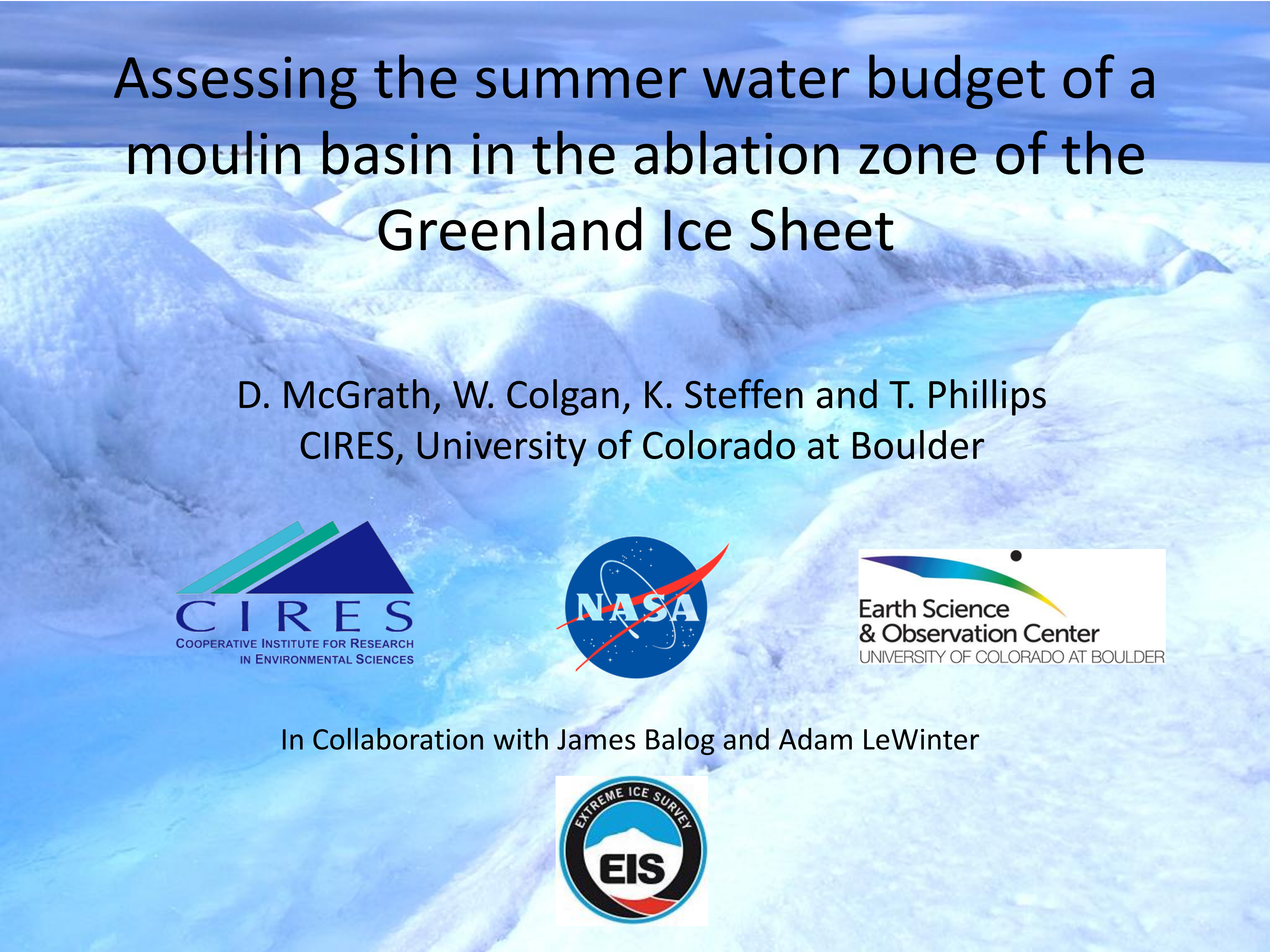

Assessing the summer water budget of a moulin basin in the ablation zone of the Greenland Ice Sheet

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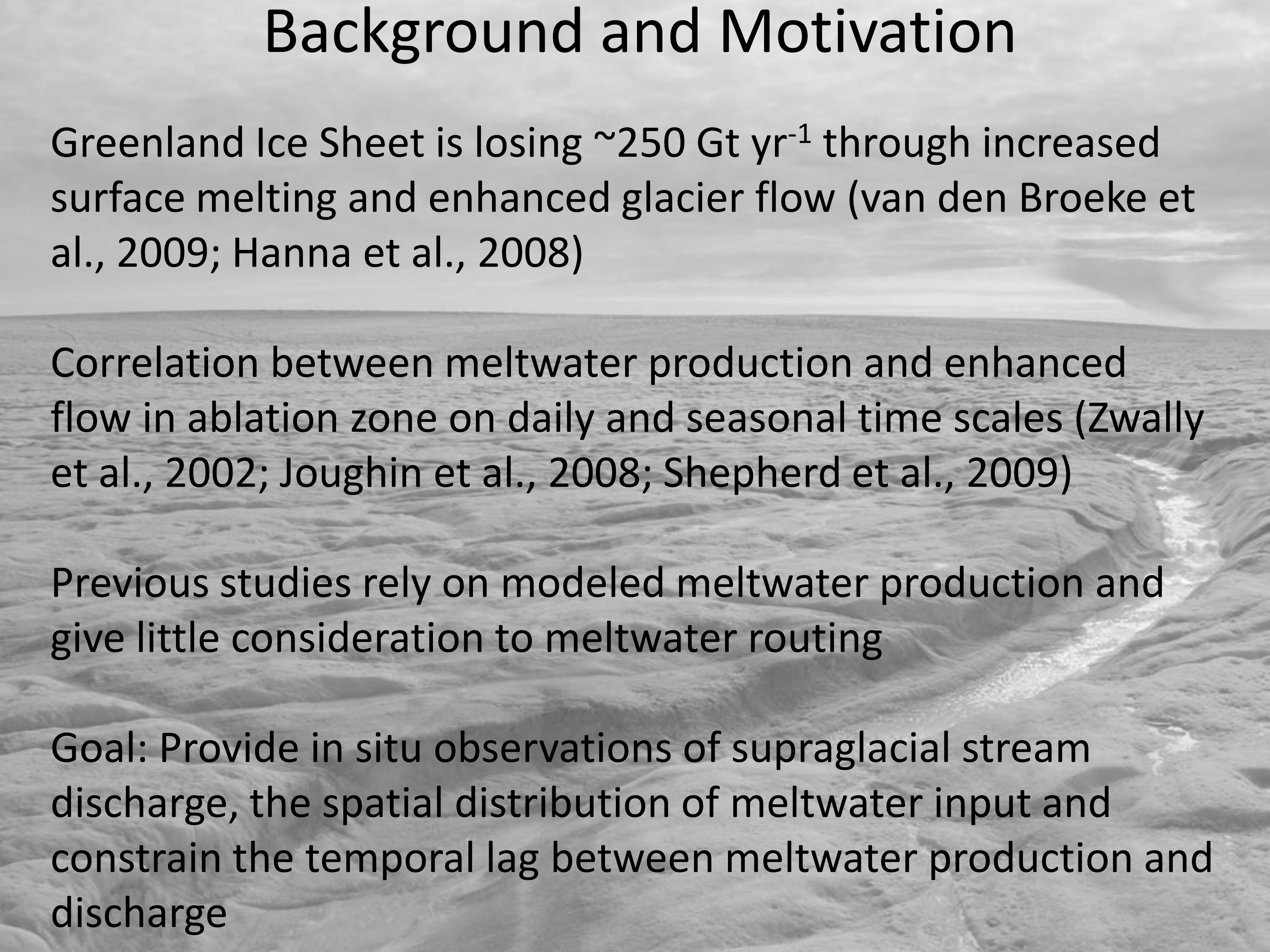
In Collaboration with James Balog and Adam LeWinter

Background and Motivation



Greenland Ice Sheet is losing ~250 Gt yr^{-1} through increased surface melting and enhanced glacier flow (van den Broeke et al., 2009; Hanna et al., 2008)

Correlation between meltwater production and enhanced flow in ablation zone on daily and seasonal time scales (Zwally et al., 2002; Joughin et al., 2008; Shepherd et al., 2009)

Previous studies rely on modeled meltwater production and give little consideration to meltwater routing

Goal: Provide in situ observations of supraglacial stream discharge, the spatial distribution of meltwater input and constrain the temporal lag between meltwater production and discharge

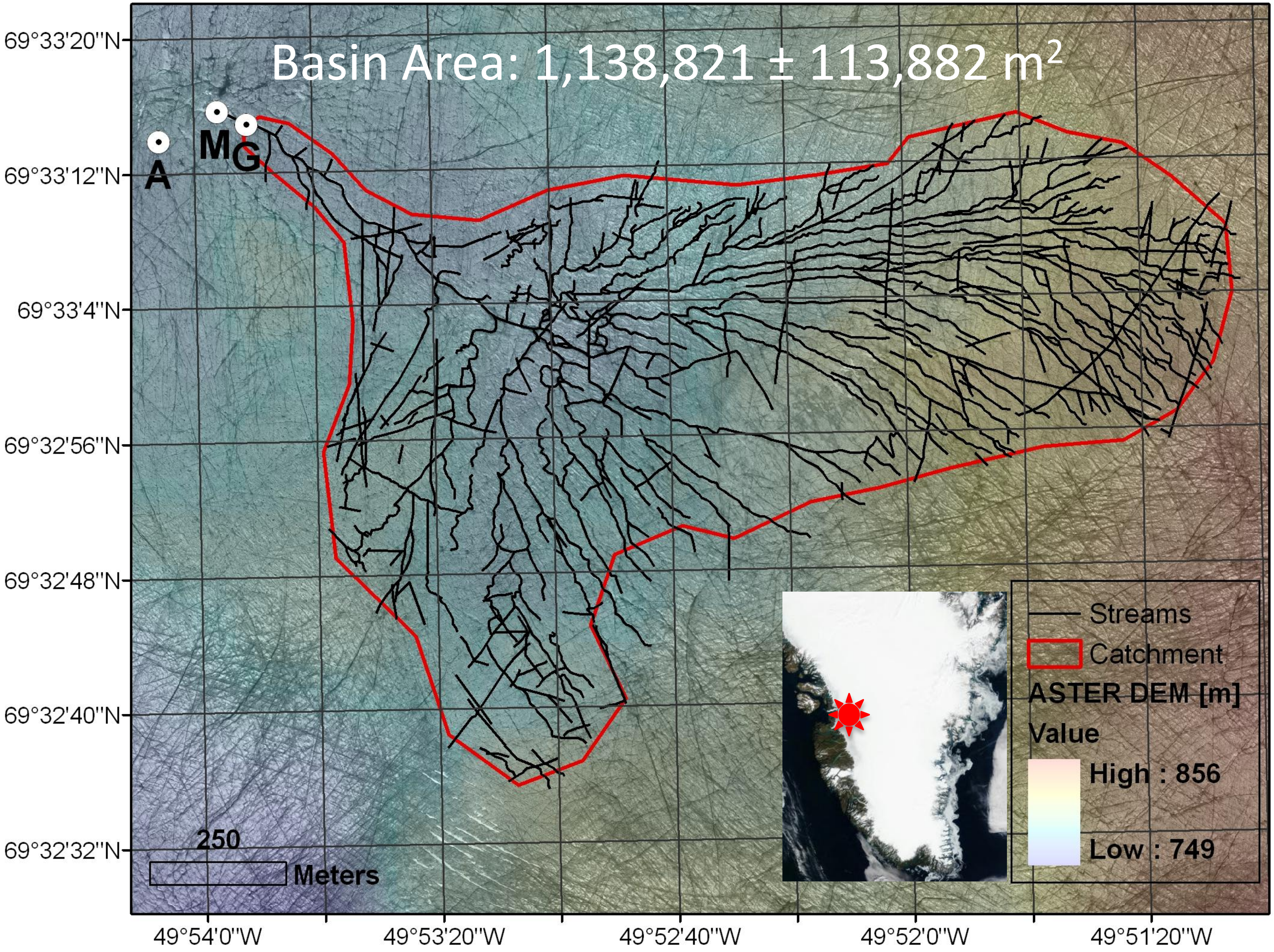
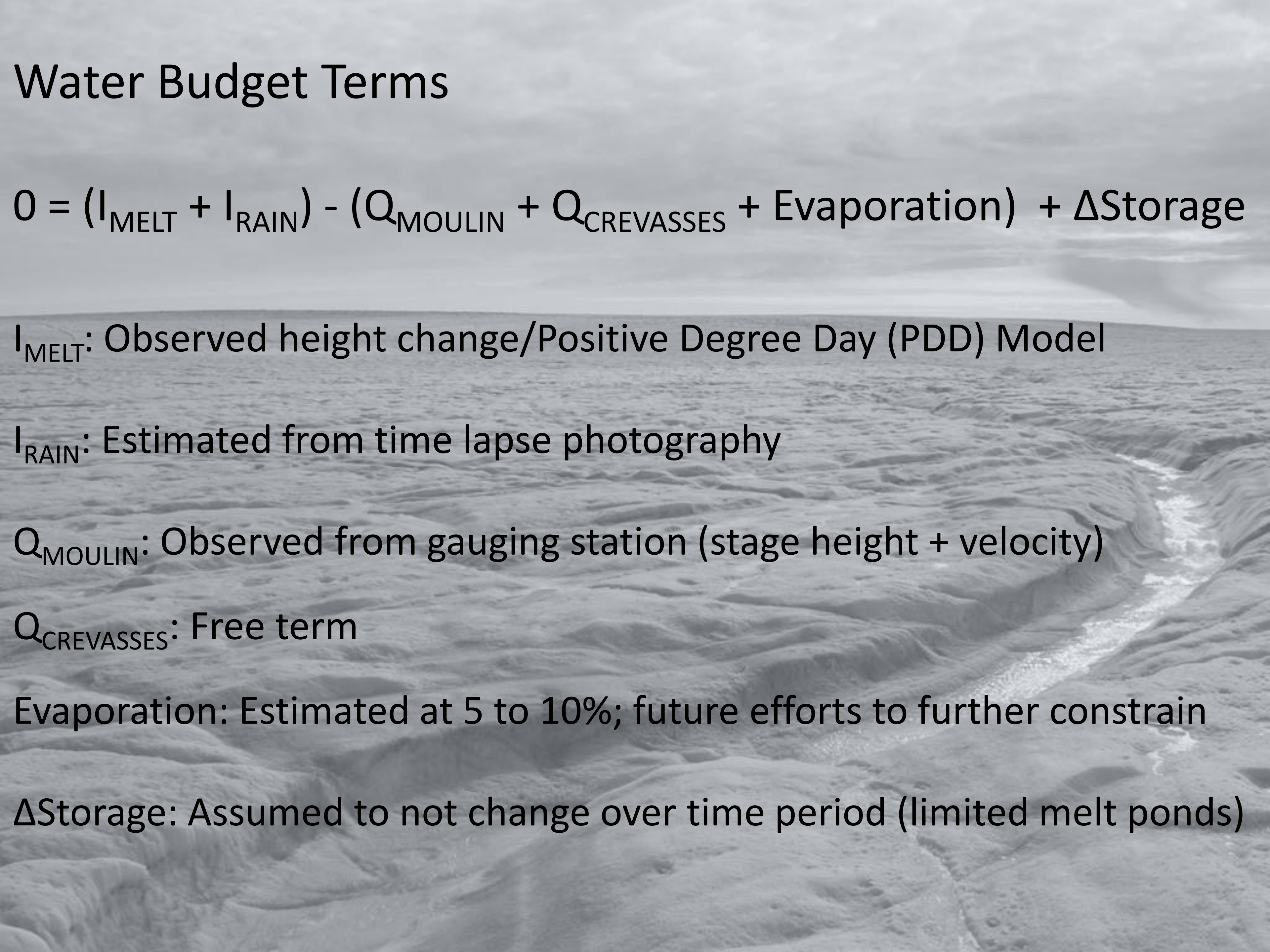


Figure 1. Moulin basin and streams delineated on WorldView-1 imagery.

Water Budget Terms



$$0 = (I_{MELT} + I_{RAIN}) - (Q_{MOULIN} + Q_{CREVASSES} + \text{Evaporation}) + \Delta\text{Storage}$$

I_{MELT}: Observed height change/Positive Degree Day (PDD) Model

I_{RAIN}: Estimated from time lapse photography

Q_{MOULIN}: Observed from gauging station (stage height + velocity)

$Q_{CREVASSES}$: Free term

Evaporation: Estimated at 5 to 10%; future efforts to further constrain

ΔStorage: Assumed to not change over time period (limited melt ponds)

AWS Temperature and Surface Height

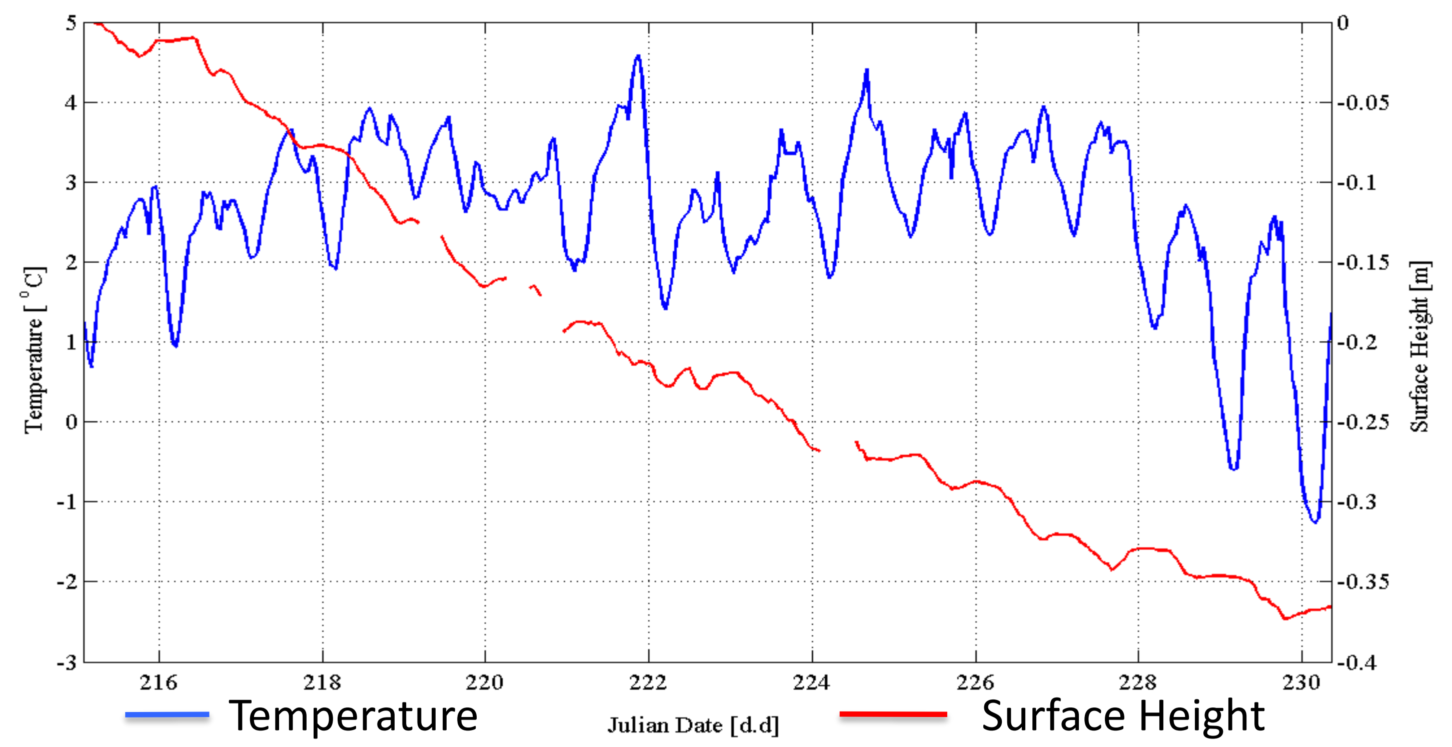


Figure 2. Observed temperature and surface height at AWS.

Positive Degree Day Modeling

-Melting of snow/ice is proportional to the sum of all temperatures above melting point over time interval (day, month)

-Simplification of complex processes that are more properly described by energy balance of surface and atmospheric boundary layer

- Use previously validated PDD factors (Braithwaite, 1995; Thomas et al., 2003)

Observed and Modeled Cumulative Meltwater Production (I_{MELT})

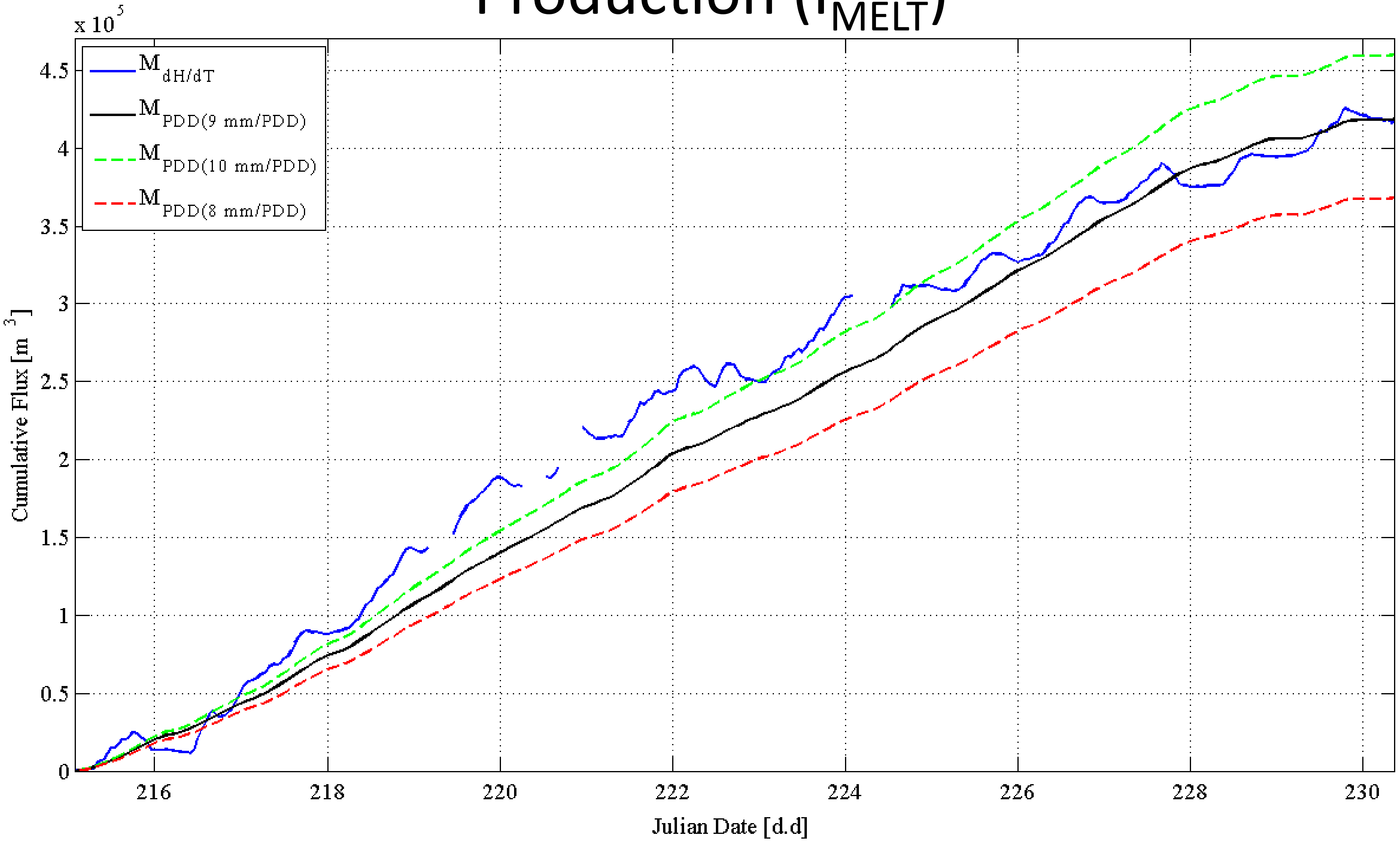


Figure 3. Observed cumulative meltwater production (dH/dt * basin area) and modeled PDD cumulative meltwater production using three PDD factors (8, 9, 10 mm PDD^{-1}).

$Q_{\text{Discharge}}$

Figure 4. Gauging station set-up.

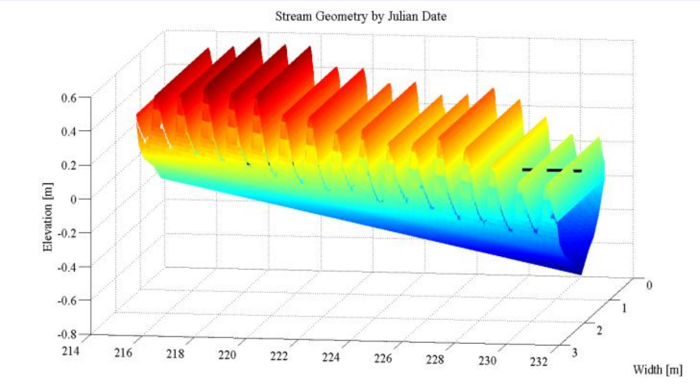


Figure 5. Cross sectional area of river channel through time.

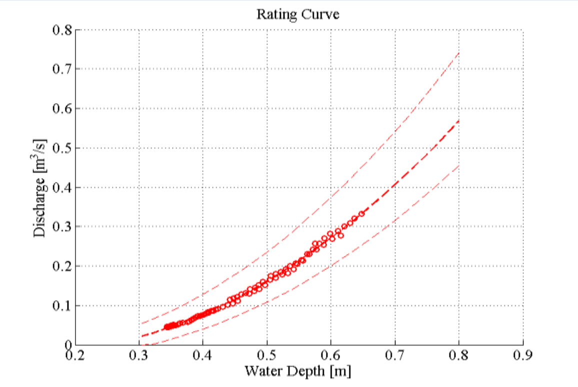


Figure 6. Rating curve.

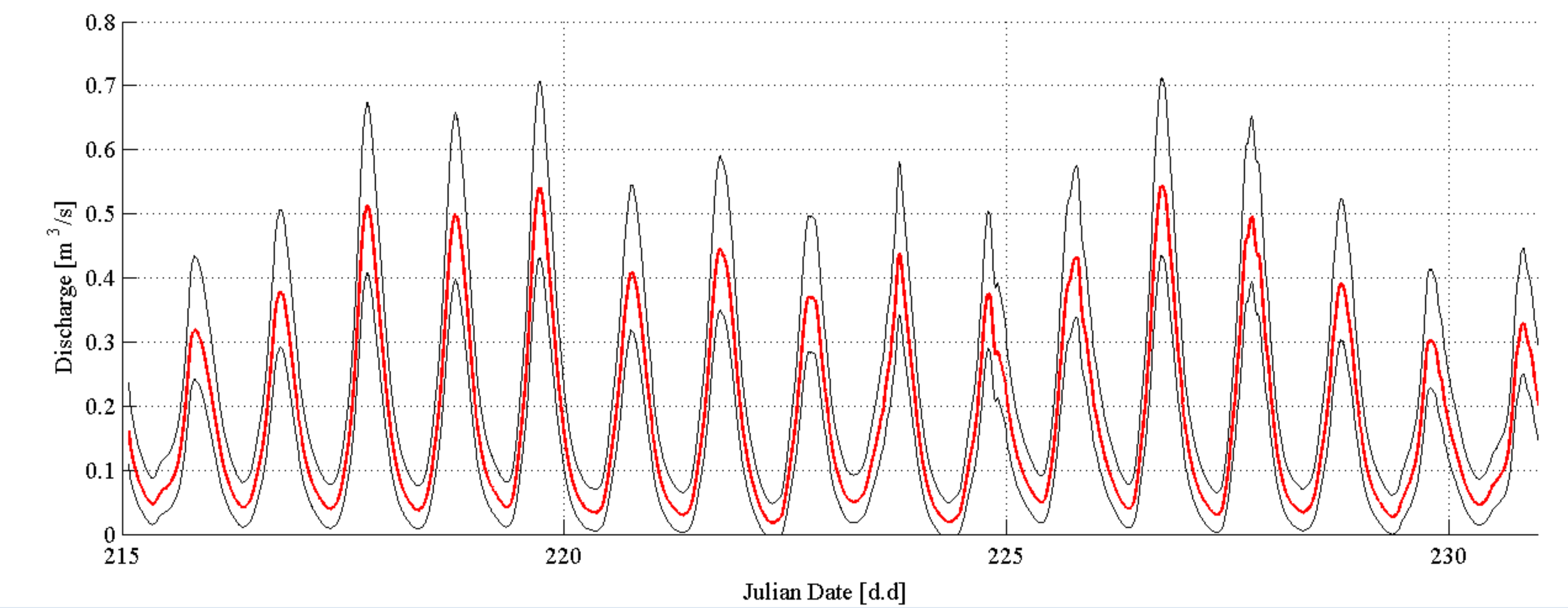


Figure 7. River discharge time series.

$I_{RAINFALL}$

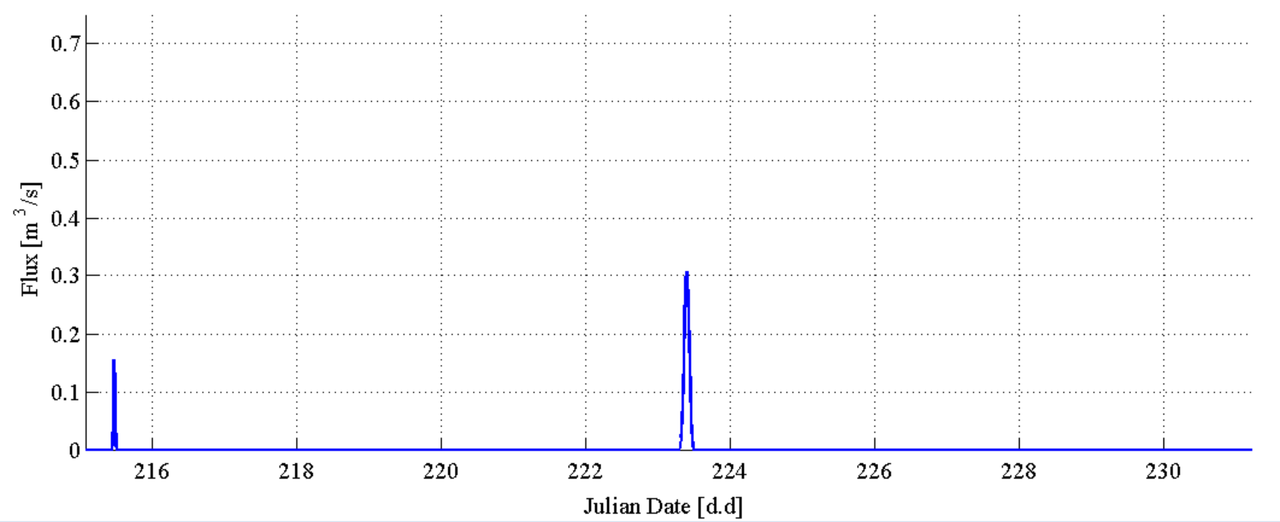


Figure 8. Rainfall time series.

-Time lapse photography used to constrain rainfall duration

-Rainfall magnitude was estimated (0.5 mm/hr and 1 mm/hr)

Evaporation

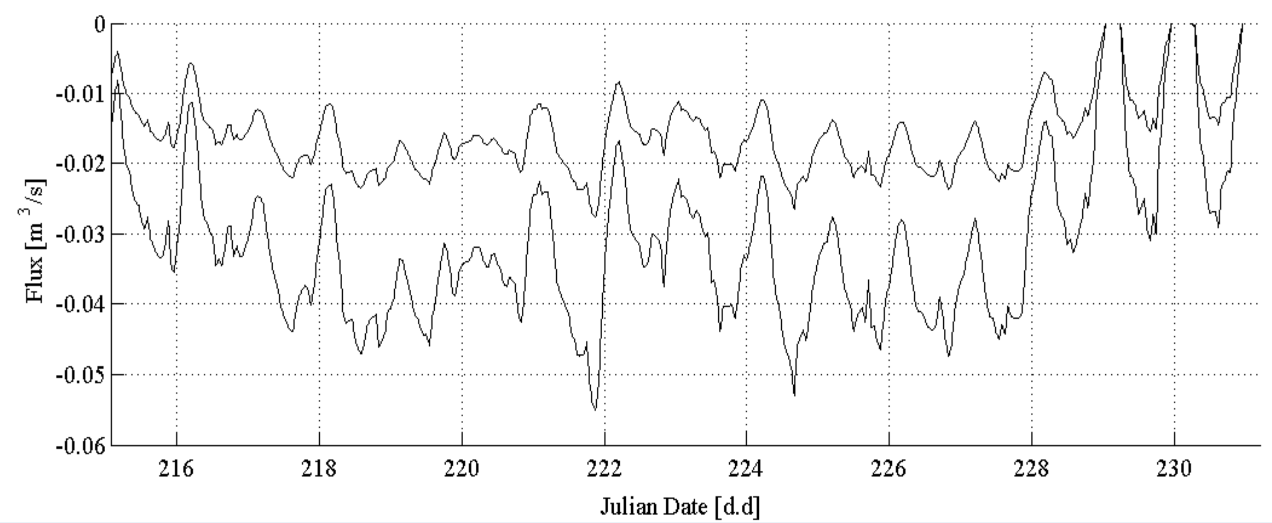


Figure 9. Evaporation time series.

-Estimated at 5 to 10% of meltwater production

-Follows diurnal cycle of radiative heating and is important energy sink

-Eq. of 1 - 3 mm/day

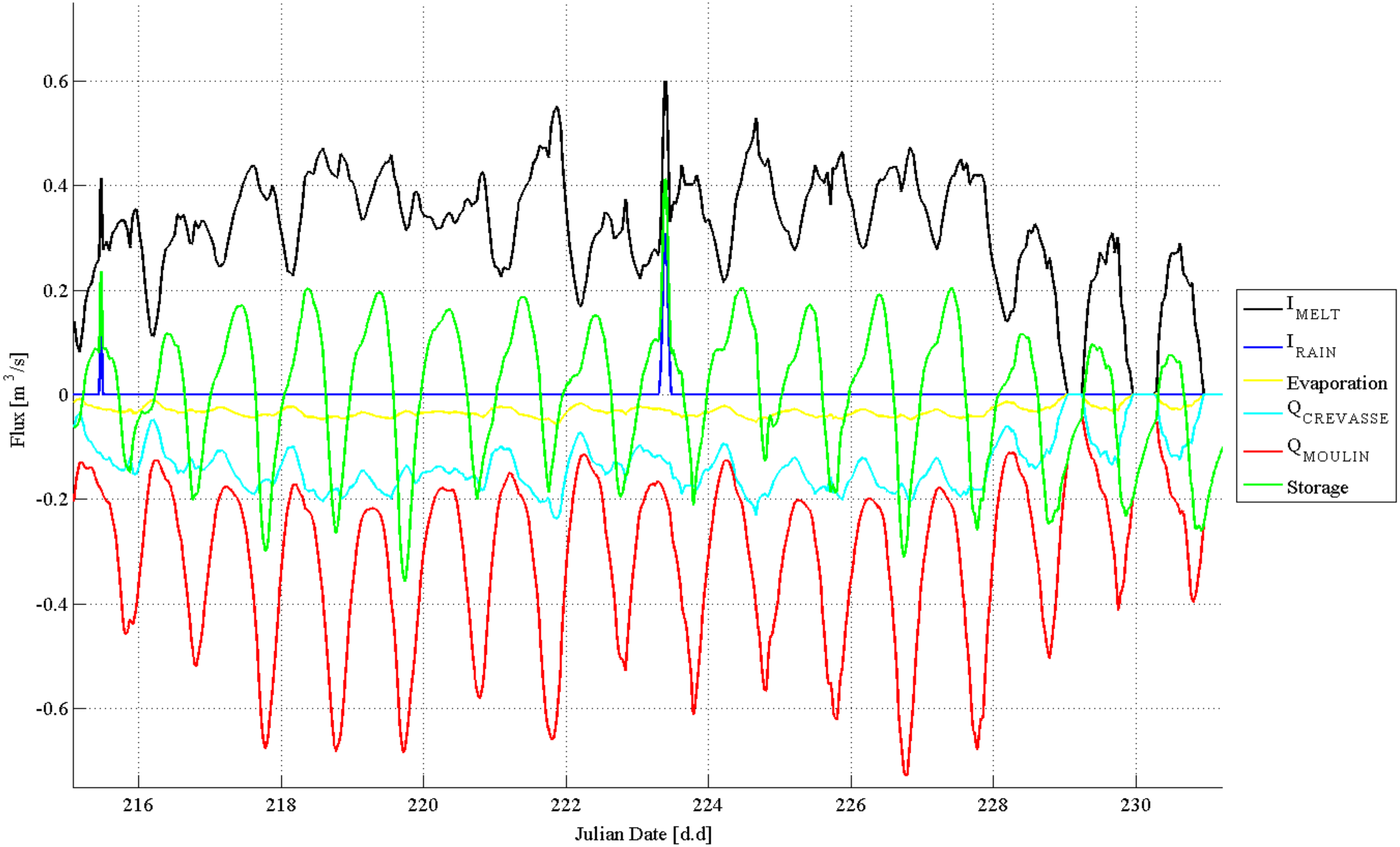


Figure 10. Instantaneous water budget time series.

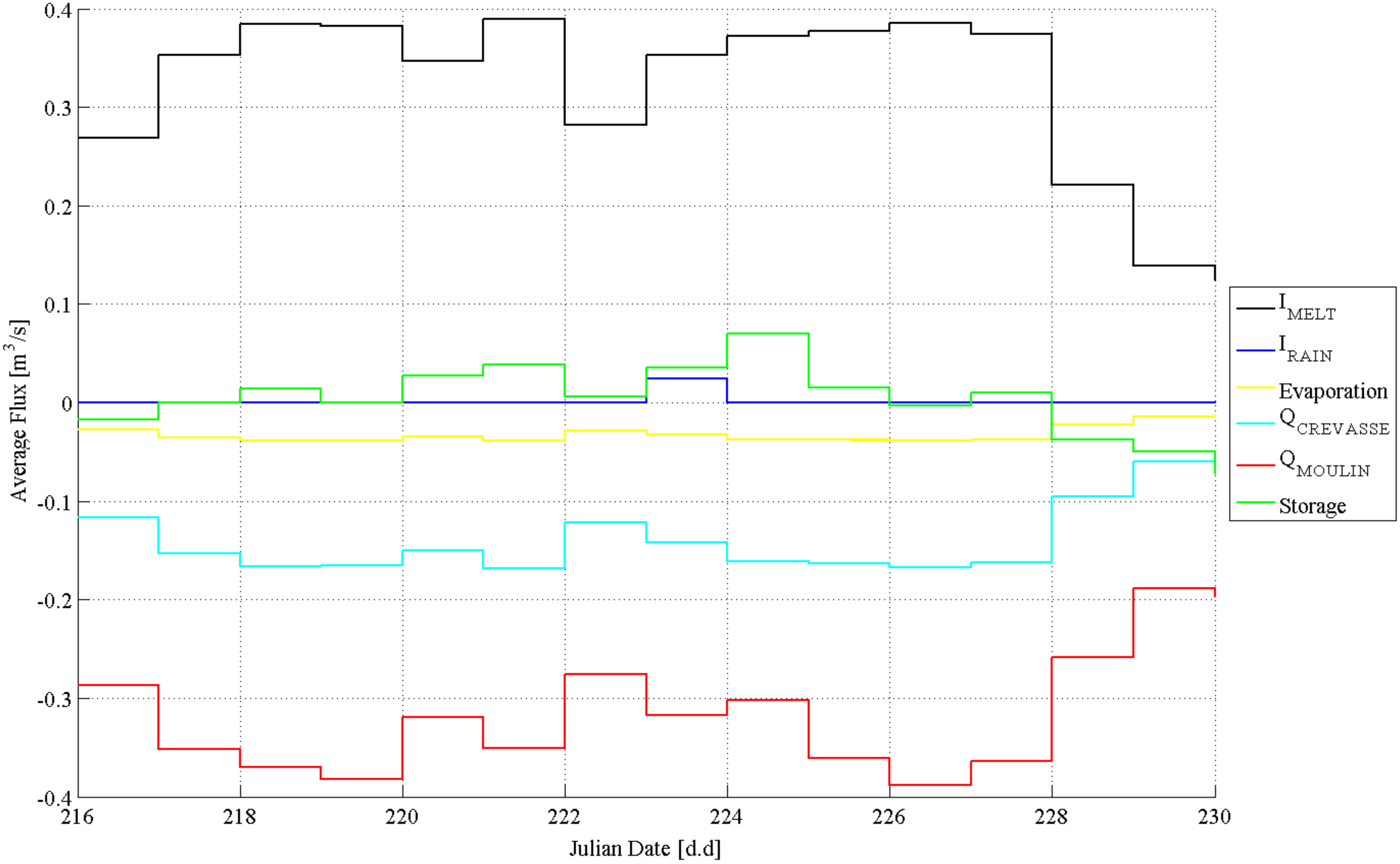
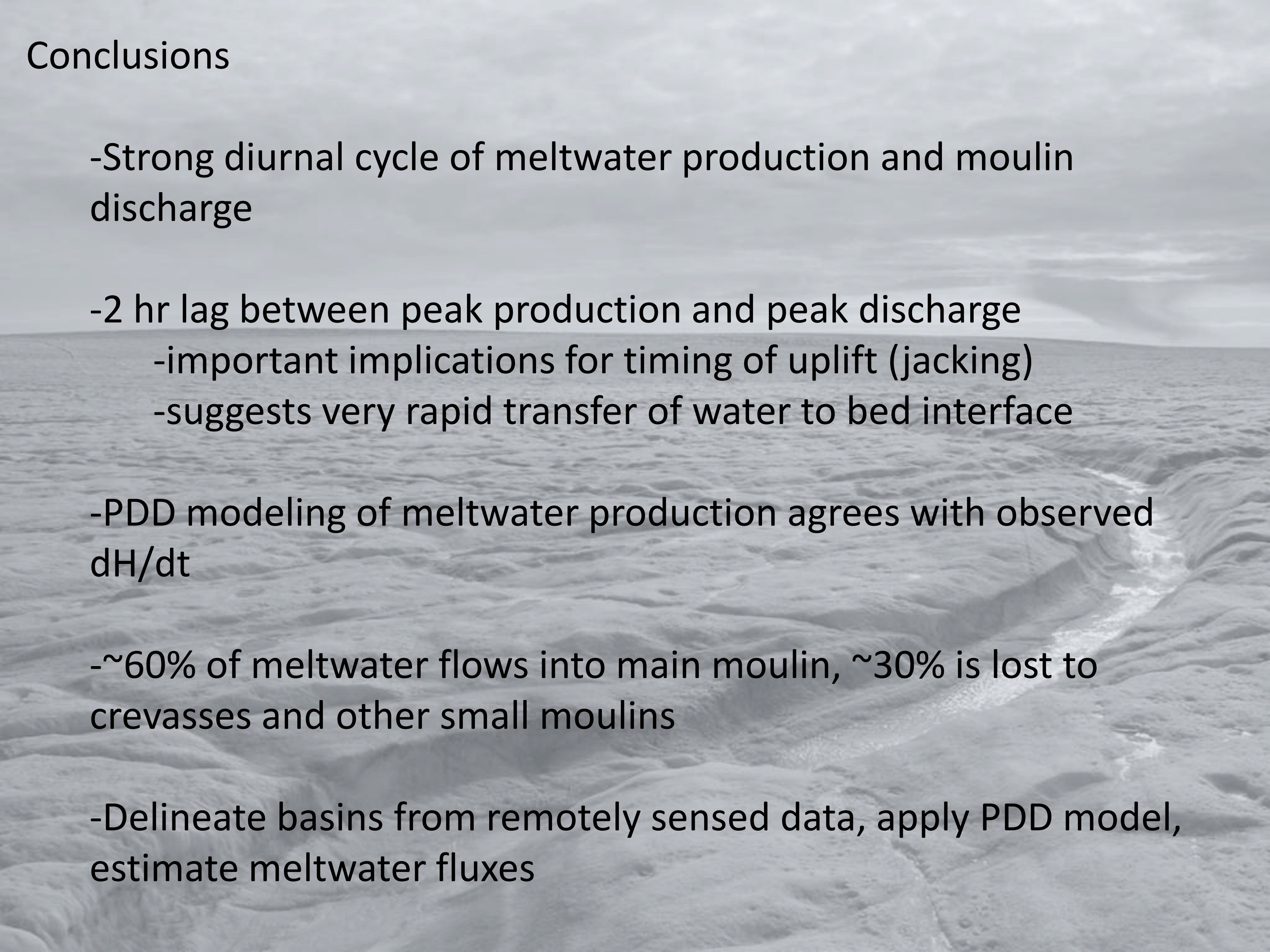


Figure 11. Daily mean water budget time series.



Conclusions

-Strong diurnal cycle of meltwater production and moulin discharge

-2 hr lag between peak production and peak discharge

- -important implications for timing of uplift (jacking)
- -suggests very rapid transfer of water to bed interface

-PDD modeling of meltwater production agrees with observed dH/dt

-~60% of meltwater flows into main moulin, ~30% is lost to crevasses and other small moulins

-Delineate basins from remotely sensed data, apply PDD model, estimate meltwater fluxes

Thanks!