Large-Scale Midlatitude–Polar Flow Interactions Leading to Rapid Surface Ice Melt over Greenland and Sea Ice Volume Loss over the Arctic Ocean in June 2019

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1) Background, Purpose, and Data

- **Background:** Massive Greenland surface ice melt event occurred in June 2019.

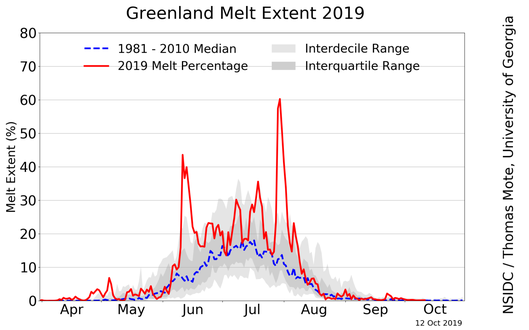

Figure 1. Greenland melt extent (%) during 2019. Source: NSIDC/Thomas Mote, University of Georgia; http://nsidc.org/greenland-today/.

- **Purpose:** Investigate upstream antecedent atmospheric conditions associated with massive Greenland surface ice melt event of June 2019.
- **Data:** CFSR gridded analyses at 0.5° resolution (Saha et al. 2010).

2) Negative NAO

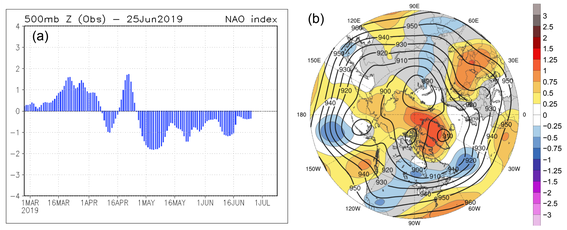

Figure 2. (a) NAO index from Climate Prediction Center, and (b) 26 April–23 June 2019 time-mean 300-hPa geopotential height (dam, black) and time-mean standardized anomalies of 300-hPa geopotential height (σ, shaded).

6) Potential Vorticity (PV) Advection

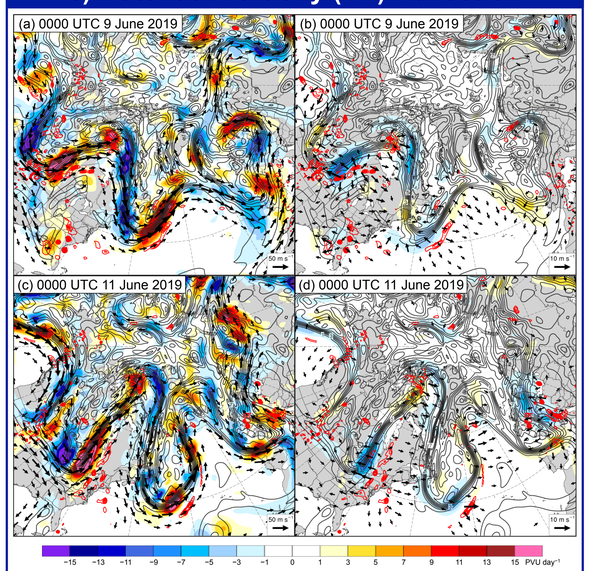

Figure 6. (left) 300–200-hPa PV (PVU, gray), nondivergent wind (m s^{-1}, vectors), and PV advection by nondivergent wind (PVU day^{-1}, shaded), and 600–400-hPa ascent (5 × 10^{-3} hPa s^{-1}, red); (right) As in (left), but for irrotational wind.

Reference and Acknowledgment

- Saha, S., and Coauthors, 2010: The NCEP Climate Forecast System Reanalysis. *Bull. Amer. Meteor. Soc.*, **91**, 1015–1057.

- Special thanks to Alicia Bentley for scripts to generate CFSR analyses.

3) Upstream North Pacific Flow Evolution

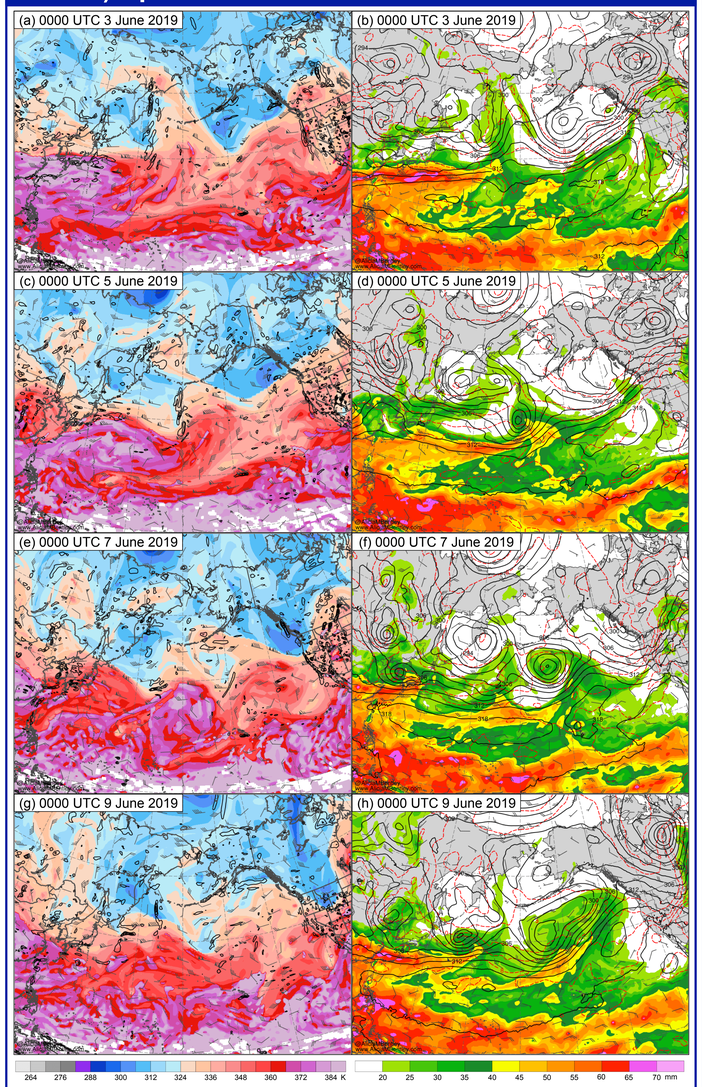

Figure 3. (left) DT (2-PVU surface) θ (K, shaded) and wind (kt, flags and barbs), and 925–850-hPa ζ (10^{-5} s^{-1}); (right) 700-hPa geopotential height (dam, black), temperature (K, red), and wind (kt, flags and barbs), and PW (mm, shaded).

4) North America Flow Evolution

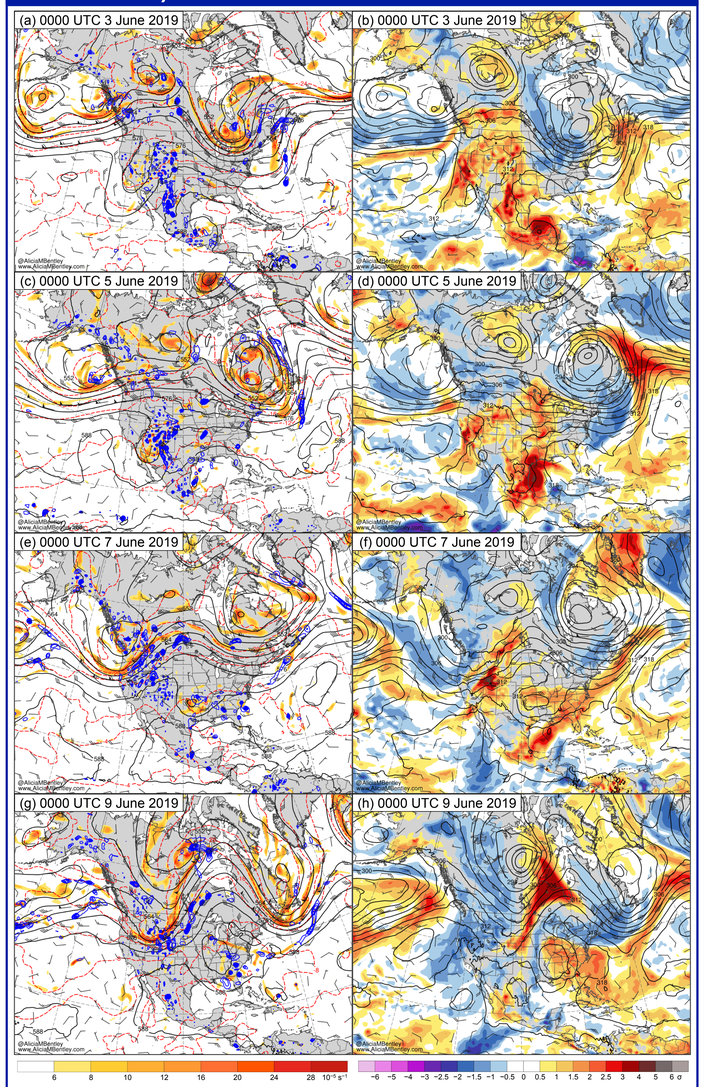

Figure 4. (left) 500-hPa ζ (10^{-5} s^{-1}, shaded), geopotential height (dam, black), temperature (K, red), ascent (5 × 10^{-3} hPa s^{-1}, blue), and wind (kt, flags and barbs); (right) 700-hPa geopotential height (dam, black) and wind (kt, flags and barbs), and standardized anomalies of PW (σ, shaded).

5) Northeast Canada and Greenland Ridging

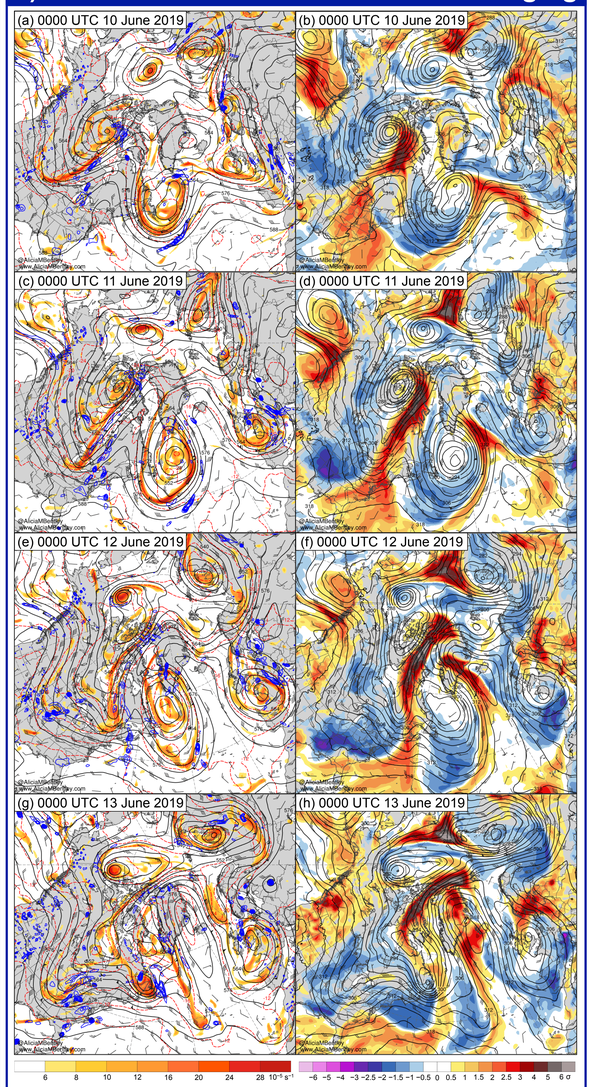

Figure 5. (left) 500-hPa ζ (10^{-5} s^{-1}, shaded), geopotential height (dam, black), temperature (K, red), ascent (5 × 10^{-3} hPa s^{-1}, blue), and wind (kt, flags and barbs); (right) 700-hPa geopotential height (dam, black) and wind (kt, flags and barbs), and standardized anomalies of PW (σ, shaded).

7) Trajectories, Time Series, and Sounding

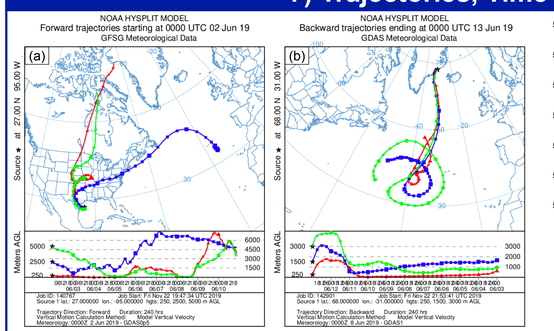

Figure 7. (a) Forward trajectories starting at 0000 UTC 2 June and (b) backward trajectories ending at 0000 UTC 13 June. Source: NOAA HYSPLIT.

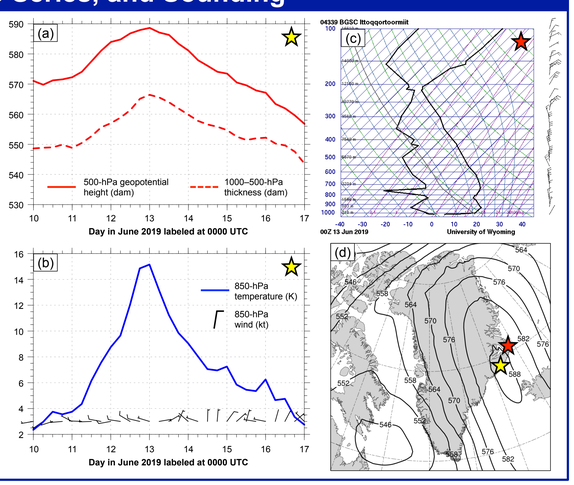

Figure 8. (a) Time series of (a) 500-hPa geopotential height (dam) and 1000–500-hPa thickness (dam), and (b) 850-hPa temperature (K) and wind (kt), for yellow star location in (d). (c) 0000 UTC 13 June 2019 sounding for Ittoqqortoormitt, Greenland [red star location in (d)] (source: University of Wyoming). (d) 500-hPa geopotential height (dam) at 0000 UTC 13 June 2019.

8) Discussion

- The massive Greenland surface ice melt event of June 2019 (Fig. 1) occurs during a persistent negative NAO regime that began in late April (Fig. 2).
- The melt event is linked to a Tibetan Plateau "heat burst" that triggers NPAC Rossby wave breaking, which subsequently leads to EPAC ridging, a CA tropical moisture surge, and a deepening progressive western North American trough (Figs. 3a–h).
- The progressive western North American trough eventually interacts with a trough over the MS Valley, and the trough interaction produces a strong moist southerly flow that allows deep tropical moisture to reach northeast Canada (Figs. 4a–h).
- Strong ridging occurs over northeast Canada ahead of a now negatively tilted trough over the Great Lakes lifting to the northeast, and strong ridging occurs over northeast Greenland to the northeast of a cutoff cyclone that forms to the northeast of Labrador (Figs. 5a–h).
- Both ridging events are associated with the transport of deep tropical moisture toward the Arctic (Figs. 5a–h; Figs. 7a,b).
- Negative PV advection by the nondivergent and irrotational winds contributes to building the Canada and Greenland ridges (Figs. 6a–d).
- Greenland ridge 500-hPa geopotential height, 1000–500-hPa thickness, and 850-hPa temperature values reach 588 dam, 566 dam, and 15°C, respectively (Figs. 8a,b), and a deep layer of above-freezing temperatures extends from the surface to near 600 hPa (Fig. 8c).