Multivariate spatial field data are increasingly common and whose modeling typically relies on building cross-covariance functions to describe cross-process relationships. An alternative viewpoint is to model the matrix of spectral measures. We develop the notions of coherence, phase and gain for multidimensional stationary processes. Coherence, as a function of frequency, can be seen to be a measure of linear relationship between two spatial processes at that frequency band. We use the coherence function to illustrate fundamental limitations on a number of previously proposed constructions for multivariate processes, suggesting these options are not viable for real data. We also give natural interpretations to cross-covariance parameters of the Matérn class, where the smoothness indexes dependence at low frequencies while the range parameter can imply dependence at low or high frequencies. Estimation follows from smoothed multivariate periodogram matrices. We illustrate the estimation and interpretation of these functions on two datasets, forecast and reanalysis sea level pressure and geopotential heights over the equatorial region. Examining these functions lends insight that would otherwise be difficult to detect and model using standard cross-covariance formulations.