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Statistical analysis of oceanographic fields observed on irregular grids with data gaps

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A characteristic feature of oceanographic satellite observations is an irregular sampling in both time and space, additionally aggravated by data gaps - e.g., due to clouds or data outages. In some cases, data gaps are created intentionally in order to eliminate time intervals during which physical constraints important for a specific research problem are violated. One example is magnetic field measurements used for analysis of variations induced by geophysical or oceanographic processes. Observed variations of the magnetic field during daytime hours are "contaminated" by ionospheric sources. Hence, only night-time data can be used. As we demonstrate, accurate estimates of power spectra and even higher-order statistical moments are still possible, although standard techniques, such as fft, are inapplicable. Our approach starts with an unbiased estimation of covariance and/or structure functions on a regular (sufficiently coarse) grid of spatio-temporal lags. These functions ultimately allow estimation of power spectra and higher-order statistics using optimization techniques. Practical examples include 2D and 3D spectra of sea surface height (SSH) variations measured by satellite altimeter, 2D spectra of chlorophyll (Chl-a) concentration from SeaWiFS and MODIS data, 1D spectra of magnetic field variations using night time measurements, and basic parameters of multifractal models of SSH and Chl-a fields' variability. Successes and limitations of the approach are discussed.