Springtime nitrogen oxides and tropospheric ozone in Svalbard: local and long-range transported air pollution

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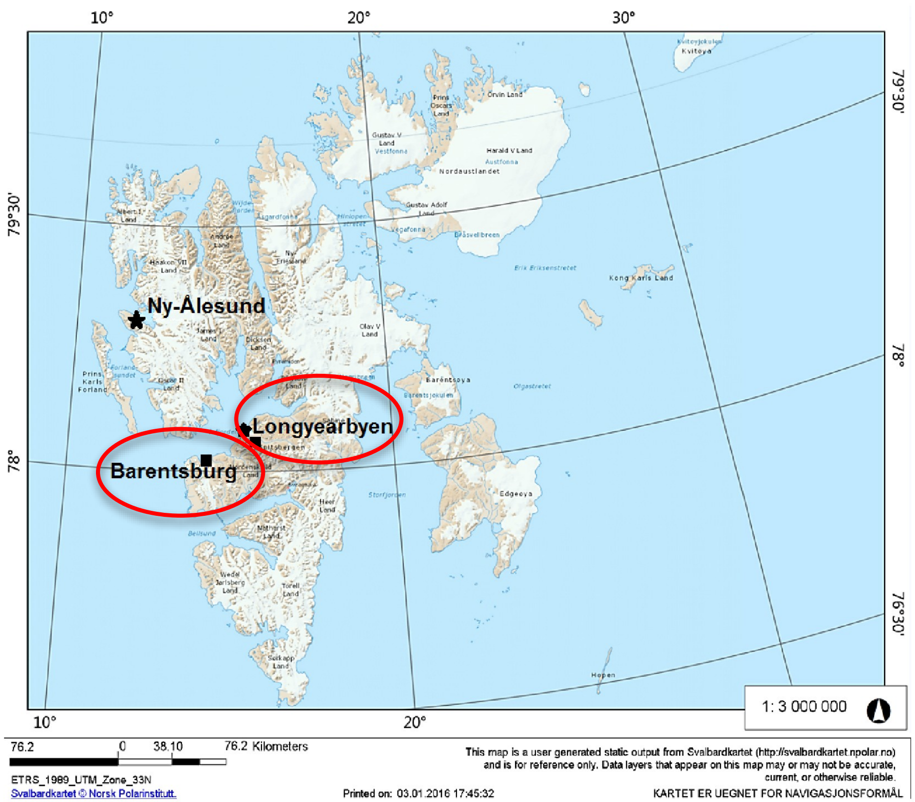
Motivation

Source: https://www.google.no/maps/

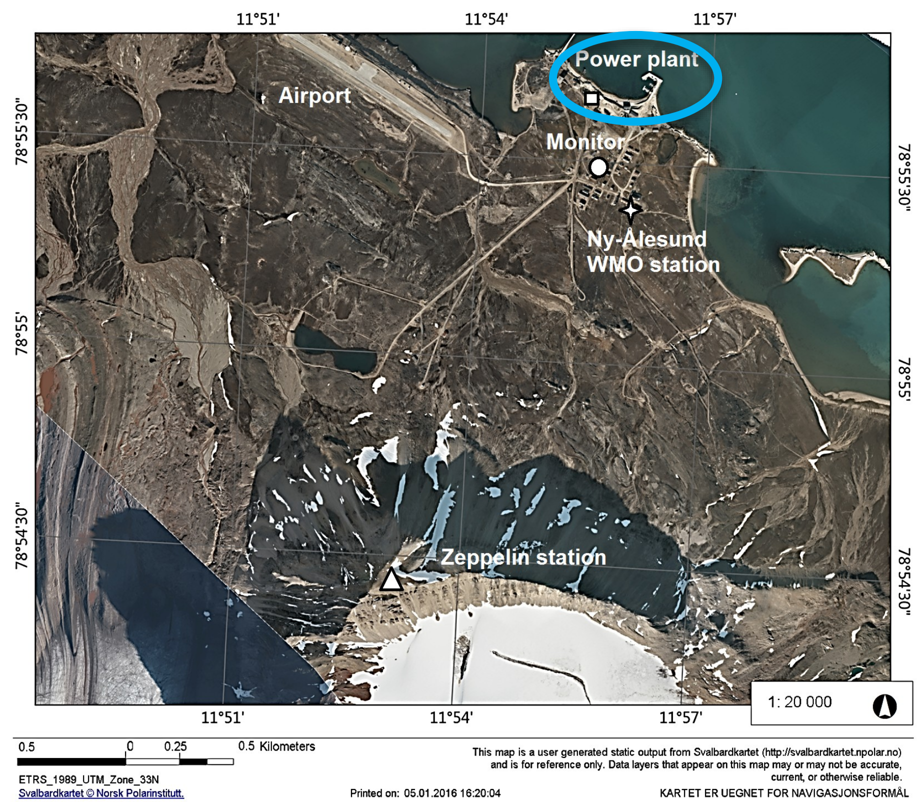
- ✓ Svalbard’s archipelago is nearly a pristine Arctic environment with a few regional and local sources of pollution
- ✓ It is an area where climate change is the most pronounced
- ➢ Svalbard offers unique opportunities for monitoring of **background** air composition, meteorological and climatological studies (AMAP, EMEP, GAW programmes etc.)

But there are also local air pollution sources in Svalbard that have not been studied thoroughly before

(a) map of Svalbard



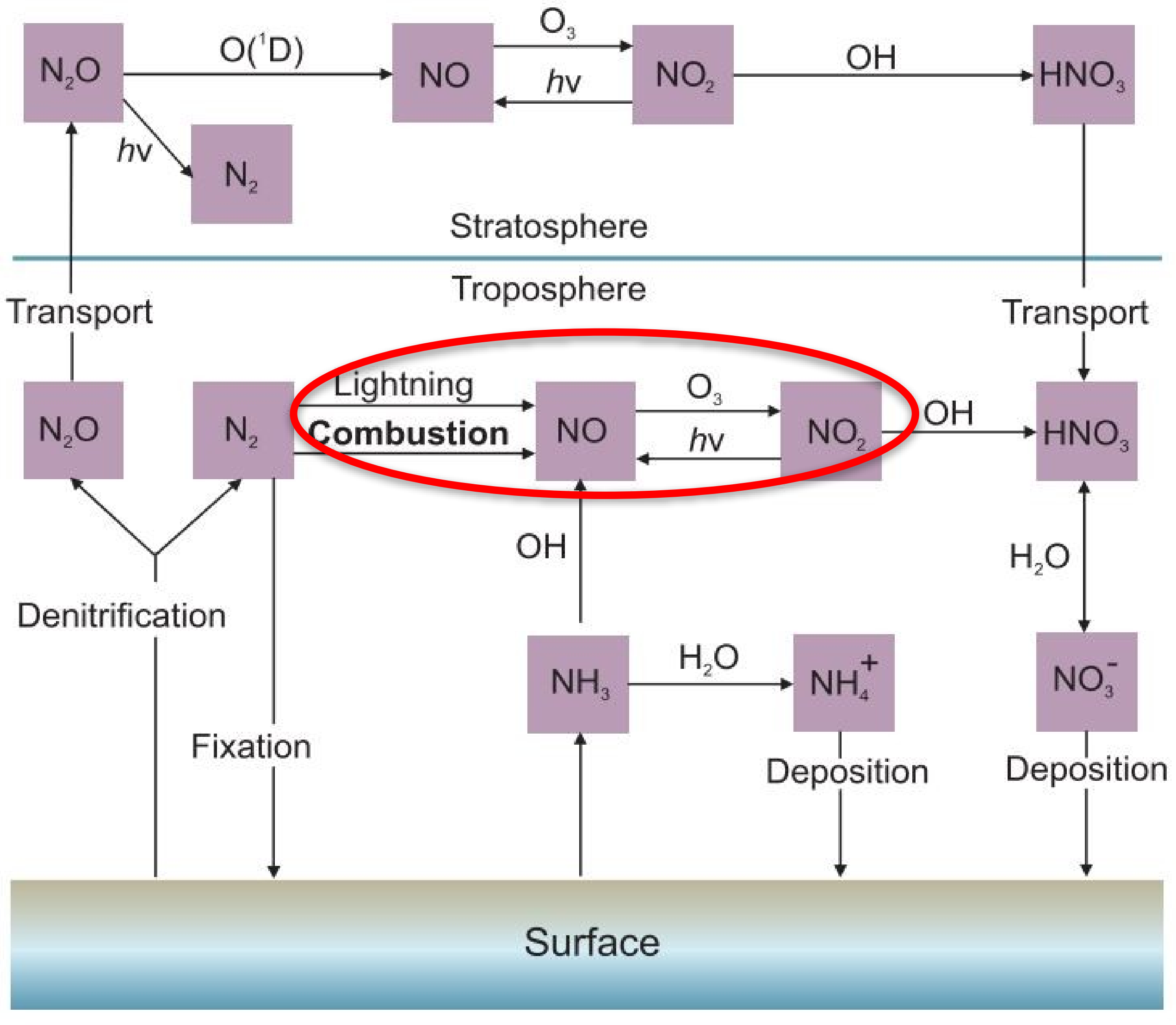
(b) local map of Ny-Ålesund



- Coal-fired power plants are regional year-round point sources of NO_x and SO_2 with seasonally variable emission rate

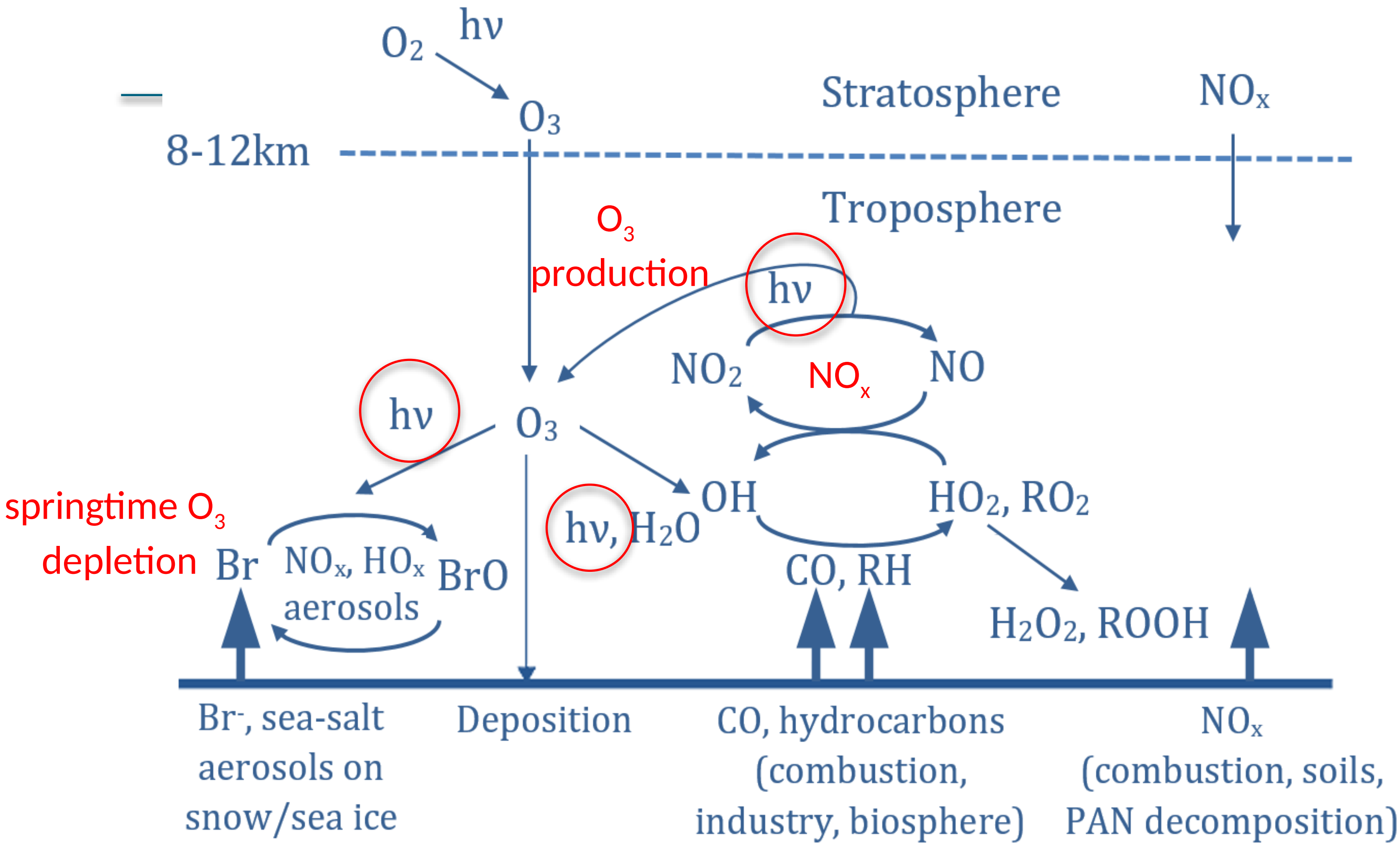
- Power plant on low-sulphur diesel is largest local source of NO_x in Ny-Ålesund

Chemistry of NO_x and O_3



Atmospheric nitrogen cycle (Fig. 3.2 in AMAP, 2006)

Chemistry of NO_x and O_3



Tropospheric O_3 chemistry where HO_x and RO_2 are peroxy radicals, R is alkyl radical, H_2O_2 and ROOH are hydrogen and organic hydroperoxides, respectively (Fan and Jacob, 1992; Jacob, 2000; Monks, 2005)).

Atmospheric lifetime and transport of pollutants to the Arctic

Arctic front extends southerly during winter→ long-range transport of pollutants intensifies

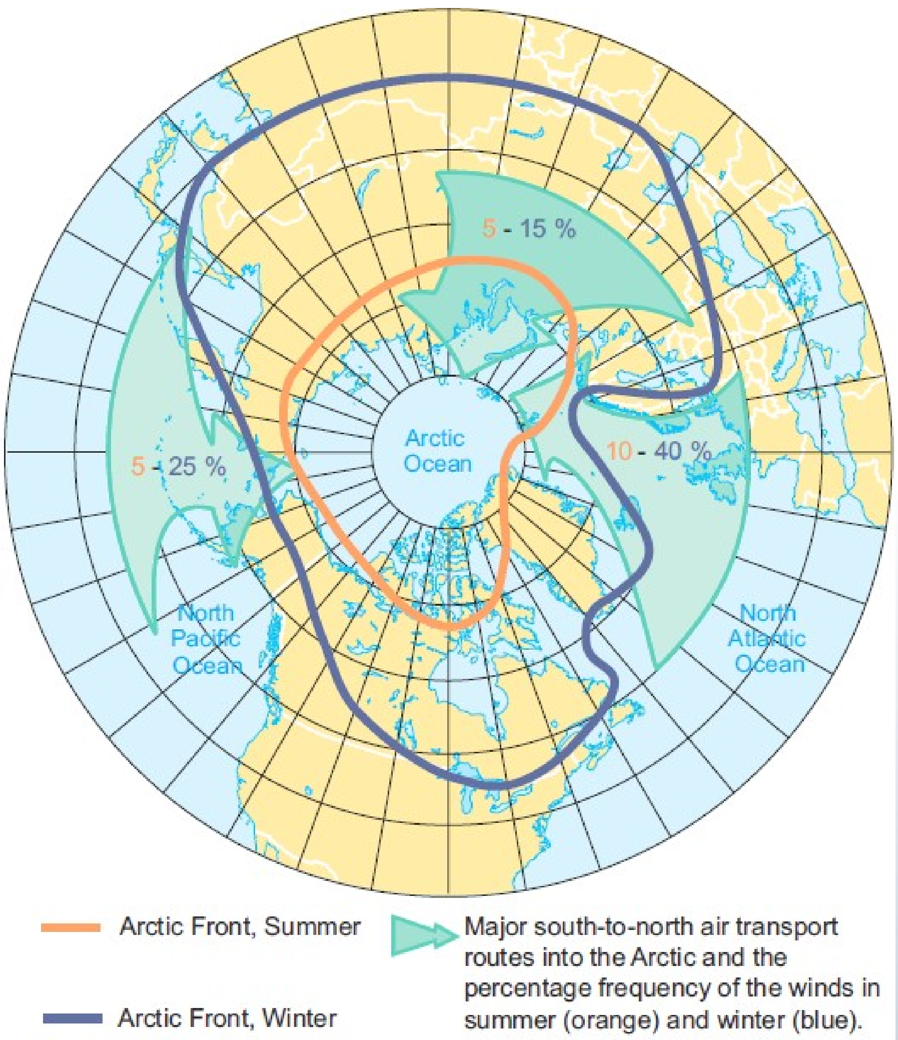


Figure 4.1. Mean position of the arctic air mass in winter (January) and summer (July), superimposed on the percentage frequency of major south-to-north transport routes into the Arctic in summer and winter (AMAP, 1998).

Lifetime of tropospheric NO_x~1 day →local or regional origin

Lifetime of tropospheric O_3→days to weeks→ local or long-range transported

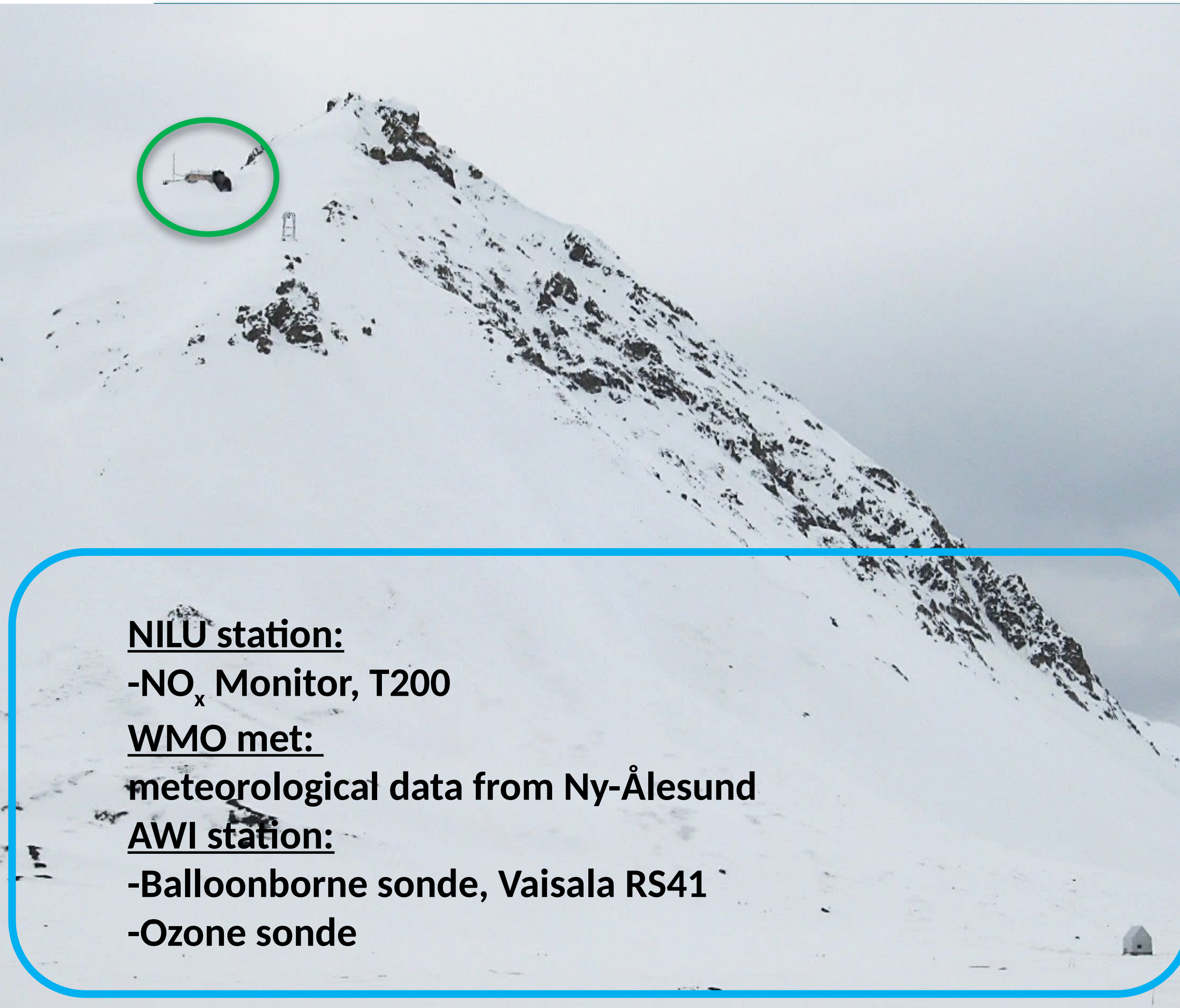
! But much longer lifetime during winter and spring in the Arctic

-due to low temperature and humidity → wet deposition is limited

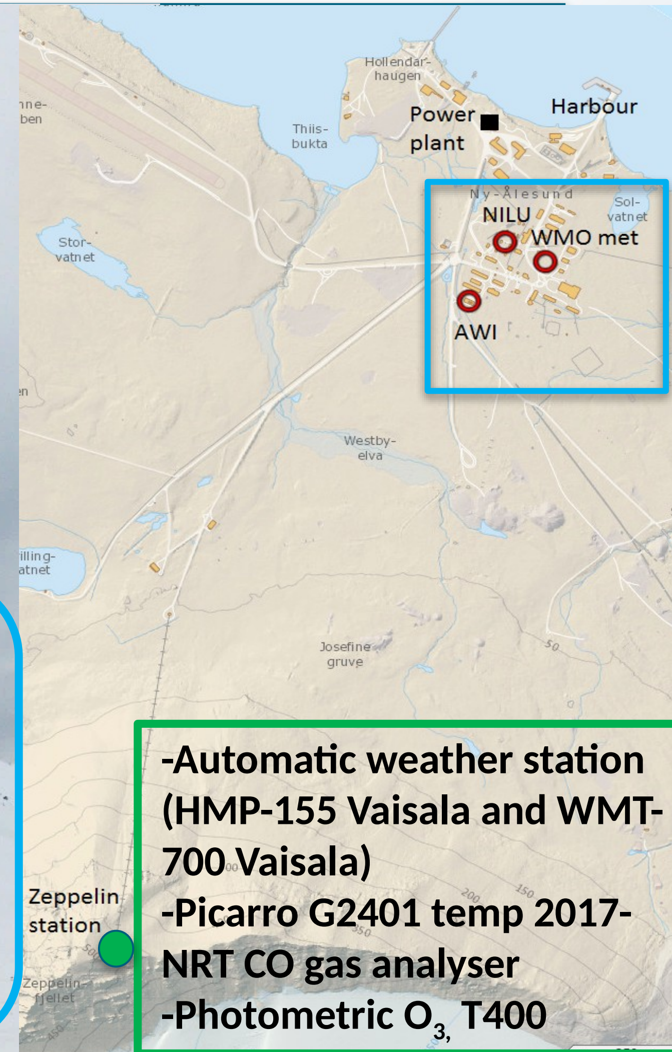
-No sunlight during polar night→ photochemical are reactions limited

-In spring, NO_x can be produced from PAN thermal decomposition

Measurements in Ny-Ålesund

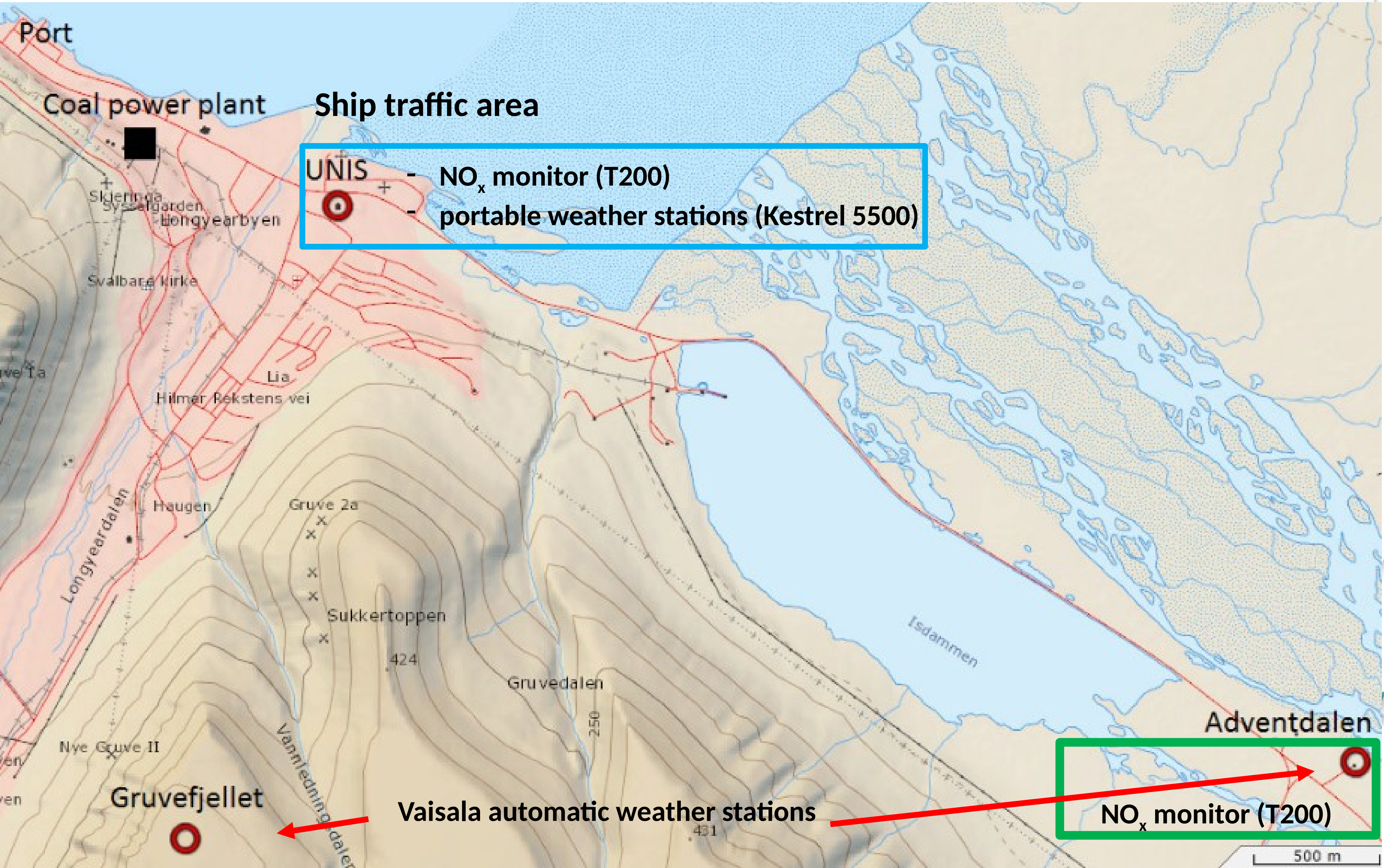


NILU station:
-NO_x Monitor, T200
WMO met:
meteorological data from Ny-Ålesund
AWI station:
-Balloonborne sonde, Vaisala RS41
-Ozone sonde



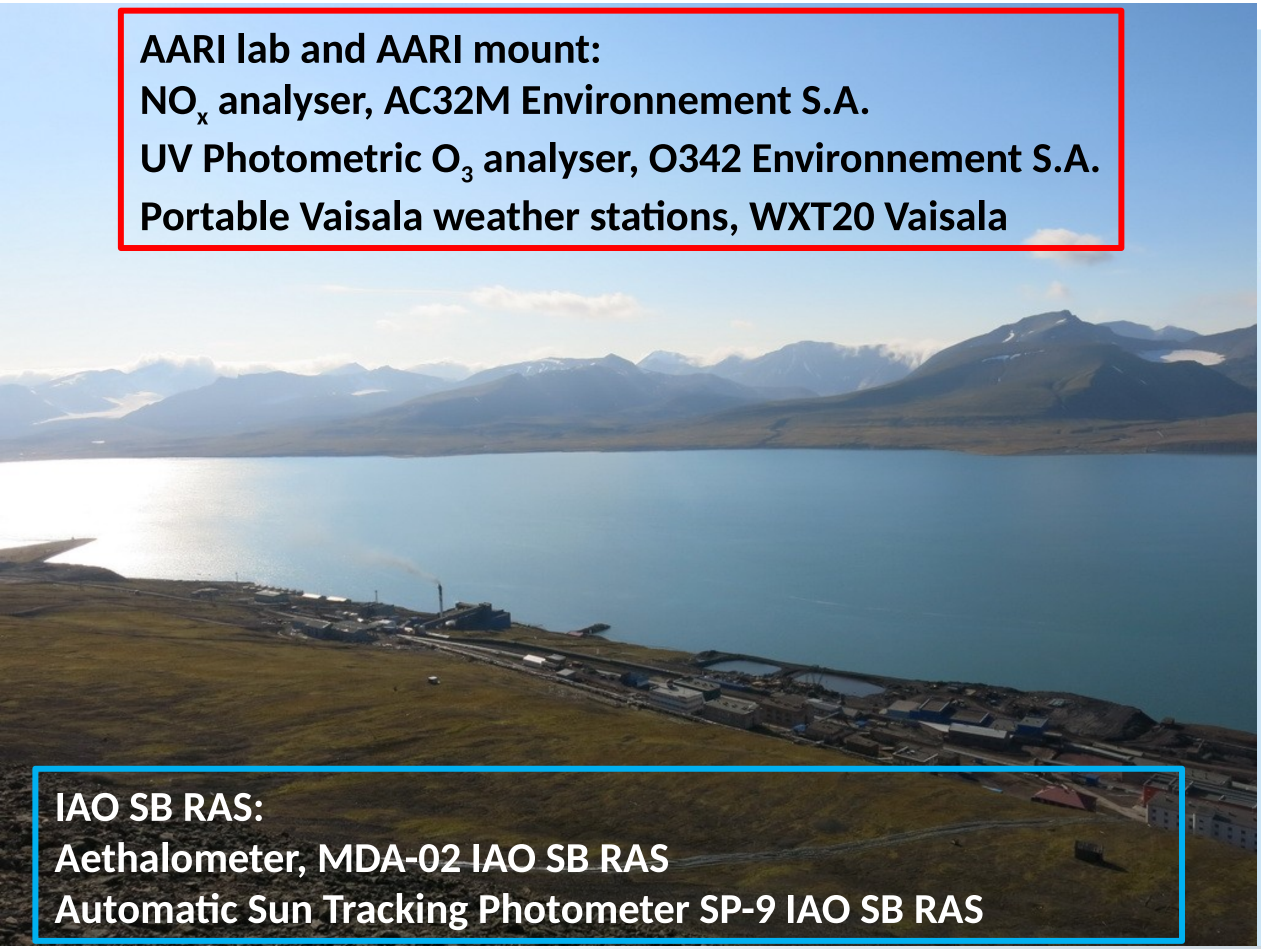
-Automatic weather station (HMP-155 Vaisala and WMT-700 Vaisala)
-Picarro G2401 temp 2017-
NRT CO gas analyser
-Photometric O_3, T400

Measurements in Longyearbyen

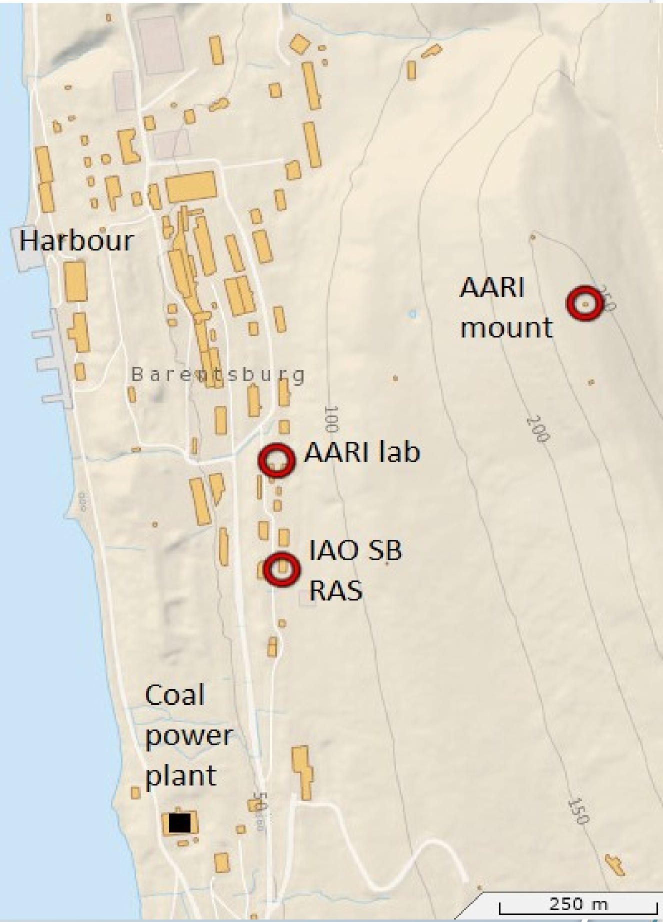


Measurements in Barentsburg

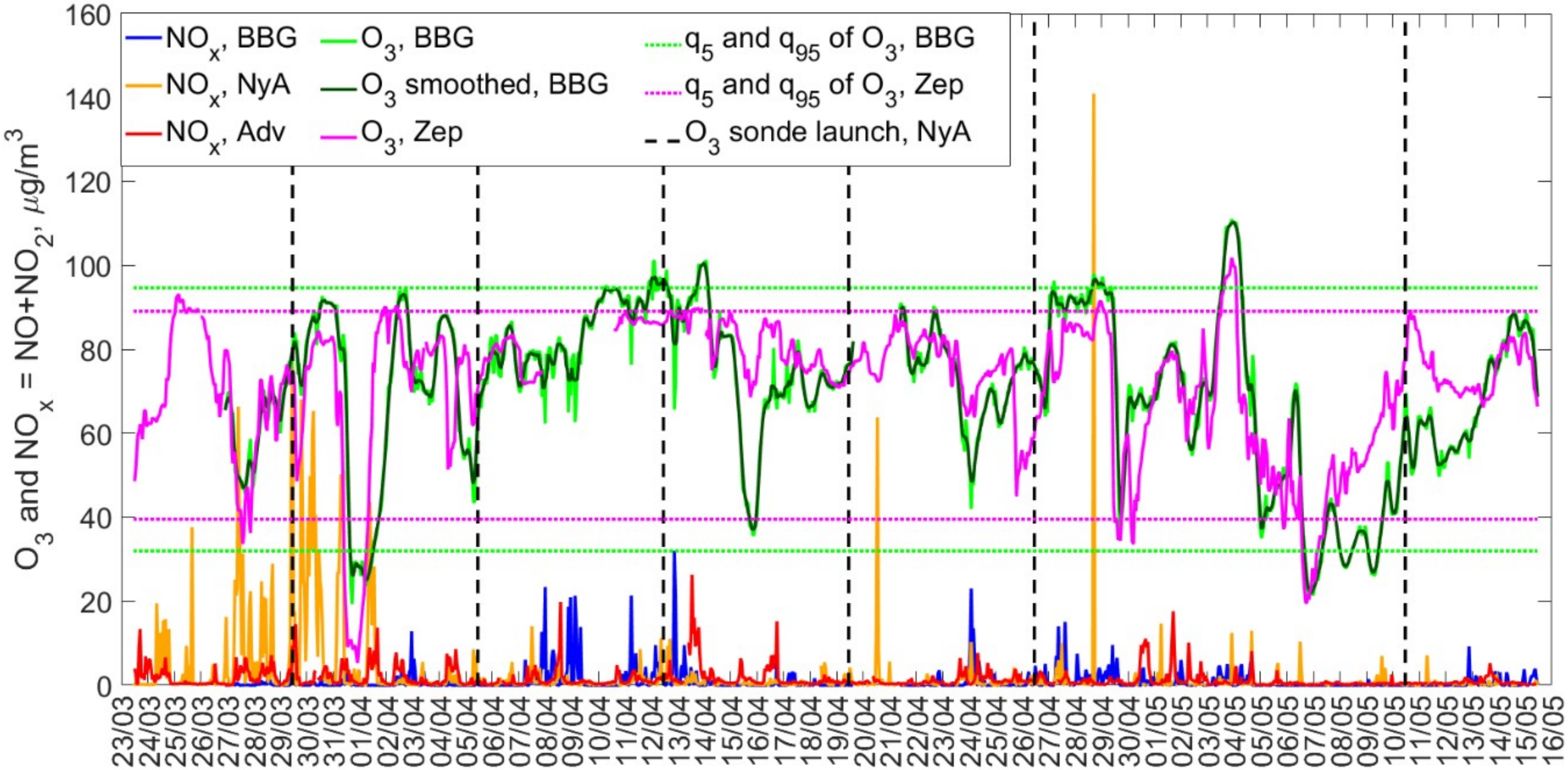
AARI lab and AARI mount:
NO_x analyser, AC32M Environnement S.A.
UV Photometric O_3 analyser, O342 Environnement S.A.
Portable Vaisala weather stations, WXT20 Vaisala



IAO SB RAS:
Aethalometer, MDA-02 IAO SB RAS
Automatic Sun Tracking Photometer SP-9 IAO SB RAS



Data series from the 3 stations: Barentsburg (BBG), Ny-Ålesund (NyA, Zep), Longyearbyen /Adventdalen station (Adv)

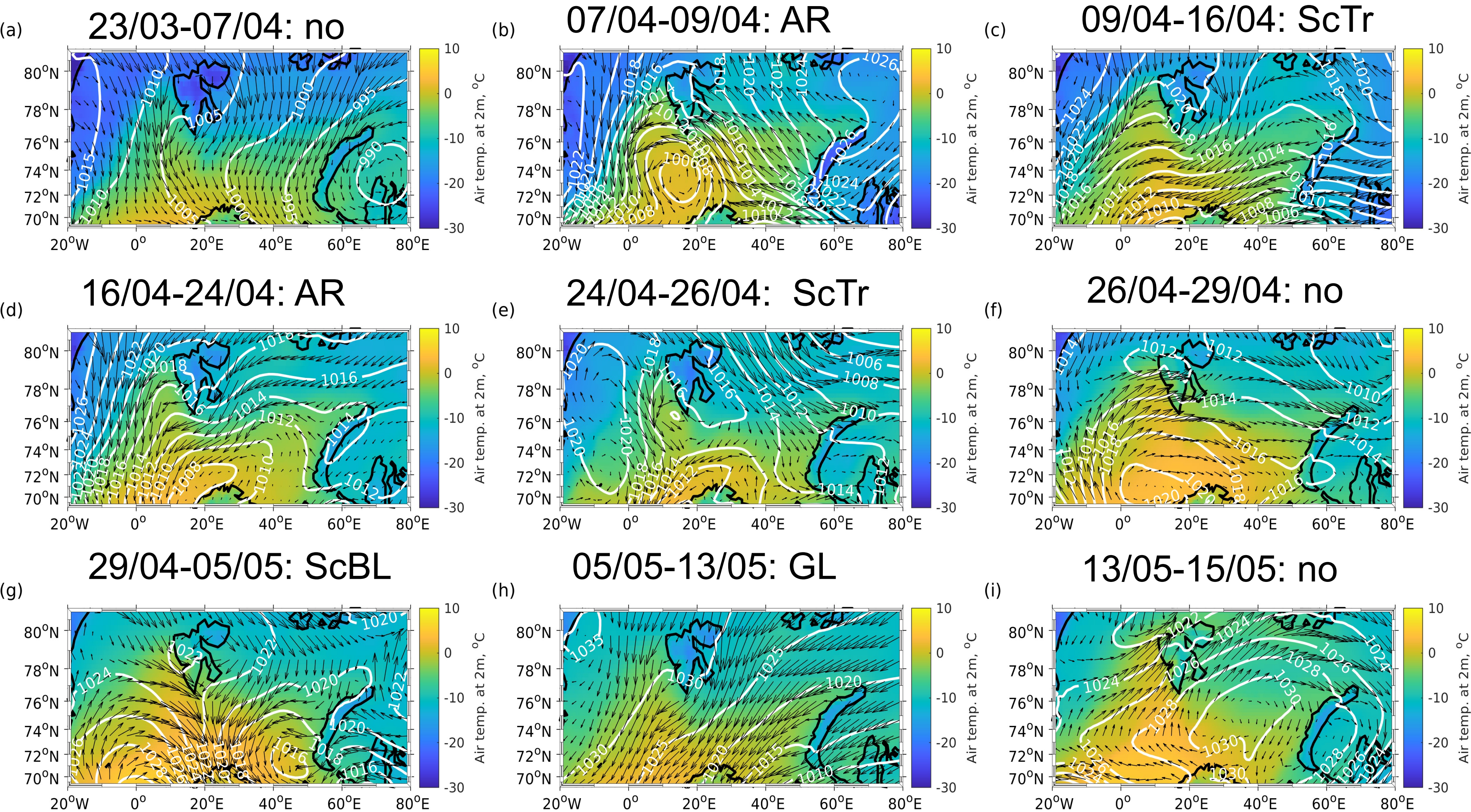


High correlation between O3 at the Zeppelin station in Ny-Ålesund and in Barentsburg--> long-range transport is important

Some local titration of O_3 with NO_x in Barentsburg is observed, but is not significant

NO_x concentrations are weakly correlated at the three stations-->different factors affect the concentration at each site (wind speed and direction, atmospheric stability and sunlight intensity)

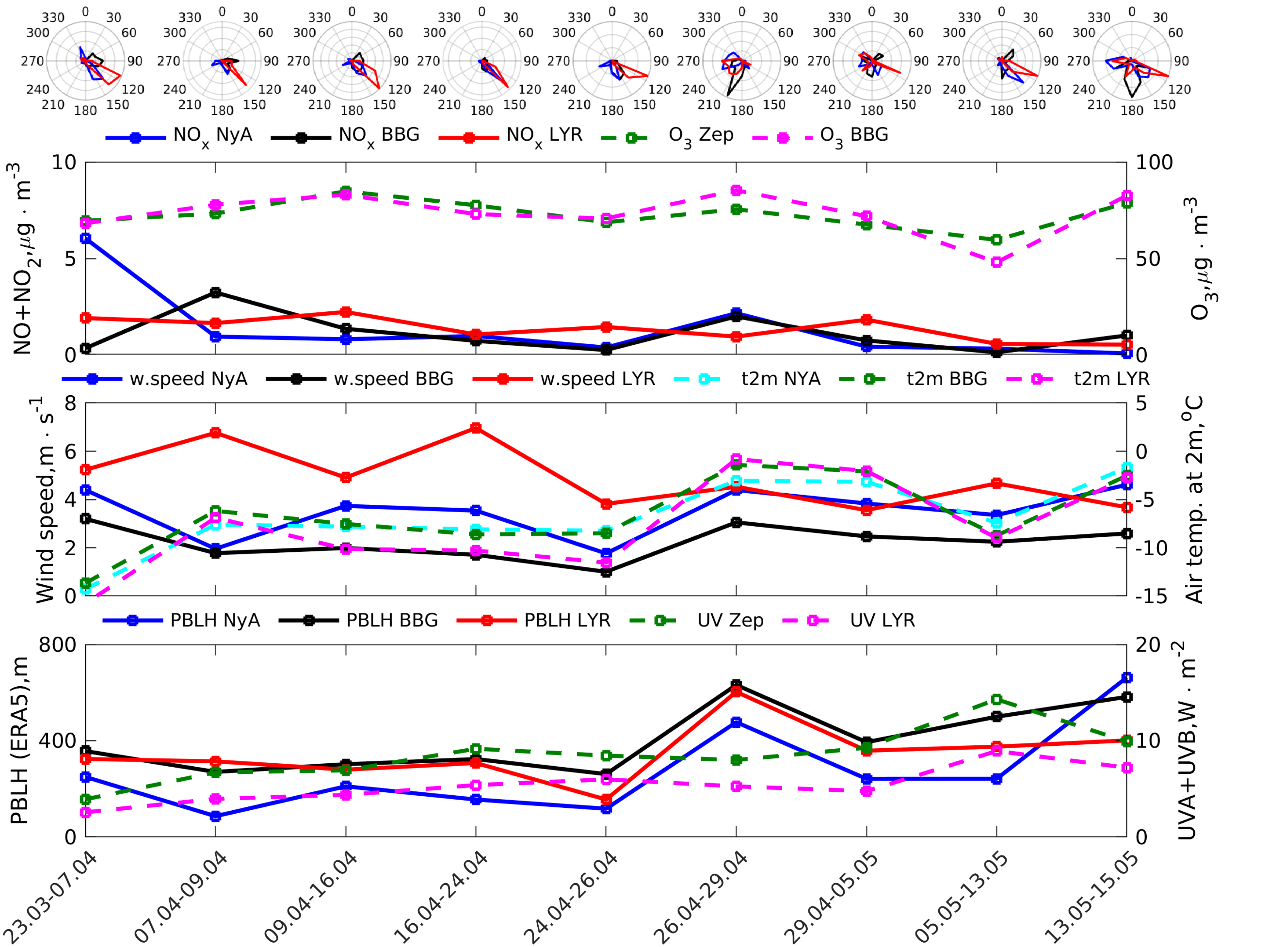
Classification of the measurement period on 9 subperiods based on 7 large-scale weather regimes (Grams et al. 2017)



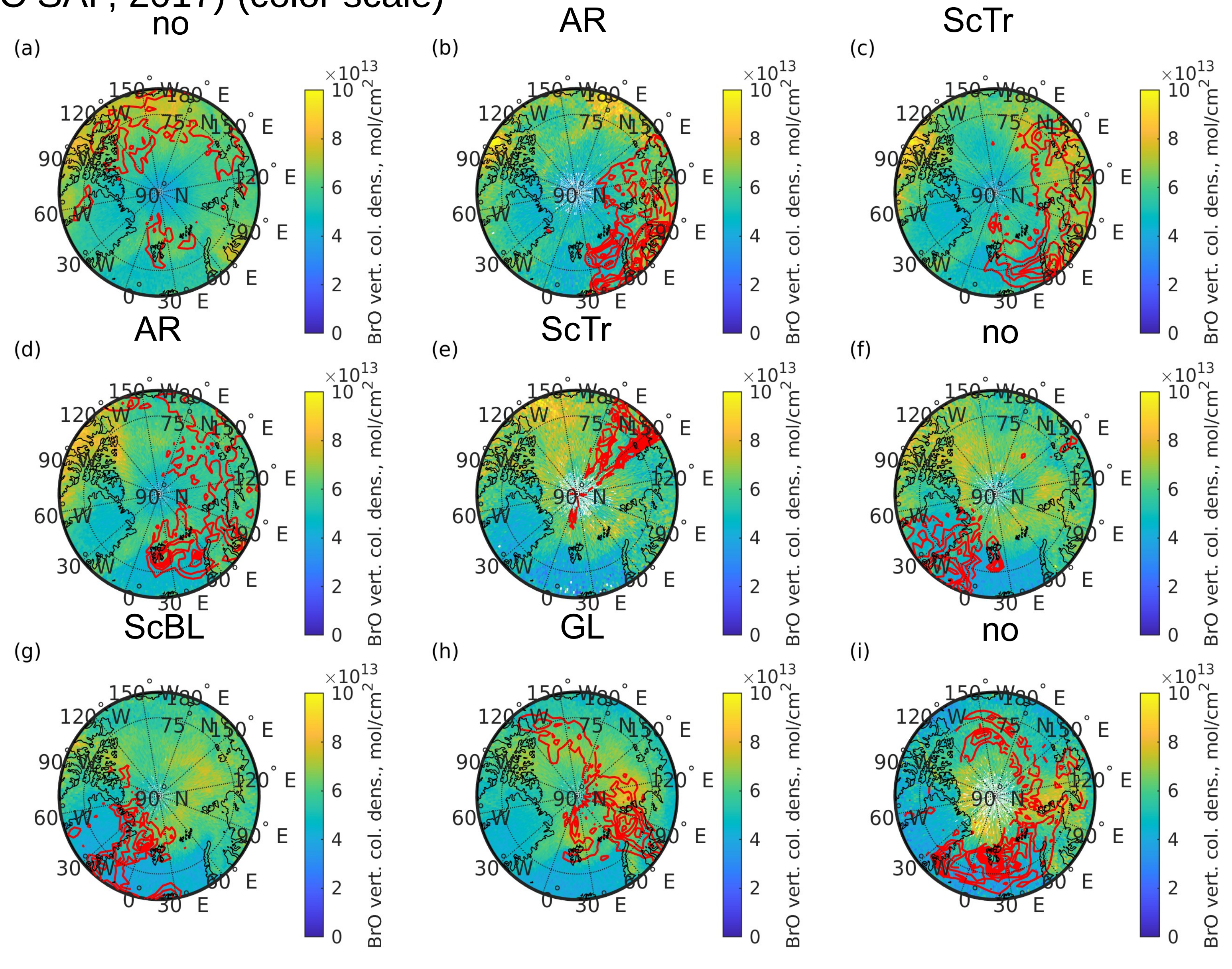
no: no regime; AR: Atlantic ridge; ScTr: Scandinavian trough; ScBL: Scandinavian blocking; GL: Greenland blocking

Grams, C. M., Beerli, R., Pfenninger, S., Staffell, I., & Wernli, H. (2017). Balancing Europe’s wind-power output through spatial deployment informed by weather regimes. *Nat. Clim. Chang.*, *7*(8), 557–562. https://doi.org/10.1038/NCLIMATE3338

Average parameters at the three stations for the defined 9 subperiods



FLEXPART (Fremme & Sodemann, 2019; Läderach & Sodemann, 2016; Stohl et al., 2005) trajectory probability for 10 days backward trajectories calculated for days 2-10 (red contours with step of 0.001), GOME2 BrO vertical column density (AC SAF, 2017) (color scale)



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