Data Assimilation Enhancements to Air Force Weather's Land Information System

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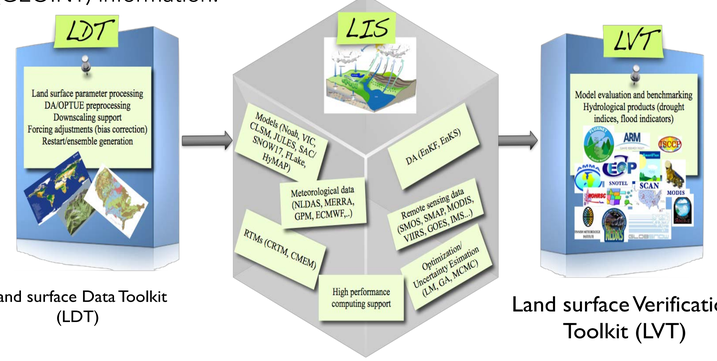
Introduction

- The United States Air Force (USAF) has a proud and storied tradition of enabling significant advancements in the area of characterizing and modeling land state information.
- 557th Weather Wing (557 WW; DoD's Executive Agent for Land Information) provides routine geospatial intelligence information to war-fighters, planners, and decision makers at all echelons and services of the U.S. military, government and intelligence community.
- 557 WW and its predecessors have been home to the DoD's ***only*** operational regional and global land data analysis systems *since January 1958*.
- As a trusted partner since 2005, Air Force Weather (AFW) has relied on the Hydrological Sciences Laboratory at NASA/GSFC to lead the interagency scientific collaboration known as the Land Information System (LIS).
- LIS is an advanced software framework[1,2,3] for high performance land surface modeling and data assimilation of geospatial intelligence (GEOINT) information.



Land surface Data Toolkit (LDT)

Land Information System (LIS)

Land surface Verification Toolkit (LVT)

- LIS consists of a large suite of land surface models and data assimilation algorithms (EnKF, EnKS, ..) and support for remote sensing data (SMAP, SMOS, AMSR2, ASCAT, AMSR-E, SSM/I, SMMR, ...).
- LDT supports the data preprocessing needs for LIS (parameter data processing, data assimilation support, forcing bias correction, ...)
- LVT includes the support of in-situ (SCAN, USDA, NASMD, ISMN, ...), remote sensing and model/analysis datasets for model benchmarking and evaluation.

Fig 1. Primary Subsystems comprising the LIS Framework.

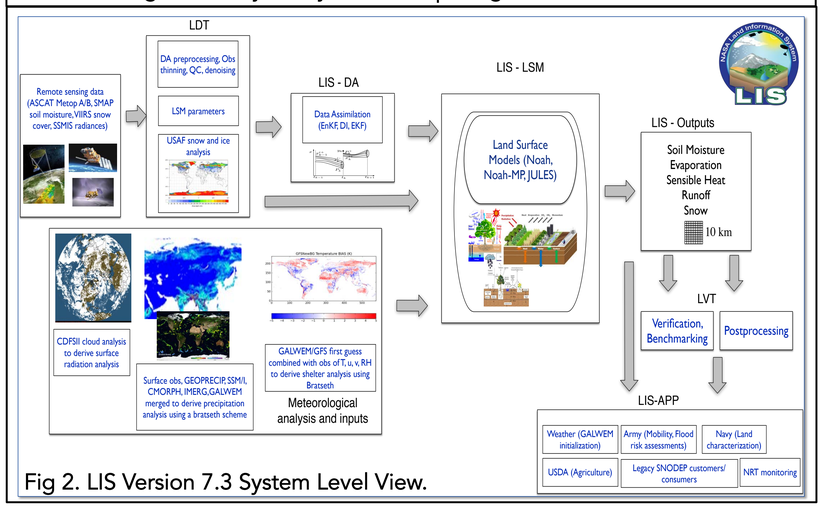


Fig 2. LIS Version 7.3 System Level View.

Recent Data Assimilation Enhancements

- Updates to the meteorological analysis (e.g., improved precipitation processing using a Bratseth scheme; Ability to ingest IMERG (see: ppm.nasa.gov/data-access/downloads/gpm); dynamic use of GALWEM as first-guess) [*Improved overall quality of analyses while enabling decommissioning of legacy GEOPRECIP application*].
- Next-generation, global 10-km "USAF Snow and Ice analysis (USAF SI) [*Enables decommissioning of legacy SNODEP application; DA-method of Direct Insertion replaced with EnKF*].
- Global 10-km configurations of NoahV3.9.1 (Last), Noah-MPV4.0.1 and JULESV5.0+ land surface models [*All of which possess optimized/tuned EnKF of 'USAF Snow & Ice Analysis', SMAP L2, and ASCAT Metop- A/B SM in model space[4] on a common 10-km global grid*].—see https://www.jpl.nasa.gov/news/news.php?feature=7544

Other Significant Enhancements to Operations

- Southern limit of domain extended from 60° S to 90° S (now truly global).
- Replaced undocumented, outdated, multi-step pre-processing method with streamlined, LDT-contained methodology using the latest/greatest source data available (to include Met Office Ancillaries needed for initialization of GALWEM).
- Replaced SOILPARM.TBL (Cosby, 1984) used with Noah with corrected SOILPARM.TBL coefficients.
- In-house LISpost replaced with LVT. Improved functionalities enabled:
  - Appending USN GOFS [Improves upon both 1/4° navysst used by WRF and provides a 1/20° (poleward of 40 N/S) U.S.-based alternative (or backup) for SSTs and Sea Ice Fraction and thickness to 1/20° (~5-km) OSTIA (produced by Met Office), respectively.] [*Enables GALWEM COOP under INFOCON-1 (.mil-to-.mil)*];
  - Uncertainty estimation applied on 12-member ensemble and mean to derive standard deviations of several parameters; [Enables satisfaction of (most) vertical profiles of land state variable requirements for PAIS]; and
  - Transition from GriB-1-to-GriB-2 [*Enables decommissioning of legacy data flows*].
- DISA STIG-compliant with zero vulnerabilities/findings.

Summary of Results

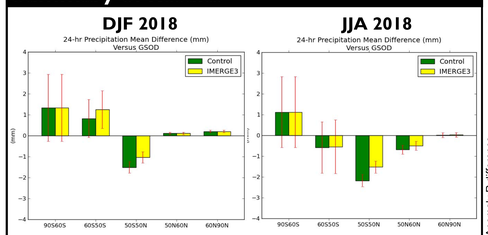


Fig 3. Mean of station bias values by latitudinal band with 95% confidence intervals shown in red. Significant bias reduction of 50S-50N for both seasons when Bratseth assimilates IMERG-ER, but adds slight wet bias from 60S-50S in DJF 2018.

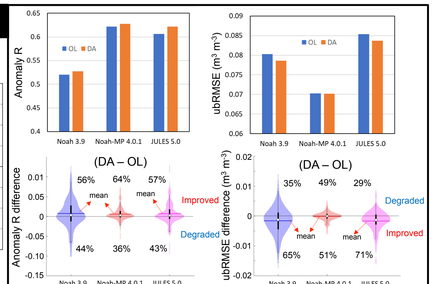


Fig 4. Summary of CONUS results (4/1/15 -1/1/18; USDA ARS, SCAN, USCRN). DA method optimized: fine-grained CDFs; Obs thinning for JULES; >50% of model grid cells improved; # obs assimilated increased.

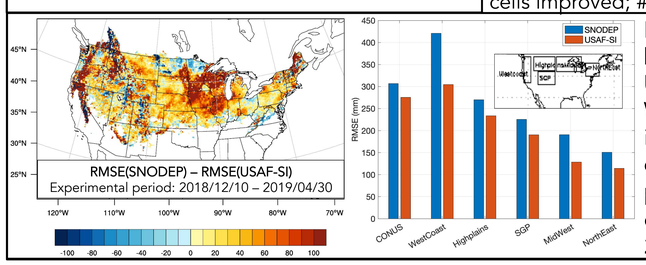


Fig 5. Difference RMSE between SNODEP and USAF-SI vs. SNODAS. Warm colors indicate improvement and cool degradation. USAF-SI performance improved over 76.6%, degraded 23.4% locations.

Future Work

- Direct radiance assimilation of NRT SMAP L1 Tb (9-km).
- Extend the NRT-assimilation of albedo, vegetation conditions, and Tsfc from MODIS/VIIRS for the Noah LSM to the Noah-MP and JULES LSMs.
- Extend the data assimilation capabilities of LIS to allow for the assimilation of near-real-time (NRT) soil moisture products from ESA's Soil Moisture and Ocean Salinity (SMOS) mission.
- Exploitation of Soil Moisture, Snow Water Equivalent (SWE) and Snow Depth derived from Weather Satellite Follow-on-Microwave (WSF-M).
- Exploitation of snow cover and SWE from GCOM (AMSR2).
- Update the snow analysis by including geostationary satellite inputs (GOES-16 and 17, Himawari- 8 and 9) and by extending the snow gauge coverage (include a broader set of GTS stations).
- Extend the data assimilation capabilities of LIS to allow for the assimilation of Total Water Storage (TWS) from GRACE Follow-On (GRACE-FO).

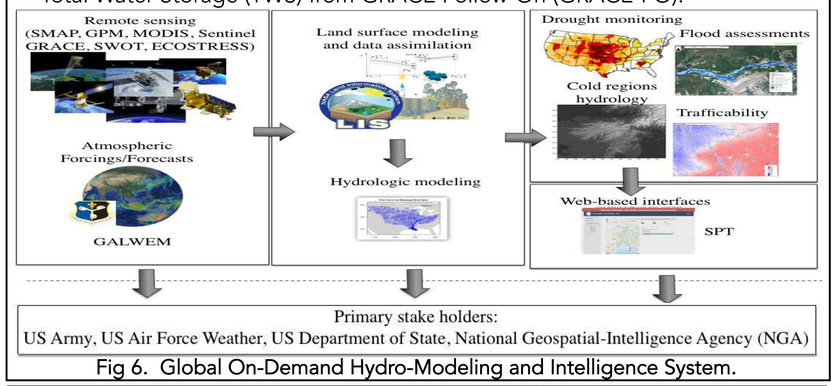


Fig 6. Global On-Demand Hydro-Modeling and Intelligence System.

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Acknowledgements

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