WinProGen: A windows status profile generator based on Markov chains and field test data

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WinProGen: A windows status profile generator based on Markov chains and field test data

- Generates windows status (open/closed) profiles
- Written in Python
- Methods: Markov Chain, TPM, Inverse transform sampling
- Data driven:
  - 6 different residential buildings, each with 10 apartments
  - 1 office building with 60 office rooms
- Three models depending on time and daily average outdoor temperature

WinProGen: A windows status profile generator based on Markov chains and field test data

- Three models depending on time and daily average outdoor temperature
  - Model 1:
    - time of day
    - daily average outdoor temperature
  - Model 2:
    - time of day,
    - daily average outdoor temperature,
    - Day of week (weekend/ weekday distinction)
  - Model 3:
    - time of day,
    - daily average outdoor temperature of actual day
    - daily average outdoor temperature of previous day
- Models validated through Markov Chain Monte Carlo (MCMC)

WinProGen: the modelling technique

- Time discrete Markov Chain

$$P = \{X_{n1}|X_{n2}, X_{n3}, X_{n4} \dots X_n\} = \{X_{n1}|X_{n2}\}$$

$$P = \{X_{n1}|X_{n2}\} \neq \{X_{n2}|X_{n3}\}$$

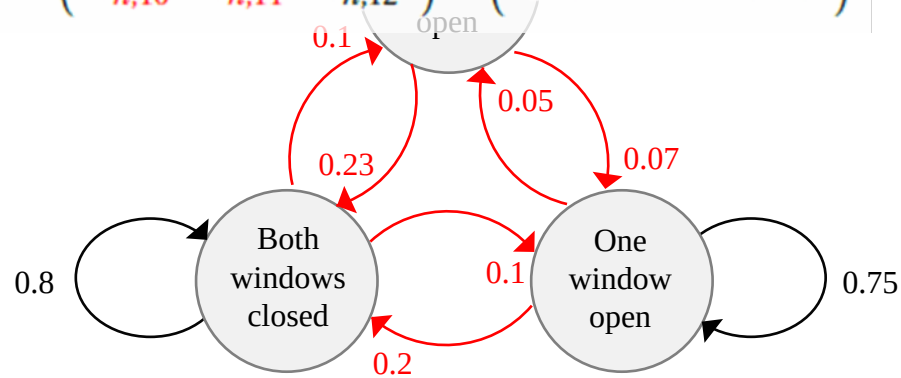
WinProGen: The Transition Probability Matrix

$$P_n = \begin{pmatrix} s_{n,00} & s_{n,01} & s_{n,02} \\ s_{n,10} & s_{n,11} & s_{n,12} \\ s_{n,10} & s_{n,11} & s_{n,12} \end{pmatrix} = \begin{pmatrix} 0.8 & 0.1 & 0.1 \\ 0.2 & 0.75 & 0.05 \\ 0.23 & 0.07 & 0.7 \end{pmatrix}$$

$$P_{n=1440} = \begin{pmatrix} s_{n,00} & s_{n,01} & s_{n,02} \\ s_{n,10} & s_{n,11} & s_{n,12} \\ s_{n,10} & s_{n,11} & s_{n,12} \end{pmatrix} = \begin{pmatrix} 0.87 & 0.02 & 0.11 \\ 0.12 & 0.79 & 0.09 \\ 0.21 & 0.03 & 0.76 \end{pmatrix}$$

$$P_{n=n} = \begin{pmatrix} s_{n,00} & s_{n,01} & s_{n,02} \\ s_{n,10} & s_{n,11} & s_{n,12} \\ s_{n,10} & s_{n,11} & s_{n,12} \end{pmatrix} = \begin{pmatrix} 0.8 & 0.1 & 0.1 \\ 0.2 & 0.75 & 0.05 \\ 0.23 & 0.07 & 0.7 \end{pmatrix}$$

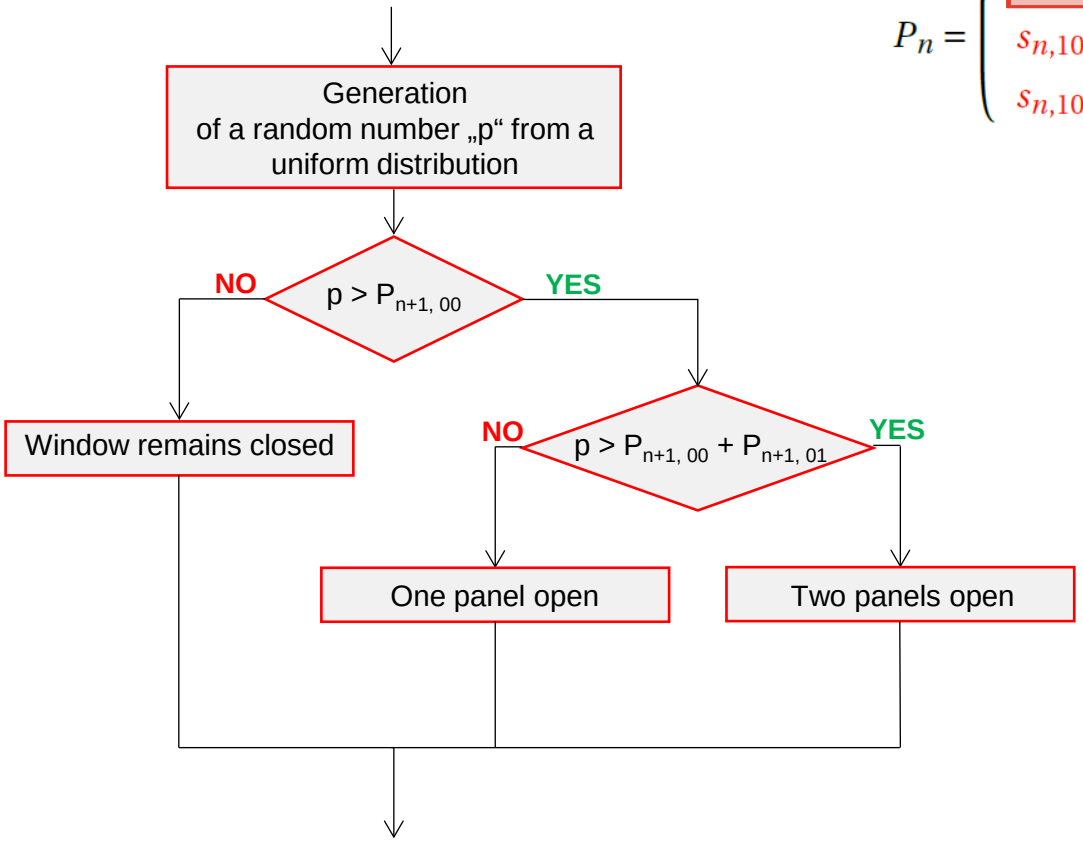
$$P_{n=1} = \begin{pmatrix} s_{n,00} & s_{n,01} & s_{n,02} \\ s_{n,10} & s_{n,11} & s_{n,12} \\ s_{n,10} & s_{n,11} & s_{n,12} \end{pmatrix} = \begin{pmatrix} 0.89 & 0.01 & 0.1 \\ 0.25 & 0.73 & 0.02 \\ 0.22 & 0.02 & 0.76 \end{pmatrix}$$



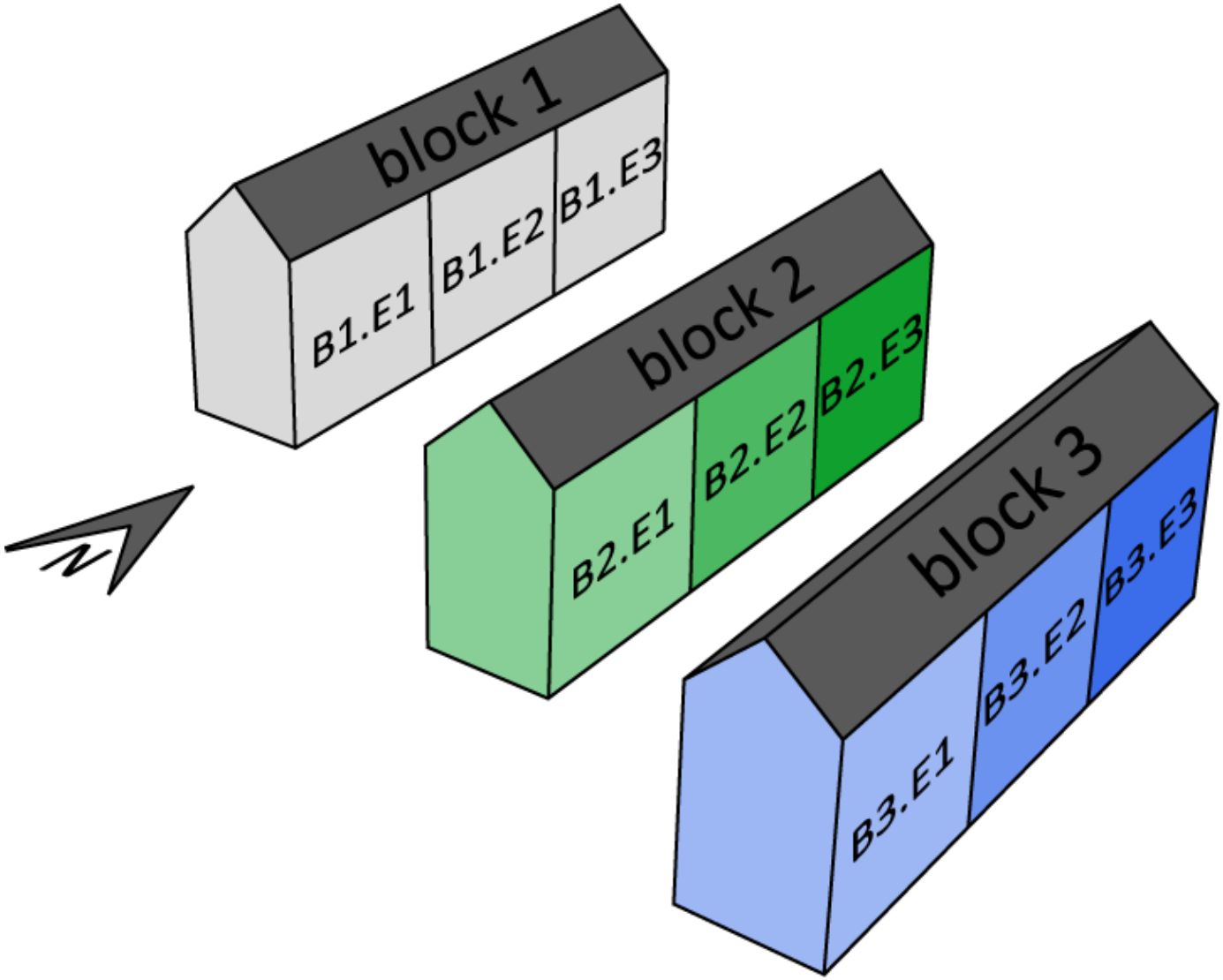
WinProGen: Inverse transform sampling

- Timestep „n“, window is closed

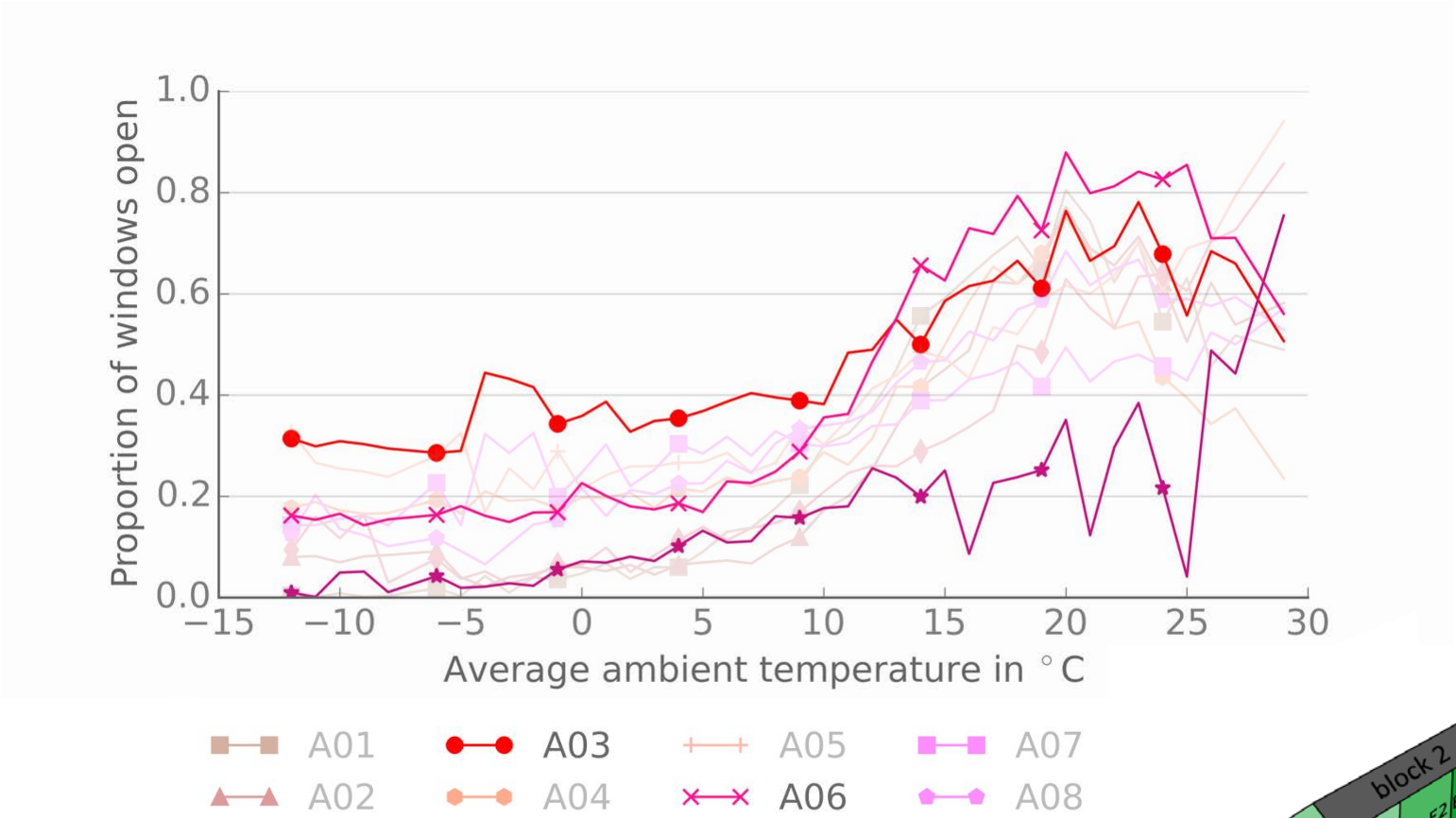
$$P_n = \begin{pmatrix} s_{n,00} & s_{n,01} & s_{n,02} \\ s_{n,10} & s_{n,11} & s_{n,12} \\ s_{n,10} & s_{n,11} & s_{n,12} \end{pmatrix} = \begin{pmatrix} 0.8 & 0.1 & 0.1 \\ 0.2 & 0.75 & 0.05 \\ 0.23 & 0.07 & 0.7 \end{pmatrix}$$

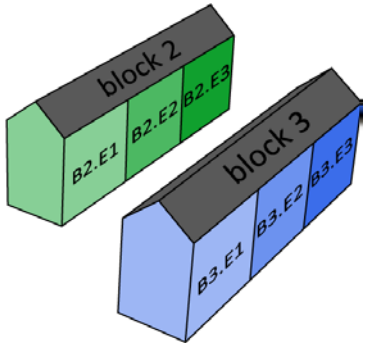


WinProGen: The residential buildings



WinProGen: Evaluation of the residential buildings data





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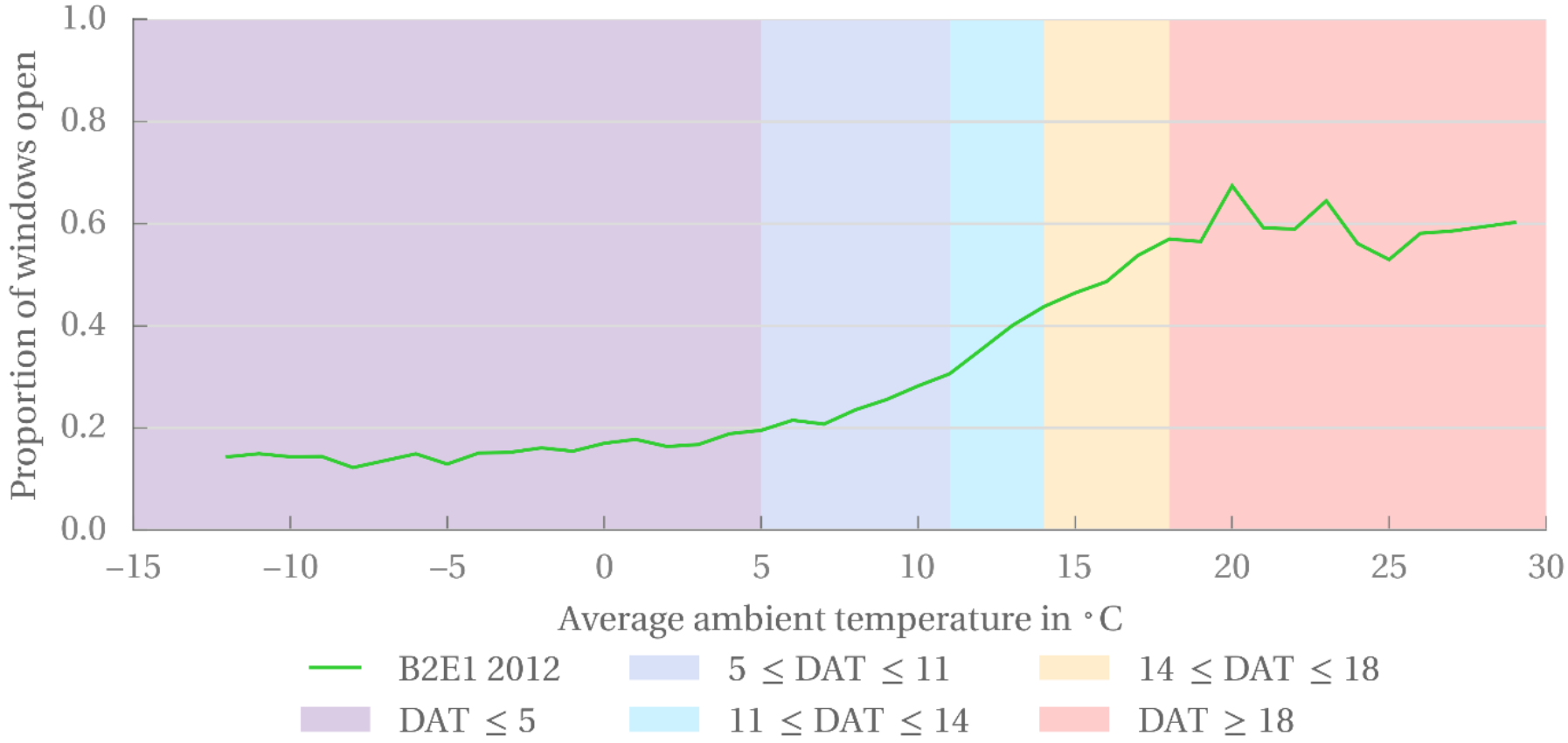
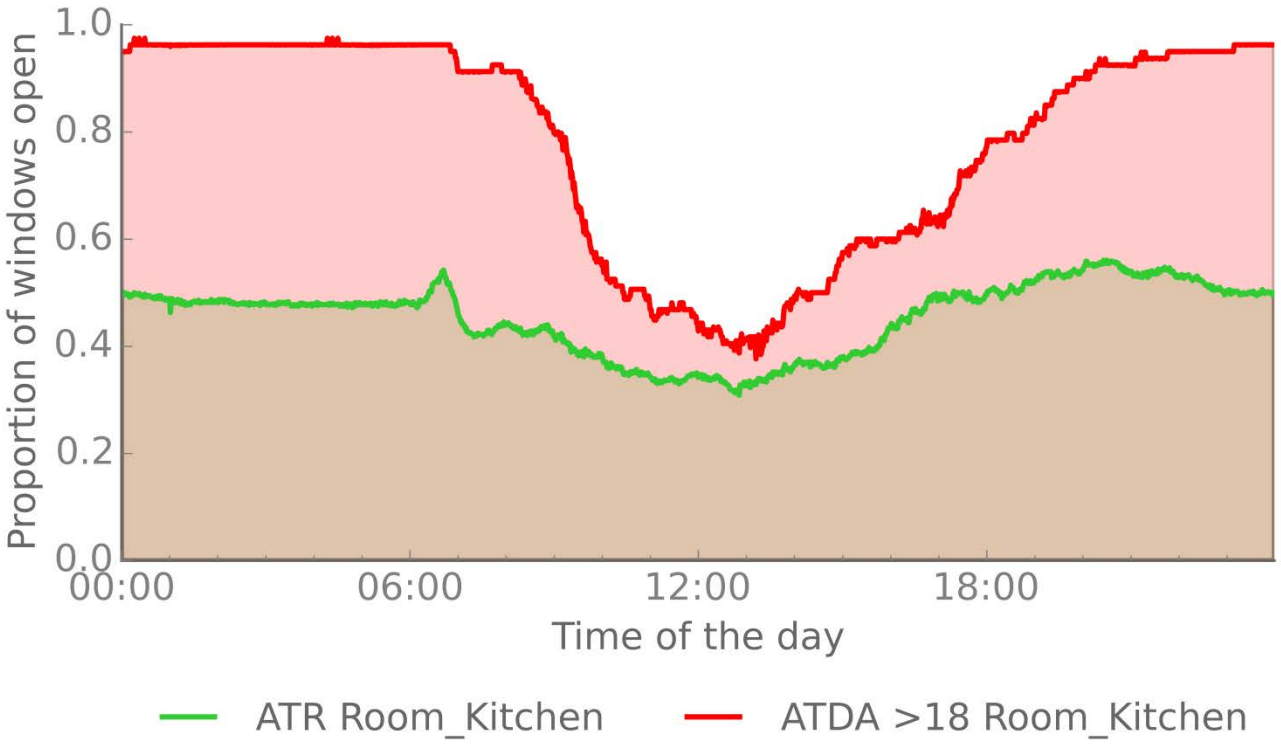
WinProGen: Evaluation of the residential buildings data

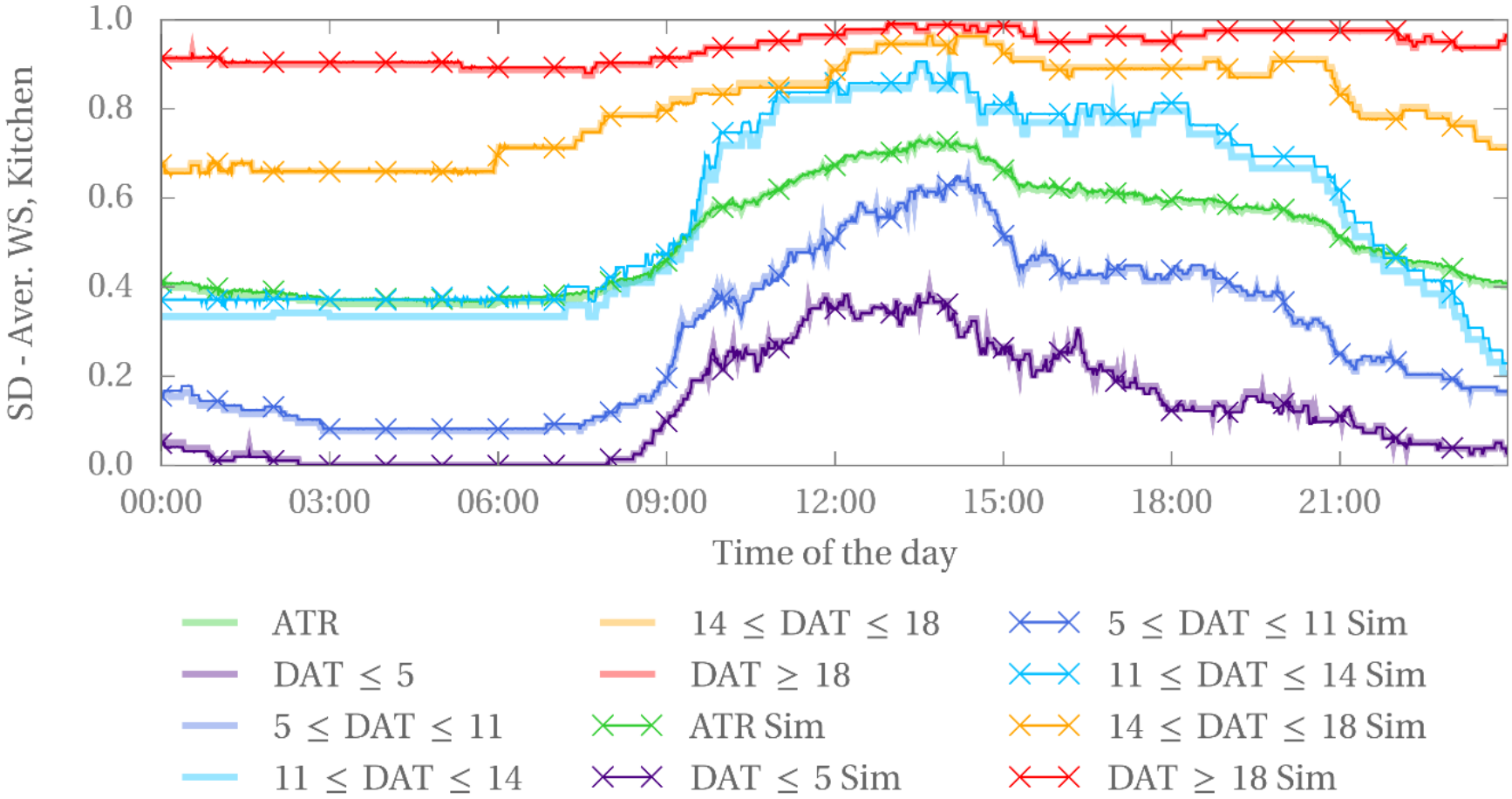
- Conditions for the selection of the temperature intervals:
  - Enough data to build the TPM
  - Small differences in the proportion of windows open



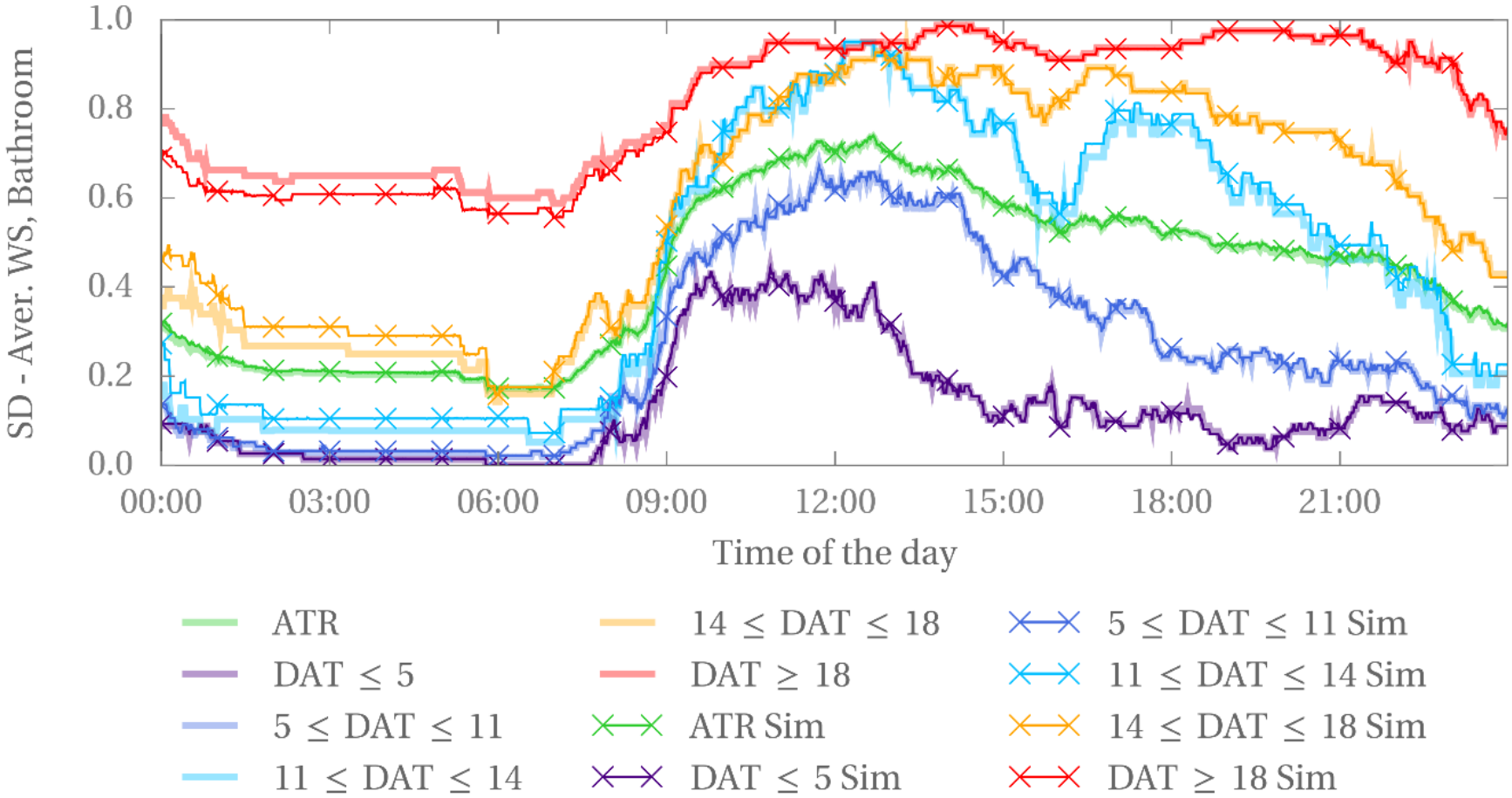
WinProGen: Evaluation of the residential buildings data, Daily profiles



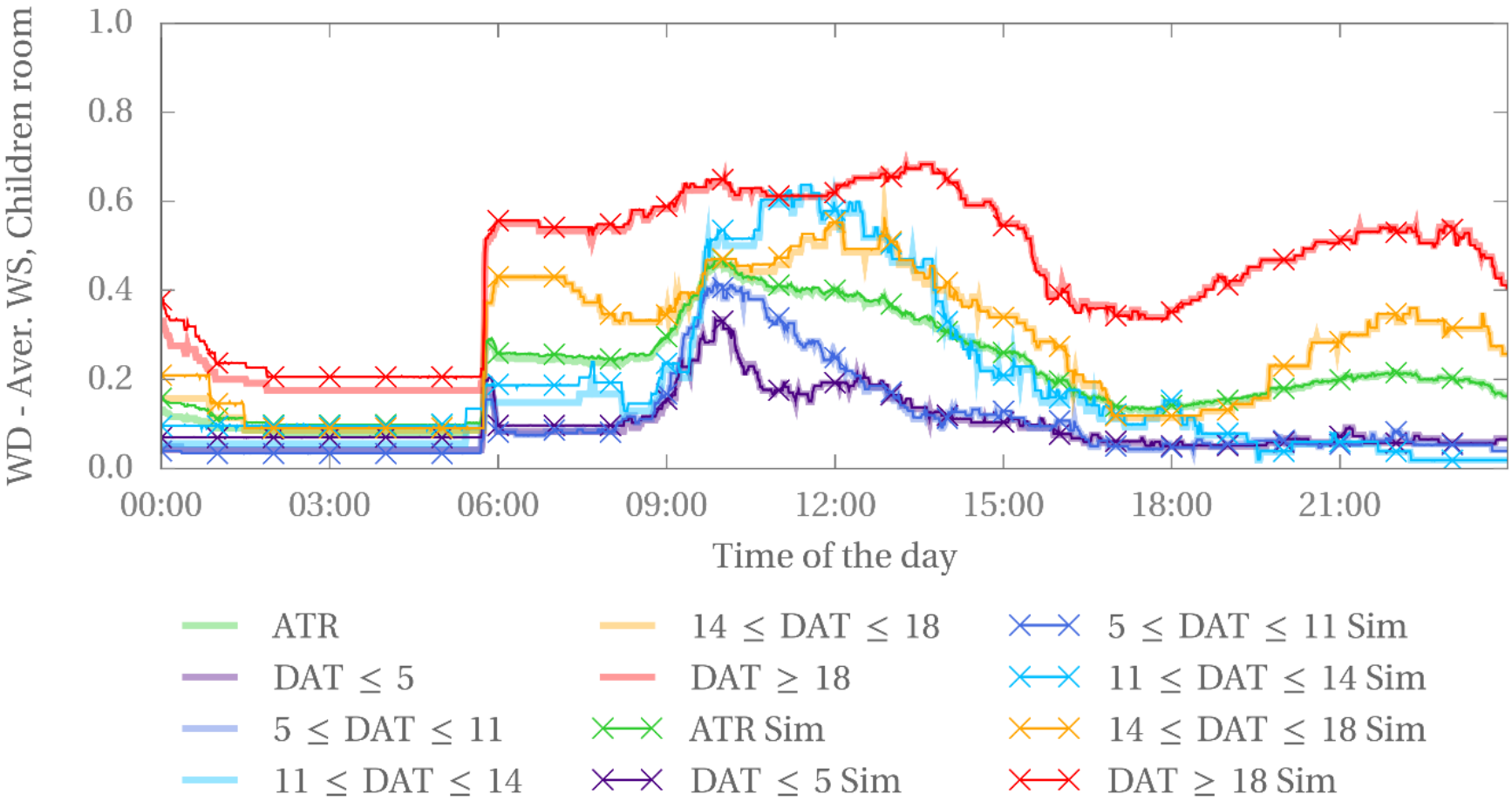
WinProGen: MCMC results, Model 1, a kitchen



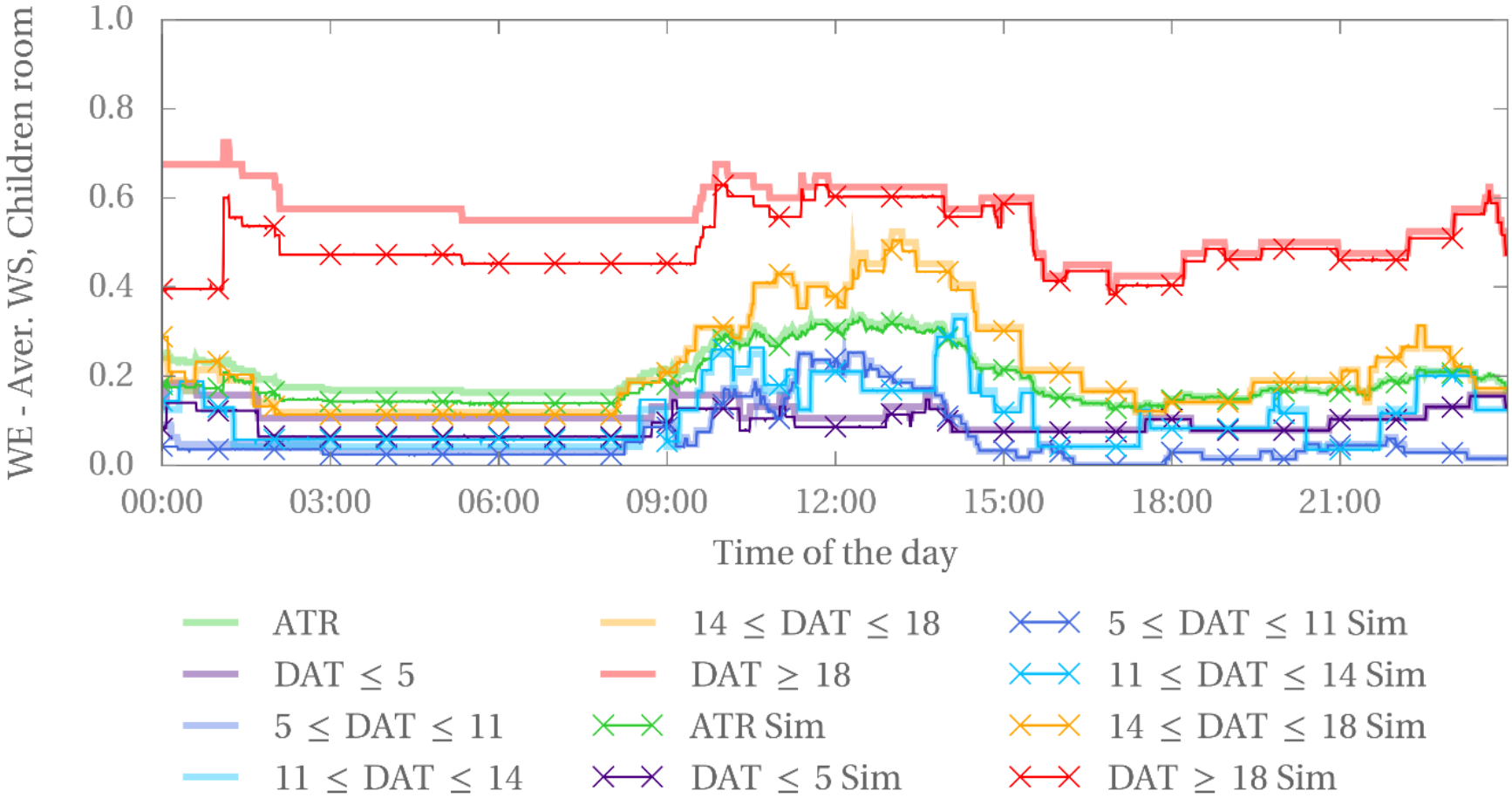
WinProGen: MCMC results, Model 1, a bathroom



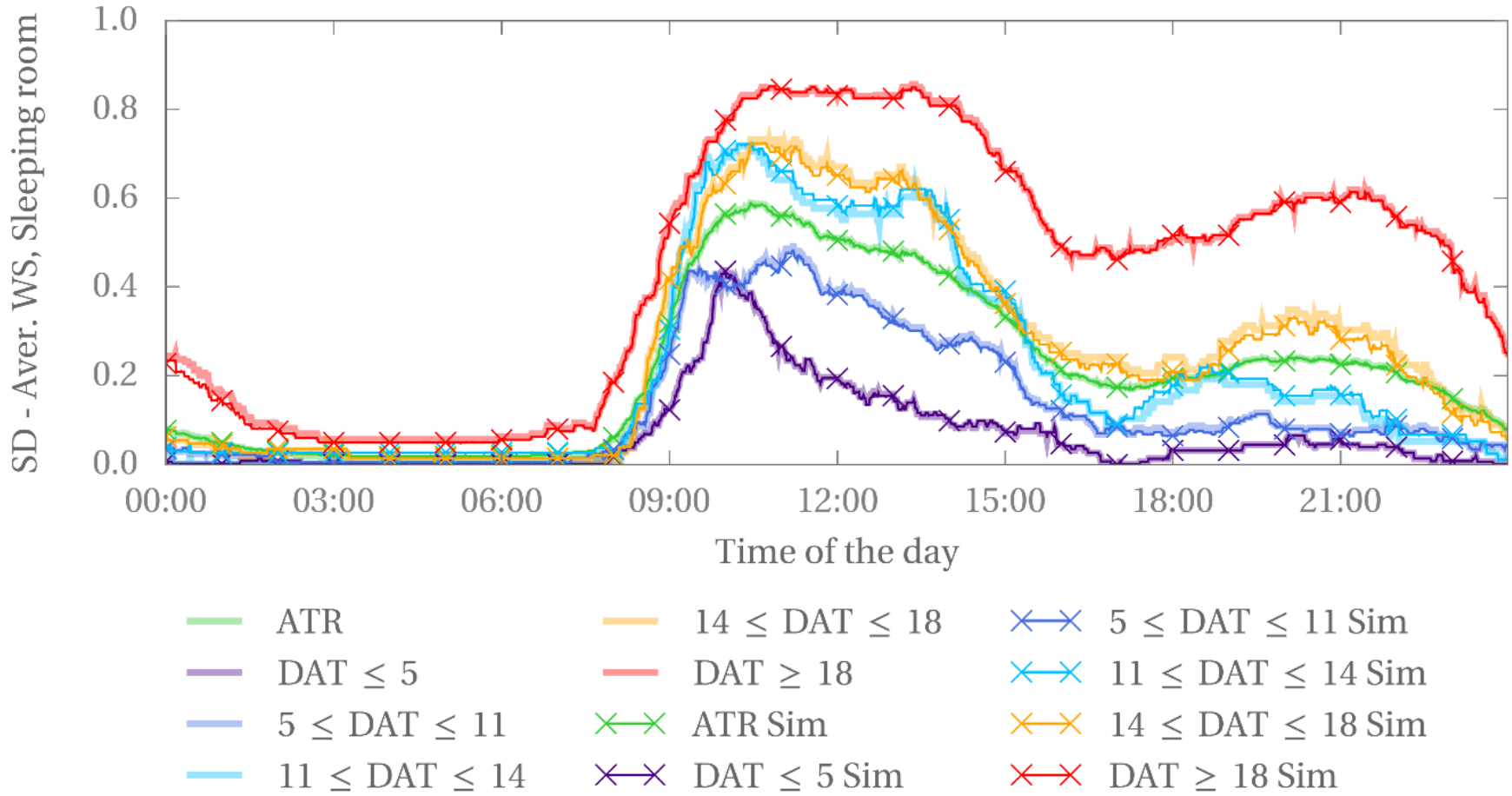
WinProGen: MCMC results, Model 2, a children room



WinProGen: MCMC results, Model 2, a children room

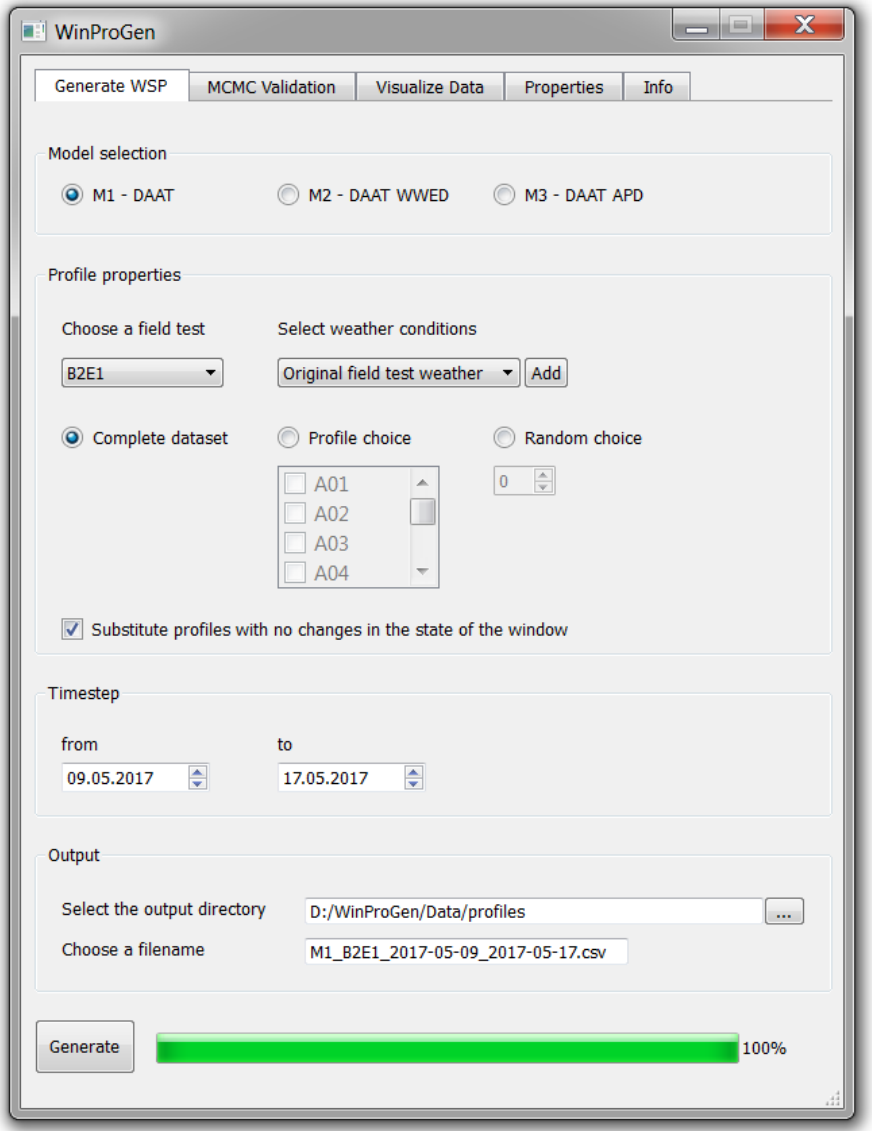


WinProGen: MCMC results, Model 3, a sleeping room



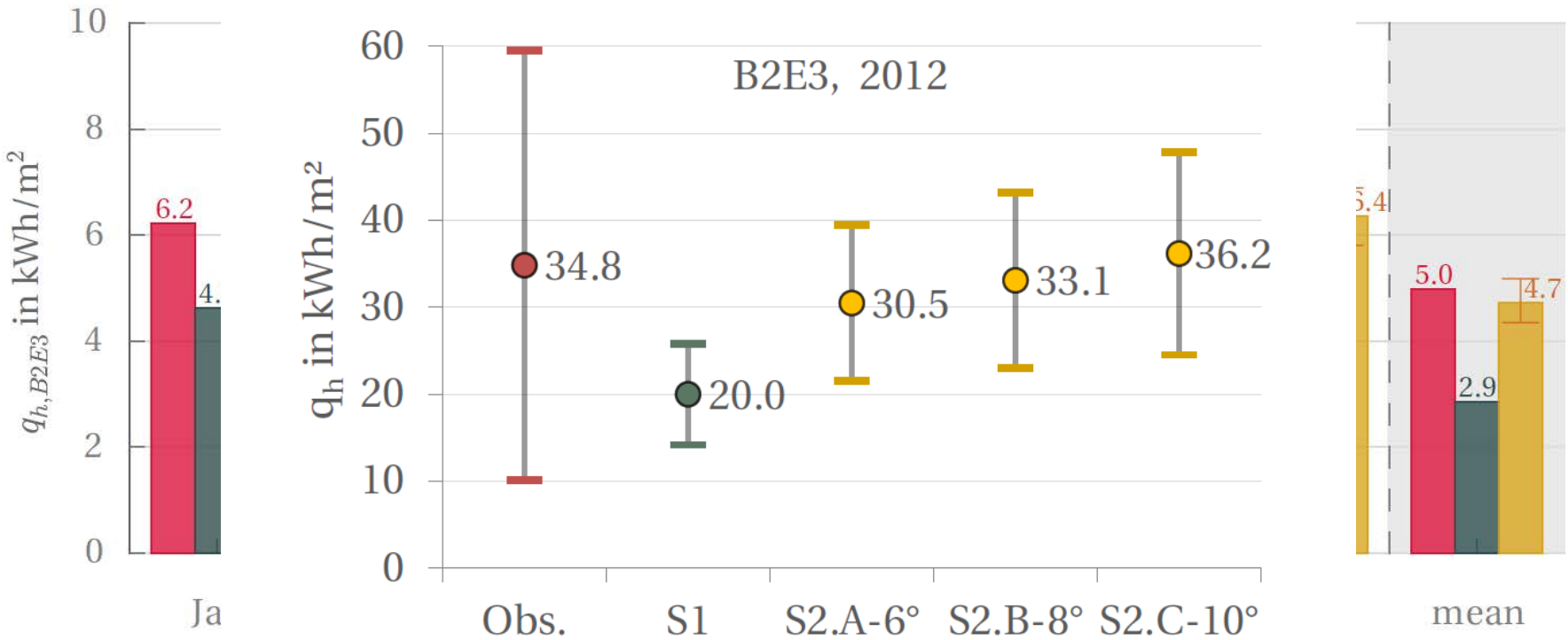
WinProGen: The Tool

- Offers 3 different models
- Based on data from 7 buildings
- Can integrate new field test data (automatic generation of TPMs)
- Permit validation (MCMC) with own data
- Weather profile can be loaded to generate specidic window state profiles
- Allows visualization of measured and generated data



Effect of natural ventilation on the expected energy use of buildings within BEPS, B2E3, 2012

- Scenario 1: T_{set}=20°C, n=0.5 1/h
- Scenario 2: T_{set}=20°C, n variable, simulated with measured windows state profiles and 3 different opening angles (6°, 8°, 10°)



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