Modelling Climate Properties Using Intelligent Machine Learning Models: Applications to Hydrology and Water Resources

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Abstract: Climate prediction based on rainfall, temperature and evaporation is beneficial for mitigating adverse consequences on water-sensitive sectors such as agriculture, ecosystems, wildlife, tourism, recreation, crop health and hydrologic engineering. Predictive models help in assessing water scarcity situations, drought identification and severity characterization.

Climate parameters may be forecast from physical models (based on interactive behaviour of ocean, atmosphere, sea ice and land surface), and statistical or machine learning data-driven models that assimilate trends in observed climatic parameters (e.g. rainfall), climate indices and sea surface temperatures to make future projections. While physical models provide reliable forecast for ancillary atmospheric variables like temperature, they are less reliable for rainfall-related parameters. Thus the development of robust models, capable of producing improved predictions as alternatives to physical models, would potentially increase confidence in rainfall projections, hence assisting agriculture and sustainable development.

Data-driven models utilize machine learning algorithms and mathematical equations that are not based on physical processes of the ocean, atmosphere or sea ice as with dynamic models but instead employ data sets to deduce relationships between climatic predictors (inputs such as climate indices and data) and objective variables (outputs).

The development of robust predictive drought models that are alternatives to physical models is desirable for improving confidence in rainfall projections, assisting agriculture and sustainable development. This project will use the Australian Water Availability Project (AWAP), freely available from the CSIRO. Rainfall, temperature, evaporation and soil moisture will be used to develop methods to assess drought and heatwaves, for which predictive models will be developed. The study area will be the drought-prone, agricultural intensive region in eastern Australia.

In this study, we consider:
1) Traditional linear models, such as ARIMA (auto regression moving average) and multi-linear regressions, and the comparison of the performance of these models with modern generation machine learning models that use linear and non-linear predictive capabilities.
2) Demonstrate the application of newest models, such as ELM (extreme learning machine) and SVM (support vector machines) for prediction of climate behaviour.

Keywords: *Machine learning, climate model, ARIMA, ELM, SVM, drought, forecast*