New *K*-Indices From South Atlantic Observatories: Port Stanley And Ascension Island

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Introduction

Port Stanley and Ascension Island magnetic observatories have been in continuous operation since the early 1990's. These remote South Atlantic locations provide much needed coverage in the global network of geomagnetic observatories and help to monitor the South Atlantic Anomaly. To enhance the production of longitude-sector planetary magnetic activity indices there is a requirement for local 3-hourly *K*-index values from Port Stanley (PST) observatory. We describe the process followed to establish an automated routine for the derivation of the indices and we assess the congruence of the indices to those available from other suitably located observatories. A similar procedure has been followed for Ascension Island observatory although this is not shown here.

Method

The 3-hourly *K* index is a range index denoted by a single digit code from 0 to 9. The code corresponds to the class in which the greater of the two Horizontal component ranges falls.

0	1	2	3	4	5	6	7	8	9
0	3	7	13	26	46	79	131	216	328

Table1: The lower limits for each PST *K* class. The *K*=9 lower limit (now supplied by ISGI) is derived from the angular distance between the observatory and the auroral oval and the rest are proportional to those defined for Niemegk (Bartels et al, 1939).

Before calculating the range in any 3-hour period it is first necessary to remove the regular daily variation Sr. The algorithm used as the basis for determining this at the BGS UK observatories (Clark, 1992) is the IAGA sanctioned Nowozynski et al (1991) adaptive smoothing method. For BGS overseas observatories we adopt this same algorithm. Daily Sr (denoted by y_i) is found by minimising the expression:

$$\min \left[\sum_{i=1}^{1440} \lambda_i^2 (y_i - x_i)^2 + \sum_{i=2}^{1439} (y_{i+1} - 2y_i + y_{i-1})^2 \right]$$

where x_i denotes the minute mean values of *H* or *D*. The first term represents the fit of *y* to *x* and the second term represents the curvature of the estimated Sr variation. The relative importance of the two terms is altered by changing the values of λ^2.

The implementation of the algorithm for PST is as determined by Clark (1992). First a preliminary Sr curve is fitted using λ^2. If, in any 3-hour period, the preliminary *K* is greater than a threshold, λ^2 is decreased during a second run (λ_u^2). Thus the estimated Sr will not follow large irregular disturbances. Also, if the preliminary *K* exceeds a second threshold, the Sr curve is ignored and only the range (max-min method) is used to compute the final *K*. Clark observed that when comparing computed *K* to hand-scaled *K* the algorithm required further adjustment to reduce bias in season and UT. Hence weighting factors for these were also introduced for the UK observatories.

Determining an 'ideal' Sr curve

For PST we had no hand-scaled *K*-indices to help judge the correct λ^2 and weights to use in determining *K*. We explored the idea of producing an 'ideal' Sr curve to help compare with the Sr produced by the algorithm.

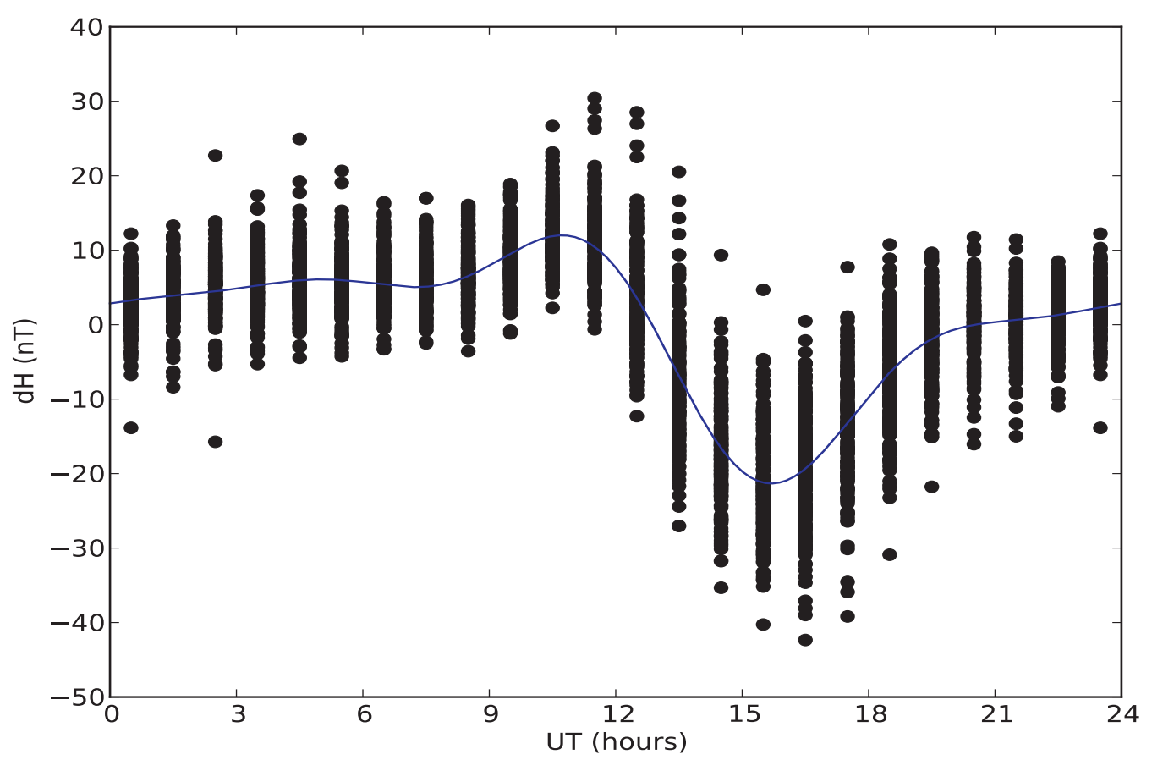

Figure 1: 'Ideal' Sr curve for PST Horizontal component (*H*) for equinoctial months (Mar, Apr, Sep, Oct)

The mean daily variation curves were derived from all available Port Stanley hourly mean data over one solar cycle (1998-2009). Data from the five international quietest days in each month were individually de-trended and mean-subtracted. It was then grouped by southern hemisphere seasons: summer (Jan, Feb, Nov, Dec), equinoctial (Mar, Apr, Sep, Oct) and winter (May, Jun, Aug, Sep). These data were then used to derive a Fourier model for each component and season with 24, 12, 8, and 6 hour coefficients.

Determining λ^2 : Adaptive Fitting of Sr

We first produced *K* for a variety of λ^2 with no weighting. It was clear that the 'ideal' curve was not helpful for selecting the best λ^2 as there was too much variation day-to-day in Sr. A trial and error approach was therefore used.

We examined many quiet-day magnetograms in equinoctial months and selected first λ^2 and then λ_u^2. The threshold for λ_u^2 was set at *K* > 0 following Clark (1992). Then we examined the computed Sr and corresponding *K* during daytime hours and judged the appropriate weights for each 3-hour period. The seasonal weights were found in a similar way.

Thresholds of K>4 and K>5 were investigated for switching to the max-min method. Optimum parameters were selected for further analysis.

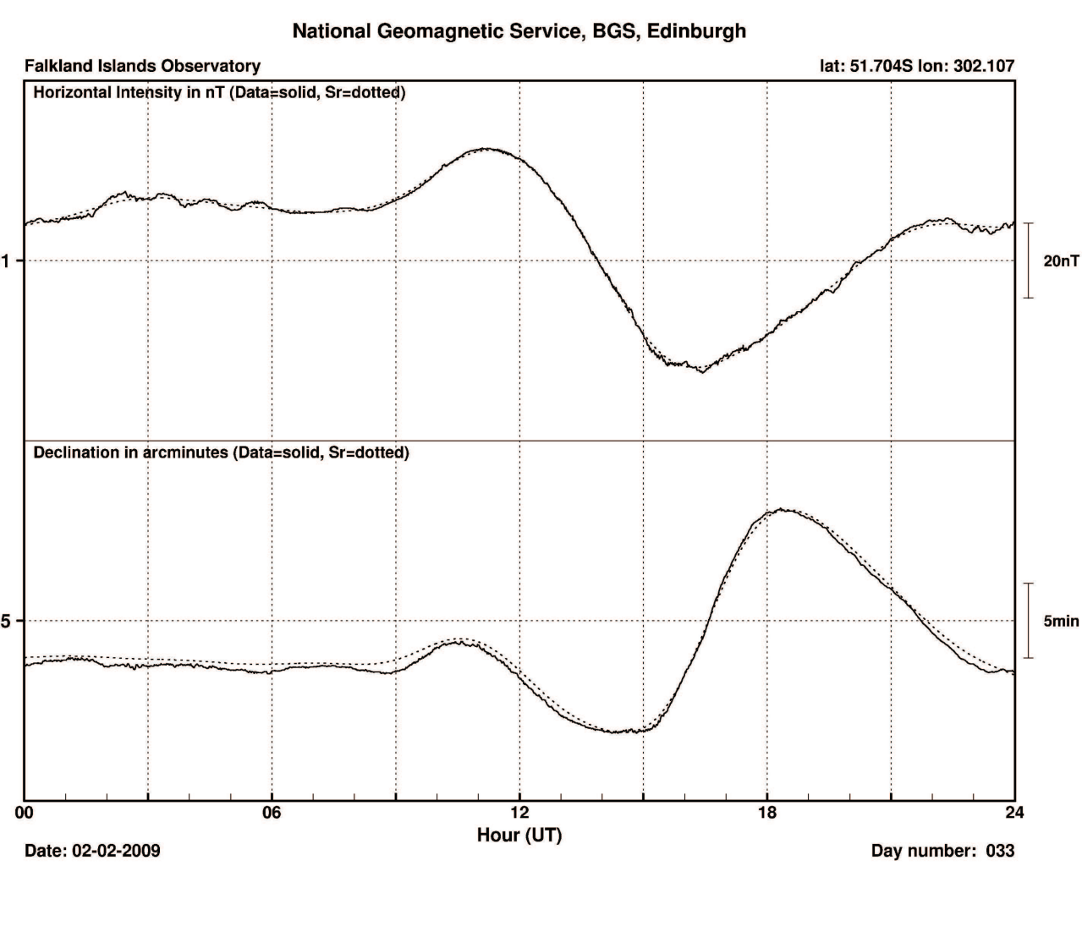

Figure 2: Example magnetogram for a quiet day showing Sr curve (dotted line) fit to the D and H data from Port Stanley.

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Analysis of *K*-indices

To assess if the parameters selected are appropriate, and in the absence of any hand-scaled indices, we have compared PST *K* to other observatories. We used observatories of similar geomagnetic latitude to test if the distribution of PST *K* is as expected and those of a similar time zone to assess the UT and seasonal weightings.

Name	Code	Geographic Coords		Corrected Geomagnetic Coords*		Lower K9-Limit (nT)	Time zone UT
		Latitude	Longitude	Latitude	Longitude		
Port Stanley	PST	-51.70	302.11	-38.78	10.43	328	-4
Tuscon	TUC	32.17	249.27	39.67	315.37	350	-7
Bay St.Louis	BSL	30.35	270.36	40.91	341.38	350	-6
Hermanus	HER	-34.42	19.23	-42.45	83.23	300	-23
Gnangara	GNA	-31.80	116.00	-43.88	187.51	450	-16
Canberra	CNB	-35.32	149.36	-45.36	227.13	450	-14
Trelew	TRW	-43.24	294.68	-30.24	4.80	286	-4
Argentine Islands	AIA	-65.24	295.74	-50.57	9.13	500	-4
Hartland	HAD	51.00	355.52	57.89	80.24	500	0

Table2: List of the observatories used in this analysis. We chose those which were similar in geomagnetic latitude or time zone.
*Corrected geomagnetic coordinates calculated from IGRF for 2010.0

Analysis: Similar Geomagnetic Latitude

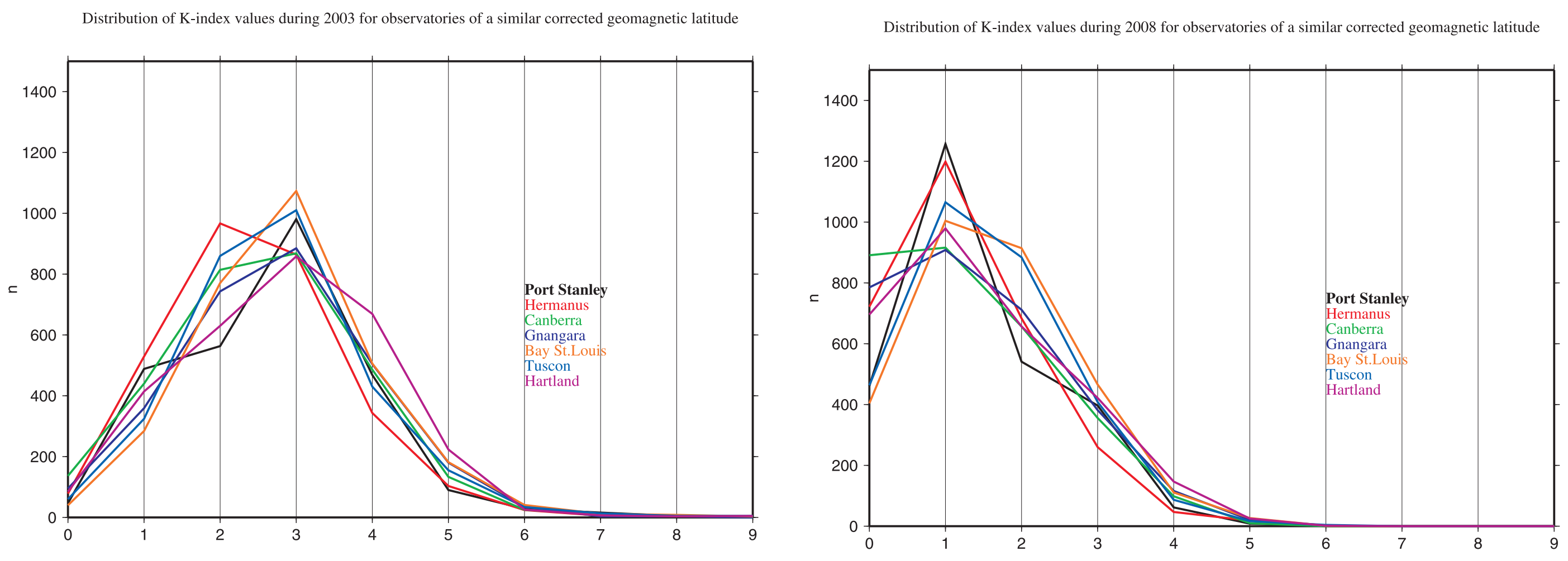

Figure 3: Distribution of K values for a geomagnetically active (2003) and quiet (2008) year for a number of observatories at similar geomagnetic latitude. Port Stanley is in **black**.

Looking at the distribution of PST to the other selected observatories it appears that *K*=0,2,4 are too low and *K*=1,3 are too high. In particular the distribution of *K*=1, *K*=2 needs improvement. However it is worth noting that there is generally an increased variation between the observatories at *K*<4.

Analysis: Similar Time Zone

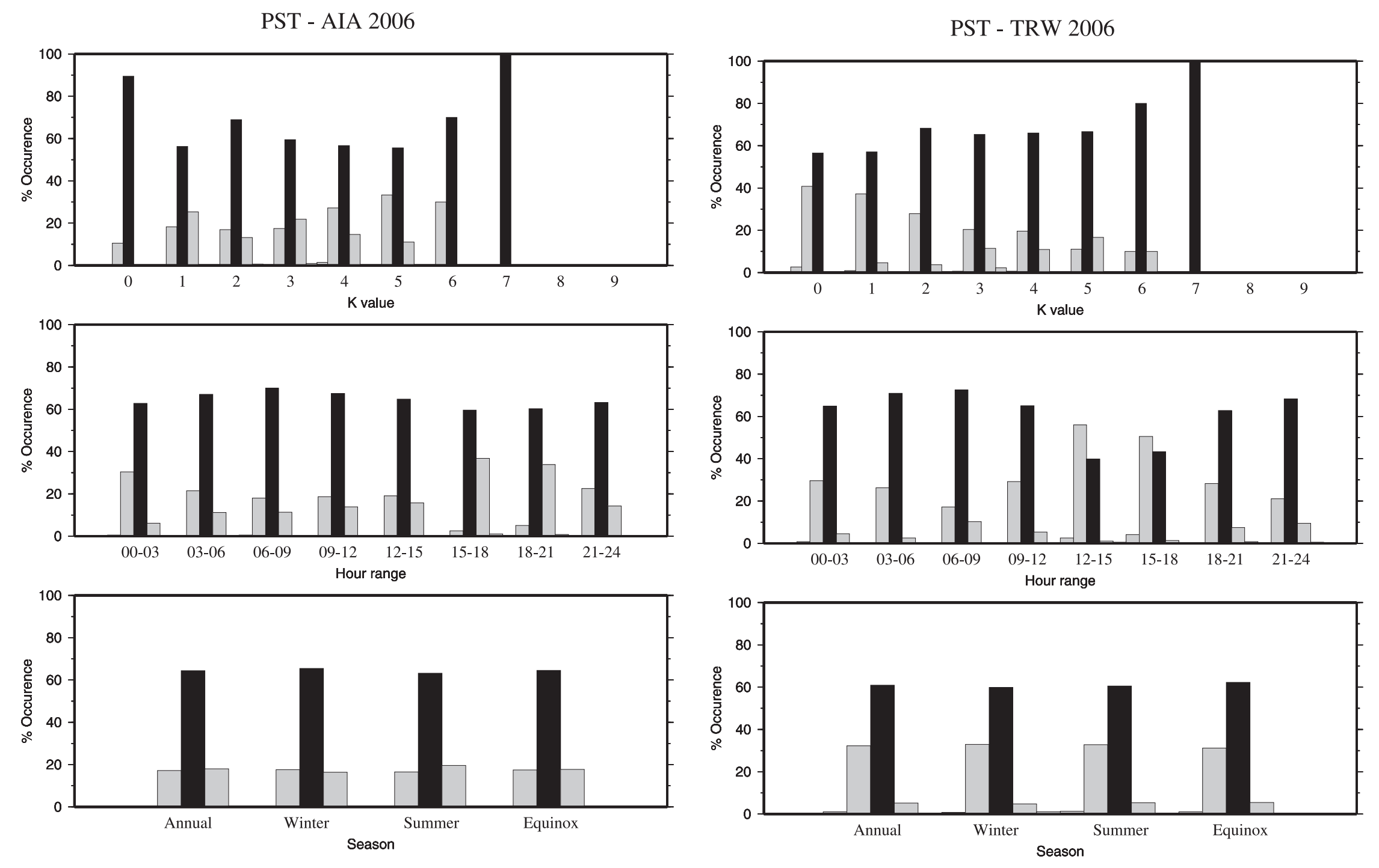

Figure 4: Comparison of difference between nearby observatories (PST-AIA and PST-TRW) for 2006. The histograms show the % occurrence that the two sets of indices agree and % occurrence that they differ by -2, -1, +1, +2 index values. The top panel shows the comparison for the whole year, the middle panel is as a function of the eight 3-hour segments and the bottom is as a function of season.

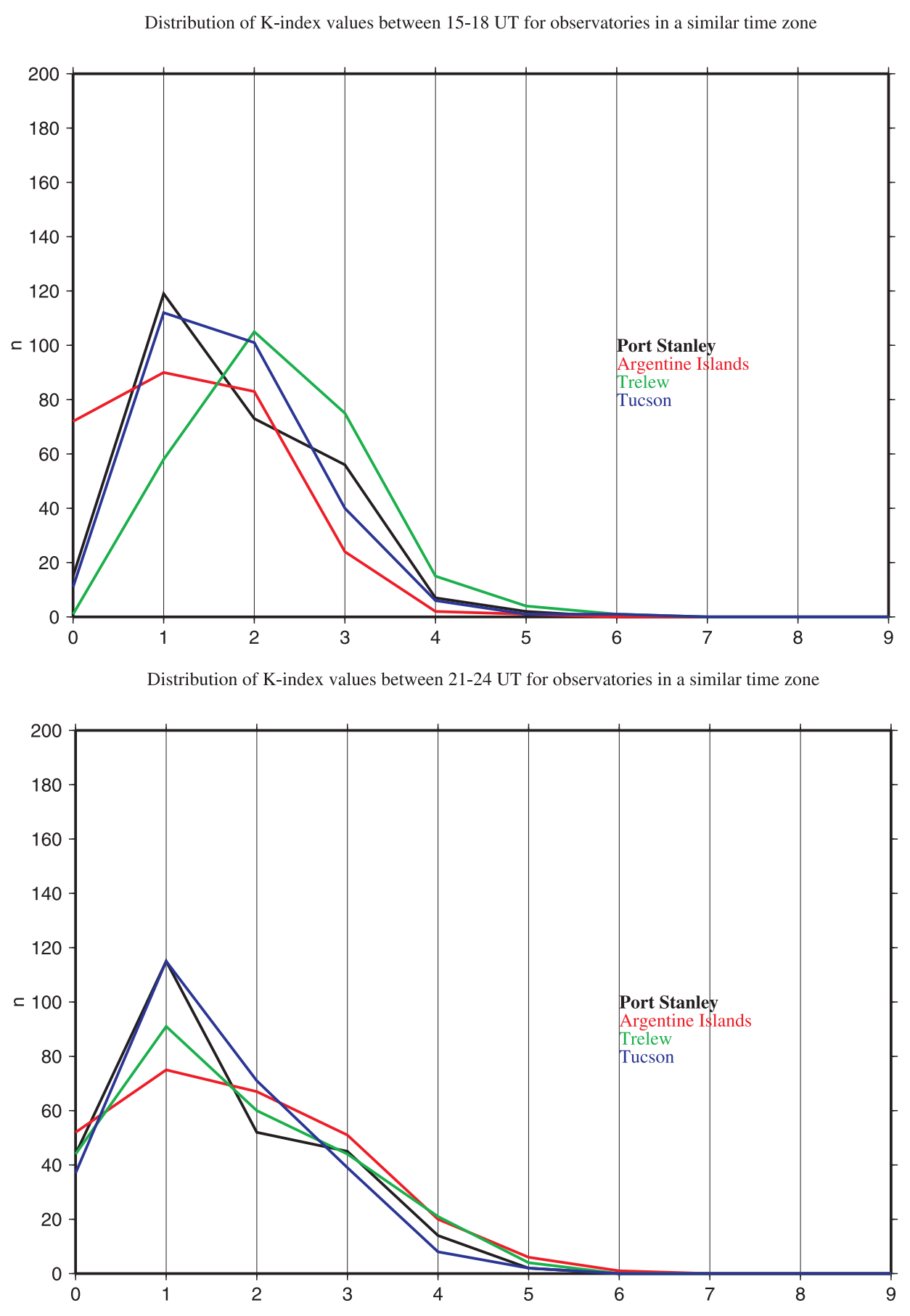

Figure 5: Distribution of K-indices by 3-hour time segment for UT-similar observatories for 2004-2007. The top chart show poorer correlation during day-time (15-18 UT). The bottom chart shows better correlation during night-time (21-24UT).

Direct comparison of individual indices with those from TRW and AIA is useful in determining if there are any unexpected biases in the PST indices. Overall the fit to both appears to be reasonably good. However, the PST indices are more often less than those at TRW, which is not expected, since TRW is located to the north of PST. This bias is more pronounced for *K*<4, indicating a possible over-fitting of the Sr curve. Overall there is no bias between the AIA and PST indices; however there is a clear bias during UT periods 15-18 and 18-21. This is in the opposite sense expected, since AIA is to the south of PST, so further investigation is required.

Conclusions and Future Work

Automatic derivation of PST *K* indices is now possible and the values produced are a reasonable match to the published indices from the two nearest observatories. In addition, the occurrence distribution of the PST *K* indices is comparable to those observed at other sites where geomagnetic activity levels are likely to be similar.

This is work in progress with further adjustments to the algorithm parameters required. In particular it should be possible to improve:

- The distribution curves at *K*=0,1,2 by modification of λ^2 and λ_u^2
- The distribution curves at *K*=3,4,5 by modification of the max-min threshold
- The UT weights by further analysis with observatories in the same time zone

Once we have determined the final parameters, the *K* indices will be computed from 1994 (PST) and from 1992 (ASC) and made available on-line.Currently the algorithm requires data over a full UT day without any gaps. Further improvements are planned to adapt it to work with data in real time using the previous 24 hours and to enable it to handle short gaps in the data.

References

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