Analysis of NOAA and NASA Surface Water and Energy Balance Data for Water Resources Applications

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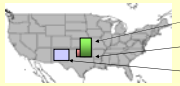
Abstract

The primary objective of the study is to evaluate surface water and energy balance for water resources applications through study of NOAA North American Regional Reanalysis (NARR) data and North American Land Data Assimilation System (NLDAS) Mosaic and Noah land surface model heat flux data. For reference we used *in situ* data from the Coordinated Enhanced Observing Periods (CEOP 3&4), the Oklahoma Mesonet sites, and the NASA-Reclamation ET tower sites in the Middle Rio Grande, New Mexico. In addition, the high spatial resolution (to 1km and finer) NASA Land Information System (LIS) is used to further study factors affecting modeled surface water and energy budget data for future improvements to NARR and NLDAS type systems. Analysis of results for the CEOP study sites show significant biases are found for the partitioning between sensible heat and latent heat fluxes during spring and summer seasons. We used LIS to assess possible factors and evaluated improvements using revised model forcing, model physics, and input parameters. Current work in the Middle Rio Grande is developing an Ensemble Kalman Filter (EnKF) capability using MODIS Land Surface Temperature with the Community Land Model (CLM-2) for improved heat fluxes. Oklahoma Mesonet data are used to evaluate NOAA NARR and NLDAS Mosaic and Noah data. Work to date has shown the NARR data tracks well the extreme wet to dry periods during the summer of 2003.

STUDY SITES



1) CEOP 3&4 Test Sites (Oct. 2002 – Dec. 2004, ½ hr)
2) Oklahoma Mesonet (1994-Present) OASIS Super Sites (1999-2003)
3) Middle Rio Grande (ET Improvement, Noah, CLM-2) (2003-Present)

NLDAS & NARR DATA SET SUMMARY

1) NARR: North America Regional Reanalysis (NOAA/NCEP)
- Coupled land-atmosphere model, 30 Pressure Levels, 196 Variables
- Temporal coverage: 1979-2003
- Spatial resolution is at 32 km
- Output at every 3-hour frequency

2) NLDAS NOAA NCEP NOAH LSM & NASA/GSFC MOSAIC LSM Real time and retrospective hourly, uncoupled land surface models
- Spatially 1/8th-degree grid cell (~13km)
- Every 1-hour frequency output from 10/1996 to present
- UMD Pinker's corrected **GOES**-based forcing

NASA LAND INFORMATION SYSTEM

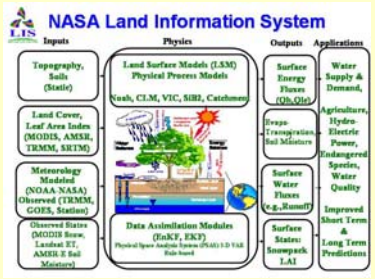


Figure Land Information System (LIS) is a high performance land surface modeling and data assimilation system capable of modeling global land-atmosphere interactions at spatial resolutions to 1km and finer. LIS was used t further investigate factors affecting surface water and energy budget data.

CEOP STUDY SITES

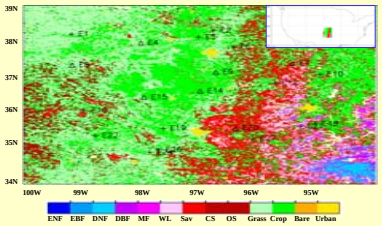


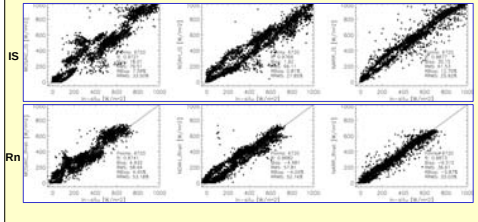
Figure shows the spatial distribution and the remote sensing land cover map at 1km spatial resolution in the South Great Plain region derived in the University of Maryland.

CEOP3&4. The Third & Fourth Coordinated Enhanced Observing Periods.
-GEWEX Americas Prediction Project - Atmospheric Radiation Measurement (GAPP-ARM) Southern Great Plains (SGP) sites.
- October 2002 to December 2004. ½ Hr Intervals
- 12 sites with near-complete surface heat fluxes, 7 sites also include full meteorological forcing data.

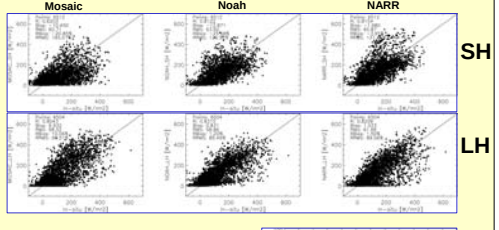
Assessment of the Model Energy Budget

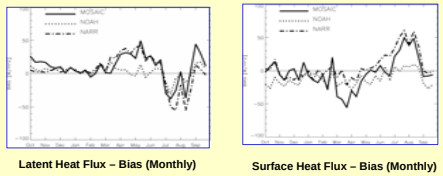
Large RMS and biases were found with the NARR and NLDAS forcing data, especially the incident shortwave radiation (IS). The **figure below** shows the "Golden Days" for the CEOP Sites for Incoming shortwave radiation and net radiation with reduced RMS and bias as compared to the *in situ* data. The golden days are defined as the ten days in each month with the largest daily mean radiation. Among the golden days, the incoming shortwave radiation shows a close agreement to the in-situ measurements with high correlation (R>0.97) and less relative bias error (7.6% for Mosaic, 0.8% for Noah, and 12.7% for NARR) and less relative RMS errors with 30% for three models (top). The LW upwelling and downwelling radiation generally show good agreement with the reference data (not shown). Similarly, good agreement is shown with the precipitation data (not shown) and net radiation (below, bottom).

Golden Days Incoming
Incident SW (IS) Radiation (Top) and Net Radiation (Bottom)



Golden Day Sensible (SH) and Latent Heat Flux – All sites





Latent Heat Flux – Bias (Monthly)

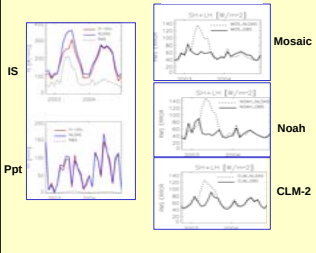
Surface Heat Flux – Bias (Monthly)

Although Golden Days improved net radiation estimates (left); however, in the **figure above** large RMS errors are still evident in the estimates of the partitioning of sensible heat and latent heat fluxes. This is further investigated using the NASA Land Information System.

(CEOP Cont'd) Using 'LIS' to Evaluate Surface Heat Fluxes

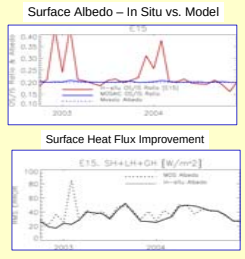
We used the LIS runs at a 1KM spatial resolution with three models (Noah, Mosaic & NCAR CLM2). Experiments were designed through LIS configurations with the original NLDAS forcing and *in-situ* data. We checked some possible reasons causing the partitioning problems between sensible heat and latent heat fluxes from (1) the inaccurate estimates of model forcing data, (2) a model scheme and parameterization, and (3) the land cover specifications.

FORCING DATA



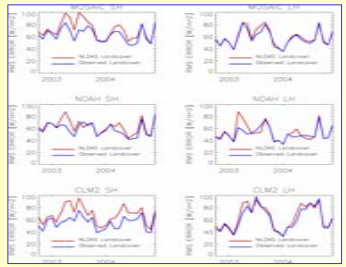
Replaced NLDAS Forcing w/ In Situ Forcing
- Shortwave, Precipitation, Longwave (↓), Ta, Qa & P
- Most significant change from Shortwave Radiation
- Improved surface heat fluxes for all 3-models (SH+LH shown)
- Large SW Errors, April-August 2003 (RMS of 220 vs. 50 W/m²). NASA/GSFC Mosaic different from NCEP Noah.

SURFACE ALBEDO



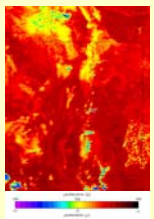
Replaced "Observed" albedo (in situ) in LIS Mosaic model
- In situ albedo directly assimilated (inserted) for each step
- Snow albedo not in Mosaic but in Observed (see Spikes)
- Improved accuracy of heat fluxes (shown SH+LH+G)
- Current work inserting *in situ* soil moisture

LAND COVER

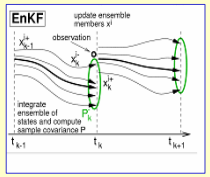


Updated NLDAS Land Cover
- 3 (E4, E7 & E20) of 12 Sites did not match in-situ cover
- Updated Dominant UMD Land Cover in NLDAS
- Significant improvements in Heat Fluxes
- Mosaic and CLM2 are more sensitive to Land Cover

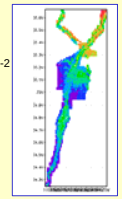
II. Middle Rio Grande LIS ET & Ensemble Kalman Filter MODIS ET Evaluation



MODIS Land Surface Temperature
- Assimilate MODIS LST from Rapid Response System
- Available within 4 hours of overpass



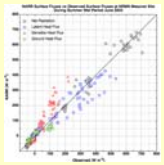
Ensemble Kalman Filter (EnKF)
- Implement EnKF in CLM-2
- 1 Km Spatial Resolution
- Developing LIS Toolbox



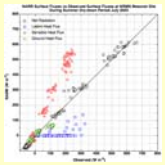
LIS ET Summary April 2004 ET (mm)
- Community Land Model (CLM-2)
- Middle Rio Grande
- 1 km Spatial Resolution
- Will test ET Data Assimilation using Eddy Covariance test sites

III. Oklahoma Mesonet (OASIS Super Sites)

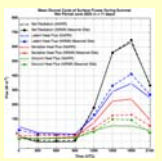
NARR Surface Heat Flux Comparison



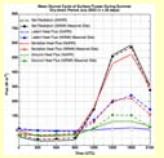
Wet June 2003



Dry July 2003

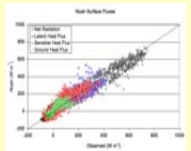


Mean Diurnal Wet June 2003



Mean Diurnal Dry July 2003

Noah LSM Heat Fluxes



Mesonet vs. Noah Heat Fluxes (May-Aug 2000)

Previous study showing comparison of Noah LSM with Mesonet data showing a Strong correspondence. "Golden Days". (Nemunaitis and Basara, 2004)

Comparison of NARR Surface Heat fluxes to Norman Oklahoma OASIS Super Site shows a large contrast in latent heat flux versus sensible heat flux due to a wet June and a dry July. Note, days (June, n=11 and July, n=20) were selected to show stark contrast. The NARR was able to pick up much of the trends.

Summary

This study evaluates NOAA and NASA land surface water and energy balance data with the goal to assess factors causing uncertainty with the goal to provide improved and useful surface energy and water flux data for water resources applications.

Acknowledgements

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