C4MIP/CMIP5
Coupled Carbon Climate Model Intercomparisons Project

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Presentation derives from

- Friedlingstein et al., submitted to JOC, “CMIP5 cliamte projections and uncertainties due to carbon cycle feedbacks”
- Jones et al., submitted to JOC, “21st century compatible CO2 emissions and airborne fraction simuated by CMIP5 Earth System models under 4 representative concentration pathways.”
- Arora et al. submitted to JOC, “Carbon-concentration and carbon-climate feedbacks in CMIP5 Earth System models”
- Hoffman and Randerson, and has a working title of "The Causes and Implications of Persistent Atmospheric CO_2 Biases in Earth System Models”, in prep
- Mahowald et al., in prep
- Others on PCMDI website: 16 total

Black: conc forcec

Red: emis forced

Friedlingstein et al., submitted

Land/Atmosphere fluxes

Ocean/atmosphere fluxes

Friedlingstein et al., submitted

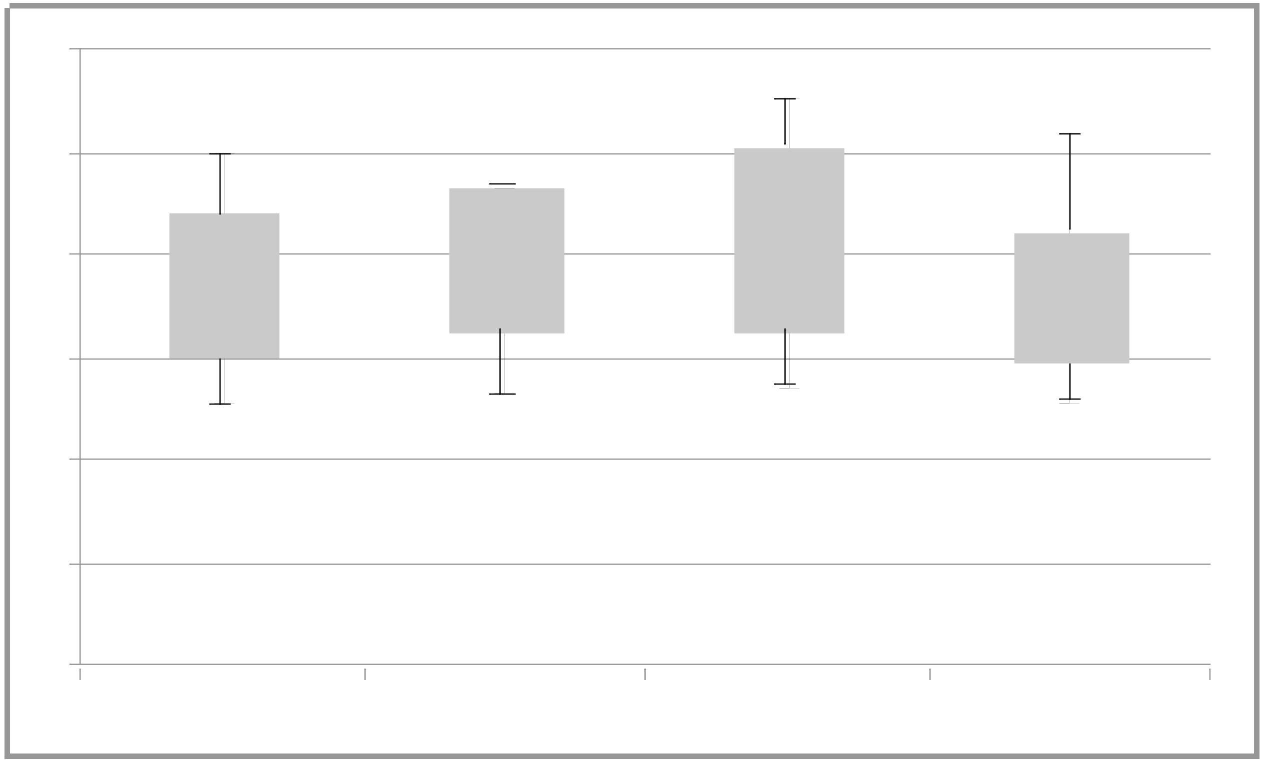
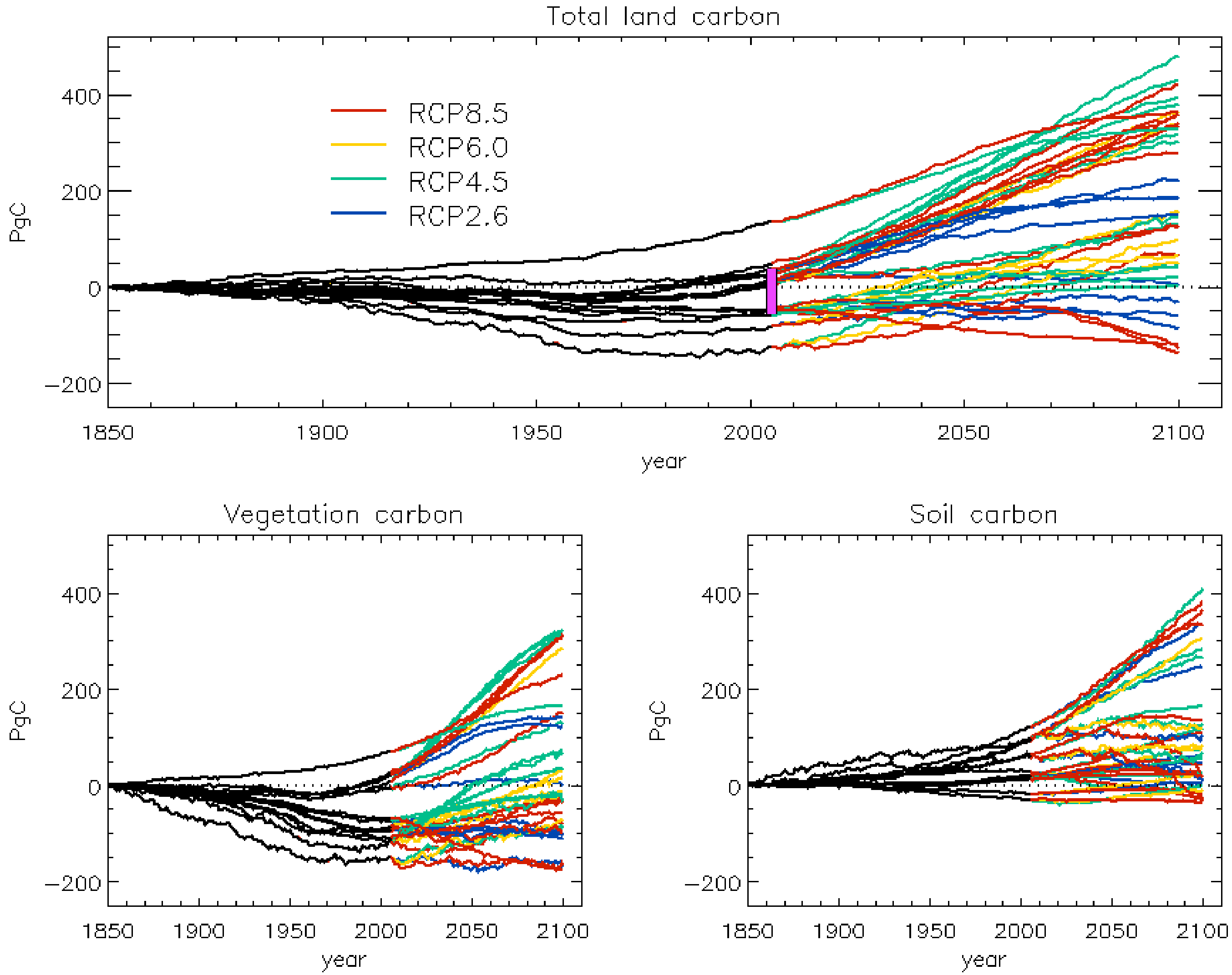


Figure 9. Model estimate of 2100 warming relative to present day (average, standard deviation and full range) for the concentration driven runs from the CMIP5 models (full database available) and from the 7 CMIP5 ESMs analysed here, and for the emission driven runs from the 7 CMIP5 ESMs analysed here and from the CMIP3/C^{4}MIP emulation using the MAGICC6 model.

Friedlingstein et al., submitted



Model variability as large as RCP variability

FIG. 2. Changes in total land carbon store (top) vegetation carbon (bottom left) and soil carbon (defined as cSoil + cLitter; bottom right) for the CMIP5 models. An observationally derived estimate of net changes (Arora et al., 2011) is shown by the vertical pink bar in the top panel.

Jones et al., sub

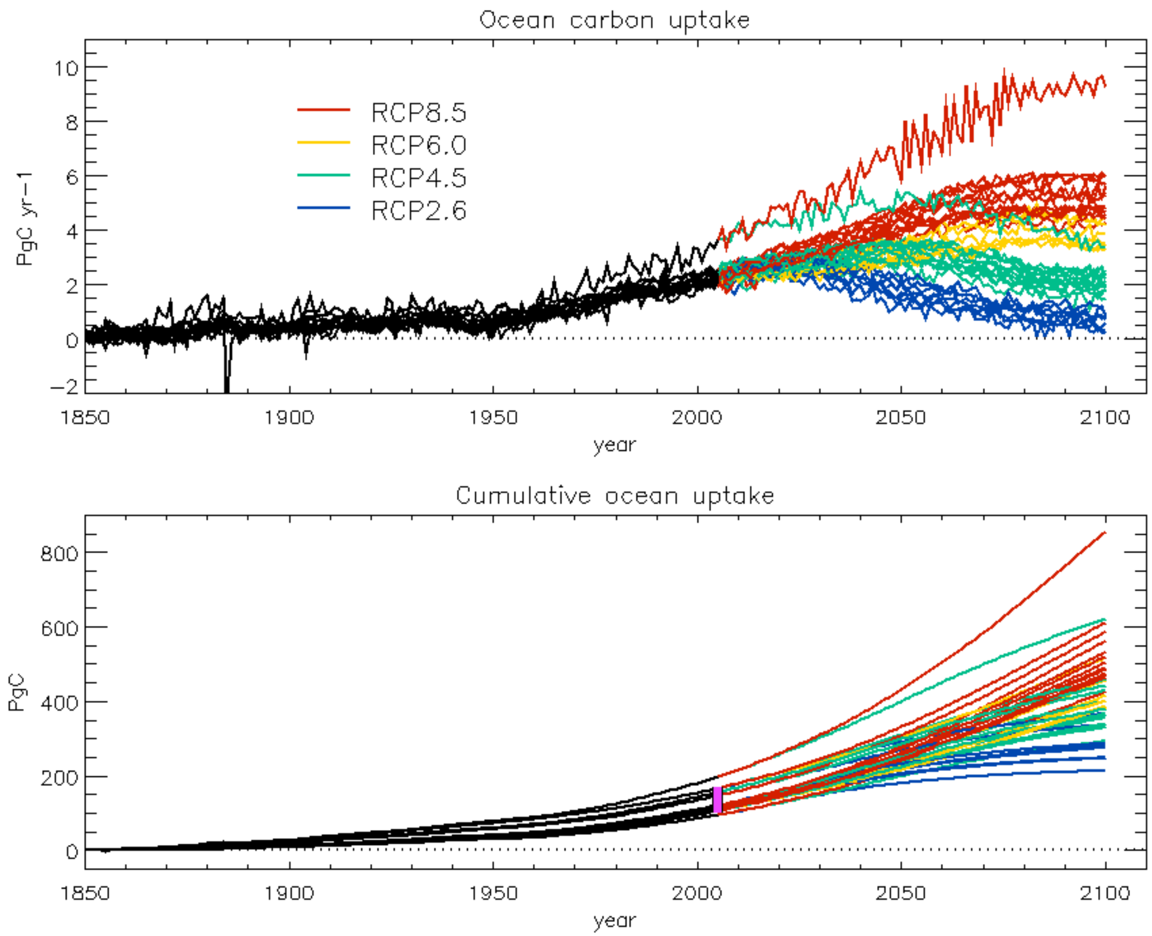
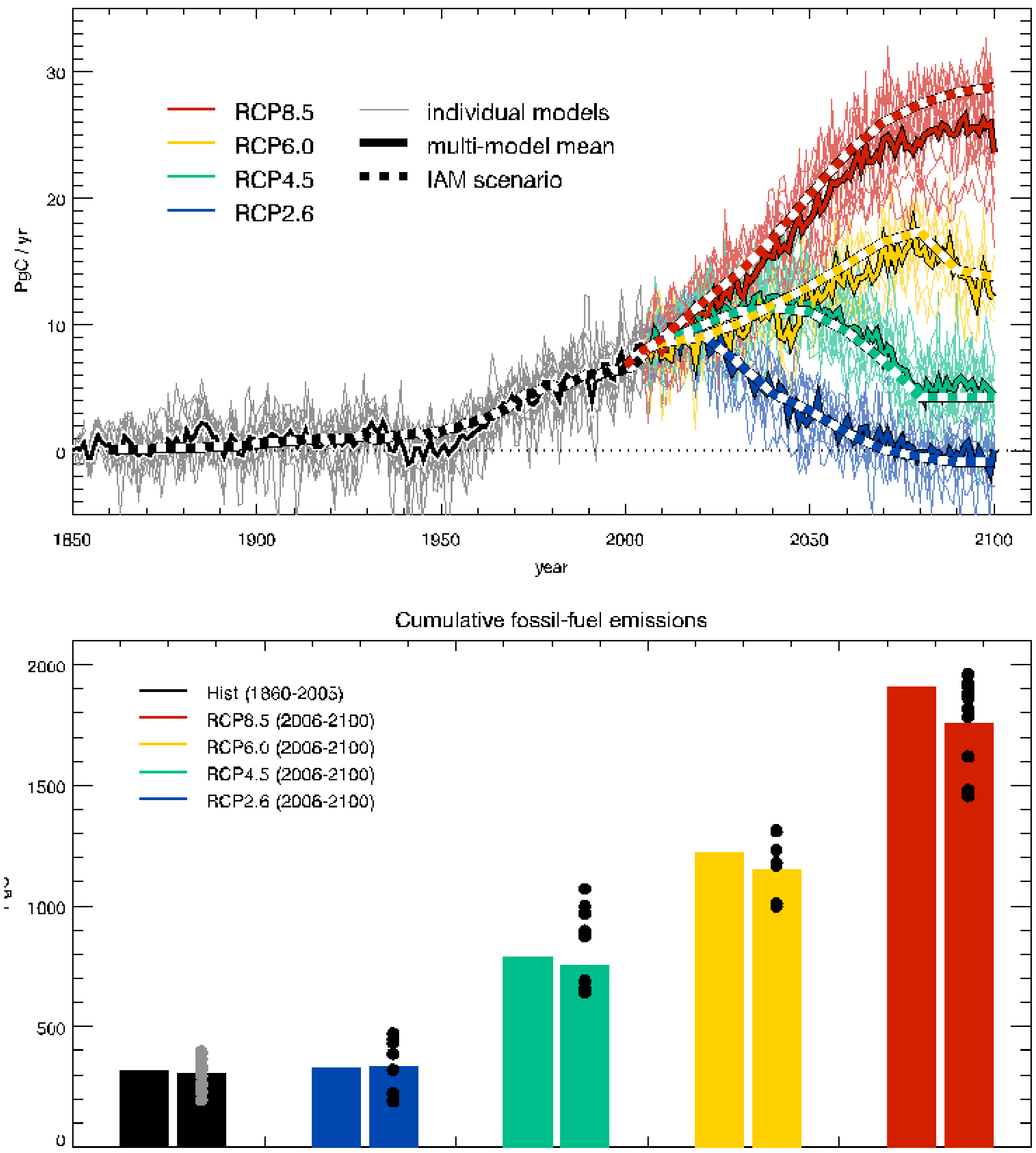


FIG. 4. Changes in annual oceanic carbon uptake (top) and cumulative uptake since 1850 (bottom) from the CMIP5 models. An observationally derived estimate of net changes (Arora et al., 2011; Le Quere, personal communication) is shown by the vertical pink bar in the bottom panel.

In some cases, uncertainties in models as large as rcp

Jones et al.,



Left bar: RCP
Right bar: model mean, dots are spread

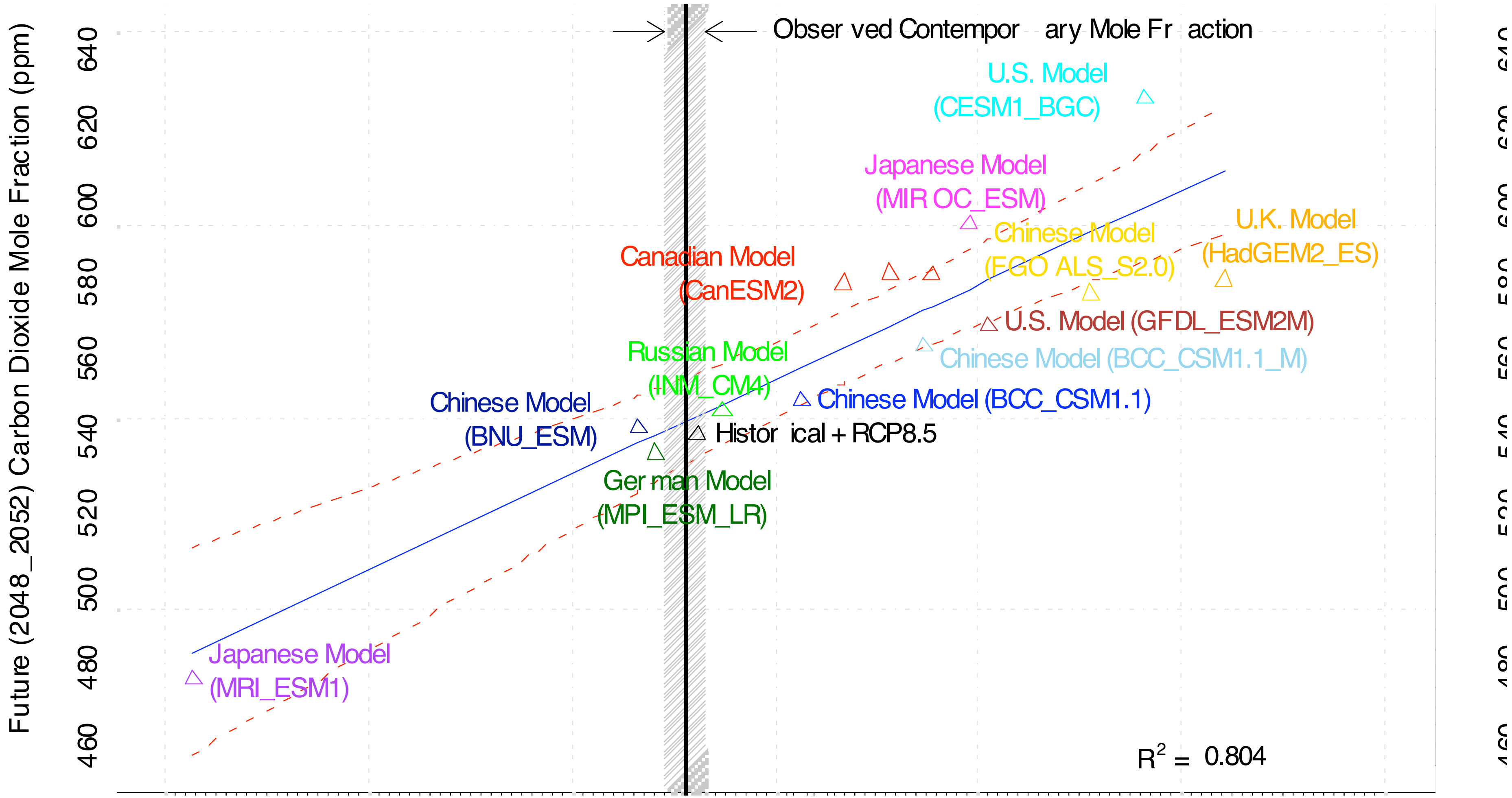
Jones et al.,

Jones et al., submtted

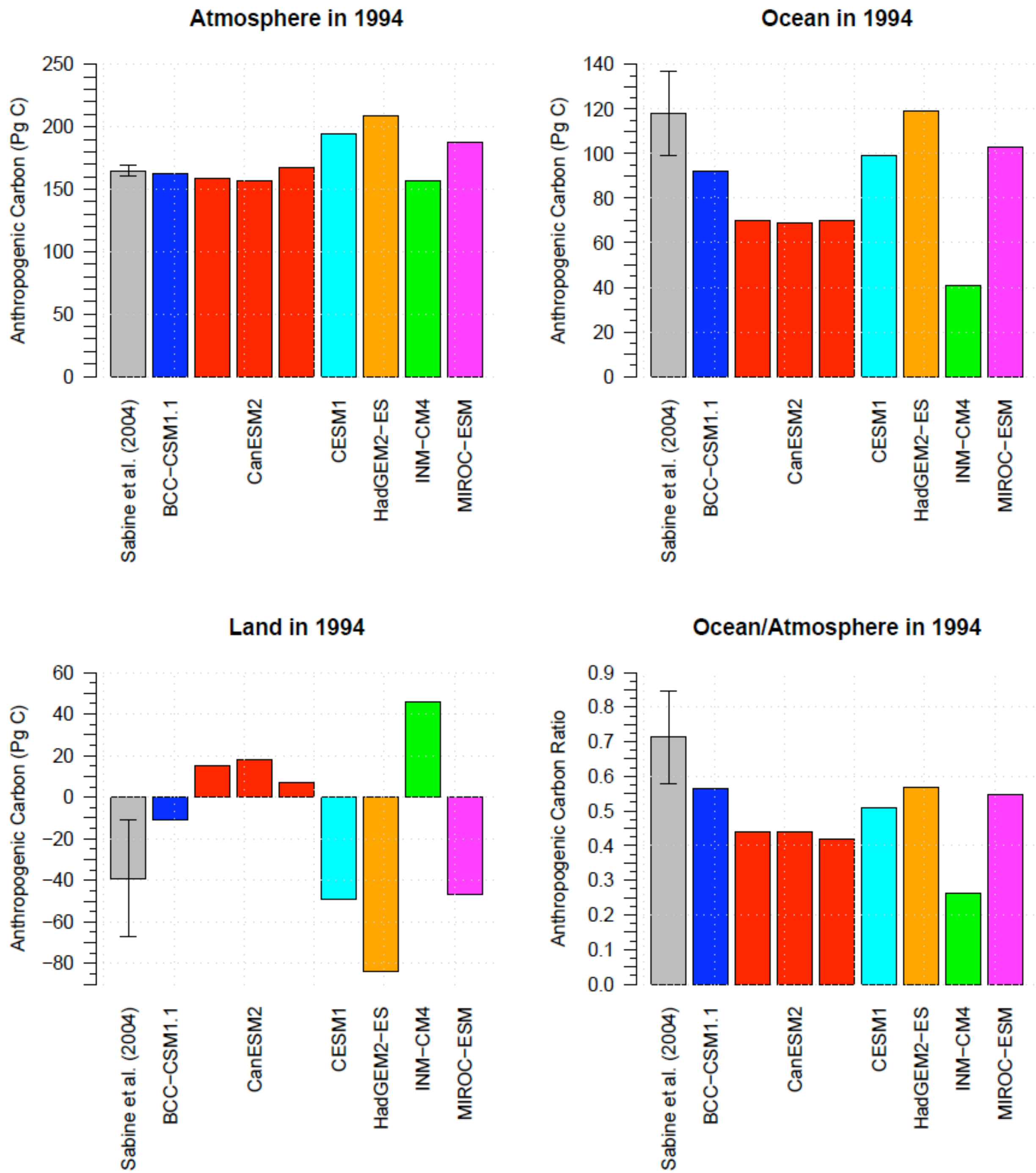
- The uncertainty in land carbon uptake due to differences among models is comparable with the spread of differences among RCP scenarios and is due in part to differing representation of anthropogenic land use change. The CMIP5 models estimate cumulative (2006-2100) fossil-fuel emissions of 331±117, 861±160, 1147±124, 1783±187 PgC respectively for the RCP2.6, RCP4.5, RCP6.0 and RCP8.5 scenarios.

Arora et al., submit

Arora et al



Hoffman et al.



What is causing the bias?

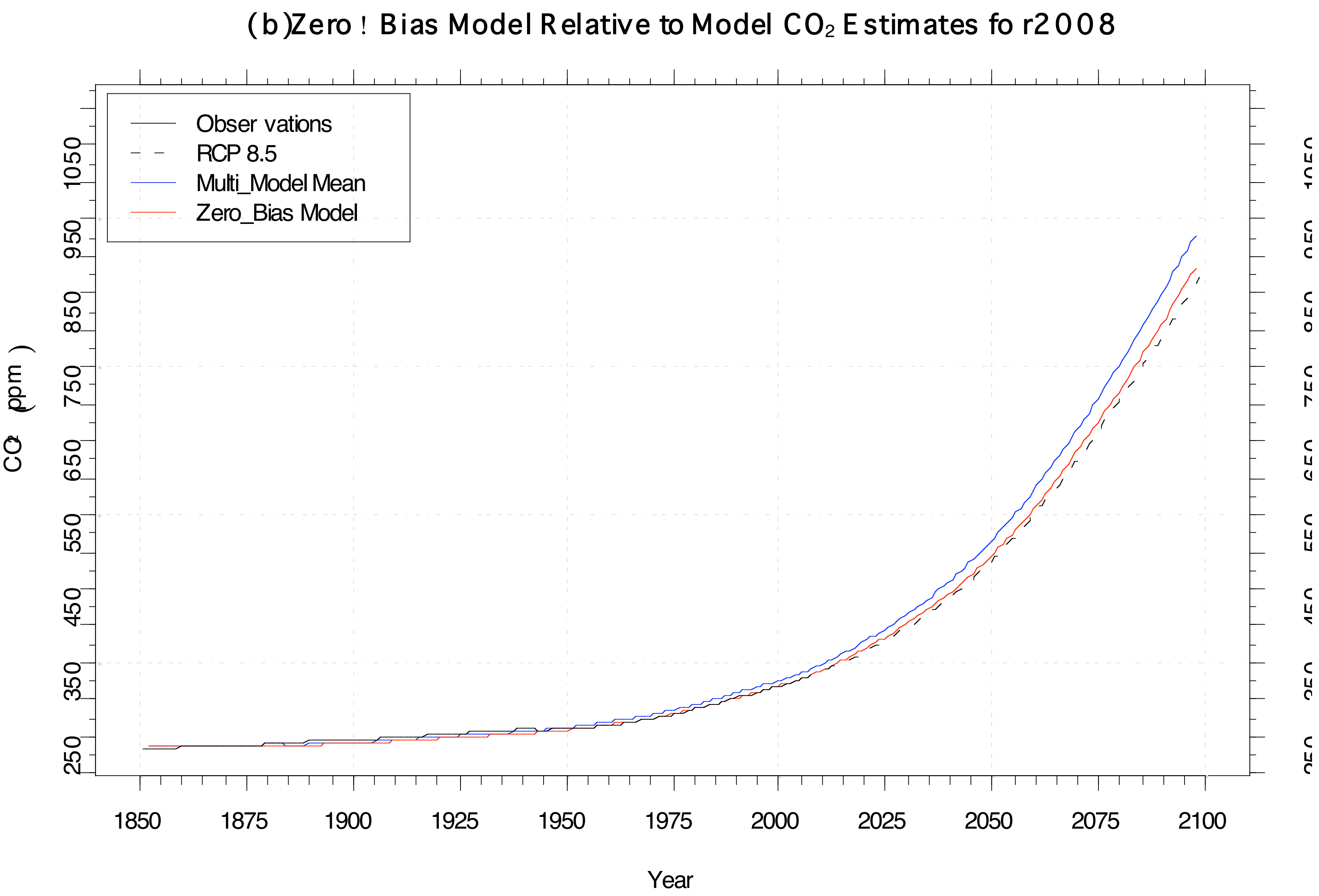
- Ocean uptake is too weak
- In 5 of the 8 models, the land sink over compensates, and is too strong

Hoffman et al.

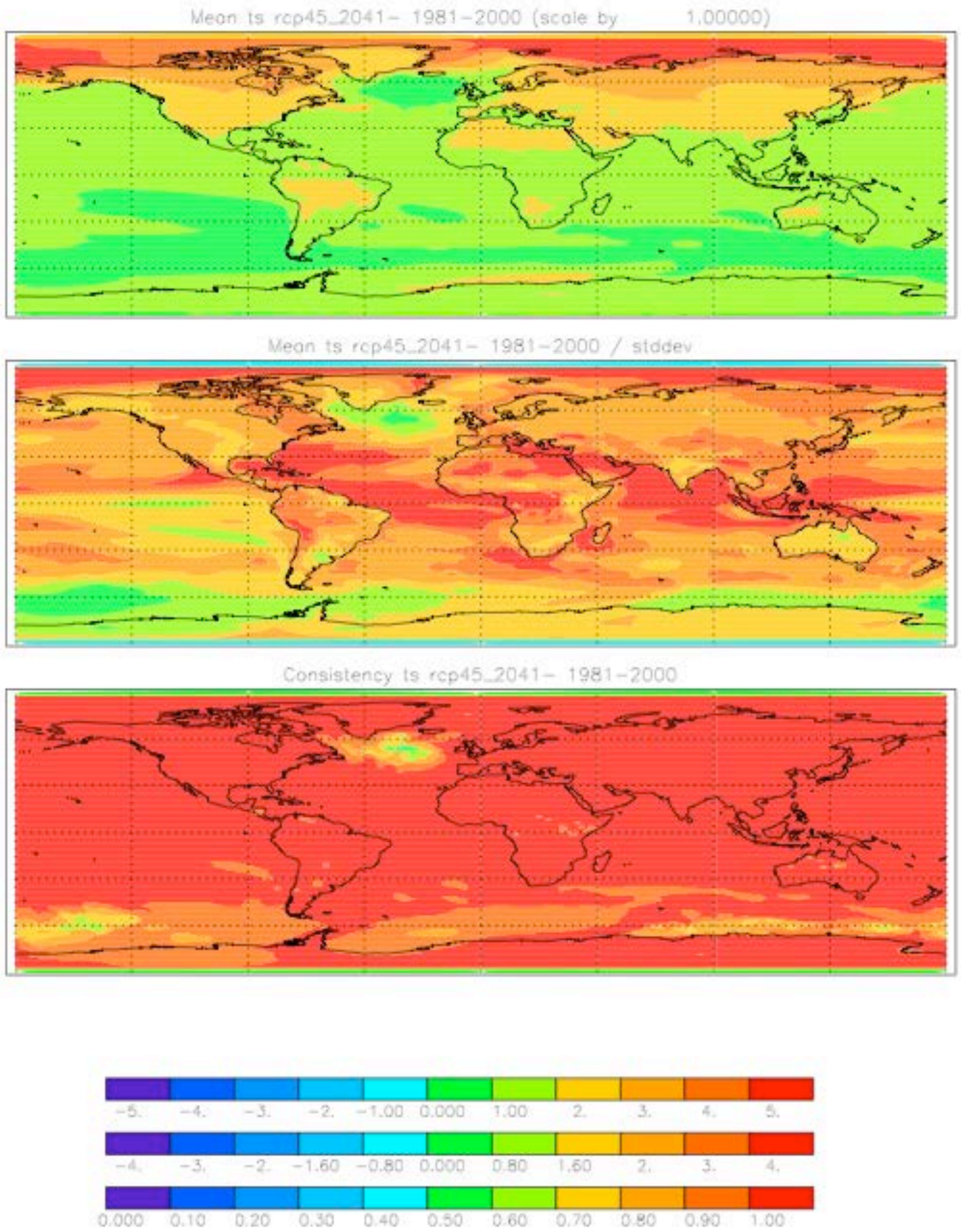
Carbon Cycle Bias Conclusions

- Tuning the carbon cycle to contemporary atm. CO_2 levels would reduce future uncertainty in a given RCP scenario because carbon cycle biases are persistent on decadal timescales
- For the next 50 years or so, structural biases regulating carbon-concentration feedbacks and land use change emissions may be more important error sources than climate-carbon feedbacks
- Carbon – concentration feedbacks are linked with many structural model components that do not change rapidly:
  - Rates of Southern Ocean overturning
  - Sensitivity of photosynthesis to elevated carbon dioxide
  - Allocation of NPP to wood and litter
- More fundamentally, on land, carbon cycle response times limited by:
  - Residence times of litter and soil carbon
  - Lifetime of trees
  - Timescales for recruitment and establishment of species

Hoffman et al.



Hoffman et al., in prep.



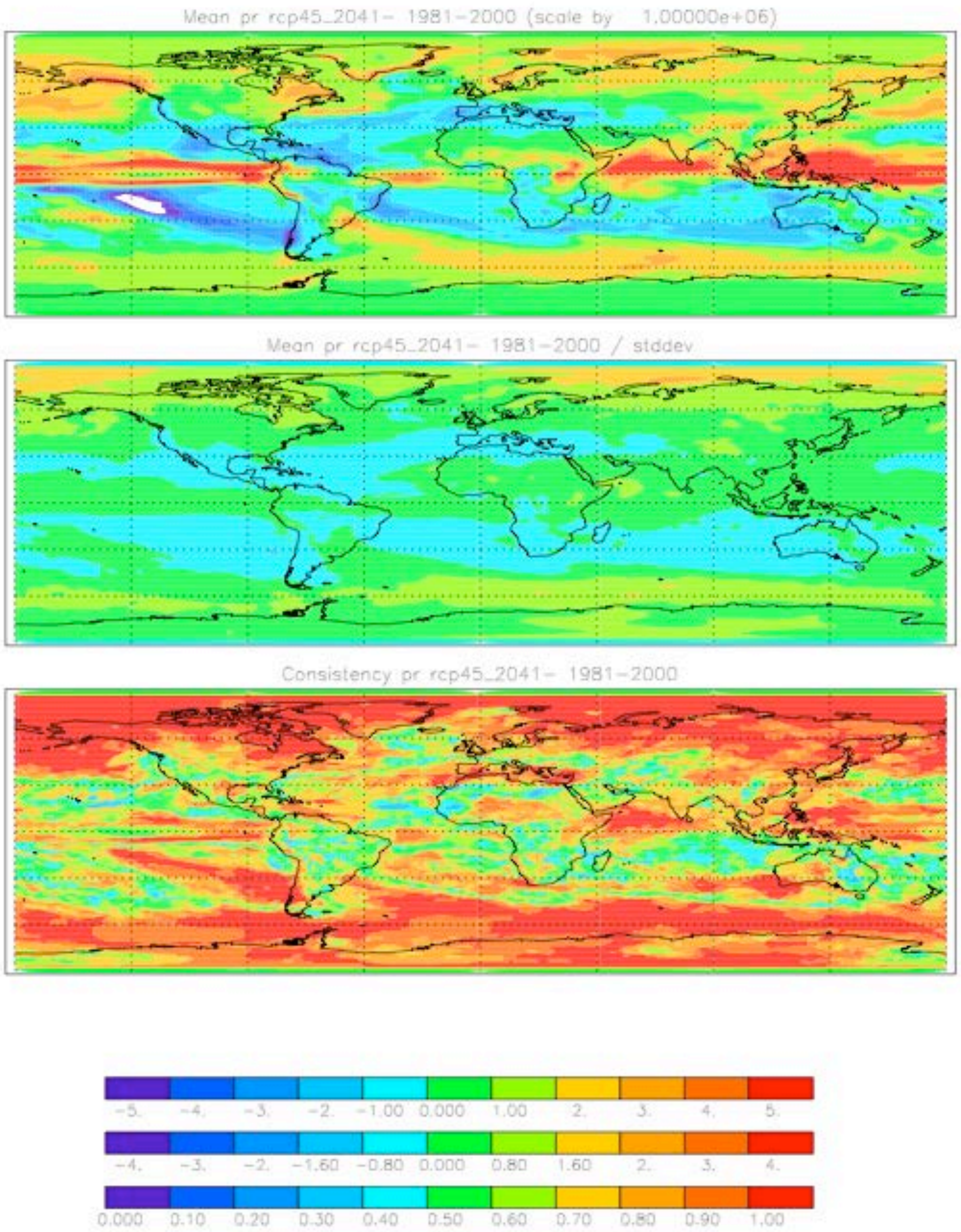
Mean change

Change/Stddev

Model consistency

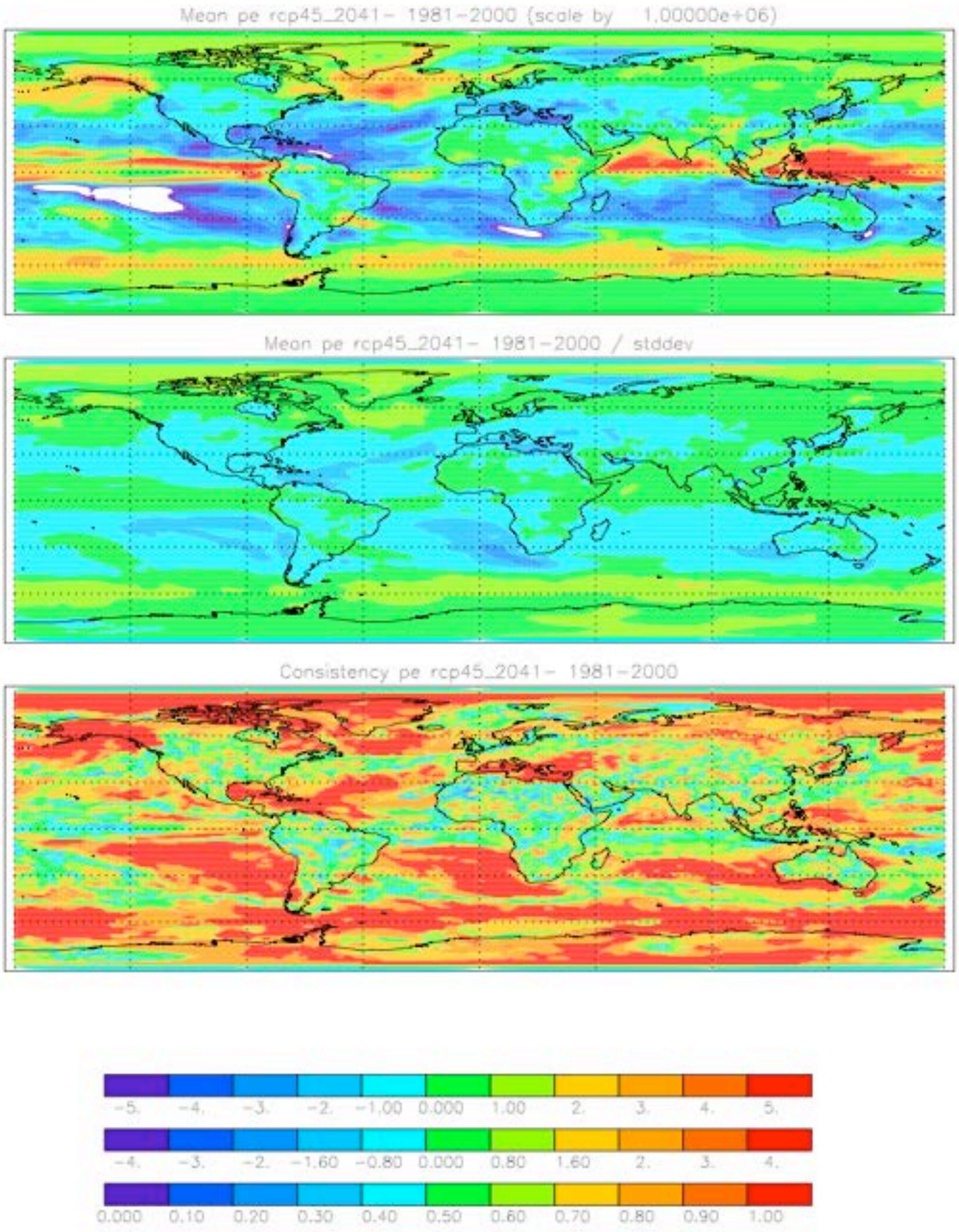
- Temperature a 2050
- RCP4.5: medium-low scenario
- It's warming

Mahowald et al., in prep



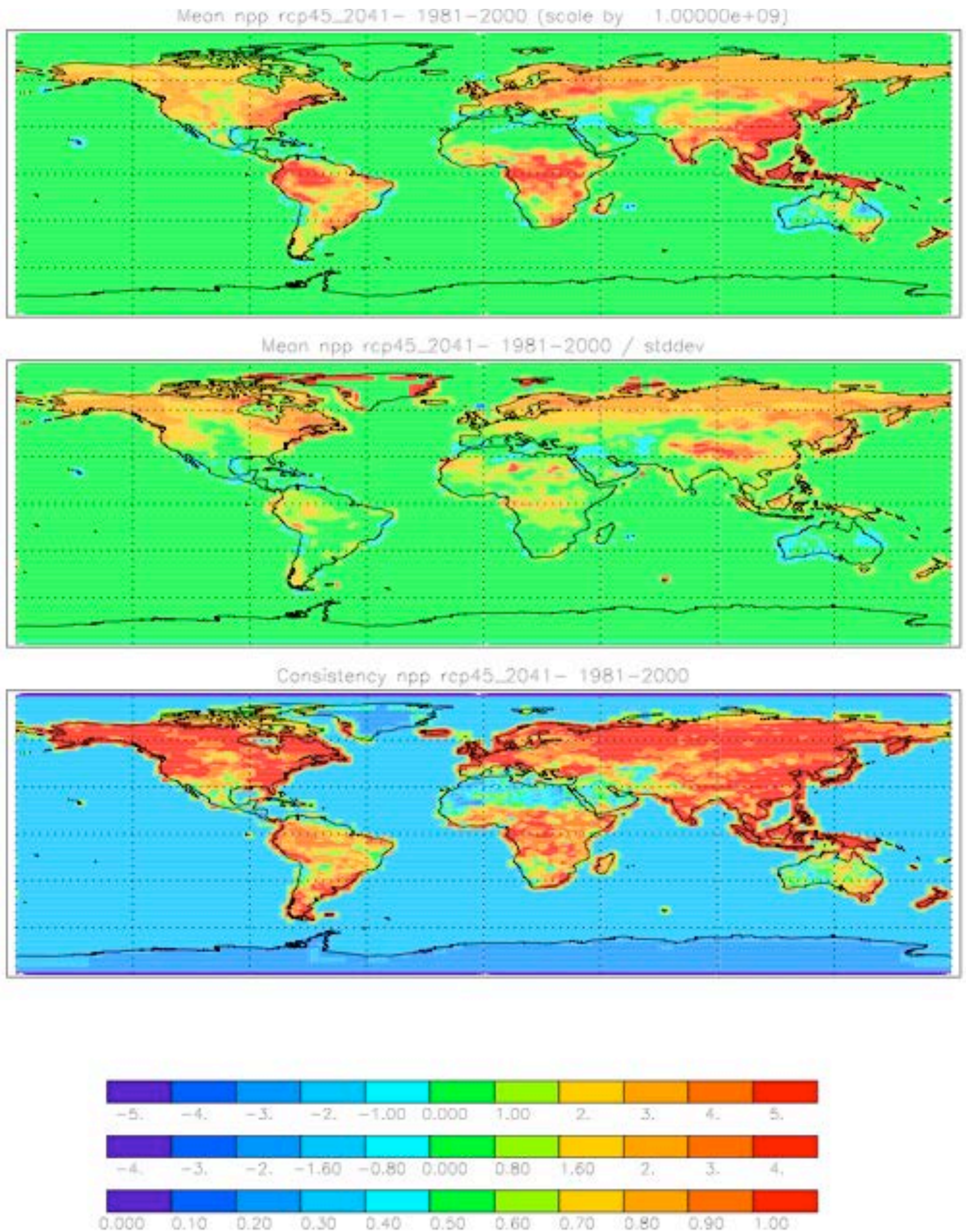
- Some areas get more precip, some less: some coherence over land

Mahowald et al., in prep



- P-E: some areas moisture, some not: not so much coherence over land

Mahowald et al., in prep



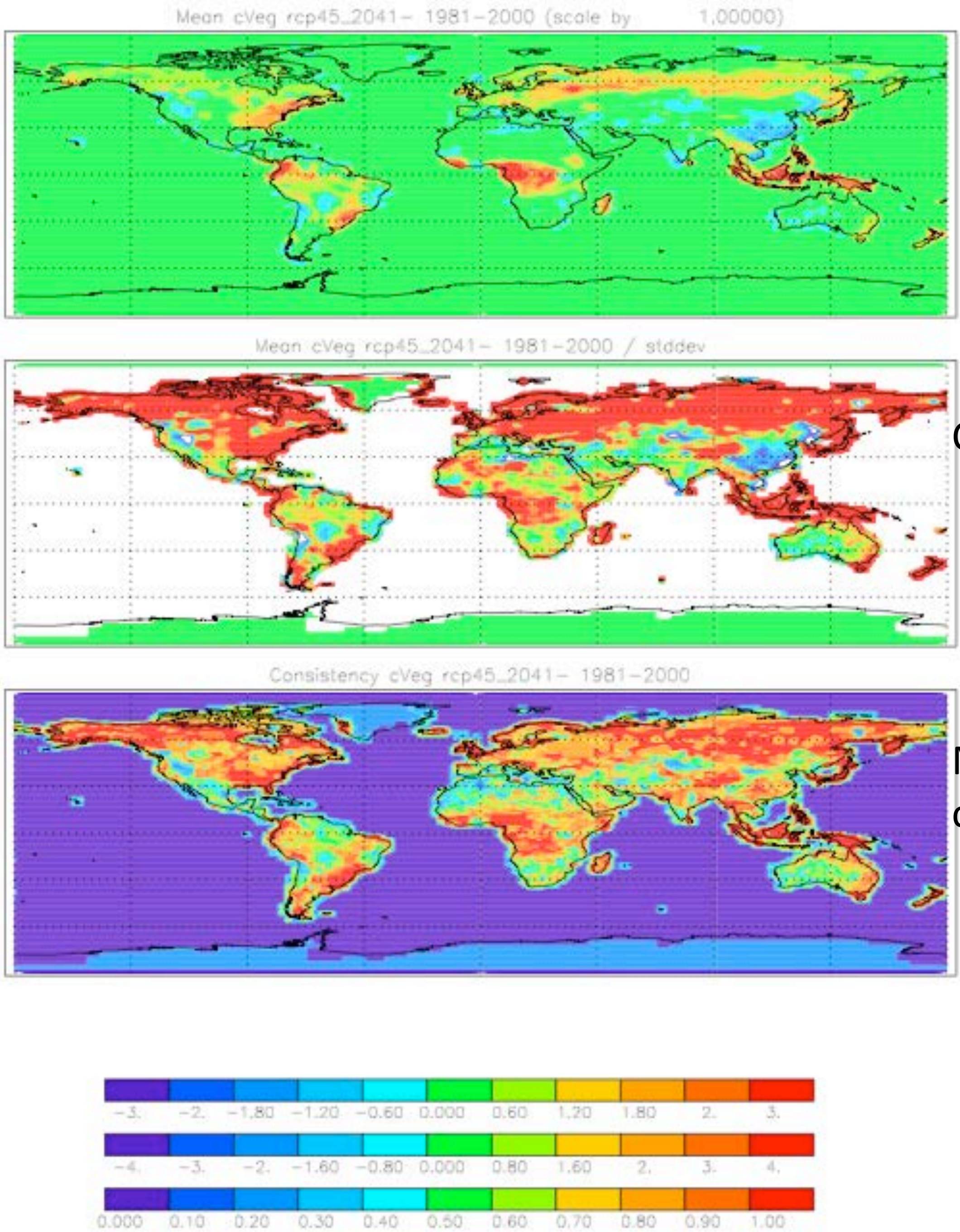
Mean change

Change/Stddev

Model consistency

- Model suggests higher Net primary production (growth), consistently, almost everywhere

Mahowald et al., in prep



Mean change

Change/Stddev

Model consistency

- Above ground vegetation higher, almost everywhere
- Models pretty optimistic! True? Most models have too strong of carbon fertilization, probably
- If not true: more carbon will stay in atmosphere.

Mahowald et al., in prep

Aerosols? Very limited comparison in literature of CMIP5 (only Shindell et al., ACCMIP; BC in ACCMIP)