Climate Change: uncertainty in projections and prospects for the future (in 10 minutes)

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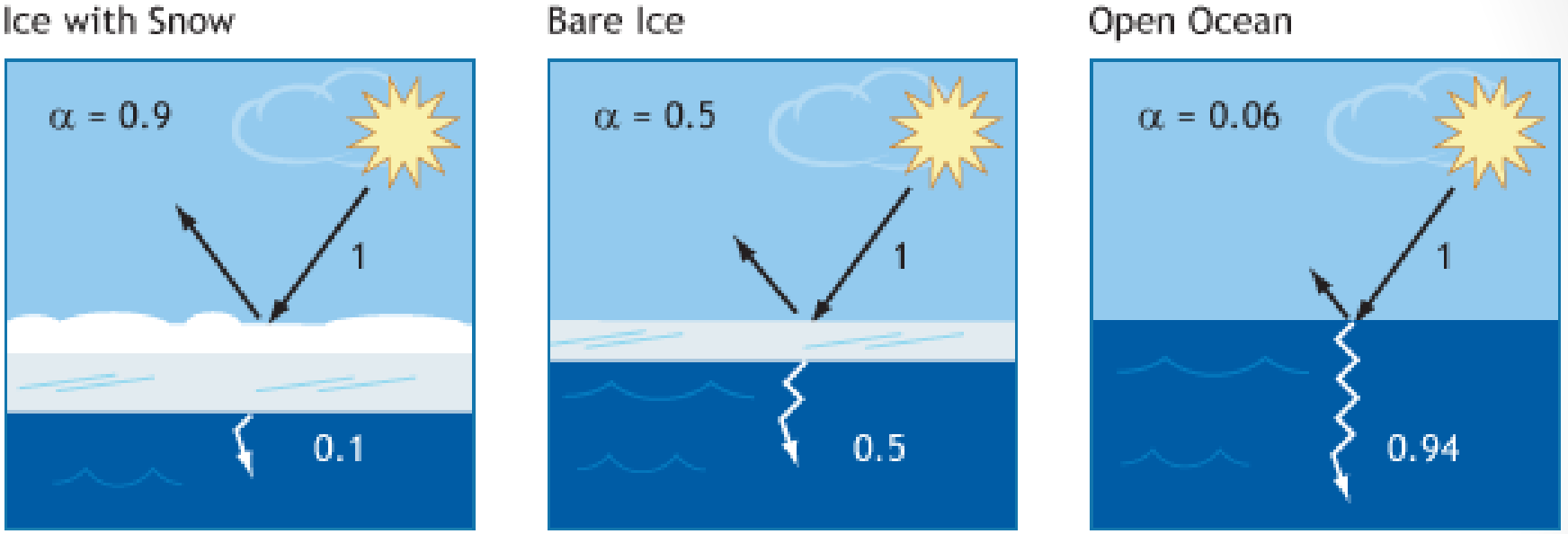
- Results taken from Intergovernmental Panel on Climate Change Working Group I: the Physical Science Basis (2013)
- Conclusions from the Intergovernmental Panel on Climate Change Synthesis Report (released Sunday November 2, 2014)

Where does the uncertainty come from in climate projections?

- Differences between models in how much the climate warms for a given increase in heat trapping gases
- Natural climate variability (like El Nino)
- Economic/demographic/development uncertainty

How much will the climate warm with a given amount of carbon dioxide and radiative forcing?

Feedbacks are key: example Ice-albedo feedback

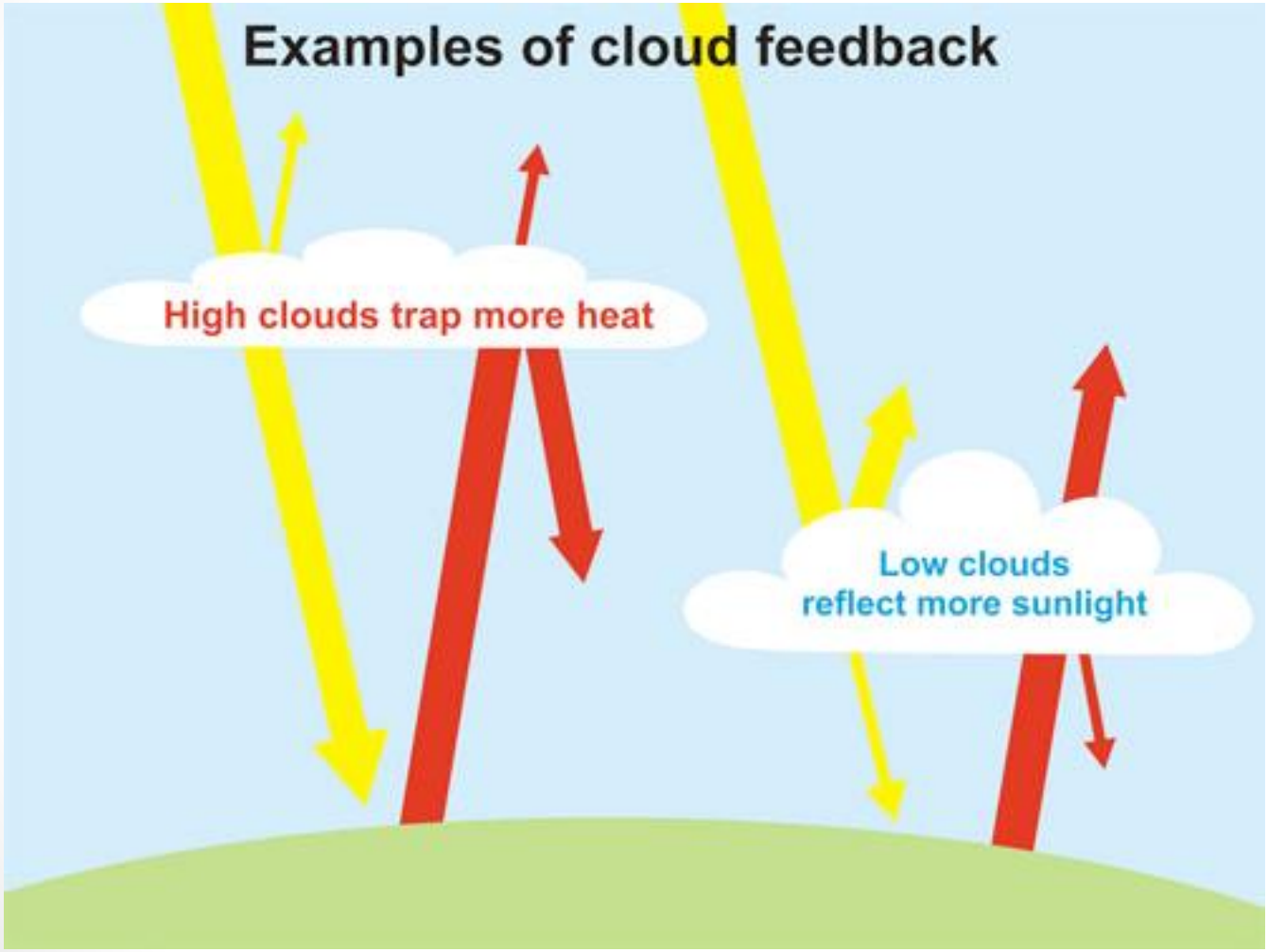


When sea ice is melted, the ocean can directly absorb the sunlight, and it warms up. This leads to more melting of sea ice: positive feedback

Radiative forcing from Wikipedia

Defined as the difference of sunlight absorbed by the Earth and energy radiated back to space. A positive forcing (more incoming energy) warms the system, while negative forcing (more outgoing energy) cools it.

Cloud Feedback– uncertain but slightly positive
High clouds warm, low clouds cool



Feedbacks multiply the response to radiative forcing by about a factor of 3

Key uncertainties from the IPCC WGI: clouds

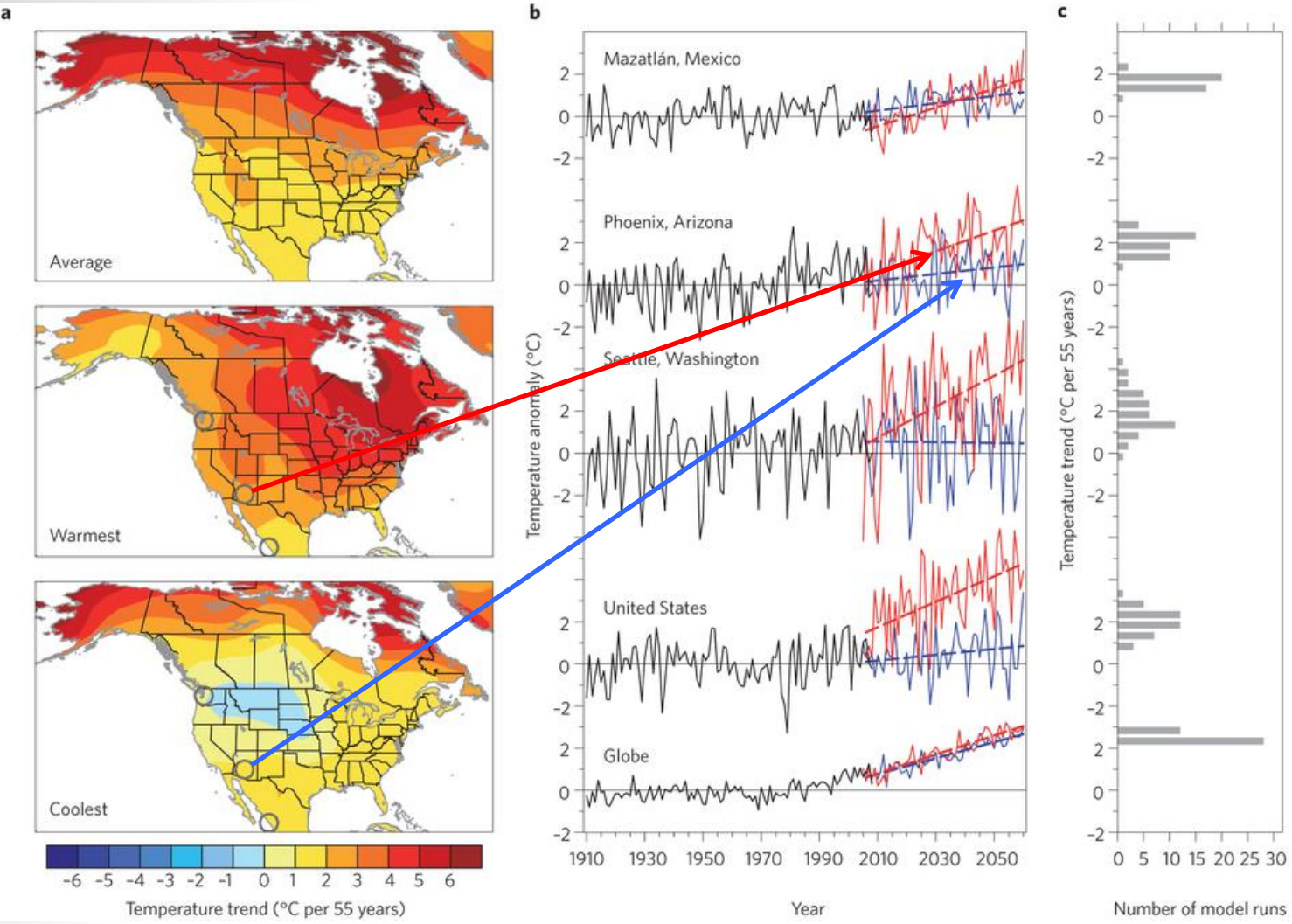
Cloud interactions and the associated radiative forcing remain large

Cloud feedback is likely positive but its quantification remains difficult.

Internal modes of variability uncertainty (Year to year and decade to decade)

El Nino every 2-7 years and is very hard to predict more than a season on two ahead

Example: Deser et al (2012) took one climate model and ran 40 simulations with it. They started the model from 40 different days from December 1999-January 2000. Everything else was held constant (the butterfly effect at work).
This created an “ensemble” of simulations



December
January
February
Temperature

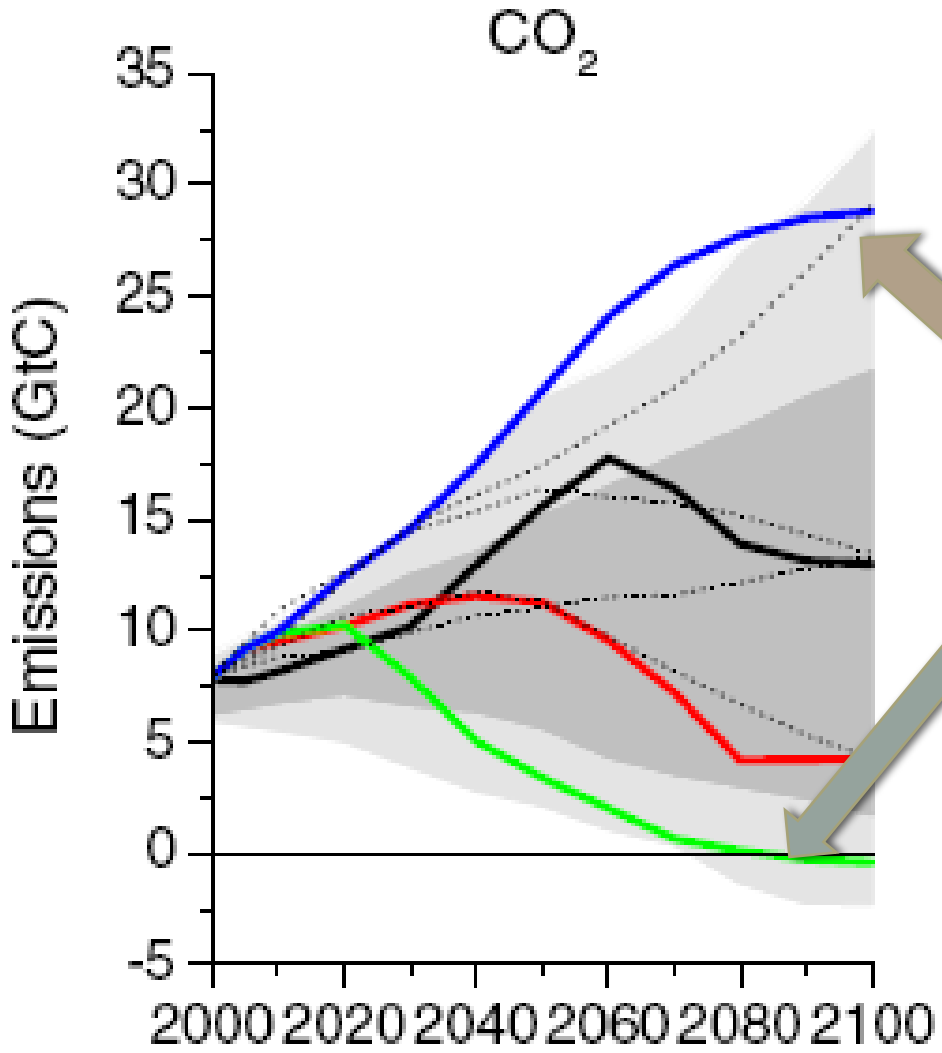
Conclusions: Decision-makers' expectations for accurate climate predictions are growing. Natural climate variability, however, poses inherent limits to climate predictability and the related goal of adaptation guidance in many places, as illustrated here for North America.

Internal variability becomes increasingly important on smaller space and time scales

Representative concentration pathways (RCP): future emissions used in the IPCC assessment (Moss et al 2010)

- Not just long term concentration but the pathway to get there is important
- The goal is to understand uncertainties in order to reach decisions that are robust under a wide range of possible futures
- Allow insights into the interaction of natural and human-induced climate processes and the potential costs and benefits of different mixes of adaptation and mitigation policy
- RCPs named by radiative forcing in 2100 in Watts/m^2 . Current forcing is about 2 Watts/m^2

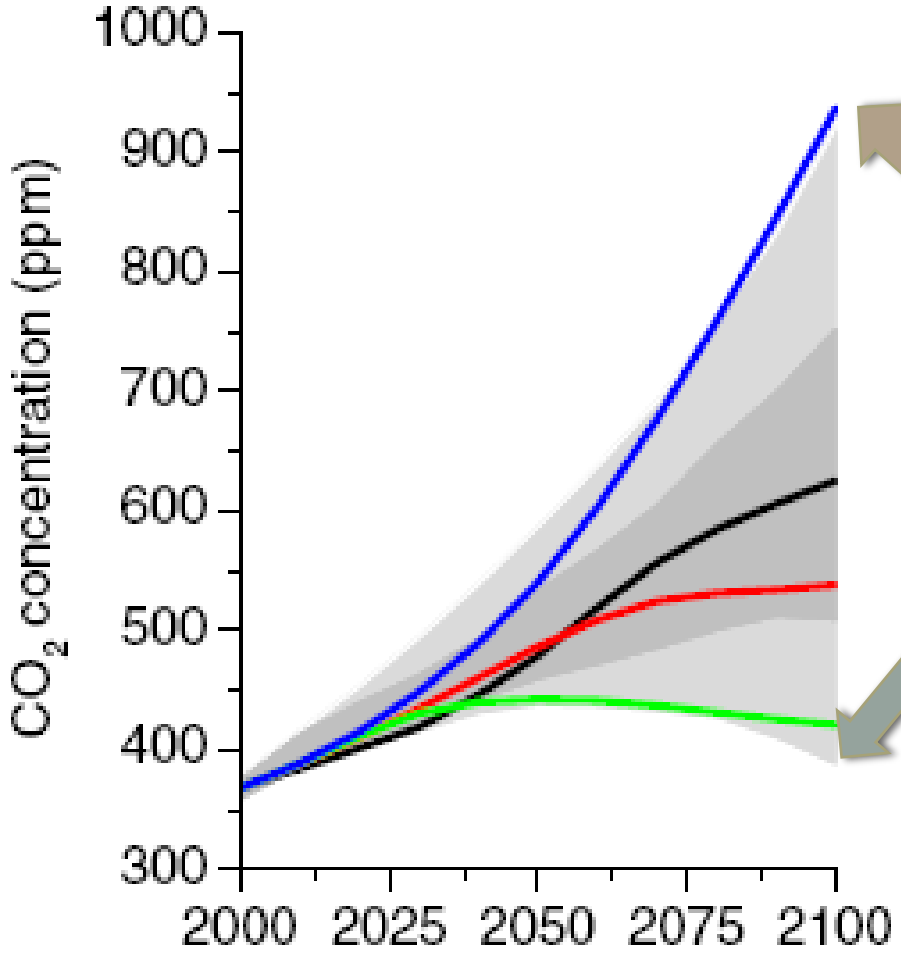
Emissions: burning fossil fuel releases carbon dioxide.



Different paths for different futures:
RCP2.6
RCP8.5

van Vuuren et.al. 2011

Concentration: there is a build up of carbon dioxide over time



Different paths for different futures:
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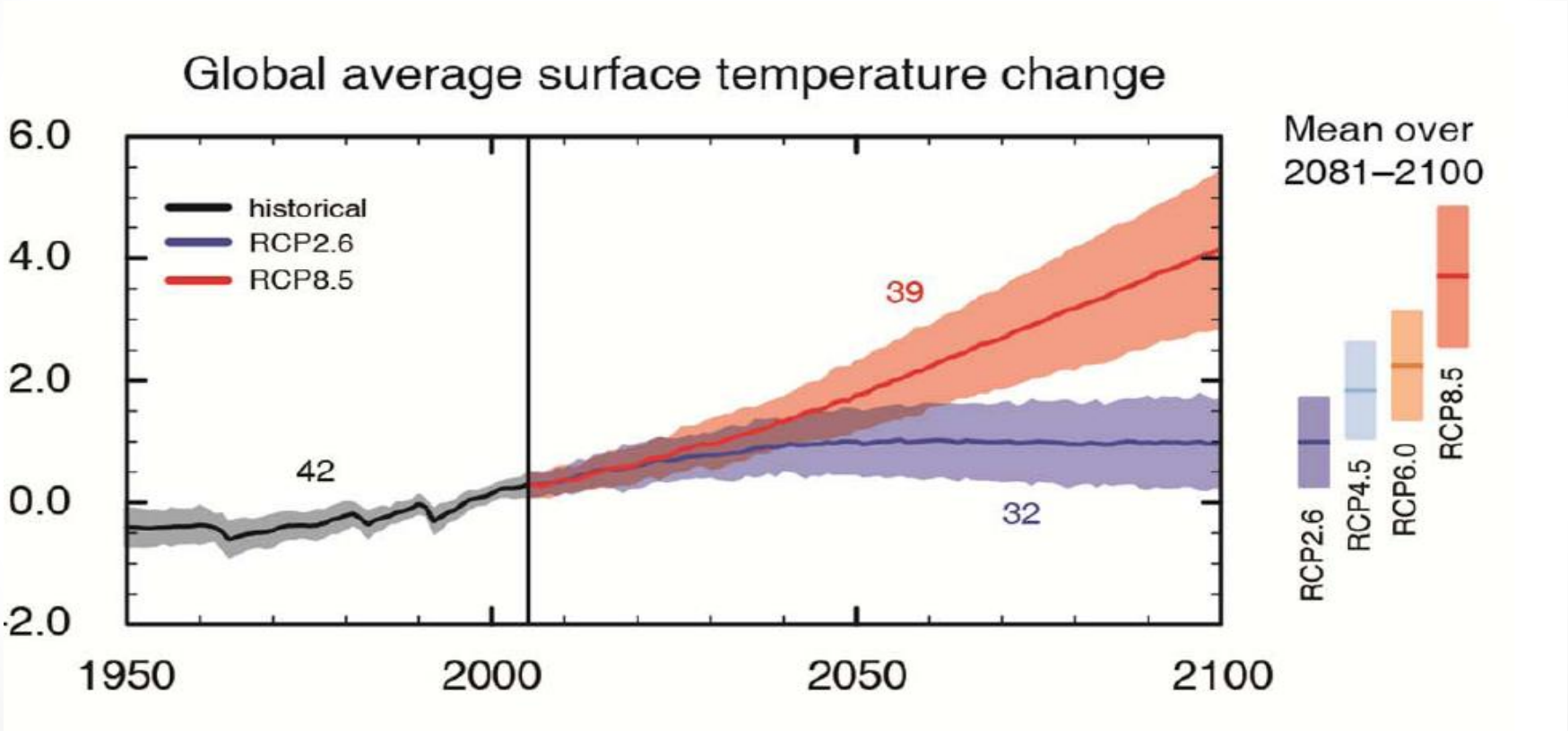
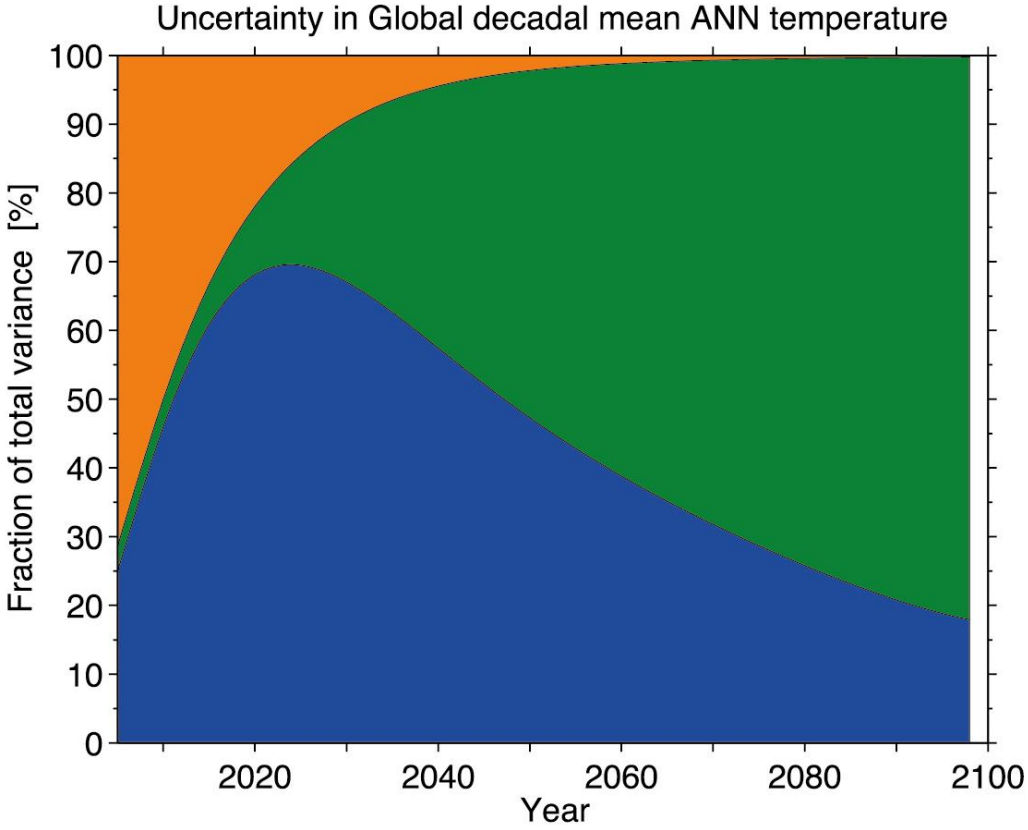
What are the projections for temperature in the 21st century from the IPCC?



Sources of uncertainty of projections



Internal variability
Model spread
RCP scenario spread

El Nino
Feedbacks
Economic/dev
elopment

Figure 11.8
WG1 2013

(1) the uncertainty in near-term projections is dominated by internal variability and model spread.

(2) Cumulative emissions of CO2 largely determine global mean surface warming by the late 21st century and beyond. Projections of greenhouse gas emissions vary over a wide range, depending on both socio-economic development and climate policy.

What is the projection for temperature at the end of the 21st century? (IPCC WG1)

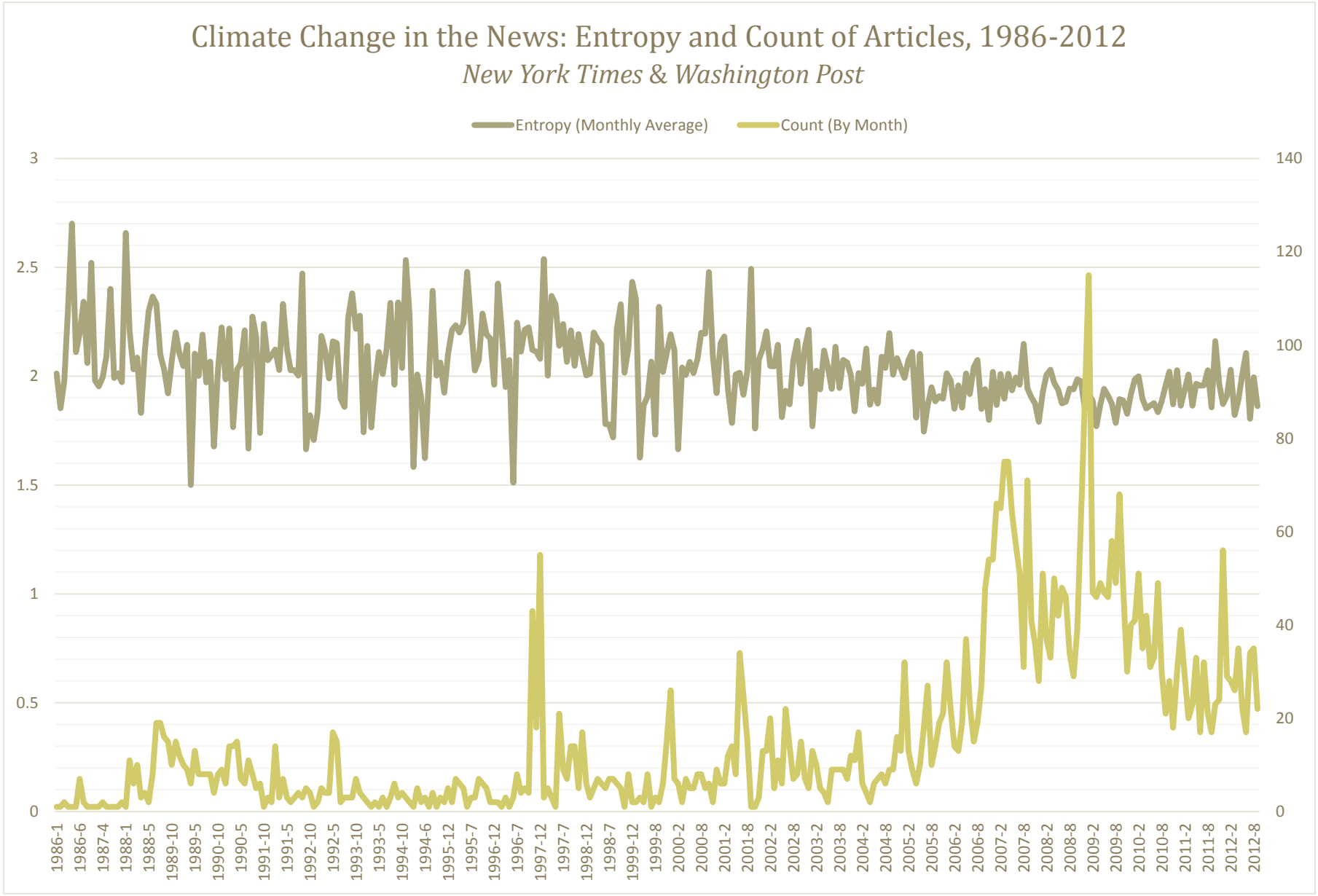
- Global surface temperature change for the end of the 21st century is *likely* to exceed 1.5°C relative to 1850 to 1900 for all RCP scenarios except RCP2.6. It is *likely* to exceed 2°C for RCP6.0 and RCP8.5, and *more likely than not* to exceed 2°C for RCP4.5. Warming will continue beyond 2100 under all RCP scenarios except RCP2.6.

The following terms have been used to indicate the assessed likelihood, and typeset in italics:

Term*	**Likelihood of the outcome**
Virtually certain	99–100% probability
Very likely	90–100% probability
Likely	66–100% probability
About as likely as not	33–66% probability
Unlikely	0–33% probability
Very unlikely	0–10% probability
Exceptionally unlikely	0–1% probability

Key results from the IPCC 2014 Synthesis report

- Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems.
- Many aspects of climate change and associated impacts will continue for centuries, even if anthropogenic emissions of greenhouse gases are stopped. Substantial emissions reductions over the next few decades can reduce climate risks in the 21st century and beyond.
- Many adaptation and mitigation options can help address climate change, but no single option is sufficient by itself. Effective implementation depends on policies and cooperation at all scales.


Climate Change in the News: Entropy and Count of Articles, 1986-2012
New York Times & Washington Post
Entropy (Monthly Average)
Count (By Month)
3
2.5
2
1.5
1
0.5
0
140
120
100
80
60
40
20
0
1986-1
1986-6
1987-4
1988-1
1988-5
1989-10
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