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Integration of Field Studies and Remote Sensing for the Prairies

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**Environment Canada
SMAP workshop, October 6, 7 2009**

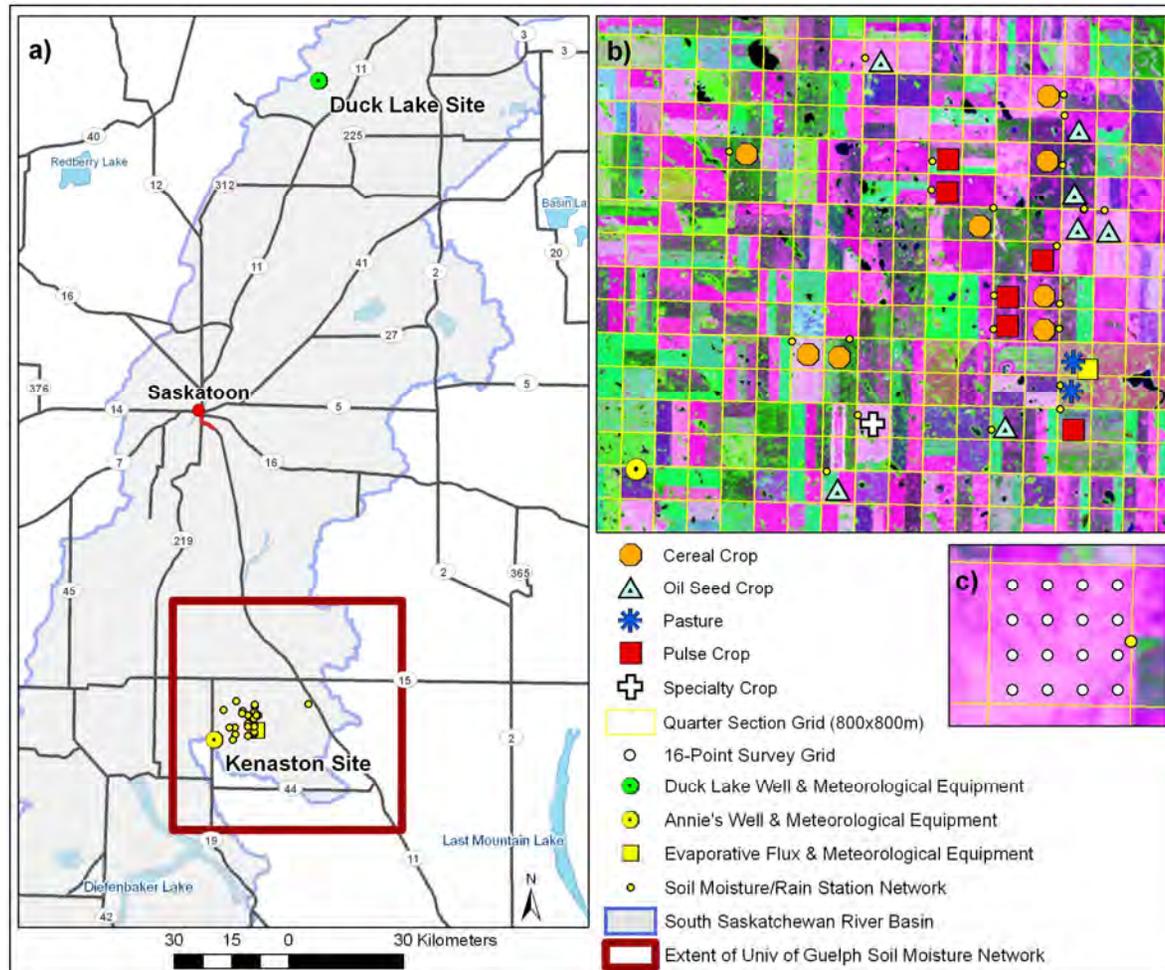


Integration of Field Studies and Remote Sensing for the Prairies

- Site description and field installations
- Calibration considerations
- Analysis of 2007 data
 - Closure of the local energy budget
 - Use of the geologic weighing lysimeter in assessing the closure of the local measured water budget
- Review of available data for 2007 - 2009
- Collaborators
- Future plans and discussion

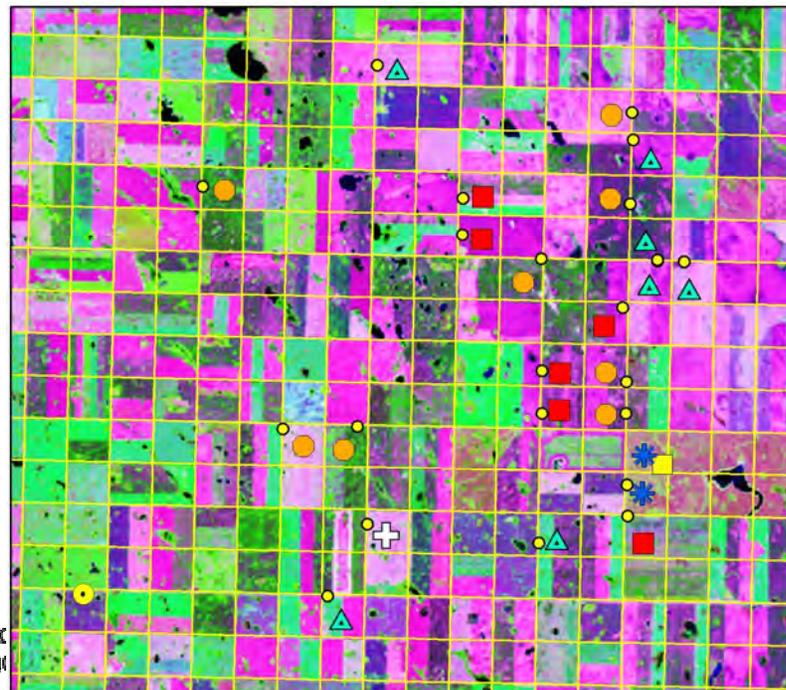
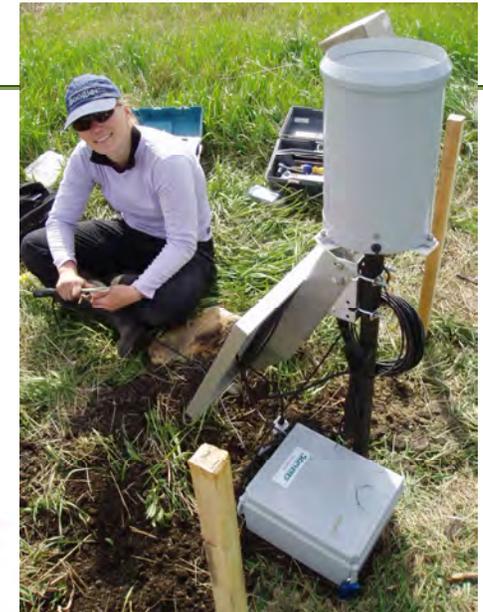


Study site – Kenaston/Brightwater Creek



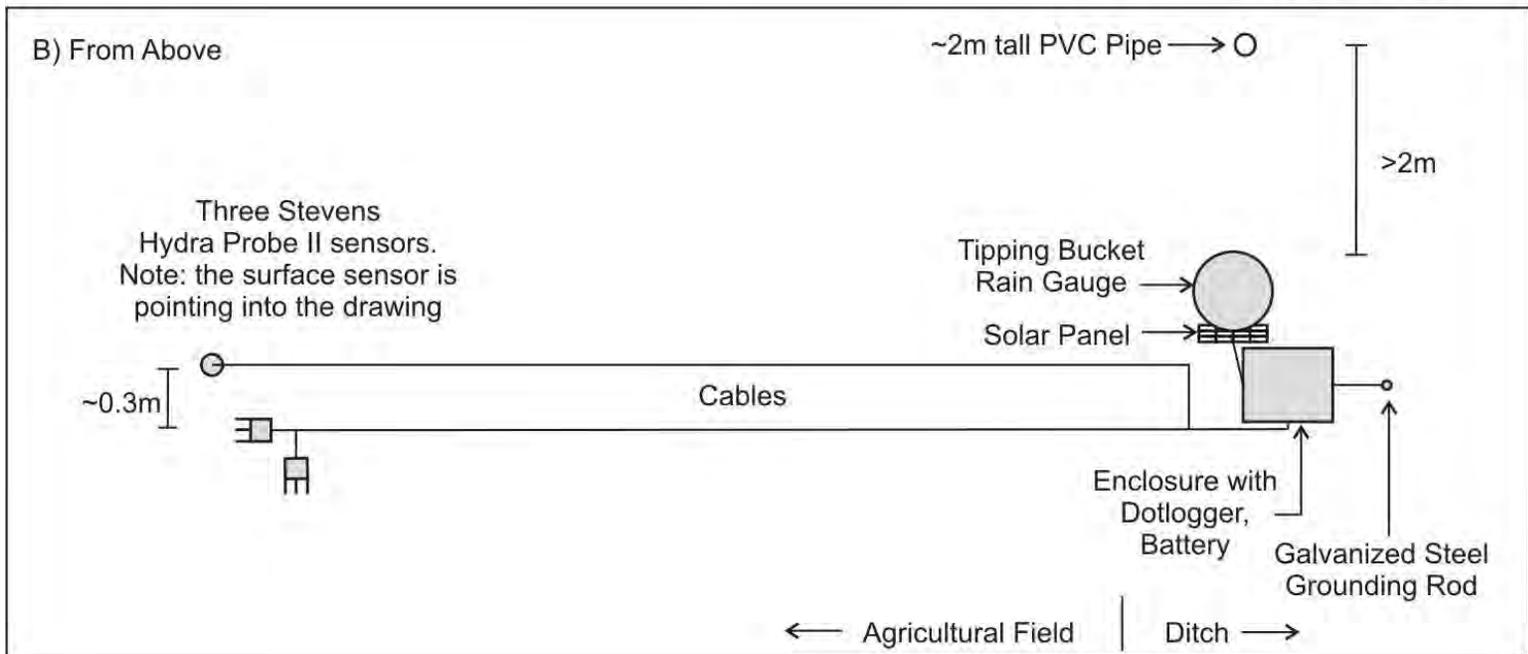
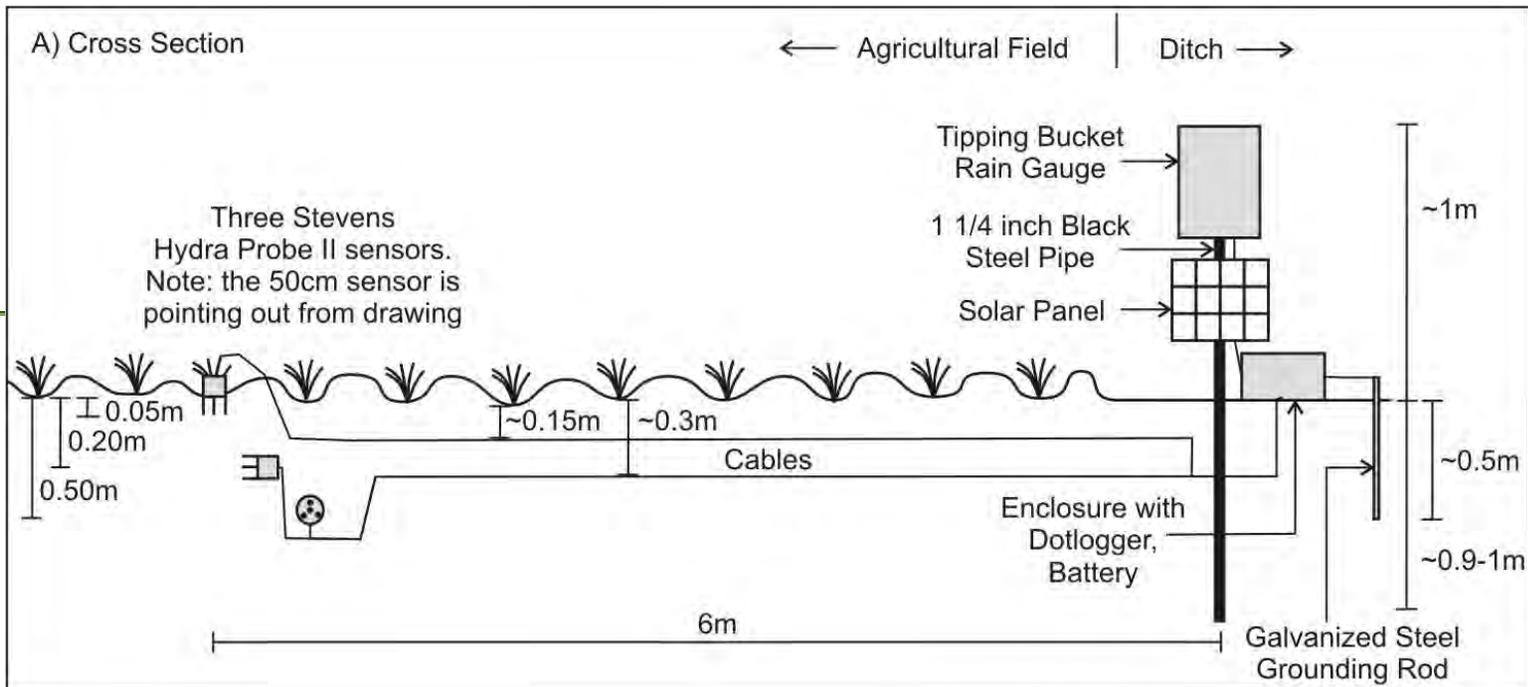
- 24 sites
- 10 x 10 km grid
- located within University of Guelph 60 x 60 km grid

Instrumentation of the grid



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- Soil Moisture & Rain Stations
- Flux & Met. Station
- Geological Weighing Lysimeter & Met. Station
- Cereal Crop
- ▲ Oil Seed Crop
- ✱ Pasture
- Pulse Crop
- ⊕ Specialty Crop
- Quarter Section Grid (800x800m)



Typical Soil Moisture/Precip site

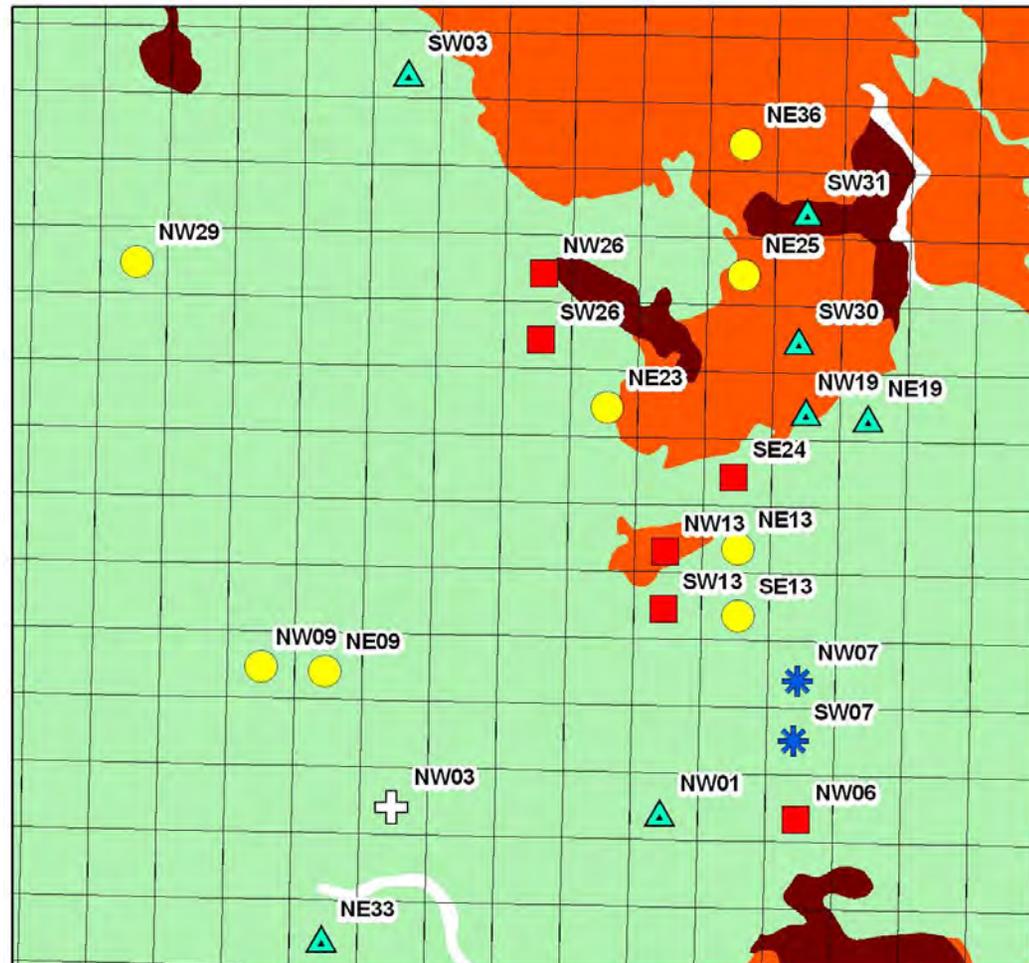


Stevens Hydra Probe II sensors
capacitance-type sensor,
previously called Vitel
Probes)

Campbell Scientific precip
TB3 and TE525M



Characterization of the landscape



- Soil texture for area and each of 24 sites
- 2007-9 crop types, and some LAI, surface roughness
- DEM, streamflow

□ Quarter Section Outlines (800m x 800m)

Fields

Crop Type

- Cereal
- ▲ Oil Seed
- ✳ Pasture
- Pulse
- ⊕ Specialty

Soil Texture (SKSISv2)

- Loam
- Clay Loam
- Clay

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Calibration

- Typically, without any knowledge of the soil type, the accuracy is +/- 0.03 wfv
 - 0.20 could be 0.17 to 0.23
- With knowledge of soil type (sand, silt, clay classification), +/- 0.015-0.020 wfv
- a soil-specific calibration for the particular soil is performed, +/- 0.005 wfv,
 - 0.195-0.205 wfv.
- remaining uncertainty is predominantly due to inaccuracies in the calibration process and the basic soil electrical properties measurement.
- Soil samples, 3 depths x 24 sites
- wfv fn (real dielectric constant)
 - 3rd order polynomial, temperature effect for sand and silt

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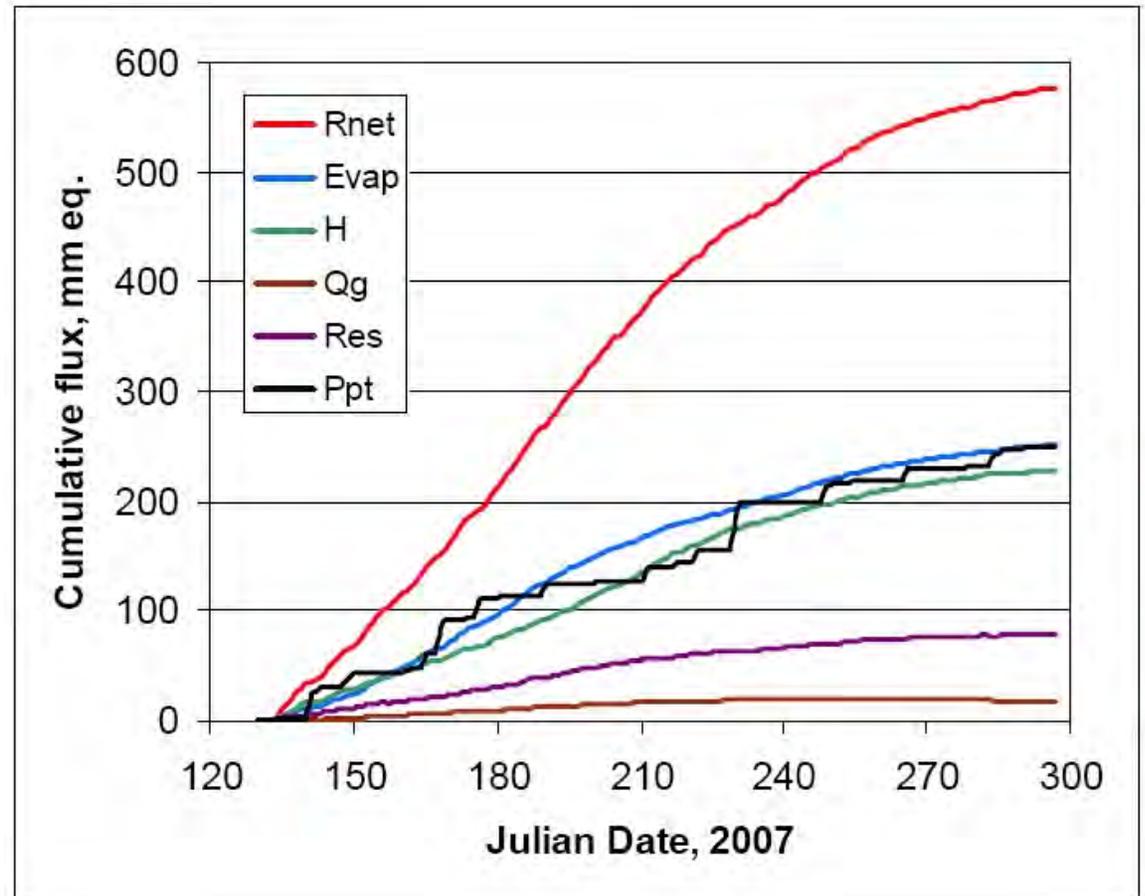
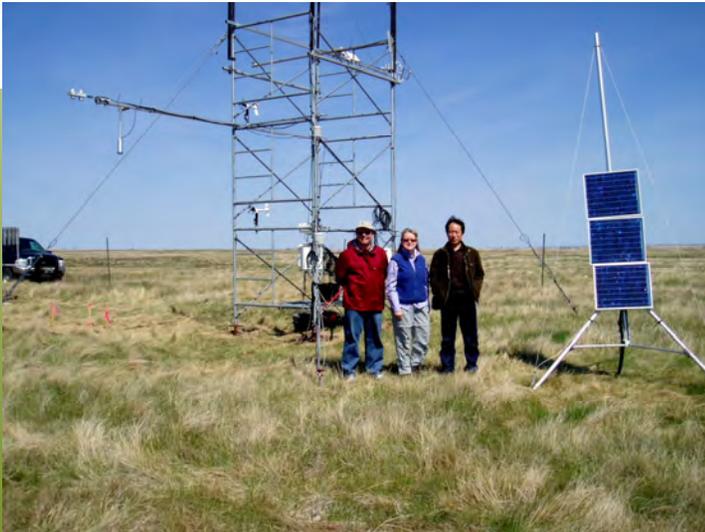
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Analysis of 2007 measured data

- Closure of the measured energy budget
 - cumulative residual is 13% of R_{net}
 - Evaporation 44%
 - Sensible heat 40%
 - Ground heat 3%



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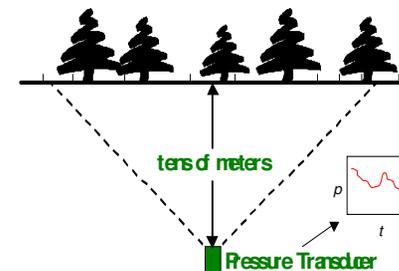
Use of geological weighing lysimeter to close the water budget

Overview of the Weighing Lysimeter Instrumentation

► Fundamentals

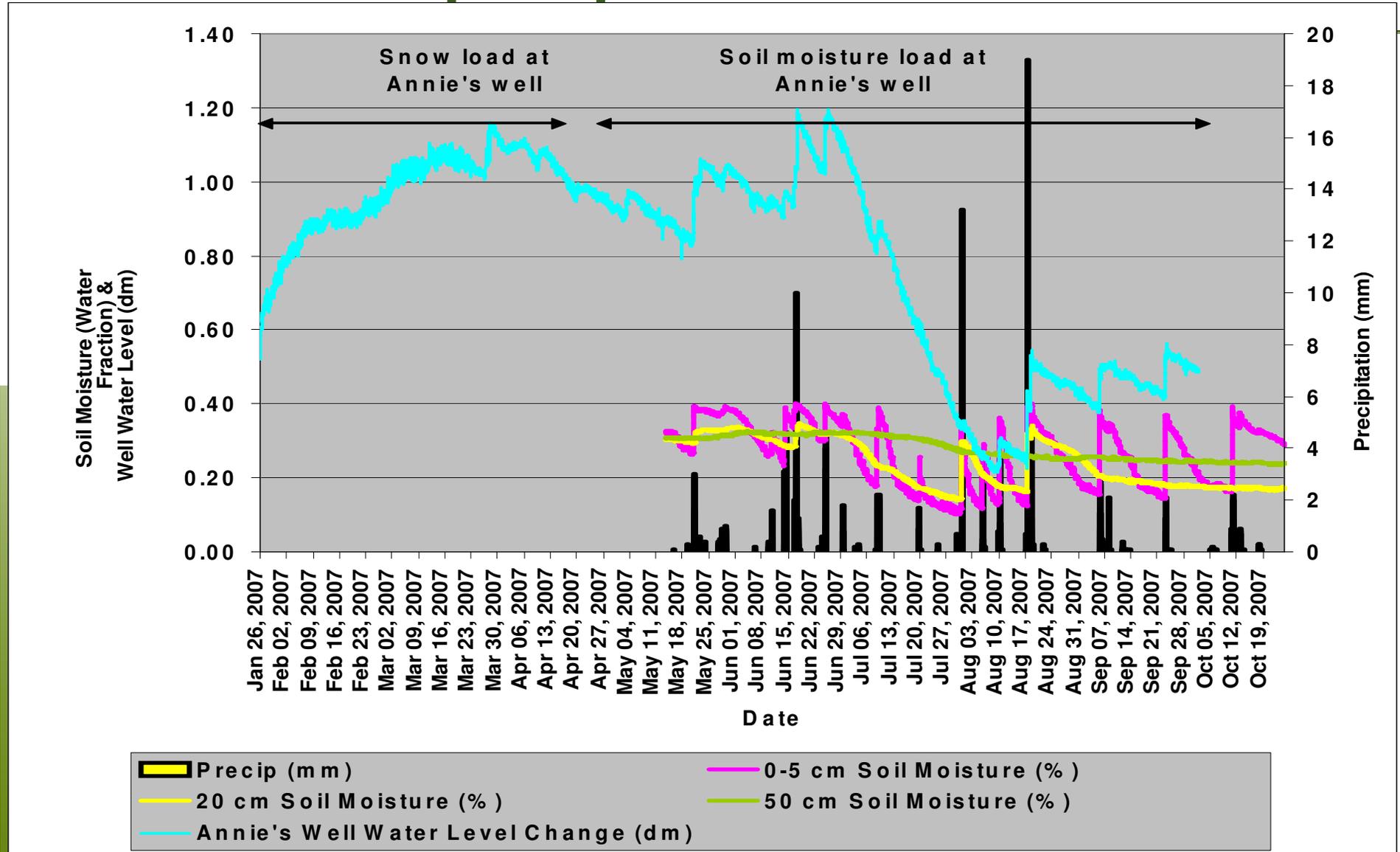
- Change of mechanical surface loading is instantaneously transmitted to deep saturated formations resulting in change of pore water pressure;
- Piezometers in saturated formations can therefore detect pore pressure changes due to hydrological processes such as:
 - ✓ Snow accumulation;
 - ✓ Rainfall;
 - ✓ Evapotranspiration

Conceptual Sketch of Piezometric Weighing Lysimeter Installation



Van der Kamp et al, 2003

Geologic weighing lysimeter with measured precip and soil moisture



Winter/Spring lysimetric, SWE and flow measurements

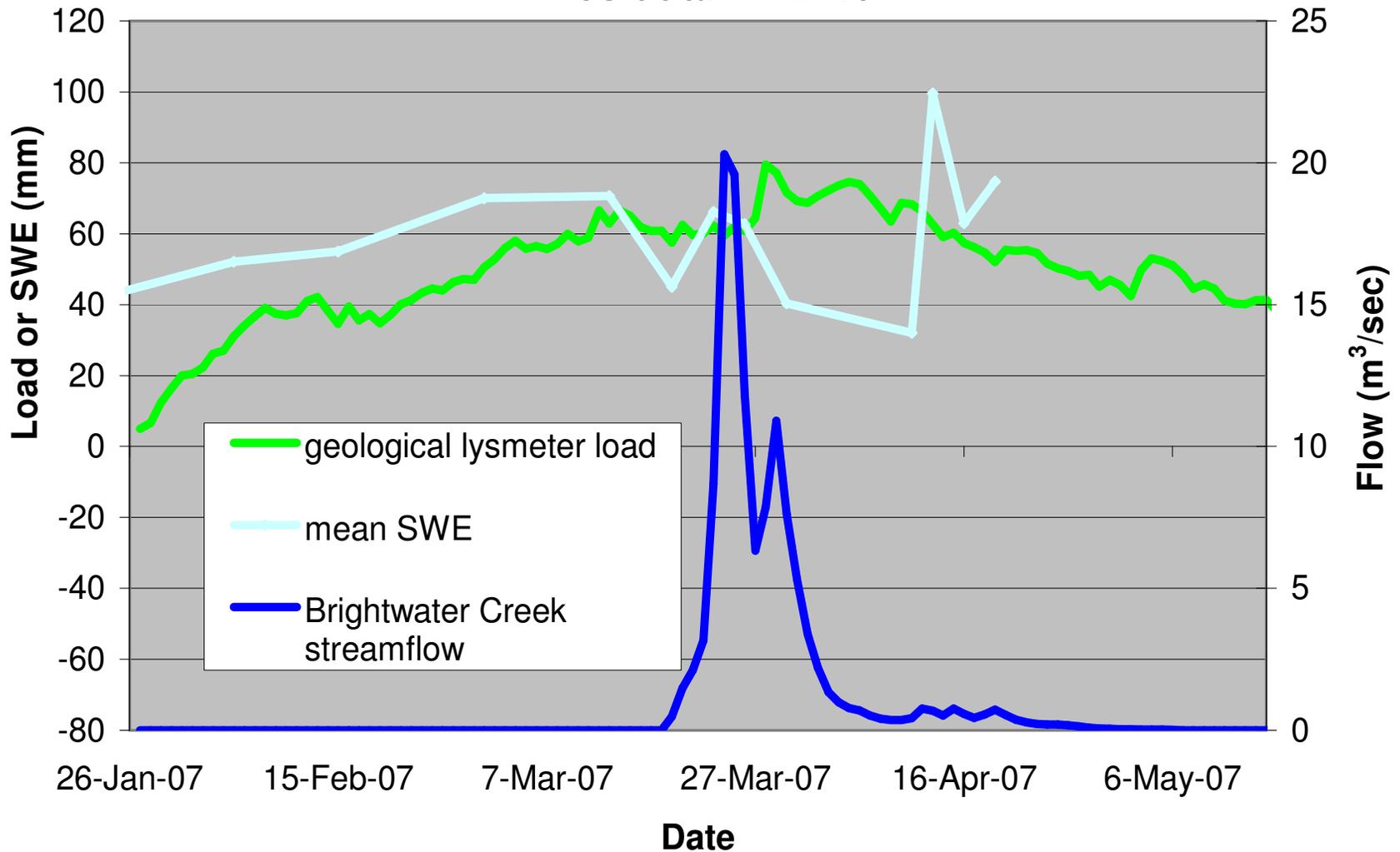
Precip = 96.5 mm

ET = 0 mm

Runoff = 32 mm

$\Delta S = 40$ mm

Residual = +24.5 mm



Summer/Fall lysimetric, flux and soil moisture measurements

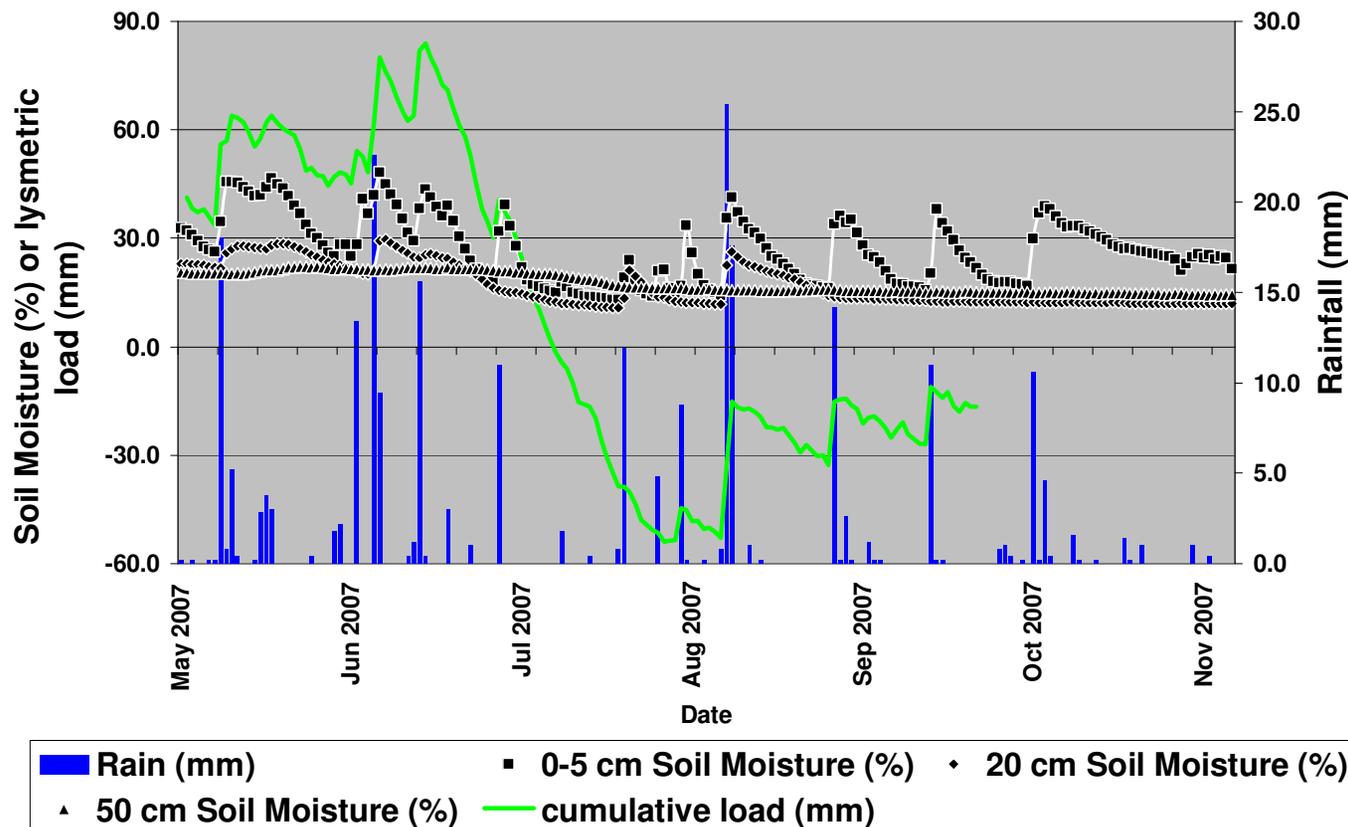
Precip = 233 mm

ET = 229 mm

Runoff = 0 mm

$\Delta S = -55$ mm

Residual = -51 mm



Precip = 329.5 mm

ET = 229 mm

Runoff = 32 mm

$\Delta S = -15$ mm

Cumulative Residual = -26.5 mm (8% of precipitation)

2007 Satellite data acquisition

| Image Date (UTC) | Image Date (Local) | Satellite Overpass Time (Local) | Orbit | In-situ Survey Date (Local) | In-situ Survey Time (Local) | Data collected | Fields Surveyed |
|------------------|--------------------|---------------------------------|------------|-----------------------------|-----------------------------|--------------------|------------------------------------|
| Jun 29 | Jun 28 | 23:30 | Ascending | Jun 28 | 21:00 – 00:00 | SM, LAI, roughness | NE36, SW31, SE25, SW30, NW19, NE19 |
| Jul 16 | Jul 15 | 23:30 | Ascending | Jul 15 | 21:00 – 00:00 | SM | NE36, SW31, SE25, SW30, NE19 |
| Aug 14 | Aug 13 | 23:30 | Ascending | Aug 14 | 21:00 – 23:00 | SM, LAI, roughness | NE36, SW31, SE25, SW30, NW19, NE19 |
| Sep 25 | Sep 25 | 11:30 | Descending | Sep 25 | 10:00 – 14:00 | SM, LAI, roughness | SE25, SW30, NW19, NE19 |

The 2007 acquisition dates and times for the ALOS PALSAR L-band active microwave images. All images are in Jaxa level 1.5 format, have an incidence angle of 34.3 degrees and they are all fine mode (20 m res) and dual polarization HH+HV (FBD).



Manual Surveys – 2007

| Date | May 16 | Jun 28 | Jul 03 | Jul 04 | Jul 10 | Jul 13 | Jul 15 | Jul 19 | Jul 24 | Aug 01 | Aug 08 | Aug 14 | Aug 16 | Aug 28 | Sep 05 | Sep 25 | Total # |
|------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| NE09 | | | | X | X | | | X | | X | | | X | | X | | 6 |
| NE13 | | | X | | X | | | X | | X | | | X | X | | | 6 |
| NE19 | | X | | | | | X | | | | | X | | | | X | 4 |
| NE23 | | | X | | | X | | | X | | X | | | X | | | 5 |
| NE25 | | X | | | | | X | | | | | X | | | | X | 4 |
| NE33 | | | | X | X | | | X | | X | | | X | X | | | 6 |
| NE36 | | X | | | | | X | | | | | X | | | | | 3 |
| NW01 | | | X | | X | | | X | | X | | | X | | X | | 6 |
| NW03 | | | | X | X | | | X | | X | | | X | | X | | 6 |
| NW06 | | | X | | X | | | X | | X | | | X | | X | | 6 |
| NW07 | | | X | | X | | | X | | X | | | X | | X | | 6 |
| NW09 | | | | X | X | | | X | | X | | | X | | X | | 6 |
| NW13 | | | X | | X | | | X | | X | | | X | | X | | 6 |
| NW19 | X | X | | | | | | X | | | | X | | | | X | 5 |
| NW26 | | | | X | | X | | | X | | X | | | X | | | 5 |
| NW29 | | | | X | | X | | | X | | X | | | X | | | 5 |
| SE13 | | | X | | X | | | X | | X | | | X | X | | | 6 |
| SE24 | | | X | | | X | | | X | | X | | | X | | | 5 |
| SW03 | | | | X | | X | | | X | | X | | | X | | | 5 |
| SW07 | | | X | | X | | | X | | X | | | X | | X | | 6 |
| SW13 | | | X | | X | | | X | | X | | | X | | X | | 6 |
| SW26 | | | | X | | X | | | X | | X | | | X | | | 5 |
| SW30 | X | X | | | | | | X | | | | X | | | | X | 5 |
| SW31 | | X | | | | | | X | | | | X | | | | | 3 |

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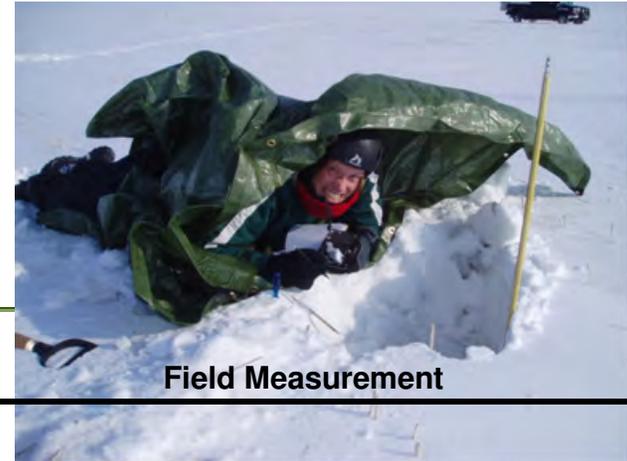
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Datasets 2007-2009

- Snow surveys
- precip/soil moisture (24)
- energy flux data (point)
- geologic weighing lysimeter (areal)
- Satellite overpass 2007, 2008, 2009.



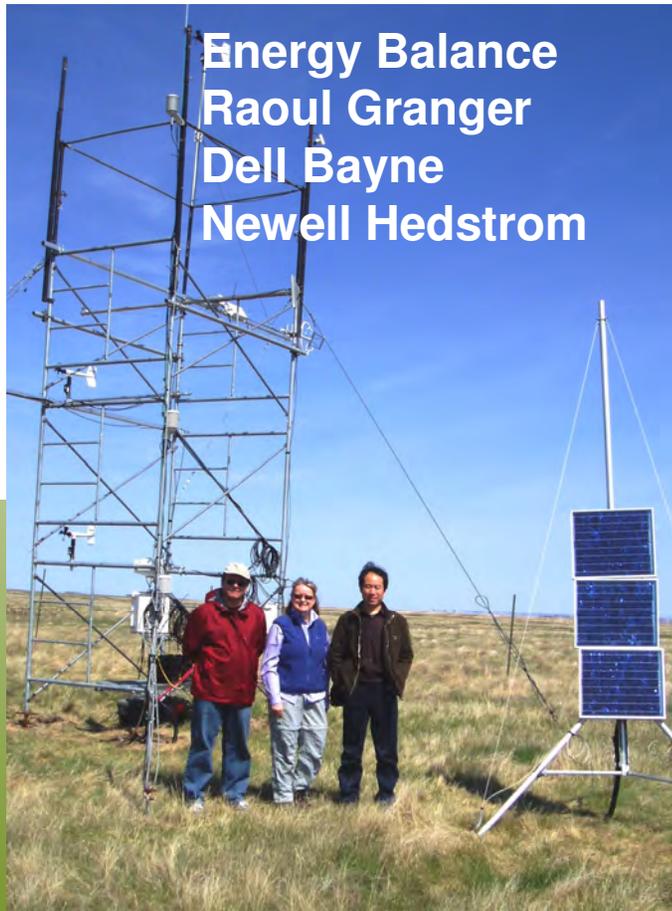
Field Measurement

| Sites | Number of Sites | |
|-----------------------------|-----------------|---|
| Soil moisture/rain stations | 24 | Soil moisture and temp at 0-5cm depth Soil moisture and temp at 20cm depth Soil moisture and temp at 50cm depth Rain (tipping buckets) |
| Annie's well and Flux site | 2 | Precipitation Snow depth Wind speed and direction at 1.5m Air temperature at 1.5m Barometric pressure |
| Flux site | 1 | Geological weighing lysimeter (deep well) water level 3D wind speed and direction Air temperature at 3m and 6m Vapour pressure at 1.5m, 3m and 6m Net radiation Latent heat flux Sensible heat flux Carbon dioxide flux Soil heat flux Friction velocity Momentum flux Water vapour and carbon dioxide density |



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Collaboration and a cast of thousands



Spring of 2001 (looking south)



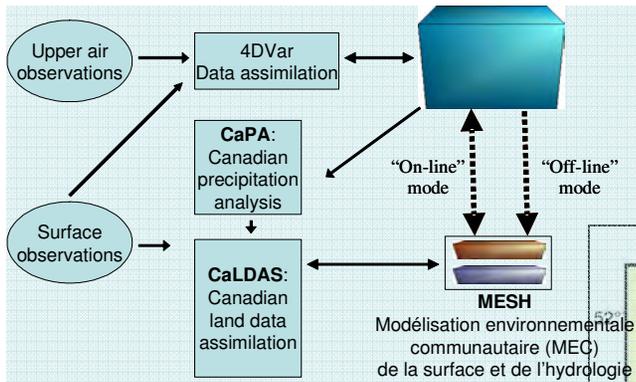
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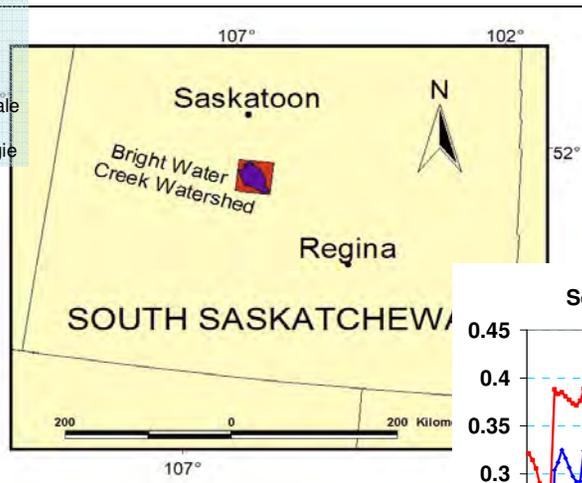
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Application of field data for verification of an Environmental Prediction System (MESH)

EC's Environmental Prediction System



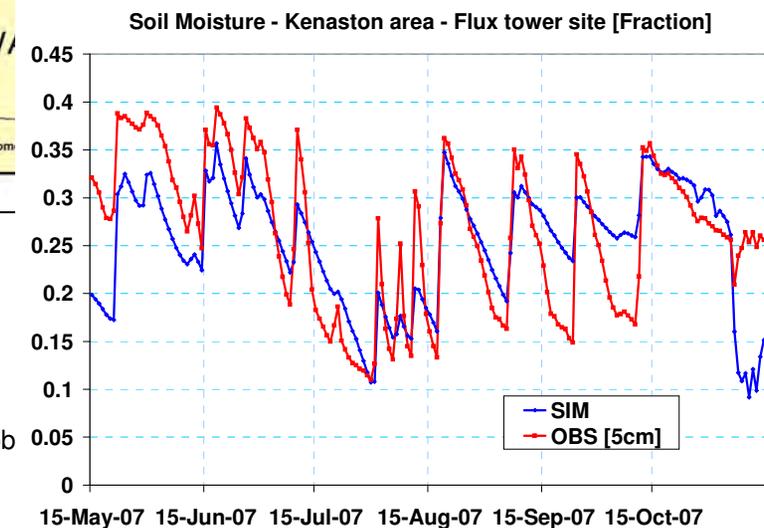
Application of model to study site



Field study



Model results and verification



Collaboration and Model development

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SMAP summary for consideration

Analysis of 2007 measured data demonstrates

- Reasonable closure of the measured water and energy budget

Long term measured dataset

- 72 site and depth specific calibration equations, including temperature dependency

2007-2009 measured data availability

- Time series
 - met, distributed soil moisture and precipitation
 - Lysimetric data
- Point data
 - Soil (24 site), SWE (16 transects)
 - satellite ground truth data (2007, 2008 and 2009 campaigns) includes surface roughness and LAI
- **Model output data for intercomparison**
- **Future efforts include LCM at Kenaston and an Okanagan site**
- **Collaborative papers in sensor calibration and network design with U of Guelph**

