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Volume 28, 2007 - [Issue 12](#)

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# Stabilizing high-order, non-classical harmonic analysis of NDVI data for average annual models by damping model roughness

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Pages 2801-2819 | Received 05 May 2006, Accepted 06 Jul 2006, Published online: 29 May 2007

Cite this article <https://doi.org/10.1080/01431160600967128>

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## Abstract

Fourier series and related harmonic methods have been demonstrably effective for identifying and characterizing the seasonal behaviour, or phenology, of a variety of terrestrial vegetation communities using Normalized Difference Vegetation Index (NDVI) time series from Earth-orbiting satellites. The ultimate temporal resolution of such applications has been limited, however, by the common practice of truncating, or low pass filtering, harmonic series to relatively low order terms, in order to suppress spurious oscillations in the model results. The temporal resolution of these techniques can be significantly improved if, along with a weighted minimization of the sum of the squared data residuals tracking the upper envelope of observed data, we also enforce an expectation of minimum model roughness to dampen spurious oscillations in predicted values. The resulting annual models have resolutions consistent with the

application of special transcendental forms, such as asymmetric Gaussian and logistic (sigmoidal) functions, recently reported in the literature.

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## Acknowledgments

This work was developed over several years of interacting and constructive discussions with Bethany Bradley and Rob Jacob, both recent recipients of PhD degrees from Brown University. Professor Jack Mustard generously supplied the AVHRR-NDVI data and the hospitable venue in which this work was possible. Financial support was provided by Brown University and private sector partners with its Environmental Geophysics/Hydrology group.

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