

# Long-term decline of spring AOD in Ny-Ålesund

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# Arctic Haze: spring-time „air-pollution“ in the Arctic

Naming from J. Murray Mitchell 1956, pilot in Alaska

Mantra for decades: anthropogenic air pollution

Shaw 1981

Quinn 2007

But Warneke 2009: BB aerosol

But: “Poo-jok” named by Inuit at least since 1750

→ purely anthropogenic?

1750: 0,79 billion humans (18% Europe)

Steam engines by Th. Newcomen

Why Arctic aerosol are important

By photometry: decline

Sources and sinks?

Combination of different measurements

Photo:

By Jürgen Graeser

Extreme event, agricultural flaming May 2006

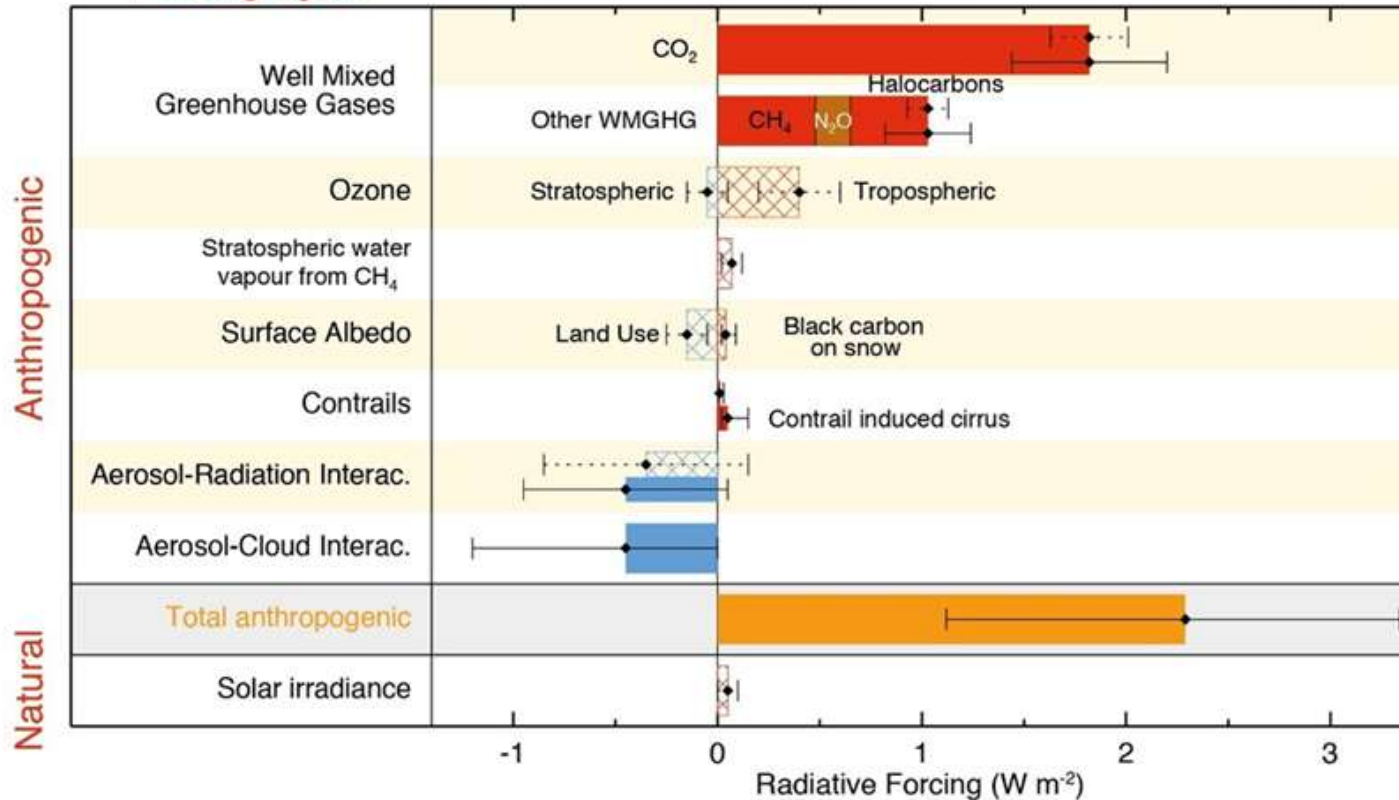
(Stohl 2006)



# Aerosol (clouds) one of the key unknown in climate models



Radiative forcing of climate between 1750 and 2011  
Forcing agent

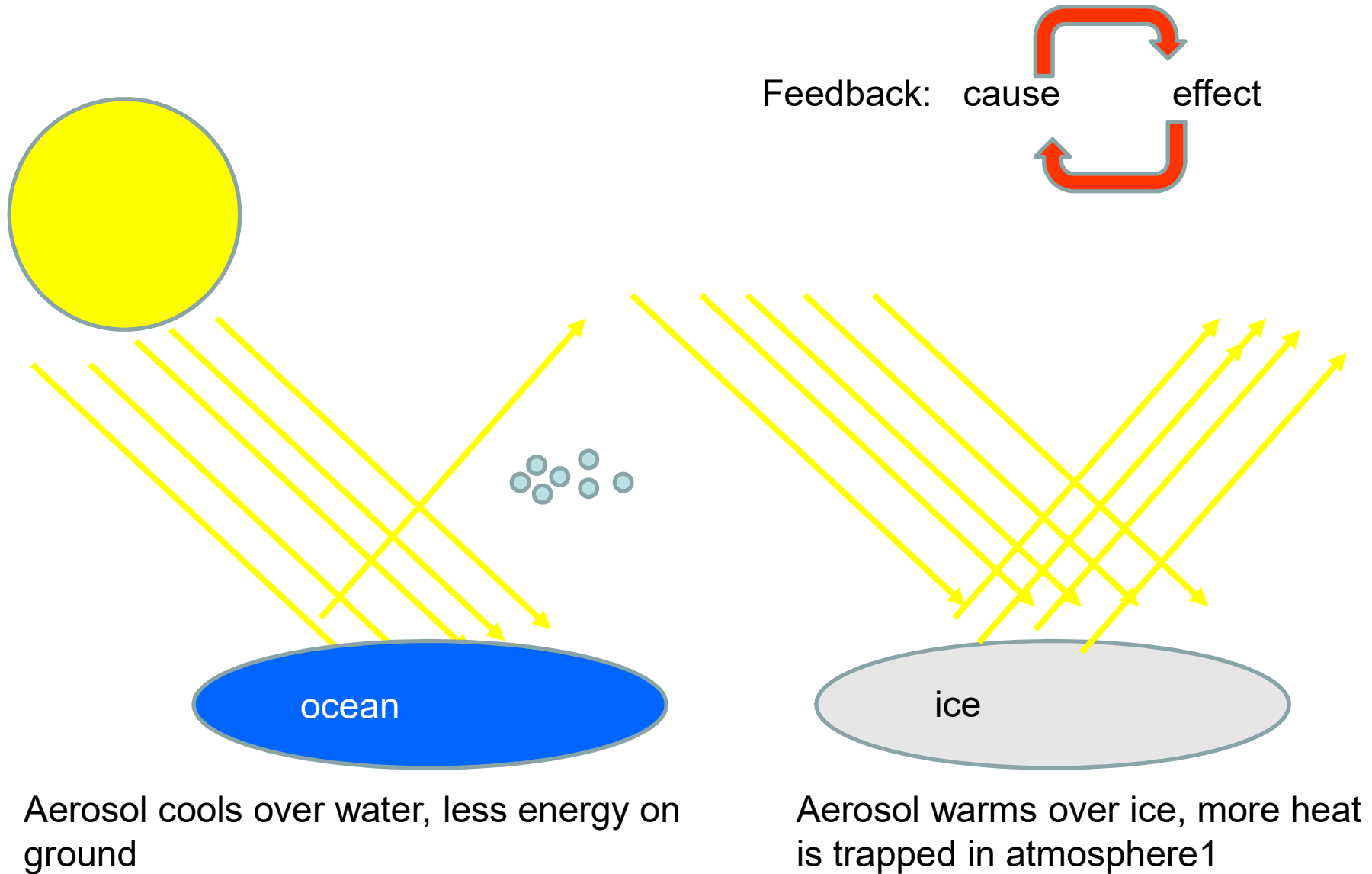


IPCC: 2018, p. 44:  
„Aerosols continue to contribute the largest uncertainty to the total radiative forcing estimate.”

We need:

- 1) Better, coordinated observations (clousre, satellites)
- 2) Close collaboration between modelers and experimentalists

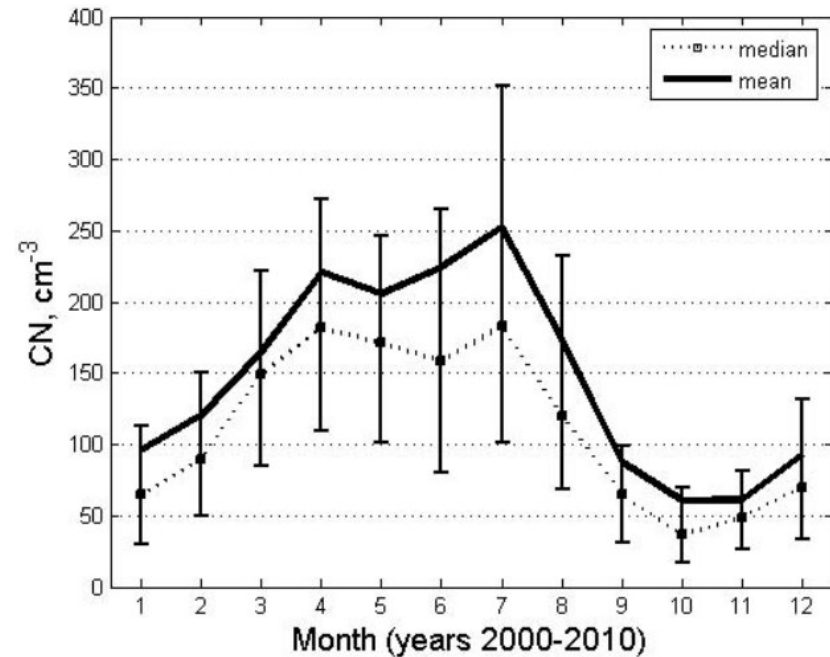
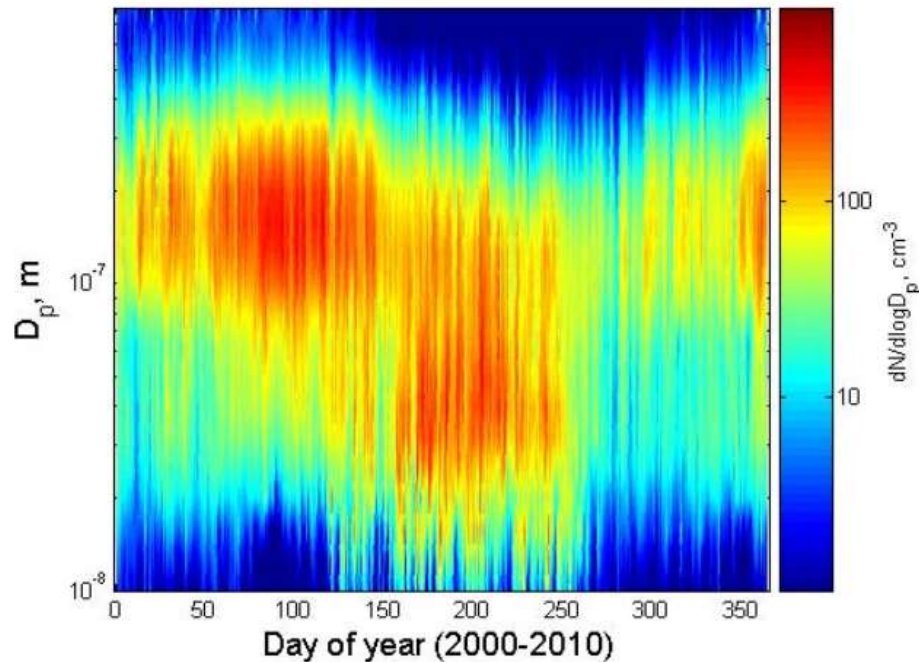
# Ice albedo feedback:



Aerosol rad. forcing should be more positive at the Poles.



# Properties of Arctic aerosol:



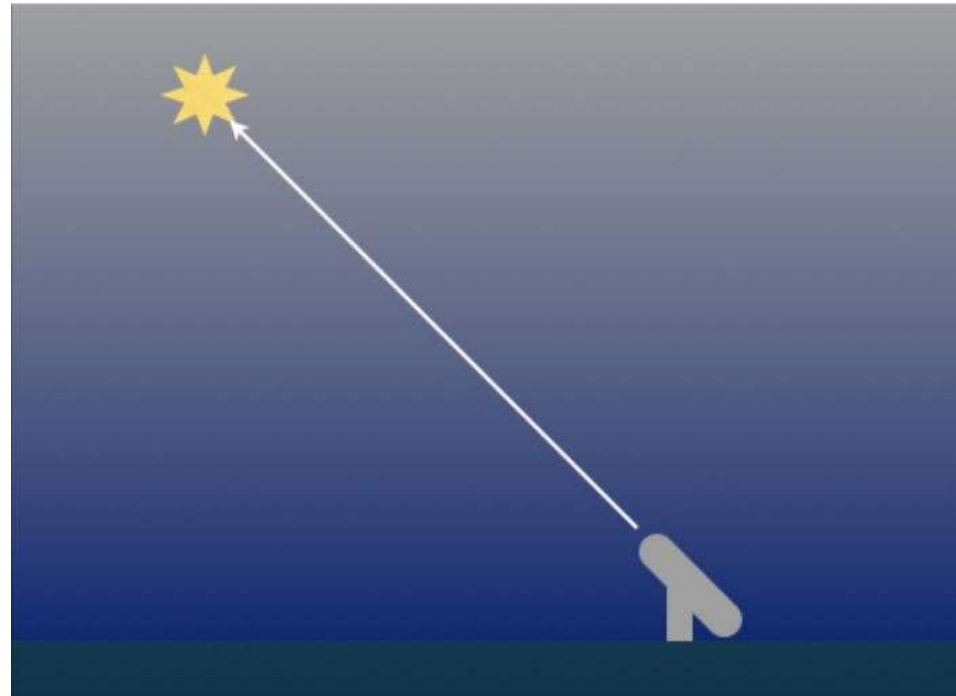
Arctic Haze in spring: because particles are larger, have larger scattering efficiency

Max. aerosol number concentration in summer due to marine aerosol

Tunved 2013, ACP: Arctic aerosol life cycle

Composition:  
Sulphates, organics, sea salt,  
few metals, BC

# The photometer



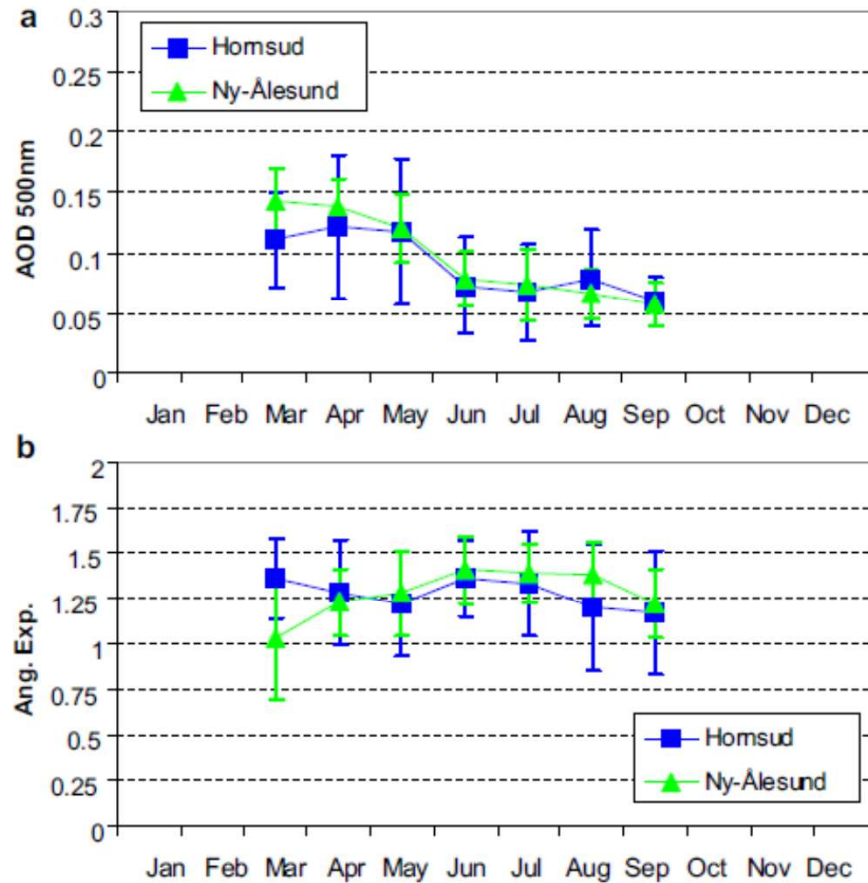
Less sunlight at ground: more aerosol

$$\text{AOD} = \int_0^{\infty} \alpha \, dz$$

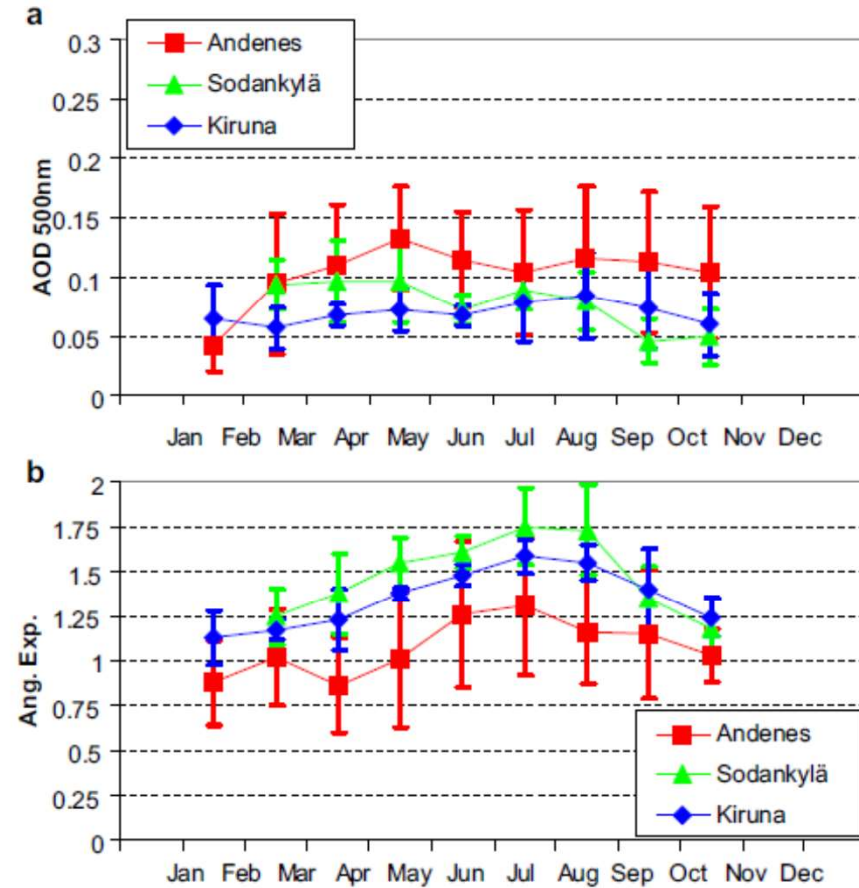
$\alpha$ : extinction coefficient [ $\text{m}^{-1}$ ]

# Typical AOD values from Toledano 2012 Atmos. Environm.

## Spitsbergen



## Scandinavia

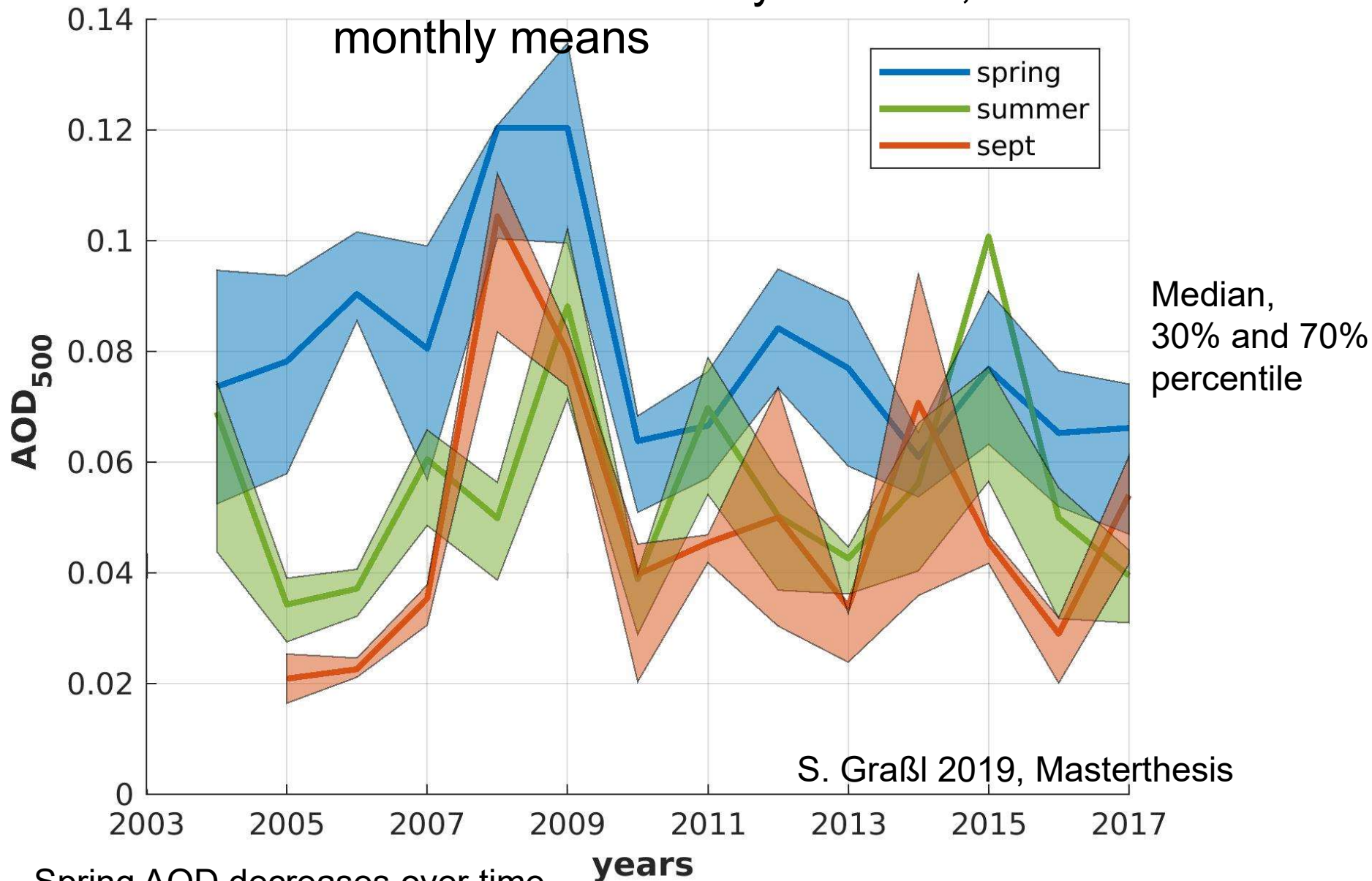


Spring: Arctic-AOD > N-European-AOD  
 No Haze in Scandinavia  
 No „easy“ direct pollution transport from Europe

Contrary: Eckhardt 2003 (Flextra, CO Tracer) „NAO + facilitates transport into Arctic“

Aerosol may have different pollution pathways than trace gases!

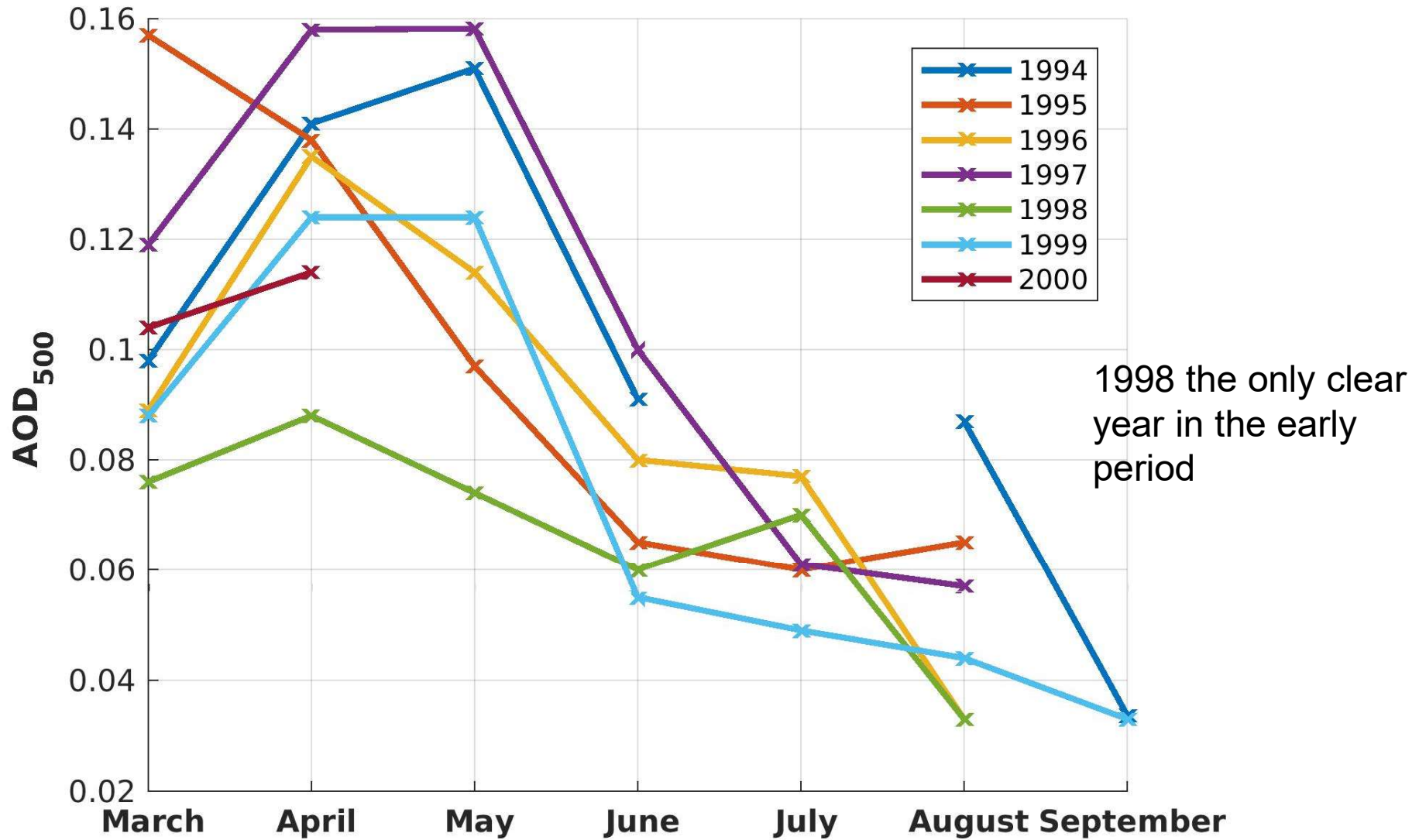
# AOD- Evolution in Ny-Ålesund, monthly means

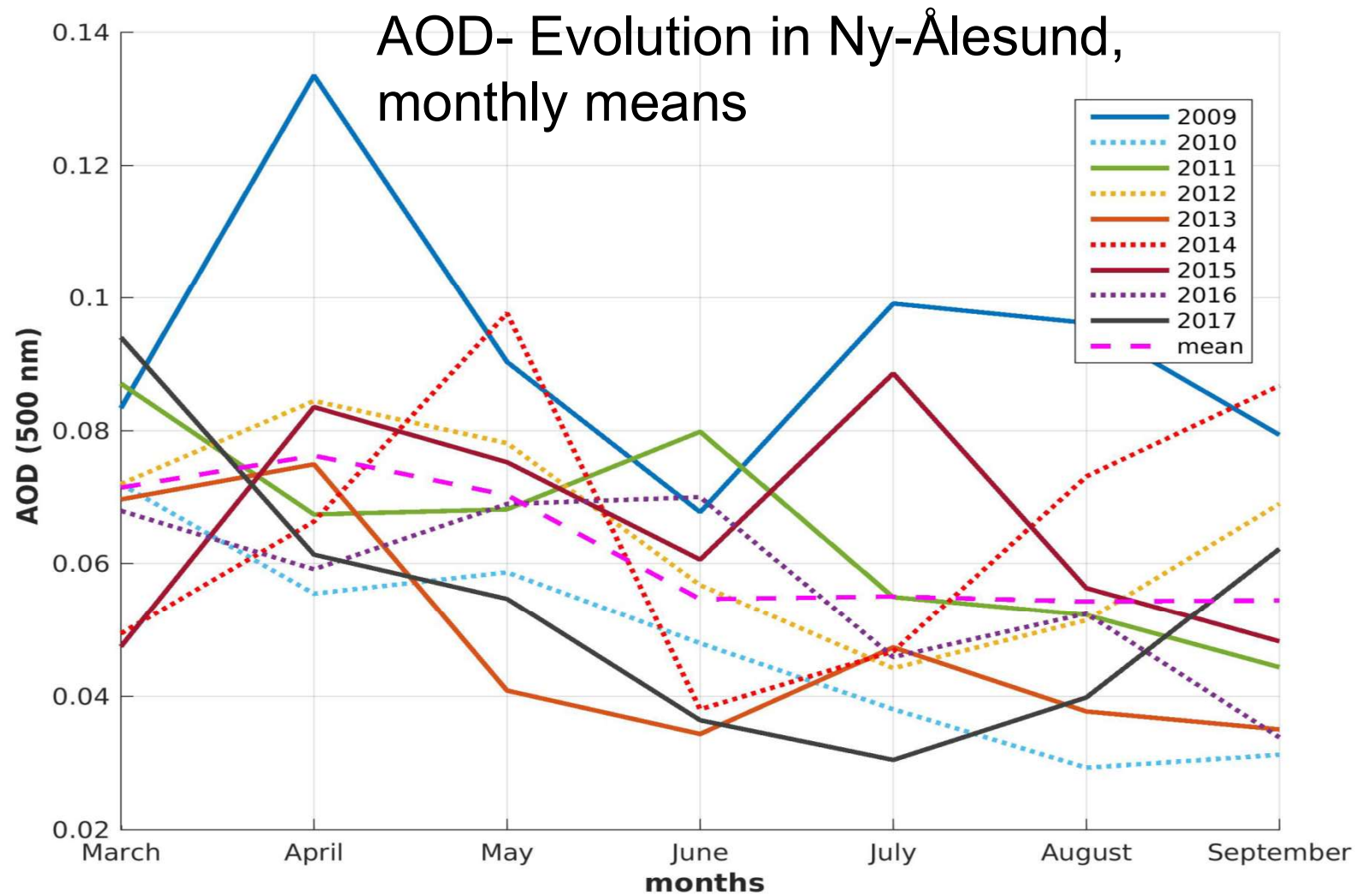


Spring AOD decreases over time  
→ annual run of AOD becomes flatter  
2009 was last polluted year    Generally high variability



Old date from Herber 2002:  
More Haze and longer Haze periods, (still in May!)



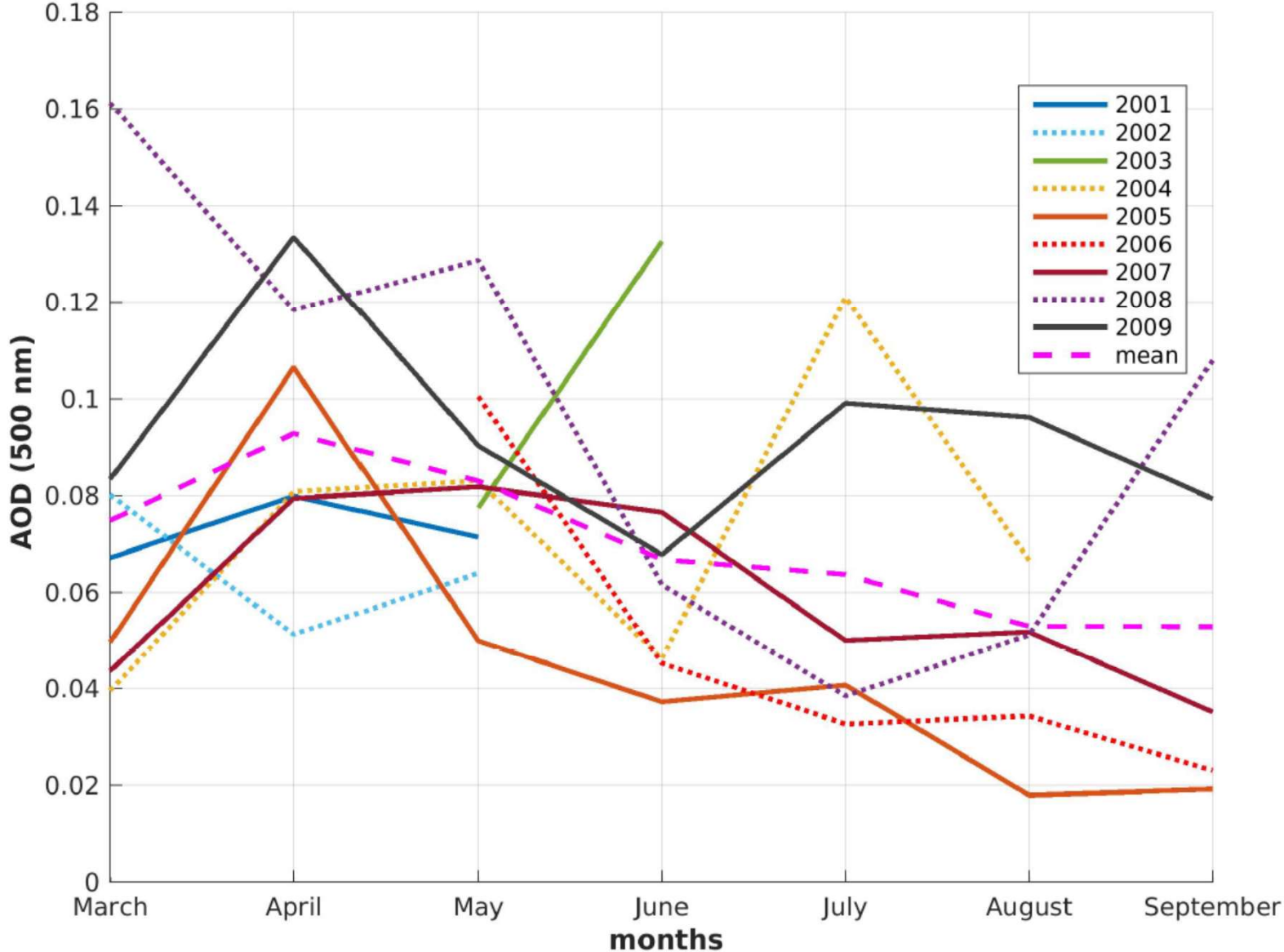


S. Graßl 2019, Masterthesis

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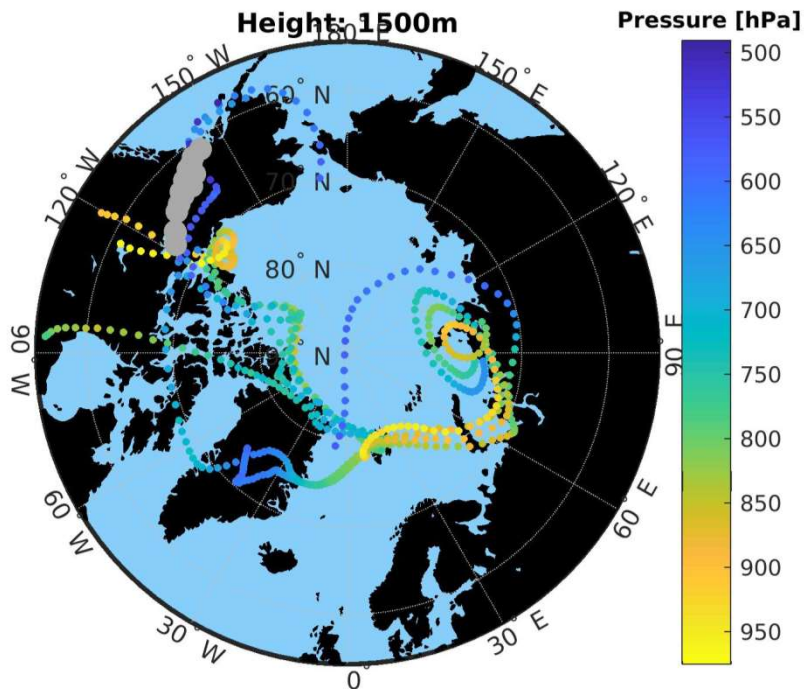
Jul- Sep 2009: Mt Sarychev

And the years in between, AOD is shrinking but with high variability



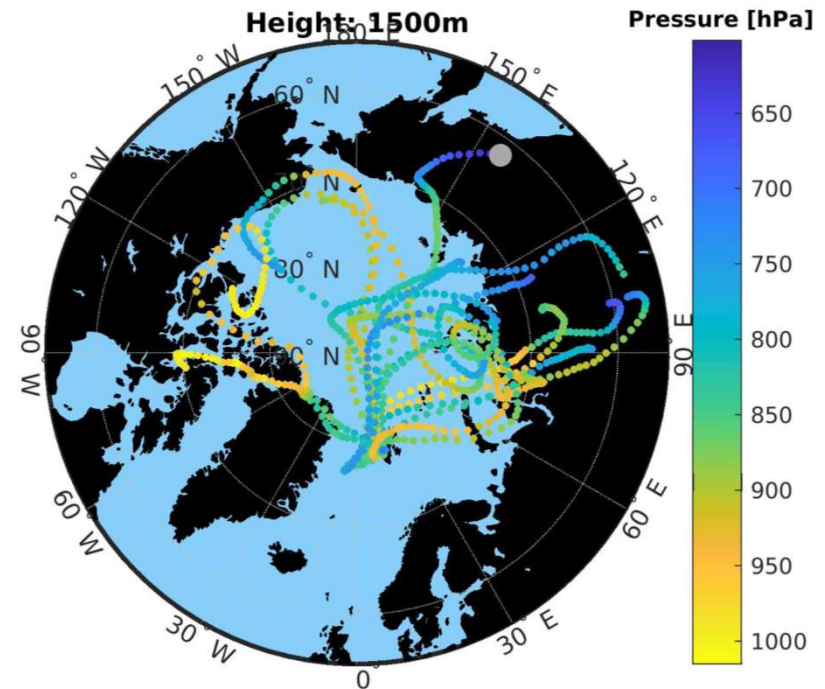
# Open questions: Pollution pathways

Graßl, 2019: Flextra with ERA-interim



Low AOD

(April 2013)

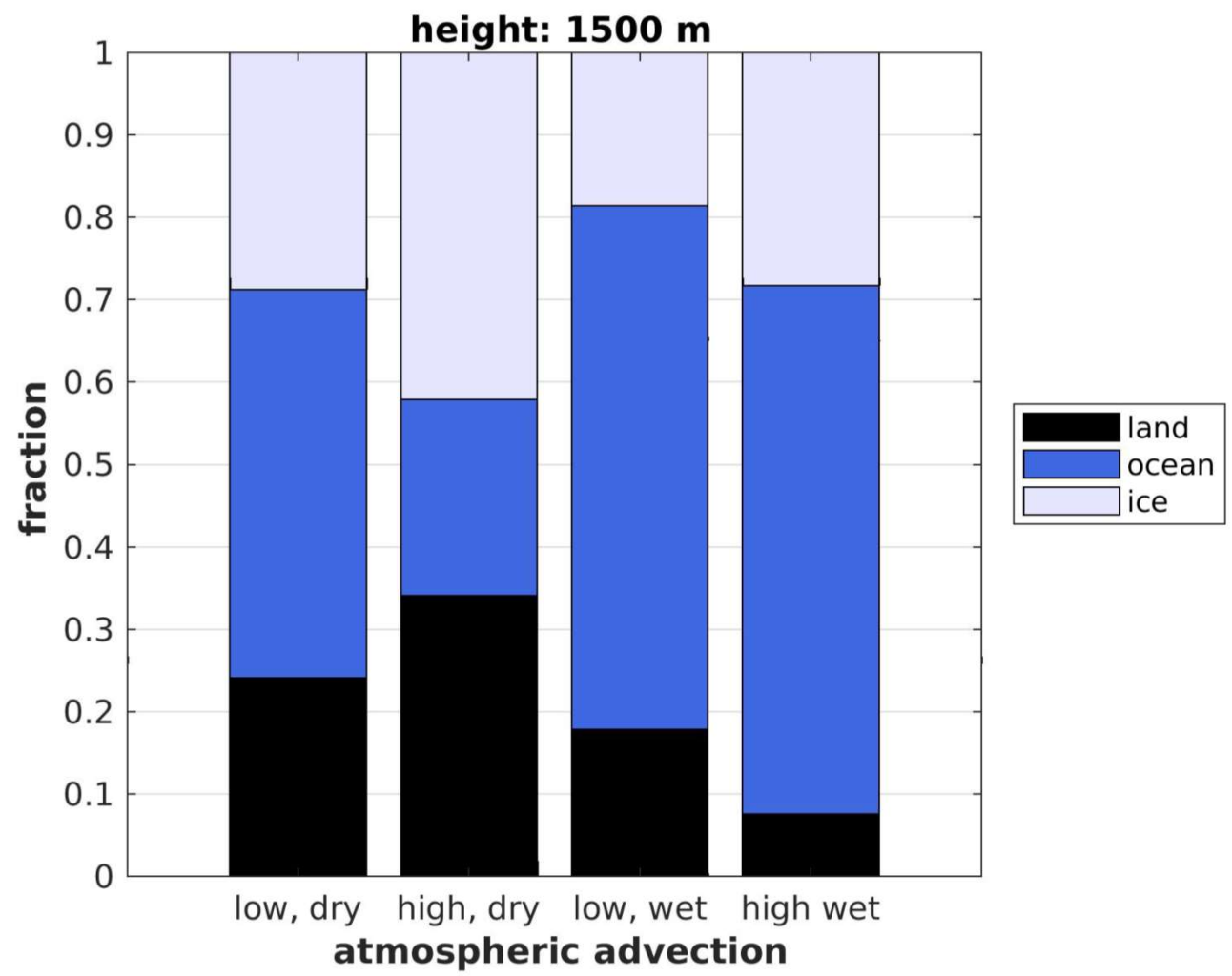


high AOD

5 days trajectories too short  
Reanalysis products show large differences  
Slightly higher AOD from Siberia



# Sea ice as reduced sinks?



High aerosol load due to sources and sinks

Sea ice: dry, stable BL  
less vertical mixing,  
longer aer. life-time

Best conditions for aerosol transport:  
Air over source regions in BL with enough wind speed  
Ascend of the air (higher wind speed, 5 days, less precipitation)  
Advection over sea ice

FLEXTRA 5 days (with photometer) Aprils 2013-2016

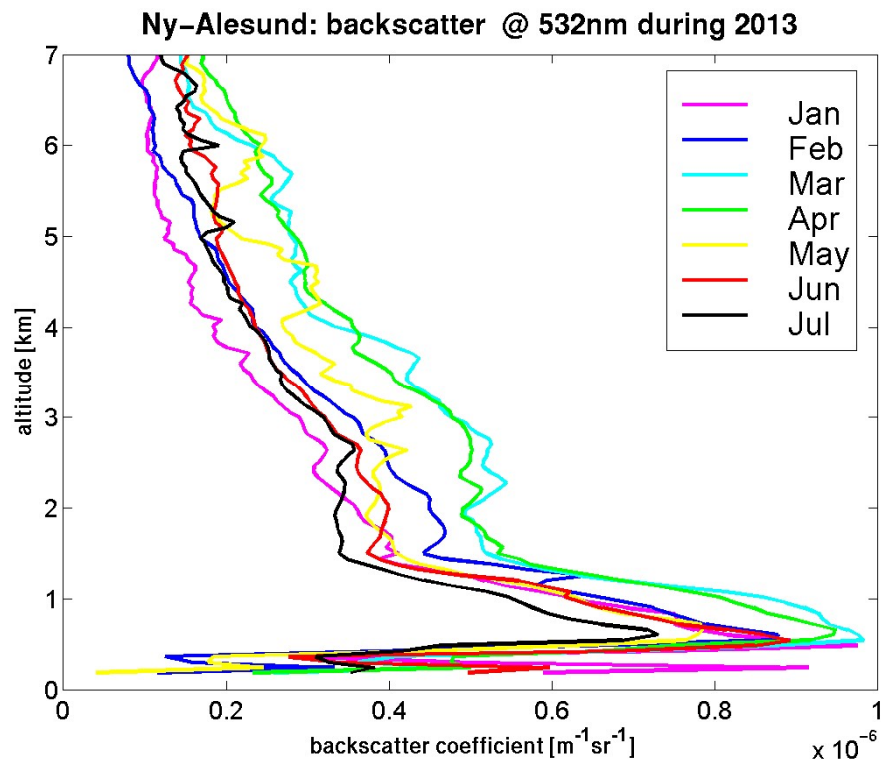
MOSAIC: coordinated observations with surrounding stations needed

# How does this fit into the pan-Arctic view?

Stone et al. 2014 Science of the anthropocene:

„BC concentrations decreased 50% from 1980 – 2010  
AOD(Barrow)  $\approx$  AOD(Alert) > AOD(Ny-Ålesund)  
trend in AOD in Barrow, Alert until 2010 not that clear“

→ **Svalbard might be the cleanest part of the Arctic**



Lidar:

Backscatter similar to extinction

Haze: turbid whole atmosphere

Shibata et al. 2018:, JGR  
Between 2014 – 2017  
Haze not more pronounced  
than summer aerosol

## Conclusions:

Arctic Haze declines – large interannual variability

Summer AOD is quite constant hence annual cycle becomes flatter

Arctic Haze will probably not disappear

Sources and sinks might equally important

The aerosol composition may change (more sea salt and marine, less long range pollution)

Svalbard: future of Arctic aerosol?



