Using Data Assimilation of Leaf Area Index to Constrain Decadal Global Carbon Dynamics in CLM5.0

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1. University of Arizona 2. National Center for Atmospheric Research 3. Joint Center for Satellite Data Assimilation

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JOINT CENTER FOR SATELLITE DATA ASSIMILATION
NOAA NASA JCSDA Navy Air Force

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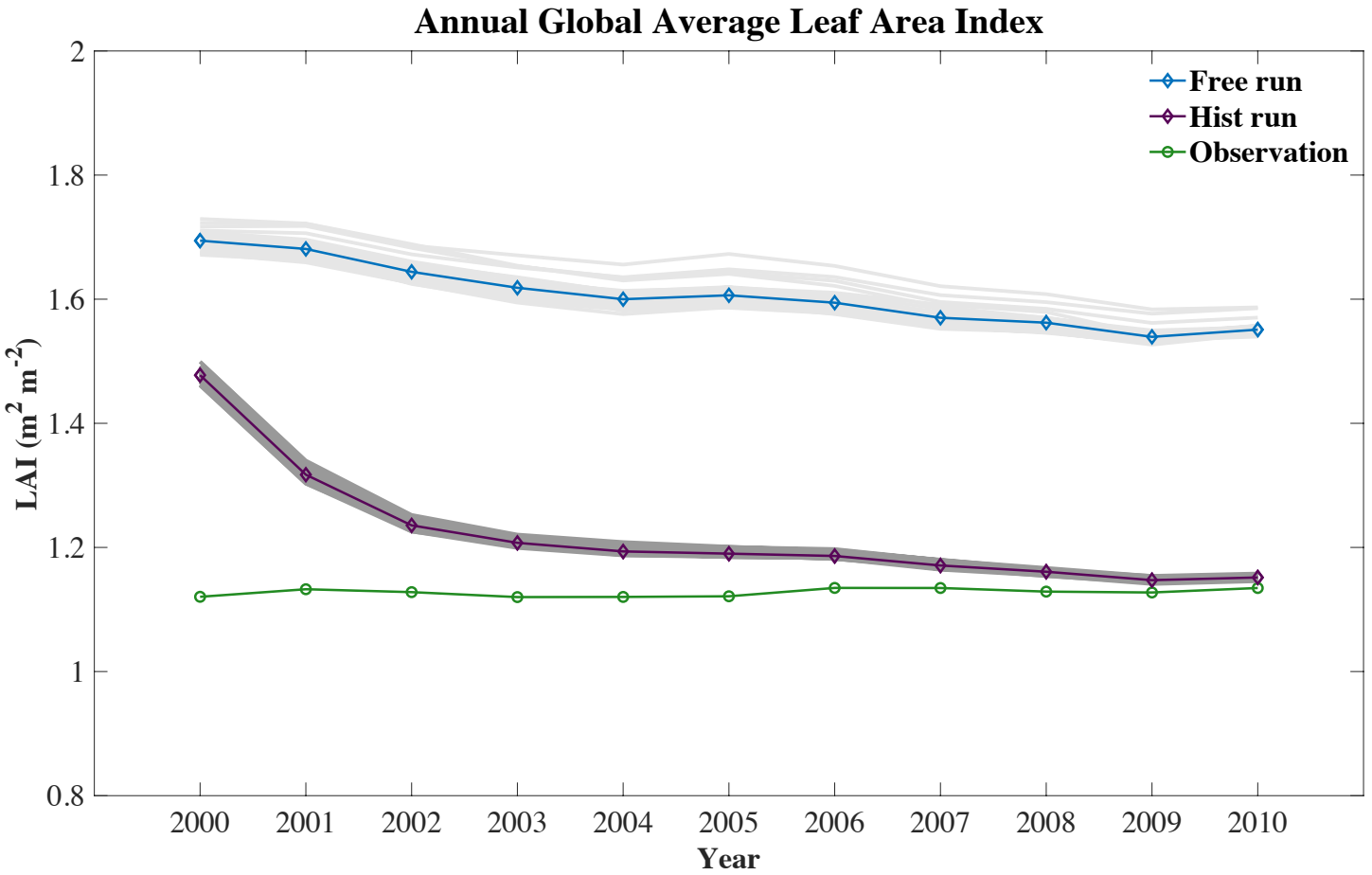
Introduction



The "official" CLM5 BGC-Crop historical run

GIMMS LAI3g data set (Zhu et al., 2013)

CLM5 ensemble run forced with CAM reanalysis

CLM5 ensemble run with data assimilation

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Outline

Global LAI Data assimilation

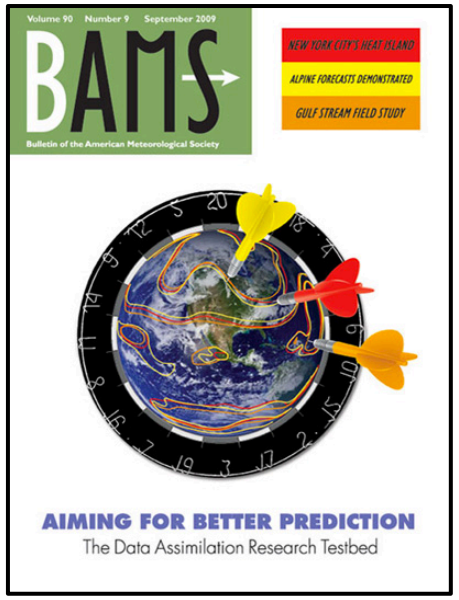
1. Assimilate LAI into CLM
2. Impact of assimilating LAI on modeled GPP and LE
3. Investigation of LAI on PFT level
4. Persistence of DA correction into forecast

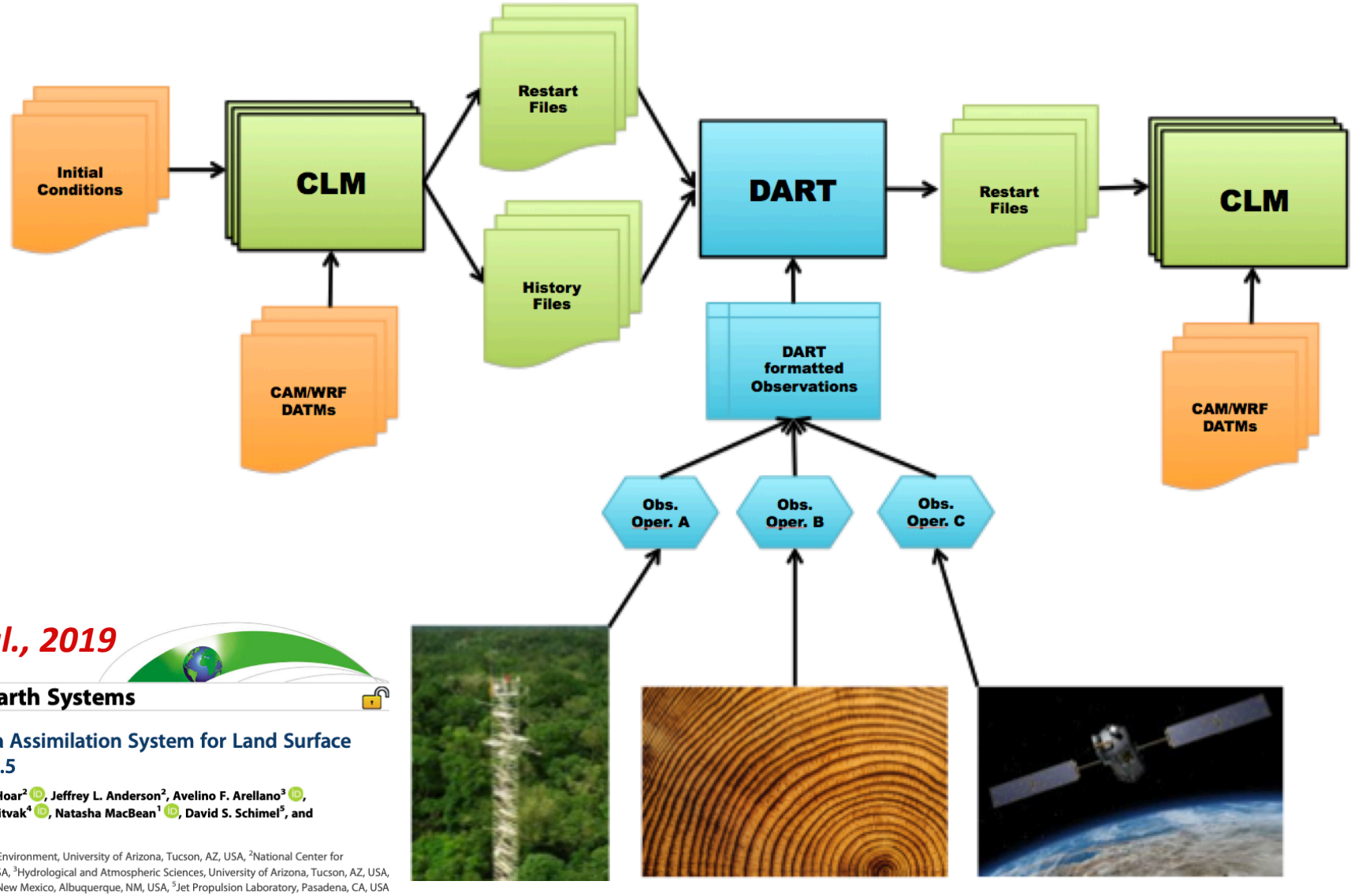
Ongoing work on Regional DA

Preparation

CLM-DART workflow

Anderson et al.,2009





AGU100 ADVANCING EARTH AND SPACE SCIENCE

Fox et al., 2019

Journal of Advances in Modeling Earth Systems

RESEARCH ARTICLE
10.1029/2018MS001362

Evaluation of a Data Assimilation System for Land Surface Models Using CLM4.5

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Key Points:
- Data assimilation was used to initialize biomass and leaf area in the Community Land Model
- Adaptive inflation was needed to give more weight to observations due to substantial discrepancies between model forecast and observations
- Data assimilation reduces forecast

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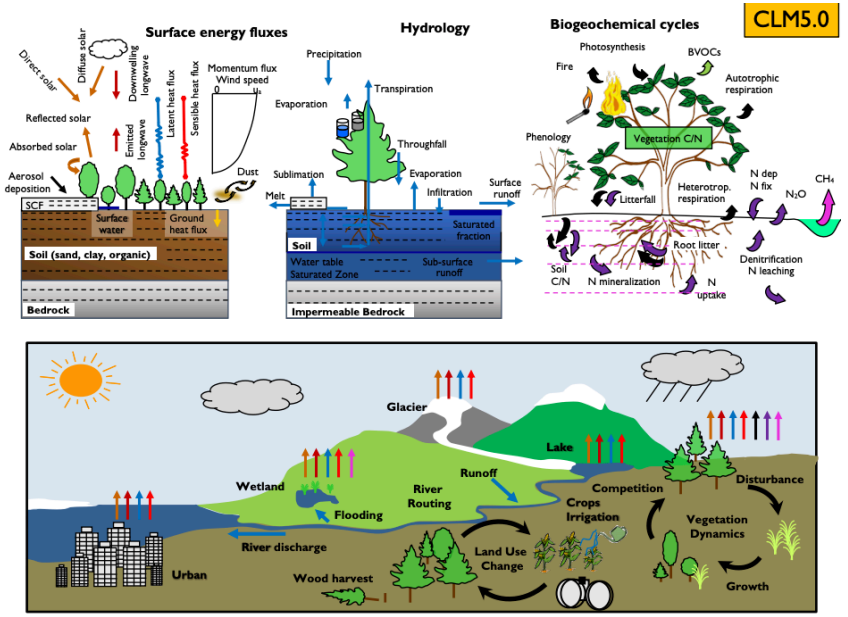
Tools and Settings

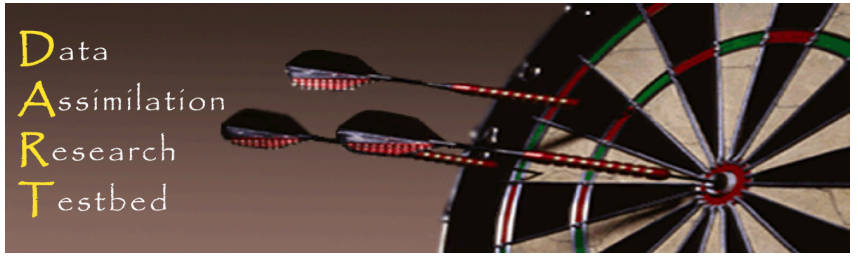
- **Community Land Model**

  Model : **CLM5.0.06**
  Resolution: f09_f09_mg17
  Forcing Data: CAM reanalysis ensemble (1.875degx2.5deg)
  Number of Ensembles: 60
  Time : 2000 Jan 1st to 2011 December 31st
  Component configuration :
  2000_DATM%GSWP3v1_CLM50%BGC-CROP_SICE_SOCN_MOSART_SGLC_SWAV



- **DART, the Data Assimilation Research Testbed**

  Observation : GIMMS LAI3g version 2, a bi-weekly data product
  interpolated onto model resolution
  Assimilation time: every 1st and 15th day each month
  Observation error variance: ***0.04*** Outlier_threshold: ***6***
  Time- and space-adaptive state-space inflation



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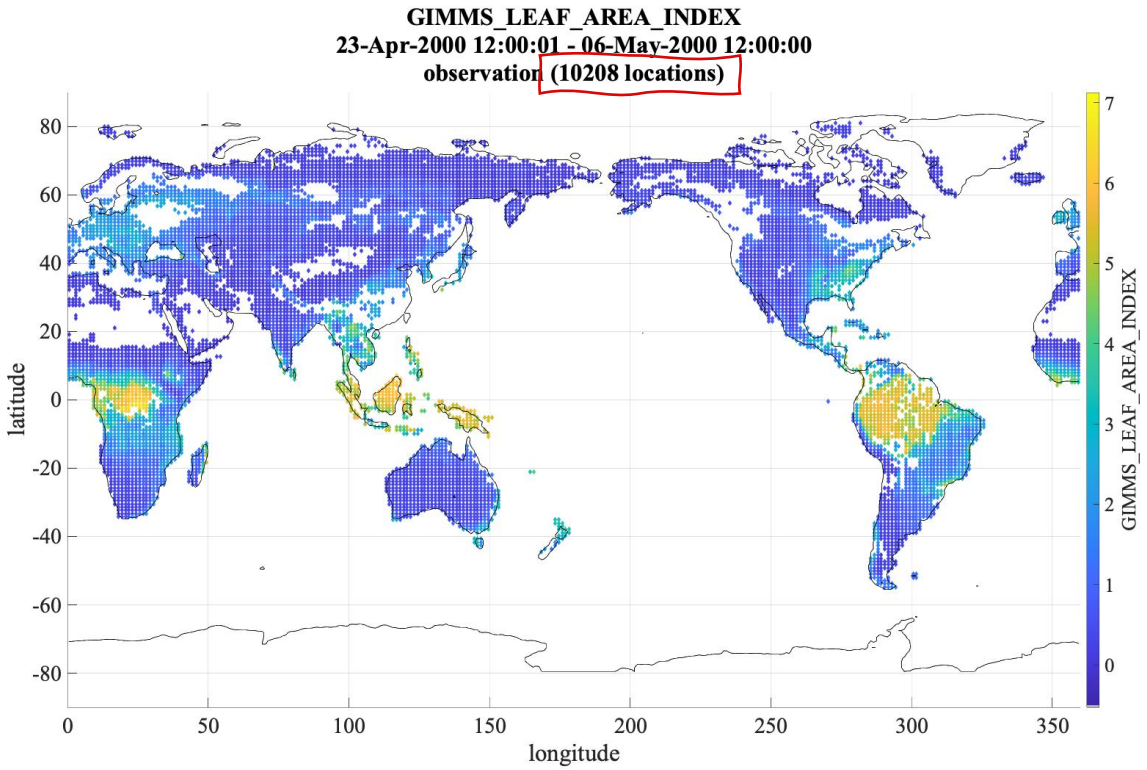
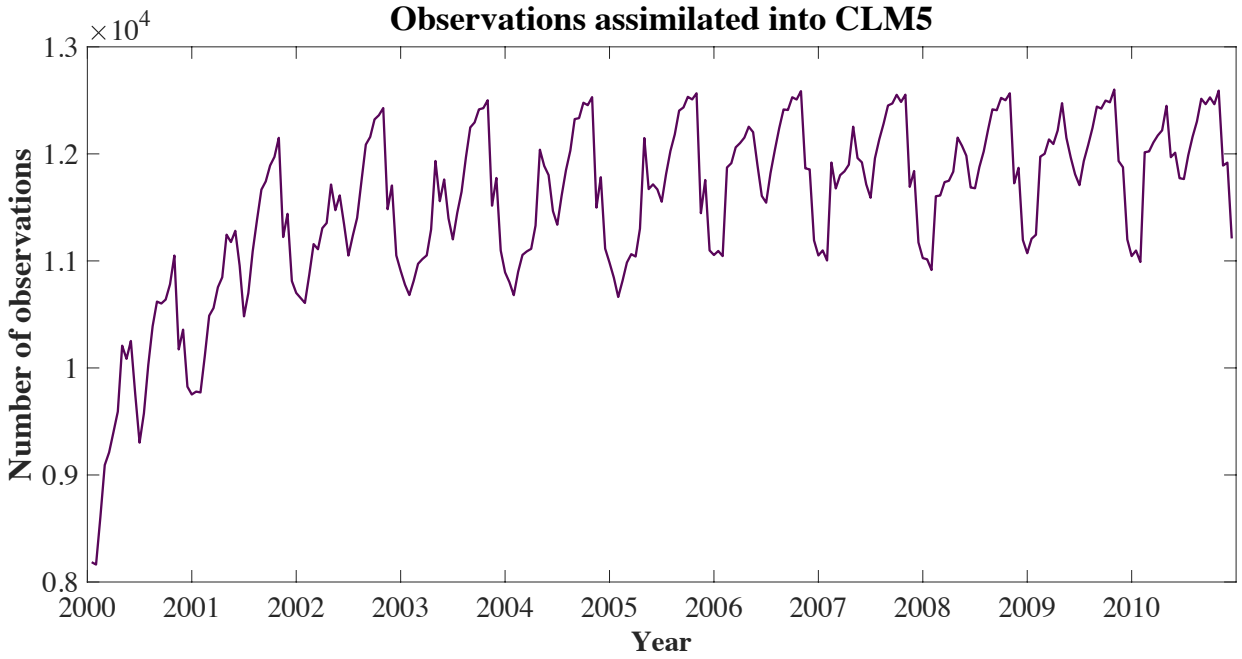
1. Assimilate LAI observation into CLM

Observation assimilated into the model

2000-05-01





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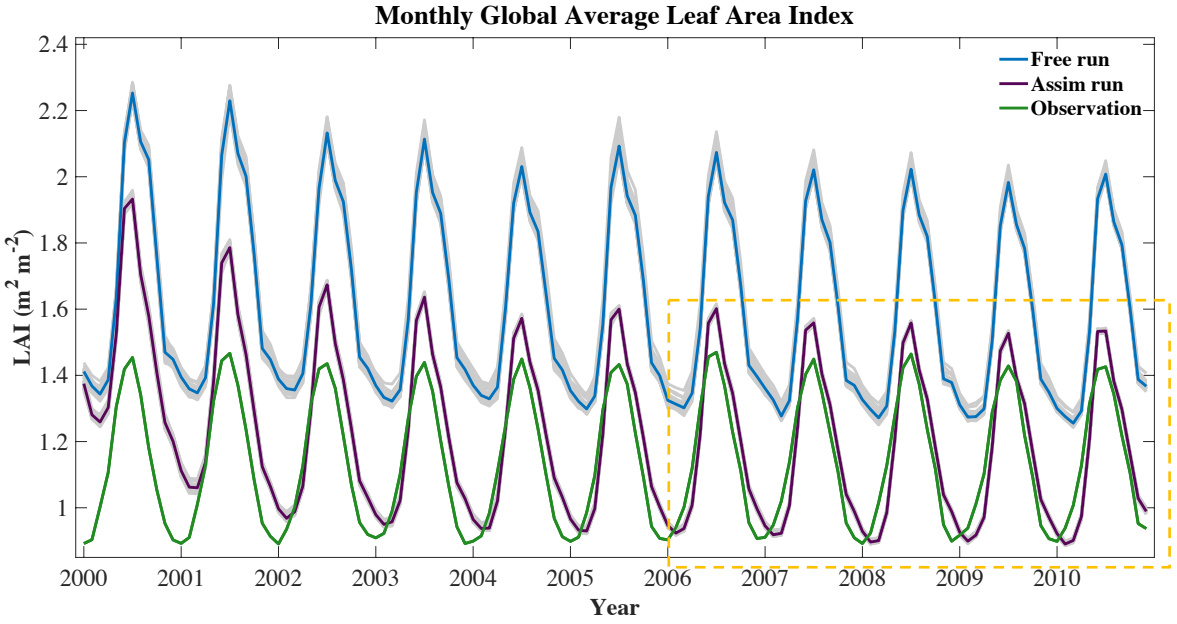

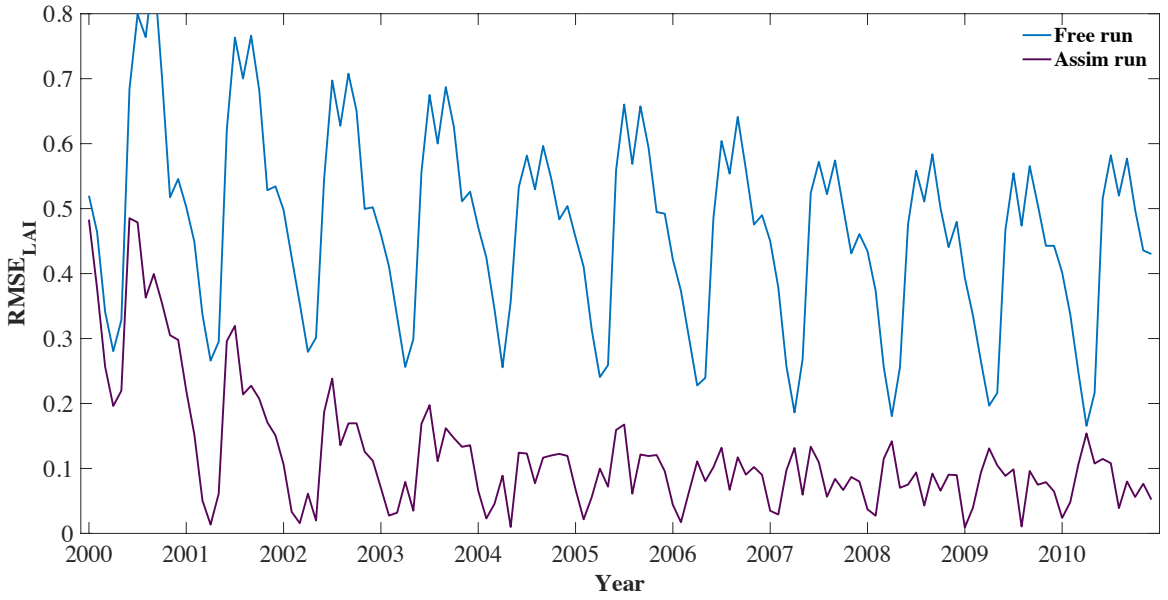

It takes four years for DA

Stable period: 2006-2010

LAI decreases by 25%

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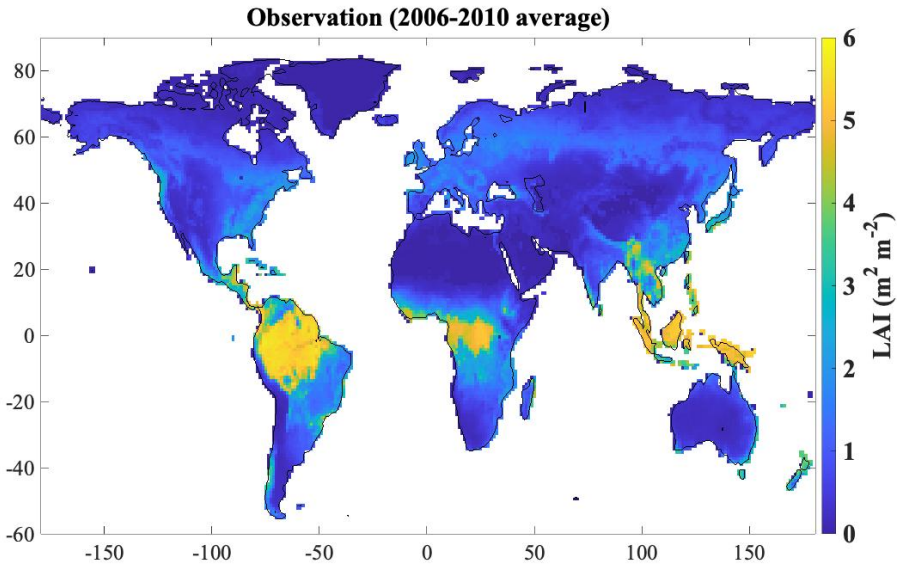
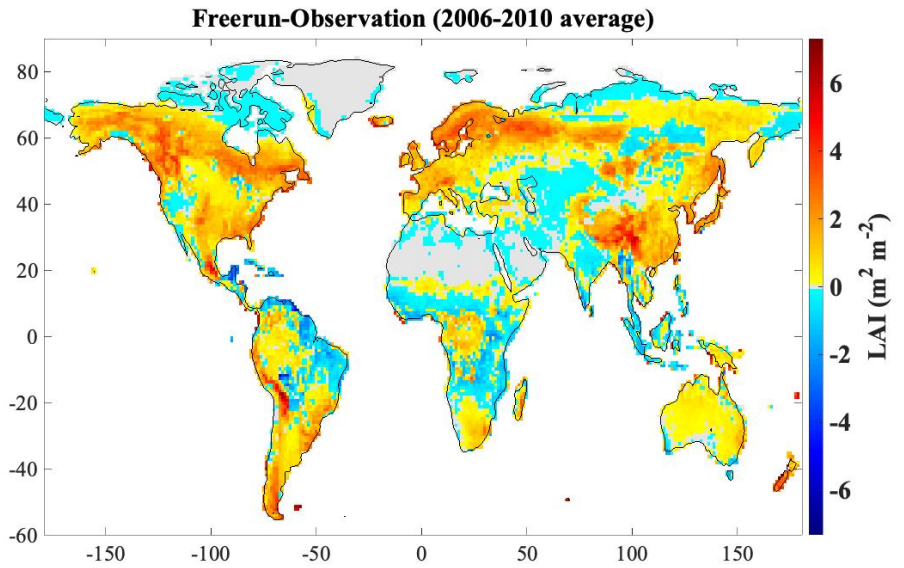
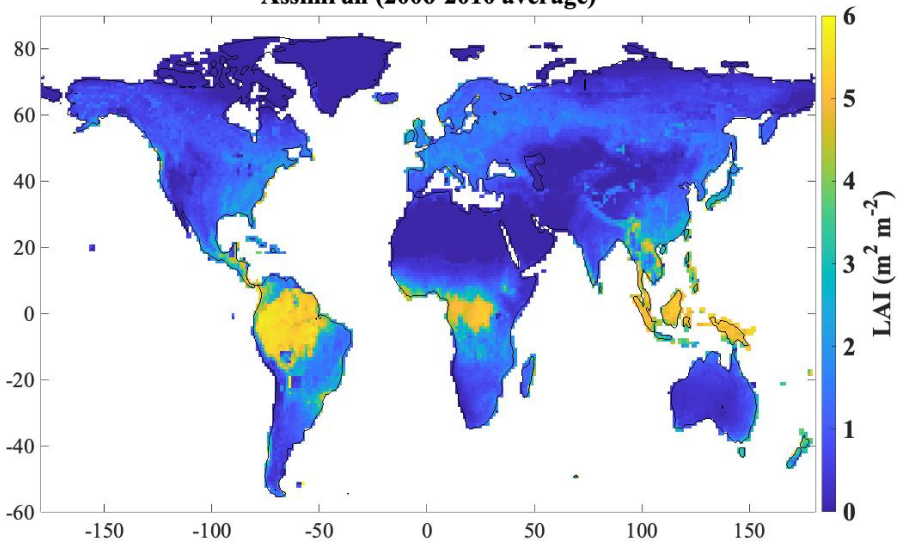
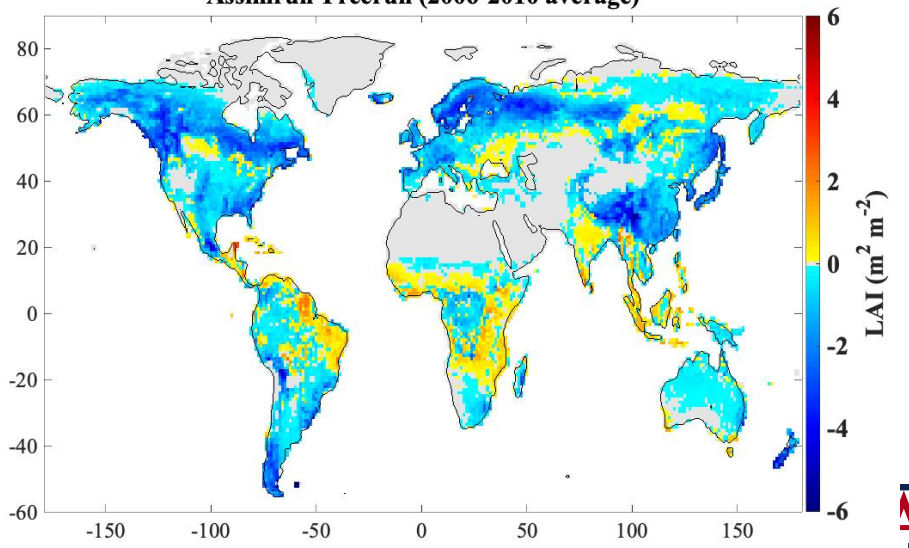
1. Assimilate LAI observation into CLM









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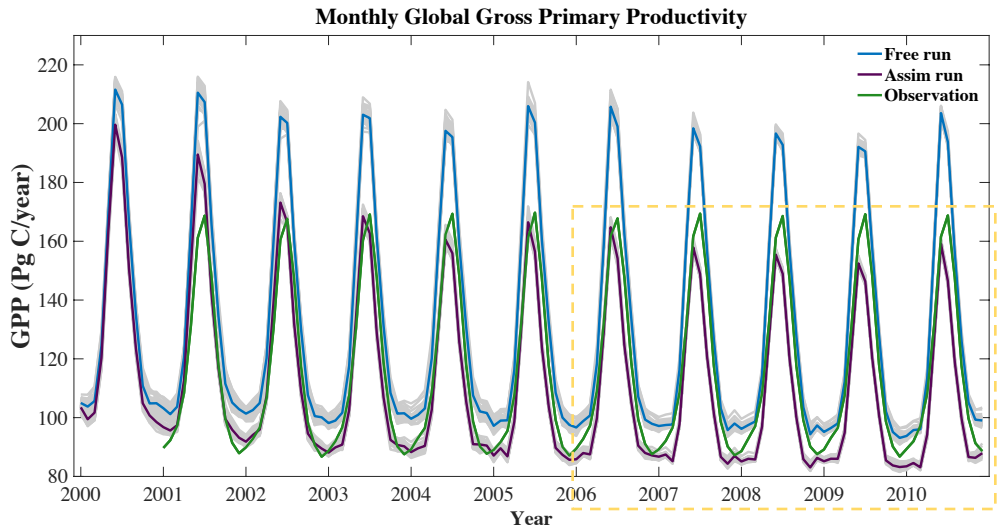
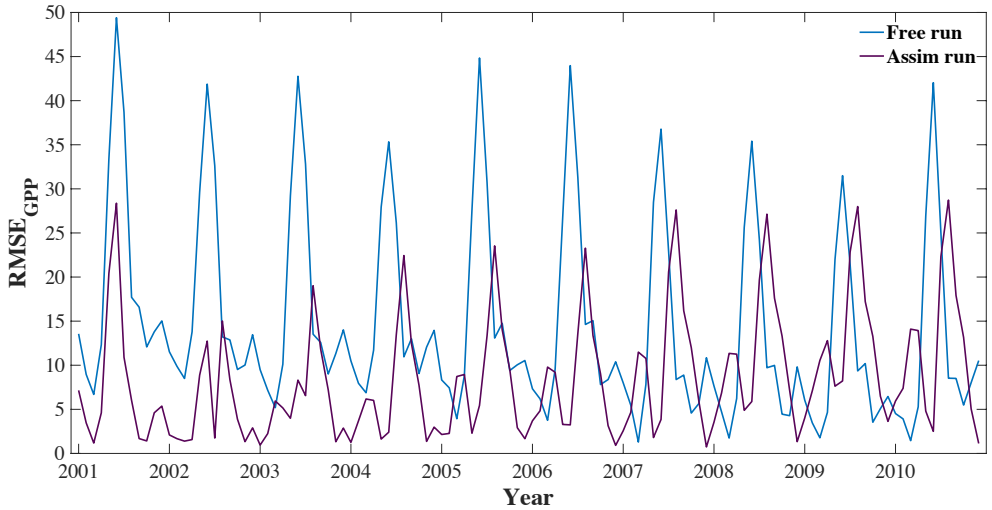
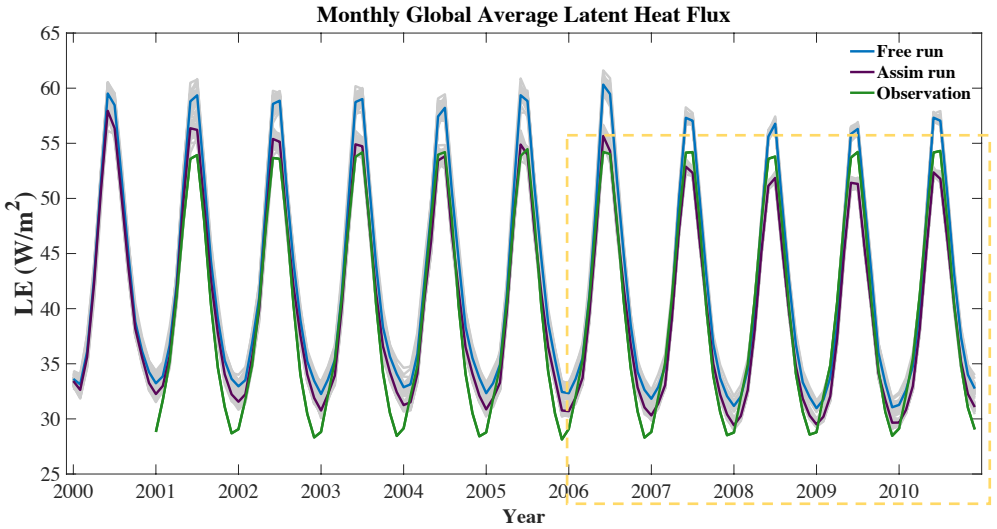
2. Impact of assimilating LAI on modeled GPP and LE

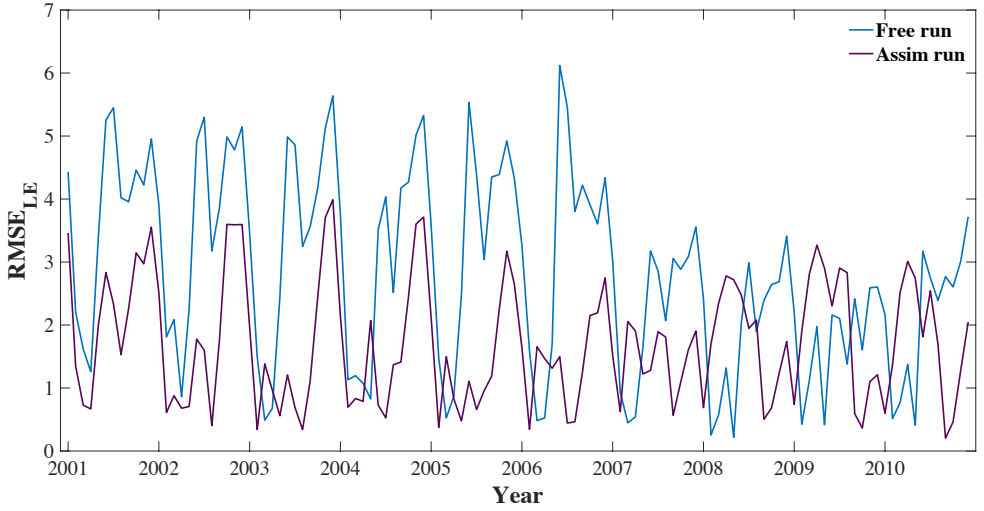
17.7%





6%





Fluxcom Data Set *Jung et al. (2019)*

Jung et al. (2020)

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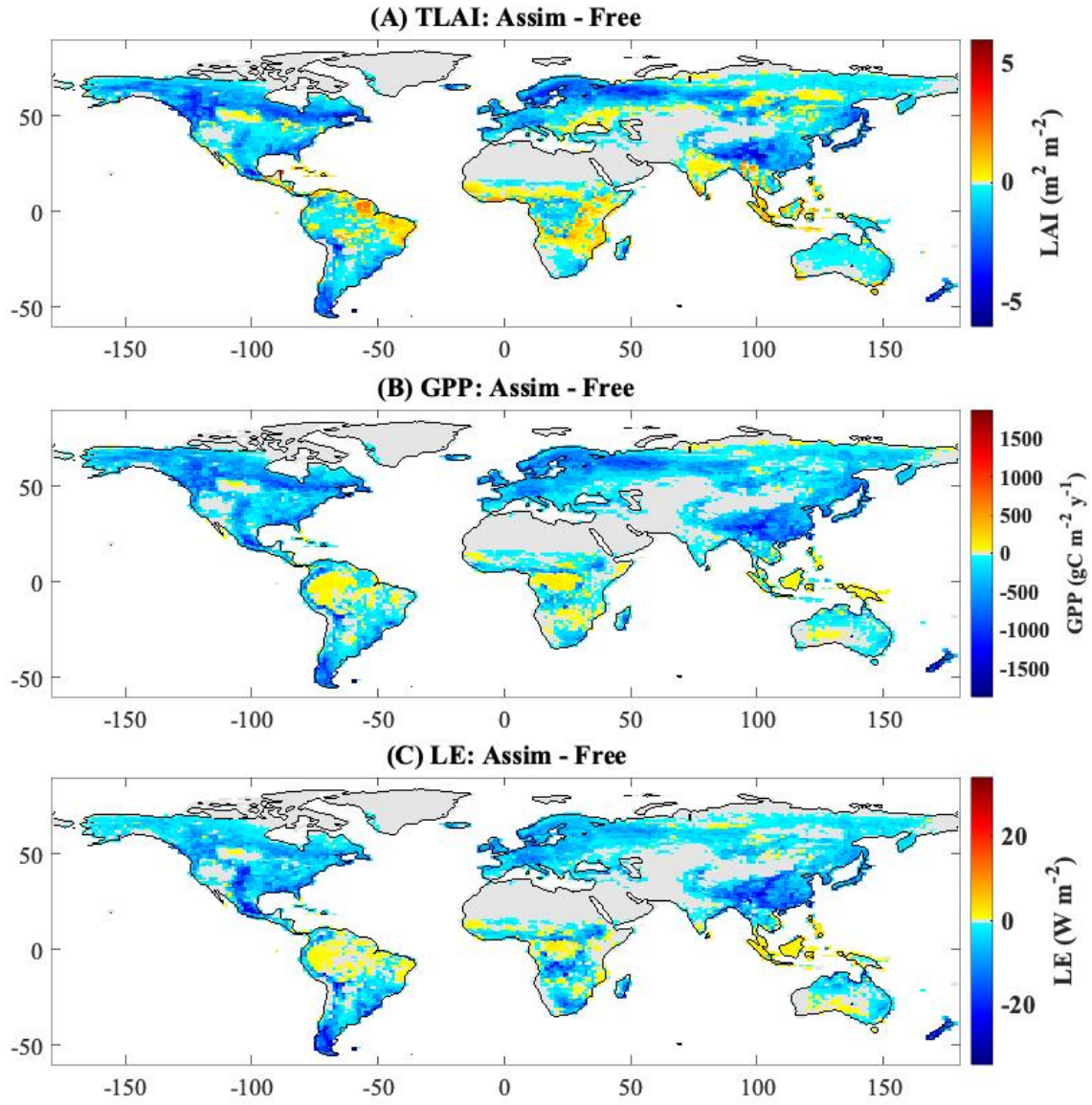
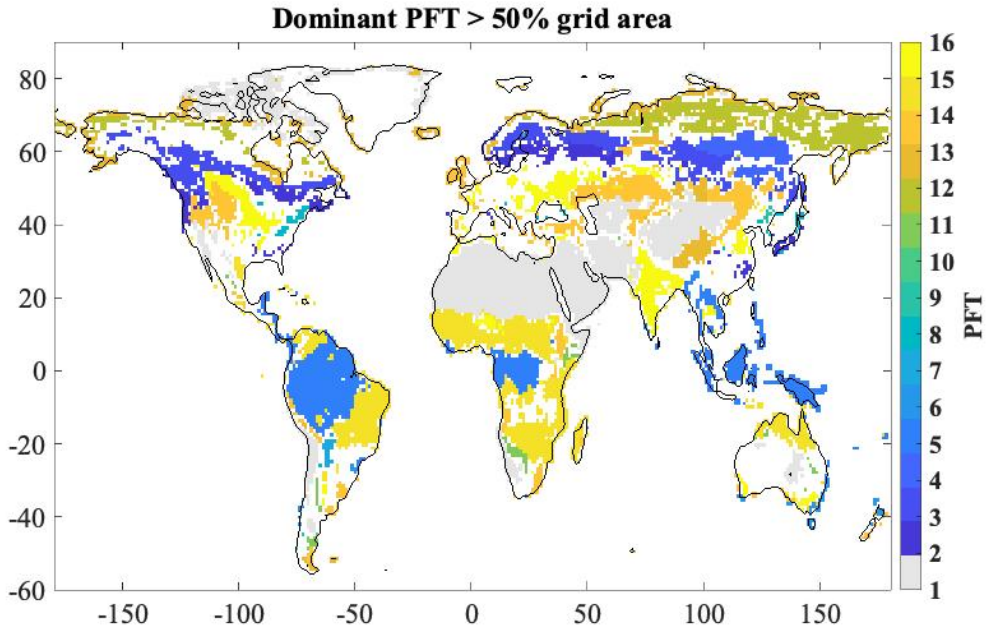
3. Investigation of LAI on PFT level

2006-2010 Average



Geographic Distribution of Dominant PFT



1. Bare ground
2. Needleleaf Evergreen Temperate Tree
3. Needleleaf Evergreen Boreal Tree
4. Needleleaf Deciduous Boreal Tree
5. Broadleaf Evergreen Tropical Tree
6. Broadleaf Evergreen Temperate Tree
7. Broadleaf Deciduous Tropical Tree
8. Broadleaf Deciduous Temperate Tree
9. Broadleaf Deciduous Boreal Tree
10. Broadleaf Evergreen Shrub
11. Broadleaf Deciduous Temperate Shrub
12. Broadleaf Deciduous Boreal Shrub
13. C3 Arctic Grass
14. C3 Grass (non-Arctic)
15. C4 grass
16. Crops

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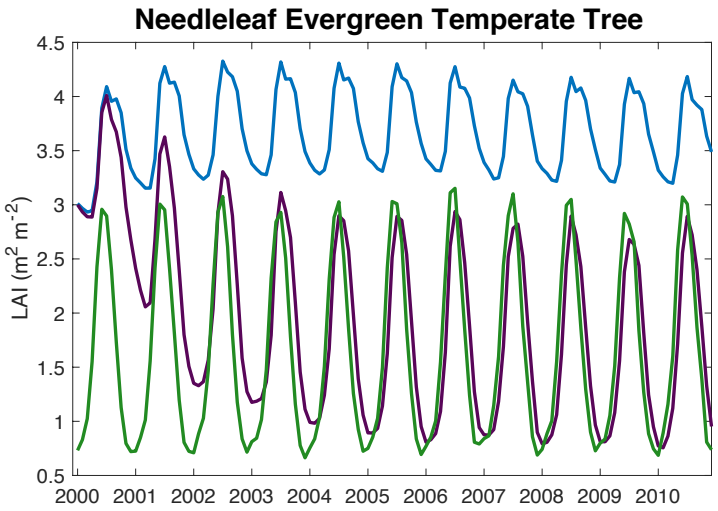
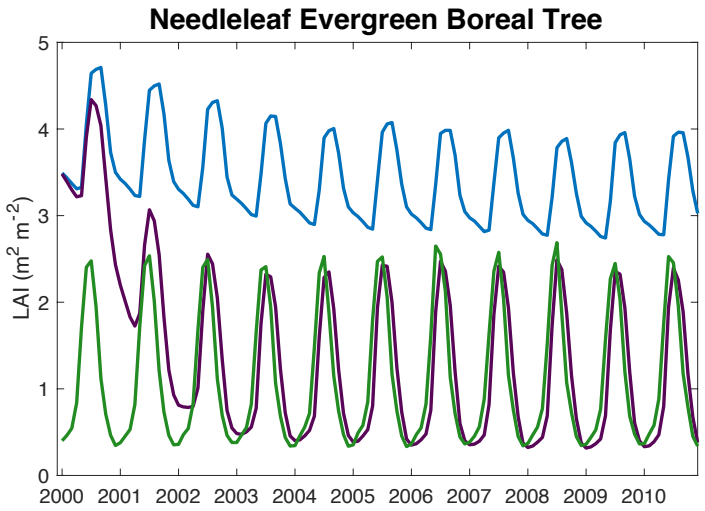
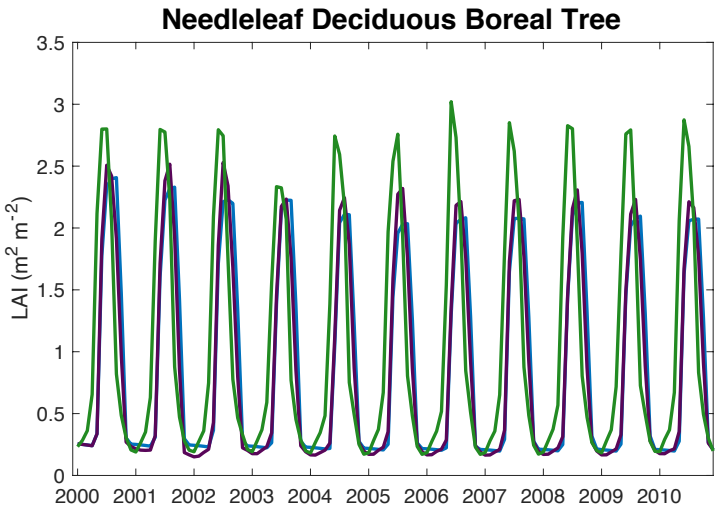
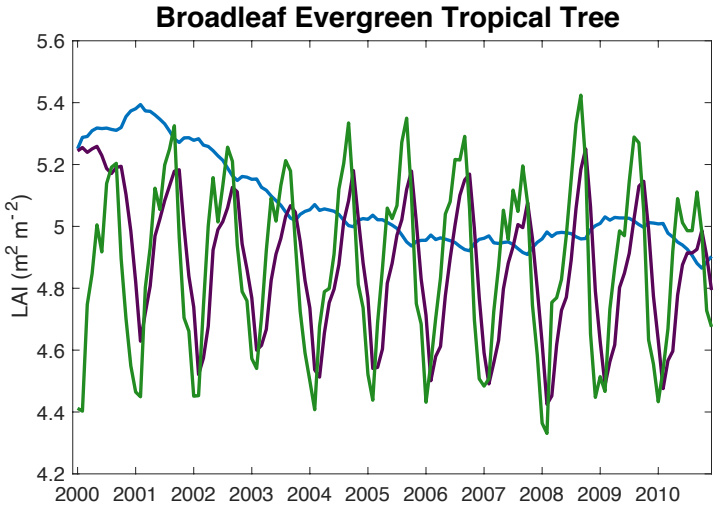
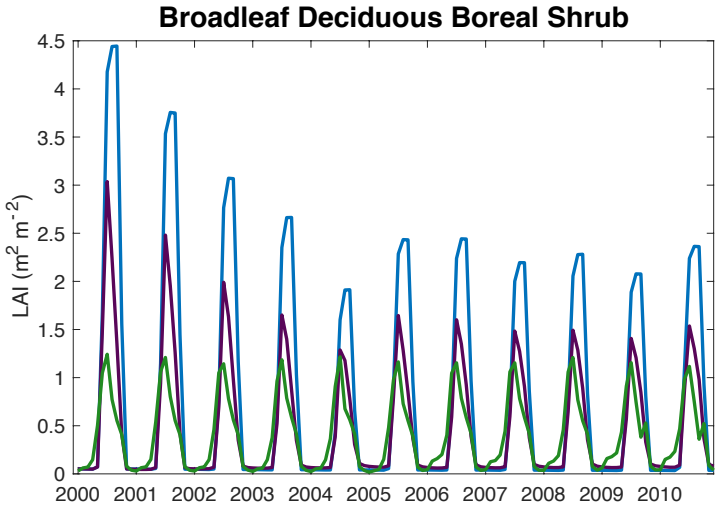
3. Investigation of LAI on PFT level

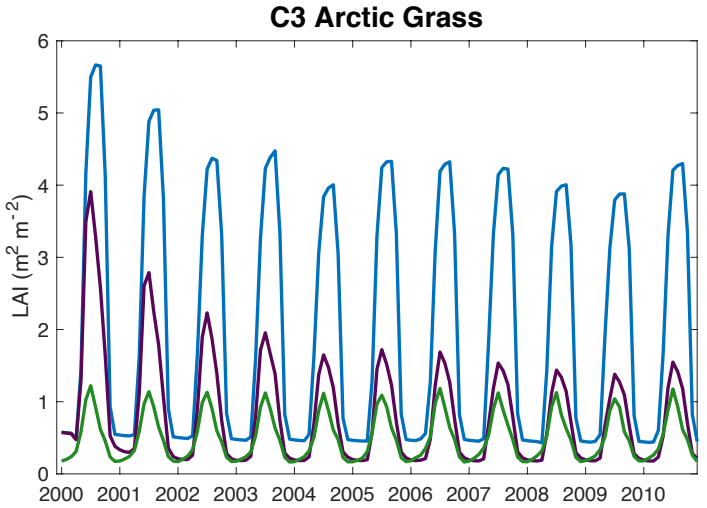












DA imposes the seasonality in the assimilation run.

The peak of LAI in the summer in the assimilation run generates higher productivity.

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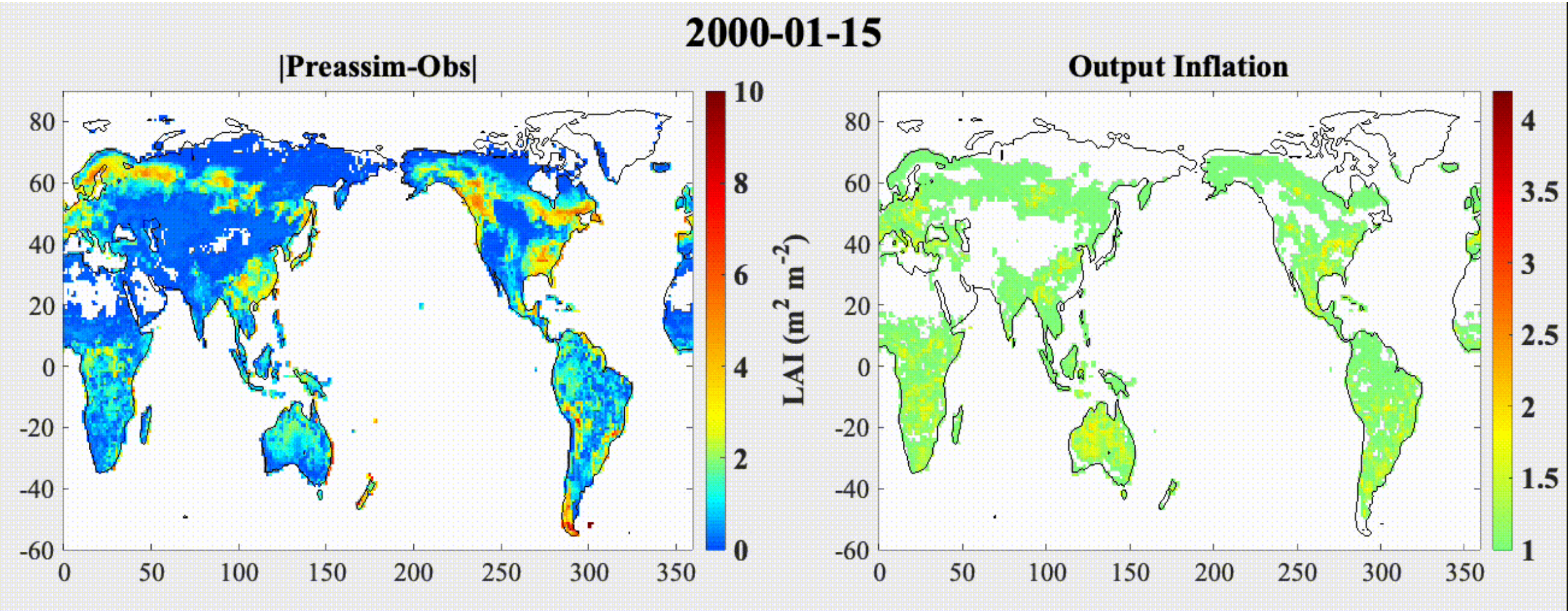
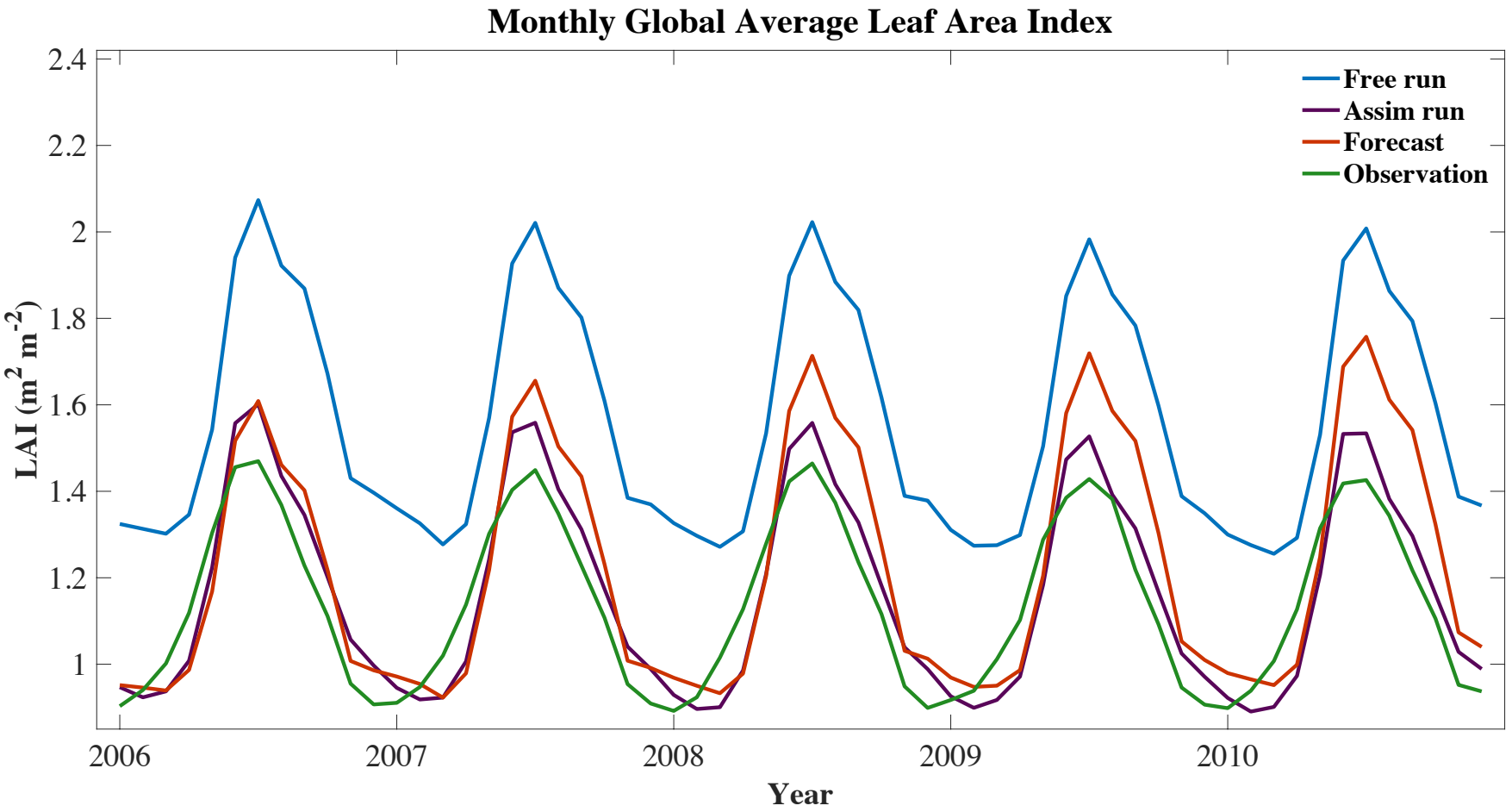
3. Investigation of LAI on PFT level

Spatial- and Time- varying Inflation



4. Persistence of DA correction into forecast



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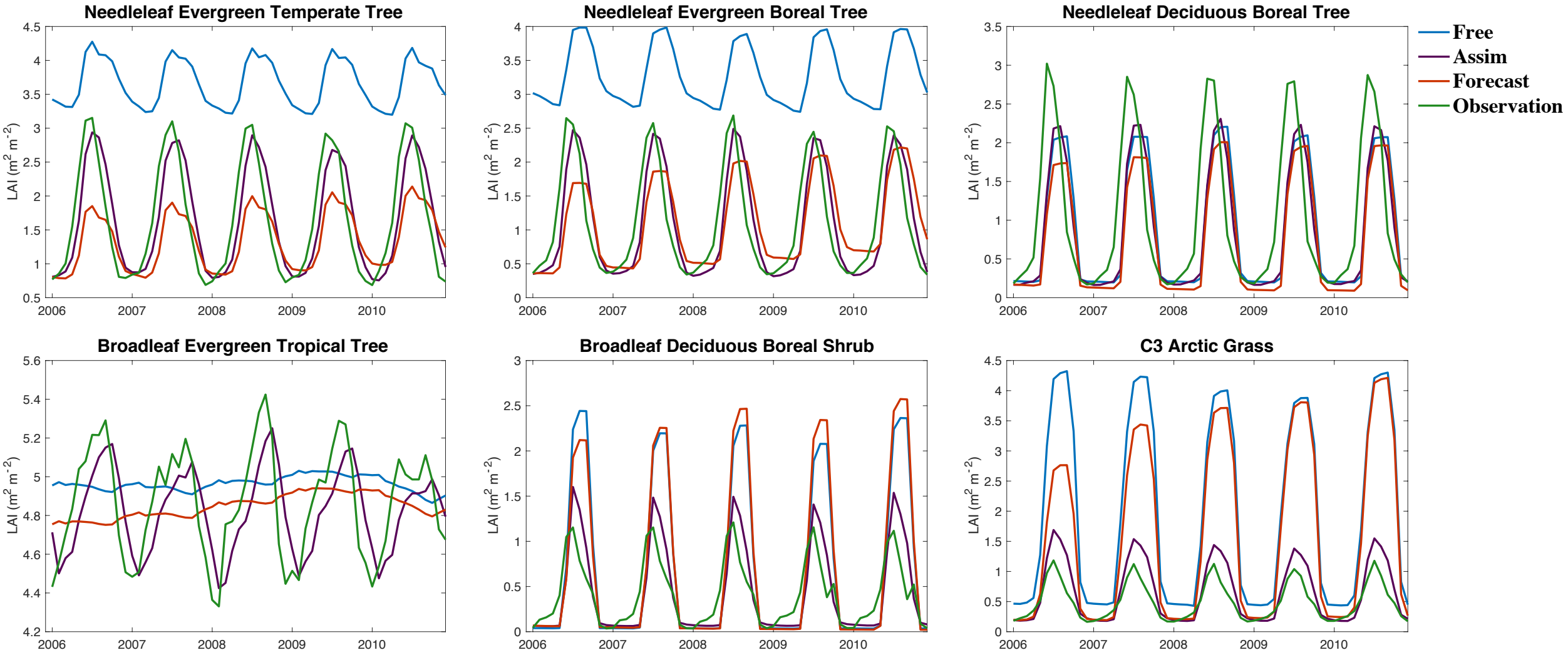


We don't change the model parameters

Summary

1. By assimilating LAI into CLM5.0, we reduced the positive bias of LAI by 25% on the global average. GPP was reduced by 17.7% and LE was reduced by 6% globally.

2. A spatial- and temporal- varying adaptive inflation allowed to reduce LAI bias across different plant function types/regions globally.

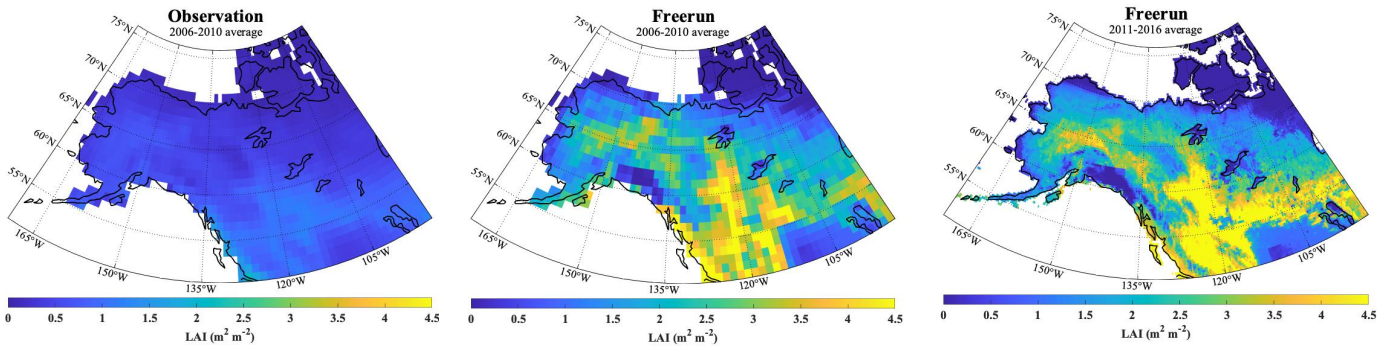
3. Forecast persistence in woody plant functional types (except BETT) was longer than the persistence in non-woody plant functional types.

High-Res Regional DA

Preparation:

1) Generate high-resolution surface data set
2) Spin the model up (1080 years)
3) Reseed
4) Check carbon equilibrium
5) Generate model ensemble spread

Research Area



0.25°x0.25°

PPE-ctsm5.1.dev012

New CAM6 reanalysis forcing data 1°x1°, 80-ensemble

Observations:
Remote sensing or in-situ upscaling products

1) LAI
2) Biomass
3) *Soil moisture*
4) *Canopy profile*
5) *Snow water equivalent, snow depth, snow cover fraction*

CLM-DA

Timeline

2021					
Jan	Feb	Mar	Apr	May	Jun …
Investigate and determine the observation to assimilate into model and generate the obs sequence		Modify the data assimilation script and tweak the DA system		Launch model runs on cheyenne	Data analysis and manuscript preparation

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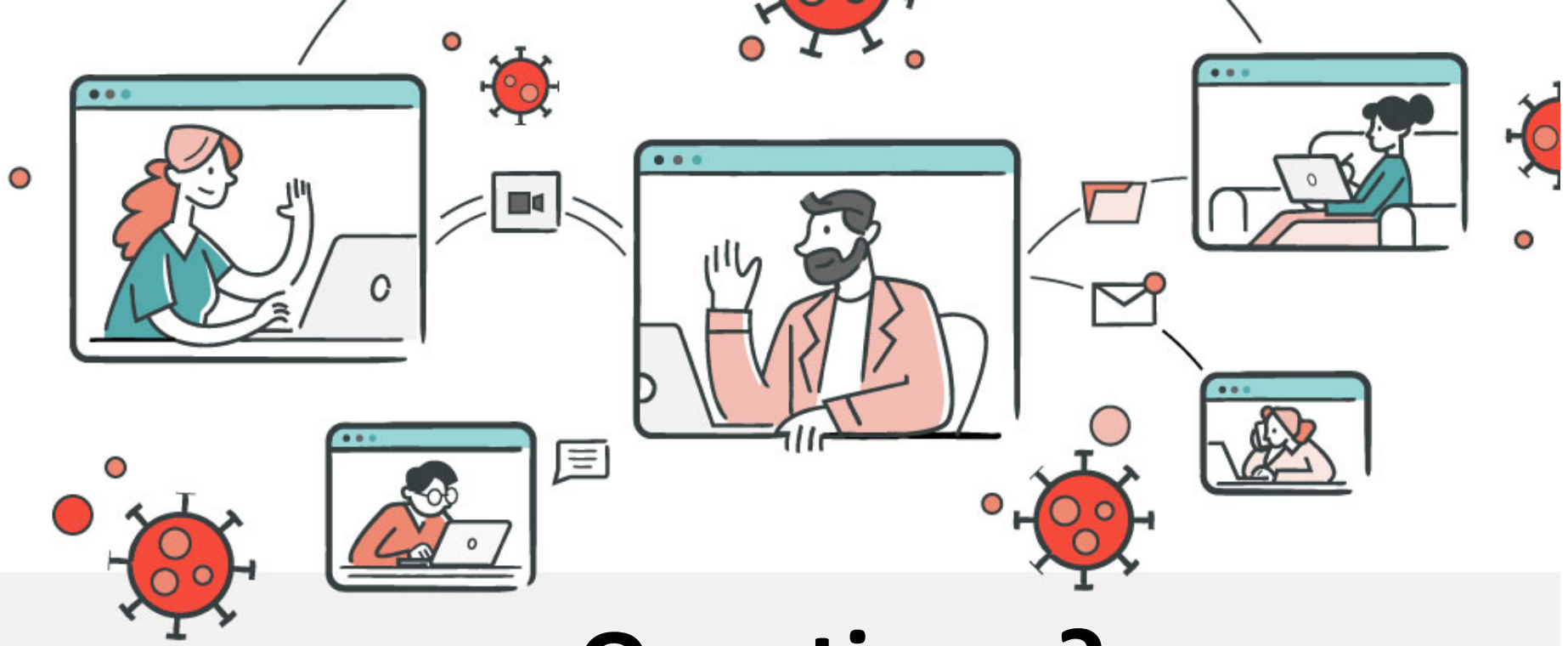

Questions ?

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