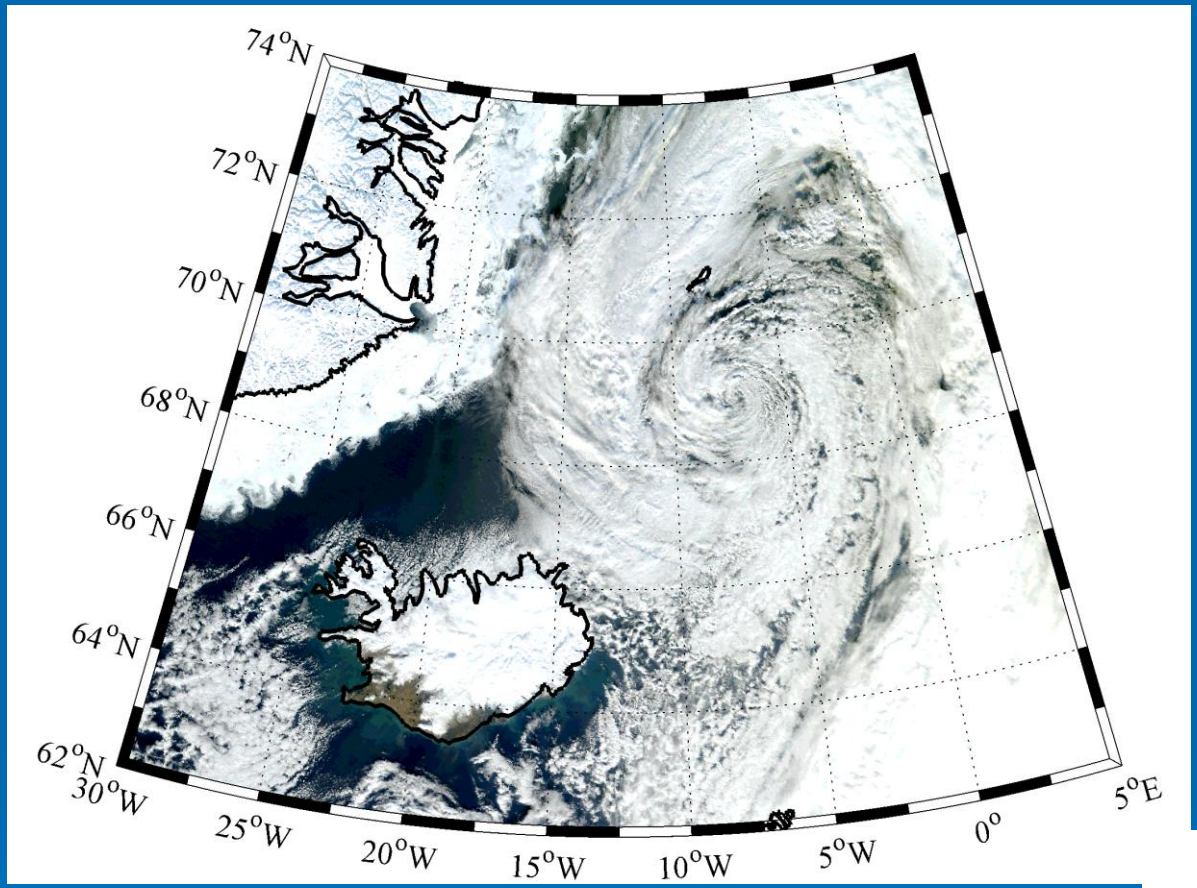
Aircraft Observations of a Polar Low over the Iceland Sea



G.W.K. Moore
I.A. Renfrew
G.N.Petersen

Greenland Flow Distortion experiment

Introduction

•Polar lows are small but intense mesoscale cyclones that develop over the high latitude ocean during the winter months.

•The high winds associated with these weather systems are a hazard to maritime traffic as well as playing a role in air-sea interaction.

•Primary formation mechanism is thought to be baroclinic instability although moist processes driven by the the large air-sea fluxes of heat and moisture also play a role.

•The interaction of upper-level potential vorticity anomalies or tropopause folds with existing surface circulations or frontal zones has also been proposed as a generation mechanism.

Introduction

•Their brief life-cycle (often less than 24 hours) and their tendency to develop in remote regions has resulted in relatively few in-situ observations of their structure.

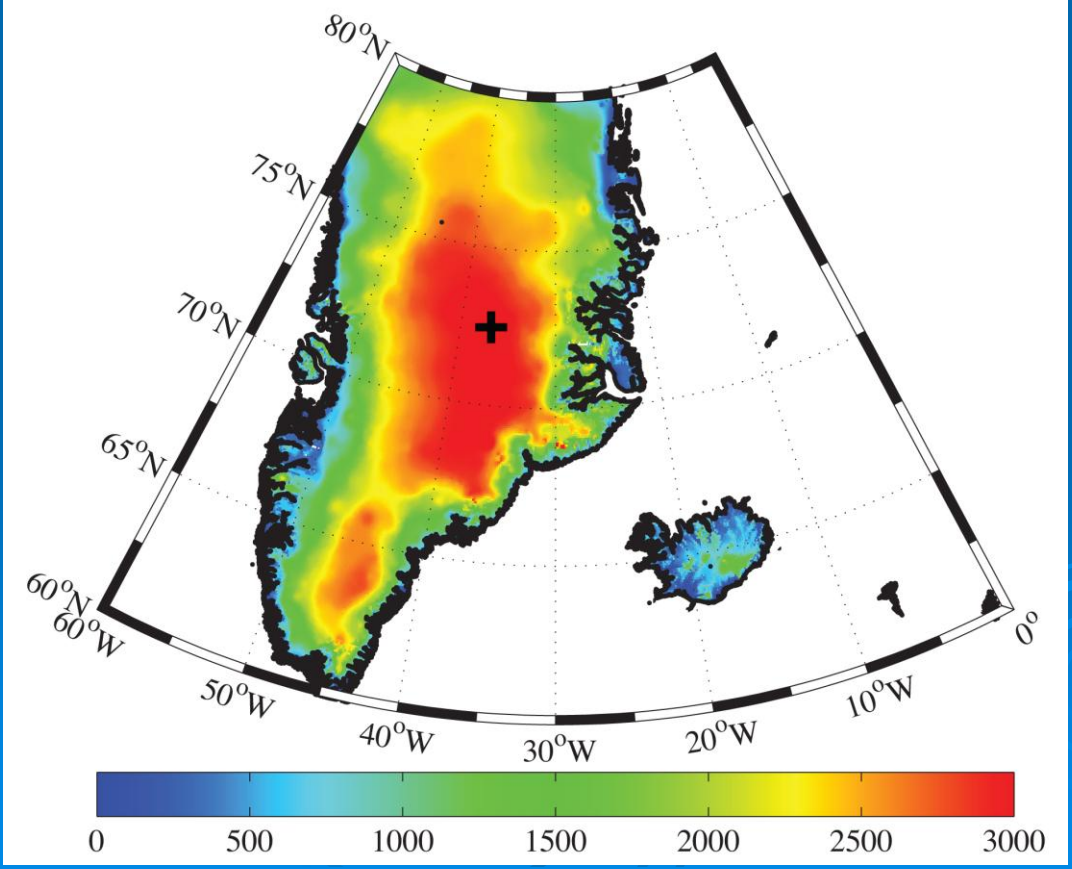
• During the Greenland Flow Distortion Experiment, a polar low developed over the Iceland Sea in a region accessible to our research aircraft.

•A mission was planned and executed to sample the low.

•After the experiment, serendipity resulted in the realization that surface ozone and Be^7 concentration measurements made at the Summit Observatory in the center of the Greenland Ice Cap captured the passage of the tropopause fold that contributed to the development of the low.

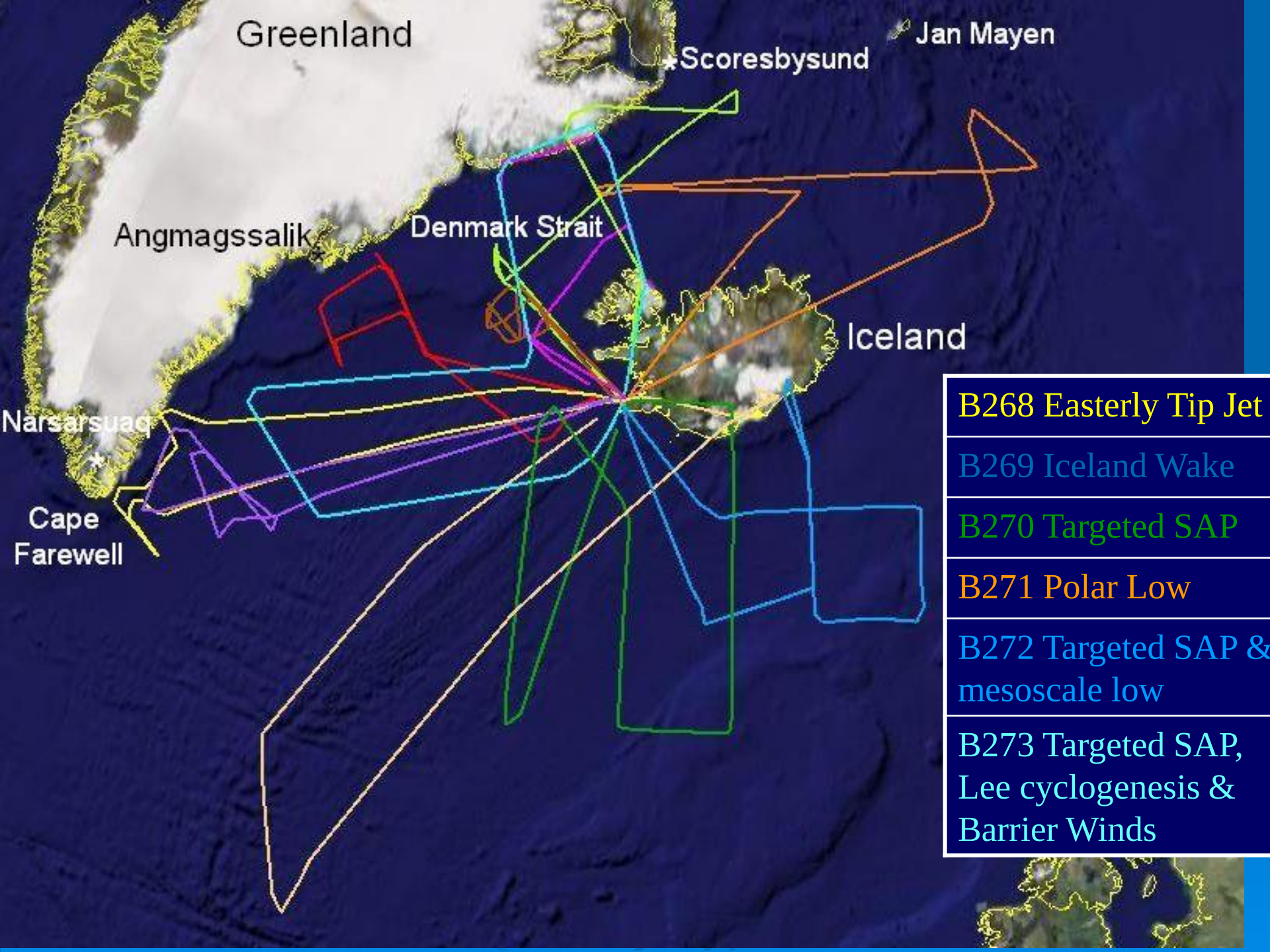
Introduction

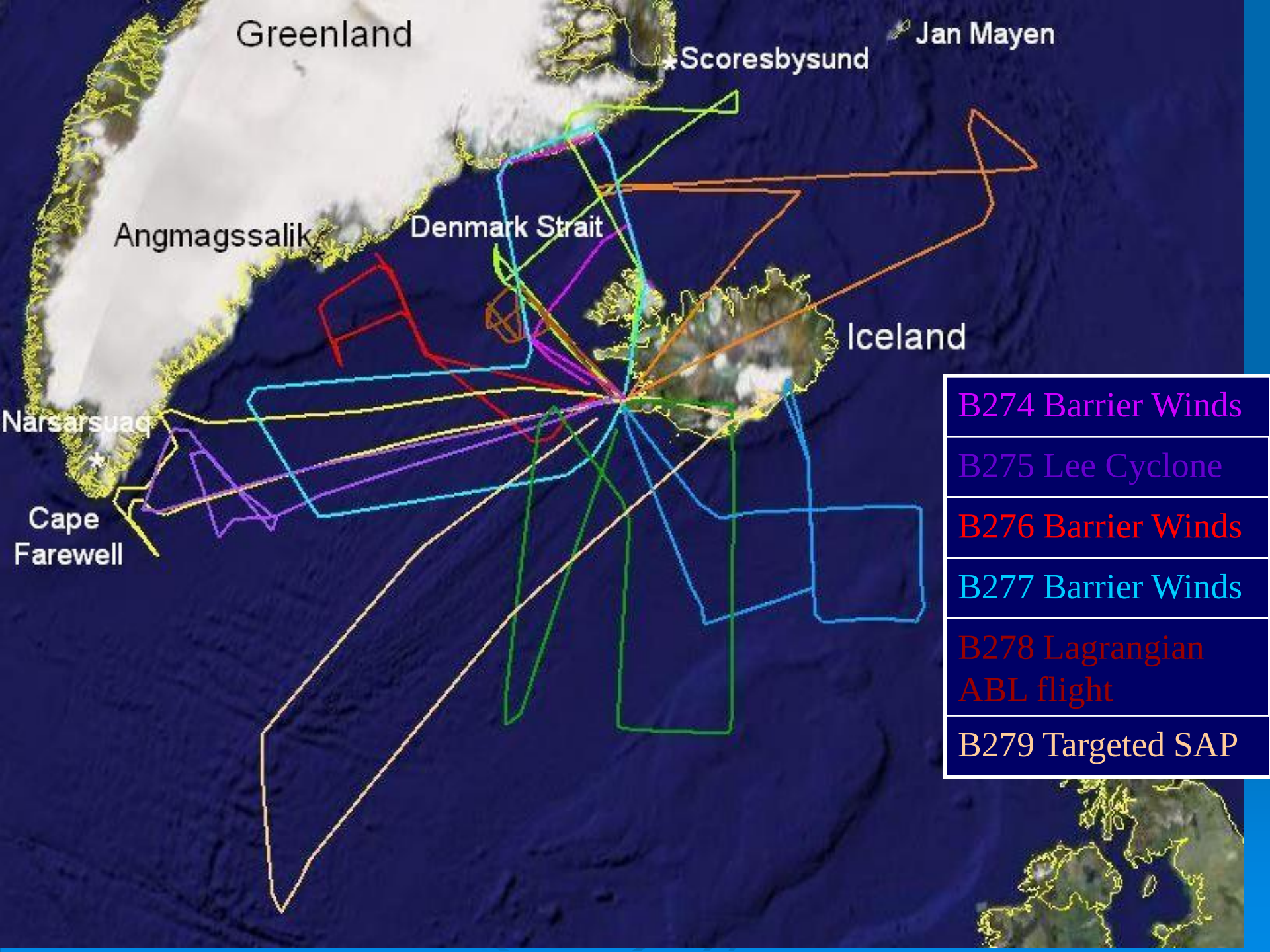
•In this paper, we will use the Interim Reanalysis from the ECMWF (ERAI) to describe the synoptic setting in which the low developed as well as the aircraft data as to its structure and the observations from the Summit Observatory.



Aircraft Observations

- During the Greenland Flow Distortion Experiment, the FAAM research aircraft was deployed to Keflavik Iceland.
- The FAAM aircraft had the capability of measuring in-situ atmospheric parameters including ozone as well as a deploying dropsondes.
- For more information on the experiment and the aircraft, please refer to Renfrew et al (BAMS 2008).


Greenland
Scoresbysund
Jan Mayen
Angmagssalik
Denmark Strait
Iceland
Narsarsuaq
Cape
Farewell
B268 Easterly Tip Jet
B269 Iceland Wake
B270 Targeted SAP
B271 Polar Low
B272 Targeted SAP & mesoscale low
B273 Targeted SAP, Lee cyclogenesis & Barrier Winds


Greenland
Jan Mayen
Scoresbysund
Angmagssalik
Denmark Strait
Iceland
Narsarsuaq
Cape
Farewell
B274 Barrier Winds
B275 Lee Cyclone
B276 Barrier Winds
B277 Barrier Winds
B278 Lagrangian
ABL flight
B279 Targeted SAP

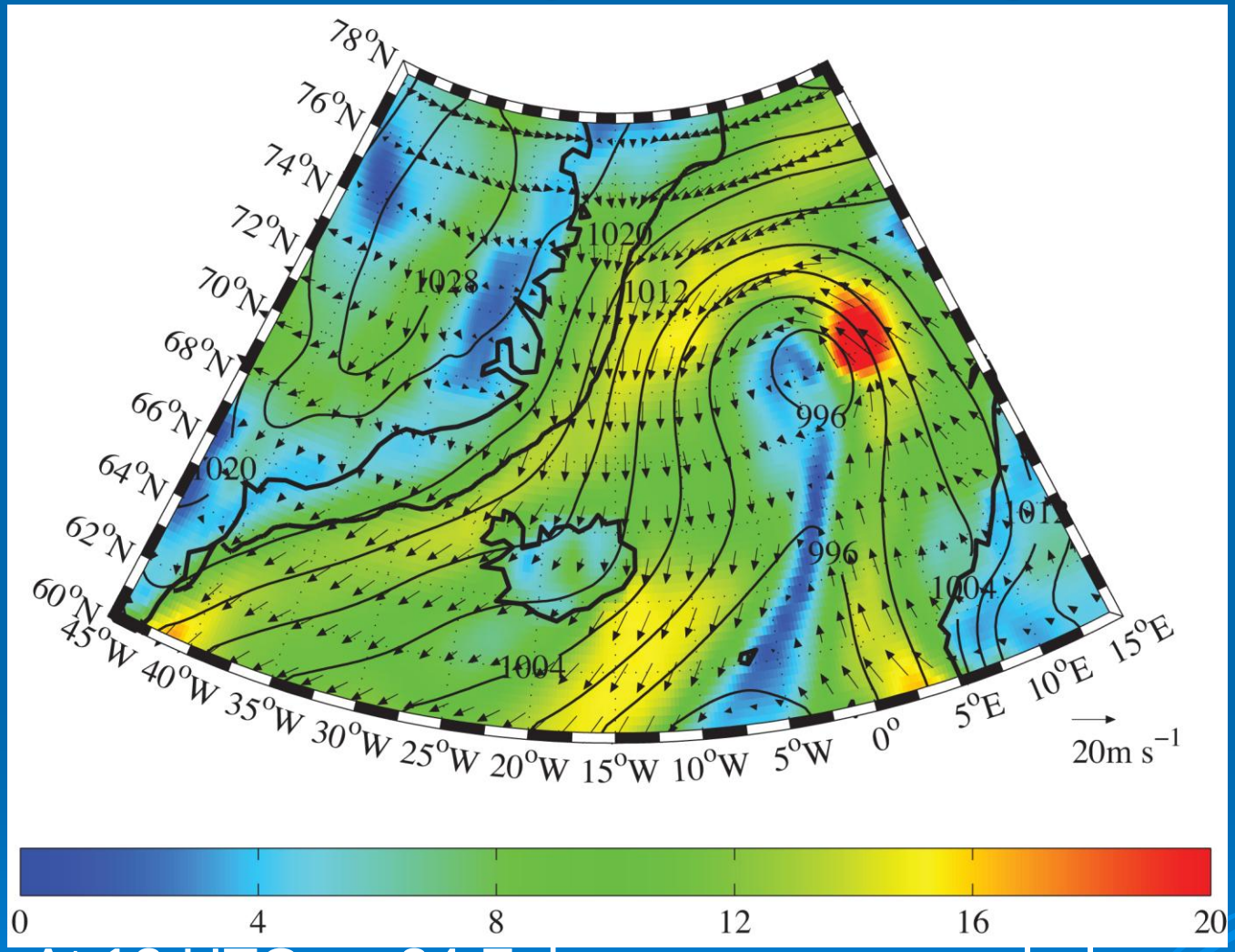
Summit Observations

• Surface ozone concentration measurements have been made at the Summit Observatory (elevation 3000m) since 2001.

•Hourly data is collected by NOAA as part the global ozone observing network.

•Be^7 measurements (*cosmogenic isotope; tracer for stratospheric air*) with a temporal resolution of 2-5 days have been made at the site since 2003 by Jack Dibbs from UNH.

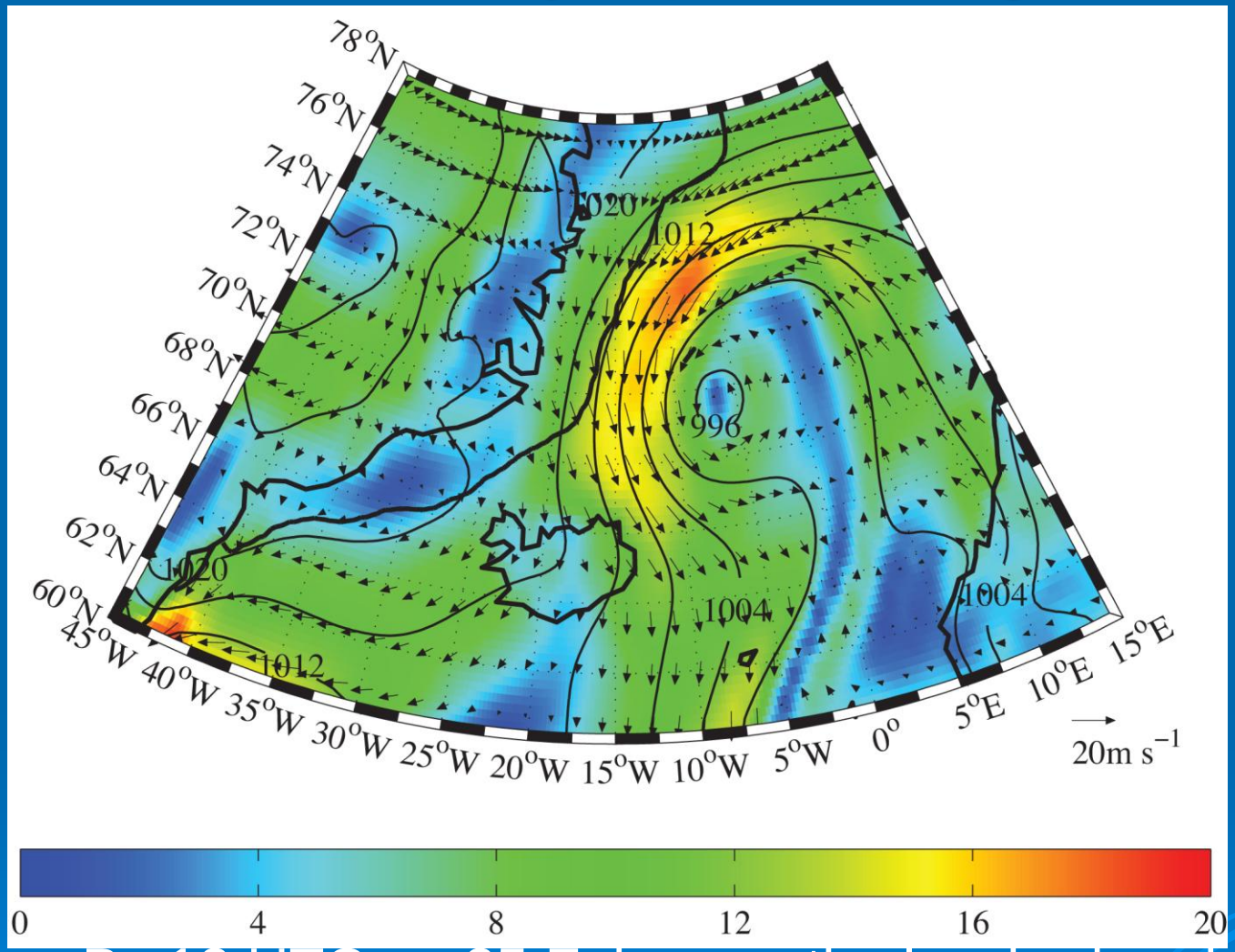
Synoptic Setting



Sea-level pressure (contours-mb), 10m wind (vectors-m/s), 10m wind speed (shading-m/s) and ice edge from the ERAI

At 12 UTC on 24 February, a mesoscale low was present over the Norwegian Sea to the northwest of Iceland.

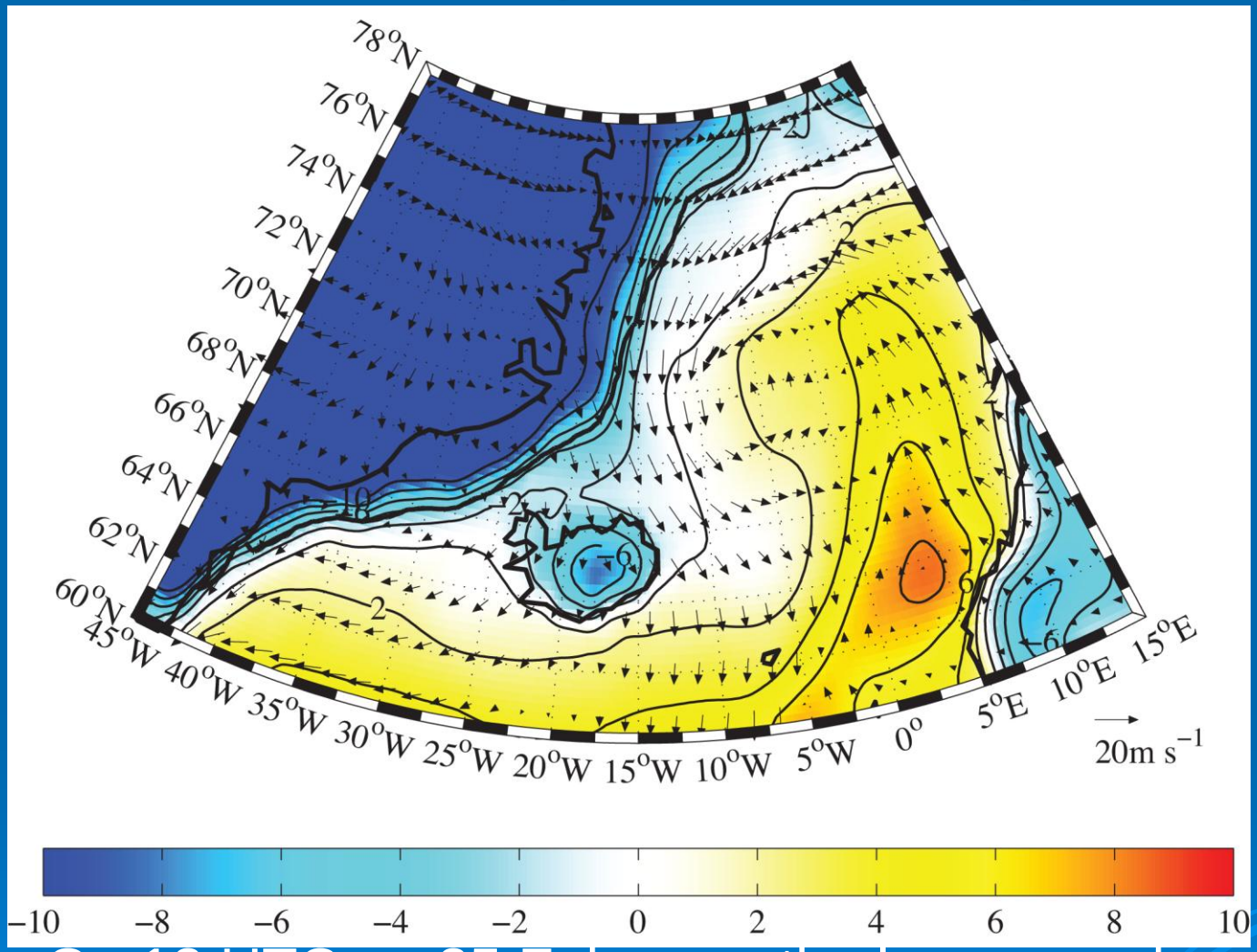
Synoptic Setting



Sea-level pressure (contours-mb), 10m wind (vectors-m/s), 10m wind speed (shading-m/s) and ice edge from the ERAI

By 12 UTC on 25 February, the low had undergone a cyclonic rotation and was within flight range of the FAAM Aircraft.

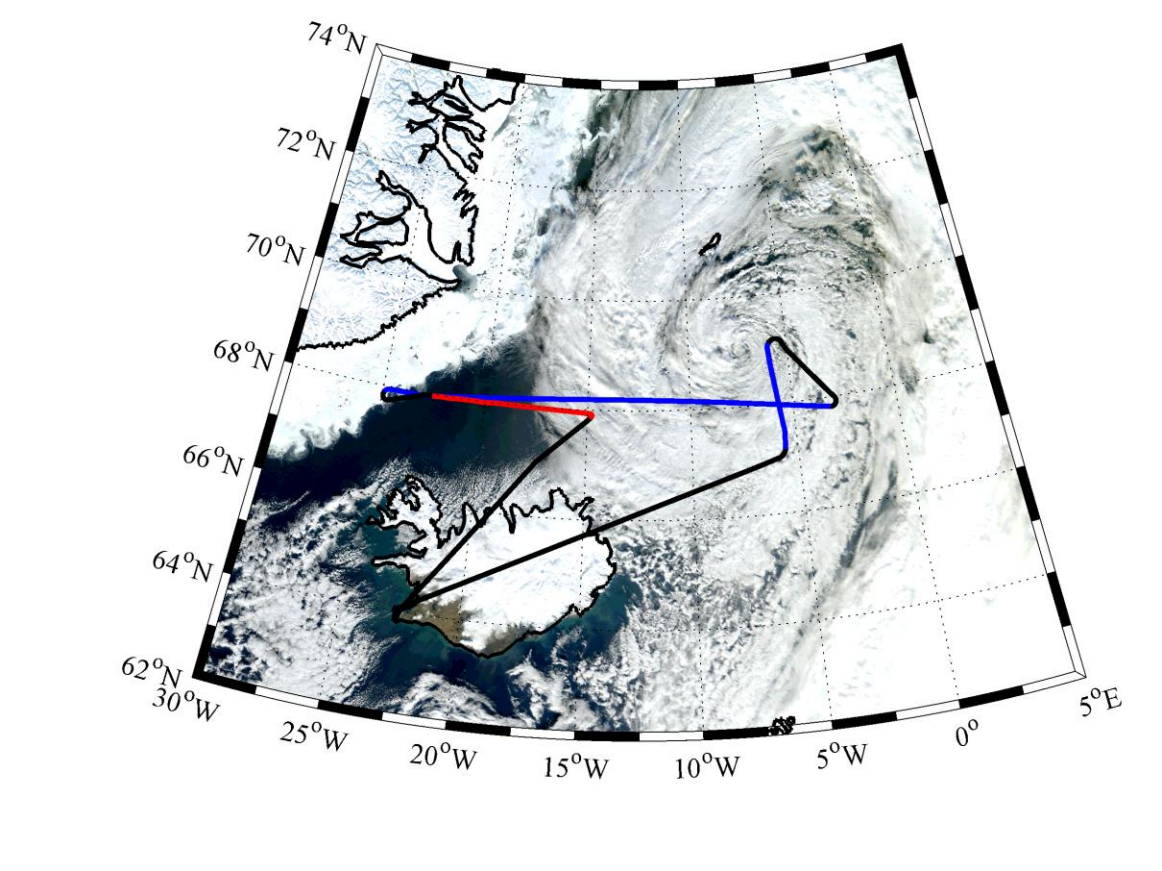
Synoptic Setting



2m air temperature (contours& shading-^{o}C) and 10m wind (vectors-m/s) and ice edge from the ERAI

On 12 UTC on 25 February, the low was advecting warm modified air into the Iceland Sea region. Moderate cold air outbreak occurred over the Denmark Strait

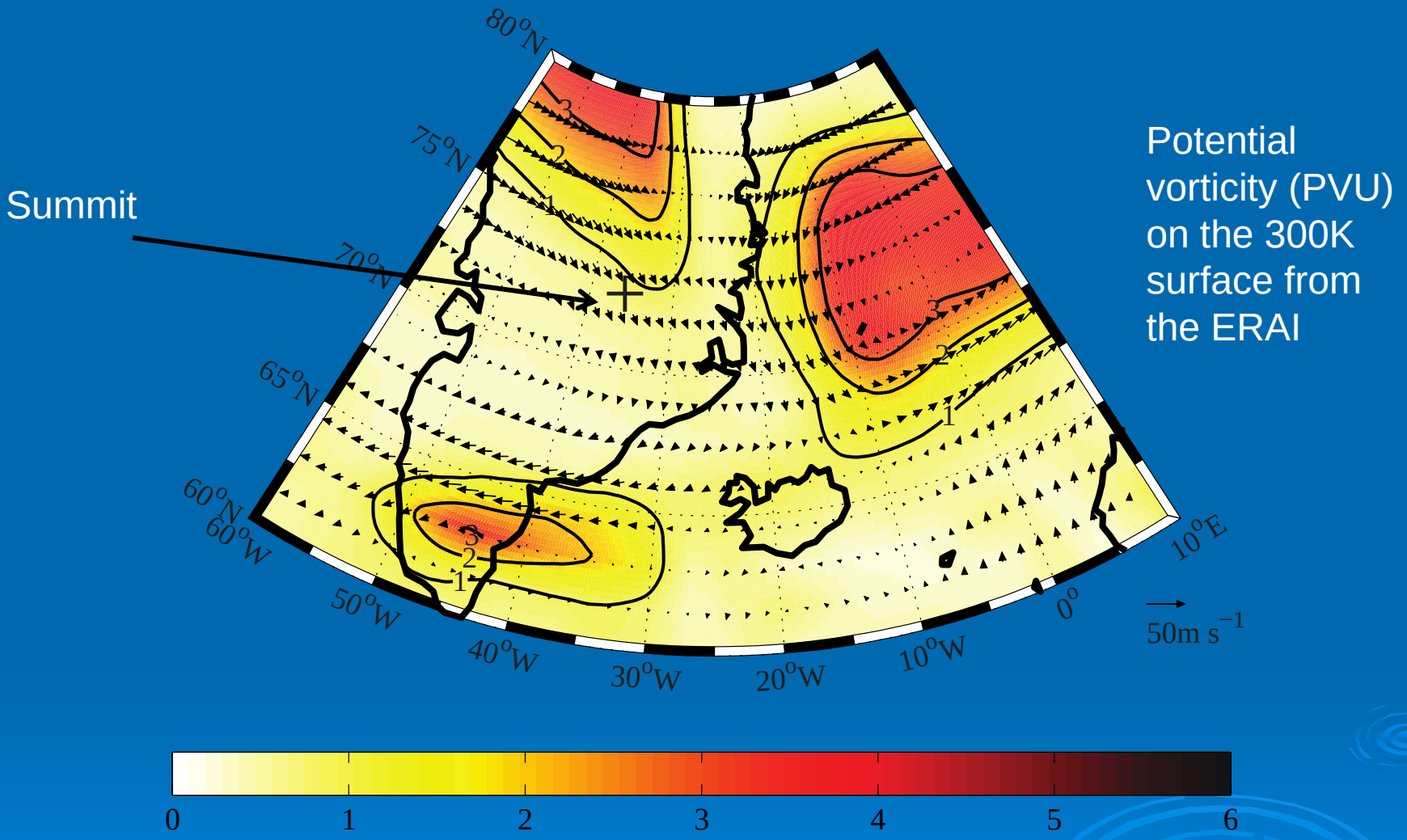
Synoptic Setting



MODIS true-color image at 13:15 UTC February 25

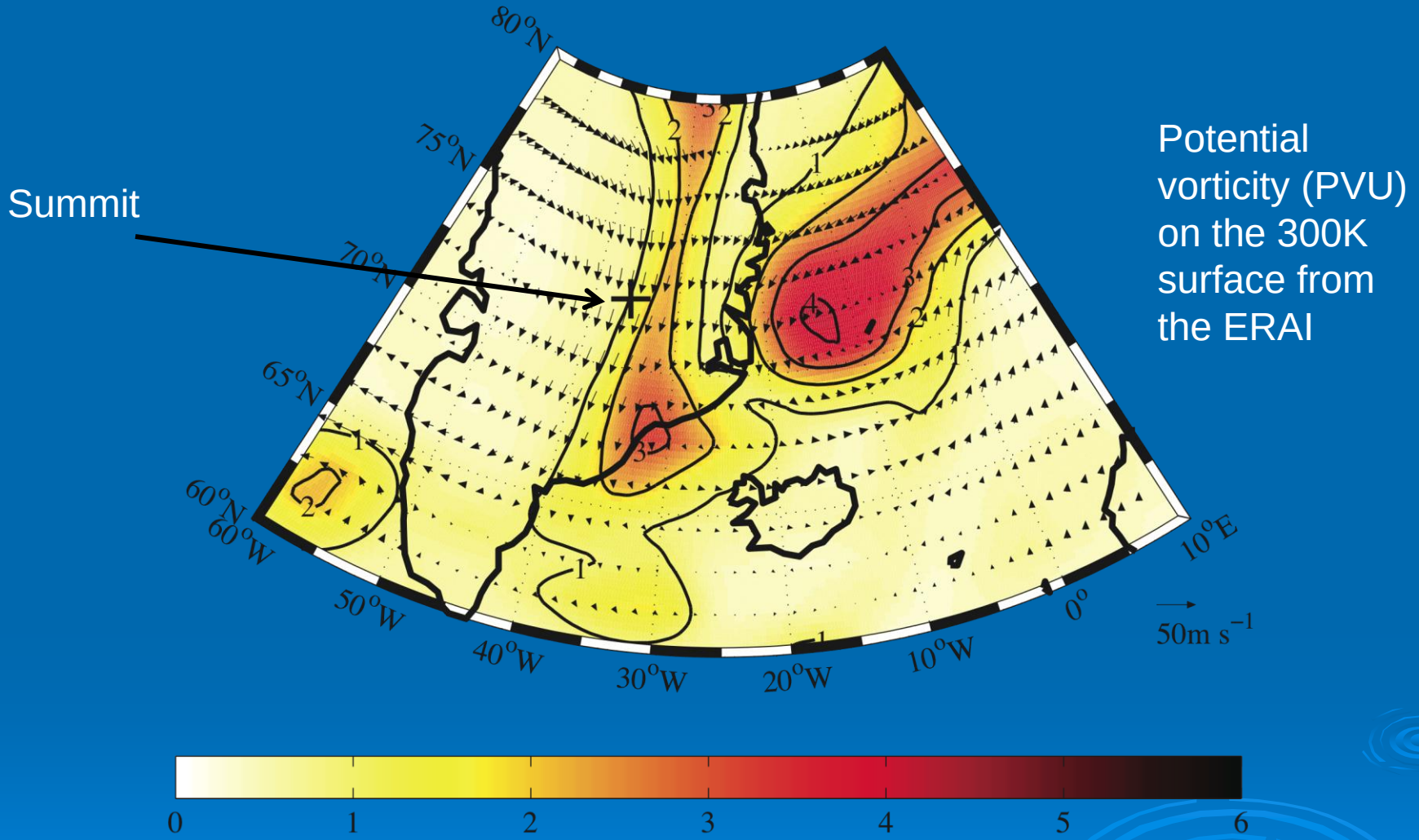
A flight into the low was planned to sample its upper-level (blue) and low-level (red) structure. *(errors in the forecast track of the low resulted in our missing its center)*

Upper-level Forcing



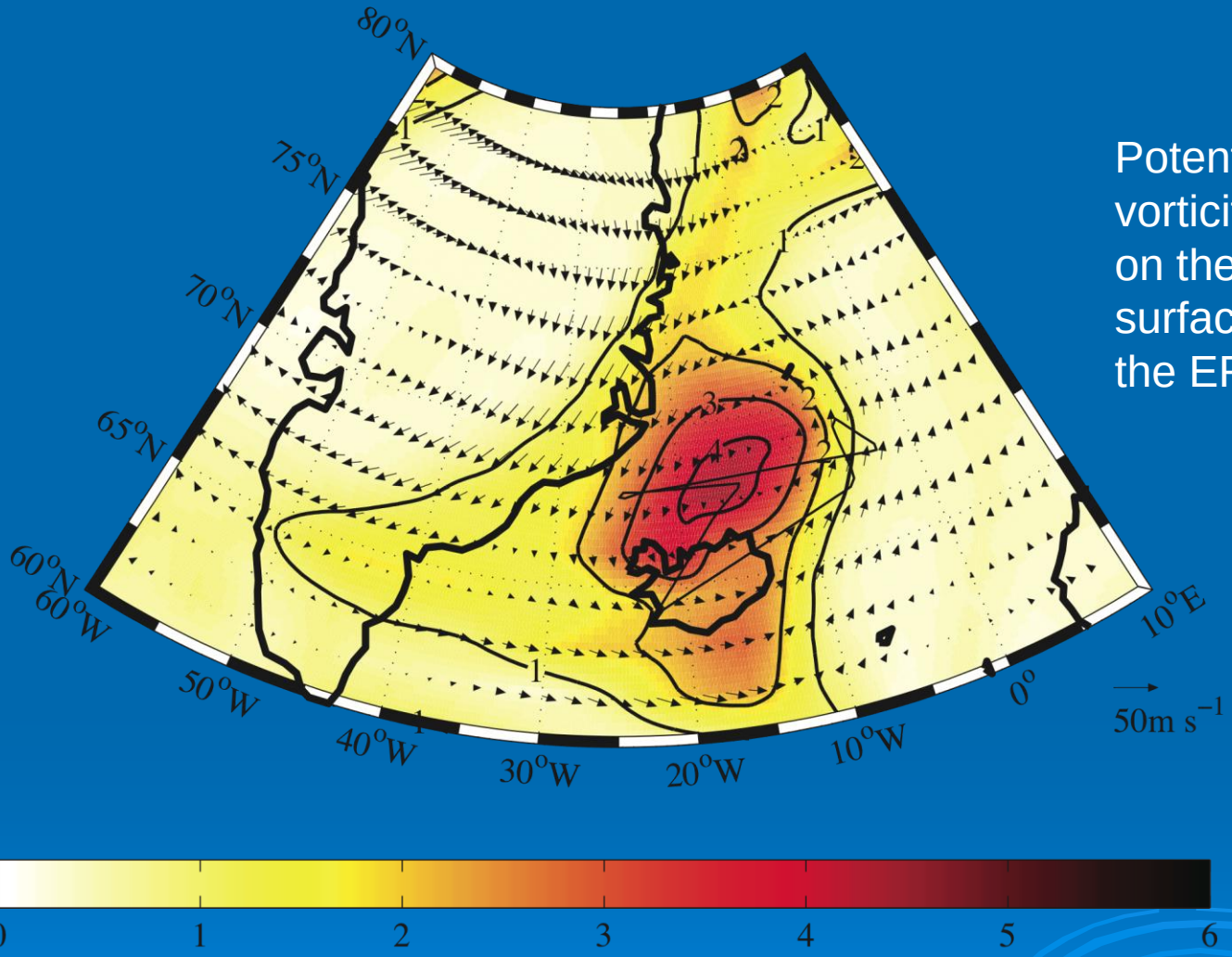
At 12 UTC on 23 February, multiple PV centers were present in the region of interest, including a filamentary structure over the Northwest Greenland

Upper-level Forcing



By 12 UTC on 24 February, PV structures had begun to merge over the Iceland Sea. PV filament passed over Summit

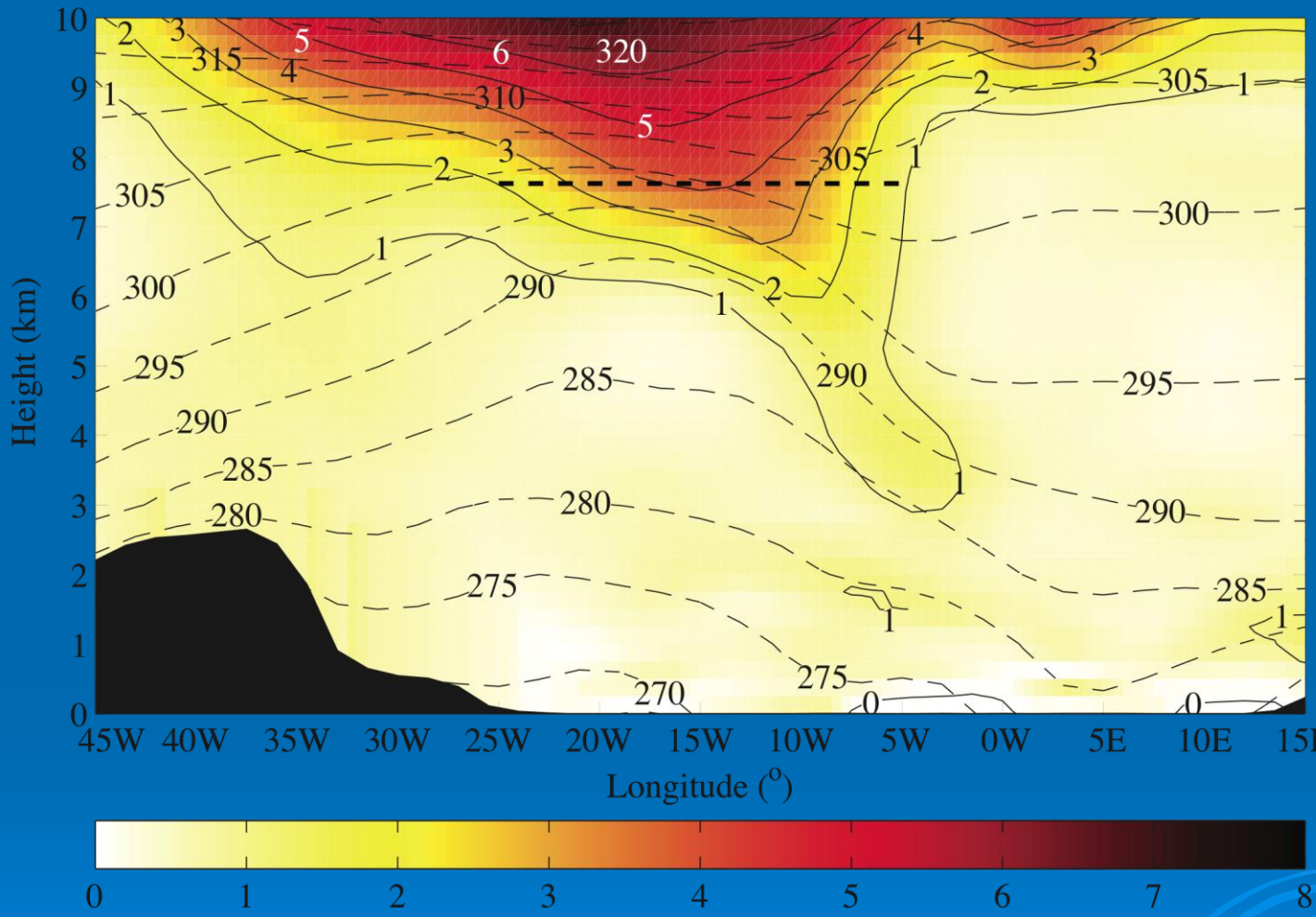
Upper-level Forcing



Potential vorticity (PVU) on the 300K surface from the ERAI

By 12 UTC on 25 February, an isolated PV maximum was present over the Iceland Sea and it was sampled by the aircraft mission (black line)

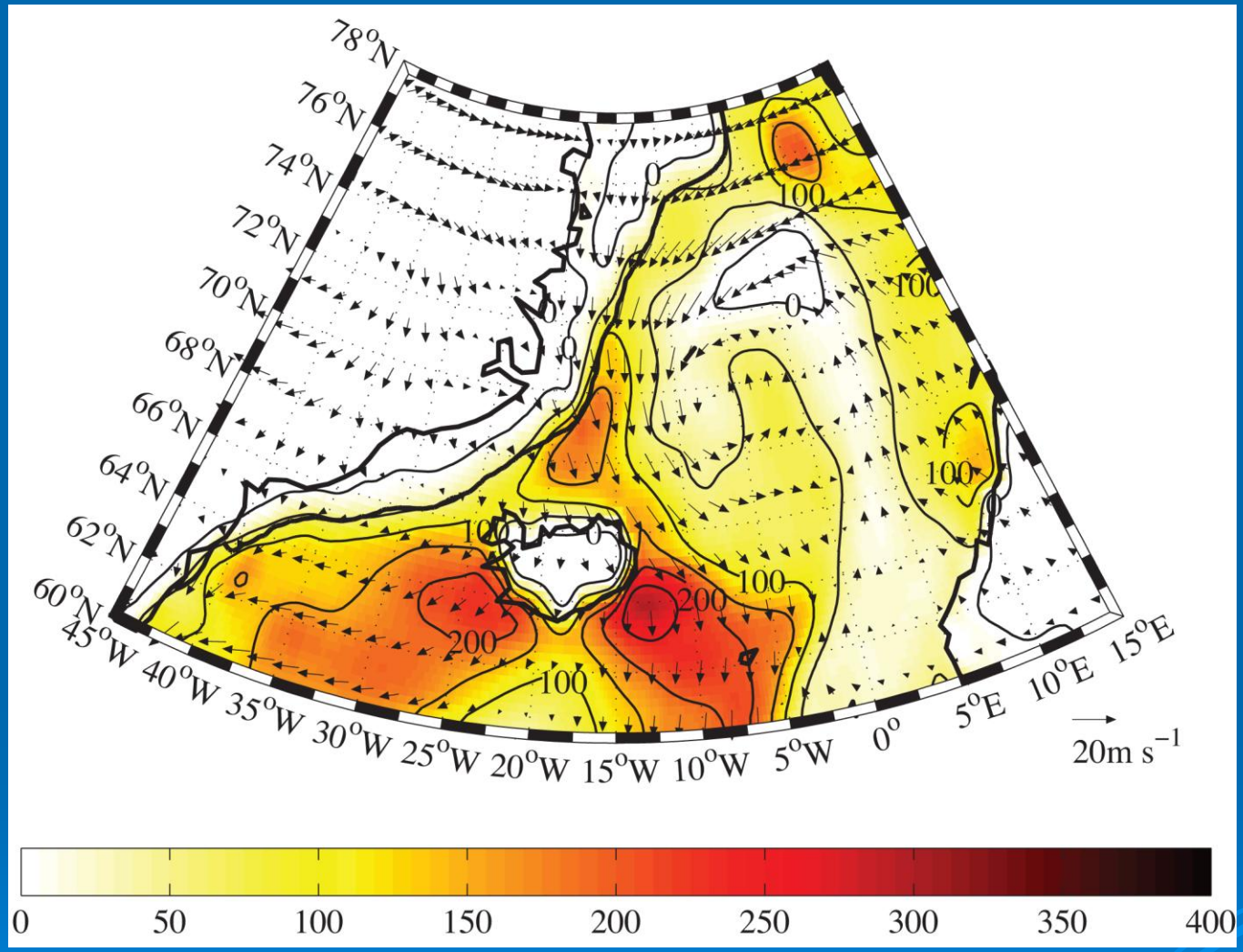
Upper-level Forcing



Meridional cross-section of potential vorticity & potential temperature along 68°N from the ERAI

By 12 UTC on 25 February, an isolated PV maxima was present over the Iceland Sea and it was sampled by the aircraft mission (dashed line)

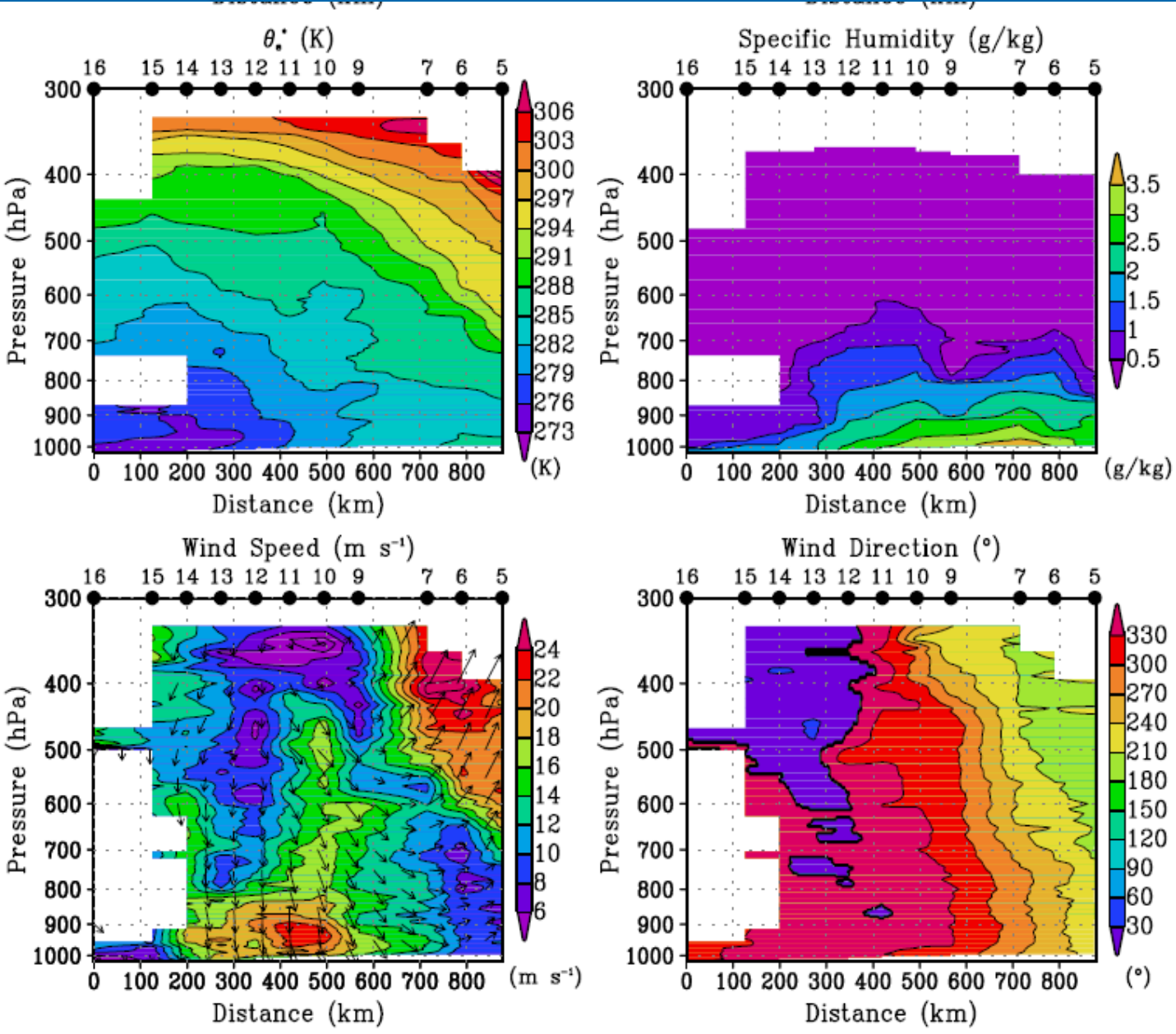
Surface Forcing



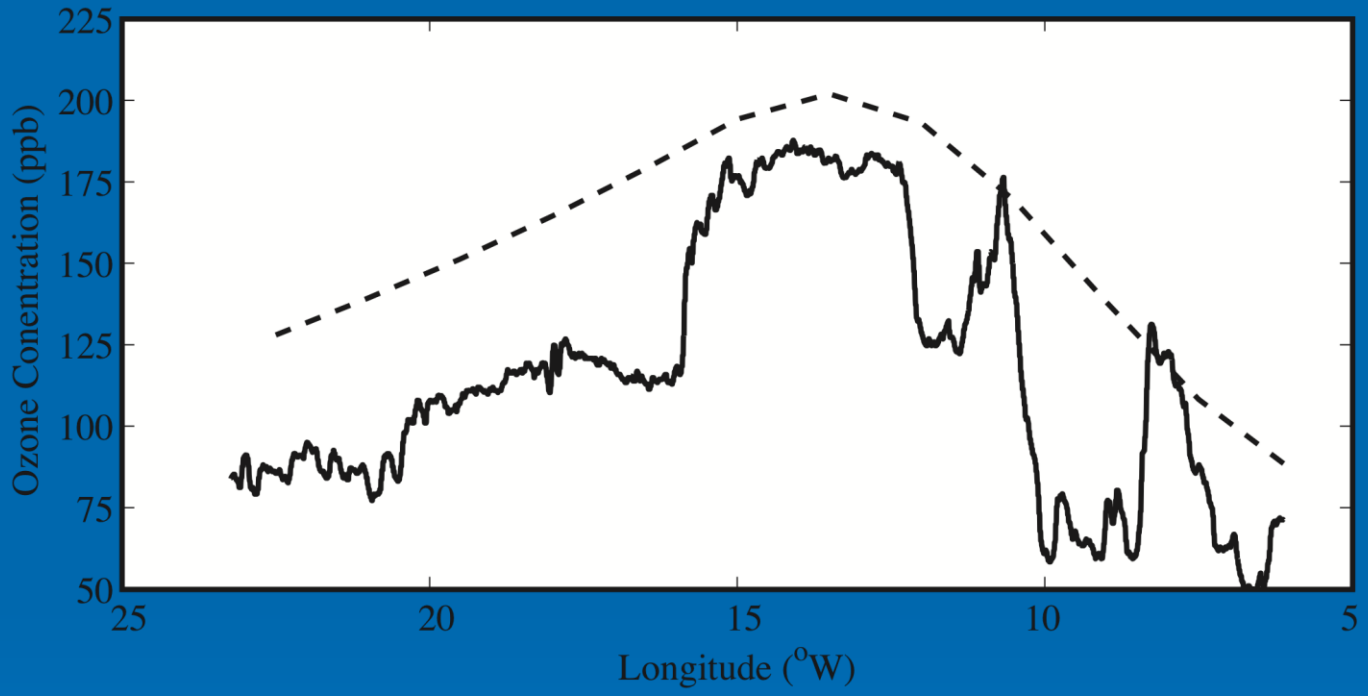
Total turbulent heat flux (contours & shading-W/m^2), 10m wind (vectors-m/s), and ice edge from the ERAI

At 12 UTC on 25 February, moderate surface air-sea fluxes were present along the periphery of the low. Warm air temperatures precluded high heat fluxes on its western edge.

Dropsonde observations

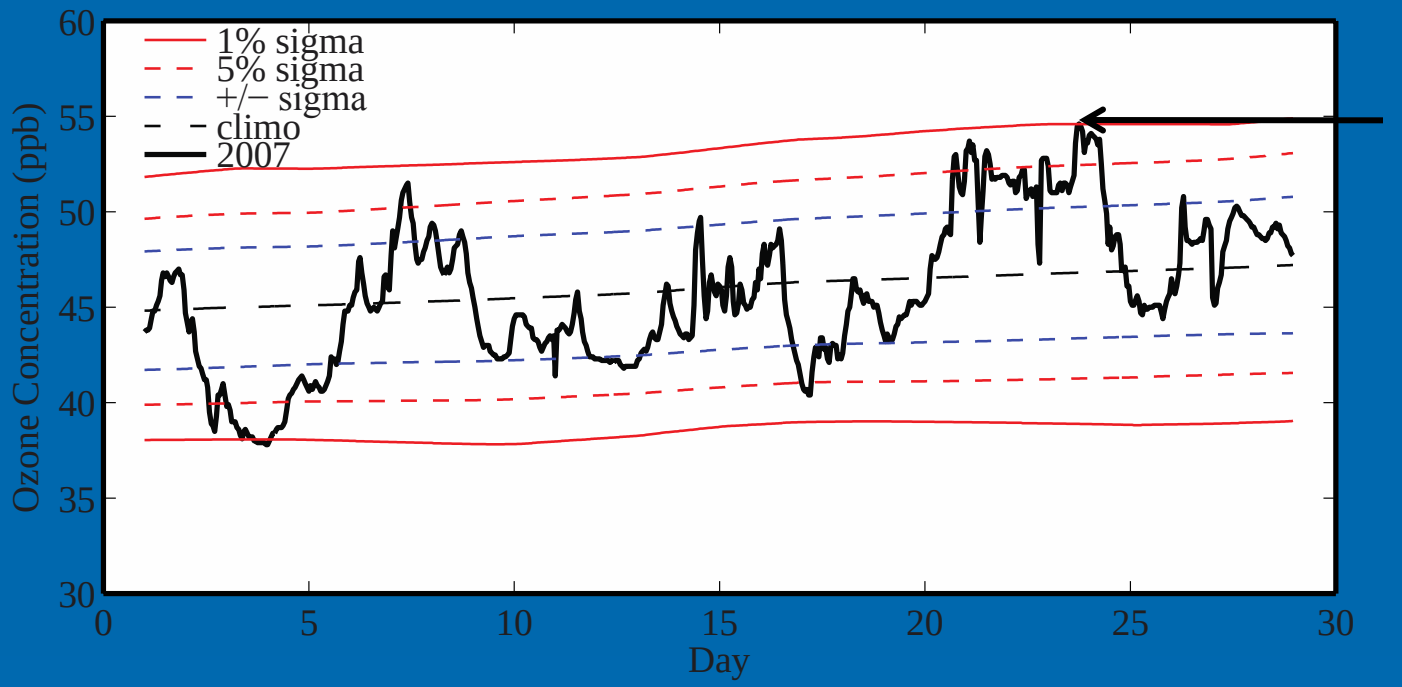


Aircraft Observations



Flight-level ozone concentration: observations- solid line
ERAI – dashed line

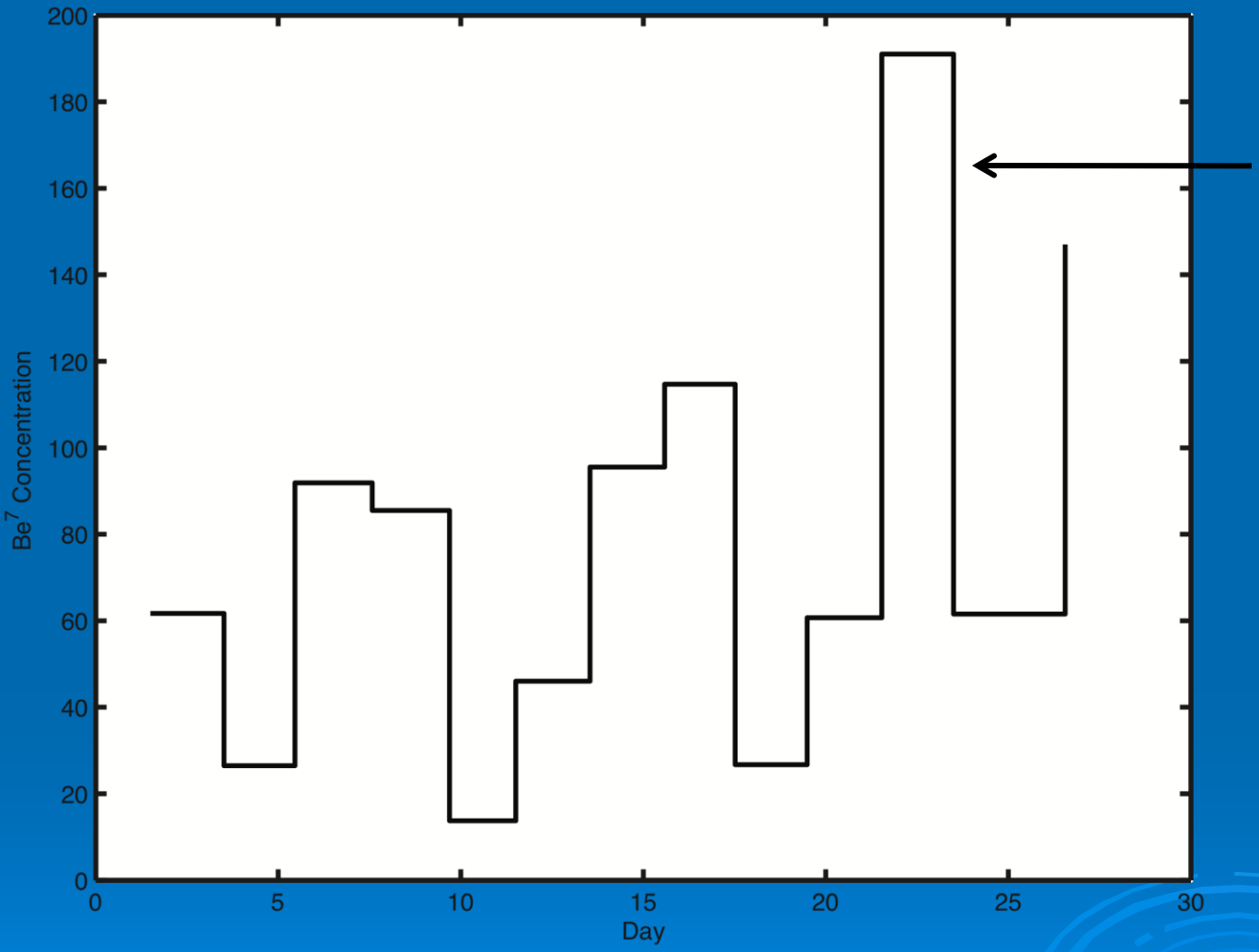
Summit Observations



Elevated values during passage of PV filament

Surface ozone concentration time series at Summit Greenland February 2007
(statistics based on data from 2001-2012 except for 2002)

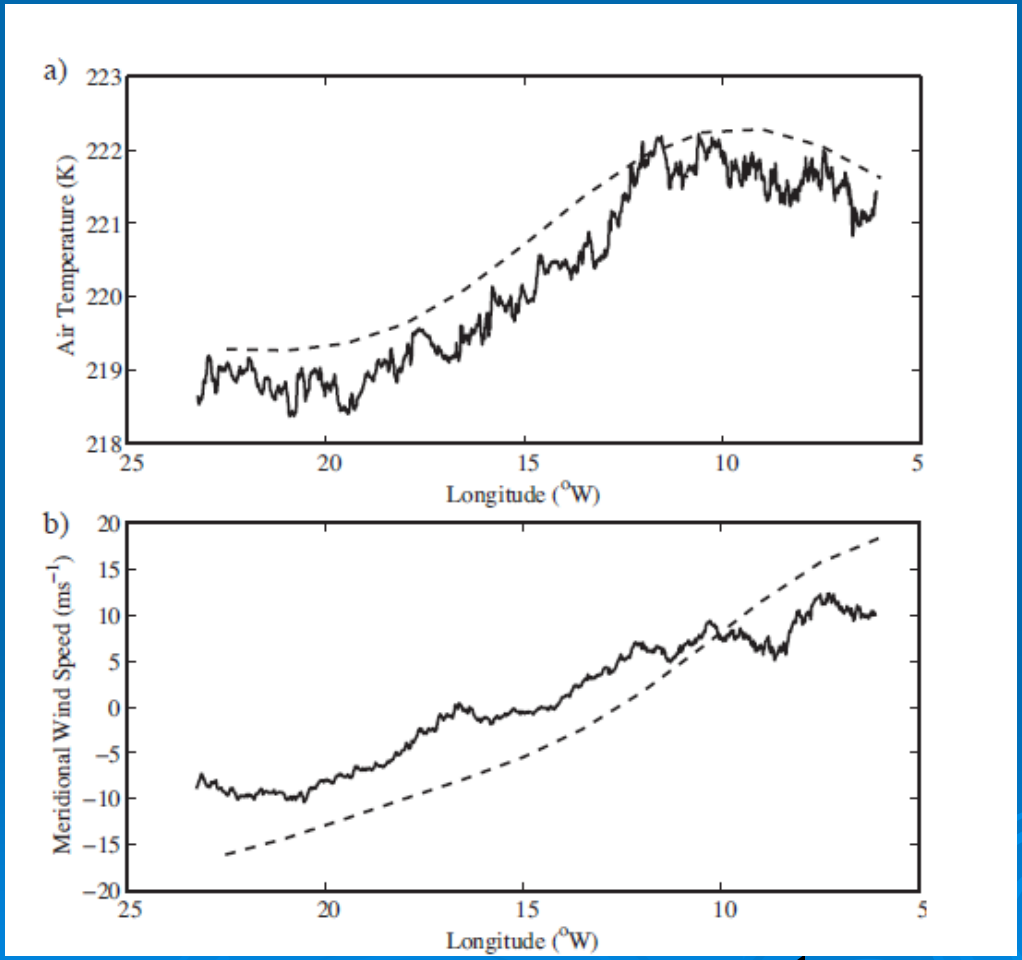
Summit Observations



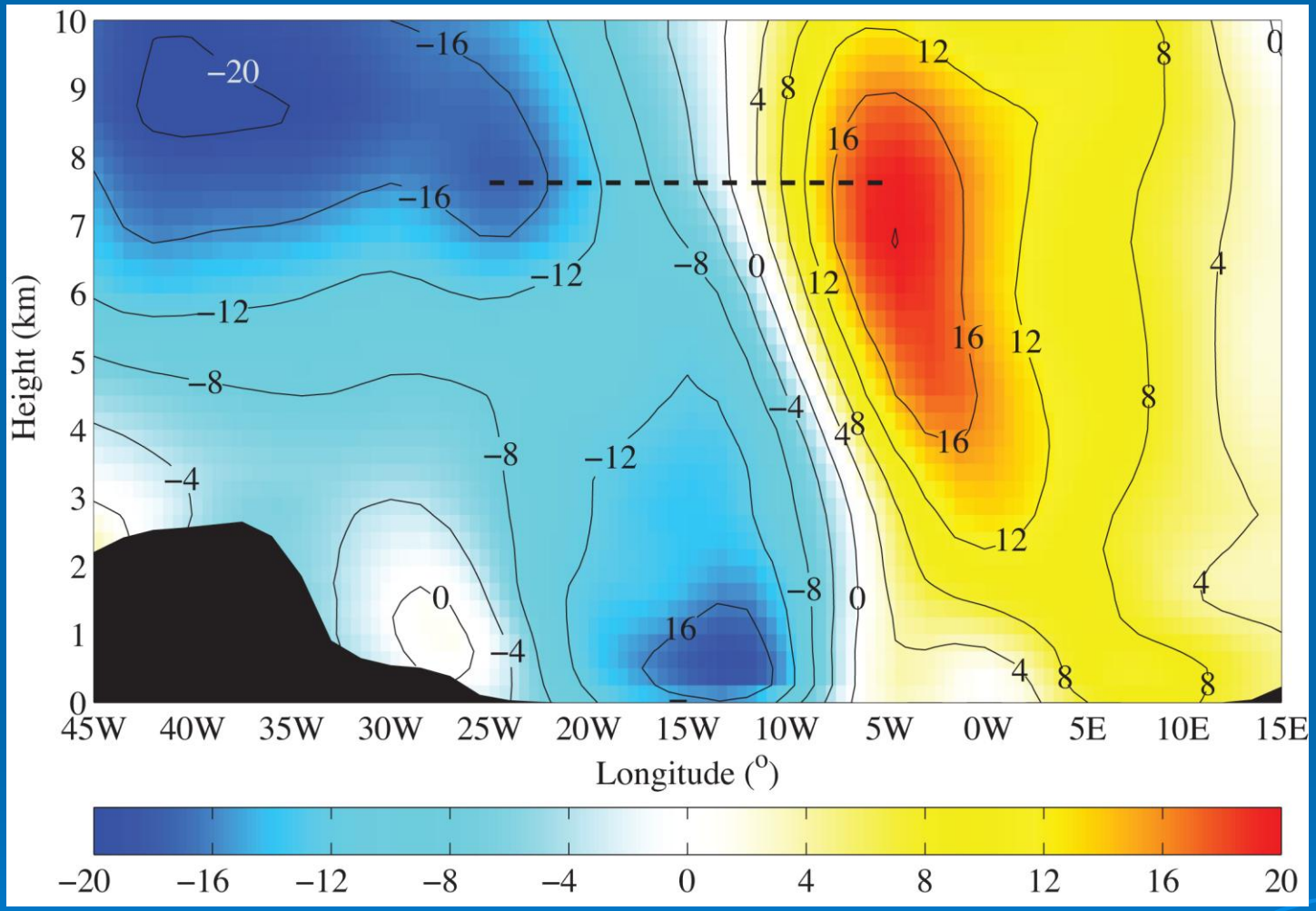
Elevated values during passage of PV filament

Surface Be^7 concentration time series at Summit Greenland February 2007

Aircraft observations



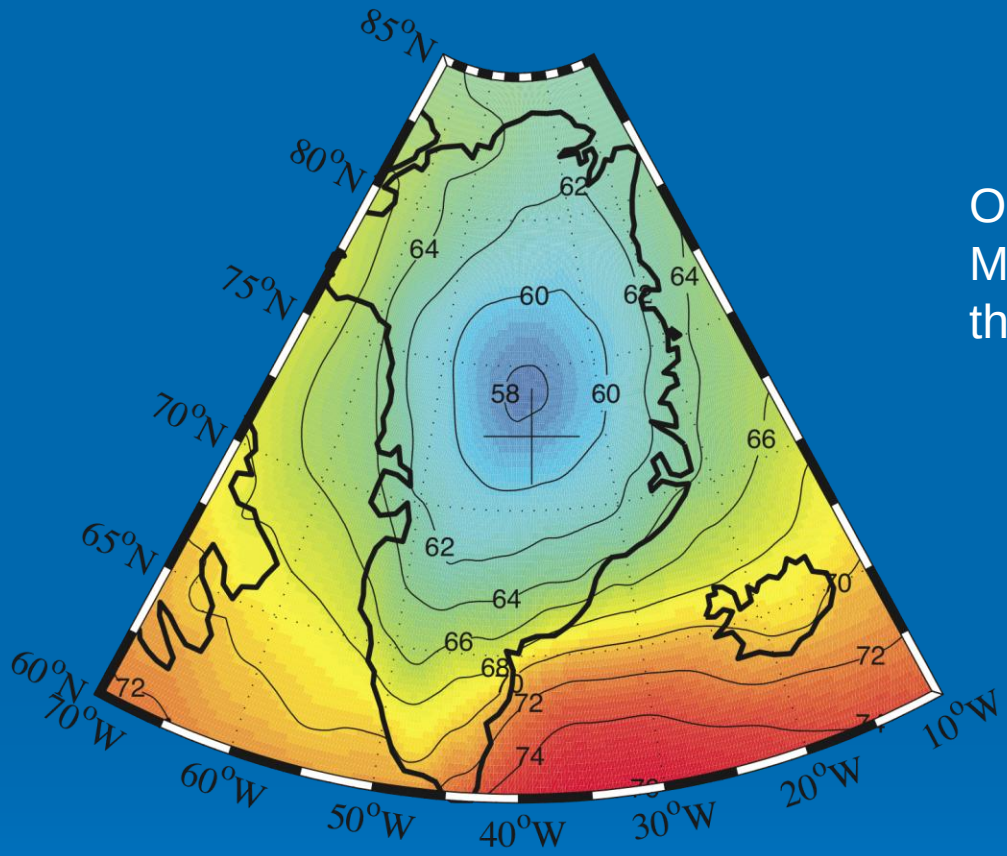
Vertical Structure



Meridional cross-section of meridional component of the wind (m/s) along 68°N from the ERAI

At 12 UTC on 25 February, the low had a complex vertical structure with an upper-level cyclonic circulation that extended westward over Greenland and a strong northerly surface jet as well as a wind nadir over East Greenland

Does Greenland Influence Upper-tropospheric Ozone?



Ozone Minimum over the Ice Cap

Winter (DJF) mean climatological ozone concentration at 400mb from the ERAI

Conclusions

- A mesoscale cyclone was present over the Iceland Sea in late February 2007.
- Met the criteria for a polar low.
- An interaction of an tropopause fold and a nascent surface circulation was responsible for its development.
- Surface fluxes were moderate as the low was unable to access the cold air over the E. Greenland MIZ
- The ERAI was able to capture the high levels of ozone that were observed by the aircraft in the vicinity of the fold.
- Observations from the Summit Observatory indicate that the the fold was associated with high levels of surface ozone and Be^{7}.

Northern Lights over Summit Station

Thank-you