Signals of Opportunity - Airborne Demonstrator (SoOP-AD): Instrument Overview, Performance during First Flights and Future Instrument Concept

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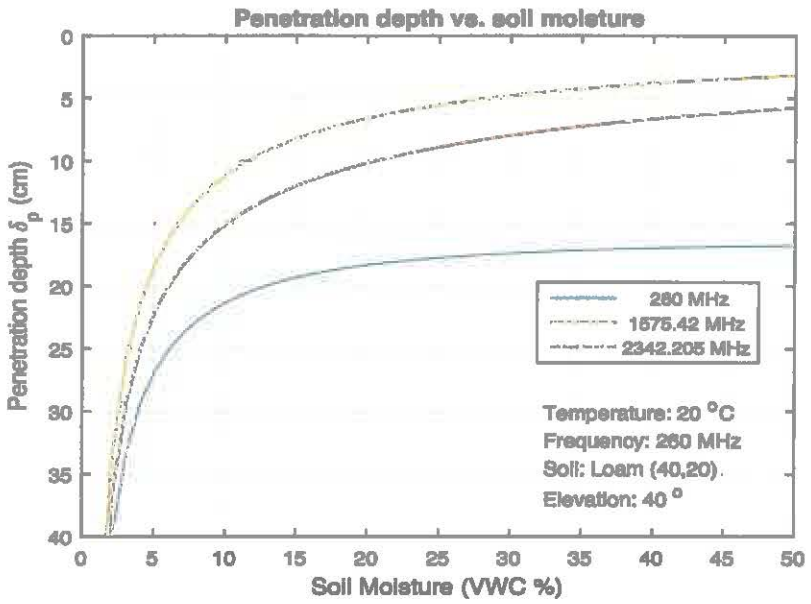
Outline

- Motivation
- Technology Developments
  - IIP 2013 – SoOp-AD
    - Airborne instrument
    - Ground-based field experiment
  - ACT 2017 (wideband deployable membrane antenna)
    - P/l Band Multi-Frequency Reflectometry Antenna for a U-Class Constellation
  - IRAD FY18
    - Cubesat Compatible Digital Back-End and Low-Noise Front-End for P-band Signals of Opportunity Remote Sensing
  - InVEST 2018
    - SigNals of Opportunity P-band Investigation (SNoOPI)
- Concluding Remarks

Motivation

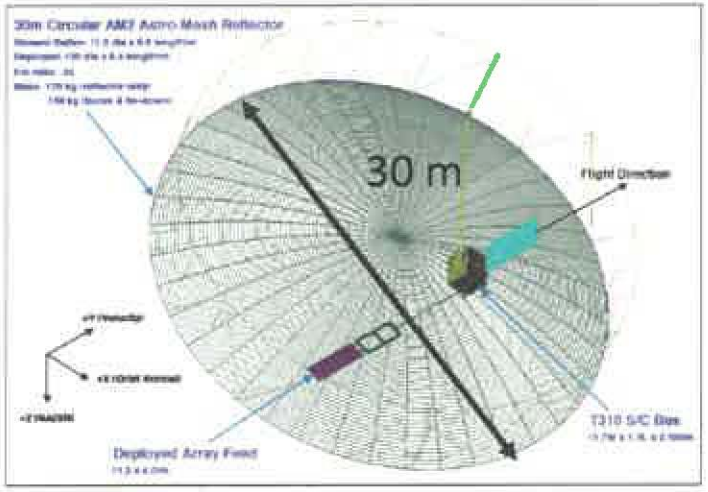
- Root Zone Soil Moisture (RZSM)
  - Water in top ~1m of soil – essential variable for understanding the water cycle and agricultural forecast.
- Penetration depth limited to few-cm at L-band
- Global RZSM from model assimilation (e.g. SMAP L4)



Motivation cont'd

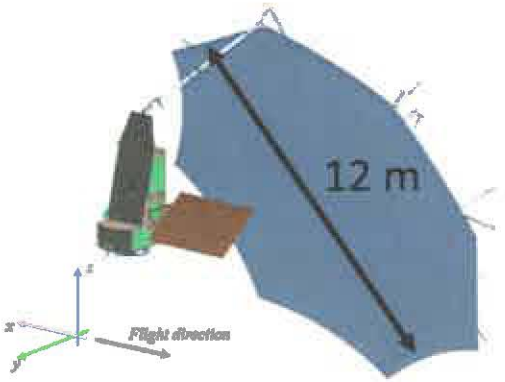
- Difficulties in sensing < 500 MHz
- Large antenna size to meet resolution requirements
- Few protected bands
- High RFI from terrestrial sources

MOSS: 435 & 137 MHz



[DOI:10.1109/TGRS.2007.898236]

ESA-BIOMASS
435 MHz (limited Ops.)



[*ESA SP-132*, 2010]

Motivation cont'd

- Re-utilization of existing transmissions (e.g. potential RFI ***sources***)
- Bands allocated for ***Space-Earth communications***
- High power, forward scatter -> High SNR/smaller antenna
- Resolution set by signal bandwidth – not antenna diameter

P-band SoOp may offer first possibility of direct remote sensing of Root-Zone Soil Moisture (RZSM) from space

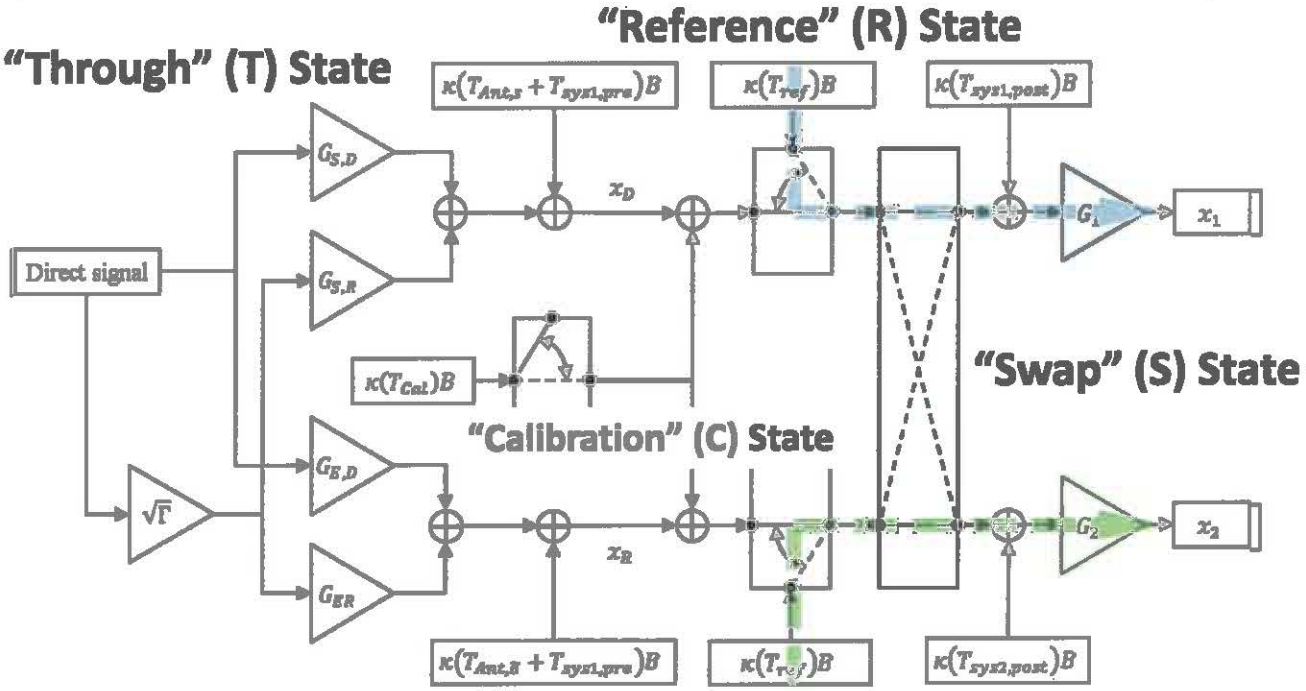
Instrument Incubator Program (IIP) 2013

- Signals of Opportunity – Airborne Demonstrator (SoOp-AD)

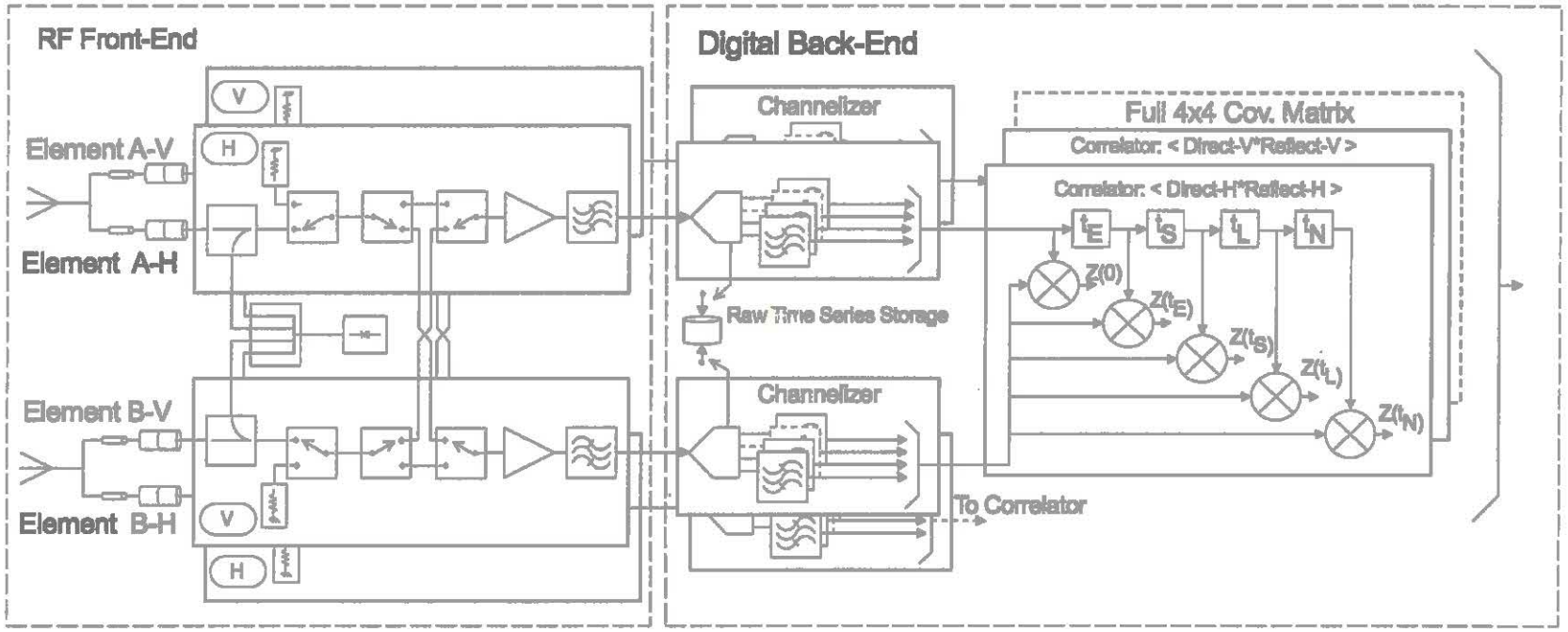
- Objectives:
  - Airborne demonstrator for P- and S-band SoOp
  - Brassboard low-noise front-end and digital receiver with "path to space" tested in relevant environment (TRL-5)
  - Airborne science instrument for future algorithm development

Successfully completed April 2018 at TRL-5

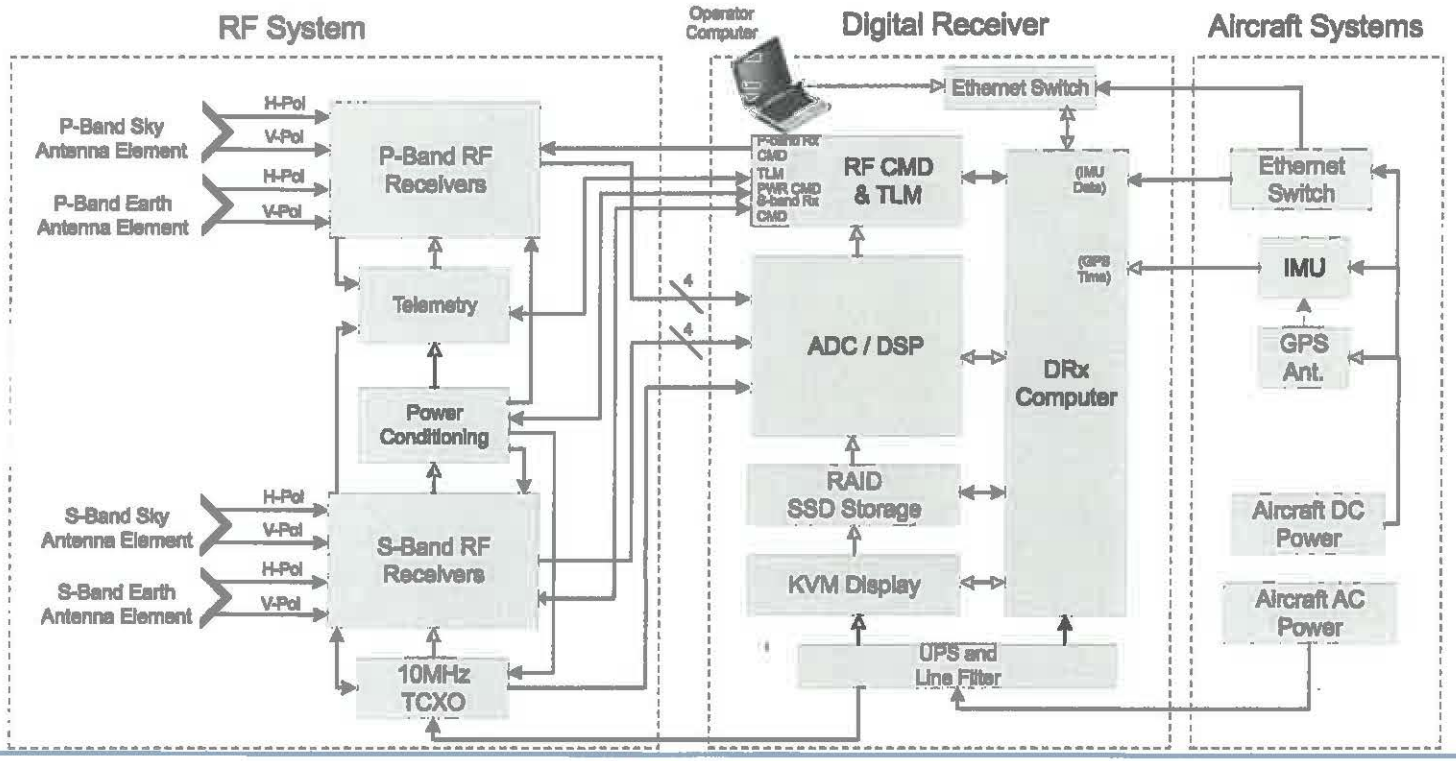
IIP 2013 – SoOp-AD Instrument Model



IIP 2013 – SoOp-AD RF and Digital Subsystems



IIP 2013 - SoOp-AD Instrument Block Diagram



IIP 2013 – SoOp-AD Integration and Testing

Prior to I&T.

With improvements made during I&T.

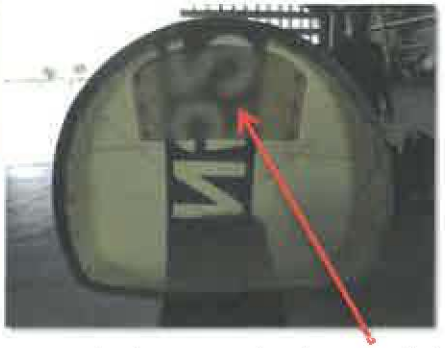
1) 3D printed air duct for improved air flow to critical components.
2) FPGA card supports to increase vibration tolerance.
3) Chassis cover vent holes also implemented to improve hot air venting to outside from ADCs and FPGAs. (not shown)

During pre-flight I&T at GSFC B19 lab.
1) Instrument in aircraft racks.

IIP 2013 – SoOp-AD Instrument

P-band elements

2x2 element S-band array (integrated assembly shown with radome cover on aircraft)



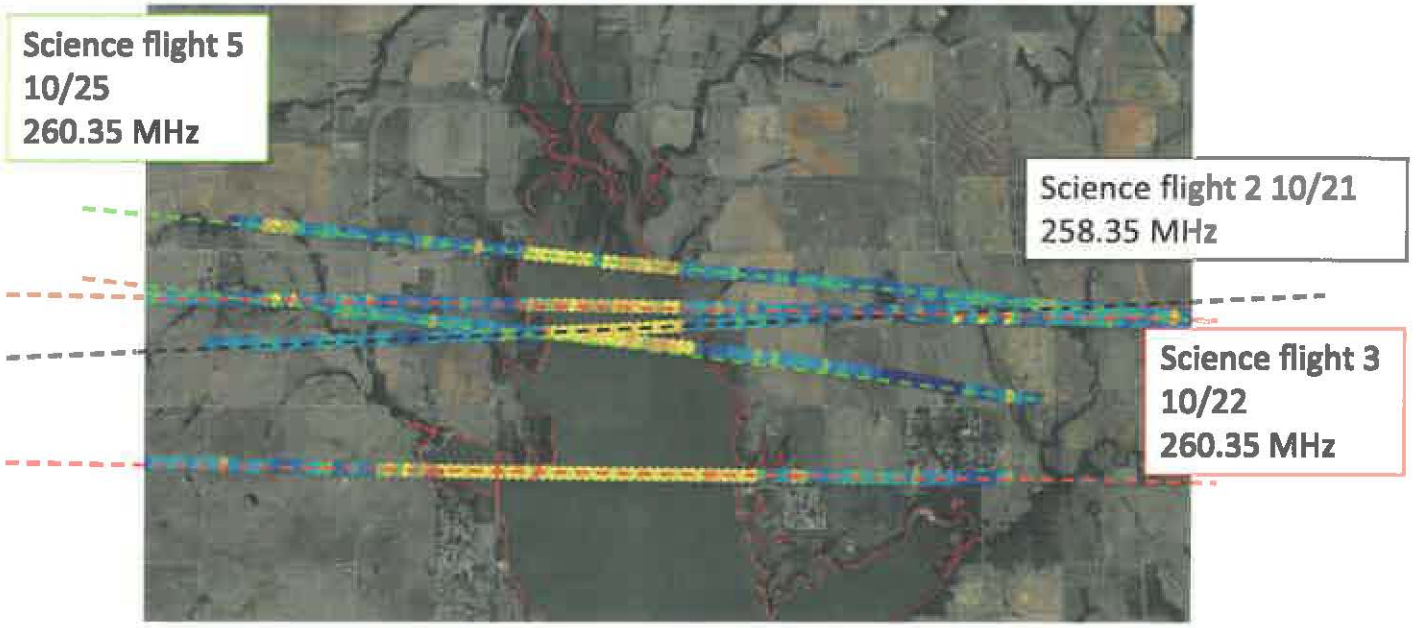
S-band wave-matching layer installed on fairing. This enabled S-band antenna mounting without any modifications to the already qualified fairing.

During vicarious calibration flight track over Lake Ellsworth, OK

Aircraft arrives in Lawton, OK Fort Sill regional airport! Instruments in good shape and ready to go!

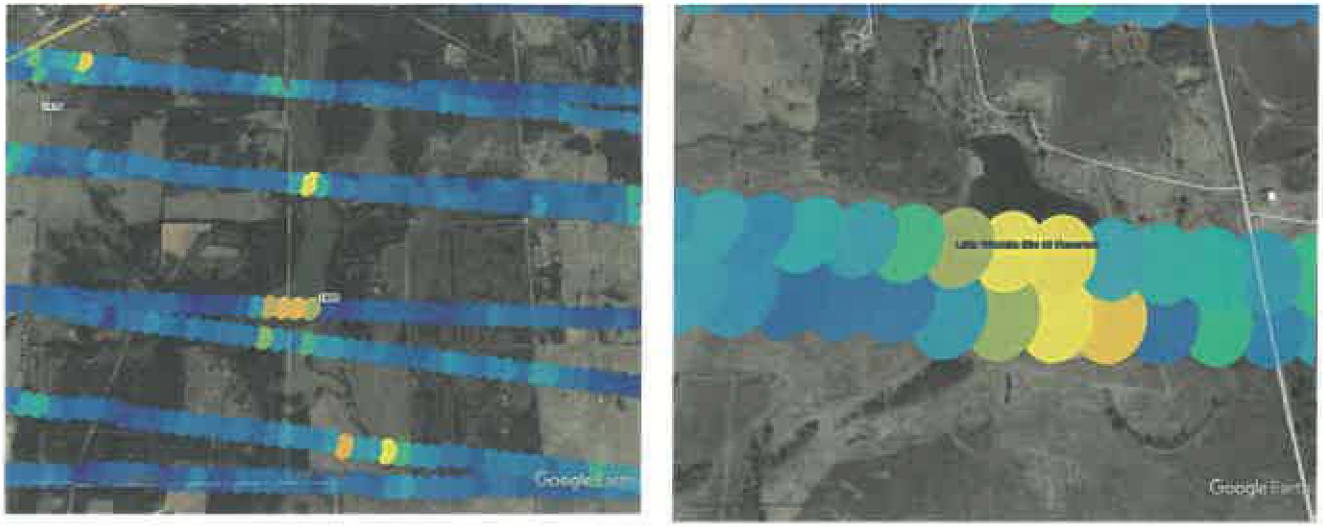
IIP 2013 – SoOp-AD Flight Results

Lake Ellsworth, OK



IIP 2013 – SoOp-AD Flight Results

High Reflectivity over Water Bodies (SF 3&5 Overlay)



Experimental verification of measurement resolution

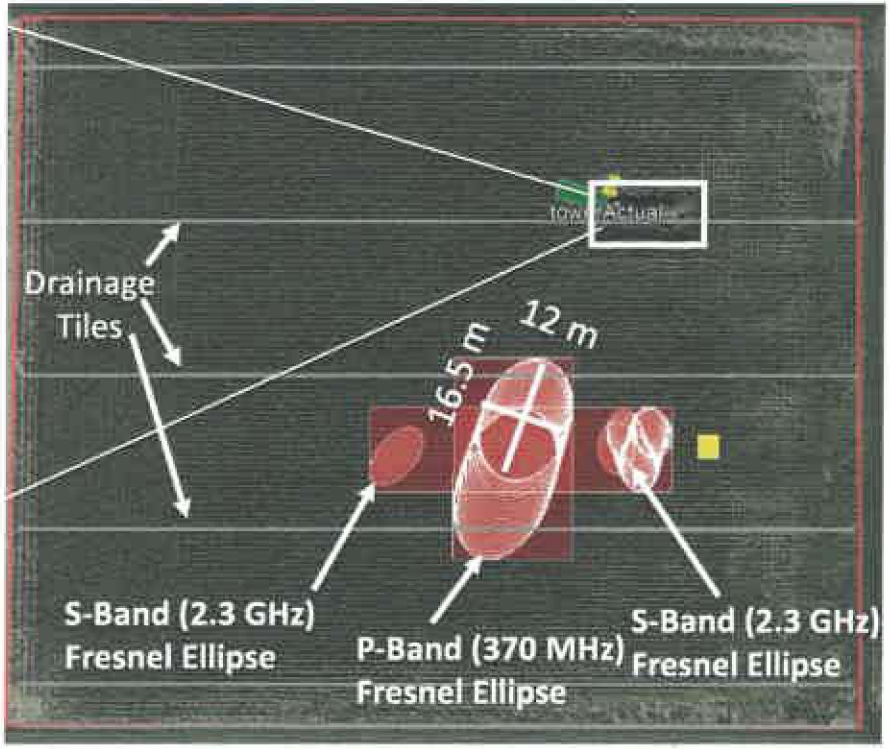
IIP 2013 – SoOp-AD Flight Results

- **Possible RFI @ 258.35 MHz? (Only example in campaign)**

- **Frequency changed to 260.375 MHz after SF 2**

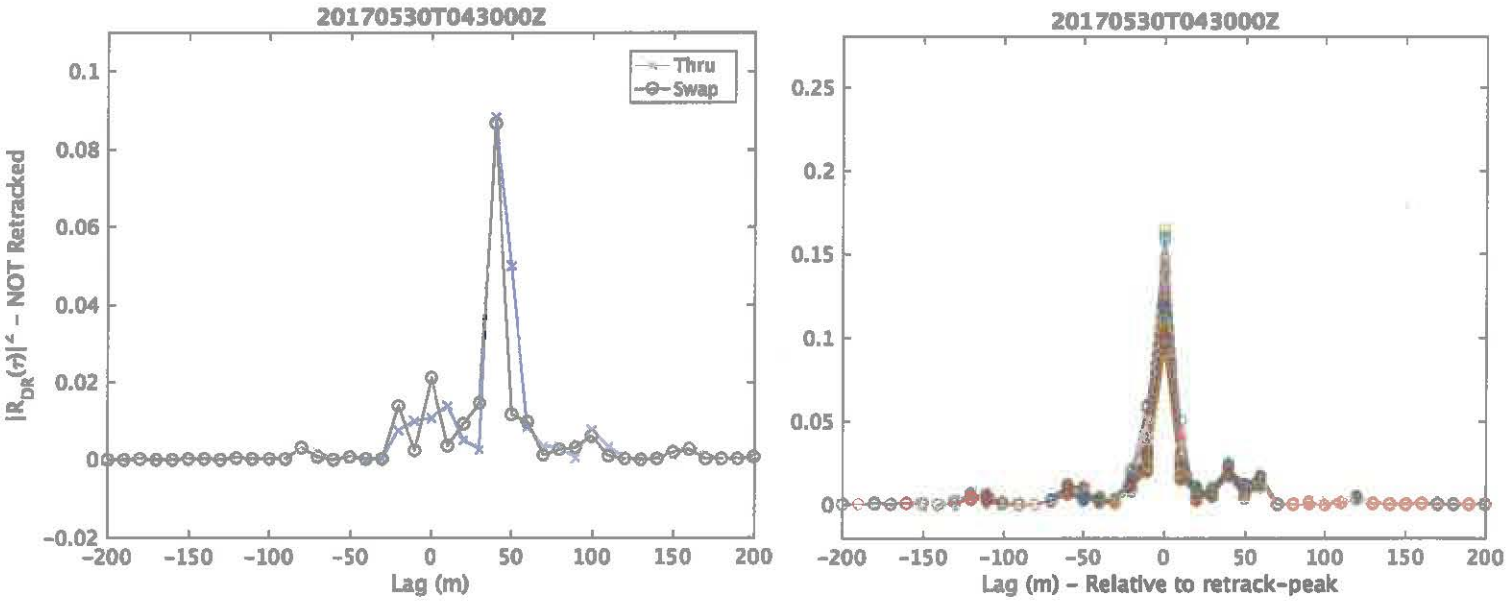
IIP 2013 – Ground-based Experiment

V-Pol antennas (dipoles)
Bare Soil: 25-May to 8-Jun



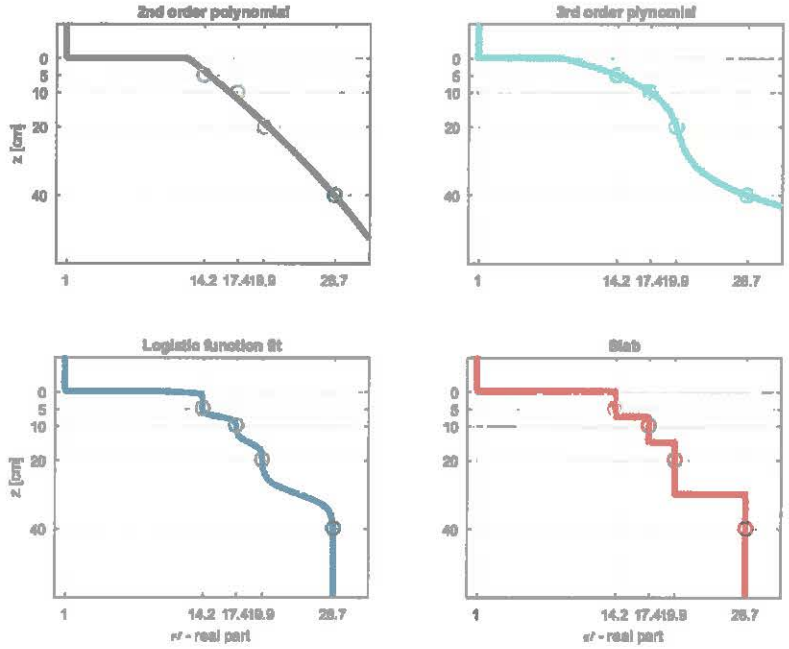
IIP 2013 – Ground-based Experiment

- Sample waveforms



IIP 2013 – Ground-based Experiment

- **Forward Model: Multi-layer SCoBI-Veg [1]**



[1] Kurum, et al, "A generalized bistatic scattering model of reflectometry from vegetation for Signals of Opportunity applications," TGARS in Review