Time series of MODIS LST in the Upper Mekong Basin

Dr. Corinne Frey, Dr. Claudia Künzer
German Remote Sensing Data Center (DFD), Earth Observation Center (EOC), Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), corinne.frey@dlr.de

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 on-going research, MODIS LST are used to derive a 12+ year time series from the Upper Mekong Basin (UMB) 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.

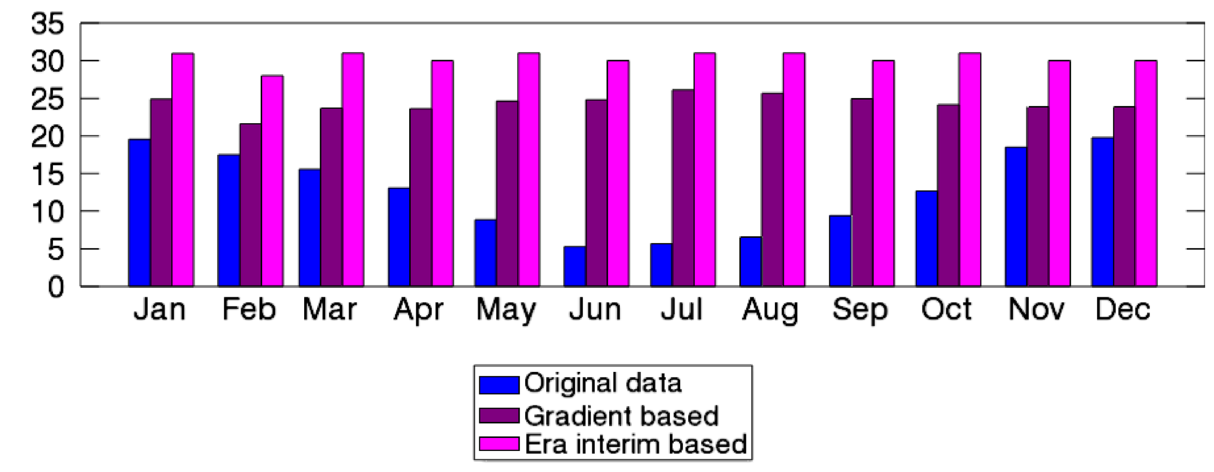

Fig. 1. Number of valid pixels – 12 year average

Temporal variations

LSTs show a considerable variation over the last 12 years. Maps of anomalies of monthly mean LST show that the Southern and the Northern part of the UMB 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 (Fig. 4).

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 higher than 0.2. The Northern and the Southern part of the UMB 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.

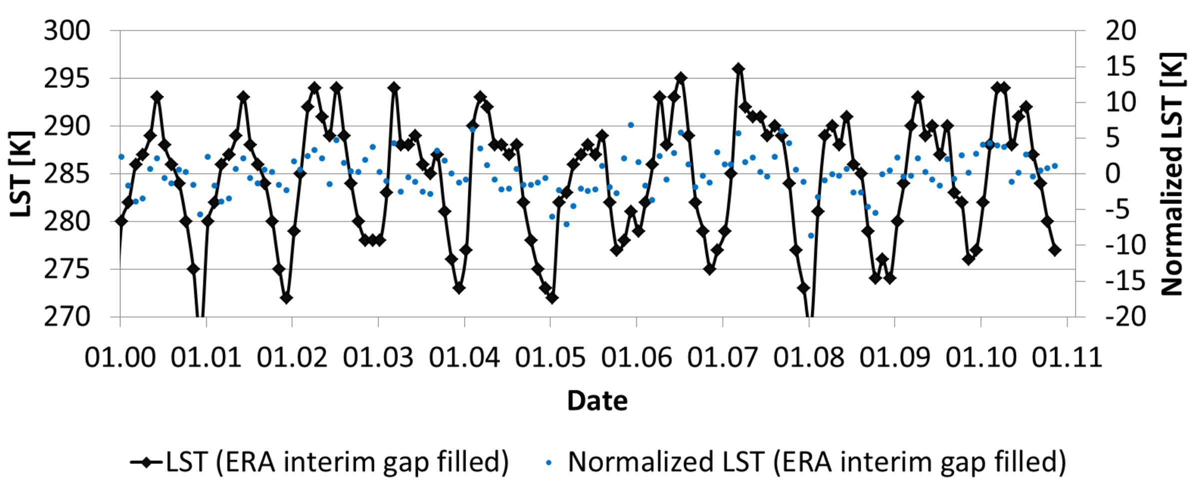

Fig. 2. Monthly mean LST of a test area in Qinghai

Effect of time shift

MODIS LST data have day-to-day differences in the local acquisition time. To asses its influence, 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.

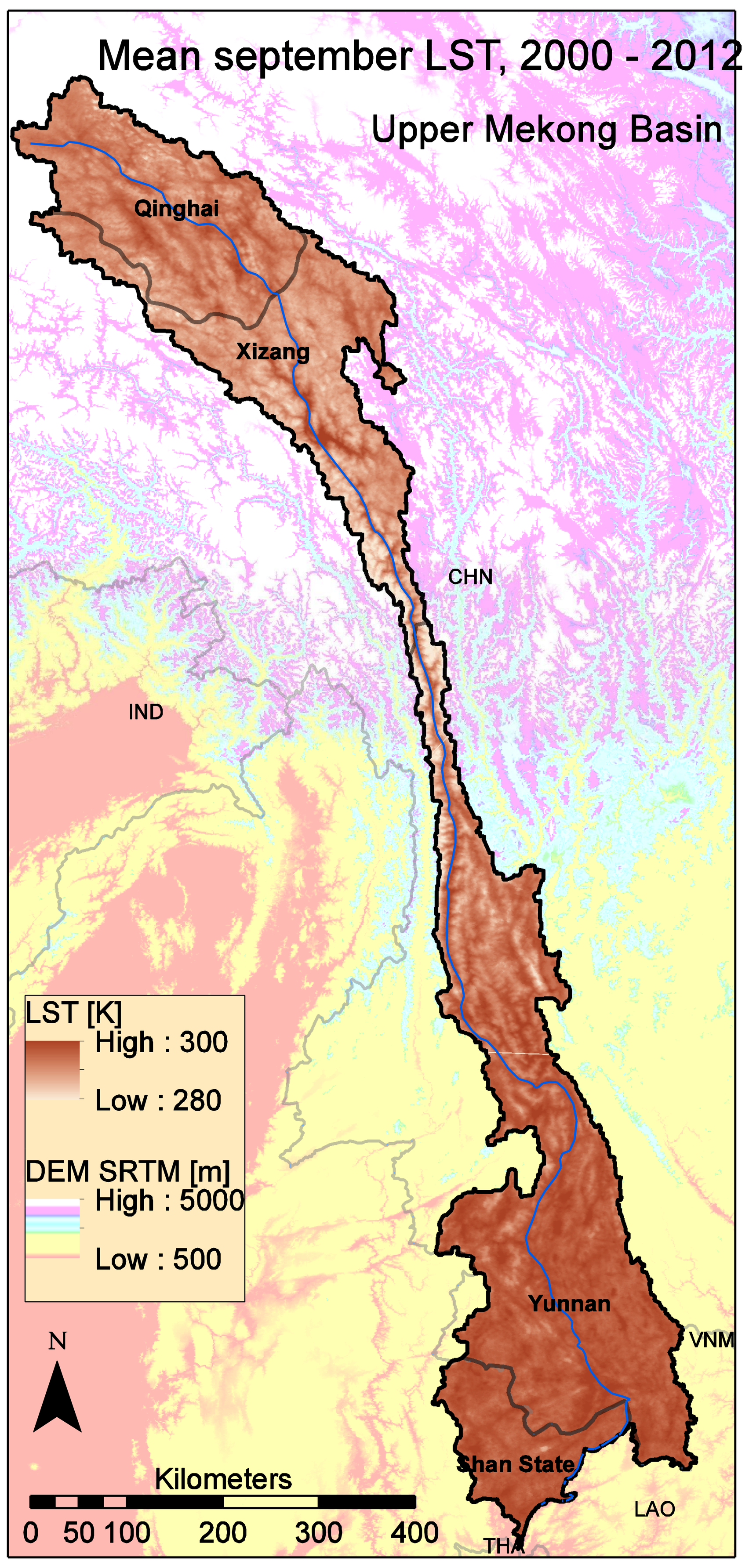

Fig. 3. Mean LST in September – 12-year average

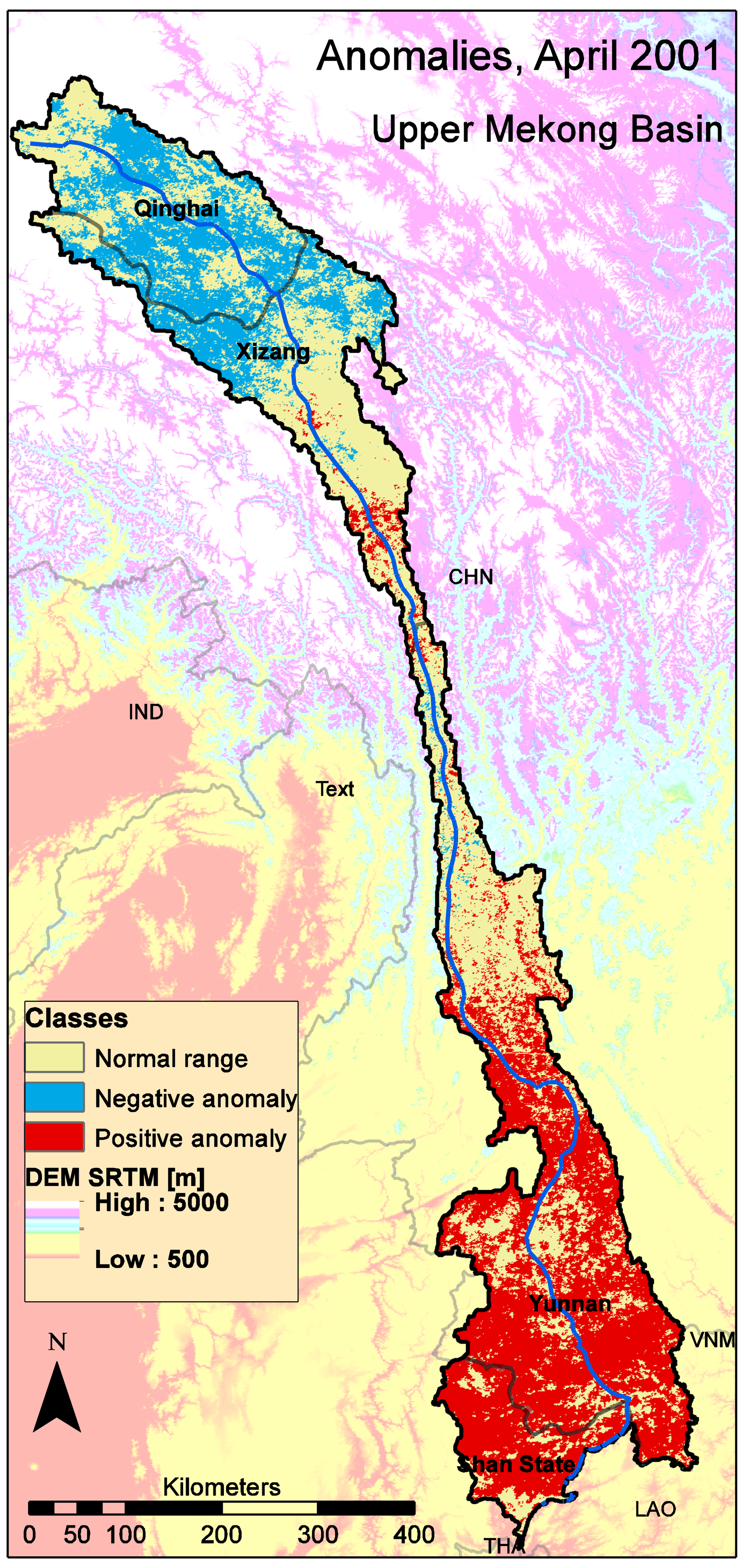

Fig. 4. April 2001 LST anomalies (anomaly = deviations larger than 2 times the pixel-based standard deviation)

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.

First quality assessment of gap filling

Visual assessment of the era interim based gap filling revealed that the method was successful in many cases. Good results were achieved especially when the cloud cover duration of a pixel was only a few days. In cases, where the cloud cover was persistent over a long time period, the method was less successful. The same is true for the gradient based method, where strongly underestimated LSTs mainly occur in the wet season.
Fig. 5 shows two areas of cloud contaminated pixels before and after the era interim gap filling (blue circles). The area on the right was filled properly. The left area seems to be filled with too high LST values. However, the pixels around the cloudy area are partly cloud-contaminated, as was proven by a reflectance image from the same acquisition. So, the low LST values around the filled area may not serve as reference and such the filling might be correct.

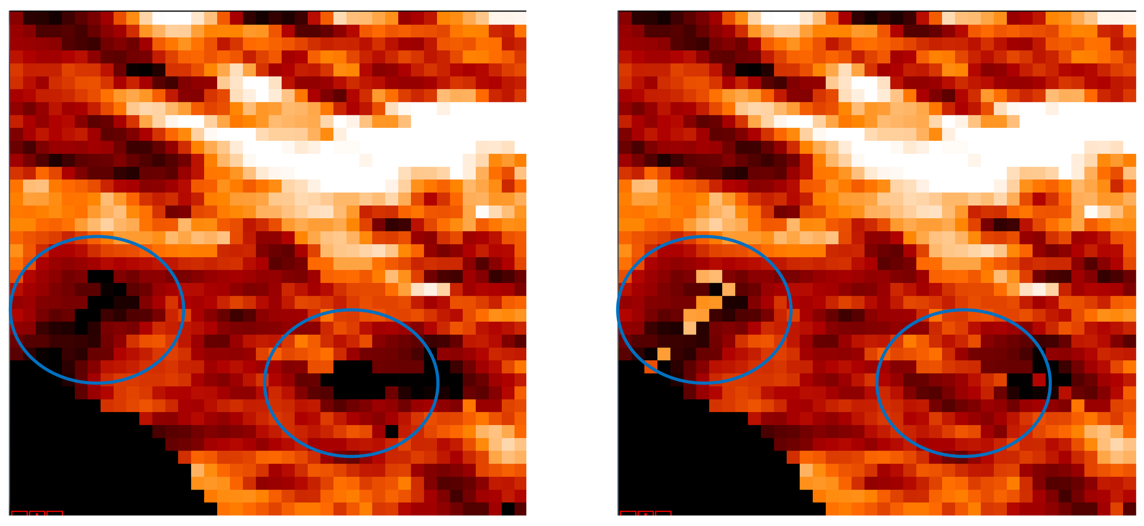

Fig. 5. Left: MODIS LST with cloud gaps (circles). Right: MODIS LST with era interim based gap filling

Gap filled versus original time series

The original dataset was filled with the estimated values to generate two new datasets. The RMS of the daily mean gap filled datasets and the daily mean original data range between 2 and 3K. The effect of errors in the gap filling on these values has to be evaluated. 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).

Conclusions

The study showed that the evolution of LST in the UMD is spatially diversified. E.g. the Northern and the Southern part often show opposite monthly anomalies.
Time series analysis on LST is affected by cloud gaps, especially when working with daily data. Monthly means are not as much affected. Proposed methods can be used to reduce the gaps. The era interim method was found to be superior to the gradient method in terms of computing speed, and data availability after the gap filling. An in-depth quantitative quality assessment of the two methods however is outstanding.