Overview of Physical Sciences on Parabolic Flight Aircraft Platforms

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April 14, 2010

Parabolic Flight Aircraft

- Parabolic flight aircraft enables research in Reduced-Gravity (“Free-Fall”) in order to address scientific questions.

- Scientific disciplines:
  - material science and processing
  - fluid physics
  - combustion
  - biotechnology

- To test mission concept technologies and operational procedures required for near-future mission designs.

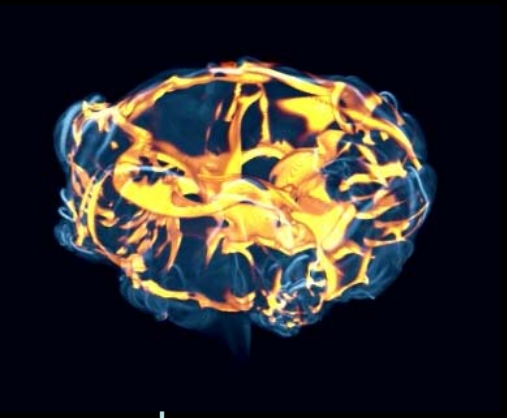
- To qualify experiment flight models to fly on suborbital rockets, orbital missions, or long-duration ISS missions.

Scientific Motivation for Reduced Gravity

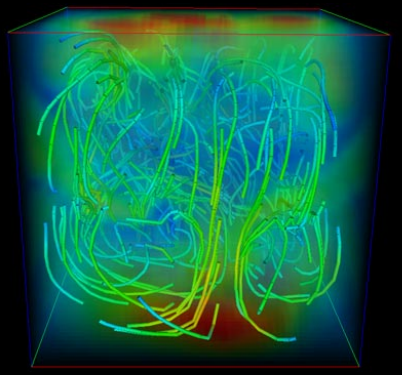
"Any damn fool can get complicated.
It takes genius to attain simplicity."

–Pete Seeger

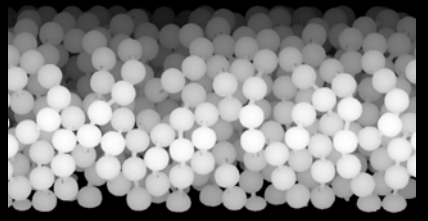
Removal of the apparent gravitational body-force eliminates:



buoyancy



convection



sedimentation

- Elimination of gravity-induced effects permits idealized phenomena to be observed, allowing access to fundamental data, model verification, and results that may otherwise be obscured.

Parabolic Flight Aircraft

- **Advantages**
  - Quantify the role of gravity on physical and chemical systems in scientific concept studies before dedicating resources required for long-term reduced-gravity experimentation.
  - Ability to conduct repeatable experiments.
  - Quick turn-around time.
  - High value for data collected (costs are negligible as compared to long-duration spaceflight mission).
  - Outstanding opportunity for students, HQP development, and training for ISS missions and operations.
- **Disadvantages**
  - Only 20 seconds of reduced-gravity.
  - Vibration hinders some experiment data sessions (can be avoided if addressed properly).
  - Weather delays.
  - Aircraft cabin size.

History of Canadian Parabolic Flight Use for Physical Sciences

- 1980's
  - NRC funded hundreds of projects, most of which flew on the KC-135, during week-long campaigns, held on a regular basis.

- 1990's
  - CSA continued to organize the KC-135 from NASA JSC / Ellington Field, as well as the DC-9 from NASA GRC.
  - CSA started to use the Falcon-20 aircraft from NRC in Ottawa.
  - Some Caravelle flight campaigns also involved Canadians.

- 2000's
  - CSA continued to use the Falcon-20, organizing ~5 campaigns per year with 4 parabolas per flight.
  - Additionally, A300B flying from Bordeaux, France.

- 2010
  - Falcon-20 is now operationally able to fly over 40 parabolas per flight, which increases its interest as a national scientific platform.

NRC Falcon-20 Usage (2008-2010)

- The Role of Microgravity on Nanowire Growth and Synthesis
  - H. Ruda, C. Fernandez (University of Toronto)

- Electrodeposition of Schiff-base Containing Conductive Polymer Films in Microgravity for Nonlinear Optical Studies
  - M. Wolf, M. MacLachlan (University of British Columbia)

- Fractal Aggregation in Microgravity
  - R. Slobodrian, C. Rioux (Université Laval)

- Flame Propagation in Particulate Suspensions
  - S. Goroshin, A. Higgins, J. Lee (McGill University)

NRC Falcon-20 Usage (2004-2008)

- Gassless Laparoscopy
  - A. Kirkpatrick (University of Calgary)
- How Gravity Affects Perception
  - L. Harris (York University)
- Physical Vapour Deposition using Traveling Flame Heating Elements
  - P. Ashrit, Université de Moncton
  - S. Goroshin, A. Higgins (McGill University)
- Nucleation phase thin film growth of TPD for OLED devices
  - P. Ashrit (Université de Moncton)
- Examination of Shear-Induced Mixing: Viscosity Measurements
  - R. Smith (Queen's University)
- Interface Effects in Multiphase Fluid Systems
  - J. Elliott (University of Alberta)
- ***The Rick Mercer Report.***

Conclusions

- Parabolic flight aircraft provide a unique platform.
- The Space Physical Science community in Canada has over 25 years of scientific experience with parabolic aircraft experimentation.
- The Canadian community is supportive of the idea of a dedicated national aircraft for reduced-gravity research.
- Community members will be attending the parabolic flight session, with some moving in and out of the sub-orbital rocket session.

Special Thanks to Dr. Marcus Dejmek (Program Scientist, Space Physical Sciences)

Next Steps

- Define under what conditions the Canadian reduced-gravity science community would require a dedicated parabolic aircraft.
- Define conditions and requirements for evolution from parabolic to sub-orbital and recoverable satellite/ISS missions.
- Consider new sub-orbital platforms, such as Virgin Galactic, for reduced-gravity research.

Zero Gravity Corporation

SpaceShipTwo
Virgin Galactic

Aircraft Platforms for Earth Observations

David Hudak

Workshop on Suborbital Platforms and Nanosatellites , 14-16 April, 2010

Convair 580 C-GRSC

- **Unique Canadian asset**
  - No similar system available for use in North America
- **Advanced airborne SAR system**
  - C- and X-band systems
  - 6 m resolution
  - Variable viewing geometry (nadir, narrow, wide)
  - Numerous operational modes
- **C-band fully polarimetric**
  - HH, HV, VH, VV polarizations
- **C-band interferometric modes (InSAR)**
  - GMTI

Satellite and Application Development

- The Convair 580 SAR system has been used for the development of SAR data processors, algorithm development, the pre-launch simulation of space-borne SAR systems (e.g. RADARSAT-1 & -2, ERS-1 and JERS-1) and the testing and evaluation of new SAR modes
- To help users of SAR data and imagery adjust to the advanced RADARSAT-2 data set, a program was undertaken by the CSA in 2001-2004 with the airborne Convair-580 SAR facility

Application Areas

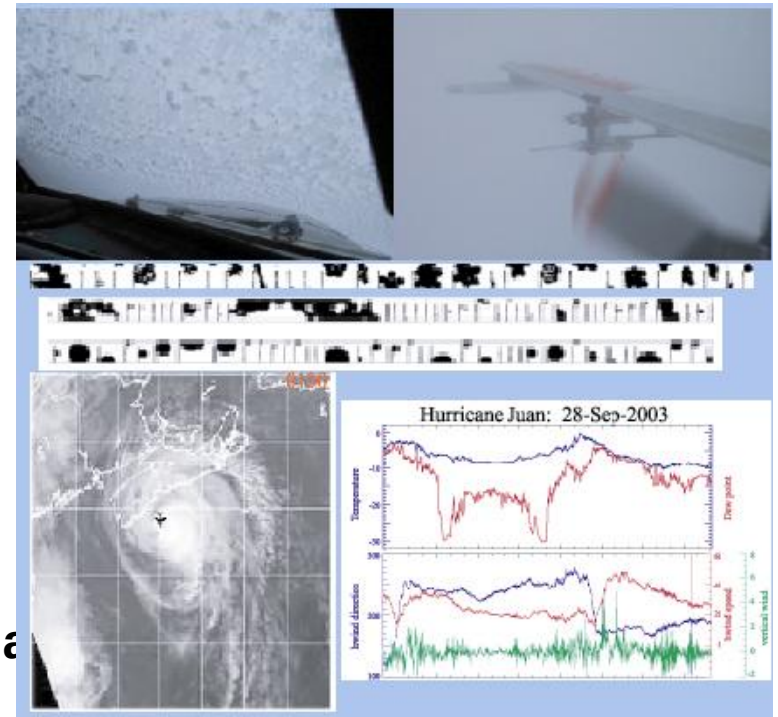
Oil Spills
Emergency Response
Sea Ice
Forestry
Agriculture

NRC·CNRC
NRCaerospace.com

NRC Convair Research Aircraft

- *Principal Canadian airborne atmospheric and geophysical research platform*
  - *Instrumented by NRC, EC and DND*

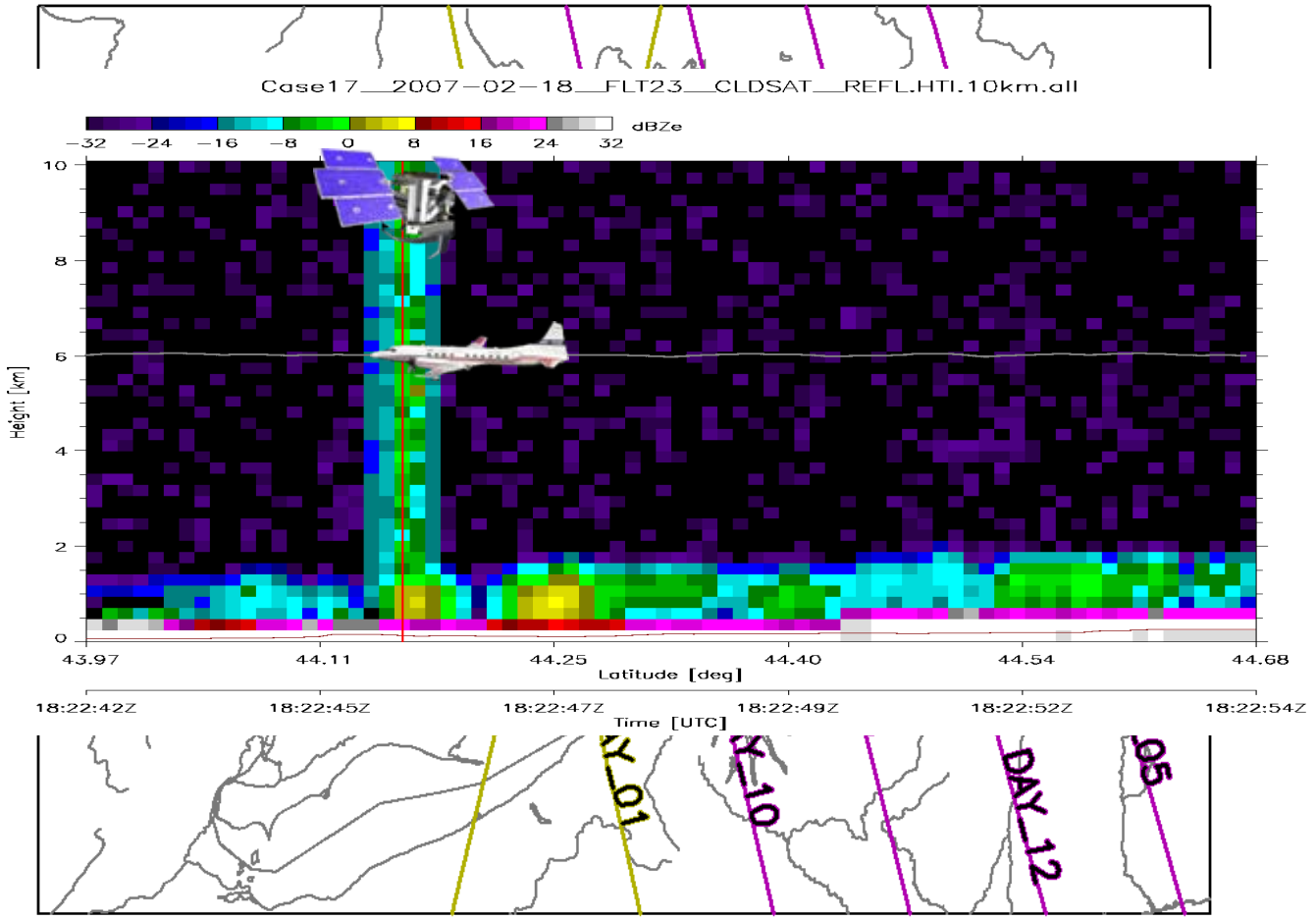
- *Used for various research applications*
  - *Icing*
  - *Hurricane*
  - *Air quality*
  - *Remote sensing system development*



Canadian CloudSat CALIPSO Validation Project Experiment Set-Up

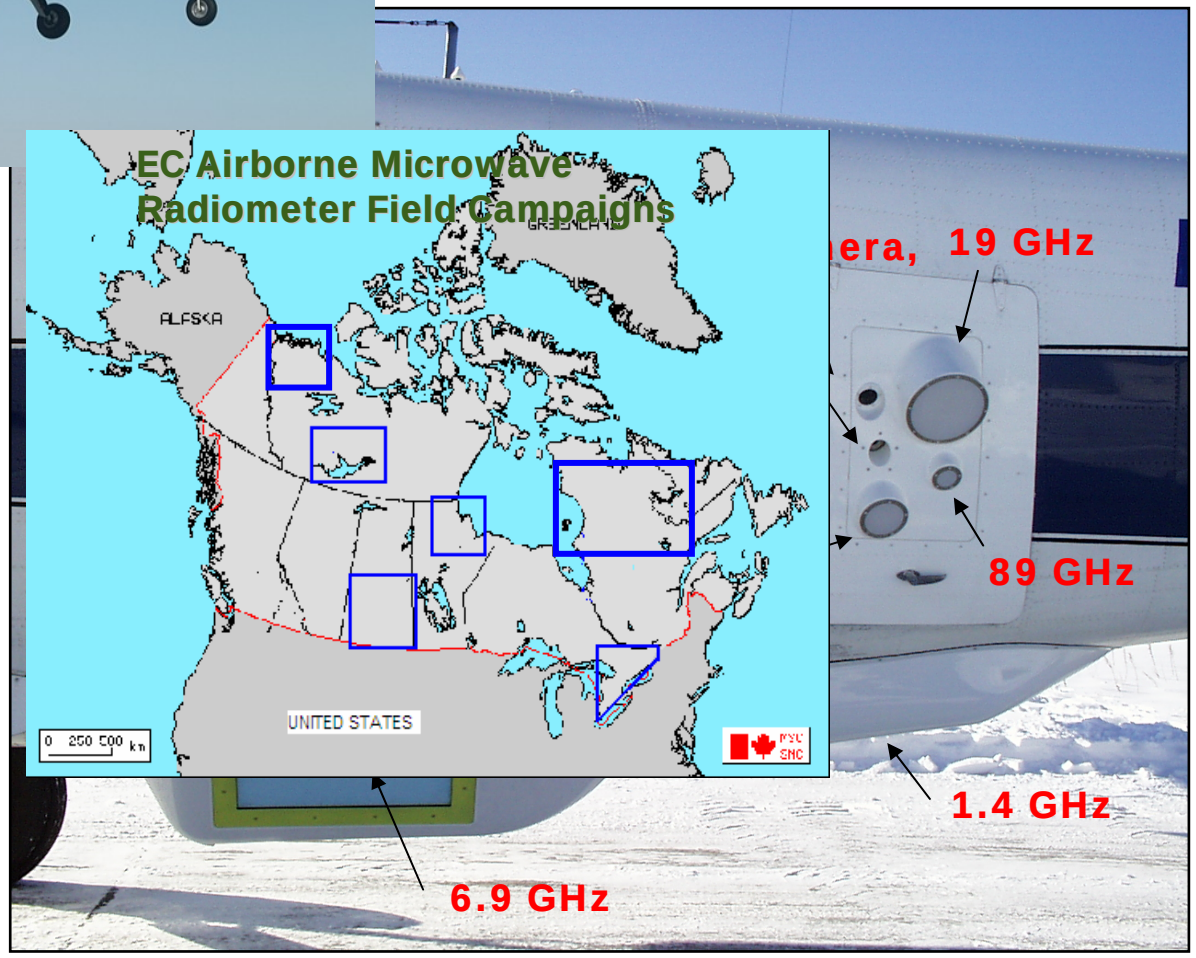
Workshop on Suborbital Platforms and Nanosatellites , 14-16 April, 2010

Validation Flights over Southern Ontario and South-western Quebec



Workshop on Suborbital Platforms and Nanosatellites , 14-16 April, 2010

NRC Twin Otter

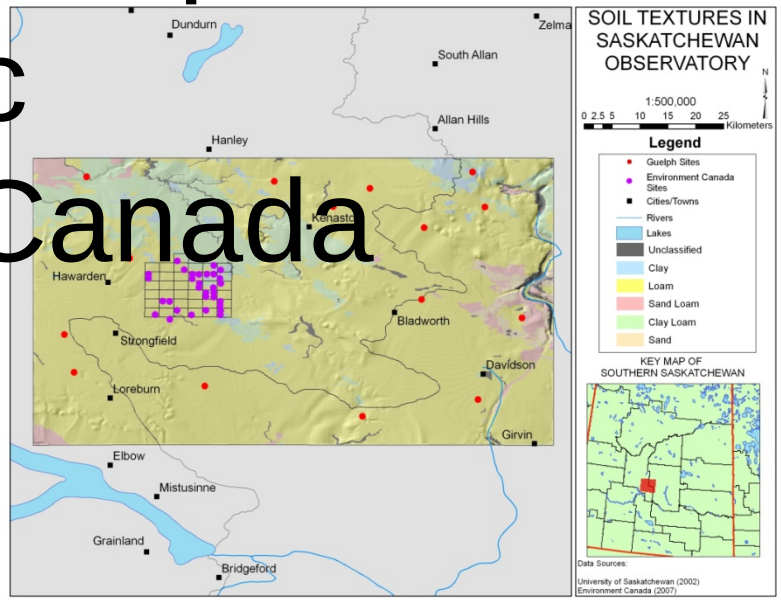


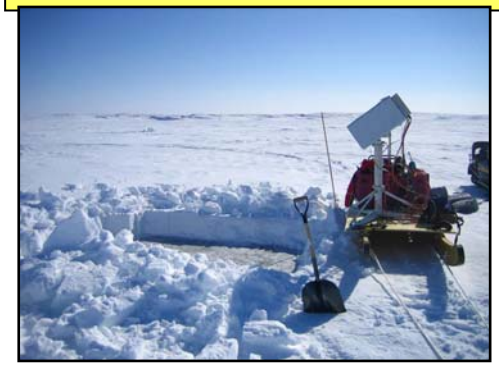
Campaign/SMAP pre-launch Algorithm Development

U. Sherbrooke, U.Guelph, U. du Québec Environment Canada

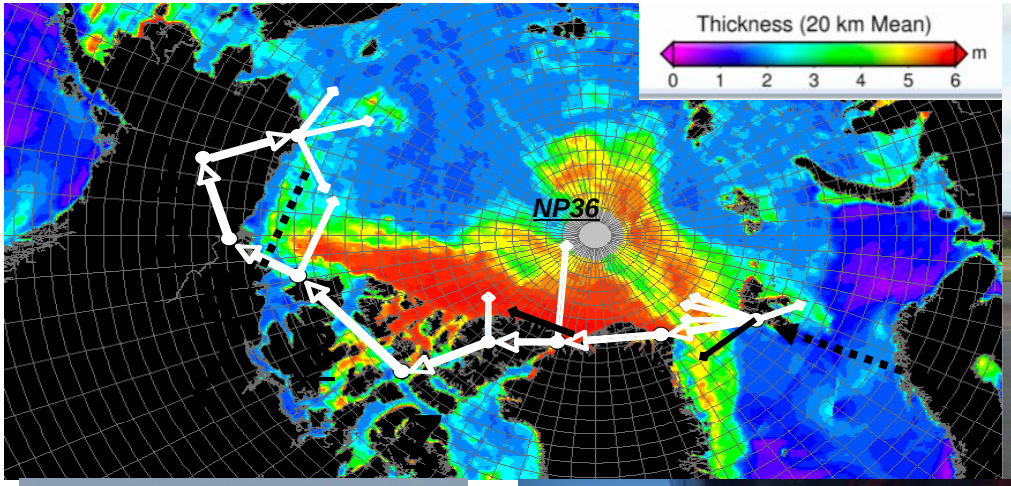
Locale: S. Saskatchewan – June 2010

- **conduct passive microwave airborne and conventional in-situ campaigns to develop and validate soil moisture and freeze / thaw products in Canadian regions**
- **investigate the spatial extent of soil freezing / thawing and the link to water, energy and carbon cycles through remote sensing, process studies (BERMS, Bratt's Lake), and modelling (CLASS)**





Alfred Wegener Institute (AWI)
Polar-5 Research Aircraft



- Sea-ice thickness
- Trace gases
  - Hg, O_3, BrO
  - O3 DIAL
- Aerosol
  - CN, size distributions
  - black carbon
  - LIDAR backscatter

International Facilities

USA (major facilities):

- National Science Foundation (NSF)
- National Aeronautics and Space Administration (NASA).
- National Oceanic and Atmospheric Administration (NOAA)

All above have continued long-term base funding to support facilities

Europe

- Varying degrees of funding support to academic and government agencies depending on country: ~40 environmental research aircraft

Directions in Airborne Facilities Developments

<u>High Altitude, long-haul aircraft:</u>

- NSF HIAPER G-5 aircraft, NASA ER-2

High troposphere, low stratosphere measurements (65 kft)

- **Large payload for air chemistry measurements**
- **Sophisticated remote sensing package of active and passive sensors for satellite calibration and validation**

NSF HIAPER G-5 Aircraft

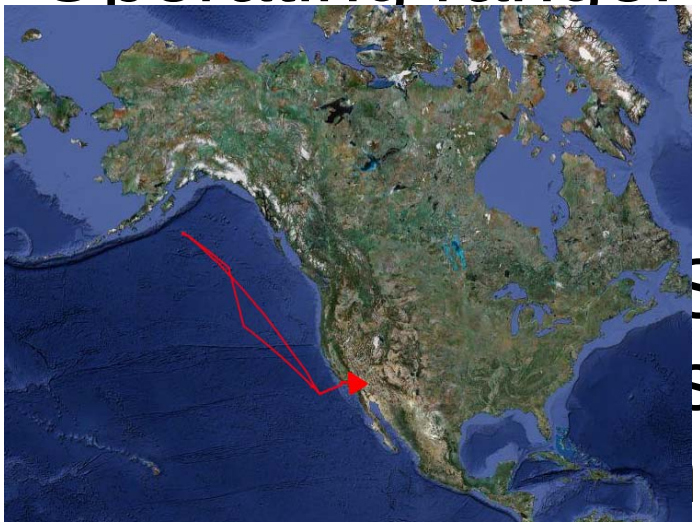
NASA ER-2 Aircraft

Directions in Airborne Facilities Developments

NASA Global Hawk (UAV)

- Max altitude: 60,000 feet
- Operating range:
-
-

NASA Global Hawk UAV



SA's

search

ia

- April 7, 2010: the first of five scheduled flights to study atmospheric science over the Pacific and Arctic oceans.
- The plane carries 11 instruments to sample the chemical composition of the troposphere and stratosphere.
- Observe polar vortex
- several flights directly under the path of NASA's Aura satellite and other "A-train" Earth-observing satellites
- The GloPac mission includes more than 130 researchers and technicians

Thank You/merci