Climate studies using a combination of models and observations

Robert W. Portmann

Regional Climate Studies

1. Spatial and seasonal patterns in climate change, temperatures, and precipitation across the United States
2. Early onset of significant local warming in low latitude countries
3. Perceptible changes in regional precipitation in a future climate
4. Identifying weekly cycles in meteorological variables: The importance of an appropriate statistical analysis
5. Influence of tropical tropopause layer cooling on Atlantic hurricane activity

Global Climate Studies

1. An observationally based energy balance for the Earth since 1950
2. Stratospheric water vapor feedback
3. Variations of stratospheric water vapor over the past three decades

Model Evaluation/Improvement Study

1. Evaluation of radiation scheme performance within chemistry climate models

CSD Authors

Robert Portmann, John Daniel, Dan Murphy, Karen Rosenlof, Sean Davis, Susan Solomon, Irina Mahlstein

Select External Collaborators

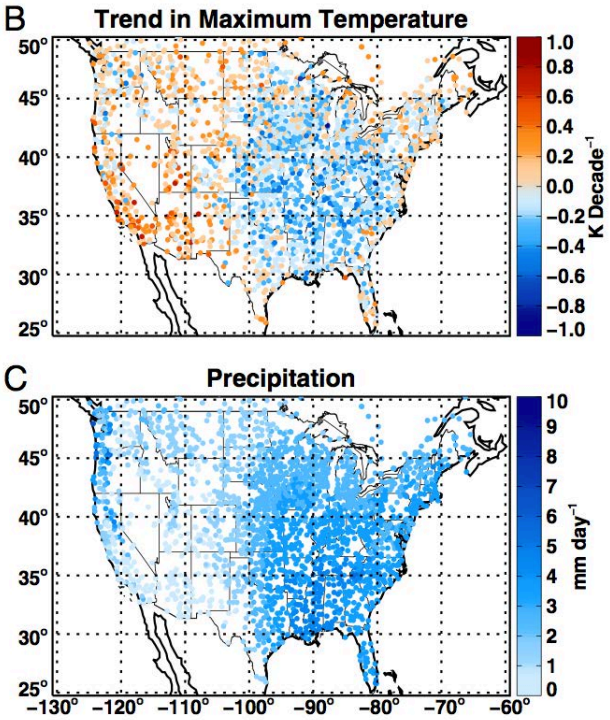
Piers Forster, Gabi Hegerl, Andy Dessler, Reto Knutti, Kerry Emanuel

Guiding principles

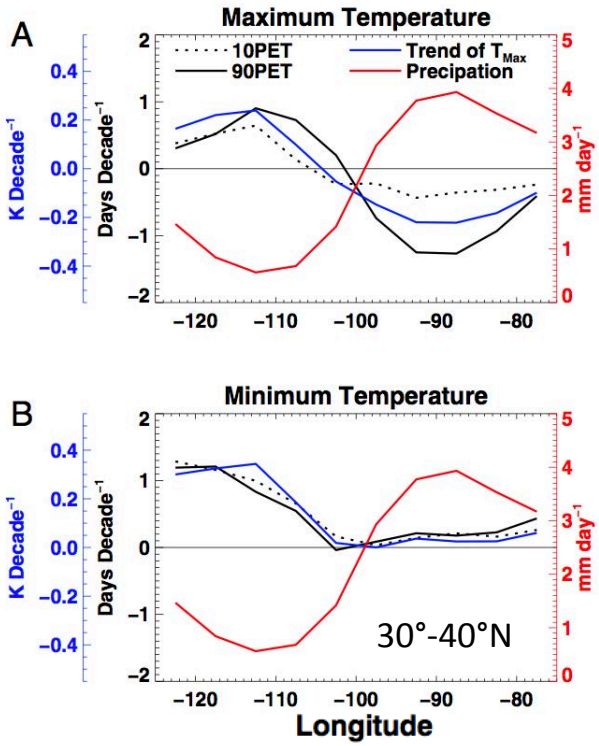
- Exploit observations whenever possible.
- Make models accountable.

Spatial patterns in Climate Variables

- "The warming hole": unusual negative temperature trends over 20th century
- Quantified the connection between precipitation and temperature trends



Results for
NCDC Daily Data
May-June
1950-2006



Analysis suggests a possible role for:

- Aerosol increases linked to anthropogenic/biogenic emissions
- Land use changes

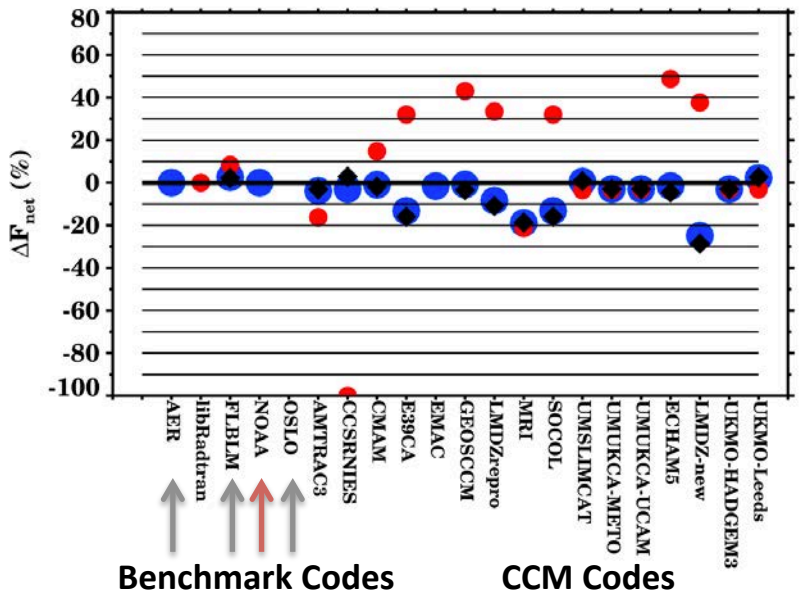
Provided inspiration for SENEX mission

Portmann et al., PNAS, 2009

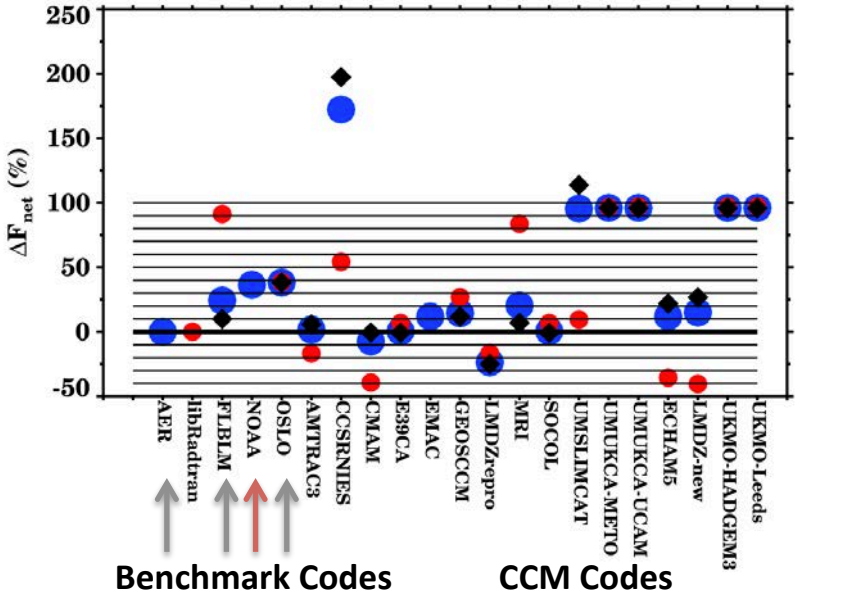
Radiation Code Comparison

Chemistry/Climate Model Validation (CCMVAL)
NOAA-LBL Code used as benchmark code (Line-by-line code)
Many Chemistry-Climate Models (CCM) radiation codes represented

Long-Lived GHG Increase (ΔFlux at Tropopause)



Stratospheric H_2O Increase (ΔFlux at Tropopause)

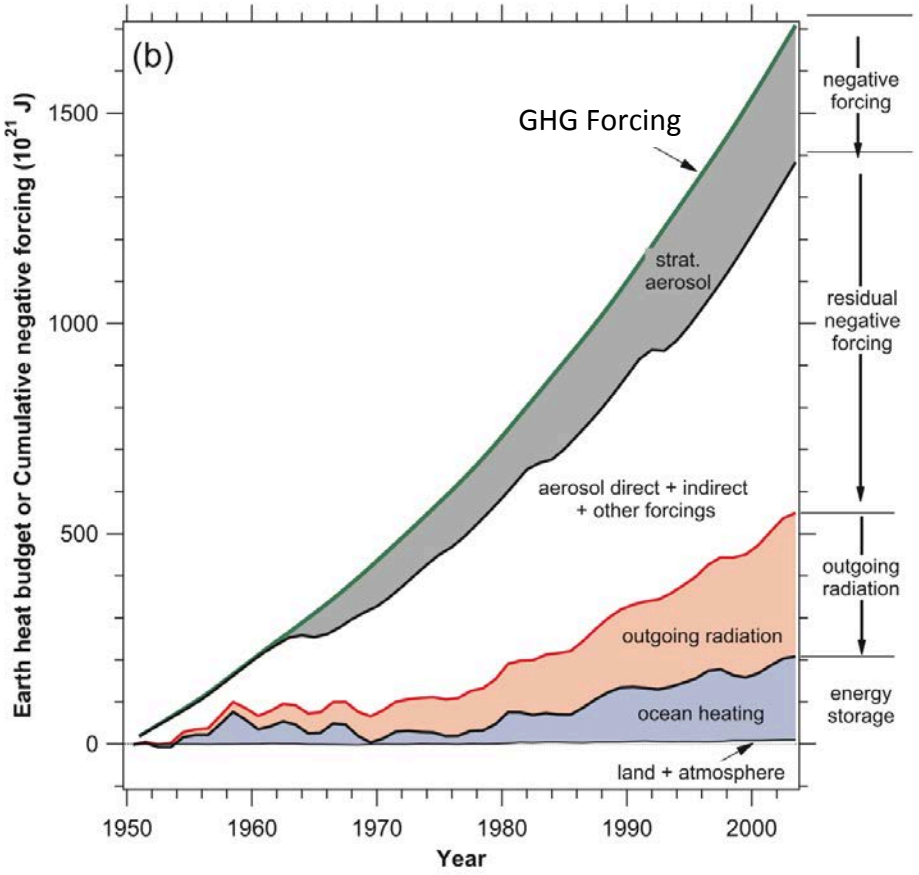


Study identified where significant improvement is necessary in chemistry-climate model radiation codes

Forster et al., JGR, 2010

Earth's Energy Balance

First attempt to use observations to constrain earth's energy budget: incoming, outgoing, & storage



Observational components energy budget

Positive Radiative Forcing:
GHG (especially CO_2)

Negative Radiative Forcing:
Stratospheric aerosol
Anthropogenic aerosol

Climate Response:
Outgoing radiation (~ΔT)

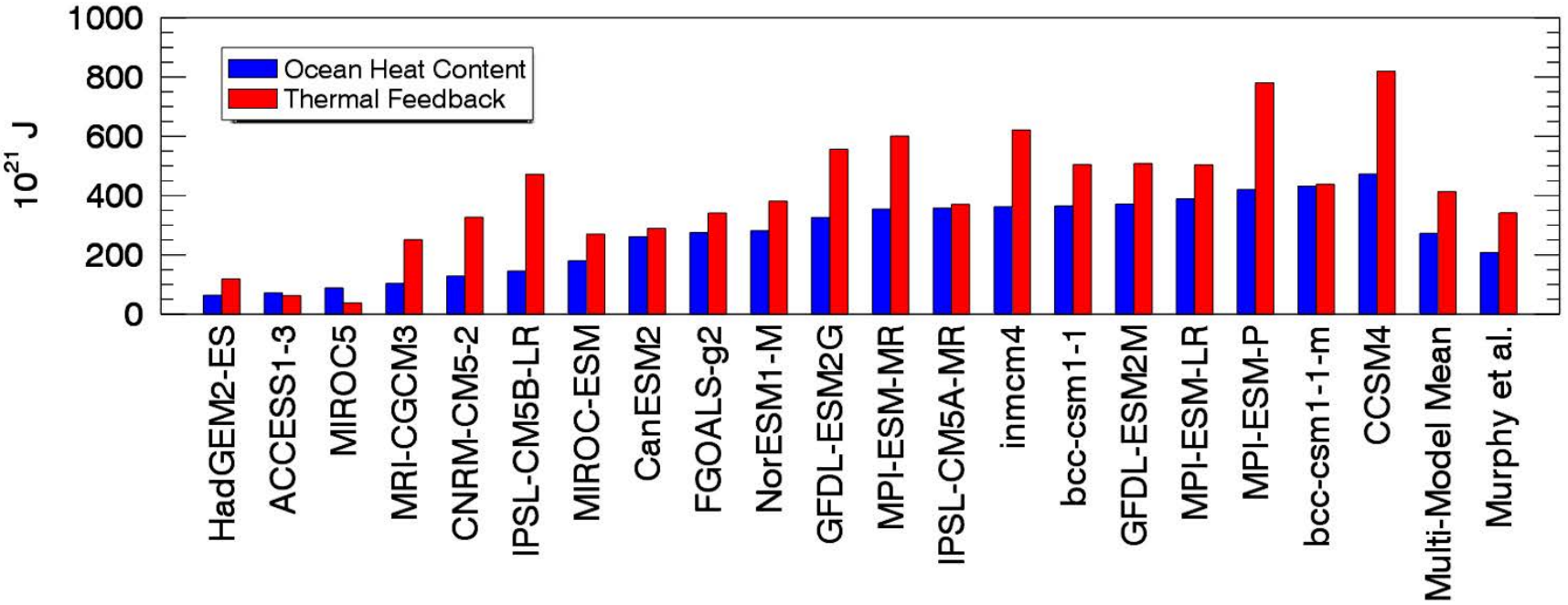
Net Imbalance:
Energy storage (primarily in ocean)

Murphy et al., JGR, 2009

- Novel estimate of aerosol forcing from residual of estimated components
- Total aerosol forcing (direct + indirect): -1.1 ± 0.4 W m^{-2}
- Consistent with IPCC estimate

Earth's Energy Balance (Models)

Climate Model Intercomparison Project (CMIP5) Estimates
Heat Accumulated in Ocean & Integrated Thermal Feedback (1950-2005)



Very large range between models but Multi-Model Mean compares well with observational estimate

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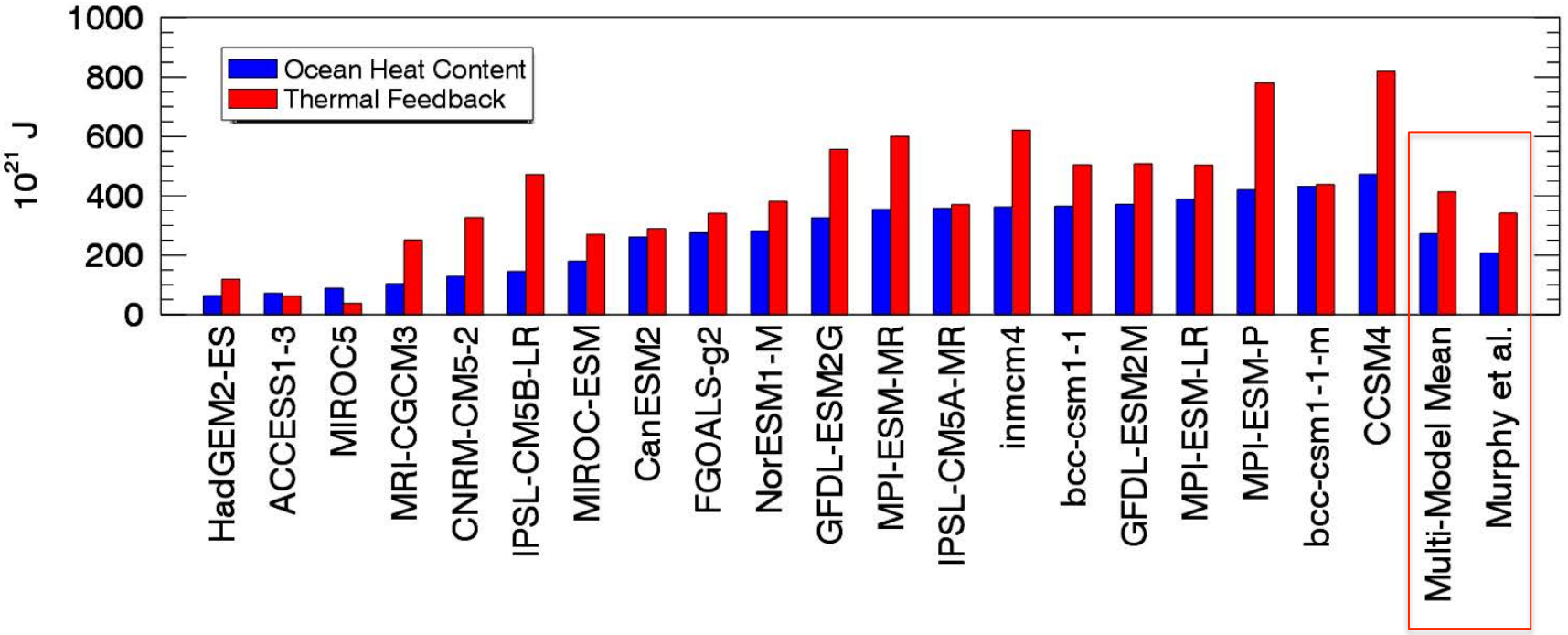

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Future Directions

Innovative science using model inter-comparison databases (e.g. CMIP5/6)

- How well do models represent the earth's energy budget?
- Can we estimate the modeled aerosol forcing from the energy budget?
- Do climate models trends spatially vary with precipitation amount?
- Stratospheric water vapor feedbacks across models (the ignored feedback)

Climate/Chemistry model studies

- Key tool: NCAR CESM (Community Earth Systems Model)
- New collaborations: GFDL Climate Model
- Is the efficacy of stratospheric forcing/feedback agents different than tropospheric forcing agents?
- Can cloud feedbacks be estimated more accurately?
- Can we isolate the factors that control stratospheric water vapor?

Guiding principles

- Exploit observations whenever possible. Make models accountable.
- Unravel the "why" of model response