Integration of Land Surface Simulation using MESH and Field Studies in the Prairies

DRI 2009 Workshop

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MSC Environment Canada
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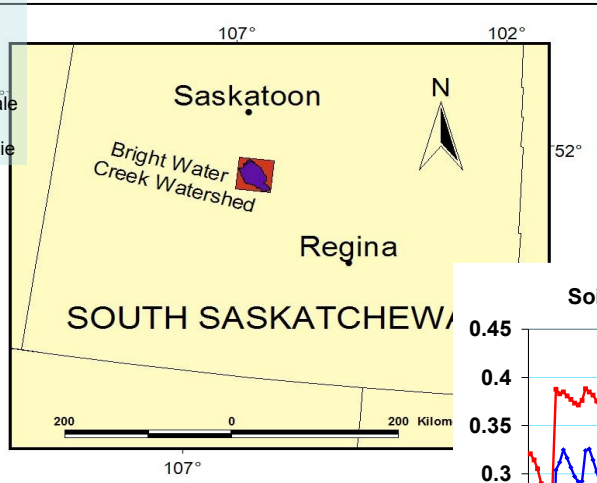# Integration of MESH and Field Studies in the Prairies

- Environmental Prediction System
  - Kenaston Mesonet/Brightwater Creek study (forced by point data and verified by local distributed soil moisture mesonet)
  - Entire SSRB (forced by regional datasets with water availability outputs)
- Analysis of 2007 data, production of the NAESI report
  - Use of the geologic weighing lysimeter in assessing the closure of the local measured water budget in 2007
  - Production of 2002-2007 water availability indicators and assessment of modelled error for water budget (SSRB)
- Review of available data for 2008
- Projected data for 2009

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Application and verification of an Environmental Prediction System (MESH)

EC's Environmental Prediction System
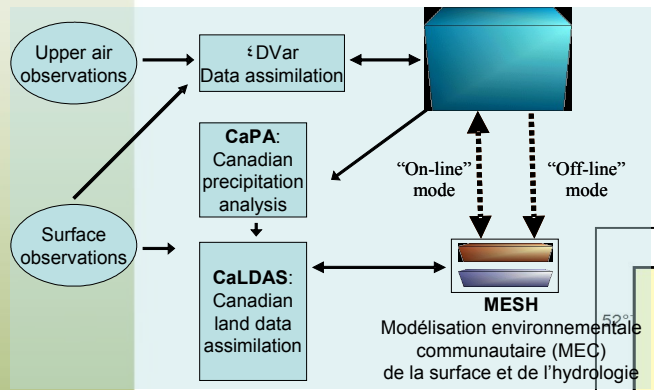
Field study

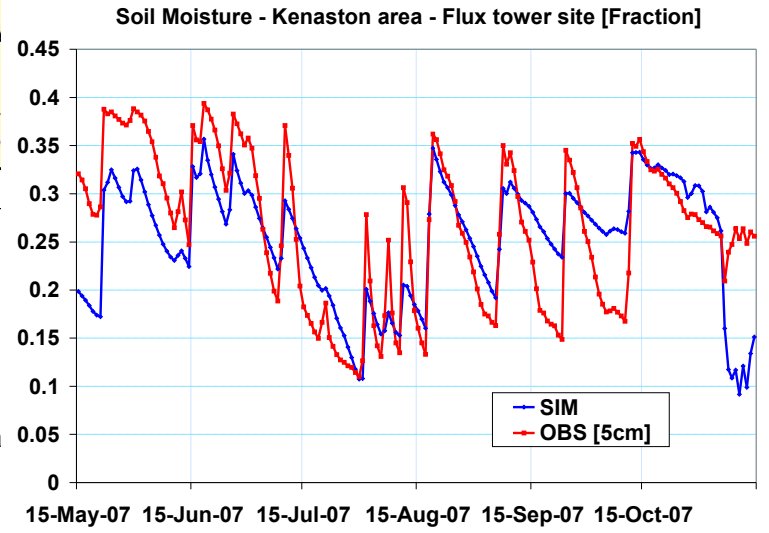## Application of model to study site
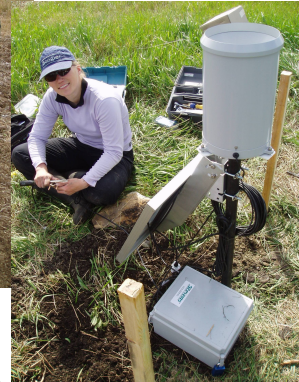
Model results and verification

Soil Moisture - Kenaston area - Flux tower site [Fraction]

Collaboration and Model development

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Two nested modelling domains

RPN MESH runs

SSRB
xOrigin	-117.0000
yOrigin	48.0000
xCount	60
yCount	27
xDelta	0.2°
yDelta	0.2°

Stand alone MESH runs

Brightwater Creek
xOrigin	-106.6836
yOrigin	51.199
xCount	54
yCount	52
xDelta	800 m
yDelta	800 m

CANADA

SOUTH SASKATCHEWAN

ALBERTA

SASKATCHEWAN

BRITISH COLUMBIA

SSRB Sub-basins
- Bigstick Lake
- Bow River
- Oldman River
- Red Deer River
- Seven Persons Creek
- South Saskatchewan River
- Swift Current Creek

U.S.A.
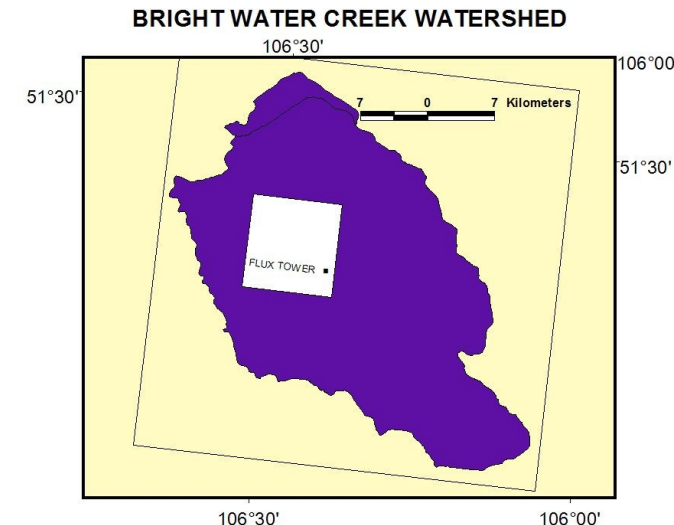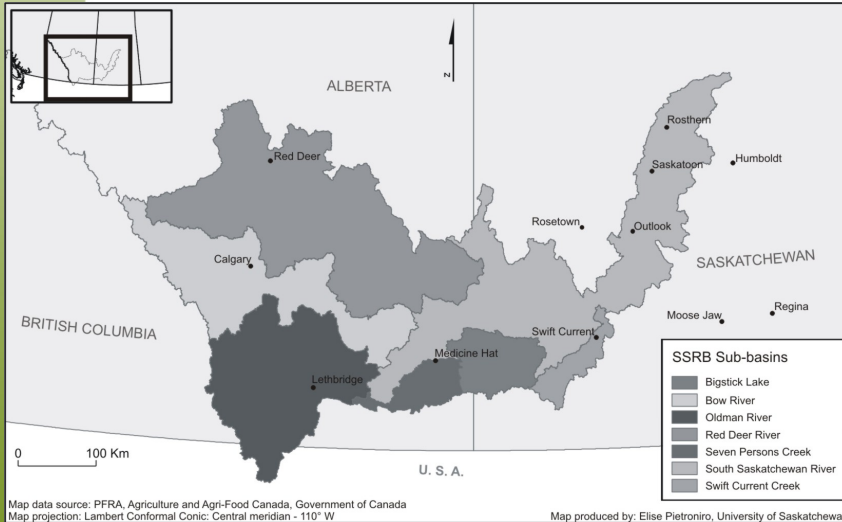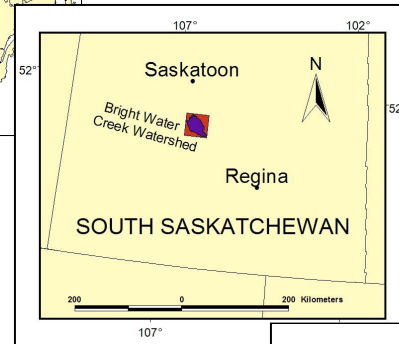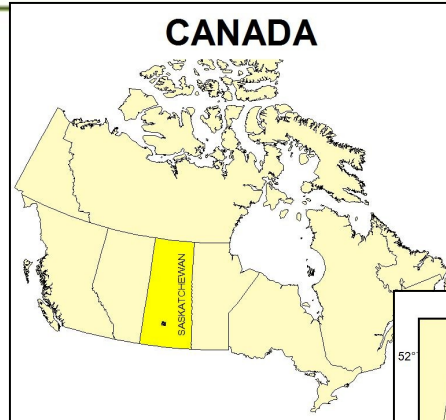
Map data source: PFRA, Agriculture and Agri-Food Canada, Government of Canada
Map projection: Lambert Conformal Conic: Central meridian - 110° W
Map produced by: Elise Pietroniro, University of Saskatchewan

BRIGHT WATER CREEK WATERSHED

FLUX TOWER

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Stand alone MESH runs
Study site – Kenaston/Brightwater Creek

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BRIGHT WATER CREEK WATERSHED

Site

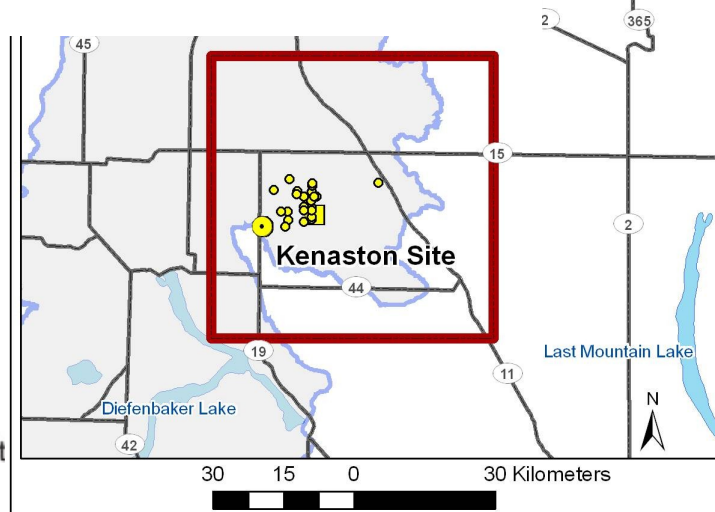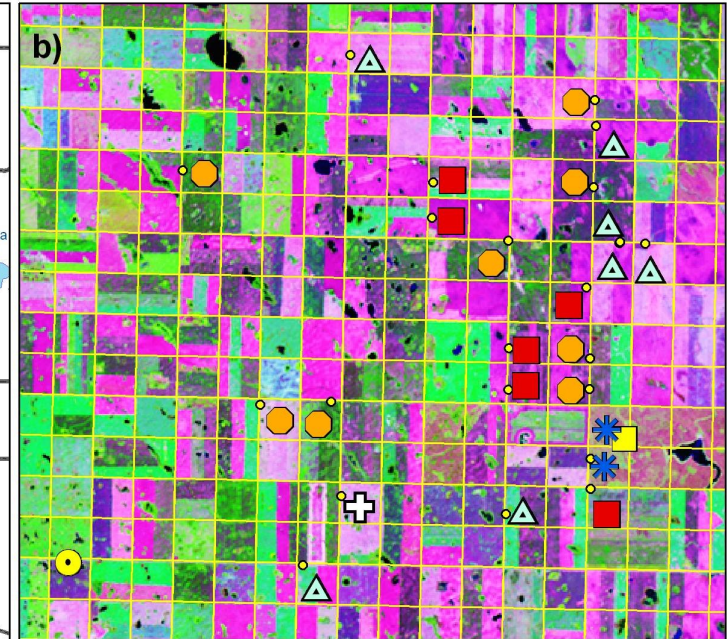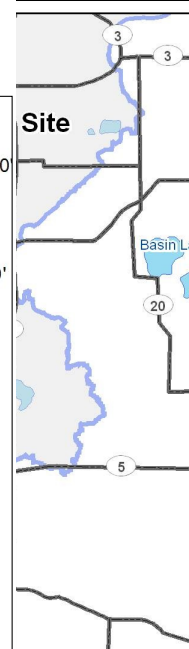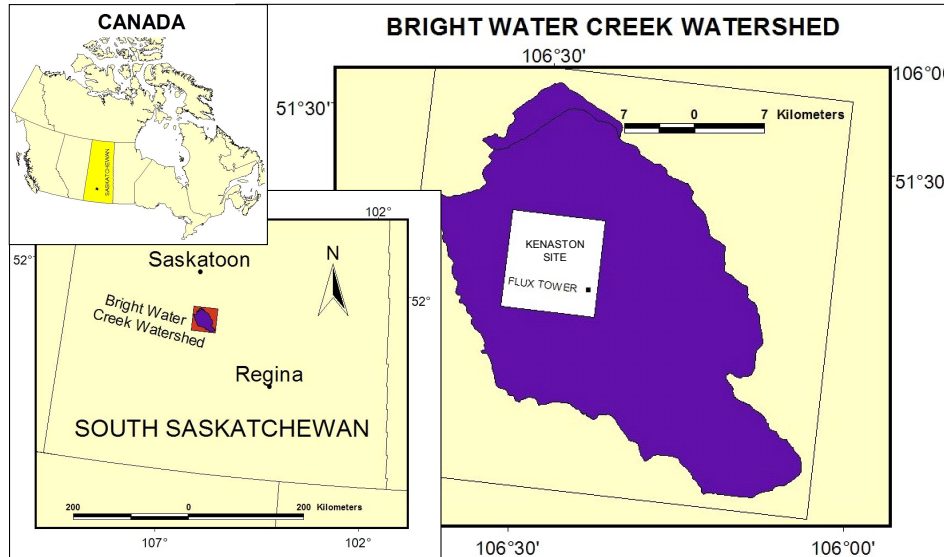KENASTON SITE

FLUX TOWER

Saskatoon

Bright Water Creek Watershed

Regina

SOUTH SASKATCHEWAN

b)

c)

Kenaston Site

Last Mountain Lake

Diefenbaker Lake

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30   15   0   30 Kilometers

- ⬡ Cereal Crop
- △ Oil Seed Crop
- ✳ Pasture
- ◼ Pulse Crop
- ✚ Specialty Crop
- ▢ Quarter Section Grid (800x800m)
- ○ 16-Point Survey Grid
- ● Duck Lake Well & Meteorological Equipment
- ⊙ Annie's Well & Meteorological Equipment
- ▢ Evaporative Flux & Meteorological Equipment
- · Soil Moisture/Rain Station Network
- ▢ South Saskatchewan River Basin
- ▢ Extent of Univ of Guelph Soil Moisture Network

Use of geological weighing lysimeter to asses closure of 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 <u>pore water pressure</u>;

  ➢ 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

tens of meters

p

t

Pressure Transducer
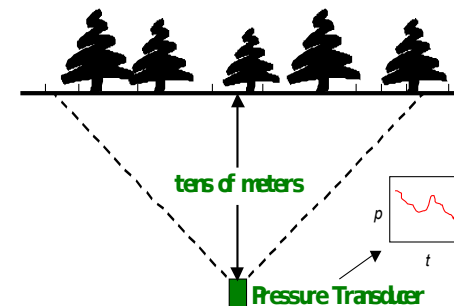
Van der Kamp et al, 2003

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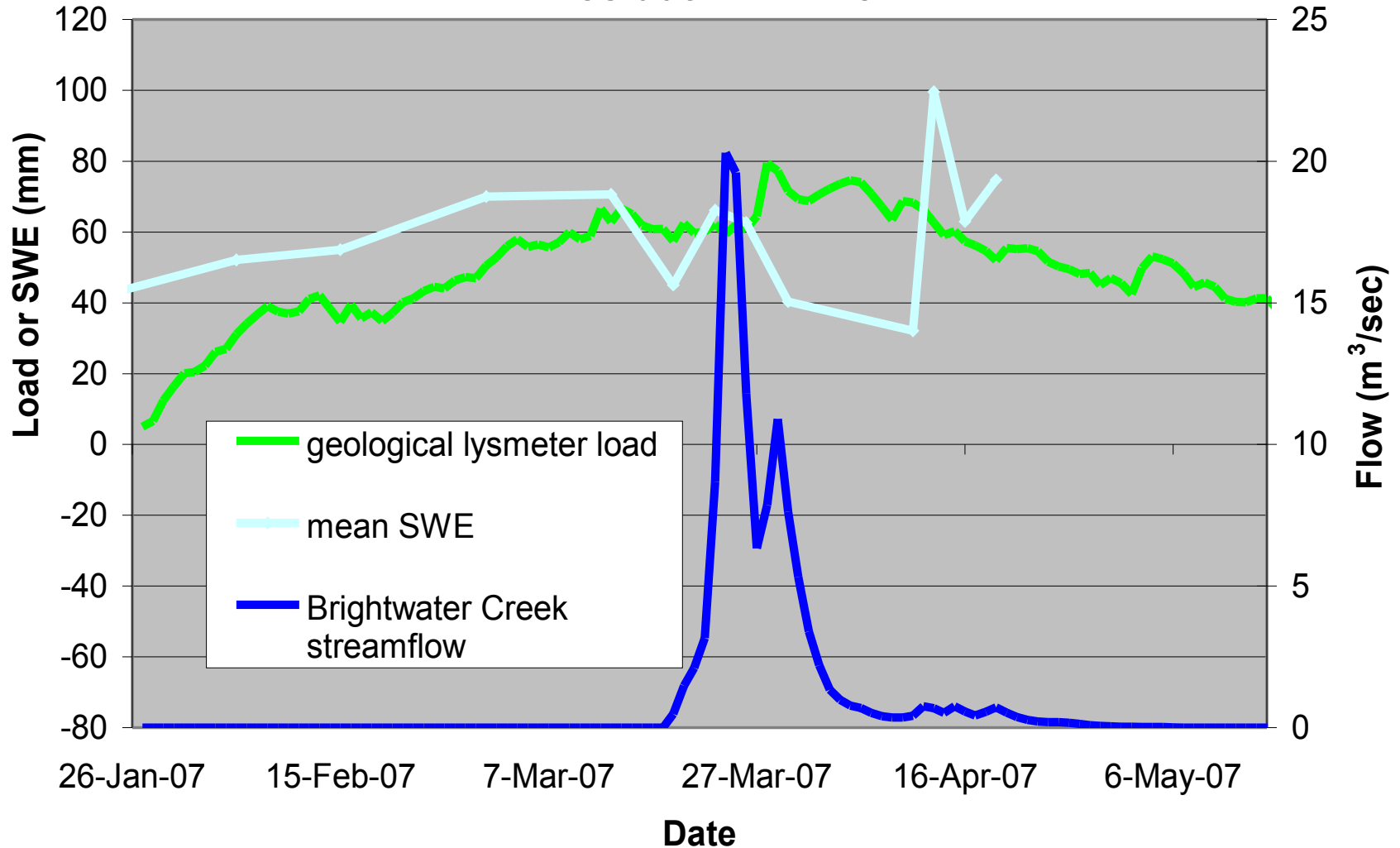# Geologic weighing lysimeter with measured precip and soil moisture
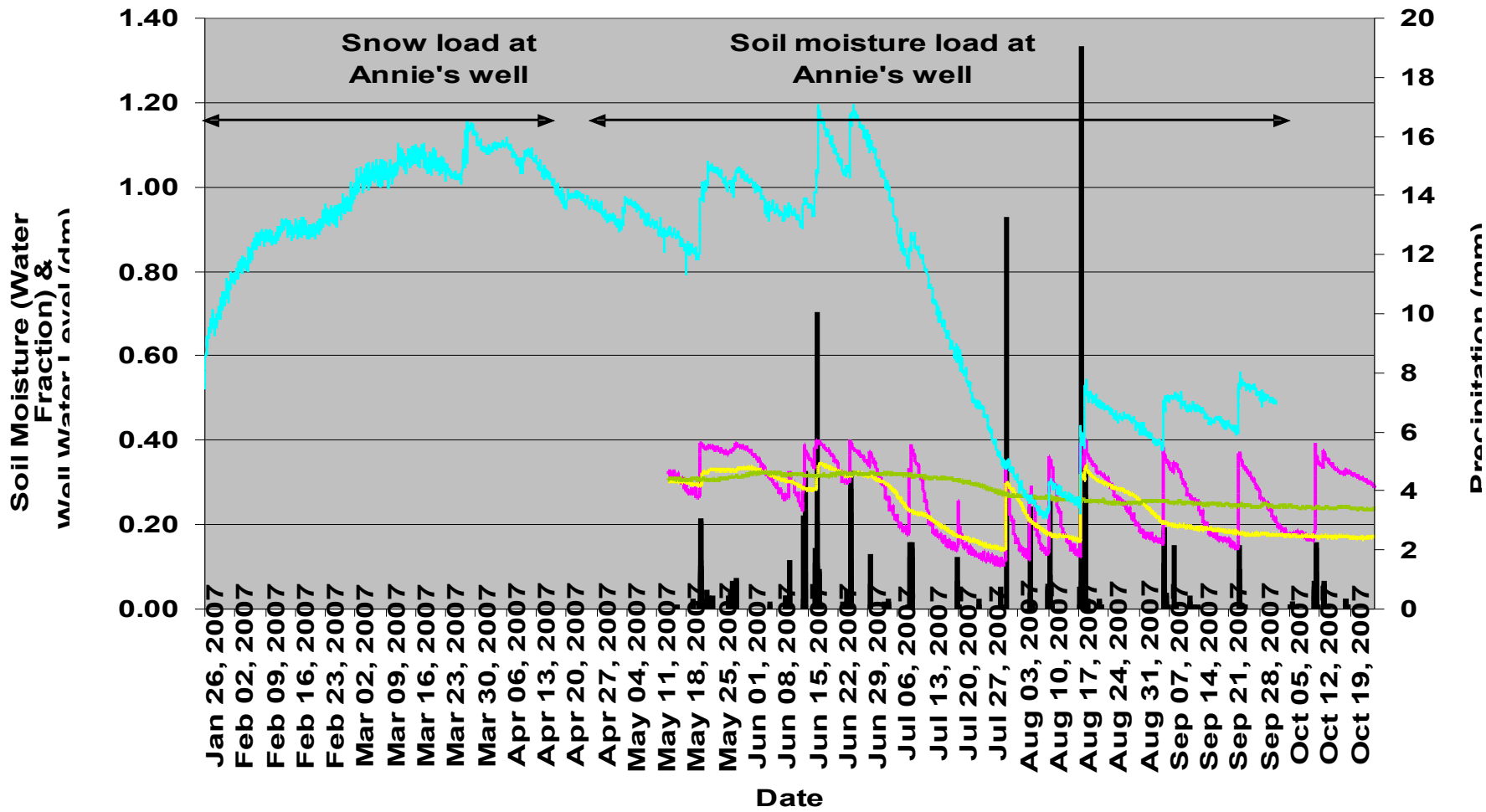
Winter/Spring lysimetric, SWE and flow measurements

Precip = 96.5 mm   **ET = 0 mm**   Runoff = 32 mm   Δ S = 40 mm

Residual = +24.5 mm

Summer/Fall lysimetric, flux and soil moisture measurements

Precip = 233 mm   ET = 229 mm   **Runoff = 0 mm**   Δ S = -55 mm
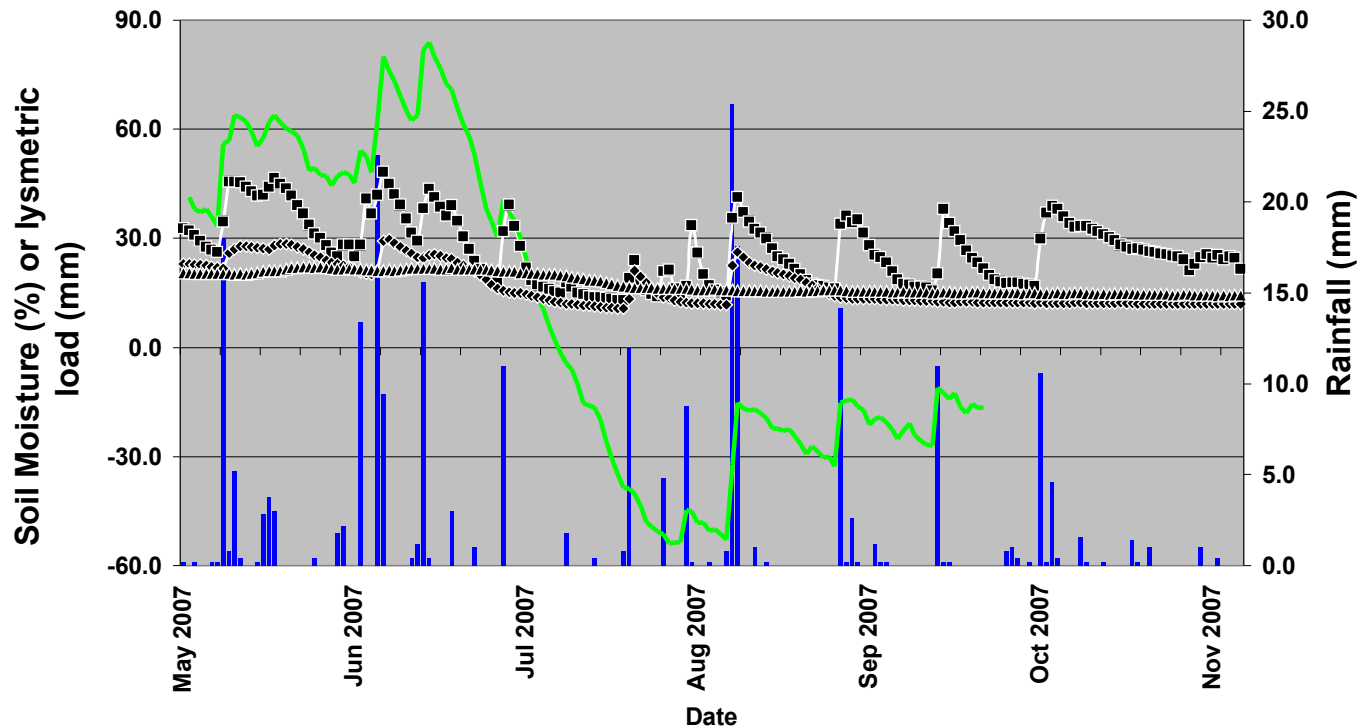
Residual = 59 mm

Precip = 329.5 mm   ET = 229 mm   Runoff = 32 mm   Δ S = -15 mm

Cumulative Residual = 83.5 mm (25% of precipitation)

Modelled and measured soil moisture
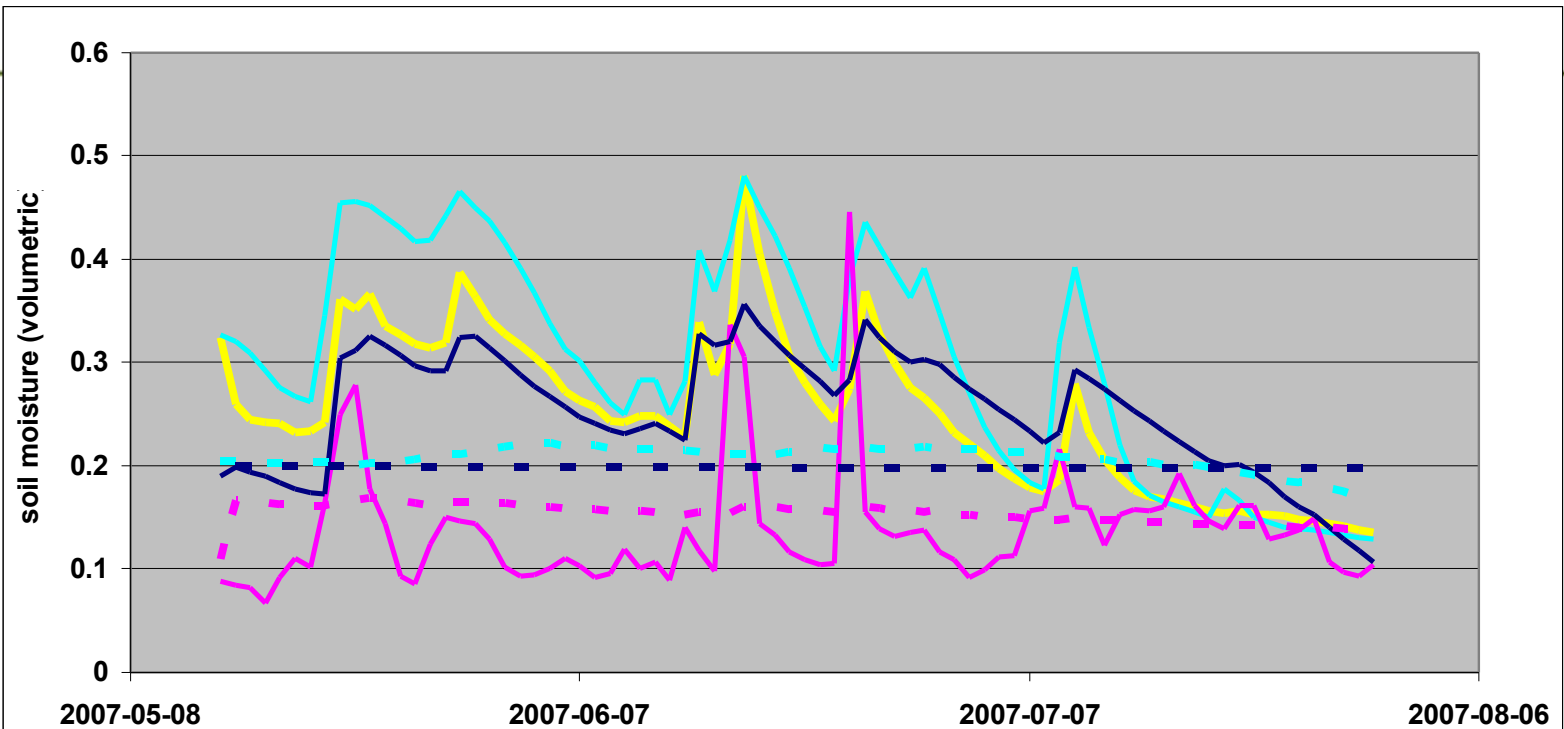
Distributed soil moisture as model output – RPN MESH runs over SSRB

- Pierre Pellerin, Vincent Fortin, Stephane Belair, Marco Carrera, Isabelle Dore, and others in RPN in Dorval
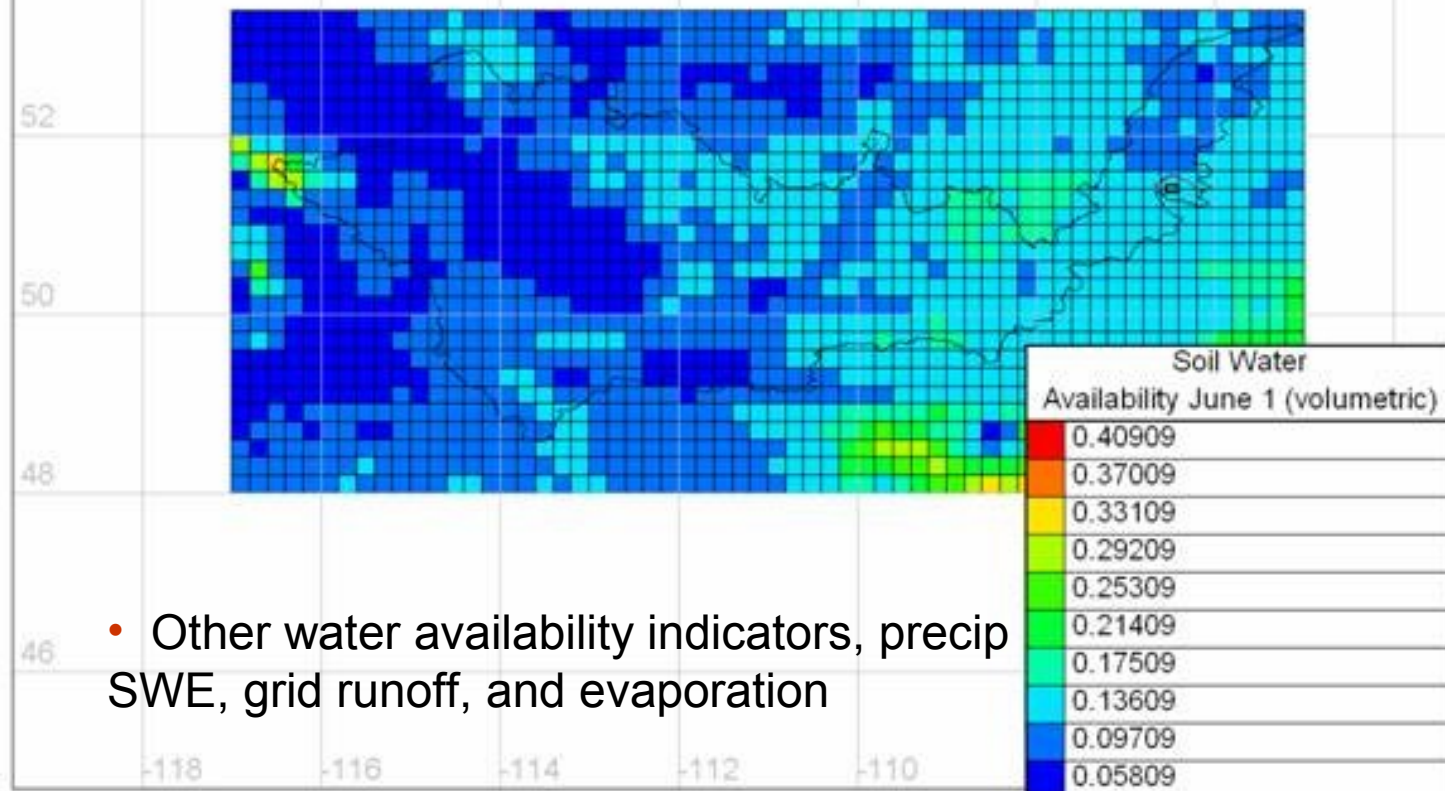
- Other water availability indicators, precip SWE, grid runoff, and evaporation

Soil Water Availability June 1 (volumetric)

0.40909
0.37009
0.33109
0.29209
0.25309
0.21409
0.17509
0.13609
0.09709
0.05809

2002-2007 modelled water availability indicators (SSRB), closure of water budget

availability parameter	2002	2003	2004	2005	2006	2007	average
total precipitation	394.7	334.0	392.5	**525.0**	396.2	447.0	414.9
evaporation	279.3	285.2	279.0	335.0	**354.4**	351.2	314.0
total runoff	59.4	61.9	61.7	**104.8**	77.0	85.5	75.0
ground water recharge	7.0	8.1	6.2	**12.6**	10.1	9.2	8.9
interflow	0.03	0.03	0.03	0.06	0.04	0.04	0.04
continuity equation *	49.0	-21.3	45.6	**72.6**	**-45.3**	0.9	16.9
error (% of precip)	17.5%	-7.5%	16.4%	**21.7%**	**-12.8%**	0.3%	5.9%
average SWE	15.9	15.7	15.9	14.6	15.0	**19.8**	16.1
average soil moisture (vol %)	0.12	0.14	0.13	0.15	**0.16**	0.15	0.14
spring soil moisture (vol %)	0.16	0.18	0.15	0.19	**0.20**	0.19	0.18
fall soil moisture (vol %)	0.11	0.12	0.12	0.13	0.13	0.13	0.12
summer withdrawal from storage	23.6	29.6	17.1	26.9	**34.8**	30.6	27.1

*   error = precip - evap - runoff - recharge -interflow - (change in storage)

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2008 datasets

- Snow surveys
- precip/soil moisture (distributed)
- energy flux data (point)
- geologic weighing lysimeter (areal)
- Satellite overpass July and November

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
	1	Geological weighing lysimeter (deep well) water level
Flux site		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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Summary for consideration to DRI

Analysis of 2007 measured and modelled data demonstrates
- Closure of the measured water budget shows a possible error of 25%
- Stand alone MESH to reasonably replicates some water availability parameters

Water availability study modelling data
- End of drought through to drought recovery comparison of indicators
- Modelled water balance closure (i.e. assessment of total error) is within measured error

2007 and 2008 measured availability
- Time series
  - met, distributed soil moisture and precipitation
  - Lysimetric data
- Point data
  - Soil (24 site), SWE (16 transects)
  - satellite ground truth data (2007 and 2008 campaigns)
- Model input/ouput (2002 – 2007 input/output data)
- Geophysical fields, forcing, output (5 indices)
- Available through NAESI and/or DRI website

2009 or 2010 data, significant ground truth data added to above

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Support and collaboration

- DRI supported post doctoral fellow Dr. Saul Marin for a portion of 2008
- Doctoral candidate Dean Shaw
- In kind support to DRI from EC
  - Bruce Davison Anthony Liu (MEC/MESH modelling)
  - Brenda Toth (NAESI)
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  - EC support for Diane Holman, Aditi Garg, Cody Fong as research assistants
  - Collaborative support from IP3 and IPY supported students Andy Salisbury, Robin Wilson, Craig Thompson
- Collaborative projects with Dr. Aaron Berg (Univ of Guelph), Ramata Maggigi (Univ of Sherbrooke), Anne Walker (EC/Downsview)

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