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GEO Work Programme Activities

GEO Community Activity Description

全球粮食作物主要病虫害遥感监测预警

Global Crop Pest and Disease Habitat Monitoring & Risk Forecasting (GCP&DMF)

1. Executive Summary

Title: 全球粮食作物主要病虫害遥感监测预警 Global Crop Pest and Disease Habitat Monitoring & Risk Forecasting

Acronym: GCP&DMF

Category: Community Activity

Overview and planned activities

Pests and diseases are the major threatens for food security in the world, especially for the wheat, rice, and soybean, the most dominant food around the world. Approximately more than 10 percent yield loss caused by pest and disease every year, while in some regions the loss may higher than 30 percent. Crop pests and diseases habitat monitoring and risk forecasting at continental and global scale are important to assess the effect of global change on agriculture production. Earth observation is very important for global crop monitoring and pest & disease forecasting due to its capability of achieving large scale data quickly and efficiently. In the year of 2018, we used the satellite images and re-analyses datasets to monitor global wheat growth, and habitat of main wheat pest and disease, which including surface temperature, humidity, surface radiation, etc, and released the first global wheat aphid and rust monitoring and forecasting product and report. In this project, we will consider three main crop types, i.e. wheat, rice and soybean, aiming to mapping main pests and diseases for these crops, which includes wheat aphid (*Rhopalosiphum padi*) and rust (*Puccinia striiformis f. sp. tritici*), rice planthopper *(Nilaparvata lugens)* and blast *(Magnaporthe oryzae)*, soybean aphid (*Aphis glycines*) and mosaic virus.

We focus on retrieving global crop planting areas, growth condition, pest and disease habitat, and risk forecasting based on some high spatial and temporal resolution satellites will be included, such as GF series, ZY series, HJ series in China, and Sentinel series in EU,

MODIS and Landsat in NASA. Firstly, we will combine land surface products and remote sensing indices to ascertain soil temperature and moisture which provides information about crop habitat, which allows us to ascertain which habitat types are attractive to pests and diseases and provide some information on where they may migrate to. Secondly, climatic and its forecast data are analysed to give a probability of immigration or dispersal of pest and disease. Finally, crop growth condition, crop pests and diseases habitat monitoring, and pest and disease biological dispersal models are integrated to mapping crop pest and disease spatial distribution and damage levels.

Three main work packages are included in the project. In WP1, we will use satellite data (e.g. MODIS and Landsat) and other higher-level remote sensing / EO products (such as re-analyses and weather forecasts) in order to perform a classification of vegetation surface in order to ascertain the habitat of the crop pests and diseases. For WP2, we will assimilate the geographic and plant protect information to the remote sensing date and then build the risk forecasting model to assess the risk of the target pests and diseases. At lastwe will develop an application and dissemination platform that will deliver our outputs to the end users to control pests and diseases and enhance yield and quality in WP3. The achievements of our project could promote the agri-food improvement and reduce poverty. Meanwhile, the tools and methods that developed could create stable, higher-paying jobs for skilled labourers.

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2. Purpose

Our project focus on global crop pest and disease habitat monitoring and risk forecasting. The objects are aphid and rust for wheat, planthopper and blast for rice, aphid and mosaic virus for soybean. In which, wheat aphid and rust are the most important pest and disease on wheat worldwide, causing significant crop losses in about 76 countries all over the world; for rice, planthopper and blast are the popular pest and disease in over 20 county, especially for the southeast Asia; for soybean, aphid and mosaic virus are the dominant pest and disease in north America, south America, and Asia. Currently, the monitoring and forecasting technologies, mainly included the field survey by people, the agrometeorology records in field, and laboratory tests, are still rarely integrated in crop pests and diseases monitoring and forecasting in that they are operated separately in different departments. Meanwhile, this information only can make the mid- and long term forecasting decision, which caused delaying effective management measurements. One main issue in crop pests and diseases management is prediction of the occurrence area, together with the damage levels. Then, habitat monitoring and early risk forecasting of crop pest and disease in main crop production regions global is especially important. We are also able to build up maps of the severity to facility the insect pests and diseases management timely and ultimately efficiently reducing the chemical pesticides and yield losses.

This project aims to bring together cutting edge researches to provide global pest and disease monitoring and forecast information on wheat, rice, and soybean, by integrating multi-source information, which includes Earth Observation (EO), meteorological, biological and plant protection datasets, to support decision making in the sustainable management of insect pests and diseases. The main objective of this project is to improve the utilization of

EO data for forecasting pest and disease through development of new algorithms and the fusion of new and existing data products using multi-source EO data to produce full cover, dynamic land surface information. The project will comprehensive consider the capability of high spatial and temporal land surface information provided by moderate- to high- resolution satellite data in crop pests and diseases monitoring and mapping at the global scale. Approaches for better estimation of surface temperature statistics, diurnal surface temperature patterns, leaf area index (LAI) and vegetation dynamics will be investigated. In addition, we will validate and prove the relevance of these data products to existing pest and disease development models, and to forecast the potential distribution of pest and disease, also the damage levels. To ensure the project outcomes will have the greatest impact, an investigation into the best practice for routes of dissemination of these information products will be conducted during the project.

Outputs

1) The project will be accessed through a novel proposed algorithm that provides the global habitat area of crop pests and diseases with the key parameters, soil moisture and temperature, which can have high correlation with the outbreaks of the target pests and diseases.

2) Developing a novel method to forecasting global crop pests and diseases outbreak risk with new technology, contributing to timely and effective management. This output provide available information for local government and farmers for making field management policy.

3) A robust model framework to produce global risk predicted product for crop pests and diseases outbreaks, these risk assessments provide insight for the development of individual pest and disease, which is benefit for deep understand the epidemic of pests and diseases for global plant protect workers

4) The periodically produced thematic map of global crop pests and diseases risk prediction to show the spatial distribution of pest and disease, also the damage levels. Worldwide users are able to benefit from the such information. Routes may include web interface, wechat, e-mail, and interactive voice response messaging.

3. Background and previous achievements

RADI aims to optimize the crop pests and diseases control and management, further to improve the efficiency (and therefore cost of) resource use, and protect environmental and human health (by reducing release of chemical pesticides into ecosystems). The work of RADI will provide a comprehensive approach to dealing with major agricultural pests combining cutting edge technologies, modelling and biological information. It developed pest and disease monitoring, forecasting and management service products on global, national and regional levels including dynamic crop pest and disease warning and risk assessment maps

During 2017-2019 period, RADI integrated with multi-source Earth Observation data, including meteorological data, field data, and remote sensing data, and self-developed models and algorithms for wheat aphid and rust monitoring and forecasting, and released the thematical maps and reports to show the spatial distribution and damage levels of pest and disease. Our outputs illustrated that, during April to May 2018, pests and diseases slightly occurred in ten main wheat production countries, including Russia, France, Turkey, China,

Pakistan, United States, Germany, Iran, Uzbekistan, and United Kingdom.

These achievements have been released in the official crop pests and diseases website (http://www.rscropmap.com/) and wechat official account (rscrop_english). Worldwide users are able to access the achievements of our achievements of wheat aphid and rust monitoring and risk forecasting products, and benefit from the thematical maps and scientific reports.

4. Key Activities
WP1: Global crop growth and pest & disease habitat monitoring

In this WP, the crop growth information and habitat conditions will be firstly collected, and then the crop growth conditions and soil moisture and temperature will be derived at the high spatial and temporal resolution satellite data from Sentinel-2, Landsat OLI, GF-6 et al. Data from the COSMOS sensors, and ground meteorological measurements will be used to improve the EO retrieval models, and the moderate to high resolution satellite, such as MODIS, would be used to calibrate and validate the retrieved EO products with full consideration of sensing and pathological mechanism of individual species of pests and diseases. Assimilating the land use investigation, meteorological data, field investigation, and epidemic mechanism of crop pests and diseases with the EO data, the remote estimates of land surface parameters and crop growth state for crop pests and diseases habitat condition mapping would be produced to identify host habitats of crop pests and diseases hotspots. Based on our previous community activity, the different pests and diseases on different crop types have evident differences in spectral and landscape patterns, which provide the evidences for monitoring and assessing their habitat conditions.

WP2: Crop pest and disease risk forecasting and warning

The aim of this WP is to integrate information from different sources (RS, biological indicators and meteorological data) to forecasting and mapping risks of pests and diseases on wheat, rice, and soybean worldwide. The specific procedures comprise four steps: Firstly, the retrieved parameters in WP1 will be inputted into individual pest or disease habitat monitoring models that specific to different areas worldwide, and to assess the suitability of the habitat area for pest and disease live and infection. And then, a novel methodology and technology to integrate multi-source and multi-temporal EO observations, environmental parameters, biological models would be developed in order to characterize the evolution and risk probability of crop pests and diseases in wheat, rice and soybean. In addition, for the early prediction, we are going to build a risk index using the locally recorded weather data at daily intervals. Finally, based on the proposed model, RS data, and meteorological data for the typical phenological stage of crop. we will output a map describing the relative risks in the typical crop planting countries and areas,

WP3: Application and dissemination

The aims of this WP are to integrate the outputs of WP1 and WP2, and to studying and improving the two-way flow of information in prediction/advisory services to end users. These end users will likely include farmers, extension workers, and suppliers. RADI will work closely with CABI, the main information customer for project outputs and the body with responsibility for public messaging. These will focus on identifying where decision-making needs, and draw up the green management and control strategy that must be matched with actionable information to smooth information flow and enable timely delivery of broadcast messages about pest and disease predictions along with suggested actions. Worldwide users

are able to benefit from the such service. Routes may include web interface, wechat, e-mail, and interactive voice response messaging.

Milestones.

NO.	Title	Responsibility	Due data
1	Sensing mechanism of crop pests and diseases infestations	RADI/CABI	M1-M9
2	Global crop and phenology growth monitoring and habitat conditions retrieval	RADI/MMU	M10-M18
3	Crop pests and diseases risk prediction for dominant global wheat, rice and soybean planting area	RADI/CABI	M19-M30
4	Outputs dissemination	NATESC/RADI/CABI	M31-M36

5. Relationship to GEO Engagement Priorities and to other Work Programme Activities

1) In this project, the global wheat, rice, and soybean pests and diseases habitat monitoring is an important achievement of our activity, which is expected to inform the achievement of SDG goal 2: *End hunger, achieve food security and improved nutrition and promote sustainable agriculture.* Thus, the timely understanding of the pests and diseases habitat conditions help maintain ecosystems, improve the quality of agriculture resources, and ensure sustainable food production systems.

2) The global crop pests and diseases risk forecasting product will support the Paris Agreement pillar of *Loss and Damage*. The global crop pests and diseases risk forecasting product is able to assess the potential loss and damage associated with the adverse effects of infestation of pests and diseases on agriculture, and promote the role of sustainable development in reducing the risk of loss and damage. What we support may include: (a) Early pests and diseases warning; (b) Emergency preparedness; (c) Comprehensive risk assessment and management.

3) The global crop pests and diseases risk assessment support achievement of the targets of the Sendai Framework: *Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020.* It will develop pest and disease monitoring, forecasting and management service products on global, national and local levels including dynamic crop pest and disease warning and risk assessment maps that will enable the Governments and service providers to determine strategies to spray pesticides.

6. Governance
Leaders: China--RADI, UK--CABI
Contributors: China--NATESC, UK--MMU

1) Remote Sensing and Digital Earth Institute, Chinese Academy of Sciences (RADI) will be the lead organization in China and will be responsible for the coordination of the Chinese team with the UK team. Prof Huang Wenjiang (PI), the team leader, is focused on quantitative and hyperspectral RS for vegetation especially on crops; data fusion

(multi-scale, multi-sensor, multi-temporal) for agricultural applications; Monitoring crop pests and diseases using hyperspectral airborne and spaceborne images. Prof. Dong Yingying and Dr. Ye Huichun are RADI experts who have conducted interdisciplinary work combining RS, agricultural, biological and other fields to identify, monitor and forecast crop pests and diseases, and published numerous research articles. Shi Yue, Zheng Qiong, Ma Huiqin and Liu Linyi are PhD candidates in RADI, majoring in Cartography and GIS. RADI will focus on the whole project to provide researches applications of crop pests and diseases risk forecasting with remote sensing technologies.

2) CAB International (CABI) will lead and co-ordinate WP across UK partners and in close collaboration with RADI. Belinda Luke is CABI experts who have work in agricultural, biological and other fields to identify, control and management of crop pests and diseases, and published numerous research articles. CABI will focus on WPs 2 and 3 to provide biological models for pest and disease dispersal.

3) Manchester Metropolitan University (MMU) will focus on WPs 1 and 3 to provide land surface temperature and humidity mapping algorithms. Liangxiu Han will build new database by integrating multi-source data, and explore the integration of image pattern recognition with reflectance models for pest and disease forecasting.

4) Ministry of Agriculture's National Agro-Tech Extension and Service Centre, China (NATESC) will focus on WP3 to assess measurement and evaluation of agricultural technological innovation. Jingquan Zhu has been working for NATESC for more than 13 years related to plant protection. He is familiar with plant quarantine and protection laws, regulations, and standards in China.

7. Data Policy

1) To cater to the developmental needs of this project, the remote sensing and digital earth institute (RADI) of Chinese Academy of Sciences (CAS) is vested with the authority to acquire and disseminate all satellite remote sensing data from Chinese satellites.

2) Government of China reserves the right to select and permit agencies to acquire/distribute satellite remote sensing data. RADI shall be competent to decide about the procedure for granting license/permission for dissemination of such data and for the levy of necessary fees.

3) RADI reserves right to impose restrictions over imaging tasks and distribution of RS data in any country when it is of the opinion that national security and/or international obligations and/or foreign policies of the Government so require.