Version Definitions of AE and Dst Geomagnetic Indices

WDC for Geomagnetism, Kyoto

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

1 Version Definition of the Auroral Electrojet (AE) Index

The fundamental calculation algorithm for the AE index is the same for all versions. The primary difference lies in the implementation of visual inspection and correction for higher-level versions. The following link describes the calculation method of the AE index (`https://wdc.kugi.kyoto-u.ac.jp/aedir/ae2/onAEindex.html`); however, please note that since December 2024, we no longer use the average values from the international five quietest days (5QDs) as the baseline for the real-time AE index.

1.1 Real-time AE Index

The real-time AE index is calculated using real-time geomagnetic field data. The calculation is performed automatically every 20 minutes (as of October 2025) for all periods up to the current month. Until November 2024, we did not publish digital values of the real-time AE index in the standard WDC format. Since December 2024, digital values of the real-time AE index have been published with a delay of about three weeks. These digital data have undergone a minimal level of quality checking and correction. The digital values can be used for scientific research, in addition to monitoring purposes.

We currently do not use the average values from the 5QDs as the baseline for the real-time AE index. Because the 5QDs are published after the end of each month, determining the baseline in near real-time with this method is problematic. The baseline is therefore determined on an as-needed basis rather than monthly, regardless of whether baseline changes are due to natural or artificial variations. For more information about the digital values of the real-time AE index, see `https://wdc.kugi.kyoto-u.ac.jp/ae_realtime/data_dir/00readme.pdf`.

1.2 Provisional AE Index

The provisional AE index is calculated with a lag of several months. For the calculation, we use the highest-level processed field data available at the time (provisional, quasi-definitive, or definitive values). The average of geomagnetic data from the international five quietest days (5QDs) is used to determine a constant baseline for a given month. Compared to the real-time index, more careful data quality checks and corrections are performed. The provisional AE index values can be used for scientific analysis, and the digital data are publicly available. However, the provisional AE index may be modified if the source field data are updated. In such cases, a notification will be published on our website. Currently, the provisional AE index is not available for the period from January 1990 onwards, nor for March 1989.

1.3 Final AE Index

The final AE index is a version for which no future modifications will be made. Final 1-minute values are available only for the period from January 1977 to June 1988, and 1-hour values are available from July 1957 to June 1988. During these periods, the geomagnetic field data for the AE index were digitized from analog magnetograms. As such, the field data used will not be updated. Since 1988, the calculation of the final AE index has been on hold. Subsequently, field data have been transferred to our center in digital format, making it necessary to calculate final AE values from definitive geomagnetic data. However, definitive geomagnetic data are not available for some of the recent AE stations. Therefore, we may need to redefine the final AE index. Note that before 1976, the AE index was calculated at the Geophysical Institute of the University of Alaska and WDC-A for STP in Boulder, not at the WDC for Geomagnetism, Kyoto (see `https://wdc.kugi.kyoto-u.ac.jp/aedir/ae2/onAEindex.html` for more details).

2 Version Definition of the Disturbance Storm Time (Dst) Index

There is an important difference in the calculation methods for the real-time/provisional Dst and the final Dst, specifically in how the baseline and Sq variation are determined. The basic calculation algorithm for the Dst index is described at the following link: `https://wdc.kugi.kyoto-u.ac.jp/dstdir/dst2/onDstindex.html`.

2.1 Real-time Dst Index

The real-time Dst index is calculated automatically every 30 minutes (as of October 2025) using real-time geomagnetic field data on a monthly basis for the current month. In principle, we do not remove artificial noise and baseline offsets. However, manual corrections may be performed if these errors are so significant that the calculated index becomes useless even for monitoring purposes. Specifically, if a large baseline offset occurs at a particular station, the biased value affects the Dst index, resulting in inadequate values.

For the production of the real-time Dst index, we use the baseline and Sq variation calculated from the international five quietest days (5QDs) of the previous month, as the data for the current month are not yet available. When recalculating the index for a past month, we use the baseline and Sq variation from the 5QDs of that specific month. Note that real-time Dst values may be modified frequently. The real-time Dst index is intended for monitoring purposes only and not for scientific analysis, but the digital data are publicly available on our webpage. The plot of the real-time Dst for a given month is removed from our webpage when the provisional Dst values for that 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 using a double Fourier transform with one year of data (January–December) and modeling the long-term secular variation with a second-order polynomial function using data from the past five years. However, these methods cannot be used for real-time Dst calculations. Instead, we use a simplified method that relies only on the field data from the 5QDs in a single month. The sum of the Sq variation and the baseline is determined by averaging the daily variation (as a function of local time) over the 5QDs and removing the linear trend. Therefore, real-time Dst values may differ significantly from the final Dst values, which are determined using the method proposed by Sugiura and Kamei (1991).

2.2 Provisional Dst Index

The provisional Dst index is generally calculated with a lag of several months. For the calculation, we use the highest-level processed field data available at that time (provisional, quasi-definitive, or definitive values). The calculation method is the same as that for the real-time Dst index, except that manual correction of artificial noise and baseline offsets is performed on the original field data. The provisional Dst values can be used for scientific analysis, and the digital data are publicly available.

2.3 Final Dst Index

The final Dst index is the highest-level version, calculated with a lag of several years, after which no further changes will be made. Currently, we use the definitive geomagnetic field data provided by INTERMAGNET. These data are reliable, having been corrected both automatically and manually, and no additional corrections are made by our center. Unlike the real-time and provisional Dst values, the baseline (secular variation) and Sq variation are calculated using the method of Sugiura and Kamei (1991). Therefore, calculations are performed on an annual basis (January to December). As a general rule, no further updates are made, although recalculation may occur under certain circumstances. Please note the caution regarding missing data for the index in 2017, 2018, and 2020 (see `https://wdc.kugi.kyoto-u.ac.jp/dst_final/caution_fin_dst_20240724.pdf` for more details).

3 Appendix: Examples of Differences in Values Between Versions of the Dst Index

As an example, we compare the three versions of the Dst index for 2014 (Figure 1). We observe that the variations are generally consistent with each other. The real-time and provisional values show good agreement because their baseline and Sq variations are determined using the same method. Minor differences exist due to variations in noise removal; the magnitude of these differences depends on the amount of intense noise in the real-time geomagnetic data and whether those errors were corrected (the same applies to the difference between the real-time and provisional AE indices).

In September and December, a substantial discrepancy of about 20–30 nT is observed between the provisional and final values. This may be because the baseline for the provisional value was determined using data from only that specific month. If the horizontal component of the geomagnetic field is lower than usual for an entire month due to a series of magnetic storms, the average magnetic field on the 5QDs will also be low. This results in a lower baseline value, which can lead to an underestimation of the magnetic storm's strength. However, the final Dst baseline is determined from a longer-term trend, making it less susceptible to large deviations caused by temporary declines in the geomagnetic field, even those lasting a month or more.

References

[1] 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).

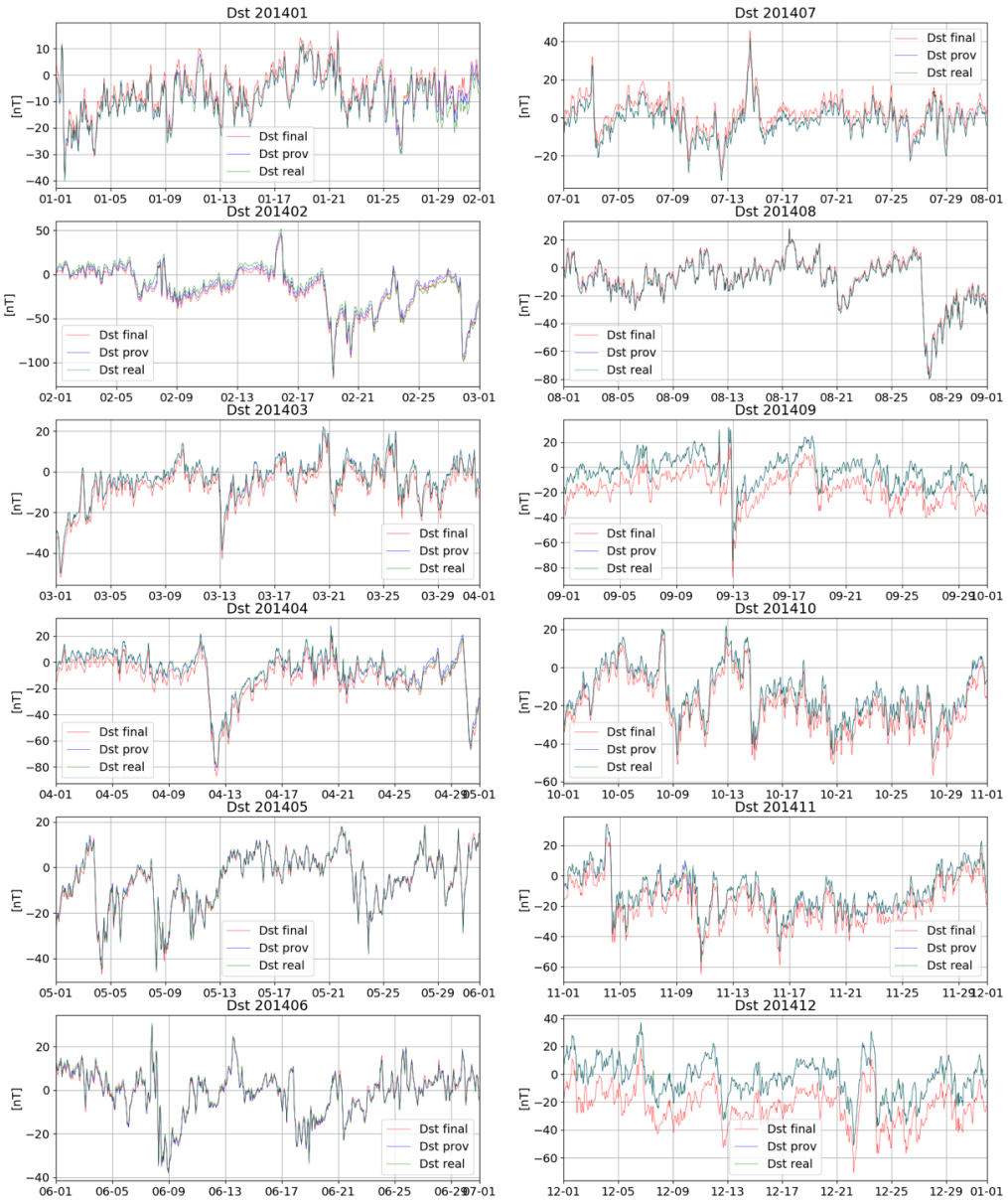

Figure 1: Comparison between final (red), provisional (blue), and real-time (green) Dst values in 2014. Data for each month are plotted in each panel.