卫星遥感叶面积指数（GLASS LAI）在陆面过程模型中的同化及应用

Assimilation of remotely sensed leaf area index (GLASS LAI) into the Community Land Model with explicit carbon and nitrogen components

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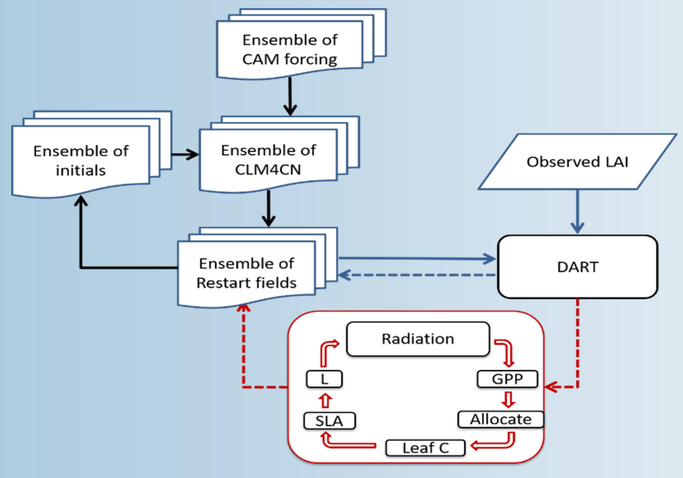
INTRODUCTION

The leaf area index (LAI), influences the exchanges of momentum, carbon, energy, and water between the terrestrial biosphere and the atmosphere, is a key variable in regulating the global carbon, energy, and water cycles. In-situ observation can provide accurate LAI data, while it is not easy for widely world use. Modern land surface models have included prognostic carbon and nitrogen components to simulate the LAI, but these LAI simulations show biases in both amplitude and phase.

Land data assimilation, combining observation and simulation together by mathematical variation method or filter method, can provide the most accurate variable estimation, and achieve spatial and temporal extension. Satellite-derived data could provide continuous temporal and spatial LAI product, which is the data basis for land data assimilation.

METHODOLOGY

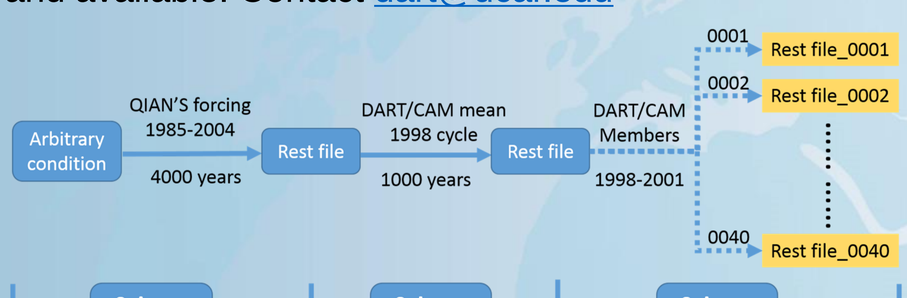
DART is a community facility for ensemble DA developed and maintained by the Data Assimilation Research Section (DAReS) at the National Center for Atmospheric Research (NCAR). *https://www.image.ucar.edu/DAReS/DART/index.php*



Flow chart of DART/CLM4-CN. Different CAM reanalysis and initial condition are used to drive the CLM Ensemble Member. If the observations are available, DART will combine the observation and CLM together to generate DART state variable. DART returned the updated variable to CLM4-CN, and move on to the next step.

ATMOSPHERIC FORCING AND INITIAL FIELD

Atmospheric Forcing Data: Assimilation uses 80 members of 2o FV CAM forced by a single ocean (Hadley+ NCEP-OI2) and produces a very competitive reanalysis (Raeder et al., 2012), 1998-2010 4x daily is free and available. Contact dart@ucar.edu



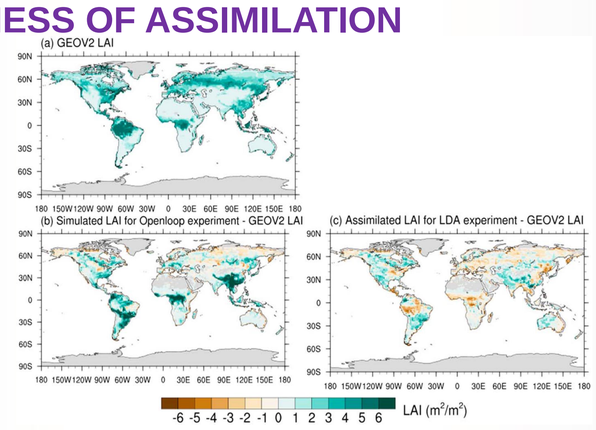
- Single Qian's forcing (Qian et al., 2006) was used to drive the model for 4000 years (Shi et al., 2013).
- Ensemble mean of 40 atmospheric forcing members for the year 1998 was used to drive the CLM4CN for 1000 years.
- 40 ensemble atmospheric forcing were used to drive the ensemble CLM4CN members for 40 plus 4 years from 1998 to 2001, and achieve 40 ensemble initial conditions.

EXPERIMENTAL DESIGN

Experiment design for LAI assimilation using DART/CLM4CN

Experiment	Assimilated variables	Updated variables	Assimilation algorithm
Openloop	No DA	-	-
Leaf DA (LDA)	GLASS LAI	LAI, Leaf C, Leaf N	EAKF

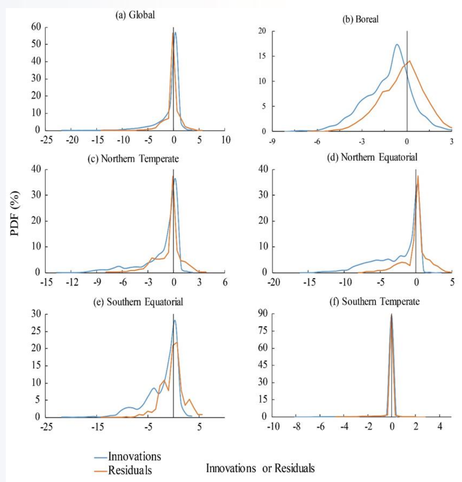
EFFECTIVENESS OF ASSIMILATION



The spatial distributions of global LAI in July 2002 for (a) observations, (b) simulation, (c) assimilation with C-N constraint.

- The simulated LAI is extremely higher than MODIS upscaled LAI at 1 degree grid.
- C-N experiment performed the best assimilation scheme, and assimilation results are better in low latitude regions.

ESTIMATED METHOD



Probability density function of innovation and residuals of LAI for (a) Global, (b) Boreal (45N-65N), (c) Northern Temperate (23N-45N), (d) Northern Equatorial (0-23N), (e) Southern Equatorial (0-23S), and (f) Southern Temperate (23S-90S) in July 2002.

- Innovation (blue lines) = observations – openloop
- Residuals (red lines) = observations – analysis

RESULTS AND DISCUSSION

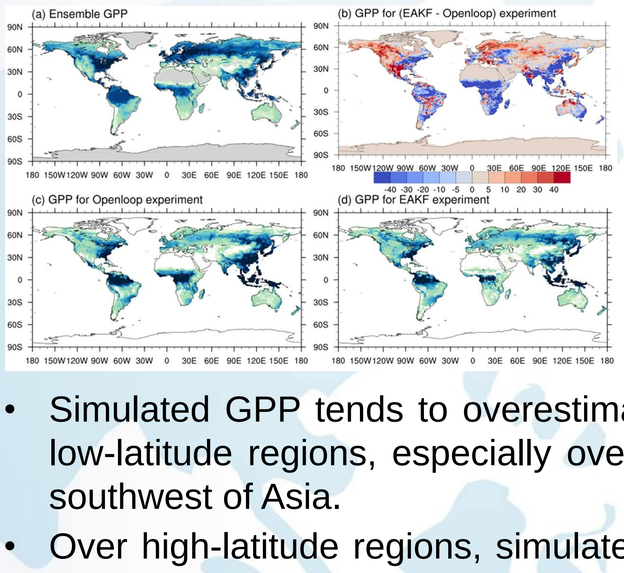


Figure. GPP from the (a) MODIS estimates, (b) Difference between LDA and Openloop experiments, (c) Openloop and the (d) analysis

- Simulated GPP tends to overestimate the monthly GPP estimates in the low-latitude regions, especially over the Amazon, central Africa, and the southwest of Asia.
- Over high-latitude regions, simulated GPP is underestimated, particularly over the 55-65° N regions covered by NET forest or mixed forests. The analyzed GPP can reduce these biases as showed.

Related Publications

Ling, Xiaolu, Congbin Fu, Weidong Guo, and Zongliang Yang. 2019. Assimilation of remotely sensed LAI into CLM4CN using DART, ***Journal of Advances in Modeling Earth Systems,*** 11, 2768–2786.

Ling, Xiaolu, Congbin Fu, Zongliang Yang, and Weidong Guo. 2019. Compariosn of different sequential assimilation algorithms for satellite-derived leaf area index using the Data Assimilation Research Testbed (version Lanai), ***Geoscientific Model Development***, 12, 3119-3133.