Research to Operations Activities of NASA's Short-term Prediction Research and Transition Center: Current and Future Mission Capabilities

Dr. Emily Berndt

NASA Marshall Space Flight Center

SPORT

Short-term Prediction Research and Transition Center

SPoRT History

<u>Mission:</u> Transition unique NASA and NOAA observations and research capabilities to the operational weather community to improve short-term weather forecasts on a regional and local scale.

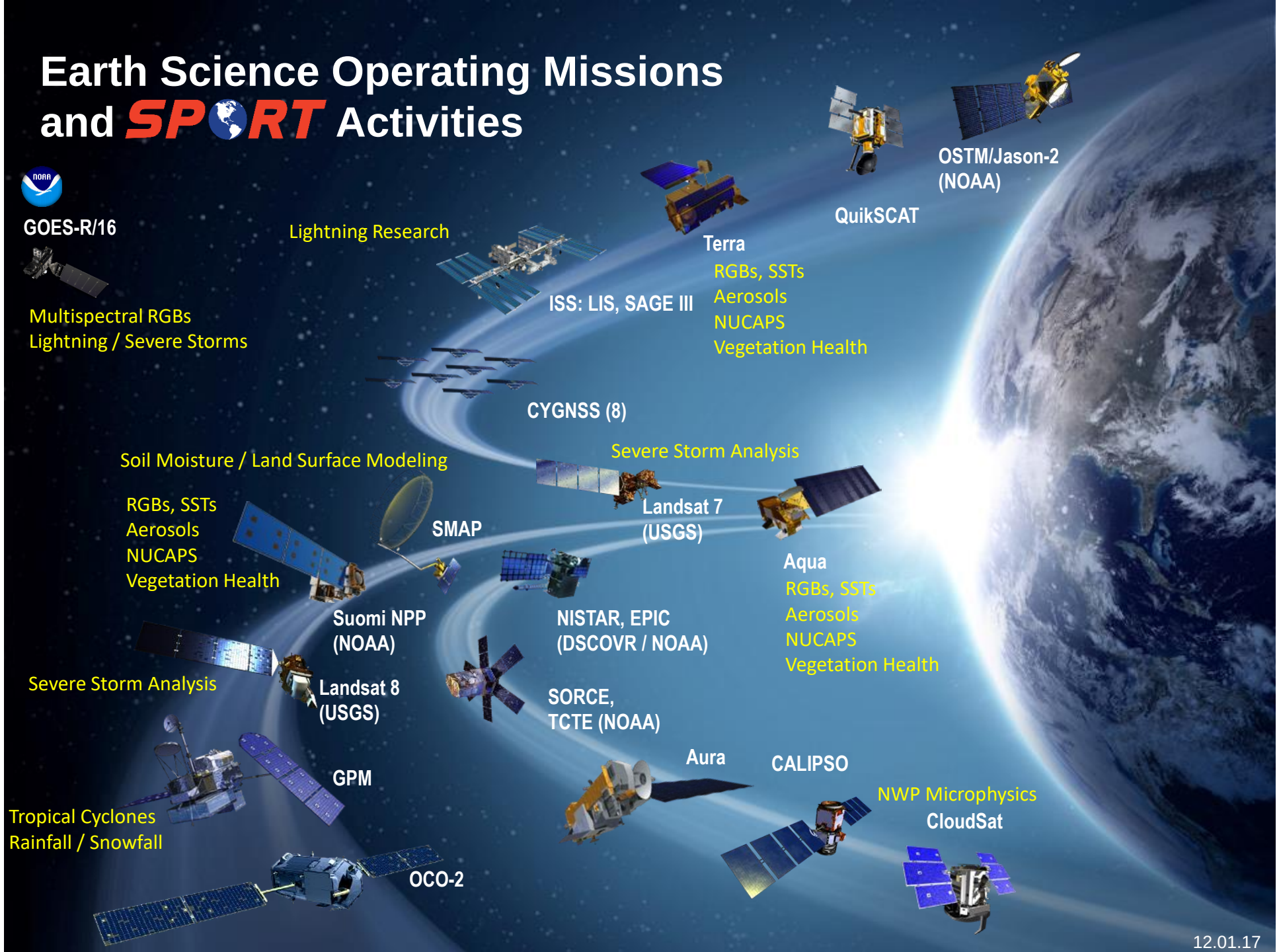
SPoRT prepares the ***community*** of ***end users and mission scientists*** for next generation satellite missions and capabilities through an interactive R2O/O2R paradigm

Established in 2002 through an unsolicited proposal from then-MSFC scientists Bill Lapenta, Steve Goodman, and Gary Jedlovec

Supported by NASA's Research and Analysis Program and the Weather Focus Area (Tsengdar Lee) and supplemented by NASA, NOAA, and other proposal areas to build upon core capabilities and partnerships.

Significant support from NOAA received through Satellite Proving Grounds (GOES-R 2009+ / JPSS 2011+) and Risk Reduction activities, and NOAA's Modeling, Analysis, Predictions, and Projections starting 2017

Earth Science Operating Missions and SPORT Activities



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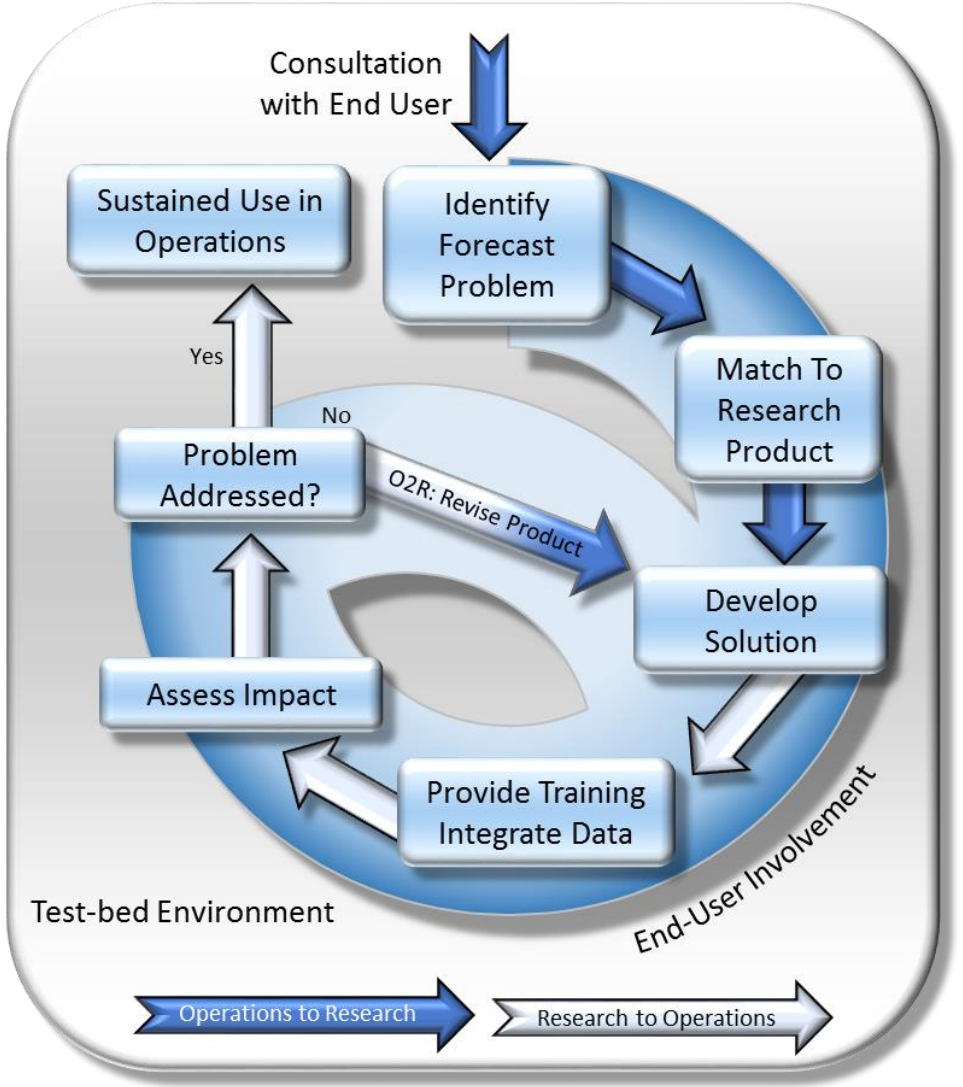
SPoRT R2O/O2R Paradigm

- Bridge the "Valley of Death" through interactive partnership with end users
  - Maintain interactive partnerships with help of specific advocates
  - Integrate into user decision support tools
  - Create product training
  - Perform targeted product assessments
- Concept has been used to successfully transition more than 40 satellite datasets to operational users for nearly 15 years



Current Partnerships

National Centers
for Environmental Prediction

- Environmental Modeling Center
- National Hurricane Center
- Weather Prediction Center
- Ocean Prediction Center
- Aviation Weather Center
- Storm Prediction Center

Over 30 NWS WFOs
and All Regional
Headquarters

NOAA Cooperative Institutes
as Data and Product Partners

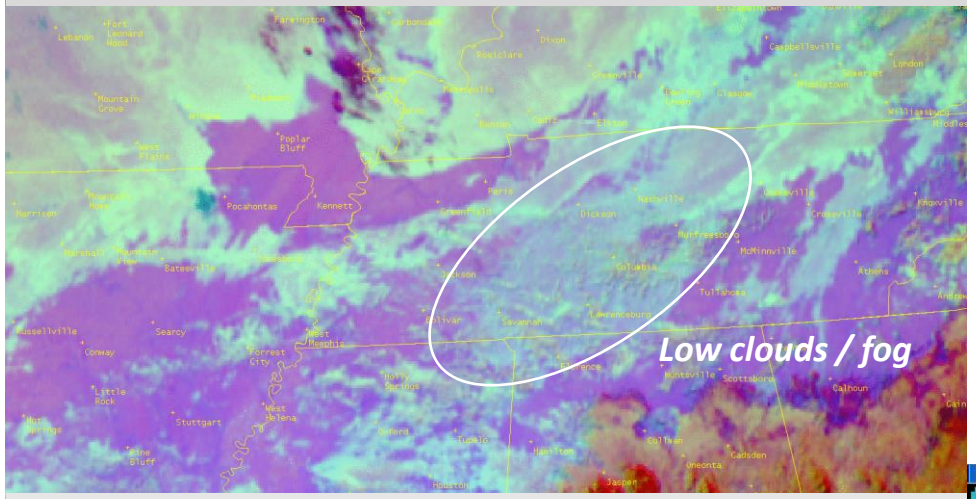
Team Focus Areas

- Remote Sensing
- Land and Atmospheric Modeling
- Lightning
- Data Dissemination and Integration
- End User Outreach

- Perform targeted research activities to exploit unique capabilities of NASA and NOAA satellites and technologies to solve specific weather forecasting challenges
- Support for product dissemination to end user display system
- Apply unique R2O/O2R paradigm for transitioning data and obtaining valuable feedback from NWS forecasters, engagement via blogs and social media

Remote Sensing

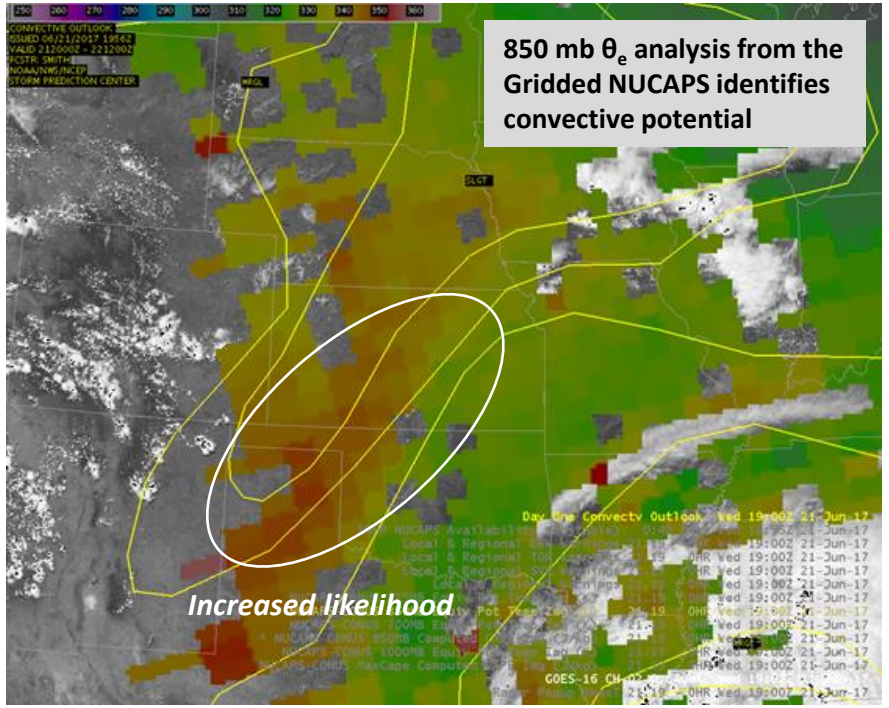
Nighttime Microphysics RGB from GOES-16 of a TN Valley fog event on 28 Mar 2017



Quickly differentiates cloud types by resulting colors / texture

False Color Composites (RGBs)

- Past assessments and demonstrated value of multispectral compositing of MODIS, VIIRS, now GOES-16 upcoming GOES-S
- Transitioned to operations through collaborations with OPG, assisting with training development and related activities.

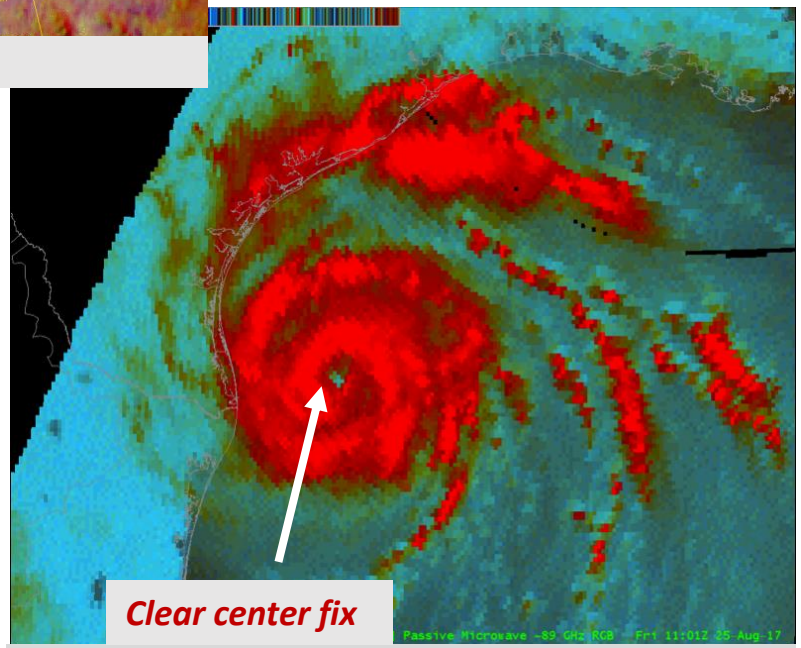


Gridded NUCAPS Applications

- Supporting new applications of NUCAPS information to support weather forecasting

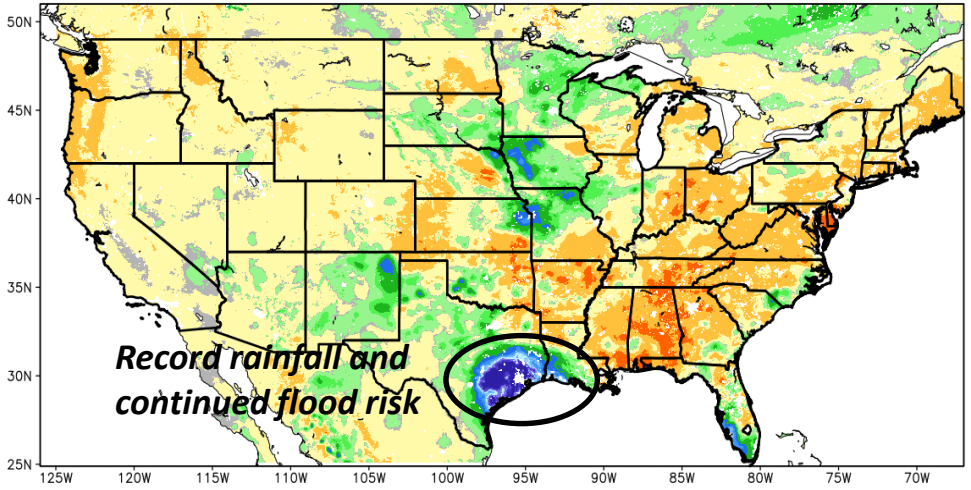
NASA GPM Data:

- False color composites for improved TC diagnosis
- IMERG rainfall estimates gap-fill radar/data-void areas

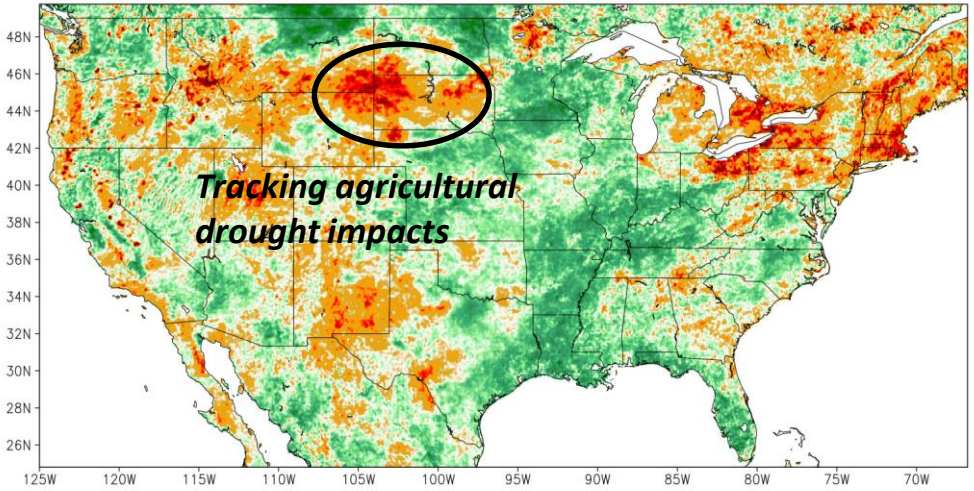


GMI clearly shows center of Hurricane Harvey on 25 Aug 2017; used by NHC

Land and Atmosphere Modeling

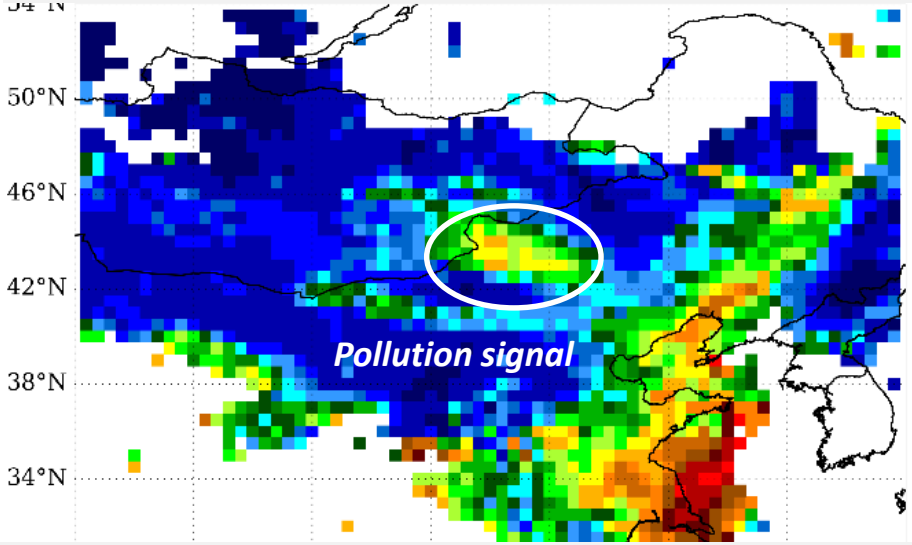


1-Week Difference in Column Relative Soil Moisture (%) on 28 Aug 2017 shows rapid changes from Hurricane Harvey



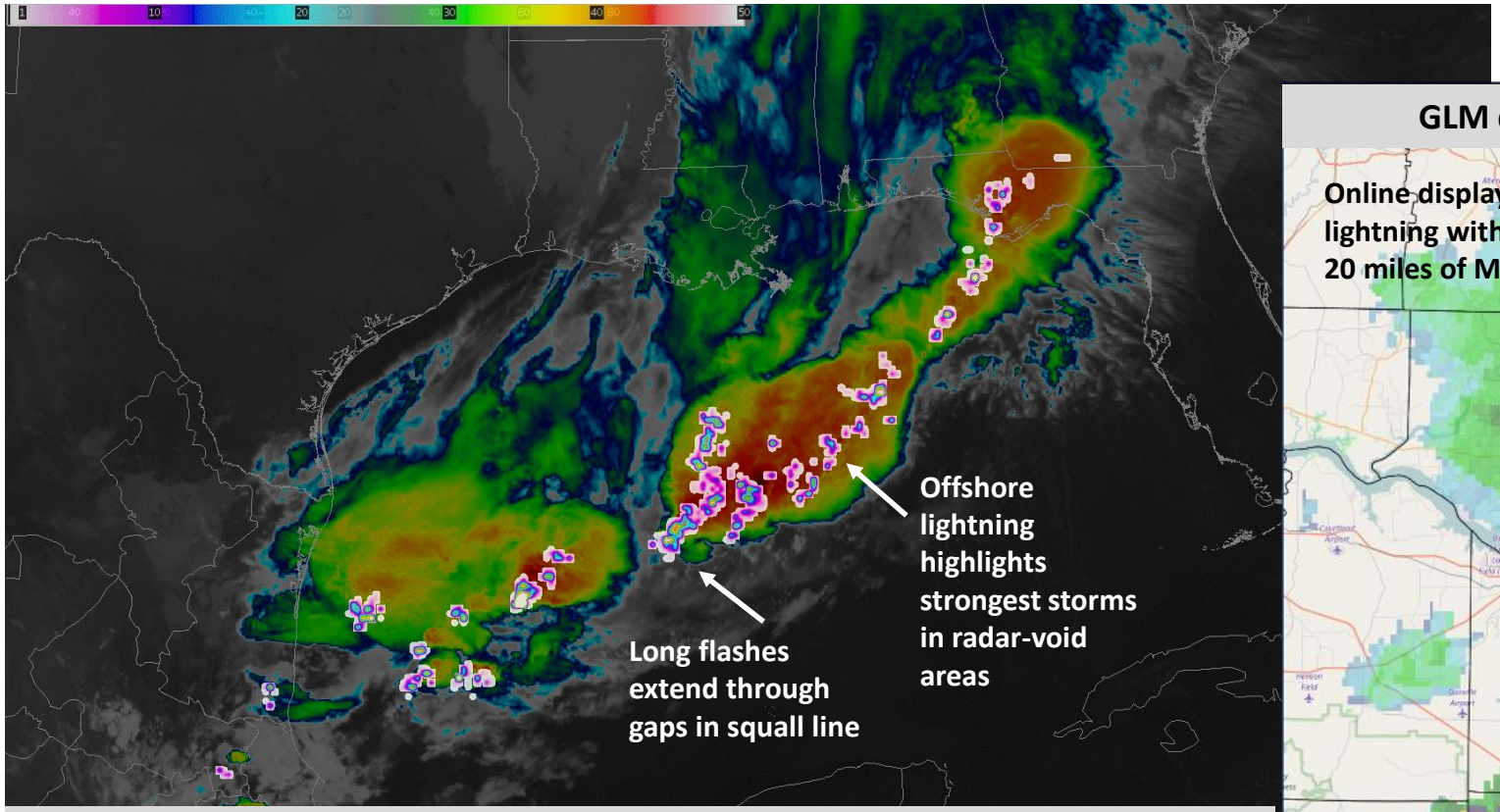
3-Mo. Evaporative Stress Index ending August 2016 captures evolving drought and informs drought monitoring

- Land surface (LIS; SMAP) to improve short-term weather and agricultural forecasts
- Use satellite-derived aerosols to improve satellite data assimilation and cloud microphysics in models



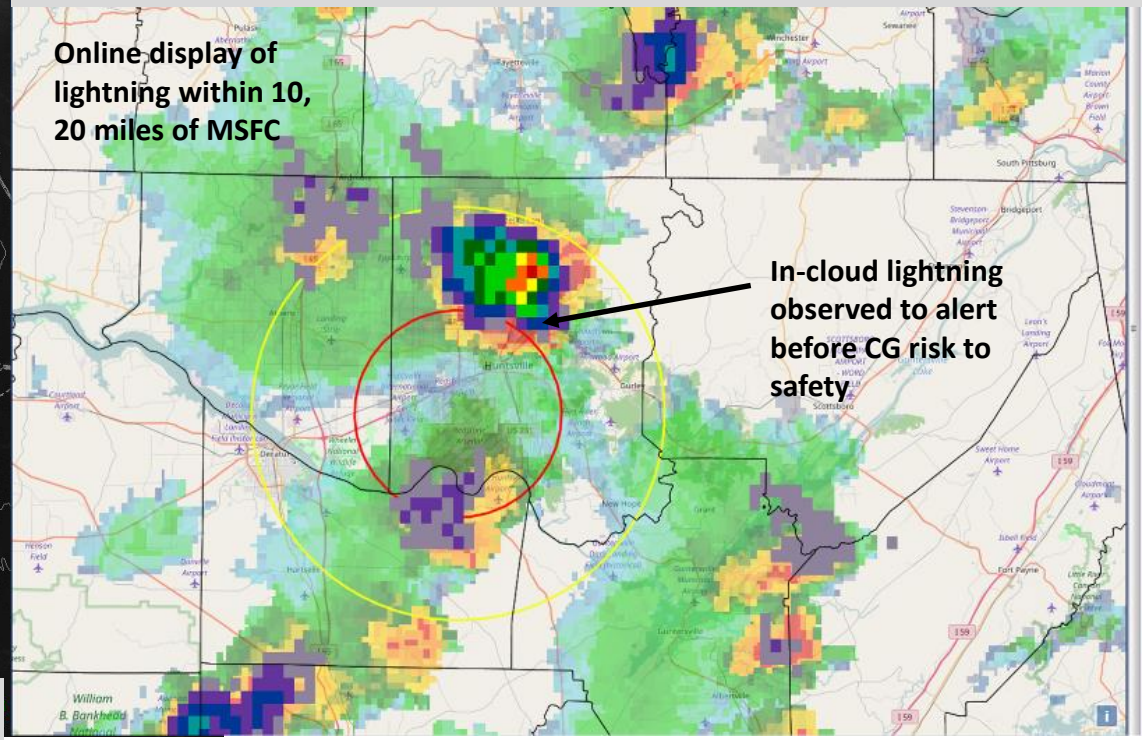
Capturing pollution transport through new AOD products and for assimilation into NWP models

Lightning



GLM detects lightning along a squall line over the Gulf of Mexico on 4 May 2017

GLM data supporting lightning safety at NASA Marshall



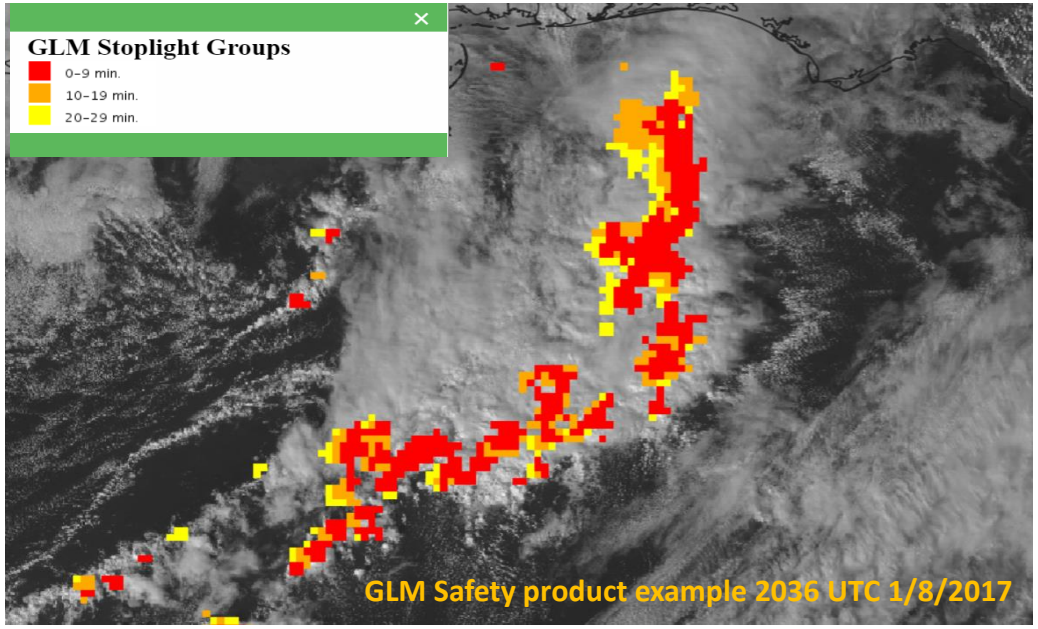
- Past experience in using ground-based Lightning Mapping Arrays (LMAs) to prepare forecasters for Geostationary Lightning Mapper applications, support continuing through liaison and training efforts focused on GOES-16/17 GLM

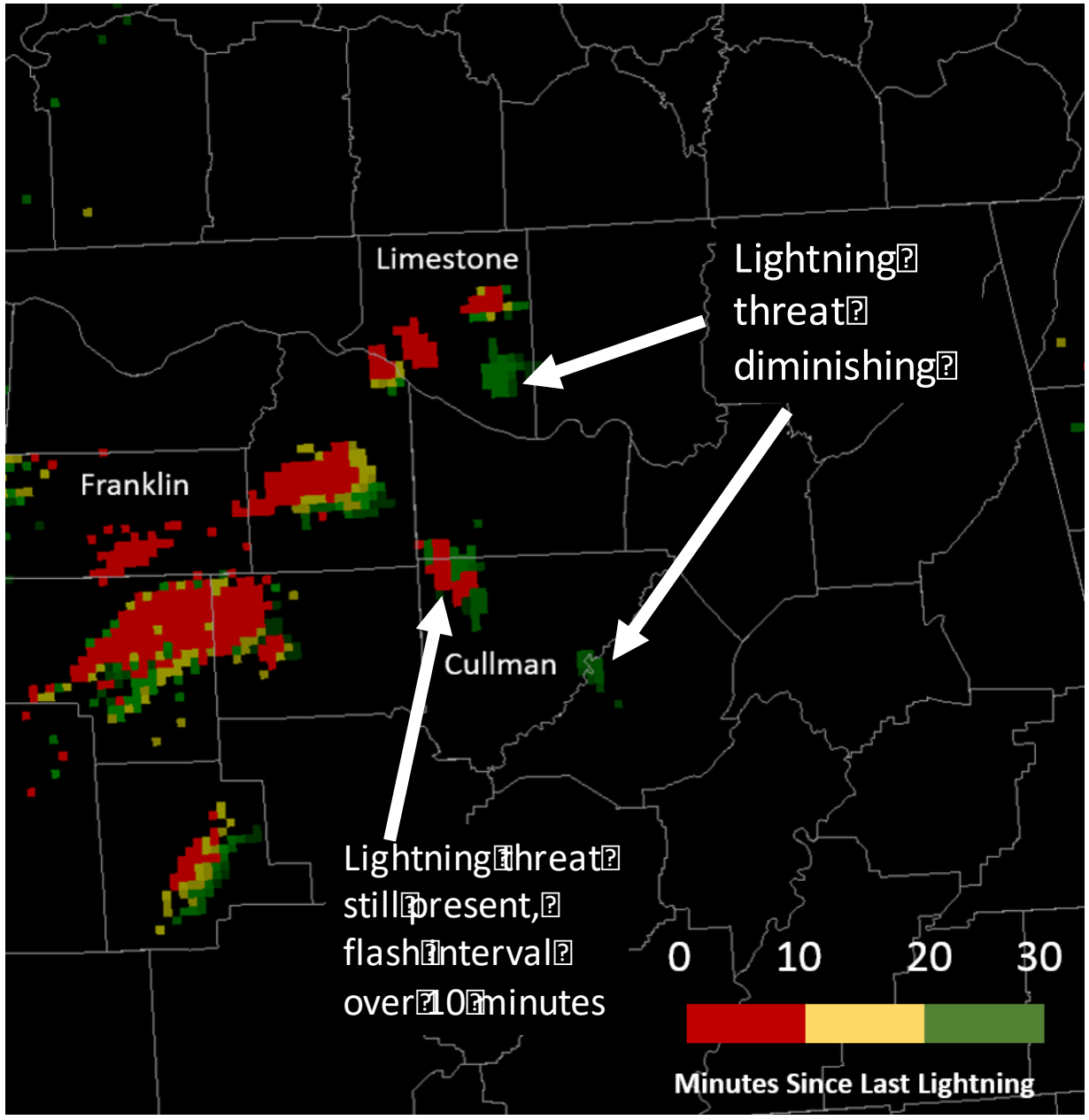
- Increased focus on lightning safety applications in collaborations with NASA Marshall, other NASA Centers, NOAA partners, and emergency managers

Lightning

- Extending interest in lightning safety research to explore displays to help advise on time since last observed lightning, and distance from recent threat

- Adopting GIS tools and other displays to extend reach of GLM and other SPoRT generated data sets





Training and Outreach

Training incorporates educational design concepts, complimenting NOAA, in collaboration with the Satellite Training Advisory Team

Diverse methods to meet a wide range of learning styles:

- Site visits by SPoRT / Subject Matter Experts
- *SPoRT Applications Library*
- User-based, operational modules
- Quick Guide format adopted for use in GOES-16 and JPSS products

Developed collaboratively with operational meteorologists to leverage their expertise

Short, Narrated Modules

"Quick Guides"

Product quick references available online or in AWIPS

Assessments and Feedback

Targeted Assessments

- Quantitative questions and qualitative feedback, soliciting open commentary on products and utility

User Engagement

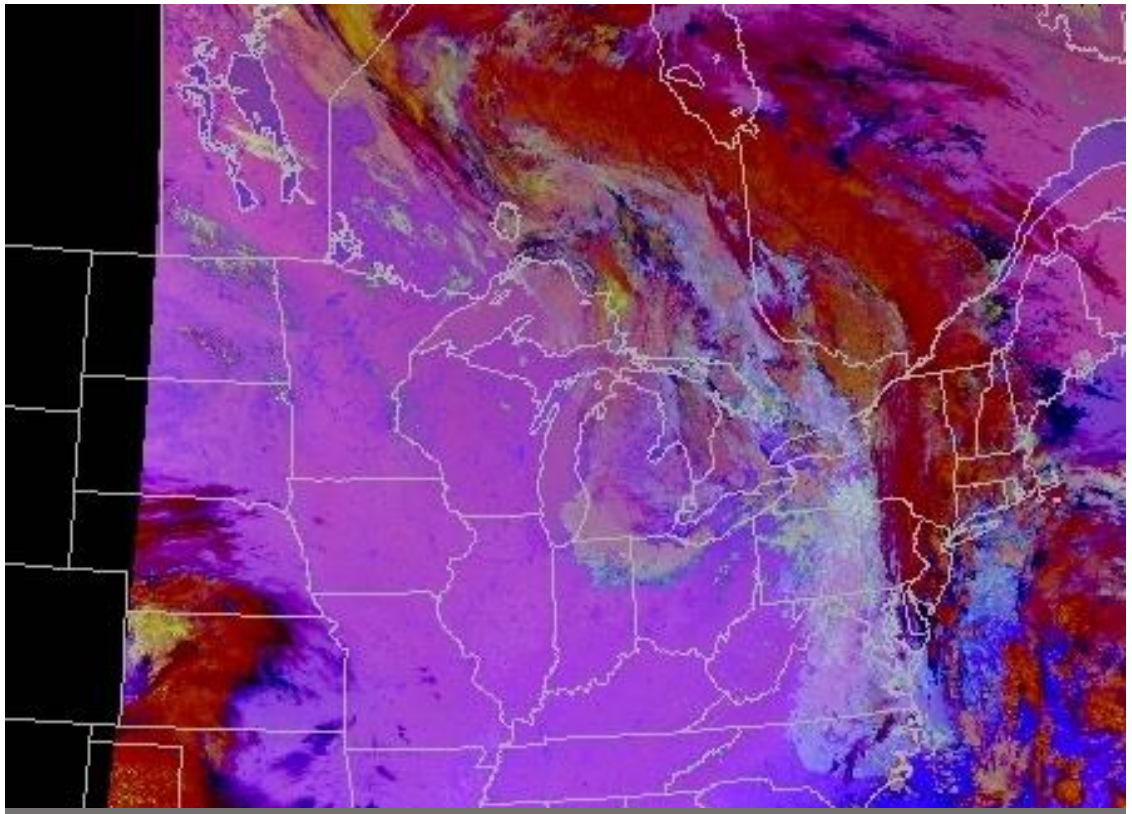
- Following up on Q&A via email and responding to questions
- Sharing between SPoRT and forecasters via email, blogs, and social media
- Assessments finalized with report shared with product developers/contributors

Outreach / Social Media

- Wide World of SPoRT blog
- @NASA_SPoRT on Twitter
- @NASA.SPoRT on Facebook

Transition of SPoRT Capabilities to focus on new NASA Missions

- Successful partnerships to prepare NWS forecasters for GOES-R and JPSS advanced capabilities through use of experimental proxy products derived from NASA assets
- Developed techniques to improve interpretation of RGB imagery across sensors and on-demand display in NWS display systems
- Working with Alaska Region to transition RGB processing and display capabilities to real-time data stream
- Collaborated with NOAA, NESDIS, NWS to transition GOES ABI RGB imagery to NWS forecast office operational systems



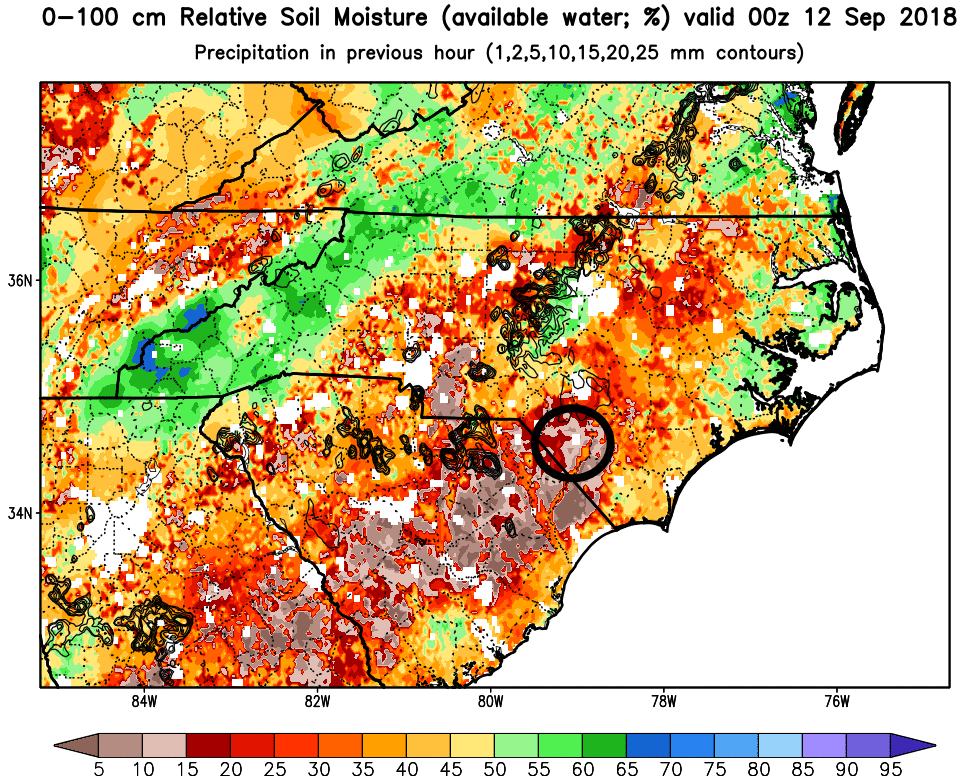
S-NPP VIIRS
Night-time Microphysics Composite

- Data from our receiving stations provides critical imagery to NOAA NWS National Centers
- Transiting processing and display of RGB imagery to NWS operations is allowing SPoRT to shift focus to New NASA missions, advanced machine learning techniques, and partner with other government agencies

SPoRT-LIS for Situational Awareness and Modeling Applications

SPoRT manages experimental Land Information System (LIS) applications

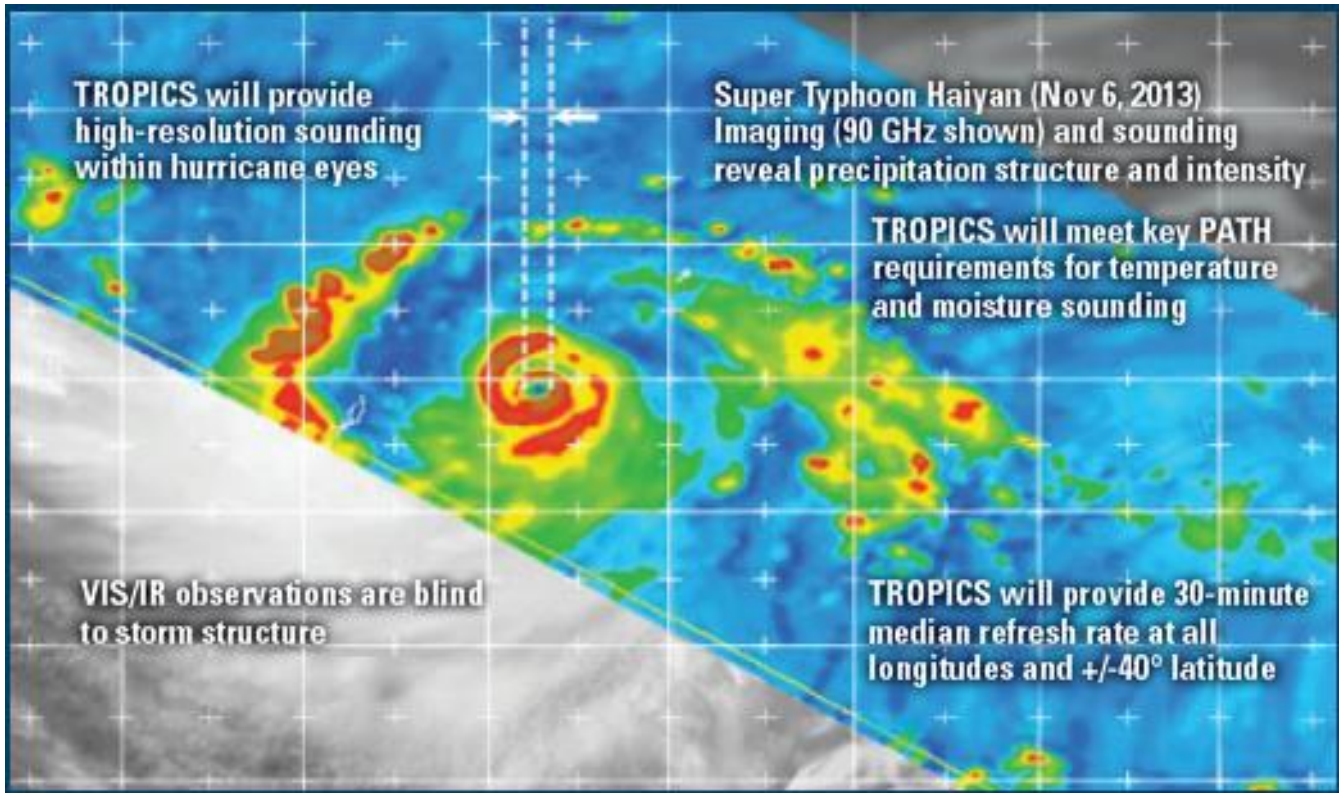
- CONUS-scale ~3-km resolution with 33-year climatology incorporating daily S-NPP/VIIRS vegetation
- Additional experimental international domains
- Multiple end-users in NOAA/NWS and other government / private sector / international organizations
- Proven vehicle for applications and research activities
  - Flooding and wildfire research
  - SMAP data assimilation
- Recent peer-reviewed publications
  - Overview: Zavodsky et al. (2013; *Earthzine*)
  - Flooding event: Case (2016; *Results Physics*)
  - Drought/wildfire: Case & Zavodsky (2018; *Results Physics*)
  - SMAP data assimilation: Blankenship et al. (2018; *IEEE GRSL*)
  - Soil moisture validation: McDonough et al. (2018; *J. Hydrol.*)



dramatic 0-2 m soil moisture transformation from anomalously dry to record wetness associated with Hurricane Florence in the Carolinas

TROPICS Early Adopter – Use of data for SPoRT Stakeholders

- Official Early Adopter
- Will have access to early release proxy data in early 2019
- Plan to evaluate use of data for hurricane case studies, develop training, and assess proxy data with forecasters
  - NWS National Hurricane Center
  - NWS Central Pacific Hurricane Center
  - Joint Typhoon Warning Center forecasters



TROPICS Early Adopter – Improving Land Surface Evaporation

- The improvements to temporal sampling from TROPICS will provide a unique opportunity to provide the diurnal details in LST that have not been possible with the current constellation of MW sensors to monitor land-surface evapotranspiration under "all-sky" conditions.

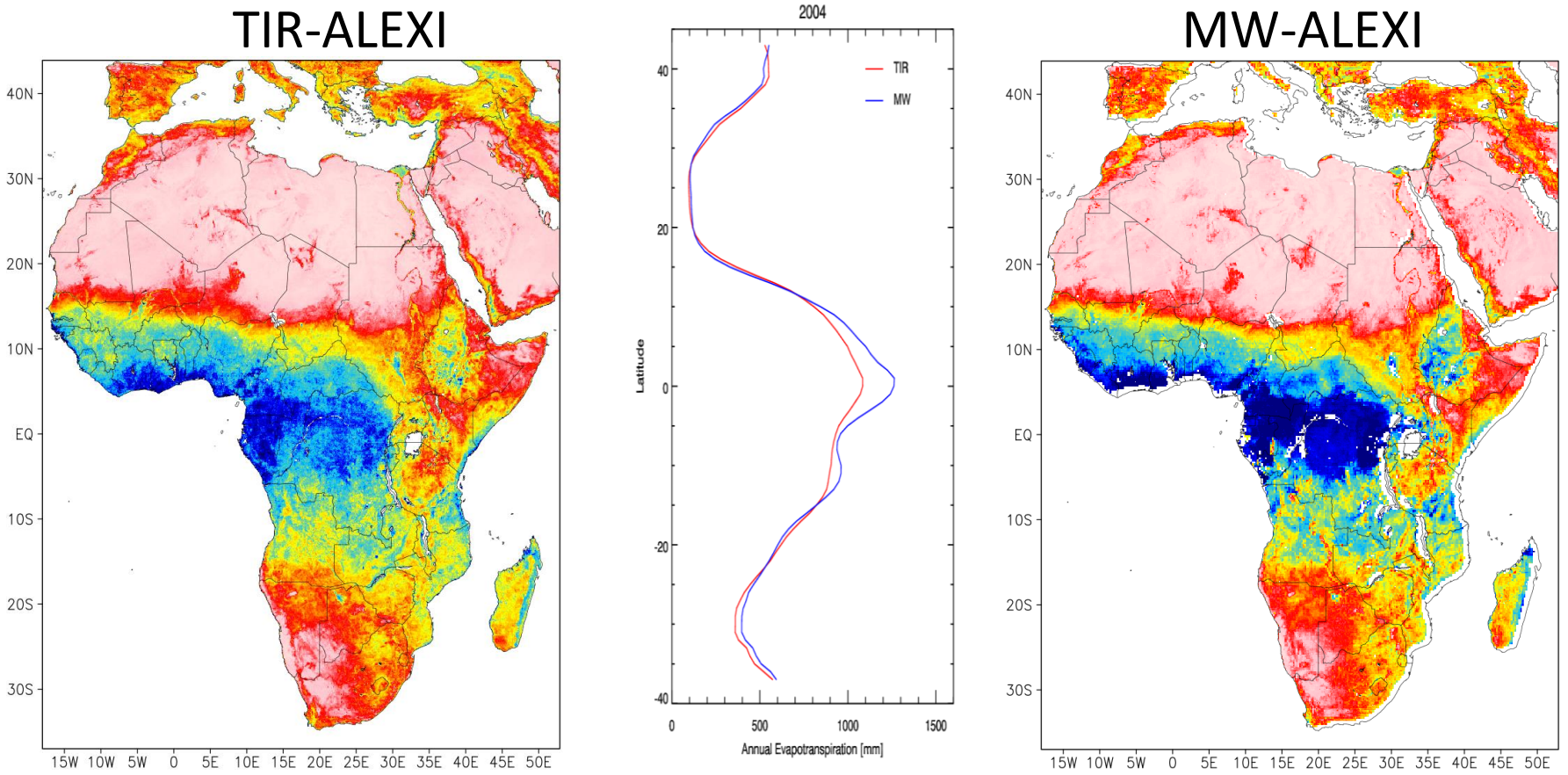
(1) Retrieve MW-based LST via data assimilation:

LST can be derived from MIRS, which will be the processing system for other geophysical variables derived from TROPICS

(2) Using 90 GHz Tb time series to improve gap-filling of 37-GHz LST:

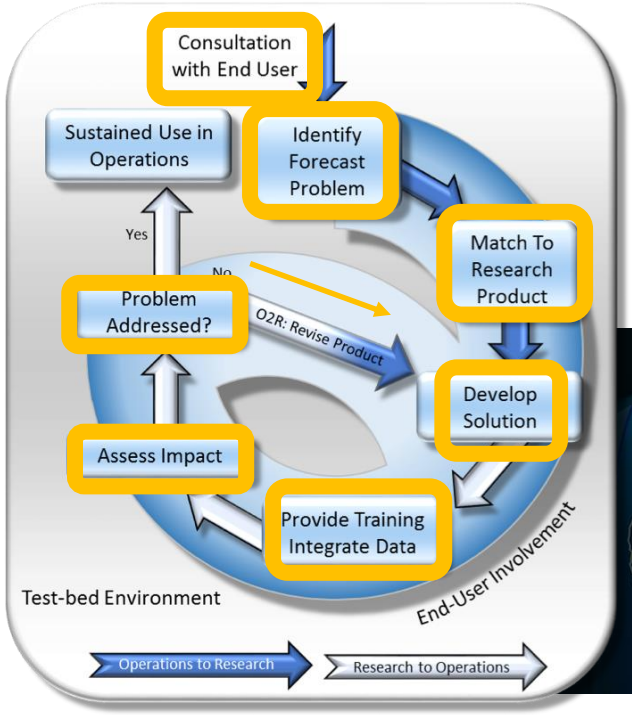
High temporal resolution TROPICS observations could be used to develop relationships to improve the diurnal fit used to retrieve LST from temporally sparse 37 GHz observations.

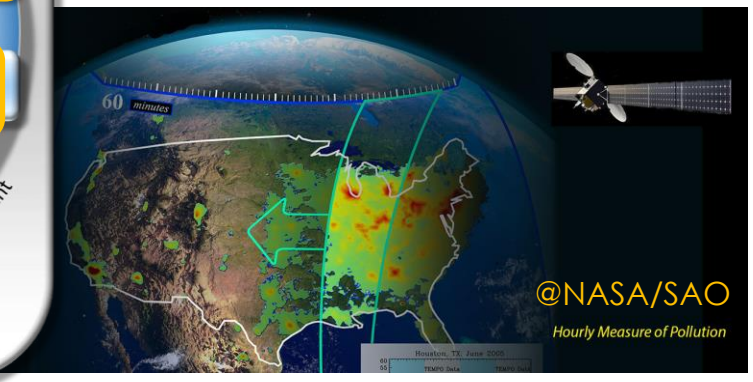
Cumulative - Clear Sky - Evapotranspiration (mm)

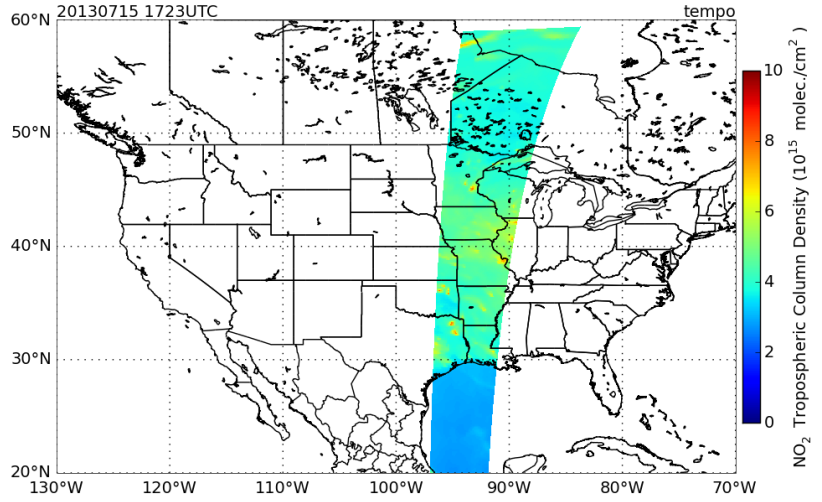


Engaging with Air Quality Stakeholders for TEMPO Applications

- Collaborate with Western U.S. partners in conjunction with the Western Regional Air Partnership
- Wildfire smoke and associated pollution and transport events
- How do TEMPO proxy products need to be formatted, tailored, and displayed to suite end user needs?
- Provide TEMPO proxy data in WMS format
- Develop targeted applications training
- Assessment and feedback from select Western U.S. partners
- Discuss feedback with mission scientists to refine the solution and assess products with end users again



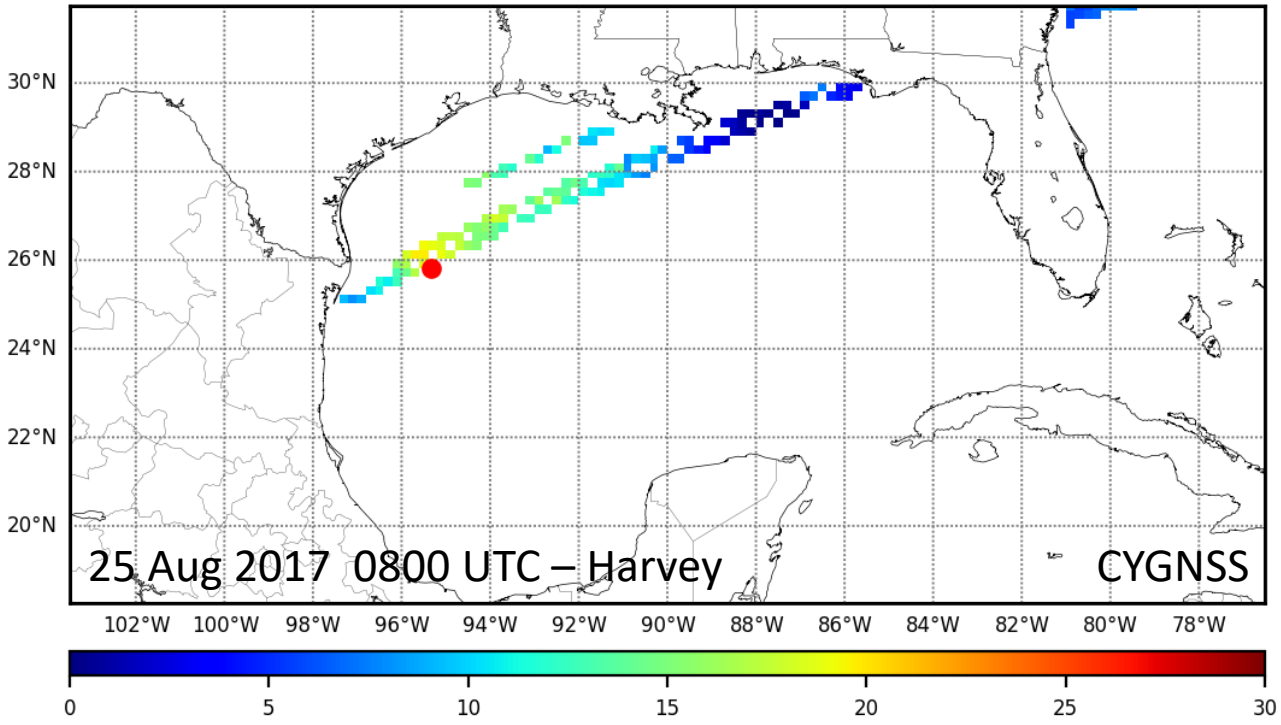


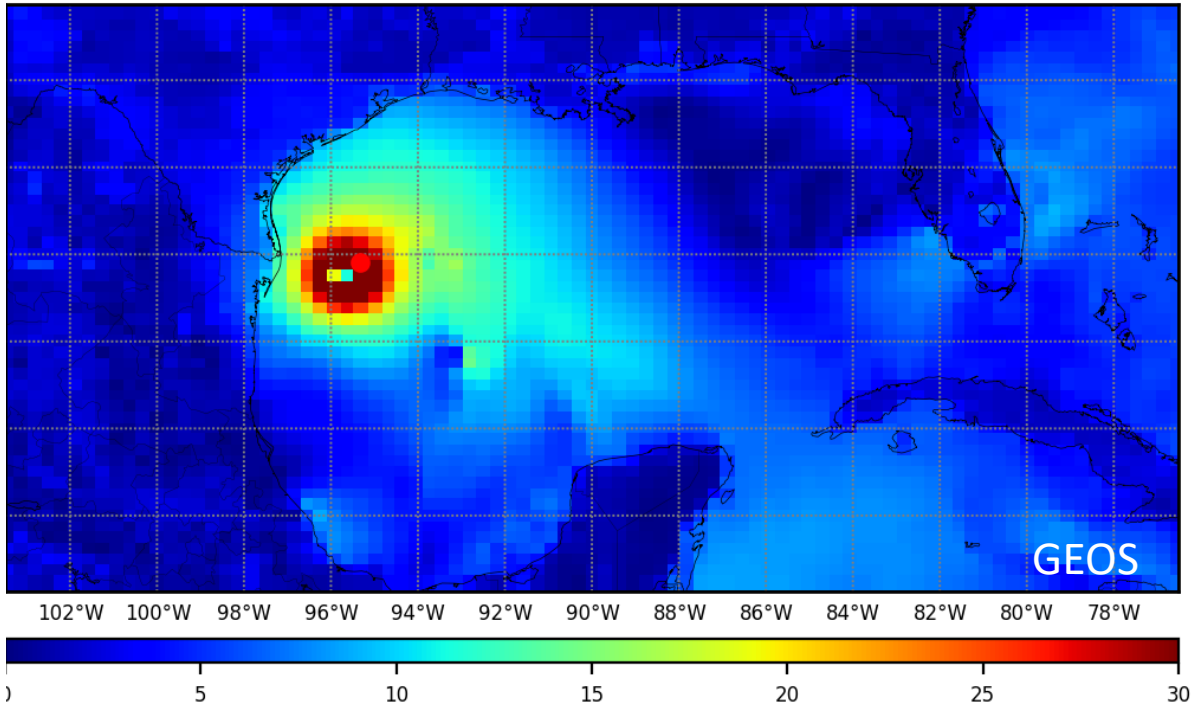


TEMPO Proxy data Courtesy of Chris Chan Miller, SAO

Developing CYGNSS Applications and Synergy with TROPICS and GPM

- Pair CYGNSS with TROPICS and GPM imagery to study case studies and evaluate the effectiveness for hurricane forecasting and partner with operational forecaster through assessment activities
- Evaluate the effectiveness of flux products for anticipating the development of extratropical cyclones and partner with long-standing Ocean Prediction Center and Weather Prediction Center partners to foster use of the NASA dataset in operations





Preparing for Next-generation Soil Moisture Products

Current and upcoming NASA missions will provide unique opportunities for the retrieval of soil moisture and vegetation information to be assimilated in the Land Information System (LIS).

- CYGNSS

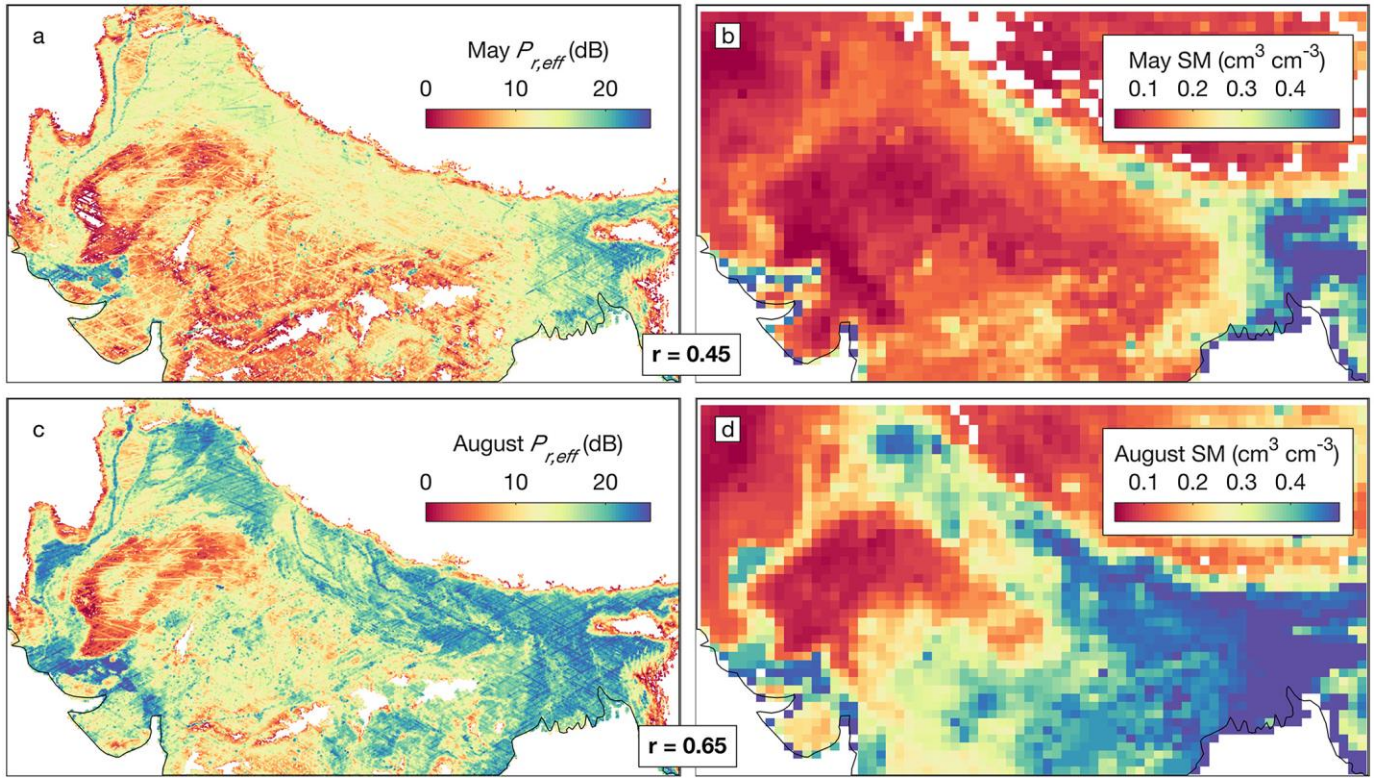
SPoRT is collaborating with NOAA ESRL who have developed a CYGNSS soil moisture product (left).

Investigating potential data assimilation or LSM evaluation activities.

- NISAR

SPoRT attended the NISAR Agricultural Applications Workshop this summer to learn about potential soil moisture vegetation applications for NISAR

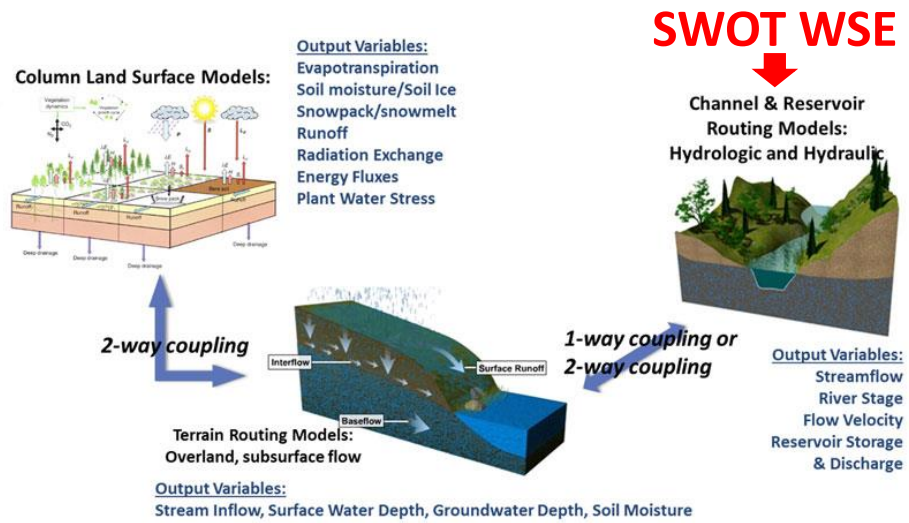
Investigating the use of the merged SMAP-Sentinel soil moisture dataset and standalone Sentinel data as a proxy for NISAR.



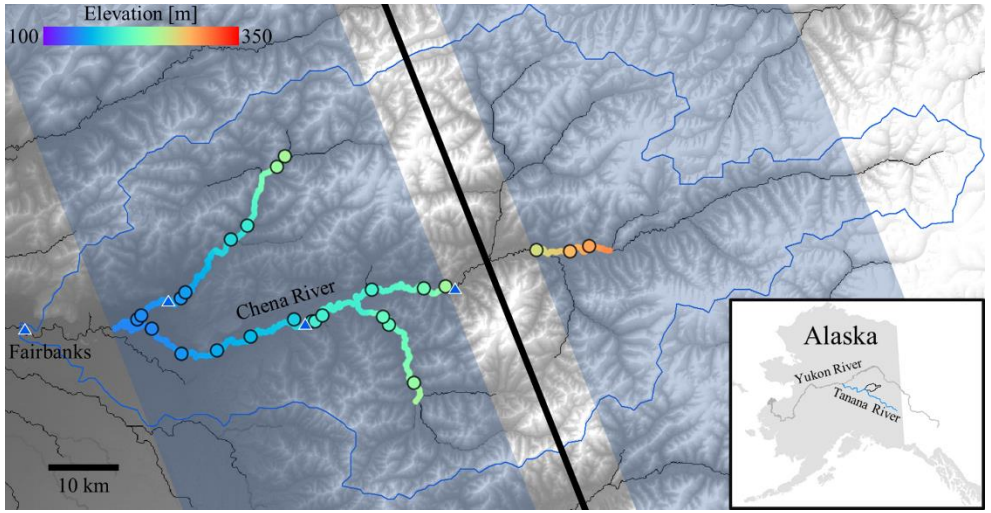
Observations of $P_{r,eff}$ for May (a) and August (c) 2017, in northern India and Pakistan. Also shown is mean soil moisture (SM) for May (b) and August (d) 2017, retrieved by Soil Moisture Active Passive for the same region (Taken from Chew et al. 2018).

Assimilating SWOT observations into the National Water Model

- NASA Surface Water Ocean Topography (SWOT) mission (2021 launch) uses Ka-band radar interferometer to measure water surface elevations (WSE) for rivers with widths greater than 50-100 meters globally
- SPoRT is collaborating with NCAR and NWC to assimilate SWOT WSE into the NOAA National Water Model (NWM) to improve operational streamflow prediction
- Future work will leverage SWOT WSE assimilation into the NWM/WRF-Hydro to support flood, drought, and wildfire applications by improving model parameters and land surface states (e.g., soil moisture) in a NASA LIS/WRF-Hydro framework



SWOT WSE is assimilated into the NWM (WRF-Hydro) channel routing module.



Model-derived synthetic SWOT WSE (colorbar) over the Chena River (AK) for a single simulated SWOT overpass. Simulated SWOT swath is shaded in blue with the nadir track indicated by the black line. Virtual stream gages, obtained by sampling the syntethic SWOT WSE, are shown by the colored circles.

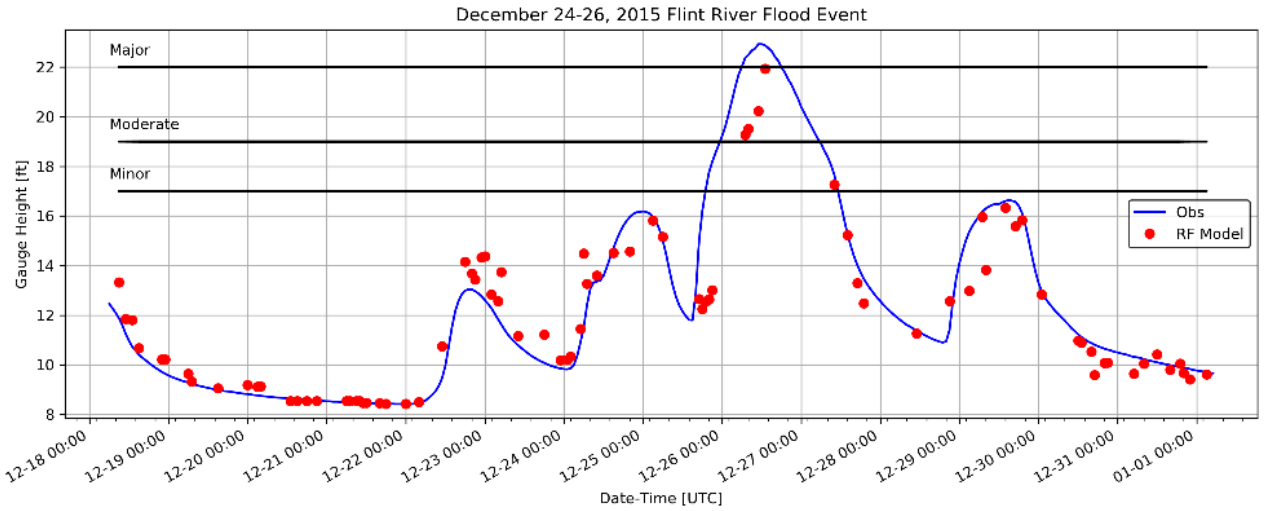
Machine Learning: Streamflow Prediction for the NWS

- In the absence of river stage forecasts prior to the onset of precipitation, local NWS forecasters rely on "rules of thumb" to asses flood risks.

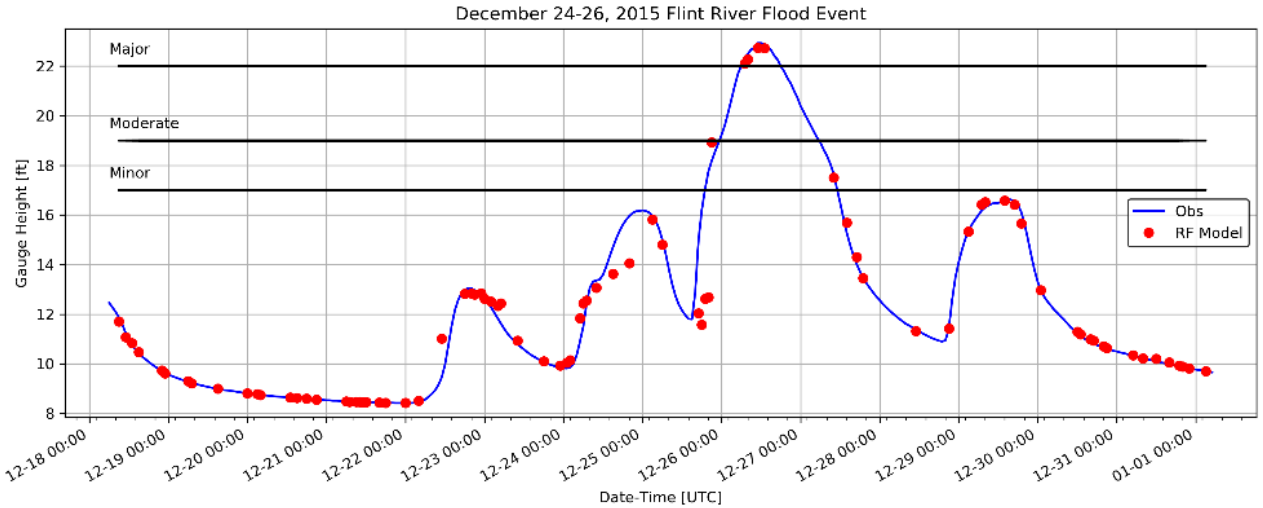
- A random forest (RF) regression ensemble machine learning technique is utilized to develop a statistical model to predict river gauge height for more robust and consistent flood risk assessments.
    - Model predictors: up to 72 hour time lagged MRMS QPE and SPoRT-LIS Relative Soil Moisture (RSM).
    - Model predictand: river gauge height

- A RF model based on precipitation alone performs reasonably well, but the added value of the SPoRT-LIS enhances the ability of the model to accurately capture the observed gauge height.
    - 6 hr lagged LIS 10 – 40 cm Relative Soil Moisture had the highest predictive skill for the December 24-26, 2015 Flint River flood event by a wide margin.

MRMS Precipitation as only Predictor



MRMS QPE and SPoRT-LIS Relative Soil Moisture

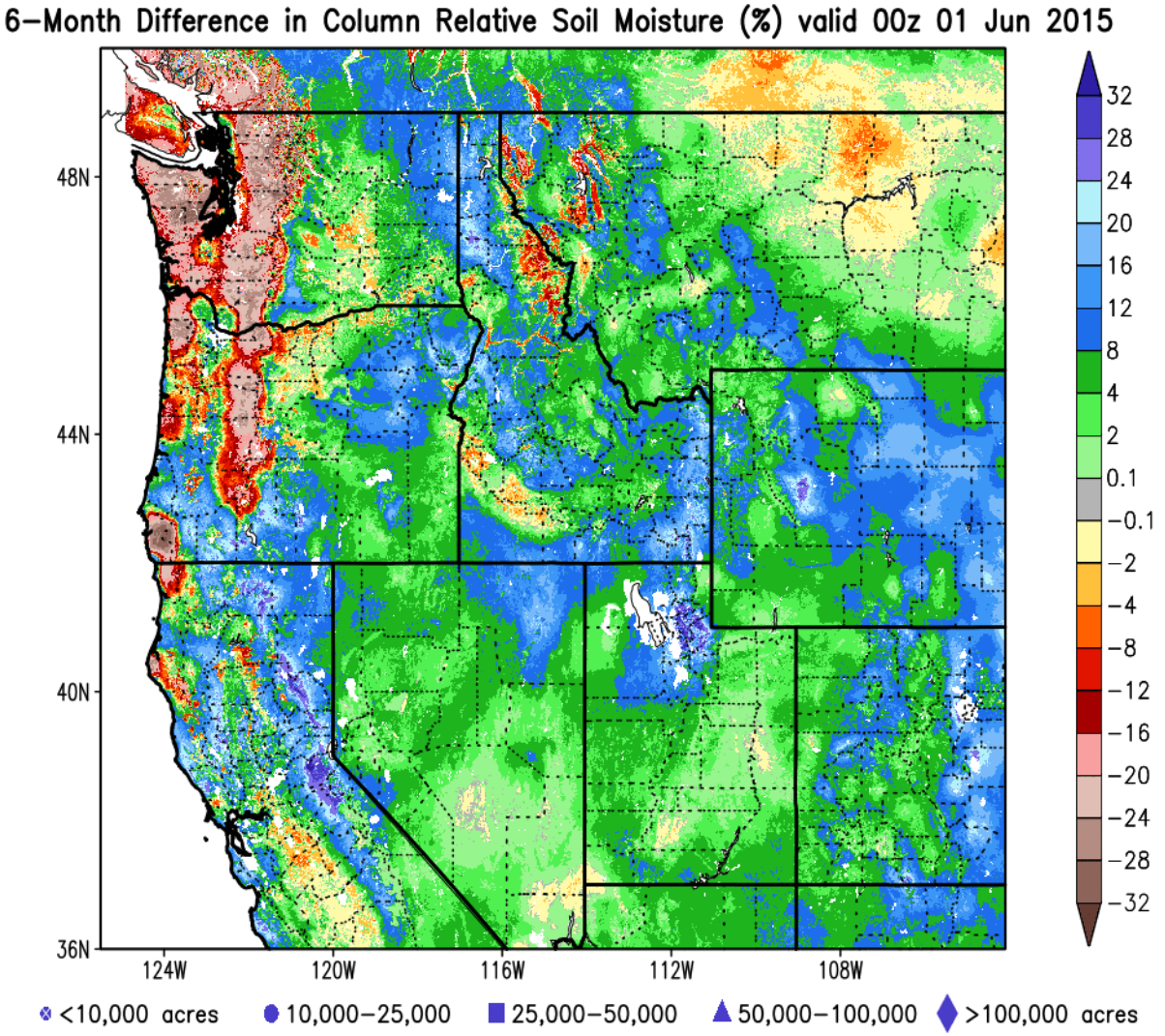


Machine Learning: Assessing Fire Risk and Probabilistic Tool for Lightning-initiated Wildfire

- Machine learning provides a pathway to synthesize large amounts of data into an interpretable result.
  - Wildfire potential is dependent on multiple atmospheric and land surface variables.

- NASA/NASA SPoRT satellite and model data provides a various sources of information on the land surface characteristics through time:
  - SPoRT-LIS model volumetric soil moisture and soil moisture percentiles
  - MODIS leaf area index and greenness vegetation fraction.
  - Evaporative Stress Index (ESI) composite images to characterize surface moisture stress.
  - Meteorological surface variables

- Overall, the goal is to use machine learning to produce predictive estimates of important fire season variables such as: start, severity and length of season, in order to provide this beneficial information to fire management officials.



Summary

Continued partnerships within NOAA's Satellite Proving Ground to engage with NWS forecasters on new applications of GOES-16/17 and S-NPP/NOAA-20 data

Engagement with the National Water Center and National Water Model, exploring data assimilation opportunities for current and future NASA mission data

Expansion of lightning activities to additional applications and end users from other government agencies

SPoRT prepares the ***community*** of ***end users and mission scientists*** for next generation satellite missions and capabilities through an interactive R2O/O2R paradigm

Currently, expanding partnerships to other government agencies and new NASA missions through Early Adopter Activities with TROPICS, TEMPO, CYGNSS, NISAR, …