

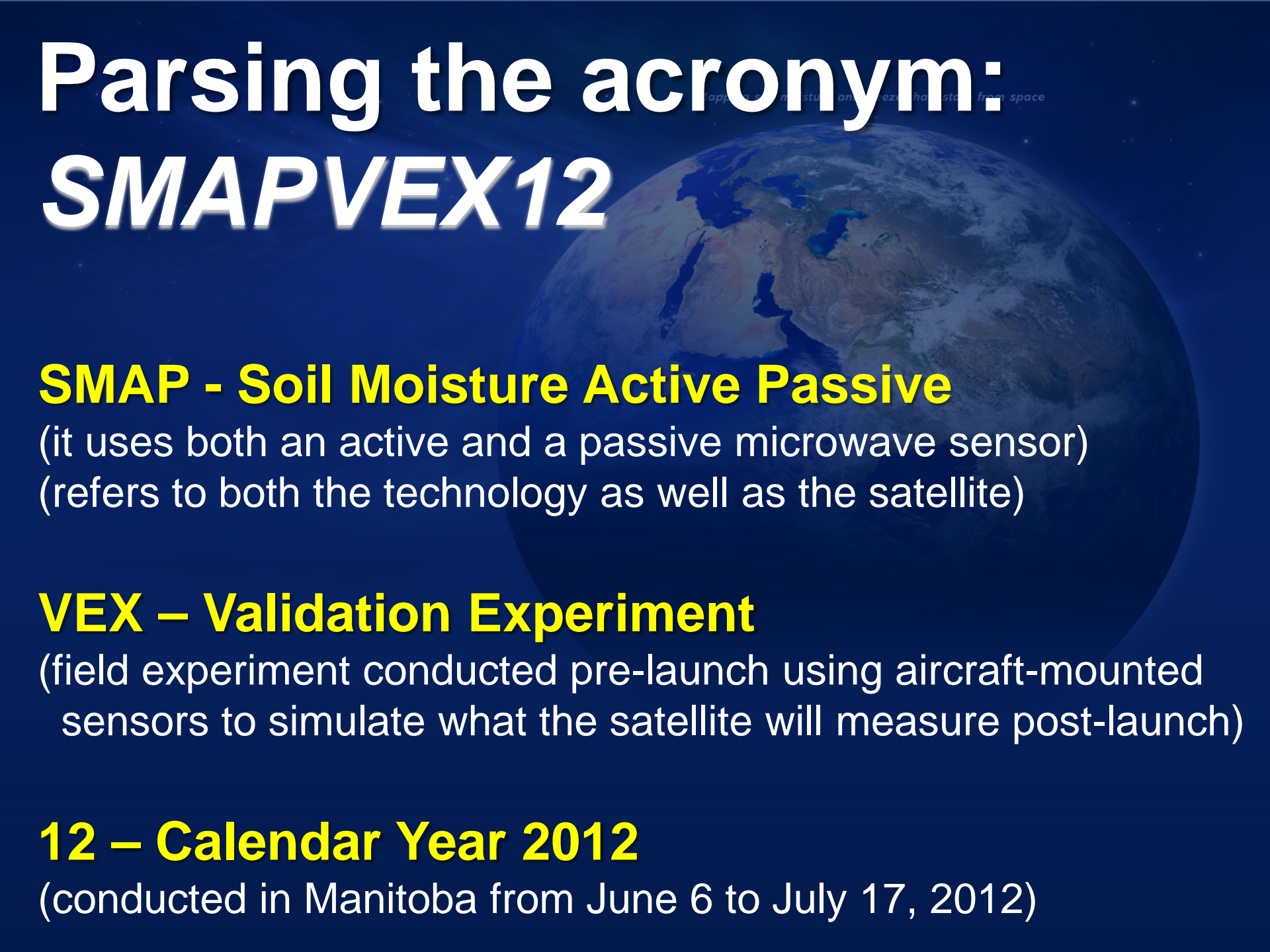
SMAPVEX12: The Latest Dirt on Soil Moisture Monitoring with Remote Sensing

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Parsing the acronym: **SMAPVEX12**



SMAP - Soil Moisture Active Passive

(it uses both an active and a passive microwave sensor)
(refers to both the technology as well as the satellite)

VEX – Validation Experiment

(field experiment conducted pre-launch using aircraft-mounted sensors to simulate what the satellite will measure post-launch)

12 – Calendar Year 2012

(conducted in Manitoba from June 6 to July 17, 2012)

SMAP Satellite:

Mapping soil moisture and freeze/thaw state from space

Mission Objectives

Provide global measurements of soil moisture and its freeze/thaw state

Goals:

- Extend the capabilities of **weather** and **climate** prediction models
- Improve **agricultural production** estimations and yield forecasting
- Develop improved **flood** prediction and **drought** monitoring capabilities
- Enhance understanding of processes that link the **water, energy** and **carbon cycles**
- SMAP satellite to be launched in November 2014

SMAP Satellite: Sensors

Artist's view of SMAP satellite

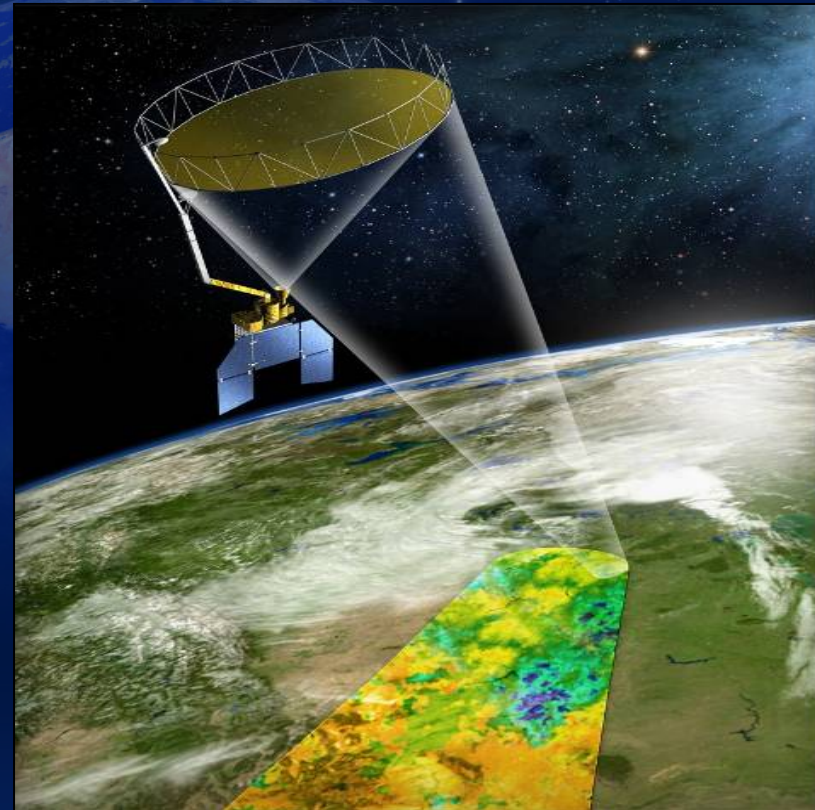
Radar (SAR) - Active

- Frequency: 1.26 GHz
- Polarizations: VV, HH, HV
- Relative accuracy: 1-3 km

Radiometer - Passive

- Frequency: 1.41 GHz
- Polarizations: H, V
- Relative accuracy: 30 km

- **Merges Active** (radar HH, VV) with **Passive** (radiometer H, V) using time-series algorithm and spatial heterogeneity radar products
- To retrieve relative accuracy: **~9 km soil moisture product**
- Global coverage **2 days** (high latitudes), **3 days** (equator)



SMAPVEX12:

Mapping soil moisture and freeze/thaw state from space

- **Objective:** Acquire and process data to calibrate, test, and improve models and algorithms for SMAP soil moisture products.
- **Approach:** Acquire a large **surface validation** database of surface measurements for the factors that influence the sensor readings coincident with the time of the aircraft data acquisition:
 - 1) **Soil Moisture**
 - 2) **Surface Temperature**
 - 3) **Biomass**
 - 4) **Surface Roughness**
- **Goal:** Improve the soil moisture retrieval algorithms for the SMAP satellite

SMAPVEX 12:

Mapping soil moisture and freeze/thaw state from space

Participating Agencies Validation Team

Canada

Canadian Space Agency
Agriculture and Agri-Food Canada
Environment Canada
Manitoba Agriculture, Food and
Rural Initiatives (MAFRI)
University of Guelph
University of Sherbrooke
University of Manitoba
University of Winnipeg

U.S.A.

NASA
U.S. Department of Agriculture
Jet Propulsion Laboratory (JPL)
Massachusetts Institute of Technology
(MIT)
University of Southern California
University of South Carolina
Texas A&M University
University of Washington
Ohio State University
University of Florida
Florida International University
University of Montana
University of Colorado

SMAPVEX12: Aircraft Sensors

- **Twin Otter - PALS, or Passive Active L- and S-band Sensor, a combined polarimetric radiometer and radar sharing an array antenna**
- **Gulfstream III - fully polarimetric Synthetic Aperture Radar in L-Band**



***DHC-6 Twin Otter
Based in Winnipeg***



***NASA Gulfstream III
Based in Grand Forks***

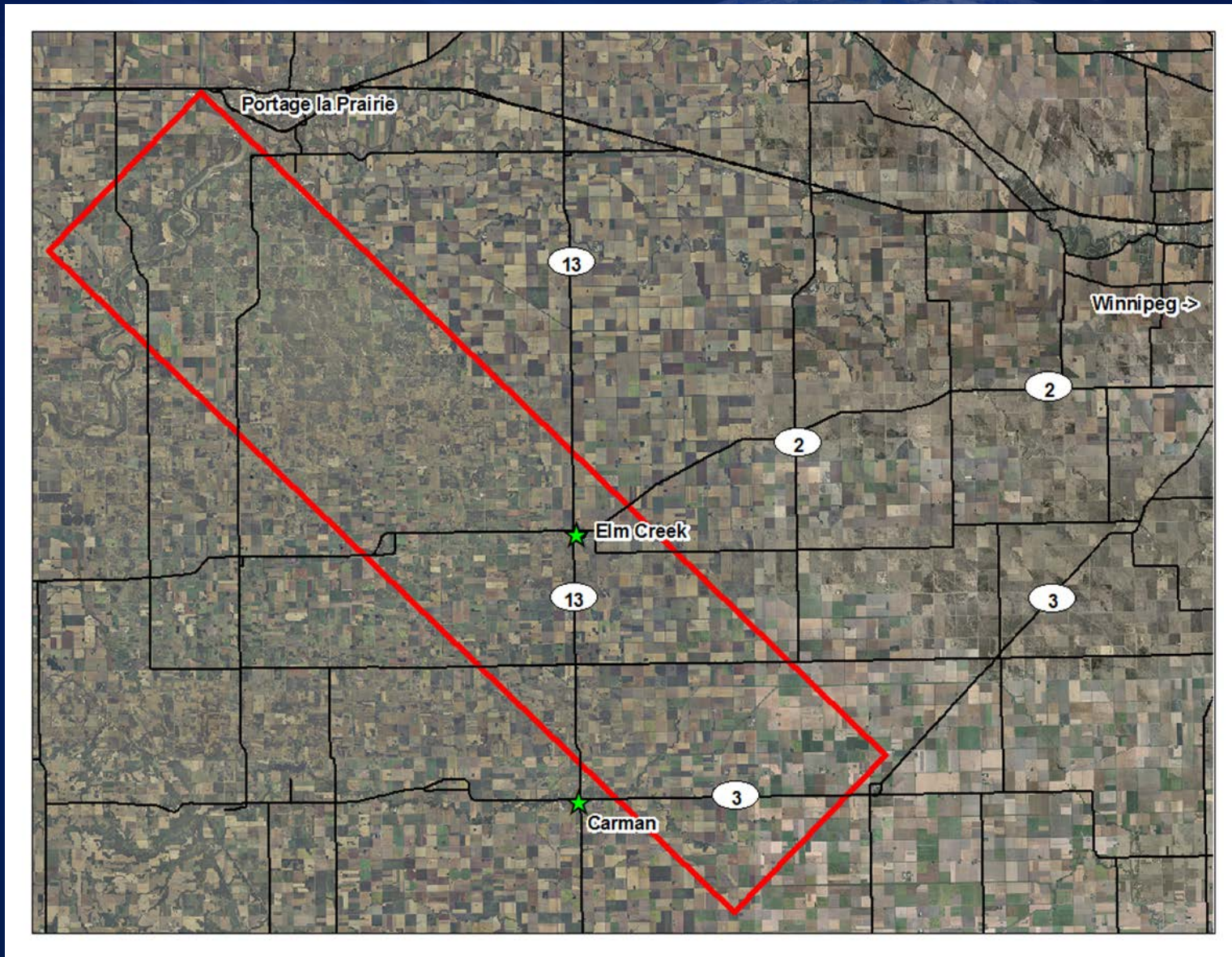
SMAPVEX12: Aircraft Sensors



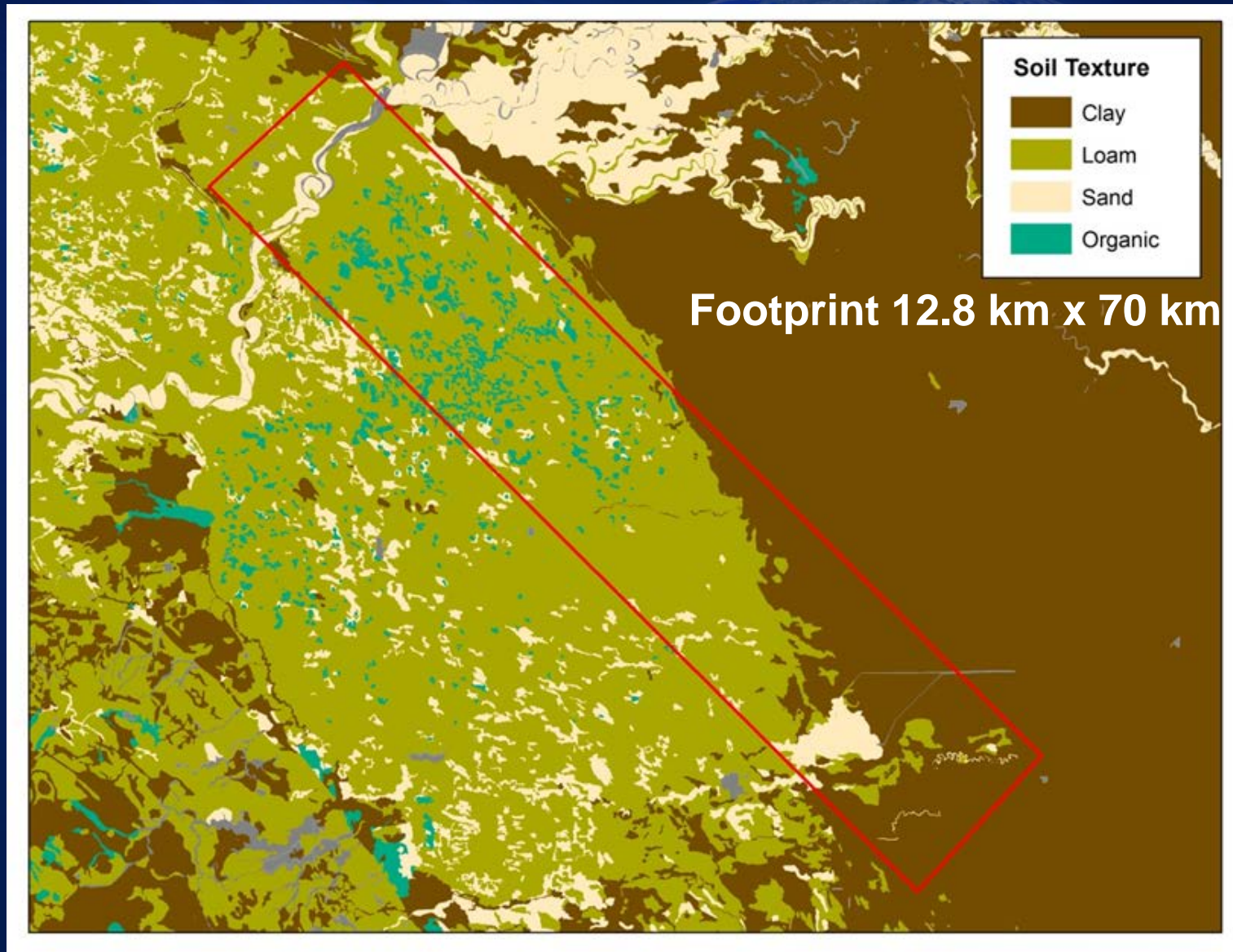
SMAPVEX12: Study Area



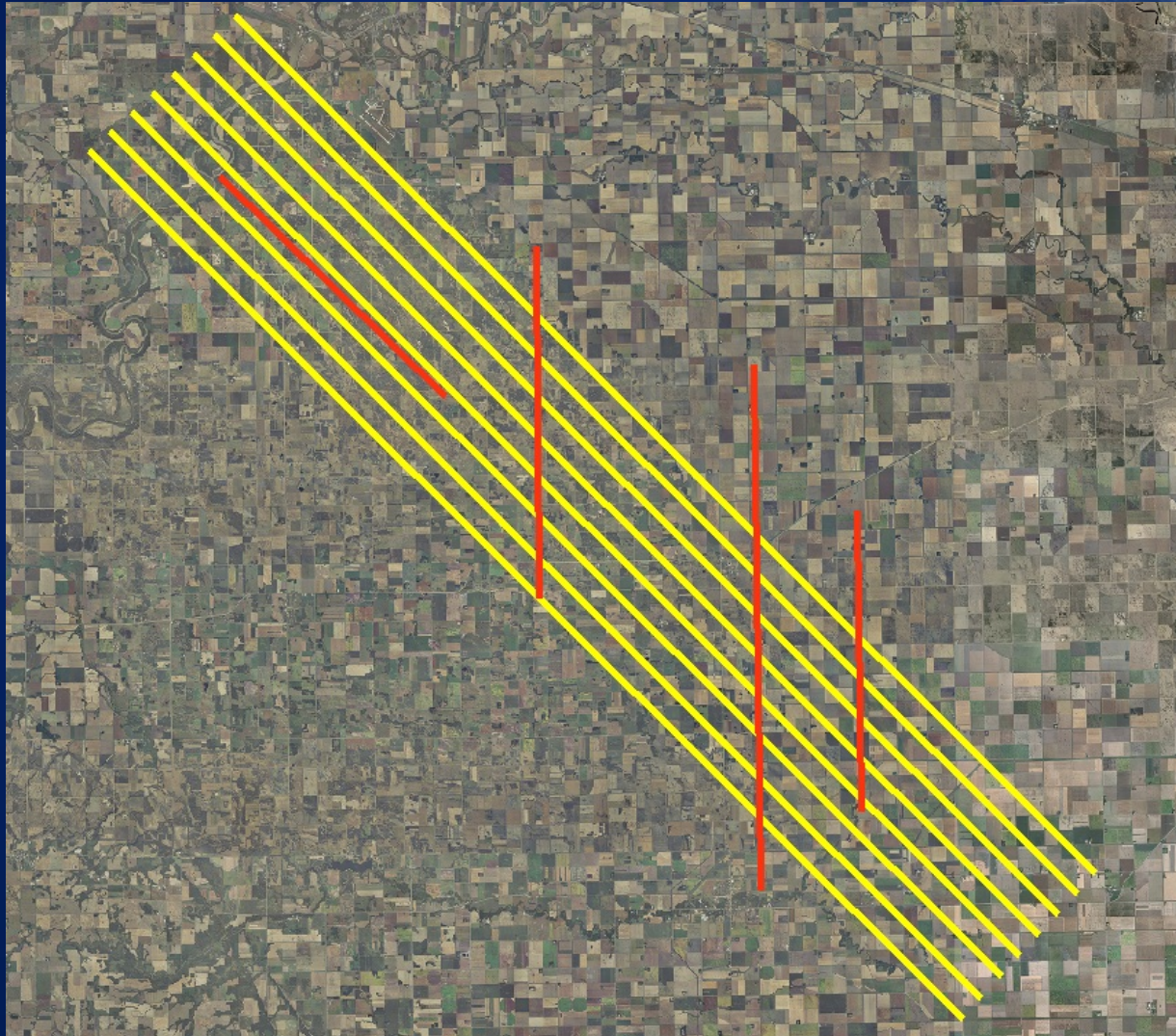
SMAPVEX12: Study Area



SMAPVEX12: Study Area



SMAPVEX12: Aircraft flights



Twin Otter-17 flight-days:

Yellow – 9,000 feet
PALS standard resolution

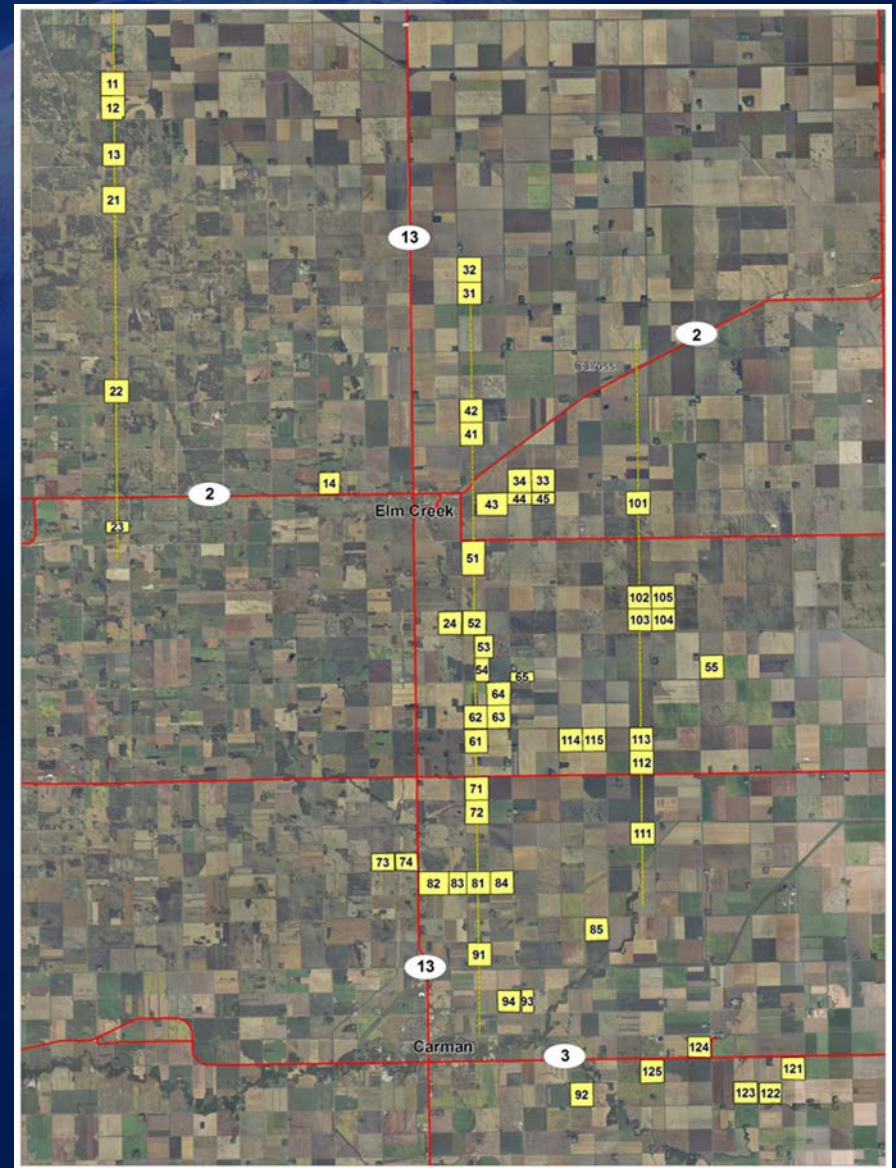
Red – 5,000 feet
PALS high resolution

G-III-14 flight-days:

Yellow – 40,000 ft
UAVSAR 1 m resolution

SMAPVEX12: *Sampling fields*

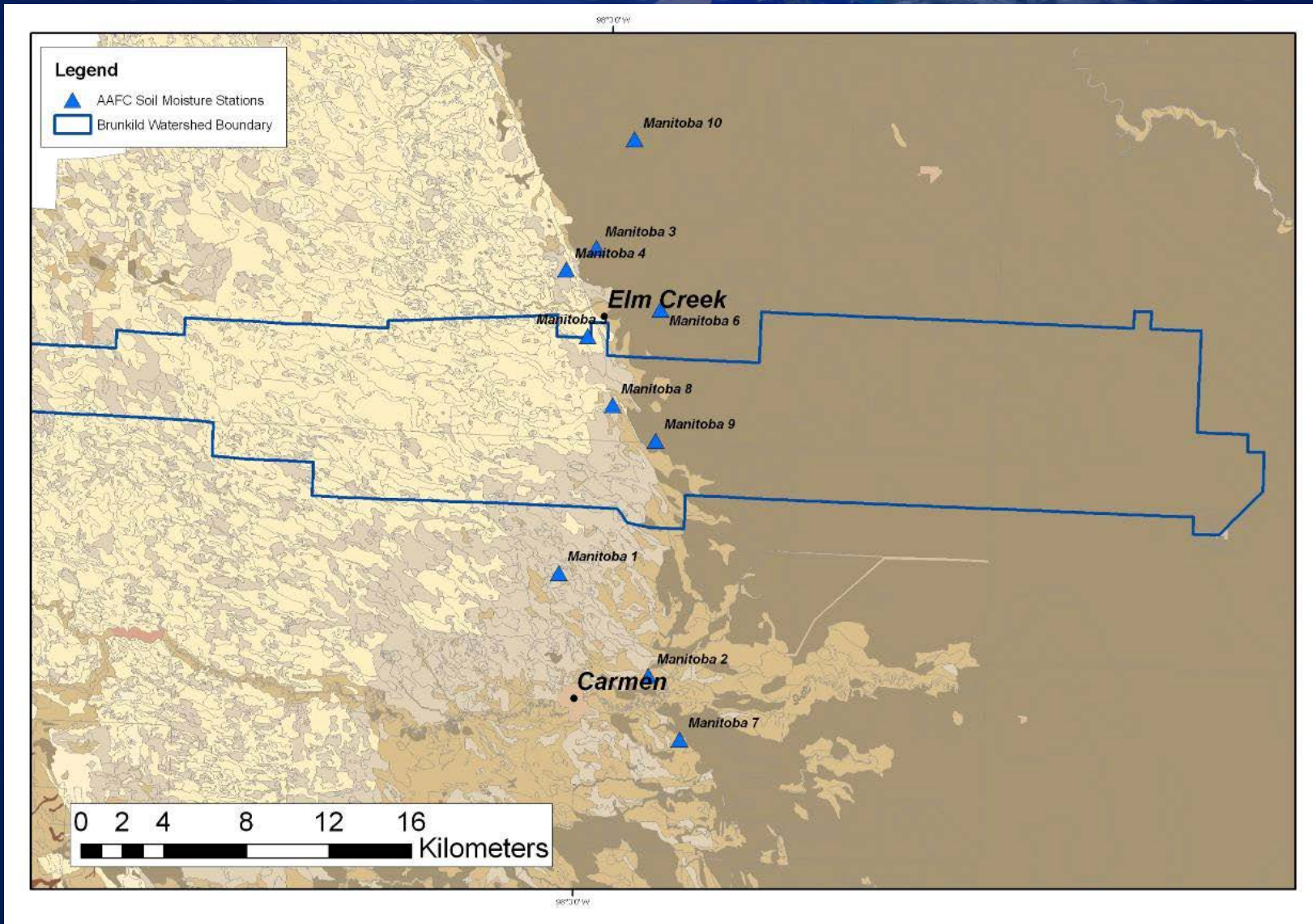
- Contracted individual farmers for access to specific fields for ground sampling purposes
- **55 Ag-Land fields** - Beans 11, Soybeans 5, Canola 6, Corn 10, Spring Wheat 14, Winter Wheat 2, Forage 1 & Pasture 6
- **5 Forested sites**, varying degrees of tree cover
- Synchronize timing of aircraft flights and ground crews



SMAPVEX12:

Mapping soil moisture and freeze/thaw state from space

AAFC Permanent In Situ Soil Moisture Stations



SMAPVEX12:

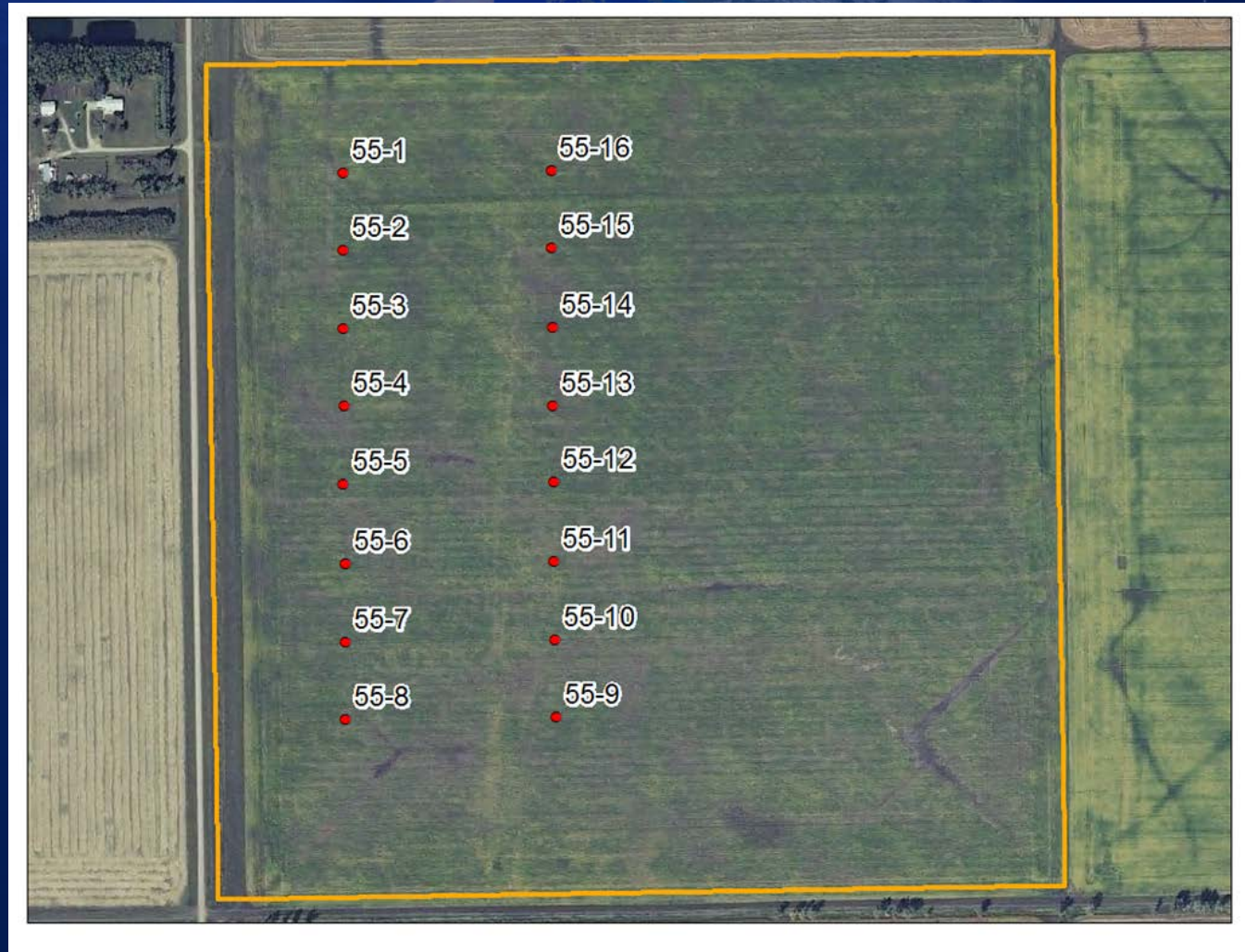
Mapping soil moisture and freeze/thaw state from space

Study Site Key Attributes

- Close to Winnipeg to provide a **base station** for ground crew training, sample processing, accommodation for the large team
- Range of **soil texture** within the study footprint to provide a range of soil moisture conditions
- Range of **annual and perennial** crops in the region
- Proximity of **wetland** and **forest** land covers to the agricultural fields
- Overlap with the Brunkild sub-watershed, an on-going **AAFC research site** with **permanent in situ** soil moisture stations

SMAPVEX12: Ag Field Sampling

- 16 sites arranged in two transects running parallel to crop row direction
- Totalling 880 Ag-Land sample points



SMAPVEX12: Soil Moisture



- Hand-held Stevens FDR hydraprobes were used to collect 3 soil moisture readings at each sampling site (48 per field) on each sampling date
- Over 44,000 moisture readings

SMAPVEX12: Soil Moisture



- At 1 sample site per sampling field per sampling day, soil cores were extracted for gravimetric soil moisture determination for the purpose of hydraprobe calibration
- 702 samples for hydraprobe calibration

- 9 Permanent soil moisture stations
- 3 Soil moisture probes at surface
- 3 Probes at 5 cm, 20cm, 50cm and 1m
- Probes are 50-100 feet from field edge
- Tipping bucket rain gauge
- Data is transmitted hourly via cell phone
- Nearly 400,000 soil moisture\temperature readings during campaign



SMAPVEX12: Soil Moisture



- Temporary continuous soil moisture stations at 1 location in 45 fields (USDA, MAFRI)
- Hourly soil moisture at 5 cm from just after seeding until harvest
- Over 525,000 readings

SMAPVEX12: Soil Temperature



- Soil temperature was measured at surface, 5 cm & 10 cm depth in sunlit and shaded areas
- Crop temperature was measured in sunlit and shaded areas
- Over 5000 soil and crop temperature readings

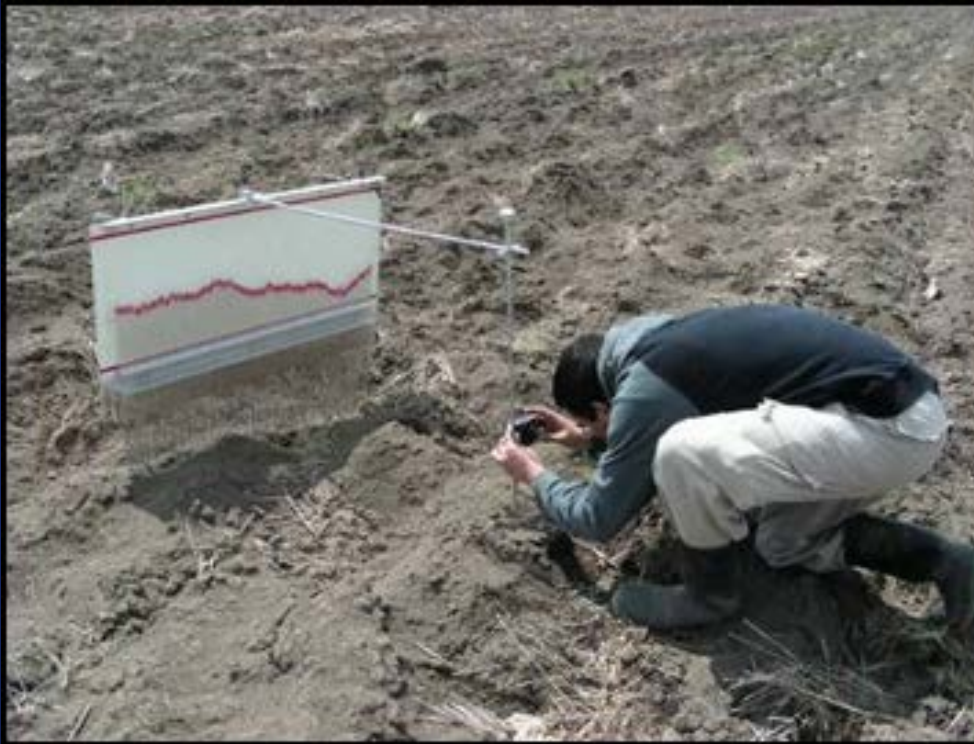
SMAPVEX12: Vegetation

Multi-mission satellite data at Earth space



- Weekly biomass samples were extracted, measured for height, stem diameter, wet and dry weight from 3 sampling locations per field
- Over 900 samples

SMAPVEX12: Surface Roughness

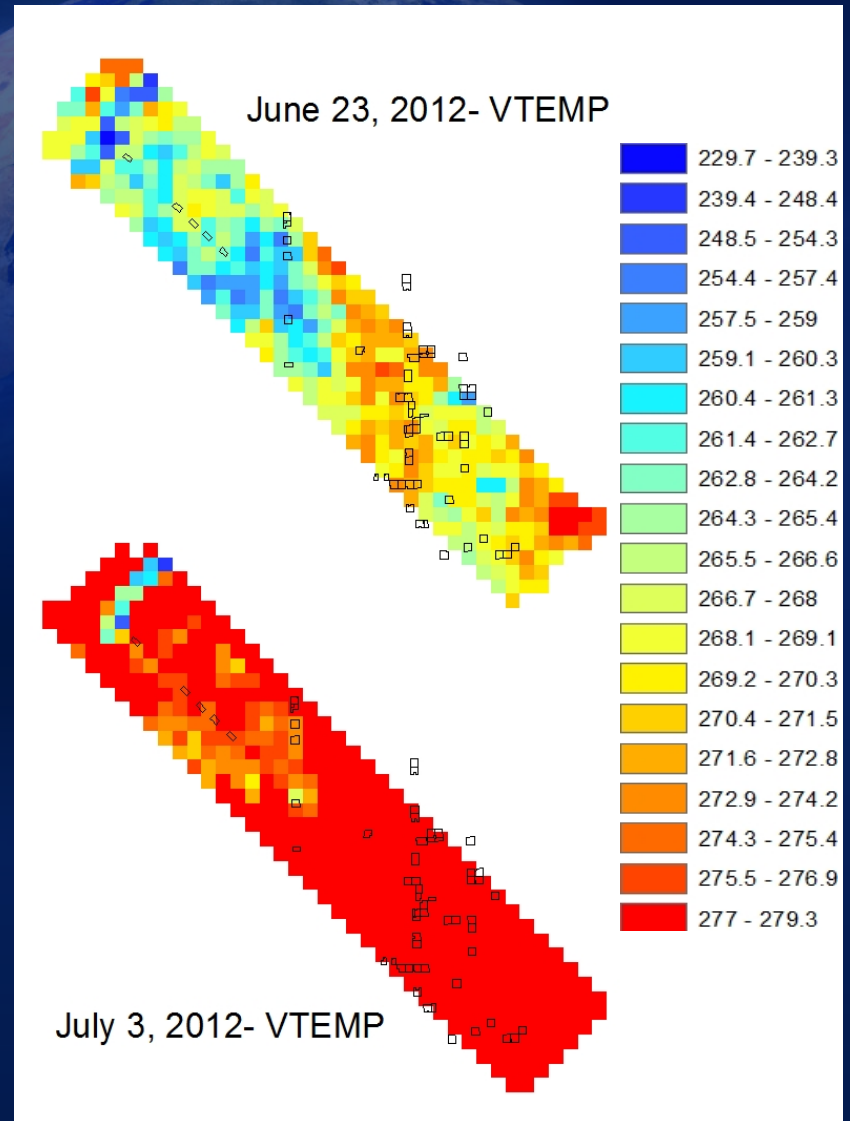


Wheat: Field #71 – June 11

- Surface roughness information was measured with a pin profile board
- Perpendicular to instrument orbit
- Sampled once after seeding

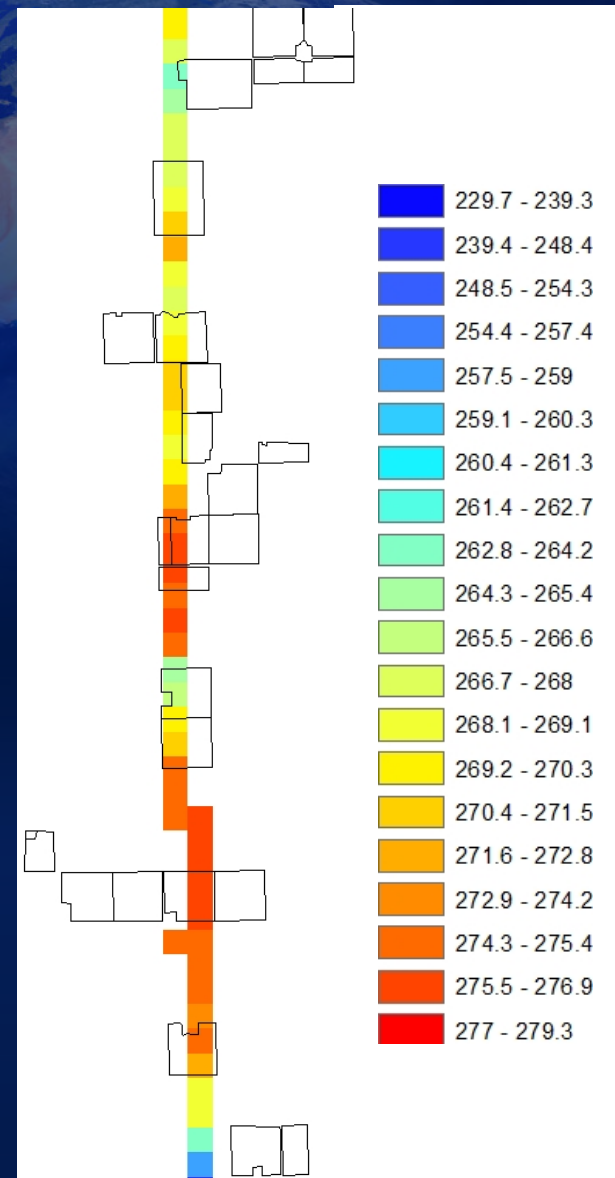
SMAPVEX12: Aircraft data

- The PALS passive sensor detects mainly wet soil conditions across the study site on June 23 especially in the forest-wetland area to the northwest.
- After 12 days without rain, PALS detects extremely dry soil conditions on July 3.
- Pixel size is about 1500 m



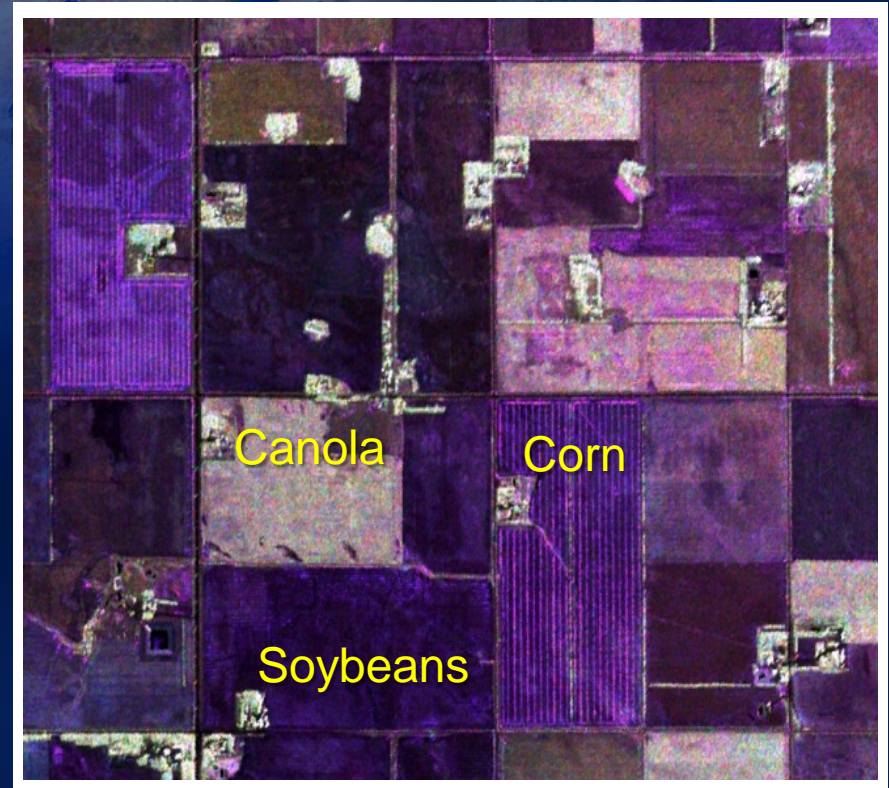
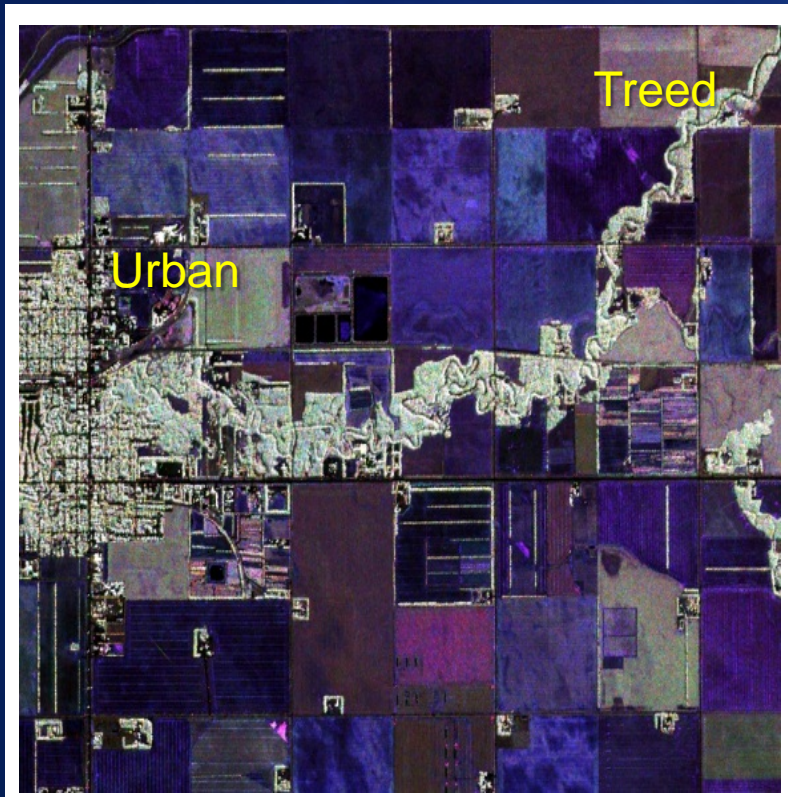
SMAPVEX12: Aircraft data

- On low-altitude passes, the PALS sensor can provide higher resolution on soil moisture change.
- Multiple readings are available per sample field for generating a comparison to the ground samples.
- Pixel size is about 400 m



SMAPVEX12: Aircraft data

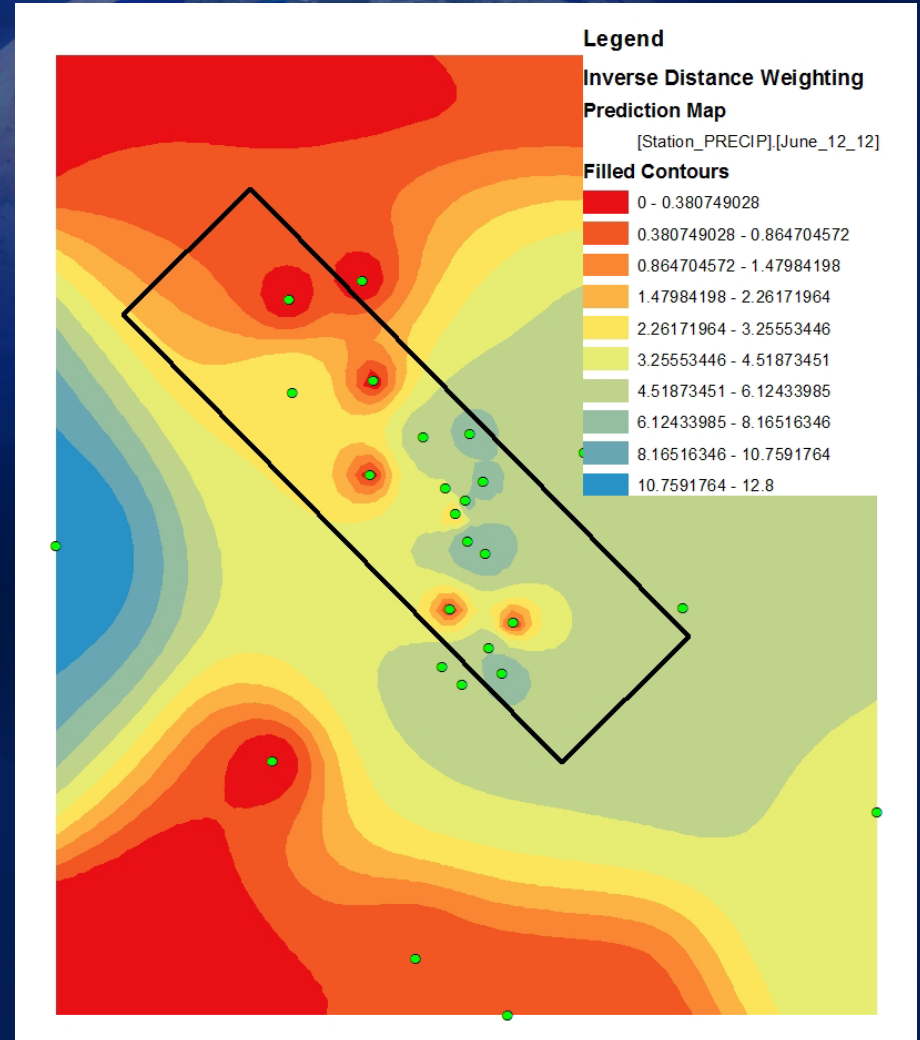
GIII - UAVSAR Active Radar Images: June 17th, 2012 Carman, MB



- Variations observed in fields are primarily due to differences in vegetation density
- Resolution of these images is approximately 1 m

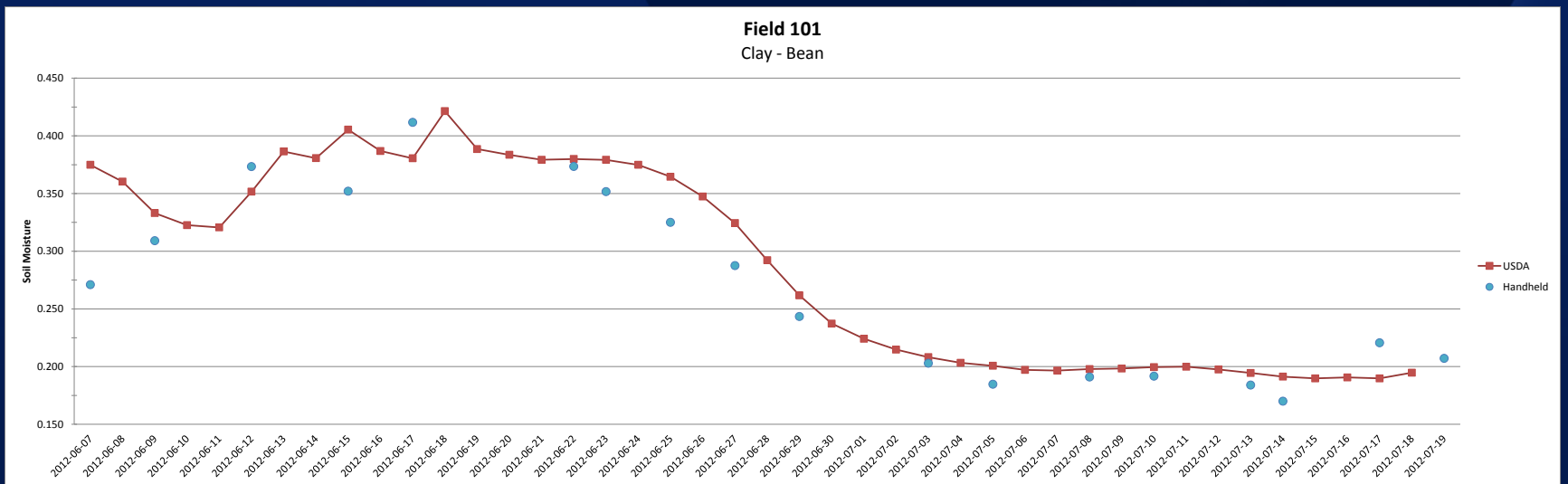
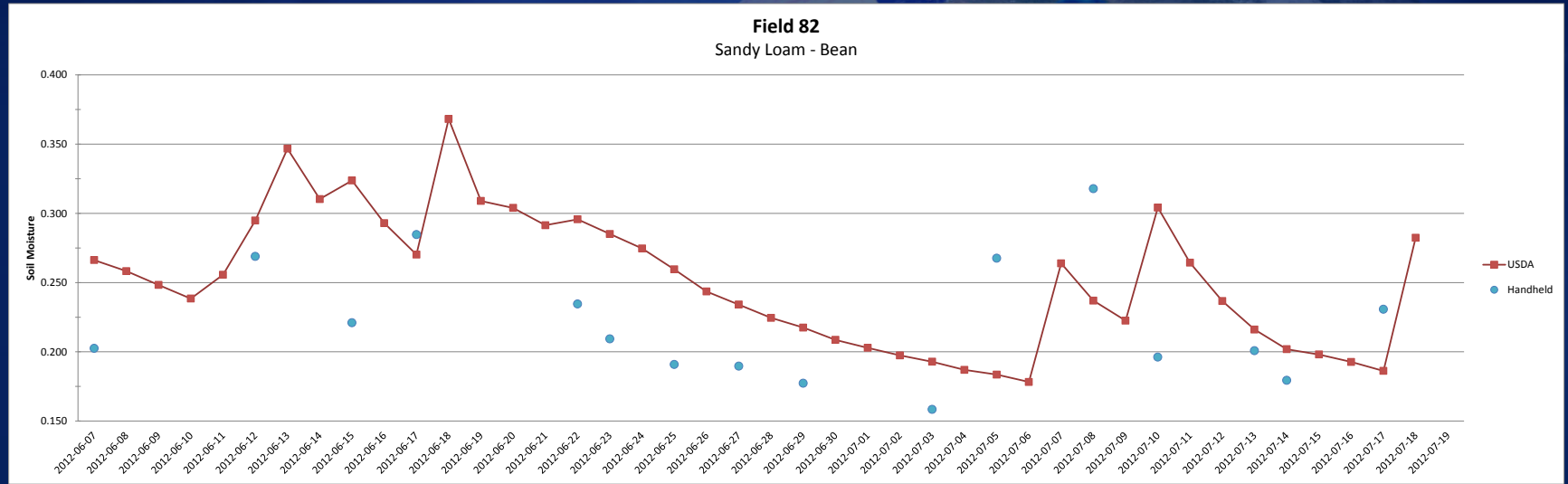
SMAPVEX12: Weather data

- Precipitation for June 12, 2012 (interpolation from rainfall gauges set up by Environment Canada, Agriculture & Agri-Food Canada, Manitoba Agriculture, Food and Rural Initiatives and Weather Farm)
- Daily maximum and minimum temperature and precipitation are being determined field-by-field throughout the sampling period (7a.m. – 7 a.m.)



SMAPVEX12: Soil Moisture data

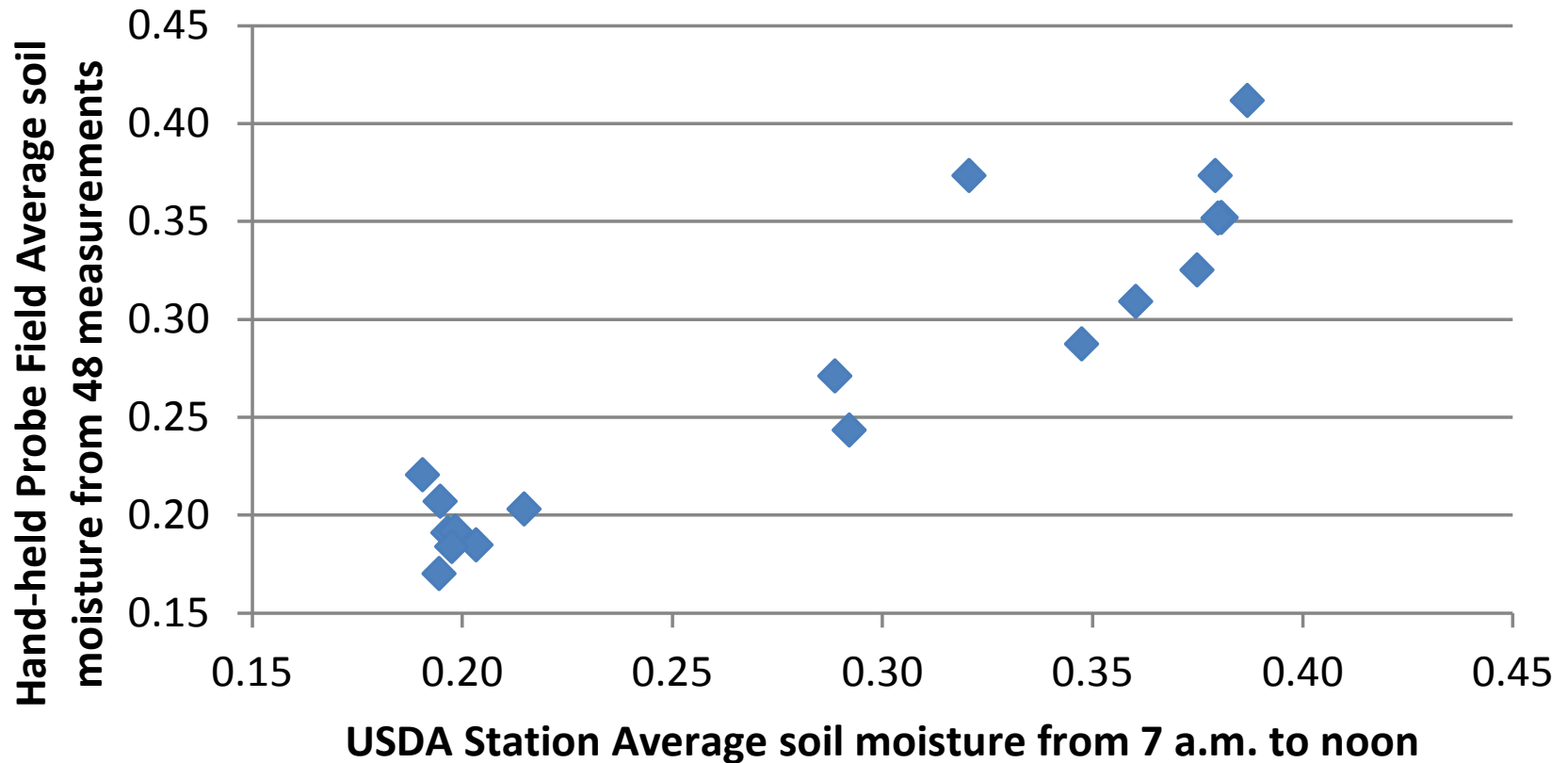
Calibrated Soil Moisture from Hand-Held and Temporary Continuous



SMAPVEX12: Soil Moisture data

Calibrated Soil Moisture from Hand-Held and Temporary Continuous

Field 101, Clay, Bean



SMAPVEX15?

Mapping soil moisture and freeze/thaw state from space

- Following the launch of the SMAP satellite, NASA is interested in using the Manitoba site for post-launch validation tests in **2015**



SMAPVEX12: *The Crew*



SMAPVEX12 field crew during training at the AAFC Regional Operations Centre in Winnipeg June 6th, 2012

