Snow and small lake processes at the Arctic forest/tundra transition in the Western Canadian Arctic

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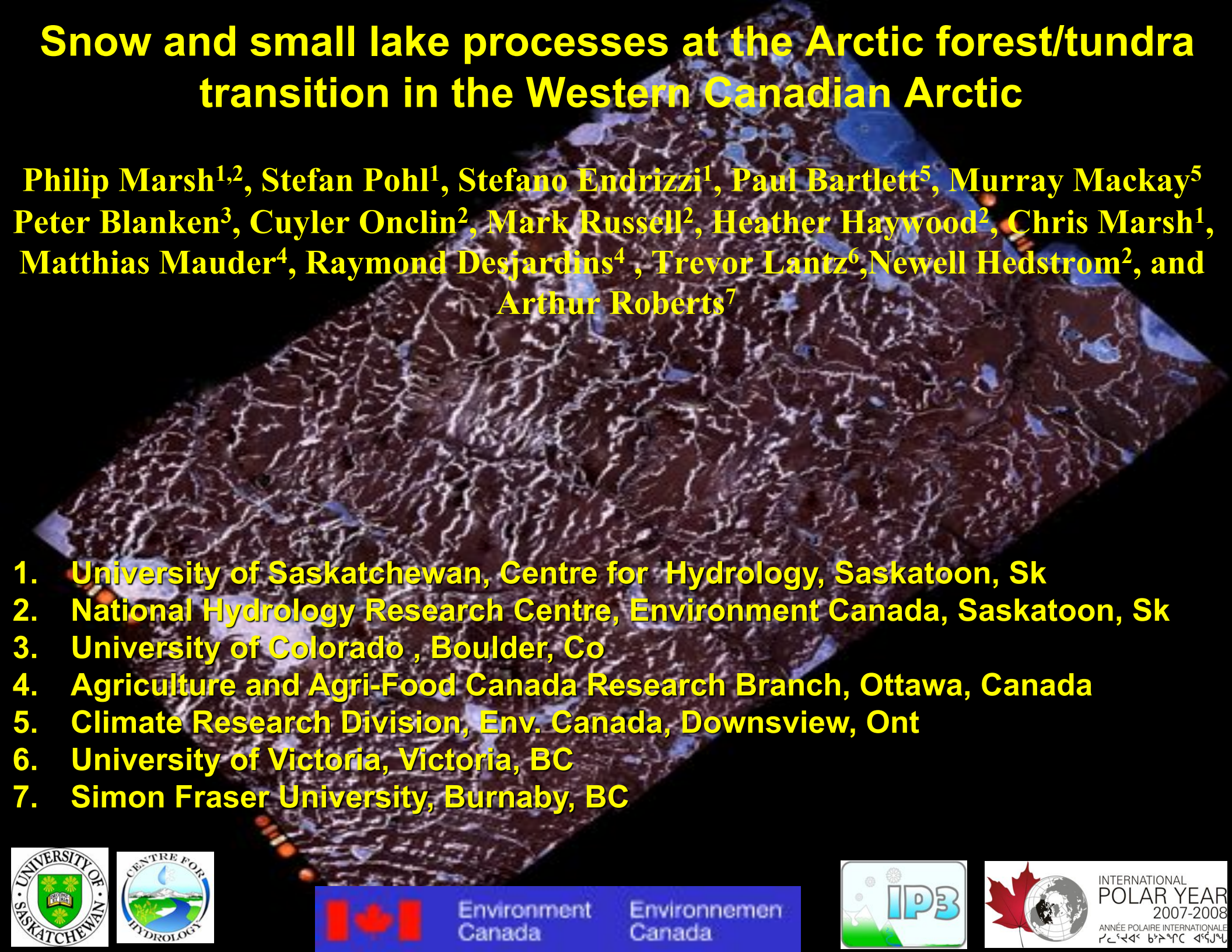


Study Objectives

- Improved understanding of spatial variability in snowcover, radiative and turbulent fluxes, at the tundra-forest transition zone, emphasis on shrubs.

- Shrubs are currently extending into tundra, and this is expected to be the largest change in vegetation in Northern Canada in coming decades

- consider the sub-grid variability at a range in scales from point to 100 km^2 in:
  - slope and aspect + vegetation (tundra, shrubs, forest)
  - Lakes
- And their effect on snowcover and energy exchange

- use a combination of:
  - detailed field observations funded by MAGS, EC, IP3, IPY, Northern Energy
  - and a variety of appropriate models (CRHM, GEOtop, CLASS, MESH)

- Finally validate and suggest improvements to CLASS and MESH

1) Outline (this talk plus the following two talks)

1. **Study sites - same sites discussed in the next 2 talks (Endrizzi and Pohl)**

2. **Turbulent fluxes, radiation, snowcover, melt and lake evaporation**
   a) **Snow accumulation and melt at shrub vs tundra site**
      - **CLASS**
      - **GEOtop (discussed in Stefano Endrizzi's talk)**
   b) **Role of Lakes – will not discuss in this talk**

3. **Spatial variability in energy fluxes**
   - **From point to basin scale (Stefano Endrizzi's talk)**
   - **Important component of this is the MAGS aircraft data set**

2) Outline (this talk plus the following two talks)

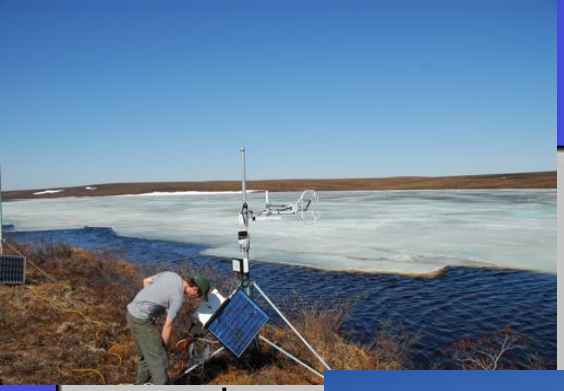
4. **Basin scale modelling**
   - **CRHM – Newell Hedstrom (will not discuss in this talk)**
   - **MESH – Stephan Pohl's talk**

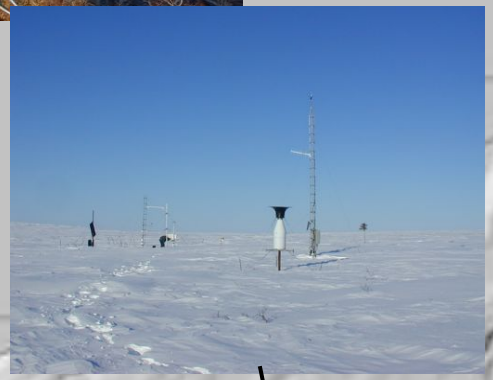
5. **Data Archiving (Stefan Pohl's talk)**

6. **Publication Plans**

1. Study Sites

Trail Valley Creek topography



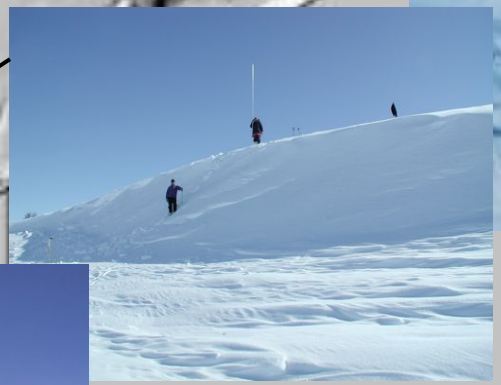


NWRI (TMM) and MSC station

WSC TVC discharge

TUP Lake

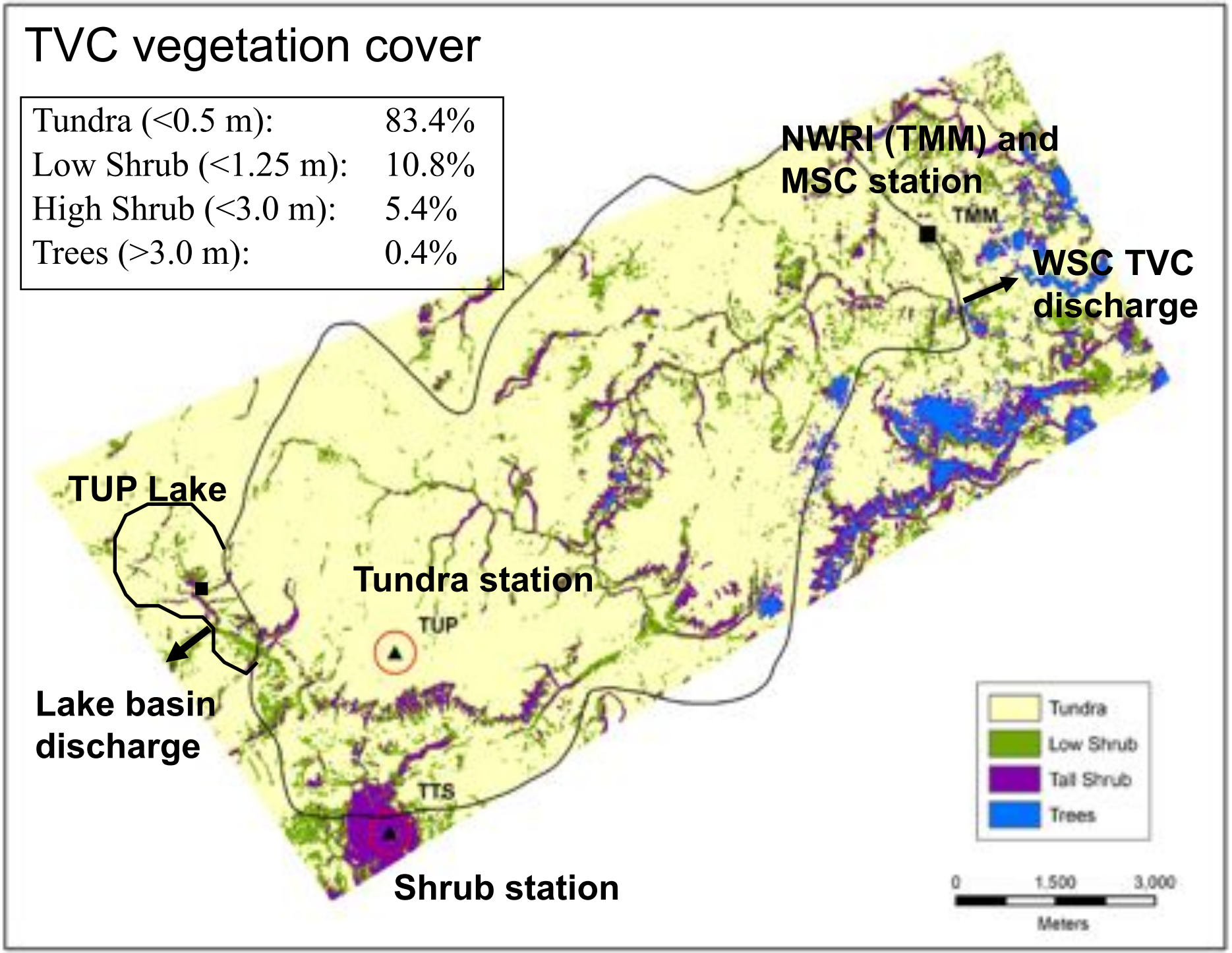
Tundra station



Shrub station

TVC vegetation cover

Tundra (<0.5 m):	83.4%
Low Shrub (<1.25 m):	10.8%
High Shrub (<3.0 m):	5.4%
Trees (>3.0 m):	0.4%

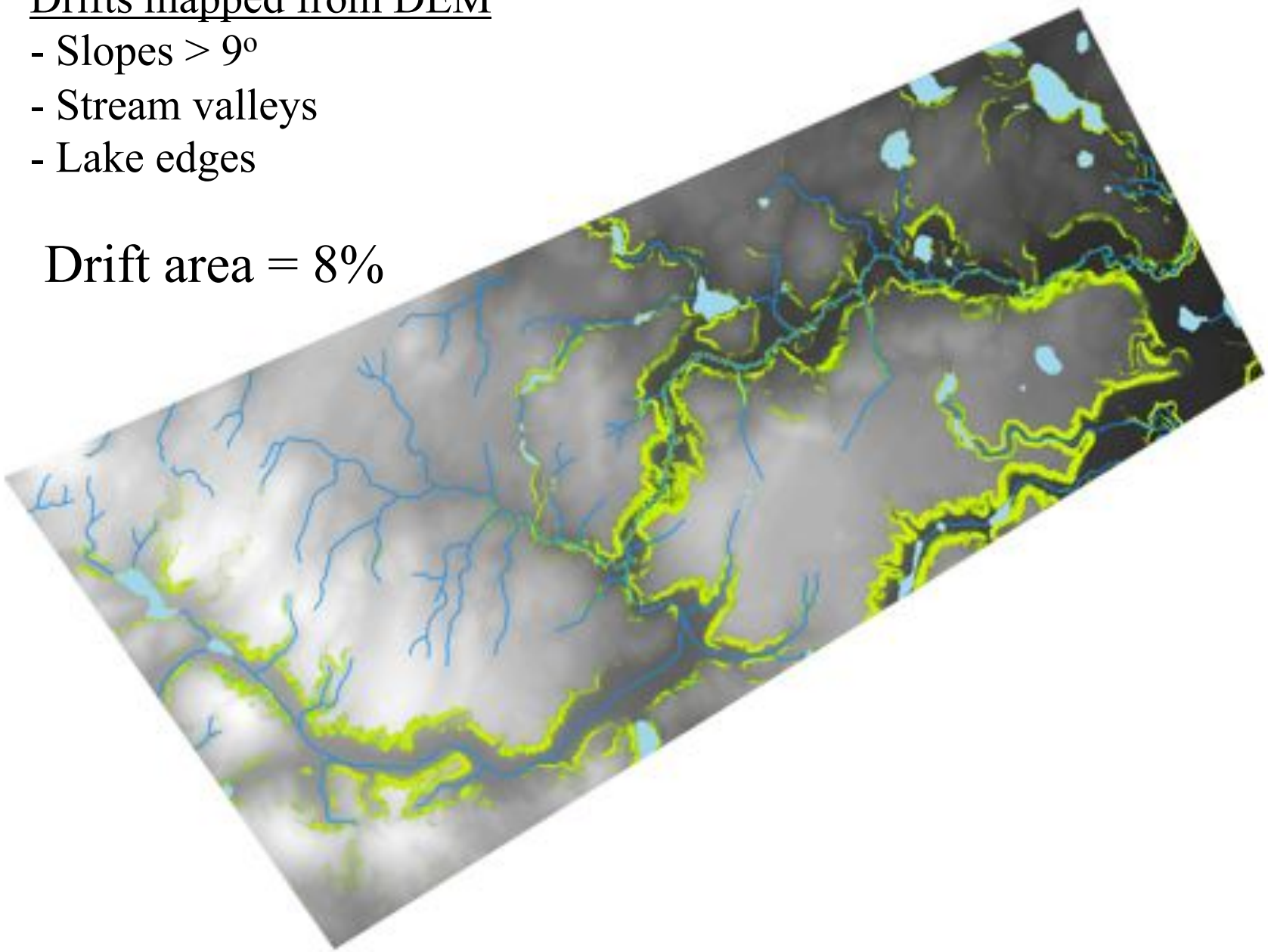


Mapping drift area and locations

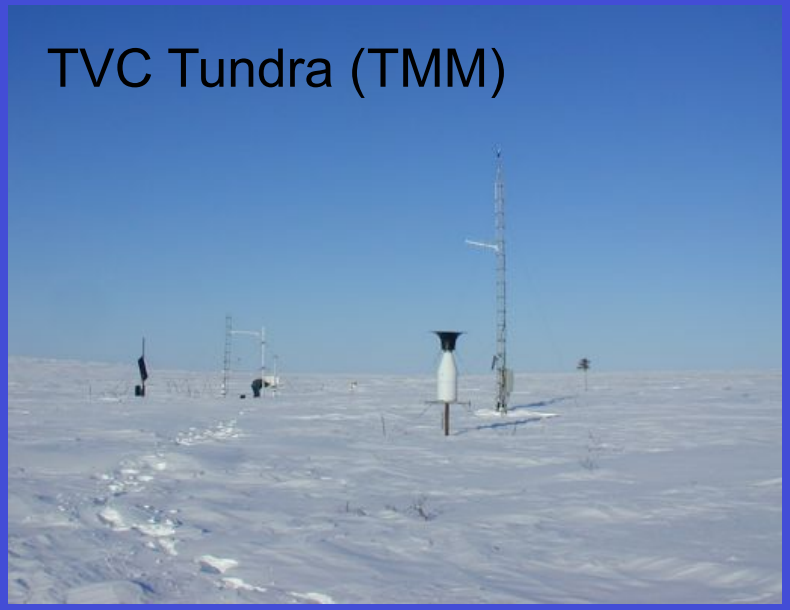
Drifts mapped from DEM

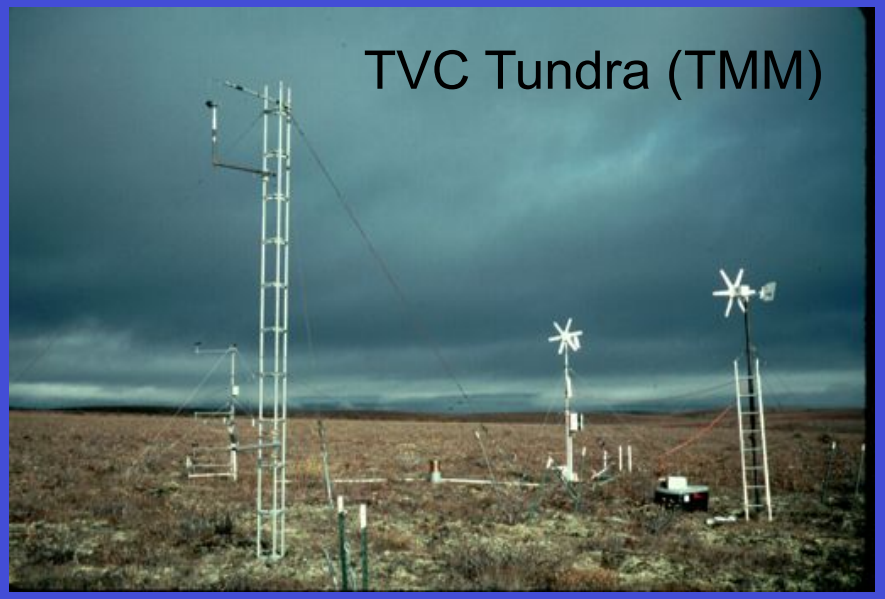
- Slopes > 9°
- Stream valleys
- Lake edges

Drift area = 8%



Data Collection Program





8 stations including:

1. HPC main met,
2. **TVC MSC,**
3. **TVC main met (TMM),**
4. **TVC shrub (TTS),**
5. **TVC tundra (TUP),**
6. **TVC Lake (TUP L.)**
7. Denis Lagoon and
8. Big Lake

Snow Surveys

- End of winter vegetation and terrain based snow surveys were conducted at: Trail Valley Creek over many years

- coordinated with additional ground and aircraft microwave surveys by Chris Dirksen of Env. Canada during IPY.

- Currently working with Chris Dirksen in the analysis of these combined snow survey data sets.

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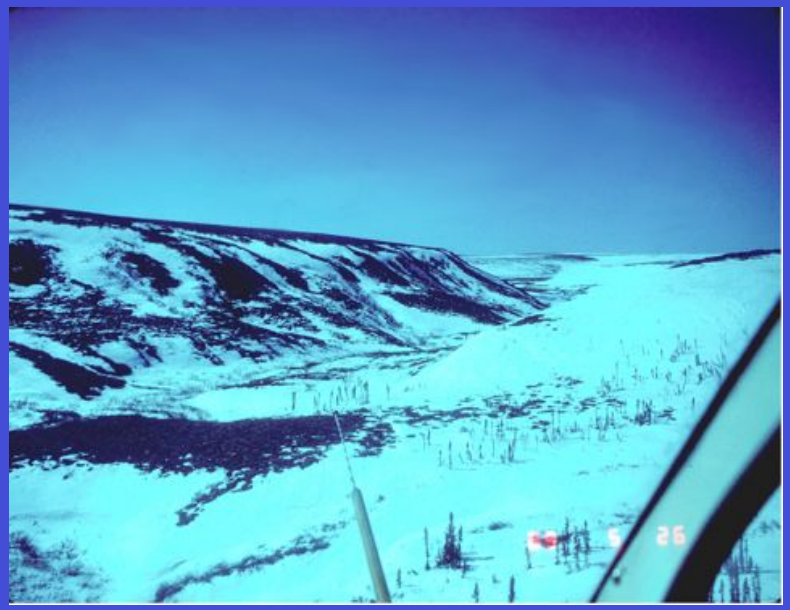
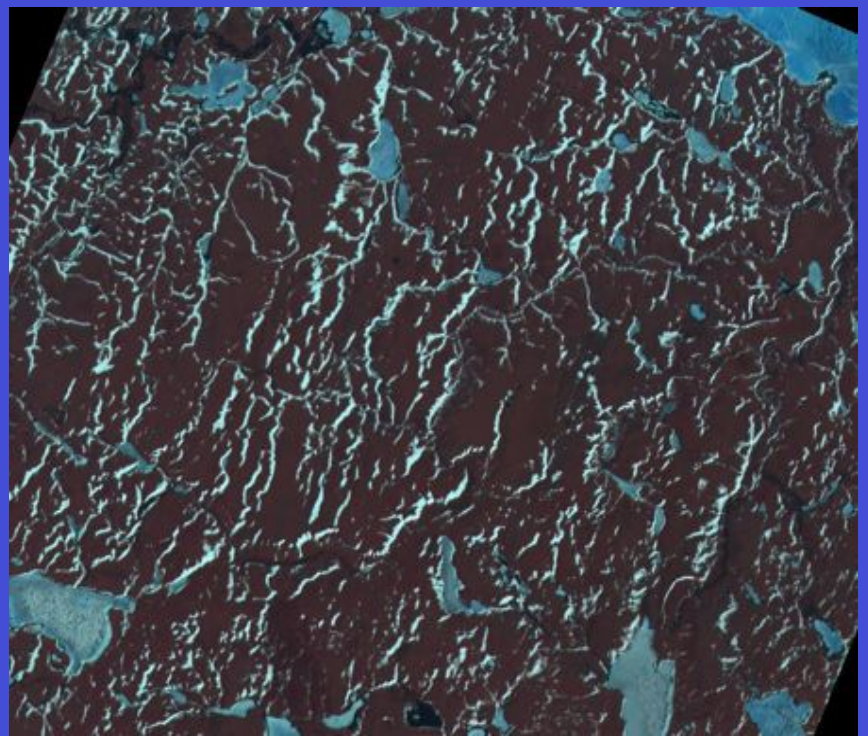
Snow surveys: Large Drifts



- large drifts up to 5 m in depth, and cover about 8% of the basin area, and may hold up to 20% of the basin SWE.

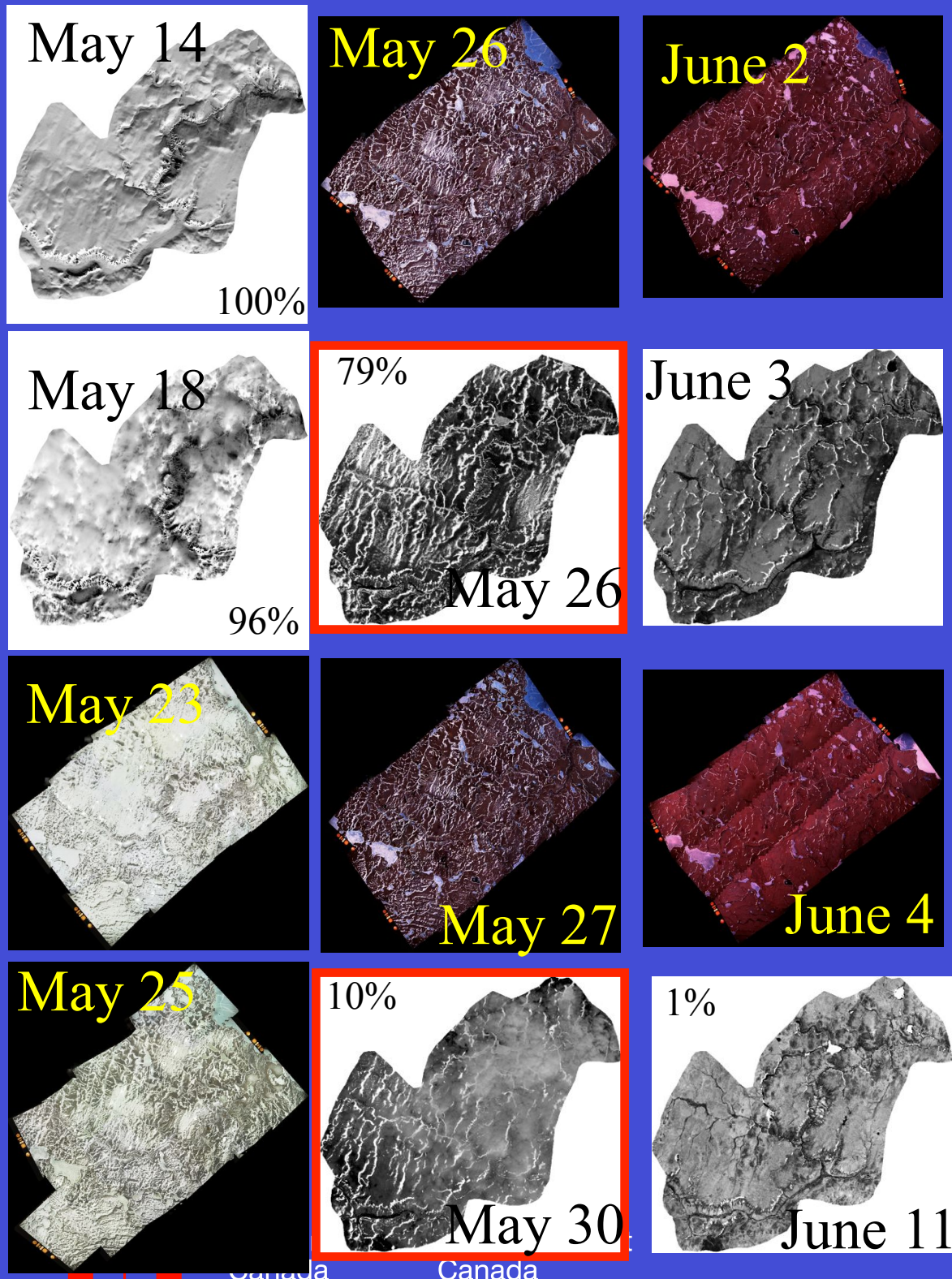
- As part of the work with Chris Dirkson, conducted a more a detailed drift survey during 2008.



Changes in snow cover during melt

- snow surveys were carried out within TVC basin during the snow melt period at representative sites.

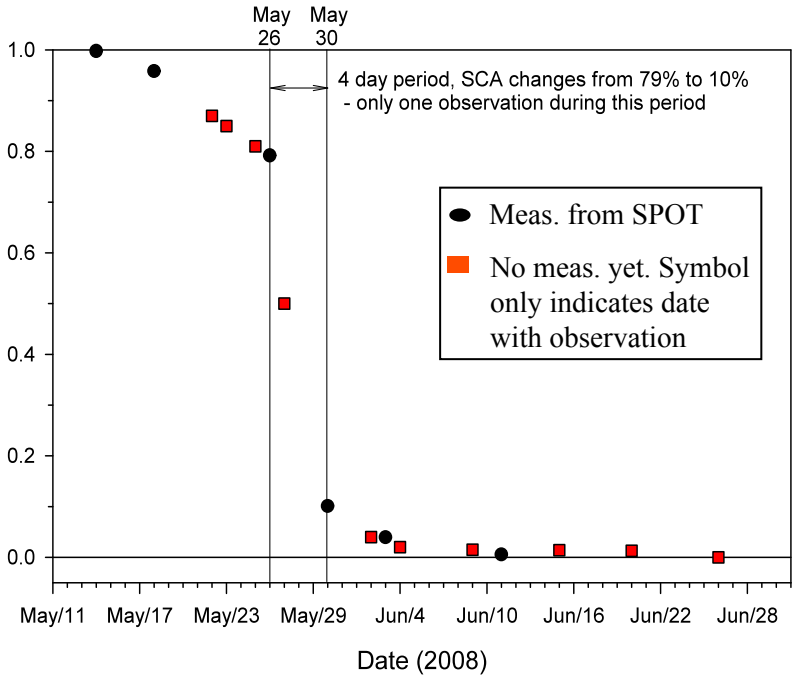
- including:
  - Tall Shrub site (TTS)
  - Tundra site (TUP)



Change in Snow Covered Area (SC)

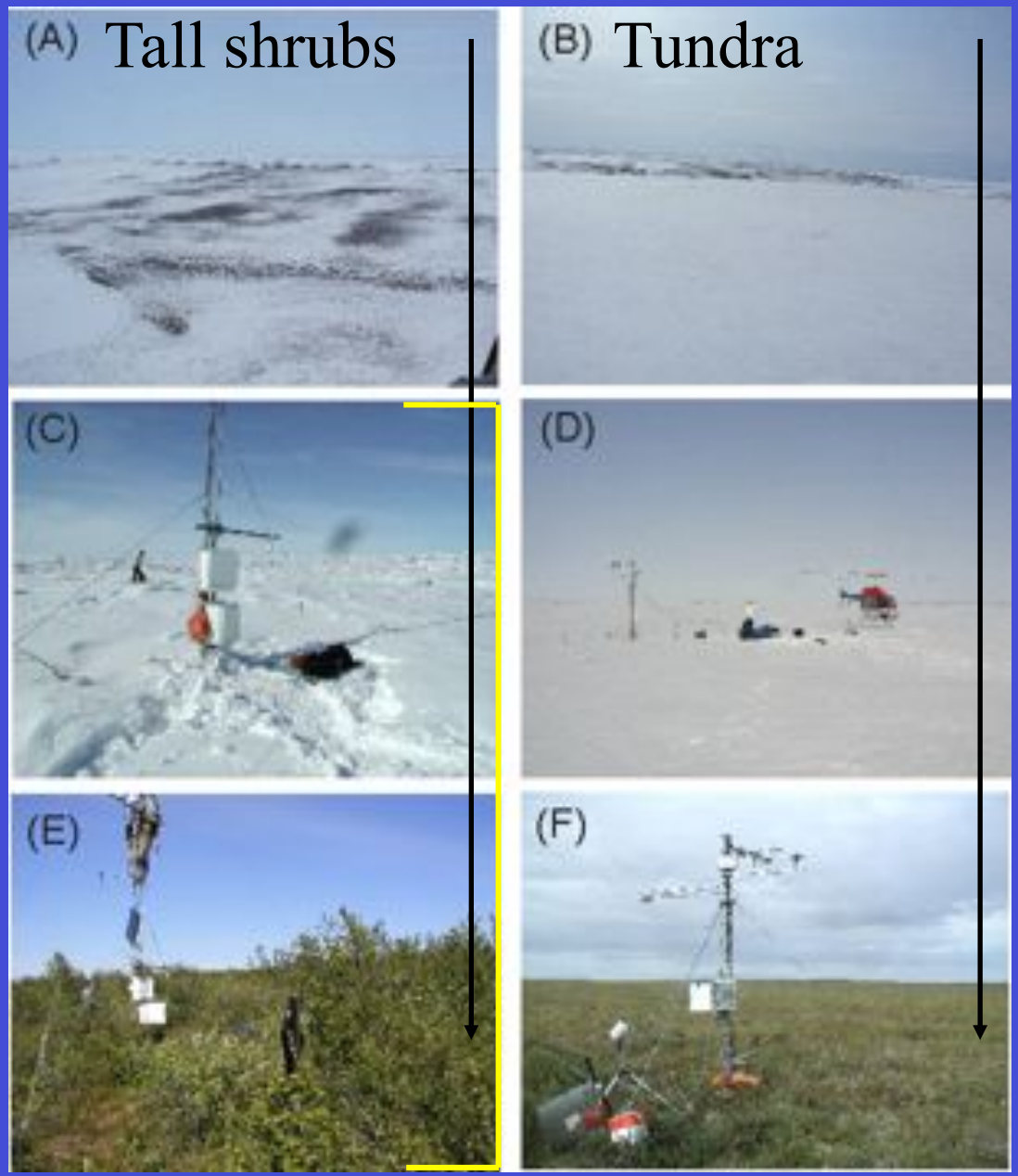
Other images to be analyzed:

May 22 (SPOT)
June 9 (SPOT)
June 15 (SPOT)
June 20 (SPOT)
June 26 (SPOT)



2a) Snow accumulation and melt: Shrub tundra vs tundra - Emphasis on the key period when shrubs emerge

(Observations + CLASS 3.3: Marsh, Bartlett, Mackay, Pohl, Lantz, submitted to HP)



Shrub burial and emergence

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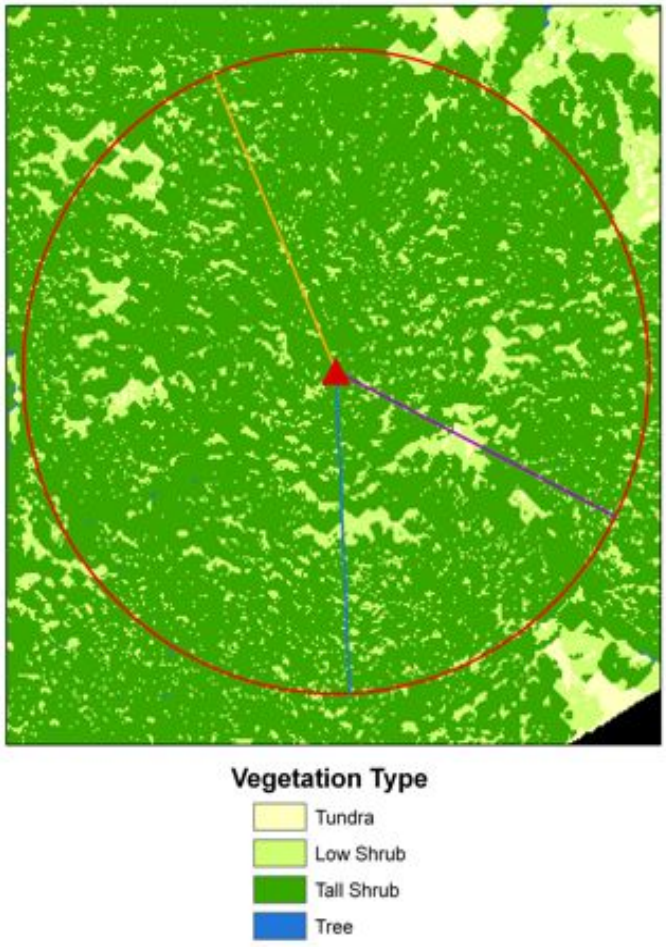
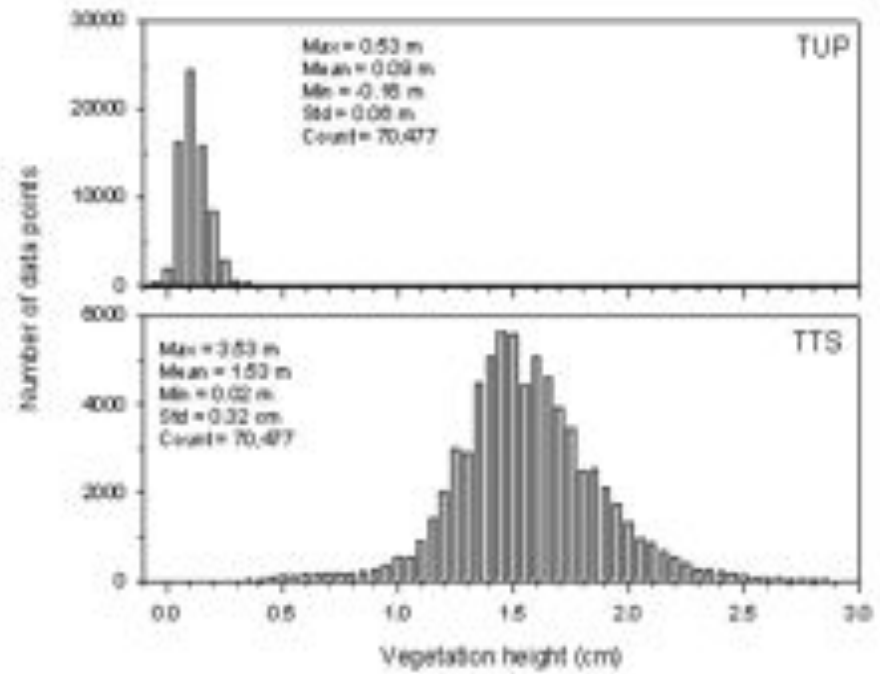
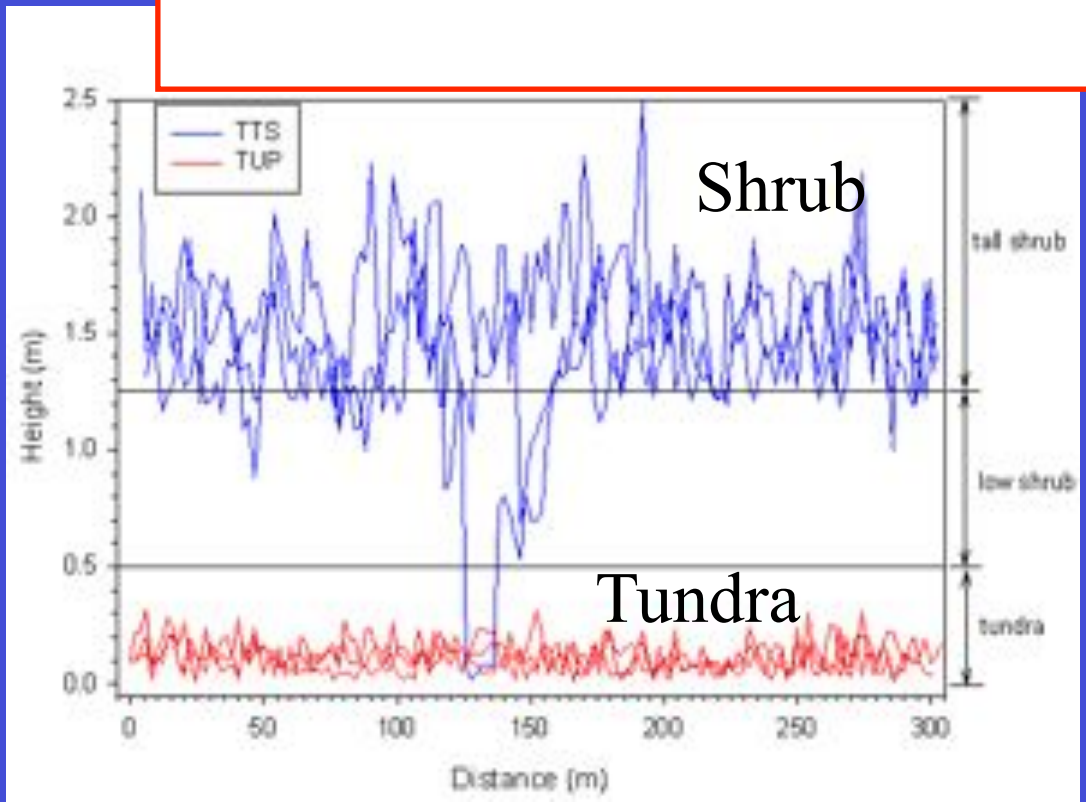
Tall Shrub (TTS) and Tundra (TUP) characteristics from Lidar

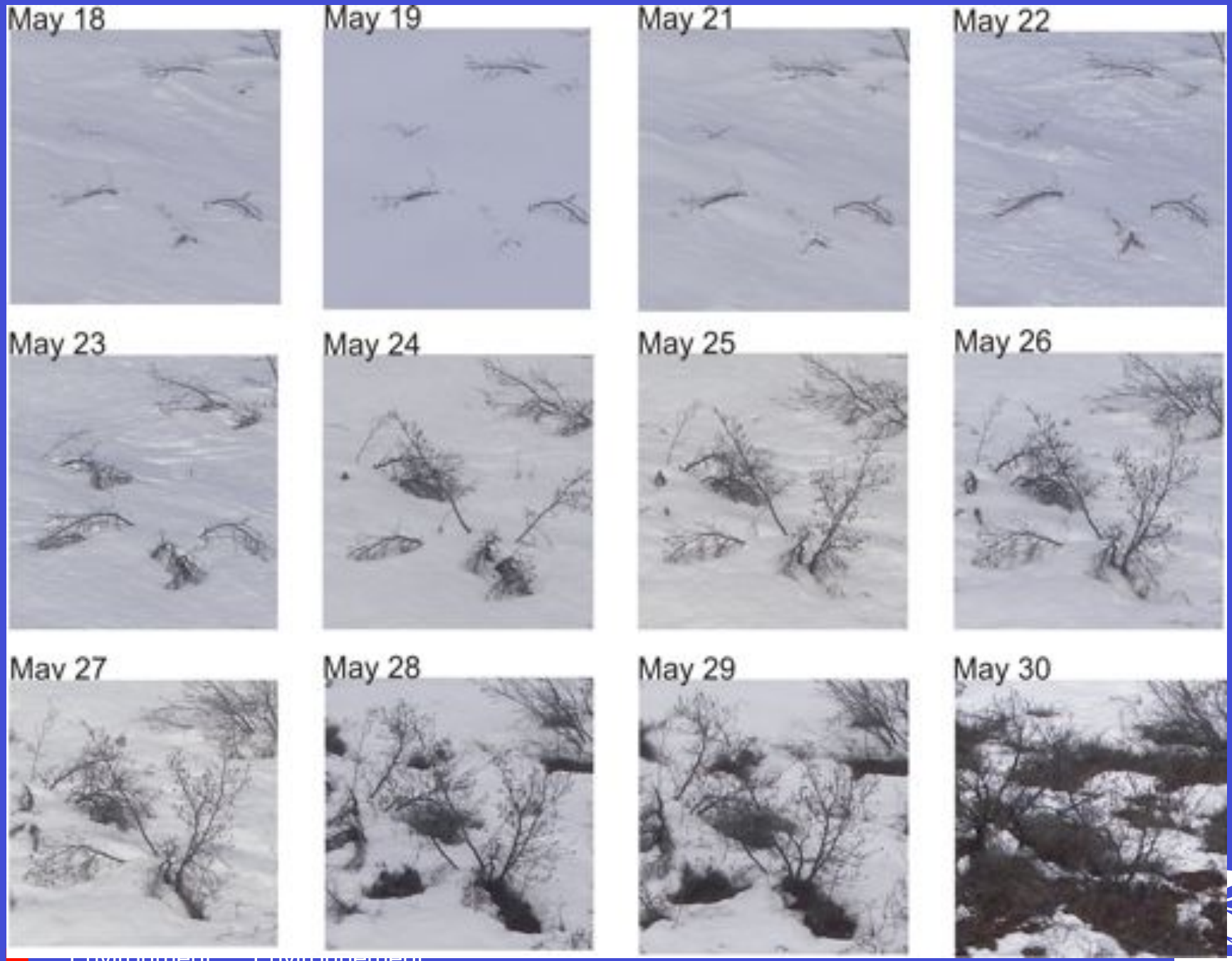




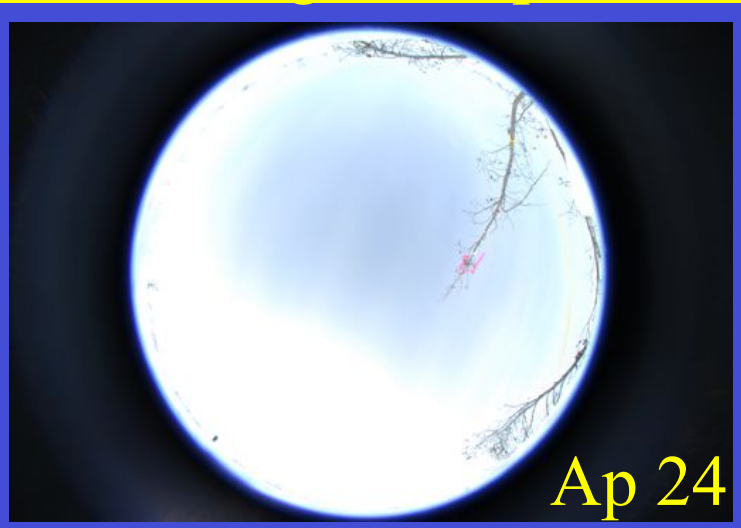


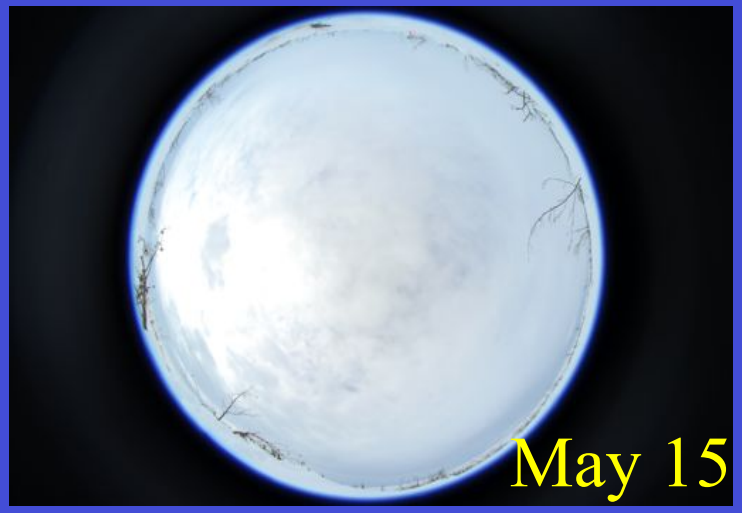
Field obs. by Trevor Lantz, validated the Lidar observations

Downward looking time lapse photographs of shrub exposure



Upward looking hemispherical photos at the TVC Shrub site 2008





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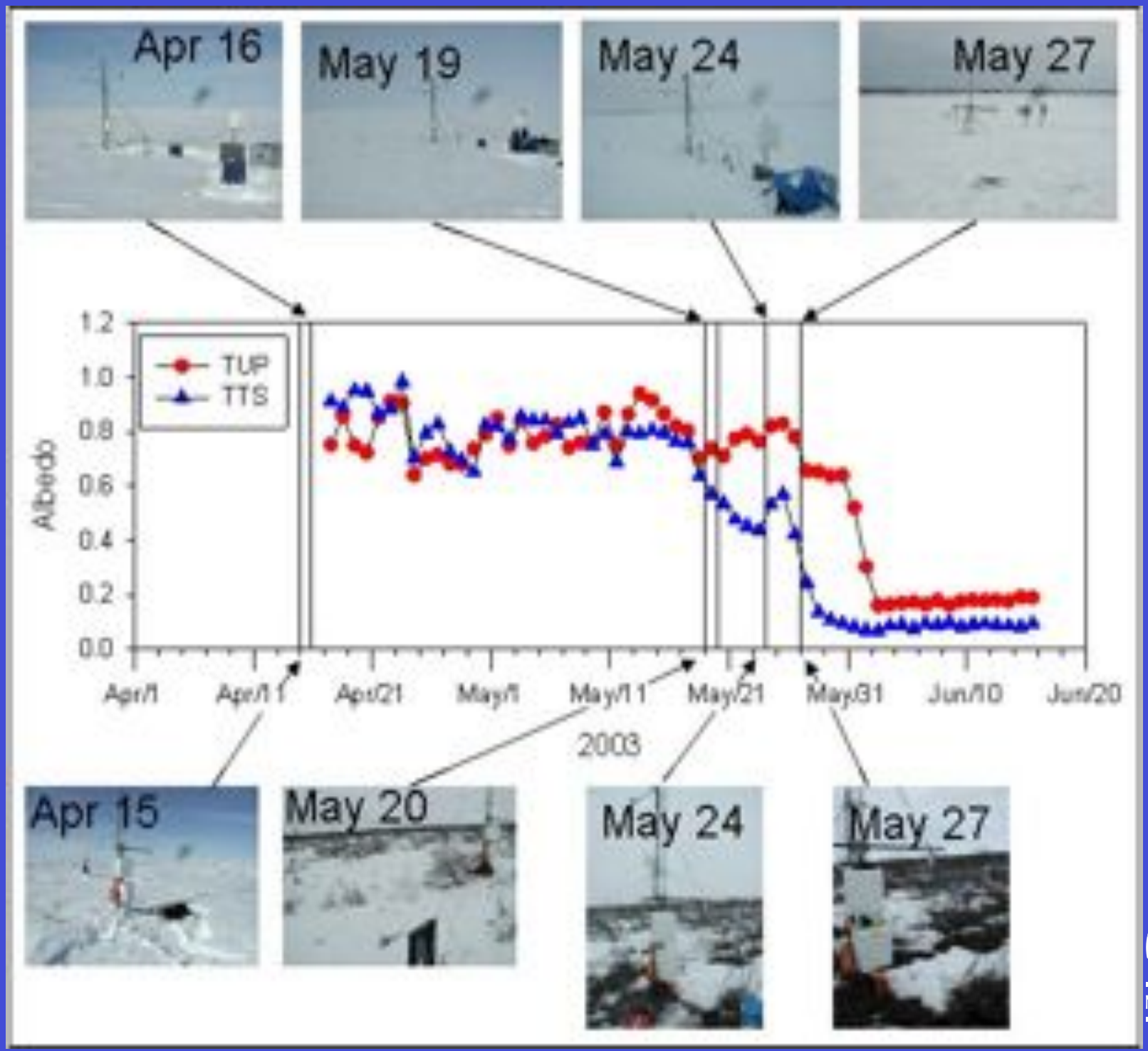
Shrub and tundra changes in albedo over the melt period



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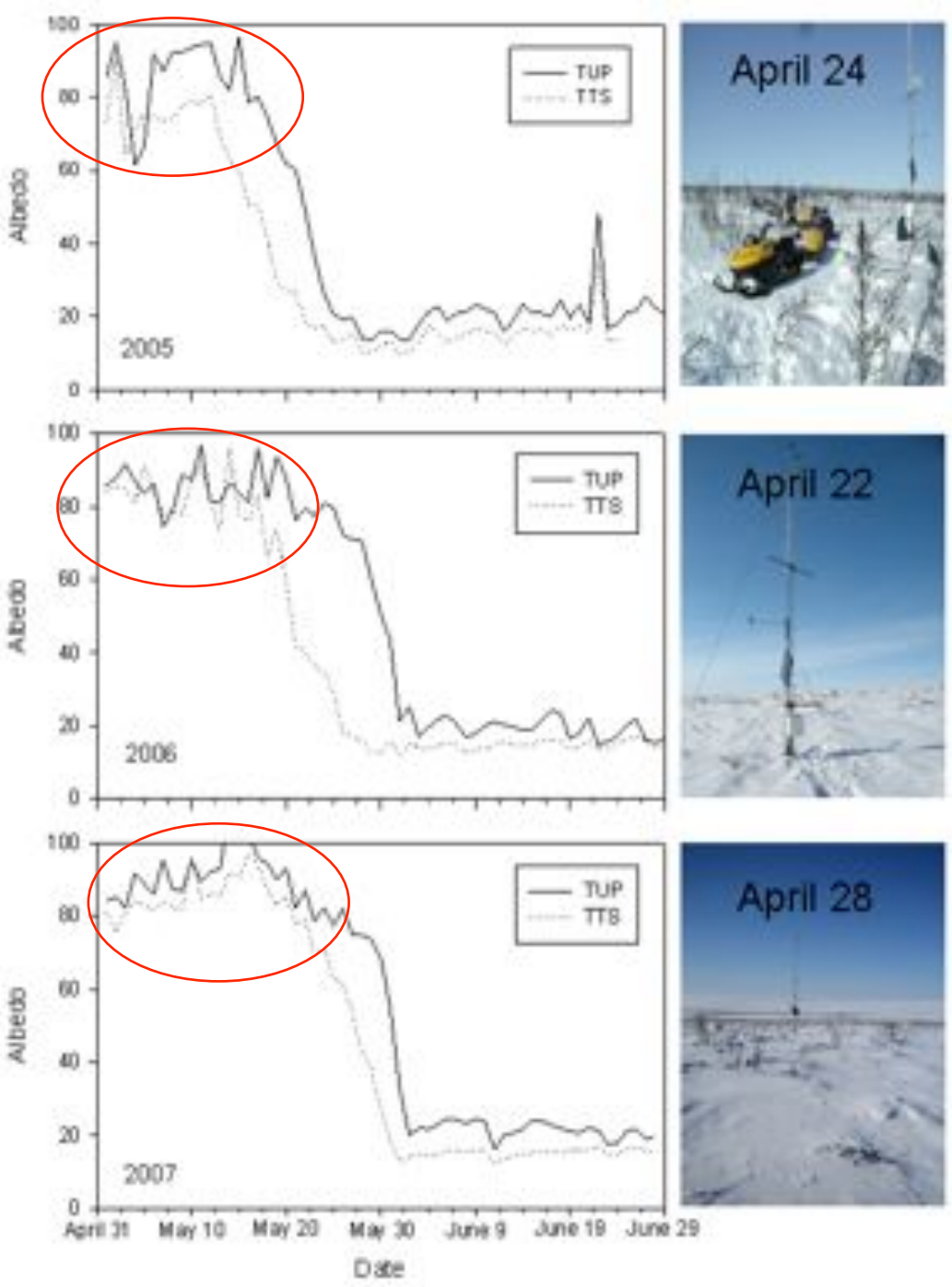
Similar pattern in albedo during 3 subsequent years



Moderate shrubs exposed

Least shrubs expose

- Similar to 2003

Moderate shrubs exposed

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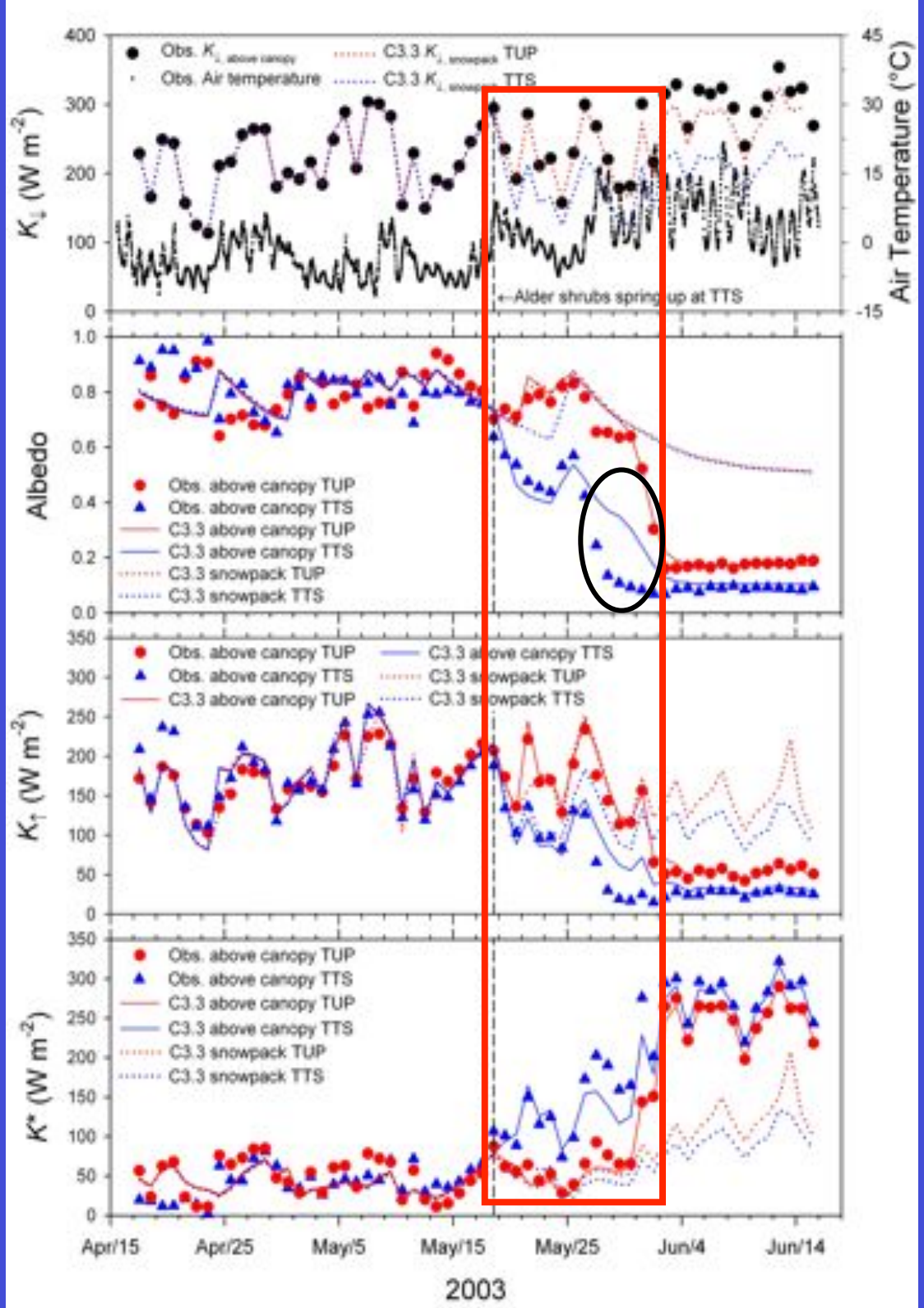
How do we parameterize shrub emergence during melt?

- First CLASS model runs showed that these changes in shrub structure must be considered if we hope to properly model areas with shrubs. How do we do this?

- Paul Bartlett then introduced a simple parameterization to use in the following CLASS runs
  - For a single year, defined when shrub exposure began and gradually increased over the melt period from May 18 to 26

- Stefano Endrizzi in the following talk will describe a more detailed parameterization scheme to see if this further improves predictions of energy fluxes and melt in shrub areas



Solar Radiation at tundra (TUP) and shrub (TTS)

- Tundra albedo greater than shrub. CLASS predicts this change well.

- As a result, Kup is larger at the shrub site

- And Knet is also larger at the shrub site

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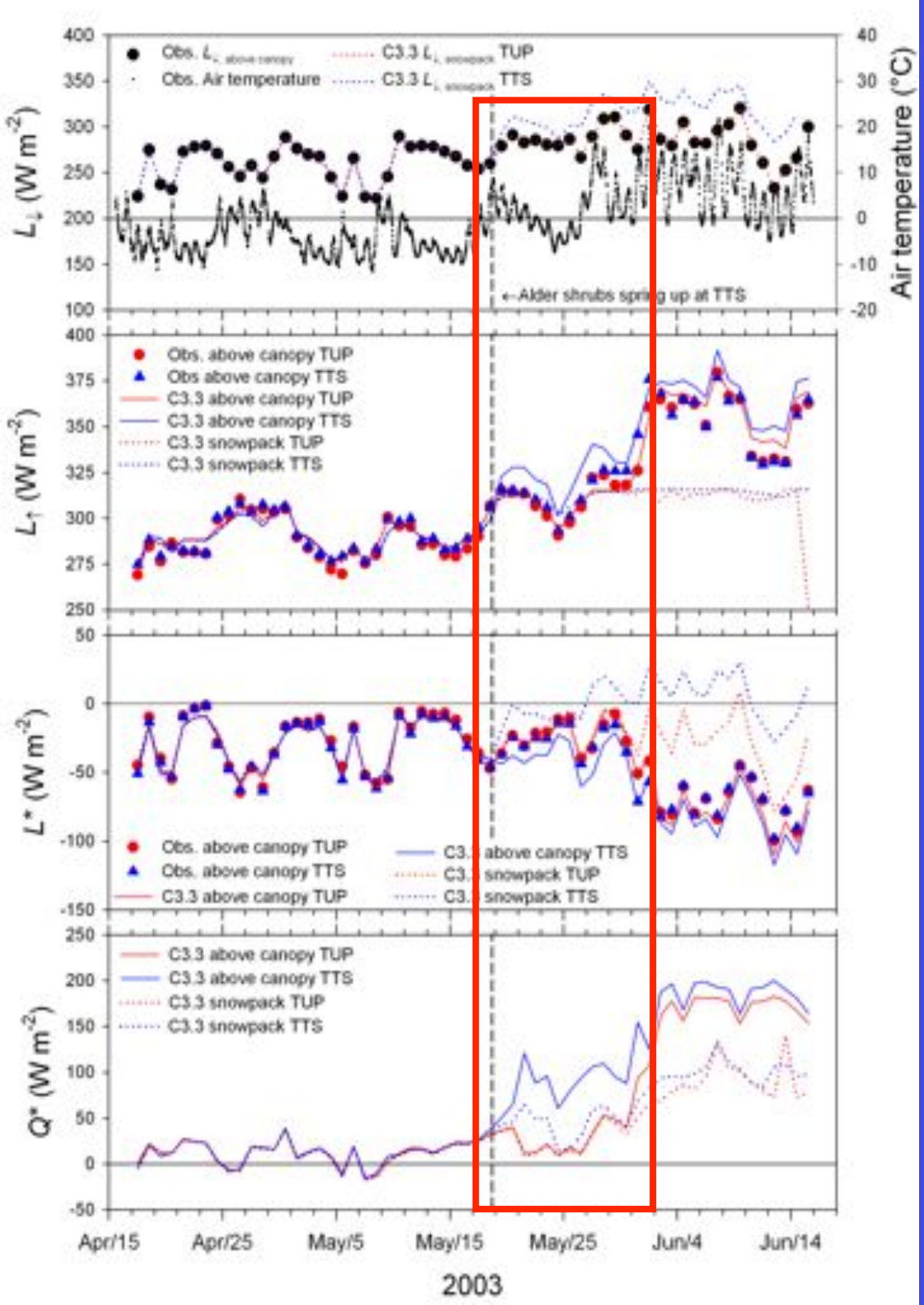

Long wave and Net Radiation at tundra (TUP) and shrub (TTS)

- Lup is slightly higher at the shrub site, but CLASS overestimates at shrub site (TTS)
- Lstar is slightly lower at shrub, but CLASS underestimates at shrub (TTS)
- As a result, Q* is higher at the shrub site than at the tundra site

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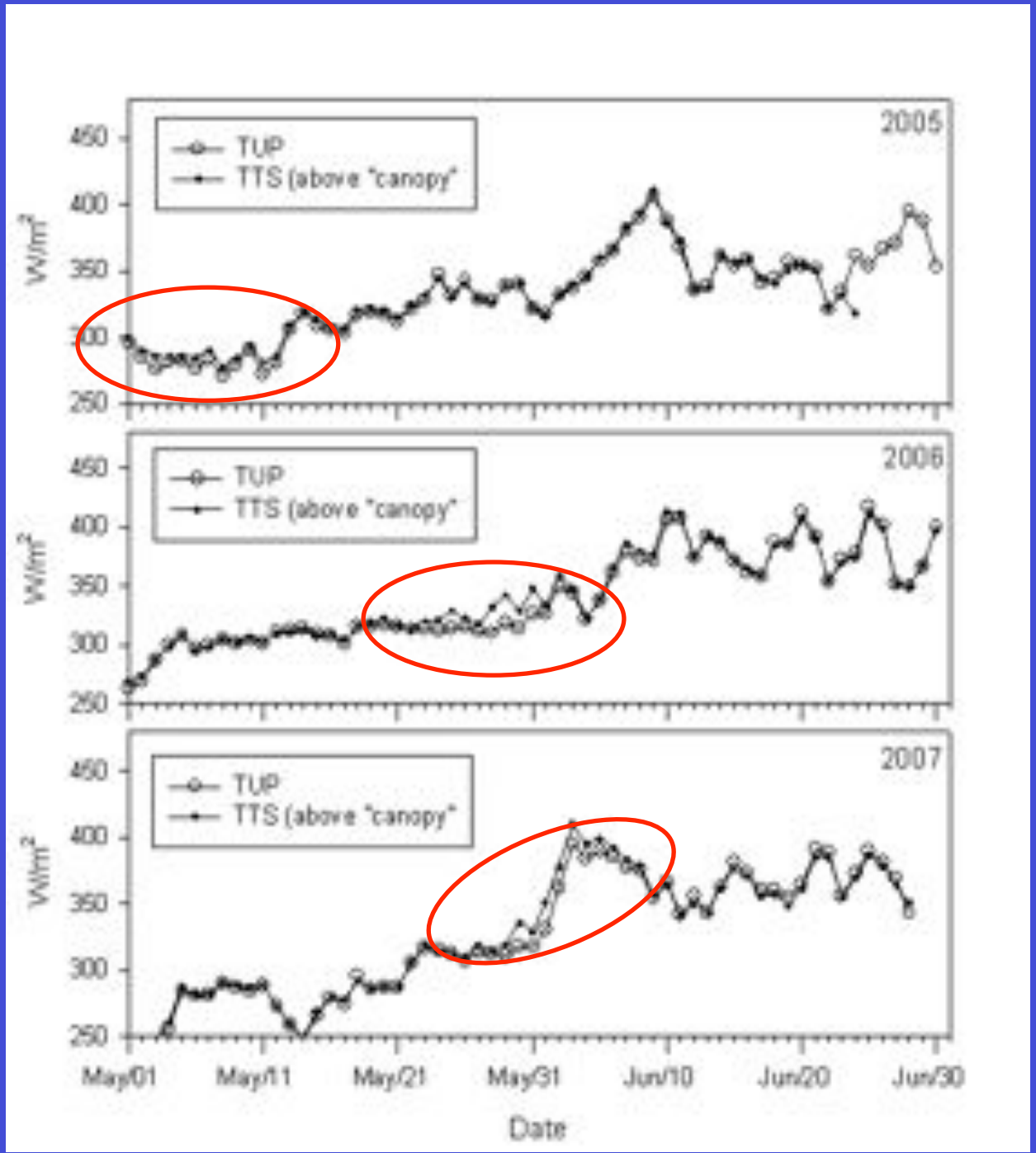
Outgoing long wave radiation at tundra (TUP) and shrub (TTS) during 3 subsequent years



- Lout over shrubs is slightly larger than at the tundra site during melt in 3 other years

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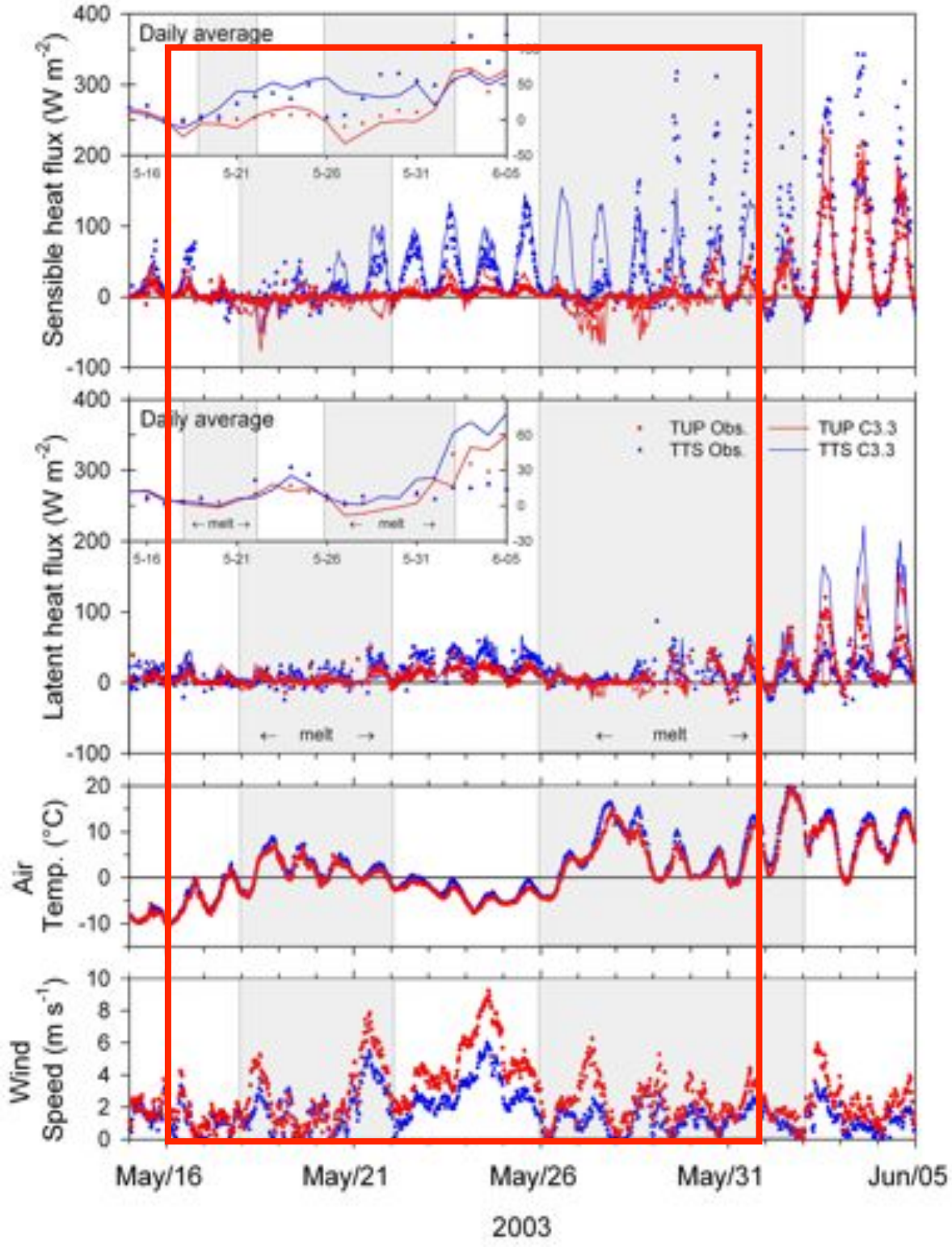
Sensible and latent heat flux



- Sensible heat gradually increases during the melt as shrubs are exposed. CLASS compares well with obs early, but not later

- Latent heat is small throughout the melt period at both sites

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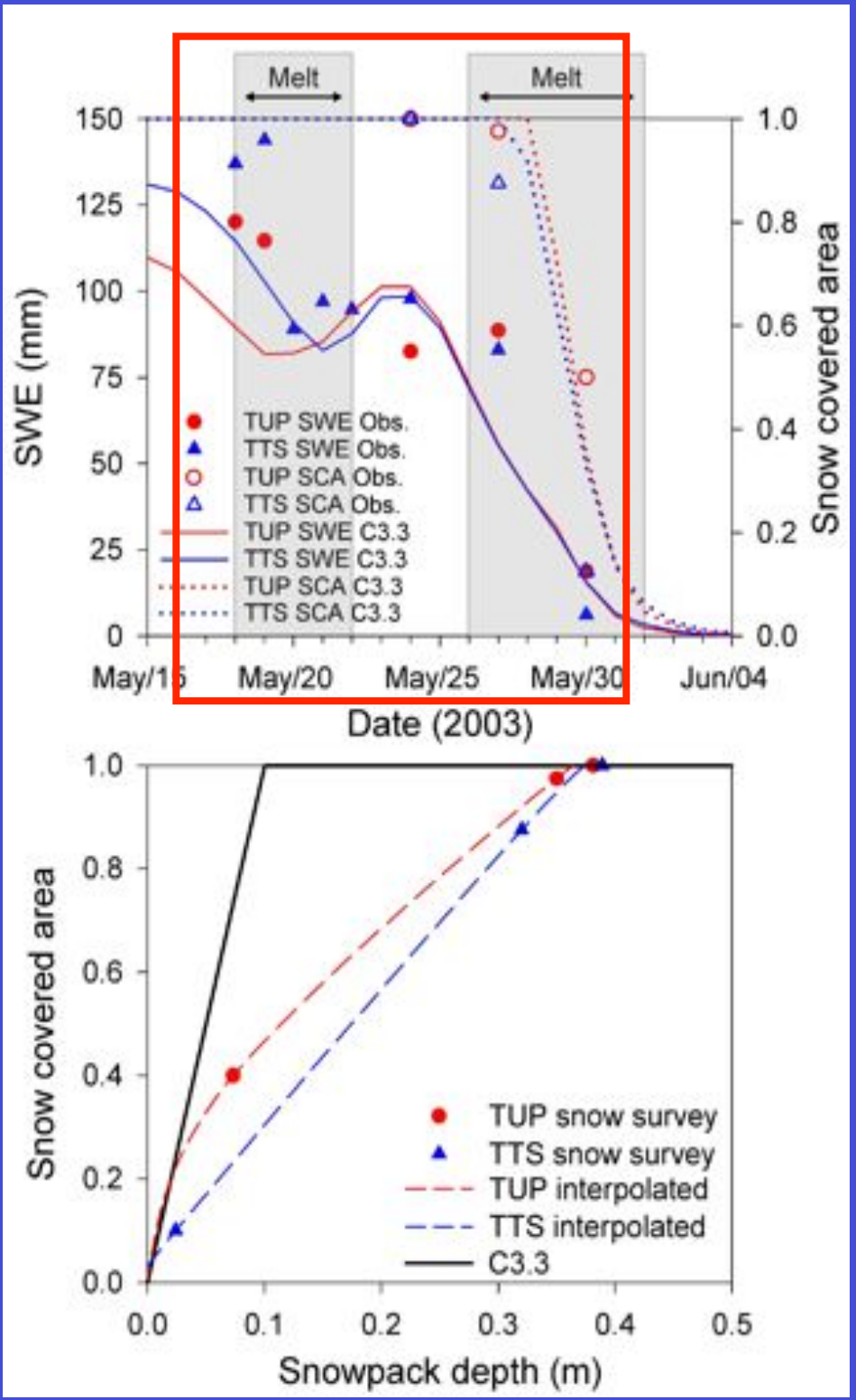

Change in SWE & SCA

- SWE: larger at TTS than TUP, but disappear at approx. the same time, suggesting increased melt rates at the shrub site
- CLASS does a reasonable job of estimating changes
- Observed snow depth vs SCA curves are quite different than used by CLASS

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(4) Publication Plans (1)

1.Improved understanding of point scale processes through observations and modelling:

- Obs + CLASS: for shrub tundra and tundra (submitted HP: Marsh, Bartlett, Mackay, Pohl, Lantz)
- Obs + GEOtop: for shrub tundra and tundra (in prep Hyd. Res.: Endrizzi, Marsh)
  - Emphasis on the shrub canopy effects on fluxes and shrub bending processes
- Obs: energy fluxes from lakes (in prep HESS: Blanken, Marsh)

2.Improved understanding of basin scale spatial variability:

- Obs + GEOtop: fine scale modelling and comparison to Aircraft flux data (in prep HESS: Endrizzi et al.)
- Obs + GEOtop: role of thaw layer development on runoff (in prep. Hyd. Res.: Endizzi, Quinton, Marsh)

Publication plans (2)

3. *Improved understanding of inter-annual variability:*

- GEOtop and MESH: for Trail Valley Creek (in prep: Pohl, Marsh, Endrizzi)

4. *GRU testing*:

- Test MESH using a variety of GRU's that are currently possible within MESH (in prep: Pohl et al.)
- Use GEOtop to consider GRU configurations not currently possible in MESH (in prep: Endrizzi et al.)

7. *Recommendations:*

- Shrub paramaterizations: shurb pop up; shrub canopy schemes; GRU configuration


THE END