

Machine learning based nowcasting of precipitation in Estonia

Summary

Nowcasting is an important and integral part of operational weather services spanning weather monitoring, road weather warnings, aviation applications etc. The explosive growth of artificial intelligence applications in recent years opens new opportunities for integrating multiple data sources and development of predictive systems for nowcasting operations. The aim of the project is to develop and test deep learning methods to enhance quality of nowcasting predictions over Estonia. The primary focus of the project is on enhancing the quantitative precipitation forecast skill based on the application of remote sensing data which will be complemented with data from traditional ground observations and numerical weather prediction models.

Research field:	Earth sciences
Supervisors:	Sander Rikka Aarne Männik
Availability:	This position is available.
Offered by:	School of Science Department of Marine Systems
Application deadline:	Applications are accepted between June 01, 2024 00:00 and June 30, 2024 23:59 (Europe/Zurich)

Description

Application of deep learning methods for various task in environmental and atmospheric science has recently grown explosively. Deep learning methods have a great potential to contribute to problem solving in all levels of typical operational environmental prediction chain spanning data acquisition, data analysis, forecast computations, physical parameterizations, model validation and dissemination to end users. Nowcasting as a methodology of weather monitoring and short term (up to 12 hours) weather forecasting has long been difficult for numerical weather prediction models due to computational speed constraints and specifics of assimilation systems not involving cloud moisture and cloud water parameters and difficulties of initialization. Traditional remote sensing and advection simulation techniques have had difficulties with representing physics of evolution of such systems. Machine learning may offer here possibilities of integrating multiple data sources and representing spatio-temporal patterns as a potential way forward and increased skill of such a predictive system.

The aim of the project is to develop and test machine learning methods to enhance quality of nowcasting predictions over Estonia. The primary focus of the project is on enhancing the quantitative precipitation forecast skill based on the application of remote sensing data which will be complemented with data from traditional ground observations and numerical weather prediction models.

The thesis should address the following questions: 1) What are the typical situations leading to precipitation events over Estonia and can we distinguish regional-temporal patterns in precipitating systems? 2) Can machine learning methods reliably represent the evolution of precipitation within time frame of 12 hours? 3) what is the most reliably model input configuration for reliable nowcast? 4) What are the characteristics and options for running such a system operationally? 5) Can such a system outperform traditional nowcasting and numerical weather prediction methods?

Responsibilities and (foreseen) tasks

- Processing of weather radar, satellite reprocessed data and model reanalysis to create a first iteration of a dataset for pattern recognition and machine learning methods. A specific task is to ready dataset which encompasses local situational awareness and connects it with the wider synoptic scale situation.
- Finding the most optimum input dataset for selected machine learning method that resolves the precipitation forecast. The task would include experiments with various data (satellite, ground based measurements, numerical models) and data fusion techniques.
- Implementation, testing and validation of the different clustering algorithms for the categorization of the convective weather events in Estonia with contributing studies correlative and covariate relationships between selected parameters.
- Selection, testing, validation and application of deep machine learning models for the nowcasting of the quantitative precipitation in Estonia. Evaluation of the predictions, improvement and finalisation of the models.

- Investigate potential relationships of the nowcasting system to an emerging high resolution Digital Twin
- Preoperational implementation of the machine learning model for the precipitating weather.

Applicants should fulfil the following requirements:

- a master's degree in natural sciences (preferably atmospheric physics, remote sensing, physics or mathematics, computer science)
- a clear interest in the topic of the position
- excellent command of English
- strong and demonstrable writing and analytical skills
- capacity to work both as an independent researcher and as part of an international team
- capacity and willingness to provide assistance in organizational tasks relevant to the project

(The following experience is beneficial:)

- Meteorology and atmospheric physics
- Programming in Python, Fortran
- Working knowledge of environmental data formats, NetCDF, GRIB, HDF
- Working knowledge of statistics
- Working under UNIX type operating system and scripting skills

The candidate should submit a personal vision of detailisation of a first task in the research description.

We offer:

- 4-year PhD position in one of the leading research departments in oceanography and related numerical modelling in Estonia
- The chance to do high-level research in cooperation with European research institutes in the framework of the Copernicus Marine Service
- Opportunities for conference visits, research stays and networking with leading universities and research centers in the fields of oceanography

About the department

Tallinn University of Technology (TalTech), the only technological university in Estonia, is the flagship of Estonian engineering and natural sciences. Here the synergy between different fields (technological, natural, exact, economic and health sciences) is created and new ideas are born.

The Department of Marine Systems at TalTech is a leading oceanographic and meteorological R&D unit in the Baltic Sea region. We focus (1) on oceanographic process research based on scientific analysis to find cause-and-effect relationships and (2) on developing marine and weather monitoring and forecasting services. The implemented methods include machine learning based algorithms for satellite image processing and for model data analysis as well as development of innovative (operational) methods for monitoring the marine environment and analyzing the changes. We have long-term experience in developing applications and methods for operational oceanography, the outputs of which are information products provided to the general public and to various authorities on water level variability, ice conditions and other parameters of marine physics. We are contributing significantly to the pan-European Copernicus program (CMEMS) and Destination Earth (DestinE) initiative.

(Additional information)

For further information, please contact Prof Aarne Männik aarne.mannik@taltech.ee and Sander Rikka sander.rikka@taltech.ee



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