Sub-grid scale processes: the role of snow and lakes at the arctic forest/tundra transition

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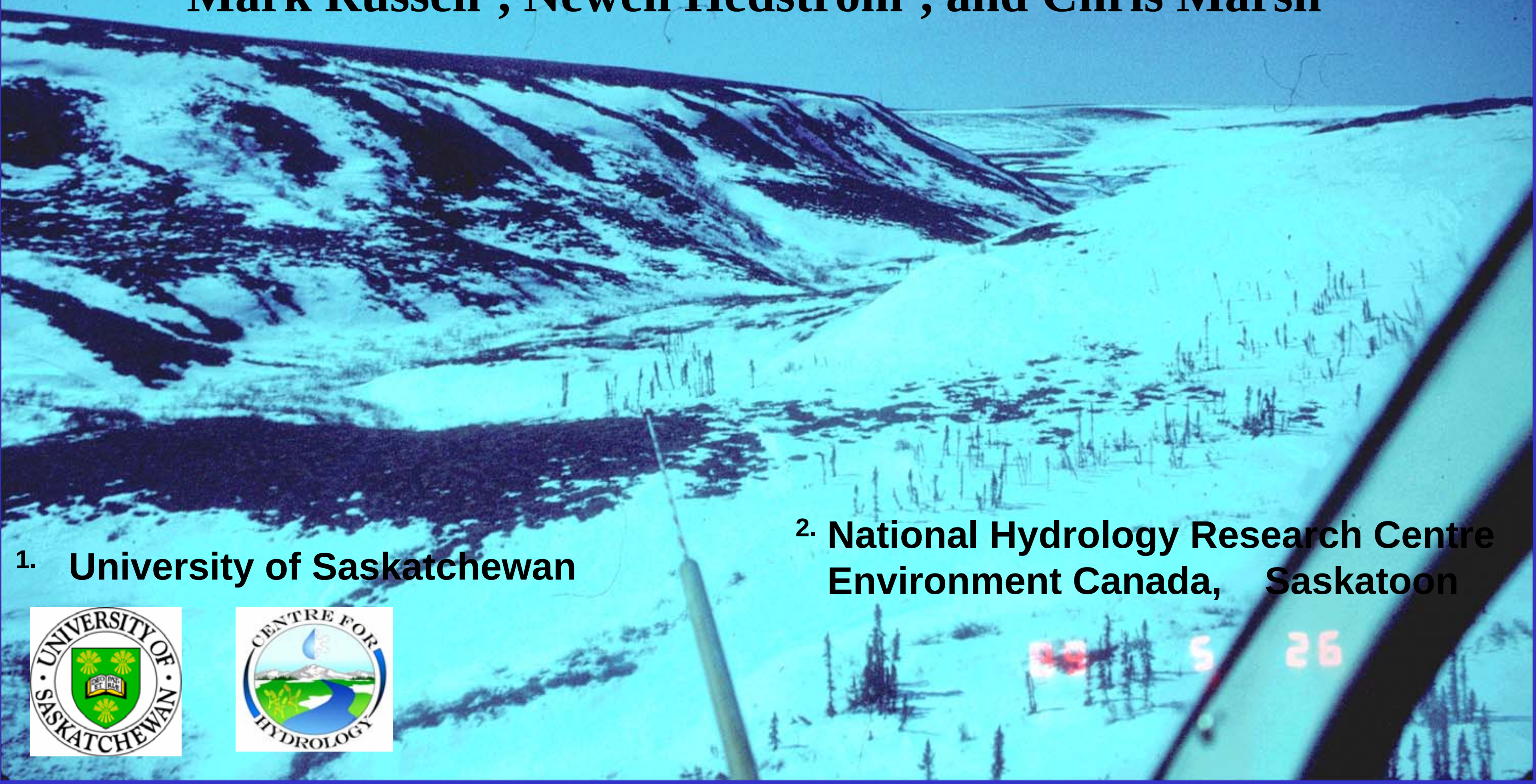

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[2.] National Hydrology Research Centre
Environment Canada, Saskatoon

Outline

1. **Study sites**

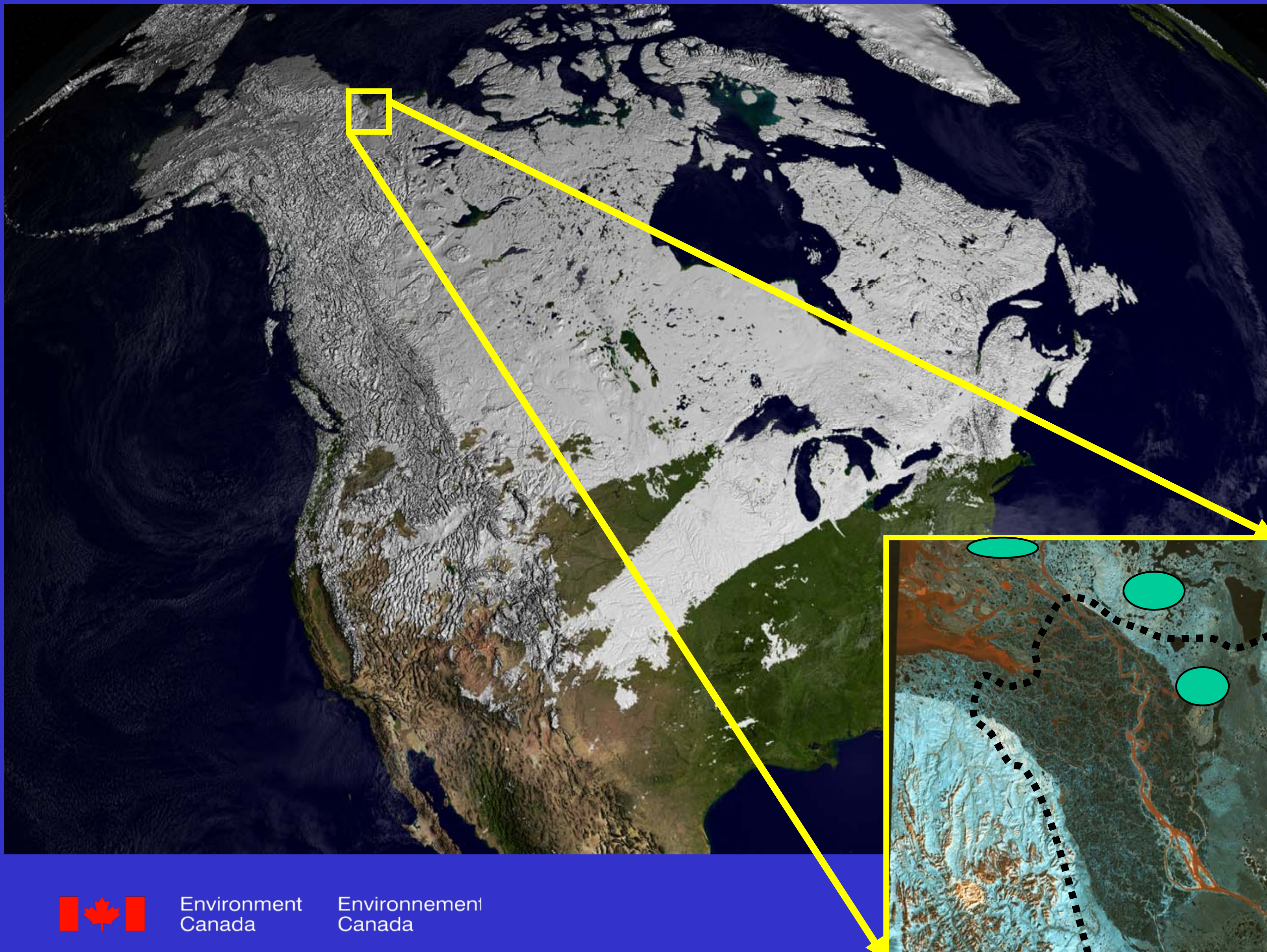
2. **2006/07 data collection**

3. **Snow processes**
   - **Compare the effect of shrub and tundra surfaces on snow accumulation and melt**

4. **Process modelling**

5. **Lakes (WILL NOT DISCUSS LAKES IN THIS TALK)**

6. **Plans for the remainder of year 2 and year 3**



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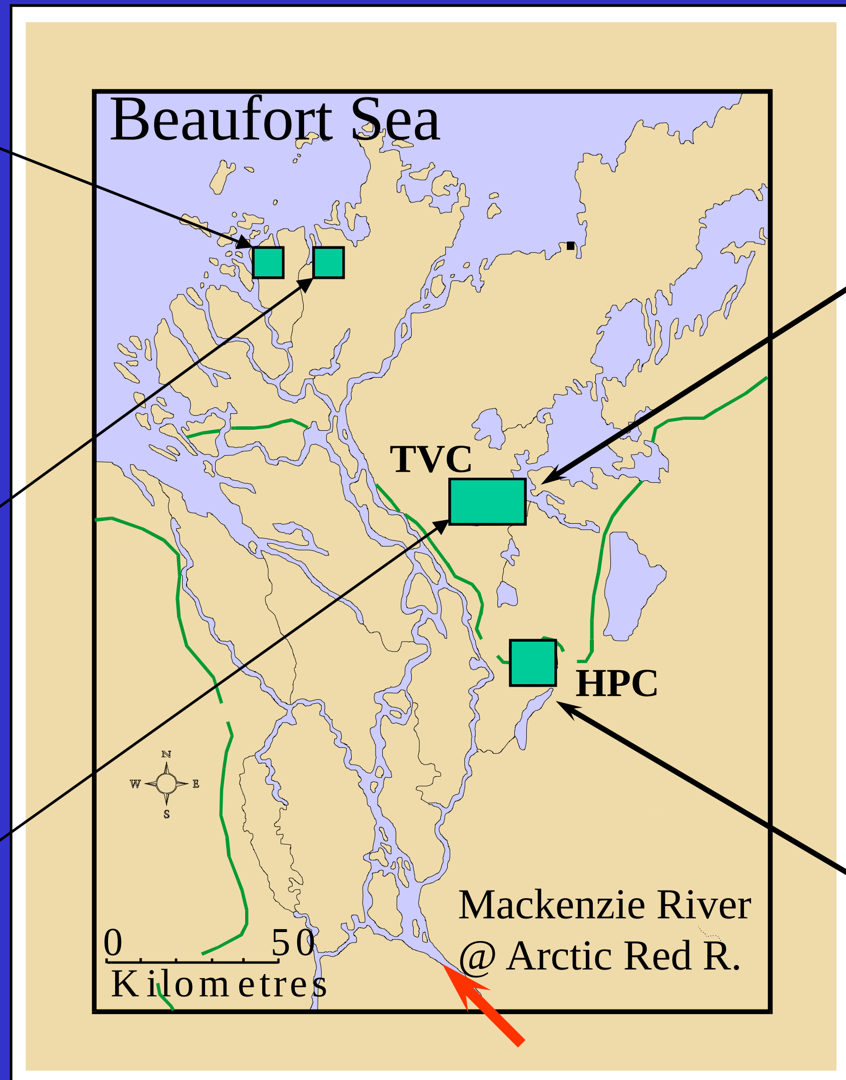
Field Sites - Inuvik, NWT area



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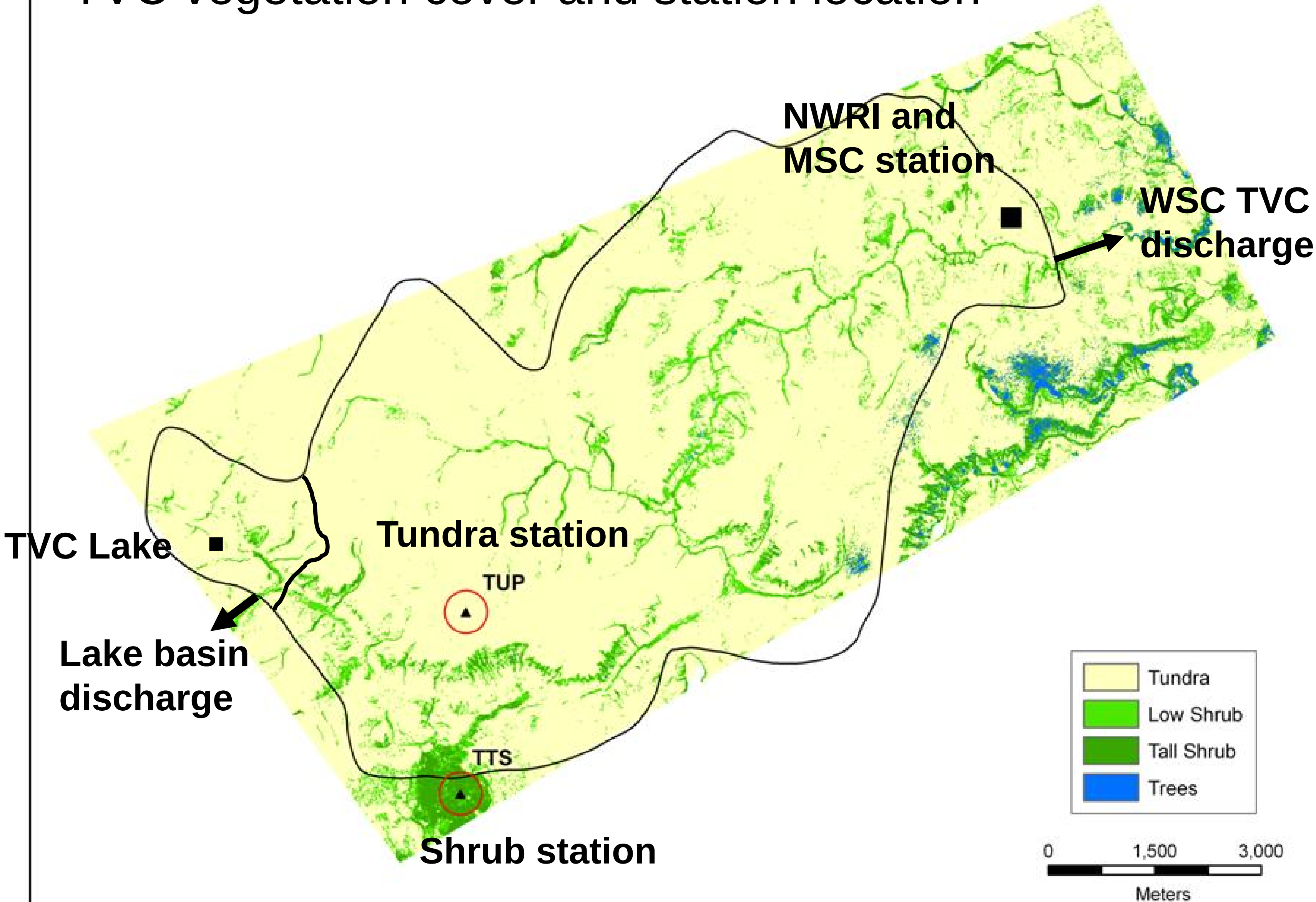
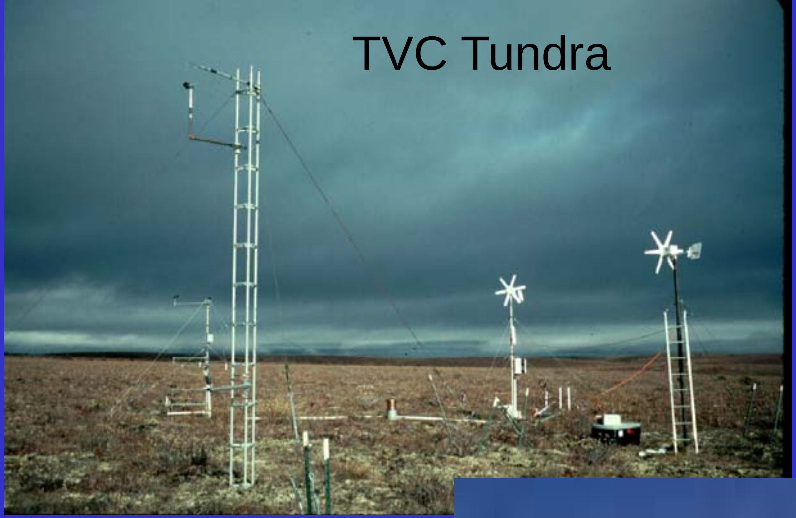
TVC vegetation cover and station location



Similar vegetation maps are available for Havikpak Creek


TVC Tundra


TVC Tundra


HPC Forest


TVC Shrub


TVC Shrub

Lake instrumentation

Water Survey Canada lake water level gauge

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Terrestrial sites: Instrumentation – 2006-07

Terrestrial sites (annual)	Instrument
Air temp/RH	HMP35CF
Barometric Pressure	Setra
Wind speed/direction	RM Young
Rainfall	Tipping bucket
Precipitation	Geonor weighing alter
Incoming/outgoing short/long	CNR1
Surface temperature	Everest IR
Ground temp + heat flux	Campbell themistors and HFP
Snow on ground	Campbell SR50
Sensible and Latent Fluxes	Campbell CSAT + Krypton Hygrometer + 21x
Discharge	Water Survey Canada
Stream velocity	Price + acoustic doppler

7 stations including:

1. HPC main met,
2. TVC MSC,
3. TVC main met,
4. TVC shrub,
5. TVC tundra,
6. Denis Lagoon and
7. Big Lake

Sensible and latent flux measurements are seasonal

Lake sites: Instrumentation 2007

Lake sites (summer only)	Instrument
Same as terrestrial sites as appropriate, plus	
Water level	RBR pressure recorder
Water temperature	RBR temperature recorder
Lake discharge	Acoustic doppler

2 sites including:

1. TVC Lake
2. Denis Lagoon

Typical problems with unattended winter measurements

Process and Parameterization

- Observations at all study sites during 2006/07, and analysis of these data are ongoing

- Process modelling to date include:
    - Cold Regions Hydrologic Model (CRHM)
    - Glen Liston's Snow model
    - GEOTOP
    - TOPOFLOW

  – All of these are small scale hydrologic models that will allow testing of, and comparison of, parameterizations on snow accumulation and melt, and allow comparison of methods to scale to the correct scale needed for prediction

Role of shrubs in controlling snow accumulation and melt

- **Previous work has shown the expansion of shrub areas into the tundra north of Inuvik**

- **Previous modelling of snow accumulation and melt at shrub sites at TVC was shown to have lower accuracy than for tundra sites or for drift locations (Pohl et al.).**

- **This uncertainty is due to difficulties in modelling:**

  - **shrub behaviour**

  - **effect of shrubs on radiation and**

  - **effects of shrubs on turbulent fluxes.**

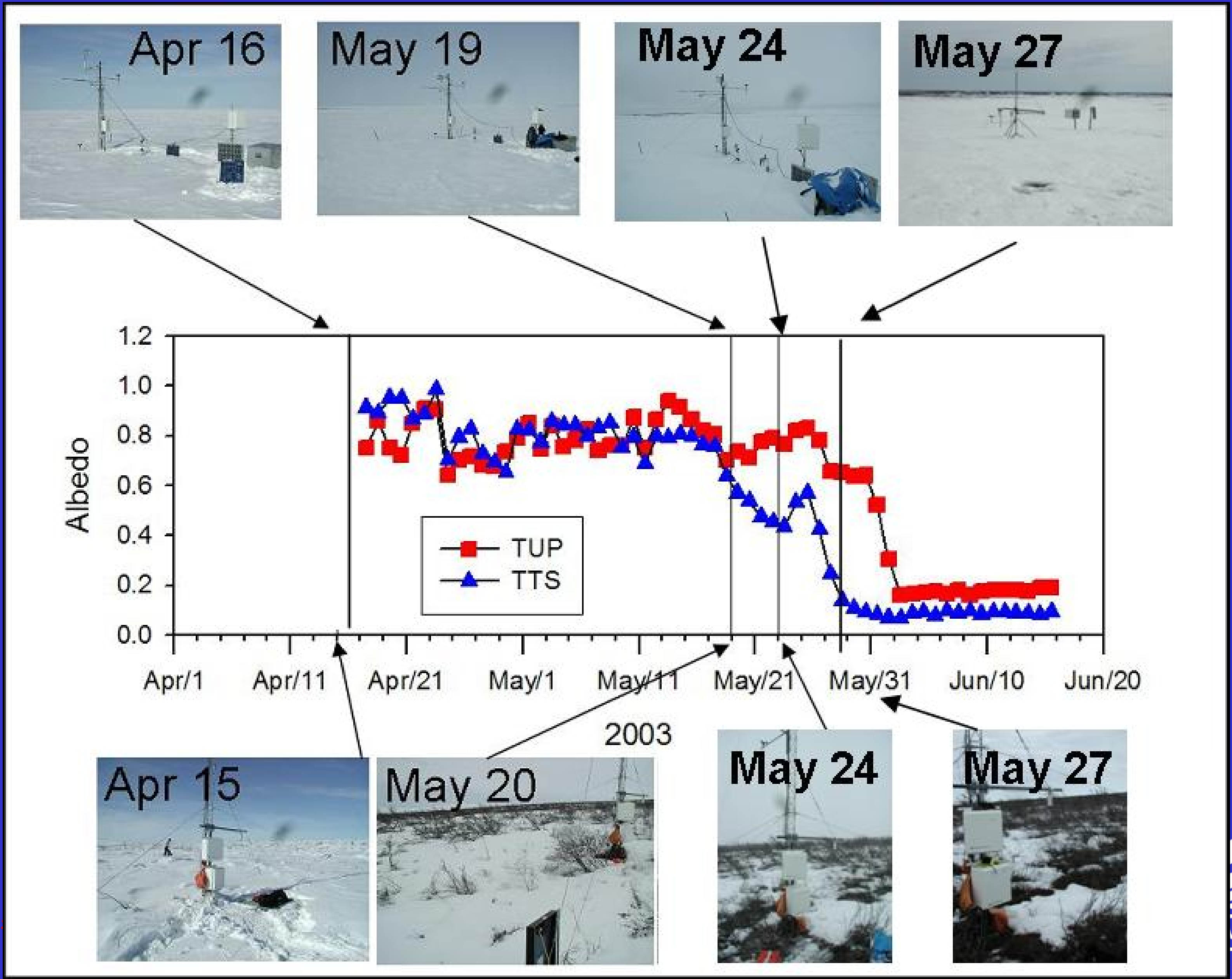
During spring 2003, most of the shrubs were ”bent” over, and covered by snow

Snow depth between 30 to 60 cm

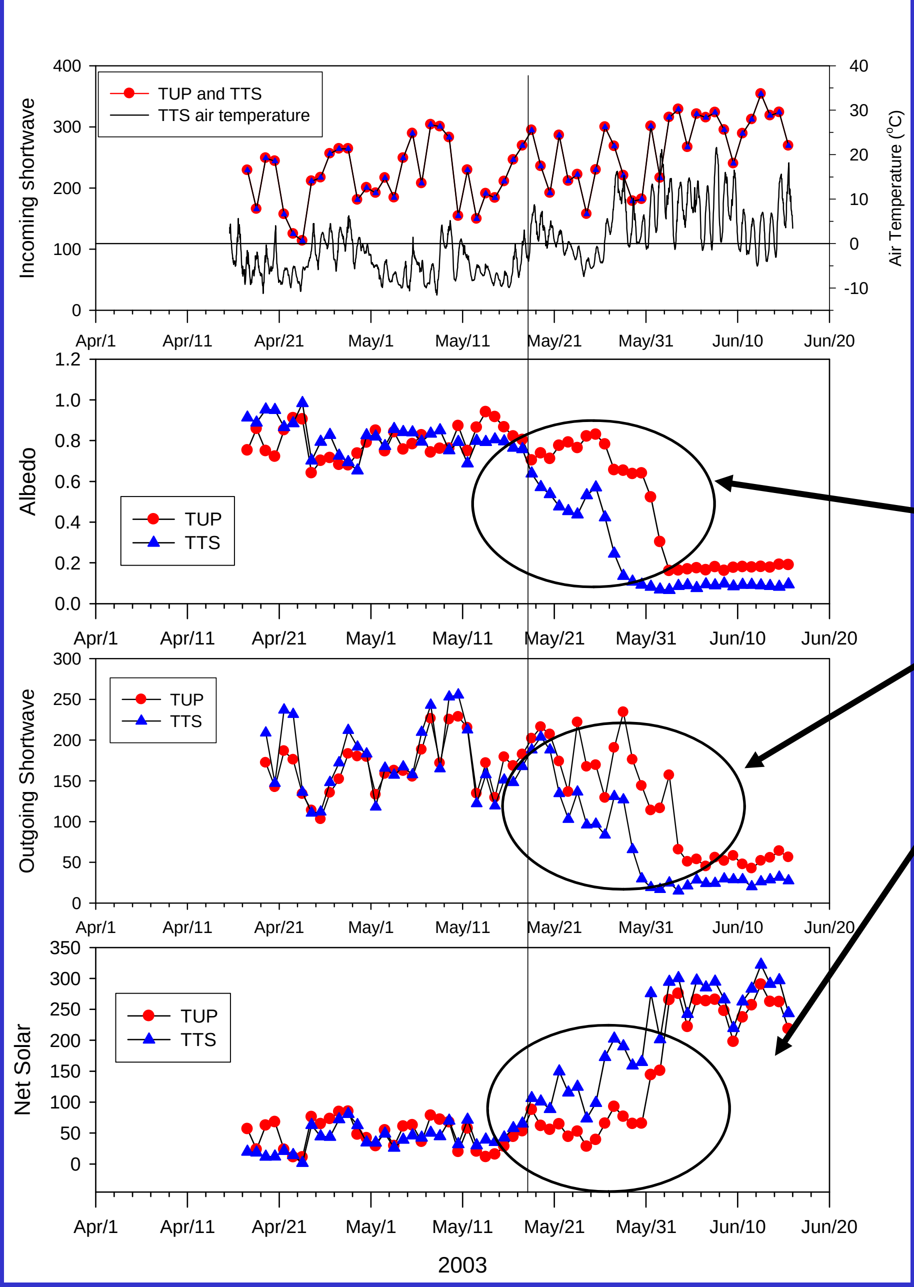
Shrub heights between 1.5 m to 3 m

Range of conditions during the 5 study years, with shrubs almost completely covered in 2003, mostly standing above the snow in 2005, and the other years being between these extremes.

Effects of shrubs on albedo during melt

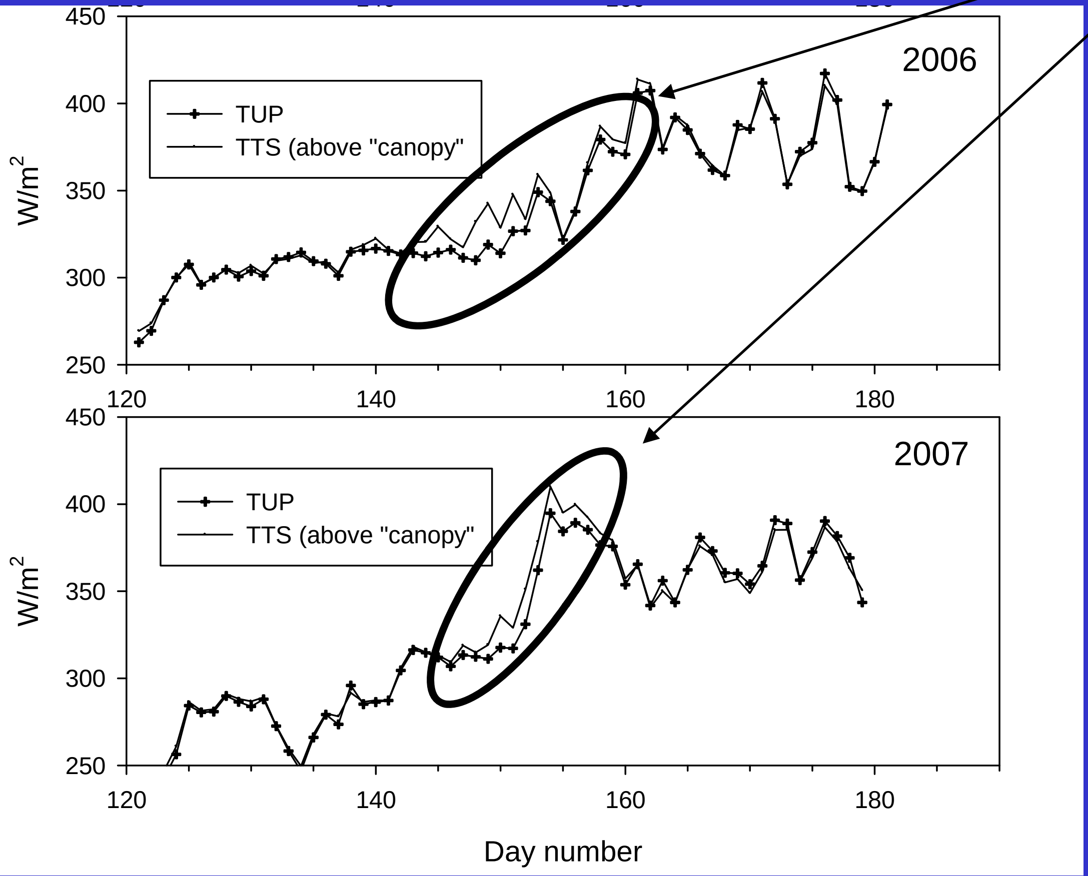


Shortwave Radiation at a shrub and tundra site



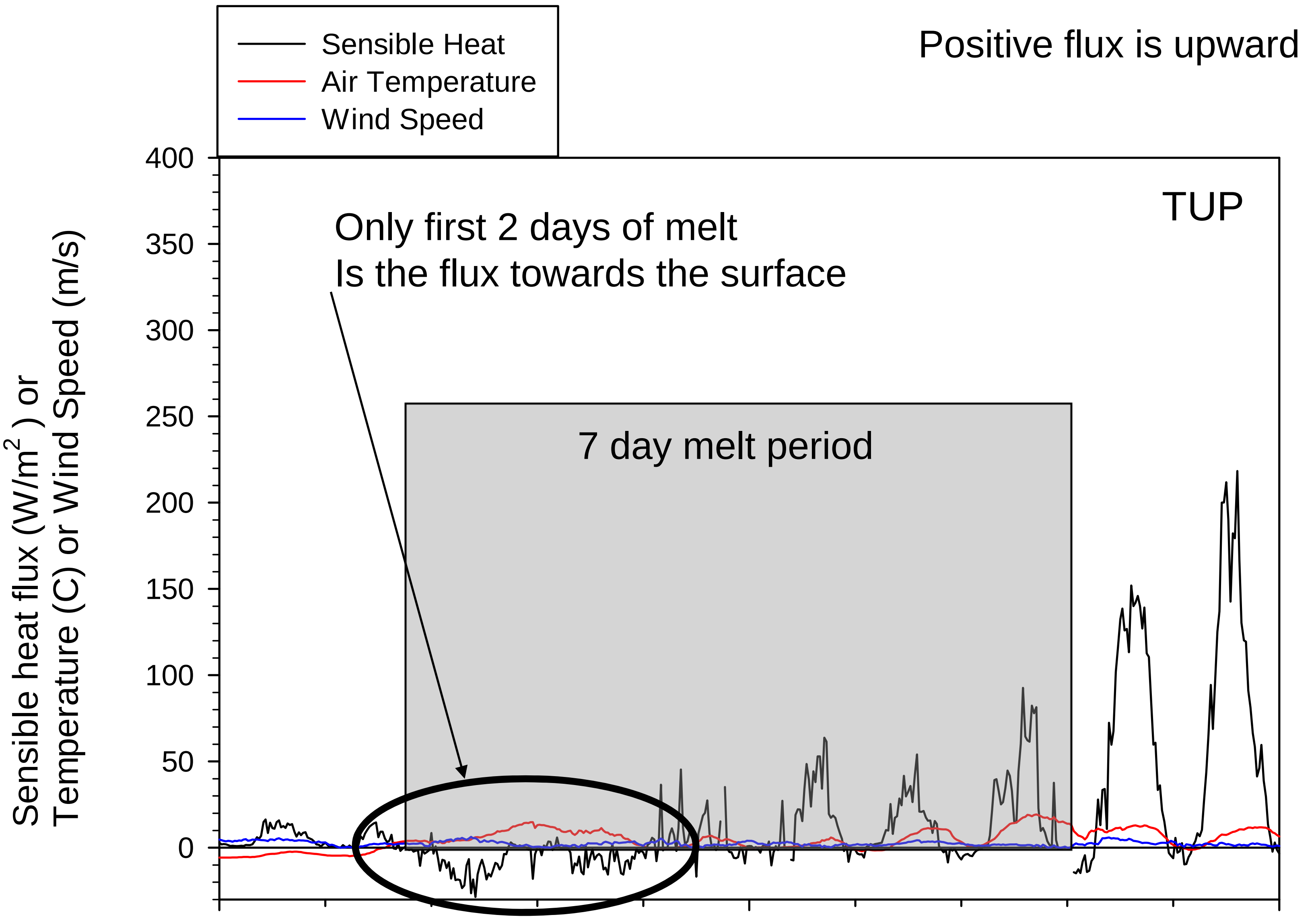
Lower albedo at the shrub site, results in less outgoing shortwave, and therefore increased absorbed shortwave

Outgoing longwave radiation at a shrub and tundra site



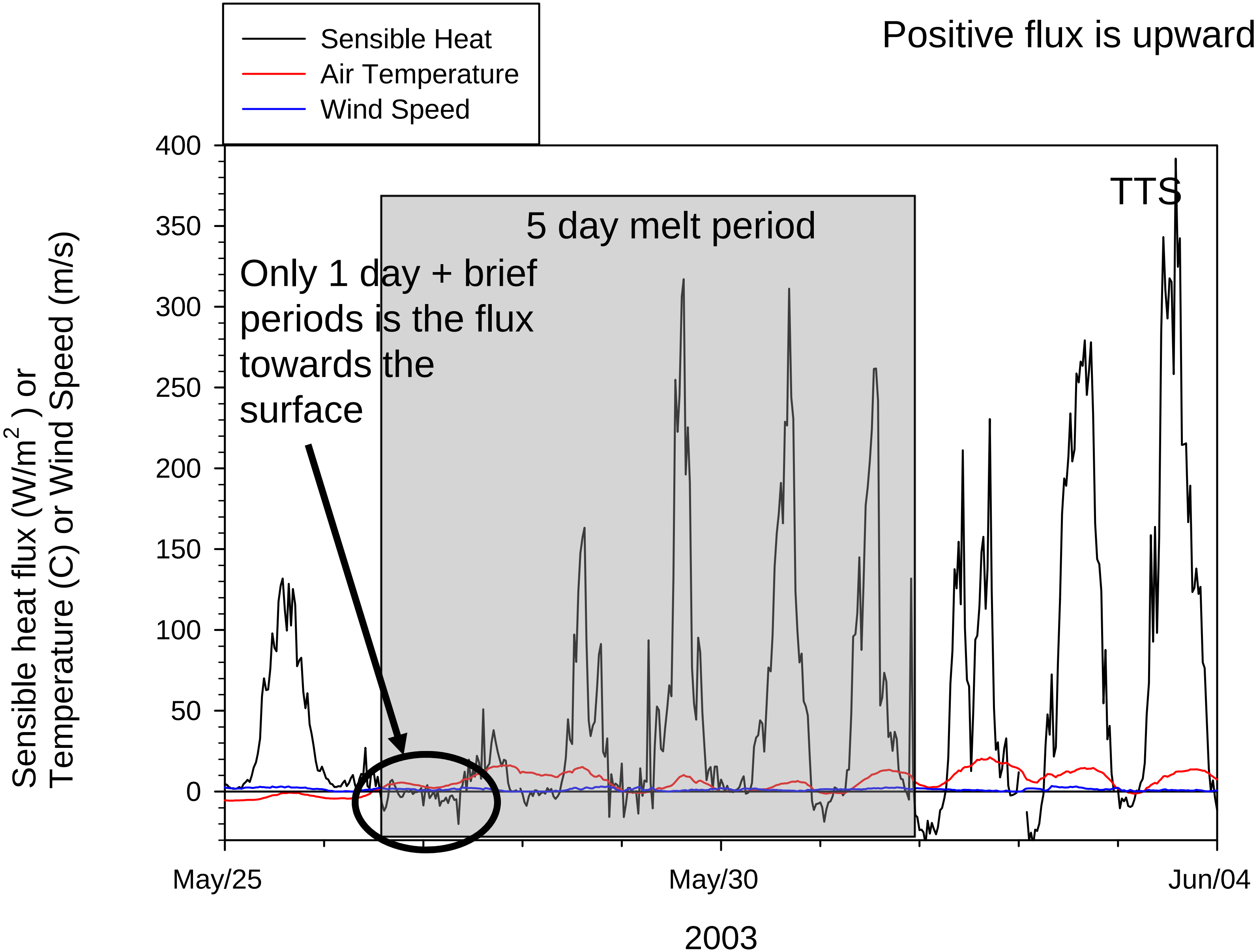
Increased longwave emission at the shrub site due to the occurrence of exposed shrubs with warmer stems

Sensible Heat Flux at a Tundra site (TUP)

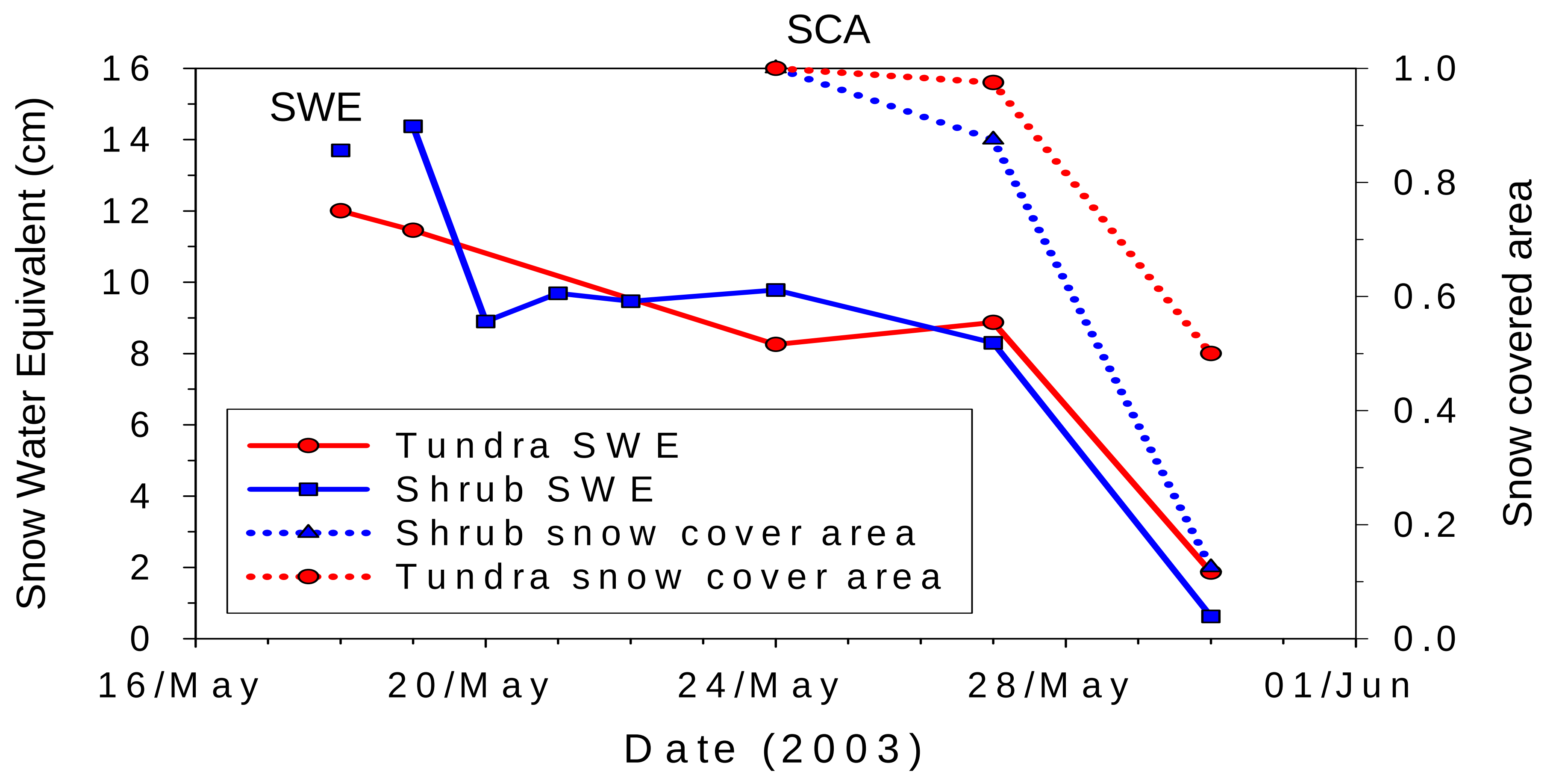


2003

Sensible Heat Flux at a Shrub site (TTS)



Change in snow covered area and snow water equivalent with increased melt at the shrub site, and snow being removed from first at the shrub site



Process modelling to date include:

- Cold Regions Hydrologic Model (CRHM)
- Glen Liston’s Snow model
- GEOTOP (see poster by Stefano Endrizzi)
- TOPOFLOW

Cold Regions Hydrological Model (CRHM

- Preliminary test as applied to Trail Valley Creek for 1998/99

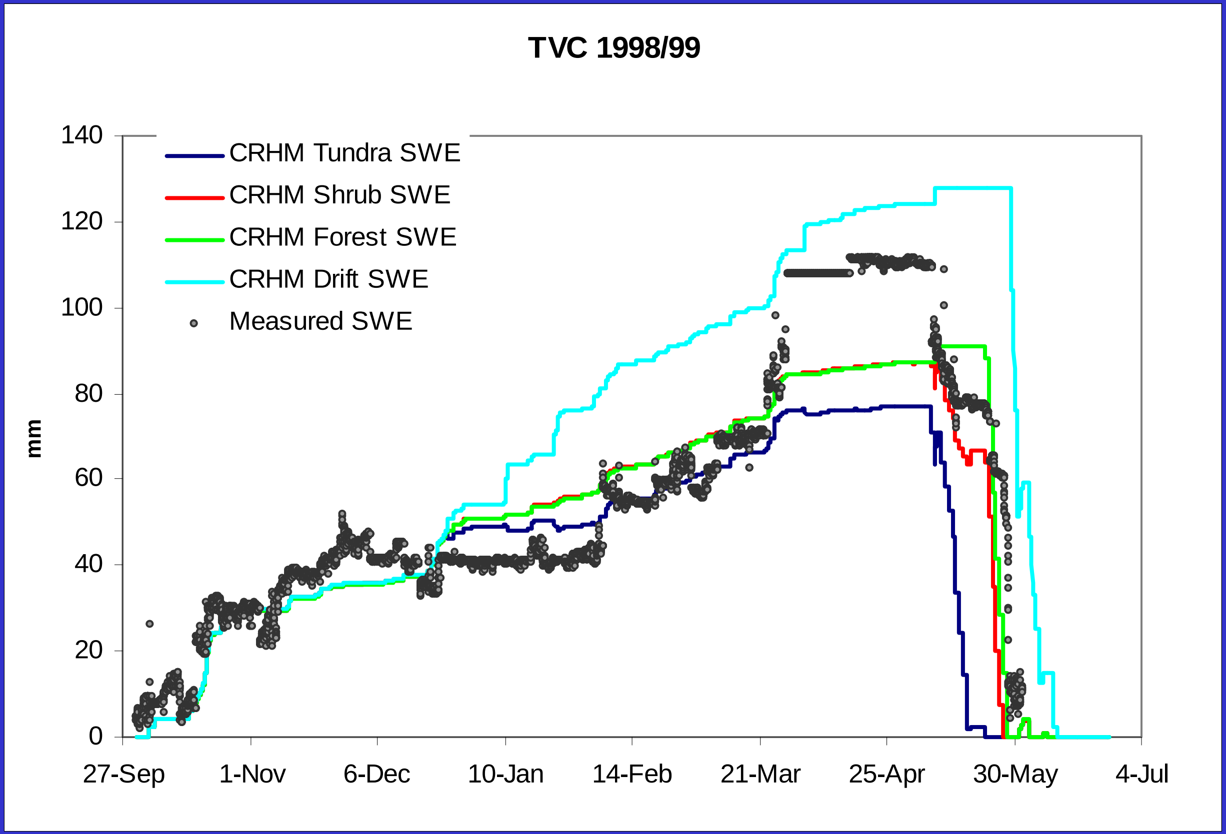
- Initial run set up as follows:

  - 4 HRUs
    - Tundra (69.8% of basin)
    - Shrub (21.5%)
    - Forest (0.5%)
    - Drift (0.2%)

  - Evaporation – used the Granger method

  - Discharge
    - Soil component set to have minimal effect
    - Did not use snow from PBSM
    - Instead used 97 mm SWE from end of winter snow survey

CRHM – snow accumulation and melt



Pohl et al.

Drift = 457 mm

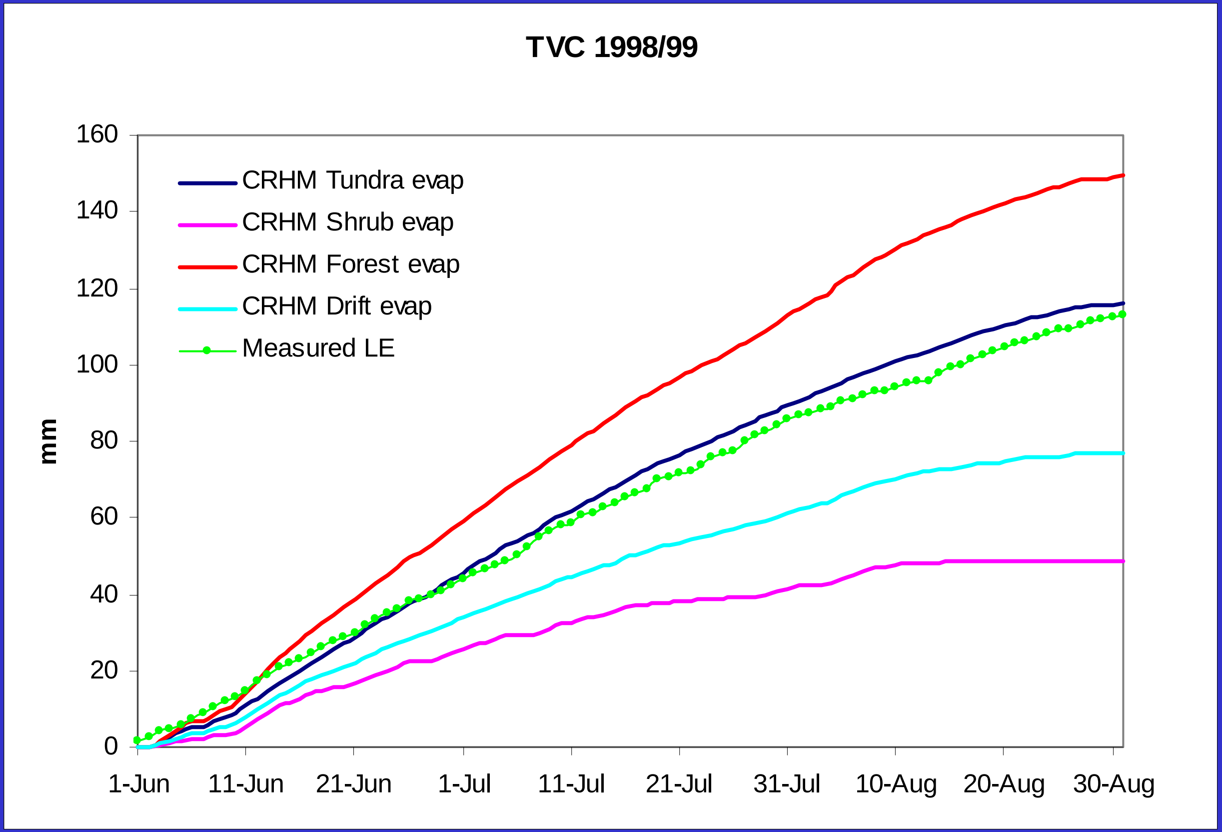
Forest = 110 mm

Tundra = 114 mm

Shrub = 197 mm

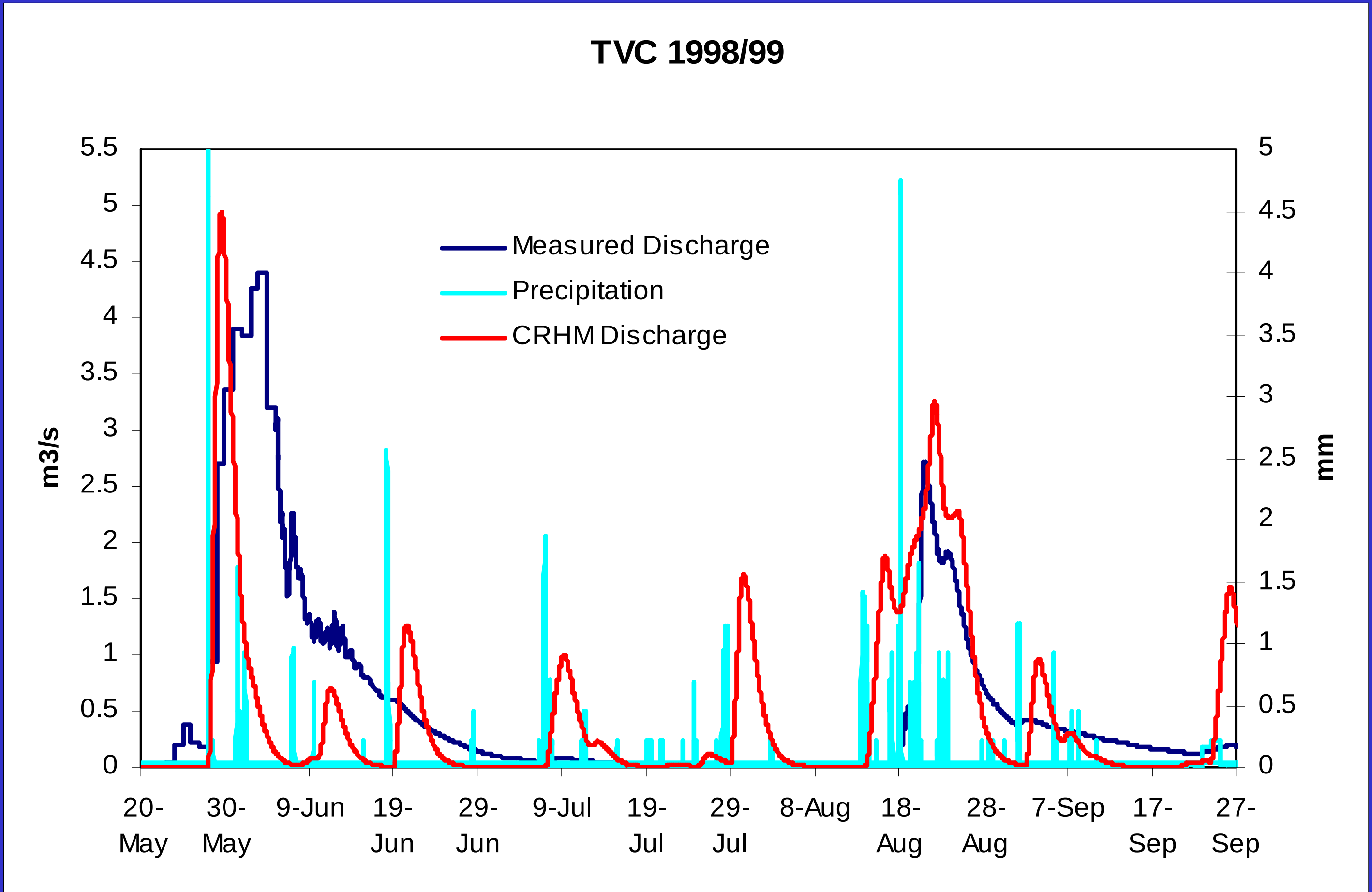
Estimated SWE is underestimated for all sites, but it seems likely that this is due to underestimating snowfall. However, it appears that the drifts are severely under estimated.

CHRM – Evaporation using Granger method



Measured LE is from Eddy Correlation

CRHM - Discharge



First test shows that CHRM underestimates total spring discharge and overestimates response to rain events

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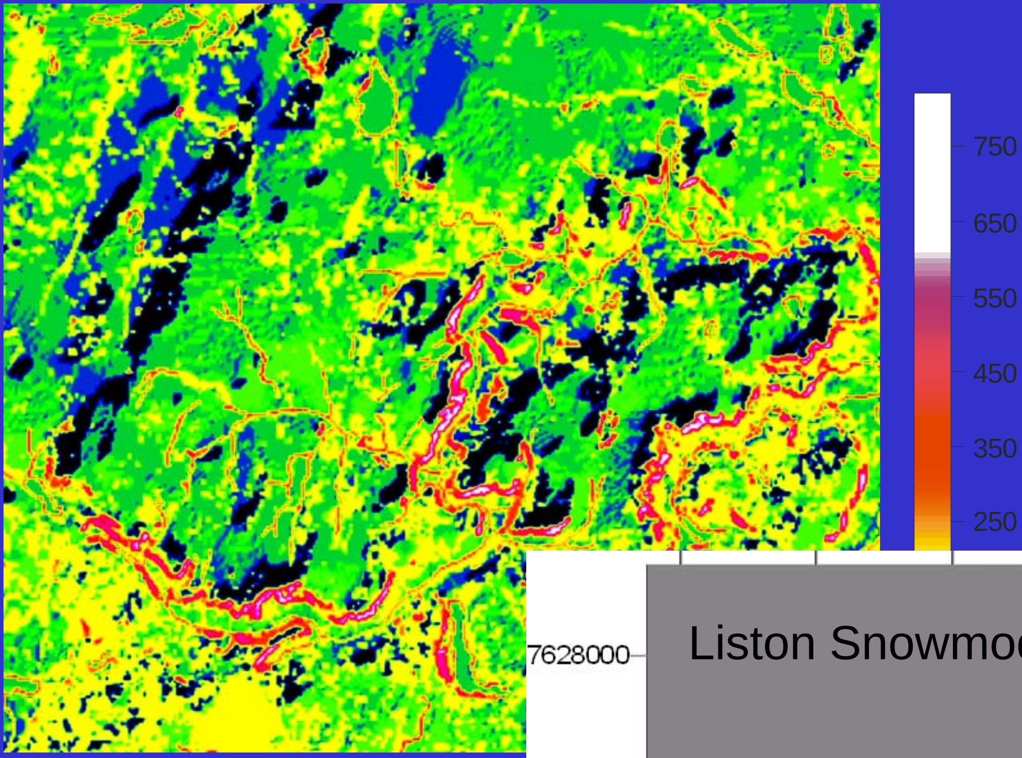
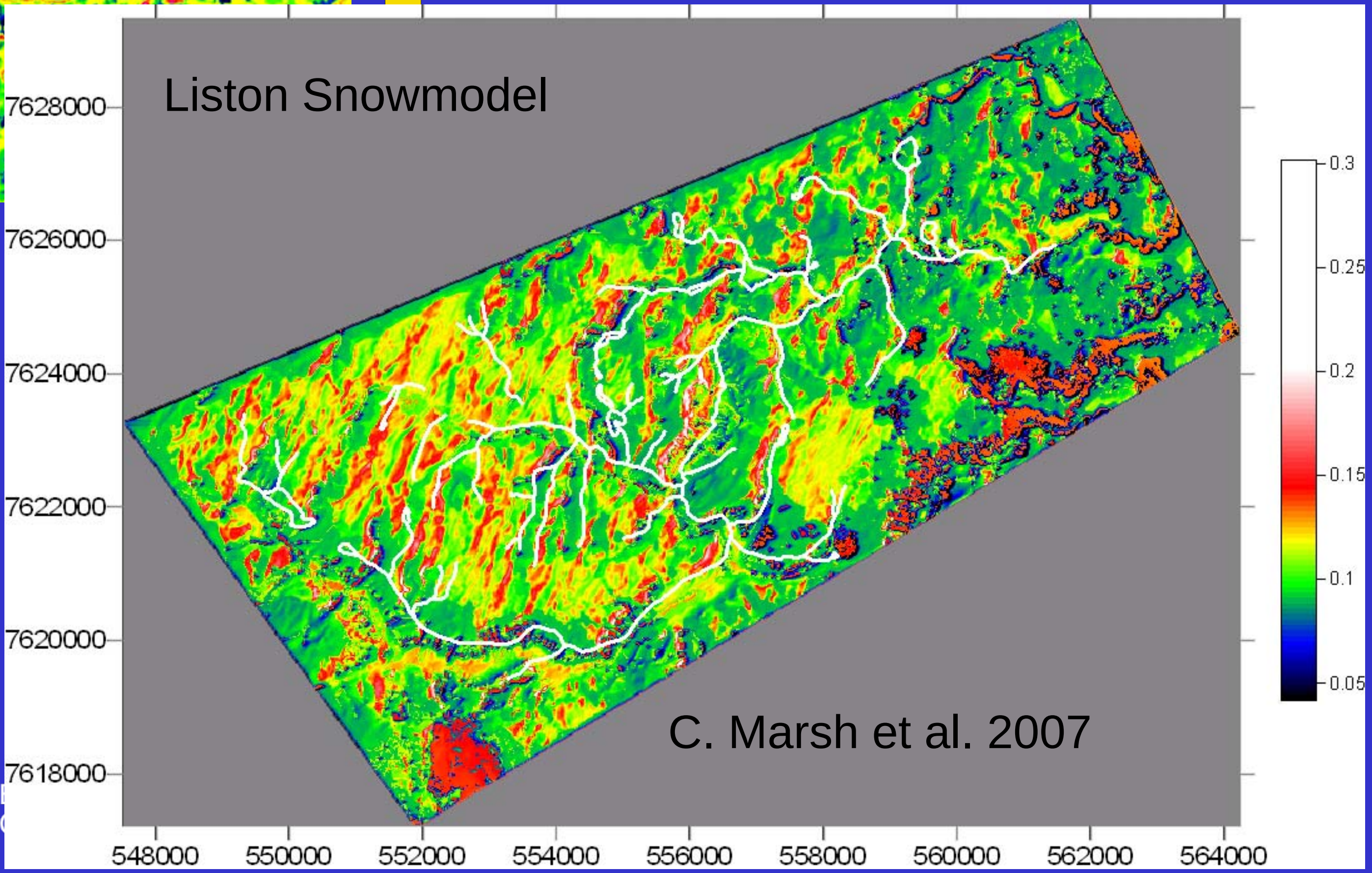
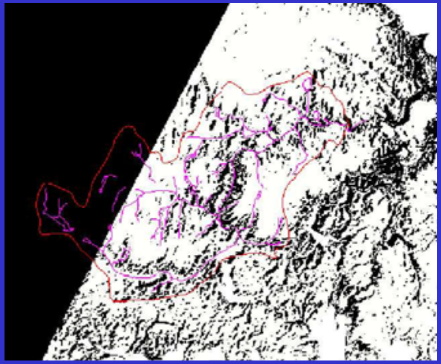
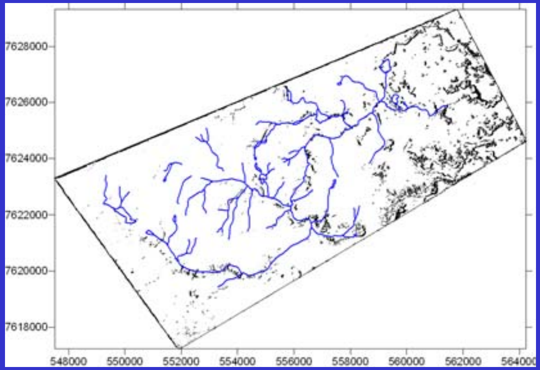
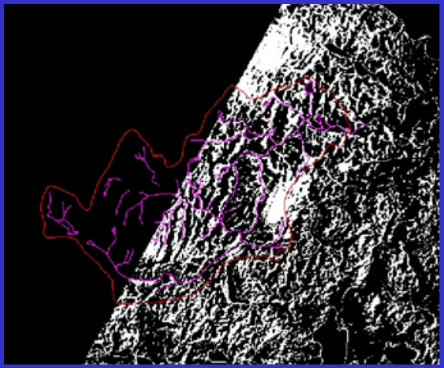
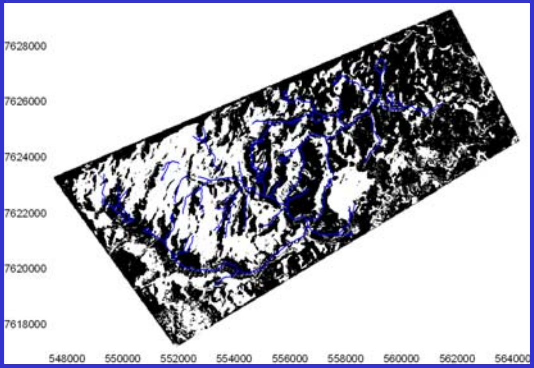
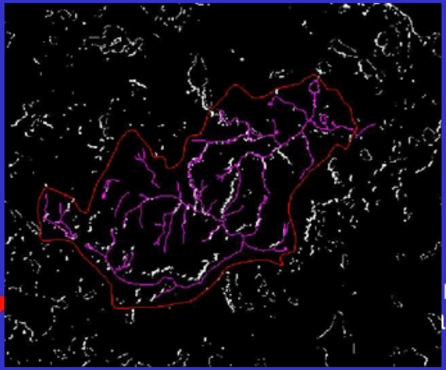
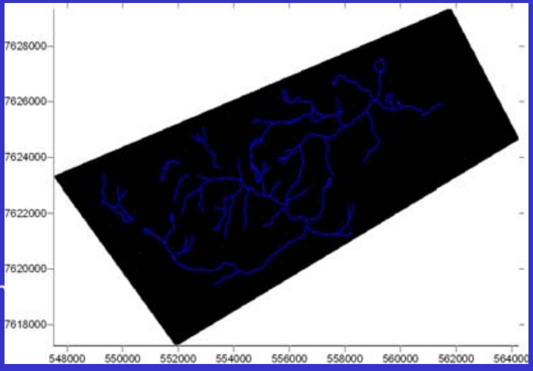
Liston Snow model, end of winter SWE



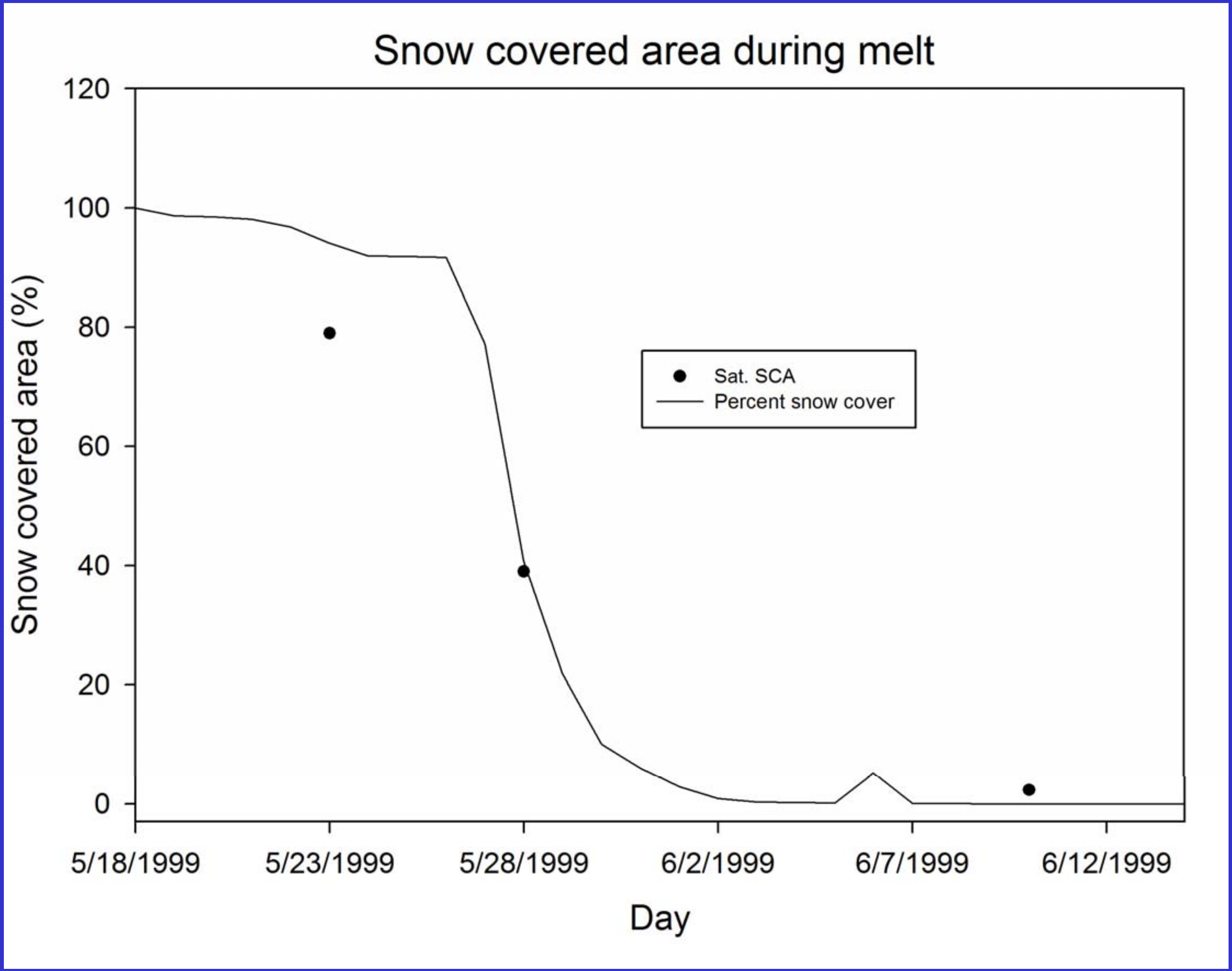
S. Pohl et al.



Observed vs modelled snow covered area

	SPOT	Model	Oblique photos
May 23 1999			
May 28 1999			
June 10 1999			

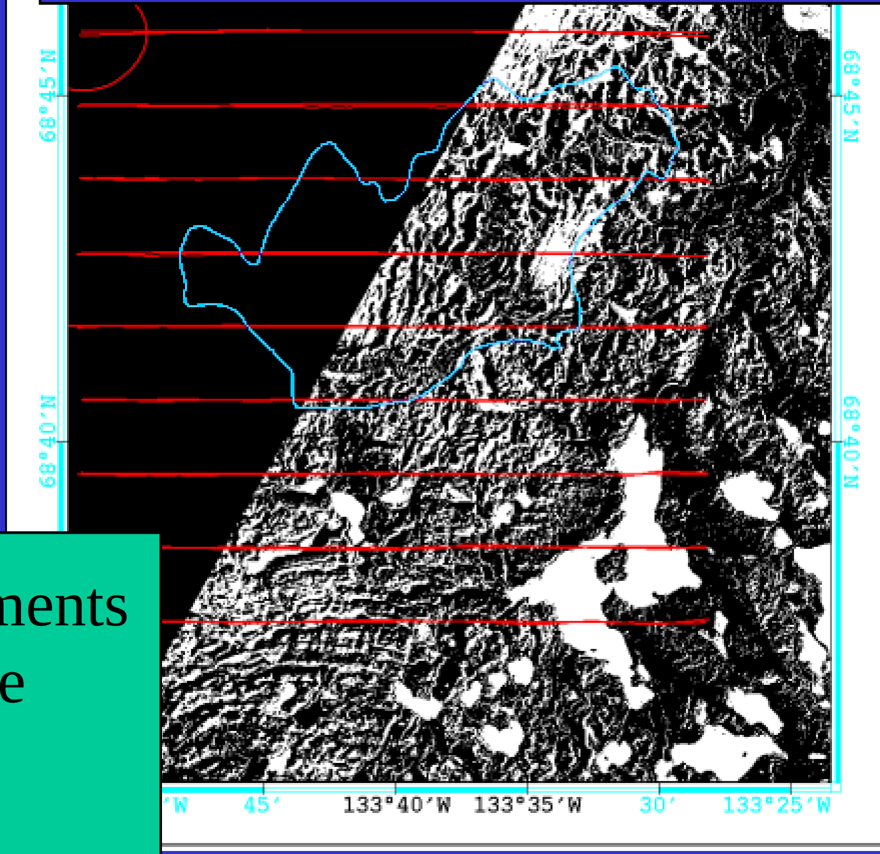
Liston Model



Planned activities over the next year

NRC Twin Otter Aircraft

9 flight lines (in red), each approx. 16 km in length



- aircraft eddy correlation measurements provide an estimate of basin average measurement of latent and sensible fluxes, and gridded fluxes at 1 km resolution. Currently working with Dr. Ray Desjardins (Agriculture Canada) to compare aircraft to modelled fluxes

MACKENZIE MAGS ÉTUDE GEWEX STUDY

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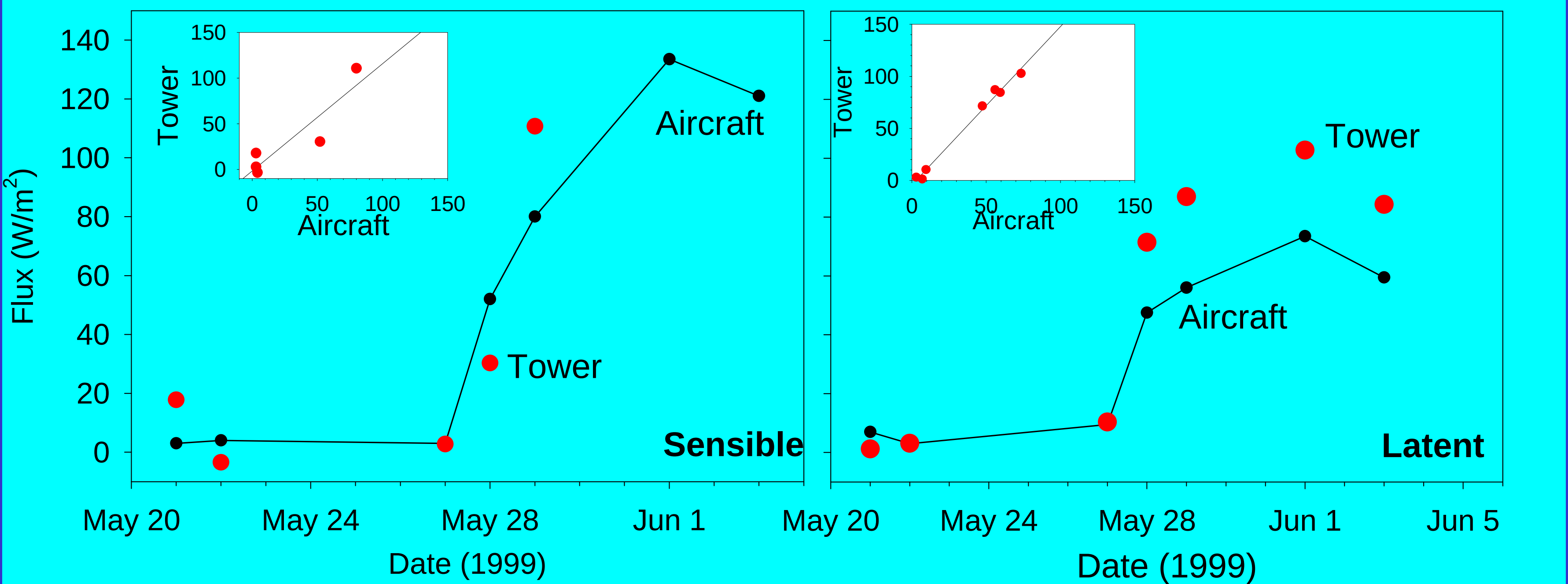
Tower vs aircraft comparison



TVC Tower vs TVC transect #8

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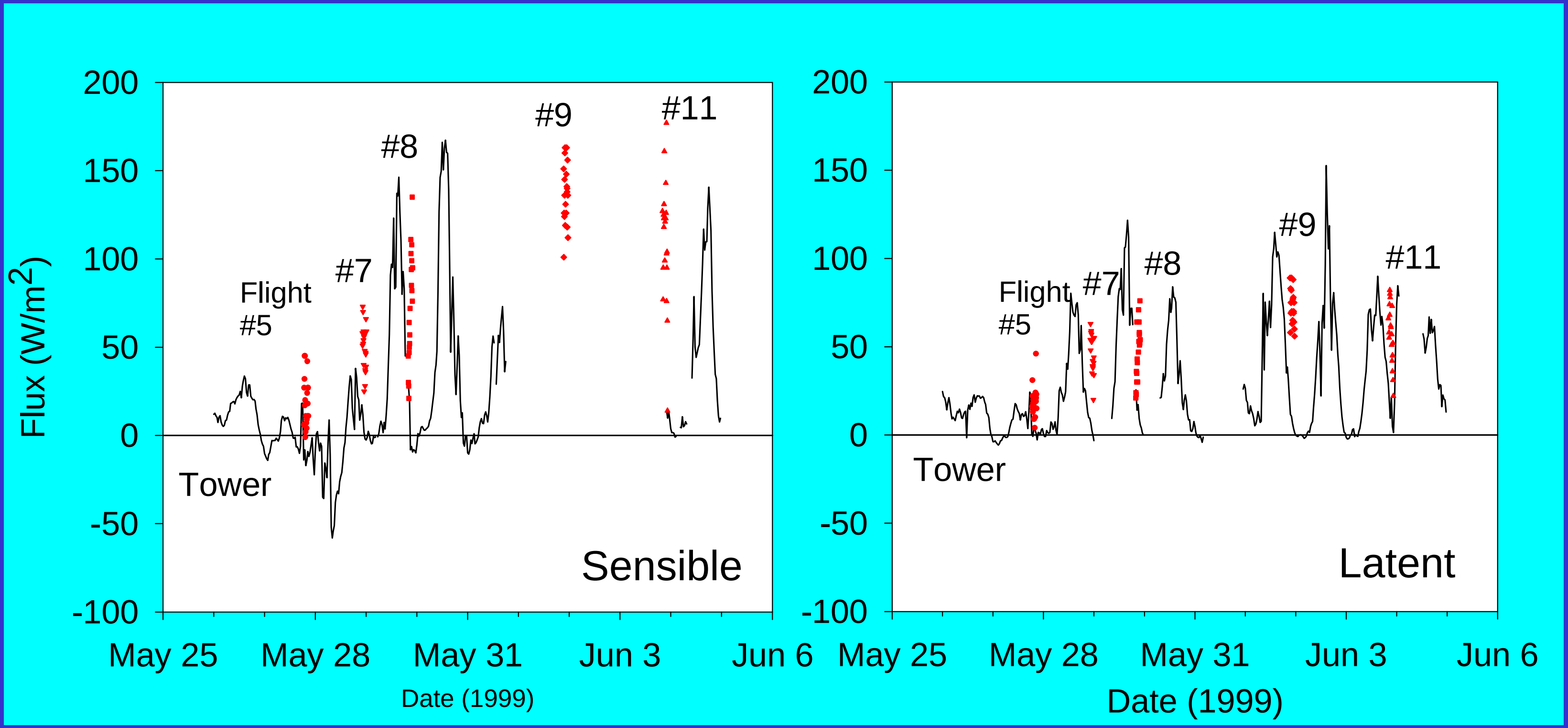
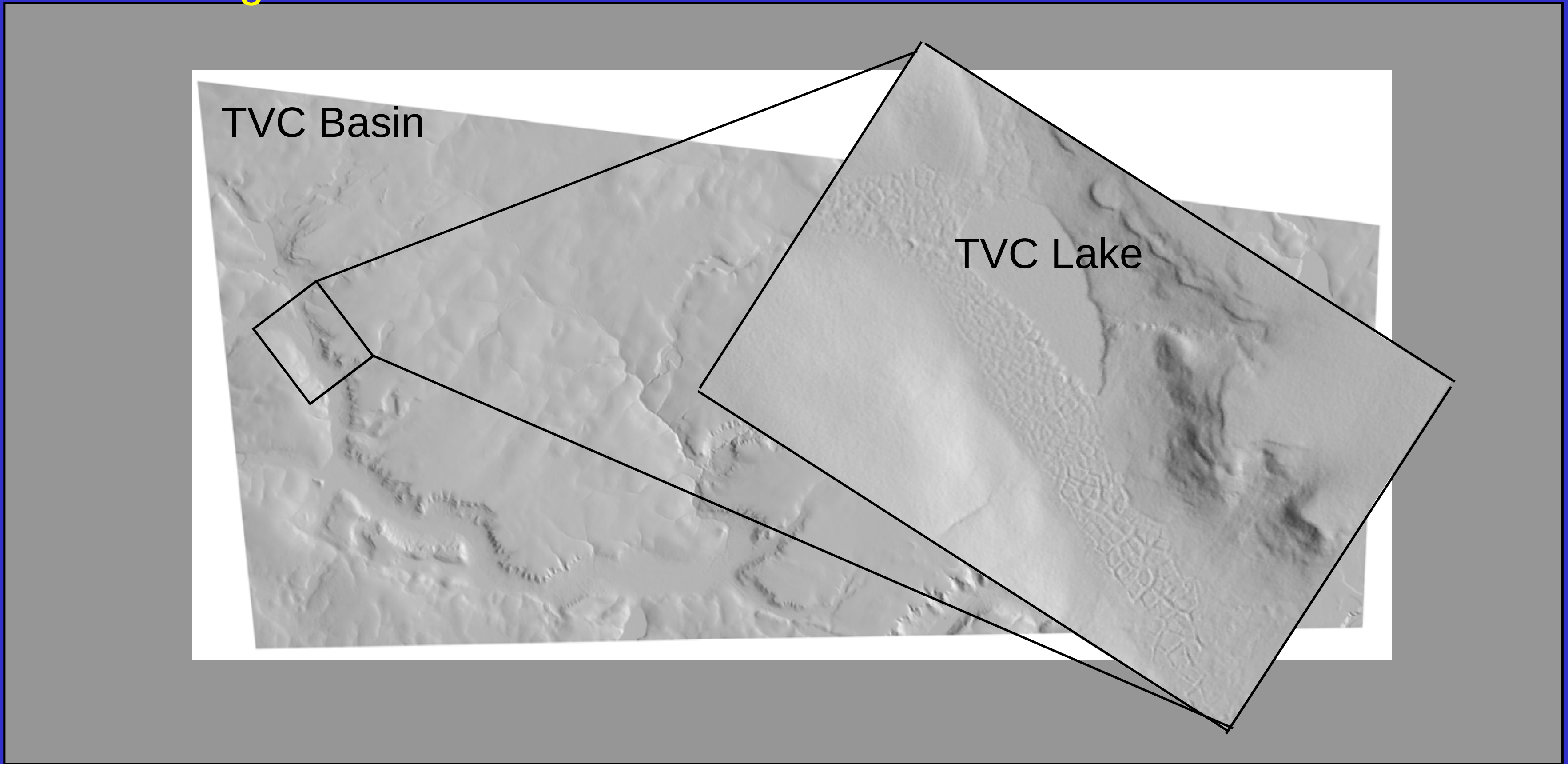
Tower vs aircraft fluxes



Lidar

1. DEM – is of sufficient accuracy for small scale hydrologic modelling
2. Vegetation – unfortunately the Lidar was flown with minimal overlap between flight paths. Although it is still useful, it has significantly reduced our ability to estimate vegetation height and density. As a result, we hope to acquire new Lidar data during the summer of 2008



Collaborative Modelling Efforts

- We are currently working with Murray Mackay (MSC) and Paul Bartlet (MSC) to use CLASS to better understand factors controlling melt at a shrub and tundra site at Trail Valley Creek

- Will be providing data to the following IP3 groups
  - Ric Soulis and Frank Seglenieks – data to initialize MESH for TVC (done) and HPC
  - Diana Verseghy – data to run CLASS for TVC

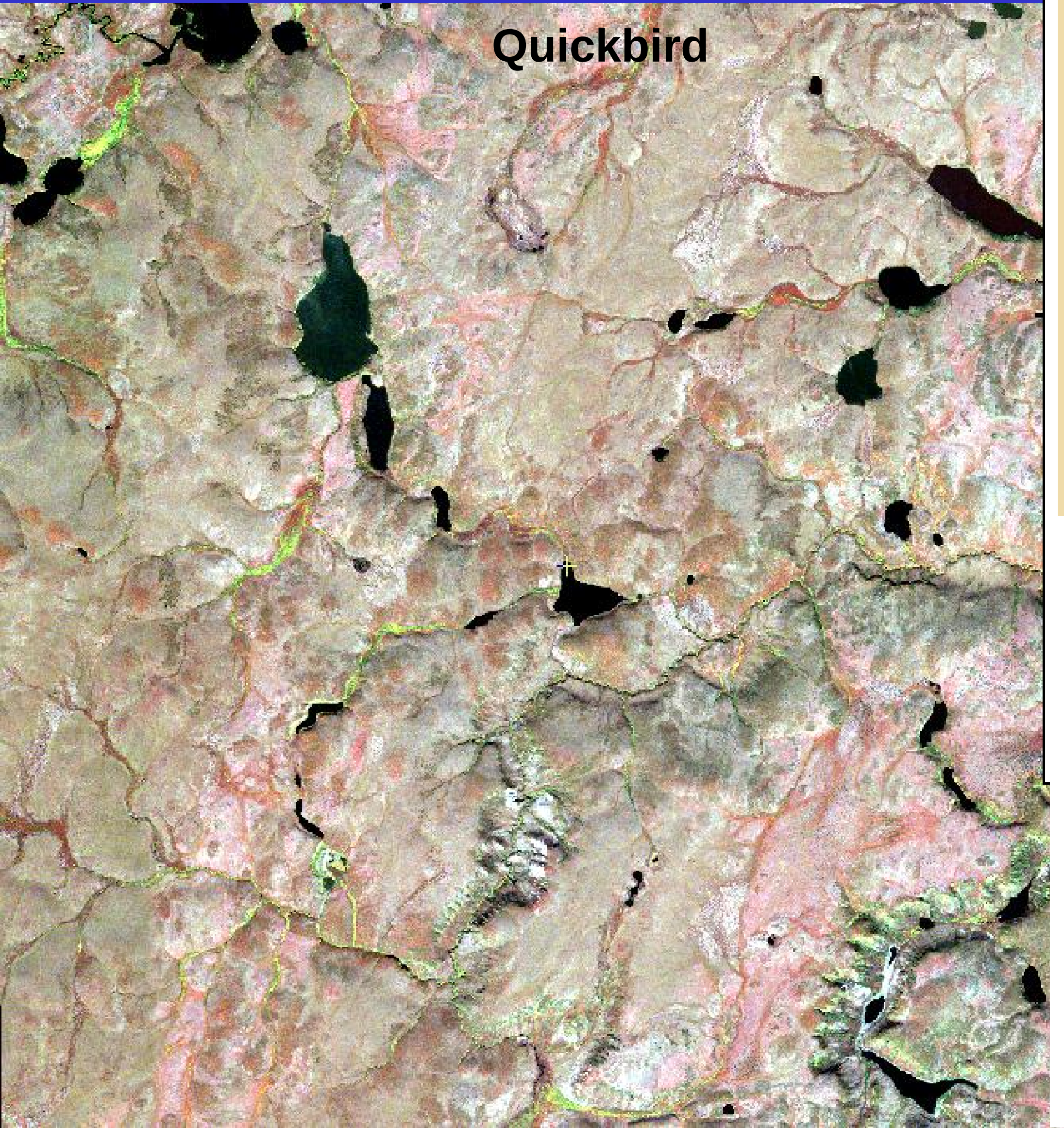
Lake studies

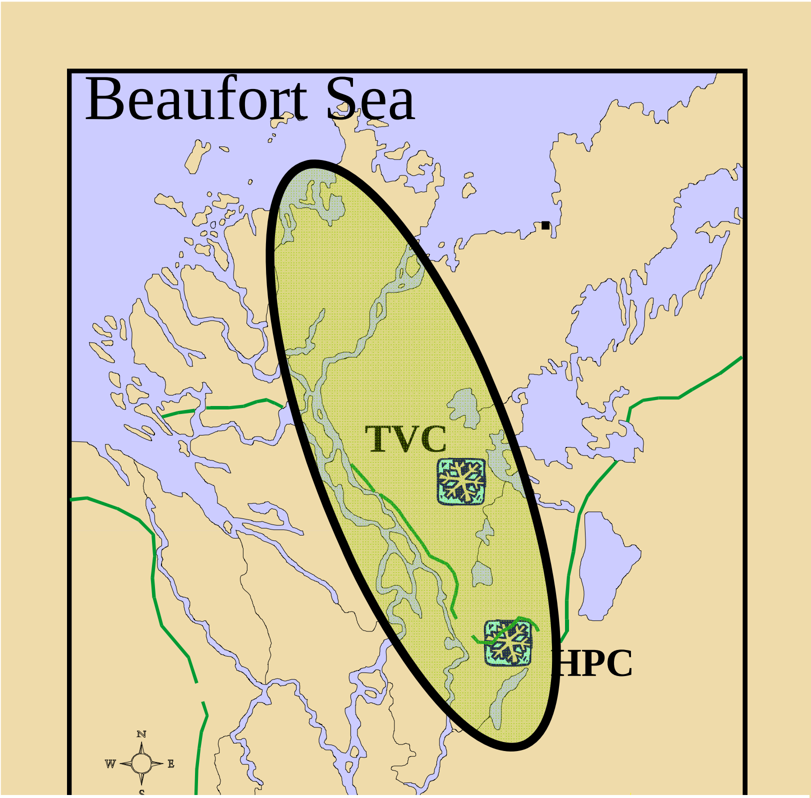
- We are collaborating with Peter Blanken (U. of Colorado Boulder) to analyze our lake flux data

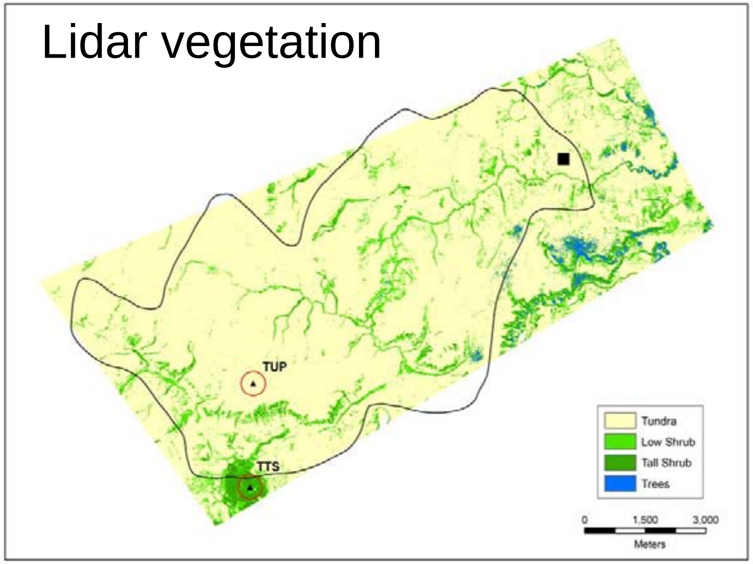
- Will be working with Raoul Granger to consider implementing his lake evaporation parameterization to the Inuvik area study sites

- We are collaborating with Dr. Ray Desjardins and hope to analyze the NRC aircraft data for the flight lines over lake rich regions near Inuvik

Map vegetation cover over entire domain using Lidar, Quickbird, Landsat and ground truthing







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