A multi-sensor RST based approach for flooded areas detection and monitoring: the November 2010 Veneto region flood

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1. Summary

In this work, a multi-sensor system for flood detection and monitoring, based on the RST (*Robust Satellite Techniques*) approach [1] is proposed. Both optical and microwave data have been used for studying the flood occurred in Veneto region in the early November 2010. Visible and near infrared channels of NOAA-AVHRR (*National Oceanic and Atmospheric Administration-Advanced Very High Resolution Radiometer*) and EOS-MODIS (*Earth Observing System-Moderate Resolution Imaging Spectroradiometer*) sensors have been used to detect areas involved by flood. Such data, thanks to their high temporal resolution, can ensure, in absence of clouds, a mapping of flood-affected areas at good spatial resolution. Passive microwave satellite data, specifically those acquired by AMSU (*Advanced Microwave Sounding Unit*), aboard NOAA satellites, have been exploited for real time monitoring of soil wetness variability, thanks to the microwave signal capability to penetrate through clouds and provide all-day data.

3. Robust Satellite Technique (RST) methodology

The RST approach is a change detection scheme, based on a multi temporal analysis of satellite data, co-located in the space time domain.

$$\otimes_v(x,y,t) = \frac{V(x,y,t) - \mu_v(x,y)}{\sigma_v(x,y)}$$

$V(x,y)$ signal under investigation

μ_v "normal" behavior of the signal

σ_v natural variability of the signal

* μ_v and σ_v are computed on multi-year time series of co-located cloud-free satellite records collected around the same time of day during the same month of the year.

[1] Tramutoli V., 2005. "Robust Satellite Techniques (RST) for natural and environmental hazards monitoring and mitigation: ten years of successful applications", The 9th International Symposium on Physical Measurements and Signatures in Remote Sensing, Shunlin Liang, Jiyuan Liu, Xiaowen Li, Ronggao Liu, Michael Schaepman Editors, Beijingina), ISPRS, Vol. XXXVI (7/W20), 792-795. ISSN 1682-1750.

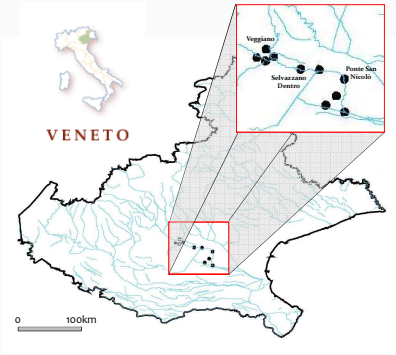

Figure 1. Veneto region: the red box shows the area affected by flood analyzed by RST approach.

2. Study Area: November 2010 Bacchiglione Flood

The flood which hit the Veneto region in early 2010 November was caused by heavy rainfall (500mm in 48 hours) that affected the region since October 30, 2010. The flood affected the area of Padua, where, the 2 November, the Bacchiglione river broke its levees at the landfill in Ponte San Nicolò, inundating also Casalserugo and Bovolenta. About 4,500 people were displaced [2]. The red box in Figure 1 shows the studied area.

[2] http://it.wikipedia.org/wiki/Alluvione_del_Veneto_del_2010

3.1 RST IMPLEMENTATION ON OPTICAL DATA

V=NIR/VIS

$$\otimes_{NIR/VIS}(x,y,t) = \frac{R_{NIR/VIS}(x,y,t) - \mu_{NIR/VIS}(x,y)}{\sigma_{NIR/VIS}(x,y)}$$

AVHRR
VIS (channel 1): 0.58-0.68μm
NIR (channel 2): 0.73-1.00μm

MODIS
VIS (channel 1): 0.62-0.67μm
NIR (channel 2): 0.841-0.876μm

Figure 2 shows the results obtained implementing the RST approach on the AVHRR and MODIS [3, 4] image of 4 November 2010. According to such an approach, high intensity values of the index, reported above, are expected in presence of areas associated to flooded zones. Over the scene, anomalies at different intensity levels, have been detected, in both MODIS and AVHRR images. confirming the presence of flooded areas

Note the large number of anomalous pixels, both on MODIS and AVHRR images, in the zone of Ponte San Nicolò (PSN), where the Bacchiglione flooded the 2 November and the great correspondence between them.

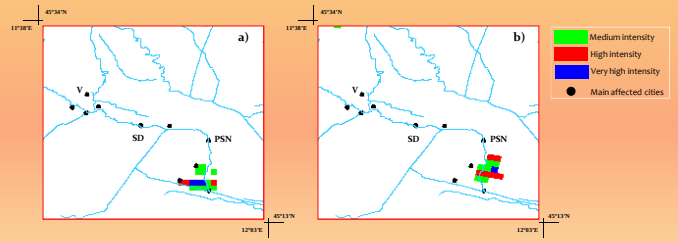

Figure 2. Results obtained for: a) MODIS image at 1Km of 4-11-2010 at 9.40GMT; b) AVHRR image at 1Km of 4-11-2010, at 11.25GMT.

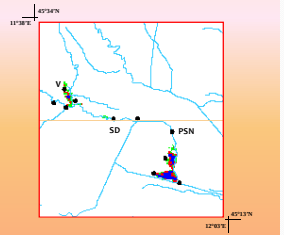

Figure 3. Results obtained for MODIS image at 250m of 4-11-2010 at 9.40GMT.

Moreover, the 250m MODIS image has been used for mapping flooded areas with a greater detail. In fact, note in Figure 3 as also in the areas around Veggiano (V) and Selvazzano Dentro (SD) anomalous pixels have been identified.

[3] Faruolo M., Coviello, I. Lacava, T. Pergola, N., Tramutoli, V., 2009 (in press). "On the potential of multi-temporal MODIS analysis for near real time mapping and monitoring of flooded areas", 33rd International Symposium on Remote Sensing of Environment, Stresa, Lago Maggiore, Northern Italy, 4-8 Maggio 2009.

[4] Faruolo M., Coviello, I. Lacava, T. Pergola, N., Tramutoli, V., 2009,."Real time monitoring of flooded areas by a multi-temporal analysis of optical satellite data", Proceedings of Geoscience and Remote Sensing Symposium, 2009 IEEE International,IGARSS 2009, Volume: 4 Page(s): 192 - 195 Digital Object Identifier: 10.1109/IGARSS.2009.5417339.

3.2RST IMPLEMENTATION ON MICROWAVE DATA

V=SWI

$$SWVI(x,y,t) = \frac{SWI(x,y,t) - \mu_{SWI}(x,y)}{\sigma_{SWI}(x,y)}$$

SWI = T89GHz–T23GHz (T is the brightness temperature acquired by AMSU in the channels 15 and 1 respectively [5, 6].

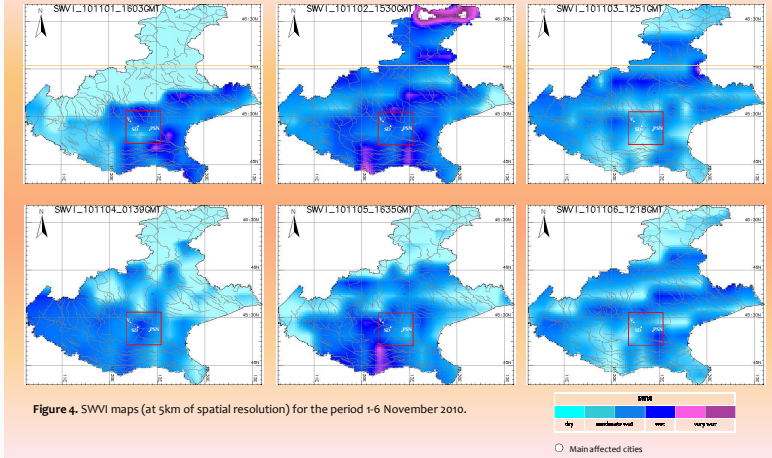

Figure 4. SWVI maps (at 5km of spatial resolution) for the period 1-6 November 2010.

The SWVI index has been used for detecting soil wetness variation over the period 1-6 November 2010 (Figure 4). Higher values of SWVI(x,y,t) are associated to the relative increase of soil wetness at each specific location.

Looking at Figure 4, observe as during all the period soils are wetter than normal due to the intense rains, in particular the 2 November, when rivers flooded. The effect of these rains seem to be quite evident also in the following days, confirming the extreme characteristics of the meteorological episode for that area.

[5] Lacava T., Cuomo V., Di Leo E.V. , Pergola N., Romano F., and Tramutoli V. 2005. "Improving soil wetness variations monitoring from passive microwave satellite data: the case of April 2000 Hungary flood", Remote Sensing of Environment, Vol. 96-2, pp. 135-148, 2005.

[6] Lacava T., Brocca L., Calice G., Melone F., Moramarco T., Pergola N., Tramutoli V., 2010a. "Soil moisture variations monitoring by AMSU-based soil wetness indices: a long-term inter-comparison with ground measurements", Remote Sensing of Environment, 114(10), 10.1016/j.rse.2010.05.008, 2317-2325, 2010b.

4. Conclusion

In this work, a multi-sensor system for flood detection and monitoring, based on the RST (Robust Satellite Techniques) approach, has been implemented on both optical and microwave data. AVHRR and MODIS optical images have been used for detecting the flooded areas with a good spatial resolution, exploiting the behavior of water in VIS-NIR channels. AMSU data, instead, which have the capability of penetrate through clouds, have been used for obtaining real time indication about soil state conditions with a lower spatial resolution. Results obtained are satisfactory and seem to encourage the use of such system for the management of flood risk.