Sensitivity Of MODIS Global Terrestrial Primary Production To The Accuracy Of Meteorological Data Sets

Maosheng Zhao1, S. W. Running1, R. R. Nemani2 (1NTSG, University of Montana, Missoula, MT, 59812, 2NASA Ames Research Center, Moffett Field, CA 94035)

Abstract:

MODIS GPP/NPP algorithm
- GPP = APAR * ε
- GPP = (SWrad * 0.45 * Fpar) * {εmax * f(VPD) * f(Tmin)}
- NPP = ΣGPP - Rm - Rg

The data sets are involved in the study:

Meteorological reanalysis data sets
- ECMWF (1961 – 2001)

Observed or pseudo-observations meteorological data sets
- Data from Weather stations
- From USA stations with daily solar radiation observations (2001 – 2002) (fig. 1a)
- From World Meteorological Organization (WMO) weather stations (2000–2004) (fig. 1b)
- Gridded by spatial interpolation

Climatic Research Unit (CRU data) from University of East Anglia , UK (1961–1990)
- Surface meteorology and Solar Energy (SSE) from Langley Research Center, NASA (1983-1993)

EMDI NPP data sets for validation MODIS NPP
- EMDI NPP data sets for validation MODIS NPP

Results:

A. The accuracy of meteorological reanalysis data sets by comparison to the observations

B. The uncertainties of MODIS global GPP and NPP propagated by meteorological reanalysis data sets

Conclusions:

The study reveals that differences in meteorological reanalyses can introduce considerable uncertainties in GPP and NPP estimates. Overestimated NCEP SWrad and underestimated ECMWF VPD are the dominant factors responsible for the highest GPP and NPP estimates by NCEP. Underestimated ECMWF SWrad in the tropics is the main reason for the lowest GPP and NPP by ECMWF for tropical forests, and ECMWF has the most accurate temperature and VPD. Underestimated VPD from DAO overestimates GPP and NPP from 5°S to 30°N. It is worth noting that large VPD uncertainties in reanalyses are mainly caused by relative small uncertainties in temperature, not by VAP, due to the magnification effect of the non-linear relationship between temperature and SVP, implying the importance of some non-linear processes in the model.

MODIS GPP/NPP data flow
- MODIS land cover
- MODIS 8-day Fpar/Lai
- MODIS 8-day GPP & PsnNet
- MODIS annual GPP & NPP

This study compares remotely-sensed GPP and NPP driven by different meteorological reanalyses (DAO, ECMWF and NCEP) to study the sensitivity of MODIS GPP and NPP to the accuracy of meteorological data inputs.

Fig. 2. Bias of (a) daily solar radiation, (b) average temperature, and (c) vapor pressure deficits for three reanalyses compared to the observations from the stations (n=323) in five regions of USA from 2001 to 2002 (2001 for ECMWF).

Fig. 3. Comparison of climatology zonal mean of surface downward solar radiation, average temperature, vapor pressure, and vapor pressure deficits from NCEP and ECMWF, with SSE (1983,1993) and CRU (1961-1990) datasets, respectively (a to d).

Intercomparison of three reanalyses for 2000 and 2001 (e-f). These comparisons are only for data over vegetated land, and vegetated land area is shown as a gray scale, where darker shades represent more vegetated area. Vertical dotted lines denote the location of the equator.

Fig. 4. Latitudinal comparison of the bias of daily average temperature, vapor pressure, and vapor pressure deficits from three reanalyses relative to observations from WMO for 2000 to 2004 (2000 and 2001 for ECMWF).

Fig. 5. Comparison of MODIS GPP, NPP driven by three reanalyses with these driven by the observations from weather stations in USA (n = 323) from 2001 to 2002.

Fig. 6. Results of annual averaged 4-year (2000-2003) 1-km MODIS NPP derived using (a) DAO, (b) ECMWF, and (c) NCEP. Only two years of data (2000-2001) for ECMWF.

Fig. 7. Comparison of annual averaged GPP, Rplant and NPP (a-c), and corresponding zonal totals (d-f) driven by the three reanalyses for 2000 and 2001.

Fig. 8. Comparison of average NPP for 2000 and 2001 driven by the three reanalyses with EMDI NPP (d) and the mean NPP from averaged NPP by three reanalyses against EMDI NPP (e).

Table 1. Comparison of global total MODIS GPP and NPP data sets from 2000 to 2003.