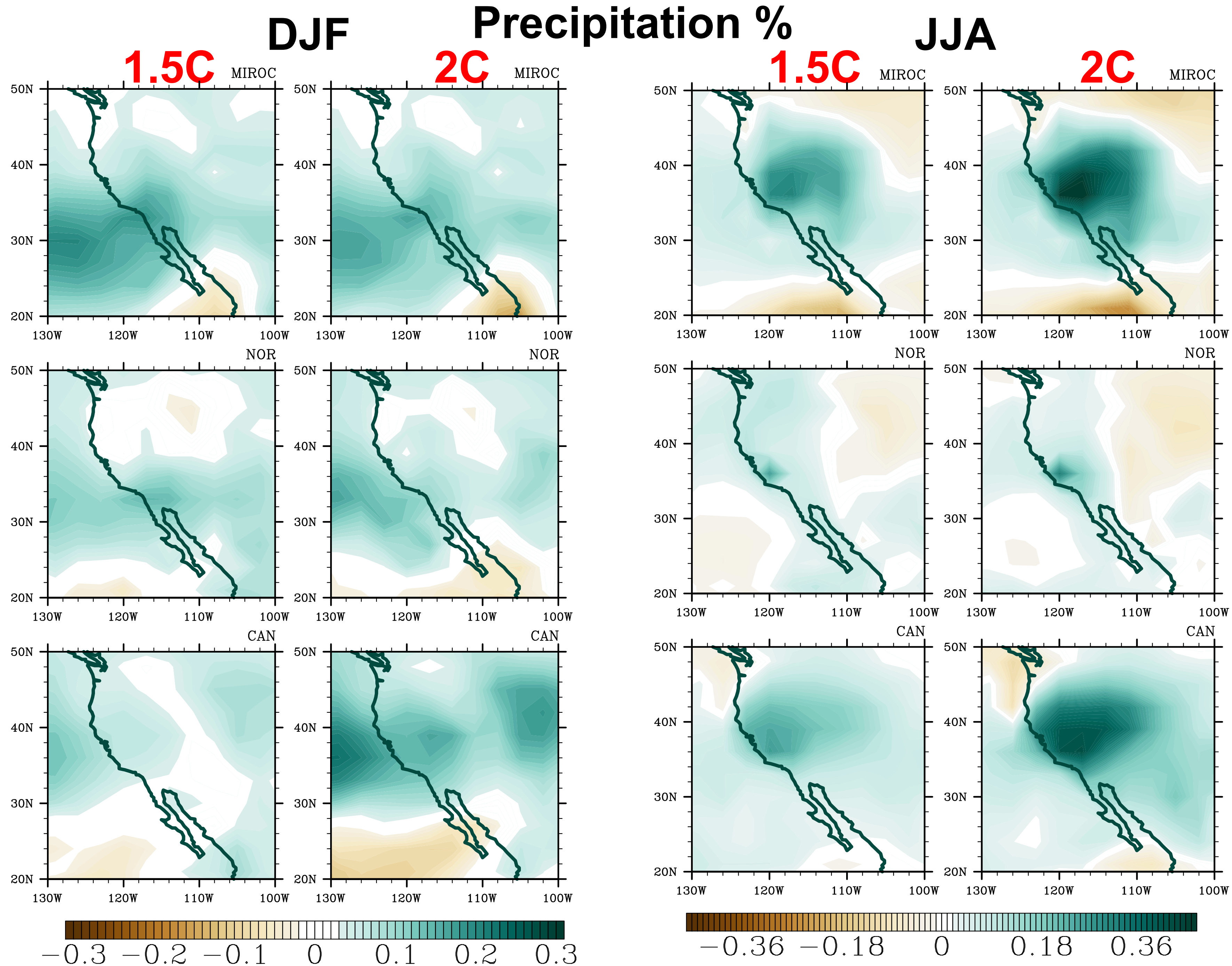


SST Forcing Patterns for the 1.5C & 2C Scenarios





Temperature
DJF
Precipitation
1.5C
2C
1.5C
2C
MIROC
NOR
CAN
50N
40N
30N
20N
130W
120W
110W
100W
−2.4 −1.6 −0.8 0 0.8 1.6 2.4
−0.4 −0.2 0 0.2 0.4


Precipitation %
DJF
JJA
1.5C
2C
1.5C
2C
MIROC
NOR
CAN
50N
40N
30N
20N
130W
120W
110W
100W
−0.3 −0.2 −0.1 0 0.1 0.2 0.3
−0.36 −0.18 0 0.18 0.36

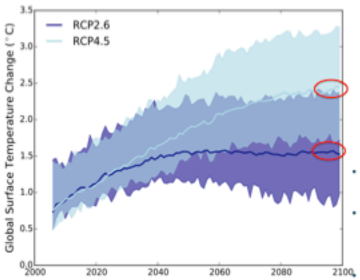
Changes in Northern Hemisphere Winter Storm Tracks, Attributed to the 1.5°C and 2°C Levels of Global Warming

Monika J. Barcikowska, Scott Weaver, Frauke Feser

Environmental Defense Fund/Helmholtz Zentrum Geesthacht

ABSTRACT

The observed hydro-climate in the Northern Hemisphere is closely tied to the large-scale atmospheric circulation over the Northern Atlantic and Pacific Ocean. Several studies have shown that recent changes in these circulation patterns (e.g. North Atlantic Oscillation/Arctic Oscillation) correspond with stronger cyclone activity, which supply heat and moisture to the parts of Europe and North America. Therefore, future changes in storminess will likely contribute to changes in a wide range of weather extremes (e.g. surges, extreme precipitation and winds).



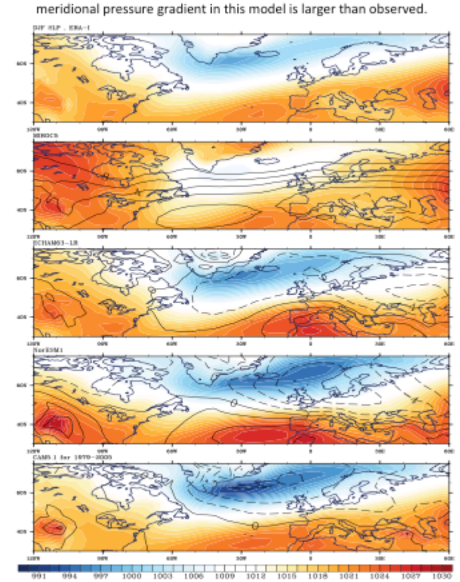
This study advances understanding of differential climate impacts between 1.5C and 2C levels of global warming by analyzing daily output of the high-resolution HAPPI simulations. We are presenting analysis of large ensemble runs to infer about changes in winter large–scale circulation, their impact on characteristics of extratropical storms and extreme precipitation events in the Northern Hemisphere. The analysis corroborates the fact that in many regions (e.g. California) precipitation extremes do not necessarily scale with the mean hydro-climate change. This underlines importance of high spatial and temporal resolution in climate simulations to derive information about a future weather, relevant for the local communities.

Half a Degree Additional warming, Prognosis, and Projected Impacts (HAPPI) project:

- present decade (2006-2015):
  - observed SSTs and sea ice;
- +1.5°C warming:
  - changes in SST from RCP2.6 runs (2091-2100 mean) are added to the observed SSTs;
  - GHG, aerosols and land-use and cover from year 2095;
- +2°C warming:
  - changes in SSTs and GHGs from weighted sum of RCP2.6 and RCP4.5 (2091-2100 mean)

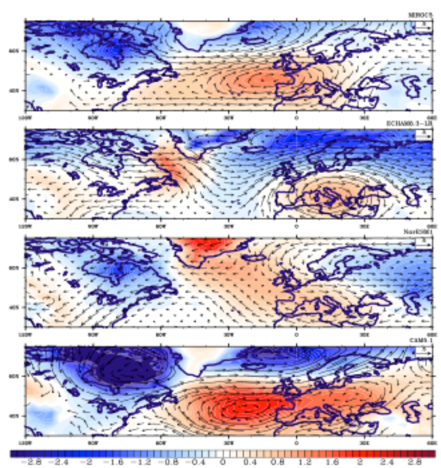
Large-scale atmospheric circulation over the North Atlantic

Comparison with observations: CMIP5 models capture reasonably well the features of meridional pressure gradient, although with strong zonal bias especially for low-resolution models (ECHAM6.3 and NorESM1). Zonal bias is reduced for the higher resolution model, i.e. CAM5.1. However the meridional pressure gradient in this model is larger than observed.



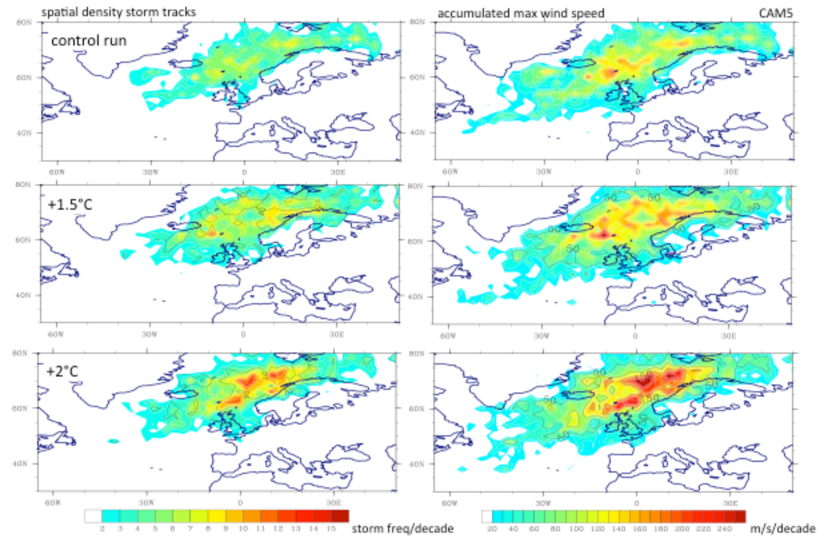
Time-mean average of sea-level pressure [hPa], derived for 1979-2015, for ERA-I reanalysis, and models: MIROC5, ECHAM6.3, NorESM1, CAM5.1, computed for 3°x3° lat-lon grid. Contour lines show a difference between observations and model.

+2°C warming climate change:
Models: MIROC5,CAM5.1 and ECHAM6.1 indicate a strengthening of the surface and 850hPa winds, which is consistent with a strengthening of meridional pressure gradient.



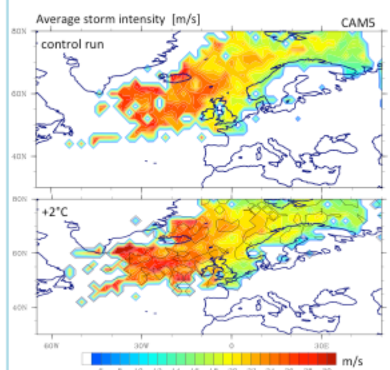
Changes in mean sea-level pressure [hPa] and wind vectors at 850hPa [m/s] for +2°C warming experiment, compared to present climate. Changes are derived for models: MIROC5, ECHAM6.3, NorESM1, CAM5.1; after interpolation to the 3°x3° lat-lon grid.

Changes in spatial characteristics of winter storm patterns and accumulated wind energy

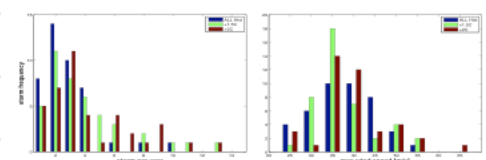


Decadal climatology of accumulated 3-hrly storm occurrences (left, [storm freq/decade], shaded) and associated with them accumulated max wind speed (right,[m/s/decade], shaded), derived for a) present climate, b) +1.5°C warming, c) +2°C warming in CAM5 model. Contour lines show differences between warming experiments and control run. Each climatology represents the ensemble mean of five climatologies computed for each member separately.

Changes in the frequency and intensity of winter storms



Climatology of storm maximum wind speed [m/s, shaded], derived for the CAM5 a) present climate, b) +1.5°C warming. Contour lines show a difference between +1.5°C and +2°C warming. Climatology is shown for grid cells with yearly average storm counts of 2 and larger.



Seasonal numbers of (left) storms, and (right) seasonal maximum intensity [m/s], derived for (blue) present climate, (green) +1.5°C warming, (red) +2°C warming. Each sample consists of 50 yearly values, i.e. ensemble of five-member decadal climatologies.

Future changes of winter storms in the North Atlantic sector:

1) northeastward shift of max density and maximum accumulated wind energy of storms (impacted north British Isles and Scandinavia);
2) increase of intensity of storms (impacted British Isles, north and western coast of Scandinavia);
3) increasing seasonal frequency and seasonal max intensity of storms

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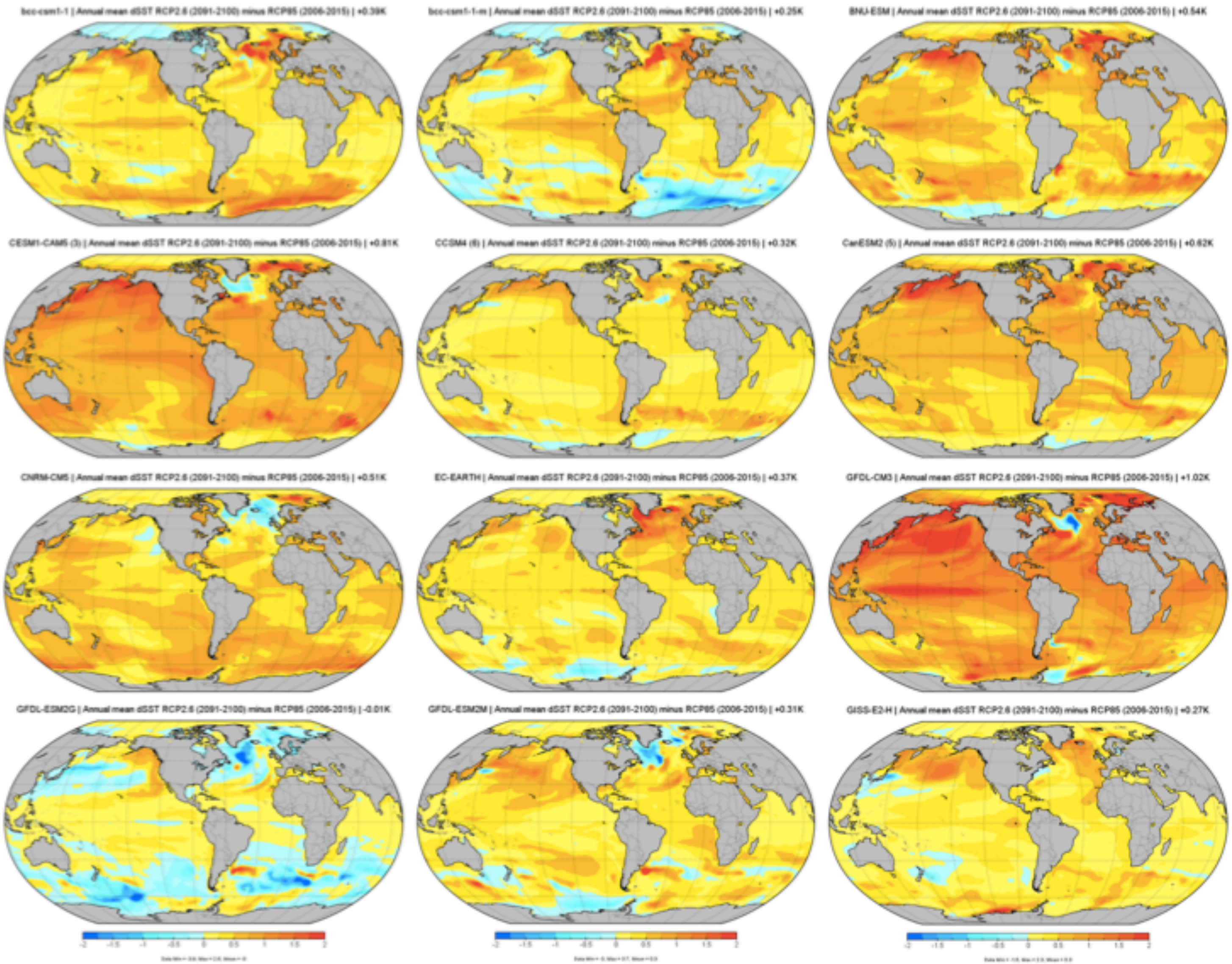
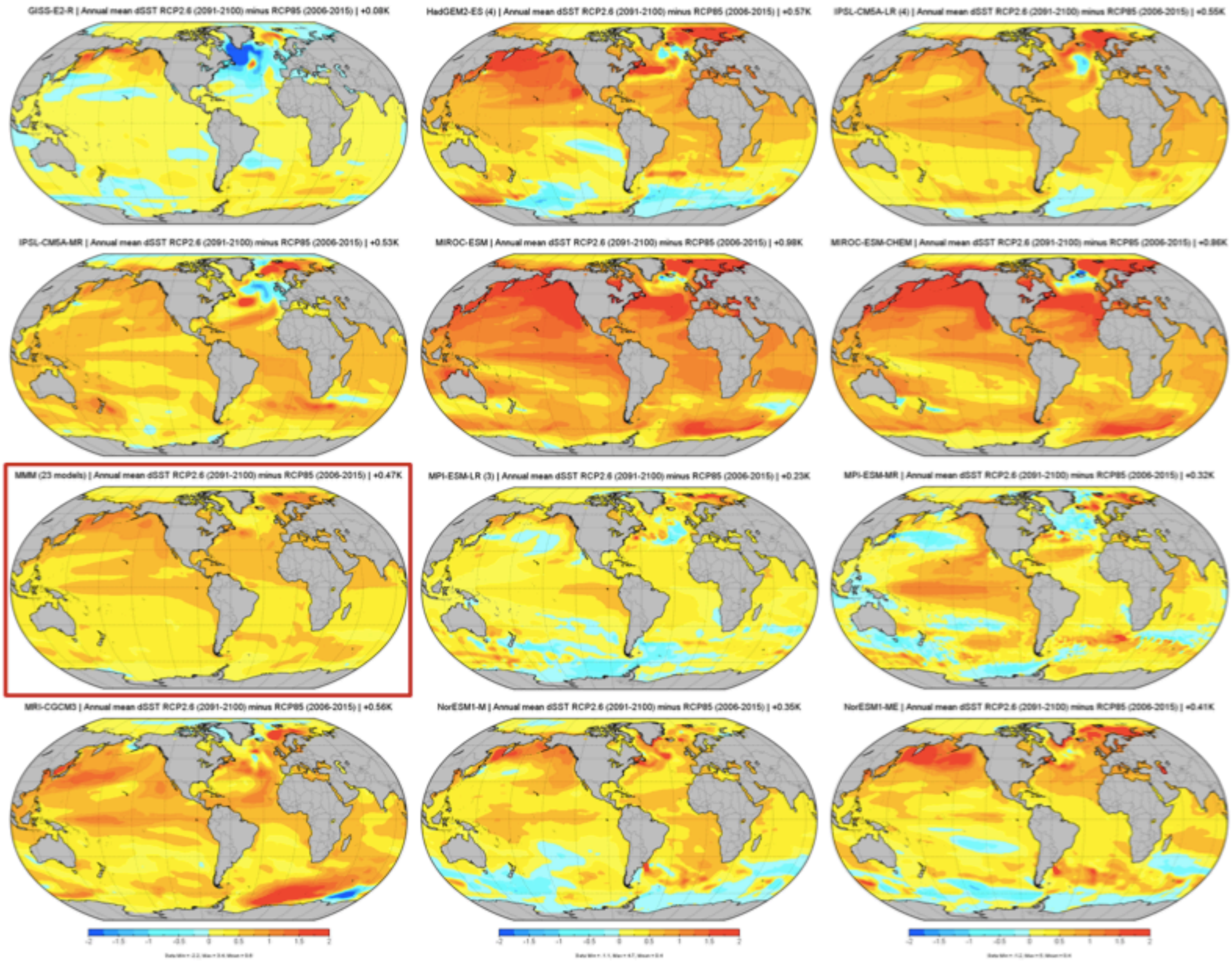
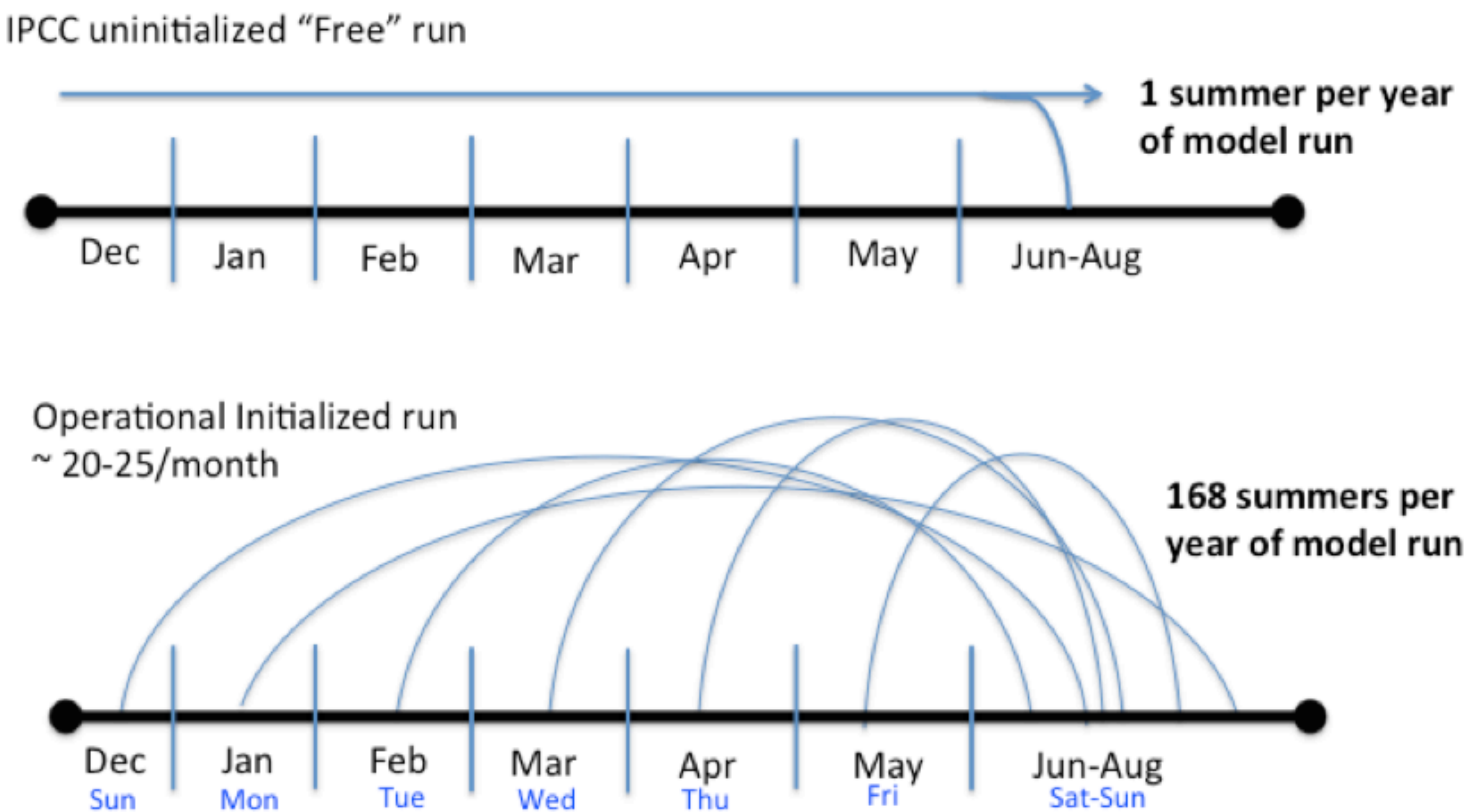


bcc-csm1-1 | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.39K
bcc-csm1-1-m | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.25K
BNU-ESM | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.54K
CESM1-CAM5 (3) | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.81K
CCSM4 (6) | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.32K
CanESM2 (5) | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.62K
CNRM-CM5 | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.51K
EC-EARTH | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.37K
GFDL-CM3 | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +1.02K
GFDL-ESM2G | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | -0.01K
GFDL-ESM2M | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.31K
GISS-E2-H | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.27K

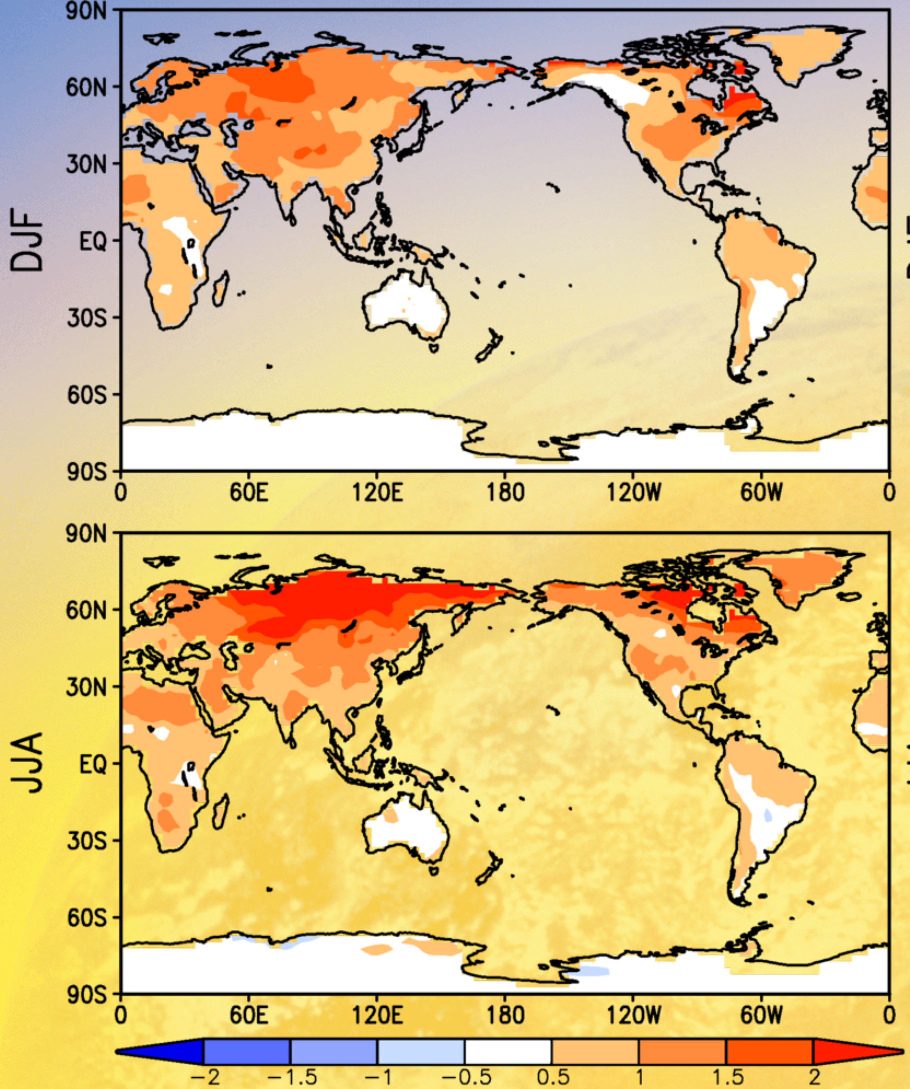

GISS-E2-R | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.08K
HadGEM2-ES (4) | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.57K
IPSL-CM5A-LR (4) | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.55K
IPSL-CM5A-MR | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.53K
MIROC-ESM | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.98K
MIROC-ESM-CHEM | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.86K
MMM (23 models) | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.47K
MPI-ESM-LR (3) | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.23K
MPI-ESM-MR | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.32K
MRI-CGCM3 | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.56K
NorESM1-M | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.35K
NorESM1-ME | Annual mean dSST RCP2.6 (2091-2100) minus RCP85 (2006-2015) | +0.41K

Simplified Example of Operational vs. IPCC Climate Model Run with increasing CO_2 in a Given Year

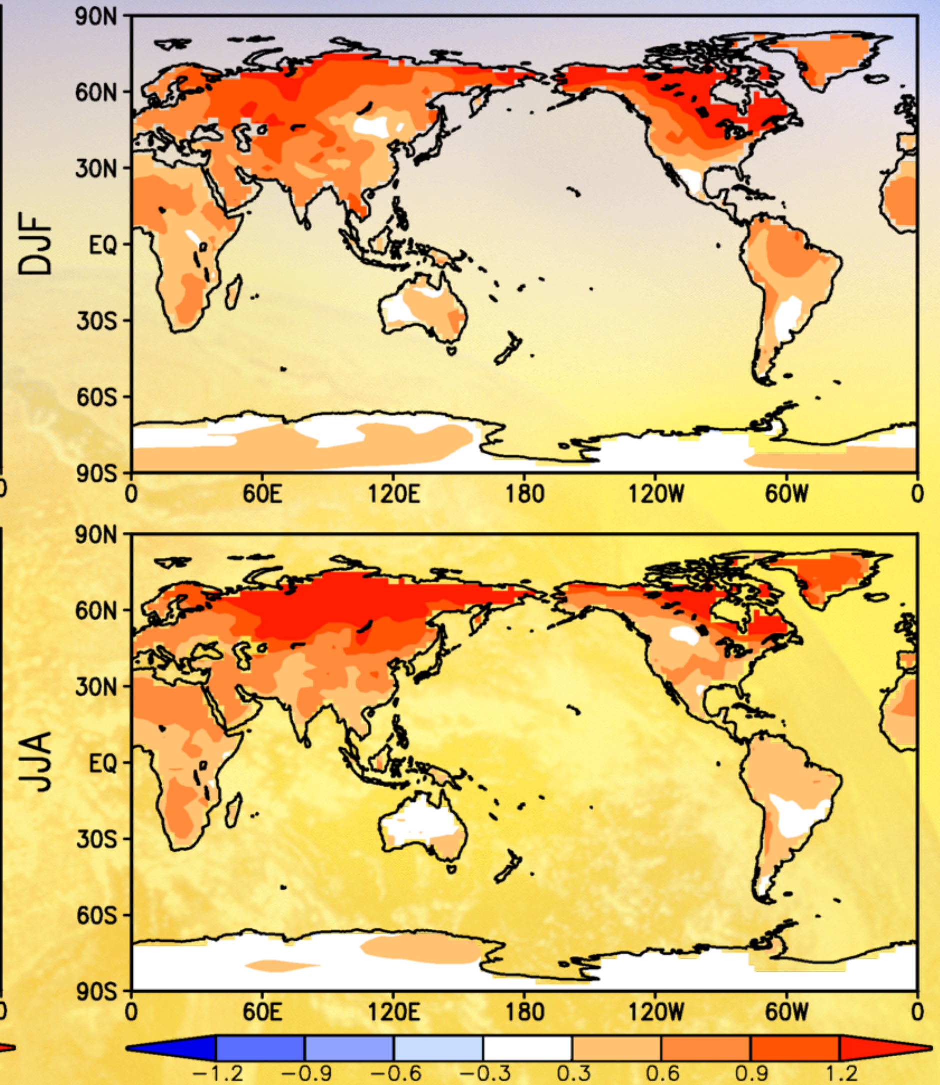


Temperature Change

4 Year Period Differences

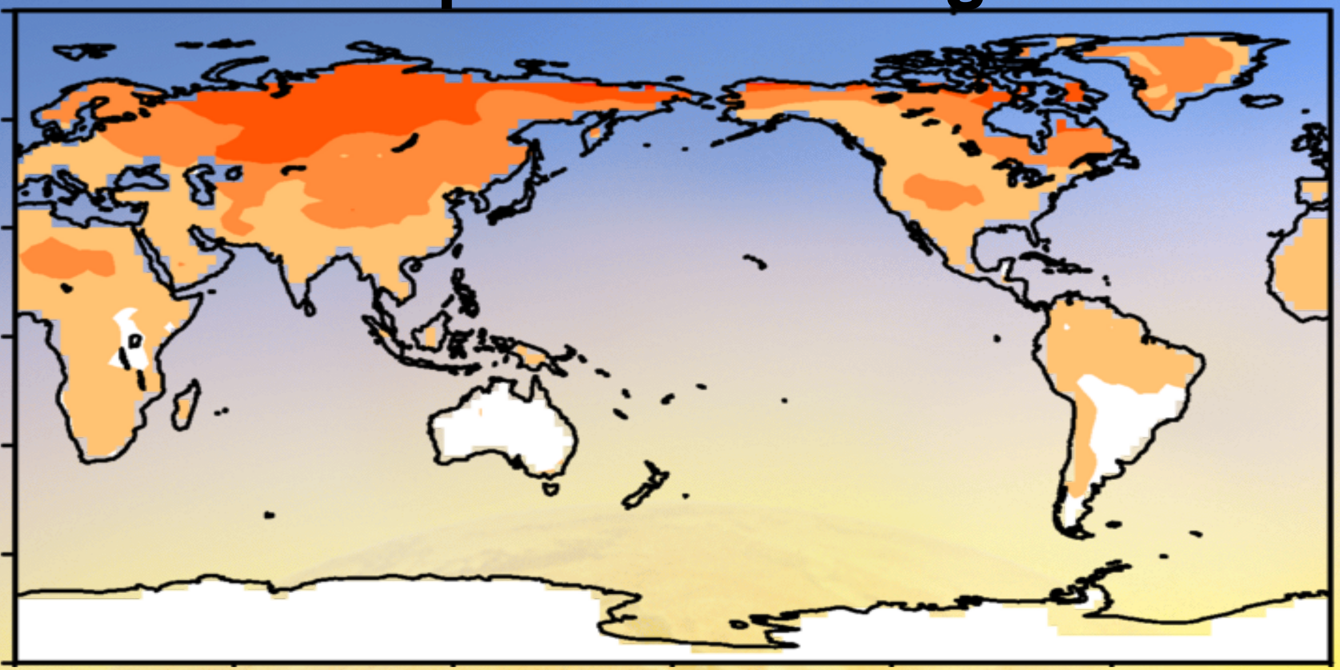


8 Year Period Differences

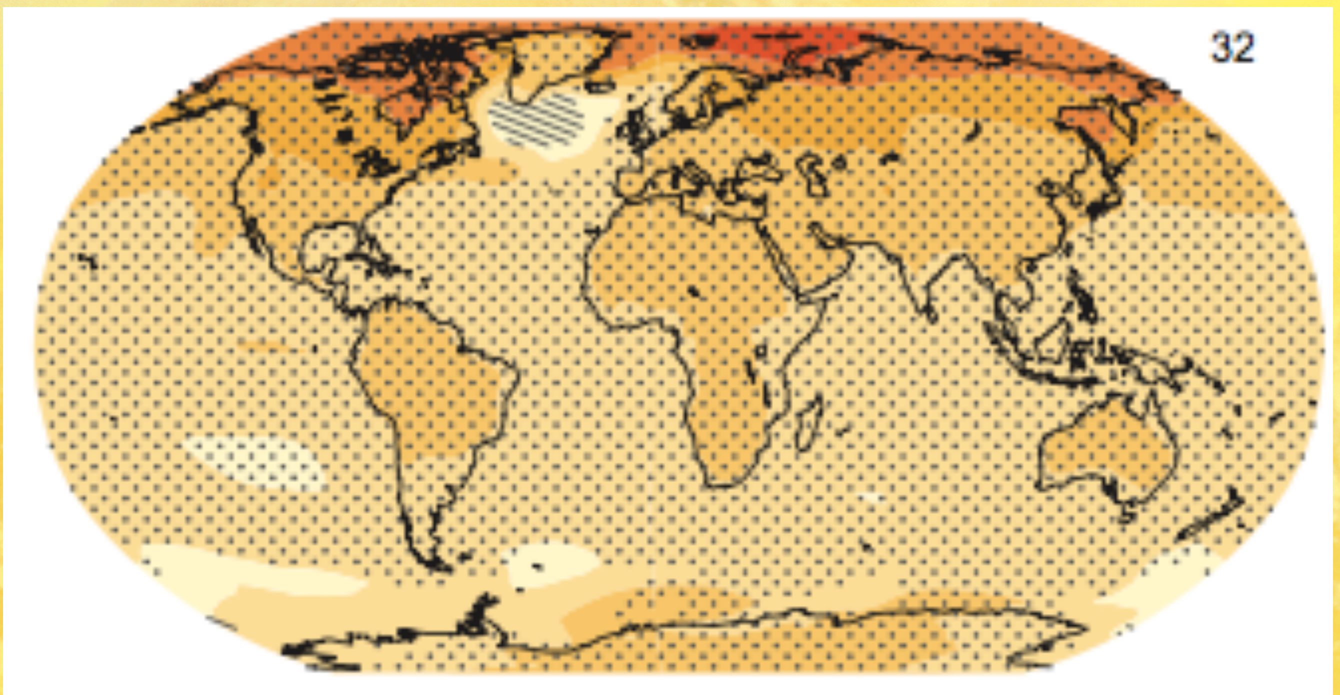


Temperature Change

N
O
A
A

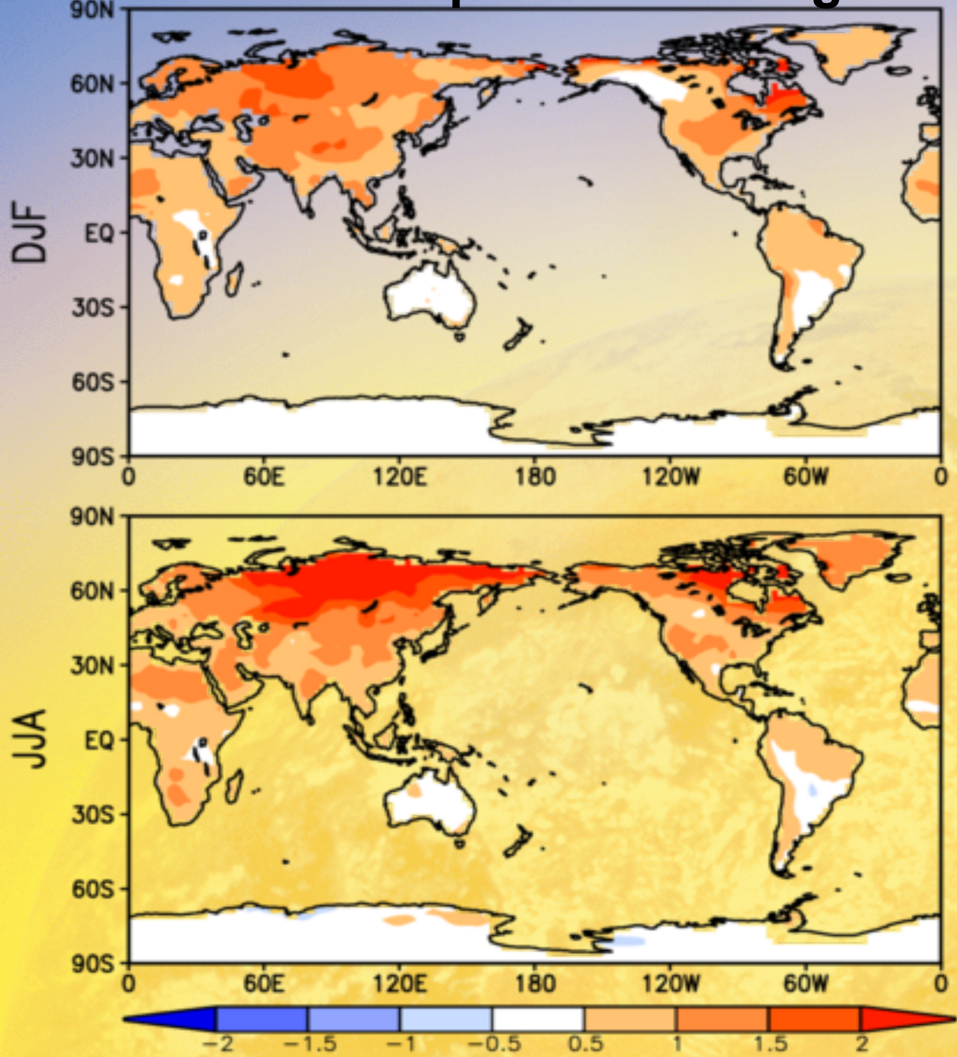


I
P
C
C

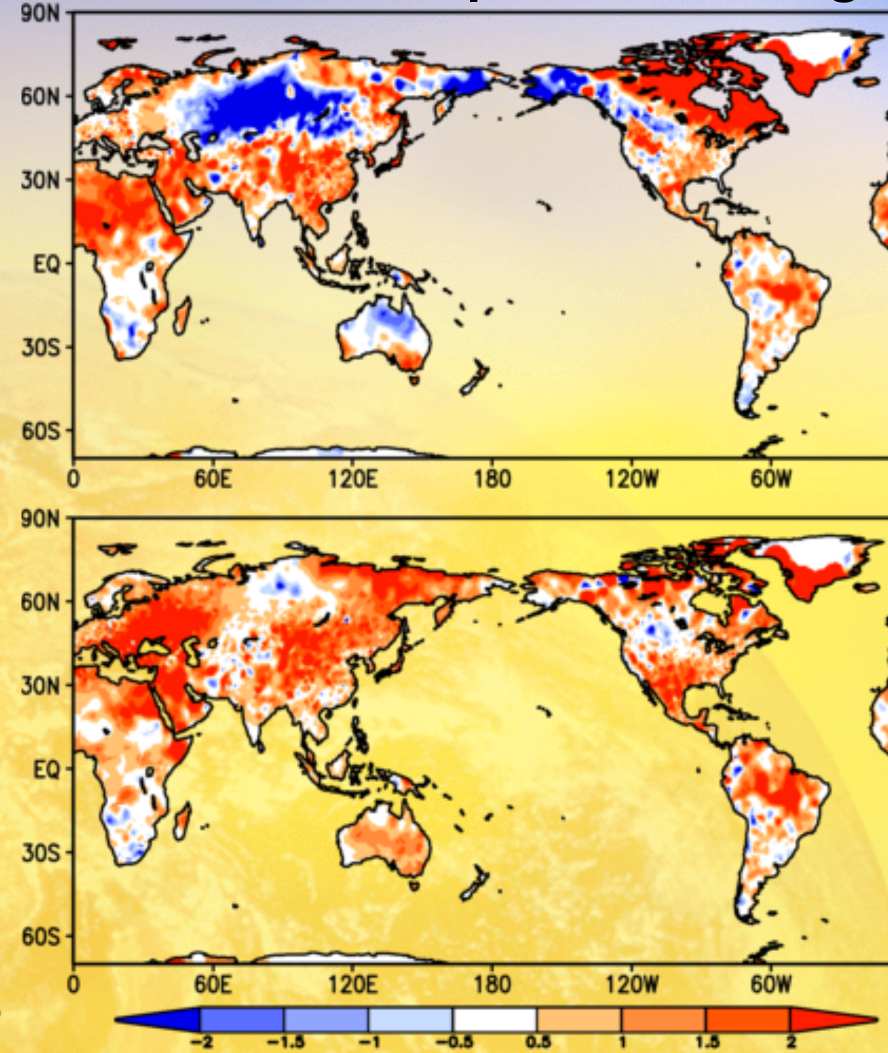


Temperature Change

Model Temperature Change



Observed Temperature Change



DAI – Dangerous Anthropogenic Interference

Article 2 of UNFCCC