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VALIDATION OF SATELLITE LONGWAVE EMISSION WITH IN-SITU MEASUREMENTS DURING BUBBLE

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Abstract

During the Basel Urban Boundary Layer Experiment (BUBBLE) a series of satellite data are analysed and validated against surface field measurements. Satellite data used are MODIS and Landsat-ETM data from July 8, 2002. MODIS data represent day and nighttime surface temperatures in a 1000 m grid size recorded at 11:10 UTC and 21:50 UTC respectively. Landsat-ETM offers a unique resolution on 60 m but only daytime imagery at about the same time of MODIS overpass is available. This enables the validation of satellite measurements from different sensors with ground measurements at locations with various degrees of spatial homogeneity/ heterogeneity (urban/rural land use).

Key words: energy balance, urban heat island, longwave emission, remote sensing

1. SATELLITE DATA

There are many satellites of different spatial, temporal and spectral resolutions which have been used for analysis of the urban heat island during the BUBBLE-Experiment. Primarily the research of BUBBLE-SARAH (**S**atellite **A**nalysis of **R**adiation **A**nd **H**eat Fluxes) is focussed on Landsat 7 ETM+. Landsat has the unmatched resolution of 60 m in the thermal IR-band, offers the possibility to compute albedo with a resolution of 30 m and possesses a panchromatic band with 15 m resolution. But also MODIS thermal data with a spatial resolution of 1000m has been used for this investigation because of it's day- and nighttime overpass on one day. The Landsat ETM+ thermal data has been atmospheric corrected with WINDOW (based on Price 1983).

2. IN SITU DATA

Also a wide set of ground data from several sites of the BUBBLE-Campaign was available for the validation of the various satellite data. The six sites Sperrstrasse, Spalenring, Messe Basel (dense urban areas), Lange Erlen, Allschwil and Village-Neuf (coarse built or rural sites) have been selected for comparison. The whereabouts of the sites is shown in the image below.

Fig. 1: Comparison sites shown on the thermal Landsat ETM+ image from 08.07.02

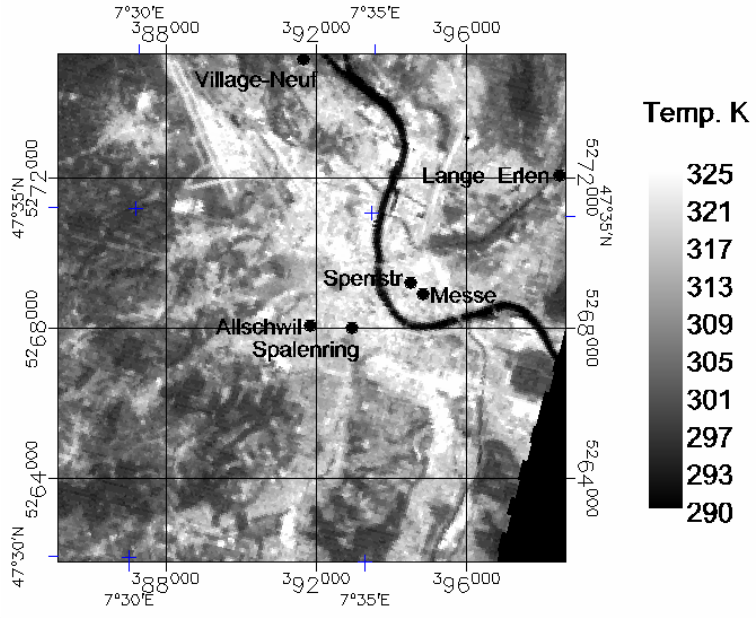
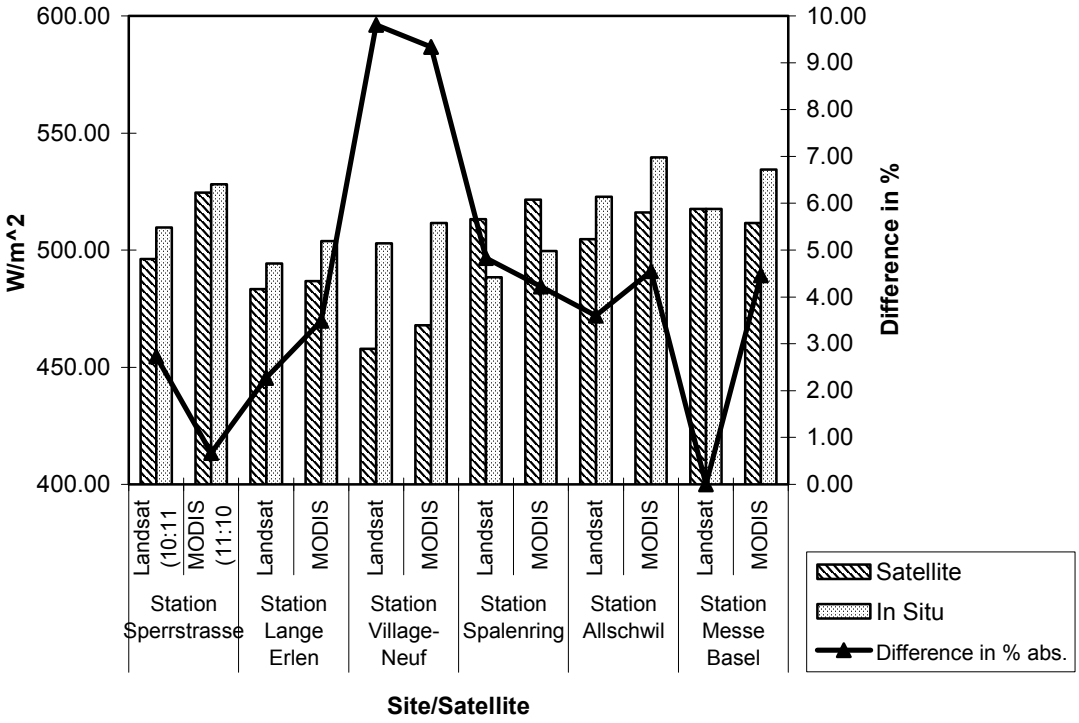


Fig. 1 shows the surface temperature of the city of Basel in K, with the Boltzmann-formula, the values can be converted into W/m^2 for better comparison with in situ data. The airport and the industrial areas are clearly visible with very high temperatures and also the River Rhine, which shows a comparable low surface temperature as it flows through the city.

The in situ measurements at the stations shown above in fig 1 have been compared to the values derived from different satellite imagery. A first comparison over a day at the different stations is shown below in fig. 2.

Fig. 2: Comparison of satellite and in situ longwave emissions



3. FIRST RESULTS

As the fig. 2 shows, the differences between the measurements are very small, they range between 0 % and 9.3 % compared to in situ measurements. It is important to know, that even the in situ instrumentation has an operational error between 5-10 W m^{-2} (≈ 1 – 3 %), even with very good calibration. In this case, the satellite measurements are in very good agreement, especially for the MODIS satellite with its sensor resolution of only 1000 m. The accuracy of Landsat is better than the accuracy of MODIS but just slightly (2.7% to 4.4%), but the nighttime overpass of MODIS yields a better accuracy of 2.38 % difference average over all the stations. The two sites Village-Neuf and Spalenring show the highest differences compared to the other sites. It has to be determined yet what causes this difference.

Fig. 3 shows the diurnal course of longwave emission at the different sites from fig. 1. It is clearly visible, that the urban sites (black) show higher values than the rural (white) ones almost all the time, except around midday/early afternoon. The rural sites cool down more and faster during the night, but they also get warmer around midday, so they have a higher daily fluctuation than the urban sites.

For the MODIS data analysis, also visible on fig. 4, there have been two more rural sites Gempen and Grenzach for data verifications which are unfortunately not covered with the Landsat-ETM image. The temporal datasets of the two satellites fits well over a two days period (07.08.07.02) with the in situ data of the Sperrstrasse-Site. There have been more MODIS data analyzed over different days also during the BUBBLE campaign and in overall, the nighttime overpasses show higher correlations with the ground data than the daytime ones.

The differences between MODIS and in situ measurements are higher during daytime in the rural areas (5.83%) than in the urban (4.45%), but in the night the difference shifts to 3.31% in urban and 2.12% in rural in the average.

Fig. 3: Diurnal course of longwave upward radiation at the different sites from the 8th of July 2002

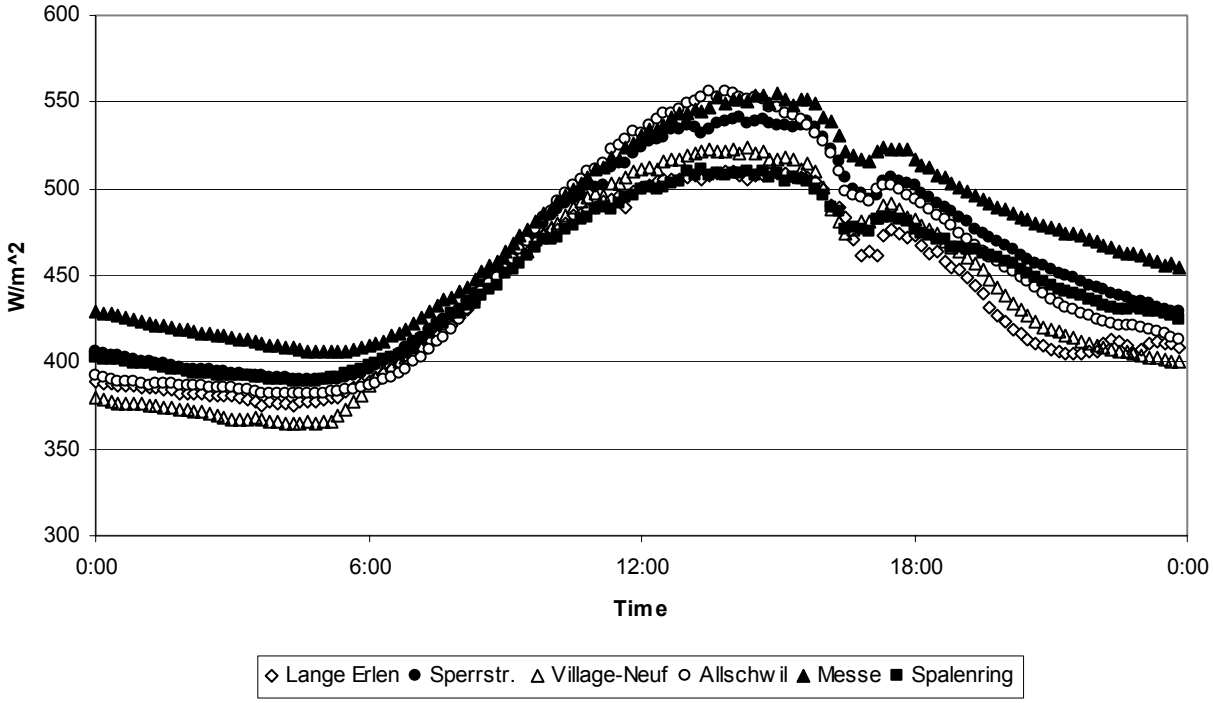
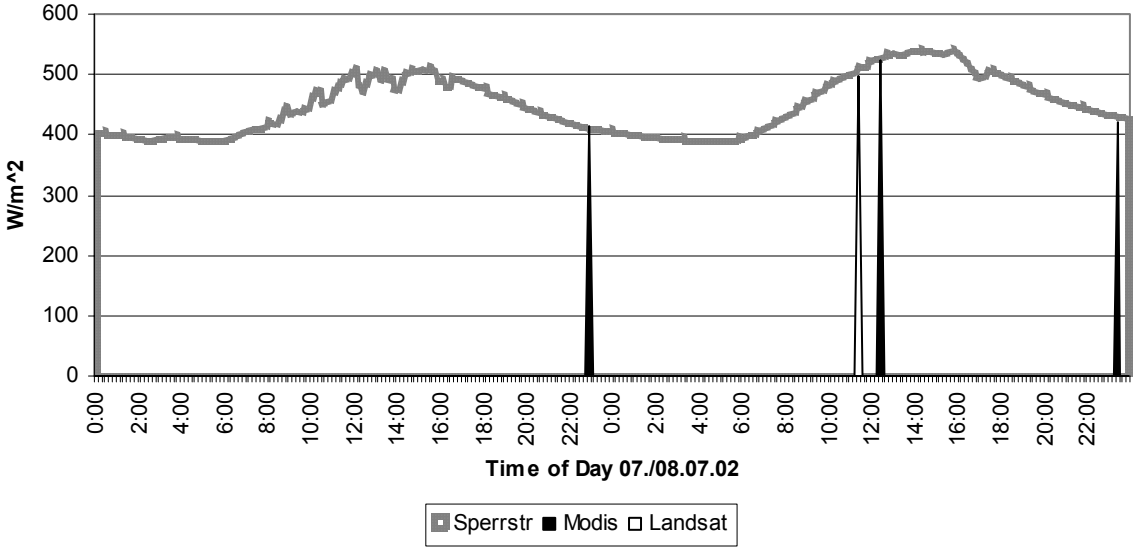


Fig. 4: Multisatellite data comparison with in-situ data of longwave emission over two days at Sperrstrasse



4. ACKNOWLEDGEMENTS

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BUBBLE: project webpage: http://www.unibas.ch/geo/mcr/Projects/BUBBLE/ (case sensitive)