Name of research institute or organization:

Institute for Atmospheric and Climate Science

Title of project:

Assessment of high altitude aerosol and cloud characteristics

Project leader and team:

Prof. Thomas Peter, project leader
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Marco Vecellio, Uwe Weers

Project description:

We use a commercial Lidar (Leosphere model ALS 450) to measure aerosol and high altitude clouds. We retrieve attenuated backscatter polarized parallel and perpendicular to the laser emission (wavelength 355 nm) and determine the depolarization ratio. The depolarization ratio depends on particle sphericity and increases with increasing asphericity. Hence this channel provides information on whether liquid or ice clouds are observed.

In 2012, continuous measurements were carried out automatically until a major failure of the laser system of the Lidar on May 25th, 2012, making a repair at the manufacturer necessary.

To allow climatological analysis like occurrence frequency of clouds, we developed a cloud detection algorithm to detect the high altitude cirrus ice clouds without need of manual intervention. The algorithm uses a filter of 7x5 pixels combining both, the parallel and perpendicular channel. It allows not only identifying the presence of clouds but also measuring their temporal and vertical extent as illustrated in Fig. 1. Of particular concern are the daytime measurements, because photons from sunlight reaching the detector result in a considerable noise signal (cp. Fig. 1). As illustrated in Fig. 1 the filter used successfully suppresses this noise signal while retrieving even optically thin cirrus clouds during day time.

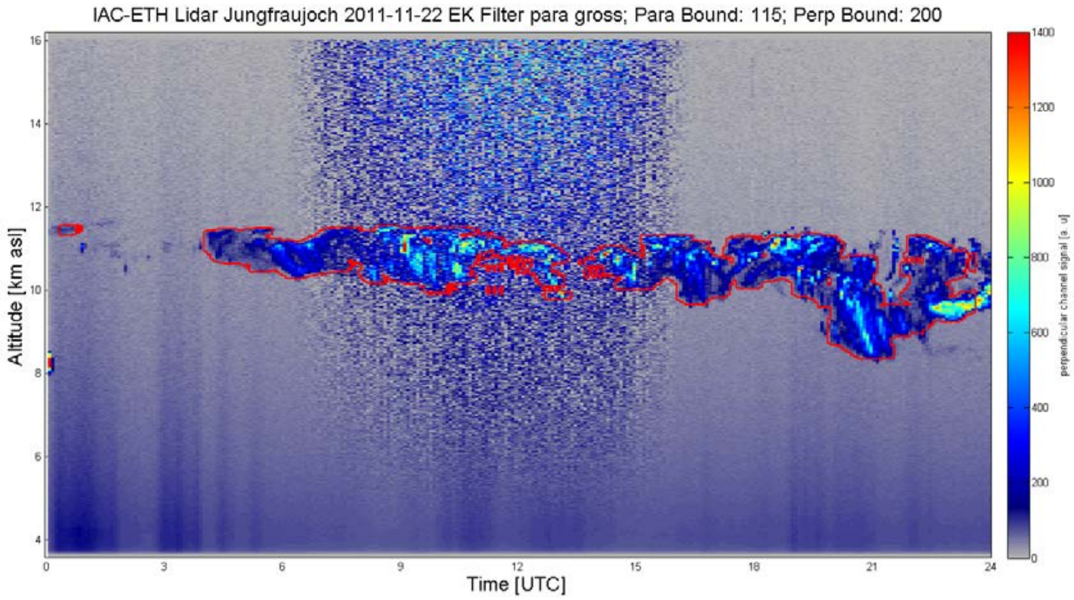

Fig. 1: Lidar signal showing extended cirrus clouds on November 22th, 2011. Attenuated backscatter intensity (perpendicular polarization channel), red line: cloud identification using the filter as described in text.

While our total observation time is still limited at present, we are confident to be able to retrieve a reliable cirrus occurrence statistic using the developed algorithm. This statistic shows distinct differences above Jungfraujoch in November 2011 compared with the long year statistics of Sassen and Comstock [2001] above Salt Lake City as illustrated in Fig. 2. At present the total number of observed cirrus does not allow to draw definite conclusions about these differences. However, we intend to continue measurements during 2013, which will improve the statistics of cirrus occurrence.

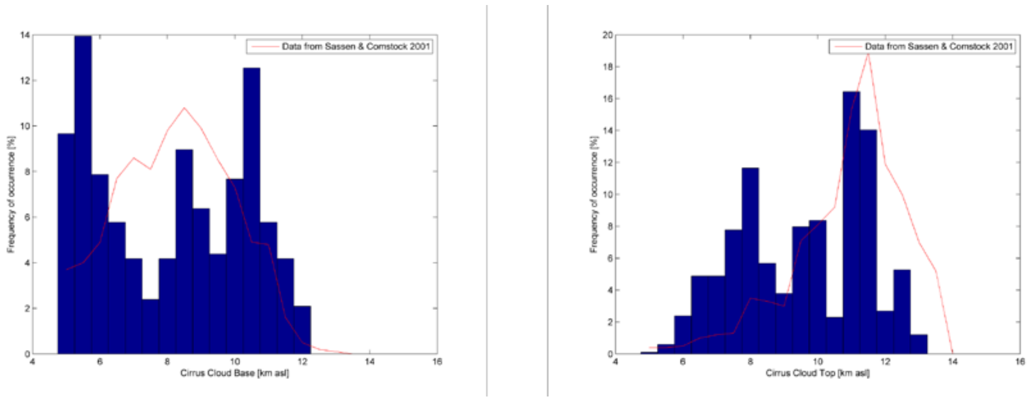

Fig. 2: Comparison on cirrus cloud occurrence frequency (left panel: cloud base, right panel: cloud top) above Jungfraujoch in November 2011 with the study by Sassen and Comstock [2001] above Salt Lake City.

One aim of the project is to evaluate how well state of the art weather prediction models perform with respect to high altitude cloud observations. We used the cloud detection scheme outlined above to compare the observed cirrus clouds with the reanalysis of the COSMO model. COSMO stands for Consortium for Small scale modeling (http://www.cosmo-model.org/) and is a nonhydrostatic limited-area atmospheric prediction model. Primitive thermo-hydrodynamical equations that describe a compressible flow in a moist atmosphere are implemented in the model and are fixed in rotated geographical coordinates and a generalized terrain following height coordinate. The model is designed to make numerical weather predictions, as well as to be used in different applications on the mesoscale. As an example we plot three different tropopause heights extracted from the model together with the Lidar observations in Fig. 3. The WMO tropopause height is defined as the height where the temperature gradient is smaller than 2 K/km over a range of 2 km, we also use the first temperature inversion and also a humidity tropopause (drop in relative humidity below 10%) to define the tropopause height.

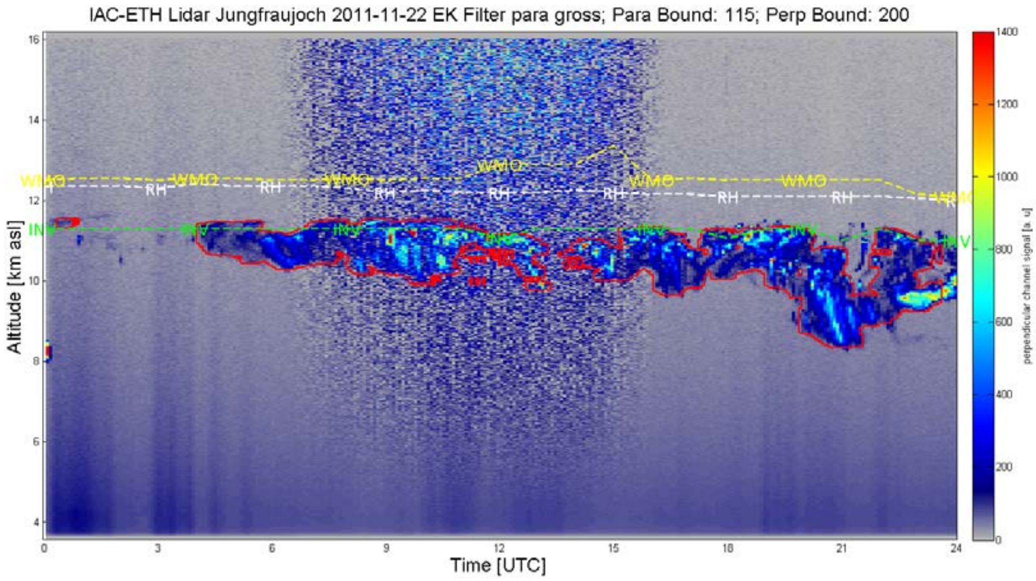

Fig.3: Same as Fig. 1 but supplemented by three different tropopause heights retrieved from the COSMO model. Tropopause height as defined by the WMO (yellow dashed line), as observed as the first temperature inversion (green dashed line) and as indicated by drop in relative humidity in the COSMO model (white dashed line). For a detailed description of the criteria see text.

For the day shown in Fig. 3 the cloud top of the cirrus clouds seem to coincide closely with the first temperature inversion based tropopause height.

To check whether this observation holds in general, we evaluated all data using the cloud detection scheme developed. The result is shown in Fig. 4.

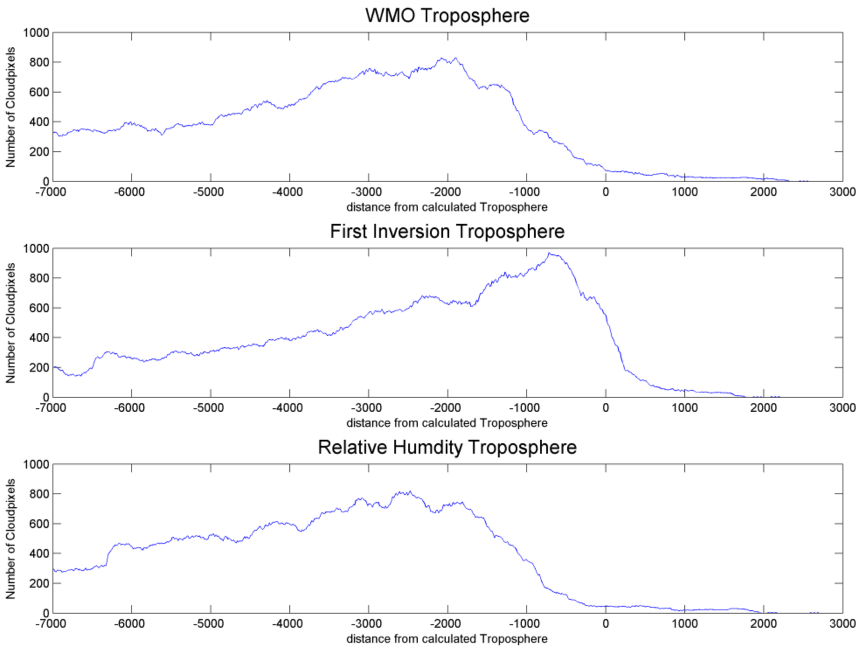

Fig. 4: Occurrence of cirrus clouds (as indicated by number of detected cloud pixels) relative to tropopause heights. Upper panel: WMO defined tropopause, middle panel: first temperature inversion tropopause height, lower panel: relative humidity derived tropopause.

Clearly the result of the single day shown is also representative for the majority of the cirrus clouds observed. The highest cloud tops observed by the Lidar above the Jungfraujoch coincide with the first temperature inversion tropopause height retrieved from the COSMO model whereas both, the WMO tropopause and the tropopause retrieved from relative humidity profiles are about 1 km higher in altitude compared to the clouds observed. The significance of this finding is currently under closer investigation.

References:

Sassen, K. and Comstock, J. M.: A midlatitude cirrus cloud climatology from the facility for atmospheric remote sensing. Part III: Radiative properties, Journal of the Atmospheric Sciences, 58, 2113–2127, doi: 10.1175/1520-0469(2001)058, 2001.

Key words:

Lidar, cirrus, tropopause, COSMO

Collaborating partners/networks:

Paul Scherrer Institut, Meteo Schweiz

Scientific publications and public outreach 2012:

Refereed journal articles and their internet access

Zieger, P., E. Kienast-Sjögren, M. Starace, J. von Bismarck, N. Bukowiecki, U. Baltensperger, F.G. Wienhold, T. Peter, T. Ruhtz, M. Collaud Coen, L. Vuilleumier, O. Maier, E. Emili, C. Popp and E. Weingartner, Spatial variation of aerosol optical properties around the high-alpine site Jungfraujoch (3580 m a.s.l.), Atmos. Chem. Phys., 12, 7231-7249, doi:10.5194/acp-12-7231-2012, 2012.

Conference papers

Kienast-Sjögren E. et. al, Lidar measurements of cirrus cloud properties at the high alpine research station Jungfraujoch, International Symposium on Tropospheric Profiling, Oral Presentation, L'Aquila, Italia, September, 2012.

Kienast-Sjögren E. et. al, Lidar measurements of cirrus cloud properties at the high alpine research station Jungfraujoch, International Conference on Clouds and Precipitation, Poster Presentation, Leipzig, Germany, July 2012.

Kienast-Sjögren E. et. al, Lidar measurements of cirrus cloud properties at the high alpine research station Jungfraujoch, WMO Cloud Modeling Workshop, Oral Presentation, Warsaw, Poland, July 2012.

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