USE WHAT IS THERE: WHAT CAN SENTINEL-2 DO FOR GEOLOGICAL REMOTE SENSING?

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ABSTRACT

Sentinel-2 MSI (MultiSpectral Instrument) is the Landsat-like spatial resolution (10–60 m) super-spectral instrument of the European Space Agency (ESA), aimed at additional data continuity for global land surface monitoring with Landsat and Satellite Pour l'Observation de la Terre (SPOT) missions. Several studies with simulated and real data have been conducted in the last several years to show the potential of Sentinel-2 MSI, including its use for geological remote sensing.

An aspect of Sentinel-2 MSI that has not yet been evaluated for geological remote sensing is the 5–10 days revisiting time. This paper shows the first results of a multi-temporal study performed in a hydro-thermal alteration system in southern Spain. Several band ratios for mapping mineral alteration have been calculated in more than 200 Sentinel-2 MSI images that cover a period of two years. Results show the effect of seasonality, illumination and weather on ground cover and the stability of the geological indices.

Index Terms— Sentinel-2 MSI, geological remote sensing, ASTER, iron oxide, multi-temporal

1. INTRODUCTION

The European Commission (EC) and European Space Agency (ESA) established the European Earth Observation programme Copernicus for monitoring of the environment. The Sentinel missions 1–5 are the space component and provide routine observations for operational Copernicus services and data continuity for already operational satellite systems [1, 2]. Sentinel-2 MSI carries a super-spectral imager with 13 bands of 10–60 m spatial resolution, covering the Visible and Near InfraRed (VNIR) and ShortWave InfraRed (SWIR) wavelength regions with a 290 km swath width. The revisit time at the equator is 10 days for a single sensor and 5 days for both operational sensors [2].

The use of Sentinel-2 MSI for geological remote sensing has been evaluated by a comparison to the Advanced Spaceborne Thermal Emission and Reflectance Radiometer (ASTER) imager onboard the Terra satellite [3]. Particularly the six SWIR bands of ASTER allow mapping of surface mineralogy due to their relatively narrow spectral resolution [4], and has lead to a series of band ratios that serve as proxies for mineral assemblages or individual mineral groups [5]. The Worldview-3 sensor has 8 SWIR bands of which four were inhereted from ASTER [6]. Fig. 1 shows that Sentinel-2 lacks such narrow SWIR bands; it was therefore concluded that geological proxies that can be mapped with Sentinel-2 are to those obtained with Landsat, albeit on a 20 m spatial resolution [3].

Fig. 1 also shows that the super-spectral design of Sentinel-2 MSI resulted in multiple, relatively narrow, bands that cover the VNIR "iron" absorption feature: While ASTER and Landsat only have a single band in the 0.9 μm wavelength region, Sentinel-2 has several. An evaluation of several current and next-generation satellite sensors, including Sentinel-2 MSI, for mapping the iron absorption

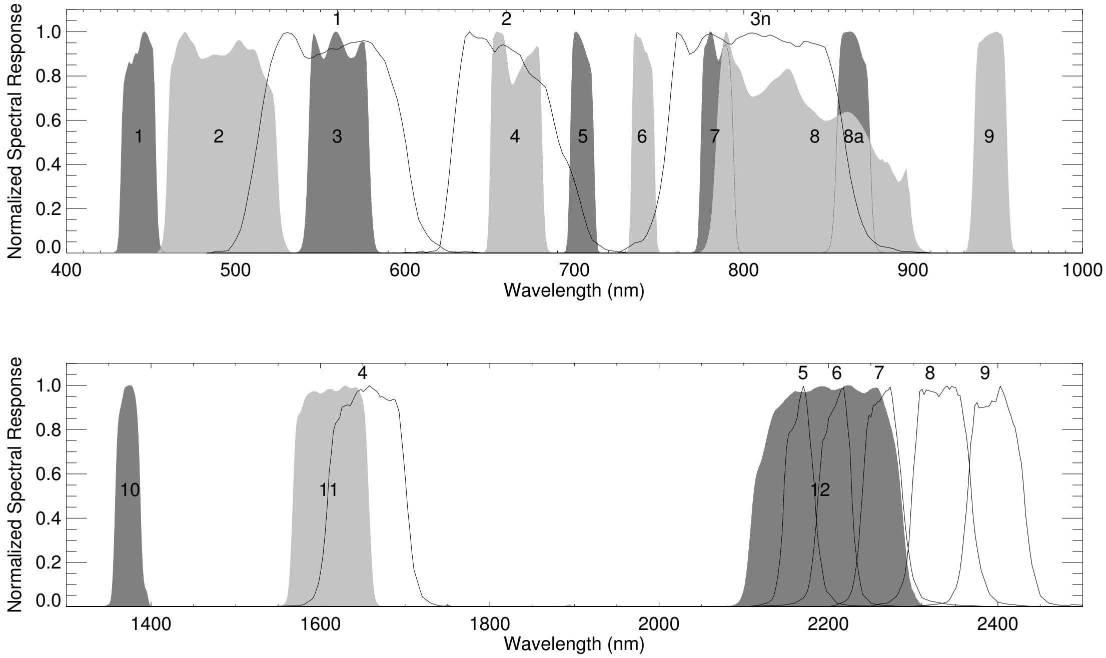

Fig. 1. The spectral bands of the Sentinel-2 sensor (shaded) in comparison to ASTER (line). ASTER has multiple narrow bands in the shortwave infrared wavelength region, while Sentinel-2 MSI has multiple narrow bands in the visible and near-infrared wavelength region.

feature depth in a band-ratio approach, reached the conclusion that the sensor potentially could save costs when used for target detection prior to hyperspectral data acquisition [7]. Sentinel-2 MSI could potentially map iron oxide mineralogy by using a line-fitting approach on bands 6–9 [8].

2. THE TIME DOMAIN

An aspect of Sentinel-2 MSI that has not yet been evaluated for geological remote sensing is the 5–10 days revisiting time. This paper shows the first results of a multi-temporal study performed in a hydro-thermal alteration system in southern Spain.

We collected over 200 Sentinel-2 MSI images that cover a period of 2 years. The data was processed from level 1C (top-of-atmopshere reflectance) to surface reflectance with sen2cor version 4.2.0 [9]. A pixel size of 20 m for the resulting level 2A product was chosen, as several band ratios require the 20 m resolution bands of Sentinel-2 MSI. The resulting dataset contained bands 1–7; 8a, 9, 11 and 12. The data were spatially subset to the study area, and further processed with the Geospatial Data Abstraction Library (GDAL) version 2.3.1. The sen2cor atmospheric correction provides a first land cover classification, which was used to mask all pixels that did not classify as bare soil (such as vegetation, water, clouds, shadow, snow). Lastly, three band ratios for mapping mineral alteration, originally defined for Landsat 5 TM [10], and the normalized difference vegetation index were calculated with GDAL (Tab. 1).

Results presented in this paper (Fig. 2) show the effect of seasonality, illumination and weather on ground cover and the spectral indices.

Table 1. Sentinel-2 MSI and Landsat 8 OLI band ratios, as an analogue of Landsat 5 TM [10] and ASTER [11] band ratios used as proxies for mapping mineralogy (modified after [3]).

Feature	ASTER	Landsat 5 TM	Landsat 8 OLI	Sentinel-2 MSI
TM Ratios				
Hydroxyl bearing alteration	4/{5,6,7}	**5/7**	6/7	11/12
All iron oxides	–	**3/1**	4/2	4/2
Ferrous iron oxides	2/4	**3/5**	4/6	4/11
Vegetation	**3/2**	4/3	5/4	8/4
NDVI ⋆	$\mathbf{(3-2)/(3+2)}$	$(4-3)/(4+3)$	$(5-4)/(5+4)$	$(8-4)/(8+4)$

† Band 12 of Sentinel-2 MSI and band 7 of Landsat 8 OLI cover ASTER bands 5–7. Landsat 5 TM band 7 also partially covers ASTER band 8. ‡ Biotite, chloride and amphibole. ⋆ Normalized Difference Vegetation Index.

3. REFERENCES

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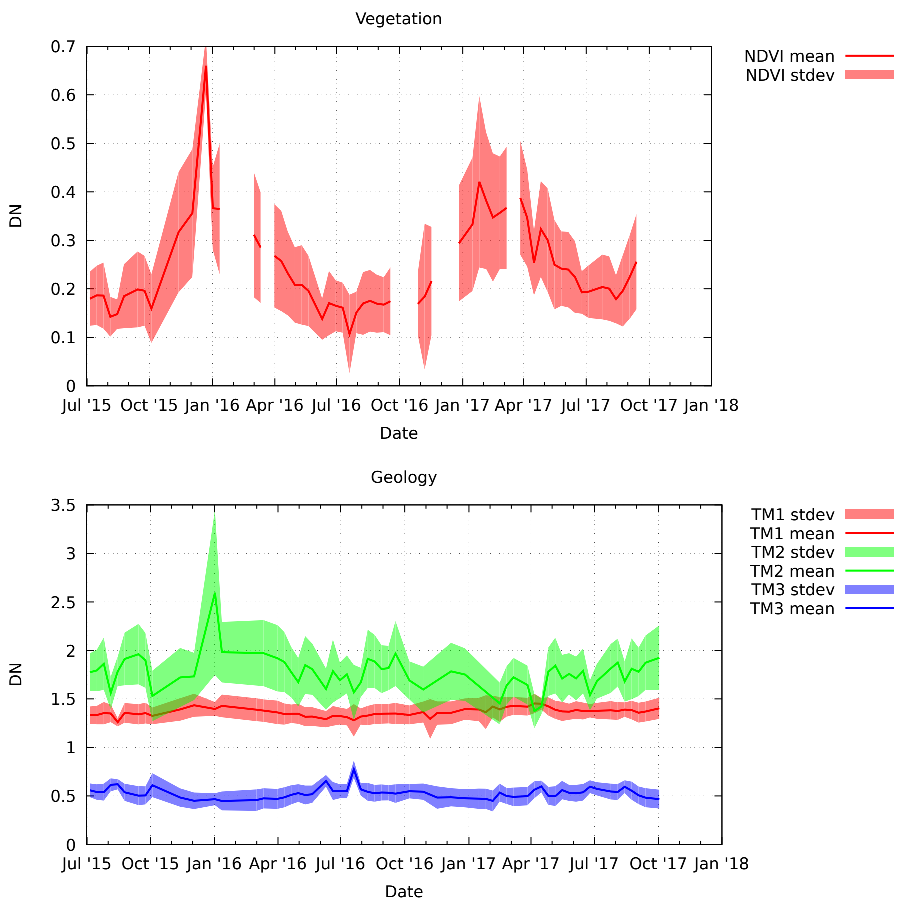

Fig. 2. Multi-temporal Sentinel-2 MSI data, showing the normalized difference vegetationindex values of the study area over a period of two years in the top figure. The bottom figure shows three geological indices [10] over the same time period: TM1 = Hydroxyl bearing alteration, TM2 = All iron oxides, TM3 = Ferrous iron oxides.