Crop Monitoring as an E-agricultural tool in Developing Countries

CROP EXPERIMENTAL DATABASE IN ANHUI

DOCUMENT CONTROL

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ACRONYMS & GLOSSARY

Term	Explanation
AIFER	Anhui Institute For Economic Research
CGMS	Crop Growth Monitoring System
DOA	Day of anthesis
DOD	Day of dough
DOE	Day of emergence
DOH	Day of heading
DOG	Day of regreening
DOL	Days Of growing Length
DOJ	Day of jointing
DOM	Day of maturity
DOP	Day of planting
DOT	Day of tillering
NUTS	Nomenclature of Territorial Units for Statistics
WOFOST	WOrld FOod STudies

EXECUTIVE SUMMARY

For calibrating CGMS/WOFOST observations are needed to adjust the model for the regional winter-wheat cultivars in Anhui. Partner AIFER collected detailed agro-experimental data from the Fengqiu Comprehensive Agro-ecology Experiment Station in Henan province (just north of Anhui) as well as regular phenological observations from 11 stations in Anhui.

The datasets were processed by Alterra in order to obtain a structure and described dataset and to have them in a format that can be used in combination with the CGMS calibration platform.

1. Introduction

This database contains three subsets based on data of: 1) crop experimental data collected Fengqiu Comprehensive Agroecology Experiment Station; 2) crop calendar data collected from 11 counties in Anhui; 3) yield statistics data from several regions (NUTS level 1) in the northern Anhui province of China.

The first dataset includes crop phenology, growth condition (LAI, and biomass) at each growth stage under different practices (water limited, fertilization limited, and water and fertilization optimization) and for different cultivars. The second dataset contains winter wheat phenology between 1992 and 2012 in 11 counties in the northern Anhui province. The third dataset is the crop yield statistics between 2000 and 2011 over a few regions (NUTS Level 2) in the study area.

Two databases were built for calibrating and running the CGMS_Anhui. One is called "Agropheno_Fenqiu_DB", which will be used for local detailed calibration of WOFOST model parameters. The other one is called "Agrophenology_Anhui_DB"), which will be used for regionalization of the crop cultivars for CGMS-Anhui but calibrating jointly for different agro-ecological zones. Fig. 1 shows the location of the area with 11 counties and Fengqiu experimental site.
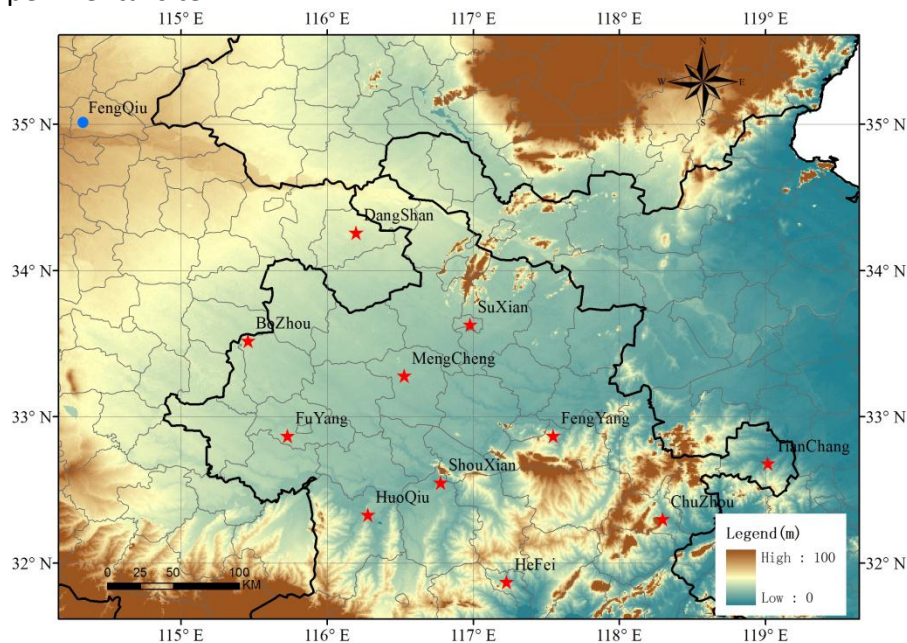

Figure 1: Overview of the study area with location of 11 counties in Anhui and Fengqiu experimental site.

2. Crop Database at Fengqiu Experimental Station

2.1. Basics of crop database at Fengqiu

Field experimental data for winter wheat at Fengqiu Comprehensive Agroecology Experiment Station (35°1' N, 114°4' E), Chinese Academy of Sciences, located in Fengqiu county of Henan province (northwest of Anhui as indicated in **Fig.1**).

The data were collected between 2003 and 2011. The experiments were carried out in 6 plots and with 4 different cultivars of winter wheat with time (years) (**Table 1**). The crops in each plot were applied by three different practices for fertilization and water supply, say, optimized practice (with optimal fertilization and water supply), no fertilization and water limited practice. The crop phenology were observed including emergence, regreening, tillering, jointing, heading, anthesis, milking, dough, grain filling and maturity (dough stage). Planting density (number of plants per square meter), mean crop height, crop leaf area index, number of tillers in each phonological stage, total above ground fresh biomass weight, stem dry biomass weight, leaf dry weight, total aboveground dry weight were also measured.

As shown in Table 1, Zhengmai9023 was cultivated between 2003 and 2007, continued by Xinmai19 between 2007 and 2011. Three treatment (optimised fertilization and water supply condition, no fertilization and water limited condition) were applied to these two cultivars for each year. Kenong199 was planted for 2007-2008 under water limited condition only.

Table 1: List of crop data collected at Fengqiu experimental station.

Cultivar	Treatment	Plots	Year	Note
Zhengmai9023	No fertilization	2	2005 – 2007	DOP,DOE and DOM are missing
	Water limited	6	2005 - 2007	DOP,DOE and DOM are missing
	Optimisation	3, 4	2003 - 2007	DOP missing
Kenong199	No fertilization	x		
	Water limited	6	2007 - 2008	DOT, DOJ, DOH, DOF, DOD
	Optimisation	x		
Xinmai19	No fertilization	1, 2	2007 - 2011	DOP, DOG, DOE, DOM missing
	Water limited	5, 6	2008 – 2011	DOP, DOG, DOE, DOM missing
	Optimisation	4	2007 - 2011	DOP, DOG, DOE, DOM missing
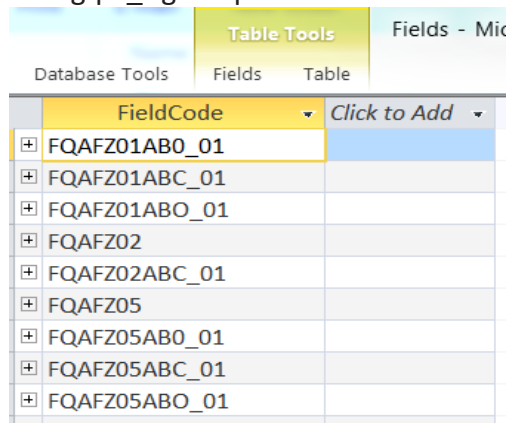
Zhengmai336	No fertilization	2	2011	DOT only
	Water limited	x	2011	DOT only
	Optimisation	4	2011	DOT only

A basic database file, named "Fengqiu_AgroExperimentalObservations_DB", was created with eight data tables as shown in Table 2 using above mentioned data from Fengqiu.

Table 2: Structure of "Fengqiu_AgroExperimentalObservations_DB".
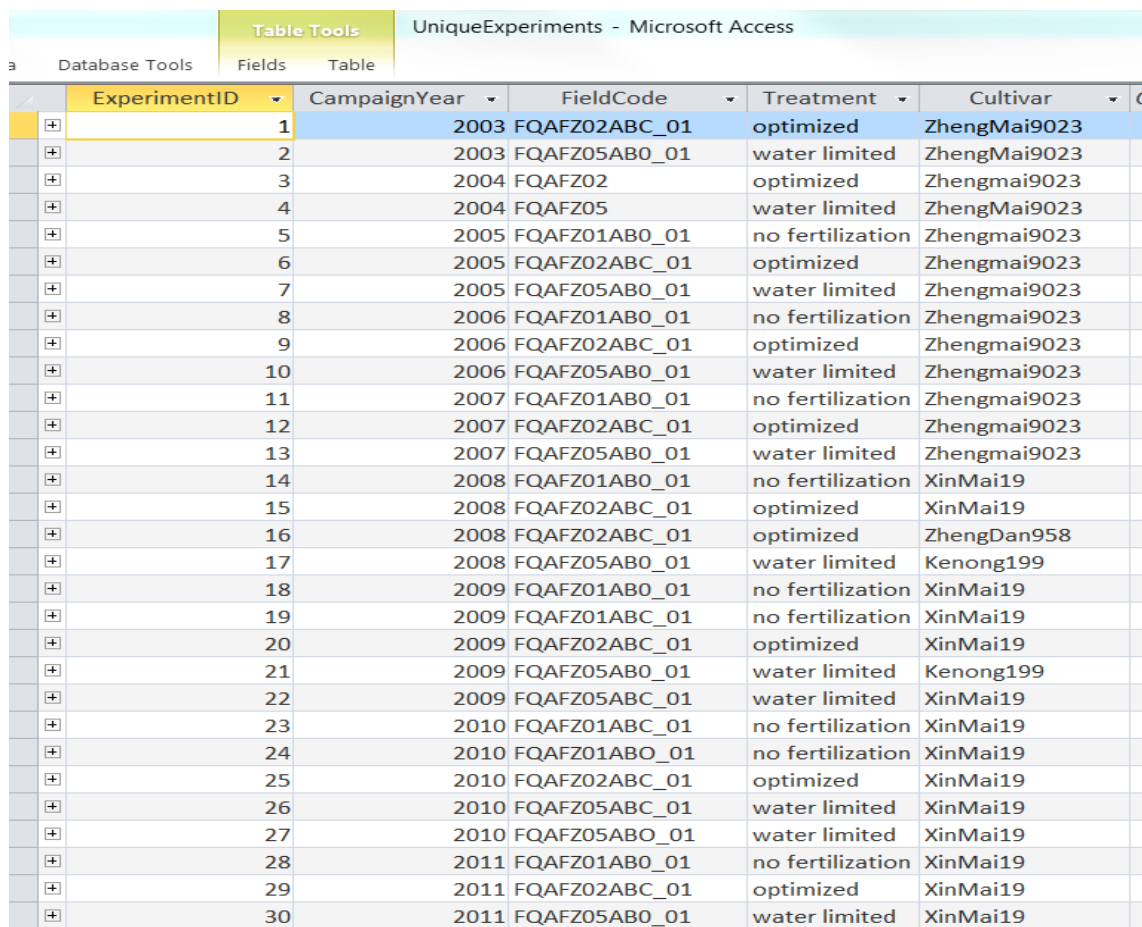
Database structure	Data Table Name	Description
Tables CropBiomassTimeSeries CropTypeAndYield Cultivars Fields Irrigation Phenology Treatments UniqueExperiments	Fields	Containing FieldCodes for 8 fields for different cultivars and practices
	Cultivars	Containing Cultivar names of 4 cultivars of winter wheat
	Treatments	Containing list of 3 treatments (no fertilization, optimized, water limited)
	UniqueExperiments	Defining experiment IDs associated with campaign years, FieldCode, Treatment, Cultivar. The IDs are unique for data table "Irrigation" , "Phenology", "CropTypeAndYield" and "CropBiomassTimeSeries".
	Irrigation	Assigning irrigation schemes to each ExperimentID.
	Phenology	List of winter wheat growth stages associated to each ExperimentID.
	CropTypeAndYield	Table containing sowing amount, sowing area, percentage of sowing and yield of all the ExperimentIDs.
	CropBiomassTimeSeries	Table containing observed Leaf Area Index, total above ground fresh weight, stem dry weight, leaf dry weight, total above ground dry weight at each growing stage for the ExperimentIDs that have complete records from sowing to harvest.

Figs. 2 – 6 show the snapshots of the few major data Tables in the database "Fengqiu_AgroExperimentalObservations_DB".

Figure 2: Main structure of dataset "Fengqiu_AgroExperimentalObservations_DB".

ExperimentID	CampaignYear	FieldCode	Treatment	Cultivar
1	2003	FQAFZ02ABC_01	optimized	ZhengMai9023
2	2003	FQAFZ05AB0_01	water limited	ZhengMai9023
3	2004	FQAFZ02	optimized	Zhengmai9023
4	2004	FQAFZ05	water limited	ZhengMai9023
5	2005	FQAFZ01AB0_01	no fertilization	Zhengmai9023
6	2005	FQAFZ02ABC_01	optimized	Zhengmai9023
7	2005	FQAFZ05AB0_01	water limited	Zhengmai9023
8	2006	FQAFZ01AB0_01	no fertilization	Zhengmai9023
9	2006	FQAFZ02ABC_01	optimized	Zhengmai9023
10	2006	FQAFZ05AB0_01	water limited	Zhengmai9023
11	2007	FQAFZ01AB0_01	no fertilization	Zhengmai9023
12	2007	FQAFZ02ABC_01	optimized	Zhengmai9023
13	2007	FQAFZ05AB0_01	water limited	Zhengmai9023
14	2008	FQAFZ01AB0_01	no fertilization	XinMai19
15	2008	FQAFZ02ABC_01	optimized	XinMai19
16	2008	FQAFZ02ABC_01	optimized	ZhengDan958
17	2008	FQAFZ05AB0_01	water limited	Kenong199
18	2009	FQAFZ01AB0_01	no fertilization	XinMai19
19	2009	FQAFZ01ABC_01	no fertilization	XinMai19
20	2009	FQAFZ02ABC_01	optimized	XinMai19
21	2009	FQAFZ05AB0_01	water limited	Kenong199
22	2009	FQAFZ05ABC_01	water limited	XinMai19
23	2010	FQAFZ01ABC_01	no fertilization	XinMai19
24	2010	FQAFZ01ABO_01	no fertilization	XinMai19
25	2010	FQAFZ02ABC_01	optimized	XinMai19
26	2010	FQAFZ05ABC_01	water limited	XinMai19
27	2010	FQAFZ05ABO_01	water limited	XinMai19
28	2011	FQAFZ01AB0_01	no fertilization	XinMai19
29	2011	FQAFZ02ABC_01	optimized	XinMai19
30	2011	FQAFZ05AB0_01	water limited	XinMai19

Figure 3: Snapshot of Table UniqueExperiments of "Fengqiu_AgroExperimentalObservations_DB".

Figure 4: Snapshot of Table Irrigation of "Fengqiu_AgroExperimentalObservations_DB".

Figure 5: Snapshot of Table Phenology of "Fengqiu_AgroExperimentalObservations_DB".

Figure 6: Snapshot of Table CropTypeAndYield of "Fengqiu_AgroExperimentalObservations_DB".

Figure 7: Snapshot of Table CropBiomassTimeSeries of "Fengqiu_AgroExperimentalObservations_DB".

2.2. Fengqiu database for calibration of CGMS-Anhui

The database "Agropheno_Fenqiu_DB" was built upon the Fengqiu comprehensive crop experimental data as described in section 2.1. Data Tables were created in the "Agropheno_Fenqiu_DB" ready for running CGMS-Fengqiu for calibrating model parameters. Table 3 gives the structure of the "*Agropheno_Fenqiu_DB*" and list of Table names and their functions.

Table 3: List of data Tables in the database "Agropheno_Fenqiu_DB" of CGMS-Anhui.

Database content	Table name	Function
All Access Objects Tables · CalibrationDataType · CalibrationGridReference · CalibrationSingleValue · CalibrationSources · CalibrationSourcesMetadata · CalibrationTimeSeries · Crop · ObservationCode · selgrids · variety_grid_link	CalibrationSources	listed all the calibration data sources (corresponding to ExperimentIDs in **Fig.3**) available in the database (See **Fig. 8** for snapshot of the Table). There are 30 sources in total.
	CalibrationSourcesMetadata	the metadata for each calibration source, givs crop type, description, location and some additional information (See **Fig. 9** for snapshot of the Table)
	CalibrationDataType	gives definition for calibration data type, 3 types are defined: 1 = Observations from field experiment 2 = Regional observation 3 = Expert estimate
	CalibrationGridReference	listed the CGMS grid numbers for which a given calibration source is assumed to be valid (See **Fig. 10** for snapshot of the Table). All the 30 sources have the same grid number 89151
	CalibrationSingleValues	actual calibration data that stores single value variables (i.e. crop phenology: DOP, DOE, DOA, DOM) (See **Fig.11** for snapshot of the Table).
	CalibrationTimeSeries	actual calibration data that stores time

		series of crop growth conditions of key variables (e.g. LAI, Total above-ground biomass, etc.) identified by "ObservationCode" in the Table for all the calibration sources with complete records in terms of phenology stages (See **Fig.12** for snapshot of the Table).
	ObservationCode	stores observation codes and their descriptions and units (See **Fig.13** for snapshot of the Table).
	Crop	gives crop type definition (See **Fig.14** for snapshot of the Table).

CalibrationSourceID	DateOfEntry	NameOfEntry	CalibrationDataType	CalibrationTableRef	CalibrationSourceStudy
6	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
7	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
8	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
9	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
10	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
11	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
12	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
13	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
14	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
15	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
17	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
19	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
20	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
22	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
24	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
25	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
27	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
28	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
29	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje
30	2013-9-20	Allard de Wit	1	3	Crop experiments for Fenqiu experimental station (China) provided by Bell Zhang through e-Agri proje

Figure 8: Snapshot of table "CalibrationSources" of "Agropheno_Fenqiu_DB" database.
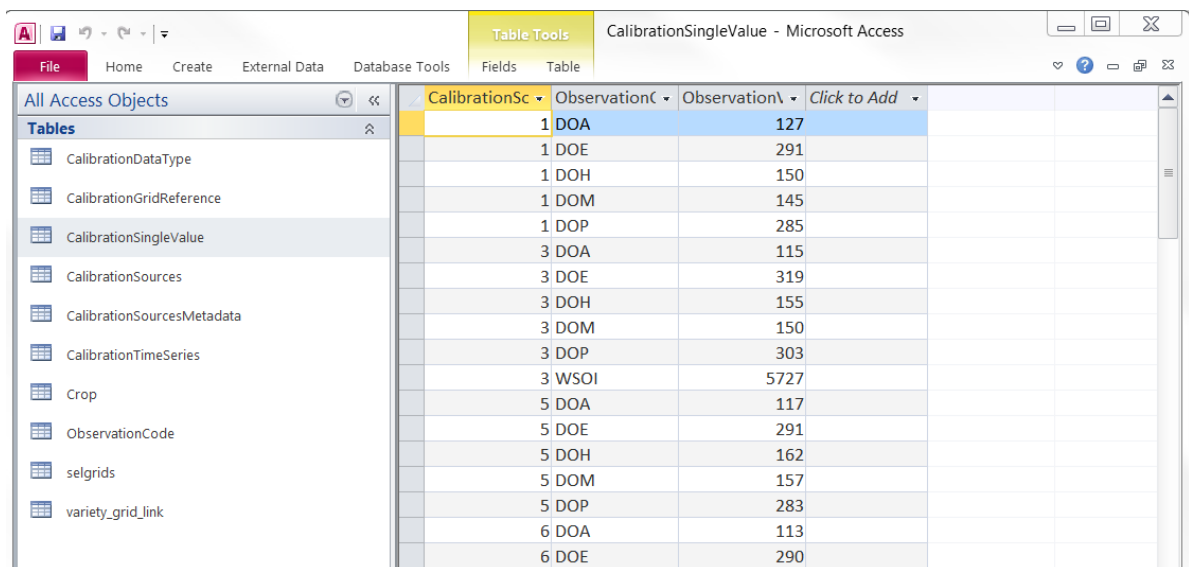
CalibrationSourceId	Cal_crop_no	Description	Location	AdditionalInfo
6	101	Experiment at Fenqiu, 'optimized' treatment with cultivar 'Zhengmai9023'	Fenqiu, Henan province, China	FieldCode: FQAFZ02ABC_01
7	101	Experiment at Fenqiu, 'water limited' treatment with cultivar 'Zhengmai9023'	Fenqiu, Henan province, China	FieldCode: FQAFZ05AB0_01
8	101	Experiment at Fenqiu, 'no fertilization' treatment with cultivar 'Zhengmai9023'	Fenqiu, Henan province, China	FieldCode: FQAFZ01AB0_01
9	101	Experiment at Fenqiu, 'optimized' treatment with cultivar 'Zhengmai9023'	Fenqiu, Henan province, China	FieldCode: FQAFZ02ABC_01
10	101	Experiment at Fenqiu, 'water limited' treatment with cultivar 'Zhengmai9023'	Fenqiu, Henan province, China	FieldCode: FQAFZ05AB0_01
11	101	Experiment at Fenqiu, 'no fertilization' treatment with cultivar 'Zhengmai9023'	Fenqiu, Henan province, China	FieldCode: FQAFZ01AB0_01
12	101	Experiment at Fenqiu, 'optimized' treatment with cultivar 'Zhengmai9023'	Fenqiu, Henan province, China	FieldCode: FQAFZ02ABC_01
13	101	Experiment at Fenqiu, 'water limited' treatment with cultivar 'Zhengmai9023'	Fenqiu, Henan province, China	FieldCode: FQAFZ05AB0_01
14	101	Experiment at Fenqiu, 'no fertilization' treatment with cultivar 'XinMai19'	Fenqiu, Henan province, China	FieldCode: FQAFZ01AB0_01
15	101	Experiment at Fenqiu, 'optimized' treatment with cultivar 'XinMai19'	Fenqiu, Henan province, China	FieldCode: FQAFZ02ABC_01
17	101	Experiment at Fenqiu, 'water limited' treatment with cultivar 'Kenong199'	Fenqiu, Henan province, China	FieldCode: FQAFZ05AB0_01
19	101	Experiment at Fenqiu, 'no fertilization' treatment with cultivar 'XinMai19'	Fenqiu, Henan province, China	FieldCode: FQAFZ01ABC_01
20	101	Experiment at Fenqiu, 'optimized' treatment with cultivar 'XinMai19'	Fenqiu, Henan province, China	FieldCode: FQAFZ02ABC_01
22	101	Experiment at Fenqiu, 'water limited' treatment with cultivar 'XinMai19'	Fenqiu, Henan province, China	FieldCode: FQAFZ05ABC_01
24	101	Experiment at Fenqiu, 'no fertilization' treatment with cultivar 'XinMai19'	Fenqiu, Henan province, China	FieldCode: FQAFZ01ABO_01
25	101	Experiment at Fenqiu, 'optimized' treatment with cultivar 'XinMai19'	Fenqiu, Henan province, China	FieldCode: FQAFZ02ABC_01
27	101	Experiment at Fenqiu, 'water limited' treatment with cultivar 'XinMai19'	Fenqiu, Henan province, China	FieldCode: FQAFZ05ABO_01
28	101	Experiment at Fenqiu, 'no fertilization' treatment with cultivar 'XinMai19'	Fenqiu, Henan province, China	FieldCode: FQAFZ01AB0_01
29	101	Experiment at Fenqiu, 'optimized' treatment with cultivar 'XinMai19'	Fenqiu, Henan province, China	FieldCode: FQAFZ02ABC_01
30	101	Experiment at Fenqiu, 'water limited' treatment with cultivar 'XinMai19'	Fenqiu, Henan province, China	FieldCode: FQAFZ05AB0_01

Figure 9: Snapshot of table "CalibrationSourcesMetadata" of "Agropheno_Fenqiu_DB" database.

The sources in **Fig. 8** are corresponding to 3 different cultivars of winter wheat (ZhengMai9023, Xinmai19 and Kenong199) each with different treatments by optimization by fertilization and water supply(refer to "optimized"), no-fertilization and water limited conditions. "AddintionalInfo" indicates the different experimental plots.

CalibrationSourceID	GridCode	Click to Add
1	89151	
3	89151	
5	89151	
6	89151	
7	89151	
8	89151	
9	89151	
10	89151	
11	89151	
12	89151	
13	89151	
14	89151	
15	89151	
17	89151	
19	89151	
20	89151	
22	89151	
24	89151	
25	89151	
27	89151	
28	89151	
29	89151	
30	89151	

Figure 10: Snapshot of table "CalibrationGridReference" of "Agropheno_Fenqiu_DB" database.

Figure 11: Snapshot of table "CalibrationSingleValues" of "Agropheno_Fenqiu_DB" database.

Figure 12: Snapshot of table "CalibrationTimeSeries" of "Agropheno_Fenqiu_DB" database.

Three variables were observed at Fengqiu site which listed below:

ObservationCode	Description
LAIITB	Leaf area index over time for irrigated crop
TAGBITB	Total above-ground biomass over time for irrigated crop
WLVITB	Weight of green leaves over time for irrigated crop

ObservationCode	CodeDescription	Unit	Type
DOA	Julian day of anthesis or start of tuber or beet filling for root/tuber crops	-	S
DOE	Julian day of emergence	-	S
DOH	Julian day of harvest	-	S
DOM	Julian day of crop maturity	-	S
DOP	Julian day of planting or sowing	-	S
LAIITB	Leaf area index over time for irrigated crop	m2 / m2	T
LAI-MAX	Maximum LAI during growth period for irrigated crop	m2 / m2	S
LAIRTB	Leaf area index over time for rainfed crop	m2 / m2	T
TAGBI	Total above-ground biomass at final harvest for irrigated crop	kg dry matter / ha	S
TAGBITB	Total above-ground biomass over time for irrigated crop	kg dry matter / ha	T
TAGBR	Total above-ground biomass at final harvest for rainfed crop	kg dry matter / ha	S
TAGBRTB	Total above-ground biomass over time for rainfed crop	kg dry matter / ha	T
TRARTB	Cumulative crop transpiration over time for rainfed crop	cm	T
WLVDRTB	Weight of dead leaves over time for rainfed crop	kg dry matter / ha	T
WLVITB	Weight of green leaves over time for irrigated crop	kg dry matter / ha	T
WLVRTB	Weight of green leaves over time for rainfed crop	kg dry matter / ha	T
WRTITB	Weight of roots over time for irrigated crop	kg dry matter / ha	T
WSOI	Weight of storage organs for irrigated crop at final harvest	kg dry matter/ ha	S
WSOITB	Weight of storage organs over time for irrigated crop	kg dry matter / ha	T
WSOR	Weight of storage organs for rainfed crop at final harvest	kg dry matter/ ha	S
WSORTB	Weight of storage organs over time for rainfed crop	kg dry matter / ha	T

Figure 13: Snapshot of table "ObservationCode" of "Agropheno_Fenqiu_DB" database.

CAL_CROP_NO	CAL_CROP_NAME	SIM_CROP_NO	SIM_CROP_NAME	WINTER_CROP	CROP_MODEL
101	winter wheat	1	winter wheat	0	0
102	grain maize	2	grain maize	0	0
103	spring barley	3	spring barley	0	0
105	rice	5	rice	0	0
106	sugar beet	6	sugar beet	0	0
107	potato	7	potato	0	0
108	field beans	8	field beans	0	0
109	soy bean	9	soy bean	0	0
110	winter rapeseed	10	winter rape seed	1	0
111	sunflower	11	sunflower	0	0
112	green maize	12	green maize	0	0
113	winter barley	13	winter barley	1	0
114	spring wheat	14	spring wheat	0	0
115	spring rapeseed	15	spring rapeseed	0	0
124	rye	24	rye	0	0
125	oats	25	oats	0	0
130	sorghum	30	sorghum	0	0
132	millet	32	millet	0	0
134	sugar cane	34	sugar cane	0	0
150	forage permanent	50	forage permanent	0	1
151	forage temporary	51	forage temporary	0	1
180	soft winter wheat	1	winter wheat	1	0
181	durum winter wheat	1	winter wheat	1	0
182	field peas	8	field beans	0	0
185	rice second season	5	rice	0	0

Figure 14: Snapshot of table "Crop" of "Agropheno_Fenqiu_DB" database.

2.3. Fengqiu Weather observations

The Fengqiu Comprehensive Agroecology Experiment Station provides dedicated weather variables that were measured at the site itself including min/max temperature, rainfall and humidity. For the calibration of WOFOST the use of locally measured weather variables should preferred over the use of weather variables interpolated from weather stations in the surroundings. Therefore, the local weather data were processed to comply with the weather data needed by CGSM/WOFOST. Not all variables needed for CGMS/WOFOST are available therefore the complete set of variables was derived from the ERA-INTERIM weather archive that is available for China from the MARSOP3 project. Within this complete set the variables related to temperature, rainfall and humidity were updated from the measured values at Fengiu. This data is provided in a separate file 'Fenqiu_GRID_WEATHER.mdb'.

3. Crop phenology data from 11 counties in northern Anhui province

This dataset of winter wheat phenology were collected from 11 counties in the northern Anhui province (**Fig.1**). The data includes winter wheat growth calendar of the following periods:

- day of planting (DOP)
- day of emergence (DOE)
- day of stop growing
- day of regreening (DOG)
- day of tillering (DOT)
- day of jointing (DOJ)
- day of heading (DOH)
- day of milking (DOm)
- day of maturing (DOM)

Since Day of Anthesis (DOA) was not measured, it was determined by adding 7 days to the heading date. The location and temporal coverage of the data are given in **Table 4**.

Table 4: Description of counties in Anhui province where the winter wheat calendar data are collected.

ID	Location	Province	Latitude	Longitude	Altitude	Time span	Nr of effective years
58015	Dangshan	Anhui	34.26	116.2		2002 - 2012	6
58102	Bozhou	Anhui	33.52	115.46		1992 – 2012	21
58118	Mengcheng	Anhui	33.28	116.53		1992 – 2012	21
58122	Suxian	Anhui	33.63	116.98		1992 – 2012	21
58203	Fuyang	Anhui	32.87	115.73		1992 – 2012	21
58214	Huoqiu	Anhui	32.33	116.28		2002 - 2012	10
58215	Shouxian	Anhui	32.55	116.78		1992 – 2012	21
58222	Fengyang	Anhui	32.87	117.55		1992 – 2012	21
58236	Chuzhou	Anhui	32.3	118.3		1992 – 2012	21
58240	Tianchang	Anhui	32.68	119.02		2002 - 2012	11
58321	Hefei	Anhui	31.87	117.23		1992 – 2012	21

Figure 15 gives the temporal statistics of days for each phenological stages in each county for the period of the collected data. The DOP and DOE showed clear gradient in this region with earlier days in the north and later days in the south (**Fig. 15**). On average, the range of DOP is varying between DOY 283 (belonging to the most northern county Dangshan) and

DOY 297 (belong to the most southern county Hefei) (**Table 4**). The trend in the DOM in this region is not as significant as the DOP and DOE, ranging between 145 and 152. The length of growth (defined as the days between the planting day and the day of maturity) showed decreasing gradient from the north to the south (from 233 days to 208 days) though with some saltation in between (**Fig. 15**).
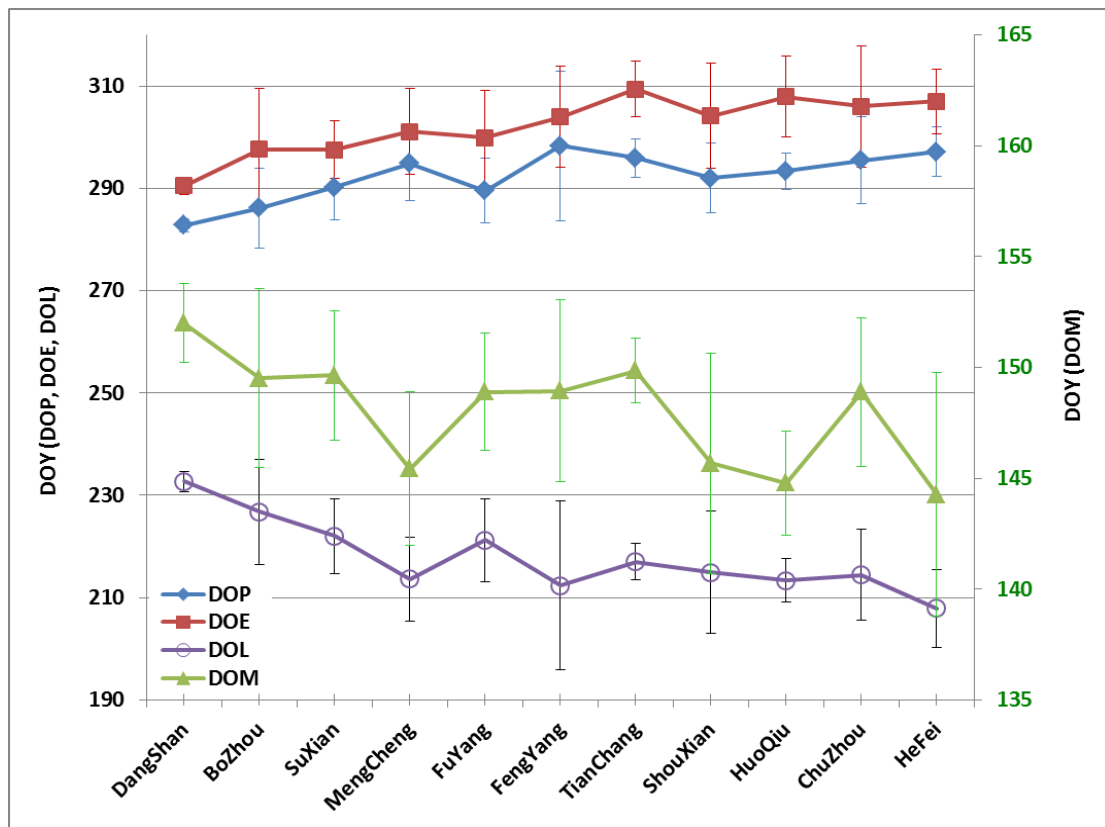
Figure 15: The mean DOP, DOE, DOM and DOL (Days Of growing Length) in each county averaged over the period when data were available. Error bars indicate the standard deviations over the statistic periods.

The "Agrophenology_Anhui_DB" database of CGMS-Anhui was built using the crop calendar data mentioned above. Seven effective data Tables were created in the "Agrophenology_Anhui_DB" as shown in **Table 5**. Detailed contents of each data table are given in the sections followed.

Table 5: List of data Tables in the database "Agrophenology_Anhui_DB" of CGMS-Anhui.

Database content	Table name	Function

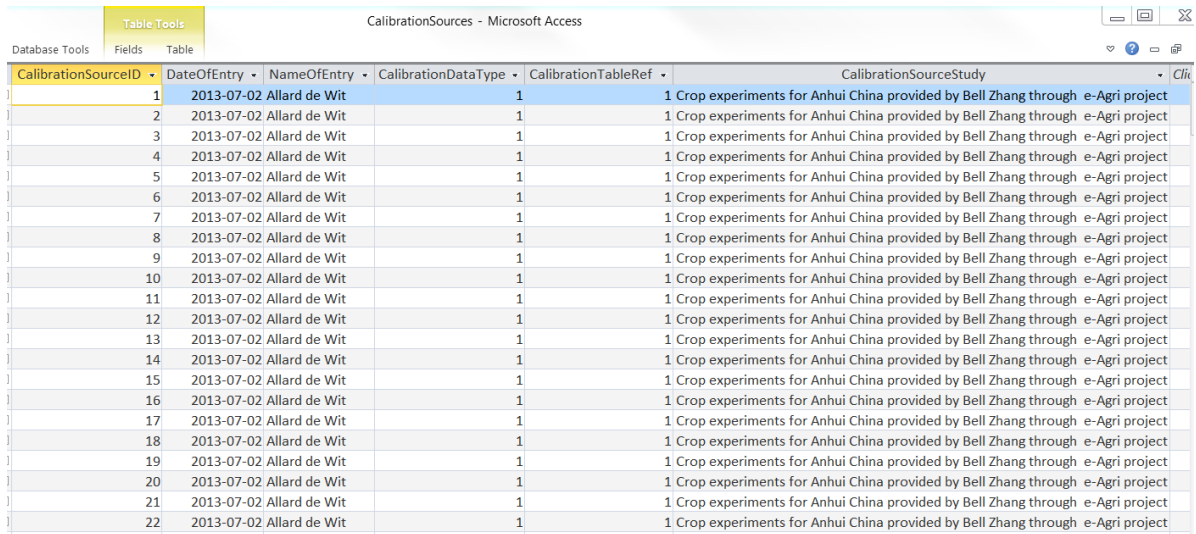|		
	CalibrationSources	listed all the calibration data sources available in the database (See **Fig. 16** for snapshot of the Table). There are 208 sources in total.
	CalibrationSourcesMetadata	the metadata for each calibration source, gives crop type, description, location and some additional information (See **Fig. 17** for snapshot of the Table)
	CalibrationDataType	gives definition for calibration data type, 3 types are defined: 1 = Observations from field experiment 2 = Regional observation 3 = Expert estimate
	CalibrationGridReference	listed the CGMS grid numbers for which a given calibration source is assumed to be valid (See **Fig. 18** for snapshot of the Table). All the 30 sources have the same grid number 89151
	CalibrationSingleValues	actual calibration data that stores single value variables (i.e. crop phenology: DOP, DOE, DOA, DOM) (See **Fig.19** for snapshot of the Table).
	CalibrationTimeSeries	This table is empty since there was no temporal dependent variables were collected.
	ObservationCode	stores observation codes and their descriptions and units (is the same as for Fengqiu database, see **Fig.13** for snapshot of the Table).
	Crop	gives crop type definition (is the same as for Fengqiu database, see **Fig.14** for snapshot of the Table).

3.1. Table CalibrationSources

Data Table "CalibrationSources" contains the information of the data sources available for all calibration datasets listed in columns. Table 6 gives the description of functions of all the columns in this data table. **Fig. 15** shows the snapshot of the table structure of "CalibrationSources". Algorithm defining the "CalibrationSourceID" is given in section 3.2.

Table 6: Structure and description of table "CalibrationSources" of CGMS-Anhui.

Column Title	Description	DataType	Values
CalibrationSourceID	Unique calibration sources ID	Number	1 - 208
DateOfEntry	Date of entry	Date/Time	
NameOfEntry	Name of person who entered the experiment into the database	Text	
CalibrationDataType	Type of calibration data: 1 = Data from field experiments 2 = Regional values 3 = Expert estimate	Number	1
CalibrationTableRef	Indicator in which table to find the data: 1 = CalibrationSingleValue 2 = CalibrationTimeSeries 3 = Both	Number	1
CalibrationSourceStudy	Study from which the data came, e.g. MOCA, Boons-Prins etc.	Text	

Figure 16: Snapshot of table "CalibrationSources" of "Agrophenology_Anhui_DB" database.
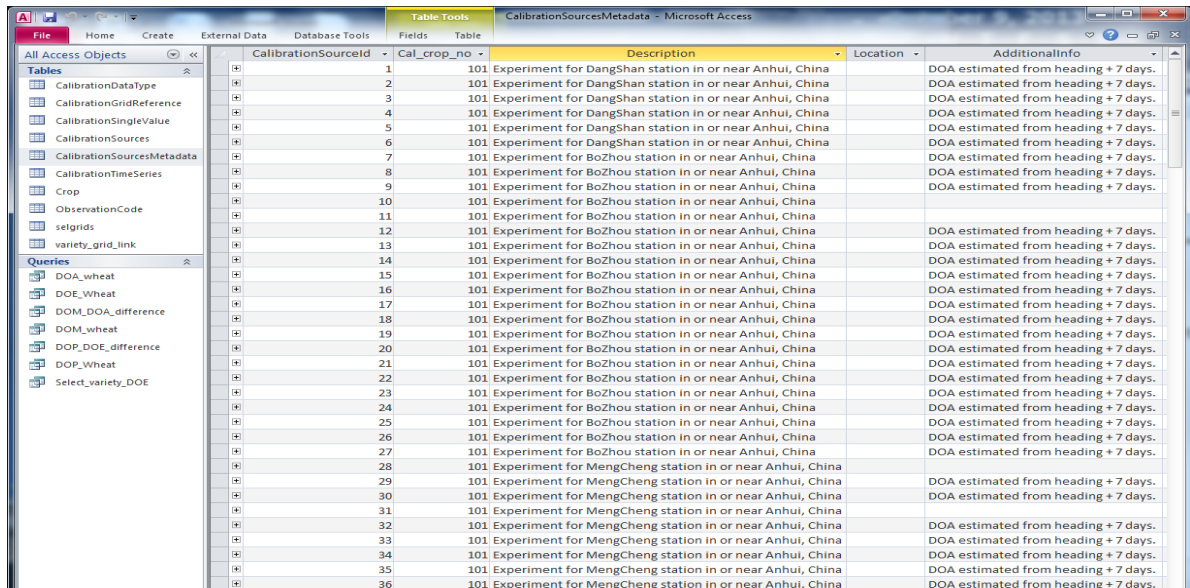
3.2. Table CalibrationSourcesMetadata

The data table 'CalibrationSourcesMetadata' lists all the ancillary data available for a the Anhui CGMS calibration source with the structure shown in Table 7. **Fig. 17** gives the snapshot of the CGMS-Anhui "CalibrationSourcesMetadata".

Table 7: Structure and description of tabel "CalibrationSourcesMetadata" of "Agrophenology_Anhui_DB" database.

Column Title	Description	DataType	Values
CalibrationSourceID	Unique calibration sources ID	Number	1 - 208
Cal_crop_no	CGMS crop number	Number	101
Description	Description of the calibration dataset	Text	
AdditionalInfo	Additional information like growing conditions, crop management, fertilizer application and land and soil characteristics	Memo	

The CalibrationSourceID in Table 7 are corresponding to all the available data from the 11 counties sequenced by the available observation years at each county. For example, "CalibrationSourcesid" 1-6 indicates the sources are from DangShan county with 5 years observations and "CalibrationSourcesid" 7-27 are the sources from BoZhou county with time series of 21 years data, etc. This leads to 208 sources in the column "CalibrationSourcesid".

Figure 17: Snapshot of table "CalibrationSourcesMetadata" of "Agrophenology_Anhui_DB" database.

3.3. Table CalibrationDataType

The table 'CalibrationDataType' lists the types of calibration data sources available in Anhui with three types of data (Table 8):

1. Point observations from field experiments
2. Regional crop calendars
3. Estimates from experts

Table 8: Structure and description of table "CalibrationSourcesMetadata" of "Agrophenology_Anhui_DB" database.
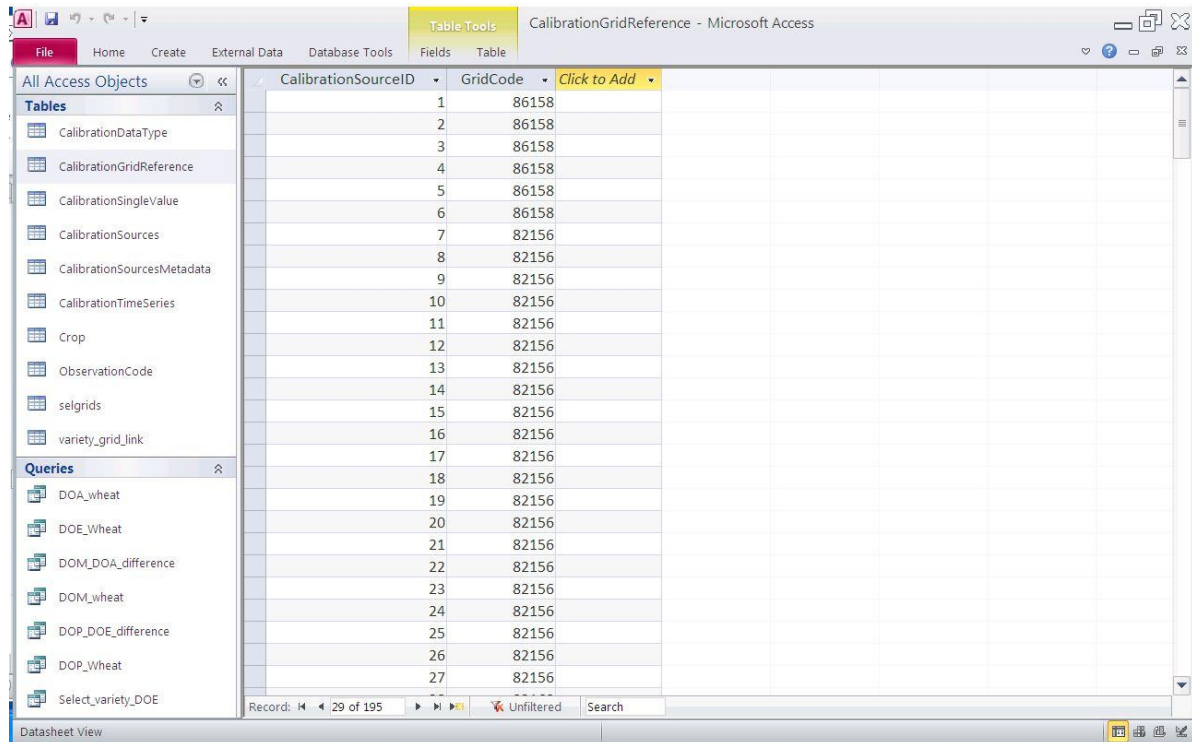
Column Title	Description	DataType	Values
CalibrationDataType	Numeric ID for a specific calibration data type	Number	1,2,3
CalibrationDataType Name	Description of the specific calibration data type: 1. Point observations from field experiments 2. Regional crop calendars 3. Estimates from experts	Text	

3.4. Table CalibrationGridReference

The table 'CalibrationGridReference' lists the CGMS-Anhui grid numbers for which a given calibration source is assumed to be valid with a structure shown in Table 9. **Fig. 18** is the snapshot to illustrate table 'CalibrationGridReference' in the database. In total there are 11 GridCode associated to 11 counties. In the database, CalibrationSourceIDs corresponding to the same county have the same GridCode.

Table 9: Structure and description of table "CalibrationGridReference" of "Agrophenology_Anhui_DB".

Column Title	Description	DataType	Values
CalibrationSourceID	Unique ID of the calibration data source	Number	1 - 208
GridCode	CGMS grid code which is linked with the calibration data, the 11 counties are corresponding to 11 GridCodes: 86158: DahngShan 82156: BoZhou 82160: MengCheng 83161: Suxian 79157: Fuyang 77159: Huoqiu 78161: ShouXian 80164: FengYang 78167: ChuZhou 80169: TianChang 76163: HeFei	Number	
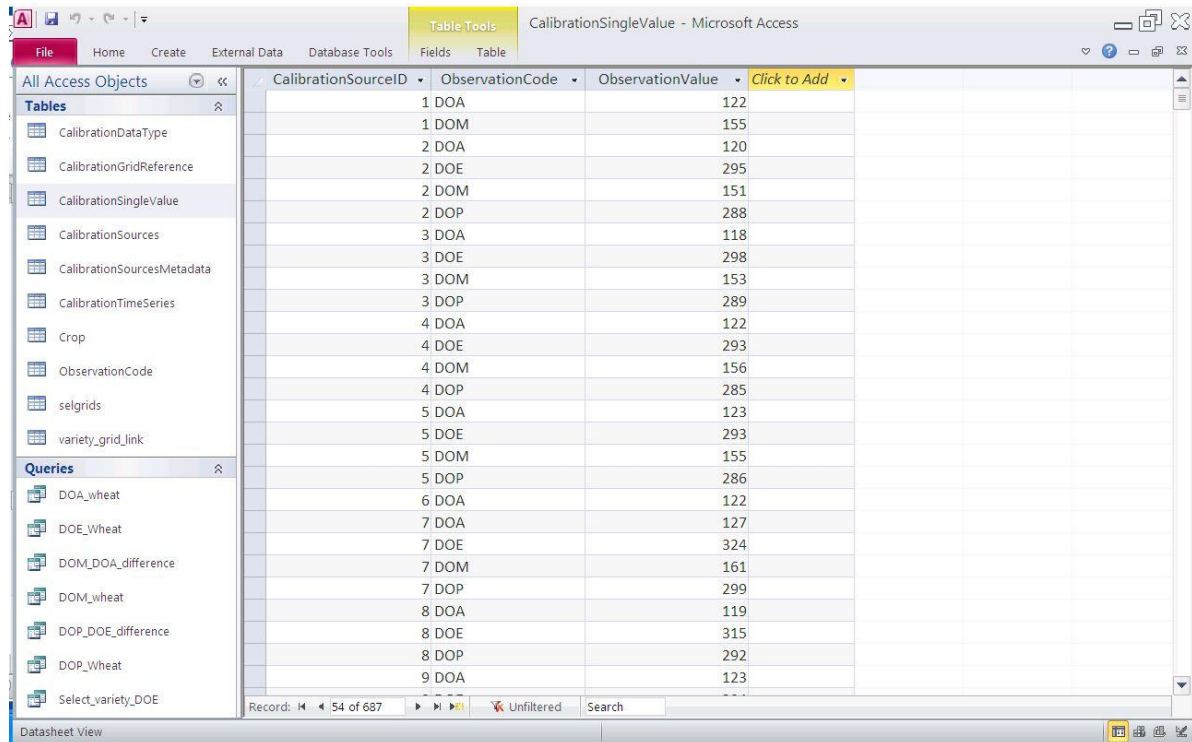
Figure 18: Snapshot of table "CalibrationGridReference" of "Agrophenology_Anhui_DB" database.

3.5. Table CalibrationSingleValues

The table 'CalibrationSingleValue' contains the actual calibration data of crop phenology, i.e. DOP (day of planting), DOE (day of emergence), DOA (day of anthesis) and DOM (day of maturity). Table 10 gives the structure of the table "*CalibrationSingleValues*" and **Fig. 19** illustrate the real database.

Table 10: Structure and description of table "CalibrationSingleValues" of "Agrophenology_Anhui_DB".

Column Title	Description	DataType	Values
CalibrationSourceID	Unique ID of the calibration data source	Number	1 - 208
ObservationCode	Text identifier of the observation type	Text	-
ObservationValue	Value of the observation	Number	observations

Figure 19: Snapshot of table "CalibrationSingleValues" of "Agrophenology_Anhui_DB" database.

3.6. Table ObservationCode

The table 'ObservationCode' stores a predefined set of observation codes with defined units. The table has the following structure as shown in Table 11 and **Fig.13**.

Table 11: Structure and description of table "ObservationCode" of "Agrophenology_Anhui_DB".

Column Title	Description	DataType
ObservationCode	Text identifier of the observations	Text
CodeDescription	Description of the observation code	Text
Unit	Unit of the observation code	Text
Type	S = single value, T = table value	Text

3.7. Table Crop

The table 'Crop' lists the crop types and the linkage to the CGMS crop numbers. The table has the structure given in Table 12. This table has the same content as that for Fengqiu database (**Fig. 14**).

Table 12: Structure and description of table "Crop" of CGMS-Anhui.

Column Title	Description	DataType	Values
Cal_crop_no	CALPLAT Code for type of crop	Number	101
Cal_crop_name	CALPLAT Description of the crop	Text	Winter wheat
Sim_crop_no	CGMS Code for type of crop	Number	
Sim_crop_name	CGMS Description of the crop	Text	
Winter_crop	1 = wintercrop, 0 = no wintercrop	Number	1
Crop_Model	0 = WOFOST, 1 = LINGRA	Number	0

4. Yield statistics data

Yield statistics and cultivated area of winter wheat over 6 regions (district, NUTS Level 1) were collected for the period between 2000 and 2011 (Fig. 20). The 6 regions together with their belonging counties are listed in Table 13 (the 6 NUTS Level 1 regions are highlighted by bold).

Table 13: The six regions and their belonging counties where the winter wheat yield statistics were collected.

NUTS				
NUTS_CODE	**NUTS_NAME**	**NUTS_LEVEL**	**BELONGS_TO**	**BELONGS_TO_NAME**
34	Anhui province	0	2	Lower Yangze
3403	**Bengbu District**	**1**	**34**	**Anhui province**
340301	Bengbu city	2	3403	Bengbu District
340321	Huaishan county	2	3403	Bengbu District
340322	Wuhe county	2	3403	Bengbu District
340323	Guzhen county	2	3403	Bengbu District
3404	**Huainan District**	**1**	**34**	**Anhui province**
340401	Huainan city	2	3404	Huainan District
340421	Fengtai county	2	3404	Huainan District
3406	**Huaibei District**	**1**	**34**	**Anhui province**
340601	Huaibei city	2	3406	Huaibei District
340621	Suixi county	2	3406	Huaibei District
3412	**Fuyang District**	**1**	**34**	**Anhui province**
341201	Fuyang city	2	3412	Fuyang District
341221	Linquan county	2	3412	Fuyang District
341222	Taihe county	2	3412	Fuyang District
341225	Funan county	2	3412	Fuyang District
341226	Yingshang county	2	3412	Fuyang District
341282	Jieshou city	2	3412	Fuyang District
3413	**Suzhou District**	**1**	**34**	**Anhui province**
341301	Suzhou city	2	3413	Suzhou District
341321	Dangshan county	2	3413	Suzhou District
341322	Xiaoxian	2	3413	Suzhou District
341323	Lingbi county	2	3413	Suzhou District
341324	Sixian	2	3413	Suzhou District
3416	**Bozhou District**	**1**	**34**	**Anhui province**
341601	Bozhou city	2	3416	Bozhou District
341621	Guoyang county	2	3416	Bozhou District

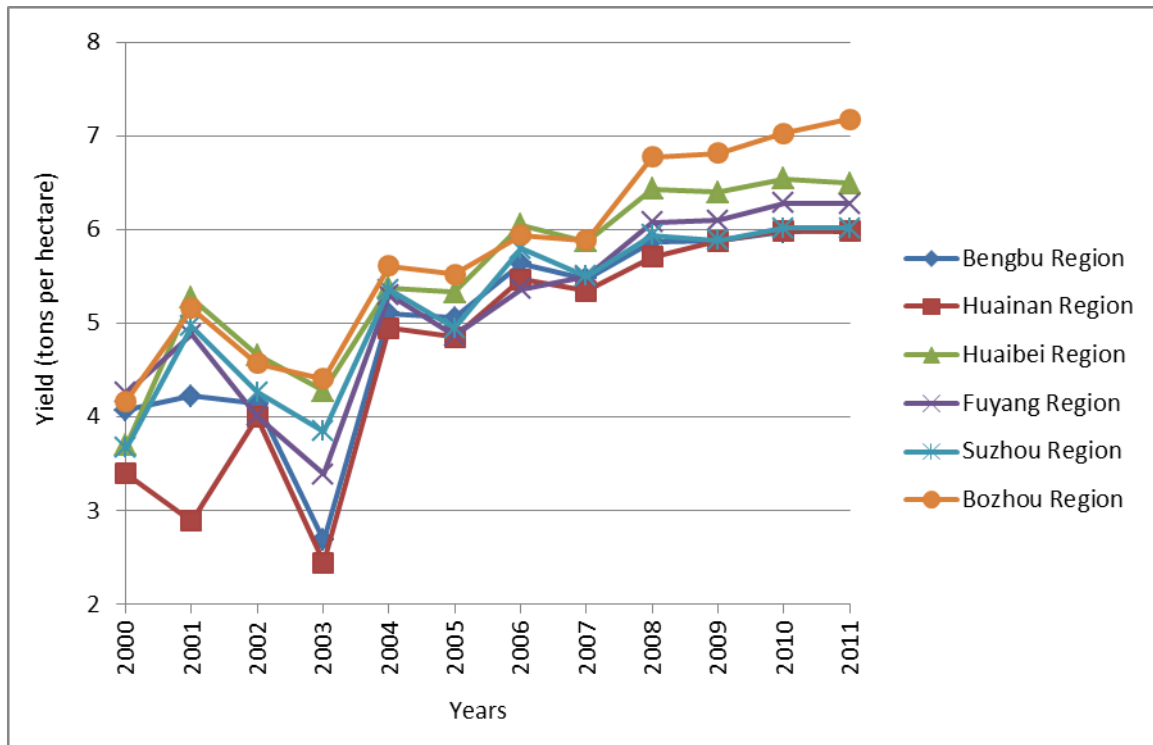| NUTS				
NUTS_CODE	NUTS_NAME	NUTS_LEVEL	BELONGS_TO	BELONGS_TO_NAME
341622	Mengcheng county	2	3416	Bozhou District
341623	Lixin county	2	3416	Bozhou District

Figure 20: Yield statistics over 6 regions in the northern Anhui province between 2000 and 2011.

5. Summary

This report describes the data that was collected by partner AIFER for calibrating the WOFOST model for monitoring winter-wheat in the Huaibei plan. Moreover, it describes the effort from partner Alterra to convert this raw data into a documented format that can be used by the CALPLAT calibration system for CGMS.

Two sources of data were collected by partner AIFER. First of all, a detailed set of agro-experimental data from the Fengqiu site which is just north of Anhui (Henan province). This data set provides detailed observations of winter-wheat which can be used to calibrate parameters of the WOFOST model in a detailed way. Second, phenological observations were collected that are routinely made for 11 weather station locations across northern Anhui. These observations were used to make regional adjustments to WOFOST phenological parameters based on an agro-ecological zonation of Northern Anhui.

These datasets were provided as relatively poorly documented Microsoft excel files and these processed by partner Alterra in order to obtained a structured dataset that is well described and can be interfaced to the calibration tools that were developed for the CGMS calibration platform.

The Fengqiu dataset was analyzed and some of the errors were corrected that were caused by misinterpretations in the translation from Chinese to Latin characters. Moreover, from excel sheet it was not directly evident which records belonged to a single experiment. Therefore a dedicated database was designed in which each experiment can be identified through a single Experiment ID and all data available for this experiment ID can be stored and analyzed (see section 2.1). Based on this dedicated database, a subset of all experiments was selected containing only the experiments with sufficient data quality. This subset was processed into a CALPLAT AgroPheno database (section 2.2) that can be interfaced with the CGMS Calibration Platform for calibrating the WOFOST model inside CGMS.

The phenological observations for the 11 stations in Northern Anhui, consisted of a much simpler structure and could be directly translated into a CALPLAT AgroPhenological database for regional calibration of WOFOST/CGMS (See section 3).

Finally, regional statistical data were already collected at the start of the E-Agri, but this data are current being updated by AIFER to include more recent and historic years. Moreover it was found that there was a mismatch between the regional subdivision that was used in CGMS-Anhui versus the regional statistical data. See table 13 for the latest codes and regional subdivision of Northern Anhui that is currently in use by the Chinese Statistical system.