Carbon and Ecosystems Data Assimilation for the ISS Instrument Suite

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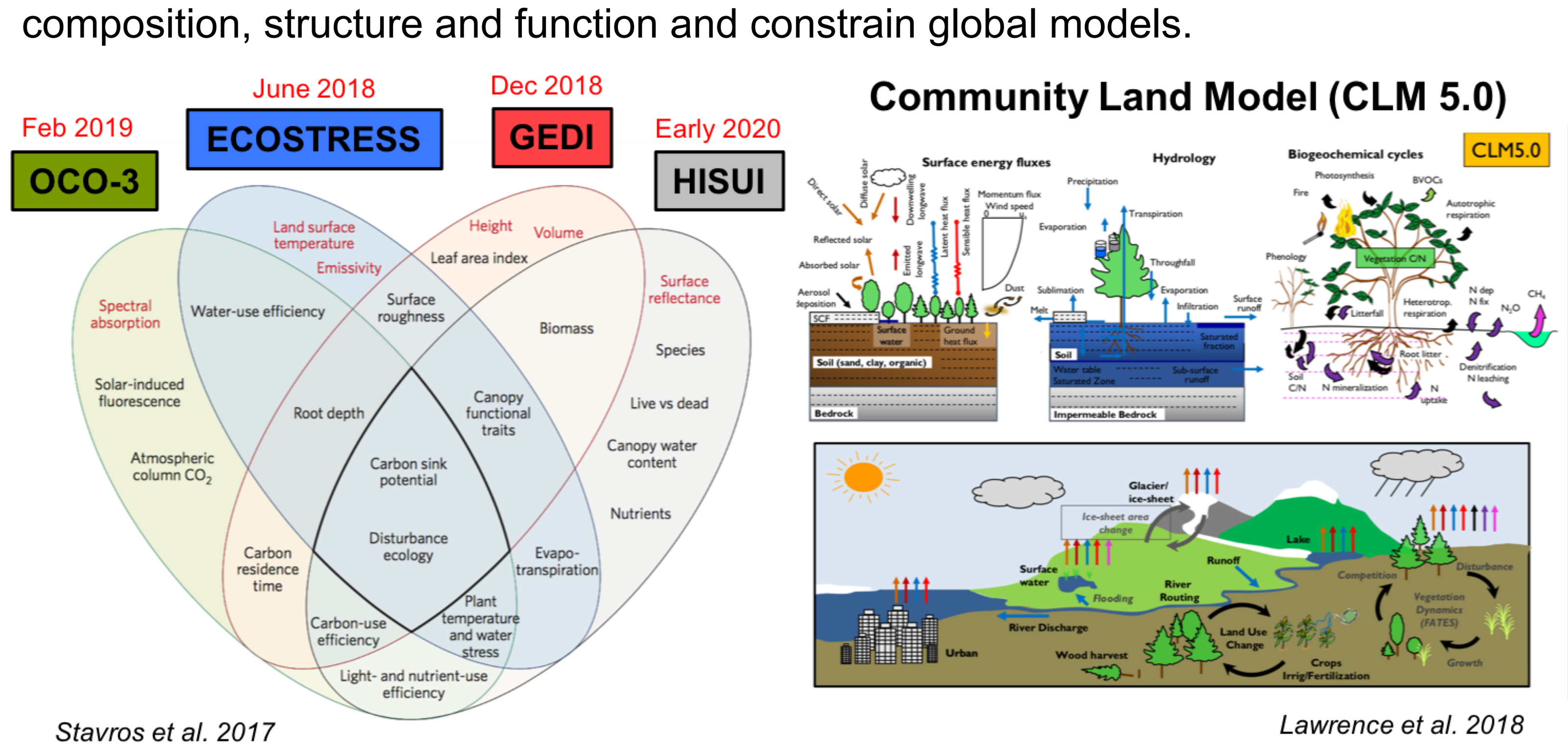
Objective

Objective: Our overall objective is to develop an integrated modeling capability to assimilate observations from JPL's ECOSTRESS and Orbiting Carbon Observatory – 3 (OCO-3) data, UMD's Global Ecosystem Dynamics Investigation Lidar (GEDI) data and the Japanese Hyperspectral Imager Suite (HISUI) data using the Community Earth System Model (CESM) and the Data Assimilation Research Testbed (DART). Specifically, we will investigate how data from these sensors can be used to inform the modeled energy, water and carbon cycles in a land surface model, the Community Land Model (CLM), which can be fully coupled to an atmospheric model and assess how this information can reduce uncertainties in predictions about future climate change. This system is capable of producing a reanalysis of the land surface with well-characterized uncertainties, with an emphasis on a tight integration between carbon stocks and fluxes. It builds upon existing development efforts and has been tested to ingest observations from this suite of sensors, which when they become available will be provide a unique combination of information about critical, linked components of the Earth System.

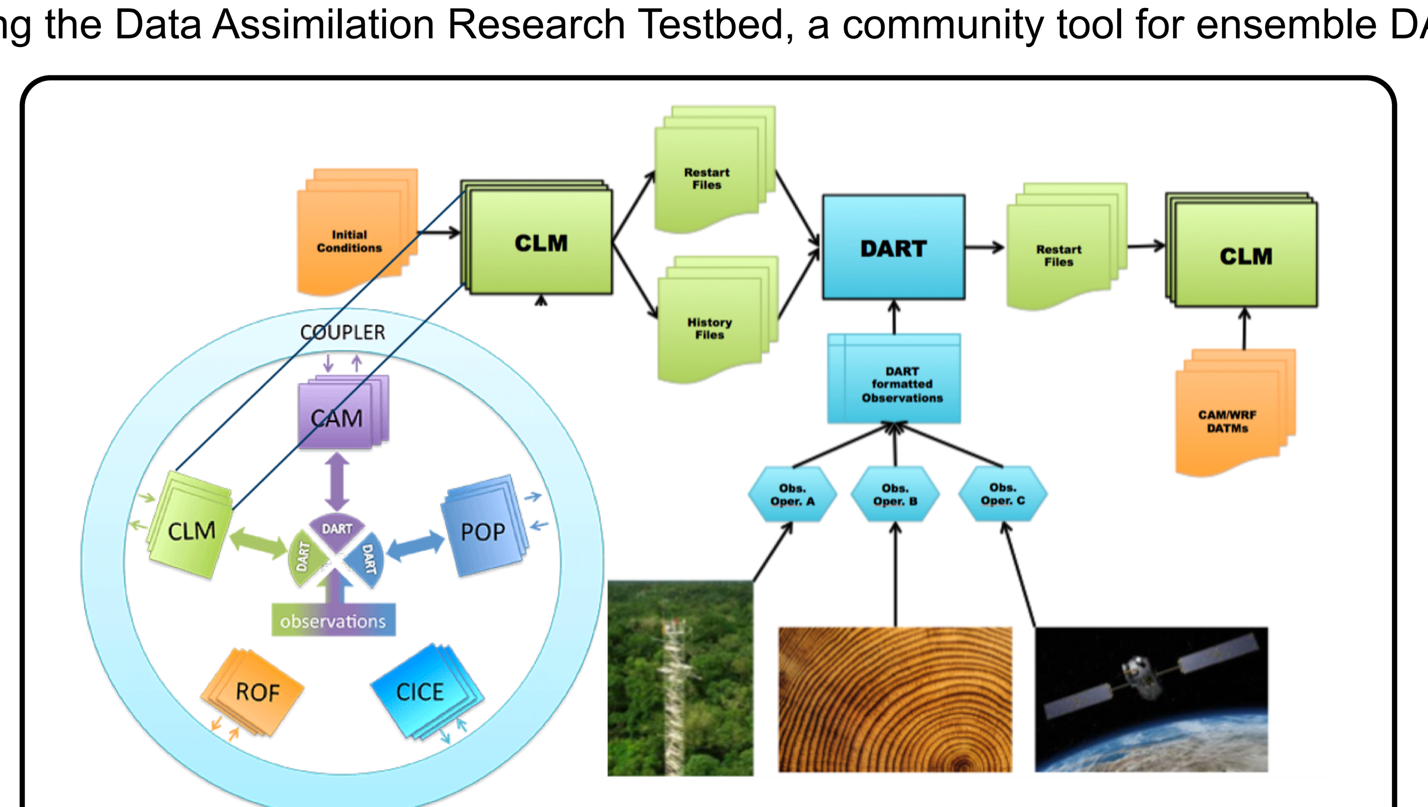
Background

Space-based observations are critical to global ecology, allowing to address questions about the carbon cycle, biodiversity, productivity and disturbance on unprecedented spatial scales. Synergisms between the suite of instruments that will available on the ISS offer unique opportunities to investigate ecosystem composition, structure and function and constrain global models.



Potential Synergies across ISS instruments and a complex Land Surface Model

One way to fuse these different observations is through Data Assimilation into a complex Land surface model such as CLM. We have developed a system to do this using the Data Assimilation Research Testbed, a community tool for ensemble DA.



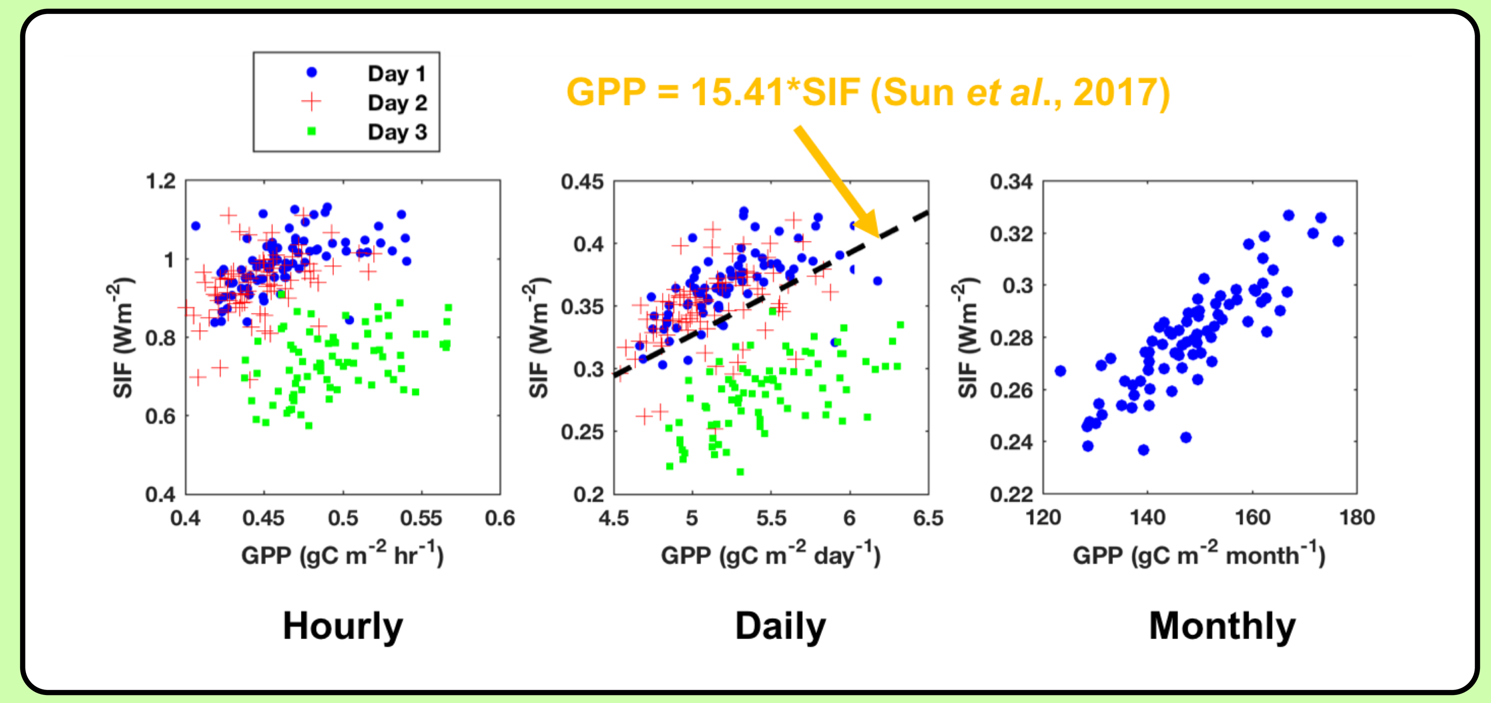
The Community Earth System Model is fully coupled with Data Assimilation Research Testbed

Developing DA capability with new observations

1. Modify model to simulate new observation type
2. Benchmark performance against observations
3. Conduct Perfect Model experiments
4. Carry out real world experiments

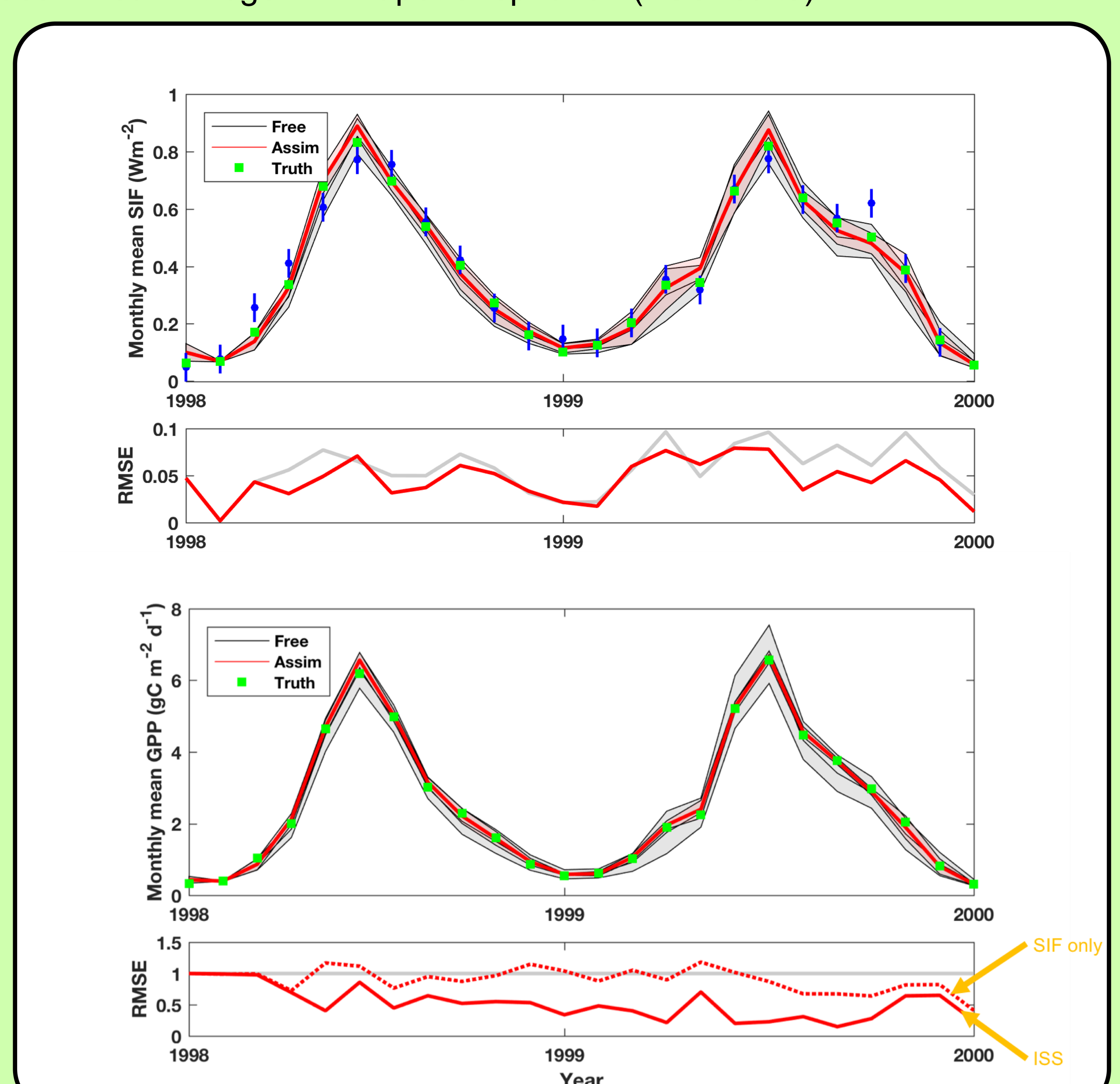
The four steps required for adding new observations to the CLM-DART DA

As a first step we had to add the capability to simulate Solar Induced Fluorescence (SIF) to CLM 5.0.



The relationship between SIF and GPP in a CLM grid cell across an 80 member ensemble. The OCO2 SIF v. flux tower GPP relationship is also plotted.

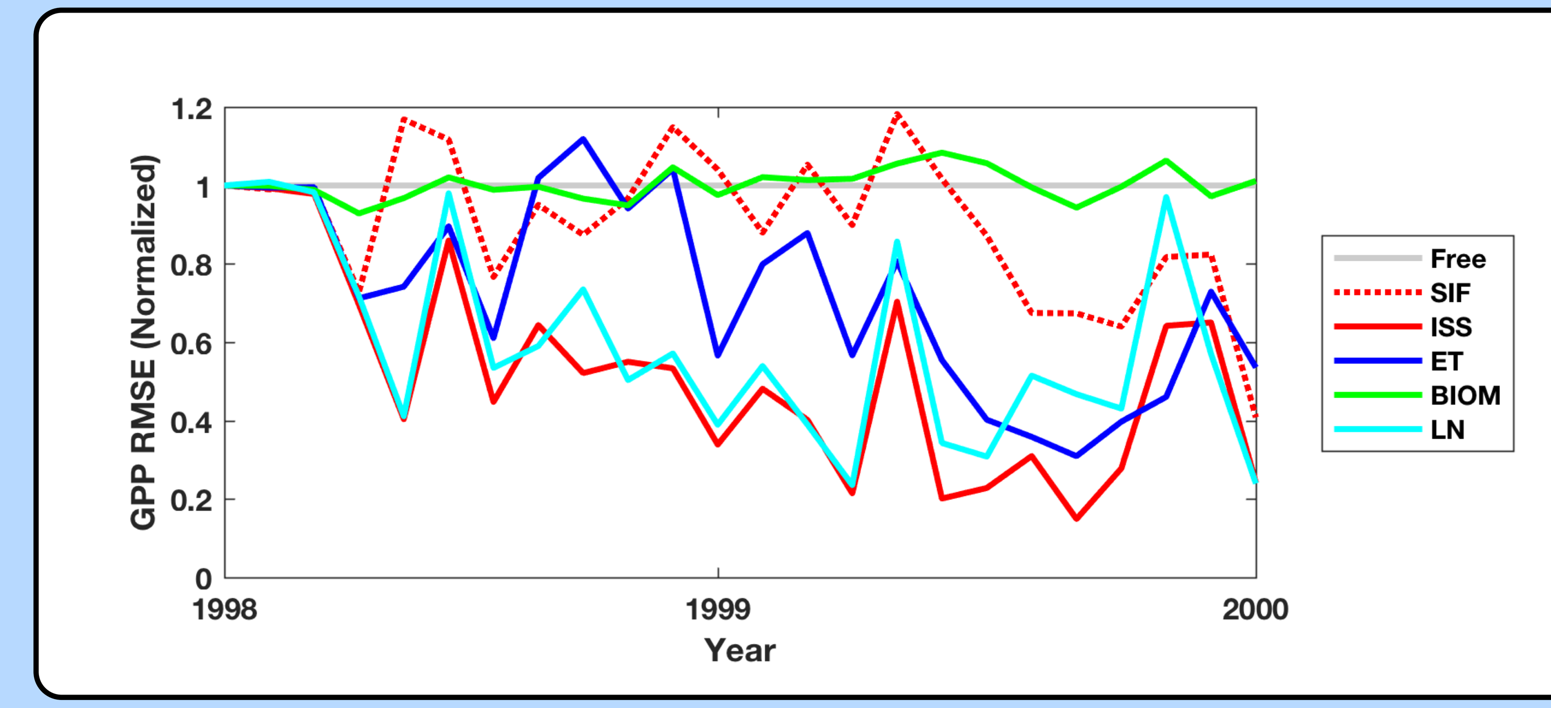
We carried out Perfect Model experiments assimilating SIF only, and then SIF + Biomass + Leaf Nitrogen + Evapotranspiration ("ISS" suite).



The assimilation of monthly SIF observations improved the model's ability to simulate SIF. However, the greatest improvements in GPP error came from assimilating all four data streams

Which data stream constrained GPP the most?

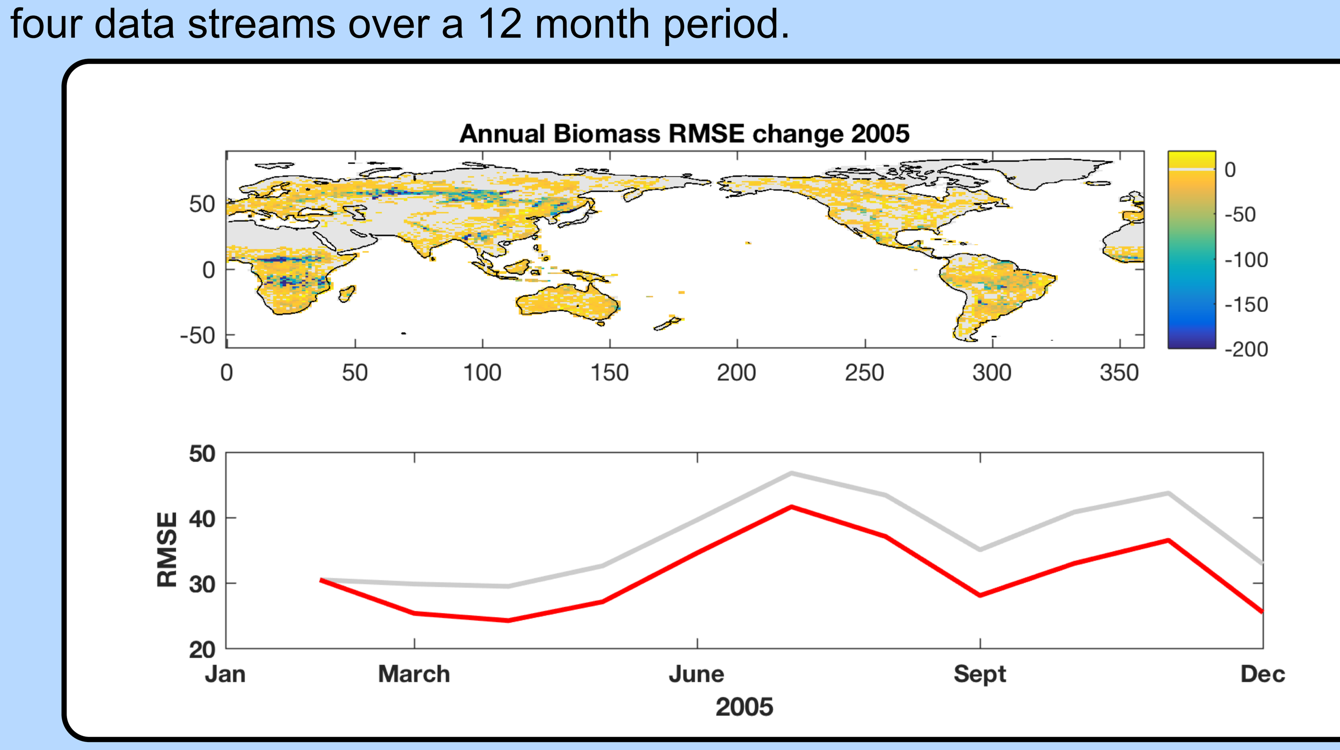
We assimilated each of the four data streams independently, and then assessed their ability to reduce error in GPP relative to the Freerun of the model.



This preliminary results suggests Leaf Nitrogen observations have the most power to constrain model estimates of GPP

Testing Globally

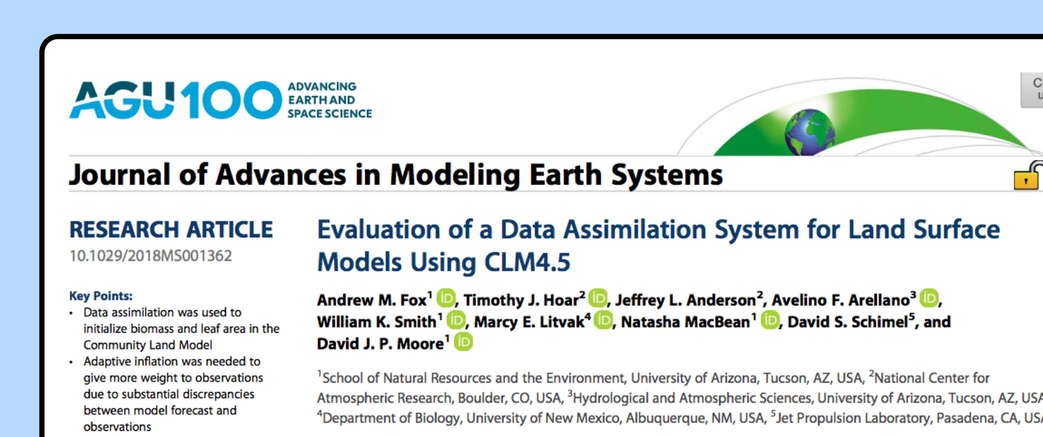
We have extended our perfect model experiments to the global scale, assimilating the four data streams over a 12 month period.



We saw large reductions in biomass error, and in the other assimilated variables. However, the ability to constrain GPP varies spatially.

Take home points

1) CLM 5.0 now incorporates fully prognostic leaf N and Vcmax
2) SIF code has been implemented, but canopy scaling still requires work
3) Multiple "ISS" observations can be assimilated simultaneously with DART
4) This combination produces the greatest reduction in error in diagnostic C fluxes
5) Going forward, we need to implement "Imperfect" model experiments to test inflation and localization
6) Now waiting for the new data streams to become available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RESEARCH ARTICLE

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