# Mean radiant temperature modeling

## A comparative model evaluation

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## Introduction

Mean radiant temperature ($T_{mrt}$) is the key parameter of many human comfort indices, and is the most influential one for outdoor human thermal comfort. While we are well aware of observational $T_{mrt}$ differences owing to different measurement methods, we know little about the differences stemming from model simplifications (e.g. the estimation of short- and long wave radiations) and from different $T_{mrt}$ calculations (e.g. the use of different shape factors) in human biometeorological models. Considering the growing number of biometeorological models, the aim of the study is to fill this gap in our knowledge.

## Materials and methods

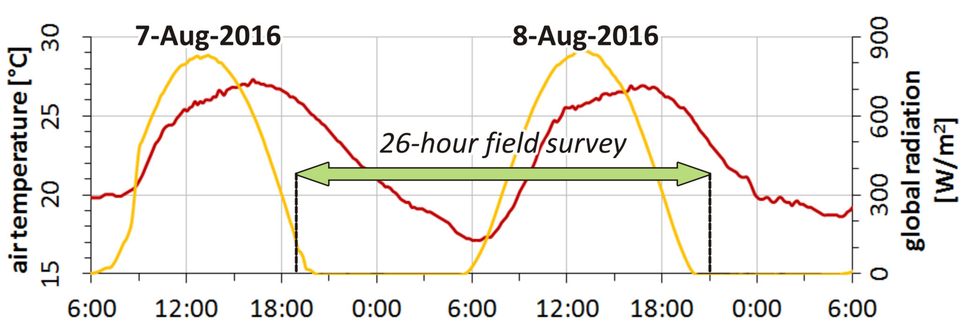
This study utilizes data from a unique, 26-hours-long filed measurement to assess the performance of three common microscale models (SOLWEIG v2016a, RayMan Pro v3.1 and ENVI-met v4.3). The measurement, conducted at Bartók Square (Szeged, Hungary), utilized two biometeorological stations equipped with Kipp & Zonen net radiometer.


Model input and basic configuration:

- The model resolution is 1 m in the case of RayMan and SOLWEG and 3 m in the case of ENVI-met.
- For forcing, data obtained from the urban meteorological station in Szeged, Hungary (operated by the Hungarian Meteorological Services and located 900 m from the site) is used.
- Simulations were started on August 7th, 2016 at 00:00 LST and run for 48 hours.
- Post-processing is done utilizing MATLAB.

| Environmental parameters | |
|---|---|
| Wall and ground albedo | 0.25 |
| Wall and ground emissivity | 0.95 |

| Human parameters | |
|---|---|
| Shortwave radiation absorption | 0.70 |
| Longwave radiation absorption | 0.97 |
| Human posture | standing |




## Conclusion

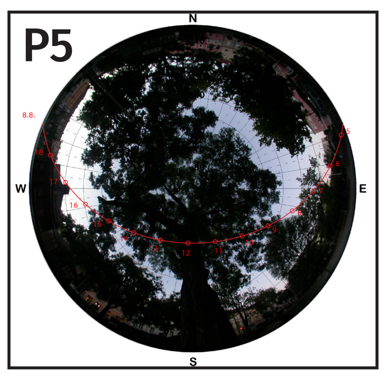
All three models tend to:

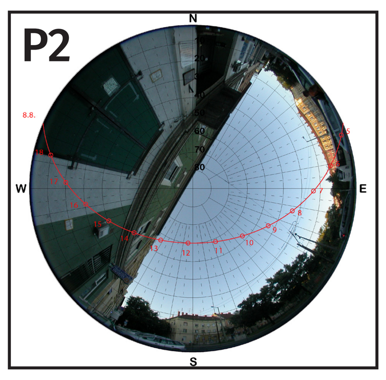
- Underestimate longwave radiation,
- Underestimate shortwave radiation when the site is exposed to direct solar radiation, and
- Overestimate shortwave radiation when in shade.

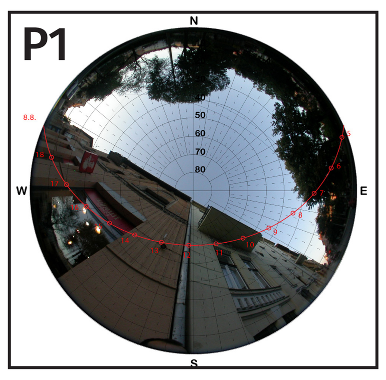
As a result, mean radiant temperature is:

- Underestimated at night,
- Generally overestimated in shade—however, $T_{mrt}$ overestimation is reduced by the underestimated longwave fluxes,
- $T_{mrt}$ is greatly underestimated in the sun due to the underestimated long- and shortwave radiation.

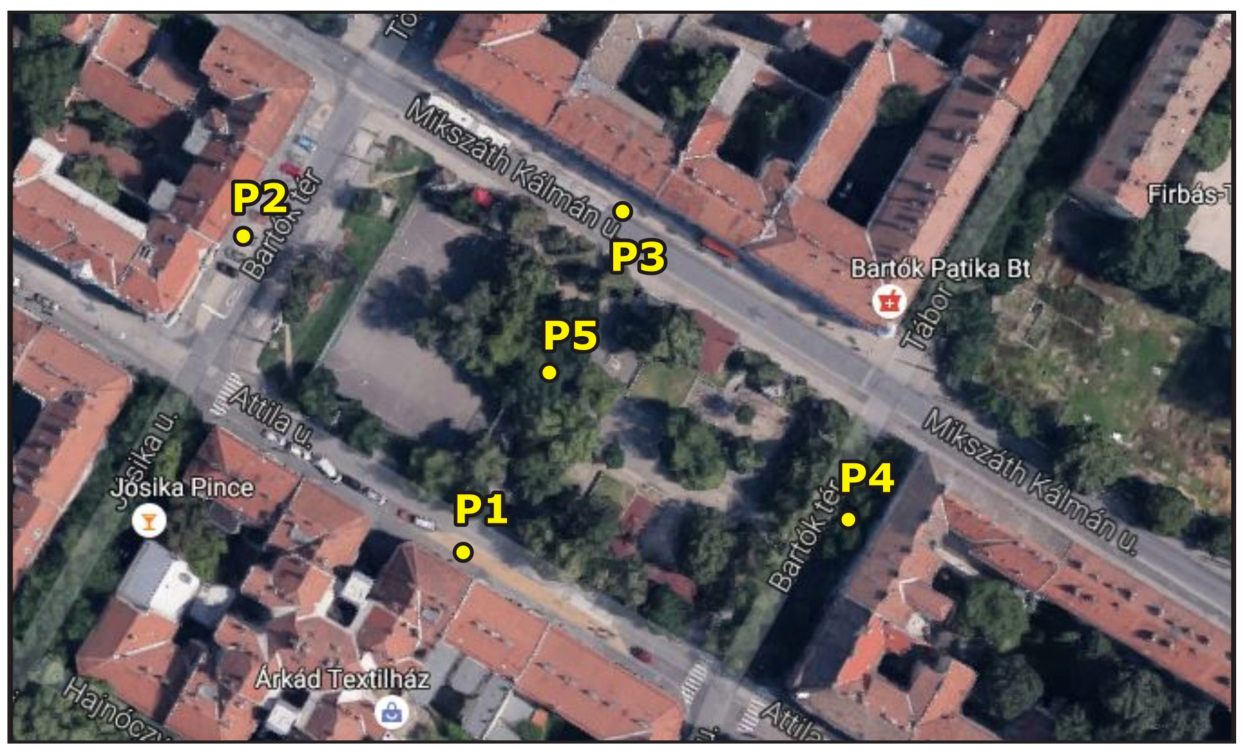
## Measurement site

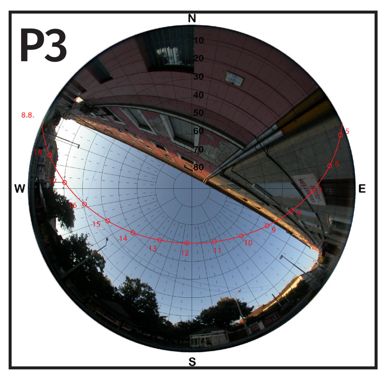


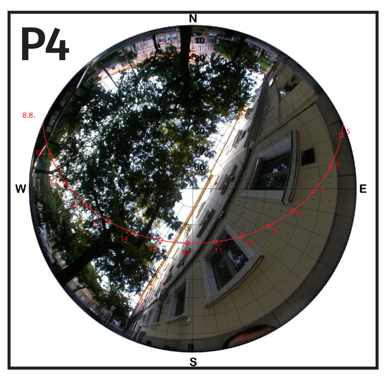



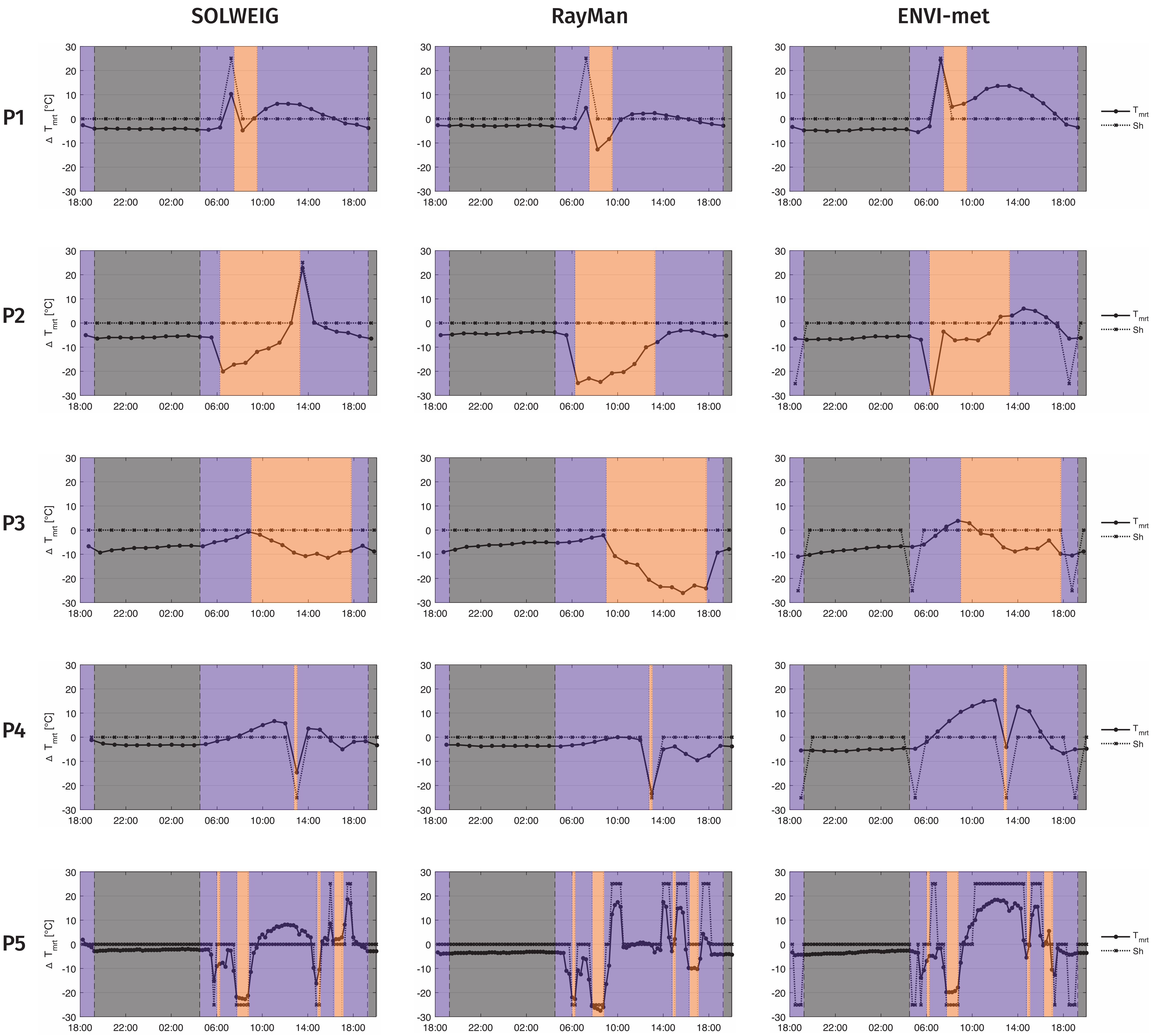

| Site | SVF |
|---|---|
| P1 | 0.43 |
| P2 | 0.48 |
| P3 | 0.50 |
| P4 | 0.08 |
| P5 | 0.17 |

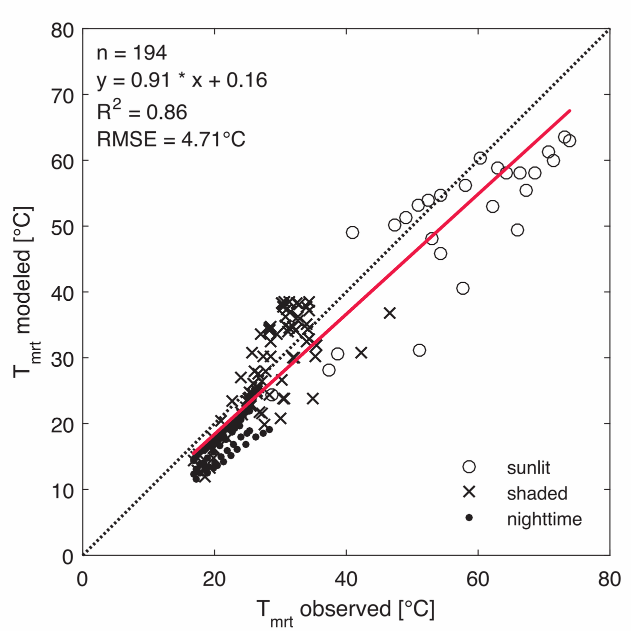


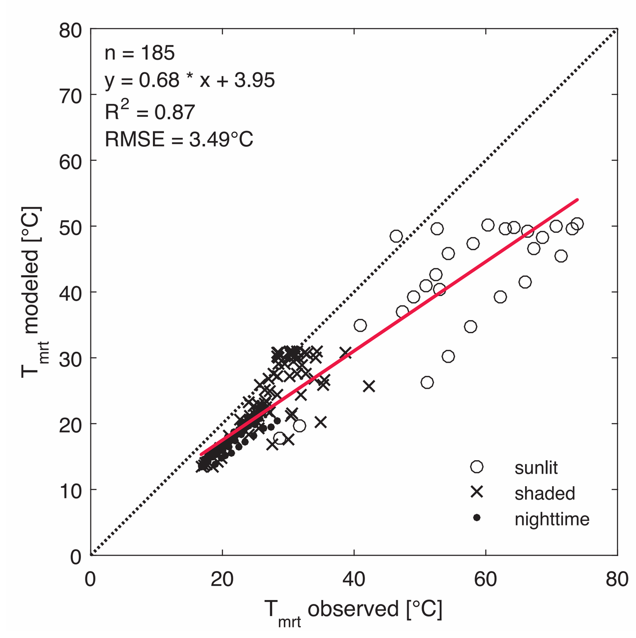



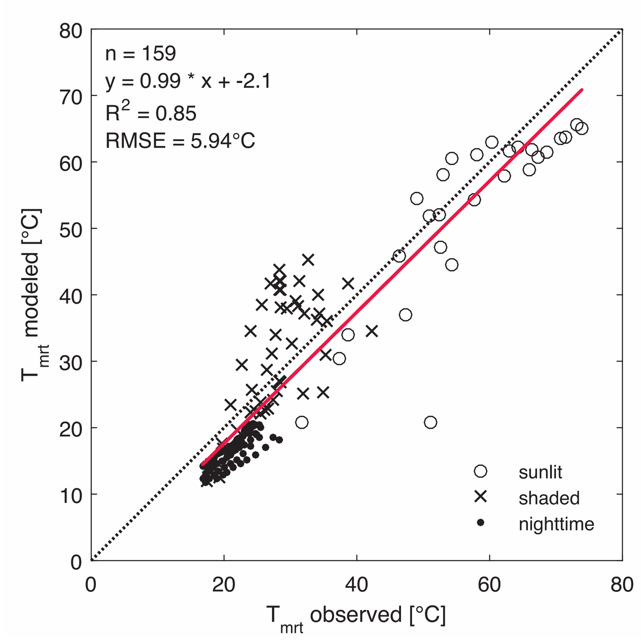




## Results




| | n | $R^2$ | RMSE |
|---|---|---|---|
| All | 194 | 0.86 | 4.71 |
| P1 | 25 | 0.89 | 3.59 |
| P2 | 25 | 0.94 | 4.04 |
| P3 | 26 | 0.99 | 2.38 |
| P4 | 25 | 0.76 | 3.13 |
| P5 | 93 | 0.83 | 4.20 |

| | n | $R^2$ | RMSE |
|---|---|---|---|
| All | 185 | 0.87 | 3.49 |
| P1 | 25 | 0.89 | 2.76 |
| P2 | 26 | 0.91 | 3.45 |
| P3 | 26 | 0.95 | 3.05 |
| P4 | 25 | 0.80 | 1.78 |
| P5 | 83 | 0.86 | 3.10 |

| | n | $R^2$ | RMSE |
|---|---|---|---|
| All | 159 | 0.85 | 5.94 |
| P1 | 25 | 0.83 | 5.80 |
| P2 | 24 | 0.88 | 6.71 |
| P3 | 23 | 0.97 | 4.02 |
| P4 | 22 | 0.48 | 7.48 |
| P5 | 65 | 0.91 | 3.04 |