Overview of SMAP Data Products

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SMAP Science Objectives

- SMAP science objectives are to provide high-resolution and frequent-revisit global mapping of **soil moisture** and **freeze/thaw state** that will enable science and applications users to:

  1. Understand processes that link the terrestrial water, energy and carbon cycles
  2. Estimate global water and energy fluxes at the land surface
  3. Quantify net carbon flux in boreal landscapes
  4. Enhance weather and climate forecast skill
  5. Develop improved flood prediction and drought monitoring capability

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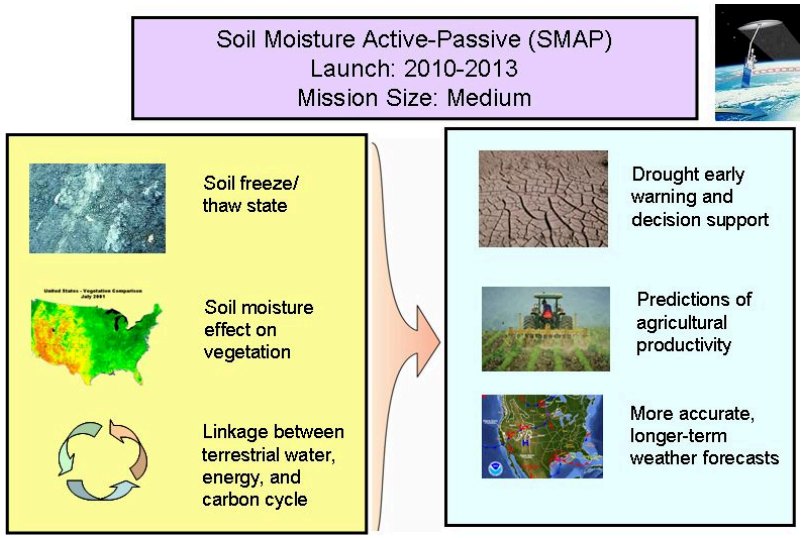
SMAP Level 1 Science Requirements Derivation



- SMAP is unique because its measurements are relevant to a wide range of Earth sciences and their applications
- Disciplinary Decadal Survey panels cite SMAP applications

Decadal Survey Panels #	Cited SMAP Applications
1. Water Resources and Hydrological Cycle	1. Floods and Drought Forecasts 2. Available Water Resources Assessment 3. Link Terrestrial Water, Energy and Carbon Cycles
2. Climate / 3. Weather	1. Longer-Term and More Reliable Atmospheric Forecasts
4. Human Health and Security	1. Heat Stress and Drought 2. Vector-Borne and Water-Borne Infectious Disease
5. Land-Use, Ecosystems, and Biodiversity	1. Ecosystem Response (Variability and Change) 2. Agricultural and Ecosystem Productivity 3. Wild-Fires 4. Mineral Dust Production

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Level 1 Science Requirements

DS Objective	Application	Science Requirement
Weather Forecast	Initialization of Numerical Weather Prediction (NWP)	Hydrometeorology
Climate Prediction	Boundary and Initial Conditions for Seasonal Climate Prediction Models	Hydroclimatology
	Testing Land Surface Models in General Circulation Models	
Drought and Agriculture Monitoring	Seasonal Precipitation Prediction	Hydroclimatology
	Regional Drought Monitoring	
	Crop Outlook	
Flood Forecast	River Forecast Model Initialization	Hydrometeorology
	Flash Flood Guidance (FFG)	
	NWP Initialization for Precipitation Forecast	
Human Health	Seasonal Heat Stress Outlook	Hydroclimatology
	Near-Term Air Temperature and Heat Stress Forecast	Hydrometeorology
	Disease Vector Seasonal Outlook	Hydroclimatology
	Disease Vector Near-Term Forecast (NWP)	Hydrometeorology
Boreal Carbon	Freeze/Thaw Date	Freeze/Thaw State

Requirement	Hydro-Meteorology	Hydro-Climatology	Carbon Cycle	Baseline Mission		Minimum Mission	
				Soil Moisture	Freeze/Thaw	Soil Moisture	Freeze/ Thaw
Resolution	4–15 km	50–100 km	1–10 km	10 km	3 km	10 km	10 km
Refresh Rate	2–3 days	3–4 days	2–3 days(1)	3 days	2 days(1)	3 days	3 days(1)
Accuracy	4–6% **	4–6%**	80–70%*	4%**	80%*	6%**	70%*

(*) % classification accuracy (binary Freeze/Thaw)
(**) % volumetric water content, 1-sigma

(1)North of 45N latitude

Mission Duration Requirement:
3 Years Baseline; 18 Months Minimum

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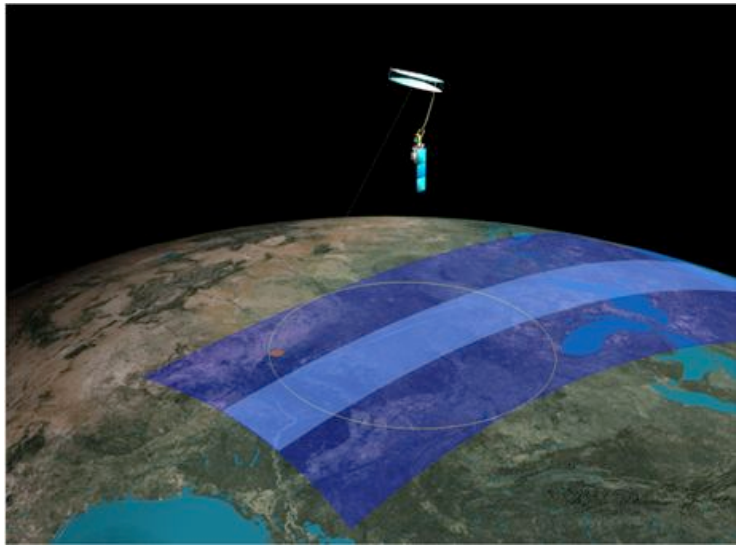
SMAP Measurement Approach

- Instruments:
  - Radar: L-band (1.26 GHz)
    - High resolution, moderate accuracy soil moisture
    - Freeze/thaw state detection
    - SAR mode: 3 km resolution
    - Real-aperture mode: 30 x 6 km resolution
  - Radiometer: L-band (1.4 GHz)
    - Moderate resolution, high accuracy soil moisture
    - 40 km resolution
  - Shared Antenna
    - 6-m diameter deployable mesh antenna
    - Conical scan at 14.6 rpm
    - Constant incidence angle: 40 degrees
      - 1000 km-wide swath
      - Swath and orbit enable 2−3 day revisit



- Orbit:
  - Sun-synchronous, 6 am/pm orbit
  - 680 km altitude
- Mission Operations:
  - 3-year baseline mission

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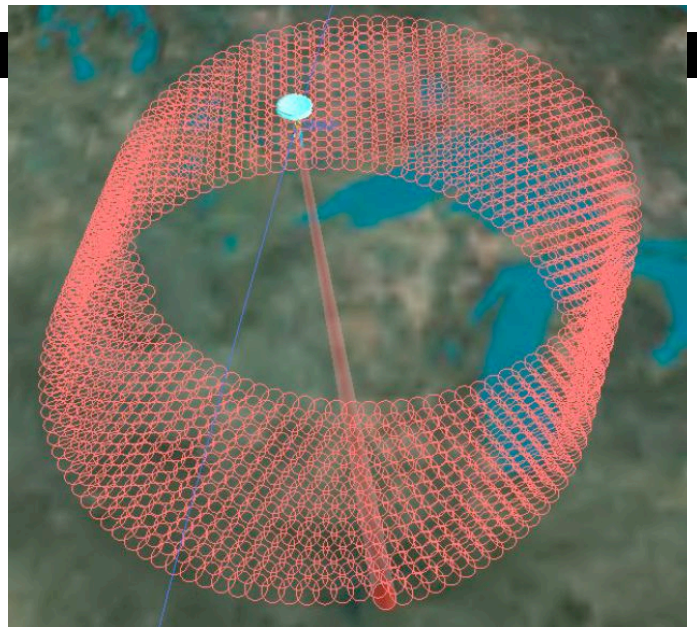
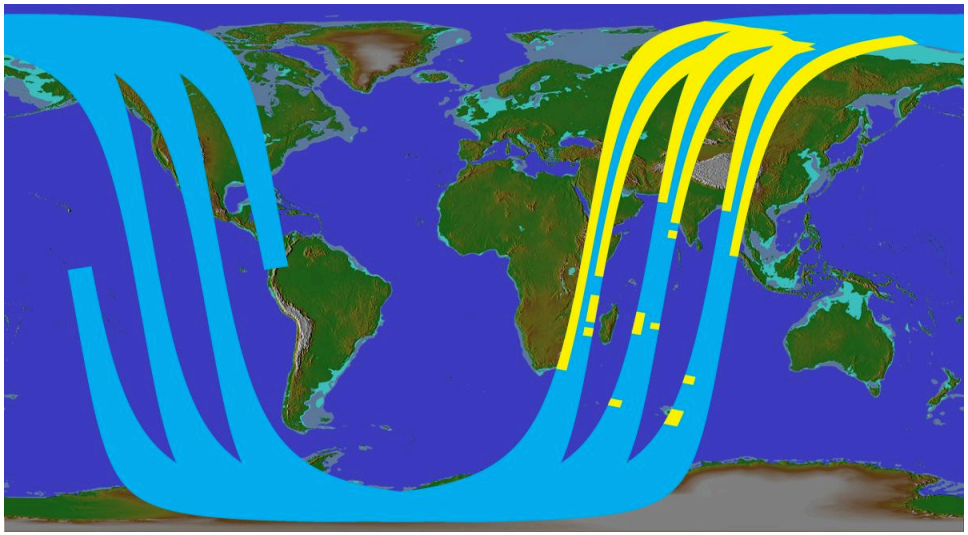
SMAP Data Acquisition

- Radiometer data collected continuously:
  - Entire orbit.
  - All 360 degrees of antenna scan (both forward and aft).
  - Capability for periodic “cold sky” looks.
- High-resolution SAR data:
  - Collected only on forward arc of scan
  - Collected only on decending (AM) portion of orbit
  - Collected only over land (using built-in land mask file).
- Radar low-resolution, real aperture data
  - Collected continuously like radiometer data; entire orbit, 360 deg





3 Sample SMAP Orbits

Radiometer and Low-Res Radar

High-Res Radar

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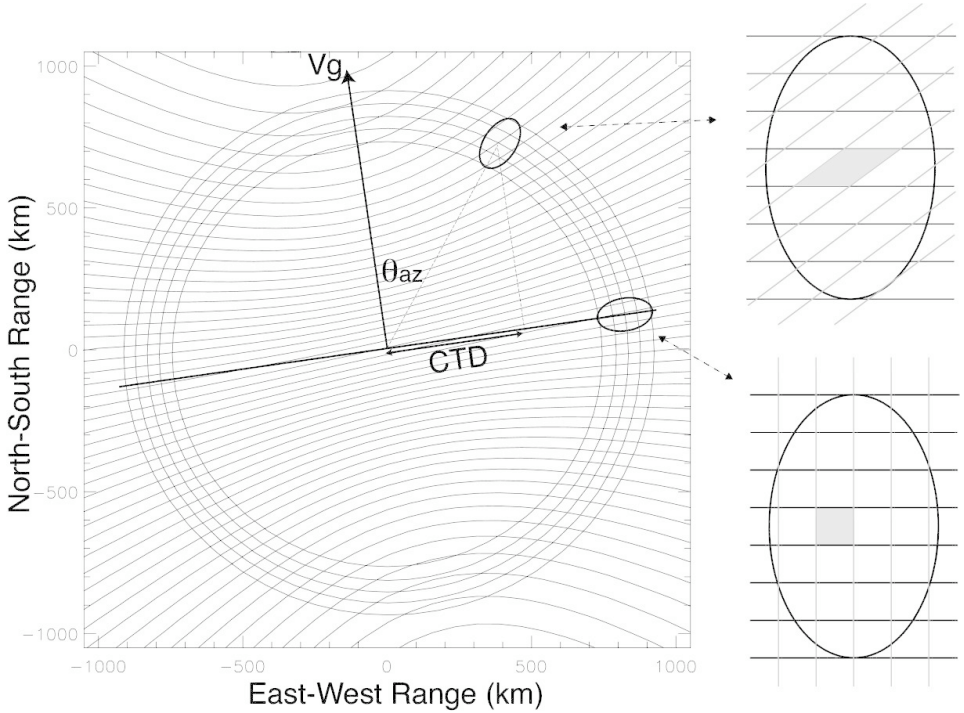
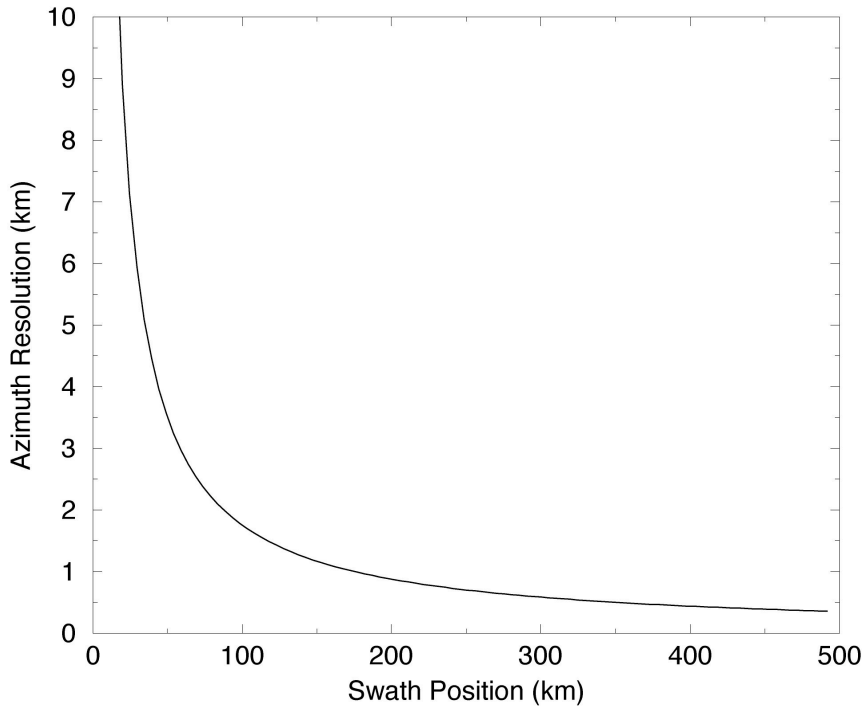
SMAP Radar Resolution





- Unfocused SAR processing.
- Azimuth resolution, and number of azimuth looks, driven by unique scanning geometry.
- High-resolution SAR data that meets science requirements for resolution and accuracy is over outer 70% of the measurement swath.

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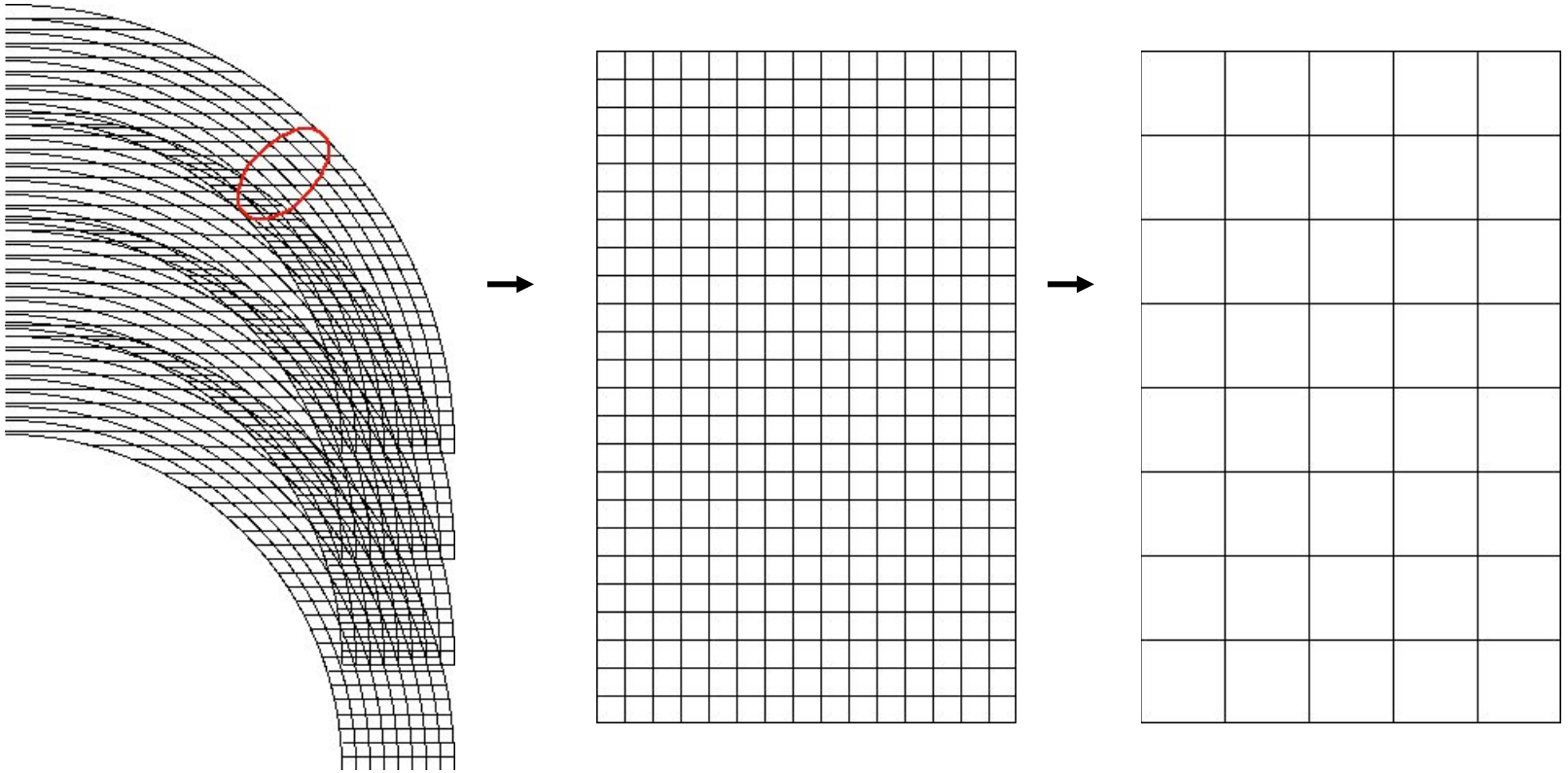
SMAP Radar Data Products



Single-Look, Time-Ordered Data

- Native resolution: 250 m in range, 400+ m resolution in azimuth.
- Each resolution element constitutes one independent "look" at surface.

1 km Gridded, Re-Sampled Data

- Data are resampled and posted on 1 km grid, resolution may still be > 1 km near nadir.
- Each resolution cell has multiple "looks" at surface, decreased measurement variance.

3 km Averaged Data

- 1 km posted product can be averaged up to 3 km, 10 km, etc. by investigators.
- Improved number of looks (and hence precision) at expense of spatial resolution.

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SMAP Baseline Science Data Products

Data Product	Description	Spatial Resolution	Latency*
L1B_S0_LoRes	Low Resolution Radar σ^o in Time Order	30 km	12 hours
L1C_S0_HiRes	High Resolution Rada σ^o on Earth Grid	1–3 km	12 hours
L1B_TB	Radiometer T_B in Time Order	40 km	12 hours
L1C_TB	Radiometer Brightness T_B on Earth Grid	40 km	12 hours
L3_F/T_HiRes	Freeze/Thaw State on Earth Grid	3 km	24 hours
L3_SM_HiRes	Radar Soil Moisture (internal product)	3 km	-------
L3_SM_40km	Radiometer Soil Moisture on Earth Grid	40 km	24 hours
L3_SM_A/P	Radar/Radiometer Soil Moisture on Earth Grid	10 km	24 hours
L4_C	Carbon Net Ecosystem Exchange on Earth Grid	10 km	14 days
L4_SM	Surface & Root Zone Soil Moisture on Earth Grid	10 km	7 days

*** The SMAP Project will make a best effort to reduce the data latencies beyond those shown in this table.**

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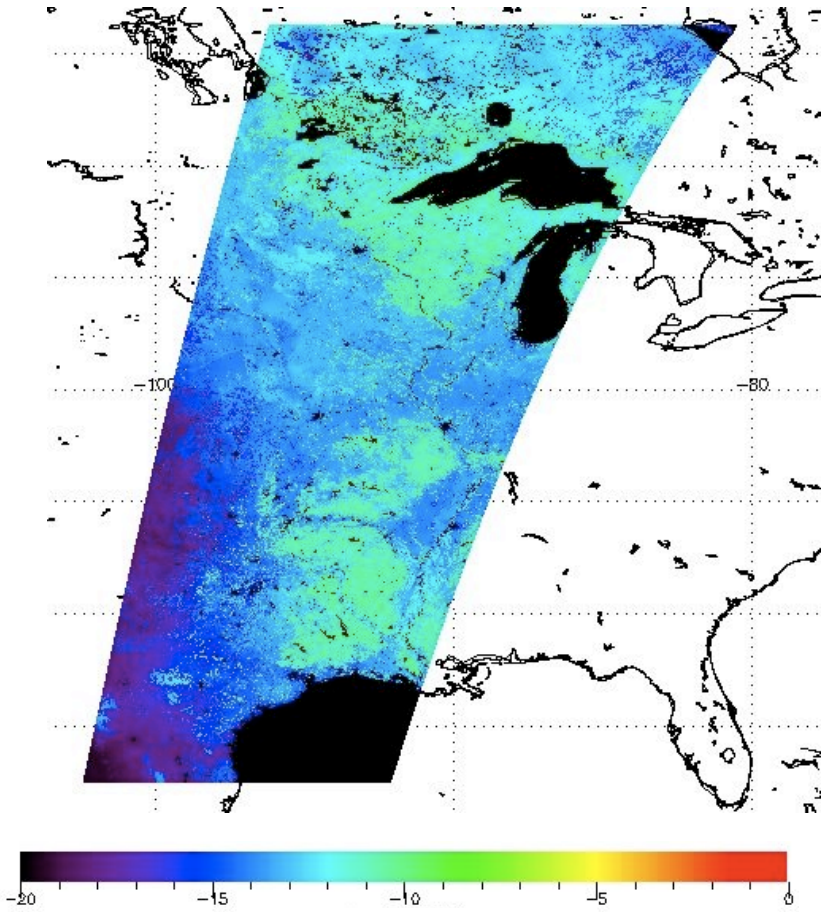
Level 1C Hi-Res Radar Backscatter Product (Example)

HH-pol Channel



Sigma0 HH (dB)

- L1C Hi-Res radar coverage is over land only, on the AM orbit pass, and using the forward part of the scan (baseline).
- SAR processing is used to achieve high-resolution single-look measurements. Resolution varies from ~400 m at the swath edge to about 1.2 km within 150 km of the subtrack. Nadir looks are thin slices as wide as the beam footprint.
- Calibrated HH, VV, and HV backscatter measurements are multi-looked and posted to a 1 km Earth-fixed grid.

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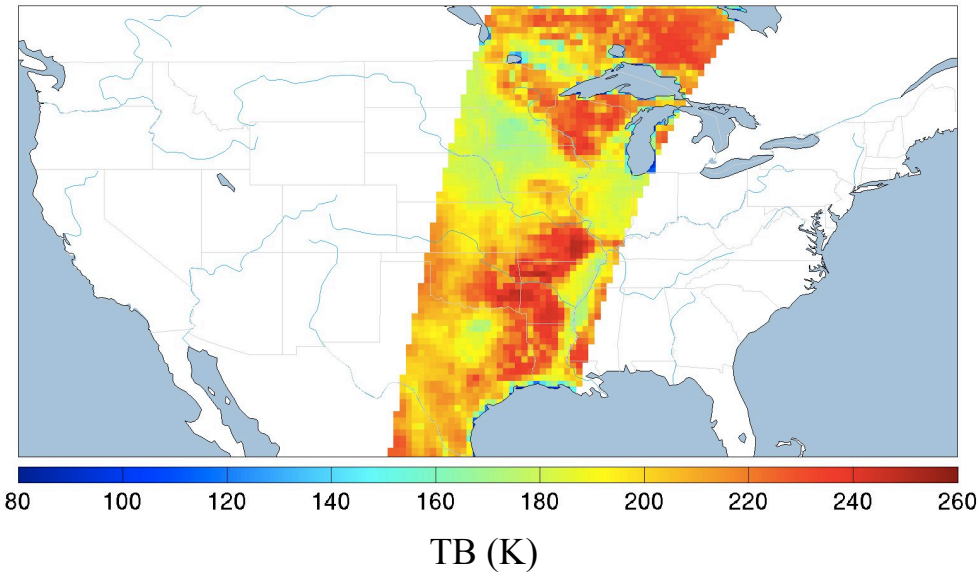
Level 1C Radiometer Brightness Temp Product (Example)

H-pol Channel



- Time-ordered Level 1B Radiometer data are gridded on a global Earth-fixed grid.
- Granularity options: half-orbit per file or daily composition of half-orbits per file. Fore- and aft-lookobservations stored separately
- Output data are posted at 36 km resolution.
- Used as input to Level 3 Radiometer 40 km soil moisture and Level 3 active/passive soil moisture processing.

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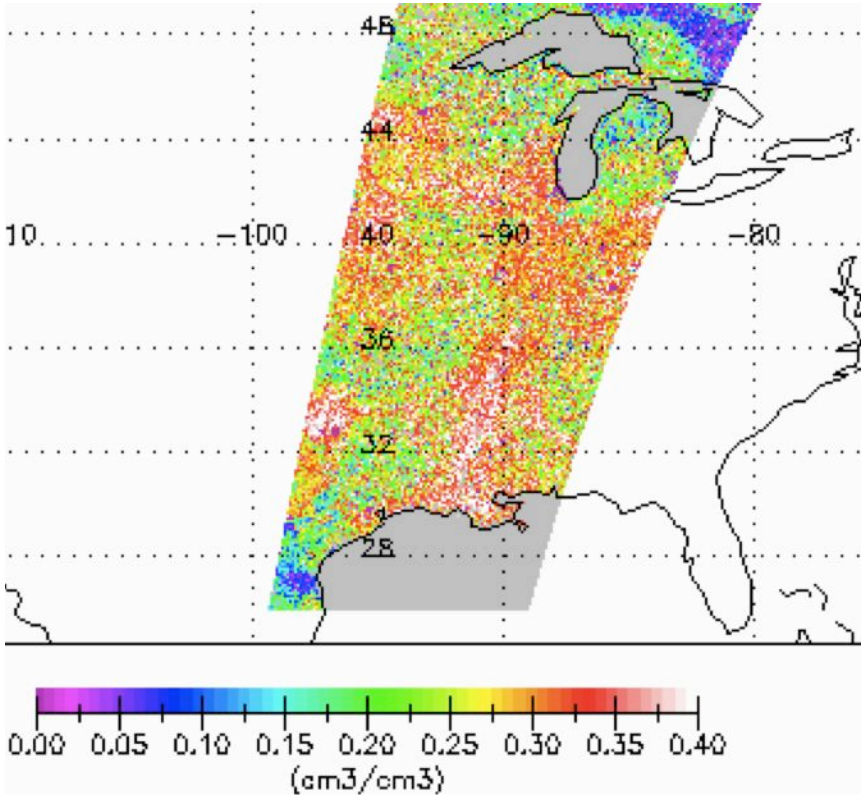
Level 3 Hi-Res Radar Soil Moisture Product (Example)



Volumetric Soil Moisture

- Retrieved soil moisture over land using Level 1C data.
- The 1 km HiRes radar L1C data are averaged to perform retrievals at 3 km grid postings, reducing radar speckle noise.
- Depending on the terrain classification, multiple optional models/algorithms may be employed for retrieval.
- Provides scene heterogeneity information for the Level 3 A/P algorithm processing.

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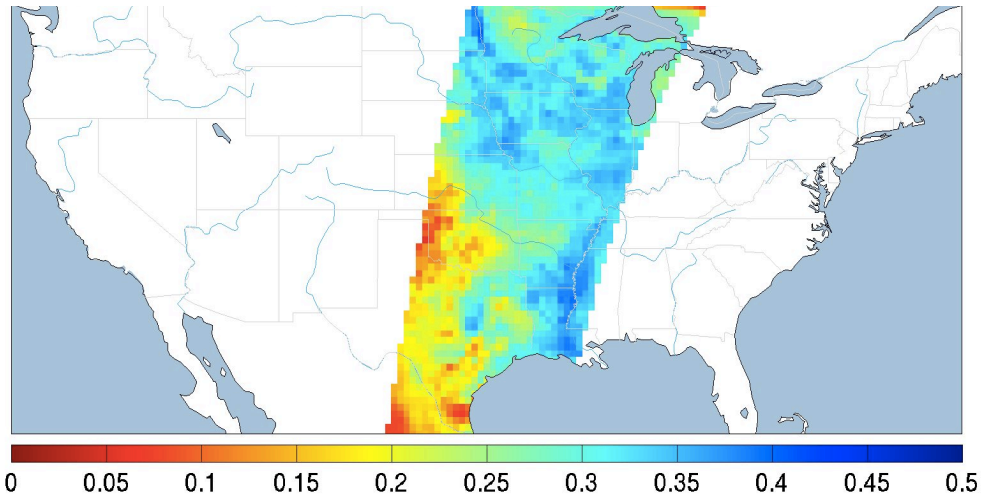
Level 3 Radiometer 40 km Soil Moisture (Example)



Volumetric Soil Moisture (cm3/cm3)

- Soil moisture estimate over land with 4% accuracy over low-to-moderately vegetated areas (VWC <= 5 kg/m2).
- Global coverage in 2-3 days.
- Estimate is made using only AM observations (current baseline)
- QC masks (e.g. urban areas, mountainous terrain, frozen ground, snow, ice) are applied

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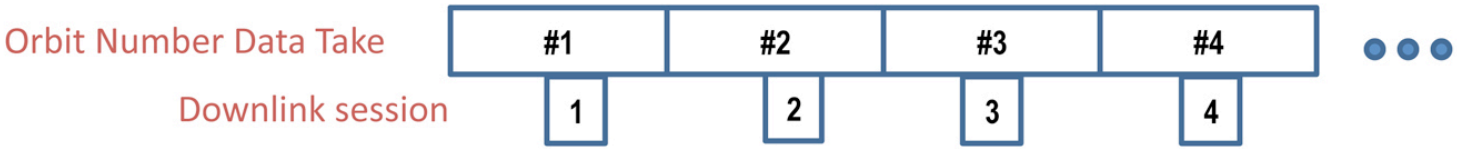
Data Acquisition and Processing Timeline



Science data processing is done by orbit; orbits count from South Pole to South Pole

- Orbit #1 data are processed after downlink session #2 is complete

Time Delay Categories	Low End	High End
Data take to downlink to ground station	1.5 orbits (135 min)	6.5[1] orbits (585 min)
Data transfer from station -> EDOS (GSFC) -> JPL	60 min	60 min
Level 1 processing	60 min	60 min
Total Level 1 Data Latency	255 min/4.25 hours	705 min/12 hours
Max additional time for ancillary data to be available for processing (360 min from first satellite data take)	105 min	540 min
Level 3 data processing	60 min	60 min
Total Level 3 Data Latency	420 min/7 hours	1305 min/22 hours

[1] Due to SMAP orbit/viewing geometry, antenna FOV, and other constraints, the worst case between contacts is 5 orbits.