FOUNDATIONAL COURSE

December 6, 2018

Satellite Foundational Course for JPSS (SatFC-J)

MICROWAVE

FOUNDATIONAL COURSE

Introduction to Microwave Remote Sensing

(with a focus on passive sensing)

JPSS NOAA NASA

NATIONAL WEATHER SERVICE

Learning Objectives

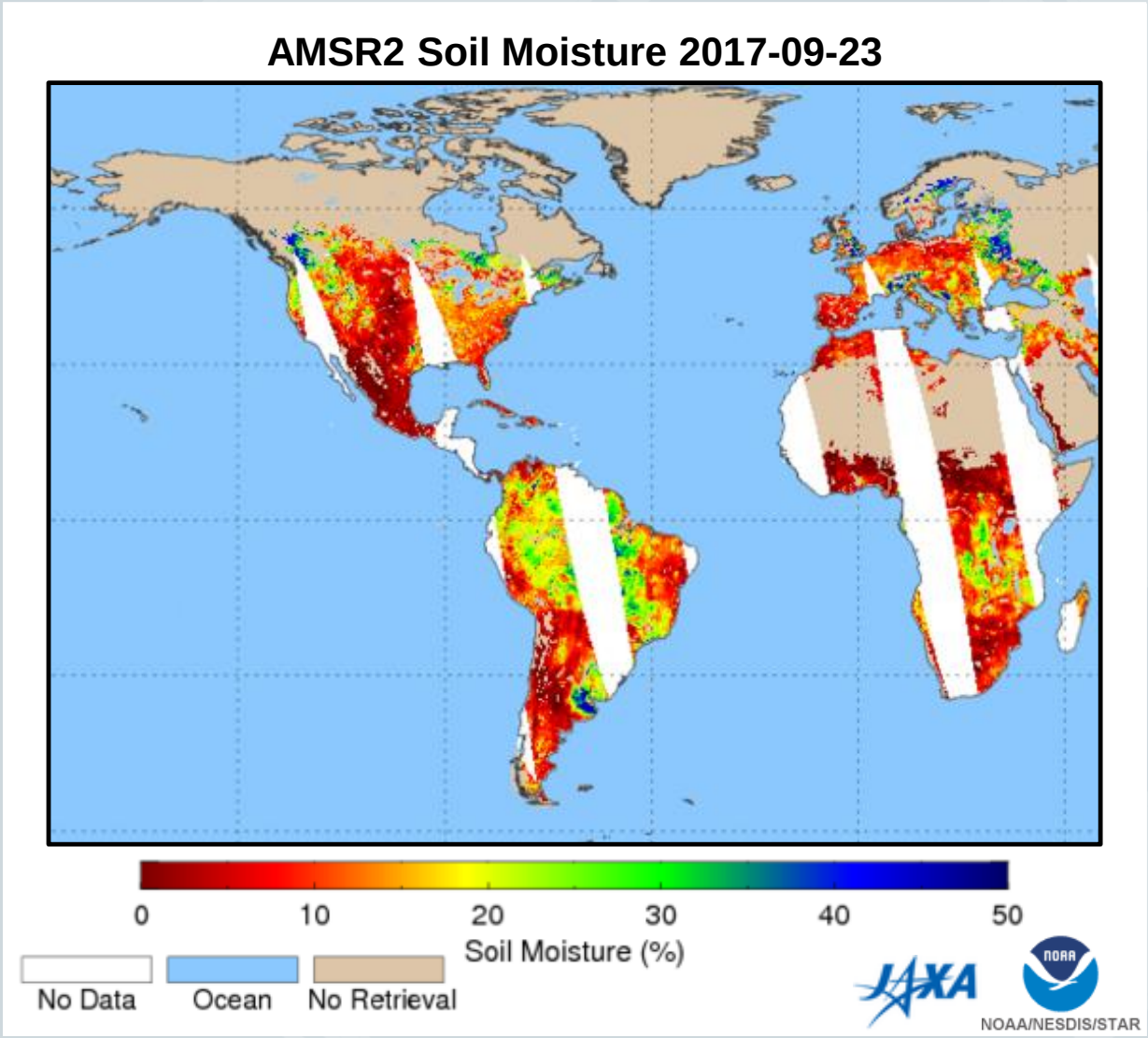
1. Provide a general introduction to microwave remote sensing that covers imagers vs. sounders, passive vs. active sensors, and microwave frequency channels

2. Understand how microwave remote sensing complements visible and infrared observation and why this is important

3. Briefly examine how absorption/emission, transmission, and scattering influences the usage and interpretation of microwave measurements

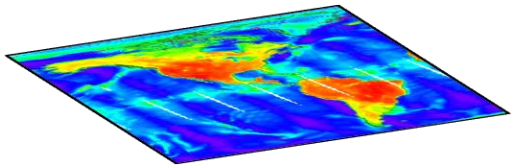
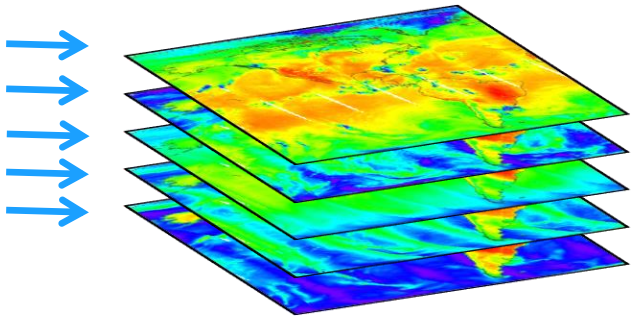
Product Preview

- A combination of channels are used to create products
  - total precipitable water
  - cloud liquid water
  - rain rate
  - wind speed
  - sea surface temperature
  - soil moisture



NOAA MiRS Products: https://www.star.nesdis.noaa.gov/jpss/EDRs/products_MiRS.php

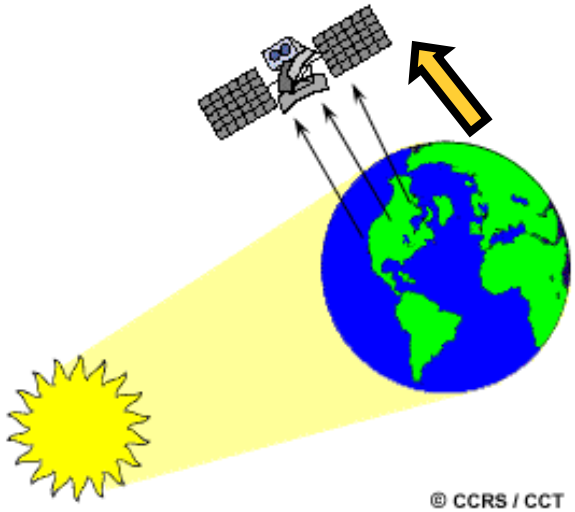
Types of Microwave Instrumentation

Imager	Sounder
▪ Horizontal detail ▪ 2-D view	▪ Vertical detail ▪ “3-D view” ▪ Provides atmospheric profiles
Ex: Advanced Microwave Scanning Radiometer-2 (AMSR-2) • 7 channels	Ex: Advanced Technology Microwave Sounder (ATMS) • 22 channels
	

Types of Microwave Sensors

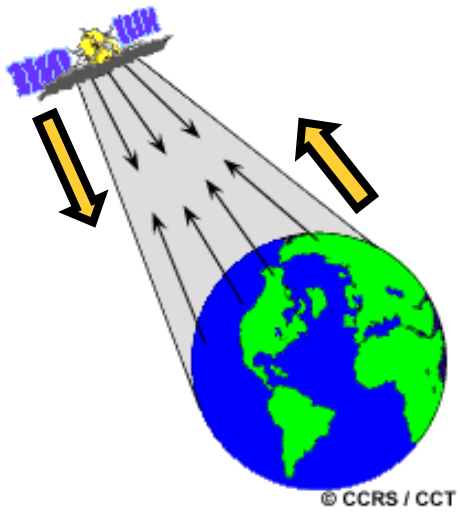
Passive

- Detects natural emission
- Used to measure atmospheric profiles
- Radiometers and scanners



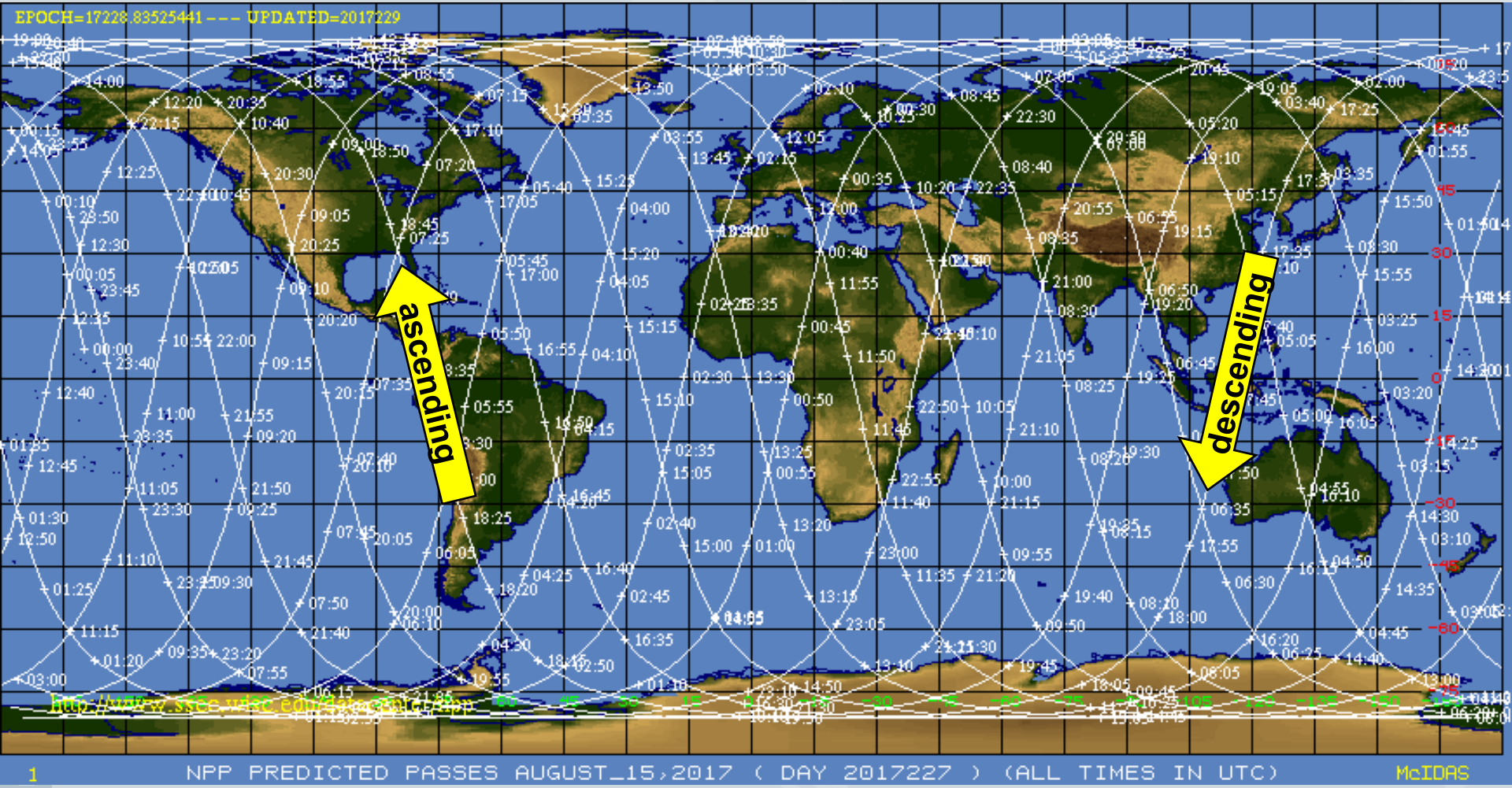
Active

- Provides source of radiation and measures backscattered signal
- Influence of other sources complicates interpretation



Global Coverage 2x Daily

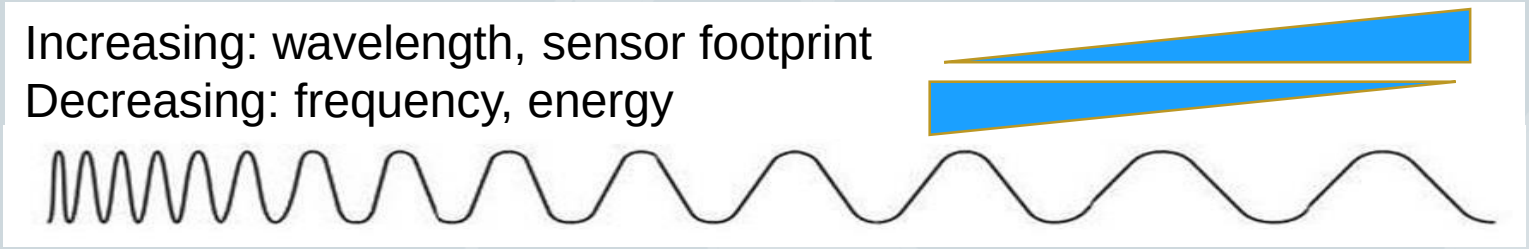
Suomi National Polar–orbiting Partnership (S-NPP) Orbit Tracks

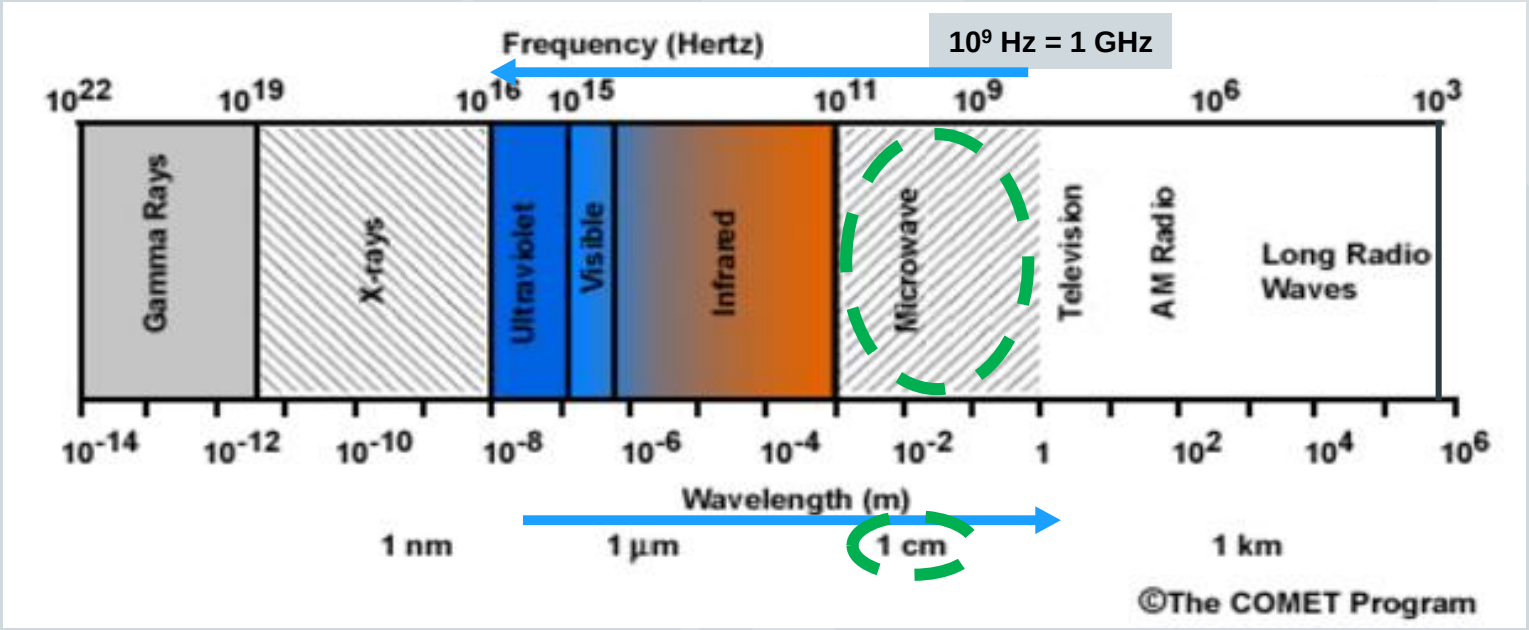


Electromagnetic Spectrum

Microwave wavelength = 0.1-30 cm (300-1 GHz)

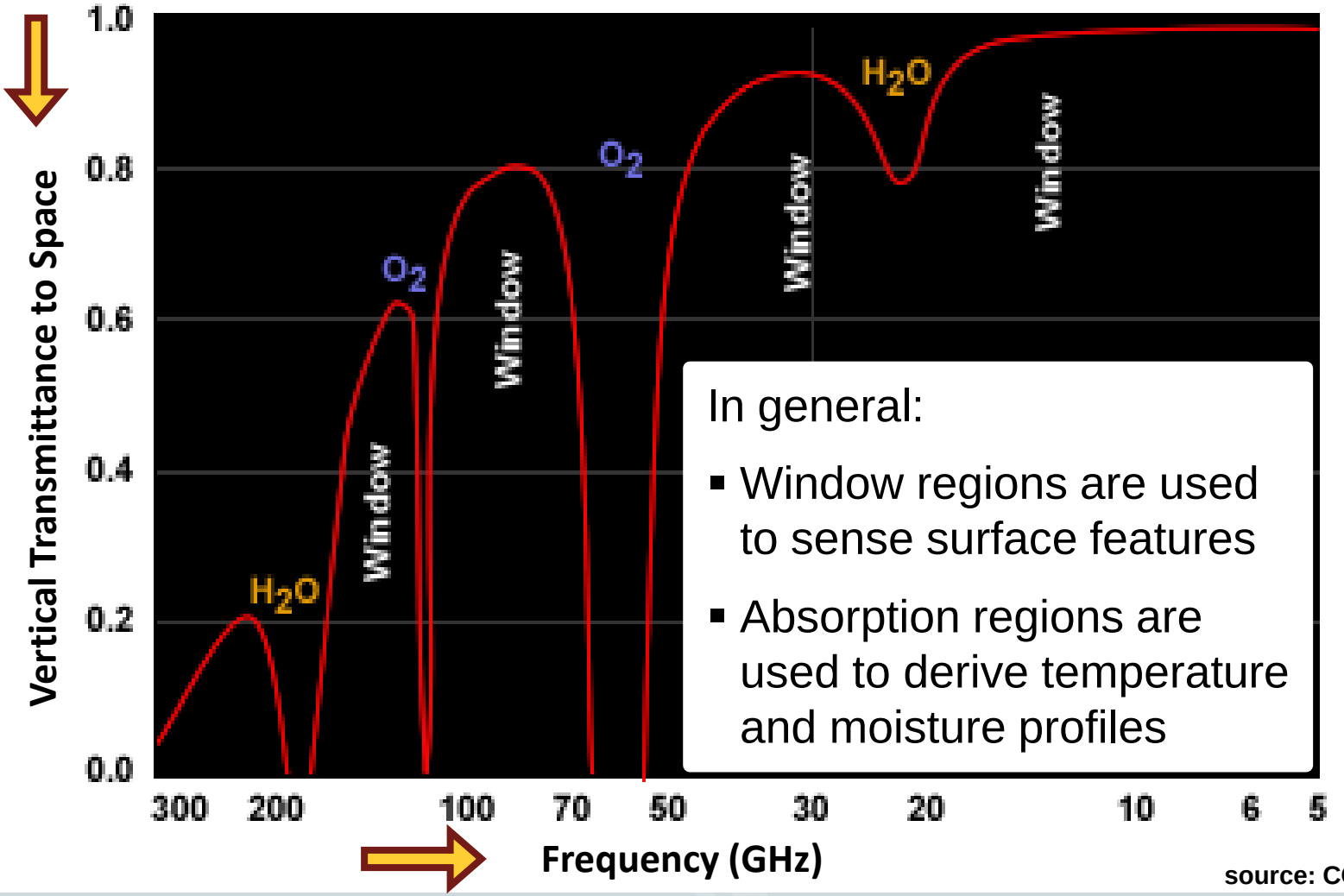
Increasing: wavelength, sensor footprint
Decreasing: frequency, energy





Additional Resource: SatFC-G Basic Principles of Radiation
https://www.meted.ucar.edu/training_module.php?id=1239#.WEcPZfkrKUl

Microwave Spectrum



In general:

- Window regions are used to sense surface features
- Absorption regions are used to derive temperature and moisture profiles

source: COMET

Measured Brightness Temperature

Absorption Regions

Clear Sky or Non-Precipitating Clouds

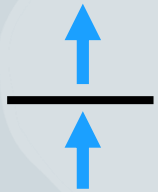
- Temperature profiles
- Moisture profiles

Precipitating Clouds

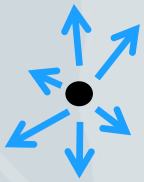
- Ice particles

absorption / emission

transmission



scattering



Window Regions

Clear Sky or Non-Precipitating Clouds

- Land surface temp.
- Sea surface temp.
- Sea ice
- Soil moisture
- Cloud droplets (< .1 mm radius)
- Ocean winds

Precipitating Clouds

- Precipitation type
- Rain rate

Window View of Surface Features

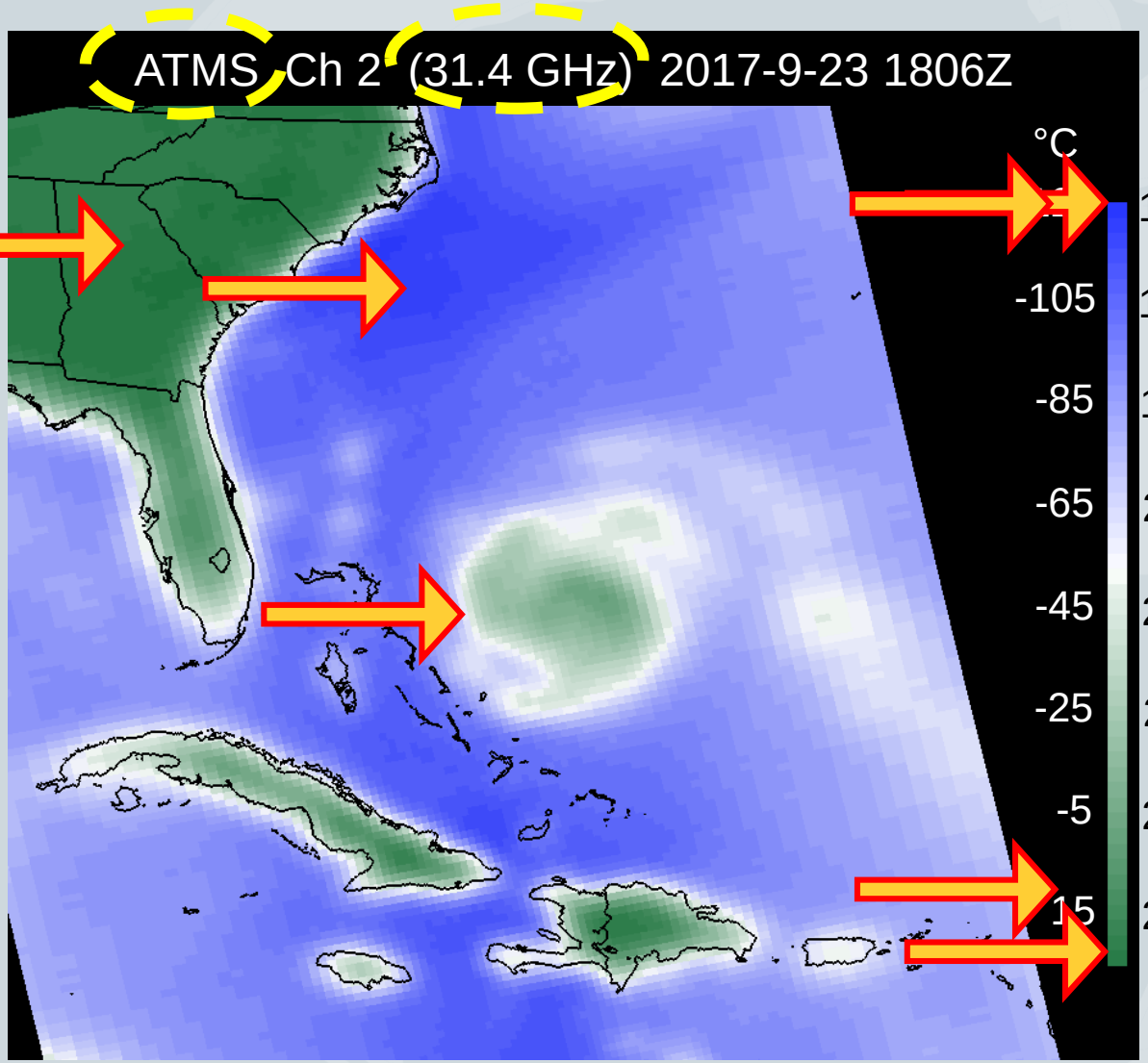
MICROWAVE
CONSTELLATION
APPLICATIONS
INITIATIVES

Ocean

- Low emissivity (~0.5) provides a uniform, cold background

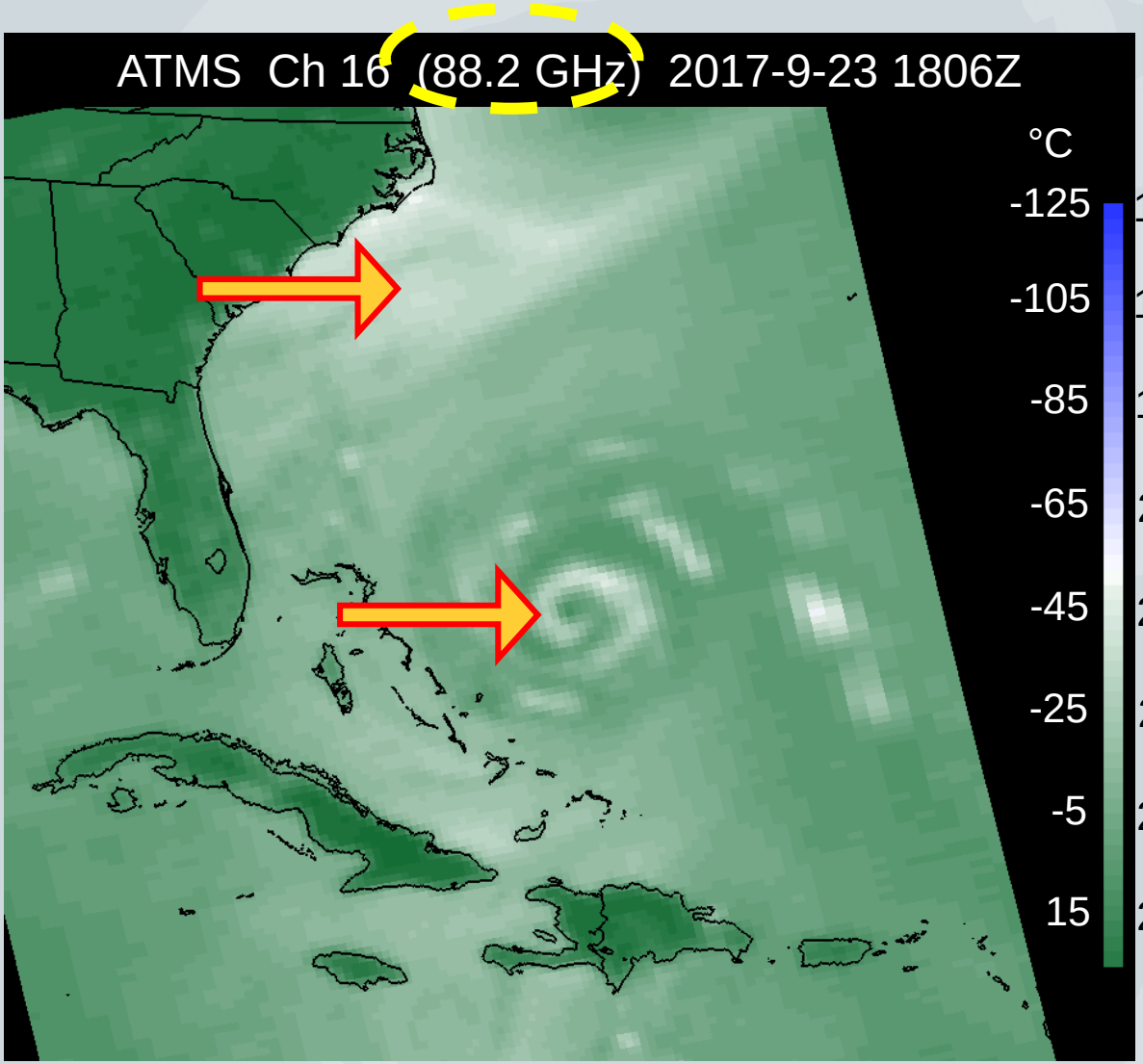
Land

- Variable emissivity (~0.95)



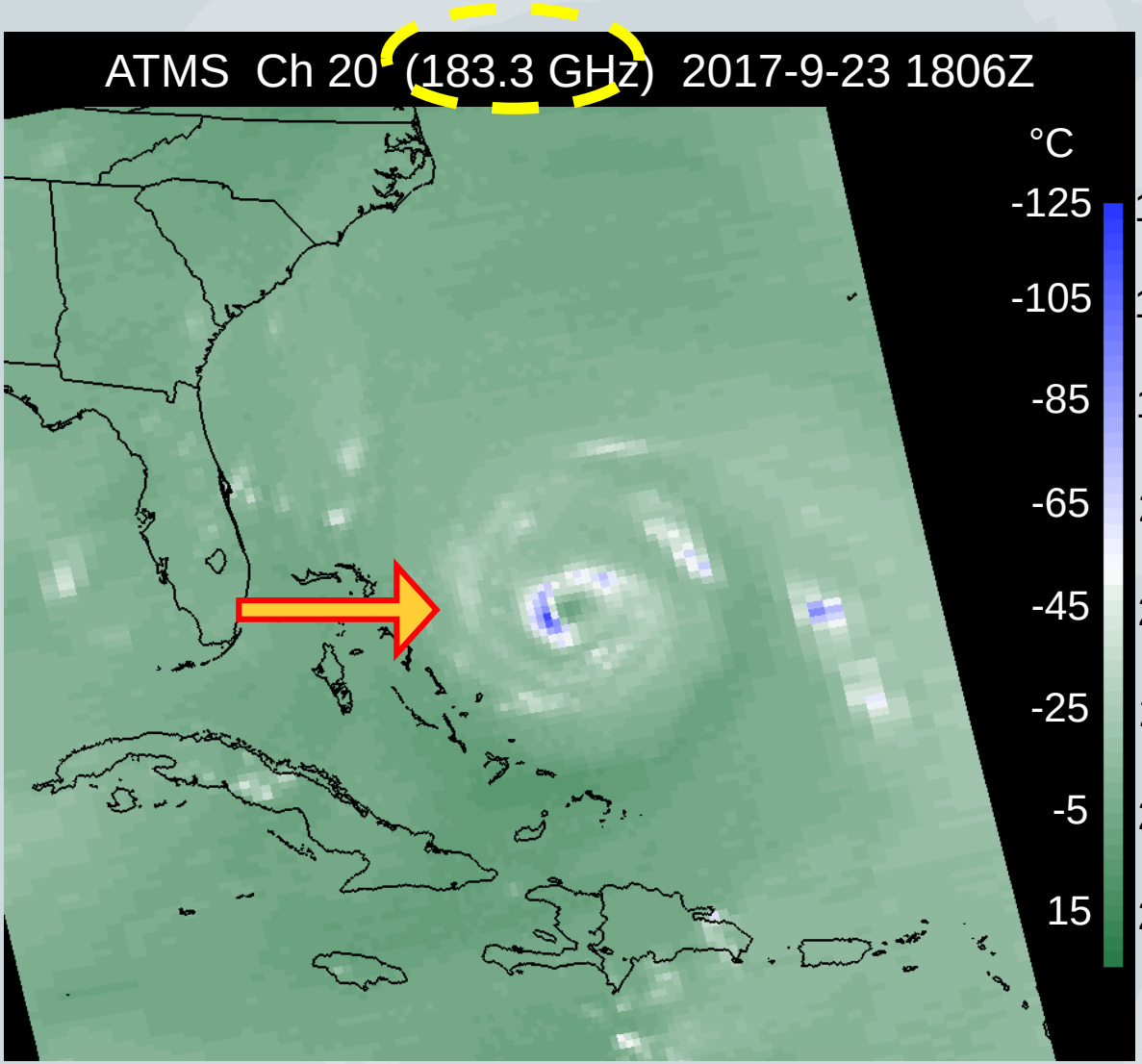
“Dirty” Window View

- Non-precipitating clouds are transparent
- Total atmospheric column can be observed



Water Vapor Absorption

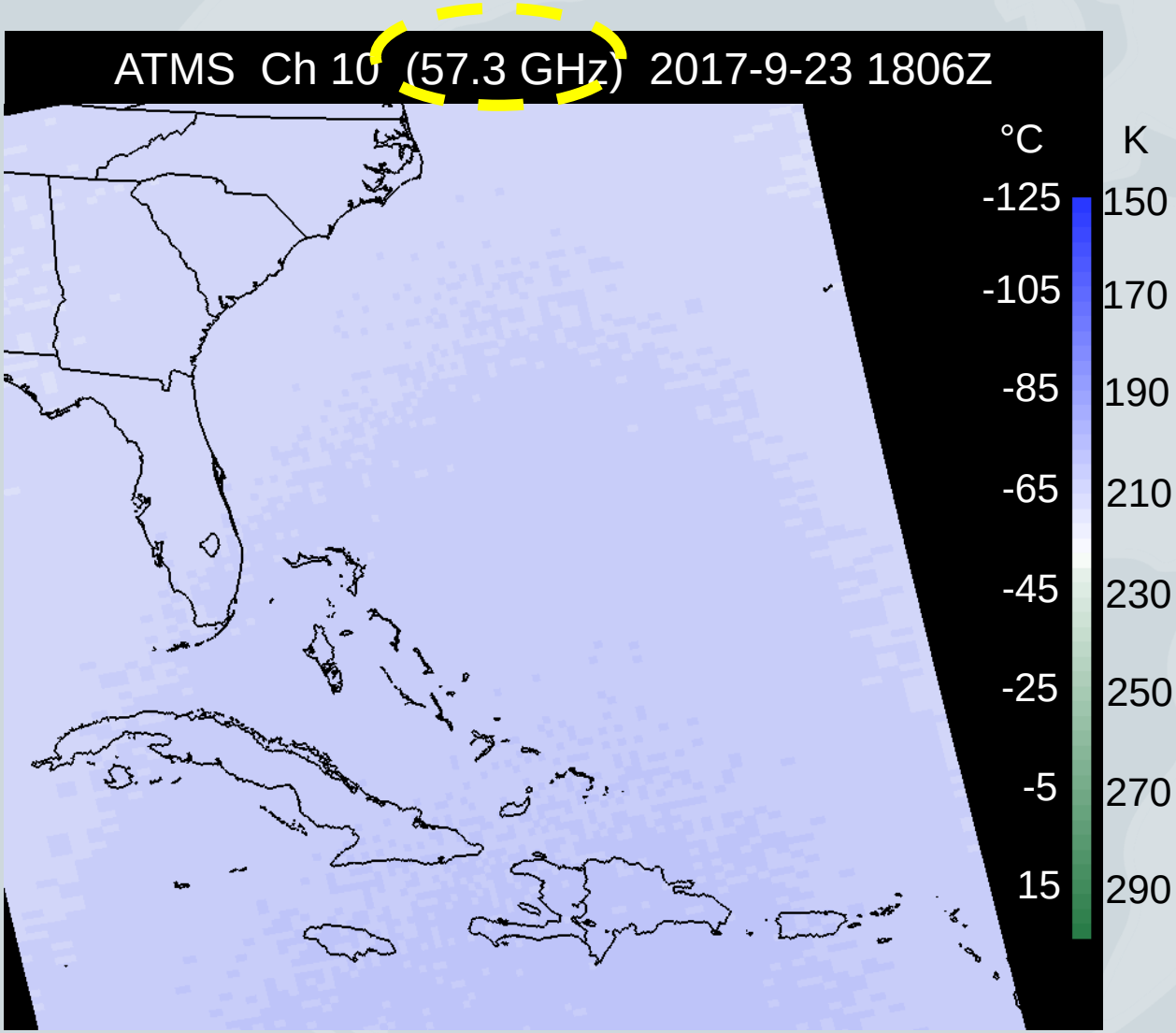
- Used to sense the moisture at various levels in the atmosphere



Oxygen Absorption

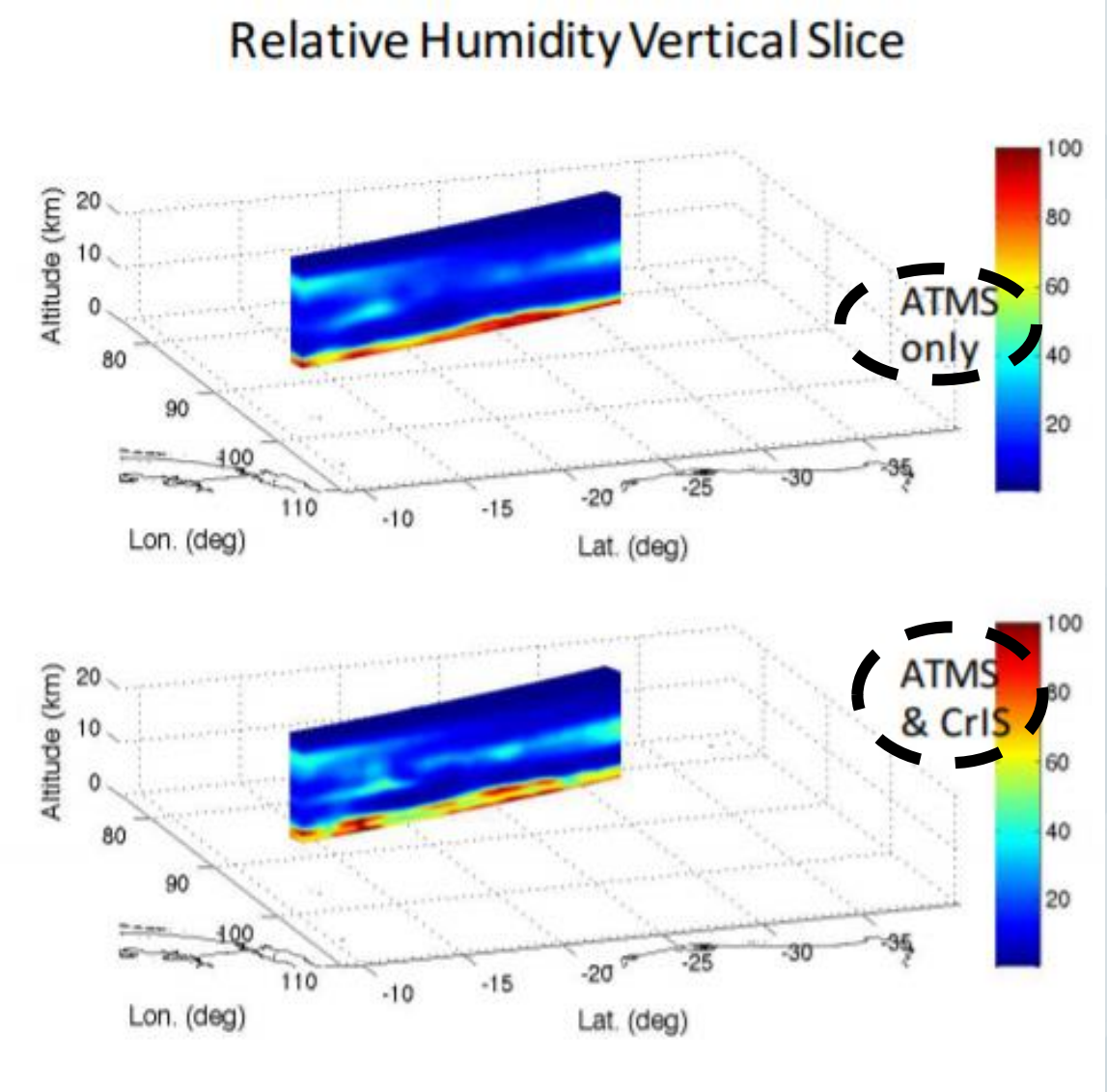
- Used to sense the temperature at various levels in the atmosphere

Small temperature variation across the image (~300 mb level)



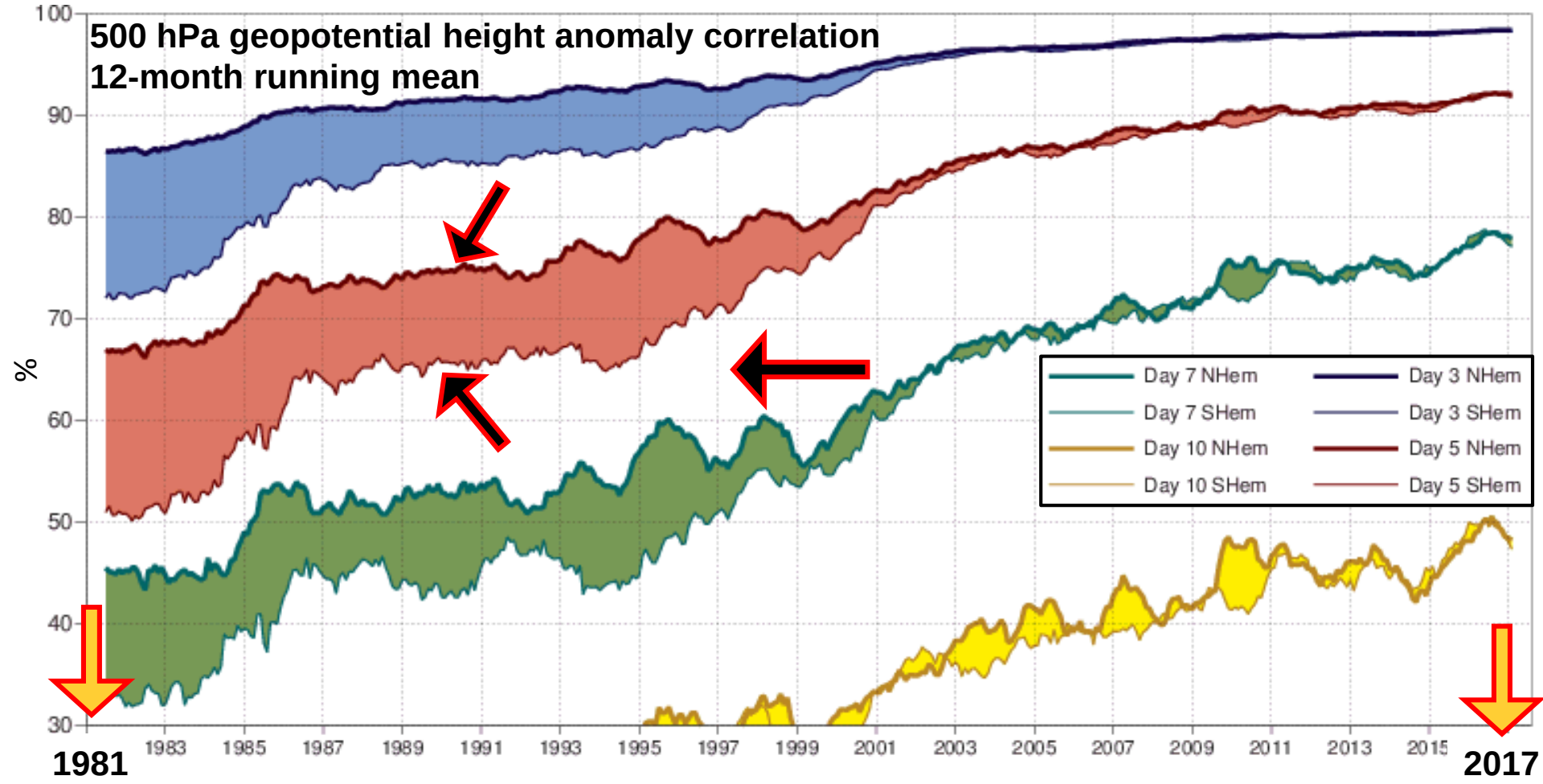
Vertical Profiles

- Displayed in AWIPS as NUCAPS soundings
- NUCAPS = **N**OAA **U**nique **C**ombined **A**tmospheric **P**rocessing **S**ystem



Assimilation into Numerical Models

- Microwave and infrared sounders have huge impacts in forecasts through assimilation into numerical weather prediction models



Advantages and Limitations

Microwave Advantages

- Non-precipitating clouds are transparent
- Precipitation rate estimation, ocean winds, soil moisture
- Atmospheric temperature and moisture profiles
- Blended with other high resolution measurements in products and assimilated into models

Microwave Limitations

- Longer wavelength limits spatial resolution
- Variations in surface emissivity complicate interpretation
- Infrequent observations: 2x daily passes per satellite

Resources

- Microwave Remote Sensing: Overview (2nd Edition)
https://www.meted.ucar.edu/training_module.php?id=979
- A First Course in Atmospheric Radiation, 2nd Ed. (Petty 2006)
- Satellite Meteorology: An Introduction (Kidder and Vonder Haar 1995)
- Basics of Visible and Infrared Remote Sensing
https://www.meted.ucar.edu/training_module.php?id=1096#.WEmPA_krKUk
- SatFC-G Basic Principles of Radiation
https://www.meted.ucar.edu/training_module.php?id=1239#.WEcPZfkrKUl

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CIRA
Connecting Models and Observations