Institute of Remote Sensing and Digital Earth
Chinese Academy of Sciences

Crop production forecasting and early warning using remote sensing data - experience of China's CropWatch system

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Outline

- Introduction of CropWatch
- CropWatch methodology and results
- CropWatch Cloud
- Outlook

Introduction of CropWatch

CropWatch® Development

- **Kick off in 1998**
- **Supported by CAS, NDRC ,MOST,…, more than 10 projects with 50 millions input**
- **Release first bulletin in August, 1998**
- **Improvement and development (18 Years)**
  - **Monitoring China -> Global**
  - **From manual judgment to quantitative monitoring**
  - **From instant investigation to dynamic monitoring**
  - **From after harvest measurement to early prediction. The crop production data can be available one month before its harvest.**
- **CropWatch aims at improving food information availability, quality and transparency**

CropWatch Methodology and results

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

Sub-national for large countries
Crop type proportion (some countries)

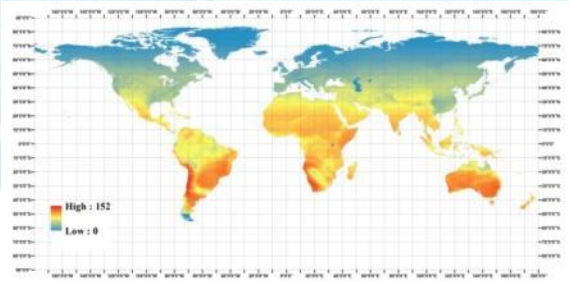
Increasing level of detail, from environmental-climatic to agronomic; from 25 km resolution to 16m

CropWatch Hierarchical approach

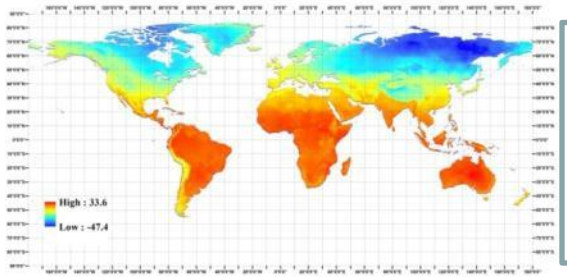
	Input	Output
Global	Rainfall Air temperature PAR Potential biomass	Crop Production System Zones (CPSZ) Climatically Indices (CI)
6 Main Production Zones	Vegetation Health Index Uncropped Arable Land Cropping Intensity Maximum VCI	Agricultural pattern Farming intensity Biomass trend
30+1 Key Countries	NDVI Crop area Time profile clustering	Cropland use intensity Crop condition Production, Yield
Sub countries	Arable land fraction Crop structure (China, USA, Australia, Canada, etc.) Field survey of Pest & disease	Cropland use intensity Crop condition Production, Yield Phytosanitary condition of crops (China)

Global food supply analysis

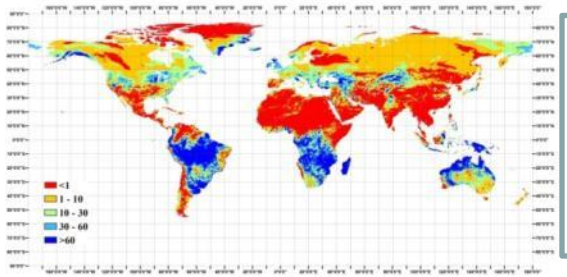
Data used at global scale



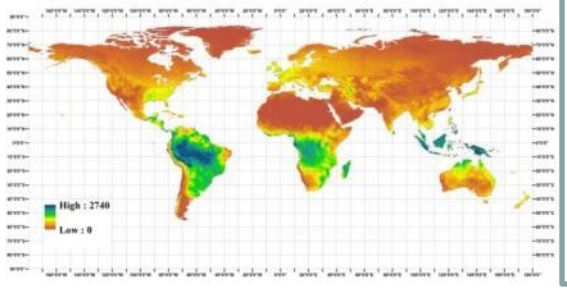
Photosynthetically active radiation (PAR) (remote sensing data)
Spatial resolution: 0.25° ;



Air temperature (Interpolated from Ground station data)
Spatial resolution: 0.25° ;



Precipitation (remote sensing data)
Spatial resolution: 0.25° ;



Potential NPP (based on station data and remote sensing data)
Spatial resolution: 0.25° ;

Weighted average over arable land and growing season

Departure calculation

65 MRUs

Abnormal weather pattern at global scale

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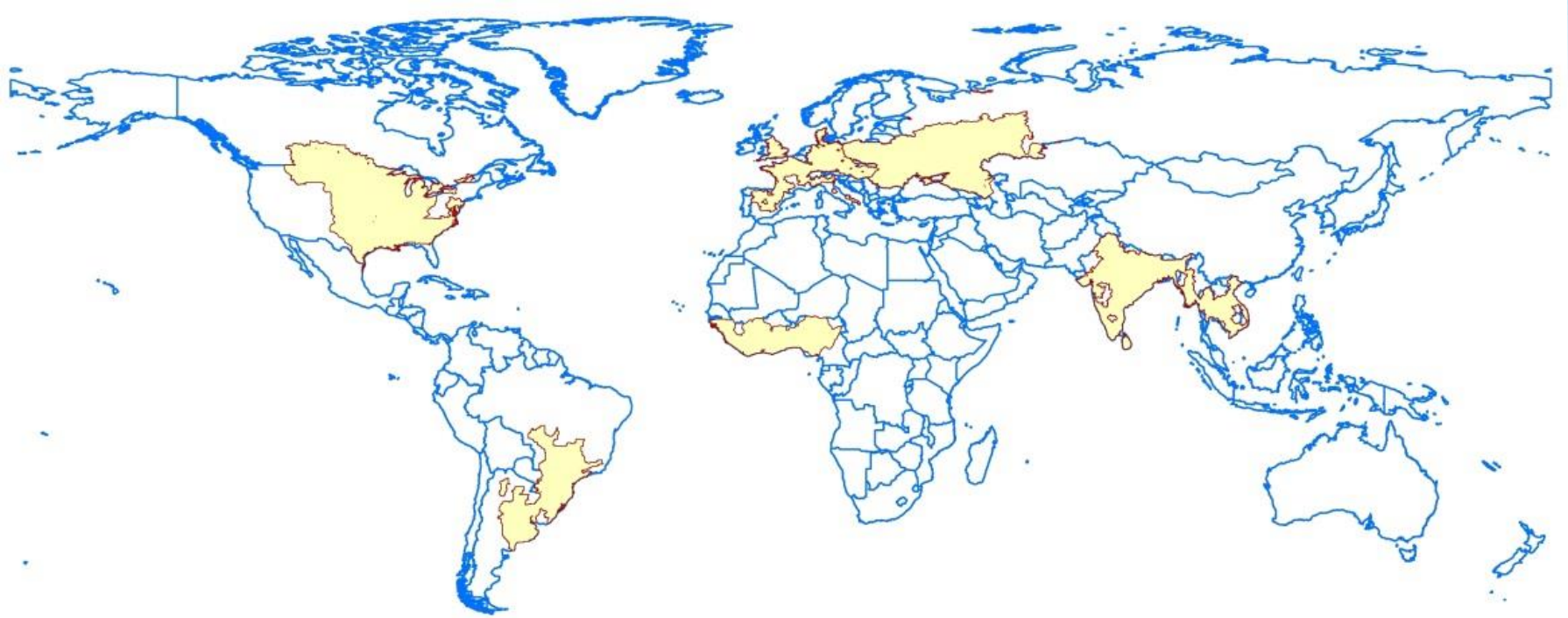
Crop pattern and stress for 6 MPZs



Agronomic indicators

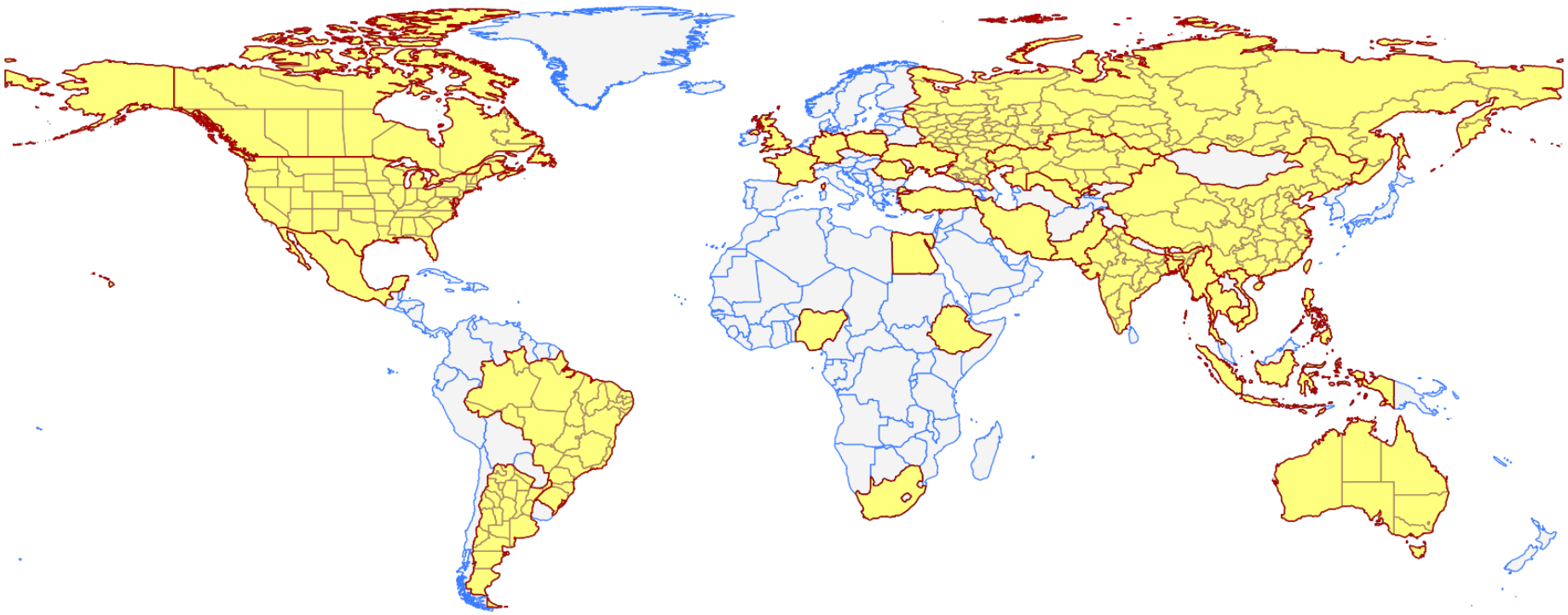
- Maximum vegetation condition index (VCIx)
- Cropped arable land fraction (CALF)
- Vegetation health index (VHI)
- Cropping intensity (CI)

+

- Abnormal weather pattern by time series clustering

31 key producing countries

- Covering at least 80 percent of global production and export of the major cereals and soybean
- Sub-national monitoring for 9 large countries



31 key producing countries

- Integrated crop condition monitoring
  - Vegetation health index
  - Maximum vegetation condition index
  - NDVI development profile
  - NDVI departure clustering
  - NDVI anomaly
  - Crop condition only for cropped arable land
  - ……

Crop area estimation

- Crop area in China, Canada, Australia, Egypt, and US

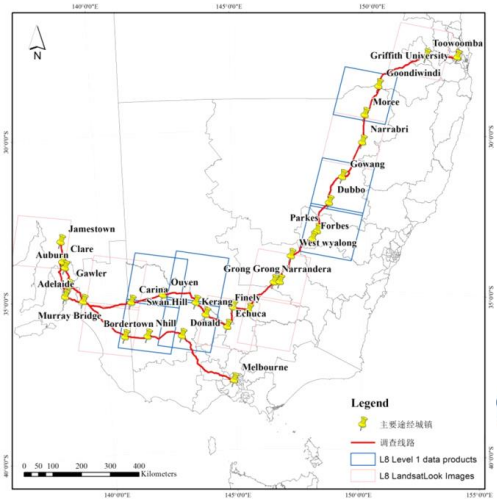
CALF=Cropped Arable Land Fraction

$$\text{Crop area} = \boxed{\text{Arable land area}} \times \boxed{\text{CALF}} \times \boxed{\text{Crop type proportion}}$$

Remote Sensing based **GVG survey**

- Crop area in other countries
  - relies on the regression of crop area against cropped arable land fraction

$$\text{Area}_i = a + b * \text{CALF}_i$$



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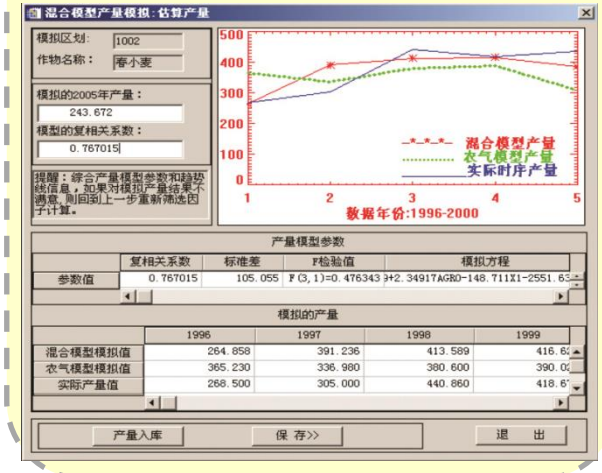
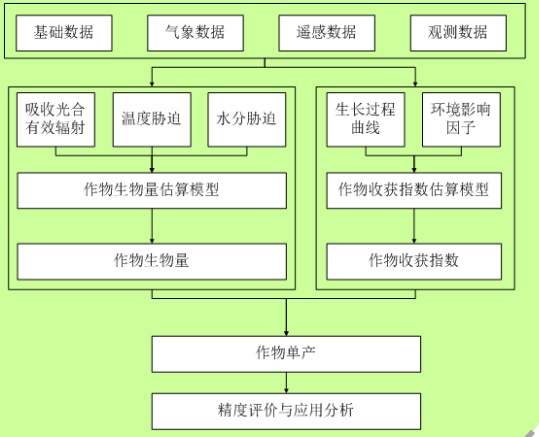
Crop yield

- Three models in CropWatch

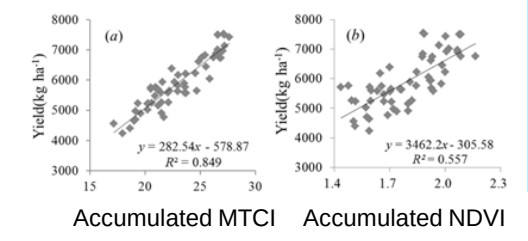
Agro-meteorological model



Biomass-HI model



VI regression model



Special methods and indicators in China

➢ Optional Drought Indices for China

Vegeatation Condition Index

$$VCIj = \frac{NDVIj - NDVIm_{in}}{NDVIm_{ax} - NDVIm_{in}} * 100\%$$

Temperature Condition Index

$$TCIj = \frac{T_{max} - Ts_j}{T_{max} - T_{min}} * 100\%$$

Vegetation Health Index

$$VHI = a * VCI + (1 - a) * TCI$$

$a = R^2_{vci} / (R^2_{vci} + R^2_{tci})$

Normalized Difference Water Index

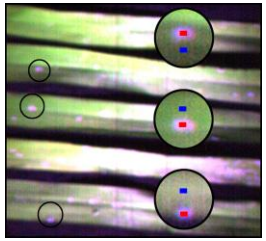
$$NDWI = \frac{\rho_{SWIR} - \rho_{NIR}}{\rho_{SWIR} + \rho_{NIR}}$$

NDVIj NDVI of date j; NDVImax and NDVImin are the maximum and minimum NDVI of all dataset ; Tmax and Tmin are the maximum and minimum Ts of all dataset. SWIR is the shortwave infrared band and NIR near infrared band

Special methods and indicators in China

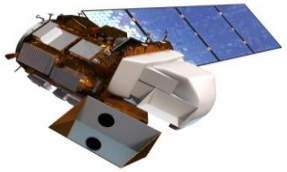
- Crop diseases and pests

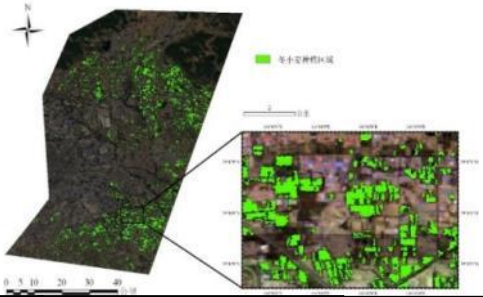
Leaf scale



Canopy scale

Regional scale

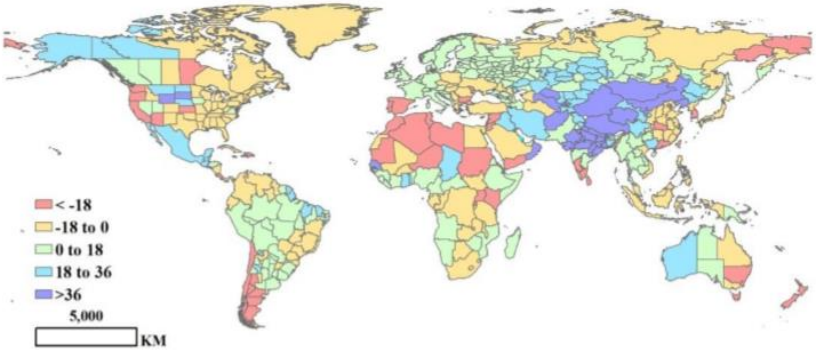




Early outlook based on CropWatch indicators

	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.

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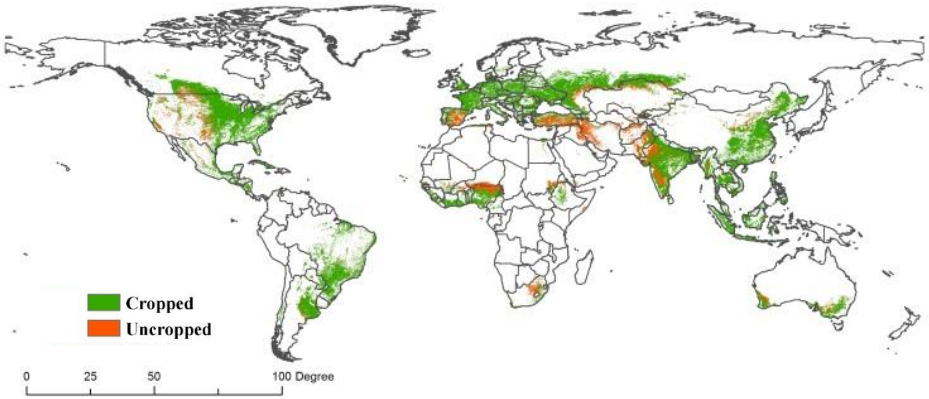
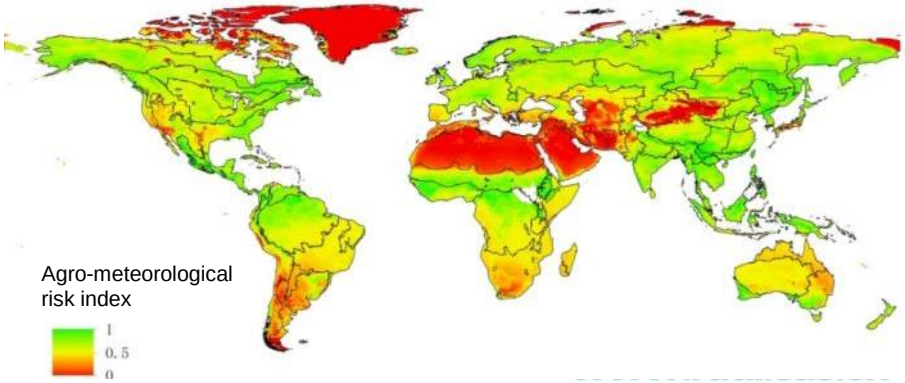
Food security early warning

- Cropped arable land fraction (CALF) at early growing stage somehow represents the total cropping area in current period is used to forecast crop area
- Agro-meteorological risk index (AMRI) considering meteorological suitability for crops at different growing stage is used for yield forecasting



July to October 2015

August 2013



Production estimation and revision

Table B.3. Canada, 2015 maize and wheat production, by province (thousand tons)

	Maize		Wheat	
	2015	Δ%	2015	Δ%
Alberta			8290	-11.3
Manitoba			3654	-0.1
Ontario	2979	-1.6	1714	-2.1
Quebec	7714	1.5		
Saskatchewan			13055	-7.8
Sub total	**10693**	**0.6**	**26713**	**-7.6**
others	1430	11.5	4428	1.3
Canada	**12123**	**1.8**	**31141**	**-6.4**

Δ% indicates percentage difference with 2014.

Early forecast one/two month before harvest

Table B.4. Canada, 2015 wheat production, by state (thousand tons)

	Maize		Wheat	
	2015	Δ%	2015	Δ%
Alberta			8290	-11.3
Manitoba			3654	-0.1
Ontario	2965	-2.0	1725	-1.5
Quebec	7559	-0.5		
Saskatchewan			13055	-7.8
Sub total	10525	-1.0	26724	-7.6
others	1320	3.0	3949	-9.7
Canada	11845	-0.5	30673	-7.9

Revised estimates at harvest using up to date RS data

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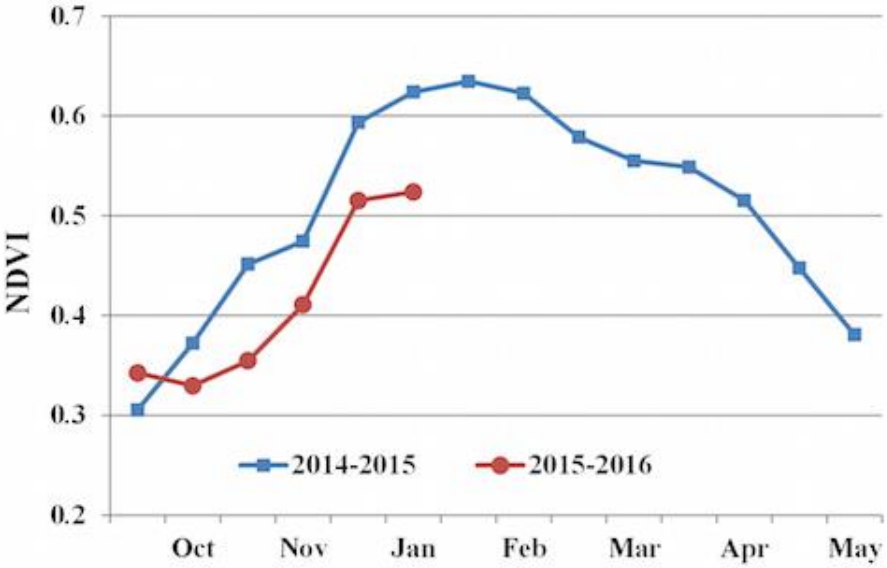
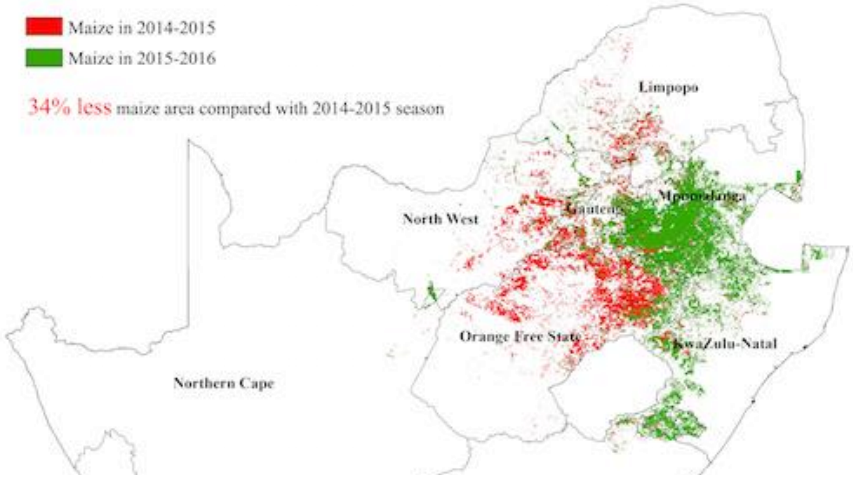
Server drought in Africa

- Server drought prevented farms sowing maize， with a reduction of 34% of maize area; yield was 16% lower than 2015. Maize production was projected at 44.6% drop. (2016 Jan. forecast)
- Since Feb 2016, rainfall benefited the maize in fields. Maize production is revised to 32% drop. (2016 April estimates)

Development of NDVI profiles over maize growing areas in 2014-15 and 2015-16



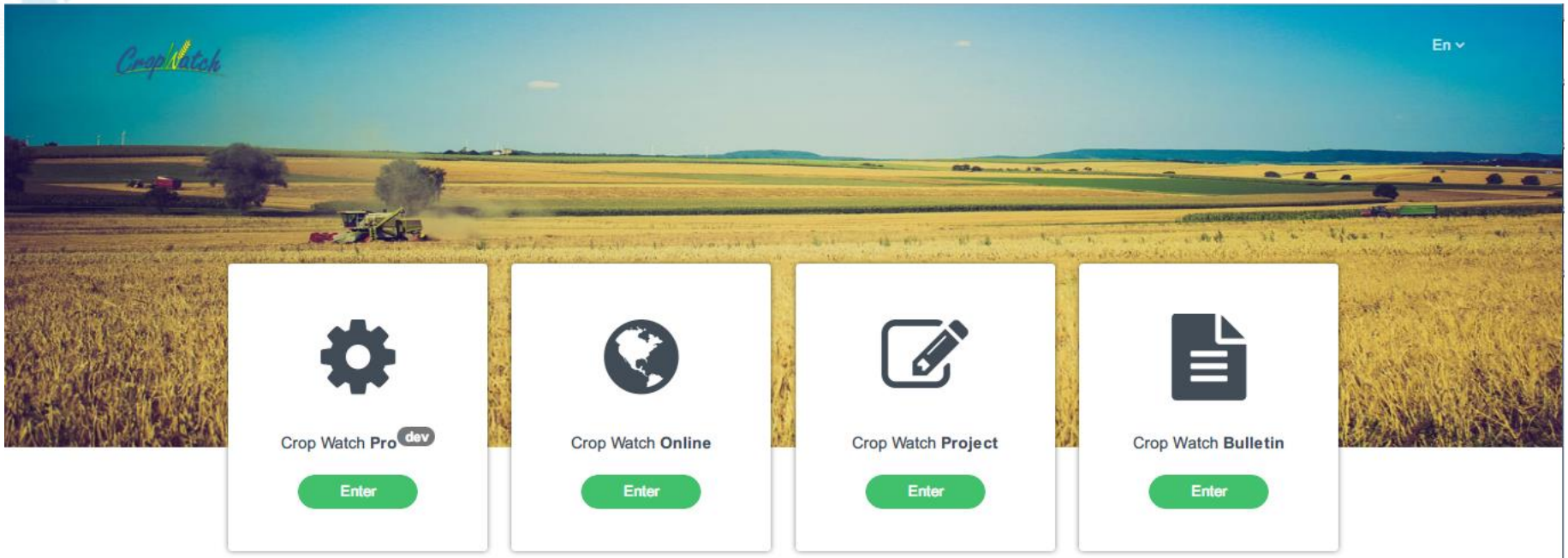
Relative distribution of maize in 2014-15 and 2015-16



Both red and green areas that grew maize in January 2015. In January 2016, only the green area had living maize crops

CropWatch Cloud

CropWatch Cloud Structure



Contact

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Cropwatch **Pro**

Enter

CropWatch-Pro

- An online tool for people to produce crop monitoring products at any time and anywhere.

Cropwatch **Online**

Enter

CropWatch-Online

- An online interface for people to explore and analysis all the crop information data easily.

Cropwatch **Project**

Enter

CropWatch-Project

- An online platform for people to create and write the crop bulletin.

Cropwatch **Bulletin**

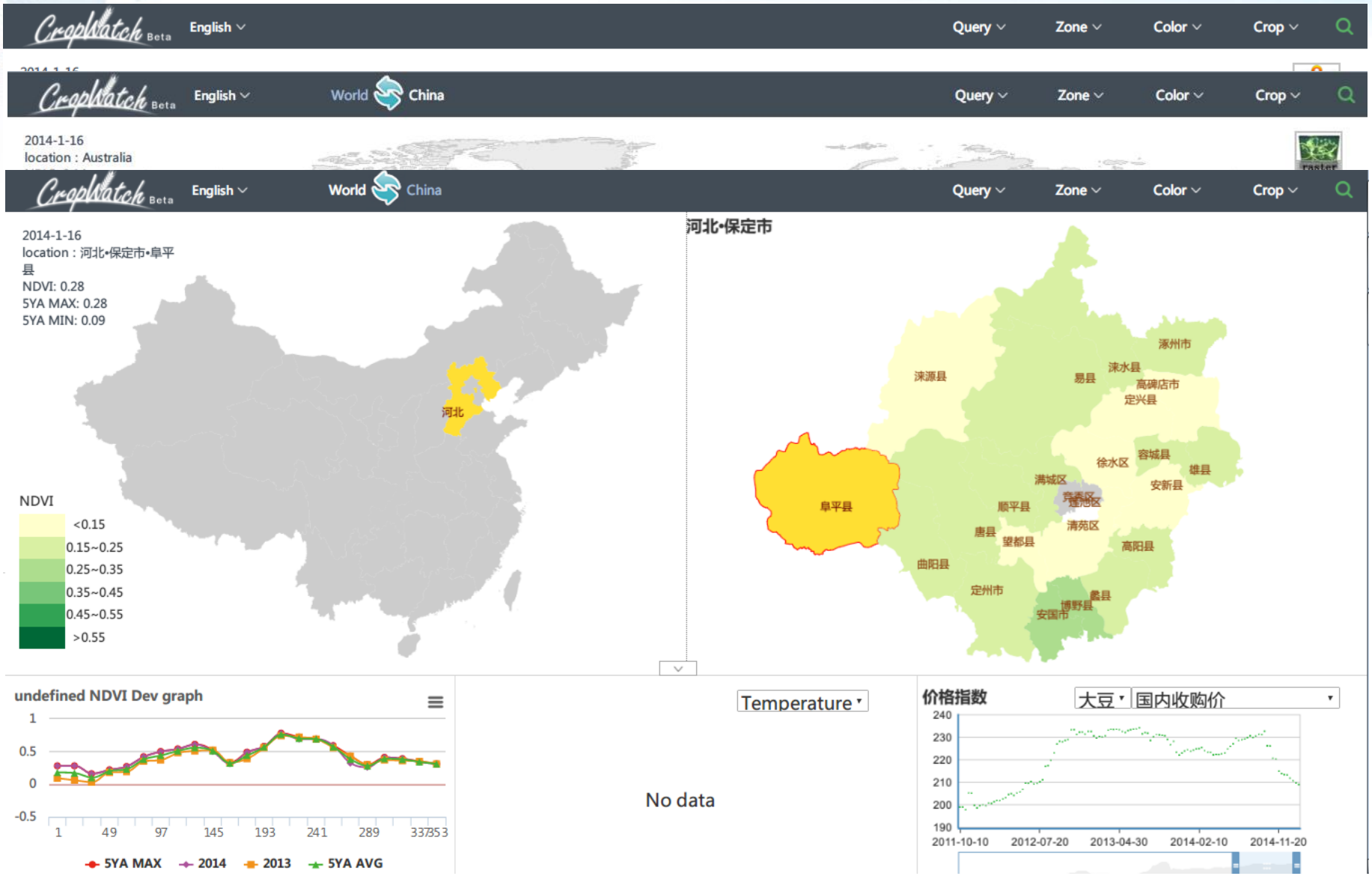
Enter

CropWatch-Bulletin

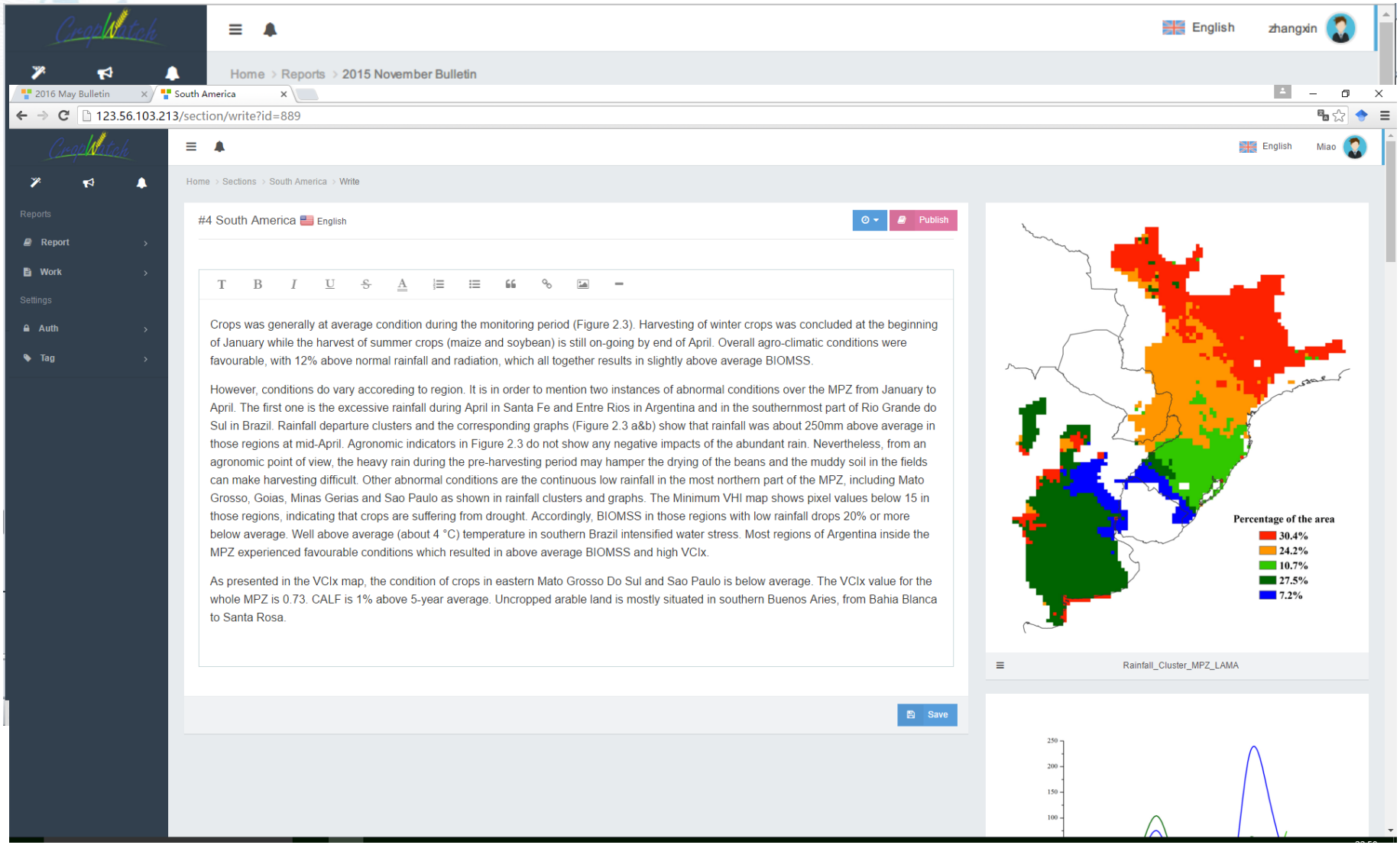
- An webpage for people to read CropWatch bulletin.

CropWatch-Pro

CropWatch-Online

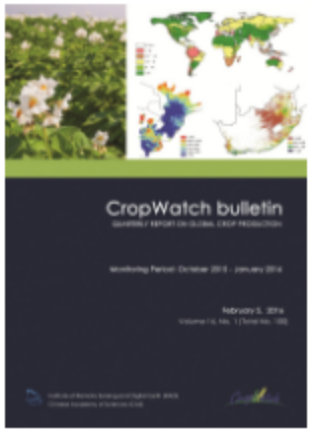


CropWatch-Project



February 2016 CropWatch bulletin (Vol. 16, No. 1)

All bulletins >>



February 2016 CropWatch bulletin released. The latest CropWatch bulletin assesses worldwide food production and other events of agricultural interest for the period October 2015 to January 2016. The bulletin as always relies on environmental and satellite-based agronomic indicators combined with other available agricultural data. A particular focus area for this bulletin is the Zambezi basin in Africa; the issue further describes other ongoing trends, a focus on Chinese domestic crop prices, disaster events, and El Niño.

Full report 报告全文

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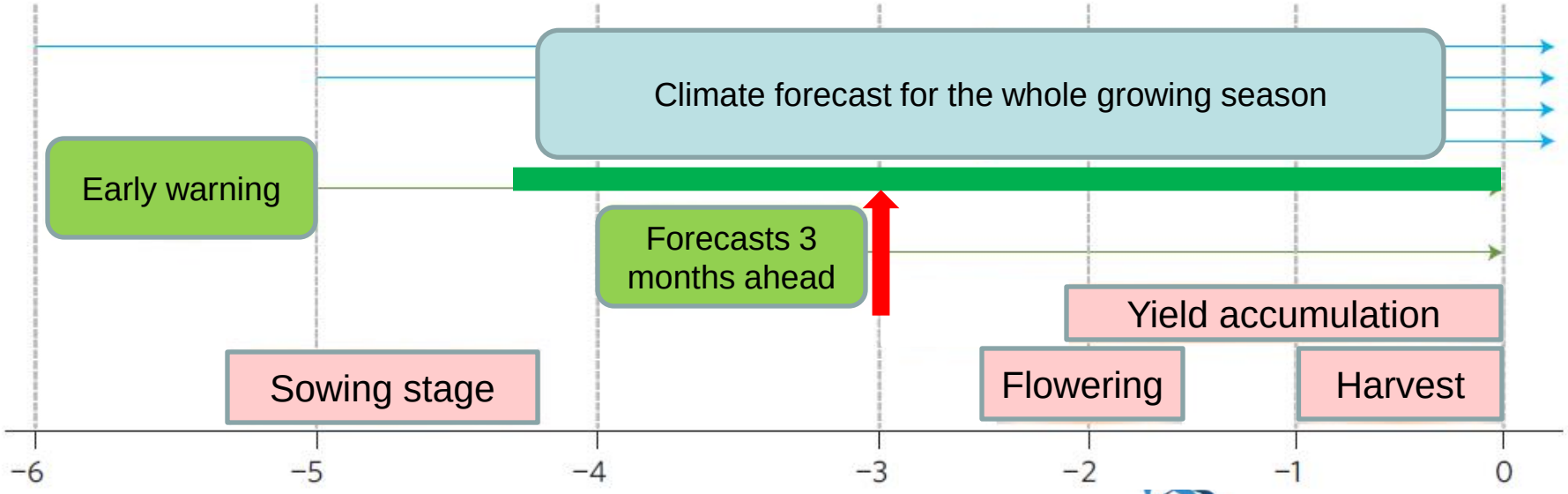
Key messages from the report:

- Global environmental conditions. Global patterns of agroclimatic variables bear the stamp of El Niño, with spatially coherent areas of rainfall, and sunshine anomalies. The resulting biomass production potential (BIOMSS) anomalies follow similar patterns. While El Niño had an impact during this reporting period, effects are likely to slow down.
- Patterns of abnormal conditions.On one hand, abundant rainfallwas seen throughout China, most of Central Asia and the Middle East, as well as sub-Saharan Northern Africa. Drought, on the other hand, was reported on an especially large scale in Southern Africa, the Horn of Africa, parts of Latin America and the Mediterranean.
- Floods. Floods hit all continents during the reporting period, with areas affected most including the USA, Egypt, Saudi Arabia, Kenya, the DRC, a large area throughout south America, Somalia, Iraq, India and Malaysia.
- Southern hemisphere updates ：total wheat production of Argentina, Australia and Brazil stands at 43 million tons, 1378 ktons decrease from

Outlook

- To introduce crop models to enhance the crop yield forecasting
- More crops will be covered, including barley and potatoes
- Production forecast three months ahead from harvest
- To invite more people from all over the world to use CropWatch to produce their own agriculture monitoring report for free



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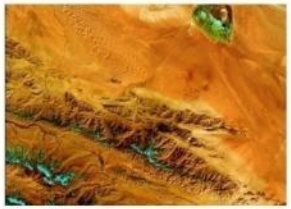
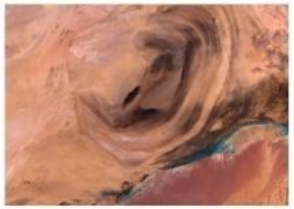
Thanks!





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