ClimaAdapt

***ADAPTATION TO CLIMATE CHANGE** - An integrated science-stakeholder-policy approach to develop an adaptation framework for water and agriculture sectors in Andhra Pradesh and Tamil Nadu states of India*

Technical report on pest forecasting priorities

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Summary: This technical brief provides an update on the progress of implementation of plant pest forecasting under the ClimaAdapt programme. The reasoning behind choice of scientific problem as well as technical properties of the software system components including data flow is explained.

ClimaAdapt Plant Pest & Disease Forecasting technology is developed to reduce crop loss to plant pests and diseases supporting farmers in their daily adaptation to climate driven changes in plant pest risks. When such services are used to reduce crop loss to pests, farmers can both mitigate climate change by reducing greenhouse gas emissions per unit food crop produced, as well improve their overall crop quality and farm economy through climate change adaptation.

Introduction

Scientific knowledge on how weather and climate conditions drive growth and development of organisms that are pests of plants vary greatly among the various species. While some pests are well studied, with scientific insights already synthesized into mathematical models describing the organism's growth and development as a function of weather data, such information is still lacking for many species.

For the first set-up of services for plant pest forecasting under ClimaAdapt it has been considered that primarily two aspects need to be balanced in order to make this a successful Integrated Pest Management (IPM) strategy: one is the potential for technology adoption by farmers based on their interest in the specific problem, and the other priority aspect is scientific robustness of the forecasting services. On the technical side, a key prerequisite for turning a potential success into an actual success is to build a technical solution that is actually able to handle the potential demand. The constructed software system with full internationalisation support and scalability is explained.

As a first service facilitated by ClimaAdapt, a weather forecasting service was set up for ClimaAdapt villages on the ClimaAdapt.org website (Figure 1). Based on feedback received when made available in mobile telephone dissemination format ClimaAdapt will consider providing this information also in local languages.

Figure 1. Weather forecasts for ClimaAdapt villages launched in 2013 on ClimaAdapt.org based on the Norwegian Yr.no weather service.

Pest prioritization: groundnut tikka disease as an initial case

Tikka disease of groundnut, caused by the fungal pathogen *Cercospora arachidicola*, is a major plant disease problem experienced by Tamil Nadu farmers. Crop losses due to groundnut tikka disease epidemics can be 15-50% and even 70%, if associated with rust disease (*Puccinia arachidicola*). The scientific knowledge on the response to weather conditions of both leaf spot

and rust diseases of groundnut is relatively well developed and a few mathematical models have been published. Among those, one model, the generic infection model[1] for foliar plant pathogens is particularly interesting for ClimaAdapt purpose. This is because it takes a generic approach whereby this model has been parameterized for several different species of plant pathogens. Thus the selection of this model as a first implementation case in the pest forecasting service of ClimaAdapt can ease the extension of the service to cover more plant diseases beyond groundnut tikka (synonymous: leaf spot disease) at a later stage.

The generic infection model

The generic infection model calculates predicted plant disease infection severity values for a given leaf wetness duration and air temperature:

$$I = W\, f(T) / W_{min} \geq W / W_{max}$$

$$f(T) = \left(\frac{T_{max}-T}{T_{max}-T_{opt}}\right)\left(\frac{T-T_{min}}{T_{opt}-T_{min}}\right)^{(T_{opt}-T_{min})/(T_{max}-T_{opt})}$$

In the above equations I mean predicted infection severity values and f is the temperature moisture response function. The farmer or farmer's advisor can recommend application of crop protection measures based on the infection risk levels.

Parameter definitions:

- T_{min} Mininimum air temperature for infection
- T_{max} Maximum air temperature for infection
- T_{opt} Optimum air temperature for infection
- W_{min} Minimum leaf wetness duration
- W_{max} Maximum leaf wetness duration

If required for some pathogens, there are options to set two more additional parameters, that is the precipitation threshold for infection and a tolerance threshold value for leaf wetness interruption.

Input variables

- Average daily air temperature (°C)
- Leaf wetness (hours per day)
- Precipitation (millimeter)

Weather data input

The first operative services will be based on weather data from three weather stations in Tamil Nadu, two weather stations situated in Erode district and one weather station in Ponnaniyar basin. In addition to measured weather data, numerical weather forecasts are important to enable projection of forecasts for certain plant pest models. For this purpose, the services from ClimaAdapt will evaluate both numerical weather forecasts from yr.no and Tamil Nadu Agriculture Network (TAWN).

Figure 2. Tamil Nadu Agricultural University will test-run the system against Tamil Nadu Agriculture Network (TAWN) http://tawn.tnau.ac.in/

Technical aspects of the VIPS open source technology platform for international collaboration and local adaptation of IPM

Bioforsk decided in early 2013 to undertake a major redesign of the software system underlying the VIPS system. The decision was taken in order to allow ease of internationalization, scientific collaboration and scalability of services.

Scalability for up-scaling

Technology uptake and up-scaling and is one of the main objectives of ClimaAdapt. Therefore the new software architecture has been built to allow easy deployment and distribution of the model computation to cloud computing services in order to allow easy up-scaling of model computations to enable handling of thousands of locations/sites for which plant pest forecasts can be computed in parallel.

Integration

As described in more detail later, the modularity of the system components when applying modern Service Oriented Architecture (SOA) IT design principles, integration of parts, or the whole collection of components of VIPS can easily be accomplished. This is an important aspect for ClimaAdapt as integration of project efforts and results into official relevant plans and coming infrastructure established by the Indian government, either at the national or state level, can be accomplished.

Internationalisation - i18n

VIPS 3.0 redesign meets the requirement of ClimaAdapt to provide new scientific knowledge in local language. VIPS 3.0 supports easy translation of all texts.

Git - source code repository for VIPS3

For development of VIPS3, handling of the source code repository and version control management use the system "Git". For the repository management, the world's most installed application "GitLab" has been chosen. The working system at http://biogit.bioforsk.no/ is operative an available to collaborators.

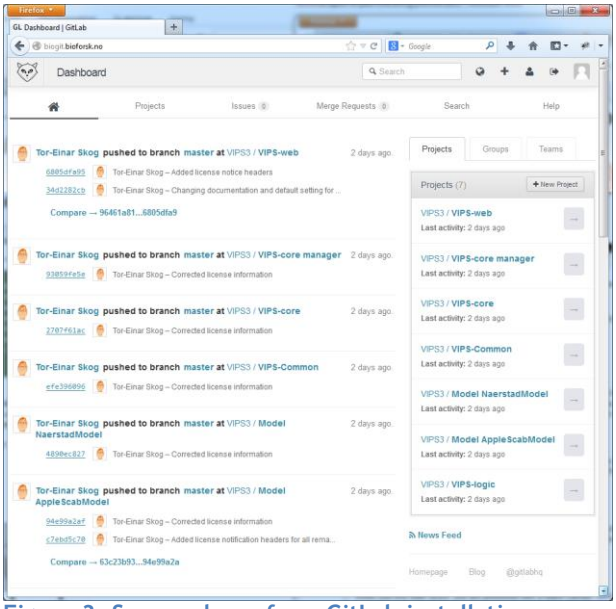

Figure 3. Screen dump from GitLab installation http://biogit.bioforsk.no

Data exchange format JSON

An interface which enables VIPS to utilize the measured weather data from the meteorological stations that are already present in Tamil Nadu and Andhra Pradesh states has been created. The lightweight data-interchange format JSON (JavaScript Object Notation) has been chosen for this purpose.

Sample model configuration along with sample weather data in JSON format:

```
[
"username":"example",
"password":"example",
"modelId":"GENERICINF",
"configParameters":{
"calculationStart":"2014-02-
09T11:00:00+01:00",
"calculationEnd":"2014-02-
09T11:00:00+01:00",
            "observations":
{"timeMeasured":"2014-02-
09T11:00:00+01:00",
"elementMeasurementTypeId":"TM",
"logIntervalId":1, "value":26.614},
{"timeMeasured": "2014-02-
09T11:00:00+01:00",
"elementMeasurementTypeId":"RR",
"logIntervalId":1, "value":1.2},
{"timeMeasured": "2014-02-
09T11:00:00+01:00",
"elementMeasurementTypeId":"BT",
"logIntervalId":1, "value":55}
]
```

Software components in redesigned system for pest & disease forecasting VIPS ver. 3.0

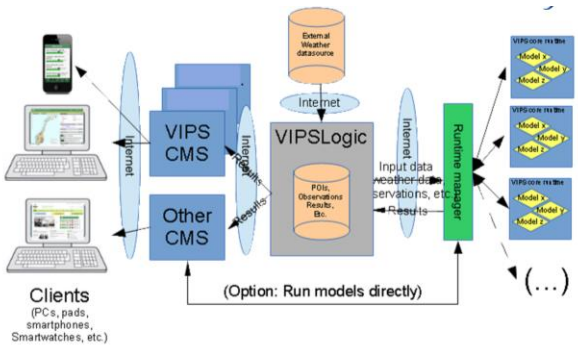

Figure 4. Overview of the redesigned VIPS system

VIPS-models

- Programmed in Java
- Must follow specific design (doc. interface)
- Input data on standard format, but model specifies freely what kind of data
- Results are returned in standard format
- Must provide its own description and usage information in at least English, and additionally in any preferred language e.g. Tamil, Telughu or other
- Implementation and testing in Java may be done by anyone

VIPS-core

- Protocols and communication identical with core runtime
- Authentication of clients
- Logging of usage
- Secure communication with client
- Auto scaling of runtimes, utilizing Amazon EC2 services
- Written in Java, running on Jboss Application Server

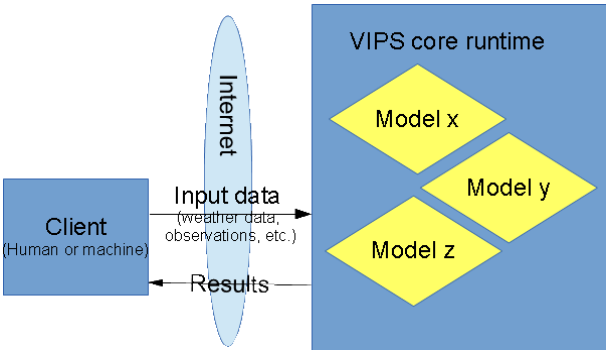

Figure 5. VIPS-core runtime for models

VIPS-core-manager

- Protocols and communication identical with core runtime
- Authentication of clients
- Logging of usage
- Secure communication with client
- Auto scaling of runtimes, utilizing Amazon EC2 services
- Written in Java, running on Jboss Application Server, but can also run on other java application servers

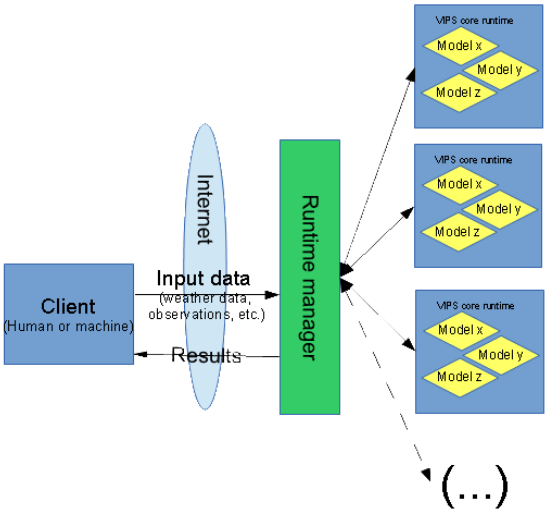

Figure 6. Overview of VIPS-core-manager

VIPS-Logic

- Scheduled running of models
- Results from scheduled jobs stored in database, available to clients
- Database of POIs, organisms, observations, weather data sources and other metadata
- Configured with web GUI (similar to the current VIPS admin system)
- Contents 100% translatable

VIPS (generic) CMS

- CMS = Content Management System
- What users view, similar to the public web page (and smartphone app) in current version of VIPS
- Template CMS, collaborating institutions may configure as needed
- Map functionality, mobile/touch views
- Content 100% translatable
- One instance per institution
- If client institution has own CMS, they can use it for displaying results from VIPSLogic, or they may run models directly from Runtime Manager (and store results locally)

Online services linking agriculture science and farming in the field through mobile information networks

In a broader scope, the software framework outlined here has many potential uses and applications beyond the pest & disease forecasting application. Typical additional information services can be irrigation scheduling, messaging and any kind of agriculture advice for rapid knowledge transfer from new scientific knowledge derived from new research could provide new insights for farmers. One exciting dimension of these information networks is the opening for interactivity, whereby farmers and other end users of new scientific advice can evaluate scientific recommendations in the field and provide feedback to the scientists whether the new information are valid when practised in the field.

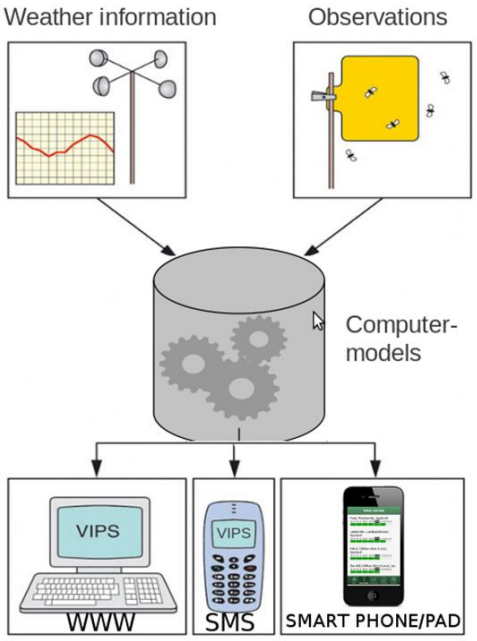

Figure 7. Conceptual underlying framework for ICT-based plant pest risk forecasting. Updated with phone/pad functionality[3].

References

1. Magarey RD, Sutton TB and Thayer CL 2005. A simple generic infection model for foliar fungal plant pathogens. Phytopathology 95: 92–100.
2. Magarey, R.D. and Sutton, T.B. (2007). How to create and deploy infection models for plant pathogens. In: A.. Ciancio and K. G. Mukerji (Eds). Integrated management of plant pests and diseases. Vol: I General concepts in integrated pest and disease management. Pages 3-26. Springer, Netherlands.
3. Rafoss, T., Shah, S.E., Kennedy, J.S., Lakshmi, V.G. & Udaya Sekhar Nagothu. 2013. Climate Adaptation and Mitigation through ICT Innovation - Exploring Potentials for Forecasting Pest and Disease Risks in Rice. ClimaRice II Technical Brief No. 17 http://www.bioforsk.no/ikbViewer/Content/102723/ClimaricellTechnicalBrief%2317PD_e.pdf

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Read more: www.climaadapt.org