Land Surface Datasets Used in NCEP Modeling Systems: *Current Status and Future Plans*

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College Park, MD, USA

...and a large number of collaborators!

Land-Surface Datasets Currently Used

Land surface data:

Vegetation type:	**IGBP-MODIS 1 km**
Soil type:	**STATSGO-FAO type 1 km**
Green vegetation fraction (GVF):	NESDIS AVHRR**, 5-yrs monthly 1/8 deg**
Leaf area index (LAI):	**Constant (3 or 4)**
Albedo:	**BU-MODIS/UAz-MODIS, monthly, 1km**
Emissivity:	**Climatology**
Phenology:	**Look-up table**

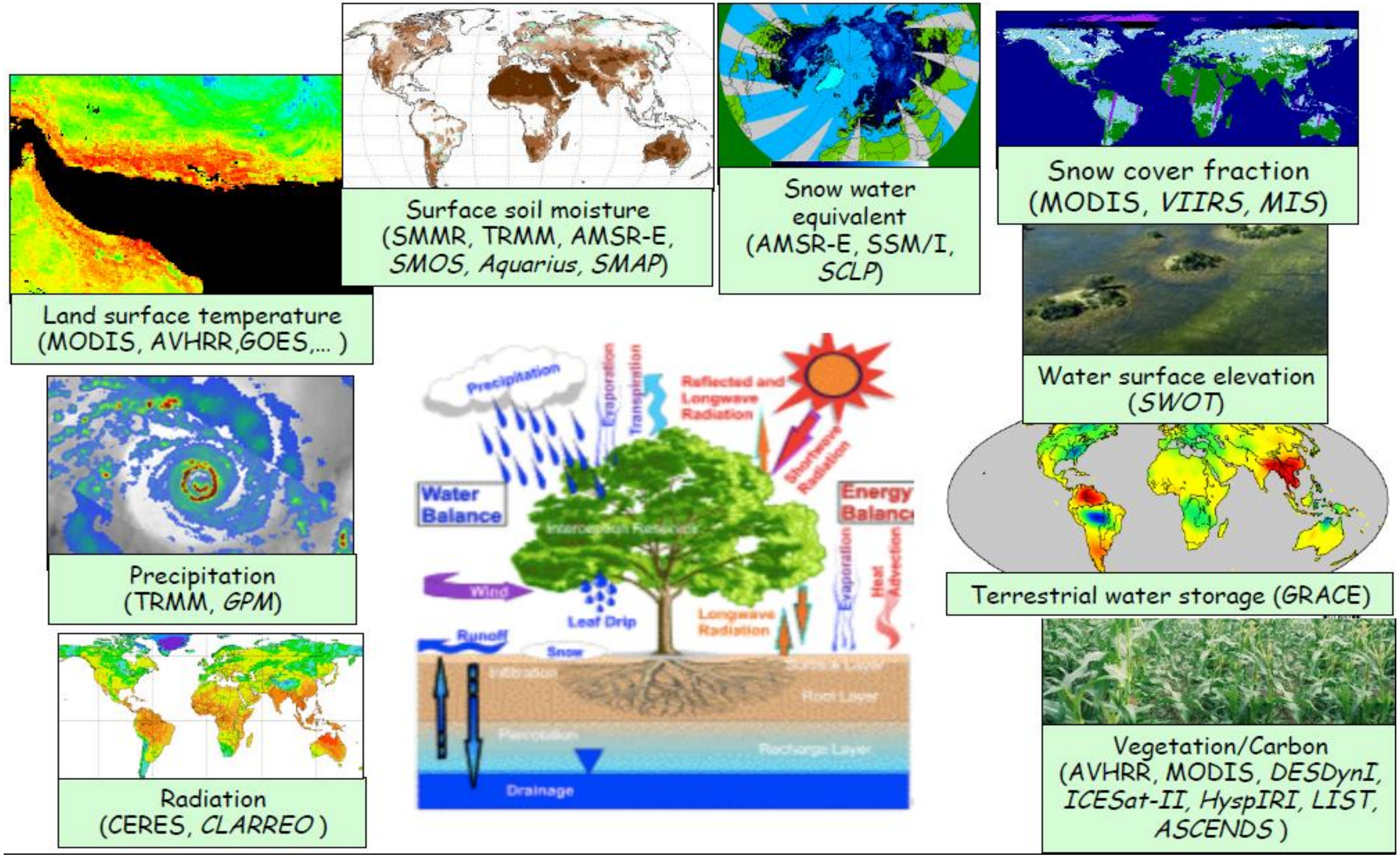
Land data assimilation:

Snow depth:	**AFWA SNODEP; ~23km**
Snow cover:	**NESDIS-IMS;**
Soil moisture:	**SMOPS; top 1-5cm, 0.25 x 0.25 deg grids**
GVF/LAI:	

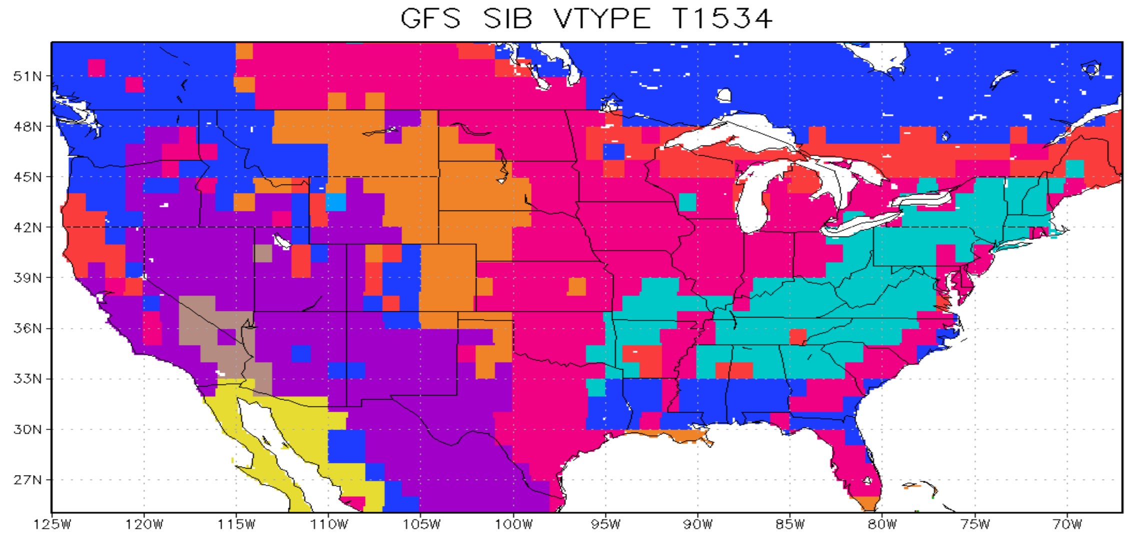
Land data evaluation:

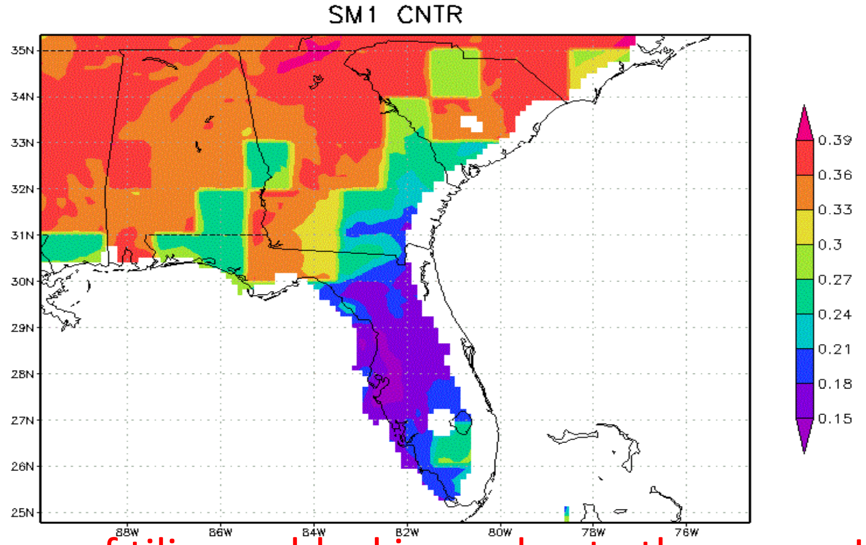
Surface radiation flux:	**SURFRAD radiation/ARMCART/** NESDIS GSIP
Sensible heat flux:	**Ameriflux/FLuxnet/ARMCART**
Latent heat flux (evaporation):	**Ameriflux/FLuxnet/ARMCART**
Soil moisture (station obs):	**NASMD (NA) & ISMN (global)**
Soil temperature (station obs):	**Oklohama/USCRN/SCAN/U.S. cooperative stations**
Surface skin temperature:	**GOES, GOES-R**

Terrestrial Hydrometeorological Observations

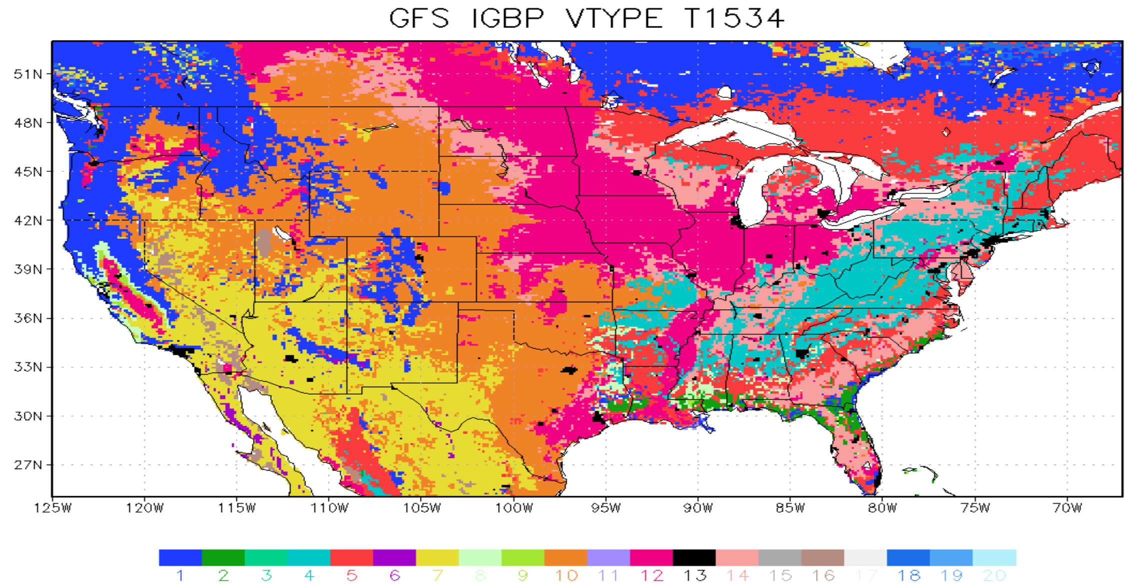


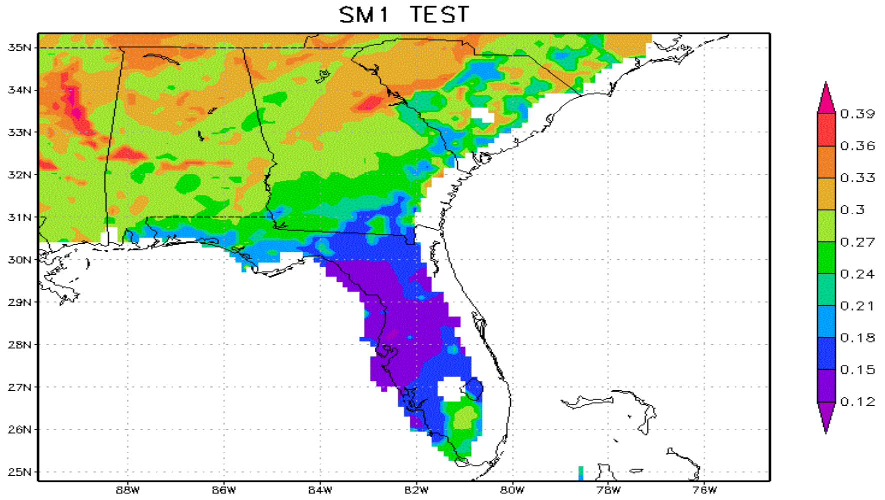
Impacts of Land Data on Forecasts





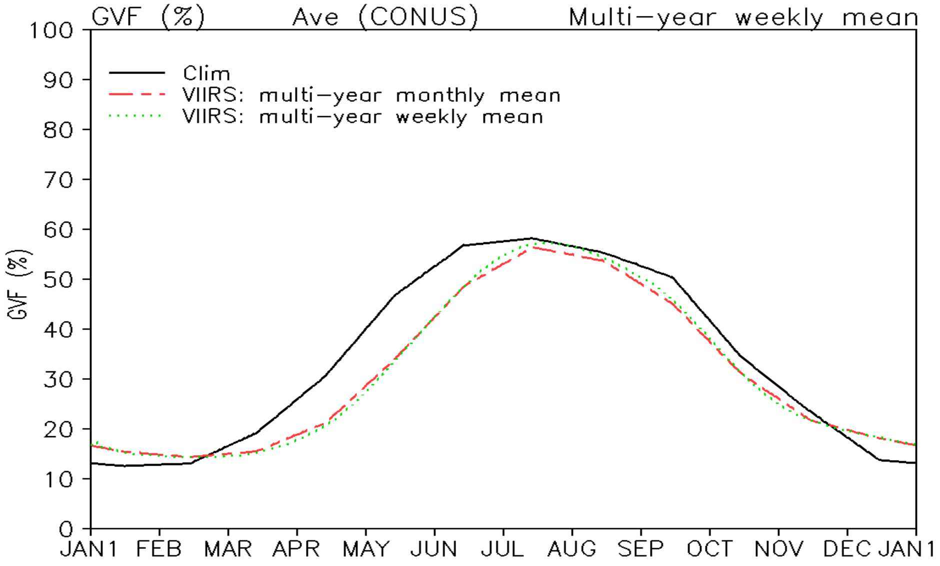
The issue of tiling or blockiness due to the coarse LSC data was solved   first soil layer moisture 18h fcst 2015122200





Collaborations between NESDIS/STAR and NCEP/EMC

Multi-year mean VIIRS GVF over CONUS

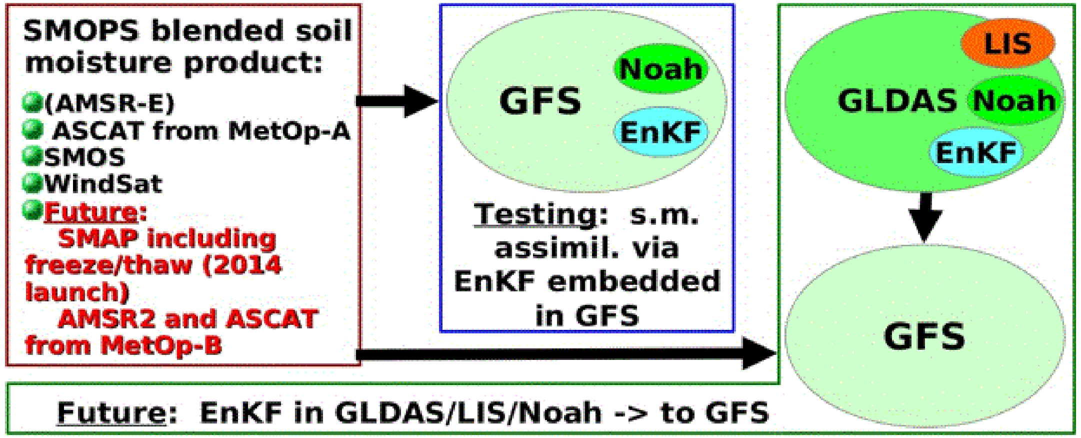


VIIRS GVF was tested in both GFS and NAM

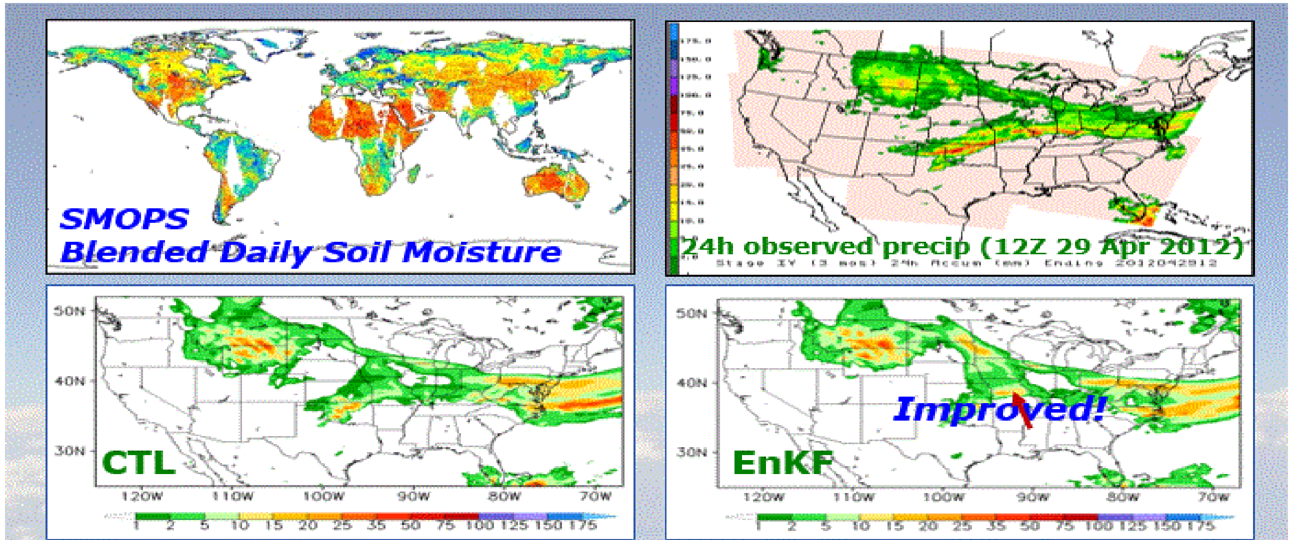
- Better AC score @500 hPa
- Better light precipitation
- Increase warm bias and RMSE
- Reduce wet bias and RMSE over ast CONUS
- Increase wet bias and RMSE over West CONUS

Soil Moisture Data Assimilation

Schematic representation of assimilating satellite soil moisture products from NESDIS/SMPOS into NCEP Global Forecast System (GFS)

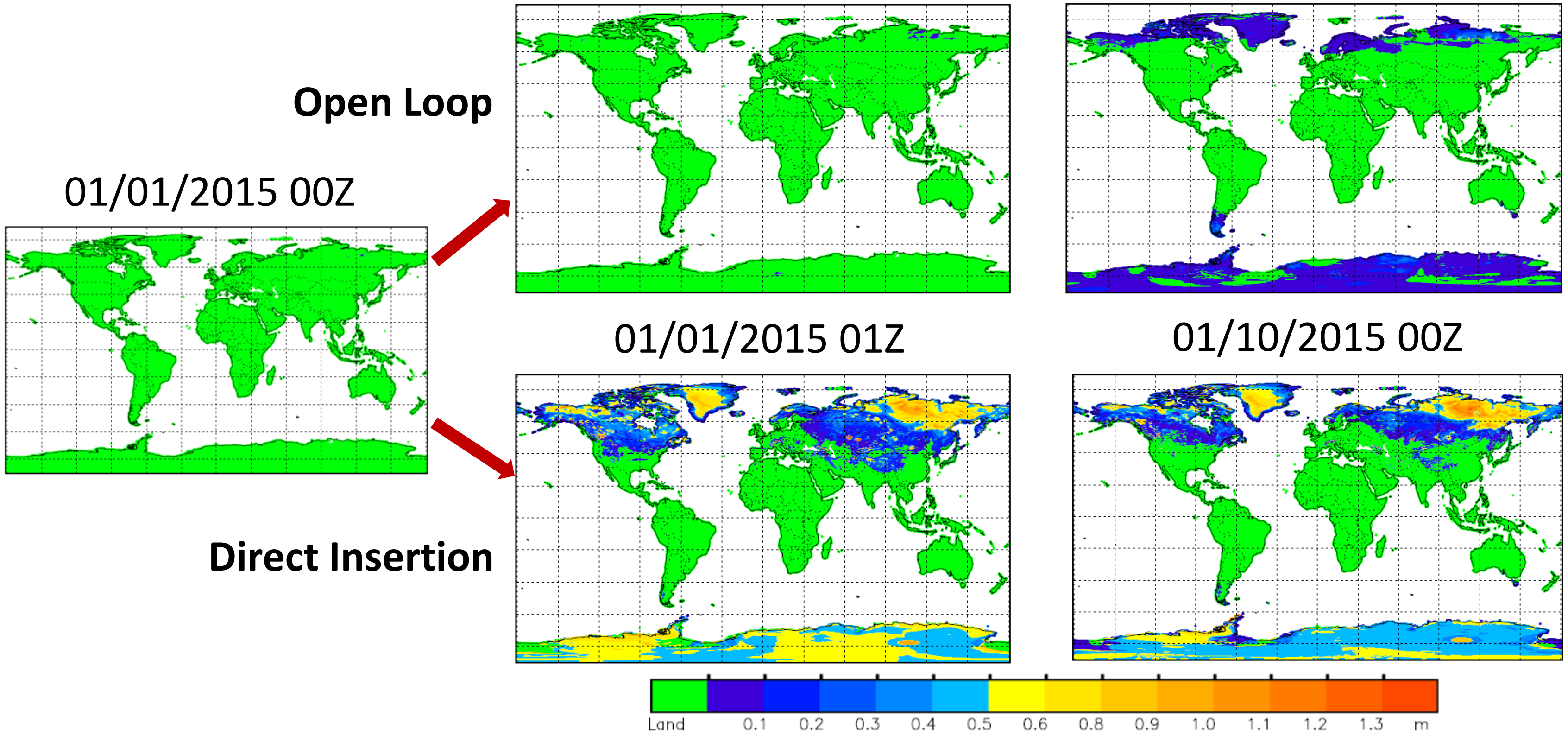


Global Land Data Assimilation System (GLDAS), NASA Land Information System (LIS), Noah land-surface model



Forecast hour 60-84, precipitation forecast 24h accum (mm) ending at 12Z 29 Apr 2012

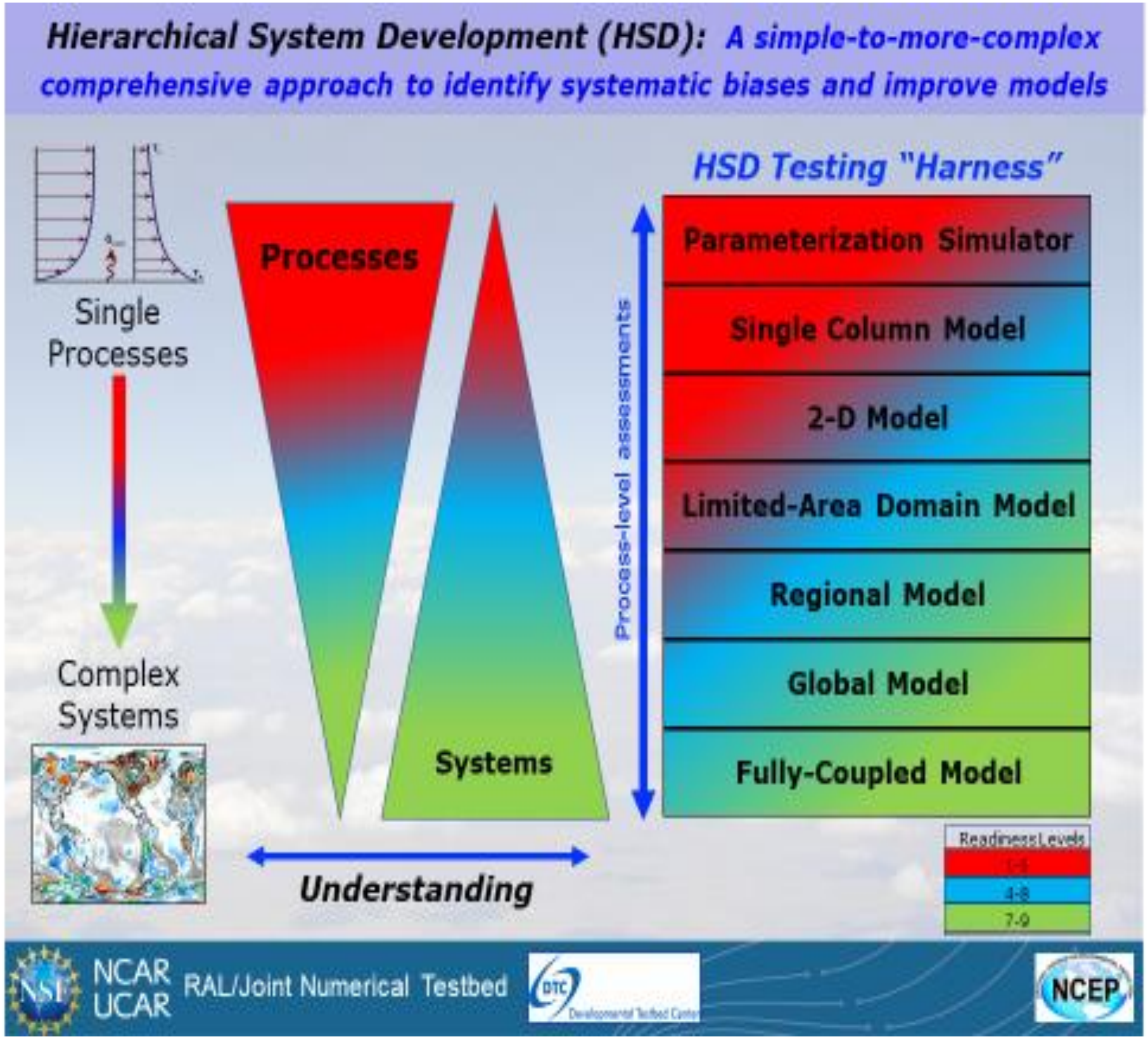
Demonstration of LIS land data assimilation of AFWA Snow Depth



EnKF

We are working on using LIS EnKF to assimilate AFWA snow depth.
The successful EnKF applications require accurate error estimates both from satellite observations and from the land model.

Procedure to Implement the New Data into the UFS



Metrics for Evaluating the Impact on Forecasts

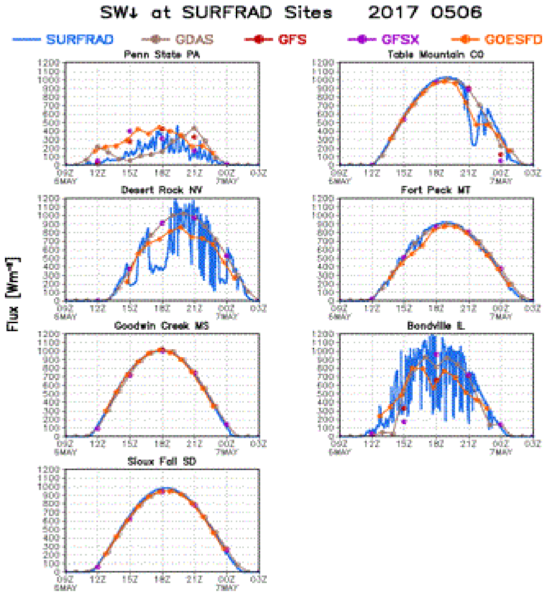
- Anomaly correlations, biases, RMSE (u,v,T,P,SLP,q,cloud)
- Hurricane track and intensity errors
- Biases and RMSE (surface fields: skin T, 2-m T and Td, 10-m wind, soil moisture, snow, precipitation, surface fluxes)

NESDIS GSIP for GFS/NAM
Surface Shortwave Flux Verification

The NESDIS Geostationary Surface and Insolation Product (GSIP) of surface shortwave flux is used for the EMC model verification.

Model predicted diurnal cycles of surface shortwave fluxes at seven sites across US are compared with GSIP and surface observations on daily basis.

Istvan Laszlo (NESDIS)
Jesse Meng (EMC)



Some issues of Satellite Land Products

- **Remote sensing in the thermal infrared is limited to clear sky conditions**
- **Snow contamination**
- **Coarse resolution (such as soil moisture)**
- **Errors from satellite images and uncertainties in the algorithms used to retrieve the data**
  - **Validation and uncertainty assessment:** lack of documentation of satellite validation strategies and methods across the different communities
  - **Representativeness**
  - **Temporal stability**
  - **Uncetainty:** random, systematic
- **latency**

Y **Land Development**
Status as of 12/17/2019

Project Information & Highlights

FOM: Jack Kain; **backup**: Vijay Tallapragada

Lead: Helin Wei

Scope: Improve land surface physics and upgrade land surface model.

Expected benefits: Improve land surface prediction for all NCEP operational systems.

Sub-projects: redmine Summary

Targeted Ops system: GLDAS, FV3GFS

Dependencies: NASA LIS, NESDIS satellite retrieval land dataset.

G Schedule

Milestones & Deliverables	Date	Status
Further optimize Noah MP options with other physics	Q4FY20	In progress
Integrate and test fresh lake model Flake in FV3GFS	Q4FY20	In progress
Unify veg/soil table among all NCEP operational systems	Q2FY20	In progress
Turning land surface physics with other physics	Q4FY20	In progress
Update Land Surface Characteristic datasets	Q1FY20	In progress
Compare different LSMS(Noah LSM, RUC, LM4) in FV3GFS	Q4FY21	Planned

Y Issues/Risks

Issue: limitation of the improvement by the other physics components;
Resolution: close cooperation with the other projects and physics groups
Issue: different versions of Noah MP in NASA LIS, WRF, and NWM;
Resolution: create a repository for standalone Noah MP
Issue: proper cold-start FV3GFS/Noah MP; **Resolution**: sufficient offline spinup using LIS/GLDAS
Issue: Noah-MP performance in GFSv16 prototype not optimized
Resolution: postpone and further optimize Noah MP options with other physics

Y Resources

Staff: 0.1 Fed FTEs + 3.5 contractor FTEs, **need additional 1 Fed FTE for Land Dev**

Funding Source: STI & CPO

Compute: WCOSS (dev and prod), RDHPS (Gaea)

Archive: Varies; TBD

R Management Attention Required	Y Potential Management Attention Needed	G On Target

Updating land surface datasets is in our plan for GFS V17. We have done many works with NESDIS to test the impact of new data on the model before. We just need to resurrect this effort and make sure the high quality data can be implemented into the UFS.

Vegetation Health Applications in USDA

Harlan D. Shannon
Meteorologist
USDA Office of the Chief Economist
World Agricultural Outlook Board

Presented at:

2020 JPSS/GOES Proving Ground/Risk Reduction (PGRR) Summit

College Park, MD

February 25, 2020

World Agricultural Outlook Board

World Agricultural Outlook Board

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ISSN: 1554-9089

World Agricultural Supply and Demand Estimates

United States Department of Agriculture

Office of the Chief Economist	Agricultural Marketing Service Farm Service Agency	Economic Research Service Foreign Agricultural Service

WASDE - 480 Approved by the World Agricultural Outlook Board March 10, 2010

WHEAT: U.S. wheat ending stocks for 2009/10 are projected 20 million bushels higher as a reduction in expected food use pushes ending stocks to 1 billion bushels. Projected food use is lowered 20 million bushels based on the latest mill grind data from the U.S. Bureau of Census. High flour extraction rates for a second straight year are reducing the amount of grain needed to produce flour. At the same time, declining per capita consumption is reducing demand for flour and wheat. Exports of all wheat are unchanged, but hard red winter wheat exports are raised 10 million bushels with an offsetting reduction for white wheat. By-class adjustments reflect the pace of export sales and shipments to date. The projected marketing-year average farm price is raised 5 cents on both ends of the range to $4.80 to $5.00 per bushel as prices received by producers remain stronger than expected.

Global wheat supplies for 2009/10 are projected 2.1 million tons higher mostly reflecting higher beginning stocks in Russia and higher production in Argentina. Beginning stocks are raised 2.1 million tons for Russia with historical revisions to estimated feed use. Partly offsetting are small reductions in 2009/10 beginning stocks for a number of other countries reflecting minor revisions to 2008/09 supplies and usage. Argentina production for 2009/10 is raised 0.6 million tons on higher reported area. Partly offsetting is a 0.3-million-ton reduction in Saudi Arabia production based on lower reported area and yields. A number of other smaller changes leave global production up 0.6 million tons this month.

Global wheat imports and exports for 2009/10 are both raised this month. Imports are raised 0.4 million tons for Bangladesh and 0.3 million tons for South Korea with smaller increases for a number of other countries. Partly offsetting are small reductions in imports for Israel, Mexico, Tunisia, and Colombia. Exports are raised 0.5 million tons for Argentina and 0.2 million tons each for Brazil, India, and Serbia. Most of the trade adjustments this month reflect the pace of reported shipments to date. Global 2009/10 wheat consumption is raised 1.2 million tons with a 1.0-million-ton increase in China wheat feeding and a 0.8-million-ton increase in India food use. The reduction in U.S. food use is partly offsetting. Global ending stocks are projected 0.9 million tons higher with larger stocks in Russia and the United States only partly offset by reductions elsewhere. At 196.8 million tons, 2009/10 world stocks are up 73.5 million tons or 60 percent from the recent low in 2007/08.

COARSE GRAINS: U.S. feed grain supplies for 2009/10 are projected slightly lower with a downward revision in estimated corn production and a reduction in projected barley imports. Corn production is lowered 20 million bushels based on updated estimates of yields for Illinois and Minnesota, and harvested area for Michigan. U.S. corn production remains a record at the revised estimate of 13.1 billion bushels. U.S. corn exports are lowered 100 million bushels as larger foreign supplies increase competition. U.S. corn ending stocks for 2009/10 are projected 80 million bushels higher with the downward revision in production more than offset by reduced export prospects.

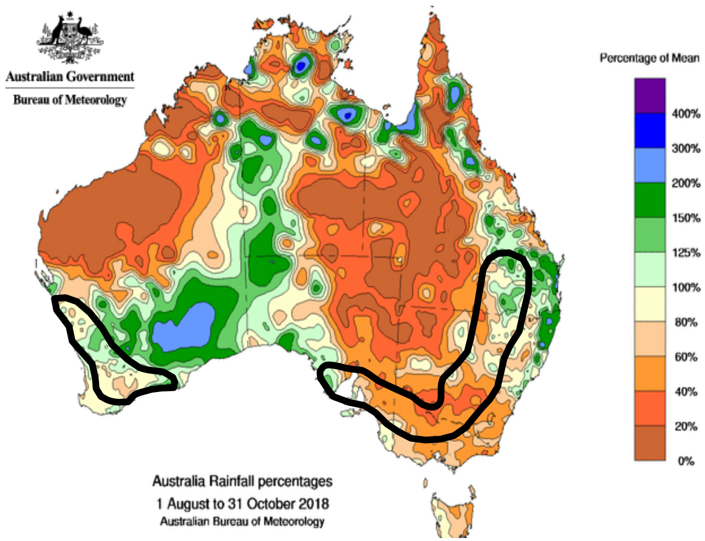
The projected 2009/10 marketing-year average farm price for corn is lowered 20 cents on the top end of the range to $3.45 to $3.75 per bushel. Projected farm prices are also lowered for

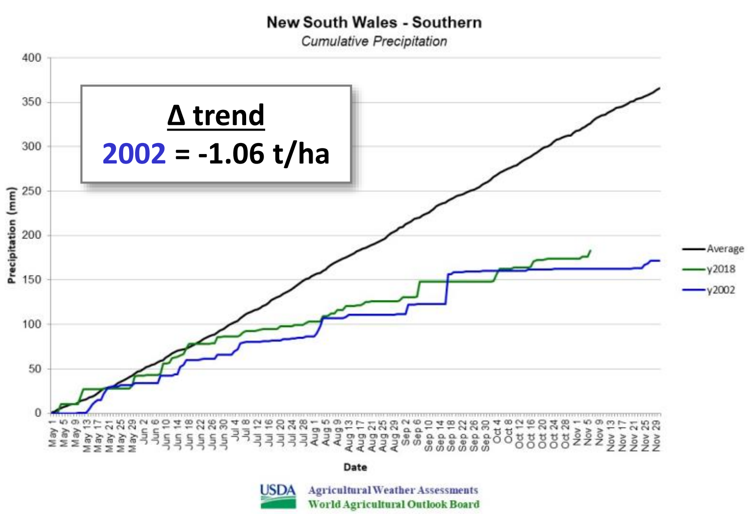
- In 1972, a severe drought led to massive crop failure in the former Soviet Union
- Some USDA officials noted an increase in Soviet grain purchasing activity, but there was limited information sharing within USDA
- As a result, the former Soviet Union was able to orchestrate a large purchase of U.S. grain at below-market prices
- This incident, known as "*The Great Grain Robbery*", significantly reduced U.S. stocks and dramatically increased consumer prices
- In 1977, the WAOB was established to coordinate official government forecasts of agricultural commodities ***monthly***

WASDE contributors include:

- Agricultural Marketing Service - information on existing prices
- Economic Research Service - market impacts on supply/demand fundamentals
- Farm Service Agency - policy impacts on producer behavior
- Foreign Agricultural Service - commodity conditions in international areas

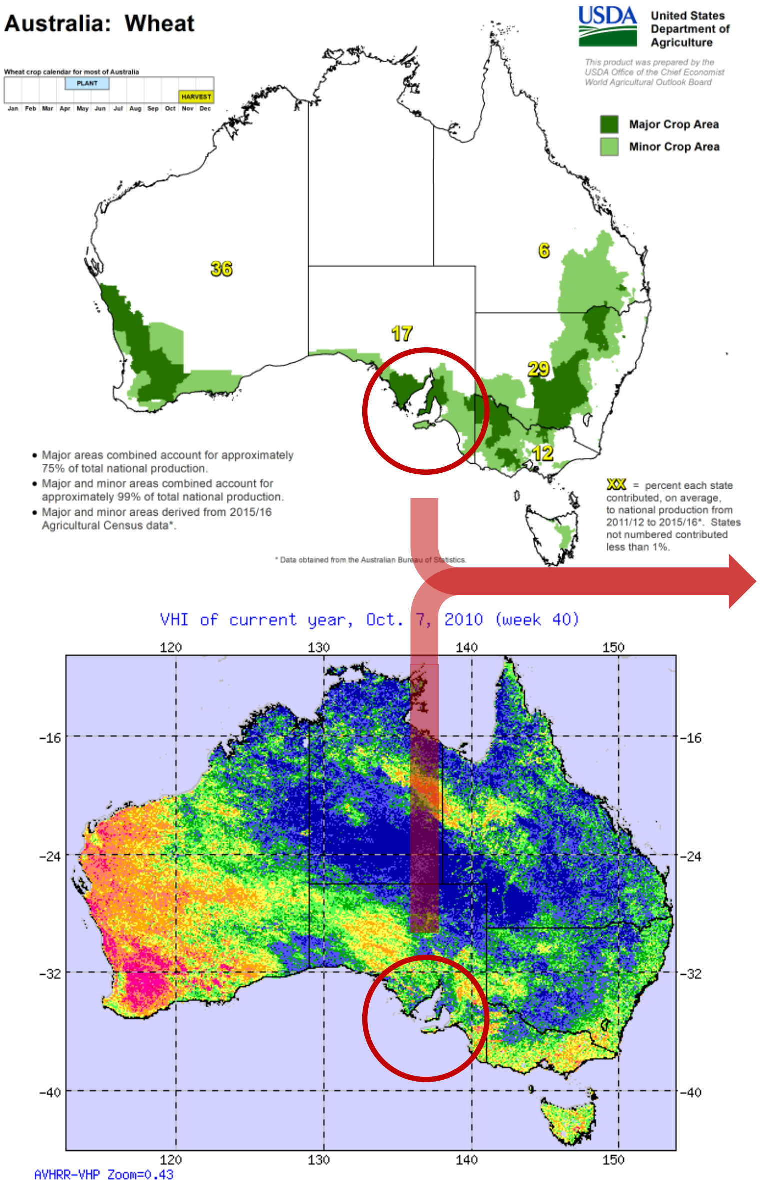
Agricultural Weather Analyses

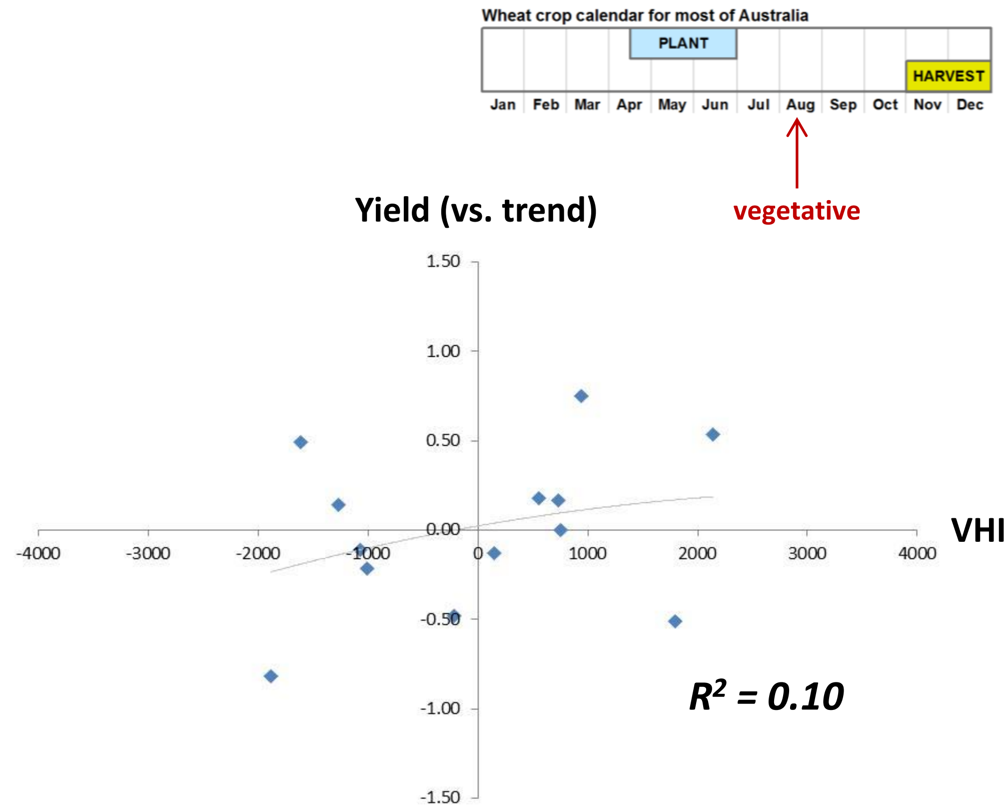




- WAOB meteorologists monitor weather and climate worldwide
- Crop weather assessments are prepared weekly using a variety of data and products:
  - precipitation
  - temperature
  - snow cover
  - reservoir level
  - stream flow
  - soil moisture
  - climate indices
  - crop progress
  - crop condition
  - satellite imagery
- At a minimum, assessments inform economists ***qualitatively*** how crop prospects are changing
- Ideally, these assessments provide ***quantitative*** yield estimates
- Simple crop models and analytical techniques aid yield analyses
- Historically, satellite data were used primarily to visually corroborate weather data
- In recent years, satellite imagery have taken on a much more robust role in our assessments

Vegetation Health and Crop Yields





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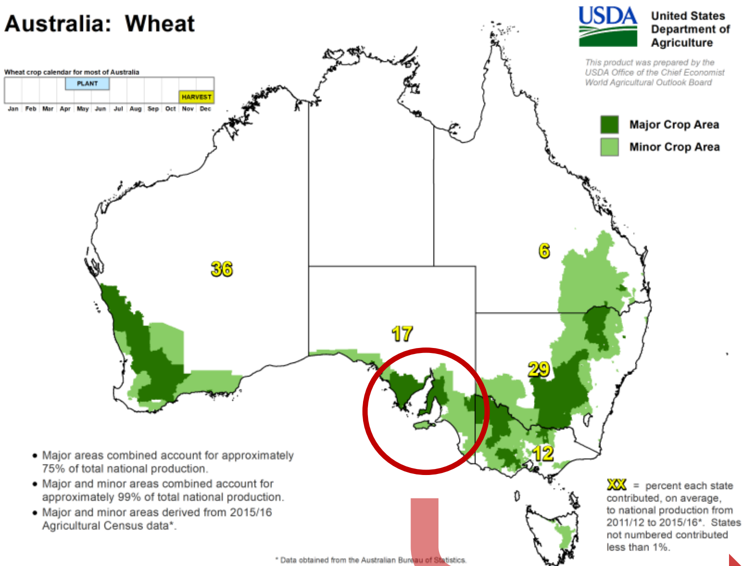

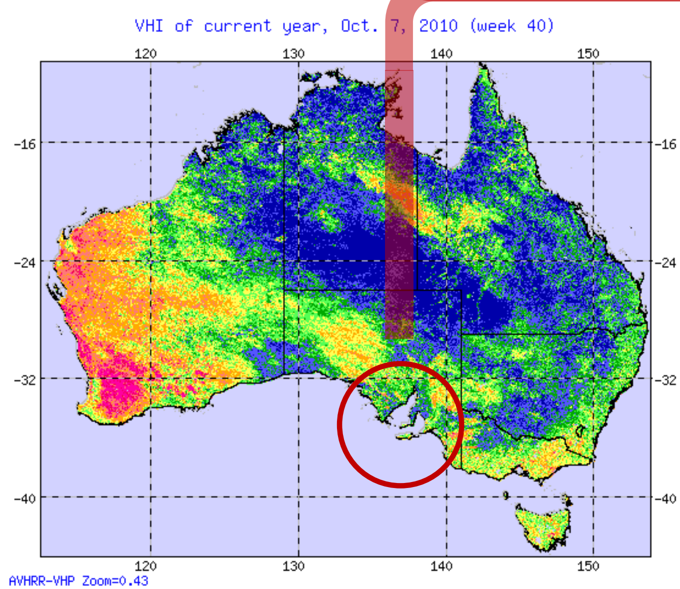

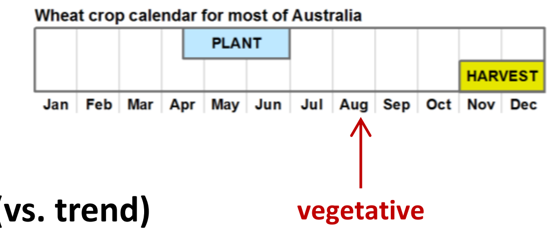

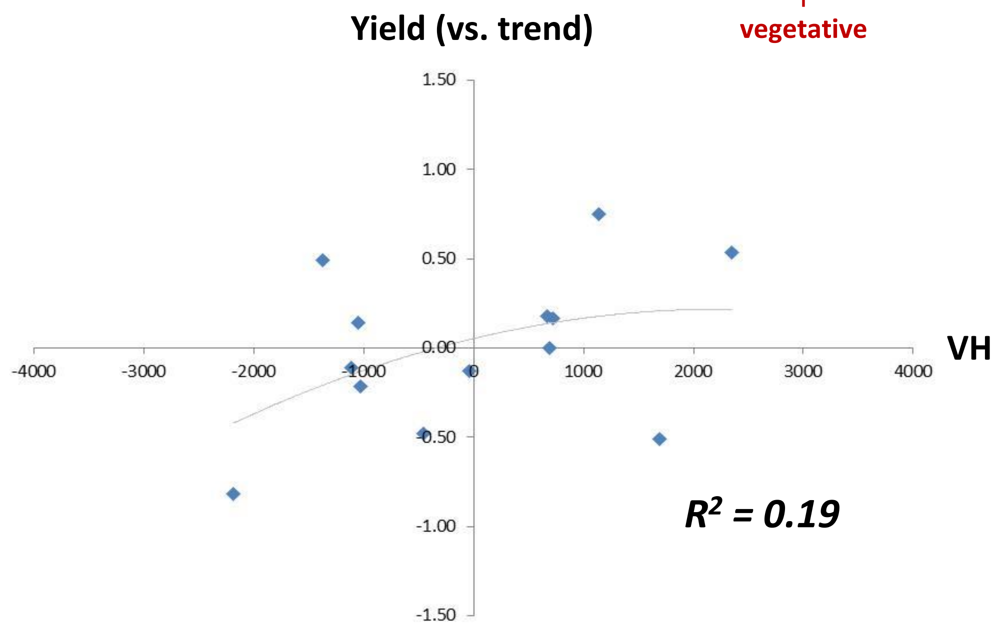

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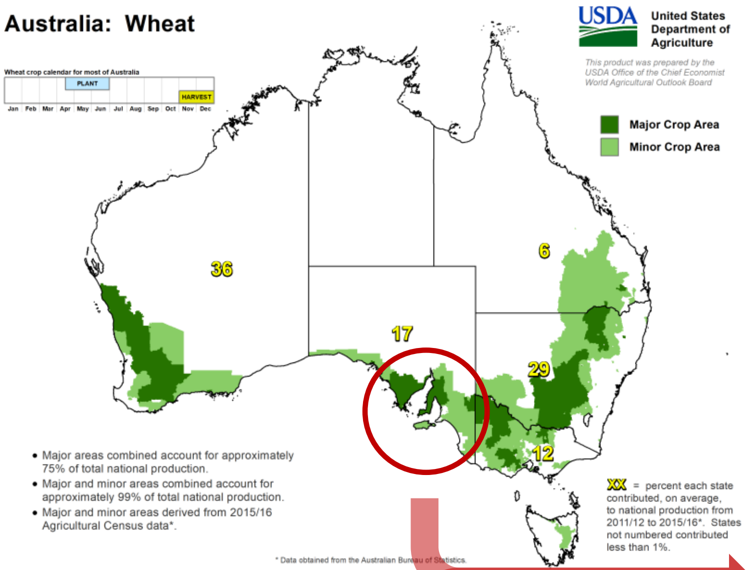

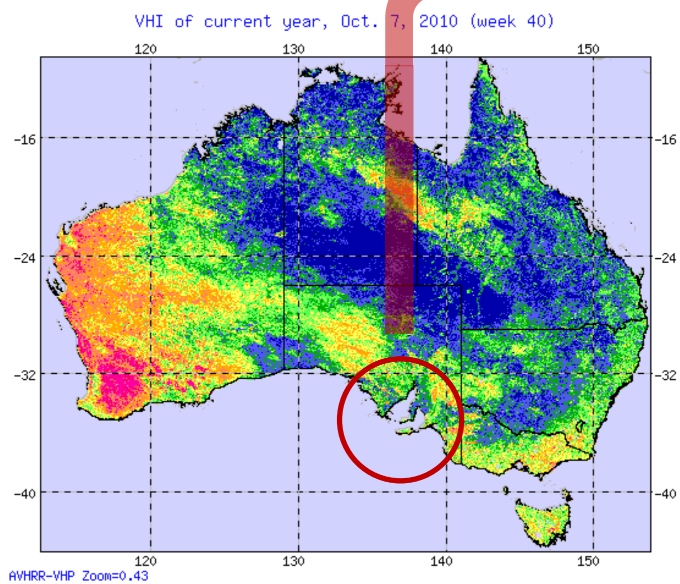

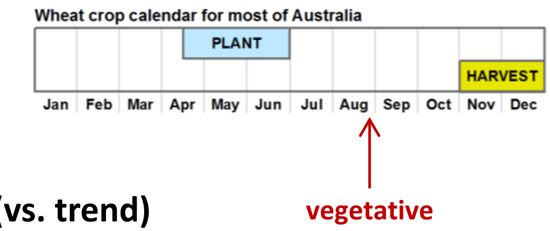

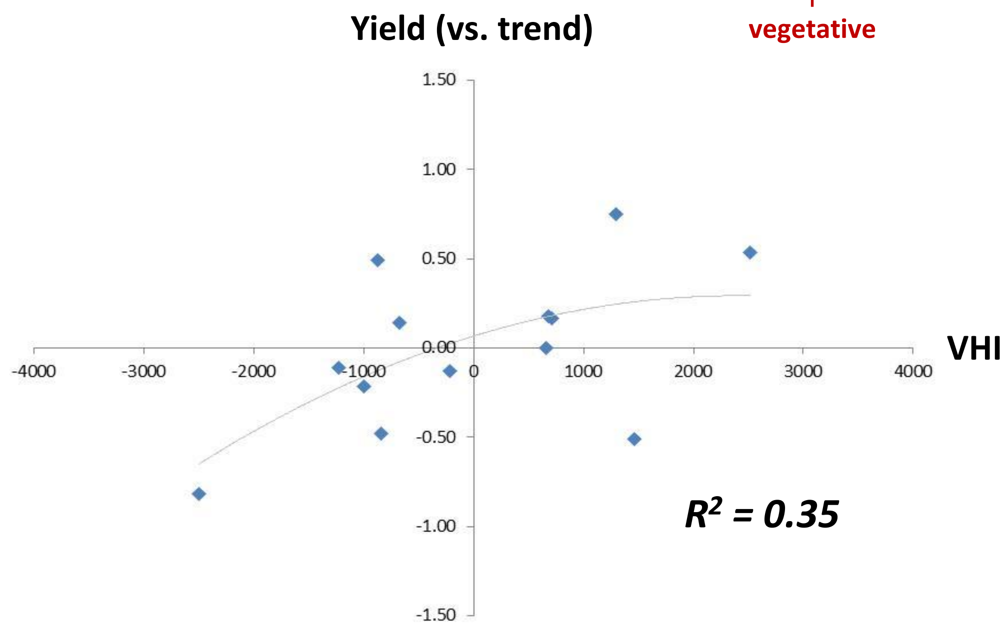

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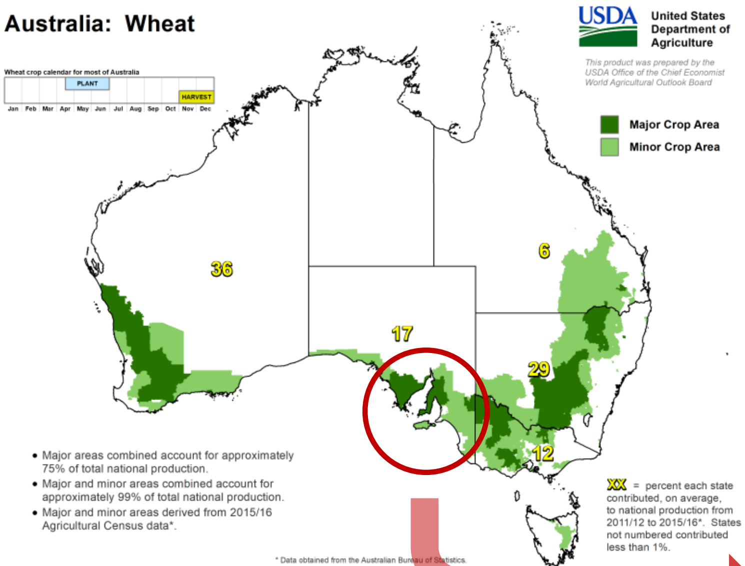

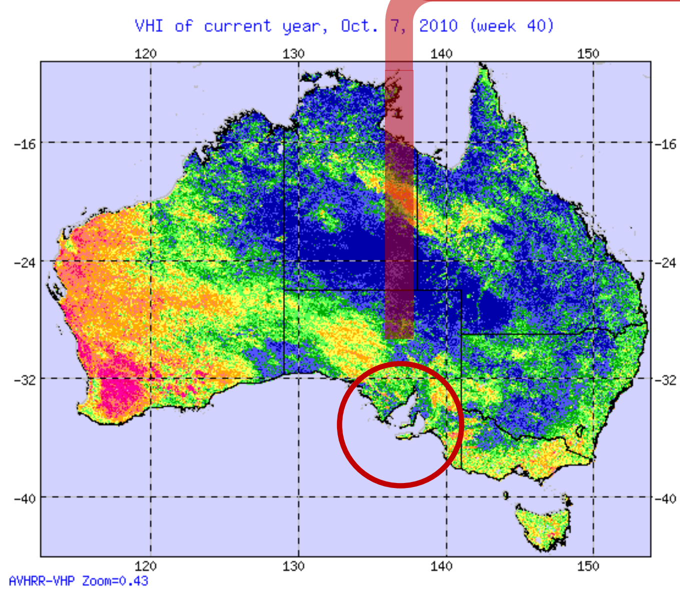

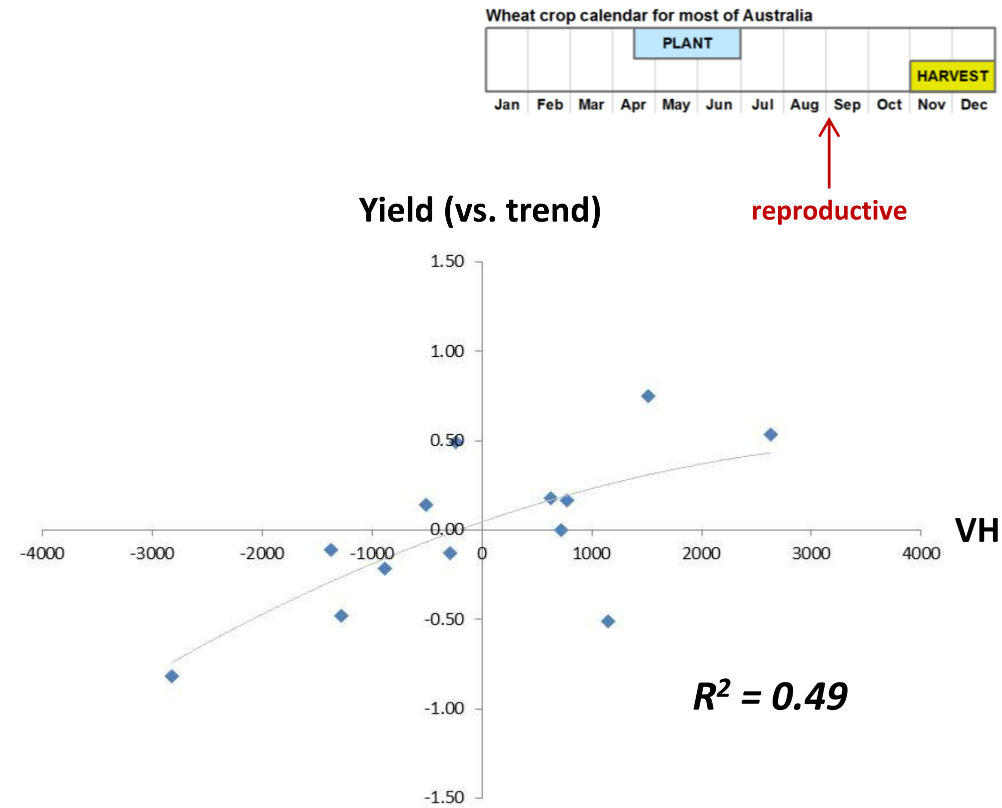

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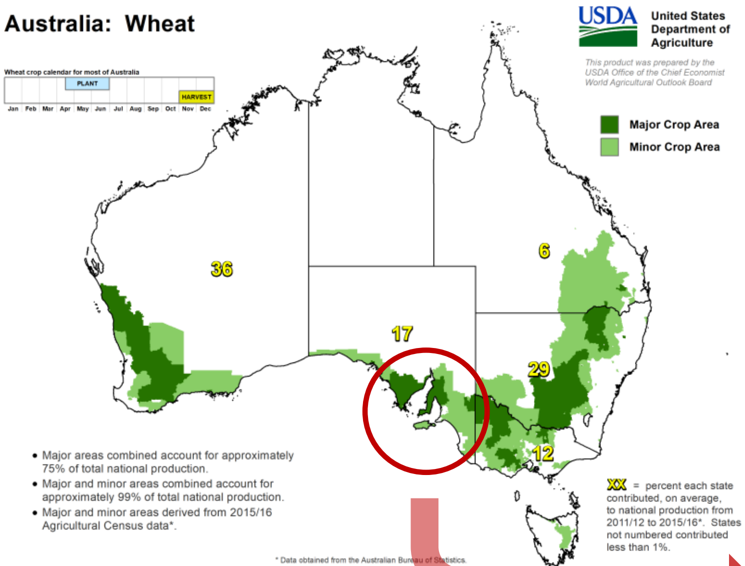

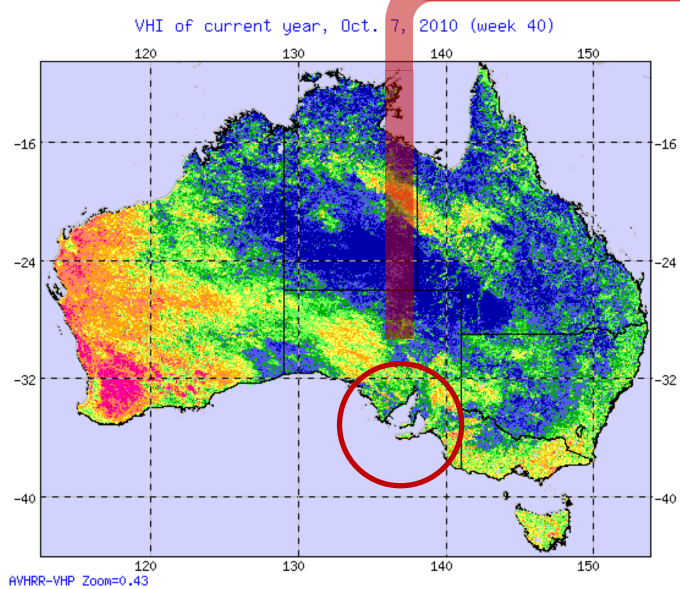

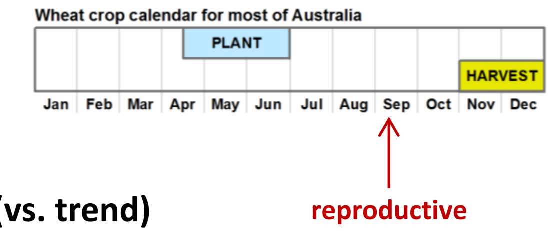

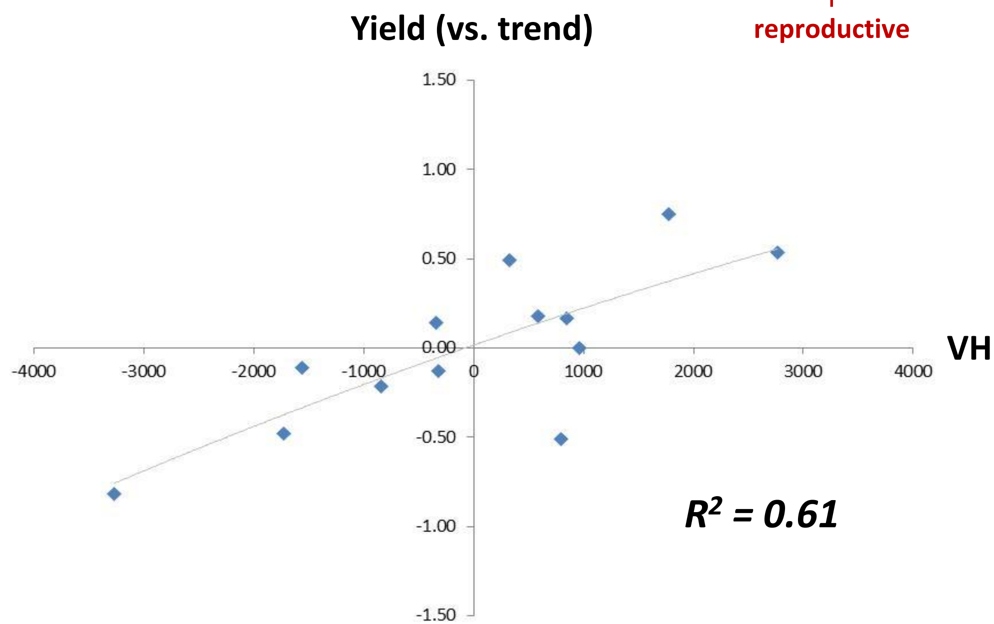

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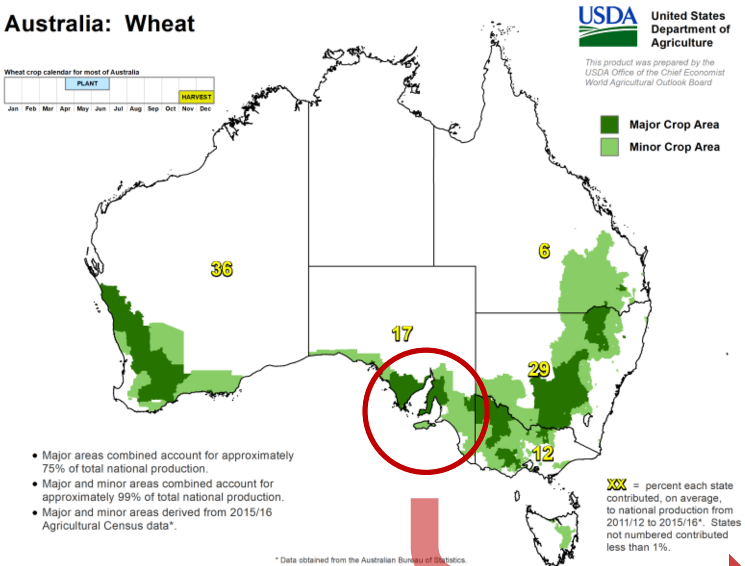

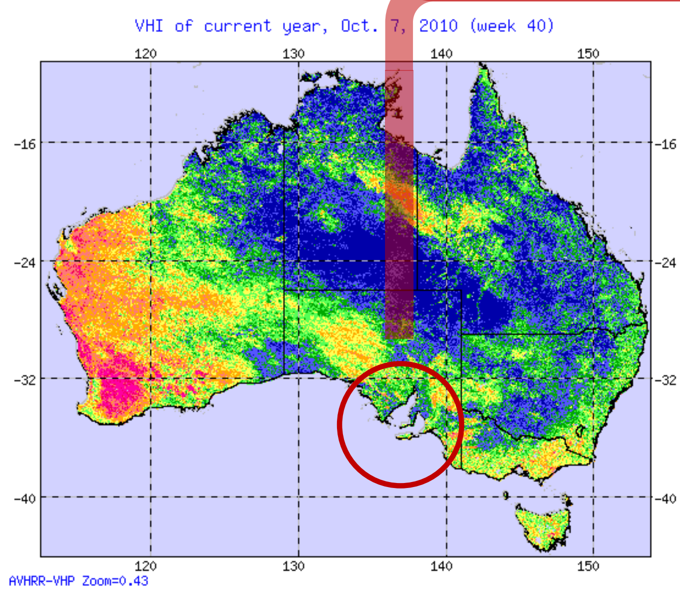

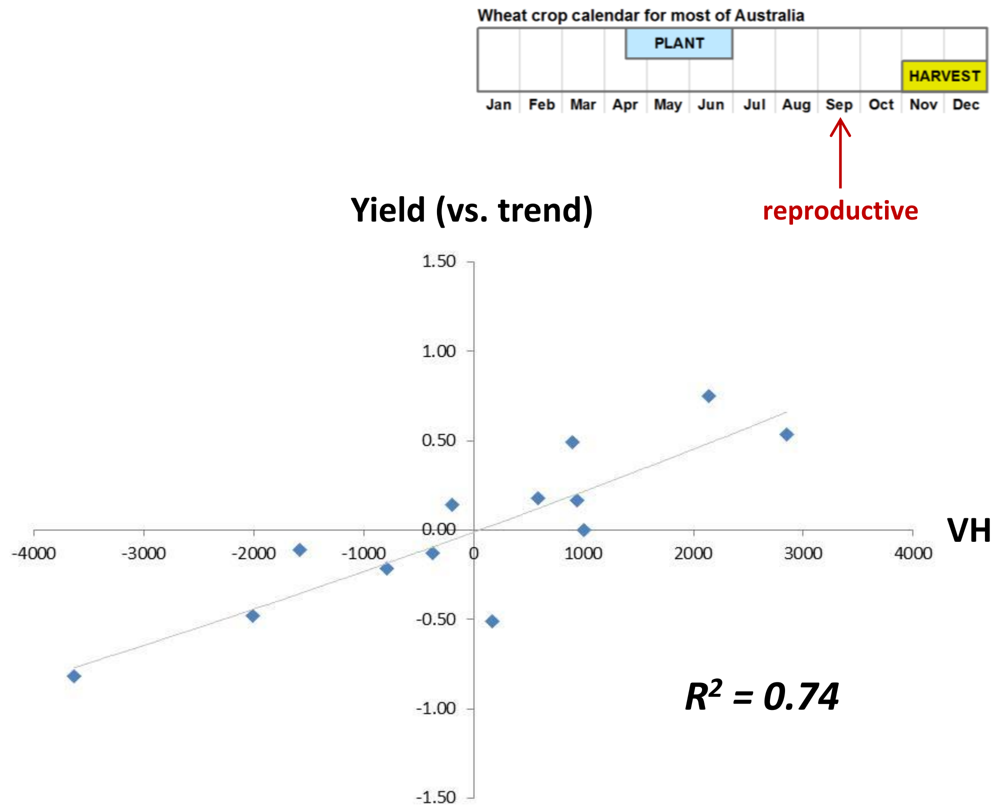

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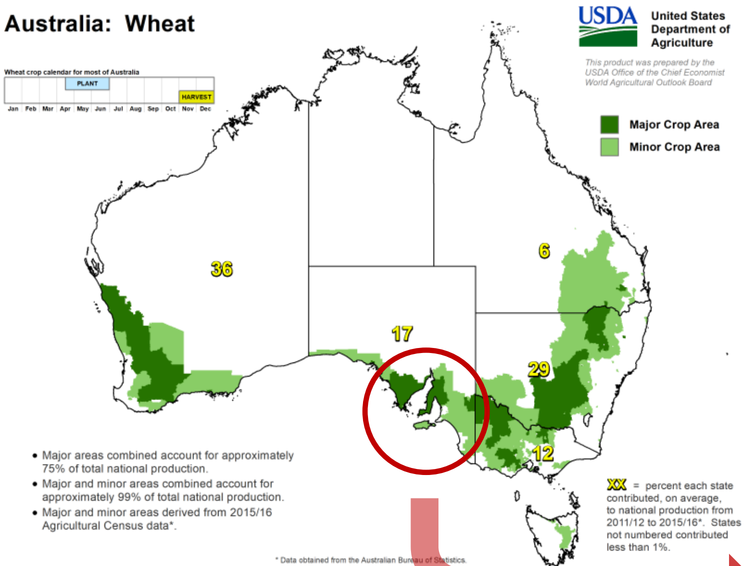

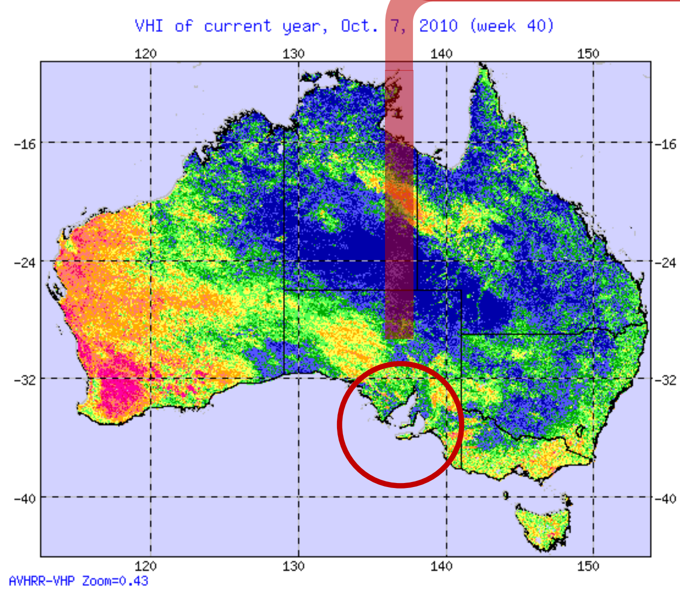

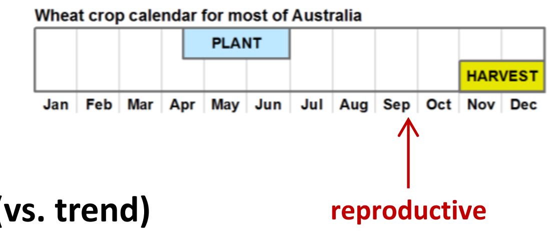

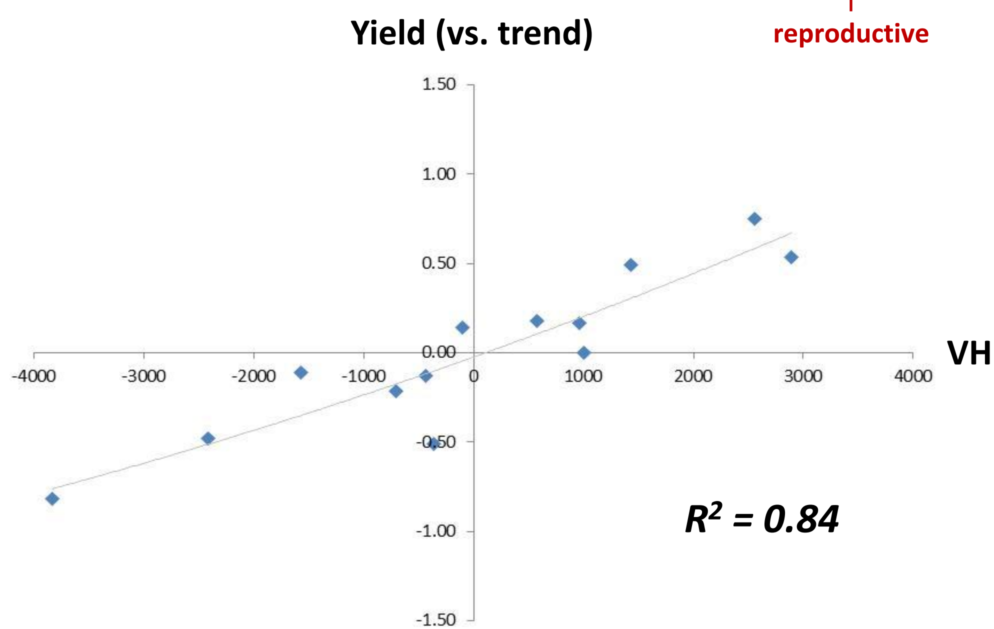

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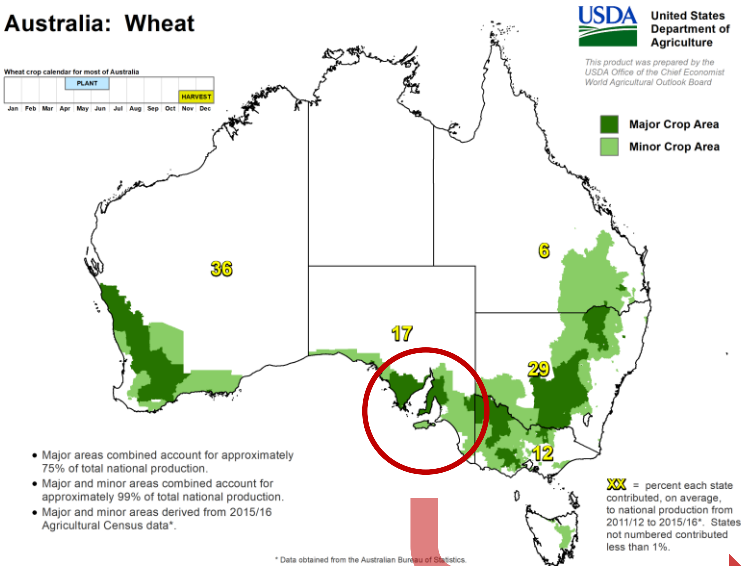

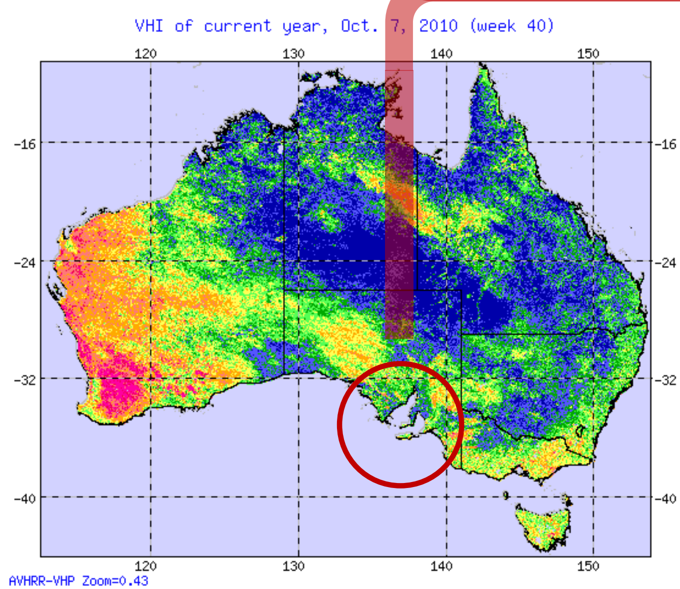

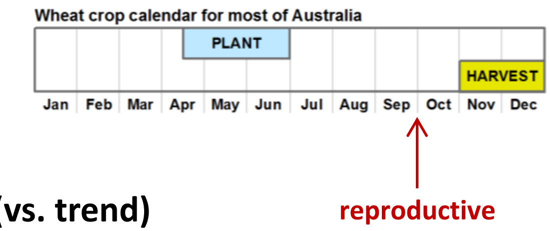

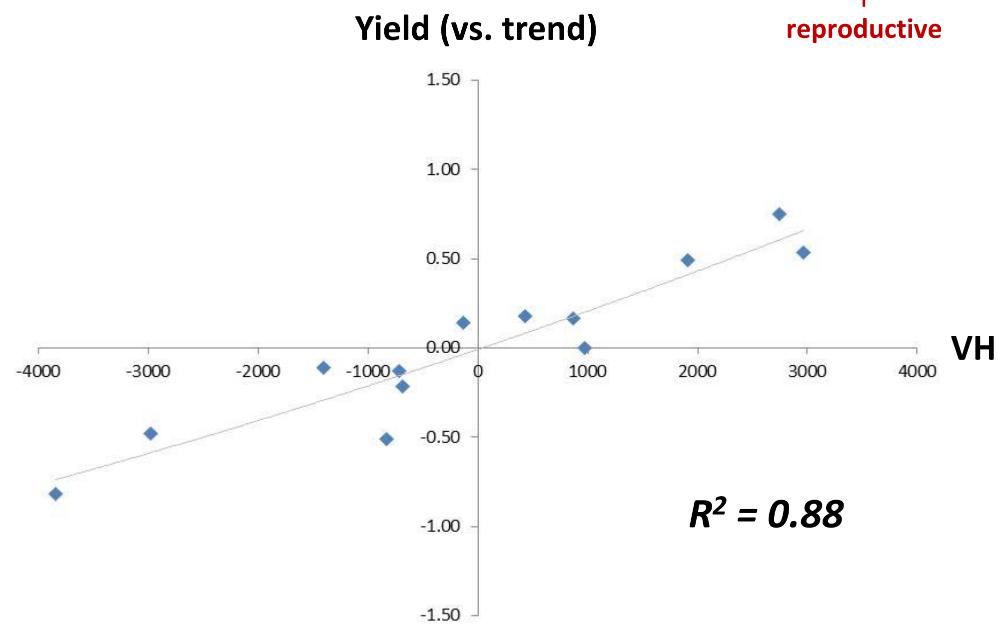

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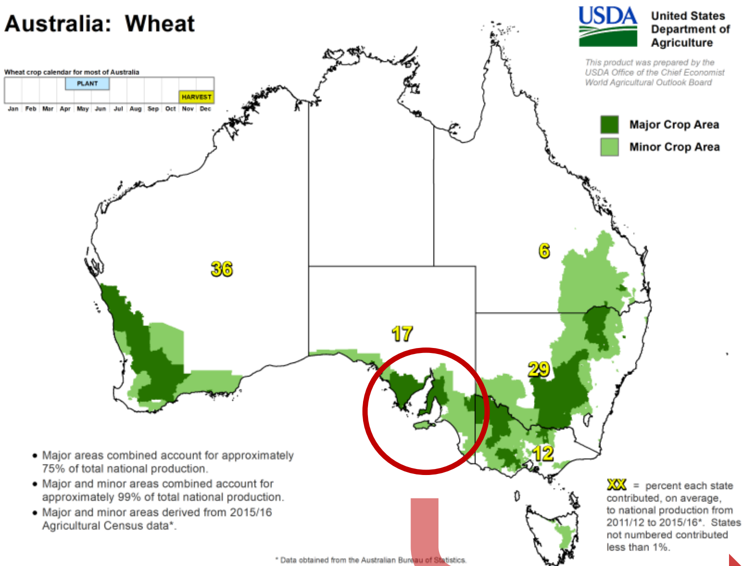

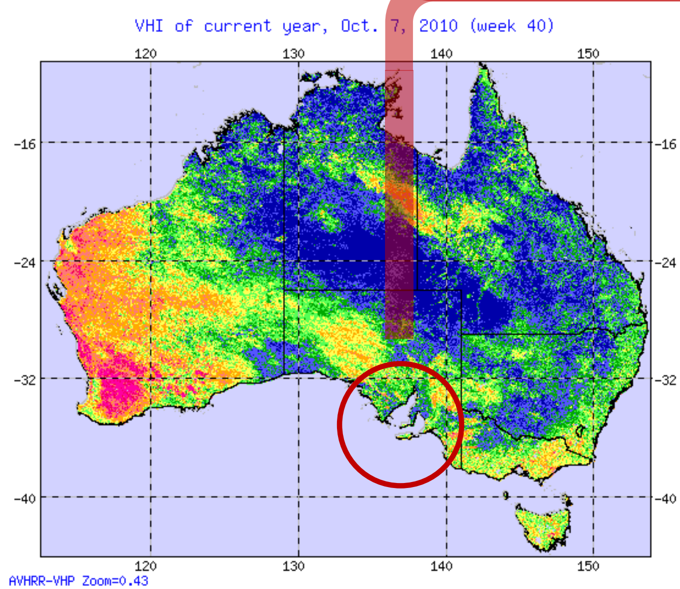

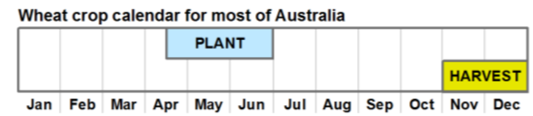

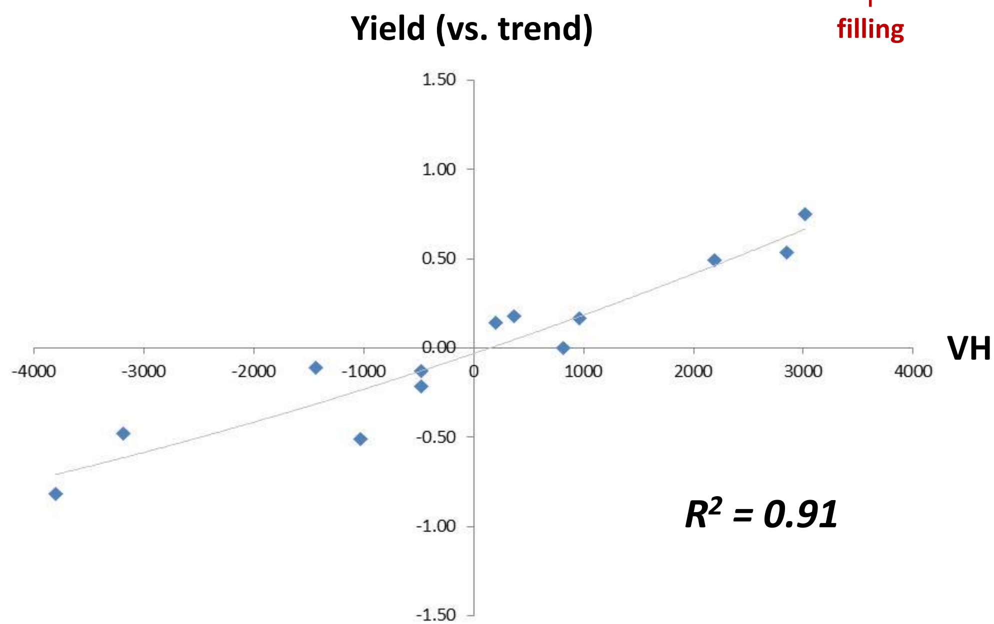

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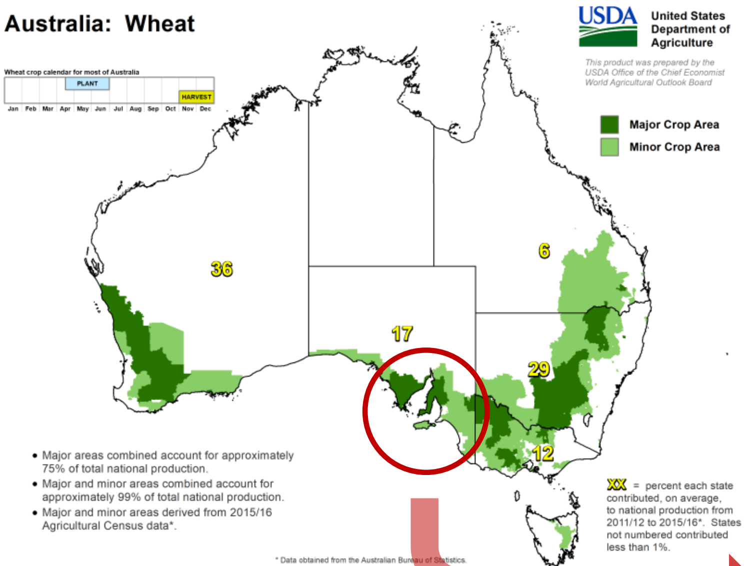
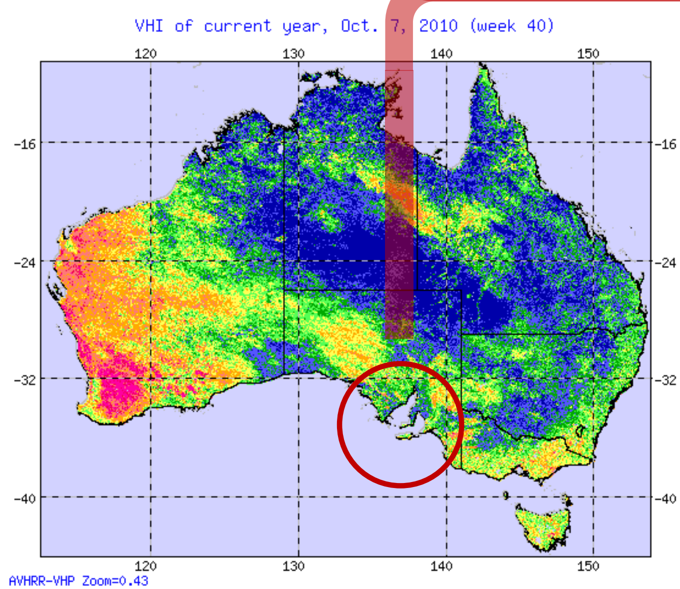
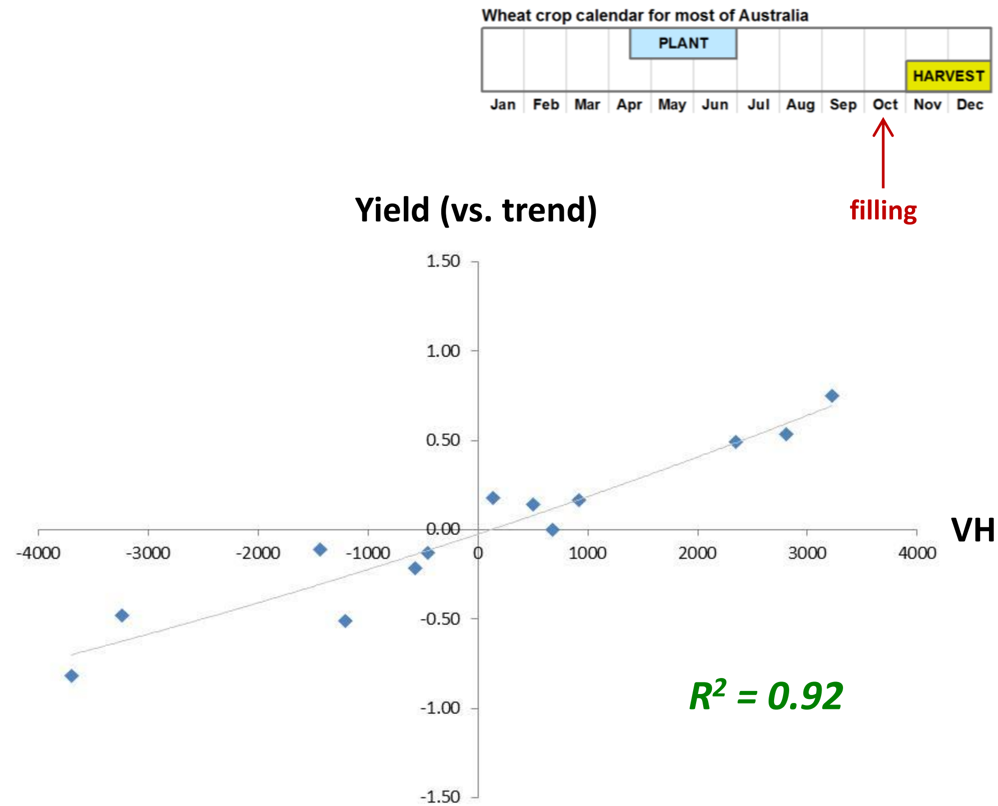
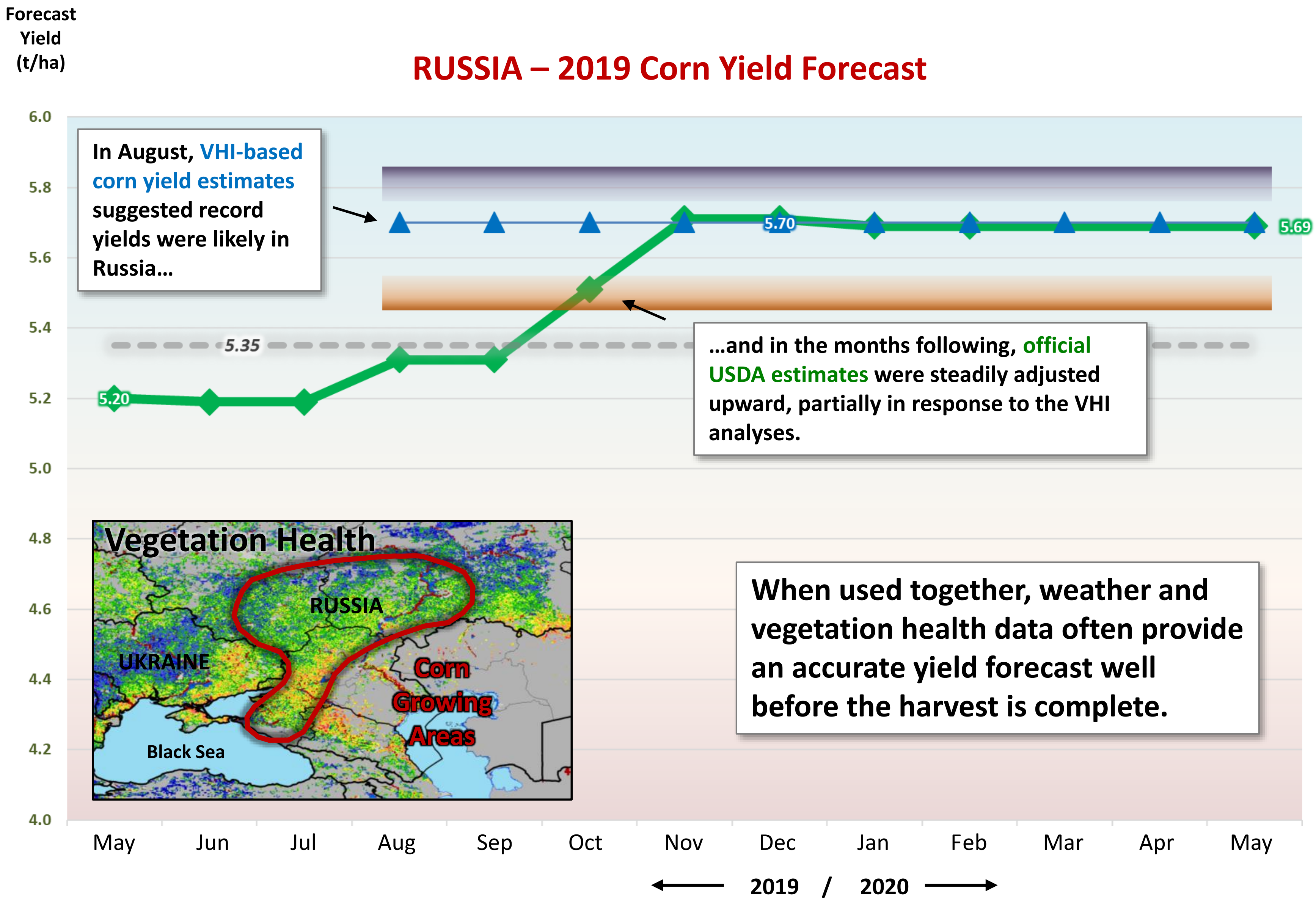




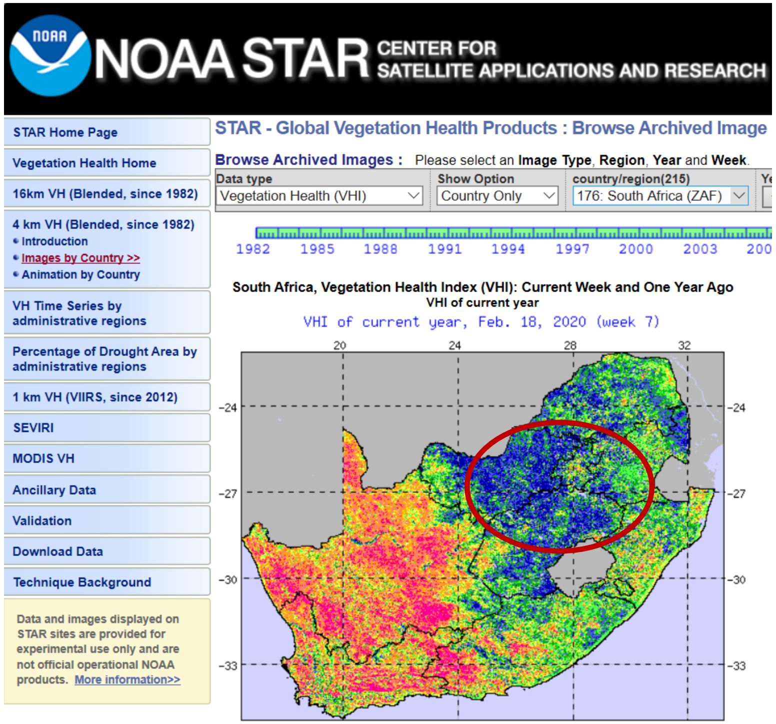


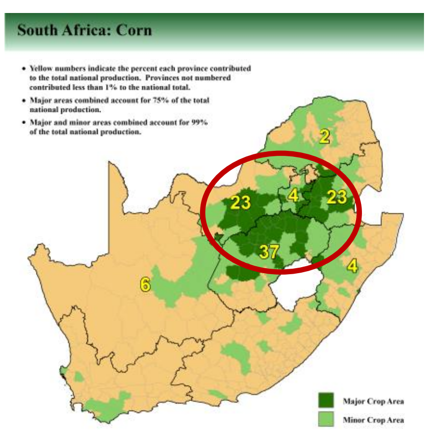
An analysis of ***vegetation health*** and ***crop yields*** revealed a ***strong correlation***.

Operational Yield Assessments



VHI Applications at USDA – A Blossoming Success Story





Several key aspects have facilitated success:

- **VHI data have a long track record** – support development of crop yield relationships
- **Data are available in a GeoTiff format** – user friendly and GIS compatible
- **Data are updated weekly** – when issues do arise, they are often addressed very quickly
- **Recalculated data incorporated in updates** – removes noise, improving yield forecasts
- **Well designed web site** – easy to navigate and promotes automated downloads
- **Development of cropland specific data sets** – significantly reduces USDA processing time and greatly increases operational value

You know a data set has value when the ICEC chairs request to see it!

Land Data Assimilation Capabilities and Opportunites

Dr. Christa D. Peters-Lidard

Deputy Director for Hydrosphere, Biosphere, and Geophysics

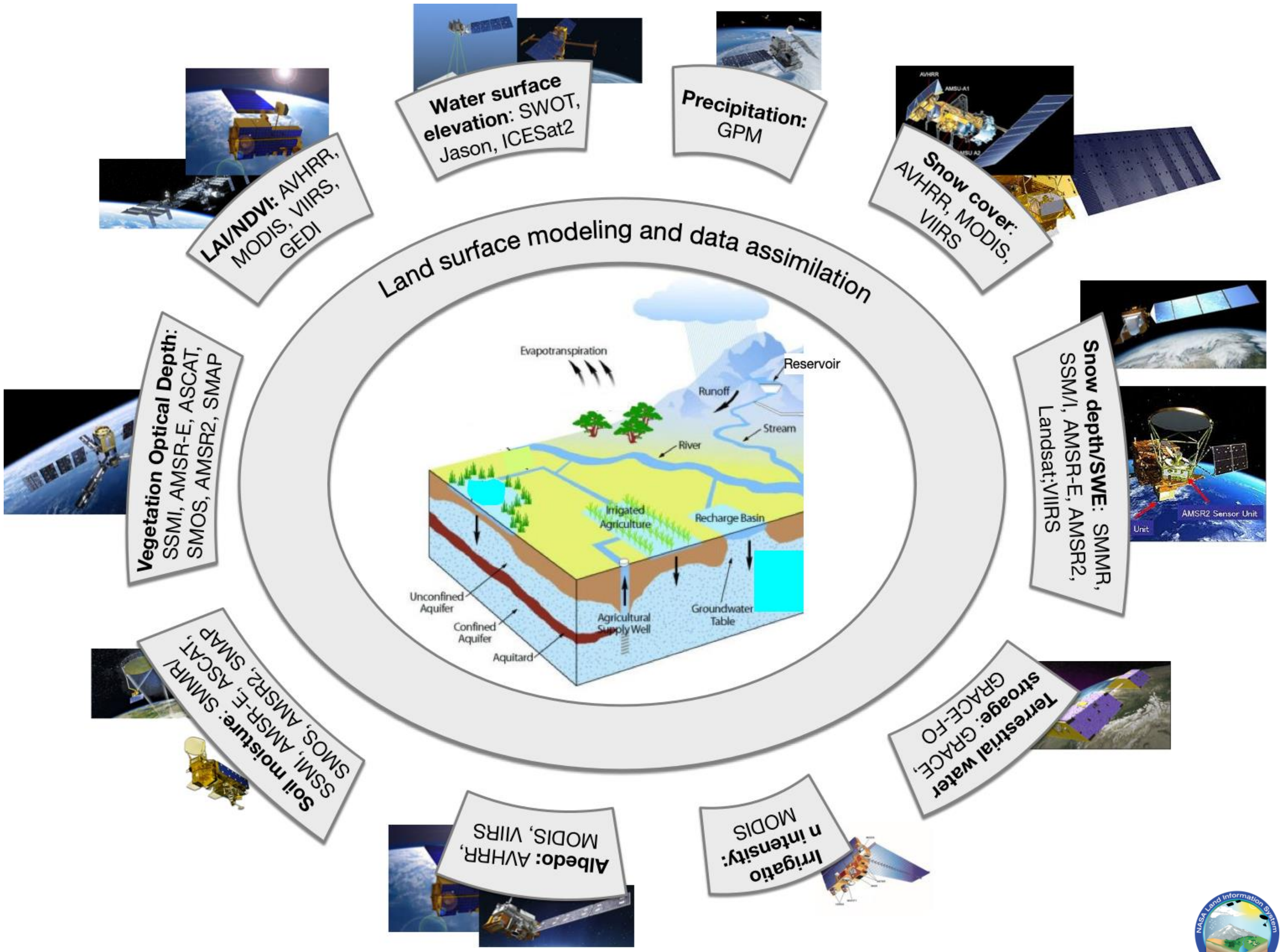
Earth Sciences Division

NASA Goddard Space Flight Center

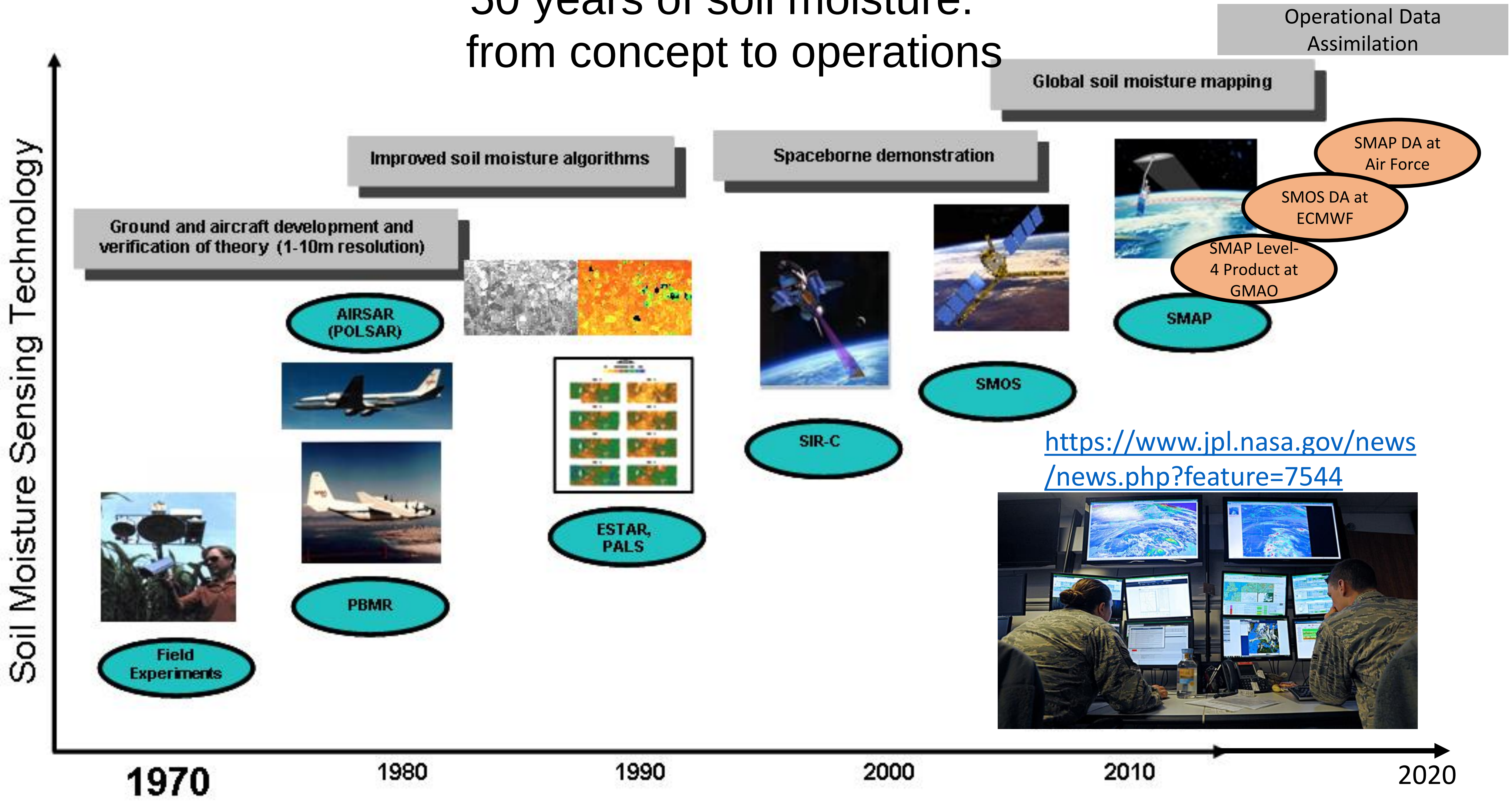
The Evolution of Land Data Assimilation

- **T,q-based soil moisture nudging concept** — Mahfouf, 1991
- **T,q-based soil moisture OI at Météo-France and ECMWF** — Giard and Bazille, 2000; Drusch and Viterbo, 2007
- **Precipitation-based LDAS (e.g., NLDAS, GLDAS, MERRA-Land)** — Mitchell et al., 2004; Rodell et al., 2004; Reichle and Koster, 2011
- **EKF/ EnKF EnKS Soil Moisture DA** — Houser et al., 1998; Reichle et al., 2002; Crow and Wood, 2003; Reichle and Koster, 2004; Dunne and Entekhabi, 2005; Kumar et al, 2009
- **EKF/EnKF Snow Cover and Snow Water Equivalent (SWE) DA** — Sun et al., 2004; Slater and Clark, 2006; De Lannoy, et al., 2012; Liu et al., 2015; Kumar et al., 2017
- **EKF/ EnKF Skin Temperature DA** — Bosilovich et al., 2007; Reichle et al., 2010; Draper et al., 2015
- **EnKS Terrestrial Water Storage (GRACE) DA** — Zaitchik et al., 2008; Kumar et al., 2016; Girotto et al. 2017; Li et al., 2019
- **EnKF Vegetation/ Albedo/ Leaf Area Index (LAI) DA** — Pauwels et al., 2007; Muñoz-Sabater et al., 2008; Barbu et al., 2011; Bousetta et al. 2015; Kumar et al., 2019
- **EnKF Water Level DA** — Paiva et al., 2013; Michailovsky et al., 2013
- **EnKF Multi-variate DA** — Kumar et al., 2019; Jasinski et al., 2019

Current Land Data Assimilation Capabilities

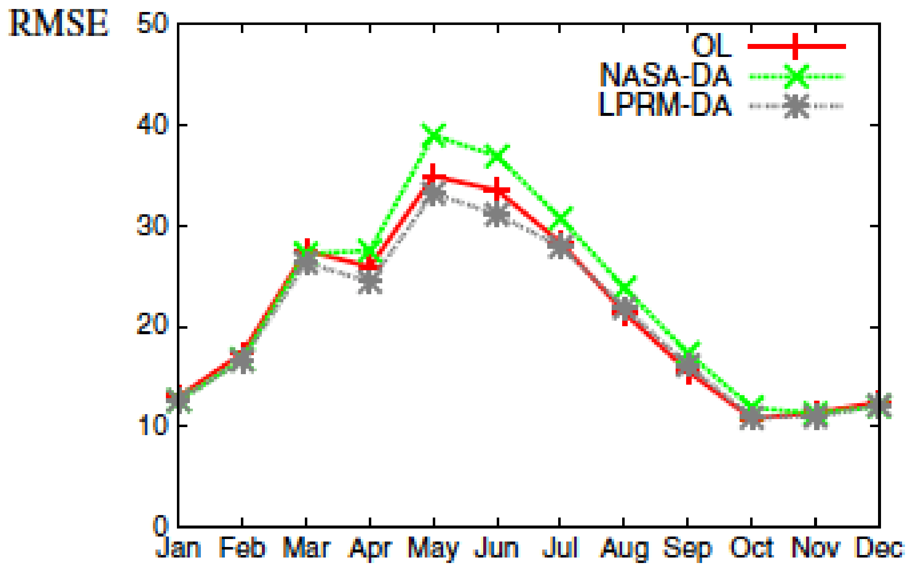


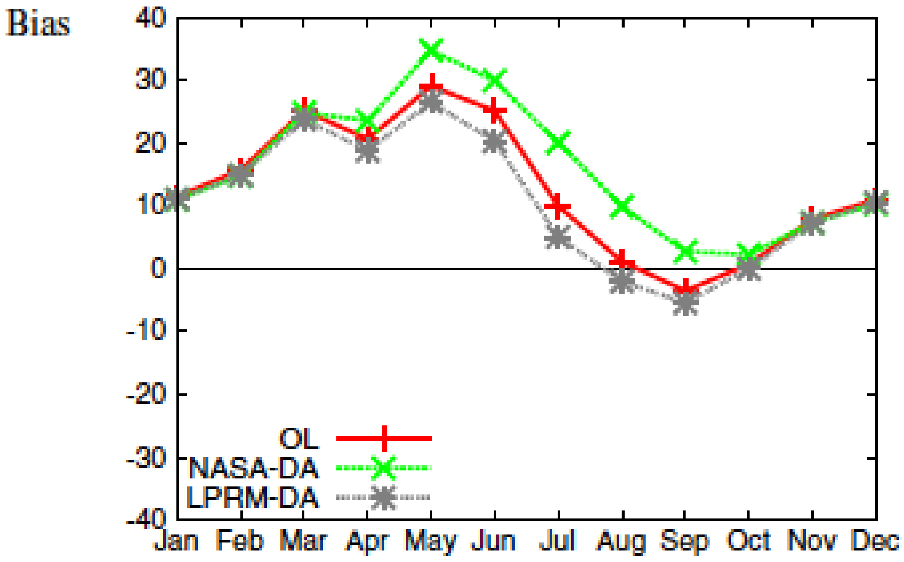
50 years of soil moisture: from concept to operations



Soil Moisture Assimilation Improves Evaporation

Latent heat flux RMSE and BIAS before (OL) and after AMSR-E soil moisture assimilation





NASA-DA is the ‘official’ NASA product,
while LPRM-DA is an alternate retrieval algorithm.

Peters-Lidard, C. D., S. V. Kumar, D. M. Mocko, and Y. Tian, 2011: Estimating evapotranspiration with land data assimilation systems. Hydrol. Process., ***25****, 3979–3992, doi:10.1002/hyp.8387.*

Soil Moisture Forecast Impacts at ECMWF

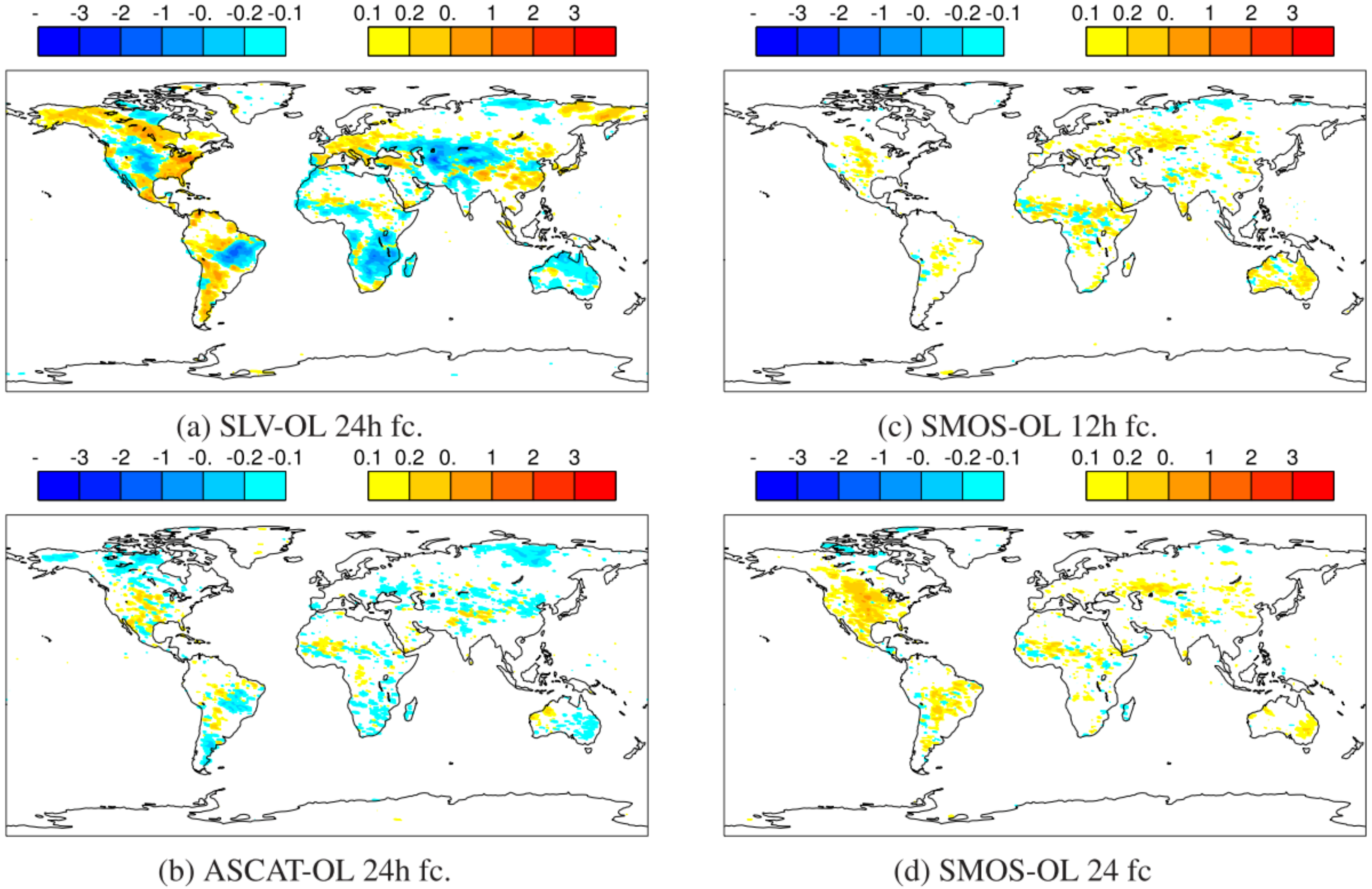
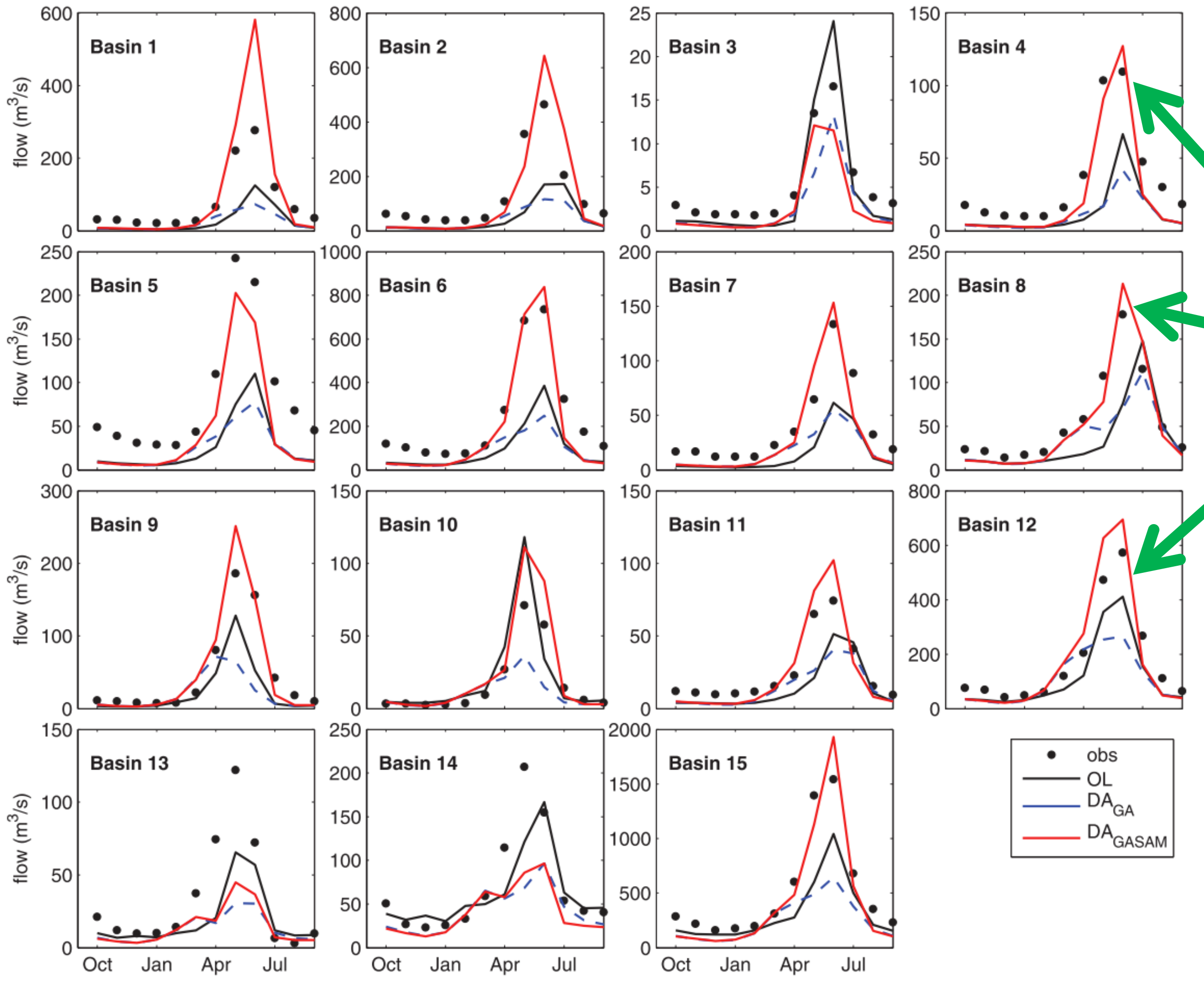


Figure 8: Sensitivity of 24 h screen level temperature forecast to the soil moisture analyses of a) ***SLV****, b)* ***ASCAT****, and to* ***SMOS*** *soil moisture analyses at c) 12 h and d) 24 h forecast. The blue colour bar indicates cooling of 2 m temperature, and red colour bar warming of 2 m temperature. The reference experiment is the* ***OL****. Units are K.*

Muñoz-Sabater, J., H. Lawrence, C. Albergel, P. Rosnay, L. Isaksen, S. Mecklenburg, Y. Kerr, and M. Drusch, 2019: Assimilation of SMOS brightness temperatures in the ECMWF Integrated Forecasting System. Q. J. R. Meteorol. Soc., 145, 2524–2548, doi:10.1002/qj.3577.

Snow Assimilation Improves Streamflow



Improvement in streamflow due to snow depth assimilation

Liu, Y., C. D. Peters-Lidard, S. V. Kumar, K. R. Arsenault, and D. M. Mocko, 2015: Blending satellite-based snow depth products with in situ observations for streamflow predictions in the Upper Colorado River Basin. Water Resour. Res., ***51****, 1182–1202, doi:10.1002/2014WR016606.*

LAI Assimilation Improves Water and Carbon Budgets

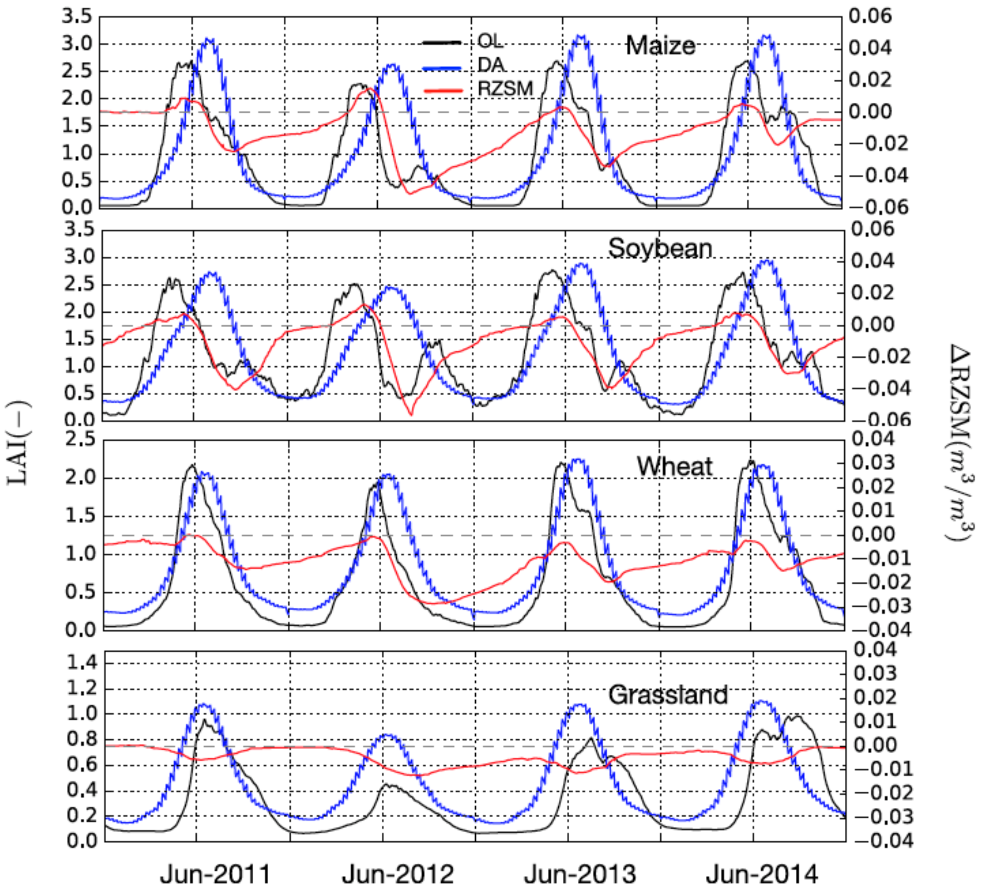
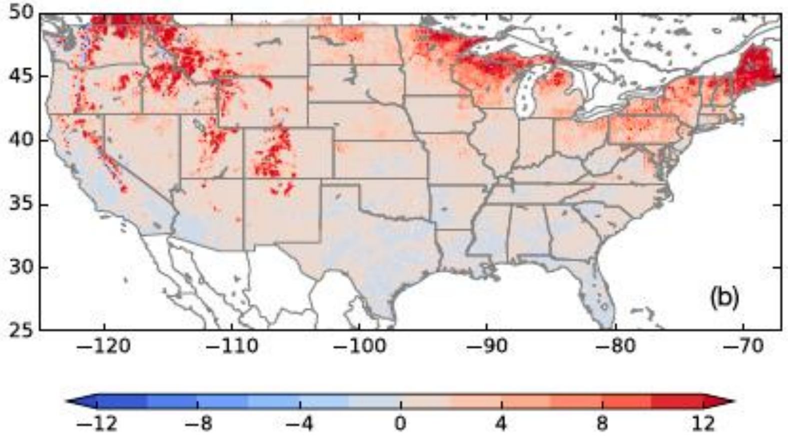
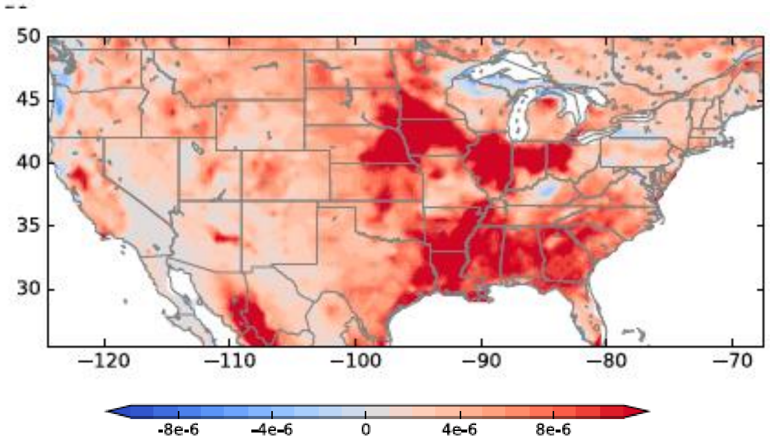


FIG. 5. Time series of area-averaged LAI over maize, soybean, wheat, and grassland areas from OL and DA integrations during 2011–15. The right vertical axis shows time series of differences in the area averaged root zone soil moisture between the DA and OL integrations.



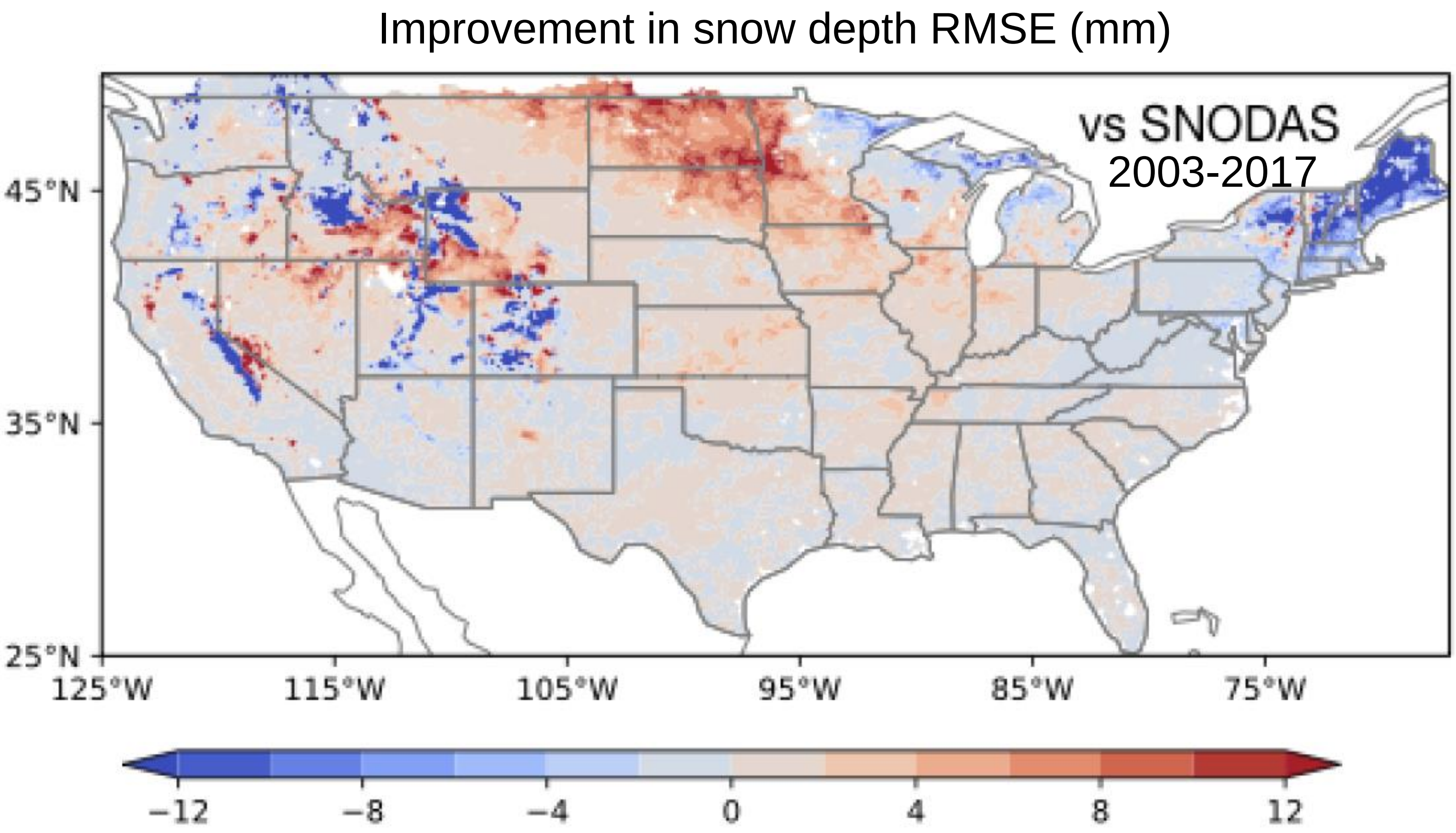
Improvement in snow depth RMSE (mm)



Improvement in GPP RMSE ($g\ m^{-2}\ s^{-1}$)

Kumar, S. V, D. M. Mocko, S. Wang, C. D. Peters-Lidard, and J. Borak, 2019: Assimilation of remotely sensed leaf area index into the Noah-MP land surface model: Impacts on water and carbon fluxes and states over the continental United States. *J. Hydrometeorol.*, **20**, 1359–1377, doi:10.1175/JHM-D-18-0237.1.

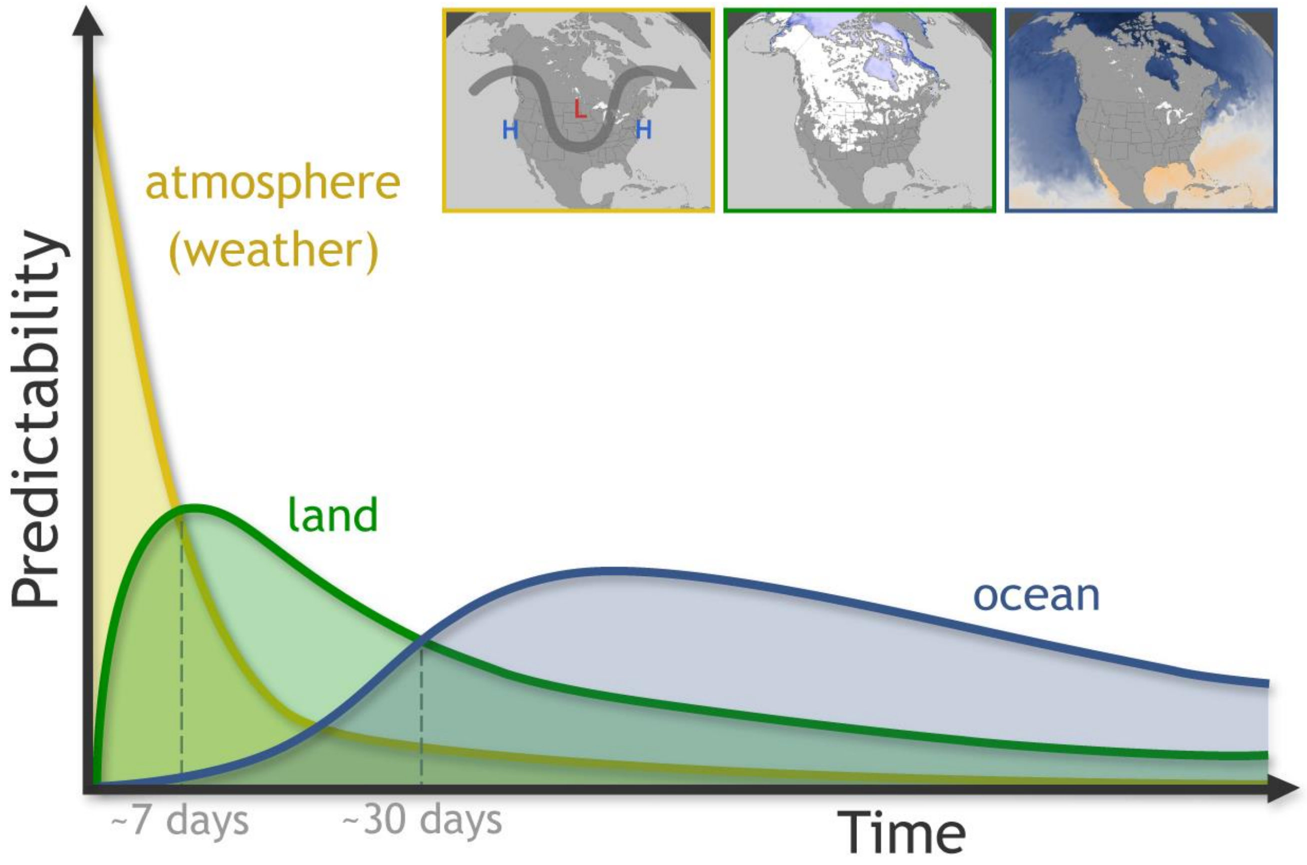
Albedo Assimilation Improves Snow Depth



Kumar, S.; Mocko, D.; Vuyovich, C.; Peters-Lidard, C., 2020: Impact of Surface Albedo Assimilation on Snow Estimation. Remote Sens., 12(4), 645; https://doi.org/10.3390/rs12040645.

The Role of Land in Earth System Prediction

- Land states (soil moisture, groundwater, snow) can provide predictability in the window from deterministic (weather) to climate (O-A) time scales, peaking at S2S.
- Vegetation states, related to soil moisture anomalies, give predictability at/beyond S2S time scales.
- L-A coupling is active where there is sensitivity, variability and memory.
- “Good” models and analyses (of atmosphere and land) needed to exploit this source of skill.



Slide courtesy Paul Dirmeyer

NASA EARTH FLEET
OPERATING & FUTURE THROUGH 2023
LANDSAT-9
NISAR
TROPICS (6)
SENTINEL-6A/B
SWOT
MAIA
PACE
TEMPO
ICESAT-2
GRACE-FO (2)
CYGNSS (8)
NISTAR, EPIC (DSCOVR/NOAA)
SORCE
CLOUDSAT
TERRA
AQUA
AURA
CALIPSO
GPM
LANDSAT 7 (USGS)
LANDSAT 8 (USGS)
OCO-2
OSTM/JASON 2 (NOAA)
SMAP
SUOMI NPP (NOAA)
TSIS-2
PREFIRE (2)
GEOCARB
GLIMR
ISS INSTRUMENTS
EMIT
CLARREO-PF
GEDI
SAGE III
OCO-3
TSIS-1
ECOSTRESS
LIS
JPSS-2, 3 & 4 INSTRUMENTS
OMPS-Limb
INVEST/CUBESATS
RAVAN
RainCube
CSIM
CubeRRT
TEMPEST-D
CIRiS
HARP
CTIM
HyTI
SNoOPI
NACHOS
(PRE) FORMULATION
IMPLEMENTATON
PRIMARY OPS
EXTENDED OPS
09.10.19

STAR Land Product Development Science Team

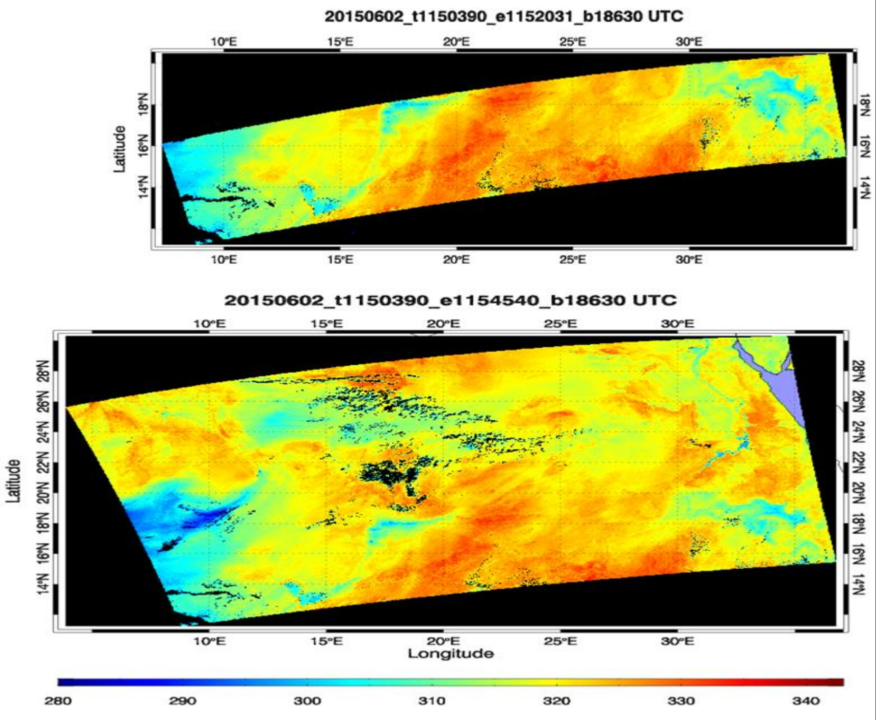
Science Team Information and Highlights	
Science Team Lead	Yunyue (Bob) Yu
Science Team Membership	LST team members, Albedo team members, VI/GVF team members, SR team
Expected Benefits	List of users **LST**: NCEP/EMC, Land Hydrology Model; USDA, STAR Soil Moisture **Albedo**: NCEP/EMC, Land Hydrology Model; STAR Cryosphere team **VI/GVF**: NCEP/EMC, HRRR Model
Operational Products	JPSS (SNPP and NOAA-20) Operational: LST, Albedo, VI, GVF GOES-R (G-16, G-17) operational: LST, Albedo
Experimental Products	Himawari AHI LST, Sentinel – 3 LST,
Group Monitoring site	https://www.star.nesdis.noaa.gov/smcd/emb/land/index.php

Operational JPSS LST Products

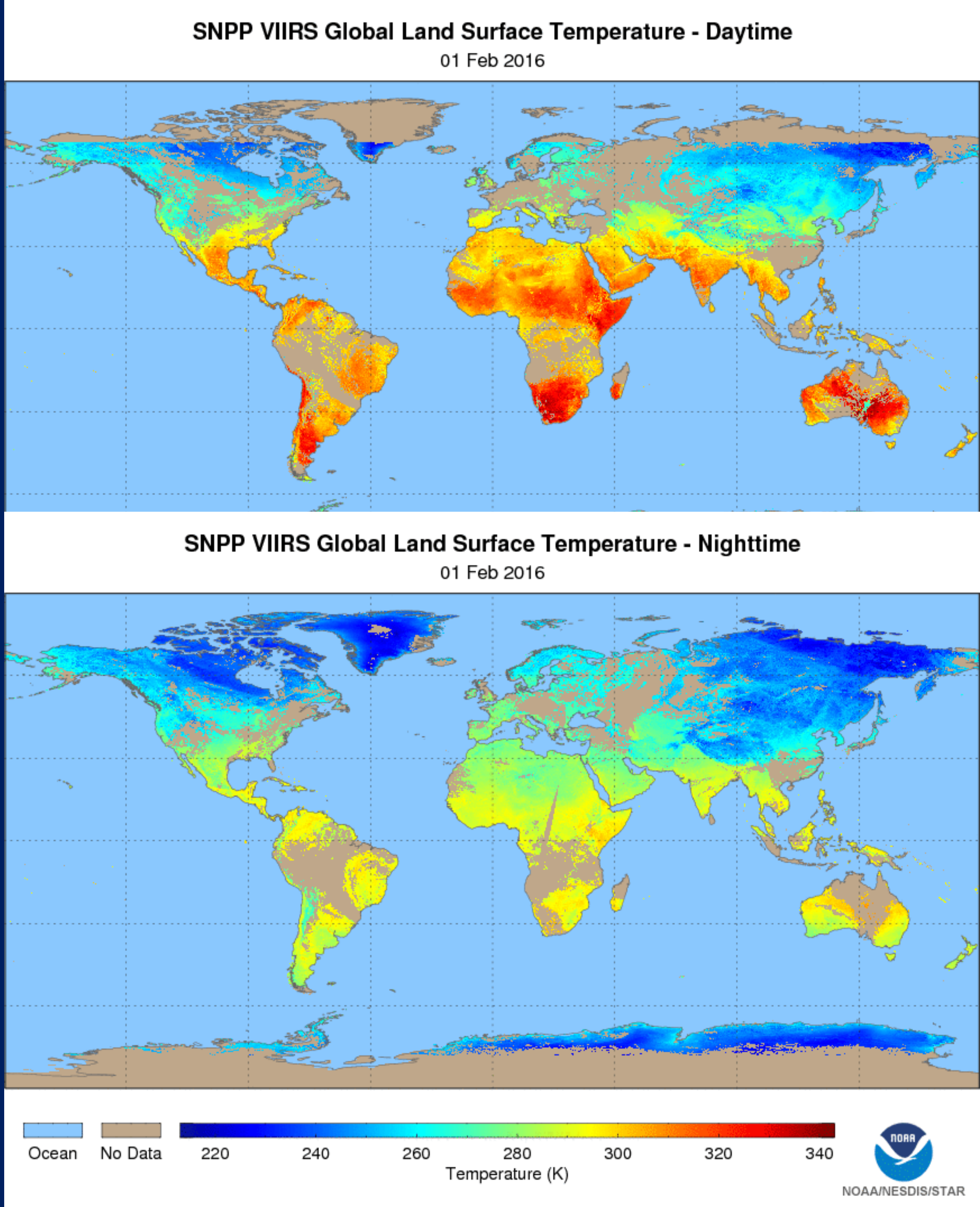
Orbit overpass time: 13:30/01:30;
Two granule products (750 m resolution)
- Single 1.5 min granule data; combined 4 x 1.5 min granule data

One gridded product (1 km resolution)
- Two grids a day : daytime and nighttime

Format: NetCDF, HDF5
Validated Maturity: Yes
Routine monitoring : Yes
ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/LTM/LST/single/JPSS1_VIIRS/
ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/LTM/LST/single/SNPP_VIIRS
STAR LST Homepage: **https://www.star.nesdis.noaa.gov/jpss/lst.php**
Archive: **https://www.class.noaa.gov (*search – VIIRS_EDR)**



Applications Performed:
- RTMA/URMA system data assimilation adjust T2M in Alaska region
- Input for high resolution SMAP data
- EMC forecasting model LST verification
- NASA DISCOVER-AQ field campaign for aircraft data verification



Operational ***GOES-R LST*** *Products*

Current satellites: GOES-16, GOES-17

Observation modes:
- FullDisk, hourly; CONUS, mins; Mesoscale, mins
- 2 km resolution

Format: NetCDF, HDF5

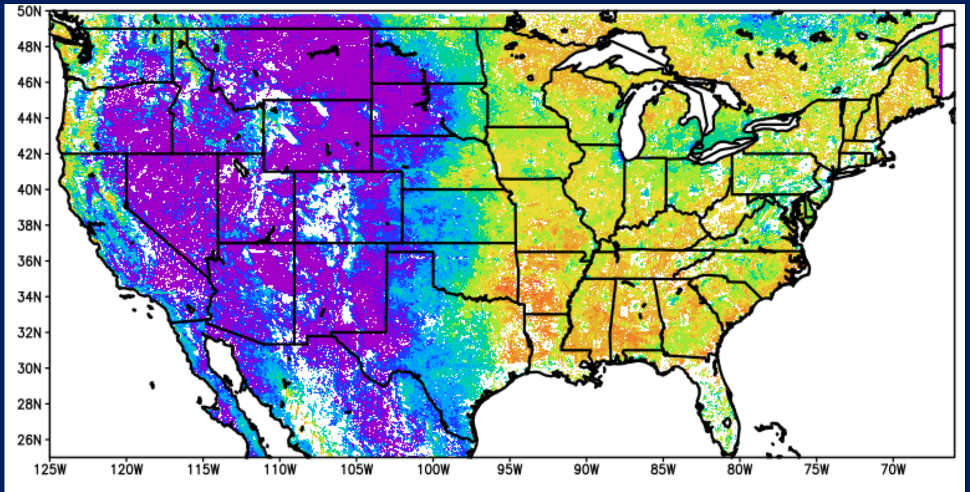
Validated Maturity: Yes (G-16)

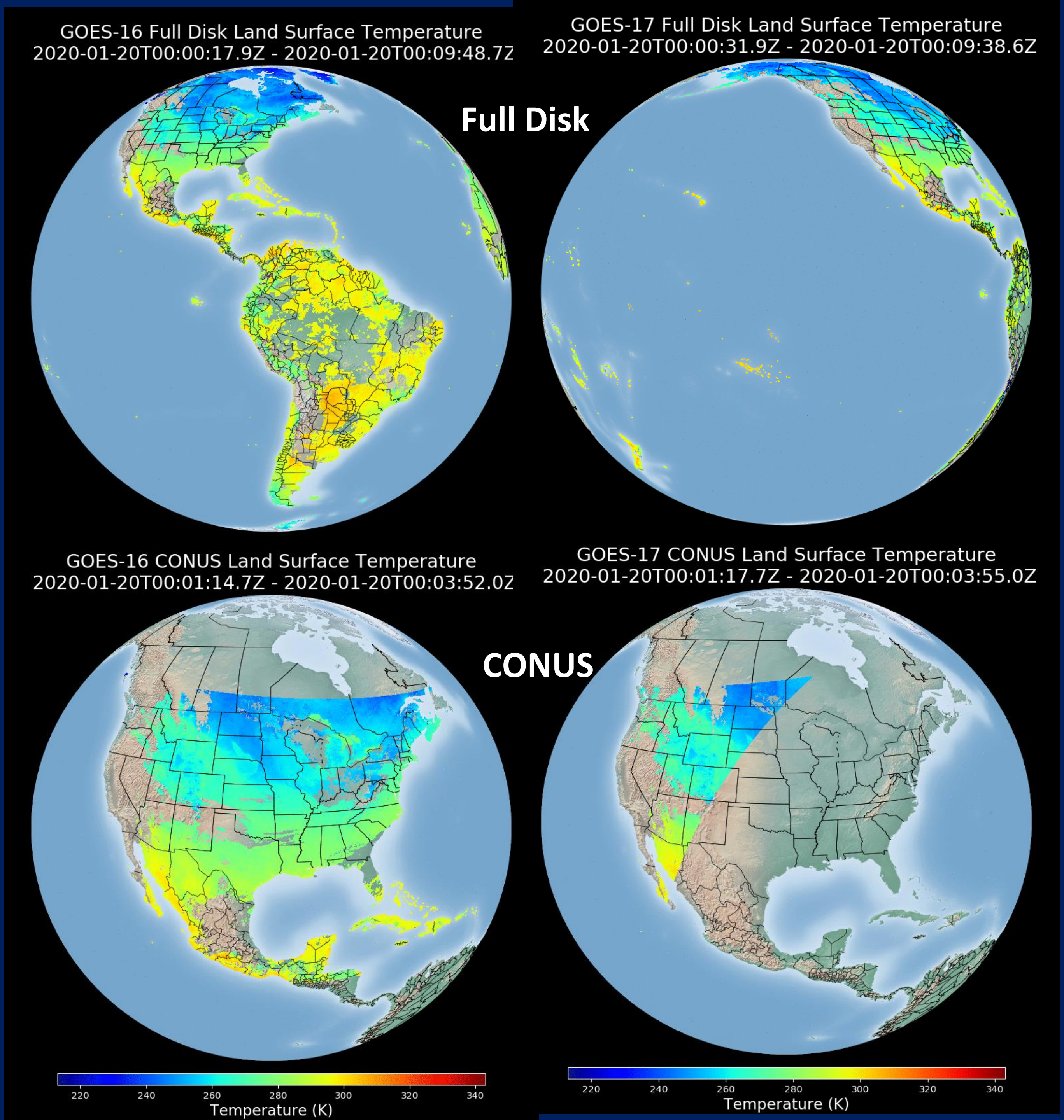
Data access:
https://www.avl.class.noaa.gov/saa/products/search?sub_id=0&datatype_family=GRABIPRD

Monitoring:
https://www.star.nesdis.noaa.gov/smcd/emb/land/index.php
ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/LTM/single/

Applications performed:
- ALEXI model exploits the mid-morning rise in **LST** from GOES to deduce the land surface fluxes, including evapotranspiration ET
- Diurnal temperatures for daily T range
- Urban air temperature model using G-16 LST

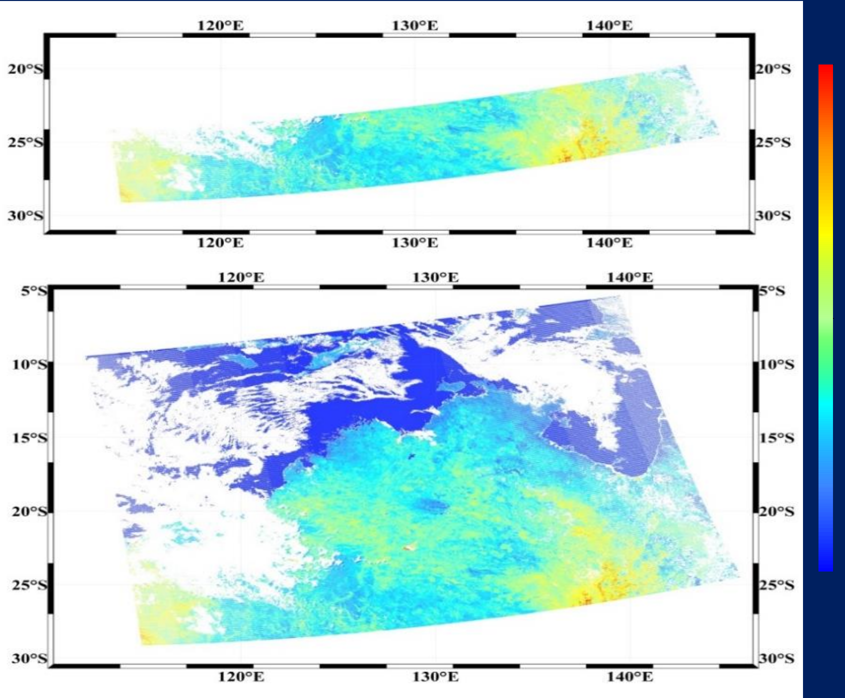
ET (mm/day) from GET-D using GOES-16 LST





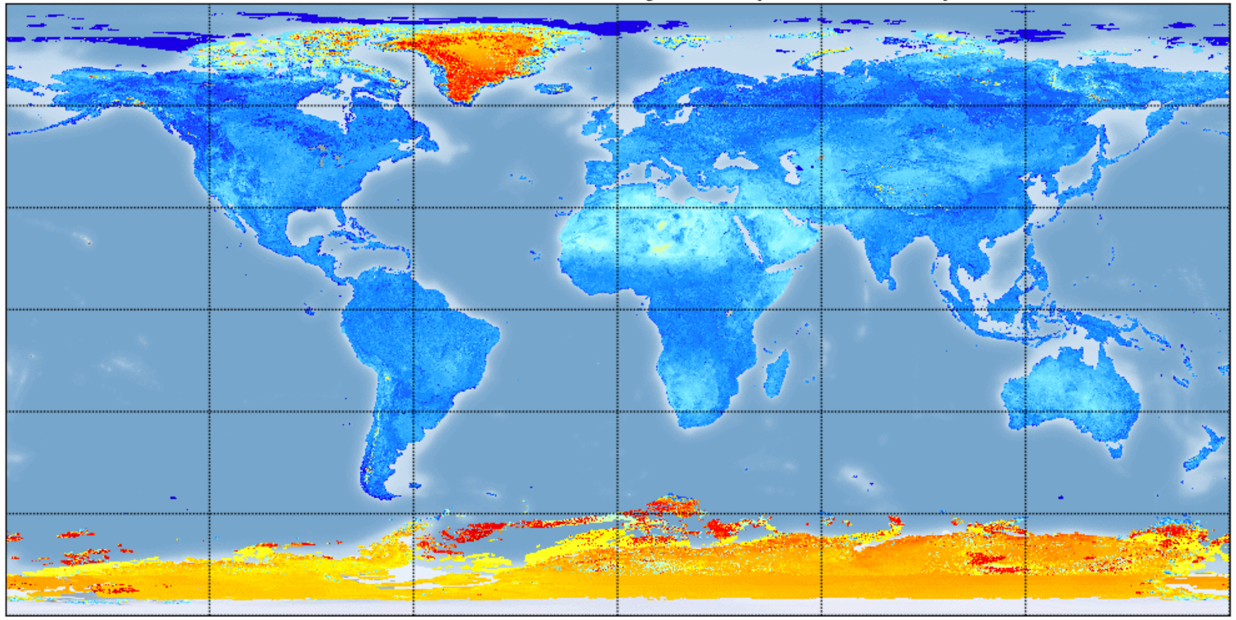
Operational ***JPSS Albedo*** Products

Orbit overpass time: 13:30/01:30;
Two granule products (750 m resolution)
— Single 1.5 min granule data; combined 4 x 1.5 min granule data
One gridded product (1 km resolution)
Format: NetCDF, HDF5
Validated Maturity: Yes
Routine monitoring : Yes
ftp://ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/LTM/LSA/single/JPSS1_VIIRS/
ftp://ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/LTM/LSA/single/SNPP_VIIRS
STAR Albedo Homepage: **https://www.star.nesdis.noaa.gov/jpss/albedo.php**
Archive: **https://www.class.noaa.gov (*search – VIIRS_EDR)**

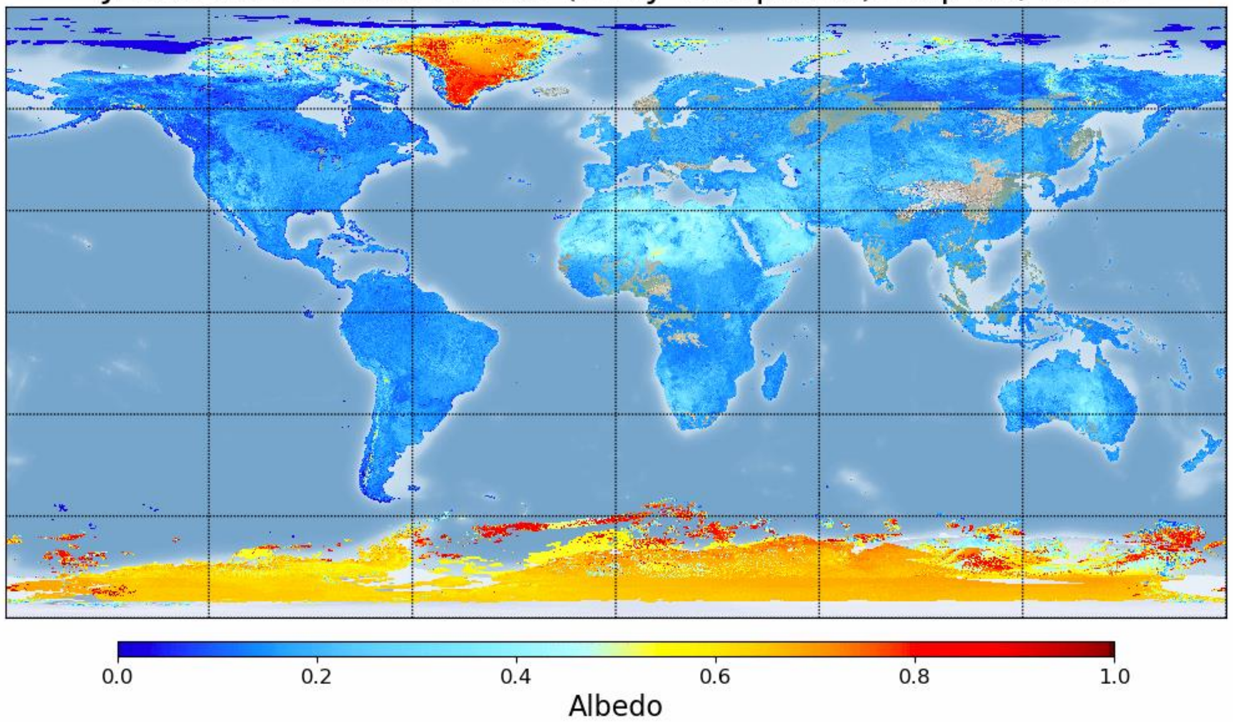


Applications Performed:
- EMC Model Albedo abnormal 7/2017
- EMC North American Land Data Assimilation System
- USDA DisALEXI model for ET estimation

SNPP VIIRS Global Albedo (Daily Composite): Sep 19, 2019



JPSS1 VIIRS Global Albedo (Daily Composite): Sep 19, 2019



Operational VI/GVF Products

Vegetation Index: TOA NDVI, TOC NDVI and EVI; daily, weekly, and 16-day composite.

Green Vegetation Fraction: daily rolling weekly

Resolution: global 4 km; regional 1 km

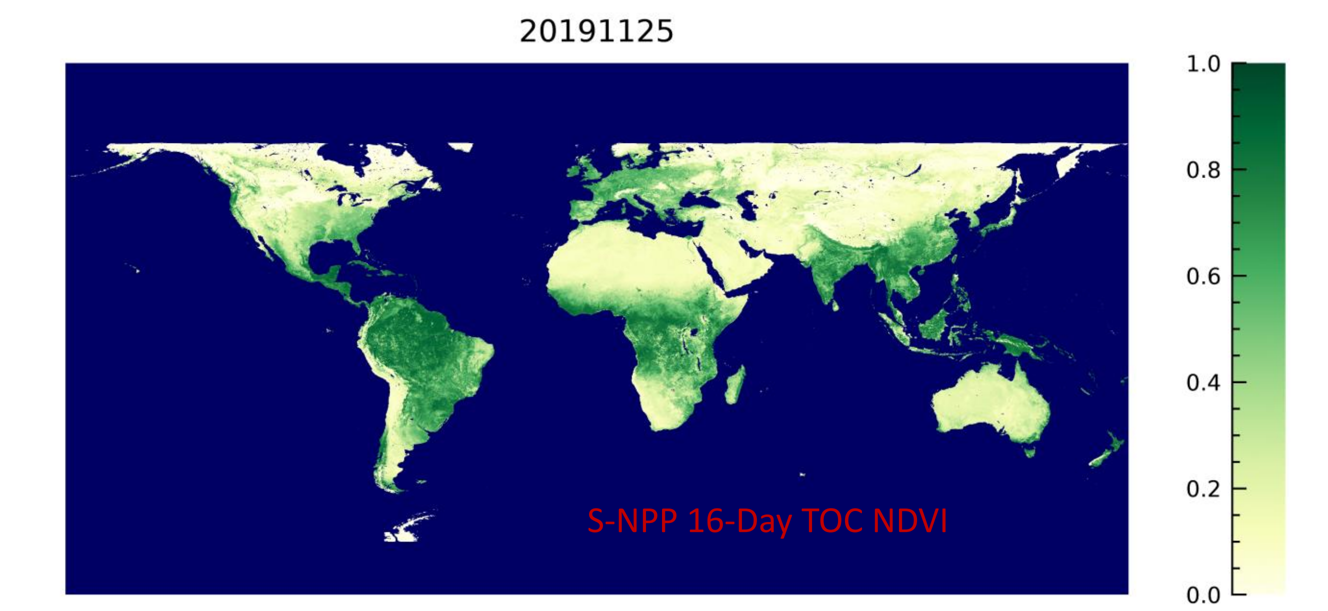
Format: NetCDF

Validated Maturity: Due in Mar 2020

Routine monitoring : draft developed

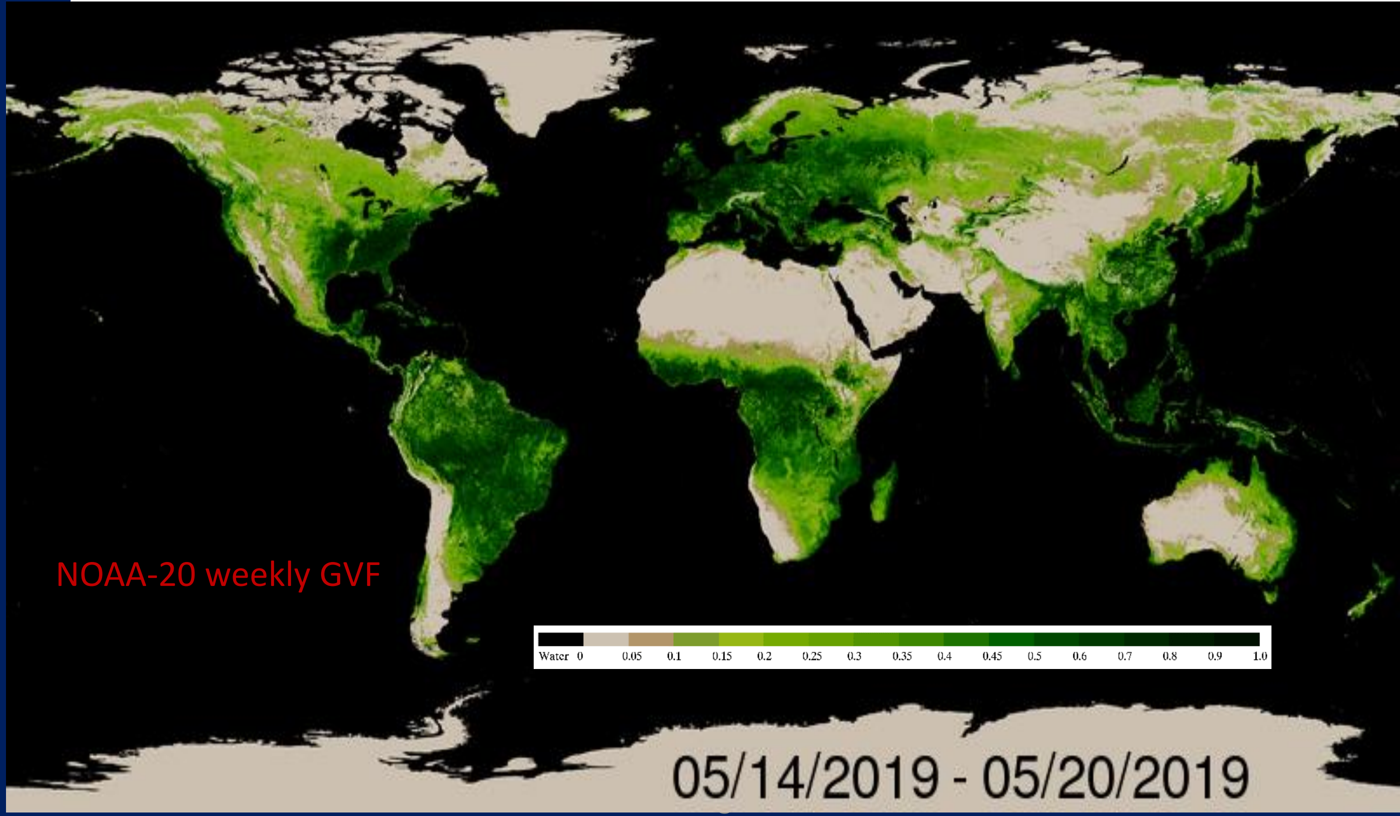
STAR LST Homepage:
https://www.star.nesdis.noaa.gov/jpss/EDRs/products_VegIndex.php

Archive: **https://www.class.noaa.gov (*search – VIIRS_EDR)**



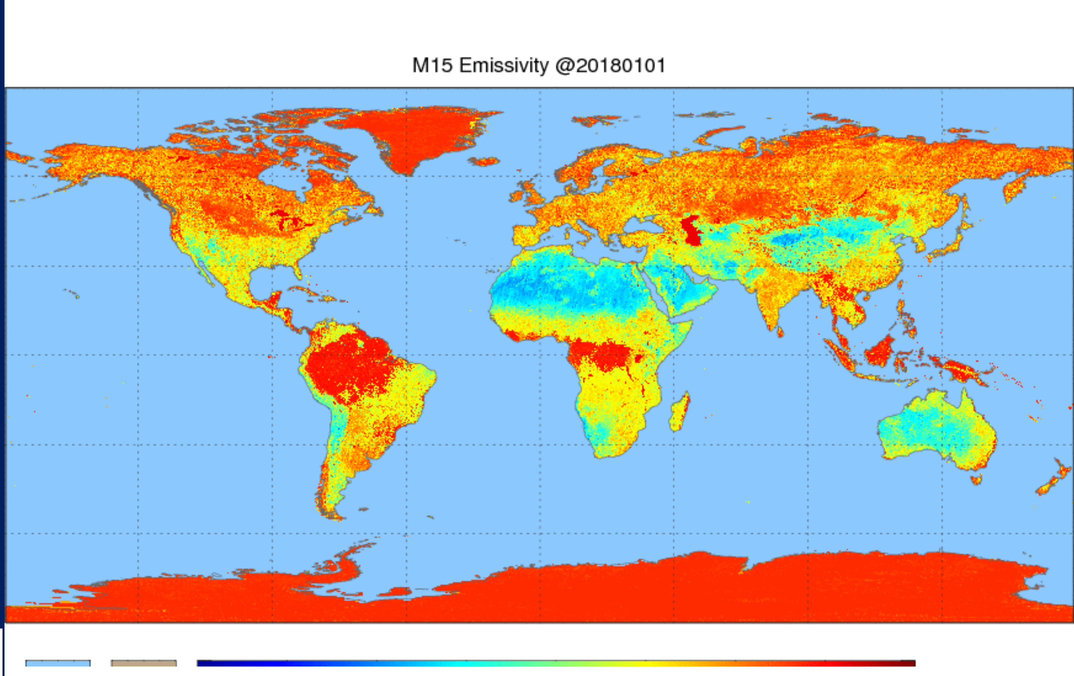
Applications Performed:

- Test of using GVF in Noah land surface model in EMC
- Test of using GVF in NCEP GFS, positive impact of reducing error
- ESRL HRRR model used GVF to replace MODIS climatology.
- NASA SpoRT used VIIRS GVF over CONUS for anomaly response analysis; also the data are available now within WRF NWP model and UEMS/WRF modeling framework
- VIIRS VI data are used for Burned Area Emergency Response , and post fire, flash flood and debris flow assessment



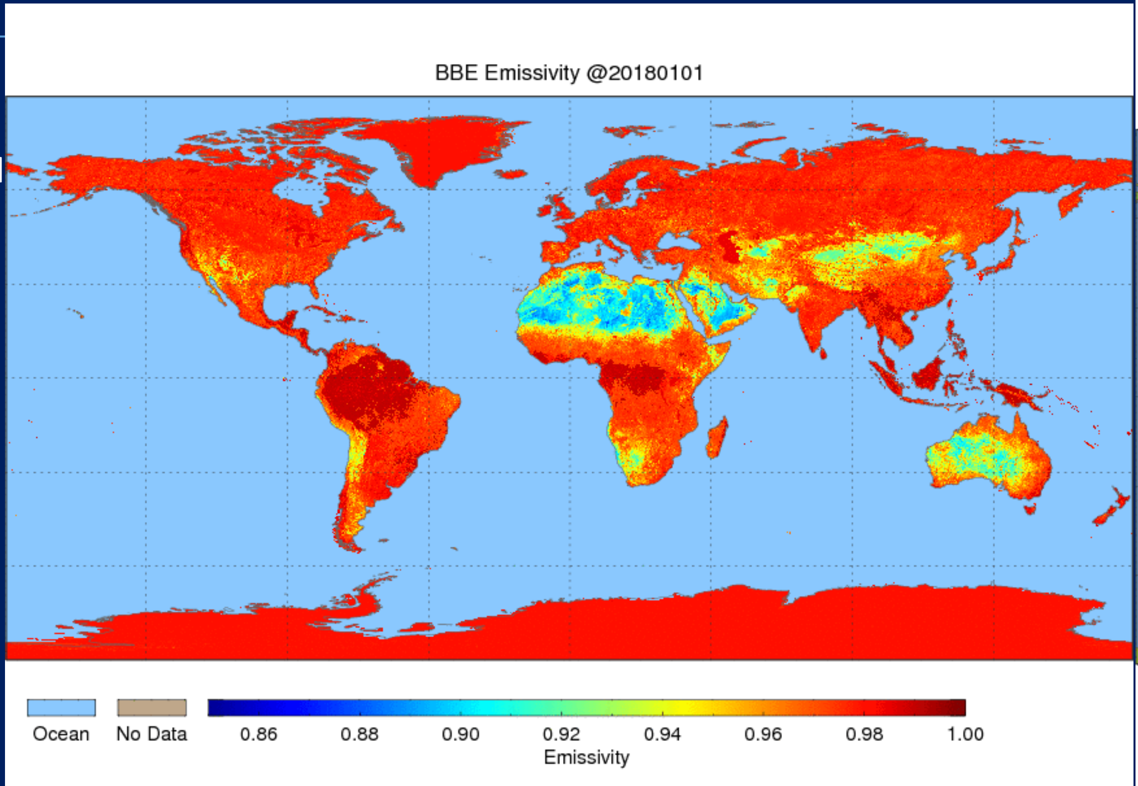
NOAA Land Surface Emissivity Product

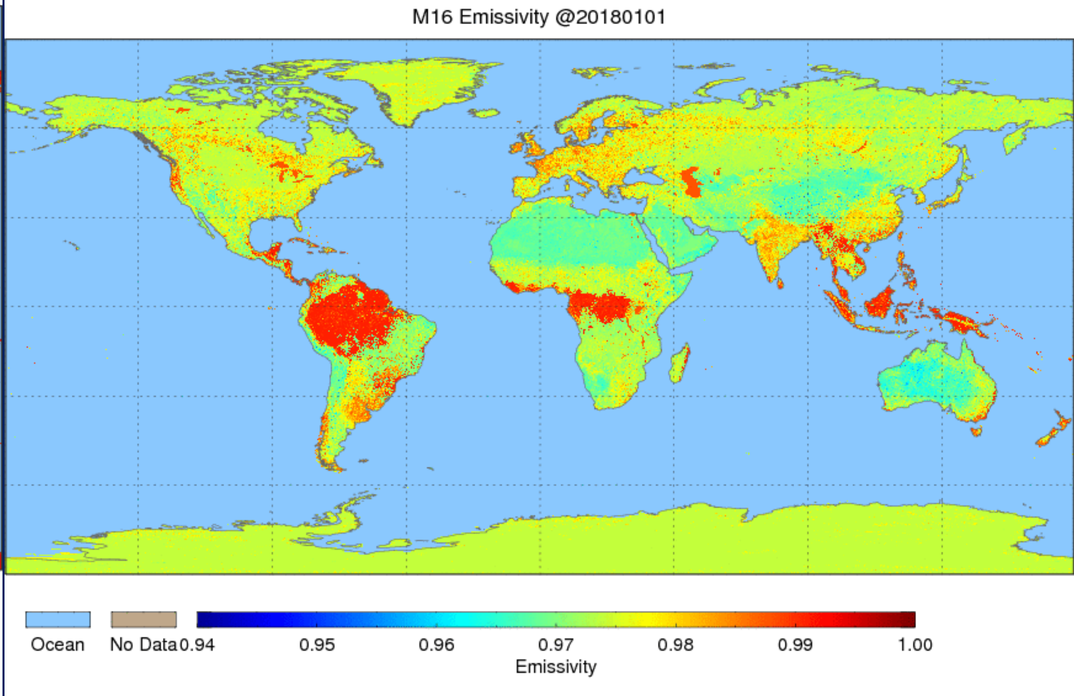
- Based on vegetation cover method (VCM)
- Bare ground emissivity is derived from multi-year averaged ASTER & MODIS LSE product.
- Use VIIRS green vegetation fraction (GVF) and snow fraction to account for the LSE dynamic change.
- Daily product at 1km resolution, including VIIRS and ABI split channels LSE and a broadband emissivity (BBE).
- Pixel based uncertainty is provided, with overall uncertainty of 1.5%.



LSE Status in NOAA

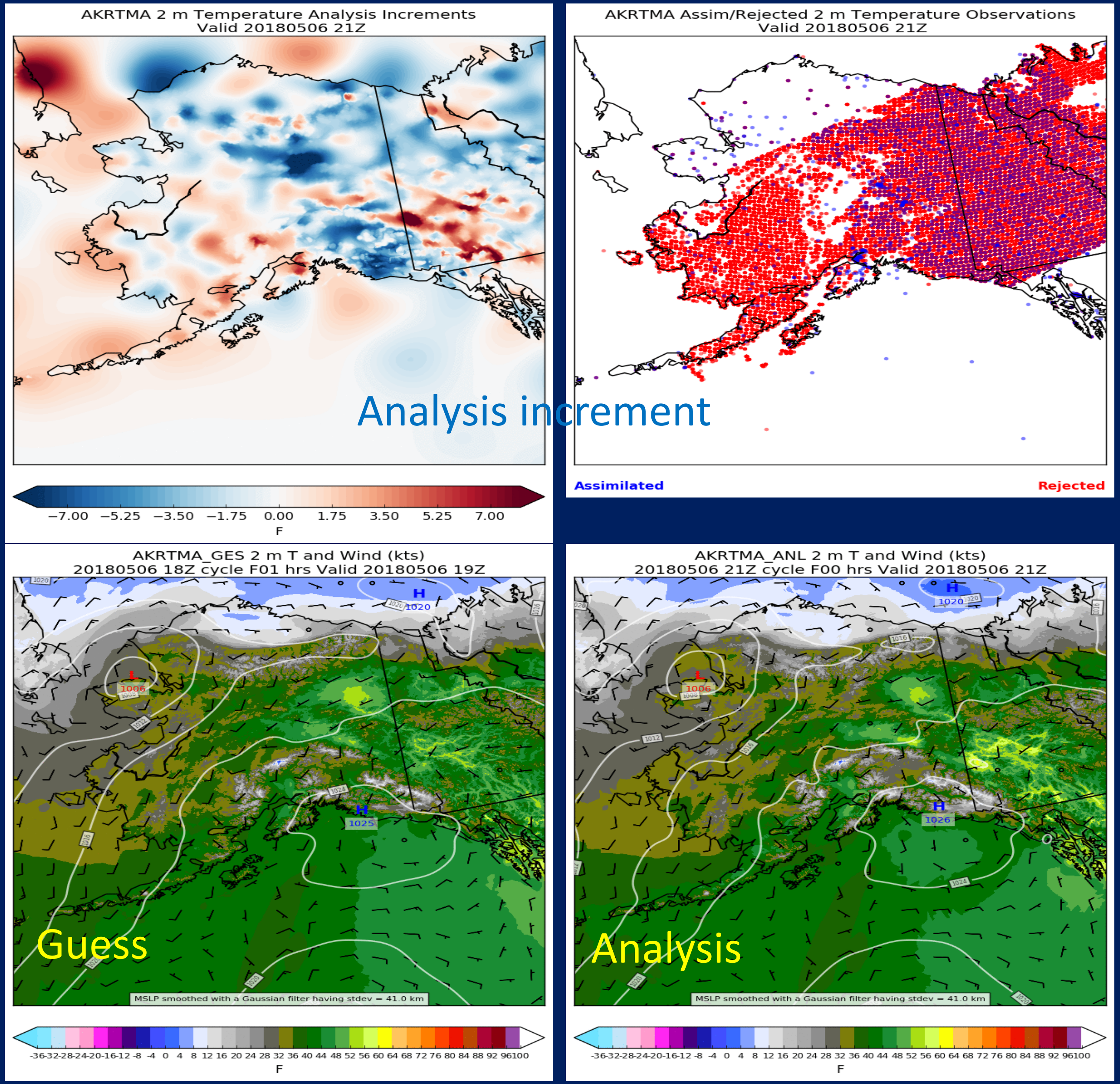
- Locally produced
- Operationally used in S-NPP and NOAA20 VIIRS LST product.
- Will be applied in GOES16/17 LST product.
- Broad band emissivity is under test in NOAA GFS and NAM model.





Back Up Slides

RTMA/URMA system data assimilation using VIIRS LST



(Top left) The analysis increment shows the difference between the adjusted T2M after/before LST assimilation. Red color indicates an increased model T2M, blue color indicates a decreased T2M.

(Top right) quality control results: red dot for pixels fail the quality control; blue dots for pixels selected for assimilation

(Bottom left)

Model T2M before data assimilation

(Bottom right) Model T2M after LST assimilation

The bottom two surface weather map show the adjust of T2M field looks reasonable.

Application of VIIRS LST on downscaled SM product development-2

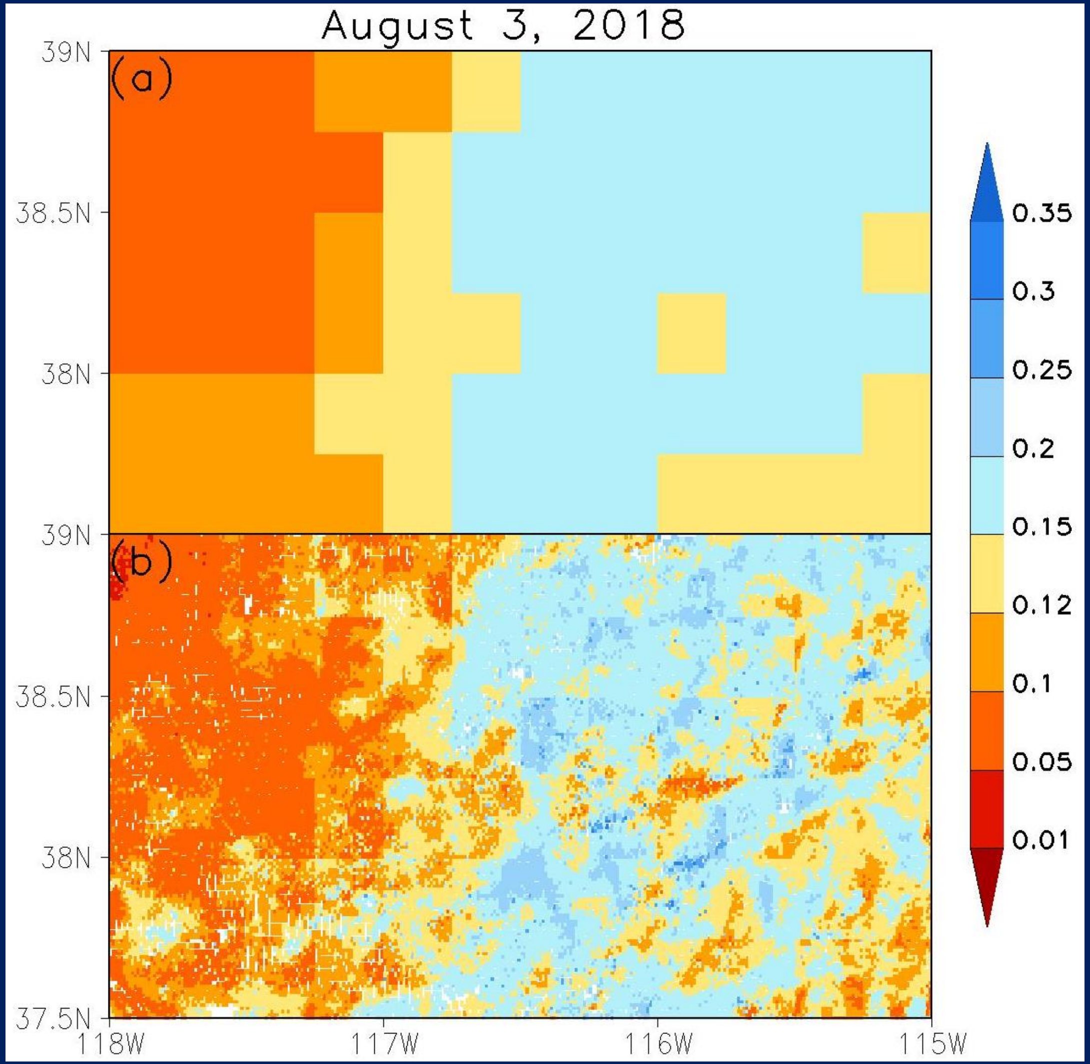


Fig.2 Sample maps for (a) SMAPV5 25 km and (b) the downloaded 1 km SMAP SM retrievals on August 3, 2018.

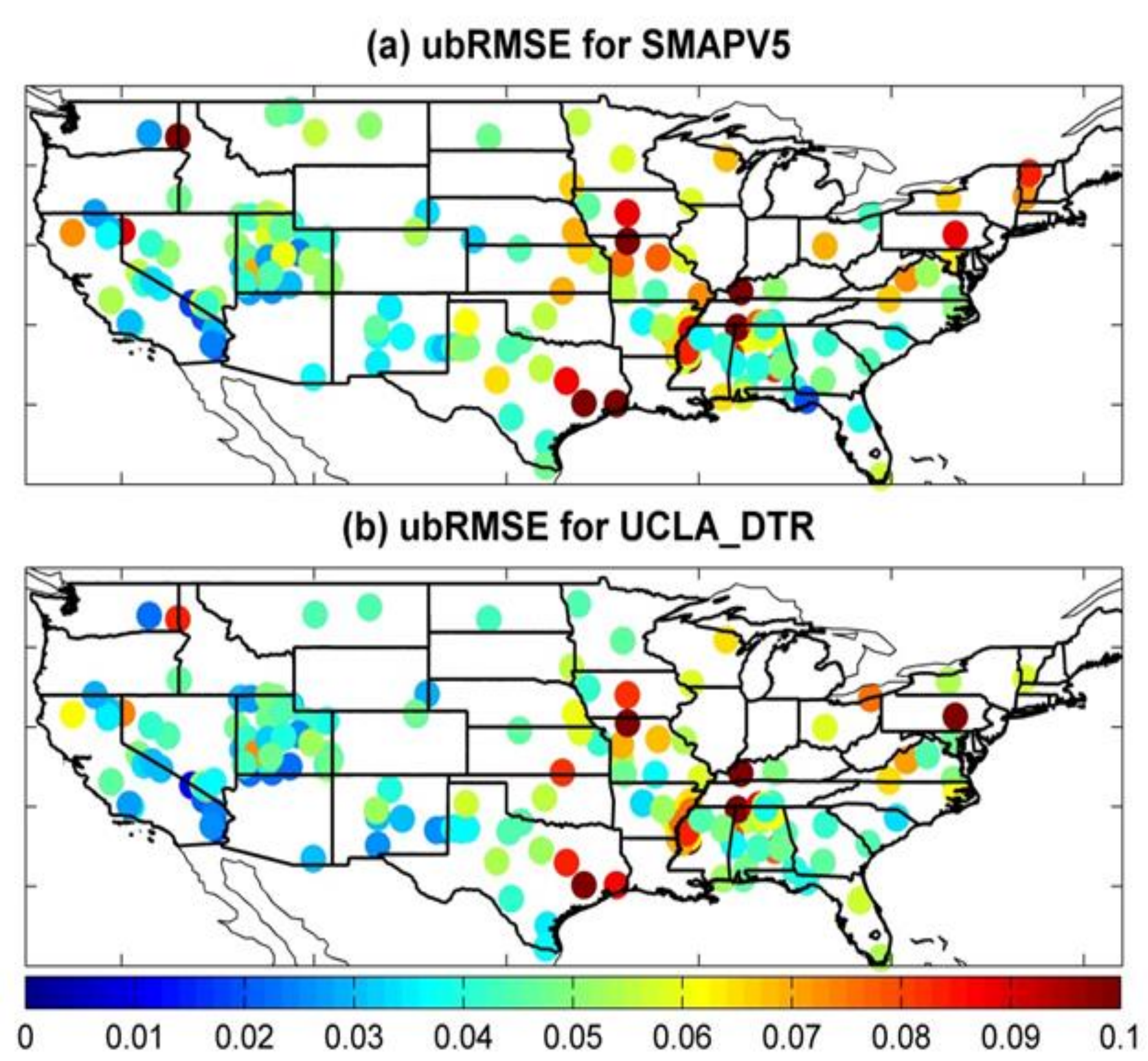
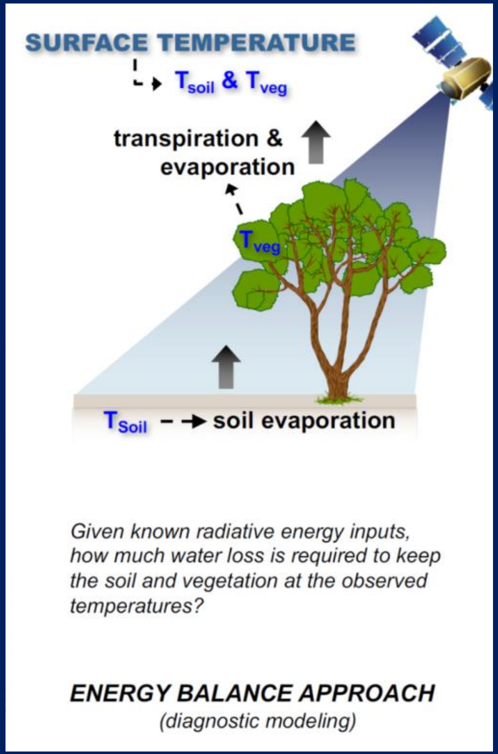
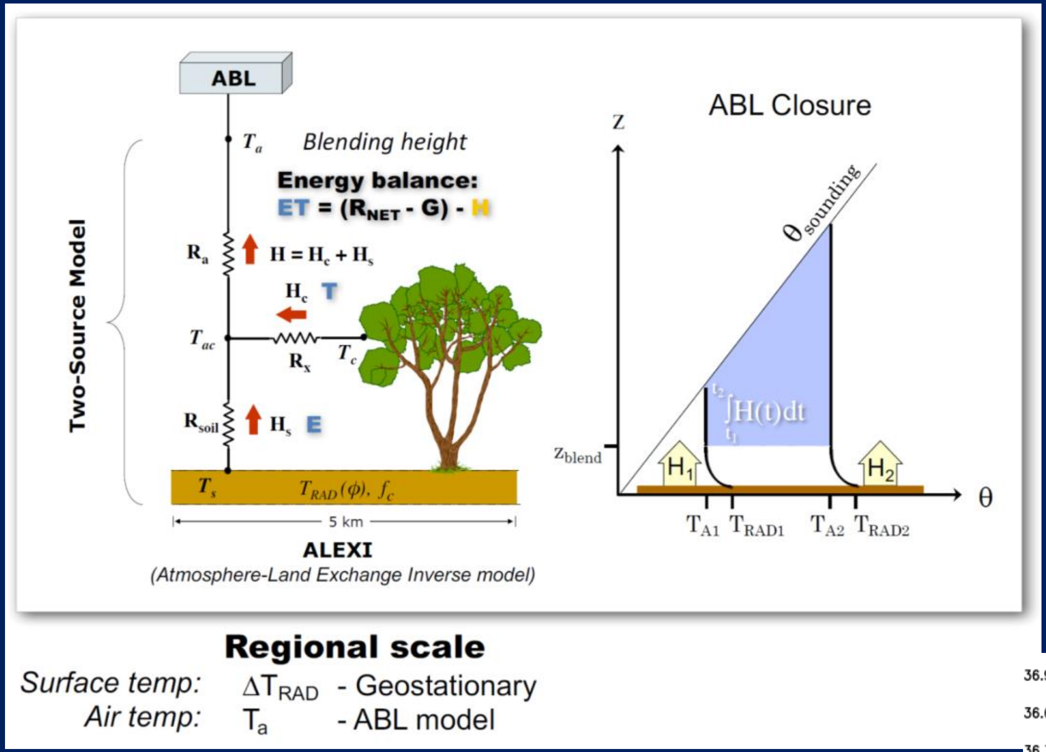


Fig. 3 With respect to the quality controlled in situ observations, ubRMSE (Unit: m^3/m^3) for (a) SMAPV5 25 km and (b) UCLA_DTR 1 km SM estimations over the 3 May 2017 to 30 April 2019 period.

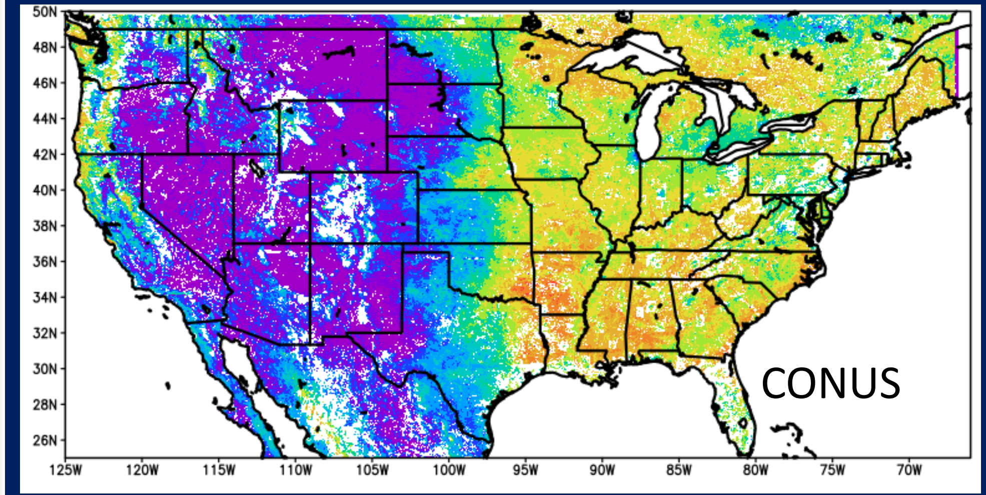
User Application Example

Application in Evapotranspiration Product

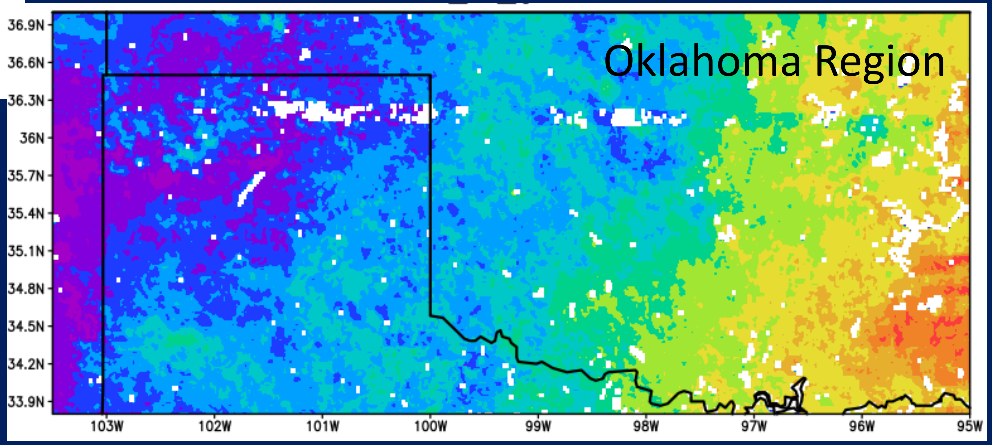


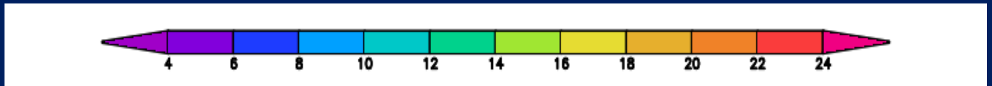


ET (mm/day) from GET-D using GOES-16 LST



One Month: July 2017

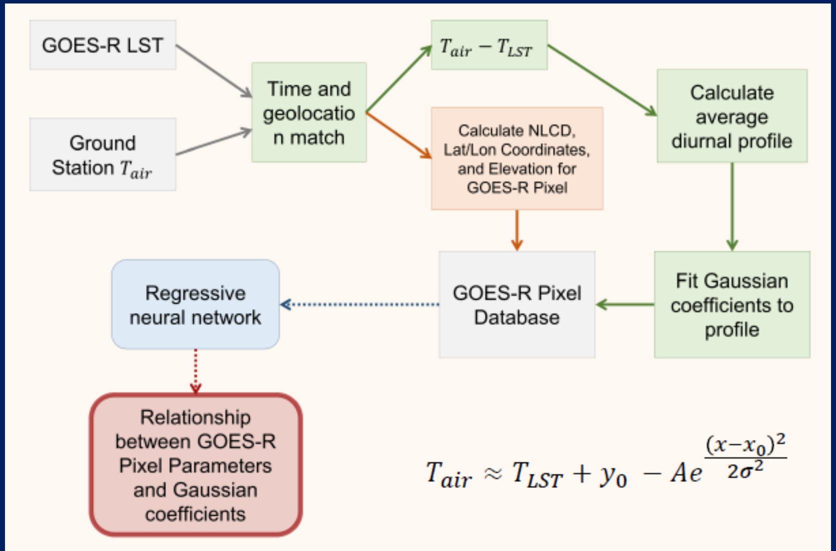




- ALEXI model exploits the mid-morning rise in **LST** from GOES to deduce the land surface fluxes, including evapotranspiration ET
- A simple evaporative stress index (ESI), the ratio of actual-to-potential ET (f_{PET}), can then be computed from ALEXI ET estimates to represent surface soil moisture status; Negative ESI anomaly may indicate drought occurrence

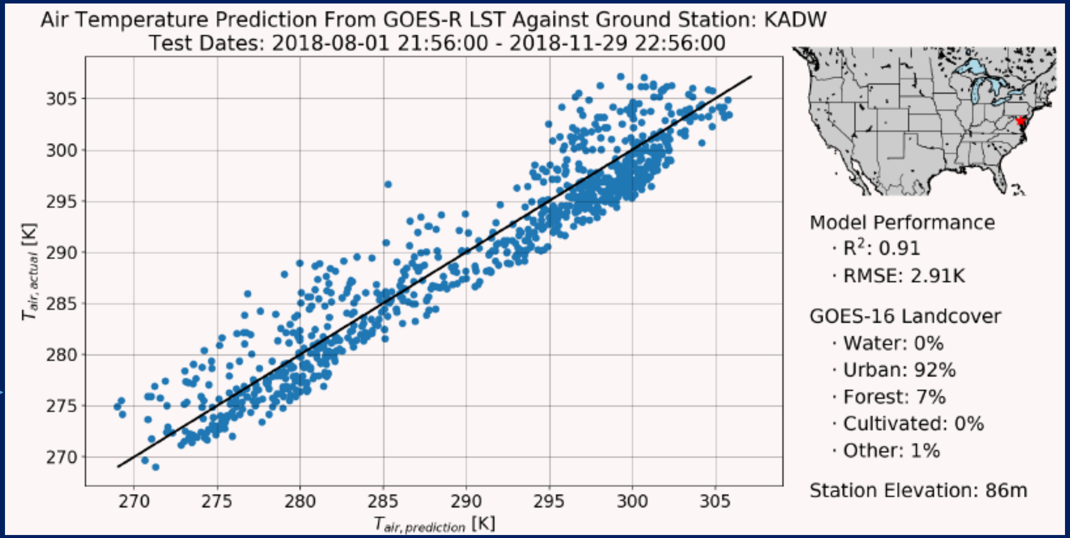
User Application Example

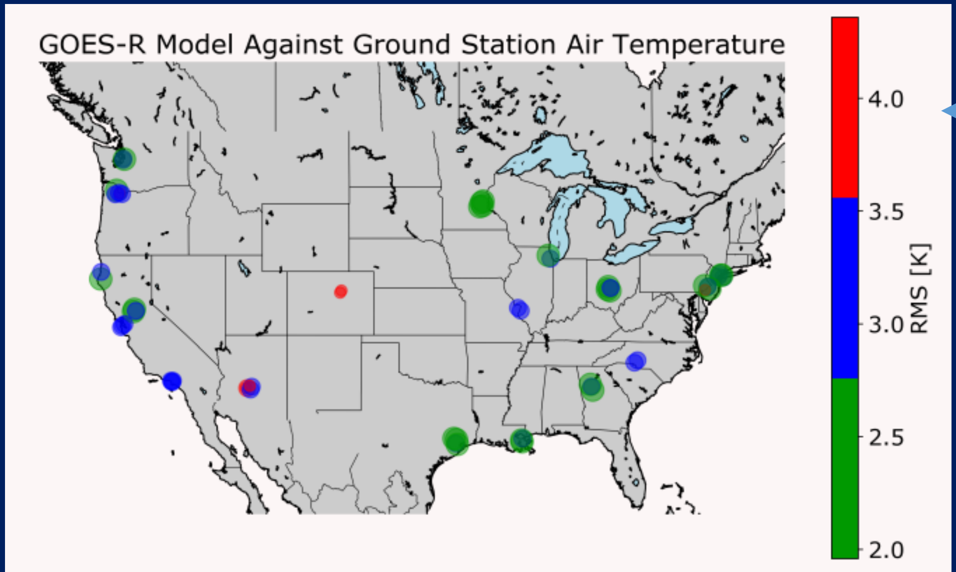
Urban Air Temperature Model Using GOES-16 LST



Methodology and flow diagram

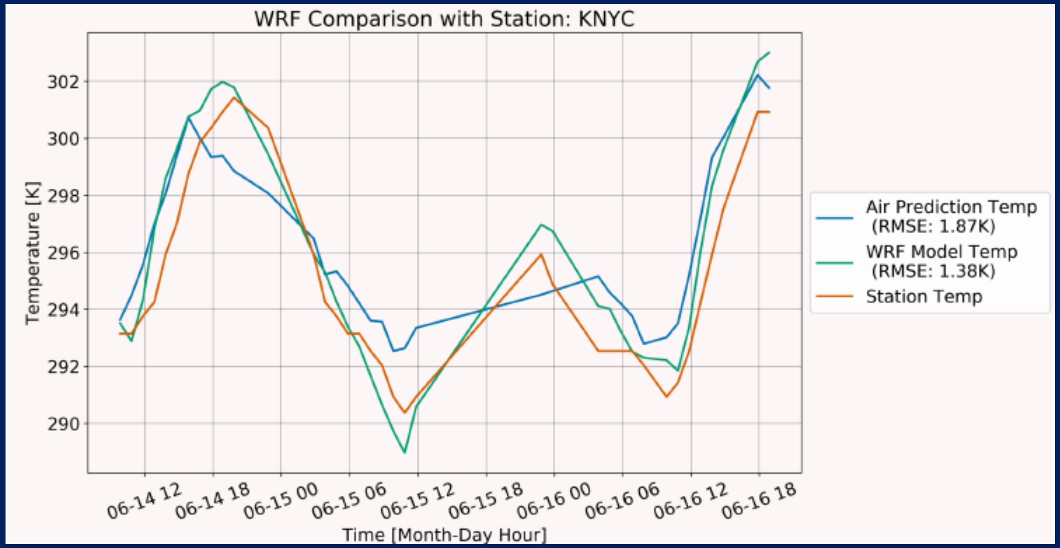
Air temperature performance at a station in Washington DC





Nationwide Statistics

WRF model air temperature compared to GOES-R air temperature prediction and in-situ observations



Satellite Land Data Products for NWP and NWM

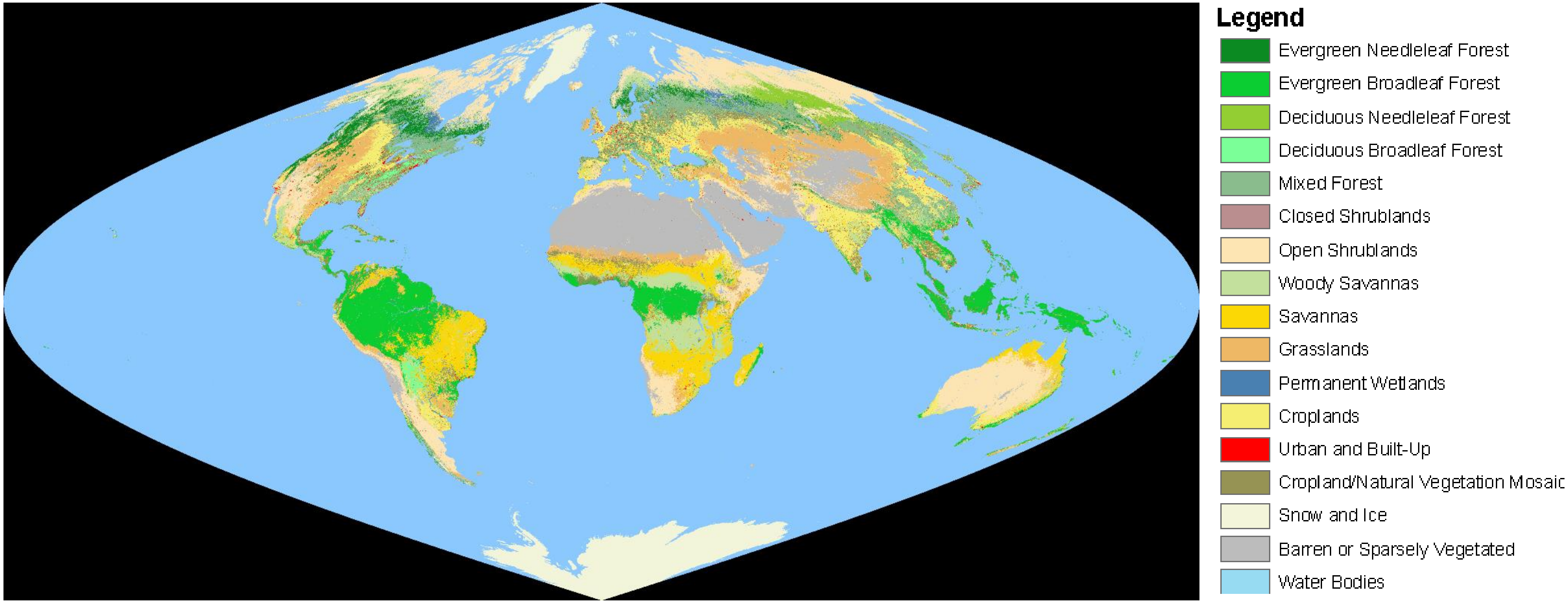
Xiwu Zhan, NESDIS STAR Land Applications Science Team Lead

- JPSS VIIRS Annual Surface Type
- Soil Moisture Operational Product System (SMOPS)
- GOES Evapotranspiration and Drought (GET-D)
- High-resolution Soil Moisture
- Soil Moisture Data Assimilation

VIIRS Annual Surface Type 2018

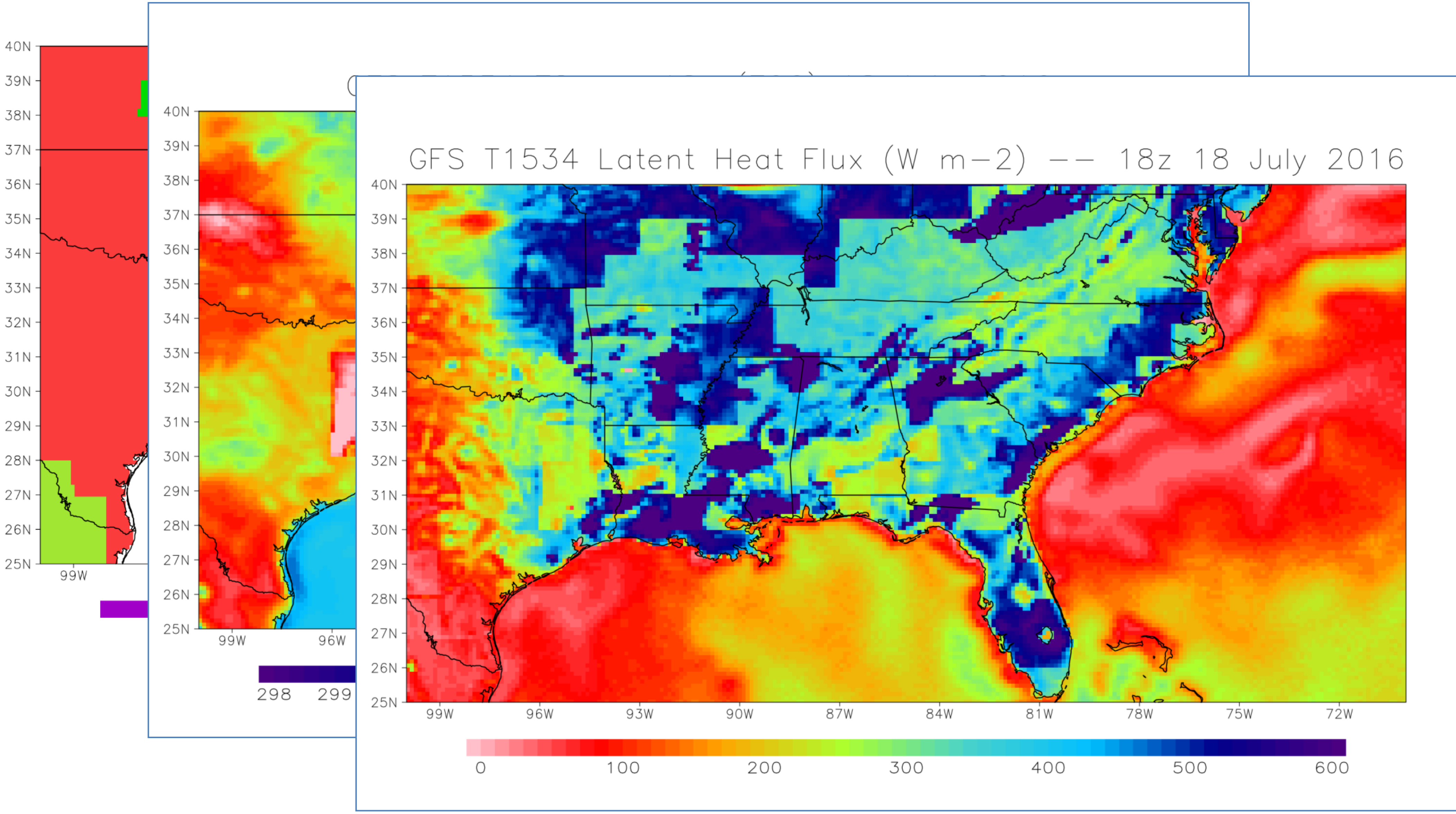
- Generated using 2018 VIIRS data acquired between:
  - 1/1/2018 – 12/31/2018
- Available in two projections:
  - Sinusoidal and Lat/long
- **VIIRS Global Annual Surface Type (AST):** The new VIIRS Annual Surface Type 2018 product (AST-2018, spatial resolution: 1km) based on 2018 whole year surface reflectance data is ready for users to download at the following FTP sites:

  GST-2018: sinusoidal projection - *FTP site*
  GST-2018: lat/lon projection - *FTP site*
  GST-2018: 20Types for NCEP-EMC NWP models - *FTP site*

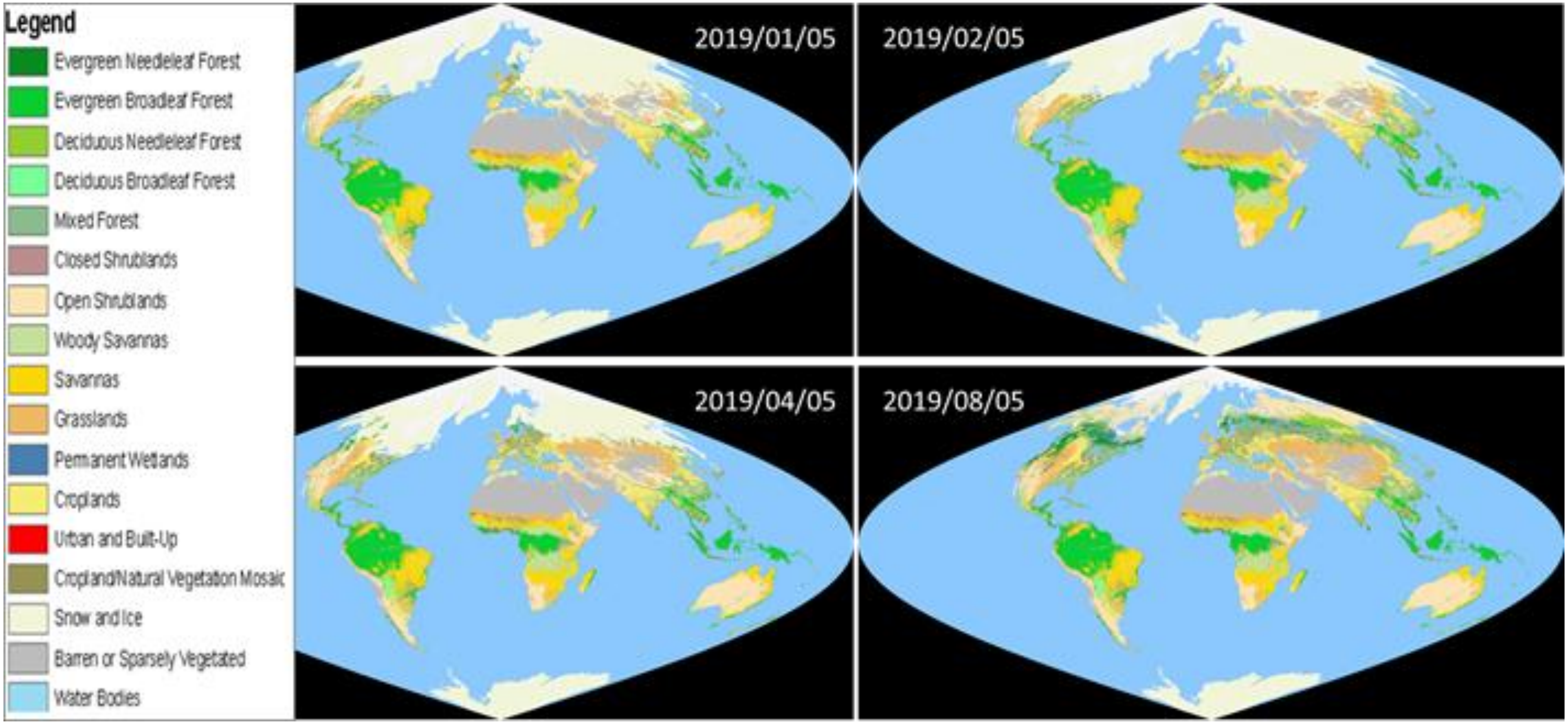


Why Surface Type

Surface Type Plays Important Roles in NWP models



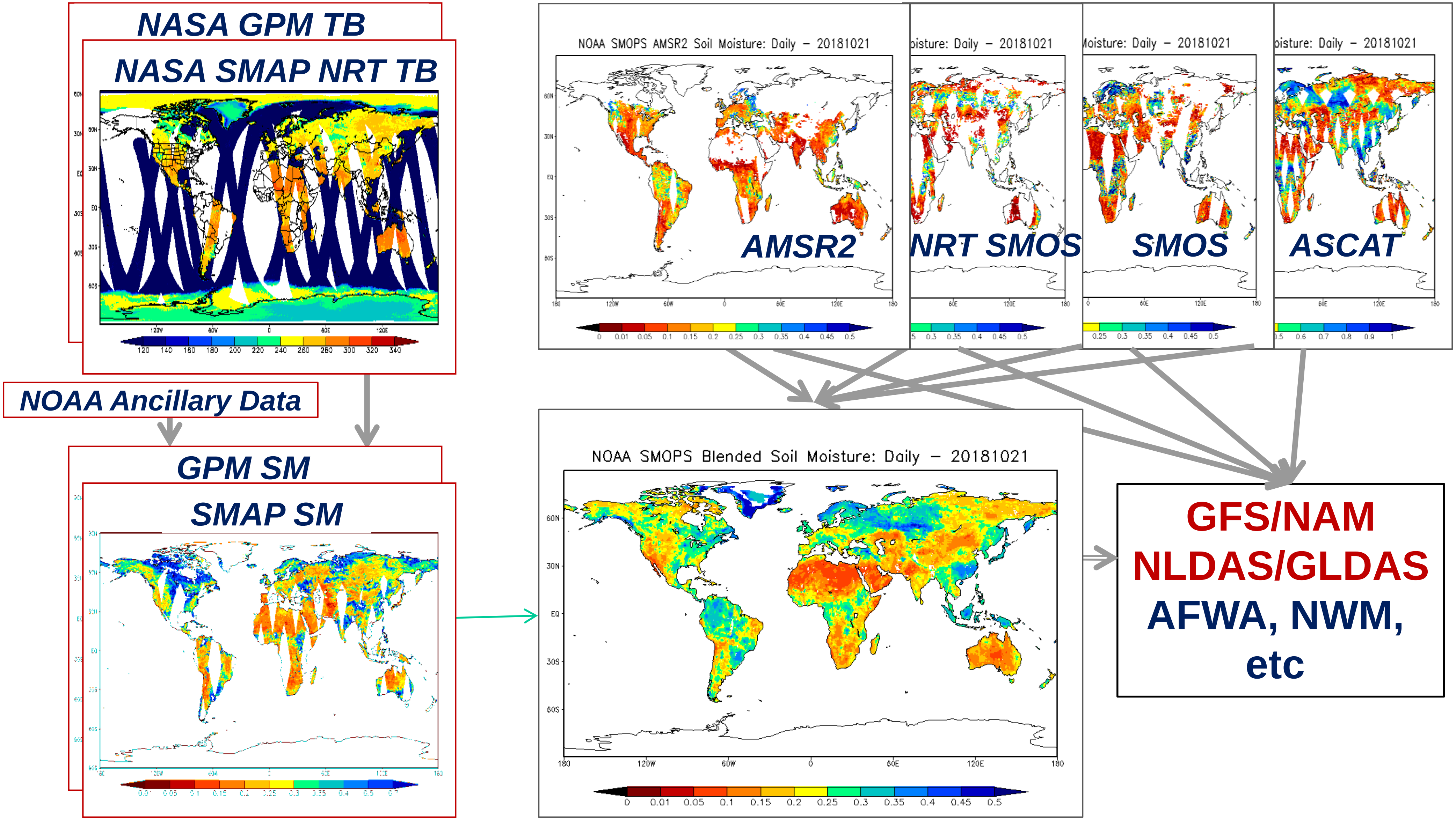
VIIRS Daily Surface Type



- Annual surface type covers long term changes
- Short term changes include snow, burn scar, flooded area, etc
- An integrated daily surface type product is being tested

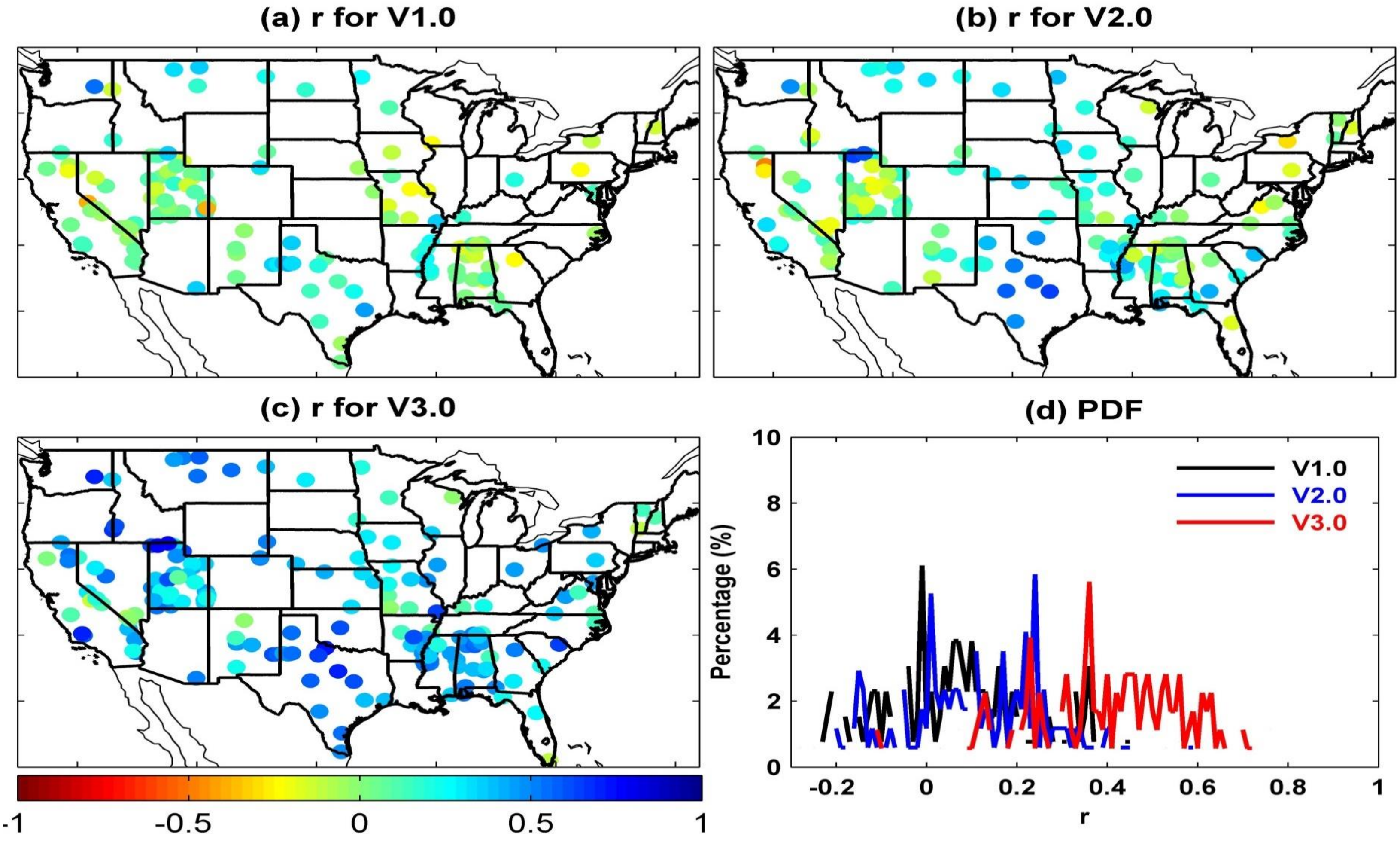
See Poster 12 by Chengquan Huang: Global Surface Type Products from VIIRS

Soil Moisture Operational Product System
SMOPS 3.0



Yin, J., Zhan, X., Liu, J., & Schull, M. (2019). An intercomparison of Noah model skills with benefits of assimilating SMOPS blended and individual soil moisture retrievals. *Water Resources Research*, *55*. https://doi.org/10.1029/2018WR024326.

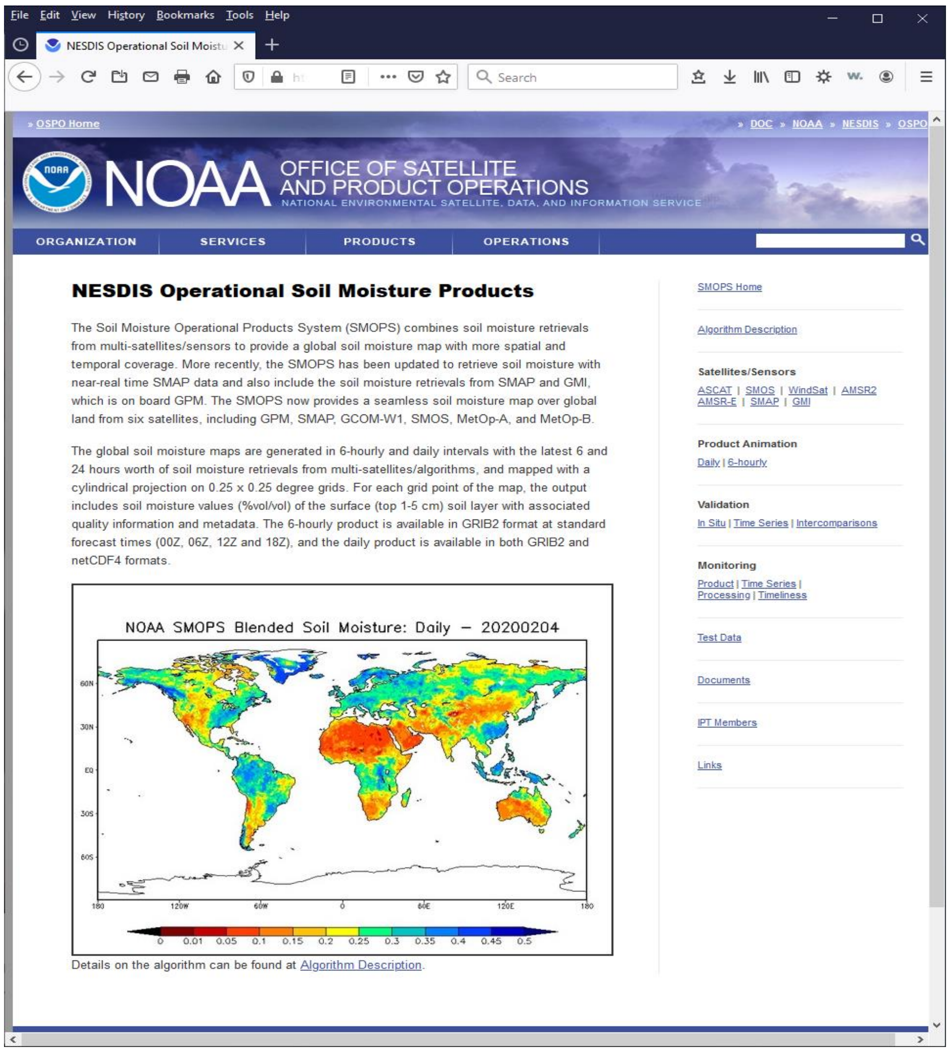
SMOPS Product Versions



V1.0 from 01 June 2007 to 03 Nov. 2010
V2.0 from 16 Nov. 2010 to 20 Sept. 2016
V3.0 from 1 April 2015 to most recent

NOAA Soil Moisture Operational Product System (SMOPS)

http://www.ospo.noaa.gov/Products/land/smops/index.html



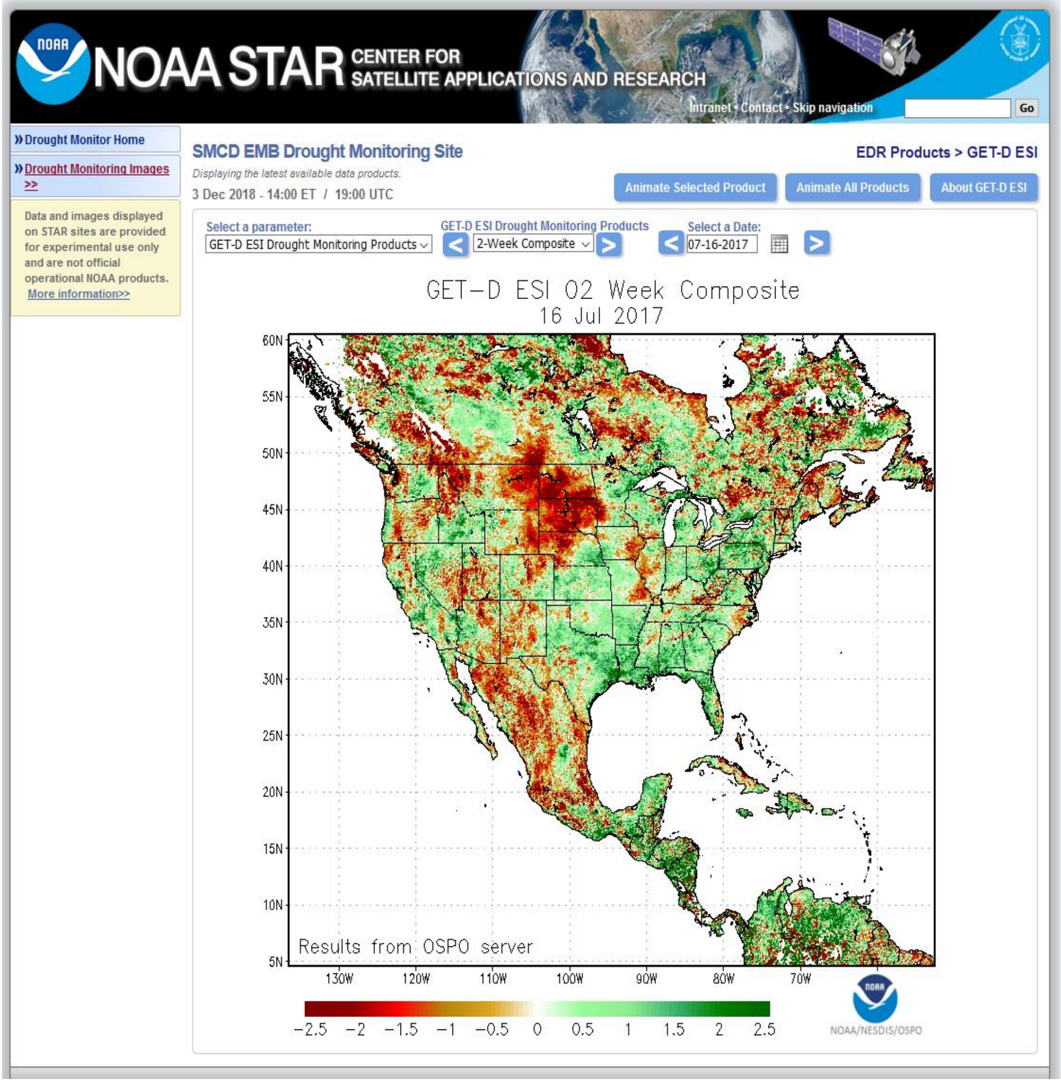
- **Developed by NOAA/NESDIS/STAR**
- **In operation at NOAA/NESDIS/OSPO**

Operational data access contact: Limin.Zhao@noaa.gov

Science and historical data contact: xiwu.zhan@noaa.gov, yanjuan.guo@noaa.gov

GOES Evapotranspiration and Drought Product System (GET-D)

- Regional daily ET at 8km has been generated from GOES-13 and GOES-15 thermal infrared (TIR) data via GET-D using the Atmosphere-Land Exchange Inversion (ALEXI) model
- Daily ET is converted to Evaporative Stress Index (ESI) that represents soil moisture status
- Negative ESI is used to monitor drought early warning and occurrence
- GET-D is being updated to generate ET and ESI from GOES-16/17 ABI 2km observations



See Poster 13 by Li Fang: An Evapotranspiration Product at 2-km resolution from NOAA GOES-16

Downscaled High Resolution Soil Moisture

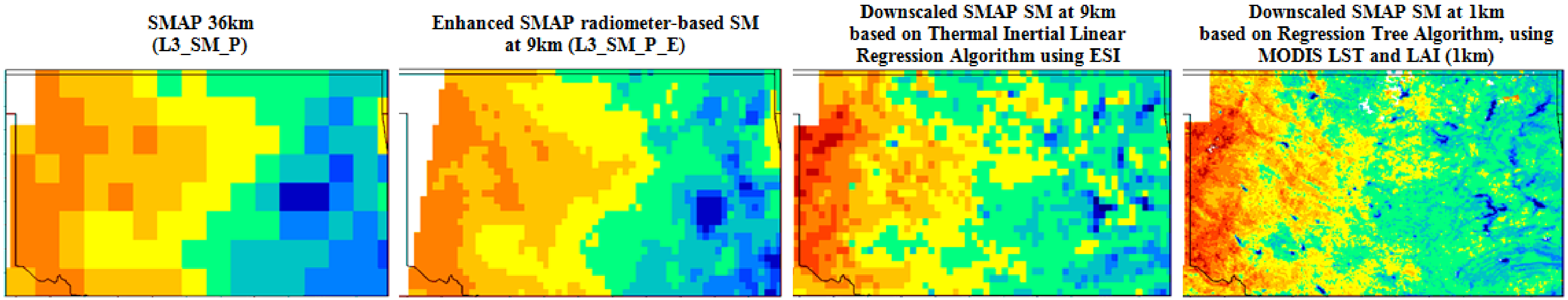


Figure 1. Comparison of SMAP SM data sets to be validated, over Oklahoma region (100.15W~ 94.53W, 34.2N~37.06N), on April 30th, 2015, including 1) SMAP SM product at 36km (L3_SM_P); 2) Enhanced SMAP radiometer-based SM at 9km (L3_SM_P_E); 3) Downscaled SMAP SM at 9km based on ESI; 4) Downscaled SMAP SM at 1km based on Regression Tree Algorithm, using MODIS LST and LAI (1km)

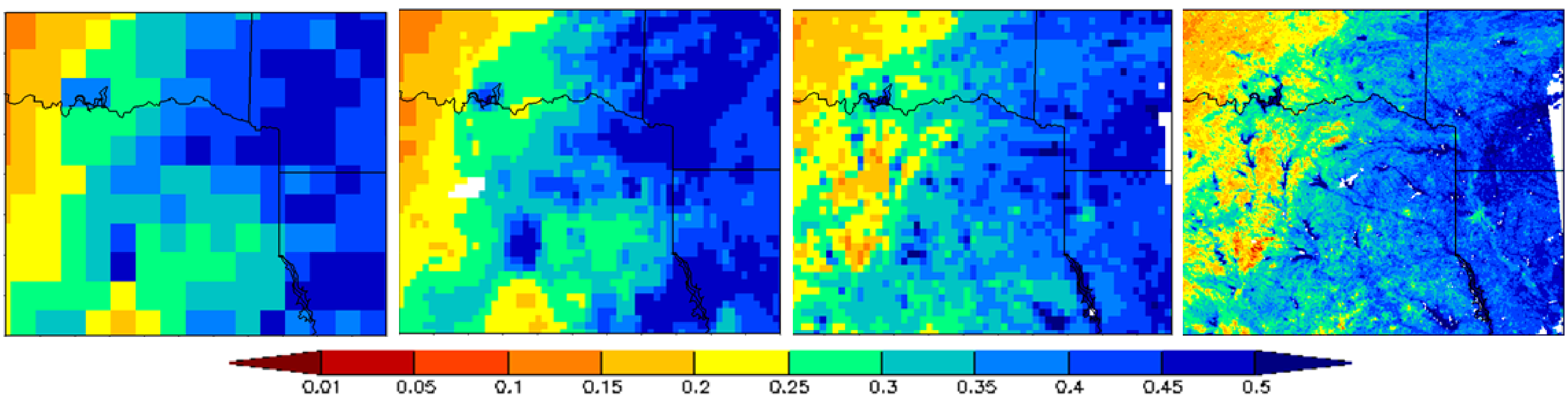
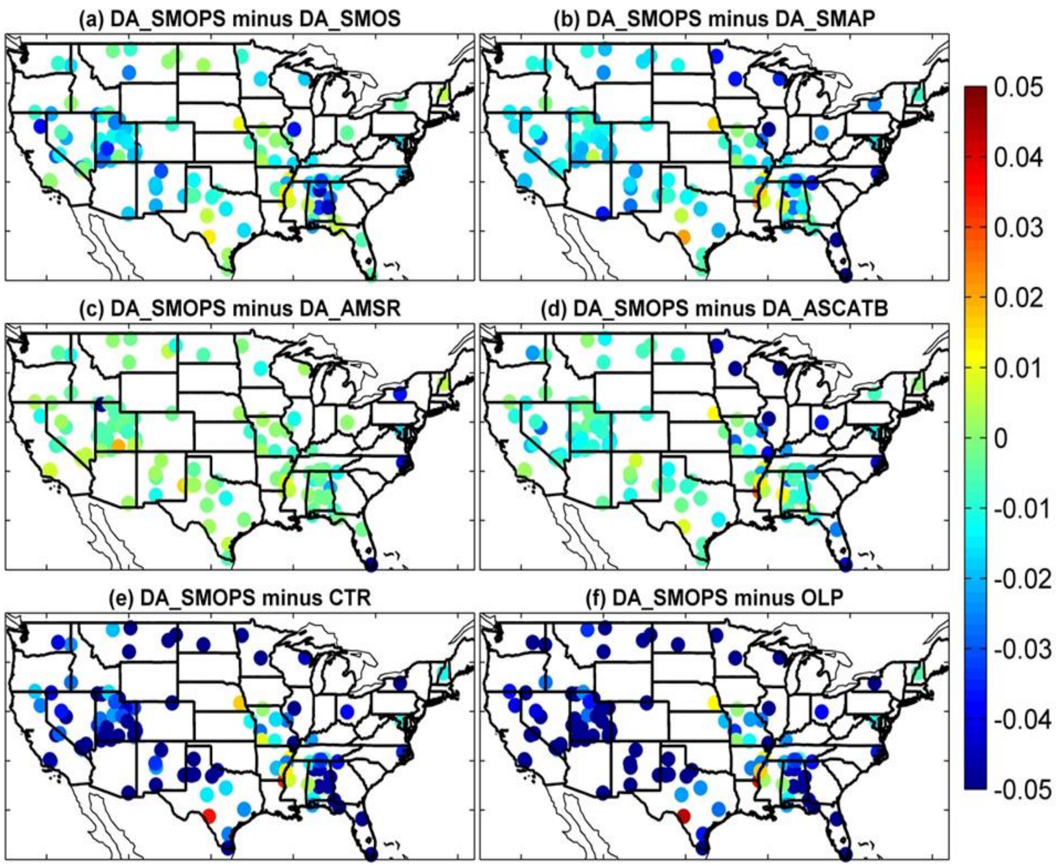


Figure 2. Comparison of SMAP SM data sets to be validated, over Texas region (98W~ 92.5W, 31N~35N), on April 2nd, 2016, including 1) SMAP SM product at 36km (L3_SM_P); 2) Enhanced SMAP radiometer-based SM at 9km (L3_SM_P_E); 3) Downscaled SMAP SM at 9km based on ESI; 4) Downscaled SMAP SM at 1km based on Regression Tree Algorithm, using MODIS LST and LAI (1km)

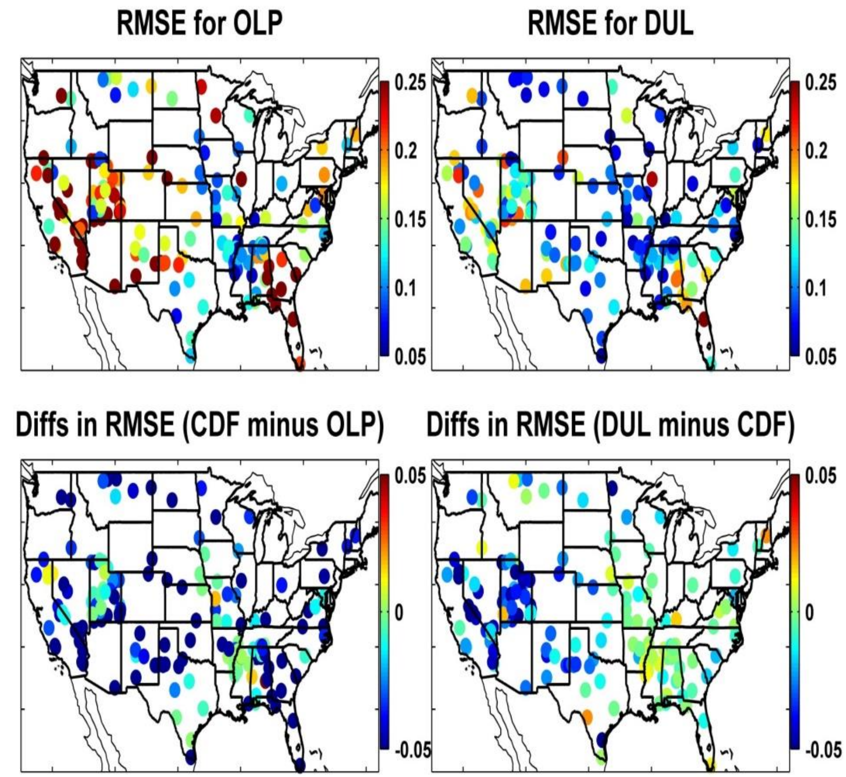
See Poster 9 by Jifu Yin: Near Rear Time 1 km SMAP Soil Moisture Data Product for Potential Use in National Water Model

Soil Moisture Data Assimilation with Noah LSM



RMSE differences of Noah LSM top-10cm soil moisture simulations after assimilating satellite products evaluated against SCAN measurements during 1 April 2015 -30 June 2017 period.

More blue indicates improvement



Noah LSM simulation evaluations with or without assimilating SMOPS soil moisture evaluated against SCAN measurements: (a) RMSE of Noah LSM OLP run, (b) RMSE of DUL DA case, (c) RMSE differences between CDF DA case and OPL run, and (d) RMSE differences between DUL and CDF DA cases over the 1 April 2015 - 31 March 2018 period.

More blue indicates improvement

Yin, J., Zhan, X., Liu, J., & Schull, M. (2019). An intercomparison of Noah model skills with benefits of assimilating SMOPS blended and individual soil moisture retrievals. *Water Resources Research*, *55*. https://doi.org/10.1029/2018WR024326.

SUMMARY:

- ❖ Several land products from JPSS and other satellites have been generated for NWP and NWM users
- ❖ Surface type and soil moisture products are consistently available with good quality
- ❖ High-resolution soil moisture is being tested
- ❖ ET and drought products from GET-D is being tested
- ❖ Land data assimilation algorithms and implementation at NCEP and NWC needs further investigation and transition efforts

THANKS!

Vegetation Health
1981-2020
APLICATIONS

Felix Kogan, Wei Guo, Wenze Yang

Feb 25, 2020

Vegetation Health

COVERAGE

40-year (1981-2018)–Blended AVHRR-VIIRS (4, 16 km)

32-Year (1981-2012) –AVHRR noaa7-19 (4, 16 km)

→

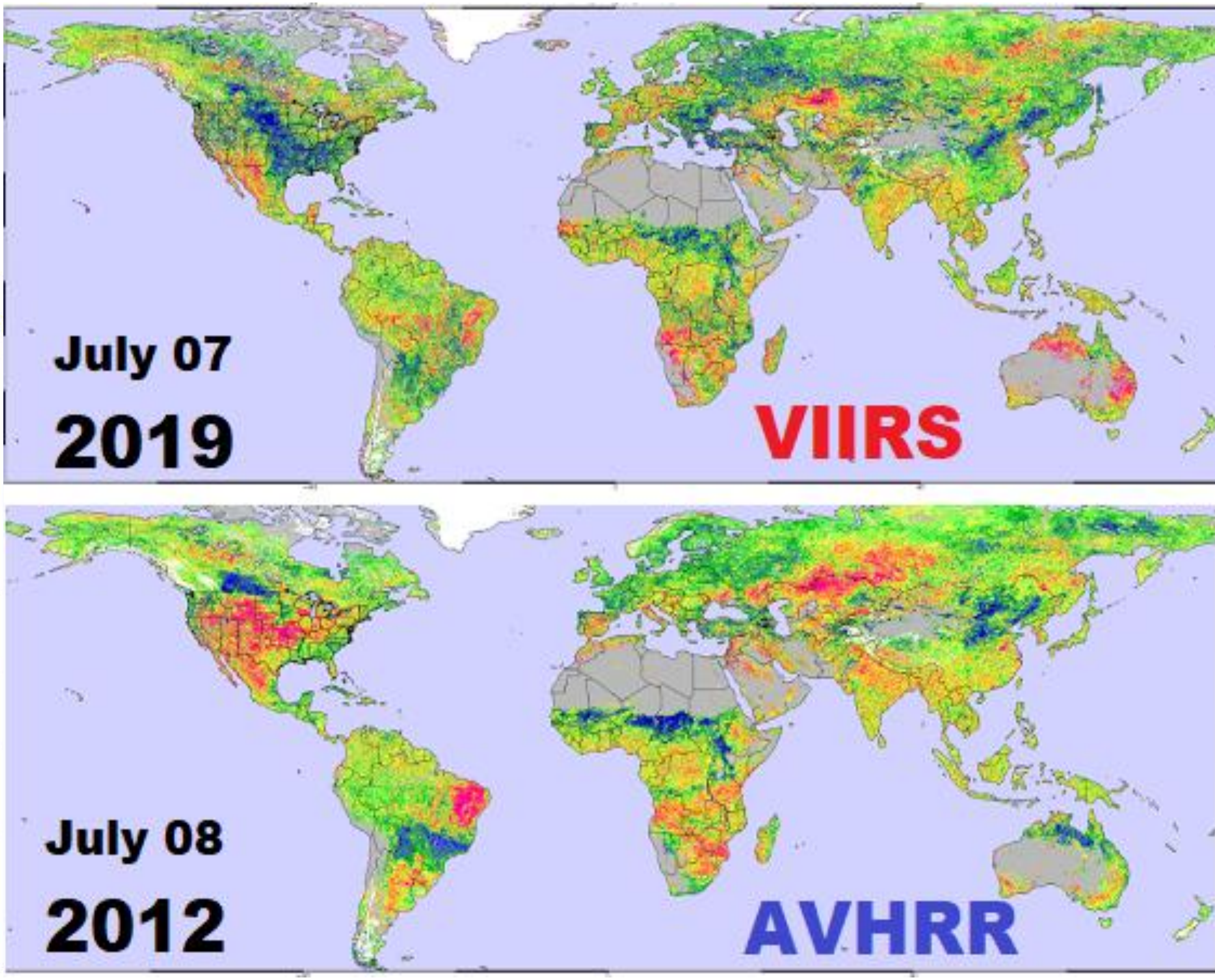
8-year (2013-2018) -VIIRS s-npp (1, 4 km)

***Next 25-year (2022-2043) –VIIRS** noaa21-24

Coverage **World**

Indices **NDVI, BT, VCI, TCI, VHI**

Vegetation Health & Applications

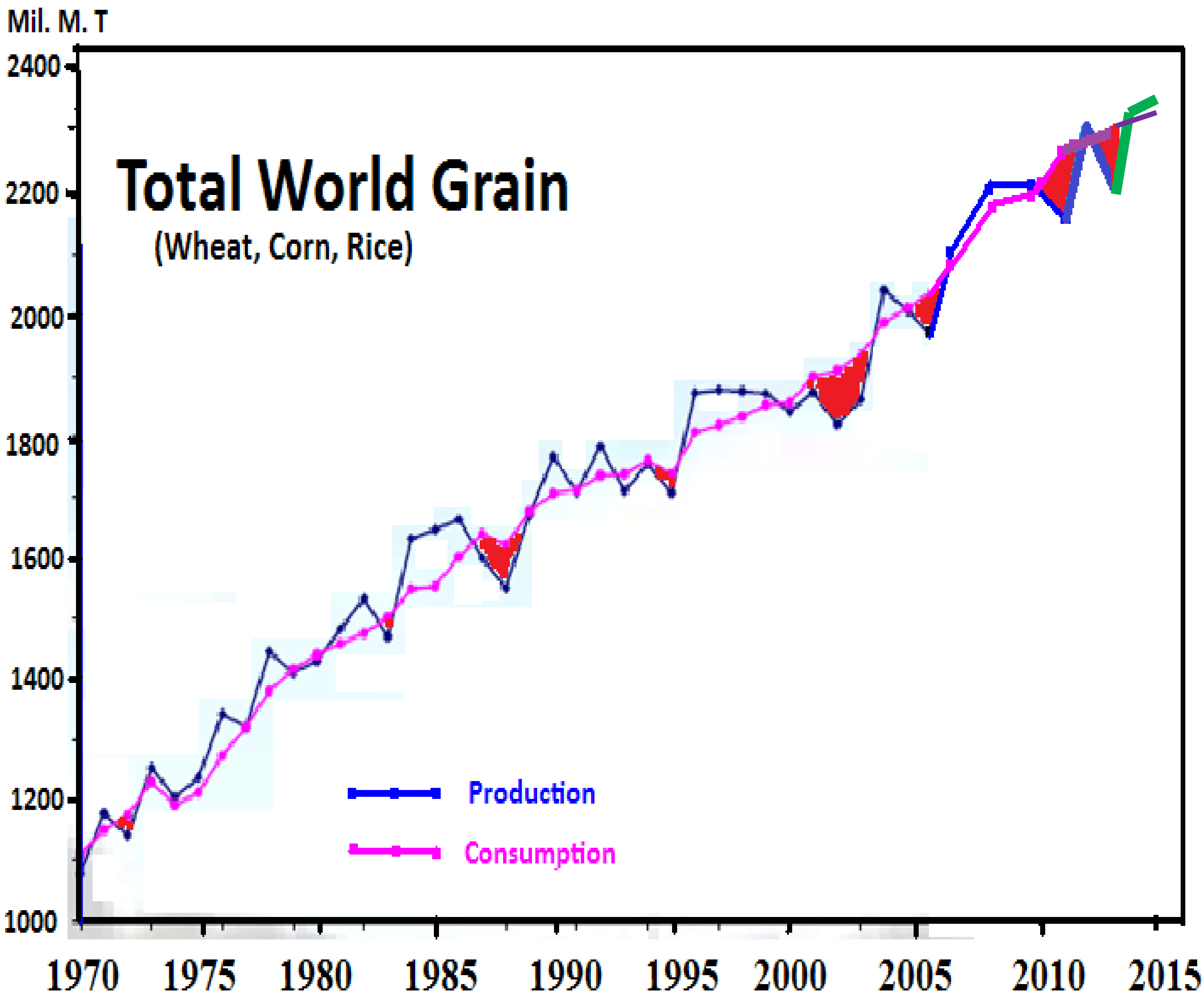


http://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/index.php

Applications

- Vegetation Health
- Drought
  - Area
  - Intensity
  - Duration
  - Start/End
  - Impacts
- Moisture Stress
- Thermal Stress
- Healthy veg.
- Crop/pasture pr.
- Fire Risk
- Soil Saturation
- Malaria
- Land greenness
- Landslides
- Food security
- Climate change

a. World Grain Production-Consumption, 1970-2013

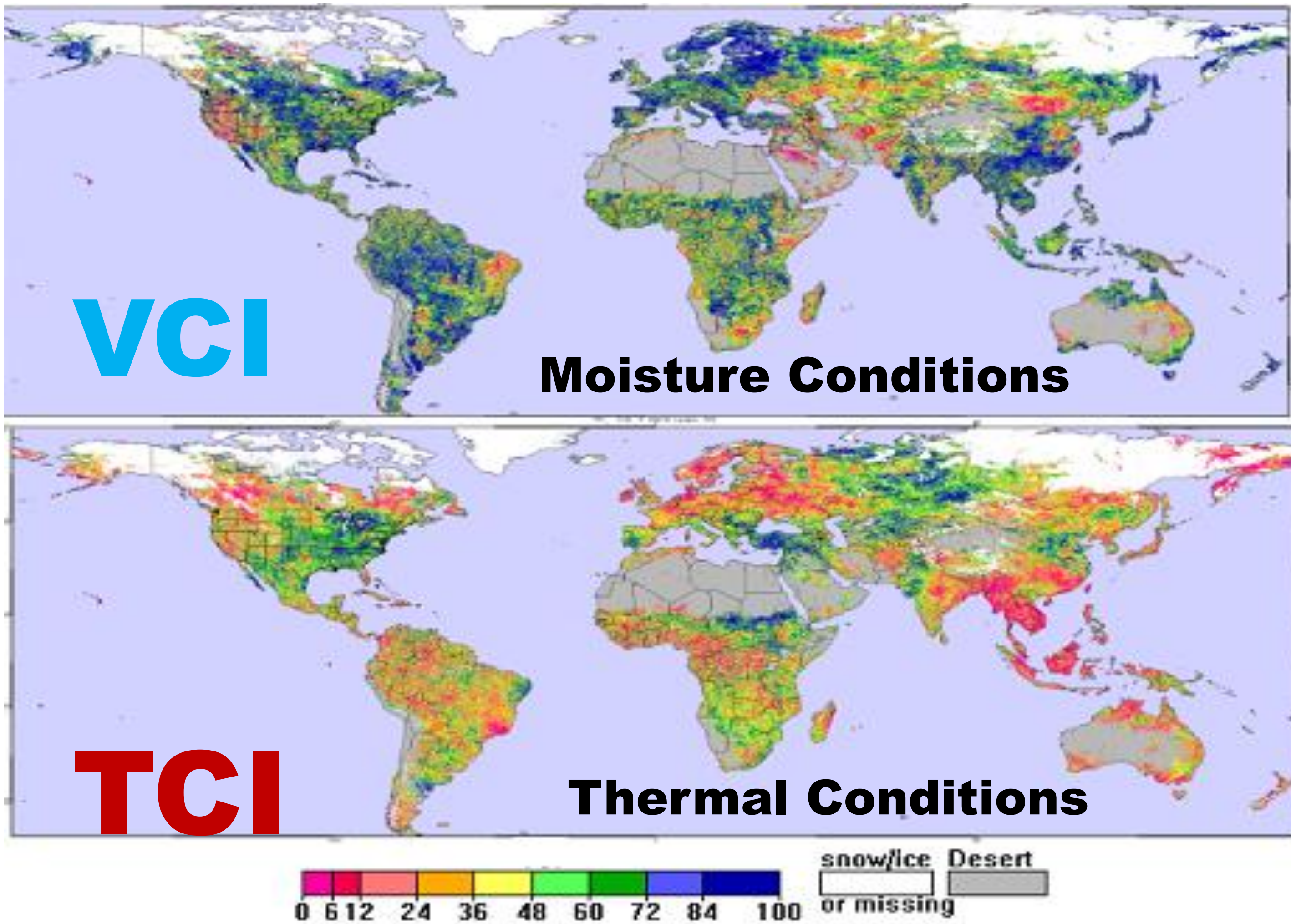


Droughts

2012 – USA
2011 – USA
2010 – Russia, Ukraine, Kazakhstan, Argentina
2007 – Australia, China, Argentina, Brazil, Ukraine
2003 – USA, Europe, Australia, India, China, Ukraine
1996 – USA, Russia, Argentina, Kazakhstan Australia
1988 – USA

Drought Crop Losses in 2014

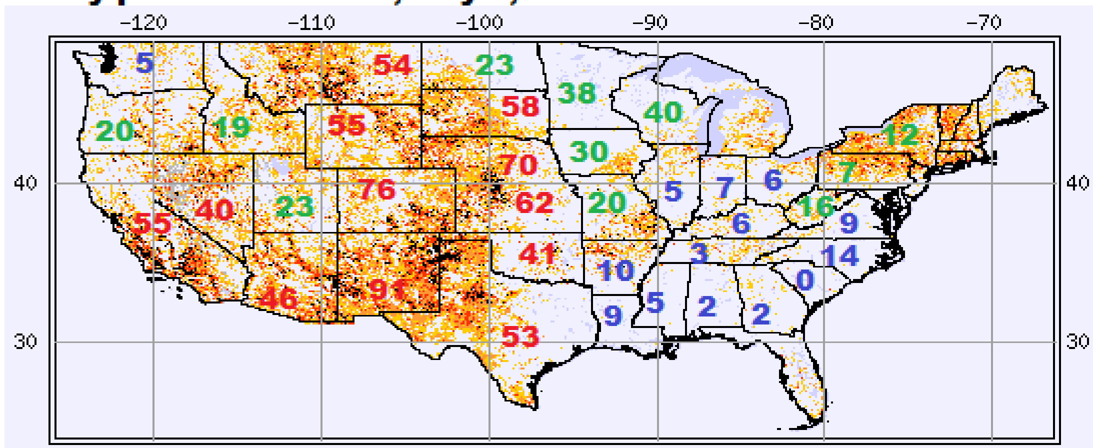
AUGUST



VH-drought stress & USDA pasture & winter wheat condition, May 6, 2013

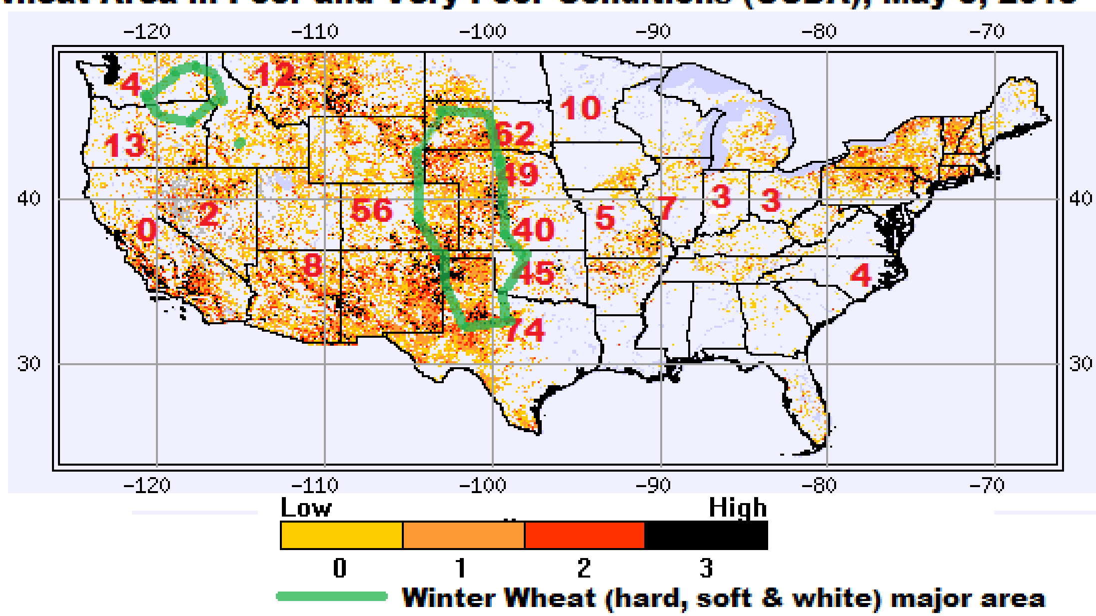
VH-based Drought Stress & % state with pasture & range land in poor & very poor cooonditions, May 6, 2013

Pasture



VH-based Drought Stress (NOAA), May 6, 2013 & Percent Whinter Wheat Area in Poor and Very Poor Conditions (USDA), May 5, 2013

Winter Wheat

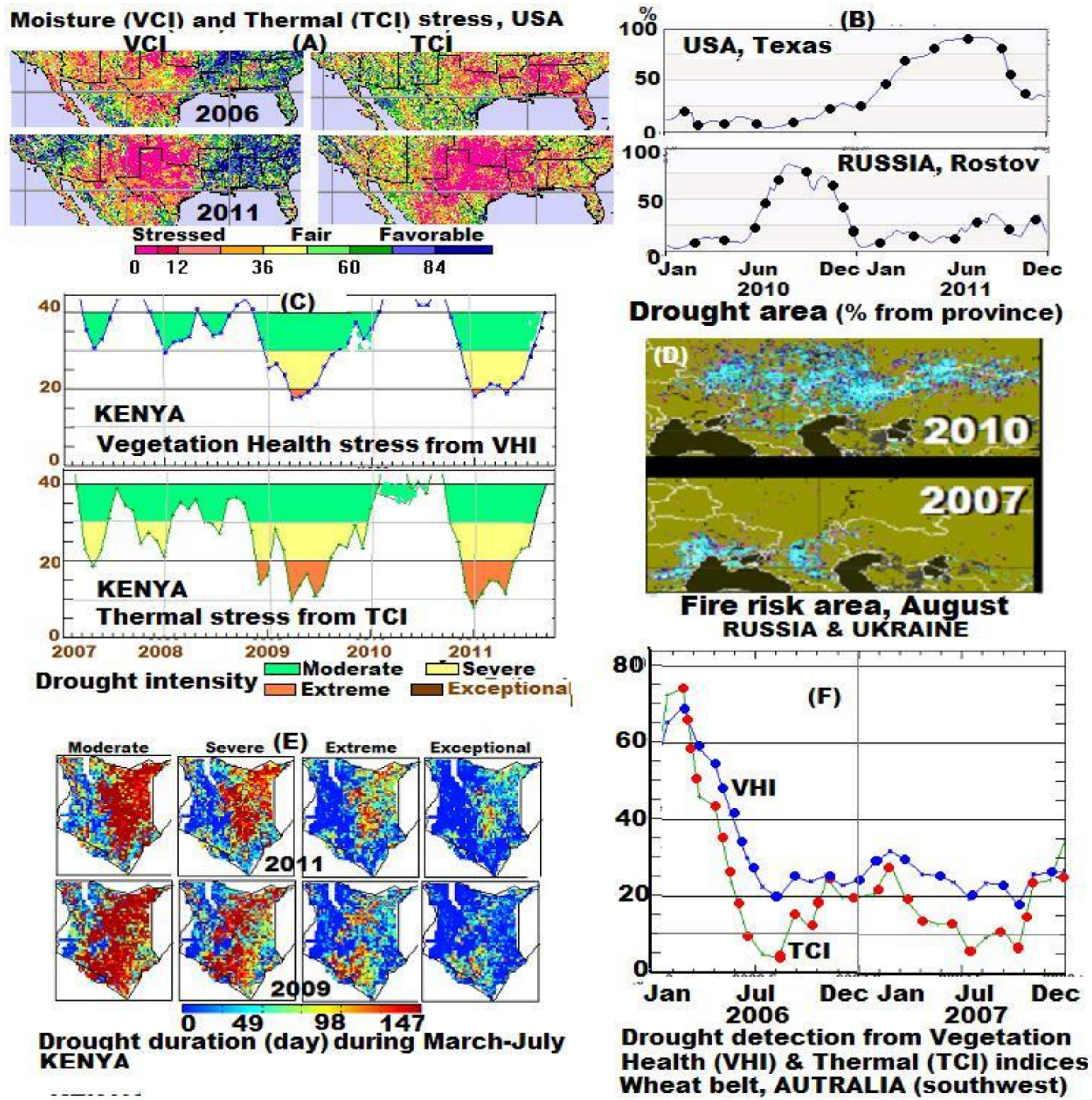


VH Applications

http://www.orbit.nesdis.noaa.gov/smcd/emb/vci

APPLICATIONS

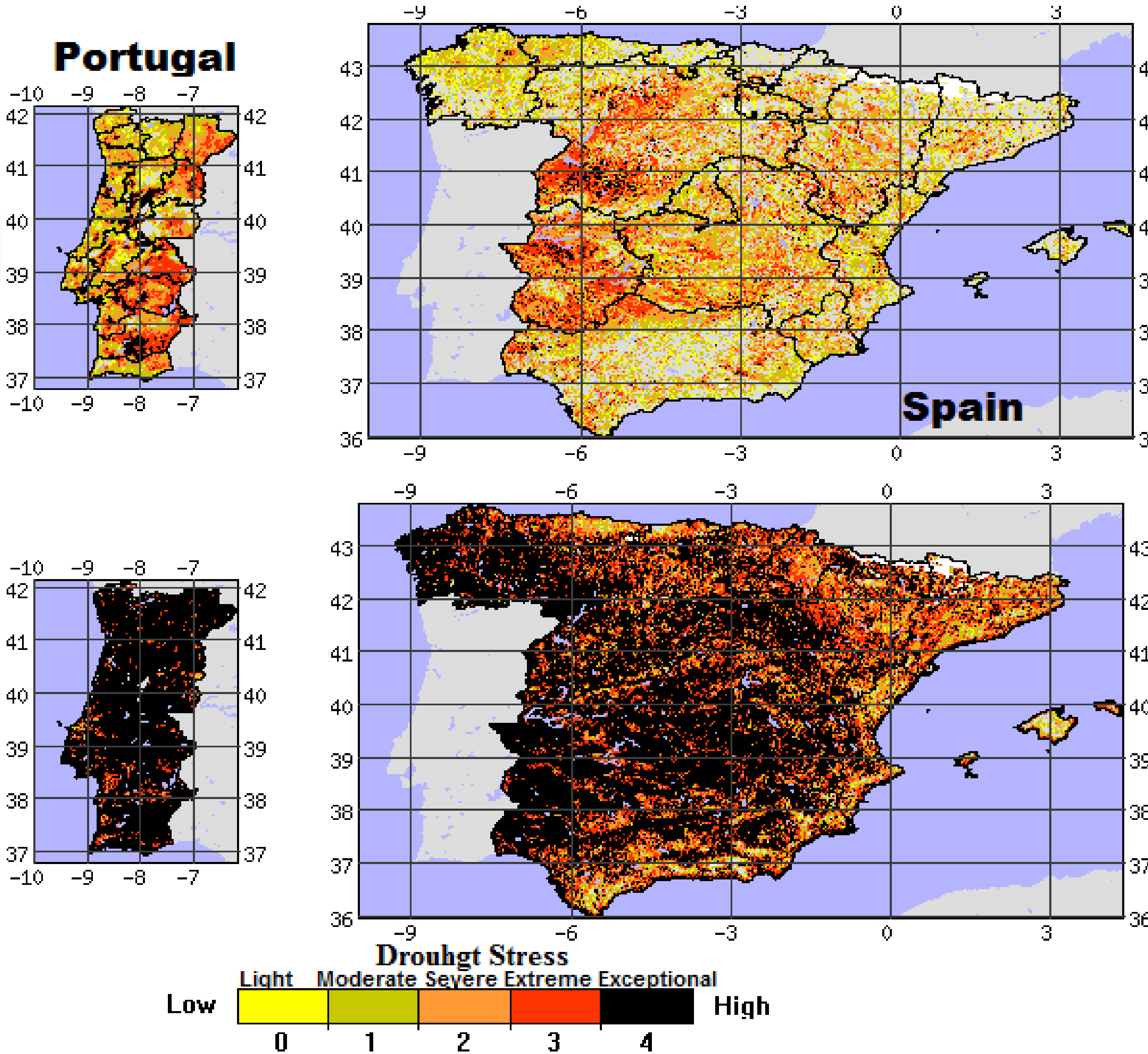
- (A) Moisture & Thermal stress
- (B) Drought area
- (C) Intensity of vegetation stress
- (D) Fire risk
- (E) Drought duration
- (F) Drought detection/prediction



Nov 25, 2017 Moisture (VCI) and **Thermal** (TCI) Vegetation Stress

VCI

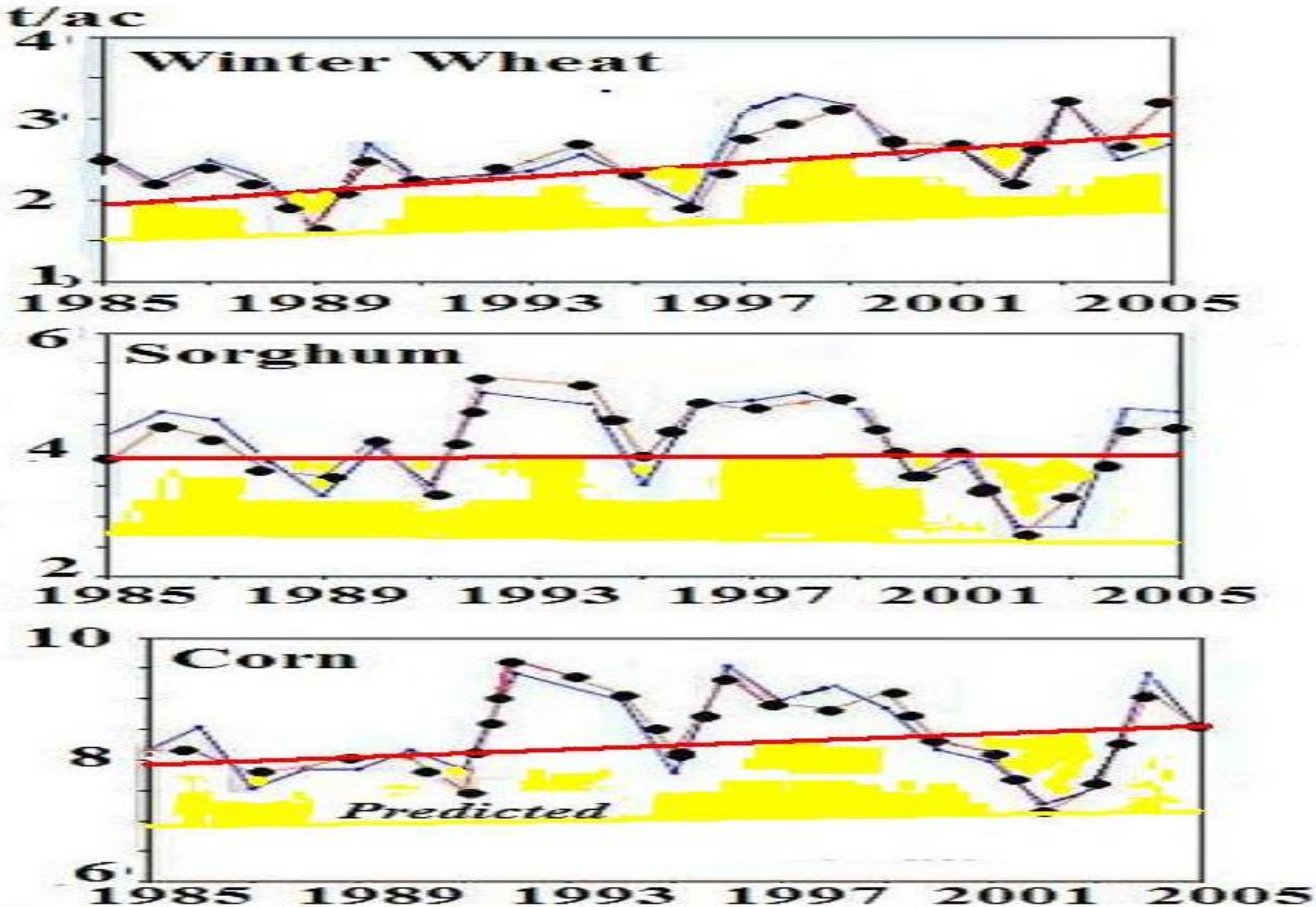
Stress from Moisture & Thermal Conditions



TCI

Stress from Thermal Conditions

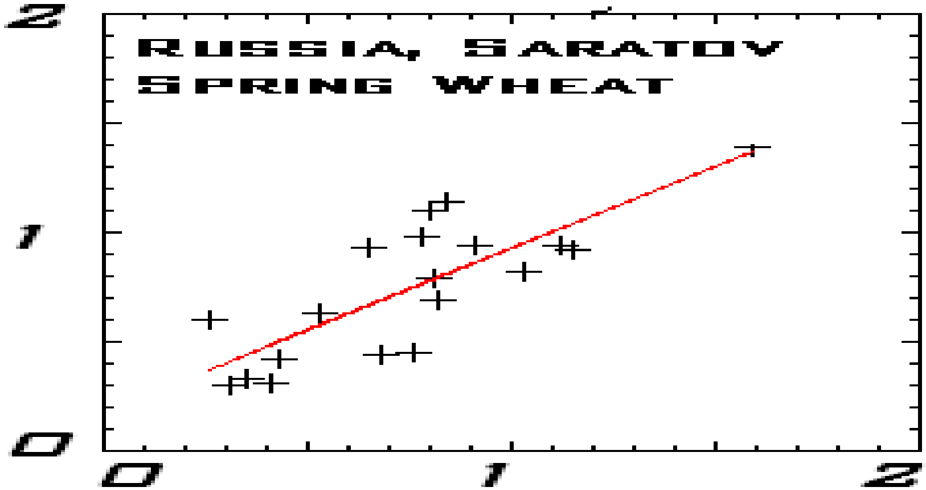
Crop Yield Actual and VH-Model Predicted in Kansas



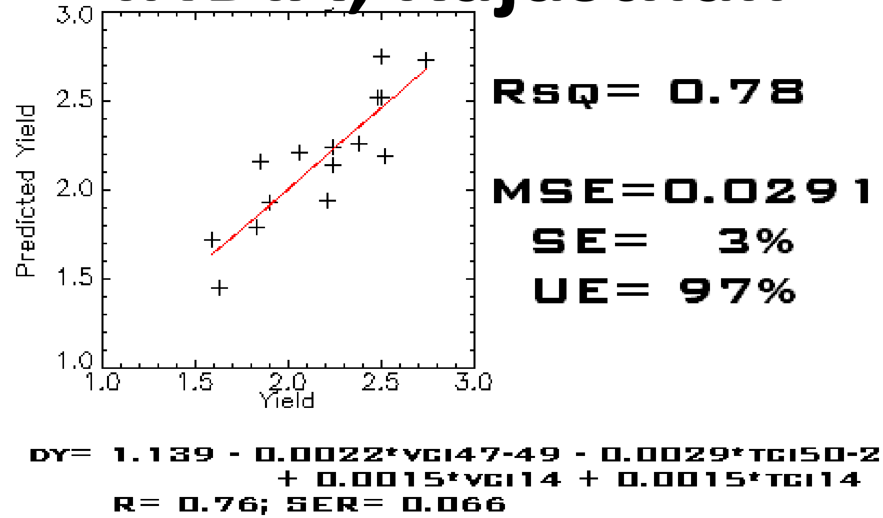
Observed & Predicted Yield, USA, Kansas

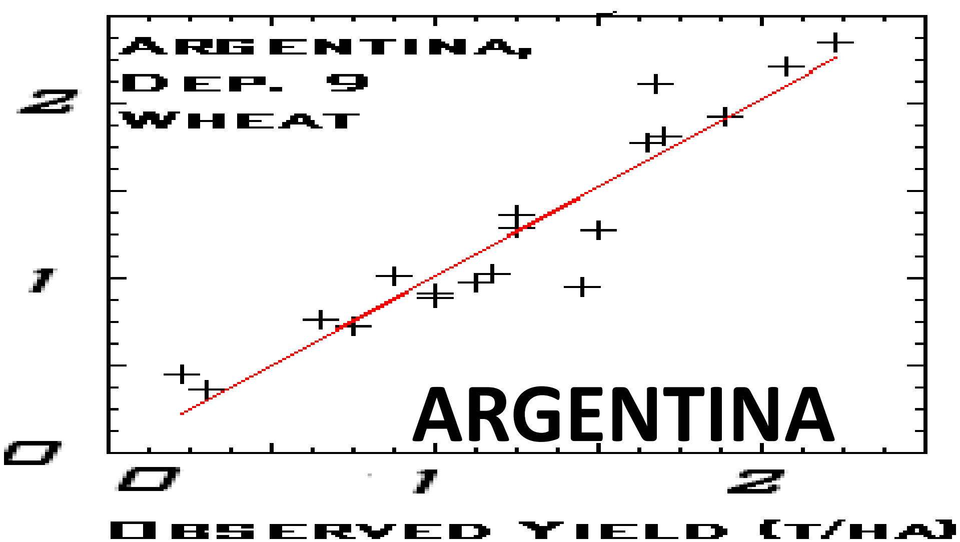
VH Predicted vs Observed Wheat Yield

RUSSIA

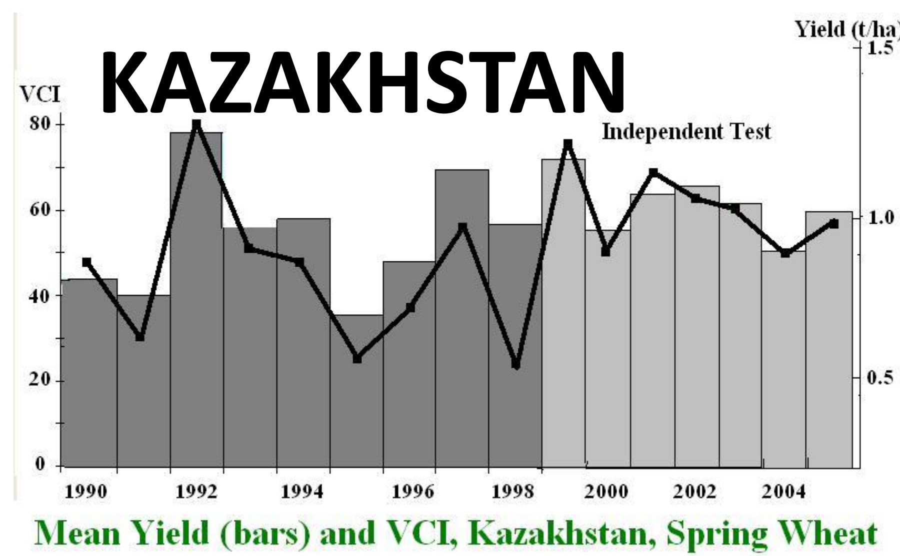


INDIA, Rajasthan

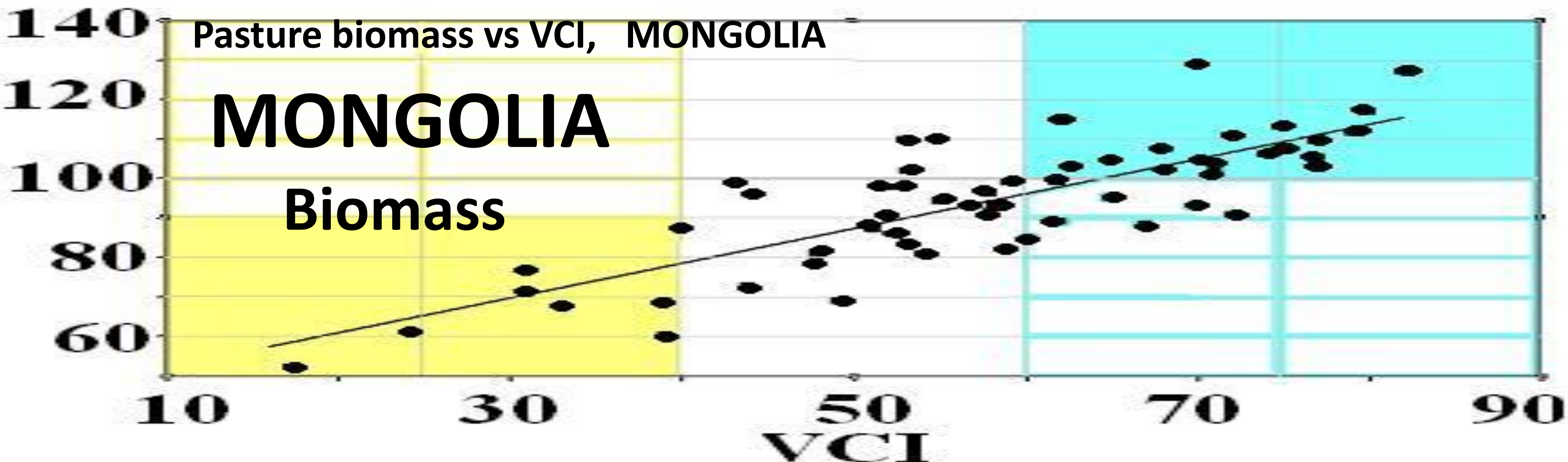




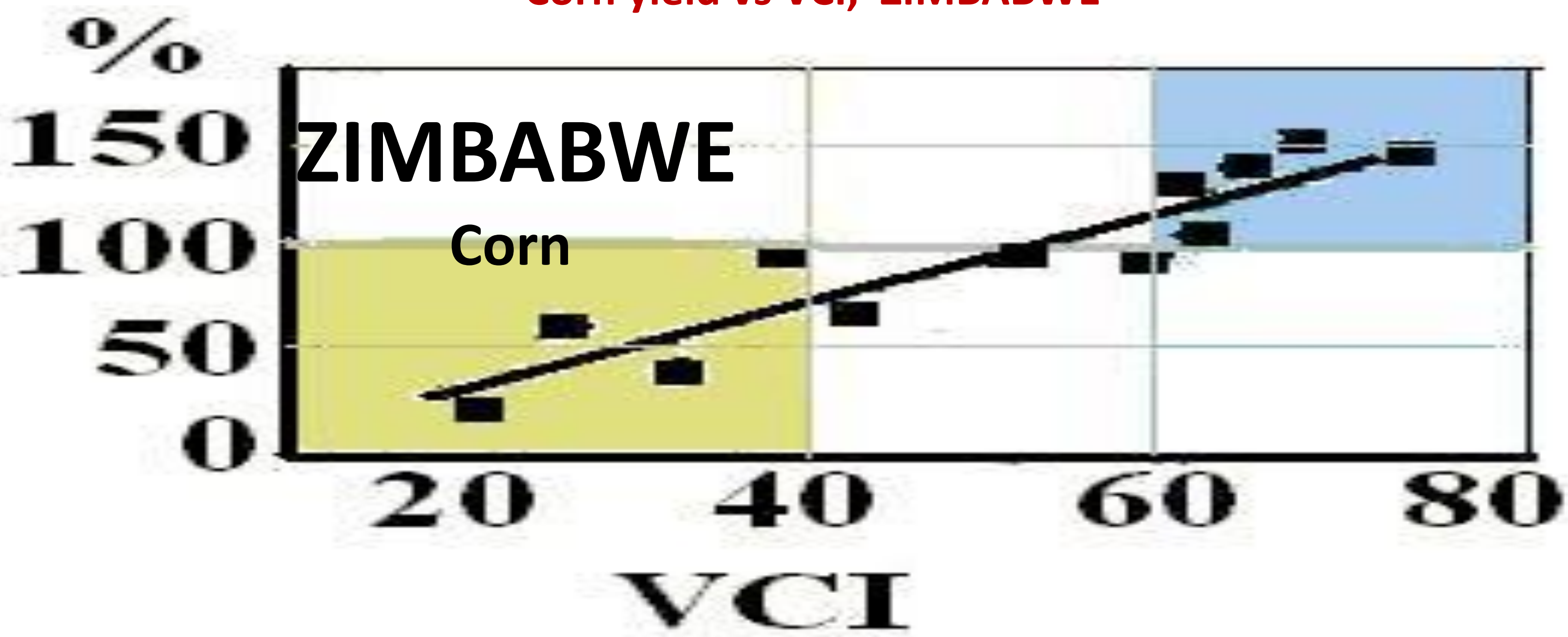
KAZAKHSTAN



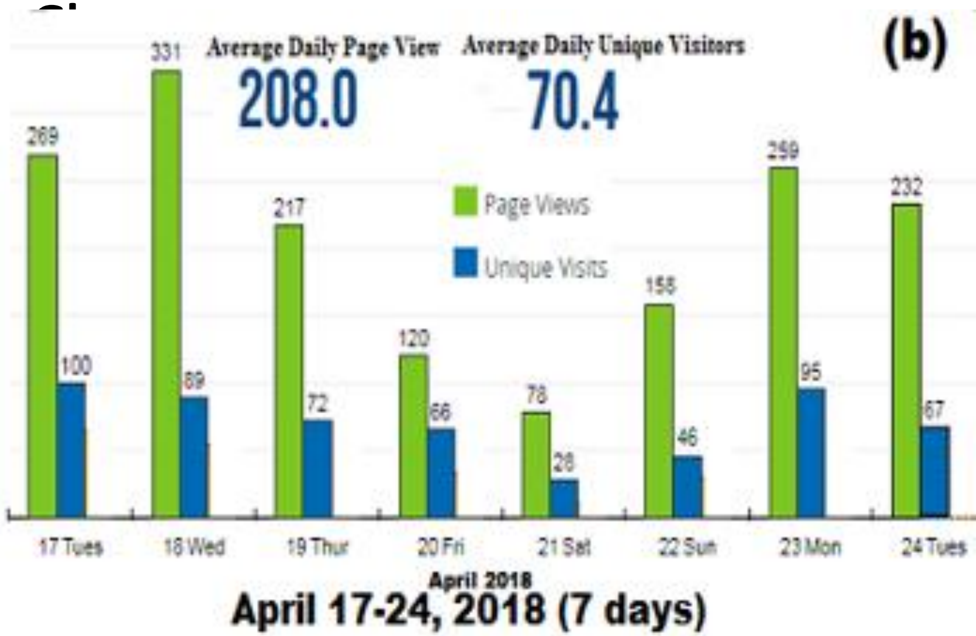
VH-Biomass & Corn Yield Modeling & Prediction



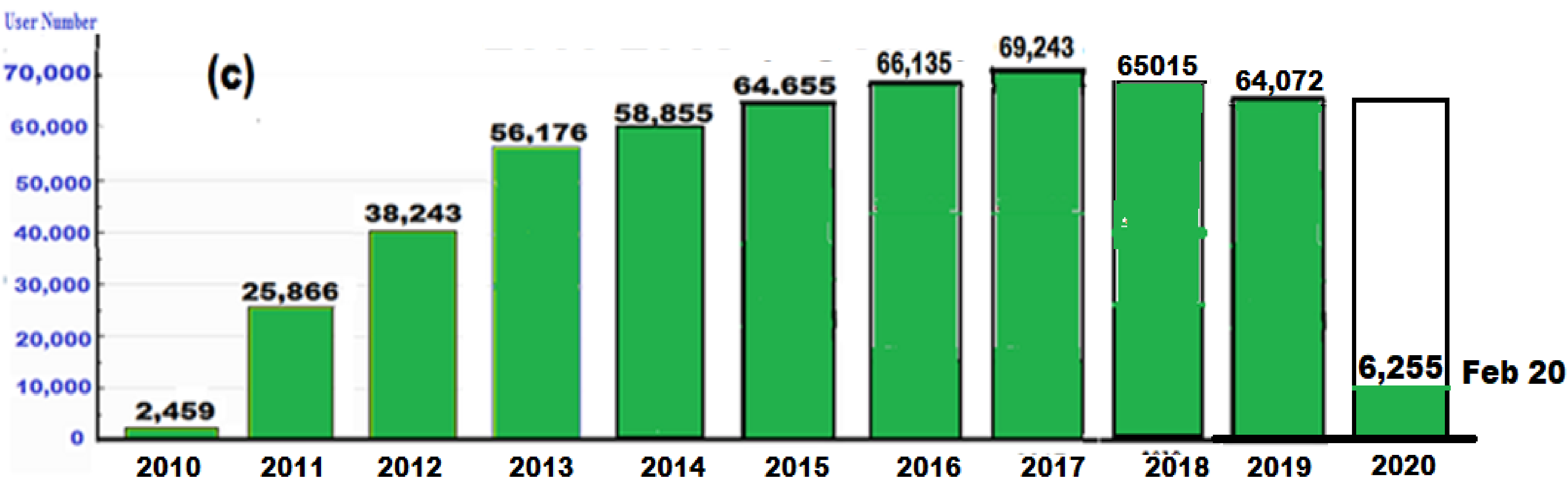
Corn yield vs VCI, ZIMBABWE



WEB Usage

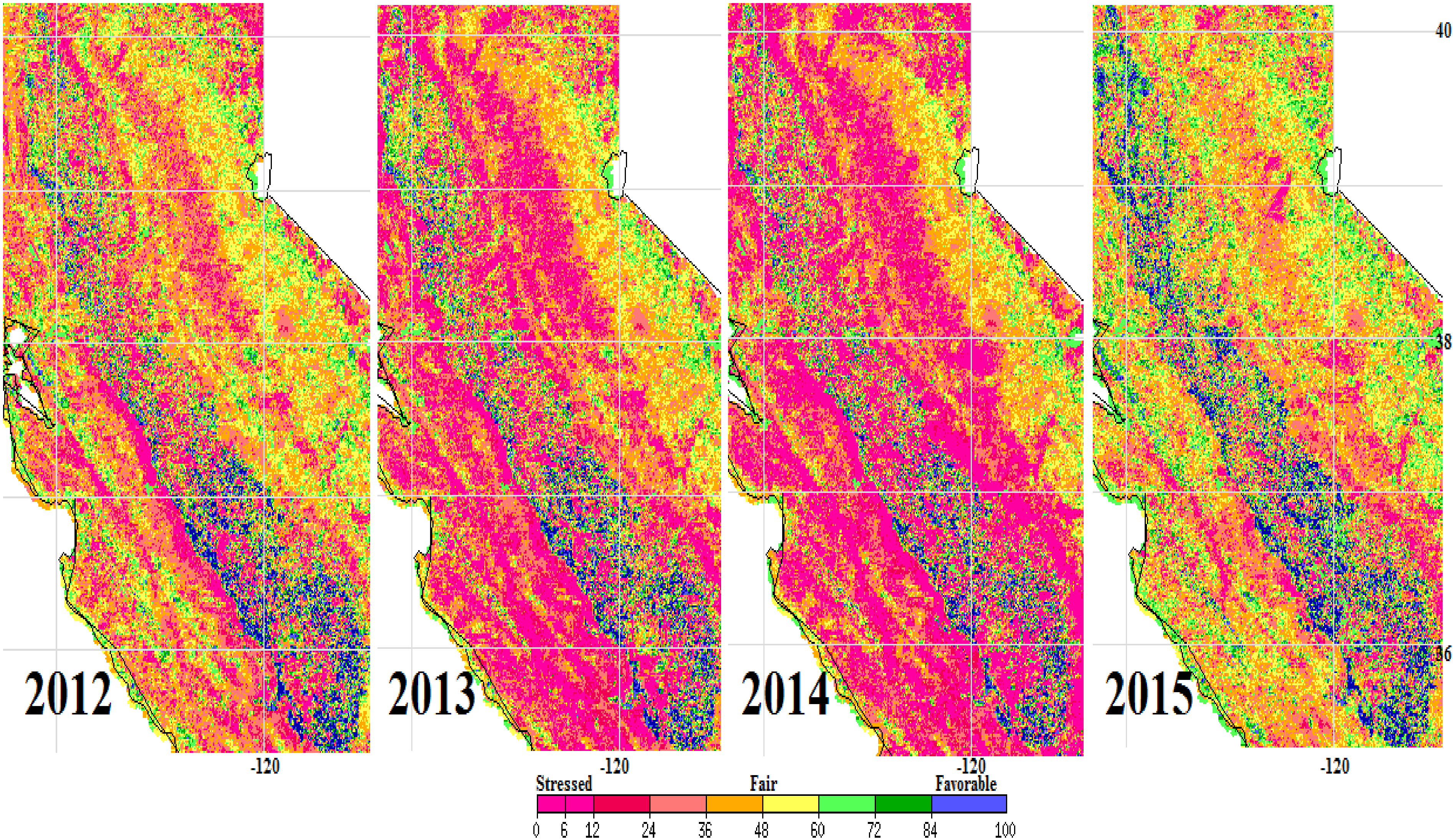


USERS 2010 - 2020



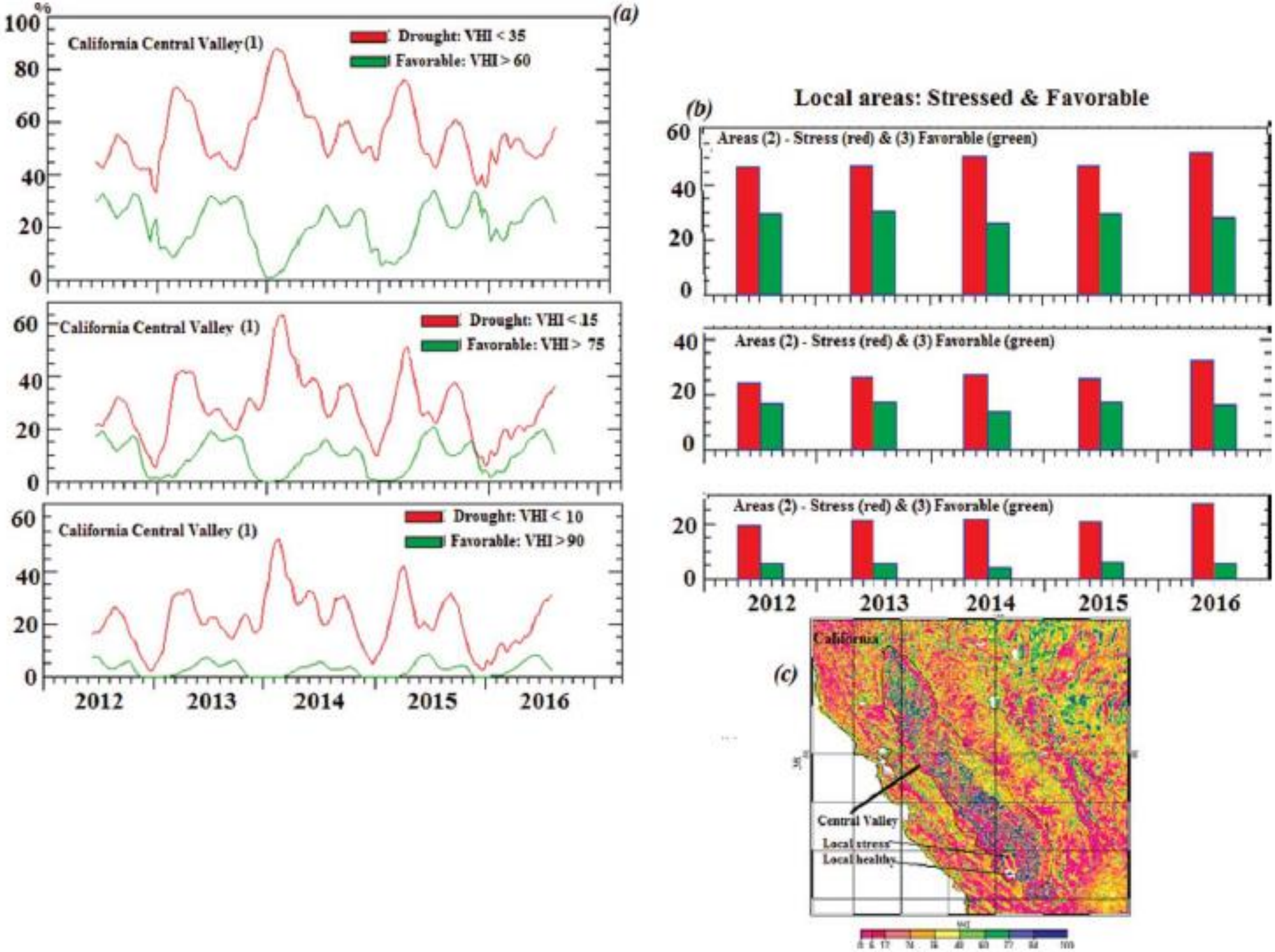
https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/ vh_browse.php

S-NPP/VIIRS Vegetation Health



S-NPP/VIIRS-500m Vegetation health, June 12, USA, California, Central Valley

0.5 km


(a)
California Central Valley (1)
Drought: VHI < 35
Favorable: VHI > 60
California Central Valley (1)
Drought: VHI < 15
Favorable: VHI > 75
California Central Valley (1)
Drought: VHI < 10
Favorable: VHI > 90
2012
2013
2014
2015
2016
Local areas: Stressed & Favorable
(b)
Areas (2) - Stress (red) & (3) Favorable (green)
Areas (2) - Stress (red) & (3) Favorable (green)
Areas (2) - Stress (red) & (3) Favorable (green)
2012
2013
2014
2015
2016
(c)
California
Central Valley
Local stress
Local healthy

Vegetation Health WEB

https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/vh_browse.php

Every week start counting from January 1

BACK UP

Conclusions

<u>2018 World Population</u> 7.6 bil. Increases with Accelerating Rate; World Grain Production Increases with Decelerating Rate

<u>Grain Supply dropped below Demands</u> (in 2001-2017 - 8 years)

<u>Severe Droughts</u> - Reduces Global Grain Production 4-7% every 3-5 years; Moderate Drought – Reduces Grain 1-3% every 1-3 years

<u>Satellite-based Vegetation Health (VH)</u> Technology Provide Tools for Drought Monitoring & 2-5 Weeks Advance Prediction of its Start/End, Area, Intensity, Duration and Impacts

<u>VH</u> Provide Prediction of Drought-related Crop & Pasture Losses: (a) 1-3 Months in Advance of Harvest, (b) During ENSO years 3-4 months prediction

<u>VH</u> Predicts Food Security Problem 3-5 Months in Advance the Developing Nations Need Assistance

<u>Drought Area & Intensity</u> has not Changed Globally & in USA's Grain Area during Global Warming since 1981