Response to referees

We thank both reviewers for their positive comments an helpful suggestions.

General Comments:

Referee 1:

We added the following text in the conclusions and the new reference:
"As a kind of textbook knowledge in the cirrus community it is usually assumed that radiation might not be important for the initial formation of cirrus clouds. The main argument is that radiative cooling would result into very low cooling rates or equivalently into vertical updraughts ibn order of millimetres per second. This would lead to very thin cirrus clouds containing only a few ice crystals per litre (see e.g. Kärcher & Spichtinger, 2009).

However, from the results of the present study this position might be revised under the comprehension of the discussed destabilisation process. In presence of weakly stable profiles both effects, i.e. radiative cooling and destabilisation might lead to the formation of visible cirrus clouds. On the other hand, the impact of radiation on the stability of the upper troposphere itself, discussed in a broader sense, should be an interesting topic for future research. From this point of view the role of convective cells in ice-supersaturated regions and cirrus cloud layers might be interesting in terms of cirrus cloud inhomogeneities and patchiness of cirrus clouds, also in terms of the radiative impact of cirrus clouds. Finally, this could also be important for more physically based parameterisations of cirrus clouds in large-scale models, including also the macroscopic structure on the cloud scale.

We could not discuss in detail the issue of frequency of occurrence of environmental conditions, which allow the radiation to have a predominant impact on the stability of the upper troposphere (and therefore be of importance for cirrus formation). The used radiosonde data originates from only one measurement site and therefore does not give an insight in global distributions. This must be investigated in future studies, using meteorological analyses and maybe also output from large-scale models in order to obtain a better overview about the importance of the described mechanism.

It remains also unclear, how important radiative destabilisation will be, when it is superimposed with other large- or meso-scale processes (i.e. frontal lifting, gravity waves etc.); this will be subject of future research."

Referee 2:

Trace gas concentrations:

The trace gas concentration (and also the ozone profile) is related to mid 1970'ies conditions. These values are default setup for the radiative transfer model code and have been used for model calibrations. Since for the temperature profile above the upper troposphere/lowermost stratosphere the US standard atmosphere (profile originated from observations during the 1970'ies) is used, generally the trace gases and the temperature profiles are more consistent than using actual values. Nevertheless we tested some of our simulations with current trace gas concentrations compositions, but the change for study-relevant variables (i.e. IWC, N or optical depth) is negligible (<< 1%). This is due to the fact that the effects of clouds and water vapour on radiation are much stronger than the impact of the trace gases.

Specific Comments:

Referee 1:

p. 1137, lines 2 to 4: The sentence has been changed to: “During the last two decades the existence of air masses in the status of supersaturation was proven by many measurements using a variety of different measurement techniques.”

p. 1137, line 14: “determined” instead of “discovered”

p. 1138, line 1-2: Sentence changed to: “But if potential stability of the environment is weak or neutral, radiative cooling can decrease the Brunt-Vaisala frequency to a critical value. This finally leads to a change (increase) of the extent and amplitude of preexisting small scale motions.”

p. 1142: changed references for figure 4. Now, 4c and 4d are cited correctly.

p. 1143, line 10: changed references for figure 5.

p. 1147, line 5-6: Sentence changed to: “If the initial RHi is reduced to less than 132%, the cooling will again get weaker and no destabilization occurs (i.e. formation of an updraft) and due to that, no nucleation can be observed during the simulation time of 8h”

p. 1147: Comments about RH = 150%. This simulations have been done, but they aren't shown in this publication. A comment about that has been added to the text.

p. 1148: Title of subsection has been changed to “Discussion of radiative impact”. We did not extend this section further, because the changes of the radiative properties depend strongly on the changes in IWC. The sensitivity of the IWC has been discussed sufficiently.

p. 1150, point 4: Distribution-functions for N are shown in the subsection “Variation of potential stability”.

Referee 2:

p. 1142: changed references for figure 4. Now, 4c and 4d are cited correctly.

p. 1143, line 10: changed references for figure 5.

p. 1146, line 23-25: Sentence changed to: “It follows that the enhanced water-vapor content increases the size of the ice crystals but not their number concentration.”

p. 1148, line 2: Reference for profile 1 added.

Minor Comments:

All additional minor comments and changes in orthography has been taken into account. Additionally, we have tried to improve the text by the help of a native english speaker.