Universität Bremen

Investigation of weather conditions and tropospheric BrO transport during Bromine Explosion Events in the Arctic and ozone depletion in Ny-Ålesund observed by satellite and ground-based remote sensing

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EGU General Assembly 2022

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Introduction – Bromine Explosion Events

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- Br_2 is released from the cryosphere in a heterogeneous, autocatalytic reaction cycle in polar spring
  - → reacts with Ozone: impact on oxidizing capacity of the troposphere
  - → BEEs often occur in combination with Ozone Depletion Events (ODE)
- Low temperatures and two meteorological conditions favouring Br_2 release (*Jones et al., 2009*):
  1. low wind speed and stable boundary layer
  2. high wind speed with blowing snow and higher boundary layer
- How are BEEs in combination with ODEs formed in Ny-Ålesund?
  - Is O_3 depleted by local Br and/or by in a long range transport over the Arctic Ocean recycled Br?
  - Where are the sources of Br_2 located?
- What are the dominating weather conditions during ODEs?

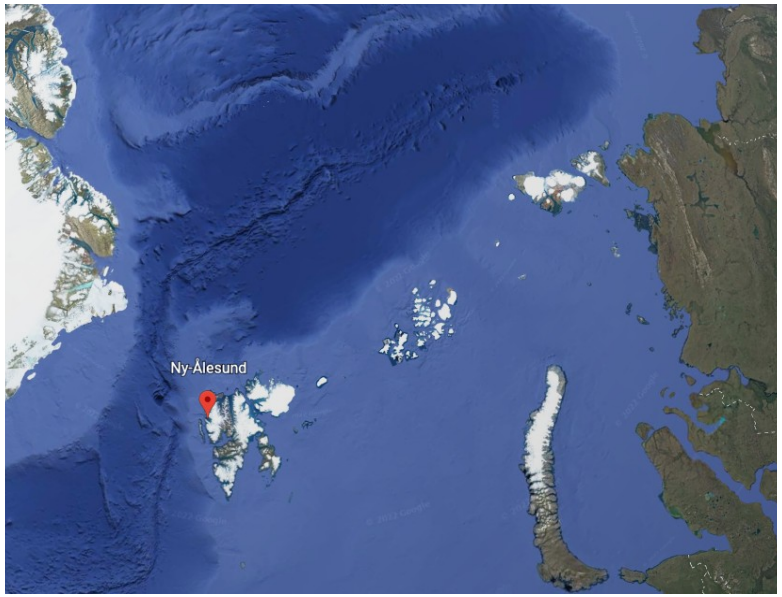

Image: https://earth.google.com

→ **Investigation of ODEs using a long-term ozone sonde data set from Ny-Ålesund and comparison with BrO satellite/MAX-DOAS measurements and weather conditions**

Introduction – Model and Data

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- **WRF – Weather Research & Forecasting model**
  - Mesoscale numerical weather prediction model
  - Input data: NCEP (National Centers for Environmental Prediction) FNL Global analysis data on a 1° x 1° grid prepared for every 6 hours
  - Purpose: Investigation of the meteorological conditions of BEE case studies
- **FLEXPART-WRF – FLEXible PARTicle dispersion model coupled with WRF**
  - Lagrangian transport and dispersion model suitable for the simulation of a large range of atmospheric transport processes
  - Input data: WRF output data, BrO retrieved from MAX-DOAS BrO profiles
  - Purpose: Tracking the BrO plume and its altitude during a BEE
- **MAX-DOAS BrO profiles and O_3-sonde measurements from Ny-Ålesund**
- **TROPOMI S5P BrO data**

Image: https://earth.google.com

Composite Analysis – Setup

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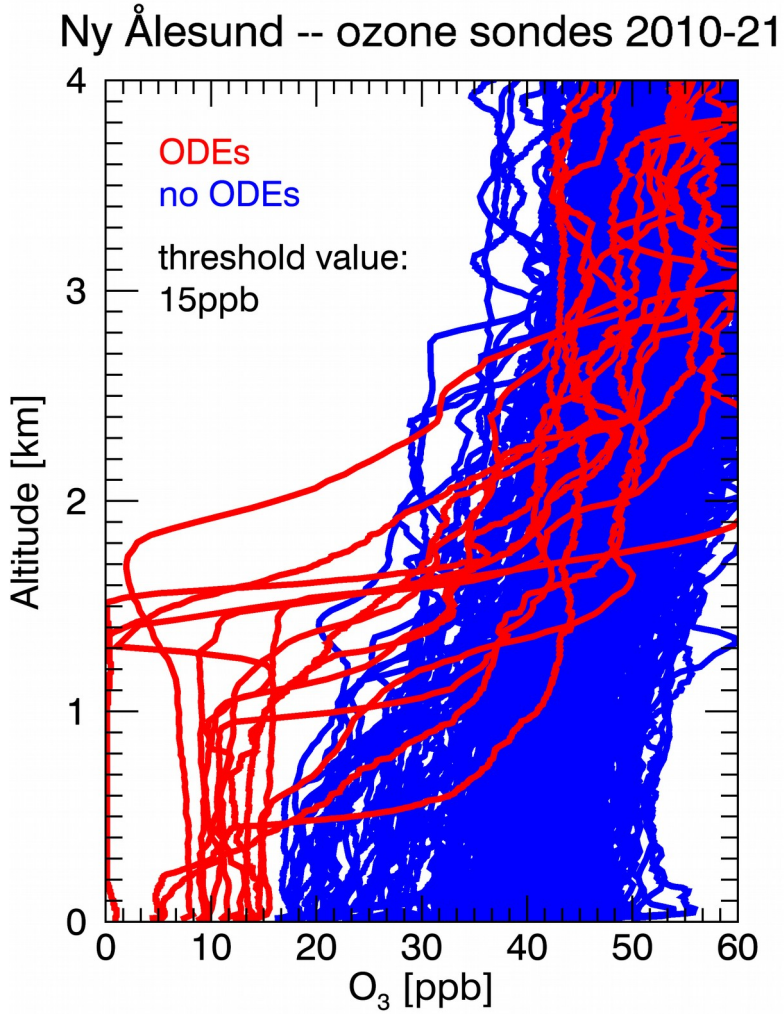
- Analysis of ozone sonde measurements in Ny-Ålesund between March – May 2010-21
- Measurements with O_3 values **< 15 ppb** are considered as ODE
- applied data sets:
  - weather conditions: NCEP FNL (Final) Operational Global Analysis data (from 2010-21)
    - Grid resolution: 1° x 1° grid
    - Time resolution: 6h
  - MAX-DOAS BrO profiles (from 2010-21)
  - TROPOMI BrO retrievals (**from 2019-21**)
- Weather/BrO anomalies are investigated by subtracting the averaged weather/BrO values at non-ODEs days from averaged values during ODEs
- The following 5 slides show the development of BrO/weather conditions over time from 2 days before to 2 days after the ODEs



Ozone data: P. von der Gathen (AWI), www-air.larc.nasa.gov/missions/ndacc

Composite Analysis – Trop. BrO VCD 2019-21 Anomaly

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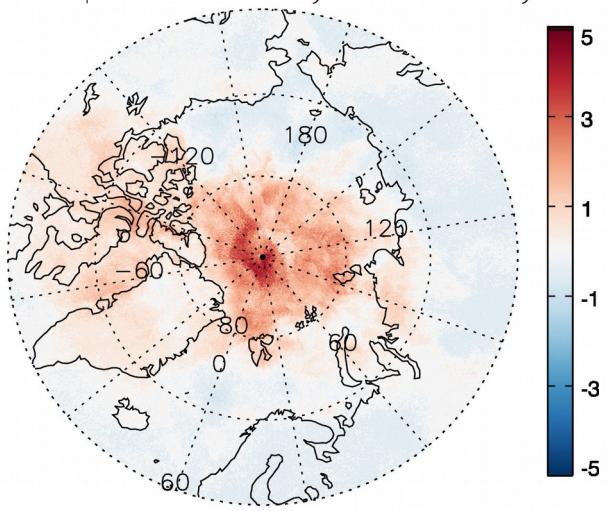
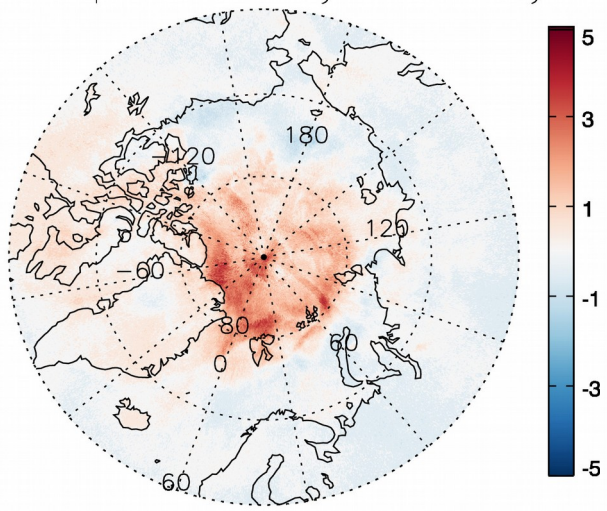
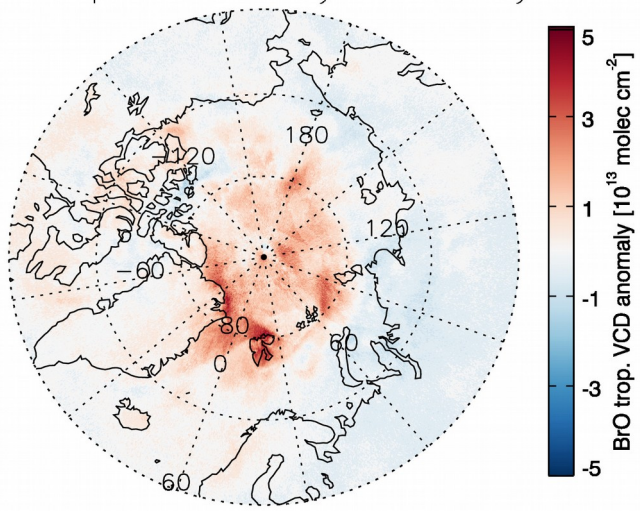
BrO trop. VCD anomaly minus 2 days



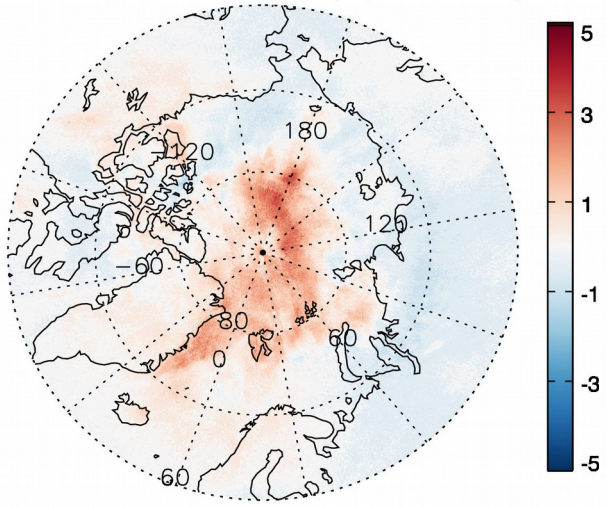
BrO trop. VCD anomaly minus 1 day



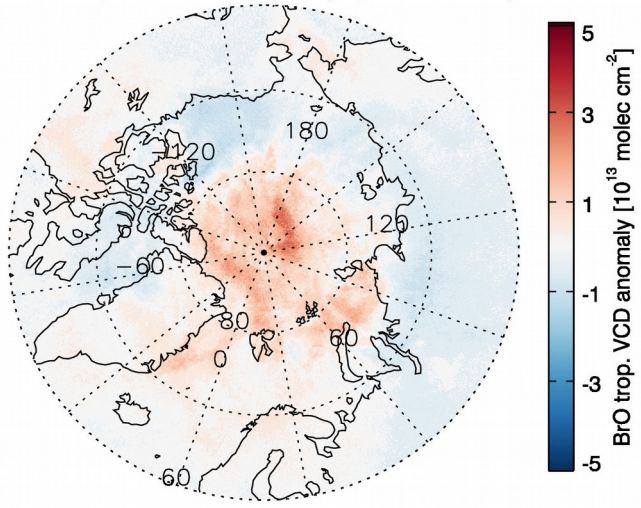
BrO trop. VCD anomaly on ODE days



BrO trop. VCD anomaly plus 1 day



BrO trop. VCD anomaly plus 2 days



Composite Analysis – Mean Sea Level Pressure 2010-21 Anomaly

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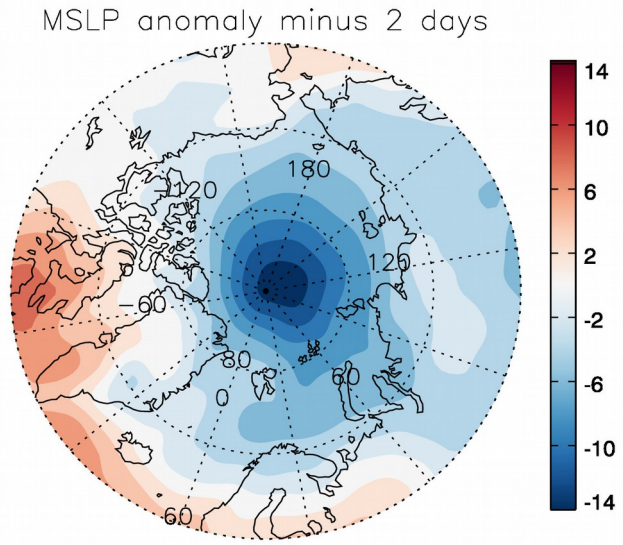

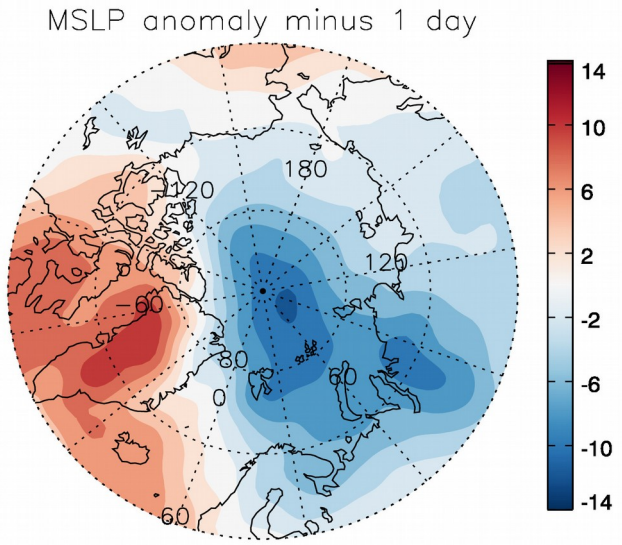

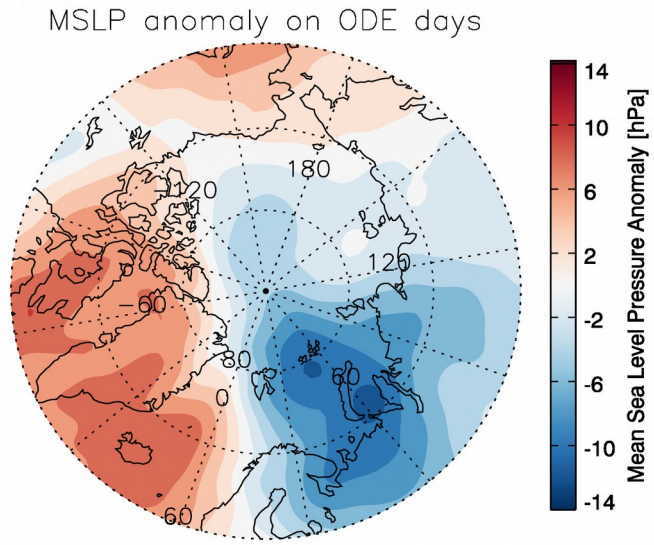

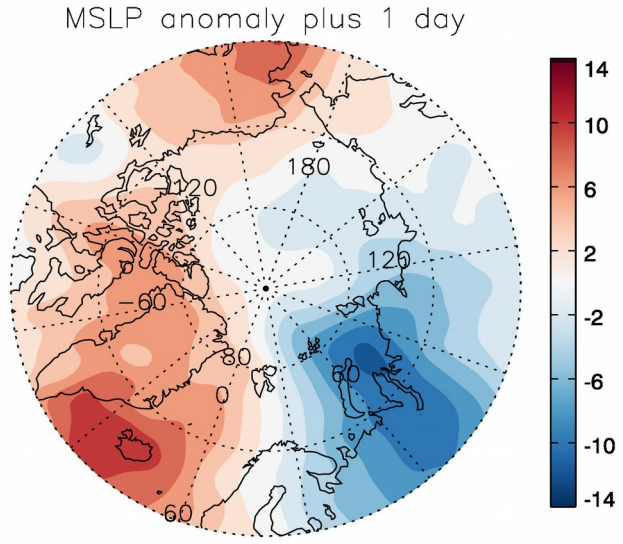

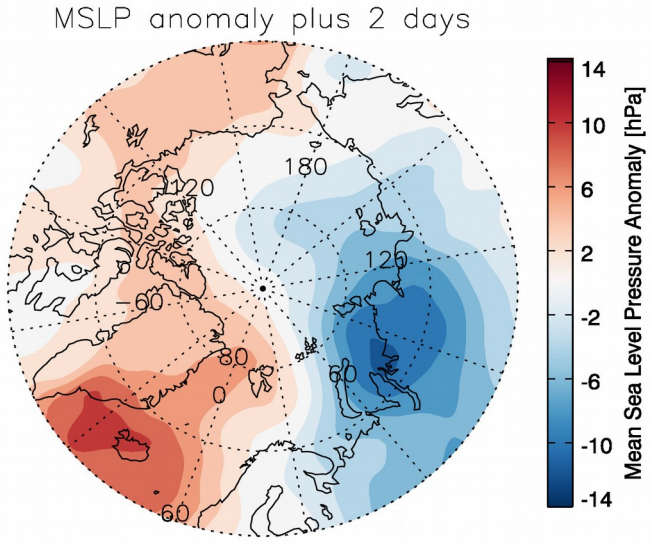

Composite Analysis – Planetary Boundary Layer Height 2010-21 Anomaly

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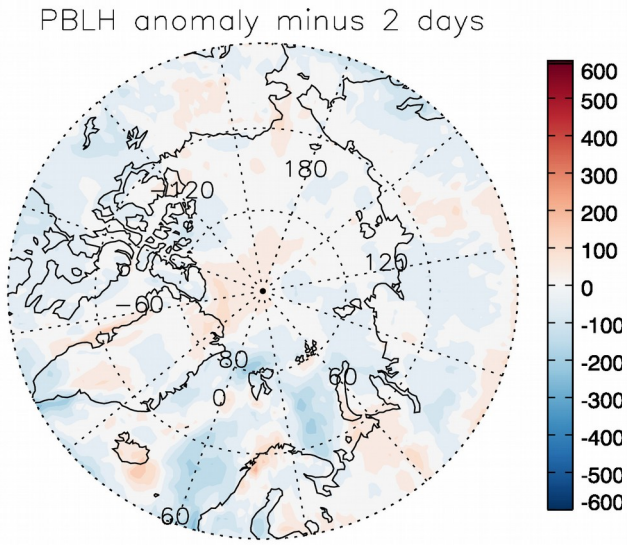

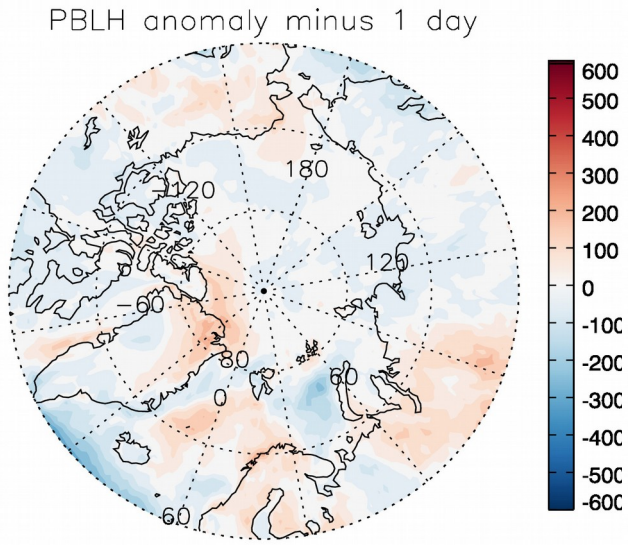

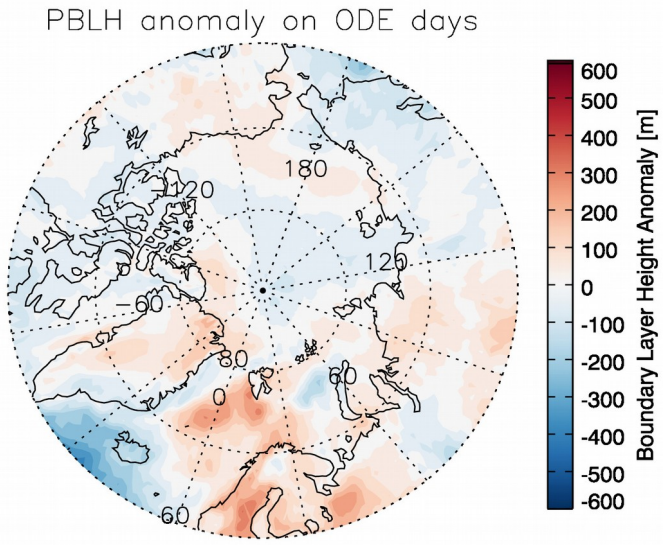

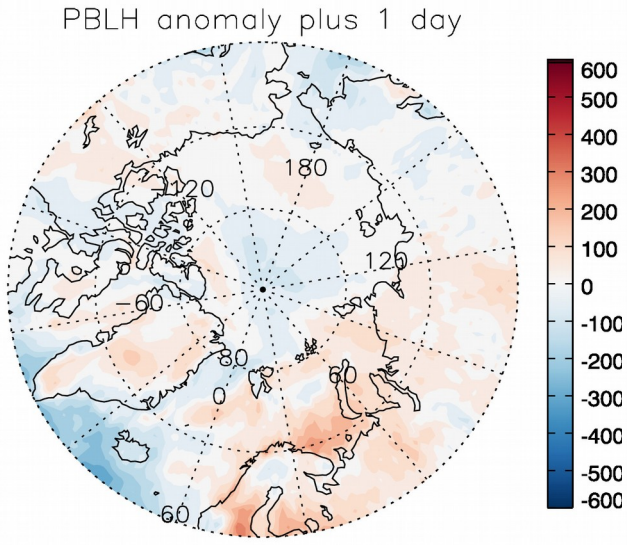

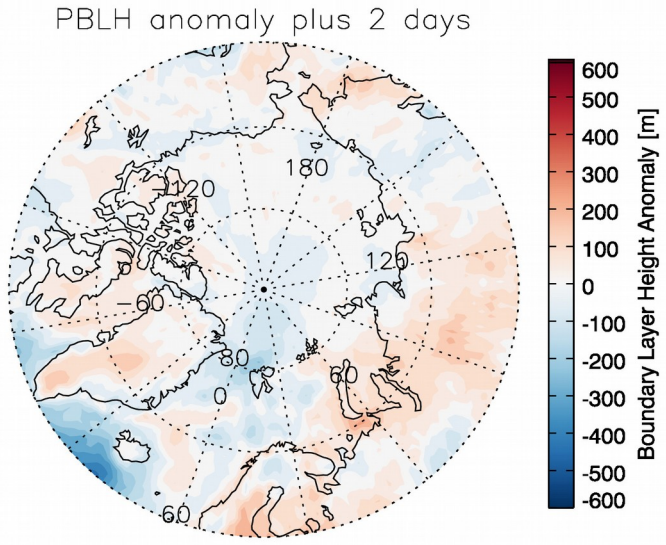

Composite Analysis – Temperature 2010-21 Anomaly

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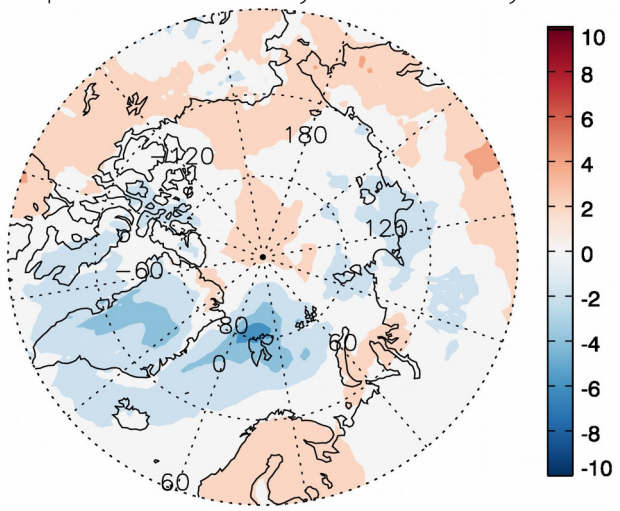
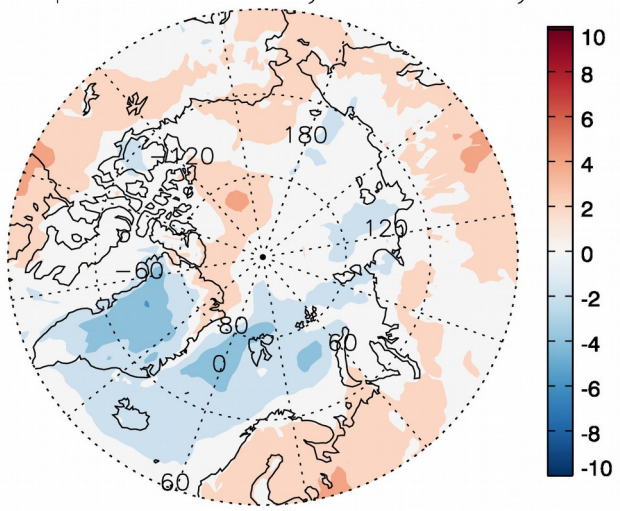
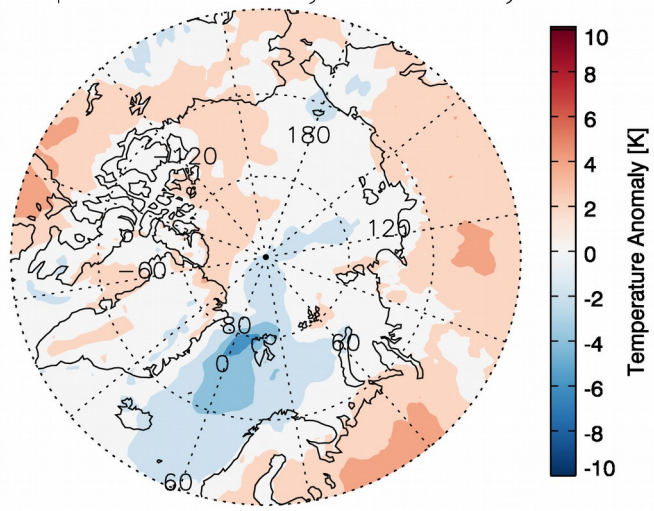
Temperature anomaly minus 2 days



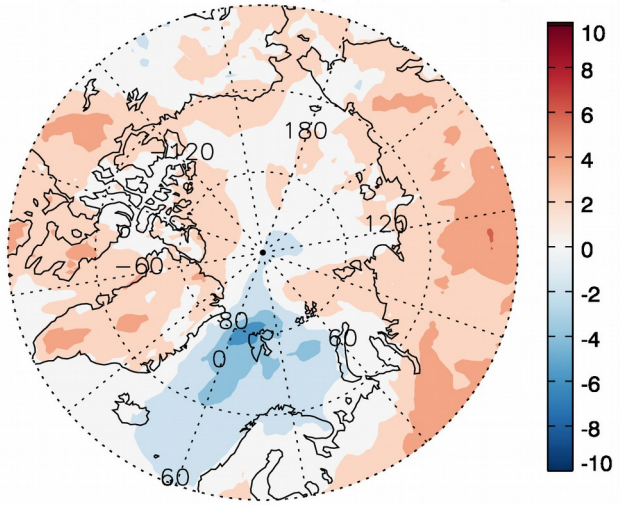
Temperature anomaly minus 1 day



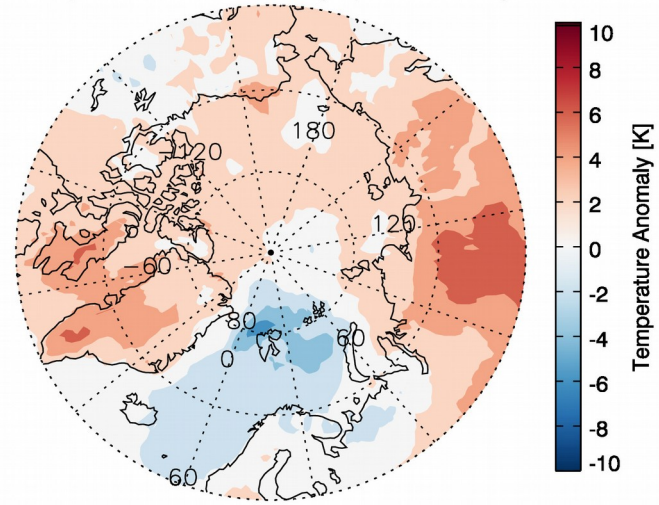
Temperature anomaly on ODE days



Temperature anomaly plus 1 day



Temperature anomaly plus 2 days



Composite Analysis – Wind Speed 2010-21 Anomaly

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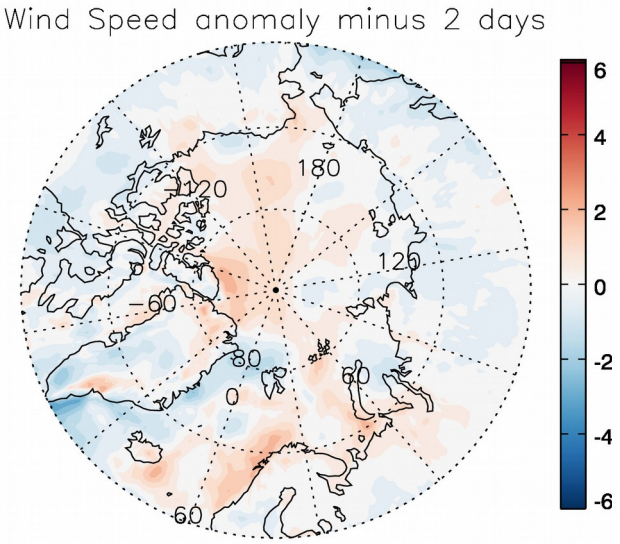

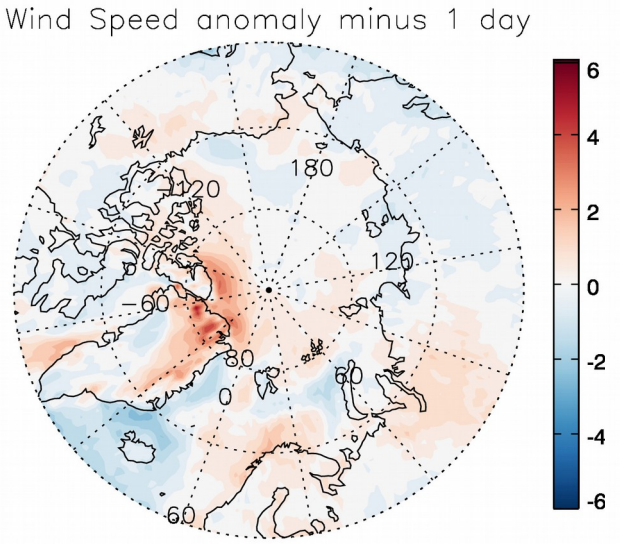

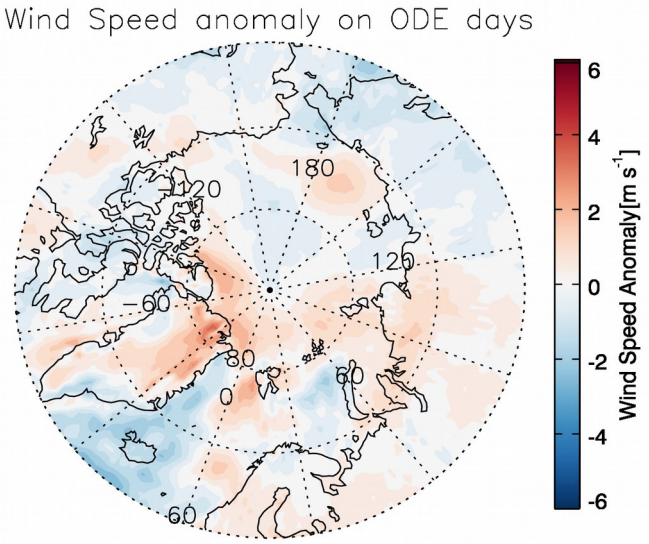

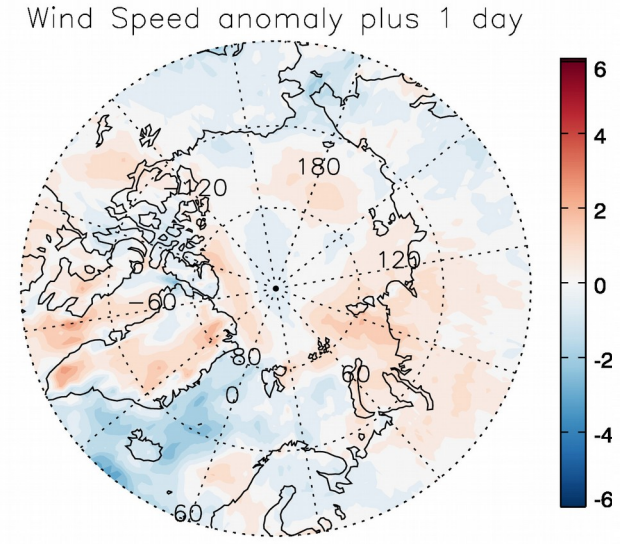

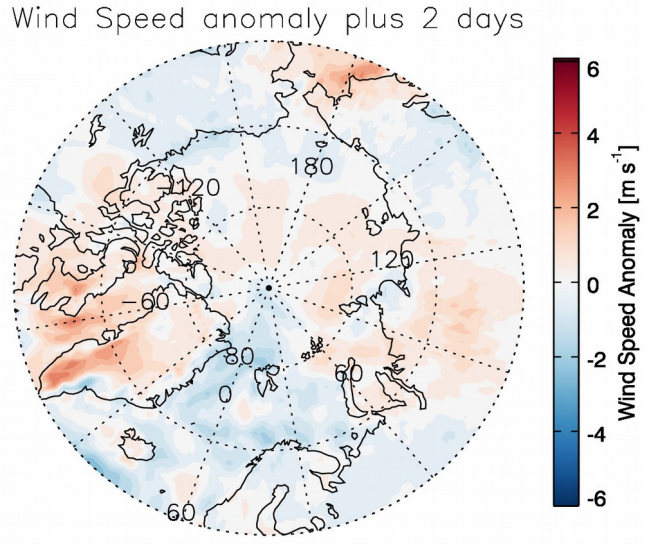

Case Study – April 1-3, 2020

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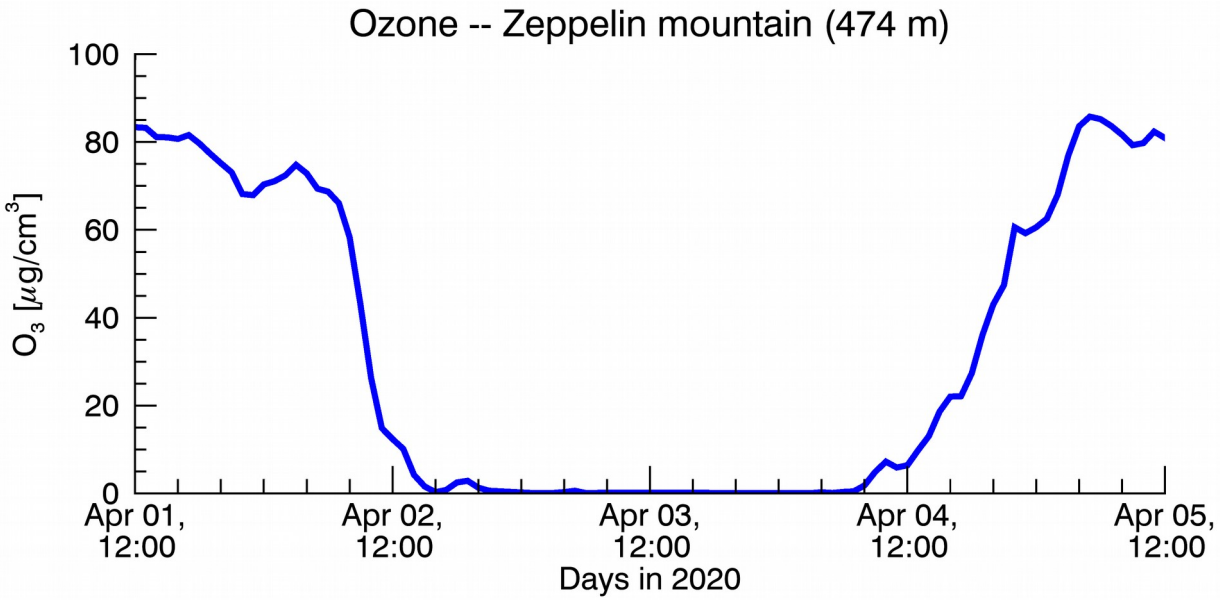
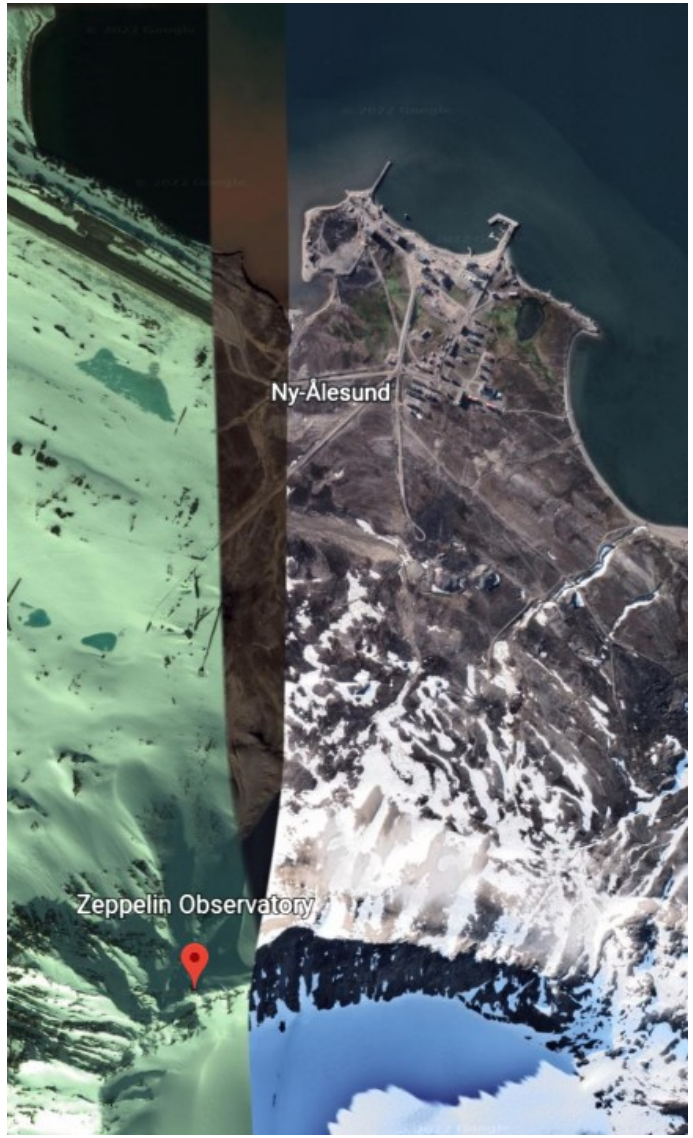
An ODE/BEE in early April 2020 has been studied, showing ozone below detection limit and high BrO values for almost 3 consecutive days in combination with a low pressure system from north-east





Ozone data: NILU, http://ebas-data.nilu.no/Pages/DataSetList.aspx?key=06AC2975478C4A6B9048C34919FFC18B
Image (left):https://earth.google.com

Case Study – April 1, 2020

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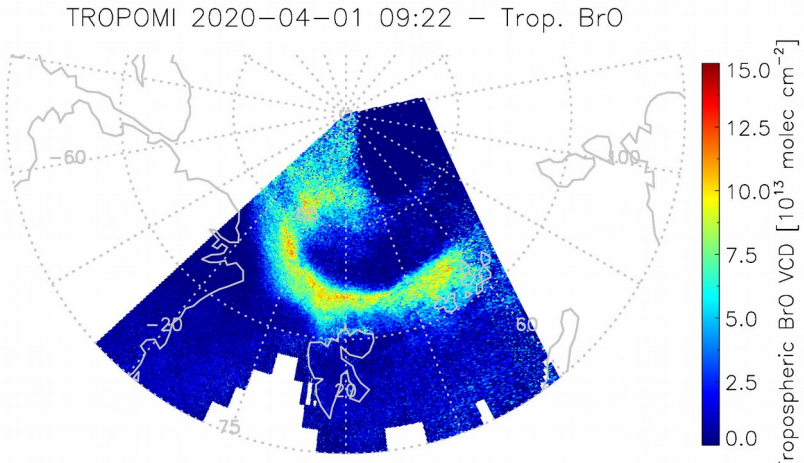

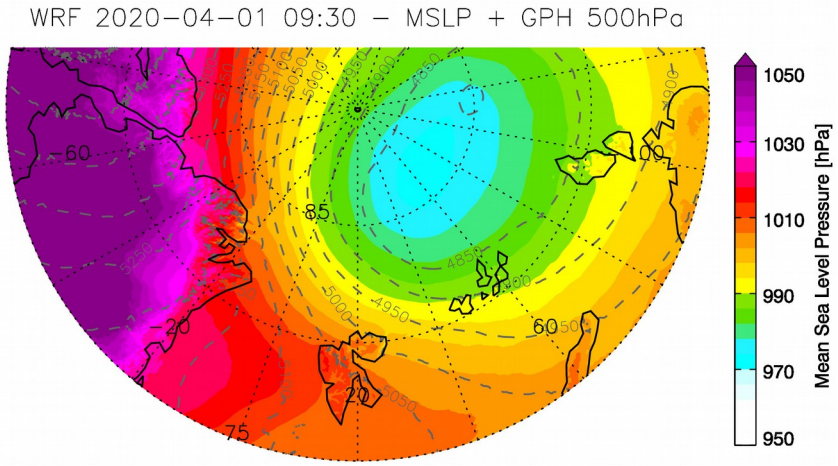

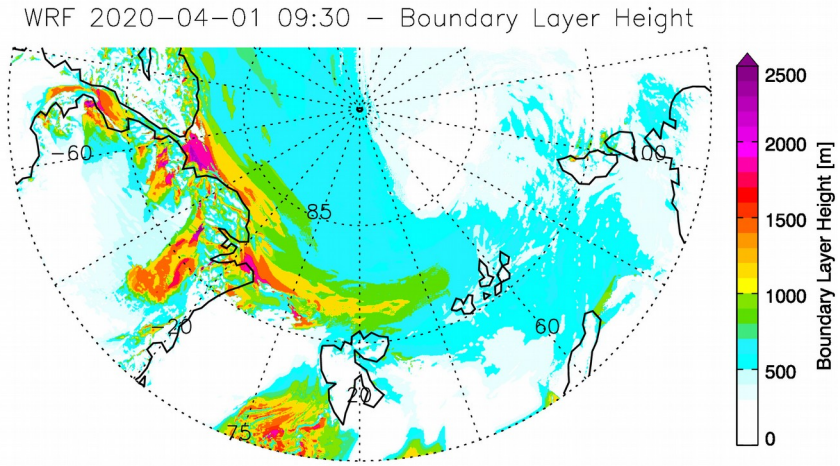

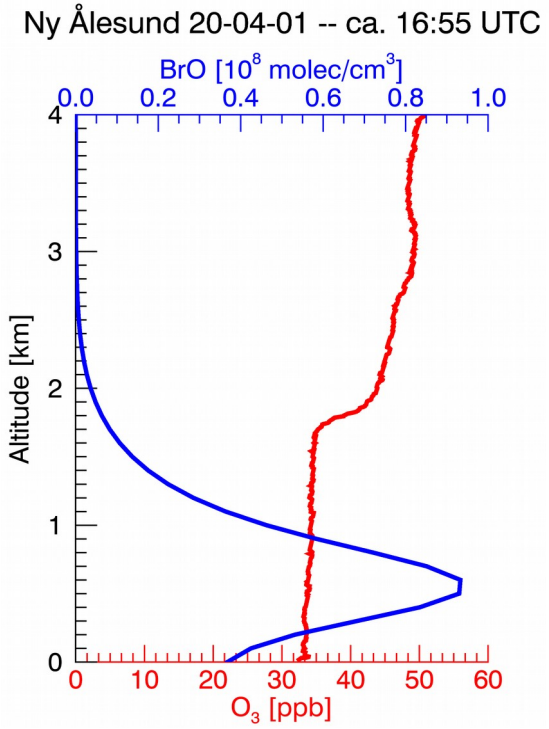

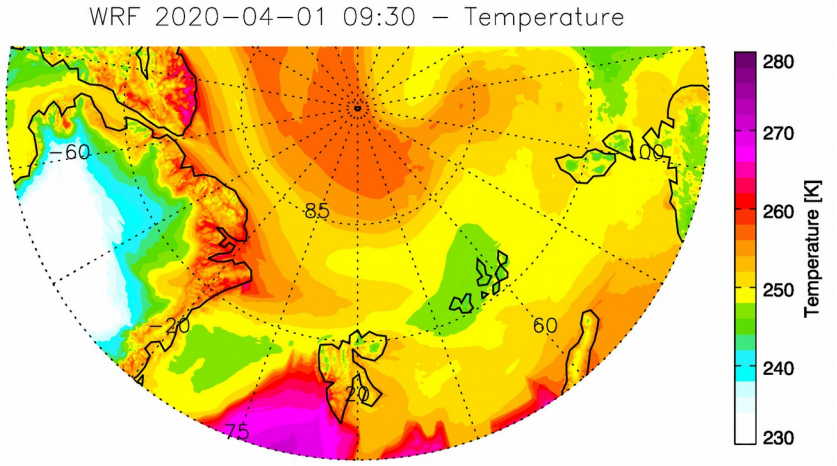

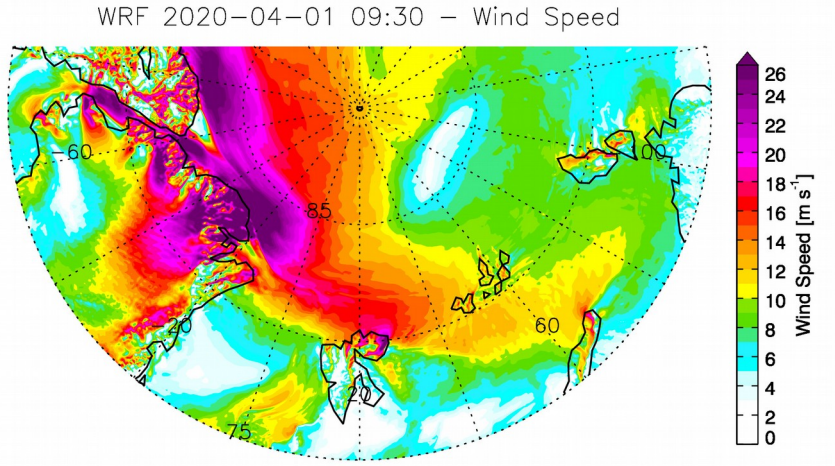

Ozone data: P. von der Gathen (AWI), www-air.larc.nasa.gov/missions/ndacc
BrO profiles: T. Bösch (IUP)

Case Study – April 2, 2020

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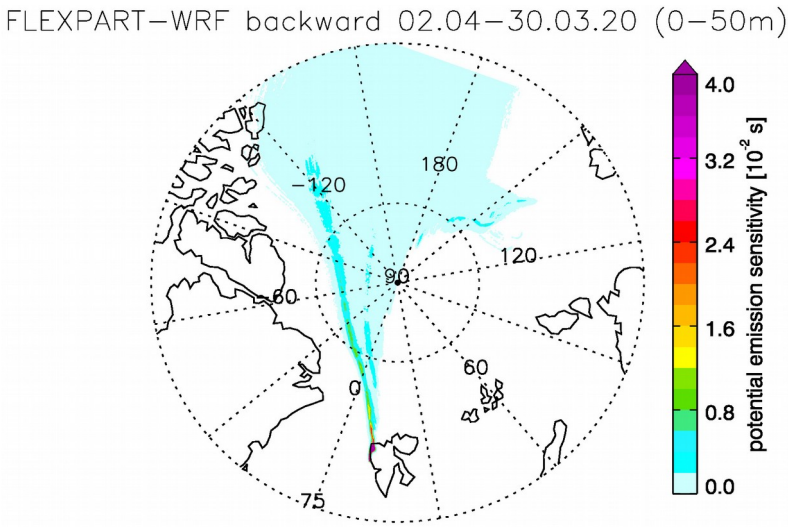

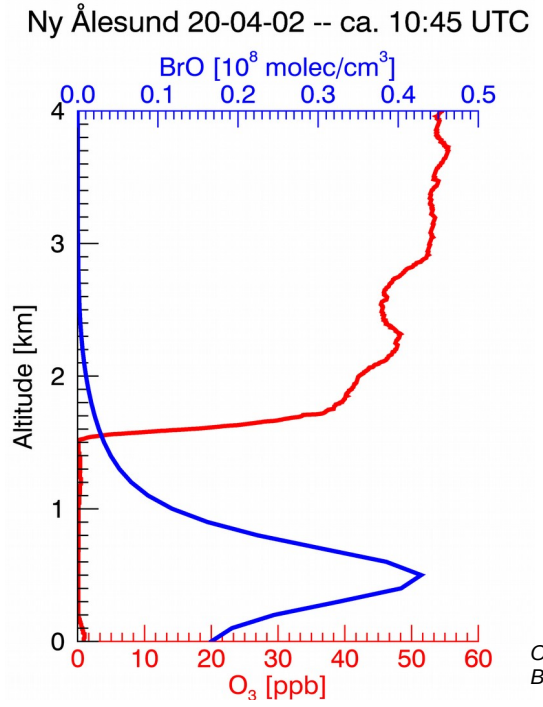

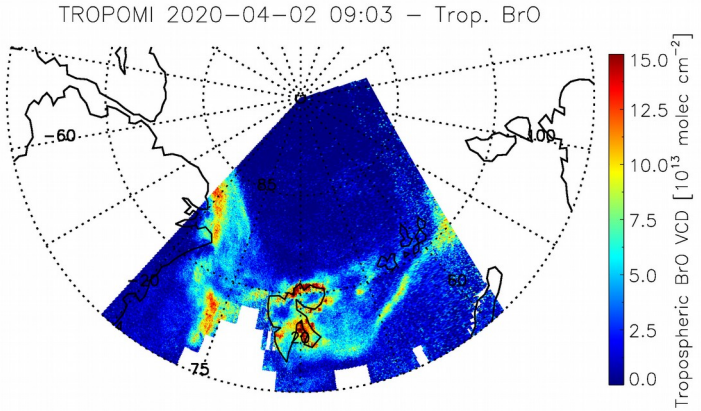

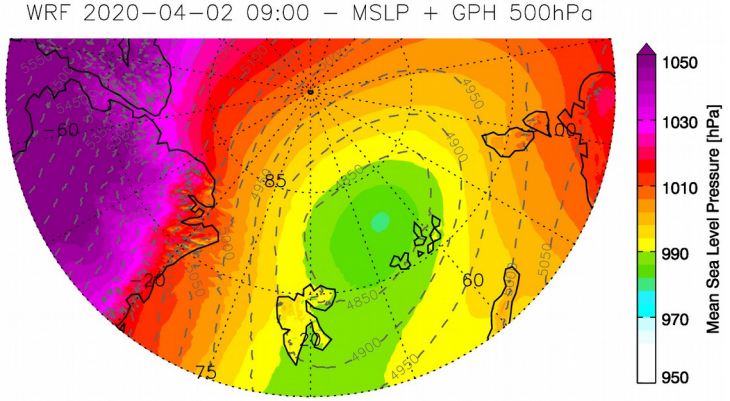

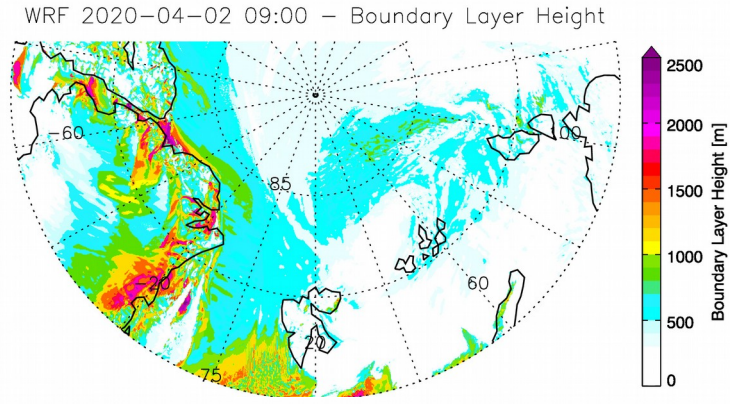

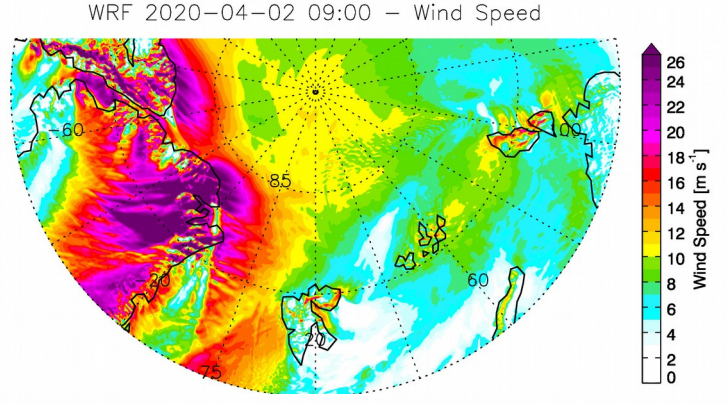

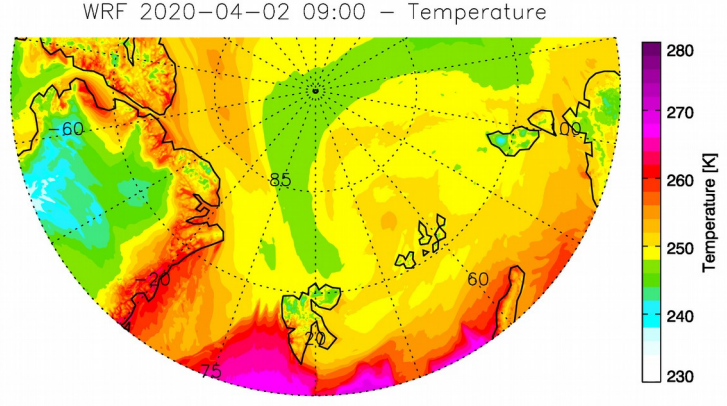

Ozone data Ny-Ålesund: P. von der Gathen (AWI), www-air.larc.nasa.gov/missions/ndacc
BrO profiles: T. Bösch (IUP Bremen)

Case Study – April 3, 2020

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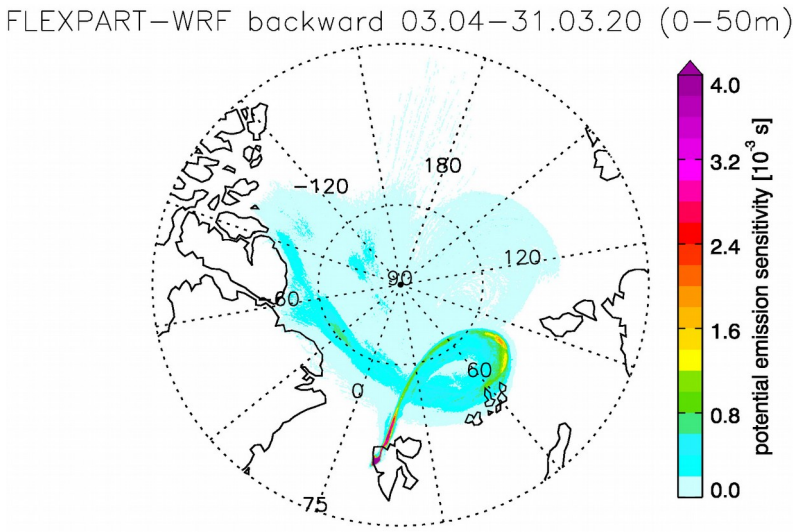

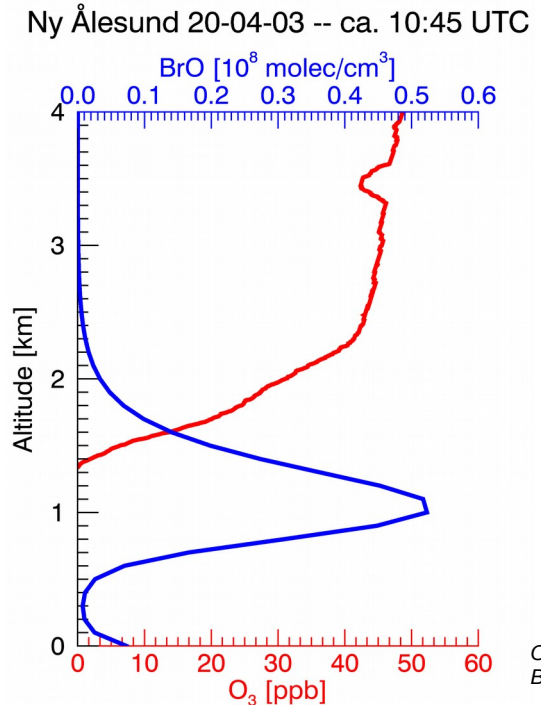

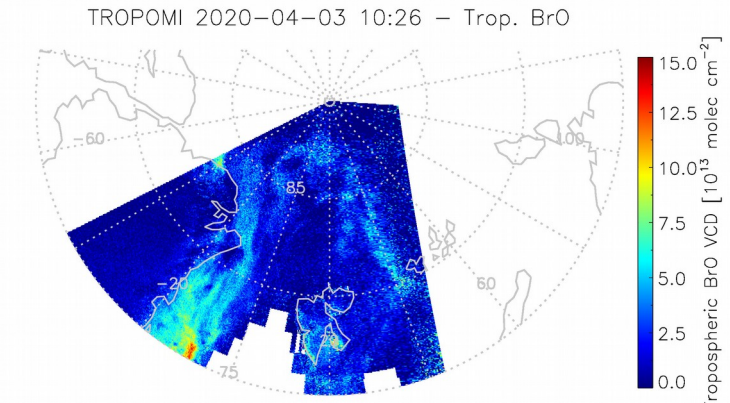

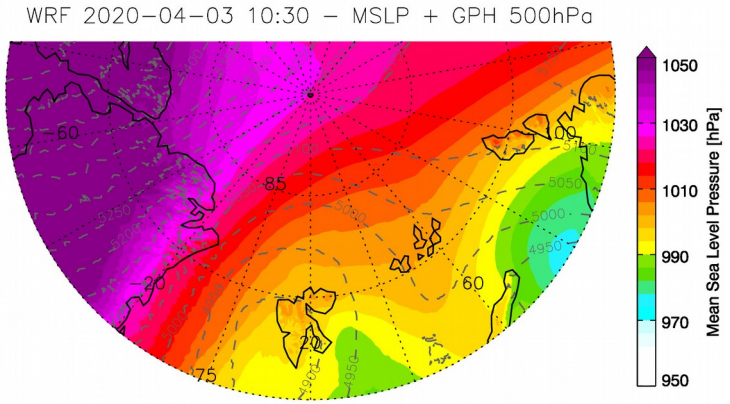

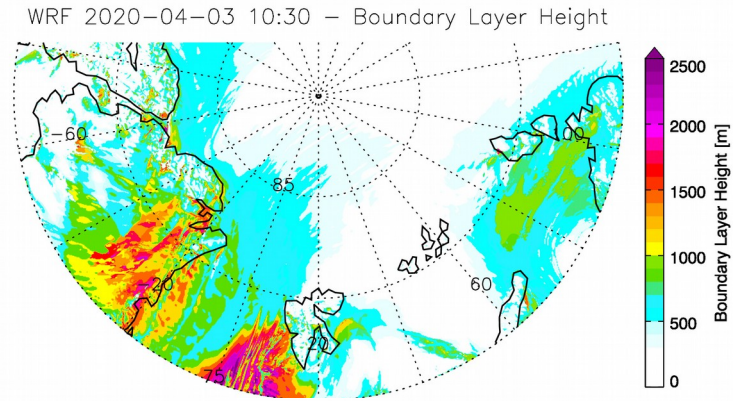

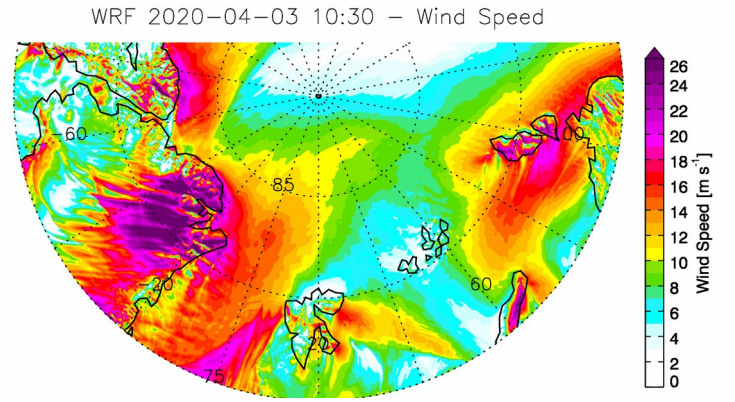

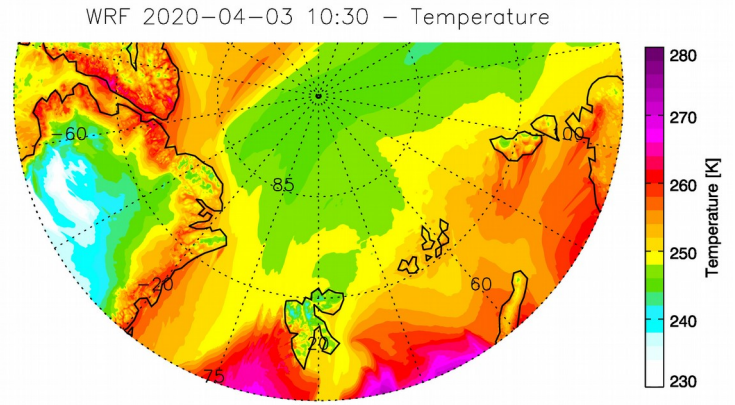

Ozone data Ny-Ålesund: P. von der Gathen (AWI), www-air.larc.nasa.gov/missions/ndacc
BrO profiles: T. Bösch (IUP Bremen)

Conclusion & Outlook

- Composite analysis and case study show:
  - Lower pressure over the Barents Sea and increased pressure over Greenland
    → transport of cold polar air to Ny-Ålesund
  - Higher wind speeds → BEEs probably formed from blowing snow
- Next steps:
  - Extension of the BrO data using satellite measurements from 2010-18
  - Additional FLEXPART backward runs for all ODEs to locate the source region
  - Investigation of sea ice data as potential Br source during ODEs