Name of research institute or organization:

University of Manchester, Centre for Atmospheric Science

Title of project:

CLACE-2013_UK (project "INUPIAQ" was funded by UK NERC only after the start of 2013 project , PI Paul Connolly)

Project leader and team:

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Project description:

The University of Manchester contributed to the joint CLACE-2013-INUIT multi-national experiment held at the Jungfraujoch (JFJ) in January-February 2013. The aims of the Manchester contribution were to:

1. Provide a comprehensive data set of aerosol, and cloud microphysics measurements.

2. To use the measurements obtained (along with those of collaborating institutes' measurements) as input to an explicit cloud-aerosol interaction model (ACPIM), developed in Manchester, to use the model to undertake a series of sensitivity studies for the purpose of identifying and understanding the important processes occurring within the aerosol-cloud system at JFJ, thus highlighting processes which might need inclusion/modification in other state-of-the-art models, such as the Met. Office Unified Model (MetUM).

3. Identify ice processes that impact cloud evolution significantly.

4. To determine 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, in particular in Cloud Condensation Nuclei (CCN) or Ice Nuclei (IN) properties.

To meet these aims of understanding the development of the ice phase in JFJ clouds and to understand in particular how aerosols are linked to this, the University of Manchester contributed to the 2013 experiment by 1) deploying a suite of instrumentation at the site to: Measure liquid and ice phase cloud particle size distributions (from which cloud liquid and ice phase water contents could be calculated - although the former was also to be measured directly); Record images of cloud drops and ice particle habits (ice crystal shapes/type); Accurately measuring the local 3-D wind vector; Measuring the biological cloud residual particle concentrations. 2) Post experiment (and when funding eventually became available through the successful funding of the INUPIAQ proposal to the UK Natural Environment Research Council) work started on quality assuring the data, and to begin the work to model the cloud evolution using the detailed cloud model (ACPIM) developed in Manchester.

The major instruments deployed by the University of Manchester at JFJ in early 2013 included:

1) a DMT Cloud Droplet Probe (CDP-100) (to measure drop size distributions: 1-50um);
2) a DMT CAPS (Cloud, Aerosol and Precipitation Spectrometer) multi-probe consisting of a Cloud and Aerosol Spectrometer with depolarisation detection (CAS-depol) (measuring aerosol and cloud particle concentrations, 0.6um-50um) (includes a depolarisation back-scattered signal channel to differentiate liquid and ice particles), and a CIP-15G (Cloud Imaging Probe 15 - Greyscale) (recording larger cloud particle images: 15-960um);

3) 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;
4) a PMS/DMT Forward Scattering Spectrometer (FSSP-SPP-100) measuring drop size distributions: 0.5-50um);
5) a Gerber Particulate Volume (PVM) monitor measuring cloud liquid water content directly;
6) a heated Metek Ultrasonic Anemometer, along with
7) temperature and humidity sensors;
8) a Biral HSS VPF750 present weather sensor;
and finally
9) a Wavelength Integrating Bio-aerosol Sensor (WIBS) (a UV flow cytometry instrument) for continuous detection/sizing of single biological particles in the cloud residual population (sampling inside off the ISI or Ice CVI).

All instruments 1-8 were mounted externally on the JFJ terrace rooftop outside the Sphinx laboratory. Instruments 1-4 were mounted on an instrument crossarm (Figure 1), which was able to rotate and tilt the cloud microphysics instruments directly into the ambient wind, automatically (as determined from the real-time sonic anemometer measurements). The crossarm and rotator were mounted on the top of a 3m (square) mast secured to the JFJ terrace rooftop (as illustrated in Figure 1 below and Figures 2-5), alongside an access platform. The PVM and sonic anemometer were fixed to a separate (triangular) mast to the west of the rotator on the other side of the access platform. The temperature/humidity sensors were attached to the fixed rotator mast. The Present Weather sensor was attached to the railings running along the northside of the rooftop. The ETH HOLIMO holographic spectrometer was also deployed on the Manchester crossarm (located centrally on the top of the wing).

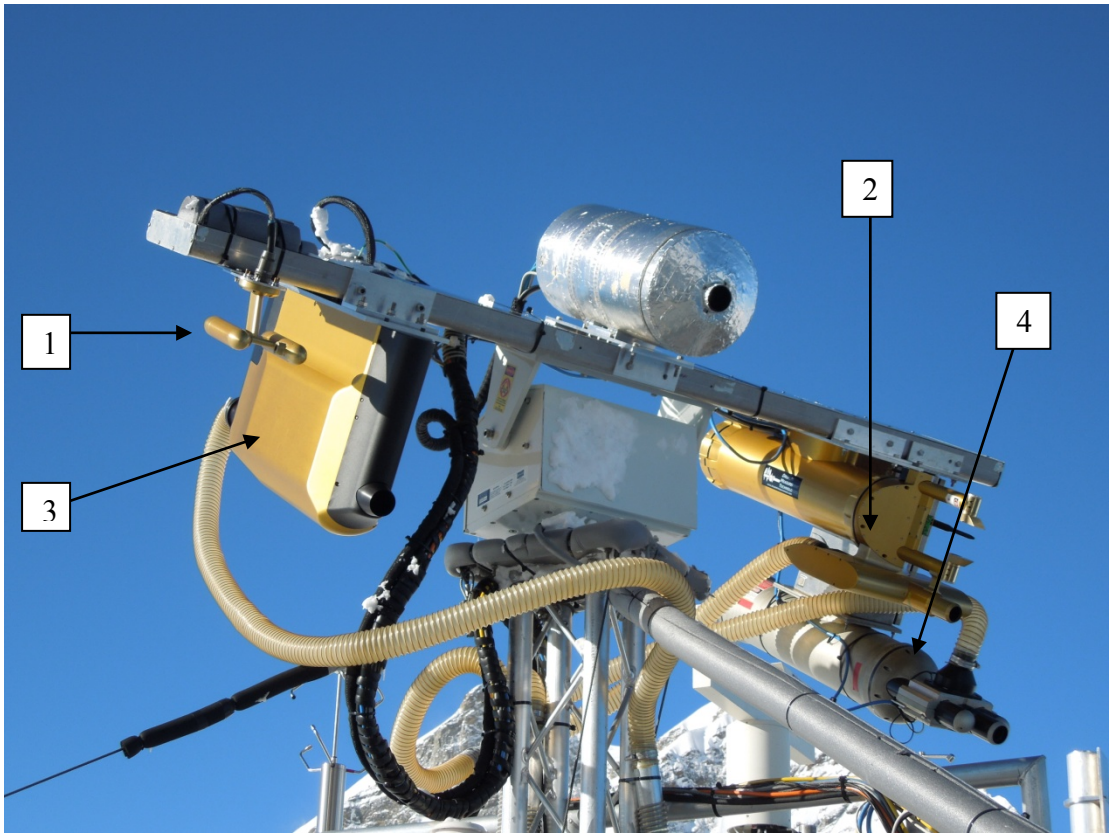
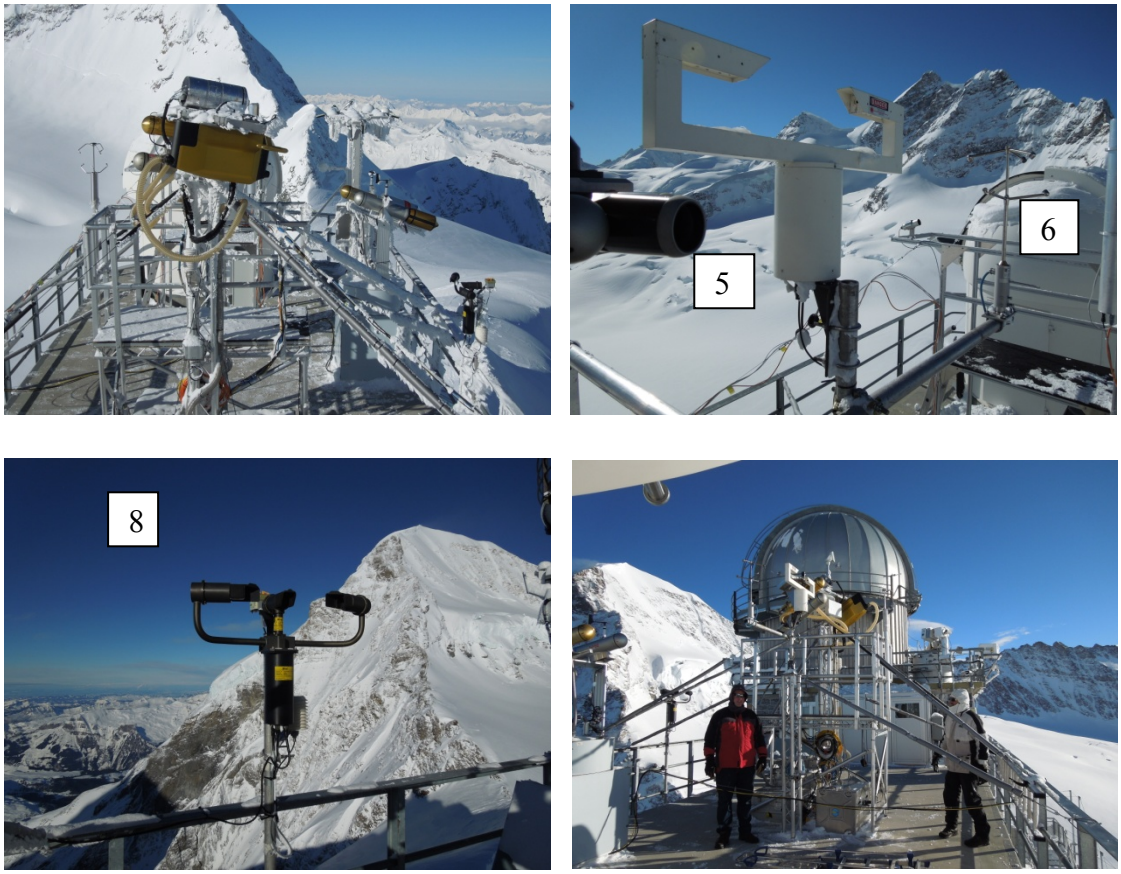


Figure 1.



Figures 2-5.

Instruments (1-4) are designed to be deployed on aircraft and hence normally sample cloud at aircraft speeds. Because of this, instruments with inlets (2a, 3 and 4) were aspirated by attaching tubing to the rear of inlets and sucking cloud through at controllable rates using vacuum pumps (located in the aluminium boxes beneath the platform) and a venturi control system. All instruments, particularly those with inlets required constant attention during sampling to prevent significant build up of rimed ice in supercooled cloud conditions During nighttime, this was not always possible when left unattended, and hence such icing incidents need careful removal during quality assurance of the data prior to analysis. All microphysics instruments were also calibrated at suitable intervals using known calibration standards (eg calibration glass spheres of known diameter for CDP, FSSP and CAS, or by the use of calibration filters in the case of PVM. The latter required frequent checks of the baseline and calibration span, to account for gradual decline of optics cleanliness etc.

Finally, the bioaerosol spectrometer (WIBS (9) was deployed internally to the Sphinx laboratory, and sampled off either the ISI or ICE-CVI inlets in conjunction with the INUIT WIBS instrument. All measurements from the external cloud microphysics instrumentation were also logged on systems set up within the Sphinx laboratory workshop, together with the controls for the crossarm rotator, alongside the HOLIMO logging computer.

Results:
The intended result of the University of Manchester contribution to CLACE-2013 is a comprehensive data set of aerosol and cloud microphysics measurements, enabling detailed cloud model sensitivity studies to be undertaken which aim to aid identification and increase understanding of the important processes occurring within the aerosol-cloud system, highlighting processes which need inclusion in other state-of-the-art models, such as the UK Met. Office Unified Model (MetUM).

The analysis and interpretation of these data collected during CLACE_2013 are proceeding now that we have funding, but these activities are in their early stages and are not yet final or ready for presentation/publication. Preliminary analysis of data from the microphysics probes suggests that ice crystal number concentrations observed are often much higher than the ice nucleus concentration observed locally or likely to be present. These results strongly suggest that a secondary ice particle production process is operating in the cloud system and work is proceeding to identify and quantify the processes contributing to the observed ice crystal number concentration. This work will be combined with that from the forthcoming CLACE-2014 experiment, and with the results of the collaborative participating institutes in the experiment to produce joint publications.

Key words:

Ice microphysics, mixed phase cloud, ice nucleation

Internet data bases:

Currently raw data storage is on a local (Manchester) data server until quality assurance and analysis is completed at which point data will be transferred to (and be publically available) at the British Atmospheric Data Centre (BADC).

Scientific publications and public outreach 2013:

None as yet – too early in funded project, but data sets were discussed/evaluated between CLACE-2013/INUIT participants at the recent "INUIT" project meeting held on 4-5th December at the University of Frankfurt, where progress towards publications was also discussed.

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