Detection of Systematic errors on different time scales in a land surface model

Tao Wang, Pierre Brender, Philippe Ciais, Catherine Ottle and FLUXNET investigators

LSCE, UMR CEA-CNRS-UVSQ, Bâtiment 709, CE L'Orme des Merisiers, Gif-sur-Yvette F-91191, France

Introduction

Since the advent of FLUXNET, land surface models are often evaluated on a handful of EC sites. Previous studies characterized the model-data errors on different time scales and pointed out that the large relative model-data errors occurred in low frequencies. However, the share of model-data error which is not random at and across different time scales is still not well understood. In this study, taking a land surface model (ORCHIDEE) as an example, we resort to time series decomposition method (SSA) and artificial neural network (ANN) for quantifying time-scale transitivity and space transitivity of model systematic errors on different time scales (diurnal, annual and interannual) based on 500 site-years of eddy covariance data from 123 sites across the global in FLUXNET database. The scientific issues we would like to answer in this study are as follows: (1) The share of model systematic errors on diurnal, annual and interannual time scales; (2) Whether model systematic errors can be transferable or not across different time scales; (3) Whether their is model systematic error transitivity within and across different vegetation types on different time scales.

Data and Methods

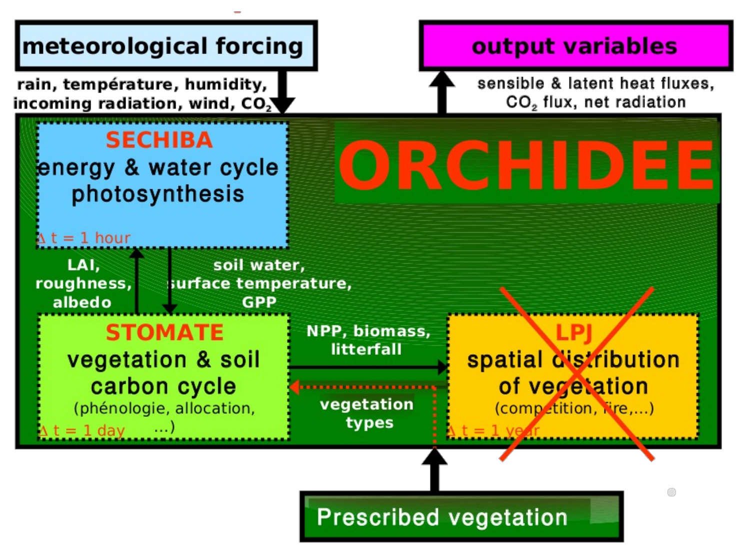
Lathuile Fluxnet dataset

Table 1. The number of sites belonging to each PFT x climate zone

Climate zone/PFT	GRA	CRO	BoENF	TeENF	TeEBF	TeDBF	TrEBF
Boreal	1	0	18	0	0	1	0
Temperate	14	5	0	10	2	6	0
Temperate-continental	4	6	0	9	0	10	0
Subtropical- Mediterranean	5	4	0	9	4	9	0
Tropical	0	0	0	0	0	0	8

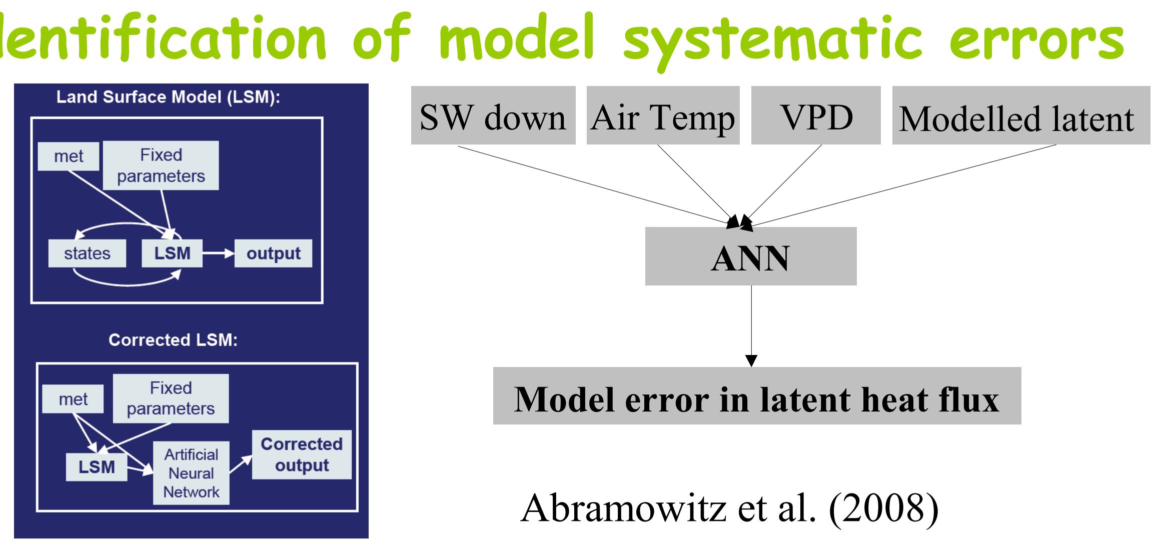
GRA: grassland; CRO: cropland; BoENF: boreal evergreen needleleaf forests; TeENF: temperate evergreen needeleaf forests; TeEBF: temperate evergreen broadleaf forests; TeDBF: temperate deciduous broadleaf forests; TrEBF: tropical evergreen broadleaf forests

ORCHIDEE model



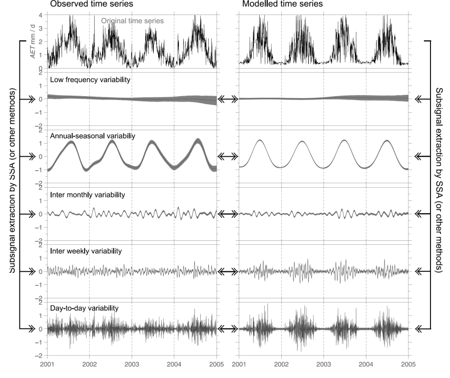
(Krinner et al., 2005)

Identification of model systematic errors



Abramowitz et al. (2008)

Time series decomposition (Singular system analysis)



(Mahecha et al., 2010)

To overcome great computer burden of decomposing half-hourly time series, we use local SSA (Yiou et al., 2000) to reconstruct diurnal cycle from the whole half-hourly time series. Daily time series are used for the reconstruction of the time series on annual and low frequencies parts.

Main Results

Model error transitivity Within and across time scales

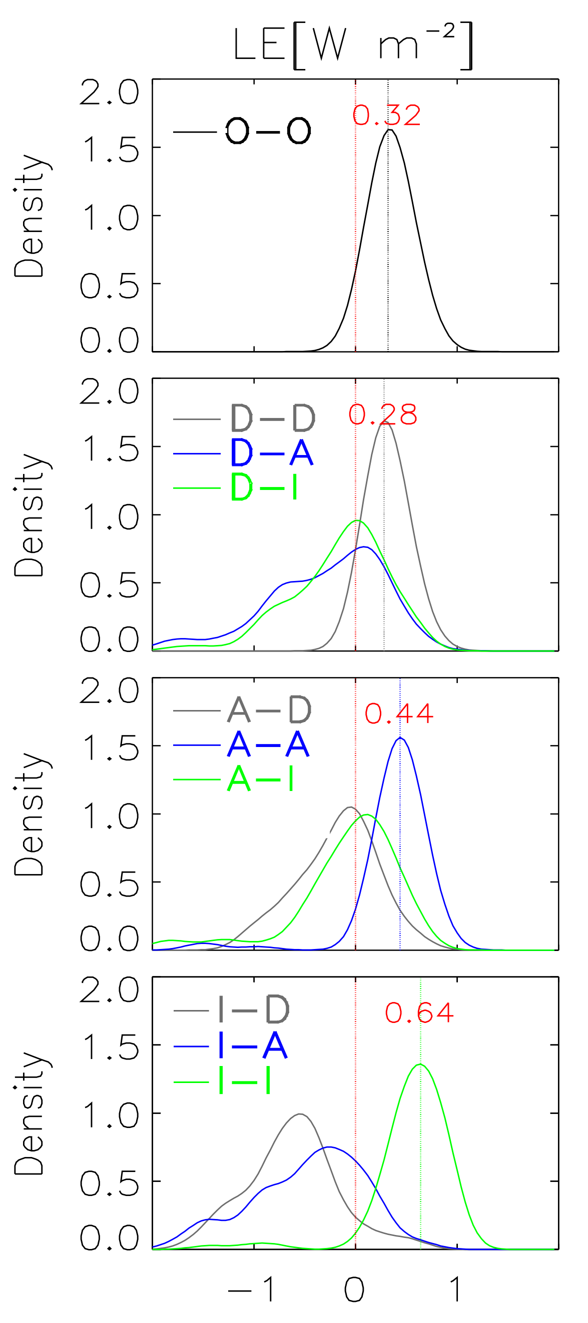


Figure 1. A single ANN is trained on one time scale (e.g. D) and then corrected on the other time scale (e.g. A) to get ANN-corrected RMSE reduction in A from D (D-A). O, D, A and I represent un-decomposed time series, diurnal, annual and interannual time scales, respectively

Poor error transitivity across time scales!!

Largest error share in low frequency part!!

Error transitivity in spatial domain

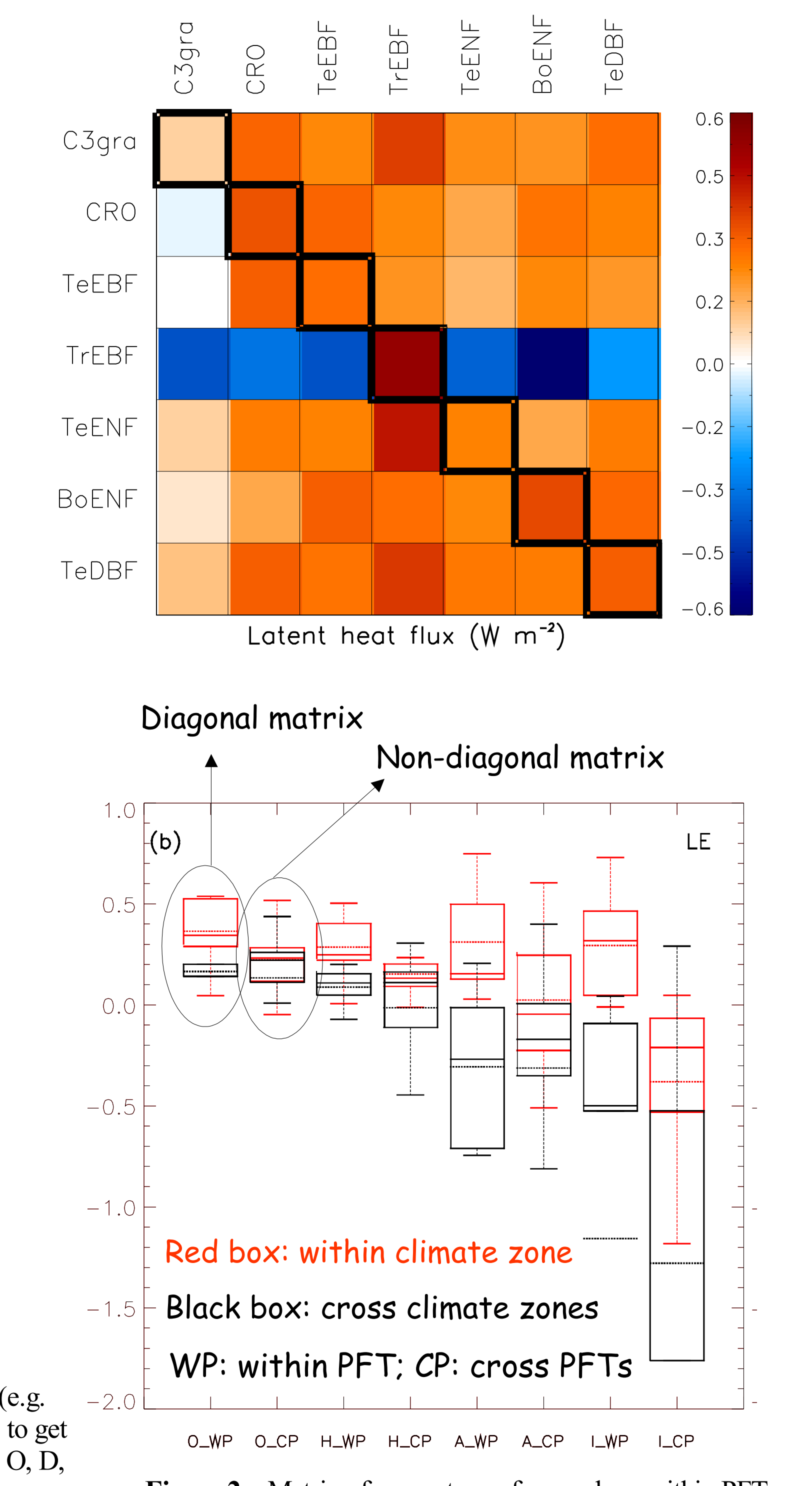


Figure 2a. Matrix of percentage of error share within PFT (diagonal) and cross PFTs (non-diagonal) in LE. A single ANN is trained on vertical PFT (e.g. CRO) and then validated on horizontal PFT (e.g. TeENF) to get ANN-derived RMSE reduction in TeENF from CRO.
Figure 2b. The whisker box of error share in LE. O, H, A and I represent undecomposed, diurnal, annual and interannual cycles.

Space transitivity of model Error is only obvious within Climate zone and PFT!!

Conclusions

Inter-annual time scale (low frequency) has the largest share of model error in the frequencies we considered; model systematic errors are poorly transferable across different time scales, which can be expected due to climate-driven processes regulating ecosystem fluxes across time scales in ORCHIDEE are different; model systematic errors is more shared within PFT and within climate zone at all frequencies, implying that model improvement based on specific sites can enhance the model behavior for the sites covered by the same PFT within the same climate zone. Our study also enables LSM community to have an idea of the theoretical bound for the space of model improvement and model uncertainties reduction, and provides the clues on how much of the benefits can be obtained for the overall model performance from site-based model calibration.

Bibliography

2. Abramowitz, G., Leuning, R., Clark, M., and Pitman, A. (2008) Evaluating the performance of land surface models. *Journal of Climate* 21, 5468-5481.
3. Krinner, G., N. Viovy, N. de Noblet, J. Ogée, J. Polcher, P. Friedlingstein, P. Ciais, S. Sitch, et I.C. Prentice, 2005. A dynamic global vegetation model for studies of the coupled atmosphere-biosphere system, Global Biogeochemical Cycles, 19, GB1015, doi:10.1029/2003GB002199.
4. Mahecha, M. D., Reichstein, M., Jung, M., Seneviratne, S.I., Zaehle, S., Beer, C., Braakhekke, M. C., Carvalhais, N., Lange, H., Le Maire, G. and Moors, E. (2010) Comparing observations and process-based simulations of biosphere-atmosphere exchanges on multiple time scales. *JGR-Biogeosciences*, doi:10.1029/2009JG001016.

Contact: Tao.Wang@lsce.ipsl.fr