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SPOT5-HRS digital terrain models and their application to the monitoring of glacier elevation changes. A case study in North-West Canada and Alaska.

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Natural Resources Canada / Ressources naturelles Canada

1 The topography of polar ice masses

✓ Poorly known (ice caps and margin of the two ice sheets)
✓ Changes in surface topography are linked to climate fluctuations and ice dynamics
✓ DTM are important for processing of satellite data

⇨SPOT5-HRS acquisitions during **IPY** (reference dataset)

Goal of this study:
Assess the quality of SPOT5-HRS DEM over glacier surfaces

2 SPOT5 – HRS sensor

Key Numbers
- Footprint: up to 120 * 600 km²
- Base-to-height ratio: 0.8
- Pixel size: 5m*10 m

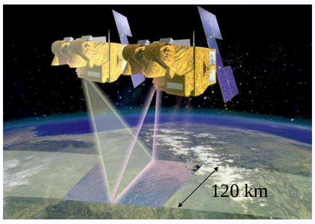


Fig. 1: Artist view of SPOT5-HRS

3 STUDY AREA

South-East Alaska / Northern British Columbia
✓ Rapid retreat since the little ice age (Molnia, 2007)
✓ Contribution to global Sea Level Rise 1970-2000: 0.04 mm/yr (Larsen et al., 2007)

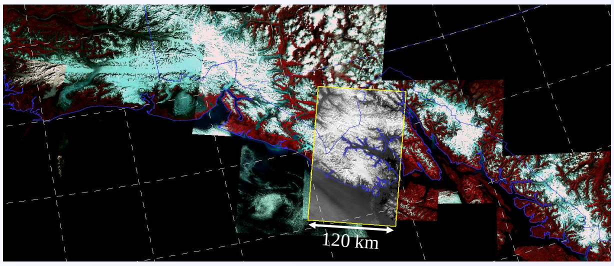


Fig. 2: HRS images (yellow contour) embedded in a Landsat mosaic (2000-01) of major icefields in South-East Alaska.

4 DEM Generation

✓ GCPs extracted by stereoscopic intersection
✓ DEM generated with PCI-Geomatica

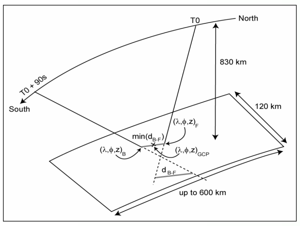


Fig. 3: Principle of GCP extraction

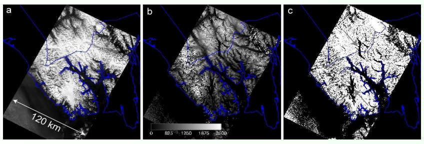
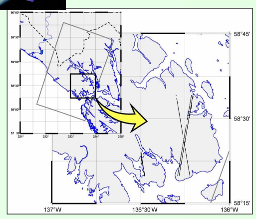


Fig. 4: HRS image, HRS DTM and map indicating regions where the DEM was computed

5 Accuracy on ICE FREE regions

✓ HRS systematically higher than SRTM (7 ± 25m): Late seasonal snow, SRTM penetration through the canopy, SRTM biases
✓A sub-region where HRS is lower by 6 m. ICESAT profiles are in agreement with HRS



	Mean difference (m)	Standard deviation (m)
SRTM - ICESat	8.7	10.5
HRS#1 - ICESat	3.0	11.4

Fig. 5: Comparison of SRTM and SPOT5-HRS with ICESAT profiles (N = 201)

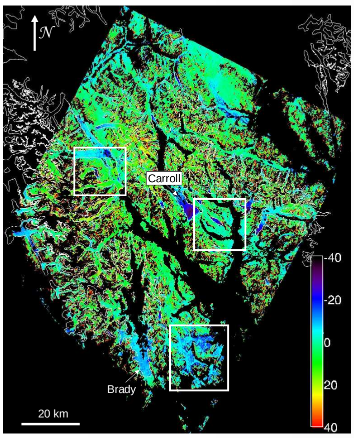


Fig. 5: Elevation differences between SPOT5-HRS (May 2004) and SRTM (Feb 2000)

6 Glacier SURGE

✓ Tributary of Ferris Glacier
✓ 0.1 km³ (± 5%) of ice was transferred between 2000 and 2004

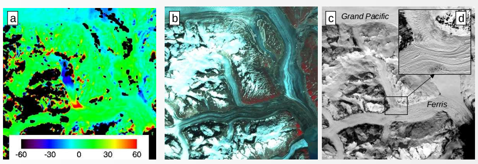


Fig. 7: Elevation changes between Feb 2000 and May 2004 induced by a surge (0.1 km³ +/- 5%)

7 Low elevation THINNING

✓ Thinning rates reaching 10 m/yr
✓ Burroughs glacier: Illustrate the Role of the surface lowering / increased temperature feedback

Fig. 8: Landsat image (10 August 2000). Note that Burroughs remnant is disconnected from any accumulation area. The elevation changes equals changes in ablation

Tab. 1: Temperature (T) rise required to explain the enhanced thinning rate (PDD factor = 6 mm w.e/d/°C). It equals the "passive" T rise due to the lowering of the glacier surface (T lapse rate 6°/km). Strong feedback.

Period	1972-2000	→	2000-2004
Ice thinning rate (m/yr)	5.4	+0.74 m/yr +3.4 mm/day **+ 0.57°C**	6.1
Mean Elevation (m)	344	- 88 m **+ 0.53°C**	256

References:
Berthier E. & Toutin T., SPOT5-HRS digital elevation models and their application to the monitoring of glacier elevation changes. A case study in North-West Canada and Alaska, submitted to Remote Sensing Environ.
Larsen, C.F. et al. (2007). Glacier changes in southeast Alaska and northwest British Columbia and contribution to sea level rise. J. Geophys. Res., 112(F1)
Molnia, B.F. (2007). Late nineteenth to early twenty-first century behavior of Alaskan glaciers as indicators of changing regional climate. Global Planet. Change, 56(1-2), 23-56.
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