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INFLUENCE OF LAND USE ON DIURNAL COURSE OF LONGWAVE EMISSIONS (NOAA-AVHRR, MODIS, LANDSAT-ETM) DURING BUBBLE

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Abstract

During the Basel Urban Boundary Layer Experiment (BUBBLE) satellite data from three different sensors (NOAA-AVHRR, MODIS and Landsat-ETM) are available for July 7 and July 8, 2002. A land use classification which was derived from Landsat multispectral data is used to investigate how the different land use classes influence the diurnal course of longwave emission. This analysis is carried out by using multiple regression analysis techniques within a GIS environment. Satellite measurements are validated with field measurements at various urban and rural sites.

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

1. SATELLITE DATA AND STUDY AREA

Table 1 shows the satellite sensors and images that were used for the analysis. The main focus was on MODIS and AVHRR data, which both have a spatial resolution of 1km in the thermal-IR wavelength. A display detail of 122 x 218 pixel (thus 26'596 km^2) was extracted. The images cover an area between 47.1° and 49.7° northern latitude which includes a good part of the Upper-Rhine-Valley, the Black Forest, the Vosges Mountains and the northern Swiss Jura.

Tab. 1: Satellites and Sensors Overview.

Satellite platform	TERRA	Landsat	NOAA-AVHRR
Sensor	MODIS	ETM+	AVHRR
No. of Spectral Bands	36	7 (8)	5
Spectral Range [µm]	0.62-14.38	0.42-12.5	0.58-12.5
Temporal Resolution	Daily	16 Days	Daily
Spatial Resolutions	250m, 500m, 1000m	15m, 30m, 60m	1000m
Overpasses, July 7, 2002 (UTC)	10:30 & 21:40 h	-	7:44, 12:13, 16:49 & 17:28 h
Overpasses, July 8, 2002 (UTC)	11:10 & 22:10 h	10:11 h	2:13, 5:07, 6:47 & 7:21 h

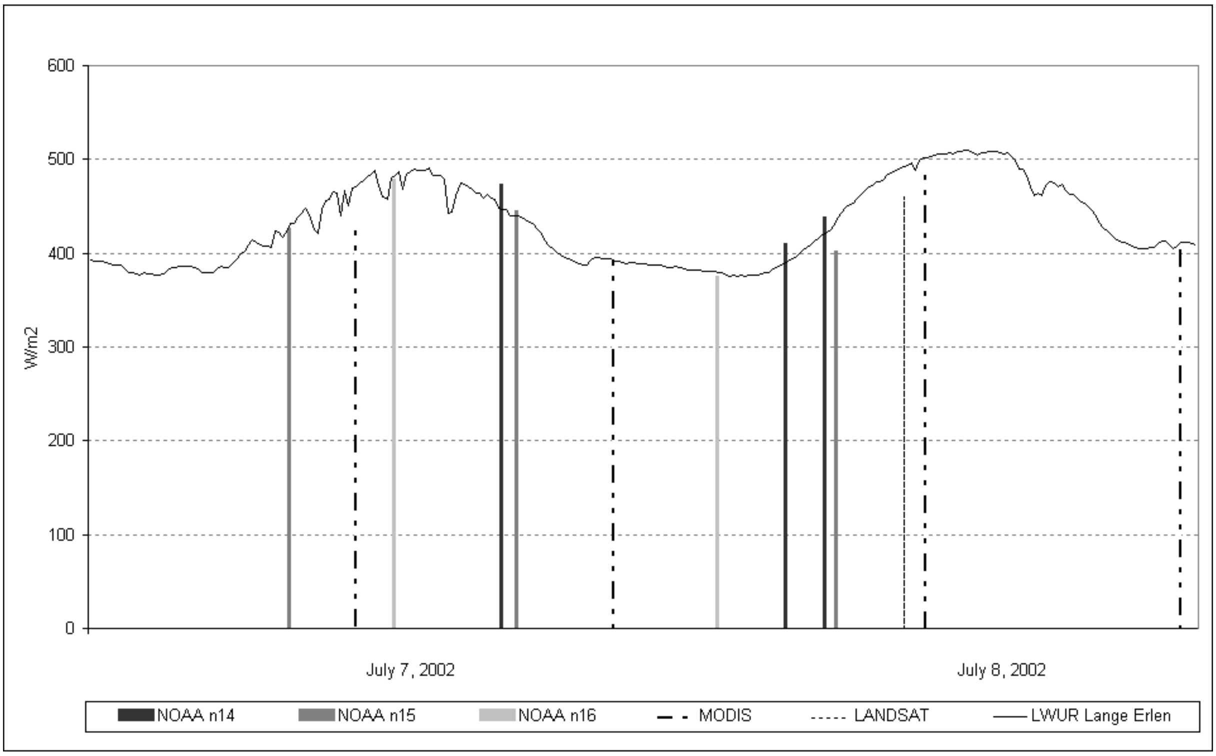

Fig. 1: Longwave upward radiation (LWUR) from the Lange Erlen measurement-site and satellite overpasses from approximate "Lange Erlen-pixel" on July 7 and 8, 2002 (in W/m^2).

2. METHODS

With the available radiation measurements from numerous BUBBLE sites, it was possible to compare and calibrate the satellite data with ground measurements ***(Fig. 1).***

All acquired images ***(Fig. 2)*** have been georeferenced to UTM projection, zone 32 north and transformed into W m^{-2}. An atmospheric correction after Price (1983) has been applied. The NOAA-AVHRR has been geocoded and pre-processed by the University of Berne.

Further a 9-class land use classification (1. water, 2. settlement of high and medium density, 3. settlement of low density, 4. industry, 5. coniferous forest, 6. deciduous forest, 7. mixed forest, 8. grassland and 9. agricultural crop land) which was derived from Landsat multispectral data (spatial resolution of 30m), has been split in it's 9 components resulting in 9 different land use images. Each land use image has been contracted by "pixel aggregation" to a spatial resolution of 1000m. Every pixel represents a class-percentage value of one land use type, ranging from 0 to 100%.

As no complete cloud-free images were available for the area in the BUBBLE measurement period, all clouds and cloud-contaminated areas have been outmasked. The land use classification as well doesn't cover the whole satellite image area, therefore a land use-mask was added to each cloud-mask and consequently a different mask for every satellite image has been obtained.

To minimize the topographic influence on solar irradiance and consequently longwave emission in mountain areas, the solar irradiance was computed with a digital terrain model and the Shortwave Irradiance Model (SWIM) (PARLOW, 1996).

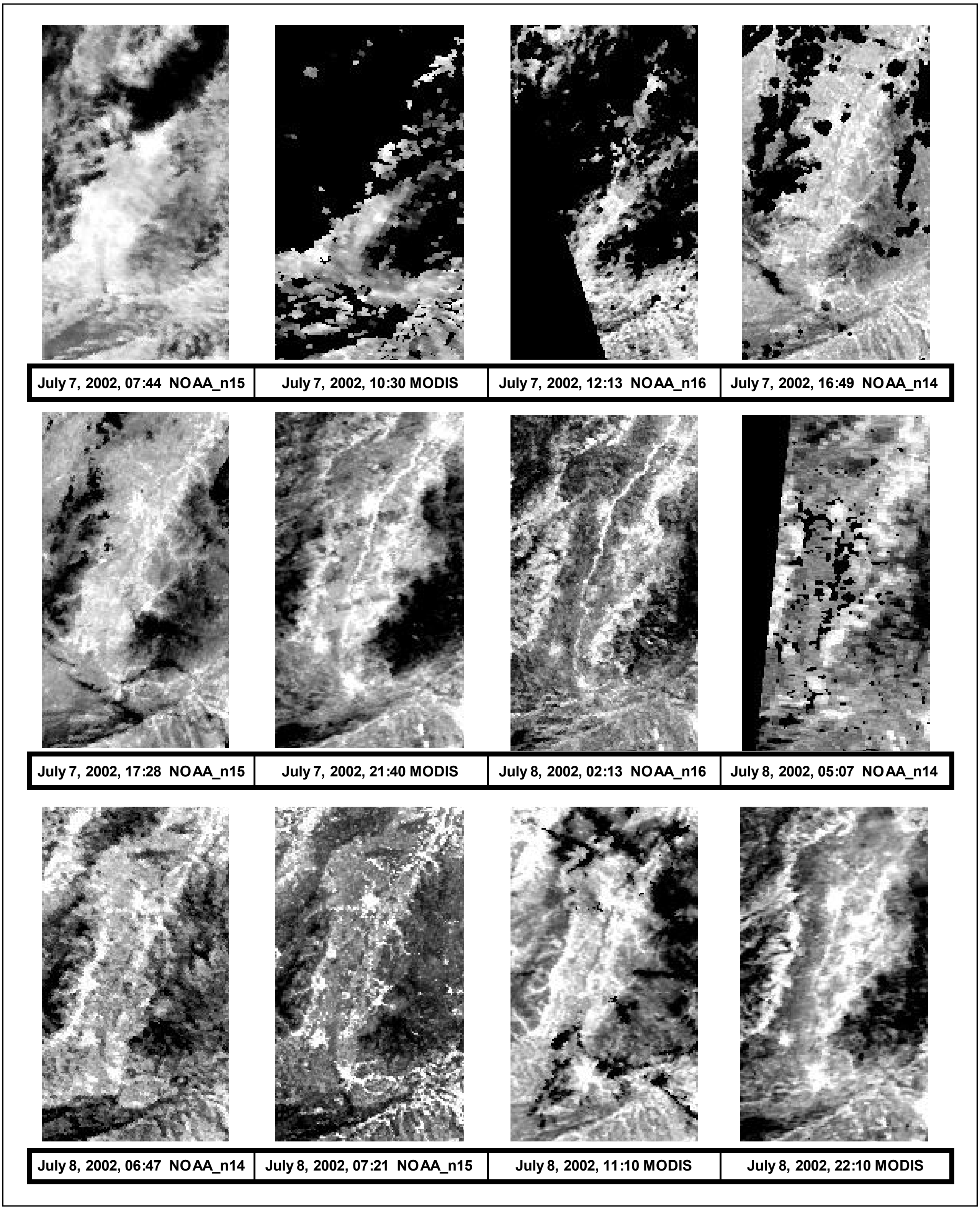

Fig. 2: Available NOAA and Modis images for July 7 and 8, 2002.

Multiple regression analysis techniques were applied to calculate the correlation between the longwave emission and the different land use classes. The thermal image was used as the dependent variable, the 9 percentage land use classes were used as 9 independent variables. By adding a MODIS-generated NDVI-image or the SWIM of the area as the 10th independent variable, R^2 values of around 0.64 were calculated. The best results were achieved by using the following equitation:

$$LWUR = \sum_{i=1}^{10} (ai * Pi) + b * SWDR + c$$

LWUR = Longwave upward radiation

a1 = 4.9584 (water)

a2 = 0.4966 (settlement of high and medium density)

a3 = 1.5350 (settlement of low density)

a4 = 0.3207 (industry)

a5 = 5.2051 (coniferous forest)

a6 = 1.1711 (deciduous forest)

a7 = 3.5749 (mixed forest)

a8 = 1.8818 (grassland)

a9 = 0.6978 (agricultural crop land)

Pi = percentage factor

b = 0.0017 = const.

SWDR = Shortwave downward radiation

c = 317.0583 = const.

Apparent R square = 0.638774

3. REFERENCES

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

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