Energy balance of Brúarjökull and circumstances leading to the August 2004 floods in the river Jökla, N-Vatnajökull

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Objective

- Describe two large flood events observed in the river Jökla during the periods August 3-6 and 9-14, 2004.
- Use glaciological and meteorological data to produce energy balance and ablation maps of the glaciated area of the drainage basin of Jökla.
- Use the result to describe the energy balance and melting of Brúarjökull and circumstances leading to the August 2004 floods in Jökla.
Study area and observations sites
Meteorological parameters and discharge of Jökla

August 2004

Discharge of Jökla

Aug. 3-6
Aug. 9-14

Precipitation

Aug. 2-3
Aug. 1-2

Daily values:
- Kárahnjúkar 656 m
- Akurnes 18 m

Temperature at Eyjabakkar 655 m

Average solar radiation at Brúarjökull

W m$^{-2}$
Observations:

**AWS:** Daily values of weather parameters and surface albedo at various elevations on the glacier — provides the full energy balance.

**b_w:** Total winter accumulation at numerous locations of stakes — information about the surface albedo (melting of snow or ice/firn).

**b_s:** Total summer melting at numerous locations of stakes — gives the total melting energy used to calibrate the energy balance calculations.

Output:

**EBM:** Daily energy balance maps with the same spatial resolution as the DEM.
Energy balance observations

**Energy balance:**

\[ M = R + H_d + H_l + H_p \]
\[ \approx R + H \]

**Radiation balance:**

\[ R = Q_i - Q_i + I_i - I_o \]
\[ = Q_i (1 - \alpha) + I_i - I_o \]

**Turbulent heat fluxes:**

\[ H = H_d + H_l \]
\[ " f(T \cdot u)" \]
Observed and calculated daily melting

Calculated as:

\[ a_s = \begin{cases} \frac{M}{\rho L} & M \geq 0 \\ 0 & \text{else} \end{cases} \]

May to Sept., 2004
Comparison of energy components, weather parameters and albedo

Example: an AWS at 1208 m

\[ r(R, Q_i(1-\alpha)) = 0.90 \]
\[ r(H, T \cdot u) = 0.97 \]
Energy balance maps

July 16-21
July 28 – Aug. 2
Aug. 9-14
Aug. 21-26

M →

R →

H →

Spatial resolution 200x200 m
Runoff from the energy balance maps and observed river discharge

**Six days in spatial average**

S: glaciated water drainage basin of Jökla

\[ M = R + H \]

\[ a_s = \begin{cases} 
\frac{M}{\rho L} & \text{if } M \geq 0 \\
0 & \text{else} 
\end{cases} \]

\[ D_M = \int_S a_s \, dS \]

May to Sept., 2004
Conclusion

• The first flood in Jökla August 3-6 was related to exceptionally intensive rain August 2-3.

• The second flood August 9-14 was caused by glacier melting.

• Circumstances leading to the second flood:
  
  i) Five days with high turbulent heat fluxes driven by strong southerly winds (July 28 to August 1) speeding up the removal of snow in the ablation area of Brúarjökull and lowering the albedo.

  ii) Exceptionally high temperatures and solar radiation along with abruptly reduced albedo of Brúarjökull (August 9-14).

• High glacial runoff is a consequence of:
  
  i) Meteorological conditions: both warm air and high solar radiation.

  ii) Glacier surface conditions: low surface albedo that increases the absorbed solar energy.

• If global warming continues ⇒ increased snowline altitude (lower albedo) as well as more frequent occurrence of extreme meteorological conditions ⇒ more frequent occurrence of glacial floods.