On the potential of Robust Satellite Techniques (RST) approach for flooded areas detection and monitoring using thermal infrared data

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ABSTRACT

The demand for near real-time (NRT) information on natural disasters has increased considerably during recent years worldwide. Flooding is considered as the world's most costly type of natural disaster in terms of both property damage and human causalities [1].

Satellite remote sensing technology is particularly employed today for supporting management and monitoring of flood situations [2]. It is, in fact, able to furnish repetitive and accurate information, at various spatial and temporal resolutions, about location, spatial extent and temporal variation of flood–affected areas, providing an economically feasible complement respect to the traditional ground-based observation systems, often limited in terms of spatial distribution, temporal sampling and timeliness of data collection and transmission [3]. The possibility to efficiently monitor flooding during the crisis and post-crisis phases is very important for supporting activities aimed at manage flood risk, helping in better evaluate (and possibly mitigate) the impact in terms of human safety and infrastructure protection. This can be done with high temporal resolution sensors, on board Earth Observation satellites, which may ensure a steady and frequent stream of images for a detailed investigation and real time monitoring of environmental changes [4]. In this context, optical instruments aboard polar and geostationary meteorological satellites are an excellent tool to monitor floods and for supporting the flood risk management cycle because, despite a coarse spatial resolution (from a few kilometers up to a few hundreds of meters), they offer temporal resolutions (from a few hours of polar satellites up to 15 minutes of geostationary satellites) high enough to guarantee timely, frequent and updated situation reports. Among these space systems, thanks to their high frequency, global coverage, multi-year operational continuity, full and free data availability [2], NOAA/AVHRR first (*National Oceanic and Atmospheric Administration/Advanced Very High Resolution Radiometer*) and, more recently, EOS/MODIS (*Earth Observing System/Moderate Resolution Imaging Spectroradiometer*) data have been extensively used for the investigation and

real time monitoring of environmental changes related to main natural hazards, including floods [5] - [8].

Recently, a new technique for automatic detection and monitoring of flooded areas by using visible (VIS) and near infrared (NIR) AVHRR data has been proposed [9]. It is based on the more general satellite data analysis methodology, the Robust Satellite Techniques (RST) approach [10] - [11]. Moreover, thanks to the complete independence of RST on the specific satellite platform, the proposed AVHRR technique has been also applied using MODIS VIS and NIR channels, in order to exploit the higher spatial resolution of such channels (i.e. 250m), to increase spatial accuracy in flooded area mapping. Results achieved, firstly by AVHRR data [9], and then confirmed with MODIS ones [12], have shown the actual potential of this technique in automatically identifying flooded areas with a low rate of false alarms, discriminating permanent water from actual inundated areas and overcoming major drawbacks related to the previously proposed AVHRR-based traditional methods [9].

In this work, a further extension of such an approach, to data acquired in the thermal infrared (TIR) region, is presented. Such an extension, in fact, will guarantee a continuous monitoring of flooded areas both during night and day. Specifically, thermal data acquired by MODIS channel 32 (11.77-12.27μm) have been used here for the first time to detect and monitor flooded areas [13] – [15]. Water presence can be potentially detected in the TIR images thanks to its thermal properties [16], which is different from those of dry soils. In particular, water exhibits higher thermal inertia than soils, which means that water bodies, compared with exposed soils, are warmer during nights and colder in daytimes. Therefore, adding water in a soil will result in its increase of temperature during night, and the opposite during the day [13] – [15]. Starting from these considerations, the RST approach has been implemented by using historical data-set of MODIS channel 32 imagery. In this paper, the Elbe river flood, occurred in Germany in August 2002 [17] and already studied with the same approach by using MODIS VIS-NIR bands [12] (Figure 1), has been considered as a test case for the proposed RST extension to TIR records. Preliminary results obtained by applying such an approach on the MODIS TIR images of 20 August 2002 are shown in Figure 2 (acquired at 10.20GMT) and Figure 3 (acquired at 21.25GMT). In detail, the areas along the Elbe rivers, between Magdeburg and Dresden, hardly hit by the flood, according to [17], are shown in these figures.

Note as, in both images, anomalous pixels along the main rivers are clearly identifiable. In particular, we can observe the high correspondence with the results achieved in VIS-NIR MODIS bands for the diurnal image (Figure 1), which confirm the reliability of these preliminary achievements.

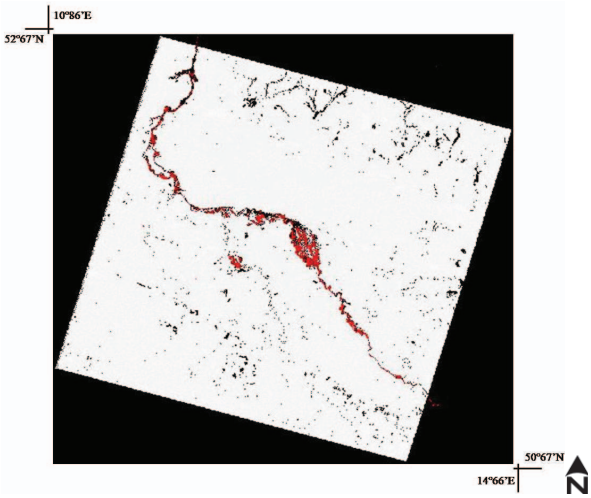

Figure 1. *Results obtained by applying the RST indexes (red pixels) on MODIS image of 20 August 2002, at 10.20GMT. In background the NIR (channel 4) band of Landsat-7 ETM of 20 August 2002.*

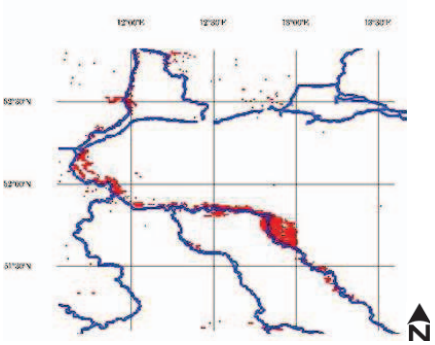

Figure 2*. RST results (red pixels) obtained for the MODIS TIR image of 20 August 2002, at 10.20GMT. Rivers have been colored in blue.*

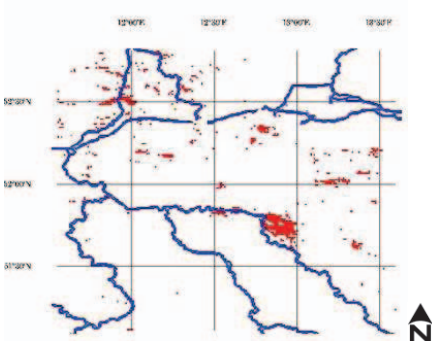

Figure 3. *RST results (red pixels) obtained for the MODIS TIR image of 20 August 2002, at 21.25GMT. Rivers have been colored in blue.*

The potential of such results for a continuous monitoring of flood-affected areas will be discussed in this work, taking into account also the opportunity to apply such an approach jointly on both MODIS and AVHRR data, with a consequent increase of frequency of acquisition and temporal sampling.

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