Time series of MODIS LST in the Upper Mekong Basin

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Time series analysis of LST

Land surface temperature (LST) is an important indicator for climate change and can be sensed remotely by satellites with a high temporal resolution on a broad spatial scale. In this research MODIS LST are used to derive an 12 year time series from the upper Mekong delta to analyse the development of LST.

A main challenge of optical satellite data is the cloud contamination over the area in the summer months, where peak rainfall occurs. In the test area of the province Qinghai for example, the average number of available daytime observations of MODIS LST in July ranges between 9 and 16 observations per month. Figure 1 shows the monthly availability of the MODIS LST data (blue bars). It can be assumed that climate statistics calculated from such data are biased.

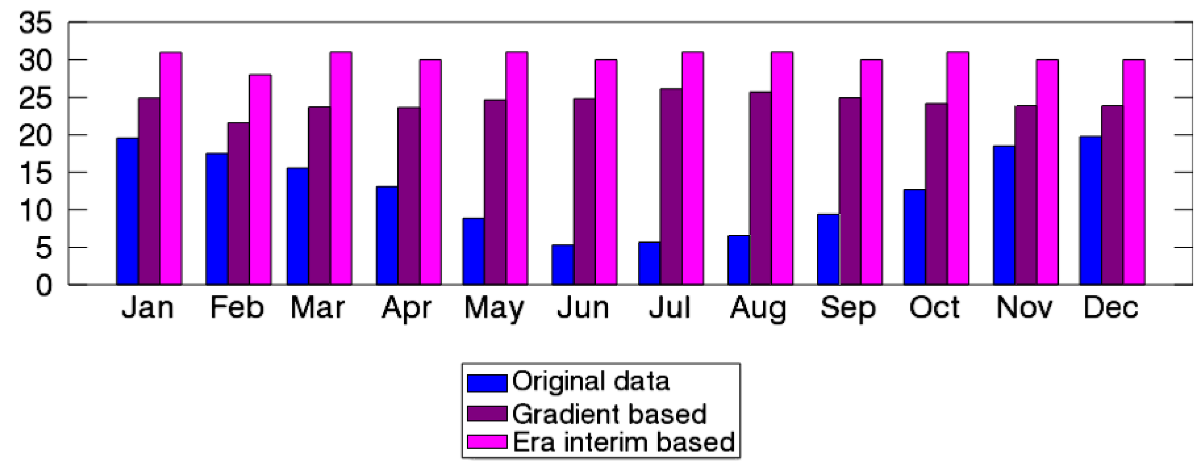

Fig. 1. Number of valid pixels – 12 year average

Gap filling

In order to overcome the problem of missing data, two methods were developed, whose output can be used to fill the gaps:

a) **Gradient based**
LST is estimated using stable inter-image gradients from a given environment in the same scene. This method is to create a set of clear-sky LSTs.

b) **Era interim based**
LST is estimated on the base of 0.25° ECMWF era interim analysis skin temperatures and creates a set of expected LSTs.

Monthly mean of modelled daytime LST correlated well with the original data (gradient based daytime: r^2 = 0.95, RMS = 3.5K, night time: r^2 = 0.98, RMS = 3.1K; era interim based daytime: r^2 = 0.98, RMS = 0.4K, night time: r^2 = 0.99, RMS = 0.5K). The gradient based method underestimates LST mainly in the summer month, leading to the high RMS values.

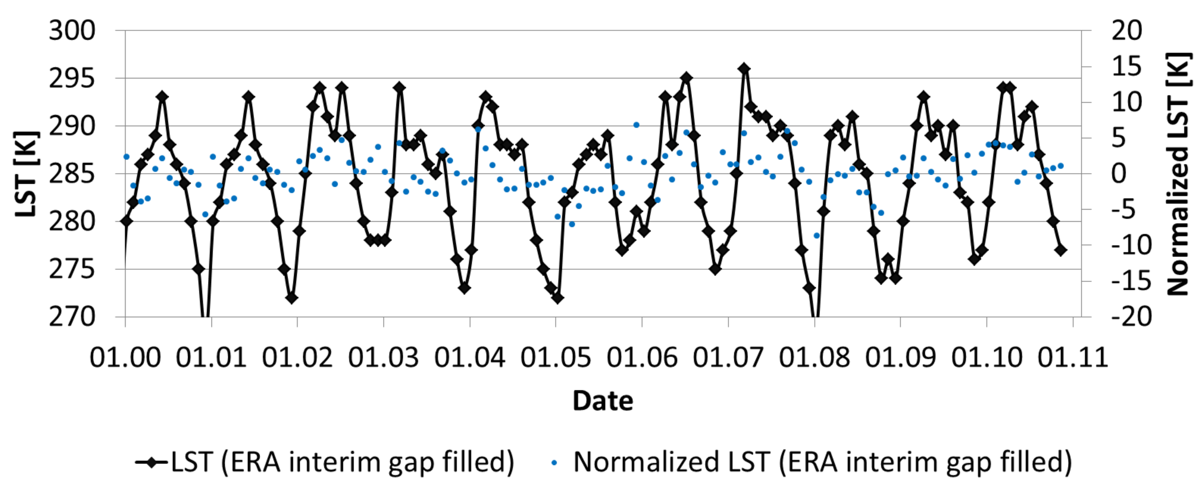

Fig. 2. Monthly mean LST of a test area in Qinghai

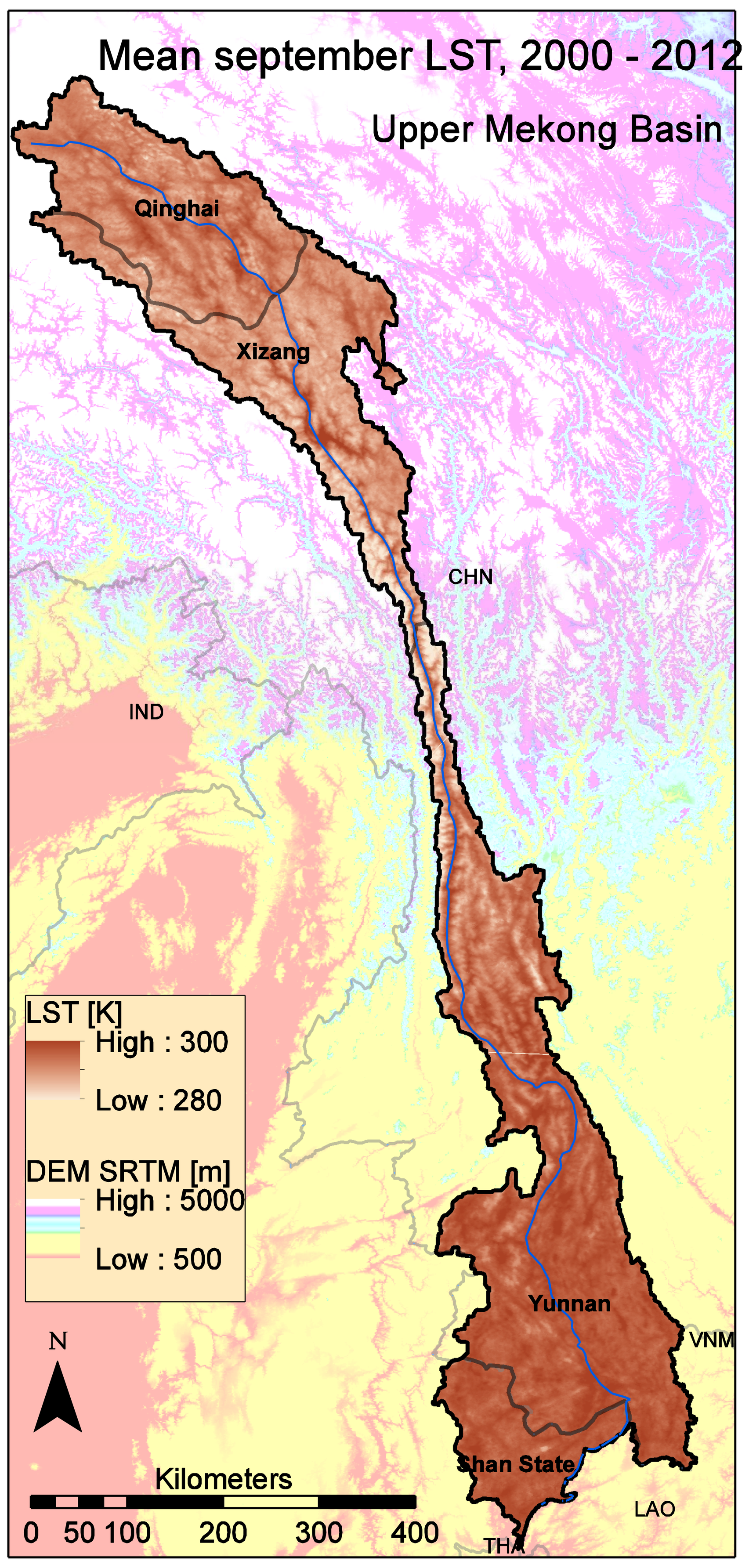

Fig. 2. Mean LST in September – 12-year average

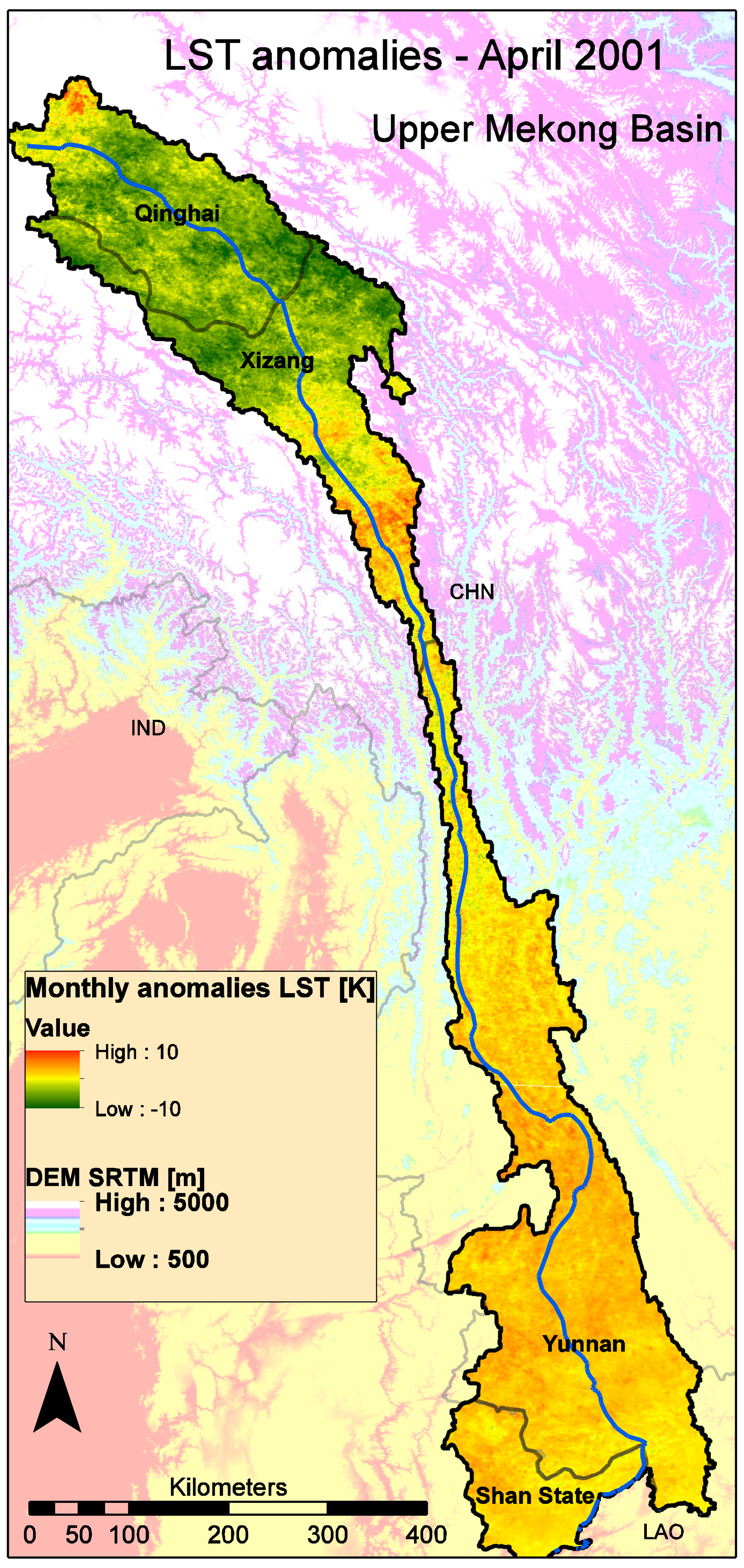

Fig. 3. April 2001 LST anomalies

Gap filled versus original time series

The original dataset was filled with the estimated values. The two new datasets (Gradient filled and Era interim filled) both showed much less missing data (see Figure 1). The root mean square (RMS) of the daily mean gap filled datasets and the daily mean original data are relatively high. (Gradient based daytime: RMS = 2.4K, night time: RMS = 2.0K, era interim based daytime: RMS = 3.0K, night time: RMS = 3.2K). These high RMS values point to the disturbing effect of cloud gaps in the original data set on statistical values. Large differences mainly occur during the rainy SW monsoon in summer in case of the gradient based filling; during the NE monsoon in winter differences are close to zero. In case of the era interim based method, no seasonal differences were found.
The RMS from monthly means are lower (gradient based daytime: RMS = 0.9K, night time: RMS = 0.7K, era interim based daytime: RMS = 1.2 K, night time: RMS = 0.8 K).

Temporal variations

LSTs show a considerable variation over the 12 years. Maps of anomalies of monthly mean LST show that the Southern and the Northern part of the Upper Mekong Delta are often decoupled: E.g. in April 2000 and 2001 lower LST than normal are found in the provinces of Qinghai and northern Xizang, while in the Southern parts of Yunnan and in Shan State slightly higher LSTs are found.

Apart from such year-to-year variations, trends spanning the 12-year period were found in both the daytime and night time data. A pixel was marked as trend, when the 12 year r^2 of the LST development was more than 0.2. The Northern and the Southern part of the Upper Mekong Delta are decoupled in some months, in others they behave similar. In the daytime scenes more negative trends were detected, while in the night time scenes positive and negative trends were about equal. However, a 12 year time series is not sufficient to deduct sound statistical trends.

Effect of time shift

MODIS LST data have day-to-day differences in the local acquisition time. A temporal correction was applied to all LST data, converting them to one fixed local acquisition time using adjusted ECMWF ERA Interim skin temperature data. The original and the corrected dataset are very well correlated and the effect on the daily/monthly mean is found to be small, especially during night (daytime: RMS = 1.2K/0.4K, night time: 0.6K/0.5K). Considering a certain error of the correction method, it is suggested that the differences in local time do only marginally influence long time series.

Conclusions

This study showed that time series analysis on land surface temperature is affected by cloud gaps, especially when working with daily data. Monthly means are not as much affected. Proposed gap filling methods can be used to reduce this effect. The era interim method was found to be superior to the gradient method in terms of accuracy, computing speed, and data availability after the gap filling. In case of access to high resolution era interim data, this method is to be preferred.