Seasonal variations in surface moisture status over east China by AVHRR

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Abstract
To identify the boarder of "wet" and "dry" in the surface moisture status (SMS), we applied the relationship Normalized Difference Vegetation Index (NDVI) and surface temperature (Ts), so-called VI/Ts method or TVX over the east China by AVHRR dataset. AVHRR dataset received by CEReS we used. After procedure about AVHRR imageries (wide-swath cut, solar angle correction and cloud screening), we adopted simple VI/Ts method (only estimation of the regression line within a window matrix of 10pixels by 10 lines). Preliminary results could be summarized as follows. Slope performed well for represent the SMS even though the simple estimation (only estimate regression line). Inter-annual variability also seems to be detectable in this methodology (wet and dry boarder was steeper in 1998 in September). However, internal phenomenon was not deeply understood, so overall analysis would be required (analysis of reanalysis dataset, and so on).

1. Introduction

For better understanding of land surface processes over a regional scale, fully utilization of satellite remote sensing dataset is essential. Particularly, surface moisture status (wet or dry; SMS) directly affected on the partitioning available energy at land surface into the sensible (heat) and the latent (water) heat fluxes into the atmosphere. Algorithms or methodologies for estimation of surface moisture by satellite data have been developed using optical and/or microwave imagers. In this article, we focus on the methodology based on the relationship between Normalized Difference Vegetation Index (NDVI) and surface temperature (Ts: so-called VI/Ts method or TVX, hereafter VI/Ts method). Nemani and Running (1989) was demonstrated firstly this relationship, after that many articles or reports have been represented the variability and/or utilizations of VI/Ts method (e.g., Nemani *et al.*, 1993; Kondoh *et al.*, 1998, Nishida *et al.*, 2002; Higuchi *et al.*, 2004). We applied VI/Ts method over east China and try to understand;

a. Is this possible to apply VI/Ts method into relatively wet region? In the drying period, Kondoh *et al.*, already applied and proofed the variability of VI/Ts method. However whole of a year, especially "Meiyu (rainy season in China)" is not yet.
b. Interannual variability is detectable or not using this methodology? In 1998, over the Yangi River had damaged by big floods, other hands in 1999 was not. Shinoda and Uyeda (2002) mentioned that paddy field (wet land) played important role on the developing deep convection due to supplying water vapor into the atmosphere by high spatial resolution's two dimensional model. So the boarder of "wet" and "dry" is important information not only hydrologists or hydrometeorologists but also meso-scale meteorologists.

2. Data processing

We used CEReS received AVHRR dataset (hereafter CEReS AVHRR) during 1998-2000. We procedure all dataset preparations and cloud screening as follows:

2.1. AVHRR preparations

CEReS AVHRR is consists of ten channels (original five AVHRR channels [already converted physical data: i.e., AVHRR Aledo for ch.1 & 2; brightness temperature for ch.3 to 5], NDVI, solar azimuth angle, scan angle, sea surface temperature [SST] and solar zenith angle). We processed the dataset especially ch.1 & 2 as follows:

a). Cut a part of image whose more than 40 degrees data in scan angle (due to the wide-swath of AVHRR)
b). Solar zenith angle correction: simply divided as cosine of solar zenith angle.

Atmospheric correction and sensor degradation correction were conducted in this analysis.

2.2. Cloud screening

Cloud screening is important process to detect "real" land surface status from optical sensors. Many cloud-screening schemes are available for AVHRR, we adopted the cloud screening thresholds noticed in White *et al.* (2002) as follows: 1. Ch.1 reflectance (AVHRR Aledo) above 35% and ch.4 less than 288 K (15 °C). We used stricter threshold in ch.1 as above 20%. 2. Simple ratio (ch.2 / ch.1) less than 1.2. 3. Difference between ch.4 and ch.5 less than –1.5K and greater than 4.5K and 4. difference between ch.3

and ch.4 greater than 15 K. **Figure 1** shows an example of original ch.2 image and after the procedure of cloud screening by above thresholds. Cloud screening look like works well. After cloud screening, we estimated NDVI obtained from ch.1 and ch.2, and surface temperature derived from split-window technique by McMillin and Crossby (1984) using ch.3, ch.4 and ch.5.

2.3. Estimate "slope" within a window (TVX matrix)

After the procedure of cloud screening, we estimated the "slope" within a scatter diagram of NDVI with Ts (window). Previous studies used some algorithms for the screening of low-NDVI data or the estimation of "always negative" value in slope (e.g., Nemani *et al.*, 1993; Kondoh *et al.*, 1998). This analysis, our target is to detect the boarder of wet and dry, so spatial information would be required. A window we selected is 10pixels by 10lines (i.e., spatial resolution is approximately 10km both in latitude and longitude). Due to the shortness (in maximum 100 pixels-data available) for the determination of slope (regression line), we simply estimated the regression line without some screening automatically. Thus, both negative (most of VI/Ts studies focus on) and positive value (Higuchi et al., 2004, mentioned about the reasons why estimate positive values in the whole of monsoon Asia) could be obtained.

3. Results and discussion

Figures 2 to **4** represent the spatial distribution of slope in "Meiyu (June, **Figure 2**)", after Meiyu (July, **Figure 3**) and dry period (September, **Figure 4**) in 1998 (flood in Yangi River) and 1999 (normal year). As general features in both 1998 and 1999, slope seems to be detectable the SMS, and performed well about seasonal march of wetness (northward migration of wet part due to the activities of Meiyu fronts by comparisons of **Figures 2** and **3**; expansion of "dry part" due to strong sunshine; compare **Figures 3** with **Figure 4**). The boarder of "wet" and "dry", around –20 in slope, were found in Figures. Inter-annual variability also can see in **Figure 4**. Latitudinal gradient was steep in 1998 (steep positive value from Yangi River to near of Heihe River) but in 1999, not confirm such definite gradient. Steep "positive" slope means that "surface temperature increase with NDVI", in a sense of energy budget over the vegetated cover, this phenomenon cannot explain. The mean NDVI around this steep positive slope area, was very small (ranged with 0.2 to 0.3, Figure not shown), this small values in NDVI maybe lead the estimation instability of slope, however similar mean NDVI also confirmed in normal negative slope region near of Peking (38N 117E). We expected that this positive slope represented the damaged region by flood, as an evidence, Ts value around this positive slope value region was less than 300K (most of this image reached more than 305K, also Figure not shown).

4. Concluding remarks

We have to see carefully each processed images for identify that "what happen over this area". Additionally to deepen our knowledge, especially interaction between land and the atmosphere have to be focused. Fortunately GAME reanalysis dataset provide fine both in spatial and time resolution in 1998, as a future study, one-by-one relationship detection between reanalysis data and satellite datasets.

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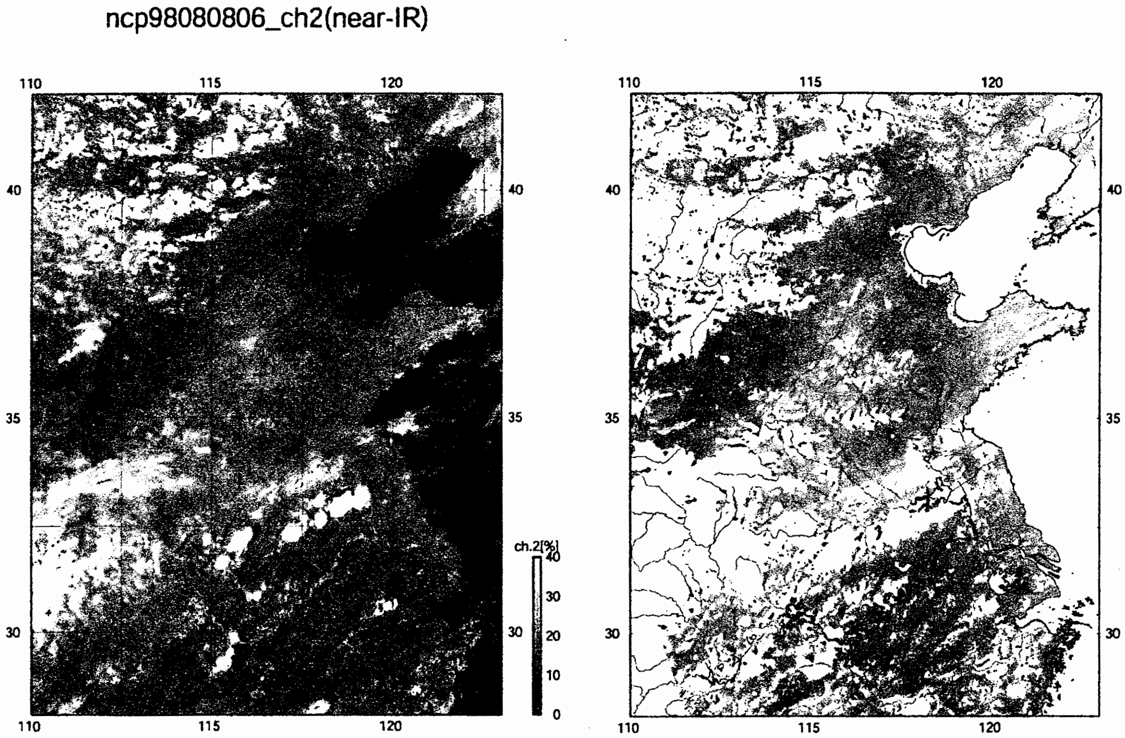

Figure 1: Original ch.2 CEReS AVHRR (left) and after cloud screening (right).

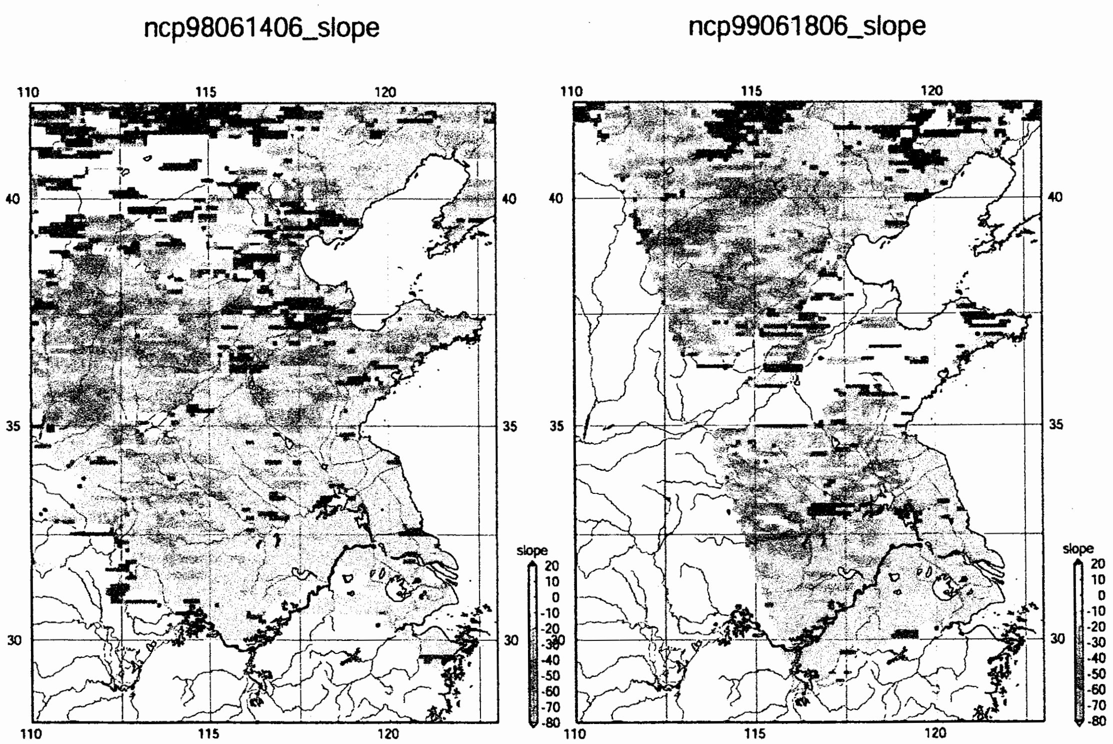

Figure 2: Estimated "slope" during "Meiyu" season (middle June), in 1998 (left: June 14, 1998), and in 1999 (right: June 18, 1999).

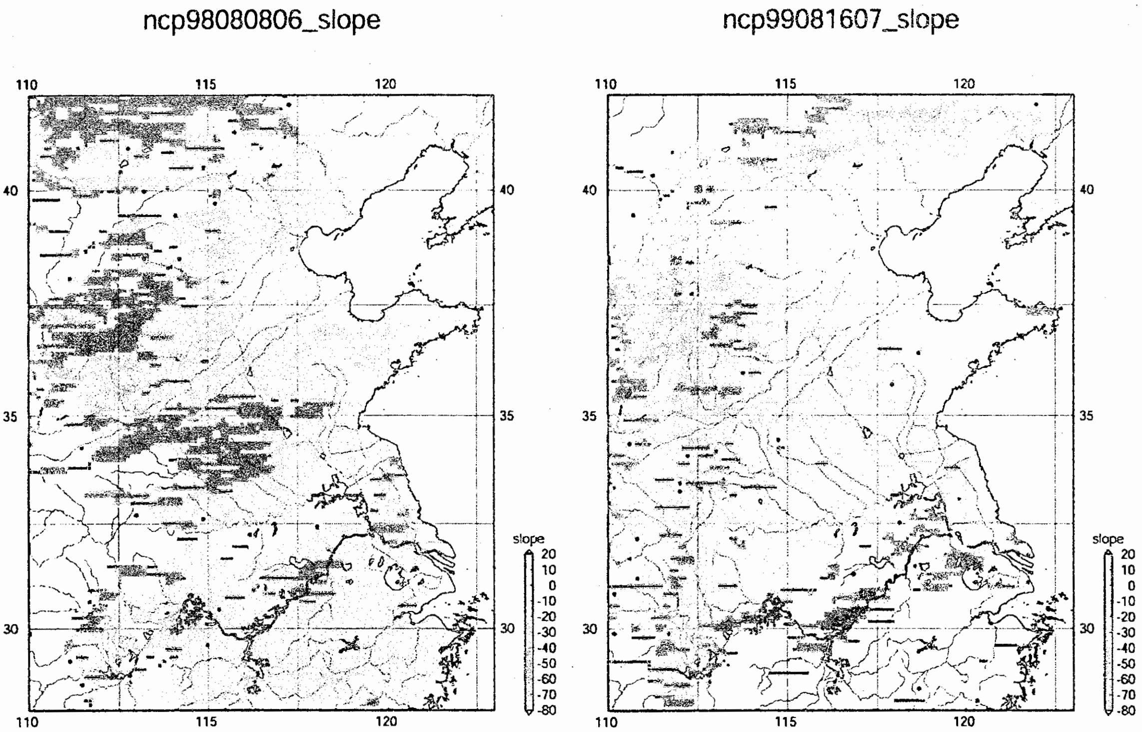

Figure 3: Estimated slope after Meiyu season (August), in 1998 (left: August 08, 1998), and in 1999 (right: August 16, 1999).

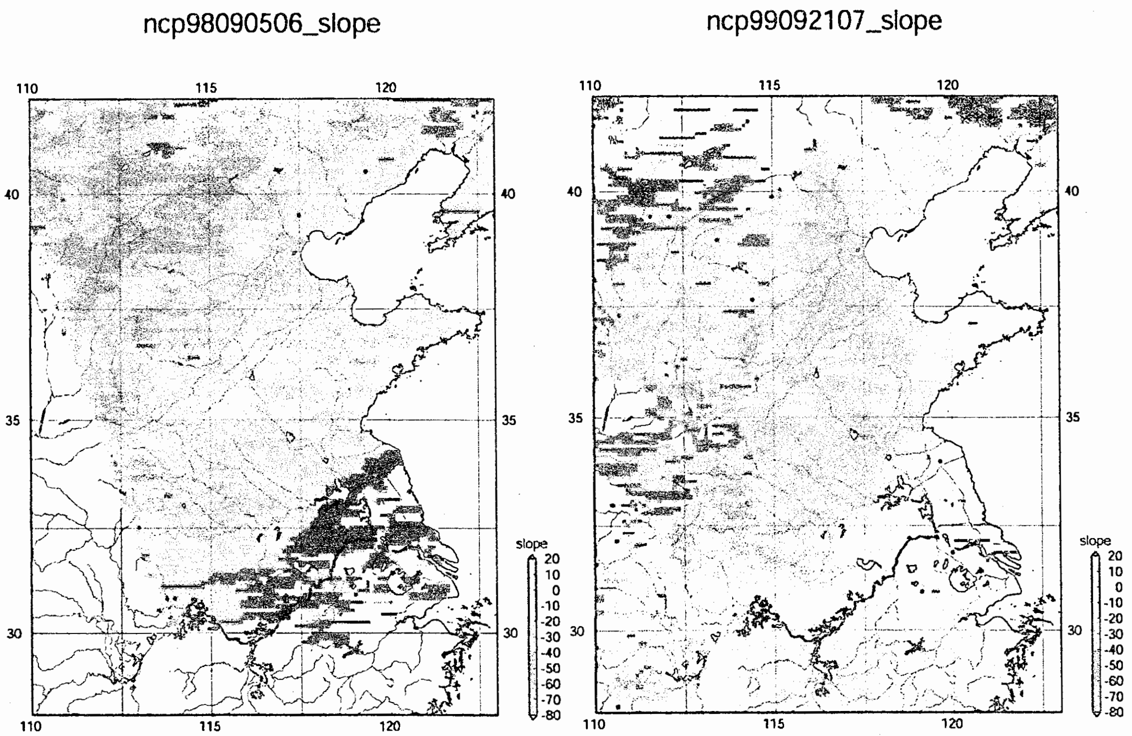

Figure 4: Estimated slope during dry period (September), in 1998 (left: September 05, 1998), and in 1999 (right: September 21, 1999).