The impact of North American and Asian emissions on carbon monoxide and ozone concentrations over Europe

S. Eckhardt[1], *A. Stohl*[1], *M. Cassiani*[1] *and J.-P. Cammas*[2]

1: NILU - Norwegian Institute for Air Research, Kjeller, Norway.

2: Laboratoire d' Aerologie, Toulouse, France.

Motivation

While there exist many model and case studies of intercontinental transatlantic transport, to date no statistical analyses of measurement data over Europe exist, which analyze the influence of Asian, North American and Bosnywash (Boston, New York and Washington region) emissions. In this study, we used a large data set of carbon monoxide (CO) and ozone (O_3) measurements to examine the influence of emissions on the chemical composition of the atmosphere over Europe.

MOZAIC Dataset

We analyzed 15 years of CO and ozone measurements from the MOZAIC programme taken during ascent and descent from European airports of commercial airliners equipped with instruments measuring meteorological parameters as well as some trace gases. All data points available over Europe (in total 250 000) were averaged over a height of 1 km.

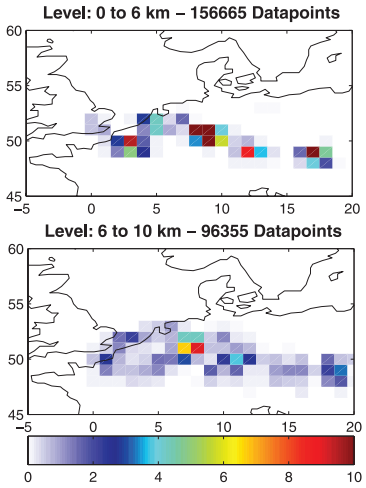

Figure 1 Distribution of the frequency of data points from the MOZAIC dataset used in this study. The upper panel shows the level up to 6 km, the lower panel the distribution above 6 km height.

FLEXPART Dispersion Model

We determined the source regions influencing the measurements with the Lagrangian particle dispersion model FLEXPART. CO and O_3 data were averaged over 1 km high layers during ascent and descent and for each individual 1-km-averaged measurement, 40000 particles were released and followed 20 days backward in time.

Using the EDGAR emission inventory and the FLEXPART backward calculation, CO concentration as predicted by the model could be derived. Comparing the modeled and simulated CO values shows that measured CO and modeled CO enhancement are well correlated and, thus, that the model captures the relevant transport processes.

Screening the dataset for all observation, which had an influence higher than 40% from the Bosnywash area, it was found, that while 22% of the observations were dominated by North American emission, only 3% are coming from the Bosnywash area. European emission dominate with 66.5%, while the contribution of modeled CO from Asia is 10%.

Case study:Transport pathway from BOSNYWASH

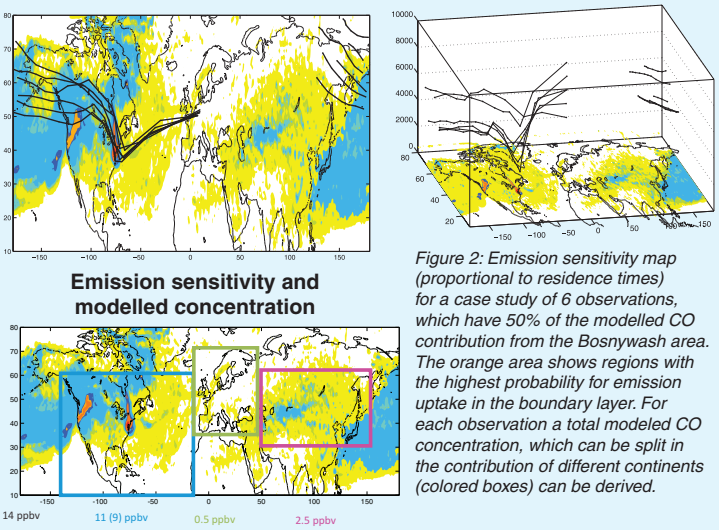

Figure 2: Emission sensitivity map (proportional to residence times) for a case study of 6 observations, which have 50% of the modelled CO contribution from the Bosnywash area. The orange area shows regions with the highest probability for emission uptake in the boundary layer. For each observation a total modeled CO concentration, which can be split in the contribution of different continents (colored boxes) can be derived.

Screening the dataset for all observations, which had an influence higher than 40% from the Bosnywash area, it was found, that while 22% of the observations were dominated by North American emission, only 3% are coming from the Bosnywash area. European emission dominate with 66.5%, while the contribution of modeled CO from Asia is 10%.

Frequency of Influence from the diff. regions

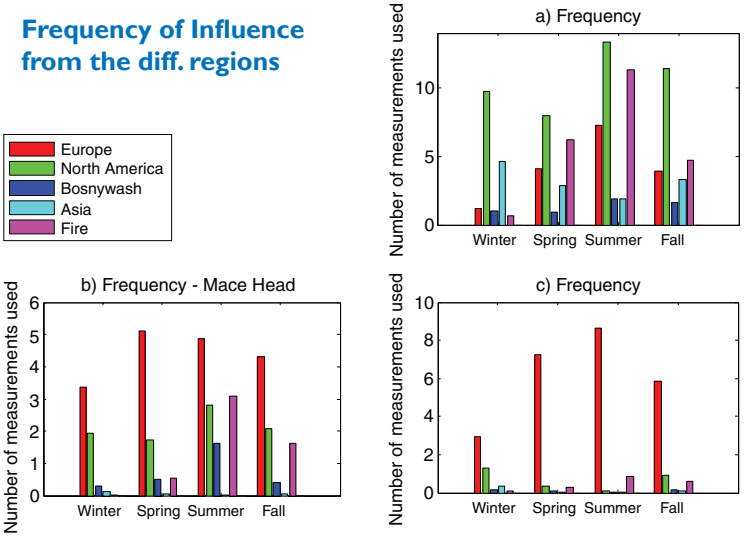

Figure 4: Frequency (in 1000s) of occurrence for dominant contributions from the various source regions. The upper panel is for the MOZAIC data set between 3 and 8 km, the lower two are for Mace Head and Zugspitze.

MOZAIC

In measured CO, European influenced samples are clearly above the average, and CO related to biomass burning during summer is also higher than average. For O_3, European dominated air masses show the highest values except for winter time. Asian influenced O_3 samples are above average during all season except spring. In winter for each year the Asian values are highest. The O_3 time series also show that, especially for winter, there are quite big interannual differences in which source region causes the highest measured O_3 values. So, while titration of O_3 by nitric oxide is important especially in the absence of light, winter time O_3 is not always anticorrelated with the influence of European air masses.

Zugspitze

For Zugspitze, due to its location in Central Europe, European-dominated CO contributions are clearly most frequent. Only during winter time North American anthropogenic emissions have a substantial share.

Average Profiles of CO and Ozone, classified by the Air Masses Source Region

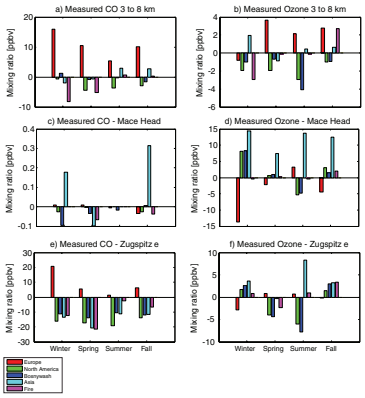

Figure 3: Average measured CO and O_3 for air masses, grouped by the dominating source region for each of the 3 data sets. Measurements are shown as a deviation from the seasonal mean.

European-dominated air masses are associated with the highest measured CO mixing ratios. The average mixing ratios for North American air masses are much lower than for the European ones. During summer, emissions from biomass burning lead to enhanced CO mixing ratios. In summer and fall, Asian emissions seem to contribute to higher CO measurements than North America.

During wintertime, O_3 values are lowest when associated with high modeled CO mixing ratios. They are highest when influenced by Asia followed by North American dominated air masses. Summer is different, when North American dominated air masses are clearly below average and Asian dominated air masses are clearly above.

Mace Head

The Mace Head station is mainly influenced by European emissions, but North American influenced air masses occur with a frequency nearly half of the European influenced ones.

During fall, North America-influenced cases exhibit lower concentrations than European-influenced cases and the average. During summer fire emissions might contribute to CO concentrations above average.

Again, the O_3 during wintertime exhibits lowest values with the anthropogenic modeled European CO.

Asian influenced measurements have a very low frequency, but the average modeled concentrations for this class are high. In winter and summer O_3 for North America as well as Bosnywash dominated source region is similar.