

Spin-up and Tuning of the Global Carbon Cycle Model Inside the GISS ModelE2 GCM

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Introduction

Planetary carbon cycle involves multiple phenomena, acting at variety of temporal and spacial scales. The typical times range from minutes for leaf stomata physiology to centuries for passive soil carbon pools and deep ocean layers. So, finding a satisfactory equilibrium state becomes a challenging and computationally expensive task. Here we present the spin-up processes for different configurations of the GISS Carbon Cycle model for the model forced with MODIS observed Leaf Area Index (LAI) and prescribed ocean and the model fully coupled to the dynamic ocean and ocean biology. We investigate the time it takes the model to reach the equilibrium and discuss the ways to speed up this process. All simulations were done for preindustrial climate conditions.

NASA Goddard Institute for Space Studies General Circulation Model (GISS ModelE2) is currently equipped with all major algorithms necessary for the simulation of the Global Carbon Cycle. The terrestrial part is presented by Ent Terrestrial Biosphere Model (Ent TBM), which includes leaf biophysics, prognostic phenology and soil biogeochemistry module (based on Carnegie-Ames-Stanford model). The ocean part is based on the NASA Ocean Biogeochemistry Model (NOBM). The transport of atmospheric CO₂ is performed by the atmospheric part of ModelE2, which employs quadratic upstream algorithm for this purpose.

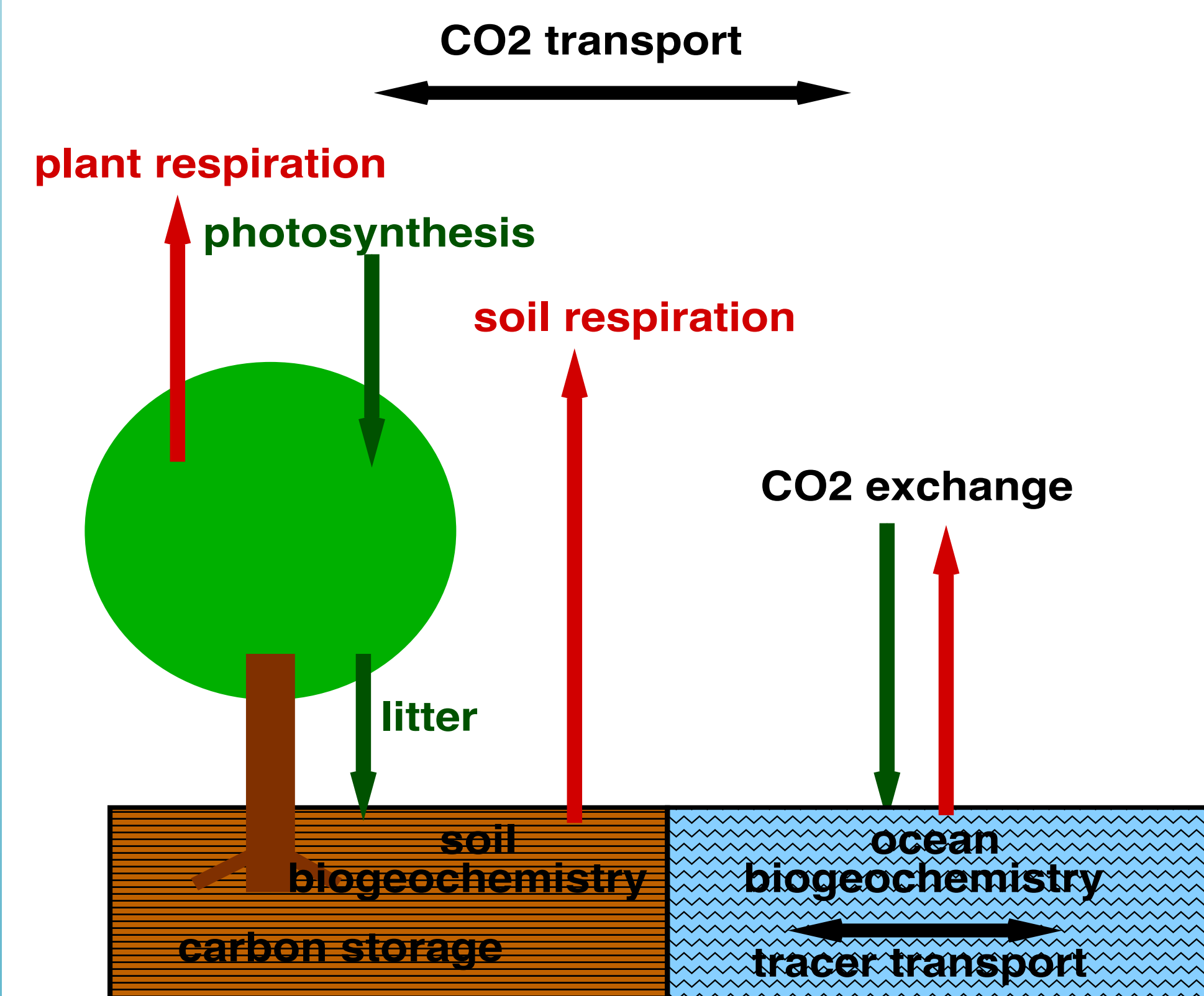
Schmidt, G.A., M. Kelley, L. Nazarenko, R. Ruedy, G.L. Russell, I. Aleinov, M. Bauer, S.E. Bauer, M.K. Bhat, R. Bleck, V. Canuto, Y.-H. Chen, Y. Cheng, T.L. Clune, A. Del Genio, R. de Fainchtein, G. Faluvegi, J.E. Hansen, R.J. Healy, N.Y. Kiang, D. Koch, A.A. Lacis, A.N. LeGrande, J. Lerner, K.K. Lo, E.E. Matthews, S. Menon, R.L. Miller, V. Oinas, A.O. Oloso, J.P. Perlwitz, M.J. Puma, W.M. Putman, D. Rind, A. Romanou, M. Sato, D.T. Shindell, S. Sun, R.A. Syed, N. Tausnev, K. Tsigaridis, N. Unger, A. Voulgarakis, M.-S. Yao, and J. Zhang, 2014: Configuration and assessment of the GISS ModelE2 contributions to the CMIP5 archive. *J. Adv. Model. Earth Syst.*, 6, no. 1, 141-184, doi:10.1002/2013MS000265.

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Acknowledgements

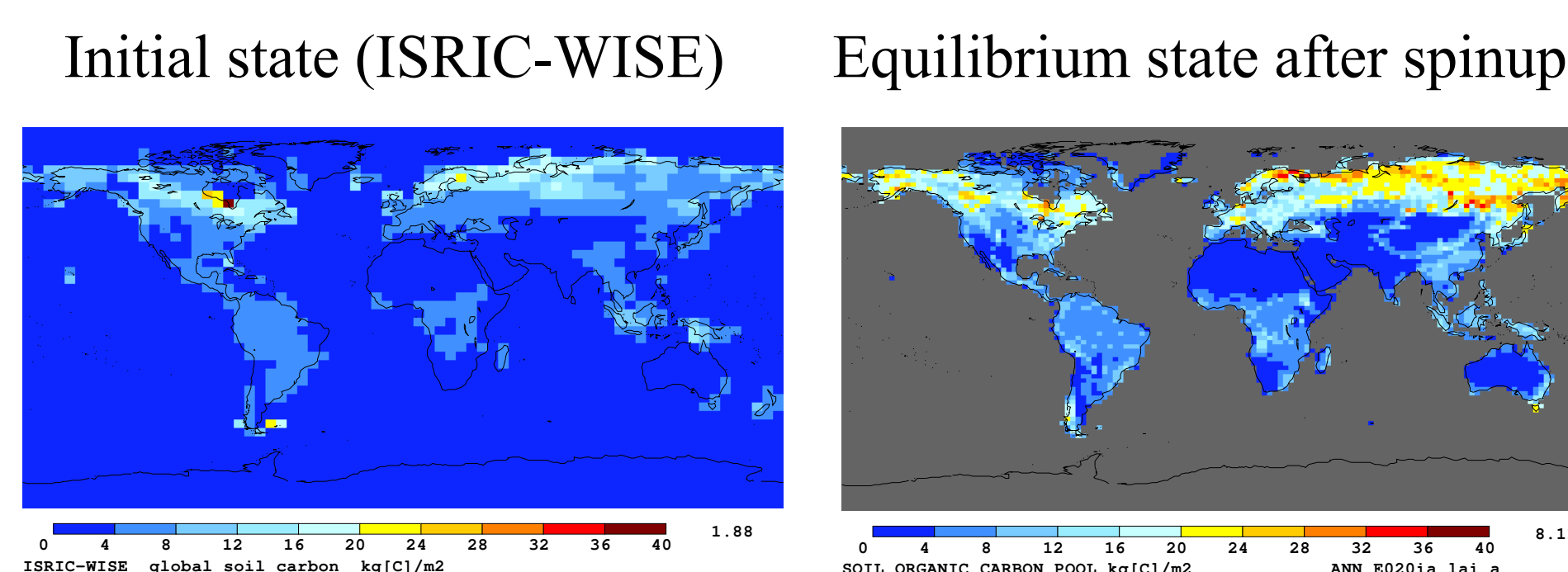
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 Observational data were provided by:
 - ISRIC World Soil Information
 - NASA Orbiting Carbon Observatory-2 (OCO-2)
 - NOAA Cooperative Global Data Integration Project
 (2015) Multi-laboratory compilation of atmospheric carbon dioxide data for the period 1968-2014; obspack_co2_1_GLOBALVIEWplus_v1.0_2015-07-30; NOAA Earth System Research Laboratory, Global Monitoring Division. <http://dx.doi.org/10.15138/G3RP42f>

General layout of the model



For presented simulations we use MODIS vegetation cover data set which was converted to 16 plant functional types, MODIS observed seasonal LAI and MODIS vegetation height.

Soil organic carbon spinup (~300 years)

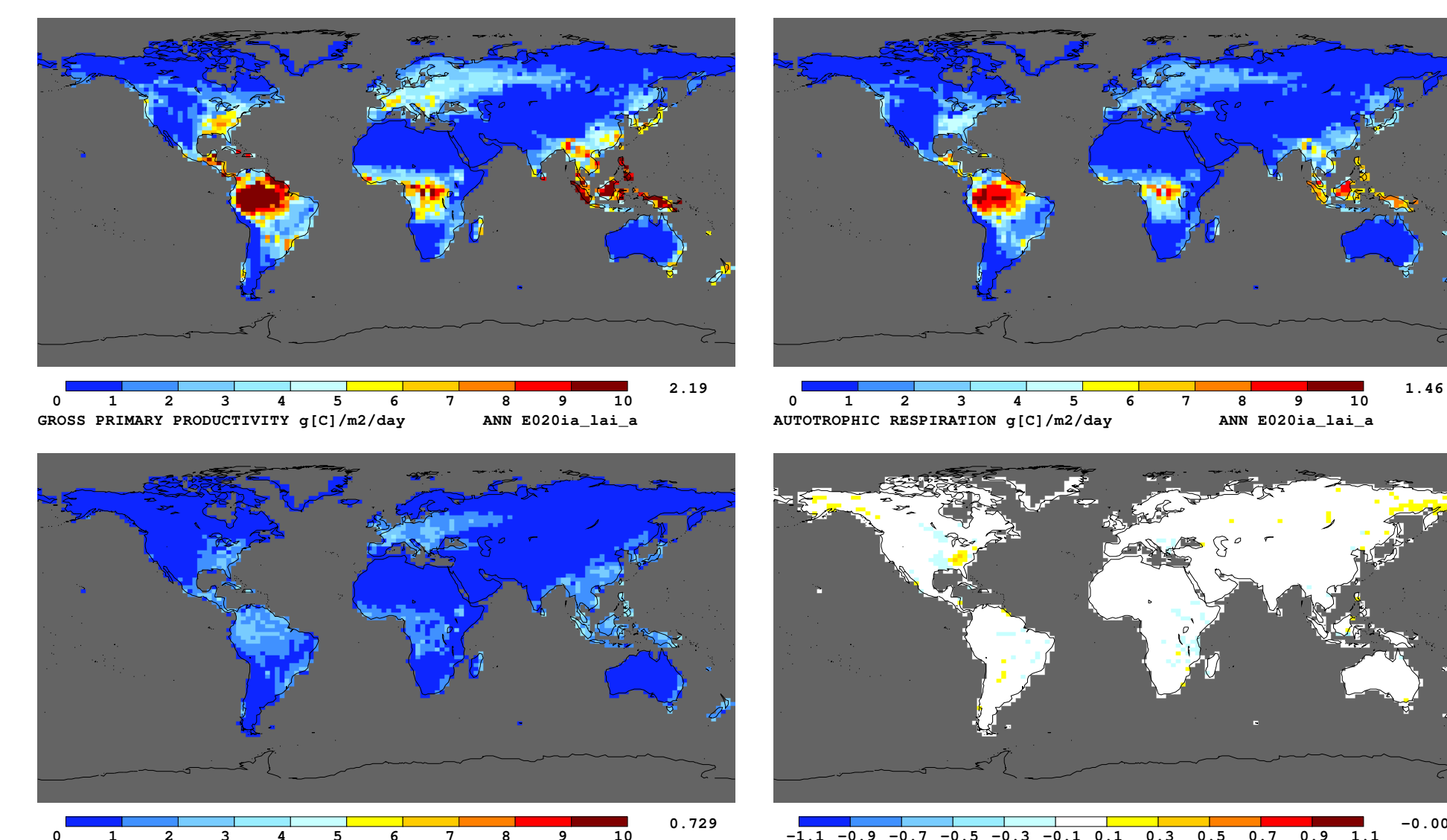


Preliminary results

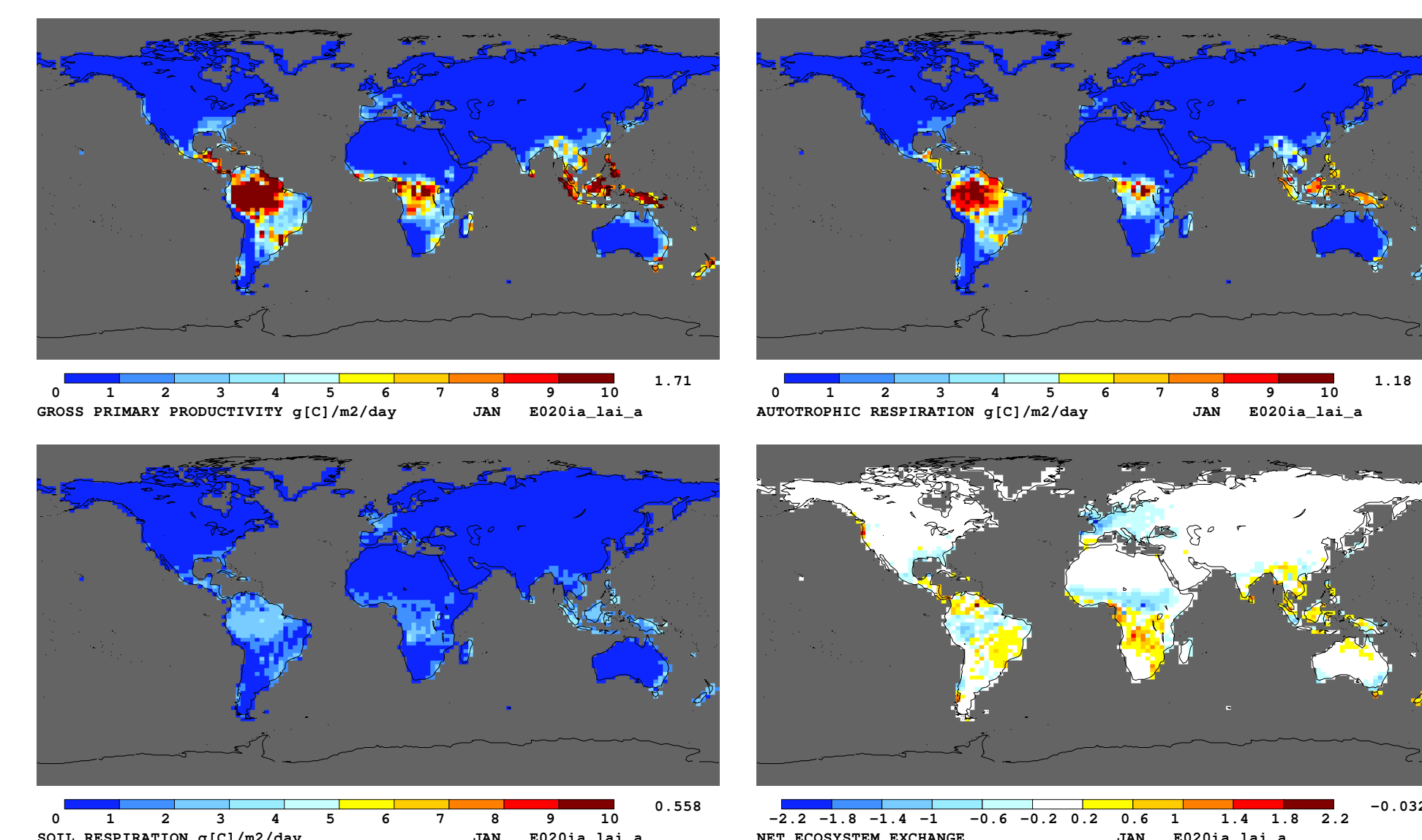
Pre-industrial simulations, prescribed ocean

Land CO₂ fluxes of Gross Primary Productivity (GPP), plant respiration, soil respiration and Net Ecosystem Exchange (NEE)

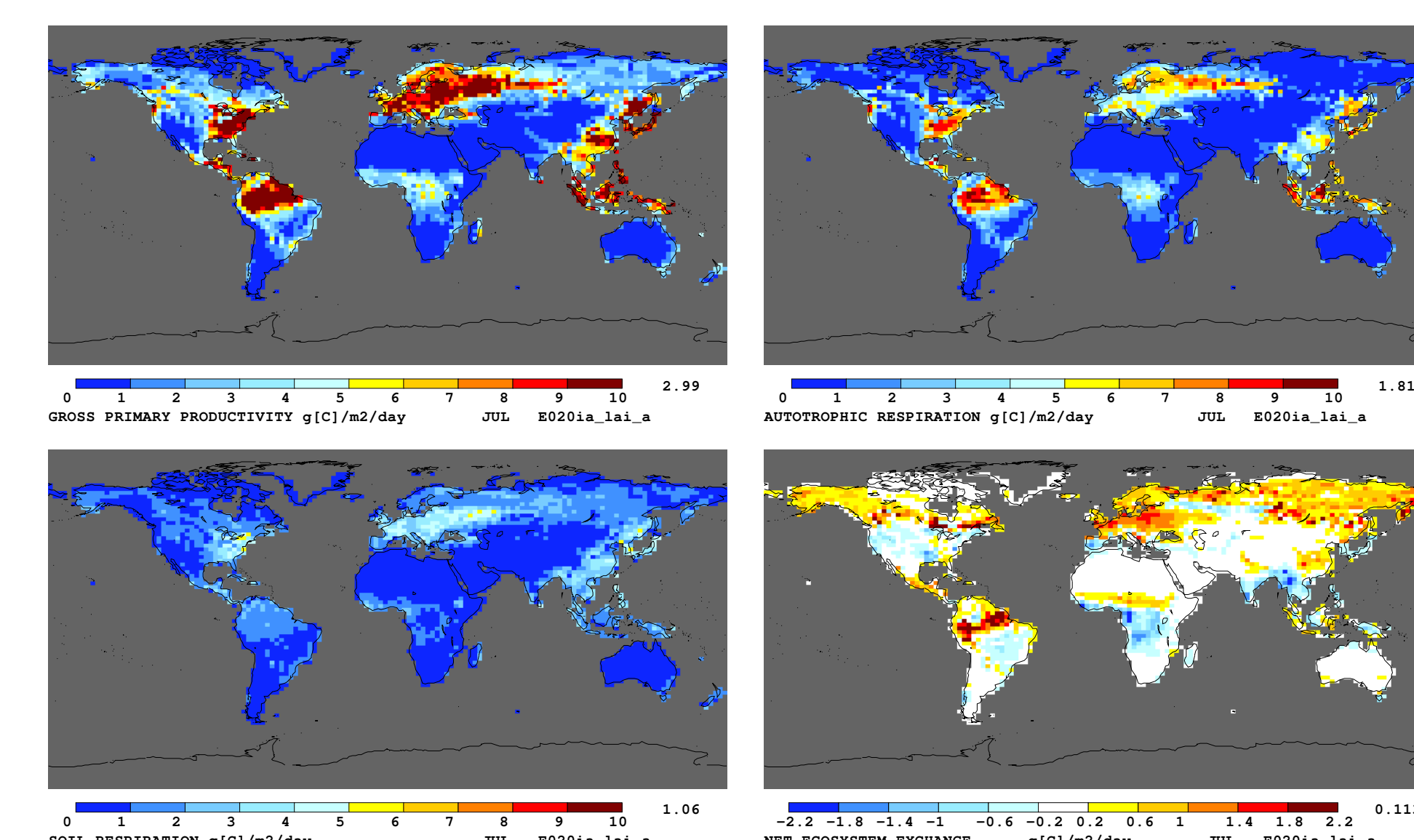
Annual mean, GPP=106.2 Gt C/year



Monthly mean, January



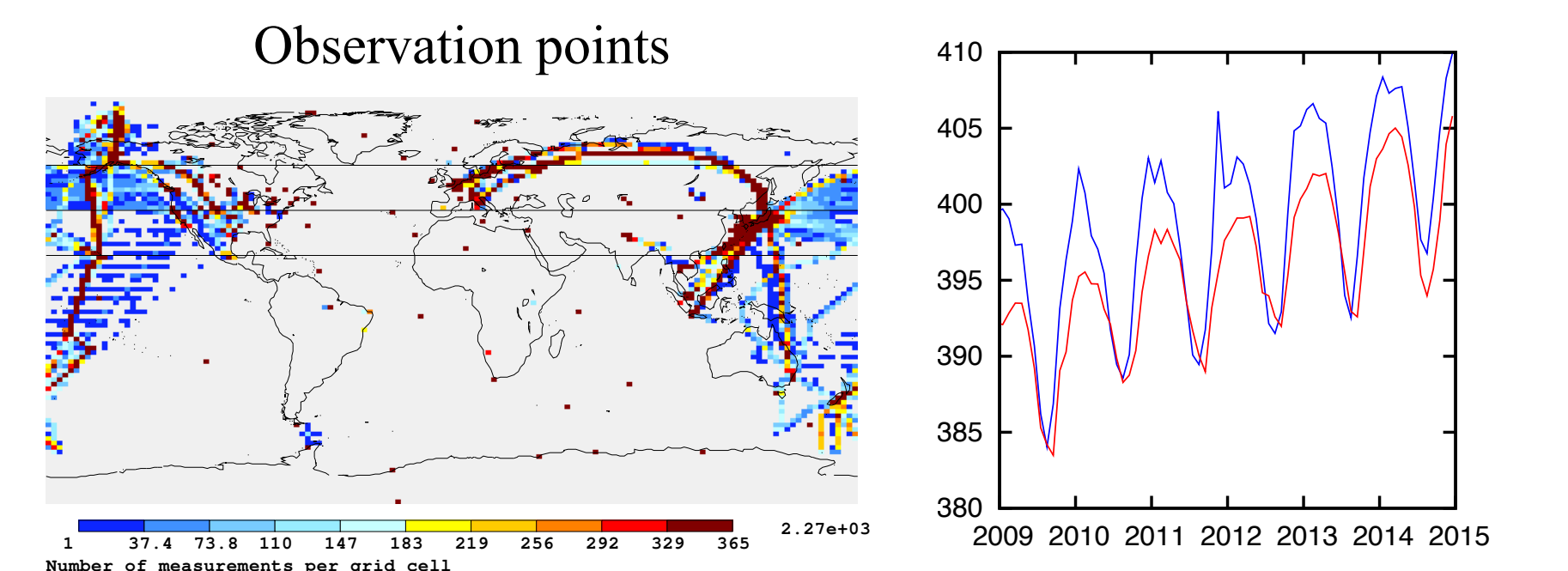
Monthly mean, July



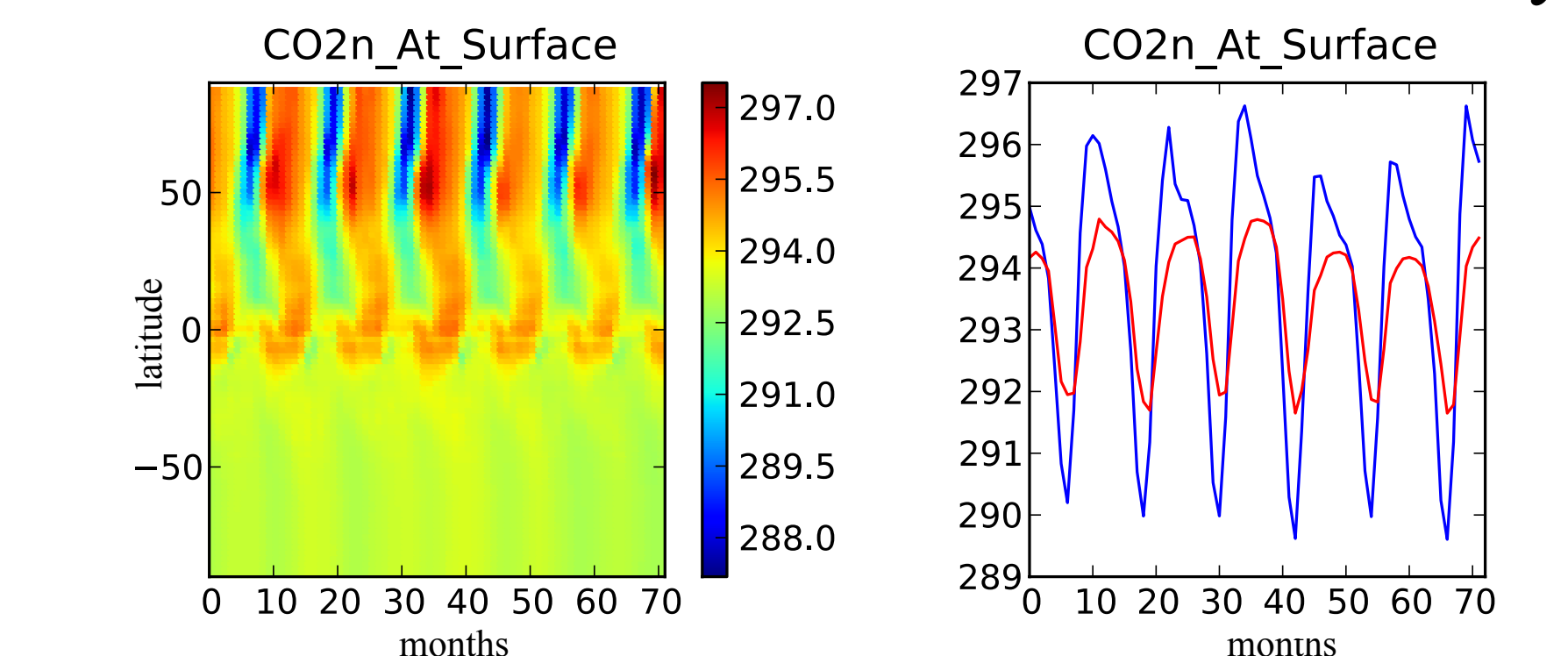
CO₂ concentration at the surface (ppm)

— 40-60N average — 20-40N average.

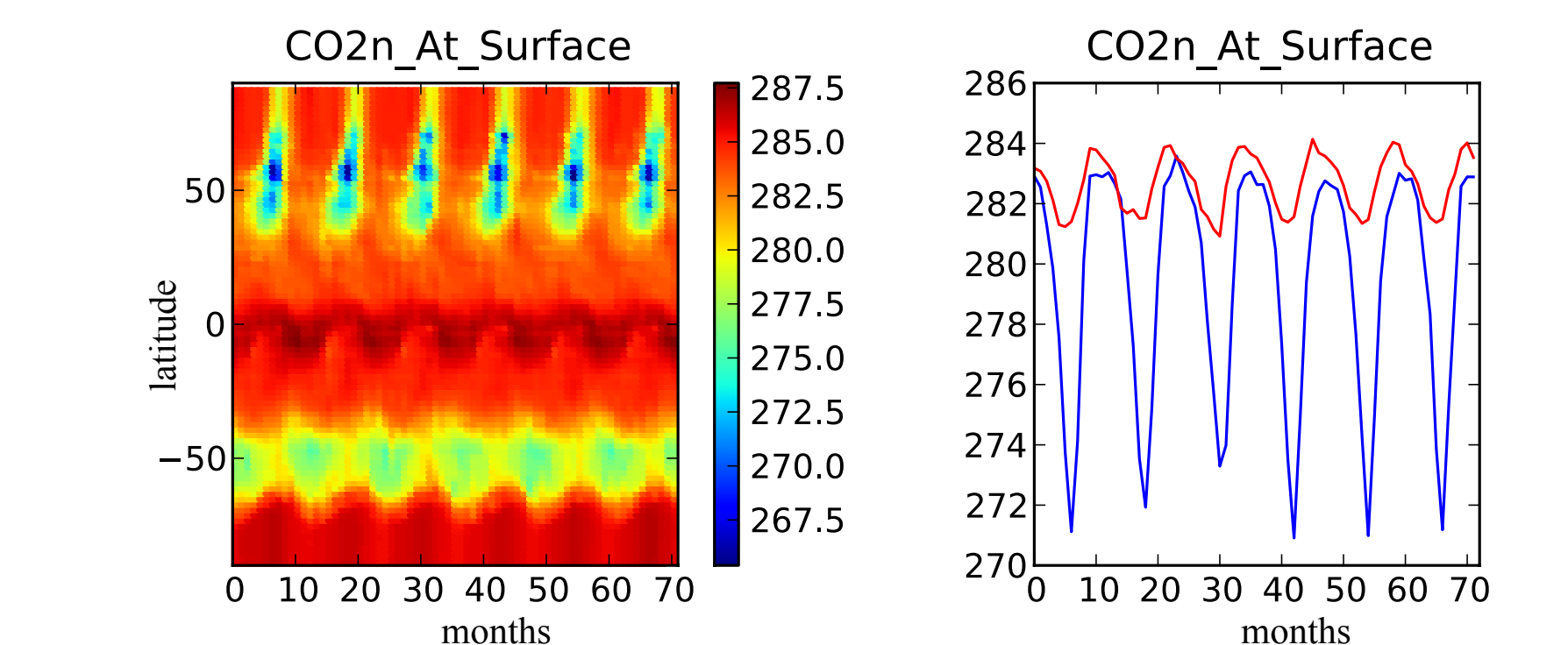
Modern observations (GLOBALVIEWplus)



Preindustrial simulations – land fluxes only

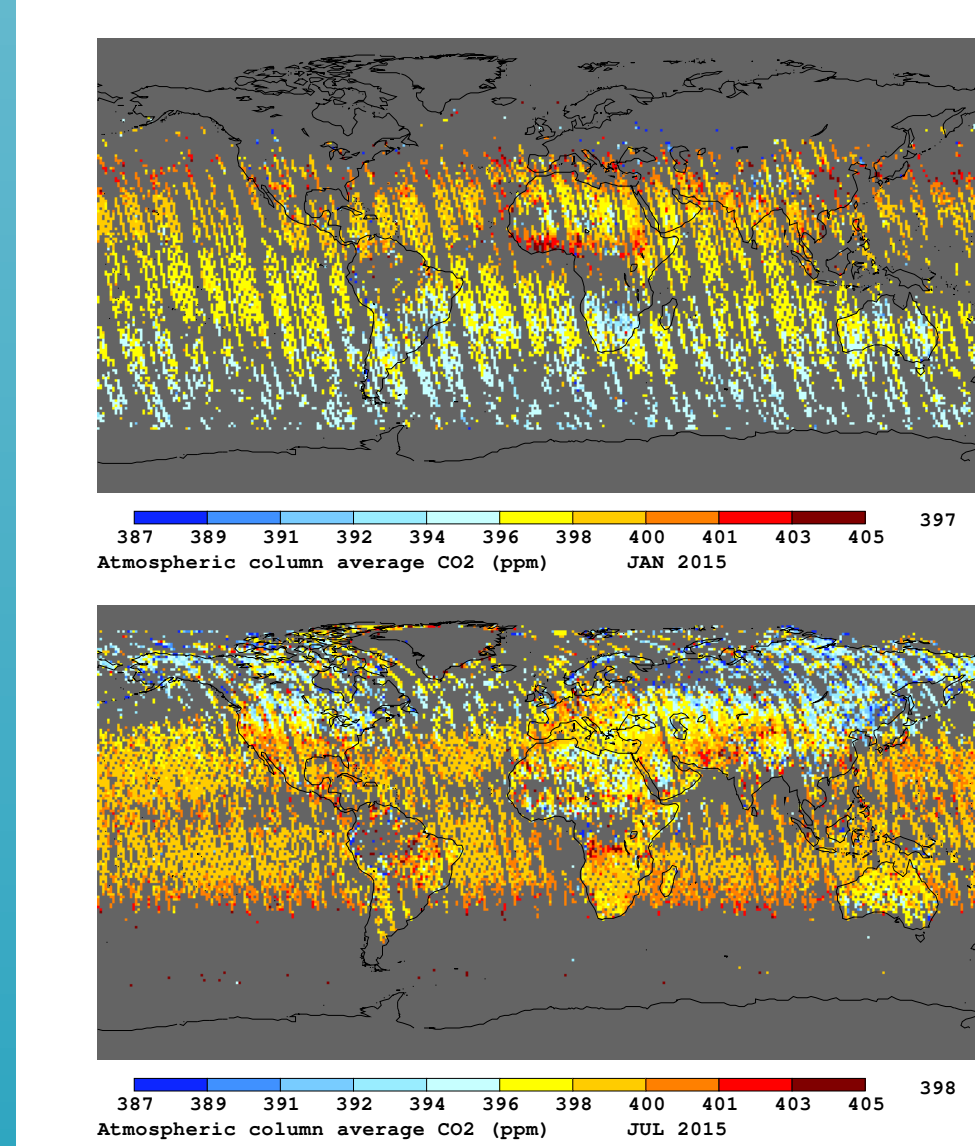


Preindustrial simulations – land+ocean

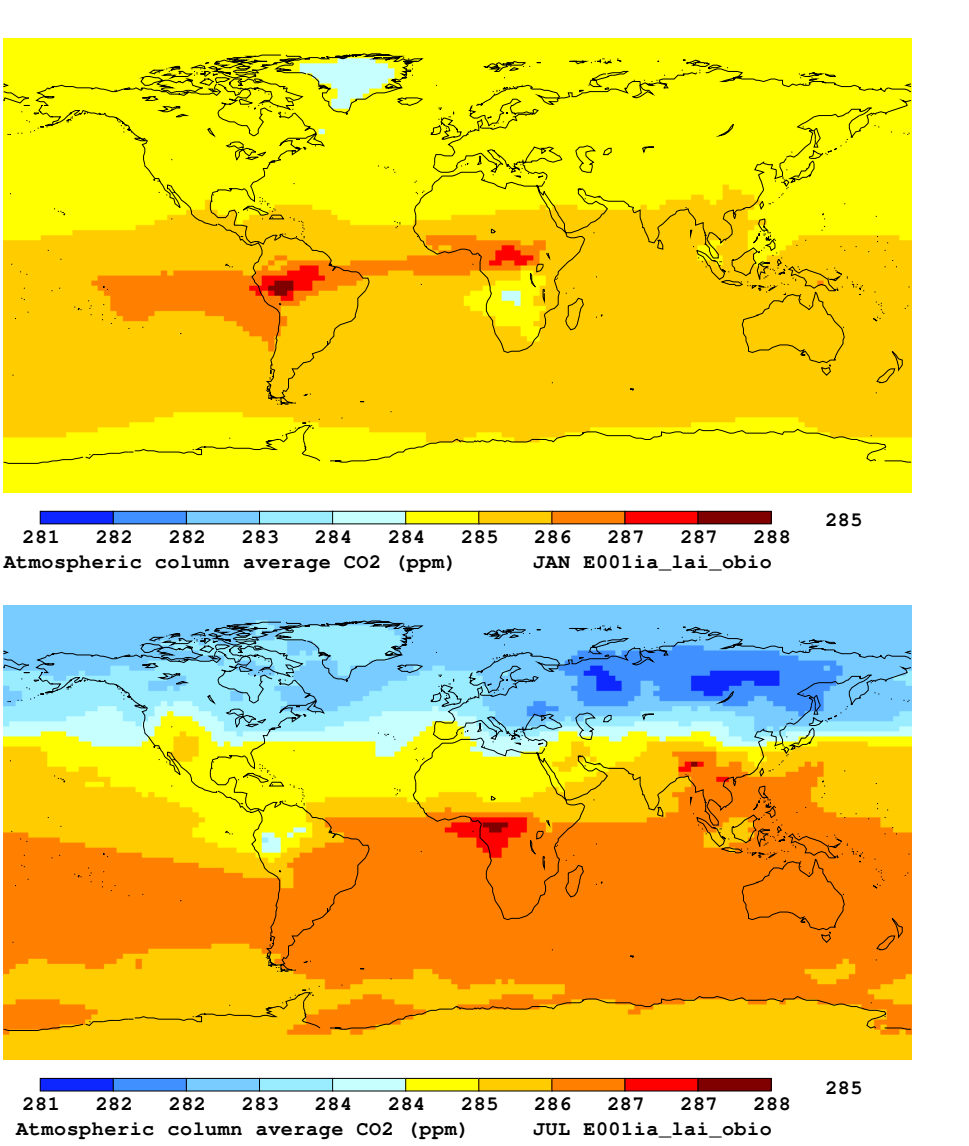


Atmospheric column average CO₂ (ppm)

Modern observations (OCO-2)



Preindustrial simulations



Conclusions and future work

- GISS ModelE2 GCM is capable of producing reasonable carbon cycle for preindustrial conditions
- Typical spinup time for terrestrial ecosystem model is 300 years, ocean biophysics requires longer spinup
- 20th century simulations are needed for validation of the model with observations