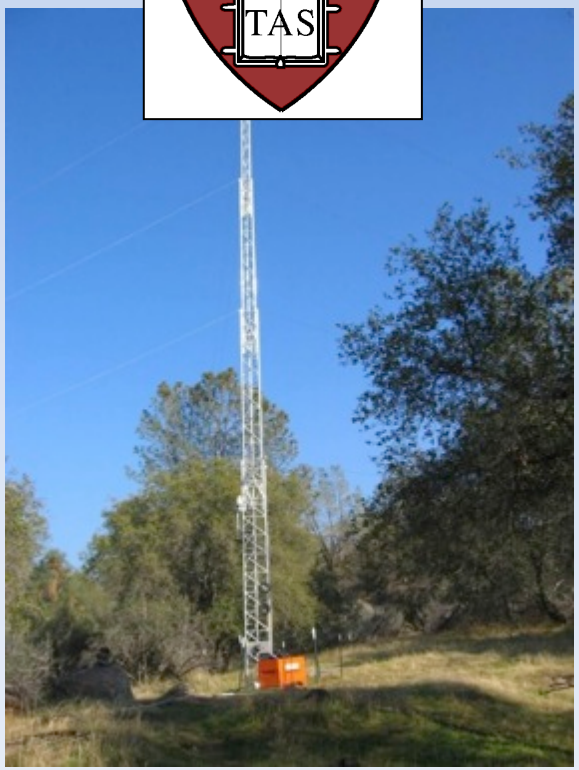
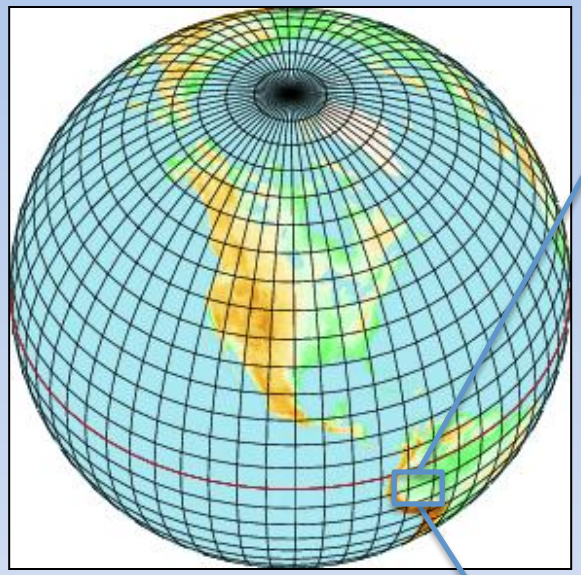
Advances in the Remote Sensing of Terrestrial Vegetation and the Development of a Predictive Science of the Biosphere

Paul R. Moorcroft



The Greening of Global Climate Models

SiB Terrestrial Biosphere model (Sellers 1986)



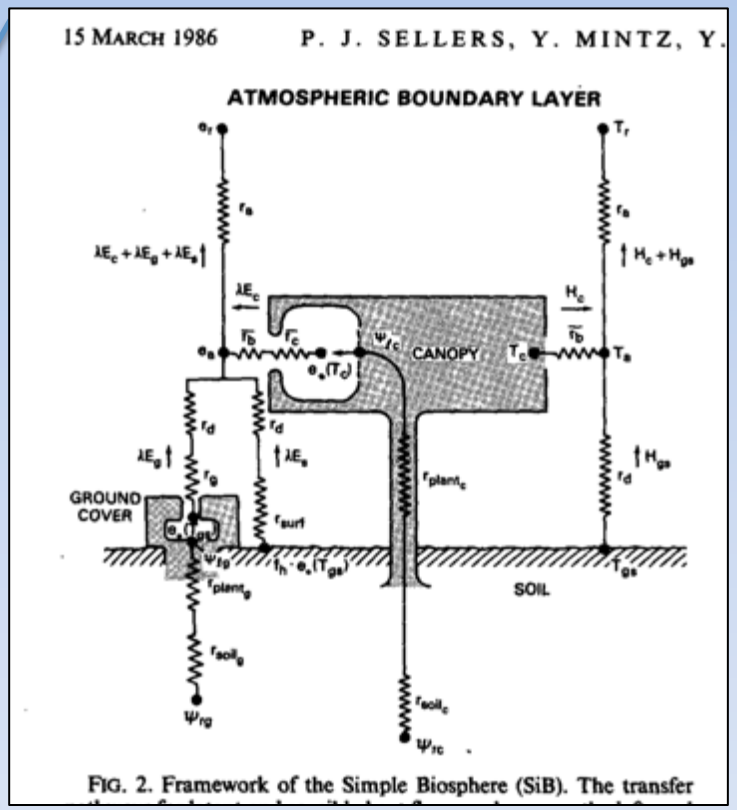


FIG. 2. Framework of the Simple Biosphere (SiB). The transfer

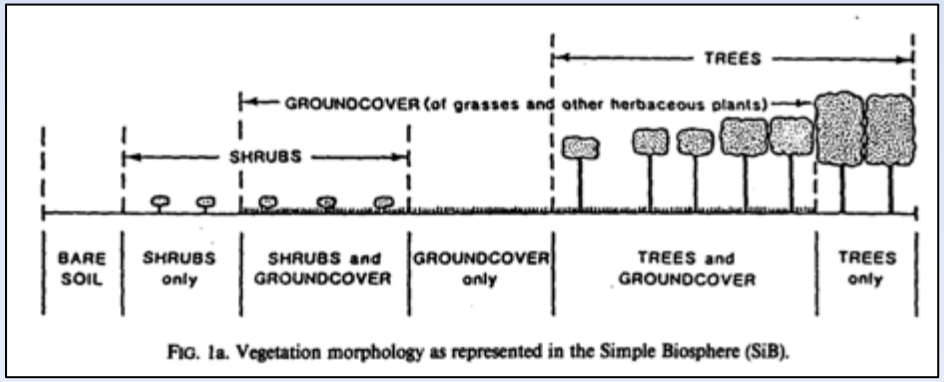
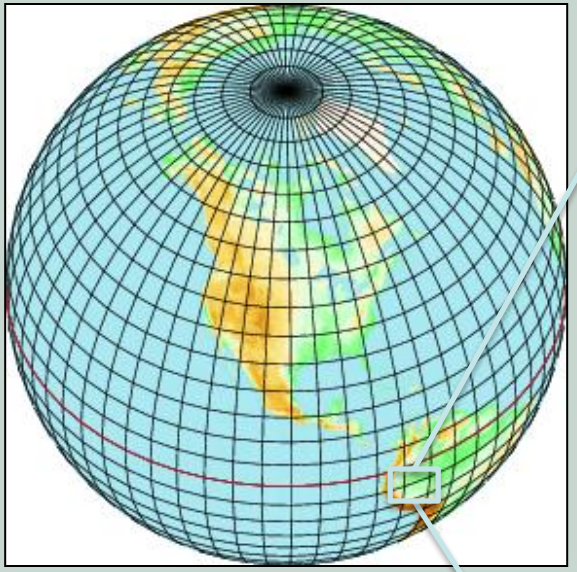
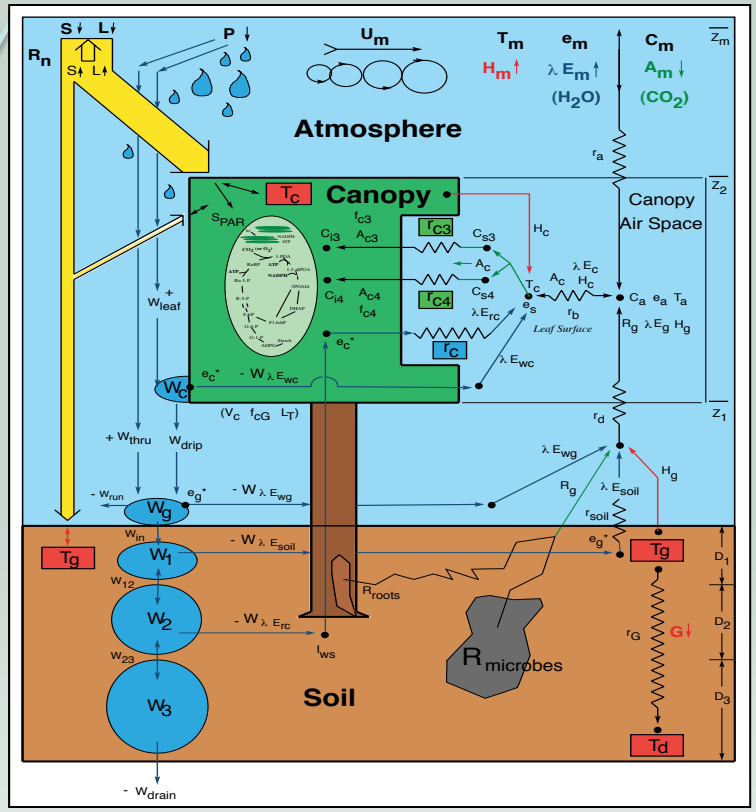


FIG. 1a. Vegetation morphology as represented in the Simple Biosphere (SiB).

The Greening of Global Climate Models

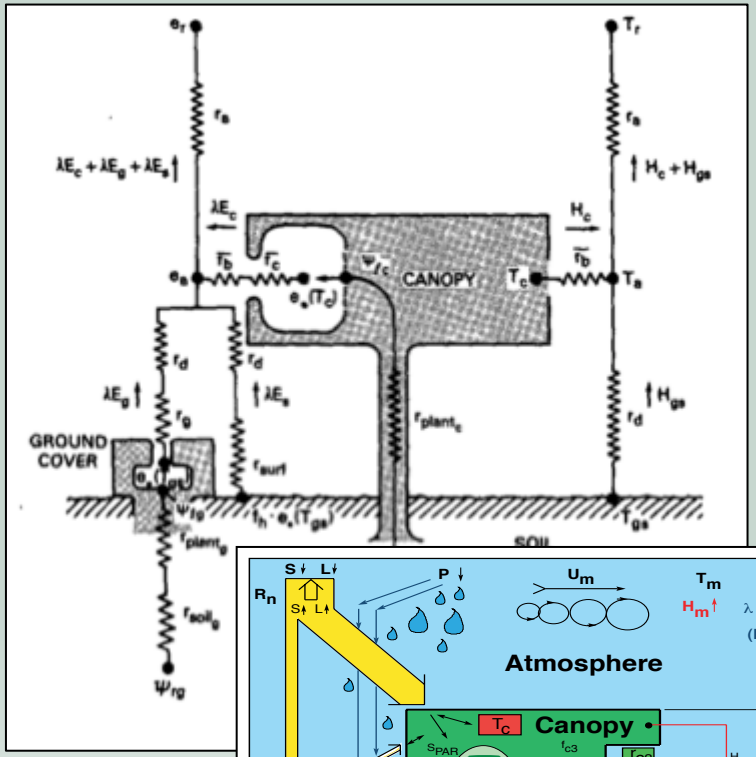
SiB2 Terrestrial Biosphere model (Sellers 1996)

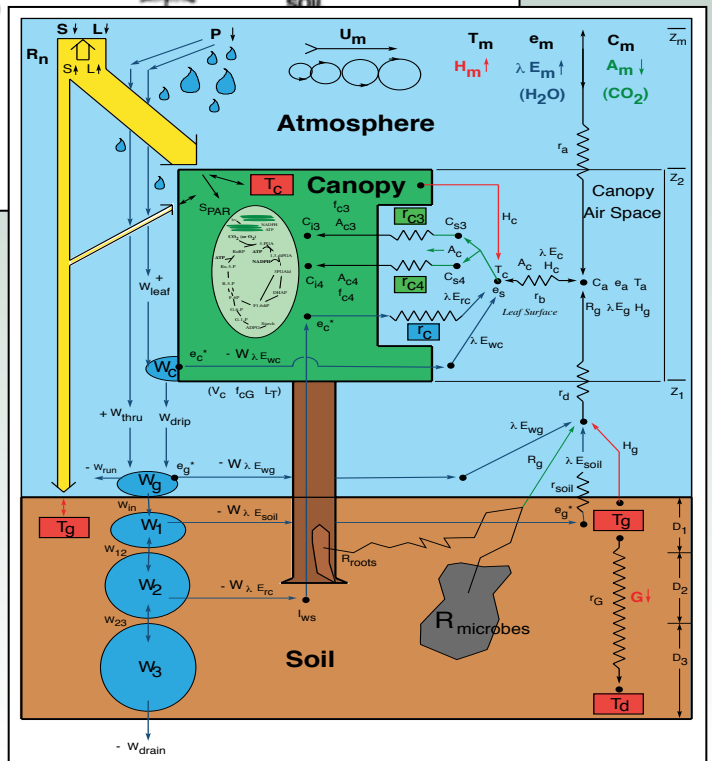


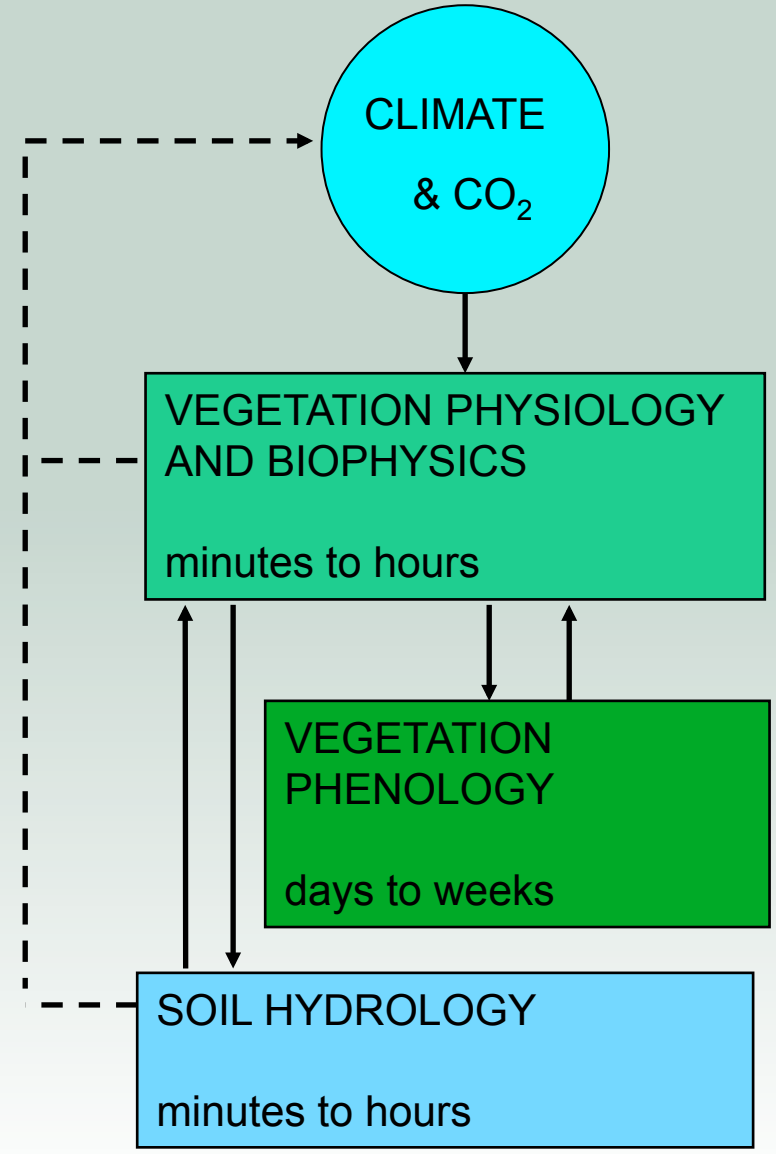


The 1st generation of terrestrial biosphere models

captured <u>biophysical biosphere-atmosphere feedbacks</u>)







Satellite-Derived Predictions of Terrestrial Carbon, and Water Fluxes and its impact on Atmospheric CO2 Concentrations

(Sellers et al. 1997)

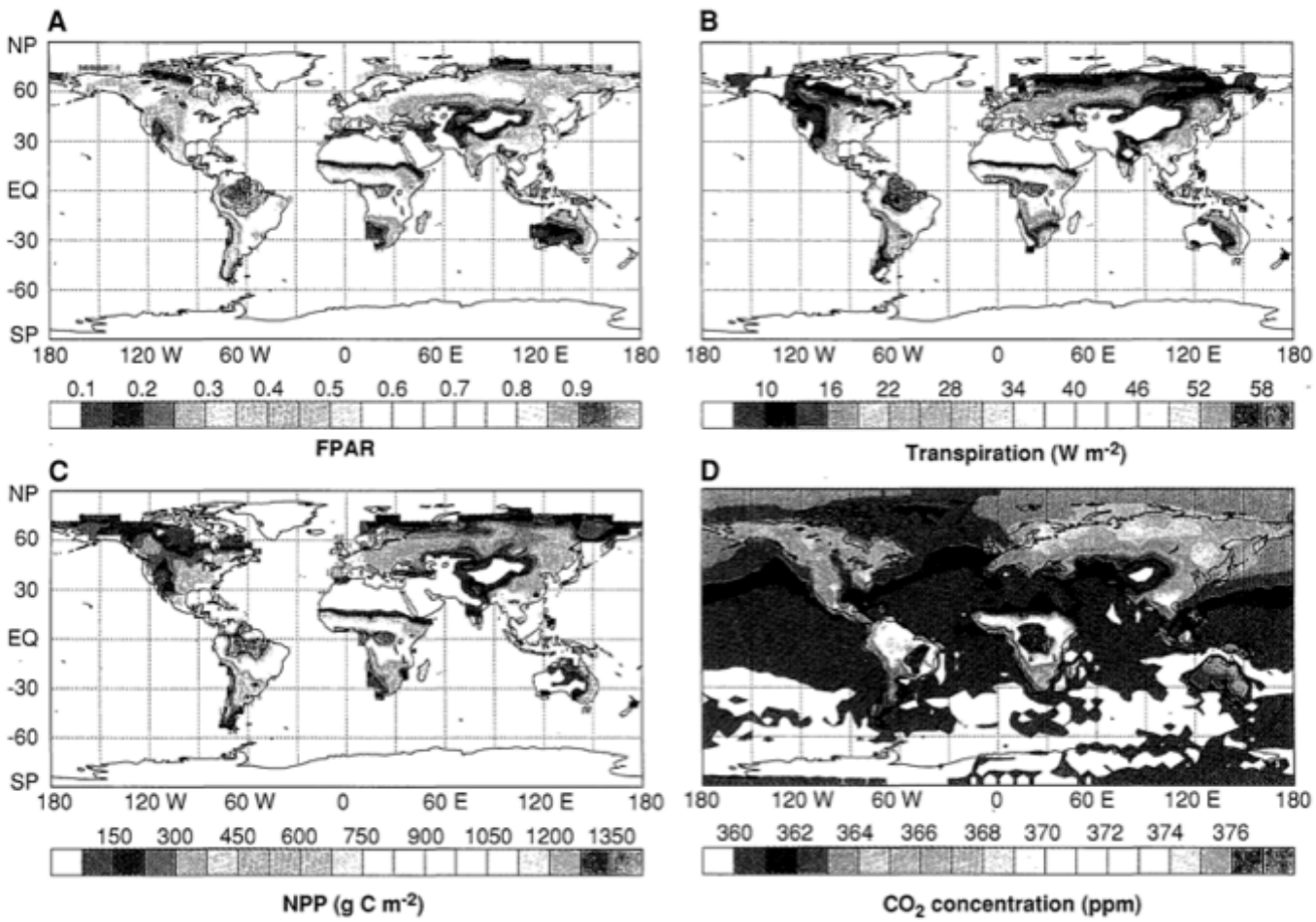
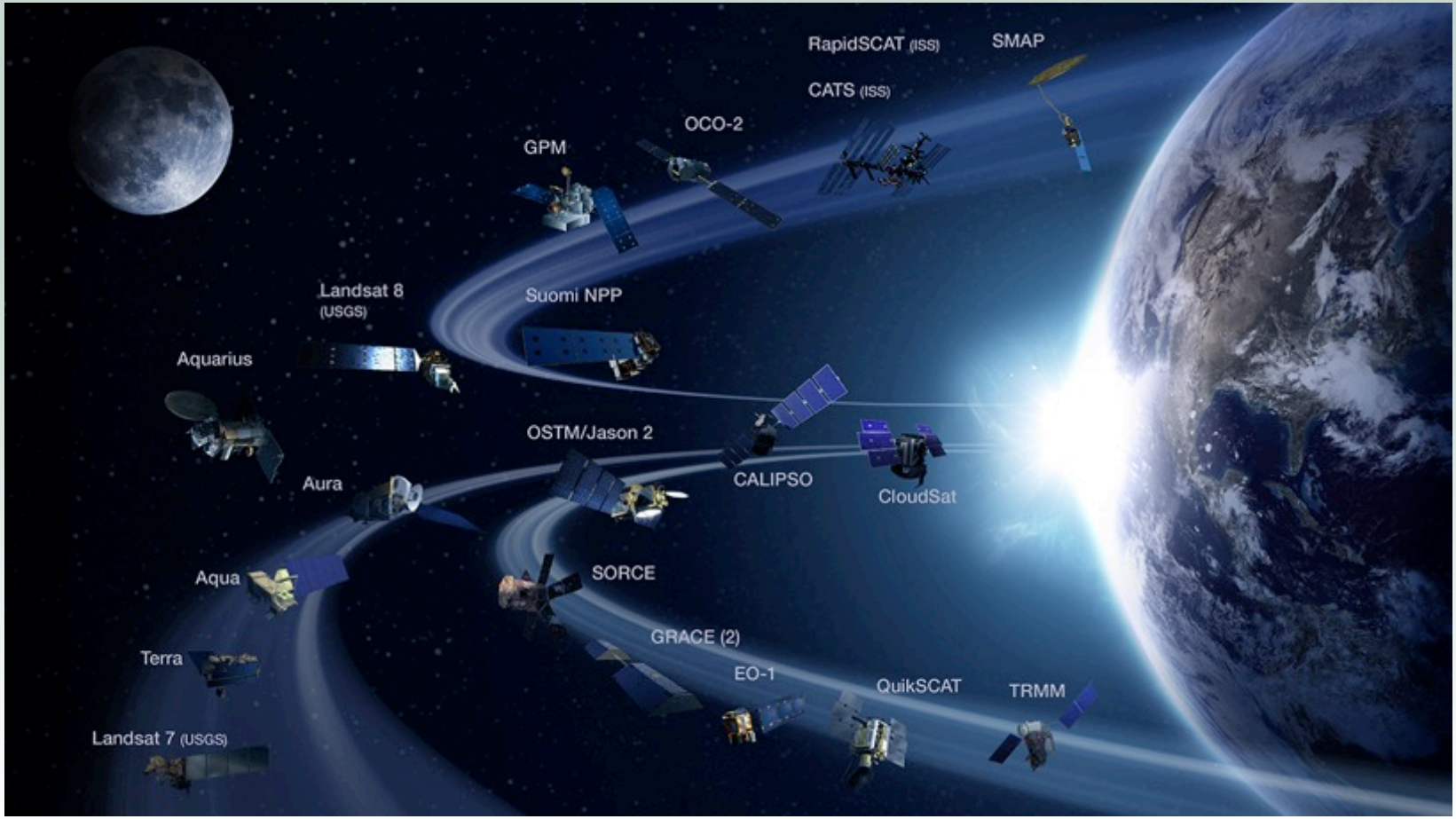


Fig. 4. Global fields used in or generated by a third-generation LSP. (**A**) Global field of FPAR calculated from AVHRR SVI data (Eq. 9). (**B**) Canopy transpiration and (**C**) canopy net photosynthetic productivity (NPP, in grams of carbon per square meter) calculated by a third-generation LSP from within an AGCM, using the FPAR field shown in (A) (*8, 48*). (**D**) Annual mean CO_2 concentration in the planetary boundary layer (*55*).

Mission to Planet Earth (MTPE)

MTPE Website (1997): “NASA's Mission to Planet Earth (MTPE) is dedicated to understanding the total Earth system and the effects of natural and human-induced changes on the global environment.”

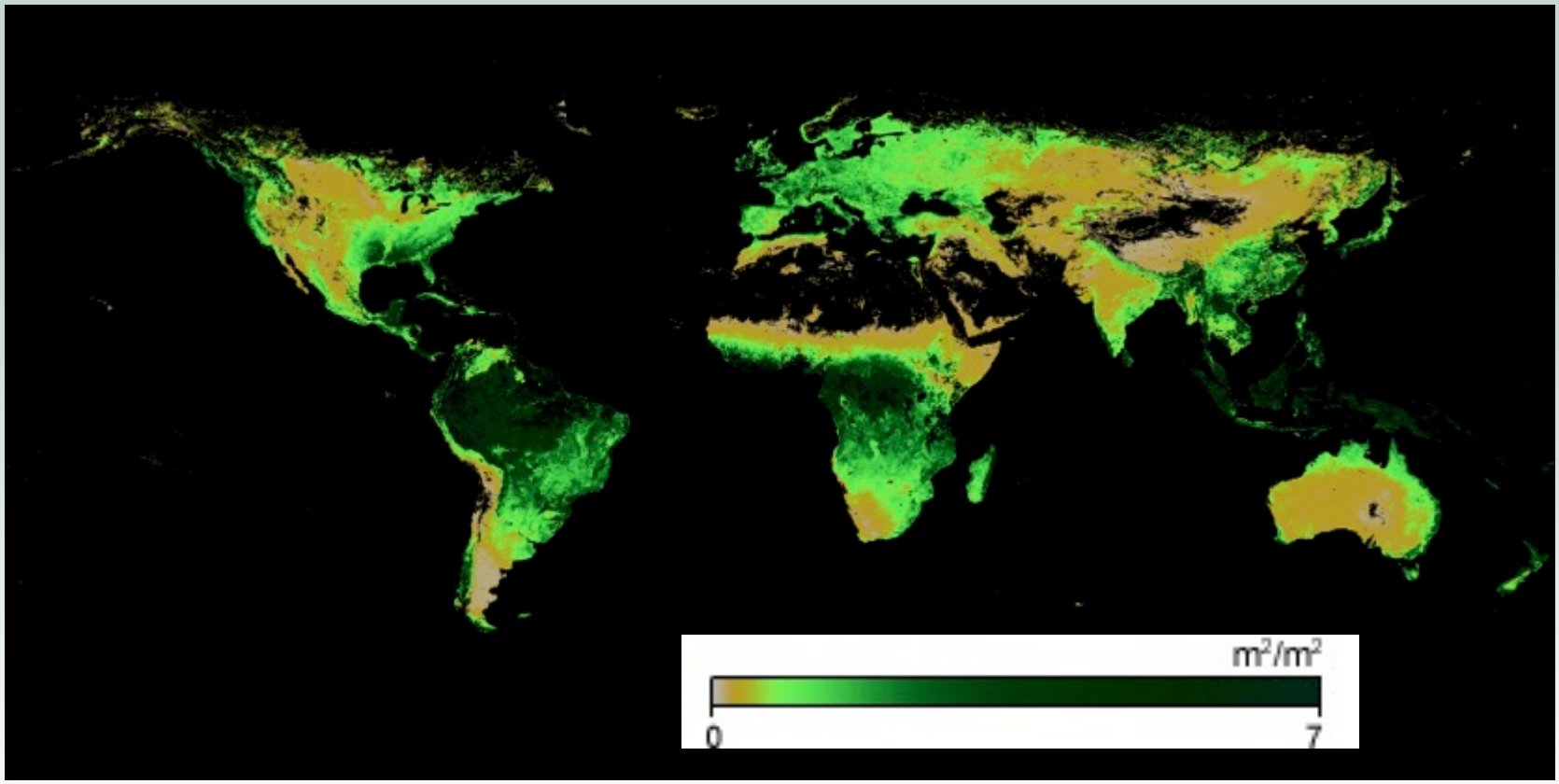
Earth Observing System (EOS) (Feb. 2015)



Moderate Resolution Imaging Spectrometer (MODIS)

Aboard: Terra (EOS AM-1, launched December 1999),
& Aqua (EOS PM-1, launched May 2002)

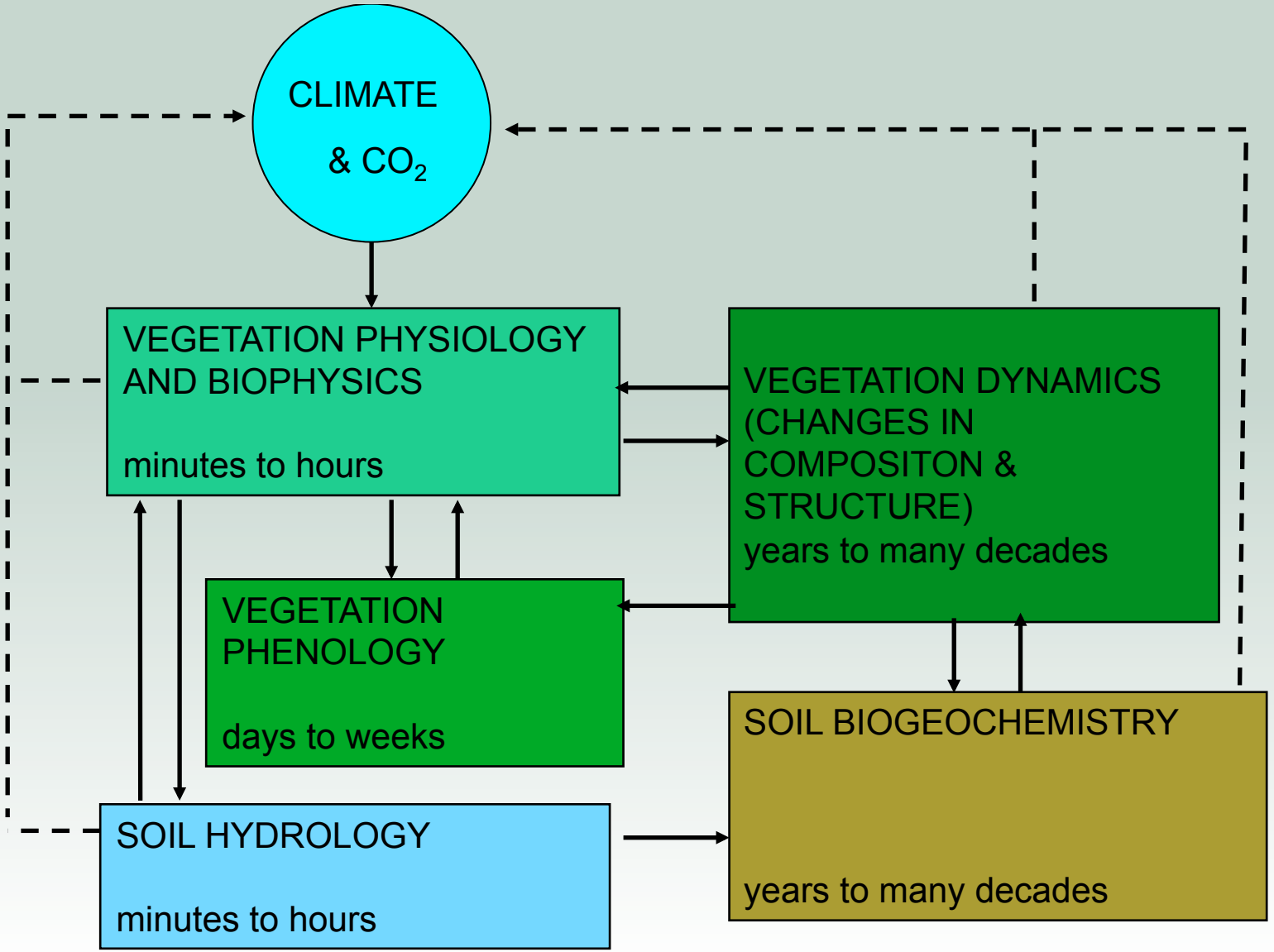
MODIS-derived Estimates of Leaf Area Index (LAI)



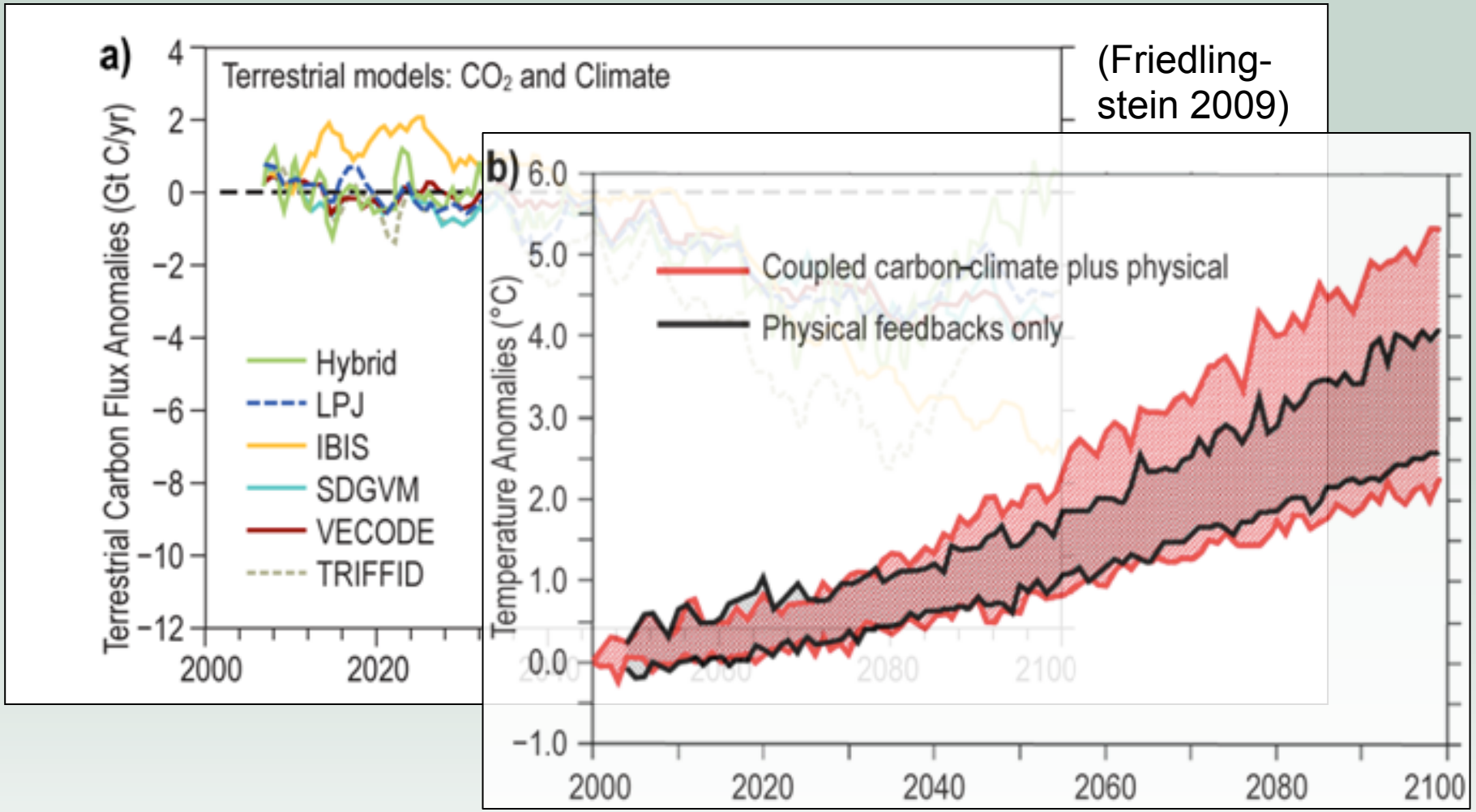
- MODIS-derived estimates of surface albedo

2nd Generation Dynamic Global Vegetation Models (DGVMs)

DGVMs incorporate the effects of long-term ecosystem change and thus incorporate both biophysical and biogeochemical feedback mechanisms



The Diverging Predictions of Terrestrial biosphere model (DVGM) for the Long-Term Response of Terrestrial Ecosystems to climate change



(Friedling-stein 2009)

- because of feedbacks onto the atmosphere, the response of the terrestrial biosphere to changes in climate is one of the largest sources of uncertainty for the amount of climate change that will occur over the coming century.

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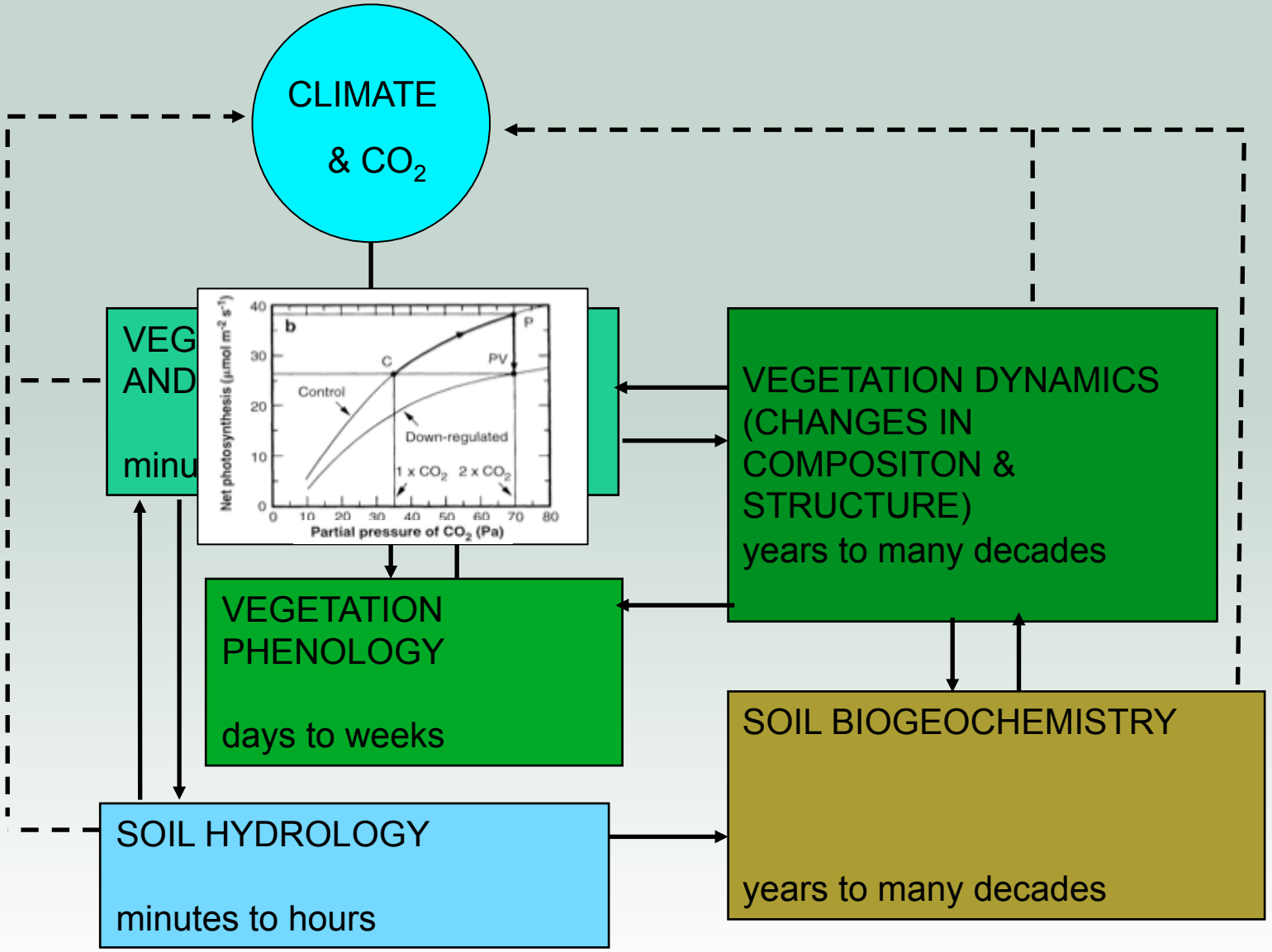

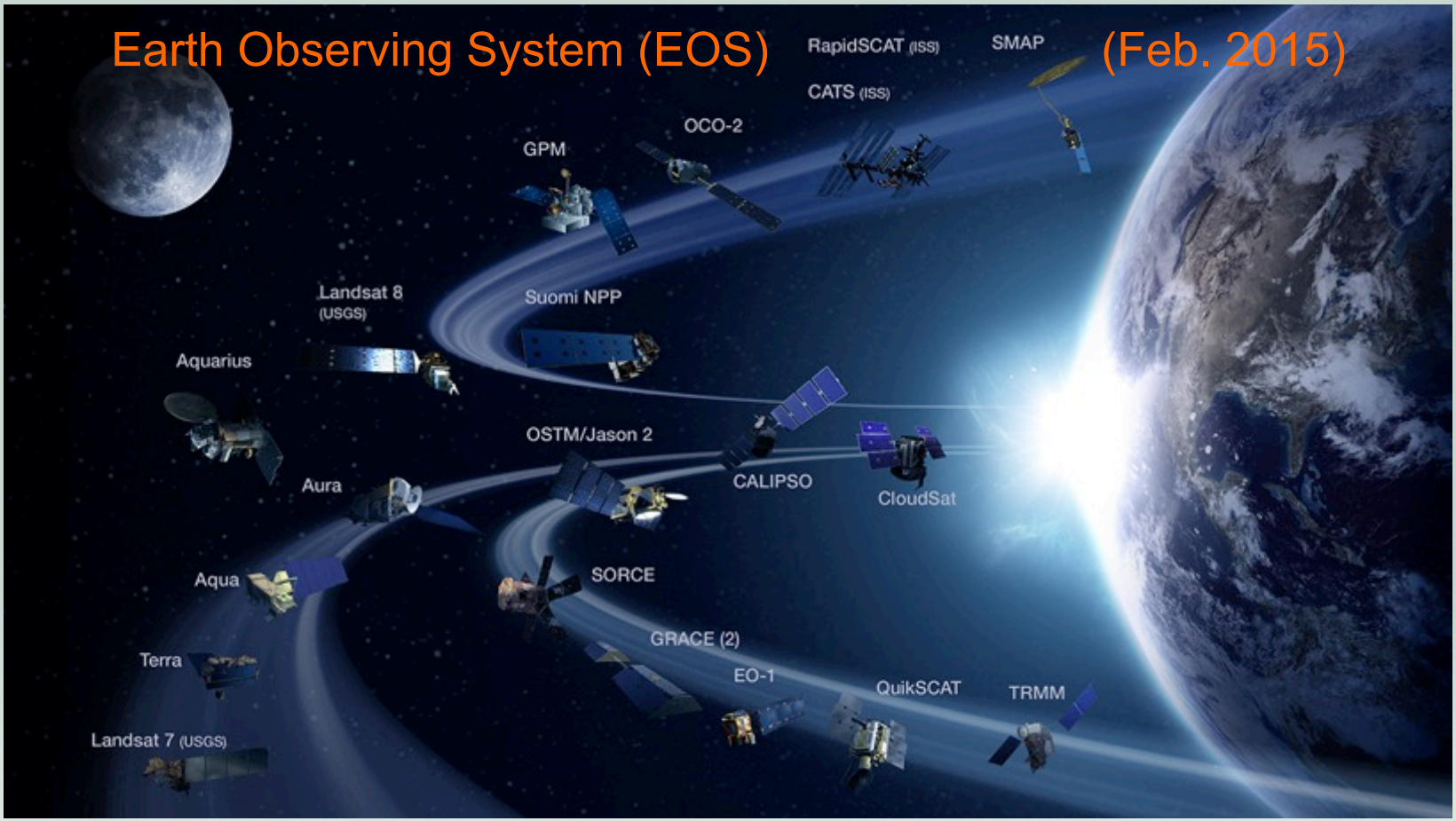

What role can NASA's Earth Observing System (EOS) play in constraining dynamic global vegetation model predictions for the fate of the terrestrial biosphere over the coming century?

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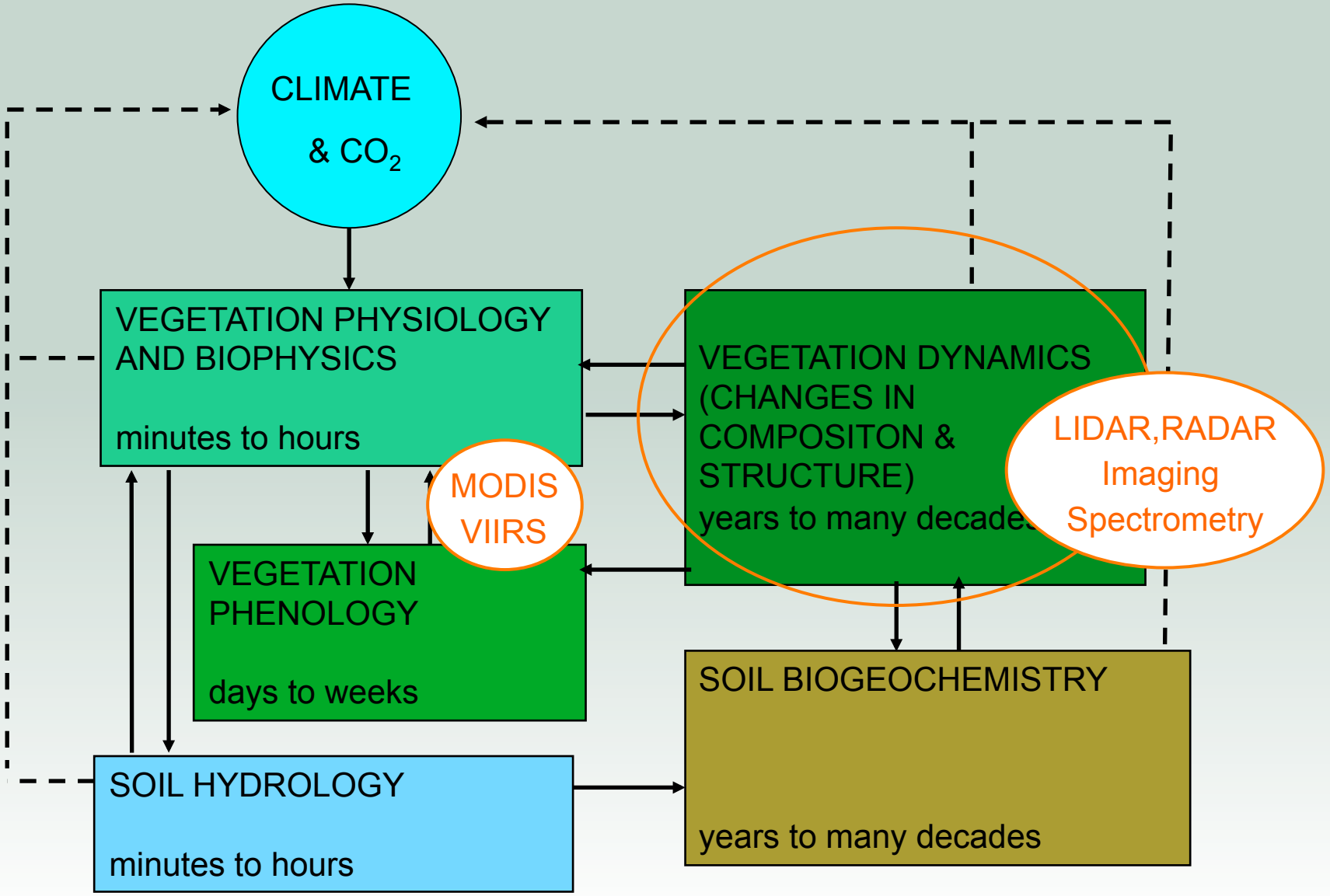
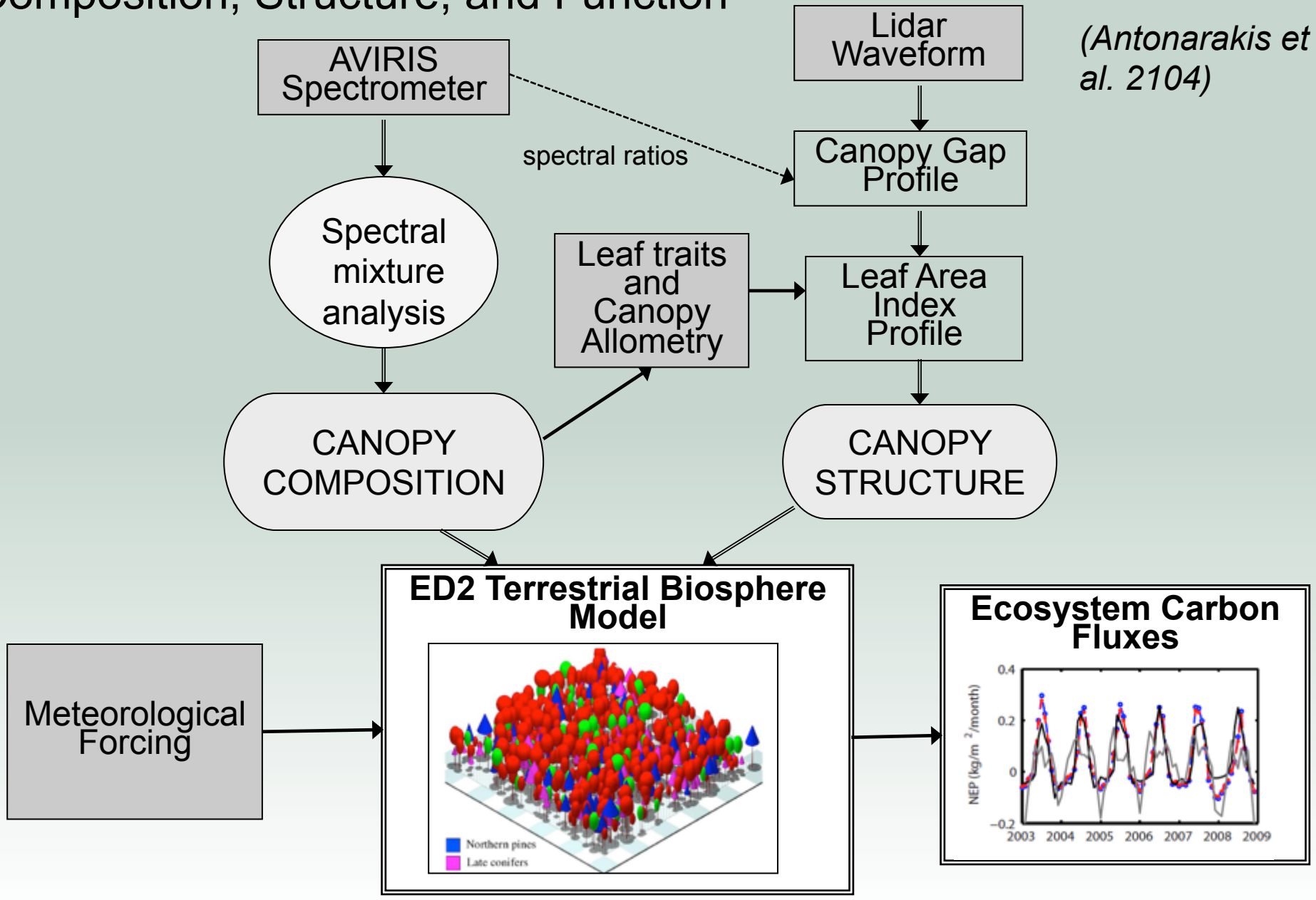
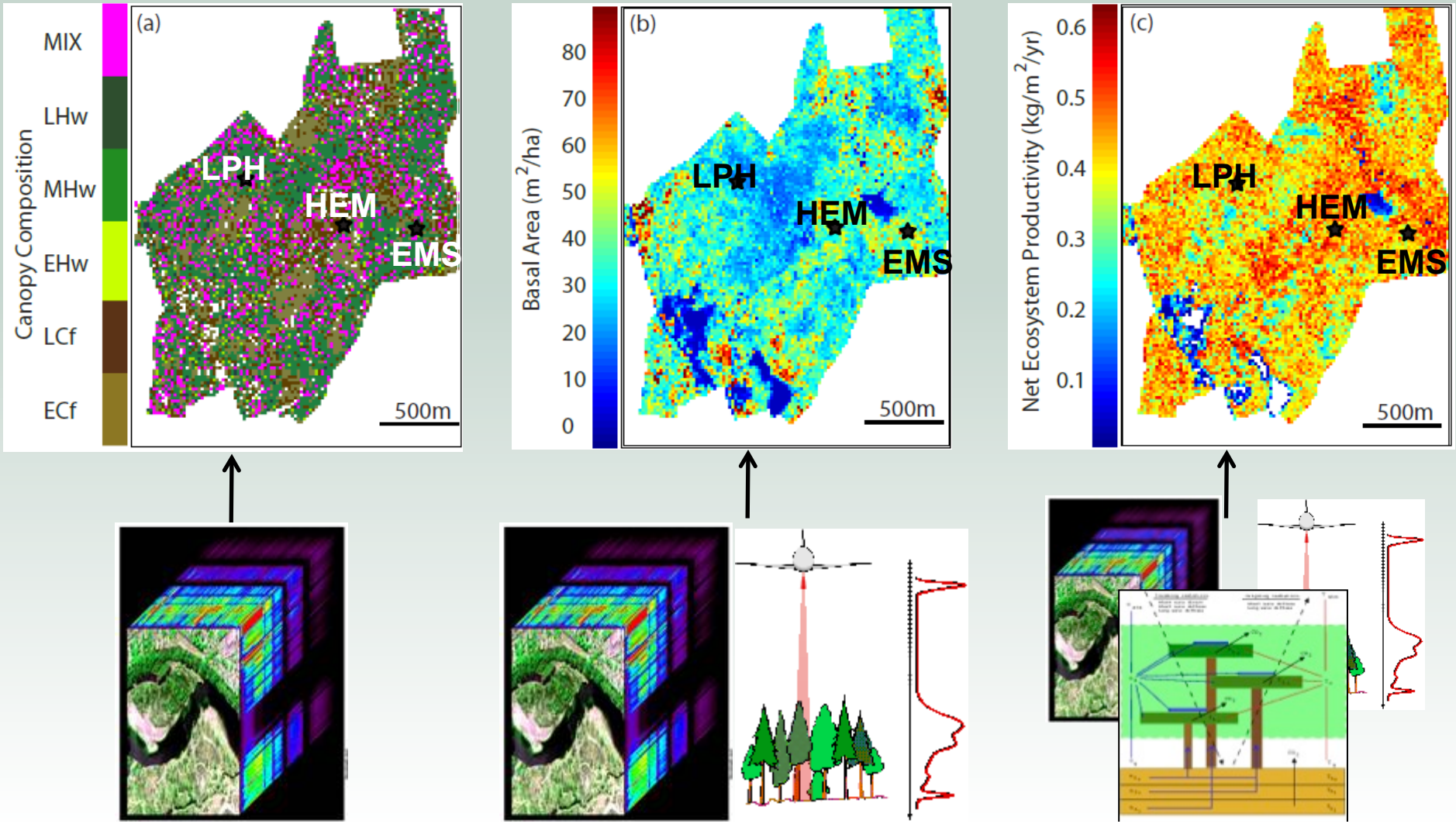


Using Remote Sensing Measurements to Estimate Ecosystem Composition, Structure, and Function



(Antonarakis et al. 2014)

Estimated Sub-Grid Scale Ecosystem Composition, Structure, and Carbon Fluxes at Harvard Forest LTER site

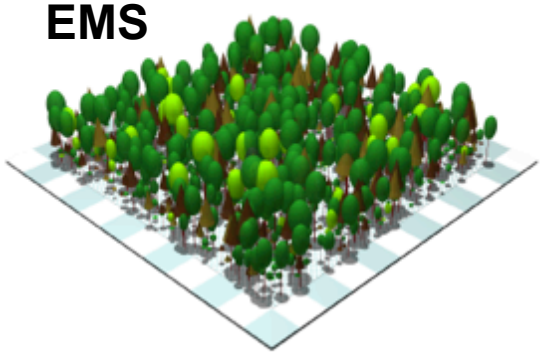


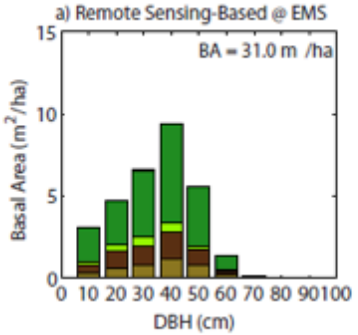
(Antonarakis et al.)

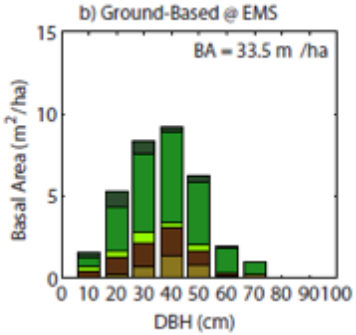
Results: Composition and Structure at 3 Harvard Forest Flux-tower sites

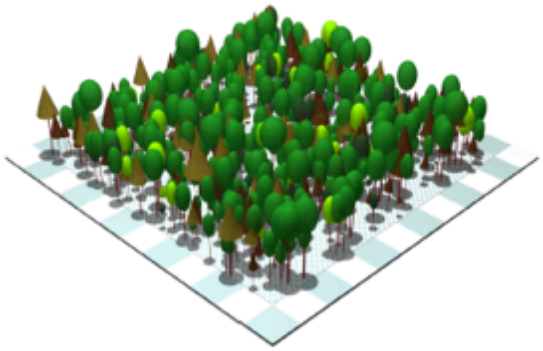
REMOTE SENSING-BASED **GROUND-BASED**

EMS

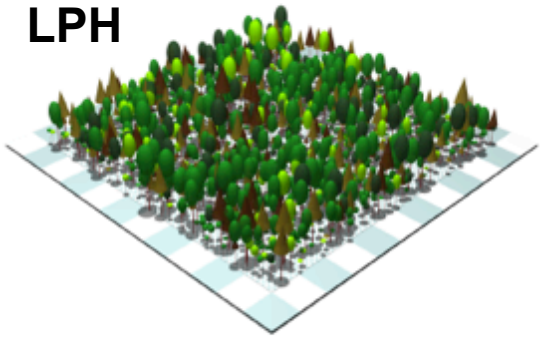


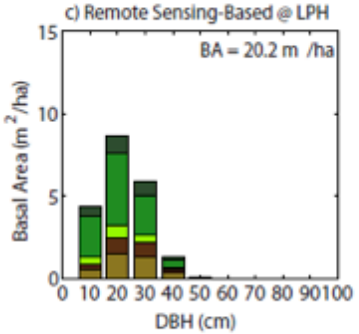


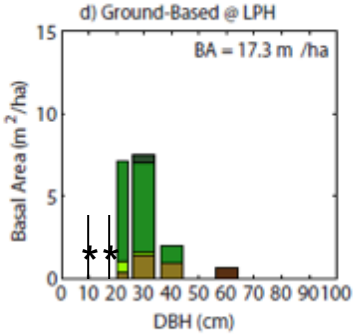


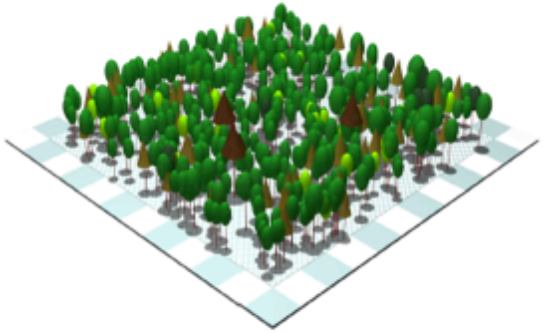


LPH

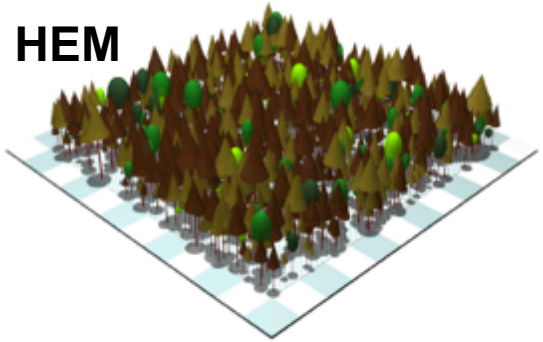


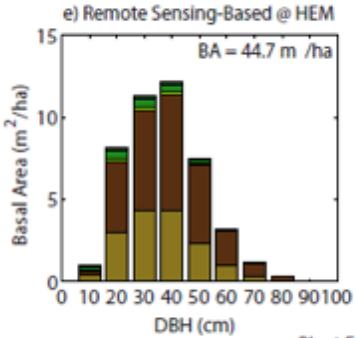


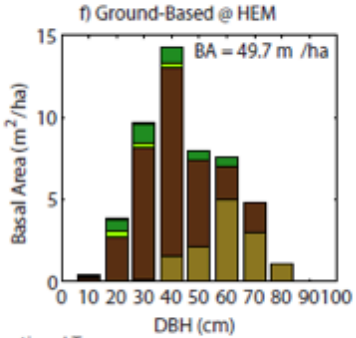


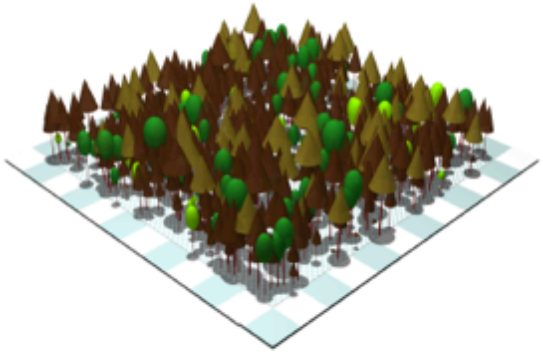


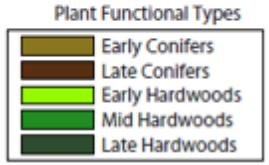
HEM







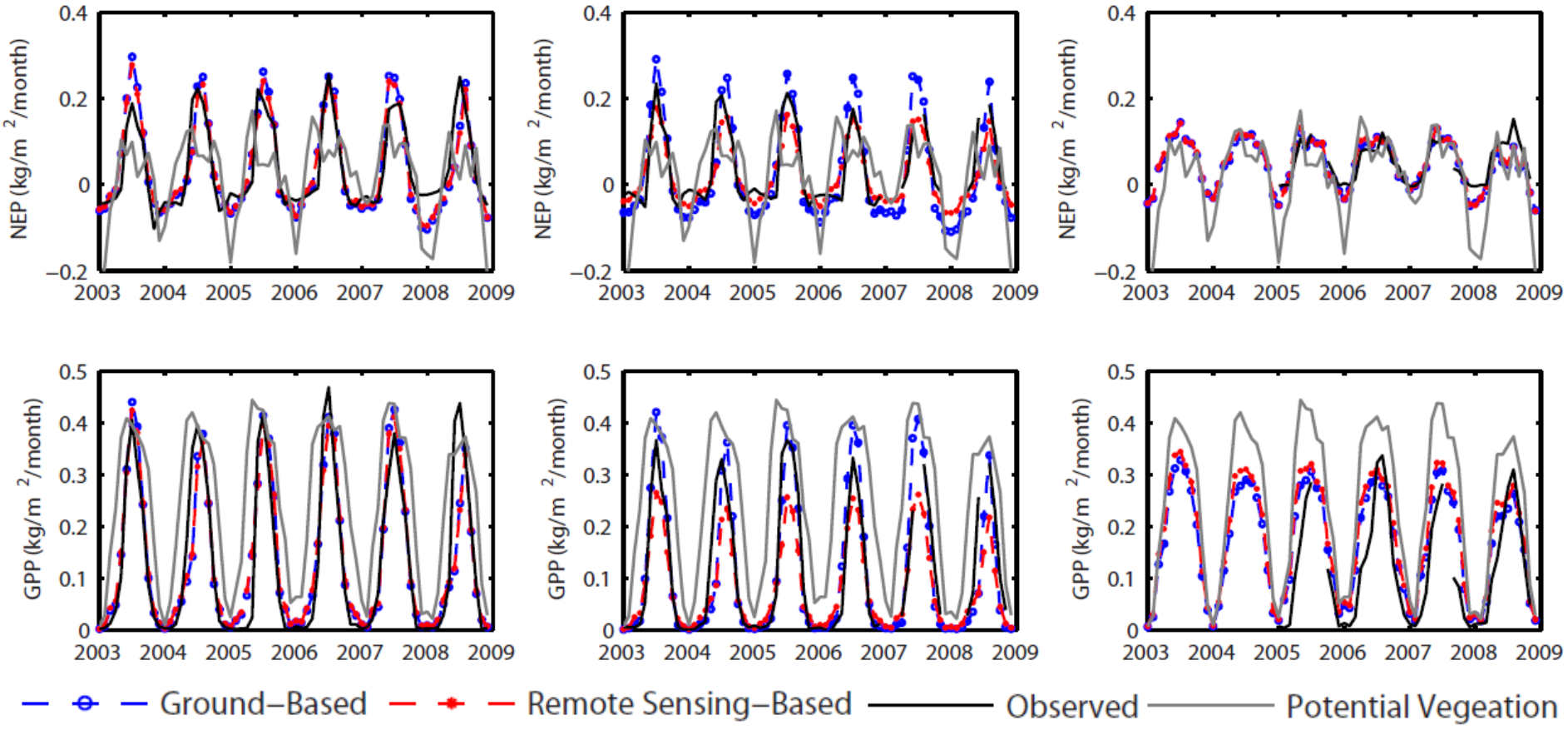




(Antonarakis et al.)

Seasonal Patterns of Carbon Fluxes (2003-2009)

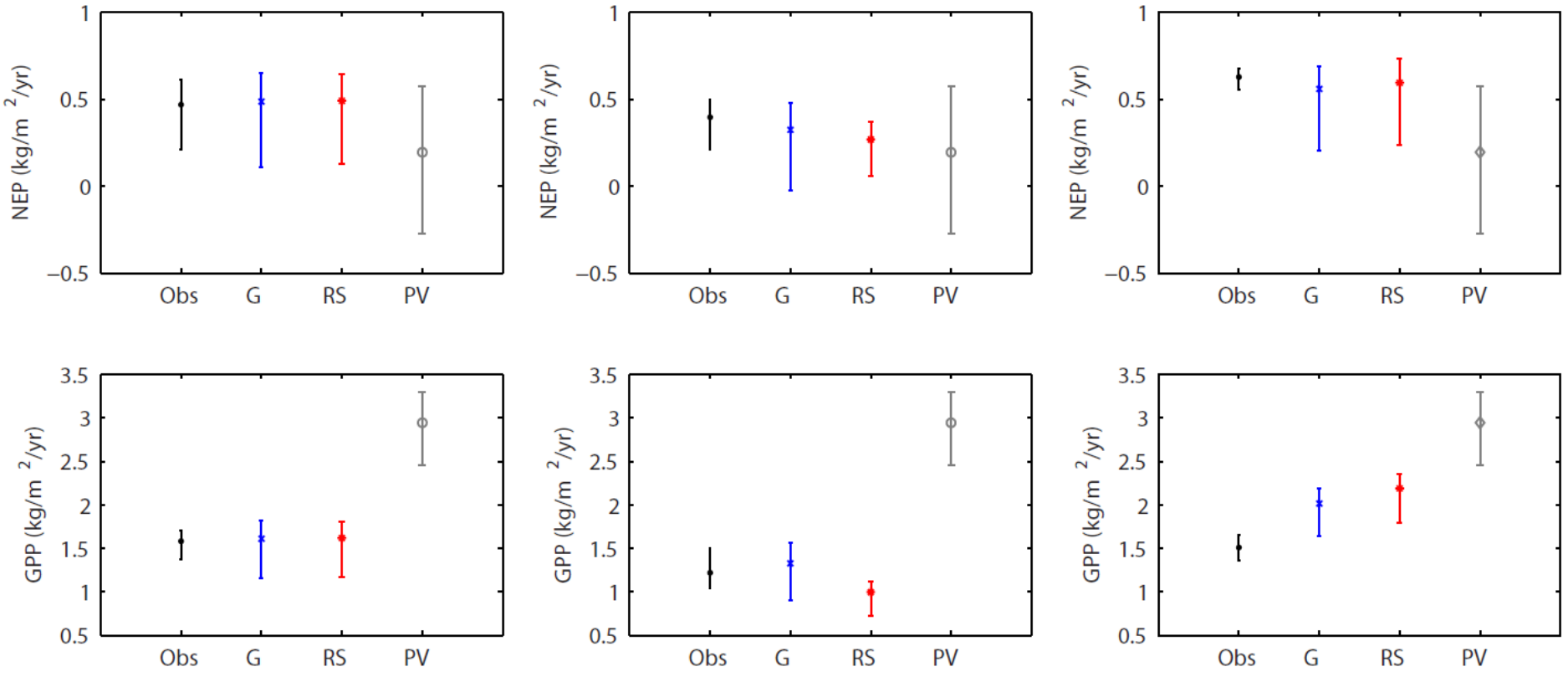
EMS LPH HEM



(Antonarakis et al.)

Yearly Carbon Fluxes (2003-2009)

EMS LPH HEM



G = ground-inventory initialized RS = remote sensing initialized PV = potential vegetation

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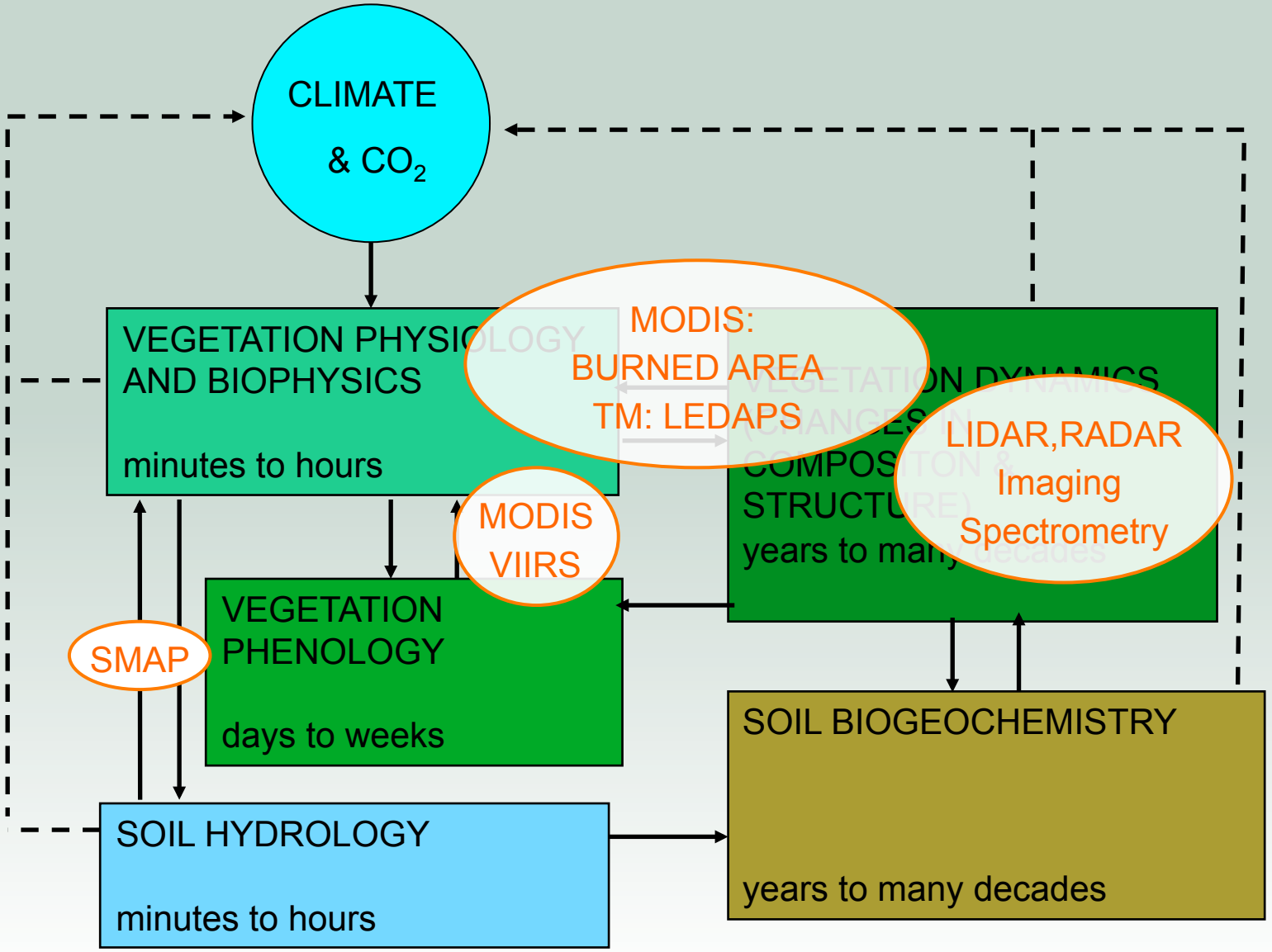
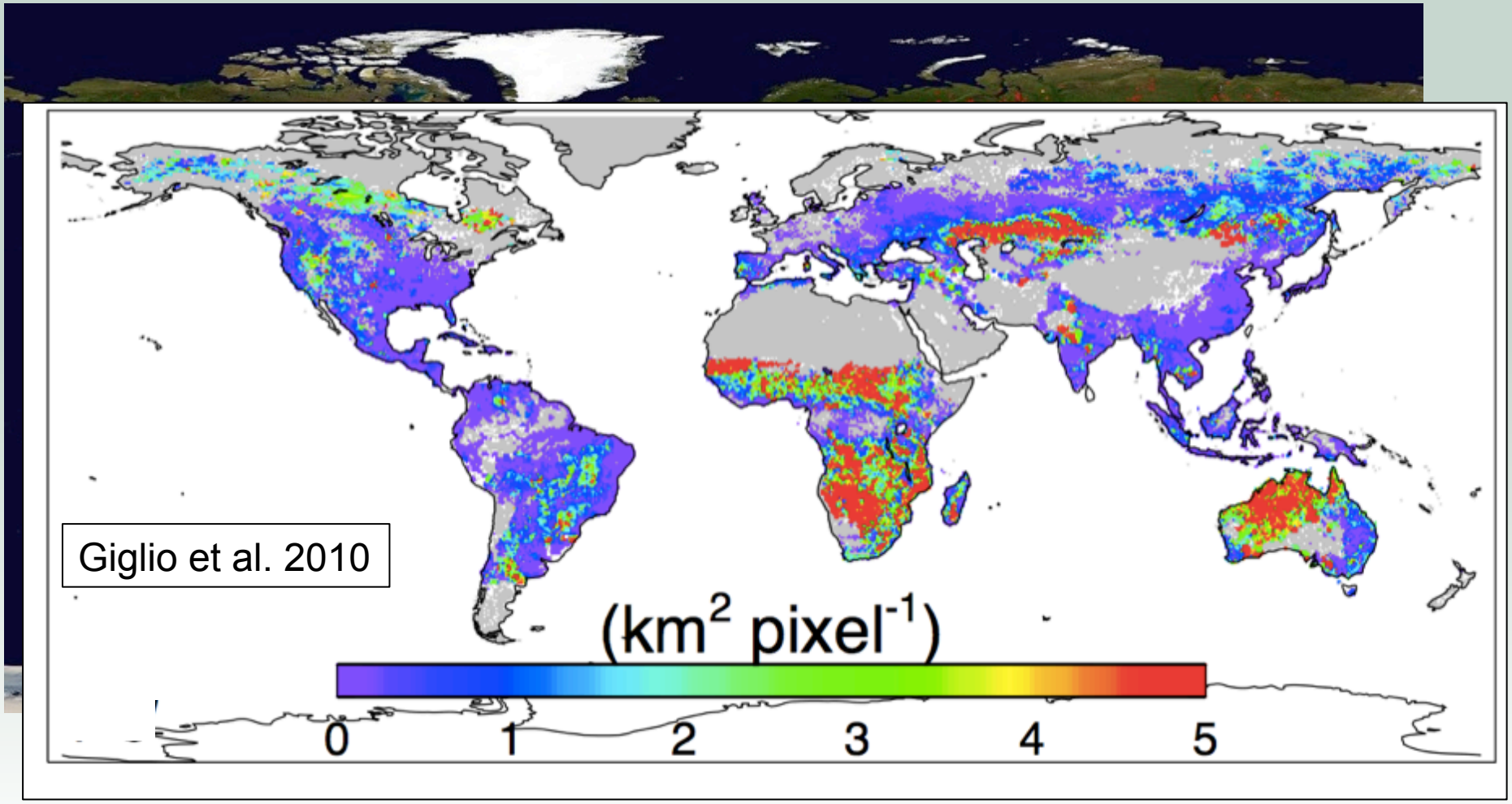
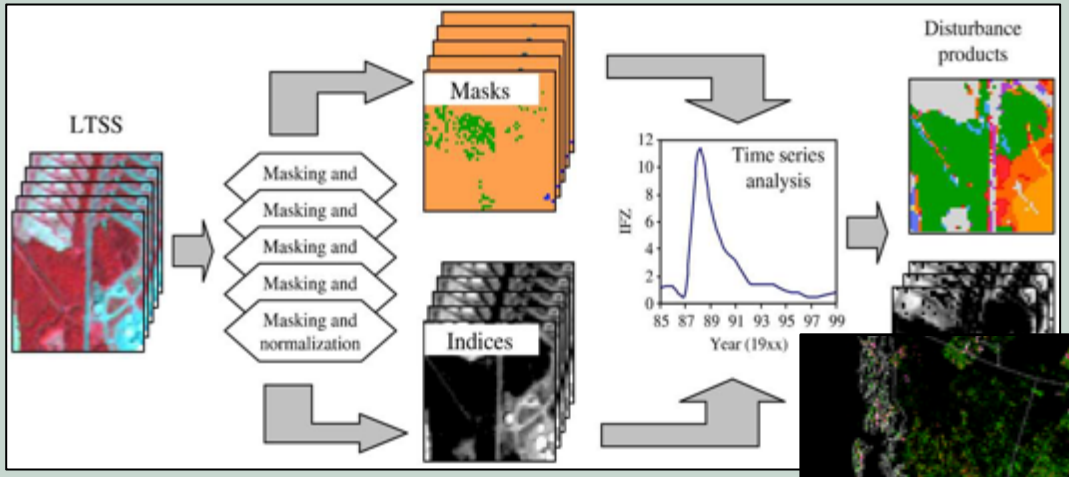
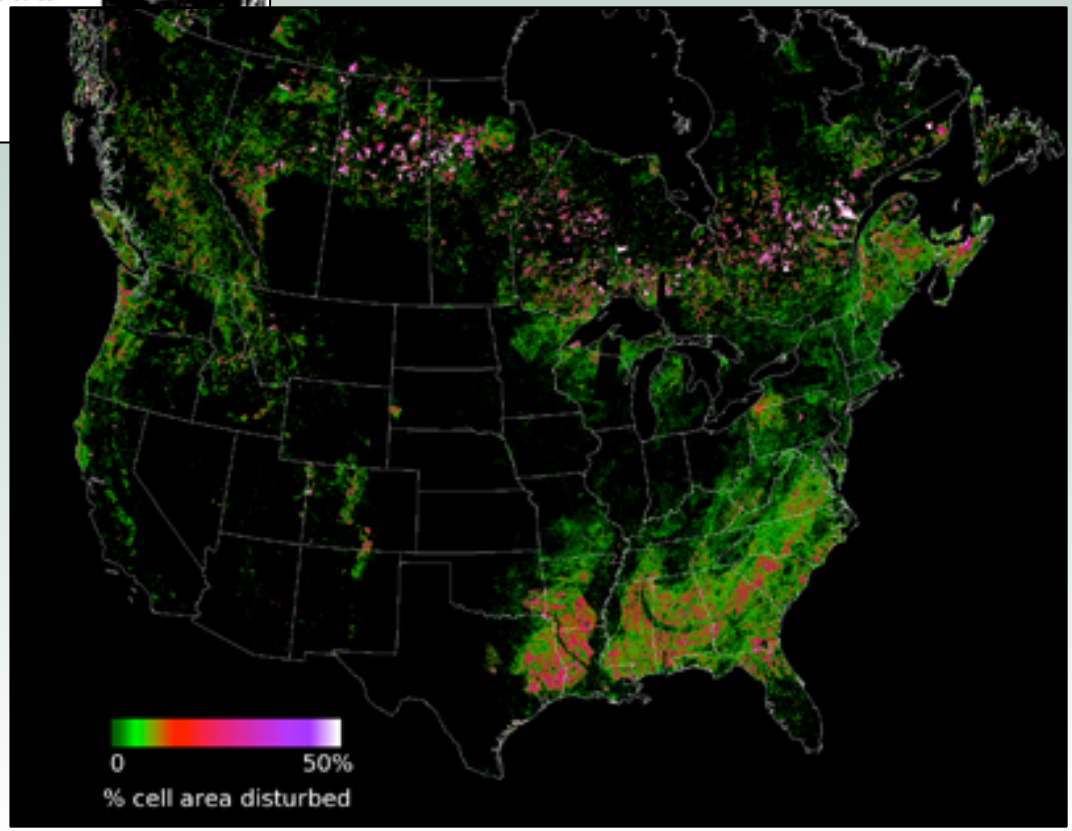


MODIS Derived Estimates of Burned Area Obtained from the Global Fire Emissions Database, Version 3 (GFEDv3.1)





Landsat TM-derived estimates of disturbance frequency



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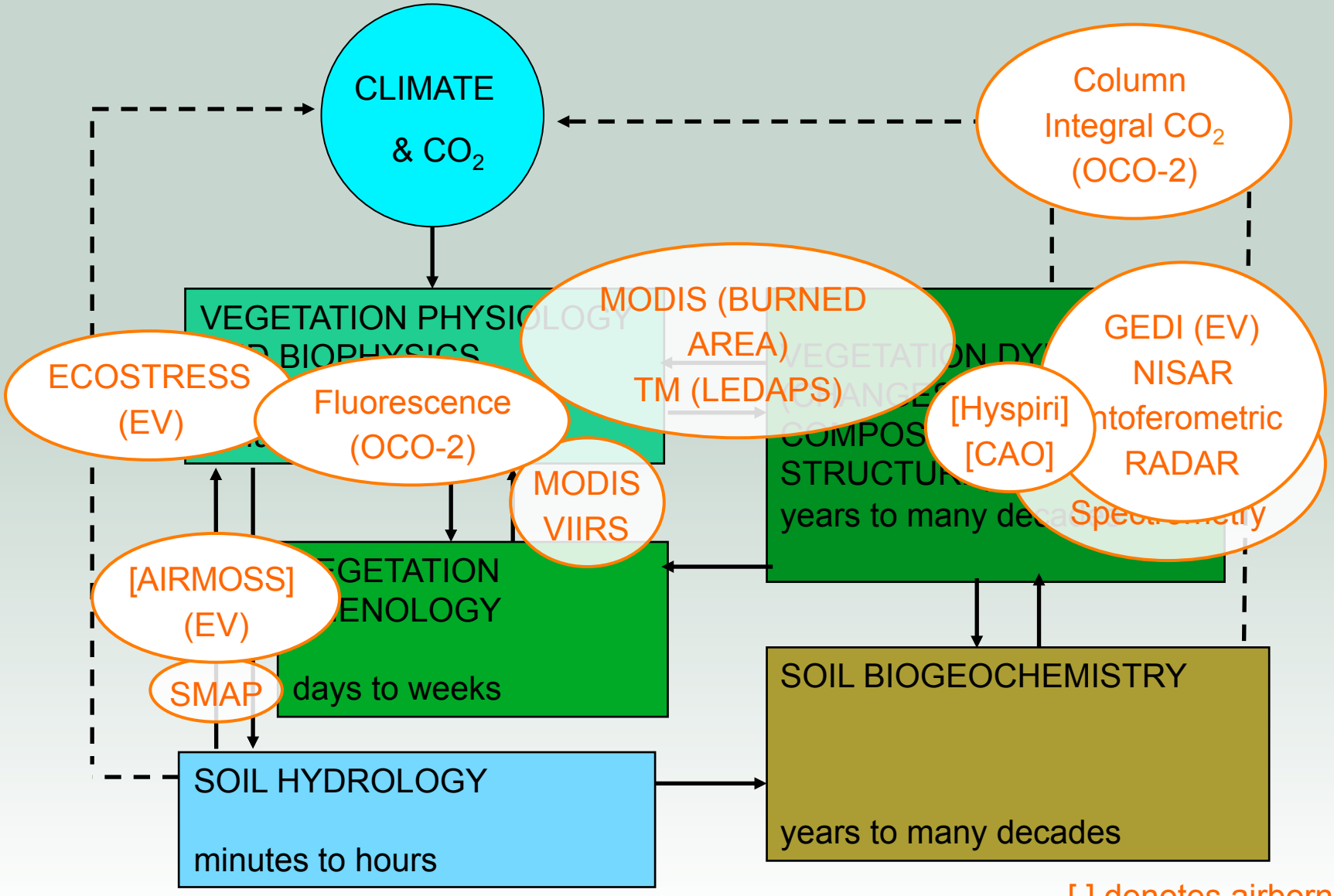
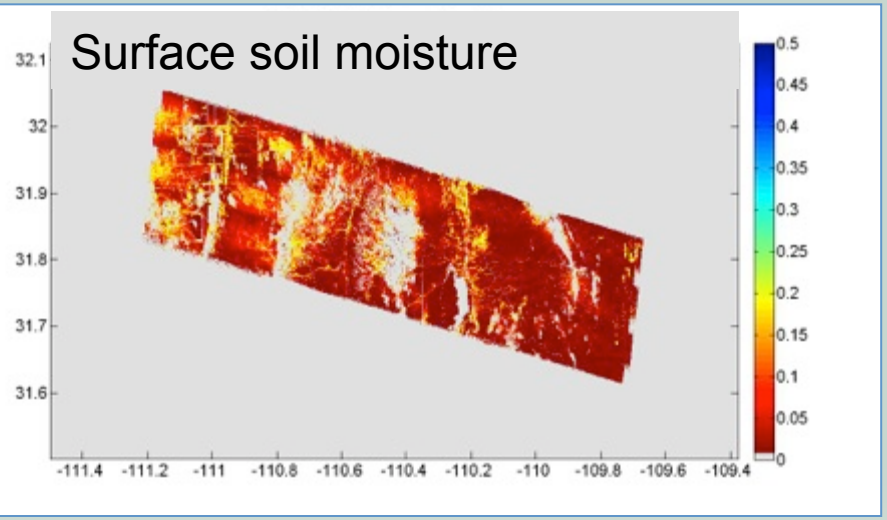
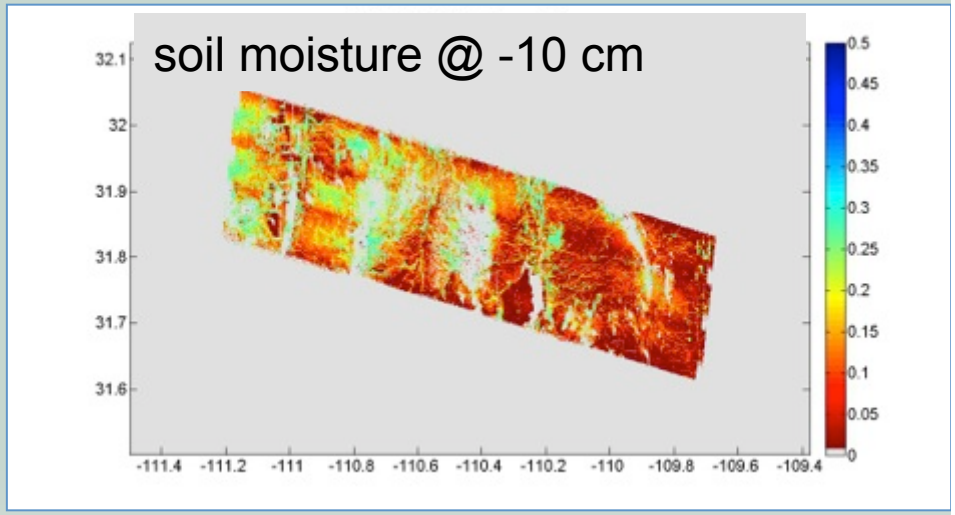


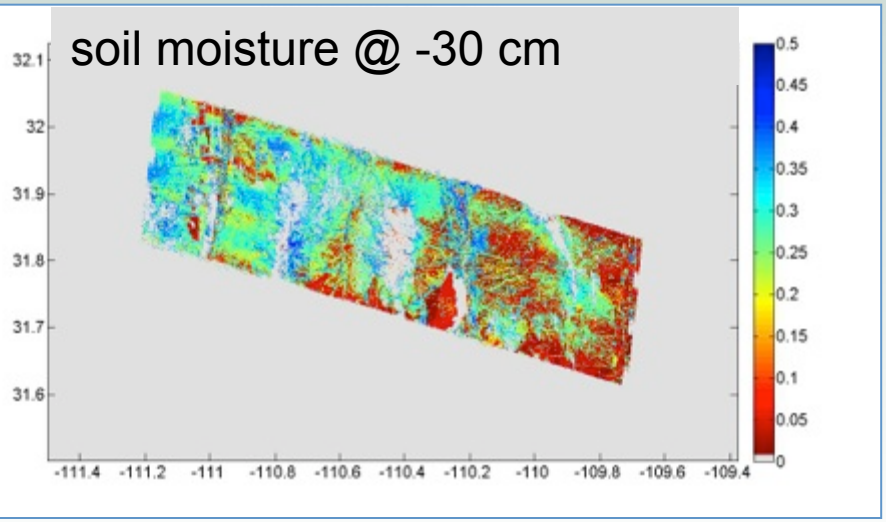
[ ] denotes airborne

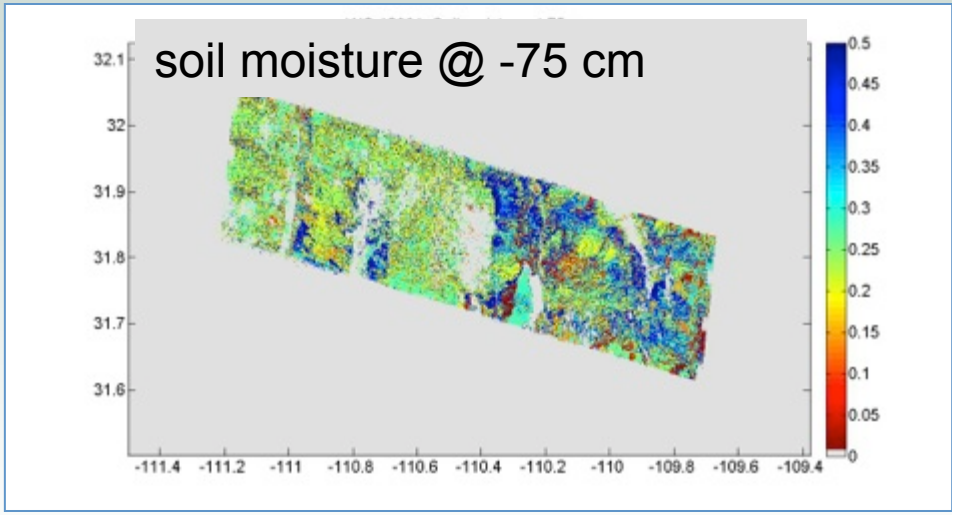
AIRMOSS EV
Walnut Gulch, AZ Subsurface Retrievals
L2/3-RZSM From Radar data 9/20/2012

PI: Mahta Moghaddam
(USC/JPL)







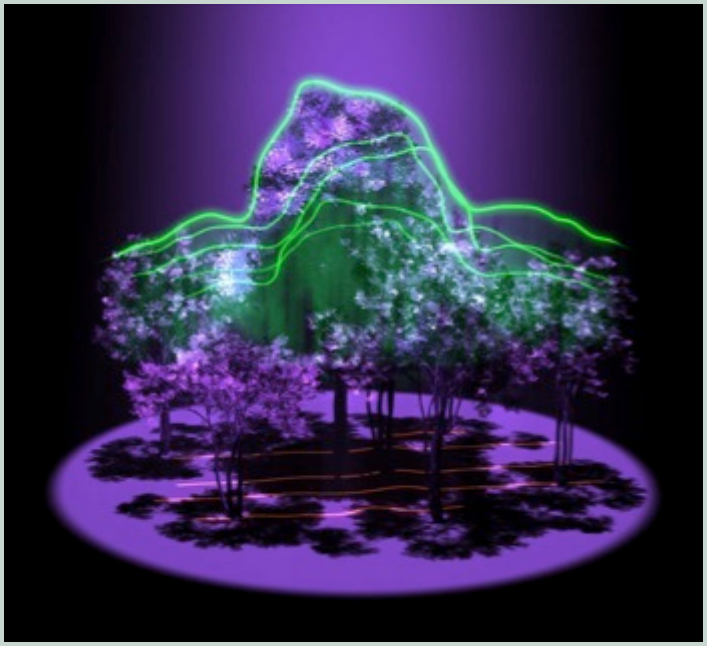


Tabatabaeenejad, A., M. Burgin, and M. Moghaddam, “P-band radar retrieval of subcanopy and subsurface soil moisture profile as a second order polynomial: First AirMOSS results,” IEEE-TGRS, in press.

The Global Ecosystem Dynamics Investigation (GEDI)

Lidar-Based Vegetation structure sampling mission

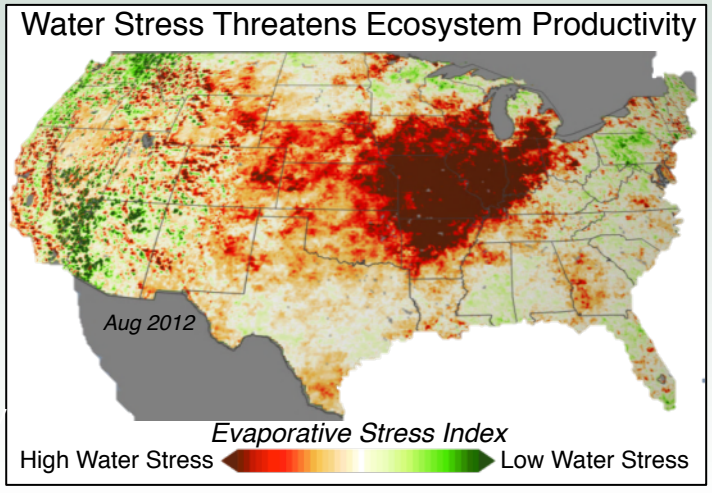
PI: R Dubayah (UMD/GSFC)

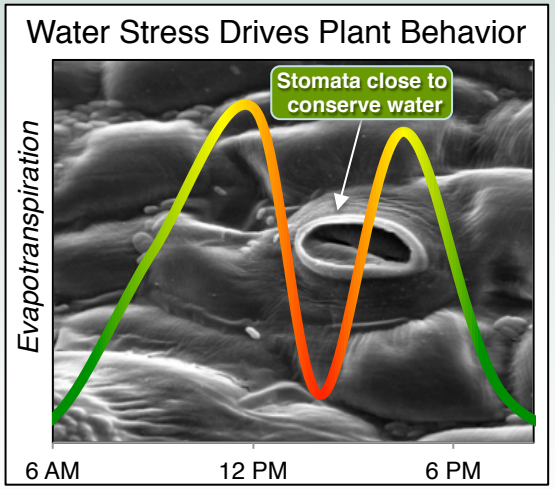


ECOSTRESS

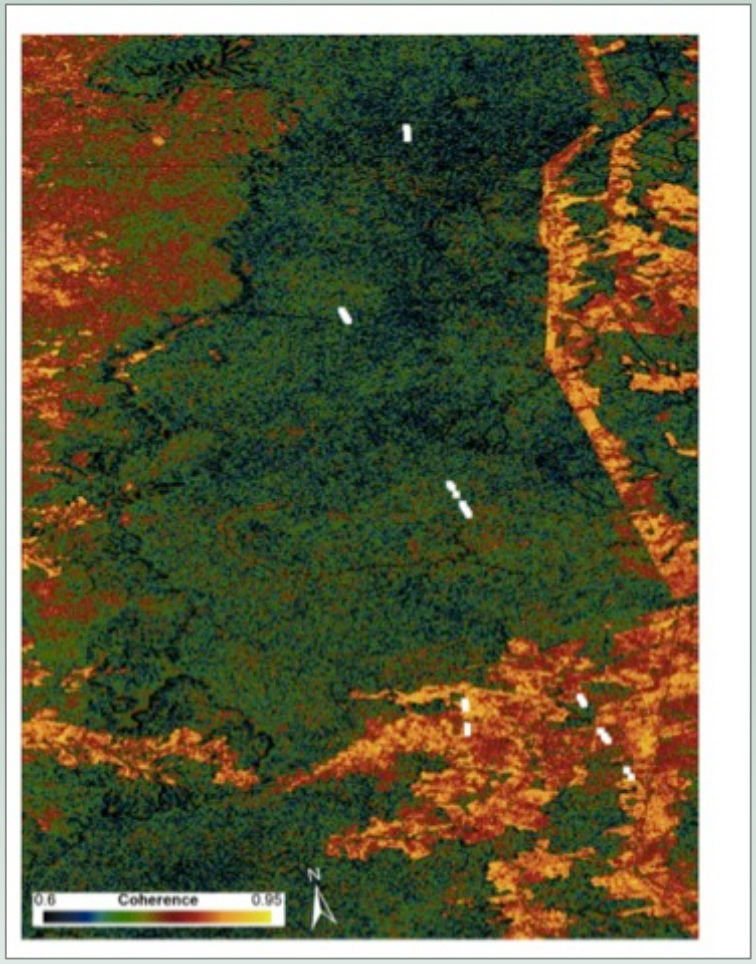
Thermally-based measurements of Plant Water Stress

PI: Simon Hook (JPL)



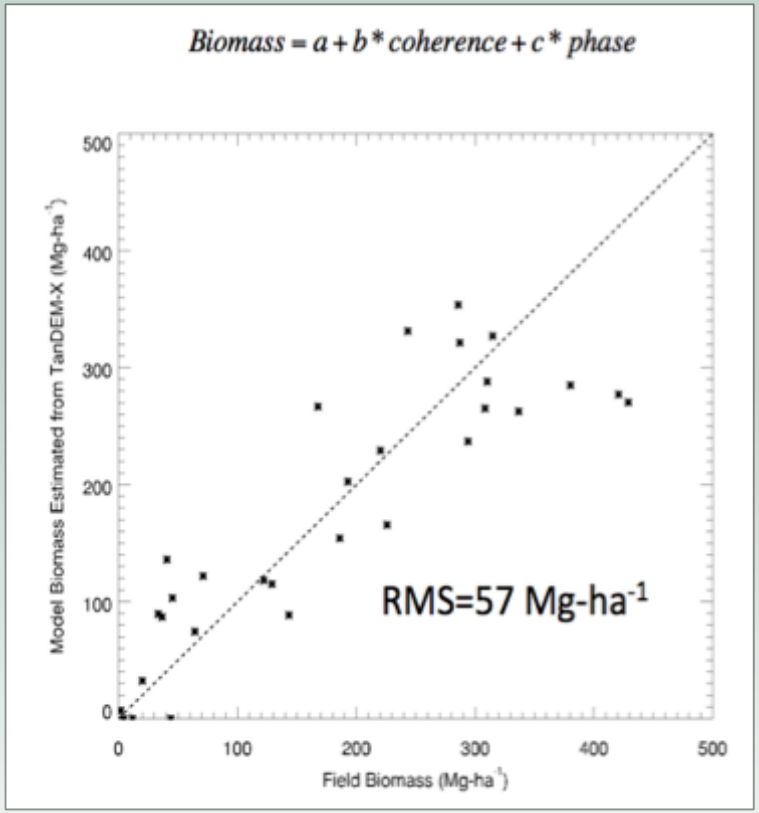


Remote Sensing Measurements of Ecosystem Structure



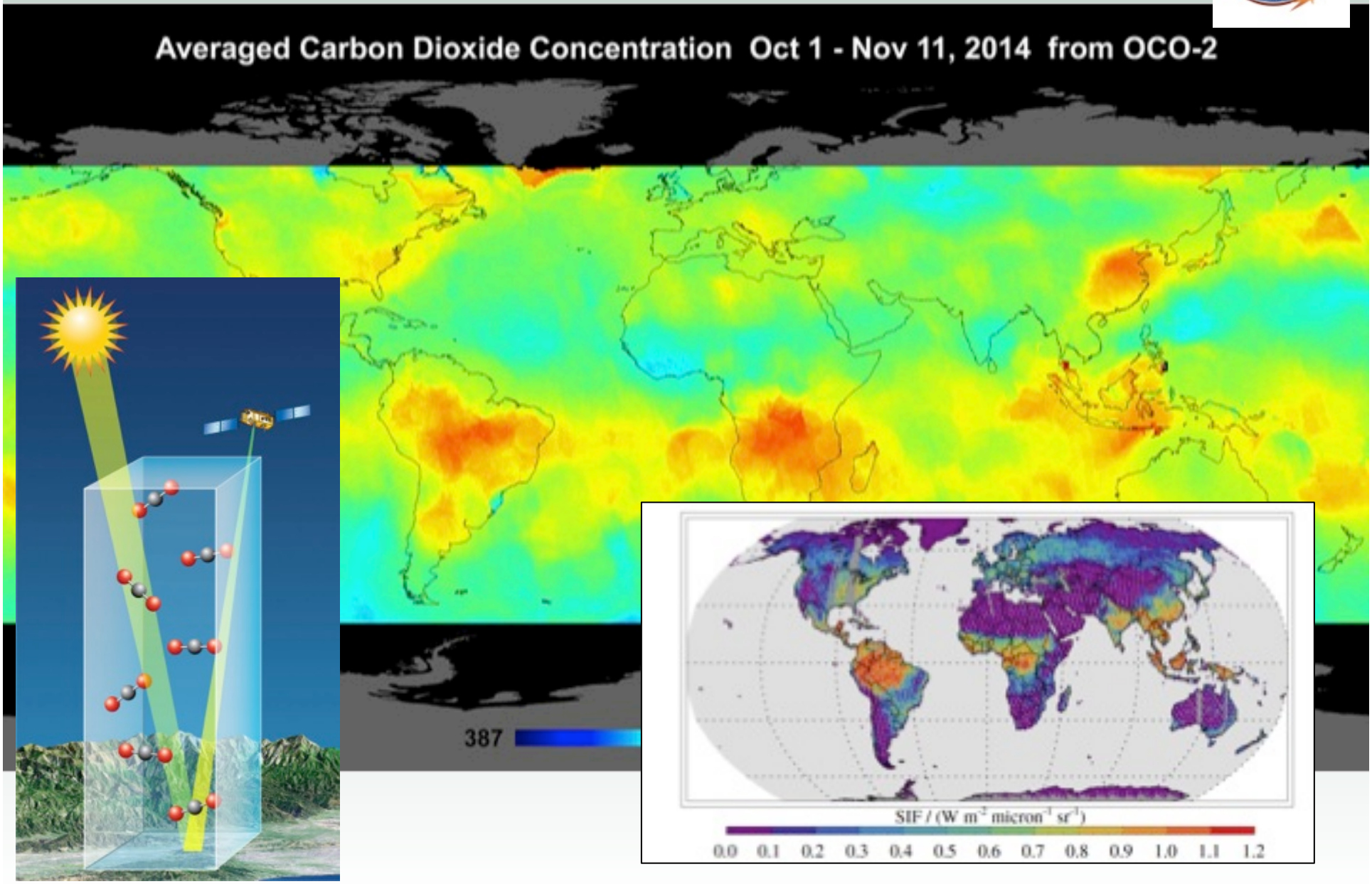
InSAR Coherence from TanDEM-X over a 47km x 18km box of the Tapajos National Forest. The center of the image is at 3.0114°S and 54.9900 °W. The white dots indicate the locations of the 30 sites. Coherence scale is indicated, along with true north. The spacecraft trajectory points downward, parallel to the long side of the box.

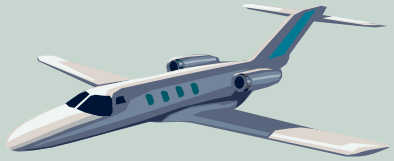
Above-Ground Biomass estimation from TanDEM-X (X-band InSAR) at Tapajos National Forest Brazil



Treuhaft et al. (2014)

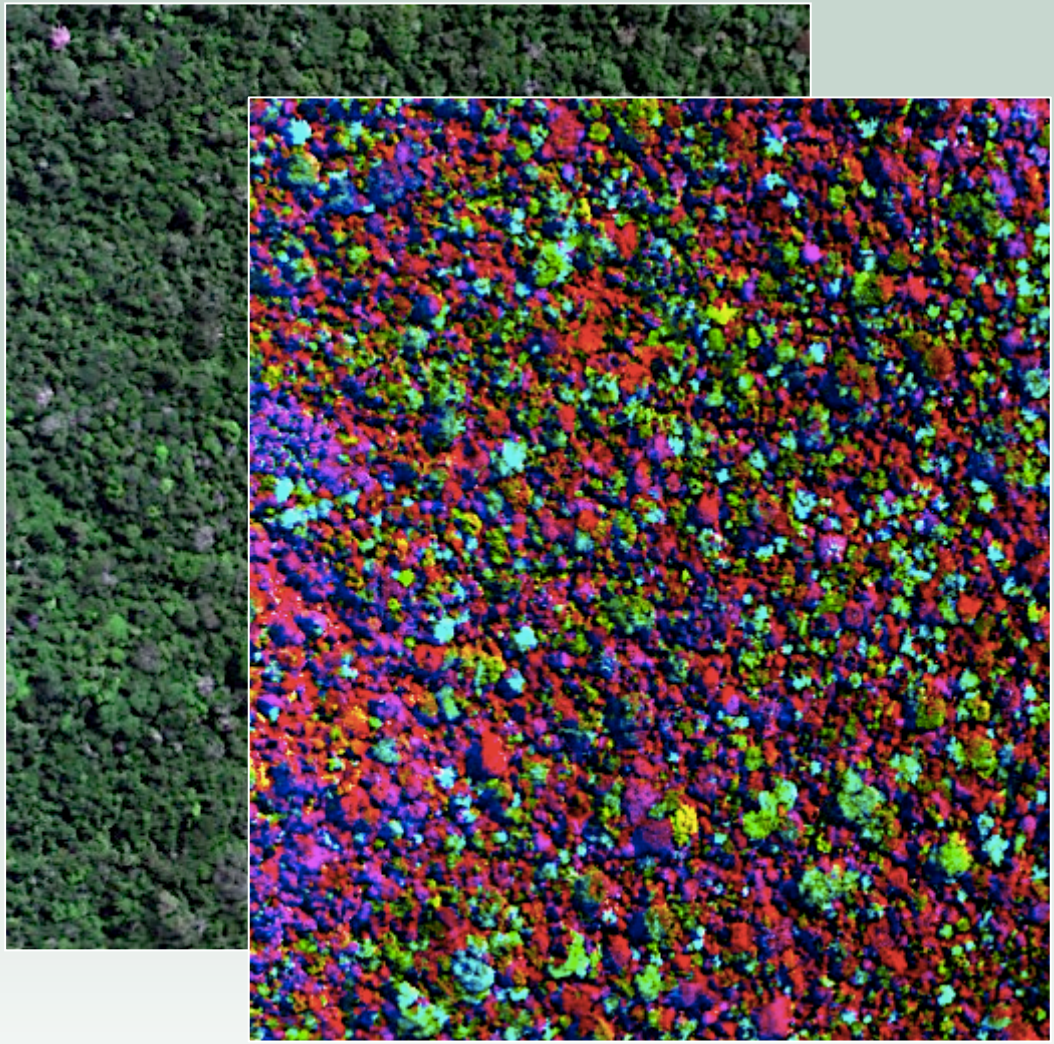
Orbiting Carbon Observatory (OCO-2)



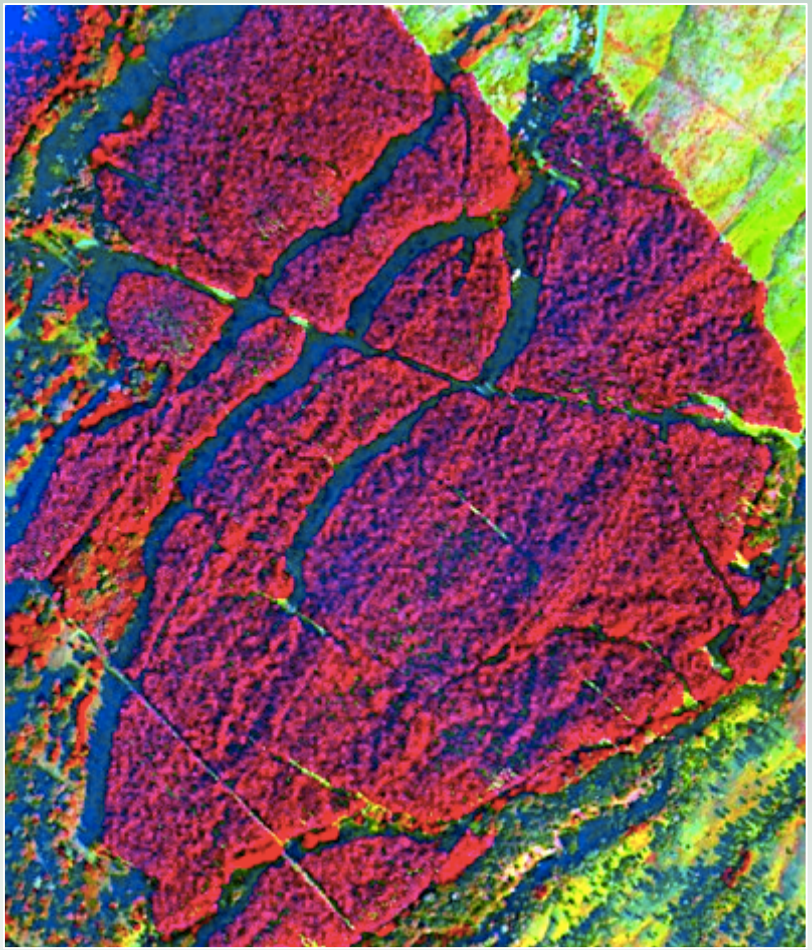


Laser-guided Spectroscopy

Asner, Martin *et al.* Carnegie Airborne Observatory



High functional diversity

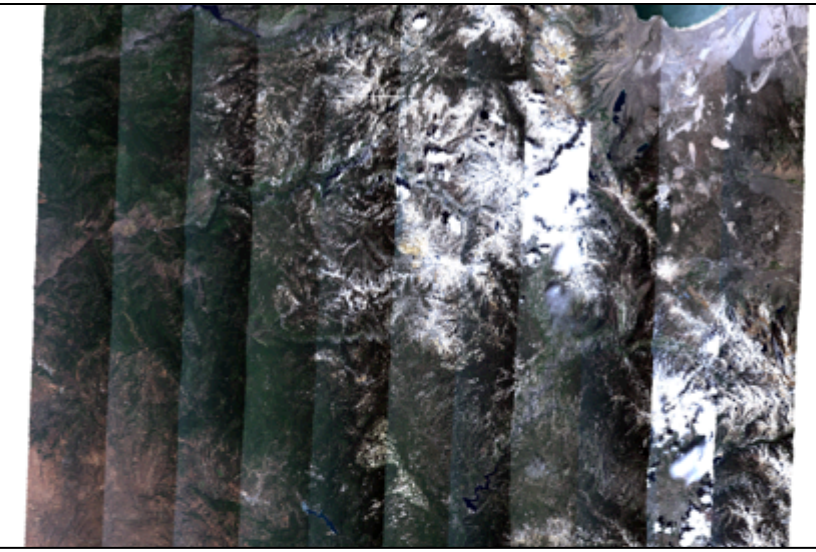


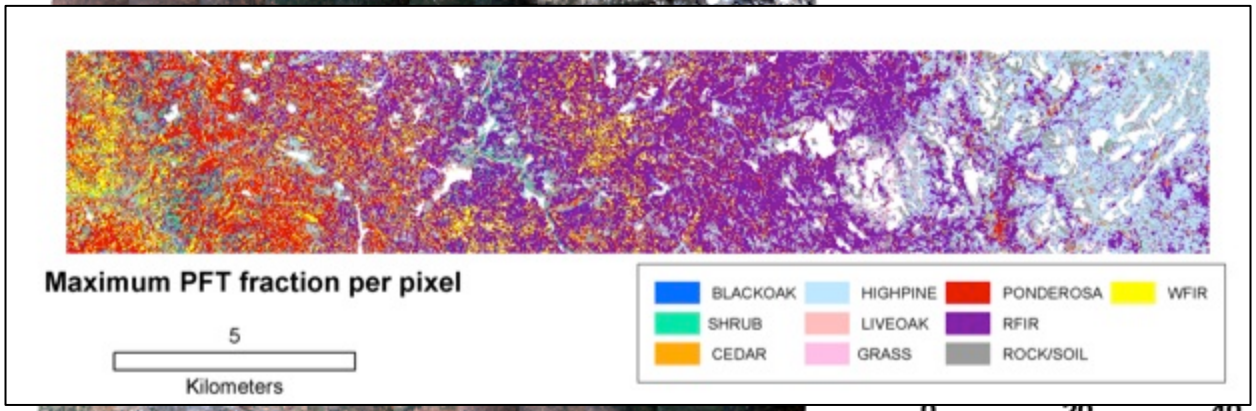
Low functional diversity

Remote Sensing Measurements of Ecosystem Composition

HyspIRI Preparatory Airborne Science Mission

Estimates of ecosystem composition obtained from imaging spectrometry (Bogan et al. unpubl)

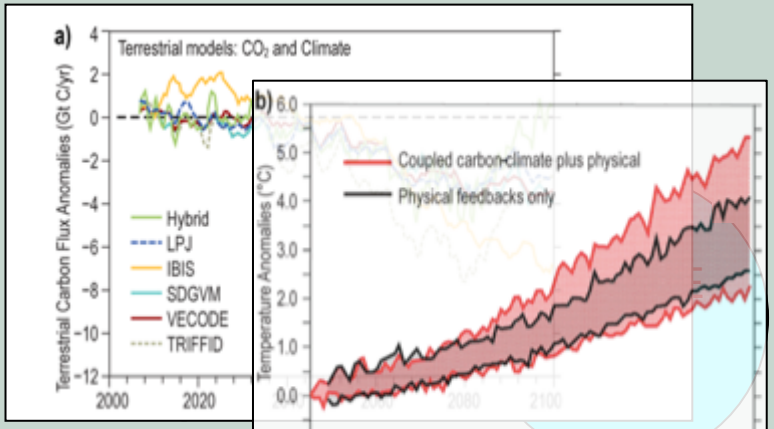




0 20 40
Kilometers

Conclusions

- The current and planned NASA Earth Observation System (EOS) has a high potential to constrain Dynamic Global Vegetation Model (DGVM) predictions for the fate of the terrestrial biosphere over the coming century.



Column Integral CO_2 (OCO-2)

MODIS (BURNED AREA)
TM (LEDAPS)

ECOSTRESS (EV)

Fluorescence (OCO-2)

MODIS VIIRS

GEDI (EV)
NISAR
[Hyspiri]
[CAO]
RADAR
Spectrometry

From the MTPE Website (1997): "MTPE addresses the fundamental question: How can we utilize the knowledge of the Sun, Earth, and other planetary bodies to develop predictive environmental, climatic, natural disaster, and natural resource models to help ensure sustainable development and improve the quality of life on Earth?"

minutes to hours

years to many decades

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References:

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