ICAM 2015
Innsbruck Austria

Poster session 2
P 2.41

RUHR-UNIVERSITÄT BOCHUM

RUB

Evaluation of infrared imaging

for measuring near-ground flow dynamics at the Barringer Meteor Crater as part of METCRAX II

Barringer Meteor Crater

The second Meteor Crater Experiment (**METCRAX II**) took place in October 2013 at the Barringer Meteorite Crater in Arizona, USA to investigate nighttime downslope-windstorm-type flows that were discovered in the crater in 2006 during METCRAX I. **Five thermal infrared (IR) cameras** supplemented the extensive meteorological instrumentation in and around the crater. The cameras looked down into the crater and its surroundings from various locations on the crater's rim, sensing thermal IR radiation and the effective radiation temperatures of the crater surfaces.

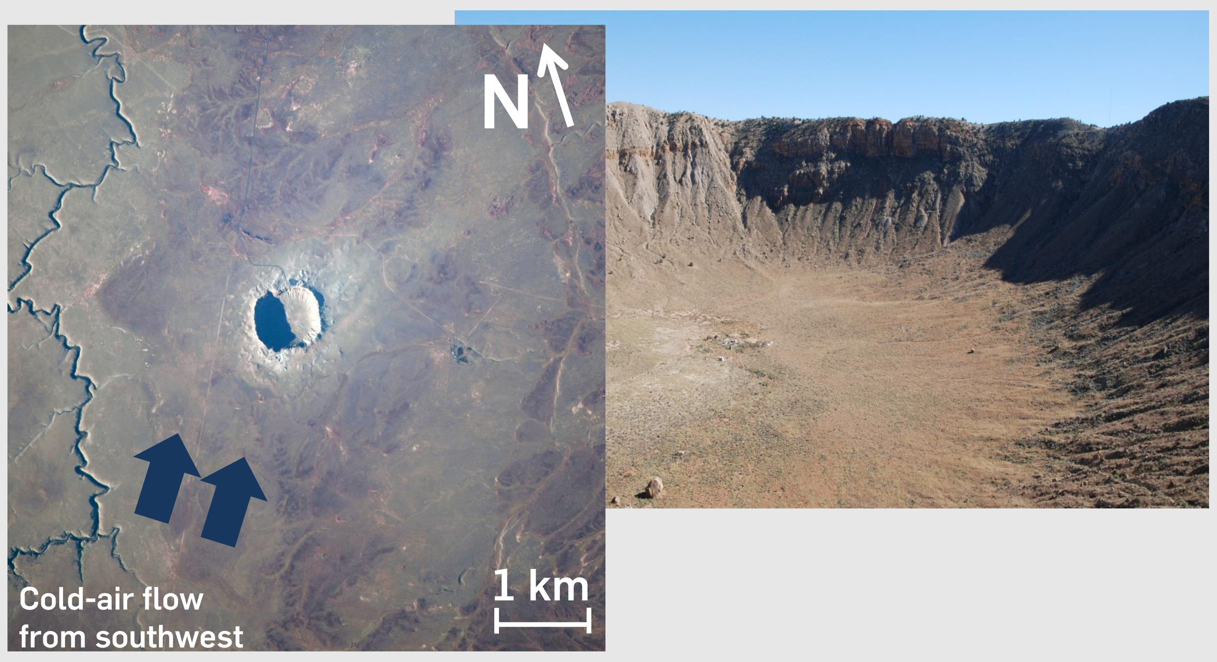

Fig. 1: Crater Orthophoto and insight view (Adapted from MODIS; Lunar and Planetary Institute)

The **Barringer Meteorite Crater** is a near circular basin, surrounded by a uniform plain sloping upwards to the SW with a 2% slope. It has a diameter of 1.2 km, is 170 m deep and its rim extends 30-50 m above the surrounding plain (s. Fig. 1).

Infrared Method

Thermographic measurements have been previously used for observations of surface temperatures in urban and environmental studies (Weng 2009).

They have the advantage of providing extensive and spatio-temporal datasets of surface radiating temperatures (see also Poster 2.40; Grudzielanek & Cermak 2015).

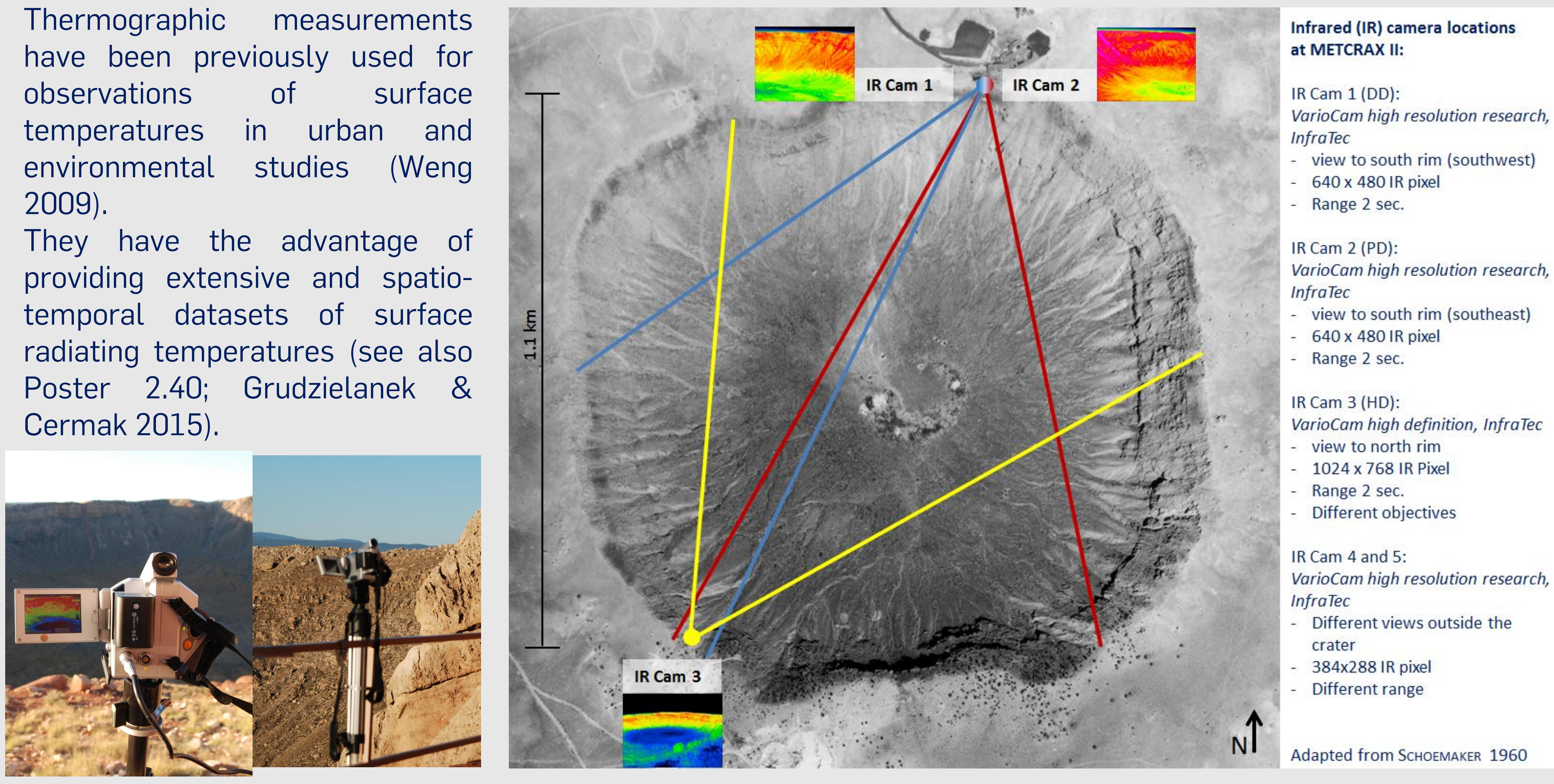

Fig. 2: Example of two installed cameras (photo by A. M. Grudzielanek) and IR camera locations with views in crater (adapted from Schoemaker 1960)

An indirect means of **sensing near-surface airflows** is possible using the high temporal and spatial resolution of surface temperatures from sequences of IR images taken at 2-s intervals and assembled into time-lapse videos. Surface properties such as emissivity, heat capacity, thermal conductivity and reactivity to air temperature changes have to be considered when analyzing IR data. To increase the usefulness of the data, the 2D IR images must be projected onto the underlying 3D terrain obtained from high-resolution digital elevation model. This georeferencing allows the user to determine the locations of IR pixels relative to other instruments and topographical features (see Poster 2.39 for details).

Workflow & Methods

By correlating IR temperature data with meteorological data obtained from other instruments during Intensive Observational Periods (IOP), the utility of the IR method for representing flow dynamics can be assessed. The raw IR data must first be corrected and adjusted. Based of data quality checks a statistical mask is developed to automatically correct IR data errors.

Thermally reactive IR pixels exhibit significant deviations from the temporal mean. These pixels can be identified in the sequence of images and allow us to identify and characterize air flow structures.

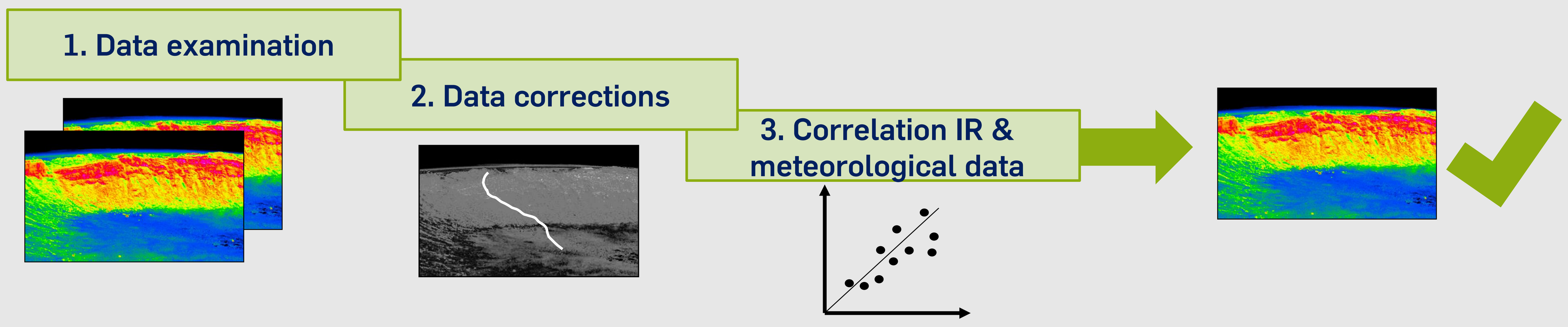

Fig. 3: Scheme of the workflow

Initial results

Changes in high resolution surface temperatures are indicative of air temperature changes induced by flow dynamics inside the crater, including the downslope-windstorm-type flows (DWF) that were the main research focus of METCRAX II.

IR data collected during IOP 4 by IR Cam 1 (s. Fig. 2) pointed toward the SW are shown in Fig. 4.

Fig. 4a shows the time series of the mean raw IR temperature from 17:49 to 07:52 MST. Between 22:00 and 4:00 MST, a series of warm air intrusions (WAIs) can be identified by local maxima in the time series (Adler et al. 2012). Measures of dispersion for this period are shown in the boxplot in Fig. 4b. Spatial details of the warm air intrusions into the cold-air pool (22:42 MST) are visible in the full IR image (Fig.4c) as red streaks that disrupt the cold-air pool, which is indicated by green and blue colors.

By calculating the deviations from the temporal avarage for each pixel very reactive pixels can be identified as well as pixels with low reactivity which may be affected by surface characterstics such as high heat capacity (Fig. 4d). These can be selected for further examinations.

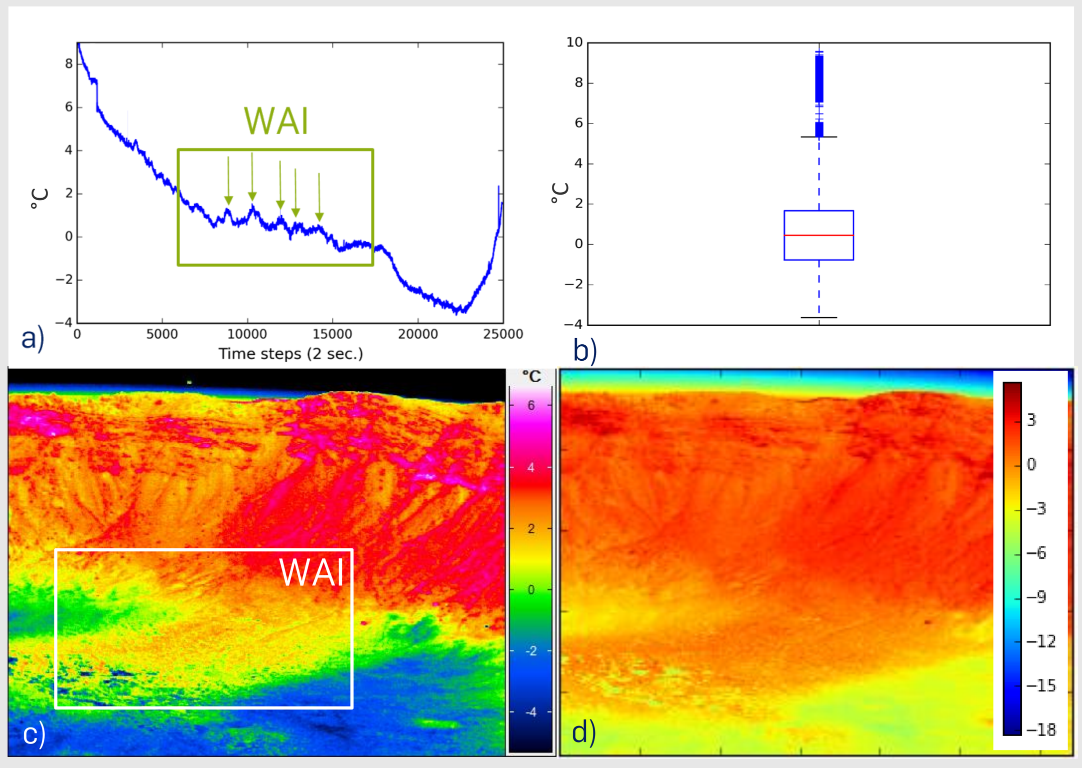

Fig. 4: IOP 4 Statistics for the period 17:49 – 07:52 MST; a) mean raw temperature curve, b) boxplot with measures of dispersion, c) WAI in the IR image at 22:42 MST, d) image of temperature sensitive pixels

Outlook

Infrared imaging is providing useful for visualizing and analyzing airflow processes. If imaged surfaces react quickly enough to air temperature changes, airflow can be detected by high-resolution IR cameras. By identifying temperature-sensitive pixels the reactivity of the crater surface can be illustrated. A correction for the differences in emissivities of each substrate inside the crater will lead to more precise results.

Analyses such as those shown here are necessary to improve the usefulness of IR data in flow evaluations.

References

Adler, B.; Whiteman, C.D.; Hoch, S.W.; Lehner, M.; Kalthoff, N. (2012): Warm-air intrusions in Arizona's Meteor Crater. In: J. Appl. Meteorol. 51: 1010-1025.

Grudzielanek A.M., Cermak J. (2015): Capturing cold-air flow using thermal imaging. In: Boundary-Layer Meteorology.

Weng, Q. (2009): Thermal infrared remote sensing for urban climate and environmental studies: Methods, applications and trends. J. of Photogramm. and Rem. Sens. 64: 335-344.

M. Maric[1], A. M. Grudzielanek[1], R. Vogt[2], J. Cermak[1], I. Feigenwinter[2], C. D. Whiteman[3], M. Lehner[3], S. W. Hoch[3]

[1]Ruhr-Universität Bochum, [2]University of Basel, [3]University of Utah

Ruhr-Universität Bochum
Department of Geography | Climatology
mateja.maric@rub.de
http://www.climate.rub.de

The METCRAX II research was supported by National Science Foundation grants AGS-1160730 and AGS-1160737 and by International Bureau of BMBF grant 01 DM 13002