Atmos. Chem. Phys. Discuss., 3, S1339–S1341, 2003
www.atmos-chem-phys.org/acpd/3/S1339/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Cirrus cloud occurrence as function of ambient relative humidity: A comparison of observations from the Southern and Northern Hemisphere midlatitudes obtained during the INCA experiment" *by* J. Ström et al.

Anonymous Referee #2

Received and published: 18 August 2003

The occurrence and the microphysical properties are critical issues concerning the climatic forcing of cirrus clouds. The data set presented in the present MS is unique and will contribute greatly to the scientific understanding on these properties of cirrus clouds. The data set are of high quality and contains data on two hemispheres.

However, the modelling part of the present MS (starting from Fig.7) is very weak. Major revisions of the modelling part are needed for the final accept for the publication.

Major comments:

1) The criteria, which determine whether the air parcels are inside or outside of the

cirrus should be discussed more in detail. The FSSP measurements show an considerable fraction with particles diameter between 0.6 and 0.9 micrometer (black line subtracted by the green line of Figure 4) along at very dry condition (RHI of 5 -60 %). If the particles with a size of 0.6 - 0.9 um in diameter were ice particles, they would evaporate in ˜ 0.02 - 0.04 s at T = 227 K and RHI = 0.5. The chance that such small ice particles exist along at such dry condition (RHI = 5-60 %) is in fact zero. Therefore, it is most likely that the air parcel contains only particles d <= 0.9 um are not ice particles at all RHIs (Fig. 4). It is even more probable to detect non-ice particles at higher RH as aqueous particles can grow in size due to water and enhanced trace gas uptake at higher RH. The threshold number density 0.001-0.003 cm-3 for CVI measurement is probably not a good measure for the cirrus-cloud-indicator either. A considerable fraction of air parcels (up to a CPF of 50 %) at very dry condition show particles (RHI as low as ĎI 5%, Figure 3, which indicates that the temperature is ˜ 30 K above the ice frost point !!!). They are unlikely ice particles, if they are not extremely large (the corresponding information of ice water content measured by CVI would be useful to clear this point). 2) The model describe in this MS is highly questionable based on the following points: a) The exponential distribution of the RHI (Eq.2) is valid only under the assumption that ice particles do not form at all. As authors mentioned, once the ice particles nucleated, the growing ice particles will reduce to gas phase H2O and bring the RHI to 100% (equilibrium). The deviation from ice saturation is kinetically controlled. I do agree that the RHI distribution for RHI >= 100% is almost exponential (Figure 2 and the black line of Figure 3 of Haag et al., 2003) without ice formation. However, the RHI distribution outside the cirrus cloud differs considerably from an exponential distribution (coloured lines of Figure 3 of Haag et al.). b) The agreement between model and measurement (Figs. 7,8,9) is not justified. At first, the good agreement is only achieved for FSSP data with a size threshold of 0.5 micrometer in diameter (Fig.8a) and CVI for n = 0.001 cm-3. However, as mentioned in comment 1, many data points at dry condition can not be interpreted as ice particles, their lifetime for evaporation is too short. The comparisons shown in Fig. 7a and 8a are therefore not adequate. Secondly, for

ACPD
3, S1339–S1341, 2003

Interactive Comment

higher number density (CVI) and higher cut-off size (FSSP), an higher critical saturation is required (Sc=2.7-2.9 for CVI and 1.9-2.1 for FSSP, respectively). The authors argued that the higher Sc may be explained by that fact that the excess water vapour is required for the ice particles grow to the detectable size (page 3315, lines 15-17). I made a rough estimate: for FSSP, the detectable size of 1 um in diameter (Fig.8b), an excess water vapour of 2.5 ppb is required to allow 1 cm-3 of ice particles to grow to a size of 1 um in diameter. The vapour pressure over ice at 226 K is about 280 ppmv (at 200 hPa). The ice particles (n= 1 cm-3, d = 1 um) contain a water amount of only ˜ 1E-5 in saturation ratio S. For CVI instrument, the ice particles (n= 1 cm-3, d = 5 um) contain a water amount of also only ˜1E-3 in S. These small values are far away from the discrepancy between the modelled Sc of 1.9 to 2.9 and Sc of 1.3 to 1.6 for ice formation. On the other side, the measured CPF increases to unit at Sc of 1.3 to 1.6 for both CVI instrument (n= 1 cm-3 , Fig.7b) and for FSSP (Fig.8b), unlike the model results. c) The authors mentioned also that the difference between modelled Sc and S is the adiabatic cloud water content. I think that the nature is more complicated. The CWC is determined mainly by the difference between the actual temperature and the frost point (if one takes the total water), if the ice particles are in equilibrium with the gas phase. The time scale for equilibrium could vary, depending on ice number density. However, in the present model, it seems that the CWC is only a function of number density (Fig.7), which is not physically.

Minor comment: I can not follow the steps to derive the CWC distribution (shown by Fig. 10, blue line) from the model. More detailed explanation is required. This is also related to my question mentioned in comment 2c). If I understand your approach probably, 40 % of total air parcels should have a CWC of more than 1.7 - 1.9 in saturation ratio S = a super saturation of 1.7 - 1.9 (see Fig. 7b and page 3515, lines 22-24), which is about 91 to 101 mg m-3 at T = 226 K. But, the blue line shows only a tiny fraction with CWC $>$ 90 mg m-3.

Interactive comment on Atmos. Chem. Phys. Discuss., 3, 3301, 2003.