Geophysical Research Abstracts, Vol. 8, 07560, 2006
SRef-ID: 1607-7962/gra/EGU06-A-07560

The Instantaneous Local Wave Vector Analysis Technique

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In order to properly observe wave field phenomena it is crucial to have multipoint measurements. This is because only by sampling the wave field at various spatially separated points is it possible to unambiguously measure both the frequency and the full wavenumber vector of a wave field. Due to its importance it is not surprising that many techniques exist to estimate these crucial wave characteristics. However, the existing techniques either assume that the wave is stationary (Fourier transform techniques), or that the waves have some particular form over all scales (wavelet transform techniques). In practice these assumptions are often not valid in space physics data which is often highly nonstationary and the wave process is often not the same over all scales. To tackle these problems, we have introduced the concept of the instantaneous local wave vector (ILW) and have developed an algorithm for computing it. The ILW analysis is a generalization of the instantaneous frequency used in signal processing to the case of multi-spatial-point data. The ILW vector concept is particularly useful in the analysis of coherent waves in space physics. We provide examples of how ILW analysis works by applying it to electric field data from the Cluster-II space mission, which is the first space mission for which direct determination of the full 3-dimensional wave vector is possible.