"Intelligent Ensemble" Projections of Precipitation and Surface Radiation in support of Agricultural Climate Change Adaptation

Patrick C. Taylor and Noel C. Baker
NASA Langley Research Center
Climate Science Branch
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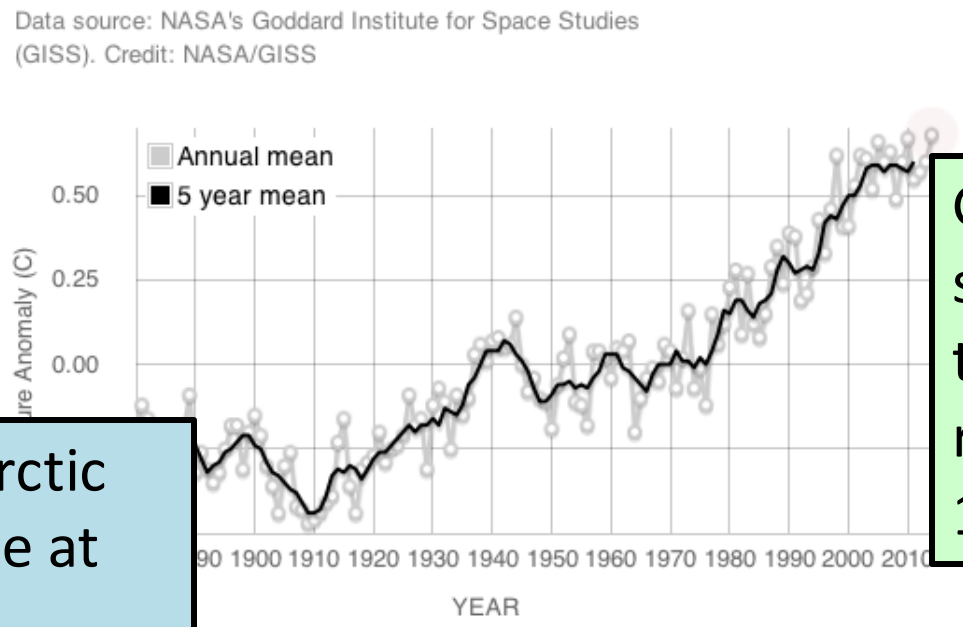
This presentation is heavily drawn from her research.

Motivation: Climate influences Society

A location climate influences

- -Agriculture
- -Energy needs
- -Water availability
- -Infrastructure
- -Building codes

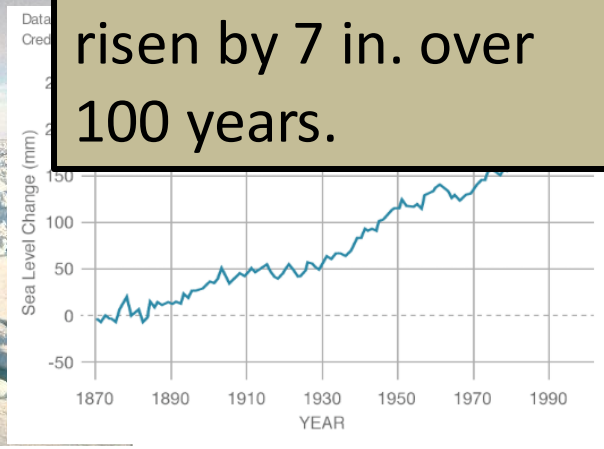
Earth's climate is changing.



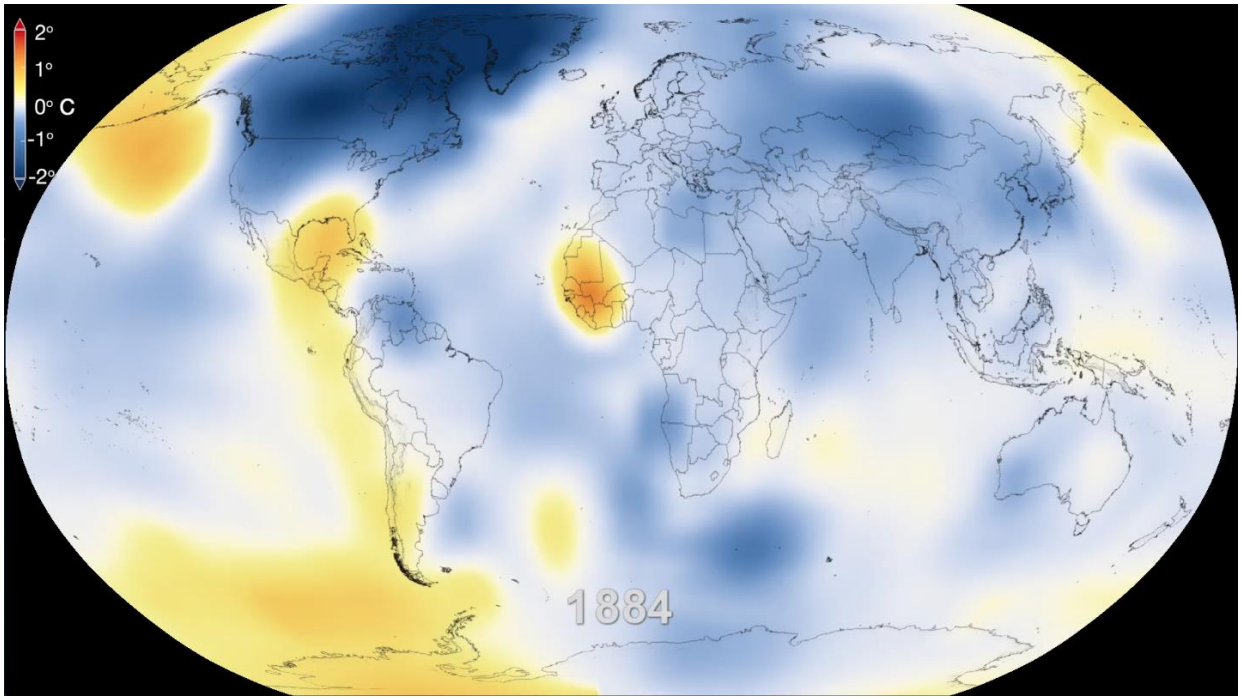
Global mean surface temperature has risen 1.4°F since 1880.

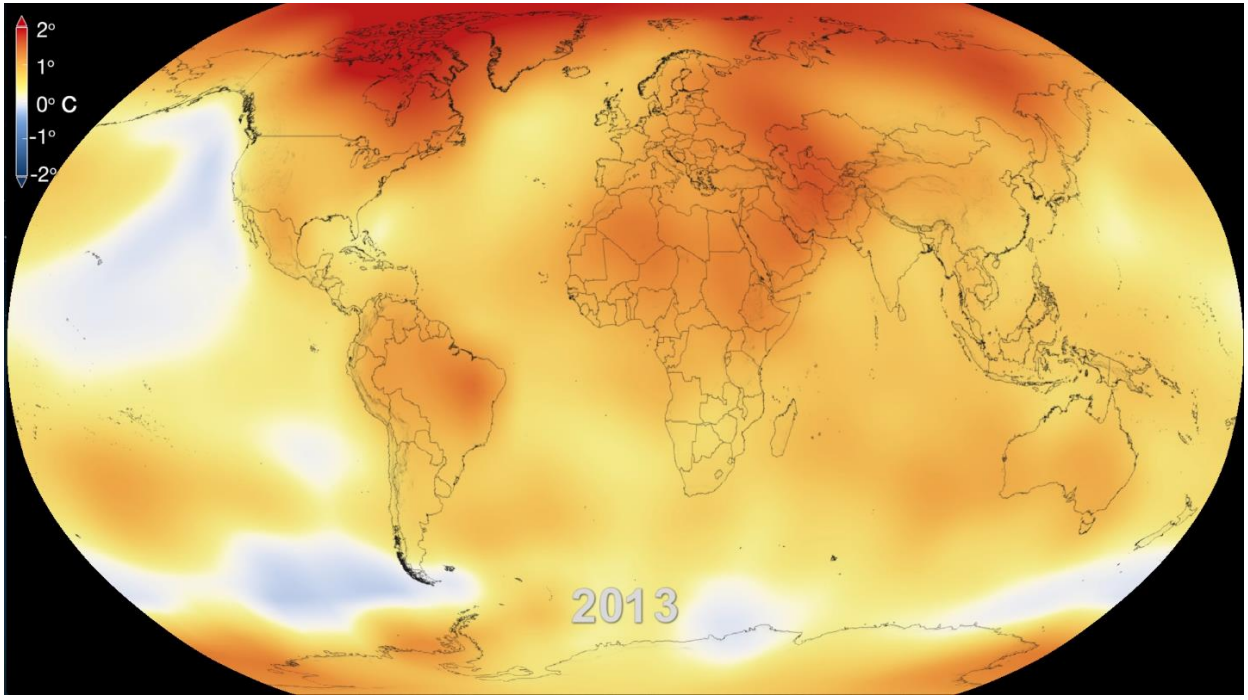
September Arctic sea ice decline at 13% per year.

Global sea level has risen by 7 in. over 100 years.



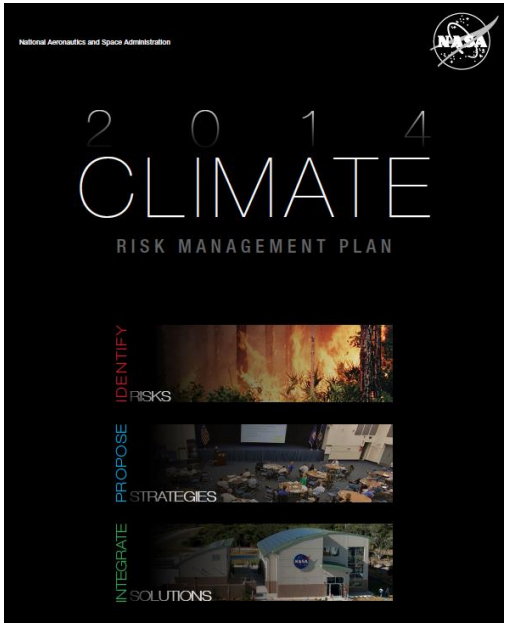
Record Extremes





Climate change is global but with a regional character.

Adaptation Planning is required



GOVERNOR'S COMMISSION ON CLIMATE CHANGE

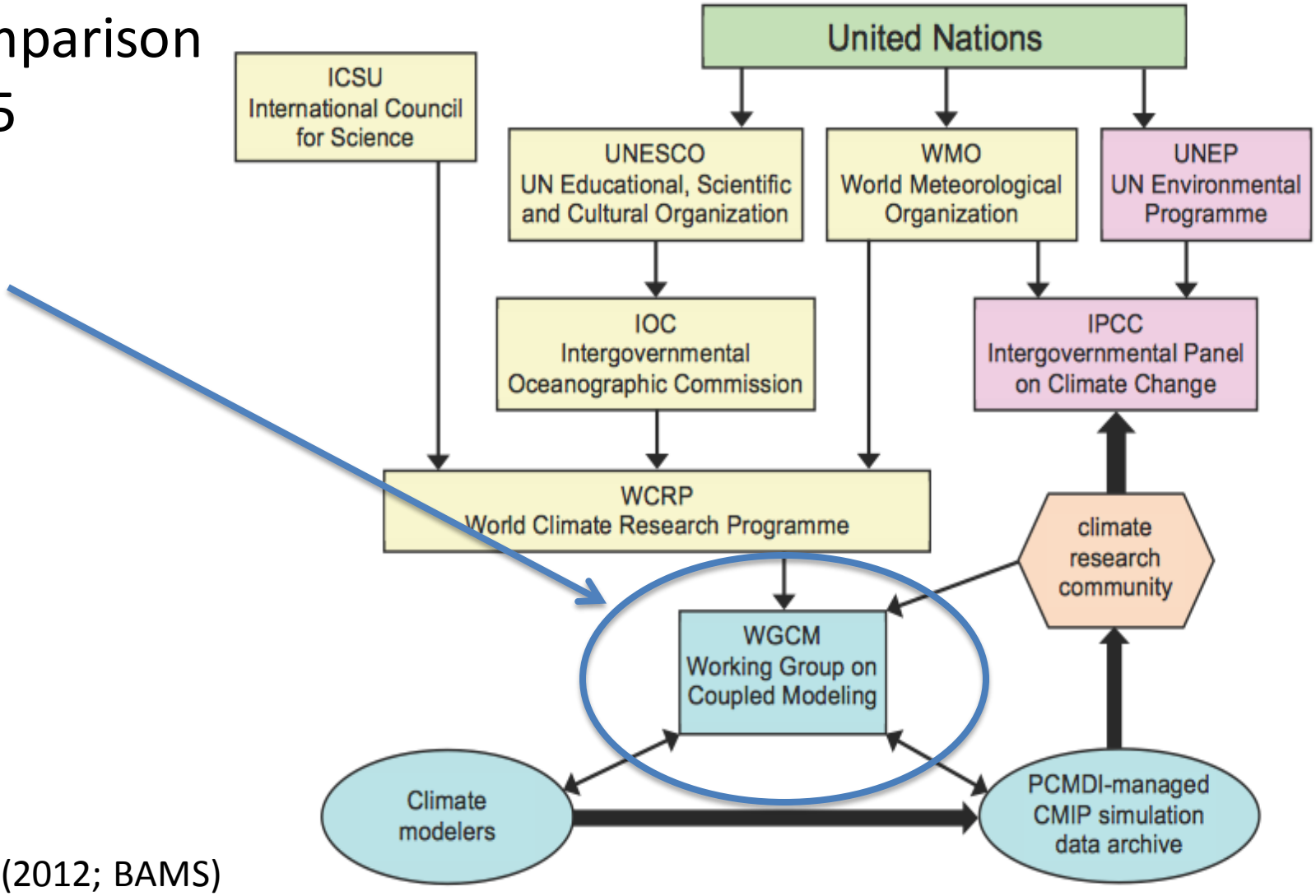
Final Report: A Climate Change Action Plan

December 15, 2008

The Honorable L. Preston Bryant, Jr.
Secretary of Natural Resources
Chair, Governor's Commission on Climate Change

Climate projections are necessary.

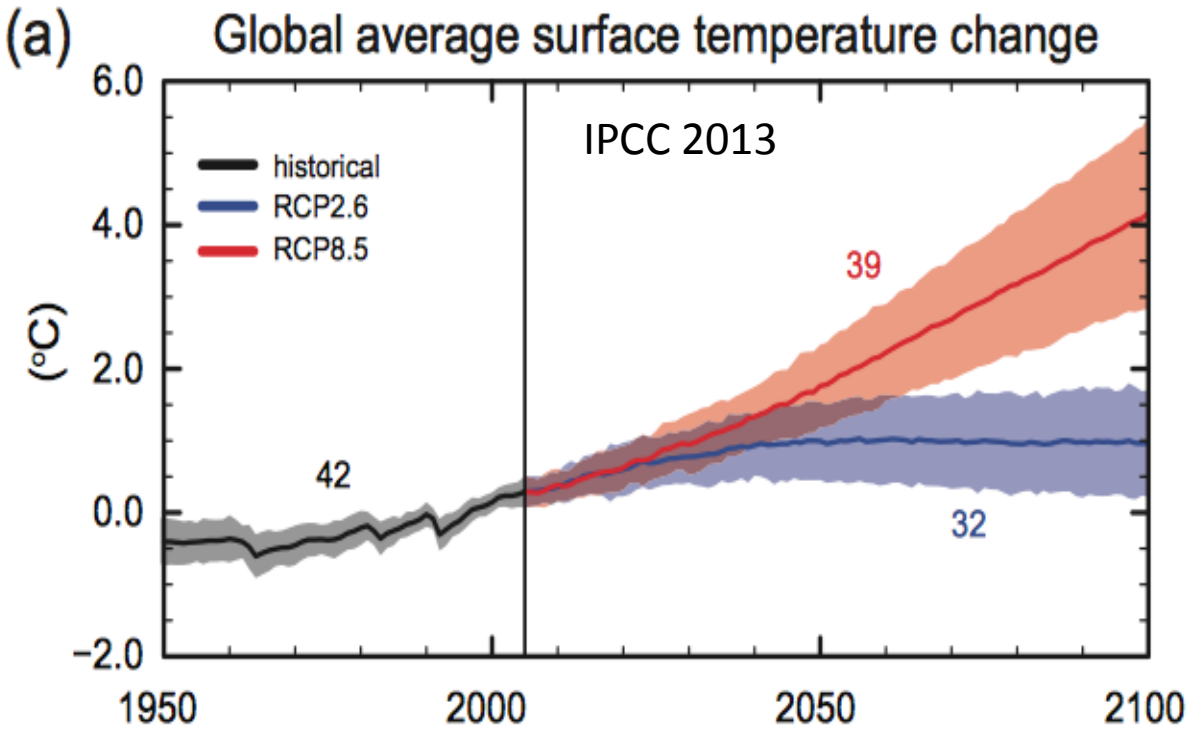
Coupled Model Intercomparison Project 5 (CMIP5)

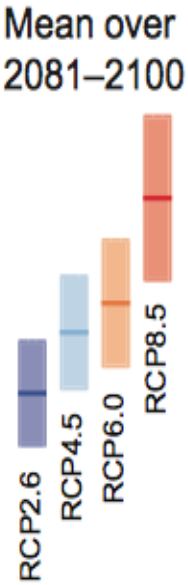


Taylor et al. (2012; BAMS)

FIG. 1. The relationship of CMIP5 to organizations established to coordinate climate research activities internationally and to the IPCC, the modeling centers, and the climate research community.

Expected Changes: Constructing climate projections

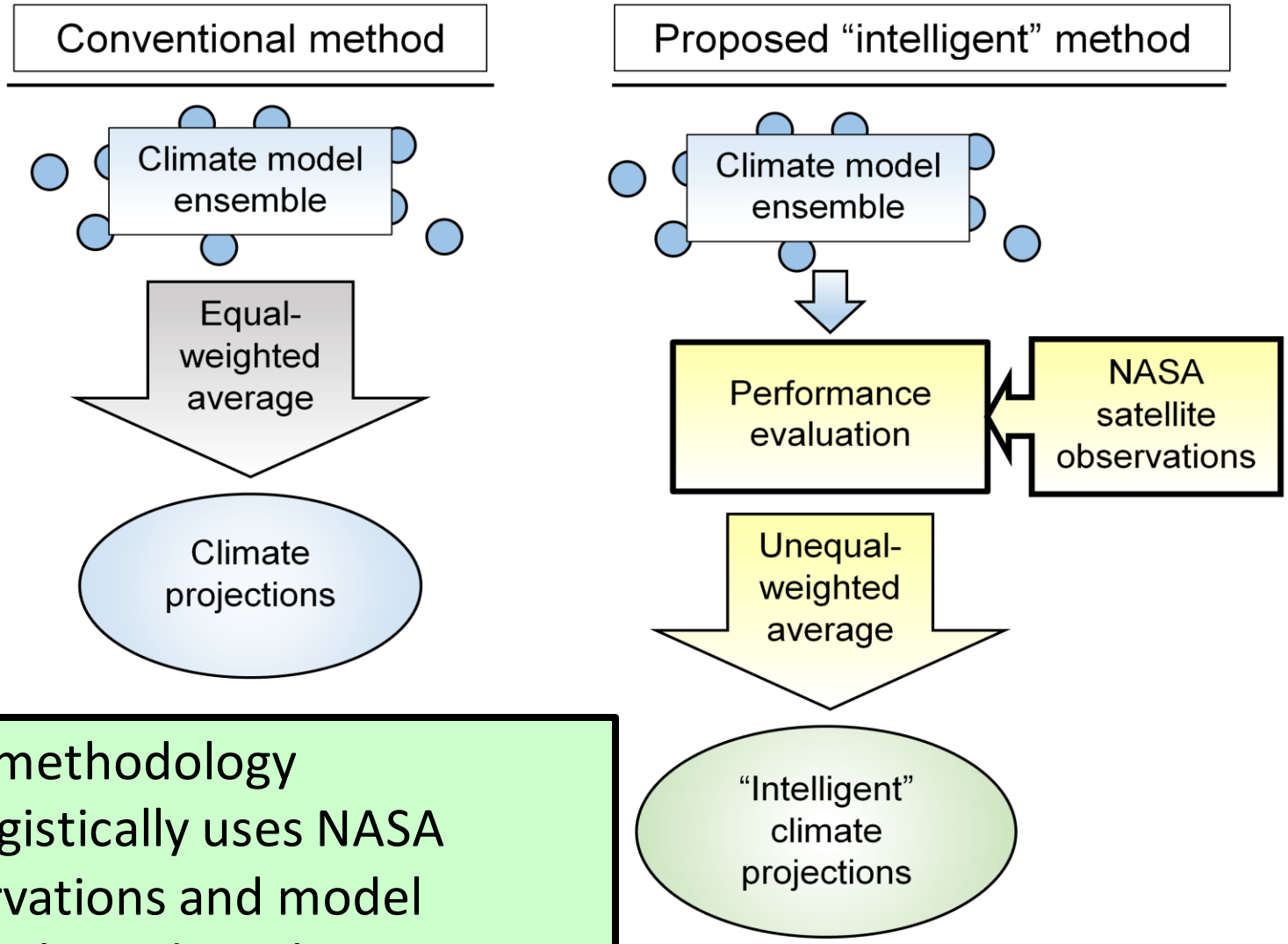




Projected Temperature Change: 2-6°C (4-10°F) by 2100

Conventional Ensemble Projection Approach: One model, one vote

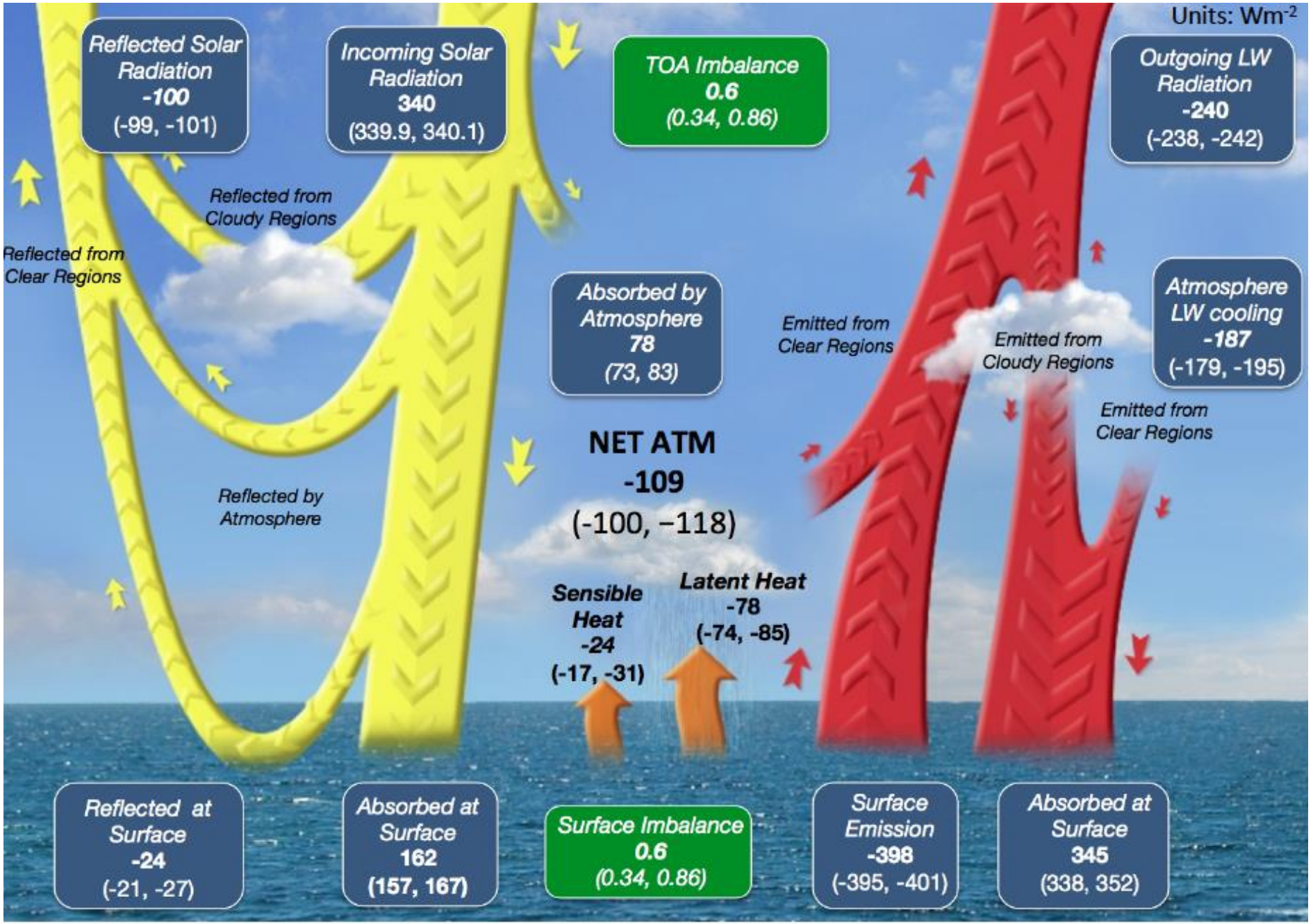
Conventional vs. "Intelligent" Ensemble Method



New methodology synergistically uses NASA observations and model strengths and weaknesses to improve climate projections.

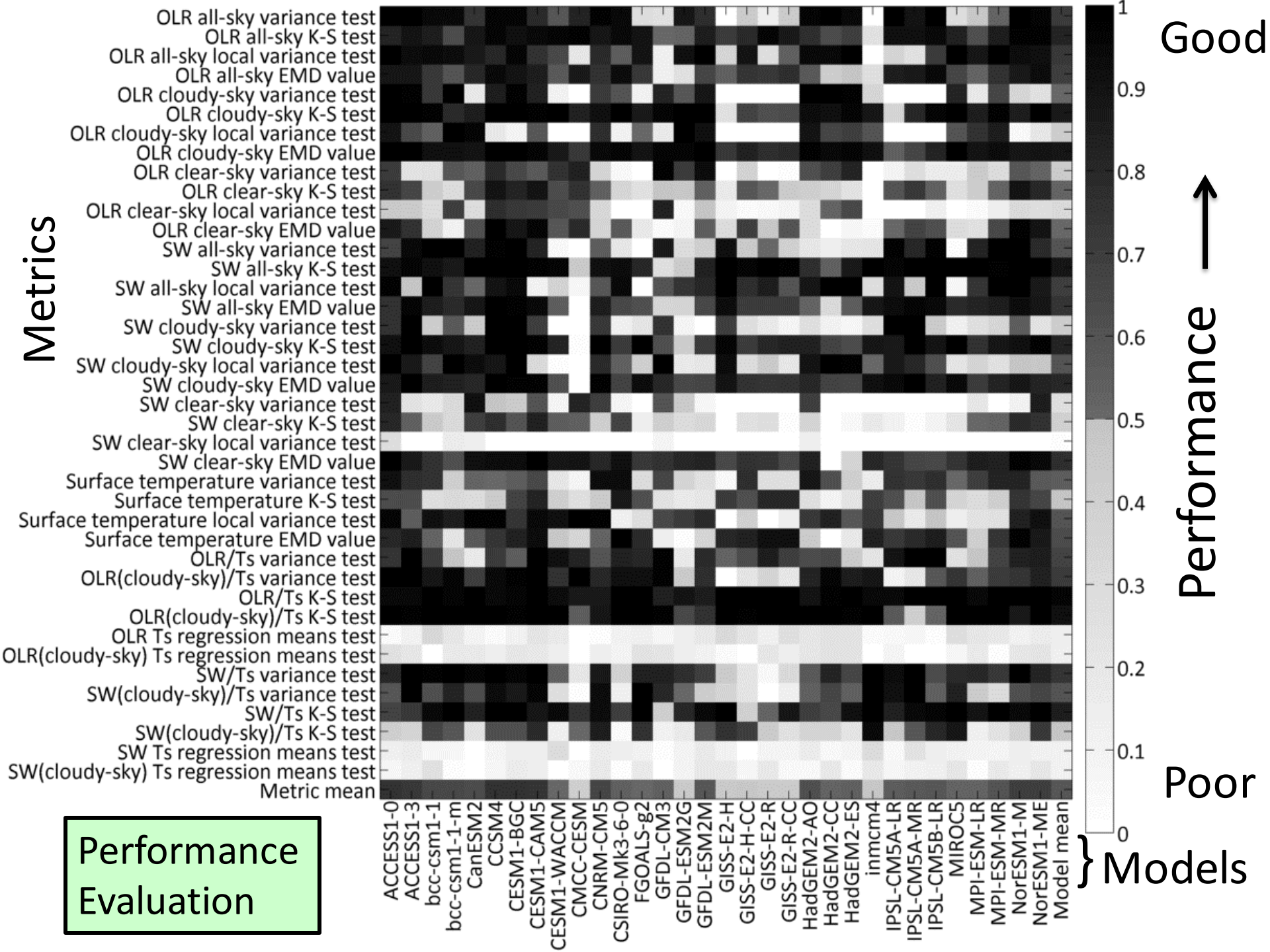
NASA Earth Science Missions
Current & Planned

Metric Selection: Earth's Climate is determine by energy flows



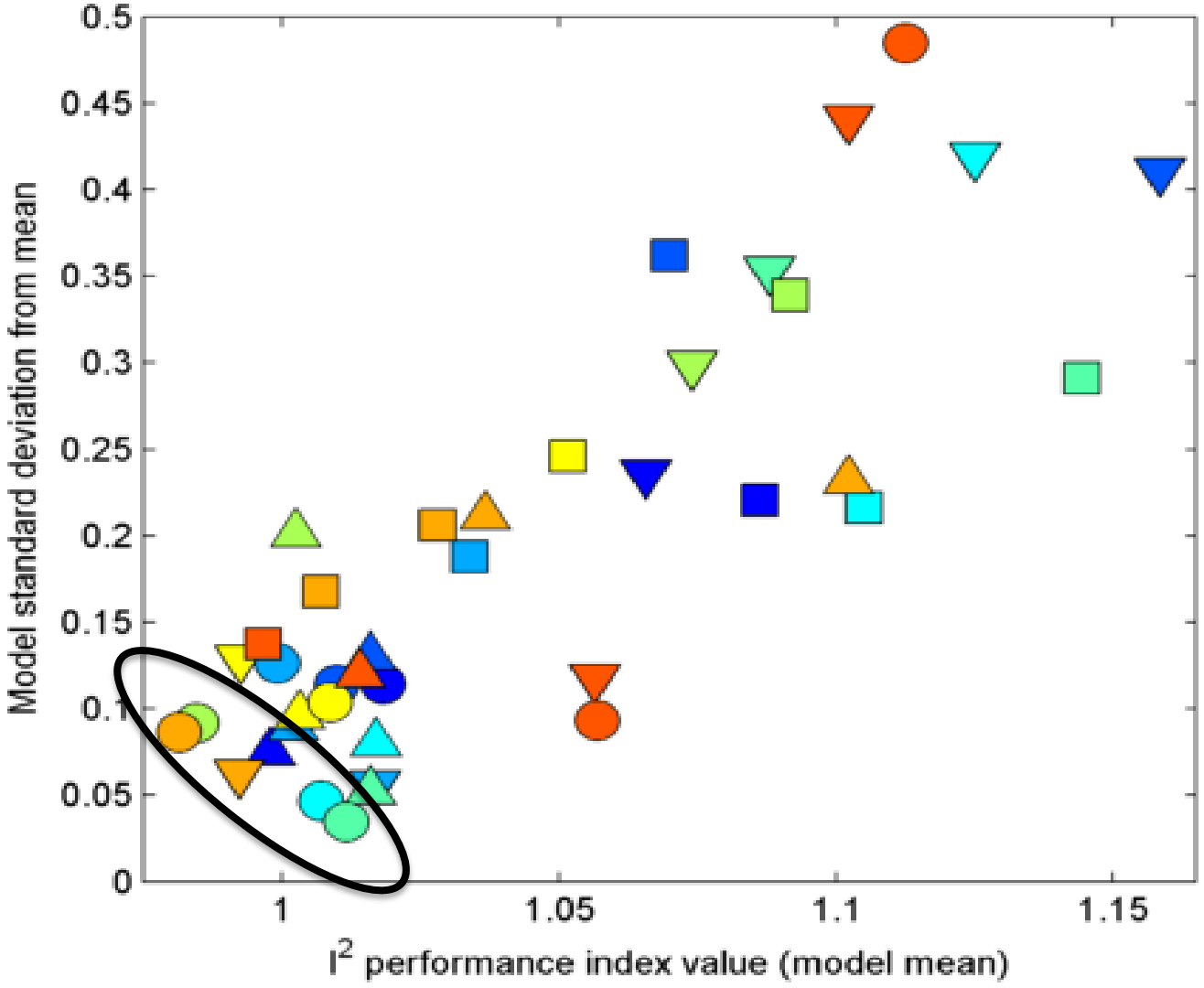
Methodology

- Use perfect model approach to determine the quantities whose performance in an unforced variability simulation robustly relates to climate projections
- Then use NASA observations to produce data-constrained climate projections
- The climate model ensemble is used to understand the relationship between variability in Earth's energy budget and the sensitivity of Earth's climate to a radiative perturbation.


Metrics
OLR all-sky variance test
OLR all-sky K-S test
OLR all-sky local variance test
OLR all-sky EMD value
OLR cloudy-sky variance test
OLR cloudy-sky K-S test
OLR cloudy-sky local variance test
OLR cloudy-sky EMD value
OLR clear-sky variance test
OLR clear-sky K-S test
OLR clear-sky local variance test
OLR clear-sky EMD value
SW all-sky variance test
SW all-sky K-S test
SW all-sky local variance test
SW all-sky EMD value
SW cloudy-sky variance test
SW cloudy-sky K-S test
SW cloudy-sky local variance test
SW cloudy-sky EMD value
SW clear-sky variance test
SW clear-sky K-S test
SW clear-sky local variance test
SW clear-sky EMD value
Surface temperature variance test
Surface temperature K-S test
Surface temperature local variance test
Surface temperature EMD value
OLR/Ts variance test
OLR(cloudy-sky)/Ts variance test
OLR/Ts K-S test
OLR(cloudy-sky)/Ts K-S test
OLR Ts regression means test
OLR(cloudy-sky) Ts regression means test
SW/Ts variance test
SW(cloudy-sky)/Ts variance test
SW/Ts K-S test
SW(cloudy-sky)/Ts K-S test
SW Ts regression means test
SW(cloudy-sky) Ts regression means test
Metric mean
ACCESS1-0
ACCESS1-3
bcc-csm1-1
bcc-csm1-1-m
CanESM2
CCSM4
CESM1-BGC
CESM1-CAM5
CESM1-WACCM
CMCC-CESM
CNRM-CM5
CSIRO-Mk3-6-0
FGOALS-g2
GFDL-CM3
GFDL-ESM2G
GFDL-ESM2M
GISS-E2-H
GISS-E2-H-CC
GISS-E2-R
GISS-E2-R-CC
HadGEM2-AO
HadGEM2-CC
HadGEM2-ES
inmcm4
IPSL-CM5A-LR
IPSL-CM5A-MR
IPSL-CM5B-LR
MIROC5
MPI-ESM-LR
MPI-ESM-MR
NorESM1-M
NorESM1-ME
Model mean
Models
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Good
Performance
Poor
Performance Evaluation

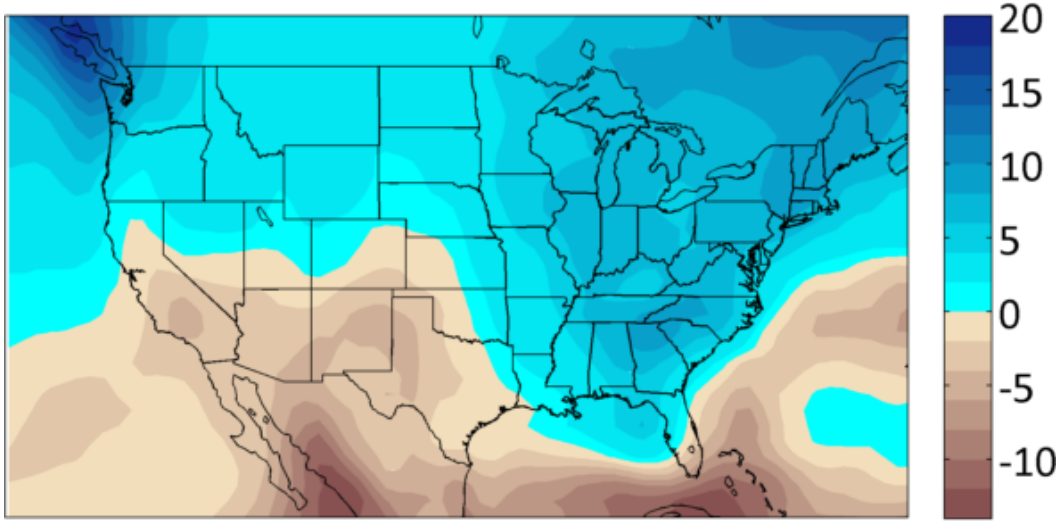
Producing “Intelligent Ensemble Projections: Selecting “Ideal” Metrics:

Best metrics have both a low standard deviation and I^2 value.

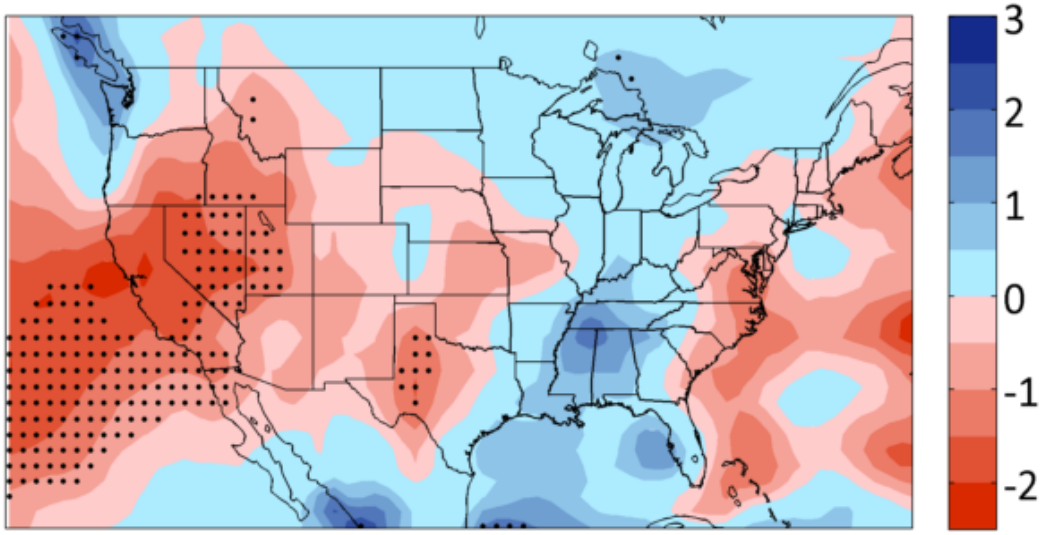


Results: 21st-century "Intelligent" projections (regional weights)

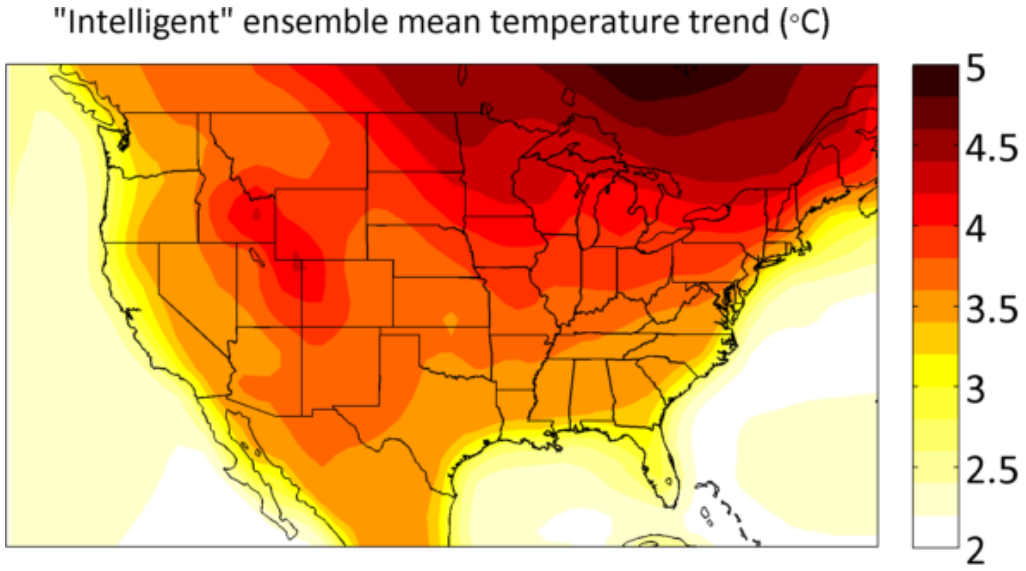
"Intelligent" ensemble mean precipitation trend (cm/year)



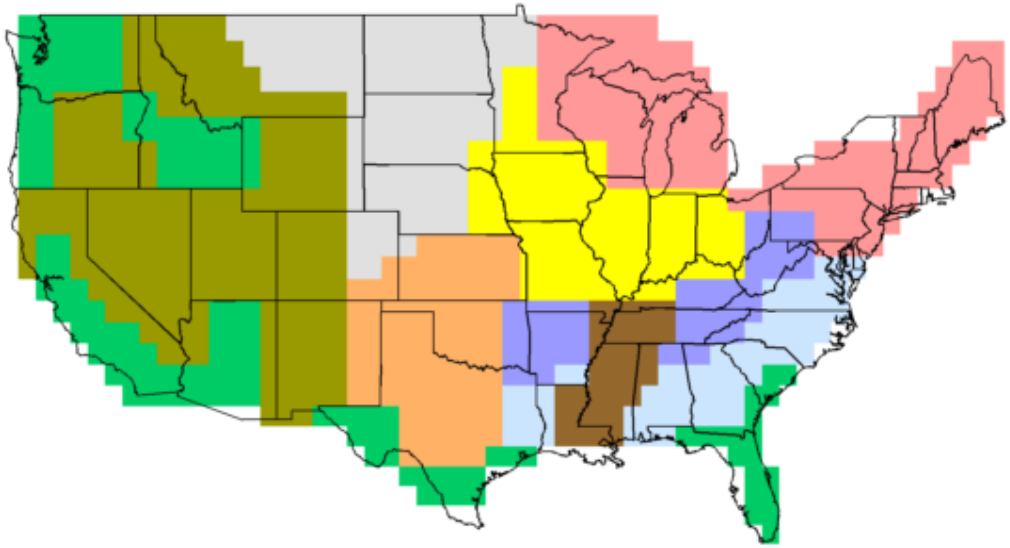
Difference between "Intelligent" and Equal-weight ensemble means (cm/year)



Results: new 21st-century projections



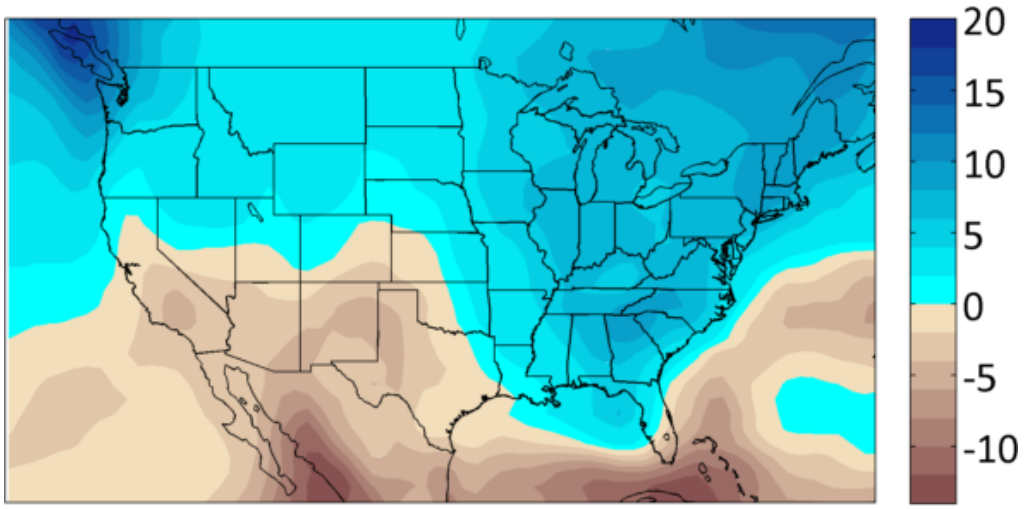
US mean temperature increase: 3.9 °C



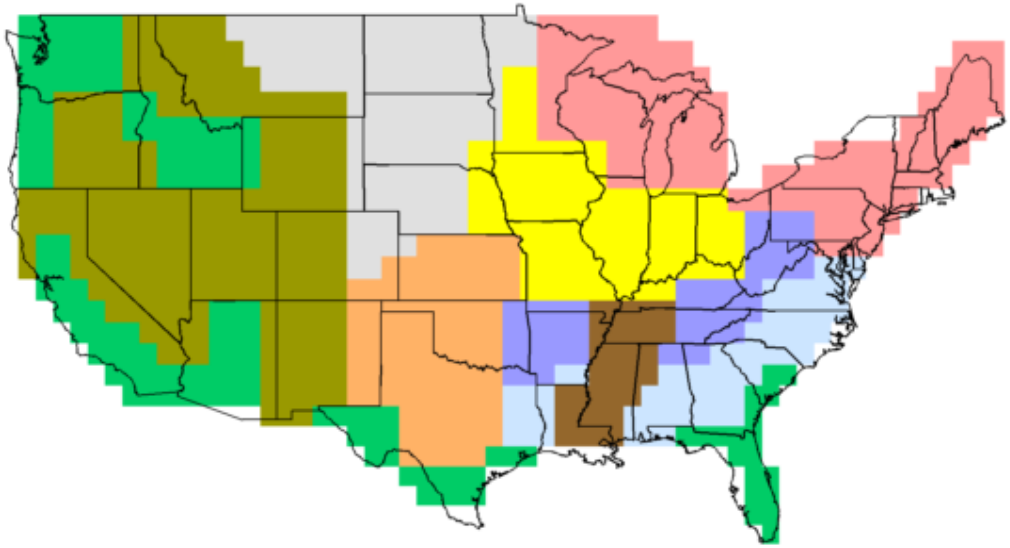
- Basin and Range: 3.9 °C
- Fruitful Rim: 3.4 °C
- Prairie Gateway: 3.8 °C
- Northern Great Plains: 4.1 °C
- Heartland: 4.1 °C
- Northern Crescent: 4.3 °C
- Eastern Uplands: 3.8 °C
- Southern Seaboard: 3.5 °C
- Mississippi Portal: 3.6 °C

Results: new 21st-century projections

"Intelligent" ensemble mean precipitation trend (cm/year)



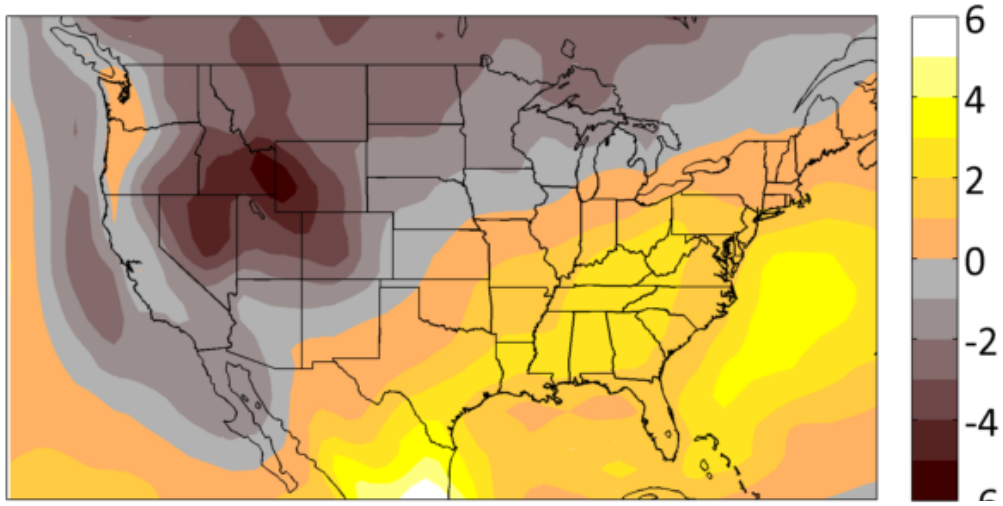
US mean precipitation increase: 3.4 cm/year



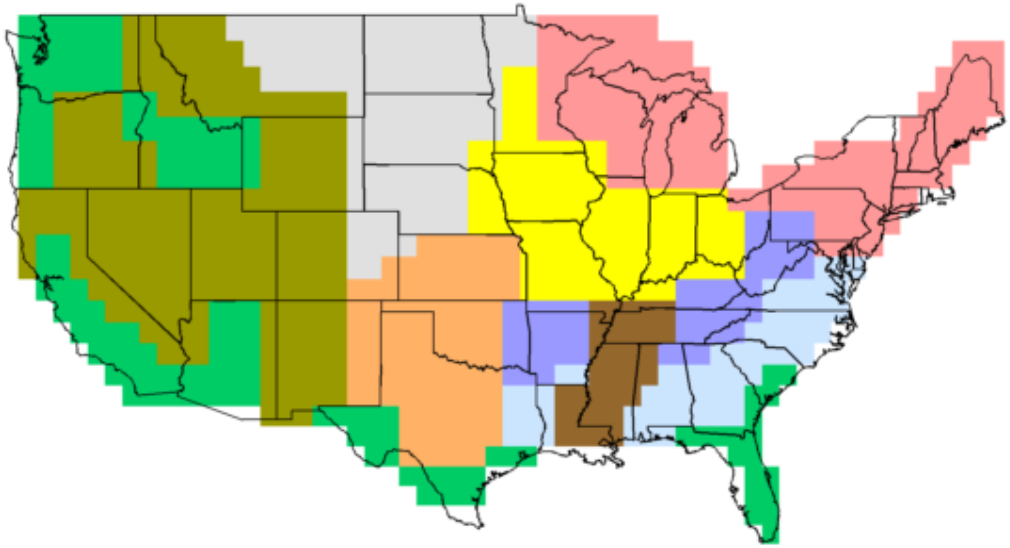
- Basin and Range: 0.6 cm/year
- Fruitful Rim: 0.8 cm/year
- Prairie Gateway: -1.8 cm/year
- Northern Great Plains: 2.7 cm/year
- Heartland: 7.2 cm/year
- Northern Crescent: 9.1 cm/year
- Eastern Uplands: 6.8 cm/year
- Southern Seaboard: 6.8 cm/year
- Mississippi Portal: 5.4 cm/year

Results: new 21st-century projections

"Intelligent" ensemble mean surface shortwave radiation trend (W/m^2)



US mean decrease in surface solar radiation: -.33 Watts/m^2



- Basin and Range: -2.4 Watts/m^2
- Fruitful Rim: -0.5 Watts/m^2
- Prairie Gateway: 0.7 Watts/m^2
- Northern Great Plains: -1.9 Watts/m^2
- Heartland: 0.7 Watts/m^2
- Northern Crescent: -0.1 Watts/m^2
- Eastern Uplands: 2.7 Watts/m^2
- Southern Seaboard: 2.5 Watts/m^2
- Mississippi Portal: 2.6 Watts/m^2

Summary and Conclusions

- Data constrained climate change projections are one way science an address society's need for better climate information.
- The "Intelligent" Ensemble method uses model performance to constrain projections.
- The data-constrained projections different from the equal weighted projections by as much as 50%.