Terrestrial ecosystem analysis using MODIS data

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Petr Votava, Andy Michaelis, Kazuhito Itchii, CSU Monterey Bay
Marcus Reichstein, Potsdam Institute, Germany
Feihua Yang, University of Wisconsin
Chris Field, Carnegie Inst., Stanford University
Chris Potter, ARC
Clark Glymour and Brian Bonnlander, Carnegie Mellon U.

MODIS Science team meeting, March 22, 2005

Outline

Prognostic/Diagnostic Analysis of Ecosystem dynamics

monitoring/modeling/forecasting System

snow cover (Snotel/MODIS)

gross primary production (Fluxnet/MODIS)

Data-driven models

carbon/Water fluxes (Fluxnet/MODIS)

wildland fire risk

MODIS data in global carbon cycling studies

mapping near-real time NPP anomalies

tropical ecosystems – new insights from MODIS

MODIS data in modeling: issues needing further attention

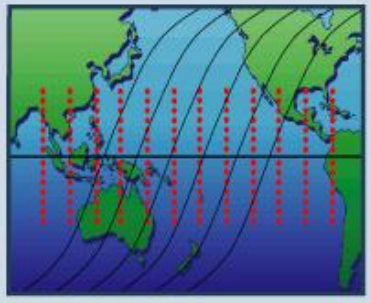
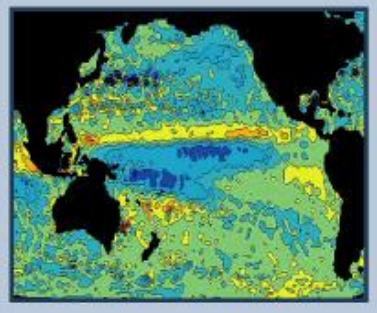
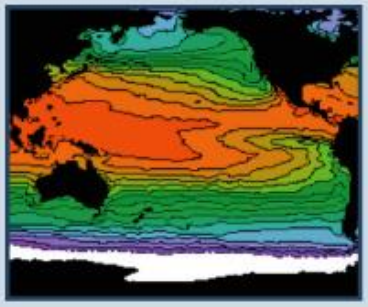
The Grand Vision

Downlink Speed

Petabytes 10^{15}	Terabytes 10^{12}	Gigabytes 10^{9}	Megabytes 10^{6}
Multi-platform, multiparameter, high spatial and temporal resolution, remote & in-situ sensing	Calibration, Transformation To Characterized Geo-physical Parameters	Interaction Between Modeling/Forecasting and Observation Systems	Interactive Dissemination and Predictions
Advanced Sensors	**Data Processing & Analysis**	**Information Synthesis**	**Access to Knowledge**






Monitoring, modeling and prediction

Terrestrial Observation and Prediction System

NASA Satellites

~1.5 TB/day

Ground Obs. Networks

Ancillary Data

Topography, River Networks, Soils, Biodiversity . . .

10-100 MB/day

EOSDIS

250+ products, > 2 Petabytes

.1-10 TB

Ecocast Architecture

IMAGEbot Planner

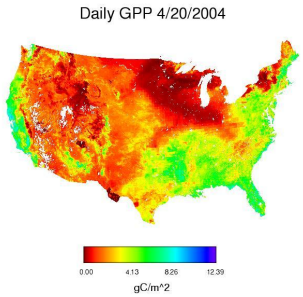
Optimizes data processing plans and retrieves appropriate data for analyses

TOPS

Biospheric models for ecological nowcasting / forecasting from data

Causal Discovery

Autonomous analysis of data for discovery of novel causal models; integrated with TOPS for model validation

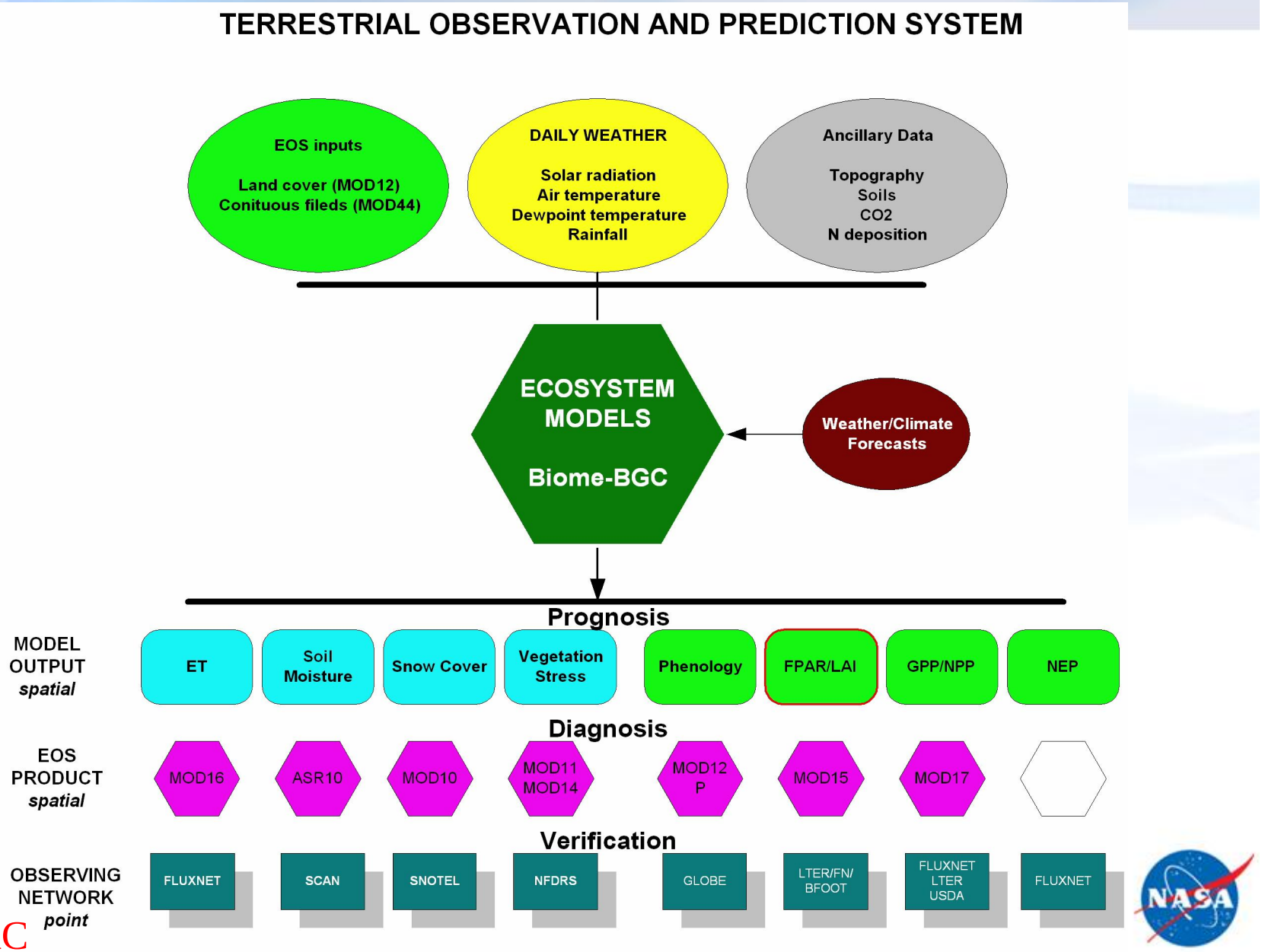


Data Overload:
1-100 TB
Massive data sets, multiple products, heterogeneous data types

Knowledge:
100K to 10 MB
Daily nowcast and forecast maps, integrated datasets, images, causal models

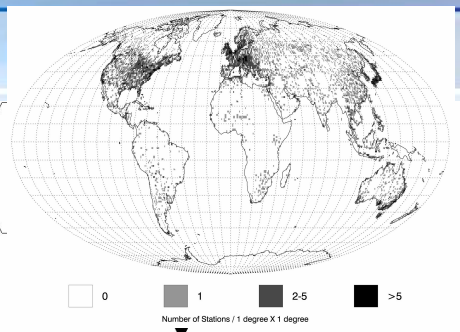
enabling information integration

Prognostic/Diagnostic Analysis



Gridding climate data

Daily weather data from Over 6000 stations worldwide



Data Retrieval

Data Retrieval and Processing

Scheduler

Unattended

SQL Database

Storage

Modular

Observations (X,Y,Z,R)

Prediction Points (X0,Y0,Z0)

Interpolation Logic

Prediction (R0)

Crossvalidation Statistics

Interpolation Logic

Prediction Control

Interpolation

Ancillary Inputs

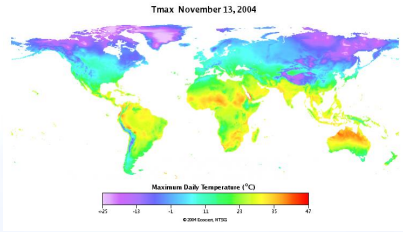
Any user Defined grid

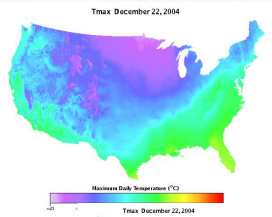
Output Handling

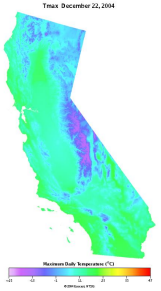
Predictions

Output

Tmax / Tmin
VPD, precipitation
Solar radiation
Daylength





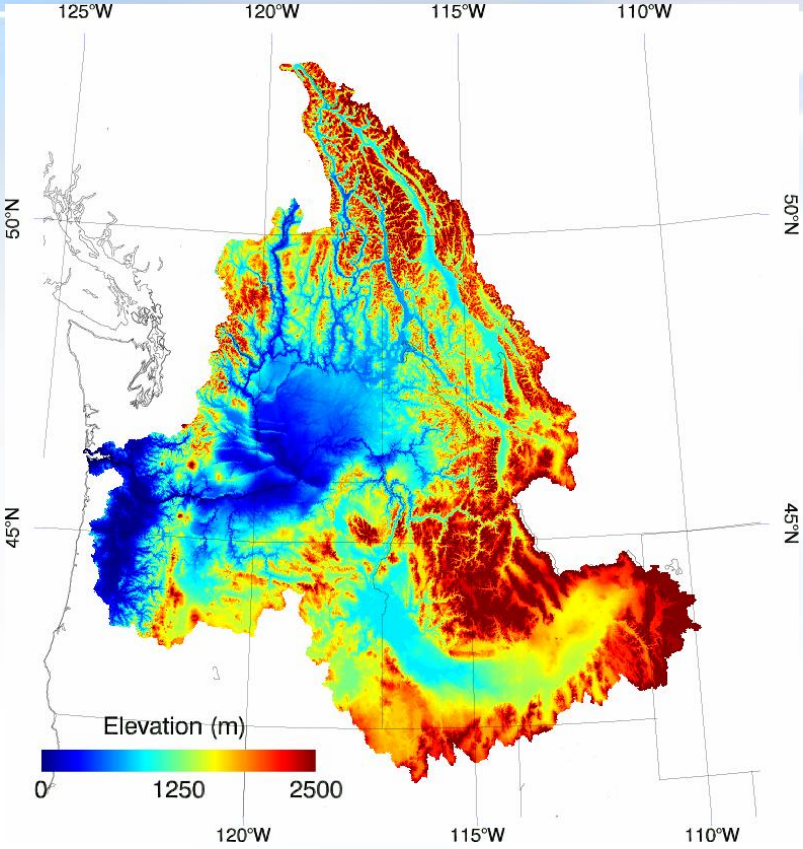


Jolly, nemani, Running…. 2004. Envi. Modeling and Software

Regional Application :Columbia River Basin

Satellite Data

e.g. Land Cover
LAI, FPAR



Ground Obs. Data

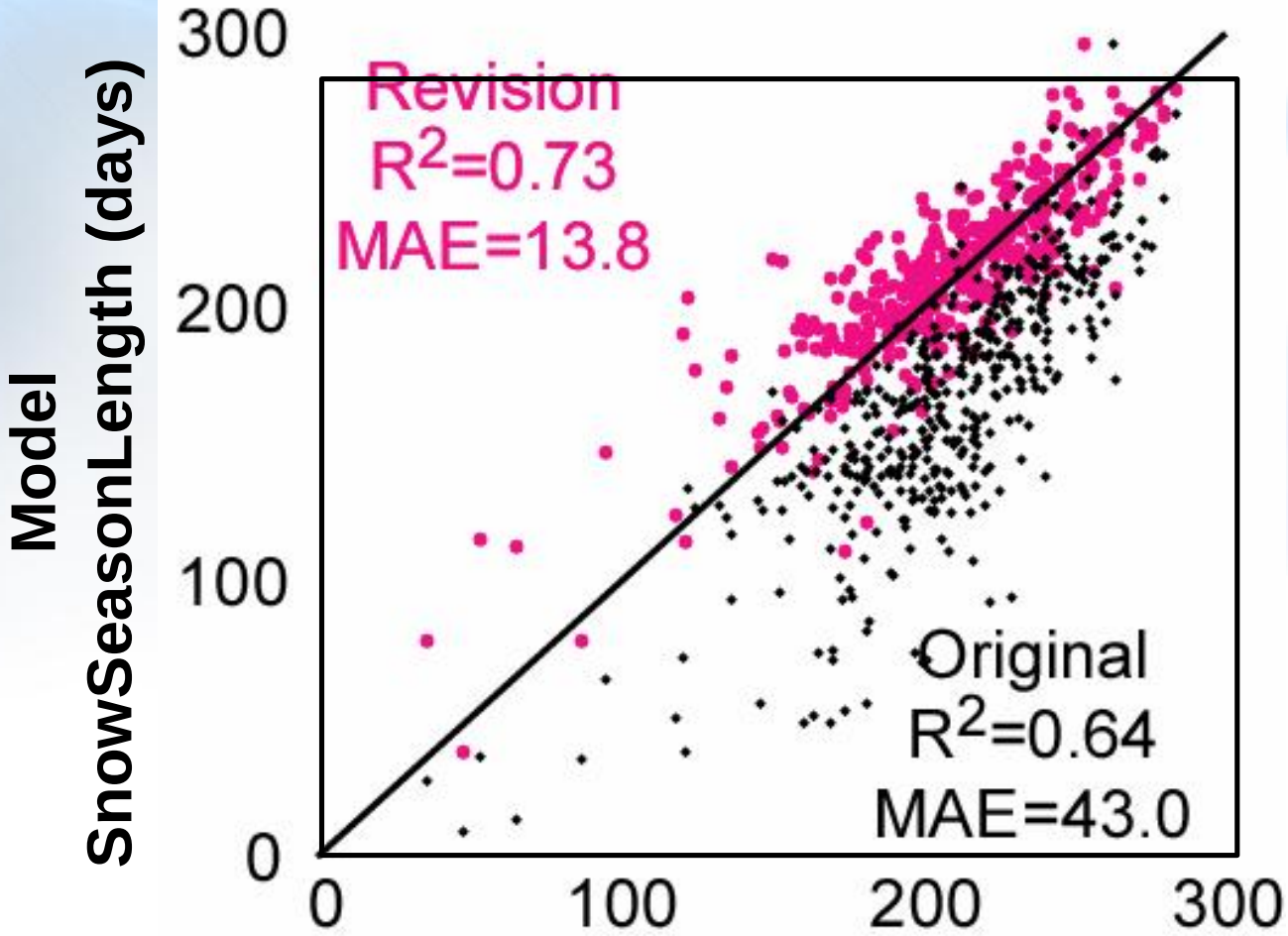
e.g. T, Prec,
VPD, Rad

Ecosystem Models (TOPS, Biome-BGC)

Soil Water, Snow, GPP, NPP, NEE

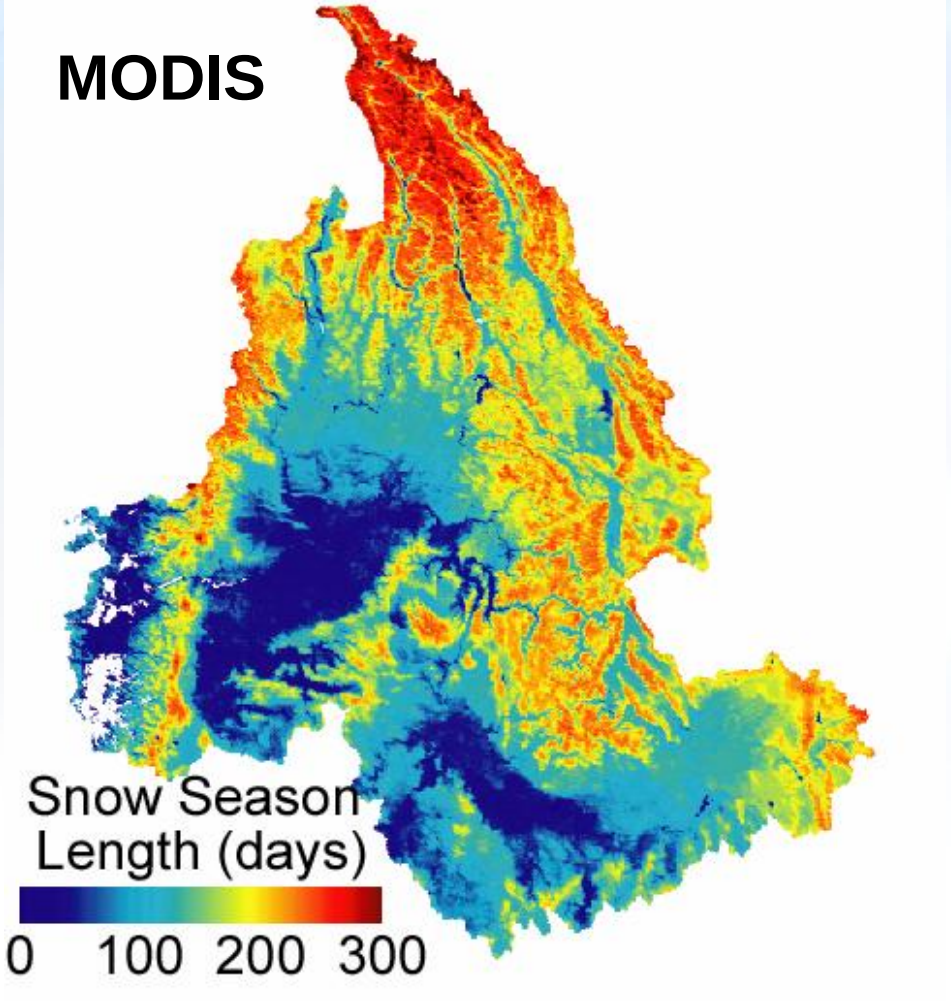
Improvement of Snow Model

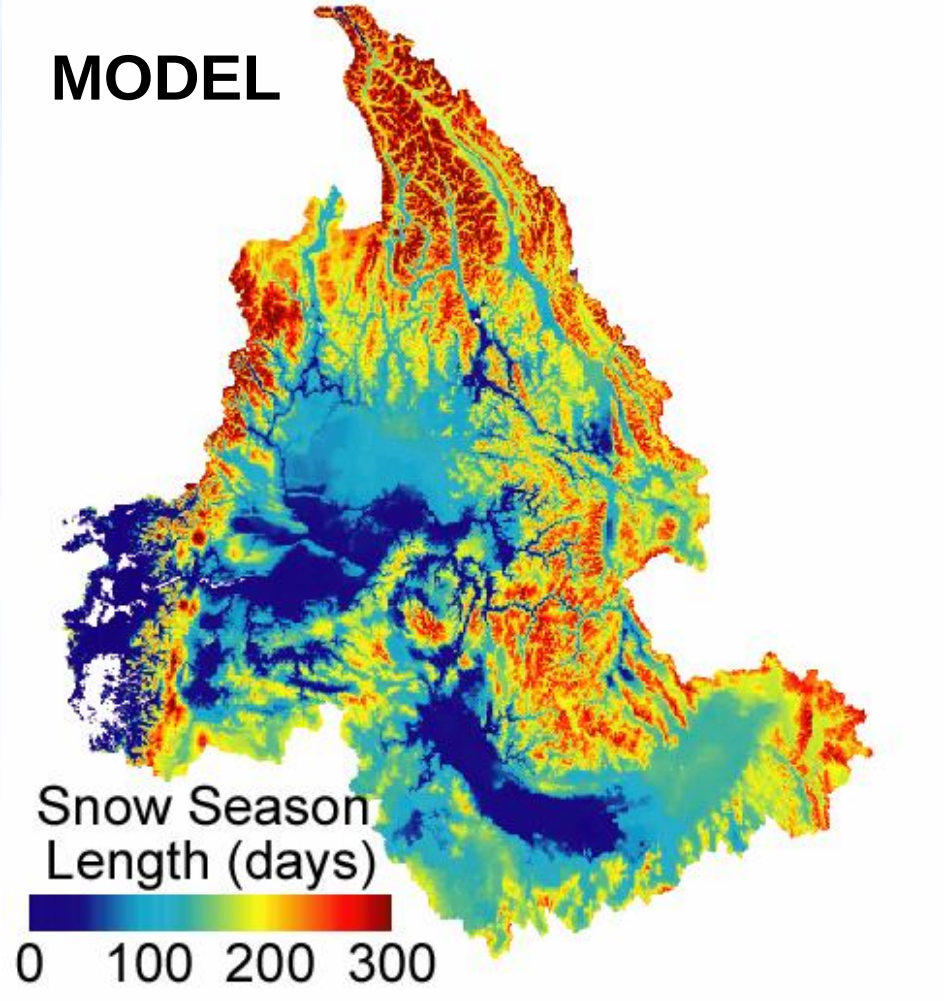
Empirical Model ⟶ Process-based Model



Itchii/Votava/Michaelis CSUMB

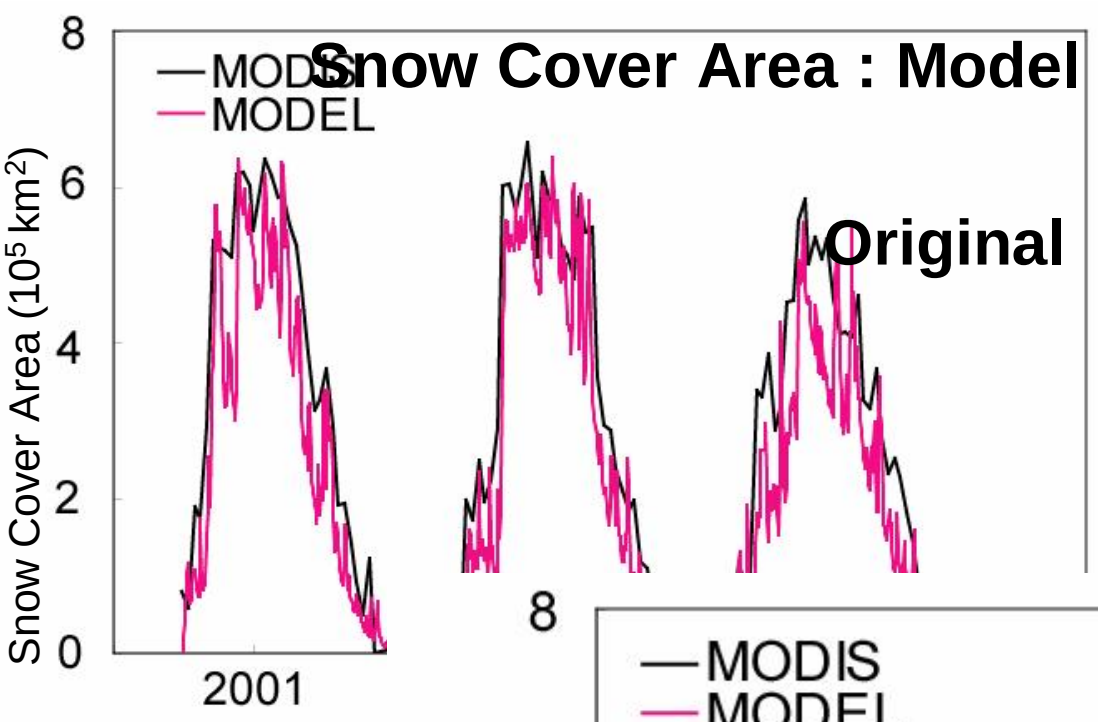
Improvement of Snow Model



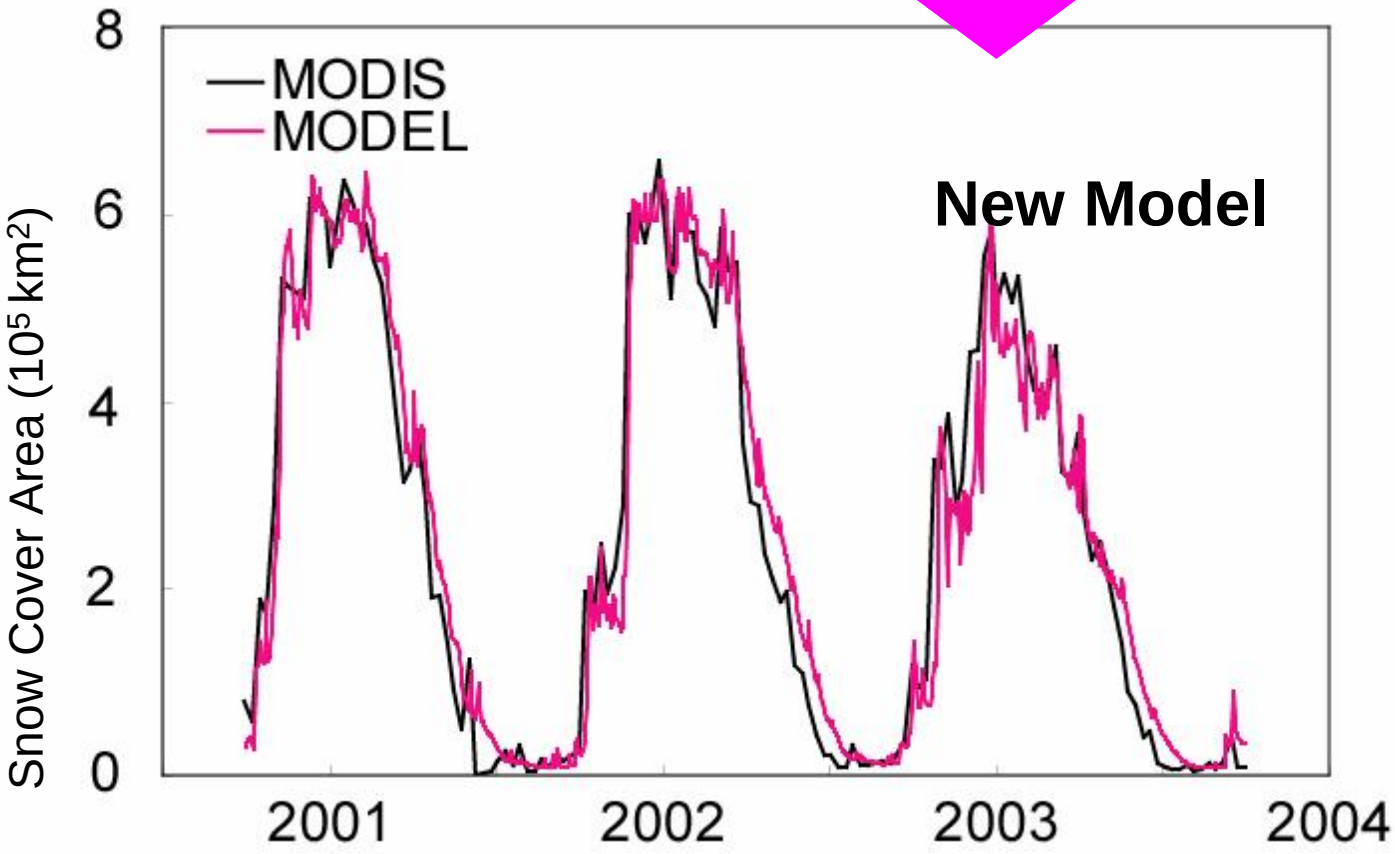


Itchii/Votava/Michaelis CSUMB

Snow Cover Area : Model vs MODIS

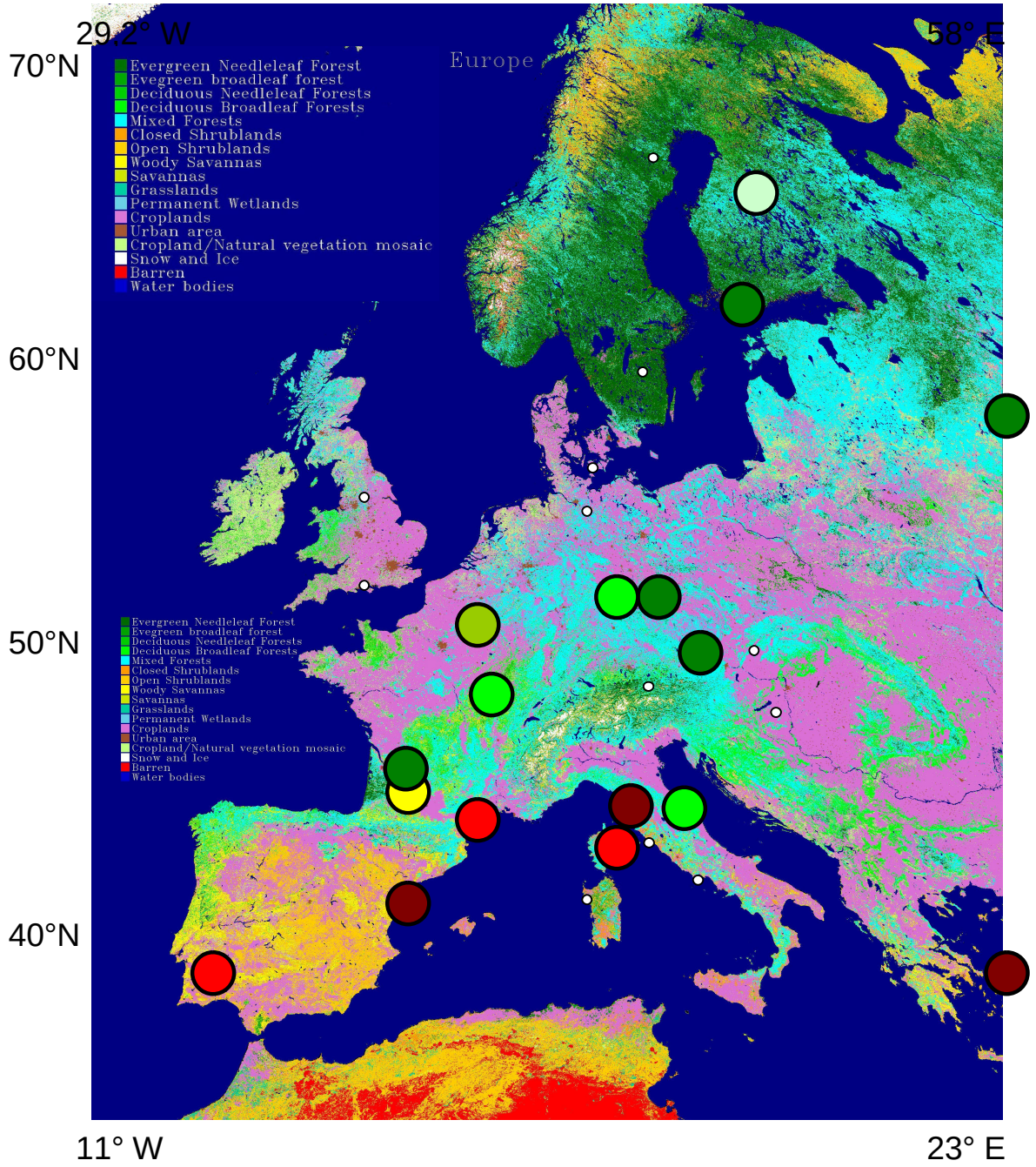


Original



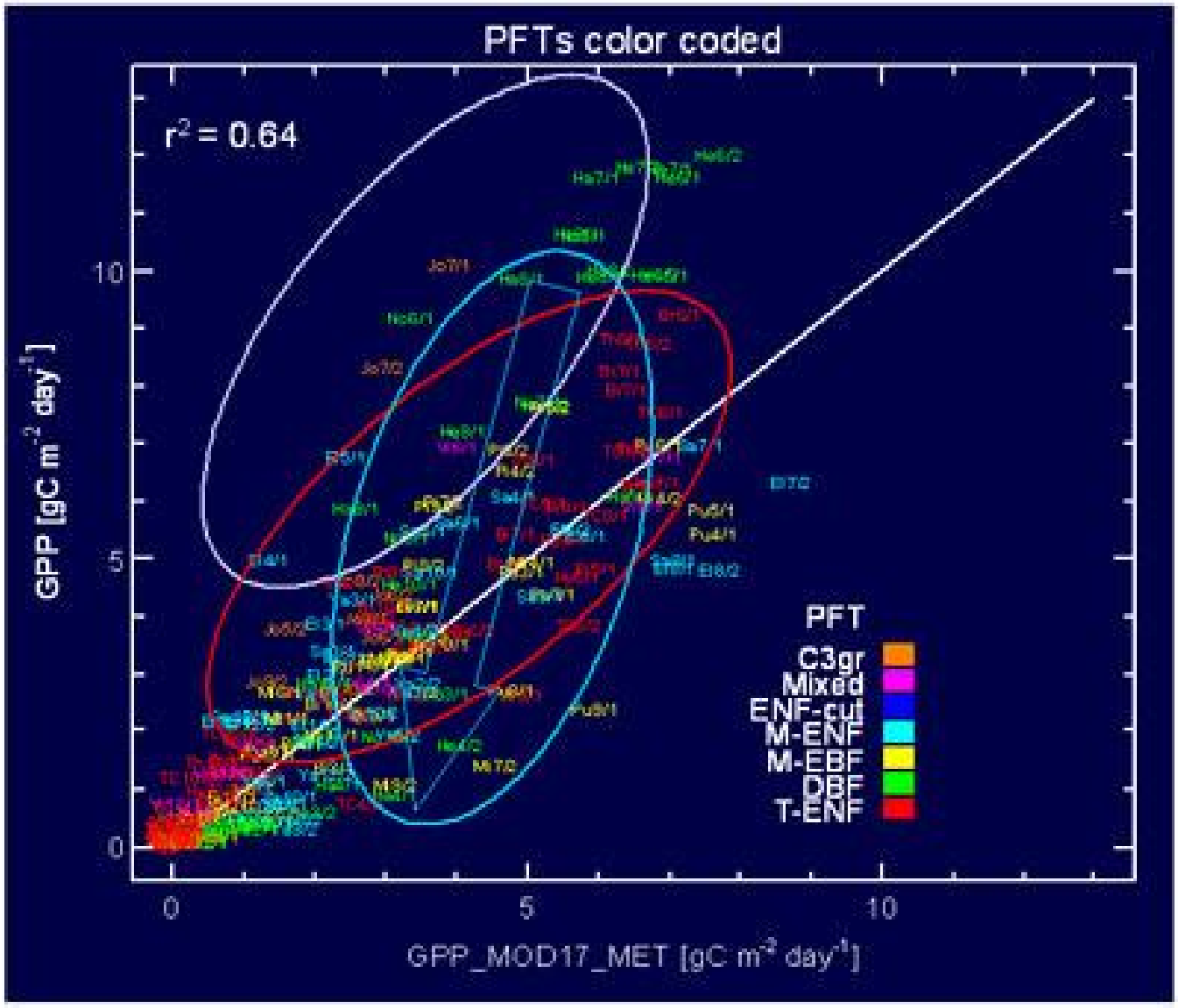
New Model

European eddy covariance network on MODIS Land-cover grid



Markus Reichstein, Carboeurope

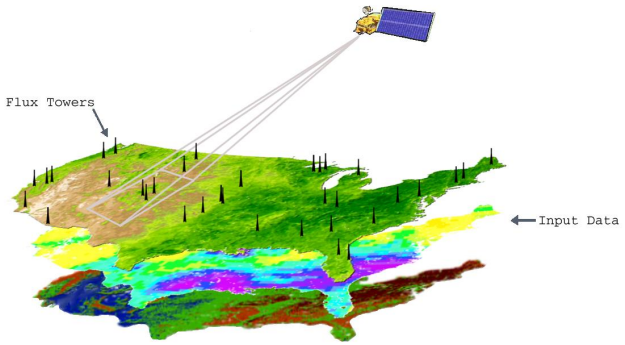
Updating MODIS GPP algorithm parameters LUE_{max}

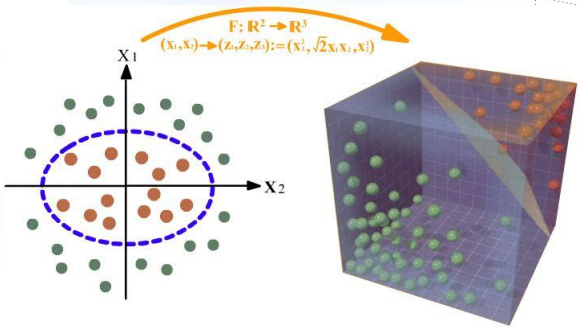


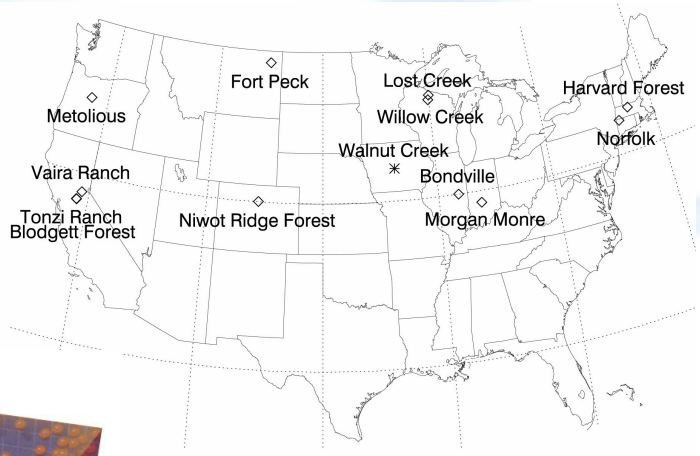
Markus Reichstein, Carboeurope

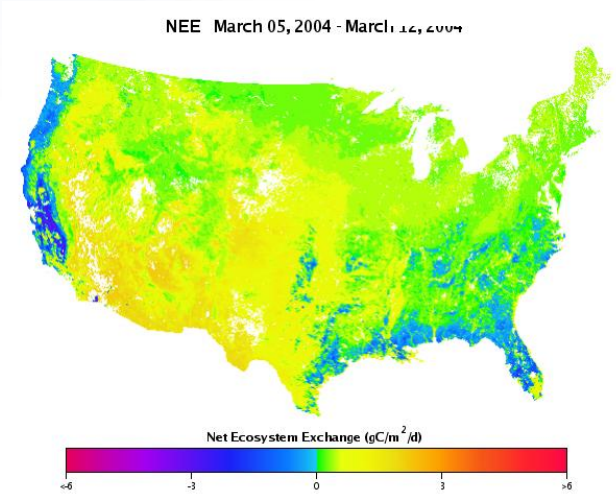
Data-driven models

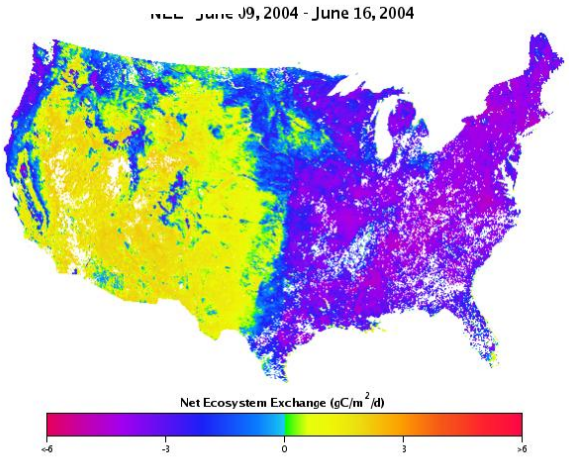
Extrapolating fluxtower observations using MODIS









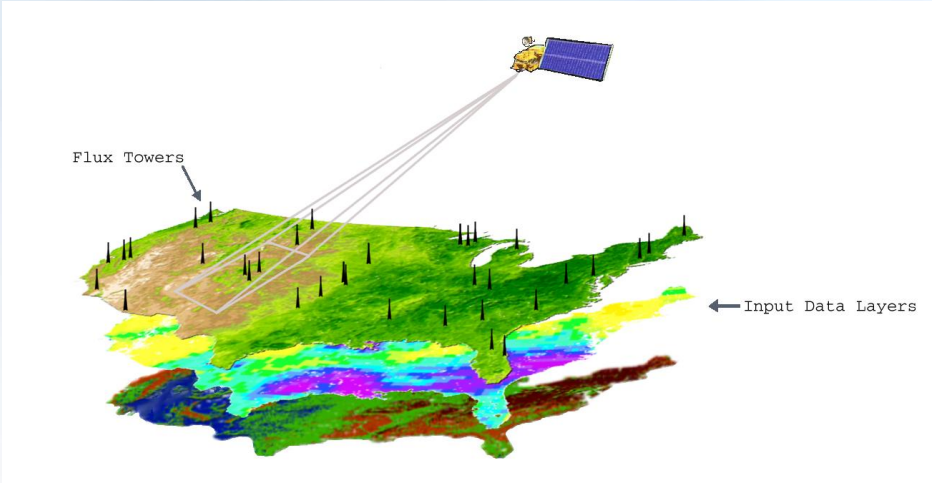


Feihua Yang, University of Wisconsin

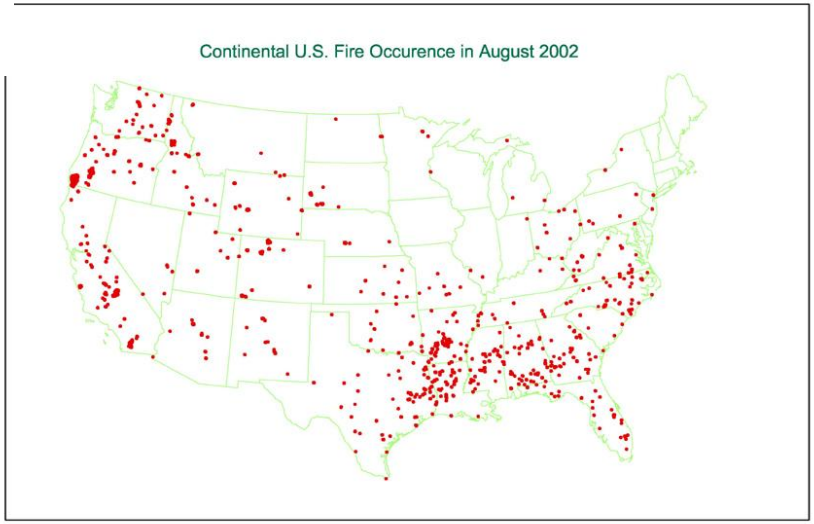
Data-driven models

MODIS data in mapping wildland fire risk

Train the algorithms on all the non-arson fires during 2000-2002

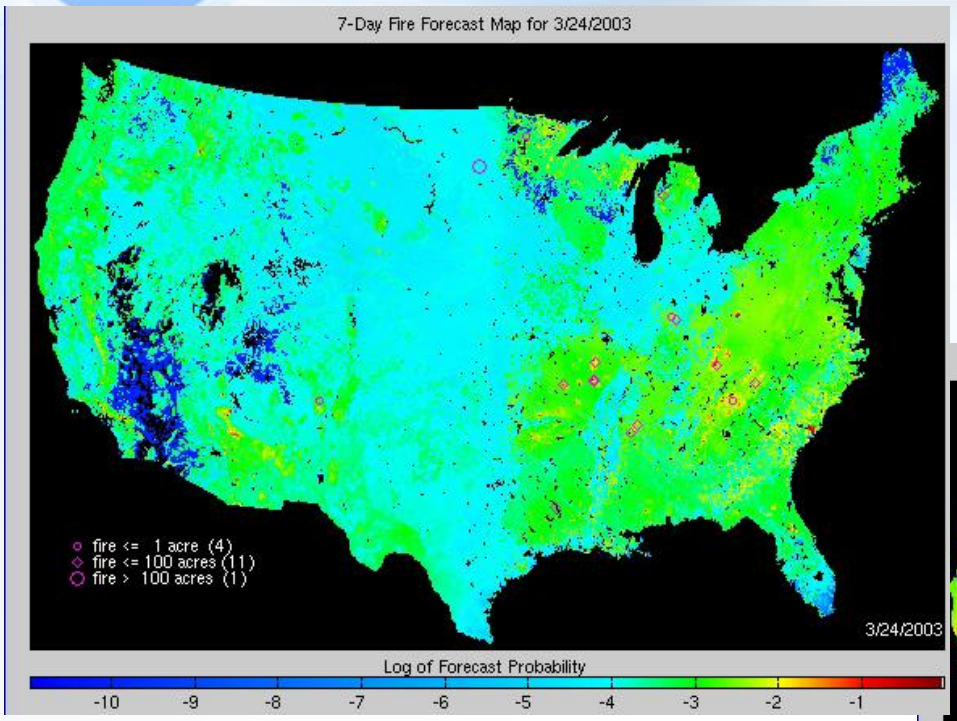


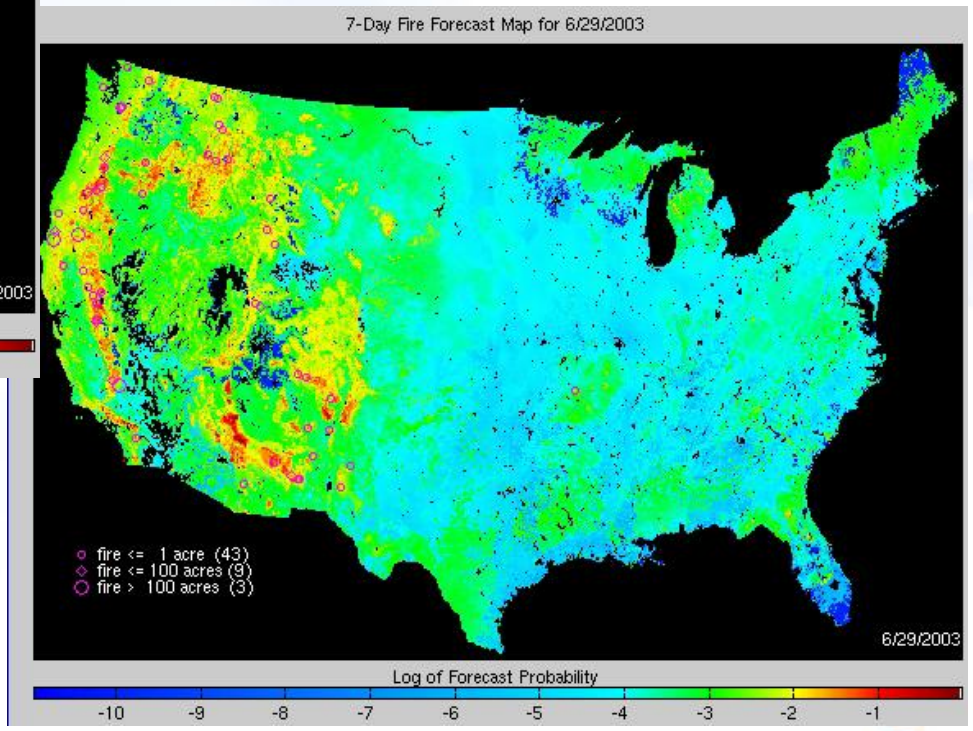
Methods include:
Support Vector Machines
Artificial Neural Networks
Logistic Regression



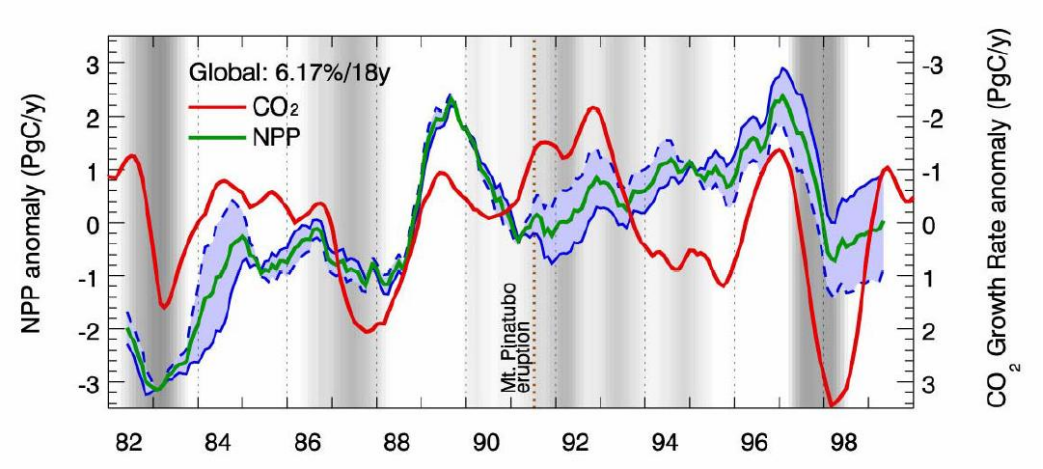
Brian Bonnlander/Clark Glymour/Votava, IHMC/ARC

Predicting fire risk



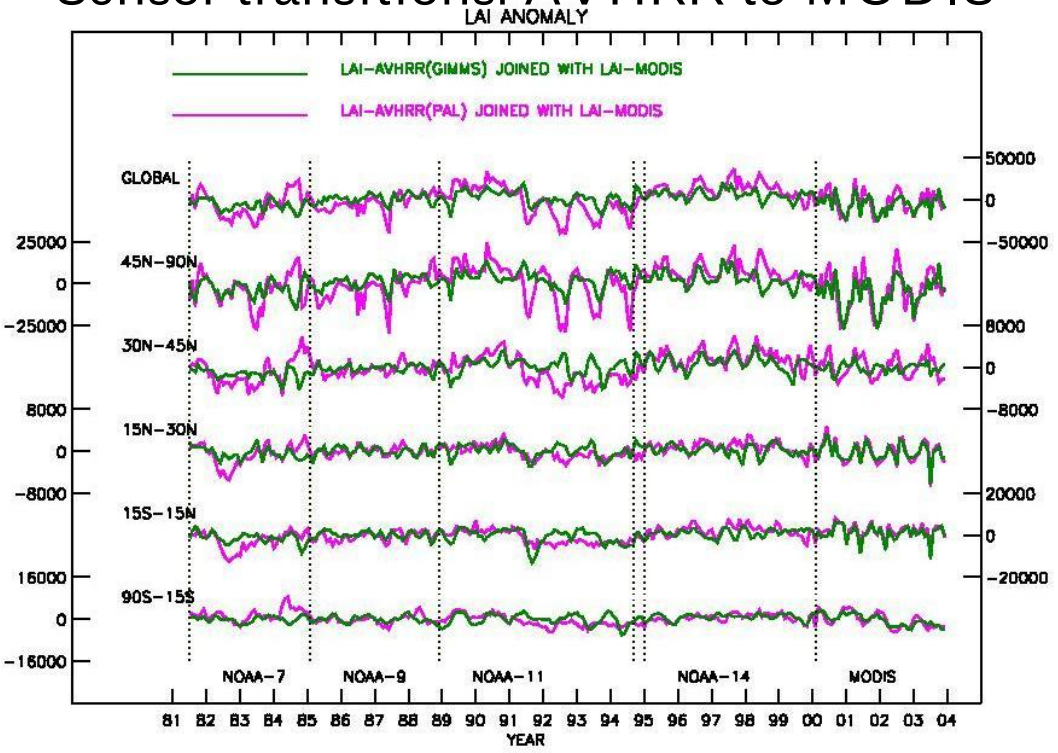


Brian Bonnlander/Clark Glymour/Votava, IHMC/ARC



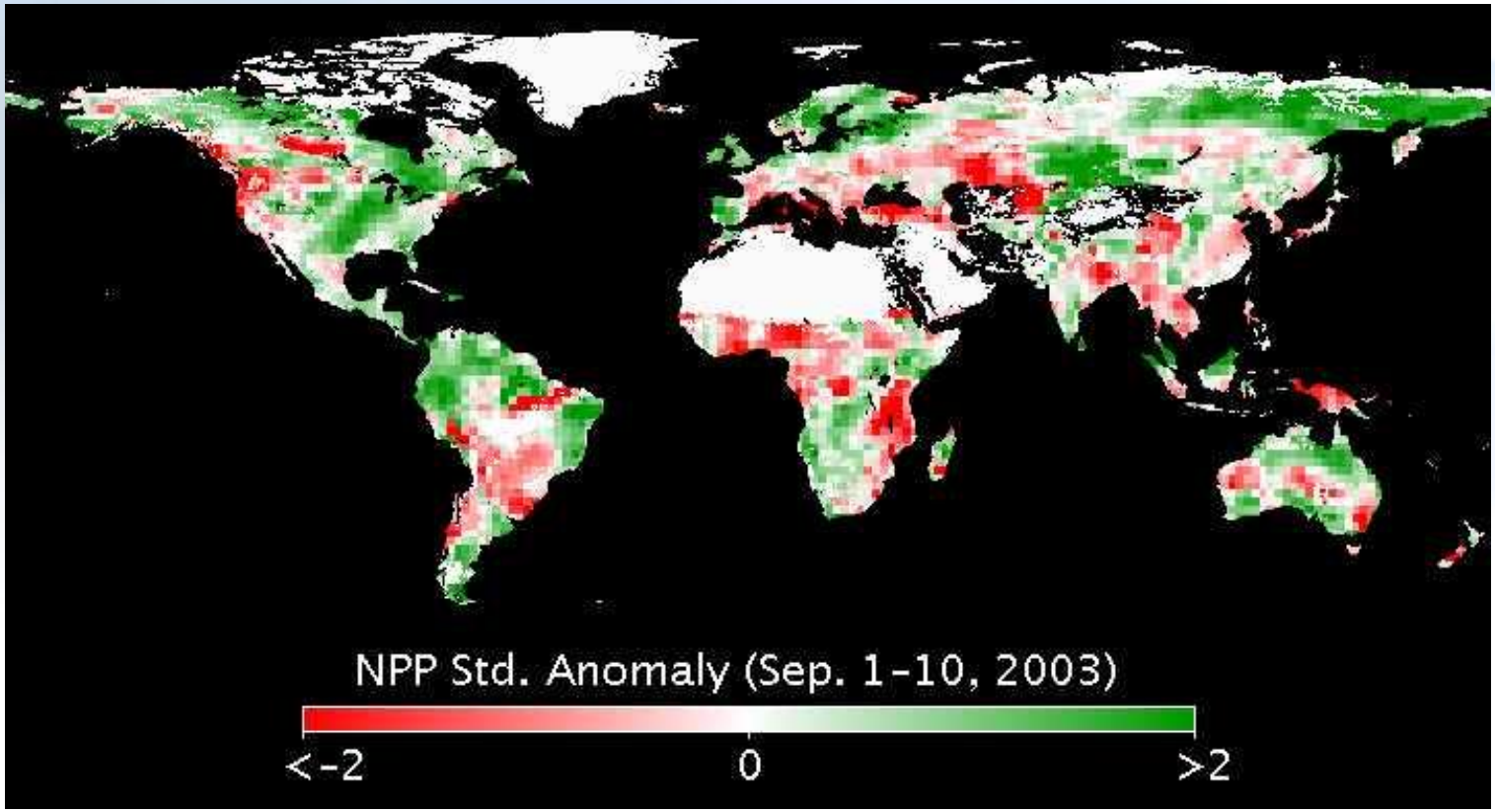
Biospheric activity and atmospheric CO_2

Sensor transitions: AVHRR to MODIS



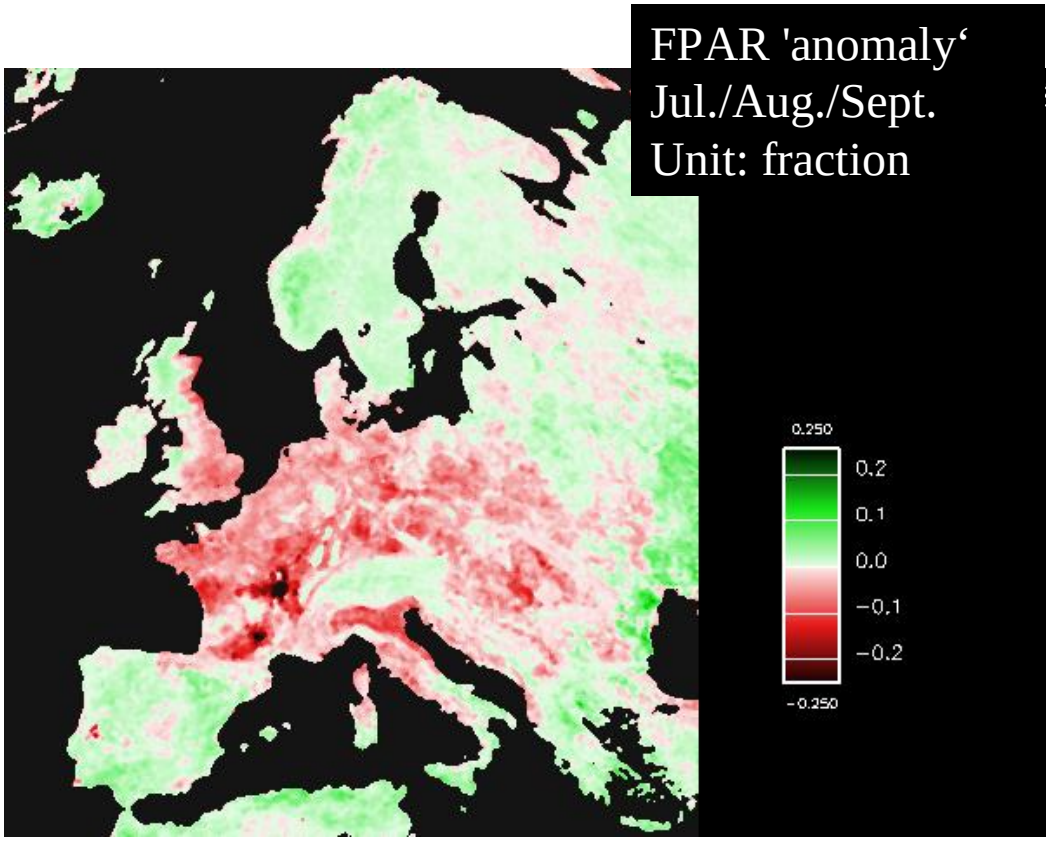
Myneni / Cliveg group / BU

TOPS enables Biospheric Monitoring Near Realtime



Based on Running, S.W and R.R. Nemani et al., Bioscience, 2004

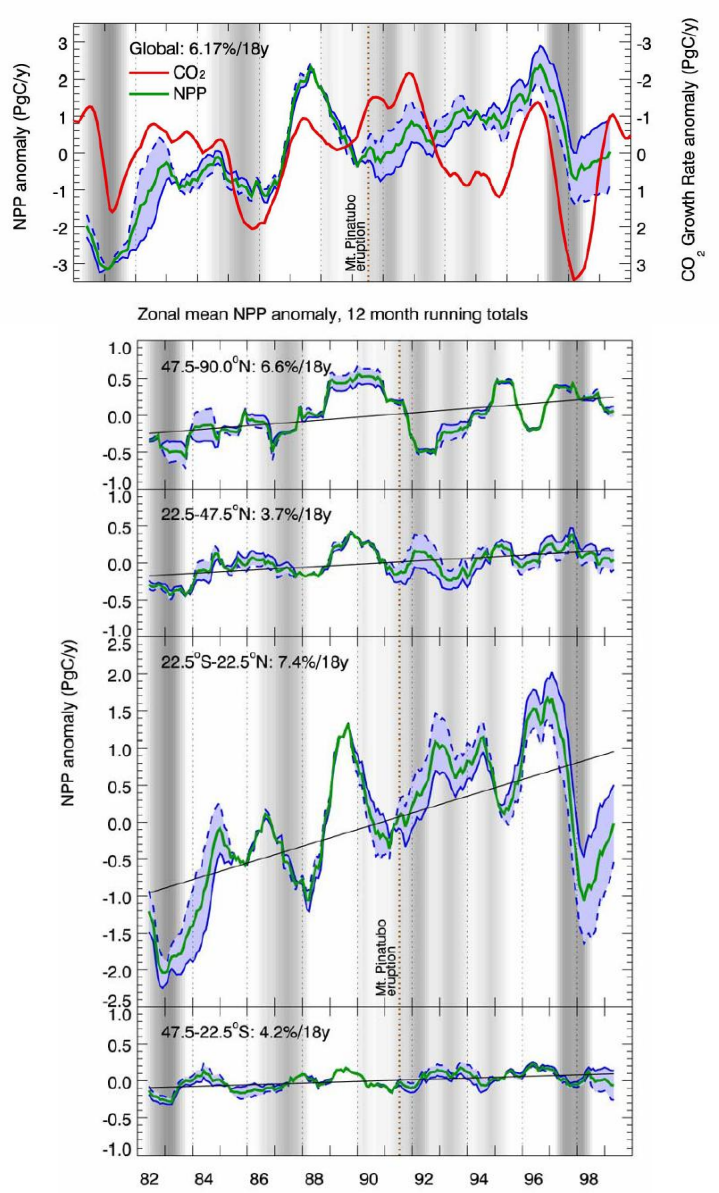
Summer 2003 European Heatwave



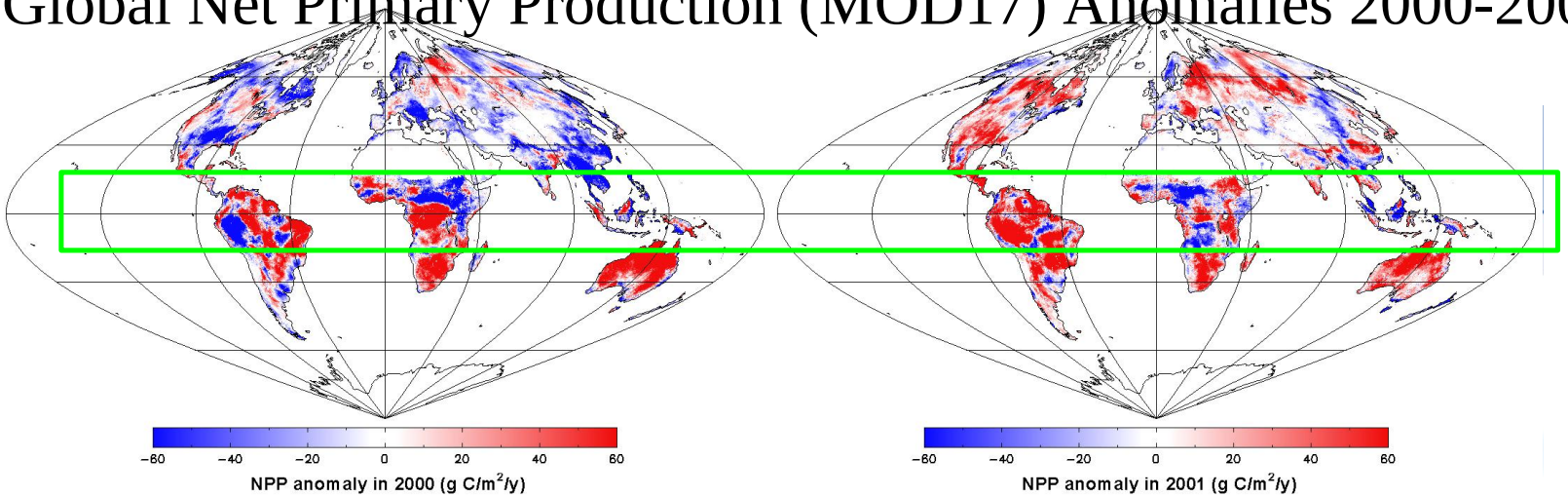
- **Warmest summer in 500 years**
- **Large scale declines in plant growth**
- **High elevation Alps did better**
- **May have contributed to the record CO_2 increase in 2003 (2.54ppm)**

Markus Reichstein, Carboeurope

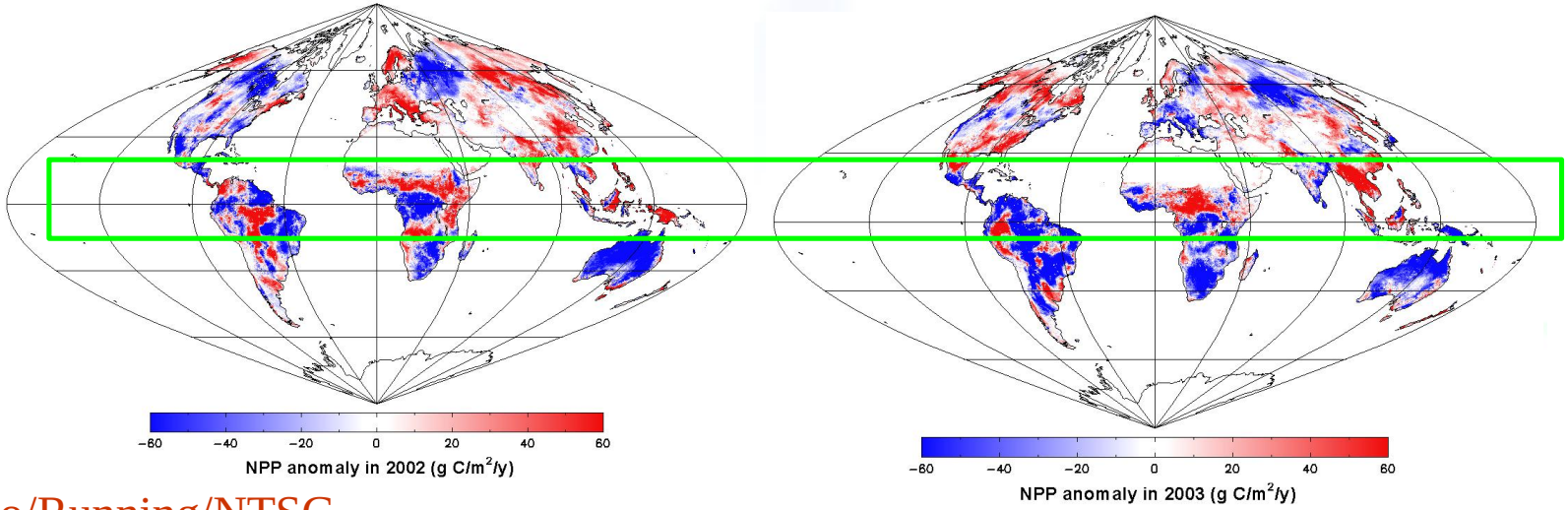
Tropical regions dominate global carbon cycling



Global Net Primary Production (MOD17) Anomalies 2000-2003

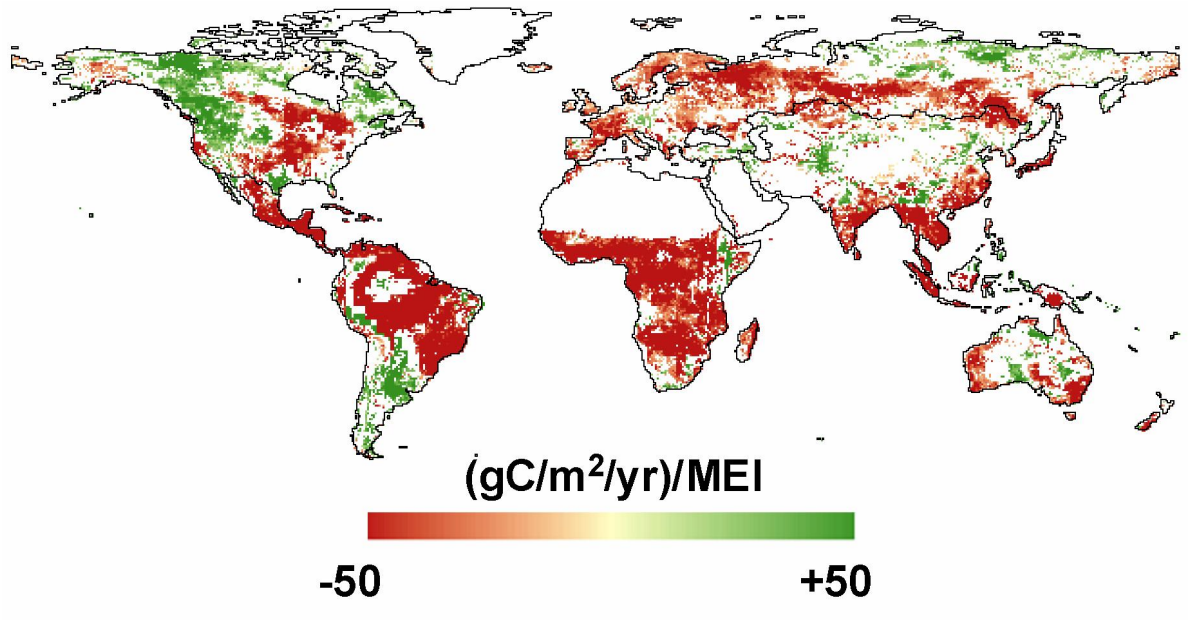


Year	NPP (Gt/y)	Trop. NPP (Gt/y)	CO2 growth rate (ppm/y)
2000	**56.06**	**32.88**	**1.17**
2001	**57.74**	**33.21**	**1.56**
2002	**55.53**	**31.97**	**2.04**
2003	**54.80**	**31.25**	**2.54**

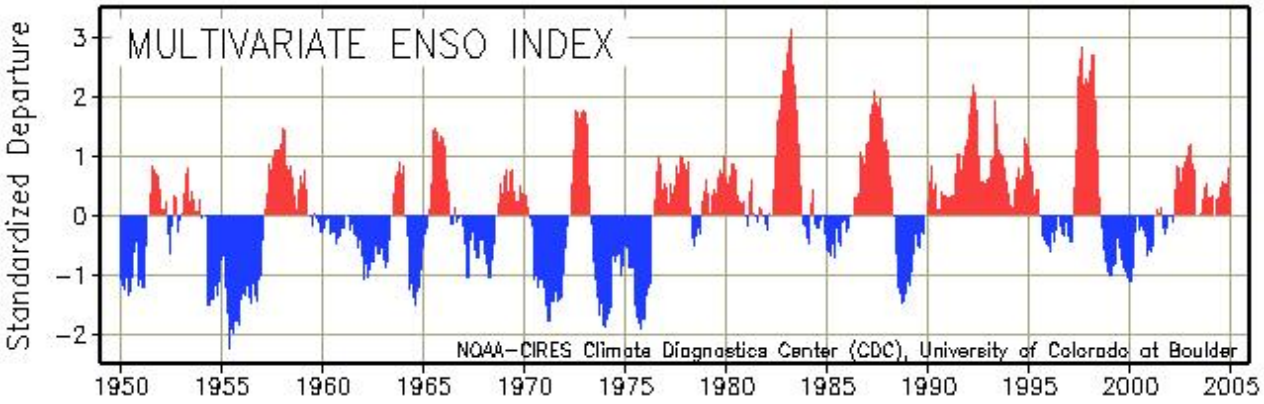


Zhao/Running/NTSG

ENSO as a possible mechanism for the enhanced behind CO_2 growth rate s during 2002-2003



Global distribution of El Nino impacts on NPP based on data from 1982 to 1999

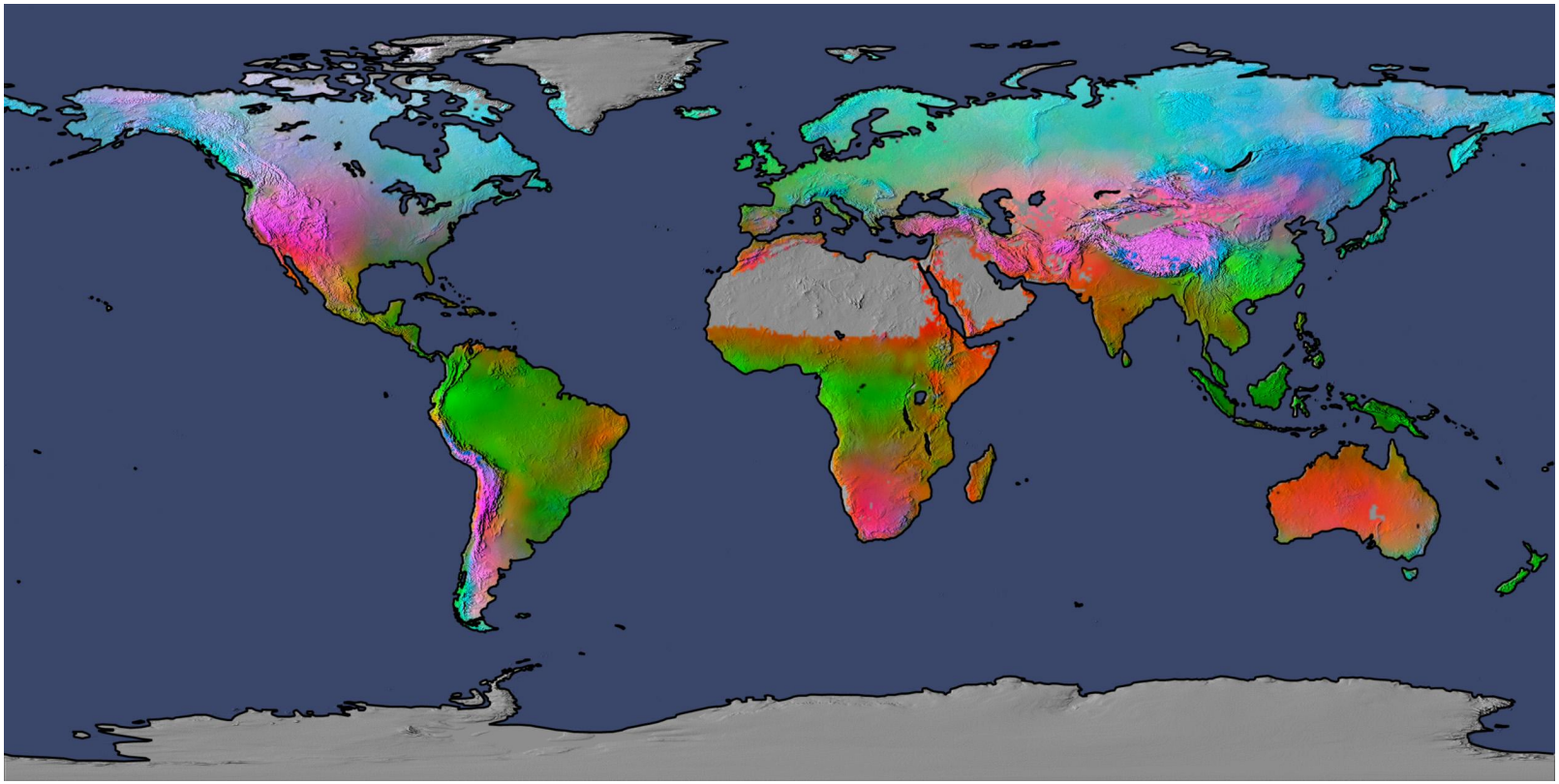


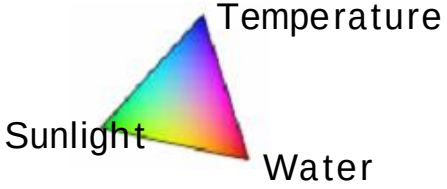
2002-2003 a mild El Nino

China!
Increased fire activity!

Hirofumi et al., JGR-atm, december, 2004

Potential Climate Limits for Plant Growth





Dominant Controls

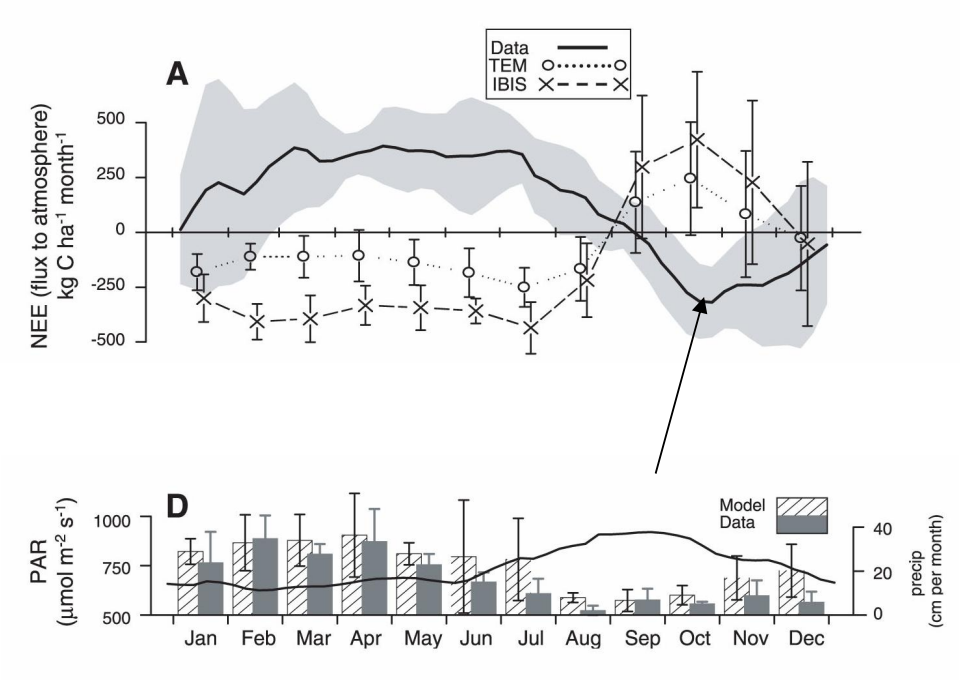
water availability 40%

temperature 33%

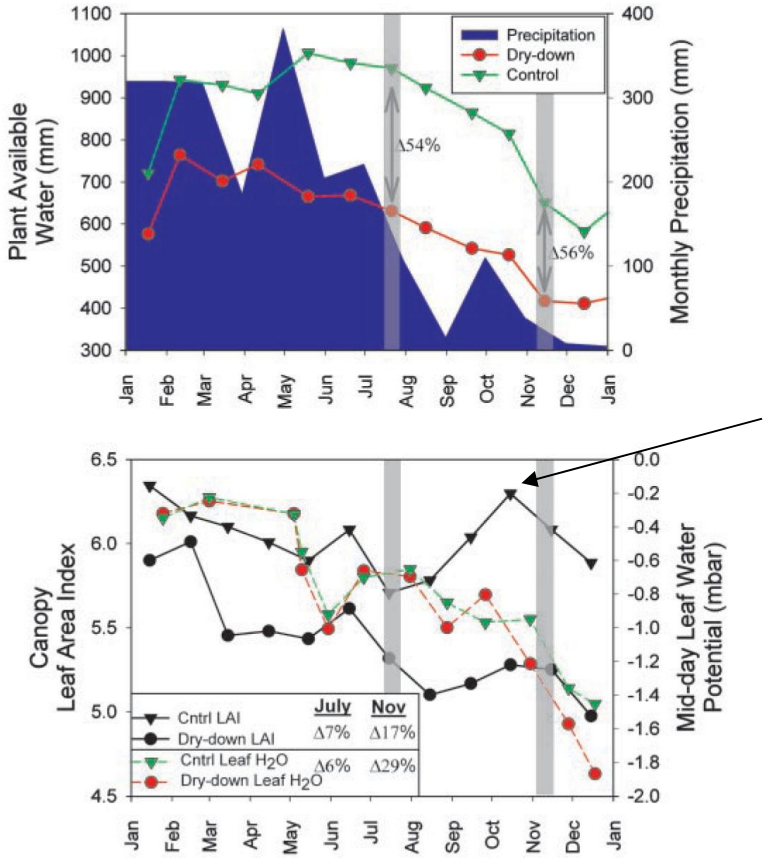
solar radiation 27%

total vegetated area 117 M km2

Evidence from field studies

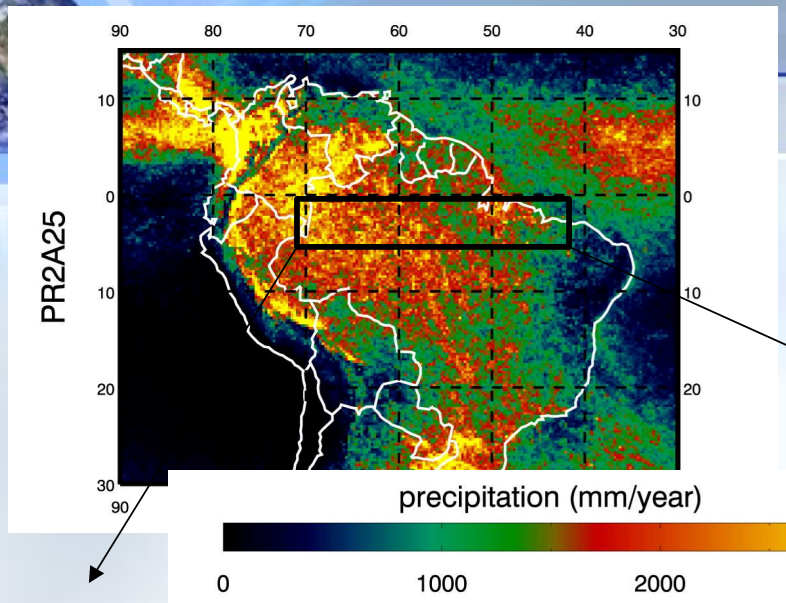


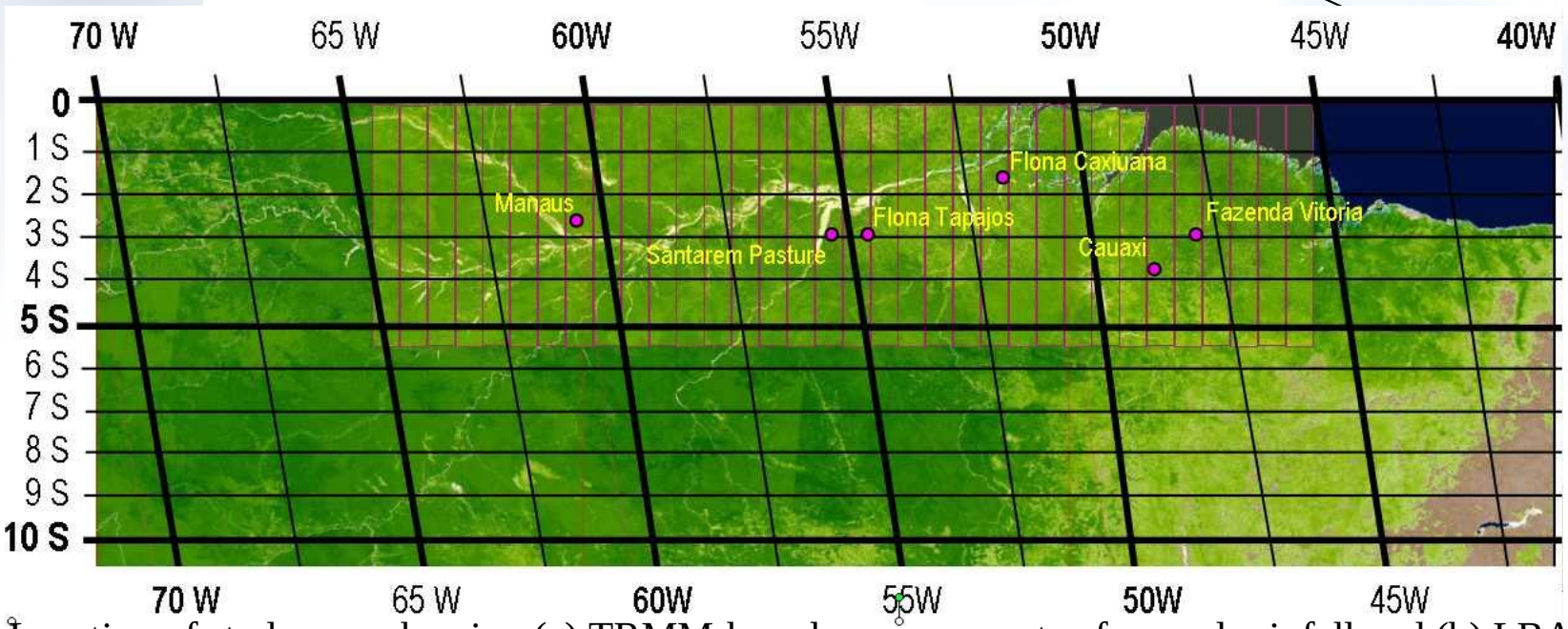
Saleska et al., Science (Nov, 2003)



Asner et al., PNAS (April 2004)

What MODIS show?



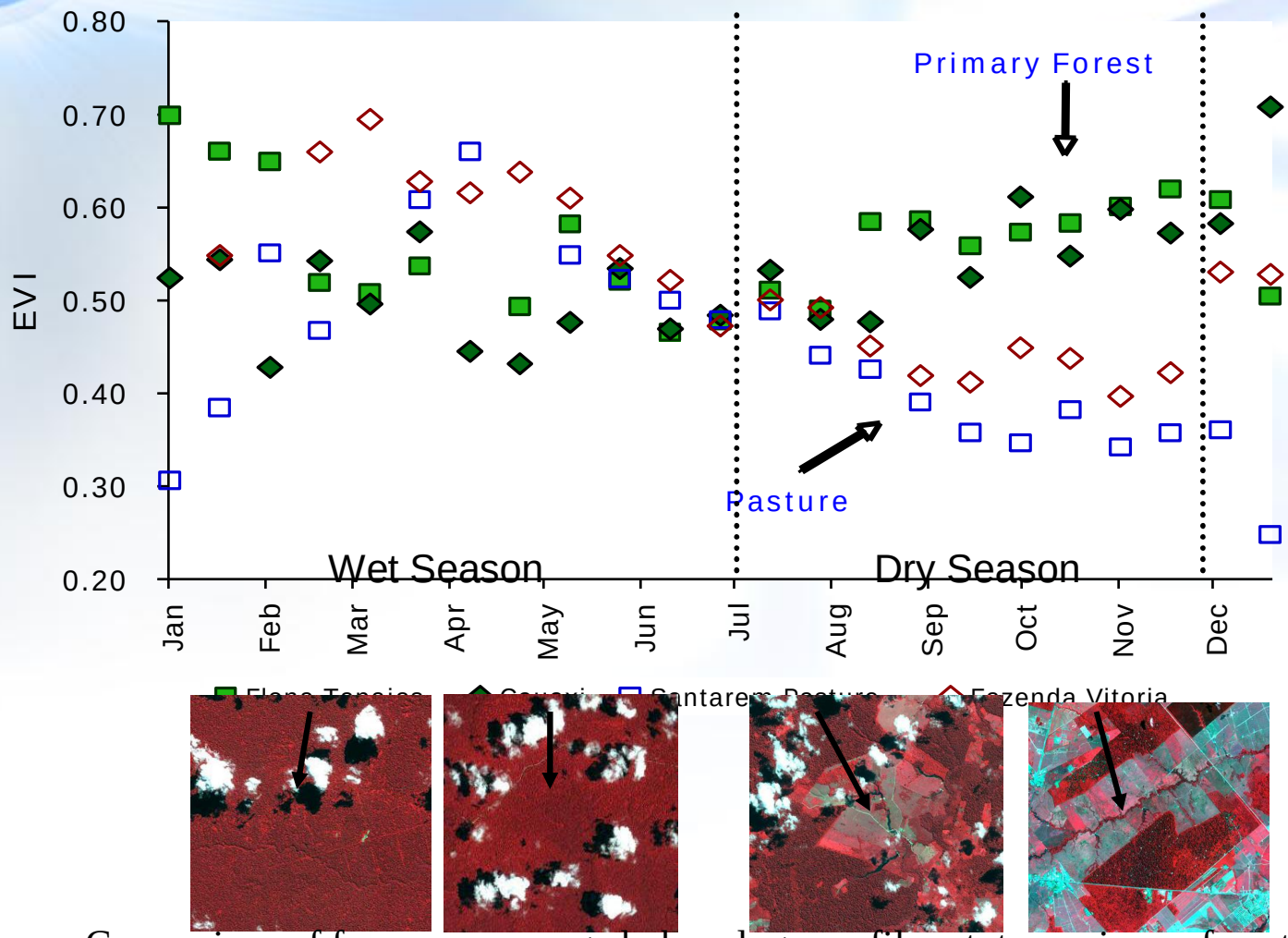


Location of study area showing (a) TRMM-based measurements of annual rainfall and (b) LBA site-intensive and climate transect areas analyzed.

Huete et al., U. Arizona

Land use and ecosystem dynamics

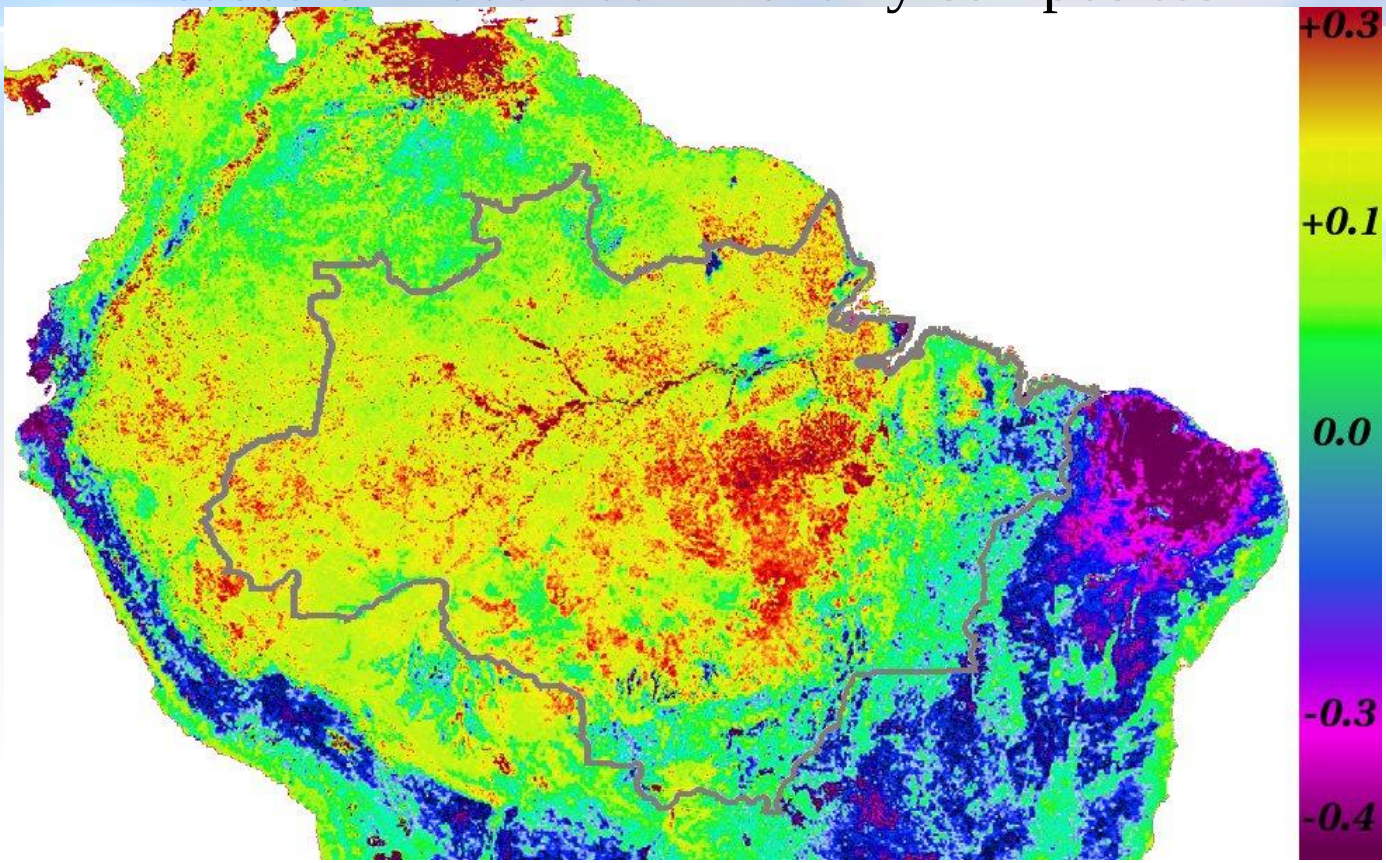
2000-2003 Average Enhanced Vegetation Index



Comparison of four-year averaged phenology profiles at two primary forest sites with nearby forest converted, pasture sites (Ikonos imagery below figure display extent of land conversion).

Huete et al., U. Arizona

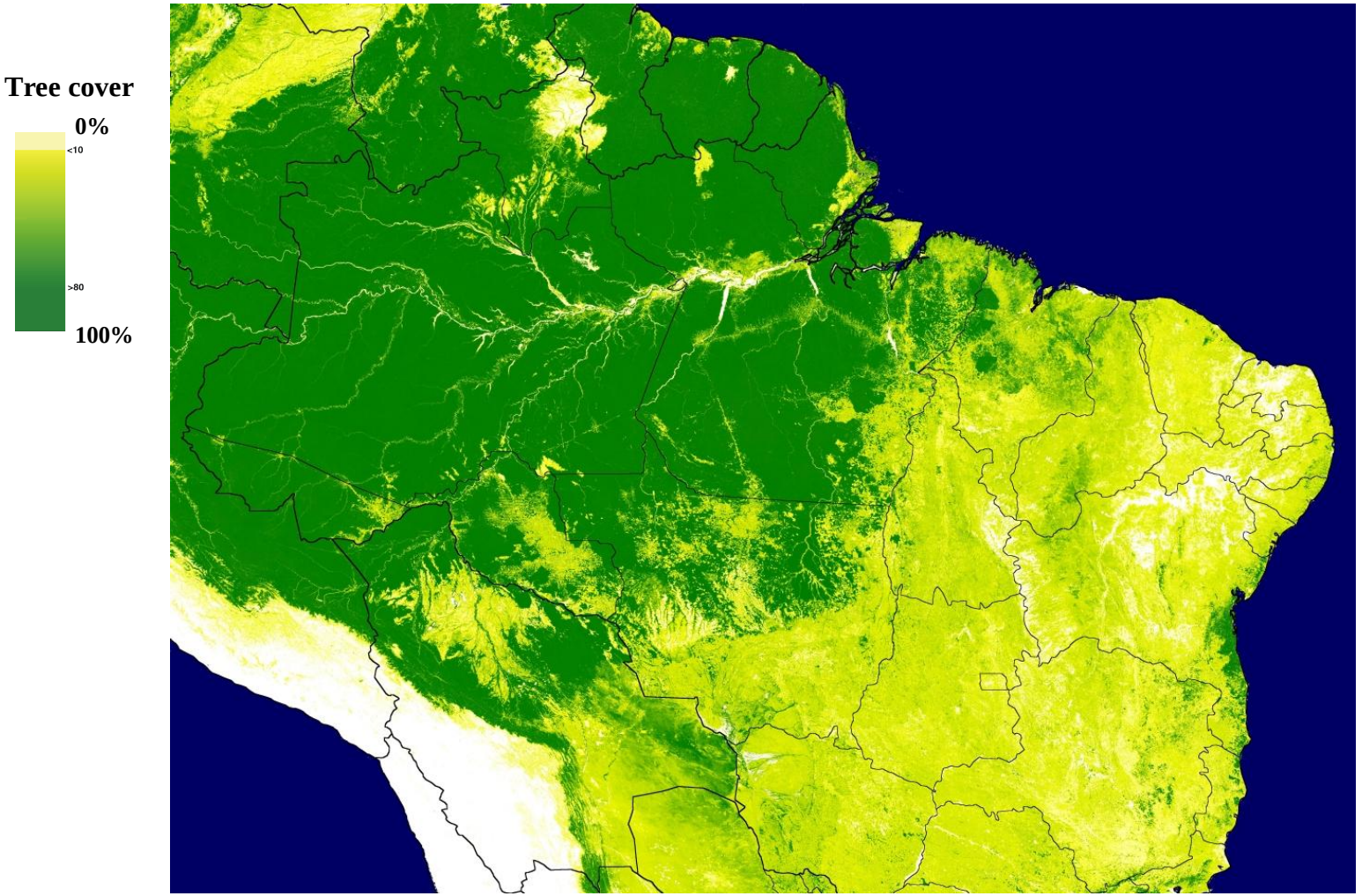
Amazonia (Dry – Wet) season Enhanced Vegetation Index based on 2000-2004 monthly composites



Increases in dry season activity (positive values) were found throughout the basin. The deforested portions of the Amazon tothe east and south, as well as near the Tapajos area, had negative values indicating less activity in the dry season.

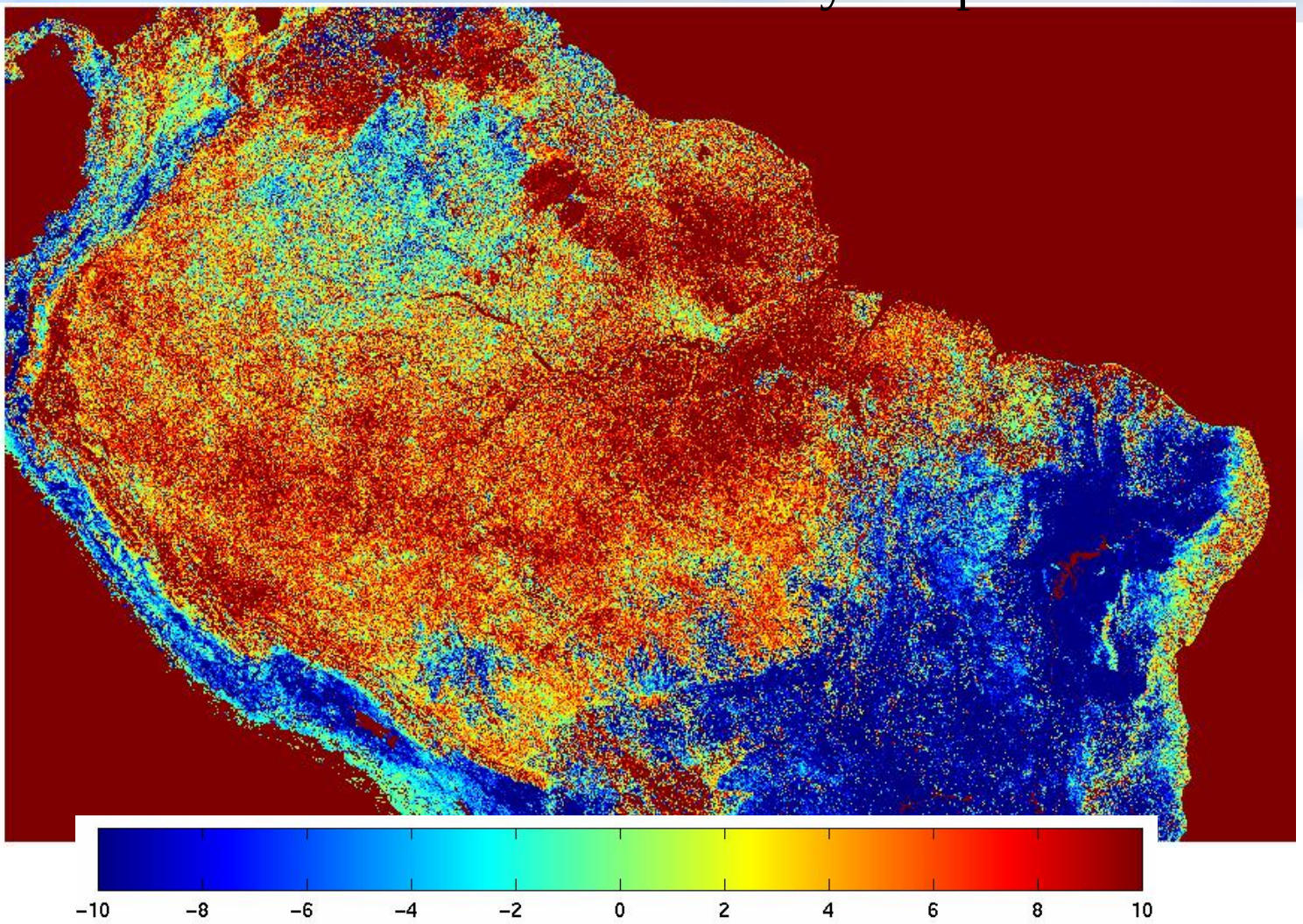
Huete et al., U. Arizona

Amazon Basin Percent Tree Cover from 500m MODIS data



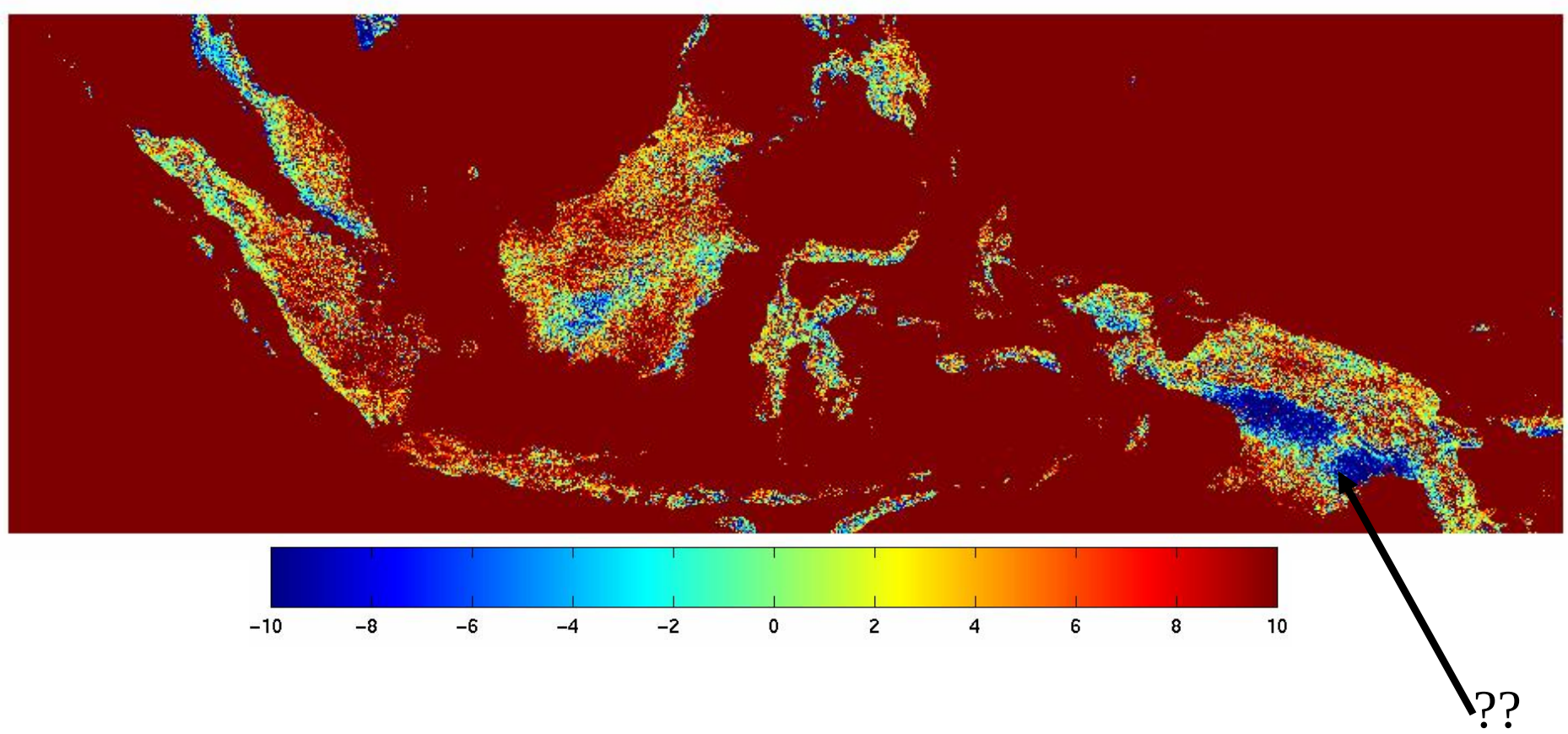
Trees with deep root systems are primarily responsible for the seasonal dynamics

Dry vs Wet season changes in MODIS Leaf Area Index based on 2000-2004 monthly composites



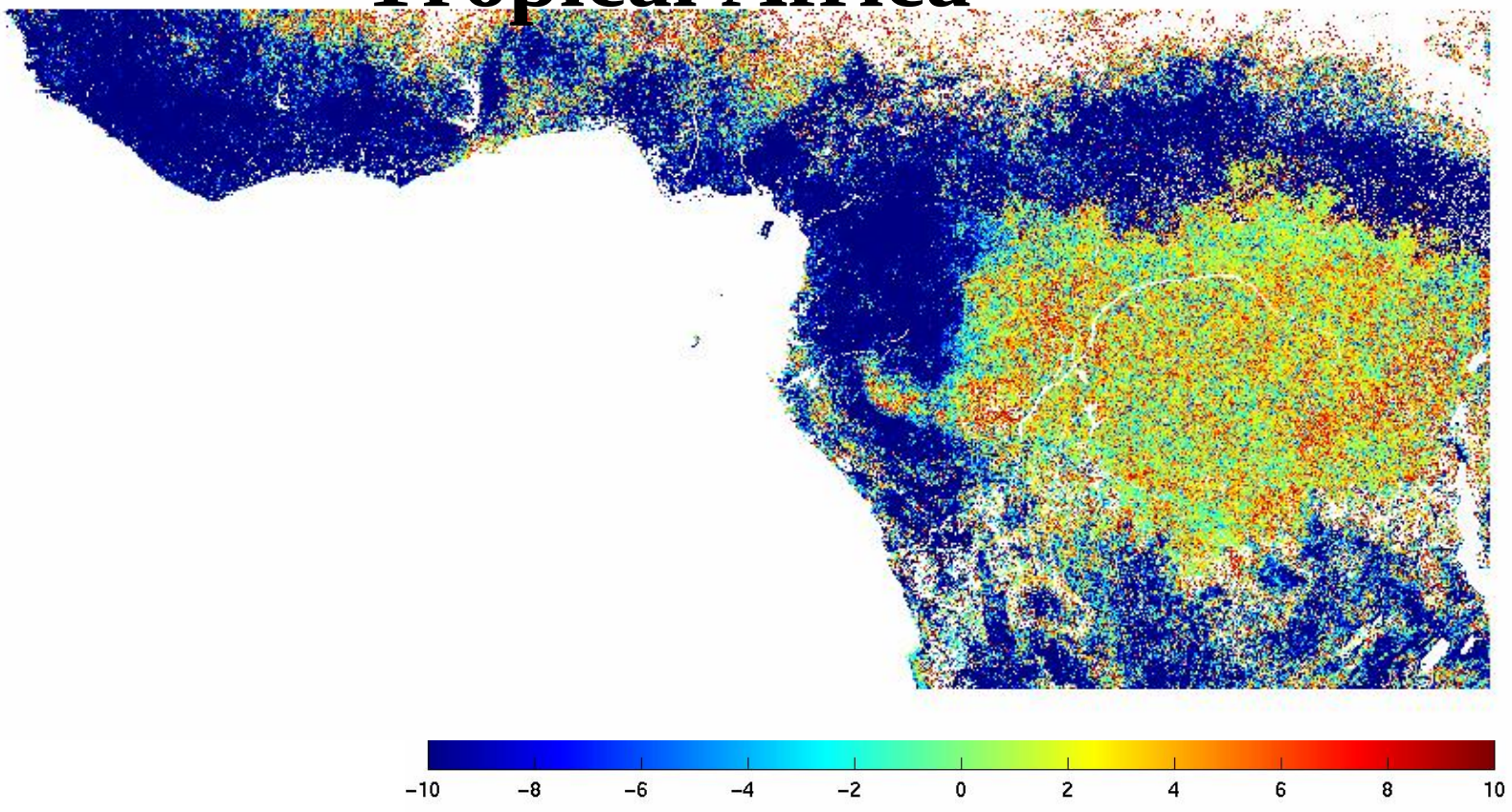
Wenze/Myneni/Nemani BU/ARC

Tropical Asia



Wenze/Myneni/Nemani BU/ARC

Tropical Africa



Low seasonal rainfall variability
Low biodiversity
Low interannual variability in cloudiness

MODIS use among modelers

- Importance of QA
  goading users to pay attention

- Produce high quality monthly average (2000-2004) products
  not all users care about interannual variability

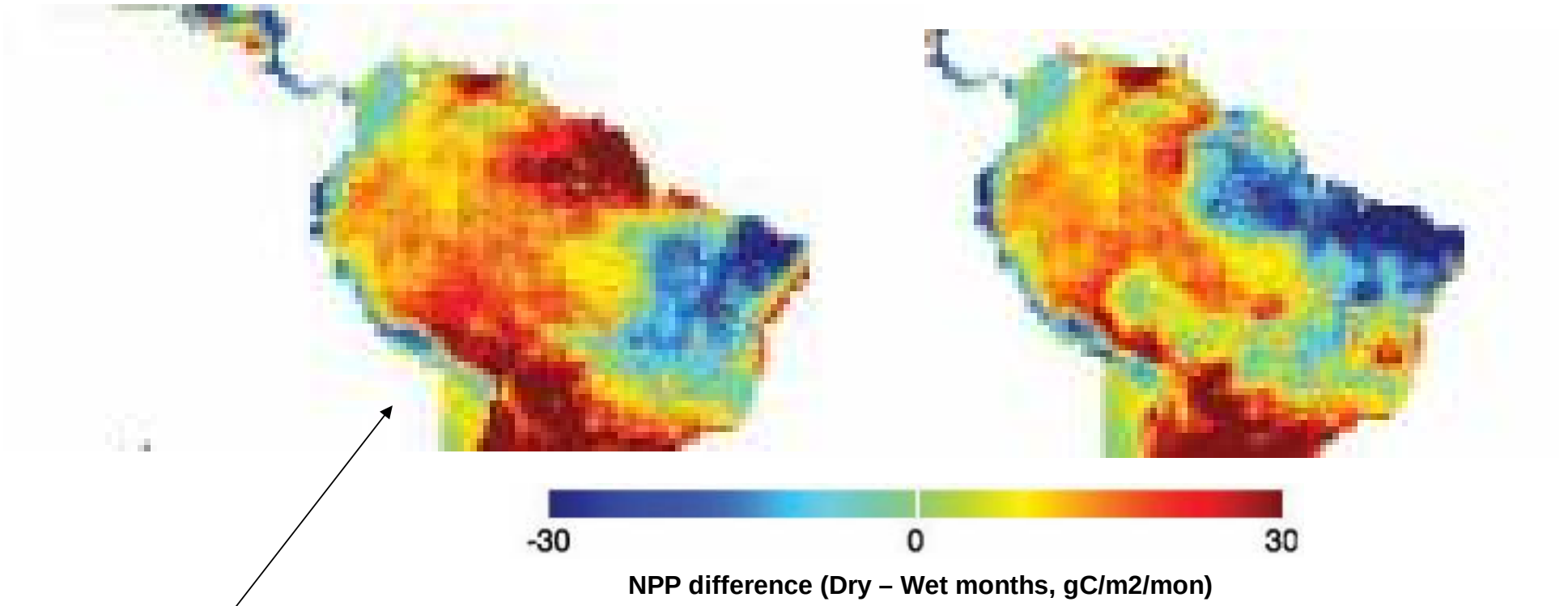
- Interdisciplinary studies – e.g., coastal ecosystems
  needs a lot more effort

- Uncertainty – may be characterized by biome or climate zone
  guidance to users on how to use the product in modeling

Modeled Wet and Dry season differences in NPP

Access to deep water

No access to deep water

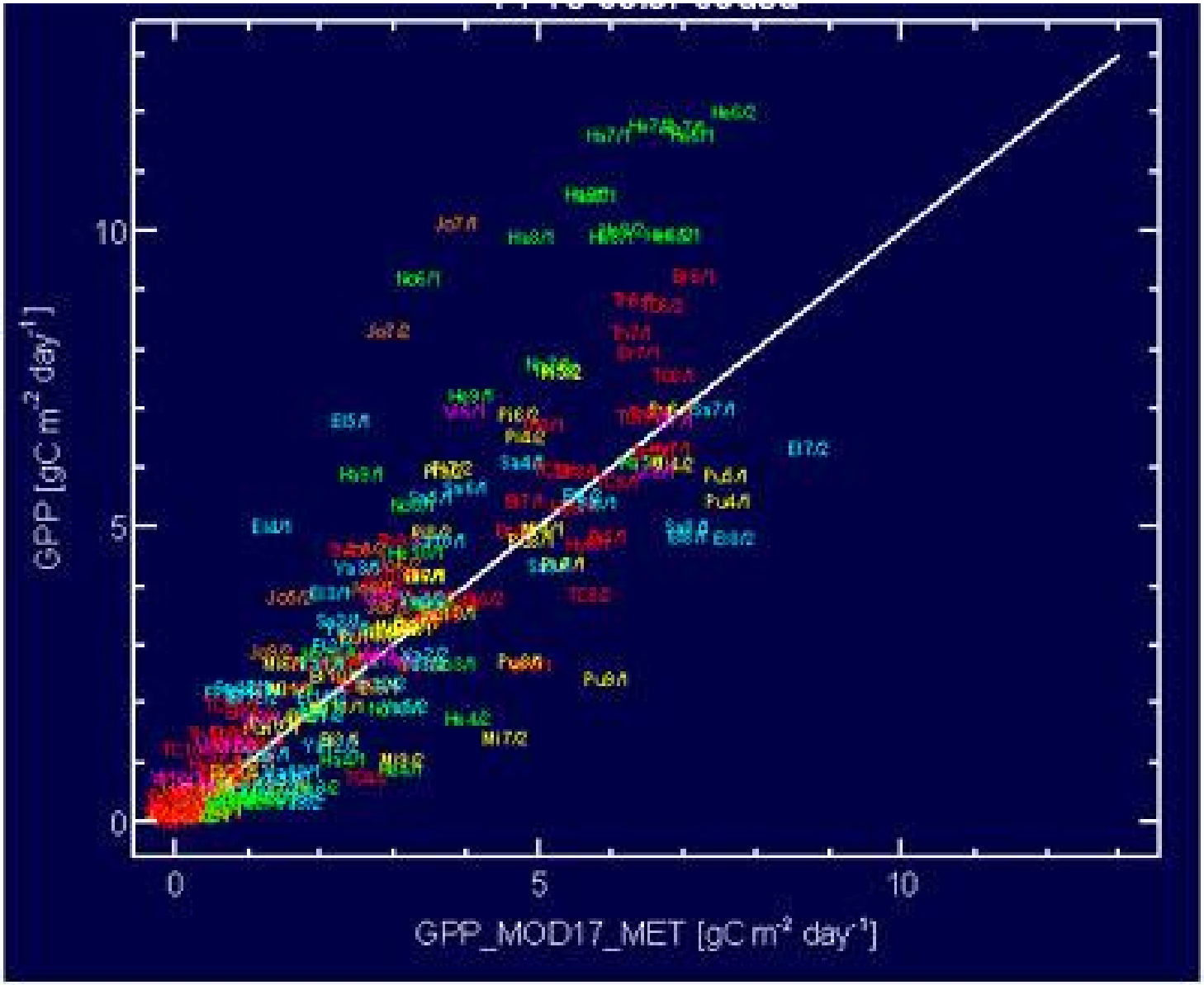


Resembles
EVI/LAI behaviour

CASA model results using monthly average LAI/FPAR from 1982-1999

CASA- Field et al., Potter et al.,

Updating MODIS GPP algorithm parameters Keyp. LUE_{max}



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