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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Balloon-borne match measurements of mid-latitude cirrus clouds" *by* A. Cirisan et al.

Anonymous Referee #2

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This paper is based on a "matched" pair of atmospheric soundings that permit a "real world" study of the evolution of the water vapor and ice content of an air mass as it is transported 120 km downstream. An attempt to replicate the observations is made using a regional weather model and a microphysical box model. Difficulties are encountered in reproducing the measurements of aerosol backscatter for both soundings and the high relative humidity values in the downstream sounding. Several meteorological and microphysical adjustments are invoked to improve the model-measurement agreement for aerosol backscatter, with some success. The large and persistent in-cloud supersaturations implied by the downstream water vapor measurements are attributed to an instrument problem because they can't be reasonably explained by theory.

General Comments:

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Interactive Discussion

Discussion Paper

The manuscript is a very comprehensive presentation of the current understanding of cirrus microphysics in the context of the specific "match" observations that were made. At times I was somewhat overwhelmed by the depth of detail presented, and ultimately became bogged down by the persistent intensity and sheer length of the manuscript. I would like to see the authors sometimes employ simpler (but still accurate) descriptions, reducing the level of detail and intensity, and therefore making the paper comprehendible by non-experts. This would not necessarily require a "watering down" of the scientific findings, only an adjustment from the current presentation style of unceasing technical details to a more fluid, readable prose. I would also encourage the authors to allow a native English speaker to refine the grammar and word usage. I've provided a few examples of this below.

The measurement artifact of the Snow White profile over Zurich is alluded to several times throughout the manuscript but a full description and its implications for the match study are not fully addressed until the very last paragraph before the conclusions section. This discussion should be moved forward to completely dismiss the large and persistent supersaturations implied by the Snow White sounding over Zurich. This will allow the reader to focus solely on the model-measurement differences in aerosol backscatter that comprise the primary emphasis of the paper.

The word "phase" is used in several contexts throughout the manuscript and sometimes the meaning is not exactly clear. Can a different word be used, especially in the context of timing? Examples: Page 14 Line 18 (P14 L18) "mixed-phase cloud"; P16 L22-23 "misjudges the phase of the warming"; P17 L21 "represent a case with poor phase matching"; P19 L17 "a pronounced warming phase"; P22 L12 "cloudy phase";P24 L9 "apply fluctuations in phase"; P28 L14 "against evaporation in the warming phase"; P32 L9 "nucleation phase"; etc.

There should be some mention of the uncertainties of the COBALD sonde measurements because they are quantitatively compared to model results. Is a 10% difference between the modeled and measured aerosol backscatter ratios within the uncertainty

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of the COBALD measurements?

Figures 5, 7, and 9-12 should be expanded to fill entire page widths so they are more easily viewed and comprehended. Figure 5 is especially difficult to understand because there are so many different traces in each panel and the panels are so narrow. Why show the HC2 Humicap profiles here if they are not used in the paper? Might the HC2 profile over Zurich give even the slightest indication that the Snow White profile is anomalously wet?

Is the 2-km spatial resolution of the weather model high enough to be expected to replicate the sounding observations? What is the typical path length of the light scattered back to the COBALD detector? Could there be substantial differences in the backscatter ratios over horizontal scales much smaller than 2 km? Might this contribute to the model-measurement differences for aerosol backscatter?

Specific Comments:

P3 L5: "under the extreme humidity conditions in the upper troposphere" makes it sound as if the UT is a very wet region instead of a dry (but sometimes saturated) region.

P6 L19: what is a "match radii"? Is this a tolerance for spatial coincidence?

P7 L14-16: The "balloon radiosondes" were not "carrying the payload". The balloons carried payloads "comprised of a Snow White . . .." (this is a correct use of "comprised")

P8 L9-11: How is the light backscattered by molecules and aerosols considered a "net signal"? (i.e., what is the "gross signal"?) How is the Rayleigh scattering by air molecules determined in regions where aerosol loading is not very low?

P10 L8: for me the phrase "within radius space" is jargon

P12 L1: The "nights" were not analyzed, their meteorological conditions were.

P12 L15-16: "finite" has no purpose here. Are 15.6 and 25 km "a few kilometers"?

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P14 L1-5: There's no need to repeat the Figure 5 caption here.

P14 L17: what are the CI values that indicate particle sizes > 3 micrometers between 6 and 13 km?

P18 L19: "balloon tracks" indicates spatial paths. "Balloon temperature profiles" is more appropriate here.

P19 L3-16: The vertical axes in Figure 9 are pressure but the text here discusses some features in terms of altitude.

P19 L23: I can't visualize how clouds clearing "further downstream" of Zurich would produce "a sunny morning over large parts of Switzerland"

P21 L28: "during the last years" is vague

P22 L22-24: This sentence is very awkward. How about: "These fluctuations have a much greater impact on cirrus properties than do the differences between the three fluctuation types."

P23 L20 and L25-26: Do the following two statements contradict one another? "The scatter in M between different fluctuations is substantial." "... while the differences between the particular type of fluctuations are less important."

P26-P28: This is the point where I really started to get bogged down. Must all the theoretical equations appear here? Can these sections be written in terms of conceptual understanding instead of mathematical rigor?

P33 L28 and P34 L26: "Reason is..." is poor grammar. "The reason is..." is better. "This occurs/occurred because..." is even better.

P34 L7: Over what temperature range does the saturation vapor pressure over ice change by 15% per degree?

P34 L16: "a very unlikely coincidence" is better than "a large coincidence".

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P34 L24: Please change “household data” to “housekeeping data”, or even better “engineering data”

P34 L27: “ohmic heating” is more commonly called “resistive heating”

P35 L2: “droplet size of approximately 1 mm diameter?” Does this describe the surface area of ice exposed to the air passing through the intake on its way to the chilled mirror?

P35 L17: “critical design reviews” is vague. Are you referring to the Snow White’s baffle that prevents air from flowing straight through the region housing the chilled mirror? Other instruments do not have this impediment to air flow because it greatly increases the potential for measurement contamination.

P36 L9-10: “Changes in microphysical properties of the clouds are not suited to lead to a significant improvement of the cloud modeling” is an awkward sentence. How about “The cloud modeling is not significantly improved by changing the microphysical properties of the clouds.”

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 25417, 2013.