Soil moisture-surface temperature interaction in monsoons

Yuhei Takaya^{1*} (<u>yuhei.Takaya@mri-jma.go.jp</u>), Naresh G. Ganeshi^{1,2}, Yu Kosaka³, X. San Liang^{4,5}, and Tomonori Sato⁶

Meteorological Research Institute, Japan Meteorological Agency, Tsukuba, Japan
Atmosphere Ocean Research Institute, The University of Tokyo, Kashiwa, Japan
Research Center for Advanced Science and Technology, The University of Tokyo, Tokyo, Japan
Department of Atmospheric and Oceanic Sciences, Fudan University, Shanghai, China
Southern Marine Science and Engineering Guangdong Laboratory (Zhuhai), Zhuhai, China
Faculty of Environmental Earth Science, Hokkaido University, Sapporo, Japan



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(cf. Dr. Akshay Deoras's presentation)

Introduction : Land impacts in S2S prediction



cf. Talk of Dr. Eleanor Blyth

Land impacts in S2S prediction: GLACE-2 results

Is S2S predictability of surface air temperature enhanced over the Asian monsoon region?

Multimodel-consensus estimate of (left) precipitation and (right) air temperature predictability associated with soil moisture initialization



Koster et al. 2011 J. Hydrometeorol.

Purpose of this study

Previous studies

4

Assessed land impacts using statistical analysis (correlation/regression) or model sensitivity experiments

Shortcomings of existing methods:

Statistical methods (lagged) correlation, regression

"Correlation does not imply causality"

Model experiments

- Impossible to compare the land influence assessed by models and observation.
- The estimated coupling strength depends on the model used.
- The model perturbed experiments may disturb the land-atmosphere interaction by intervening physical processes in models



This study uses an **information based causal analysis**. (Liang-Kleeman information flow)

Method: Liang-Kleeman information flow

Liang (2014) deduced rigorous formula to compute the maximum likelihood estimate of information flow $(T_{2\rightarrow 1})$ using variance and covariance of X_1 and X_2 .

$$T_{2\to 1} = \frac{C_{11}C_{12}C_{2,d1} - C_{12}^2C_{1,d1}}{C_{11}^2C_{22} - C_{11}C_{12}^2},$$

C: covariance, d1: forward differential of X_1

This study uses the normalized information flow (Liang 2015)

$$\tau_{2 \to 1} = T_{2 \to 1}/Z_{2 \to 1}$$
. $Z_{2 \to 1} \equiv |T_{2 \to 1}| + \left|\frac{dH_1^*}{dt}\right| + \left|\frac{dH_1^{\text{noise}}}{dt}\right|$.

Liang (2014) *Phys Rev E* Liang (2015) *Phys Rev E*

Seasonality of SM influence on SAT

Maximum monthly normalized LKIF(SM→SAT)



Large LKIF over typical wet tropical areas (Amazon, Indonesia).

Seasonality of SM influence on SAT



Takaya et al. *submitted.*

SM influence on SAT in Asian monsoon





SM influence on SAT in Asian monsoon



Similar seasonality was observed in MERRA-2.

SM-SAT coupling regimes

Infomation flow (SWV \rightarrow T2m) 40N-40S



SM influence on SAT in Asian monsoon



Hot days and SM in pre-monsoon seasons





Land desiccation and strong insolation together work to increase hot days during pre-monsoon periods.

Take-home message

- The Liang-Kleeman information flow analysis is introduced to quantify soil-moisture influence on surface air temperature in monsoon regions.
- Large soil moisture influence on surface air temperature is observed in rainy seasons of monsoon regions.
- Soil moisture influence on surface air temperature is intricately linked to the seasonal monsoon cycle.
- Land desiccation is strongly connected to the occurrence of extremely hot days in pre-monsoon periods.

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