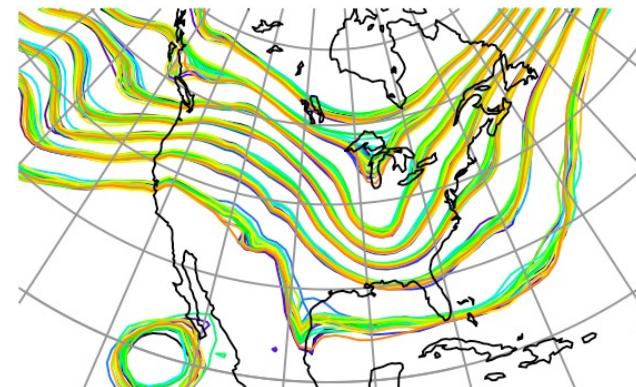


Data  
Assimilation  
Research  
Testbed



## Applying Ensemble Data Assimilation to CLM

Brett Raczka, NCAR, Data Assimilation Research Section (DAReS)



©UCAR 2019



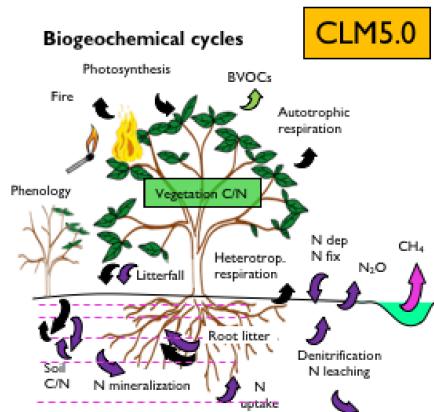
The National Center for Atmospheric Research is sponsored by the National Science Foundation. Any opinions, findings and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

NCAR | National Center for  
Atmospheric Research

# Overview of CLM-DART

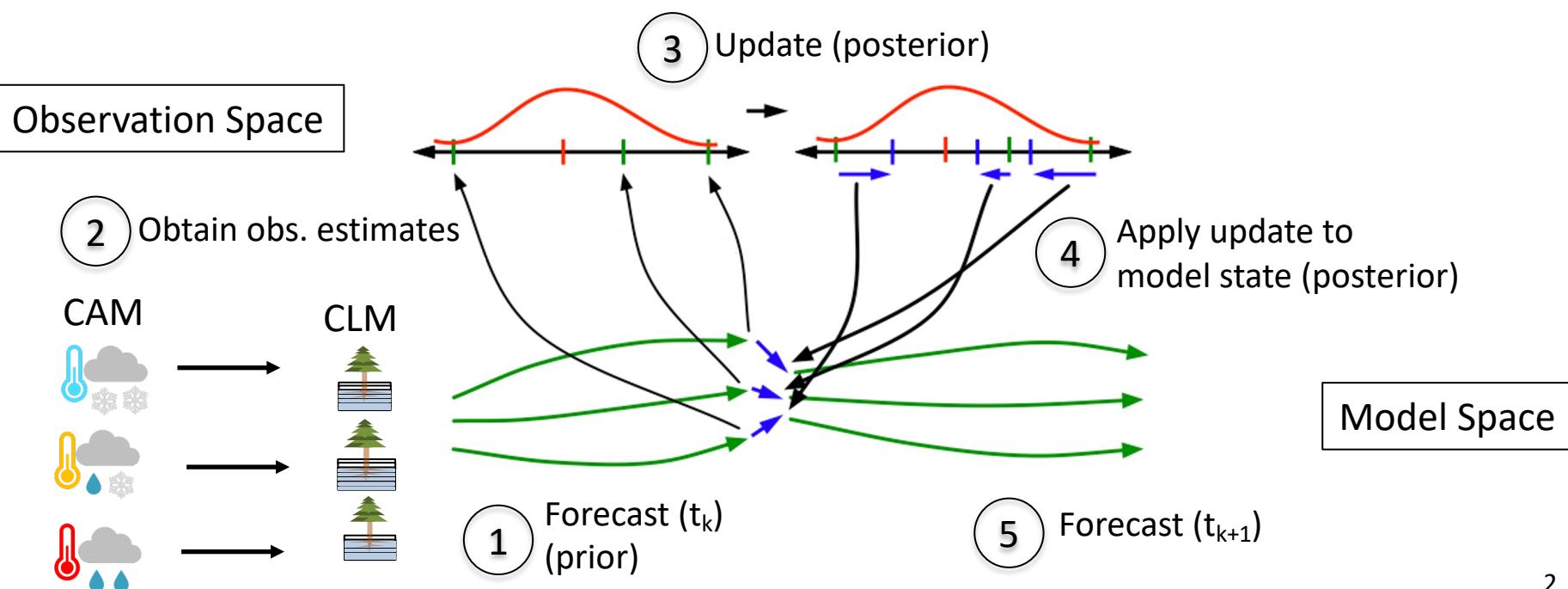
## Community Land Model (4.5, 5.0)

- Carbon, Nitrogen, Water, Energy, Cycling



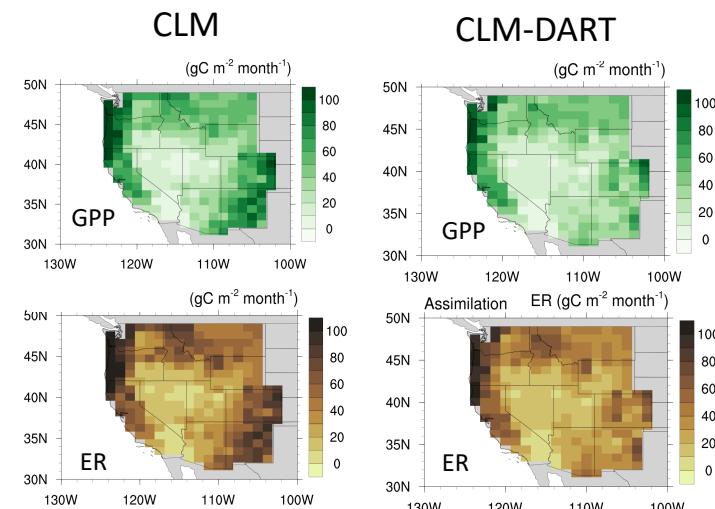
## Data Assimilation Research Testbed

- Ensemble Kalman Filter (Deterministic)
- 40-80 ensemble members
- Temporal and Spatially Varying Adaptive Inflation
- Localization (Horizontal, Vertical, State)



# CLM-DART Applications

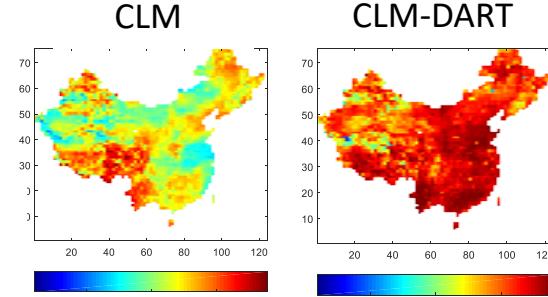
Carbon Exchange  
(Western U.S.)



Raczka et al, (2021)



Soil Moisture  
(China)



surface

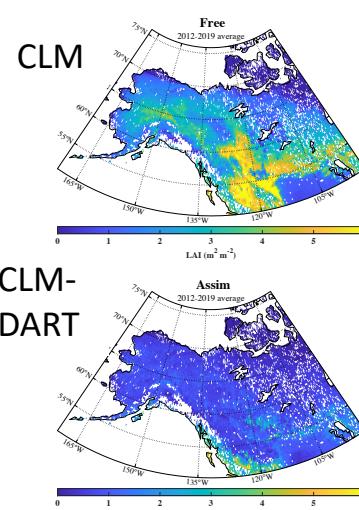
Correlations (R) w/  
ERA5 reanalysis

Sub-surface

D. Hagan et al, (in prep)

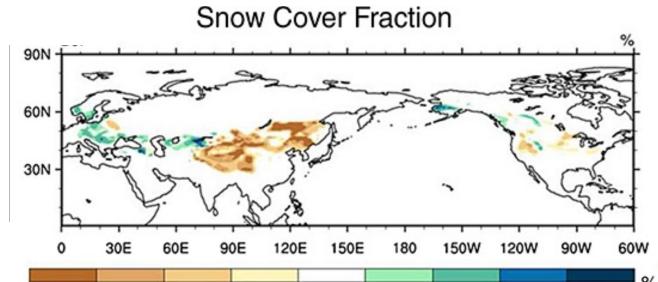


Leaf Area,  
Biomass  
(Arctic)

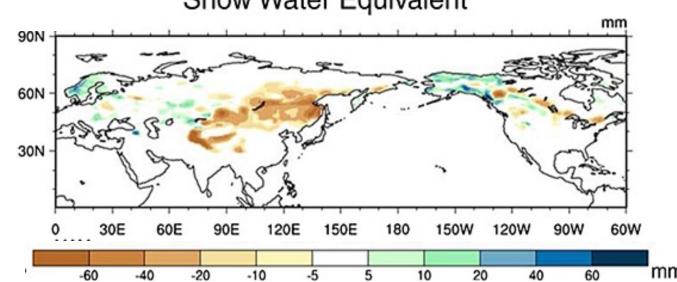


X. Huo et al, (in prep), See Poster Session, June 13th

Snow  
(Global)



CLM  
minus  
(CLM-DART)

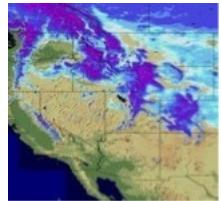


Zhang et al., 2014

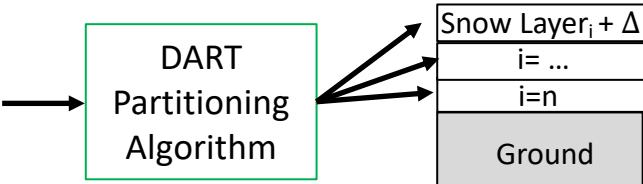
grow/yr/inr		free/run	assim/run
Ecosystem and Carbon Cycle			
Aboveground Biomass			
Biomass			
Gross Primary Productivity			
Leaf Area Index			
Net Ecosystem Exchange			
Ecosystem Respiration			
Soil Carbon			
Hydrology Cycle			
Evapotranspiration			
Latent Heat			
Sensible Heat			
Snow Water Equivalent			
Terrestrial Water Storage Anomaly			
Radiation and Energy Cycle			
Albedo			
Relationships			
LeafAreaIndex/AVH15C1			
Relative Scale			
Worse Value		Orange	Dark Blue
Better Value		Dark Blue	Orange
Missing Data or Error		Grey	Grey

# New/Future Developments

## Snow Water Equivalent (SWE)

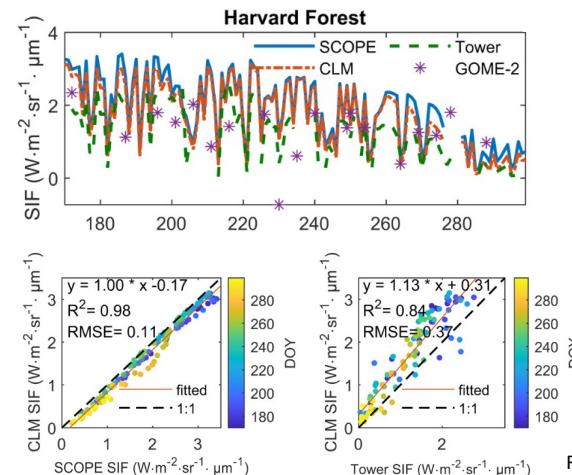


Observed  
SWE

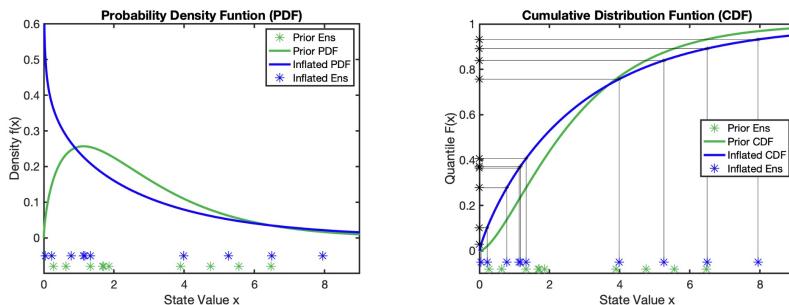


$$\begin{aligned}\Delta \text{ Total SWE} &= \sum(\Delta \text{Layers}) \\ \Delta \text{ Total Ice} &= \sum(\Delta \text{Layers}) \\ \Delta \text{ Total Liquid} &= \sum(\Delta \text{Layers}) \\ \Delta \text{ Total Depth} &= \sum(\Delta \text{Layers})\end{aligned}$$

## Solar-Induced Fluorescence (SIF)



## Filter w/ Bounded Quantity Capabilities



- Leveraging quantile information



Fortran

## CLM5-DART Tutorial

The CLM5-DART tutorial provides a detailed description of the download, setup, execution and diagnostic steps required for a simple global assimilation run using CLM5. It is intended to be performed after the completion of the more general DART tutorial which covers the fundamental concepts of the Ensemble Kalman Filter used within DART.

<https://dart.ucar.edu/tutorials/>

# For more information:

*CAM*

*GCOM*

*CAM-Chem*

*FESOM*

*ROMS*

*GITM*

*CABLE*

*WRF-Hydro*

*WACCM*

*WRF*

*CLM*

Data  
Assimilation  
Research  
Testbed



*POP*

*AM2*

*BGRID*

*SQG*

<https://dart.ucar.edu>

*NOAH*

*COAMPS*

<https://docs.dart.ucar.edu>

*NCOMMAS*

dart@ucar.edu

*PE2LYR*

*MITgcm\_ocean*

*COAMPS\_nest*

*NAAPS*

*WRF-Chem*

*TIEGCM*

*MPAS\_ATM*

*WACCM-X*

*MPAS\_OCN*

*PBL\_1d*

*NOAH-MP*