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P1.40 Recent Upgrades to NASA SPoRT Initialization Datasets for the Environmental Modeling System

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ABSTRACT

The NASA Short-term Prediction Research and Transition (SPoRT) Center has developed several products for its NOAA/National Weather Service (NWS) partners that can initialize specific fields for local model runs within the NOAA/NWS Science and Training Resource Center Environmental Modeling System (EMS). The suite of SPoRT products for use in the EMS consists of a Sea Surface Temperature (SST) composite that includes a Lake Surface Temperature (LST) analysis over the Great Lakes, a Great Lakes sea-ice extent within the SST composite, a real-time Green Vegetation Fraction (GVF) composite, and NASA Land Information System (LIS) gridded output. This paper and companion poster describe each dataset and provide recent upgrades made to the SST, Great Lakes LST, GVF composites, and the real-time LIS runs.

1. Introduction

The NASA Short-term Prediction Research and Transition (SPoRT) Center has developed several products for its NOAA/National Weather Service (NWS) partners that can initialize specific fields for local model runs within the NOAA/NWS Science and Training Resource Center (STRC) Environmental Modeling System (EMS). In last year's National Weather Association abstract on this topic, the suite of SPoRT products supported in the STRC EMS was presented, which includes a Sea Surface Temperature (SST) composite, a Great Lakes sea-ice extent, a Green Vegetation Fraction (GVF) composite, and NASA Land Information System (LIS)

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gridded output. In the past year, several upgrades have occurred with these datasets in response to changes in operational data feeds and domain requirements. This paper describes each of these real-time SPoRT products that support local modeling initiatives in the STRC EMS and documents the changes to each product.

2. SPoRT Datasets for the STRC EMS

The STRC EMS (hereafter simply "EMS") is a complete, full-physics, state-of-the-science numerical weather prediction (NWP) package based on the Weather Research and Forecasting (WRF) model. The EMS incorporates dynamical cores from both the National Center for Atmospheric Research (NCAR) Advanced Research WRF (ARW) and the National Center for Environmental Predictions (NCEP) non-hydrostatic mesoscale model (NMM) into a single end-to-end forecasting system. All the capability of the NCEP and NCAR WRF models are retained within the EMS; however, the installation, configuration, and execution of each core has been greatly simplified to encourage their use throughout the operational, private, and University forecasting and research communities (Rozumalski 2012).

Nearly every element of an operational NWP system has been integrated into the EMS, including the acquisition and processing of initialization data, model execution, output data processing, and file migration and archiving. Tools for the display of the model output are also provided within the EMS. Real-time forecasting operations are enhanced through the use of an automated process that integrates various fail-over options and the synchronous post processing and distribution of forecast files.

The SPoRT Center has taken advantage of this streamlined approach to mesoscale modeling by conforming its datasets to the EMS construct. By making these datasets available in the EMS, SPoRT partners and other end-users can easily incorporate the SPoRT datasets in place of the default static datasets or fields interpolated down from a large-scale or global NWP model. These datasets are also generated at a resolution more consistent with local model configurations compared to some of the default static fields or the data interpolated from large-scale models. The ultimate goal is to provide SPoRT end-users within the NOAA/NWS with high-quality, timely, and reliable datasets that can improve the accuracy of local model simulations made with the EMS.

a. SPoRT SST and Great Lakes analyses

The SPoRT SST product consists of time latency-weighted swaths of Moderate Resolution Imaging Spectroradiometer (MODIS) infrared (IR) SST measurements in cloud-free regions (based on Haines et al. 2007), blended with GOES/POES SST analyses from the National Environmental Satellite Data and Information Service (Nalli et al. 2004), and the European's global Operational Sea Surface Temperature and Sea Ice Analysis (Stark et al. 2007). To preserve horizontal detail, MODIS is given the largest weight relative to the other data sources, with the newest cloud-masked swaths receiving the greatest weight. The composites are generated at 2-km horizontal grid spacing from 0°N to 80°N latitude and 130°E to 10°E longitude (domain shown in Fig. 1a).

Embedded within the hemispheric-scale SST composite is a unique analysis over the Great Lakes region (Fig. 1b). To obtain lake surface temperature (LST), MODIS IR is blended with the Great Lakes Surface Environmental Analysis data (GLSEA2; Schwab et al. 1999) from the NOAA Great Lakes Environmental Research Laboratory (GLERL). Oftentimes in the fall and winter, MODIS IR data are unavailable in parts of the Great Lakes due to persistent cloud cover. Thus, reliable background LST data from the GLSEA2 product is important to maintain a quality product.

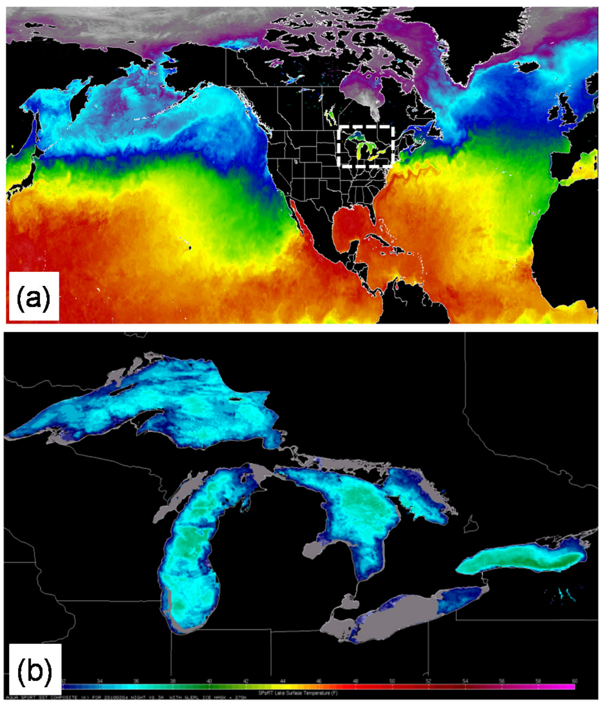

Figure 1. Depiction of the (a) twice-daily SPoRT SST domain, covering much of the union between the northern and western hemispheres, and (b) embedded Great Lakes LST and ice extent analysis domain, as denoted by the box in (a). Gray shading indicates regions of ice cover in the Great Lakes LST analysis, where LST is set to 270 K at ice-covered grid points.

The lake ice cover extent is established using data from the National Ice Center analysis (http://www.natice.noaa.gov/products/great_lakes.html), in which a grid pixel is flagged as ice-covered based on fractional ice exceeding 90%. For initializing ice cover in the EMS or WRF model, the LST is set to 270 K at ice points, thereby enabling ice cover initialization in the model based on a simple threshold approach.

Several previous studies have illustrated the utility of using variations of the SPoRT SST composites in numerical modeling simulations, including LaCasse et al. (2008), Case et al. (2008b), Schiferl et al. (2010), and Case et al. (2011a).

b. SPoRT-MODIS GVF

On 1 June 2010, SPoRT began generating a daily GVF dataset over the Continental U.S. (CONUS) at 0.01° (~1 km) grid spacing over the domain shown in Fig. 2. The data are derived from near real-time swaths of MODIS normalized difference vegetation index (NDVI) that SPoRT receives from the University of Wisconsin Direct Broadcast. CONUS grids of latency-weighted NDVI are produced using a similar technique to the current SPoRT SST product. The GVF represents the fraction of a grid pixel containing photosynthetically active vegetation. Details on how the SPoRT GVF data are calculated for modeling applications can be found in Case et al. (2011b).

A sample comparison between the default monthly climatology and the real-time SPoRT GVF on 1 September 2012 is shown in Fig. 2. The climatological GVF in Fig. 2a represents a linear time-interpolation from the monthly climatology (represented by one value for the 15th of each month) to 1 September. The monthly GVF climatology is the default dataset in the public WRF model and the EMS, and was derived from the Advanced Very High Resolution Radiometer using a collection of NDVI data from 1985 to 1991 (Gutman and Ignatov 1998; Jiang et al. 2010). Besides being a dated product that is static from year-to-year, the grid spacing of the climatology GVF (0.144°, or ~16 km) is approximately an order of magnitude coarser than the SPoRT-MODIS product (~1 km).

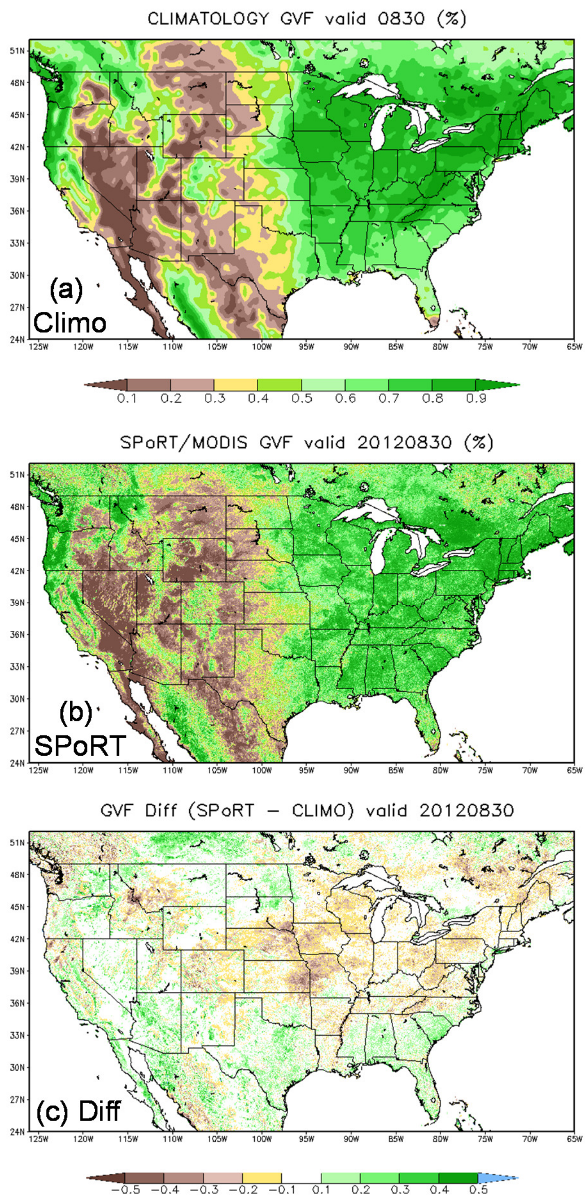

Figure 2. Comparison between the (a) EMS default monthly GVF climatology, time-interpolated to 1 September, (b) real-time SPoRT-MODIS GVF composite produced on 30 August 2012, and (c) difference between the SPoRT-MODIS and climatology GVF.

The differences in the level of detail are quite prevalent when comparing the climatological GVF (Fig. 2a) to the SPoRT-MODIS GVF (Fig. 2b). While the large-scale patterns are fairly similar, the SPoRT-MODIS GVF shows much more local detail, and also depicts lower GVF in the Midwest region, as seen in the difference plot in Fig. 2c, corresponding to the ongoing severe drought of Summer 2012 (not shown). Case et al. (2012) illustrated the potential impact of real-time SPoRT-MODIS GVF in place of climatological GVF in simulating severe weather events.

c. SPoRT LIS

The SPoRT Center has been operating a real-time configuration of the NASA LIS (Kumar et al. 2006; Peters-Lidard et al. 2007; Kumar et al. 2007) that runs the Noah Land Surface Model (LSM) in an uncoupled, or offline mode, since summer 2010. In an offline mode, the LSM is run apart from a numerical weather prediction model, with input variables (i.e. forcings) provided by atmospheric analyses. The LIS run is made on a domain that covers much of the eastern CONUS at 3-km grid spacing (extent of domain shown in Fig. 3).

The SPoRT-LIS simulation consists of a long-term integration of the Noah LSM spanning multiple years, which is restarted four times each day and driven by atmospheric analyses from the NCEP Global Data Assimilation System (GDAS; Parrish and Derber 1992; Derber and Wu 1998; NCEP EMC 2004), North American Land Data Assimilation System Phase 2 (NLDAS2; Xia et al. 2012), and hourly precipitation estimates from the NCEP Stage IV product (Lin and Mitchell 2005; Lin et al. 2005). To ensure data availability in real time applications, short-term forecasts up to 15 hours from the NCEP Global Forecast System (GFS) model are used in each 6-hourly SPoRT-LIS cycle, thus providing a small forecast component to the real-time LIS. Output forced by the GFS forecasts is over-written in subsequent cycles as atmospheric analyses become available, ensuring that the land surface model converges to a best modeled solution based on analyses and not forecasts.

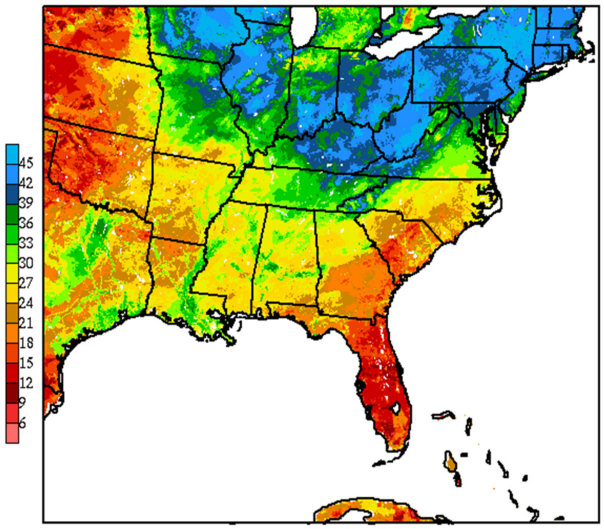

Figure 3. Sample 0-10 cm volumetric soil moisture map illustrating the extent of the real-time 3-km LIS-Noah land surface model domain for use in the EMS.

The real-time system is designed to provide the best modeled depiction of soil moisture and temperature, skin temperature, and snow-water equivalent at a resolution consistent with local models at NWS weather forecast offices. Case et al. (2008a) and Case et al. (2011a) demonstrated the utility of initializing local NWP models with high-resolution, consistent LSM fields from LIS over the Southeastern U.S. during the warm-season months.

Recent versions of the EMS contain an option to use LIS data for initializing land surface variables in local model runs. The SPoRT-LIS can also provide weather forecast offices with modeled land surface fields that can aid short-term forecasting, situational awareness, and drought monitoring. Output is written into gridded binary format, thus enabling an easy incorporation into the EMS via the WRF Preprocessing System utilities. Finally, the SPoRT-LIS has been incorporating the SPoRT GVF composites since April 2011.

3. Recent Upgrades to SPoRT Datasets

Several upgrades have been made to each of the SPoRT datasets described in Section 2, except for the Great Lakes ice product which has remained the same in the past year. These changes are documented in the following sub-sections.

a. SPoRT SST and Great Lakes analyses

In the past year, the SPoRT SST composites were expanded from a CONUS+ domain to one that covers much of the northern and western hemispheres. Because of this expansion, the horizontal grid spacing was coarsened from 1 km to 2 km — a necessary change in order to accommodate the expanded domain. In addition, the previous iteration of the SPoRT SST lost the Advanced Microwave Scanning Radiometer – EOS (AMSR-E) SST information in December 2011, which was used to help fill-in data in MODIS cloud-masked regions. To back-fill the loss of AMSR-E data, SPoRT included the NESDIS GOES/POES SST analysis as a "background field" behind the MODIS IR SST data.

Over the Great Lakes, SPoRT had been using background LST data from Remote Sensing Systems (REMSS) in the previous CONUS+ SST product. However, the REMSS SST product has been consistently latent during the past year such that SPoRT decided to replace this information with more timely data from the GLSEA2 product. Ice cover over the Great Lakes remains unchanged.

b. SPoRT-MODIS GVF

The only recent modification to the SPoRT-MODIS GVF composite has been to expand the domain west, north, and eastward. The decision to expand these three edges was mainly to support CONUS-scale modeling experiments on a similar domain to the real-time National Severe Storms Laboratory convection-allowing resolution WRF model runs (described in Kain et al. 2010). The expanded SPoRT-MODIS GVF domain covers a region from 23°N to 55°N latitude, and 130°W to 62°W longitude.

c. SPoRT LIS

The SPoRT LIS was upgraded in early September 2012 with several improvements. Table 1 summarizes the various real-time SPoRT LIS characteristics, aspects of the model run that have changed, and specific information on the configuration details. The upgrade is generally transparent to end users, since file and data formats are the same. The most noteworthy modifications and improvements are:

- Updated LIS software to support an upgrade from Noah LSM version 2.7.1 to version 3.2. This upgrade includes an improved look-up table methodology for some static fields and improved handling of heat fluxes over snow-covered regions.
- Changed land-use classification (vegetation type) from the U.S. Geological Survey 24-class database to the newer International Geosphere Biosphere Programme (IGBP)/MODIS 20-class database. The IGBP/MODIS database is more up-to-date, especially for recently-expanded urban areas.
- Switched from a coarse-resolution surface albedo climatology to a look-up table methodology for surface albedo based on (a) input GVF from the high-resolution SPoRT-MODIS real-time product and (b) the newer IGBP/MODIS land-use database. An example comparison between the original climatological specification of surface albedo and the newer look-up table methodology based on real-time SPoRT-MODIS vegetation data is given in Fig. 4.
- Modified the long-term atmospheric forcing (excluding precipitation) that drives the LIS-Noah LSM integration from the NLDAS to NLDAS phase 2 (NLDAS-2). The NLDAS-2 is an improved long-term satellite-era reanalysis database.

The upgrades to the SPoRT LIS will help improve the representation of urban areas, the partitioning of surface heat and moisture fluxes through the use of the IGBP/MODIS land use database, better represent the surface energy budget through the use of surface albedo consistent with real-time SPoRT-MODIS GVF, and improve the soil moisture distribution in the LIS output. These impacts will in turn translate to benefits in the forecast 2-m temperature, dewpoint, and instability fields in local model forecasts using LIS initialization data, especially during the warm season.

4. Summary

This paper described three SPoRT datasets made available to the STRC EMS for initializing local model forecasts:

(1) northern / western hemispheric SST composite with embedded Great Lakes LST / ice analysis,
(2) daily MODIS GVF over the CONUS, and
(3) real-time 3-km SPoRT-LIS land surface model output.

Numerous studies have demonstrated the potential utility that these real-time, high-resolution land and water surface datasets can have on subsequent local and regional model simulations. These datasets have undergone numerous upgrades and modifications in recent months in order to accommodate changing domain requirements, and to improve the quality and timeliness of the datasets. In the near-term, SPoRT seeks to expand the LIS domain to a full CONUS scale in order to provide LSM initialization data to a wide base.

SPoRT has produced documentation to help explain the process of incorporating these datasets into the EMS. Those interested in initializing the EMS with SPoRT datasets are encouraged to contact the corresponding author of this paper to obtain instructions.

Acknowledgements. The authors are grateful to the numerous end-users of the EMS who currently incorporate the NASA SPoRT initialization datasets. These partners include NOAA/NWS forecast offices in Huntsville, AL; Mobile, AL; Houston, TX; Melbourne, FL, Miami, FL, and Albuquerque, NM, among others. The authors are particularly appreciative of the collaboration with Lance Wood and Jeff Medlin at the Houston and Mobile NWS offices, respectively.

Table 1. *List of configuration details of the real-time SPoRT LIS, notation as to whether the configuration is unchanged or modified, and specific noteworthy details.*

Configuration Detail	Unchanged	Modified	Notes
Domain extent	X		Eastern United States
Grid spacing	X		3 km
Soil type	X		State Soil Geographic database
Land use		X	Upgraded to IGBP/MODIS 20-class vegetation type
Land surface model		X	Upgraded to Noah version 3.2 (formerly v2.7.1)
GVF database	X		Daily real-time SPoRT-MODIS Green Vegetation Fraction generated at native 0.01° resolution
Surface albedo		X	Improved look-up table methodology based on input real-time SPoRT-MODIS GVF
Atmospheric forcing (excludes precip)		X	Long-term Noah LSM integration driven by NLDAS-2 (formerly first-generation NLDAS)
Precipitation forcing	X		Hourly NCEP Stage IV precipitation analyses

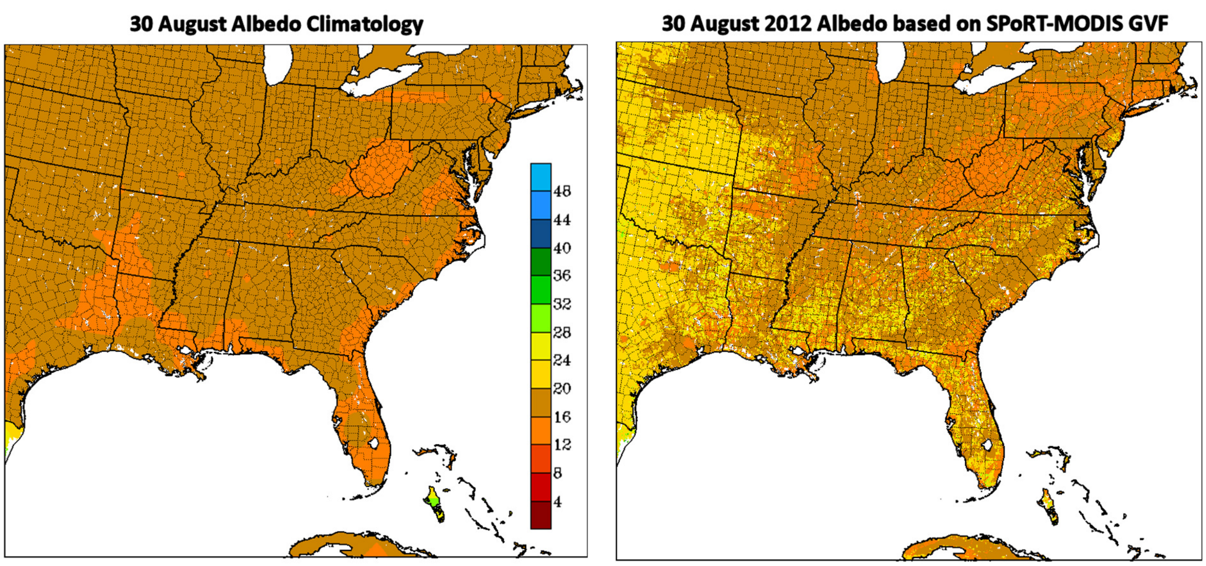

Figure 4. Comparison between climatological surface albedo time-interpolated to 30 August in the former LIS configuration (left), and surface albedo as a function of the real-time SPoRT-MODIS GVF in the upgraded LIS configuration (right). Note the higher surface albedo corresponding to lower SPoRT-MODIS GVF in the Plains and Midwest regions from Fig. 2.

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