Satellite Soil Moisture Products and Their Application to Drought Monitoring

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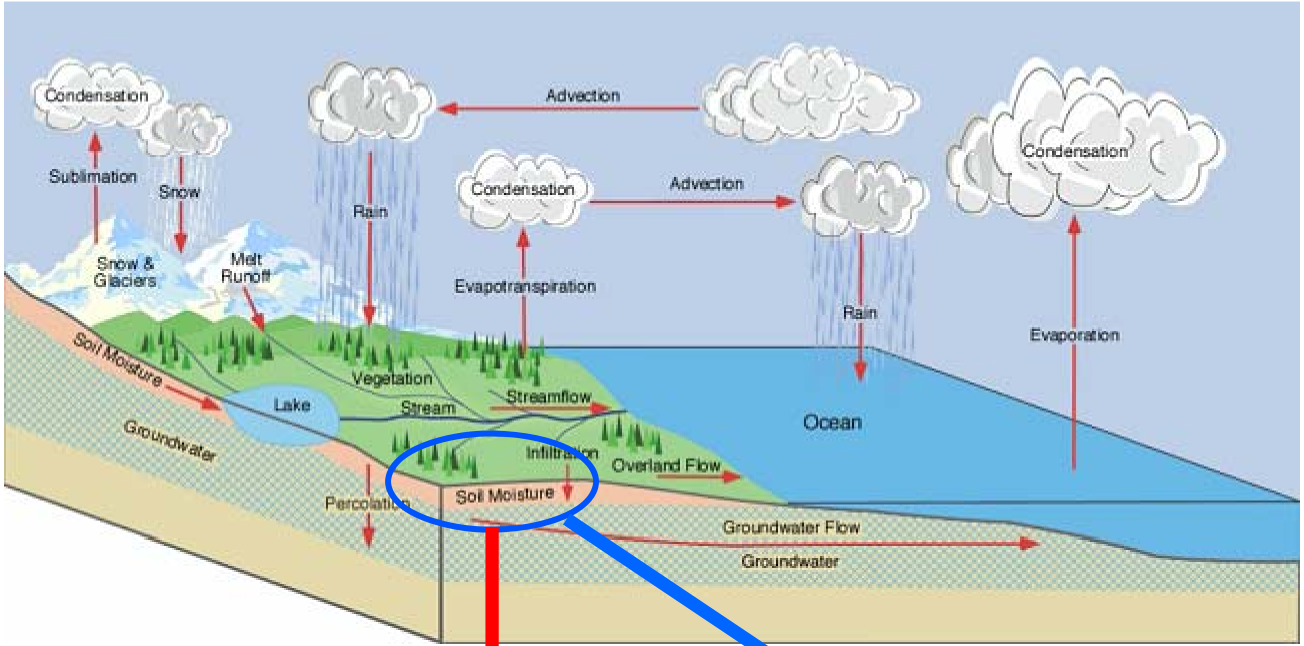
Outline

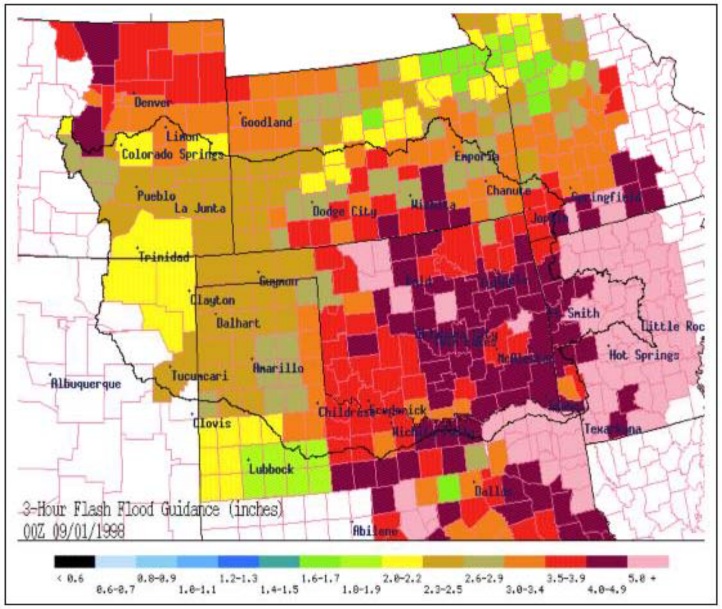
- ***Why Soil Moisture***
- ***SMOPS and Products***
- ***Blended Drought Index***
- ***Summary***

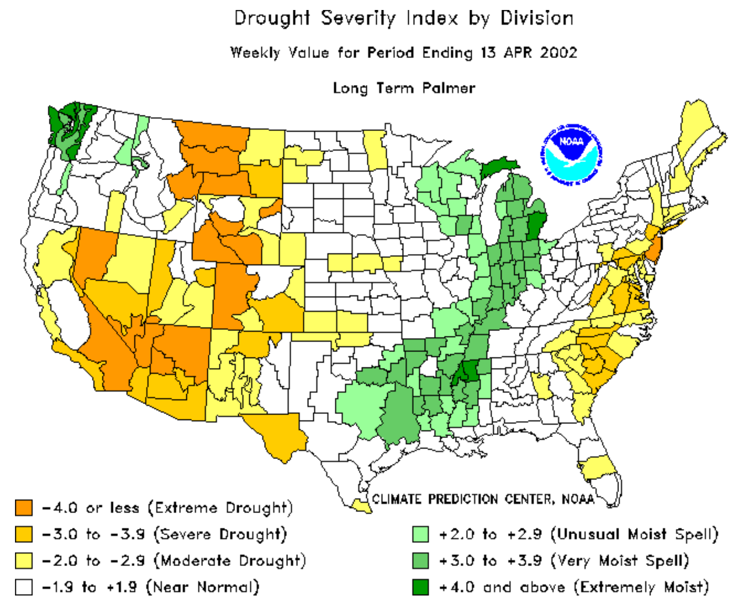


Soil moisture statuses at various soil layers are very important to well understand drought and flood development.

Soil Moisture for Flood & Drought Monitoring

Current NWS Operational 30 km Flash Flood Guidance (FFG) is Based on ***Model Surface Soil Moisture Deficit***

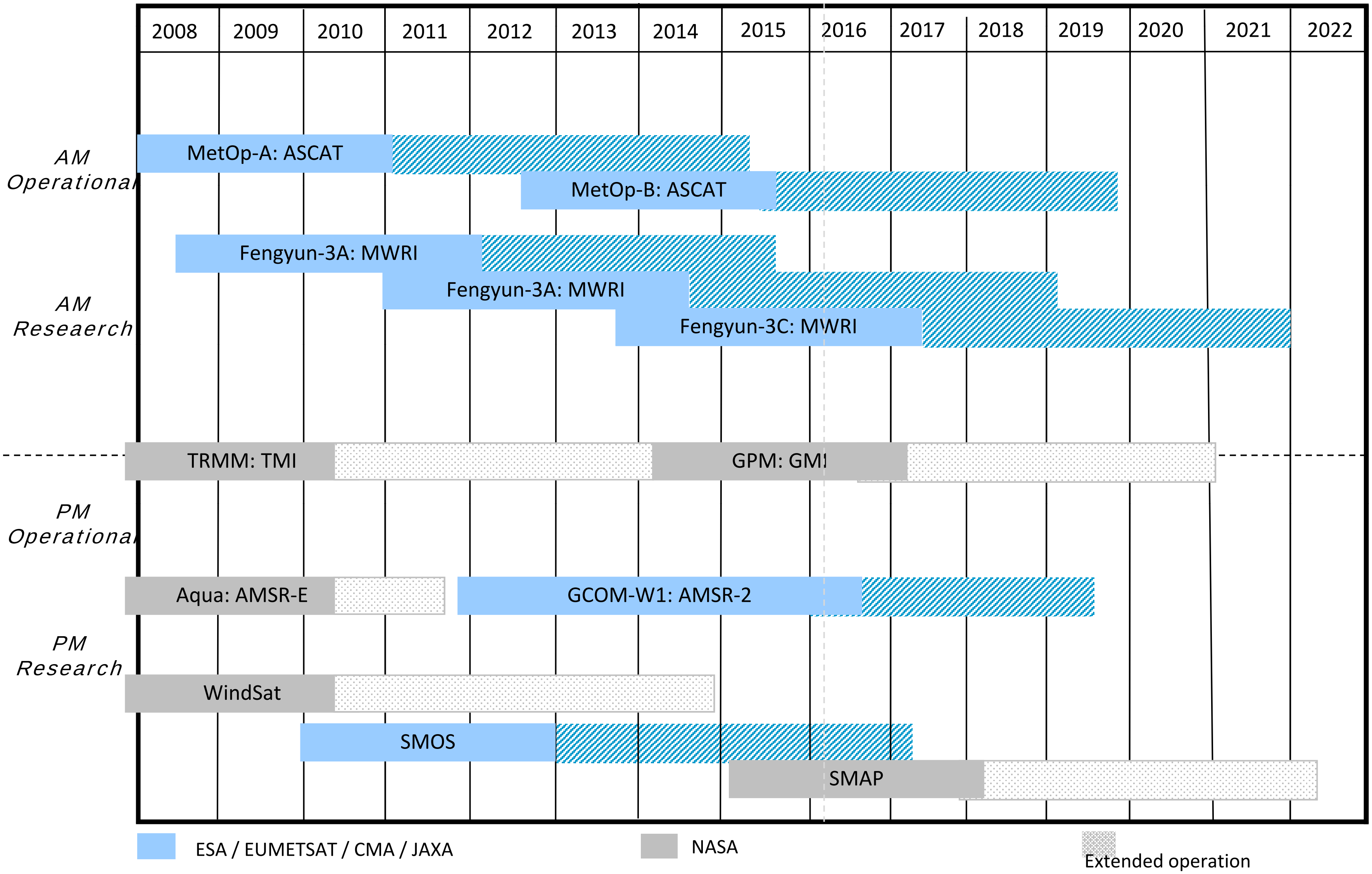




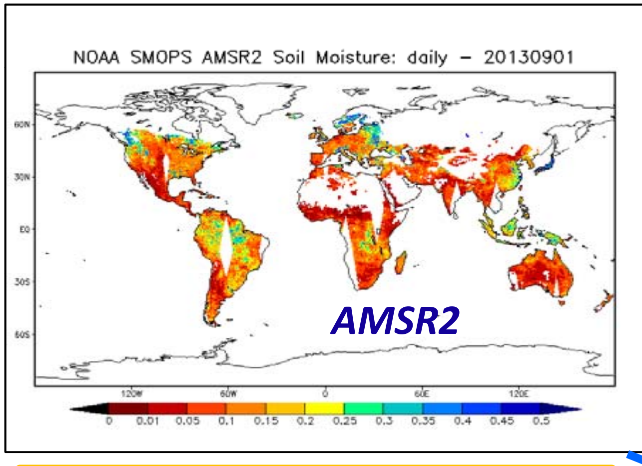
Current NOAA and National Drought Mitigation Center (NDMC) Operational Drought Index is also based on ***Modeled Soil Moisture Data***.

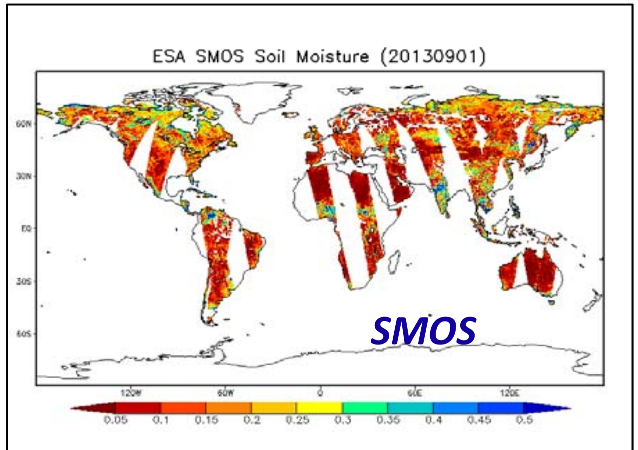
- ***Soil moisture Observational data should replace model or proxy SM***

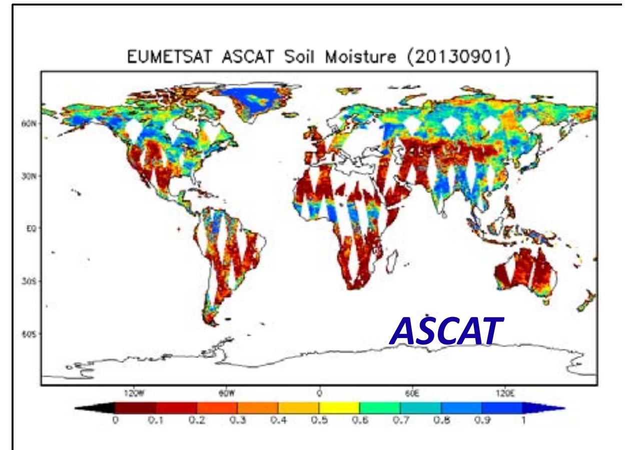
Current and Future Soil Moisture Satellites



Soil Moisture Operational Product System (SMOPS)







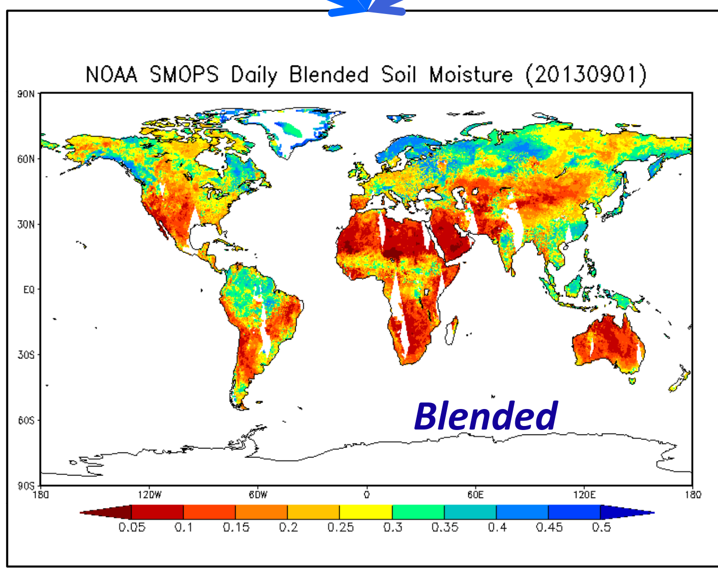
SMOPS2.0 improves the SMOPS product in following ways:

1) A new SMOS SM product is produced using single channel retrieval algorithm to reduce the time latency;

2) Soil moisture product from ASCAT on MetOp-B satellite is ingested in the system;

3) Soil moisture product from the AMSR2 onboard the GCOM-W satellite is ingested in the system;

4) The updated CDF with longer time range is used to produce the blended product.



AFWA
USDA
NASA

NCEP
GFS/NAM

Funding: NESDIS PSDI

Major SMOPS Soil Moisture Products

SMOPS has *3 sets of products:* *6-hourly product, daily product and archive product* to meet different needs.

Product	Description	Format	Projection	Spatial Coverage	Spatial Resolution	Product Latency
SMOPS 6 Hour Product	6 hour Gridded Soil Moisture	GRIB2	Lat/Long	Global	0.25 degrees (720x1440)	3 Hours
SMOPS Daily Product	Daily Gridded Soil Moisture	GRIB2	Lat/Long	Global	0.25 degrees (720x1440)	6 Hours
SMOPS Archive Product	Daily Gridded Soil Moisture	netCDF4	Lat/Long	Global	0.25 degrees (720x1440)	30 Hours

Layers in Each Product: ***Each of above products has following layers of soil moisture*: *Blended Soil Moisture, AMSR2 Soil Moisture, NOAA SMOS Soil Moisture, ESA SMOS Soil Moisture, and ASCAT Soil Moisture, and QA and Time layers* associated with each of these soil moisture products.**

Ingesting SMAP soil moisture product into SMOPS will be a major future work for SMOPS in next step.

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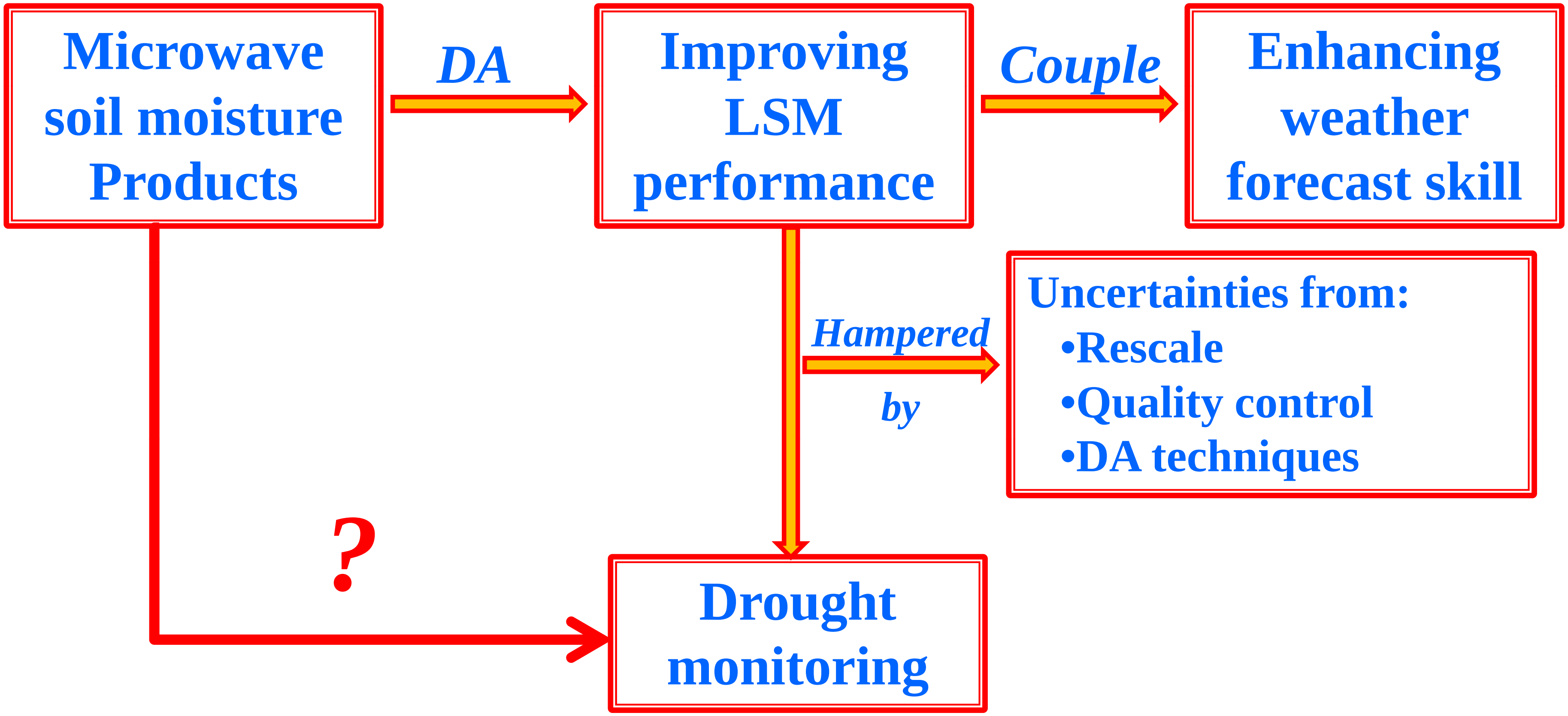
How to Use the Remote Sensing Soil Moisture Products?



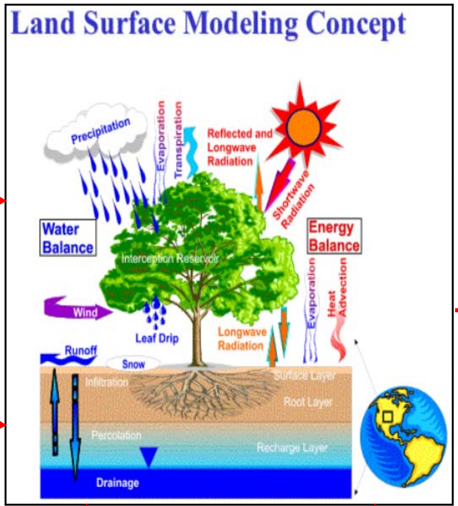
Triple Collocation Error Model (TCEM)

Triple collocation error model (TCEM) is based on three separate time series assumed to approximate grid-scale SM products with the same physical quantity.

Noah3.2 LSM implemented in LIS 6.2

GDAS: downward SW/LW radiation, near-surface t_{air} / RH/wind and surface P

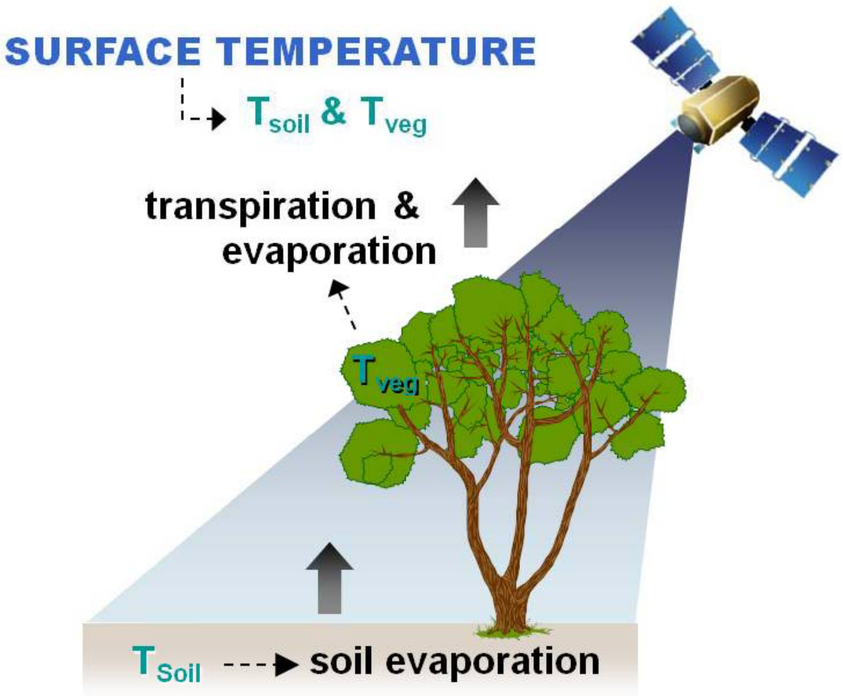
GLDAS: Precip



Daily Root-zone SM (NLSM)

2007-10 MODIS C5 land cover map

8-day MODIS LAI-based GVF



ALEXI model-based ESI

TCEM-based Root Mean Square Error (RMSE)

Three separate drought detection sources:

***Microwave remote sensing SM (MRS)**:* which suffer from the instrument noise and uncertainty in microwave emission modeling.

Evaporative stress index (ESI): using land surface temperature (LST) data retrieved from satellite thermal infrared imagery, requires no information about antecedent precipitation or subsurface soil characteristics;

Noah model SM (NLSM): which typically includes water and energy balance formulations based on time-varying meteorological and radiation forcing;

Based on ***the standardized anomalies*** (ψ) for MRS (including SMOS, SMOPS, ASCAT and WindSat) , ESI and NLSM are then expressed as:

$$\psi_{MRS} = \Pi + \mu$$
$$\psi_{ESI} = \Pi + \omega$$
$$\psi_{NLSM} = \Pi + \rho$$

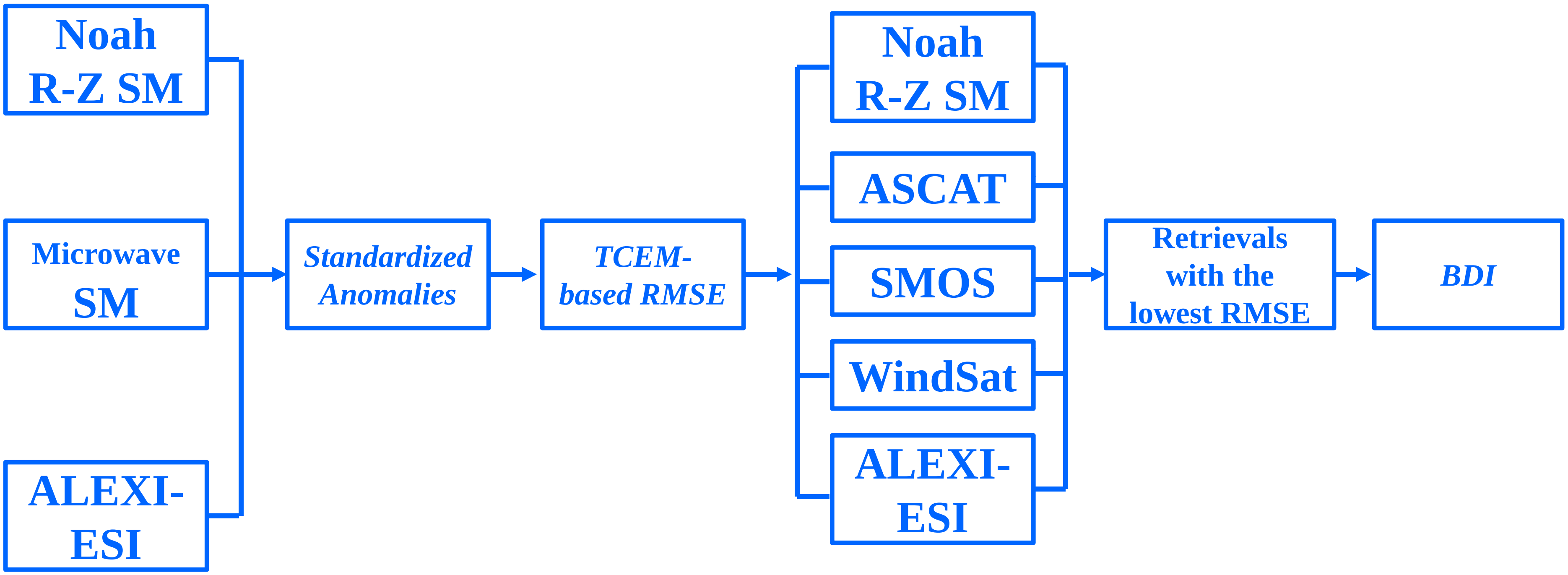
First we assume:

$$\mu\rho = 0, \quad \mu\omega = 0, \quad \rho\omega = 0$$

Then the ***RMSE values for MRS , ESI and NLSM*** are given by

$$\xi_{RSM} = (\psi_{MRS} - \psi_{ESI})(\psi_{MRS} - \psi_{NLSM}) = \mu^2$$
$$\xi_{NLSM} = (\psi_{NLSM} - \psi_{ESI})(\psi_{NLSM} - \psi_{MRS}) = \omega^2$$
$$\xi_{ESI} = (\psi_{ESI} - \psi_{NLSM})(\psi_{ESI} - \psi_{MRS}) = \rho^2$$

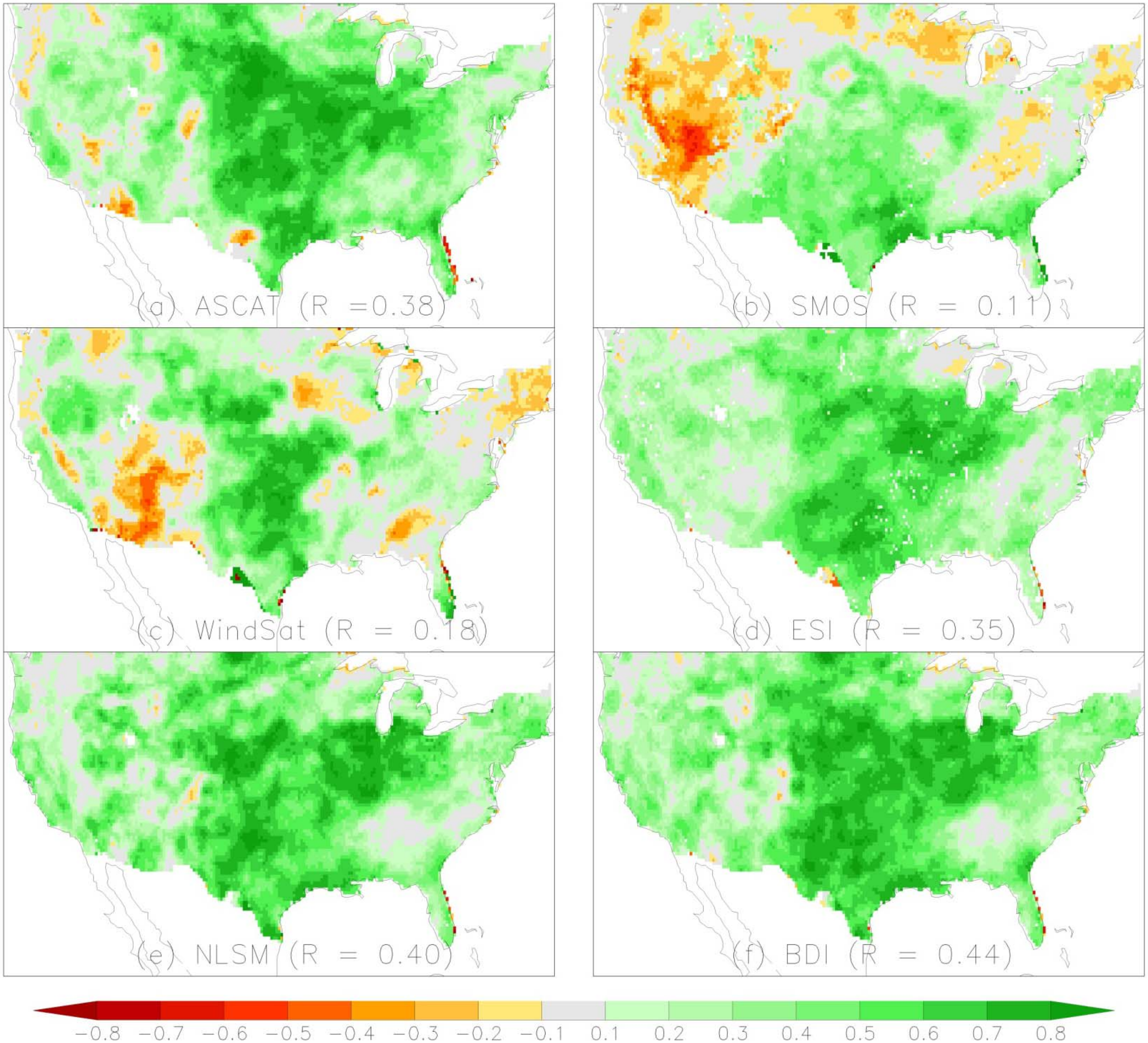
Blended Drought Index (BDI)



Schematic for the production of the Blended Drought Index.

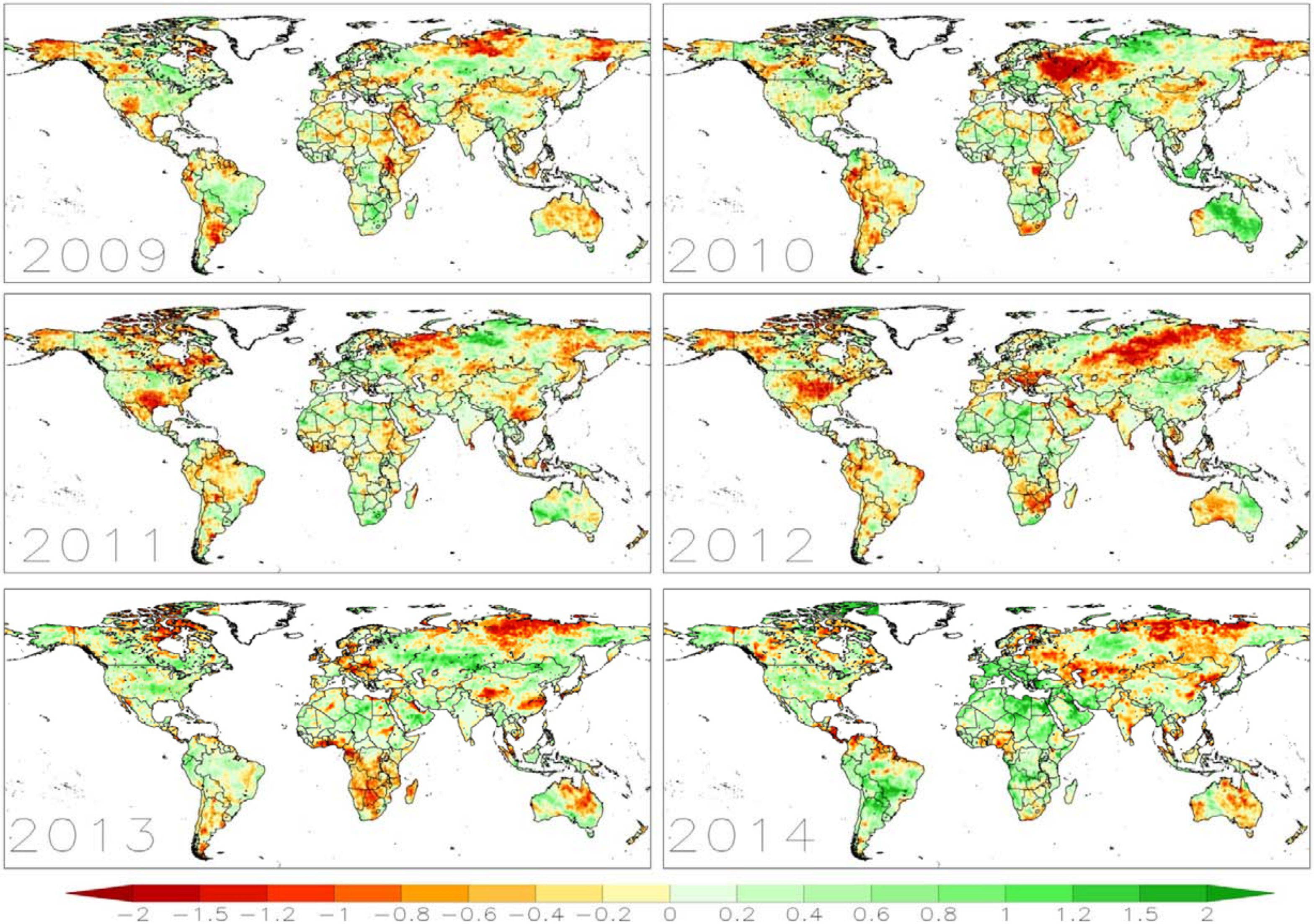
BDI: each pixel will be filled by the retrievals that are proven to be more accurate than others, which can ensure all of the grids across global domain can be covered by the optimal drought estimation information.

Validation with USDM



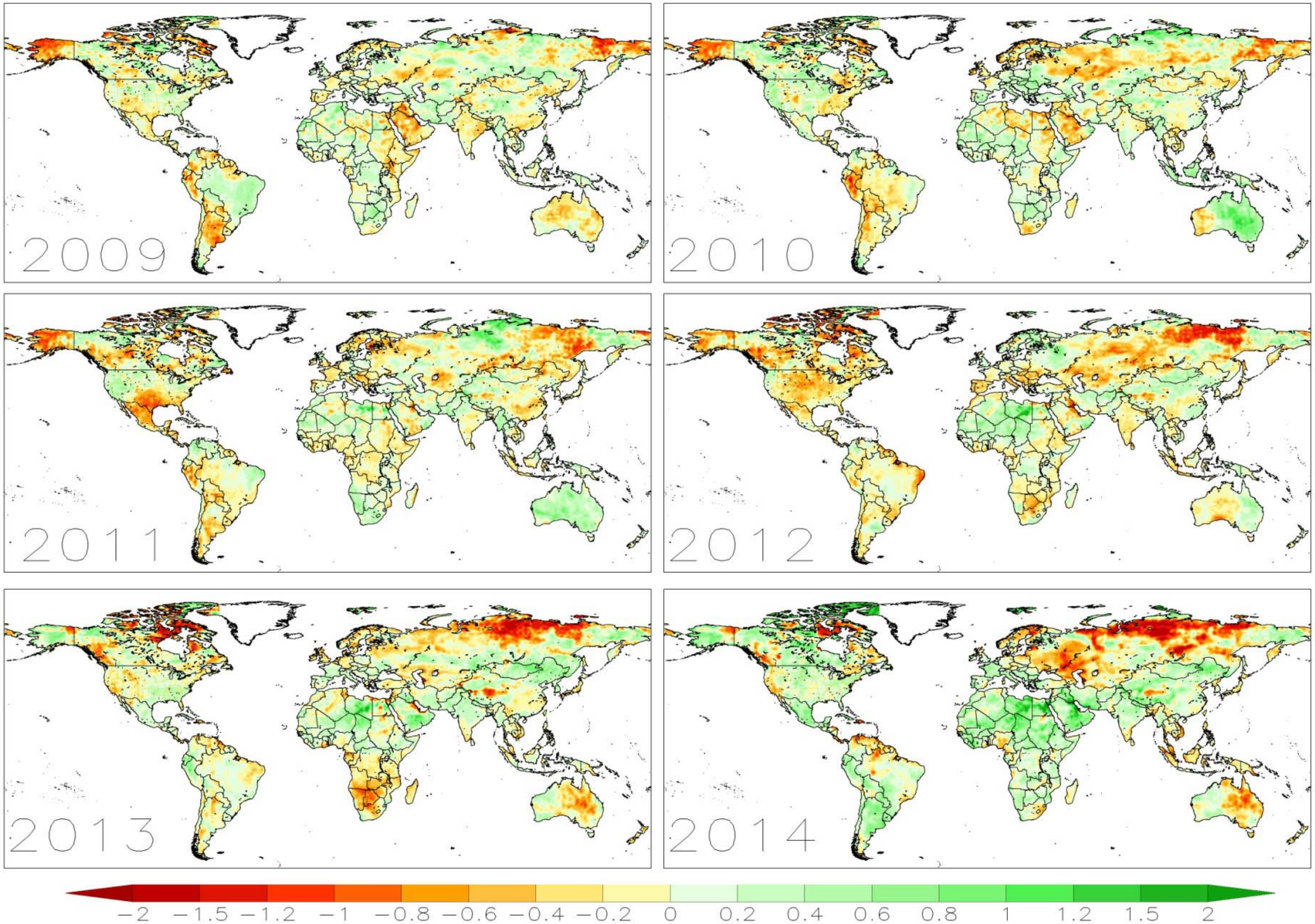
Correlation coefficients (R) ***between USDM and (a) ASCAT, (b) SMOS, (c) WindSat, (d) ESI, (e) NLSM and (f) BDI*****. The grey color indicates insignificantly.**

Monthly BDI Patterns for August



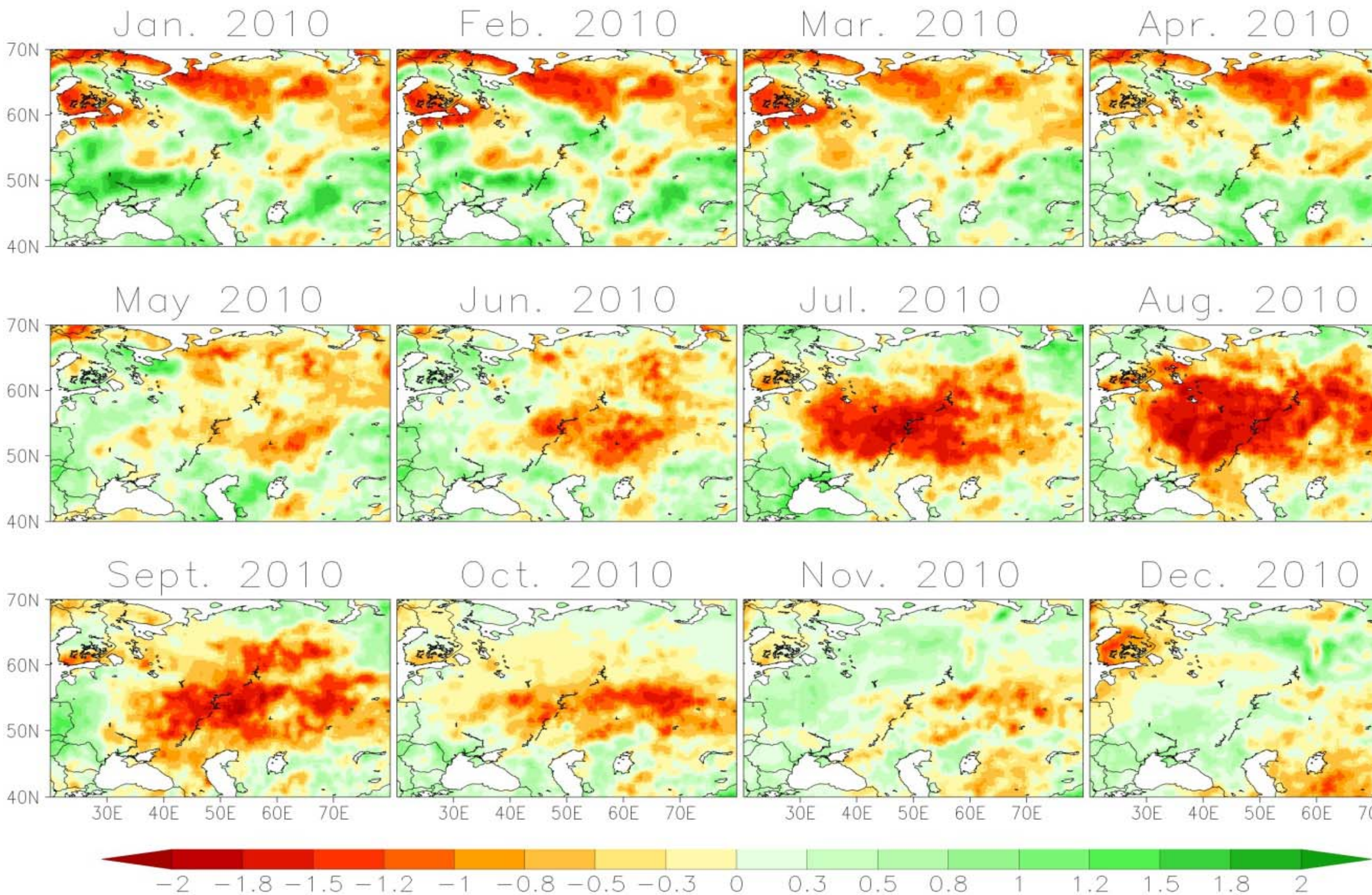
Global terrestrial BDI patterns for August during the period from 2009 to 2014. **The BDI ranges from negative (red) to positive (green) values indicate for dry to wet conditions.**

Annual BDI Patterns



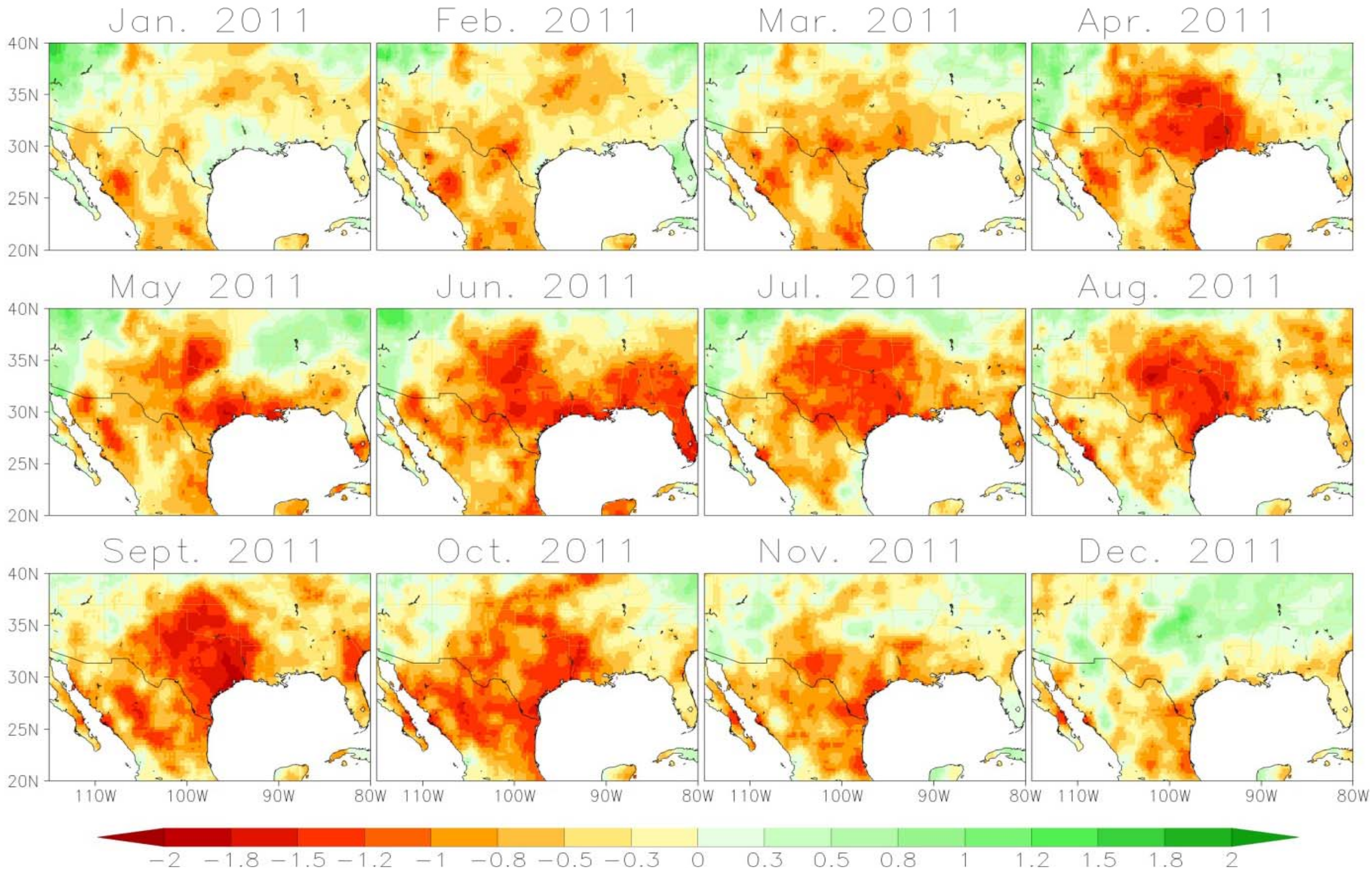
Annual global terrestrial BDI patterns over 2009-2014 period. **The BDI ranges from negative (red) to positive (green) values indicate for dry to wet conditions.**

Monthly Drought Maps for 2010 Russia Drought



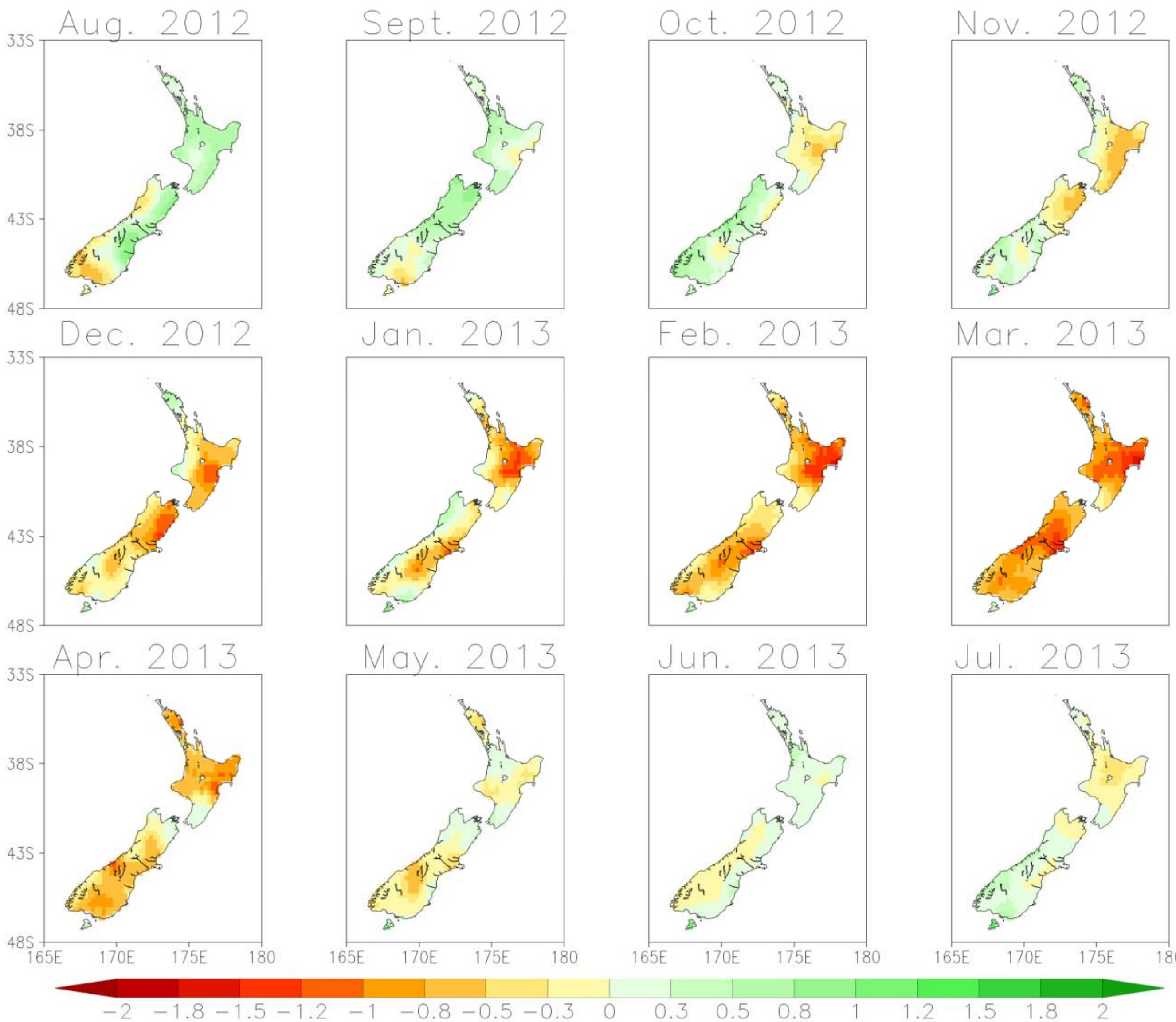
BDI-based monthly drought monitoring ***on the sub-region (from 40ºN, 20ºE to 70ºN, 80ºE) domain in 2010.***

Monthly Drought Maps for 2011 USA Drought



BDI-based monthly drought monitoring ***on the sub-region (from 25ºN, -115ºW to 40ºN, -90ºW) domain in 2011*****.**

Monthly Drought Maps for 2013 New Zealand Drought



BDI-based monthly drought monitoring ***across New Zealand (from 48ºS, 165ºE to -33ºS, 180ºE) domain in 2013.***

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Summary

1. ***NOAA SMOPS Version 2.0*** **can provide** ***6-hourly and daily*** **gridded soil moisture products** ***from individual satellite sensors (SMOS, ASCAT-B and AMSR2)*** **and a** ***blended product that has much better spatial and temporal coverage*****; and the available SMAP SM data will be ingested into SMOPS.**

2. ***The BDI can perform well*** **in comparison with its compositions (such as ASCAT, ESI, NLSM and the like), and can** ***reasonably track the time evolution of drought patterns*** **reported in past few years.**

3. ***The advantages of BDI include:***

   •It is ***a sustainable developed indicator*** **with merging more available agricultural drought evaluations (such as** ***the upcoming SM products*****);**

   •The BDI can highlight timely drought monitoring;

   •The BDI can characterize ***the high spatial resolution monitoring*** **at regional- and global- scales;**

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Thanks for your attention !