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A Comparison Between Computer Derived (Adaptive Smoothing Method) and Hand Scaled K Indices at Tuntungan Geophysical Station

Yosi Setiawan, Daryono
Meteorology and Geophysical Academy
Meteorology, Climatology and Geophysical Agency
Jakarta
yosi.setiawan@yahoo.com

***Abstract*—Instrument transition at Tuntungan Geophysical Station from La Cour analog variograph to digital fluxgate magnetometer LEMI-018 change the way to derive K-indices value. This study is done to ensure that the K-indices value from manual hand scaled and the software derived with ASm (Adaptive Smoothing Method) is not differing enough. Using data from January until September 2010 minus July, confirm the results: about 17% of K-indices are in agreement and about 15% differ by more than one unit, the percentage of differences equal to 0 are varies for K=0-6 with 28%, 26%, 17%, 14%, 6%, 17%, and 100% for each K-value, the percentage of differences equal to 0 with the UT 3-hour interval have variation between 13% to 21%.**

Keywords—Geomagnetism, K-indices, ASm method

IV. INTRODUCTION

Tuntungan Geophysical Station (IAGA code: TUN),located at 3.517 N and 98.567 E with elevation 86 meters above sea level, is the Technical Implementation Unit of the Meteorology, Climatology and Geophysical Agency (BMKG) in North Sumatra (Fig. 1) that making observations in the field of geophysics, and one of them is geomagnetic observation.Data generated from the geomagnetic observations are including daily data of all components of the geomagnetic field, disturbed day data, and K-indices data.

Geomagnetic observations at Tuntungan began in 1982 with analog variograph La Cour. Then in 2003, it is received additional digital magnetometer DMI from BGS (British Geological Survey), but its condition is now broken. In 2008 Tuntungan received again an additional digital fluxgate magnetometer LEMI-018 that are still in service today, but it was only used as a backup of the analog variograph La Cour. This digital fluxgate magnetometer was stop working for several times because of sensor trouble.

Since September 2012 the analog variograph La Cour has discontinued for operations due to huge cost for treatment, so that the data of digital fluxgate magnetometer LEMI-018 are used as the main data. Consequently the calculation to obtain the variation values of each component, the disturbed days, and K-indices data has changed. It is not too difficult to get the variation values of each component and to determine the disturbed days. The problem is how to get the K-indices value.

As in [1], K-indices are an index designed to quantify the level of disturbances caused by the influence of the solar wind at a single location using magnetic observatory measurements and it is produced for eight three-hour segments in a UT day. K-indices measured in nT and denoted by a single digit code from 0 to 9 according to a quasi-logarithmic scale where K=0 indicates completely quiet conditions and K=9 indicates highly disturbed conditions. Reference [2] said that K=0–2 correspond toperiods of magnetic quietness; K=3–5 correspondto periods of moderate geomagnetic activity; and K=6–9 correspond to periods of intense to very intensegeomagnetic activity. Table 1 shows the K-indices scale at Tuntungan.

In Tuntungan previously, it was performed by manual measurement on the magnetogram (hand scaled), now it is used computer to get the K-indices from the digital data. The software used here is KAsm which uses Adaptive Smoothing Method.

The purposes of this study are to compare the K-indices data from manually measurement results (hand scaled) with the data from KAsm calculation and to determine the accuracy of the Adaptive Smoothing Method in K-indices calculation specially at Tuntungan Geophysical Station.

TABLE I. K-INDICES SCALE FOR TUNTUNGAN GEOPHYSICAL STATION. THE RANGE ARE EXPRESSED IN NT.

Range	0	4.5	9	18	36	63	108	180	297	450
K-value	0	1	2	3	4	5	6	7	8	9

V. DATA

To comparing the K-indices data, itneeds two data obtained from the same period. And to determine the quantitative estimation of an algorithm accuracy requires the K-indices data from manual measurements on the classical magnetogram by a well-trained observer. In the case of

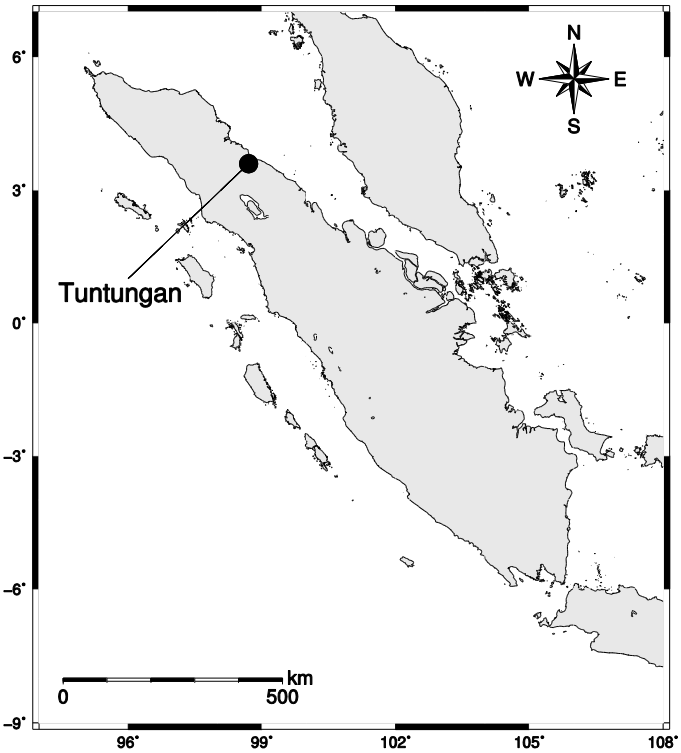

Fig. 1. Fig. 1. Location map of Tuntungan Geophysical Station

Tuntungan (TUN) observatories, the data from analog and digital magnetometer that operates at the same period is only at January until September 2010 minus July.

A. *Hand Scaled K-indices*

The analog variograph derived K-indices obtained from the variation amplitude of the horizontal component using a glass scale and the Solar Regular (S_R) variation must be eliminated. The analog variograph La Cour measures the HDZ component. These data are used as the reference data.

The lack of this data is there are alot of lost record data. These lost record are mostly caused by an error when washing the photographic paper in the dark room that made the paper to burn out. The other shortage is the K-indices was measured by different people that made the subjectivity level is relatively high.

B. *Computer Derived K-indices*

The digital fluxgate magnetometer LEMI-018 measures the XYZ component and has 1 second sampling rate and the resolution is 0.01 nT on each component. The measured range of total magnetic field at the display is ±65.000 nT and the temperature drift is less than0.2 nT/°C. To calculate the K-indices value using KAsm, the output text data from LEMI-018 must be converted into IMFV 1.22 format.

VI. METHOD

Reference [3] said that the problem in measuring the K-indices lies in how to identify the S_R variation ($S_R$for Solar Regular) in magnetogramwhich is the imagined curve for the day inquestion in quiet magnetic conditions. In the method called Adaptive Smoothing as in [4], the SR-curve is deduced from a least squares fit of one-minute values with an additional limitations on the second derivatives and with weight factors to make the influence of quiet periods greaterthan that of the disturbed ones. In the final algorithm, there are three free parameters to be adjusted (in reality, two of them are the same) for each observatory to achieve the best agreement with hand-scaled K-indices, two smoothing parameters and one involved in the definition of the weight factors.

The S_R is estimated through the minimization of the expression:

$$\min_{y_1,\ldots,y_n}\left\{\sum_{i=1}^{n} l_i^2\,(y_i-x_i)^2+\sum_{i=2}^{n-1}\lambda^2[(y_{i+1}-2y_i+y_{i-1})/h]^2\right\} \quad (1)$$

where λ is the smoothing coefficient, l=(l_i) (i=1,...n)are the weighting factors, x=(x_i) and y=(y_i) (i=1,...n) are the input (observed variations) and output (S_R);h=1, because the effect of h can be included inλ. The calculations are made with data series that represent 1 day with additional night weight (n=1440). The procedure has two steps. First, l_i=1 for i=1,...1440, and $\lambda=\lambda_1$. For every hour, differences between minimum and maximum values of (x-y) are calculated. Let V_j be these values (j=1,...24). In the second step, the procedure is used once more with the same smoothing factor λ_1, and the weights are defined as follows:

$$l_i = exp\left(1 - V_j/M\right) \quad (2)$$

where j=1,...24 and i=60(j-1)+1,...60j;λ_1 and M are the two parameters to be adjusted.

In this study, the K-indices data from the results of manually measurement abbreviated with K(HS) for hand scaled. While the K-indices data from the results of computer calculation abbreviated with K(ASM) for adaptive smoothing method. As in [5], in order to characterize the results obtained from the calculation method, we first compared the K(HS)and K(ASM) distributions for the whole data.We then studied the distribution of thedifferences using following formula:

$$DK = K(ASM) - K(HS) \quad (3)$$

where DK are the differences betweencomputer derived and hand-scaled K-indices. To illustrate the calculation results obtained from the ASm method, we make the plot of DK distribution. To determine the distribution pattern of DK toward the reference K-indices, DK is plotted against the K(HS) value. The last method is DK plotted against the time (in UT) with a 3-hour intervals to determine the pattern of the distribution.

VII. RESULTS AND DISCUSSIONS

All K-indices are showed at Fig. 2 and Fig. 3. K-indices from computer calculation results are plotted as blue bar, while manual measurement results are plotted as red bar. The values below zero line are the lost record data. It can concludes that there are alot of lost record data on both K-indices.

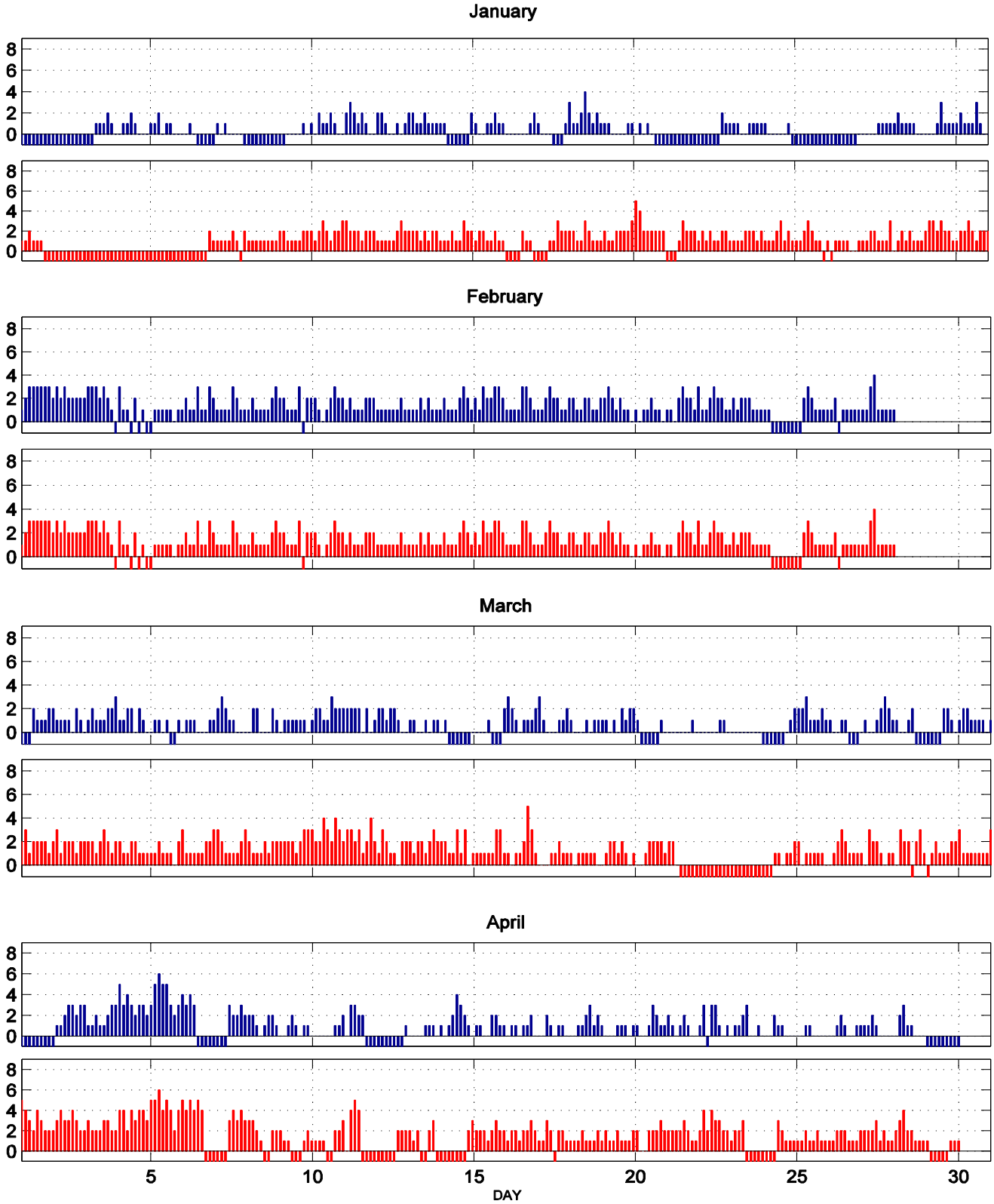

Fig. 2. K-indices in graphical form, January 2010 until April 2010. Blue bars are the computer calculation results while red bars are the manual measurement results. The values below zero line are the lost record data.

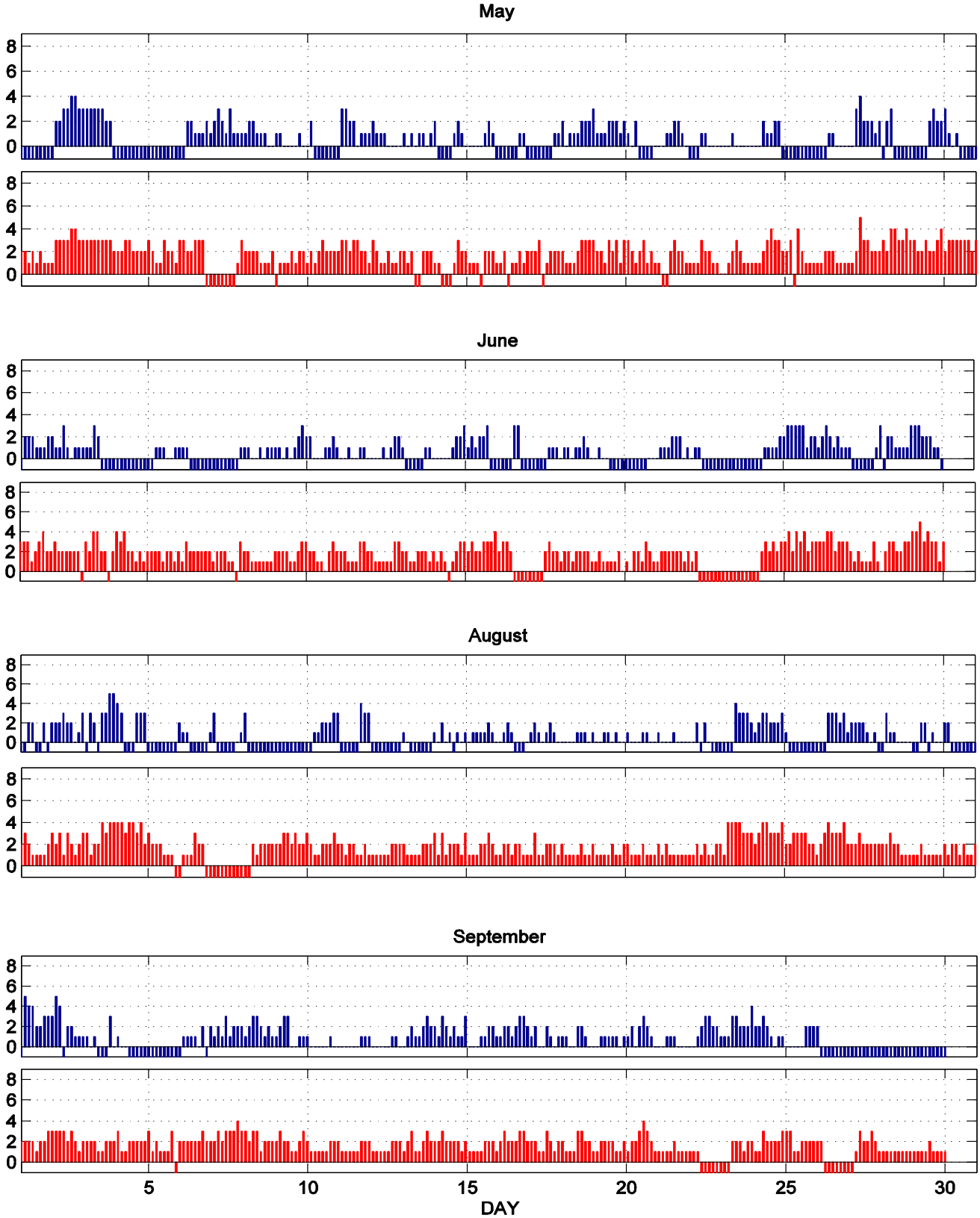

Fig. 3. K-indices in graphical form, May 2010 until September 2010 minus July 2010. Blue bars are the computer calculation results while red bars are the manual measurement results. The values below zero line are the lost record data.

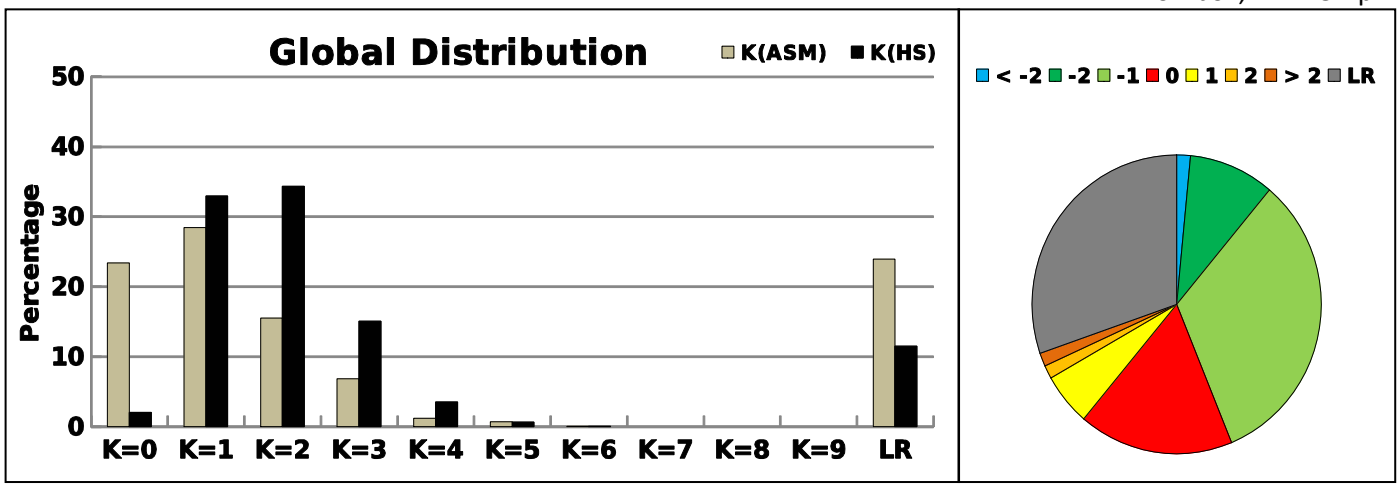

Fig. 4. Left: distribution of K-indices from manual measurement results and from computer calculation (LR is Lost Record data).Right: distribution of DK.

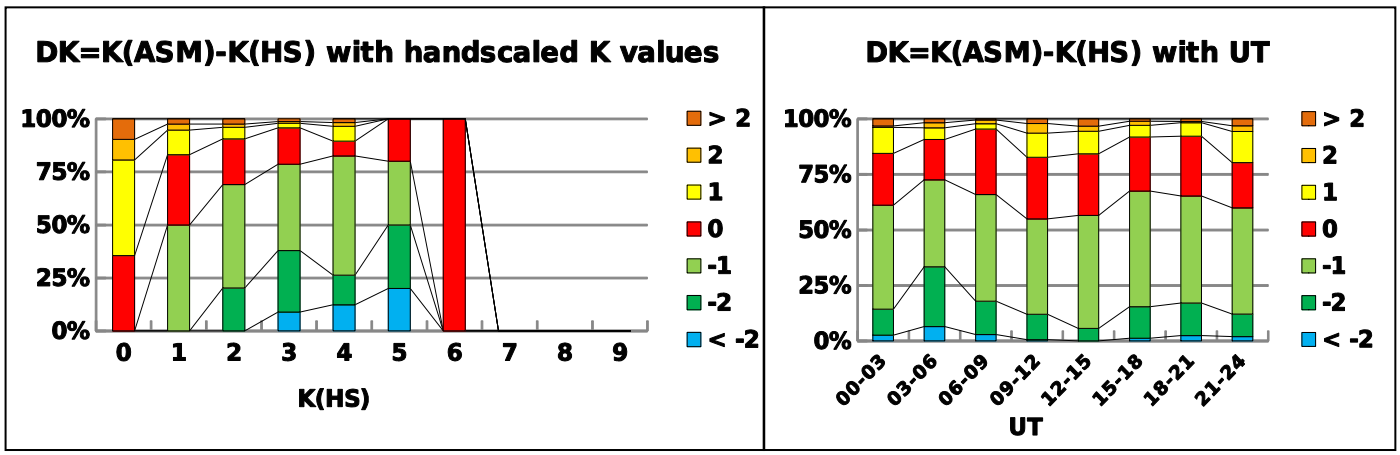

Fig. 5. Left: Distribution of DK with handscaled K values. Right: Distribution of DK with UT.

A. *Global K-indices Distribution*

Fig. 4 shows the distribution of K-indices from manual measurement results and from computer calculation.Overall, the maximum percentage of K(HS) is at K=2 and K(ASM) is at K=1. The difference of maximum percentage is probably caused by a false reading of the scale by observer. Also it mustbe considered that the percentage of the lost record data are relatively high and it will certainly affect the final result.

Fig. 4 also shows the distribution of difference value DK = K(ASM) – K(HS) or difference between K-indices from computer calculation results and manual measurement results. Overall, the percentage of K(ASM) and K(HS) which has equal value or DK=0 is 17%, while the DK is equal or greater than ±2 is 15% with 30% of missing data.

B. *Hand-scaled KValue Dependance*

Fig. 5 shows the distribution of DK value against the reference K-indices (K(HS)). The percentage of manual measurement K-indices which has the same value (DK=0) with the computer calculation K-indices varies on K=0-6 respectively 28%, 26%, 17%, 14%, 6%, 17%, and 100%. In this figure, the lost record data are not included in the graphic.

C. *UT Dependance*

Fig. 5 also illustrates the distribution pattern of DK value against time (in UT) in 3-hour intervals. The percentage of DK=0 against UT varies between 13% to 21%. K-indices varies from 00-24 UT with 3-hour interval respectively 15%, 13%, 21%, 21%, 20%, 17%, 18%, and 13%. In this figure, the lost record data also not included in the graphic.

VIII. Conclusion

The conclusions of this study can be summarized as follows: (1) there are some differences between K-indices from computer calculation results and the manual measurement results. This is likely due to error measurement by observer; (2) The accuracy of Adaptive Smoothing Method in K-indices calculation is not high enough in this study, but that must be considered is the high number of the loss record data.

References

[1] S.J. Reay, E. Clarke, and B. Hamilton, " First steps towards K indices from South Atlantic Observatories: Port Stanley Observatory", Data Science Journal, Volume 30, 2011.

[2] M. Menvielle, T. Iyemori, A. Marchaudon, and M. Nosé,"Geomagnetic indices," inGeomagnetic Observations and Models, IAGA Special Sopron Book Series 5, M. Mandea and M. Korte, Eds. DOI 10.1007/978-90481-9858-_8,SpringerScience+BusinessMediaB.V.2011.

[3] J. Jankowski, and C. Sucksdorff, " Guide for magnetic measurements and observatory practice", IAGA, Warsaw, 1996.

[4] M. Menvielle, N. Papitashvili, L. Häkkinen,and C. Sucksdorff, "Computer production of K indices: review and comparison of methods", Geophys. J. Int. 123, 866-886, 1995.

[5] M. Bitterly, M. Menvielle, J. Bitterly, and A. Berthelier, "A comparison between computer derived (FMI method) and hand scaled K indices at Port Aux Francais and Port Alfred French Observatories", ISGI, 1997.