

Very high temporal resolution mapping of total suspended matter in the North Sea with SEVIRI data: a feasibility study

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Abstract

This pilot study shows the potential of a meteorological geostationary satellite system for suspended matter mapping in the North Sea. Total Suspended Matter (TSM) maps can now become available at a very high temporal resolution – every 15 minutes – for the first time.

Methodology

SEVIRI IMAGERY

The Spinning Enhanced Visible and InfraRed Imager (SEVIRI), designed for meteorological now-casting, has 11 spectral channels with a spatial resolution at nadir of 3km and one visual broad-band channel where the spatial resolution is 1km. Two spectral channels were selected for TSM mapping: the red and near-infrared, at central wavelengths of 0.64 and 1.64µm, respectively. An image test data set was obtained from the Royal Meteorological Institute of Belgium (RMIB).

IMAGE PRE-PROCESSING

The light reaching the SEVIRI sensor (ρ_{total}) does not come entirely from the sea, on the contrary: approximately 65-95% of the light comes from the atmosphere from various scattering processes. This noise is removed from the total signal by atmospheric correction to obtain the marine component (ρ_{water}). In this study, we applied a simple atmospheric correction algorithm based on the Single Scattering Approximation, conceptually depicted in Figure 1.

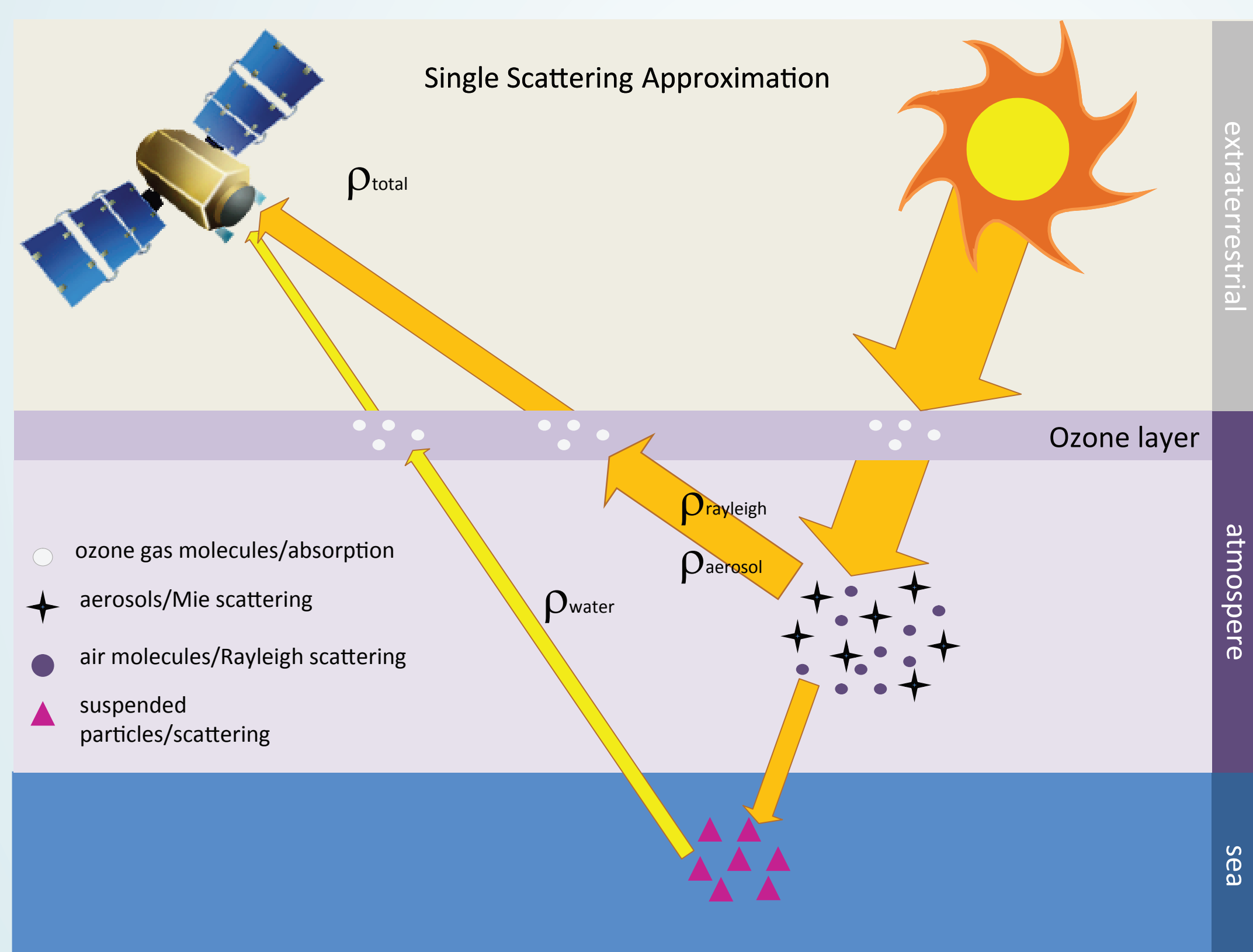


Figure 1. Conceptual depiction of the Single Scattering Approximation for atmospheric correction of satellite data.

The main steps in the atmospheric correction of the red band are (see Figure 2):

1. Correction for absorption by ozone gases for two trips through the ozone layer
2. Correction for scattering by air molecules: subtraction of the Rayleigh reflectance
3. Correction for aerosol scattering: subtraction of the Rayleigh corrected reflectance in the near-infrared band, where the ocean is considered a black body.

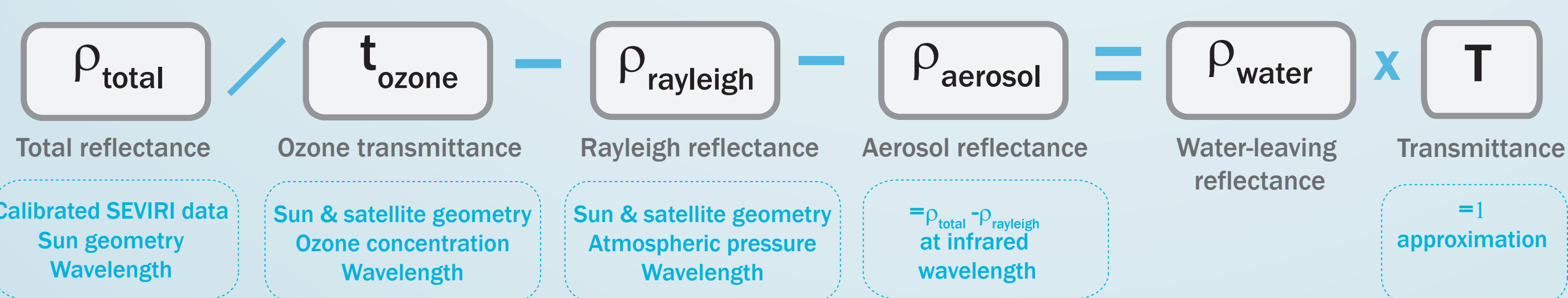


Figure 2. Main steps in the atmospheric correction. Dashed boxes show parameter dependence.

TSM MAPPING

TSM is then estimated from ρ_{water} in the red band using an algorithm calibrated by non-linear regression of seaborne measurements of TSM and ρ_{water} (Figure 3). The algorithm is applied without the regression offset caused by in situ measurement bias.

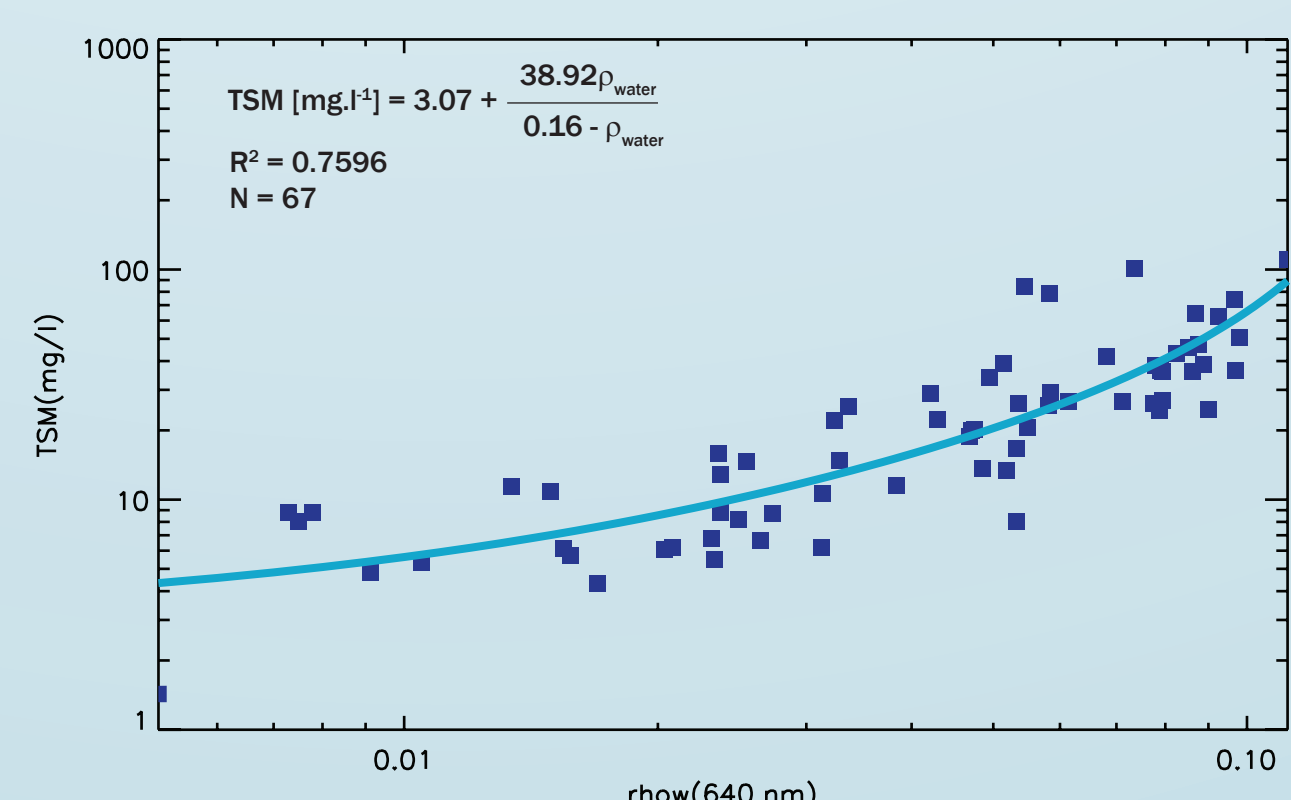


Figure 3. Non-linear regression between seaborne measurements and ρ_{water} .

Results and discussion

Figure 4 shows the concentration of TSM in mg/l. TSM is highest in the shallow coastal waters of the Southern North Sea (at the mouth of rivers Scheldt and Thames) and lower offshore, in the deeper waters of the Skagerrak and the Central/Northern North Sea.

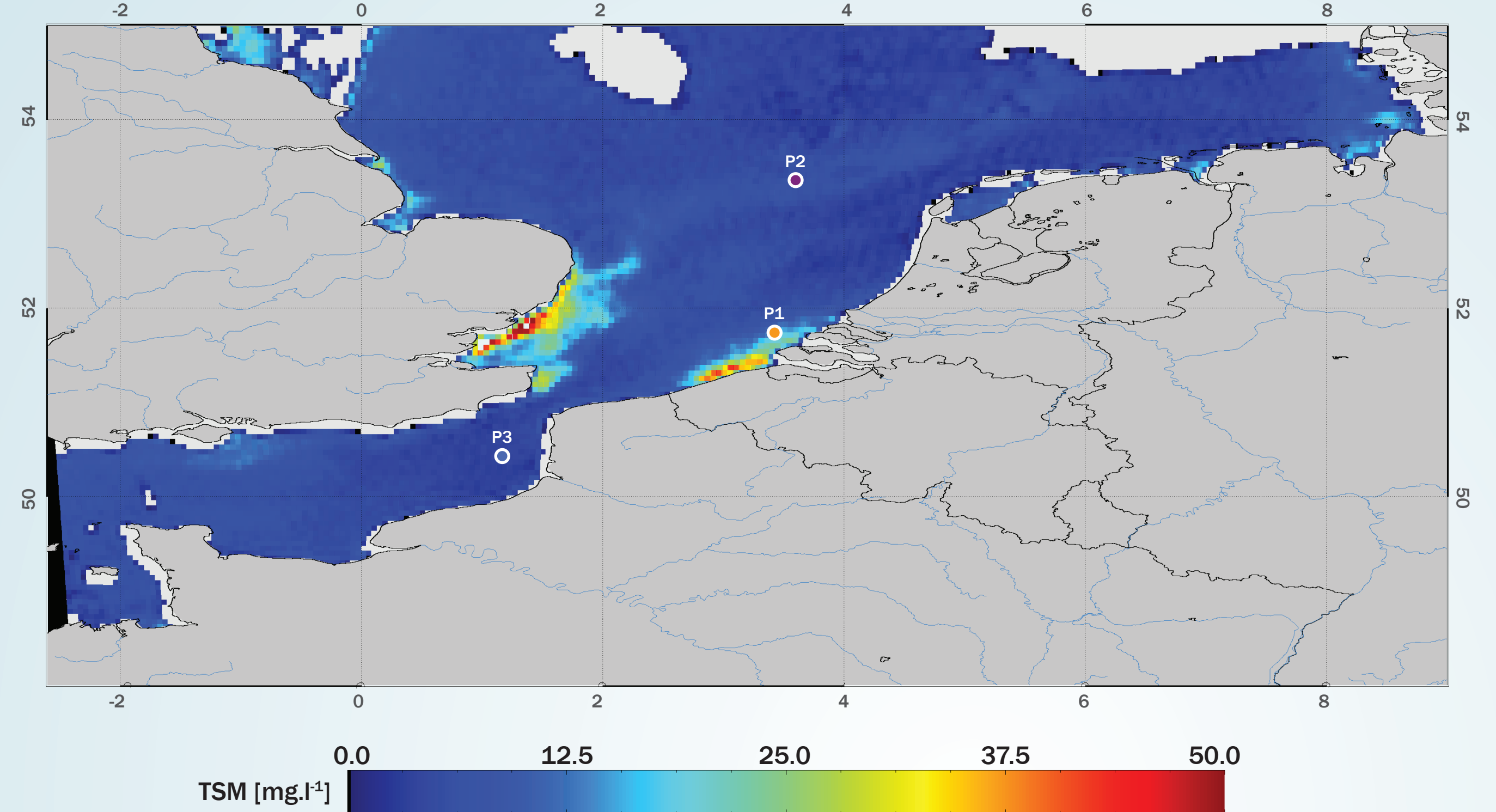


Figure 4. Map of TSM concentration in the North Sea on 10/09/2006 at 10:00 am (UTC). Clouds are masked out. Positions of P1-P3 are shown.

The high frequency variability of TSM is studied on a cloudfree day on 10 september 2006 at 3 different locations: P1 close to the mouth of river Scheldt (very turbid water), P2 in the Middle of the North Sea (medium turbidity water) and P3 off shore Calais in clear water (see Figure 5a). TSM at P1 shows a variability possibly related to the tidal cycle (see Figure 5b).

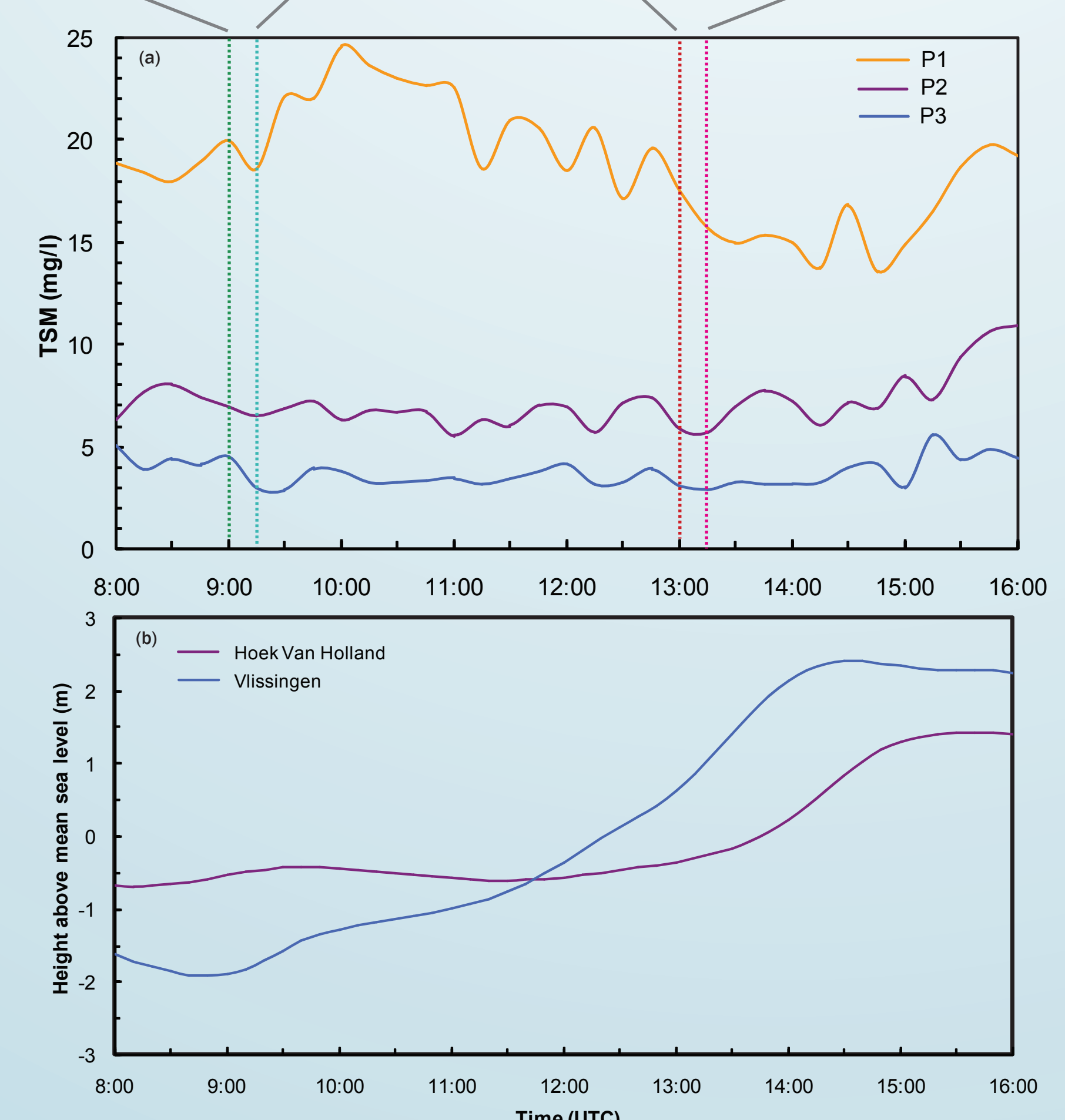
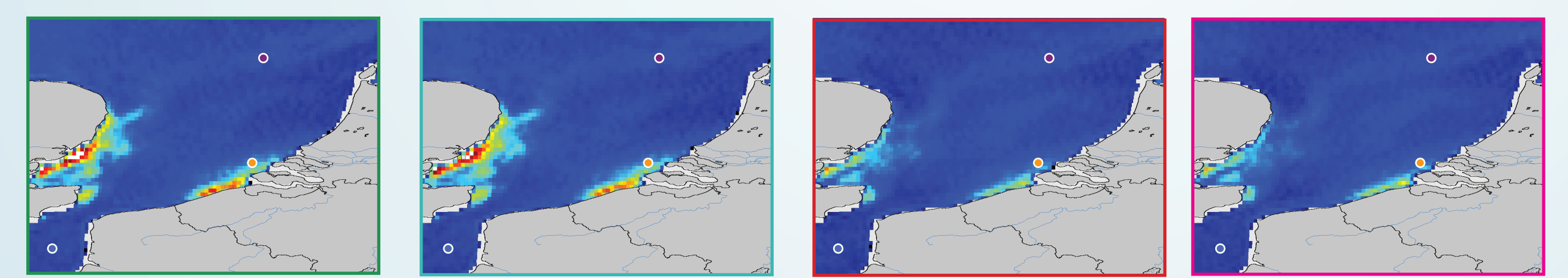


Figure 5. (a) Variability of TSM on 10/09/2006 at locations P1, P2 and P3. (b) Tidal amplitude variation on 10/09/2006 at Vlissingen and Hoek Van Holland.

Conclusion and future prospects

This feasibility study shows the potential of the SEVIRI radiometer for TSM mapping for the first time, opening perspectives of:

1. Studying high frequency dynamics of the coastal ecosystem: resuspension of bottom sediments, growth, decay and advection of algal blooms
2. Mitigating problems of cloudiness encountered with the current generation of polar-orbiters (MODIS, MERIS, SeaWiFS), through daily averaging of the SEVIRI images.
3. Studying the relationship between TSM, the amount of light available for photosynthesis by phytoplankton and the timing of the spring phytoplankton bloom