Minor pulsations of Abramov glacier (Kyrgyzstan) observed with multi-sensor optical remote sensing

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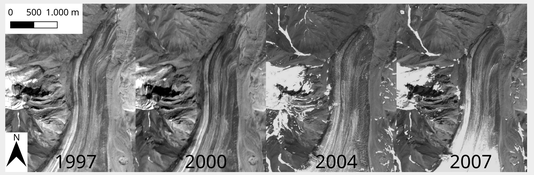
CROMO-ADAPT
Cryospheric Observation and Modelling for improved Adaptation in Central Asia

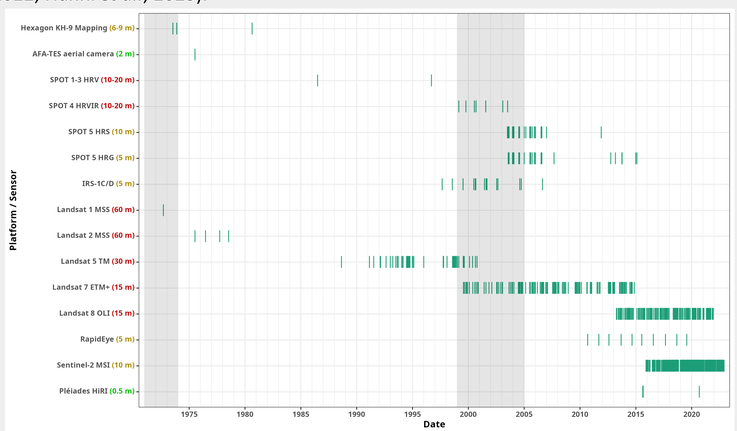
1. In short

- **We process data from multiple sub-10 m optical sensors to quantify the dynamics of Abramov glacier over the past 50 years.**
- **We find evidence of minor dynamic instability of the glacier, with a recurrence interval of 25-30 years. We observe a pulsation in the early 2000s with several characters of a minor surge, possibly incomplete.**
- **Unsteady flow appears to be widespread over the Eastern Alai ridge. High-resolution DEMs of difference enable to disentangle terminus behavior from the mass balance signal, even for small glaciers.**



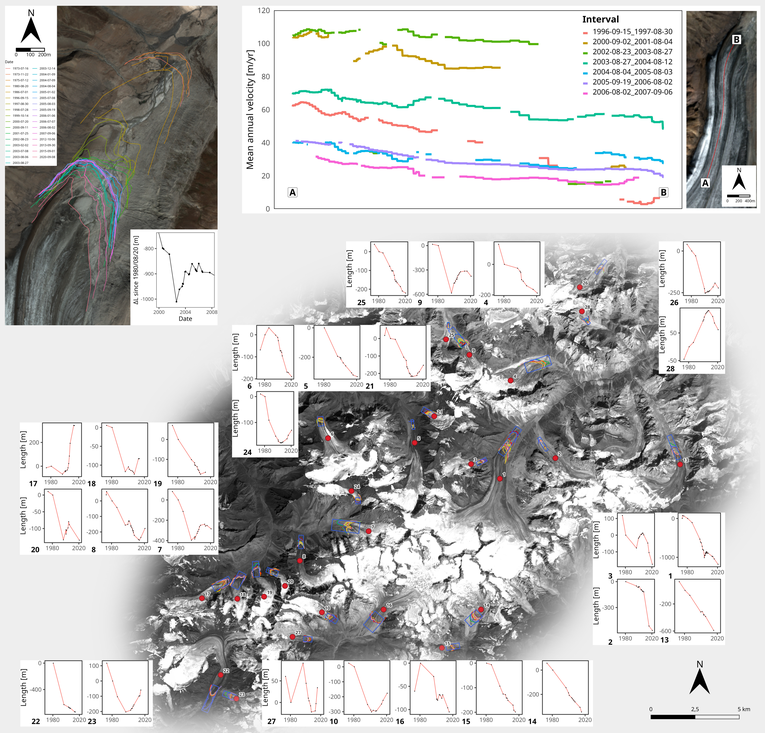
2. Data and Methods

- GCP-based orthorectification of 50 scenes from SPOT (images acquired by CNES's Spot World Heritage Programme) and IRS-1C.
- Additional imagery from KH-9 Hexagon (Dehecq *et al.*, 2020), RapidEye, Pléiades and Sentinel-2.
- Front advance and retreat computed with the rectilinear box method on 291 km of digitized glacier termini (Abramov and 25 neighbors).
- Annual and sub-seasonal surface velocities from geoCosiCorr3D correlation (Aati *et al.*, 2022; Nanni *et al.*, 2023).



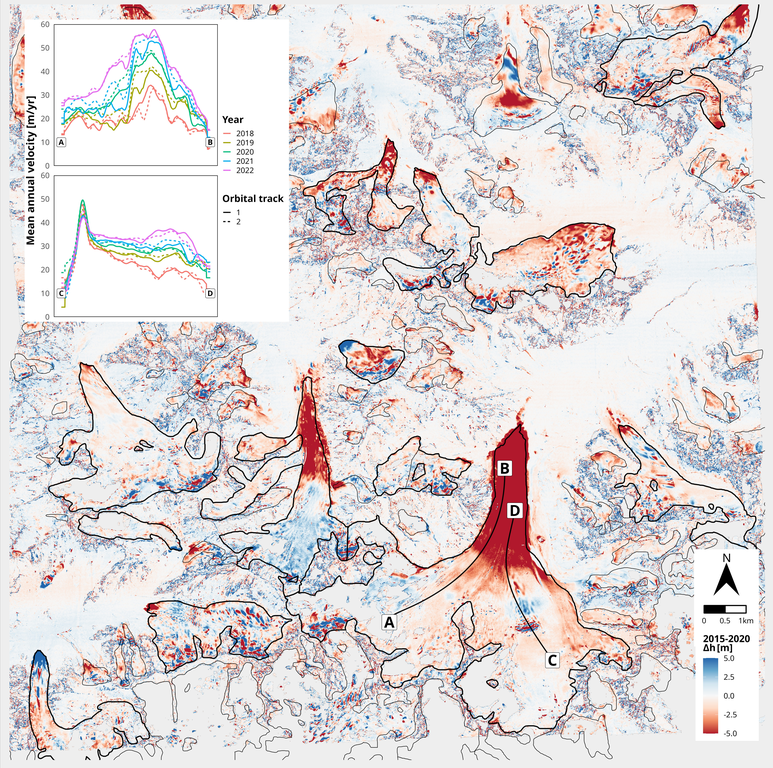
3. Historical evolution

- Abramov glacier had a surge in 1972/73, well-documented by extensive local measurements (Emelyianov *et al.*, 1974).
- The tongue accelerated and advanced again by 151 m over 2000-2006 (with no *in situ* observations), after 30 years of almost continuous mass loss (> 20 m w.e.; Barandun *et al.*, 2018).
- We find mean annual surface velocities up to 110 m yr^{-1} in 2002/03 (2x increase from quiescence), and an advance rate up to 0.44 m d^{-1} at the terminus in late 2003. In 1972/73: 400 m yr^{-1}, 2 m d^{-1}.
- The front stopped advancing in 2006, with flow velocities over the tongue decreasing to 20-30 m yr^{-1}.
- SPOT and IRS imagery at 5 m/px reveals strong glacier-wide crevassing during the advance, invisible on Landsat.
- At the mountain range-scale, front dynamics are highly heterogeneous and not correlated with modeled mass balances or glacier geometry.



4. Present-day dynamics

- The Abramov tongue is experiencing continued thinning and retreat.
- At the same time, ice flow exhibits a slow, diffuse and protracted acceleration.
- The glacier is possibly building up a new pulsation, 20 years after the last.
- The regional DEM of difference from Pléiades (2015-2020) shows clear patterns of localized thinning and thickening, indicating widespread dynamic instability.



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