NPOESS Interests and Data Support

Gary McWilliams, Li Li, David Kunkee, Karen St. Germain

Soil Moisture Active-Passive (SMAP) Mission
Arlington, VA
July 9, 2007

Mission

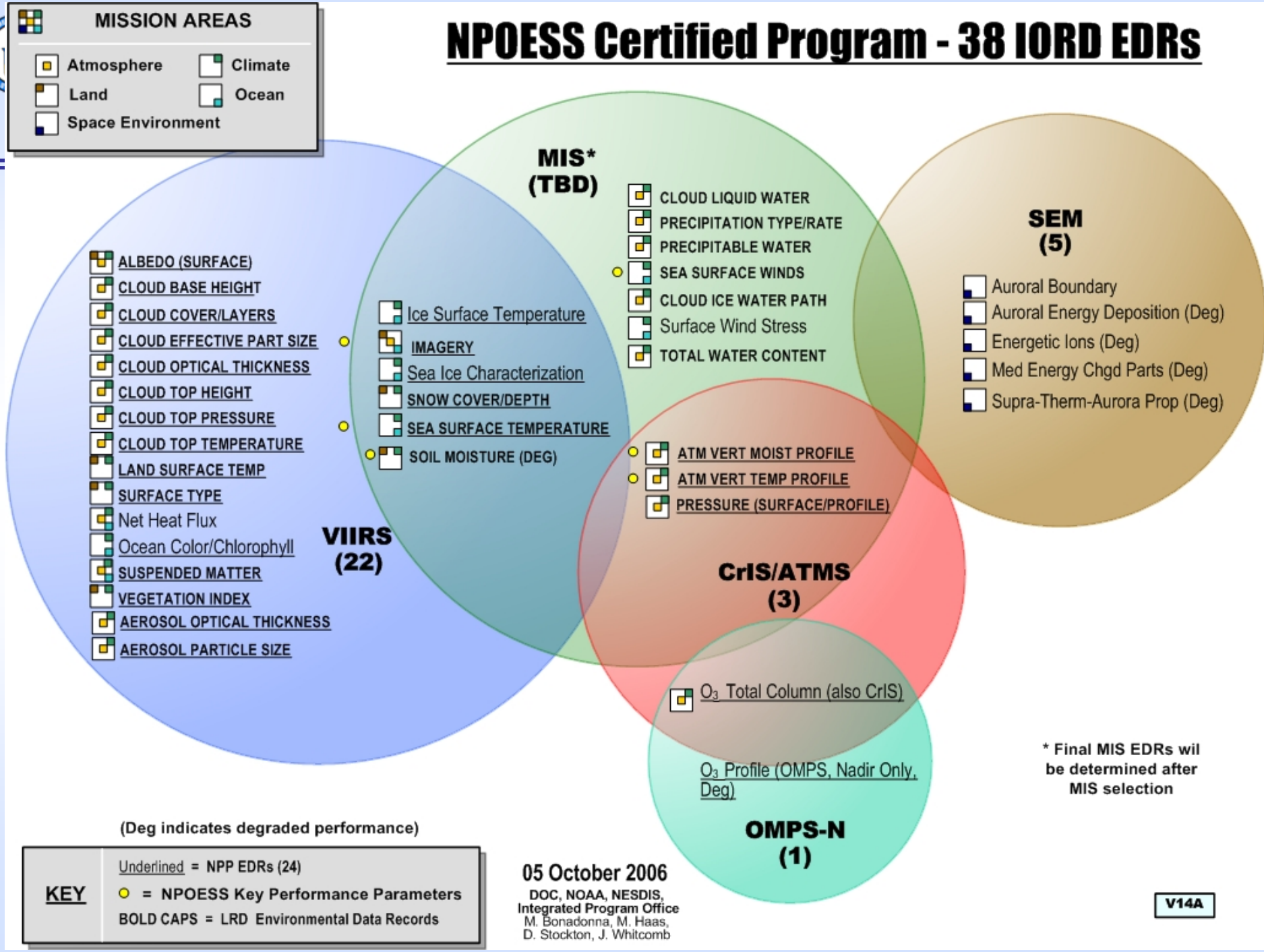
Provide a national, operational, polar-orbiting environmental capability

Achieve National Performance Review savings by converging DoD and NOAA polar satellite programs

Incorporate new technologies from NASA and others

International Cooperation (EUMETSAT)

NPOESS Certified Program - 38 IORD EDRs



* Final MIS EDRs wil be determined after MIS selection

(Deg indicates degraded performance)

KEY

Underlined = NPP EDRs (24)

○ = NPOESS Key Performance Parameters

BOLD CAPS = LRD Environmental Data Records

05 October 2006

DOC, NOAA, NESDIS,
Integrated Program Office
M. Bonadonna, M. Haas,
D. Stockton, J. Whitcomb

V14A

IORD Priority Requirements

NPOESS ***Integrated Operational Requirements Document (IORD) II***

Soil moisture is Category 1-A Key Performance Parameter (KPP) Requirement

JROC-Approved NPOESS IORD-II EDR:

"*Key Performance Parameter (KPP) 4.1.6.1.6 …Soil moisture measurements are needed to derive trafficability information useful for support of the deployment of amphibious and ground forces.*"

Definitions:

"*KPPs are those parameters so significant that failure to meet the threshold is cause for the system to be reevaluated or the program to be reassessed or terminated*."

Category "A": "*There is a value to the Government if thresholds are exceeded and/or objectives are approached*."

Notes:

NPOESS has 55 EDR Requirements (38 addressed by current NPOESS configuration); 6 Are (EDR) KPPs

VIIRS at a Glance

- **VIIRS: Visible Infrared Imaging Radiometer Suite**
- **VIIRS will continue the observational program of:**
  - OLS: Optical Line Scanner
  - AVHRR: Advanced Very High Resolution Radiometer
  - SeaWiFS: Sea Wide-Field Sensor
  - MODIS: Moderate Resolution Imaging Spectroradiometer
- **VIIRS will provide operational and research users with:**
  - Spectral coverage from 412 nm to 12 microns
    - Moderate resolution (~742 m at nadir) radiometric quality data
    - Imagery at 371 m nadir resolution in 5 bands
  - Complete global daily coverage with a single sensor
- **Routine data products of:**
  - Cloud cover, cloud layers
  - Cloud and aerosol physical properties
  - Land & ocean biosphere properties, snow & ice
  - Sea Surface Temperature, Land & Ice Temperatures

MIS Trade Study

Soil Moisture Key Performance Parameter (KPP)

- Evaluation of Soil Moisture utility based on availability of 6-GHz, 10-GHz and 19/18-GHz measurements

Considerations for microwave sounding

- Utility for Numerical Weather Prediction (NWP)
- System reliability for delivering temperature and moisture profile KPPs

Cost relationships of channel selection and reflector size

- 6-GHz / larger reflector: Soil Moisture, Sea Surface Temperature
- Polarimetric channels: Sea Surface Wind Direction
- 50 to 60-GHz channel suite with 166/183-GHz channels: Atmospheric Temperature and Moisture Profiles
- Sensor and Reflector Size relationship to cost

Acquisition strategy

- Use models of similar successful sensor developments

Soil Moisture IORD Specification and NPOESS Approach

- **Requirements**

Systems Capabilities	IORD-II Requirements	
	Threshold	Objective
Sensing Depth	0.1 cm	80 cm
Spatial Resolution	1-4 km Clear 40-50 km Cloudy	2 km All Weather
Uncertainty	10% (40-50 km Cloudy) 20% (1-4 km, clear)	Surface: 1% 80 cm Column: 5%
Latency	90 minutes	30 minutes
Refresh	8 hours	3 hours

- **Approach:** *move toward IORD requirements for depth, uncertainty and resolution*
  - Build on heritage technology and risk reduction
  - Improve model physics and retrieval algorithm
  - Study synergism of microwave and Vis/IR data
  - Address depth requirement through data assimilation

SMAP Exceeds IORD Threshold and Approaches Objective Requirement

Systems Capabilities	IORD-II Requirements		SMAP
	Threshold	Objective	
Sensing Depth	0.1 cm	80 cm	5 cm (Most Vegetation)
Spatial Resolution	1-4 km Clear 40-50 km Cloudy	2 km All Weather	Clear and Cloudy 3 km Radar **1.2 GHz** 40 km Radiom. **1.4 GHz**

Comparison to Alternatives and Capability:

Higher Frequency Microwave Radiometers: Limited to Sensing the Surface Moisture at Coarse Resolution and Across Low to Moderate Vegetation Cover Regions

SMAP Low Frequency Microwave Measurements: Capable of Sensing Through Most Vegetation Cover and Soil Moisture to Greater Depth

SMAP Added Active Radar Measurements: Achieve Higher Resolution Mapping for Key DoD Applications

NPOESS Interests

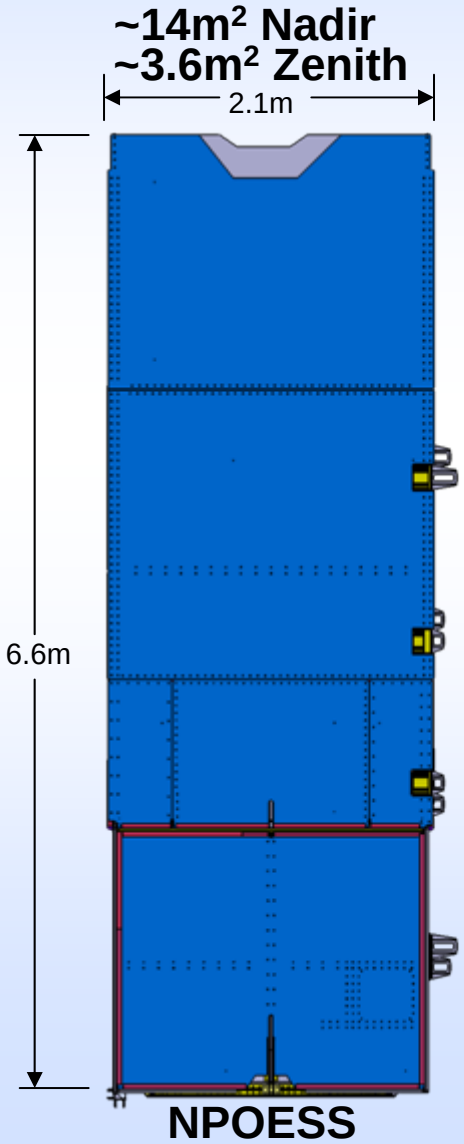
NPOESS will benefit from SMAP mission:

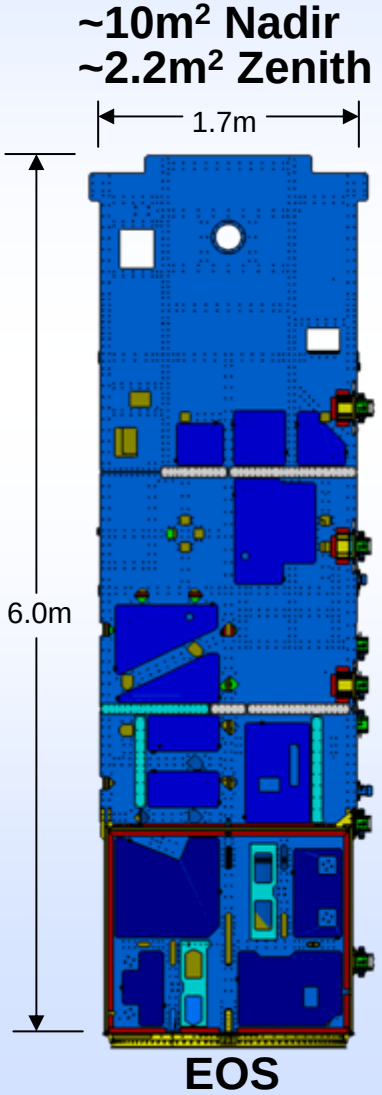
- Better accuracy and higher resolution
- Wider range of validity
- Improved MIS algorithm performance
  - Better estimation of vegetation effects
- Cal/Val
  - Data/resource sharing, planning and coordination
- Potential synergy of L- to X-band data
  - Significant sensitivities to both soil moisture and vegetation

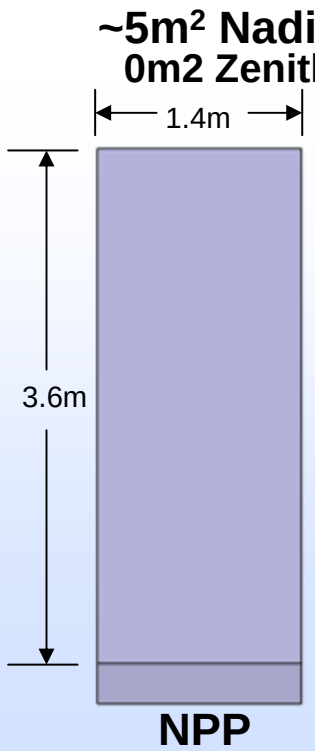
Potential NPOESS Support to SMAP

- **NPOESS bus support through P3I program**
  - Pre-Planned Program Improvements (P3I) process.
  - The P3I program allows for continued examination of possible solutions to NPOESS mission needs, including new or modified instrumentation in future space segments beyond NPOESS Initial Operational Capability (IOC).
- **NPOESS Ground System support**
- **NPOESS Cal/Val system and procedures**

T430 structure has ample growth margin for sensor growth







Satellite	NPP	C1	C2	C3	C4
Launch	Sep 2009	2013	2016	2020	2022
Nodal Time	1330	1330	0530	1330	0530
VIIRS	X	X	X	X	X
Microwave Imager/Sounder			X	X	X

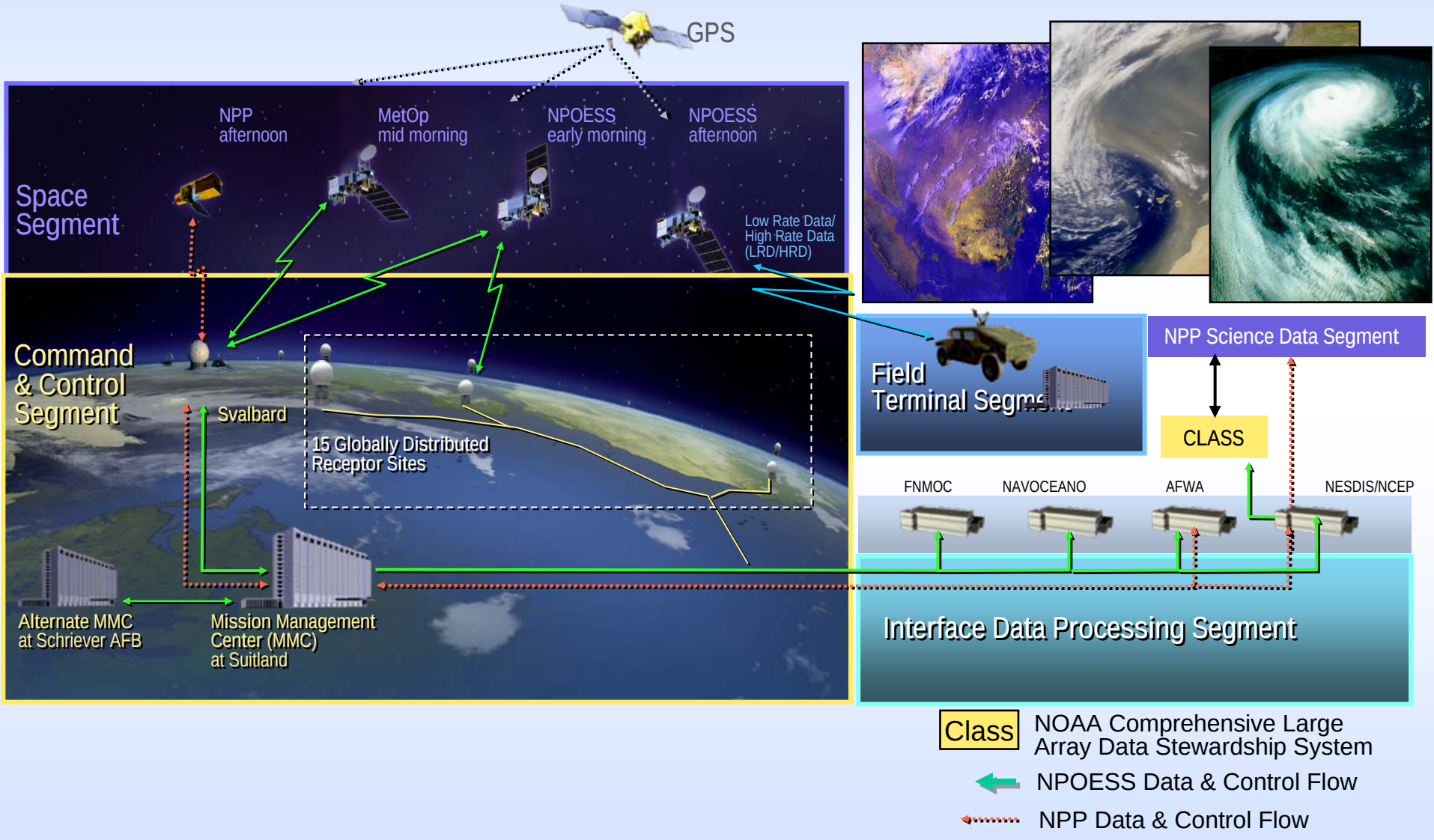
NPOESS BUS:

Unused Real Estate:
10-17 ft²

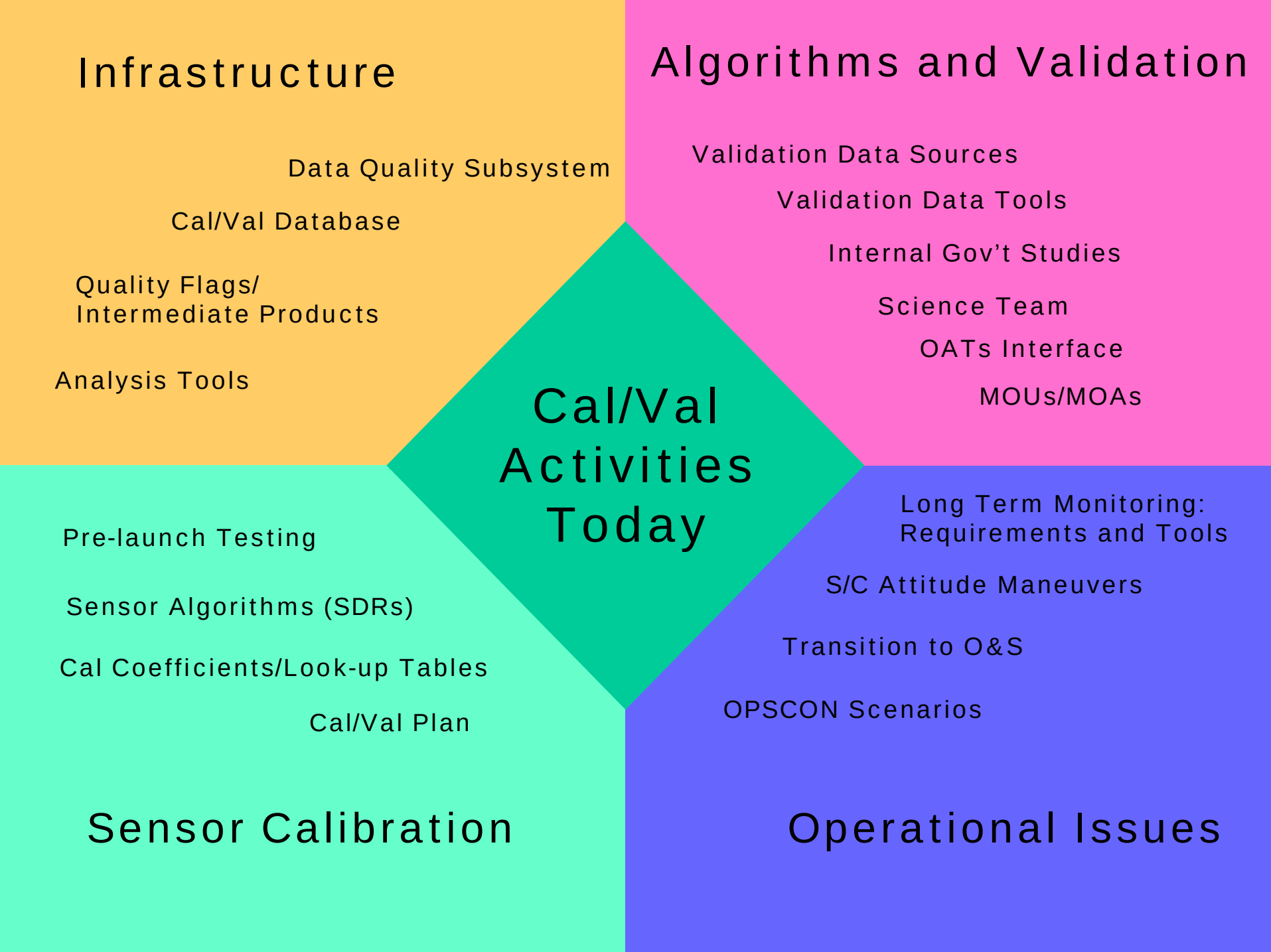
NO P3I on NPOESS C1

From Stan Schneider/IPO

Restructured NPOESS Top Level Architecture



Global Connection— High Speed Network for Rapid Data Dissemination


Infrastructure
Data Quality Subsystem
Cal/Val Database
Quality Flags/
Intermediate Products
Analysis Tools
Algorithms and Validation
Validation Data Sources
Validation Data Tools
Internal Gov't Studies
Science Team
OATs Interface
MOUs/MOAs
Cal/Val
Activities
Today
Pre-launch Testing
Sensor Algorithms (SDRs)
Cal Coefficients/Look-up Tables
Cal/Val Plan
Sensor Calibration
Long Term Monitoring:
Requirements and Tools
S/C Attitude Maneuvers
Transition to O&S
OPSCON Scenarios
Operational Issues

Current NPOESS Research Activities

- Gravite Lab
  - Government Resource for Algorithm Verification & Independent Test & Evaluation
  - Build end-to-end simulator, infrastructure and tools
  - Integrate all elements of Cal/Val
- EDR algorithm (uncertainty and resolution)
  - Microwave & Vis/IR
- Data Assimilation (Depth)
- RFI mitigation
  - hardware and software
- Field experiments
  - Soil moisture and snow

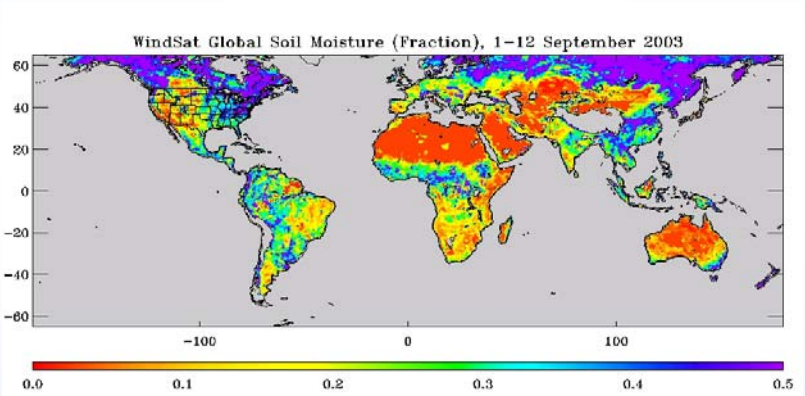
Algorithm Study Priorities

- Algorithm performance error model
  - Surface state, heterogeneity
- The effects of:
  - Water body fraction, vegetation, surface roughness
- RFI mitigation requirements
- In-situ data requirements
  - Coverage, vegetation regime, standardization, stability
- Synergy of MW and Vis/IR

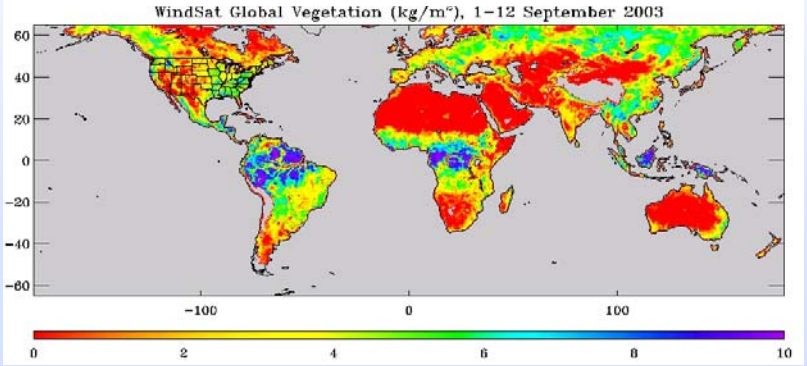
Baseline EDR Algorithms

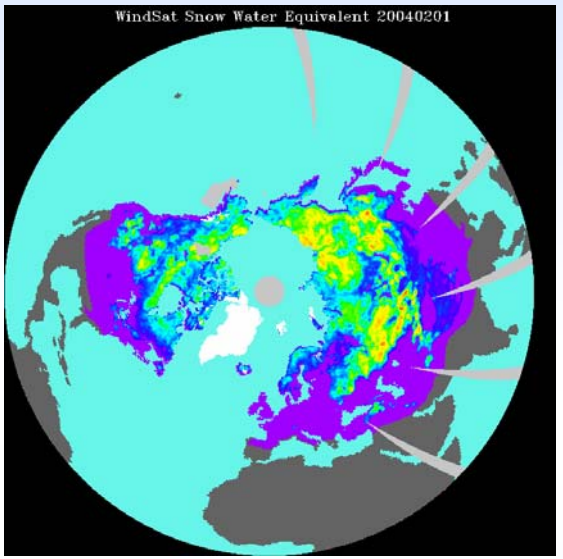
Baseline WindSat land algorithms have been developed.

Soil Moisture Retrieval

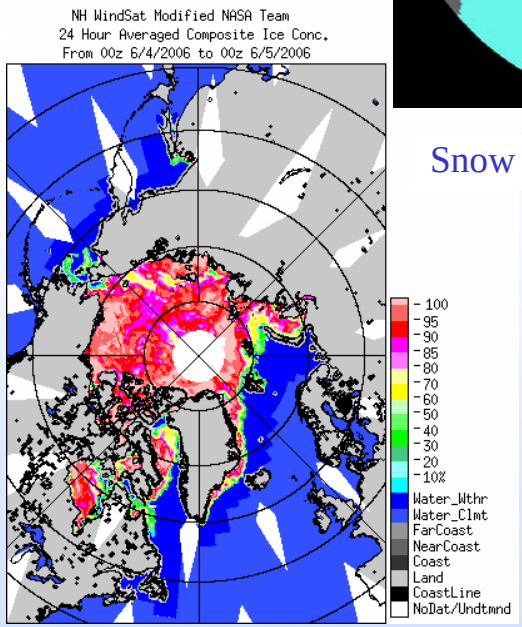


Vegetation Water Content Retrieval





Snow Water Equivalent Retrieval

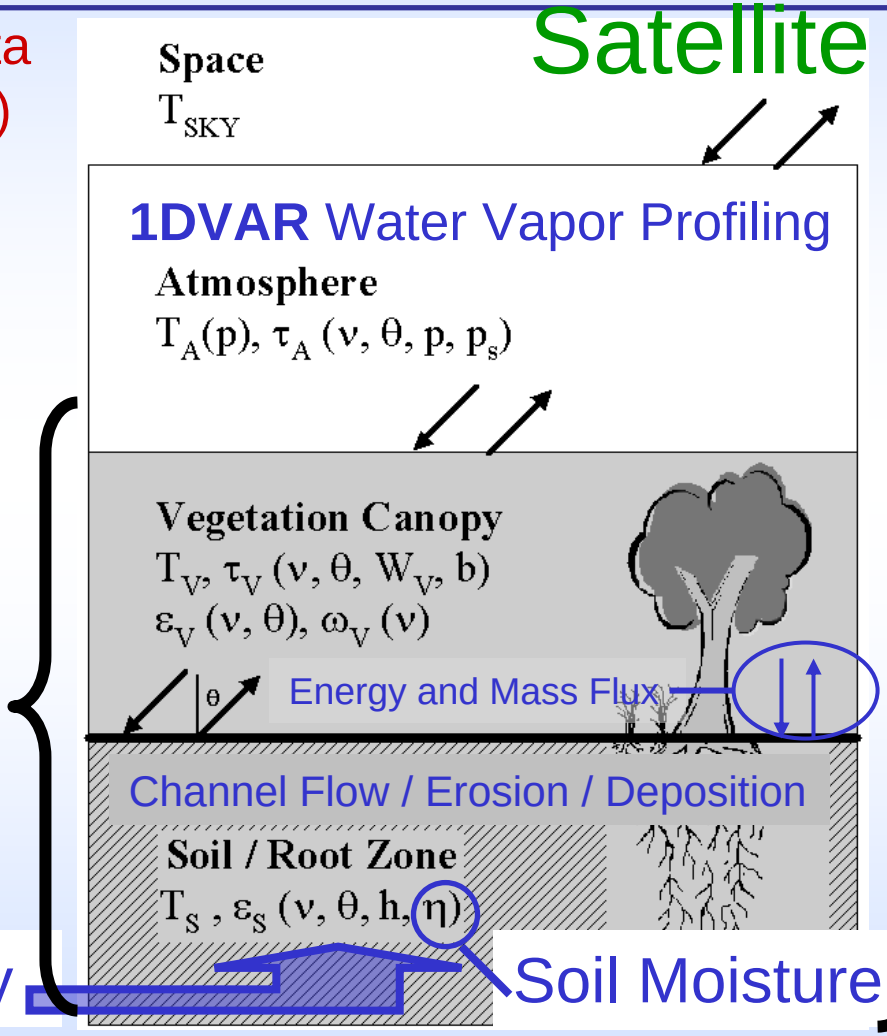


Sea Ice Concentration Retrieval

The Deep Soil Moisture Problem

A four-dimensional data assimilation (4DDA) methodology to retrieve deep soil moisture profiles using the WindSat data

Physical Hydrological Models



Data Assimilation and Modeling

Physically links the system together in space and time

4DDA Atmospheric and Land (includes clouds)

CSU/CIRA Dr. Andrew S. Jones; ARL Gary McWilliams.

RFI Mitigation

- 6 GHz Measurements over land will require effective RFI mitigation
  - CMIS planned 4x190 MHz sub-bands covering from 6.2 – 7.3 GHz
- Alternatives for MIS include
  - Alternate center frequencies near 5.75 GHz with time domain mitigation
  - 6.8 GHz center frequency with frequency domain mitigation (FFT)
  - Sub-banding similar to CMIS

Soil Moisture Experiment 2005

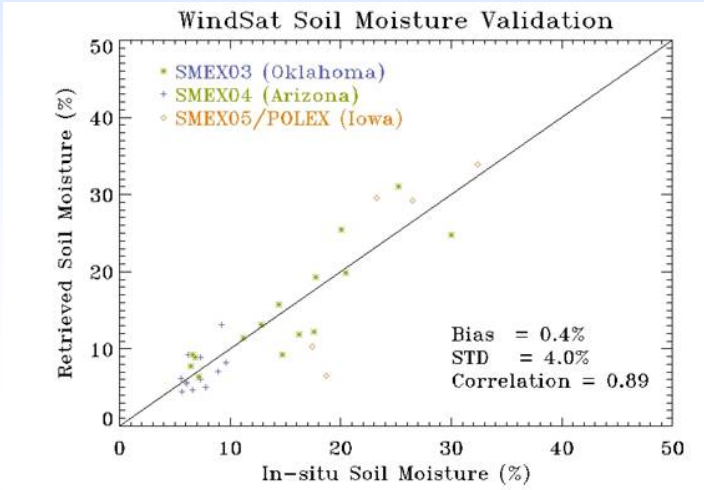
Where: June-July, 2005.

When: Ames, Iowa.

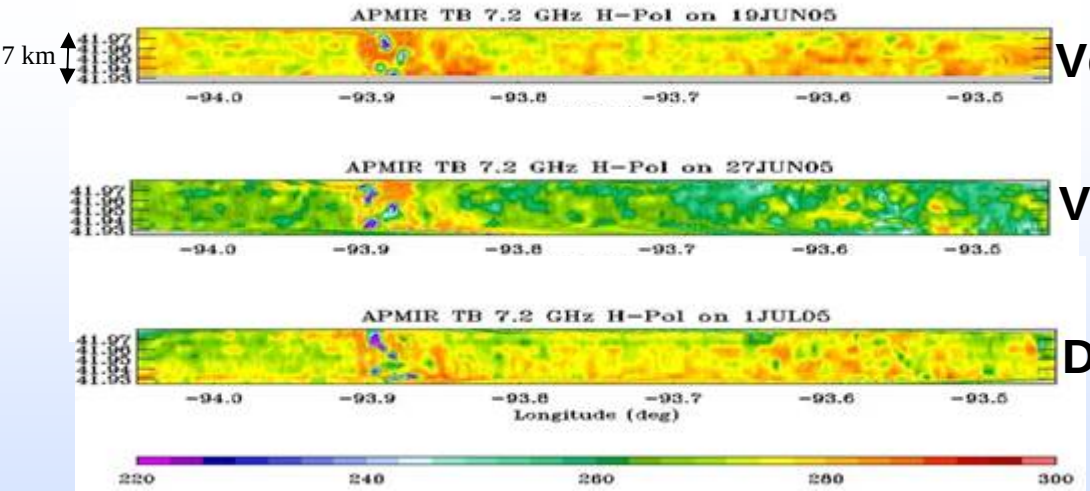
Objective: Polarimetric signature, Satellite Ca/Val.

Measurements: APMIR, WindSat, AMSR-E, In-Situ Soil Moisture, Vegetation, Dew, CO2 flux

Sponsors: NRL/ONR, NPOESS IPO, THP/NASA.



APMIR Data Capturing Soil Moisture Variations



Very Dry

Very Wet

Drying

Summary

- **The SMAP mission will provide an important risk reduction for NPOESS MIS to move toward IORD specifications in terms of measurement uncertainty and resolution.**
- **NPOESS can potentially accommodate SMAP instrument through its P3I program**
- **NPOESS can potentially provide Ground System support**
- **Leveraging NPOESS and SMAP Cal/Val system and procedures will result in better efficiency and lower cost**