Quantifying surface melt in western Greenland from zigzag patterns in exposed stratigraphy.

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Mass balance measurements

Fig. 1. The K-transect in West Greenland. The sites 4, 5, SHR, 6, 7, 8, 9 and 10 are mass balance sites. The blue squares indicate the position of the IMAU weather stations. The equilibrium line altitude is located close to site 9. The two coloured lines indicate the dark zone where albedo is lower than in the surrounding areas (Wientjes and Oerlemans, 2010; Wientjes et al., 2011).

![Graph showing surface mass balance](chart.png)

- Site 6 (1010 m asl)
- Year

- Surface mass balance (m w.e.)
- -0.50 -1.00 -1.50 -2.00 -2.50 -3.00 -3.50
Exposed strata

300 km
Exposed strata

50 km
Exposed strata

10 km
Exposed strata

CreSiS shallow radar
Rule of Vs

- Dipping strata on an incised surface produce V-shaped outcrops

http://www.marlimillerphoto.com/Vblocks.html
Rule of Vs

- Dipping strata on an incised surface produce V-shaped outcrops
Rule of Vs

- Dipping strata on an incised surface produce V-shaped outcrops
- Undulating strata produce more complicated Vs

Predicted surface hydrology: Winnie Chu
Rule of Vs

- Dipping strata on an incised surface produce V-shaped outcrops
- Undulating strata produce more complicated Vs
- Ice flow moves Vs towards the coast
- Surface melt moves Vs down dip
Rule of Vs

- Dipping strata on an incised surface produce V-shaped outcrops
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Inland Migration of Layers Along Meltwater Channel and Downstream of Lake
Dip estimates $\sim 1^\circ$

Radar profile

Structure contours/best fit a plane
2011
Rivers and Roads

Road: 112 m/yr

1273 m

-17.5 m 2002-2011
Rivers and Roads

6.7 + 8.9 = 15.6 m lowering = 14 m w.e.
(c.f. K-transect 17.5 m)
Cross correlation

- 300 m cells
- 15 m pixels (Landsat 7 panchromatic)
- search within neighbouring cells

2010

Cross-correlation: Dave Porter
Cross correlation

- 300 m cells
- 15 m pixels (Landsat 7 panchromatic)
- search within neighbouring cells

2012

Cross-correlation: Dave Porter
Cross correlation 2011-2012

Towards coast

-ve X
X-velocity component

Joughin, I., B. Smith, I. Howat, and T. Scambos.. 2010. MEaSUREs Greenland Ice Sheet Velocity Map from InSAR Data.
Cross correlation – minus horizontal flow

+ve X
Towards interior
Cross correlation – 2010-2011

Very +ve X
Towards interior
Cross correlation – variable melt??

2010-2011
2011-2012

Average 3x more lowering 2010-2011 than 2011-2012

Assume constant geometry
Conclusions

• Displacement of exposed strata in western Greenland gives a regional record of surface melt
  • Depends on
    • Local velocity
    • Local dip of strata
    • Local surface slope

• Can identify known surface mass balance anomalies

• Reveals regional variations in melt