Approaches to the evaluation of the predictive performance of occupant behavior models

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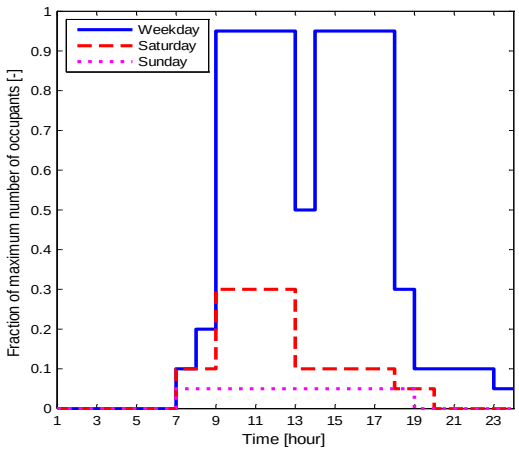
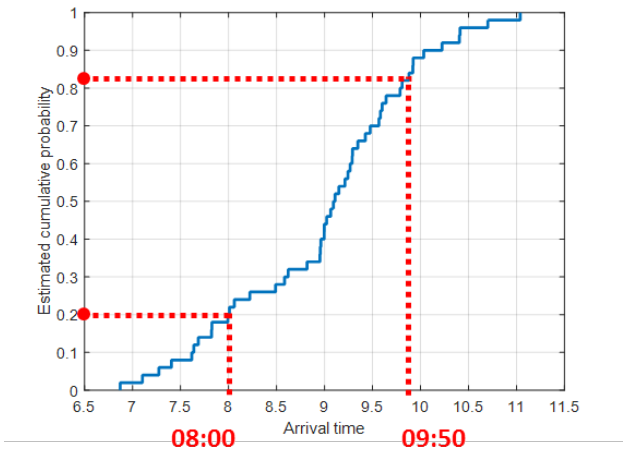
Reliability of occupant behaviour models

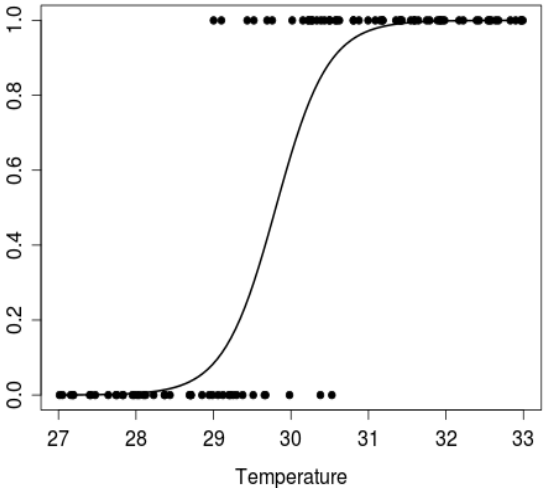
- Limited underlying empirical information
- Evaluation statistics
- Original and calibrated model coefficients
- Addressing the model feedback in the process

On the quality evaluation of behavioral models for building performance applications

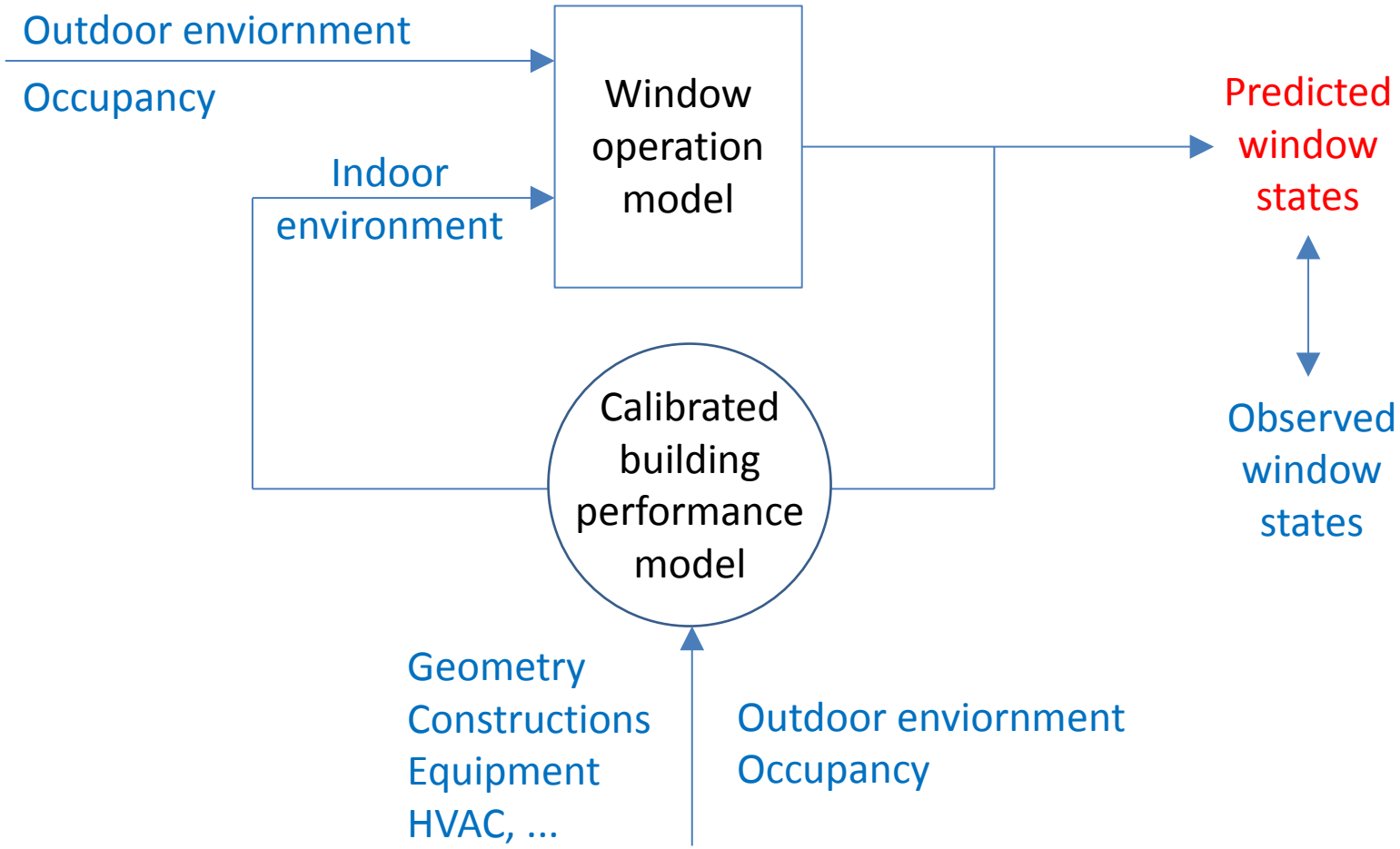
A. Mahdavi, F. Tahmasebi
Journal of Building Performance Simulation (2016)







Inclusion of feedback loop in model evaluation

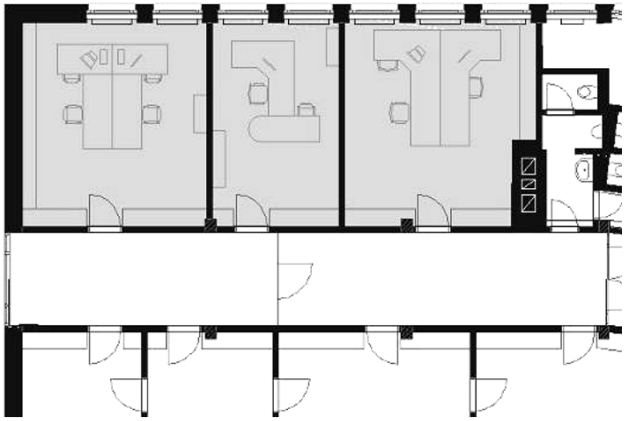


An inquiry into the reliability of window operation models in building performance simulation

F. Tahmasebi, A. Mahdavi
Building and Environment 105 (2016), 343–357

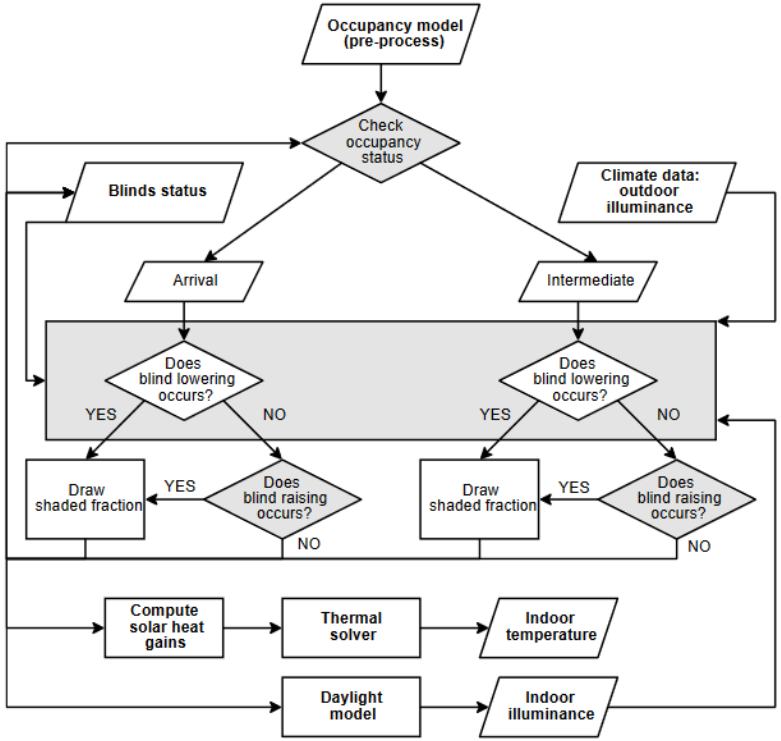
Case study – An external evaluation

- An office building located in Hartberg, Austria
- 6 offices on 2 floors
- Single and double occupant offices
- 10 workstations and 14 windows
- Internal shades: drapes
- External shades: venetian blinds



A model for operation of shades (Haldi & Robinson 2010)

- Check the occupancy states (Arrival, intermediate)
- Calculation of $P_{closing}$ and $P_{opening}$ to set the action type
  (ind. variables: indoor illuminance, shade state)
- Inverse transform sampling to trigger action
- Check the occurrence of a full opening or closing action
  (ind. variables: outdoor illuminance, shade state)
- If not a full action, deriving the shaded fraction from a fitted Weibull distributions
  (as function of the initial shade state)



Model evaluation approaches

E.1) Predicted and observed states

- 100-run Monte-Carlo simulation
- Discontinuous and continuous model run

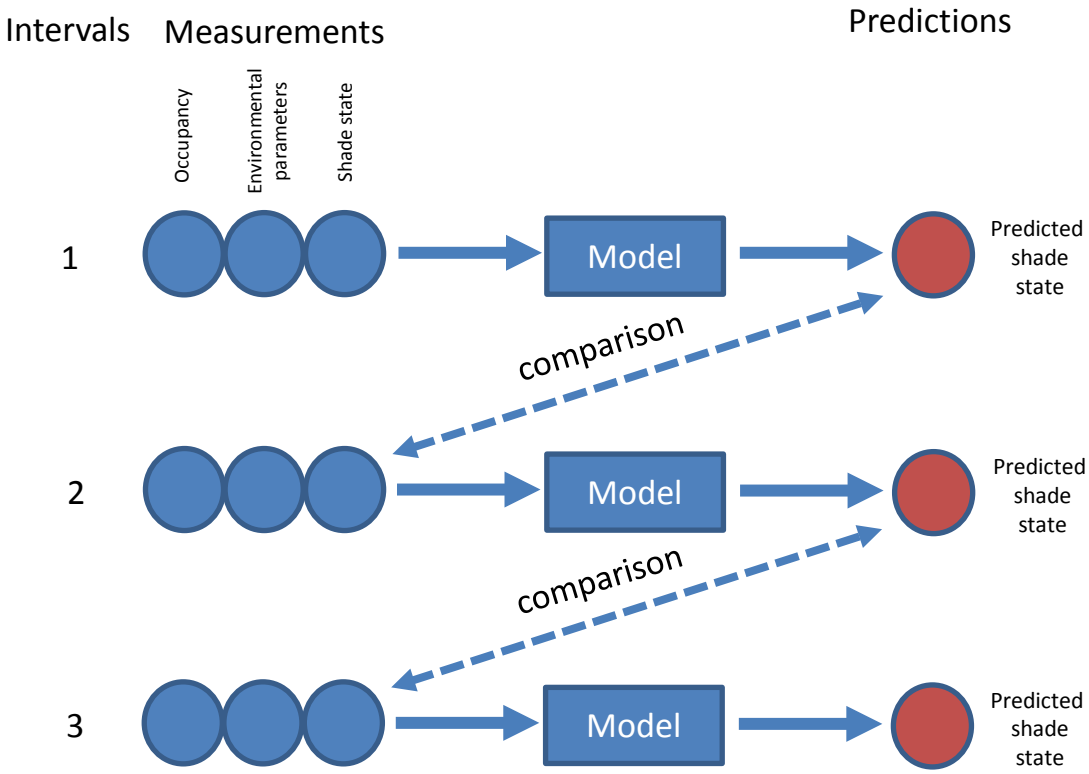
E.2) Predicted actions probabilities and observed actions

- One-time model run
- Inclusion of model feedback not necessary

E.3) Predicted and observed action

- 100-run Monte-Carlo simulation
- Continuous model run

E.1) Predicted and observed states - Discontinuous model run



E.1) Predicted and observed states - Discontinuous model run

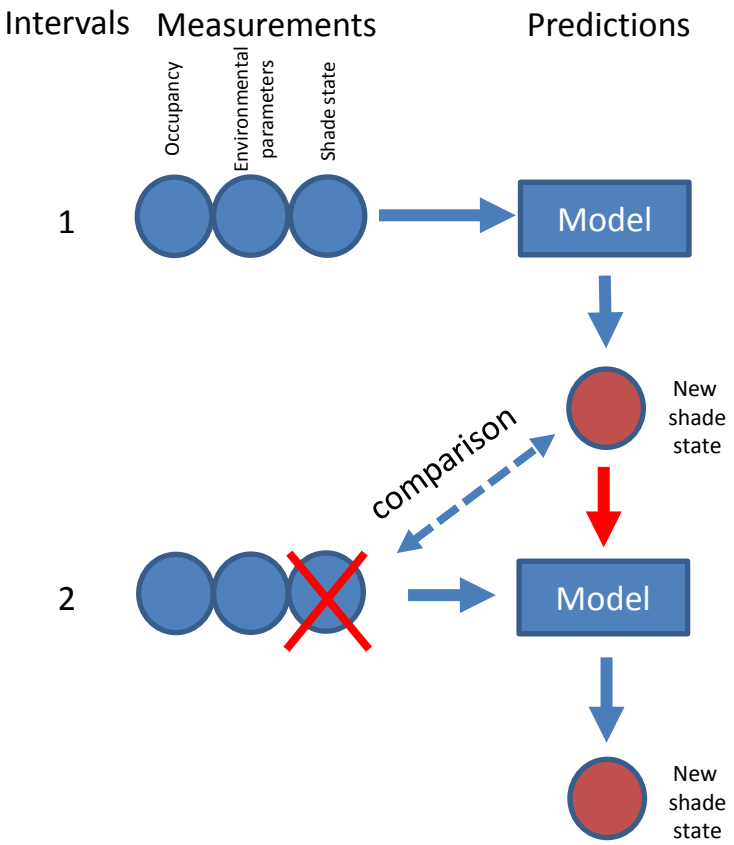
Interior shading

Shading states source	Mean shaded fraction	MBE	RMSE
Measured	42.2%	0.00%	0.0%
Stochastic shading model	42.1%	-0.05%	3.9%
No-Action model	42.2%	0.00%	2.8%

Exterior shading

Shading states source	Mean shaded fraction	MBE	RMSE
Measured	4.3%	0.00%	0.0%
Stochastic shading model	4.4%	0.02%	2.2%
No-Action model	4.3%	0.00%	1.1%

E.1) Predicted and observed states - Continuous model run



E.1) Predicted and observed states - Continuous model run

Interior shading

Shading operation model	Mean shaded fraction	MBE	RMSE
Measured	42.0%	0.0%	0.0%
Stochastic shading model	14.3%	-27.9%	64.3%

Exterior shading

Shading operation model	Mean shaded fraction	MBE	RMSE
Measured	4.0%	0.0%	0.0%
Stochastic shading model	14.0%	9.7%	40.3%

E.2) Predicted actions probabilities and observed actions

Intervals	Observed state	Observed openings	Predicted opening probabilities	Absolute residuals
1	1	0	0.1	0.1
2	1	0	0.1	0.1
3	1	1	0.2	0.8
4	0	0	-	-
5	0	0	-	-
6	1	1	0.3	0.7
7	0	0	-	-
8	1	0	0.1	0.1

1: closed
0: open

1: opening
0: no opening

Mean absolute residuals of opening probabilities $= \dfrac{0.1 + 0.1 + 0.8 + 0.7 + 0.1}{5} = 0.36$

E.2) Predicted actions probabilities and observed actions

Interior shading

Window number	Mean absolute residual of predicted probabilities	
	Opening	Closing
1	0.053	0.001
2	0.035	0.002
3	0.002	0.003
4	0.016	0.001
5	0.002	0.112
6	0.002	NaN
7	0.003	0.071
8	0.905	0.002
9	0.028	0.003
10	0.997	0.001
11	0.036	0.001
12	NaN	0.005
13	0.028	0.007
14	0.052	0.005
Total	**0.003**	**0.002**

- One-time model run
- Inclusion of feedback not required
- Interpretation not necessarily straightforward
- Not the overal performace of the model in time frames such as a day or a saason (e.g., state duration of devices or frequency of actions in specific time periods)

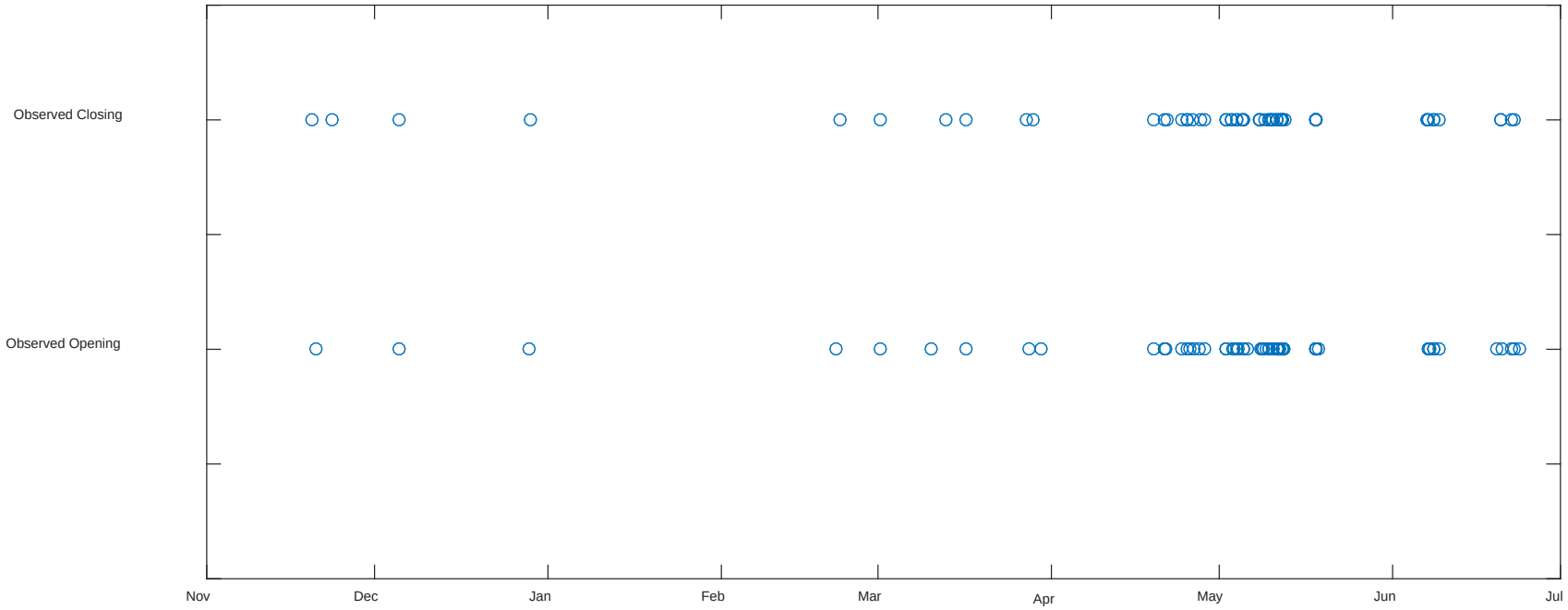
E.3) Predicted and observed action – Number of actions

Interior shading

Window number	Number of measured actions		Number of predicted actions		Number of actions Relative Error	
	Opening	Closing	Opening	Closing	Opening	Closing
1	6	6	0.1	4.2	-97.8%	-29.7%
2	17	17	0.6	5.1	-96.7%	-70.2%
3	1	1	20.8	0.2	1981.0%	-83.0%
4	2	2	0.3	4.6	-85.5%	131.0%
5	4	4	18.5	0.1	361.3%	-98.8%
6	0	0	20.6	0.0	NaN	NaN
7	11	11	20.1	0.1	82.8%	-99.2%
8	1	1	0.1	1.2	-88.0%	24.0%
9	3	3	0.2	2.2	-92.0%	-28.0%
10	2	2	0.0	3.9	-99.0%	92.5%
11	3	3	0.1	2.3	-95.7%	-25.0%
12	0	0	0.0	7.0	NaN	NaN
13	8	8	0.6	2.5	-93.1%	-68.6%
14	3	3	0.1	3.2	-97.0%	5.3%
Total	**61**	**61**	**82.1**	**36.4**	**34.5%**	**-40.3%**

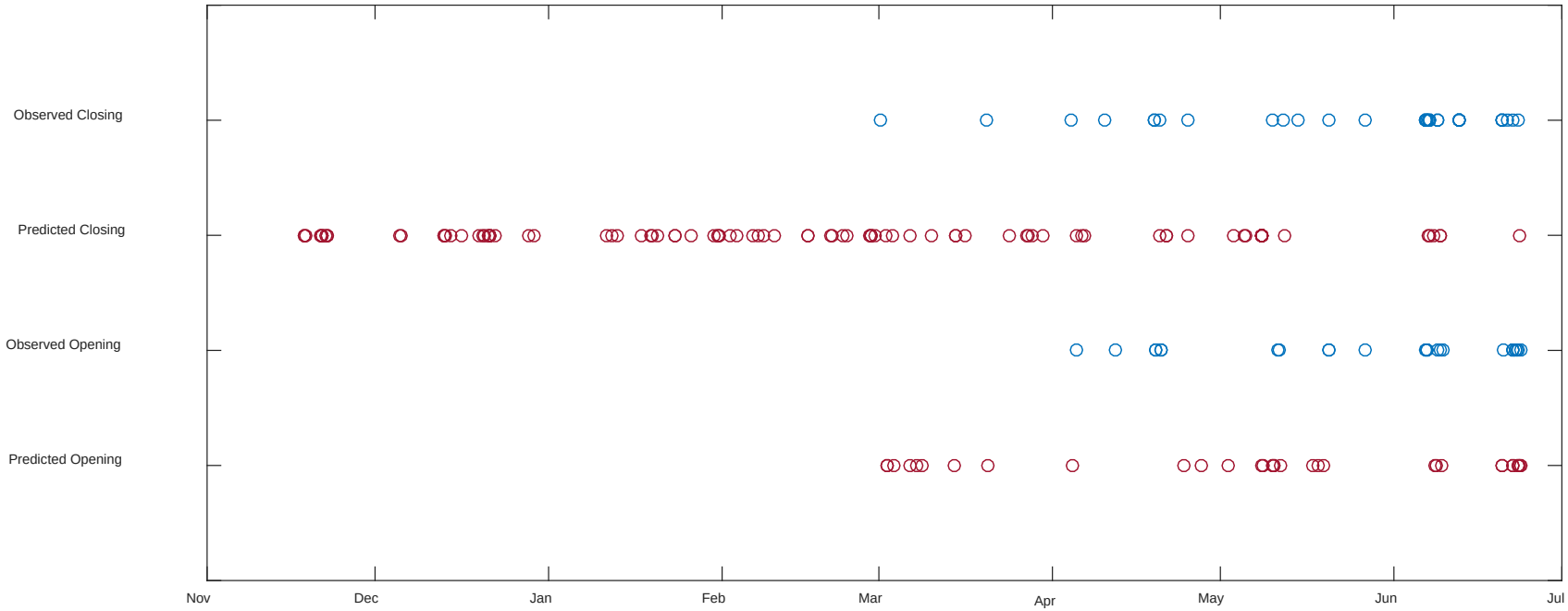
E.3) Predicted and observed action – Seasonal patterns

Interior shades



E.3) Predicted and observed action – Seasonal patterns

Exterior shades



Conclusion

- Occupant behavior models developed based on limited number of buildings may not perform satisfactory in new settings.
- Different type of shades need different models / coefficients
- Without inclusion of models' feedback, occupant behavior models cannot be fully evaluated.
- Further work necessary in formaulation of evaluation procedures and indicators.

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