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Space weather effects related to pre-storm turbulence-borne structures in the solar wind

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Prediction of geomagnetic storms represents one of the key tasks of solar-terrestrial physics. Recent studies show that knowing the pre-history of geomagnetic storms may improve the rate of geomagnetic storm predictions considerably (*). Turbulence-borne structures, namely magnetic islands, waves and current sheets produced by geoeffective streams in the solar wind approaching to the Earth may represent a precursor of geomagnetic storms. Corresponding density/IMF variations (DIVs) in the ULF range are found to be a very important parameter reflecting a current state of pre-storm disturbances in the solar wind plasma. ULF solar wind pressure variations are known for their “instantaneous” geoeffectiveness, but we show that pre-storm ULF DIVs can be used as predictors of geomagnetic storms. DIVs are mostly related to the occurrence of small-scale magnetic islands (SMIs) in large-scale magnetic cavities formed by strong current sheets of various origins (Khabarova et al., ApJ, 2015,2016; Khabarova & Zank, ApJ, 2017). Magnetic cavities can be created by the heliospheric current sheet from one side and an ICME or a CIR from the other. For an observer at the Earth’s position, characteristic ULF DIVs occur before the onset of a geomagnetic storm produced by a geoeffective ICME or CIR. Furthermore, SMI contraction or merging can produce energetic particle flux enhancements up to 1 MeV, according to observations and the theory developed by Zank et al. ApJ, 2014,2015. Such Atypical Energetic Particle Events (AEPEs) often precede geomagnetic storms and may be as dangerous as well-known SEP events.
We find that DIVs represent the most appropriate input parameter for the mid-term forecast of geomagnetic storms in agreement with (Khabarova, SunGeo,2007; Khabarova & Yermolaev, JASTP,2008). We build a mid-term prognosis of geomagnetic storm, showing that if the rate of a smooth density growth as well as the power of density and IMF variations exceed certain thresholds, a geomagnetic storm is highly probable to occur in the next few days.

* T.G. Kogai, O.V. Khabarova, O.V. Mingalev, Pre-storm ULF variations in the solar wind density and interplanetary magnetic field as key parameters to build a mid-term prognosis of geomagnetic storms. https://www.researchgate.net/publication/327781146_Pre-storm_ULF_variations_in_the_solar_wind_density_and_interplanetary_magnetic_field_as_key_parameters_to_build_a_mid-term_prognosis_of_geomagnetic_storms .