Spatiotemporal Variability in Seasonal Velocity Drivers at Sermeq Kujalleq, Greenland

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Runoff and terminus position influence tidewater glacier motion

Seasonal fluctuations influence long-term projections of mass loss and are therefore important to understand for improving future sea level rise projections. Subannual changes in velocity are driven primarily by changes in terminus position and runoff, but the spatial and temporal influence of these forcings are difficult to disentangle.

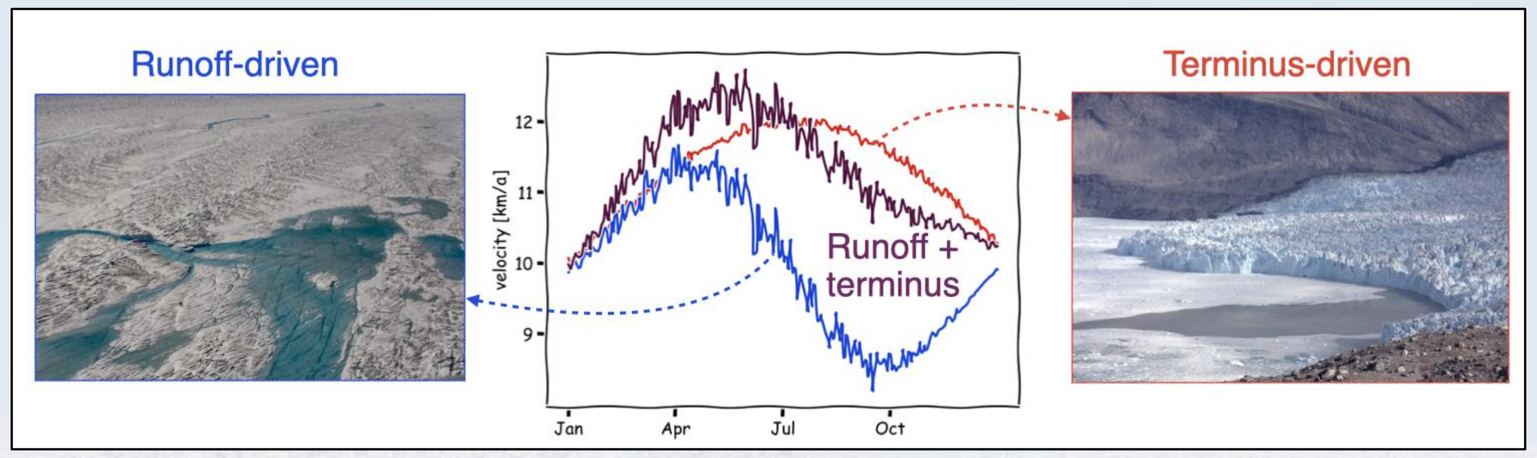

Figure 1: Artificial representation of the deconstructed influence of runoff and terminus position on velocity and the combined net effect.

At Sermeq Kujalleq (Jakobshavn), Greenland's fastest-flowing glacier, terminus position exerts a strong control on ice motion [1], however, it remains unclear how far upstream terminus position acts as the dominant driver of ice flow [2]. To explore the spatial variability in the relative influence of terminus position and runoff, we analyze three areas of the glacier (Fig. 2) and apply time series methods similar to [3].

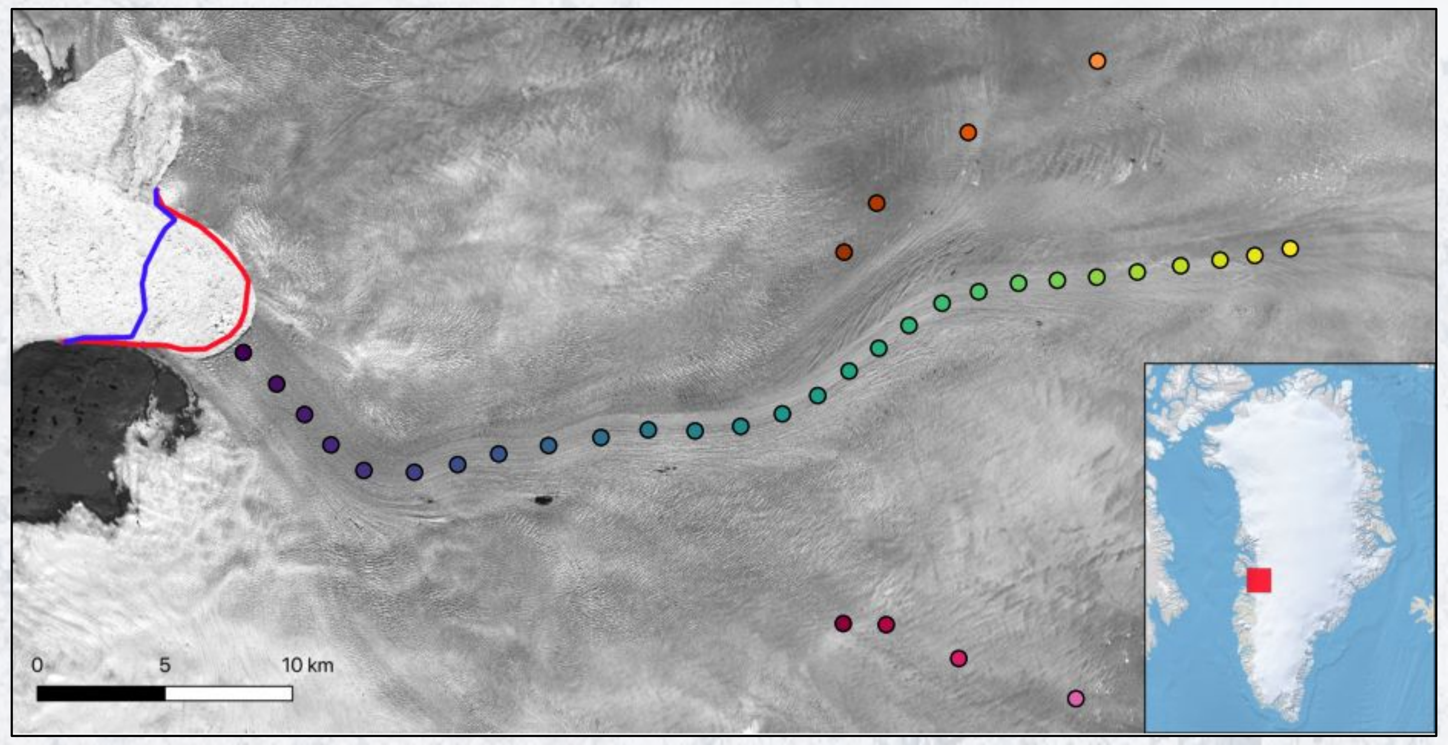

Figure 2: A Landsat image of Sermeq Kujalleq in 2019 and inset map of Sermeq Kujalleq location within Greenland. Sampled points along north, center, and south flowlines are shown in orange, viridis, and pink, respectively, with the darkest colors near the terminus. Seasonal changes in terminus position in 2018 are shown with the most advanced position in winter (blue) and most retreated in summer (red) [4].

Time series analysis and cross-correlation methods allows us to disentangle velocity forcings

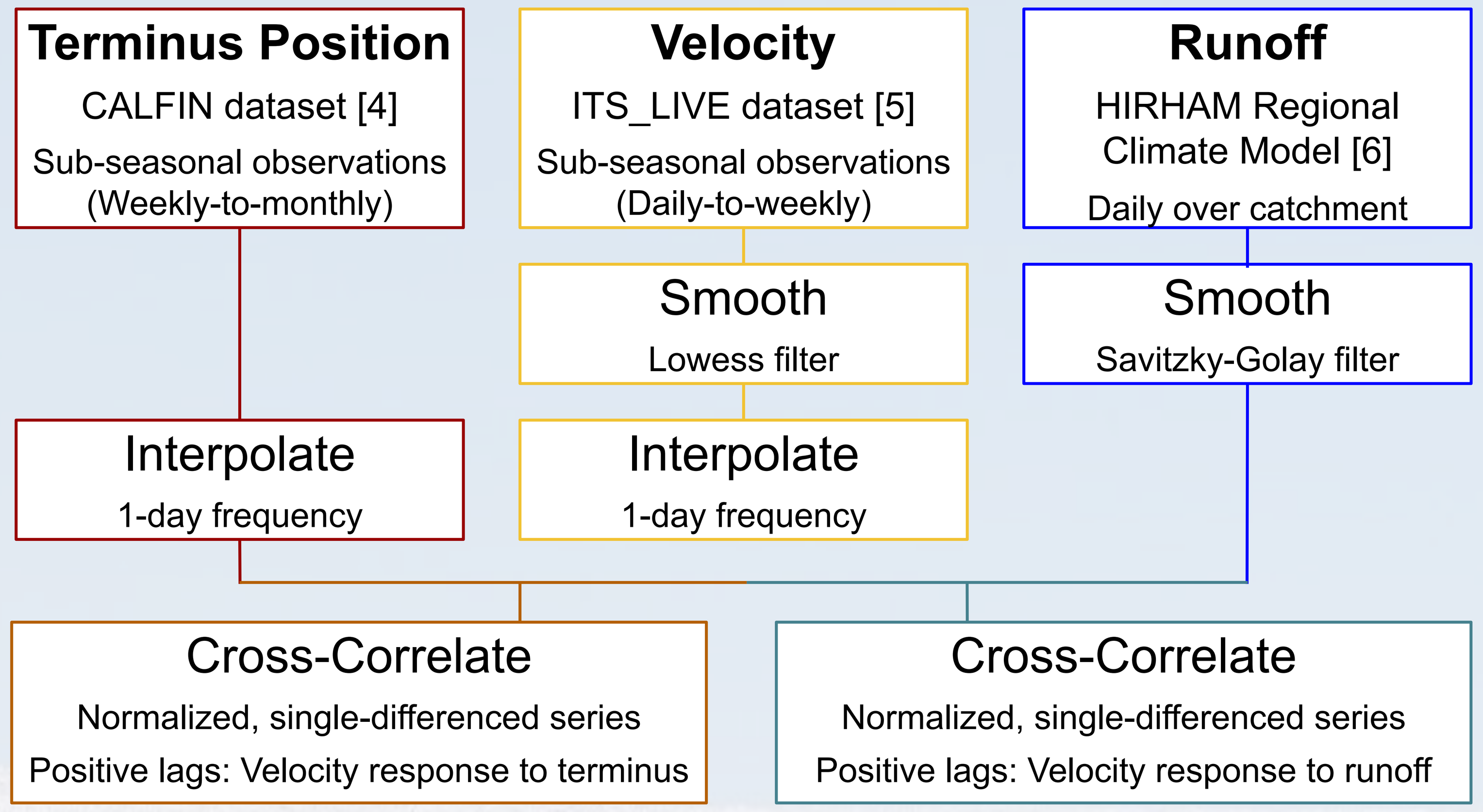

Figure 3: Flowchart demonstrating the terminus position, velocity, and runoff datasets used in this study and the workflow used to prepare time series for cross-correlation.

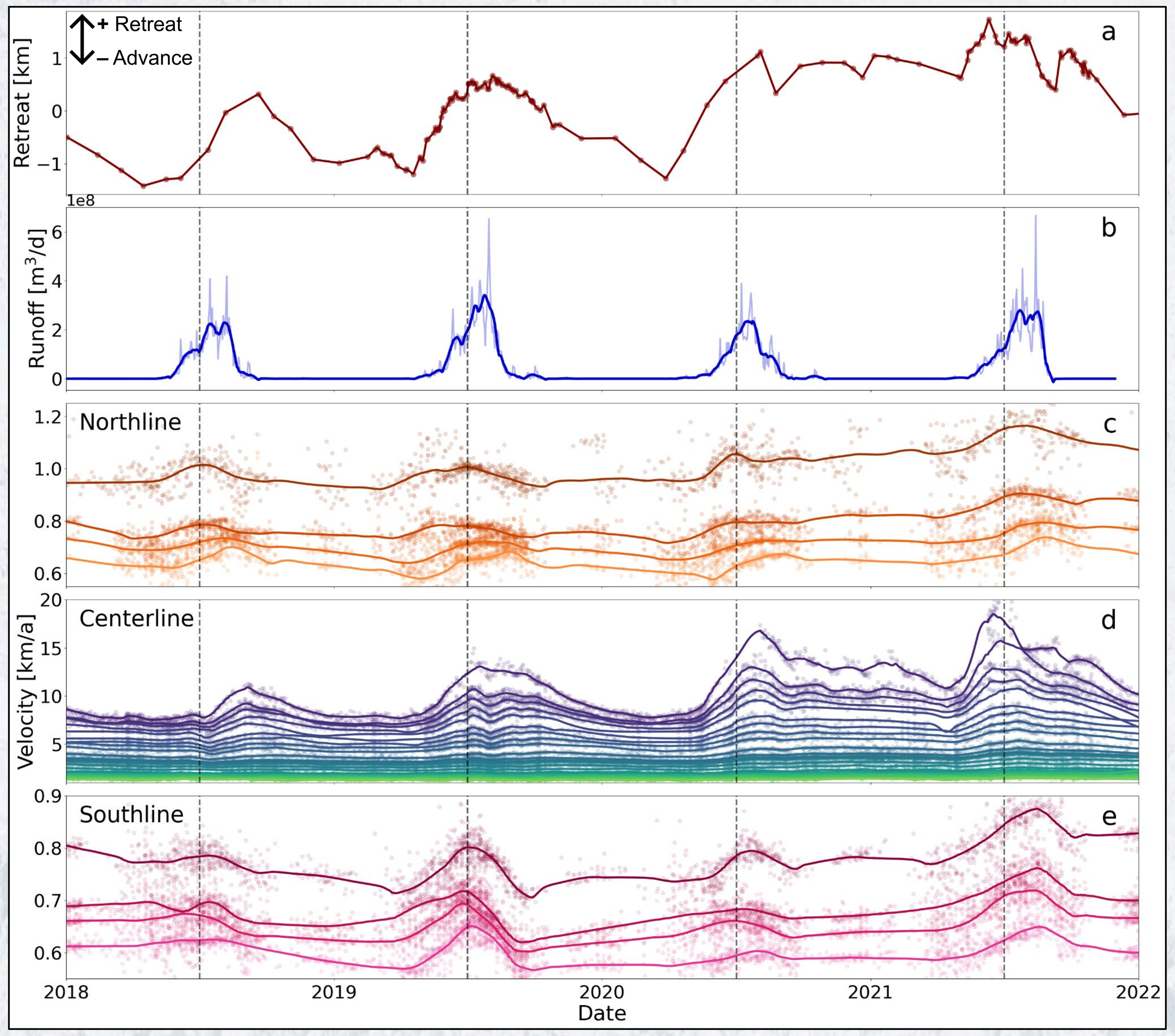

Figure 4: Original data and smoothed time series for (a) terminus position (retreat is positive), (b) runoff, and (c-e) north, center, and southline velocities from 2018–2022. Dashed vertical lines mark the middle of each year (July 2).

Runoff highly correlated with velocity on Southline

All southline sites show significant runoff-velocity correlations across all years, while patterns along the northline and centerline are less spatially and temporally consistent. Centerline sites nearest the terminus show strong short-lag correlations in 2018 and 2019, as expected.

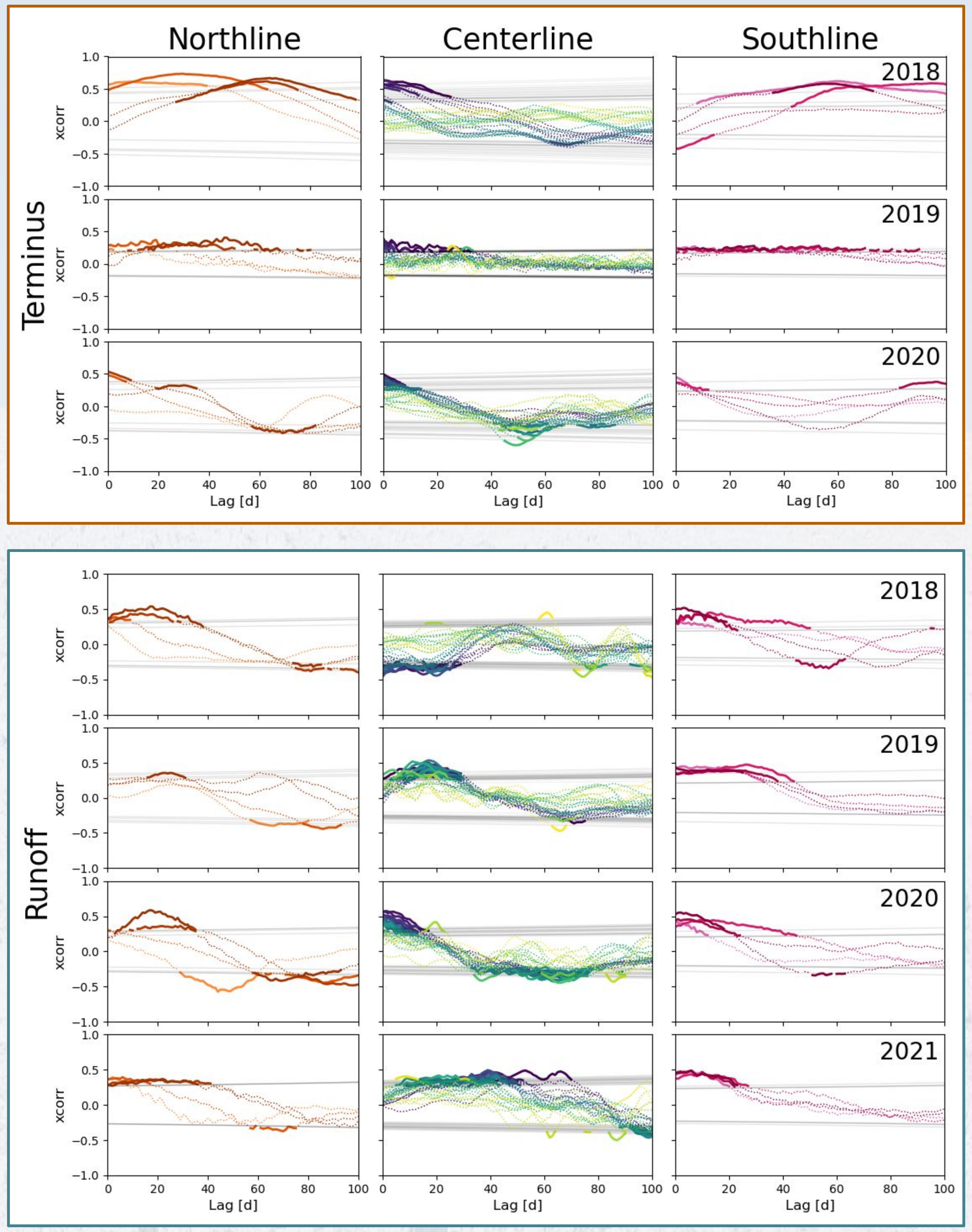

Figure 5: Cross-correlation values for different lags in days for each flow line (columns) and study year (rows). The top box shows terminus-velocity correlations, and the bottom box shows runoff-velocity correlations. Solid lines mark lags where correlations exceed the 95% confidence interval (black lines). Note that terminus-velocity plots for 2021 were excluded as there were no seasonal terminus signals for that year, and no significant correlations.

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