Why should Community Land Model users care about DART?

Andy Fox[1,2], Tim Hoar[2], Marcy Litvak[3], Jeff Anderson[2] & David Moore[1]

1. University of Arizona
2. National Center for Atmospheric Research
3. University of New Mexico

Fate of anthropogenic CO_2 emissions

34.1 $GtCO_2$/yr

91%

9%

3.5 $GtCO_2$/yr

Sources = Sinks

16.4 $GtCO_2$/yr

44%

31%

11.6 $GtCO_2$/yr

26%

9.7 $GtCO_2$/yr

GLOBAL CARBON PROJECT

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Uncertainty in Coupled Climate-Carbon Models

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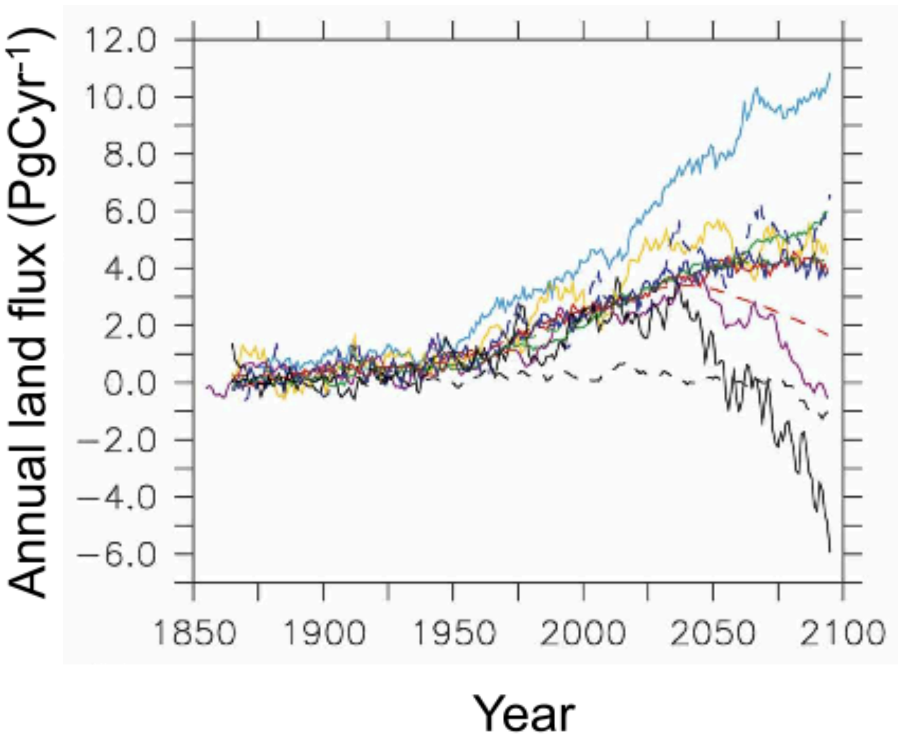

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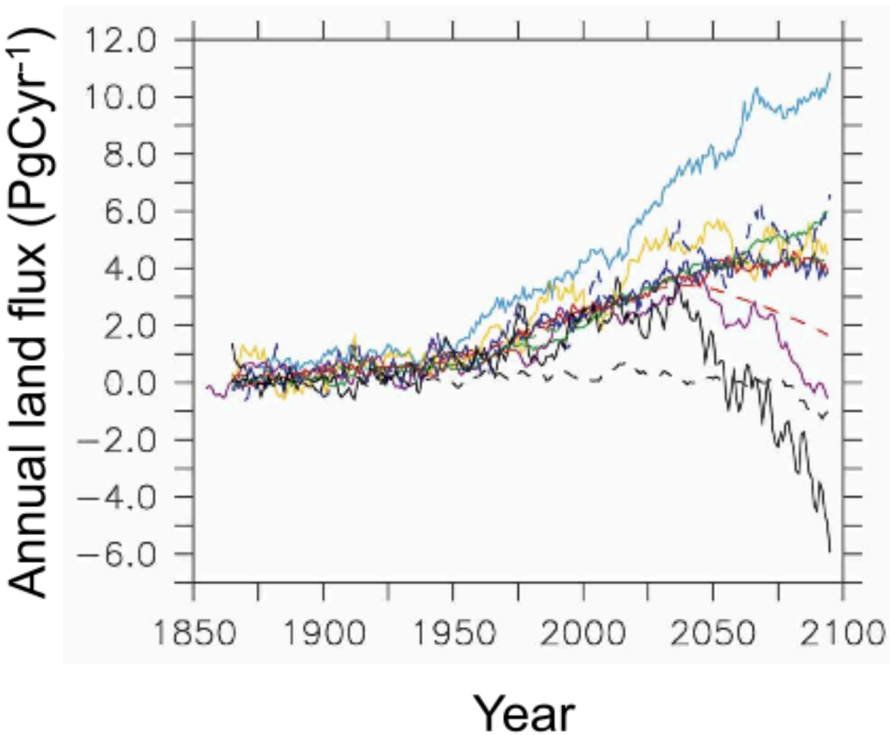


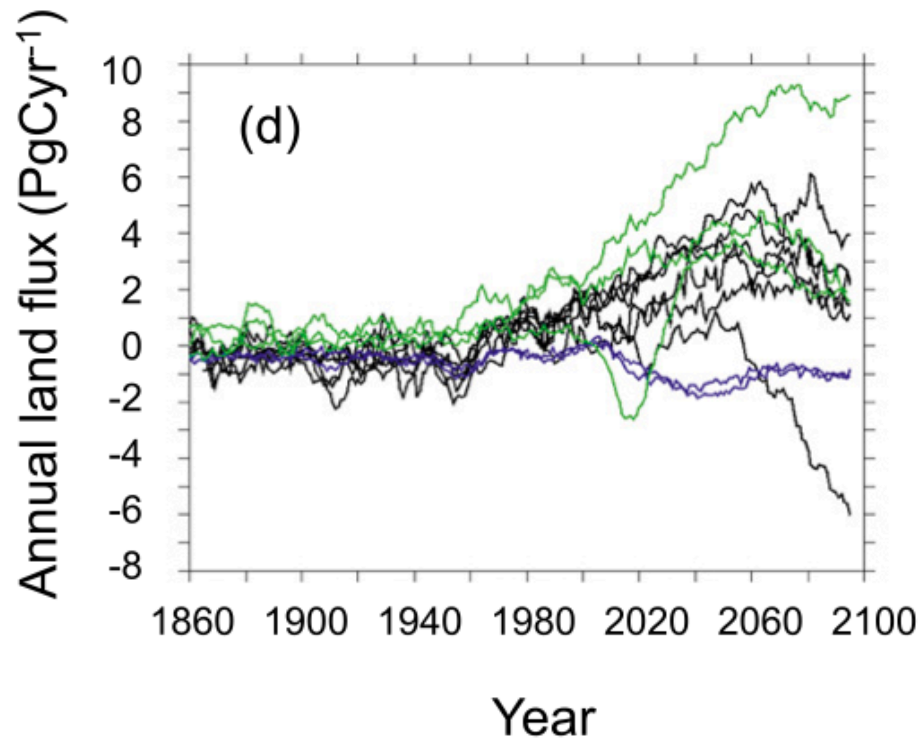
15 JANUARY 2014 FRIEDLINGSTEIN ET AL. 511

SPECIAL C4MIP COLLECTION

2014

Uncertainties in CMIP5 Climate Projections due to Carbon Cycle Feedbacks

PIERRE FRIEDLINGSTEIN,* MALTE MEINSHAUSEN,+ VIVEK K. ARORA,# CHRIS D. JONES,@ ALESSANDRO ANAV,* SPENCER K. LIDDICOAT,@ AND RETO KNUTTI&



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Sources of Uncertainty

- Model Structure
- Model Parameter
- Initial Conditions/Model States
- Spin Up
- Boundary Conditions

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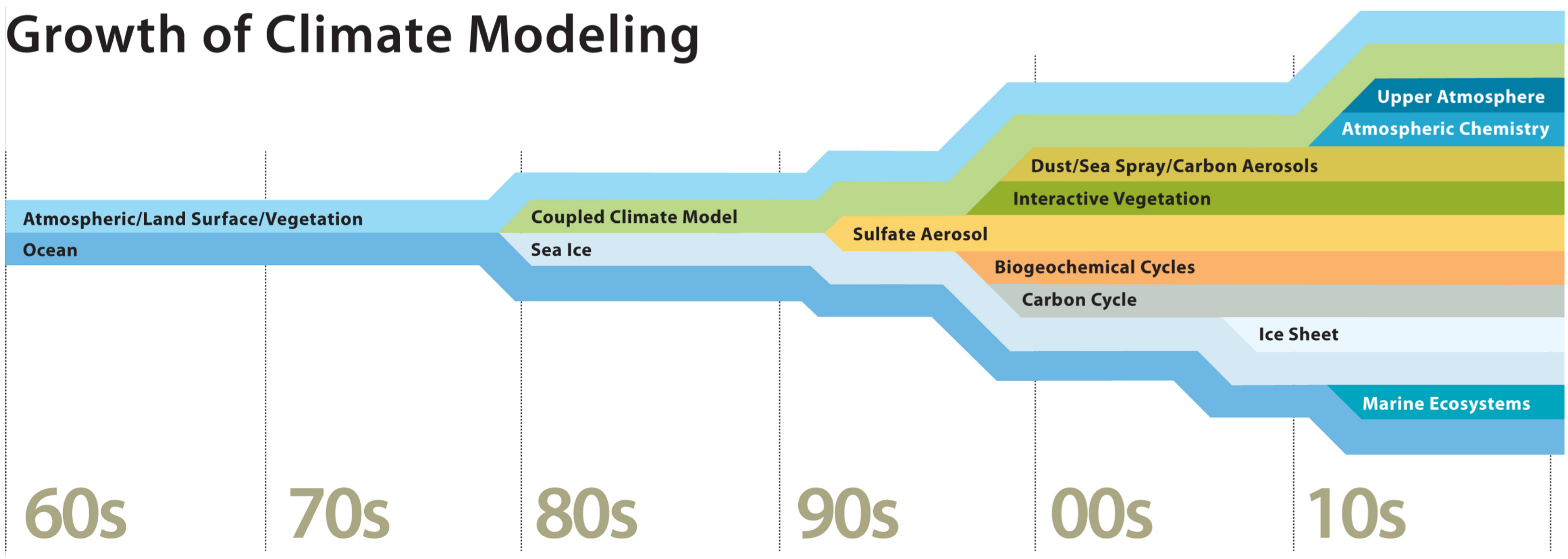
CAN DATA ASSIMILATION HELP?

Is DA different for NWP and CC models?

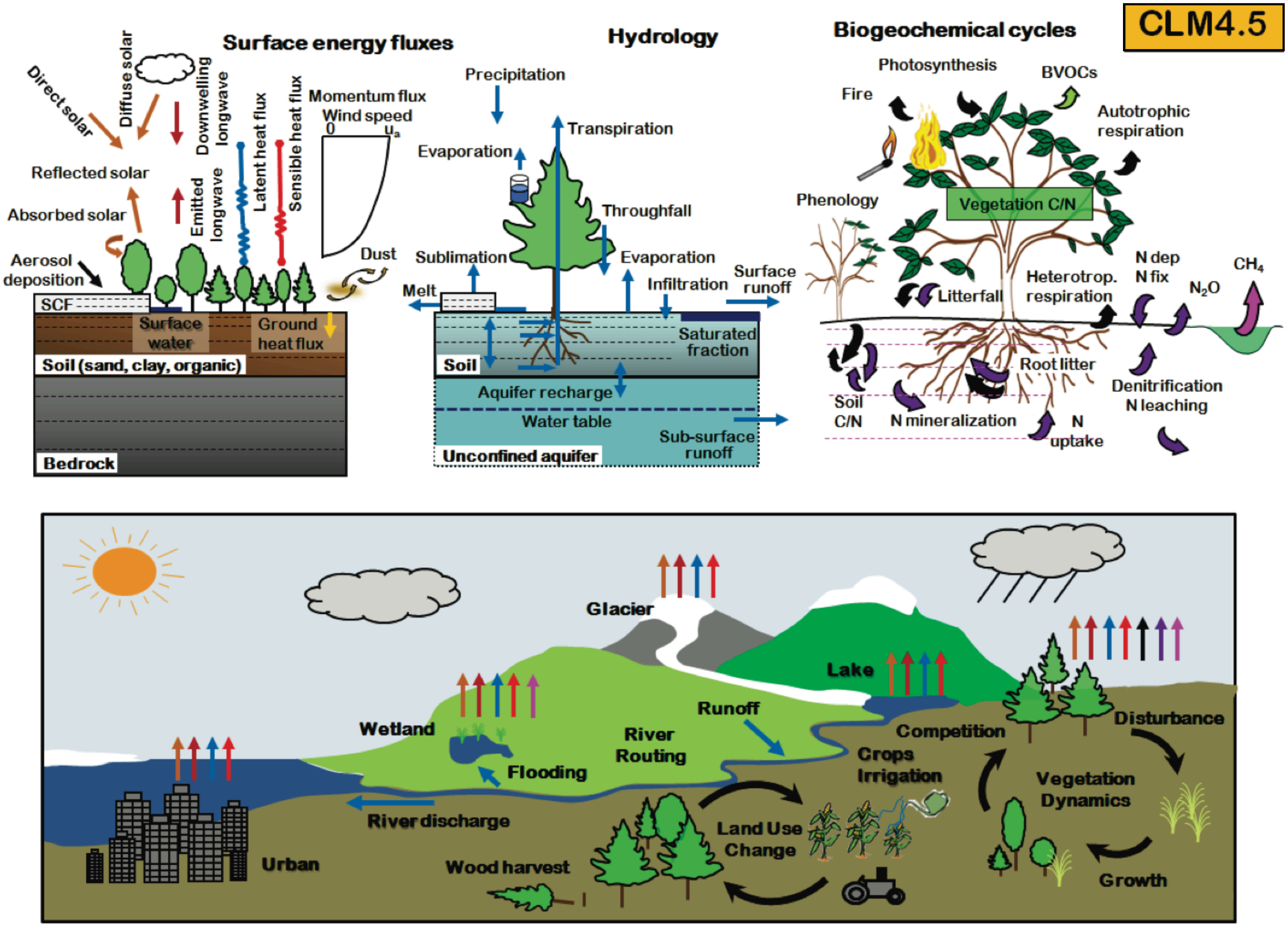
	Data Assimilation in NWP	Data Assimilation in CLM
Main objective	Forecast improvement	Process understanding Regional quantification Forecast improvement
Dynamics	Physics – essentially well known from first principles	Physical, biological, chemical – Only partially known, empirical relationships, optimized parameters
Spatial representation	Smoothly varying, continuous fields	Sub-grid heterogeneity with discrete boundaries, no lateral flow
Observations	High spatial and temporal density	Very different spatial and temporal characteristics
Mathematical problem	Optimization of initial conditions	Initial value problem (e.g. pools) Boundary conditions (e.g. fluxes) Parameter optimization

THE MODEL

The evolution of Earth System Models



The Community Land Model



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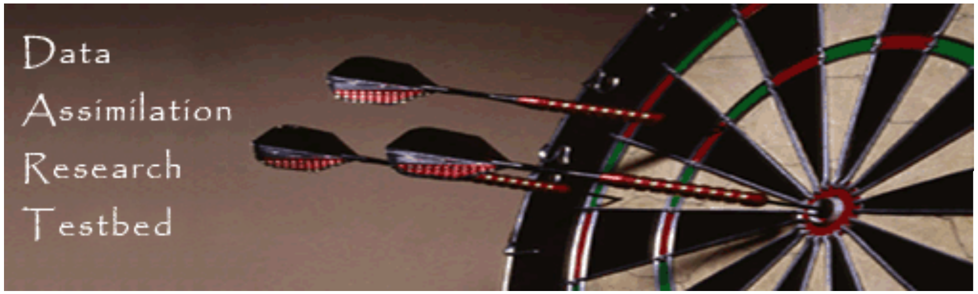
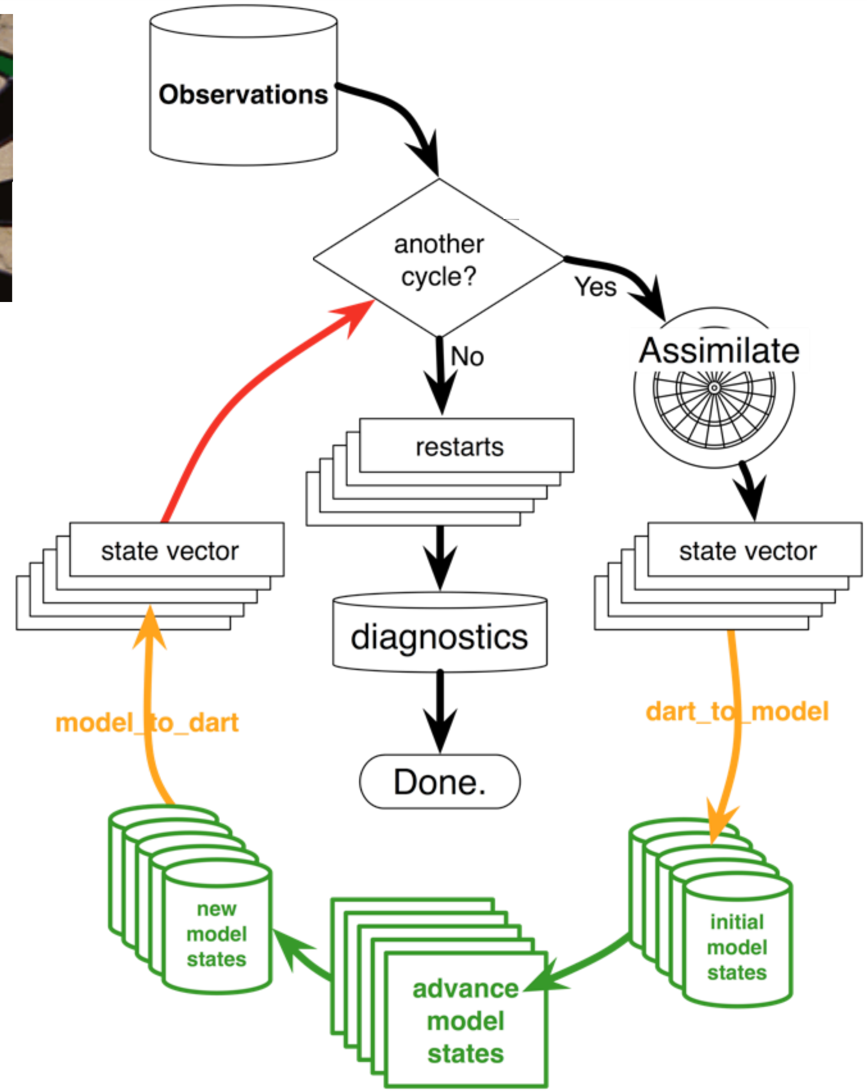
DATA ASSIMILATION RESEARCH TESTBED

Data Assimilation Research Testbed (DART)



- DART is a community facility for ensemble DA
- Uses a variety of flavors of filters
  - Ensemble Adjustment Kalman Filter
- Many enhancements to basic filtering algorithms
  - Adaptive inflation
  - Localization
- Uses new multi-instance capability within CESM



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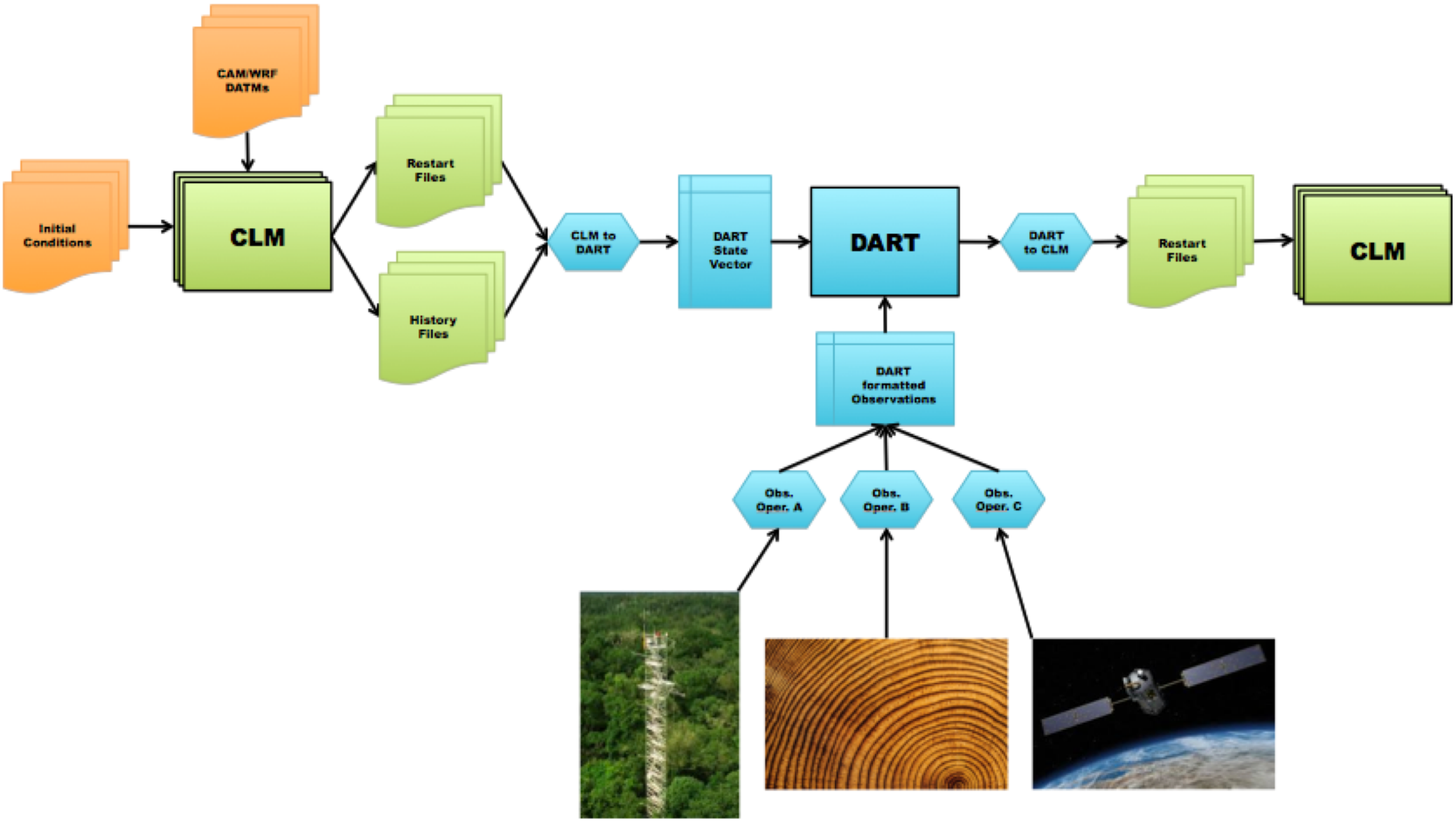
DART-CLM



CAM/WRF
DATMs
Initial
Conditions
CLM
Restart
Files
History
Files
CLM to
DART
DART
State
Vector
DART
DART
to CLM
Restart
Files
CLM
DART
formatted
Observations
Obs.
Oper. A
Obs.
Oper. B
Obs.
Oper. C

Observations we can use with CLM-DART

- Leaf area index
- Above ground biomass
- Canopy nitrogen
- Snow cover fraction
- Microwave brightness temperature
- Cosmic ray neutron intensities
- Total water storage anomalies (GRACE)
- Soil moisture and temperature
- Latent heat flux
- Sensible heat flux
- Carbon fluxes (NEP, GPP, ER, SR)

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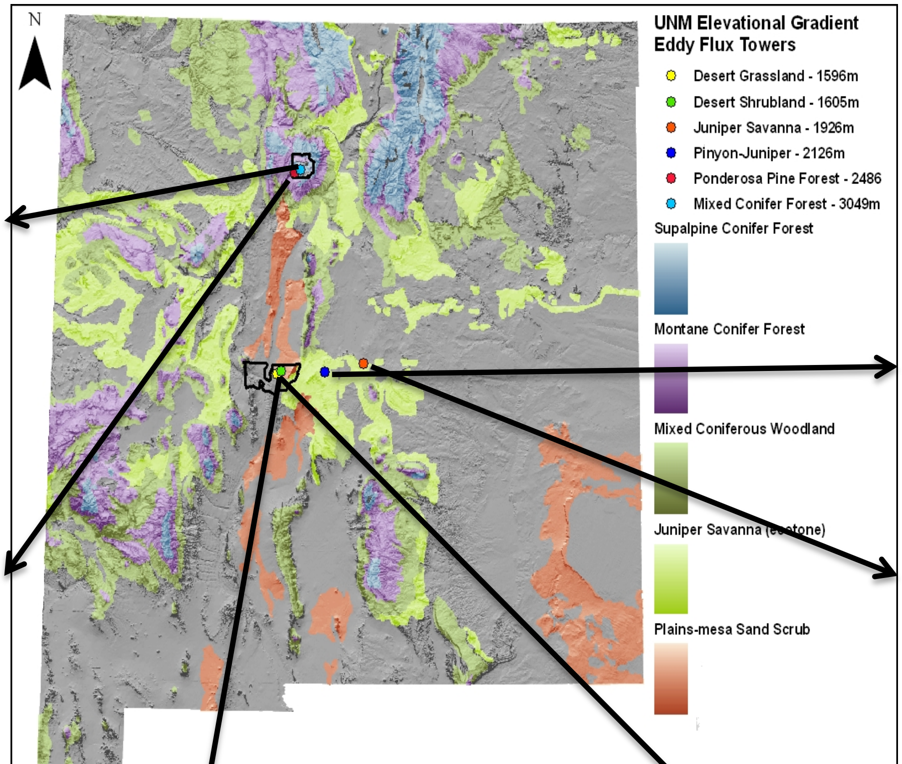
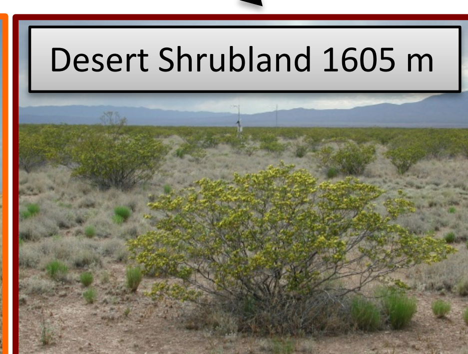
DEMONSTRATE IT WORKS

New Mexico Elevation Gradient (NMEG)





AMERIFLUX

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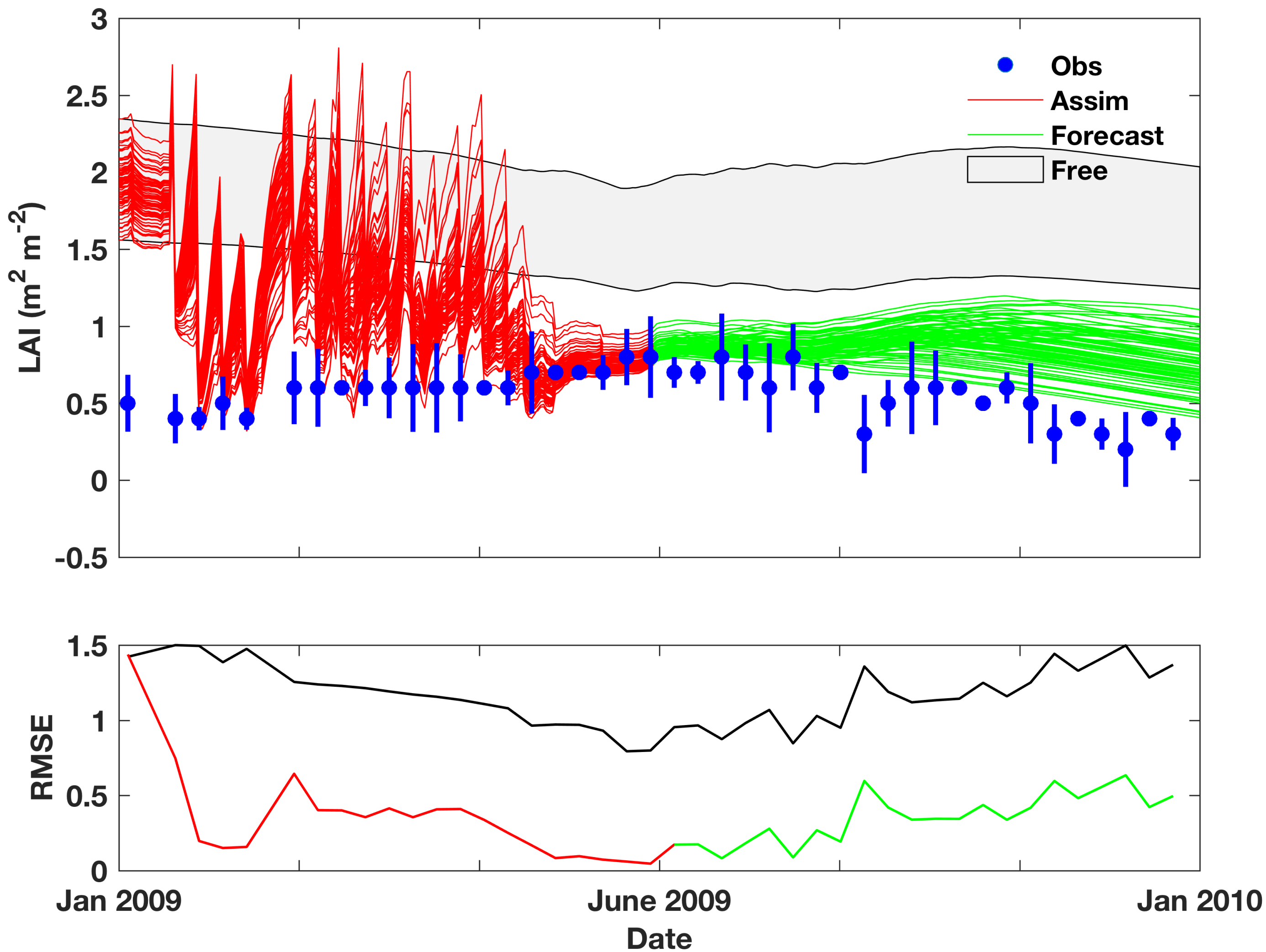
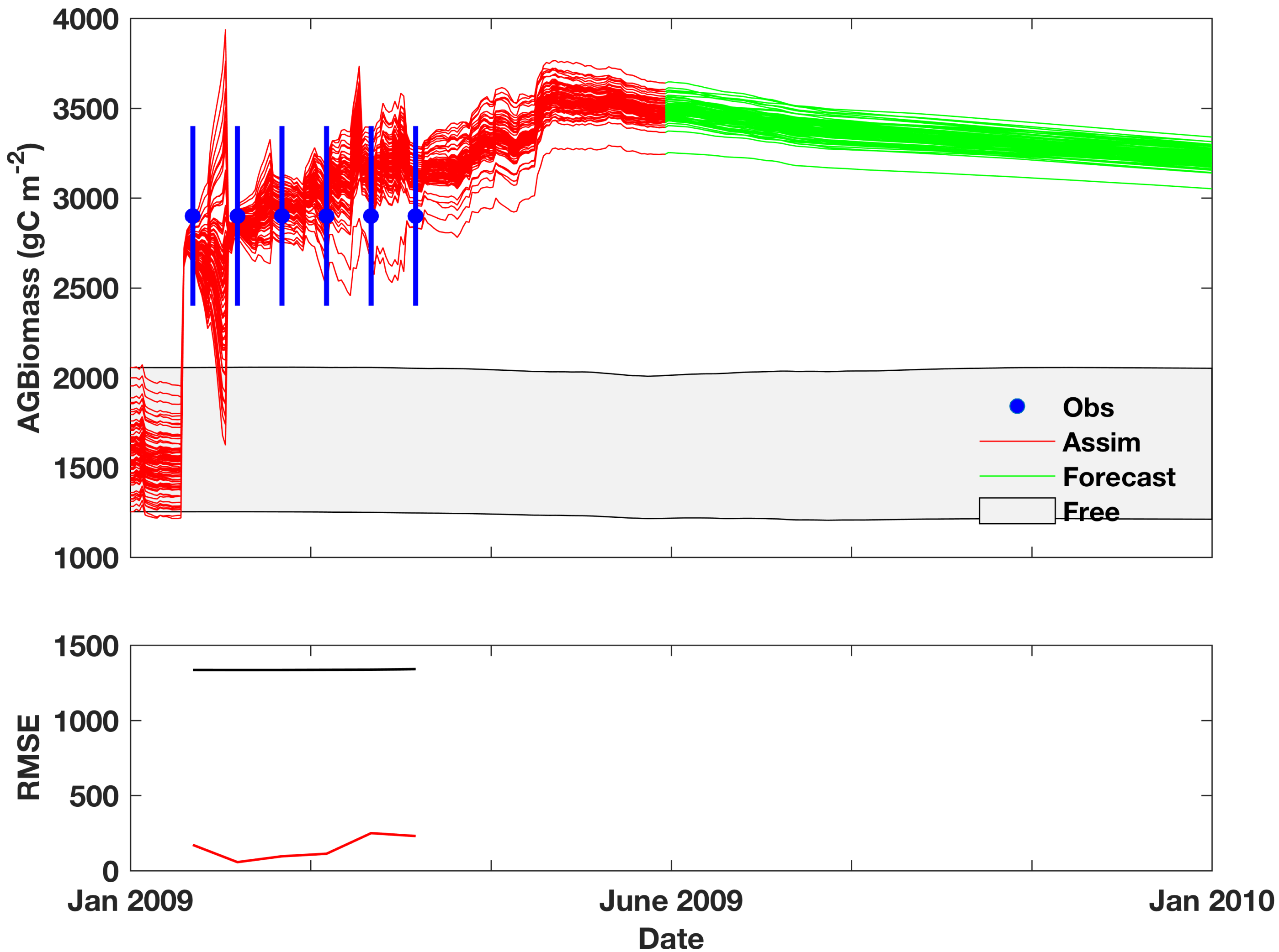
Site level assimilation of MODIS LAI



Site level assimilation of Biomass



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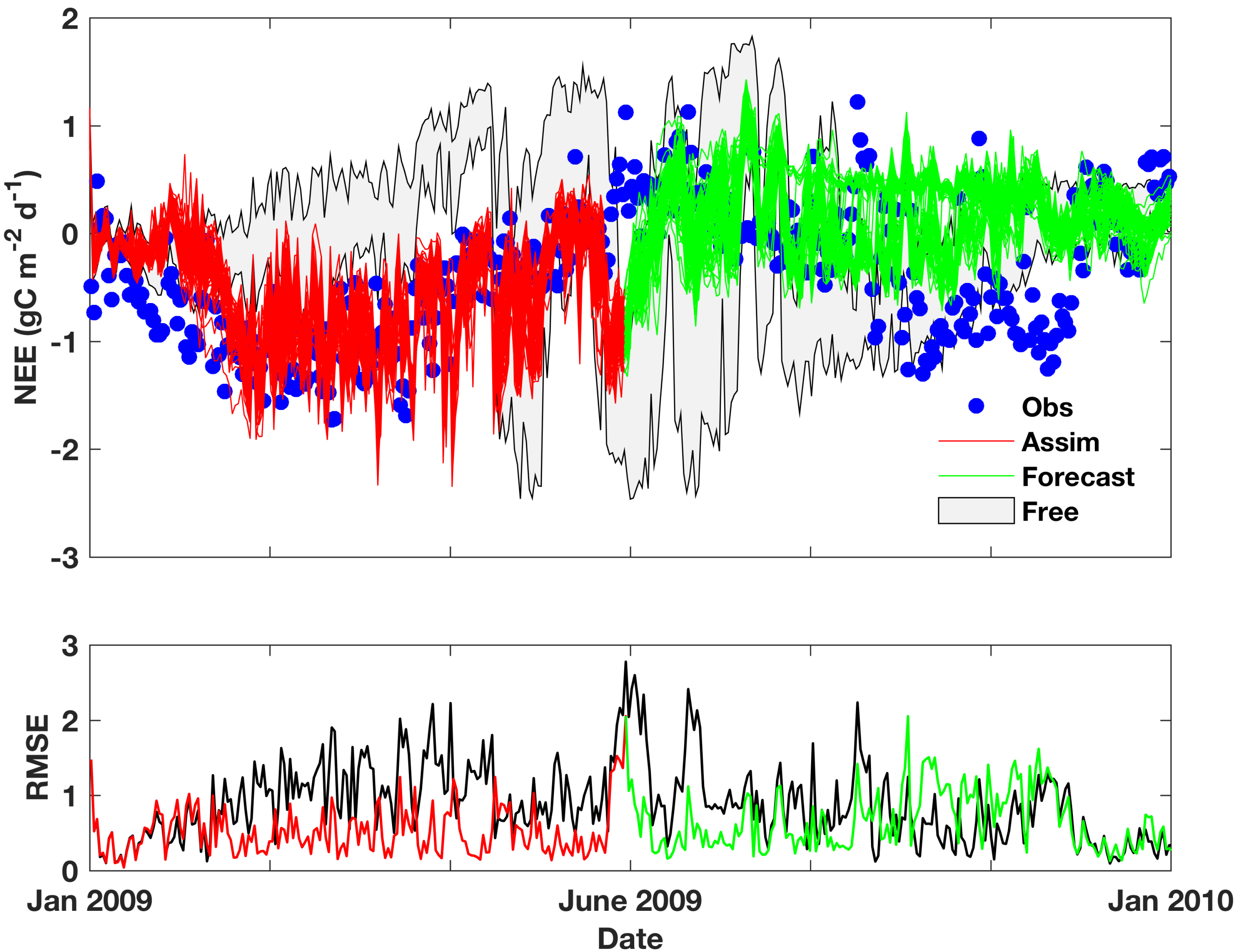
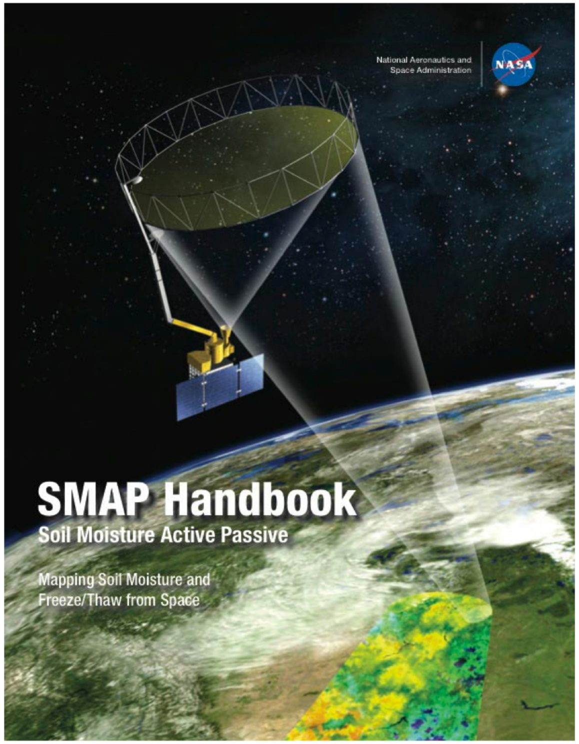
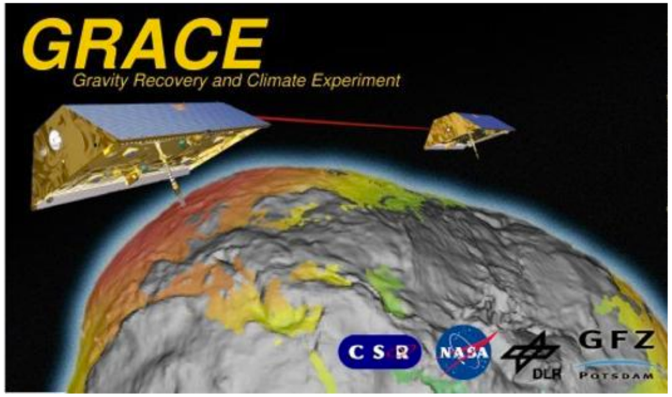
Impact of assimilation on CO_2 flux



NEW OBSERVATIONS

New Remote Sensing Observations





OCO-3
ORBITING CARBON OBSERVATORY

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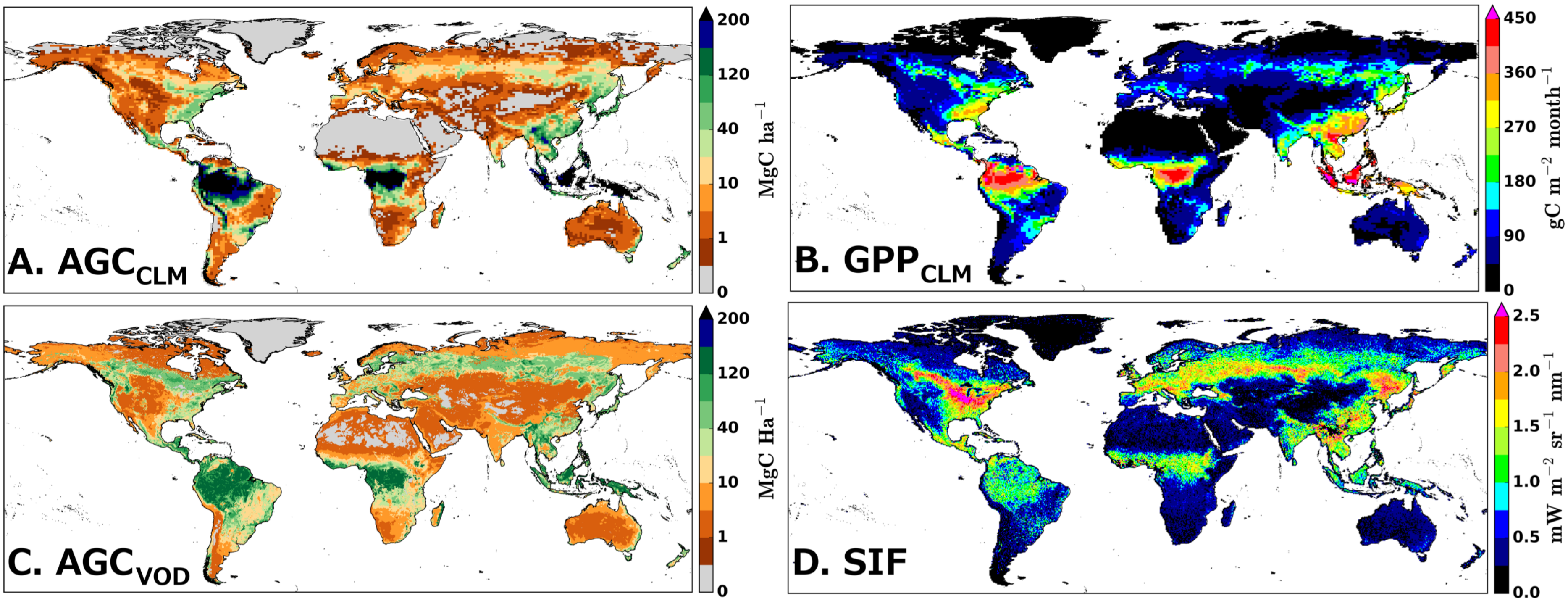
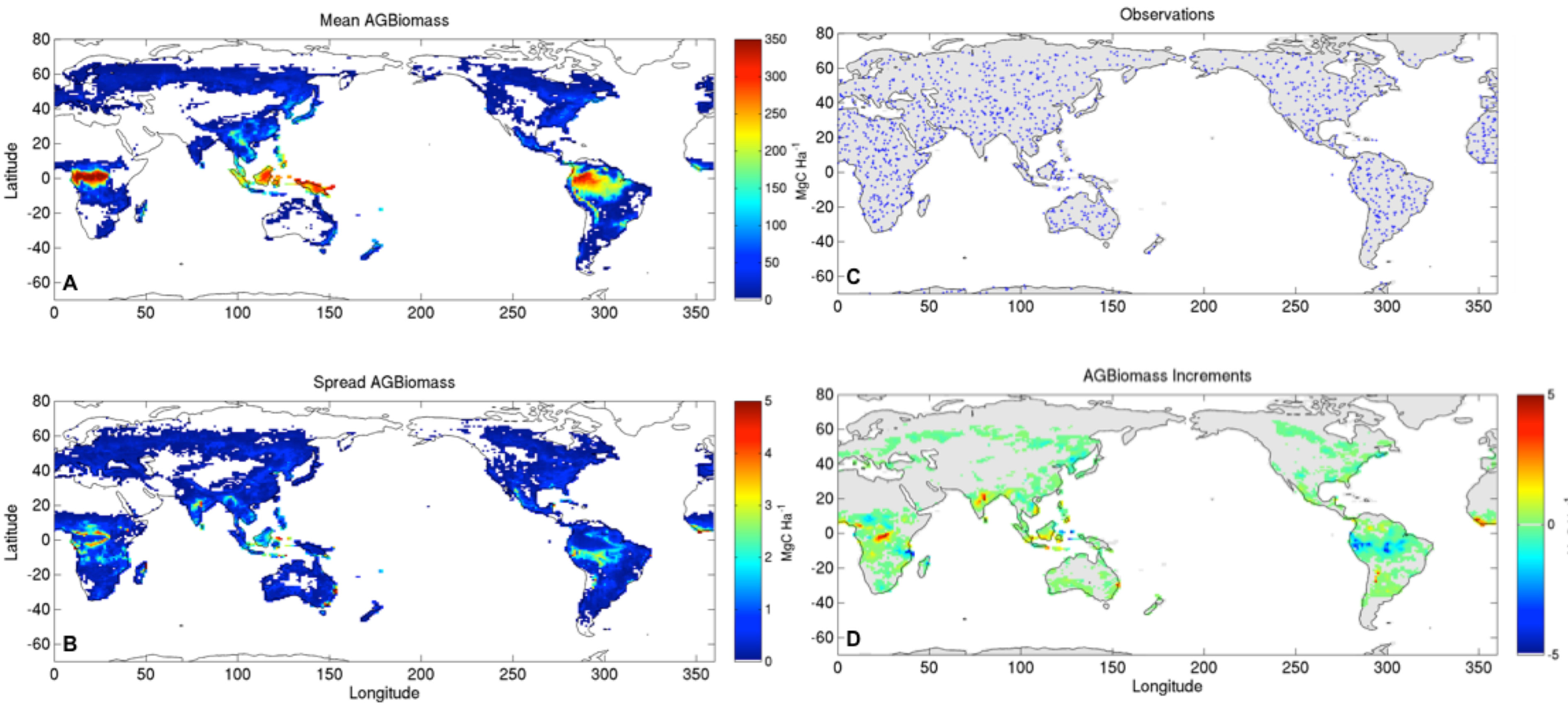
Vegetation Optical Depth and SIF

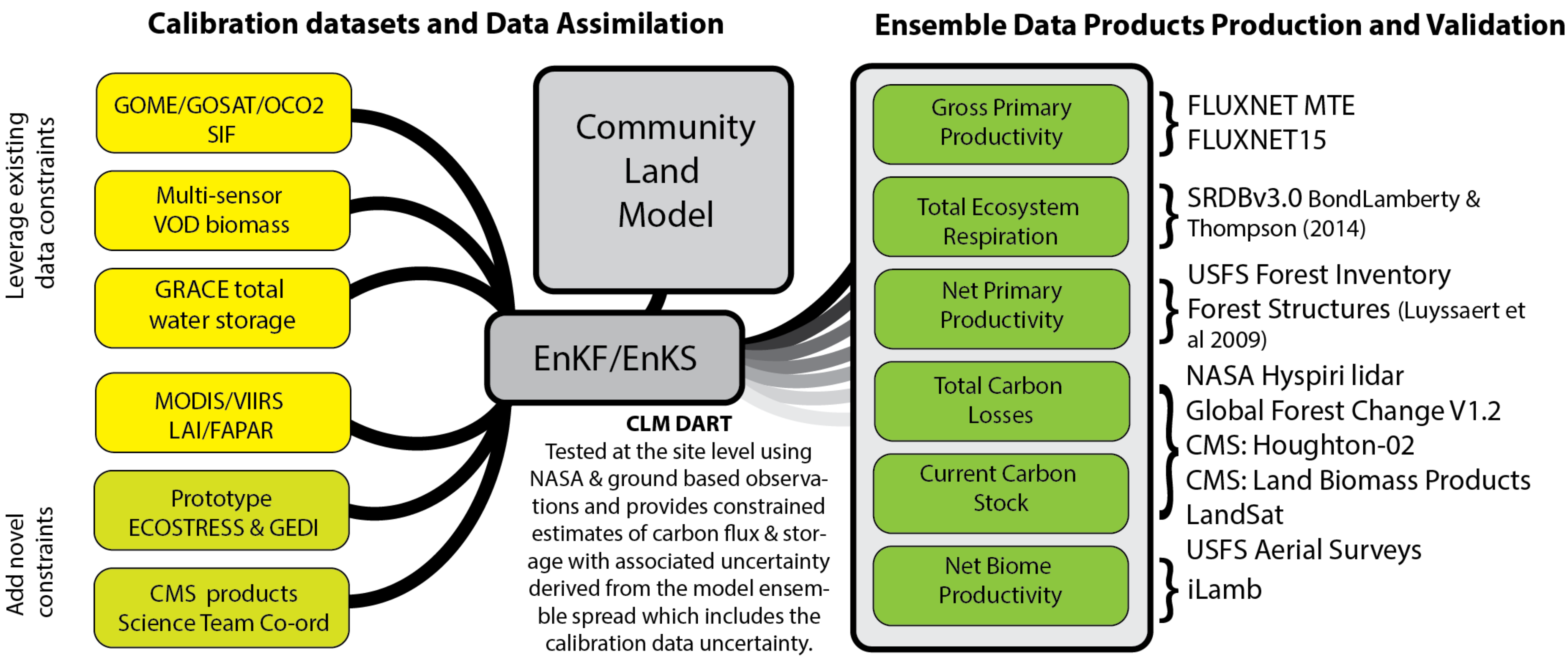


Courtesy Bill Kolby-Smith, UA

Global Biomass OSSE



You can take the boy out of Data Products…



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The _actual_ work in process

1. Finish GMD paper that documents details of implementation, flux tower observations and global OSSE
2. Compare global carbon balance calculated from CLM – satellite phenology, CLM – Biogeochemistry and CLM-BGC with DART and satellite leaf area observations
3. A NASA Terrestrial Hydrology proposal to use GRACE, SMAP, and ECOSTRESS observations
4. Switch to using CLM5
5. Parameter estimation in CLM with DART – how and which parameters?
6. Make CLM-DART a useful, popular, routine and effective tool for the CLM user community