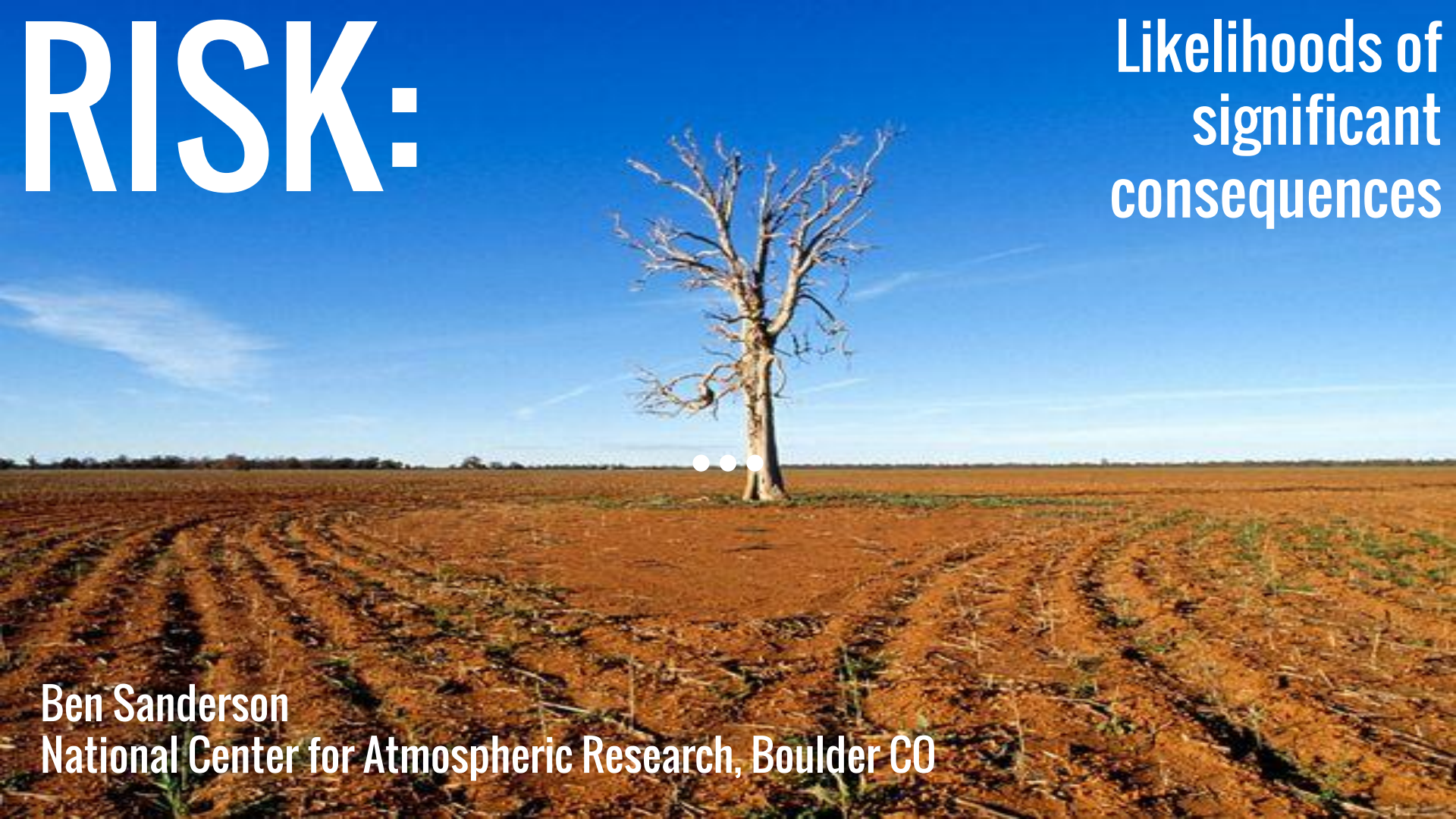
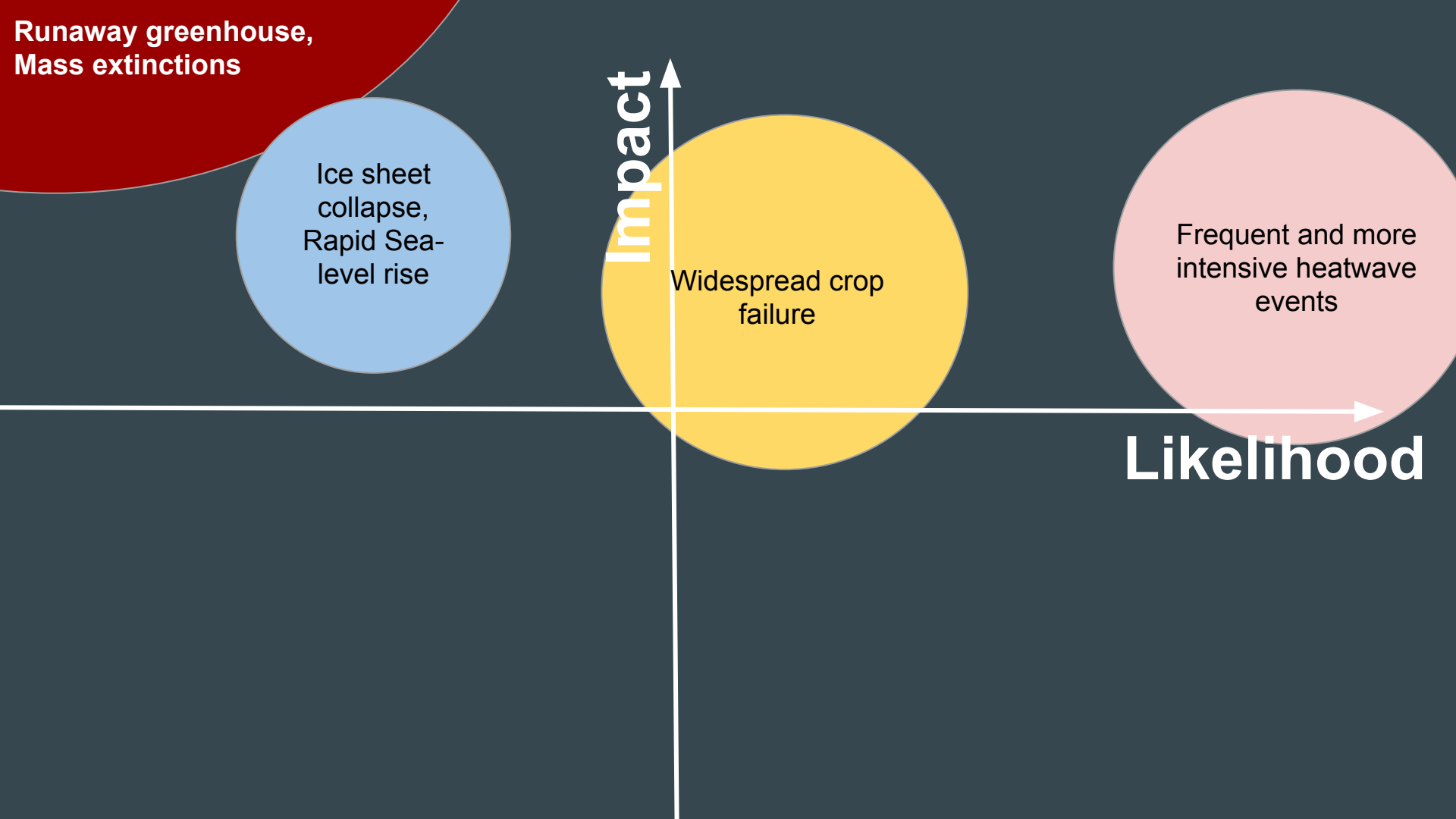
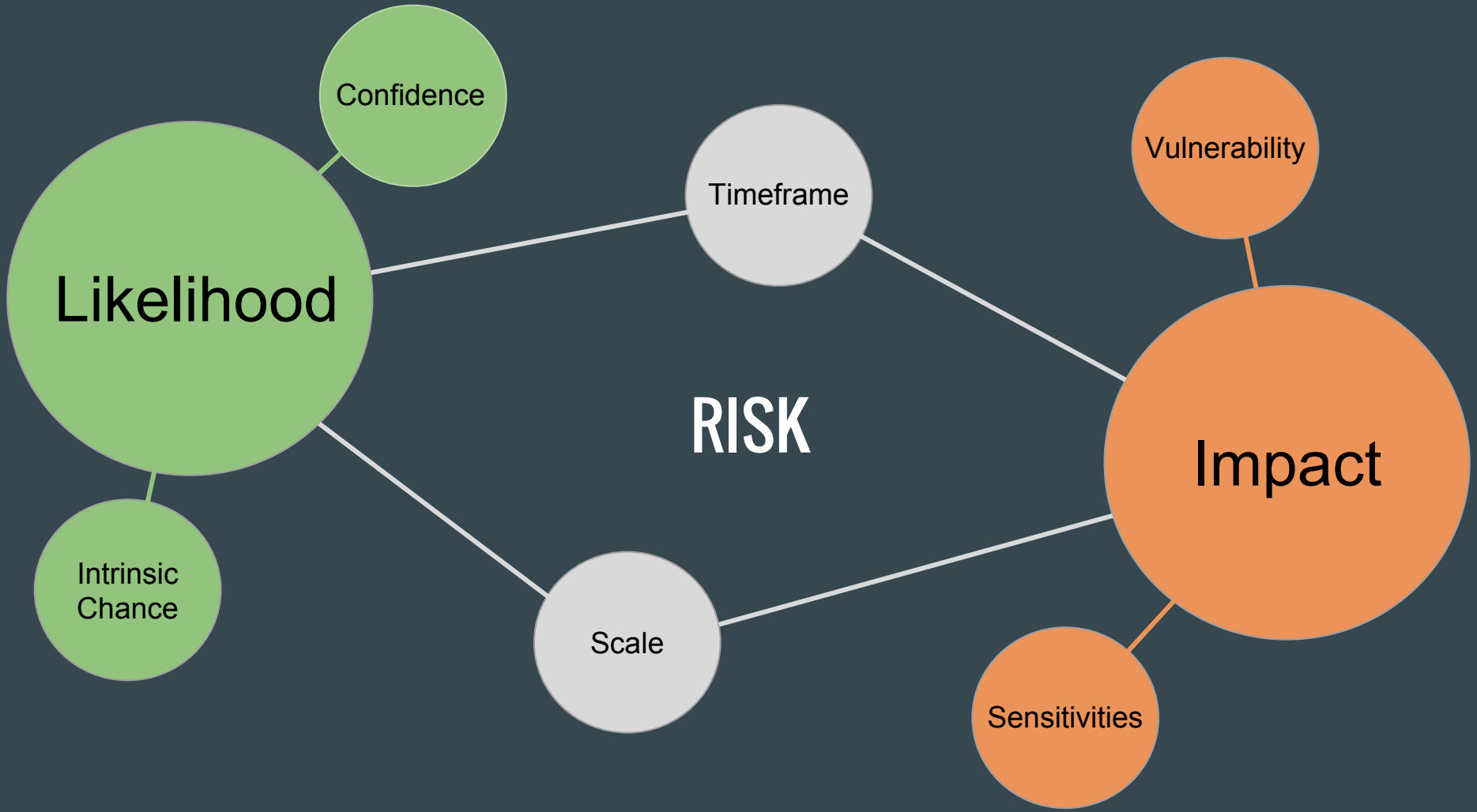
RISK:

Likelihoods of significant consequences

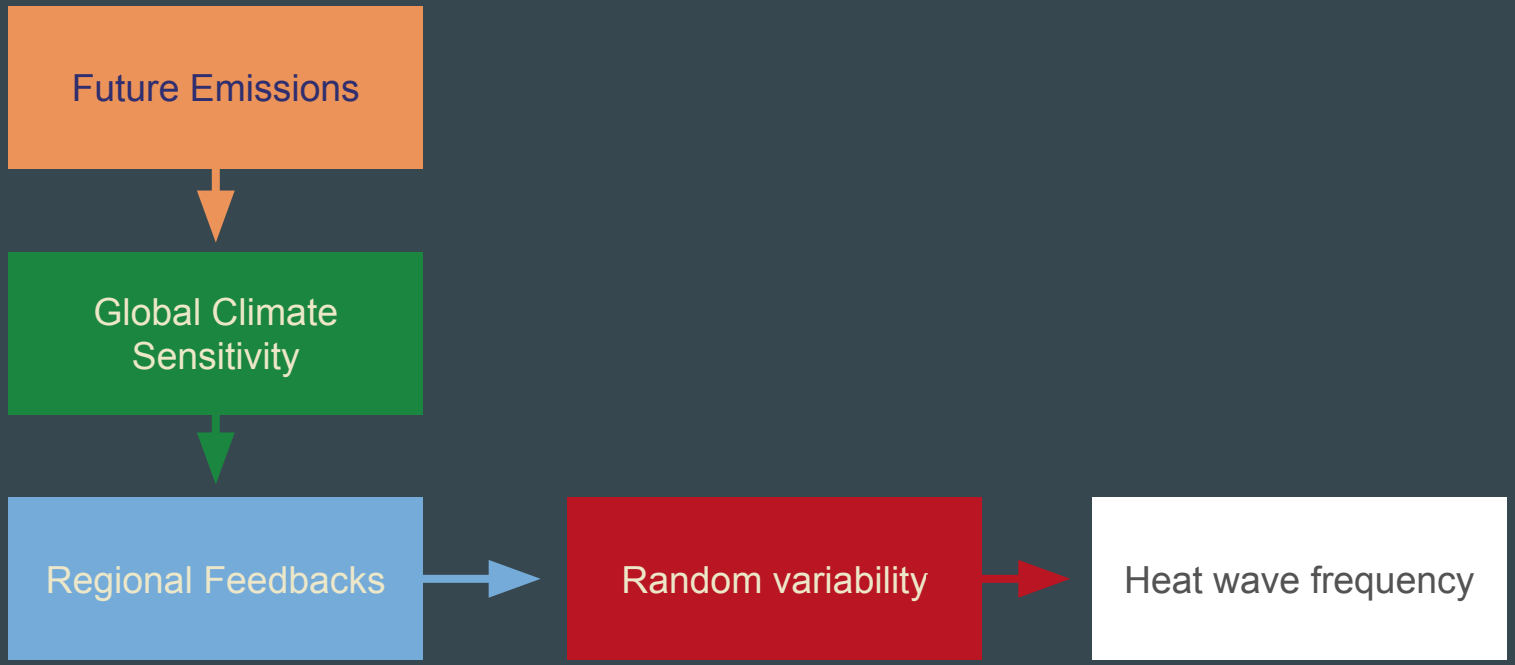


Ben Sanderson
National Center for Atmospheric Research, Boulder CO


Runaway greenhouse,
Mass extinctions
Ice sheet collapse, Rapid Sea-level rise
Impact
Widespread crop failure
Frequent and more intensive heatwave events
Likelihood

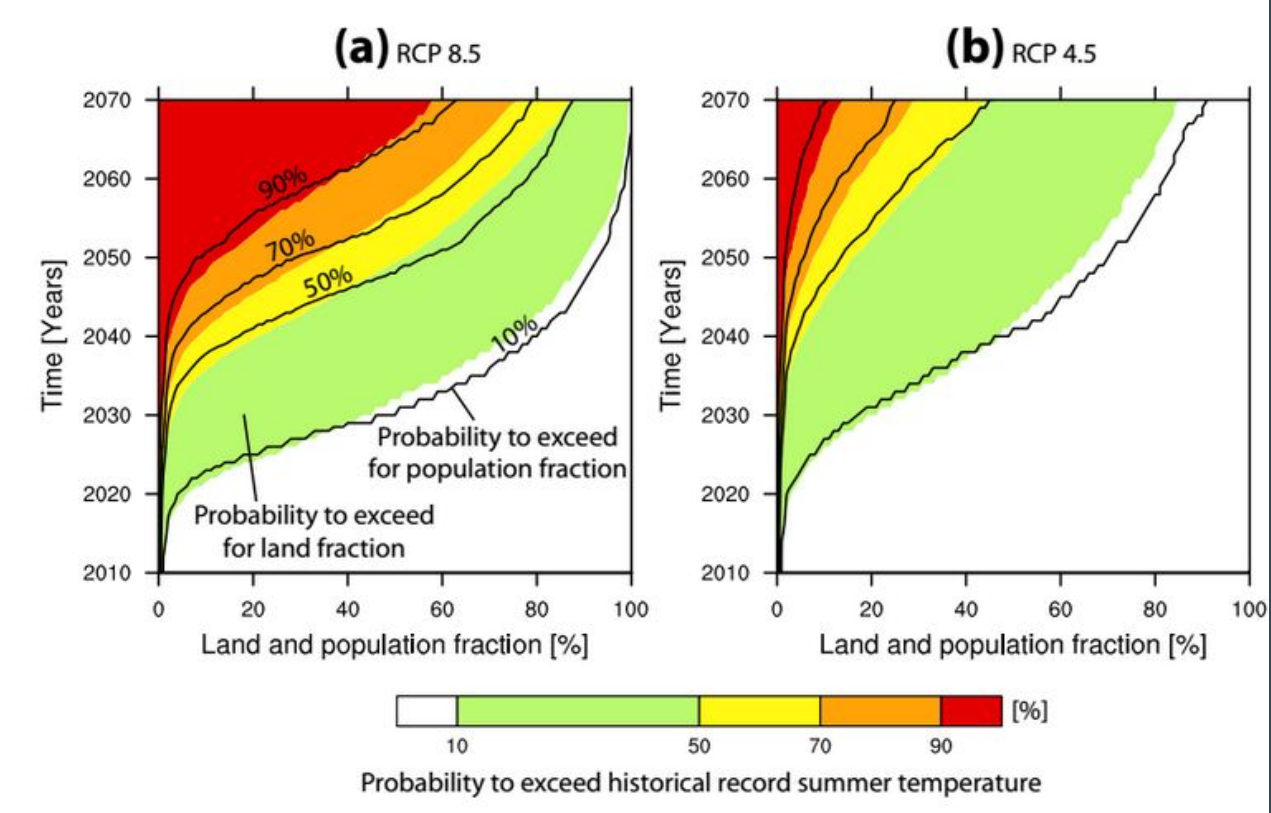

Confidence
Likelihood
Timeframe
Vulnerability
RISK
Impact
Intrinsic Chance
Scale
Sensitivities

The Chain of Uncertainty: Heat waves

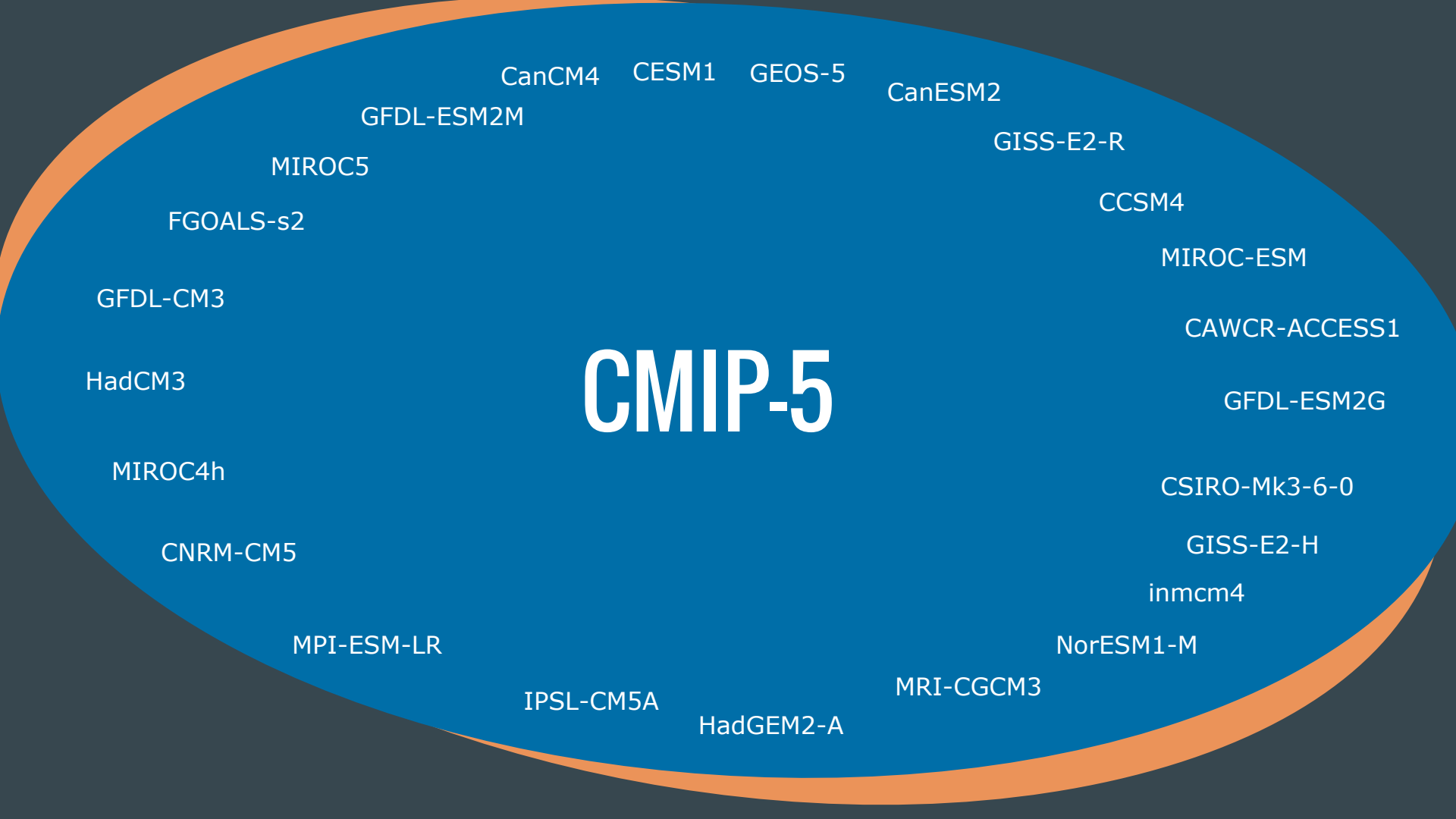


The Chain of Uncertainty: Heat waves

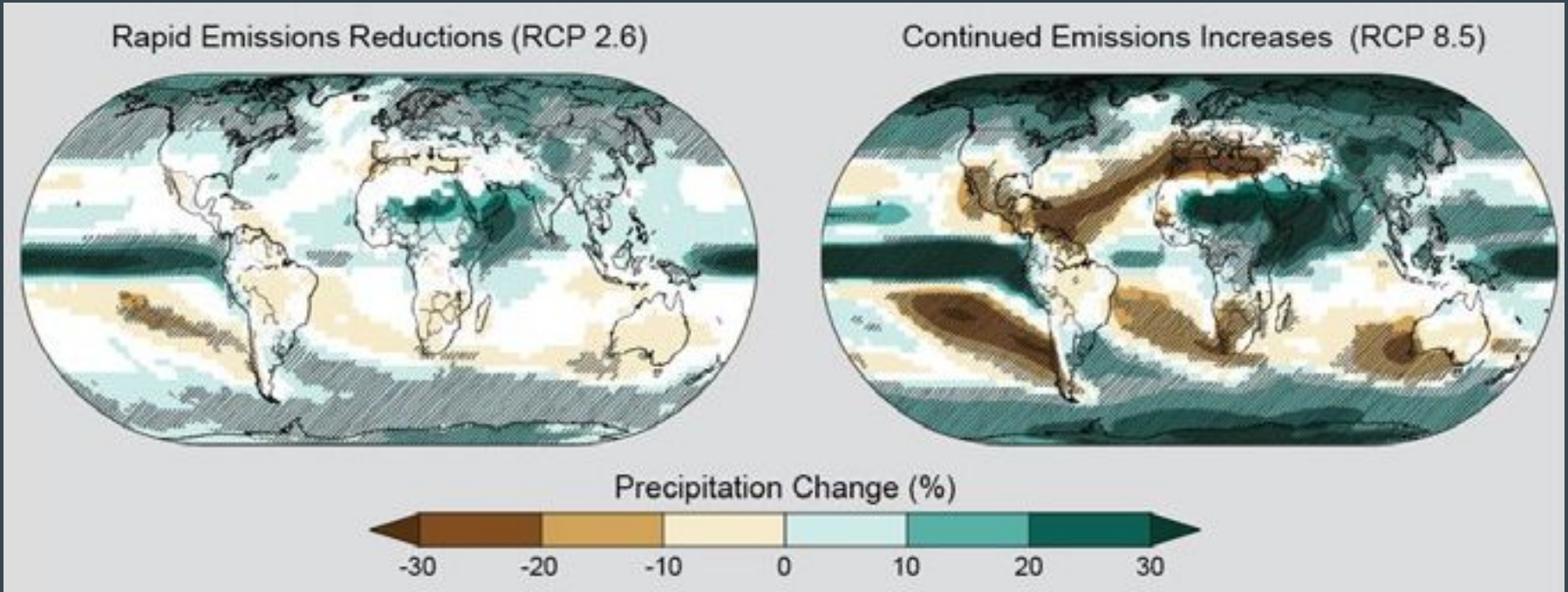
Large ensembles can sample ‘weather’ noise

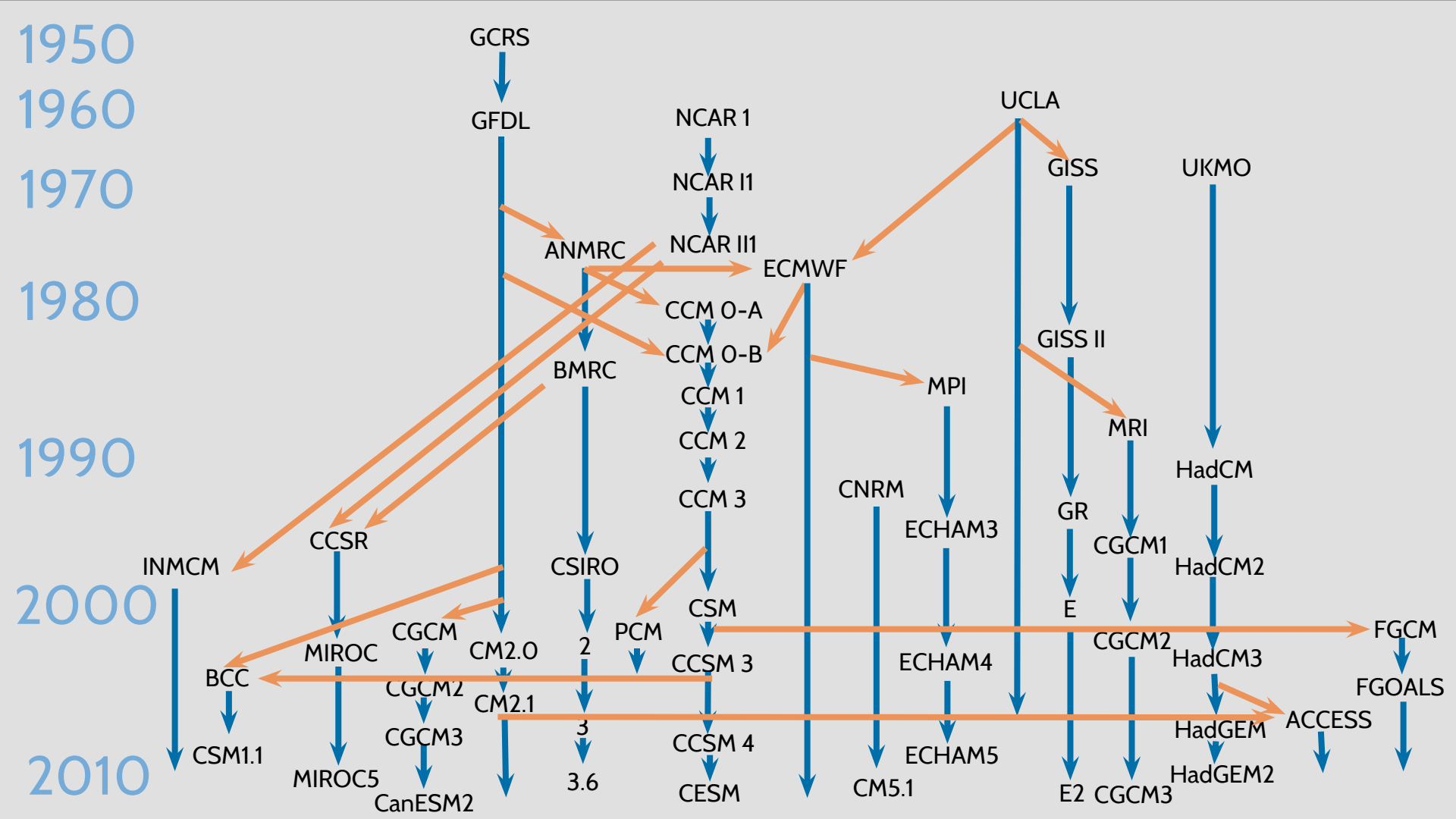


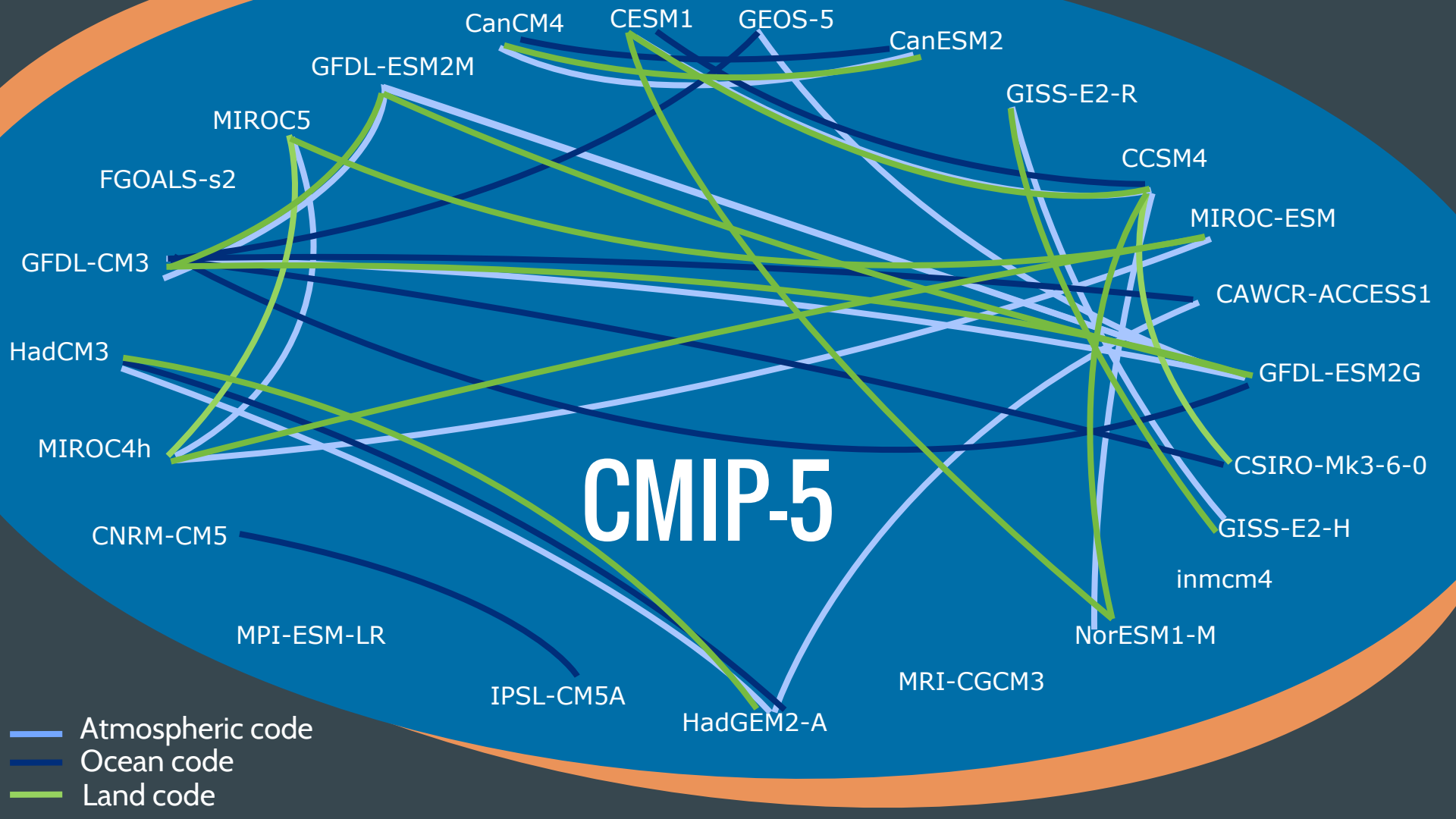
The Chain of Uncertainty: Heat waves


CanCM4
CESM1
GEOS-5
CanESM2
GFDL-ESM2M
GISS-E2-R
MIROC5
CCSM4
FGOALS-s2
MIROC-ESM
GFDL-CM3
CAWCR-ACCESS1
CMIP-5
HadCM3
GFDL-ESM2G
MIROC4h
CSIRO-Mk3-6-0
CNRM-CM5
GISS-E2-H
inmcm4
MPI-ESM-LR
NorESM1-M
MRI-CGCM3
IPSL-CM5A
HadGEM2-A

Does model agreement mean anything?




1950
1960
1970
1980
1990
2000
2010
GCRS
GFDL
NCAR 1
NCAR I1
NCAR II1
ANMRC
ECMWF
UCLA
GISS
UKMO
CCM 0-A
CCM 0-B
CCM 1
CCM 2
CCM 3
BMRC
GISS II
MPI
MRI
HadCM
CNRM
ECHAM3
GR
CGCM1
HadCM2
INMCM
CCSR
CSIRO
CSM
E
FGCM
CGCM
PCM
CGCM2
HadCM3
MIROC
CM2.0
2
CCSM 3
ECHAM4
FGOALS
BCC
CGCM2
CM2.1
ACCESS
CGCM3
3
CCSM 4
HadGEM
CSM1.1
ECHAM5
MIROC5
3.6
HadGEM2
CanESM2
CESM
CM5.1
E2
CGCM3


CanCM4
CESM1
GEOS-5
CanESM2
GFDL-ESM2M
GISS-E2-R
MIROC5
CCSM4
FGOALS-s2
MIROC-ESM
GFDL-CM3
CAWCR-ACCESS1
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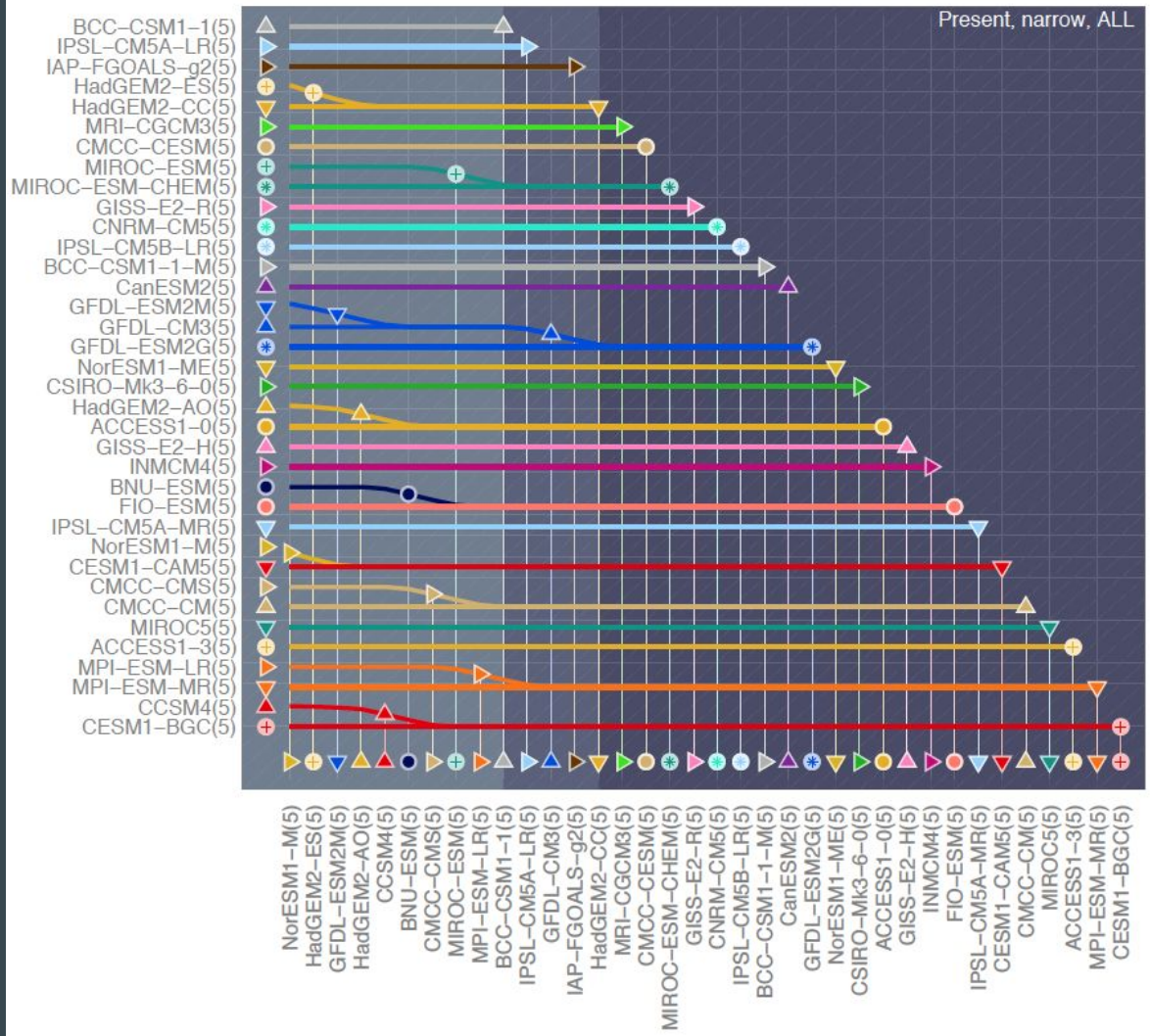
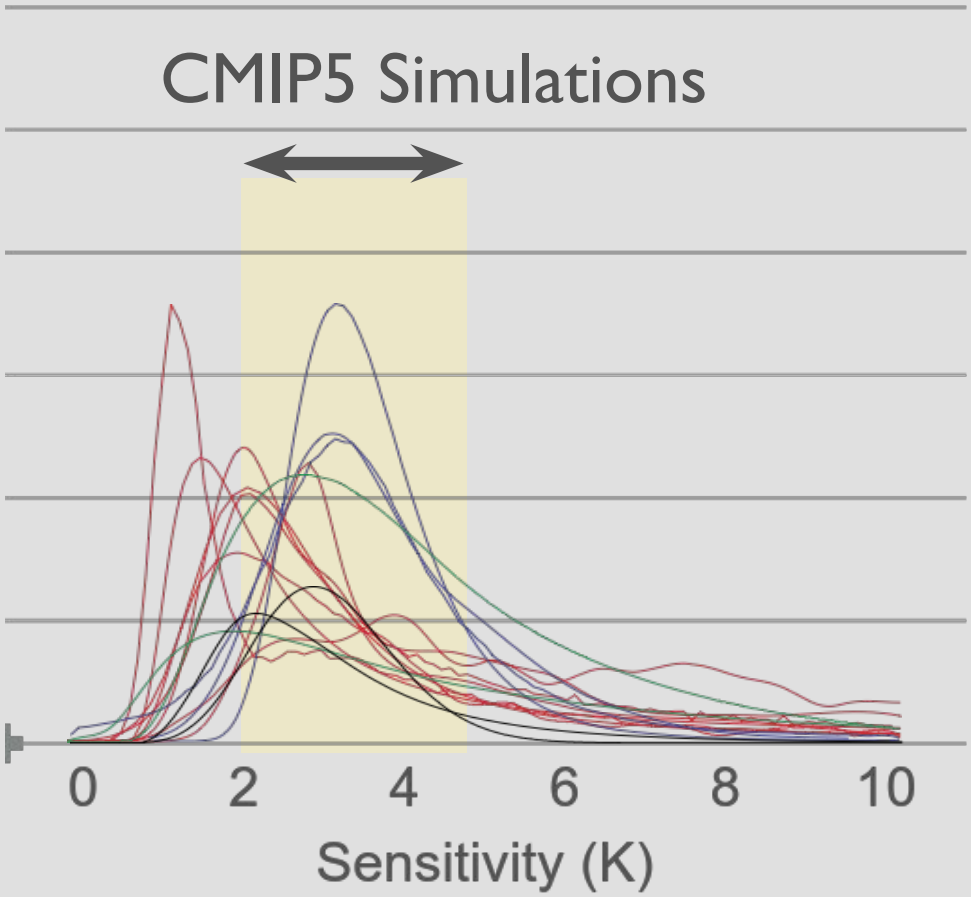
GFDL-ESM2G
MIROC4h
CSIRO-Mk3-6-0
CMIP-5
GISS-E2-H
CNRM-CM5
inmcm4
MPI-ESM-LR
NorESM1-M
MRI-CGCM3
IPSL-CM5A
HadGEM2-A
Atmospheric code
Ocean code
Land code

Strategies for addressing interdependency



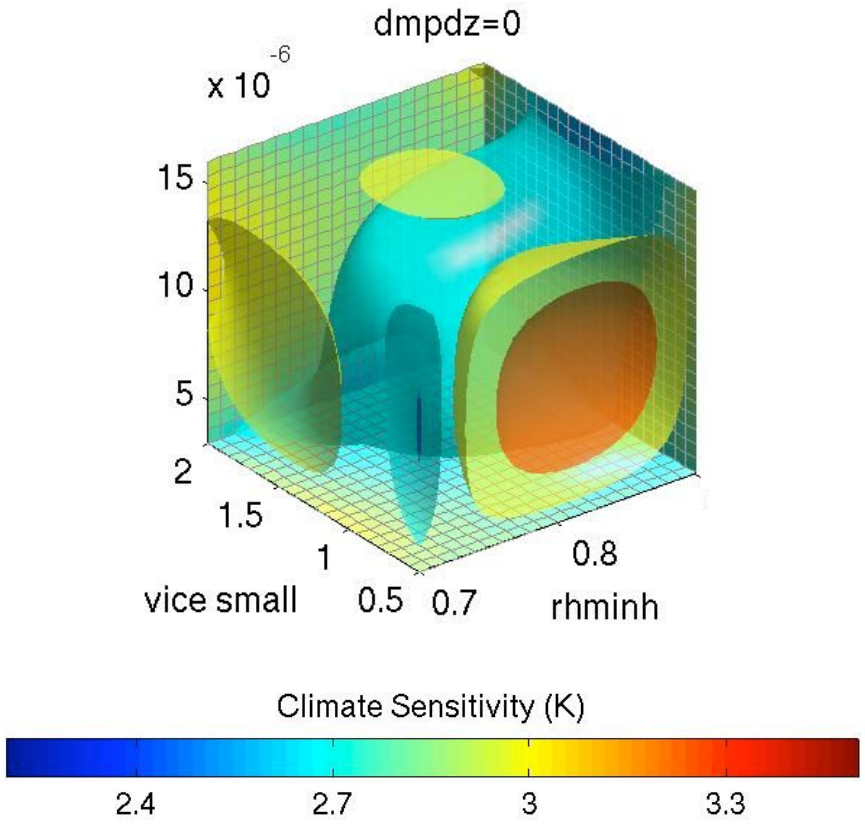
The Chain of Uncertainty: Heat waves

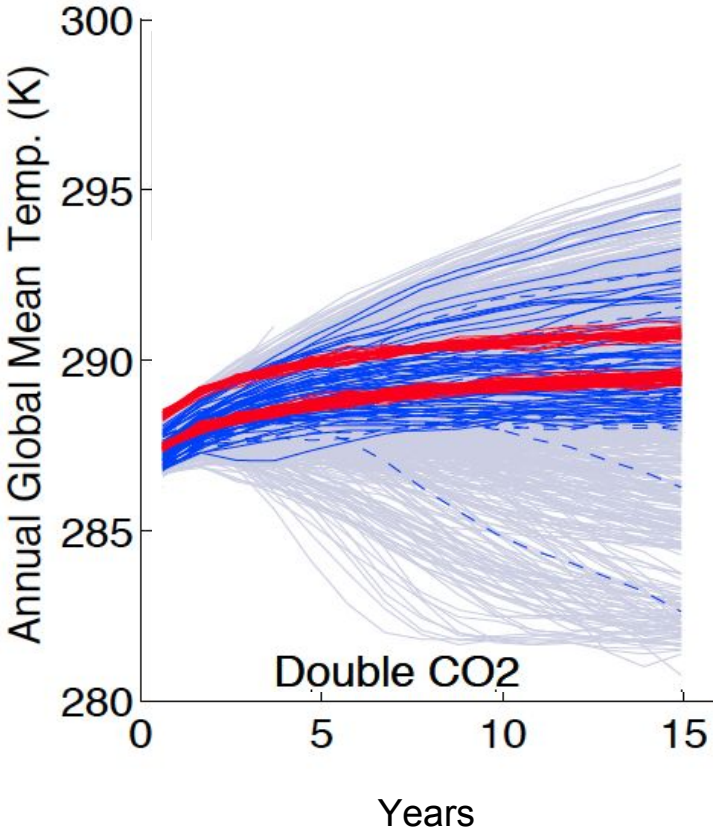


- Instrumental Period
- Mean State
- Paleo Records
- Bayesian Combination

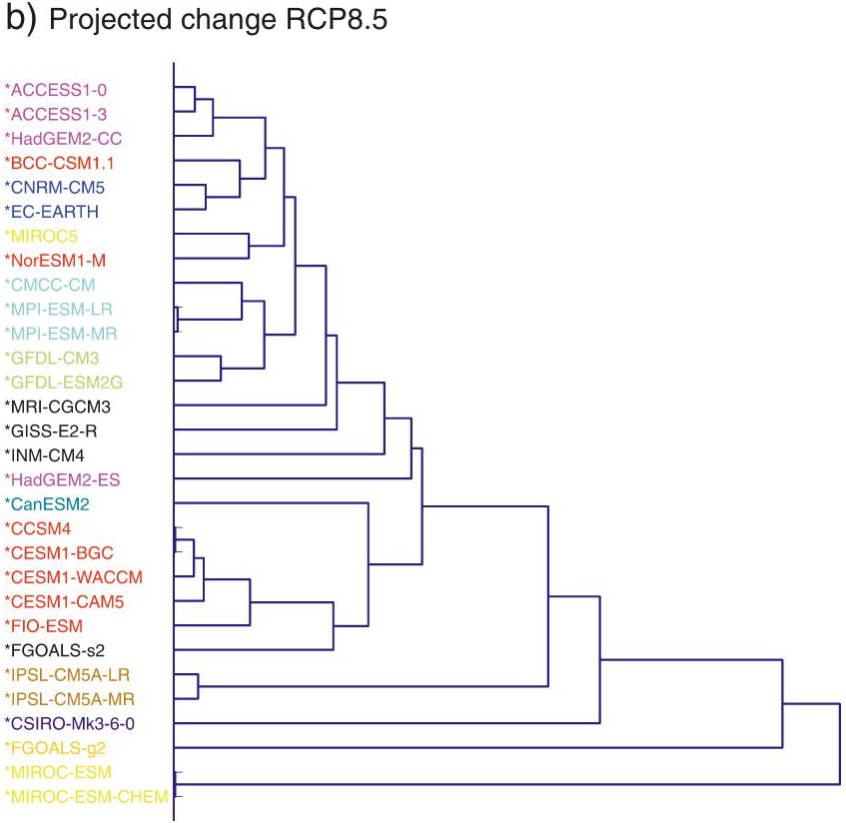
Data from Knutti et al (2008)

Climate Sensitivity is a function of uncertain model parameters

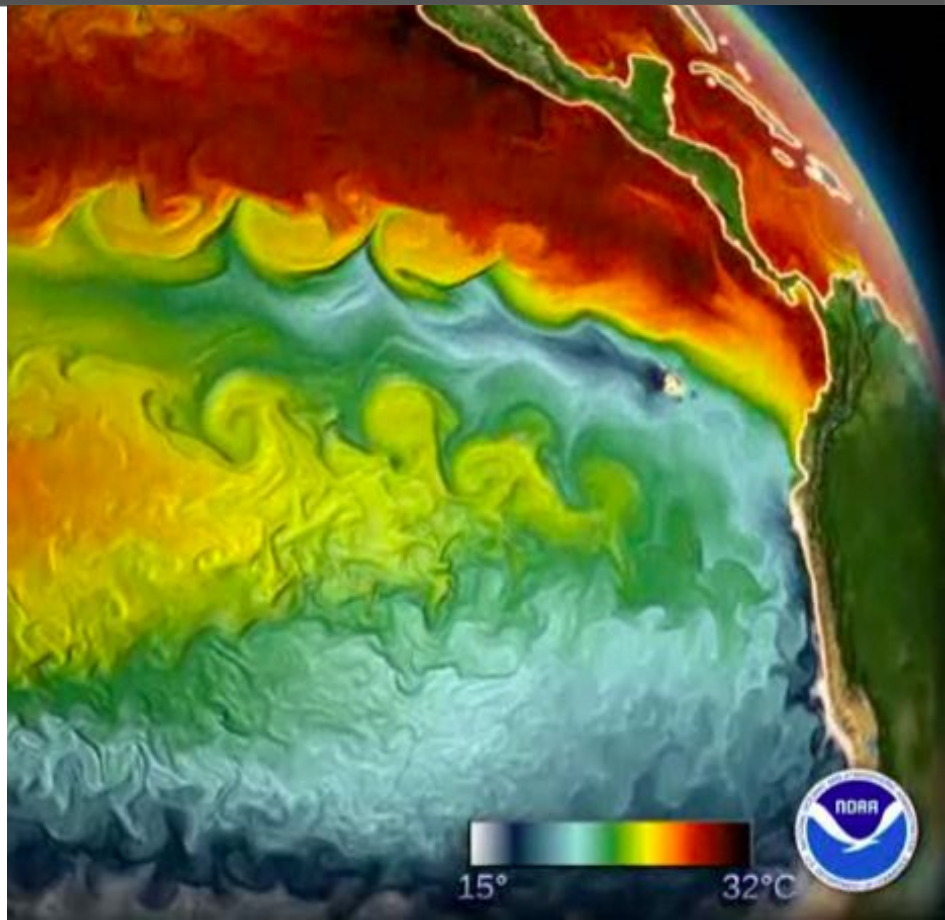


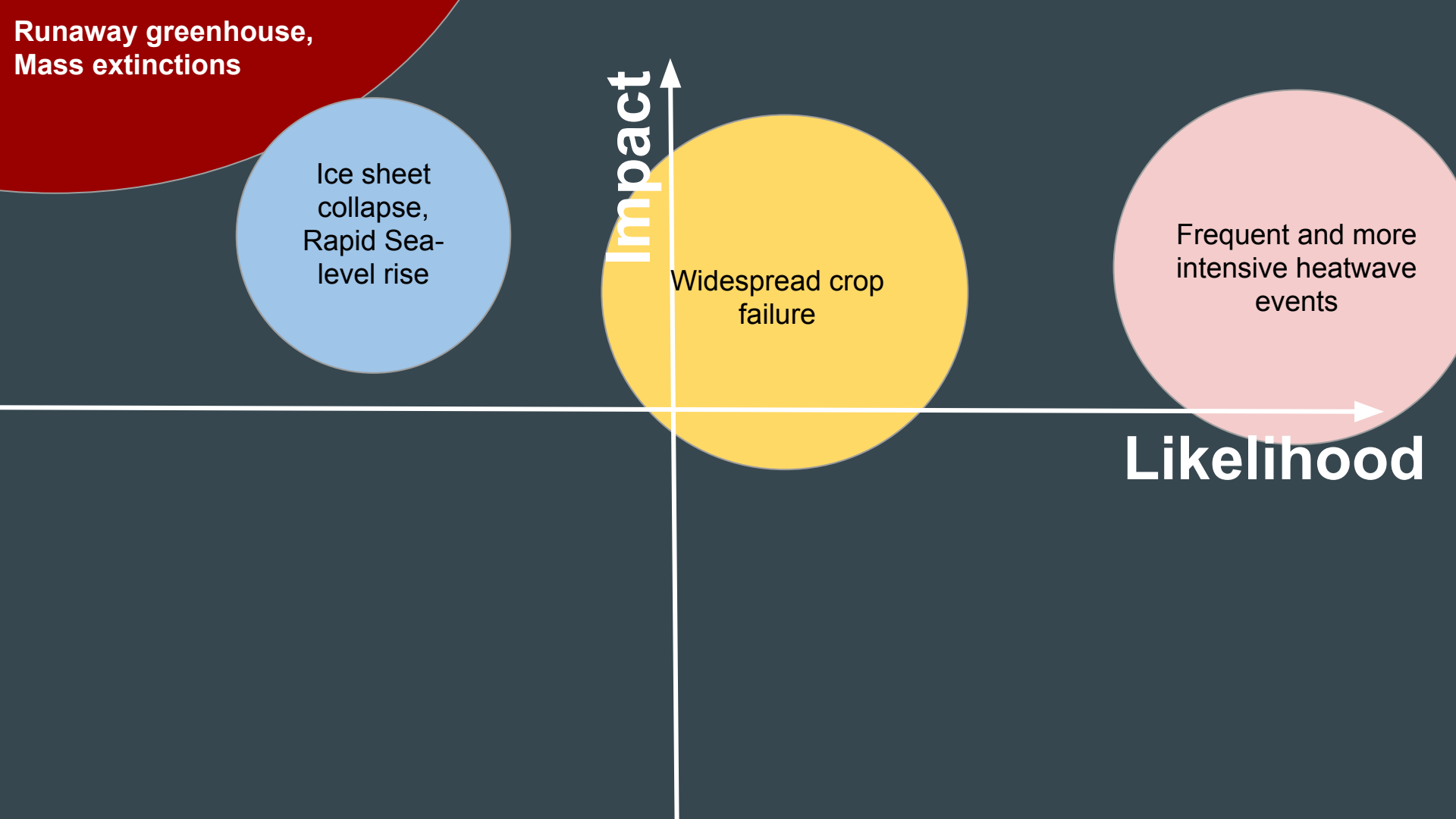


The folly of high resolution simulations for risk analysis



Knutti *et al* (2013)

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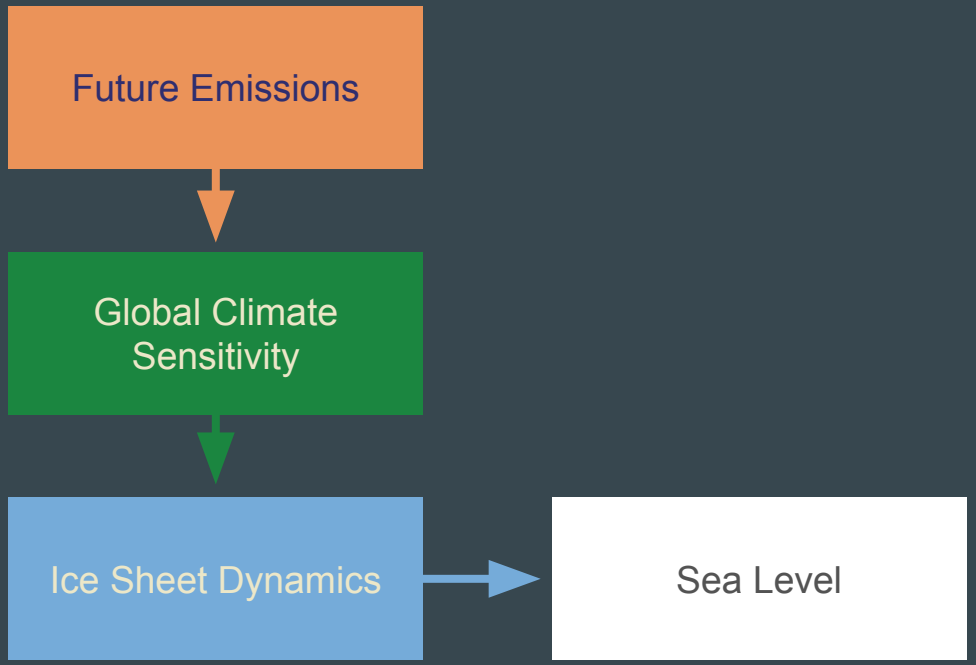
The Chain of Uncertainty: Sea Level Rise



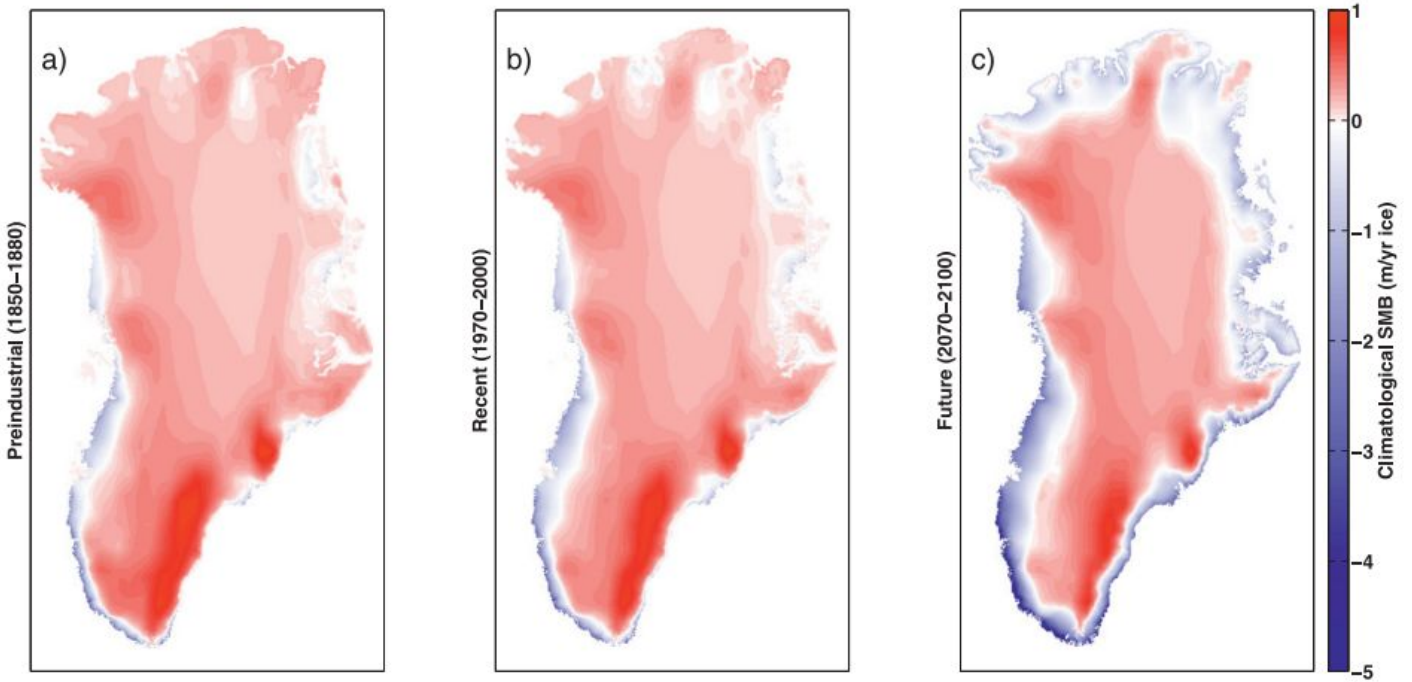
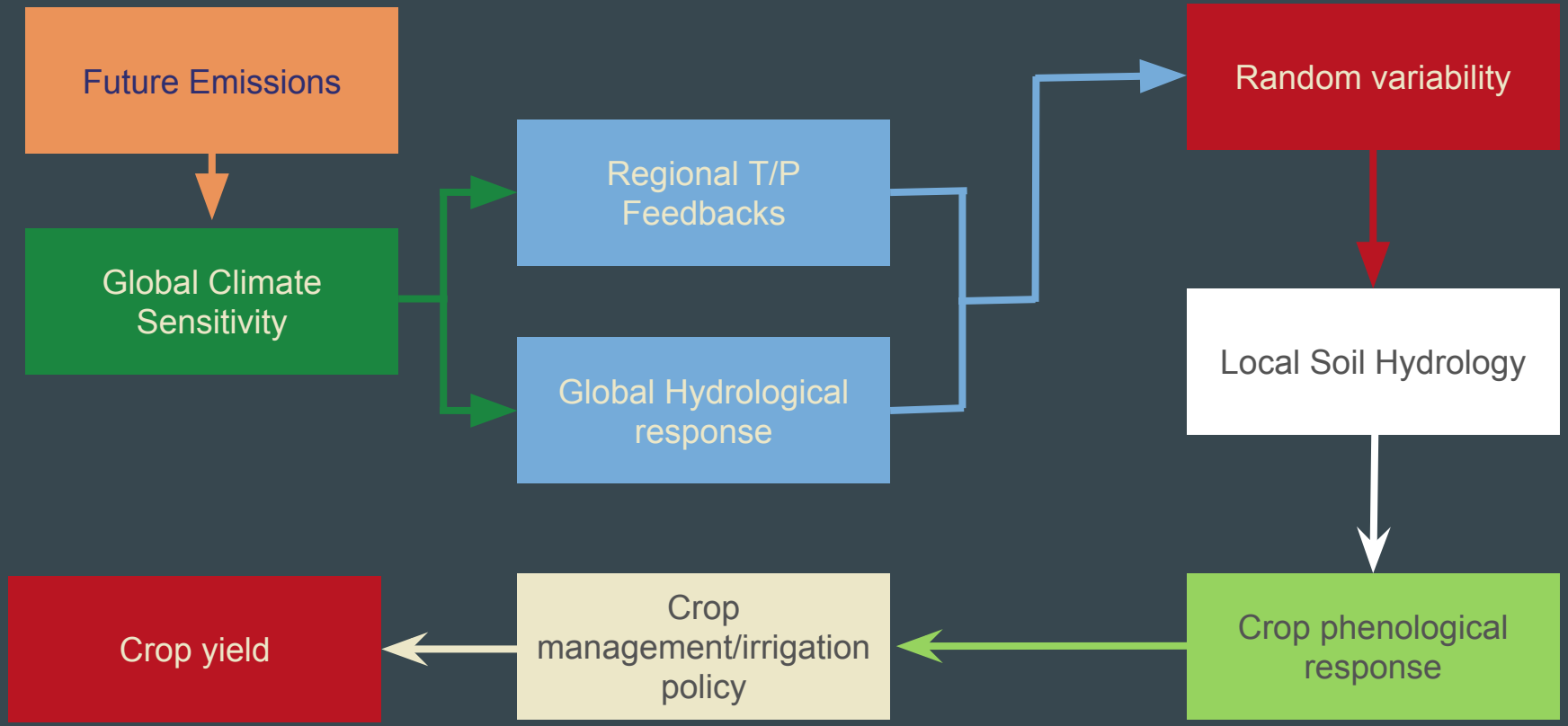


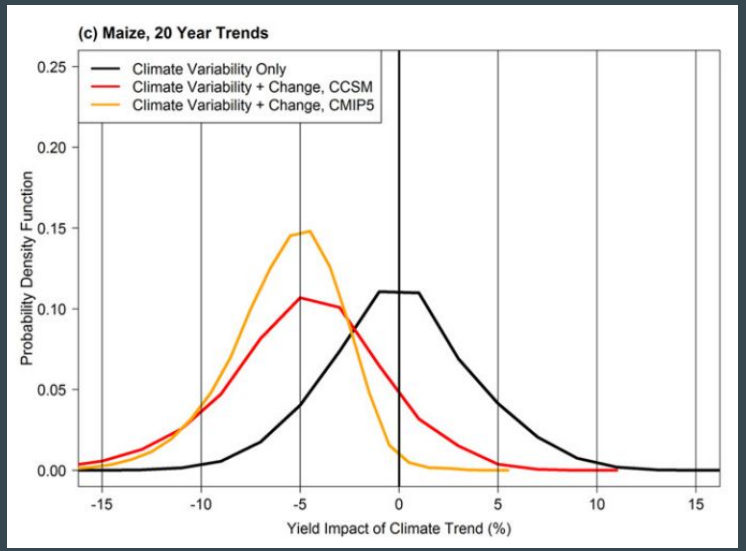
FIG. 10. Climatological SMB of the simulated GIS for the (a) preindustrial (1850–80), (b) modern (1970–2000), and (c) future (2070–2100) periods averaged over the five top-ranking ensemble members.

Lipscomb et al (2013)

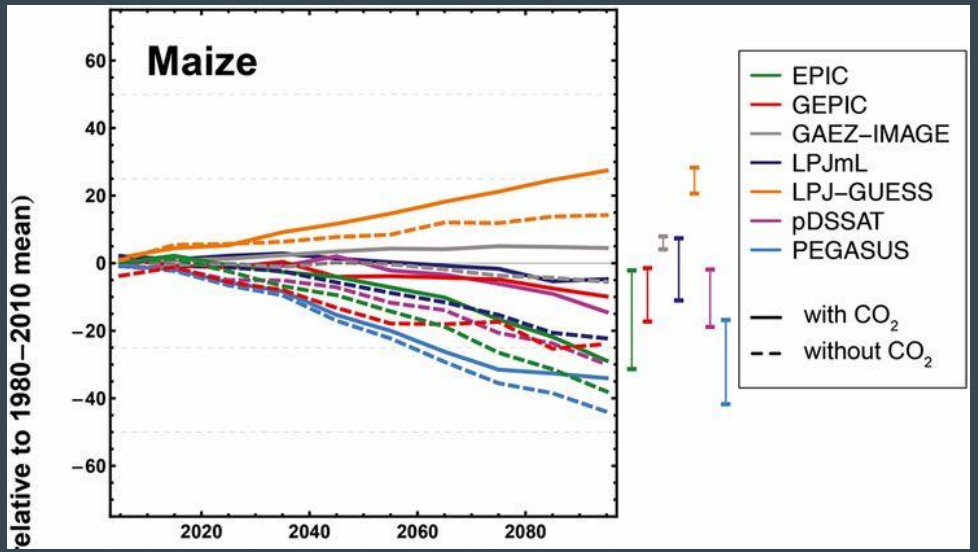
The Chain of Uncertainty: Crop yields



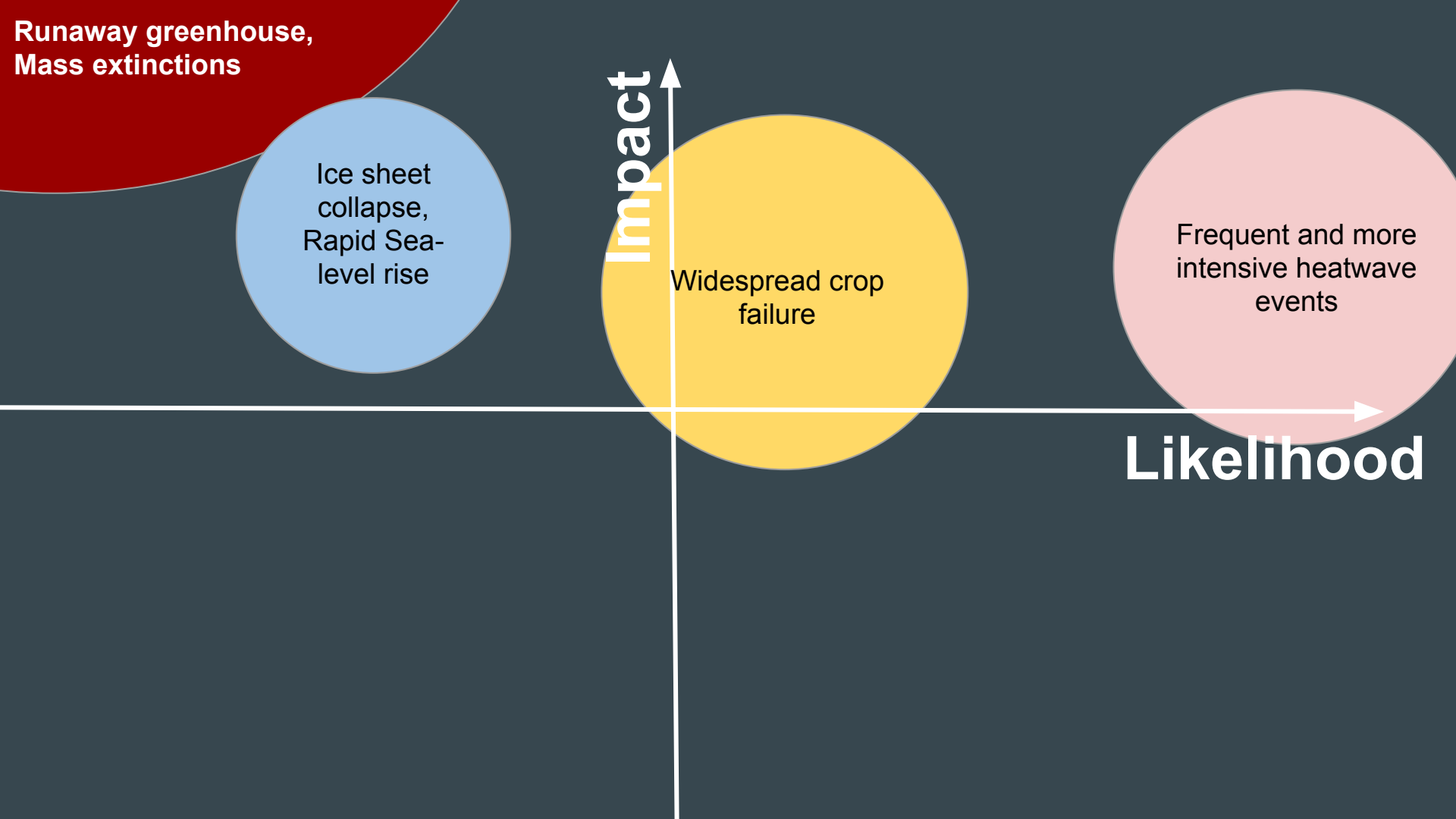
The Chain of Uncertainty: Crop yields



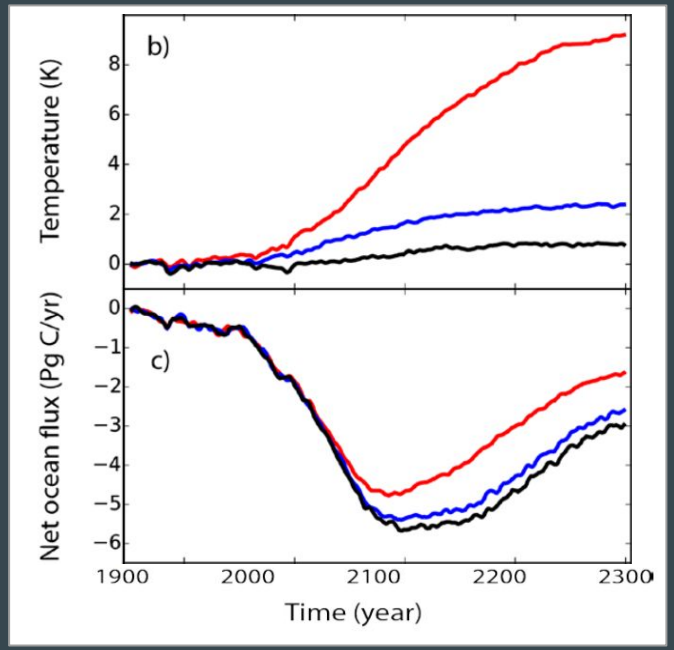
Lobell and Tebaldi (2015)



Rosenzweig et al (2014)


Runaway greenhouse,
Mass extinctions
Ice sheet collapse, Rapid Sea-level rise
Impact
Widespread crop failure
Frequent and more intensive heatwave events
Likelihood

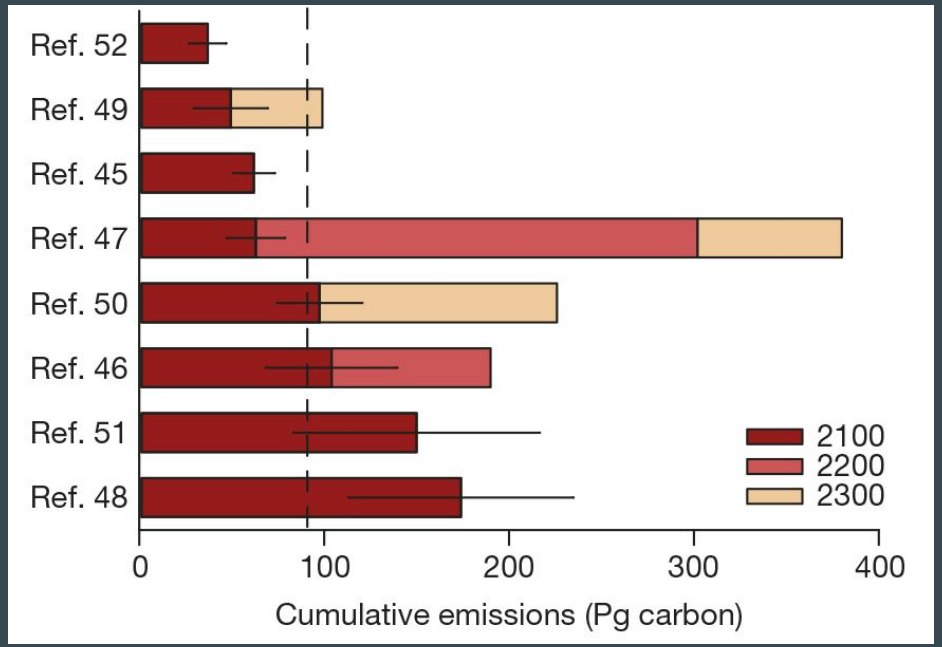
Are we underestimating long term warming?



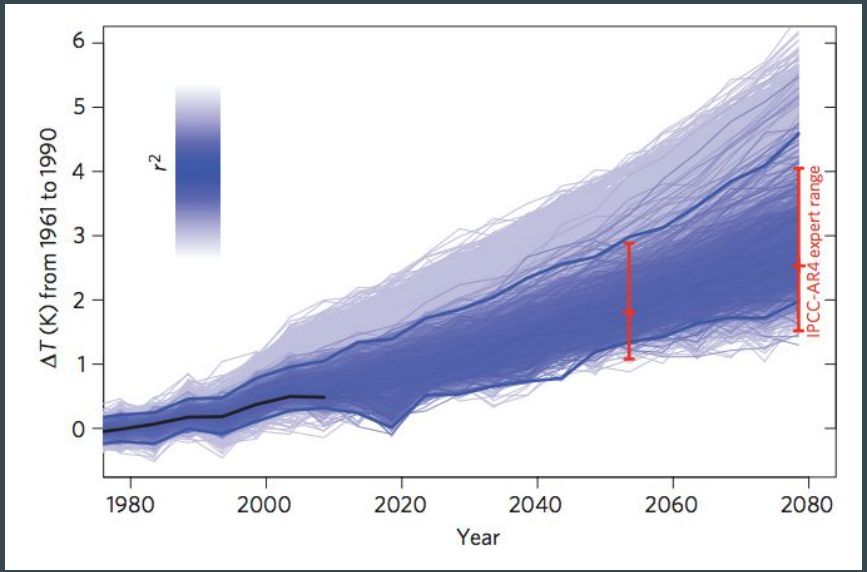
Randerson et al (2015)

1. We aren't running coupled simulations for long enough

2. We are missing some critical carbon cycle feedbacks



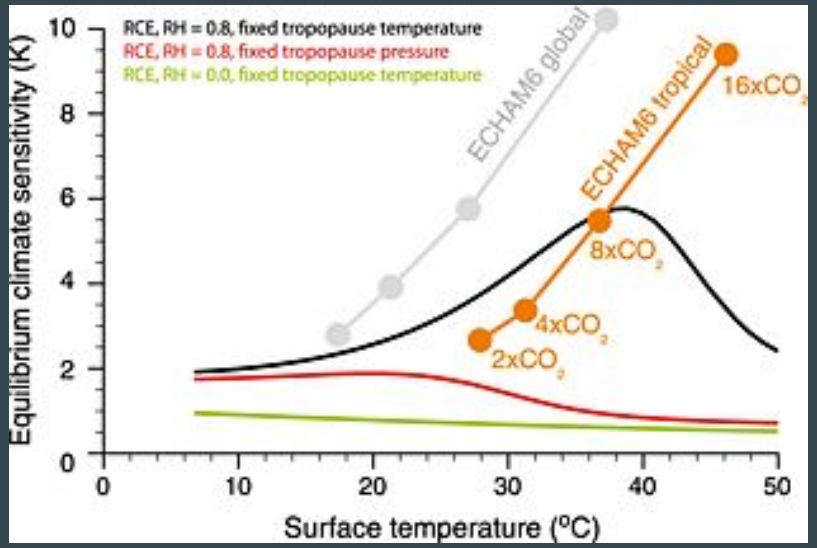
Schuur et al (2015)



Rowlands et al (2013)

3. We do not (as a matter of course) sample parameter uncertainty

4. We are assuming climate sensitivity is one number, but evidence suggests it increases as the world warms



Meraner et al (2013)

Conclusions

CMIP is not a comprehensive tool for evaluating global risk of significant impacts, with a small number of independent models, each a central estimate of future change with many missing global carbon feedback processes

In order to sample the high impact tails of the distribution, we must consider:

- perturbed parameter experiments of existing models
- strategies for increasing model interdependency
- long term coupled carbon cycle experiments
- efforts to include processes which could potentially increase Earth system sensitivity.