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FROM PRE-EARTQUAKES TO EQUOS: HOW TO EXPLOIT MULTI-PARAMETRIC OBSERVATIONS WITHIN A NOVEL SYSTEM FOR TIME-DEPENDENT ASSESSMENT OF SEISMIC HAZARD (T-DASH) IN A PRE-OPERATIONAL CIVIL PROTECTION CONTEXT.

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The integration of different observations together with the refinement of data analysis methods is generally expected to improve our actual knowledge of preparatory phases of earthquakes and of their possible precursors. These were also the main goals of PRE-EARTHQUAKES (Processing Russian and European EARTH observations for earthQUAKE precursors Studies, http://www.pre-earthquakes.org/) the first project funded by the European Union in order to investigate possible short-

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term precursors of earthquakes. In the learning phase, different parameters (e.g. thermal anomalies, total electron content, radon concentration, etc.), measured from ground and satellite systems and analyzed by using different data analysis approaches (Table 1), have been studied for selected geographic areas and specific seismic events in the past.

Table 1: PRE-EARTHQUAKES observational capabilities

	Parameters	Instruments	Source	Methodology - Partner	Products
Ionosphere	TEC (Total electron content)	DEMETER	CNRS	LPCEE algorithm (Parrot et al. 2006) LPCEE-CNRS	Maps of space plasma and ionospheric anomalies (TEC)
		Meteor-M/GGAK	ROSKOSMOS	Correlation Algorithm (Pulinets et al. 2004, 2007) FIAG	
		GPS	IGS ESA RSS	Differential algorithm (Pulinets et al., 2007) WD IZMIRAN	
			IGS EUREF	Algorithm for GPS TEC (Jakowski et al., 1998) DLR	
			IGS EUREF RSS	Algorithm for vertical TEC reconstructions, Algorithm of TEC maps creation; Algorithm of differential mapping. (Baran et al., 1997); Algorithm of GEC calculation. (Afraimovich et al., 2006). Algorithm of wave-like disturbances calculations (Krankowski et al., 2005). Numerical modeling WD IZMIRAN	
		GLONASS	ROSKOSMOS		
		GALILEO and EGNOS	ESA		
		FORMOSAT-3/COSMIC	UCAR	Algorithm of COSMIC profiles analysis – WD IZMIRAN	Vertical profile of the ionospheric electron density
		CHAMP	GFZ Potsdam	Radio Occultation technique (Jakowski et al., 2002, 2005) - DLR	
		GRACE	NASA - GFZ Potsdam		
		COSMOS /2407/2414/2429 /2454	ROSKOSMOS	Ionosphere electron concentration vertical distribution reconstruction technology (Romanov, et al., 2009) – RSS	
Near surface low atmosphere	Longwave Earth Radiation	AQUA/AIRS	NASA	University of Chapmann (Ouzounov et al. 2007)	OLR anomalies map
	Solar reflected, Earth's thermally emitted, radiation	METEOR-M/MSU-MR	ROSKOSMOS	Cloud detection algorithms. Visual inspection - RSS	Identified anomalous cloud shapes
	MW thermally emitted, radiation	METEOR-M/MTVZA	ROSKOSMOS	Standard inversion procedures RSS	Temperature and humidity profiles
	Earth's thermally emitted radiation	MSG/SEVIRI	ESA	RST Technique (Tramutoli et al., 2005) UNIBAS	Maps of TIR anomalies by RETIRA index
		EOS/MODIS	NASA		
		MTSAT	JMA		
		NOAA/AVHRR	NOAA NESDIS		
	VIS-NIR Spectral signatures in reflectance	RESOURS-DK/GEOTON-1	ROSKOSMOS	Visual interpretation, supervised and unsupervised classification – UNIBAS	Land cover maps
	Air Temperature	NCEP Stations	NOAA NESDIS	Chapman University Approach	Air Temperature time-series
	VLF/LF Radio Frequency	VLF/LF radio stations	World VLF/LF Stations	Institute of Physics of the Earth Russia (Rozhnoi, et al., 2004, 2006, 2009)	VLF/LF radio signal anomalies
Lithosphere	Concentration of Ground radon	RADON STATIONS	TUBITAK MAM-EMSI NETWORK	Time series data analysis (İnan et al., 2007) TUBITAK MAM	Punctual anomalies of radon concentration
	Magnetic and electric fields, electrical resistivity	Permanent station	UNIBAS IMAA-CNR	Time series data analysis (Balasco et al., 2008) IMAA-CNR	Electrical resistivity profiles 0-10km
	Seismicity	Seismometric Networks	World Seismological Stations	FORMA algorithm (Papadopulos et al., 2010) National Observatory of Athens	Gutenberg-Richter b-value anomalies

European Russian Other countries

Since July 2012 the PRIME (Pre-earthquakes Real-time Integration and Monitoring Experiment) started attempting to perform, on the base of independent observations collected and integrated in real-time through the PEG (Pre-earthquakes Geo-portal), a time-Dependent Assessment of Seismic Hazard (t-DASH) on selected geographic areas of Europe (Italy-Greece-Turkey) and Asia (Kamchatka, Sakhalin, Japan). In this paper, results so far achieved as well as the potential and opportunities they open for a worldwide Earthquake Observation System (EQuOS) - as a dedicated component of GEOSS (Global Earth Observation System of Systems) - will be presented.

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