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Uneven weighting of stations in the Dst index

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ABSTRACT

We note in this paper that the average disturbances of the four *Dst* stations are systematically different and, therefore, the stations contribute to the *Dst* index by unequal weights. This is an important problem, e.g., for the estimated longitudinal asymmetries of the ring current and the long-term averages of the *Dst* index where the contribution of the most dominant station (HON) is twice as large as the weakest station (KAK). We use an extended network of stations to demonstrate that the averaged local *Dst* indices are ordered according to the station's geographic longitude, with westernmost stations depicting the largest disturbances and contributions to the *Dst* index and easternmost the smallest. We show that the problem is related to the way that the quiet days are treated in the *Dst* recipe. We modify the recipe so that UT-fixed quiet days are used in all stations, whence the corrected local *Dcx* indices have equal weights at all stations. This gives strong support for using the corrected *Dcx* index instead of the *Dst* index.

1. Introduction

Several magnetic indices have been developed that describe some aspects of the near-Earth space currents, and allow to study the impact of solar wind upon the Earth's space environment over long time intervals. The *Dst* index is one of the most important solar-terrestrial indices, which aims to describe the temporal development of magnetic storms and the intensity of the ring current, although other current systems also have, at least occasionally, a significant contribution to the *Dst* index (see, e.g., Burton et al., 1975; Campbell, 1996, 2004). During magnetic storms the *Dst* index depicts a large negative deflection, reflecting the westward drift of the energetic, positively charged ions produced during the storm and carrying a westward directed electric current. The *Dst* index is being calculated at the World Data Center WDC-C2 at Kyoto, Japan, since the International Geophysical Year, 1957, using data from four observatories at low to mid-latitudes (Hermanus, HER; Honolulu, HON; Kakioka, KAK; San Juan, SJG; for coordinates of these and other stations used here, see Table 1).

Although *Dst* index proxies based on other principles have also been developed recently (see, e.g., Love and Gannon, 2009; Xu et al., 2008), we (Karinen and Mursula, 2005) have recalculated the *Dst* index following the original *Dst* derivation method (see, e.g., Sugiura, 1969; Sugiura and Kamei, 1991; WDC-C2, 2004) as closely as possible and using the original data from the above mentioned four magnetic stations. This extended and reconstructed *Dst* index is called the *Dxt* index, and has a correlation coefficient of 0.987 with the hourly values of the *Dst* index during the overlapping time interval of about 50 years. As noted earlier (Karinen and Mursula, 2005), the *Dxt* index corrects some errors in the original *Dst* index and extends the time span of the *Dst* index by more than 25 years to start in 1932.

The *Dst* index is known to include an excessively large seasonal variation which is unrelated to magnetic storms (Cliver et al., 2001) and therefore artificial. This "non-storm component" arises from the seasonal quiet-time variation of the magnetic field which is erroneously eliminated from the quiet day curve and, therefore, remains in the *Dst* index (and in the *Dxt* index). A modest revision in the treatment of the quiet day curve removes this excessive component (Mursula and Karinen, 2005; Karinen and Mursula, 2006). We call the *Dst*/*Dxt* index without the excessive seasonal variation the *Dcx* index (*c* for corrected; *x* for extended). In effect, the absolute level of the *Dcx* index is raised by a factor which depends on the season, with largest corrections taking place around the equinoxes. However, since the typical time duration of a storm is rather short, the temporal evolution of all the three indices remains quite similar during any individual storm, only the overall levels are different and seasonally varying.

Here we report of another problem in the *Dst* index: The average disturbances of the four *Dst* stations are systematically different. Accordingly, the stations contribute to the *Dst* index by unequal weights. The paper is organized as follows. In Section 2 we present the problem and the level of the difference between the stations and discuss its consequences. Then, in Section 3, using an extended network of stations, we demonstrate convincingly that the disturbances are ordered according to the station's geographic longitude, with westernmost stations

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Table 1
Names, codes and coordinates of stations of the extended network.

Station	Geographic		Geomagnetic	
(IAGA code)	Lat.	Long.	Lat.	Long.
Alma Ata (AAA)	43.25°N	76.92°E	34.29°	152.74°
L'Aquila (AQU)	42.38°N	13.32°E	42.42°	94.50°
Canberra (CNB)	35.32°S	149.4°E	−42.71°	226.94°
Crozet (CZT)	46.43°S	51.86°E	−51.35°	113.27°
Del Rio (DLR)	29.49°N	100.9°W	38.30°	327.31°
Eyerewell (EYR)	43.41°S	172.4°E	−47.11°	253.83°
Gnangara (GNA)	31.78°S	116.0°E	−41.93°	188.84°
Guimar (GUI)	28.32°N	16.44°W	33.78°	60.59°
Hartebeesthoek (HBK)	25.88°S	27.71°E	−27.13°	94.40°
Hermanus (HER)	34.43°S	19.23°E	−33.98°	84.02°
Honolulu (HON)	21.32°N	158.0°W	21.64°	269.74°
Kakioka (KAK)	36.23°N	140.2°E	27.37°	208.75°
Lanzhou (LZH)	36.09°N	103.8°E	25.86°	176.1°
San Juan (SJG)	18.11°N	66.15°W	28.31°	6.08°
Trelew (TRW)	43.25°S	65.32°W	−33.05°	5.62°
Tucson (TUC)	32.17°N	110.7°W	39.88°	316.11°
Vassouras (VSS)	22.40°S	43.65°W	−13.29	26.61°

depicting the largest disturbances and contributions to the *Dst* index, and easternmost the smallest. In Section 4 we discuss how the geographic dependence is related to how the quiet days are treated in the original *Dst* recipe. We correct the *Dst* recipe for this error in Section 5 and show that the seasonally corrected *Dcx* index depicts equal weighting from all stations. In Section 6 we demonstrate how, using UT fixed quiet days, the local *Dcx* indices, but not the local *Dst* indices, of the four stations are practically zero during quiet days. Accordingly, as the final conclusion we note that the original *Dst* index cannot be corrected for this problem, which gives strong support for using the corrected *Dcx* index instead of the *Dst* index.

2. Unequal weighting of Dst stations

The global *Dst* index is an hourly measure of magnetic storminess which is calculated as an average of the local disturbances, or local *Dst* indices, observed in the magnetic H-component of the four *Dst* stations. The derivation of the local *Dst* indices contains two basic steps, the removal of the secular variation and the removal of the quiet day variation, both of which are calculated using the five quietest days of each month. The local disturbances must also be normalized by the cosine of the geomagnetic latitude of the station in order to correct for the latitude dependent projection of the equatorial disturbance to the local horizontal component of the geomagnetic field. We have recently reanalyzed this question in detail and shown that magnetic variability at the four *Dst* stations indeed becomes equal by cosine normalization (Mursula et al., 2008). However, although the need for this normalization is known since long and is even part of the original recipe, no such correction is made at WDC-C2. On the other hand, the *Dxt* and *Dcx* indices do take this latitude correction into account. (The centennial change of the geomagnetic latitude is taken into account according to the varying IGRF models in our 75-year long index series).

Fig. 1 depicts the yearly averaged *Dxt* and *Dcx* indices for the four *Dst* stations. The upper row shows the actual, latitude normalized indices and the lower row shows the corresponding disturbances that have not been normalized by the cosine of station's geomagnetic latitude. One can see in Fig. 1a that the *Dxt* (i.e., *Dst*) indices of the four stations are at completely different levels, HON showing systematically the largest disturbances (lowest index values) and KAK the smallest. If one takes every year the difference between the highest and lowest value, the average difference in 1932–2007 is about 14.8 nT. The mean difference between KAK and HON is 14.2 nT, which shows the systematic ordering of the station disturbances. HER is slightly below KAK, with an average difference of about 2.4 nT, and SJG about 7.8 nT below HER.

Accordingly, Fig. 1a shows that HON registers, on an average, roughly twice larger annually averaged disturbances than KAK, and thereby contributes roughly twice more strongly to the global *Dst* index at time scales longer than a couple of weeks. Obviously, this immediately imposes a problem, since a situation where one station measures the ring current to be, on an average, much stronger than another station in physically untenable. As we will show later, this problem is related to the treatment of the quiet daily variation, and can easily be solved by slightly modifying the *Dst* recipe on this part.

We would like to emphasize that both the *Dst*, *SymH* and *AsyH* indices suffer from this problem. In particular, this problem affects various estimates of the longitudinal asymmetry of the ring current like the *AsyH* index, and studies aiming to estimate (Søraas et al., 2004; Maltsev and Ostapenko, 2004; Shi et al., 2005; Kalegaev et al., 2008) or model the ring current asymmetry (Jordanova et al., 2009). Also, any results based on the long-term evolution of the *Dst* index, like those aiming to extract the long-term evolution of the heliospheric magnetic field from the *Dst* index (Svalgaard and Cliver, 2005) are affected. Although the average difference between the stations is not very large compared to typical disturbances during an intense storm, it is large enough to affect the longer and less intense storms due to high-speed streams, leading to long intervals of moderate activity called HILDCAA (high intensity long duration continuous AE activity; Tsurutani and Gonzalez, 1987; Tsurutani et al., 2006).

Comparing Figs. 1a and b shows that this problem has nothing to do with the latitudinal normalization of indices. In fact, the above mentioned systematic ordering of station averages remains the same and the mean differences between the four stations using unnormalized indices are only slightly smaller than for normalized indices. E.g., the mean maximum–minimum station difference in Fig. 1b is 14.1 nT, and the KAK–HON (HER–SJG; KAK–HER) difference is 13.6 nT (7.2 nT; 1.4 nT, respectively). (Actually, the ratio between the largest unnormalized and normalized differences roughly corresponds to the cosine of a typical station latitude.)

Fig. 1 also shows that this problem is less severe in the *Dcx* index. E.g., in the normalized local *Dcx* indices depicted in Fig. 1c, the average difference between the highest and lowest value is about 5.0 nT, and between KAK–HON (HER–SJG; KAK–HER) about 4.9 nT (2.2 nT; 1.4 nT, respectively). As mentioned above, the seasonal correction adopted in the *Dcx* index raises the absolute level of this index somewhat higher than in the *Dst* index. This correction is seen to most effectively raise the level of the most disturbed stations (HON and SJG), thereby also considerably decreasing the inter-station differences. However, since the absolute level of the global *Dcx* is at about −10 to −15 nT only, the relative contributions of the four stations still differ by some 30–40%. Thus, it is important to try to correct this problem even in the *Dcx* index. (As we will see later, the correction of seasonal variation adopted in the *Dcx* index and the solution of the present problem are connected.) Fig. 1d shows that, as for the *Dxt* index, latitudinal cosine normalization does not much help in alleviating the problem of inter-station differences.

Fig. 2 shows the UT distribution histograms of local *Dcx* indices smaller than −50 nT observed at HON and KAK stations in 1932–2008. The distributions in both cases reproduce the well known fact that the largest disturbances are found in the local

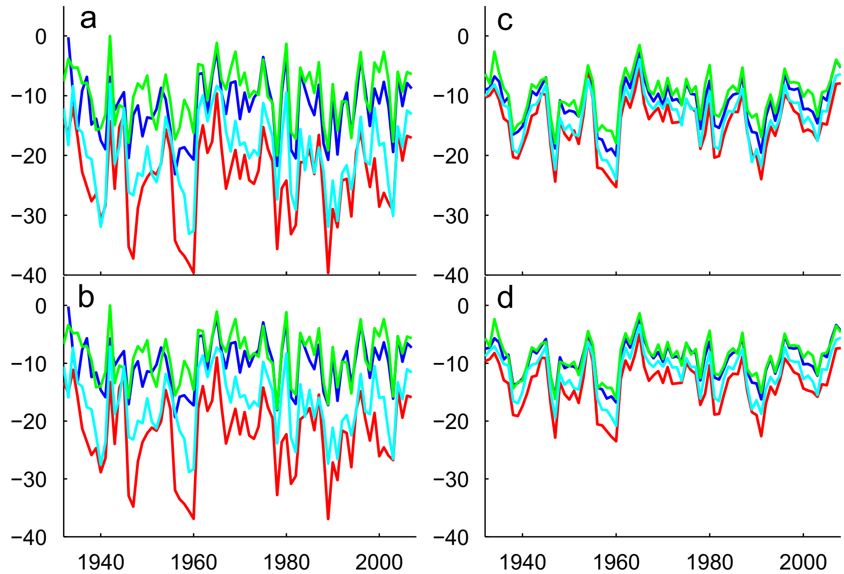

Fig. 1. Yearly averages of Dxt (left panels) and Dcx indices (right panels) normalized (upper row) and unnormalized (lower row) by the cosine of station's geomagnetic latitude. Stations are color coded in color figure (green: KAK; dark blue: HER; light blue: SJG; red: HON) and b&w intensity and line coded in b&w figures (black solid: KAK; gray solid: HER; gray dashed: SJG; black dashed: HON).

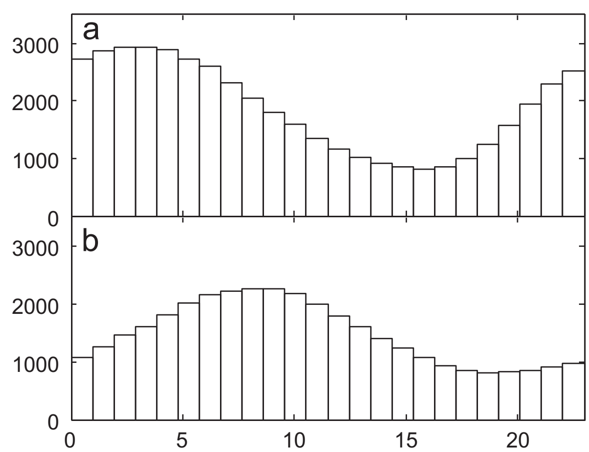

Fig. 2. UT distribution histograms of local *Dcx* indices below −50 nT observed at (a) HON and (b) KAK. Maxima are found in the local late afternoon to evening sector. HON is 11 h behind UT, KAK 9 h ahead of it.

evening sector (Cummings, 1966), corresponding to the evening LT maximum of the asymmetric ring current. However, the overall number in the two distributions are different: There are 44 990 hourly HON *Dcx* indices below −50 nT but only 35 531 such values observed at KAK. Accordingly, there are some 27% more of storm-time hourly values in HON than in KAK. This shows that the above discussed differences in the absolute levels of the four stations are large enough to even affect the occurrence of fairly large local *Dcx* disturbances typical of moderately intense storms. (Note that the maximum of HON distribution is at 15–16 LT, so slightly earlier than at KAK or normally recorded, which suggests that the additional low *Dcx* values at HON are indeed not related to the ring current.)

3. Enhanced station network: longitudinal ordering of disturbances

In order to find out the cause of the different absolute levels of the *Dcx* stations, we have enhanced the station network to 17 low to mid-latitude stations, nine of which are in the northern hemisphere and eight in the southern (see Table 1 for station coordinates). We have calculated the *Dcx* indices for all these stations from the year 2000 to 2007. Fig. 3a shows the location of all these stations on the map by circles. The circle color (in web color figures) or b&w intensity (in print b&w figures) indicates the overall average value of the local *Dcx* index.

Fig. 3a shows that the average values of the local *Dcx* indices vary from about −14 nT at the westernmost station (HON) to −9 nT at the easternmost stations (CNB and EYR). This difference (and related absolute levels) is nearly the same as the difference found between the average levels of the *Dcx* indices of the four *Dst* stations over a longer time interval depicted in Fig. 1c. Most interestingly, even using this greatly enhanced set of stations, the local *Dcx* indices seem to be clearly ordered with longitude.

We have studied the longitudinal ordering of the local *Dcx* indices in more detail in Fig. 3a, which depicts the yearly averages of the local *Dcx* indices at the 17 stations in 2000–2007. Fig. 3a shows a very similar time evolution of disturbances at each station during the declining phase of solar cycle 23. Activity increases slightly during the first years, reaching the maximum disturbance level in each station in 2003, followed by a rapid decline thereafter. Note that we have color coded the time series of each station by the station's longitudinal location. So, Fig. 4a shows clearly that the westernmost stations (blue lines in color figure, dark gray in b&w figure) have systematically every year the lowest *Dcx* values (largest disturbances) and the easternmost stations (red color, light b&w intensity) the highest values (smallest disturbances). The difference between the yearly highest and lowest index varies between 4.1 nT in 2003 and 7.6 nT in 2000.

4. Solution: quiet days in UT

The longitudinal ordering of disturbances depicted in Fig. 3a and 4a strongly suggests that the problem of unequal absolute levels is related to a rather abrupt boundary at the longitude of ±180°. Of course the only natural (or, actually, man-made) boundary in this location is the international date boundary. In fact, this was the key observation in solving the problem. When

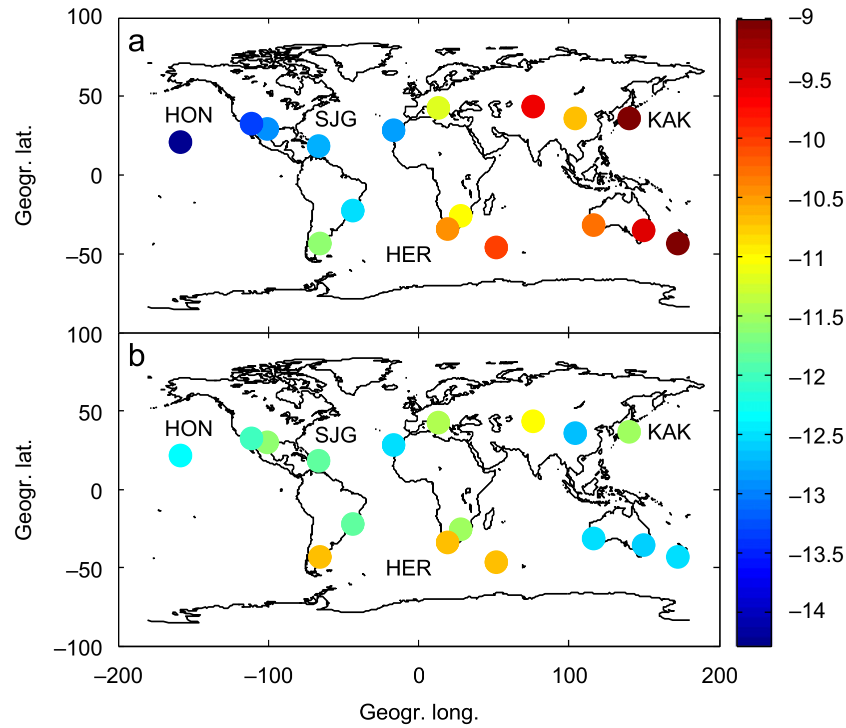

Fig. 3. (a) Locations of the 17 *Dcx* stations of Table 1 indicated on map by colored (in color figure) or gray circles (in b&w figure) with color or b&w intensity denoting the average local *Dcx* index in 2000– 2007. The four *Dst* stations are denoted by code. (b) The same with index values corrected by using UT-fixed quiet days. The same color/b&w intensity code applies to both (a) and (b) figures.

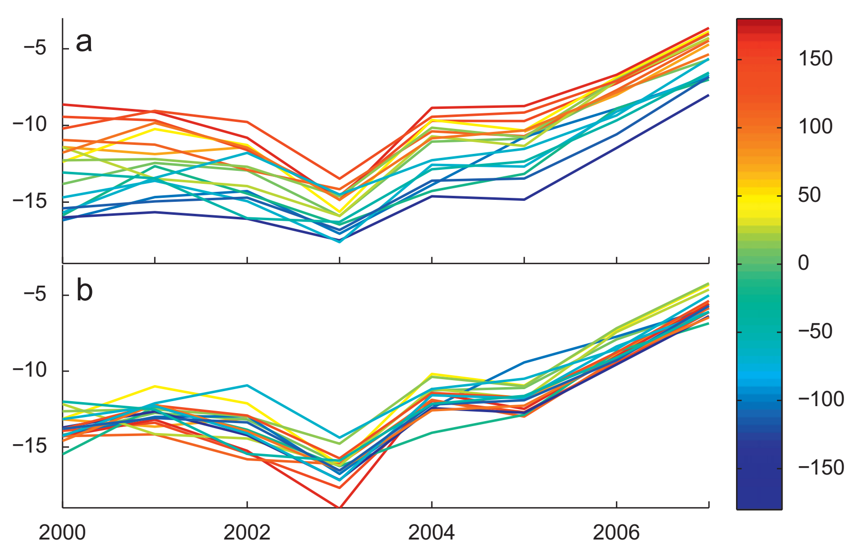

Fig. 4. (a) Yearly averages of local *Dcx* indices at the 17 stations in 2000–2007. Line color (in color figure) or line intensity (in b&w figure) indicates the station's geographic longitude from -180° to $+180^\circ$ (longitude in degrees in color/gray intensity bar). (b) The same with index values corrected by using UT-fixed quiet days. The same color/b&w intensity code applies to both (a) and (b) figures.

studying the *Dst* recipe in detail, there is a very understandable reason for these problems.

As mentioned above, the quiet day variation must be removed from observations in order to find the disturbances. The quiet day variation, also called the *Sq* curve, is calculated at each station as an average daily curve from five internationally selected quietest days of every month. Thereafter, a linear trend $L(t)=a\times t+b$ from one day to another is calculated using local midnight values, and then removed from the superposed quiet day curve. This removal is done in order to reduce the day-to-day change in case the quiet day occurs during the storm recovery phase when the baseline is changing rapidly.

However, the station's longitudinal location makes a difference in this removal. If the station is located west (east) of the Greenwich central meridian, the midnight hours will be later (earlier) than the UT night hours. Due to the quiet days located in the recovery phase of a storm (there are none in the main phase), there is a small but systematic trend for the *Sq* baseline to increase with time. Thus, subtracting a slightly higher (less negative) *Sq* curve from the western (later) stations will remain their disturbances on a somewhat lower (more disturbed) absolute level than at the eastern stations, leading to larger local *Dcx* indices in the west than in the east.

The obvious solution of the problem is then to modify the *Sq* treatment so that in all stations we use the same UT (midnight) hours to remove the trend from one day to another. According to this modified recipe (to be called the UT quiet day, or UT QD method) the *Sq* curves of stations at different longitudes will have different levels but all the local *Dcx* indices will have the same absolute levels, irrespective of the longitude. Fig. 3b shows the average values of the 17 local *Dcx* indices calculated according to the modified UT QD recipe. One can see that the differences between the indices are much smaller there than in Fig. 3a and, most importantly, that there is no longer any ordering of *Dcx* indices according to the station's longitude (or any other geographic or other coordinate).

The yearly averages of the local *Dcx* indices of the enhanced station network calculated according to the modified recipe are depicted in Fig. 4b. It is seen that the difference between the yearly highest and lowest index is smaller than in Fig. 4a for all years, varying now between 2.4 and 4.9 nT. Even more importantly, there is no systematic ordering of lines in Fig. 4b according to the station's geographic longitude, contrary to Fig. 4a. Rather, a western station (blue line in color figure, dark intensity in b&w figure) can be among the lowest in one year and among the highest in another year, and similarly for an eastern station (red line in color figure, light intensity in b&w figure), or any other station as well. Indeed, the remaining differences in Fig. 4b between the 17 *Dcx* indices calculated according to the UT QD recipe are purely random.

5. UT quiet day corrected Dcx and Dxt

We have calculated the UT quiet day corrected local *Dxt* and *Dcx* indices in 1932–2007 for the four *Dst* stations and depicted them in Fig. 5. The four local *Dcx* indices (Fig. 5b) have so closely similar values that they lie almost on top of each other and are practically impossible to distinguish from each other in the figure. The average difference between the yearly highest and lowest *Dcx* index is only 1.8 nT, i.e., considerably smaller than for the uncorrected *Dcx* indices of Fig. 1c. Also, the differences between any two stations are variable from year to year and, most importantly, there is no systematic ordering in index baselines according to longitude. This is further demonstrated by the fact that the largest mean difference of 1.0 nT is between HER and SJG, not between KAK and HON which is only 0.6 nT. It is now clear that the UT quiet time corrected *Dcx* indices are properly balanced in their average levels and that they contribute with equal weights to the global *Dcx* index. Accordingly, this solves the problem posed by the initial observation of unequally weighted contributions by the different stations to the global index.

We have also calculated the histogram distribution of UT QD corrected local *Dcx* index values smaller than −50 nT for HON and KAK stations (analog of Fig. 2; not shown here). There are 40 604 such hourly values at HON and 39 892 at KAK. Accordingly, the difference between HON and KAK is only less than 2%, compared to the roughly 27% difference in Fig. 2. Thus, only after implementing the UT QD correction, do the local *Dcx* indices at the different stations give closely equal numbers for equally intense disturbances. Moreover, after UT QD correction the histogram distributions (not shown here) are slightly modified so that both HON and KAK have their maxima at 17 local time. This verifies that the additional index values in Fig. 2 are not related to ring current but to the erroneous baseline.

Fig. 5a shows that the above conclusion about the equal *Dcx* indices after UT QD correction does not apply to the local *Dxt* indices. Instead, the mutual differences between the four *Dxt* indices are now, after UT QD correction, even larger than in Fig. 1a. The average difference between the yearly highest and lowest index is now as large as 18.7 nT and, as earlier, the KAK–HON pair shows the largest inter-station difference of 18.2 nT, nearly all of the annual range. However, the stations are no longer systematically ordered by longitude (neither in original or reversed sense) although the easternmost station (KAK) does now show the lowest indices, i.e., largest disturbances, and the westernmost station (HON) the smallest disturbances.

This modified ordering is the combined effect of two facts. Firstly, according to the UT QD treatment, the above discussed time lags between the local midnights of the four stations is removed and the baselines of the stations are set equal. However, there is another effect which affects the *Dxt* indices but not the *Dcx* indices. This is related to the fact that, in the UT quiet day scheme, the linear trend is calculated using different LT sectors of the daily curve in each station. E.g., at HON which is 11 h behind Greenwich, the UT day starts at 13 LT. Since the daily curve has its minimum close to local noon, HON UT midnight level is much lower than its LT midnight level. Therefore, the UT QD corrected HON *Dxt* index is raised highest in Fig. 5a. On the other, while HER station (1 h head of Greenwich) is almost unchanged in UT correction, SJG (4 h behind Greenwich) and KAK (9 h ahead of Greenwich) are placed below HER since the pre-midnight and morning sectors in the respective *Sq* curves are slightly above local LT midnights.

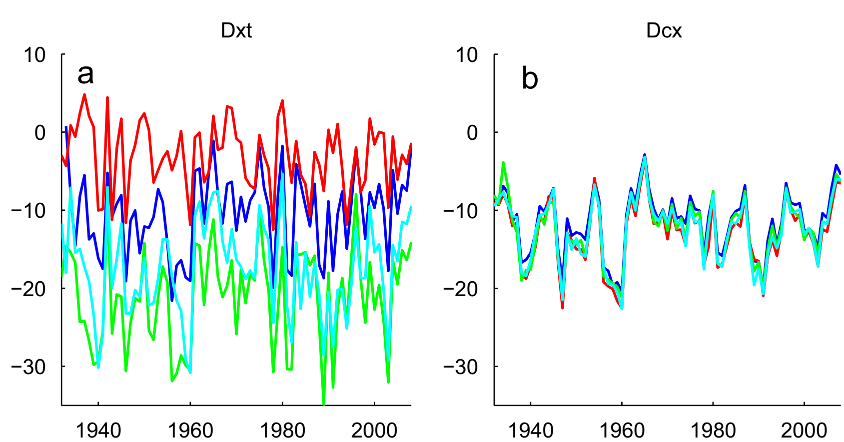

Fig. 5. Yearly averages of UT quiet day corrected local (a) *Dxt* indices and (b) *Dcx* indices for the four *Dst* stations calculated only during the quiet days in 1932–2007. Stations are coded as in Fig. 1.

Note that the calculation of the *Dcx* indices differs slightly from the original recipe (according to which the *Dxt* indices are calculated) in the treatment of the *Sq* variation, which also makes an important difference for the UT QD correction between the two indices. In the original *Dst* recipe, the seasonally varying absolute level is reduced from the *Sq* curves, and thereby retained in the *Dst*/*Dxt* indices as the excessive "non-storm" component (Mursula and Karinen, 2005). Similarly, the different absolute levels due to the different LT sectors in the UT fixed treatment are also reduced from the *Sq* curves but retained in the *Dxt* indices, leading to the greatly different *Dxt* index levels of Fig. 5a. The reverse is true for the *Dcx* indices: The *Sq* curves vary according to the seasonal and LT difference, but the *Dcx* indices are free from these differences and have the closely similar absolute levels for all stations depicted in Fig. 5b.

6. Quiet time Dcx and Dxt

We have also calculated the yearly averages of the *Dxt* and *Dcx* indices during the official quiet days. Fig. 6 shows the two indices in quiet times using the original (LT quiet day) treatment and the corrected UT QD method. It would desirable, of course, that the local indices, would be around zero during quiet days, i.e., when there are no significant disturbances in the magnetosphere. So, the zero level of the indices would correspond to the zero (or very weak) ring current in the magnetosphere. Accordingly, the accuracy to which the different indices and treatments fulfill this aim can be used to evaluate their success as truthful indices of magnetospheric disturbance level.

We can see that the four stations have widely different absolute levels in the local *Dxt* indices in both LT and UT QD methods. Accordingly, the local *Dxt* indices are not equally normalized and cannot be considered to be reliable indicators of magnetospheric disturbances. On the other hand, the *Dcx* indices depict significantly smaller differences between the four stations. However, there are still systematic differences between the *Dcx* indices calculated according to the original (LT) method. These differences are of the same order of magnitude as those depicted in Fig. 1c and are, similarly, ordered by the geographic longitude.

The best agreement between the four stations is obtained for the *Dcx* indices calculated according to the new UT QD method. The differences are very close to zero (within an accuracy of less than 0.7 nT) for all stations and there is no ordering in longitude or any other way. This gives convincing evidence that the local *Dcx* indices calculated according to the new UT QD method are indeed the best version to calculate the *Dst* type indices as an estimate of the ring current intensity and magnetospheric disturbance level in general.

7. Conclusions

We have noted in this paper that the average disturbances of the four *Dst* stations are systematically different and, therefore, the stations contribute to the *Dst* index by unequal weights. This is an important problem not only for the *Dst* index and the symmetric *SymH* index but also for the asymmetric *AsyH* index which aims to estimate the maximum momentary longitudinal asymmetry of the ring current. Although the average difference between the local *Dst*/*Dxt* indices of the four *Dst* stations, about 14–15 nT, is not very large compared to typical disturbances during the main phase of an intense storm, it greatly affects results on the long-term evolution of the *Dst* index, and the index values during the long, moderately intense storms due to high-speed streams, leading to HILDCAA intervals (Tsurutani and Gonzalez, 1987; Tsurutani et al., 2006). In fact, it has already been known for long that the quiet day variation is important for ring current asymmetry (Clauer et al., 1980). Also, earlier studies of ring current asymmetry using the *AsyH* index (Weygand and McPherron, 2006) found that this index does not behave as expected but, rather, depicts significant offsets. Thus, a more

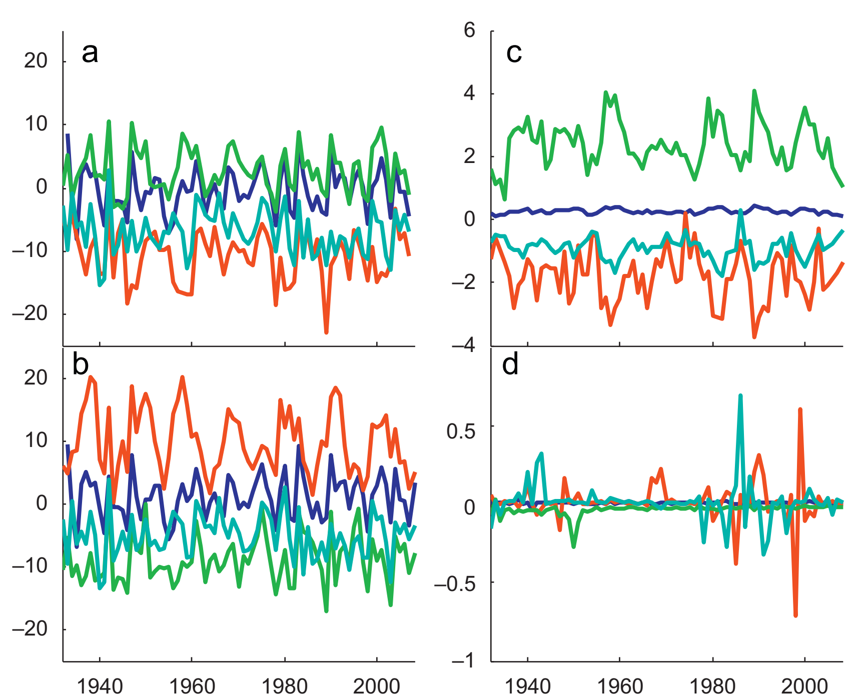

Fig. 6. Yearly averages of LT fixed (upper row) and UT quiet day corrected (lower row) local *Dxt* indices (left) and *Dcx* indices (right) for the four *Dst* stations during quiet days in 1932–2007. Stations are coded as in Fig. 1.

correct estimate of local disturbances and asymmetries is useful for the needs of both experimental (Søraas et al., 2004; Maltsev and Ostapenko, 2004; Shi et al., 2005; Kalegaev et al., 2008) and modeling studies (Jordanova et al., 2009) of the ring current development and asymmetry.

Using an extended network of 17 stations, we have demonstrated that the local *Dst*/*Dxt*/*Dcx* disturbances are ordered according to the station's geographic longitude, with westernmost stations depicting the largest disturbances and contributions to the *Dst* index and easternmost the smallest. Accordingly, the differences are related to abrupt changes at the international date boundary, and the way the quiet days are treated in the *Dst* recipe. We modified the recipe by using UT-fixed quiet days in all stations and showed that, then, the local *Dcx* indices of all stations have equal weights. We also showed that the UT quiet day correction does not alleviate the problem in the *Dst*/*Dxt* indices where the local indices still remain at unequal levels. We showed that, before the UT quiet day correction, there is a difference of about 27% in the number of moderately disturbed (*Dcx* below -50 nT) index values between HON and KAK stations. After correction all stations depict almost equal (less than 2%) numbers and distributions. Also, only after the correction, all stations depict the maximum number of disturbances at the same local time, while before correction the local time distributions depict shifts by 1–2 h.

Concluding, we have found a way to correct the problem of why the local *Dst*/*Dxt*/*Dcx* disturbances are different and contribute by unequal weights to the *Dst* index. We have shown that the UT quiet time corrected *Dcx* indices have equal average levels so that they will contribute with equal weights to the global *Dcx* index. However, the *Dst*/*Dxt* index cannot be corrected for this problem, which gives strong support for using the corrected *Dcx* index instead of the *Dst* index.

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