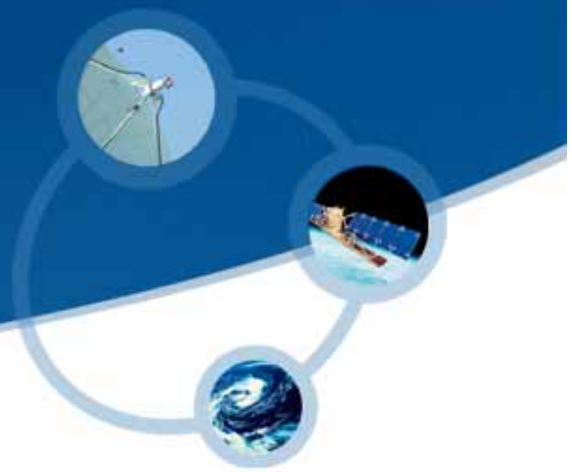
Canadian Space Agency | Agence spatiale canadienne

Canadian Space Agency And Environment Canada



- Stella Melo

- CEOS- ACC workshop on Air Quality
  Frascati June 15-18 2009

Canada

Earth Observation at the CSA

- The Canadian space program has received increased attention in 2009
- Earth Observation is well aligned with government priorities
- Focus on utility for government departments and purpose-driven science, especially for high latitude observation needs

EO mission topics of particular interest to Canadian government departments and science community

RADARSAT Constellation: sea and land ice, ships, oil slicks, agriculture

Water cycle: soil moisture, clouds, precipitation

Atmospheric composition: pollutants, aerosols, carbon cycle, ozone and other relevant gases

Atmospheric dynamics: high latitude tropospheric winds, stratospheric winds, UTLS exchanges

Many of these will be best addressed as partnership missions.

Cost Effectiveness Drives Investment Choices

- Make good use of available data.
- Contribute to enable partnership missions and obtain recognition when well suited to Canadian interests and capabilities.
- Lead missions when required.

CSA led mission concepts:

Air quality and climate

APOCC RFP

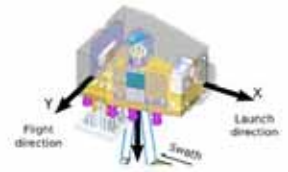
We selected innovative ideas for missions that:

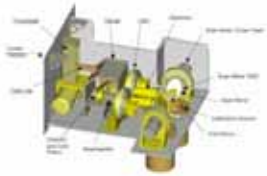
- Will lead to new scientific understanding of atmospheric processes that regulate Earth's climate and thereby lead to reduced uncertainty in climate forecasts;
- Address questions of particular importance for northern latitudes or that otherwise benefit Canadians;
- Build on Canada’s considerable experience and capacity in atmospheric science;
- Complement and are synergistic with planned international satellite missions.
- 6 mission concepts are in development.

MISSION FOR CLIMATE AND AIR POLLUTION (MCAP)

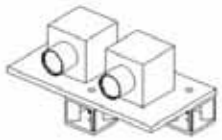
Mission Objective:
To provide insight into the developing issues of atmospheric change;
To provide input into monitoring the effectiveness of air quality policy;
And to provide predictive capability for future generations.

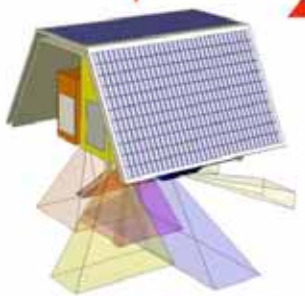
MCAP-SRS NO_2, O_3, HCHO, SO_2, BrO, +others

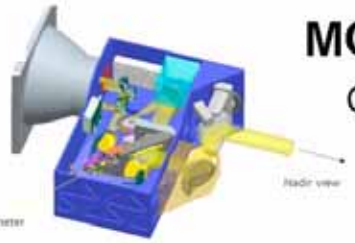




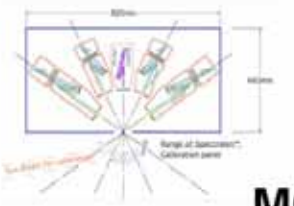
MCAP-CR
CO mapping







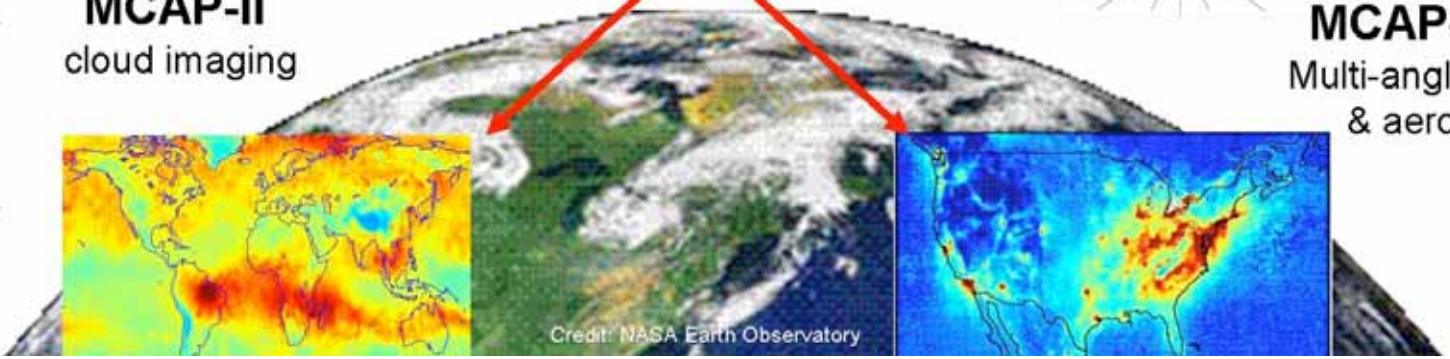
MCAP-FTS
CO_2 CH_4



Sun-synchronous polar orbit

MCAP-II
cloud imaging

MCAP-MAI
Multi-angle cloud & aerosols



MCAP Team

PI: Prof. James R. Drummond - Dalhousie University
Dr. Henry L. Buijs - ABB BOMEM
Prof. J. Burrows - University of Bremen
Gary Buttner – McDonald Detweiller Associates
Prof. Doug Degenstein - Unviersity of Saskatchewan
Dr. D. Diner – Jet Propulsion Laboratory
Prof. Dylan Jones - University of Toronto
John Hackett - COMDEV
Dr. Jacek Kaminski - York University
Prof. Randall Martin - Dalhousie University
Prof. J.C. McConnell - York University
Prof. Kimberly Strong University of Toronto
Prof. K. Walker University of Toronto

Miniature Earth Observing Satellite: MEOS

Climate Studies:

- Tropospheric concentrations of CO_2, CH_4, CO, N_2O, and H_2O and their seasonal variations due to interactions with the Boreal Forest
- Measurements of surface vegetation and land cover as affected by changes in glaciers, permafrost and snowpack.

Air Quality:

- High resolution measurements of lower tropospheric O_3, NO_X, SO_2, certain VOCs and PM near megacities

Modelling:

- Each of the missions will have real-time modelling and data assimilation of the satellite (and other surface) measurements.

Miniature Earth Observing Satellite: MEOS

3-axis stabilized microsat, LEO

Table 2: Summary of the MEOS nadir and off-nadir preliminary instrument requirements.

Measurement	Spatial Resolution	Spectral Resolution	Spectral Range
Nadir UV/VIS Imaging Spectrometer	Sixteen 5 km x 10 km pixels with 160 km swath.	0.3 nm pixel FWHM	300 to 550 nm using 2-D CMOS array
Nadir FP/IOSPEC	5 x 10 km FOV x 16 simultaneous spatial pixels	30 pm FWHM, 32 simultaneous microchannels	32 Selected channels in 1.5 to 2.45 µm with 16 x 32 pixel PbS array
Nadir O2 A band Spectrometer	5 km x 10 km FOV x 16 pixels	20 pm FWHM	0.75 to 0.78 µm
Nadir CMOS VIS Imager	30 x 30 m at full resolution	Selectable spectal window	400 nm, 640 nm filters
Limb FP/IOSPEC	Sixteen 2.5 x 160 km^2 vertical slices.	30 pm FWHM, 32 simultaneous microchannels	32 Selected channels in 1.5 to 2.45 µm with 16 x 32 pixel PbS array
LIMB CMOS VIS Imager	768 x 488 pixels	130m x 210 m	400 nm, 640 nm filters
Cryoradiator	Passive cooling (like MOST) for 200 K PbS Detector Array temperature.		

Roman V. Kruzelecky et al, CASI 2008

MEOS Team

Dr. J. Sloan, University of Waterloo;
Dr. E. Cloutis, University of Winnipeg; Surface Measurements
Dr. D. Jones, University of Toronto; Atmospheric Modelling
Dr. R. Martin, Dalhousie University; Atmospheric Modelling
Dr. K. Strong, University of Toronto: Retrievals, Validation
Dr. L. Garand, Environment Canada; Meteorology, Product Applications
Dr. R. Menard, Environment Canada; Meteorology, Data Assimilation
Dr. A. Trishchenko, Canada Centre for Remote Sensing; Surface Modelling
Dr. S. Wang, Canada Centre for Remote Sensing; Surface Modelling
Dr. T. Kurosu, Harvard-Smithsonian Center for Astrophysics ; Retrievals
Dr. K. Chance, Harvard-Smithsonian Center for Astrophysics; Retrievals
Prof. IlseAben, SRON, Netherlands, Trace Gas Measurements
Dr. R. Kruzelecky, MPB Communications; Instrument Principal Investigator
Dr. IliasSamir, Francis Picard, Michel Poirier, INO, custom optics and coatings
Eric Edwards, Xiphos Technologies, fault-tolerant electronics

Stratosphere-Troposphere Exchange Processes (STEP)

- Scientific Objectives:
  - To characterize the spatial structure and temporal dependence of the key radiative gases ozone and water vapour, and also aerosols, in the UTLS, and the transport processes controlling that structure.
  - To provide measurements of key species (including NO_2, CO, HNO_3 and ClO) needed for the characterization of the UTLS.
- Platform:
  - MAC-200 Multi-Mission Small Satellite Bus (MMSSB)
- Orbit:
  - Sun-Synchronous LEO (~650 km altitude)

Stratosphere-Troposphere Exchange Processes (STEP)

- **Academia:**
  - **Prof. Doug Degenstein,** University of Saskatchewan (Mission PI and CATS PI)
  - Prof. Theodore Shepherd, University of Toronto (Mission Scientist)
  - Prof. Brian Solheim, York University (SHOW PI)
  - Chalmers University (STEAMR PI)
- **Industry:**
  - Bristol Aerospace (Concept Study Prime)
  - Routes AstroEngineering (CATS Prime)
  - COM DEV (SHOW Prime)
- **International Collaborators:**
  - Swedish Space Corporation (STEAMR Prime)

Solar Occultation for Atmospheric Research (SOAR)

Scientific Objectives:

- Understand the chemistry and dynamics of trace gases in the free troposphere with a particular focus on organic molecules associated with global air quality.
- Monitor trends in atmospheric composition with a view to improving our knowledge of climate change and stratospheric ozone recovery.
- Study chemistry-climate coupling especially in the upper troposphere and lower stratosphere (UTLS).

- Solar occultation, three instruments: IR FTS, UV/Vis spectrometer, imagers.
- Small satellite bus in an inclined circular orbit (~60º).

Solar Occultation for Atmospheric Research (SOAR)

Academia:

K. A. Walker (PI), D. B. Jones, K. Strong, U. Toronto;

J. C. McConnell, J. Kaminski, W. F. J. Evans, York U.;

P. F. Bernath, K. Gilbert, U. Waterloo;

I. Folkins, Dalhousie U.

Industrial partners:

ABB-Bomem;

Bristol Aerospace

Environment Canada:

C. T. McElroy; C. Sioris

Thin Ice Clouds in a Far IR Experiment: TICFIRE

Primary Scientific Objectives:

- Monitor the formation of cold temperature and moisture anomalies in polar regions and near the tropopause.
- Determine contribution of thin ice clouds (TIC) to the energy balance and the role of their microphysical properties.

Secondary Scientific Objectives:

- Improve measurements of water vapour concentration in the low concentration limit where cold climate is most sensitive to greenhouse effect.
- Assess the implication of aerosol-cloud-radiation-precipitation forcing induced by anthropogenic activities in cold regions.

Payload:

- Narrow band microbolometer-radiometers in the far IR range

Platform and Orbit:

- Nano/Micro satellite on a sun synchronous polar orbit (LEO)

Thin **I**ce **C**louds in a **F**ar **IR E**xperiment: **TICFIRE**

Academia

- UQAM: **J.-P Blanchet,** T. Ayash (UQAM) and P. Gauthier (UQAM)
- CARTEL U. Sherbrooke: A. Royer and N. O'Neil,

Industry

- INO: L. Marchese and F. Châteauneuf
- NGC: J. de Lafontaine
- COM DEV: J. Hackett

Collaborations

- L. Garand (EC), J. Jiang (JPL), G. Stephen (CSU), P. Joe (EC), T. Wehr (ESA)

SnowSat

Primary objectives

- *Develop and demonstrate the technology that can monitor the occurrence, magnitude, and variation of frozen and light precipitation across Canada with special consideration given to high latitudes;*

- P*rovide data needed to assess the treatment of frozen precipitation by global climate and weather models and thereby further knowledge of precipitation-related processes in cold regions.*

SnowSat

Novel spaceborne radar sampling strategy

- innovative sampling scheme for a 94-GHz spaceborne radar that cycles through cloud (CL) and precipitation (PR) modes

Advanced Signal Processing Scheme for reliable Doppler measurements

Radar polarimetric measurements

- co- and cross channel Doppler spectra and moments

Explore the benefit of a dual-radar system operating at 35/94-GHz , especially for determination of quantitative snowfall rates

Examine the added value of other small instruments (e.g., hyperspectral, spectral polarization measurements, radiometers, broadband IR) to complement the active radar

SnowSat Team

Dr. Paul Joe

Dr. Howard Barker.

Dr. Jean-Pierre Blanchet.

Dr. David Hudak

Dr. Pavlos Kollias

Dr. Ron Stewart

Dr. Wanda Szyrmer

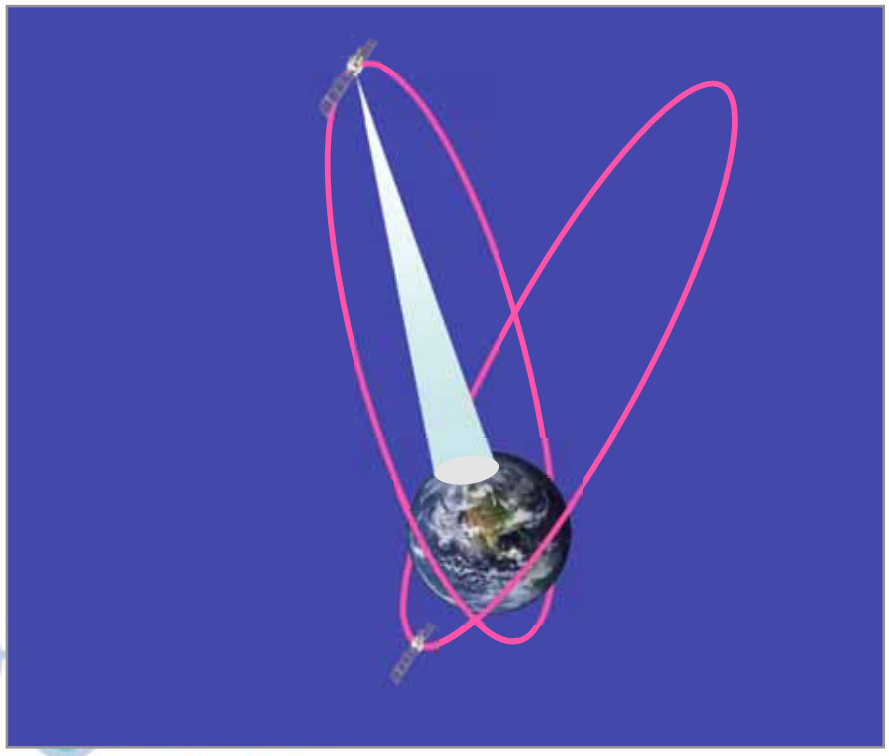
COMDEV

Environment Canada – Air quality

- Products we deliver
  - Host the Ozone and UV data centre (WMO)
  - Ozone daily maps, UV index, air quality forecast (available at web);
  - Air quality and ozone assessments and scenarios for policy at national and international level
  - Provide expertise in the field for other Departments
- Activities
  - Research on chemical-transport modeling,
  - transformation and deposition of air pollutants,
  - monitoring of atmospheric constituents,
  - chemical data assimilation
  - improving air quality forecasting and numerical weather forecasting by the use of constituent data
  - Development instrumentation and maintenance of observational networks (Brewer, AeroCan, CANDAC Arctic observatory, CORALNet Lidar, surface AQ sites)
- What data we use
  - Torpospheric NO2, BrO, O3, SO2, HCHO, H2O, aerosols, … (GOME, OMI, MAESTRO…)
  - Stratospheric O3, NOy, Chlorine, Bry, aerosols, (OSIRIS, MAESTRO, ACE-FTS, MIPAS, SCIAMACHY….)
  - UV maps (TOMS, OMI, …), surface reflectivity,…

PCW: a Constellation in Molniya Orbit

A CSA, DND, EC, and NRCan mission to continuously obtain and disseminate in real time multi-band images of cloud and water vapor and the planetary surface north of 60N.



2 satellites in a 63.4 deg. Inclination to provide continuous GEO-like imagery from 55-90 N. with resolution of 0.5-1 km in the VIS and 2 km in the IR

Apogee: ~39,500 km
Perigee: ~600 km
Stereo views available several hours daily

Polar Communication and Weather Satellite (PCW)

Mission objectives

- Demonstrate the capability to continuously measure the atmospheric flow field over high northern latitudes (North of 60 N);
- Disseminate calibrated, rectified, and geolocated images and processed wind observations (into Atmospheric Motion Vectors) to operational meteorological users in Canada and around the world in NRT,
- To provide retrievals of surface characteristics (temperature, albedo, and emissivity), sea/ice analysis, cloud analysis (cloud cover, height, emissivity, and particle size) and environmental monitoring (aerosols, dust, and fire).

PCW: a key mission for Environment Canada

- EC New mandate: provide meteorological imagery and derived products in near real time nationally and internationally
- Fills a gap in Earth data observation: seamless high temporal/spatial resolution over the entire circumpolar region 50-90 N
- Vast variety of key applications encompassing needs for weather prediction, environmental monitoring and climate change monitoring
- *Unique opportunity for new science and international collaboration!*

PCW Payloads (committed/possible)

- Primary
  - 2-way HDR antenna/transponder sub-system (Ka)
  - Imaging Spectroradiometer (20 channels, 0.5-1 km VIS, 2 km IR)
  - Space weather instruments
- Secondary
  - Scientific instruments:
    - Broadband radiometer
    - Aurora Imager
    - Atmospheric composition instrument (UV-VIS-NIR)
    - Fourier Transform spectrometer (IR, similar to IASI)

Community consultation Workshop on December 2009:

- Evaluation of the 6 APOCC mission concept studies and recommendation on the way forward;
- Identification of the needs of the space as platform for the next decade;
- Recommendation on Canadian involvement on missions in development;
- ….