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Atmospheric Measurement Techniques Discussions

Interactive comment on "Measurements of air pollution emission factors for marine transportation" *by* B. Alföldy et al.

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The authors thank the Referee his/her efforts to correct the mistakes and the critical points and new ideas for increasing the scientific level of the paper. Detailed responses to the Referees can be found below.

The Referee raises the question of why the paper has been submitted to AMT and not to ACP which in his opinion would be more appropriate. He argues that the applied technique is a "well-established approach for measuring emission factors from mobile sources", because two investigations of air craft emission factors based on the same principle have been published previously. It is certainly true that in the literature there are a few reports of applications of the same basic principle for determination of emis-

sion factors for airplanes and also for ships, based on airborne measurements (Hobbs, 2000), but in our opinion this does not necessarily imply that this principle can be successfully applied for determining emission factors of ships in a harbour environment. Thus we find that the paper, particularly the revised version with more experimental details, is suitable for AMT.

Responses for the Specific Comments

1."The manuscript does not provide an adequate description of the measurement campaign. Key information on the dates, season, weather situation, relative humidity, prevailing wind directions as well as horizontal wind speed and average atmospheric residence times of investigated plumes are missing. The latter information however is crucial for the interpretation of aerosol number concentration data provided by a Condensation Particle Counter (CPC) which detects particles above 10 nm in diameter. Sulfate-containing particles show signiïňĄcant particle growth at high relative humidity which will shift particles above the lower detection size of the deployed CPC, simply by taking up water vapor from the humid atmosphere."

The required details for the campaign have been added. We have summarises the meteorological conditions in a new figure (Fig. 6) and added a new phrase on Pg 8929 about the dates and a new chapter (2.2.) on 8930-8931 about meteorological conditions and sampling strategy of the campaign. We fully agree with the Referee that the size distribution of sulphate aerosol strongly depends on the relative humidity, which could affect our number concentration measurement (since we could not see the whole size distribution, only particles over 10 nm). However, as we calculated, the MMD of sulphate particles in the fresh plume is around 42 nm, so the lost part of the size distribution under 10 nm could be neglected. On the other hand, we measured in the fresh plume, thus the atmospheric conditions slightly affect the measurement conditions. Indeed, we cannot find significant differences between the average particle EF on days with lower or higher relative humidity.

2.“A schematic of the sampling set-up is missing. Applied instruments and methods are described in detail while no information is given on the equipment of the mobile labs, sampling height, identiïňĄcation of plumes etc.”

Information on sampling heights was given in the original manuscript on Pg 8930. The way of plume identification was also described on Pg 8930. However, we have added a schema on the sampling situation (Fig. 4) and new phrases on Pg 8930 about ship and plume identification.

3.“Equation 2 should be checked for correctness. Shouldn’t it read: s[%] = 32/64 x EFR x 10? At least the equation was applied in this version in Section 3.1 for calculating SO2 EF.”

Eq. 2 (Eq. 3 in the revision) is correct. If R can be neglected, EF=20xS. S was calculated accordingly on Pg 8936.

4.“The section on particle emissions is not acceptable in the current form. The number emission factors determined in the proposed manner are not applicable as described. Particle growth during plume aging will have a signiïňĄcant impact on the determined number concentration as well as on the mass median diameter; see Lobo et al. (2007) as an example. The effect of water associated to sulfate molecules (hydrated sulfate) is neglected in the mass determination although water will make a substantial contribution to the total mass of emitted PM (Agrawal et al., 2008; Petzold et al., 2010). Additionally, the number emission factors determined here are only of limited use for determining the global particle emissions impact because engine operation conditions at port are totally different to operation conditions at cruise, whereas the effect of engine power on particle emissions was demonstrated in many of the referenced emission studies.”

We fully agree with the Referee in the PM dependence on the relative humidity due to the hygroscopic behaviour of sulphate particles. However, we have to emphasise that we did not do any PM measurement. We measured the particle number and the sulphate mass concentration, and calculated the MMD of the sulphate core assuming

spherical shape and 1.84 gcm-3 density. Water content does not play any role in this calculation since we did not say anything about the real size of the particle (sulphate core + water). Regarding the effect of relative humidity on the number concentration measurement see the second paragraph of response 1. In the revised manuscript we emphasise the limits of validity of our measurement and discuss the possible effect of hygroscopic growth and particle coagulation (Pg 8939).

5. Typographic errors have been corrected.

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 8925, 2012.

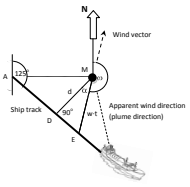

Fig. 1. Figure 4

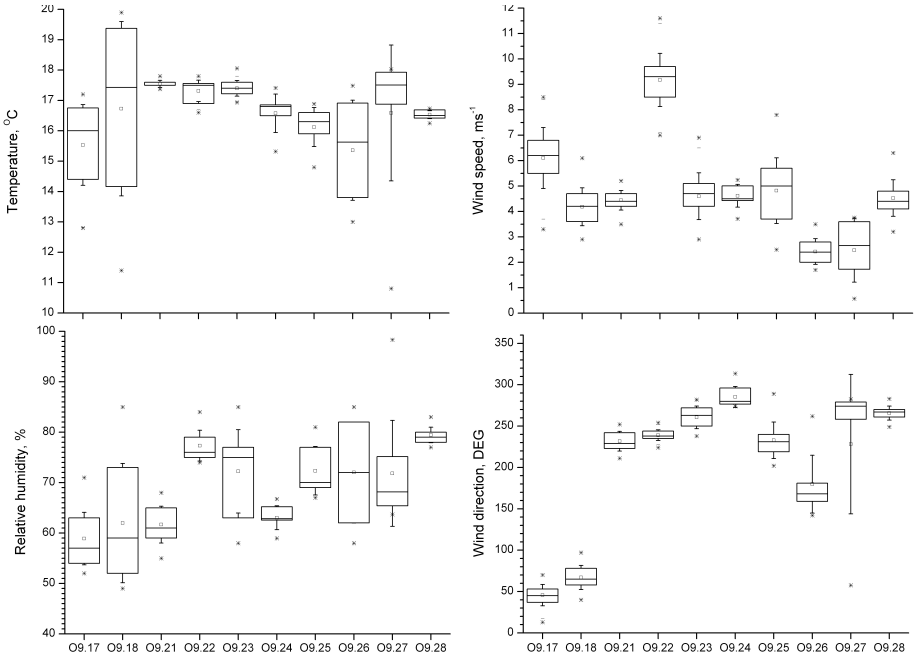

Fig. 2. Figure 6