PROPOSAL FOR A MULTIDISCIPLINARY MONITORING NETWORK IN CANSIGLIO PLATEAU (NORTH-EASTERN ITALY)

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Introduction. The study region is located in northeastern Italy, in the seismic area of the karstic Cansiglio Plateau. We propose an interdisciplinary study of karstic aquifers using hydrogeologic data, tiltmeters and GPS observations. During the year 2010 two data acquisition campaigns have been carried out: hydrogeological flow measurements and other physical parameters (level, conductivity and temperature) in two principal springs from 15 August to 8 December 2010 and the installation of a small geodetic network. From May to October 2010 we measured two GPS benchmarks in the neighborhood of the FReDNet permanent station CANV (Zuliani et al. 2003, 2009): one at the Forest Museum "Zanardo" Pian Cansiglio (1040 m.a.s.l.) and one on Mount Pizzoc (1565 m.a.s.l.). Furthermore, two Zöllner type Marussi tiltmeters are installed in a natural cavity at 25 m depth (Bus de la Genziana) and operated continuously since 2005 (Braitenberg et al., 2007). The Cansiglio Plateau is part of an interesting karstic area of particular hydrogeologic importance. The Livenza river originates from a number of springs at the foothills of the karstic massif and flows through the Friuli-Veneto plain into the Adriatic Sea. Comparing the tiltmeter signal with the local pluviometric data and the hydrometric series of the Livenza river, a clear correlation is recognized (Longuevergne, 2009). Moreover, the data of the CANV GPS station, located on the southern slopes of the Cansiglio Massif, show also a clear correspondence with the

water runoff. Here we present the hydrologic induced deformations as observed by tiltmeter and GPS. After heavy rain events we record rapid deformations both by tiltmeters and GPS corresponding to the rainfall duration. In the following days a slow geodetic motion recovers the accumulated deformation with a distinctive pattern both in tilt and GPS data, which correlates with the runoff of the karstic aquifer. In particular the event of the Livenza flood from 31 October to 3 November shows a clear correspondence in the recordings.

Hydrogeological campaign. The Cansiglio karst aquifer is characterized by medium and high development of karst deep, resulting in high permeability and rapid runoff in pipes and fractures, although mitigated by the existence of a basic flow (Grillo, 2007). The underground karst phenomenon is mainly developed in Monte Cavallo limestone with a complex caves 600 and 800 meters deep, conditioned by geological-structural setting. The Cansiglio-Cavallo mountain has three big sources in Caneva e Polcenigo: Molinetto, Santissima, Gorgazzo, from which Livenza River is born. Considering the past studies the aquifer has a high conductivity and high vulnerability (Cucchi et al., 1999). The short hydrogeological campaign regarded only Gorgazzo and Santissima springs and confirms what previous studies had shown: the Gorgazzo is characterized by a dominant drainage network, because it has highly variable conductivity, sudden and abundant rate of flow, that normalizes after a few hours and thus falls within the classic case of upward siphons; the Santissima has constrained conductivity values between 220 and 250 microS/cm and temperature values of 8-9 °C, typical of an interdependent network draining with mixing of waters and a small

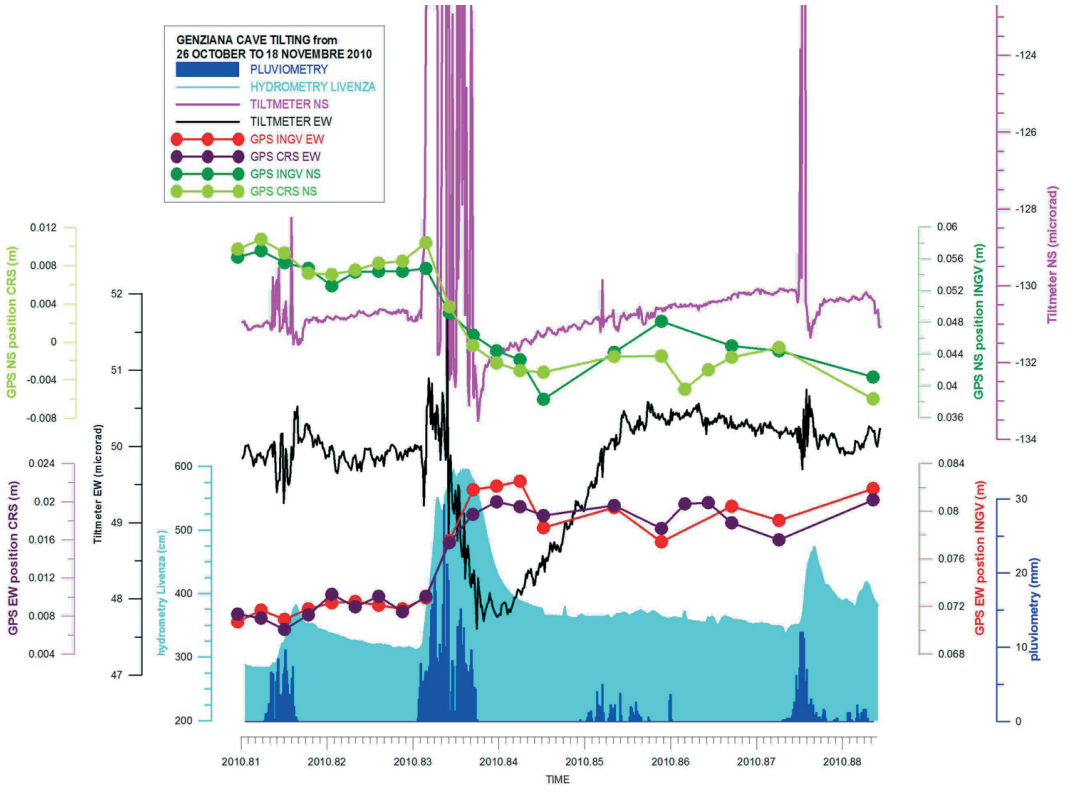

Fig. 1 - Comparison between signal Genziana tiltmeters and GPS station CANV (CRS solution and INGV) of EW and N-S components, Cansiglio rainfall, hydrometric Livenza River to highlight the effects of flooding. The periodic variation of the tiltmeter is due to the Earth tide, which varies in amplitude with a fortnightly cycle. During the hydrological signal tidal deformation is masked. The scale of the tiltmeter NS has been extended in order to better highlight the signal.

piston effect. The system of this spring is different because it has smaller water level fluctuations with longer times of normalization. This, in terms of chemical and physical properties, is in support of a water reservoir of significant extensions made with a composite grid of drainage (A.R.P.A.F.V.G., 2006).

Geodetic campaign. The geodetic GPS campaign, lasted six months, show the time series of the three GPS stations placed on the Cansiglio Plateau. Unfortunately there were no major rainfall events during this time period. The few rainfall events were however detected by the tiltmeters, thanks to their high accuracy and their sampling rate. The tiltmeters react to the rainfall with an impulsive response that becomes well defined with rains exceeding 10-15 mm per hour. Usually the NS component variation is one order of magnitude larger than the EW component and at the same time the Earth tide deformation is completely masked by the rainfall response. The hydrologic induced deformations were particularly evident during the flood of the Livenza River between October 31 and November 3, 2010; unfortunately the GPS campaign was concluded at that time (Fig. 1). In those days a total amount of 520 mm of water fell with a peak 35 mm per hour. Both geodetic GPS stations and the tiltmeters recorded the hydraulic load instantly, whose signal is carried out in the underground water runoff during the flood. The flood resulted in a GPS maximum displacement of 1 cm to the east and 1.5 cm to the north. The tiltmeters show a 1 microrad variation towards east and then a continuous westward drift of about 3 microrad during the rainy days, recovering the initial easterly position in the following week. The NS component provided initial complex variations during the rainy period drifting slowly to the south, recovering the initial position in the following week. On the vertical component the GPS shows a shift of more than 1 cm.

Discussion. Considering that the southern Alpine front accommodates a compression of a few millimeters per year and that the area is known to be in Zone 2 at medium to high seismic risk, we are asking how and if these sudden shifts due to hydraulic load may influence the geophysical and geodynamic context of the Cansiglio area. The analysis of time series of the permanent GPS at Caneva suggests an elastic response of a hydro-structure with a drainage system directed along NW-SE, parallel to the direction of the complex headwater of Polcenigo-Caneva. Whereas the tiltmeter data, sampled more frequently, indicate not only a slow drift towards SE, but describe also the impulsive loading and unloading phases.

We can approximate the behavior of the Cansiglio massiv as a network of drainage channels with dominant preferential directions, flowing in the karst vadose reticulum with different trigger times depending on the amount and duration of rainfall. The long term deformation pattern revealed by geodetic instruments probably reflects the discharge of the karst aquifer, a first impulsive reaction due to rapid and turbulent flow in the conduit network and followed by a slow discharge in the porous matrix (pores and fissures).

Conclusion. The purpose of this research is to open a new multidisciplinary frontier between geodetic and karstic system studies to improve the knowledge of the underground fluid flow circulation in karstic areas. Furthermore a better characterization of the hydrologic effects on GPS and tilt observations will have the benefit that these signals can be correctly treated when the focus of the study is to recover the tectonic deformation. The future prospects are to reposition the GPS on the benchmarks for a longer period and to expand the GPS monitoring network making the comparison between GPS and tiltmeters more fruitful.

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