The Stratospheric Wind Interferometer for Transport studies (SWIFT) is a Canadian satellite instrument designed to measure stratospheric winds and ozone in the 20-45km region.

**ABSTRACT**

SWIFT is a field-wide imaging system similar, in principle, to the WINDH (WIND Imaging Interferometer) instrument but will operate in the infrared rather than the visible. An overview of the current instrument is described, followed by a description of a preliminary forward model to compute limb radiances for the Michelson interferometer imaging system of SWIFT. The model is a derivative of the Fast Line-by-Line Radiative Transfer model, this model, with the addition of a gradient model, will be initially tested in retrieval mode with the aim of eventual use by the Canadian data assimilation system. This paper will briefly describe the SWIFT instrument to be flown on the Canadian Space Agency's Chinook Mission in late 2010 followed by a description of the forward model.

**Overall Objectives of SWIFT**

To provide high resolution global measurements of horizontal wind vectors in the stratosphere under both daytime and night time conditions in order to study:

- Atmospheric dynamics in general
- Ozone transport from co-located wind and column measurements
- The potential of operational stratospheric wind measurements for medium range forecasting

**Brief History and Current Status of SWIFT**

- SWIFT originally proposed to ESA as an Earth Explorer Mission Phase A/B mission.
- In 2006 the CSA selected ARGO (a GPS occultation mission) as the next SciSat mission.
- In 2005 the CSA made SWIFT the primary instrument for their next SciSat mission.
- In 2004 the CSA selected ARGO (a GPS occultation experiment) to accompany SWIFT.
- Mission now named Chinook.
- SWIFT is in Mission Phase A/B stage.
- Scheduled launch in 2010 for a minimum 2 year mission.

**Measurement Technique**

A relatively isolated O₃ line (ν = 133.4335 cm⁻¹) in the IR region is separated from the complex limb spectrum of the stratosphere using a narrow-band filter system with a width of about .1 cm⁻¹. A field-wide Michelson interferometer placed in the beam is used to sample the interferogram of the Doppler wind shifted spectrum at 4 points (Fig 1, 2, 3, 4). The stratospheric wind and ozone density profiles are recovered from the 4-point measurement images.

**Line of Sight Wind Recovery**

The relative velocity of the source and instrument is determined by a combination of Earth rotation, satellite motion and line of sight (LOS) wind. Each of these causes a shift in the phase of the interferogram. The intensity, \( I_{ij} \), for each pixel \( i,j \) and each mirror step, \( k \), can be written as

\[
I_{ij} = I_{ij}^{\text{meas}} (1 + U_{ij} V_{ij} \cos(\phi_{ij} + \psi_{ij}))
\]

In practice, the Michelson mirror may not step in exactly the same direction resulting in a shift in the phase of the interferogram. The intensity, \( I_{ij} \), for each pixel \( i,j \) can be written as

\[
I_{ij} = I_{ij}^{\text{meas}} (1 + U_{ij} V_{ij} \cos(\phi_{ij} + \psi_{ij}))
\]

Forward Model

SWIFT interferograms are simulated by the integral of limb emission, \( S(j,k) \), convoluted with a complex instrument function, \( J(j,k) \), as follows:

\[
S(j,k) = \frac{1}{(2\pi\Delta\nu)^2} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} (\Delta\nu^{-1})(\Delta\nu^{-1})^{-1} \Delta\nu J_{ij}(\nu,\Delta\nu) S_{ij}(\nu) d\nu d\Delta\nu
\]

where \( \Delta\nu \) is the channel width of the instrument.

Another consideration is how many sublayers are required to estimate the layer properties before an impact on winds appears. Figure 7 illustrates the differences between 20 sublayers model (001-003) and 4 other values. At least 6 or 7 layers are required to minimize the impact on derived winds.

All possible combinations of gases were tested in order to determine if the list may be reduced. Figure 8 shows the samples where a single absorber has been dropped off the list. It appears that at least HDO and NH could be ignored, as could CFCl2 if one wished to exclude winds below 20 km.

**Discussion**

A preliminary forward model for SWIFT has been chosen. To date it has been optimized to execute as on a LINUX machine. One complete interferogram (0.2 cm⁻¹) takes about 40CPUsec. It remains to be seen if the FLBL is suitable on ASTD’s IBM cluster of p690s.

The preliminary wind impact studies indicate that discarding the outer 20 columns of the interferogram then a lower resolution and fewer sub layers can be used, resulting in a speed up of 3 or 4 times. One or more absorbers may be potentially omitted, however more testing is required assuming other atmospheric conditions before any decision on omitting gases is made.

The testing and optimizing the FLBL is incomplete. In addition, the gradient portion remains to be completed, tested and integrated into a data assimilation system in order to test the feasibility for assimilating SWIFT into an NWP. If the FLBL is too slow on the IBM cluster, then efforts will turn to a more parameterized model.

The final instrument architecture is not finalized, as it still has to be optimized. Thus, the algorithm may have to be refined in order to reduce the wind errors to better than 5 m/s for 20-45 km and to better than 5 m/s for the extended range of 15 to 55 km through the entire life of the mission.

**Acknowledgements**

The authors acknowledge the support of the Canadian Space Agency (CSA).

**References**


**SWIFT web page**

http://swift.yorku.ca

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Fig 1: The impact of a Doppler shift on a line spectrum on its interferogram. The diagram on the left shows the narrow emission line (ν = νo) Doppler shifted by δν. Their corresponding interferograms are shown on the right.

Fig 2: Four point measurement of a pixel interferogram. Every pixel on the detector array has a similar interferogram associated with it.

Fig 3: The Michelson modulates the radiation by stepping the movable mirror (ν = νo) to vary the optical path by creating an interferogram for each pixel in the field of view. Each of the above images corresponds to one of the four points on the sample pixel interferogram in figure 2.

Fig 4: SWIFT fields of view as seen from the side (upper) and from above (lower) the satellite.

Fig 5: Schematic drawing of an earlier optical concept for SWIFT.

Fig 6: Difference between winds derived using a .0001 (cm⁻¹) model and .004 are unacceptable. At .003(cm⁻¹) the corners are solidly over 1m/s differences over 1m/s just start to appear in the upper corners. At .003(cm⁻¹) the solid is slightly over 1m/s. Resolutions over .004 are unacceptable.

Fig 7: Impact on wind upon removing an absorbers from the current list. (scale is the same as in figure 6 & 7.)