

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

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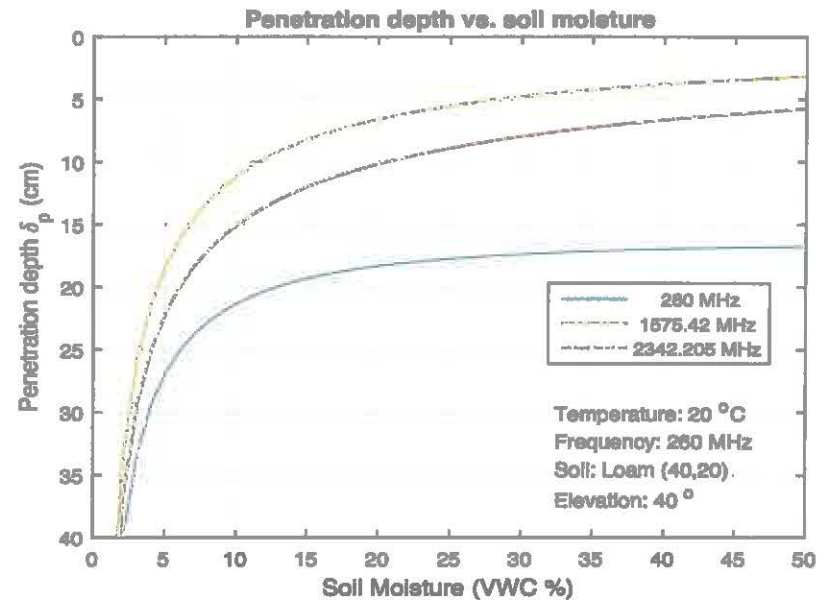


Outline

- **Motivation**
- **Technology Developments**
 - IIP 2013 – SoOp-AD
 - Airborne instrument
 - Ground-based field experiment
 - ACT 2017 (wideband deployable membrane antenna)
 - P/I 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

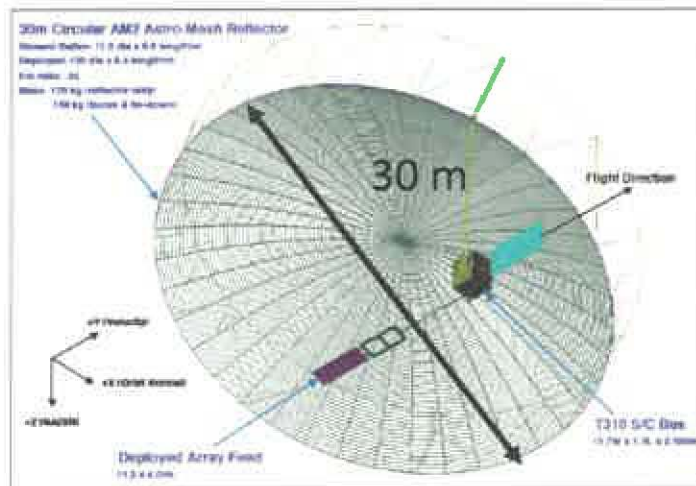
- Root Zone Soil Moisture (RZSM)
 - Water in top ~1m of soil – essential variable for understanding the water cycle and agricultural forecast.
- Penetration depth limited to few-cm at L-band
- Global RZSM from model assimilation (e.g. SMAP L4)



Motivation cont'd

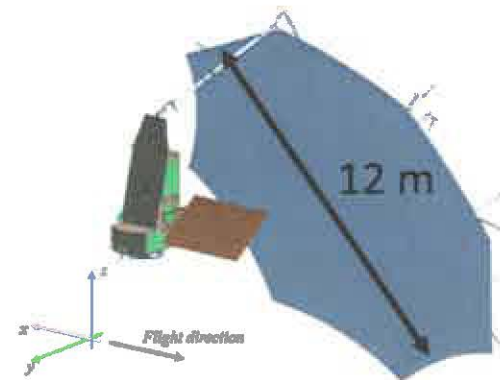
- Difficulties in sensing < 500 MHz
- Large antenna size to meet resolution requirements
- Few protected bands
- High RFI from terrestrial sources

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

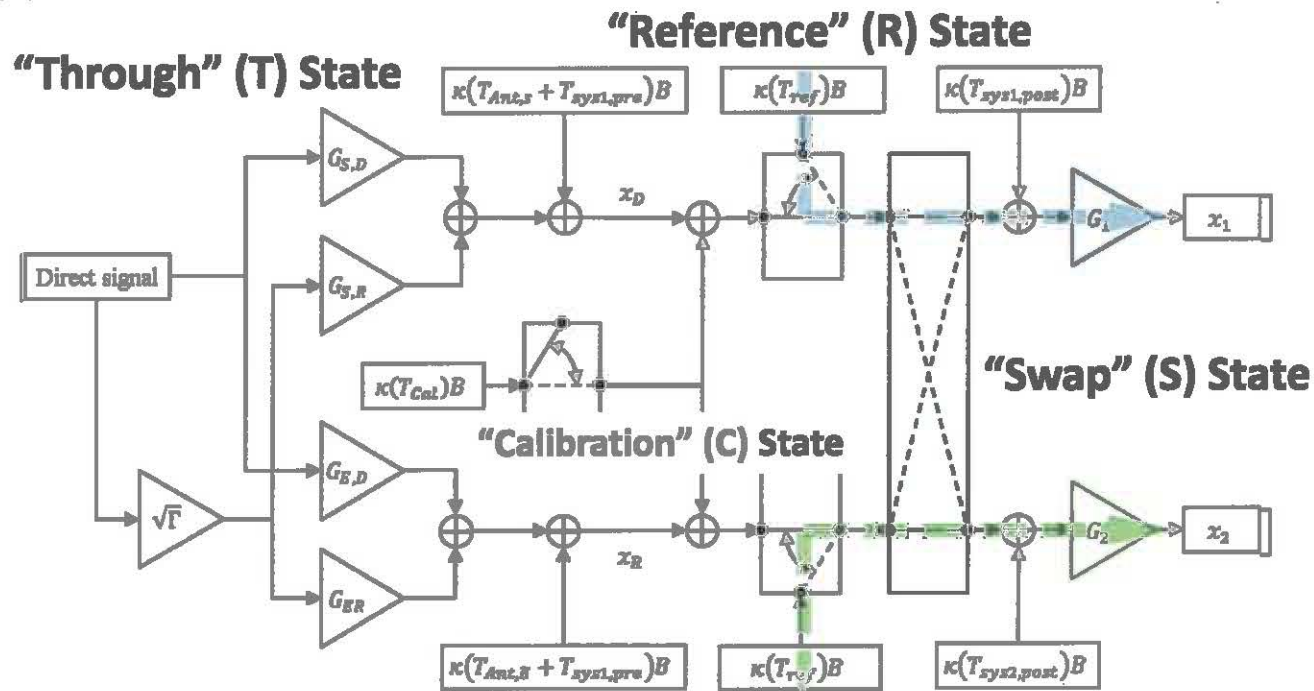
P-band SoOp may offer first possibility of direct remote sensing of Root-Zone Soil Moisture (RZSM) from space

Instrument Incubator Program (IIP) 2013

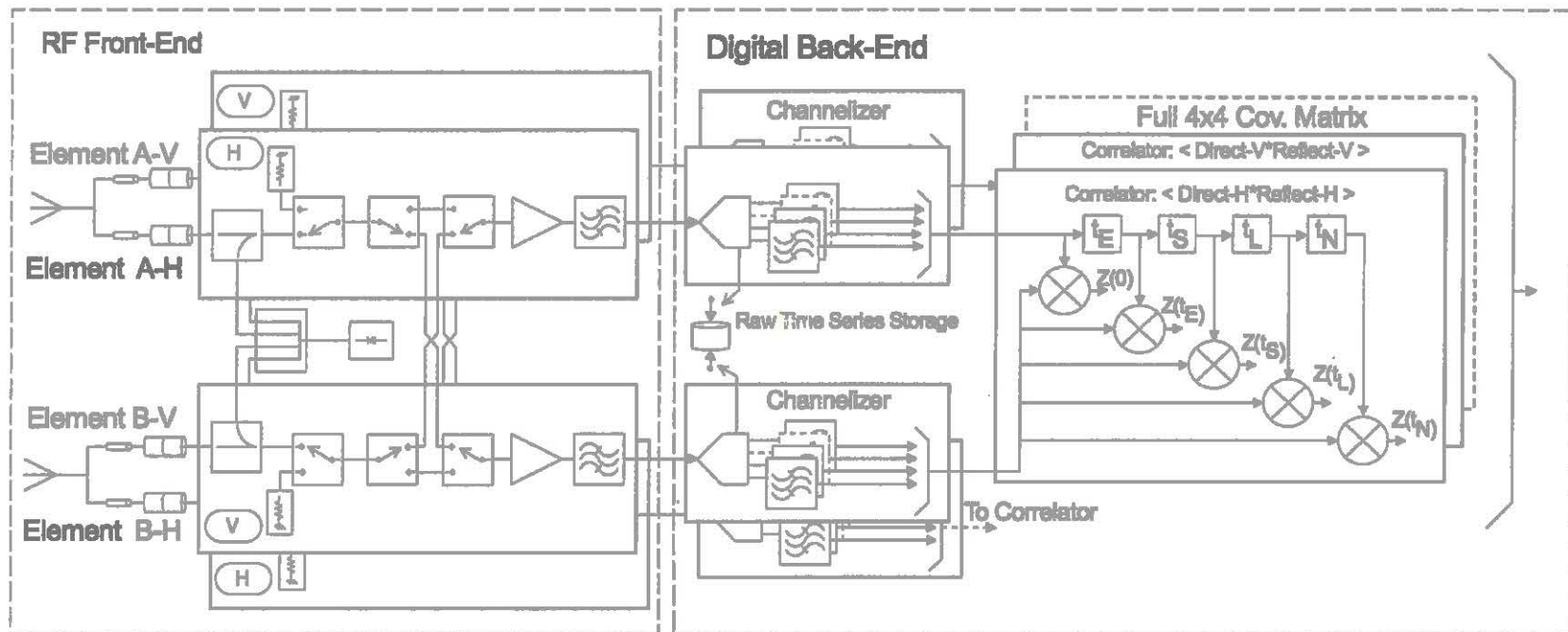
- Signals of Opportunity – Airborne Demonstrator (SoOp-AD)
- Objectives:
 - Airborne demonstrator for P- and S-band SoOp
 - Brassboard low-noise front-end and digital receiver with “path to space” tested in relevant environment (TRL-5)
 - Airborne science instrument for future algorithm development

Successfully completed April 2018 at TRL-5

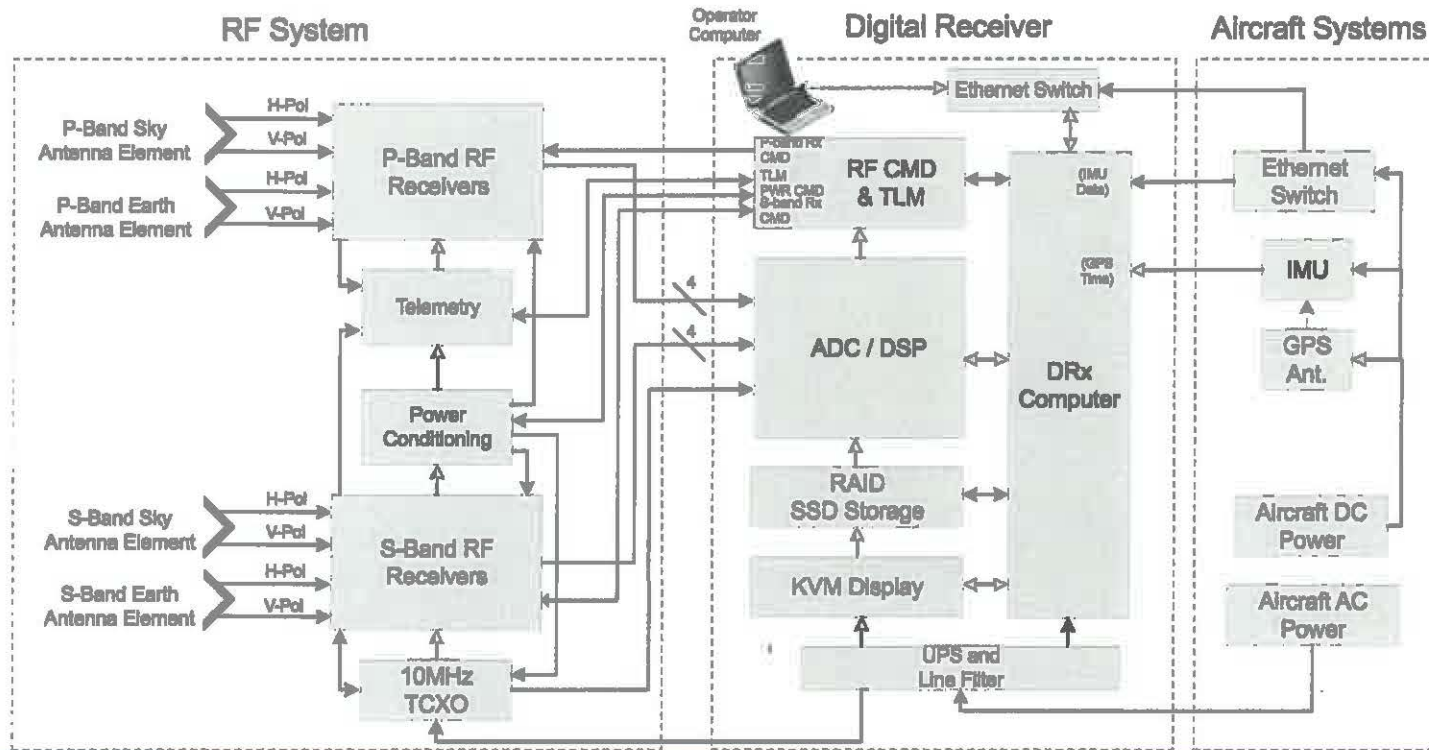
IIP 2013 – SoOp-AD Instrument Model



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.

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



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)

IIP 2013 – SoOp-AD Instrument



P-band elements



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



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

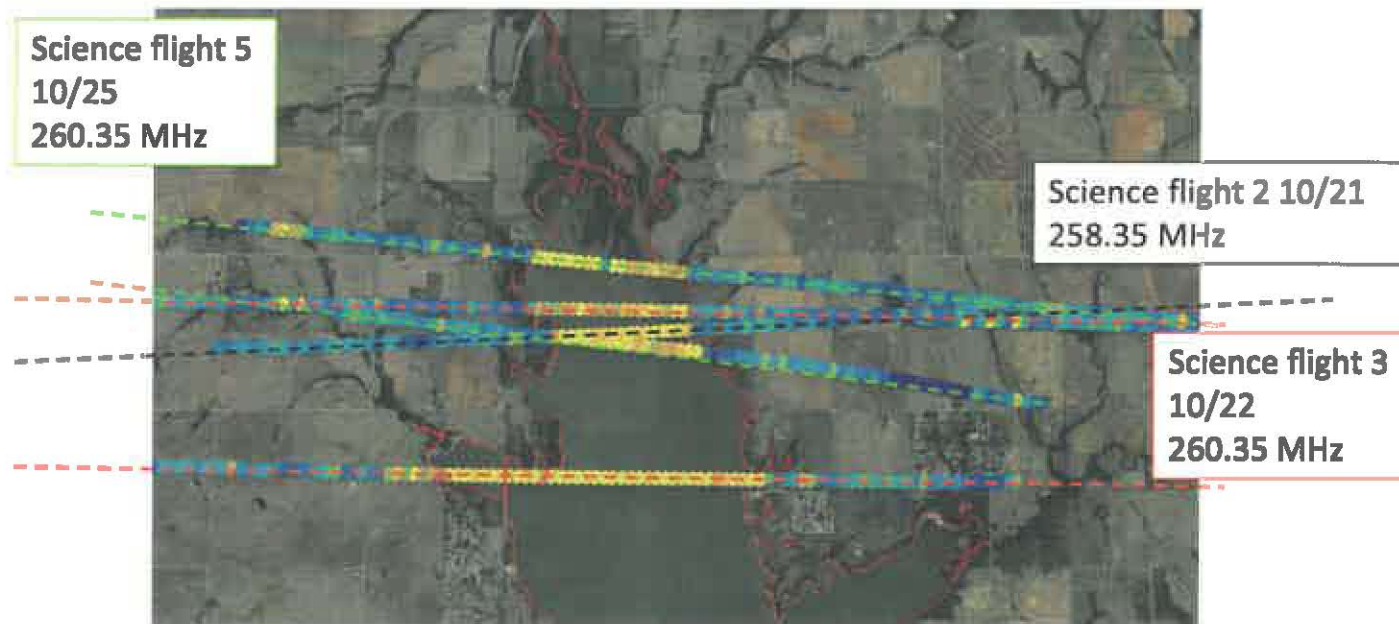


Aircraft arrives in Lawton, OK Fort Sill regional airport! Instruments in good shape and ready to go!



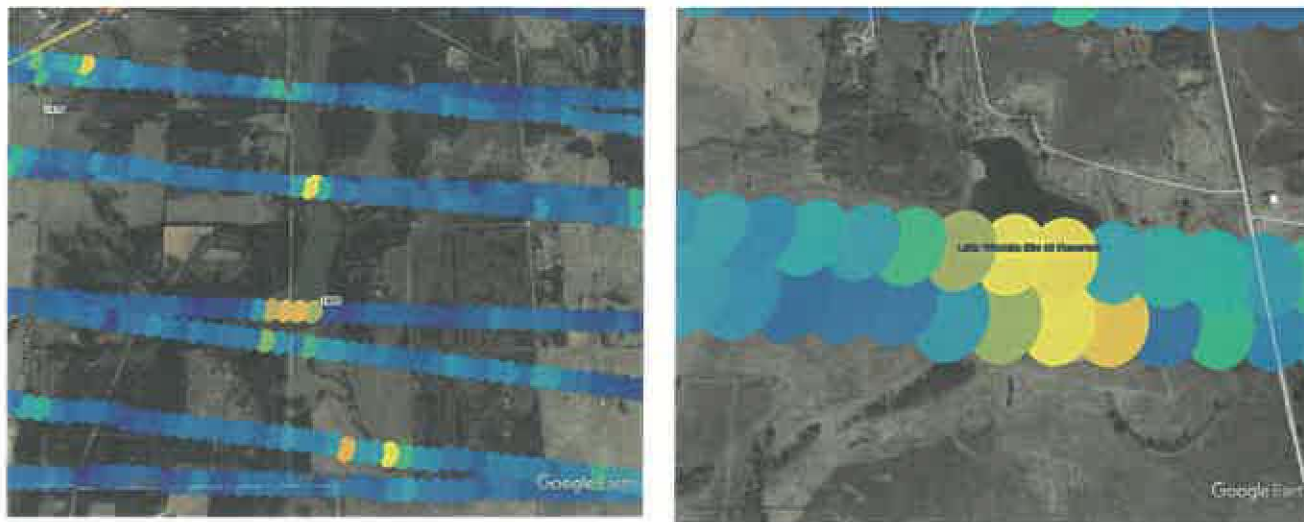
IIP 2013 – SoOp-AD Flight Results

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)

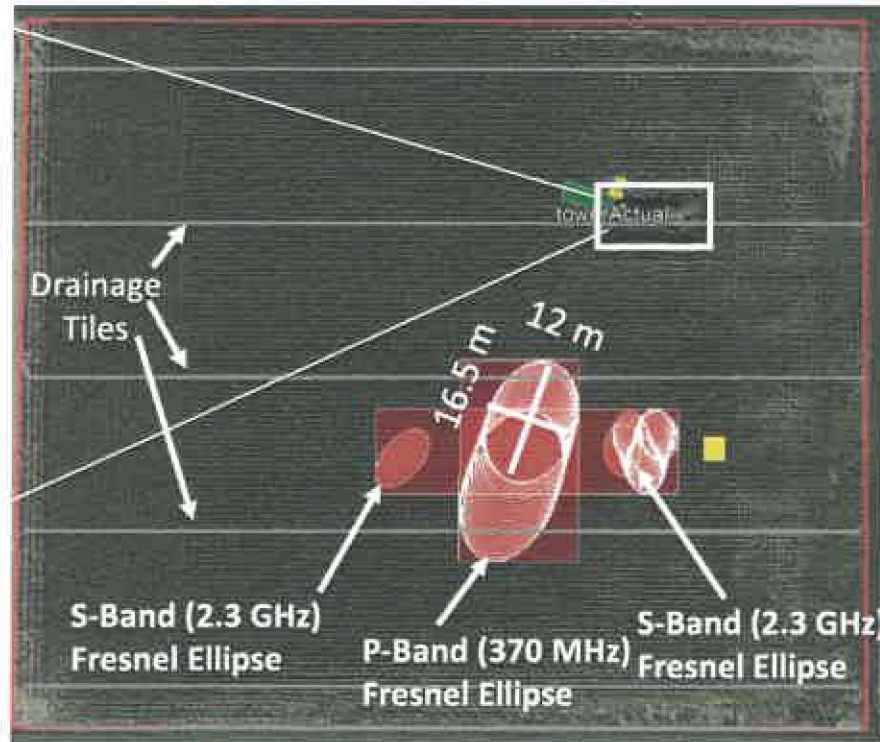


- Frequency changed to 260.375 MHz after SF 2

IIP 2013 – Ground-based Experiment

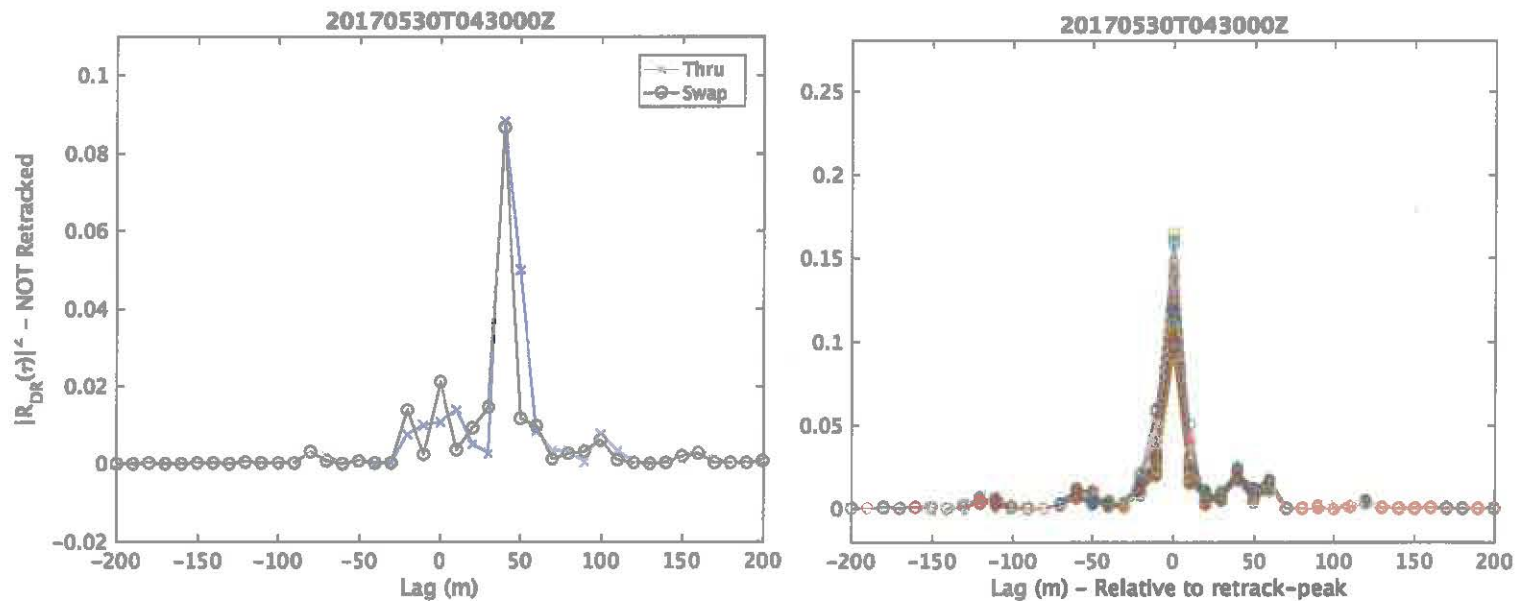


V-Pol antennas (dipoles)
Bare Soil: 25-May to 8-Jun



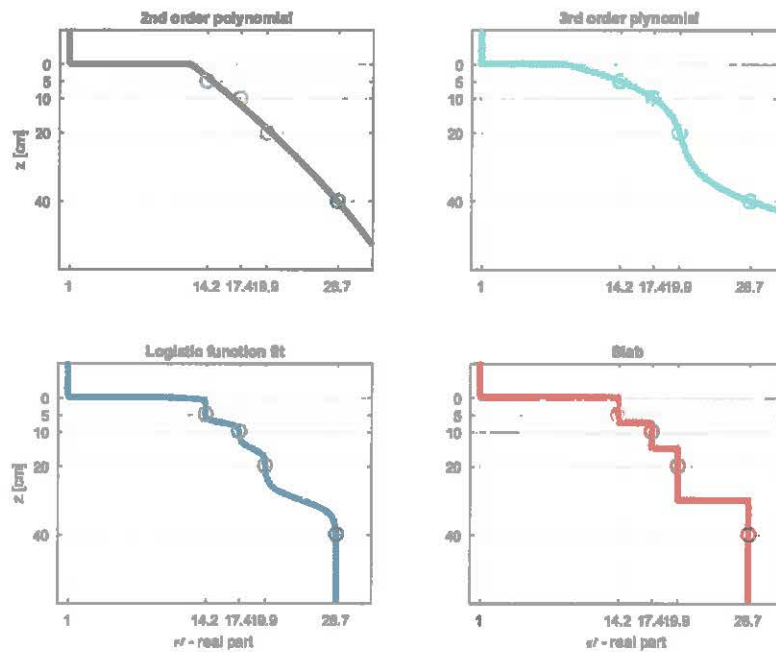
IIP 2013 – Ground-based Experiment

- 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