Black carbon concentrations in Svalbard explained by Lagrangian transport modelling

Sabine Eckhardt, Karl Espen Yttri, Stephen Platt, Kerstin Stebel, Nikolaos Evangeliou

nilu

sabine.eckhardt@nilu.no

Zeppelin Observatory at Svalbard 78 ° N

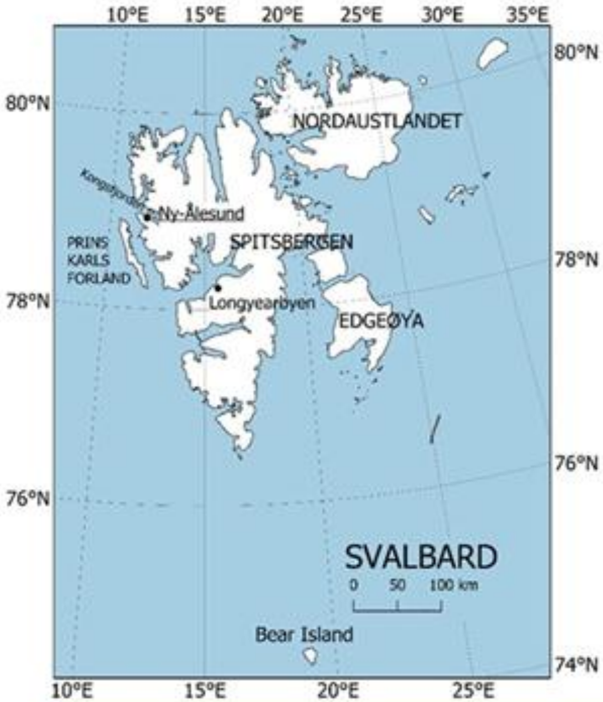
Established 1989, Norway

Zeppelin mountain, 472 asl., 78.9N, 11.9E

Global/European monitoring programs
(EMEP, AMAP, ICOS, ACTRIS)

Observations of GHG, POPs, heavy metals,
aerosol – important to have long-term timeseries

Platt et al. (2022) give a summary over the measurements carried out in the last 30 years



Platt et al., 2022

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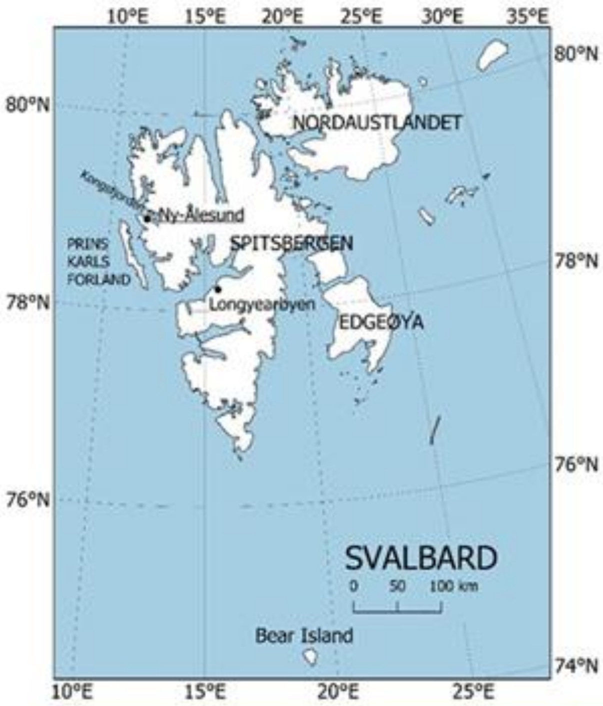
Change in Air Quality at Svalbard, April-May 2006



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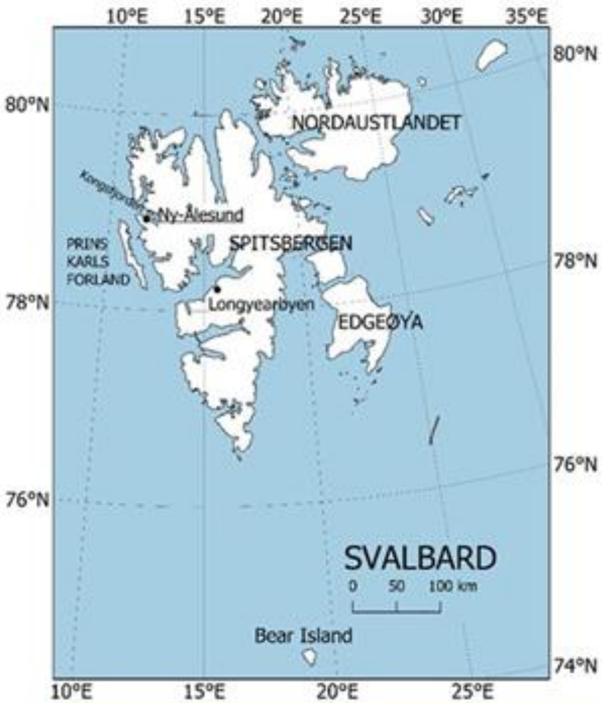
Change in Air Quality at Svalbard, April-May 2006

A.C. Engvall



Platt et al., 2022

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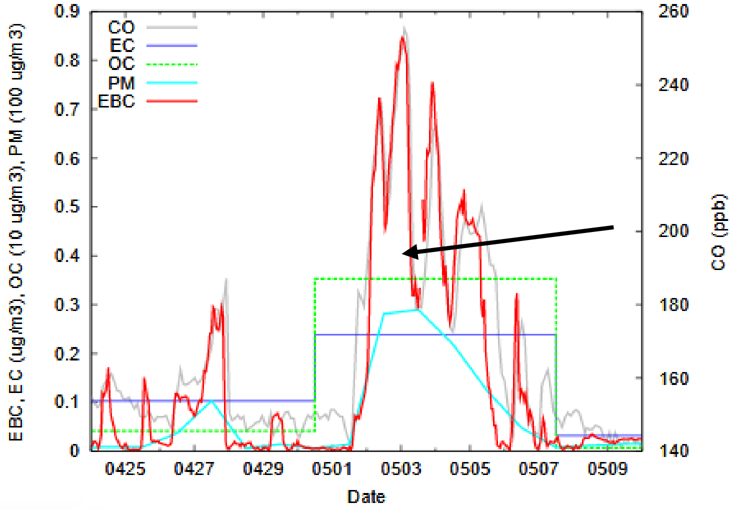
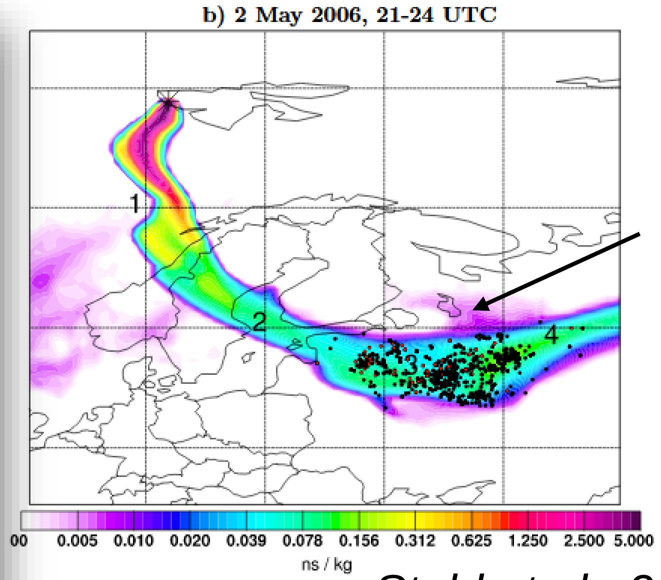
A sign of the changing Arctic with warming climate?



May 2006,
Record high pollutant concentrations measured
During record high temperatures



Can be tracked back
(backward in time)
to intense
agricultural waste burning
and induced wild fires

Stohl et al., 2007

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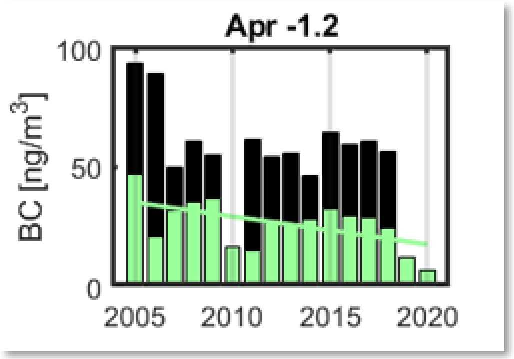
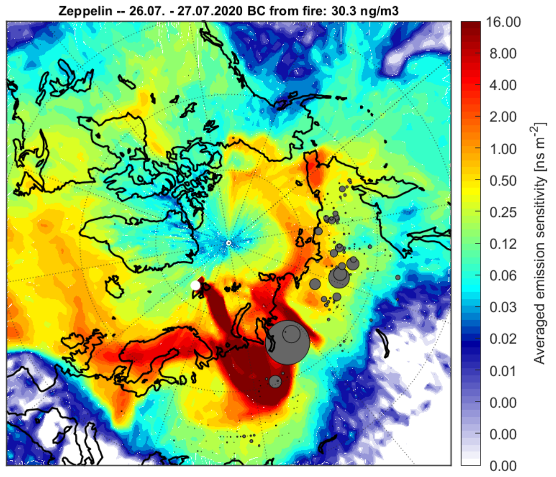
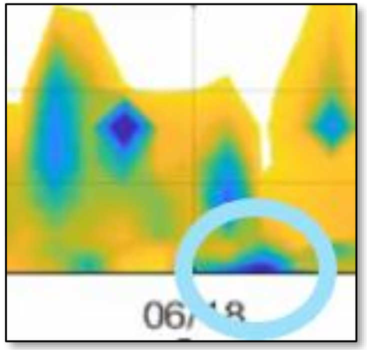
BC observed in Svalbard



How did the BC concentration develop over the years?



What are the most important sources?



Are all episodes captured at the surface?

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sabine.eckhardt@nilu.no

Black Carbon aerosol, short lived climate forcer

Aerosol

Product of incomplete combustion

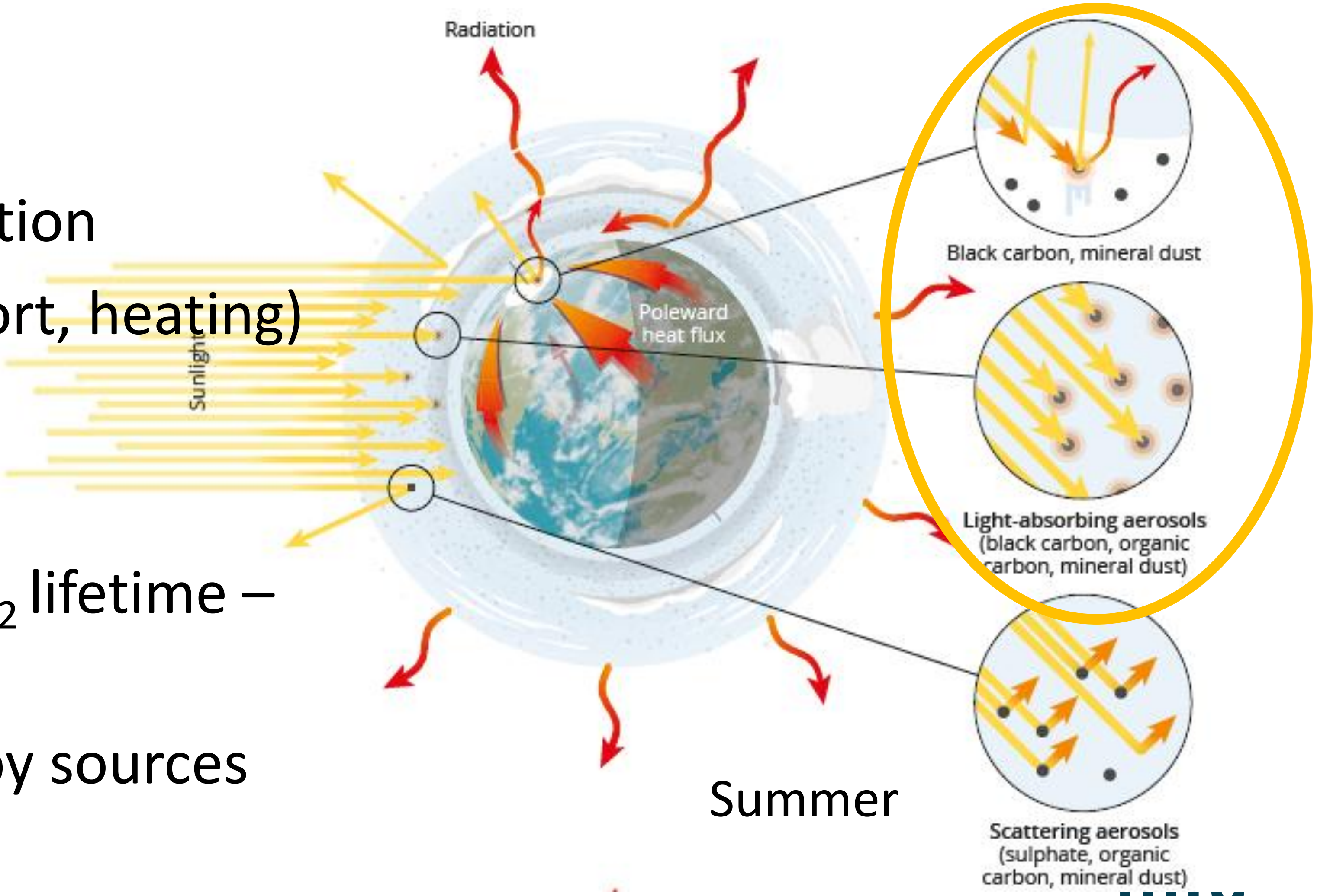
Anthropogenic (flaring, transport, heating)

Natural (wild fire)

Alter radiative budget

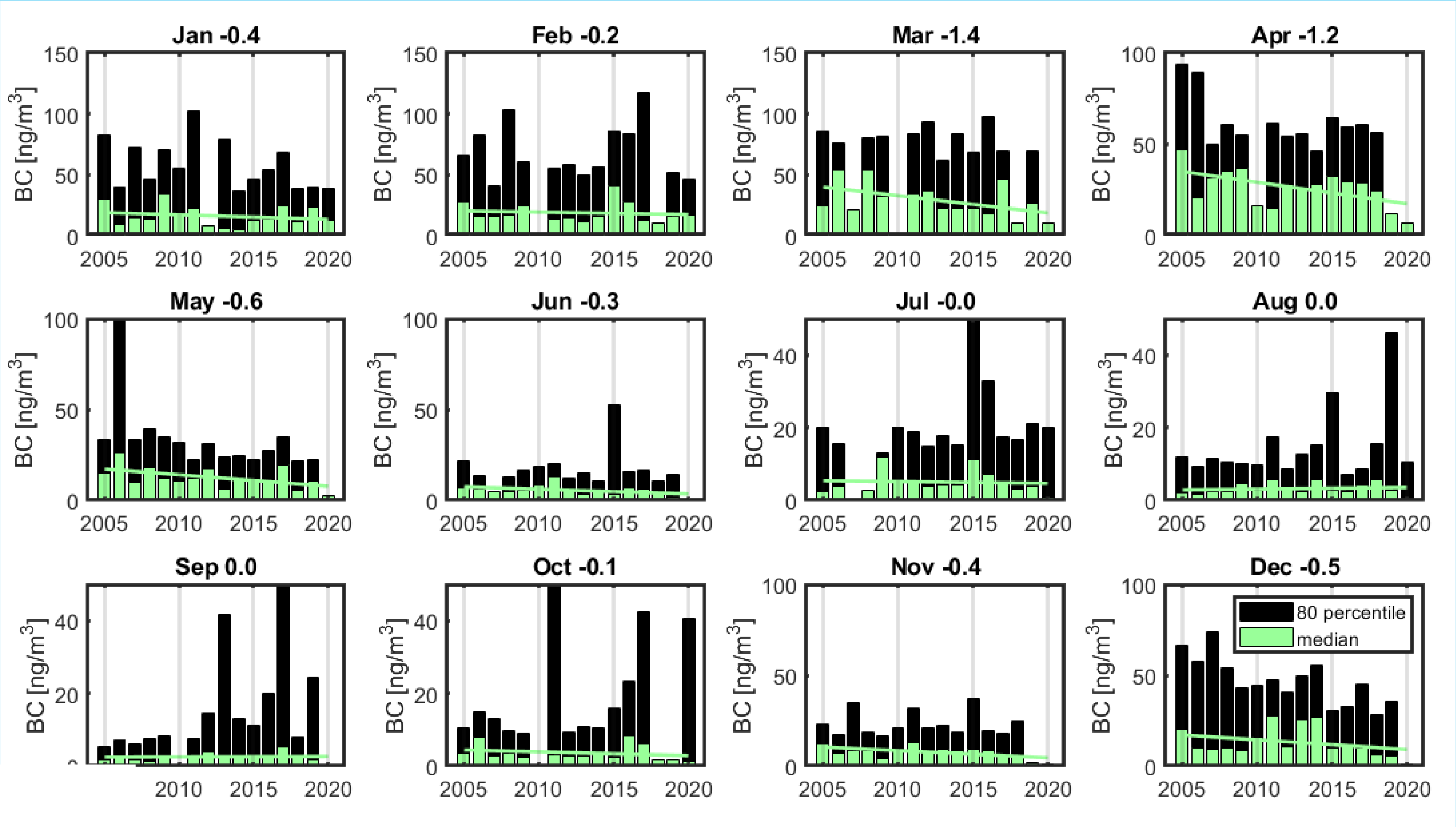
Lifetime much shorter than CO_2 lifetime – days to weeks

Highly inhomogenous, driven by sources



Summer

AAC – eBC, Spitsbergen (2005-2020)



Median of daily eBC concentrations

80 percentile of daily eBC concentrations

GR05_L_aethalomether_AE31, Eleftheriadis et al., 2009

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Trend in observed BC (AAC) at Zeppelin

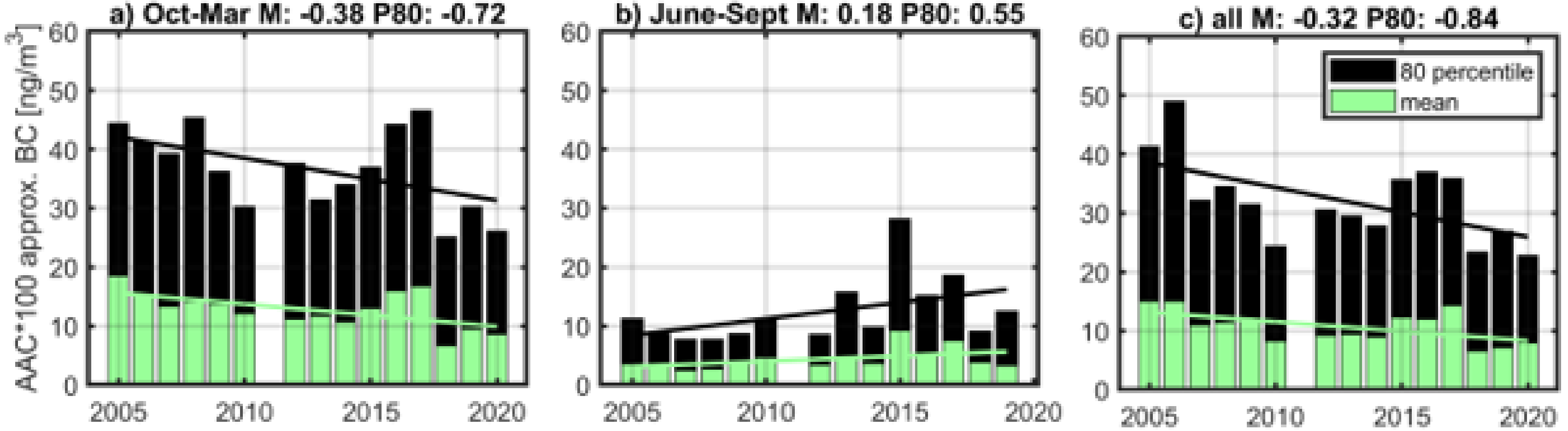
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Figure 5: Aerosol absorption coefficient (GR05L_aethalometer_AE31, Eleftheriadis et al., 2009) based on three-hourly observations at Zeppelin from 2005 to 2020. Mean values (black bars) and 80th percentiles (green bars) for different periods: October to March in panel a), June to September in panel b), and for the entire year in panel c). The green and black line represents the linear trends for the mean and 80th percentile values, respectively. The title above each panel indicates the trends as 100 times aerosol absorption coefficient per year.

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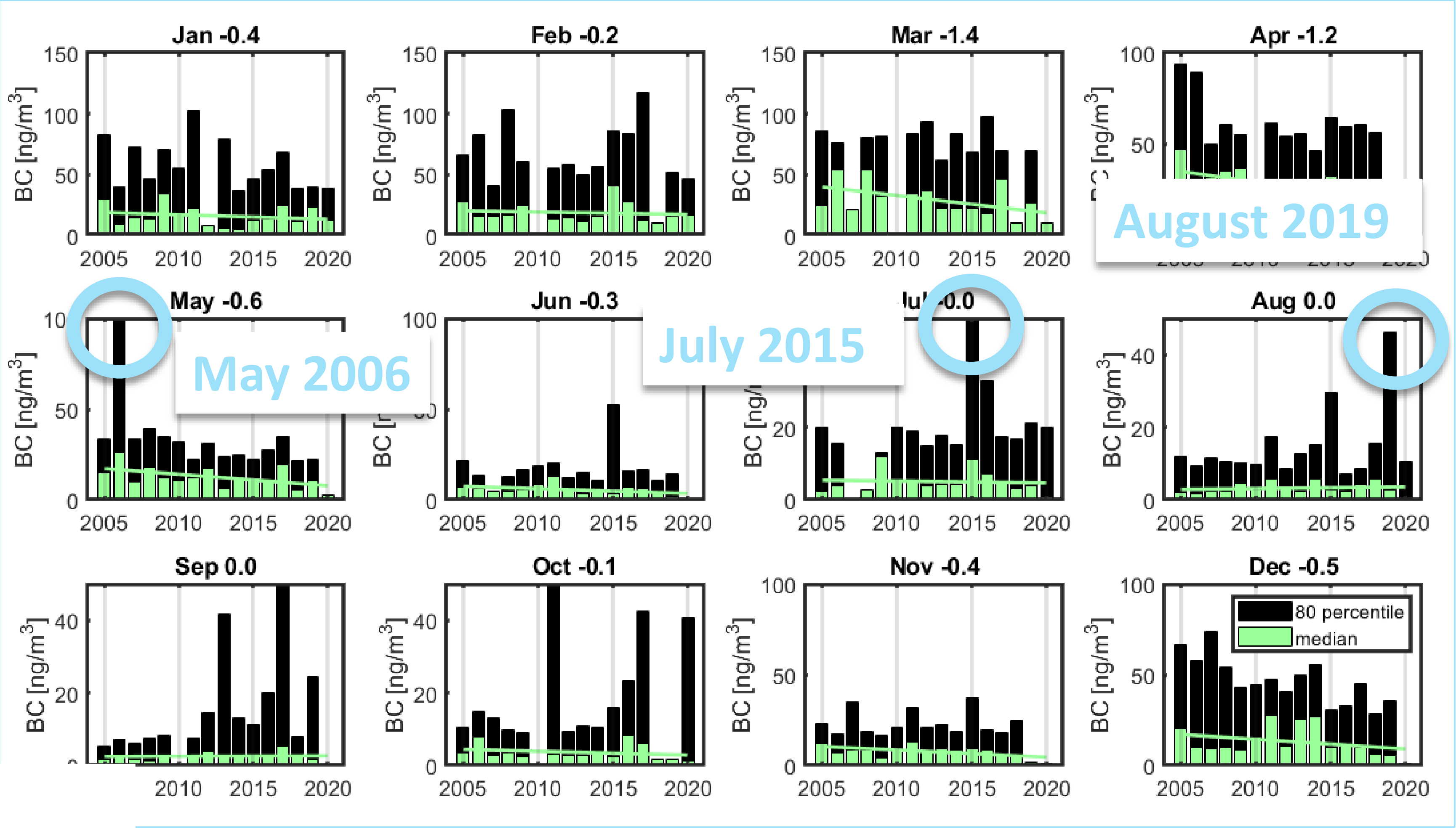
sabine.eckhardt@nilu.no

AAC – eBC, Spitsbergen (2005-2020)



Median of daily eBC concentrations

80 percentile of daily eBC concentrations

GR05_L_aethalomether_AE31, Eleftheriadis et al., 2009

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sabine.eckhardt@nilu.no

Lagrangian transport model FLEXPART

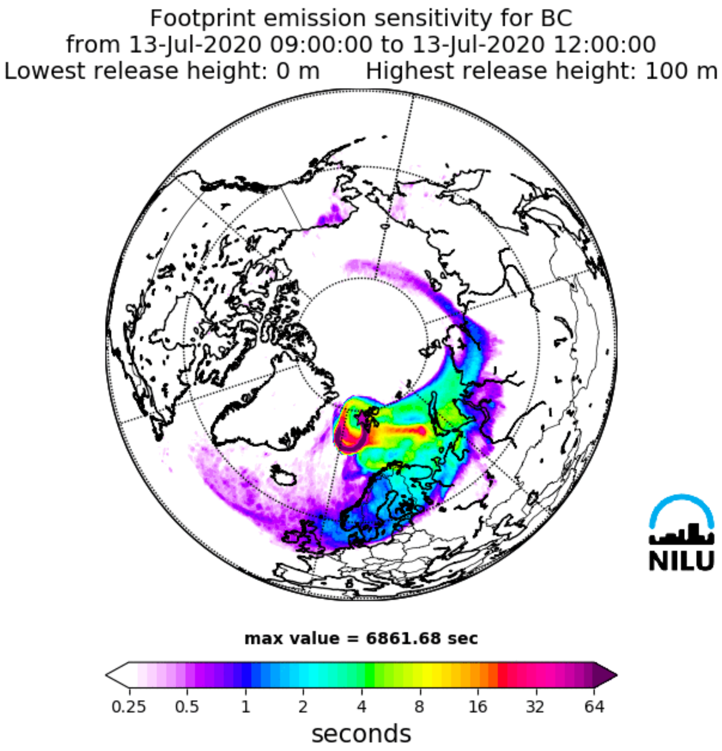
Transport, wet and dry deposition driven by ECMWF 0.5°x 0.5° hourly ERA5 winds

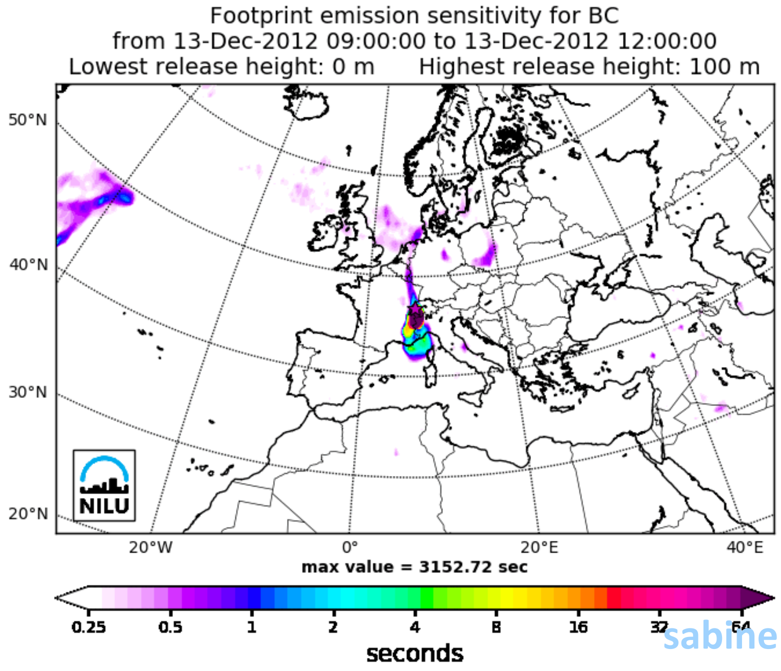
Retroplume mode simulating backward concentration

It gives a gridded output of 0.5°x 0.5°

SRM (s) * EI (kg m^{-2} s^{-1}) / ALT (m) = kg m^{-3}

By folding with emissions ➡ modelled concentrations





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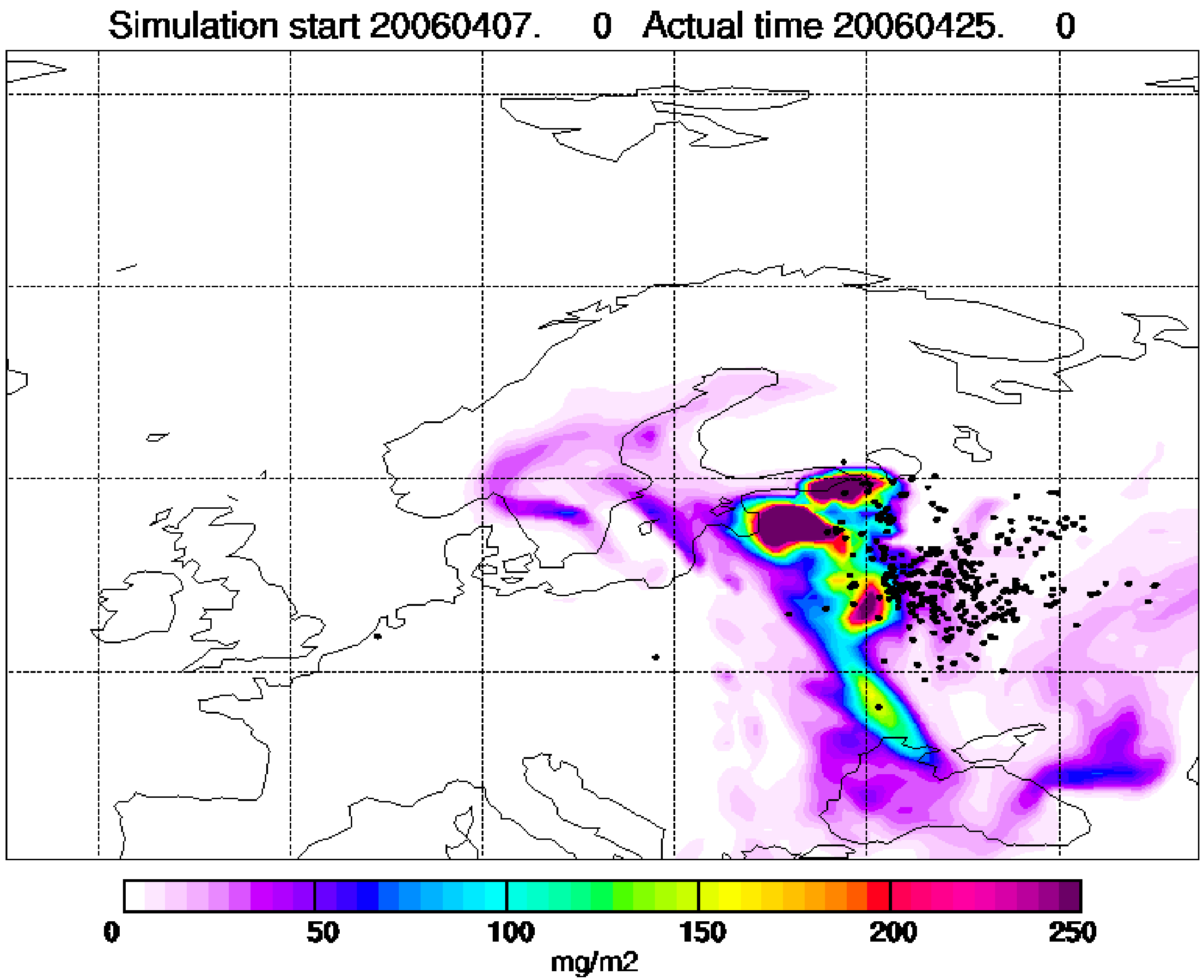
Transport of fire emissions into the European Arctic



Forward Perspective

Fire May 2006

Transport over 3-4 days

Agricultural land burned
Spring (beginning May)

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Transport of fire emissions into the European Arctic

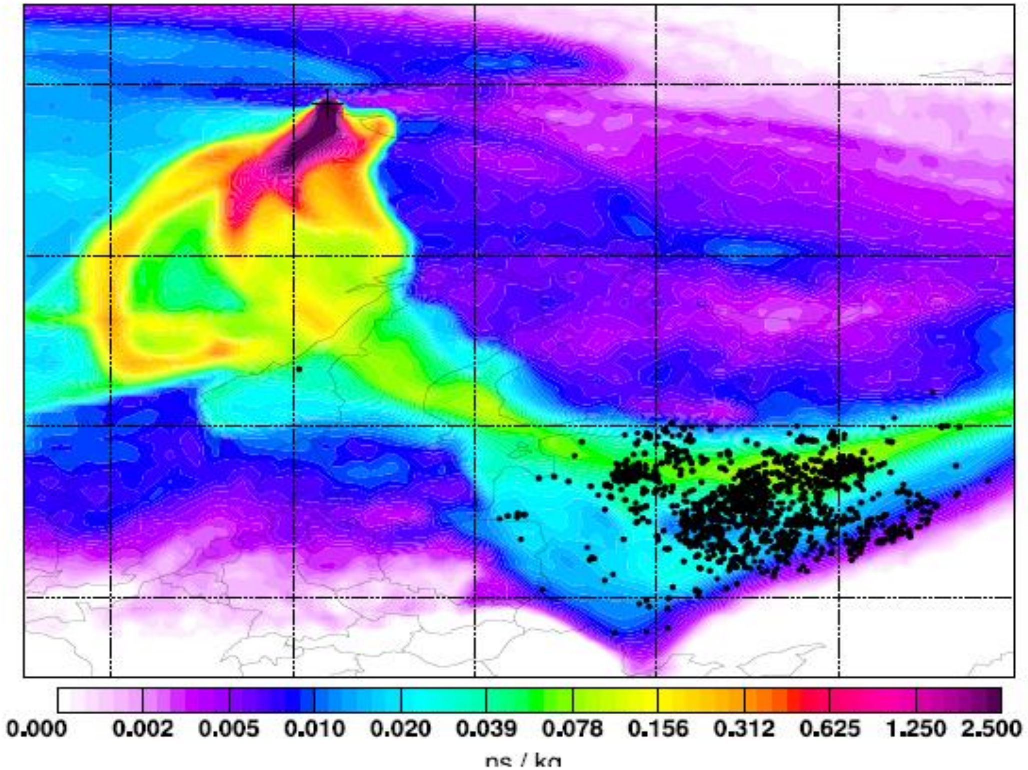

Figure 1: Potential emission sensitivity (PES) footprint map for air arriving at Zeppelin between 1 May 2006 at 10:14 UTC and 3 May 2006 at 8:38 UTC 2006. Black dots show MODIS fire detections on days when the footprint emission sensitivity in the corresponding grid cell on that day exceeded 2 ps kg^{-1}.

(Stohl, 2007)

Backward Perspective

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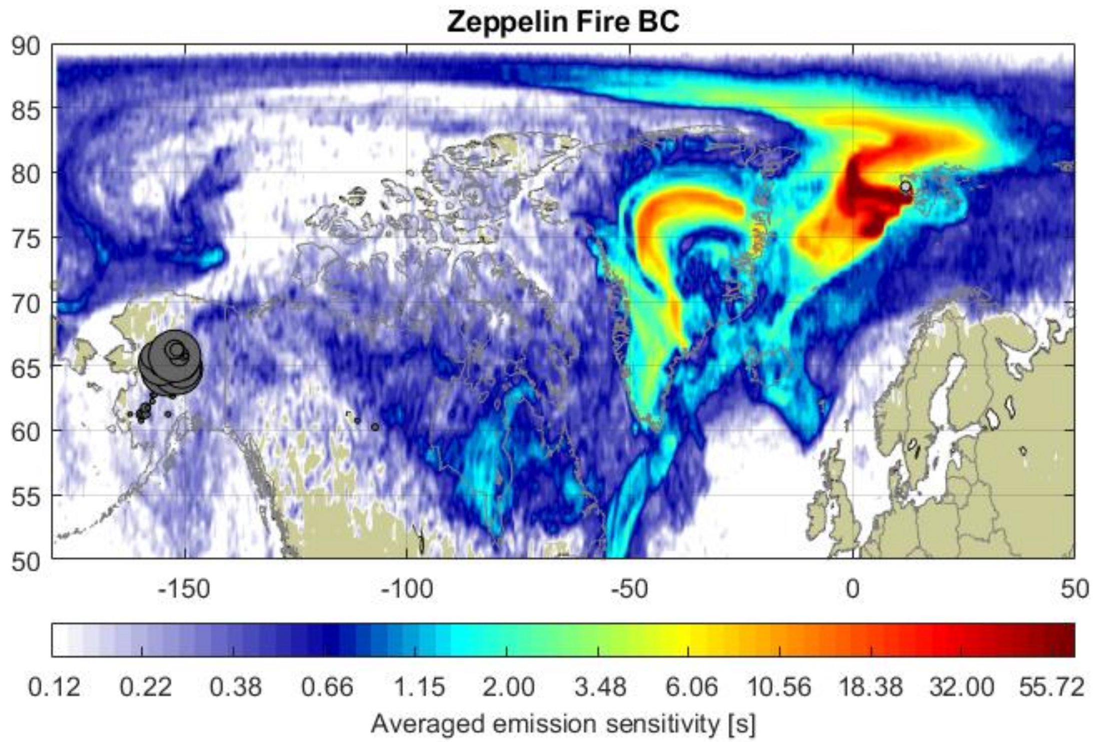
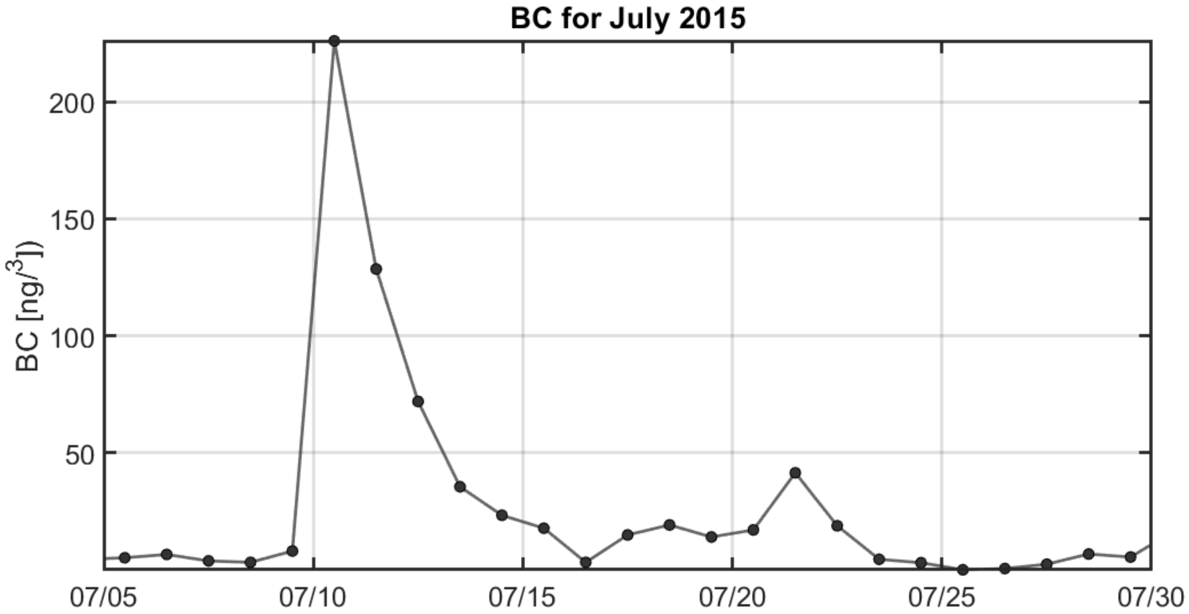
sabine.eckhardt@nilu.no

Alaskan wild fires, July 2015





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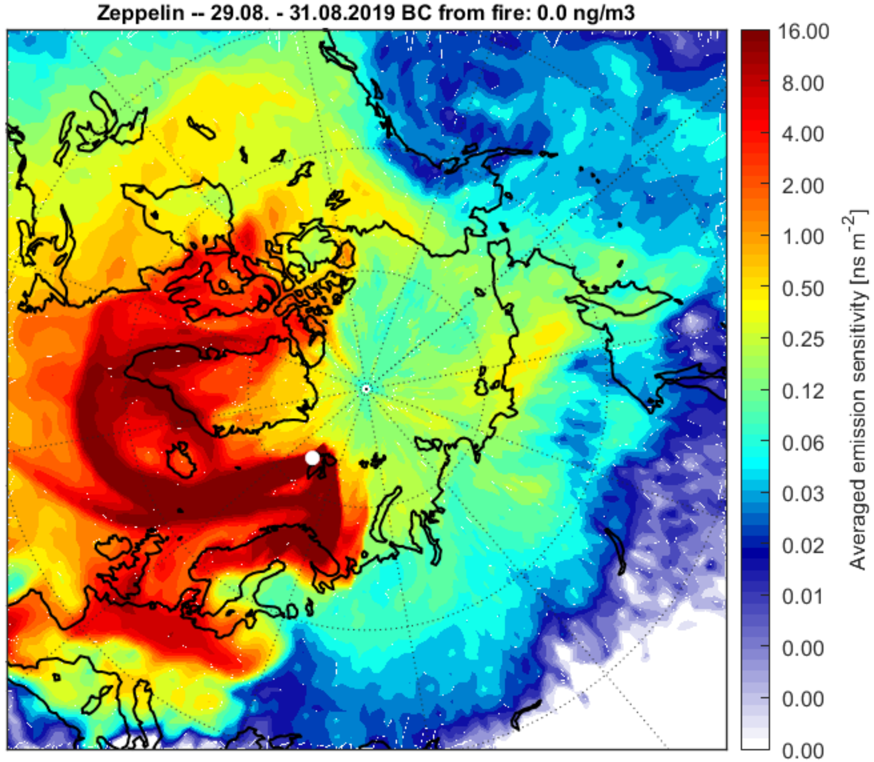
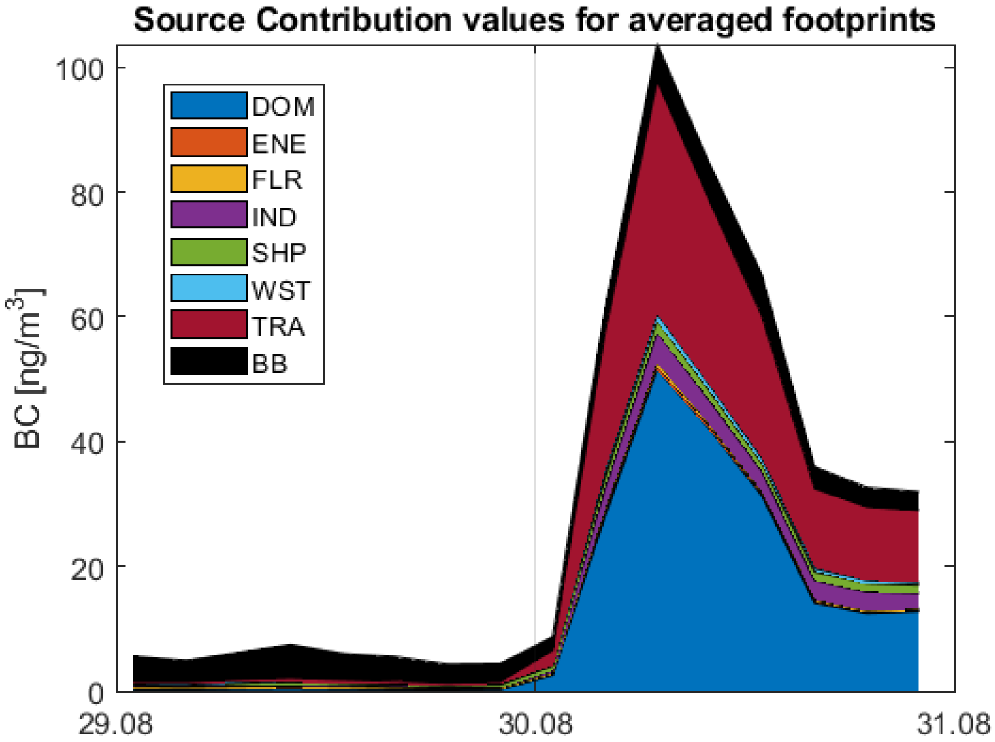
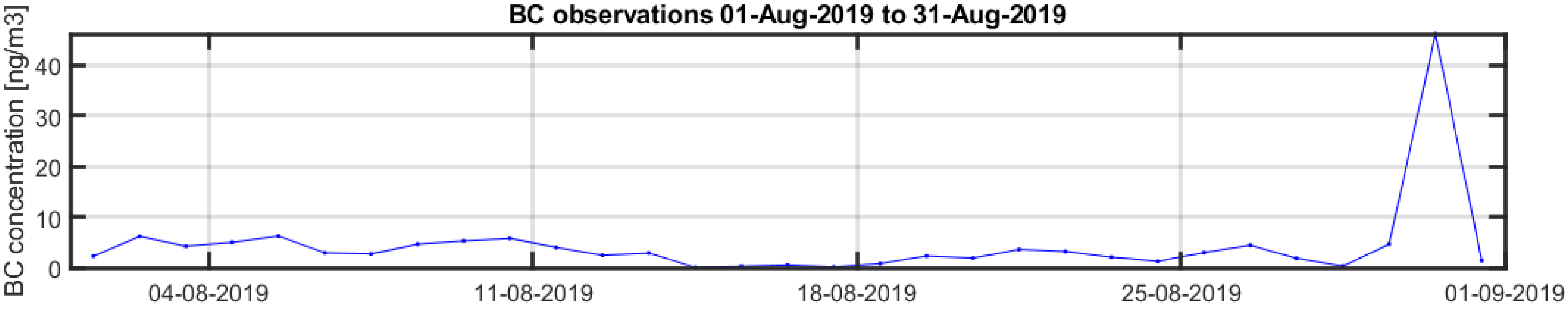
Purely anthropogenic episode, August 2019







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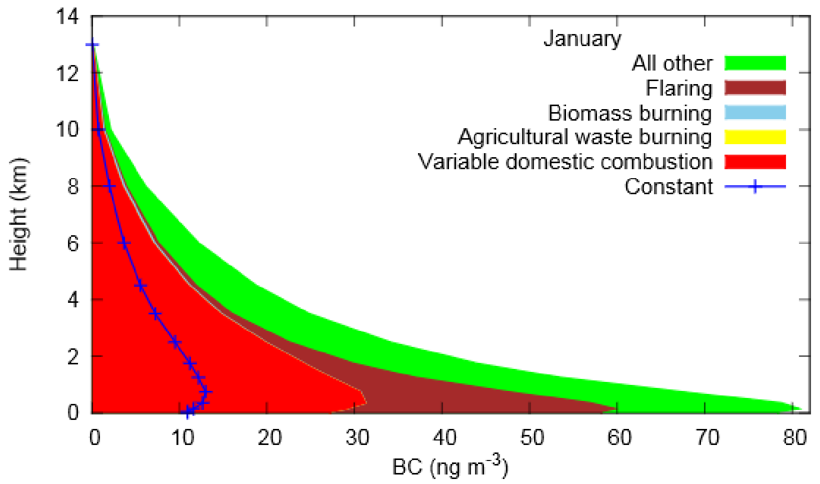
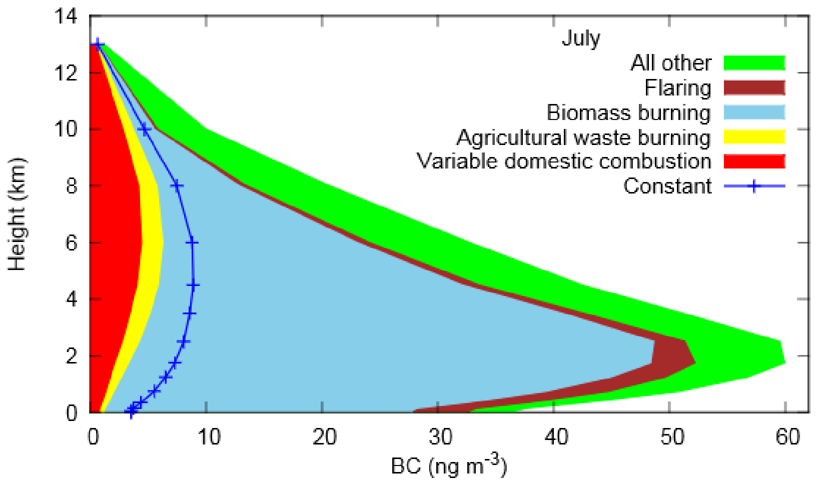
Variability for different seasons for BC at Zeppelin

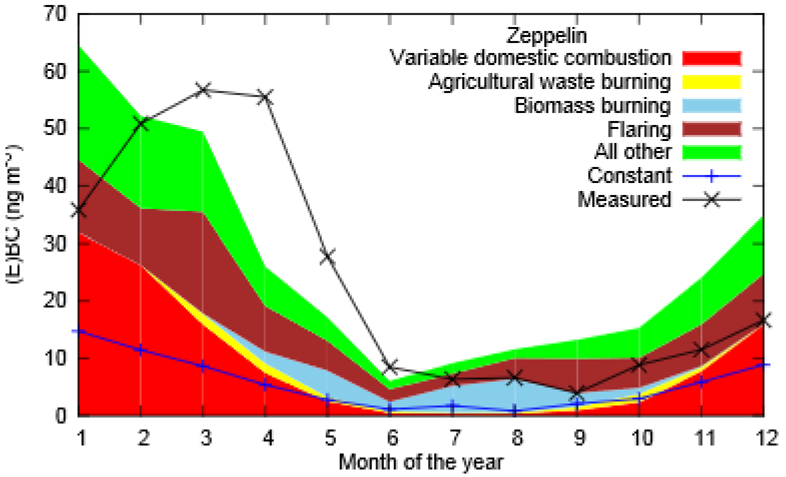


Anthropogenic emission (domestic burning, flaring) in Winter; Biomass burning in summer

High latitude sources, e.g. flaring has due to short transport distances great impact on the Arctic BC concentrations

The highest BC concentrations relate to summer BB are expected at a height of 2 km

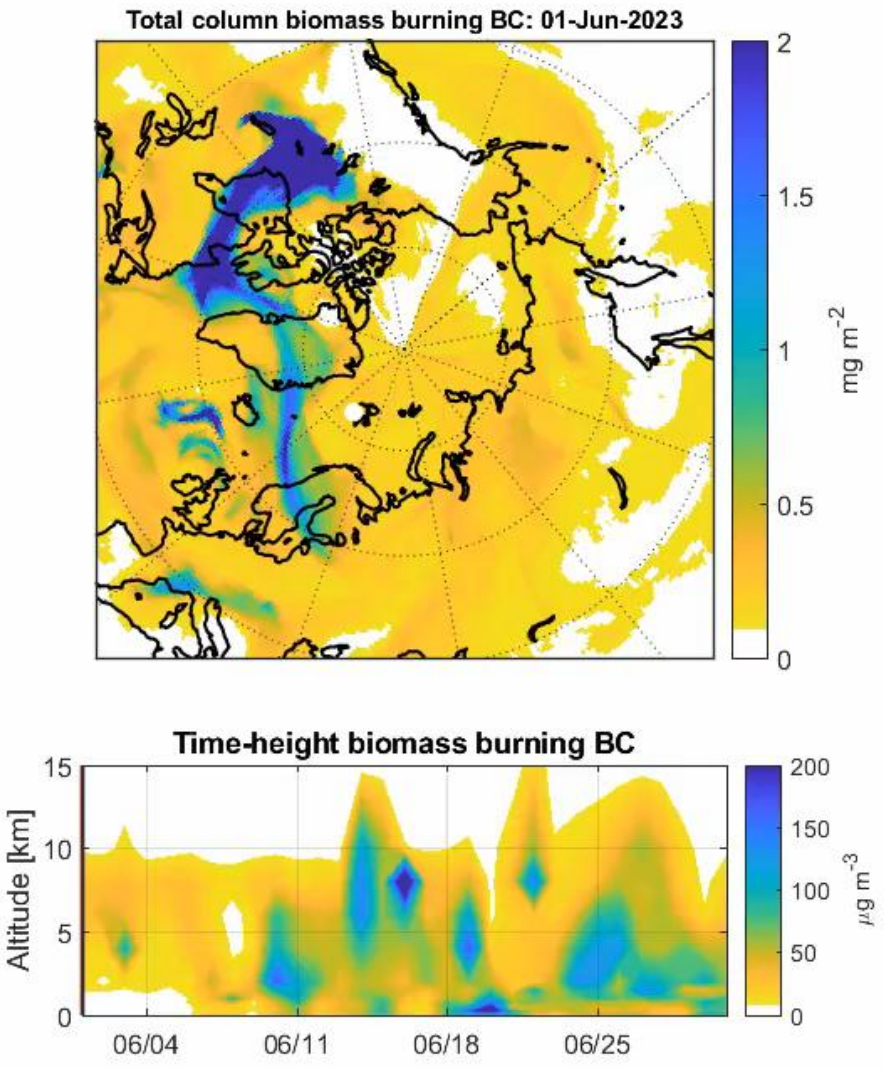


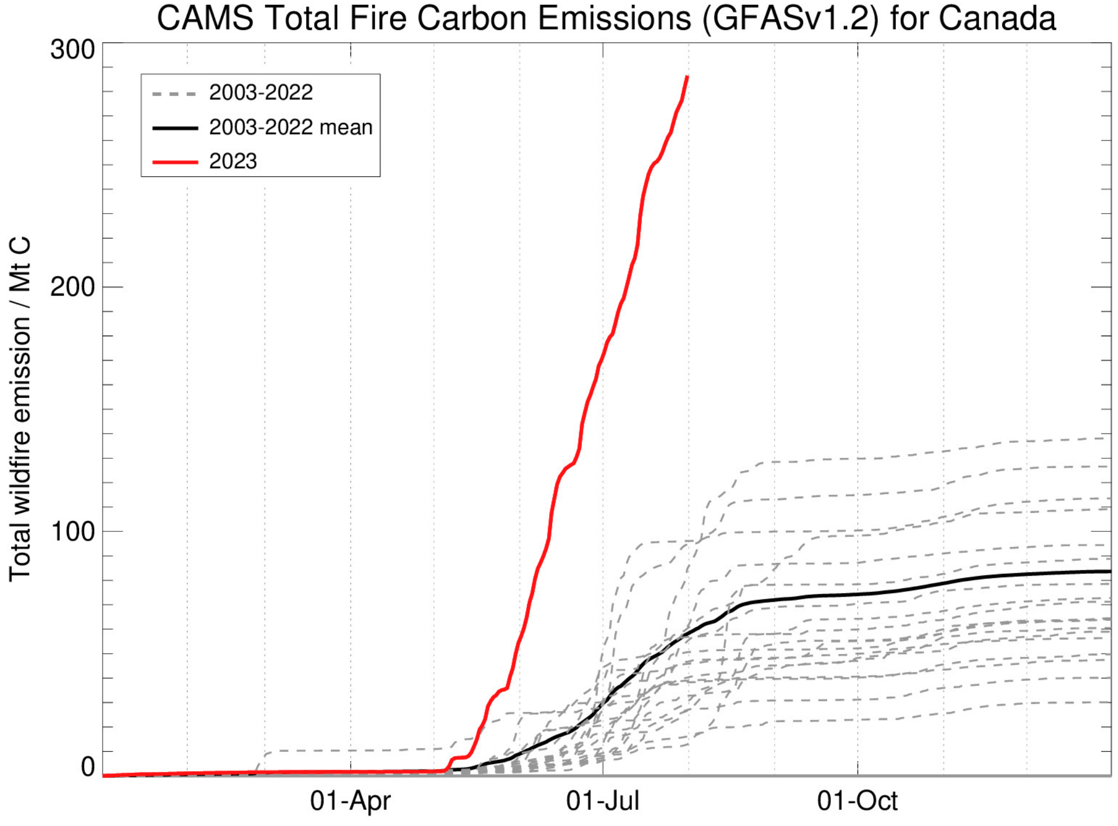


Stohl et al., 2013

nilu
sabine.eckhardt@nilu.no

June 2023, Canadian wild fires





PROGRAMME OF THE EUROPEAN UNION

IMPLEMENTED BY

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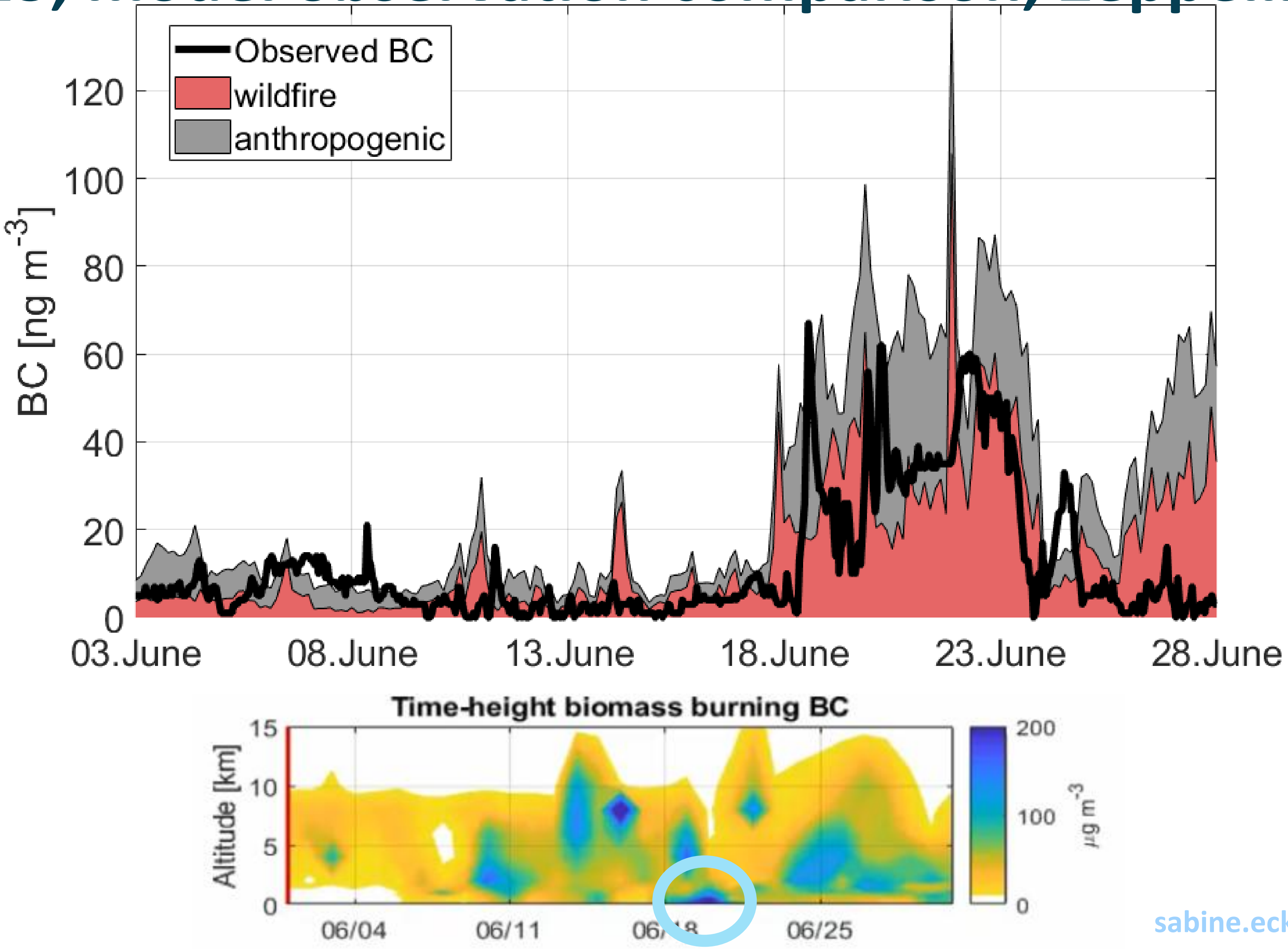
June 2023, model observation comparison, Zeppelin



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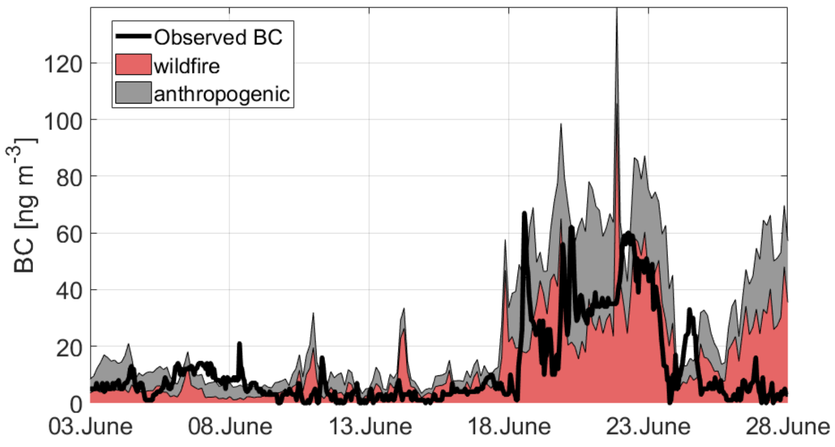
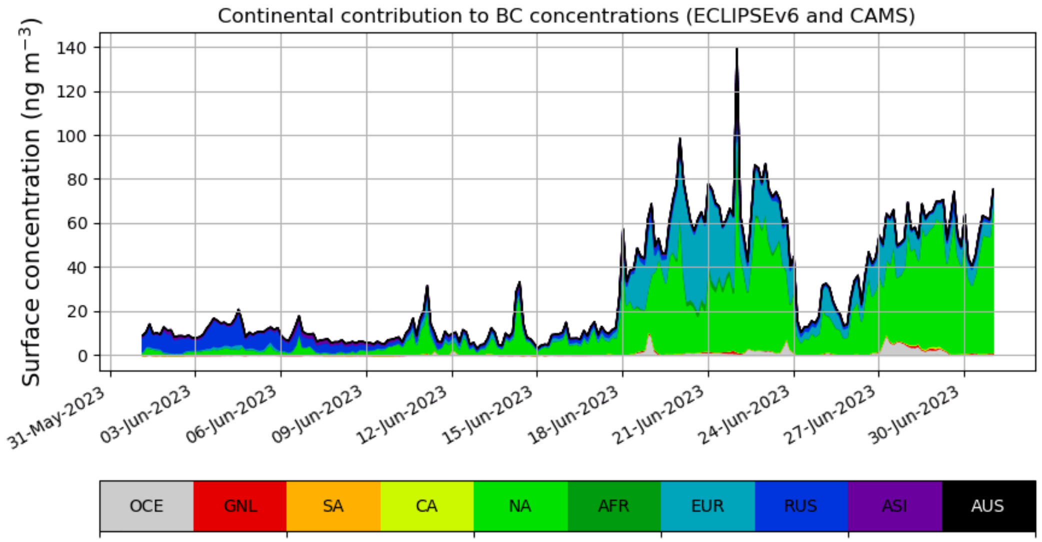
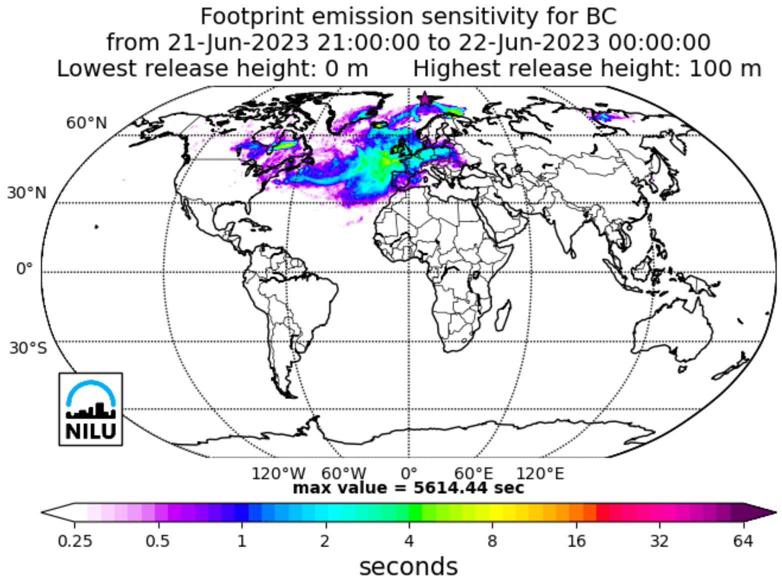
FLEXPART modelled source contribution and source region







Mix of Canadian wildfires and European anthropogenic emission

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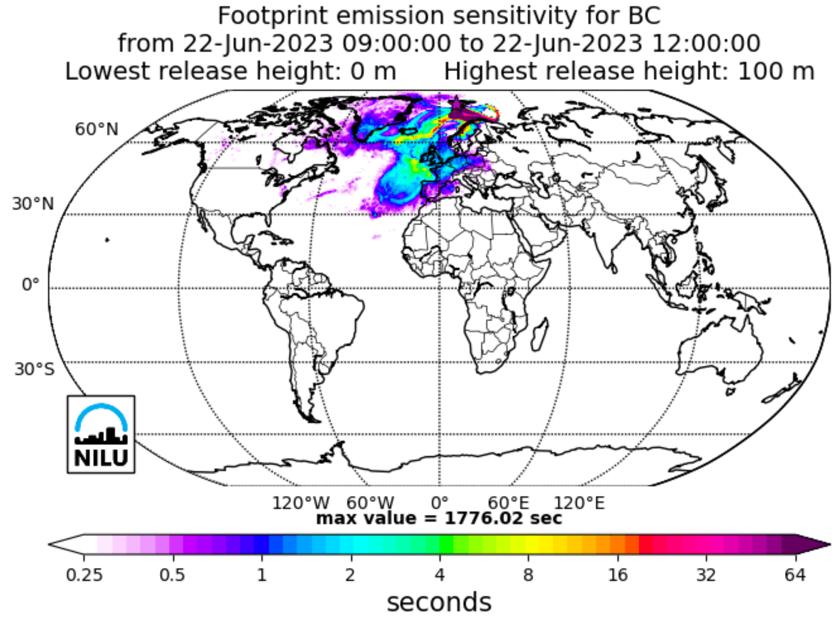
Service for obtaining FLEXPART analysis: ATMO ACCESS

FLEXPART products for BC measurements

For support and more information please submit a request here: https://flexpart-request.nilu.no/support

STATION YEAR MONTH PRODUCT

NO0042G | 2023 | June | Footprint | global | FIRST | -10 | PREV | NEXT | +10 | LAST | VIEW PLOT | SUBMIT



EU = 1776.02, AS = 0.37, NA = 5.46, SA = 0, AF = 0.27, AU = 0

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ATMO-ACCESS Virtual Access Portal

This portal provides you with access to the new online services developed in the ATMO-ACCESS project. This include access to:

Homeless data portal:
A portal for submission of measurement data from research projects, not associated to any long-term projects/networks nor sustainable data centres.

Footprint analysis tool for greenhouse gases, aerosols, reactive trace gases:
Model tools for interpretation of measurement data both measured at the ground and from aircrafts. You can request model runs to produce data products (e.g footprint, source

Developed by N. Evangeliou (ne@nilu.no) and S. Eckhardt (sec@nilu.no) (NILU) under ATMO-ACCESS, EU grant agreement No 101008004

The computations/simulations/[SIMILAR] were performed on resources provided by Sigma2 - the National Infrastructure for High Performance Computing and Data Storage in Norway

To download all data from this website in your pc, please use the following command: wget -r --no-parent --reject "index.html*" https://secondary-data-archive.nilu.no/atmo-access/[STATION CODE]

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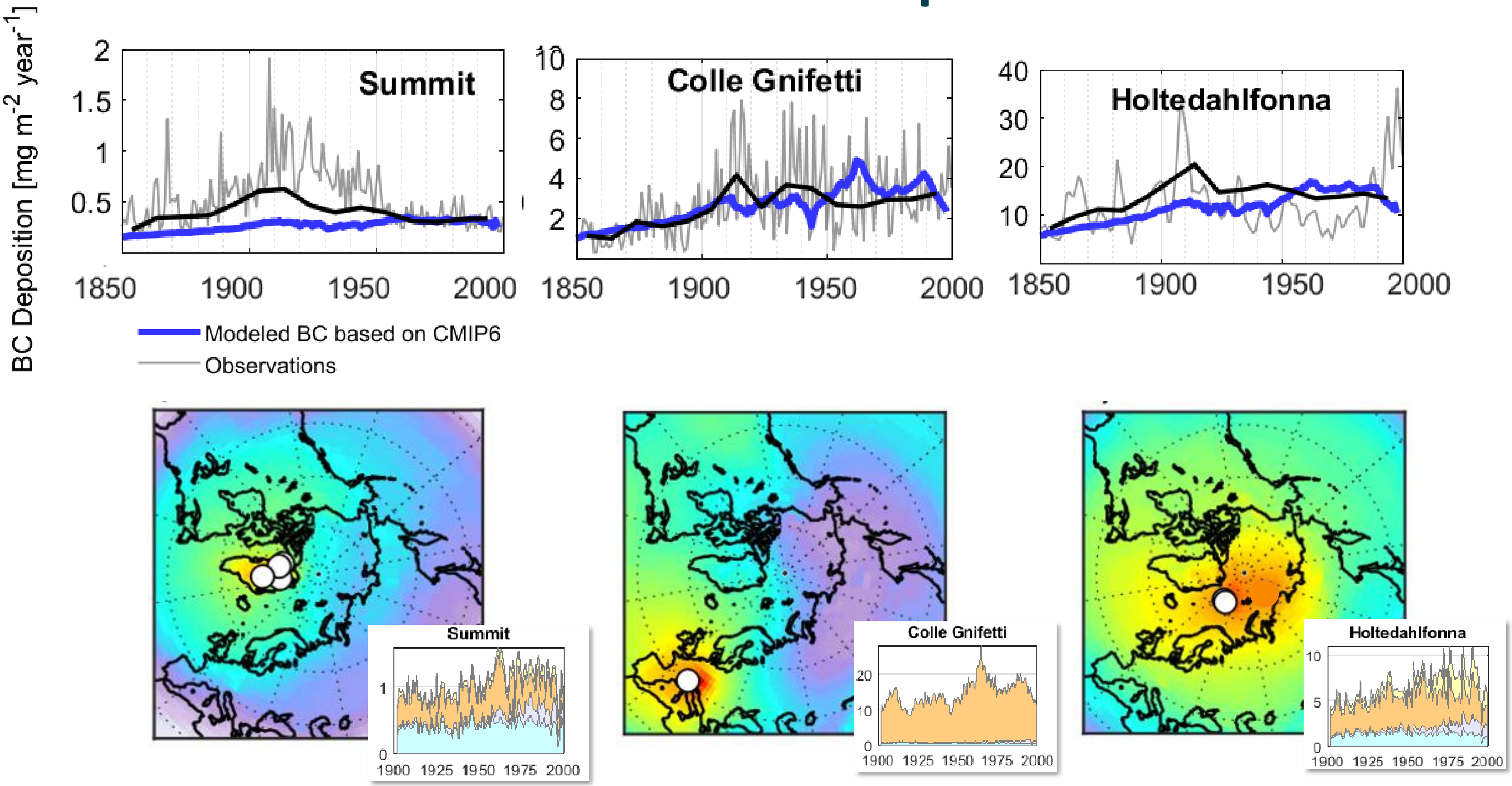
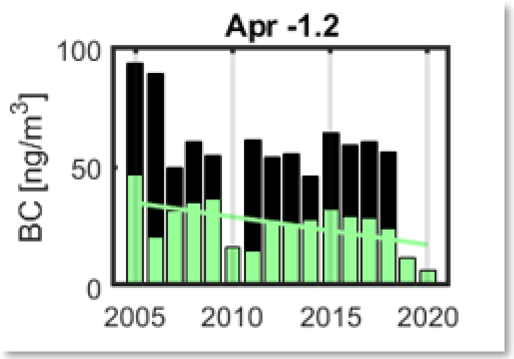
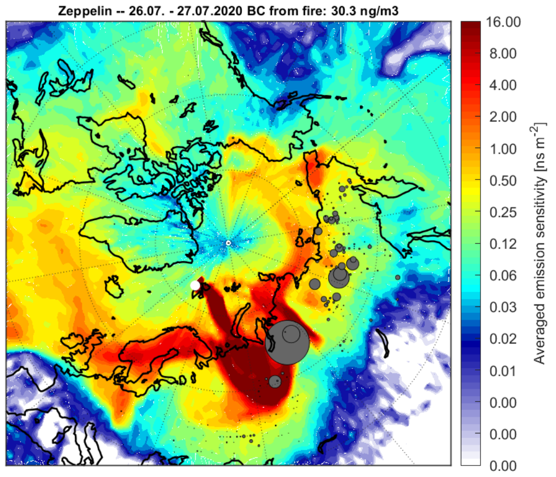
Observed and modelled BC deposition fluxes



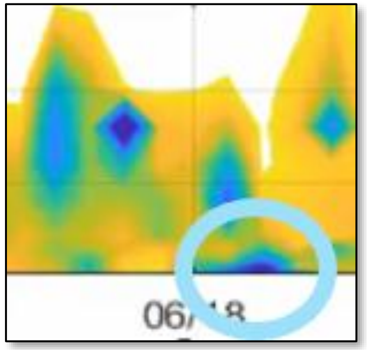
BC observed in Svalbard



How did the BC concentration develop over the years?



What are the most important sources?



Are all episodes captured at the surface?

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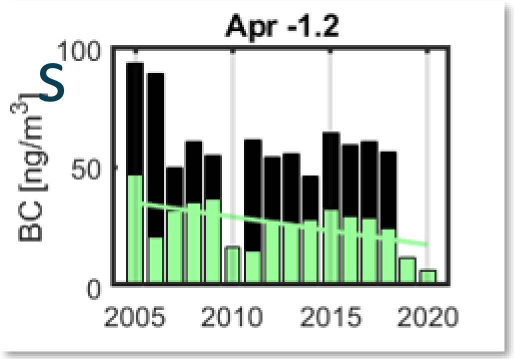
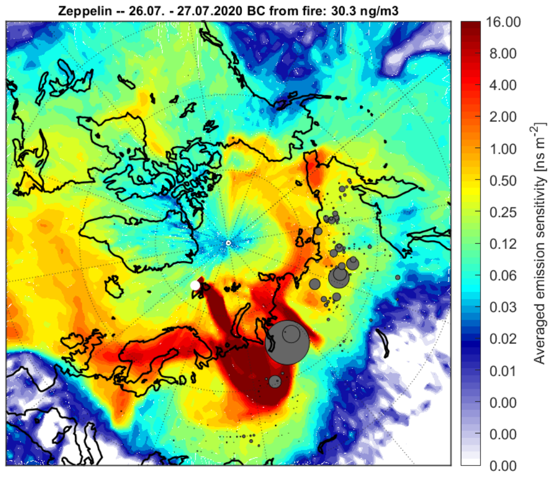
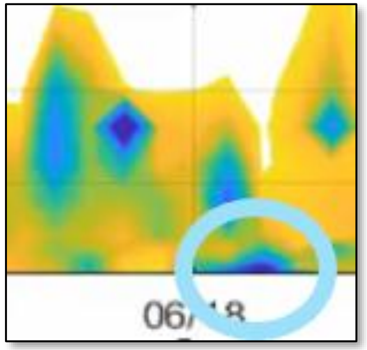
Black Carbon over Svalbard



Anthropogenic BC decreasing
Wildfire BC increasing

Siberia and Canada both important
Flaring and Scandinavian anthropogenic





Many surface episodes visible, but especially in summer aerosol arrive at higher altitudes

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sabine.eckhardt@nilu.no