Microclimate Weather Forecasting

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Weather Logistics

Abstract

In recent years, there has been a growing concern about the impact of climate variability on human activities, such as food security. For the agriculture sector, it is well established that there is a need for managing risks associated with climate and weather. Air frosts in particular, are damaging to productions if the crops are not protected.

Method

Machine learning and deep learning algorithms were implemented in an attempt to detect localised extreme weather in advance. The model is location-specific and is otherwise not available from general weather providers.

Regression Analysis

It is known that extreme low temperatures cause air frosts on farmlands, given other weather conditions such as low wind speed are also satisfied. Random forest regressor was employed to identify key climate variables that affect the frequency of air frost events.

Long Short-Term Memory (LSTM)

Recurrent Neural Network is one of the most powerful way for time series predictive problems. Han et al. (2021) showed an 185% improvement in accuracy using the LSTM approach to predict localised weather, when compared with conventional weather models.

Aim

The existing approaches are often not sufficiently detailed, and may rely on expensive instrumentation. However, with satellite data now widely available, high-resolution data could help tackle this challenge. The aim of the project is to develop a data-driven solution of localised weather prediction, in particular the events of extreme low temperature and the risk of frosts on top-fruit production in orchards.

Data

ESA's Sentinel Evapotranspiration (Sen-ET) Project

The Sen-ET project provides high resolution land surface temperature data at 20m × 20m, based on synergistic use of Sentinel 2 and Sentinel 3 satellites.

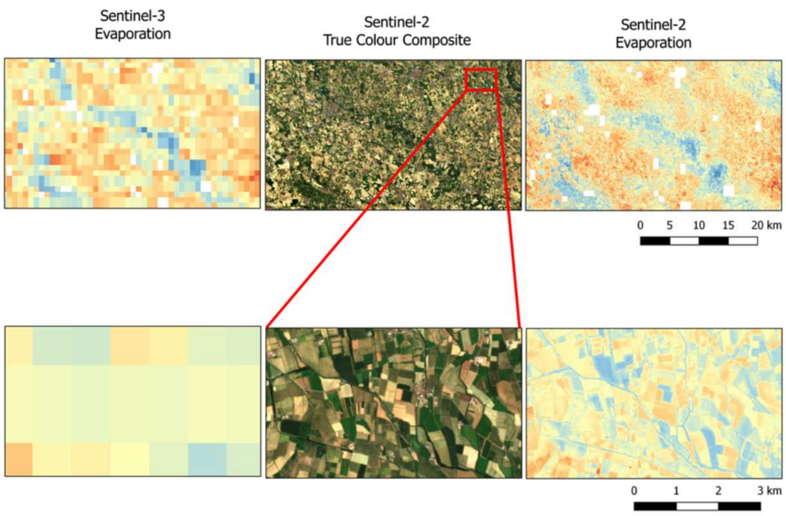

Figure 1: Improved spatial resolution of thermal images through data fusion.(Image Credit: Sen-ET[1])

Results

Regression Analysis

Our regression model is able to identify 5 out of 10 extreme low temperature events on the exact dates in year 2013.

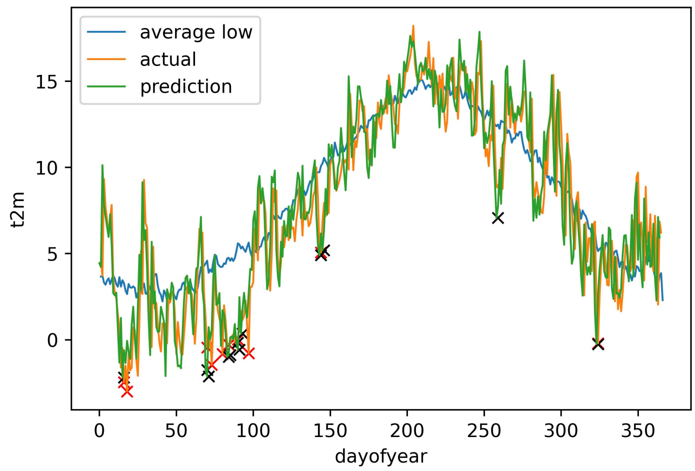

Figure 2: Temperature (°C) in year 2013. Crosses represent extreme low temperatures, with actual (red) compared with predicted (black).

Long Short-Term Memory (LSTM)

A 6-hour forecast model is constructed with 48 hours of observation as inputs. The mean absolute error for this test model is 5.32%.

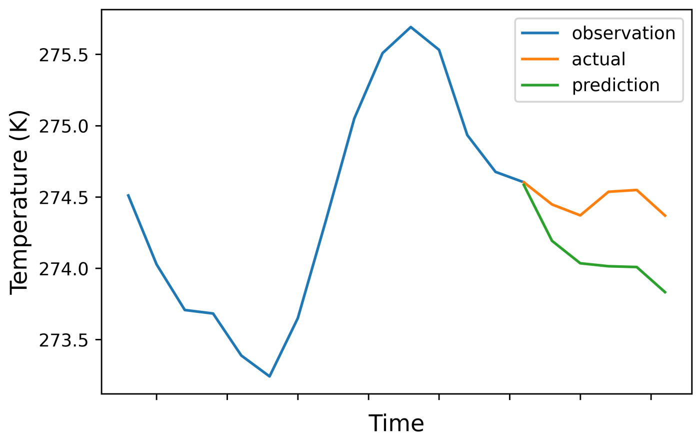

Figure 3: A sample of 6-hour temperature forecast.

Conclusion

In order to pinpoint the severity and duration of air frosts ahead of time, a model of higher accuracy will be required. Nevertheless, the trial LSTM model has shown great potential to become the foundation of a practical frost alert system.

References

[1] Radoslaw Guzinski, Hector Nieto, Inge Sandholt, and Georgios Karamitilios. Modelling high-resolution actual evapotranspiration through sentinel-2 and sentinel-3 data fusion. *Remote Sensing*, 12(9):1433, 2020.

[2] Jung Min Han, Yu Qian Ang, Ali Malkawi, and Holly W Samuelson. Using recurrent neural networks for localized weather prediction with combined use of public airport data and on-site measurements. *Building and Environment*, 192:107601, 2021.