Crop Monitoring as an
E-agricutural tool in
Developping Countries

USABILITY REPORT FOR CGMS APPLICATION IN ANHUI CHINA

Final v2

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EXECUTIVE SUMMARY

The purpose of the usability review is to assess if the Crop Growth Monitoring System (CGMS) can be applied for the study area in Anhui. This assessment is carried out on two aspects:

- Availability of data sources needed to run CGMS.
- Inventory of technical and institutation facilities needed to operate CGMS.

With regard to the available data sources we conclude that the data sources to build and calibrate the system are available. Moreover, it is encouraging that meteorological data have been made available by AIFER within the e-AGRI project, because Chinese meteorological data have been regarded as sensitive data in previous projects and were not available outside China. However, a critical issue is still the near real-time delivery of meteorological data. As long as sustained delivery of meteorological data is not secured, a real-time operation of CGMS for agricultural monitoring in Anhui is uncertain. Less critical, but still important is the collection of crop experimental data for calibrating and validating crop model simulations.

Computer systems are not generally recognized to be a bottleneck because of the limited spatial extent of the CGMS setup in Anhui. However, the handling of relational database systems (like ORACLE) has demonstrated to be a bottleneck in other projects in the past. It is therefore recommended that AIFER sets up a dedicated team that can build and share experience with CGMS and is also educated in the use of relational database systems. Or dedicated personnel should be added to the team to carry out database maintenance.

The mandate of AIFER seems sufficient to carry out agricultural monitoring with CGMS. However, sustained funding (after E-AGRI) of CGMS activities is not yet clear and this will have to be sorted out during the project.

1. Introduction

The European Crop Growth Monitoring System (CGMS) embedded in the MARS Crop Yield Forecasting System (MCYFS) has been developed since the start of the MARS project in 1988. CGMS has been operational since 1994 and gradually extended within the MCYFS over the EU (EU12 towards EU27, Belarus, Ukraine and Russia) and more recently for large parts of Asia as well.

Setting up the Crop Growth Monitoring System (CGMS) for a particular region requires that a considerable number of datasets are collected which are related to meteorology, soil types, soil biophysical properties as well as crop cultivars, land use, cropping patterns and crop management. Equally important is the fact that the database is not a static database. Instead it needs to be updated in regular intervals (daily or 10-daily) in order to keep up with the current growing season, as well as yearly updates of regional statistics related to crop acreage and crop yield.

Besides the data aspects that are important in running CGMS, there are also aspects related to technological know-how in managing and maintaining the system as well as the institutional settings in which a system is operated (e.g. the mandate of the relevant organisation) and funding.

Finally, this usability report intends to verify the suitability of the underlying biophysical elements in the current CGMS approach for the target region and possible identify missing elements in the system. The latter is done through a questionnaire that was circulated among local experts and/or reports on local crop conditions.

2. Inventory of data sources for Anhui, China

2.1. Meteorological data

Despite the fact China has a dense and well-functioning network of (agro-) meteorological stations, collection of archived as well as near real-time meteorological data can be a difficult issue in China. First of all, meteorological data are regarded as sensitive in China and often cannot be distributed outside China. Secondly, also within China exchange of meteorological data between institutions is not necessarily allowed and/or guaranteed to be without costs (this problem is not exclusive to China but is also the case in Europe).

Within the framework of E-Agri, AIFER, the Chinese local partner, contacted the local meteorological network and obtained daily meteorological data from 15 meteorological stations in the region. Three stations are inside Anhui province, while 12 stations are over the neighbouring area of Anhui (figure 1). The data from these stations are archived data covering the period 1990-2010. The available meteorological variable are sufficient for running CGMS (table 2), only some work will be necessary to calibrate the Angstrom equation in order convert sunshine duration (in hours) to estimates of global solar radiation in kJ/m^2/day.

The dataset presents a good start to build up the CGMS database for Anhui, to test procedures and to calibrate the WOFOST crop model. However, what is still unclear are the possibilities to update the meteorological data in near real-time which is needed for running CGMS in an operational mode, meaning monitoring crop conditions and modelling crop growth on 10 daily bases. Until now, updates of meteorological data can only be achieved with a delay of three months, which is insufficient for near real-time monitoring.

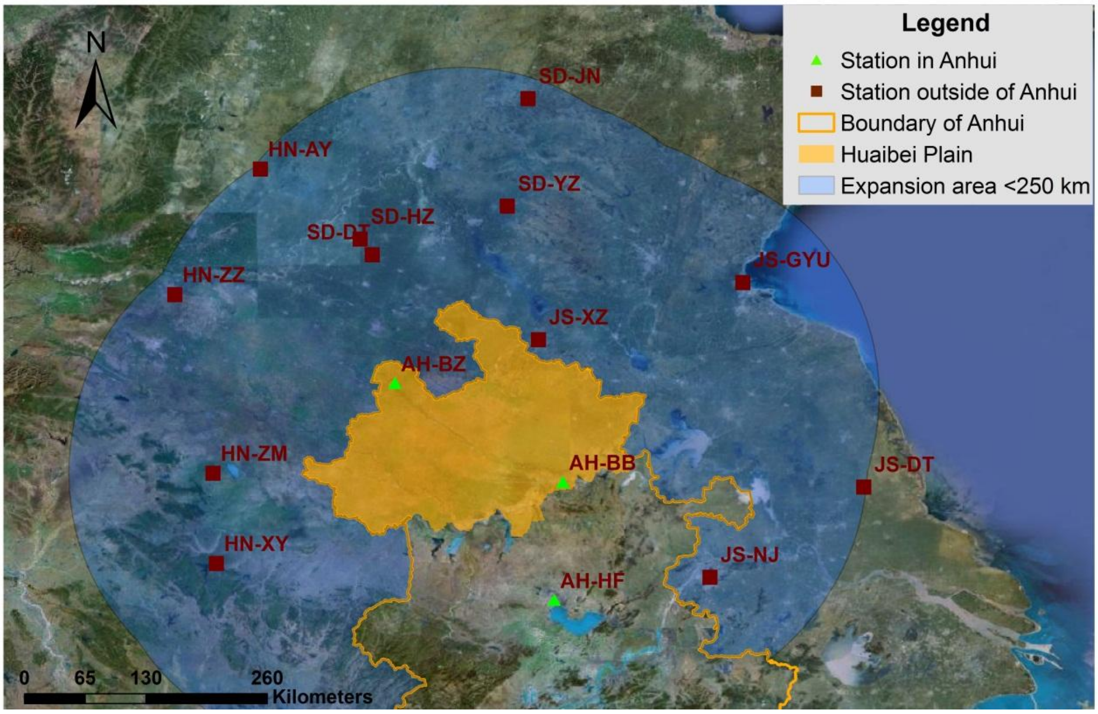

Figure 1. Spatial distribution of meteorological stations in Anhui and surrounding regions

Table. 1 Description of meteorological stations within and surrounding Anhui province.

ID	Location	Province	Latitude	Longitude	Altitude	Time Range
AH-BB	Bengbu	Anhui	32.9167	117.3833	21.9	1990-2011
AH-BZ	Bozhou	Anhui	33.8667	115.7667	37.7	1990-2011
AH-HF	Hefei	Anhui	31.7833	117.3000	27.0	1990-2011
HN-XY	Xinyang	Henan	32.1333	114.0500	114.5	1990-2011
HN-AY	Anyang	Henan	36.0500	114.4000	62.9	1990-2011
HN-ZM	Zhumadian	Henan	33.0000	114.0167	82.7	1990-2011
HN-ZZ	Zhengzhou	Henan	34.7167	113.6500	110.4	1990-2011
JS-DT	Dongtai	Jiangsu	32.8667	120.3167	4.3	1990-2011
JS-NJ	Nanjing	Jiangsu	32.0000	118.8000	7.1	1990-2011
JS-GYU	Ganyu	Jiangsu	34.8333	119.1167	3.3	1990-2011
JS-XZ	Xuzhou	Jiangsu	34.2833	117.1500	41.2	1990-2011
SD-DT	Dingtao	Shandong	35.1000	115.5500	50.5	1995-2011
SD-HZ	Heze	Shandong	35.2500	115.4333	49.7	1990-1994,

						2007-2008
SD-YZ	Yanzhou	Shandong	35.5667	116.8500	51.7	1990-2011
SD-JN	Jinan	Shandong	36.6000	117.0500	170.3	1990-2011

Table 2. Meteorological variables and units available from the meteorological stations within Anhui province.

Meteorological variable	Unit
Max Temp	0.1 ℃
Min Temp	0.1 ℃
Mean Temp	0.1 ℃
Mean Relative Humidity	1 %
Precipitation	0.1 mm
Mean Windspeed	0.1 m/s
Extreme Windspeed	0.1 m/s
Sunshine Duration.	0.1 hour

2.2. Soil map and soil physical parameters

The soil map in CGMS has two main purposes in CGMS:

- selecting soils that are suitable for cultivation of a particular crop type, while the available crop masks are also a valuable source of information for this selection.
- estimating the soil water holding capacity for the crop water balance.

For both purposes information is needed about the soil hydrological properties (wilting point, field capacity and porosity) as well as the maximum rootable depth. Together these variables define the total water holding capacity of the soil. Note that CGMS does not use information about soil fertility.

For Anhui province a soil map from Chinese sources is available at the scale of 1:500,000 but with a Chinese classification which will need a manual interpretation and conversion to a more generalized soil classification (such as FAO or USDA). The main alternative is the FAO Soil and Terrain database for Eurasia (SOTER) with a scale of 1:1M (figure 2) for which the soil hydraulic properties and maximum rootable depth have already been estimated.

The SOTER map for Anhui demonstrates that the variability of soil types within the Huaibei plain almost complete falls within a single major soil type (type FL= fluvisols). It is therefore expected that refining the soil map in CGMS using the Chinese soil map will not yield much more detailed information, also because the scale of the SOTER database (1:1M) and the Chinese soil map (1:500k) are not very different.

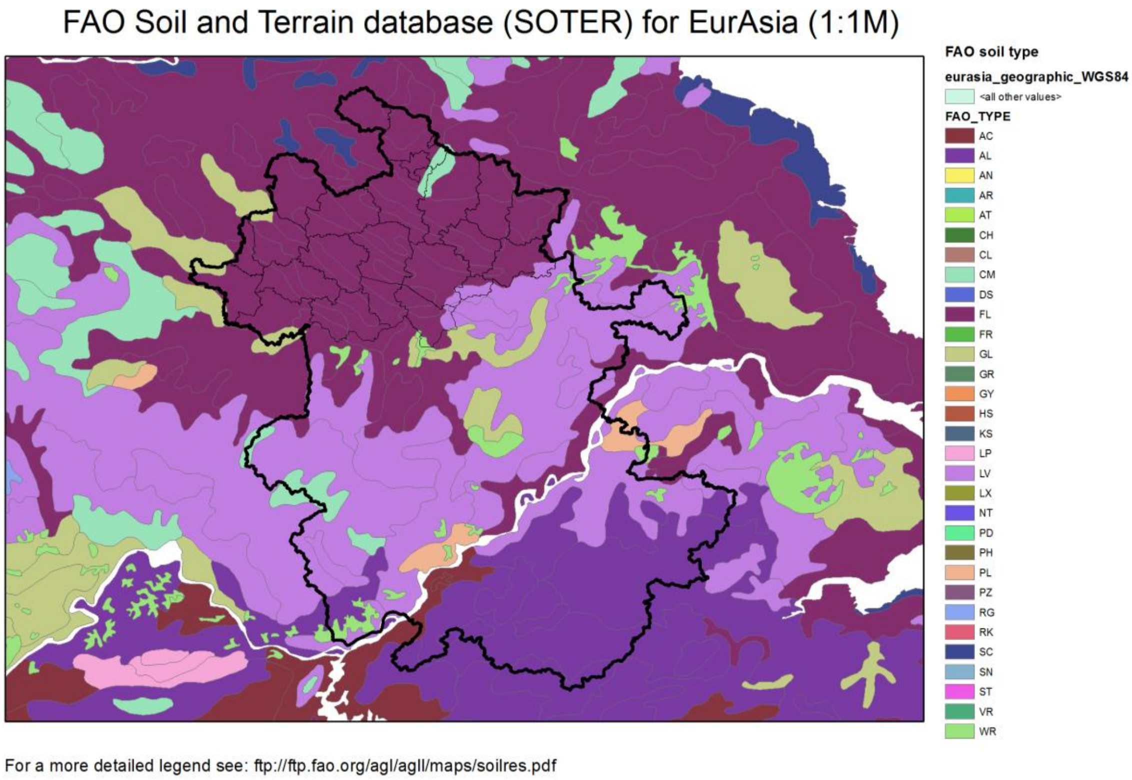

Figure 2. SOTER soil map of Eurasia for Anhui province. Province boundaries in dark black lines, counties boundaries for the Huaibei plain in thin black lines.

2.3. Crop masks and land use

A crop mask for the Huaibei Plain has been made available by AIFER with a spatial resolution of 100m (figure 3). The crop mask only makes a distinction between the land use classes “arable land” and “other land use”, moreover the crop mask is not crop specific. However, given that the distribution of crop types over the area is fairly homogeneous there is little difference between a general crop mask and a crop-specific mask. Therefore, the current crop mask is deemed sufficient for setting up CGMS-Anhui.

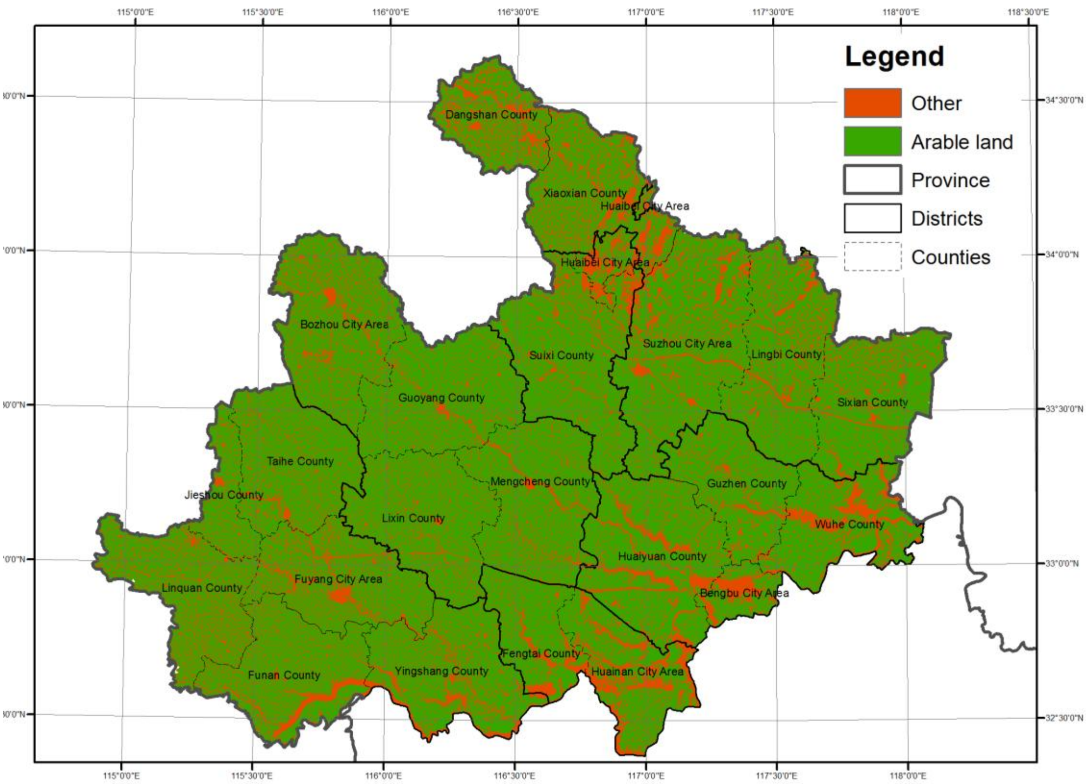

Figure 3. Crop mask for the Huaibei plain. Province boundaries in dark black lines, district boundaries for the Huaibei plain in thin black lines.

2.4. Crop experimental data

The WOFOST crop model inside CGMS was originally calibrated using wheat cultivars in Western-Europe. In China different wheat cultivars are used which are different particularly with regard to growing season length and cold hardiness. For this purpose, parameters within WOFOST need to be adapted in order to match model simulations with the wheat cultivars that are used in Anhui.

Preferably, recalibration of WOFOST model parameters should be carried out on the basis of controlled field experiments where various biophysical properties of the plant are measured, a list of properties has been sent around in May 2011:

Tabel 3. List of crop experimental observations needed for different calibration levels of the WOFOST model.

1. Phenology
• A) Observations of *dates of sowing, emergence, anthesis (flowering), maturity and/or harvest*. Preferably for a similar (group of) cultivar(s) and the dataset should contain some interannual and spatial variability. This will allow to calibrate the TSUMEM, TSUM1 and TSUM2 parameters
2. Potential yield level (assuming near optimal conditions)
• A) Observations of *crop total biomass* and *Maximum LAI*: Calibrate the maximum assimilation rate (AMAXTB) and the specific leaf area (SLA)
• B) Observations of *crop yield*: Calibrate the fraction of dry matter partitioned to the storage organs
• C) Observations of *time trajectories of LAI, biomass and yield*: detailed calibration of the partitioning tables, AMAXTB and SLA
3. Water-limited yield level (observations on water-limited crops):
• A) Observations of *profile soil moisture, crop total biomass and yield*: calibrate the crop maximum rooting depth (RMDCR)
• B) Observations of *crop transpiration*: Calibrate the correction factor for transpration (CFET)

It is known that China has an extensive network of agro-meteorological stations where such measurements (at least partially) are being made. Data from such networks have been used in the past during other Sino-European cooperation projects (such as the European Huabei CGMS project) and were found to be very suitable for WOFOST calibration. At this stage of the project, requests for delivery of crop experimental data have been made to CAAS but no clarity has yet been received on availability (and suitability) of such data for the study area in Anhui.

Nevertheless, a crop calendar for winter-wheat has been made available by AIFER which describes indicative (long-term average) dates for different crop phenological stages (table 4). Such crop calendars are also used in Europe in the MARS system for calibrating WOFOST in areas where otherwise no data is available and it allows to make reasonable estimates of the phenological parameters in WOFOST. It is therefore proposed to start building CGMS using the available crop calendar and refine the system at a later stage of the project using detailed crop experimental data when available.

Table 4. Crop calendar for winter-wheat in the Huaibei plain.

Crop stage	Indicative date
sowing time	12-Oct
emergence	19-Oct
three leaf stage	2-Nov
wintering period	20-Dec
turning green	10-Feb
Jointing	10-Mar
booting	10-Apr
heading	22-Apr
flowering	25-Apr
maturity	1-Jun

2.5. Regional statistics

Regional statistics have been made available by AIFER for all six districts (or prefectures) in the Huaibei plain (figures 4,5) for the period 2000-2009. These data represent a first insight into the regional and inter-annual yield variability over the Huaibei plain. The statistical data demonstrates that yield is increasing with time and was quite variable during 2000-2004. Cultivated area is increasing since 2004.

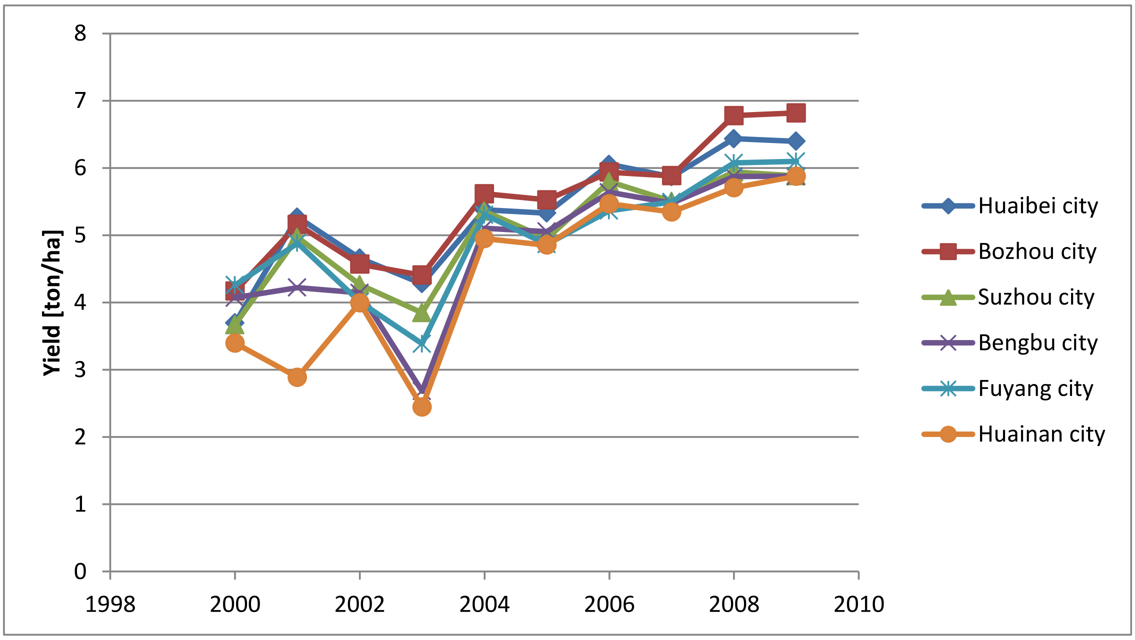

Figure 4. Yield of winter-wheat for all 6 districts in the Huaibei plain.

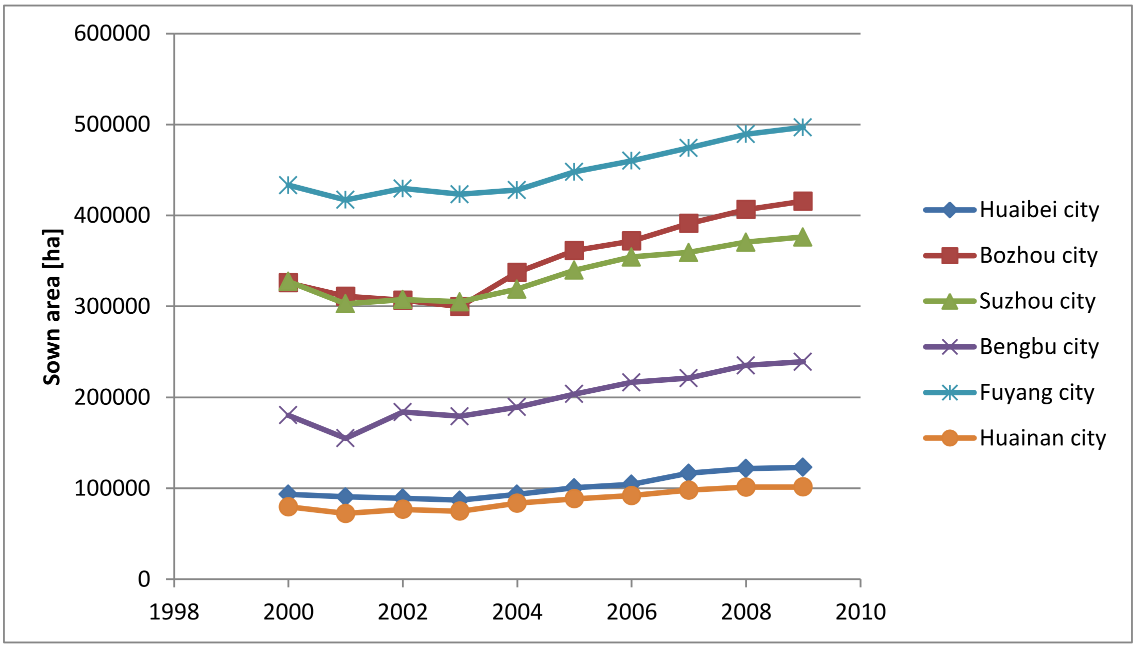

Figure 5. Sown area of winter-wheat for all 6 districts in the Huaibei plain.

3. Inventory of technical facilities and institutional setting for running and maintaining CGMS

3.1. Computer and database systems

Given that the CGMS setup for the Huaibei and neighbouring Juanghuai plains, presents a relatively small setup it is not expected that heavy computer systems will be necessary. This applies both for the client computers that run the CGMS processing as well as the database system that is used for storing, analysing and visualizing CGMS results. Therefore, generally available desktop computers will be sufficient initially, although during the project it will be beneficial to appoint dedicated hardware for CGMS processing.

Given that the AIFER has no prior experience with CGMS, it was decided during the November training session to start building the CGMS database using a Microsoft Access database where data are much easier to be manipulated and loaded in comparison with other database systems. After the system has been setup in Access and experience has been gained, it will be beneficial to migrate the CGMS database to a database system that is based on a client-server principle rather than a Microsoft Access database (which is a single-user database). This is absolutely needed when many users will start using the CGMS database for analysis.

Which database system should be used for operationalizing Huaibei CGMS is still an unresolved issue. Partner AIFER has indicated that they have experience using ORACLE, but the licensing issue remains to be clarified. An alternative would be to use free database systems such as MySQL or PostgreSQL. The former has been known to work with CGMS (but is not well tested), the latter database has some advantages over MySQL and is becoming the standard database of choice at Alterra. In both cases, adaptations and testing of CGMS will be necessary.

3.2. Software for analysis of CGMS results

A general bottleneck in the use of CGMS output is that dedicated software for analysis of CGMS output is not readily available. In practice, it is possible to analyse CGMS output and create charts and maps with general office tools and GIS systems like ArcGIS/QGIS, however in practice this procedure is cumbersome and prone to error. For the European MARS system this has been resolved by building dedicated viewers that query the MARS database and generate maps and charts on-the-fly. However, these viewers are not available within E-AGRI and are also not easy to install and maintain.

An alternative solution is to use the CGMS Classic viewer that was built within the framework of MARSOP2 and ASEMARS (Figure 6). This viewer is basically superseded by the web-based viewers that are used in MARSOP3, but they were known to work well and can be relatively easily adapted and installed. Nevertheless, CGMS Classic Viewer currently only works with ORACLE databases and adaptations will be needed to work with MySQL and/or PostgreSQL.

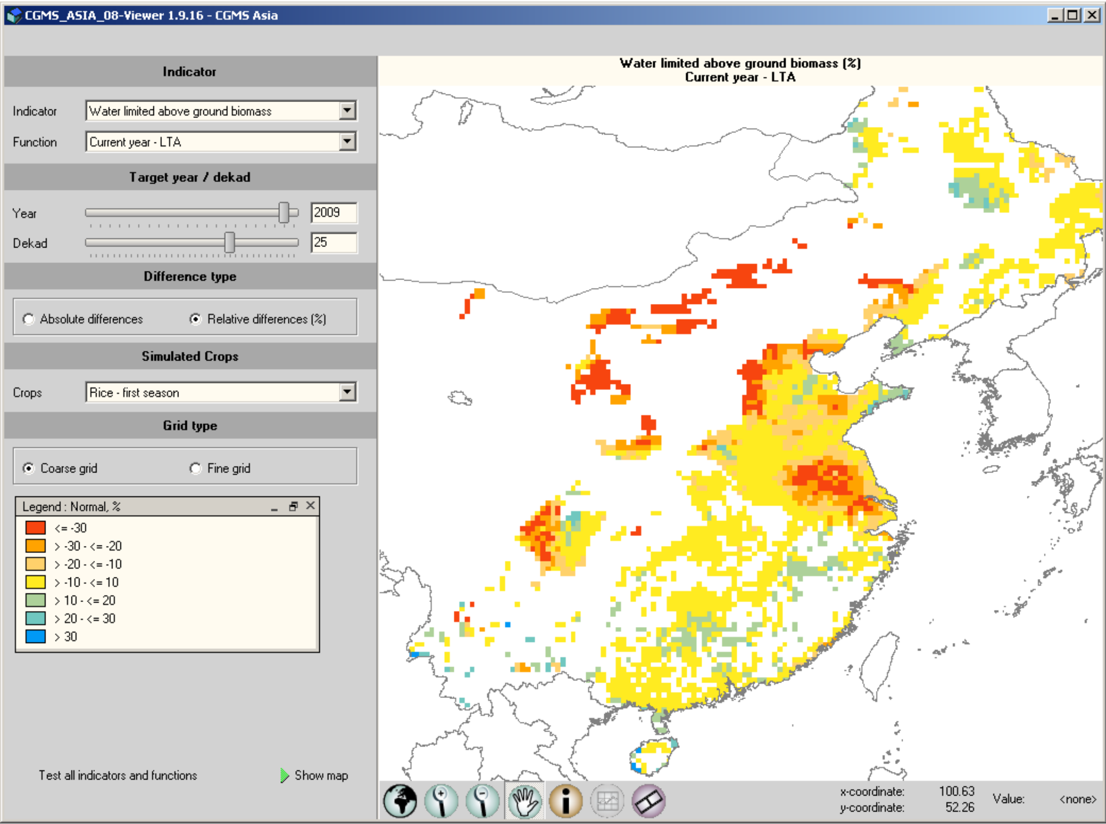

Figure 6. Screenshot of the CGMS classic viewer operating on the ASIA database in MARSOP3.

3.3. Institutional setting and technical know-how

AIFER has a mandate for monitoring and assessment regarding agriculture and natural damage in Anhui Province. Moreover, AIFER also hosts the Central Agricultural Remote Sensing Centre of the Ministry of Agriculture. Therefore from an institutional perspective

AIFER has some clear mandates and associated activities (like satellite monitoring), that make embedding CGMS a logical extension of these activities.

AIFER has no background in using and operating CGMS and therefore needs to build its expertise on the use of crop models for agricultural monitoring. Currently, this expertise building involves one or two persons who are actively involved in the E-AGRI project. However, experience from earlier projects shows that this will be insufficient for sustained use of CGMS. It is therefore needed that during the course of E-AGRI, AIFER will search for an embedding of the CGMS work in a dedicated team of people, that can share expertise among each other and which will ensure continuity.

Similarly, maintenance of the CGMS database has demonstrated to be a bottleneck in the past, particularly when CGMS was installed in an ORACLE database environment. In such cases it has been noticed that the team who should be operating CGMS was putting more time in solving difficulties with ORACLE rather than analysing CGMS output and producing crop bulletins. It is therefore advised that during the course of E-AGRI, AIFER takes care of educating people on the use of relational database systems, for example through dedicated courses. Another solution would be to hire dedicated personnel whom can execute commonly occurring maintenance tasks as well as dedicated database maintenance procedures and tuning.

4. Origins of variability in winter-wheat yields in Anhui

To be written based on questionnaire results

5. Conclusions and recommendations

- With regard to the setting up of CGMS for the Huaibei plain in Anhui we conclude that the basic datasets are available. However, a critical issue is still the near real-time delivery of meteorological data. As long as sustained delivery of meteorological data is not secured, a real-time operation of CGMS for agricultural monitoring in Anhui is uncertain. Less critical, but still important is the collection of crop experimental data for calibrating and validating crop model simulations.
- Computer systems are not generally recognized to be a bottleneck because of the limited spatial extent of the CGMS setup in Anhui. However, the handling of relational database systems (like ORACLE) has demonstrated to be a bottleneck in other projects in the past. It is therefore recommended that AIFER sets up a dedicated team that can build and share experience with CGMS and is also educated in the use of relational database systems. Or dedicated personnel should be added to the team to carry out database maintenance.
- Currently, tools are lacking to easily visualize and analyse data from the CGMS database. Currently existing tools that were developed for MARSOP3 are not suitable to roll out at the premises of AIFER. This gap in capabilities will be tackled by Alterra in 2012, by developing an improved version of the CGMS Classic viewer that can be easily installed and used.
- The mandate of AIFER seems sufficient to carry out agricultural monitoring with CGMS. However, sustained funding (after E-AGRI) of CGMS activities is not yet clear and this will have to be sorted out during the project.