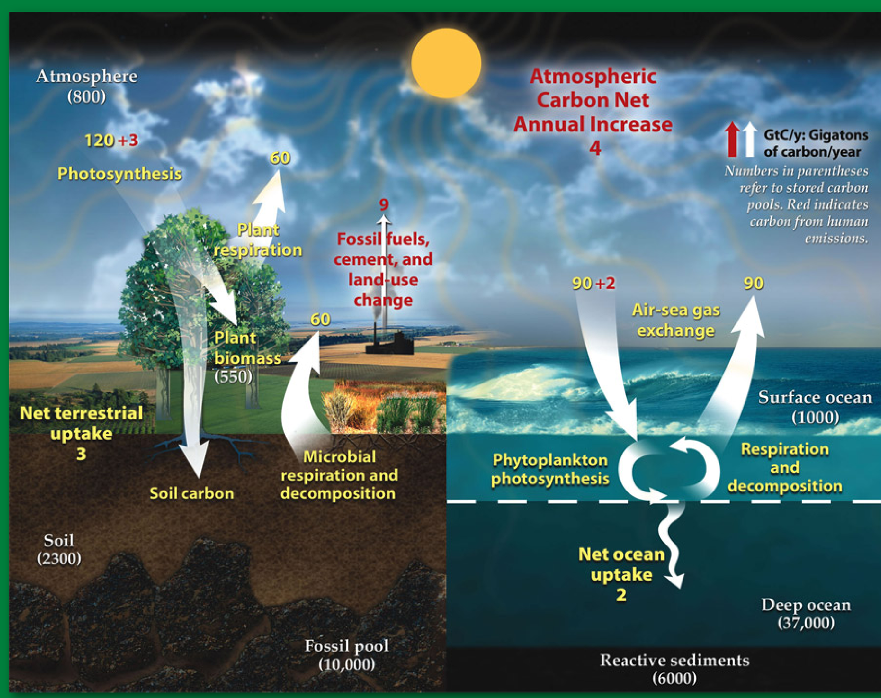

Biogeochemistry–Climate Feedbacks

Forrest M. Hoffman, Jiafu Mao, Xiaojuan Yang, Nathan Collier, Xiaoying Shi, Gangsheng Wang, Min Xu, and Cheng-En Yang

Emergent Constraint Discovered from Climate Change Simulations

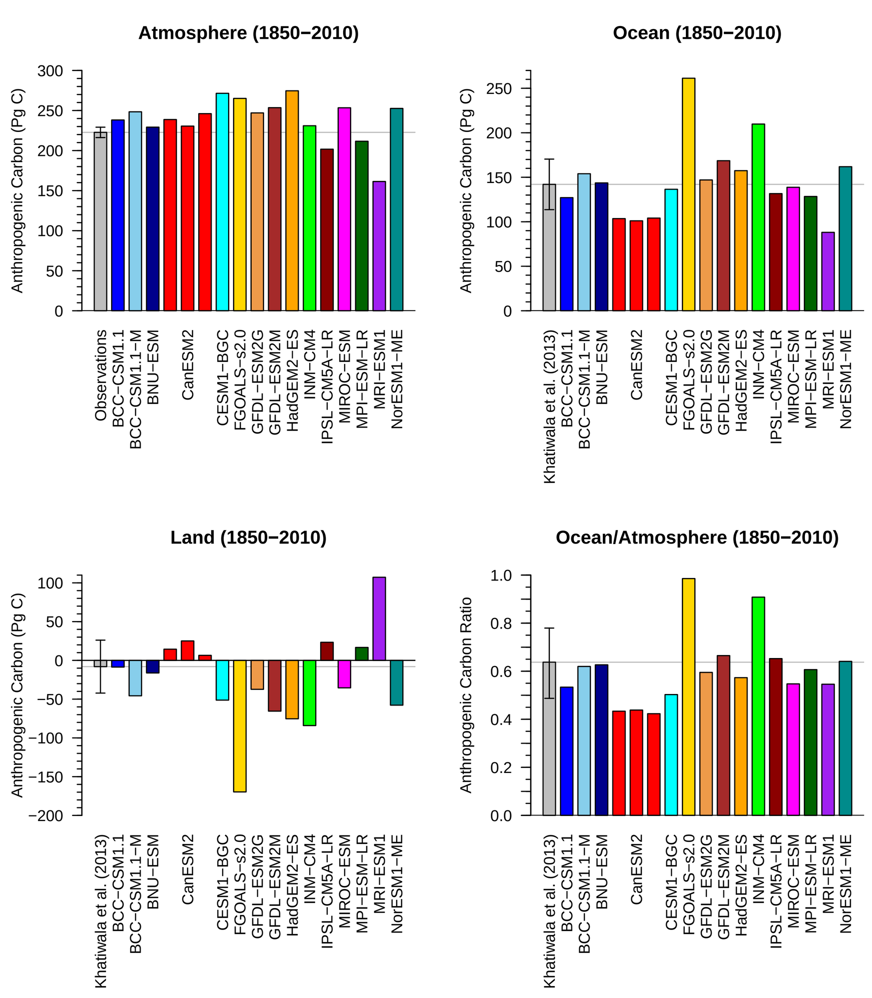

Figure 1: *Reconstructed carbon inventory estimates from observations and CMIP5 Earth system models (ESMs).*

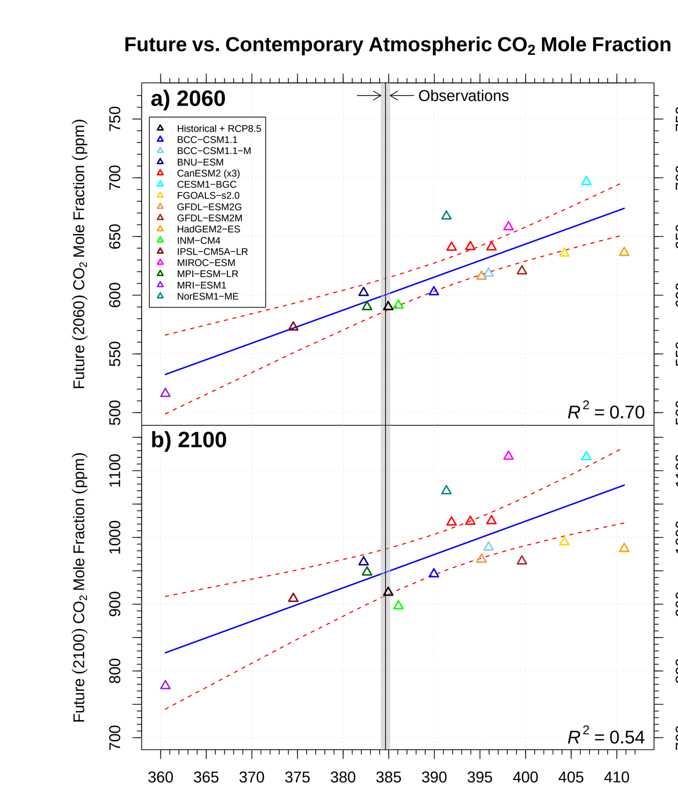

Figure 2: *We applied contemporary observations to constrain future projections of atmospheric CO_2 from ESMs.*

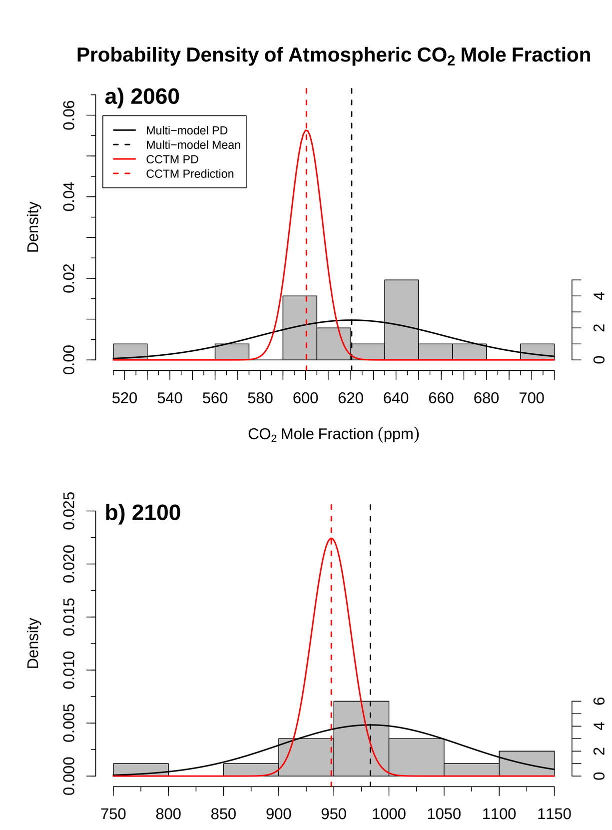

Figure 3: *By correcting contemporary bias, we reduced projections of future atmospheric CO_2 and uncertainties.*

Best estimate using Mauna Loa CO_2

At 2060: 600 ± 14 ppm, 21 ppm below multi-model mean

At 2100: 947 ± 35 ppm, 32 ppm below multi-model mean

Hoffman, F. M., J. T. Randerson, V. K. Arora, Q. Bao, P. Cadule, D. Ji, C. D. Jones, M. Kawamiya, S. Khatiwala, K. Lindsay, A. Obata, E. Shevliakova, K. D. Six, J. F. Tjiputra, E. M. Volodin, and T. Wu (2014), Causes and implications of persistent atmospheric carbon dioxide biases in Earth system models, *J. Geophys. Res. Biogeosci.*, 119(2):141–162, doi:10.1002/2013JG002381.

Disentangling Controls on Global Terrestrial ET Trends

Combining 11 long-term *in situ* and satellite observational data sets, we examined natural and anthropogenic controls on **terrestrial evapotranspiration (ET)** changes from 1982 to 2010 in single- and multi-factor simulations from the Multi-Scale Synthesis and Terrestrial Model Intercomparison Project (MsTMIP).

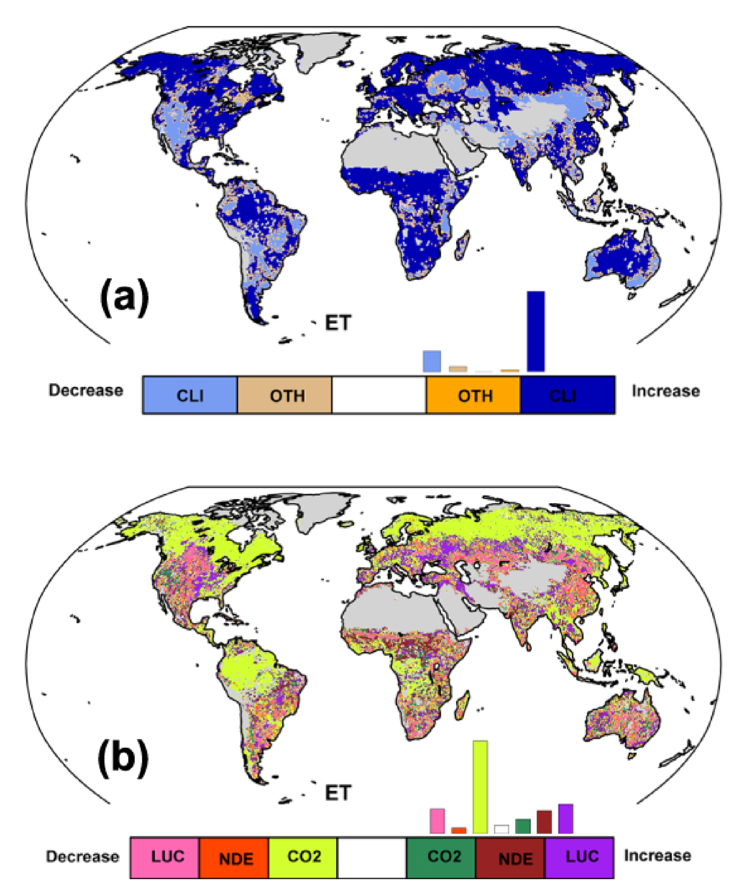

Figure 4: *Spatial distribution of dominant drivers for ET. (a) Changing climate was the dominant control on spatiotemporal variations in ET. (b) Rising atmospheric CO_2 levels drove the human-induced decreasing trend in ET.*

Mao, J., W. Fu, X. Shi, D. M. Ricciuto, J. B. Fisher, R. E. Dickinson, Y. Wei, W. Shem, S. Piao, K. Wang, C. R. Schwalm, H. Tian, M. Mu, et al. (2015), Disentangling climatic and anthropogenic controls on global terrestrial evapotranspiration trends, *Environ. Res. Lett.*, 10(9):094008, doi:10.1088/1748-9326/10/9/094008.

Climate–Carbon Feedbacks Intensify Over Time?

We used CESM1(BGC) to assess long term carbon cycle dynamics to understand how land and ocean contributions to **climate–carbon feedbacks** evolve over time from 1850 to 2300.

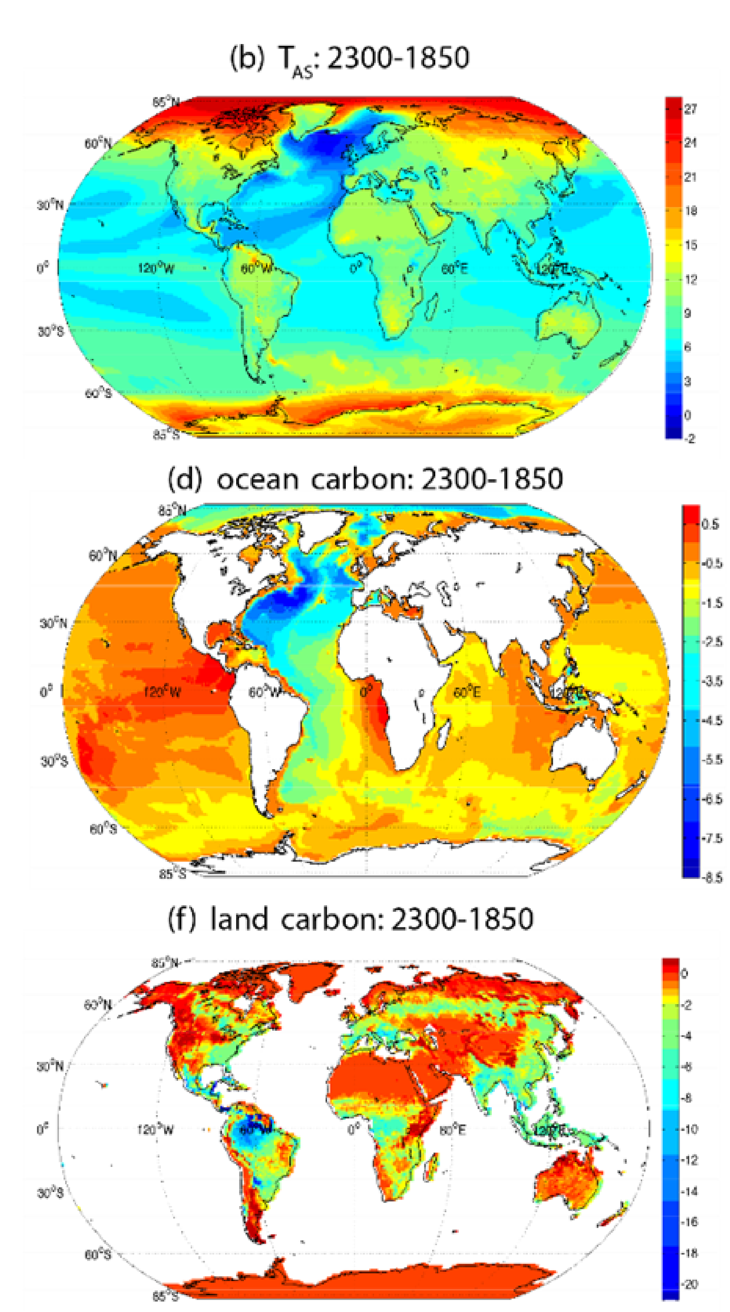

Figure 5: *Changes in surface air temperature and ocean and land carbon at year 2300 from RCP 8.5 and ECP 8.5.*

Randerson, J. T., K. Lindsay, E. Muñoz, W. Fu, J. K. Moore, F. M. Hoffman, N. M. Mahowald, and S. C. Doney (2015), Multicentury changes in ocean and land contributions to the climate–carbon feedback, *Global Biogeochem. Cycles*, 29(6):744–759, doi:10.1002/2014GB005079.

International Land Model Benchmarking (ILAMB) Project

The **BGC Feedbacks SFA** project is developing an Open Source benchmarking software package for use by the international Earth system modeling community.

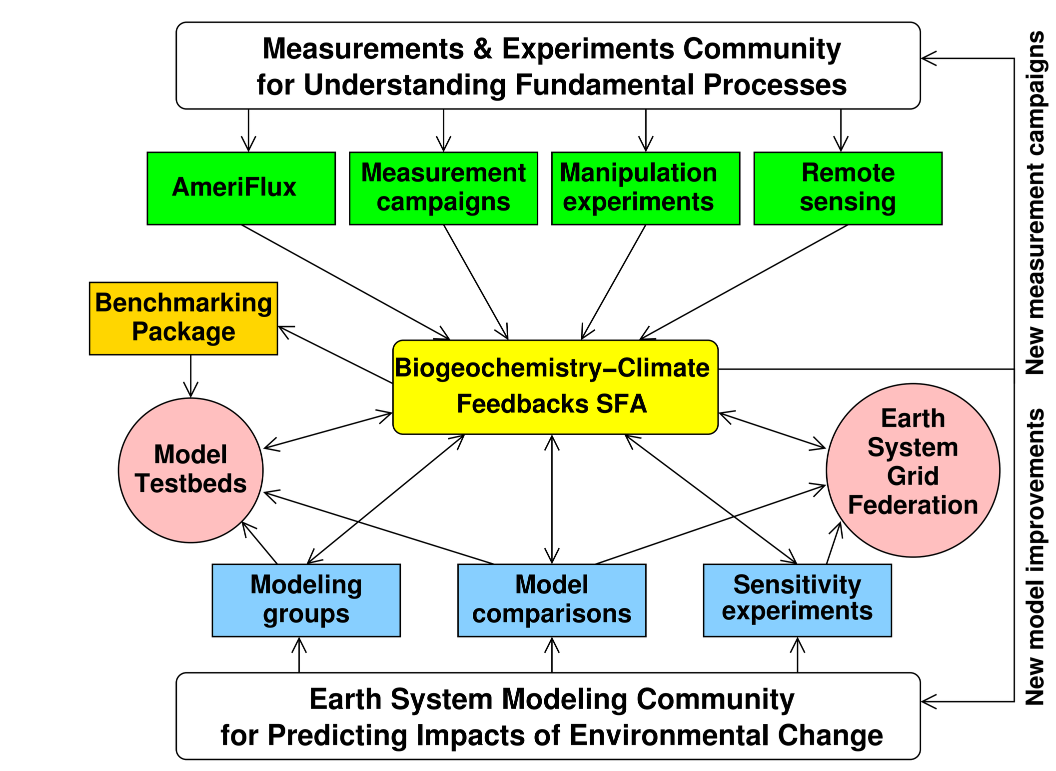

Figure 6: *The BGC Feedbacks SFA integrates the modeling and measurement communities.*

The package is being contributed to **ILAMB**, a model–data intercomparison activity designed to reduce uncertainties associated with key land surface process representations and inform the design of new measurement campaigns.

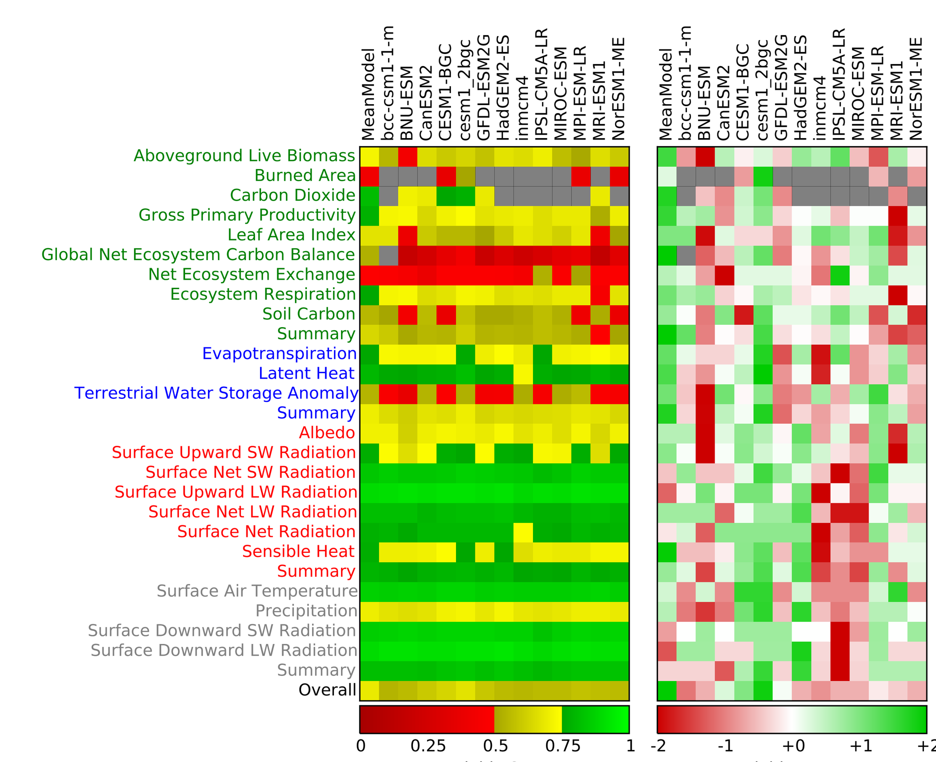

Figure 7: *Model performance is scored based on comparisons with observational data.*

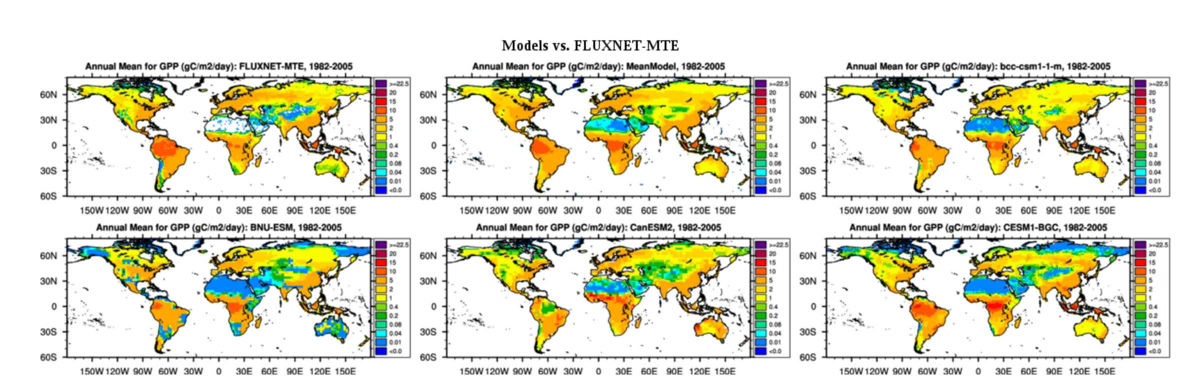

Figure 8: *Simulated global annual mean vegetation productivity is compared with an observational estimate.*

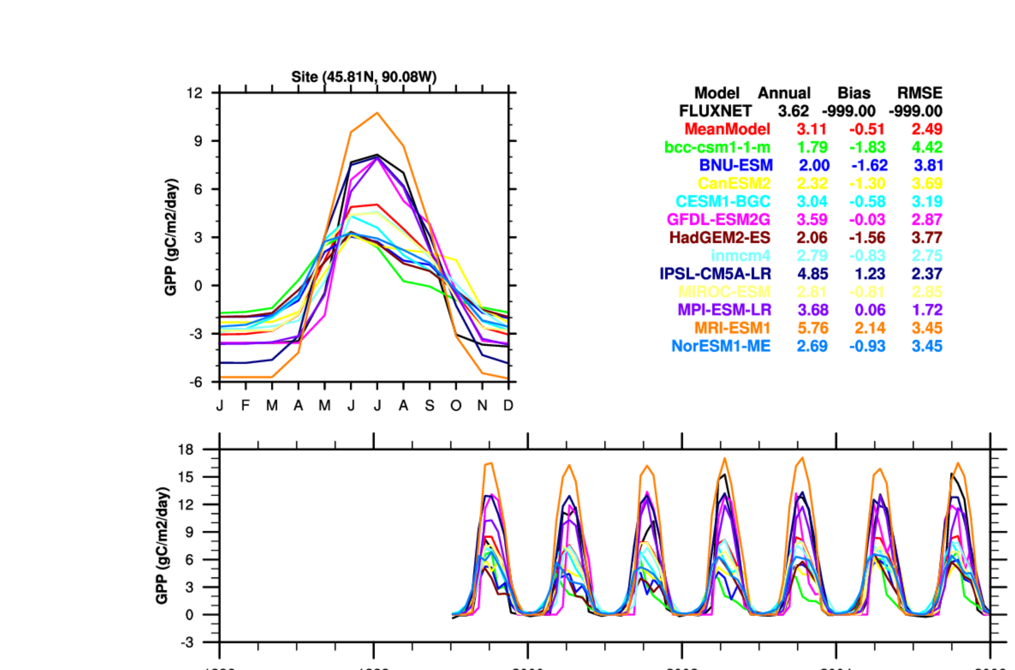

Figure 9: *Regional comparisons show differences in seasonal timing of maximum productivity.*

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