Atmospheric Limb Sounding Satellite (ALISS)

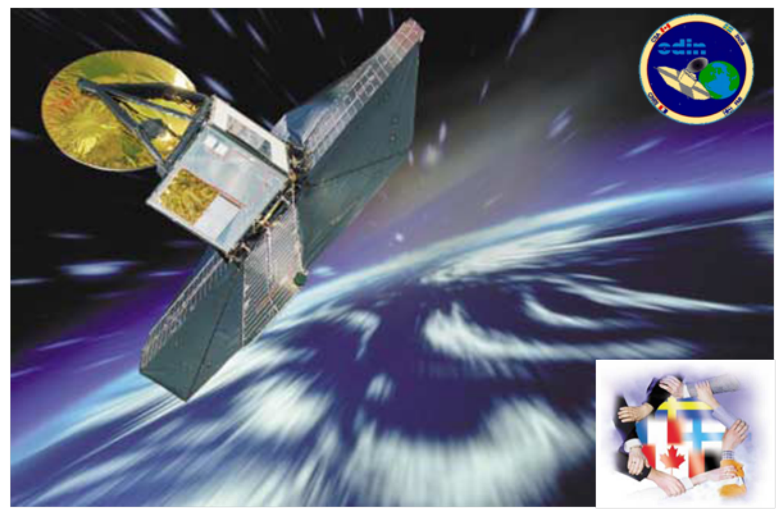
4-5 June 2014

Agence spatiale Canadienne
Canadian Space Agency

RYMDSTYRELSEN
Swedish National Space Board

ALISS Origin

- Following discussions with ESA during summer 2013 about a possible Small Mission Initiative for atmospheric limb sounding, SNSB and CSA decided to undertake a joint study for a collaborative mission that builds on the very successful cooperation in the Odin satellite, launched in 2001.
- A Memorandum Of Understanding was signed on 5 December 2013 and the study was initiated with a two-day science and engineering meeting. The UK Space Agency expressed interest in participating and sent two delegates to the meeting.



ALISS Background

- The vision was for a mission that would fly synergistic, high-performance limb-profiling instruments:
  - CATS, Canadian Atmospheric Tomography System, is the next generation of the Optical Spectrograph and InfraRed Imaging System (OSIRIS: on Odin), for measurement (270-960 nm) of several important gases, cirrus, and stratospheric aerosols at hundreds of points along the sun-lit side of each orbit.
  - STEAMR, Stratosphere Troposphere Exchange And climate Monitoring Radiometer, is a Swedish microwave limb sounder measuring emissions in the 324-355 GHz range. It draws heritage from the Sub-Millimeter Radiometer (SMR: on Odin). STEAMR was originally proposed as part of the PREMIER mission. Ongoing development aims to reduce mass and power requirements.
  - *SHOW, Spatial Heterodyne Observation of Water (optional instrument), being prepared for stratospheric balloon demonstration in 2014. A novel Canadian instrument designed to make high spatial resolution measurements of water vapour in the Upper Troposphere Lower Stratosphere (UTLS) region*
- A small spacecraft carrying these in an Odin-like orbit would build on considerable instrument and data retrieval expertise.

ALISS Mission Statement

The Atmospheric Limb Sounding Satellite (ALISS) is:

- An international science mission to provide high quality atmospheric composition measurements of ***scientific*** and ***operational*** interest from a low Earth orbit satellite platform.
- It responds to the strongly expressed national and international need for the ***continuation*** and ***scope broadening*** of high resolution vertical profile measurements to meet the rapidly evolving requirements for atmospheric sciences and services, to support monitoring of the efficacy of regulatory protocols and policies, and to answer key science questions on the processes that link atmospheric composition and climate.

The vision that SNSB and CSA share of ALISS

- The mission must be well aligned with our respective space policies.
- The core payload is comprised of two instruments with strong heritage:
  - CATS (OSIRIS)
  - STEAMR (SMR)
- We seek collaborators to add value to the mission and to share common costs.
- We welcome the inclusion of synergistic instruments while acknowledging that additional instruments add cost, complexity and risk.
- We need a common-sense approach to low-cost development for this high performance mission:
  - empower a small dedicated project team,
  - design driven by essential requirements,
  - competitive procurement,
  - extensive testing

The current status of ALISS

- A preliminary study was performed by the CSA Concurrent Design Facility (January – April). It focused on assessing the feasibility of accomodating the instruments on two commercial platforms (SSTL-600 from UK and Elite-1000 from France) and identifying significant issues. These platforms were considered because of these countries' potential interest to contribute to the mission and because of the low cost of the ELITE platform due to the high production volume for a major programme.
- At the request of Environment Canada, a GNSS-RO instrument was included in the study.
- The preliminary Mission Concept Review was held on March 17-18 at SNSB. Results indicate that the ALISS mission is feasible using these buses; however each of them presents constraints for the payload package.

Approximate mass budget: 500 kg platform plus 200 kg instruments
Orbit: Local Time Ascending Node, LTAN= 19:45

ALISS Instrument Synergy

CATS	280–960 nm limb scatter	Hartley–Huggins and Chappuis O_3, NO_2, BrO, sulfate aerosol extinction, cirrus optical depth
SHOW	1363–1366 nm limb scatter	H_2O in the UTLS region
STEAMR	324–355 GHz thermal emissions	O_3, H_2O, T, N_2O, HNO_3, CO, CH_3Cl, CH_3CN, HCN, ClO, HDO
GNSS–RO	GNSS signal occultation	T, H_2O in the troposphere

Short term mission development timeline

➢ Develop SOW and RFP	summer 2014
➢ Complete the draft URD	summer 2014
➢ Industrial contract	autumn 2014 – summer 2015
➢ Science Advisory Group	autumn 2014
➢ Workshop II (open)	Sept 2015

Potential partners have been invited to consider collaboration. The mission concept will be further developed through an industrial contract. The mission concept study would be concluded in summer 2015. A commitment to the mission would need to be made at that time.

Long term mission development timeline:

Launch	2020

Science and Data Product Slides

Mission Objectives

- Demonstrate improvements in air quality forecasting applications

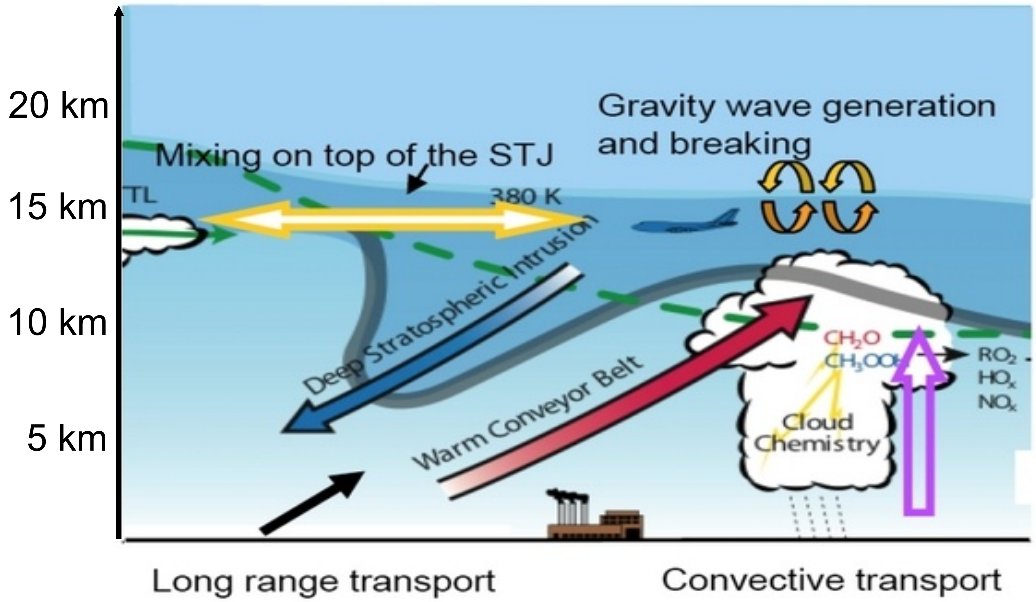
  In combination with nadir-viewing air pollution satellite missions, enable a much more accurate separation of stratospheric and tropospheric concentrations in order to better identify and forecast surface air quality.

- Demonstrate improvements in UV forecast applications, provided space-based observations of ozone are made available in near real time (NRT) and the assimilation systems are developed to ingest NRT data.
- Demonstrate initial operational capability by providing NRT data for a limited set of products from year 2 of the mission. *Once the value of the operational chemical data assimilation is confirmed, additional funding contributions may be required to operationalize the NRT data reception, processing and distribution*

Additional Science Objectives

- Further our understanding of how the Earth's atmospheric composition is evolving and responding to both natural and anthropogenic changes
- Further our knowledge of science in the critical and under-measured upper-troposphere and lower stratosphere (UTLS) region, including
  - Understanding the variability of the UTLS, particularly water vapour
  - Linking this variability to changes in surface climate
  - Measurements of the exchange between the troposphere and stratosphere
  - Understanding the role of convection
  - The impacts of the exchange of pollution and biomass burning
- Further our knowledge of the coupling between the recovery of the ozone layer from the effect of ozone-depleting substances and climate change.

O_3
T
NO_2
CH_3Cl
BrO N_2O
CH_3CN
HNO_3



H_2O
HDO
CO
Cirrus Clouds
ClO
Sulphate aerosols
HCN

This schematic highlights the important processes coupling dynamics, chemistry, and cloud microphysics in the UTLS region. The green line denotes the time average tropopause. The gray line illustrates synoptic scale processes that contribute to stratosphere-troposphere two-way exchange, such as frontal lifting, tropopause folds, and intrusions. In addition, convection brings near-surface pollutants into the upper troposphere, strongly influencing global-scale chemistry. Major transport pathways are indicated by bold arrows. The yellow arrow indicates the dynamical coupling of the tropical UT and extratropical LS by large-scale wave activities. The blue arrow shows the stratospheric intrusions into the troposphere near the jet streams. The red arrow represents the upward transport by frontal lifting along the warm conveyor belts. The white cloud represents the convective transport. In addition, large scale stratospheric circulation contributes to the downward transport.

CATS Data Products

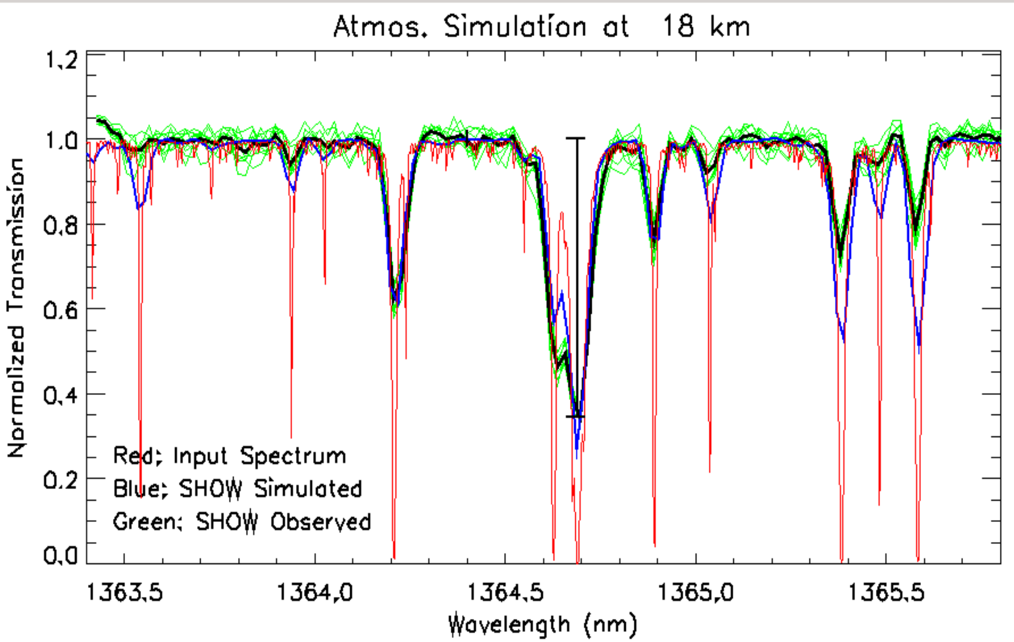
	Height Range / Vertical Resolution / Horizontal Sampling	Precision	Accuracy
O_3 (cm^{-3})	8-55 km / 200 m / 100 km	<= 5%	<= 2%
NO_2 (cm^{-3})	8-40 km / 200 m / 100 km	<= 10%	<= 10%
Aerosol extinction (km^{-1})	Tropopause-35 km / 200 m / 100 km	< 10%	<= 10%
BrO (cm^{-3})	10-40 km / 200 m / 100 km	TBD	TBD
Cirrus cloud optical depth	10-20 km / 200 m / 100 km	TBD	TBD

STEAMR data products

	Height Range / Vertical Resolution / Horizontal Sampling
O_3 (vmr)	6–40 km / 1.5–3 km / 50 km
H_2O (vmr)	6–40 km / 1.5–3 km / 50 km
T (°K)	6–40 km / 2–3 km / 50 km
N_2O (vmr)	8–40 km / 1.5–3 km / 50 km
HNO_3 (vmr)	12–40 km / 1.5–3 km / 50 km
CO (vmr)	6–35 km / 2–3 km / 50 km
CH_3Cl (vmr)	10–30 km / 1.5–3 km / 50 km
CH_3CN (vmr)	10–35 km / 2–3 km / 50 km
HCN (vmr)	10–35 km / 2–3 km / 50 km
ClO (vmr)	10–40 km / 3–4 km / 50 km
HDO (vmr)	10–35 km / 3–4 km / 50 km

SHOW Data Product: High resolution UTLS H_2O

- H_2O (cm^{-3}) – from tomographic inversion of retrieved spectra
- Vertical range: 10 – 40 km
- Spatial resolution: 1 km vertical and 7 km horizontal



Simulated limb radiance (red) and simulated SHOW spectrum (blue) compared to observations of water cell with equivalent column H_2O (green).

- Spatial Heterodyne Spectrometer
- Spectral Resolution: 0.02 nm
- Spectral range: 1363 – 1366 nm
- 2D image with spectral information in horizontal and spatial (full vertical limb) in vertical.
- One image per second yields full spectrum at each altitude for each image.
- Dayside, limb scatter observations