INTERCOMPARISON OF GLOBAL LAND SURFACE SOLAR INSOLATION IN OPERATIONAL GCMS

C. Jesse Meng
jesse@hsb.gsfc.nasa.gov
GEST, University of Maryland Baltimore County, Baltimore, Maryland 21250

Co-workers
P. R. Houser, K. Mitchell, M. Rodell, U. Jambor, J. Gottschalck, K. Arsenault, B. Cosgrove, J. Radakovich, M. Bosilovich, J. K. Entin, J. P. Walker, H. L. Pan, and G. Gayno

1. INTRODUCTION

Solar insolation absorbed at the Earth's surface is the primary forcing of the surface water and energy cycles. However, it is one of the most misrepresented variables in general circulation models (GCMs), due to the inaccuracy in modeled cloud structure and its variation. In a GCM, errors in surface radiation budget can lead to inaccurate simulations in surface temperature, soil moisture, surface heat fluxes, and consequently, the atmospheric circulation. This has motivated the development of a Global Land Data Assimilation System (GLDAS) (Rodell et al., 2003), which is collaboration between the National Aeronautics and Space Administration's Goddard Space Flight Center (NASA/GSFC) and the National Oceanic and Atmospheric Administration's National Centers of Environmental Prediction (NOAA/NCEP). The concept of GLDAS is taking a GCM-constructed land-atmosphere environment, and using an un-coupled land surface scheme, forced by observations, to produce optimal fields of land surface states and fluxes.

A 1/4 degree resolution GLDAS has been implemented in near real time, using various satellite- and ground-based observing systems. Currently, two operational GCMs, namely, the NASA/GSFC GEOS (Pfaendtner et al., 1995) and the NOAA/NCEP GDAS (Derber et al., 1991), are available in GLDAS to provide the baseline land-atmosphere environment. Surface solar insolation from the GCM is then replaced by an observation-based product to force GLDAS. The Air Force Weather Agency (AFWA) Real Time Neph-analysis (RTNEPH) is implemented, which is a global cloud analysis using geostationary and polar orbiting satellite observations. In RTNEPH, the observed cloud properties (cloud amount, type, and top and base heights) are reported every hour globally at a 24 km resolution. Surface downward shortwave and longwave fluxes are estimated from the observed cloud properties using the radiation scheme of the AFWA AGRMET model (Shapiro, 1987). In this study we evaluate the surface downward shortwave fluxes from the three models against ground observations. The main purpose is to understand the sources and feedbacks of the land surface water and energy cycles, thereby, contributing to the future development of land and atmosphere modeling and data assimilation systems.

2. EVALUATION OF SURFACE SHORTWAVE FLUXES

(a) (b)

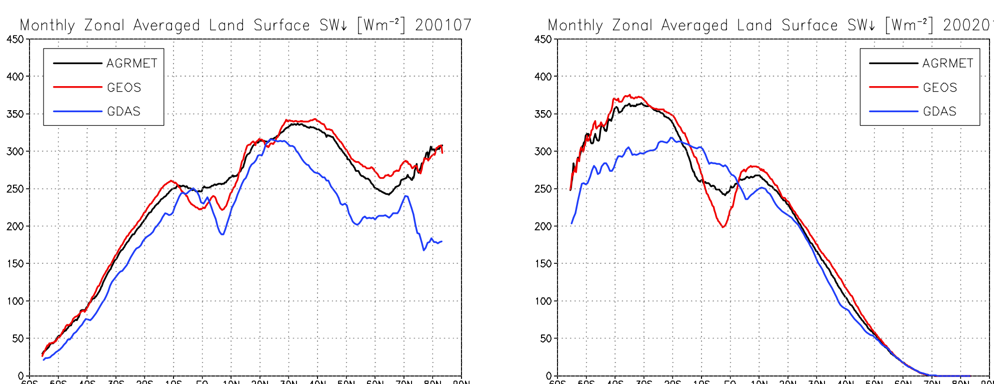

Figure 1. Monthly mean, zonal averaged, land surface downward shortwave fluxes for (a) July 2001, and (b) January 2002. Values are in Wm^{-2}.

Monthly mean, zonal averaged, land surface downward shortwave fluxes from the three models (AGRMET, GEOS, and GDAS) for July 2001 and January 2002 are shown in Figure 1. AGRMET and GEOS exhibit very similar patterns, except in the tropics. The differences in mid- and high-latitudes are within 10%. On the other hand, GDAS is about 10% lower than AGRMET in most of the winter hemisphere, and is about 20-25% lower in most of the summer hemisphere. Smaller spatial and temporal scale analysis indicates that the modeled fluxes are in a better agreement under clear-sky conditions, suggesting that the differences between the fluxes are attributed to the differences between the modeled (GEOS and GDAS) and observed (AGRMET/RTNEPH) cloud structures.

Monthly mean surface downward shortwave fluxes from the three models have been compared to the ground observations from the SURFRAD network. SURFRAD operates six sites over the continental United States to measure the surface radiation budget. The comparison results for July 2001 and January 2002 are summarized in Table 1. In general, AGRMET has an about 10% high bias in both summer and winter. The largest bias occurs at the site of Goodwin Creek, Mississippi (GWN) in January 2002. It is due to an underestimated fog effect, which has been improved in later experiments. Both GEOS and GDAS substantially overestimate (in percentage) surface shortwave fluxes in January 2002, suggesting that these two models underestimate the wintertime cloudiness.

(a) July 2001

SITE	SURFRAD	AGRMET	GEOS	GDAS
FPK	276	330	307	291
PSU	257	372	325	246
TBL	268	307	353	274
BON	275	313	269	274
DRA	340	346	362	331
GWN	257	273	256	260
BIAS		**10%**	**12%**	**0%**
RMS		**12%**	**17%**	**3%**

(b) January 2002

SITE	SURFRAD	AGRMET	GEOS	GDAS
FPK	55	58	77	72
PSU	74	78	102	83
TBL	104	99	133	121
BON	80	98	108	99
DRA	123	123	147	134
GWN	89	116	132	119
BIAS		**9%**	**33%**	**20%**
RMS		**15%**	**33%**	**20%**

Table 1. Comparison of modeled and observed surface downward shortwave fluxes at SURFRAD sites for (a) July 2001, and (b) January 2002. Values are in Wm^{-2}.

3. CONCLUSION

There is a large discrepancy between modeled land surface radiation budgets (up to 25%), due to the differences in modeled cloud structures. The impact of the different radiative forcing on the land surface water and energy cycles, namely, altering the surface heating, cooling, evaporating, and snow melting processes, will be investigated through the GLDAS experiments. Analyses on the European Centre for Medium-Range Weather Forecasts (ECMWF) output will be included in the future work.

REFERENCES

Derber, J. C., D. F. Parrish, and S. J. Lord, 1991: The new global operational analysis system at the National Meteorological Center. *Wea. and Forecasting,* **6,** 538-547.

Pfaendtner, J., S. Bloom, D. Lamich, M. Seablom, M. Sienkiewicz, J. Stobie, and A. da Silva, 1995: Documentation of the Goddard Earth Observing System (GEOS) Data Assimilation System - Version 1, *NASA Technical Memorandum 104606*, **4**, 44 pp.

Rodell, M., P. R. Houser, U. Jambor, J. Gottschalck, K. Mitchell, C. J. Meng, K. Arsenault, B. Cosgrove, J. Radakovich, M. Bosilovich, J. K. Entin, J. P. Walker, D. Lohmann, and D. Toll, 2003: The Global Land Data Assimilation System (GLDAS), *Bull. Amer. Meteor. Soc., accepted.*

Shapiro, R., 1987: A simple model for the calculation of the flux of direct and diffuse solar radiation through the atmosphere, *AFGL Scientific Report*, **35**, 40 pp.