TWINS Equatorial Pitch Angle Anisotropy

The deconvolved ion pitch angle anisotropy is defined as [*Chen et al.* 1998]

$$A = \frac{I_{\perp} - 2I_{||}}{I_{\perp} + 2I_{||}}$$

where

$$I_{\perp} \equiv \int_{-1}^{1} f_{eq} \sin^2 \alpha \, d(\cos\alpha) \quad \& \quad I_{||} \equiv \int_{-1}^{1} f_{eq} \cos^2 \alpha \, d(\cos\alpha)$$

where the I ($I_{||}$) emphasize the perpendicular (parallel) part of the pitch angle distribution, f_{eq} is the ion distribution function at the minimum magnetic field position along the field line (e.g., the SM equator for dipole field lines), and α is the ion pitch angle. Using this definition, a field-aligned distribution corresponds to 1, a perpendicular distribution corresponds to +1, and an isotropic distribution corresponds to 0. It should be noted that sometimes there are strongly nonisotropic distributions observed in small regions which correspond to areas with very low ion intensity and are not valid. These areas are shown in white. Iso-contours of the anisotropy are in red with the black line for 0.0 or isotropic pitch angle distribution.

The technique used to extract the equatorial ion pitch angle distributions from the ENA images is described in Appendix A of *Perez, et al.* [2012]. In this method, the ion equatorial pitch angle distribution is expanded in a linear combination of tri-cubic splines [*deBoor*, 1978]. The expansion coefficients are then obtained by minimizing a combination of normalized chi-squared and a penalty function derived by *Wahba* [1990]. Requiring that normalized chi-squared is near unity ensures that the resulting distribution fits the data. Including the penalty function in the minimization ensures that the result is as smooth (in the sense of a minimum second derivative) as is consistent with fitting the data. In this procedure, spatial structure is minimized and appears in the result only to the extent that it is necessary. Thus, while there may be more and smaller scale structure that is not resolved, the structure that is found is statistically required to fit the data, i.e., match the ENA images.

The uncertainties in each pixel of the ENA image are a statistical measure of the information content of the data. The second moment of the 15-16 individual sweeps is used to estimate the uncertainties in each pixel of the time-integrated image.

In order to deconvolve the ion distributions, magnetic field mapping is required. For this study the *Tsyganenko and Sitnov* [2005] magnetic field model was used. The density of neutral hydrogen, i.e., the geocorona, is also needed. The TWINS exospheric neutral hydrogen density model was used *[Zoennchen, et al.* 2013]. To include the LAEs (Low Altitude Emissions), the thick target approximation of *Bazell et al.* [2010] was used.

References:

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