Interaction between aerosols to rain clouds as a function of aerosols type and source (ASTCI)

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- **Introduction and motivation:**

Precipitation forming processes can be divided into two categories: Warm processes, where the rain forms mainly from the liquid phase in the cloud, and cold processes, where the rain forms mainly from the ice phase in the cloud (Rogers and Yau, 1989). In order for cold processes to occur in temperatures higher than -38^{0}C (homogeneous freezing temperature), ice nuclei (IN) are needed to be present in the cloud (heterogenic freezing) (Szyrmer and Isztar, 1997; Rogers and Yau, 1989). Heterogenic freezing enables ice crystals to grow at the expanse of liquid droplets in a process called Wegener–Bergeron–Findeisen Mechanism (Rogers and Yau, 1989). This is the primary process which initiates precipitation in the mid latitudes (Pruppacher and Klett, 1977; Gagin, 1975). Quantifying aerosol-cloud interactions involves large uncertainty, both at the micro-scale (e.g., the influence of aerosols on precipitation forming processes) and at the global scale (e.g., aerosol influence on the energy budget and on the hydrological cycle). Therefore the interest in this subject has been growing (Menon et al, 2002; Lohmann and Feichter, 2005; Rosenfeld, 2007; Kaufman and Koren, 2006).
The influence of aerosol's size on cloud processes is well recognized, and the conventional wisdom is that larger aerosols (diameter>0.5 μm) are better cloud condensation nuclei (CCN) and better ice nuclei (IN). In contrast, the influence of the chemical composition of aerosols on cloud processes is still not as important to their CCN activity (Dusek et al. 2006; Andreae and Rosenfeld 2008).
Aerosols can originate from natural (desert dust, sea spray, etc) or anthropogenic (industrial, transport, fossil-fuel power plant emissions) sources. As can be imagined, each aerosol type has different chemical composition, for example, desert dust contains high concentrations of terrestrial elements, while sea spray contains sea salt (mostly Na, Cl, and a few other elements).

- **Scientific objectives:**

In this work I aim to characterize aerosols' sources according to their chemical composition verified by HYSPLIT back trajectory calculations. Using satellite images from the geostationary satellite (MSG) I will investigate aerosol- cloud interactions as a function of aerosols' sources and types. In addition, my chemical data will be compared with data from the PINC (spell out) which measures IN concentrations (Chou et al, 2011), and with SP2 (spell out) which measures black carbon concentrations (Gao et al, 2007). My results might help constraining aerosol-cloud interaction models by using different IN efficiencies for different sources and chemical compositions.
I plan to analyze the chemical composition of cloud and snow samples collected at Jungfraujoch (JFJ). My results will be used to investigate cloud-aerosol interactions and the influence of different air masses on aerosols' composition, and in turn, its effect on ice formation in clouds. The JFJ's remote location, high altitude and state-of-the-art instruments provides a great advantage for studying cloud-aerosol interactions and precipitation forming processes.
My objectives are:

1. To examine the influence of different aerosol sources and types on cloud properties. The identification of aerosols' sources will be done by chemical and isotopic analyses of snow and cloud samples. Back trajectories will be used to verify these findings. After classification of the aerosol sources, the relationships between snow and cloud chemical composition will be examined.
This data will be examined with combination of the cloud properties (in situ and top temperatures, cloud water content, precipitation types and intensities) determined by other instruments available in JFJ and by satellite images. I intend to examine the influence of different air masses and the detailed composition of aerosols carried by them on cloud microstructures and precipitation forming processes. For example: marine aerosols have been considered as ineffective ice-nuclei, but marine air mass does induce effective ice formation. However, if these marine aerosols also contain pollutants or dust adsorbed on their surfaces, they might change their affectivity as ice or water nuclei.
2. To compare data from aerosol chemical specifications monitor (ACSM) and single particle soot photometer (PC2) with our data. The findings of the PC2 will be compared with my results in order to examine the different black carbon (soot) sources and their influence on cloud physics.
In addition, my data will be compared with data from PINC instrument who measure the IN concentration in the air mass.

- **Reason for choosing station:**

I chose to do my measurements in the JFJ research station since its high altitude and remote location are instrumental for studying cloud-aerosol interactions. In addition to its unique location, during the CLACE 2014 campaign, many instruments will be operating at the research station, generating a high quality data set that can be used.

- **Method and experimental set-up:**

Snow sampling: Snow samples were collected with plastic funnel placed at the Sphinx's lower terrace. The funnel was places outside for 30-60 minutes (deepened on the snow rate) and was replaced by another plastic funnel. I brought the full funnel inside, and placed it on a funnel shape heater. The melted snow was collected into a 50ml tube. In order to prevent contamination, I covered the funnel and the tube with a plastic bag.
Cloud sampling: Cloud samples were collected using a Teflon impact surface that was placed at the Sphinx's lower terrace. As super cooled droplets hit the impact surface and freeze into rimed ice. Every few hours (depending on the sample size), I took the impact surface with the cloud sample, and using a plastic spatula, scratched the rimed ice into a clean zip-lock bag. After the rimed ice melted, it was collected into 50ml tube.
Snow photography: Approximately every 15 minutes, I took a black surface outside for a few seconds and collected a few snowflakes on it. Then, the surface was placed under a Nikon Camera (D5100) with a macro lens (Nikkor 105mm, 2.8f) and several photos were taken. Analysis of the photos is done manually, where each photo gets a value of 1 to 5 according to the riming rate that is observed.
Snow density: Another way to characterize the snow is by its density. I tried to conduct density measurement each time I changed a snow sample, but sometimes not enough snow was accumulated on the ground. In order to measure the snow, I used a plastic tube with a diameter of 12.5 cm. Using the tube I took snow that was accumulated on the surface, and placed it on a digital scale. Then, I measured the height of the snow column and by that I calculated the snow volume

and density. After each snow density determination, I cleaned the surface, so new snow will accumulate on it.

- **Preliminary results and conclusions:**
- During the campaign 127 different snow samples and 25 different cloud water samples were collected. At the same time that our samples were collected, the other instruments were also working (SP2, ACSM and PINC) and collecting data. Since our samples have not been analyzed for chemical and isotopic composition yet, we still do not have any results of the chemical composition influence on cloud processes. The back trajectory analysis identified several sources, which is a very encouraging result.

- **Outcome and future studies:**
  The future studies that are based on the collected data in the campaign are described in detail above.

- **References:**

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