Satellite Hydrological Products - Recent Advances and Applications, Future Challenges

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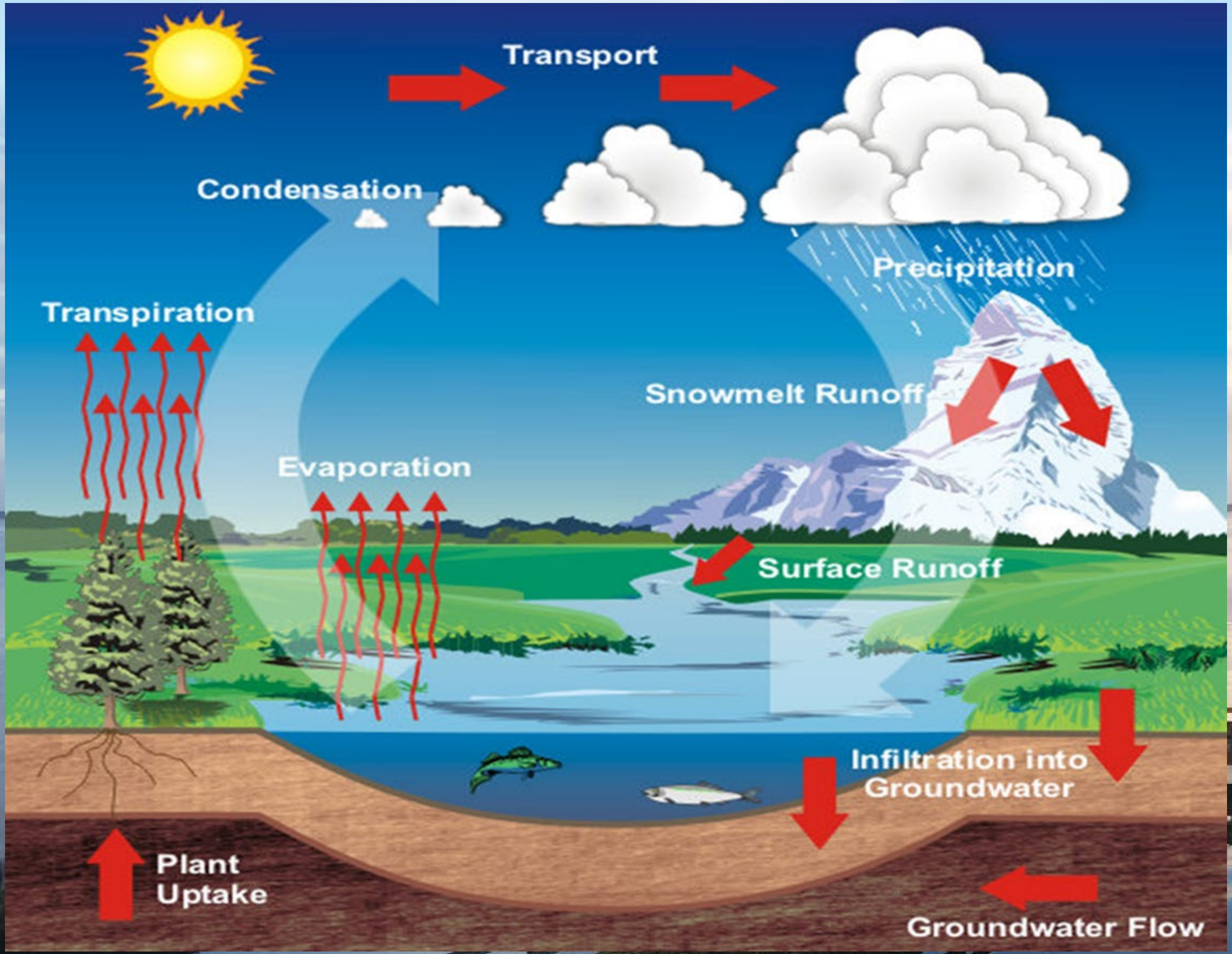
[with contributions from STAR and CISESS colleagues]

Outline

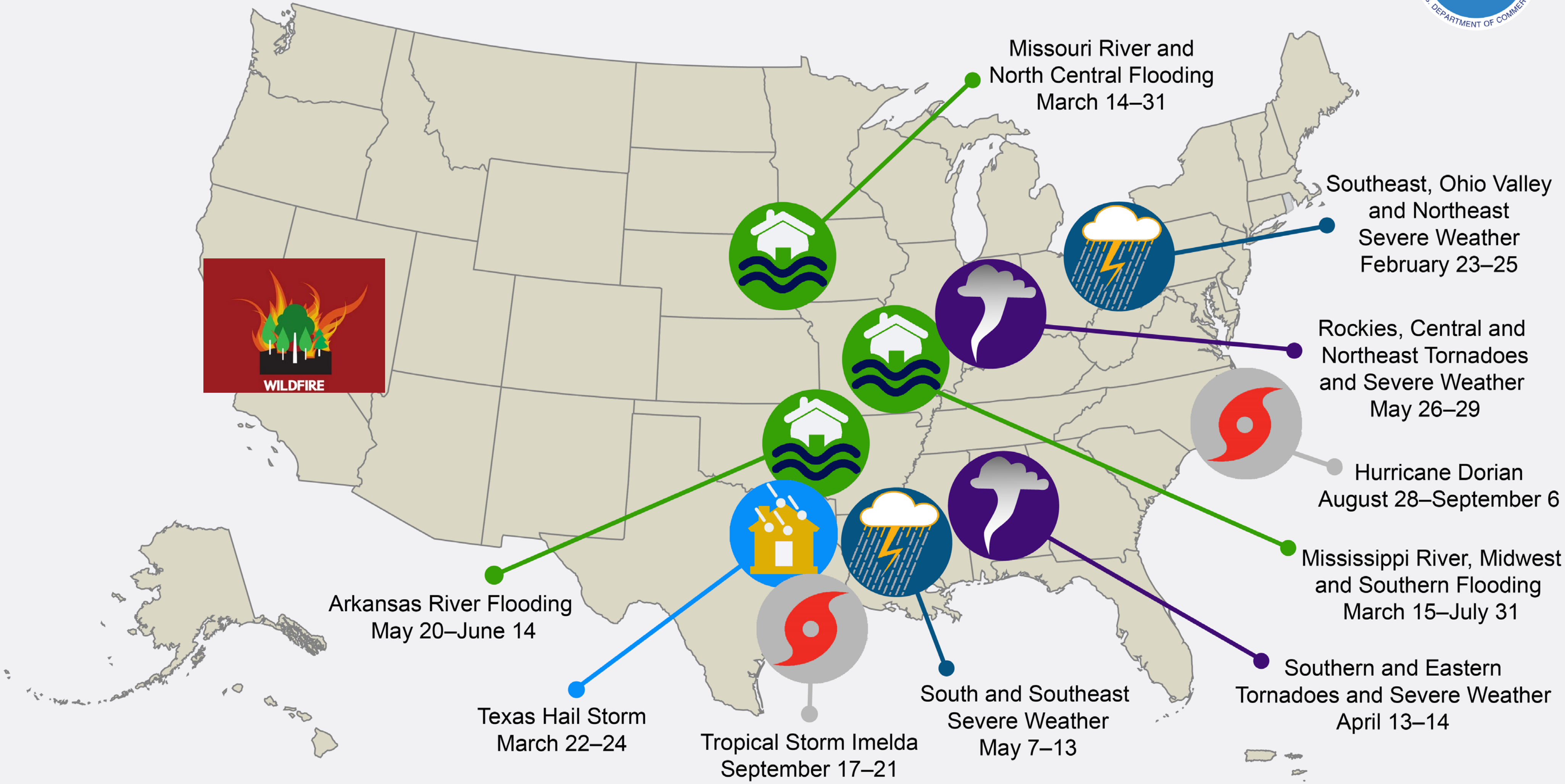
- Importance of the Hydrological Cycle and observational gaps
- Microwave retrievals – cornerstone for many variables
- NESDIS product lines and operational product systems
- Emerging products
- Application Examples
- Summary and Future Challenges

The Hydrological Cycle and Observational Gaps



- In-situ data generally covers well populated land regions
- Where we have data, we can measure precipitation, snow depth/water equivalent, soil moisture relatively well
- Where satellite offer the most help:
  - Where no other data exists – remote land regions, open ocean
  - Where in-situ data isn't all that good or is sparse – water vapor transport, cloudiness
- The best solution is an integrated observing approach!

U.S. 2019 Billion-Dollar Weather and Climate Disasters



*This map denotes the approximate location for each of the **10 separate billion-dollar weather and climate disasters** that impacted the United States **from Jan–Sept 2019**.*

Satellite Attributes:

Integrated Observing from Space

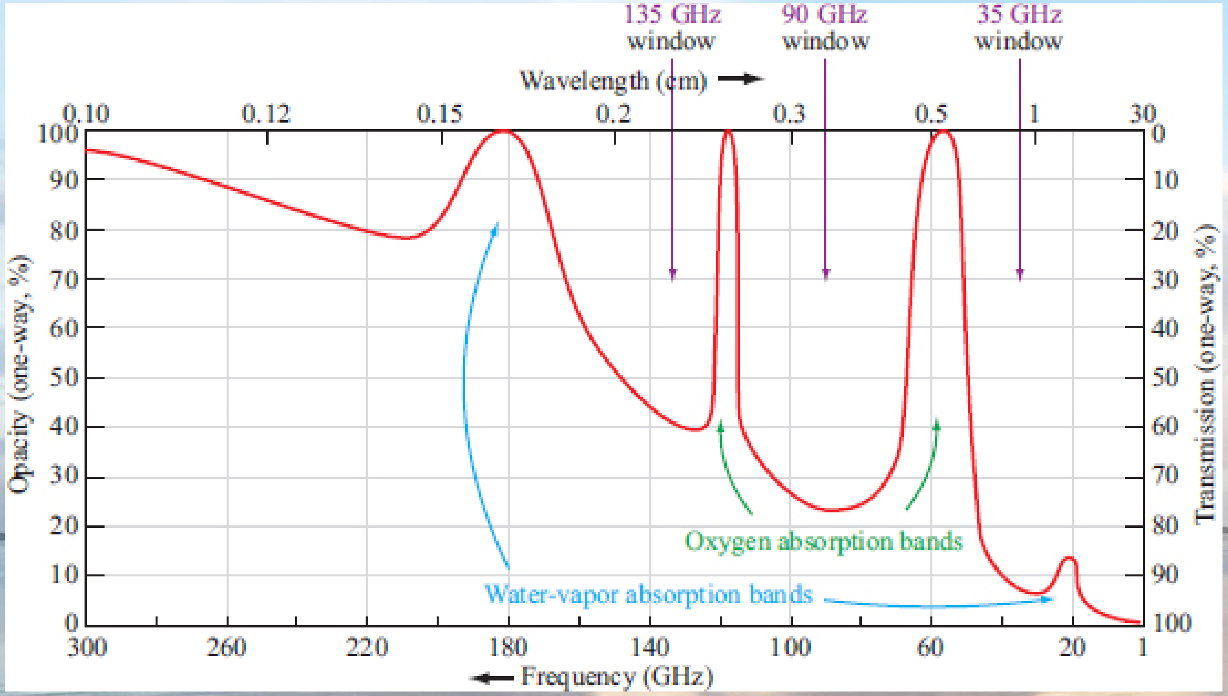
Geostationary Satellites

- Fixed location
- Short data latency
- Visible and IR (and lightning)
    - Rapid scan available
- Movement
    - Clouds, water vapor, ocean currents, etc.
- Rapidly changing events – hurricanes, thunderstorms, fires, volcanic ash, aerosols,…
- Cloud drift winds/NWP

Low Earth Orbiting Satellites

- (Near) Global coverage
- Longer data latency (except CONUS/DB)
- Wider variety of sensors and applications
    - Visible and IR (including hyperspectral sounders)
    - Passive (active) MW
- Unique capabilities, including
    - Vertical profiles of atmos. (NWP)
    - Atmospheric Chemistry
    - Vegetation & Soil Moisture
    - Water Quality
    - MW – cloud penetration, ocean surface

Microwave Sensors – Key to Water Cycle Observations



Satellite	Sensor	Key Channels
GCOM-W1	AMSR-2	6.9, 10.7, 18.7, 23.8, 36.5, 89.0 GHz
S-NPP	ATMS	23.8, 31.4, 50.3, 89.5, 165.5, 183.3 (5 channels)
NOAA-20	ATMS	

"Typical" MW channel compliments from both imagers and sounders

◎ and ○ denotes necessary and important channels, respectively

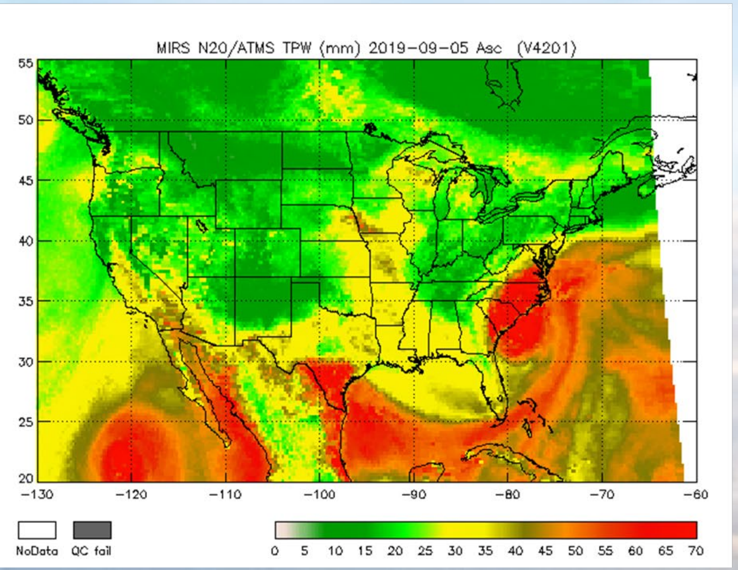
	7 GHz	10 GHz	19 GHz	23 GHz	37 GHz	89 GHz	183 GHz
TPW			○	◎	○		
CLW			○	○	◎		
Rain Rate		○	◎		○		
Snowfall Rate					○	◎	○
SST	◎	◎	○	○			
Sea Surface Wind	○	○	○		◎		
Sea Ice		○	◎		◎	○	
Snow Water Equiv. (L)			◎		◎	○	
Soil moisture (L)	◎	◎	○				

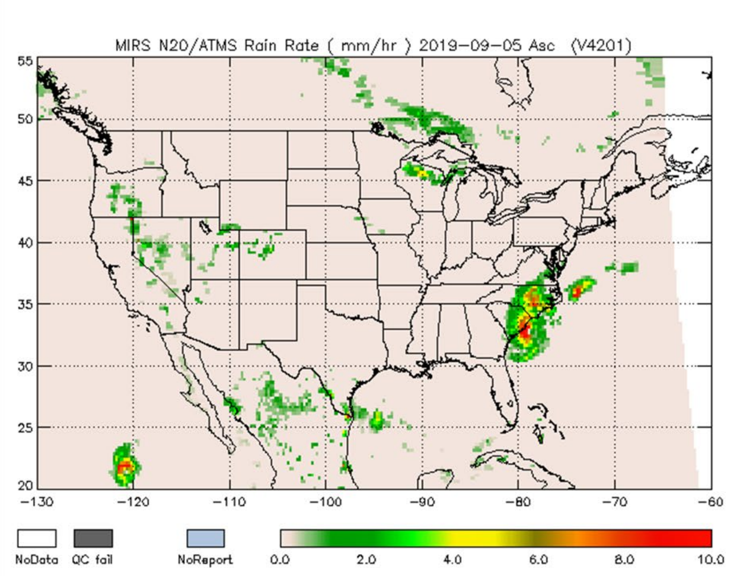
NOAA Operational Product Systems – LEO and blended focus

- Microwave Integrated Retrieval System (MiRS)
  - http://www.ospo.noaa.gov/Products/atmosphere/mirs/index.html
- Microwave Snowfall Rate (SFR)
  - http://www.ospo.noaa.gov/Products/atmosphere/mirs/index.html
- NOAA Operational GCOM-W1 AMSR2 Products System (NOGAPS)
  - http://www.ospo.noaa.gov/Products/atmosphere/gpds/
- NESDIS Operational Soil Moisture Products (SMOPS)
  - http://www.ospo.noaa.gov/Products/land/smops/index.html
- Blended TPW/RR
  - http://www.ospo.noaa.gov/Products/atmosphere/brr/
- VIIRS snow and ice products
  - https://www.star.nesdis.noaa.gov/jpss/EDRs/products_cryosphere.php
  - http://hippy.gina.alaska.edu/distro/ice_eval/
  - http://hippy.gina.alaska.edu/distro/ice_motion_eval/
- Interactive MultiSensor Snow & Ice Mapping System (IMS)
  - http://www.natice.noaa.gov/ims/index.html

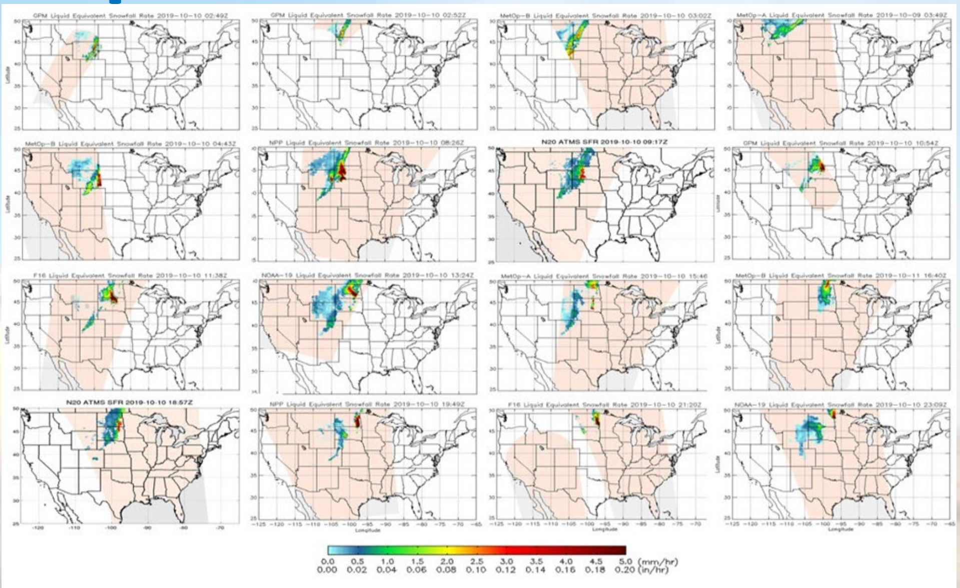
Huan Meng, Mark Liu, Jerry Zhan – STAR
Chris Grassotti, Jun Dong, Cezar Kongoil,
Jifu Yin, Pat Meyers – CISESS

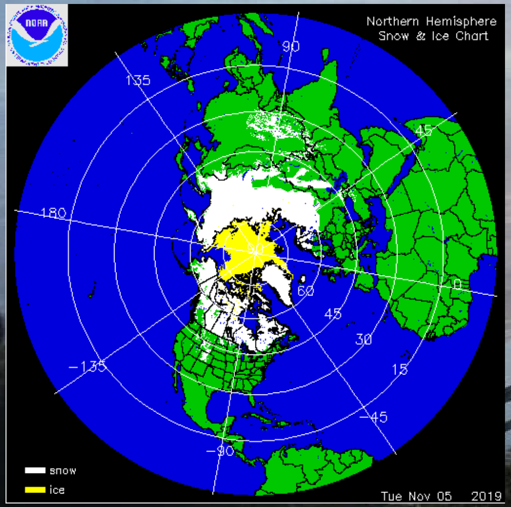
Some Product Examples

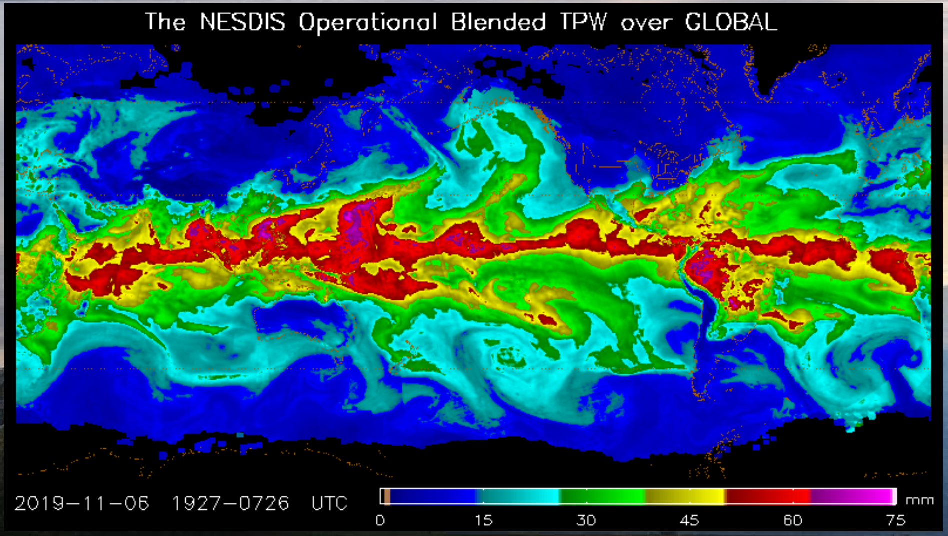


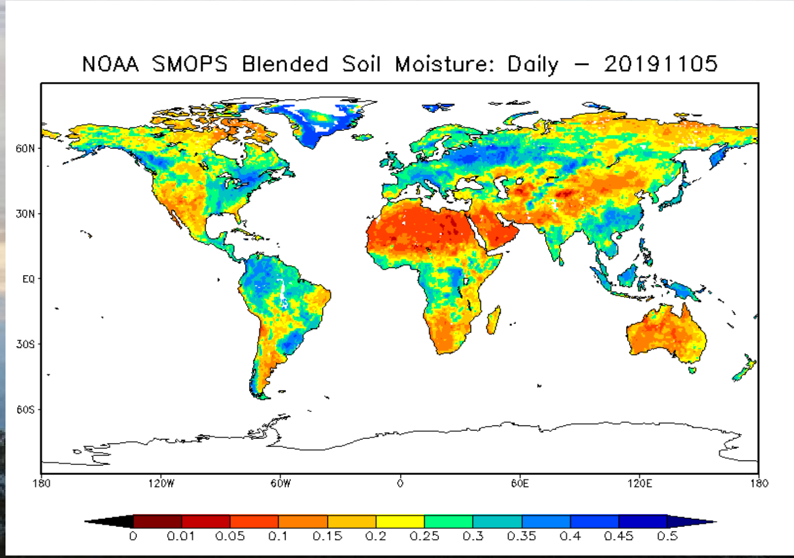


Snowfall Rates





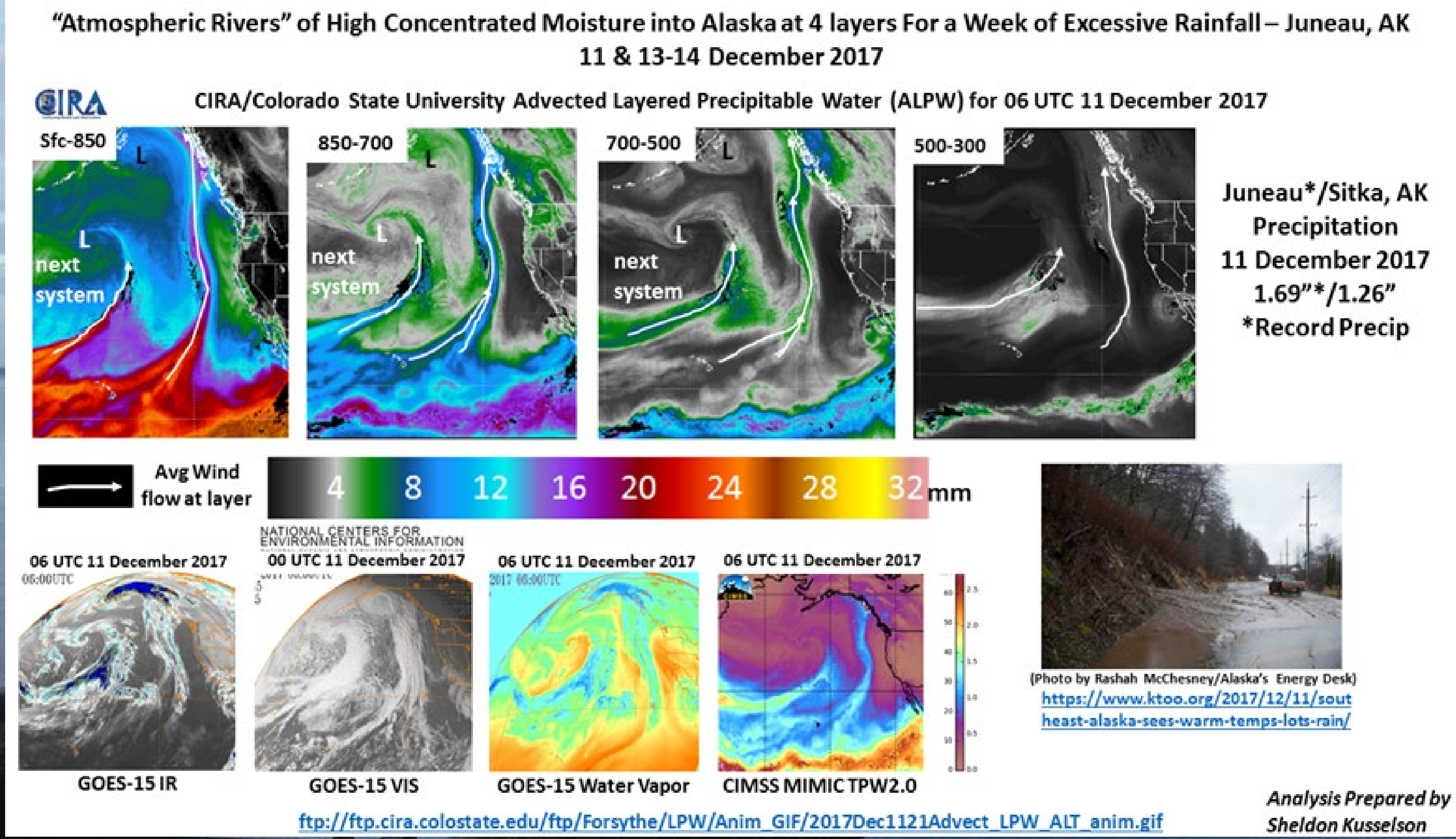


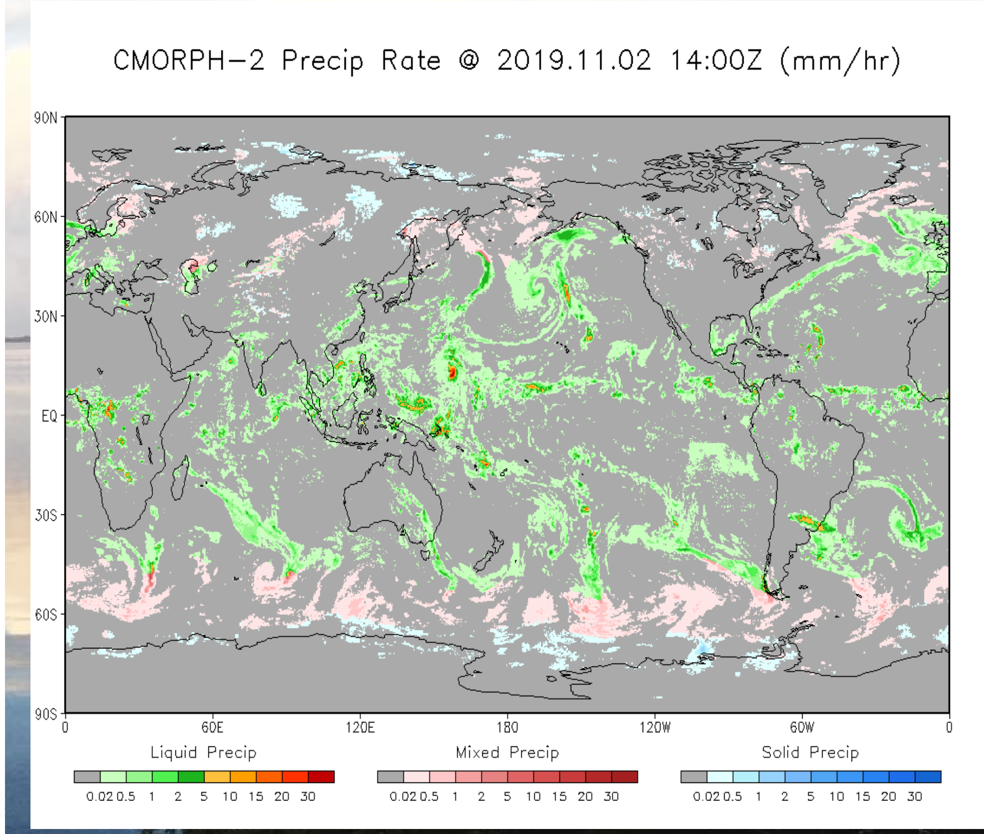


Putting some of the pieces together

John Forsythe, Sheldon Kusselson, CIRA

Pingping Xie, NWS

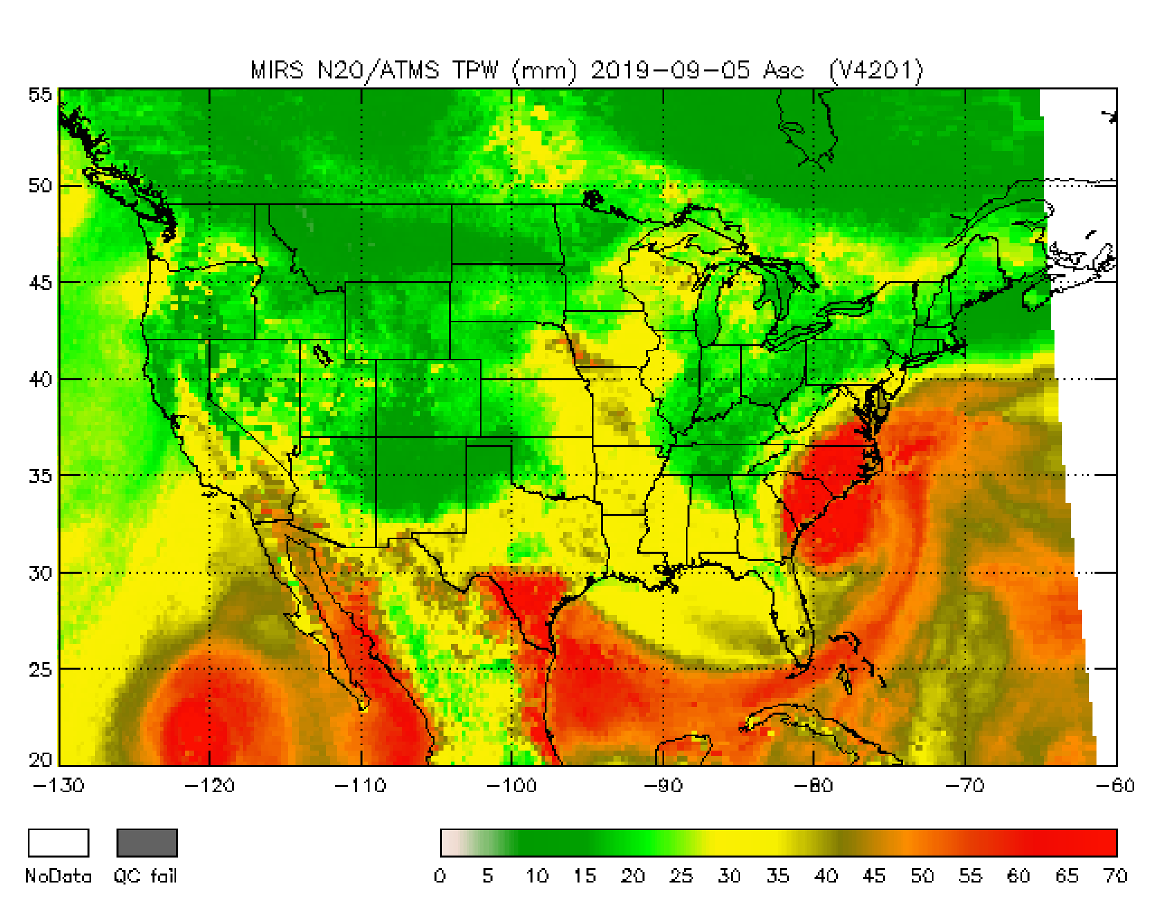


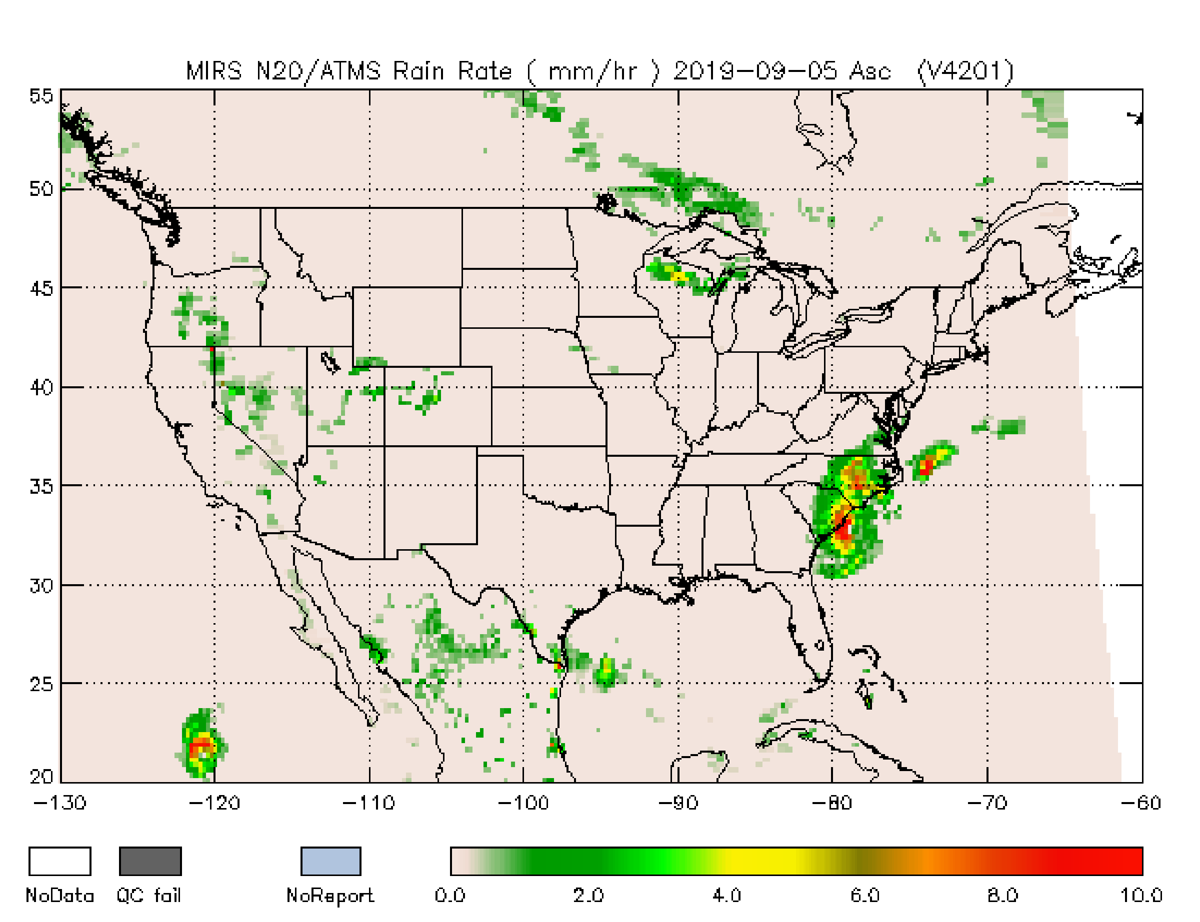


Hurricane Dorian from NOAA-20 – MiRS Products

September 5, 2019

Chris Grassotti, CISESS

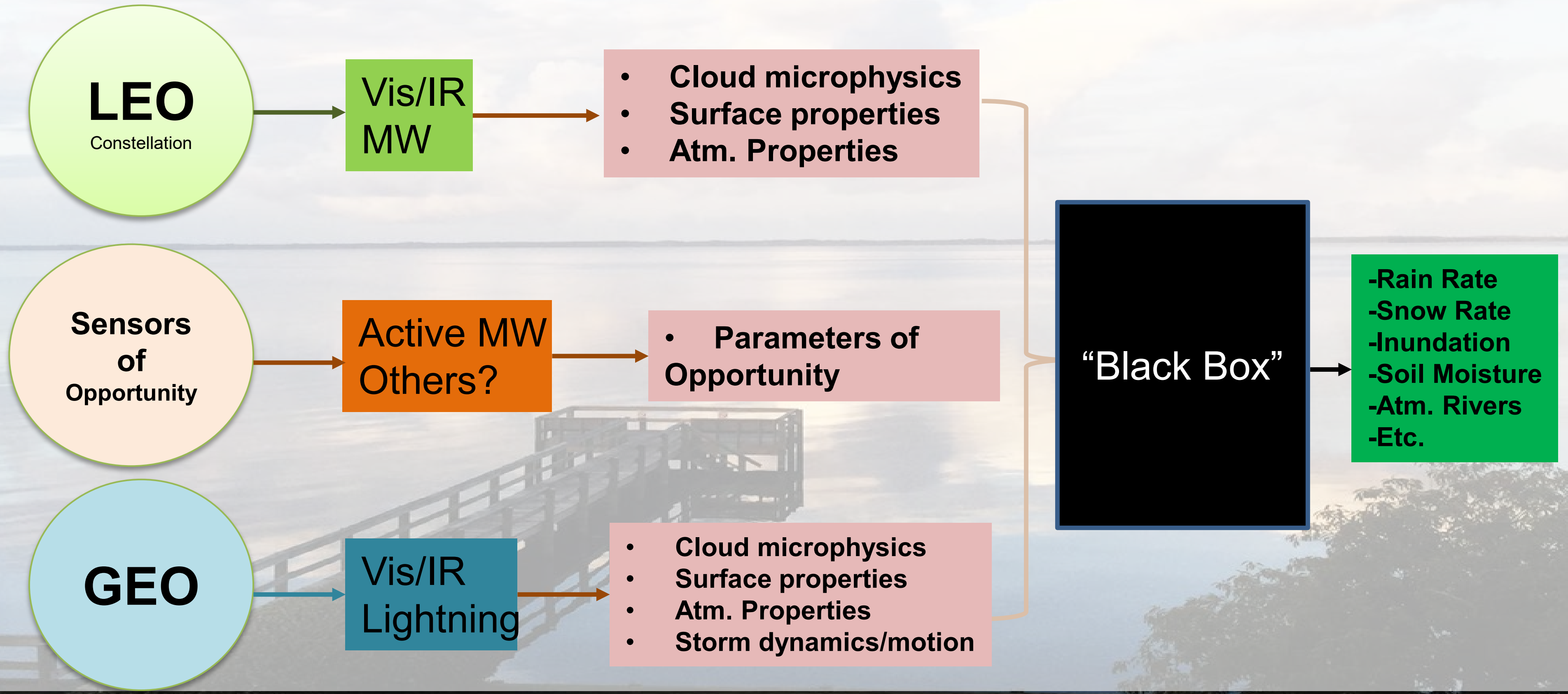




Summary and future challenges

- Satellite derived hydrological products provide valuable information in regions which lack in-situ data
- Emerging “blended products” exploit multiple satellites & sensors
- Moving forward:
  - –Exploiting the best information from all sources & thinking “out of the box”.
    - Everyone is excited about AI…I am intrigued about the “adaptability” aspect of it all
  - –Using other measurements (lightning) and other methods (VR)
  - –Can we make all of the parameters self-consistent?

One vision moving forward – exploit "level 2" information from all possible remote sensing observations. To date, we have not done this!



Obstacles, to name a few….

- Data availability
  - Latency
  - Complex international agreements and restrictions…
- Satellites “see” different things
  - View geometery
  - Spatial resolution
- Likely growing use of private sector data
  - Cubesats won’t be everywhere when you want them
  - How precise will they be
- Solutions will require engaging other disciplines and a paradigm shift
  - VR, cloud computing, etc.
- Resources
  - Convincing leaderships that to make advances, its going to require investment