

Interactive comment on “A case study on the formation and evolution of ice supersaturation in the vicinity of a warm conveyor belt’s outflow region” by P. Spichtinger et al.

P. Spichtinger et al.

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Response to referees’ comments on paper ACPD-2004-si05004

Referee #3

Ad General points

First and second analysis of ISSR:

At the beginning of the paper we raise the question whether it is possible to determine how an observed supersaturated air mass has reached supersaturation. In section 4.3.2 we try to do that by looking at changes of RH_i and the three parts of it along the

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trajectories. For this purpose it is sufficient to use the original relative humidities from the ECMWF model. We can say that the dominant influence on the relative humidity (and therefore also the predominant pathway to supersaturation) in this case is adiabatic cooling, and this statement can be made without reference to supersaturation and without correction of the RH_i values along the trajectories. So, to our view, this is not a first analysis of the ISSR, it is only an analysis of humidity tendencies along trajectories. Only in the next sections 4.3.3 and 4.3.4 we study properties of the super-saturated airmasses. Hence, to our view there are no two independent investigations of the ISSR, there is a study of humidity tendencies and a study of when and where RH_i exceeds saturation on the trajectories. Section 4.3.2 now begins with an introductory sentence that should clarify its meaning in the paper.

The formulation on page 8162 (“the lifetime of the observed ISSR...”) is misleading, and we have improved it now by rewriting section 4.3.4. It is better to say that the considered airparcel was for 24 h a part of the ISSR. It is probably not appropriate to speak of the lifetime of the ISSR because it may turn out difficult to define an ISSR as a single entity. Air parcels get part of an ISSR and leave it eventually, but the ISSR itself is still there. The situation is similar to that in orographic clouds: The cloud exists longer than the airparcels are within the cloud. It is also similar to the situation with contrail clusters: the cluster exists longer than single contrails are part of it.

The clearest indication of the vertical extension of ISSRs comes from the radiosonde measurement taken in Lindenberg (Spichtinger et al., 2003a). Since this is the only measurement we have it would be dangerous to estimate the vertical extension of the ISSR at locations off the trajectories through the Lindenberg grid point.

The WCB (warm conveyor belt) contributes to the ISSR in this case, at least to the northern part of the ISSR. This result cannot be generalised and we do not do so. Neither we say that moisture transport from below is important for the formation of the ISSR. We say in the paper that in this case supersaturation is caused by adiabatic cooling. This is probably valid for both parts of the ISSR. In the northern grid points the

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air in the ISSR was pushed up by the WCB below it, and thereby adiabatically cooled. Note that the WCB is *below* the ISSR, and the moist ascending airstreams mentioned in section 3 belong to the WCB.

At the end of section 5 we have added some information about physical differences between both parts of the ISSR. We have deleted the phrase “from the boundary layer” because it is misleading (the WCB trajectories rise up from the boundary layer, but not the ISSR trajectories).

Ad Scientific comments

Unfortunately, the page and line numbers indicated in the review seem not to correspond to the page numbers in the online manuscript version and we had to puzzle around to find the text the referee comments to. We hope, we did it right.

The global distribution of ISSRs is presented in the quoted paper (Spichtinger et al., 2003b). The text in the 1st paragraph of the introduction is a bit expanded in the revised version, to say where ISSRs are. The persistence duration of ISSRs is unknown, due to lack of data. From observations of widely extended thin clouds in the tropics (sub-visible cirrus and ultrathin tropical tropopause clouds) and of contrail clusters in the northern mid-latitudes (moist lenses) one can estimate that some ISSRs may have life times of a few days.

Horizontal extent of the ISSRs. It depends a bit on the Delta RH_i in Figures 8,9, where we could give an order of magnitude of 1 million square kilometers. This value cannot certainly be taken as a general value for ISSRs over Europe or even the world. Therefore, in order to avoid misinterpretations, we prefer not to quote such numbers in the paper.

Measurement at t+18. We changed the text on page 8261, line 15, and avoid to use “detected” and “measurement” here.

Again the horizontal extent. See above.

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Fig. 11 and the corresponding sentence in the conclusions has been deleted, as suggested by the referee.

Ad Technical Corrections

wrt is now expanded (with respect to).

Figure 5: the open square was a remanant from an old version of the manuscript. It is unnecessary, hence deleted now. Figure 3, font size: will be big enough in the final version. Figs 8/9: we change the colour bar, then the red star gets better visible. Fig. 10: correspondences are now given in the Figure caption.

Referee #5

Ad Major Comments

1. We agree that it is very difficult to obtain accurate observations of RH_i in the UTLS region. But for our paper it is not so critical a problem, hence we do not agree that this is fundamental for the paper. Nowhere we make a statement that requires to have RH_i accurate to 1 percent or so. Anyway, we have now added a cautionary note in the introduction section where we first mention the Lindenberg data, and we avoid to repeat the precision value that we have quoted from Nagel et al. (2001) in the original manuscript.

Another really fundamental problem is the lack of supersaturation in the ECMWF model (in other NWP models as well). This is a problem that we currently can only partly solve with some tricks as in section 4.2.4 or as on Figures 8,9. This problem can only be solved by substantial changes in the cloud physics parametrisations of these models.

2. Yes, can be done. It is then also easier to see the red star.

3. Why are ISSRs important? We think: because they are there in the UTLS and because they occur frequently. Aside from that they are of course important for cirrus formation, contrail formation and contrail to cirrus transformation. Perhaps they are

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also important for the radiative energy flow through the atmosphere. There is now an additional sentence in the first paragraph of the introduction.

Ad Minor Comments

1. Supersaturation is also dealt with, e.g. in papers by Eric Jensen and coworkers, or by Heymsfield and Miloshevich. But these papers do not fit to what we say in the introduction. They do not show the global distribution of ISSRs and do not study the contrasts between ISSRs and their subsaturated environment.

2. We have just quoted the number from Nagel et al. (2001) which may be believed or not. As stated above, a high accuracy of RHi measurements is not critical for the paper, so we change the sentence a little bit and avoid quoting the number.

3. We hope the formulation in the revised version is clearer.

4. Longwave cooling at the cloud tops can lead to inversions. But we change the sentence and say that the inversions are “at” the cloud tops.

5. Agreed.

6. “and $t=0$ ” included.

7. Agreed.

8. In the UTLS where the absolute humidity is very low an instrument needs a longer integration time to measure the local humidity. Since the radiosonde is ascending while it is measuring, local humidity maxima and minima will be smeared out like in a moving average. The maximum supersaturation in the ISSR will therefore probably be underestimated. We have added a sentence in brackets for this explanation).

9. This is just an additional piece of information for those who like it. It is not so important as to warrant an own figure. But we have shifted the text as the reviewer suggested.

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10. Agreed.

11. We prefer to indicate the official time of the METEOSAT image, not the time when it actually measured Lindenberg. If somebody would be interested to look, say, at the corresponding visual channel for the situation, the image could be located in a data base under its official time stamp, not under a subjective time for a certain location.

Interactive comment on Atmos. Chem. Phys. Discuss., 4, 8245, 2004.

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