Land Data Assimilation Breakout Summary

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NCEP/EMC (NOAA)

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Outline:

- Overall goals
- Strategy
- Science Accomplishments
- Transition Accomplishments and Prospects
- Recommendations

Goals of Land-arena in JCSDA:

Improved Environmental Forecast Skill Through Use and Assimilation of Satellite Land Data

- Maximize use of satellite data over land
  - Current, NPOESS, NASA Decadal survey
  - Improve CRTM land surface radiative transfer
- Improve NWP forecast skill
- Improve climate forecast skill
- Improve hydrometeorological forecast skill

Strategies:

Improved Environmental Forecast Skill Through Use and Assimilation of Satellite Land Data

- **Derive and apply new satellite-based land surface characteristics**
  - **Boston U. (M. Friedl)**
  - **U. Arizona (X. Zeng)**
  - **NESDIS (L. Jiang)**
- **Improve land surface forward modeling of surface emission**
  - **Princeton U. / U. Washington (E. Wood/D. Lettenmaier)**
  - **U. Maryland (S. Liang)**
  - **NRL (B. Ruston)**
  - **NESDIS (R. Vogel)**
- **Improve Noah LSM physics to use satellite data (e.g.improve LST)**
  - **U. Arizona (X. Zeng)**
  - **NCAR / Purdue U. (F. Chen, D. Niyogi)**
  - **NCEP/EMC (K. Mitchell, W. Zheng, J. Meng)**
- **Execute model impact studies for new land-sfc satellite products**
  - **NCEP/EMC (W. Zheng), NASA/HSB (Peters-Lidard), NASA/GMAO (R. Reichle)**
  - **NESDIS (C.-Z. Zao)**
- **Demonstrate Land 4DDA methods for land analysis**
  - **George Mason U. (P. Houser)**
  - **NASA/HSB (S. Kumar, C. Peters-Lidard), NASA/GMAO (R. Reichle)**
  - **NESDIS/ORA (X. Zhan)**
- **Provide infrastructure to accelerate transition to operations**
  - **NCEP/EMC, AFWA, NESDIS, NASA/GSFC**

Span of JCSDA Land Arena

(Coordination via monthly telecons hosted by NCEP/EMC)

– **External** JCSDA-funded PIs

Presently

- U. Arizona: Xubin Zeng
- NCAR / Purdue U.: F. Chen and D. Niyogi
- U. Maryland: S. Liang

Recent Past

- Boston U.: M. Friedl
- Princeton.U / U.Washington: E. Wood and D. Lettenmaier
- George Mason U.: P. Houser
- NRL: B. Ruston

– **Internal** JCSDA Investigators:

- NCEP/EMC Land Team: K. Mitchell, W. Zheng, J. Meng, V. Wong
- NESDIS: X. Zhan, Ron Vogel, C.-Z. Zao
- NASA GSFC/HSB: C. Peters-Lidard, S. Kumar, LIS Team
- NASA GSFC/GMAO: R. Reichle
- Air Force Weather Agency J. Eylander

Science Accomplishments

- **Reducing large differences between simulated and observed satellite Tb for sfc-sensitive channels by improve physics of modeled land surface**
  - Aerodynamic resistance (Xubin Zeng)
  - Canopy resistance (Fei Chen and Dev Niyogi)
  - Surface emissivity (Shunlin Liang, Kaicun Wang, John Townshend, Ron Vogel)

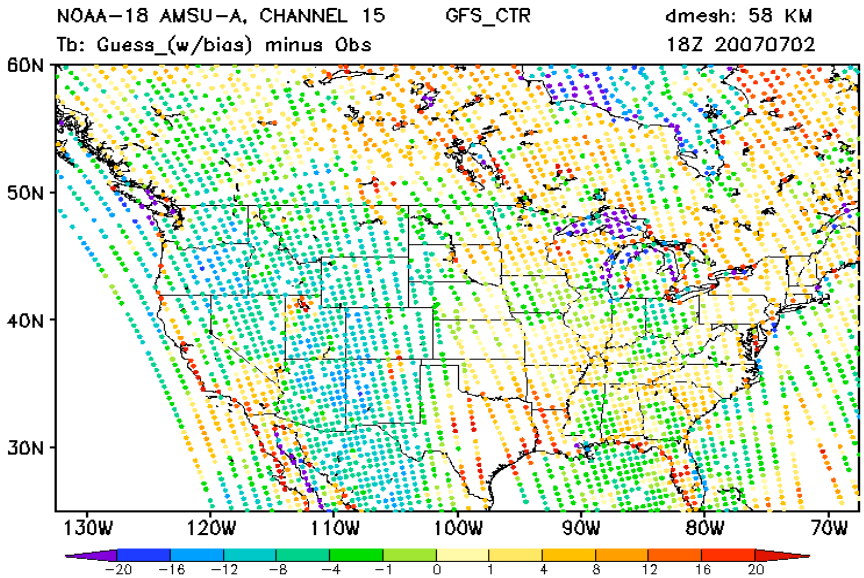
Left column: Ops GFS/GSI Right Column: Test GFS/GSI (Zot)

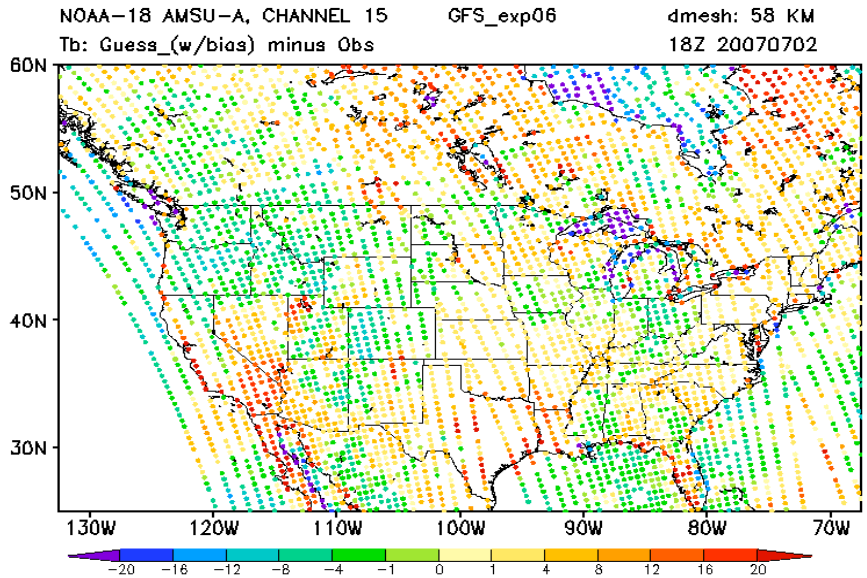
Top Row: Simulated Tb minus observed Tb

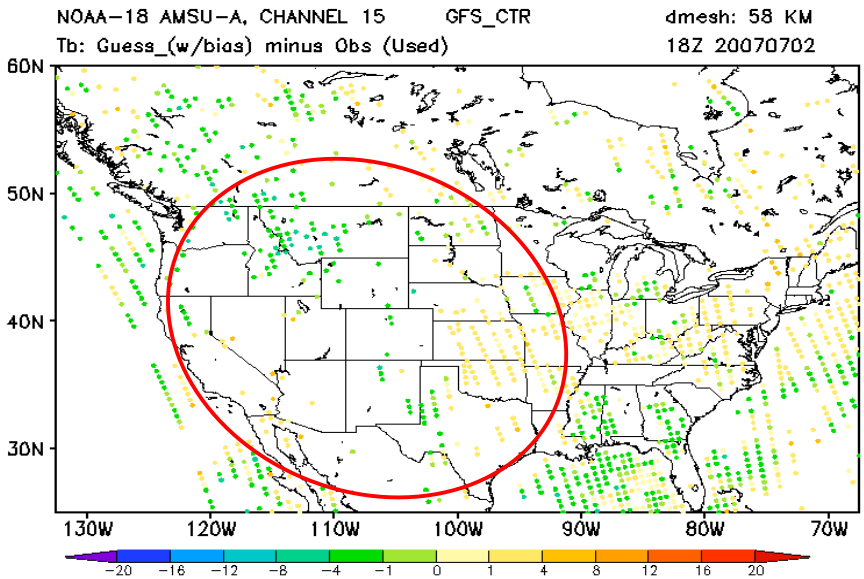
Bottom Row: Locations of assimilated Tb

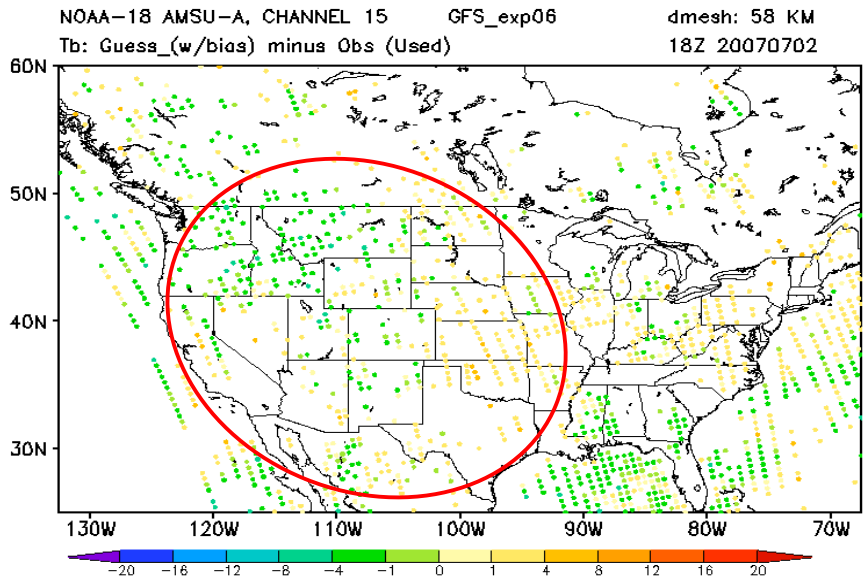
Case: NOAA-18, AMSU-A, Channel 15

18Z, 20070702









Integrating Remote Sensing Products to Improve the Vegetation and Transpiration Processes in the Noah LSM Model

PIs and Co-PIs: Fei Chen, Dev Niyogi

NCEP Collaborators: Ken Mitchell, Mike Ek

Accomplishments

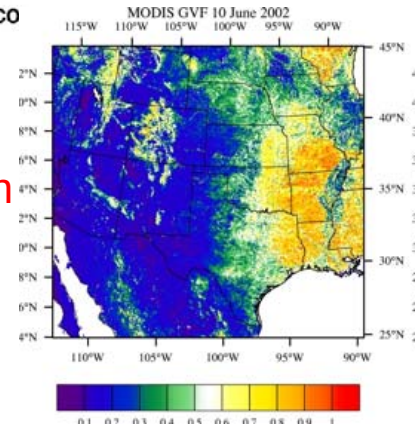
- **IHOP data show significant temporal evolution of minimum canopy resistance (current a constant in Noah)**
- **Evaluation with field data show promising use of the photosynthesis-based schemes (GEM) to improve water vapor in WRF/Noah, and deposition velocity in WRF-Chem/Noah.**

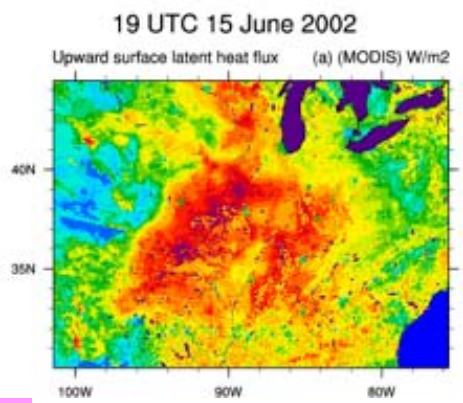
Future Plan

- **Explore the better integration of new MODIS and JCSDA satellite data to improve the coupled WRF/Noah/GEM modeling system.**

Improved vegetation Model (GEM)

Incorporate high-resolution MOIDIS data



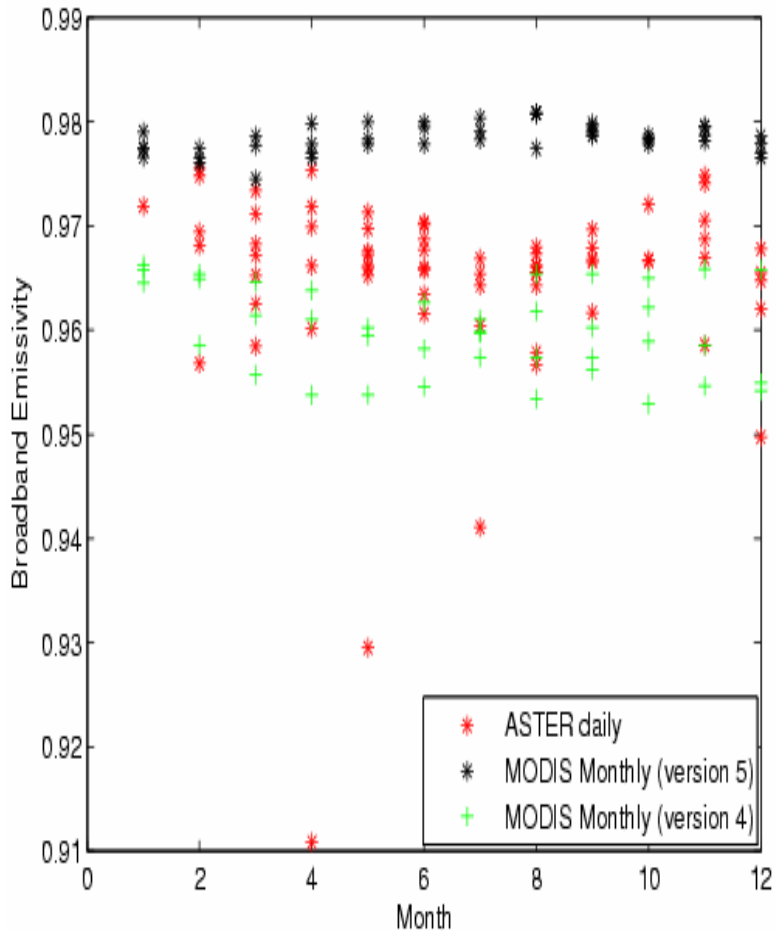


Improved surface heat fluxes in WRF/Noah/GEM

Land Surface Thermal-IR Emissivity Modeling

(Shunlin Liang, Kaicun Wang, John Townshend)

- Land surface thermal-IR broadband emissivities from MODIS and ASTER have been evaluated by FLUXNET and SURFRAD data.
- MODIS version 5 emissivity corrects the underestimations of MODIS version 4 for vegetated surfaces. ASTER product tends to underestimate emissivity, especially for summer time.
- Data fusion methods and emissivity model are under developing.



Transition Accomplishments (NCEP/EMC, NASA/HSB, AFWA/EMB)

- Develop & demonstrate a unified land modeling and assimilation framework
- Develop & demonstrate stand-alone driver for CRTM
  - Next step now underway: add NASA LIS as land component
- Test new NESDIS realtime weekly green vegetation fraction (GVF) product in GFS
- Refine MODIS IGBP 1-km landuse database
  - Add three tundra classes

A Unified Land Surface Modeling and Data Assimilation Framework for the JCSDA

S.V. Kumar, R.H. Reichle, C.D. Peters-Lidard, R.D. Koster, X. Zhan, W. Crow,
J.B. Eylander, P.R. Houser

•NASA/GMAO-developed capabilities for sequential data assimilation have been implemented in the NASA/HSB Land Information System (LIS) framework.

•LIS is a comprehensive system that integrates the use of various land surface models, assimilation algorithms, observational sources for users at NASA, AFWA, NCEP and JCSDA investigators.

•Capabilities have been demonstrated for assimilating soil moisture, snow and skin temperature observations.

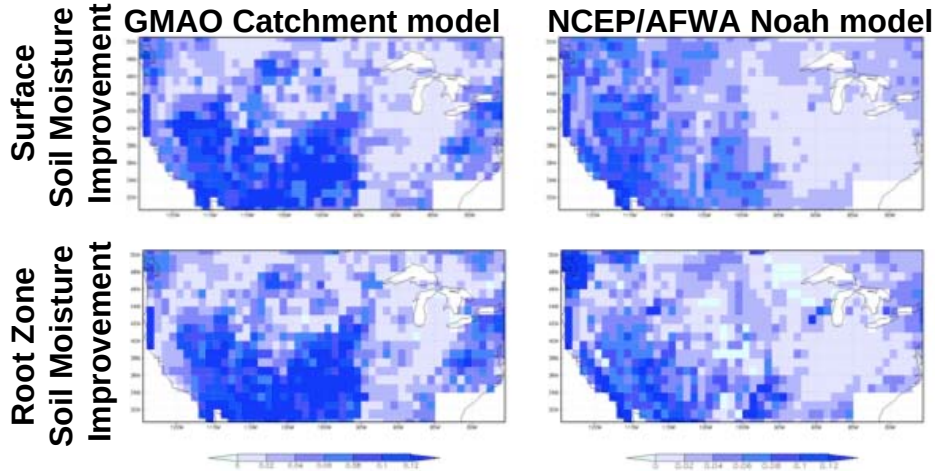


Figure 1: Soil Moisture Assimilation

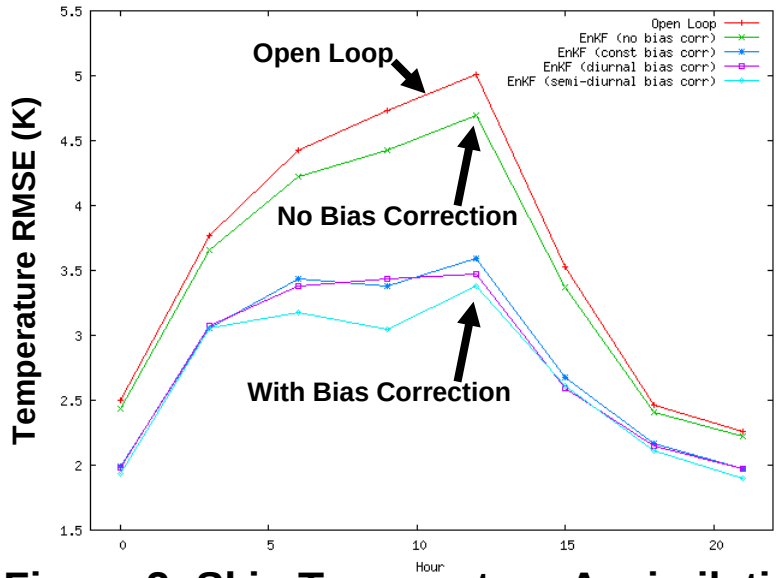


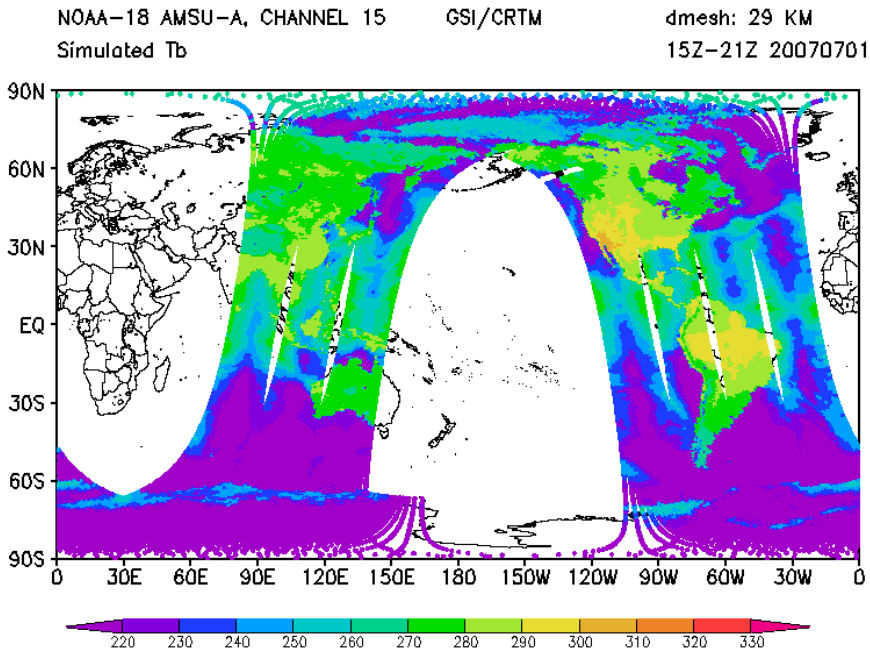
Figure 2: Skin Temperature Assimilation

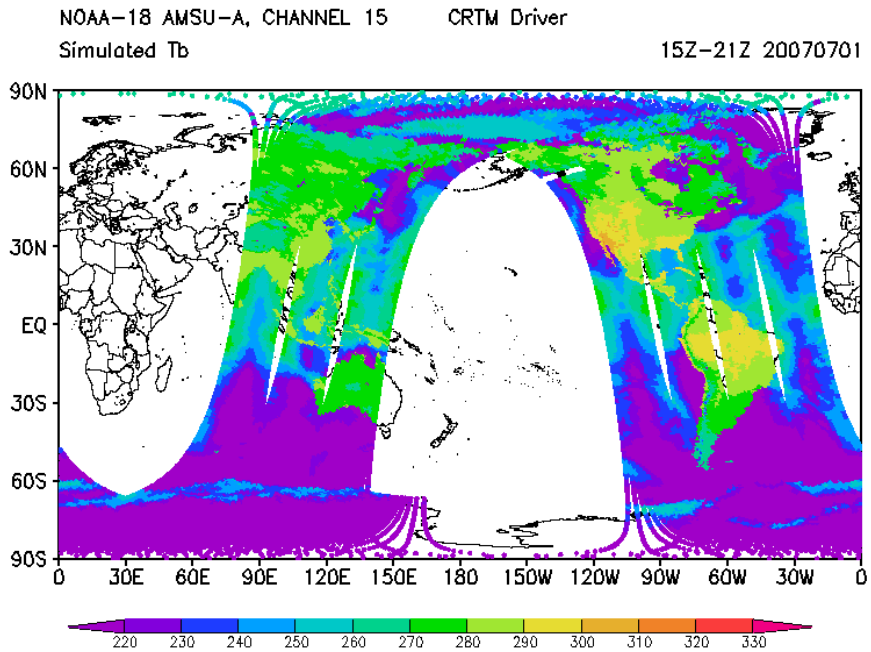
Kumar, S.V., R.H. Reichle, C.D. Peters-Lidard, R.D. Koster, X. Zhan, W.T. Crow, J.B. Eylander, and P.R. Houser, 2008. A Land Information System Data Assimilation Framework using the Land Information System, In Press, Advances in Water Resources.

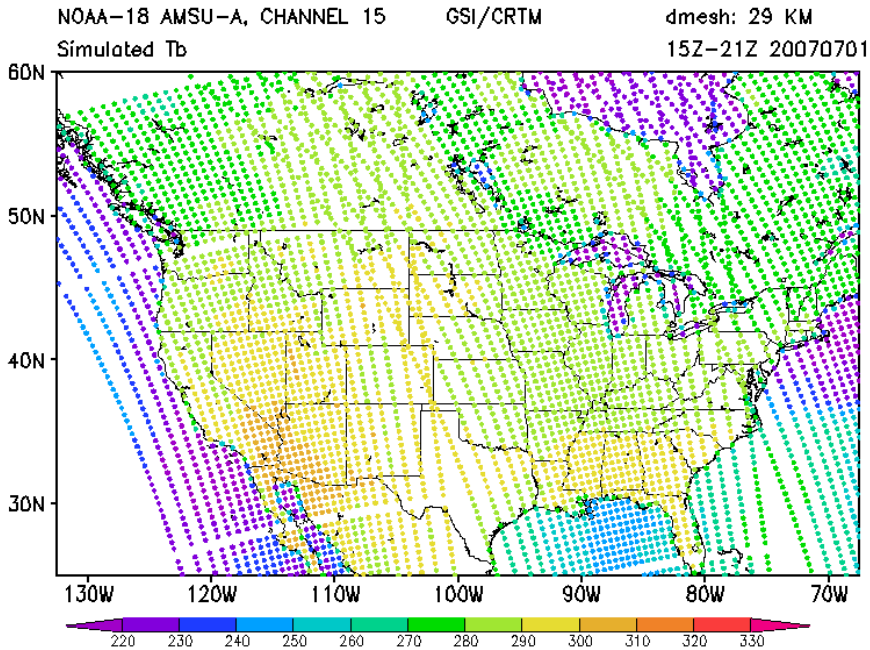
Kumar, S. V., C. D. Peters-Lidard, Y. Tian, J. Geiger, P. R. Houser, S. Olden, L. Lighty, J. L. Eastman, P. Dirmeyer, B. Doty, J. Adams, E. Wood and J. Sheffield, 2006. LIS - An Interoperable Framework for High Resolution Land Surface Modeling. Environmental Modeling and Software, Vol. 21, pp 1402-1415.

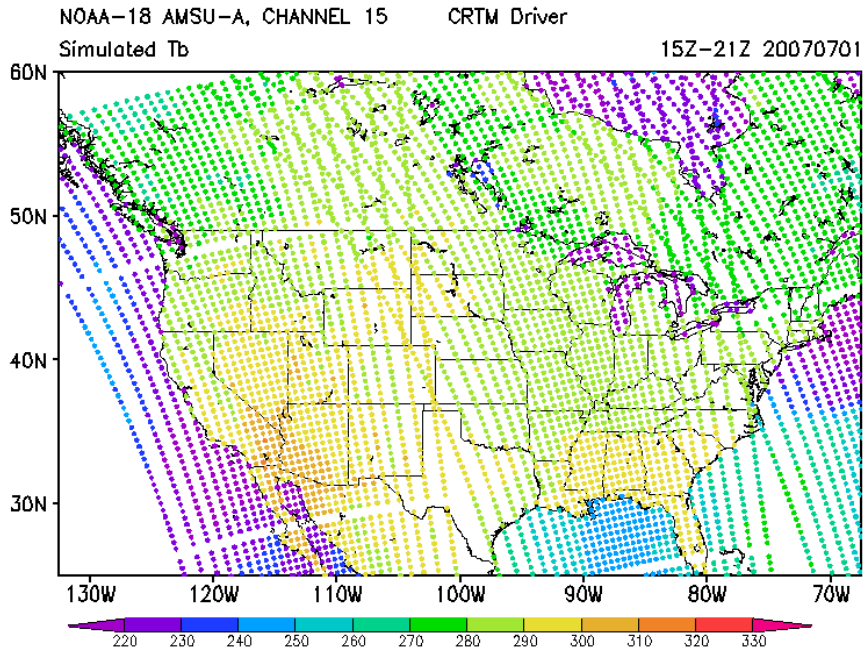
Comparison of GSI/CRTM and CRTM Driver: Tb Simulation

Case: 18Z, 20070701



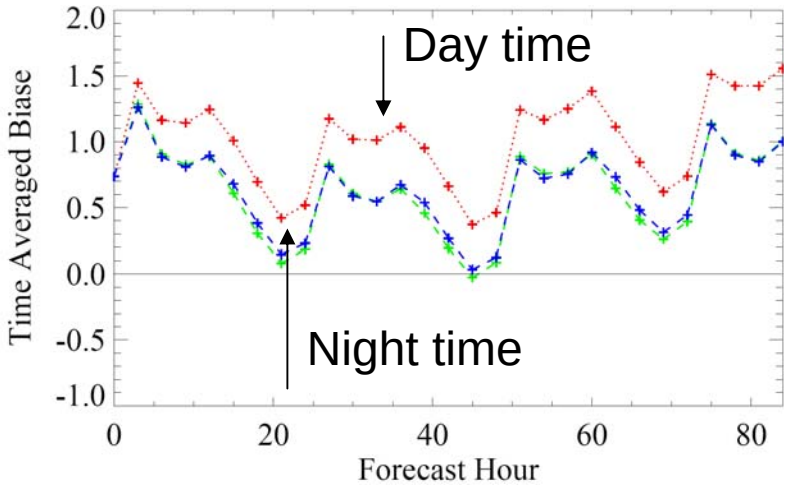


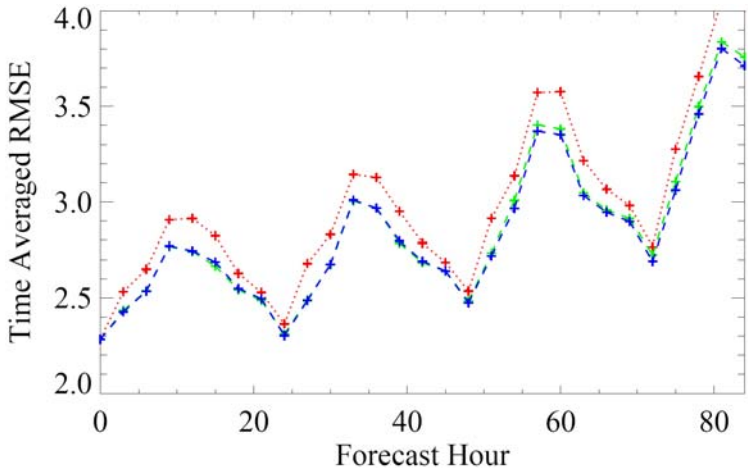




Improved WRF-launcher 2-m temperature and RH forecasts using NESDIS new GVF data

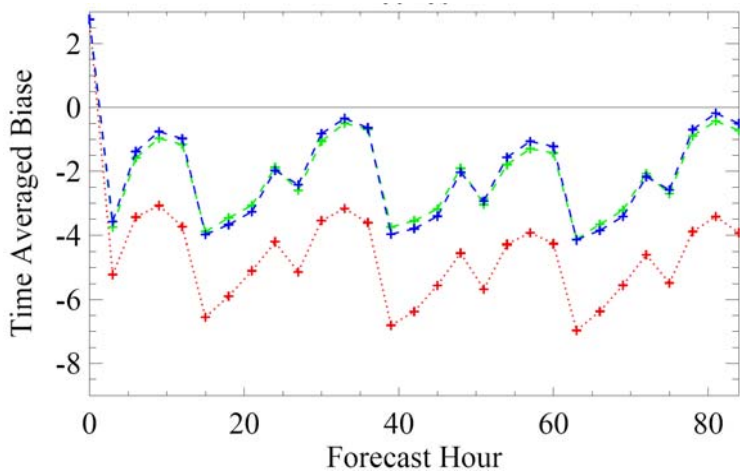
2-m air temperature (°C)

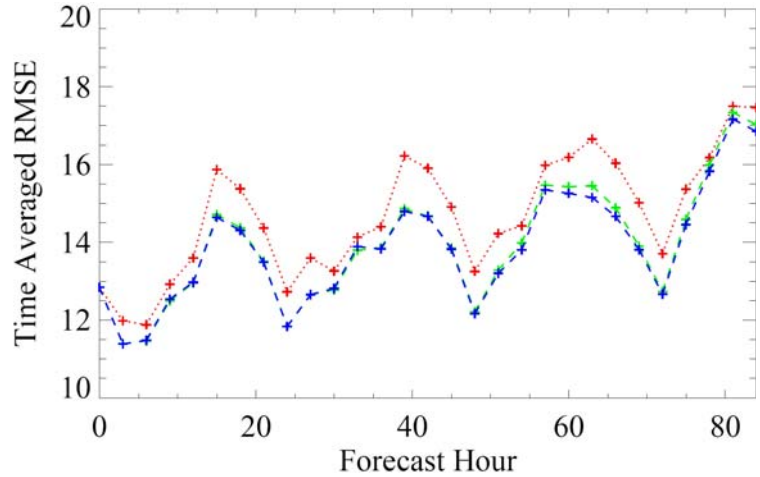




New Real Time GVF Run
New Climatology GVF Run
Old GVF Run

2-m Relative Humidity (%)





July 08 ~ July 18 2006,
continental USA

Recommendations: Metrics

- **Maximize assimilation of satellite data over land**
  - **Need improved Tskin, emissivity, snow, soil moisture**
- **Metrics**
  - **# satellite obs rejected over land**
  - **500mb heights; precip; 2m T,q; boundary layer T,q,u,v**
  - **Land oriented metrics (Climate Reference Network)**
    - **Skin temperature**
    - **Snow cover**
    - **Soil moisture and profiles**
    - **Soil temperature and profiles**
    - **States vs. resistances (invert flux obs)**
- **Benchmarks showing major issues to help set funding priorities**
  - **Winter (Snow)**
  - **Warm Season (Soil Moisture, Land Cover, GVF, LAI)**

Recommendations: Integration

- **Demonstrate impact of prior investigations in JCSDA partner systems**
  - **Global and regional models**
- **Readiness for Future Missions**
  - **NPOESS**
  - **NASA Decadal Survey (GPM, SMAP)**
  - **ESA (SMOS), JAXA (GCOM-W)**
- **Cross-group integration**
  - **CRTM (Continue to strengthen collaboration on CRTM-Land, esp. snow, land ice, veg)**
  - **Air Quality (Need better collaboration on land-emissions/deposition)**
  - **Atmospheric Data Assimilation (e.g. Precip.)**

Recommendations: Development

- **Land models need to be able to simulate additional processes to better assimilate satellite observations and forecast variables relevant to:**
  - **Irrigation**
  - **Inland lakes**
  - **Wetlands**
  - **Fires**
  - **Streamflow**
  - **Invasive Species (e.g. Beetle Damage to West forests)**
  - **Groundwater**
  - **DoD Surface profile characterization**
- **Remote sensing over land is critical for detecting and forecasting impacts due to humans**
  - **Agriculture—planting, harvest**
  - **Irrigation**
  - **Urban**
  - **Deforestation**