Aerospace Information Research Institute (AIR)
Chinese Academy of Sciences (CAS)

Introduction of CropWatch Cloud Platform

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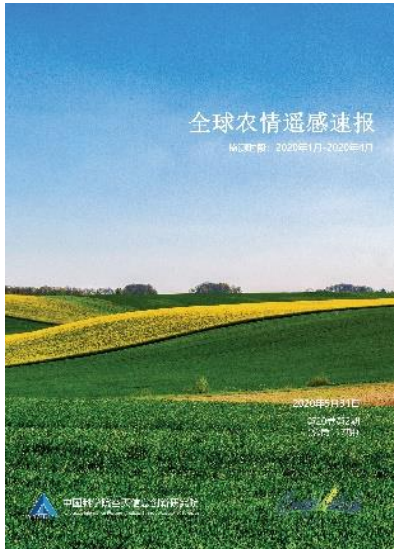
Workshop on advancing satellite-based crop monitoring to increase resilience in the face of global food insecurity, 2-5 July 2024, Nigeria

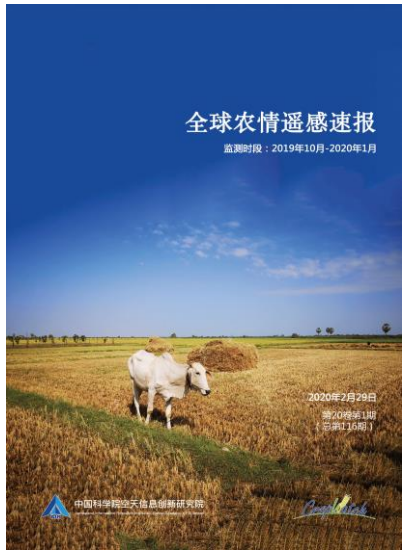
Outlines

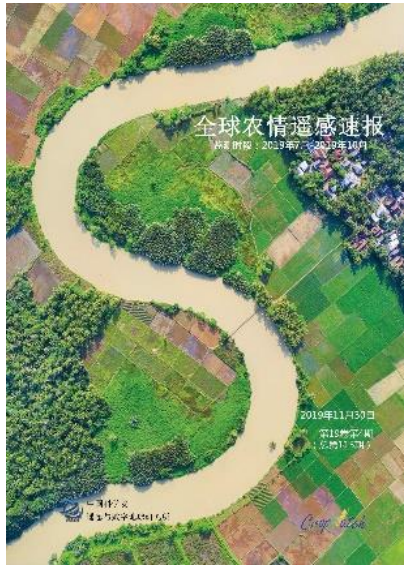
- CropWatch Cloud and the methodologies
- Updates
  - Service modes
  - New tools for field data collection
  - Baseline dataset
  - User defined crop monitoring
- Conclusion remarks

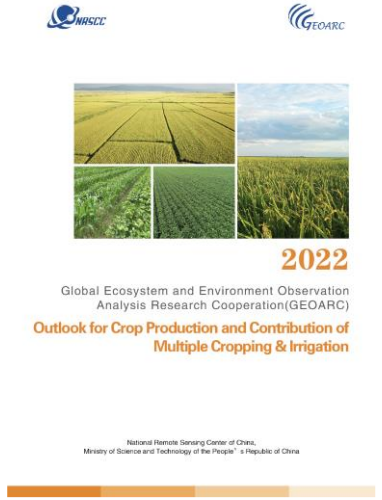
CropWatch Cloud

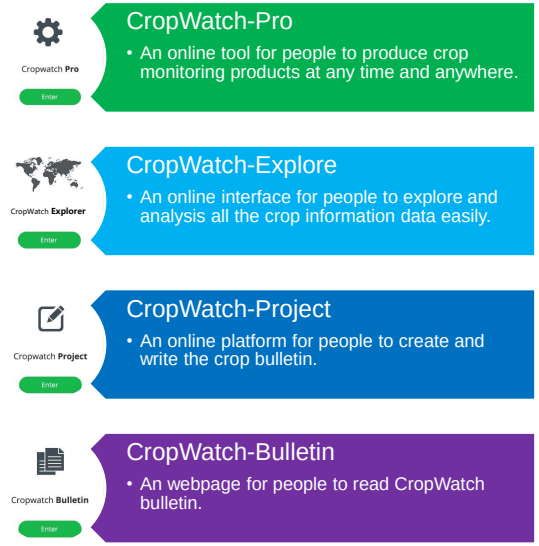
- CropWatch is a satellite-based hierarchical method of crop monitoring, with indicators of agro-climatic, agronomics, area, yield and production, earlier warning
- Release Quarterly and annually bulletins on global crop monitoring, covering 173 countries and regions down to provincial scales, with special focus on 47 key agricultural countries



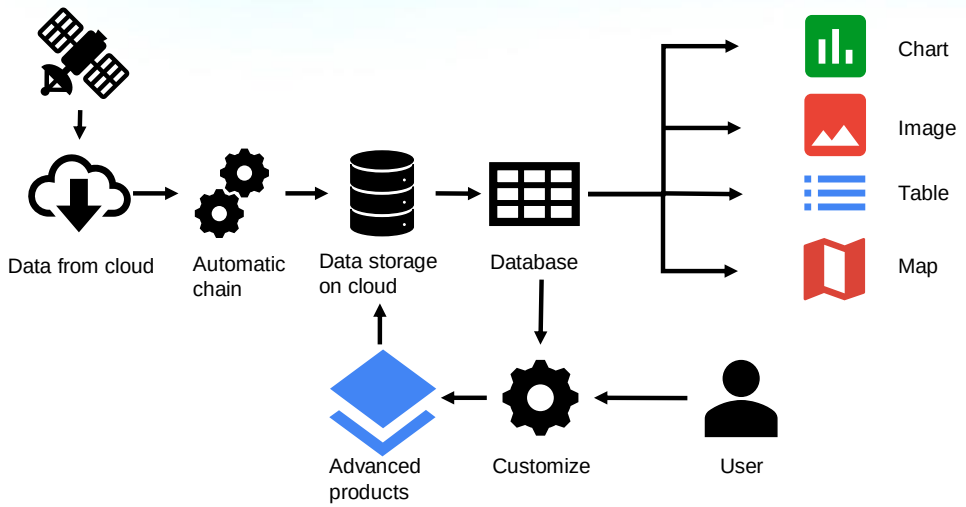






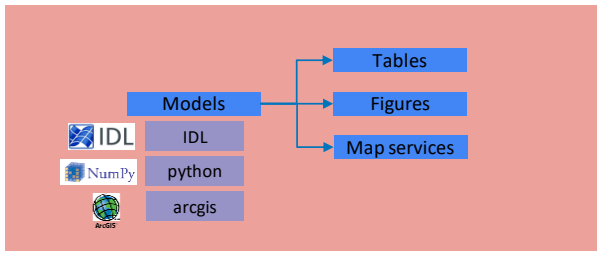


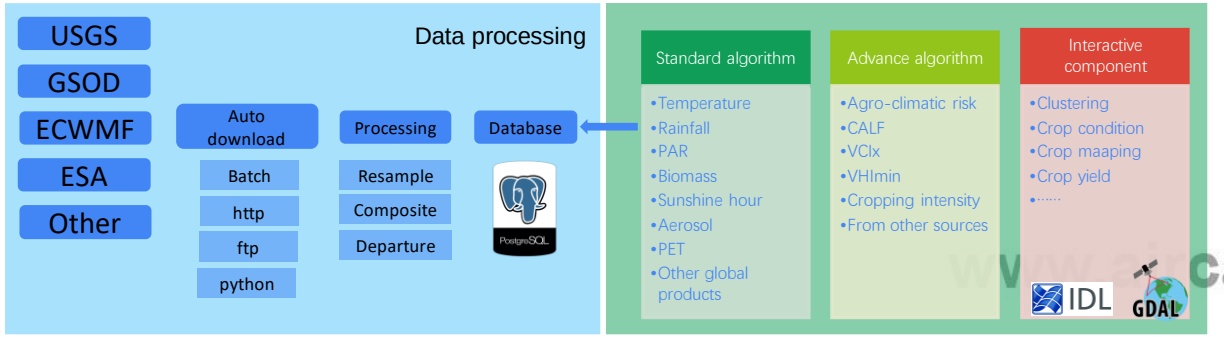
Auto data fetching and preprocessing



Automatic fetching

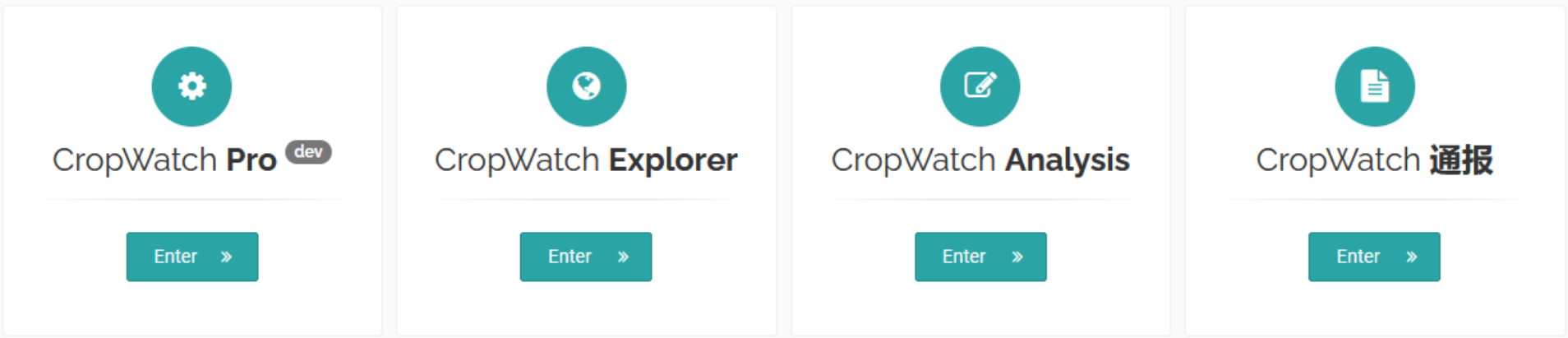
Auto preprocessing





CropWatch Components

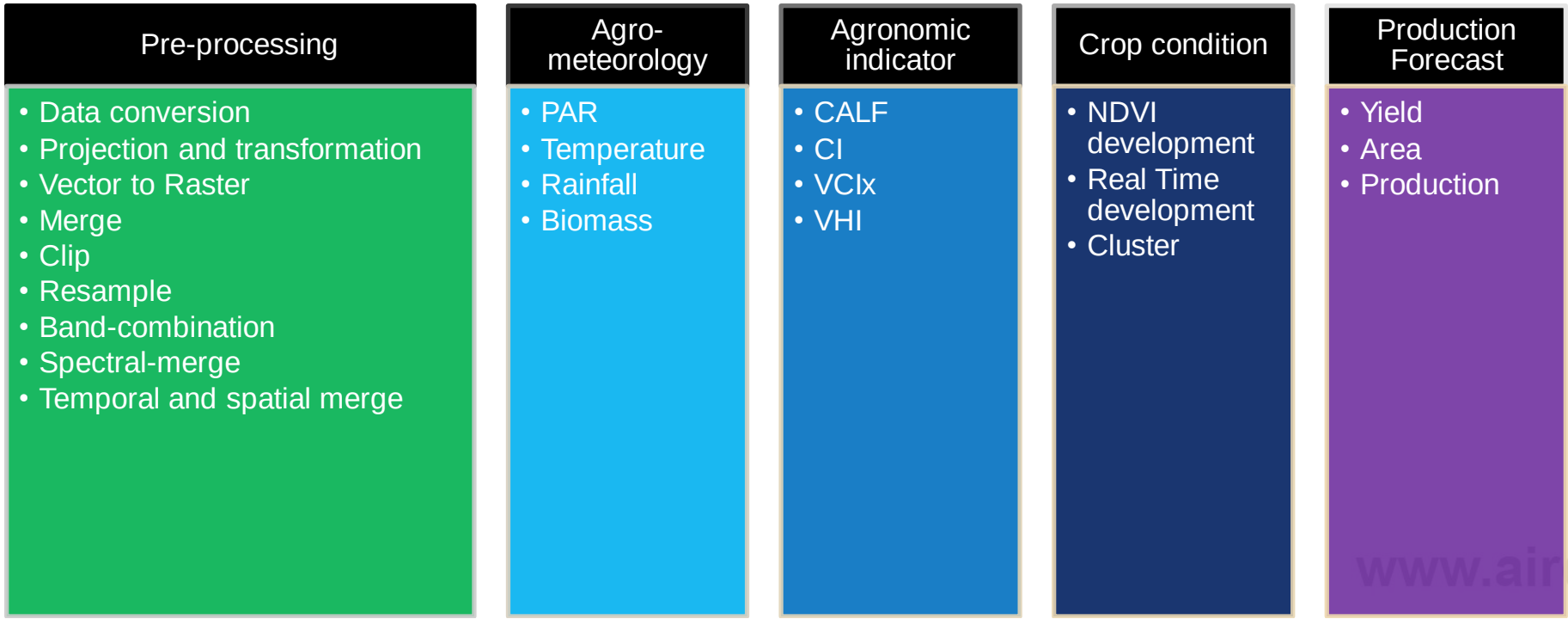
- ***CropWatch-Pro*：to produce crop indicators at any time and anywhere**
- ***CropWatch-Explorer*：to explore and download crop information**
- ***CropWatch-Analysis*：to analyze crop information jointly or individually**
- ***CropWatch-Bulletins*： an web page for release bulletins, and methods**



cloud.cropwatch.com.cn

Component 1: CropWatch Processing

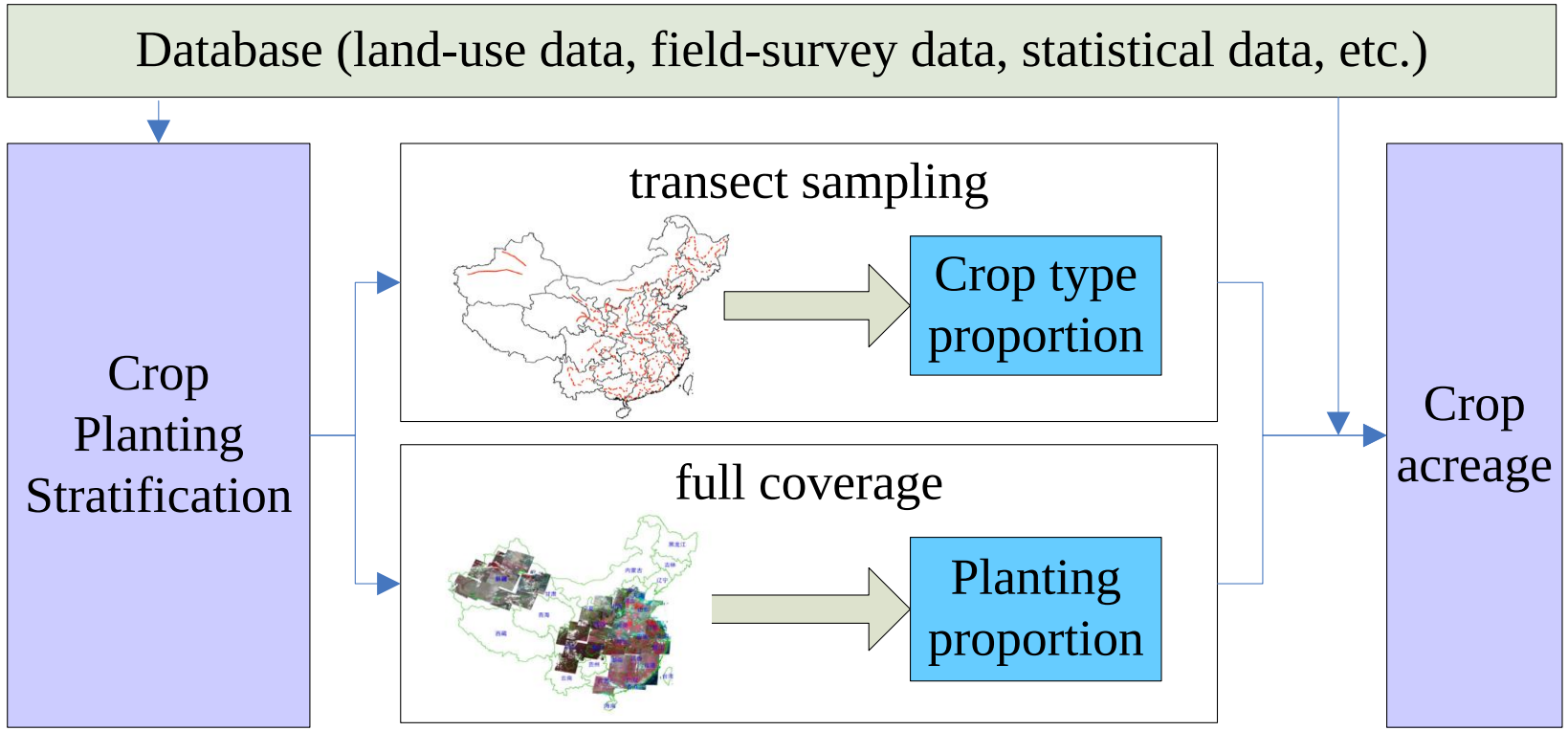
- CropWatch Processing offers an auto-processing chain from pre-processing of raw data to production outlook
- CropWatch generates 32 agro-climatic, agronomic, early warning indicators, and crop production (area, yield) and early warning,
  - Drought indices are included, spi, spei, vci, tci and vhi, cdwi,

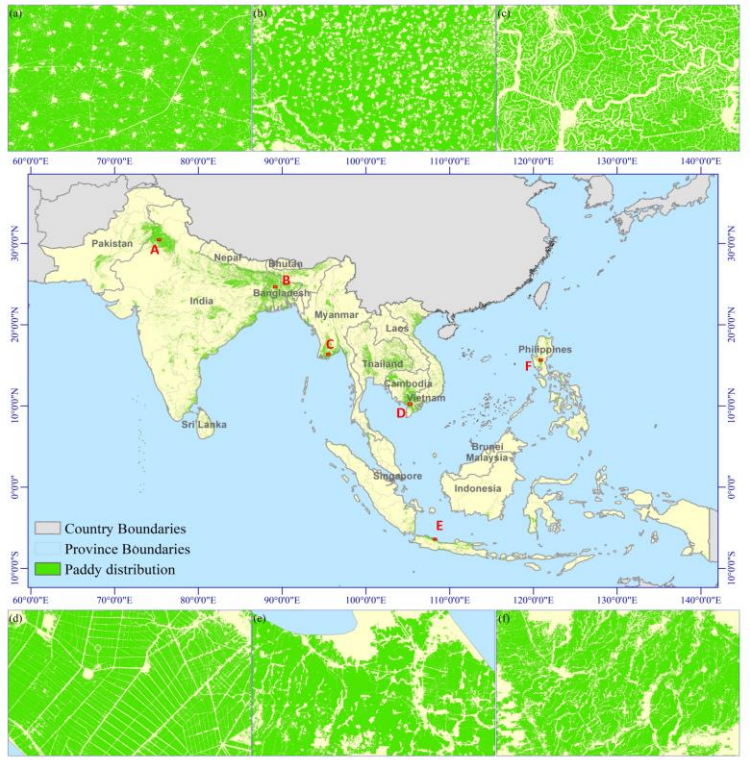


Crop Areas

- Crop area information needs field data
- CropWatch integrates crop area estimation with geo-statistics & crop mapping
  - The CPTP method in complex agricultural landscapes (66%)
  - Transfer learning methods are integrated to reduce the reliance on in situ data (34%)

Crop type area = Cropland area * UEC * cropping proportion * crop type proportion

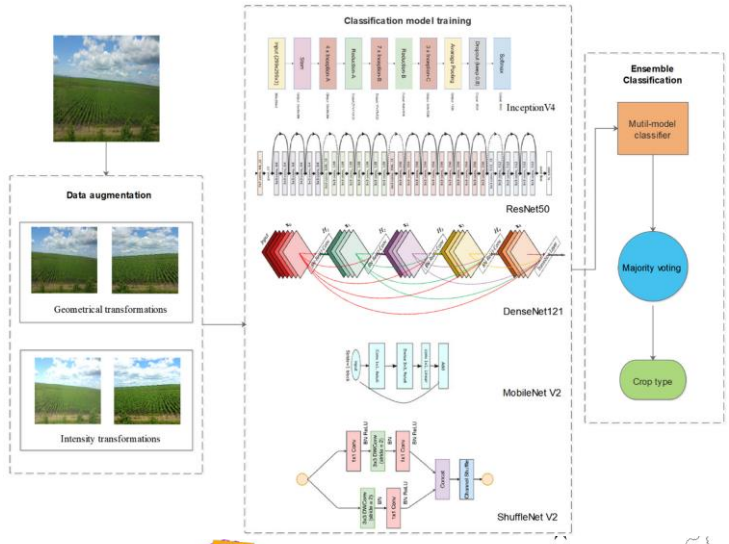




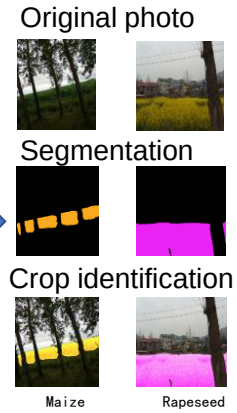
Area estimates at fragmented areas

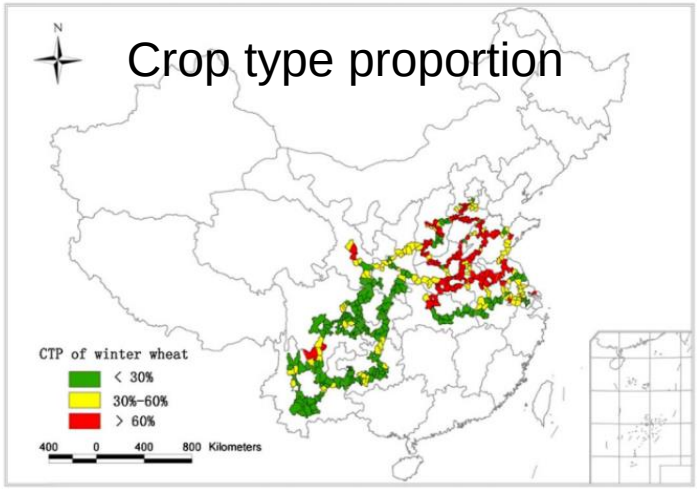
- Fully automated objects identification from massive photos by integration of multiple deep learning networks
- Currently major crops such as wheat, soybean, rice, maize, rapeseed could be precisely identified

GVG APP

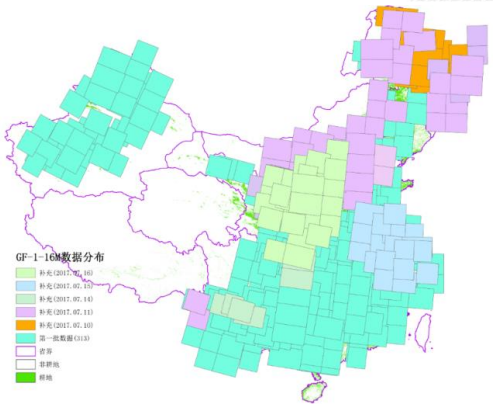


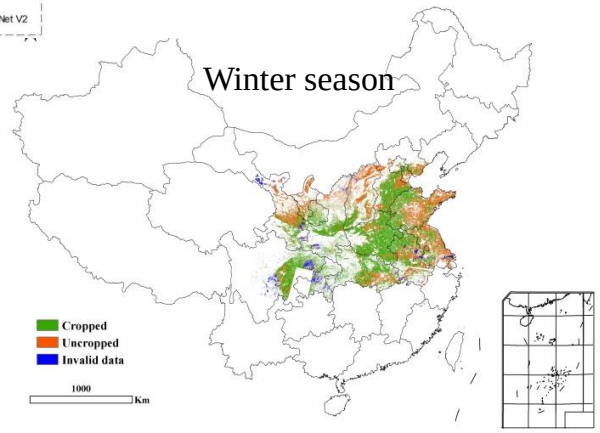
Wu et al., 2021

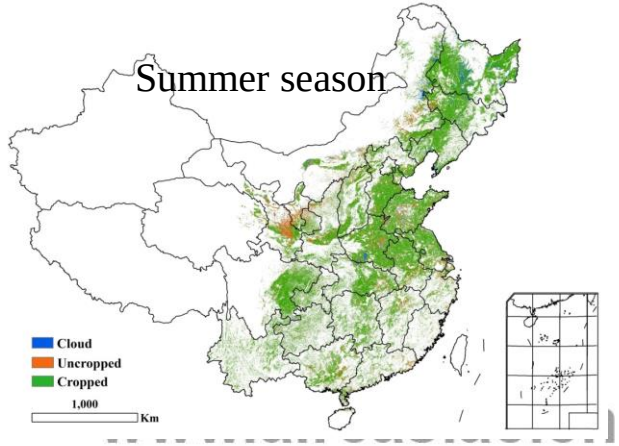




Remote sensing-based identification of cropped and fallow fields





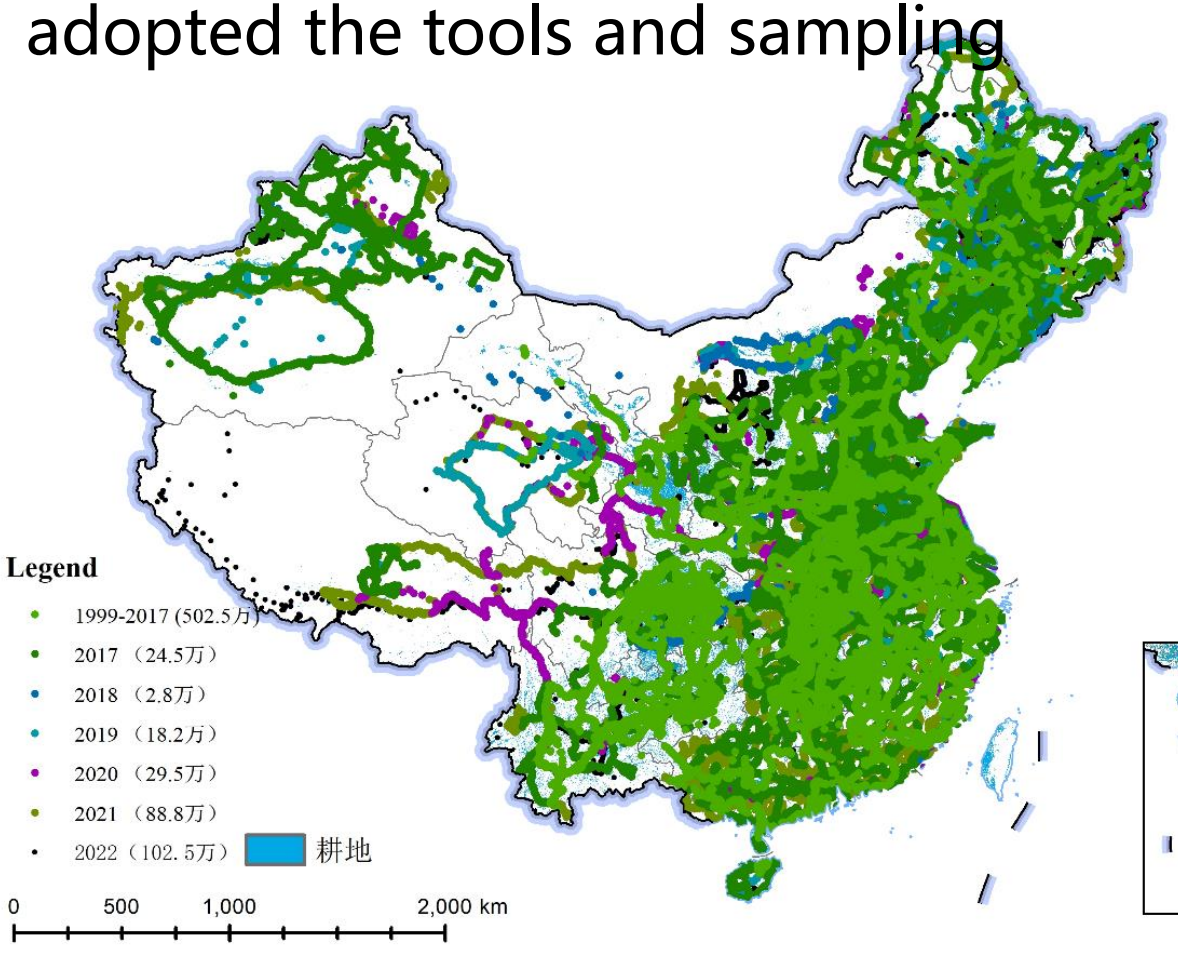


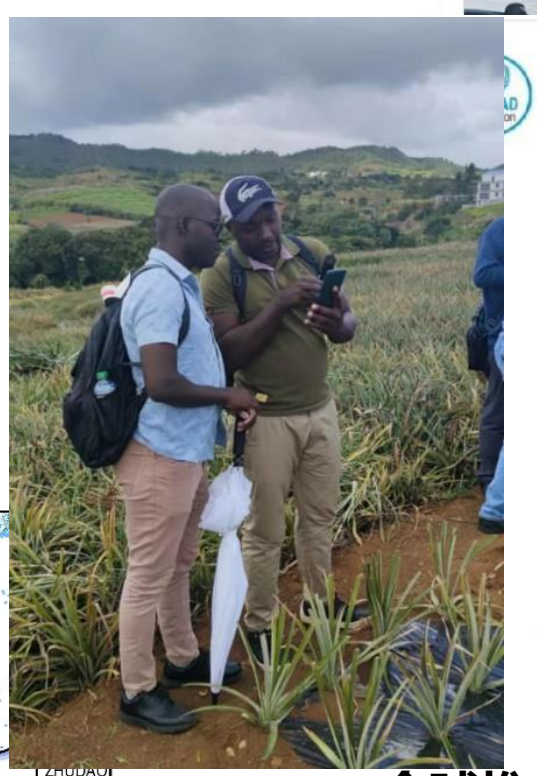
Crop type area = cropland area * cropping proportion * crop type proportion

Crop type proportion sampling

China: Millions of samples collected every year

Global application: More than 20 countries already adopted the tools and sampling

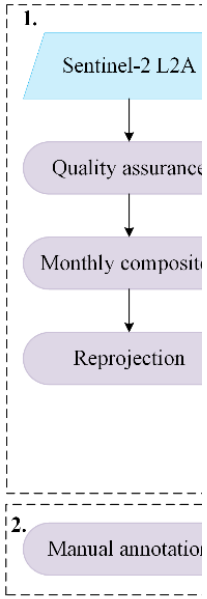


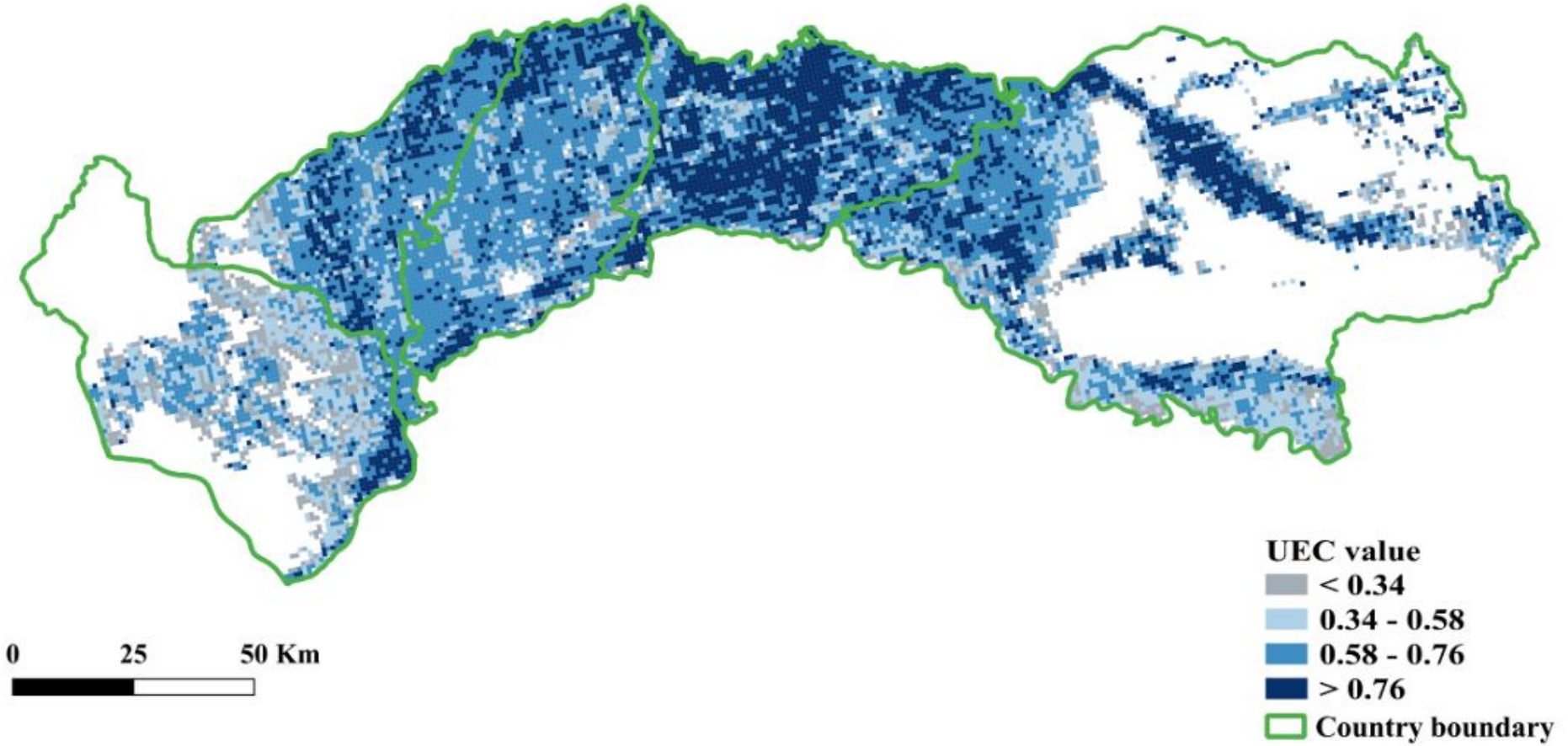


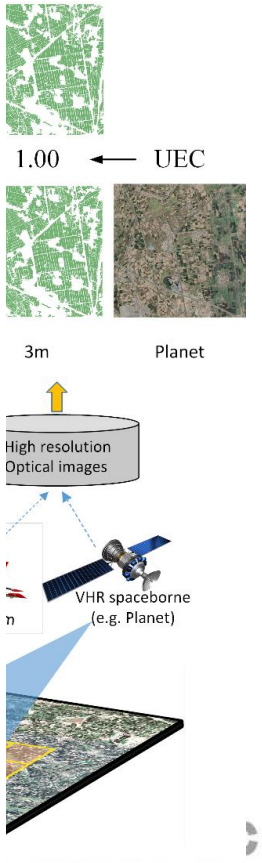
全球推广应用

Unbiased estimating coefficient for existing cropland datasets

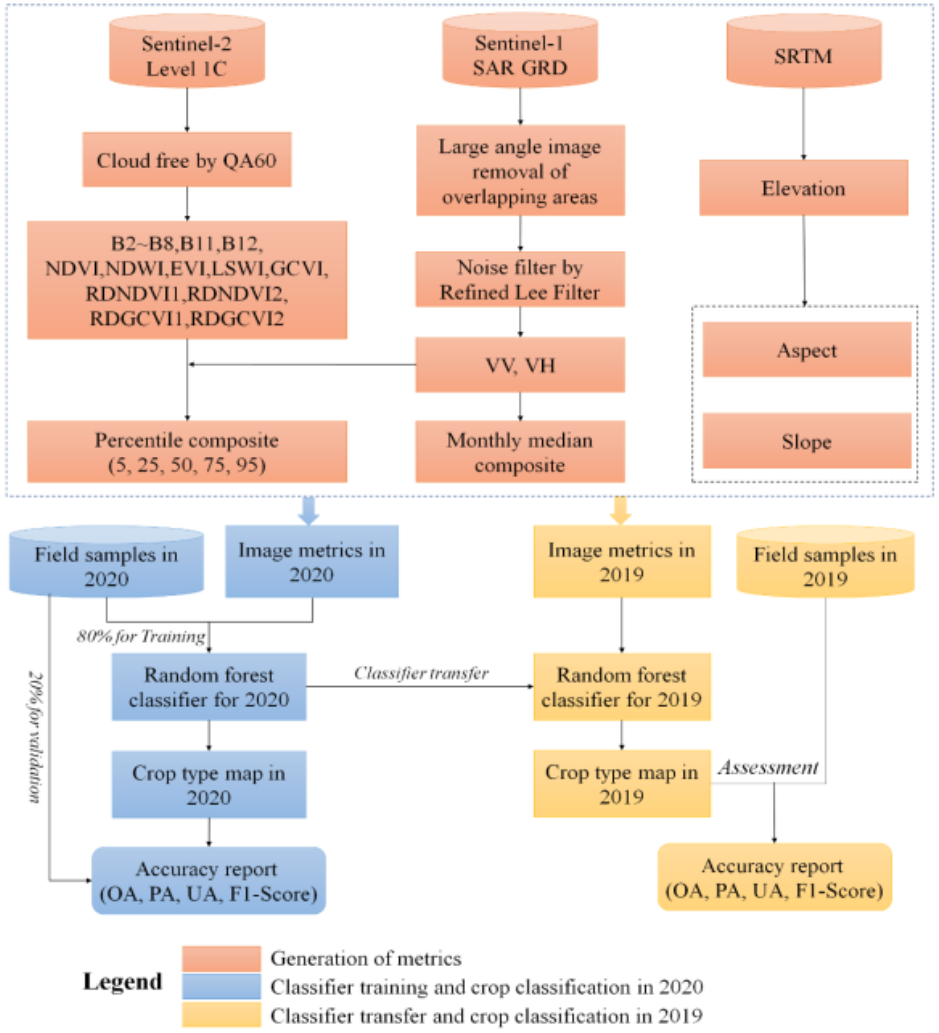
Due to both scaling effect and classification errors, we proposes a method for accurately estimating cropland area using the unbiased estimating coefficient (UEC) from existing cropland datasets

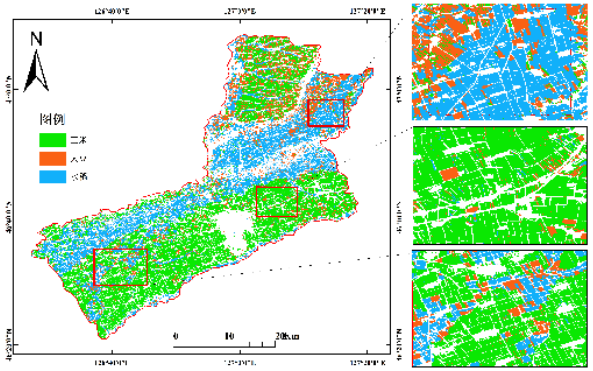


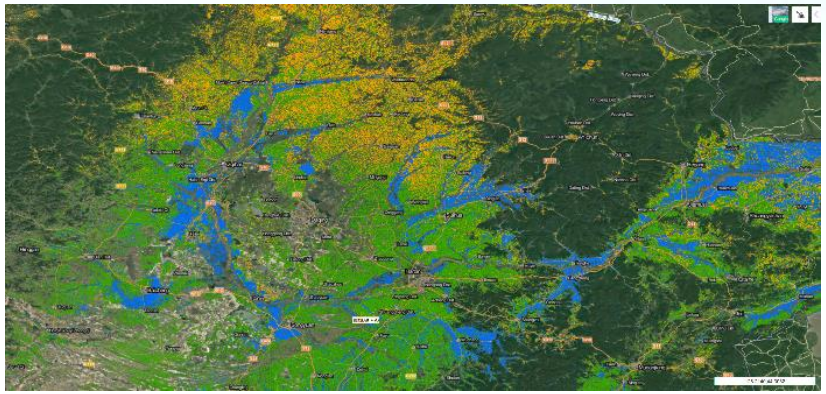


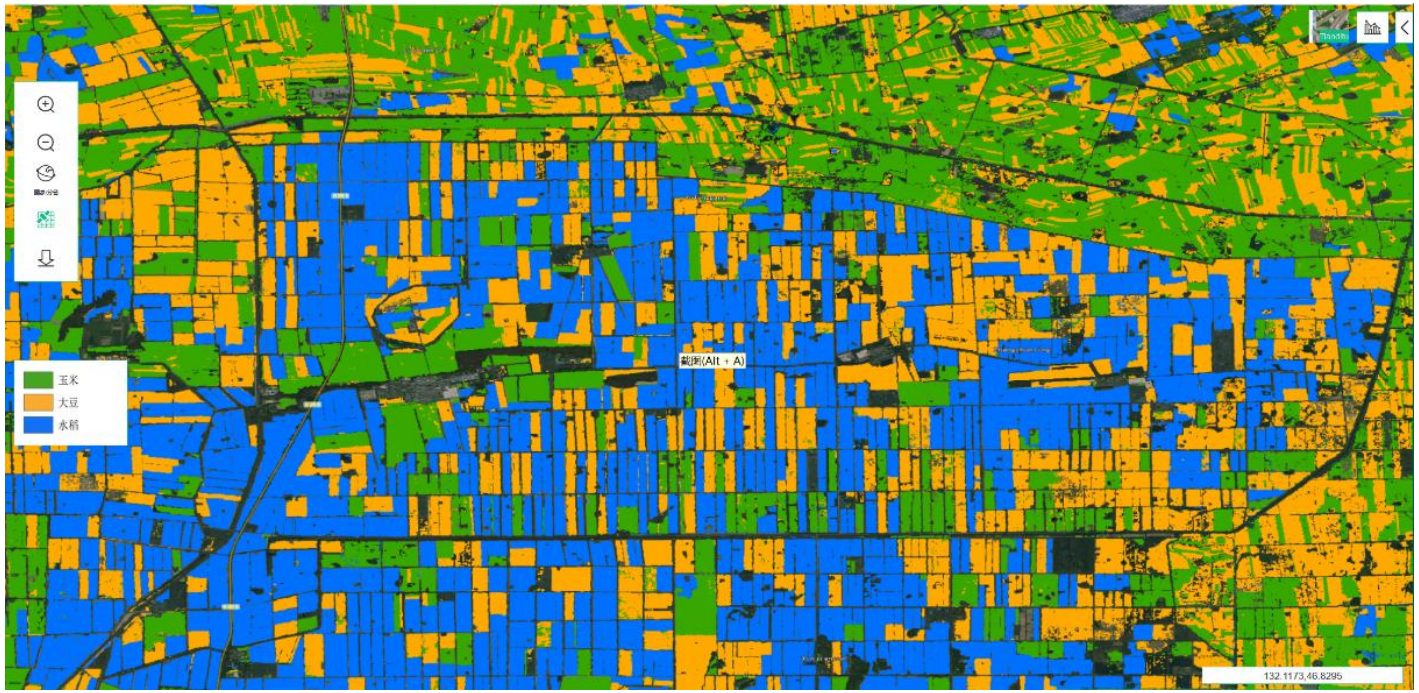


High resolution crop type monitoring services



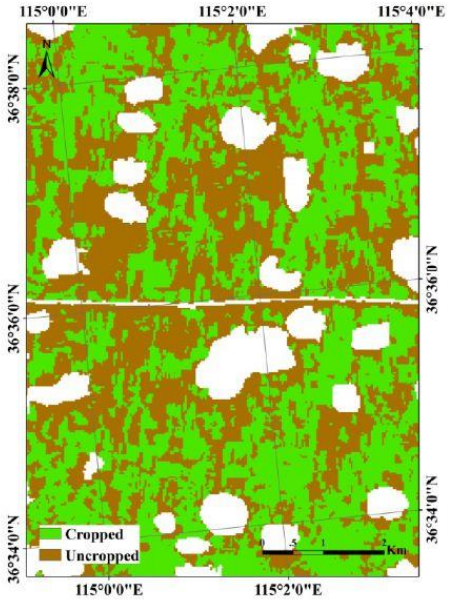




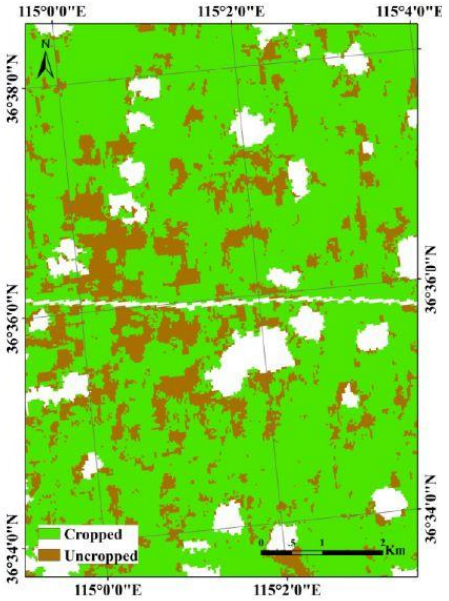


Crop Condition

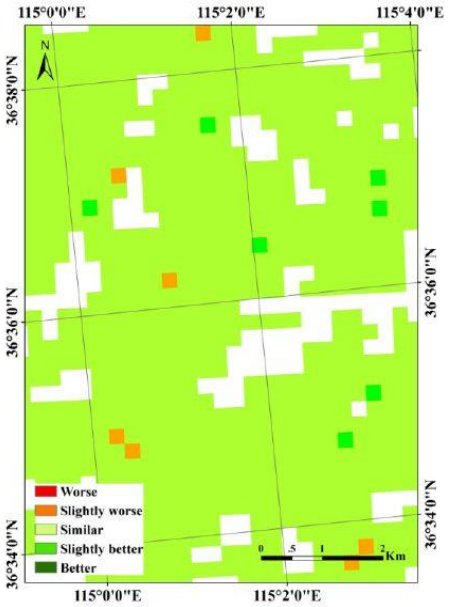
- adopting NDVI adjustments characterizing crop rotations or interannual phenological shifts, and this omission results in misleading information.



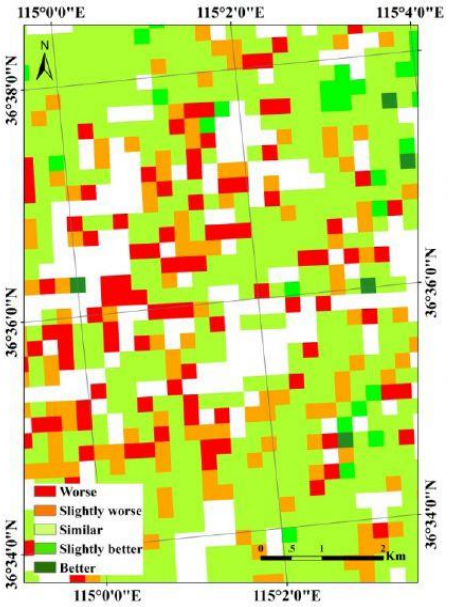
Cropped/uncropped map in reference year



Cropped/uncropped map in reference year +1



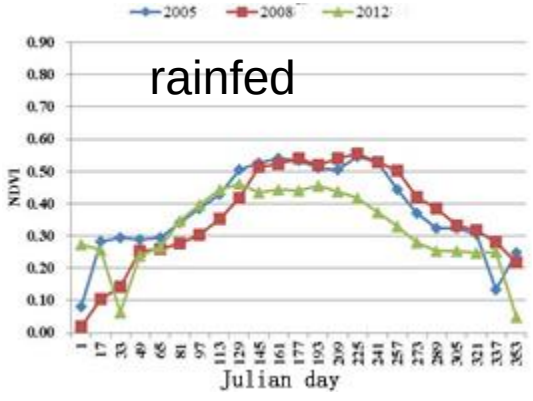
Crop condition



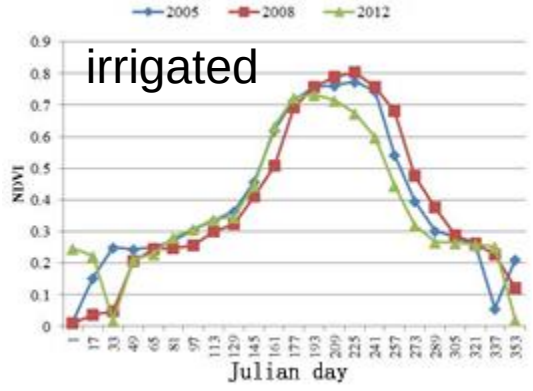
Crop condition with CALF-adjusted NDVI

Crop Condition by separating irrigation and rainfed fields

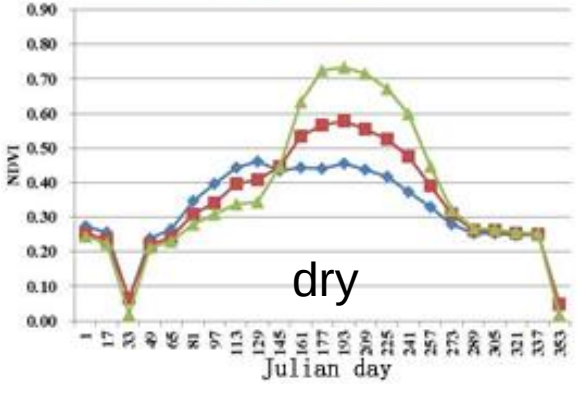
- Improve condition monitoring by separating irrigated and rain-fed arable land

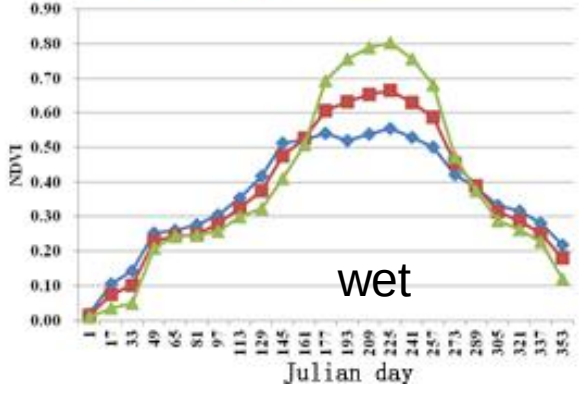


Wet year: 2005
Normal year: 2008
Dry year: 2012.



The difference of crop condition between rainfed and irrigated fields: Because of sufficient water, crop condition and production remain stable in irrigated areas, while they fluctuate between wet and dry years in rainfed areas.

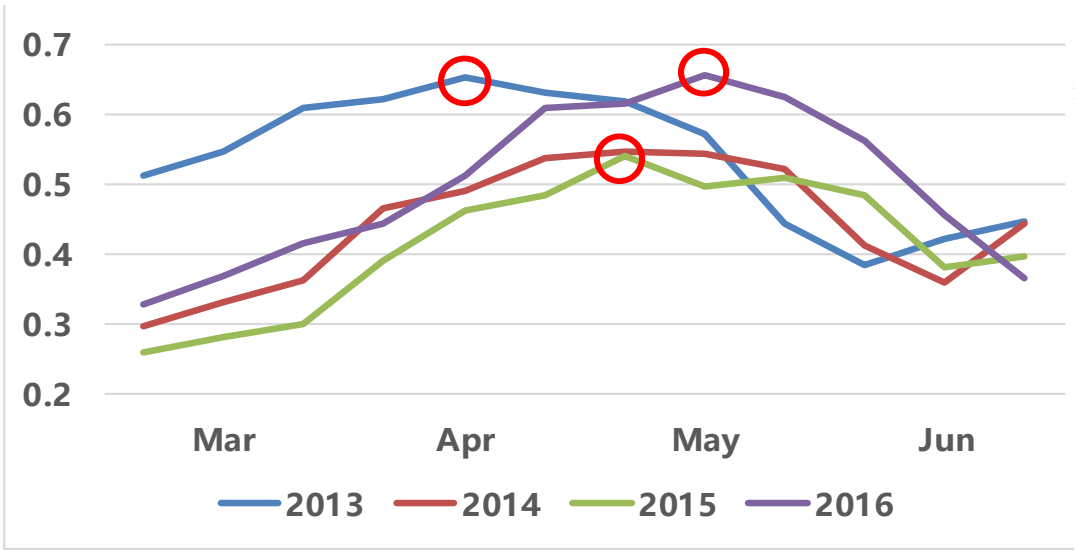


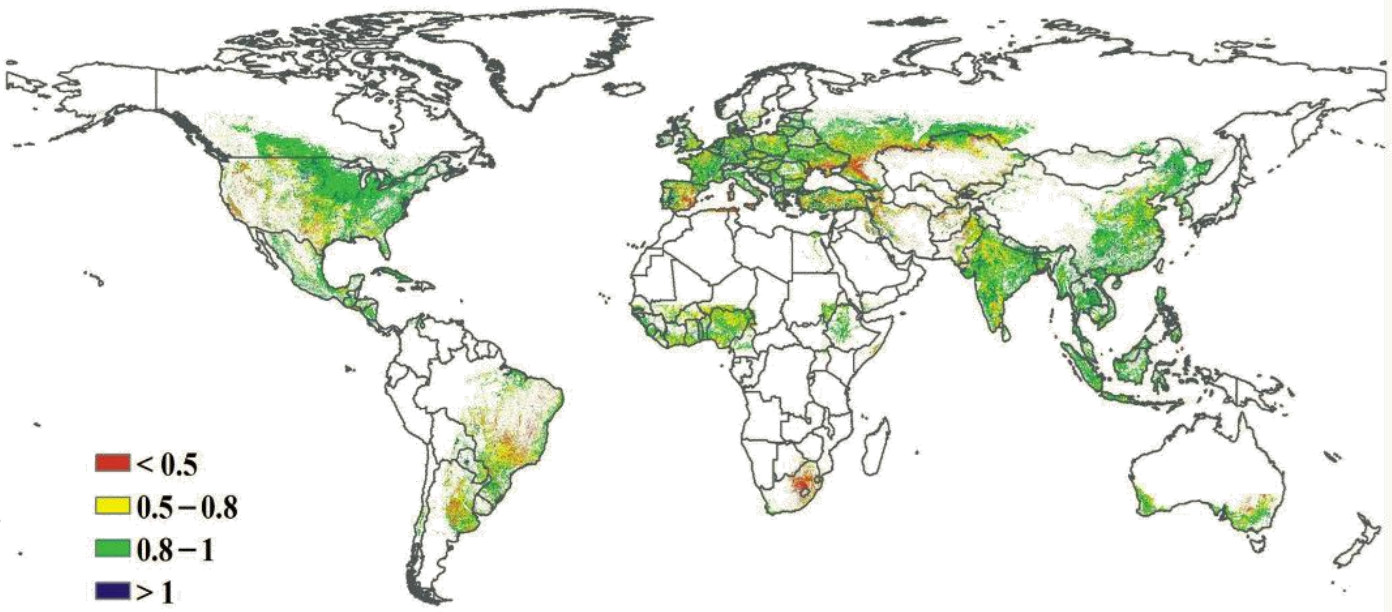


Rainfed: Blue
Irrigated: Green
Mixed: Red

Seasonal maximum vegetation condition index

- VCIx is designed to eliminate the impacts of the crop phenology shifts between years and at different latitude
  - VCIx compares peak of vegetation index profile with the historic peak over the same growing season
  - VCIx is at range of [0, 1], where the high values are better crop condition and low values indicate worse crop condition

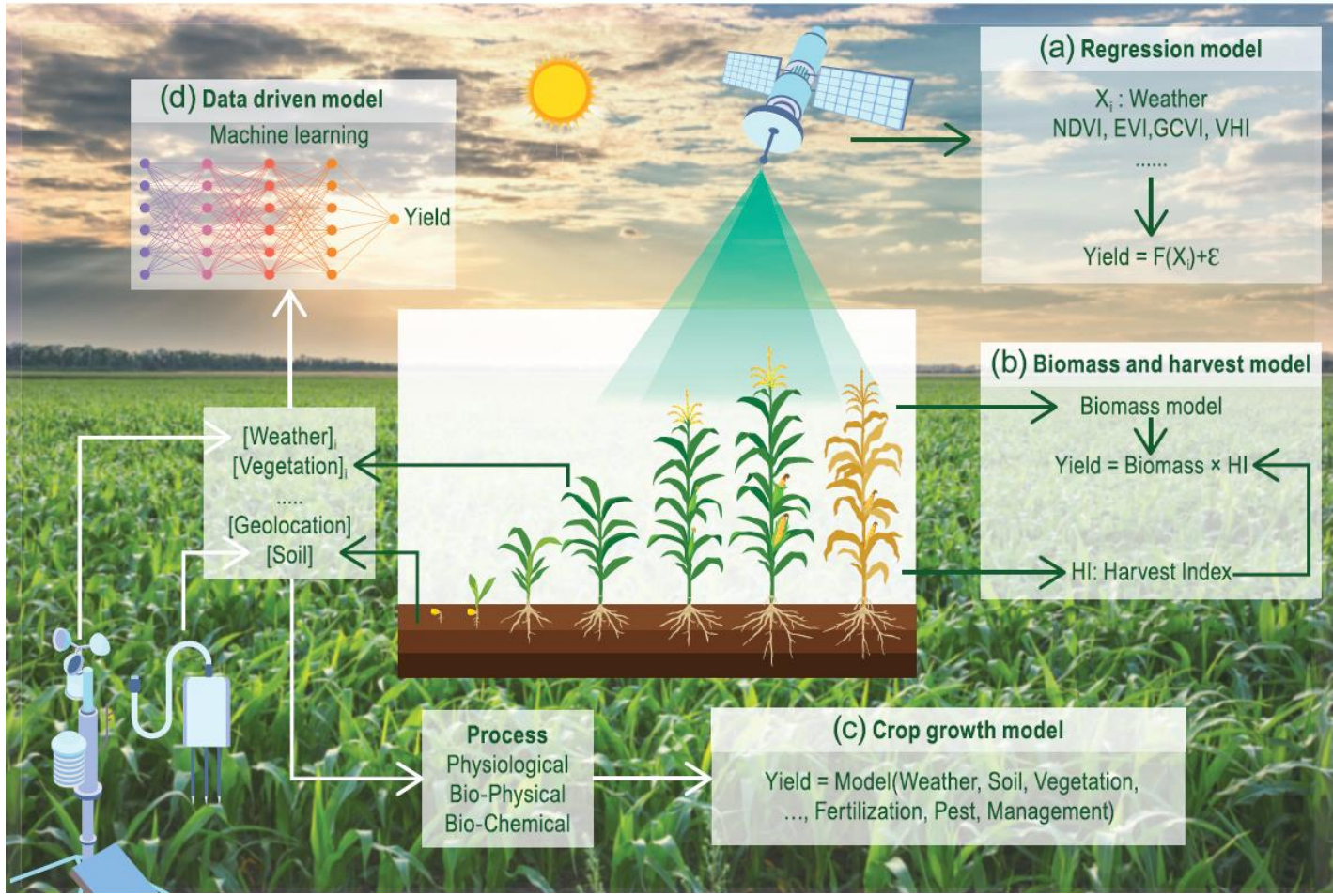




$$VCIx=\frac{NDVI_{\max\_c}-\mathrm{NDVI}_{\min\_h}}{NDVI_{\max\_h}-\mathrm{NDVI}_{\min\_h}}$$

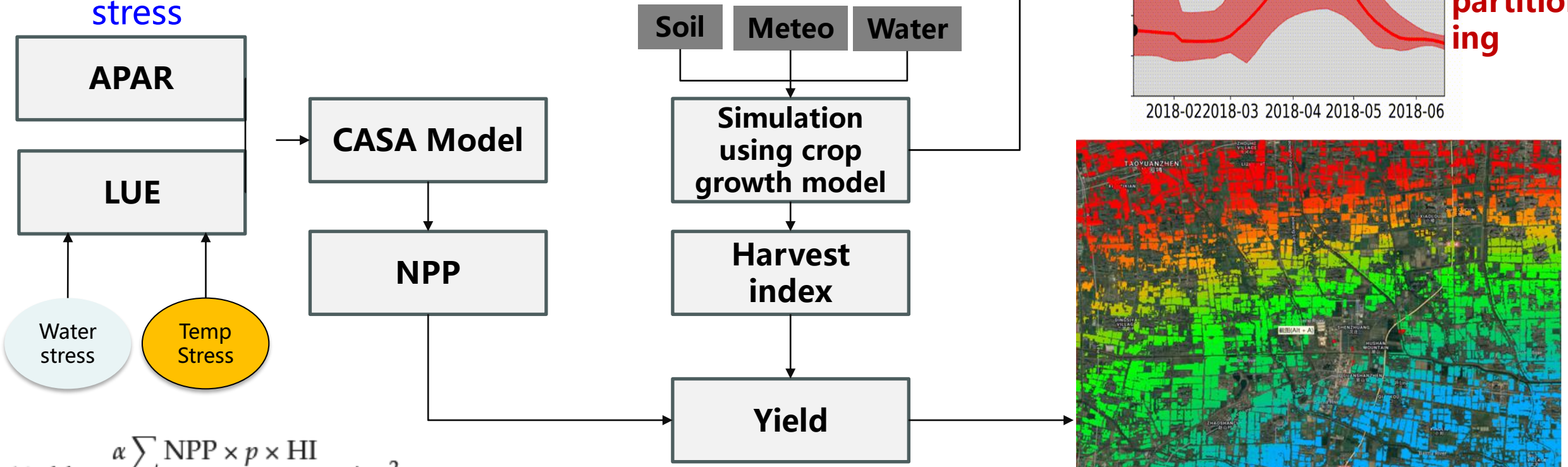
Yield models

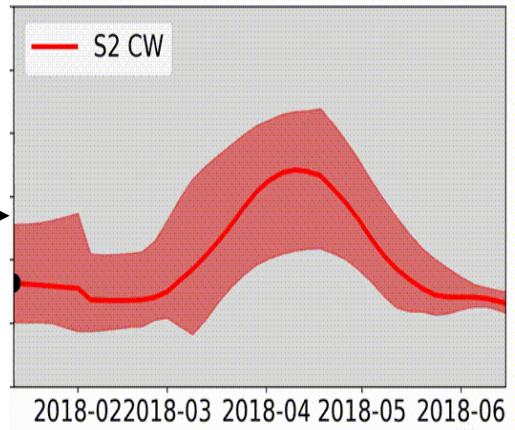
- Yield prediction component is the weakest component in crop monitoring
  - VI saturation leads to poor performance when predicting yields, especially in dense or irrigated crop regions.
  - VIs have not precisely captured crop yield determinants, especially under extreme climatic conditions.
  - The uncertainty of current crop growth models makes it difficult to scale up to facilitate operational yield predictions.
- 4 types yield models are developed and integrated into CropWatch to reduce the uncertainty of yield prediction
  - Agro climate
  - VIs
  - Biomass-harvest
  - Machine learning



Biomass - harvest index model for yield

- A light use efficiency model was used to integrate environmental factors and the characteristics of vegetation to calculate crop biomass
- Harvest index is simulated by crop growth model under stress





Simulate biomass partitioning

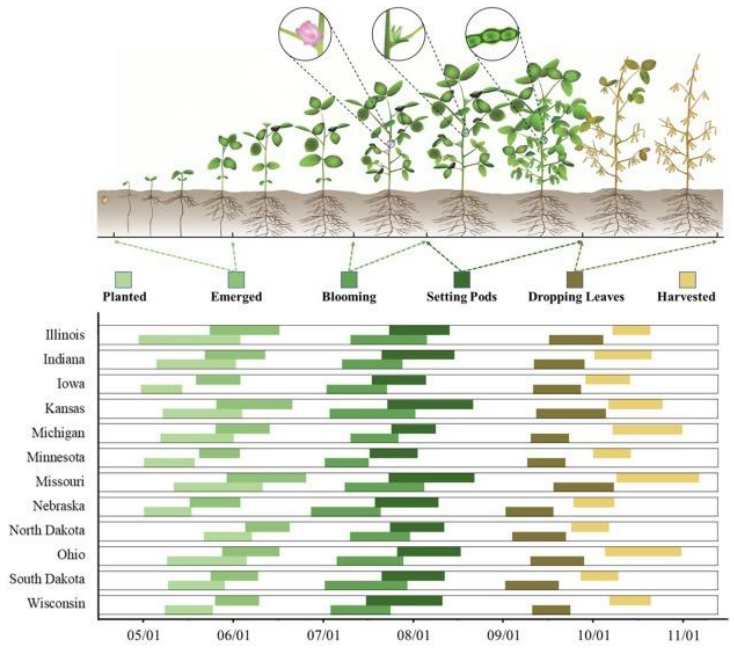
$$\text{Yield} = \frac{\alpha \sum \text{NPP} \times p \times \text{HI}}{1-\omega} \times 10^{-2}$$

$$\text{NPP}(x,t) = \text{APAR}(x,t) \times \varepsilon(x,t)$$

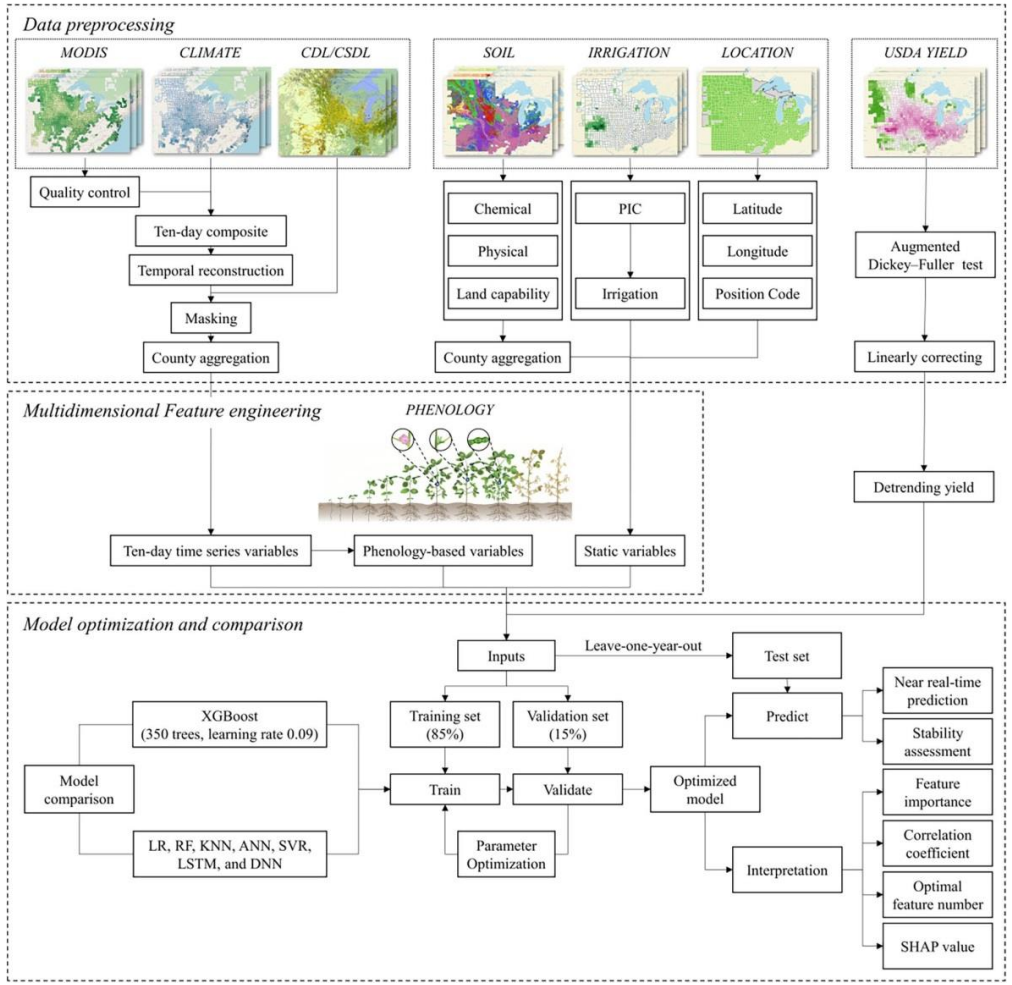
Data Driven Model for yield prediction

Yield = Function(climate, soil, vegetation, management)

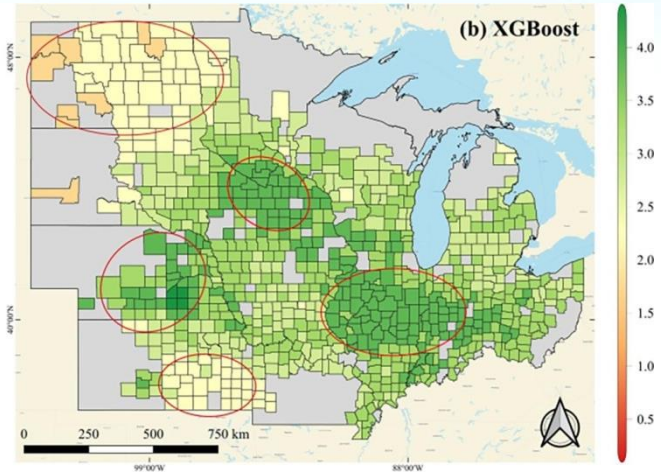
Function: ML or DL
X: climate, soil, veg, management variables at different phenological stage.



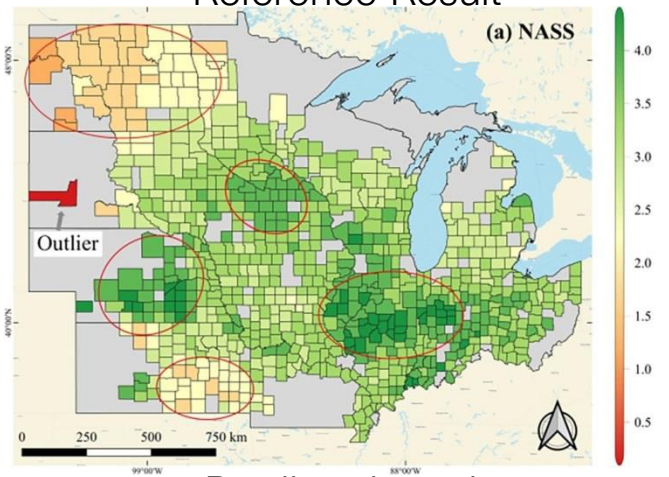
Phenological stage



Flowchart of Data Driven



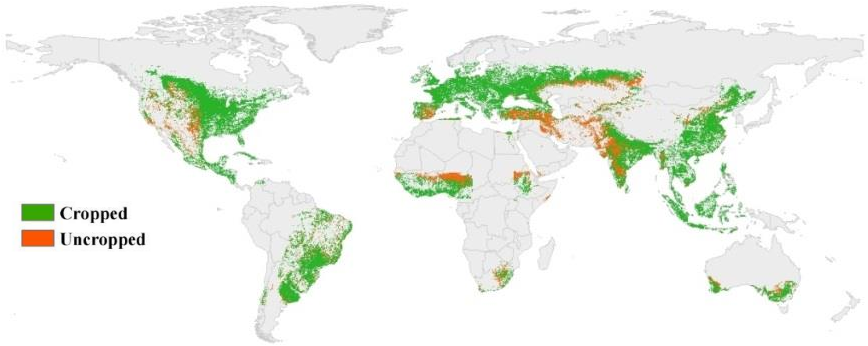
Reference Result



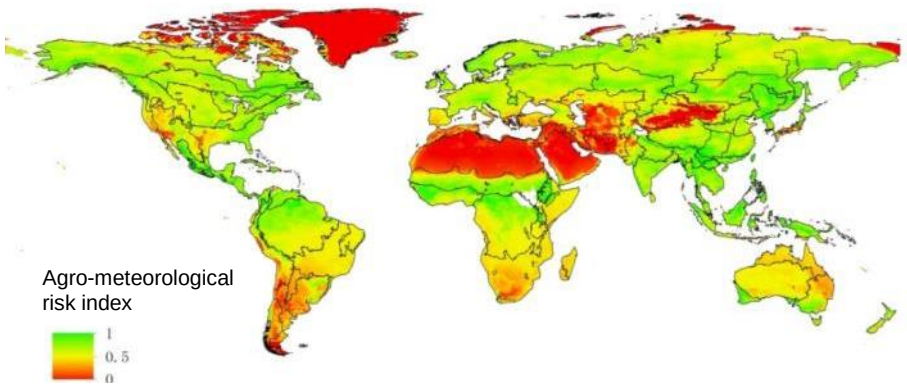
Predicted result

Early warning indicators

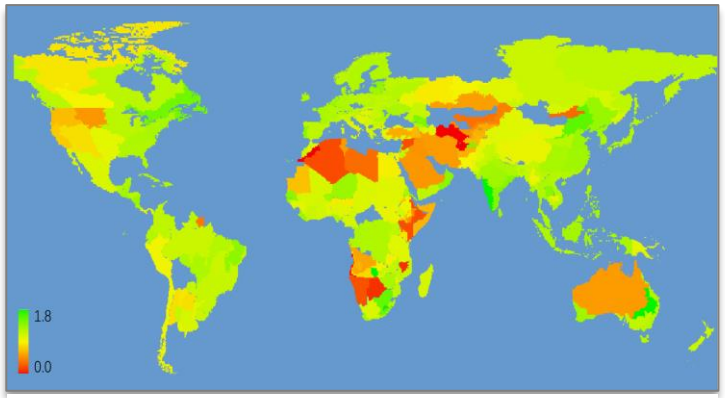
- Cropped arable land fraction (CALF) represents the total cropping proportion at early growing stage
- Agro-meteorological risk index (AMRI) considering meteorological suitability for crops at different growing stage is used for yield alarming
- Crop production index (CPI), integrating cropping area, condition,irrigation, intensity, productivity



CALF



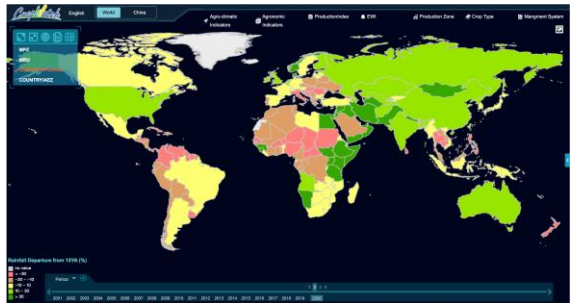
AMR

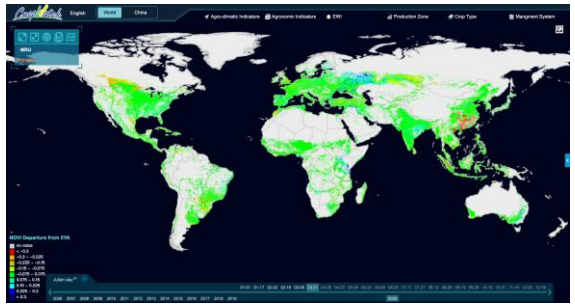


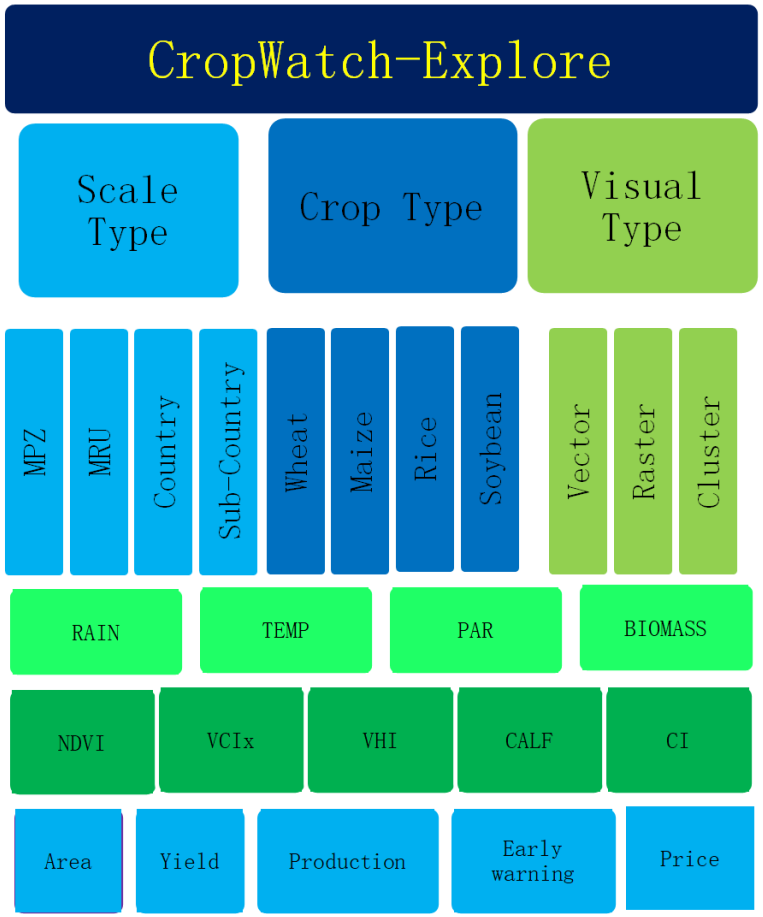
CPI

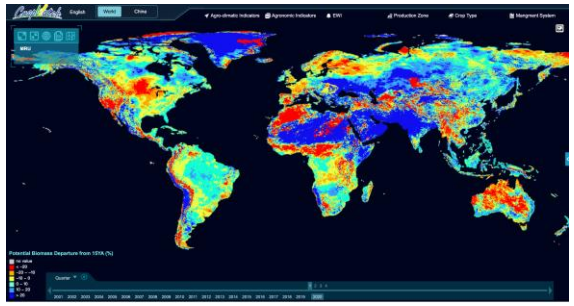
Component 2: CropWatch Explore

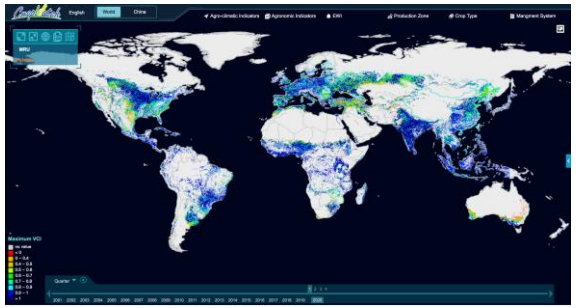
CropWatch-Explore explore and visualize data products in vector, raster, global, country, districts, crops, indicators….











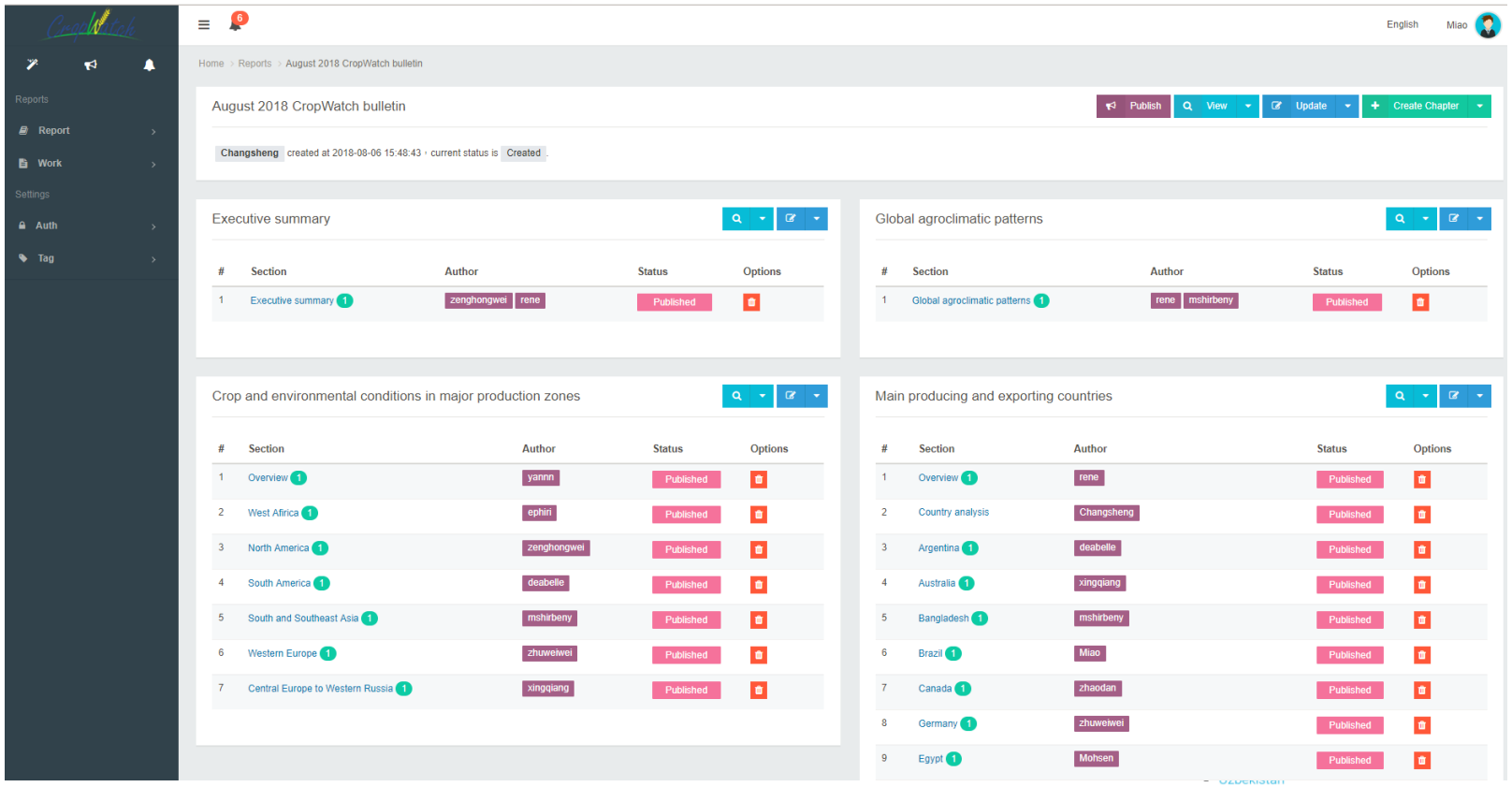
Component 3: CropWatch Analysis

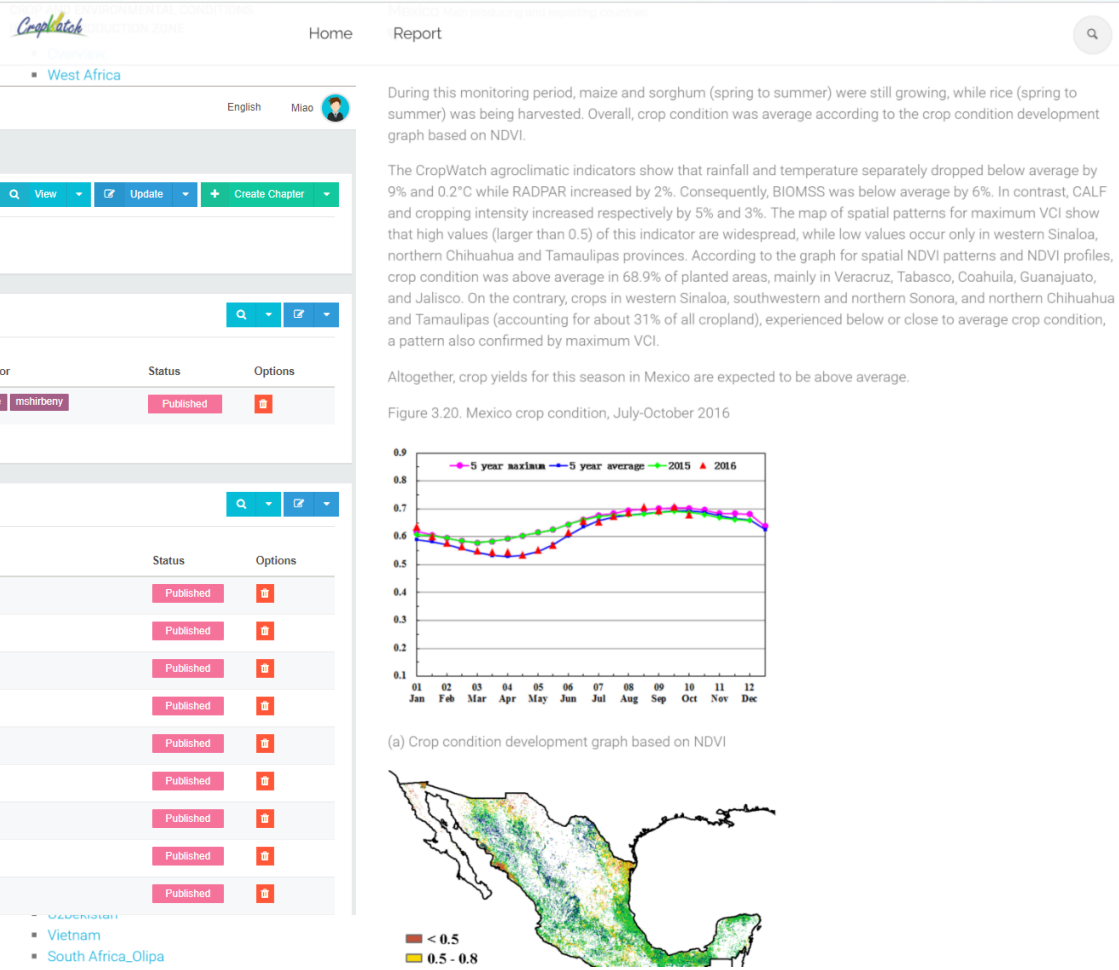
- CropWatch Analysis is cloud based participatory platform for individuals or team from over the world analyzing CropWatch indicators for the global, a country or IOA to better use local knowledge.
- It provides create document, allocate and manage tasks, monitor schedule and publish the document online functions which let people over the world finish their documents together on the cloud platform.

CropWatch Team

Experts across the world

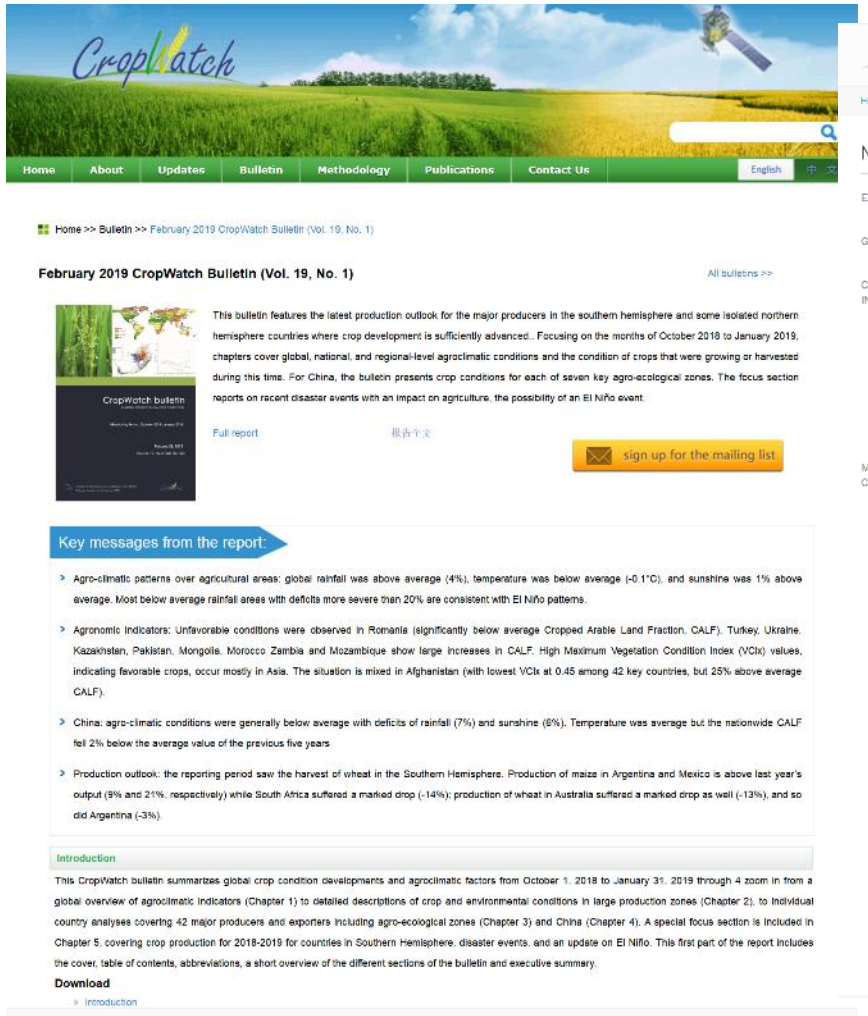
Author assignment and analysis

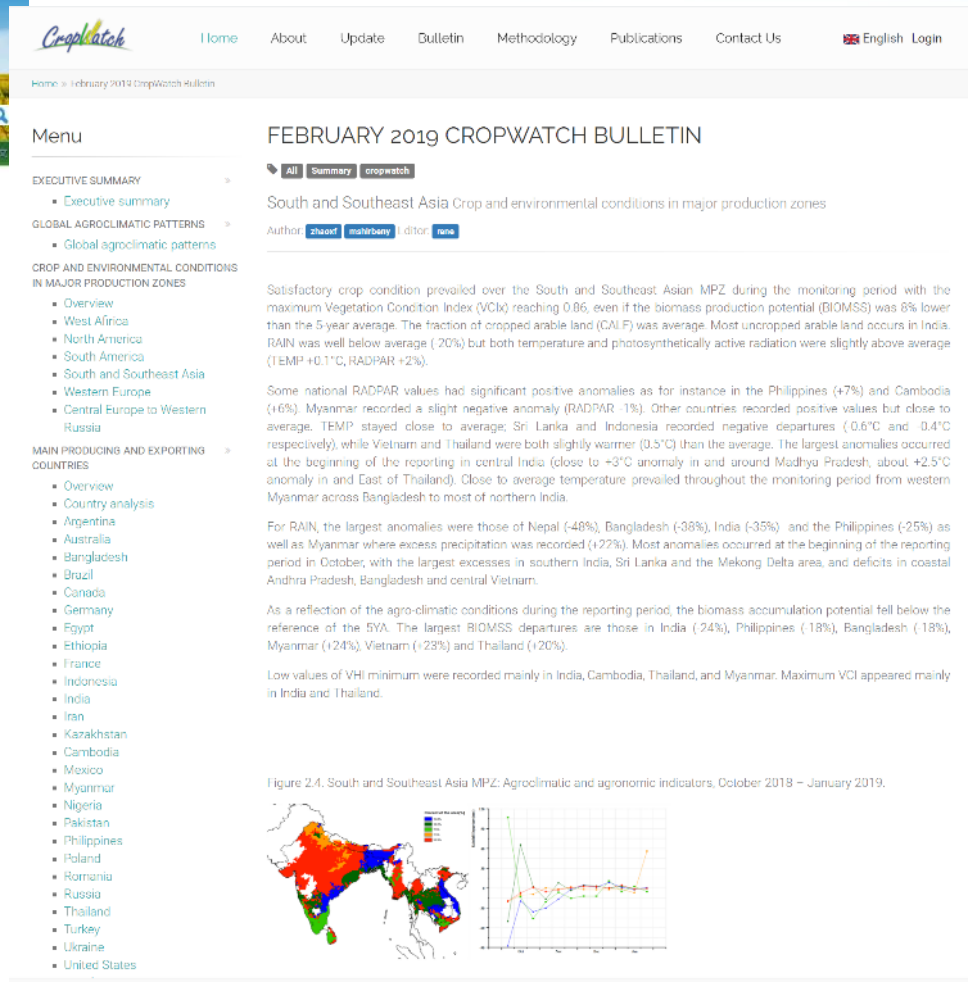




Component 4: CropWatch Bulletin

Provide global crop report as pdf or html format



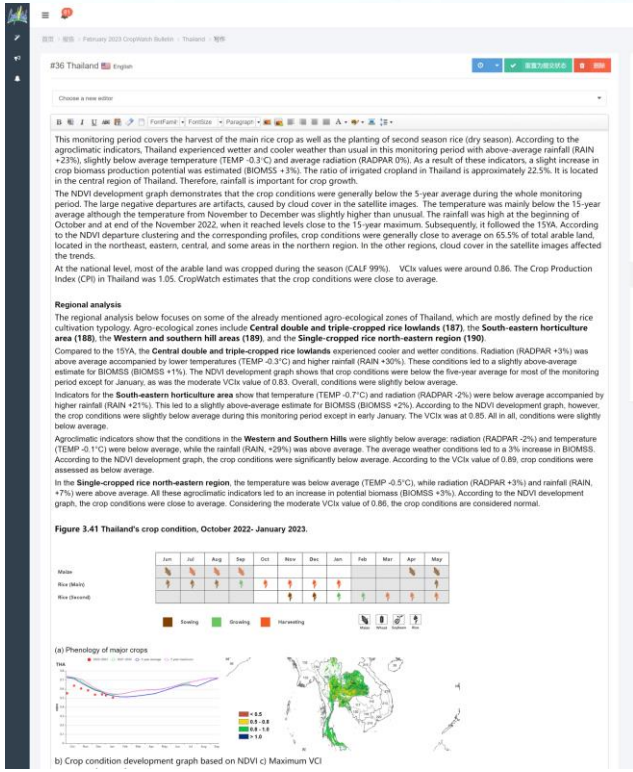


Outlines

- CropWatch Cloud and the methodologies
- Updates
  - Service modes
  - New tools for field data collection
  - Baseline dataset
  - User defined crop monitoring
- Conclusion remarks

Service modes

- **Customization of CropWatch and/or development of CMS for specific needs (Mozambique),**
- **data processing engine and download for local services (Thailand),**
- **independent analysis for a country or IOA (Argentina, Cambodia, Mongolia)**

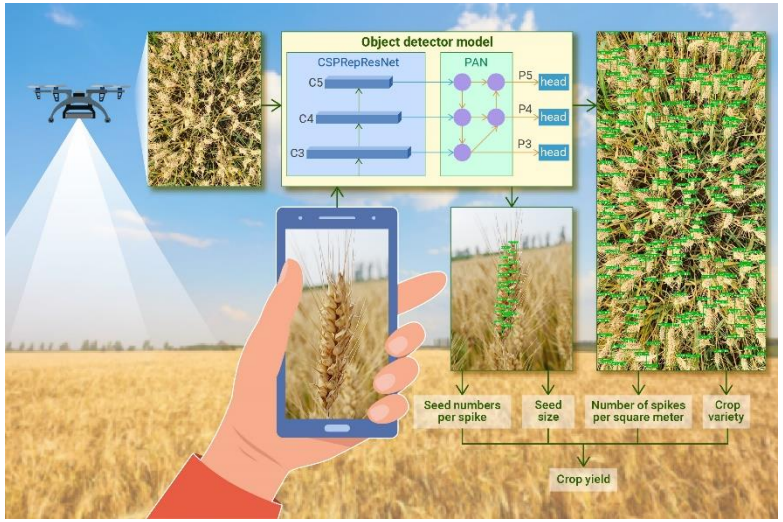


- **Reducing the cost and technical barrier of establishing CMS**

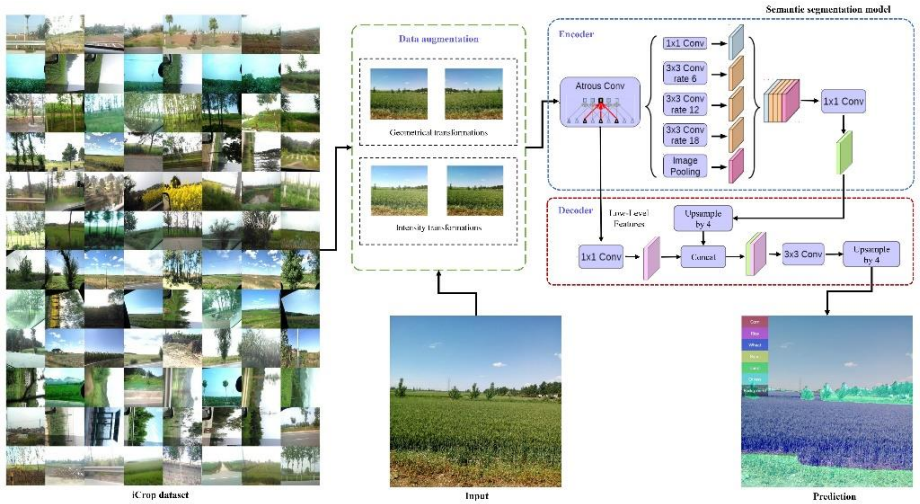
Wu F, et al. Environmental Modelling and Software , 2021; Wu B, et al. National Science Review, 2023

Tools for ground truth data collection

- The field data collection prevents most systems have crop area and yield components
  - Cost, labor and time consuming
- Two tools developed for free use
  - GVG app for crop identification and FieldWatch for yield measurement with image recognition



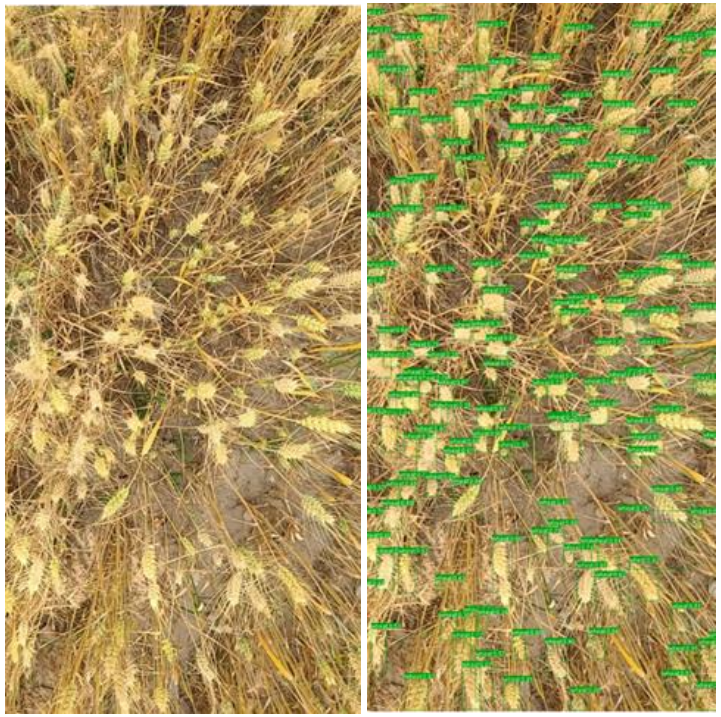
FieldWatch for yield data measurements



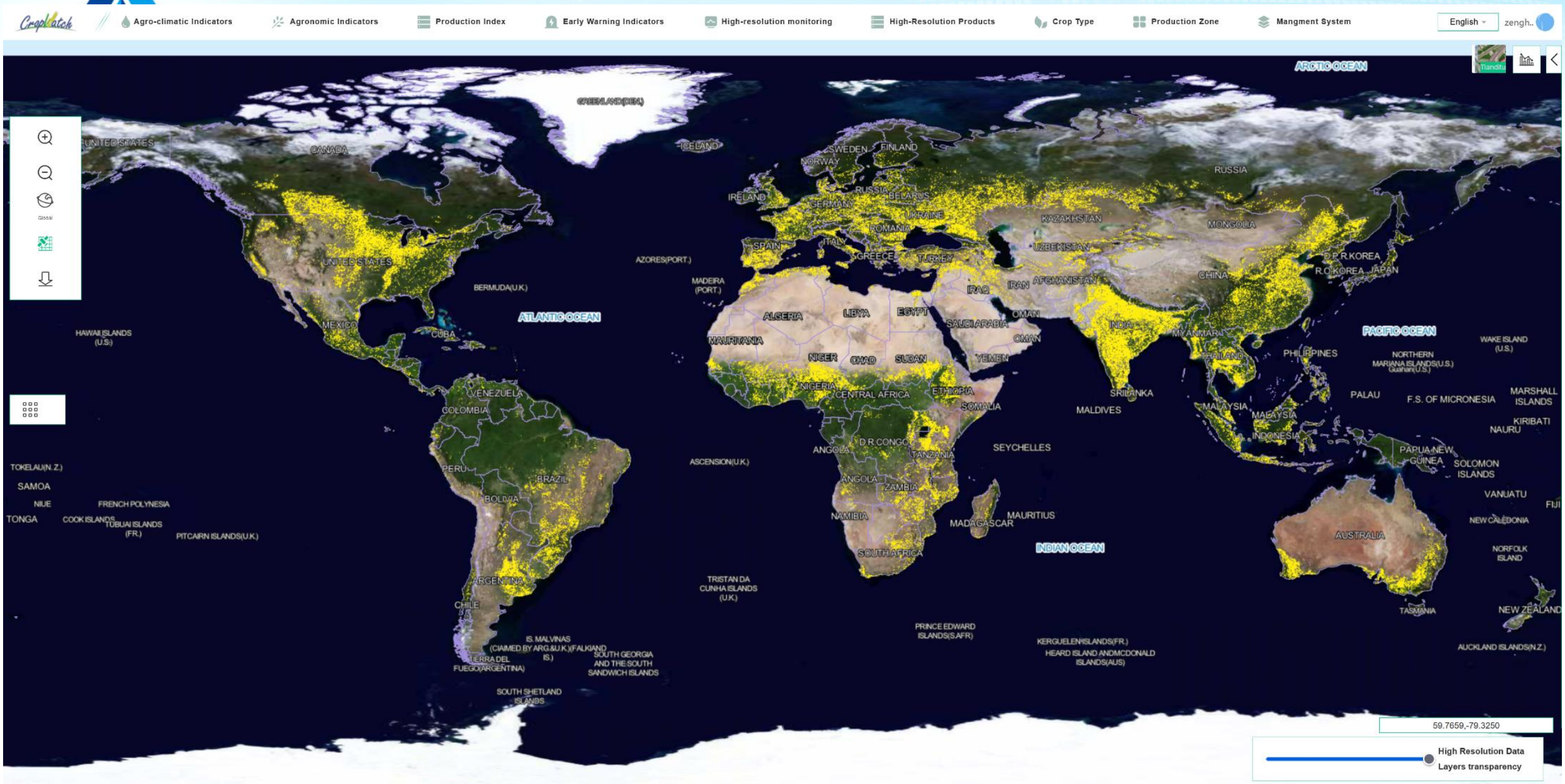
GVG Crop type identification from geo-tagged photos

FieldWatch for yield data collection

- **With the support of the DL model, the number of ears/m2, and seed number per ear, size of seed are determined for crop yield estimation with accuracy of 92%**
- **FieldWatch supports disease identification, parcel crop condition and production**

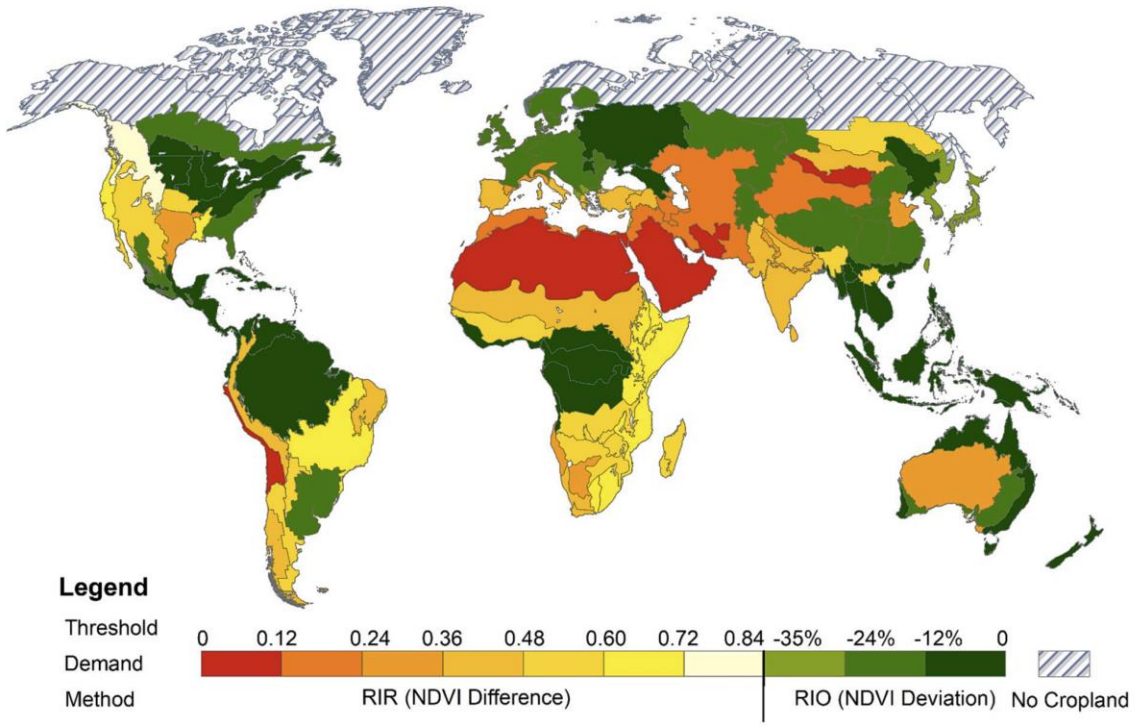


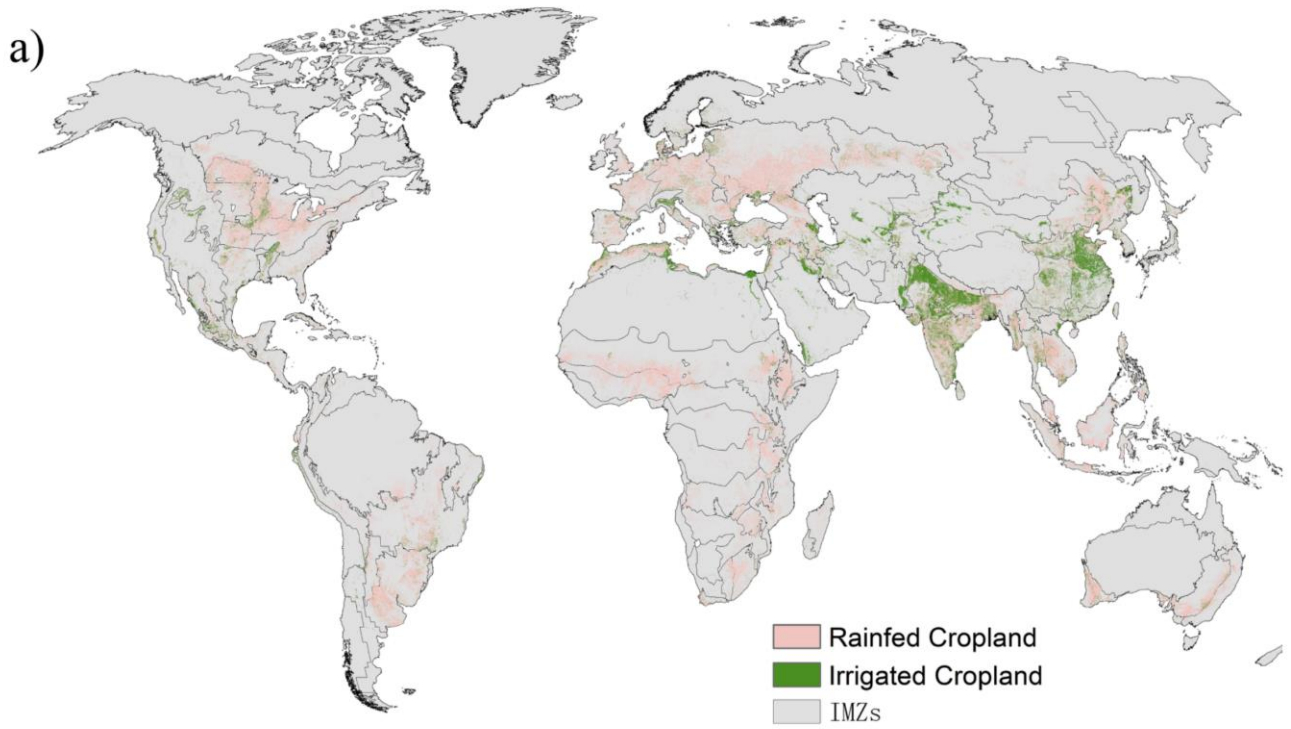
Global Cropland Data at 30m



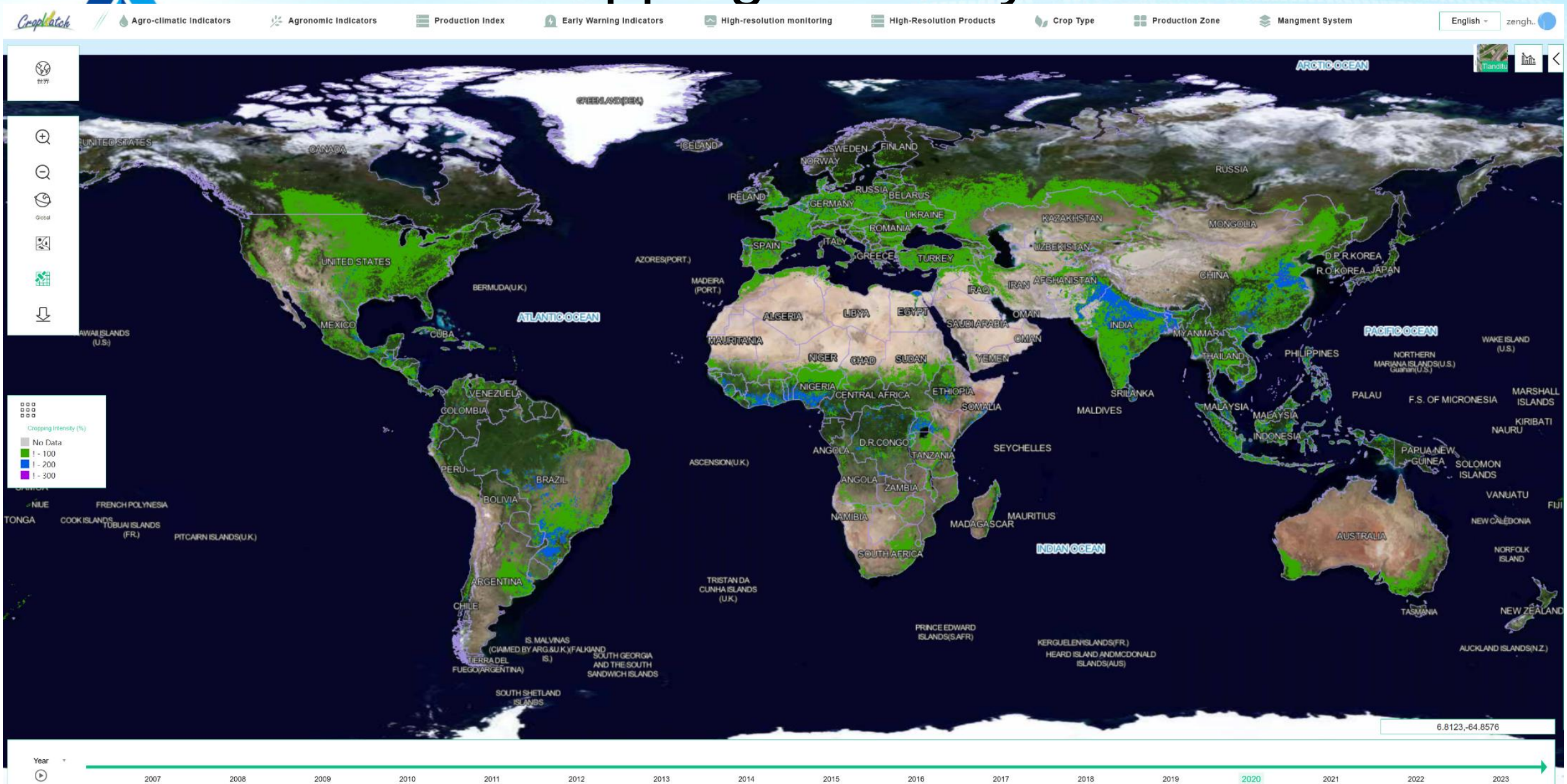
Irrigated Cropland Mapping

- Mapping the extent of irrigation with the NDVI differences between irrigated and non-irrigated croplands under water stress;
- The irrigation area at a 30-m resolution is 23.4 % of global cropland in the period 2010–2019, with an overall accuracy of 83.6 % globally
- Separating regular and intermittent irrigation





Global Cropping Intensity at 30m



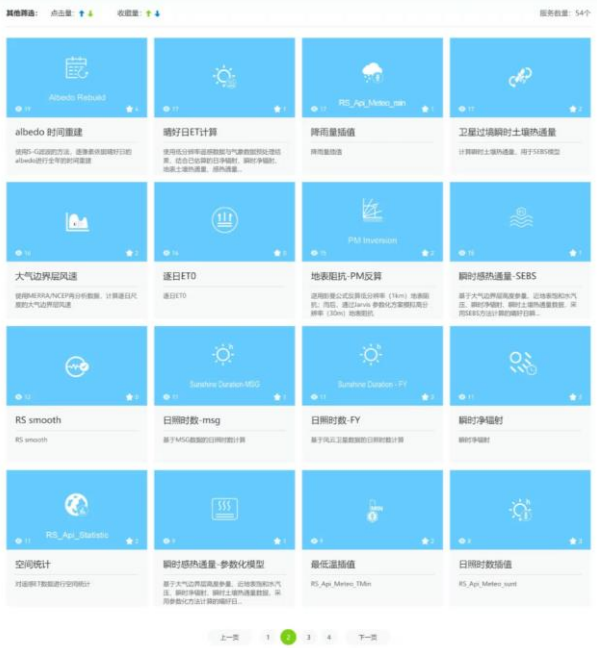
Users to conduct crop monitoring on your own

- CropWatch provide solutions for users to carry out self-serviced crop monitoring by selecting their preferred indicators, models for the user's area of interest, allowing users actively involved from remote sensing data preparation to the final synthesized analysis

地面调查APP

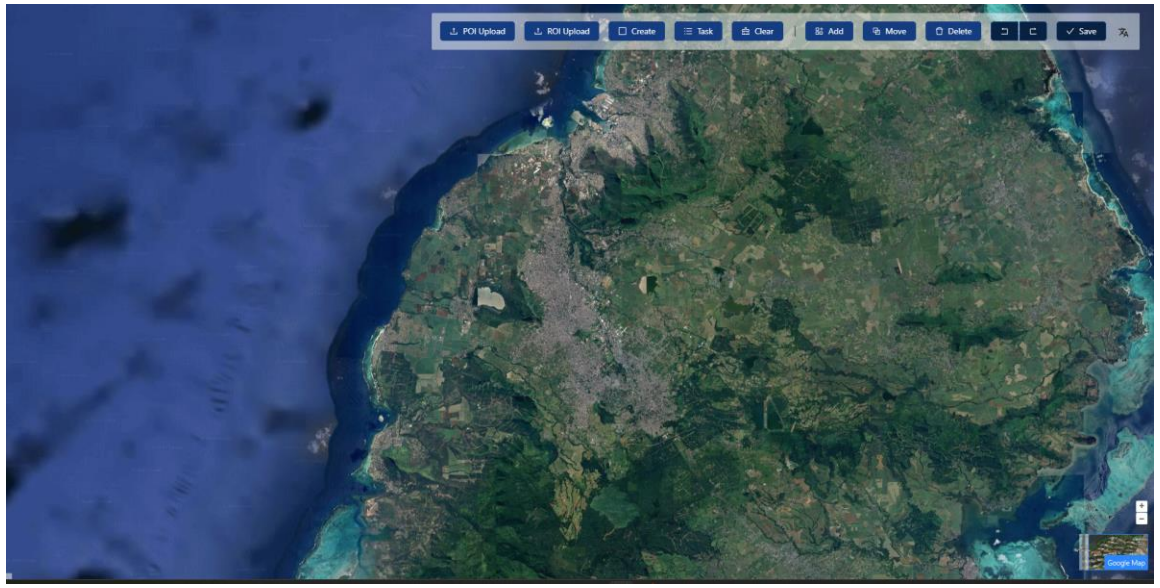
单产观测APP

Smart APPs providing ground truth data support



Microservice

Process engine



User-defined roi, indicators, models and self-calibration

API center

Dockerization

Algorithms in Docker

Deploy

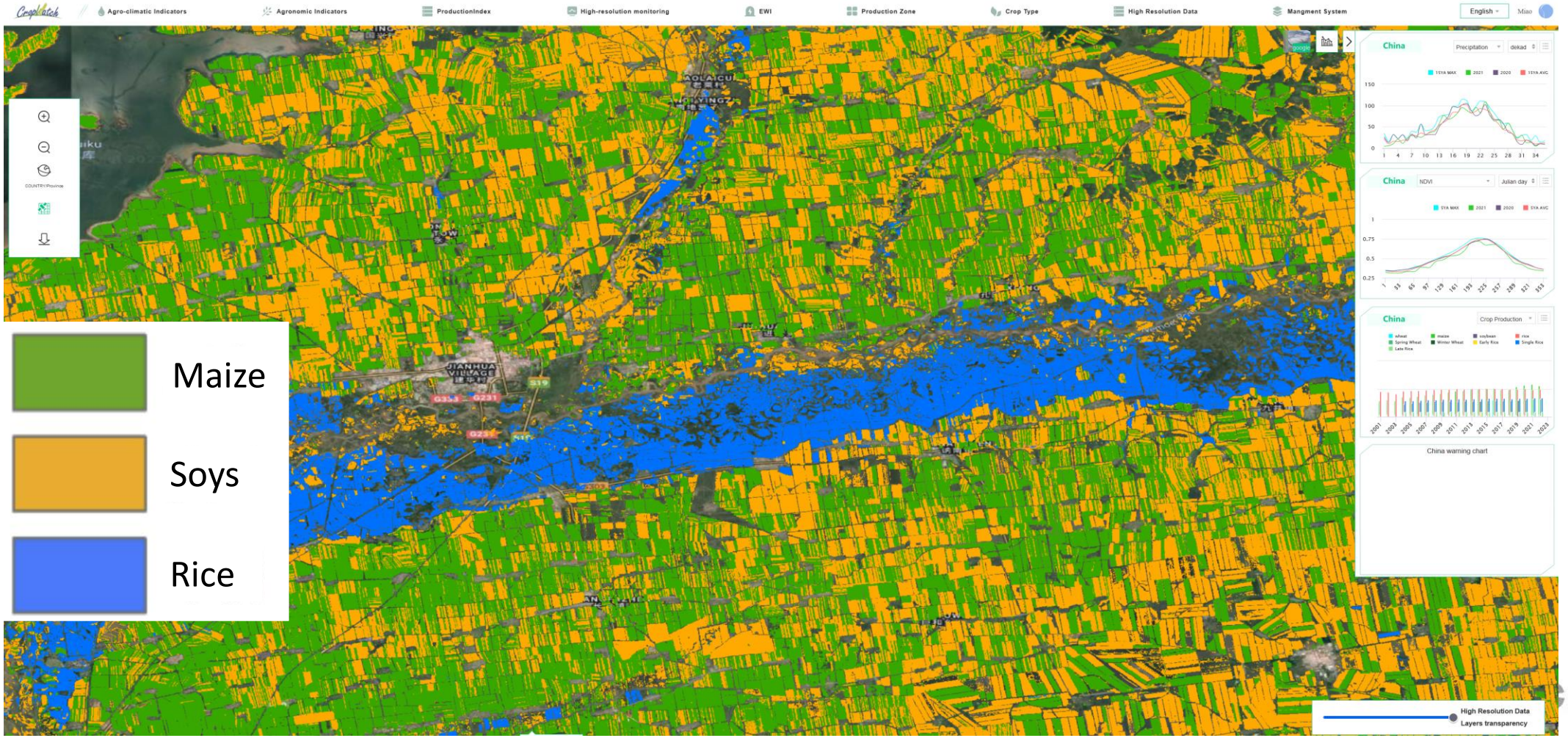
User devices

Edge computing mode

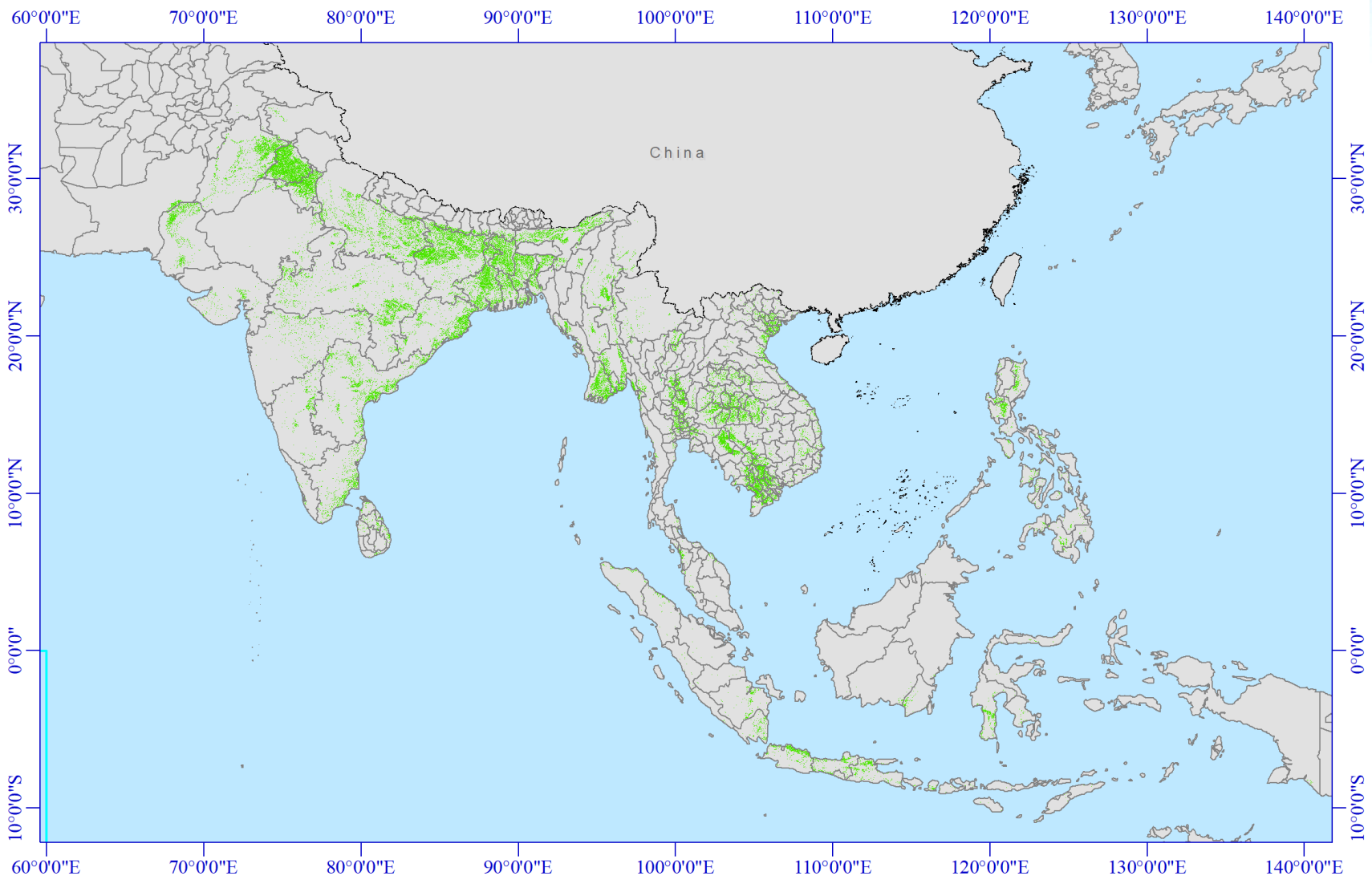
- ✓ **Computation on user devices, enabling users allocate computing resources for high-performance tasks.**
- ✓ **Data retained locally, protecting user data sovereignty.**

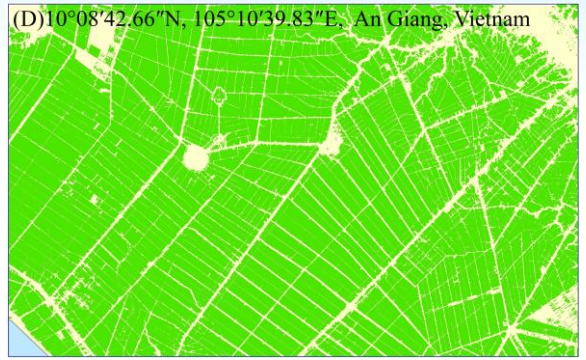
Field-based high resolution crop type mapping

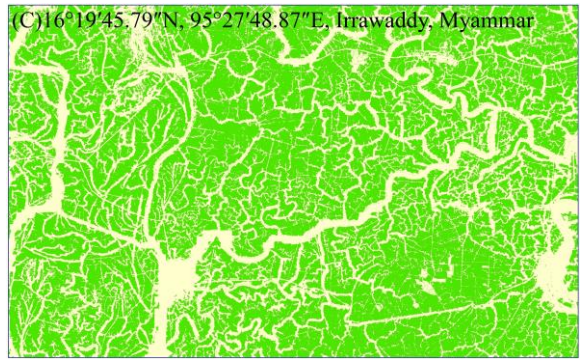
Field level crop map

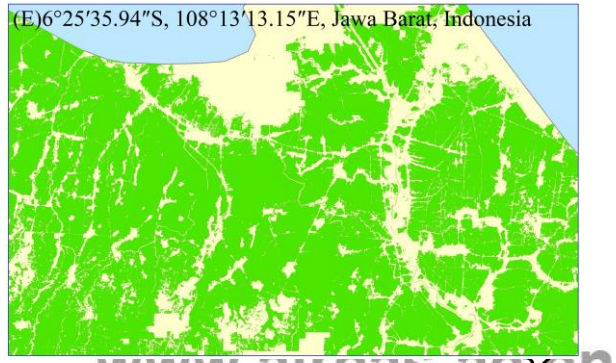


Paddy rice mapping









Outlines

- Overview of CropWatch
- Updates
  - Service modes
  - New tools for field data collection
  - Baseline dataset
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CropWatch Vision

- Promoting ownership
  - Customized according to the specific demand for each country and work as a national/regional system
- Respecting privacy and data sovereignty
  - Providing crop monitoring APIs to address the data sovereignty
  - Countries will strengthen the agricultural monitoring capacity on their own
- Reducing constraints
  - Cloud based system assessable from internet everywhere without investment on computing infrastructure, storage, etc

Take home message

- Website http://cloud.cropwatch.com.cn/
- GVG APP: https://gvgserver.cropwatch.com.cn/download (Android) https://apps.apple.com/py/app/gvg%E5%86%9C%E6%83%85%E9%87%87%E9%9B%86/id1244686128 (iOS)
- FieldWatch APP: https://play.google.com/store/apps/details?id=com.wisewoods.xtt&pli=1
- CropWatch Knowledge Package on GEO Knowledge Hub: https://gkhub.earthobservations.org/packages/pps5h-ea276
- Archive bulletins: http://cloud.cropwatch.com.cn/site/bulletin
- Research publications: http://cloud.cropwatch.com.cn/publications/index
- Email address: cropwatch@aircas.ac.cn

Openly shared datasets

- Global cropland mask @30m: https://data.casearth.cn/thematic/cbas_2022/158
- Global cropping intensity @30m: https://doi.org/10.7910/DVN/86M4PO https://data.casearth.cn/thematic/cbas_2022/160
- Global irrigation proportion @100m: https://doi.org/10.7910/DVN/HKBAQQ
- Global crop area, yield and production: https://doi.org/10.7910/DVN/G1HBNK
- Synthesis of Global ET: https://doi.org/10.7910/DVN/ZGOUED
- Africa Cropland Layer: https://doi.org/10.6084/m9.figshare.13520141.v1

Thank you!

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