Preliminary Plans for Airborne Measurements of High-IWC in Deep Tropical Convection in Australia January-February 2009

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Australian Government
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CURRENT PARTNERS:

- NASA Glenn Research Center Icing Branch
- Environment Canada Cloud Physics and Severe Weather Research Section
- Australian Bureau of Meteorology
- The Boeing Company

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Motivation

- More than 100 events of jet engine power loss in passenger-carrying aircraft while flying near deep convection
- All sizes of aircraft; essentially all engine types
- Concentration of cases in southeast Asia

- COST and SAFETY issue :
  - Damage to engine from shed ice can exceed $100K per event
  - One recent case of no-power landing in Florida – the FAA icing specialist considers this to be a "precursor to a catastrophic accident"

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HYPOTHESIS:

- Engine events are caused by flight into very high IWC regions near the cores of deep convection
- This is not a classical icing situation (i.e. no supercooled LWC is required)
- Engine icing is thought to perhaps result from melting and refreezing of ice particles in the engine.
- Very few measurements of the maximum levels of IWC in deep convection exist (probably most extensive are from the 1950s)

- For more information, please see:

Mason, J.G., J.W. Strapp, and P. Chow, 2006: The Ice Particle Threat to Engines in Flight, *44th AIAA Aerospace Sciences Meeting and Exhibit,* Reno, NV, Jan 9-12, 2006, AIAA 2006-206.

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ENGINE OBJECTIVES:

- characterize the high IWC environment that is though to cause engine powerloss events, providing duration statistics of TWC, and particle characteristic size

- Study the potential for flight-deck recognition of the high IWC environment, including pilot external visual and aural cues, and the response of the pilot's radar to the high IWC environment

- Make internal measurements of engine performance during high IWC encounters ro assist in the detailed description of the engine-icing phenomenon

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SCIENCE OBJECTIVES:

- Characterize the cloud microphysics of high IWC regions of convective storms
- Determine the origin of small ice particles in high IWC regions
- Determine how the ice fraction evolves in convective updrafts, and the characteristic temperature and altitudes for glaciation
- Improve understanding of precipitation formation mechanisms and precipitation efficiency in deep convection.
- Characterize draft statistics to ~ 12 km (most obs < 7 km)
- Validation of C-Pol microphysical retrievals and accuracy of IWC estimates
- Extend TWPICE observations of anvil structure to convecive cores
- Statistical sampling for model validation

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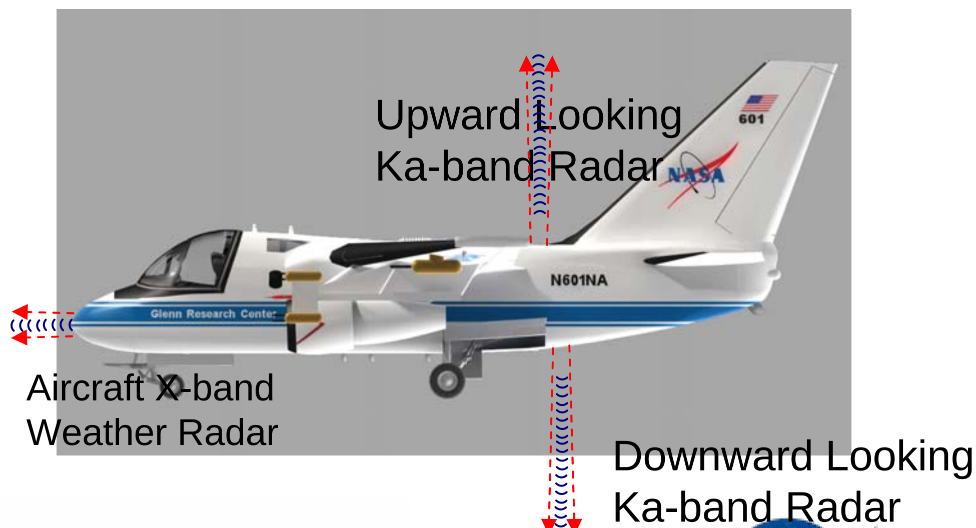
The NASA S3 aircraft

- **ceiling 40,000'**
- **range 1800 nmiles**
- **high payload and electrical power**
- **fully acrobatic**



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The NASA S3 aircraft

- combination of new and traditional microphysical probes
- acknowledge that much current instrumentation will fail or saturate in high IWC situations without further work
- develop a new high-IWC isokinetic evaporator for 10 gm^{-3} at 200 ms^{-1}
- ruggedize much equipment for high IWC environment
- test equipment in high IWC environment in ice particle simulation tunnels
- focus on small-ice particle issue:
  - expecting measurements to indicate very small median mass diameters
  - long-path extinction measurement to provide new information

High IWC Program Cloud Instrumentation:

Particle Spectrometers	Bulk LWC/TWC measurements
FSSP (2-32 um)	PMS King probe
FSSP (5-95 um)	SEA multiwire LWC/TWC probe
SPEC CPI (2.3 - ?? um)	Nevzorov LWC/TWC probe ??
Phase Doppler PDI (2-120 um)	DMT CVI
DMT CDP (2-50 um)	isokinetic evaporator (new design)
PMS 2D2C (50-1600 um)	
PMS 2DC-grey (30-1920 um)	
DMT CIP (25-1600 um)	
SPEC 2D-S (10-1280 um)	
PMS 2D-P (200-6400 um)	

Other Measurements:
35 GHz radar (up/down static antennae)
forward looking pilot's radar (increased sensitivity)
extinction probe
ice detector with decelerator (proposed)
ruggedized AIMMS-20 for winds and gusts
TDL water vapour
radiometric in-cloud temperature

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Flight Sampling Strategy

Proposal:

- ~75% oceanic (incl. ~2 tropical storms), ~25% continental
- Oceanic convection flights:
  - monsoon oceanic convection or tropical storms
  - Perform a certain fraction within CPOL coverage and/or dual-Doppler region (e.g. 75%), and the rest (e.g. 25%) more remote from coast.
- Continental convection flights:
  - do between monsoon periods,
  - sample vigorous clouds only in anvil away from direct core
  - sample after cloud advects over water or in dissipating stage over land

- ~2 month field project in January-February 2009 based at RAAF Darwin. 100+ research hrs, 60 transit hrs

Jan-Feb 2010 Proposals – UK STACCATO (A. Baran, NERC and U. Manchester team)

- NERC BA146 aircraft
- Have chemistry, microphysics, aerosol and radiation
- Focus on cirrus, radiation measurements

- Potential very preliminary partners/platforms
- ARA Egrett (high altitude, microphysics, aerosol, chemistry)
- M55 Geophysica (very high altitude aircraft, chemistry, H_2O)
- New German aircraft

- Do we want AAVP involvement?