DROUGHT MONITORING AND PREDICTION OVER CHINA

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ABSTRACT

The objective of the Dragon Drought monitoring and prediction project was to develop the understanding for an operational system for nation wide drought monitoring and drought impact assessment for application in agriculture and hydrology in China using ESA and other relevant satellite data as major data source in combination with other data source (e.g. meteorological and drought statistics, etc.). In detail the project generated: (1) scientifically based drought monitoring methodologies and experimental datasets, (2) improved understanding of land surface processes over heterogeneous terrain, (3) algorithms for estimation of land surface parameters and heat fluxes over China, (4) evaporation and real time drought monitoring and prediction maps, and (5) training of students and young scientists for the use of advanced earth observation satellite data in applications related to drought monitoring and prediction.

1. INTRODUCTION

The conflict between supply and demand of water resources constitutes the biggest problem for food security of a huge population in China. The distribution of water resources in China is strongly heterogeneous both in time and space. For instance, to the north of the Yangtze river, the population is 46.5% of the total, with 43% farm land, but the available water resources is only 9.8% of the national total. In the mid north, the population is 11.8% with 13.7% farm land, the amount of water resources is only 1.8% of the national total. Due to the shortage of water

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resources and its inhomogeneous distribution in space and time, large scale droughts occur frequently in China, with a big drought disaster every two years. Since 1949, average annual areas affected by drought disaster amounts 303 million mu (or 20.2 million hectares) and accounts 59.3% of areas of weather/climate induced disasters according the Ministry of Water resources. In 1959, 1960, 1961, 1978, and 2000, the areas affected by droughts are all above 33.3 million hectares and the annual average loss of grains due to drought amounts above 10 billion kilogram. Around 20 provinces are affected annually. Consequently, drought has become a key factor constraining China's economic development. In the 21st century, the Chinese population will reach 1.6 billion, food security will be a major issue which demands a proper solution of drought problem.

Since 1970's, some progresses have been made in drought quantification and research. However, the methods employed are mostly based on data collected on local meteorological variables and can not quantify real time, large scale actual drought process – i.e. its starting and ending time and its actual extent and severity. It has also often happened that a drought is not recognized while it is in fact already underway of its development. As a result of this inability, no adequate measure can be deployed to effectively fight any big drought disaster often causing great hunger and social instability. The "Agriculture Action Plan for China's Agenda 21" issued by the Ministry of Agriculture in 1998 called for China's sustainable agricultural development, with the following specific needs: (1) collection and assessment of information on crops; (2) survey and monitoring of agricultural and ecological resources; (3) assessment of the influence of severe natural disasters to agriculture and (4) development of precision agriculture. The current project directly contributes to the needs as formulated above and beyond. The objective of this project was to develop an operational system for nation wide drought monitoring and drought impact assessment for application in agriculture and hydrology. In the following sections, we will first describe the methodologies developed, followed by data and field experiments as contributions to this project, the results obtained so far and a outlook into the future.

2. METHODOLOGIES

In the development of methodologies for drought monitoring and prediction, emphasis was given to the understanding of the underlying physical processes and the necessary data and information for the quantification of the severity and extent of droughts as a physical phenomenon. We started with a simple question as indicated in Fig. 1, namely what is the difference of the two ecosystems?

Figure 1. Two contrasting ecosystems in the Heihe River Basin in Northwest China

Obviously the availability of water was the cause to the life and dead states of the two ecosystems. In order to answer precisely the above question, it was necessary to quantify the available water content in the rooting zone. As such scientifically based drought monitoring methodologies were proposed as a quantitative measure of the drought situation and two approaches were identified. Fig. 2 presents a sketch of the above strategy.

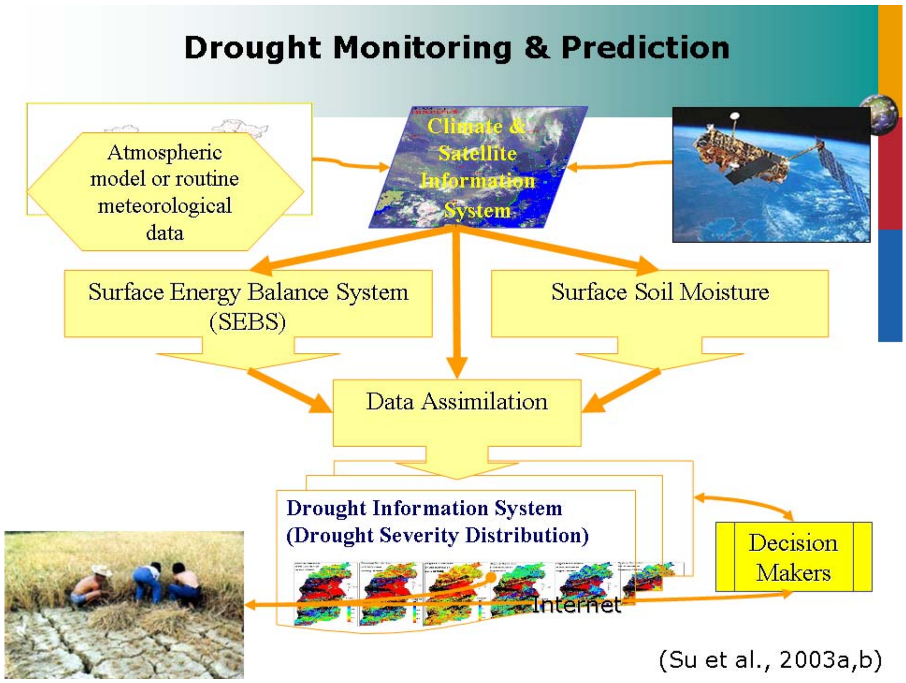

Figure 2. Strategy for drought monitoring and prediction

Approach 1: Surface Energy Balance. This approach starts with the derivation of relative evaporation and relates it to relative soil moisture in the root zone from land surface energy balance. After which a quantitative drought severity index (DSI) is defined for large scale drought monitoring [1,2]. The advantage of such an approach is the direct quantification of the water availability to the vegetation and comparison in space and time are made available.

Approach 2: Soil Moisture Retrieval. This approach starts with the direct determination of surface soil determine surface soil moisture using active microwave observations [3,4,5]. Subsequently this information needs to be assimilated into a land surface hydrological model to derive root zone soil moisture. This is because that microwave observation does not provide the necessary information for the whole rooting zone but rather the surface or near surface information. The advantage of this approach is that it is not influenced by cloud cover.

To validate the methodologies large scale field experiments were conducted as described in the following.

3. FIELD EXPERIMENTS

Various field campaigns were organized, including campaigns for algorithms development and validation (SPARC2004, SEN2FELX2005, CAMP/Tibet, LOPEX2005) and other dedicated comprehensive field experiments were conduced in the summer 2006 (EAGLE2006, Tibetan soil moisture experiment 2006, field expedition to the Heihe river basin in 2006) [6-8].

Various ESA and third party mission earth observation data were acquired and investigated including MERIS, AATSR and ASAR data over different sites in Europe and China and some data processing were reported elsewhere [7-10]. An overview of the experimental sites in China is given in Fig. 3, while Fig. 4 presents the setup of the comprehensive EAGLE2006 campaign for algorithm validation. Fig. 5 shows some soil moisture sensors installed on the Tibetan plateau.

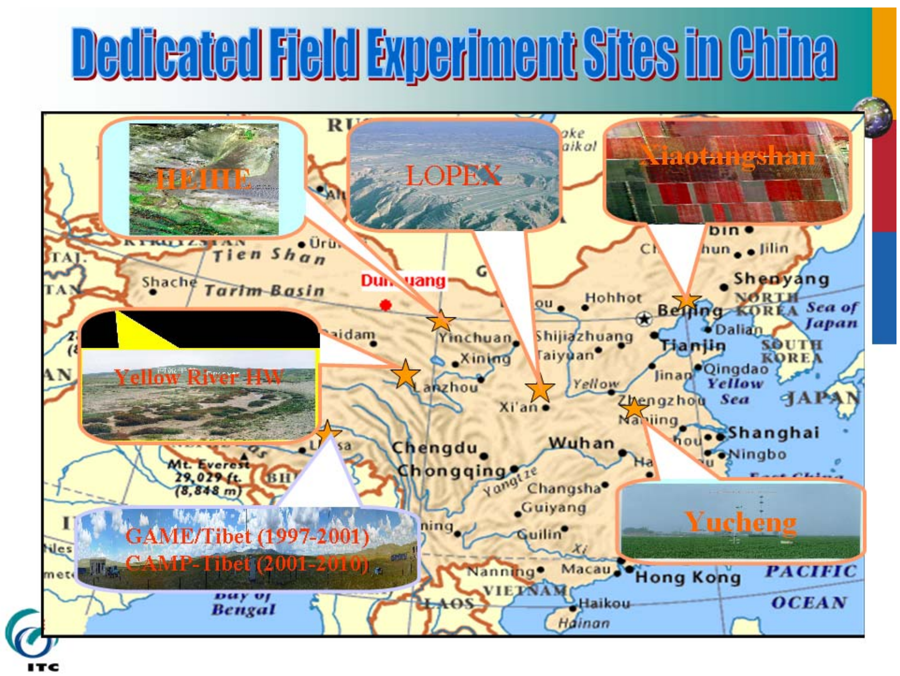

Figure 3. An overview of the experimental sites in Chinain the Dragon drought project

Figure 4. Overview of the EAGLE2006 experimental sites in the Netherlands – Cabauw, Loobos and Speulderbos towers.

Figure 5. Soil moisture sensors installed at the BJ-Site in Naqu on the Tibetan plateau

3. RESUTLS

The achieved results include (1) improved understanding of land surface processes over heterogeneous terrain, (2) algorithms for estimation of land surface parameters and heat fluxes over China, (3) evaporation and real time drought monitoring and prediction maps, and (4) training of students and young scientists for the use of advanced earth observation satellite data in applications related to drought monitoring and prediction. In particular, the following specific results were obtained.

1. A new campaign data set was collected during EAGLE2006 where multi-sensor satellite data (MERIS, AATSR, ASAR, ASTER, MODIS, CHRIS/PROBA, SEVIRI) have been collected [6].
2. Data over several test sites in China have been continuously acquired and analyzed [7, 8].
3. Preliminary data assimilation using a mesoscale atmospheric data has started and is ongoing [8].
4. A case study was conducted to estimate evapotranspiration for the entire Heihe River basin using MODIS data was completed [9, 10].
5. An operational land data assimilation system for drought monitoring and prediction is under construction that will be capable to assimilate land surface states, surface energy balance fluxes and land surface soil moisture. Some simulation examples over China are shown in Figs. 6-7.
6. Several visits took place to China by ITC scientists for field experiments and data analysis. Two MSc students were trained using Dragon datasets and methodologies. ITC has accepted three Chinese Dragon participants as a sandwich PhD candidates (Xin Tian, Yijian Zeng, & Lei Zhong).

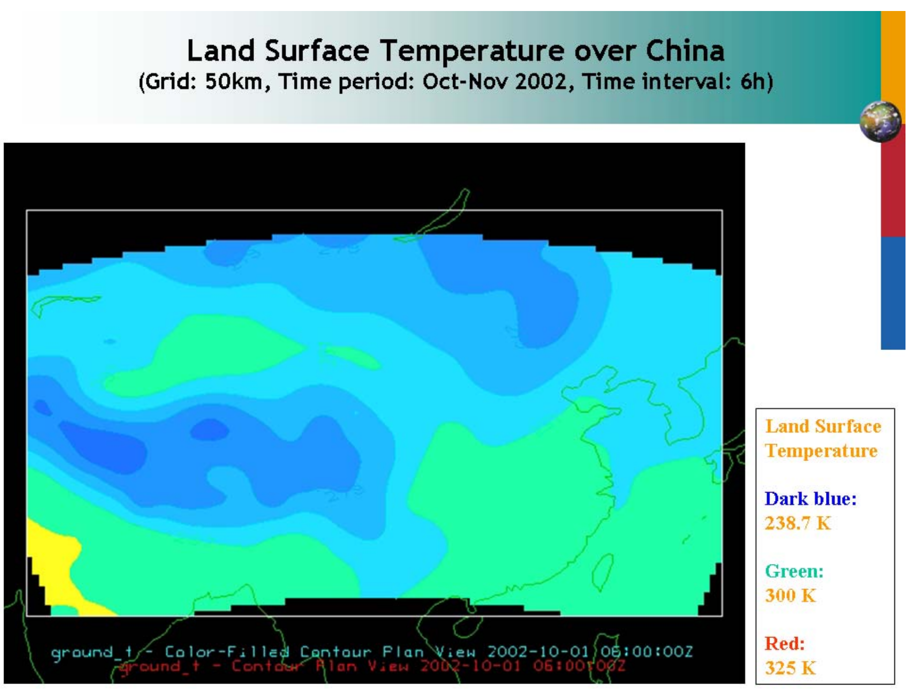

Figure 6. Simulation examples for land surface temperature over China

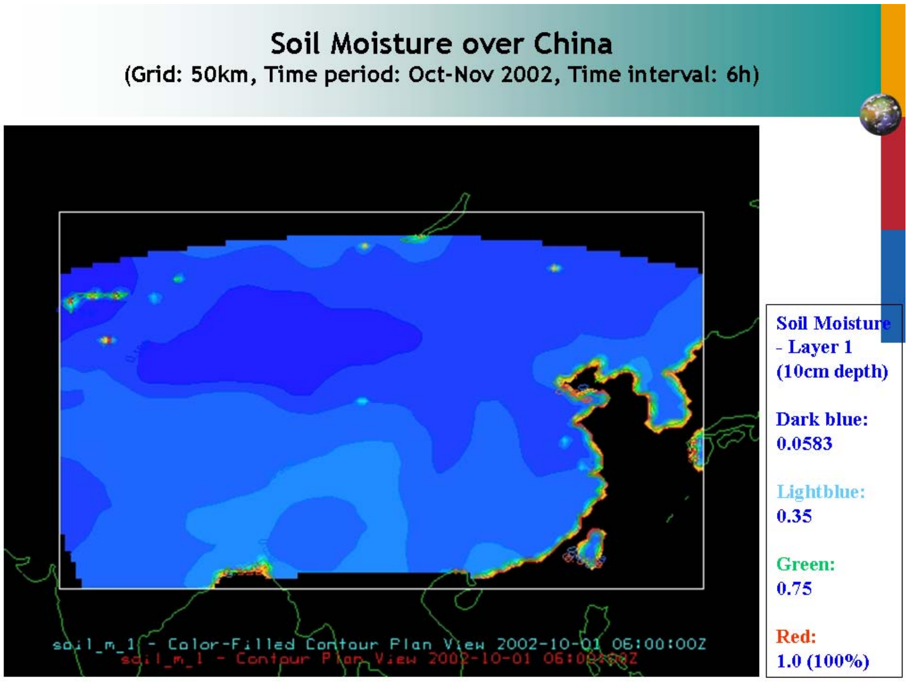

Figure 7. Simulation examples for land surface soil moisture over China

4. OUTLOOK

The progress and achievements in this project has been very substantial and should be continued in Dragon II. In particular, the scientific results should be further utilized and deployed in operational processing chain, training of technical personnel, reporting. A web based information drought monitoring system, Operational data processing, validation of data products, consultation with end users could now be established and should be used in operation. Future collaboration should be extended to other major Chinese partners in the field of Earth Observation and Water Cycle research and applications.

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