ICE-D UK

- If the US component were to take place in 2017 then the Met Office could in principle support the 146 in 2017 rather than 2015, especially if this significantly strengthens the US proposal.

- In terms of the science quality and actually doing the required sorties, it is better to be part of a multi-aircraft campaign with the 146, C-130 and Learjet involved at the same time.

- Met Office 146 flying in 2016 is already 'over-booked' with the Indian campaign and probably Clarify. There is very little chance we could support any Ice-D flying in 2016.

- There are benefits instrument-wise to doing the campaign in 2017. The key instruments INC and SPIN would have had some flight time prior to Ice-D, and the new Met Office Aerosol rack - photo-acoustic spectrometer and cavity ringdown spectrometer and other sizing instruments will be ready (both key for the 2016 campaigns).

Options

A – 146 campaign in 2015 (hours secured +earlier gas phase chem proposal submitted)

Disadvantageous for NSF c130 proposal

B- C130 and 146 campaign in 2017.

Stronger science and synergy arguments.

146 has to give up hours secured in 2015.

C – C130 campaign in 2016

146 very unlikely to participate in 2016 - ~100 hours devoted to Indian monsoon SWAMI in JJA timeframe. +other campaigns

If the c130 goes in 2016, unlikely that NERC funding would be available for 146 ice-d flying later

Proposed way forward

- ICE-D will be a multi-year project taking place over 2015/2016. An advantage of deploying over two years in the increased likelihood of getting good case-studies.
- The BAe146 deploys to Cape Verde in 2015 along with ground based measurements at CV. The UK science team will identify 1/3-1/2 of the ICE-D science objectives that the 146 will tackle.
- The C130/Lear will deploy in 2016 and tackle all of the identified ICE-D objectives allowing for increased data availability on the objectives that are in common with the BAe146.
- Data will be shared between the US and UK science teams between the different platforms and different deployments.
- Funds will be sought (e.g. NERC) to invite ICE-D participants to take an active part in the science management of the 2015/16 deployments.
- Joint workshops will be carried out to advertise data to all participants and foster data sharing and collaborative research to satisfy the science objectives.
- The AIDA facility will take part in both deployments (subject to negotiation with AIDA team).

Incorporation of EDO Scientific objectives into NERC proposal

- Attempt to observe the conditions leading to glaciation of maritime cumulus with cloudtop temperatures warmer than -10C.

Yes

- Use improved probes to measure CCN and IN concentrations and composition.
- Characterize the aerosol as CCN and IN and investigate the dependence on temperature, size and aging (special interest in dust and biological material).

Some – limited to physical characteristics (size, number)

- Use improved probes and processing techniques for measuring properties (concentrations, shapes) of the cloud drops and ice particles.

Some probes – not all that will be available to c130

- Characterize how dust composition/mineralogy affect the ability of dust aerosols to act as CCN and IN.

Simple lab experiments using filters – potentially involvement of AIDA.

- Characterize the link between drizzle size and larger drops and primary and secondary ice processes (e. g., ice splintering) as a function of time and environmental conditions. As part of this characterization, estimate the fraction of vapor flowing into cloud base (the cloud base mixing ratio) that arrives at the 00C, -50C and -100C temperature levels in the form of vapor+supercooled liquid water+ice? How does dust affect these fractions? How does this depend on the cloud lifecycle?

Yes

- Determine if primary ice nucleation can explain the onset and glaciation of maritime cumuli.
- Determine whether secondary ice formation processes are critical to the glaciation of cumuli. If so, what concentration of primary IN are sufficient to trigger them and how does the process work?

Yes (above 2) from a combination of observations and modelling

- Determine whether mid-level entrainment plays a role in feeding CCN and IN into maritime convective clouds.

Not in detail – but measure aerosol at levels above cloud base that may be entrained into cloud

- Test primary and secondary ice nucleation schemes in models and evaluate them against observations

Yes – global, LAM, CRM,parcel

- Define the composition of African dust and its carbonaceous (organic and black carbon) fraction.

Some, SP2 available on 146

- Characterize how aging and cloud processing during transport of dust influence their CCN and IN potential.

No

- Measure how mineral dust properties impact cloud microphysical, radiative and dynamical properties and precipitation

Radiative and microphysical measurements

146 payload-1

CLOUD-ICE-WATER (Combination dependent on pylon mounting point availability)

- CIP-15 (Cloud Imagine probe), DMT, 15–930 μm at 15 μm resolution (antishatter tips fitted).
- CIP-100 (Cloud Imaging probe), DMT, 100–6200 μm at 100 μm resolution (antishatter tips fitted).
- CDP (Cloud Droplet Probe), DMT, 2-50 μm) (antishatter tips fitted) .
- BCPOL-1 (combined with CDP) <2 to 30 μm, resolution 1 μm, with particle by particle polarisation backscatter.
- CAPS (Cloud, Aerosol and Precipitation Spectrometer),CIP-15 15–930 μm at 15 μm resolution (anti-shatter tips fitted), CAS 0.5-50 μm 0.5-2 μm resolution, backscatter depolarisation (water-ice discrimination) uses inlet – ice shatter rtefact removal reliant on inter-arrival analysis), Hot-wire LWC (0-3 g m-3), DMT.
- 3V-CPI (Three-View Cloud Particle Imager), Spec, Inc.10-2,300 μm, resolution 2.3 μm, 256 bit grey scale, 340 fps.
- 2D-S (Stereo) probe, 10–1280 μm, 10 μm resolution, 100 Hz,Spec.
- SID (Small Ice Detector) 2 or 3, University of Hertfordshire.
- Liquid and ice water content will be measured by the Nevzorov probe.
- LWC will also be measured with a Johnson-Williams hot-wire instrument (0-1 g m-3).
- A Lyman-alpha evaporator probe will measure total water content.
- Under discussion – upgrade to FSSP-100 to FCDP (SPEC) for high speed droplet measurement and cloud top entrainment.

AEROSOL

- CCN-200, CCN concentration as a function of super-saturation, Kappa model closure.
- SP-2 (Single Particle Soot Photometer), scattering absorbing size distribution, mixing state and black carbon mass, 0.15-0.9 μm.
- PCASP-100, Aerosol size distribution >0.1μm to < 3μm optical scattering size distribution.
- Filter samples (on LTI inlet, < 20 kft) for post refractory and inorganic particle analysis
- C-TOF Aerosol Mass Spectrometer, volatile organic, inorganic (SO4, NO3 etc) mass size distribution
- MBS-1, Multi-Diagnostic Bioaerosol Spectrometer. Fluroscent bioaerosol size distributions with generic bioaerosol type discrimination. Single particle (0.5-20 μm), 8 channel UV-LIF spectrum and particle shape, optical size (installation under discussion)
- Ice Nuclei Counter developed by the Met office based on a continuous diffusion chamber will characterise the ice nucleating ability of the aerosols.

146 payload-2

MET & TURBULENCE

•High-resolution 3D wind measurements will be made with the aircraft's standard 5-hole turbulence probe.

•In-cloud temperatures will be measured by a Rosemount sensor and AIMMS probe T/RH sensor.

•Weather radar.

•AIMMS-20 (Aircraft-Integrated Meteorological Measurement System), Aventech Research, Inc.

•Video camera systems.

•Airborne lidar – detection of cloud and aerosol layers. Leosphere ALS450 eye-safe system, installed in a nadir-viewing geometry, and working at 355 nm (near-ultraviolet).

TRACE GASES

CORE

•Chemistry Instrumentation. There is likely to be more advanced instruments, but the FAAM core chemistry includes the following:

•O_3 (Tei49C, 2BTech model 205)

•SO_2 (Tei43C TL)

•CO (AL5002)

•CO_2 (FGGA)

Part CORE

•CH_4 (FGGA)

•NO_x (AQD)

NON-CORE

Source identification TBD

Ground based observations (2015,2016)

REMTOTE SENSING

- Cloud radar
- Polarisation lidar (Leipzig may deploy one of these? TBC)

In SITU Aerosol

- **Laser Ablation Aerosol Time-of-Flight (LAAP-TOF) bipolar mass spectrometer**. Provides sizing and bipolar particle mass spectra for particles. LAAP-TOF is capable of analyzing aerosol particles in the range of 70 nm to 2.5 μm. It provides combined information on the size of the particles and their chemical signature, from inorganic and organic particles but of particular interest to this project, mineral dust and soot particles for IN studies, but also potentially for analyzing for the presence of biological particles.
- **TSI SMPS and APS** (NCAS supplied) for size distribution from 10 nm to 20 μm.
- **TSI Single particle soot photometer (SP-2D)** for quantitative number and mass size distribution of sub-micron absorbing and scattering aerosols from 0.15 to 0.9 μm. This would complement the instrument on the FAAM aircraft
- **APS-D Depolarisation aerosol spectrometer for mineral dust**, ($0.3<Dp<20$ μm). Useful for discriminating mineral dust and for comparison with the LAAP-TOF.
- **WIBS-4**. UV-LIF Single particle bioaerosol spectrometer – FBAP size distribution and bioaerosol emissions modelling (Hummel et al. 2013). Pending funding second MBS may be available as a replacement or if existing instrument cannot be installed on the aircraft in time.
- **CCN-100 spectrometer with DMA polydisperse modification**. For comparison with aircraft CCN spectrometer and Kappa closure studies.
- **SPIN Ice Nuclei Spectrometer** (British Antarctic Survey instrument) – as per aircraft instrument. Will require a dedicated person to operate and analyse data.

Other in situ Measurements

- Aerodyne PMssa – single particle scattering albedo
- Filter samples – as per aircraft

- Additional T+S for 1-2 US partners to take part in 2015 field campaign and post-campaign meeting
- Request funds for intercoparison of instruments if not able to coordinate flying activities.