Use of SMAP Data in NOAA NWP and Drought Monitoring:

Early Results and Near Term Plan

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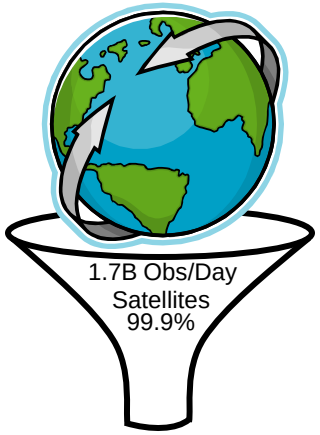
OUTLINE

- NCEP NWP operations and research
- NESDIS SMOPS
- NCEP SM data assimilation
- Early results
- Three year plan
- Summary

NCEP Global Forecast System



Global Data Assimilation

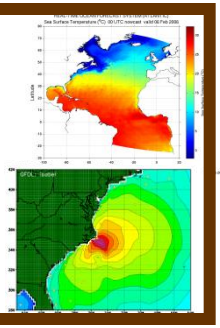
Global Forecast System

Climate
CFS
MOM3

Hurricane
GFDL
HWRF

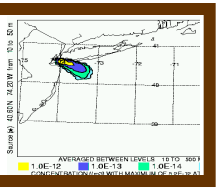
Coupled

Oceans
RTOFS/HYCOM
WaveWatch III

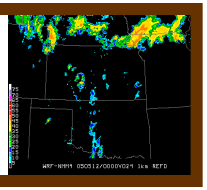


Regional NAM
WRF NMM

Dispersion
ARL/HYSPLIT



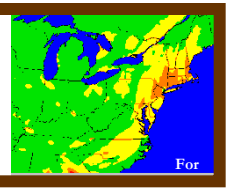
Severe Weather
WRF NMM/ARW
Workstation WRF



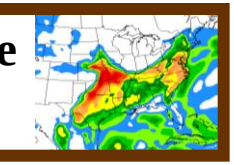
North American Ensemble Forecast System
GFS, Canadian Global Model

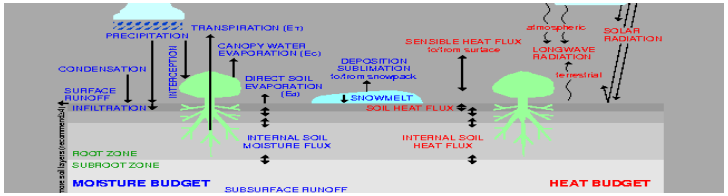
Short-Range Ensemble Forecast
WRF: ARW, NMM
ETA, RSM

Air Quality
NAM/CMAQ



Rapid Update for Aviation





Noah Land Surface Model

From Louis Uccellini (2009)

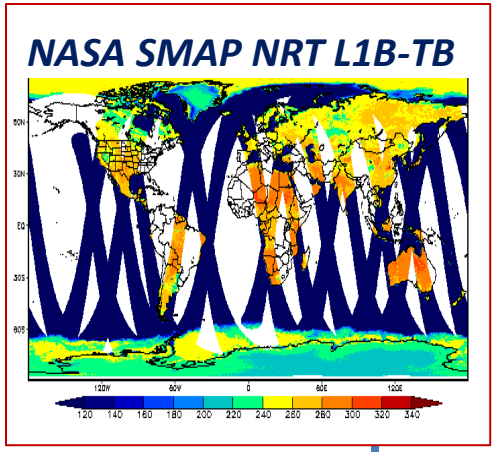
Caveats on NCEP Data Need for SMAP Products

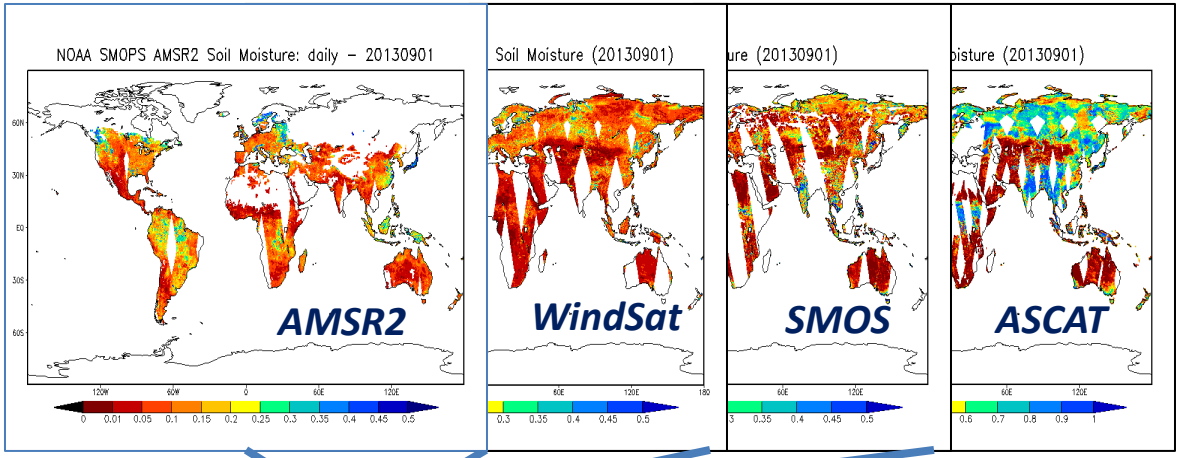
- *SM impact intra-seasonal, inter-seasonal, to inter-annual climate varibilities.*
- *SM are used in model initializations.*
- *SM observational data are also important for LSM validation as well as other land remote sensing data, e.g.: soil Temperature, snow, albedo, green vegetation fraction.*
- *Operational use of land remote sensing data including SM may start from North America Land Data Assimilation System (NLDAS) that is current operational at NCEP Center of Operations*

From Weizhong Zheng & Michael Ek

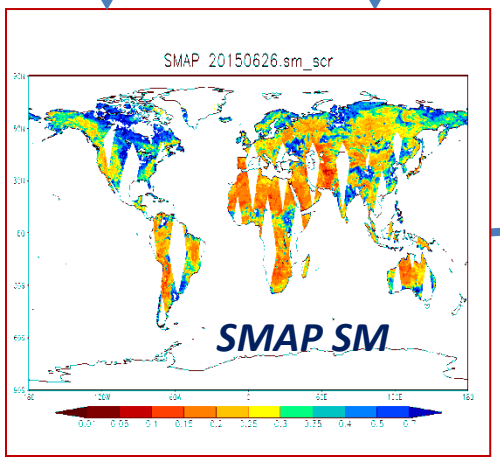
Soil Moisture Operational Product System

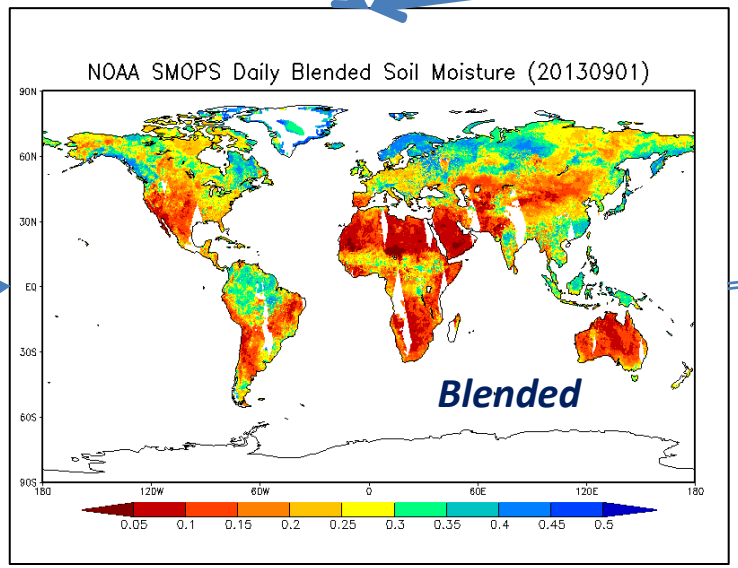
SMOPS





NOAA Ancillary Data

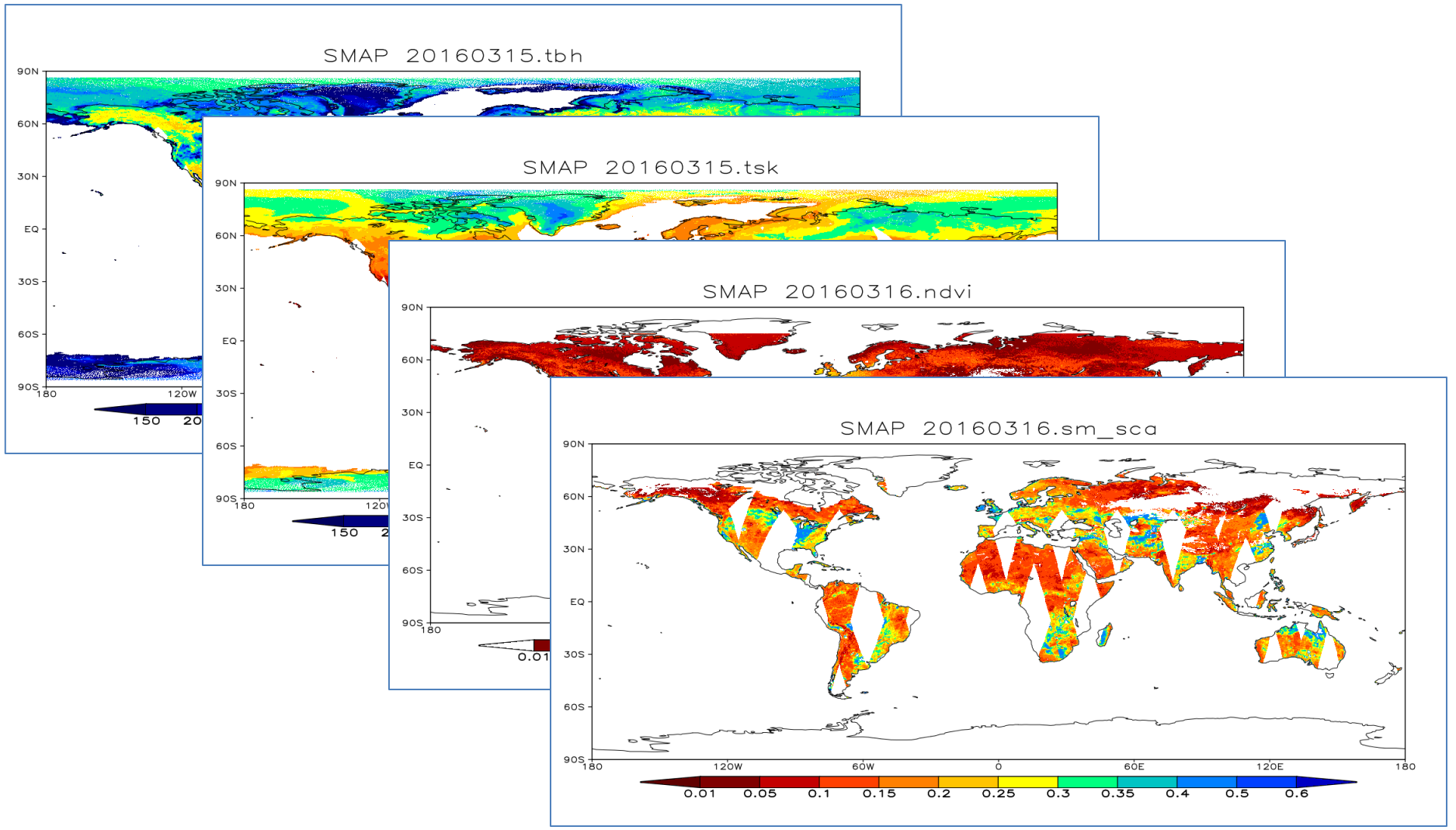




NCEP
NWP models
GFS/NAM
NLDAS/GLDAS

NESDIS SMOPS Ingests NASA SMAP NRT Data to retrieve global soil moisture with NOAA ancillary Data and blends them with other satellite observations for NCEP use

SMAP Soil Moisture Retrieved from SMOPS



NESDIS SMOPS uses NASA SMAP NRT L1B_TB and NOAA ancillary data (GDAS Tskn and VIIRS NDVI) to retrieve soil moisture

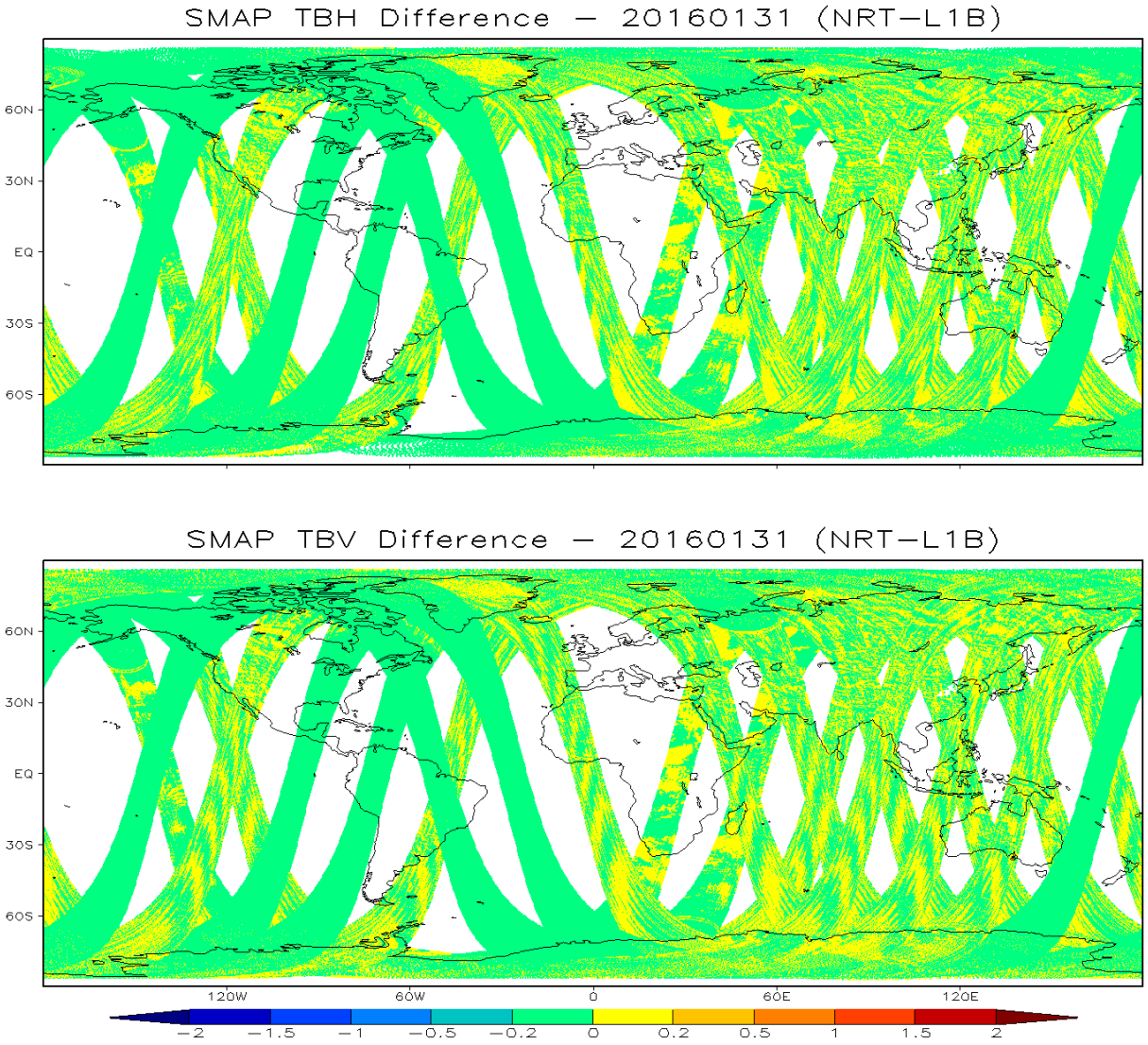
Latencies of SMAP L1B-TB Data from JPL SMAP NRT Data Server

Date	Total_In	Total_Orbits	Percent_In	Minimum	Median	Average	Maximum
Oct 1	11	29	38	1:33	3:56	4:17	6:09
2	14	27	52	1:20	3:57	4:02	5:51
3	13	29	45	1:23	3:30	3:50	5:54
4	14	28	50	1:58	3:56	4:04	5:39
5	12	30	40	1:28	3:59	9:30	87:25
6	14	27	52	1:32	4:13	4:01	5:50
7	13	28	46	1:33	4:33	4:12	5:22
8	13	27	48	1:35	4:15	4:10	6:05
9	11	29	38	1:58	4:07	4:15	5:29
10	11	28	39	1:20	4:31	4:11	5:48
11	11	27	41	1:23	4:02	4:07	5:32
12	14	29	48	1:46	4:35	4:16	5:39
13	13	26	50	1:28	4:12	3:54	5:43
14	11	28	39	1:10	3:57	4:01	5:39
15	13	28	46	1:28	4:07	3:58	6:00
16	12	27	44	1:30	3:51	3:58	6:01
17	12	29	41	1:28	3:59	4:08	6:20
18	13	28	46	1:16	3:55	4:04	5:48
19	13	26	50	1:18	3:48	3:55	5:53
20	13	27	48	1:41	4:08	4:04	5:34
21	11	27	41	1:58	3:53	4:13	8:26

Latencies of SMAP L1B-TB Data from NSIDC Data Server

Date	Total_In	Total_Orbits	Percent_In	Minimum	Median	Average	Maximum
Oct 1	1	30	3	4:29	5:37	7:49	15:41
2	5	28	18	4:29	5:20	5:47	12:31
3	6	30	20	4:43	5:17	5:38	10:40
4	7	29	24	4:36	5:13	5:30	6:37
5	6	32	19	4:34	5:06	10:33	87:43
6	5	33	15	4:36	5:22	40:23	351:13
7	2	29	7	4:45	323:45	252:09	344:13
8	3	29	10	4:05	5:05	5:25	6:57
9	6	30	20	4:08	5:16	5:31	7:00
10	6	29	21	4:29	5:17	5:33	6:28
11	5	29	17	4:31	5:19	5:28	6:29
12	7	29	24	4:54	5:23	5:35	6:39
13	5	30	17	4:34	5:09	5:28	6:40
14	4	29	14	4:52	6:02	12:21	26:03
15	2	29	7	4:29	5:43	8:08	16:13
16	5	29	17	4:26	5:14	5:27	6:36
17	6	30	20	4:22	5:09	5:28	7:12
18	5	29	17	4:29	5:17	5:33	6:51
19	3	29	10	4:32	5:22	5:36	7:18
20	2	29	7	4:55	11:16	15:22	29:14
21	5	30	17	4:59	5:30	6:32	11:25

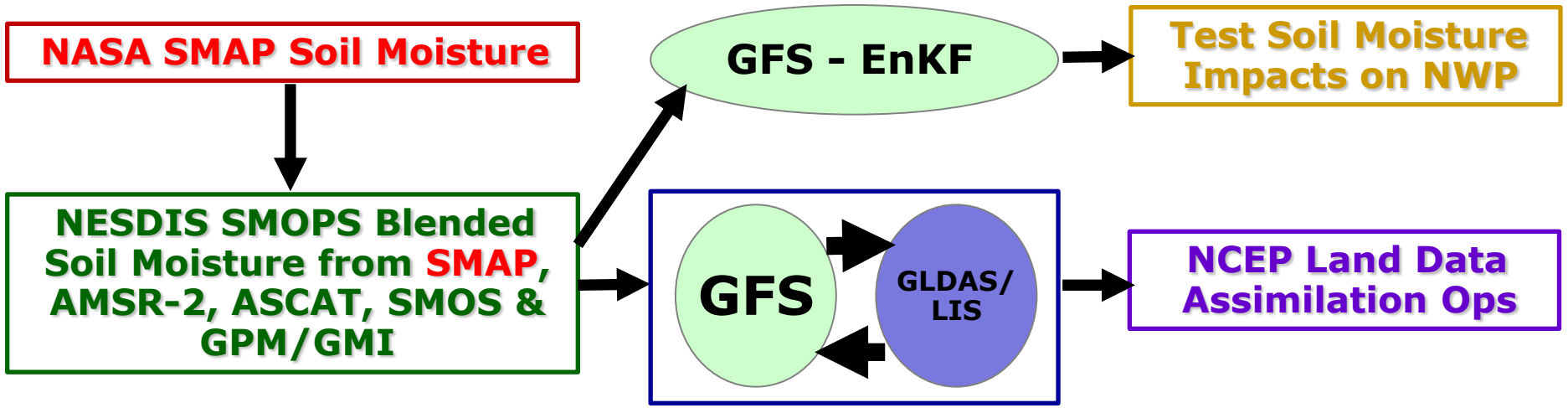
SMAP L1B_TB: JPL NRT vs NSIDC



More than 99% of footprint TBs have difference smaller than 0.2 degree.

SMAP SM Use in NCEP Models

- NESDIS is ingesting SMAP data through Soil Moisture Operational Product System (SMOPS) to provide inputs to NWS-NCEP models
- NWS-NCEP has tested a GFS-EnKF coupled system to test impact of assimilating satellite soil moisture data on numerical weather prediction (NWP)
- NWS-NCEP and NESDIS-STAR are collaborating on the development of a GFS-GLDAS/LIS semi-coupled system for operational land data assimilation

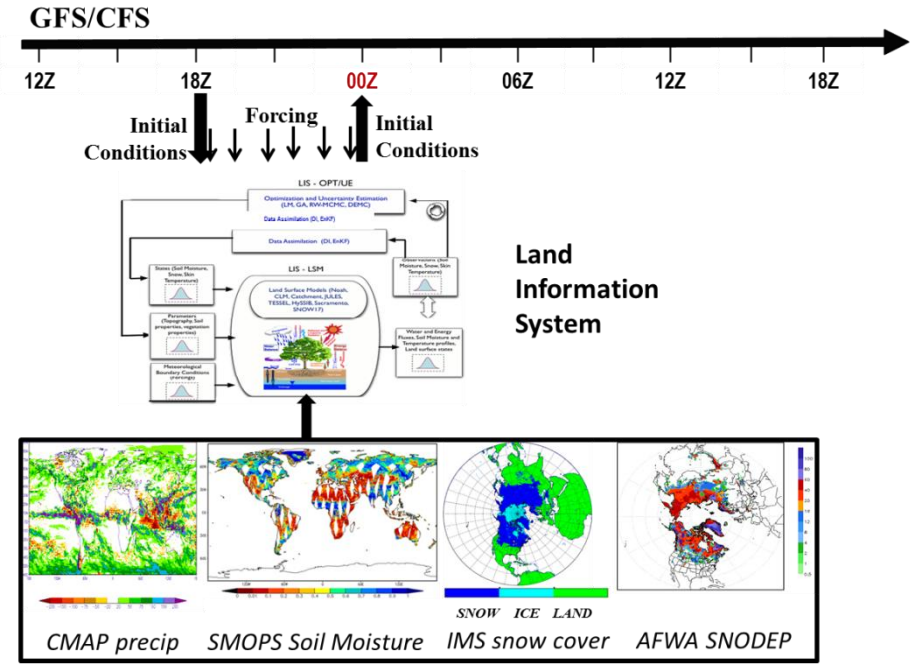


From Weizhong Zheng & Michael Ek

Satellite-based Land Data Assimilation Tests in NWS GFS/CFS Operational Systems

PI: Michael Ek (NOAA/NCEP/EMC)
Co-Is: Jiarui Dong and Weizhong Zheng (IMSG at NOAA/NCEP/EMC)
Christa Peters-Lidard (NASA/GSFC) and Grey Nearing (SAIC at NASA/GSFC)

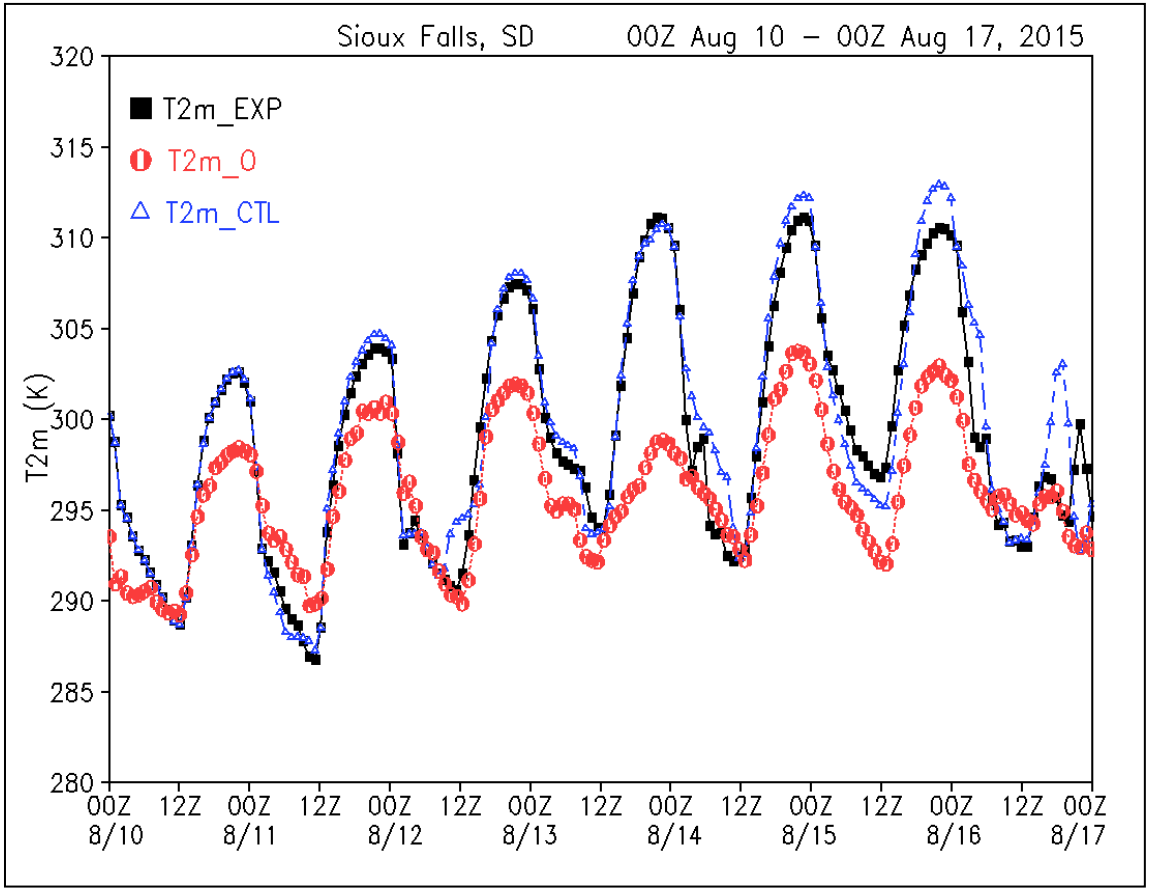
We propose to enable the existing NASA Land Information System (LIS) to serve as a global Land Data Assimilation System (LDAS) for both GFS and CFS. LIS integrates NOAA/NCEP's operational land surface model (NCEP's Noah), high-resolution satellite and observational data, and land data assimilation (DA) tools.



The LIS EnKF-based land Data Assimilation tool is used to assimilate soil moisture from the NESDIS global Soil Moisture Operational Product System (SMOPS), snow cover area (SCA) from operational NESDIS Interactive Multisensor Snow and Ice Mapping System (IMS) and AFWA snow depth (SNODEP) products.

Courtesy Jiarui Dong

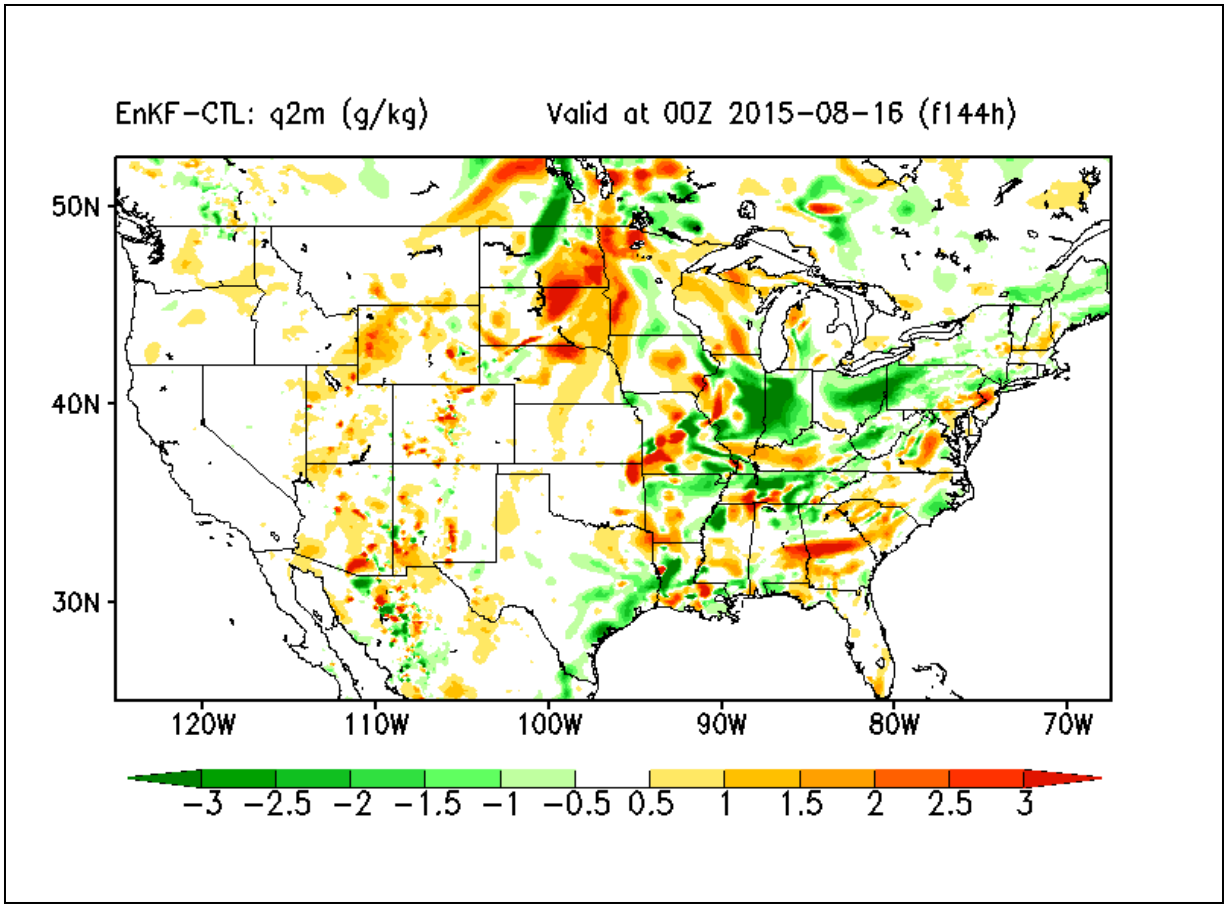
SMAP SM Impact on GFS Forecasts



Assimilating SMAP SM from 8/1 – 8/10/2016 Reduces the warm biases of NCEP GFS four (4) day forecasts of 2 meter air temperature

From Weizhong Zheng & Michael Ek

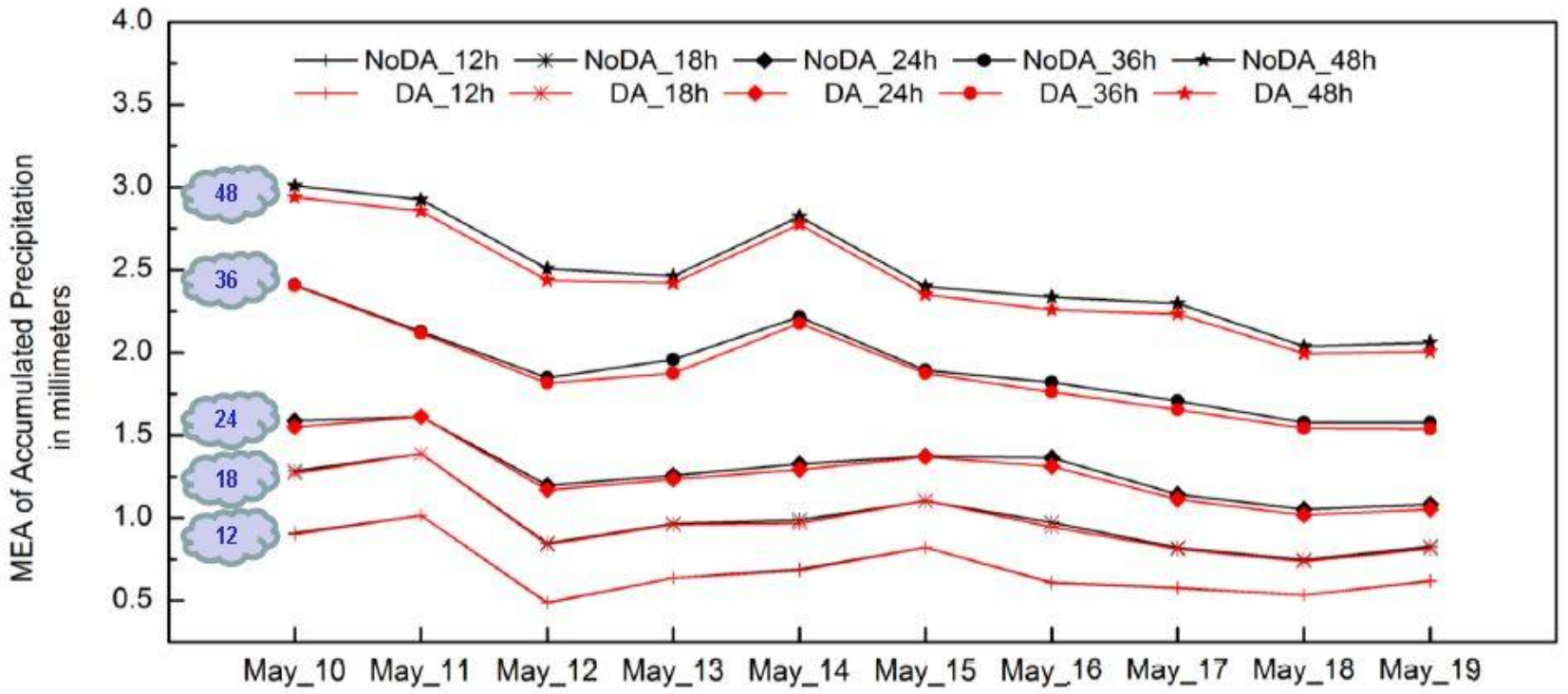
SMAP SM Impact on GFS Forecasts



Impact of assimilating SMAP SM from 8/1 – 8/10/2016 on NCEP GFS four (4) day forecasts of 2 meter humidity varies significantly spatially

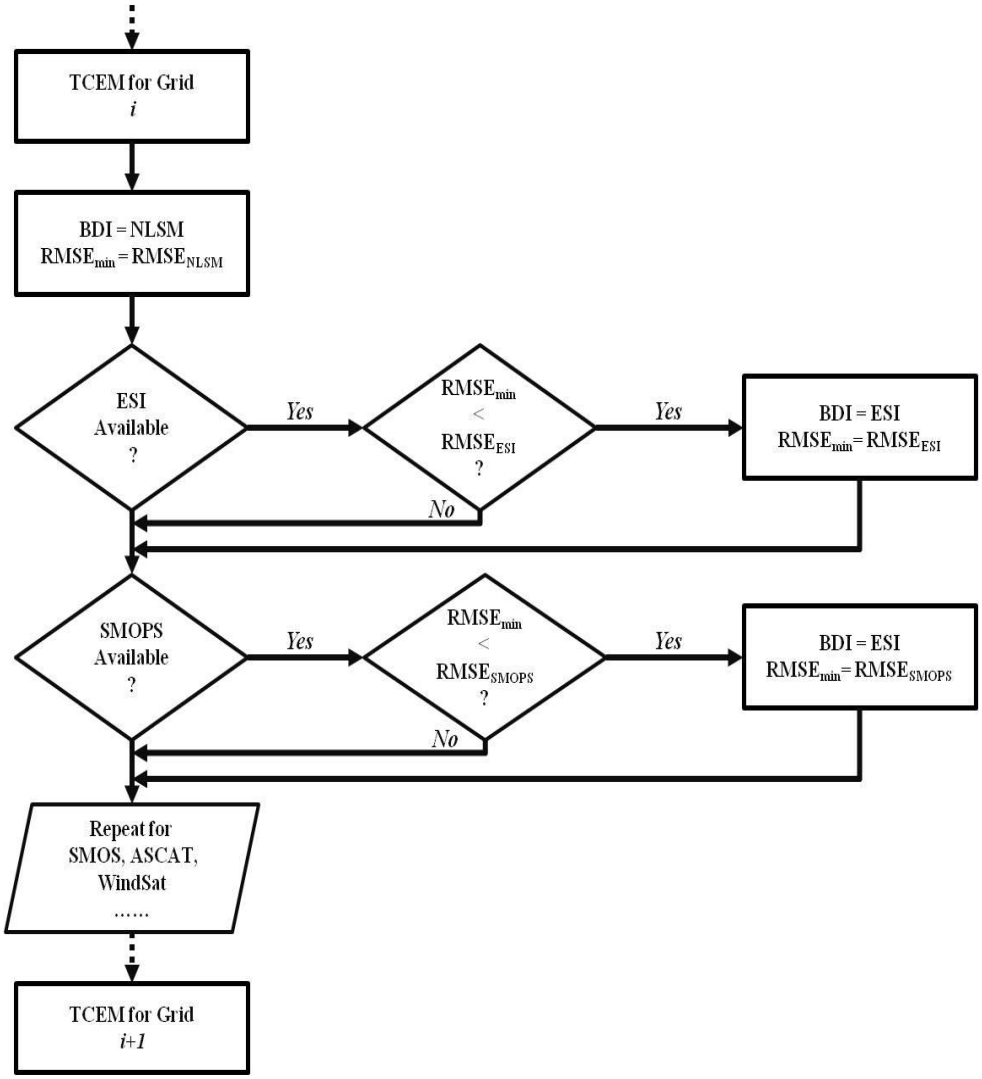
From Weizhong Zheng & Michael Ek

SM DA Impact on NUWRF Forecasts



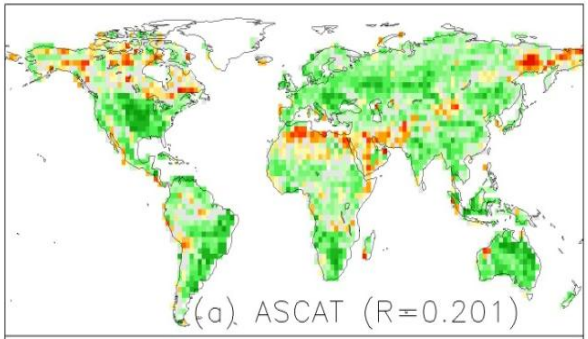
Mean-absolute-error (MAE) of 24 hour accumulated precipitation forecasts of NUWRF model assimilating or without assimilating ESA CCI soil moisture data for the whole CONUS domain from May 10 - May 17, 2012. The bubbles show the forecast hours.

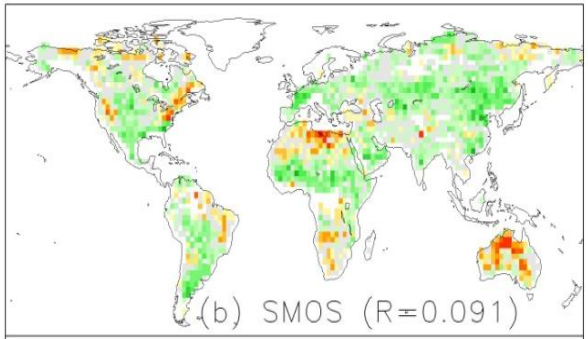
Blending Sat SM for Drought Monitoring

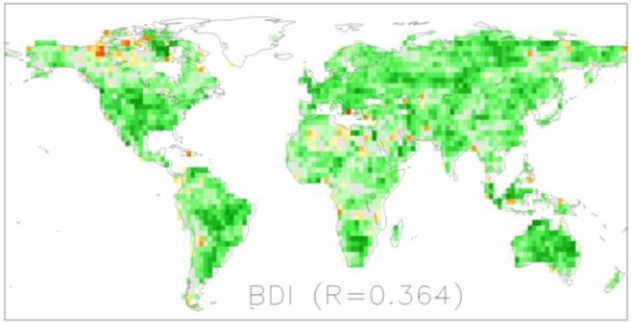


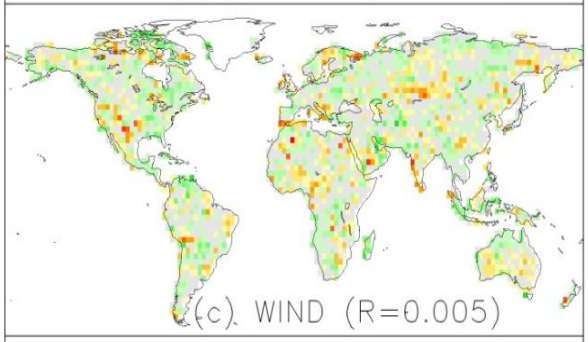
Procedure of constructing the Blended Drought Index (BDI) using the RMSEs estimated from the Triple Collocation Error Model implemented for each grid in each calendar month. RMSEmin is the minimum RMSE for the grid. And $RMSE_{SMOPS}$, $RMSE_{NLSM}$ and $RMSE_{ESI}$ are the monthly RMSE values for soil moisture data sets from SMOPS, NLSM and ESI cases, respectively.

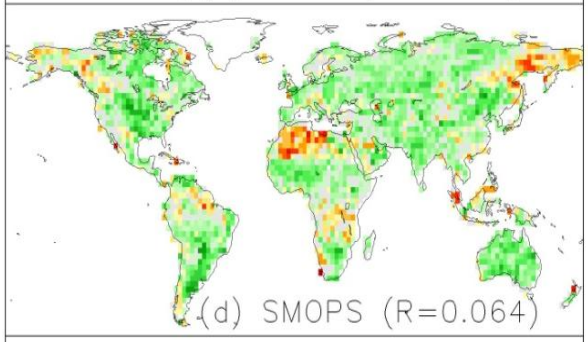
Blending Sat SM for Drought Monitoring

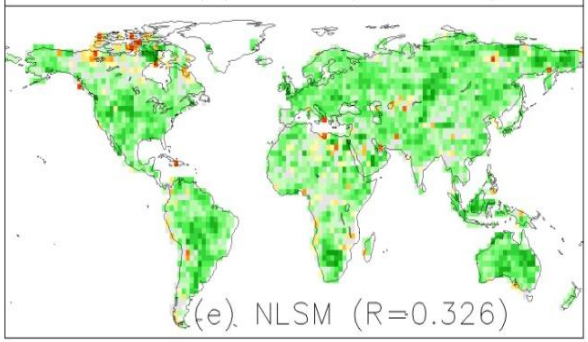


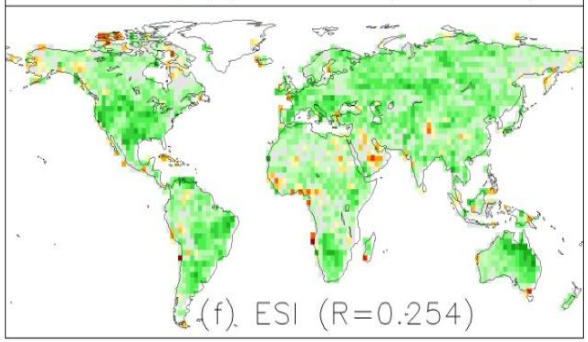


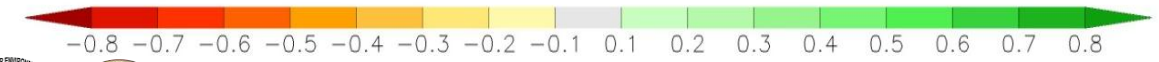












Correlation coefficients (R) between PDSI standard anomalies (against 1985-2014 averages) and drought estimations for (a) ASCAT, (b) SMOS, (c) WindSat, (d) SMOPS, (e) NLSM and (f) ESI cases. Grey color indicates insignificant correlation. The Blended Drought Index (BDI) has better correlation than all other data sources

NOAA 3 Year Plan for SMAP Data Use

NOAA Research Transition Acceleration Program will support the following tasks from FY17:

- Enhance NESDIS operational Soil Moisture Product System (SMOPS) for high resolution and high quality soil moisture data from NASA SMAP with reduced latency for NWS numerical weather prediction (NWP) models and drought monitoring
- Assimilate SMAP soil moisture data by coupling NASA Land Information System (LIS) with NWS NWP models-GFS/CFS.
- Enhance United States and global drought monitoring by assimilating SMAP soil moisture into North America and Global Land Data Assimilation Systems (NLDAS and GLDAS).

SUMMARY

- *NOAA NESDIS Soil Moisture Operational Product System is capable of processing SMAP L1-L4 data products for NWS operational and research uses*
- *Early results of SMAP and other satellite SM data assimilation demonstrated their impacts on NCEP weather forecasts and drought monitors*
- *NOAA is committed to support NOAA SMAP Early Adopters with high priority through its Research Transition Acceleration Program (RTAP) and JCSDA.*