Cloud properties during marine cold air outbreaks in COMBLE: a preliminary survey



Bart Geerts[1], Yazhe Hu[1], Yonggang Wang[2]

Zachary J. Lebo[1], Yishi Hu[1]

[1]University of Wyoming [2]Texas Tech University

COMBLE break-out session, 6/25/2020

COMBLE Objectives

In a nutshell:
What is the role of marine boundary layer clouds during cold-air outbreaks over open water in the Arctic climate system?

Context: the COMBLE campaign addresses fundamental questions related to aerosol-cloud-precipitation feedbacks in the Arctic climate system. The campaigns focus on a cloud regime that remains poorly understood: shallow convection in the marine boundary layer during cold air outbreak events.

… how to define cold-air outbreaks (CAOs)?

looking NE

CAO conditions

looking NW

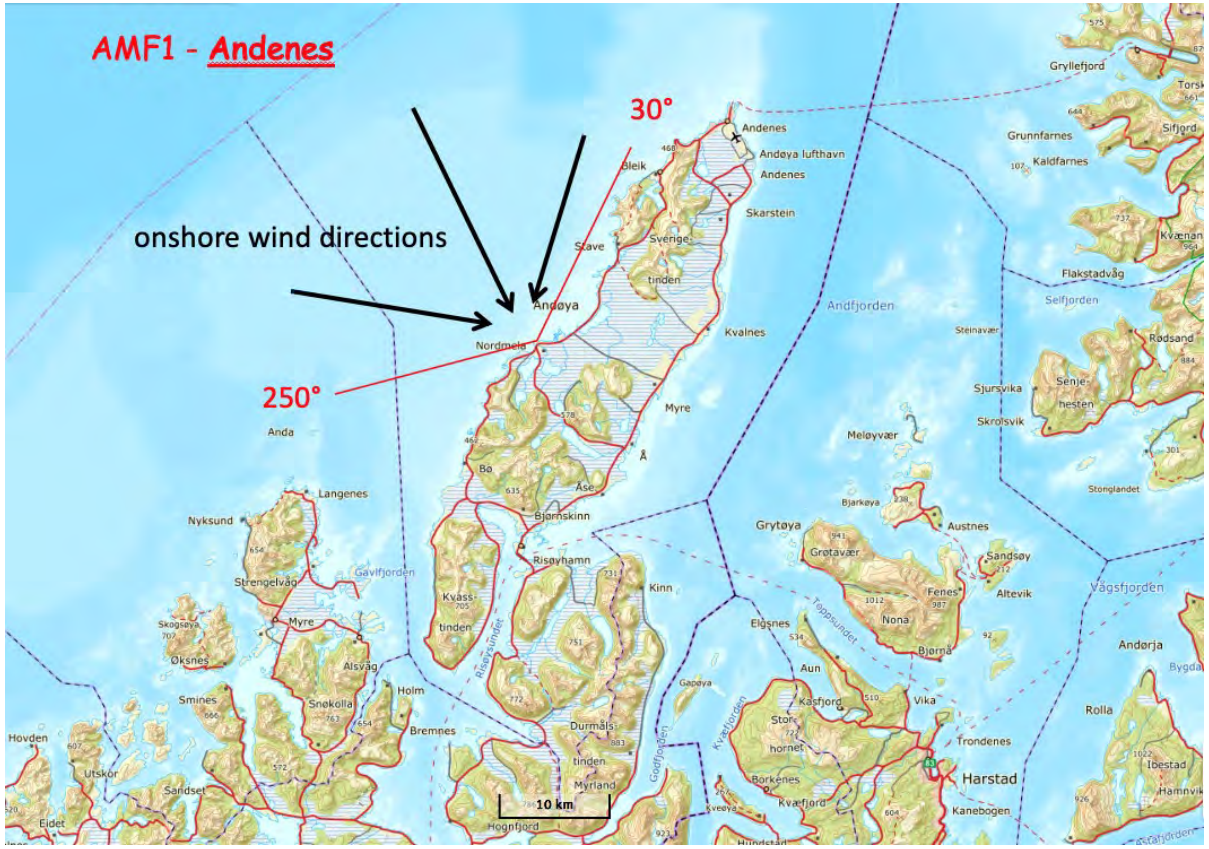
Andoya (M1)

1. M > 0 K
2. U_{10} > 10 kts (5 m/s)
3. Wind direction: as below:

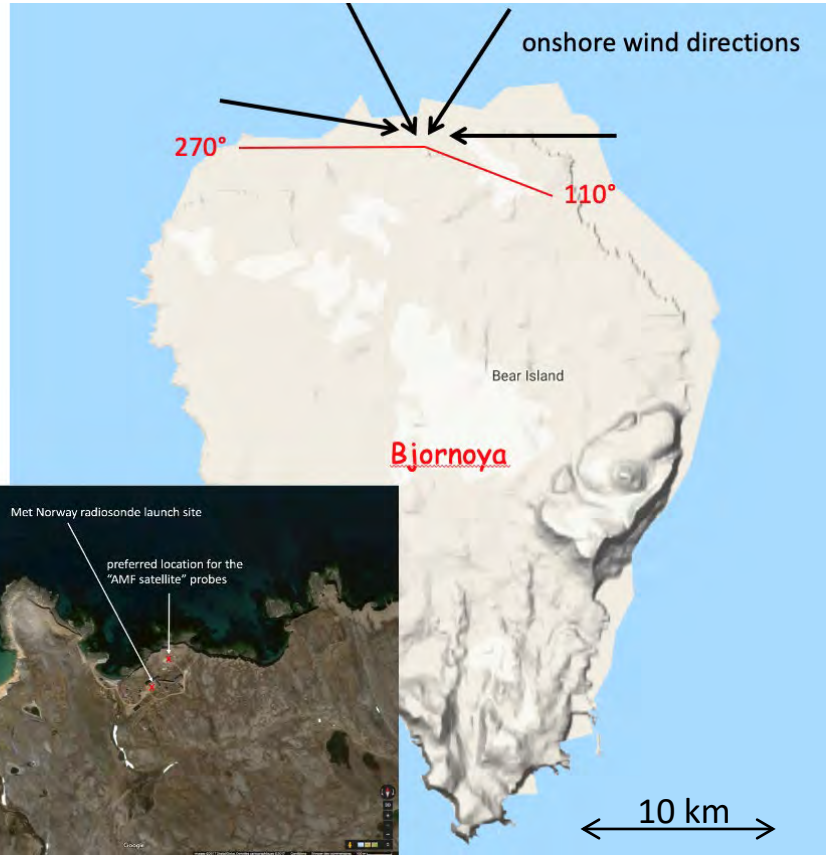
$$M \equiv \theta_{SST} - \theta_{850\,hPa}$$

Bjornoya (S2)

1. M > 1 K
2. U_{10} > 10 kts
3. Wind direction: as below:

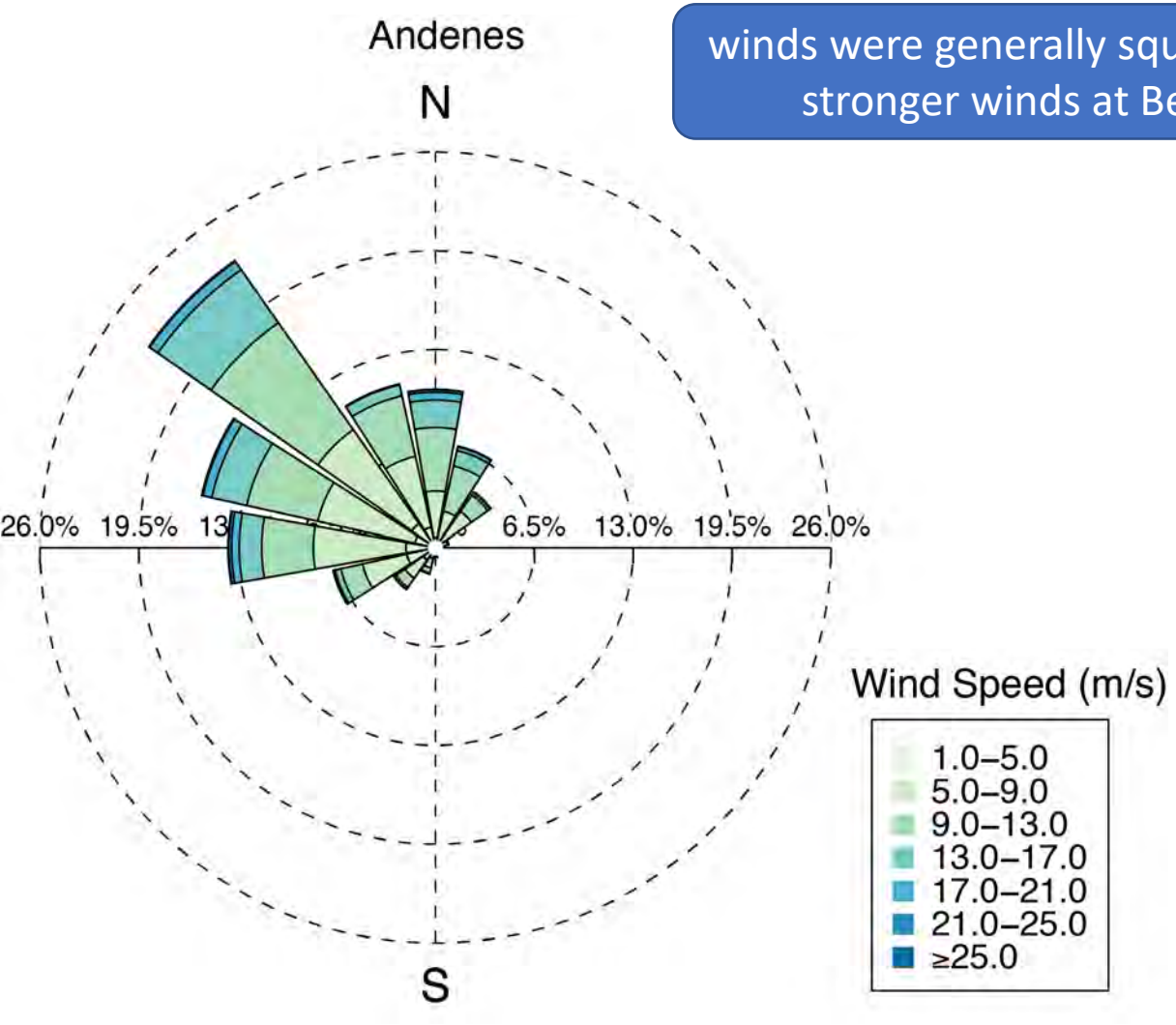


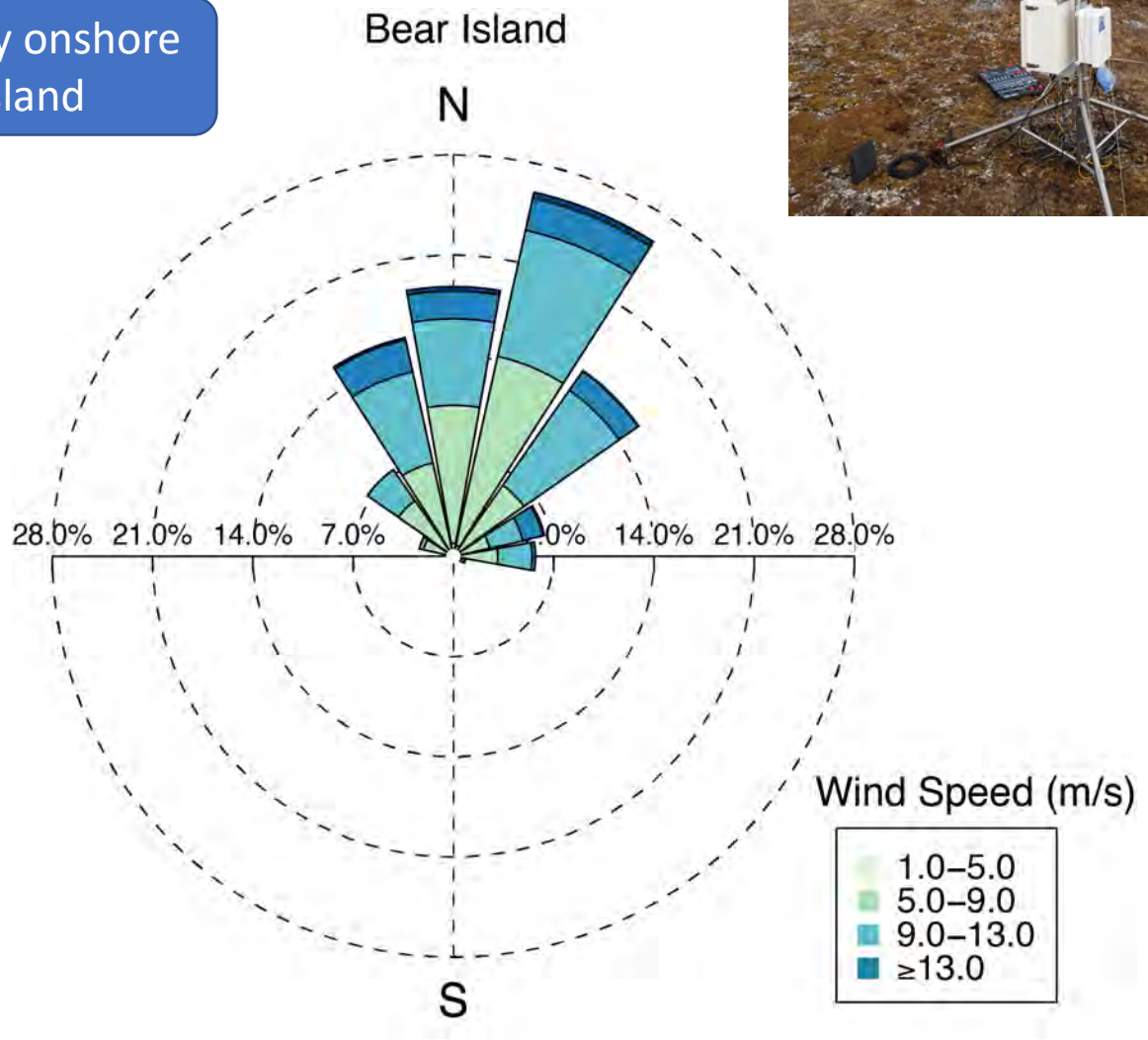
Data sources: radiosonde (hourly interpolated at M1, 3-6 hourly WMO soundings at S2), MET, NOAA SST



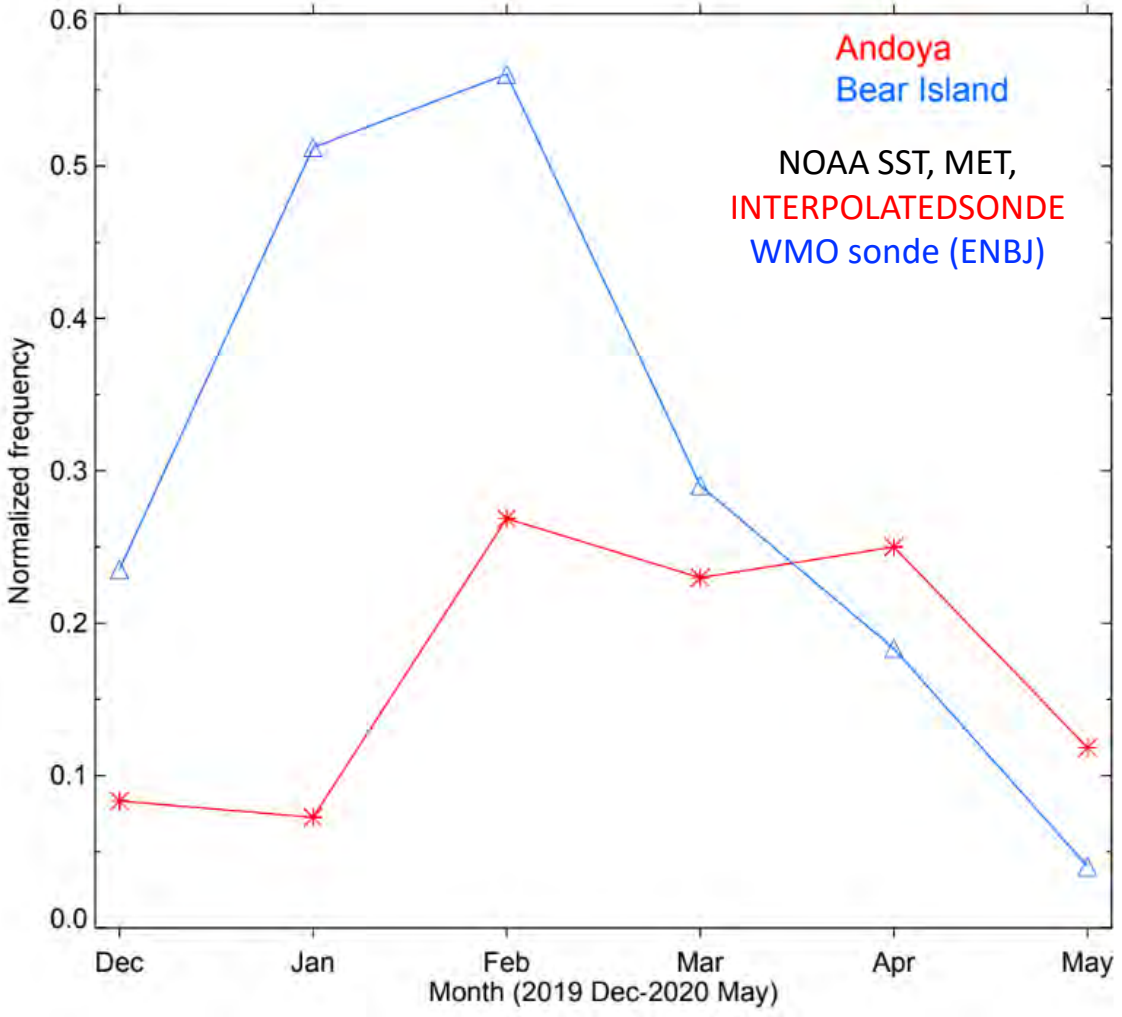
surface winds during CAOs in COMBLE

winds were generally squarely onshore
stronger winds at Bear Island

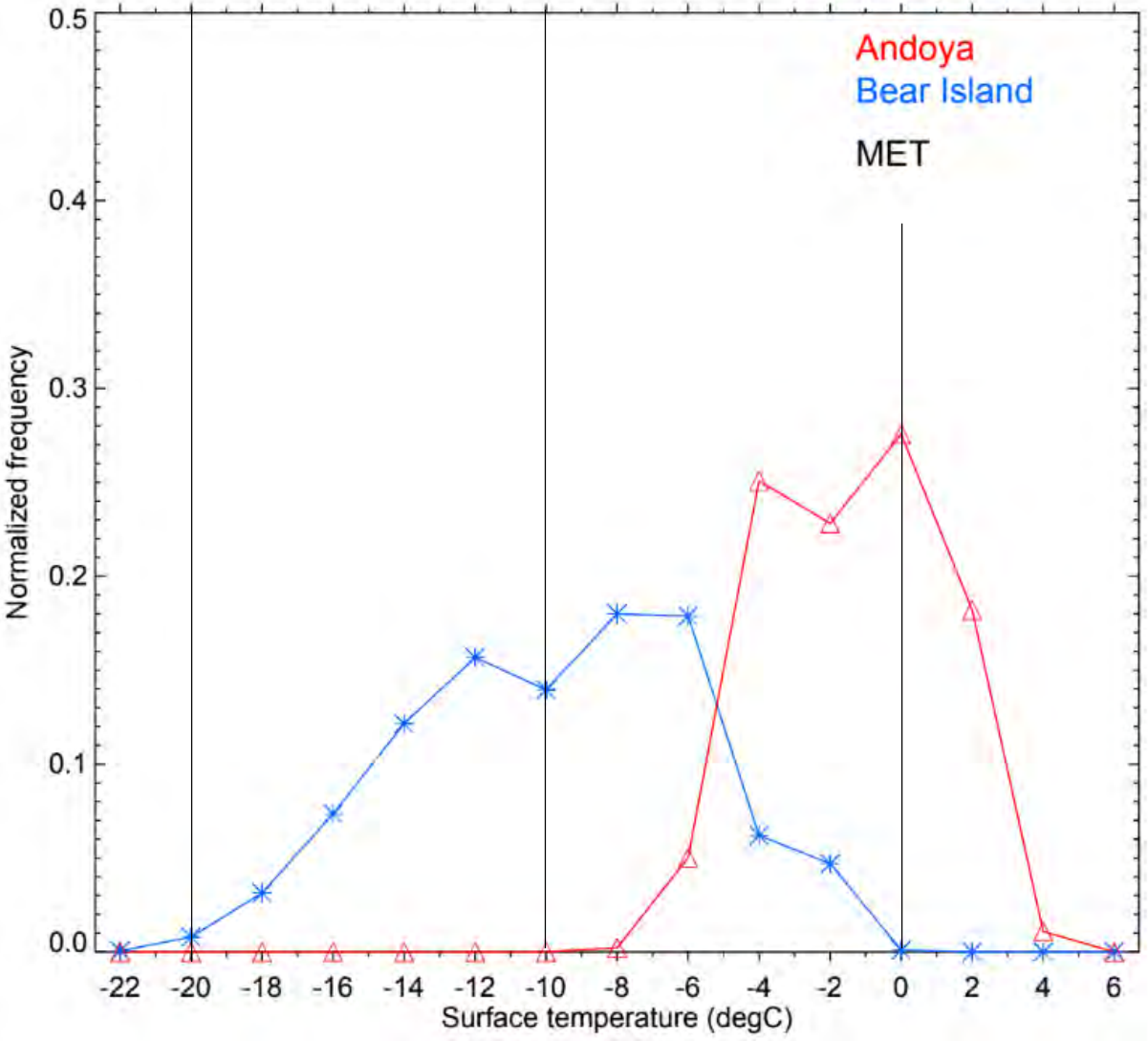




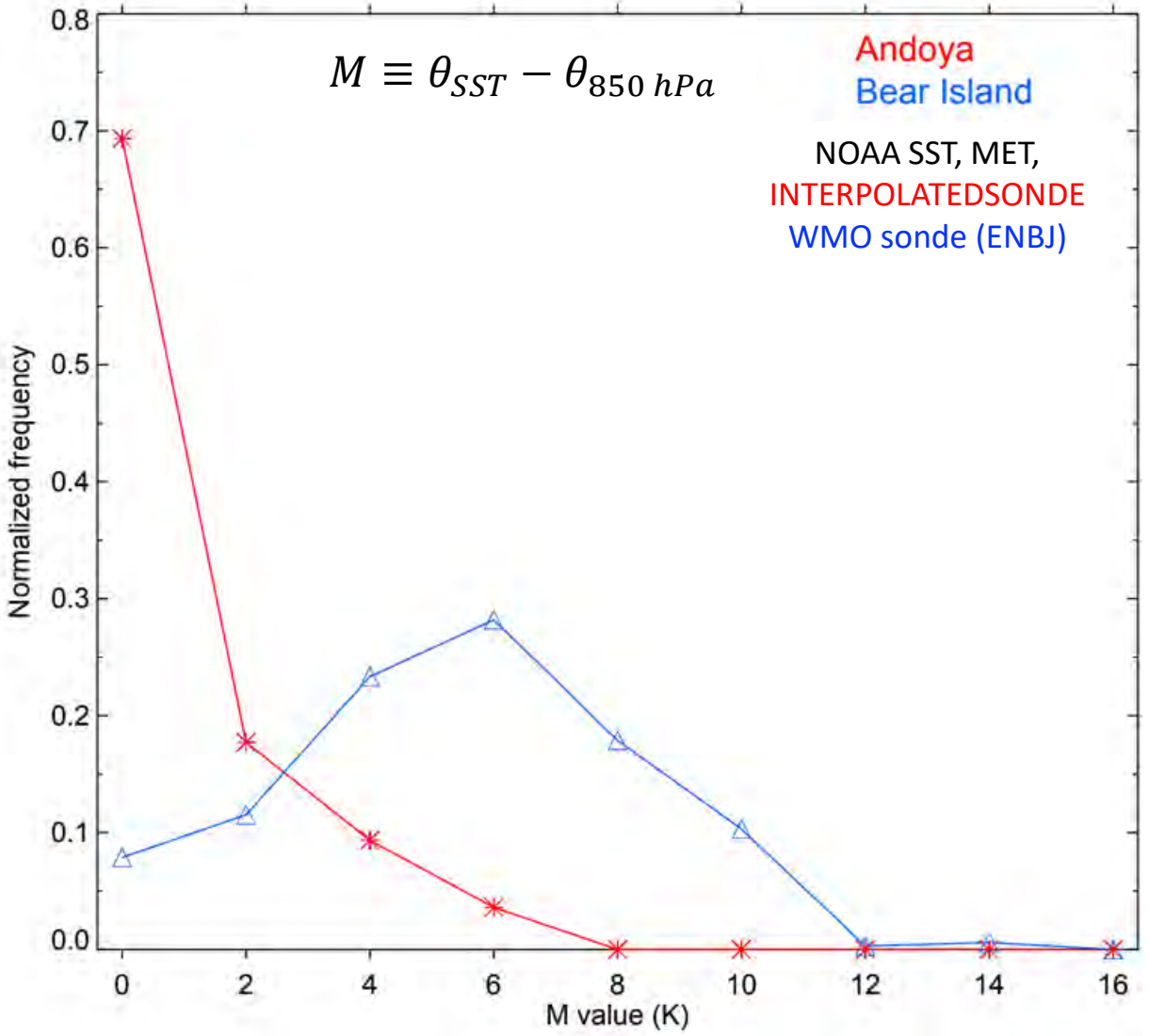
CAO frequency by month (fraction of time)



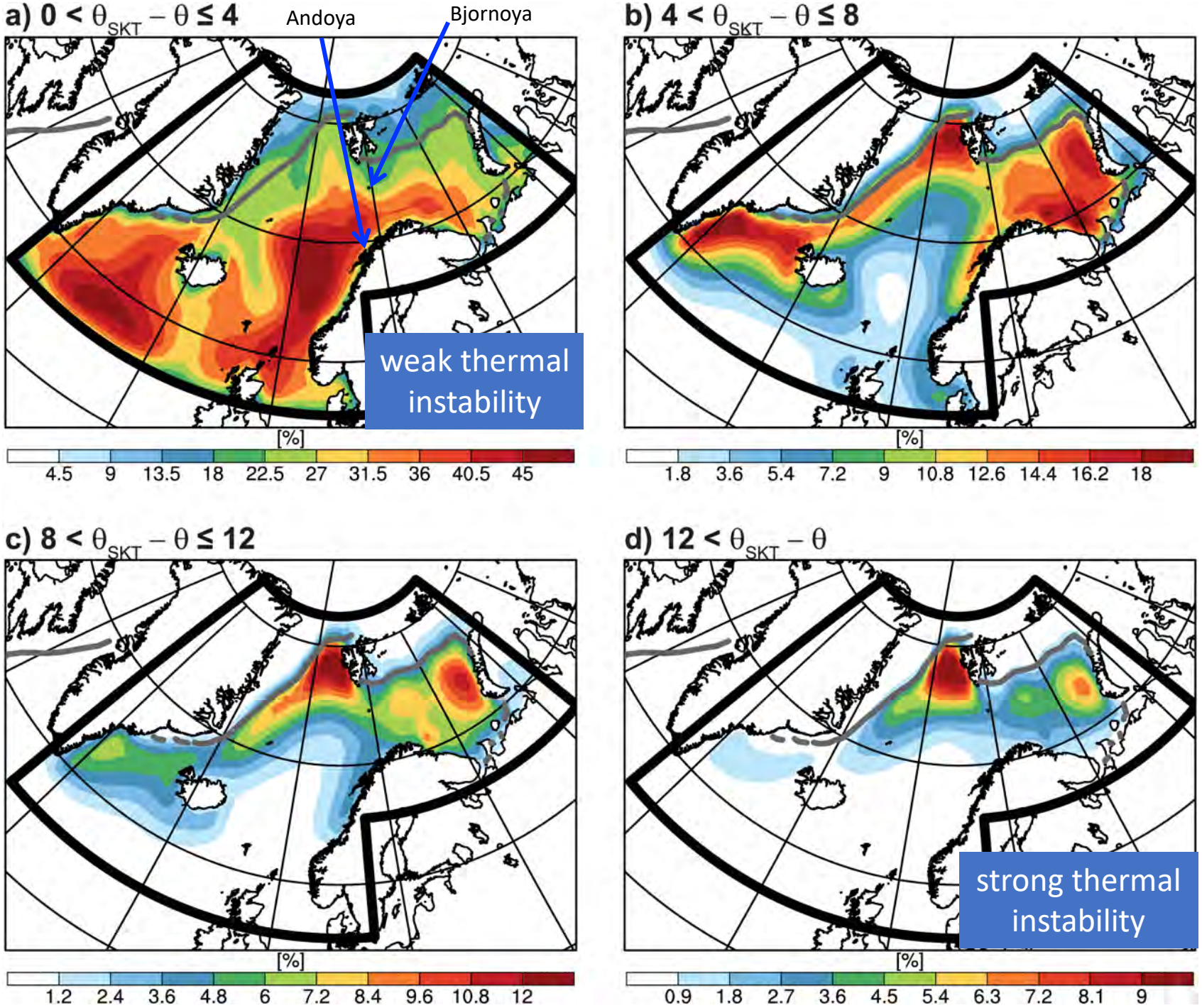
surface temperature during CAOs



BL thermal instability during CAOs

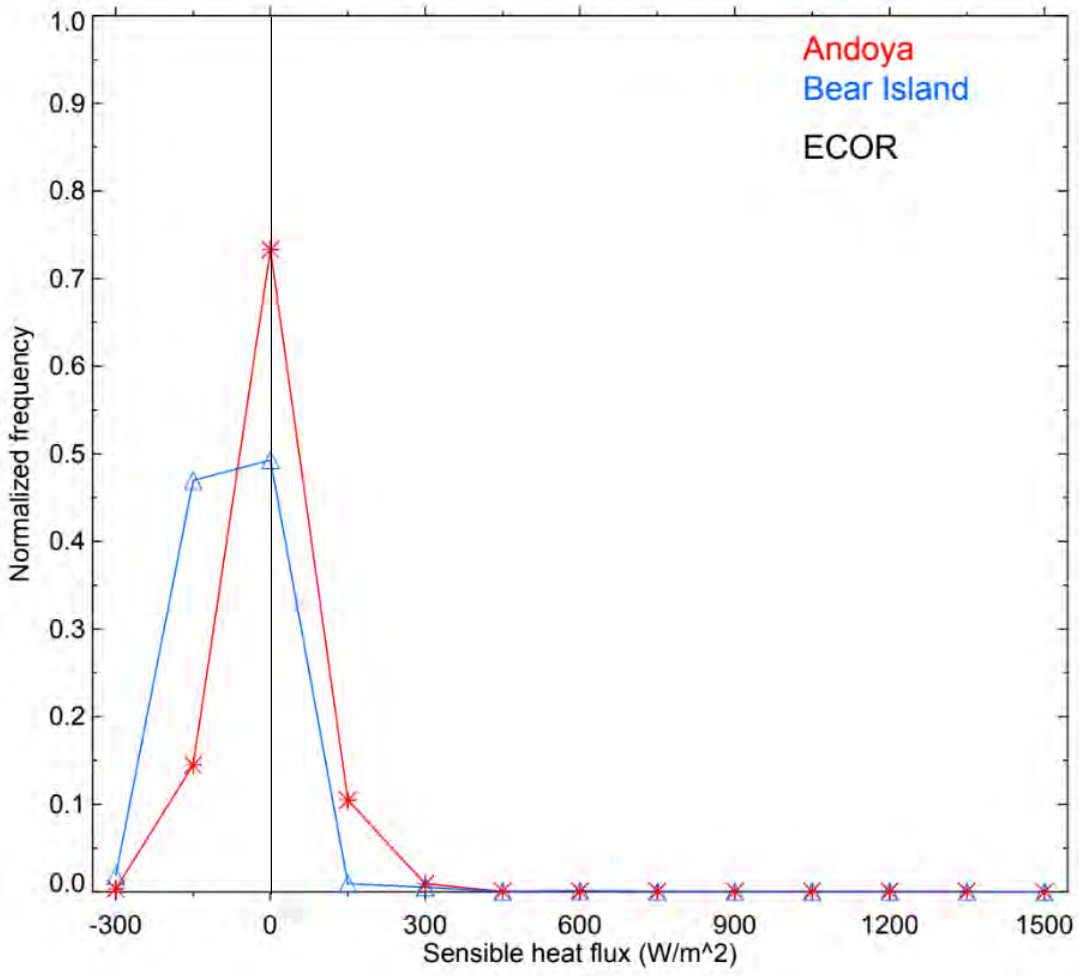


climatological frequency of M values

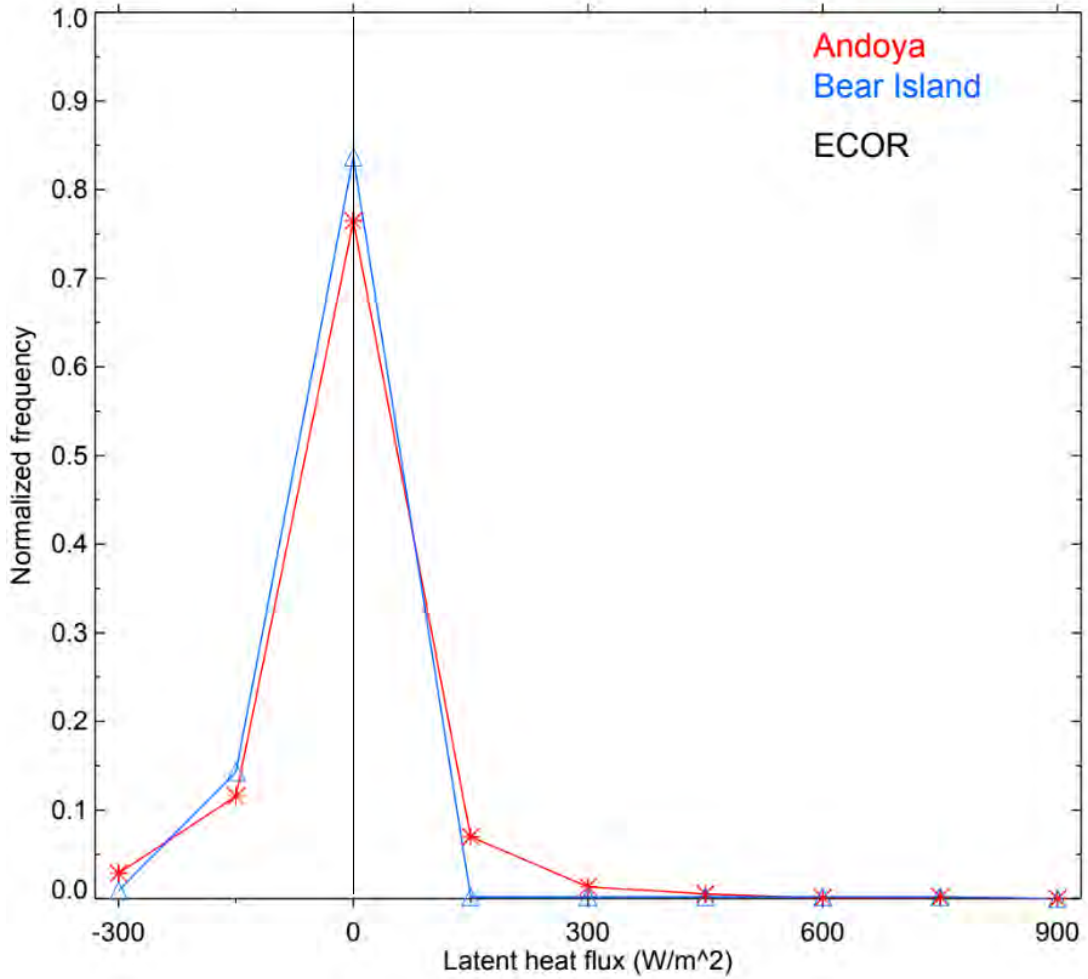


Papritz and Spengler 2017

sensible heat flux during CAOs



latent heat flux during CAOs



expected values in CAOs: 100-600 Wm^{-2} (Brummer et al. 1997; Papritz et al. 2015; Papritz and Spengler 2017)

sensible heat flux during CAOs

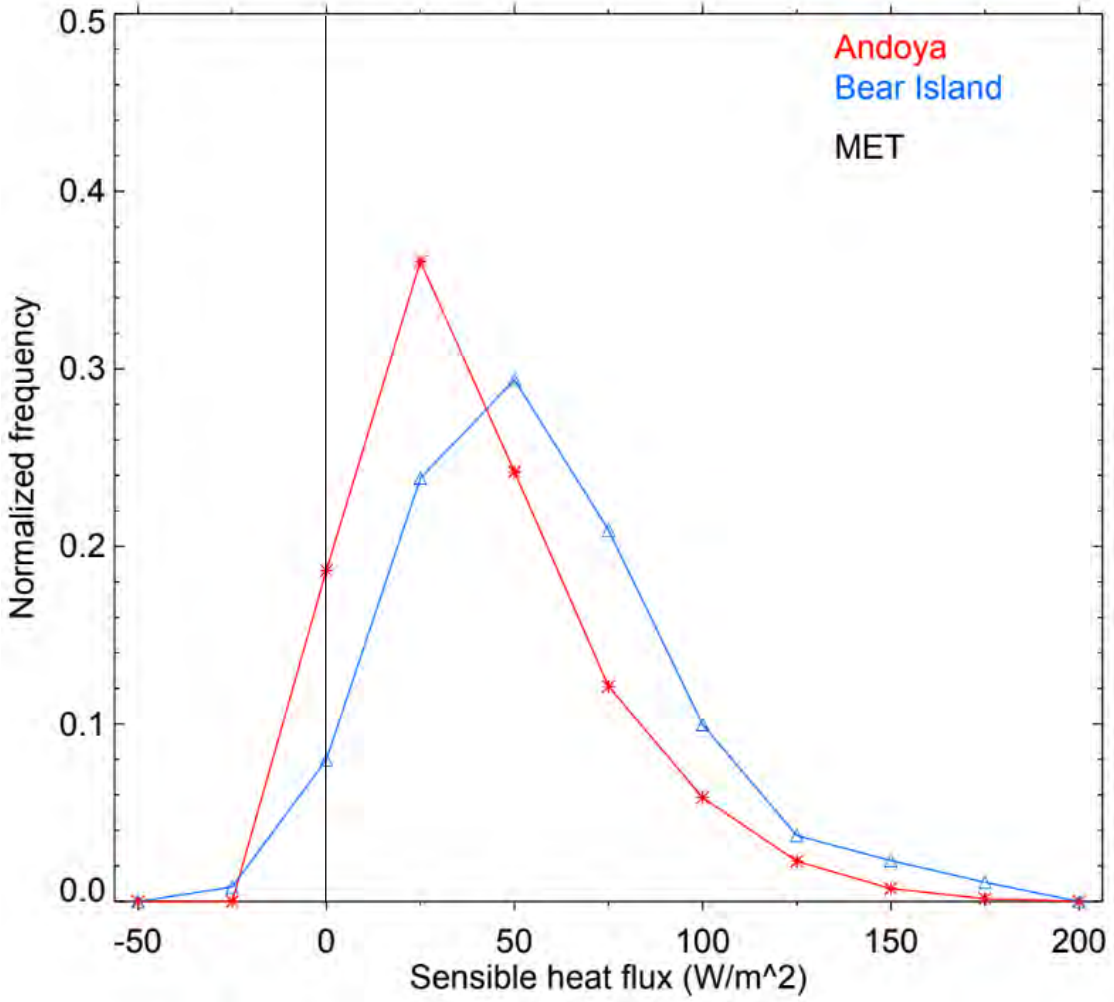
bulk aerodynamic formula estimates

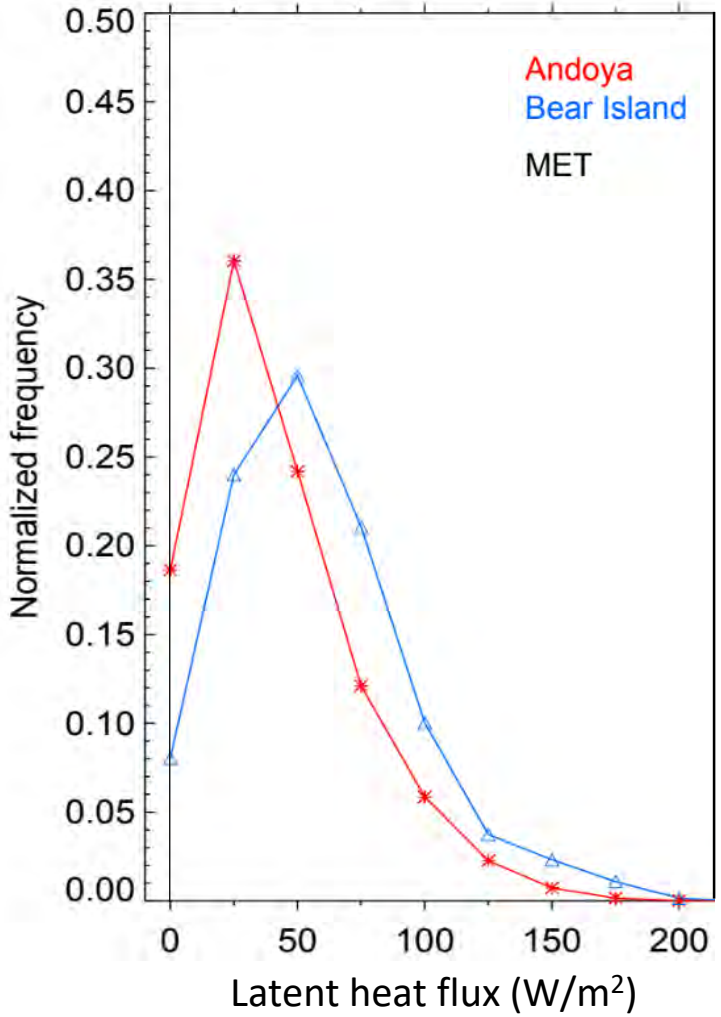
U: 10m wind speed, q: specific humidity

latent heat flux during CAOs

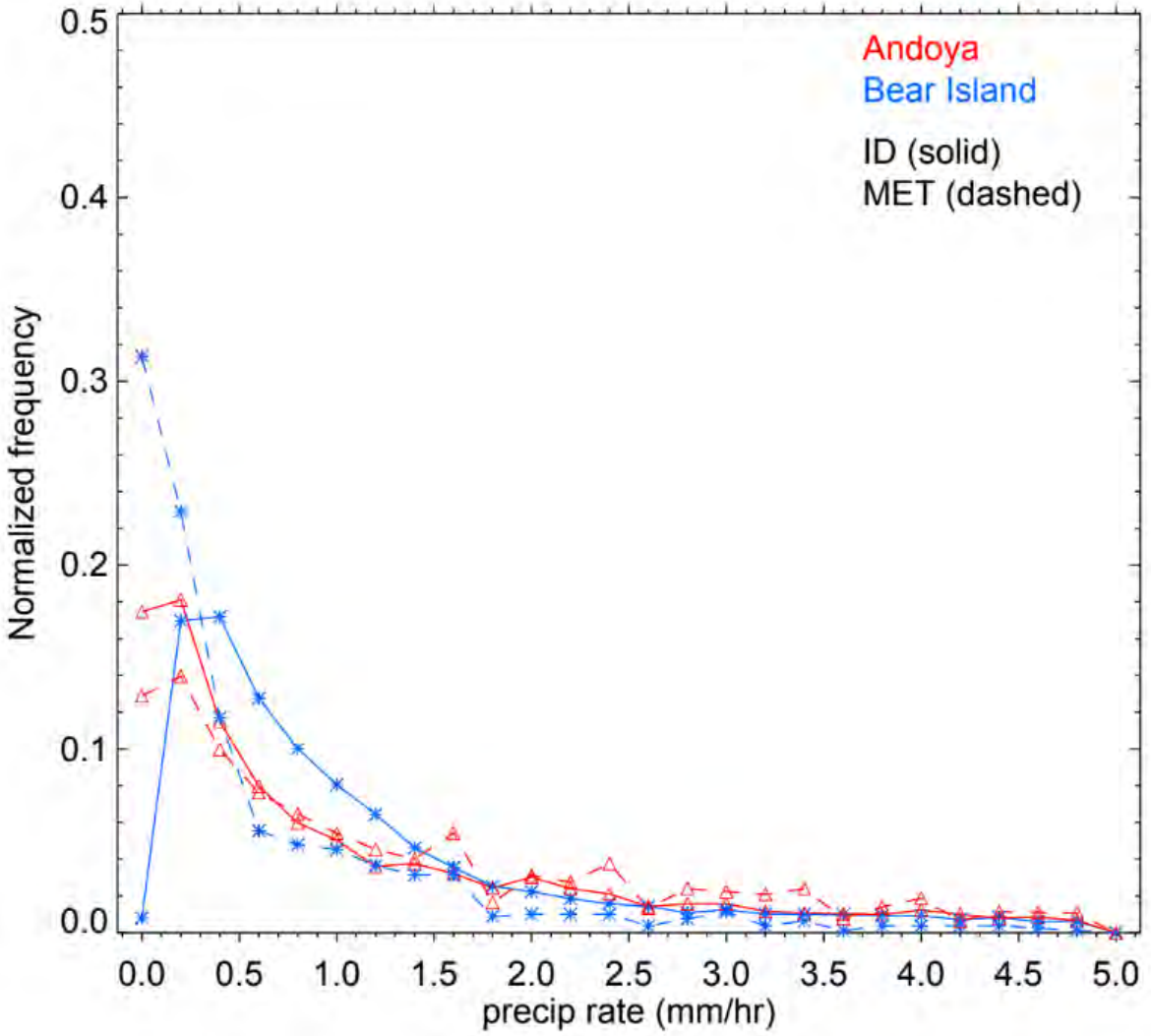
$$SH = \rho C_p C_{SH} U (T_{SST} - T_{2m})$$

$$LH = \rho L_v C_{LH} U (q_{sat,SST} - q_{2m})$$

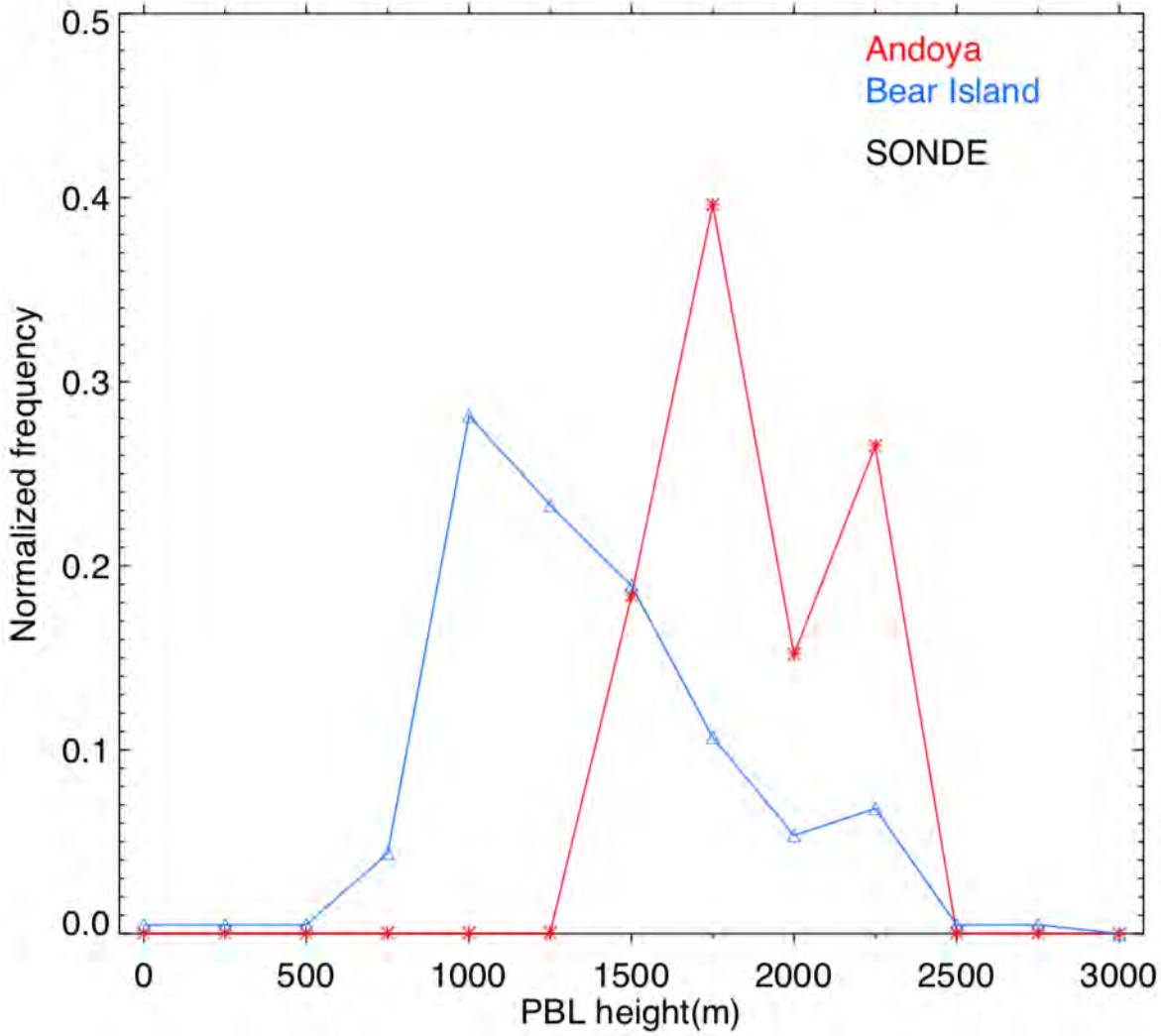




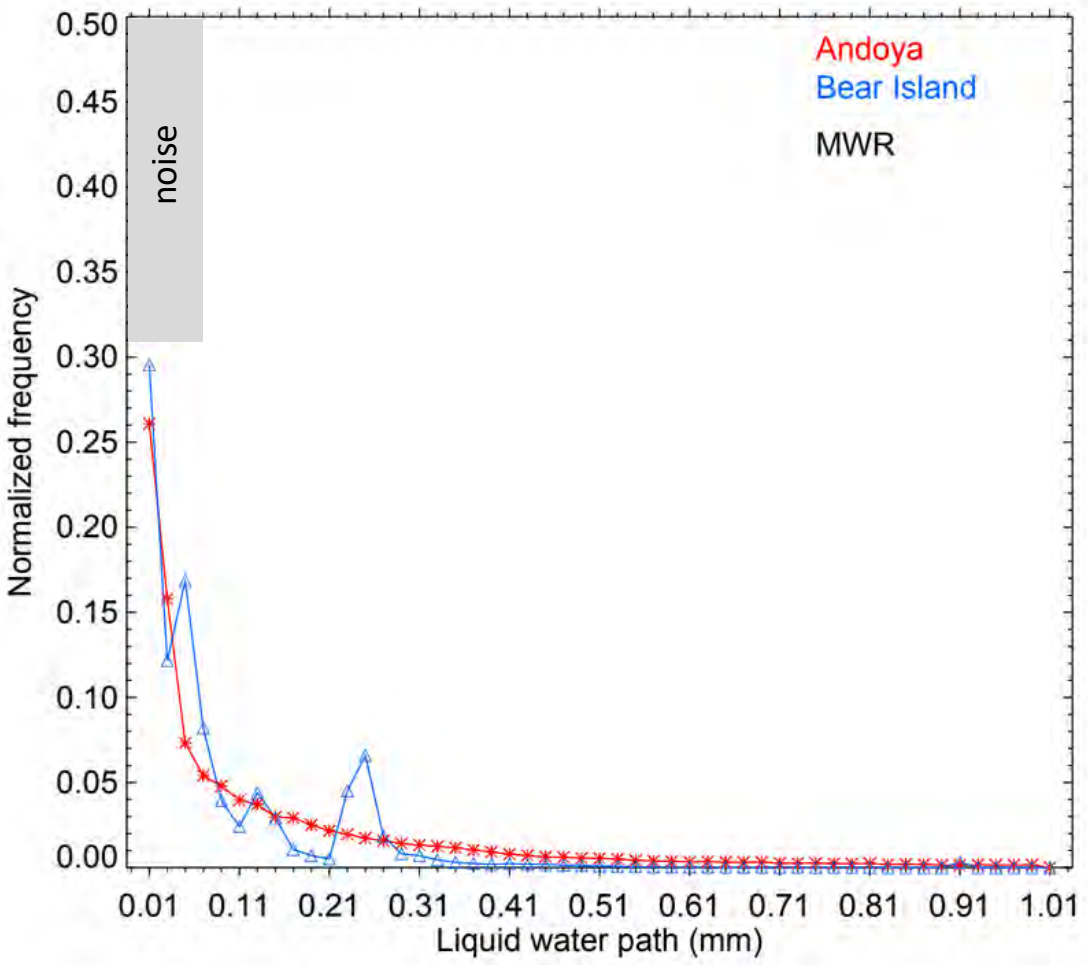
precipitation rate during CAOs



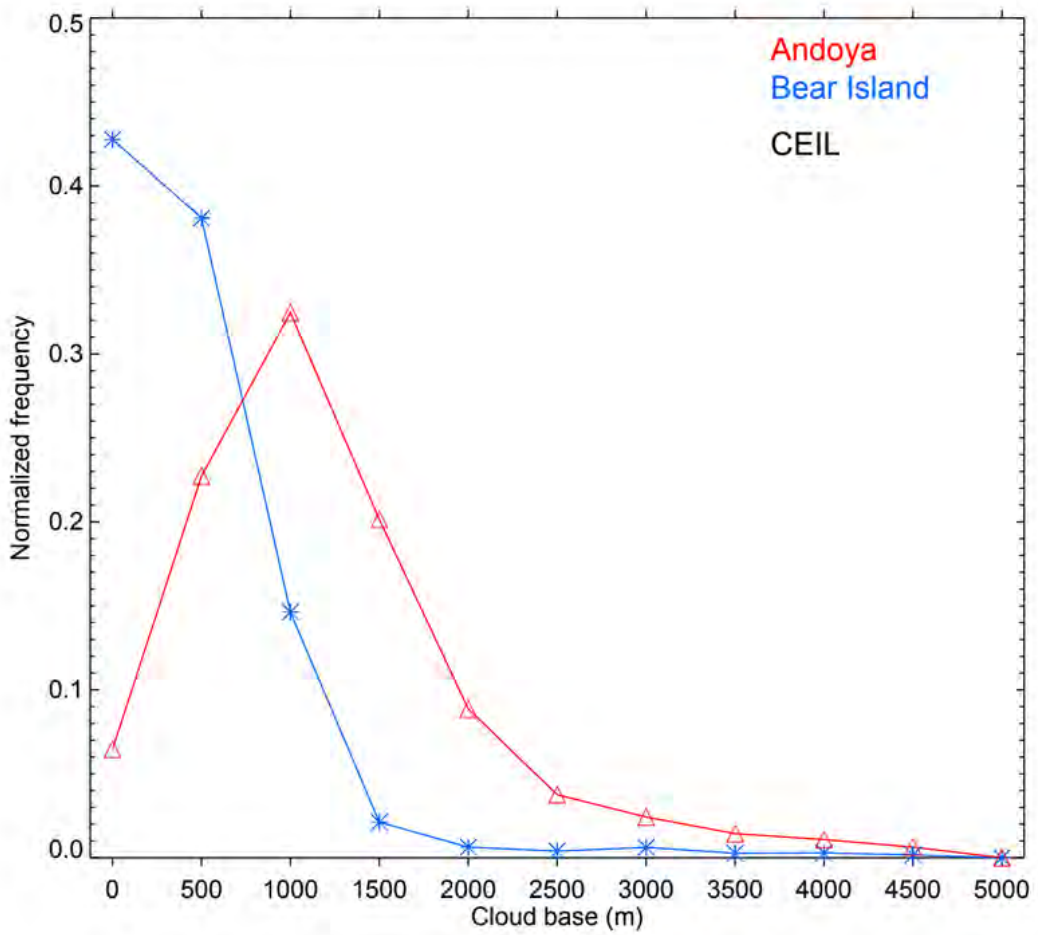
PBL depth during CAOs

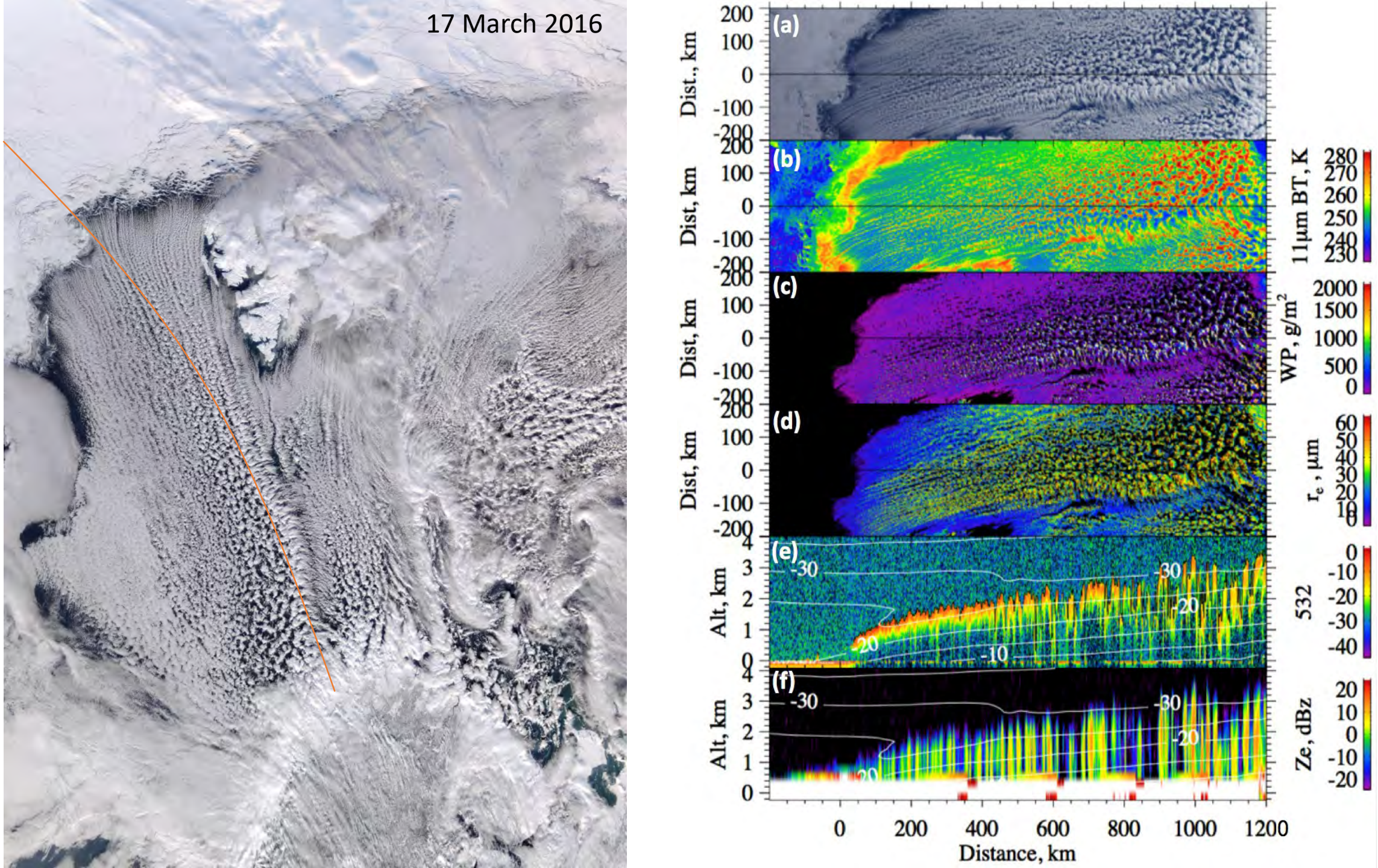


liquid water path during CAOs



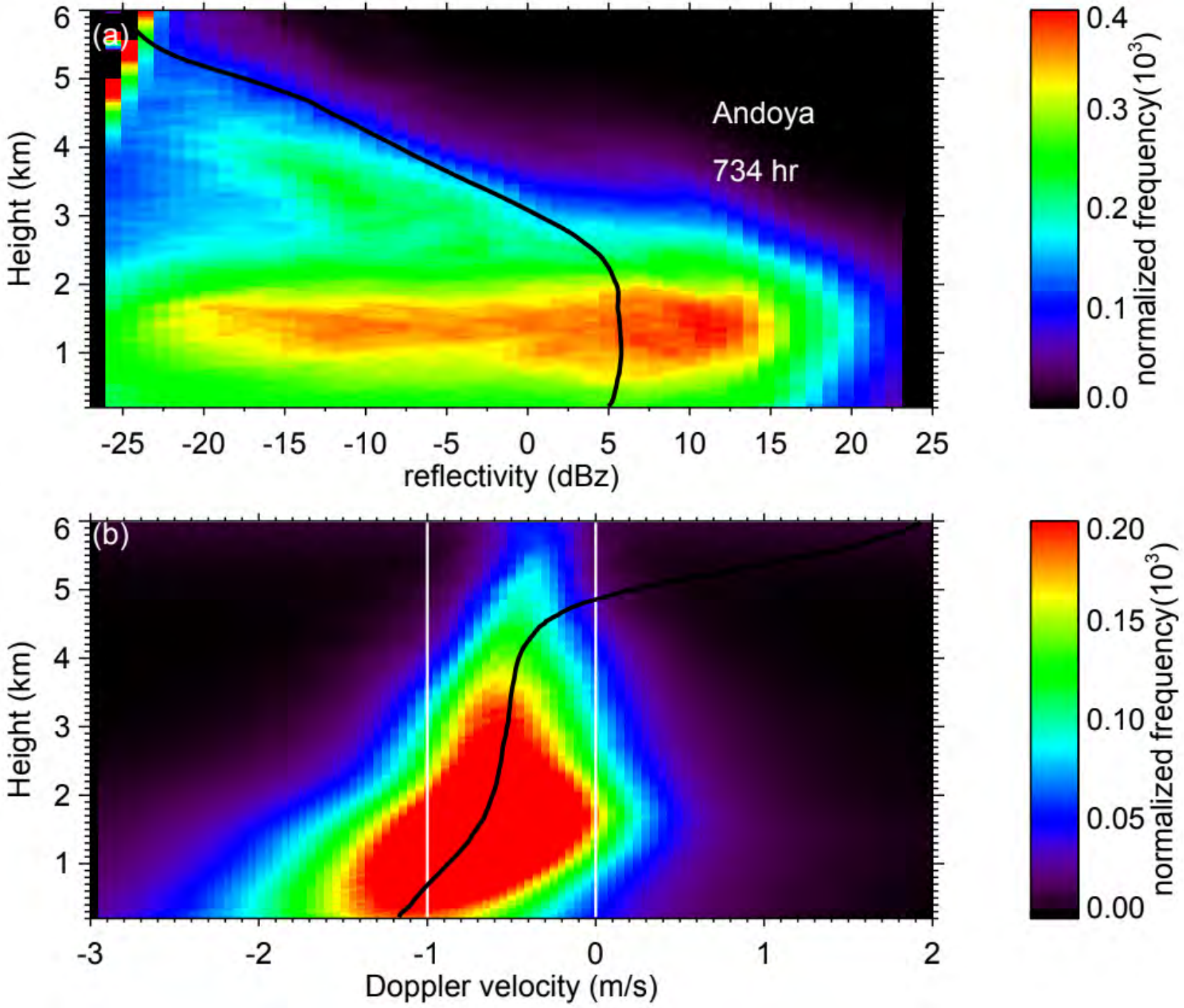
cloud base height during CAOs




17 March 2016
(a)
(b)
(c)
(d)
(e)
(f)
Dist., km
Dist, km
Alt, km
Distance, km
11μm BT, K
WP, g/m²
r_e, μm
532
Ze, dBz
-30
-20
-10

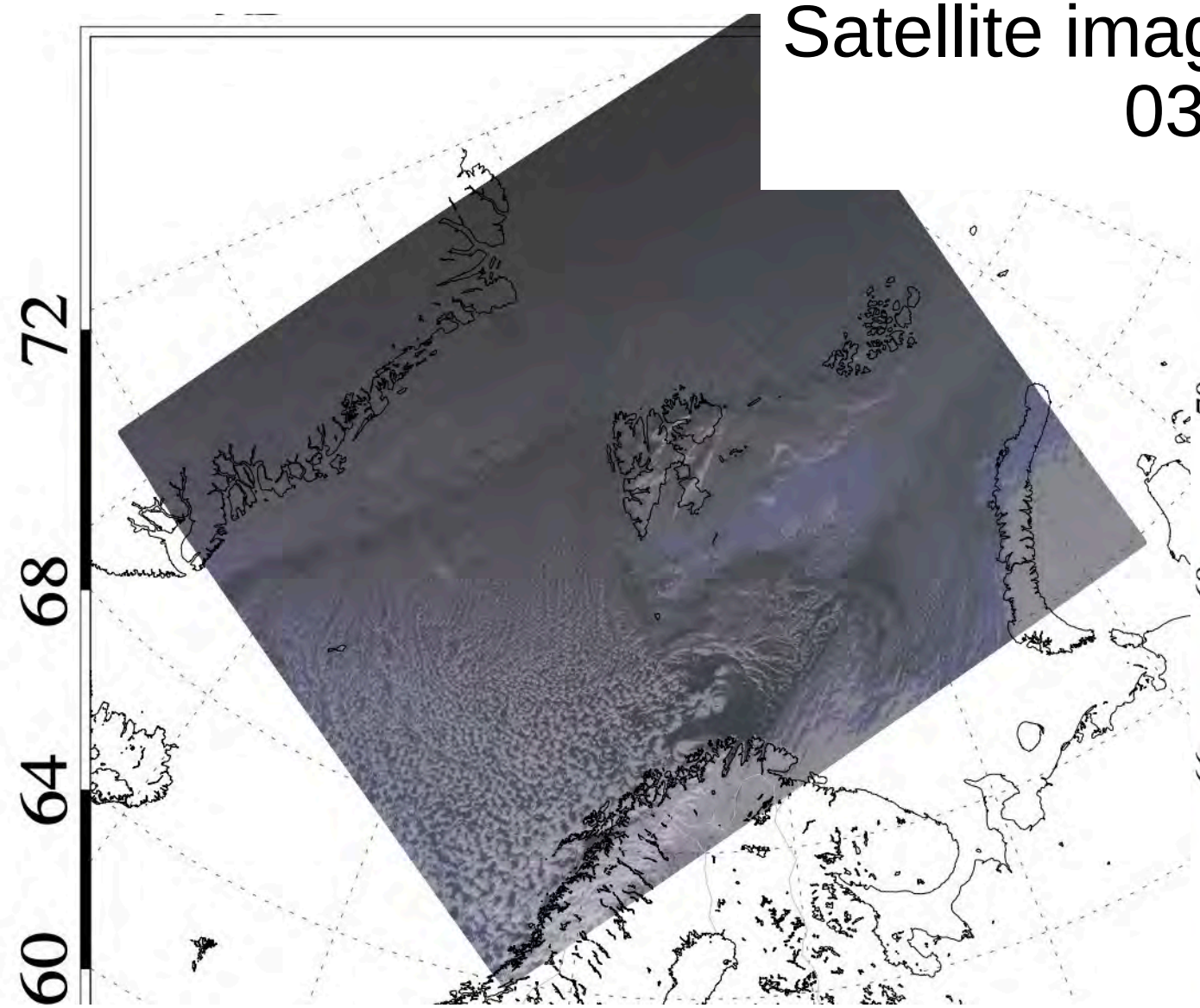
Cloud vertical structure during CAOs

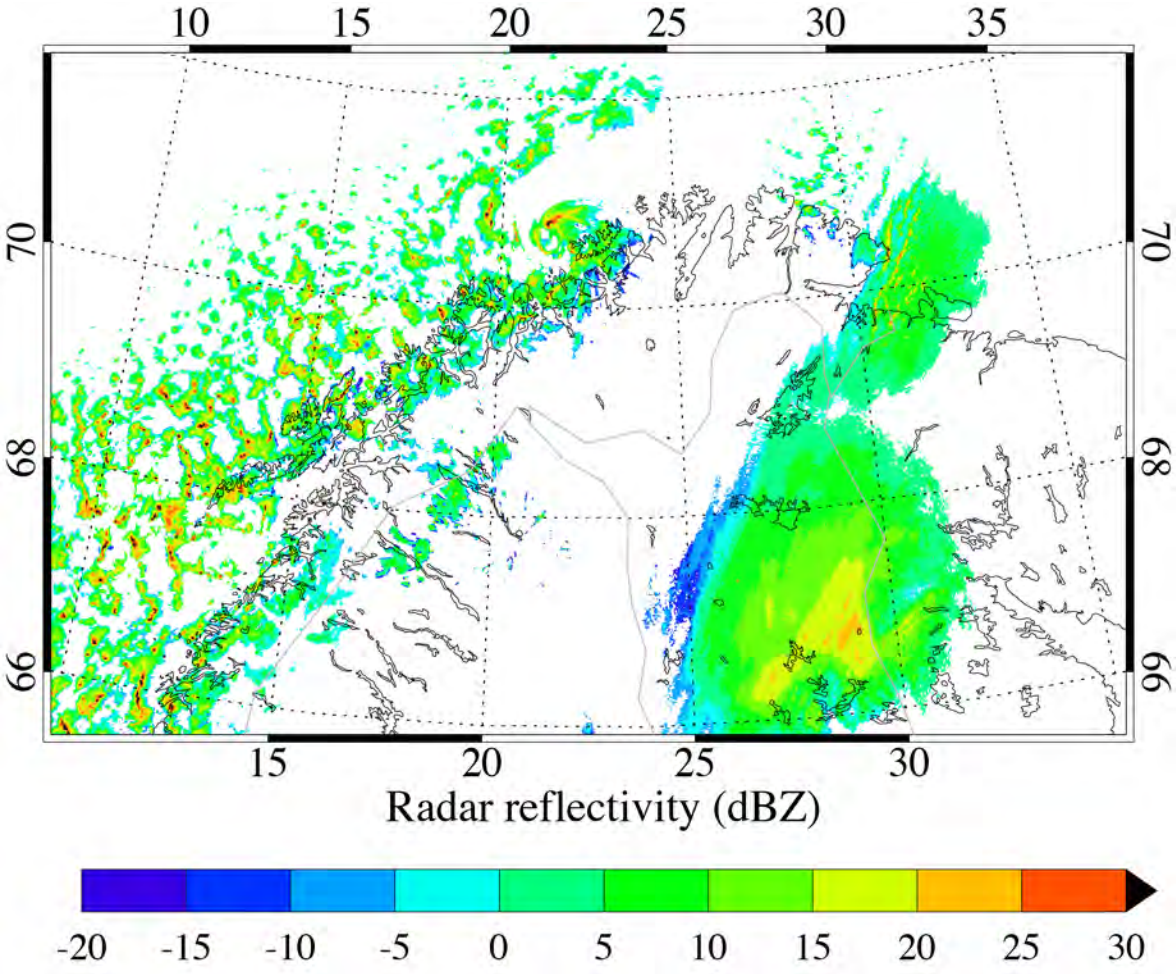
KAZR



Some good CAO cases

Satellite imagery & radar mosaic reflectivity
03/13/2020 0950 UTC

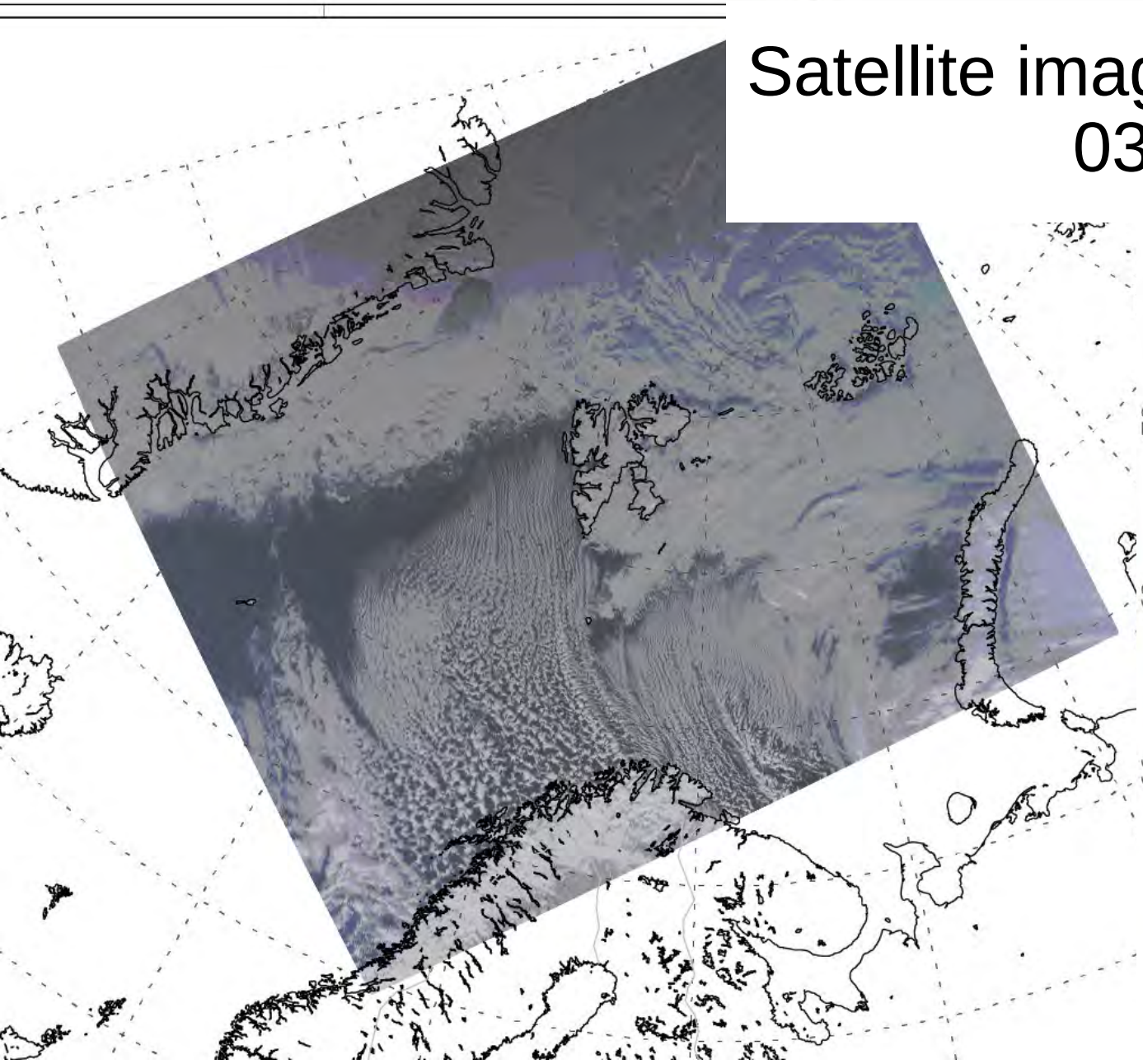




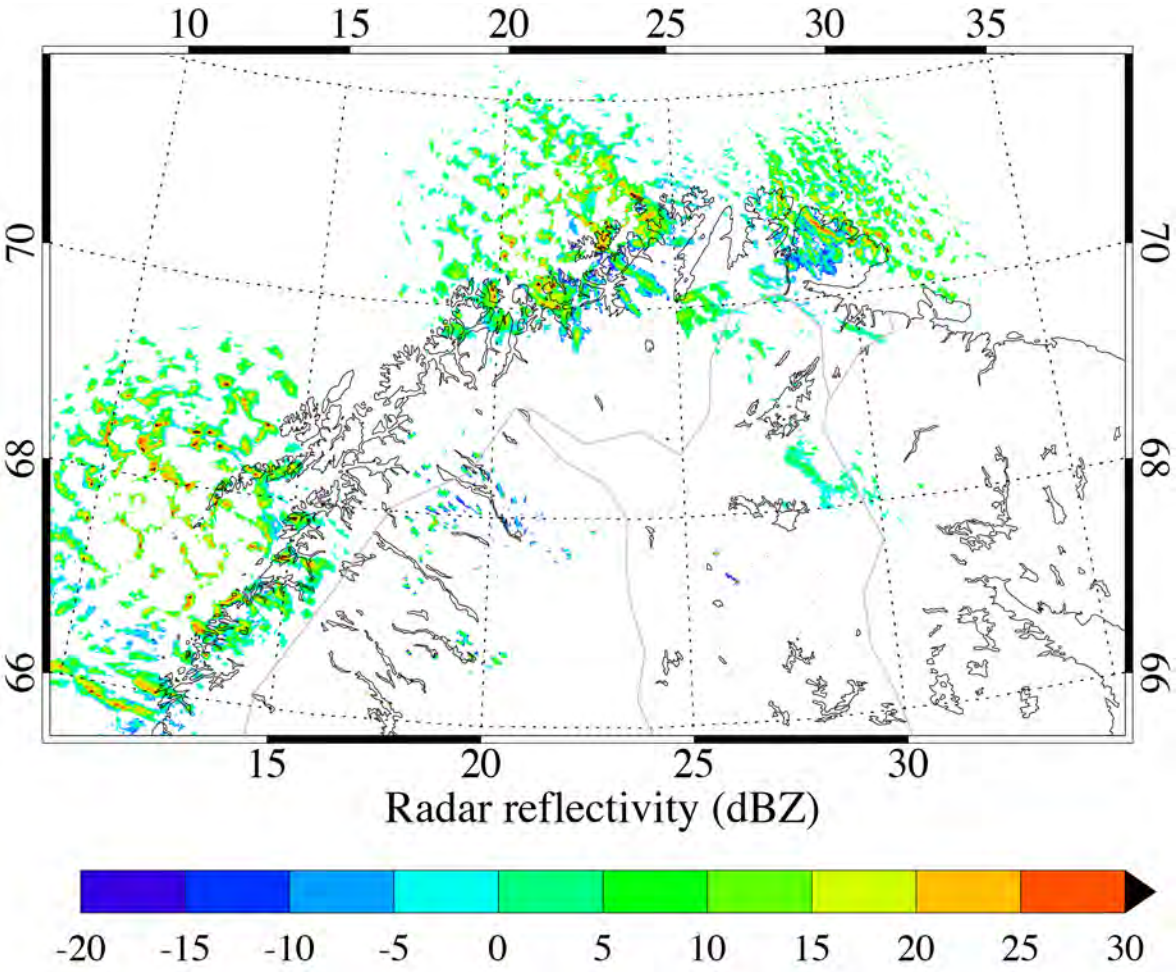
MODIS image
(data source: https://earthobservatory.nasa.gov/)

MET Norway radar mosaic
(data source: https://thredds.met.no)

Satellite imagery & radar mosaic reflectivity 03/29/2020 0950 UTC



MODIS image
(data source: https://earthobservatory.nasa.gov/)



MET Norway radar mosaic
(data source: https://thredds.met.no)