FEDERATION DES SERVICES D'ANALYSE DE DONNEES ASTRONOMIQUES ET GEOPHYSIQUES
FEDERATION OF ASTRONOMICAL AND GEOPHYSICAL DATA ANALYSIS SERVICES
SERVICE INTERNATIONAL DES INDICES GEOMAGNETIQUES
INTERNATIONAL SERVICE OF GEOMAGNETIC INDICES

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CONTENTS

This special issue is an explanatory sheet containing informations about data published in the ISGI Monthly Bulletins, namely :

The International Service of Geomagnetic Indices (ISGI) is a permanent scientific service of the International Association of Geomagnetism and Aeronomy (IAGA). It operates under the supervision of the IAGA Division V : Observatories, Instruments, Surveys and Analysis, and it adheres to the Federation of Astronomical and Geophysical Data Analysis Centers (FAGS) of the International Council of Scientific Unions (ICSU).

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The data distributed in the monthly Bulletin are provided by the collaborating Institutes, under the responsability of the adjoining collaborators :

- Observatorio del Ebro, ROQUETAS (J.O. CARDUS) :
  Rapid Variations.
- Laboratoire de Physique de la Terre et des Planètes, ORSAY (M. MENVIELLE) :
  am, Km and aa indices, quiet days.
- Institut für Geophysik, GÖTTINGEN (M. SIEBERT) :
  Kp, ap, international quietest and most disturbed days.
- Data Analysis Center for Geomagnetism and Spacemagnetism, KYOTO (M. SUGIURA) :
  Dst

A short recall of the definition of the published data is given below. More details can be found in the following references :

- P.N. MAYAUD, Derivation, Meaning and Use of Geomagnetic Indices, Geophysical Monograph 22, Am. Geophys. Union, WASHINGTON D.C., 1980 ;
- IAGA Bulletin 32 series - Last issue published : Geomagnetic data 1987 - IAGA INDICES : aa, am, Kp, Dst, AE - RAPID VARIATIONS, edited by A. BERTHELIER and M. MENVIELLE, ISGI Publications Office 1993 ;
- M. MENVIELLE and A. BERTHELIER, *The K-derived planetary indices : description and availability,* Rev. Geophys., 29, 3, 415-432, 1991 ;
- A. BERTHELIER, *The Geomagnetic indices : derivation, meaning and uses in solar-terrestrial physics,* in *STPW-IV - Proceedings,* edited by J. HRUSKA et al, in vol. 3, 3-20, US Gov. Publications Office, 1994.

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TABLE 1a - List of am and aa observatories

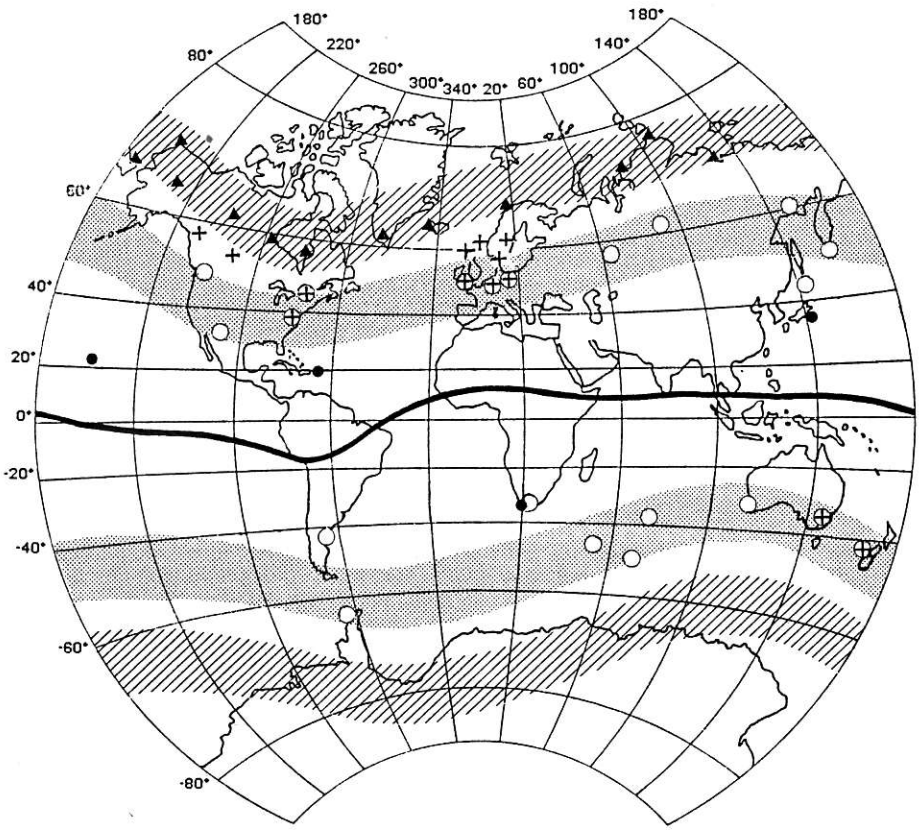
	Northern Hemisphere				*Southern Hemisphere*		
	Observatories	*IAGA Code*	*Corr. Geom. Lat.*		*Observatories*	*IAGA Code*	*Corr. Geom.Lat.*
G1	Magadan	MGD	53.8°	G6	Eyrewell	EYR	50.2°
	Petropavlosk	PET	46.4°		**Canberra**	**CAN**	**45.2°**
	Memabetsu	MMB	37.4°				
G2	Podkammenkaya	POD	57.2°	G7	Gnangara	GNA	44.1°
	Sverdlovsk (Ekaterinenburg)	SVD	52.2°		Amsterdam	AMS	48.3°
G3	**Hartland**	**HAD**	**50.0°**	G8	Kerguelen	PAF	58.8°
	Niemegk	NGK	48.8°		Crozet	CZT	52.4°
					Hermanus	HER	41.1°
G4	Ottawa	OTT	58.9°	G9	Argentine Islands	AIA	49.7°
	Frederiksburg	FRD	51.8°		Trelew	TRW	27.8°
G5	Victoria	VIC	53.9°	**Antipodal observatories used for aa derivation are in bold type face**			
	Tucson	TUC	39.7°				

TABLE 1b - List of Kp observatories

Northern Hemisphere			*Southern Hemisphere*		
Observatories	*IAGA Code*	*Corr. Geom.Lat.*	*Observatories*	*IAGA Code*	*Corr. Geom.Lat.*
Meanook	MEA	62.5°	Eyrewell	EYR	50.2°
Sitka	SIT	60.0°	Canberra	CAN	45.2°
Lerwick	LER	58.9°			
Ottawa	OTT	58.9°			
Lovö	LOV	56.5°			
Eskdalemuir	ESK	54.3°			
Brorfelde	BJE	52.7°			
Fredericksburg	FRD	51.8°			
Wingst	WNG	50.9°			
Hartland	HAD	50.0°			

TABLE 1c - List of Dst observatories

Observatories	*IAGA Code*	*Dipole Lat.*	*Dipole Long.*
Honolulu	HON	21.0°N	266.4°
San Juan	SJG	29.9°N	3.2°
Hermanus	HER	33.3°N	80.3°
Kakioka	KAK	26.0°N	206.0°



Geographical world map on which are indicated the location of the stations belonging to the different networks used in deriving geomagnetic indices: o for am,Km, + for Kp,ap, and ⊕ for stations belonging to both am,Km and Kp,ap networks, ● for Dst, and ▲ for AE. A solid line indicates the position of the dip equator. The average extension of the auroral zone is sketched by the hatched area, that of the subauroral region by the shaded area.

1. K DERIVED INDICES

1.1. K definition

K indices have been designed by Bartels (1939) in order to monitor the transient irregular variations of the geomagnetic field, in a similar way at all geomagnetic observatories. For a given 3-hour interval, the K index is the number of the class in which ranks the largest of the two ranges measured during this 3-hour interval on the two horizontal components. The ranges are measured after having substracted the solar regular (S_R) daily variation. The limits of the grids used in the determination of K indices follow a quasi logarithmic scale in order to allow studies of both quietness and storminess ; all grids are proportional to that of Niemegk where K indices have first been designed. The K indices can be converted back into a_K equivalent amplitudes through conversion tables, using mid-class range amplitudes. (For further details on K and a_K, see references quoted above, and a note by Berthelier and Menvielle, p. 23-25 in IAGA News n° 32, 1993).

1.2. aa indices

The aa indices are derived using data from two nearly antipodal observatories, respectively situated in Australia and Great Britain, where magnetograms were available since 1868, (see Figure 1). For each three hour interval, K indices measured at the two stations are converted back into amplitude ; a three-hour aa index is the average of the northern and southern values, weighted to account for the small difference in latitude of the two stations, and for the slight changes in the place of the observatories. The observatories used to derive aa are given in Table 1-a.

The aa index is in nanotesla (nT) and it represents the activity level at an invariant magnetic latitude of about 50°.

The following values are given in the table published in the monthly Bulletin :

N	=	*daily values for the Northern observatory (U.T. day)*
S	=	*daily values for the Southern observatory*
am, pm	=	*half-daily values of aa indices (U.T. day, before noon and after noon)*
D	=	*daily values of aa indices.*

Three-hourly aa values are displayed in the form of musical diagram for the month corresponding to the Bulletin, and for the following days up to the latest available data.

1.3. am indices

am, an and as indices are derived from K indices measured at observatories located in the subauroral zones of the Northern and Southern hemispheres (Figure 1). The stations are arranged in groups (G1 to G9), each group representing a longitude sector in one of the hemisphere (see Table 1-a). The IAGA three-letter code, and the corrected geomagnetic latitude (calculated by Mayaud, 1980) are given in this Table.

For each three-hour interval, the K values from the observatories of one group are averaged and converted back to amplitude. Then amplitudes of each group are weighted for balancing the differences in longitude width of the sectors, and the hemispheric averages of the weighted amplitudes give the three-hour an and as indices respectively.

The am index is equal to (an + as)/2; Am is the daily mean value of am. They are all expressed in nanoteslas (nT).

For the sake of tradition and convenience, Km equivalent values are also made available by means of a conversion table (see below); they are as usually expressed by values from 0o to 9o, corresponding to the given interval of am.

am	0.0	1.4	3.4	5.4	7.4	10.4	13.4	16.4	20.4	26.4	
Km	0o	0+	1-	1o	1+	2-	2o	2+	3-		
am	26.4	33.4	40.4	50.4	60.4	70.4	86.4	103.4	120.4	146.4	
Km	*3o*	*3+*	*4-*	*4o*	*4+*	*5-*	*5o*	*5+*	*6-*		
am	146.4	173.4	200.4	243.4	286.4	330.4	386.4	443.4	500.4	611.4	
Km	*6o*	*6+*	*7-*	*7o*	*7+*	*8-*	*8o*	*8+*	*9-*	*9o*	

1.3. am indices *(continued)*

In monthly Bulletins, are displayed the provisional values of :

- *three hourly am, and Km*
- *daily mean value Am, and daily sum* ΣKm.

These provisional values are computed monthly with the data available six weeks after the end of the month, by using an appropriate weighting in longitude.

Three-hourly Km values are displayed in the form of "musical diagram" for the month of the Bulletin. The annual compilations of Km values in the form of musical diagrams from 1959 onwards are available on request at ISGI Publications Office.

1.4. Kp indices

The planetary three-hour range index Kp is the average of the "standardized" K-index from 13 observatories between 44° and 60° geomagnetic latitude (Figure 1, and Table 1-b). For further details on the standardization process, see references quoted above. The scale is 0o to 9o, expressed in thirds of a unit.

A Kp value can be converted into equivalent amplitude ap (unit ≈ 2nT), by using the following table :

Kp	=	0o	0+	1-	1o	1+	2-	2o	2+	3-	3o	3+	4-	4o	4+
ap	=	0	2	3	4	5	6	7	9	12	15	18	22	27	32
Kp	=	5-	5o	5+	6-	6o	6+	7-	7o	7+	8-	8o	8+	9-	9o
ap	=	39	48	56	67	80	94	111	132	154	179	207	236	300	400

Daily mean values of ap, Ap, and daily sum ΣKp *are given in the monthly Bulletin. (Three-hourly values of Kp, and musical diagrams are presently sent separately by Pr. Siebert, at Göttingen).*

2. RAPID VARIATIONS

About 50 magnetic observatories are collaborating to the Service of Rapid Variations, at Ebro Observatory. They report monthly about the special events they have observed on their magnetograms. The reports sent to the Service of Rapid Variations within a delay of one month are gathered, and used for preparing a preliminary report. This report on rapid magnetic is communicated to ISGI and published in the monthly Bulletin, with the list of reporting observatories, identified by their three letter IAGA codes.

The rapid variations here reported are ***ssc****, that is storm sudden commencements, and* ***sfe****, that is solar flare effects (see more precise definition in Bulletin 32 and references therein).*

- *The list of ssc (day, hour, minute) is given with the qualification attributed by reporting observatories, that is letters A (very remarkable), B (fair, but unmistakable) or C (very poor, doubtful) and "-" means no quality figure given. The * means that the SSC, at least in one component, was preceded by a small reversed impulse.*

- *The list of sfe (day, and beginning - ending in hour, minute) is given with the list of observatories having reported it, and eventually the mention "doubtful". If an sfe is confirmed by solar or ionospheric events, the name of the station is underlined.*

SSCs are given only when five or more stations report the event. SFEs include all reports.

The annual lists are prepared by J.O. Cardus at Ebro, after having checked all reported events and asked for confirmation through a complete routine procedure described in IAGA Bulletin 32, where these final lists are published.

3. CLASSIFICATION OF DAYS

3.1. International quietest and most disturbed days

The selection of the quietest and most disturbed days of each month is made on the basis of three criteria : (a) = the sum of the eight values of Kp; (b) = the sum of the squares of these values; (c) = the greatest of the eight values of Kp.

According to each of these criteria, a relative "order number" is assigned to each day of a month, the three order numbers are averaged and the days with the lowest and the highest mean order numbers are selected as the five quietest, the ten quietest and the five most disturbed days.

It should be noted that these selection criteria give only a relative indication on the activity level of the selected days with respect to the other days of the same month. As the general disturbance level may be quite different for different years and also for different months of the same year, the selected quietest days of a month may sometimes be rather disturbed (or vice versa).

> *We give in the monthly Bulletin the lists of the five quietest days and of the five most disturbed days of the month. The five quietest days are also marked by an * in the table of indices.*

3.2. Quiet and really quiet periods of 24 or 48 hours

This classification is made using aa indices. A 24 hour or a 48 hour period is **quiet** when the average of aa is lower than 13 nT. Then a weight p is given to each three hour interval of the period, according to the value of aa :

aa	≤ 17	17 < aa ≤ 21	21 < aa ≤ 28	28 < aa ≤ 32	> 32
p	0	1	2	4	6

A quiet day for which Σp is lower than 4, or a quiet 48 hour period for which Σp is lower than 6, are **really quiet**.

> *The letters **K** for **quiet**, **C** for **really quiet** periods are reported in the monthly tables of indices, in the first column following aa indices for the U.T. day, and in the next column to the right for the 48 hour period centered on the U.T. day.*
> *Let us note that in such periods, every local day, at any longitude, is really quiet.*

4. DEVIATION INDICES

4.1. Dst index

The Dst indices are derived using the data from the four magnetic observatories given in Table 1-c. These observatories were chosen on the basis of the quality of observation and for the reason that their locations are sufficiently distant from the auroral and equatorial electrojets and that they are distributed in longitude as evenly as possible. (See Figure 1).
Detailed explanation of the calculation of Dst is given in IAGA Bulletin n° 40 with a compilation of Dst values and plots for 1957-1986, and also in Bulletin 32 series. We only recall here the main guide lines.

The baseline for H is defined for each observatory in a manner that takes into account the secular variation. It is expressed by a power series in time and the coefficients for terms up to the quadratic are determined by the method of least squares, using the annual means for the current year and the four preceeding years.

$$H_{base}(\tau) = A + B\tau + C\tau^2$$

where τ is time in years measured from a reference epoch.

For each of the observatories, the deviations ΔH(T) are calculated for each UT hour of the current year from the mean hourly values H_{obs} and H_{base} by :

$$\Delta H(T) = H_{obs}(T) - H_{base}(T)$$

The solar quiet daily variation, Sq, is derived for each observatory from the values of H(T) for the internationally selected five quietest days of each month. A representation of Sq determined for the year is given by a double Fourier series with local time, **t**, and month number, **s**, as two variables:

$$S_q(t,s) = \sum_m \sum_n A_{mn} \cos(mt + \alpha_m) \cos(ns + \beta_n)$$

This representation allows to calculate Sq(T) at any UT hour of the year, for each Dst observatory.

The hourly disturbance variation, D(T), is computed for each observatory :

$$D(T) = \Delta H(T) - S_q(T)$$

The hourly Dst value is finally derived by averaging over the four observatories the D(T) values normalized to the dipole equator.

> *Provisional values of hourly Dst are computed using estimates of secular and Sq variations, the confirmation requiring data from the whole year.*
> *Monthly tables of hourly provisional Dst-values and plots, prepared by M. SUGIURA and T. KAMEI are joined to ISGI monthly Bulletin.*

4.2. AE index

The AE indices are derived from geomagnetic variations in the horizontal component observed at selected observatories along the auroral zone in the northern hemisphere (See Figure 1). These variations are measured from a baseline determined for each of the observatories.

The AU and AL indices are respectively defined as the maximum and minimum values among the one minute values of the variations from all the AE observatories. The AE index is defined by AU-AL, A0 is (AU+AL)/2.
The AU and AL indices are intended to represent a measure of the maximum current density of the eastward and westward auroral electrojets, respectively, so the AE index gives a representation of global auroral electrojet activity.

One minute values of the AE indices (AU, AL, AE and A0) are calculated at the Data Analysis Center for Geomagnetism and Spacemagnetism, (M. SUGIURA).

Unfortunately, the AE indices are not at present prepared in time to be joined to the monthly Bulletin because of the delay induced by the digitization of the data in some AE observatories.

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