Name of research institute or organization:

Institute for Atmospheric and Climate Science, ETH Zürich

Title of project:

Assessment of high altitude aerosol and cloud characteristics by remote sensing

Project leader and team:

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Project description:

Cirrus clouds play an important role in the Earth's climate system. Depending on optical thickness and altitude of the clouds they have a cooling or warming effect on climate. Only optically thick clouds are cooling, but with climate change occurrence the properties of these clouds may change as well.

The aim of the project is to establish a longer term climatology of mid-latitude cirrus clouds. This is supplemented by case studies aiming at a better understanding of cirrus cloud formation, in particular at understanding how much heterogeneous ice nucleation contributes to cirrus formation.

We use an elastic Lidar with a depolarization channel (Leosphere ALS450, emission wavelength 355 nm) coupled with a ceilometer (Vaisala CL31) to perform the measurements. For comparison we also perform measurements at Zurich and are collaborating with the Forschungszentrum Jülich, Germany where the group of Dr. Martina Krämer uses the same instrumentation. For case studies the comprehensive Zurich spectral optical and microphysical Lagrangian box model (ZOMM) is used to perform detailed microphysical analyses. For estimating the radiative impact of cirrus clouds we use a simple model for cloud radiative forcing developed by Thierry Corti and Thomas Peter.

An automated data evaluation algorithm FLICA (Fast LIdar Cirrus Algorithm) has been developed, which uses a cloud detection scheme in combination with a Lidar retrieval. An example of the cloud detection using the raw signal of the co-polarized and cross-polarized channel is shown in Fig. 1.

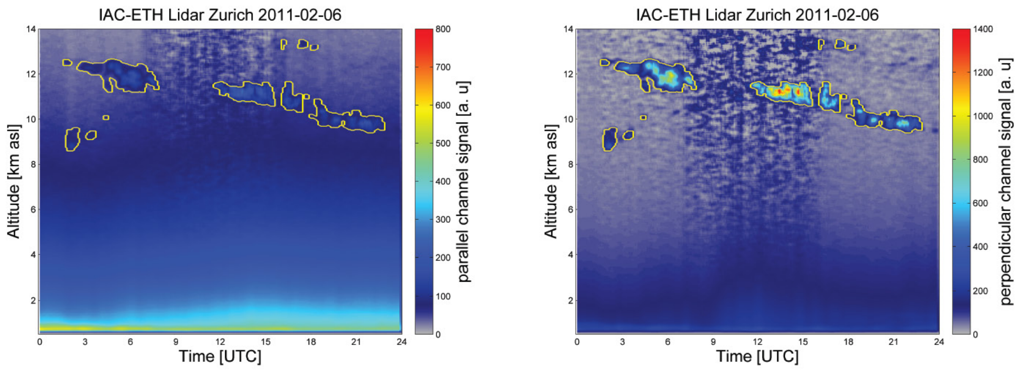

Figure 1. Cloud detection on a lidar measurement from Zurich, co-polarized (left) and cross-polarized (right) channel.

In 2014 the Lidar was operational during 5 months due to a failure of the power supply of the laser, measurements have resumed in December only. Nevertheless, over the past years we collected an impressive total amount of coverage given in Table 1 line 1 below:

	JFJ	Zürich	Jülich
Hours of measurements	5170	4678	3274
Number of cirrus detected	11276	7725	7176
Cirrus cloud coverage in %	15	12	15
Low cloud coverage in %	15	8	26
Cirrus Catogories			
Subvisible cirrus in %	38	31	31
Thin cirrus in %	51	55	52
Opaque cirrus in %	11	14	17
mean τ	0.13	0.16	0.17
Measurements by season in %			
DJF	24	17	18
MAM	40	15	39
JJA	14	48	32
SON	22	20	12

Table 1. Cloud properties of detected cirrus clouds.

Over the whole dataset the optical depth of the cirrus differs between JFJ and Zurich as illustrated in Fig. 2.

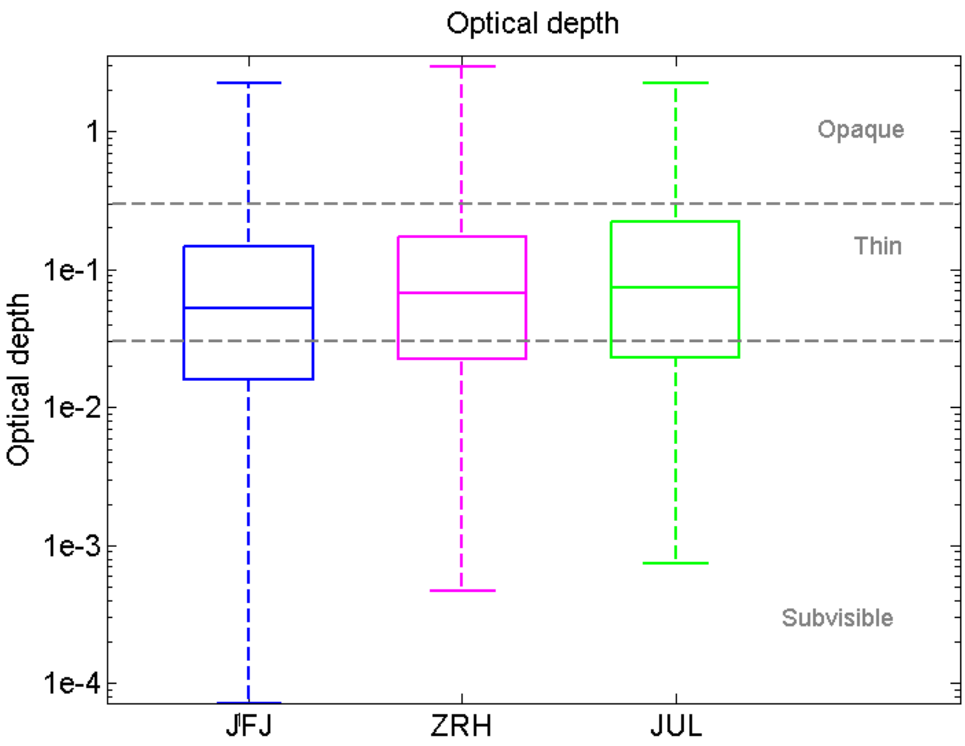

Figure 2. Optical depth for the different measurement sites, mean over whole dataset. Horizontal line in box: median. Boxes: the upper and lower quartile. Whisker: extremes. Gray horizontal lines: Cirrus categories.

At present we are analyzing whether the thinner cirrus observed at the JFJ are caused by the lower detection threshold of our instrument because of the favorable conditions at the JFJ site, namely, closer distance to the cirrus clouds and less influence of boundary layer pollution, or whether they are an atmospheric phenomenon.

We applied the radiative forcing model to the complete dataset as shown in Fig. 3.

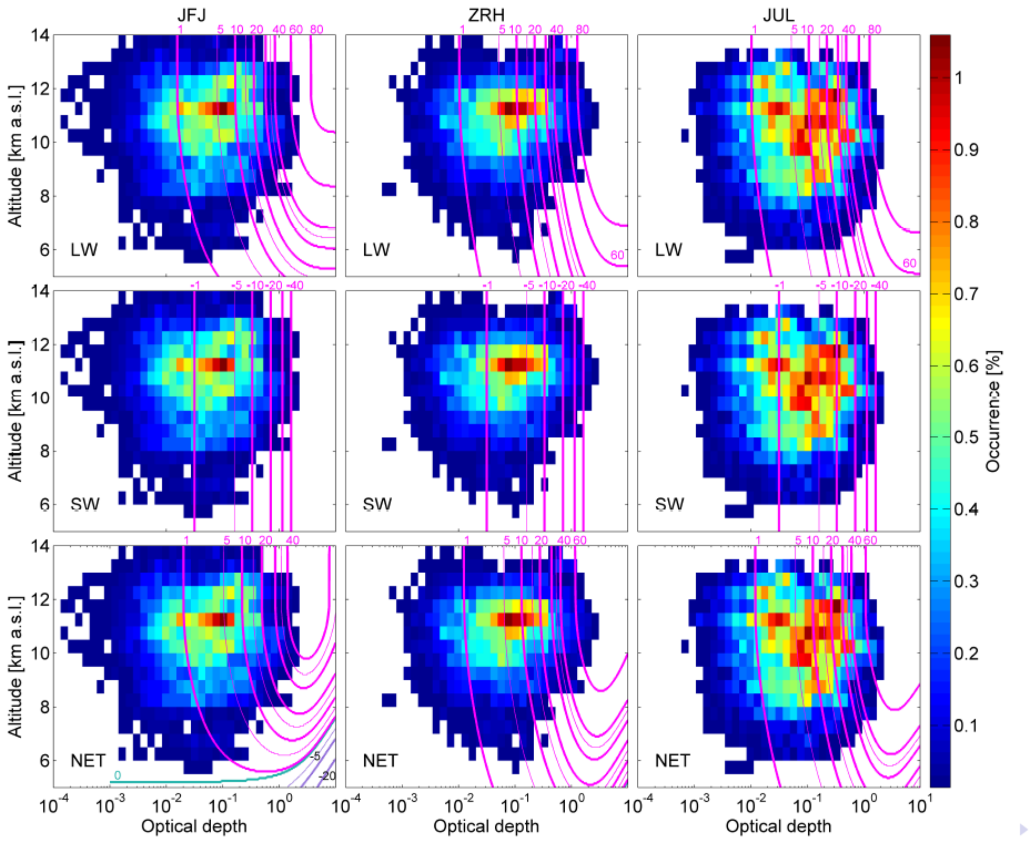

Figure 3. Cloud radiative forcing (CRF) in Wm^{-2} for the different sites. Magenta isolines: values from CRF-model. Color coding: occurrence frequency of cirrus clouds depending on altitude and optical depth. First row: long wave CRF, second row: short wave CRF, third row: net CRF.

We see that the cirrus cloud occurrence is quite similar at Jungfraujoch and Zurich, although the Jungfraujoch cirrus clouds show a slightly broader distribution in optical depth, in particular showing ultrathin cirrus, cp. Fig. 2. Most cirrus layers are present at 11 km a.s.l. with optical depths between 0.01(0.04) and 0.2(0.4) at Jungfraujoch (in Zurich). The Jülich cirrus clouds are common between 8 and 12 km a.s.l. with optical depths ranging between 0.02 and 0.7. The wider distribution of high occurrence frequencies in altitude may be due to the high frequency of frontal systems appearing over Jülich. The shift towards thinner clouds at Jungfraujoch explains the lower CRF net effect at that site in comparison to the other two. For overcast cirrus situations the net effect at JFJ is 6.2 W/m^2 while it amounts to 0.9 W/m^2 warming when accounting for cirrus occurrence.

Key words:

Lidar, cirrus, radiative forcing

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