573241

J4.5 THE EFFECT OF ERRORS IN SNOW ASSIMILATION ON LAND SURFACE MODELING

Brian A. Cosgrove[1] and Paul R. Houser[2]

[1]SAIC / Hydrological Sciences Branch & Data Assimilation Office
[2]Hydrological Sciences Branch & Data Assimilation Office
NASA Goddard Space Flight Center

1. INTRODUCTION

The accurate portrayal of the hydrological cycle is extremely important in land surface modeling. Central to this effort is the treatment of snow, as errors in the representation of this quantity can impact practically all other modeled quantities through alterations in the water and energy balances. Although land surface model (LSM) simulations can benefit from the assimilation of snow cover and snow depth observations, they can be negatively impacted if such observations contain errors or if a model bias exists in the simulation of surface or soil temperatures. Both cases may lead to excessive melting or growth of snow packs, and to large alterations in both the energy and water balances. Such problems in the snow assimilation process, made evident by the repeated melting and replenishing of snow pack over significant areas of the United States, exists in the Eta Data Assimilation System (EDAS, Rogers et al., 1996) and is a product of the EDAS system's direct insertion assimilation of snow data (Figures 1a-c, 2). Occurring on a 24 hour cycle, the repeated melting infuses the soil column with a large quantity of water that upsets the hydrological cycle.

2. DISCUSSION

In an effort to quantify the impacts of such errors in snow assimilation on water and energy budgets, a series of Mosaic LSM (Koster and Suarez 1996) simulations were performed over the 12 month period covering October 1998 to October 1999. A control run was conducted to provide "perfect" snow observations that were then directly assimilated into experimental runs once per day (Figure 3). Featuring a range of warm and cold biases created by the manipulation of shortwave and temperature forcing data, these experimental simulations show that even a 0.5°C warm bias can interact with assimilated snow data to significantly impact the water budget. After one month of directly inserting snow data into an experimental Mosaic run characterized by this forcing bias, the total column soil moisture changed by up to 3.5%, and changed by up to 11% in a run featuring a 2°C bias (Figure 4). The error in the water budget is also substantial in both experimental runs, with the largest residuals of up to 250mm occurring over mountainous regions (Figure 5) in the 2°C bias run.

*Corresponding Author: Brian A. Cosgrove
NASA Goddard Space Flight Center
Mail Code 974, Greenbelt, MD 20771
Email: Brian.Cosgrove@gsfc.nasa.gov

3. CONCLUSION

These preliminary results demonstrate that while it might be expected that the assimilation of error-free snow observations would lead to improved LSM results, a small LSM temperature bias leads to large-scale errors in the water balance. Even if the snow assimilation system perfectly reconciled modeled and observed snowpack states, the law of mass conservation could still be violated if biases exist in the model. Complicating the issue is the fact that in practice, snow observations are not without error. As such, more research is needed to determine how best to reconcile imperfect snow observations with LSMs that may be characterized by model biases.

4. REFERENCES

Koster, R. D., Suarez, M. J., 1996: Energy and Water Balance Calculations in the Mosaic LSM. *NASA Tech Memorandum 104606*, **9**.

Rogers, E., et al., 1996: Changes to the operational "early" Eta analysis/forecast system at the National Centers for Environmental Prediction. *Wea. Forecasting*, **11**, 391-413.

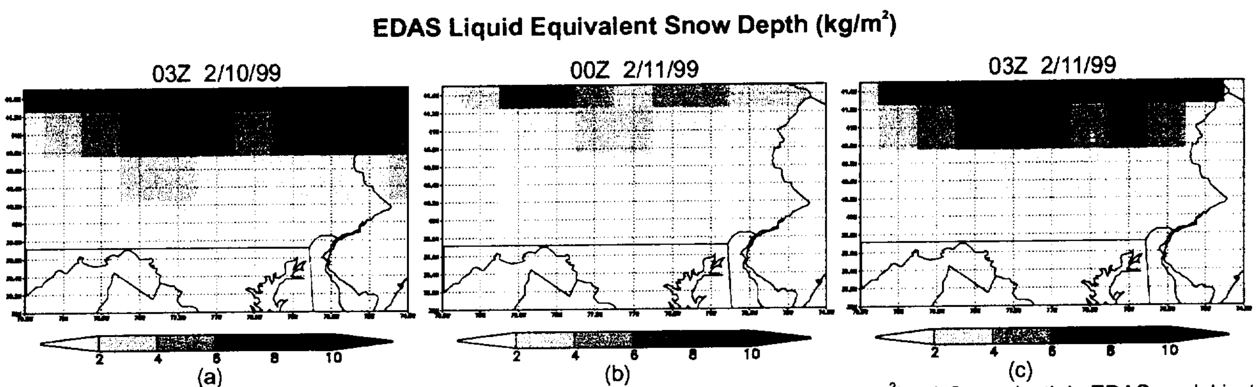

Figure 1. Series of images show repeated updating and melting of EDAS snow depth (kg/m^2). a) Snow depth in EDAS model just after update on 2/1/99, b) Snow depth before update on 2/11/99, c) Snow depth just after update on 2/11/99.

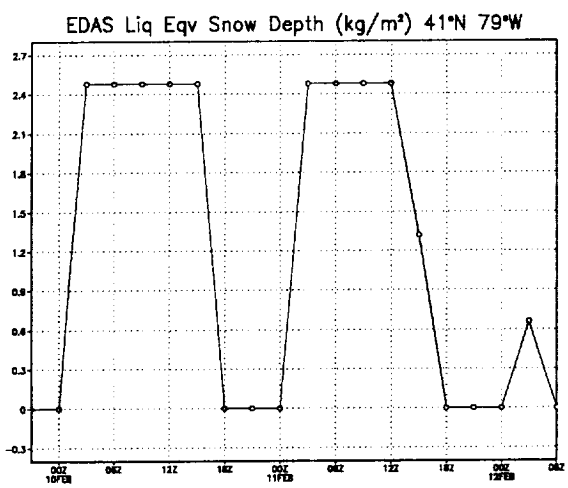

Figure 2. Change in EDAS snow depth (kg/m^2) over time. Snow is replenished between 0Z and 3Z when snow data is assimilated through direct insertion method, but repeatedly melts due to model biases, infusing soil column with added moisture.

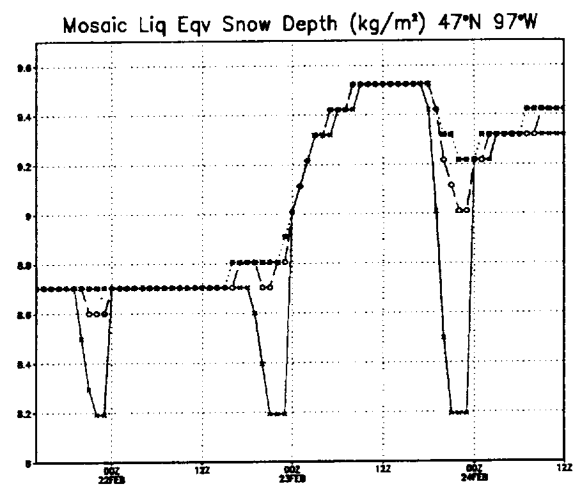

Figure 3. Change in Mosaic snow depth (kg/m^2) over time. Squares (upper line) represent control run, while open circles (middle line) and X's (bottom line) represent experimental runs with, respectively, 0.5°C and 2.0°C temperature biases. Direct insertion snow update occurs between 23Z and 0Z, leading to melting as in Figure 2.

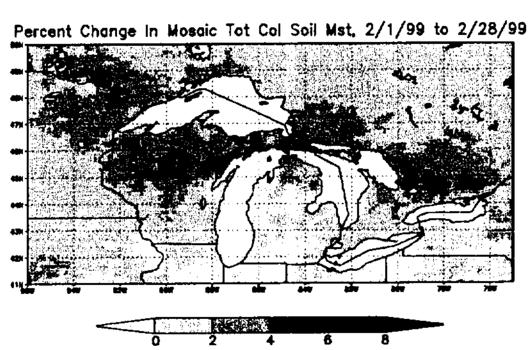

Figure 4. Percent difference in Mosaic total column soil moisture between 2°C bias run and control run. Direct insertion of snow data into run with 2°C bias leads to moistening of soil column.

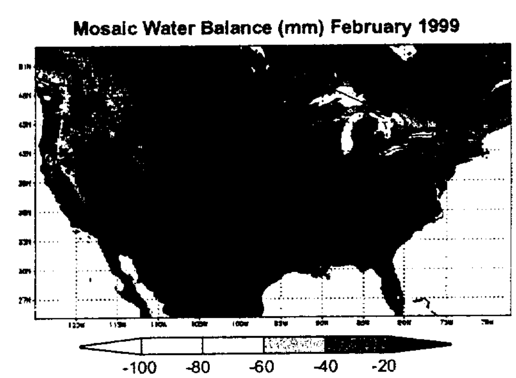

Figure 5. Error in Mosaic water balance (mm) after 1 month of direct insertion of snow data. Negative errors result from infusion of snowmelt into soil column, when using equation: Water Balance Error = Rain + Snow – Evap – Runoff - Δ Water Storage