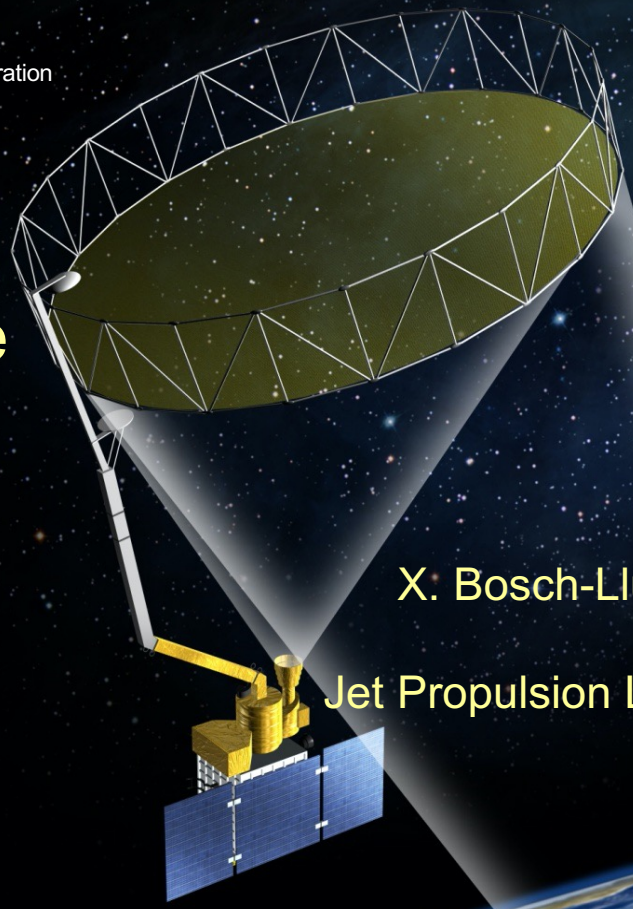
National Aeronautics and Space Administration

Soil Moisture Active Passive Mission

SMAP



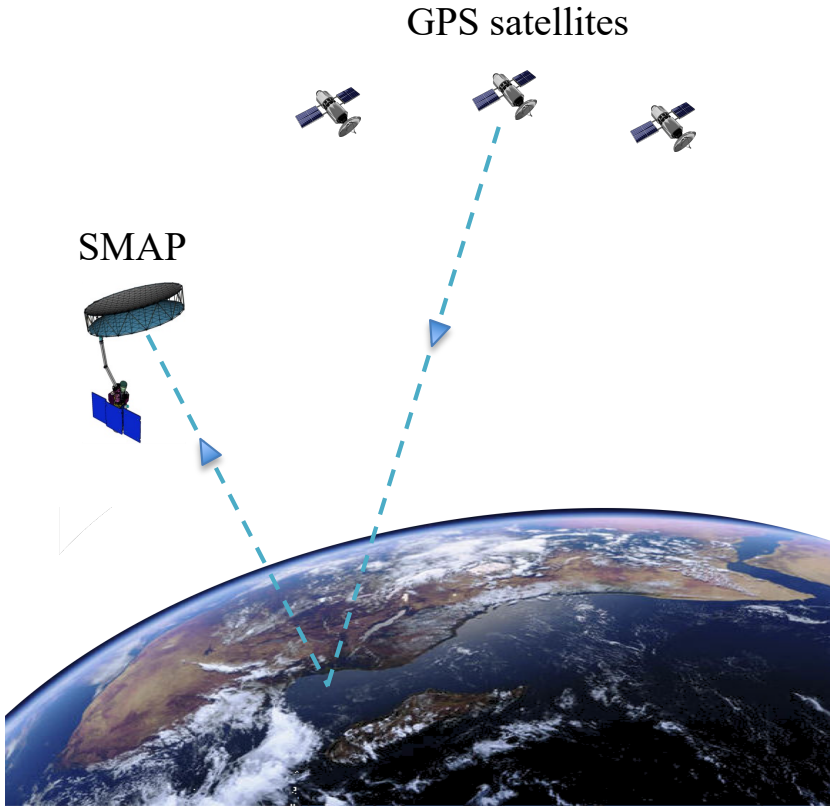
SMAP-Reflectometry DDM processor: Status and next steps

Nereida Rodriguez-Alvarez, K. Oudrhiri, X. Bosch-Lluis, Oscar Yang, S. Lowe, and A. Colliander

Jet Propulsion Laboratory/California Institute of Technology

SMAP Science Team Meeting
September 8, 2021

Introduction



SMAP-R: SMAP radar receiver operating in bistatic radar configuration collecting Global Positioning System (GPS) signals reflected off the Earth surface at L-band (L2C: 1227.45 MHz)

This proposal aims to:

- bring the dataset to a calibrated format useful for the scientific community
- demonstrate the advantages and capabilities of this unique and valuable dual-polarization polar coverage L-band bistatic radar dataset by developing algorithms to obtain:
  - freeze/thaw (F/T) state transition retrievals,
  - vegetation water content (VWC) estimates,
  - sea ice detection, sea ice type classification, and
  - river flow estimations.
  - develop downscaling approaches using the SMAP-R products in combination with SMAP official F/T and soil moisture (SM)

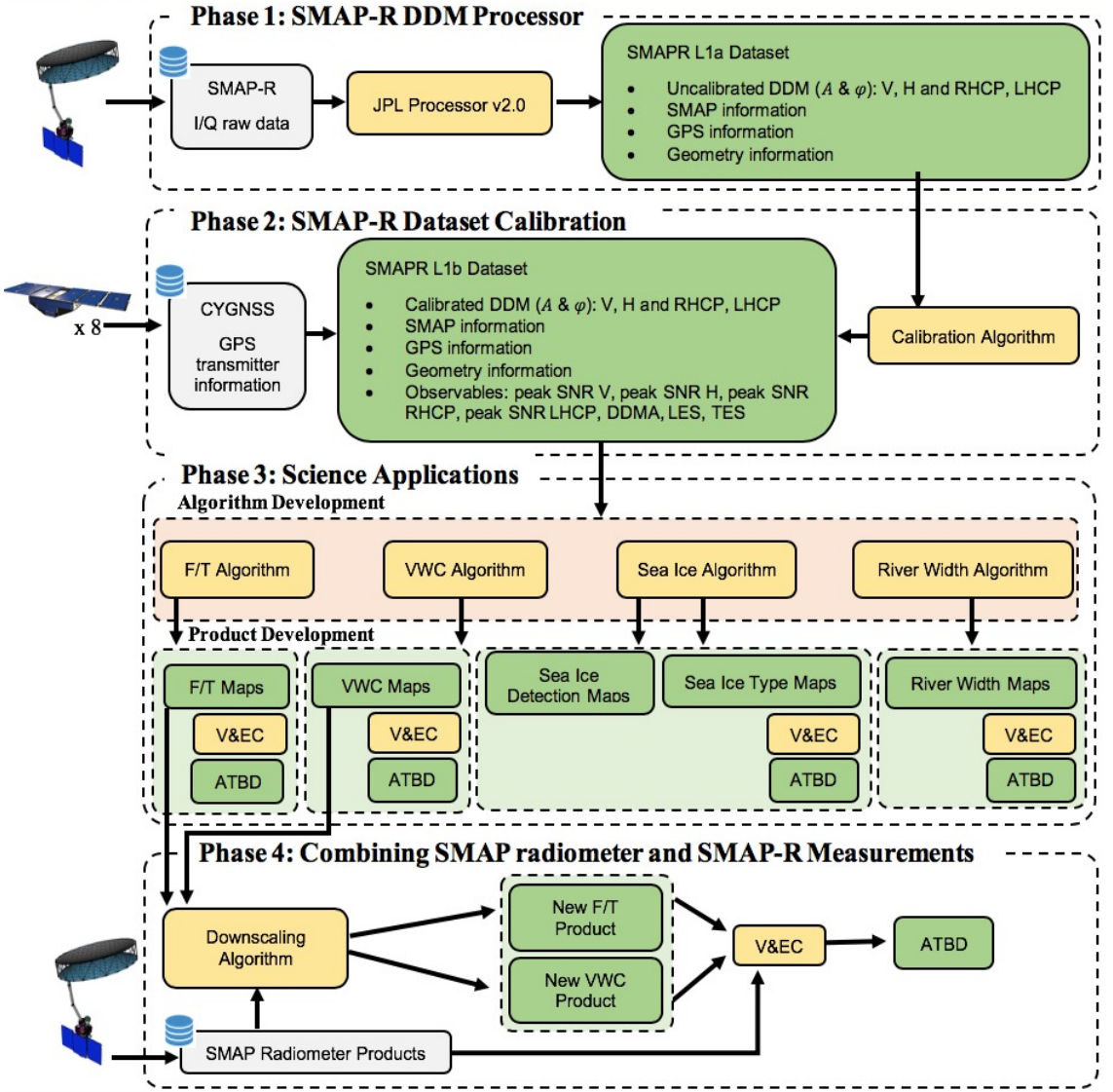
Goal: increase the scientific outcome of SMAP-R dataset

Plan

Phase	Schedule	Fiscal Year
1	12/2020 – 10/2021	FY21
2	08/2021 – 04/2022	FY22
3	04/2022 – 08/2023	FY22 + FY23
4	02/2023 – 11/2023	FY23

Funding was provided at the end of November and I received it beginning of December, so everything is moved towards the December start date.

I consider that the years run from December to November of the following year.



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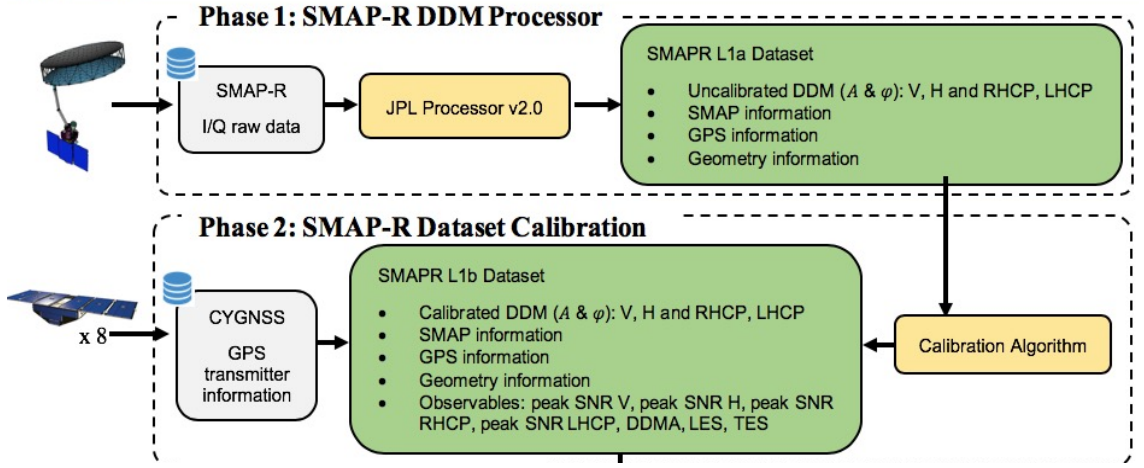
Status

Phase	Schedule	Fiscal Year
1	12/2020 – 10/2021	FY21
2	08/2021 – 04/2022	FY22



Phase 1: SMAP-R DDM Processor

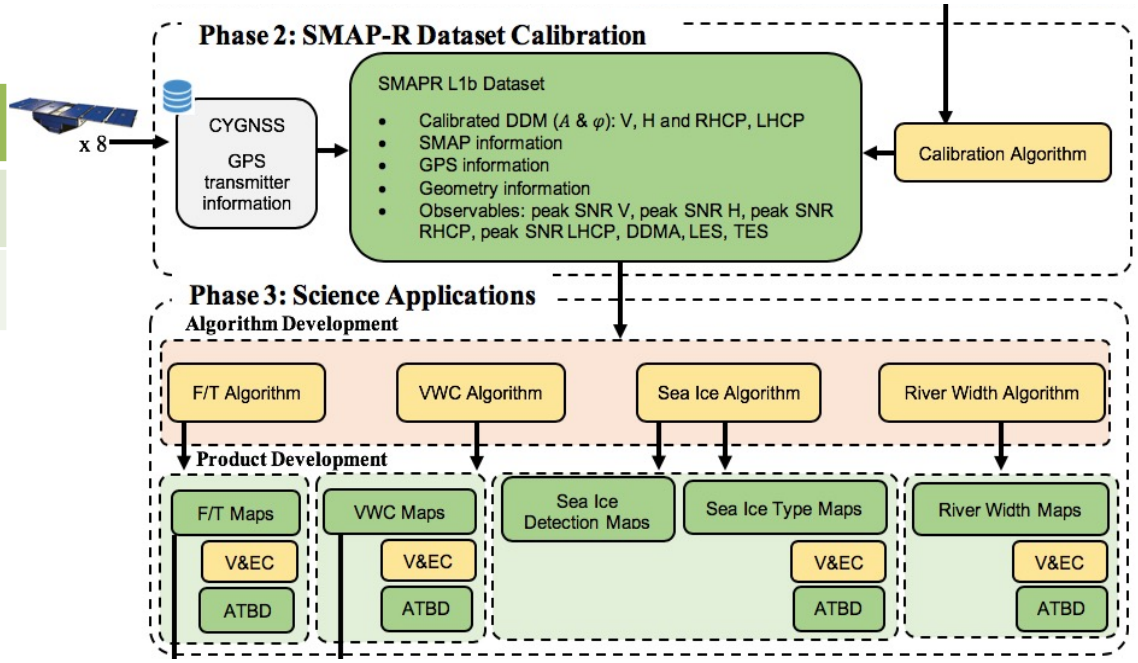
- We have completed the Python coding for the SMAP-R DDM Processor. On SCHEDULE
- We are in the process of debugging and validating the code and the production of the L1a dataset – to be completed by the end of 10/2021. On SCHEDULE

Phase 2: SMAP-R Dataset Calibration

- We have started on 08/2021 with the Calibration Algorithm. On SCHEDULE

Next Year of Funding

Phase	Schedule	Fiscal Year
2	08/2021 – 04/2022	FY22
3	04/2022 – 08/2023	FY22 + FY23



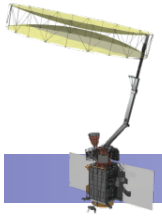
Phase 2: SMAP-R Dataset Calibration

- Complete the Calibration Algorithm and produce L1b Dataset.
- Debug and test the SMAP-R L1b Dataset
- To be completed by 04/2022

Phase 3: Science Algorithm – When the fun starts!!

- Algorithm development will start on 04/2022 for each application and extend until 08/2023 (1 year and 4 months)

A **post-doctoral researched** will start on 09/2021, and will greatly contribute to the project.
The post-doc arrival is delayed because of COVID. He was expected in June.



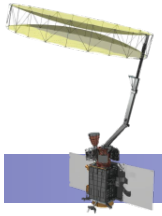
Science Algorithms

General Method for Science Applications (GMSA)

To compensate the low sampling and low repeat of SMAP-R:

- We will implement an observational strategy using measurements over long periods of stability in two extremes and average them together.
- These two states that become the reference of the observations.
- We analyze the variability of the measurements at both V-pol and H-pol and the polarimetric ratio (PR) during transitional periods.

Understand how the observed surfaces transition from one state to the other.



Science Applications

F/T Algorithm

- Method: Build on the methodology developed on our previous studies. Analyze the peak SNR of SMAP-R data at both V-pol and H-pol and the polarimetric ratio (PR) by implementing our **GMSA**.

- Coverage and Frequency: Extend the algorithms to a **global** scale. Assess SNR evolution between F/T states providing transitional information at a pixel level through **daily updates**.

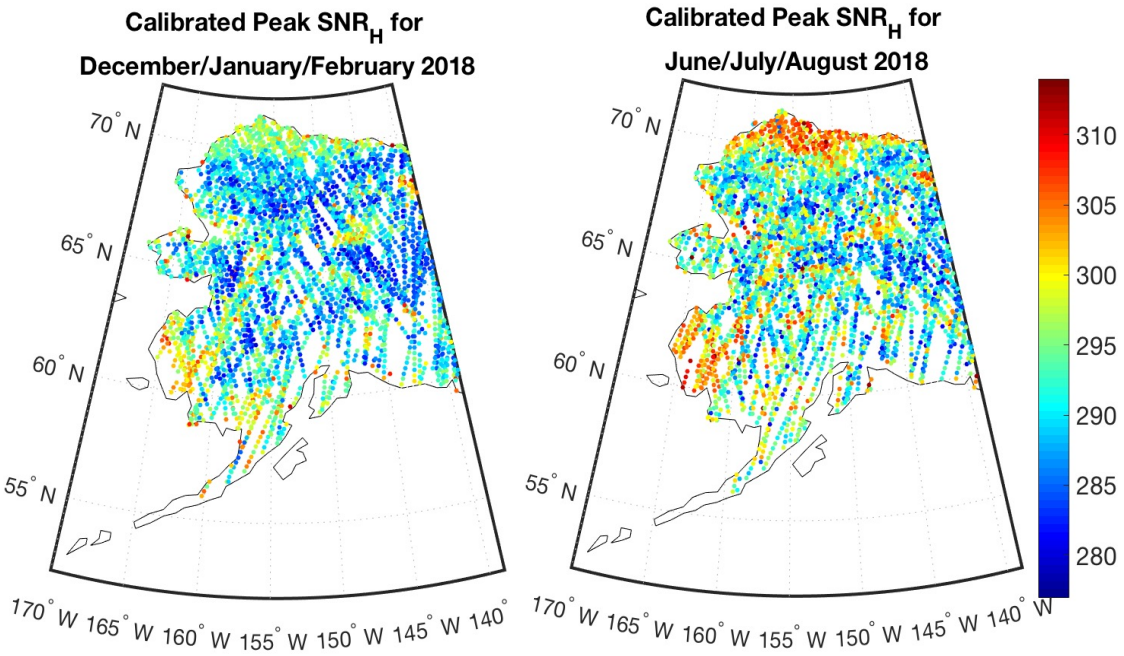
- Validation and Error Characterization: Utilize independent F/T estimates derived from in situ daily surface air temperature measurements from 5,020 weather stations which report daily observations to the World Meteorological Organization (WMO) located across the global FT domain.

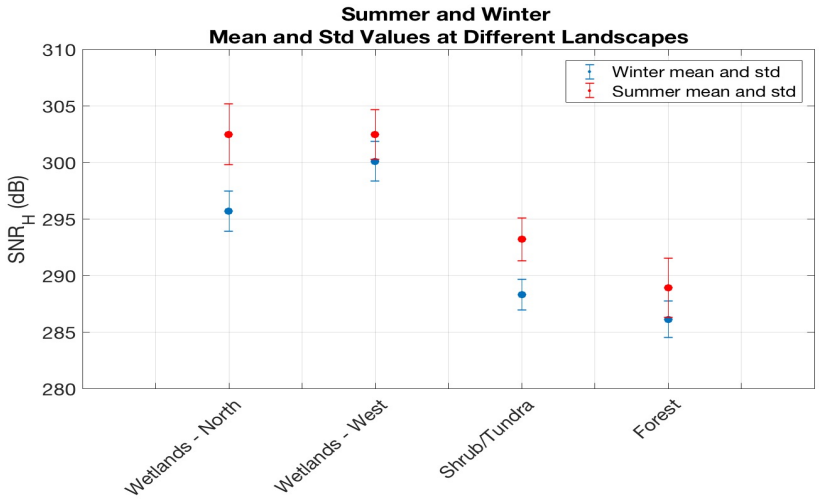
- Resolution and Sensitivity: Provide spatial resolutions between **1 km** x 1 km and **10 km** x 10 km, depending on the land type which impacts the scattering surface. Sensitivity of **4 to 7 dB of peak SNR from frozen to thaw states**.

Science Applications

F/T Algorithm

Previous Development: There is potential for F/T state determination.





SMAP-R SNR increases when the surface is thawed, and at the same time the SNR varies as a function of the different land types.

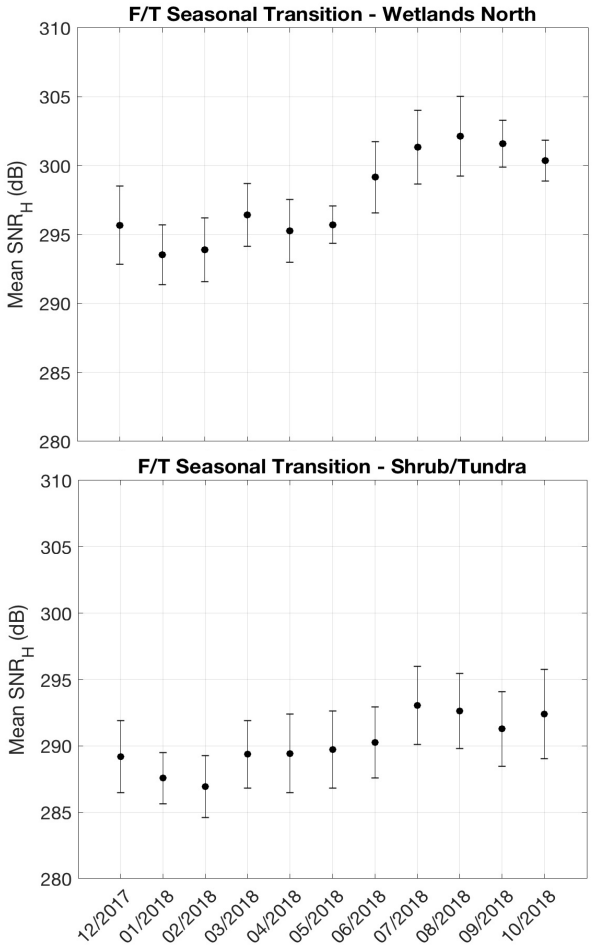
Science Applications

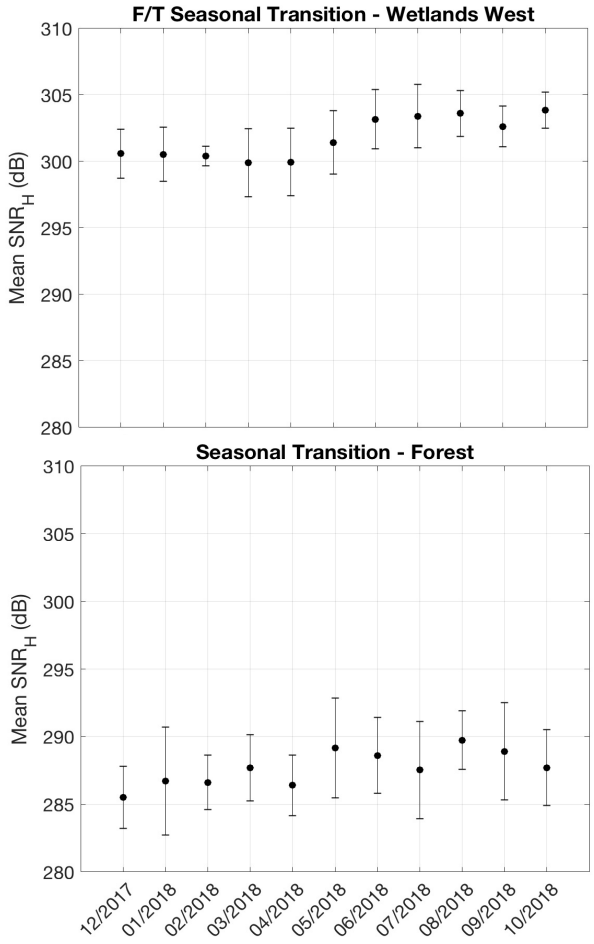
F/T Algorithm

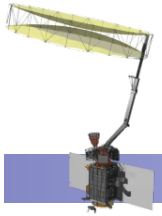
Previous Development: There is potential for F/T state determination.

Seasonal transition between states for different soil types

Monthly SNR averages show the transition between states.







Science Applications

VWC Algorithm

- Method: Build on the methodology developed on our previous studies. Analyze the peak SNR of SMAP-R data at both V-pol and H-pol and the polarimetric ratio (PR) by implementing our **GMSA**.

- Coverage and Frequency: Extend the algorithms to a **global** scale and assess VWC transitions from low to high water content with **daily updates**.

- Validation and Error Characterization: Utilize Olson's Major World Ecosystem Complexes Ranked by Carbon in Live Vegetation: An Updated Database Using the GLC2000 Land Cover Product or MODIS MOD15A2 LAI data product.

- Resolution and Sensitivity: Provide spatial resolutions between **3 km** x 3 km and **10 km** to 10 km, depending on the crop type. Sensitivity of **0.4 kg/m^2 per dB of peak SNR.**

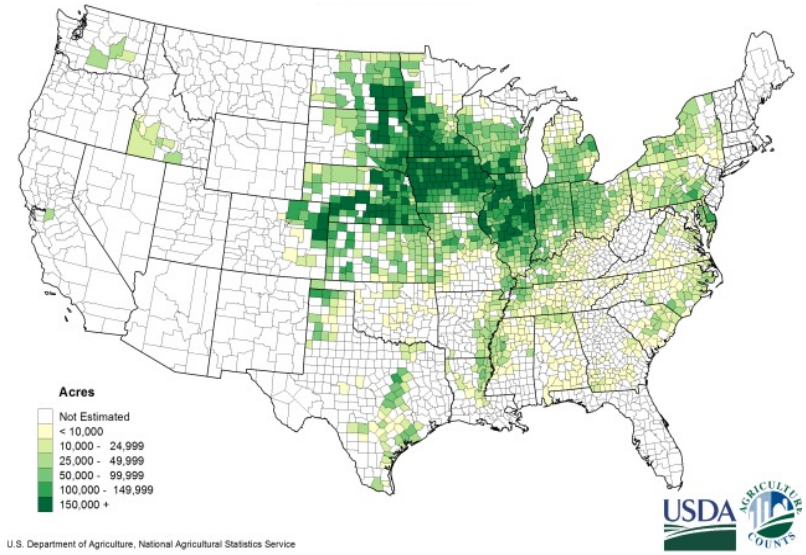
Science Applications

N. Rodriguez-Alvarez; Misra, S.; Morris, M. The Polarimetric Sensitivity of SMAP-Reflectometry Signals to Crop Growth in the U.S. Corn Belt. Remote Sens. 2020, 12, 1007.

VWC Algorithm

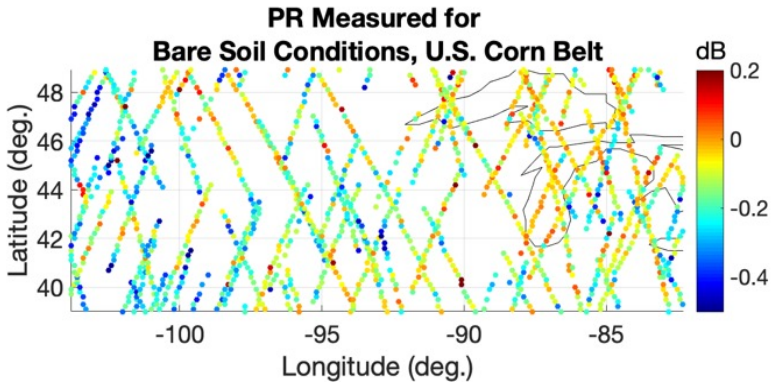
Previous Development: There is potential for VWC state determination.

Number of planted acres in the Corn Belt, USA

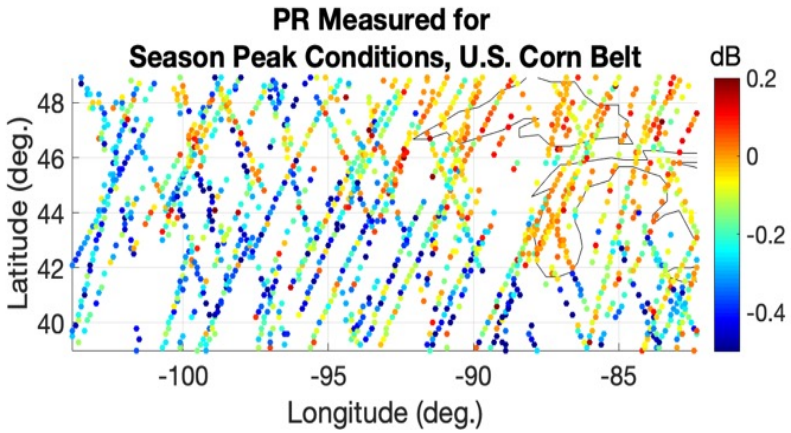


SMAP-R polarimetric ratio (PR): Two states

March/April 2017



July/August 2017



The higher the VWC (or VOP), the lower the PR

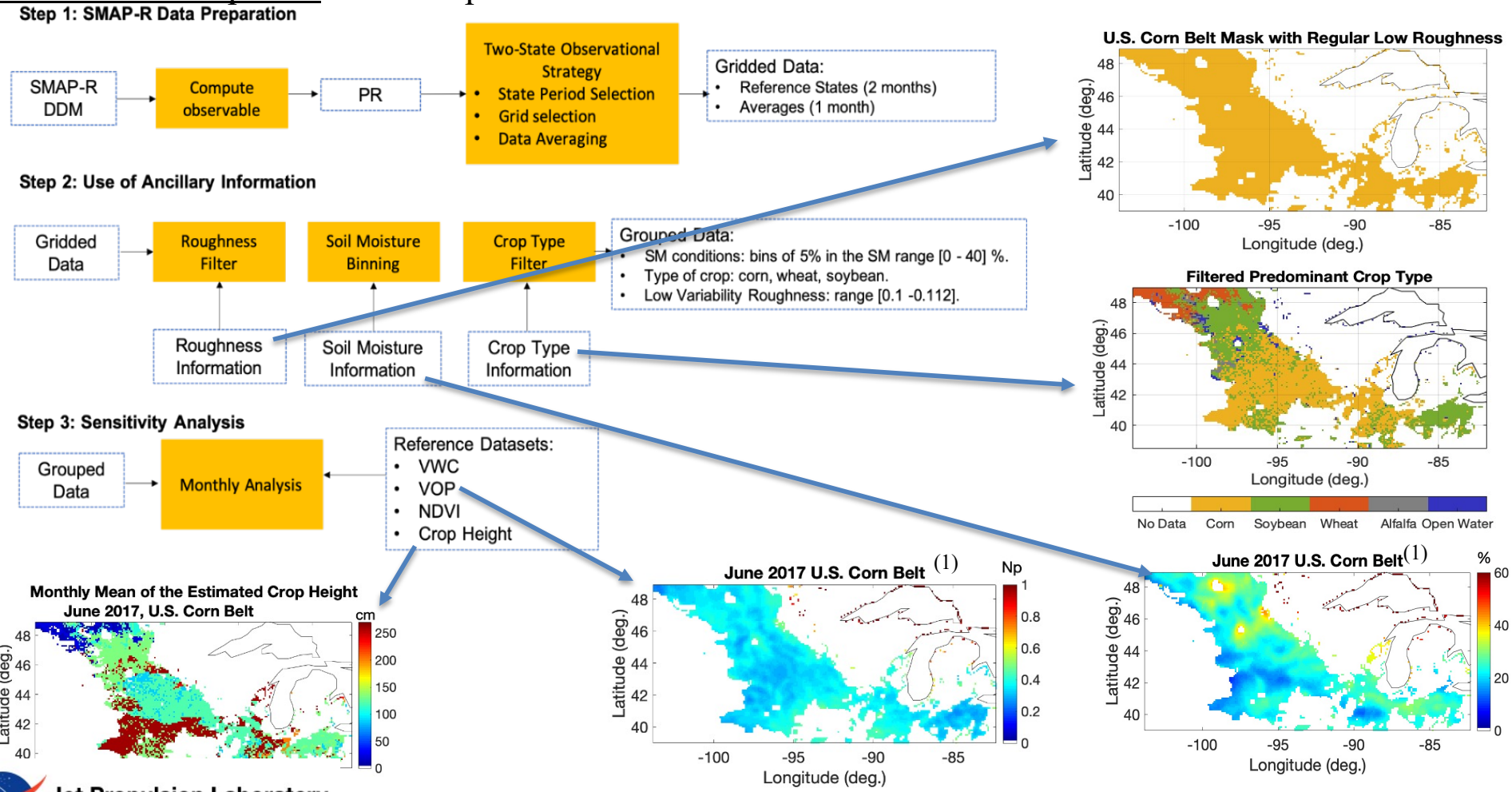
Science Applications

N. Rodriguez-Alvarez; Misra, S.; Morris, M. The Polarimetric Sensitivity of SMAP-Reflectometry Signals to Crop Growth in the U.S. Corn Belt. Remote Sens. 2020, 12, 1007.

[1]SMAP Enhanced L3 Radiometer Global Daily 9 km Soil Moisture Version 2 product

VWC Algorithm

Previous Development: There is potential for VWC state determination.



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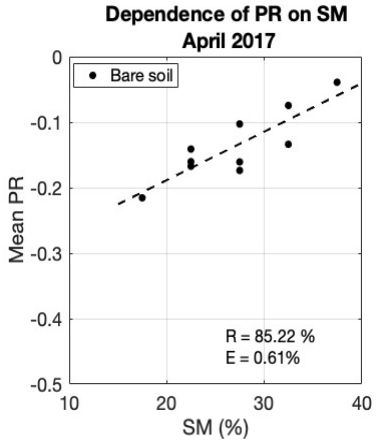
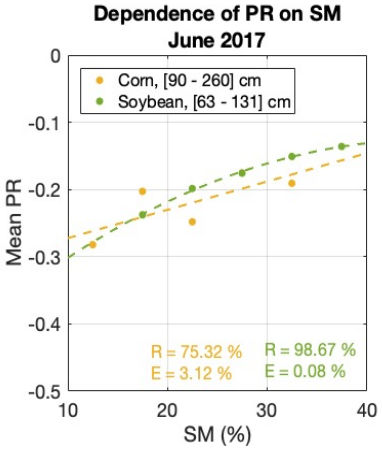
Science Applications

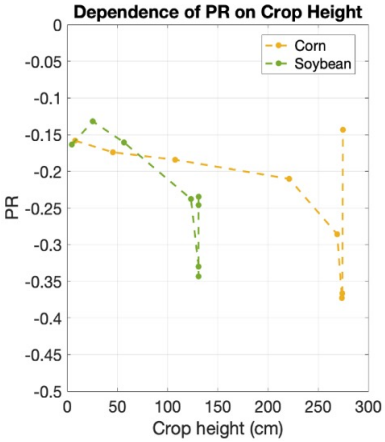
N. Rodriguez-Alvarez; Misra, S.; Morris, M. The Polarimetric Sensitivity of SMAP-Reflectometry Signals to Crop Growth in the U.S. Corn Belt. Remote Sens. 2020, 12, 1007.

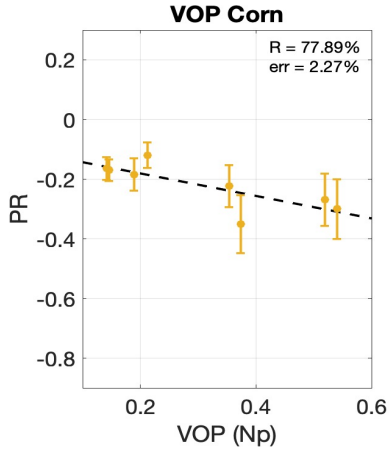
VWC Algorithm

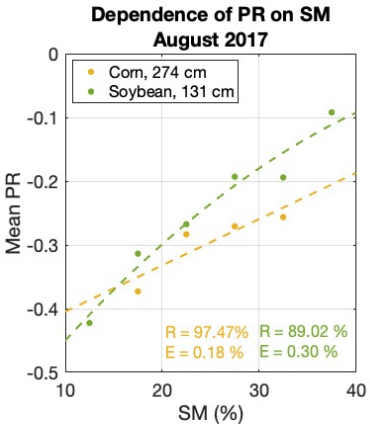
Previous Development: There is potential for VWC and SM determination.

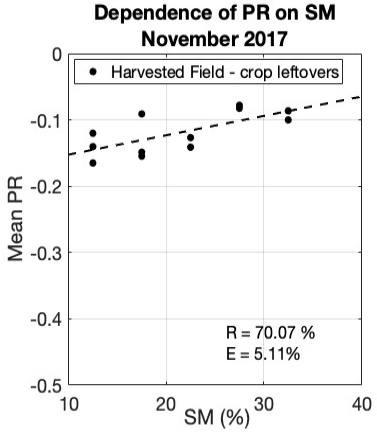


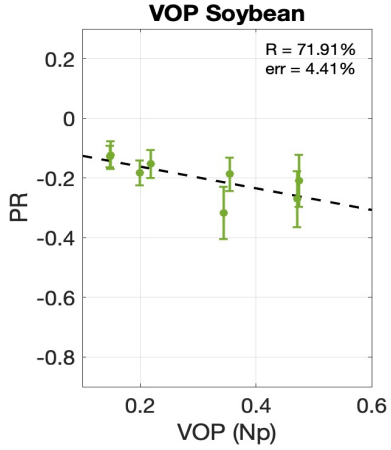


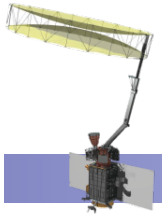












Science Applications

Sea Ice Algorithm

- Method: Build on the methodology developed on our previous studies: **thresholding and decision-tree classification methods** applied to standard observables based on power and shape of the TDS-1 measurements. Algorithms will be adapted to SMAP-R dataset to include peak SNR at both V-pol and H-pol and the polarimetric ratio (PR).
- Coverage and Frequency: **Arctic** and **Antarctic** seasonal sea ice type classifications, analyzing formation and melting characterization for the years of SMAP-R data available. We will produce **daily updates**.
- Validation and Error Characterization:
  - EUMETSAT OSI SAF Global Sea Ice Type product obtained from DMSP/SSMIS, Metop/ASCAT and GCOM-W/AMSR-2 at a daily rate and at spatial resolutions of 10 km.
  - Sea ice products from the US NIC and NWS, which include extensive types of ice at 200 m resolution every 7 days.
- Resolution and Sensitivity: Provide spatial resolutions on the order of **1 km** x 1 km, due to the coherency of the sea ice scattering surfaces. Sensitivity proven to at least 3 **ice types: new, first year and multi-year**.

Science Applications

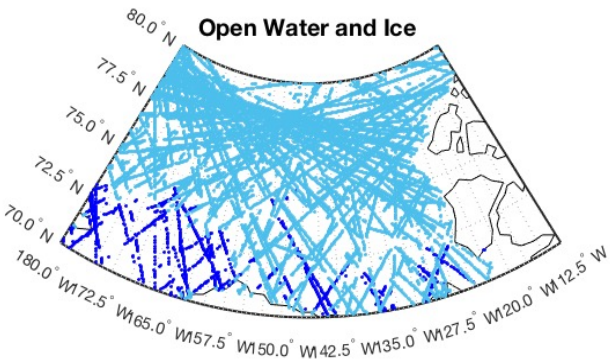
Sea Ice Algorithm

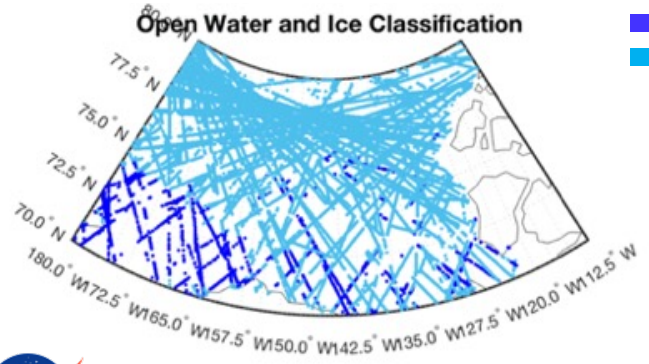
N. Rodriguez-Alvarez, B. Holt, et al., An Arctic sea ice multi-step classification based on GNSS-R data from the TDS-1 mission, Remote Sensing of the environment, Remote Sensing of Environment 230C, 111202, September 2019. Available online from May 27, 2019.

Previous Development: There is potential for sea ice detection and type classification.

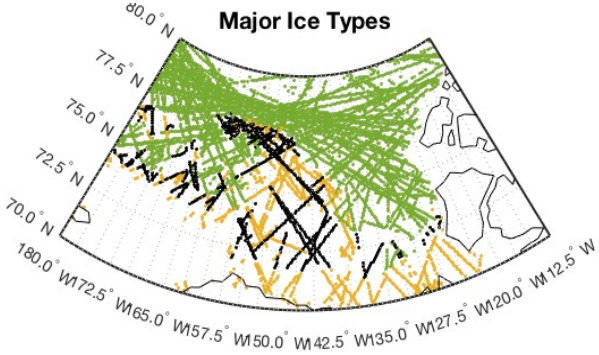
TDS-1 GNSS-R LHCP signals where used to detect sea ice and classify it in three major types. Derived:

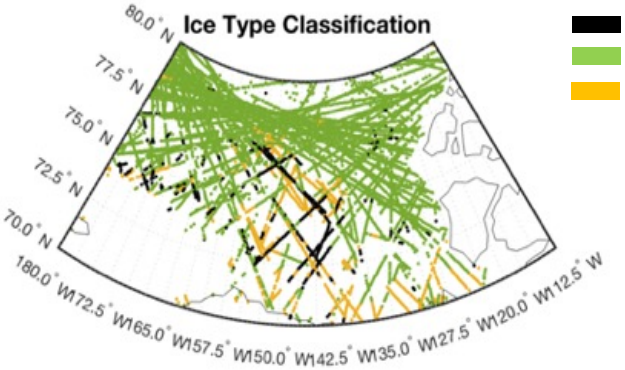
- classifications of sea ice–open water samples with a success rate of 97%,
- classifications sea ice type: FYI, MYI and young ice with success rates of 70%, 82% and 81% each.





Open water
Sea Ice





First Year Ice
Multi Year Ice
Young Ice

Science Applications

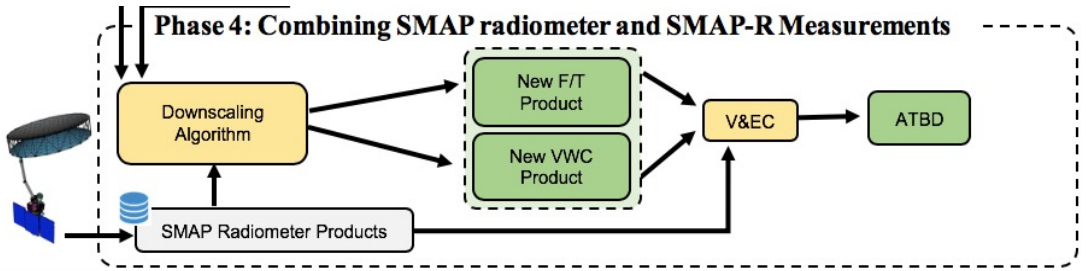
And More to Come in Phase 3:

- Stephen Lowe: River Flow Algorithm and Products

Phase 4: Combining SMAP Radiometer and SMAP-R Measurements – When the fun continues!

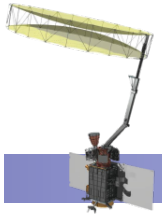
Phase	Schedule	Fiscal Year
4	02/2023 – 11/2023	FY23

In collaboration with co-I Andreas Colliander



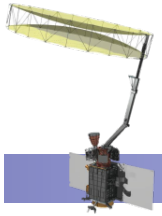
Downscaling Method for Enhancing Products (DMEP): We will perform pixel disaggregation of the SMAP official products using proxy information describing the spatial patterns within each coarse scale satellite pixel:

- exploit the sensitivity of SMAP-R measurements to F/T states for different landscapes.
- exploit the sensitivity of SMAP-R to VWC utilizing our VWC product to correct the current ancillary VWC product used in the official SMAP SM product. Our product provides L-band polarimetric information on the VWC which represents an independent source of information respect the NDVI-based products.



Acknowledgement

This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration. © 2021. California Institute of Technology. Government sponsorship acknowledged.



Thank you!!

Questions?