[CLACE-3013 - INUPIAQ]

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- Introduction and motivation, scientific objectives:
  The proposed work (INUPIAQ) was part of the CLACE-2013 campaign at the Jungfraujoch (JFJ). The University of Manchester contributed/is contributing to the experiment by:
  1. Providing a comprehensive data set of aerosol, and cloud microphysics measurements.
  2. Using these measurements (along with collaborators measurements) as input to an explicit cloud-aerosol interaction model (ACPIM), which will undertake sensitivity studies for the purpose of understanding the important processes occurring within the aerosol-cloud system, thus highlighting processes which need inclusion in other state-of-the-art models, such as the Met. Office Unified Model (MetUM).
  3. Identifying ice processes that impact cloud evolution significantly.
  4. Determining whether observations in previous CLACE experiments e.g. the observed very sharp transitions between ice and liquid clouds [Choularton et al. 2008] are due to changes in aerosol chemical composition, Cloud Condensation Nuclei (CCN) or Ice Nuclei (IN) properties.

  The motivation for the UoM deployment is to understand the development of the ice phase in clouds and to understand how aerosols are linked to this. The proposed instrument suite (below) offers a unique opportunity to probe the science questions such as: why do mixed-phase clouds persist for much longer than expected?; to what extent do cloud dynamics and/or the aerosols govern the phase of clouds over a range of spatial scales? It is clear from previous campaigns at JFJ (and elsewhere) that rapid transitions occur between the liquid and ice phase and we wish to probe this and other features further, to better parameterise such behaviour, since this isn't as yet included in models.

- Reason for choosing station: The JFJ site has been chosen for a series of CLACE experiments over the years because it provides a unique environment to investigate the detailed interactions occurring between aerosols and clouds both in liquid and mixed phase conditions. In addition, the ongoing collaborations that have occurred over the years at the site have enabled a world leading level of expertise to be built up which together with improvements in the state-of-the-art instrumentation deployed, provides the best chance to investigate the complexities of interactions and processes which govern the development and evolution of the ice phase in these clouds. Hence the JFJ provides a unique natural laboratory for these investigations.

- Method and experimental set-up: The University of Manchester (UoM) made measurements of the Microphysical parameters of the Clouds enveloping the Sphinx laboratory on the Jungfraujoch (JFJ). A suite of new state-of-the-art instruments was deployed. Many of these were mounted on a purpose built platform capable of automatically rotating and tilting the instruments directly into the ambient wind for un-perturbed cloud sampling. These instruments were complementary to, and filled gaps within, the instrument suite already being deployed by other collaborating groups participating in the CLACE-2013 experiment.

Externally, the UoM measured the liquid and ice phase cloud particle size distributions (using a range of cloud spectrometers) from which the cloud liquid and ice phase water contents can be calculated. The former was also be measured directly (by a Gerber PVM-100 - Particulate Volume Monitor). The instruments also: recorded images of cloud drops and ice particle habits (ice crystal shapes/type); accurately measured the local 3-D wind vector next to the cloud microphysical instruments (enabling correct sampling alignment, and for determining instrument sample volume corrections); measured local temperature, humidity.

Internally, within the Sphinx laboratory and sampling off the new Ice selective Inlet (ISI) or the Total Sample Inlet (TSI), the biological cloud residual particle concentration fraction was also measured, in conjunction with another institute using similar instrumentation

Instruments that were deployed by UoM included:

(i) a DMT Cloud Droplet Probe (CDP-100) (drop size distributions: 1-50um);
(ii) a DMT CAPS (Cloud, Aerosol and Precipitation Spectrometer) multi-probe consisting of a Cloud and Aerosol Spectrometer with depolarisation detection (CAS-depol) (aerosol-cloud particle concentrations, 0.6um-50um) which includes a depolarision back-scattered signal channel to differentiate liquid and ice particles), and a CIP-15G (Cloud Imaging Probe 15 - Greyscale) (cloud particle images: 15-960um);
(iii) a SPEC 3-View Cloud Particle Imaging probe (3V-CPI) combining a fast response (10Hz) 2D Stereoscopic (2D-S) shadow imaging probe (10-1280um) and a new high speed (400 frames per second) high resolution CCD CPI;
(iv) a PMS/DMT Forward Scattering Spectrometer Probe (FSSP-SP100) (drop size distributions: 1-50um)
all mounted on a moveable Pan/Tilt platform (remotely controlled to direct instruments into wind).

Also deployed were:
(v) a Gerber Particulate Volume Monitor (PVM-100) (bulk cloud liquid water content);
(vi) a Metek heated Ultra-sonic anemometer USA1 (3D windspeed at XX Hz);
(vii) a Biral HSS VPF-750 Visibility, Present and Past Weather Sensor
(viii) a Rotronics hygroclip T and RH sensor

The results from the anemometer were used to automatically move the pan and tilt instrument wing so as to direct the instruments mounted on it (CPI, CDP, CAPS and FSSP) into wind. At all times Aircraft instruments with inlets (FSSP, CAS, CPI) were aspirated using a controllable vacuum pump. Instruments were routinely cleaned, calibrated (and where required – aligned) following published standard protocols.

Internally deployed on either the ISI or TSI inlets was:
(ix) a Wavelength Integrating Bio-aerosol Sensor (WIBS) (UV flow cytometry instrument) for continuous detection/sizing of single biological particles in the cloud residual population (sampling inside off the ISI).

- Preliminary results and conclusions

A comprehensive data set of cloud microphysics in mixed phase clouds through a wide temperature range has been gathered. These data have been quality checked and are currently being analysed. Interpretation of the combined aerosol and cloud data set (which will be available to all) is presently being undertaken to identify the important ice formation mechanisms acting within the clouds. To do this State-of-the-science numerical models will be used, including an explicit bin-microphysics model, ACPIM (developed at UoM), and also the Met Office Unified Model with a new cloud-aerosol scheme, (available through collaboration with the Met. Office)

- Outcome and future studies

Project workshop meetings will take place (organized by the experiment coordinators) beginning in autumn 2013. At this stage data analysis of all the partners should be well underway or complete, and so collaborative paper titles will be discussed and set. Those involving UoM will include the investigations of the origin of the ice phase in the clouds observed. These joint papers will then be prepared and submitted for publication in open access peer reviewed journals.

The UoM has now received national funding (from NERC) to return to the JFJ high altitude site in early 2014 to repeat the above set of measurements at the Sphinx laboratory site, and also to measure the aerosol interacting with the cloud prior to this interaction. To facilitate this, options for an upwind (out-of-cloud) site are currently being investigated with staff from the host institute.

- References

From previous CLACE experiments and other relevant work:

Observations and modelling of microphysical variability, aggregation and sedimentation in tropical anvil cirrus outflow regions: M. W. Gallagher, P. J. Connolly, et al. Atmos. Chem. Phys., 12, 6609-6628, 2012

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