A land data assimilation system using the MODIS-derived land data and its application to WRF prediction in East Asia

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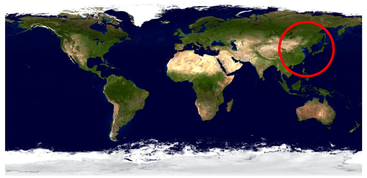
Land Data Assimilation System



• An uncoupled land surface models that are forced primarily by observations are not affected by NWP forcing biases.

• Land data assimilation systems also have the ability to maximize the utility of limited land surface observations by propagating their information throughout the land system to unmeasured times and locations

Global ⊃ North America, Europe, South America, East Asia (China, Japan, Korea), Arab, North Africa..

Land Data Assimilation System for East Asia (especially KOREA) with MODIS land product

NWP modeler
Hydrologist
Agriculturist
.
.
.

→ KLDAS →

* Land surface initial condition
* Terrestrial water cycle
* Cultivation plan
.
.

Korea Land Data Assimilation System

*** Noah land surface model V.2.5.2**

*** WRF WPS-based land surface variables**

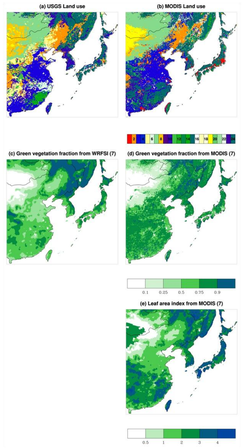
*** MODIS-based land surface variables**

a) Land cover
- MOD12C1 IGBP type → KLDAS USGS type

b) Vegetation Fraction (with Enhanced Vegetation Index (Mu et al. 2007))
- Generation of monthly VF using MOD13C2 EVI

$$Vegetation\ fraction = \frac{EVI - EVI_{min}}{EVI_{max} - EVI_{min}}$$

c) Leaf Area Index (MOD15_BU_v5)
- Change from the fixed value to monthly dynamics



OLD NEW

*** KLDAS input forcing data**

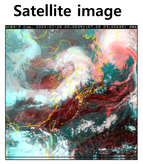
a) Model-based near-surface meteorological conditions
+ 6 hourly 0.5625° Global Data Assimilation and Prediction System (GDAPS) analysis fields of KMA
+ Bilinear interpolation from GDAPS grid to KLDAS domain
+ Temporal interpolation from 6-h to the 1-h time step

b) Observation-based meteorological conditions

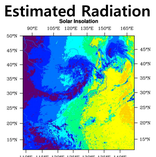
1) Downward Shortwave radiation
•**Source :** By the algorithm of Li et al.(1993) using MTSAT-1R

Visible reflectance at TOA
↓
Albedo setting (satellite angle information, solar zenith angle, relative azimath angle, and land use type)
↓
Calculation of atmospheric correction variables (Cloud fraction, Effective cloud height, and Precipitable water)
↓
Li and Trishchenko (1999) Narrowband to Braodband conversion & Li et al. (1993) algorithm
↓
Solar radiation at the surface

Satellite image

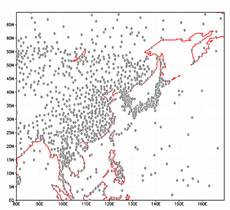


Estimated Radiation



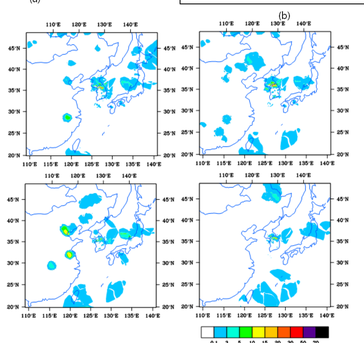
2) Precipitation

GTS accumulated precipitation & AWS hourly precipitation, and cloud fraction using MTSAT-1R



(a)

Extraction of GTS 6hr accumulated precipitation in the area of concern (Lat 21~60°, Lon 107~145°)
↓
Temporal disaggregation of GTS data using cloud fraction information
↓
Merging GTS data with AWS hourly precipitation over the Korean peninsula
↓
Generation of KLDAS hourly precipitation through Willmott's objective analysis method



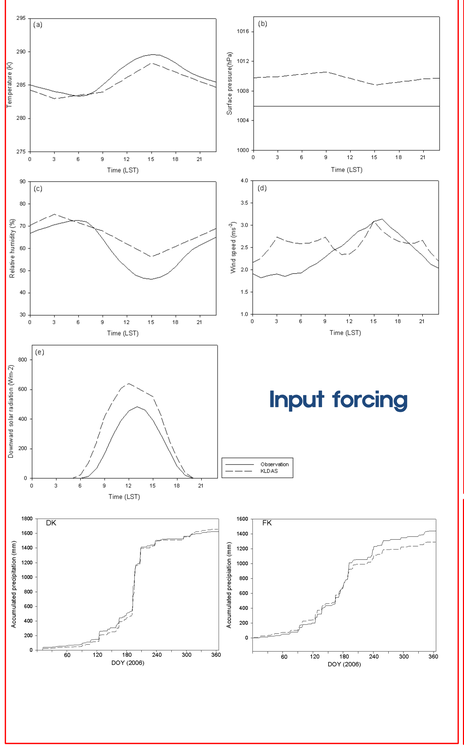
(b)

KLDAS dataset

The data are in 10 km resolution grid spacing and
rage from 01 Jan 2004 to 12 Dec 2008 for input forcing
and from 01 Jan 2006 to Dec 2008 for output data.
KLDAS forcing data can be downloaded from Yonsei LAMOR file server.
contact point : Yoonjin Lim (yj.lim@yonsei.ac.kr or yoonjin.lim@nims.re.kr)

Variables	
Input forcing for land surface modeling	
Surface temperature	KMA global Analysis based data (2004 ~ 2008)
Surface pressure	
Wind speed	
Relative humidity	
Downward solar radiation	Satellite and observation based data (2004~2008)
Precipitation	
Output	
Fluxes (sensible, latent, ground soil)	(Unit: W/m2)
Soil moisture, soil temperature	4 –layers data
Evapotranspiration, runoff	(mm/year)

Verification

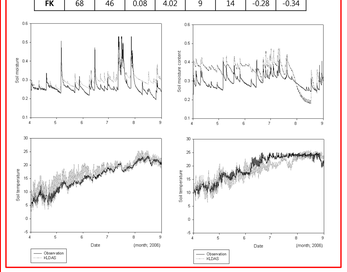


Input forcing

Output
Latent heat flux,
Sensible heat flux
Evapotranspiration
Soil moisture
Soil temperature on Asiaflux (Koflux) sites

Root mean square error (RMSE) and bias, averaged over 2006, of KLDAS surface fluxes and soil variables against the KoFlux data. SH and LH indicates the sensible and latent heat fluxes, respectively, and SM1 and ST1 are soil moisture

	RMSE (unit)				Bias (unit)			
Site	SH (W m^{-2})	LH (W m^{-2})	SM1 (m^3 m^{-3})	ST1 (K)	SH (W m^{-2})	LH (W m^{-2})	SM1 (m^3 m^{-3})	ST1 (K)
DK	56	55	0.07	2.14	11	26	0.04	0.14
FK	68	46	0.08	4.02	9	14	-0.28	-0.34

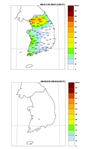


The impact of surface initialization on the simulated weather

EXP design

	Control	LSM/KLDAS
Model	WRFV2.2	
Microphysics	WSM6	
PBL	YSU	
Radiation	RRTM/Duhdia	
LSM	Noah LSM	
Initial & Boundary	GDAPS + NCEP GFS land surface condition	GDAPS + KLDAS output (including MODIS)

Two cases (in the summer time)

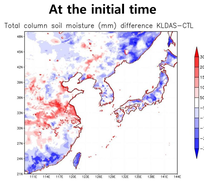


1. Rainy 20060711 ~ 13 UTC

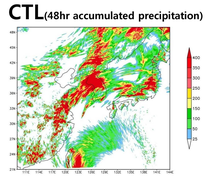
2. Sunny 20060802 ~ 04 UTC

1

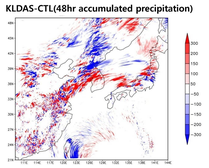
At the initial time



CTL(48hr accumulated precipitation)

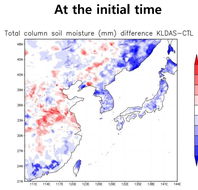


KLDAS-CTL(48hr accumulated precipitation)



2

At the initial time



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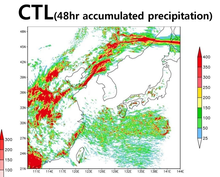
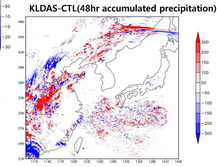
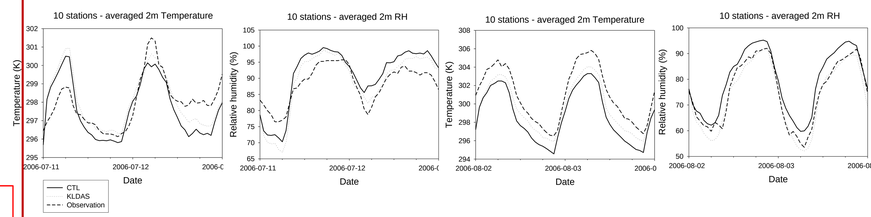


KLDAS-CTL(48hr accumulated precipitation)





Summary

* The Korea Land Data Assimilation System has been constructed to produce an accurate initial land surface condition for NWP model over East Asia.
* We have generated a 5-year, 10km, hourly atmospheric forcing dataset for use in KLDAS operating across East Asia.
* The KLDAS has effectively reproduced the observed patterns of soil moisture, soil temperature, and surface fluxes
* The numerical simulation incorporating the KLDAS outputs showed better agreement in both simulated near-surface conditions and simulated rainfall distribution, compared to those without the KLDAS over the Korean Peninsula

References

Li, Z. and Trishchenko, A., 1999: A study toward an improved understanding of the relationship between visible and shortwave measurements. *Journal of Atmospheric and Oceanic Technology*, **16**, 347 - 360
Li, Z., H. G. Leighton, K. Masuda, and T. Takashima, 1993: Estimation of SW flux absorbed at the surface from TOA reflected flux, *J. Climate*, **6**, 317-330.
Mu, Q., F. A. Heinsch, M. Zhao, S. W. Running, 2007: Development of a global evapotranspiratino algorithm based on MODIS and global meteorology data, *Remote Sensing of Environment*, **111**, 519,536. doi: 10.1016/j.rse.2007.04.015

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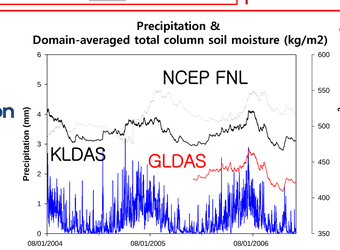
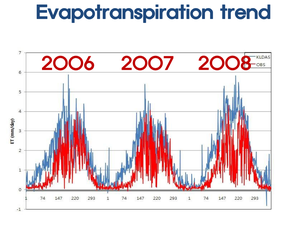
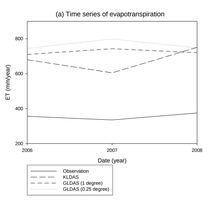
Comparison to GLDAS



Evapotranspiration trend





	Observation	KLDAS (10km)	GLDAS (0.25 degree)
2006	356 (1624.9)	680 (1655)	735 (1652)
2007	335 (1355.7)	605 (1164.1)	799 (1900)
2008	375 (1421)	751 (1348.4)	742 (1108.7)

Evapotranspiration (mm/year) (precipitation mm/year)