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Performances of the Data Compression and Binning Algorithms adopted on the VIRTIS-M Spectrometer onboard Rosetta

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Abstract

This paper describes the analysis of the consequences on the retrieval of reflectance spectra of using several levels of data compression algorithms and of degrading the instrument resolution by means of spectral/spatial binning. These are software algorithms available on the spectrometer VIRTIS-M onboard the ESA's Rosetta spacecraft.

An accurate knowledge of the compression algorithms performances and of the spectral/spatial binning performances will be very useful when Rosetta will arrive to its main target (comet 67P/Churyumov-Gerasimenko) in order to define the limits of operability of VIRTIS-M and therefore to plan a set of observation types which can be adapted to various phases and to various scientific objectives.

This analysis has used observations performed during Earth swing-by#1 and Earth swing-by#3 which have been planned explicitly for this purpose.

1. VIRTIS-M Compression and Binning Performances

The International Rosetta Mission is one of ESA's Planetary Cornerstone Missions. The spacecraft is now on cruise to the main target (comet 67P/Churyumov-Gerasimenko).

One of the remote sensing instruments carried by spacecraft is VIRTIS (Visible Infrared Thermal Imaging Spectrometer).

VIRTIS is a spectrometer which uses two optical heads (-M,-H), respectively dedicated to the VIS-NIR imaging spectroscopy (250-5000 nm) and infrared spectroscopy (2500-5000 nm) with high spectral resolution [1].

The VIRTIS instrument shall perform a series of observations during the comet escort phases in order to fulfill different scientific objectives:

- Nucleus global coverage
- Nucleus active and/or "interesting" areas monitoring
- Determination of surface properties (temperature, thermal inertia, etc.)
- Large scale coma mapping
- Nucleus/coma interaction region study
- Jet characterization study

Assuming one 35 meters antenna pass per day, during the comet escort phases, the Mission Operation Center has evaluated the downloadable data volume per day expected for the whole payload (Figure 1).

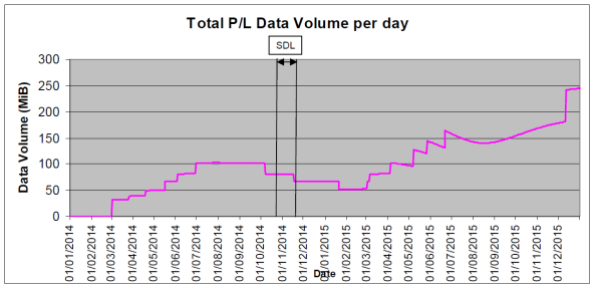

Figure 1: Total S/C data volume in MB per day throughout the mission. The two vertical lines define the Lander Mission (SDL stands for Separation, Descent and Landing)

Due to data volume constraints, during the definition of the observation strategy for comet escort phases, it has evinced that in addition to demonstrating that a

certain scientific objective is within the capabilities of the instrument (in terms of radiometric sensitivity, operability, etc.), it is also necessary to evaluate its feasibility taking into account the capabilities of the spacecraft in terms of downloadable data volume.

Therefore it has been decided to perform an accurate analysis of the compression algorithms performances and of the spectral/spatial binning performances of VIRTIS-M.

The VIRTIS-M data compression is managed by the on board software. On VIRTIS-M is possible to use 1 lossless and 3 lossy algorithms with a selectable compression factor comprised between 2 and 12. In particular the lossless algorithm is completely reversible (error-free) and allows a compression factor between 2 and 3 as a function of the entropy level of the acquisition. The lossy compression is based on the Wavelets approach [2].

Another way of compressing data is to reduce the total number of downloaded pixels by means of averaging thus effectively reducing the spectral and/or spatial resolution of the instrument.

The possible binning modes for VIRTIS-M are:

- High resolution full window
- Nominal mode 3x4 (also summing subsequent frames)
- High Spatial mode 3x1
- High Spectral mode 1x4

2. Earth Swing-By#1 and Earth Swing-By#3 observations

On cruise to the main target (comet 67P/Churyumov-Gerasimenko) the spacecraft has been scheduled 3 Earth swing-bys.

The Earth Swing-by#1 of the 4th and 5th of March 2005 has been the first opportunity to observe extended objects (the Moon and the Earth) since the launch.

This was considered a good opportunity to perform calibration and scientific observations using our planet and its satellite.

Therefore several tests were performed to verify the software operability of the various compression mode available onboard using the same target to verify results.

During Earth Swing-by#3 it is been decided to thoroughly test, for both channels, not only the software routines which deals with the data compression but also the ones dealing with the binning/averaging of spatial/spectral pixels.

The instrument pointed the Earth on 13th November 2009 and performed four acquisitions with the four compression levels.

With the same pointing the instrument performed four subsequent acquisition using the four different binning modes.

3. Conclusions

The analysis of the compression algorithms and of the spectral/spatial binning performances is extremely useful to properly plan the observation strategy during the comet escort phases in order to optimize the instrument performances and to have an accurate evaluation of the data volume required by the observations.

The presentation will describe in detail the results achieved and their application to some observation types which will be performed during the comet escort phases.

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