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Development of a local nowcast magnetospheric ring current index based on geomagnetic observatory data: activity within the ESA's SSA SWE G-ESC

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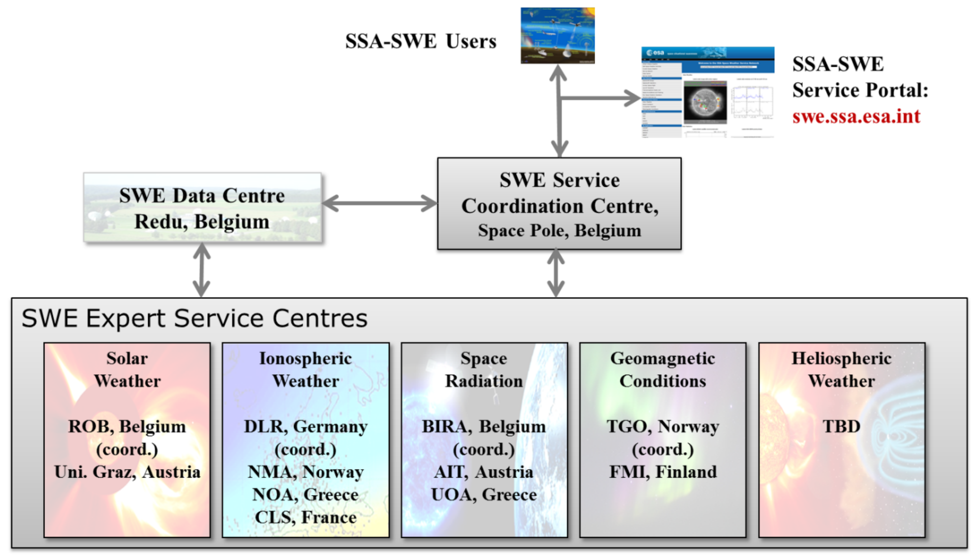
Introduction

Contribution of GFZ-Potsdam to ESA's SSA SWE G-ESC Network

is a project funded by the European Space Agency's (ESA) Space Situational Awareness (SSA) Space Weather (SWE) programme from 2019 to 2020. ESA's SSA SWE segment (http://swe.ssa.esa.int/ssa-space-weather-activities) includes the Space Weather Coordination Centre (SSCC) and five Expert Service Centres (ESC). SSA SWE data and products are provided through the ESC network where each ESC consist of Expert Groups (EG) that contribute particular data, products and/or expertise.



A local nowcast Dst index will be integrated as a new product into Geomagnetic Conditions ESC (G-ESC) after successful scientific validation. GFZ already contributes to G-ESC with two sets of products, termed as GFZ and SUA (Swarm Utilisation Analysis).

GFZ set includes nowcast Kp index (G.107), most recent definitive Kp index (G.108), Kp and Ap index on tabular form (G.109), Kp and Ap index archive (G.110).

SUA set includes products based on Swarm mission data, Swarm Polar Electrojet (G.123), Swarm Field-Aligned Current (G.124), Swarm Vector Magnetic Field (G.125).

Development of a local nowcast Dst index

The Disturbance storm time (Dst) index is defined as the average perturbation of the H-component on magnetometers from four observatories that are located at distance to the equatorial and auroral electrojets and near the Sq (Solar quiet) variation focus. These magnetic observatories are Hermanus (HER, South Africa), Kakioka (KAK, Japan), Honolulu (HON, Hawaii, USA), and San Juan (SJG, Puerto Rico). The Dst index is a quantitative measure of geomagnetic activity (major disturbances are negative) that monitors the intensity of the magnetospheric ring current and it is derived and maintained by the World Data Center (WDC) for Geomagnetism Kyoto, Japan. The local nowcast Dst index presented here is defined for the magnetic observatory **Tristan da Cunha (TDC), South Atlantic**. This local index is intended to be derived also for the following low- and mid-latitude observatories: St. Helena (SHE, South Atlantic), Keetmanshoop (KMH, Namibia), Vassouras (VSS, Brazilian), Gan (GAN, Maldives), and Panagjurishte (PAG, Bulgaria).

The local Dst index is derived for the single magnetic observatory as follows. First, the baseline (quiet curve) is defined for the H-component of the magnetic field. The baseline is calculated using the given numbers of quiet days over the defined time interval. Second, ΔH is calculated for each day by subtracting the baseline. Third, the Solar quiet (Sq) variations are determined for each month using the ΔH values from the quiet days.

Finally, the local Dst index is calculated by subtracting the Sq monthly values from daily ΔH values for the corresponding month. Definitions and more details about each step and some **preliminary results of the local Dst index based on the TDC magnetic observatory for years 2009-2016 are presented below**.

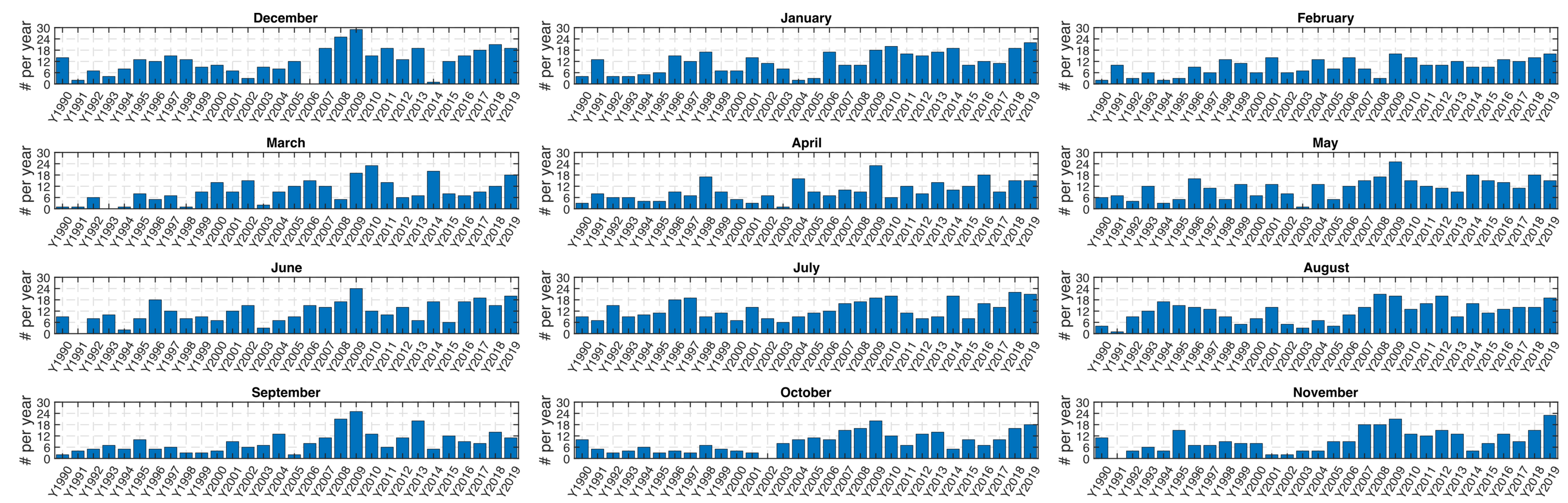
Preliminary Results

H-component baseline derivation

The baseline, H_{bl}, is calculated for each day using the number of quiet days in the past 180 days where linear regression and interpolation is used to get the baseline value for the given day. This number of quiet days should be at least 30. The Dst and Kp indices are used to define the quietest days in the previous 180 days as follows:

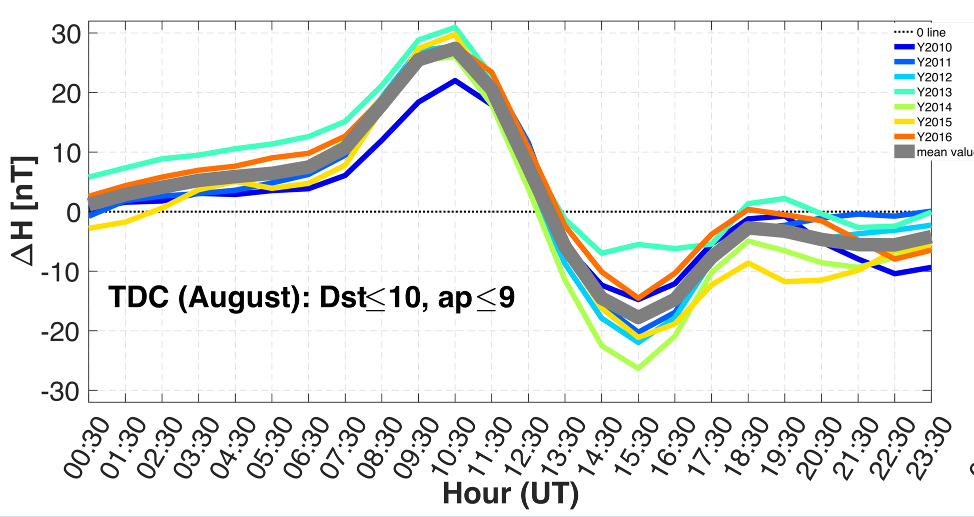
$$|Dst| \leq 10 \quad \text{and} \quad \mathrm{Kp} \leq 2+ \,(ap \leq 9).$$

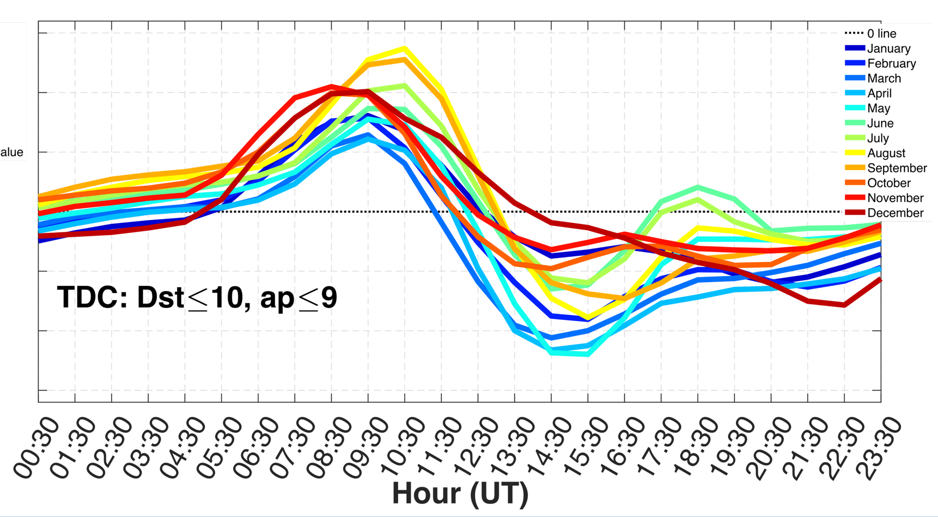
These conditions must be satisfied during local night between 0 and 3 hr. The figure below shows this number for each months as a function of year from 1990 to 2019. This shows that quietest day condition can be satisfied for all days in the 1180 day interval.



Sq variation derivation

Sq variation is determined for each month using the quietest days for the given month according to $|Dst| \leq 10$ and $ap \leq 9$ (see figure above). The hourly means of $\Delta H = H - H_{bl}$ values are used to calculate Sq for each year and then the mean value for all years is determined (see left figure below). The dotted black curve shows a zero value line. The right figure below shows these mean Sq curves for each month (corresponds the grey curve example for August).



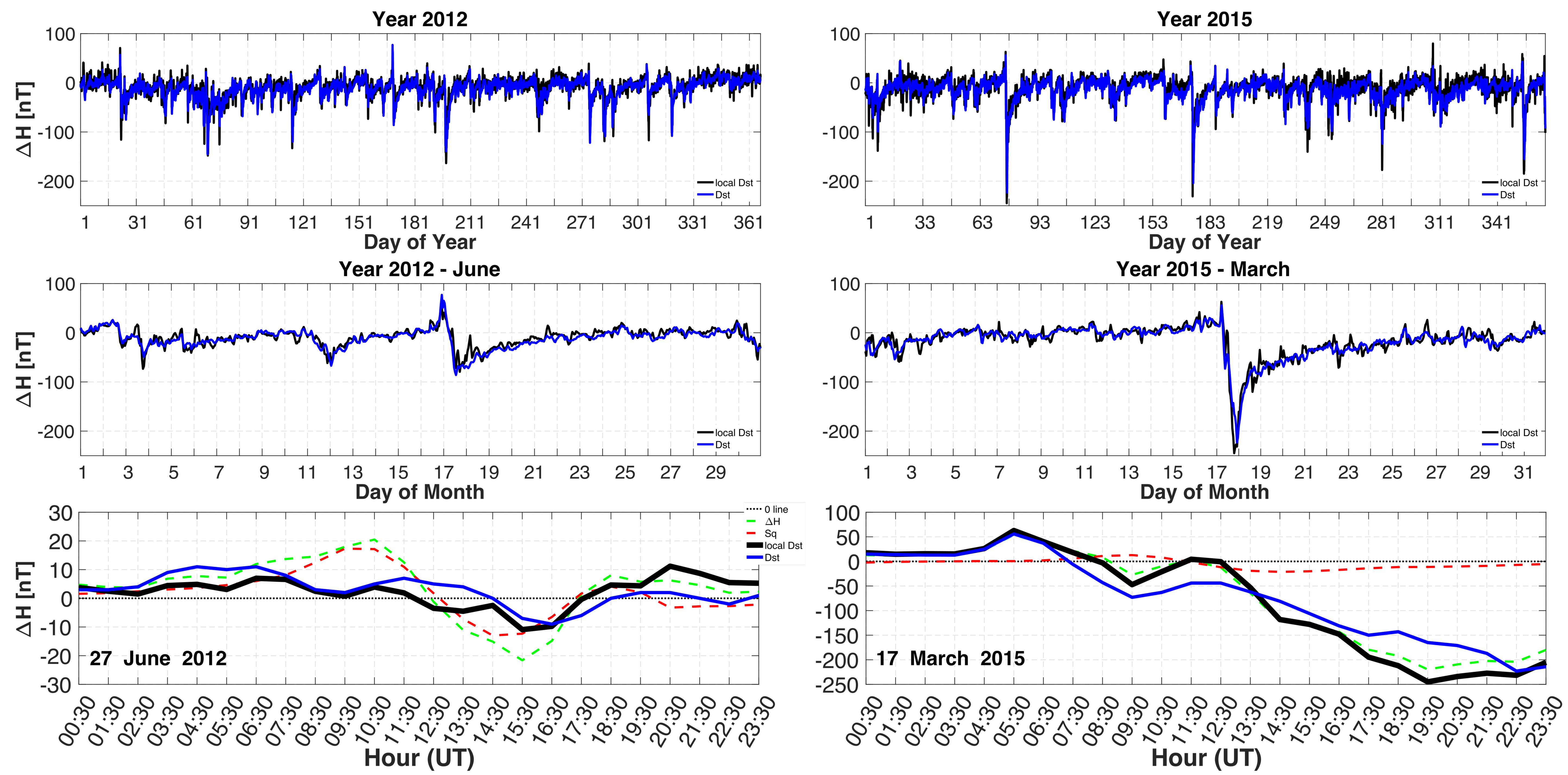


Local nowcast Dst index

The local Dst index is calculated by subtracting the Sq monthly values from daily ΔH $(H - H_{bl})$ values for the corresponding month

$$local\ Dst = (\Delta H - Sq)/\cos(mlat).$$

where $mlat$ is a magnetic latitude. Figures below show local Dst examples for years 2012 (left) and 2015 (right). The corresponding month and day examples for each year are also shown for relatively quiet and disturbed conditions. Also, the Dst index is plotted (blue curve) for comparison. Overall, both indices agree quiet good for the quiet and disturbed conditions.



On-going activity

All conclusion and result presented here are preliminary. Validation work is in progress.