“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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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

Climate projections are necessary.
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.

Taylor et al. (2012; BAMS)
Expected Changes: Constructing climate projections

Conventional Ensemble Projection Approach: One model, one vote

Projected Temperature Change: 2-6°C (4-10°F) by 2100
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 determined 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.
Producing “Intelligent Ensemble Projections: Selecting “Ideal” Metrics:

Best metrics have both a low standard deviation and \( I^2 \) value.
Results: 21\textsuperscript{st}-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

"Intelligent" ensemble mean temperature trend (°C)

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/m²)

US mean decrease in surface solar radiation: -0.33 Watts/m²

Basin and Range: -2.4 Watts/m²
Fruitful Rim: -0.5 Watts/m²
Prairie Gateway: 0.7 Watts/m²
Northern Great Plains: -1.9 Watts/m²
Heartland: 0.7 Watts/m²
Northern Crescent: -0.1 Watts/m²
Eastern Uplands: 2.7 Watts/m²
Southern Seaboard: 2.5 Watts/m²
Mississippi Portal: 2.6 Watts/m²
Summary and Conclusions

• Data constrained climate change projections are one way science can address society’s need for better climate information.

• The “Intelligent” Ensemble method uses model performance to constrain projections.

• The data-constrained projections differ from the equal weighted projections by as much as 50%.