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FINNISH METEOROLOGICAL INSTITUTE

Airborne measurements of ship emissions

H. Lihavainen, E. Asmi, J.-P. Jalkanen, A. Hyvärinen, T. Laurila, J. Walden, S. Saarikoski, J. Alanen*, E. Saukko* and R. Hillamo

Finnish Meteorological Institute, Helsinki, FI-00101, Finland
*Tampere University of Technology, Tampere FI-33101, Finland

Introduction

From the beginning of 2015 sulphur is to be removed from marine fuels and only the use of 0.1%S marine gas oil is allowed in SECAs according to the new EU directive (2012/33/EC), whereas shipping globally have to switch to 0.5%S fuel by 2020. There should exist methods how to monitor the fuel sulfur content of the ships.

Ship emission has also climate impacts besides health impavts. Ship missions of sulphate aerosol are thought to have significant climate cooling impacts, either directly by scattering incoming solar radiation or indirectly by acting as cloud condensation nuclei and thus modifying cloud albedo. On the other hand, black carbon (BC) aerosol can warm the climate when it absorbs solar radiation in the atmosphere as well as by reducing the surface albedo in snow and ice covered regions

Goals;
-to test the method to monitor marine fuel sulphur content
- make detailed measurements on aerosol chemical and physical properties

Methods

SKYVAN
Measurements :
Aerosol chemical composition (AMS)
SO_2 (Thermo Andesrsson, 43 i)
CO_2, CH_4, H_2O (Picarro)
Particle concentration (>3 nm) (UFCNC)
Particle size distribution (EEPS)
T, RH, P
Inlet optimized for aerosol measurements

Cessna 172
Measurements :
SO_2 (Thermo Andesrsson, 43 i)
CO_2, CH_4, H_2O (Picarro)
Particle concentration (>3 nm) (UFCNC)
T, RH, P

Cessna 172
Measurements :
SO_2 (Thermo Andersson, 43 i)
CO_2, CH_4, H_2O (Picarro)
No_x (Thermo Andresson,)
Particle concentration (>3 nm) (UFCNC)
T, RH, P

Figure 1 Measurement platforms

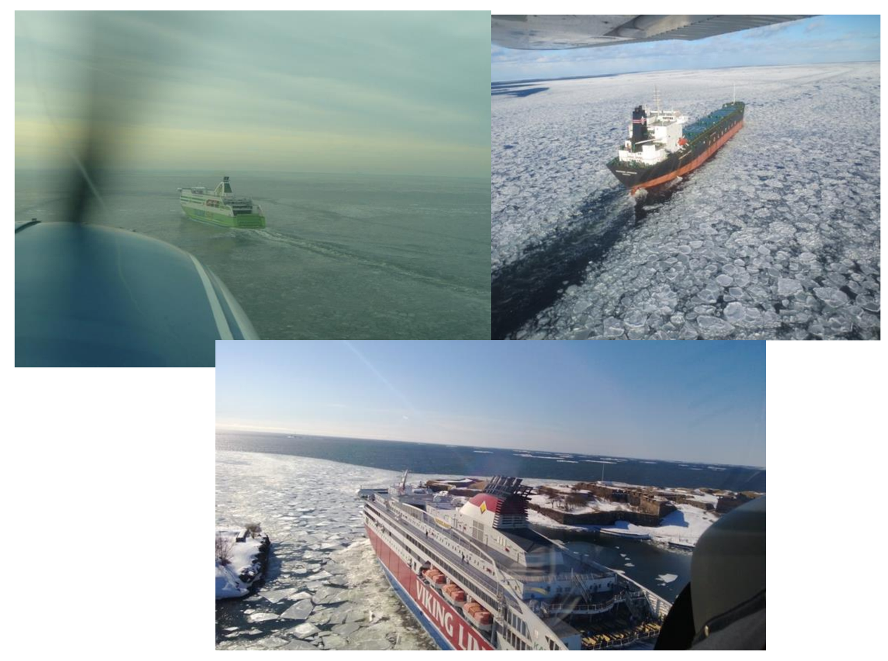

Figure 2: Measurement targets; random ships on Gulf of Finland, close to Helsinki

Fuel sulphur content was estimated with relation [1]:

$$S[\%] = \frac{c(SO_2)[ppb]}{c(SO_2)[ppb]} \cdot \frac{32}{12} \cdot 0.87 \cdot 100 = \frac{c(SO_2)[ppb]}{c(SO_2)[ppb]} \cdot 0.232$$

Results

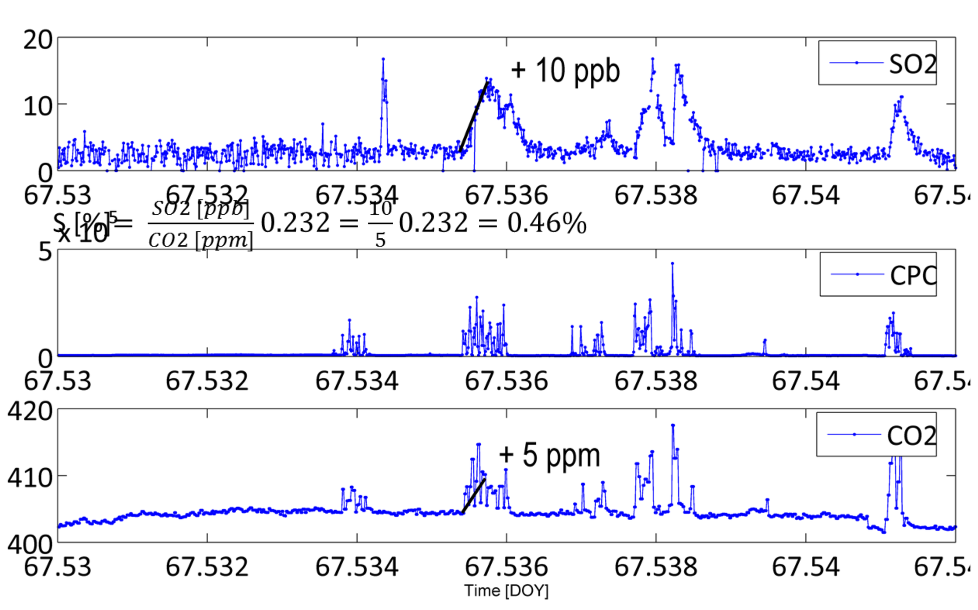

Figure 3 testing of the monitoring method with Cessna

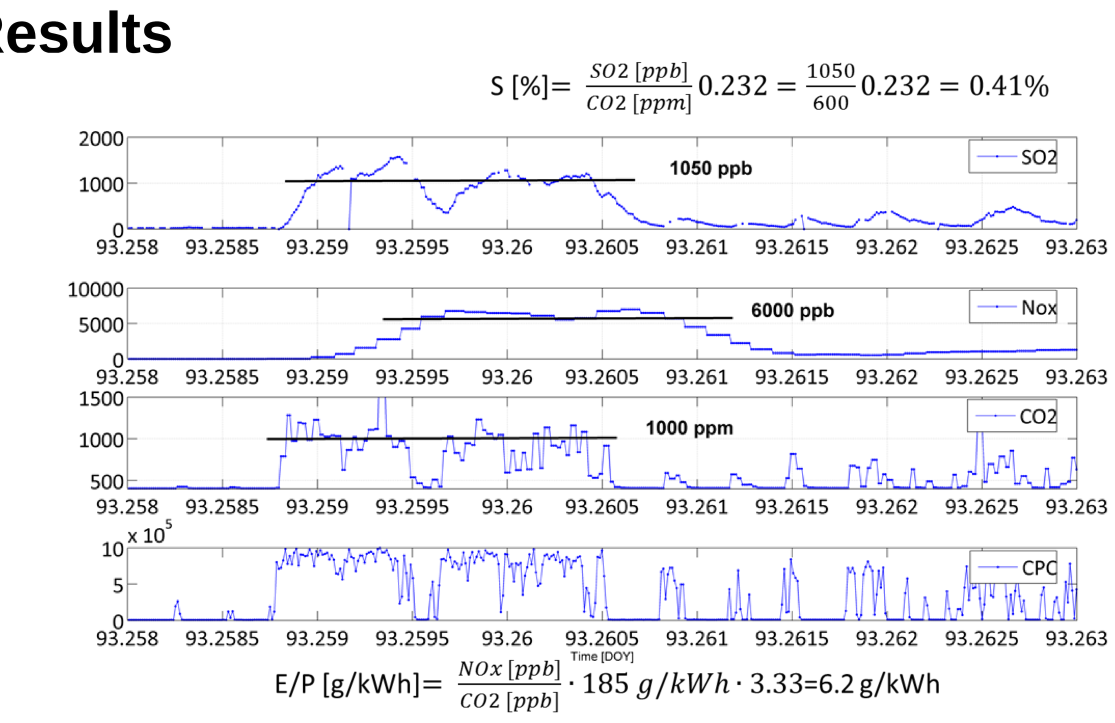

Figure 4 testing of the monitoring method with helicopter

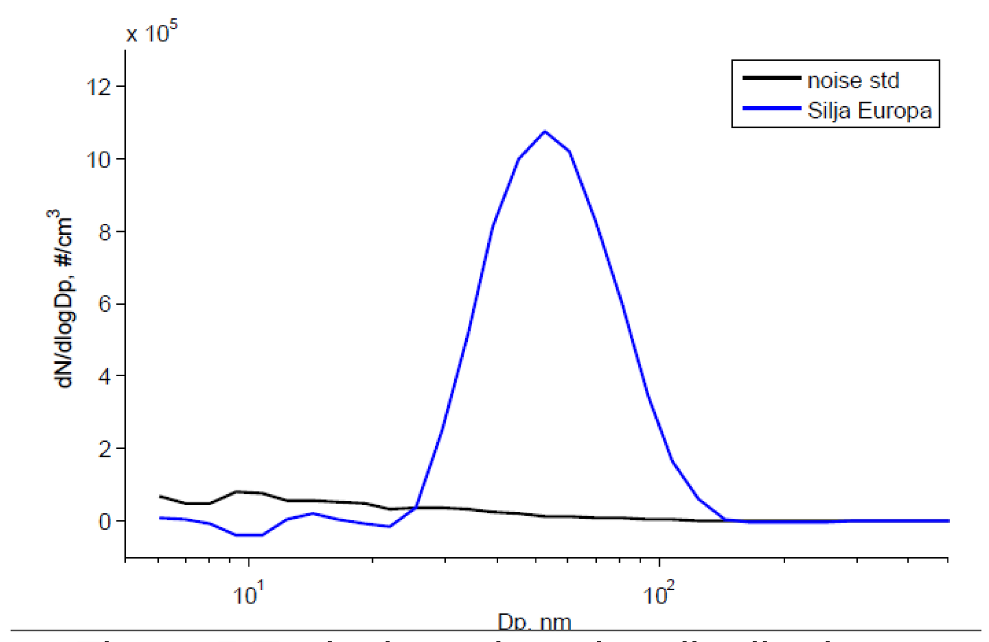

Figure 5 Typical number size distribution measured with Skyvan

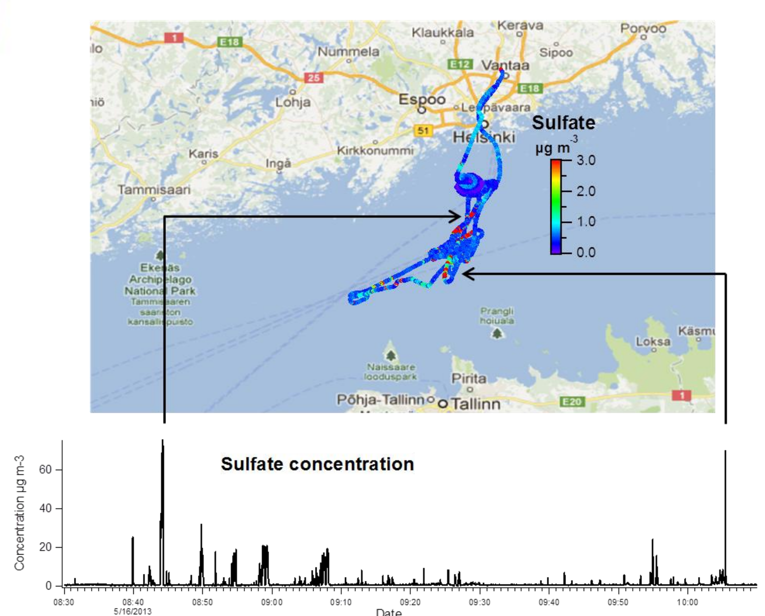

Figure 6 The concentration of sulfate on the flight path of Skyvan on May 16, 2013 (upper figure) and the corresponding time trend for sulfate. Black arrows point the locations of the highest sulfate concentrations (shown by red dots). Sulfate concentrations were measured by the SP-AMS.

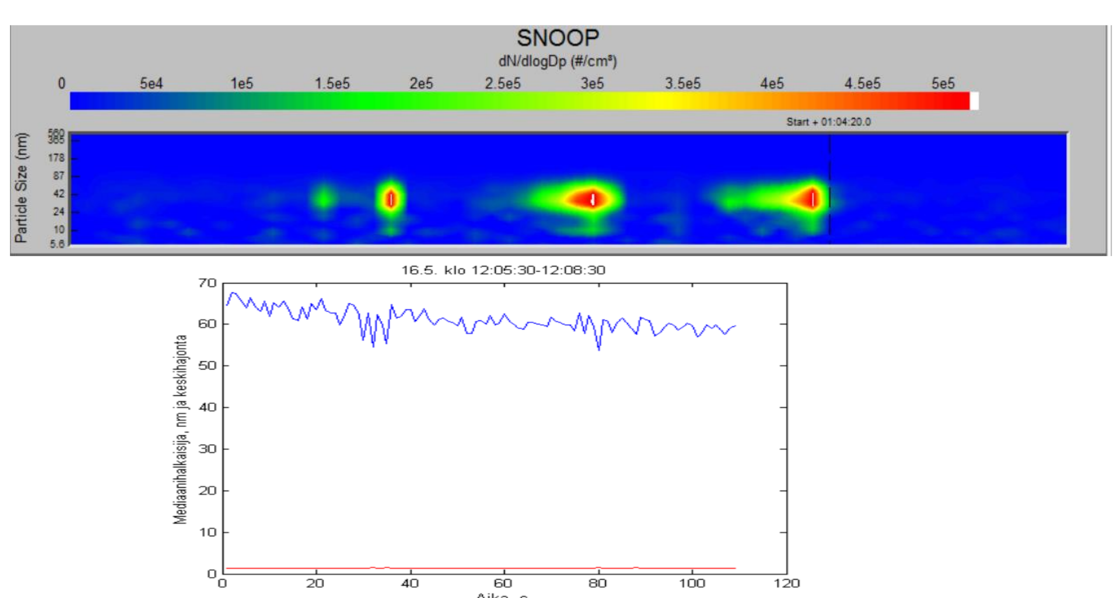

Figure 7 UP: size distrubutions in 3 approach to a ship with Skyvan
LEFT: evolution of mean diameter when approaching a ship with skyvan

The method that was tested can be used to monitor the fuel content of marine fuel of ship. With the used instrumentation, helicopter platform was the most convinient to achieve reliable results.

More detailed measurements can be done with SKYVAN platform. In proper meteorological conditions, the evolutio of chemical and physical properties of aerosol of ship plumes was studied.

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References

[1] IMO MEPC.184(59) "2009 Guidelines for exhaust gas cleaning systems"