Draft Course: Machine Learning for Geosciences

Module 1: Statistics for spatio-temporal data [5 hours]

1 hour: Review of basic statistics: parameter estimate, inference

1 hour: Spatial and temporal autocorrelation, spatial interpolation/kriging.

1 hour: Hierarchical modelling with spatial data including latent variables

1 hour: Gaussian spatio-temporal process. Spatio-temporal point processes and dynamic spatial models.

1 hour: Markov Random Fields.

Module 2: Spatio-temporal Data Mining [5 hours]

1 hour: Missing value prediction (isolated and en bloc)

1 hour: Spatio-temporal pattern mining, spatial segmentation and change-point detection

1 hour: Anomaly detection in spatio-temporal data (including MRF approach)

1 hour: Modeling of extreme events

1 hour: Correlation and event-synchronization networks

Module 3: Machine Learning for Hydrology [5 hours]

2 hours: Important problems in hydrology: groundwater level prediction, stream flow prediction. Tackling the above problems using SVM. [Guest lecture: Dr. Rajib Maity]

1 hour: Modeling of daily, monthly, annual precipitation at different scales.

1 hour: Stochastic rainfall generator.

1 hour: Statistical downscaling of rainfall [Guest lecture: Dr. Sudeshna Sarkar]

Module 4: Machine Learning for Climate Informatics [12 hours]

1 hour: Predictor selection for forecasting

1 hour: Causality Analysis for attribution, Causal graphs and Granger causality

1 hour: Attribution of specific extreme events in recent times

1 hour: Hurricane/cyclone path analysis and prediction

1 hour: Heat wave and drought discovery using Markov Random Field

3 hours: Indian Monsoon – characteristics and main challenges, annual rainfall forecasting [guest lecture: Dr. Pabitra Mitra], spatial pattern and anomaly discovery

1 hour: Identification of teleconnections

2 hour: GCM and RCM simulations: can Machine Learning improve them? [Guest lecture: Dr. Amey Pathak]

1 hour: Identifying climate change from change-point detection in time series

Module 5: Machine Learning for Environment Monitoring [3 hours]

2 hour: Lake surface temperature monitoring (Vipin Kumar et al)

1 hour: Air pollution monitoring prediction

Module 6: Machine Learning for Remote Sensing [6 hours]

1 hour: Review of CNN, U-Net for Image segmentation

1 hour: Segmentation of satellite images for Land-use and Land-cover classification

1 hour: Identification of extreme climatic events from satellite images

1 hour: Dynamics of vegetation/LULC change from satellite image sequence (using RNN)

2 hours: Challenges of ground-water monitoring, Satellite-based vegetation index to estimate ground-water [Guest lecture: Dr. Abhijit Mukherjee]

References: https://github.com/treigerm/WaterNet, https://github.com/TUM-LMF/fieldRNN