Version definitions of AE and Dst geomagnetic indices

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WDC for Geomagnetism, Kyoto

Note: These definitions can be applied to current procedures for the index calculation but may differ from those in the early years.

Version definition of the auroral electrojet (AE) Index

The production method of the AE index is the same among the versions, but the primary difference is the implementation of correction with visual inspection for higher-grade versions. The following link shows the calculation method of the AE index (https://wdc.kugi.kyoto-u.ac.jp/aedir/ae2/onAEindex.html).

Real-time AE index

The real-time AE index is an AE version calculated using real-time geomagnetic field data. The calculation is performed automatically every 20 min (as of October 17, 2022) for all periods up to the current month. We do not remove artificial noise and baseline offset, while we perform manual corrections when these errors are significant so that the calculated index is useless, even for monitoring purposes. Specifically, if a large baseline offset occurs in a specific station, the biased value could affect the AL or AU, resulting in inadequate AE values.

We used a baseline calculated from the international five quietest days (5QDs) data of the previous month instead of the current month for real-time AE index production. We recalculated the index of the previous month with a baseline value calculated from the data on 5QDs of the same month. It was noted that real-time AE values may often be modified. The real-time index is used for monitoring but not in the scientific analysis, and digital data are not publicly available. On our webpage, the plot of the real-time AE for each month disappears when the provisional AE index of the corresponding month is released.

Provisional AE index

The provisional AE index is calculated with a lag of several months, and during the calculation period, we use field data with the highest processing level (provisional/quasi-definitive/definitive values). The calculation method is the same as for the real-time AE index, except that manual correction of artificial noises and baseline offset are performed on the original field data. Recently, there has been an attempt to automate this process as much as possible. The provisional AE index values can be used for scientific analysis, and the digital data are publicly available. However, the provisional AE index may also be modified if the field data are updated. At that time, we publish the news of the modification on our website. Currently, the provisional AE since January 1990 and in March 1989 are available.

Final AE index

The final AE index is a version for which no modification will be made in the future. The final values for every minute are available only from January 1977–June 1988 and those for every hour from July 1957–June 1988. During these periods, the geomagnetic field data were digitalized from analog magnetograms for the AE index. As such, the field data used will not be updated in the future. Since 1988, the final AE value calculation has been on hold. Later, the field data were transferred to our center in digital format, and it is necessary to calculate the final AE values from INTERMAGNET-approved definitive geomagnetic data. However, definitive geomagnetic data are not available for some AE stations. Thus, we probably have to redefine the final AE index. Note that the AE index before 1976 had been calculated at the Geophysical Institute of the University of Alaska and WDC-A for STP in Boulder not at WDC for Geomagnetism Kyoto (see https://wdc.kugi.kyoto-u.ac.jp/aedir/ae2/onAEindex.html for more detail).

Version definition of the disturbance storm time (Dst) index

There is an essential difference between the methods used to calculate the real-time/provisional Dst and final Dst. The following link shows the calculation method for the Dst index https://wdc.kugi.kyoto-u.ac.jp/dstdir/dst2/onDstindex.html).

Real-time Dst index

The real-time Dst index calculation using the real-time geomagnetic field data was performed automatically every 30 min (as of October 17, 2022) for all periods up to the current month. We do not remove artificial noise and baseline offset, while we perform manual corrections when these errors are significant so that the calculated index is useless, even for monitoring purposes. Specifically, if a large baseline offset occurs at a specific station, the biased value would affect Dst, in inadequate Dst values.

For the real-time Dst index production, we used the baseline value and Sq variation calculated from the data on the international five quietest days (5QDs) of the previous month instead of the current month. We recalculated the previous month's index using the baseline value and the Sq variation from the data on the 5QDs of the same month. Note that the real-time Dst values may often be modified. The real-time Dst index is approved only for monitoring purposes and not for scientific analysis, but digital data are publicly available on our webpage. The plot of the real-time Dst for each month on our webpage disappears when provisional Dst values for the corresponding month are released.

Note that the method to determine the baseline and Sq variation for real-time Dst differs significantly from the method proposed by Sugiura and Kamei (1991). They suggested modeling Sq variations by the double-Fourier transformation with data in one year (January–December) and modeling the long-period secular variation by the second-order polynomial function with the data from the past five years. However, we cannot use these methods for real-time Dst calculations, but we used another, which uses only the field data and 5QDs in the current month (or the previous month's 5QDs). The sum of Sq variation and baseline is determined by averaging the daily variation (as a function of the local time) over 5QDs and removing the linear trend. Therefore, the real-time Dst

values may be significantly different from the final Dst values, which can be determined using the method proposed by Sugiura and Kamei (1991).

Provisional Dst index

Generally, the provisional Dst index is calculated with a lag of several months. During the calculation period, we used field data with the highest processing level (provisional/quasi-definitive/definitive values). The calculation method is the same as for the real-time Dst index, except that the manual correction of artificial noises and baseline offsets is performed on the original field data. We can use the provisional Dst values for scientific analysis, and the digital data are publicly available.

Final Dst index

The Dst final value is the Dst index with the highest processing level calculated with a lag of several years, and in the future, no further changes will be made. Currently, we use the definitive geomagnetic field data provided by INTERMAGNET. These data are reliable and have been corrected automatically and manually, and our center has not made additional corrections. Unlike the real-time and provisional Dst values, the calculation method of baseline (secular variation) and Sq variation used the Sugiura and Kamei (1991) method. Therefore, calculations are made from January to December (annually), and no updates are made unless INTERMAGNET updates the definitive values.

Appendix: Examples of differences in values between versions of the Dst index

We compared the three-version Dst values in 2014 (Figure 1) as an example. We observed that these variations were consistent with each other. The real-time and provisional values appear to be in good agreement because the baseline and Sq variations were determined using the same method. Though there are some minor differences due to the differences in noise removal, this depends on the extent to which real-time geomagnetic field data had intense noises, and the errors were corrected (the same applies to the difference between the real-time and provisional AE). In September and December, there was a substantial discrepancy of about 20–30 nT between the provisional and final values, which may be because the baseline for the provisional value was determined using only the data for that month. If the horizontal component of the geomagnetic field is smaller than usual for a month due to a series of magnetic storms. The magnetic field average on the 5QDs was small, resulting in a lower baseline value, which may lead to an underestimation of the strength of magnetic storms. However, we determined the final Dst baseline from a longer-term trend, so even when the geomagnetic field declines temporarily, such as for a month or more, it does not cause a high baseline deviation.

Reference

Sugiura, M., and T. Kamei (1991), Equatorial Dst-index 1957–1986, in IAGA Bulletin No. 40, ed. by A. Berthelier, M. Menvielle (ISGI Publ. Off., Saint. Maur-des-Fosses, 1991)

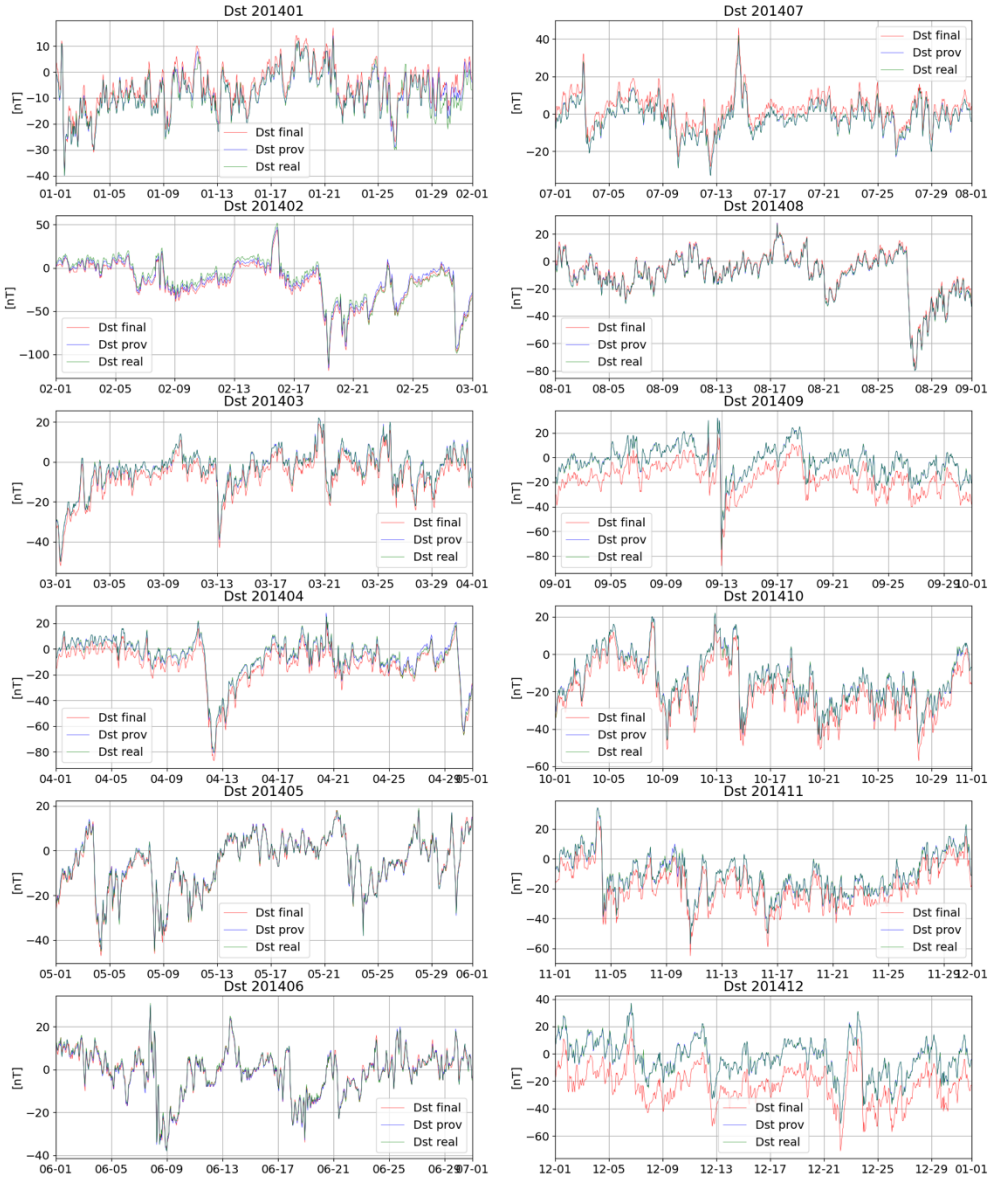

Figure 1: Comparison between final (red), provisional (blue), and real-time (green) Dst values in 2014. Data for each month are plotted in each panel.