IPM Decisions

Deliverable 2.9 - Publications in peer reviewed journals

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Contents

1   Public Summary

Outline of two papers relating to the integration and sharing of data, models and tools in the IPM Decisions platform prepared for submission to peer review journals as output from the WP2 developments.

2   Executive Summary

Two manuscripts for peer review journals are prepared to describe the technical developments which are outcomes from WP2. A paper describing validation of multiple leaf wetness models, and the practical implementation of a model for leaf wetness duration for use in the weather API will be submitted to Smart Agricultural Technology by end of 2024. A second paper describing the development of a DSS API and a weather API, including examples of their use in relation to the IPM Decisions platform is submitted to Smart Agricultural Technology.

3 Paper 1 – Leaf Wetness

3.1 Title

Leaf wetness – calculations for use in agricultural decision support systems for integrated pest management across multiple climate zones

3.2 Abstract

Leaf wetness is an important input variable in web-based decisions support systems developed for optimized crop protection, as presence of leaf wetness is crucial for infection and reproduction of both bacterial and fungal pathogens. Leaf wetness is difficult to measure as no international standardization in how to measure leaf wetness exists. The variable is often missing in standardized weather data services, hence mathematical models to estimate leaf wetness from other commonly available weather variables are developed and used. Numerous mathematical models have been developed to estimate leaf wetness duration, but still, no standard model has been chosen for exclusive use internationally. The objective of this study was to identify a robust "default" model to calculate leaf wetness accurately across geographical regions and different climate zones within Europe.

Five machine learning based models were developed in this study and compared with five existing empirical models from the peer-reviewed literature. All the newly developed models performed better or on the same level as the existing empirical models in the predictions of leaf wetness. The Long Short-Term Memory (LSTM) model was the most advanced algorithm included in this study and stood out as the overall best model to predict leaf wetness. The model performed with the overall highest accuracy, the second highest specificity and the second lowest sensitivity. In addition, it was found to perform well across locations, having the second lowest variability in accuracy. The LSTM model should thus work well to provide inputs for decision support systems across multiple climate zones. Still, through a site-specific training and testing of the LSTM model, using data from Norwegian weather stations within the cold climate zone only, an improved sensitivity was achieved along with an unchanged accuracy and specificity. Hence, if possible, a site-specific training of the LSTM model should replace the general model.

3.3   Impact statement

Leaf wetness is an important input variable in agricultural decision support model (DSS models) for prediction of infection risk, as presence of leaf wetness is crucial for infection and reproduction of both bacterial and fungal pathogens. Leaf Wetness Duration (LWD) is defined as the period of time when free water, caused by dew, rain or irrigation, remains deposited on the leaf surface. LWD is often measured at weather stations set up for agricultural purposes, but is usually not available from other public weather measurement networks or as part of weather forecasts. LWD is therefore often estimated using mathematical models, and several models to estimate LWD exist in the peer reviewed literature.

In this paper we have aimed to identify a robust "default" model to calculate leaf wetness accurately across geographical regions and different climate zones within Europe. Our approach was to develop classification models to estimate leaf wetness and to test and compare the performance of these models with a selection of available established models from the literature. A total of five machine learning based models were developed in this study and compared with five existing empirical models from the peer-reviewed literature. The Long Short-Term Memory (LSTM) model was the most advanced algorithm and stood out as the overall best model to predict leaf wetness.

The LSTM model developed in this study is published as a webservice at https://github.com/H2020-IPM-Decisions/LWDLSTMModel, and made available in the Weather API (https://github.com/H2020-IPM-Decisions/WeatherService). The model is used for calculation of leaf wetness in datasets where this variable is missing as part of the Weather API developed for IPM Decisions. The paper will be published with gold open access.

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3.4   Relevance to tasks

The work and results presented in Paper 1 is referring to Task 2.1. *Weather data;* subtask 2.1.2. *Virtual weather data.*

The following is stated in the description of subtask 2.1.2. "To provide locally relevant data at farm or field level, there is a need to provide data at a high resolution in time and space. For locations where measured data are unavailable, we will use best practice methods to provide estimated weather data, for instance, NWP-Analysis (preferable post-processed) and interpolated values. We will evaluate to what extent forecasts and other synthetic (calculated, derived) weather data can replace missing variables from weather stations*".*

"We will survey and when necessary develop generic models for indices needed as model inputs. For calculation of LWD we will evaluate and compare available models, while considering if other approaches such as observation based machine learning can enhance the model output. One or more relevant models will be selected for implementation in WP3 and included in the library of data manipulation algorithms developed in WP3 (M2.3)."

In Paper 1, we describe how different models for leaf wetness duration have been tested, and further developed to deliver the necessary weather indices on leaf wetness. The approach included the use of machine learning in model development, and the implementation of selected models for use in the weather API.

4   Paper 2 – DSS and weather APIs

4.1   Title

Developing a generic DSS model metadata catalogue and APIs for crop protection

4.2   Abstract

Decision Support Systems (DSS) in crop protection can give helpful pest risk prognosis or recommendations for pest control, allowing farmers or advisors to make better-informed decisions. DSS´s for crop protection have become increasingly relevant, as control measures are to be carried out with best available information to lessen the environmental pressure and harmful organisms in cultivation are spreading to new areas.

As a part European Union policy strategy to steer at sustainable use of plant protection products, the EU H2020 project "IPM Decisions" assessed and analyzed a set of very heterogeneous research verified DSS´s for integrated pest management. Information on these models have been collected into a freely available model catalogue, which is employed as models are provided for use in the IPM Decisions platform.

Application Programming Interfaces (APIs) have been built to access to the model catalogue and models in it, one managing DSS Model data (DSS API) and another to access and manage weather input data (Weather API). The new APIs work as part of the IPM Decisions Platform, but they are publicly available and as such they also enable other agricultural software such as farm management information systems (FMIS) or crop protection applications to use them.

In the spirit of FAIR (Findable, Accessible, Interoperable, Reproducible), the DSS API provides access to DSS models with their metadata, including description of their input- and output parameters. Weather API allow access to European on-line weather data sources and adapt their offering to the needs of the DSS models. In this article we discuss the development of DSS and Weather APIs. We review the requirements for the model metadata, input- and output schemas that are stemming from the characteristics of available DSS models. In addition, we review the requirements of the weather data as model input and present the respective schema. Finally, we present the services that DSS API and Weather API provide, and demonstrate the use of the APIs in three application cases.

4.3   Impact statement

Many DSS require access to weather data and additional metadata (such as crop information) in order to calculate pest risk. In this paper we describe how we have identified suitable sources of weather and/or metadata and created the software necessary to enable DSS models within the platform to access them. Available datasets must meet the input requirements of a wide range of DSS models, be locally relevant, quality controlled and easy to find for the user. These requirements are met in the establishment of two APIs, the weather service and the DSS service. The Weather API is a web service providing a catalogue of weather data sources and a standard for weather data exchange, while the DSS API is made for interaction with a repository of model metadata.

In addition, we demonstrate the use of the APIs in three application cases:
- IPM Decisions platform and the use of the DSS and weather APIs
- Integration of a DSS in other webservices; VIPS as a user case
- Integration in Python and the Open Alea research targeted modelling platform

The DSS and weather APIs described in this paper provides a powerful way to share functionalities for other developers to use, and to potentially build on top of them.

The APIs allow developers to connect different systems or their components without having to deal with all the complexity involved. This paper ensures that the process of development and structure of the APIs is well documented, available and findable for others to use and expand on, thus providing sustainability of the services developed as part of the IPM Decisions platform. The manuscript will be published with gold open access.

Links to resources

Documentation for all end points in the DSS API

https://platform.ipmdecisions.net/api/dss/apidocs/resource_DSSService.html
https://platform.ipmdecisions.net/api/dss/apidocs/resource_MetaDataService.html
https://platform.ipmdecisions.net/api/dss/apidocs/resource_AdminService.htm

Documentation for all endpoints in the Weather API

https://platform.ipmdecisions.net/api/wx/apidocs/#resources

Source code and documentation for the DSS API in GitHub

https://github.com/H2020-IPM-Decisions/DSSService

Source code and documentation for the weather API in GitHub

https://github.com/H2020-IPM-Decisions/WeatherService

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4.4. Relevance to tasks

The work and results presented in Paper 2 is providing an overarching description of the APIs developed in WP2; where the contents of the APIs consist of the overall results from Task 2.1. *Weather data*, Task 2.2. *Model categorisation and input data* and Task 2.3. *Standards and data formats*.

The demonstrated application cases for use of the APIs are referring to the outputs from WP2 and WP3 as follows:

- IPM Decisions platform and the use of the DSS and weather APIs; refer to results from Task 3.3. *Development of platform and associated web services*
- Integration of a DSS in other webservices; VIPS as a user case; refer to results from Task 2.3. *Standards and data formats.*
- Integration in Python and the Open Alea research targeted modelling platform; refer to results from Task 3.2. *DSS Integration Dashboard Development*