The water cycle from space: Use of satellite data in land surface hydrology and water resource management

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Istanbul, 14-17 September 2010

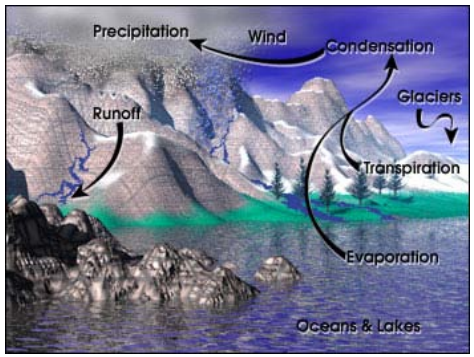
NASA's Earth Science Mission

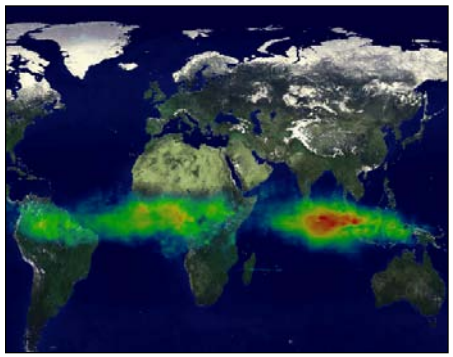
. . . to understand and protect our home planet by using our view from space to study the Earth system and improve prediction of Earth system change.

NASA's Earth Science Focus Areas

Earth Science Research Foci

- Atmospheric Chemistry and Composition
- Carbon Cycle and Ecosystems
- Climate Variability and Change
- Earth Surface and Interior
- Water and Energy Cycle
- Weather





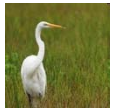
Earth Science Applications

- Agriculture

- Air Quality

- Climate

- Natural Disasters



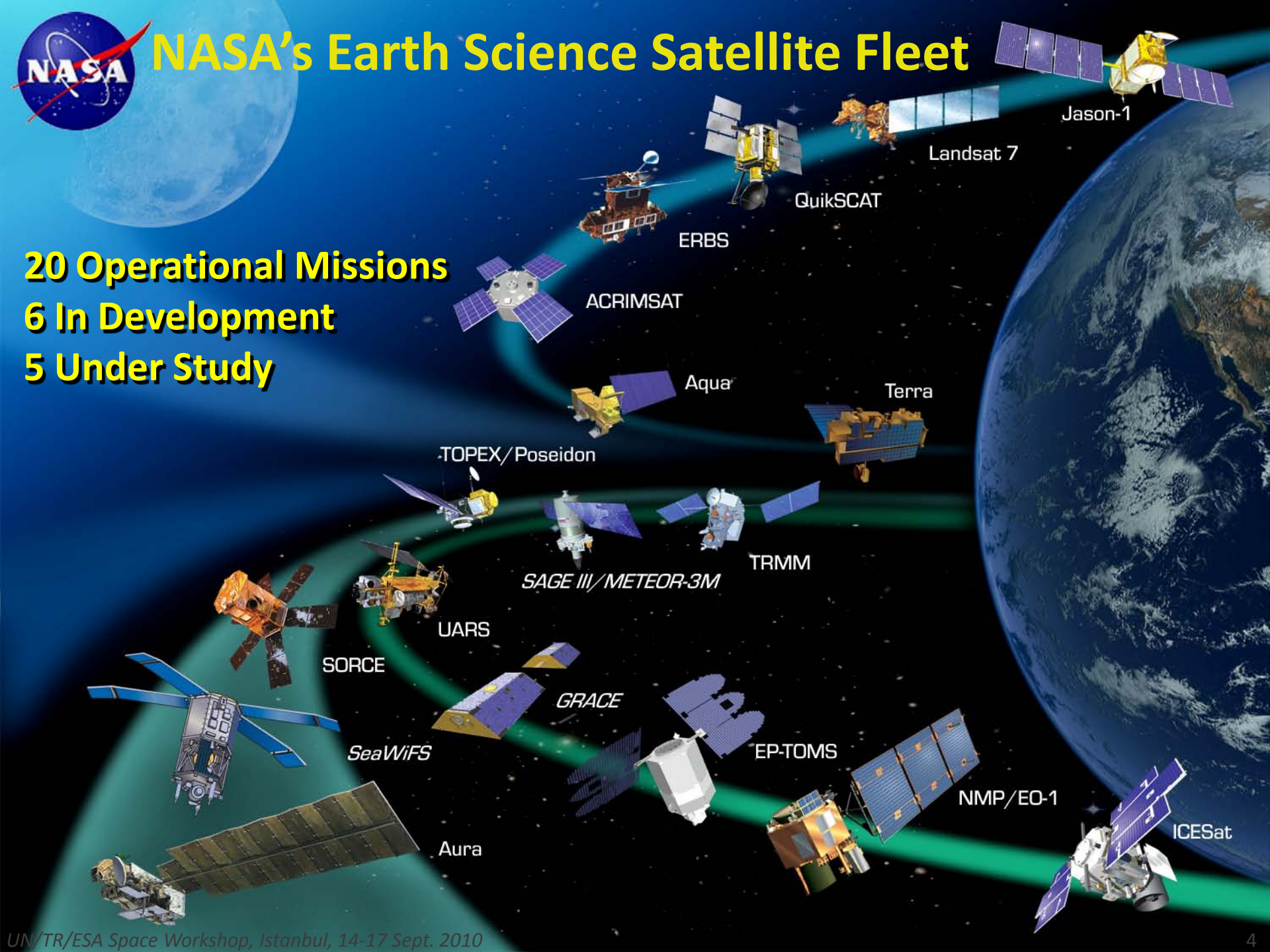
- Ecological Forecasting

- Public Health

- Water Resources

- Weather

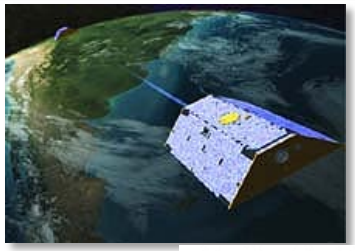
NASA's Earth Science Satellite Fleet



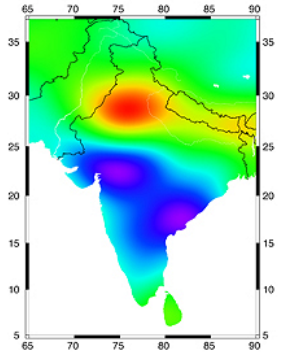
Hydrometeorological Missions - Current

GRACE

2002-2015+



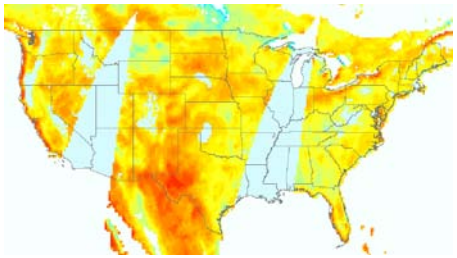
- Provide detailed measurements of Earth's gravity field
- Retrieve changes in groundwater storage



AMSR-E (NASA-JAXA)

2002-??

- On NASA Aqua satellite
- 6 frequencies, 6.9-89 GHz
- C-band subject to serious RFI; higher frequencies used for soil moisture estimation
- Near-daily coverage



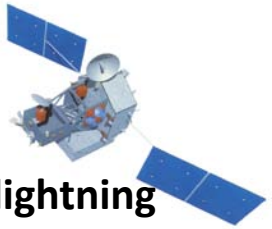
SMOS (European Space Agency)

2009-??

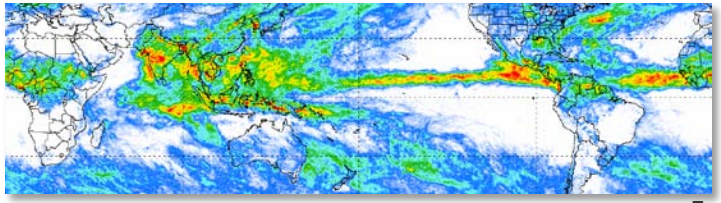
- L-band imaging radiometer
- Global observation soil moisture and ocean salinity

TRMM (NASA-JAXA)

1997-??



- Radar, imager, VIS/NIR scanner, lightning sensor
- Estimates rainfall from equator to ~35° N/S
- Hourly - monthly rainfall estimates

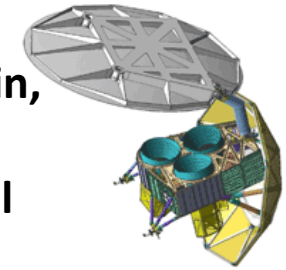


Hydrometeorological Missions - Future

Aquarius (NASA/Argentina)

Expected launch 2011

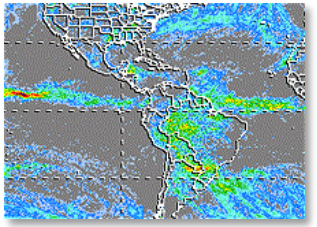
- L-band radiometer/scatterometer
- Global coverage every 7 days
- Sea surface salinity, sea ice, rain, cloud water
- Map seasonal and inter-annual variations in sea surface salinity



GPM

Expected launch 2013

- International satellite network
- Global measurement of precipitation, its distribution, and physical processes
- Will improve the accuracy of weather forecasts and understanding of climate



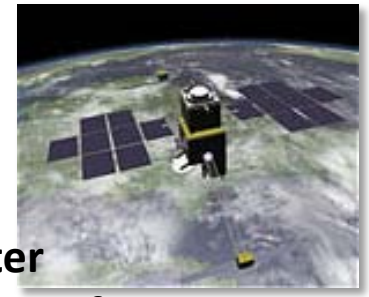
SMAP

Expected launch 2015

- L-band radiometer/radar
- Global measurement of surface soil moisture and freeze/thaw state.

SWOT

Expected launch 2020



- Ka-band radar interferometer
- First global survey of Earth's surface water
- Will measure water storage changes in all wetlands, lakes, and reservoirs
- Repeated measurements of water height during floods

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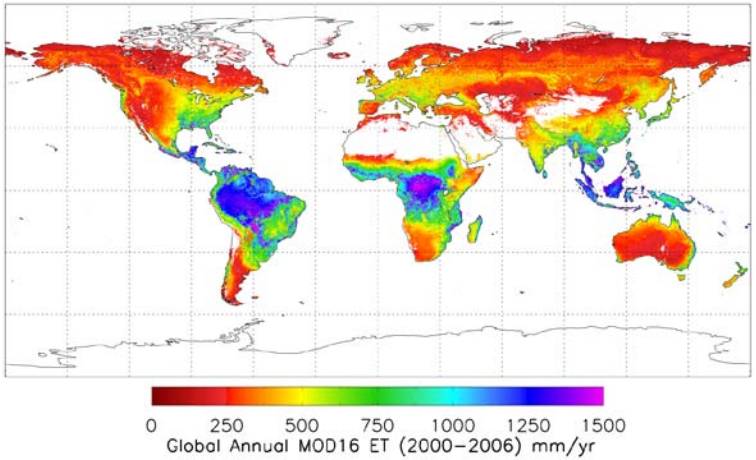
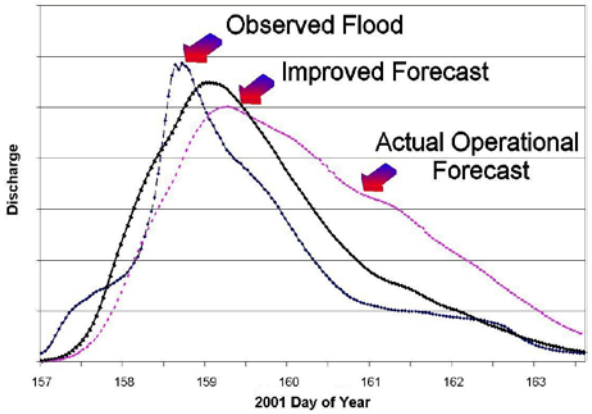
Remote Sensing for Land Surface Hydrology

- Flood mapping/damage assessment
- Groundwater changes (GRACE mission)
- Precipitation
- Evapotranspiration
- Irrigation
- Lake and reservoir monitoring; streamflow forecasting
- Wetland mapping
- Soil moisture

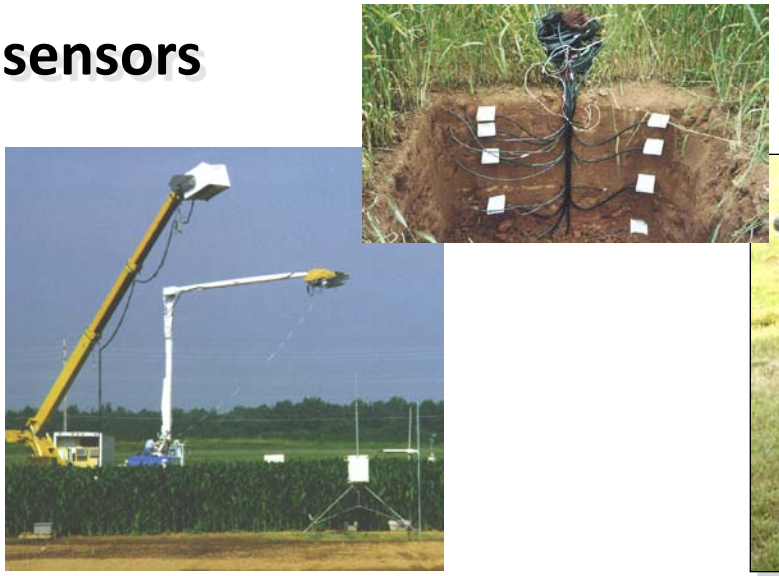




Soil Moisture Estimation - History

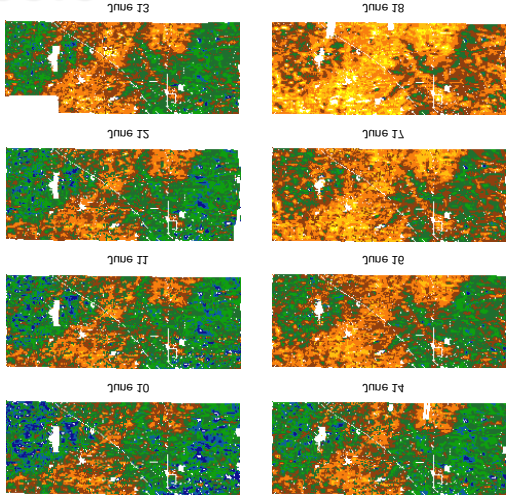
1970's-present: Ground-based sensors

- Field experiments use ground-based radiometers, usually mounted on mobile booms
- Monitor temporal changes in soil moisture at a point
- No spatial mapping
- In situ measurements provide excellent validation



1980's – present: Airborne sensors

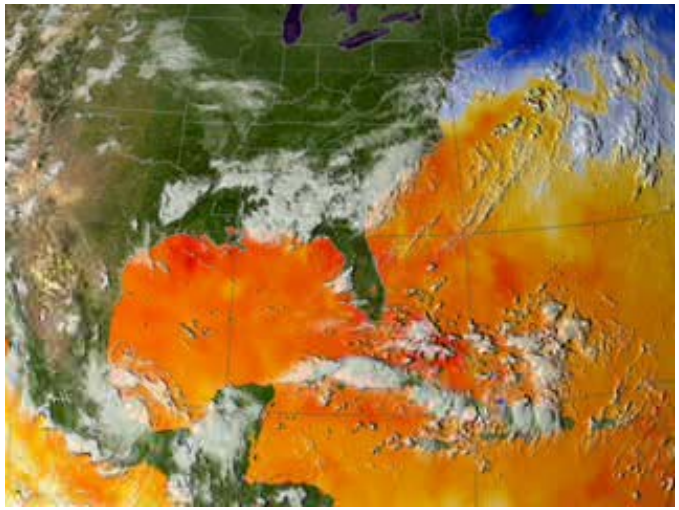
- Airborne radiometers used to map soil moisture at regional scale (~100 km)
- Monitor temporal changes in soil moisture over region via repeated flights
- In situ validation very labor-intensive



Soil Moisture Estimation - History

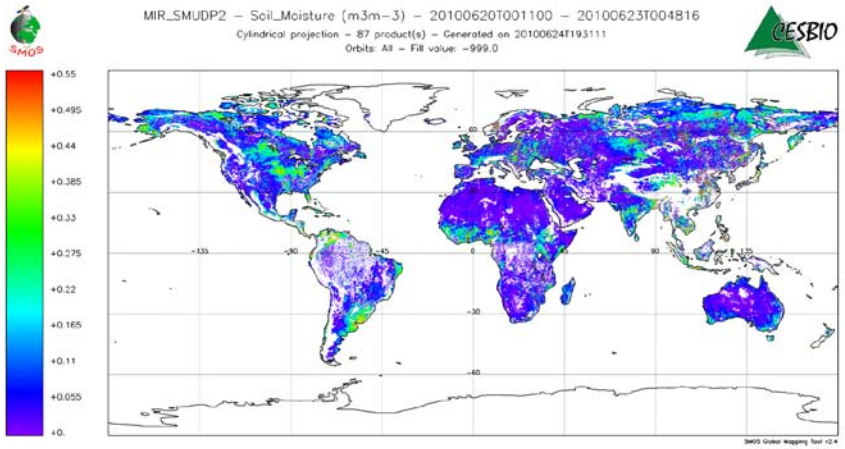
2002: AMSR-E

- Measures rainfall, atmospheric water vapor, cloud properties, snow cover, sea ice, sea surface temperature, soil moisture



Future: L-band satellite sensors (SMOS, SMAP, Aquarius)

- Provide soil moisture estimates globally except over densely vegetated regions
- Sensitive to soil moisture in top 3-5 cm
- Algorithms for mitigation/elimination of Radio Frequency Interference (RFI) being developed



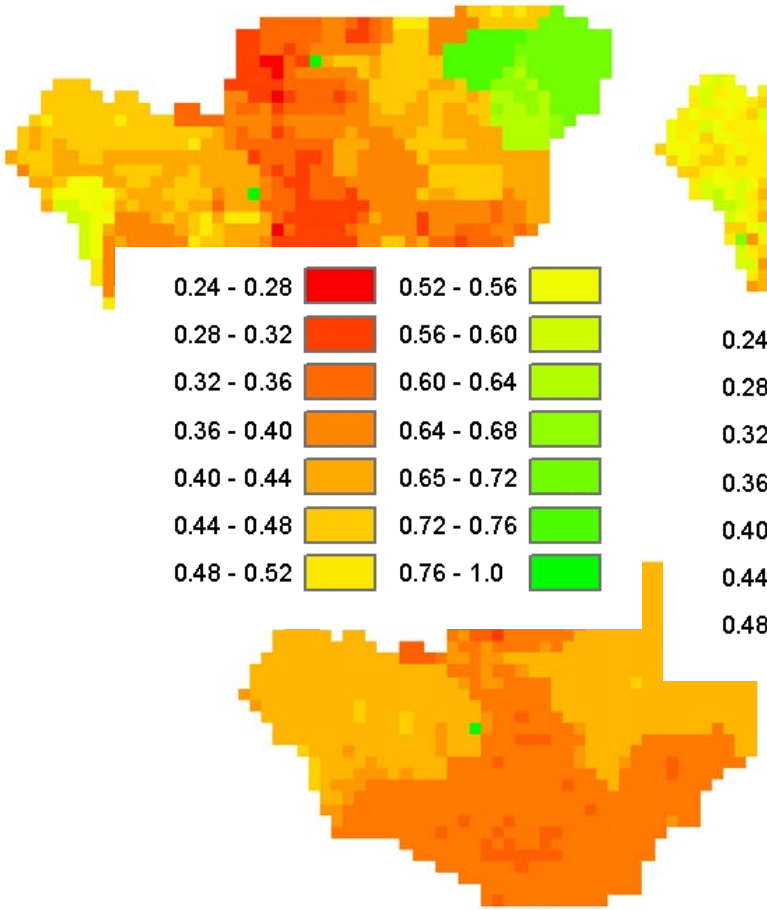
Soil Moisture Remote Sensing

- **Estimation of soil moisture using remote sensing typically relies on microwave radiometers (passive) and radars (active).**
  - **Active RS gives better spatial resolution.**
  - **Passive RS is more sensitive to soil moisture with fewer confounding factors.**

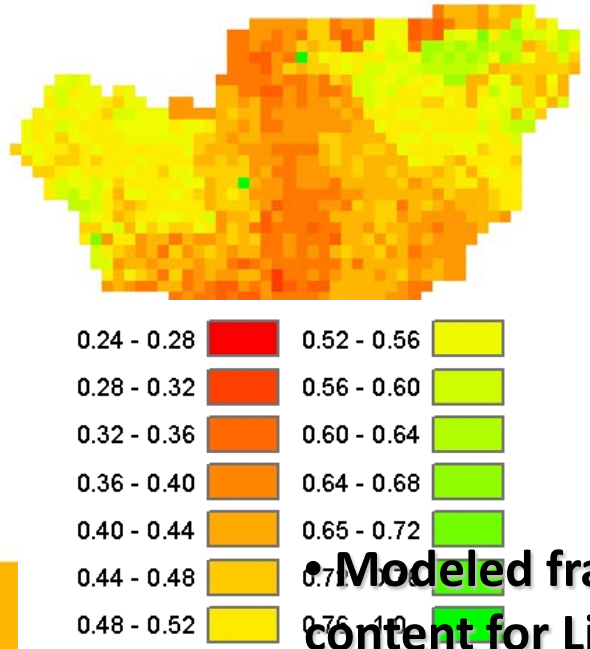
- **Lower frequencies (L-band) allow more robust retrievals but introduce engineering problems (larger antenna required to achieve same spatial resolution as higher frequencies).**

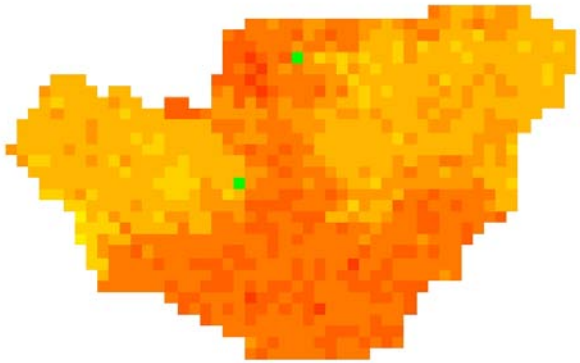
Band	Frequency (GHz)	Wavelength (cm)	Penetration depth (cm)	Sensitivity to vegetation	RFI contamination
L	1.4	21.3	3-5	Moderate	Moderate
C	6.9	4.3	1.0 – 1.5	High	Very high
X	10.7	2.8	0.5 - 1.0	Very high	High

Assimilation of Soil Moisture in a Land Surface Model



No updates





3-day updates

- Modeled fractional soil water content for Little Washita River watershed, Oklahoma, USA
- 'Updates' performed by assimilating aircraft microwave observations at different intervals
- More frequent updates result in more accurate soil moisture mapping