Institute of Remote Sensing and Digital Earth
Chinese Academy of Sciences

CropWatch and ETWatch for Food Security

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Institute of Remote Sensing and Digital Earth (RADI)
Chinese Academy of Sciences

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INTRODUCTION

Remote Sensing can be used to improve monitoring and management for food security. This can be done through:

Focus	Applications
Disaster Management	• Flood mapping and forecasting modeling • Drought monitoring and early warning
Water Management	• Water balance analysis/Water use efficiency • Ground water to surface water integration • Satellite and in situ precipitation data merging • Evapotranspiration measurement and monitoring • Climate change impact analysis on water
Agriculture Management	• Crop and irrigation mapping • Agriculture and water productivity • Climate change impact on agriculture production • Crop yield forecasting • Locust monitoring

CropWatch

- Global Crop Monitoring System

DroughtWatch

- Drought monitoring system

ETWatch

- Evapotranspiration monitoring system

CropWatch Mission

***CropWatch** aims at improving food information availability, quality and transparency*

- To improve access to global information about the worldwide production of major cereals and soybean
- Serve as a science-based Chinese voice on global food security perception
- To provide additional, reliable information for developing countries to fight against hunger
- Offer cloud-based services

CropWatch Hierarchical Approach

Global: homogeneous crop mapping and reporting units
Using CropWatch Agroclimatic Indicators (CWAIs) for rainfall, air temperature, photosynthetically active radiation, and potential biomass

Regional: Major production zones
In addition to CWAIS, Vegetation health index, uncropped arable land, cropping intensity, and maximum vegetation condition index

National: 31 countries
In addition to previous indicators, crop cultivated area, time profile clustering

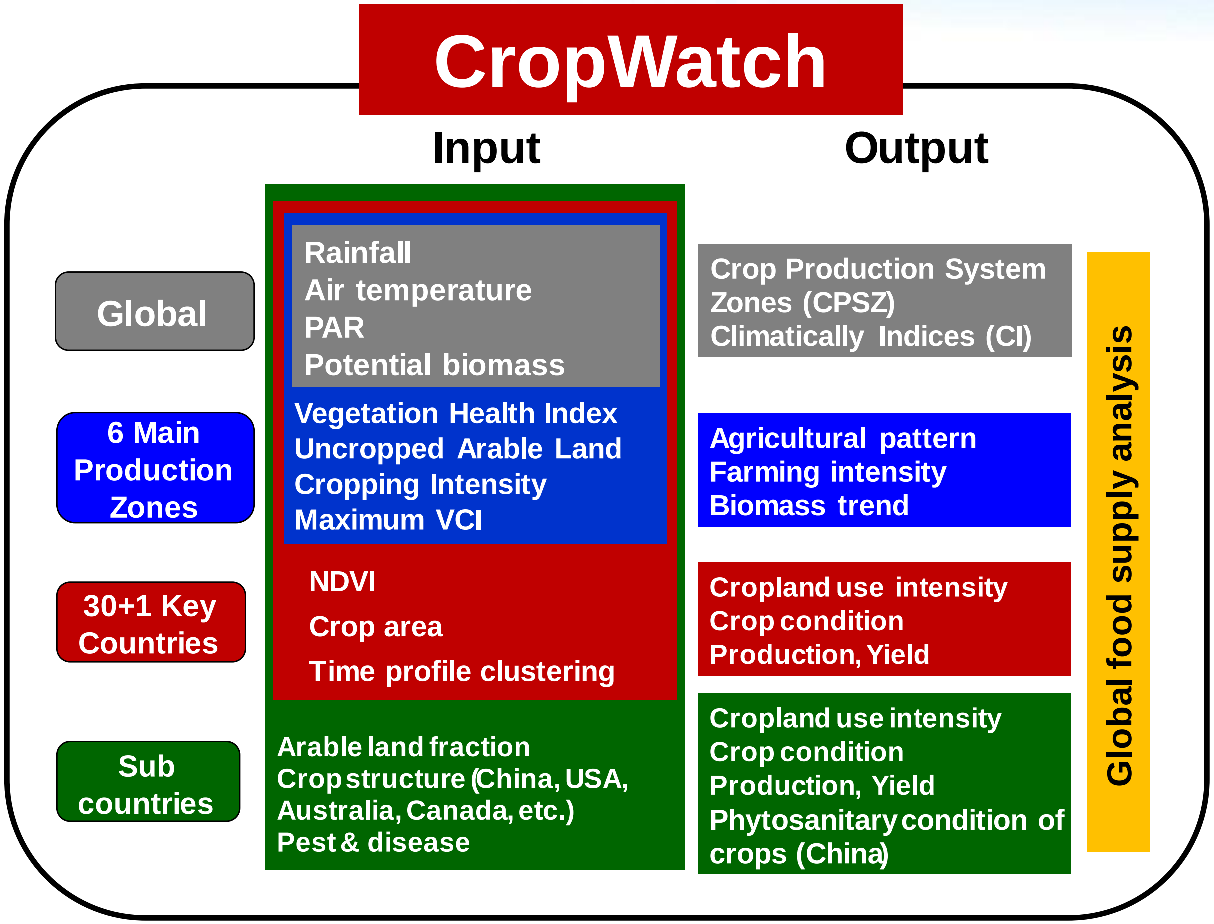
Province or State for large countries
Crop type proportion

From agroclimatic to agronomic indicators

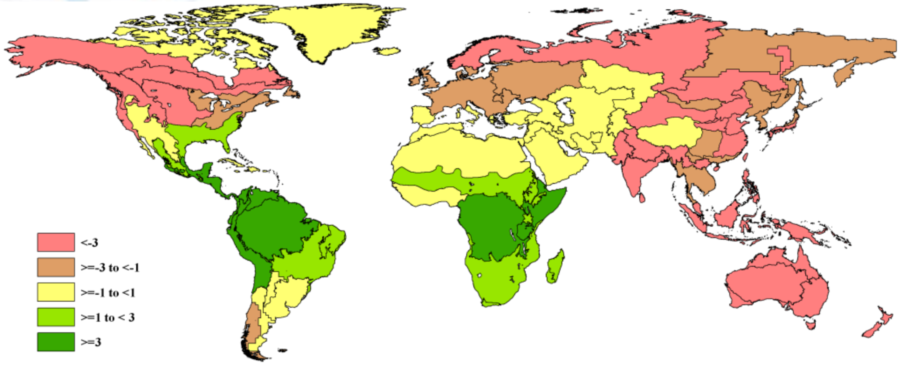
From 25 km to 10m

CropWatch Hierarchical Approach

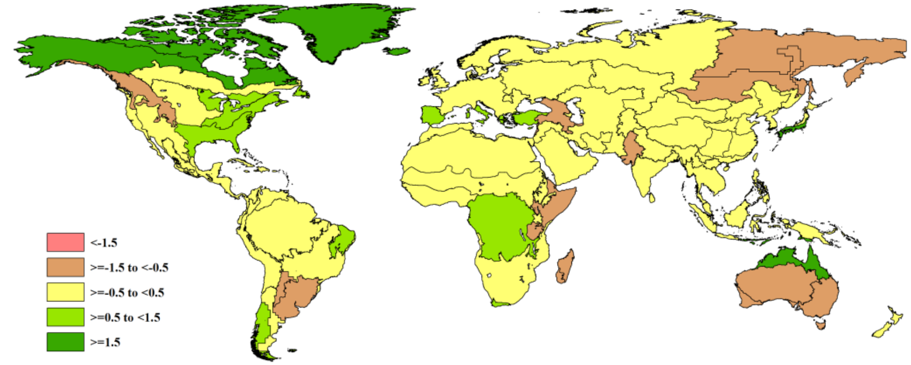
- **4 scales**
  - Covering 31 main crop producing countries
  - Taking account of 80% of global production and exports
- **4 temporal resolution**
  - 16 Days: NDVI, Crop condition
  - Seasonal：Agro-climatic indicators, CAL, VHI, VCIx
  - Growing season：Area, Yield, Production
  - Year: Cropping intensity
- **4 spatial resolution**
  - 0.25° (Global)
  - 1km (7 MPZ, 31 countries, Sub countries)
  - 250m China
  - 30m/16m main production regions in China



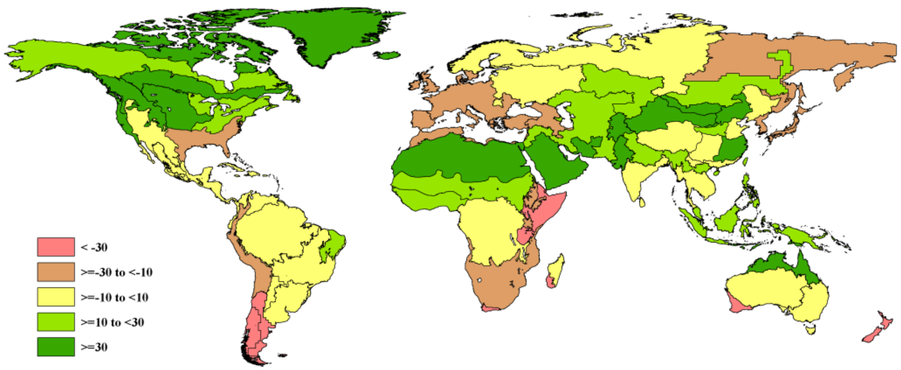
Global: 65 MRUs



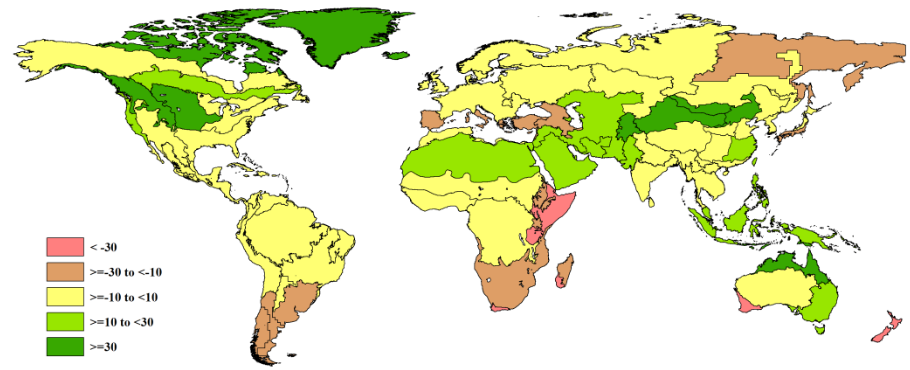
PAR departure



Temperature departure

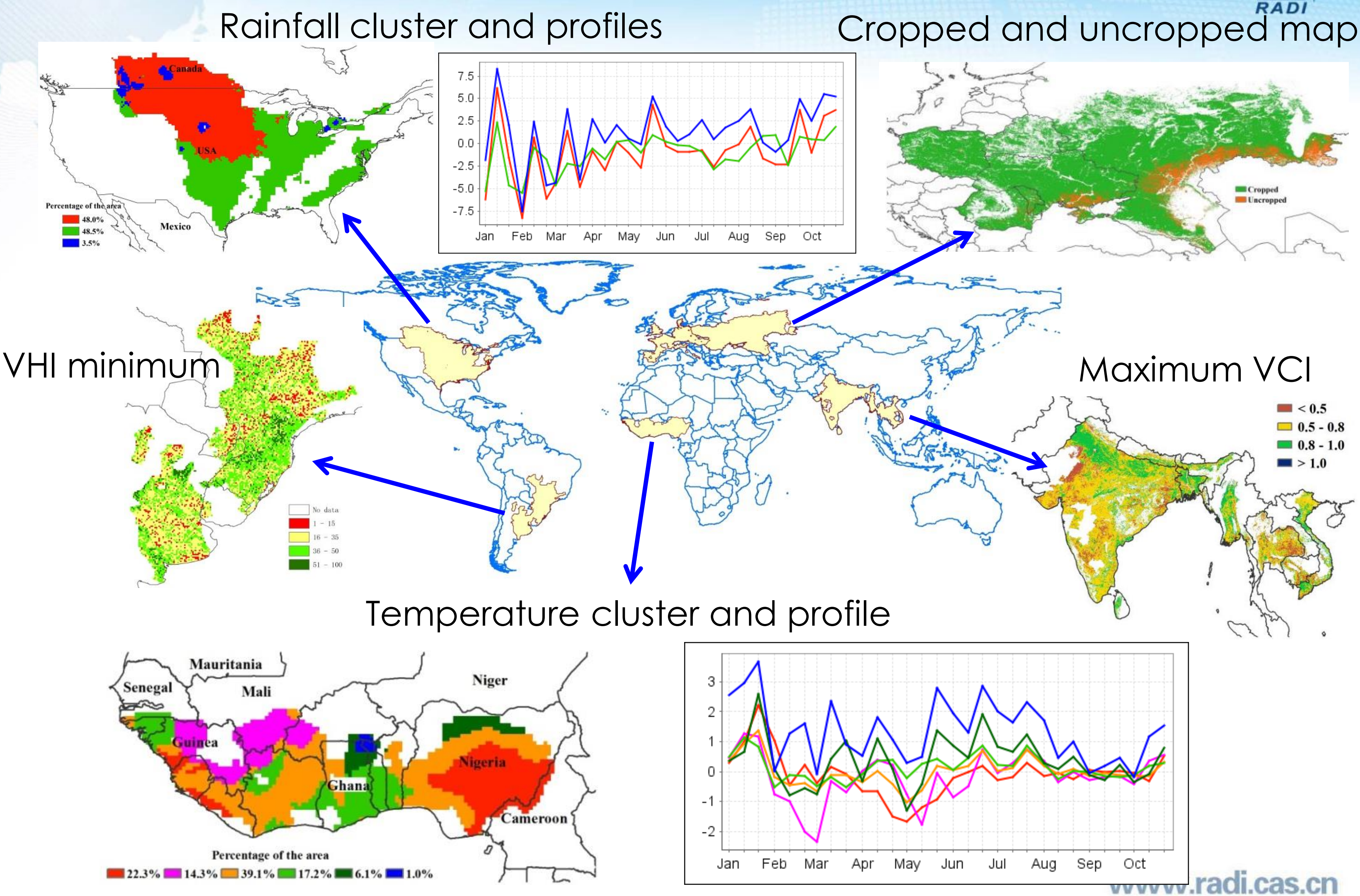


Precipitation departure



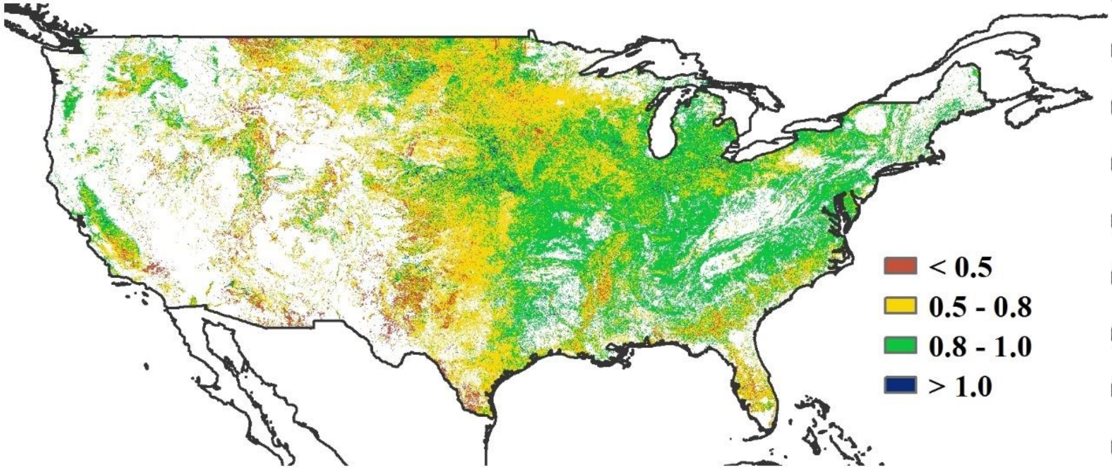
Biomass departure

6 MPZs - Cropping Intensity & Stress

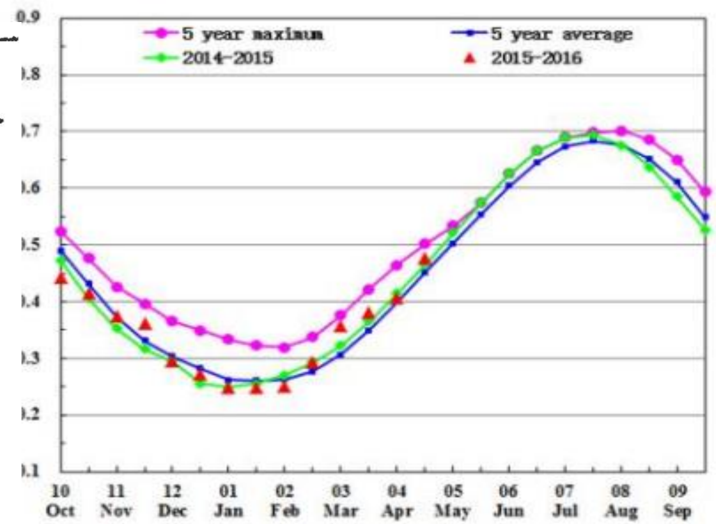


31 Countries - Crop Condition

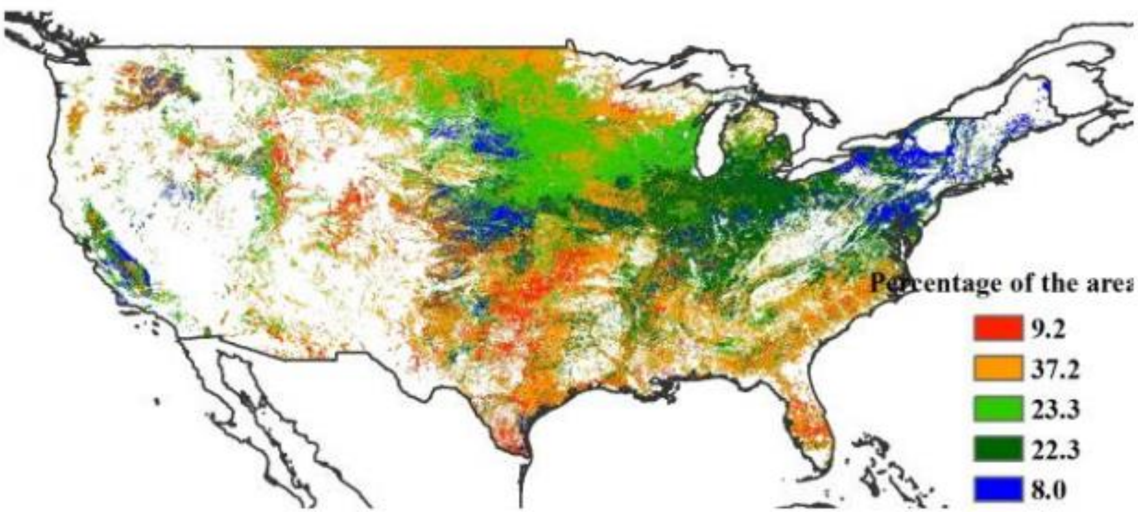
Maximum VCI from Jan. to Apr. 2016

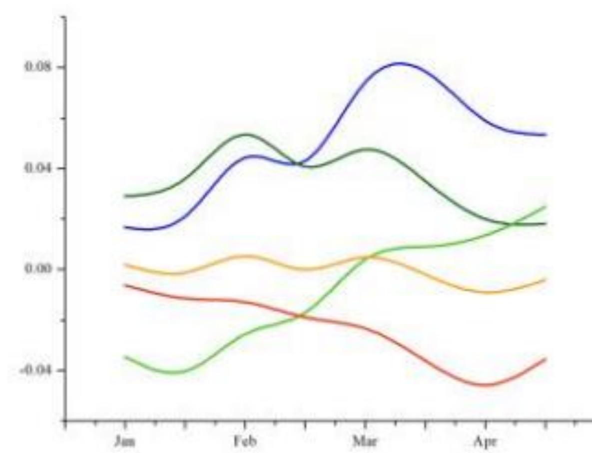


Crop condition development graph based on NDVI



NDVI departure from 5 year average map and cluster (Jan. to Apr. 2016)



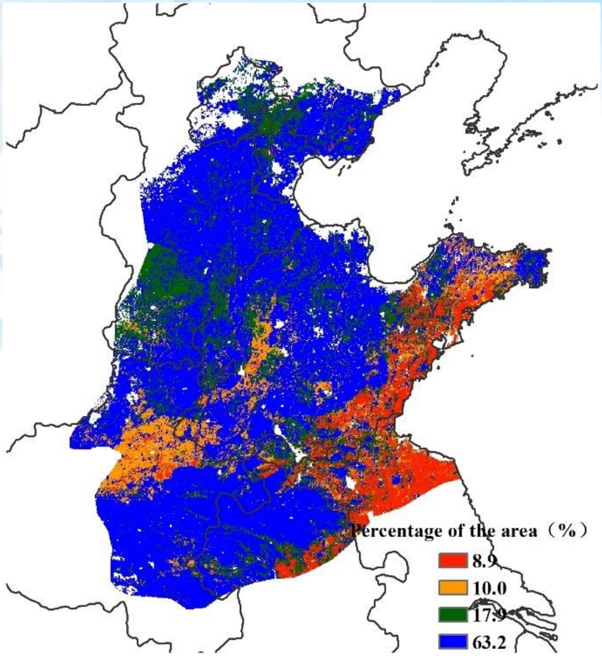


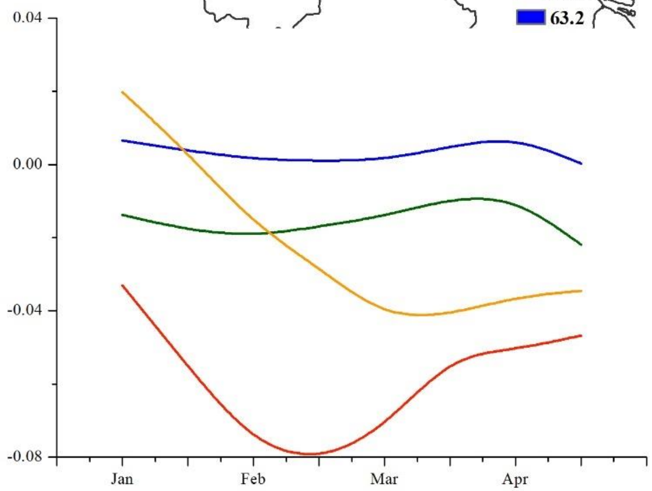
31 Countries - Production for 2016

	Maize		Rice		Wheat		Soybean	
	2016	Δ%	2016	Δ%	2016	Δ%	2016	Δ%
Argentina	**25710**	**1**	**1695**	**0**	**11630**	**−4**	**51080**	**−1**
Australia	470	3	1507	14	**31600**	**25**	99	7
Bangladesh	**2375**	**6**	**47722**	**−6**	**1317**	**0**		
Brazil	**70433**	**−12**	**11055**	**−7**	**7545**	**8**	**91774**	**2**
Cambodia	779	−0	**8588**	**−10**			166	4
Canada	**11701**	**−1**			**33290**	**9**	**5386**	**−1**
China	**200361**	**0**	**200532**	**−1**	**118591**	**−1**	**13287**	**2**
Egypt	**5701**	**−4**	**6293**	**−4**	**10207**	**3**	28	−1
Ethiopia	**7157**	**10**	134	5	**4743**	**12**	100	14
France	**14703**	**−1**	78	−8	**37984**	**−3**	208	9
Germany	**4602**	**0**			**28106**	**3**		
India	**18649**	**−1**	**156783**	**1**	**86099**	**−6**	**12176**	**0**
Indonesia	**18316**	**2**	**69304**	**3**			884	0
Iran	**2692**	**8**	**2763**	**9**	**16073**	**15**	174	−1
Kazakhstan	689	5	411	4	**18199**	**14**	271	10
Mexico	**23780**	**0**	177	−4	**3550**	**−2**	399	10
Myanmar	**1746**	**2**	**25541**	**−8**	187	1	127	−11
Nigeria	**10770**	**4**	**4588**	**1**	115	3	662	4
Pakistan	**4528**	**−7**	**9142**	**−3**	**24638**	**−1**		
Philippines	**7565**	**0**	**20106**	**3**				
Poland	**3681**	**0**			**10704**	**3**		
Romania	**11491**	**7**	47	−4	**7675**	**7**	208	8
Russia	**12337**	**3**	**1017**	**0**	**57506**	**6**	**2099**	**3**
South Africa	**9018**	**−32**	3	1	**1704**	**0**	1105	9
Thailand	**5080**	**1**	**39661**	**1**	1	4	231	3
Turkey	**5920**	**0**	937	2	**18981**	**−17**	218	12
Ukraine	**30774**	**9**	107	−4	**24059**	**3**	**3799**	**2**
United Kingdom					**14337**	**−3**		
United States	**367862**	**5**	**10528**	**6**	**56877**	**0**	**110024**	**3**
Uzbekistan	425	7	437	10	**6391**	**−5**		
Vietnam	**5234**	**1**	**42550**	**−6**				
Major producers	884549	1.0	661706	−1.0	632109	1.1	294505	1.8
Minor producers	110391	2.8	74319	1.4	97457	1.6	21158	7.0
All countries	994940	1.2	736025	−0.8	729566	1.2	315663	2.1

Notes: "All countries" combines major and minor producers. Major producers are all the countries listed in the table; minor producers are the remaining countries. Boldfaced numbers in red are model-based estimates by CropWatch calibrated against data up to 2015; normal faced numbers are simple statistical projections based on FAOSTAT data up to 2014.

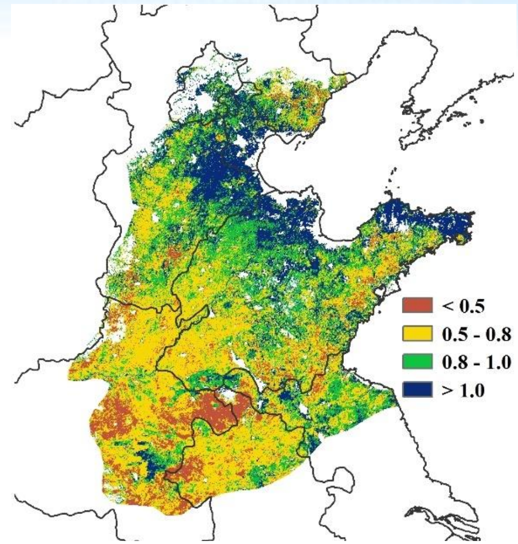
Sub-national - Crop Condition in North China Plain

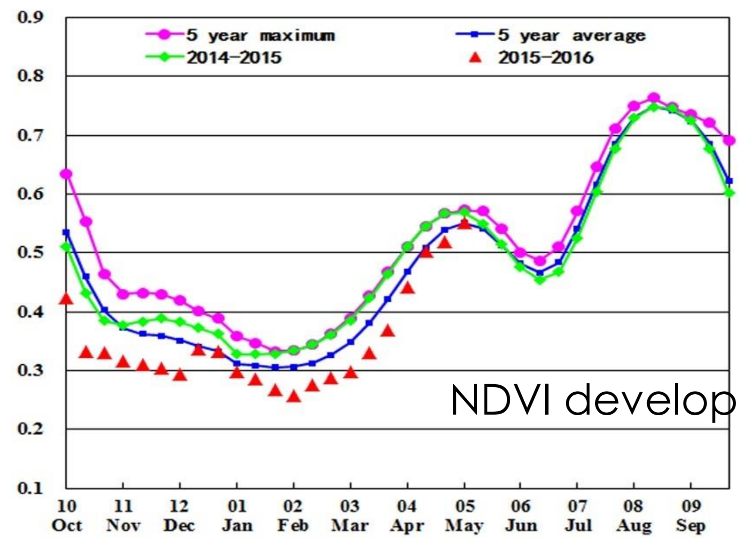




NDVI departure from 5 year average map and cluster (March to October)

Maximum VCI from Jan to Apr

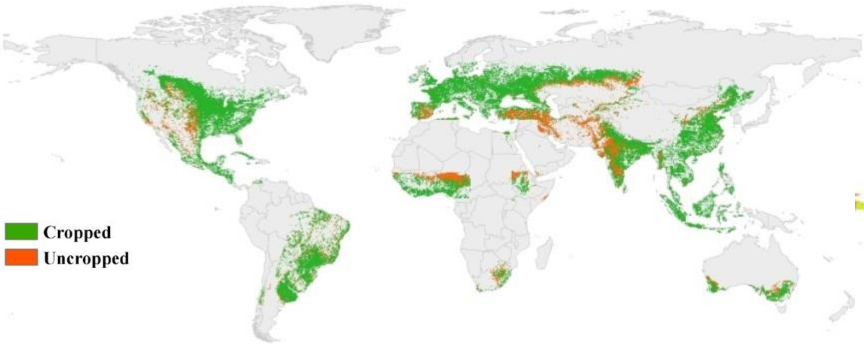




NDVI development

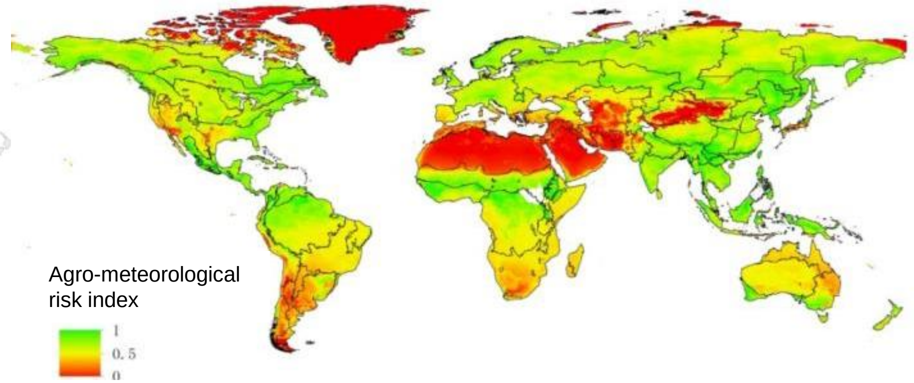
Food security early warning

- 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



July to October 2015

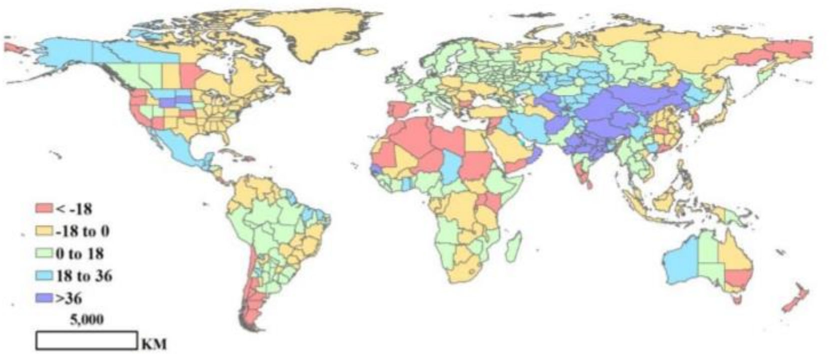
August 2013



Early outlook based on CropWatch

	Environmental indices departure from 12YA (2001-2013)				Crop indicators departure from 5YA (2008-2013)	
	Rainfall total (%)	Temperature average (°C)	PAR accumulation (%)	Biomass accumulation (%)	Uncropped arable land in % of pixels (Absolute difference in % points)	Maximum VCI (absolute difference)
Argentina	5	1.0	0.1	-1	0.7	-0.05
Australia	-27	0.3	3	3	9.2	0.01
Bangladesh	11	-0.5	-0.5	33	-0.2	0.06
Brazil	-1	0.2	-0.4	2	-0.4	0.01
Cambodia	5	-0.8	5	8	0.5	-0.01
Canada	8	-1.3	6	-2	10.7	0.01
China	19	0.5	8	21	-3.3	0.03
Egypt	-24	0.2	3	26	-1.0	0.05
Ethiopia	28	0.3	0.2	16	-4.3	0.01
France	-3	0.8	0.1	4	-2.0	0.07
Germany	5	1.2	-0.4	8	-10.7	0.11

Figure 3.1. Global map of biomass accumulation by country and sub-national areas, departure from twelve-year average (2001-13) average (percentage)



Overall, CropWatch tentatively summarizes the ongoing season as follows:

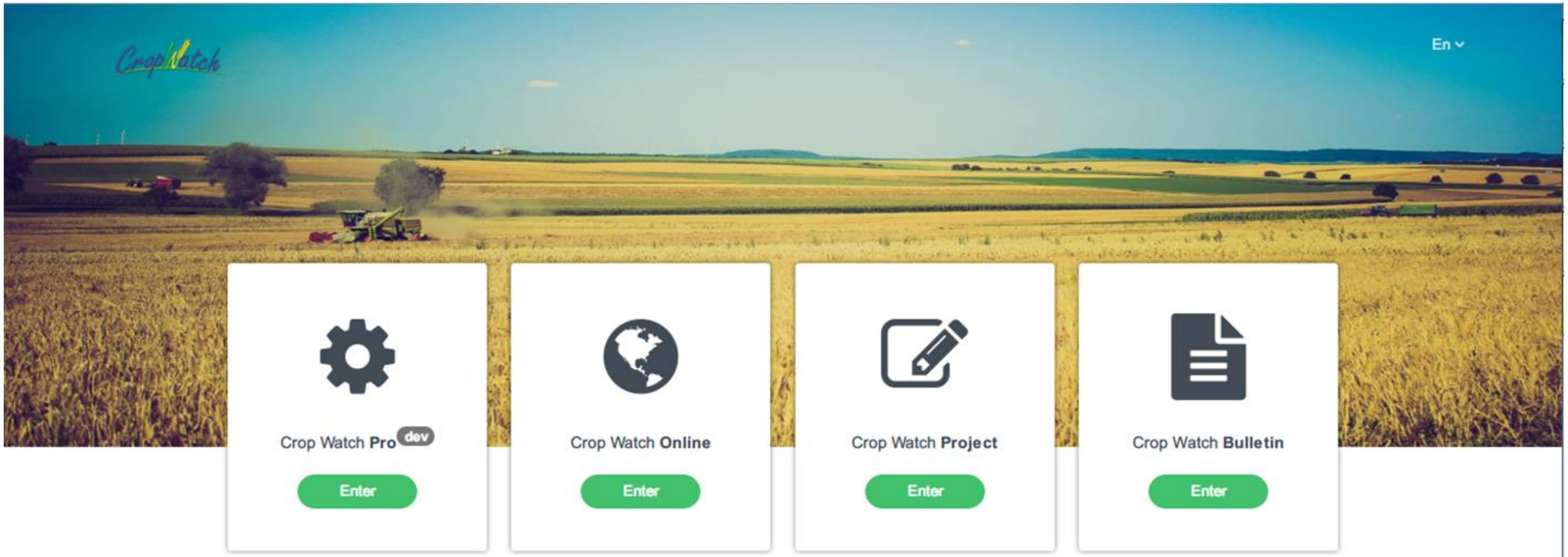
Mostly unfavorable: Armenia, Azerbaijan, Canada, Georgia, Philippines, Poland, Spain, Turkey, Ukraine, Moldova, Morocco, United States, and Vietnam.

Mixed: Argentina, Brazil, China, Denmark, Egypt, France, Hungary, Indonesia, Iran, Italy, Nigeria, Romania, Russia, South Africa, United Kingdom, and Uzbekistan.

Mostly favorable: Bangladesh, Czechia, Germany, India, Kazakhstan, Mexico, Myanmar, Pakistan, and Thailand.

CropWatch Cloud System

CropWatch cloud system is composed of cropwatch processing, cropwatch explore, cropwatch analysis and cropwatch bulletin, it is a system of agricultural monitoring system.



The System is based on Alibaba E-MapReduce.

Contact
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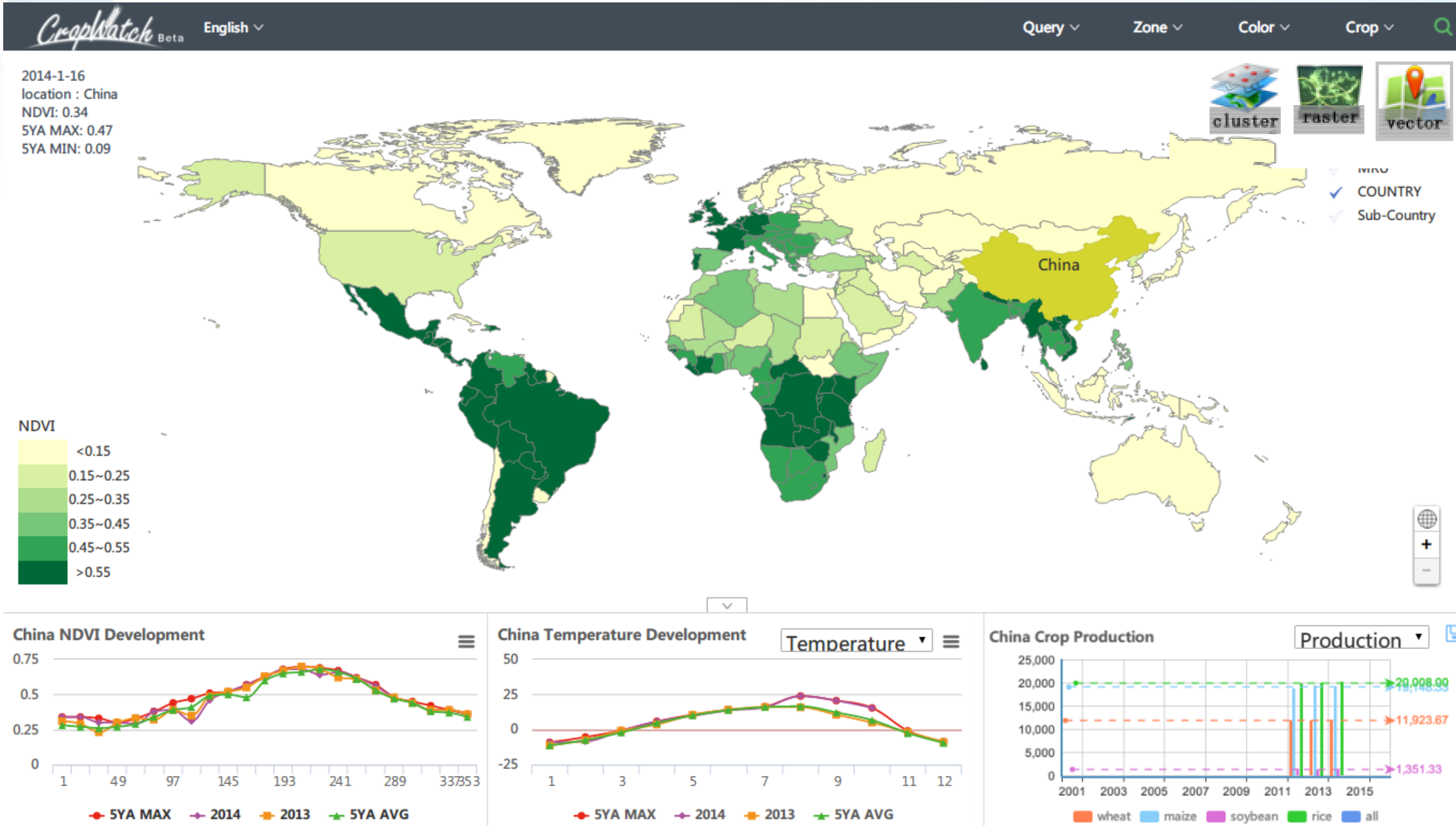
Institue of Remote Sensing and Digital Earth (RADI)
Chinese Academy of Sicences (CAS)

CropWatch-Processing

CropWatch-Explore-vector



CropWatch-Analysis

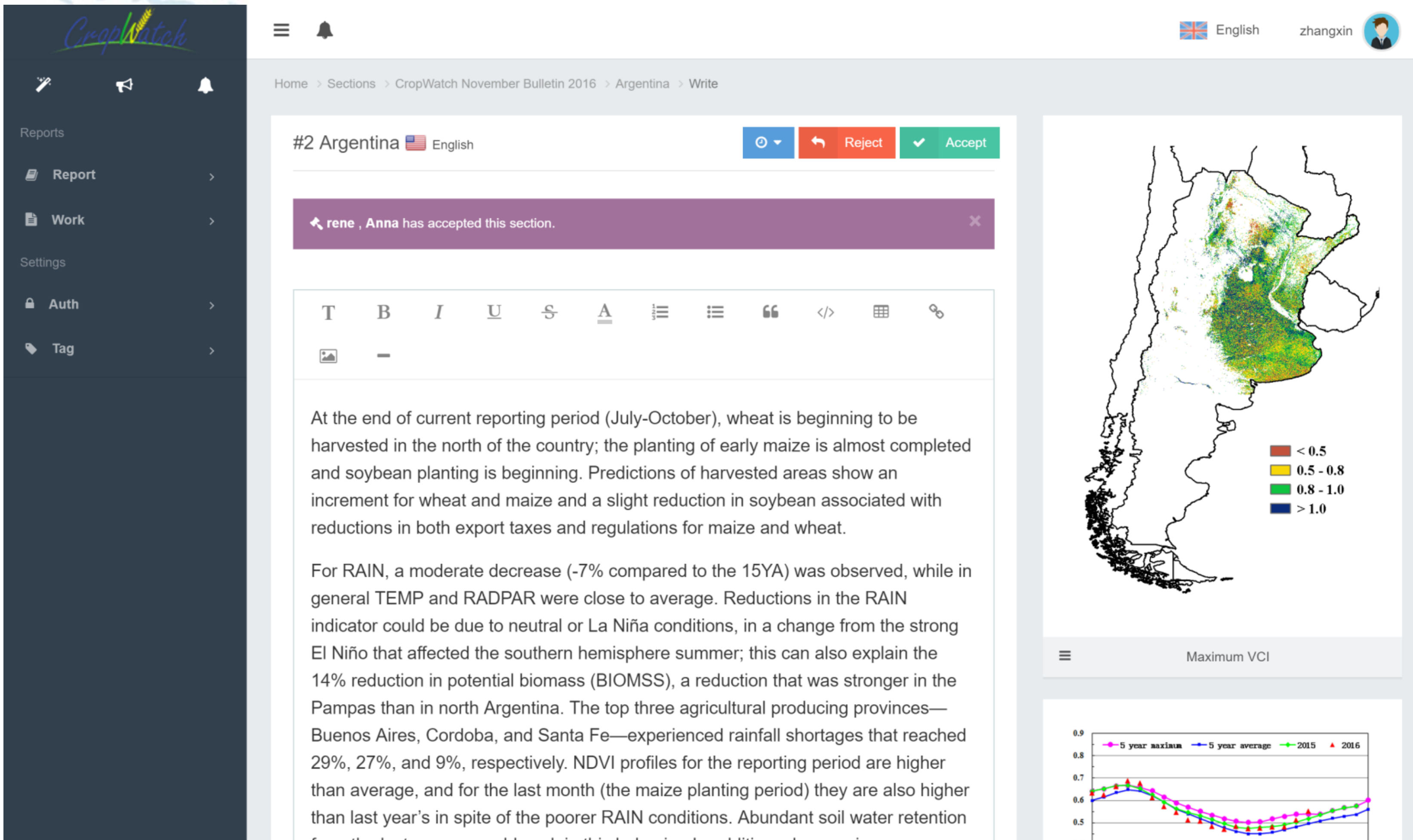
CropWatch Analysis is cloud collaboration documentation tool for the CropWatch teams or individual people from over the world analyzing their CropWatch indicators anywhere. It provides create document, allocate and manage tasks, monitor schedule and publish the document online functions.

CropWatch Team

In November 2016 CropWatch bulletin (Vol. 16, No. 4)，37 colleagues from 9 countries and 4 teams (Digital Agricultural Lab., Pets and disease team of RADI, 3DS company(price prediction), Agricultural Information Institute of CAAS(Grain and soybeans imports and exports in China)) have joined the Cropwatch analysis platform.

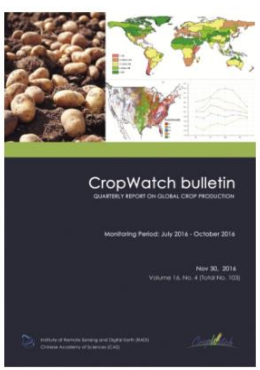
CropWatch-Analysis

Write and revise the analysis



CropWatch-Bulletin

The CropWatch bulletin is published four times a year in English and Chinese. The bulletin presents the latest CropWatch forecast of global and national crop production and condition.



November 2016 CropWatch bulletin (Vol. 16, No. 4)

November 2016 CropWatch bulletin released. The November 2016 CropWatch bulletin presents the latest CropWatch production estimates for 2016, in addition to the usual updates on prevailing weather conditions, resulting crop condition, and size of cultivated areas, among others, focusing on crop growth from July until the end of October. The bulletin naturally includes detailed analyses for China as well as thirty major agricultural countries; for China, regional conditions and an update on pests and diseases, prices, and prospects for import and export are presented. The geographic focus in this bulletin on the Middle East.

LATEST BULLETIN

sign up for the mailing list

Linkage of CropWatch and food security

- CropWatch can provide latest, near real time, transparency agro-climatic and agronomic information.
- CropWatch is able to provide early warning.
- CropWatch provides a easy way to be customized into local environment for interesting countries.

CropWatch

- Global Crop Monitoring System

DroughtWatch

- Drought monitoring system

ETWatch

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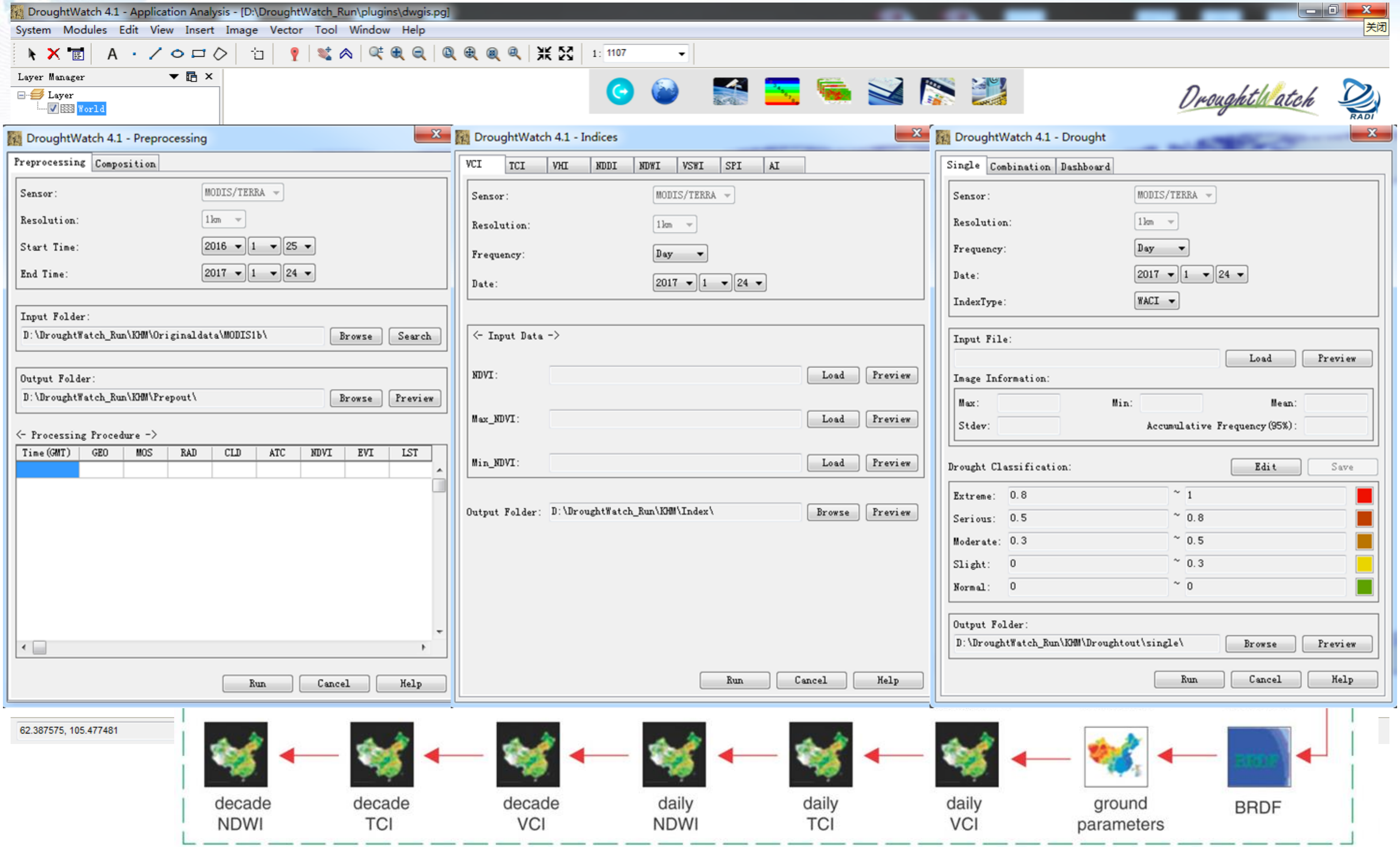
DroughtWatch



UN ESCAP Regional Drought Monitoring Mechanism

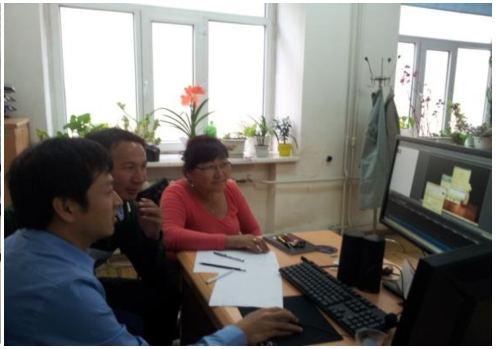
Services provided by RADI:

- **Technical Assistance Service:** to assist the pilot country to customize well demonstrated agricultural drought monitoring methodology and models, development of products and services that adapted to local conditions, including different areas of a requested country.
- **Satellite Data Service:** to provide low- and medium-resolution satellite data based products at near-real-time by responsible Service Nodes to requested local service providers.
- **Satellite Data Based Monitoring Service：** to provide relevant interim products and analytical services by responsible service nodes to requested local service providers (LSPs) of less capable countries.

Customized for Mongolia

- **Data management**
  (in-situ, statistics, Geotiff etc.)
- **Data preprocessing**
  (RS data processing, composition)
- **Indices calculation**
- **Drought monitoring**
  (by single index and combination indices, dashboard)
- **Statistics and analysis**
  (over the spatial, over time interval)
- **Batch for the whole procedure**

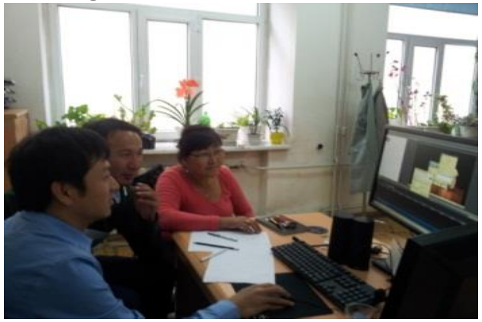
- ***DroughtWatch3.1(English+Chinese)***



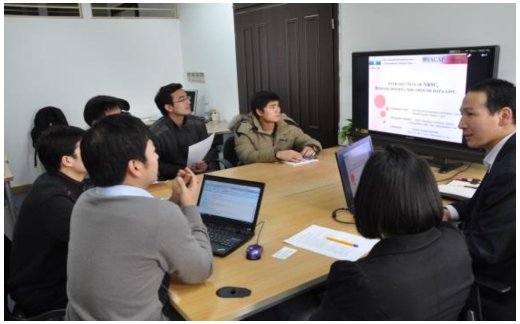
Training and workshop for Mongolia

Cooperative field campaign from 27 July to 5 August of 2015 had been carried out in the large region covering main steppe type of north Mongolia.

The latest version of drought monitoring system (DroughtWatch3.1) had been **installed and deployed** in Mongolia.



January of 2015, hand-on **training** meeting for two Mongolians about two weeks, later hand-on training meeting for two Mongolians about one month, the Chinese experts offered methodology and experiences about drought model validation.

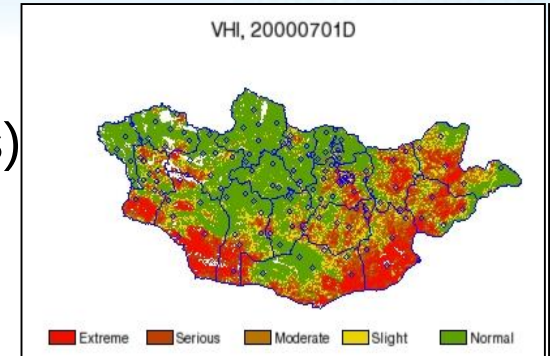


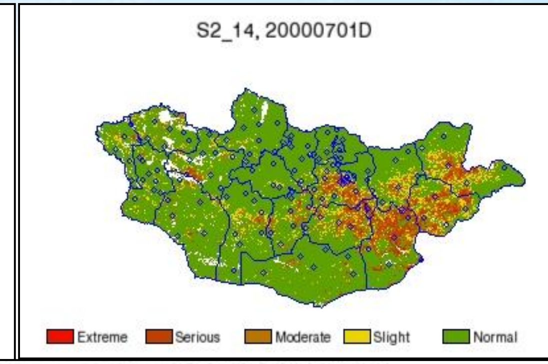
February of 2014, **Workshop** on the Technology Service for Mongolia under the Cooperation Mechanism of Drought Monitoring for the Asia-Pacific regions

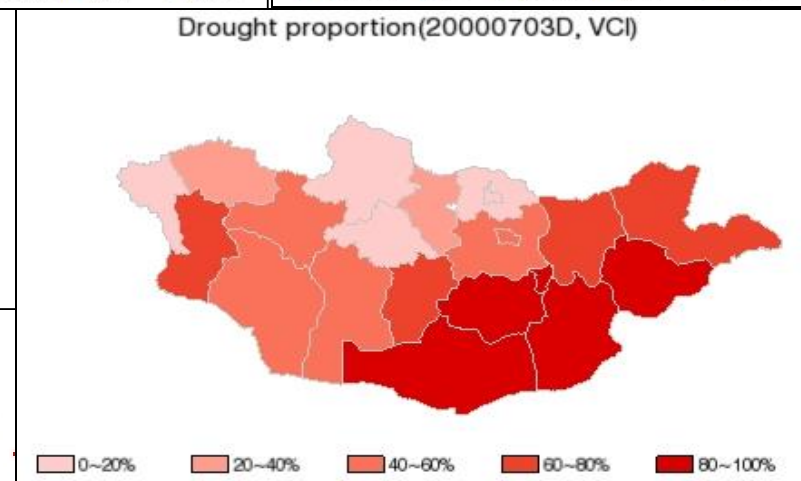
Output products

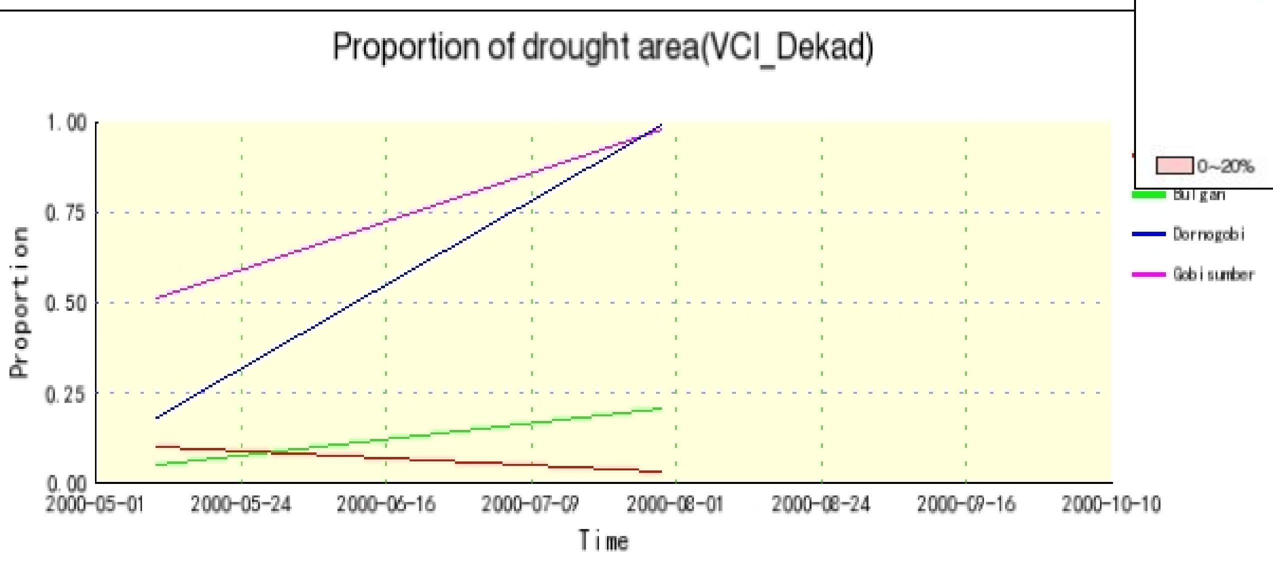
Products Forms(database, tables, files, maps, charts, graphs)

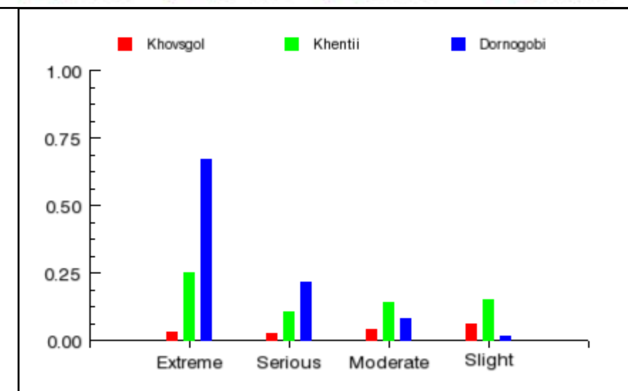
- Drought map and comparison results
- Spatial distribution maps
- Time change charts
- Drought classification graphs



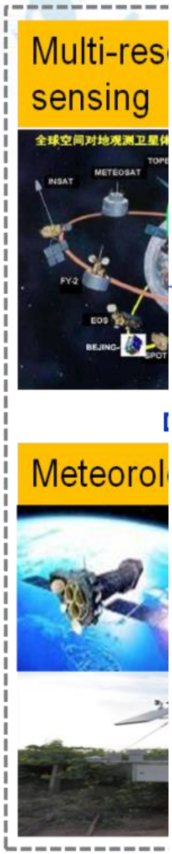








Drought system transfer to Sri Lanka



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நவீன தொழினுட்பவியல்களுக்கான ஆர்தர் சீ கிளார்க் நிறுவகம்
Arthur C Clarke Institute for Modern Technologies
(A corporate body established by Act No. 11 of 1994)
කටුබැද්ද මොරටුව ශ්‍රී ලංකාව
கட்டுபெத்த, மொறட்டுவ, ஸ்ரீ லங்கா
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Telephone +94(0)11 2650838, +94(0)11 2650569
Fax +94(0)11 2650462

My No. Your No. Date

DECLARATION

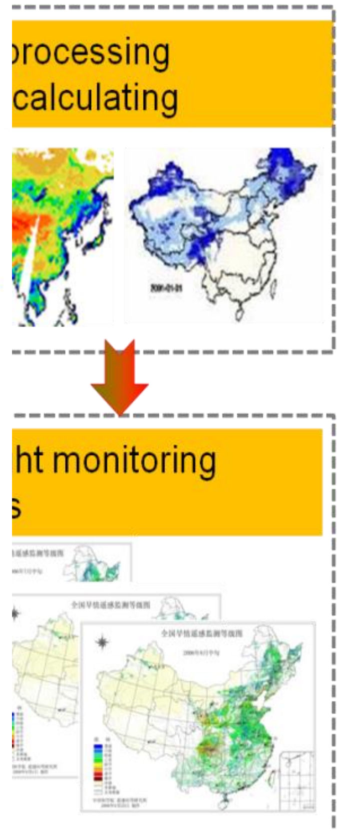
I, the undersigned, Eng. Sanath Panawennage, the Director General & Chief Executive Officer of the Arthur C. Clarke Institute for Modern Technologies of Sri Lanka (hereinafter referred to as ACCIMT), declare the following:

- ACCIMT has received and installed a test version of DroughtWatch software, developed and owned by CropWatch Unit, Institute of Remote Sensing and Digital Earth (RADI), Chinese Academy of Sciences (hereafter referred to as CropWatch);
- ACCIMT will use the software for a period of time not exceeding 6 months on an experimental basis, and will report back to CropWatch about any requirements, bugs or deficiencies for improvement;
- ACCIMT will sign the license agreement with CropWatch once the final version of DroughtWatch has been received and installed in ACCIMT, with a Representative of UNESCAP as witness.

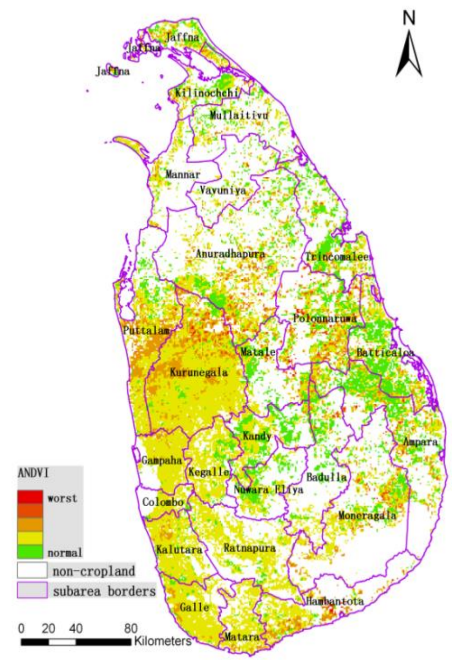
Eng. Sanath Panawennage
Director General & CEO
Date: 20 February, 2015.

Director General
Arthur C. Clarke Institute for
Modern Technologies
Katubedda, Moratuwa,
Sri Lanka.

Ministry of Technology, Research and Atomic Energy



Drought in Sri Lanka
Mid-March 2014



CropWatch

- Global Crop Monitoring System

DroughtWatch

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ETWatch

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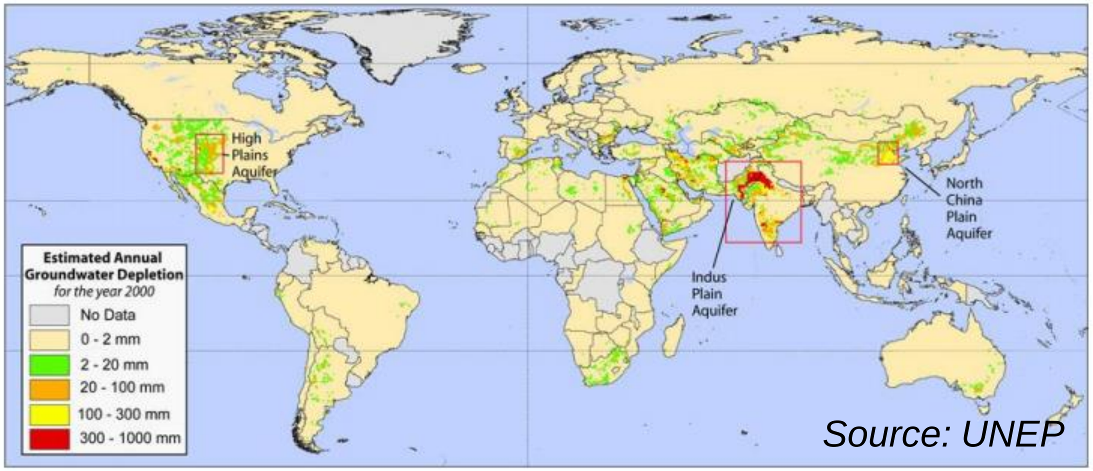
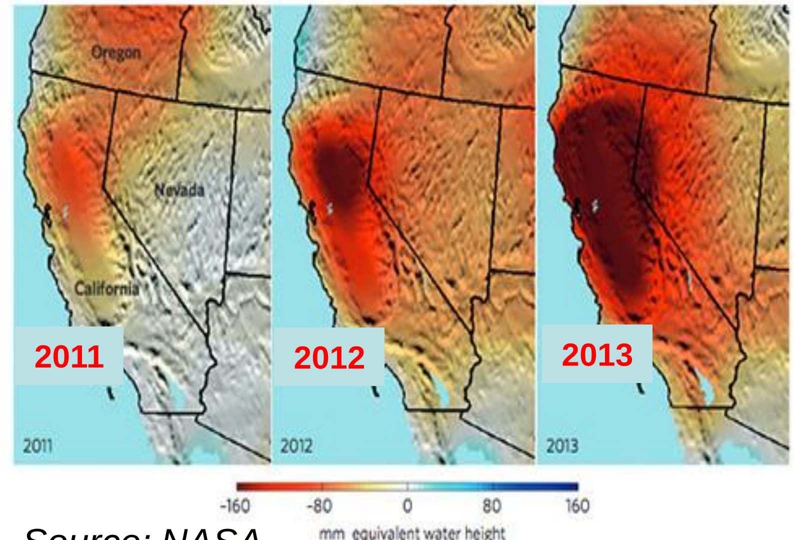
Groundwater depletion in the world

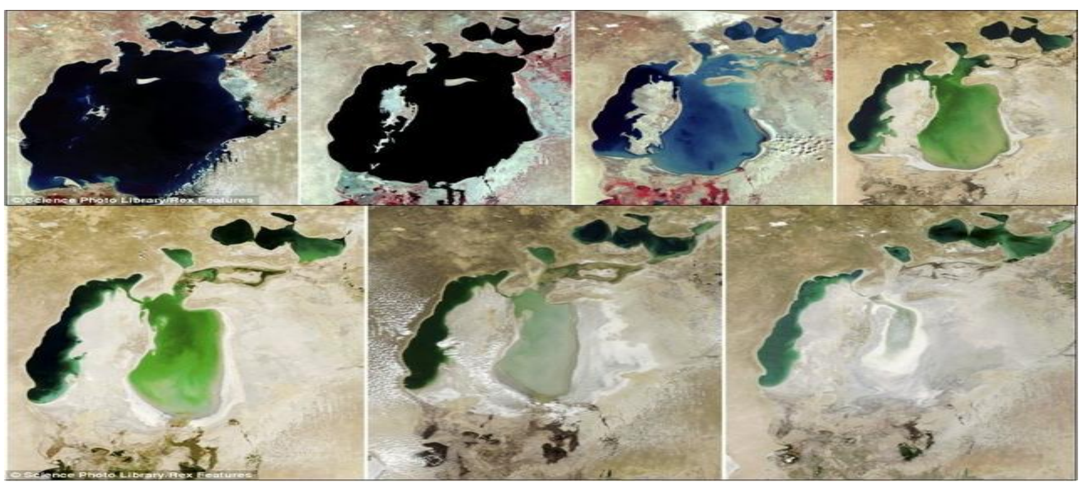
In most arid and semi-arid sub-basin in the world are suffering serious groundwater depletion. Where water gone?



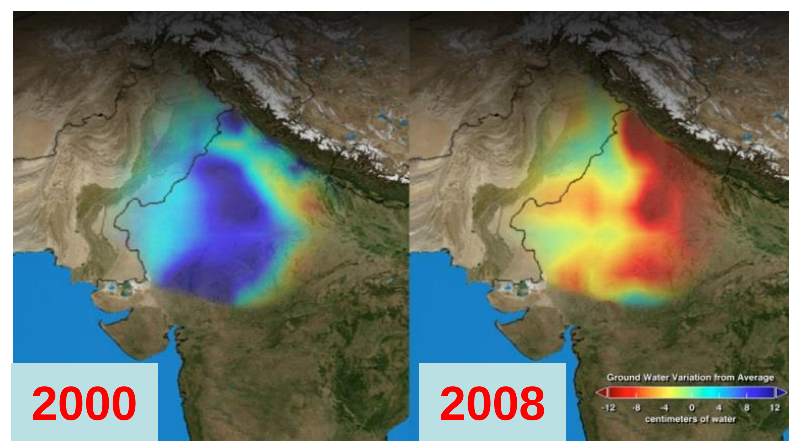
Source: UNEP



Source: NASA



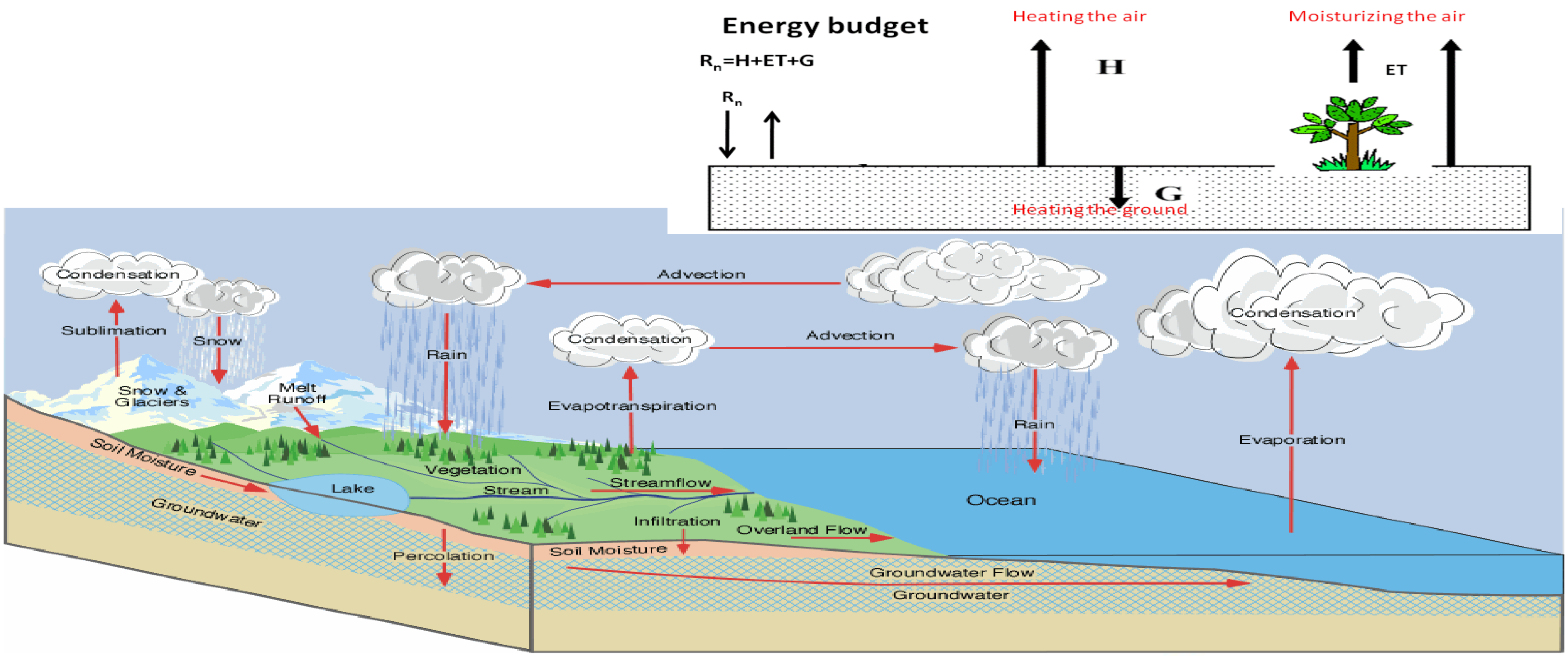
Water surface shrinkage of Aral Sea



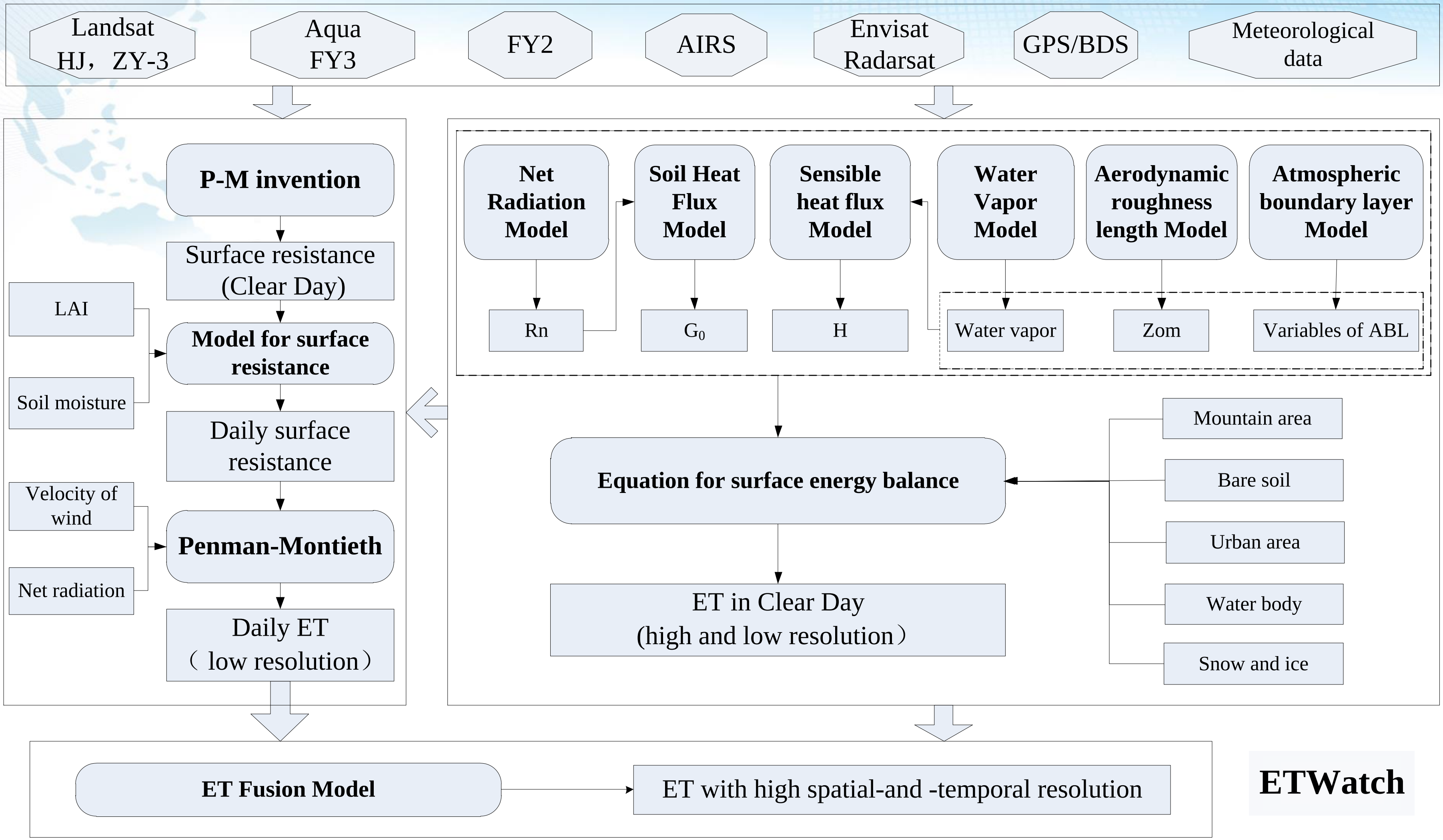
ET

Evapotranspiration: the canopy transpiration and soil evaporation

- ET is the actual water consumption.
- ET is the important segment of water circulation.
- ET is equally important to precipitation, hydrological observation.



ETWatch – operational remote sensing model



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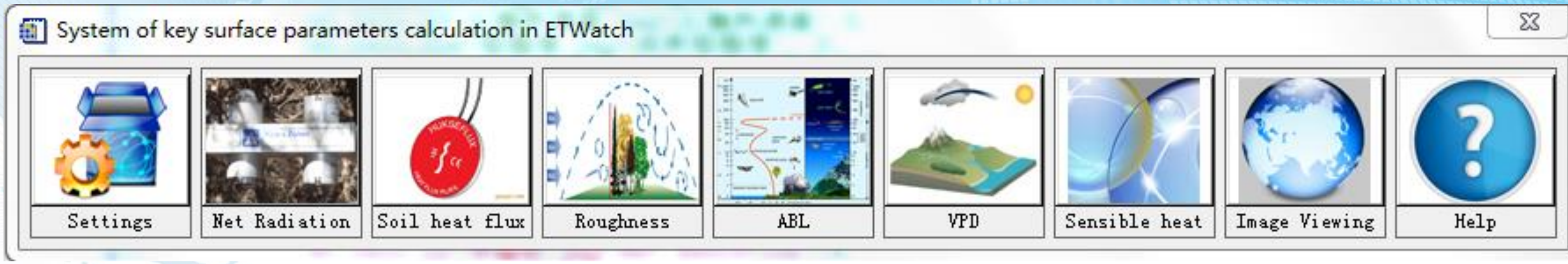
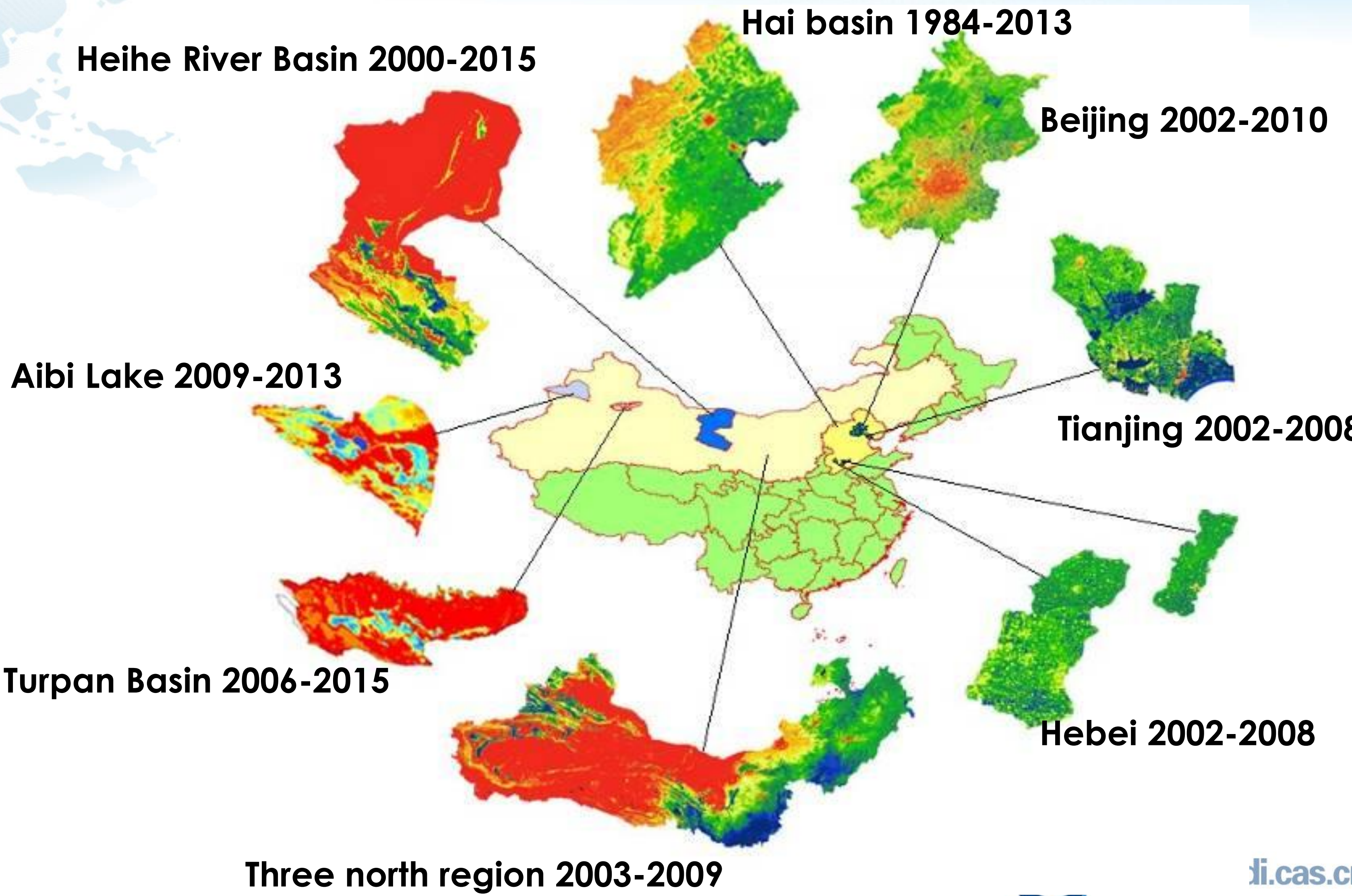
Models in ETWatch



- Net-radiance model
- Soil heat flux model
- Aerodynamic roughness length model
- Atmospheric Boundary Layer model
- Vapor pressure deficit model
- Sensible heat flux model
- Surface resistance model: Daily Surface resistance (Rs)
- ET model on bare land
- ET model on water surface, snow and ice
- ET data fusion algorithm: data-fusion algorithm between high and low resolution data

Application: ETWatch in China

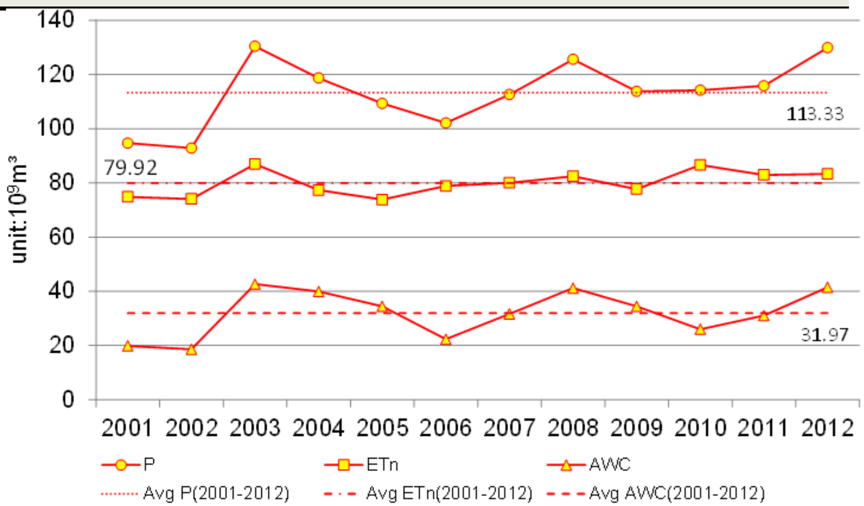


Hai Basin: Allowable Water for Human Consumption

Year	P	Natural ET							Total/P (%)	$Flow_{unc}$	ACW	ACW/P (%)
		ET_{for}	ET_{gra}	ET_{wet}	ET_{fal}	ET_{urb}	ET_{bar}	Total				
2001	94.69	25.35	14.54	2.35	31.51	0.91	0.2	74.86	79.06	0	19.83	20.94
2002	92.84	22.95	13.01	2.18	34.68	1.03	0.23	74.08	79.79	0.15	18.61	20.04
2003	130.4	30.68	17.68	2.58	34.67	1.07	0.29	86.97	66.68	0.83	42.64	32.69
2004	118.7	27.01	13.41	2.36	33.1	1.24	0.23	77.35	65.16	1.4	39.95	33.66
2005	109.3	24.42	12.16	2.3	33.53	1.24	0.19	73.84	67.54	1.04	34.44	31.5
2006	102.1	27.24	13.77	2.37	34.03	1.22	0.23	78.87	77.24	0.93	22.31	21.85
2007	112.6	27.13	14.43	2.26	34.71	1.27	0.24	80.04	71.08	0.92	31.65	28.1
2008	125.6	31.09	14.1	2.34	33.15	1.52	0.26	82.46	65.65	1.94	41.2	32.8
2009	113.8	28.91	13.07	2.39	31.62	1.45	0.27	77.71	68.31	1.59	34.46	30.29
2010	114.2	31.95	14.47	2.37	36.12	1.52	0.24	86.67	75.89	1.52	26.01	22.78
2011	115.8	29.62	14.22	2.33	34.98	1.52	0.27	82.94	71.61	1.84	31.05	26.8
2012	129.9	30.74	13.84	2.4	34.48	1.6	0.27	83.33	64.15	5.08	41.49	31.94
Average	113.3	28.09	14.06	2.35	33.88	1.3	0.24	79.92	70.52	1.44	31.97	28.21

unit: 10^9m^3

The average ACW from 2001 to 2012 for the entire Hai Basin is $31.97 \times 10^9 m^3 yr^{-1}$, signifying the average amount of water available for human consumption in the basin.



Hai Basin: Water Balance Analysis

Year	ACW	Actual water consumed					Water
		Crops	Urban	Biological	Industrial	Sum	Depeltion
2001	19.8	31.93	2.09	0.06	2.04	36.1	-16.29
2002	18.6	29.11	2.04	0.06	2.04	33.3	-14.64
2003	42.6	38.68	2.95	0.06	2.04	43.7	-1.09
2004	40	34.87	2.75	0.06	2.04	39.7	0.23
2005	34.4	28.38	2.42	0.06	2.04	32.9	1.55
2006	22.3	32.09	2.48	0.06	2.04	36.7	-14.35
2007	31.7	30.89	2.34	0.06	2.04	35.3	-3.69
2008	41.2	39.38	3.23	0.06	2.04	44.7	-3.51
2009	34.5	32.99	3.28	0.06	2.04	38.4	-3.91
2010	26	28.35	3.17	0.06	2.04	33.6	-7.61
2011	31.1	28.75	3.29	0.06	2.04	34.1	-3.09
2012	41.5	32.2	3.53	0.06	2.04	37.8	3.66
Average	32	32.3	2.8	0.06	2.04	37.2	-5.23

unit: $10^9 m^3$

- For the period 2001-2012 this leads to average aquifer depletion in Hai Basin of $5.23 \times 10^9 m^3 yr^{-1}$ based on actual outflow.
- Agriculture is largest water consumption sector.

Hai Basin: water saving potential

	Coverage of anniversary stalks (wheat-corn)	The row spacing adjustment (wheat-corn)	Optimization of irrigation system(wheat)	Water saving and high yielding(wheat)	planting structure adjustment	Integrated water saving of wheat and corn
Area /10^4km^2	4.3	4.3	4.3	4.3	4.3	4.3
Water saving amount /mm	37.9	20-30	40-50	25-40	82	30-45
Water saving total amount /10^8m^3	16.3	8.6-13	17.2-21.5	10.8-17.2	35.3	13-19.4
Scene 1			Scene 2			
Wheat growing season controllable ET/mm		187.9	Farmland controllable ET/mm			331.2
Wheat fallow area /km^2		26,000	Farmland fallow area /km^2			15,000
Proportion /%		24.8%	Proportion/%			14.1%

- The water deficit was 5.23 *10^9m^3 from 2001 to 2012 in Hai basin;
- The total water saving of integrated water saving measures was up to 1.94 *10^9m^3;
- 14.8% (24.8%) of cultivated land (wheat) need to be fallow.

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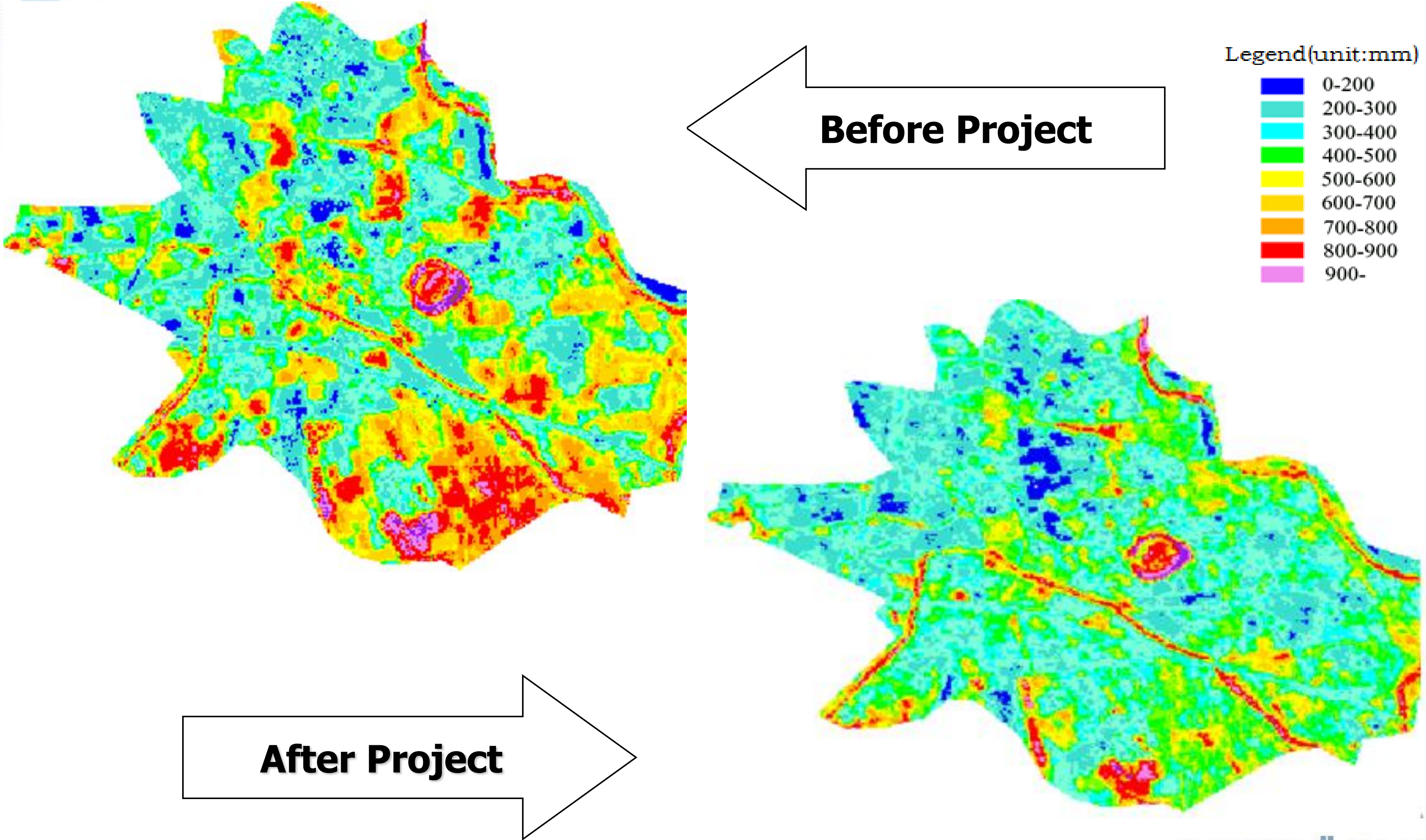
Water saving supervision: cropping pattern

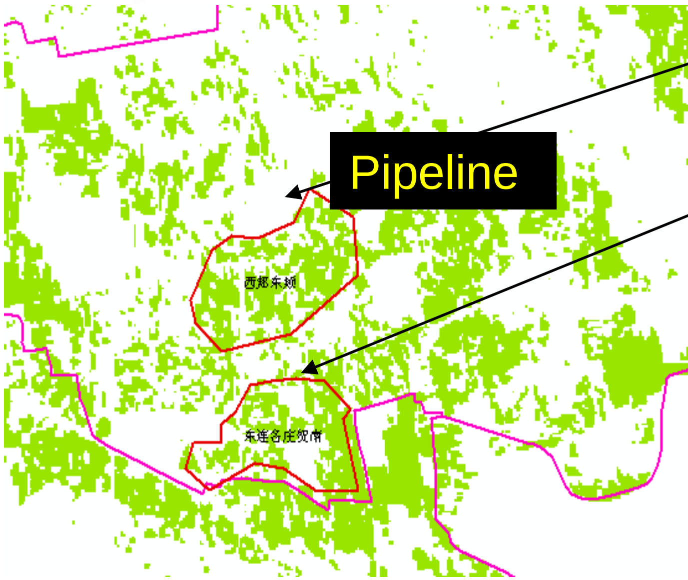
- Evaluation of water consumption for water saving measures.

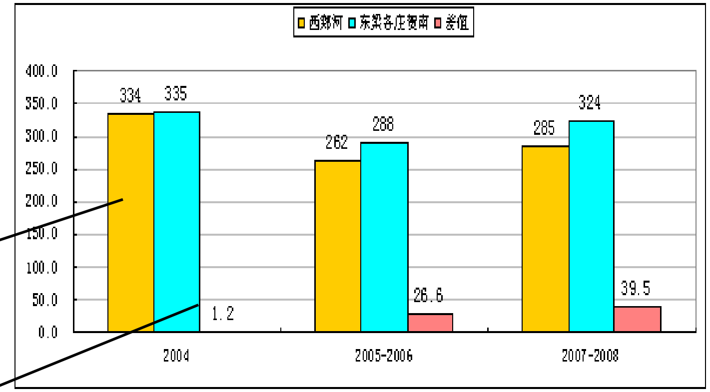


Water saving supervision: irrigation

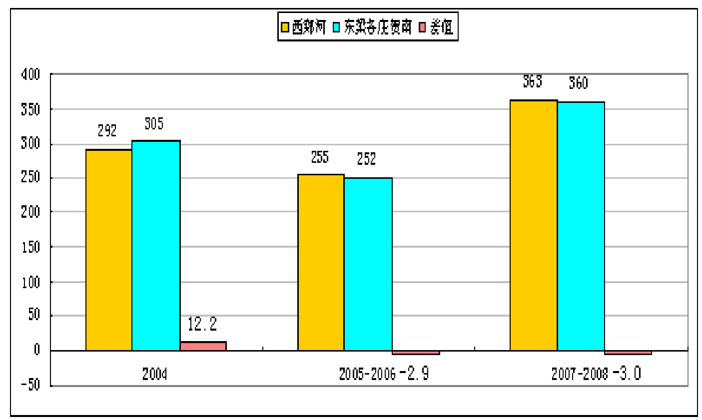
- Evaluation of water consumption for water saving measures.

Water Saving





Wheat



Maize

- Water saving measure: Xijiahe, pipeline irrigation since 2005
- Since 2005, ET in Xijiahe is lower than Donliangezhuang in wheat growth season; But there is little difference in maize

Well Water Retrivel Supervision

Water supervision for an electric-mechanism well

– Total/monthly allowable water use

$$WU_a = \sum_{i=c1}^{cn} IQ_i \times A_i$$

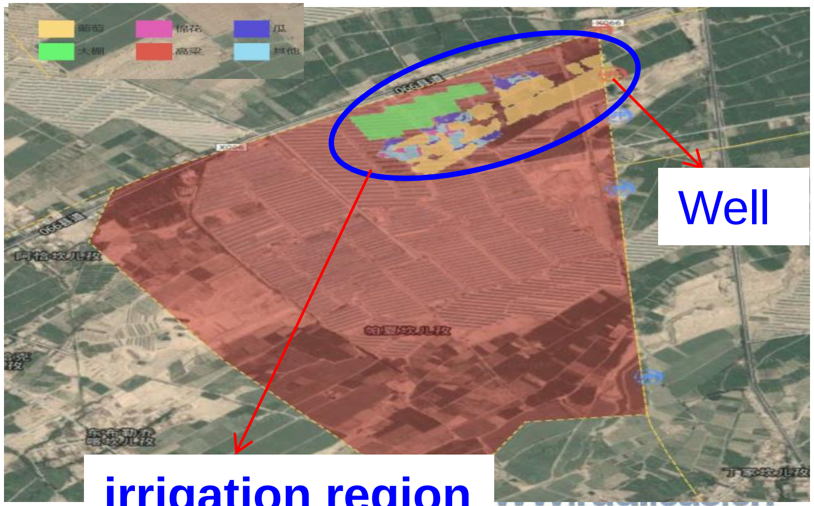
WUa is the total or monthly retrieval water amount for a well, IQ*i* is the irrigation quota for crop *I* for different period; A*i* is the area for crop *i*. Irrigation quota is calculated from the recommended irrigation scheme.

– Water use control

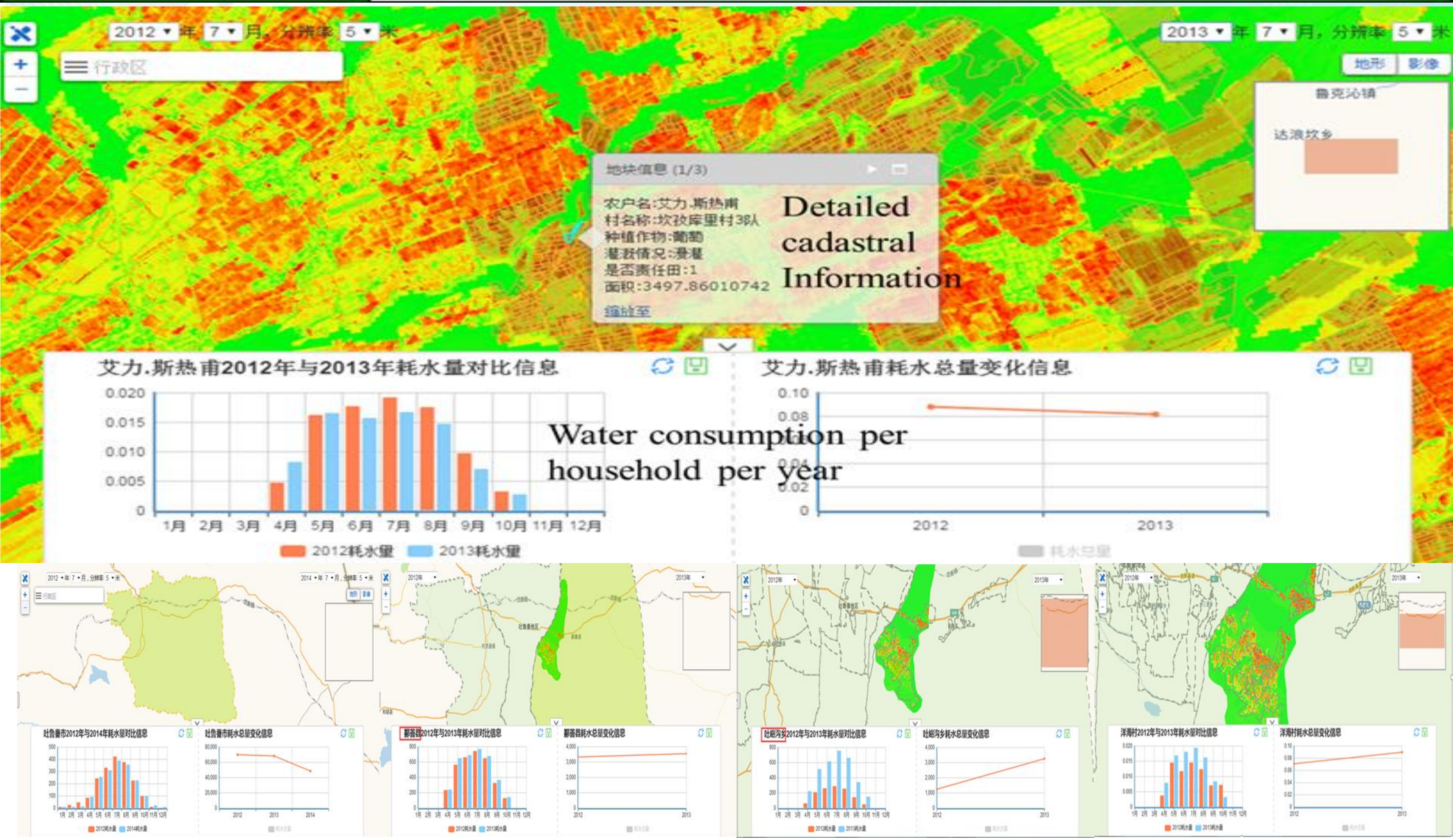
The actual water retrieval could be monitored by comparing with WUa, and provide the alert information to control draft water for a certain well.

Irrigation Scheme for grape

灌水次数	灌水定额（m3/亩）	灌水时间			灌水延续时间
		始	终	中间日	
1	75	3/26	4/10	4/2	16
2	90	4/26	5/5	4/30	10
3	100	5/16	5/25	5/20	10
4	60	6/1	6/10	6/5	10
5	60	6/21	6/30	6/25	10
6	70	7/5	7/15	7/10	11
7	70	7/21	7/30	7/25	10
8	60	8/10	8/20	8/15	11
9	50	8/26	9/4	8/30	10
10	30	9/21	9/30	9/25	10
11	70	10/10	10/20	10/15	11
小计	735				

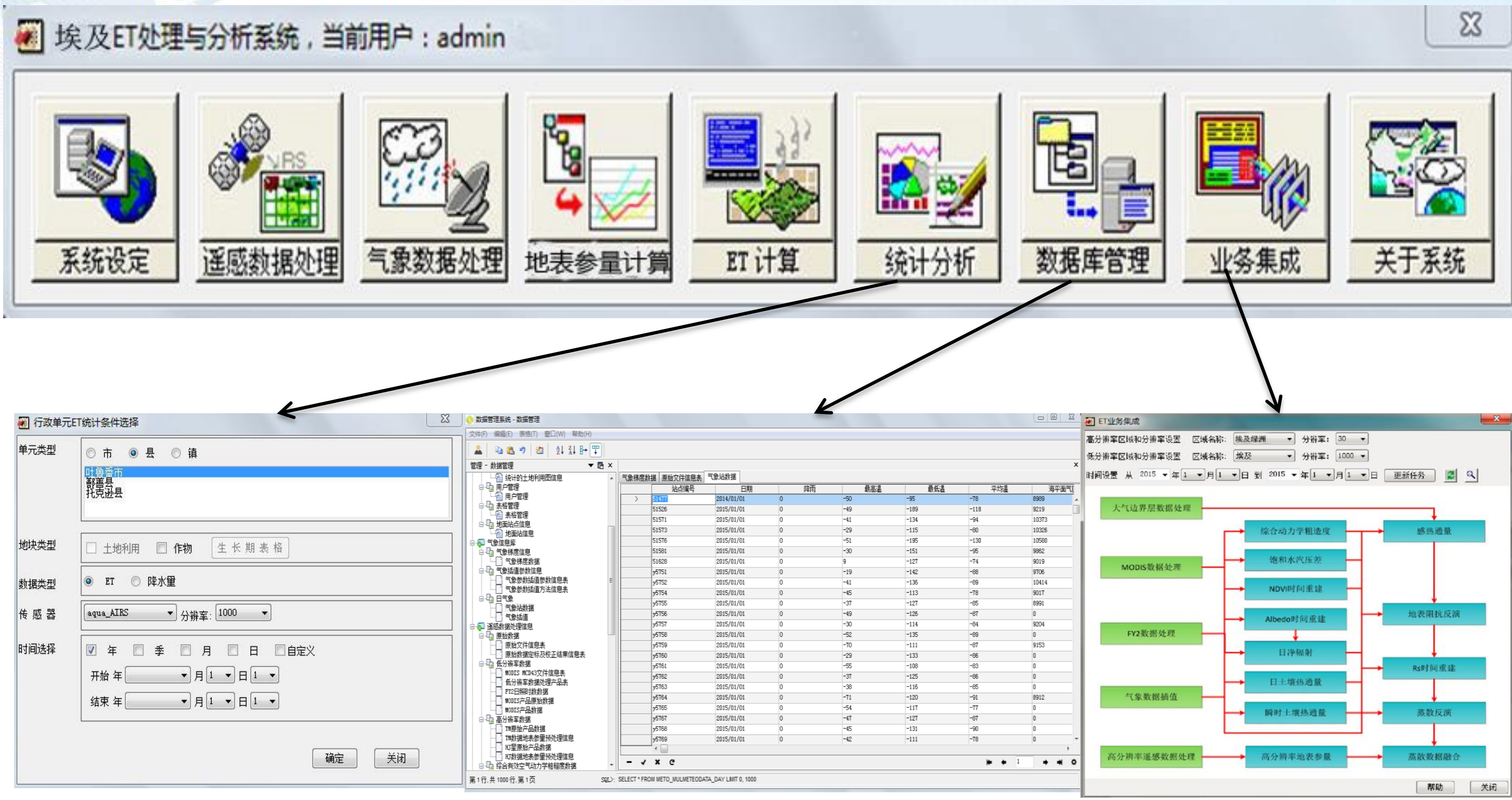


Water saving supervision: farmer



- Including field location, area, crop types, farm name, water consumption, water source.

ETWatch for Egypt



Data statistics   Database management   System integration

New Action plan of China

人民网 >> 环保

水利部、发展改革委联合召开视频会议

全面实施水资源消耗总量和强度双控行动

2016年11月11日09:15　来源：人民网-环保频道　分享到：

人民网北京11月11日电 昨日，水利部、发展改革委在北京联合召开全面实施水资源消耗总量和强度双控行动视频会议。会议指出，实施水资源消耗总量和强度双控行动，是破解我国水资源短缺瓶颈、确保水资源可持续利用的战略举措，是贯彻落实绿色发展理念、加快推进生态文明建设的内在要求。

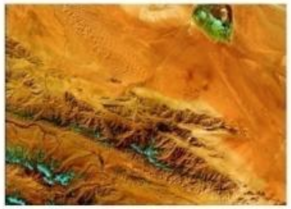
水利部部长陈雷指出，党的十八大以来，以习近平同志为核心的党中央高度重视水资源问题，明确提出“节水优先、空间均衡、系统治理、两手发力”新时期水利工作方针。党的十八届五中全会明确要求实施水资源消耗总量和强度双控行动。近日，经国务院同意，水利部和发展改革委联合印发了《“十三五”水资源消耗总量和强度双控行动方案》。实施水资源消耗双控行动，全面节约和高效利用水资源，是破解我国水资源短缺瓶颈、确保水资源可持续利用的战略举措，是助推供给侧结构性改革、加快转变经济发展方式的有力抓手，是贯彻落实绿色发展理念、加快推进生态文明建设的内在要求，是创新水资源管理体制机制、提升水治理能力的重要途径，事关“五位一体”总体布局和“四个全面”战略布局，事关中华民族永续发展和国家长治久安。要充分认识实施双控行动的重大意义，切实把思想、认识和行动统一到中央的决策部署上来。

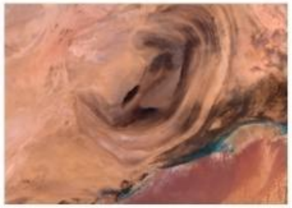
陈雷强调，《“十三五”水资源消耗总量和强度双控行动方案》是做好“十三五”期间双控工作的指导性文件。要深刻理解、准确把握实施双控行动的指导思

Nov.11, 2016, water consumption and intensity control action plan was released by Chinese government.

Water resource management enters ET management period.

Thanks!



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