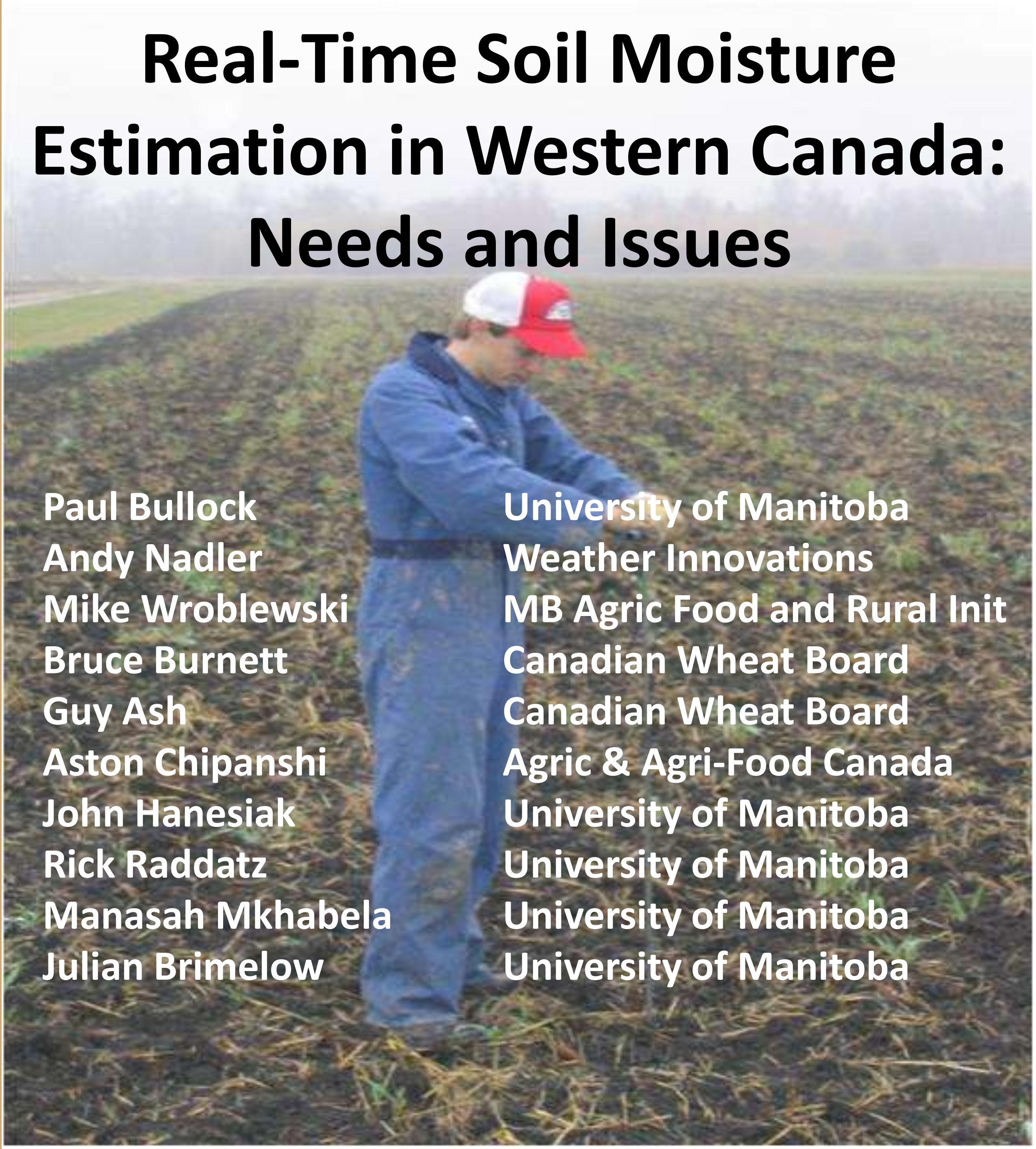
Real-Time Soil Moisture Estimation in Western Canada: Needs and Issues



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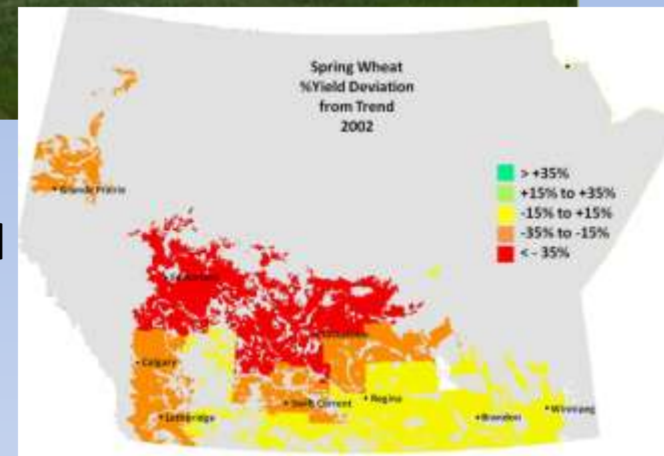
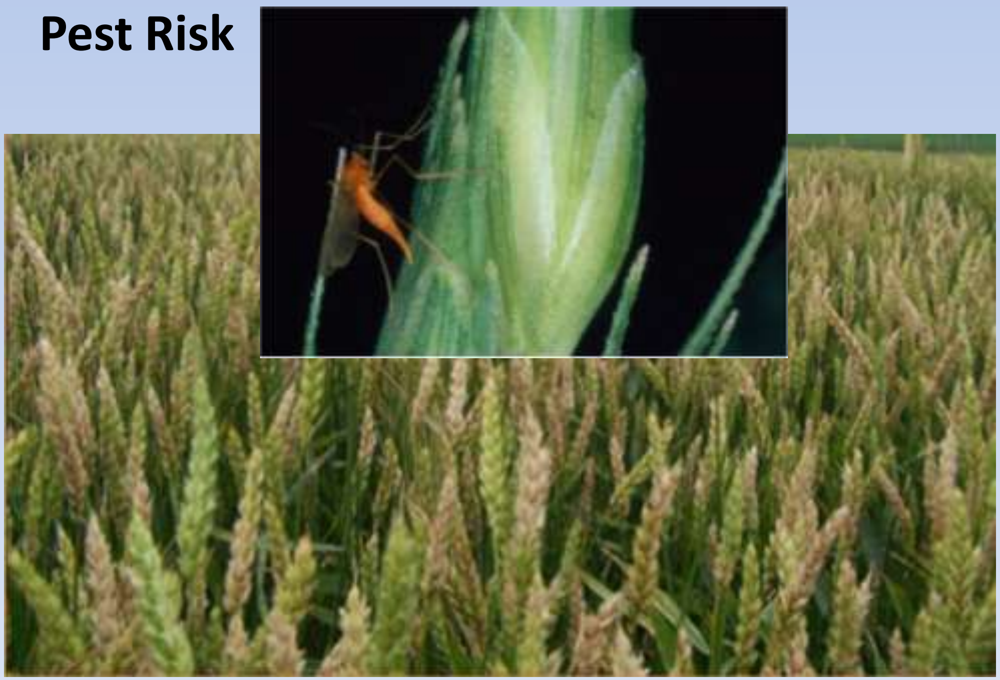
Applications for Soil Moisture Data

Soil Trafficability

Crop Yield Potential – both local and regional



Crop Disease and Pest Risk



Severe weather risk assessment

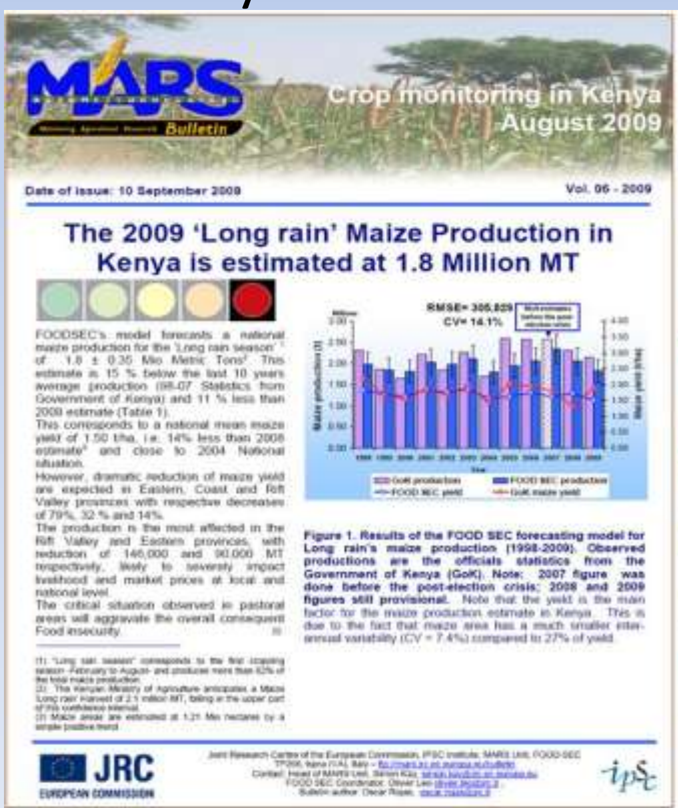
Extent of flooded or drought soils

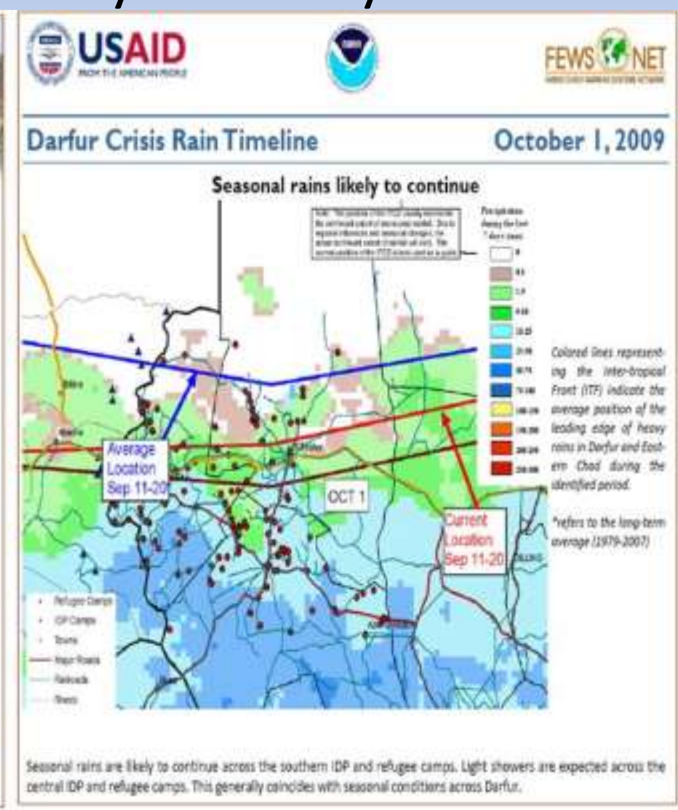
Flood risk assessment and runoff potential

Issues

"For agrometeorological information to be useful, it must deliver the right information to the right user at the right time." (Motha 2001, Agrometeorological Bulletins: How Can We Improve Them? Proc. Inter-regional Workshop, www.wamis.org /tools/dissem/ImproveAgBull.pdf)

Timely information delivery is usually critical.



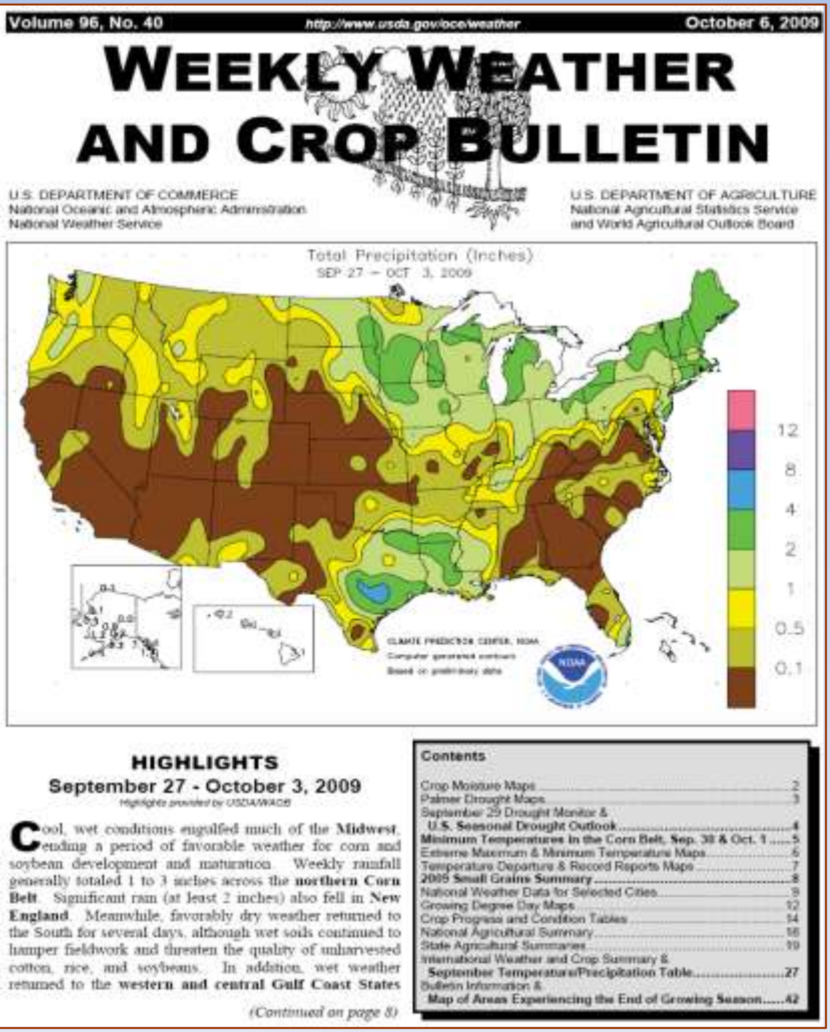


User needs vary in terms of scale

i. Broad area assessment for policy or support programs

ii. Local area assessment for insurance, municipality or industry

iii. Field scale for producer decision support



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WEEKLY WEATHER AND CROP BULLETIN

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service

U.S. DEPARTMENT OF AGRICULTURE
National Agricultural Statistics Service
and World Agricultural Outlook Board

HIGHLIGHTS
September 27 - October 3, 2009
Highlights provided by USDA/WAOB

Cool, wet conditions engulfed much of the **Midwest**, ending a period of favorable weather for corn and soybean development and maturation. Weekly rainfall generally totaled 1 to 3 inches across the **northern Corn Belt**. Significant rain (at least 2 inches) also fell in **New England**. Meanwhile, favorably dry weather returned to the South for several days, although wet soils continued to hamper fieldwork and threaten the quality of unharvested cotton, rice, and soybeans. In addition, wet weather returned to the **western and central Gulf Coast States**

(Continued on page 8)

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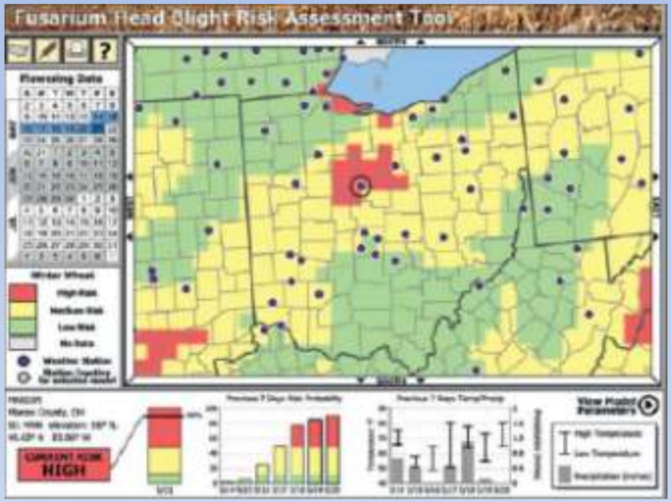
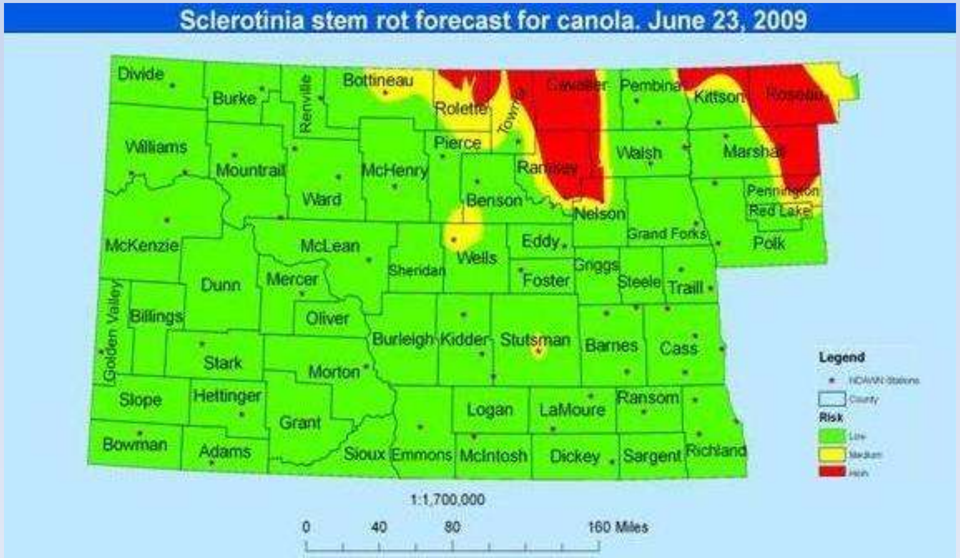




Type of soil moisture information needed varies

i. Depth
  - surface (0-5 cm)?
  - top zone (0-15 cm)?
  - root zone (0-120 cm)?
  - 0ther?

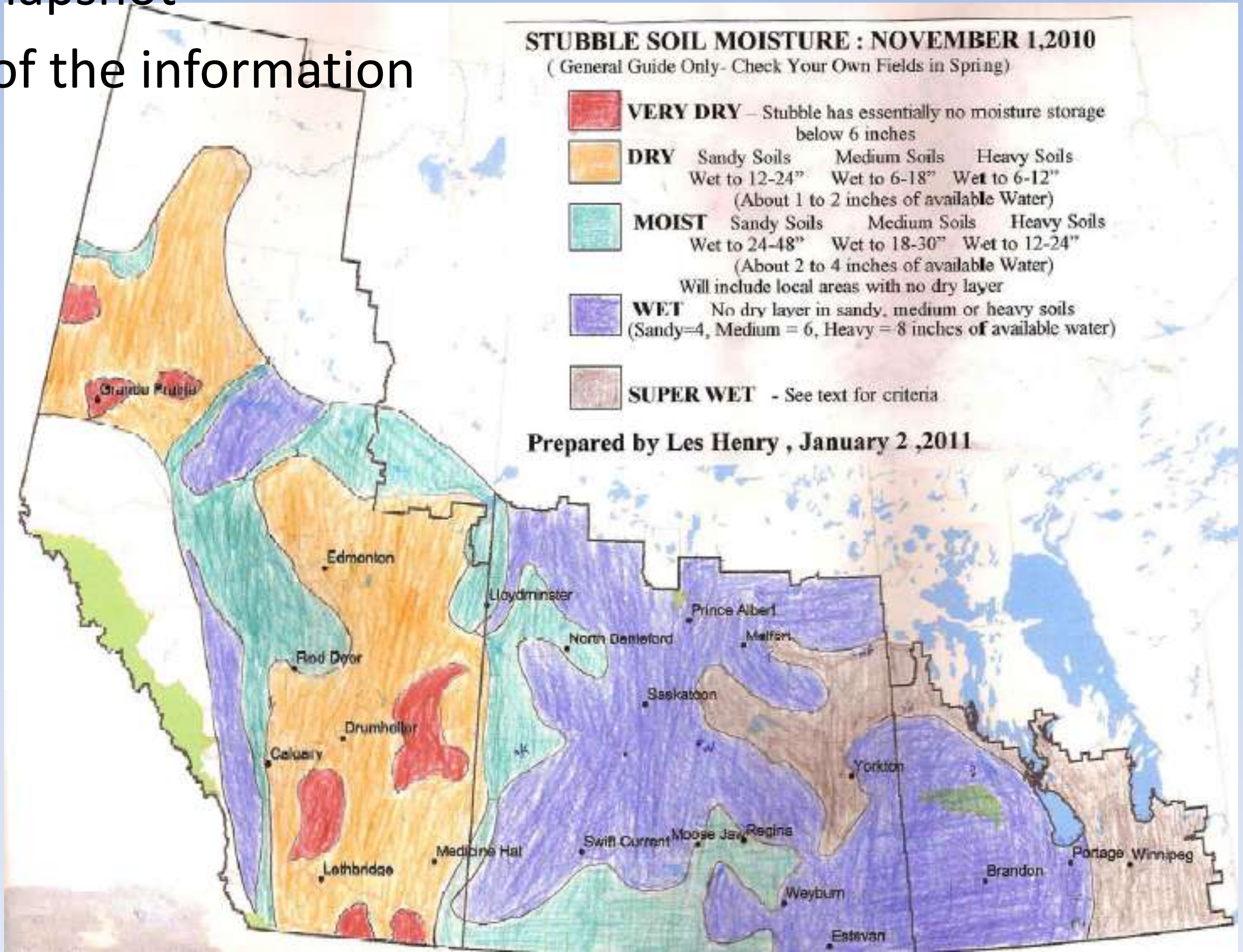
ii. Unit of Measurement
  - total soil water?
  - plant available water?
  - % of water-holding capacity?
  - index?

iii. Frequency
  - monthly?
  - weekly?
  - daily?

iv. Period of interest
  - spring?
  - fall?
  - growing season?
  - other?

Potential Approaches and Issues

1. Soil sampling (e.g. Les Henry's fall stubble moisture map)
   - one-time snapshot
   - timeliness of the information

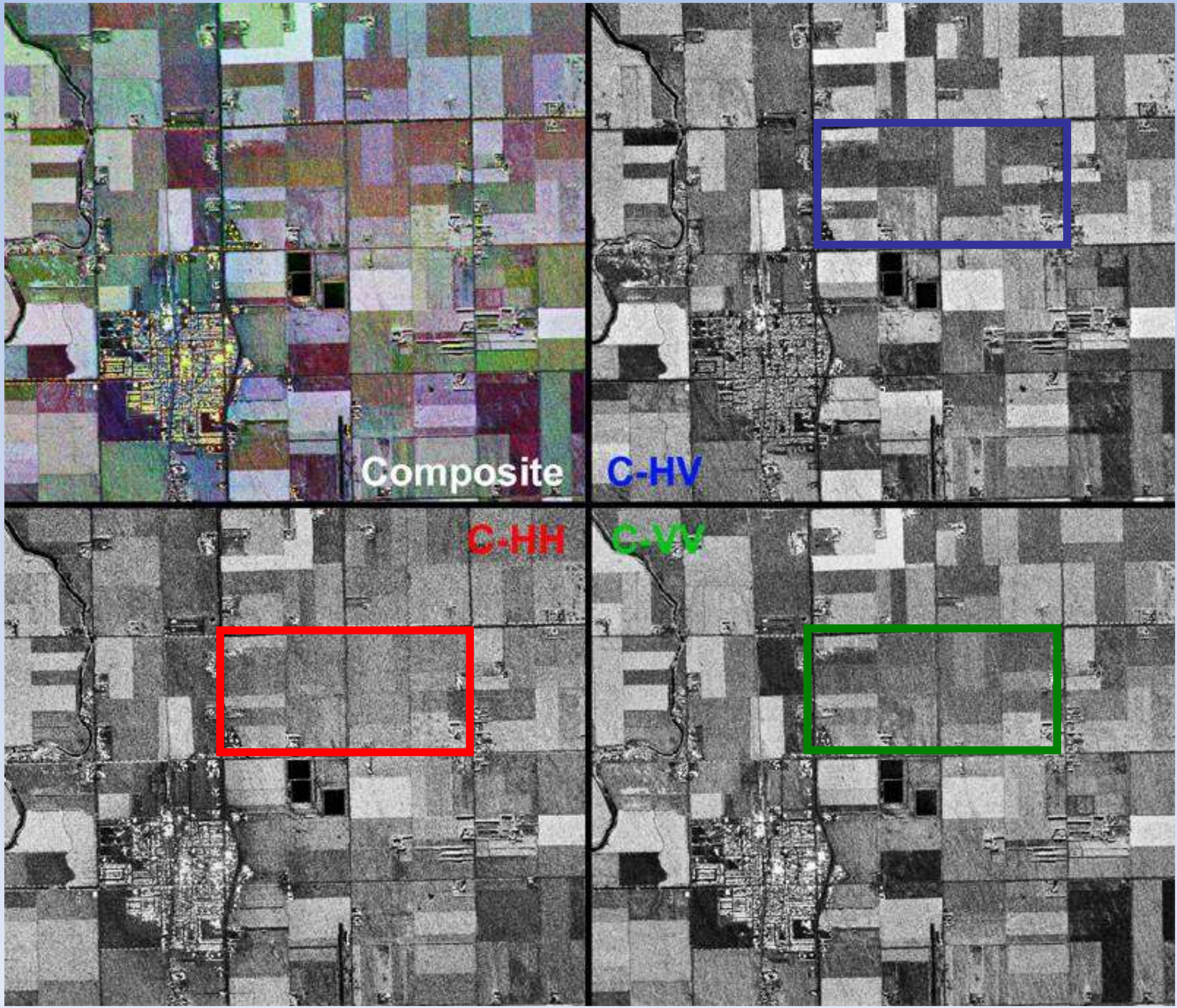


Potential Approaches and Issues

2. Remote Sensing (e.g. Radarsat, Radarsat II)

   - surface 5 cm only

   - vegetation issues

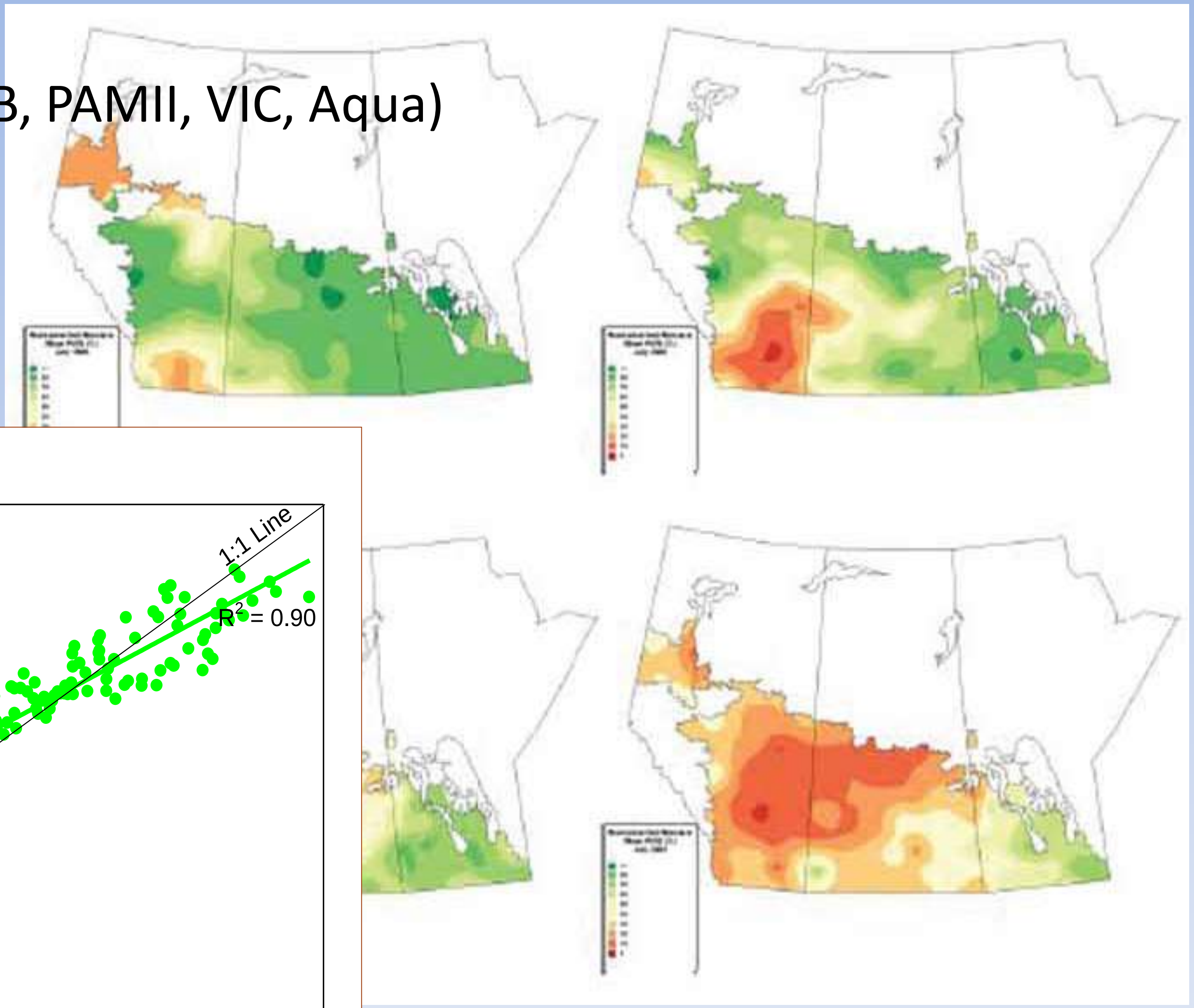


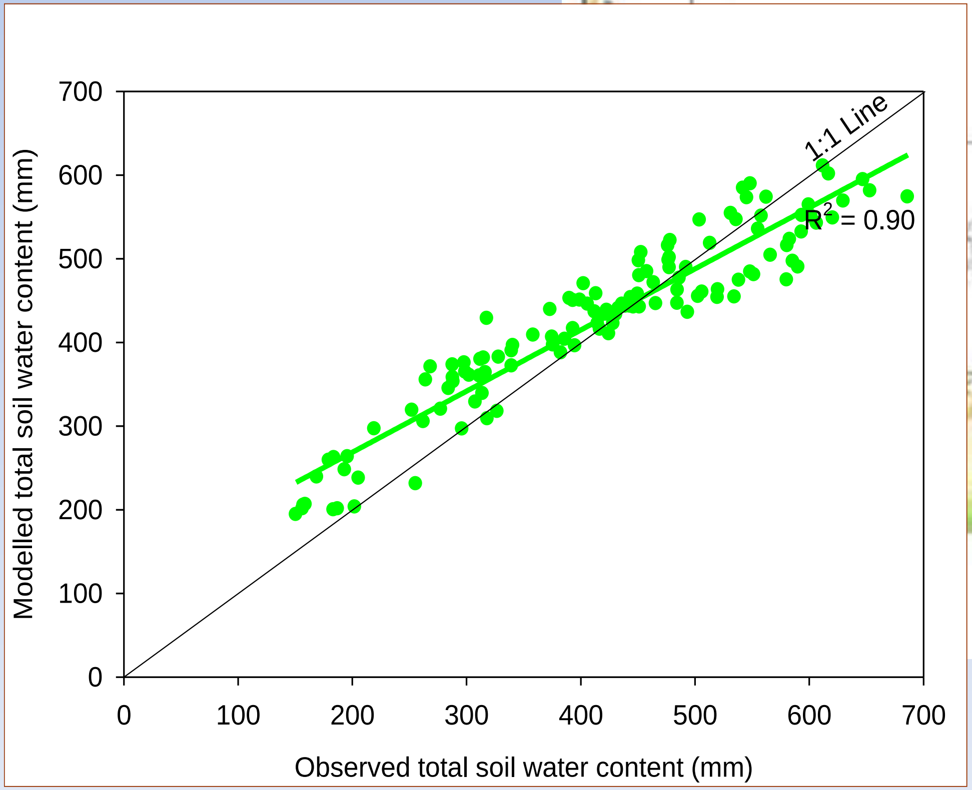
Potential Approaches and Issues

3. Monitoring network (e.g. Alberta soil moisture network)
   - cost
   - extent and representativeness

Potential Approaches and Issues

4. Models (e.g. VSMB, PAMII, VIC, Aqua)
   - input data
   - accuracy





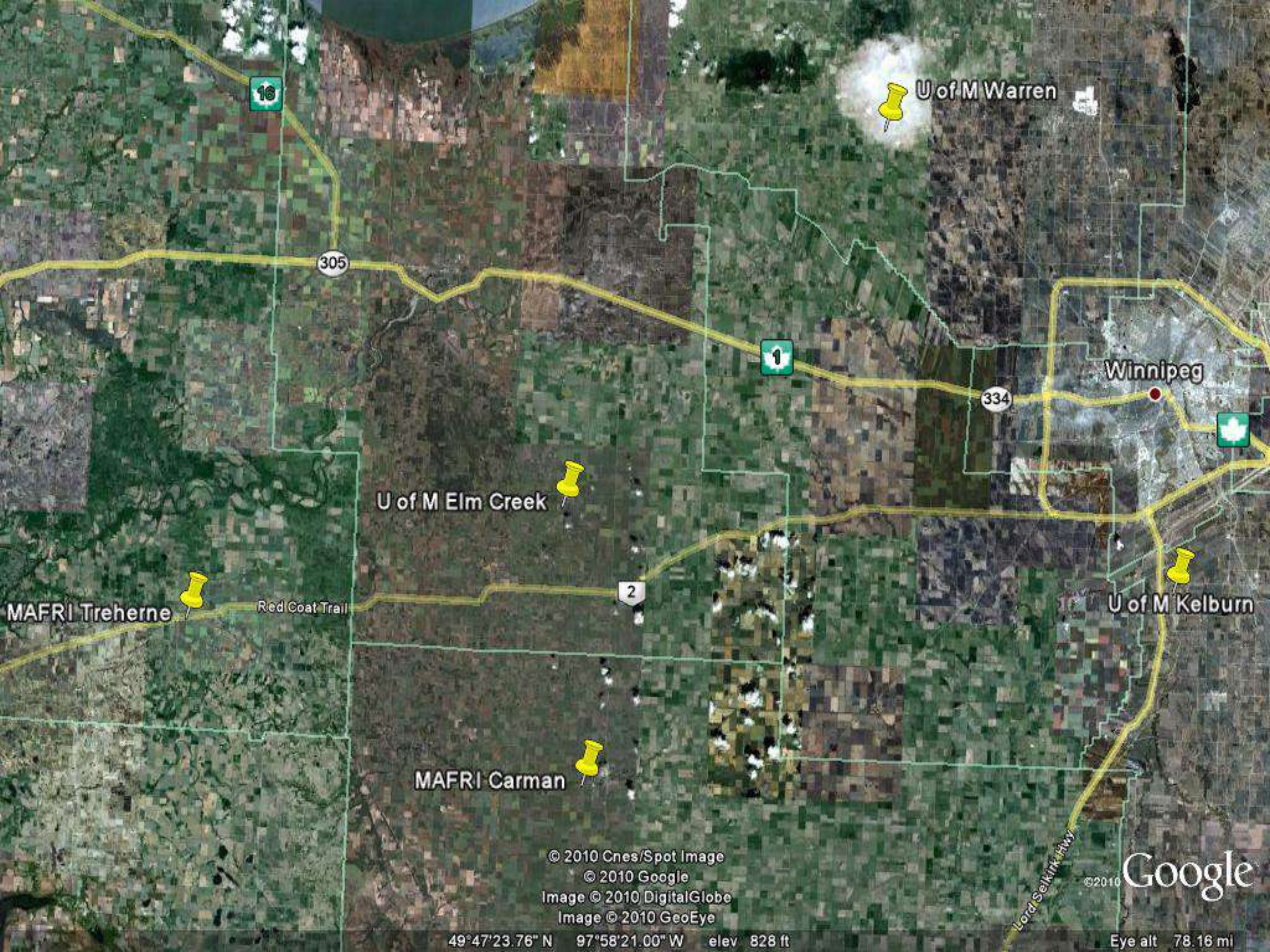
Operational Soil Moisture Monitoring Group

Currently considering soil moisture models that use real-time weather data.

On-going model output verification from in situ sensor networks, remote sensing and soil sample data.

Soil moisture products considered:

- AAFC "Total" Soil Moisture (www.agr.gc.ca/drought)
- McGill Soil Moisture Anomaly Index (www.meteo.mcgill.ca/~leiwen/vic/prairies/index2.html)
- Canadian Wheat Board Moisture Model (weatherfarm.weatherbug.com/farm)



U of M Warren
16
305
1
334
Winnipeg
U of M Elm Creek
MAFRI Treherne
Red Coat Trail
2
U of M Kelburn
MAFRI Carman
Lord Selkirk Hwy
© 2010 Cnes/Spot Image
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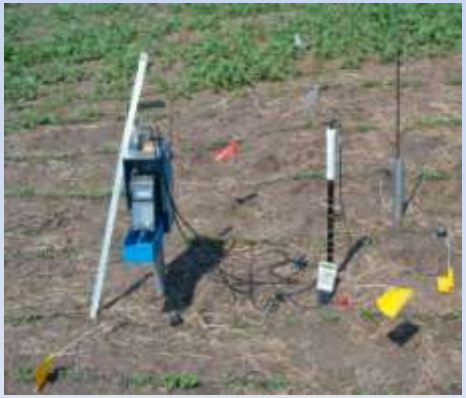
Image © 2010 GeoEye
©2010 Google
49°47'23.76" N 97°58'21.00" W elev 828 ft
Eye alt 78.16 mi

Research Background (Field Installations)



Factory Calibration Equations

$$\theta = A + B\varepsilon_{R,TC} + C\varepsilon_{R,TC}^2 + D\varepsilon_{R,TC}^3 \quad [1]$$

$$\theta = A + B\varepsilon_R + C\varepsilon_R^2 + D\varepsilon_R^3 \quad [2]$$

$$\theta = A\sqrt{\varepsilon_{R,TC}} + B \quad [3]$$

$$\theta = A\sqrt{\varepsilon_R} + B \quad [4]$$

θ	Soil Moisture in units of water fraction by volume (m^3m^{-3})
$\varepsilon_{R,TC}$	Temperature Corrected Real dielectric Permittivity
ε_R	Real Dielectric Permittivity
A, B, C, D	Coefficients see table 2.

Table 1, Variable definitions

Soil Texture	Equa-tion	A	B	C	D	Pedology/Mineralogy
Sand (1)	1	-8.63	3.216	-9.54 E-2	1.579 E-3	Most Sands (Default)
Silt (1)	1	-13.04	3.819	-9.129 E-2	7.342E-4	(Default)
Clay (1)	2	-20.93	6.553	-0.2464	3.2414E-3	(Default)
Loam (1)	4	0.109	-0.179			Suitable for Most Soils (Default)
Silt Loam (1)	3	0.1226	-0.1903			A Horizon
Sandy Loam (1)	4	0.1017	-0.1786			A Horizon
Sandy Clay Loam (1)	4	0.1132	-0.1989			Bk Horizon
Loam (2)	4					Bk Horizon
Sandy Loam (2)	3	0.1251	-0.2065			Ap Horizon/Kaolinite
Clay (2)	4	0.1111	-0.1725			Bt Horizon/Kaolinite, Gibbsite
Sandy Loam (3)	4	0.1070	-0.1825			A Horizon
Loam (3)	3	0.1170	-0.1847			Ap Horizon/ Kaolinite, Vermiculite
Loam (4)	3	0.1161	-0.1909			E Horizon
Silty Loam (2)	3	0.1031	-0.1648			Ap Horizon/Montmorillonite
Silty Clay Loam (2)	4	0.0967	-0.1613			Bg Horizon
Silty Loam (3)	3	0.0958	-0.1610			Bw Horizon
Clay Loam	4	0.1033	-0.1768			A Horizon/Montmorillonite
Silty Clay	4	0.1088	-0.1738			Bg Horizon Montmorillonite
Silty Loam (4)	4	0.1004	-0.1588			
Loamy Sand	3	0.1204	-0.2025			Ap Horizon
Sandy Loam (4)	3	0.1105	-0.1725			Ap Horizon
Sandy Clay Loam (3)	3	0.1078	-0.1723			Bt Horizon
Silty Clay Loam (4)	4	0.1033	-0.1702			A Horizon

Table 2, calibration coefficients according to texture and mineralogy

http://www.stevenswater.com/catalog/products/soil_sensors/datasheet/The%20Stevens%20Hydra%20Probe%20Inorganic%20Soil%20Calibrations.pdf

Initial Results

- Factory calibration results were poor in clay soils (with the volumetric content higher than porosity) but no distinct textural pattern was observed

- While FDRs are good instruments that provide real time soil moisture estimates, soil-specific calibration must be carried out if a high level of accuracy is required

- Field calibration requires adequate gravimetric data points. Increasing the number of calibration points boosts our confidence in the regression equation

Acknowledgements

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