Interactive comments on "Ground-based passive remote sensing of thin ice clouds: challenges caused by sensor, method and atmosphere" by Tobias Zinner et al.

General Vote

The manuscript provides an important contribution to the state of the art focused on remote sensing of cirrus. I recommend its publication after the authors have revised the manuscript with regard to the comments listed below.

Referee´s Synopsis

The authors introduce a method to retrieve cloud optical (cloud optical thickness τ) and microphysical (effective particle size r_{eff}) properties from ground-based measurements of solar spectral radiance transmitted through cirrus. To avoid ambiguity in the retrieved data the authors extend the classical approach by Nakajima and King (1990) by a third dimension; a slope fit between 485 and 560 nm. To test this approach and to estimate the retrieval uncertainties, the manuscript provides an intensive sensitive study on different uncertainty sources using extensive radiative transfer simulations. Furthermore, the retrieval results for two test cases (measured in the visible and near-infrared wavelength range using the imaging spectrometer system specMACS during the ACRIDICON-Zugspitze campaign) are compared to satellite retrievals of cloud optical thickness and effective radius.

Major comments

1. **Literature review:** One main issue of the manuscript is the insufficient literature review and comparison to recently published studies. This concerns in particular the handling of the ambiguity between transmitted solar spectral radiance and cloud optical thickness as well as to comparisons of the results of the sensitivity study to literature values.

    a. **Ambiguity:** In the current manuscript, a third dimension is applied to the classical two-wavelength cloud retrieval by Nakajima and King (1990) to avoid the ambiguity between transmitted solar spectral radiance and cloud optical thickness. This third dimension is given by a slope-fit/ratio in the visible wavelength range between 485 and 560 nm. Recently, Brückner et al. (2014) published a similar method using ratios in the visible wavelength range for the third dimension. The method presented by Brückner et al. (2014) definitely should be considered and discussed in the current manuscript.

    b. **Sensitivity study:** The present manuscript provides a detailed and impressive sensitive study on possible retrieval uncertainties. However, the results should be compared to the results of the sensitivity study given by Schäfer et al. (2013). For a cirrus retrieval adapted to the measurements with a ground-based imaging spectrometer in the visible wavelength range, Schäfer et al. (2013) investigated the retrieval uncertainties of cloud optical thickness retrievals, e. g. including surface albedo and cirrus crystal shape.

2. **2nd test case:** From my point of view, the discussion of the second test case from 2 October 2012 should be removed from the manuscript. The first case is already sufficient to demonstrate the ability of the introduced cirrus retrieval to give proper results. The manuscript will not benefit from the second case. Of course, it would be nice to have two satellite products to compare, but due to the contamination by low clouds, a comparison will not be significant. Furthermore, the data seem to be overexposed at multiple parts of the image, which may be the reason that no cloud retrieval could be adapted at those parts.

Minor and technical comments

1. **Acronyms**: Acronyms are often used several times before they were introduced the first time. Examples are LMU, specMACS, ACRIDICON, MODIS, SEVIRI, CloudSat, CALIPSO. I don't know if I got them all. Please check all acronyms throughout the manuscript and introduce their full names whenever they are used for the first time.

2. **Indices and units:** Indices and units are sometimes written in italic letters and sometimes in non-italic letters. Throughout the manuscript this happens also for one and the same index or unit. For reasons of consistency you should write all indices and units in non-italic letters.

3. **P1, L7:** Typo, remove dot from "noise,."

4. **P3, L7:** Typo: persepctive → perspective

5. **P5, L29:** Remove "-" from "lookup-table". Throughout the whole text "lookup table" is written without hyphen (-)

6. **P8,L11:** remove "using"

7. **P9, L13:** lookup → lookup table

8. **P12, L12:** "At quality values above 0.5." is no full sentence. You could connect this one to the sentence before.

9. **P11, L10-L14:** The phase discrimination is the first step of the retrieval procedure. Therefore, my recommendation is to shift the discussion of this part to the beginning of chapter 3.5 instead of keeping it at the end.

10. **Fig. 6:** Some colors are used twice. For example for tau=10.4 and tau=16.9, for tau=8.6 and tau=12.3, … Please revise this figure.

11. **Fig. 8, 9, 12:** Please increase font size

12. **Fig. 8:** Only as a suggestion. Would it be possible to indicate the time of measurement in Fig. 8?

13. **Fig. 12:** Time axis does not fit the time given in the figure caption and does not fit the time given on P11, L18

Bibliography:

Brückner, M., Pospichal, B., Macke, A., and Wendisch, M.: A new multispectral cloud retrieval method for ship-based solar transmissivity measurements, J. Geophys. Res. Atmos., 119, 11.338–11.354, doi:10.1002/2014JD021775, 2014.

Schäfer, M., Bierwirth, E., Ehrlich, A., Heyner, F., and Wendisch, M.: Retrieval of cirrus optical thickness and assessment of ice crystal shape from ground-based imaging spectrometry, Atmos. Meas. Tech., 6, 1855–1868, doi:10.5194/amt-6-1855-2013, 2013.