NEAR REAL-TIME DECISION SUPPORT SYSTEM FOR DROUGHT MONITORING AND IMPACT ASSESSMENT ON RICE IN UBOON RATCHATHANI, NORTHEASTERN THAILAND

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ABSTRACT

Food security becomes one of the worldwide long-term goals. However, recurring and cumulative damage from drought has worsened dramatically the yield production in many regions. The development of strategies for enhanced and effective drought management is recognized as a challenge by the government or at national level. In Thailand, drought has caused bad effect to many economics crops especially rice production in Northeastern region. It is crucial to have a good decision support system for assisting the authorized people to understand and handle the situation properly. Towards a decision support system, an efficient drought monitoring system for rice cultivation is firstly needed.

In this paper, our developed network stations of real-time weather and soil moisture observations were presented as well as some preliminary analyzed results. We installed 2 weather stations at our test sites - rainfed rice fields in Trakan Phutphon and Det Udom districts, Ubon Ratchathani Province, Northeastern Thailand. Both stations have real-time communication systems and accessible via internet. An Agro-hydrological model called SWAP-RS-GA (Soil Water Atmosphere and Plant-Remote Sensing-Genetic Algorithm) is processed to get the simulated values of evapotranspiration, soil moisture, leaf area index and so on. The simulated parameters are very useful basis to study in other areas when ground data is not available. The simulated results are however, should be validated before further use. The observed and derived data from our stations is a good reference for validation.

INTRODUCTION

The cumulative damage from drought has worsened dramatically the yield production of rainfed crop in Northeastern Thailand, especially in dry season and growing season. Drought evidently has caused not only a negative impact in the yields of the major crops, including rice, cassava, maize, sugarcane and sorghum but forced also some household members to find new careers out of the villages.

The scope of drought monitoring and drought impact assessment of this study is limited on agricultural sector; rice cropping which significantly affected by droughts. The targeted area is Ubon Ratchathani, one of the provinces in Northeast region which has agricultural damaged and affected by drought for many years (DPMP, 2006).
A developing method is based on the capabilities of remote sensing (RS) in near real time monitoring and agro-hydrological crop simulation called SEBAL (Surface Energy Balance Algorithm for Land) and SWAP-RS-GA (Soil Water Atmosphere Plant – Remote Sensing-Genetic Algorithm). In 1998, SEBAL (Surface Energy Balance Algorithm for Land) was developed by Bastiaansen to estimate surface energy fluxes and actual evapotranspiration from remotely sensed data (Ines et.,al 2006). Although the model can be used to estimate the important factor in drought assessment in agricultural field, it works well only cloud free day, the limitation of satellites which observes land surface in Visible-Infrared wavelengths. This limitation is faded when using high temporal resolution images like NOAA, MODIS and SPOT VEGETATION, with daily acquisitions it has high possibility to get cloud free data of the targeted area during wet season. High temporal resolution images are very useful for various applications including drought monitoring in the area that has frequent cloud cover all year-round as Southeast Asia (Sawada, 2001).

The outputs from the models are potential and actual evapotranspiration (ETp and ETa), leaf area index (LAI), soil moisture and yield. These simulated parameters will be validated with field observation instruments.

OBJECTIVES

To develop a near real-time drought monitoring system and impact estimation on rice cropping in Ubon Ratchathani Province by using remote sensing and agro-hydrological crop models. This target is breaking down as listed below.

2.1 To create near real time potential evapotranspiration (ETp), actual evapotranspiration (ETa) for drought study using remote sensing.

2.2 To estimate parameters of agro-hydrological crop model using a SWAP-GA-RS method to simulate the impact of drought on soil moisture and on rice crop growth.

STUDY AREA

Two weather stations were set up in Ubon Ratchathani province, Northeastern region of Thailand. One station locates in Trakan Phutphon district (15° 42’ 22” N  105° 00’ 21” E), the upper part of Ubon ratcathani and another station sits in Det Udom district, the lower part of Ubon Ratchathani province (see Fig. 1).
Rainfed rice cropping is the major activity in Ubon Ratchathani province while upland field crops, forest and grazing also exist. With the reliance on irregular rainfall, rainfed rice cropping normally starts in May-August and harvested in October-January. After harvesting, farmer in the study area always leave the field fallow because of drought or limitation of irrigation system.

**STUDY FRAME WORK**

In our development, sensors and equipments for meteorological and soil moisture measurements are installed in 2 districts – Trakan Phutphon and Det Údom, Ubon Ratchathani Province as near real-time communication systems and accessible via internet. The instruments used at the meteorological stations in both study areas are shown in Fig. 2.

**Lists of observation instruments:**
1. Davis Weather Station
2. Bowen Ratio Instrument (2m, 10m)
3. IP Star (Fix IP)
4. Net Radiometer (2.5 m)
5. Wind speed (2 m, 10 m) and Wind direction (2 m) and + Rain gauge 2 m and 10m
6. Control Box
7. Soil moisture sensors (At 3cm, 12cm, 28cm and 60cm - depth)
8. Sensirion sensors (2 m, 10 m)
9. 3-D Sonic Anemometer - Campbell Scientific’s model CSAT3 (belong to our external collaborator)

**Soil moisture sensors**
at 3 cm, 12 cm, 28 cm and 60 cm depths.

Fig.2 Observation System and Configuration

Fig.3 shows the continuous observation from Terra/MODIS (Moderate Resolution Imaging Spectroradiometer) satellite and meteorological data of the study area, which are applied for model development. The proposed SWAP-GA-RS method is based on data assimilation. It estimates most reasonable model parameters which can be used to explain the crop dynamics observed by RS. A SWAP model simulated the dynamics of the agricultural land uses, the sowing dates and area fractions in the pixel. In addition, a modified micro-Genetic Algorithm (µGA) helps solve the mixed-pixel model using generated RS data (Chemin and Honda, 2006). The estimation of parameters is still possible, even though most of the crop model parameter cannot be seen from RS directly (Chemin et al., 2005).

The important outputs from the model development are ET, LAI, soil moisture and yield. The validation of these outputs will be carried on by using field observation data, the simulated ET will be validated with calculated ET from Bowen Ratio method and calculated ET from
Penman Monteith method, simulated soil moisture will be validated with soil moisture sensors, LAI will be validated with LAI meter and the estimated yield will be compared with the recorded yield of the study area. The simulated ET, LAI, soil moisture and estimated yield are very useful for drought early warning and impact assessment.

**Fig. 3 Study Frame Work**

**Preliminary Results**

The preliminary simulated results of actual evapotranspiration (ETa), LAI and soil moisture of the test site in Trakan Phutphon District are presented in this paper. The focused period is a Year 2007.

**Fig. 4. Actual evapotranspiration (ETa) from MODIS.**
Fig. 4 shows the extracted ETa from MODIS in 2006-2007. From Satellite, ETa of rice in Trakan Phutphon has raised up to 6 mm/day in cropping season while the calculated Penman-Monteith ETa and Bowen Ratio ETa are raised up around 5 mm/day. Therefore, the combination of model calibration is necessary to acquire more reliable estimation of ETa.

Fig. 5 SWAP LAI and Satellite (MODIS)

Fig. 5 shows a good agreement between the simulated LAI from SWAP model and Satellite LAI from MODIS time series. The simulated LAI shows high potential that are suitable for substitution when the satellite data is not available. Although field LAI has higher values than others but the fluctuation trend is matched with satellite LAI. More observation is necessary to get the reliable conclusion between different sources of LAI. The validation of these LAI is not yet to be finalized at this step.

Fig. 6 Comparisons of Soil Moisture Simulation and Observation

Fig. 6 shows the comparison of simulated soil moisture profiles from SWAP model with the readings of soil moisture sensors at various depths; 3 cm, 12 cm, 28 cm and 60 cm. During the observation and simulation from 1st – 20th April 2007, there was heavy rain on 14th around 22.00-24.00 hours. At 3 cm and 12 cm, soil moisture sensors and simulated soil moisture showed good response with rainfall while almost no response to rainfall appeared at 28 cm depth, gravel mixed layer. At 60 cm, the sensor and simulation show very less and slow response to rainfall, soil moisture moved up after 2-3 days of raining.
DISCUSSIONS

LAI from MODIS satellite and calculated ETa from SEBAL are available only in a cloud free day, no data or less reliable data can be derived in the cloudy day. For the missing period, the combination with model calibration generates more reliable estimation.

The simulated soil moisture from SWAP showed good matching with the profiles of soil moisture sensors at 12, 28 and 60cm. The simulation data at 3 cm is not coinciding with the reading from soil moisture sensor, more detail tuning of assimilation process is highly recommended. The soil moisture profiles from the sensors at 3 cm and 12 cm has responded to the rainfall slower than the simulated soil moisture because SWAP is more concern about the total amount of daily rainfall, not timing of the moisture movement in soil layers.

The simulated ET, LAI and soil moisture are very useful in monitoring near real time water stress in wide area and also help predict yield in next step. Not only monitoring the related parameters, the impact to yield will also be assessed. The outcomes of this study will be a good basis for undertaking drought disaster preparedness and mitigation activities at provincial level. Drought concerned agencies in Ubon Ratchathani province such as Agriculture Regional office, Local Administrators: CEO, Disaster Prevention and Mitigation Regional office (Land Development Regional offices, and Irrigation Regional office) could use the simulated and estimated information from this study to support their decision in handling the situation and mitigate the drought impact from agricultural sector.

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