Glacier atmosphere interactions and hydrology: Peyto field experiment discoveries.

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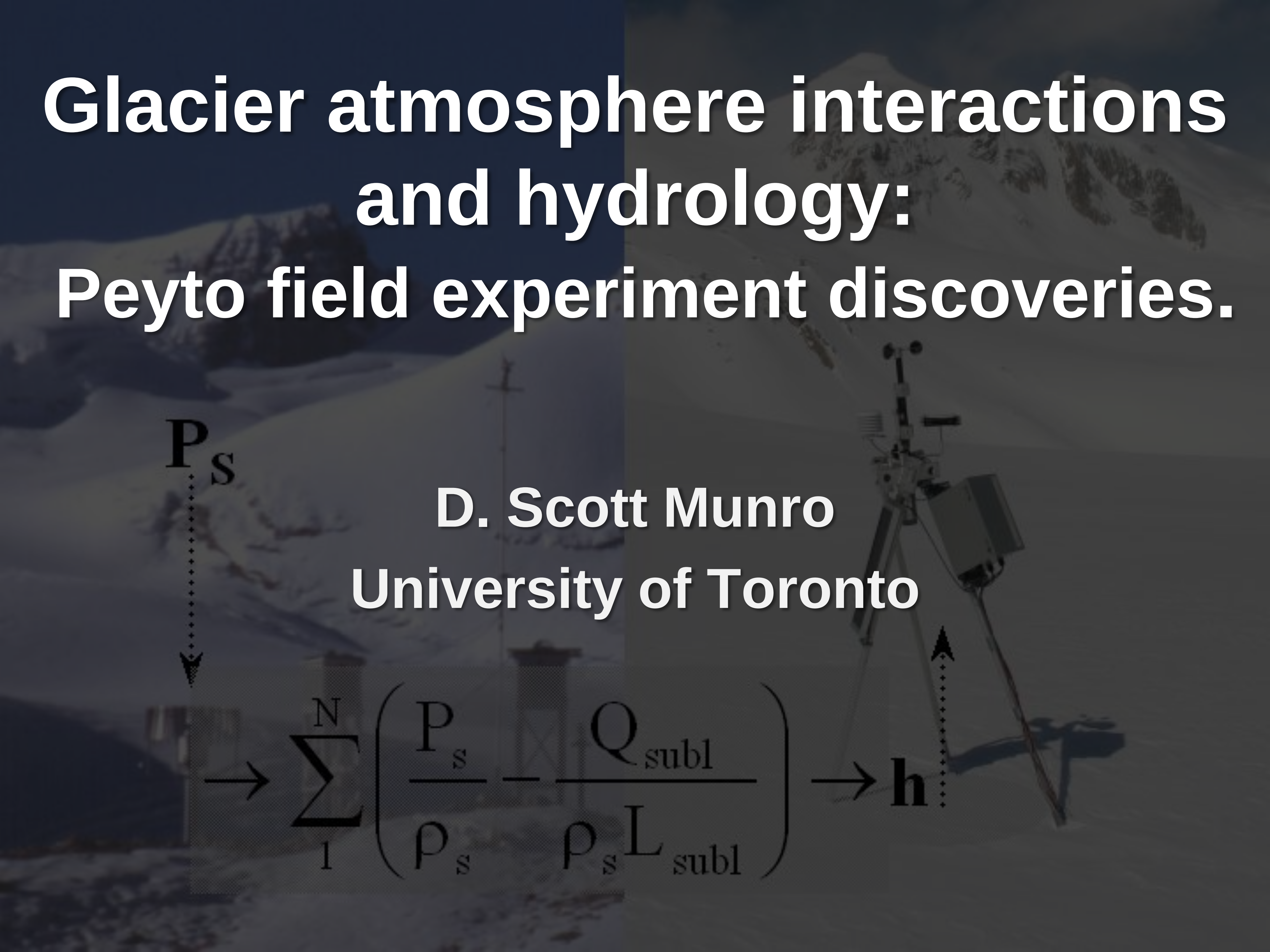
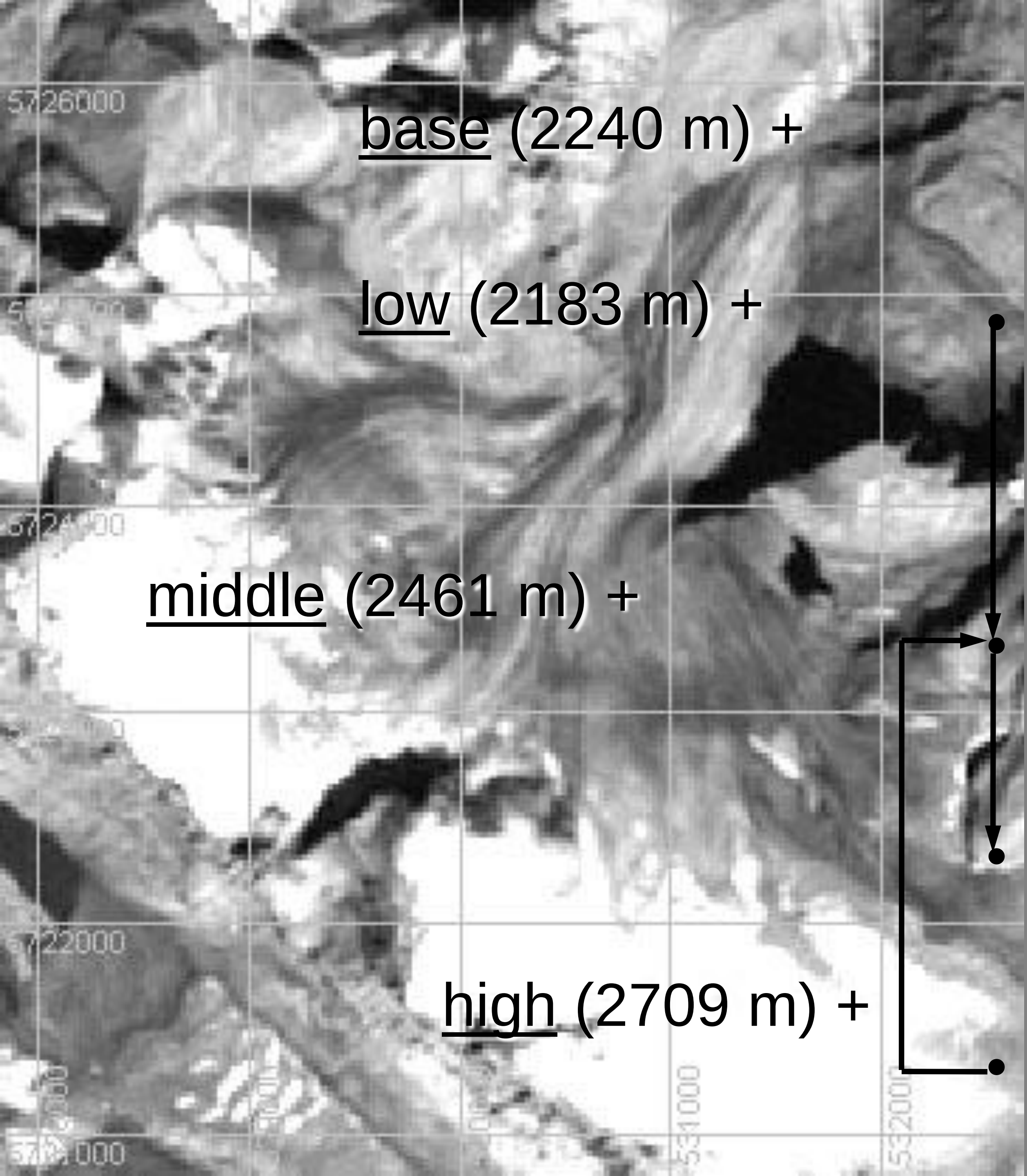


$$P_s \downarrow \rightarrow \sum_{1}^{N}\left(\frac{P_s}{\rho_s} - \frac{Q_{subl}}{\rho_s L_{subl}}\right) \rightarrow \mathbf{h} \uparrow$$

AWS Network

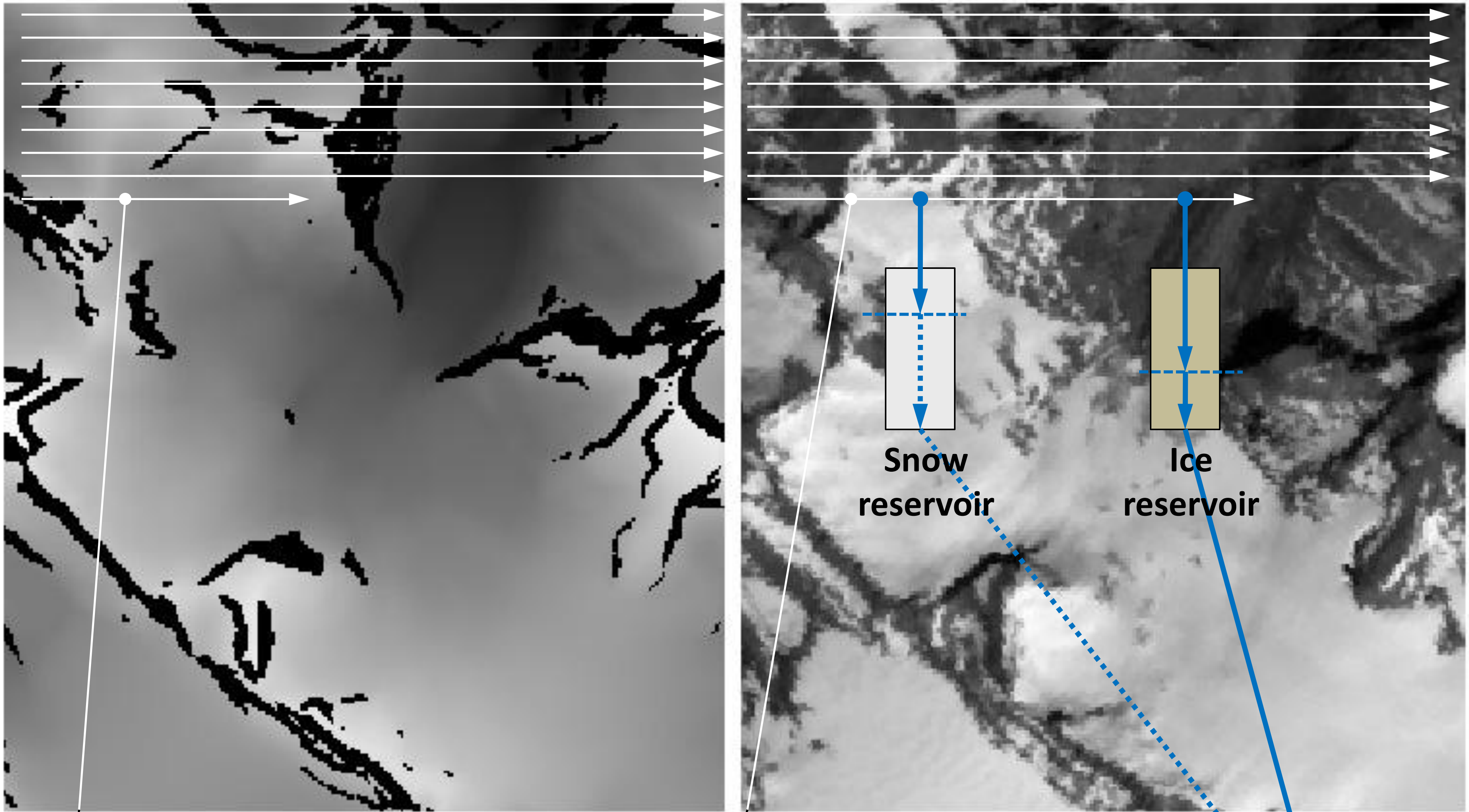


← Point ***process*** **investigation: glacier atmosphere interactions and hydrology**

← **Distribution tools (DEM, trigonometry,** ***parameterization*****)**

← **Distributed modelling and** ***prediction***

← **Base AWS/RCM forcing**

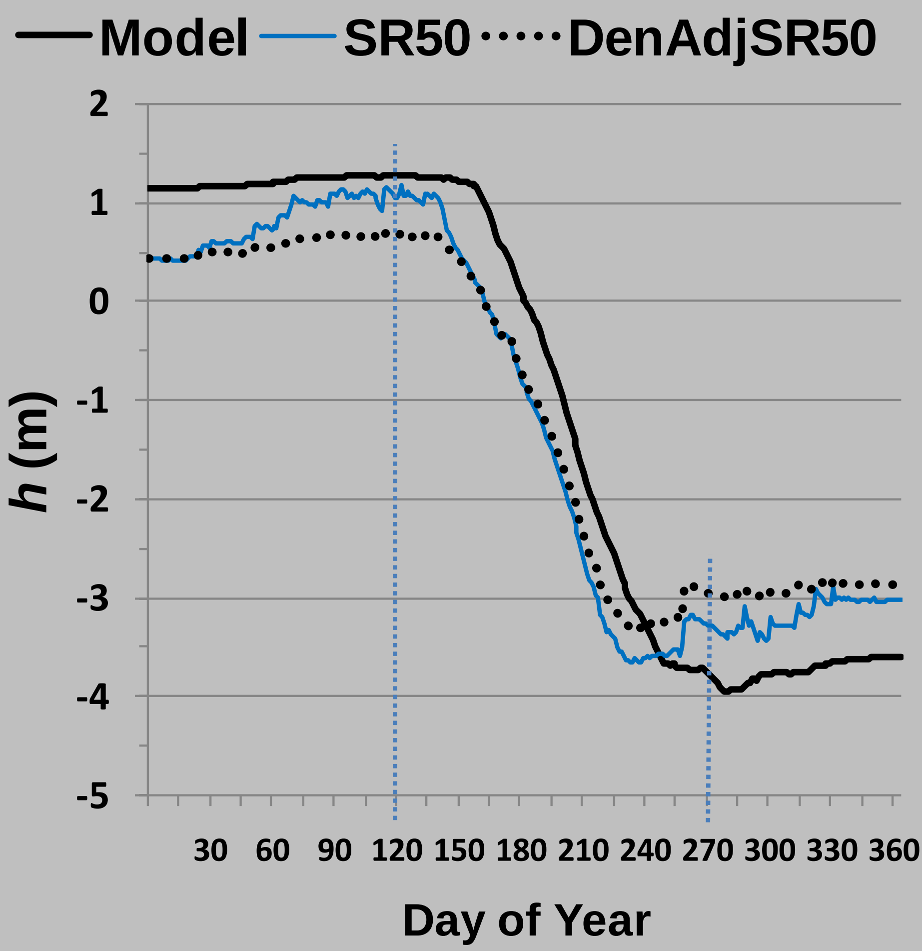


Snow accumulation **Ice & Snow melt**

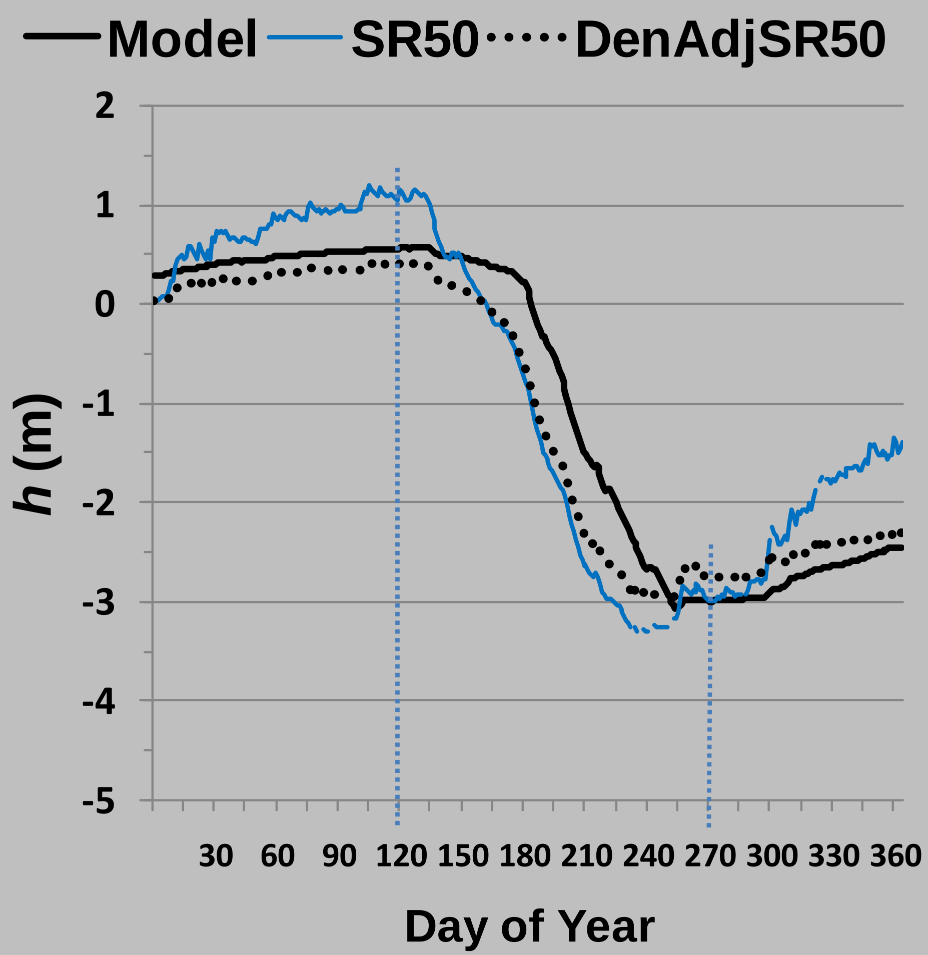
$$\left\{ P_{r/s} + \frac{K\downarrow\left(1-\alpha_{i/s}\right)+L_{*}+Q_{H}+Q_{E}}{\rho_{i/s}L_{f}} \right\}_{j} = \delta M_{j} \qquad q_{j}$$

Model – AWS Comparisons

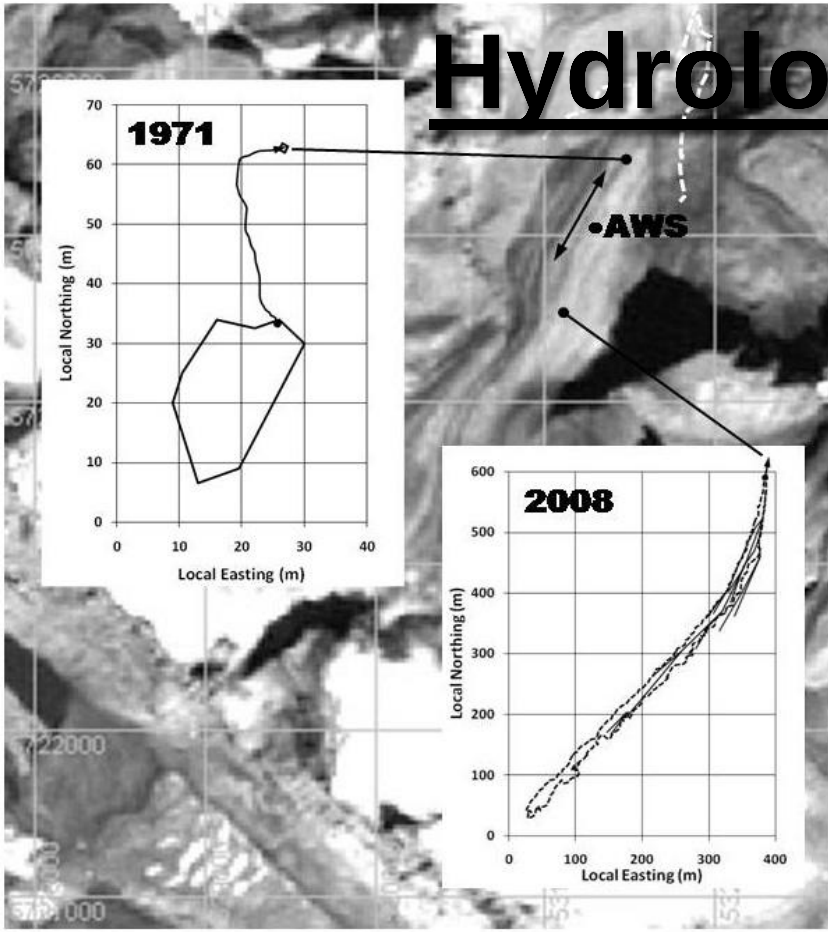
Low AWS - 2003



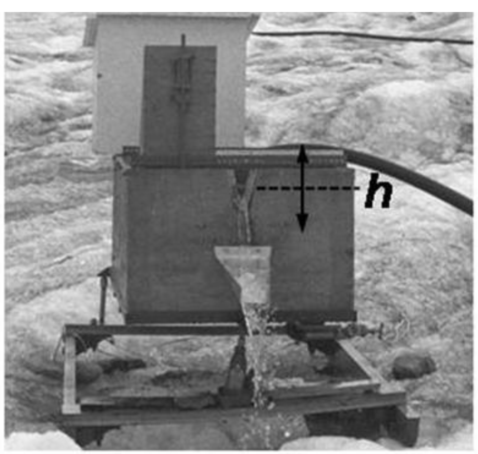
Middle AWS - 2006



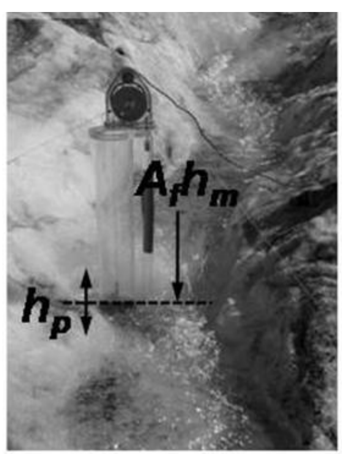
Hydrology



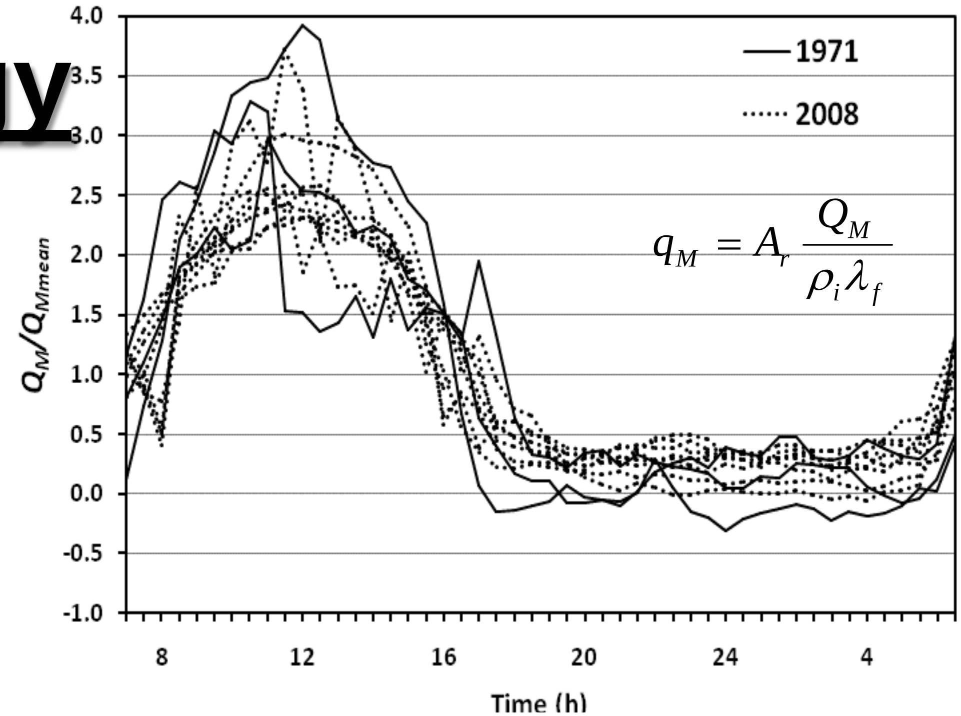
1971
Local Northing (m)
Local Easting (m)
•AWS
2008
Local Northing (m)
Local Easting (m)



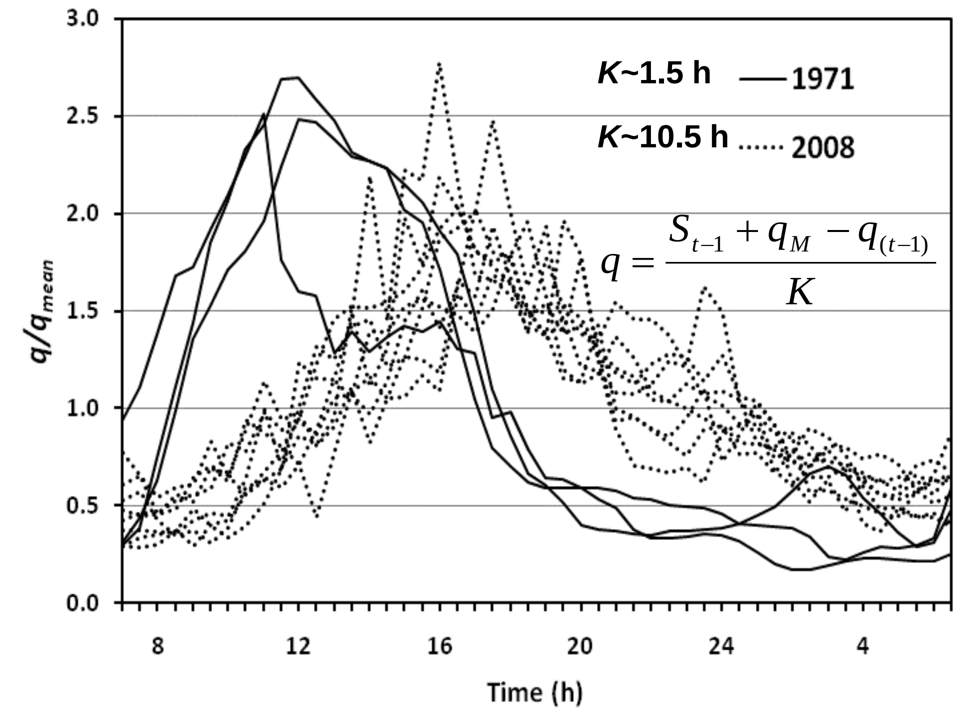
h



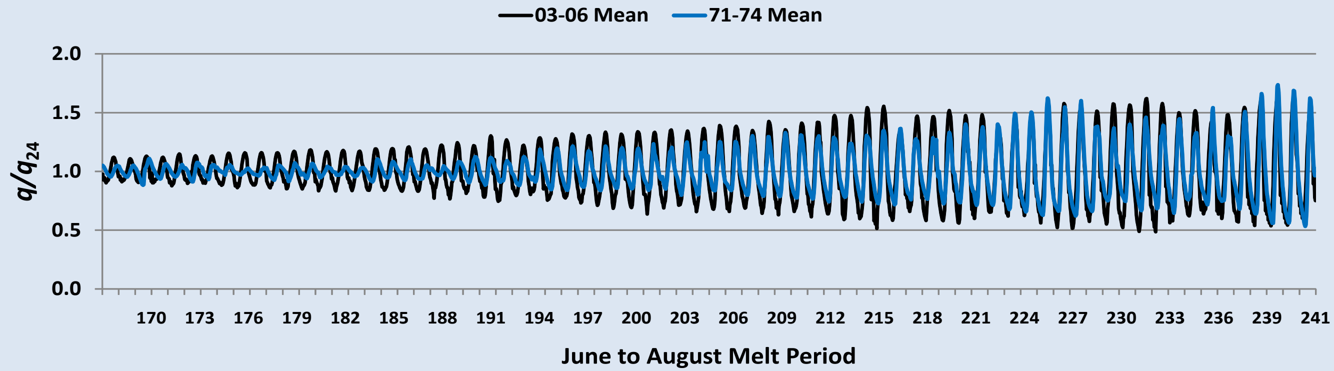
$A_r h_m$
h_p

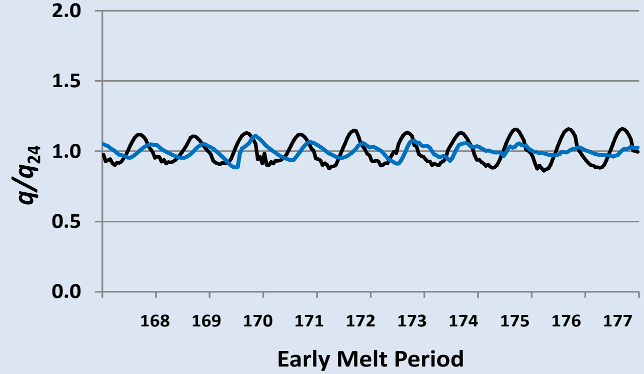


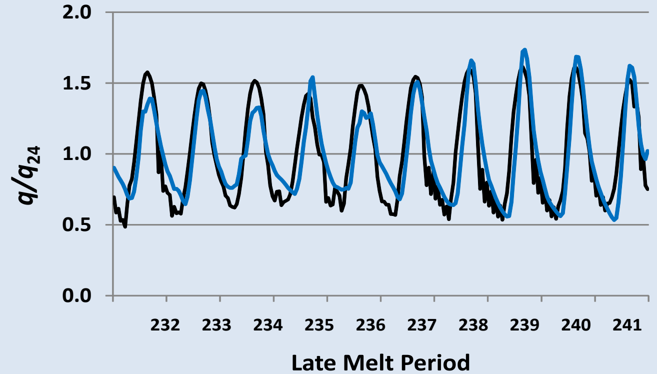
1971
2008
$q_M = A_r \frac{Q_M}{\rho_i \lambda_f}$
Q_M/Q_{Mmean}
Time (h)

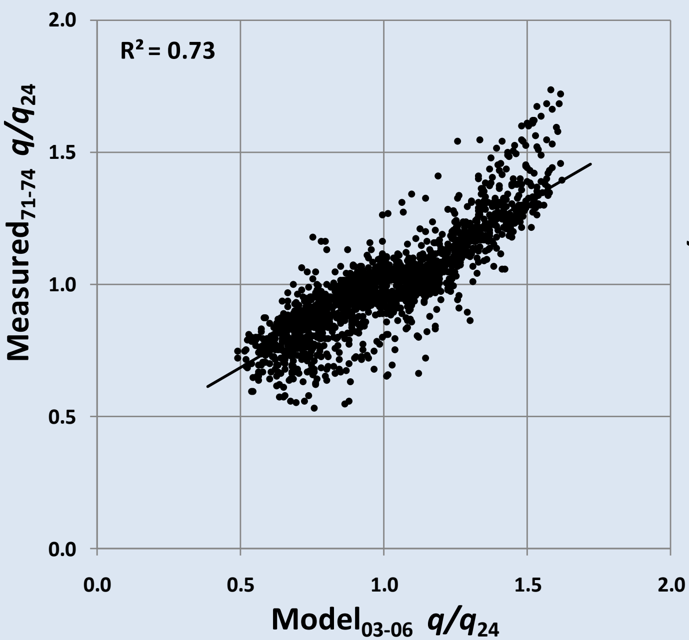


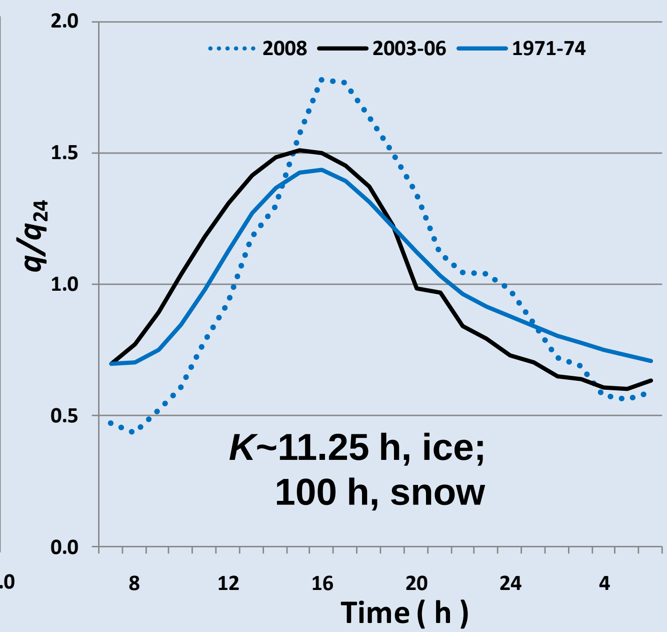
K~1.5 h 1971
K~10.5 h 2008
$q = \frac{S_{t-1} + q_M - q_{(t-1)}}{K}$
q/q_{mean}
Time (h)



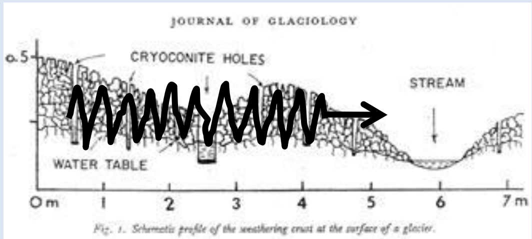


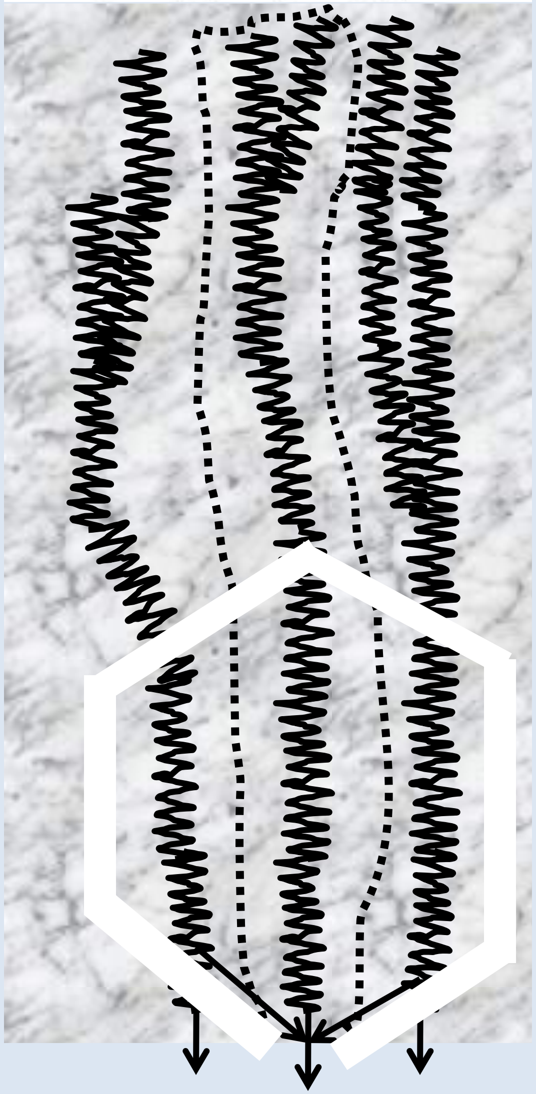






Müller & Keeler 1969





Glacier – Atmosphere Interaction

- **Focusing on the sensible heat flux, Q_H, there are respectively to the right of the equal sign the gradient, eddy correlation (EC) and bulk transfer methods of obtaining the flux density:**

$$Q_H = \rho c_p k^2 z^2 \left(\frac{\Delta \bar{u}}{\Delta z} \cdot \frac{\Delta \bar{T}}{\Delta z} \right) \Phi^{-2} = \rho c_p \overline{w'T'} = \rho c_p k^2 \bar{u} \frac{\left(\bar{T} - T_S\right)}{\left(\ln[z/z_o] + \psi\right)^2}$$

- **The key feature of the flow regime is a local wind speed maximum, close to the surface, through which heat should not flow because *$\Delta u/\Delta z = 0$*, yet the bulk transfer approach seems to provide reasonable heat flux values, regardless of the measurement height used.**
- **Although EC measurements of Q_H below the local wind speed maximum seem to agree with bulk transfer estimates, less is known about EC measurements near to and above the level of maximum wind speed.**
- **Also to consider is the Oerlemans-Grisogono parameterization (OG) which is convenient for modelling, but contrary to classical thinking about the nature of the glacier atmospheric boundary-layer.**

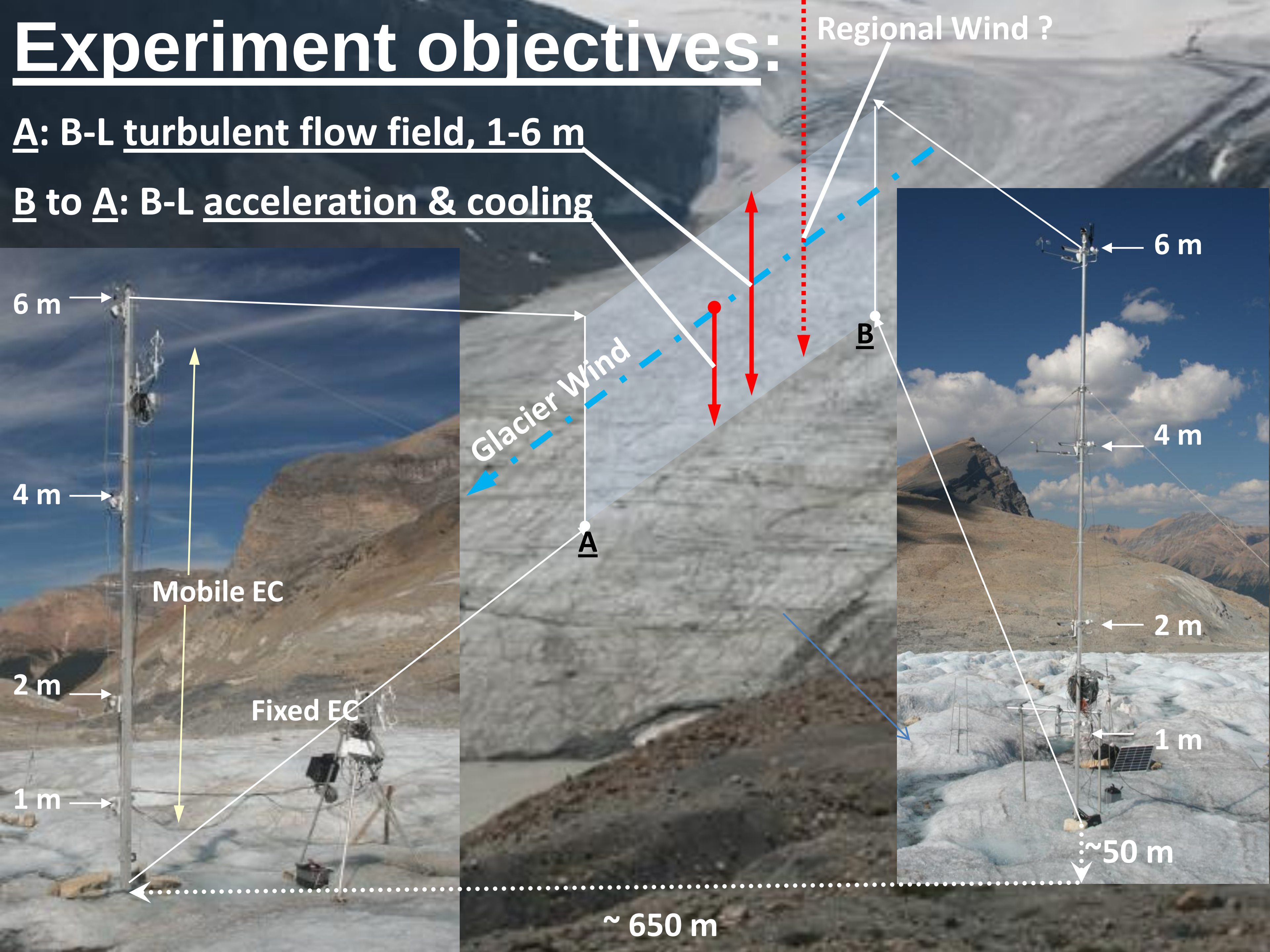
$$Q_H = \rho c_p \left(\frac{K_{geo} + K_{kat}}{2} \right) (\bar{T} - T_S)$$

- **If classical thinking is correct EC measurements of $Q_H \rightarrow 0$ near the local wind speed maximum, but if OG is correct the Q_H measurements will show a step change across the level of maximum wind speed.**

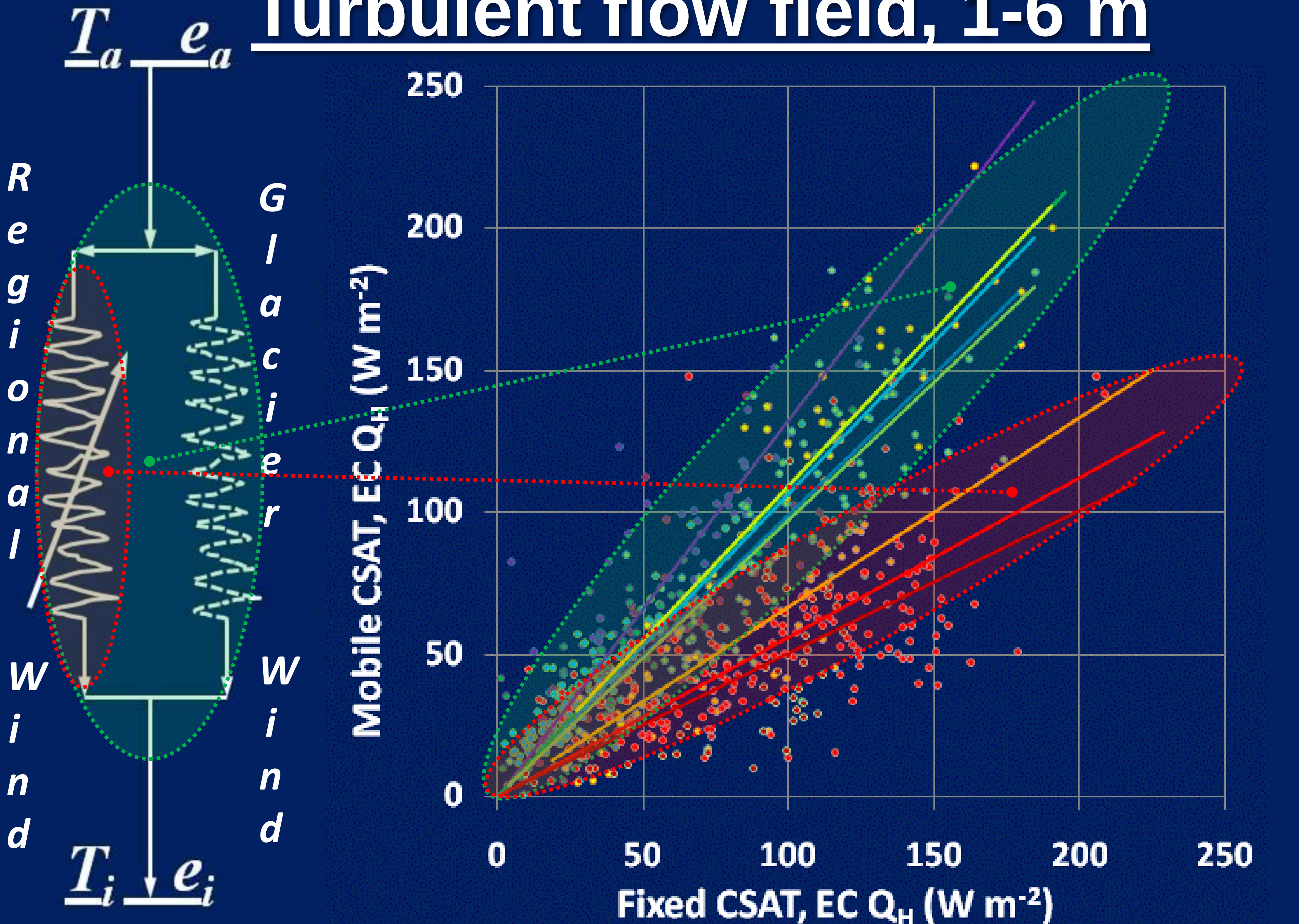
Experiment objectives:

A: B-L turbulent flow field, 1-6 m

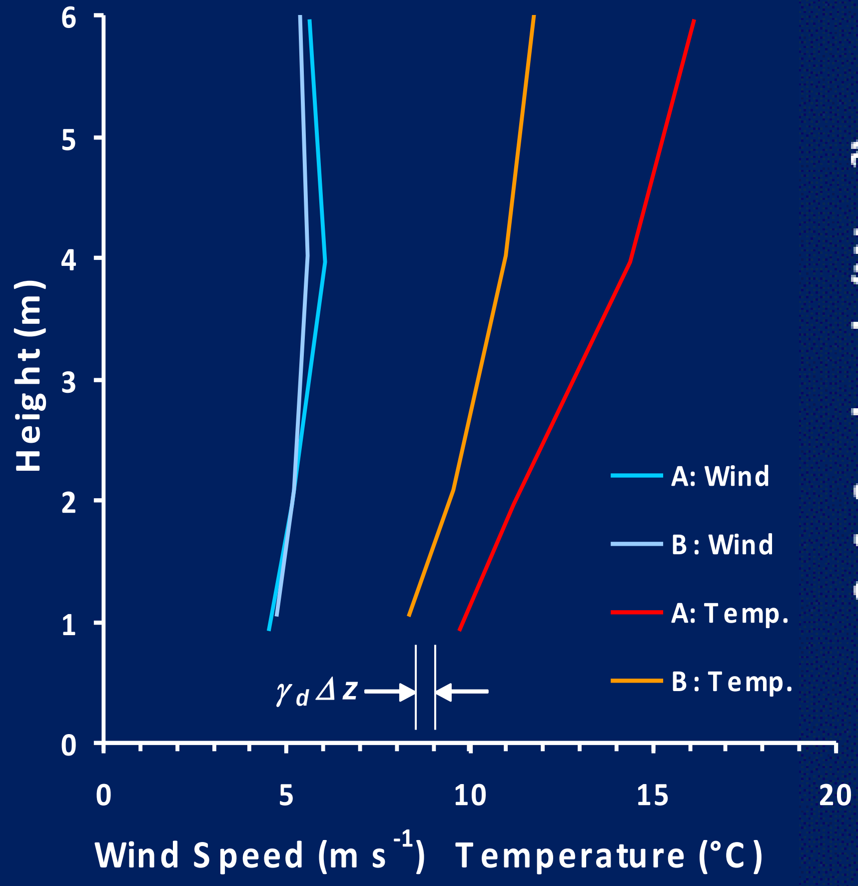
B to A: B-L acceleration & cooling

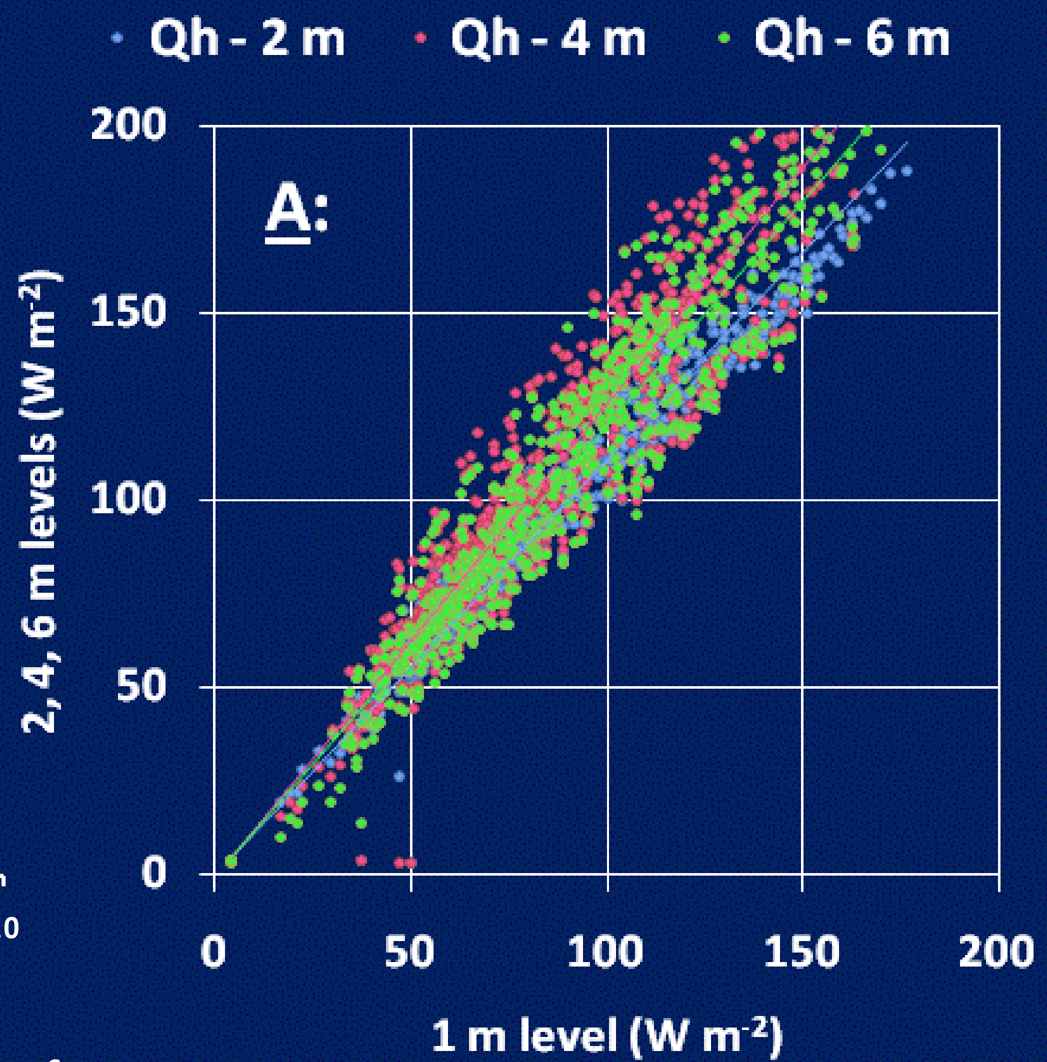


Turbulent flow field, 1-6 m



Acceleration & cooling





Taking mean values, assuming no heat transfer across 4 m and correcting for adiabatic warming, expect 1 & 2 m $T_A < T_B$ by ~2 °C.

Concluding with analogues:

On hydrology:

- An electrical analogue to consider for supraglacial runoff is a series resistance system that links the runoff potential of the melting ice surface to supraglacial stream discharge.
- In such a system resistance should increase with weathering crust development, decrease with decay, so a good test of this idea is to continuously measure short-term runoff from a supraglacial basin all summer to see if K depends on the weather.

On glacier-atmosphere interactions:

- An electrical analogue to consider for boundary-layer heat transfer to the glacier is a parallel resistance system that links the energy potential of the regional air mass to surface melt.
- One branch of such a system is the geostrophic flow, the other a katabatic flow that is subject to sporadic breakdown, thus explaining *hot flash* behaviour.
- This is supported by the 2008 eddy correlation data that suggest two turbulent transfer fields adjacent to the glacier surface, one of which extends above the level of the wind speed maximum.

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