Title：
Frequency domain approach in spatio-temporal data analysis

Abstract
We study the irregularly spaced data by Continuous-time Autoregressive and Moving Average (CARMA) random fields. We extended the univariate CARMA random fields to a multivariate version and develop a spectral approach in estimation and kriging. Next, we regard spatial data as square-integrable function-valued random variables and construct a regression model for spatio-temporal data by a bounded linear operator on L2(R2), which is a Functional regression model. In functional regression models, both dependent and independent variables are function-valued, which is regarded as a functional extension of regression models. In this study, we employ the CARMA kernel function, which is a convolution operator rather than the Hilbert Schmidt operator, the straightforward extension of the regression coefficient. We propose a frequency domain approach to estimate parameters that can overcome typical difficulties in spatial data analysis, including irregularly spaced observation locations with huge sample sizes, lots of NAs, and so on. We clarify the asymptotic regime under which the estimator is consistent and asymptotic normal, as asymptotic for spatial data is not trivial at all unlike time series one. We apply our functional regression to the spatial dataset of US weather data to predict the precipitation of the US, and both New York Times report and NTT Docomo human mobility survey in order to examine the COVID-19 pandemic in the US and Japan.