

The Need for a New Climate Observing System

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National Academy Charney Report, 1979

Concerning Anthropogenic Climate Change:

“In order to address this question in its entirety, one would have to peer into the world of our grandchildren, the world of the twenty-first century.”

Foreword by Vern Suomi

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35 Years Later ...



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35 Years Later ... More urgent, but ...

- Lack of a climate observing system (vs. weather)
 - Climate is 10x the variables and 10x the accuracy of weather.
- Struggles to get sufficient resources for climate modeling
- Science questions typically qualitative not quantitative
 - Understand and explore vs rigorous hypothesis testing
 - Leads to intuitive “Seat of the Pants” requirements
 - After > 30 years of climate research: time to improve
- *What is the right amount to invest in climate science?*
 - Requires link of science to economics
 - Requires thinking outside narrow disciplines
 - Requires arguing for climate science, not our own science

Climate Observations: No Long Term Plan

- Global Satellite Observations without long term commitments
 - Radiation Budget (e.g. CERES)
 - Gravity (ice sheet mass) (e.g. GRACE)
 - Ice Sheet Elevation (e.g. ICESAT/Cryosat)
 - Sea Level Altimetry (e.g. JASON)
 - Sea surface Salinity (e.g. Aquarius)
 - Cloud and Aerosol Profiles (e.g. CALIPSO/Cloudsat, EarthCARE)
 - Precipitation (e.g. GPM, CloudSat/EarthCARE)
 - Soil Moisture (e.g. SMAP)
 - Ocean surface winds (e.g. QuickSCAT)
 - Carbon Source/Sinks (e.g. OCO)
 - Methane/Carbon Monoxide (MOPPIT)
 - In orbit Calibration References (e.g. CLARREO)
- Surface and In-situ observations have similar issues

Why No Climate Observing System?

- We do have an international weather observing system: committed in-situ and satellite observations (e.g. METOP + JPSS, radiosondes, surface met stations, surface radar)
- Reasons for the lack of a climate observing system:
 - 10 times the key variables that weather has (50 vs 6)
 - 10 times the accuracy needed to observe decadal change signals vs short term weather signals (1K vs 0.05K, 10% vs 1% rel humidity or precipitation).
 - Regional to zonal to global sampling needed
 - Deep ocean to Thermosphere vertical profiles needed
 - Minutes to Century time scales needed
 - While many nations have weather agencies, there are no climate agencies.
 - In the U.S. climate is 3rd or 4th priority in 13 different agencies (NASA, NOAA, NSF, DOE, EPA, USGS, etc)

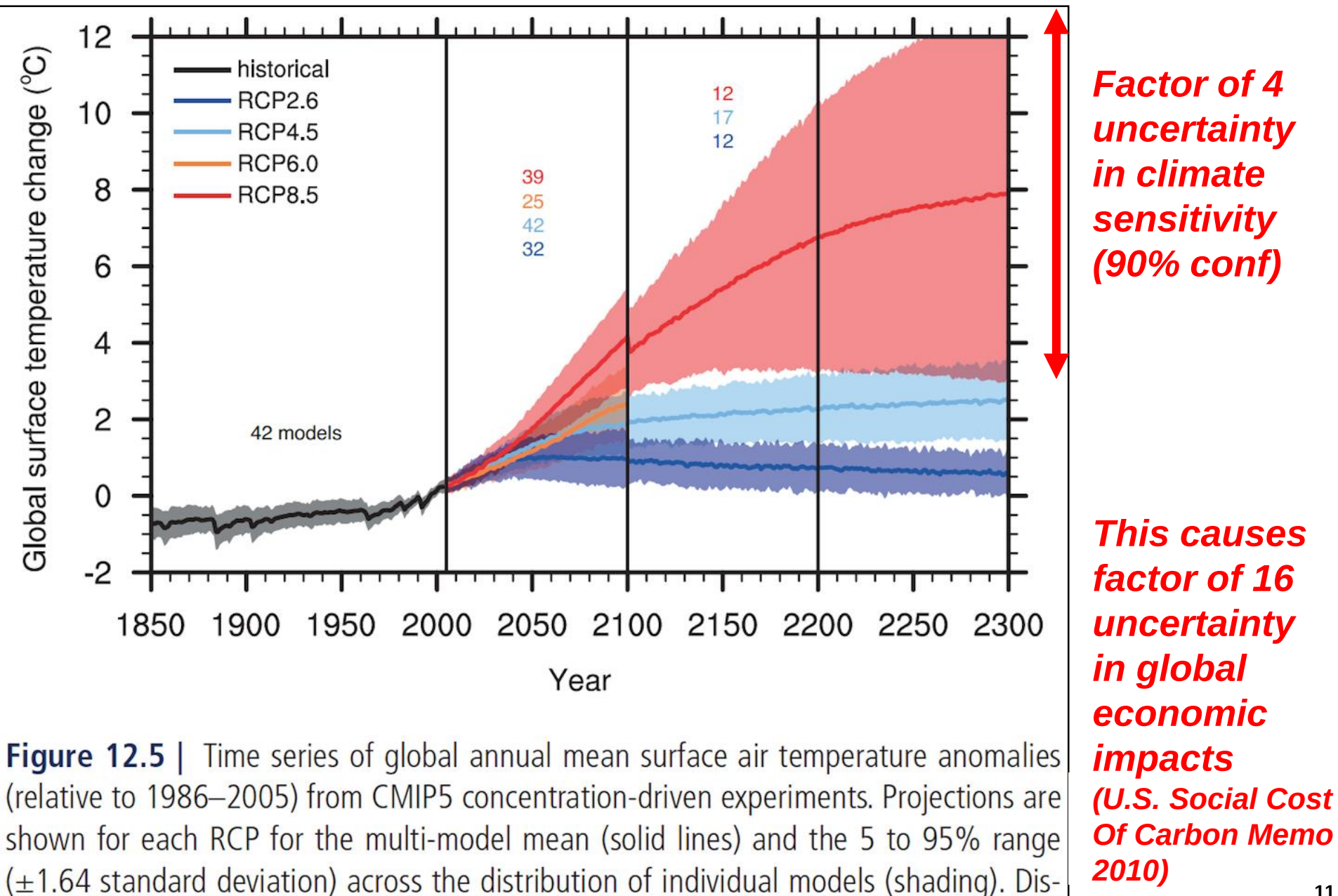


Why No Climate Observing System?

- Reasons for the lack of a climate observing system: continued
 - Scientists are by nature highly focused discipline specialists, while climate change is an incredibly diverse and nonlinearly linked cross discipline system: oceans, atmosphere, cryosphere, biosphere, chemistry, diverse modeling types and observation types (surface, deep ocean, aircraft, satellites, field campaigns)
 - Benefits of climate science are realized decades into the future, but society has become focused on short term returns (corporations, stock markets, politics)
 - Climate scientists are poor at making economic value arguments
 - Humans respond more strongly to short term threats than to long term threats
 - Concerns of lost revenues by fossil fuel industry
 - Concerns of government carbon regulation by the public
 - Curse of the Commons: almost all countries have to act

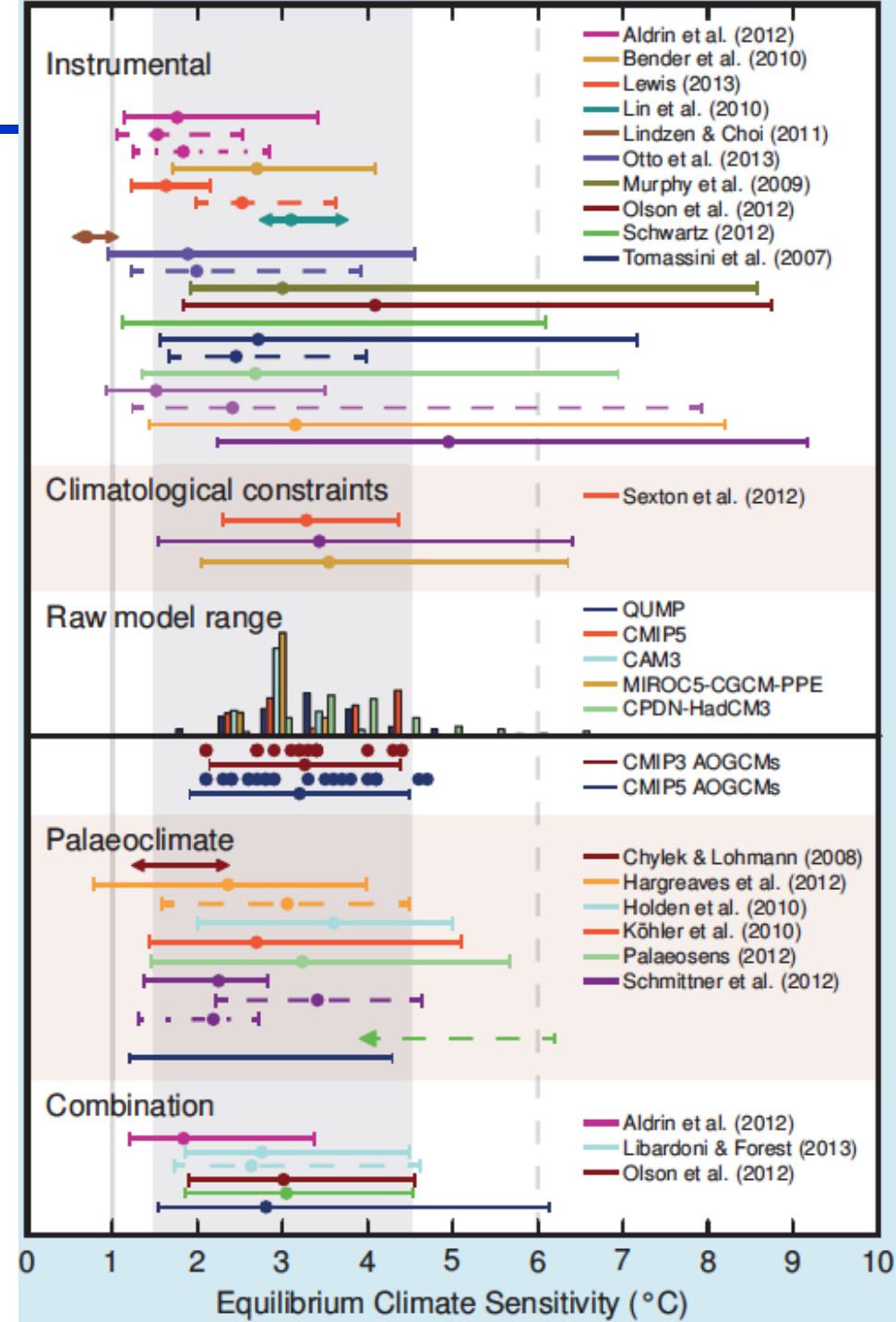
An Example of Why Climate Science Matters

Future Warming Uncertainty, IPCC AR5, 2013

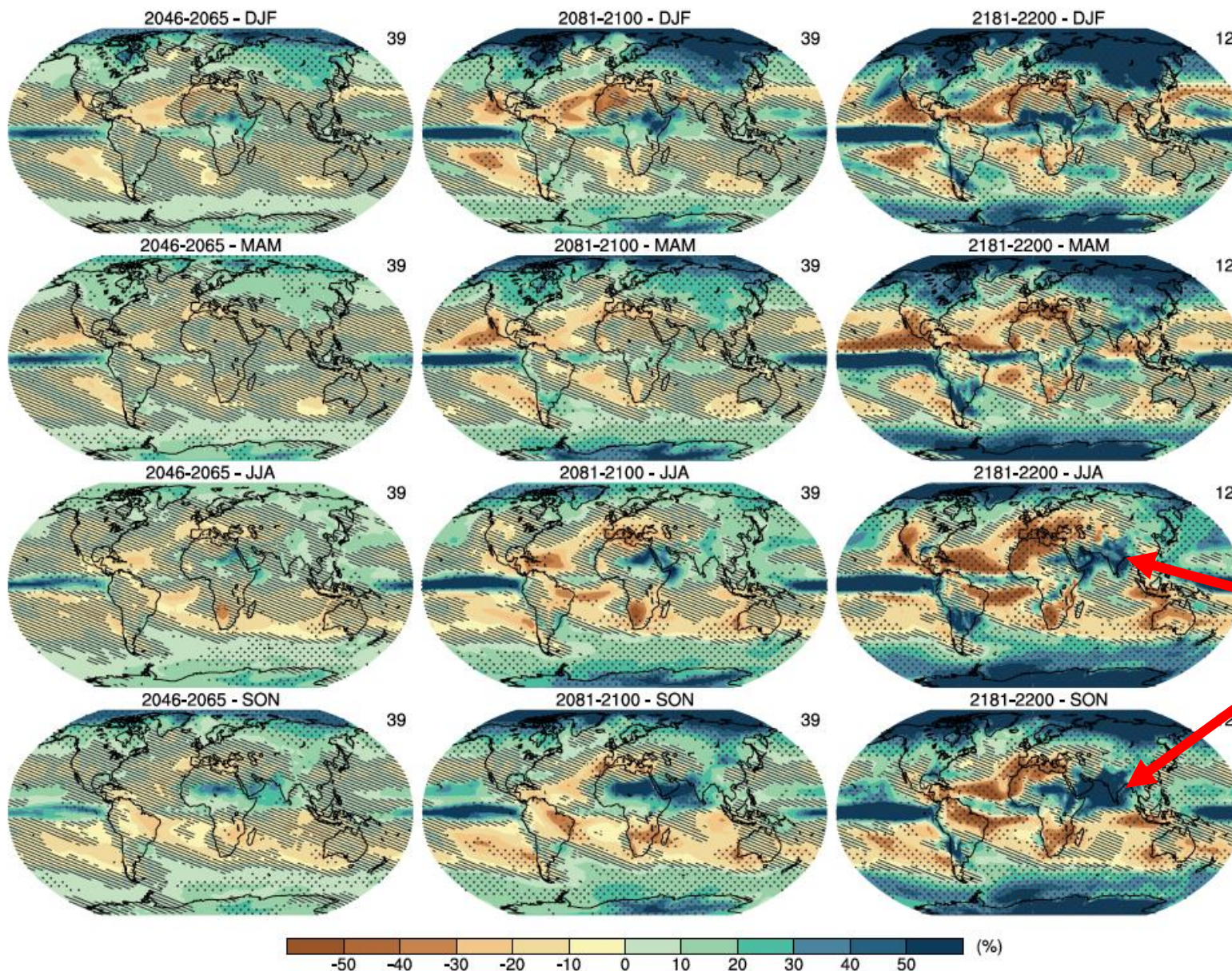


Climate Sensitivity Estimates

Box 12.2, Figure 1,
IPCC AR5, 2013



Seasonal mean percentage precipitation change (RCP8.5)



**Large
Potential
Precip
Increase
In India
JJA and
SON
Seasons**

**Figure
12.22,
IPCC AR5
2013**

Figure 12.22 | Multi-model CMIP5 average percentage change in seasonal mean precipitation relative to the reference period 1986–2005 averaged over the periods 2045–2065, 2081–2100 and 2181–2200 under the RCP8.5 forcing scenario. Hatching indicates regions where the multi-model mean change is less than one standard deviation of internal variability. Stippling indicates regions where the multi-model mean change is greater than two standard deviations of internal variability and where at least 90% of models agree on the sign of change (see Box 12.1).

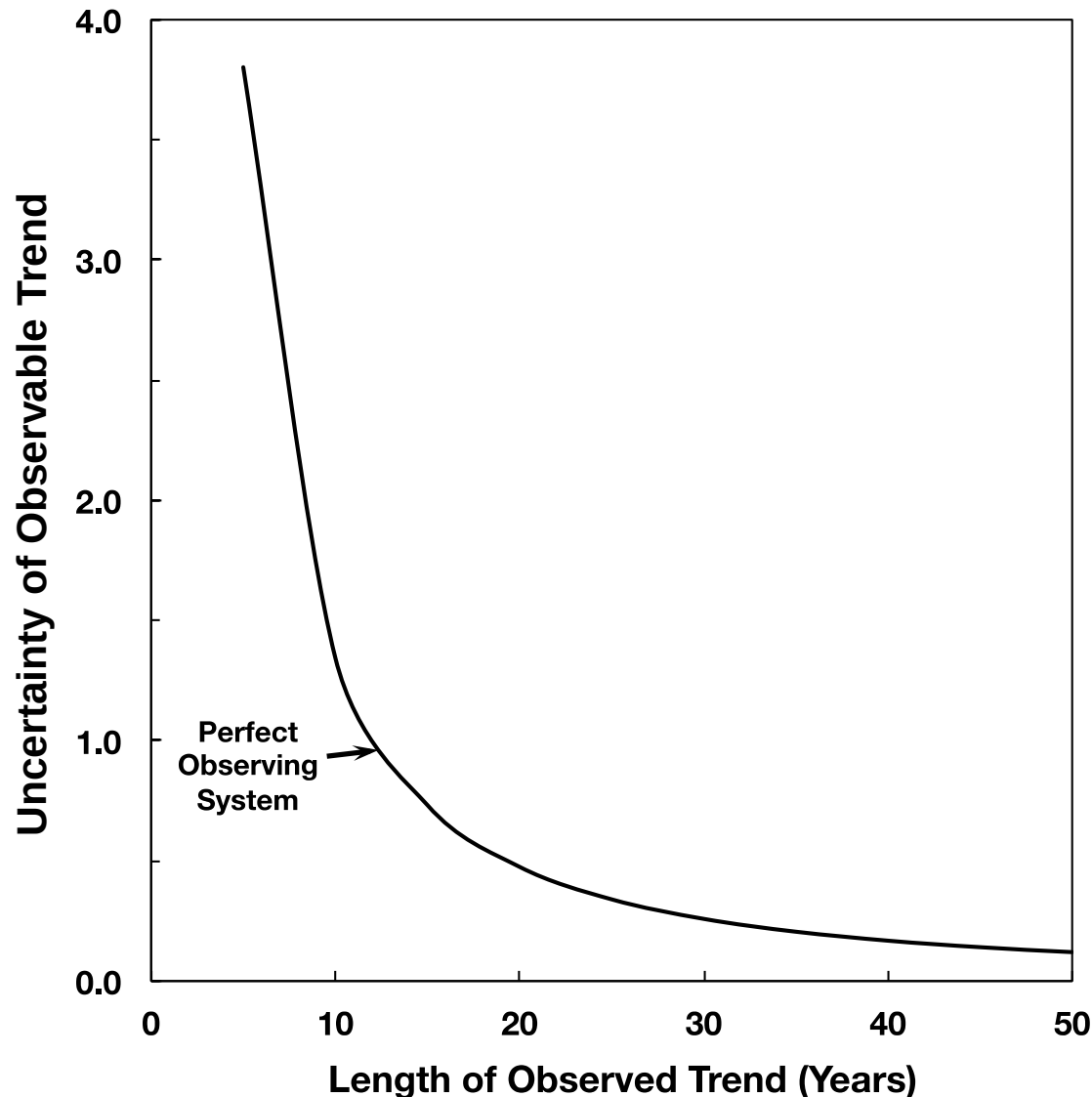
Climate Sensitivity

Climate sensitivity is the “volume dial” on the climate system.

All climate change responses and impacts including precipitation and sea level rise will scale with the amount of global warming.

***All economic impact assessments use global mean temperature change to
Scale the economic impacts: usually
As a roughly quadratic relationship:
2x warming = 4x economic impacts***

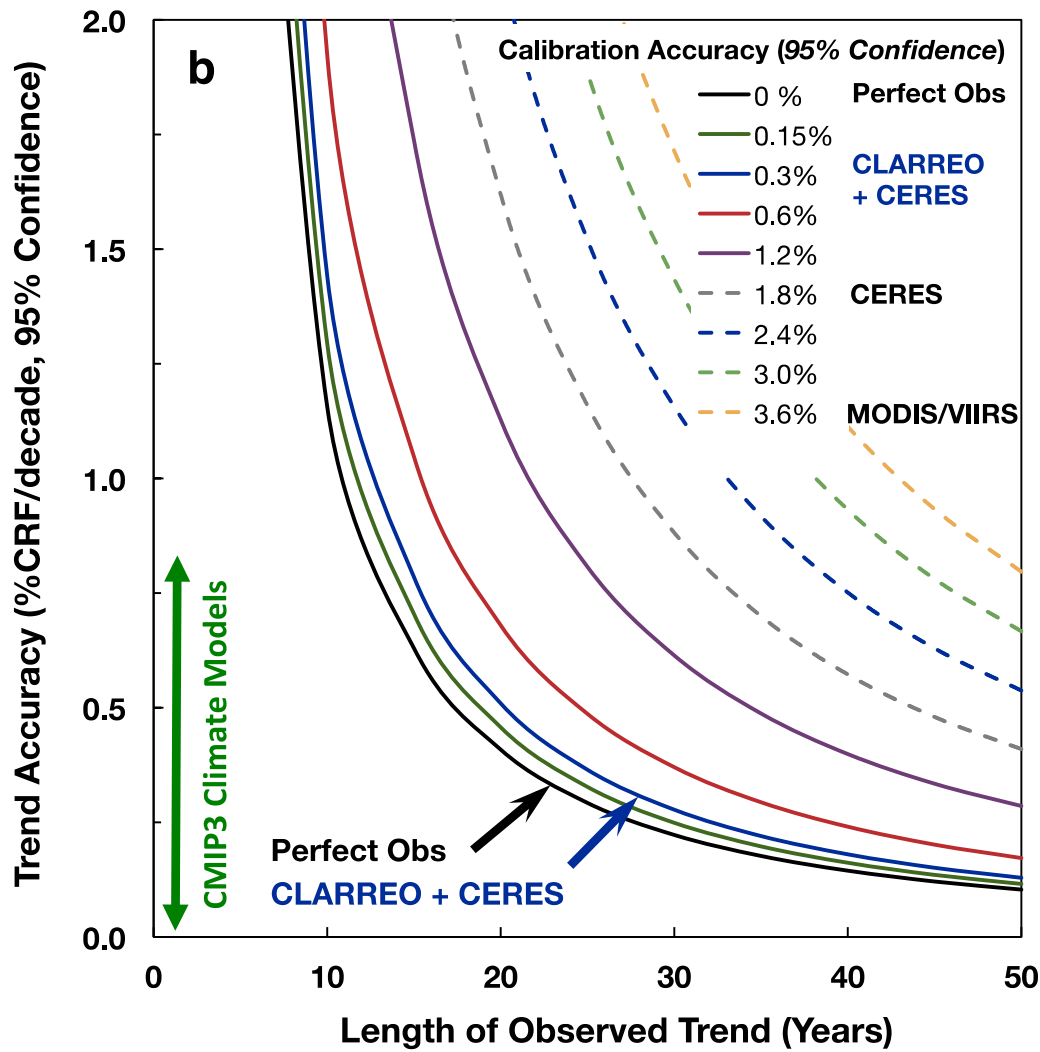
Accuracy Requirements of the Climate Observing System



The length of time required to detect a climate trend caused by human activities is determined by:

- *Natural variability*
- *The magnitude of human driven climate change*
- *The accuracy of the observing system*

Reflected Solar Accuracy and Climate Trends

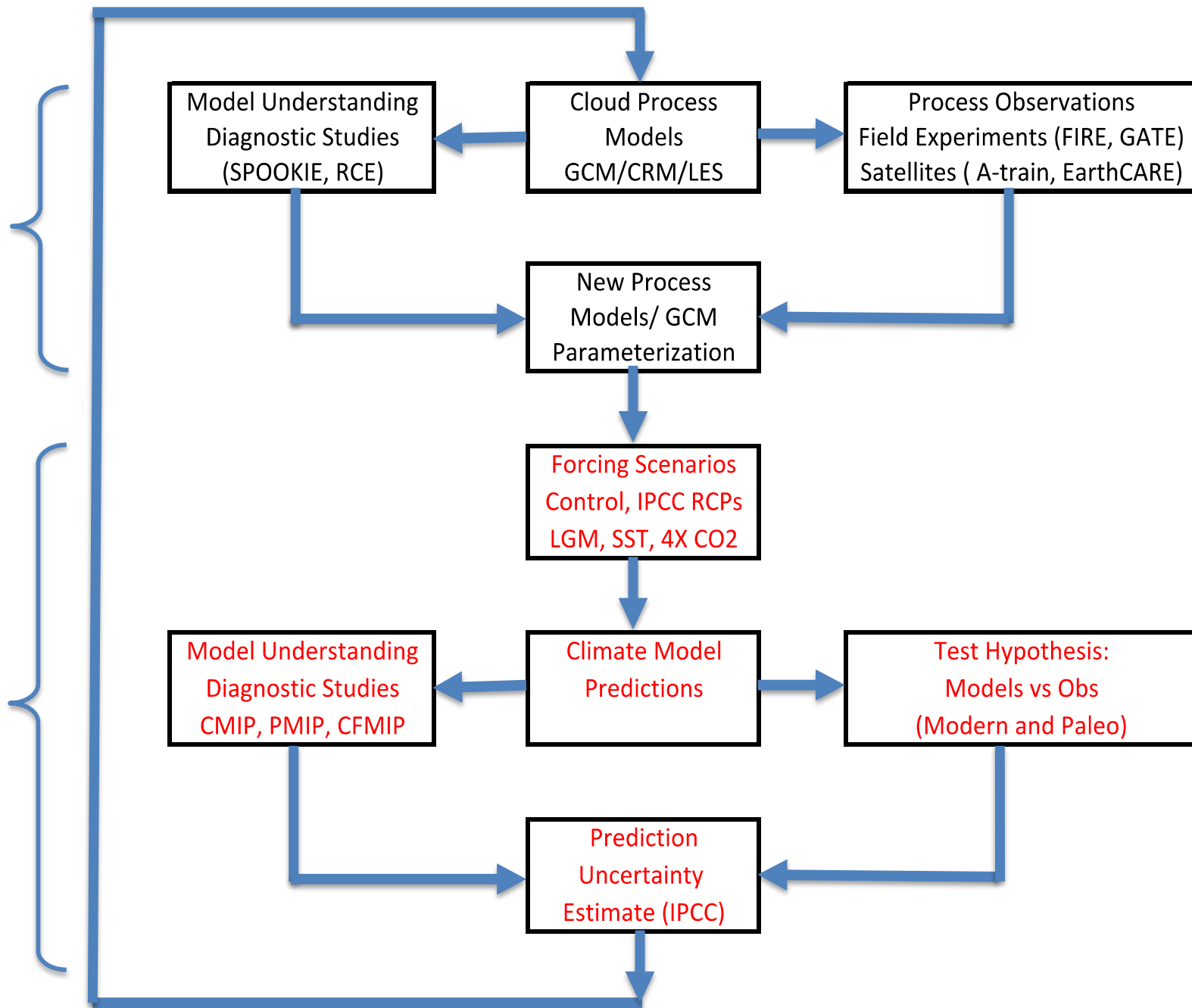


Climate Sensitivity Uncertainty is a factor of 4 (IPCC, 90% conf) which = *factor of 16 uncertainty in climate change economic impacts*

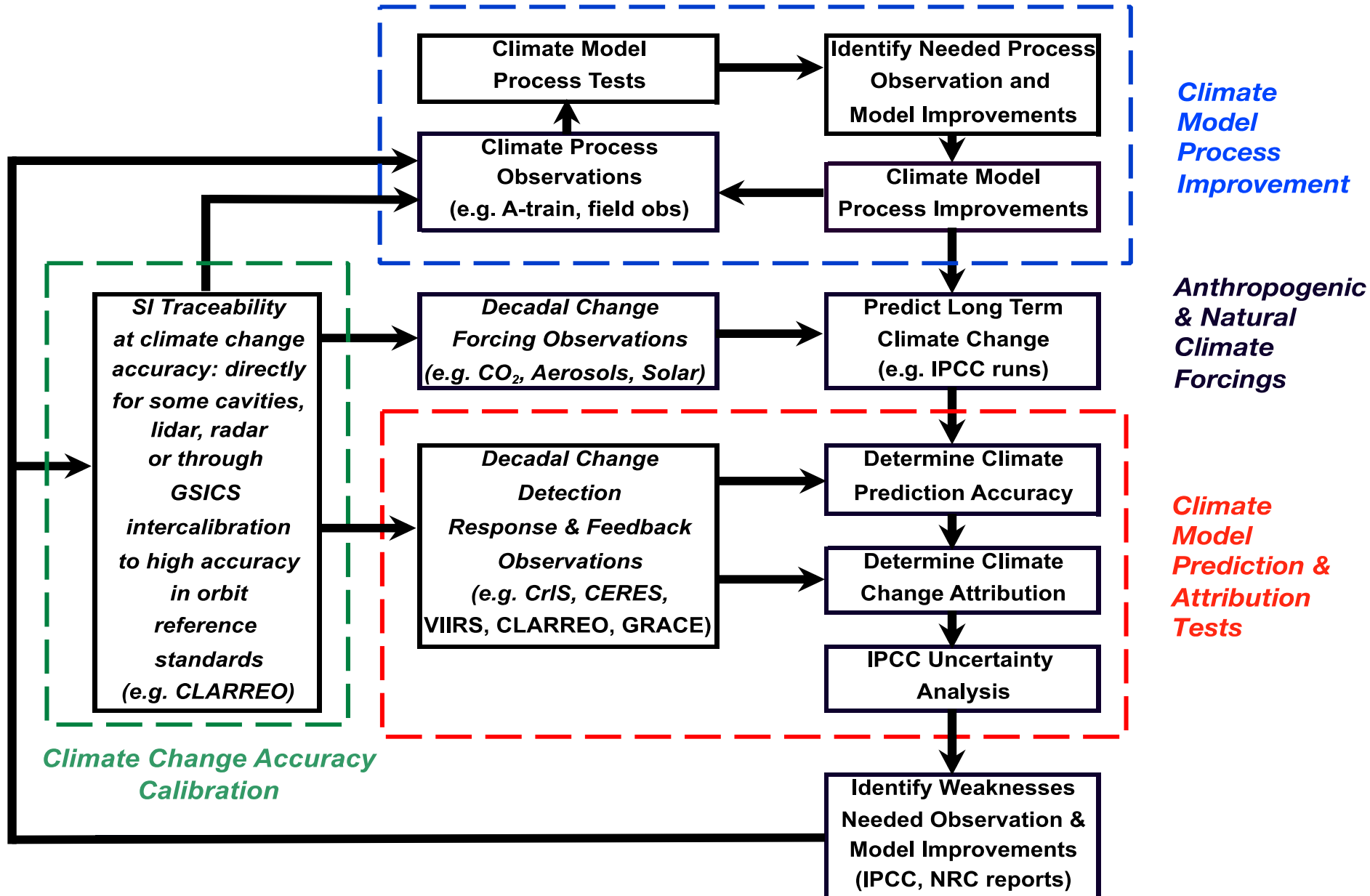
Climate Sensitivity Uncertainty = Cloud Feedback Uncertainty = Low Cloud Feedback = *Changes in SW CRF/decade (y-axis of figure)*

Higher Accuracy Observations = CLARREO reference intercal of CERES = *narrowed uncertainty 15 to 20 years earlier*

**Model
Hypothesis
Development**



Decadal Change Climate Science



Suggested Directions

- Quantitative Science Questions
 - Hypothesis Tests not “improve and explore”, think Higgs Boson
- Observing System Simulation Experiments (OSSEs)
 - Improve observing system requirements
 - Move from “base state” to “climate change” climate model tests
- Higher Accuracy Observations for Climate Change
 - See BAMS Oct 2013 paper for example: broadly applicable
- Economic Value of Improved Climate Observations and Models
 - See J. Env. Sys. Decisions paper for example: broadly applicable

Summary

Lack of accuracy = delayed knowledge

We lack a climate observing system capable of testing climate predictions with sufficient accuracy or completeness

At our current pace, it seems unlikely that we will understand climate change even after another 35 years.

We cannot go back in time and measure what we failed to observe.

It's time to invest in an advanced climate observing system

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