FOUNDATIONAL COURSE

August 14, 2018

Satellite Foundational Course for JPSS (SatFC-J)

MICROWAVE

FOUNDATIONAL COURSE

Influence of Clouds and Precipitation

JPSS NOAA NASA

NATIONAL WEATHER SERVICE

Learning Objectives

1. Understand how microwave sensors provide moisture, cloud properties, and precipitation information against different surface backgrounds (land vs. ocean).

2. Interpret Total Precipitable Water (TPW), Cloud Liquid Water (CLW), Rain Rate (RR), and Liquid Equivalent Snowfall Rate (SFR) products from example imagery.

3. Describe how blended microwave and infrared precipitation products are used to improve coverage of significant precipitation events.

Advantage of Microwave Remote Sensing

Non-precipitating clouds are transparent

- Microwave detects moisture at all levels
- Infrared can detect moisture at different levels, but only in cloud-free regions

Total Precipitable Water (TPW)

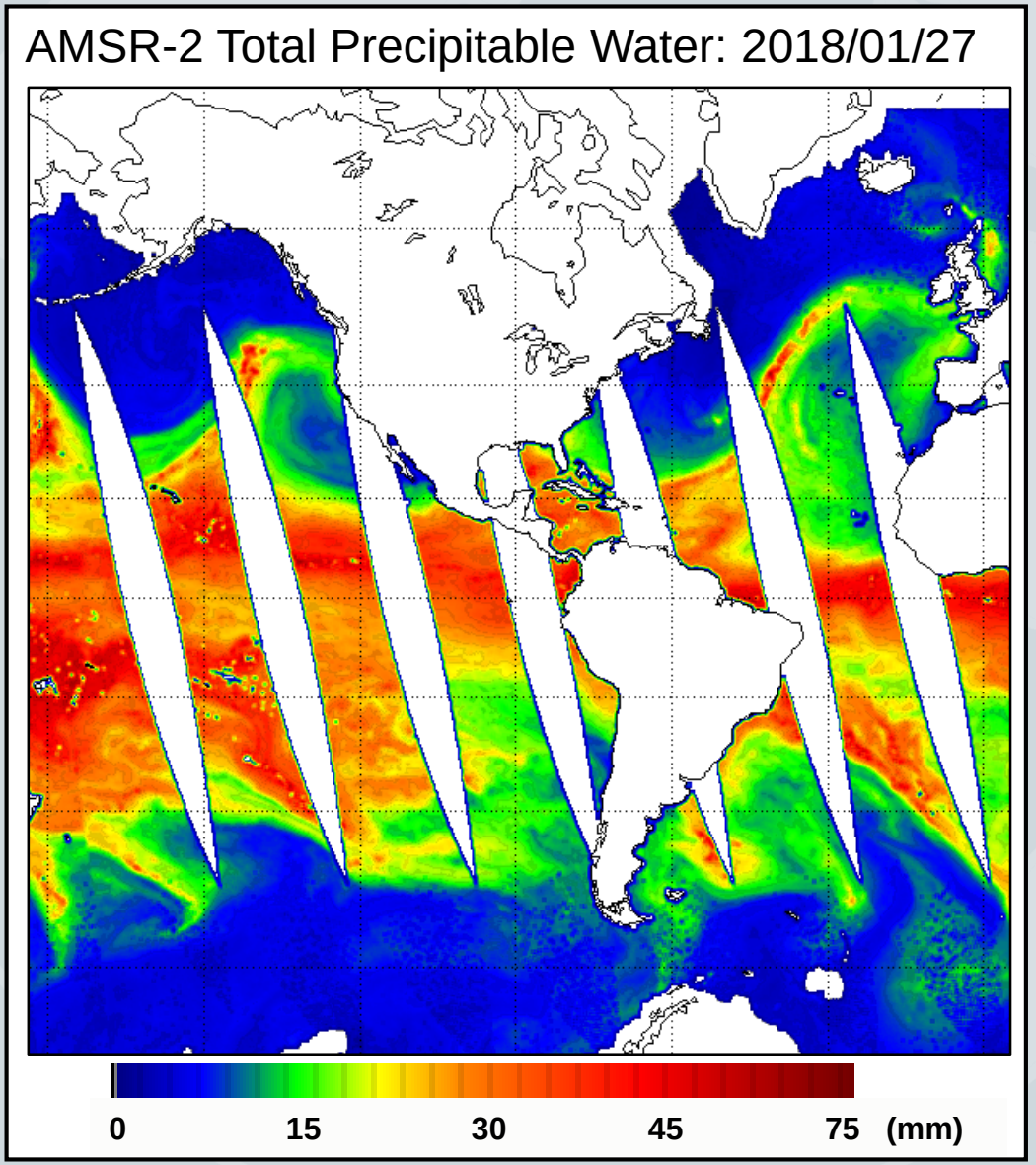
- Definition:

  Liquid water equivalent if all the ***water vapor*** were condensed within a column of the atmosphere

- Observation Region:
  - global, over the oceans
  - excluding areas of sea ice and precipitation
- Observation Range:

  0-75 mm

  0-75 kg/m^2



NOAA Operational GCOM-W1 AMSR-2 Product Maps
http://www.ospo.noaa.gov/Products/atmosphere/gpds/maps.html?GPLCT#gpdsMaps

Cloud Liquid Water (CLW)

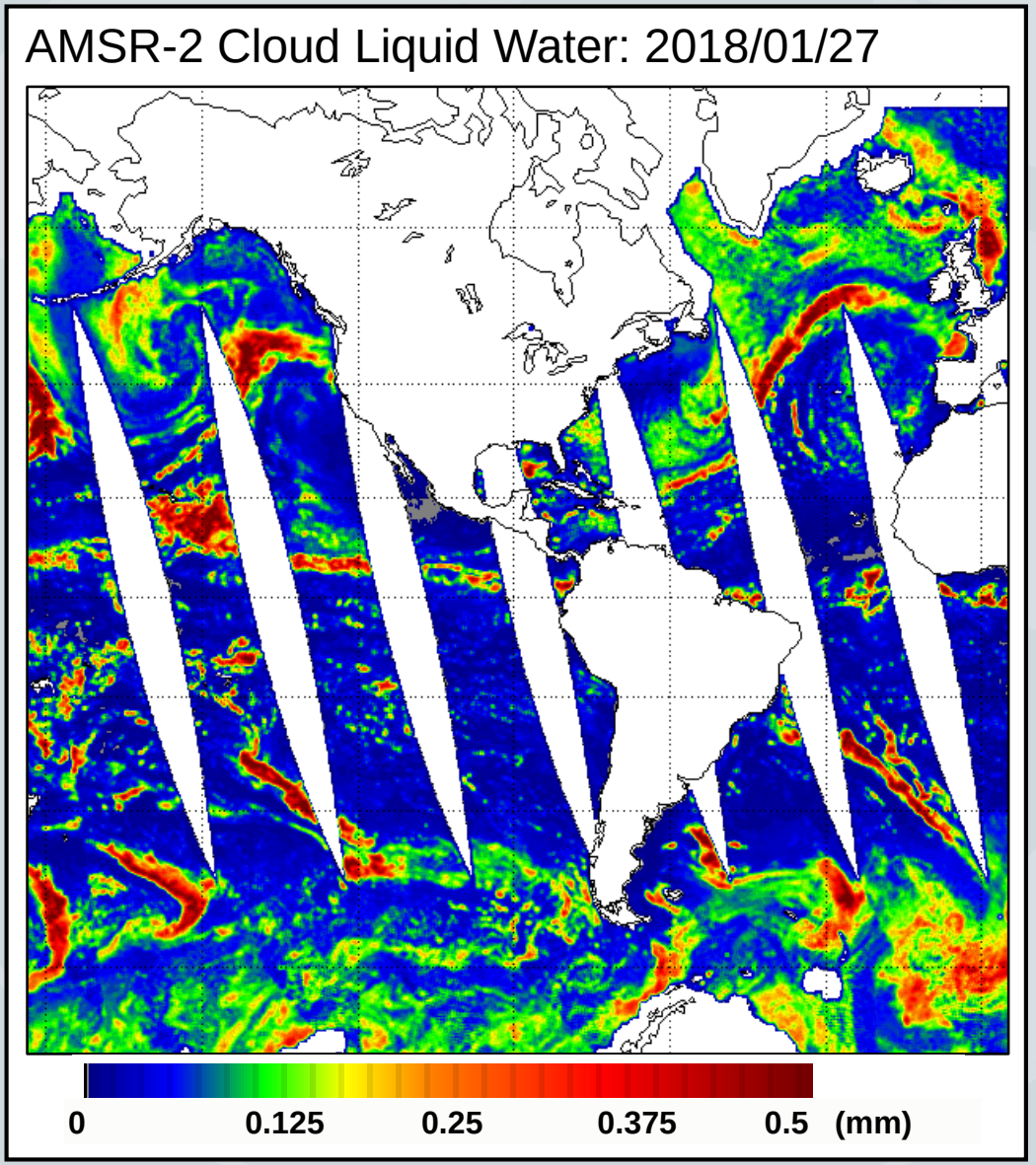
- Definition:

  Depth of water if all the ***cloud droplets*** were accumulated within a column of the atmosphere

- Observation Region:
  - global, over the oceans
  - excluding areas of sea ice and precipitation
- Observation Range:

  0-1.0 mm

  0-1.0 kg/m^2



NOAA Operational GCOM-W1 AMSR-2 Product Maps
http://www.ospo.noaa.gov/Products/atmosphere/gpds/maps.html?GPLCT#gpdsMaps

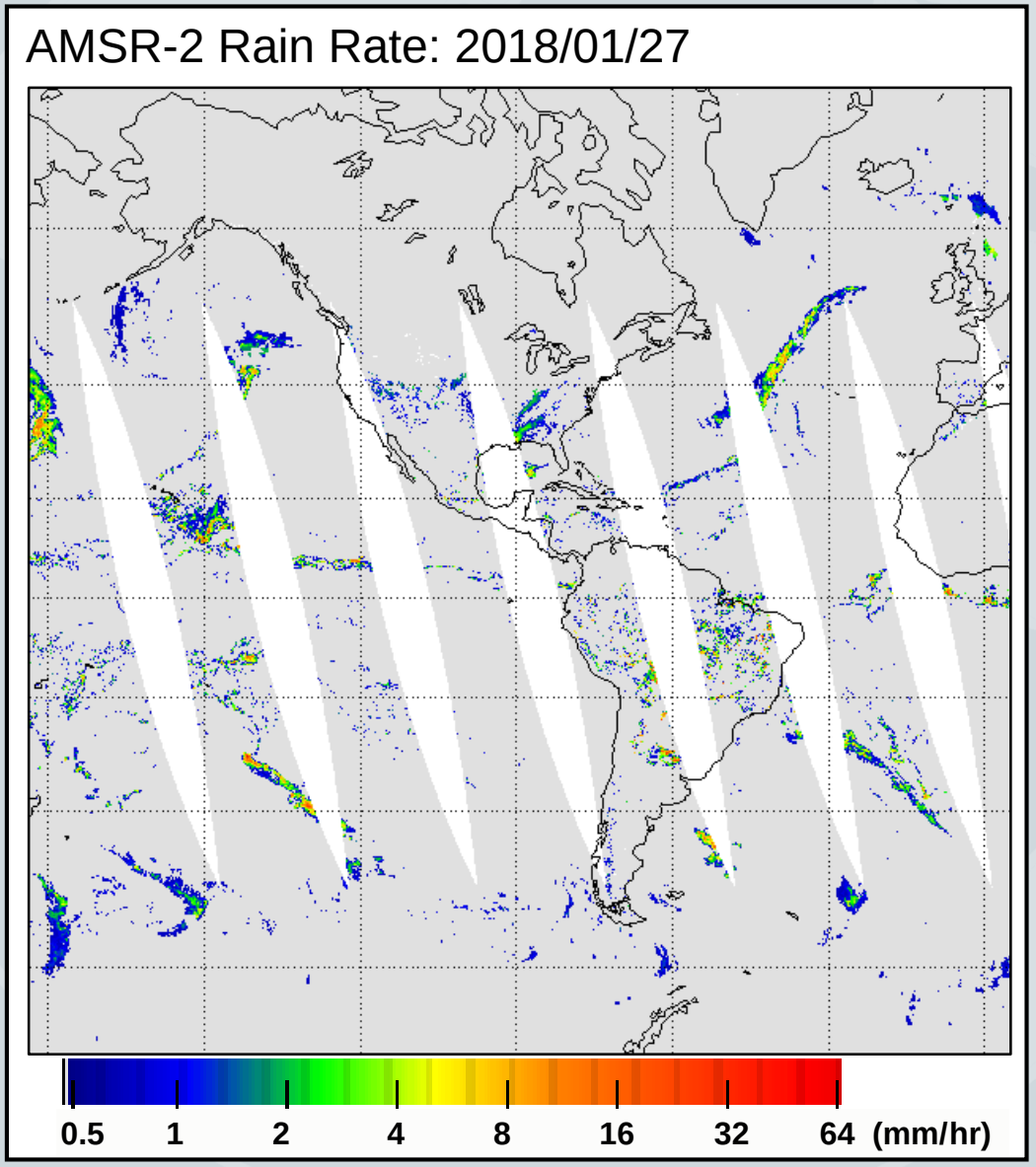
Rain Rate (RR)

- Definition:

  Depth of hourly rainfall at the ground surface

- Observation Region:
  - tropical to mid-latitude
  - higher accuracy over ocean than over land
- Observation Range:

  0-50 mm/hr



NOAA Operational GCOM-W1 AMSR-2 Product Maps
http://www.ospo.noaa.gov/Products/atmosphere/gpds/maps.html?GPLCT#gpdsMaps

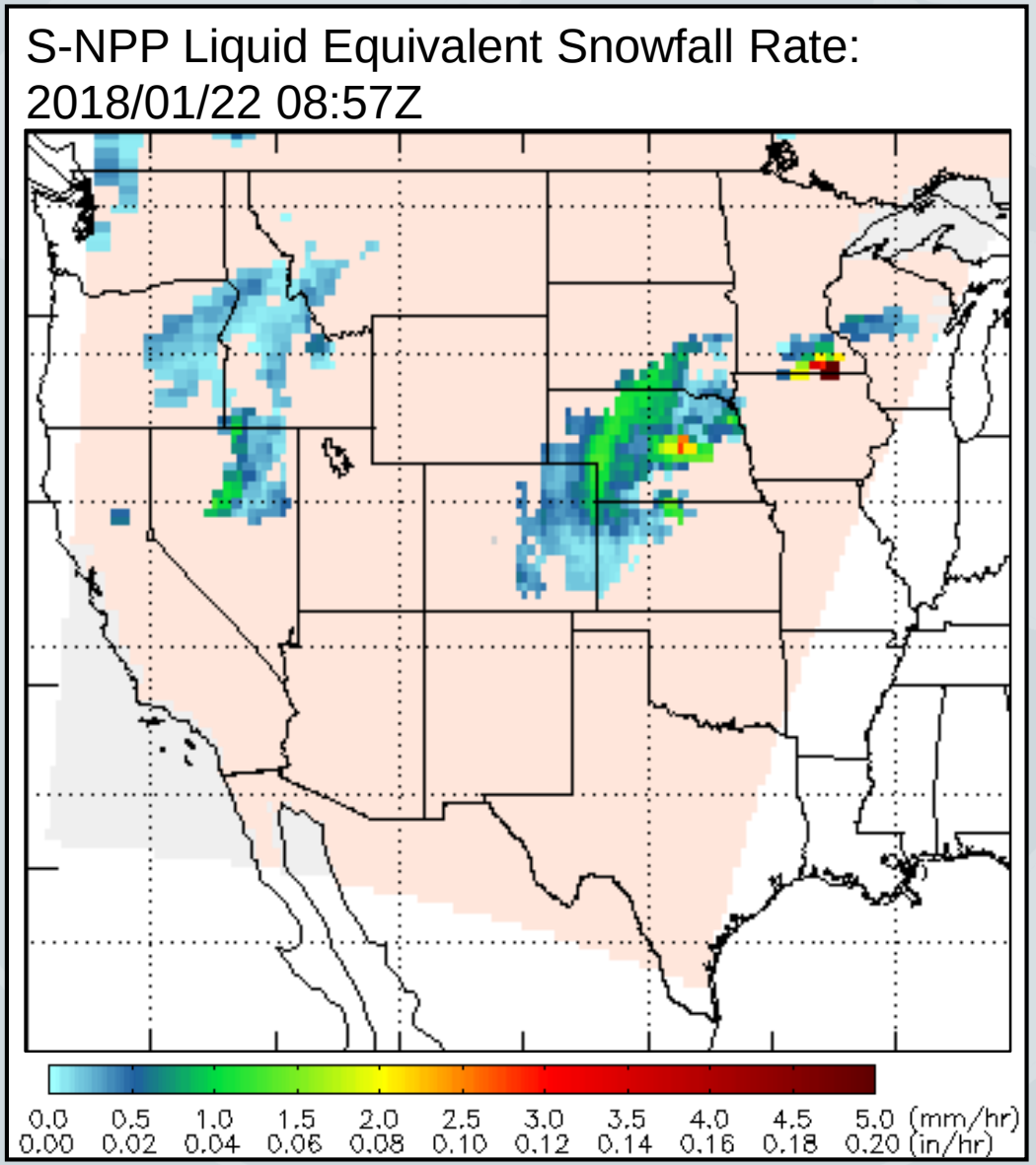
Liquid Equivalent Snowfall Rate (SFR)

- Definition:

  Depth of hourly *liquid equivalent* of snowfall in the atmospheric column

- Observation Region:
  - temperatures >7 °F
  - mid and high latitudes
- Observation Range:

  0.0012-0.2 in/hr (liquid)

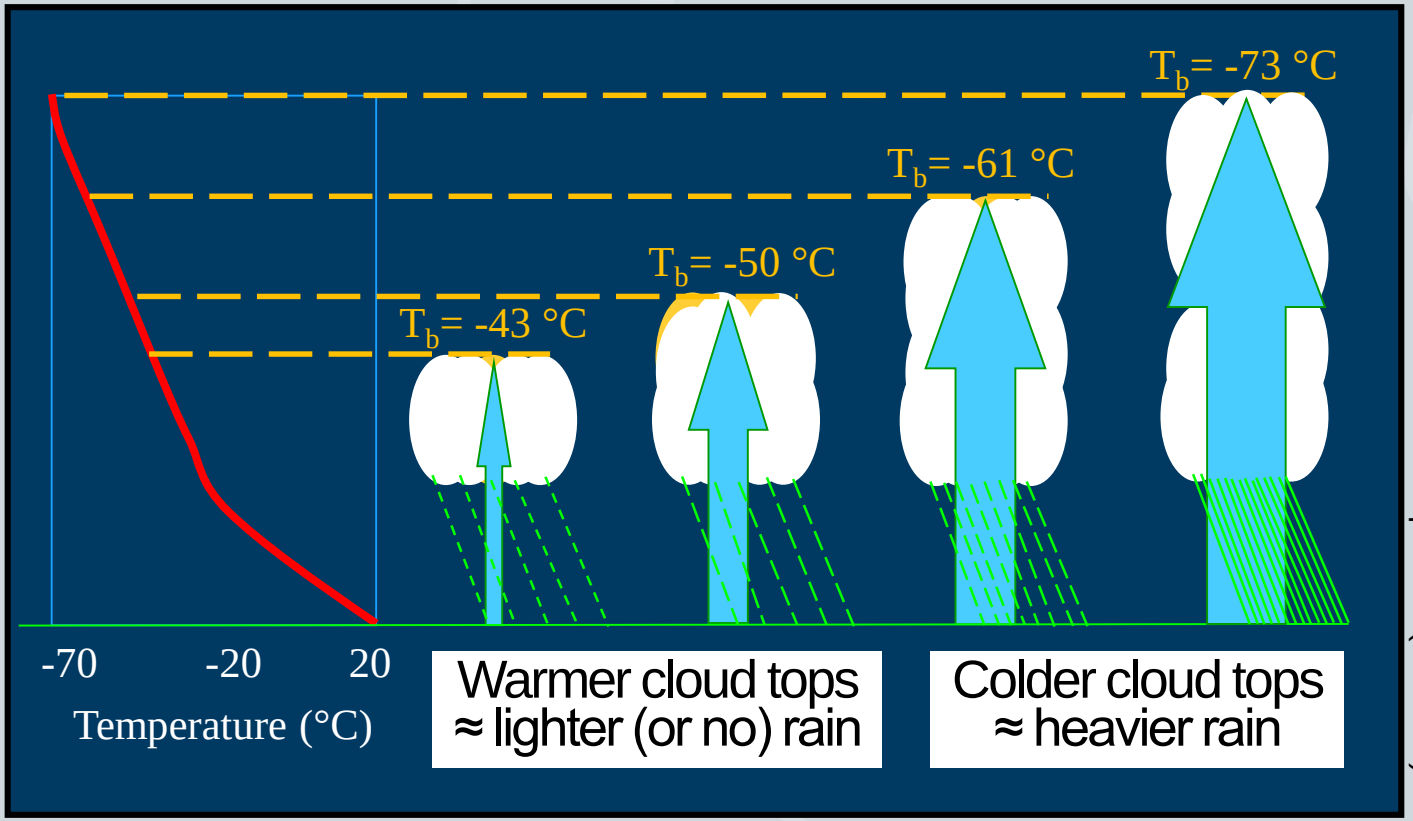


https://cics.umd.edu/sfr/

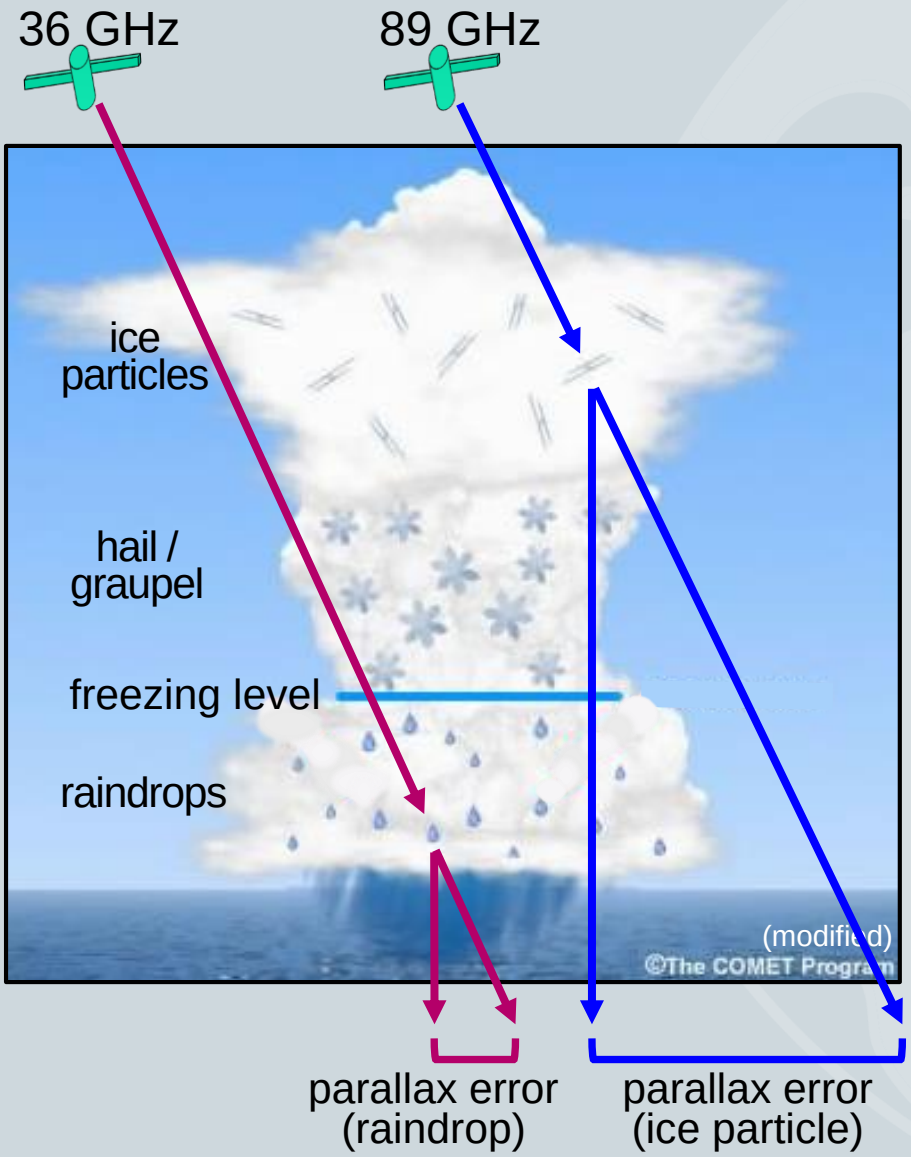
Rain Rate from Infrared

Basic assumptions for opaque mid-latitude clouds:

- Cloud-top temperature (IR) is related to cloud-top height
- Cloud-top height is related to the strength of the updraft and rain rate



Microwave Interaction with Rain Cloud



Ice particles

- Scattering
- Higher frequencies (> 60 GHz)

Liquid raindrops

- Absorption / emission
- Lower frequencies (< 22 GHz)

Displacement due to viewing geometry (parallax error) is greater for ice than for raindrops.

Tropical Cyclone Analysis

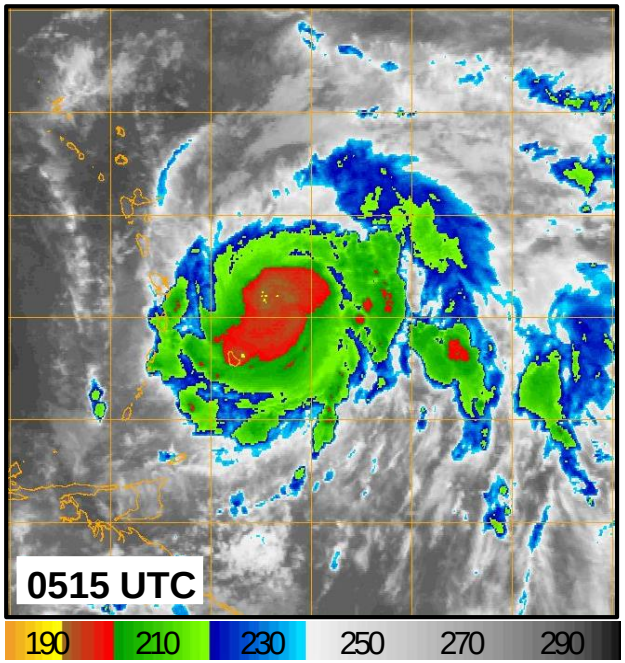
MICROWAVE

- The low-level center and convective rain bands directly related to tropical cyclone intensity are often obscured by high clouds in visible, infrared, and water vapor imagery
- ~36 GHz able to sense clouds and moisture close to the surface
- ~89 GHz sensitive to both rain and ice rates

https://www.nrlmry.navy.mil/TC.html

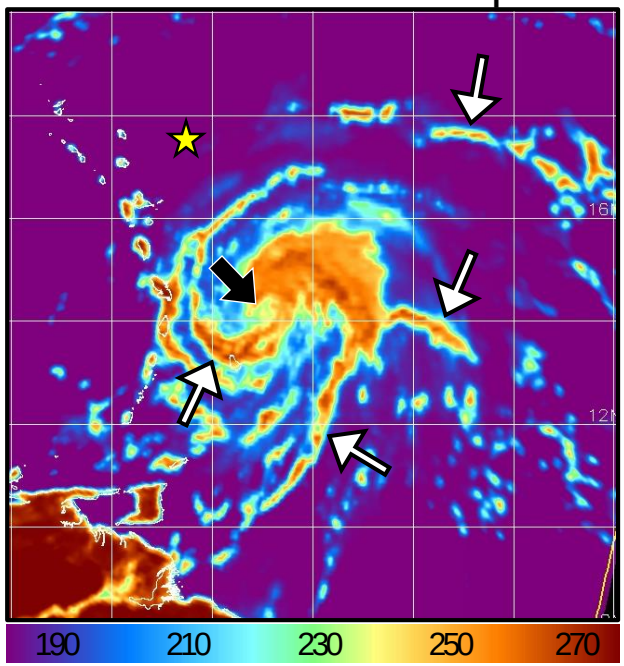
Hurricane Maria: 18 September 2017

GOES-13 Infrared



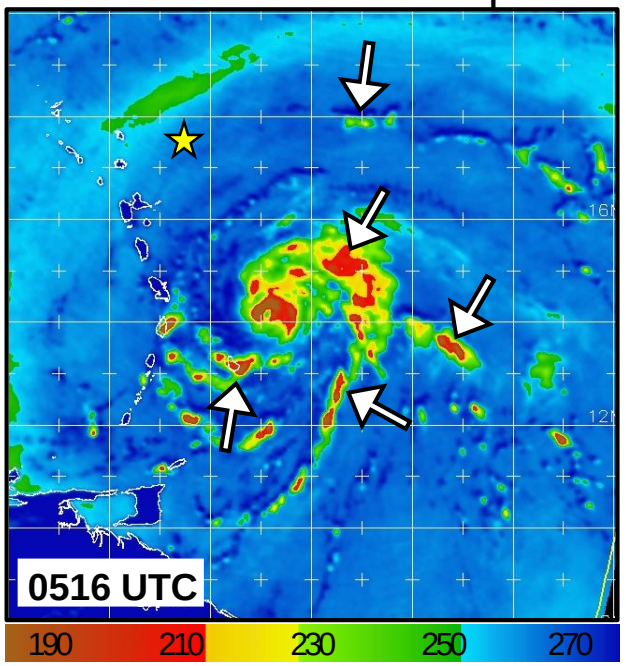
Brightness Temperature [K]

AMSR-2 36 GHz H-pol



Brightness Temperature [K]

AMSR-2 89 GHz H-pol



Brightness Temperature [K]

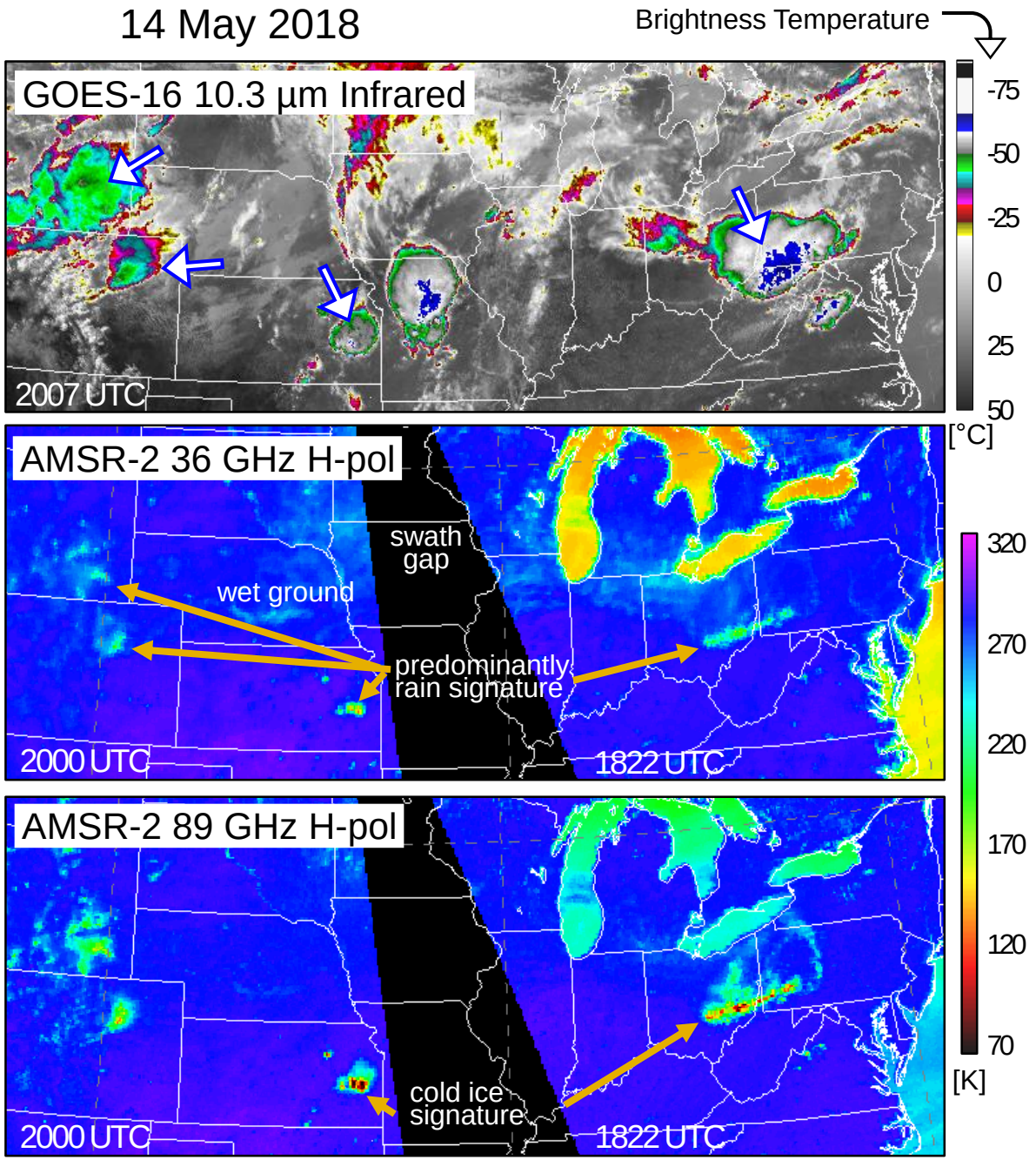
Thunderstorms

- Precipitating clouds are not transparent

What makes brightness temperatures cooler over land surfaces?

36 GHz:
- rain and wet ground

89 GHz:
- rain, ice, and wet ground



Summary

- Microwave products related to atmospheric moisture include:
  - Total Precipitable Water
  - Cloud Liquid Water
  - Rain Rate
  - Liquid Equivalent Snowfall Rate

- The best precipitation estimation algorithms use a combination of:
  - infrared data from geostationary satellites (temporal advantage)
  - microwave data from polar-orbiting satellites (higher accuracy)

- Precipitation estimation is more reliable over the ocean, which provides a cold contrasting background.

Resources

- Microwave Remote Sensing: Clouds, Precipitation, and Water Vapor
https://www.meted.ucar.edu/training_module.php?id=226

- A First Course in Atmospheric Radiation, 2nd Ed. (Petty 2006)

- SatFC-G: GOES-R Rainfall Rate
http://rammb.cira.colostate.edu/training/visit/training_sessions/goes_r_rainfall_rate/

Questions? Email: Bernie.Connell@colostate.edu

Narrator: Erin Dagg
Editors: Erin Dagg, Bernie Connell
Other Contributors: Jorel Torres, Bob Kuligowski, Roger Edson