Re-examining the timing and magnitude of recent dynamic changes in NW Greenland

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Background:

• Geophysical observations, such as GRACE and GPS, indicate that mass loss acceleration spread from SE to NW Greenland after ~2005 [Khan et al., 2010; Svendsen et al., 2013], possibly due to the onset of regional dynamic acceleration of marine-terminating outlet glaciers, as observed in the SE.

• Outlet glacier observations suggest that widespread but variable dynamic changes initiated prior to 2005 [Moon & Joughin, 2008; Howat & Eddy, 2011; McFadden et al., 2011; Moon et al., 2012].

• Above-average surface mass balance (SMB) in the early half of the decade may have obscured dynamic mass loss from the region [Sasgen et al., 2012].

• We analyze time series of thickness, speed, discharge, and surface mass balance for 34 large outlet glaciers to determine whether mass loss acceleration can be attributed to regional dynamic change.

Thickness & Speed Change:

• Inter-annual changes in ice thickness calculated using mean annual elevation profiles (Fig. 1b)
  – ASTER DEMs, SPOT-5 DEMs, and NASA ATM elevation swaths over grounded portions of trunks

• RACMO2/GR reanalysis data used to estimate elevation change due to SMB variability (Fig. 1c)

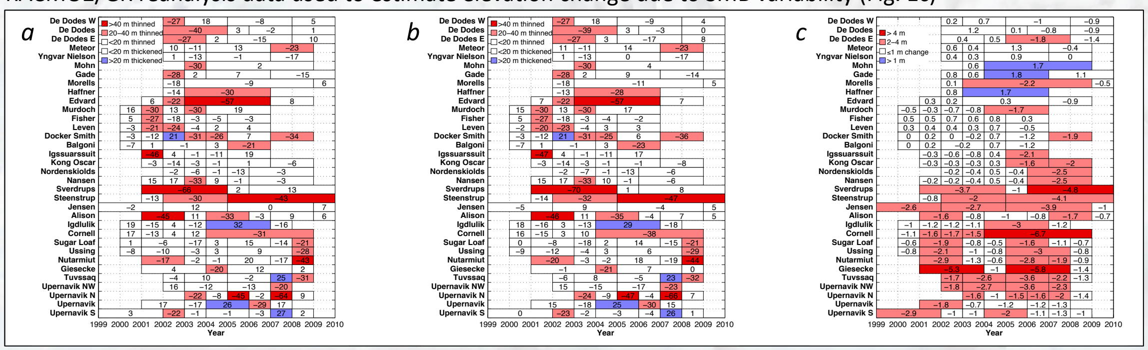

Fig. 1: (a) Dynamic thinning = (b) observed elevation change – (c) SMB anomalies

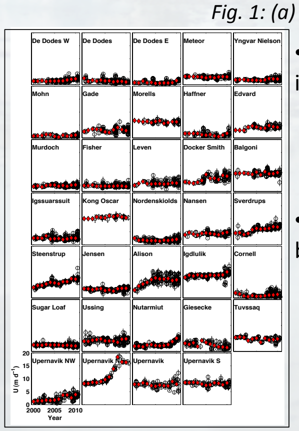

Fig. 2: Median annual (red diamonds) & filtered speeds (black circles)

• Speed time series constructed using repeat image feature tracking software (Fig. 2)
  – grounding zone, melt season speeds
  – Nearly annual temporal sampling from combined Landsat & ASTER datasets

• Widespread dynamic thinning & acceleration before 2005 (Figs. 1a, 2, & 3)
  – 21 glaciers thinned significantly (i.e., >20 m uncertainty)
  – all glaciers that thinned significantly accelerated part of the 2000-2005 period
  – high spatial & temporal variability

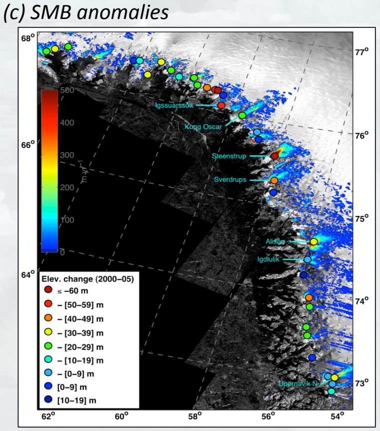

Fig. 3: Grounding line elevation change (circles) overlaid on an InSAR acceleration map (colorbar)

Discharge Time Series:

• Discharge calculated using thickness, speed, & width data
  – assume a parabolic cross sectional shape
  – thickness calculated using Bamber et al. [2013] bedmap
  – time series gaps filled with interpolated values

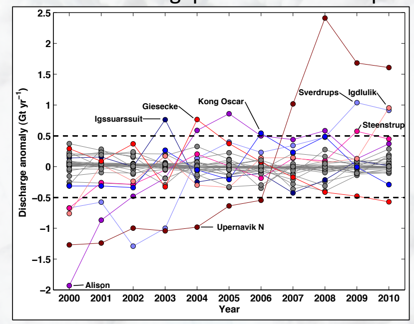

Fig. 4: Discharge anomaly time series. Glaciers with anomalies >0.5 Gt/yr are colored and labeled.

• Discharge anomalies calculated with respect to 2000-2010 mean discharge for each glacier (Fig. 4)

• No clear <u>regional</u> pattern
  – 8 of 34 glaciers have anomalies > 0.5 Gt/yr
  – only 2 glaciers (Alison & Upernavik) make-up 63% of the total 2000-2010 increase in discharge from the region

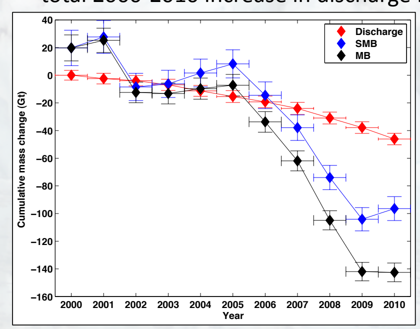

Fig. 5: Cumulative mass change (black diamonds) from discharge & SMB anomalies (red & blue diamonds). Discharge & SMB anomalies calculated with respect to 2000 and 1960-1990 reference values, respectively.

• Linear increase in total discharge from 51.0 ± 3.6 Gt/yr to 59.3 ± 3.6 Gt/yr between 2000 and 2010

• Cumulative loss from accelerated discharge of ~40 Gt (Fig. 5)

• Mass loss acceleration after 2005 primarily due to negative SMB anomalies, not accelerated discharge

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