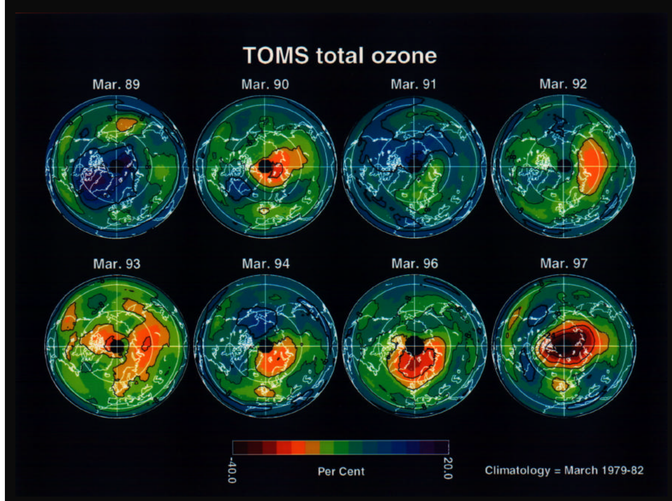
ACE-FTS Instrument: 2 first months on-orbit

Marc-André Soucy, Christophe Deutsch, Serge Fortin

ABB Inc., ACE-FTS Prime Contractor

The Arctic Ozone Problem



Change in total Arctic ozone column in the spring as measured by the Total Ozone Mapping Spectrometer (TOMS) . Declines of more than 40% were measured near the pole in March 1997.

The ACE/SciSat-1 Mission

Science goals

The primary scientific goal of the Atmospheric Chemistry Experiment (ACE) is unchanged from the original proposal: **"to measure and understand the chemical and dynamical processes that control the distribution of ozone in the upper troposphere and stratosphere".** We have, however, decided to focus on one important and serious aspect of the atmospheric ozone problem - the decline of stratospheric ozone at northern mid-latitudes and in the Arctic.

Anthropogenic changes in atmospheric ozone are increasing the amount of ultraviolet radiation received by Canadians and may also affect the climate. A comprehensive set of simultaneous measurements of trace gases, thin clouds, aerosols, and temperature will be made by solar occultation from a satellite in low earth orbit.

Mission Description

The principle of ACE measurement is the solar occultation technique. A high inclination (74 degrees) low earth orbit (650 km) will give ACE coverage of tropical, mid-latitudes and polar regions. The vertical resolution will be better than 4 km from the cloud tops (or the boundary layer for clear scenes) up to about 100 km. During sunrises and sunsets, the instrument will measure the infrared and visible signals that contain information on the different atmospheric layers, which will provide the vertical profiles of atmospheric components. The sunrise/sunset events are called an occultation event. During such an event, the instrument will make a set of spectral measurements, corresponding to science and calibration data. The solar occultation technique advantages are high sensitivity and self-calibration capability of the instrument.

ABB-Bomem inc. is the prime contractor of the main instrument, the ACE-FTS spectrometer. The instrument will be integrated to the SciSat-1 bus built by Bristol Aerospace in Winnipeg. A second instrument, Measurements of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation (MAESTRO), built by MSC, University of Toronto and EMS Technologies, will also fly onboard SCISAT-1. The SciSat-1 spacecraft was launched by NASA on 12 August 2003 by a Pegasus XL launch vehicle. The mission lifetime will be higher than 2 years.

The ACE/SciSat-1 Program is funded by the Space Science program of the Canadian Space Agency

The ACE-FTS Instrument

Instrument Overview

The ACE-FTS is a high resolution (0.02 cm^{-1}) infrared Fourier Transform Spectrometer (FTS) operating from 750-4100 cm^{-1} that will measure the vertical distribution of trace gases and temperature. The spectrometer is an adapted version of the classical Michelson interferometer using an optimized optical layout. The spectrometer will achieve a signal-to-noise ratio better than 100 with a field of view of 1.25 mrad and an aperture size of 100 mm. A semiconductor laser is used as metrology source for the interferometer sub-system.

Instrument Key Requirements

Operating Parameters	Nominal	Units	Comments
Spectral resolution	0.026	cm^{-1}	ILS FWHM
NESR	< 1	%	Of a 5800K blackbody
Transmittance accuracy	< 1	%	Absolute between 0-100%
Spectral range	750-4100	cm^{-1}	InSb & MCT (2 bands)
Instrument FOV	1.25	mrad	Circular
Interferometer divergence (full)	6.25	mrad	5x telescope
Interferometer aperture diameter	20	mm	Circular
Optical path difference	+/-25	cm	Optical units, double-sided
Sweep velocity	25	cm/s	Optical units (factor 8)
Measurement duration	2	sec	+ 75 msec turnaround
VIS/NIR imager bands	525, 1020	nm	Two distincts imagers
VIS/NIR SNR	> 2000		
Suntracker pointing knowledge	< 15	µrad	
Suntracker pointing accuracy	< 500	µrad	
Suntracker pointing stability	< 5	µrad	
Weight	41.4	kg	
Average power	37	W	
Instrument lifetime	> 2	years	On-orbit

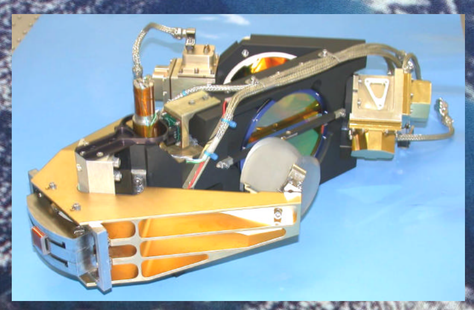
The FTS, operating from 2.4 to 13.3 microns, will measure at high resolution (0.02 cm^{-1}) the infrared absorption signals that contain information on different atmospheric layers to provide vertical profiles of atmospheric constituents. Its highly folded design results in a very high performance instrument with a compact size. The imager will monitor aerosols based on the extinction of solar radiation using two filtered detectors at 1.02 and 0.525 microns. The instrument also includes a suntracker, which provides the sun radiance to both the FTS and the imager during solar occultation of the earth's atmosphere.

The opto-mechanical design of the interferometer sub-system is highly folded, fully compensated, and insensitive to the tilt and shear of any of its components. Though retro-reflectors are used, the ACE-FTS is closer to a flat-mirror interferometer and no shear of the interfering beams is induced by a misalignment of the retro-reflectors. The compensation and tilt insensitivity is even preserved in the presence of a wedge mismatch between the beamsplitter and the compensator substrates or of a wedged air gap.

Photos of ACE-FTS Flight Model

Interferometer Side

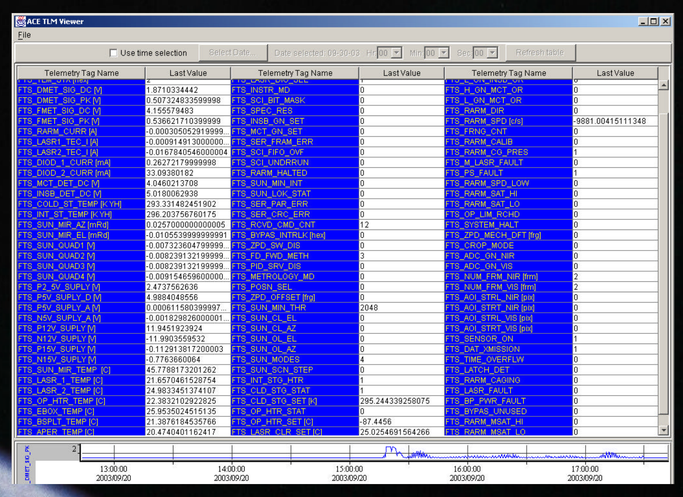
Input Optics Side

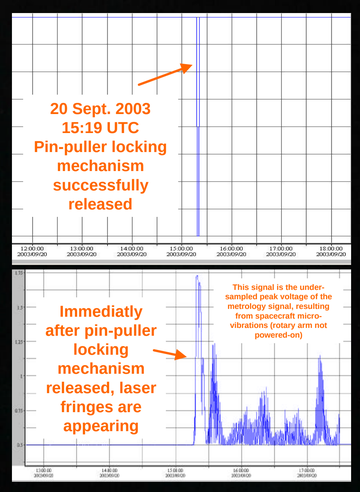


ACE-FTS interferometer sub-system

SciSat-1 Satellite

2 first months on-orbit





Status of ACE-FTS/SciSat-1

Commissioning phase is on-going:

- FTS telemetry is nominal
- FTS outgassing (cryocooler & detectors) completed
- FTS pin-puller locking mechanism released
- FTS temperatures nominal (near room temperature)
- FTS metrology laser turned-on, very good thermal control
- FTS voltage rails are all nominal
- FTS heater controls for intermediate and cold stage are operational.
- Momentum wheel powered-on
- Spacecraft is sun-pointing using fine sun sensor
- Attitude control is nominal
- All S/C bus systems are nominal except slightly noisier command receiver (minor problem)

Planned activities in the short-term:

- Interferometer commissioning, power-on of rotary arm
- Vis/NIR imager commissioning
- Suntracker commissioning