# AIITS: Preliminary light scattering data from Tropical Tropopause Layer cirrus

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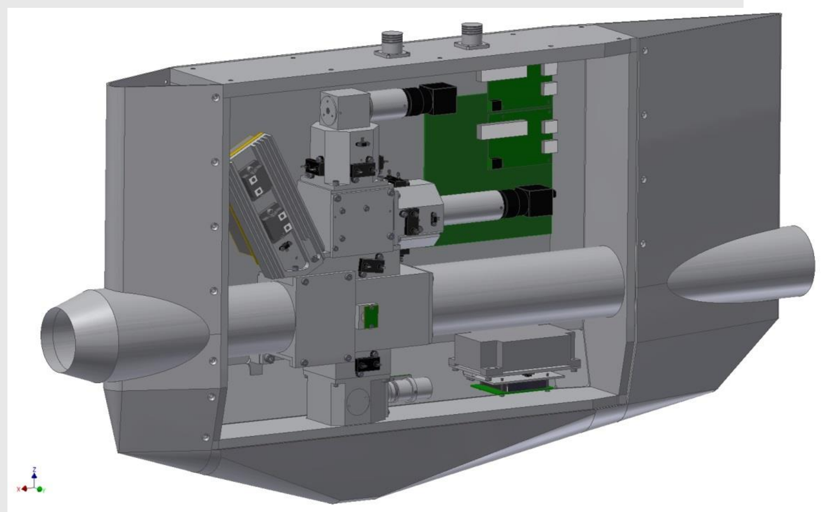
## Introducing AIITS

AIITS (**A**erosol **I**ce **I**nterface **T**ransition **S**pectrometer) captures two 2D forward scattered images, backscatter depolarisation and bulk side-scatter from individual particles in the size range of ~1-50µm.

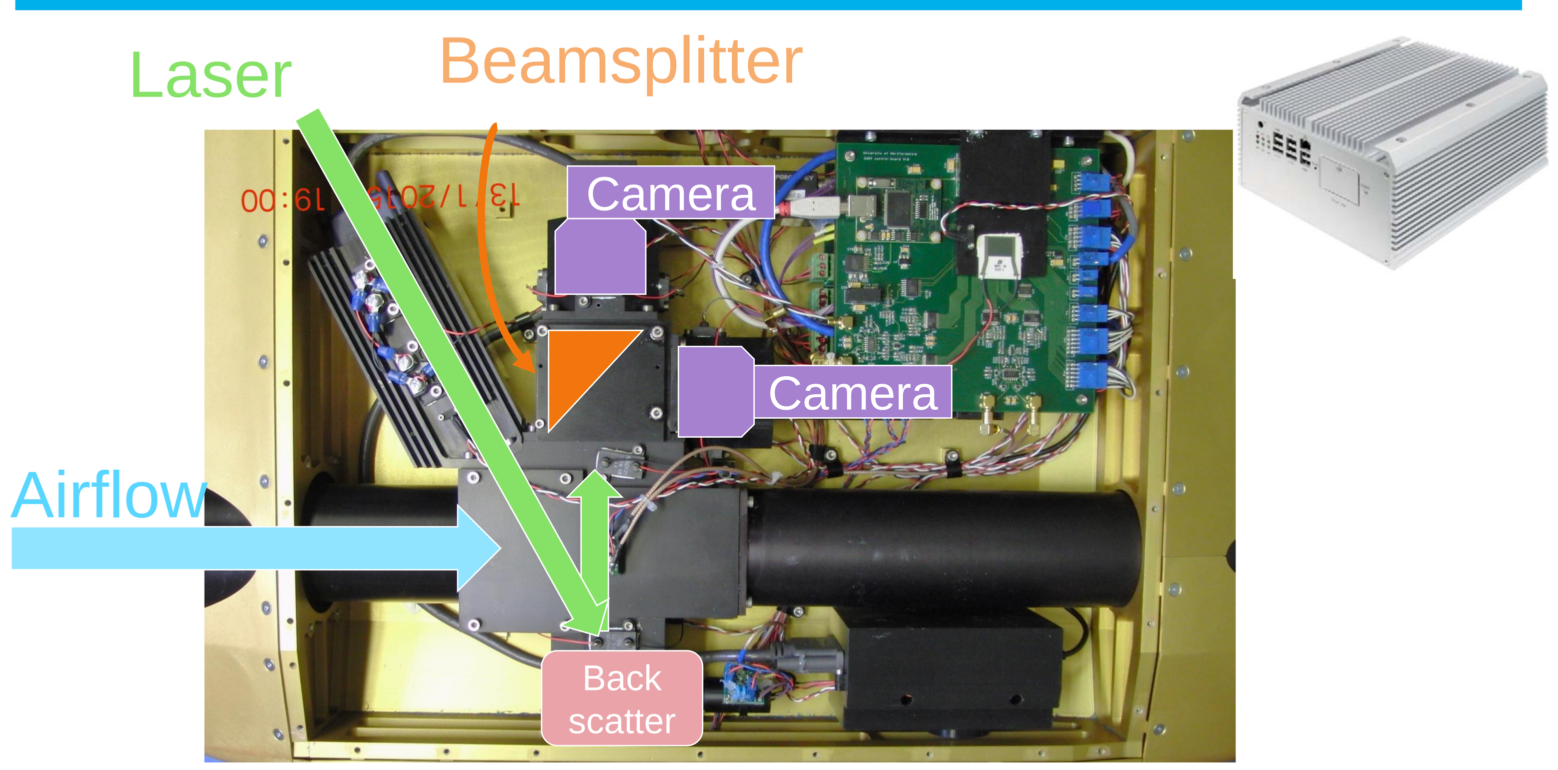
These data are used to determine:

- Particle number concentration
- Particle size (~1-50µm)
- Particle shape
- Particle roughness
- Aspherical particle fraction
- Liquid/ice water content



AIITS was developed at the University of Hertfordshire as an addition to the Small Ice Detector (SID) range of probes.

## Instrument design




**Cameras**: 2 intensified cameras (~30FPS)
**Laser**: 532nm, 150mW Coherent
**Forward scatter**: 6-25°
**Backward scatter**: 163.5-173.7°
**Beamsplitter:** Pellicle (swappable)

**Host**: i7 3610, Win7, 8GB, 2TB
**Image data**: 8-bit JPG
**Metadata**: XML
**Comms**: UDP, TCP, FTP, SSH
**Power:** Host 9-36V, Probe 28V

There are two available modes of operation. One is similar to SID-3 which captures forward scattering intensity data. In this mode the second camera may use a different gain to increase the useful size range. The second mode is used to quantify forward 2D depolarisation.

### Scattering Intensity mode

- Circularly polarised incident beam
- Intensity patterns captured
- High dynamic range available by using different intensifier gains
- Comparable data to SID-3 instrument
- Includes backscatter depolarisation

### Forward Depolarisation mode

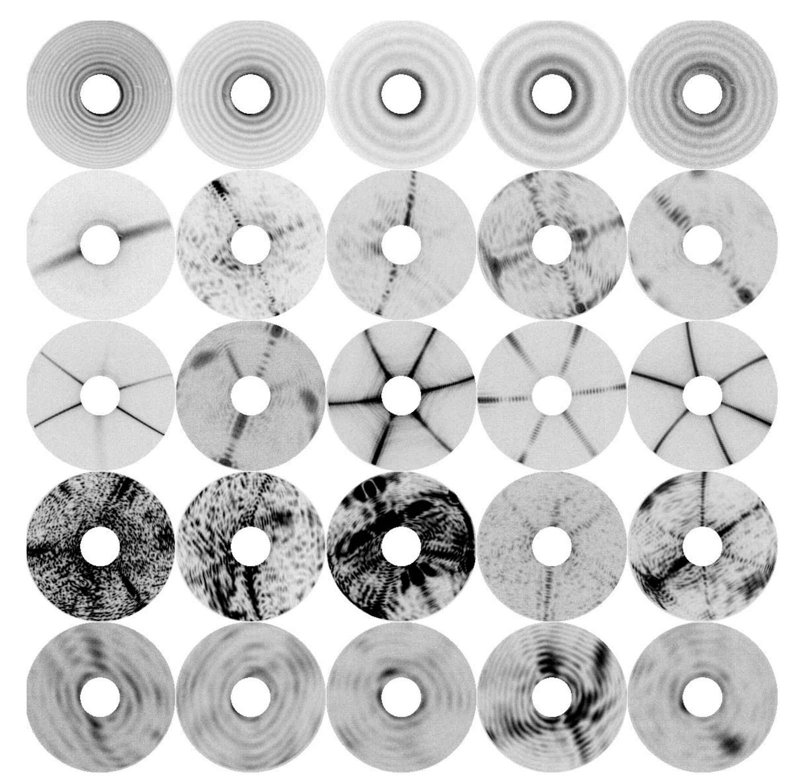
- Linearly polarised incident beam
- Parallel and perpendicular polarisation images captured independently
- Potential to differentiate frozen spheres from liquid spheres
- Includes backscatter depolarisation

## Characterisation of forward scattering

By collecting forward scattered light from individual particles we can characterise details such as the size, surface roughness & morphology of the particle.

The technique is able to record data from smaller particles than imaging probes, as well as small-scale features such as surface roughness and indentations.

The Small Ice Detector (SID) instruments are currently in use in the UK, USA & Germany.

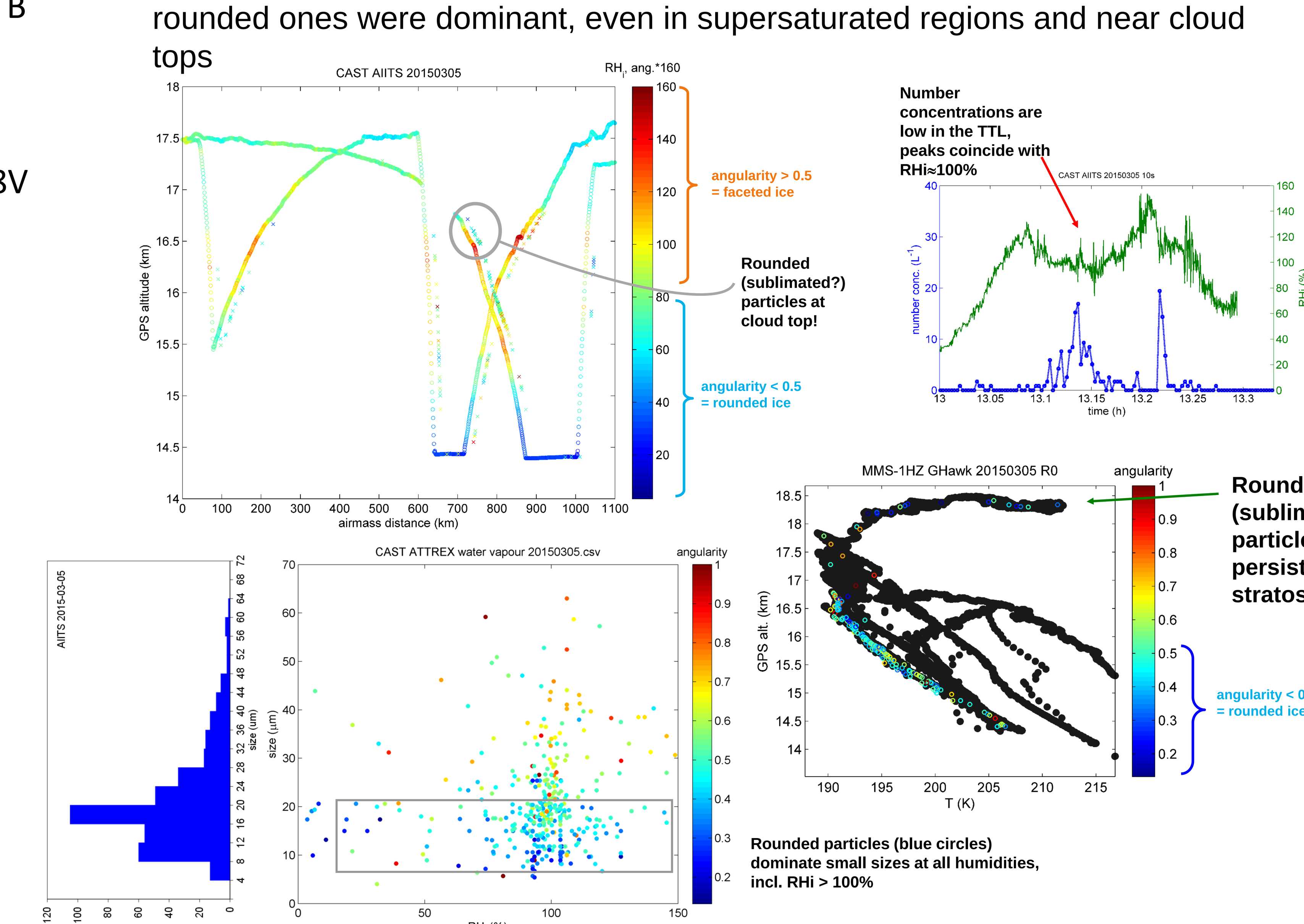


Droplets
Columns
Smooth plates
Rough prisms
Rounded particles

## Campaign Results

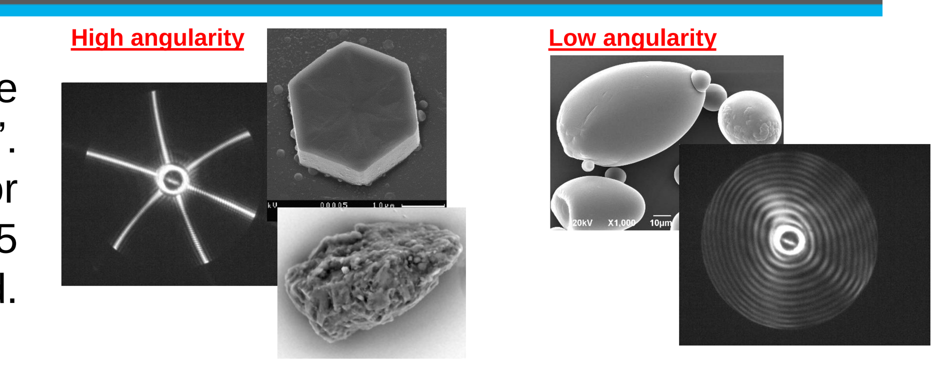
In February 2015 the AIITS was certified for flight on NASA's Global Hawk as part of the CAST campaign. Four flights were made for a total of ~40hrs, up to 60k ft.

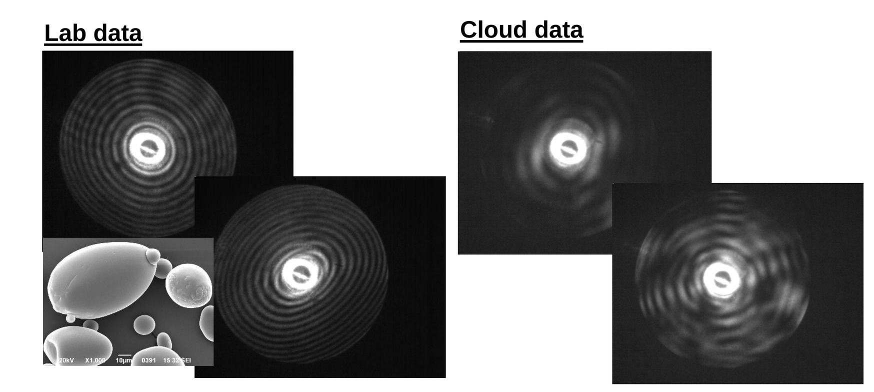
Ice particles were present across wide range of saturation ratios, up to the homogeneous nucleation level. Various particle shapes were observed, but rounded ones were dominant, even in supersaturated regions and near cloud tops




## Rounded particles

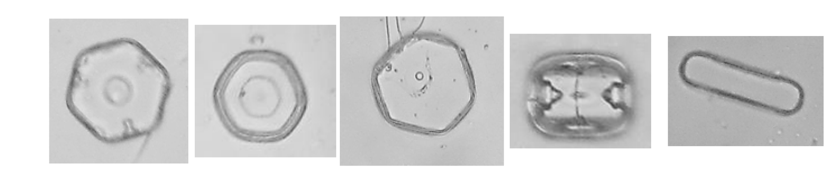
We now quantify particle morphology using "angularity". This is greater than 0.5 for faceted surfaces, or less than 0.5 for rounded.

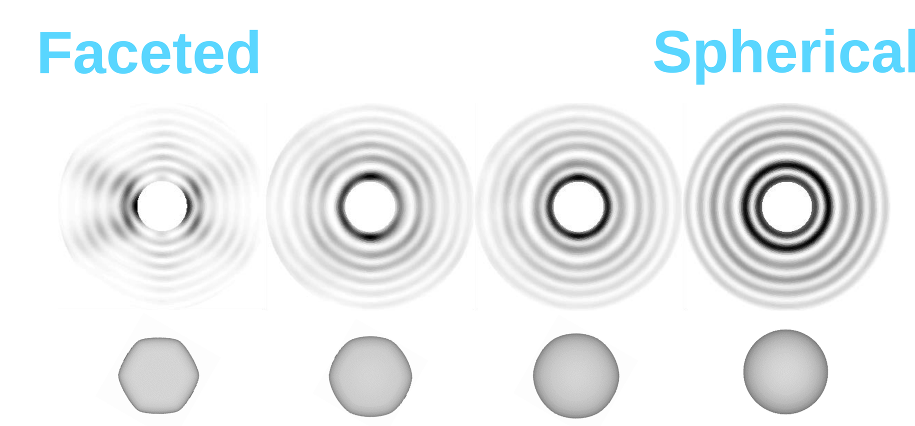



These laboratory data of rounded ellipsoidal particles show similar scattering patterns.

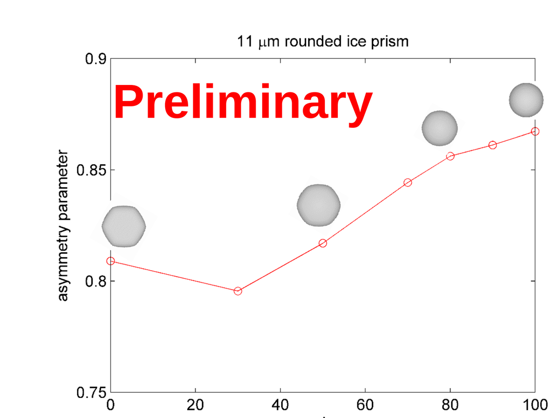
Rounded particles have been observed during cloud chamber experiments.






Modelled data Indicates that as sphere is 'morphed' into a hexagonal prism the superposition of rings and scattering arcs becomes apparent.

Rough ice, now accepted as "normal" in mid-latitude clouds, have lower asymmetry parameter (*g*) than facetted ice. Does TTL ice go in the opposite direction, towards higher *g*?!




## Future work

- Develop analysis algorithms for rounded particle data
- Long-term cirrus evolution at high resolution, with Lagrangian particle tracking?
- Scattering properties of rounded ice and impact on radiative heating and forcing
- Impact on water vapour transport etc.
- Cloud chamber testing for sublimation? (Long lifetime & low temps)
- Fly more TTL campaigns (other aircraft?)

## Acknowledgements

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NATURAL ENVIRONMENT RESEARCH COUNCIL
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