Venμs reflectance time series : interest of constant observation angles

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1. INTRODUCTION

The VENμS mission (see Dedieu et al, this conference) will provide:

1- high resolution images

2- observations every 2-days

3- in 12 narrow spectral bands ranging from 415 nm to 910 nm

4- with constant observation angles

This fourth feature is often omitted when Venμs project is described, but nonetheless, this property of Venμs images is one key of the enhanced quality of Venμs time series. This short note aims at showing the great interest of constant observation angles for the quality of reflectance time series, thanks to a data-set acquired with FORMOSAT2, a Taiwanese satellite that also acquires images with constant observation angles.

Usually, reflectance time series in the visible or near-infrared domain, such as those provided by high resolution satellites such as SPOT, or by wide field of view instruments, such as VEGETATION, MERIS or MODIS, are degraded by two geo-physical sources of noise : 1) directional effects, since the observed surface reflectances depend on solar and observation angles. and 2) atmospheric effects, mainly because of aerosol scattering, difficult to correct because aerosol optical properties are highly variable and difficult to characterise

Thanks to the constant observation angles, directional effects will be minimized, since the only variation of observation and illumination geometry will be caused by the variations of solar elevation during the year. As a result, the directional effects variations will be quite slow with time, and moreover, when comparing data acquired at a one year interval, no directional effects will be observed.

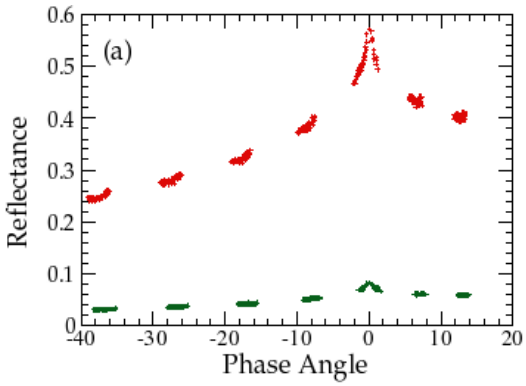


Fig 1. Examples of reflectance variations for a needle-leaf forest as a function of phase angle for POLDER near infra-red band (in red) and for red band (in green). Phase angle is the angular distance to the backscattering direction (when the pixel, the satellite and the sun are aligned). Reflectance variation can be greater than 100% if observation angles from day to day..

Furthermore, the quasi absence of directional effects can be used to enhance the atmospheric corrections. For this, we will use the following properties:

- aerosol optical properties vary quickly with time but slowly with location.

- reflectances vary quickly with location but slowly with time, when there are no directional effects.

In a few days period, the top of atmosphere reflectance variations are mainly caused by variations of aerosol optical properties, providing a way to estimate these properties. Such a method will be implemented in Venμs level 2 algorithms.

2. EXEMPLE DATA-SET WITH FORMOSAT-2 DATA

To prepare Venμs algorithms, to promote the use of Venμs-like time series of images, and to train the future users of Venμs data, a data set partly similar to those of Venμs has been acquired thanks to FORMOSAT-2 satellite. FORMOSAT2 is a Taiwanese high resolution satellite (NSPO, distribution by SPOT-IMAGE) with the following features:

1- high resolution images (8m), field of view : 24 km

2- observations possible every day (not global)

3- 4 spectral bands (broader than Venμs) ranging from 490 to 850 nm

4- with constant observation angles

Images are being acquired every 3 days for a site in France, every 4 days for a site in Morocco. We are showing below a sequence of 12 images acquired during a 2 months period, between 2005-11-16 and 2006-02-16. The images displayed below are top of atmosphere reflectances, with a constant colour table defined below.

Red : 0-255	***Near infrared band (B4) : 0.15-0.5***
Green : 0-255	***Red band (B3) : 0.06-0.28***
Blue : 0-255	***Blue band (B1) : 0.08-0.2***

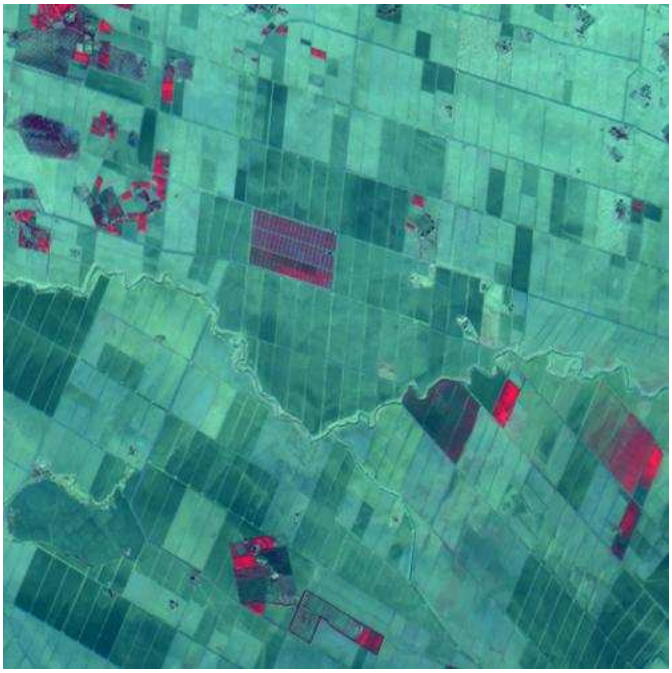
The first striking feature of this series of images is their similarity: except for a few accidents, all the images look the same. The accidents come from various phenomena:

- on 2005-11-20, the aerosol optical depth was higher than on the other days of this time-series (an AERONET sun photometer is available nearby the site). Venμs level-2 products will use the day-to-day variations of the atmospheric transparency, as well as the stability of reflectances, to invert the atmospheric aerosol content.

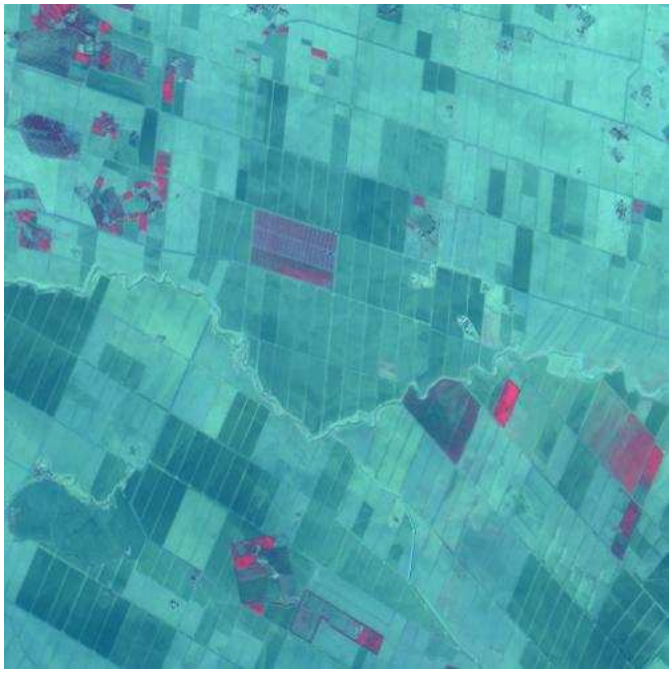
- on 2005-12-29 and 2006-01-18, the images were acquired after heavy rain events

- on 2006-02-16, some semi transparent clouds appear in the images, and the start of the growing season for vegetation is easily visible. The start of the growing season was already noticeable on many fields in the image of 2006-01-22.

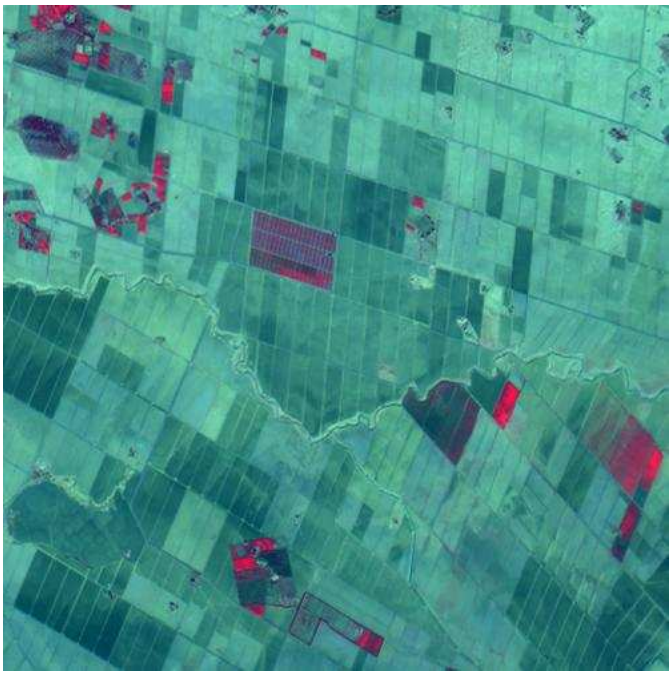
Between the images acquired on 2005-11-16 and 2005-11-28, some much localised changes in reflectances can also be noticed. The reflectance of naked ground on some parcels suddenly decreases. This change occurs because the parcel has been ploughed. Detecting the date of ploughing in this region is very important because wheat is sowed when the parcel is ploughed.



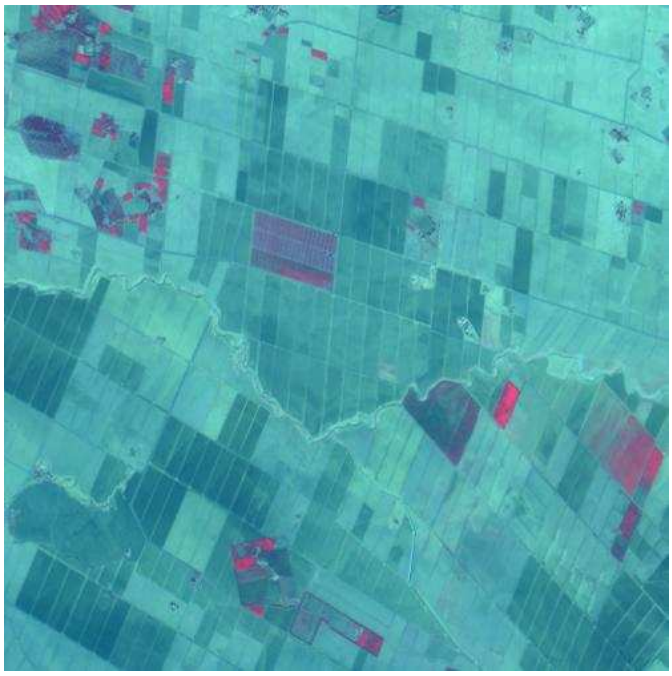
2005-11-16



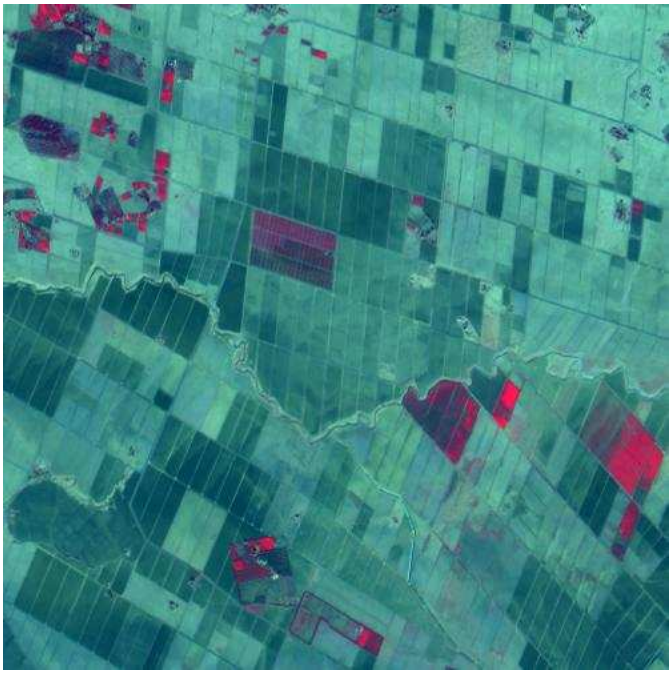
2005-11-20



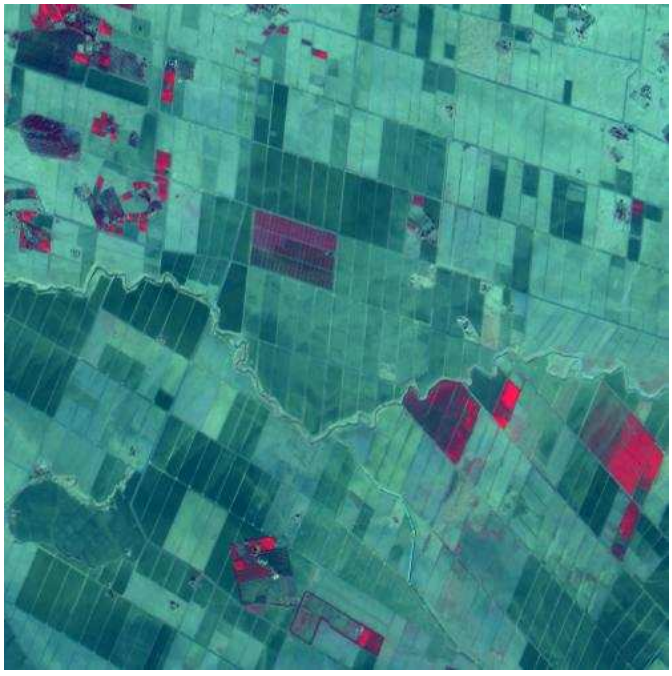
2005-11-16



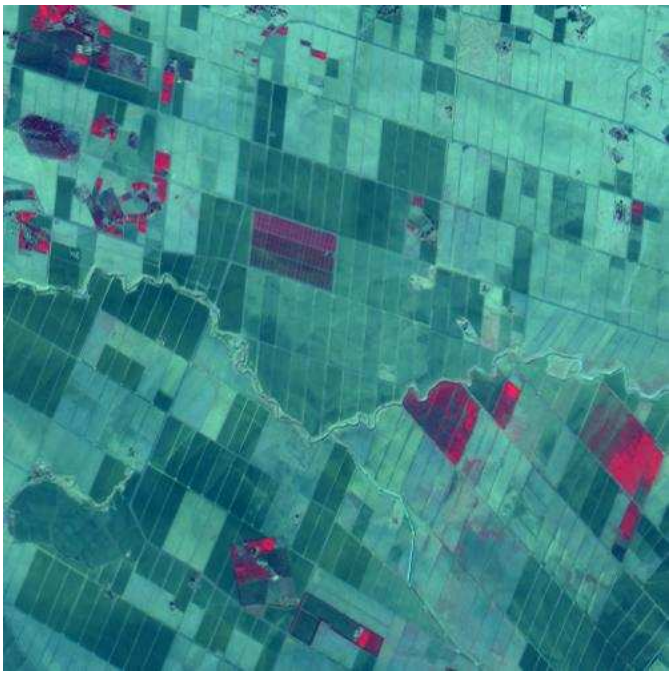
2005-11-20



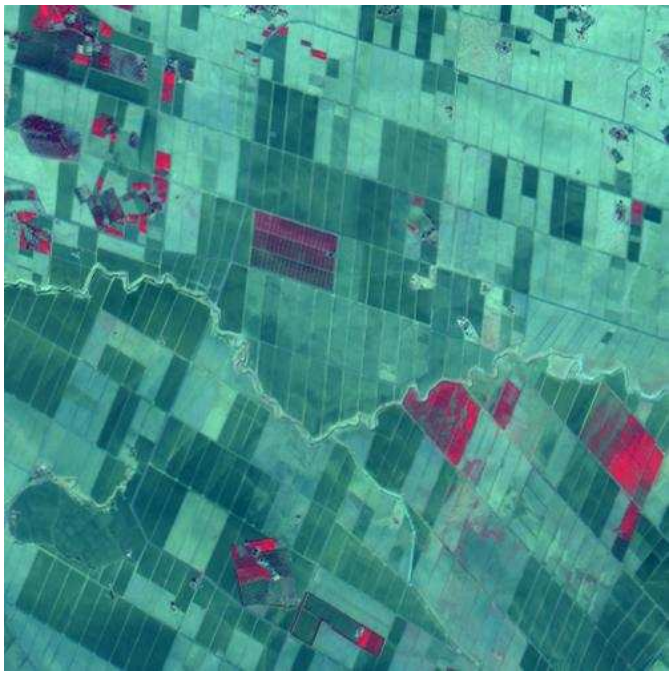
2005-11-28



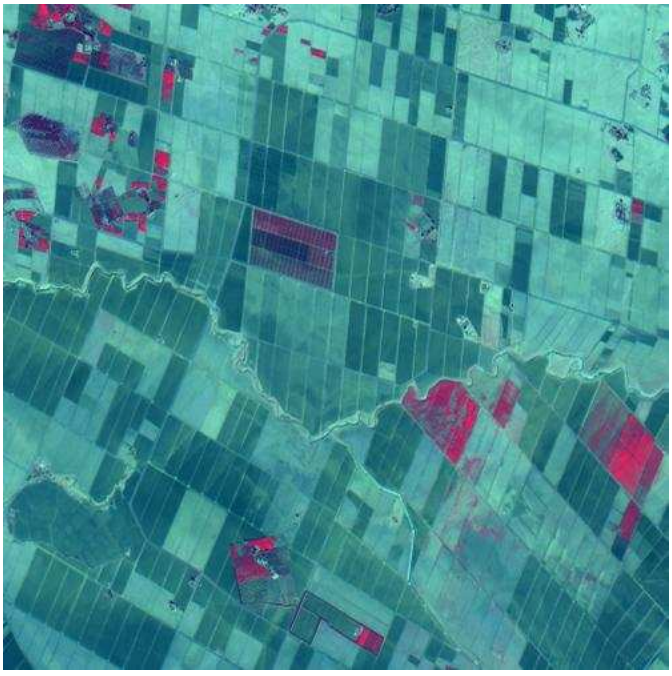
2005-12-04



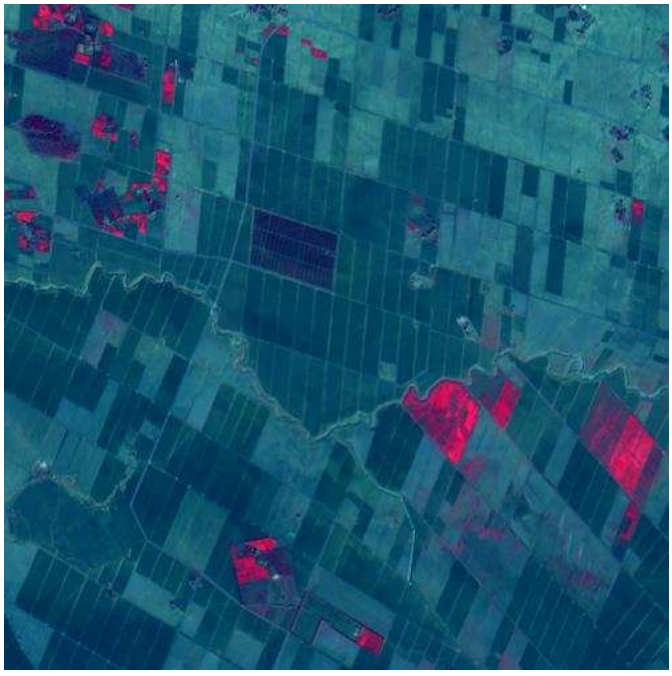
2005-12-08



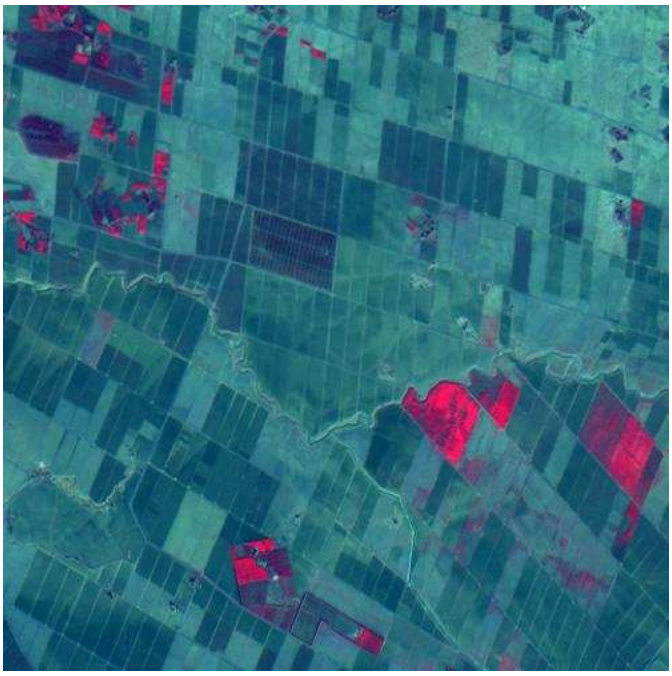
2005-12-12



2005-12-16

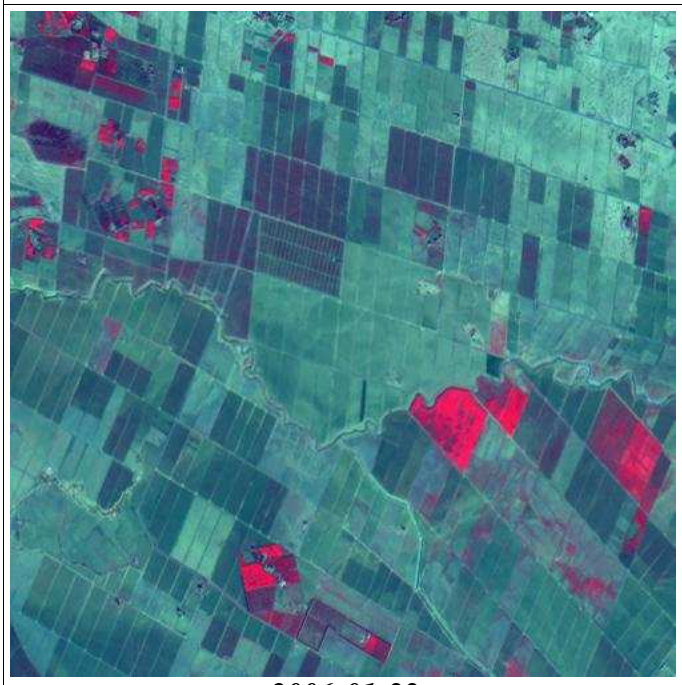


2005-12-29



2006-01-10

2006-01-18



2006-01-22

2006-02-16

It is possible to plot the reflectance of a given pixel as a function of time to have an idea of the future quality of Venμs time series. On Fig.3, one can note that the amount of noise on the time series is really

low thanks to the quasi absence of directional effects. The higher reflectance values in the blue and red channels on November 20th are due to a higher optical thickness. The sudden drop of reflectances in all channels on December 12th is due to the ploughing of the field. The reflectance decrease in the green and red channels on December 29th is related to the heavy rain event, but it is less visible on ploughed fields than on fields that are not yet ploughed. Finally, on the last date, vegetation start is clearly visible thanks to the near-infrared reflectance.

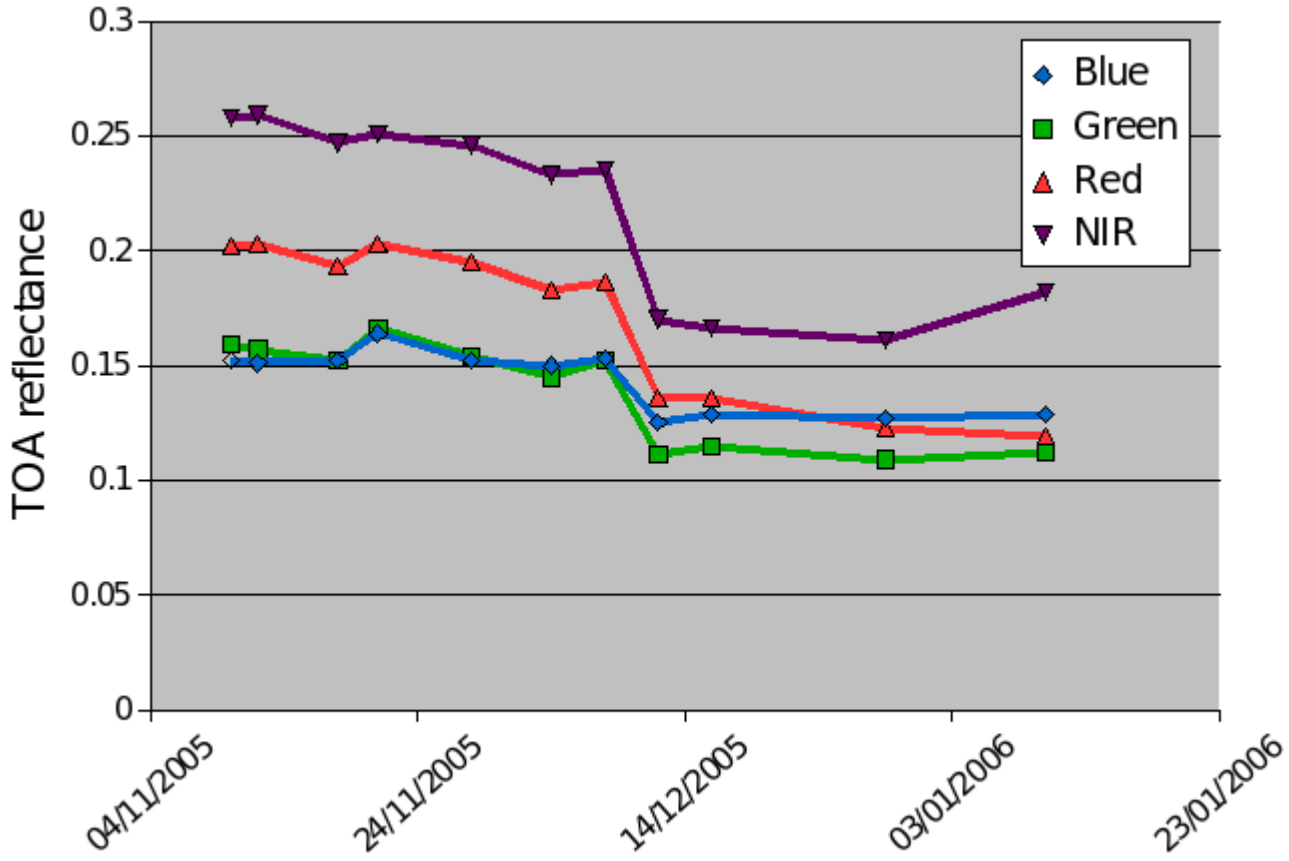


Fig 3 This figure shows the top of atmosphere variations of reflectance as a function of time for a ground pixel, for FORMOSAT four channels: blue, green, red, near-infra-red.