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 equally 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.

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 $y$) is found by minimising the expression:

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

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 $\lambda^2$.

The implementation of the algorithm for PST is as determined by Clark (1992). First a preliminary Sr curve is fitted using $\lambda = 1$. If, in any 3-hour period, the preliminary $K$ is greater than a threshold, $K$ is decreased during a second run ($\lambda = 2$). 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 to observed Sr, the Sr curve is ignored and only the range (max-min method) is used to compute the final $K$. This was done to handle short gaps in the data.

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

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 used in the Sr algorithm. The Sr curve was then used to derive the Sr for each 3-hour period and season with 24, 12, 8, and 6 hour coefficients.

Determining $\lambda^2$: Adaptive Fitting of Sr
We first produced K for a variety of $\lambda$ without weighting. It was clear that the ideal curve was not helpful for selecting the best $\lambda$ 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 $\lambda = 1$ and then $\lambda = 2$. The threshold for $\lambda = 2$ 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.

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.

Analysis: Similar Geomagnetic Latitude
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
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 are possible.

- The distribution curves at $K=0,1,2$ by modification of $\lambda^2$ and $\lambda^3$
- 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 to enable it to handle short gaps in the data.

References
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