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Measurements and modelling of the duration of the safe sunbathing during the Baltic Sea coast campaign in 2015 – comparison of methods.

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1.Introduction

We present a comparison of various methods to calculate the UVI (ultraviolet index) and the duration of UV exposures, to get the Minimal Erythemal Dose (MED). The campaign took place at the Baltic Sea coast in the 2- week period (13th to 24th July 2015) during summer vacation. The following models were considered: the prognostic UVI models with various parameterizations of the cloud cover, smartphone application based on the measured UVR by low-cost hand-held biometer, another smartphone application using prognostic value of the noon cloudless-sky UVI for the sunbathing site (available for all smartphone users for any location) corrected for any sun elevation and cloud fraction (CF) seen by the user.

2. Measurements and instruments

The field campaign:
- took place at the Baltic Sea beach in Katy Rybackie (54.3°N, 19.2°E),
- UVI was measured in the period from 13th to 24th July 2015,
- measurements were taken from 7 am to 2 pm (GMT),
- readings were taken every 30 minutes and during two days every 15 minutes,
- synchronously, cloud cover was assessed by 5 categories (cloudless sky, scattered clouds, broken clouds, almost overcast, overcast),
- instruments used and technical details can be found in Tab. 1.

The most accurate device was SM6.5. Details of meters' comparison with Brewer spectrophotometr No. 207 (BS207) are available in Guzikowski et al., 2017.
Maximum exposure time (MET) is calculated as the time needed to obtain erythemal exposure of 1 MED. MET depends on the personal skin phototype and individual sensitivity (Fitzpatrick, 1988). The results presented in the poster are for a person with skin phototype II, for whom 1 MED = 250 J/m^2.

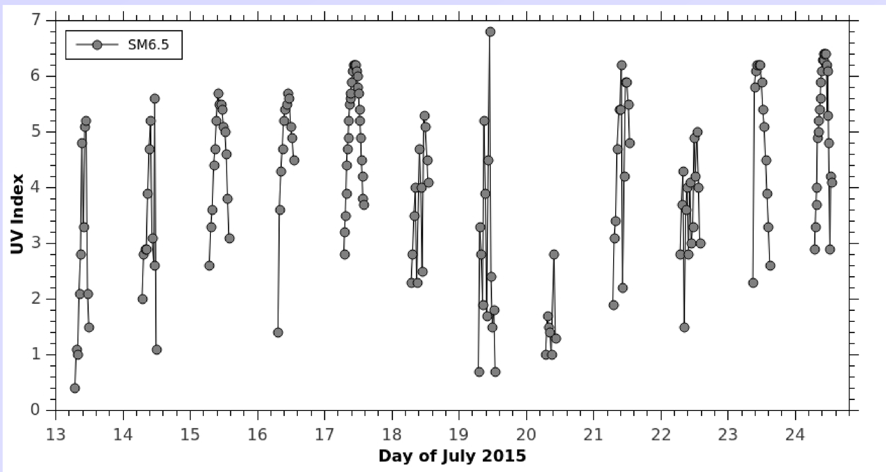

Fig. 1. UVI time series during Baltic Sea campaign at Katy Rybackie (54.3°N, 19.2°E) from 13th to 24th of July 2015.

Fig. 2. Measurements site at Katy Rybackie (54.3°N, 19.2°E).

Meter	SM6.5	SC	OS
Model	Solarmeter 6.5	H14338B	EB612/UV 88
UVI range	0-199.9	no data	1-25
UVI resolution	0.1	0.5	1
Operating temperature (°C)	0-37.8	0-50	0-60
Accuracy (%)	+/- 10	no data	no data
Calibration by producer	YES	no data	no data

Tab. 1. Technical specification (provided by producers) of hand-held UVI meters used in the Baltic campaign.

Fig. 3. Hand-held meters used during Baltic campaign (from the left: SM6.5, SC, OS).

3. Exposure models

The following methods were examined to estimate MET at the sunbathing site:
- "hand-held" – the method based on measurements. The results obtained by SM6.5 were treated as a reference for other model output.
- "smart 1" – Cloudless-sky UVI index from standard smartphone resources was multiplied by cloud modification factor (CMF) derived from CF observations at the site. The cloud observations were taken every 30 minute and CMF values were calculated for 5 cloud-cover categories.
- "smart 2" – UVI was measured at the start of sunbathing. The smartphone application provided further UVI time series with 1-minute resolution assuming constant cloud cover as it was at the start. In the case of an observed change in cloud cover, it is possible to insert new values of UVI into the application. After that, a value of MET will be obtained taking into account previous exposure.
- "forecast" – Modelled UV indices based on 24h forecast (with 15-minute resolution) of TO_3 and CF by low, mid-, and high-level clouds were interpolated from the model grid to the site location. Various options of CMF dependence on CF of the low, mid-, and high-level clouds were considered in calculations (10 ensemble members) of the all-sky UVIs. Finally, MET was obtained by the all-sky UVI integration over time until 1 MED was reached.

Details are available in Guzikowski et al., 2017.

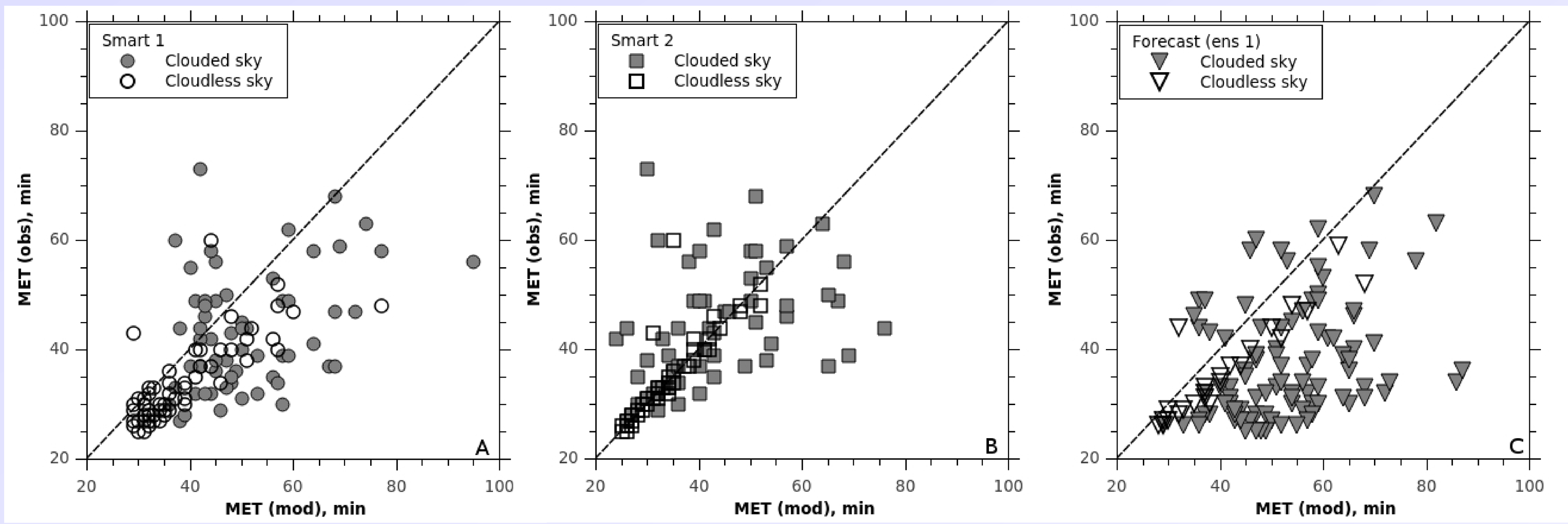

Fig. 4. Comparison between maximum exposure time (MET) calculated from SM6.5 and models: "smart 1"(A), "smart 2"(B), and "forecast" ens 1(C).

4. Conclusions

- Smartphone applications provided more reliable estimates of erythemal UV exposure than that derived from numerical weather prognostic models based on the ensemble approach.
- Although the forecast cloud model could not reproduce real cloud cover, the correlation coefficient with the measured UVI values was around 0.6 for the whole ensemble set.
- The prognostic cloudless-sky UVI and corresponding MET could be useful for a user in planning a next day pro-health outdoor activity if heavy clouds do not appear over the chosen site.
- Smartphone applications allow us to monitor UV exposure during cloudy conditions, especially "smart 2". However, a calibrated UVI instrument should be used for monitoring UV exposure during outdoor activities, and preferably with resolution < 1 UVI.
- "smart 1" seems to be the best option from the practical point of view.
- It is recommended that in the case of rapid change of cloud conditions, the user should adopt values for cloudless-sky.

The smartphone applications (on Android) used in this study are available for any user at **http://cirrus.cba.pl/erythema/**. They are also available after scanning QR codes.

"smart 1" is based on cloud observation at the site of sunbathing:

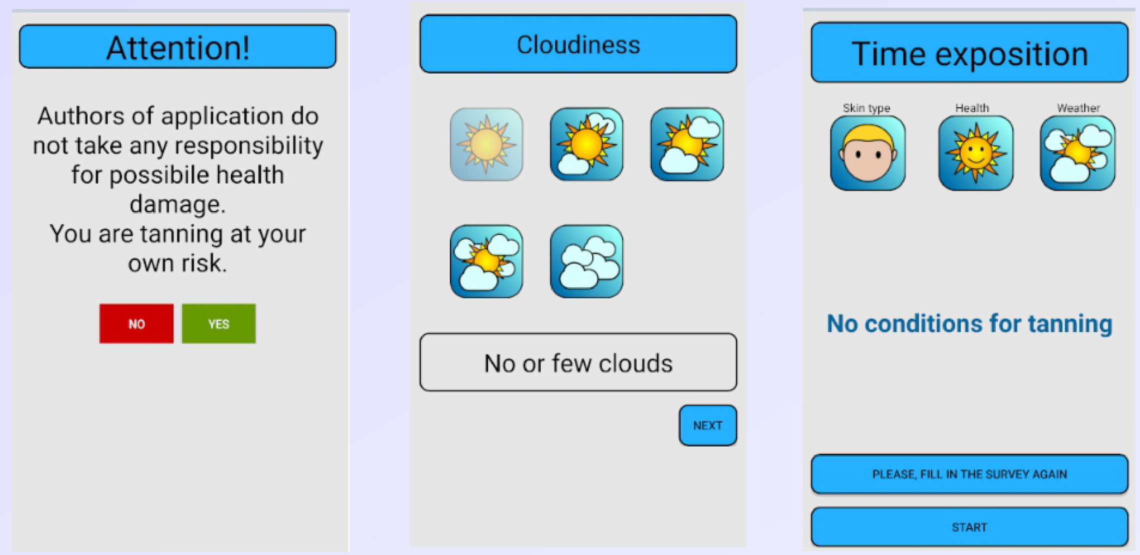

Fig. 5. Screenshots from "smart 1" application and QR code.

"smart 2" is based on measurements by hand-held UVI meter:

Fig. 6. Screenshots from "smart 2" application and QR code.

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5. Literature

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- Guzikowski J., Czerwińska A.E., Krzyścin J.W., Czerwiński M.A.: Controlling sunbathing safety during the summer holidays - The solar UV campaign at Baltic Sea coast in 2015, Journal of Photochemistry and Photobiology B: Biology, Available online 8 April 2017, ISSN 1011-1344, http://doi.org/10.1016/j.jphotobiol.2017.04.005.

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