# Excercise 3 - Grey-box models (continued)

*Marco Hernandez Velasco*

*August 2018*

The exercise is focused on grey-box modelling of the heat dynamics of a (small) building using stochastic differential equations (SDEs). In addition to the first exercise on greybox modelling, we will in this exercise test different techniques to:

1. Alter the noise level or system uncertainty to account for e.g. non-linear phenomena.

2. Build a semi-parametric model to take into account that the solar penetration (i.e. relation between measured solar radiation and radiation entering into the building) as function of the position of the sun.

3. Balance heat gains to the air temperature and the temperature of the thermal mass.

The data consists of several measurement from a small test box with a single window. In this exercise the following signals are used:

- Ti (yTi in data) the observed indoor temperatures. (C)

- Qi (Qi in data) the heat emitted by the electrical heaters in the test box (W)

- Te (Te in data) the ambient temperature (C)

- Gv (Gv in the data) the vertical south total solar radiation (W/m2)

- Gvn (Gvn in data) the vertical north total solar radiation (W/m2)

# Question 1
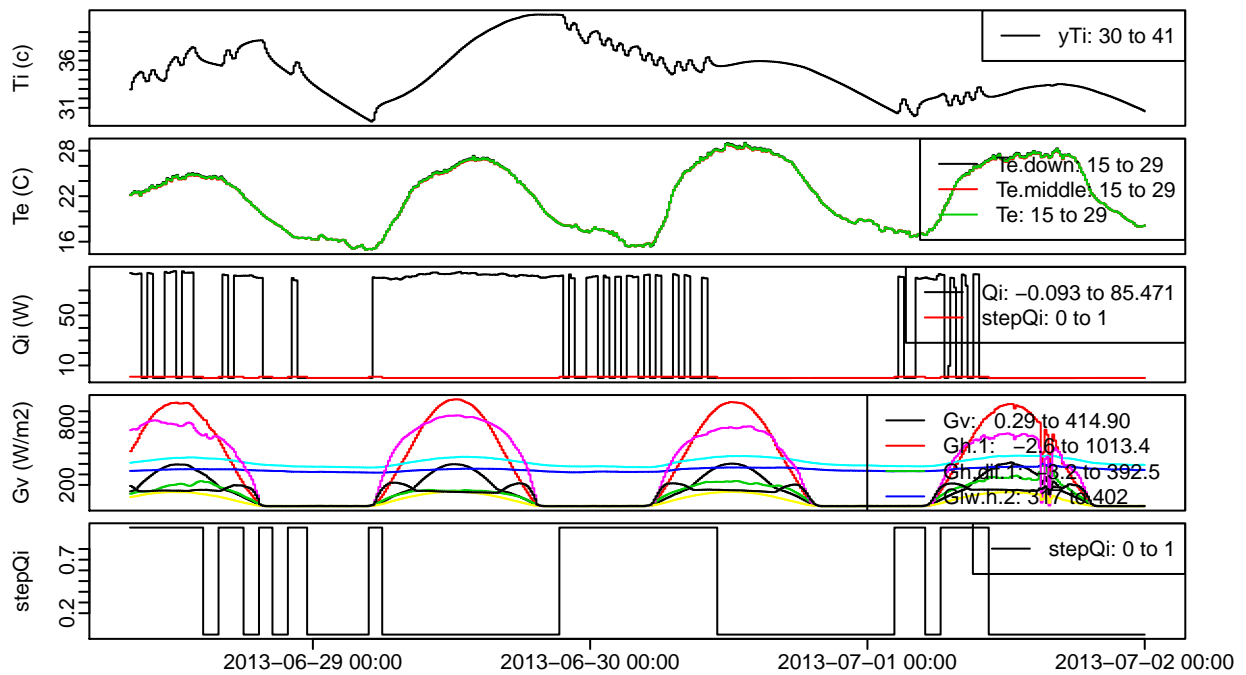


The lower time series plot is of stepQi, which goes from 0 to 1. Try to change the argument samples_after_Qi_step above in the function preparing the data. How does it change stepQi?
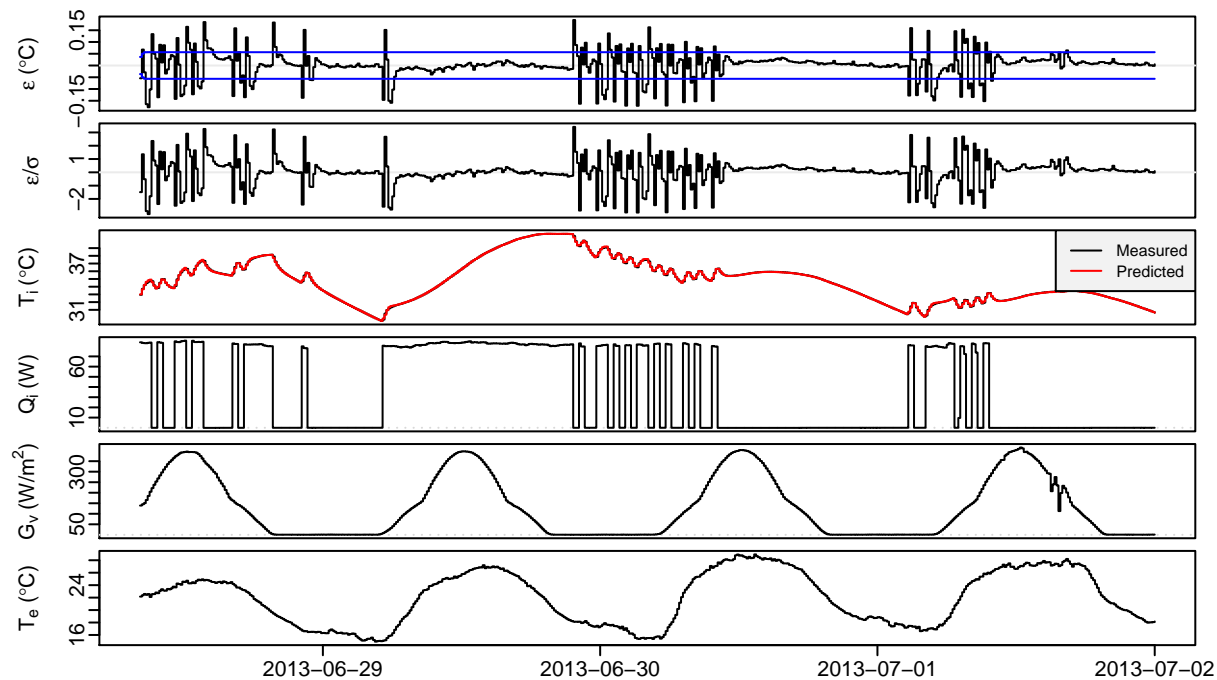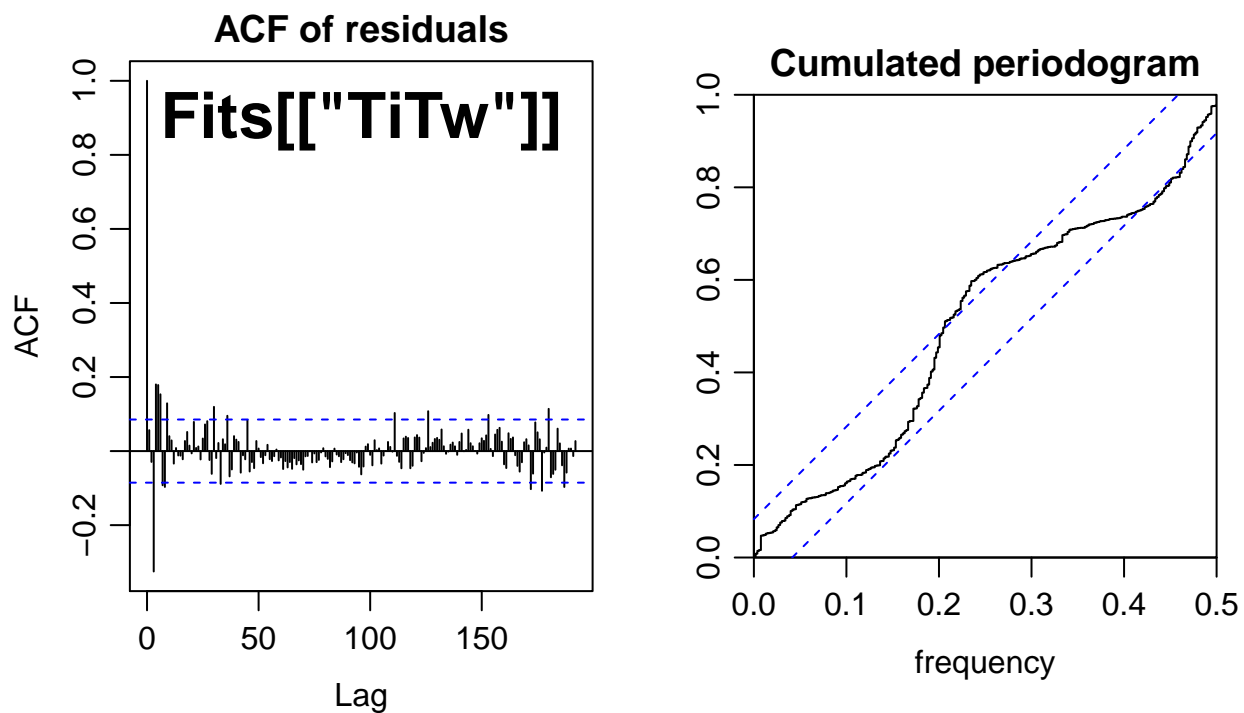
*Making the samples_afterQi_step, makes the on/off intervals longer or shorter and makes it able to correspond better to the actual heater's behavior. Like below with a step = 0.5.*
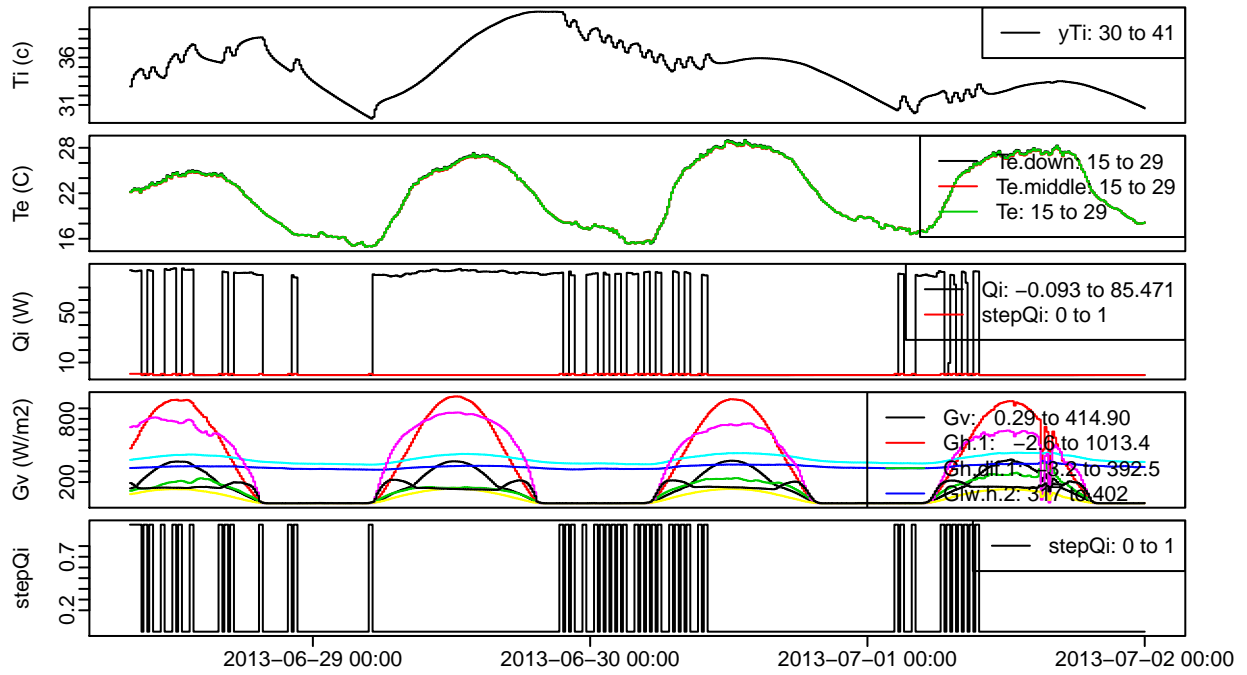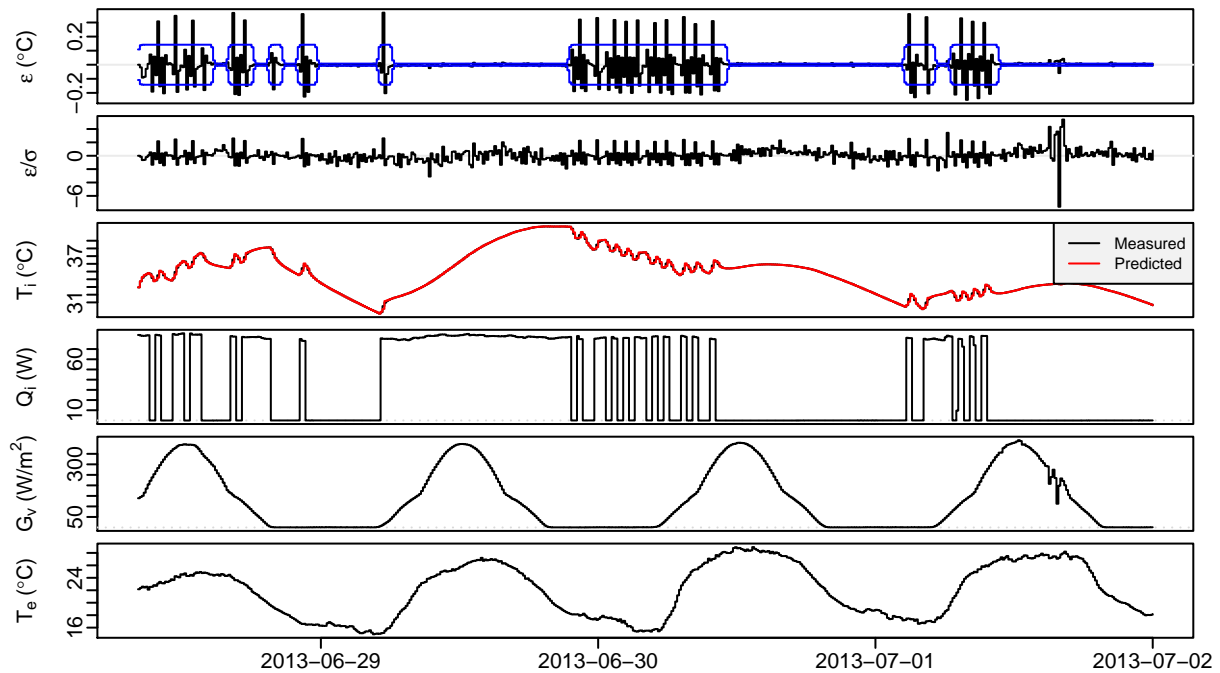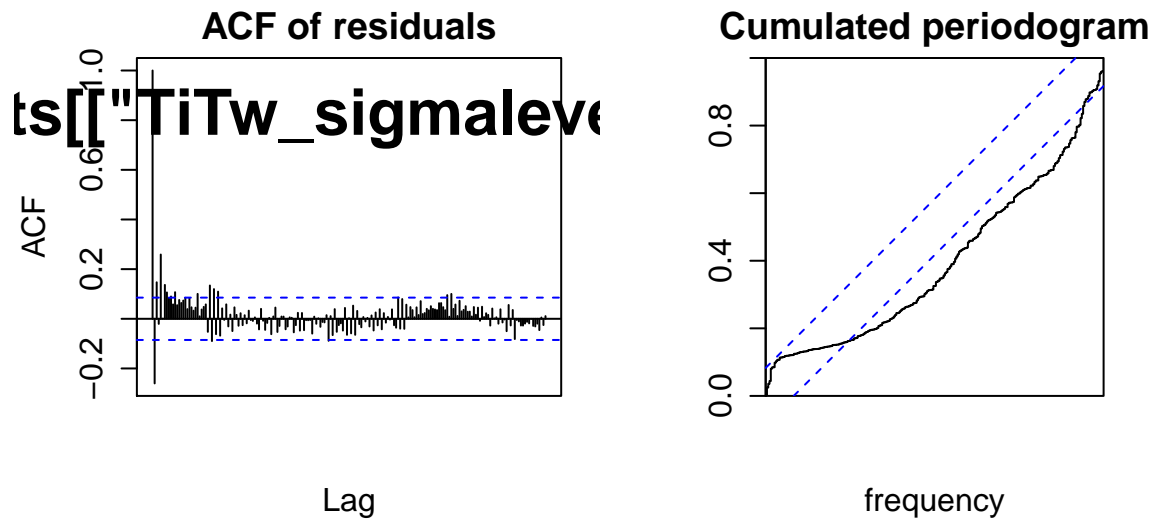
## Comparing the two models

Now compare the two models implemented in functions/sdeTiTw.R and functions/sdeTiTw_sigmalevels.R. What is the difference?

*The second model includes with sigma levels include $(1 + (stepQi * sigmalevel))$ in the error term allowing to account for the noise of turning on/off the heater.*

4

**ACF of residuals**

**Cumulated periodogram**



Lag

frequency



2013−06−29    2013−06−30    2013−07−01    2013−07−02

What is plotted in the upper two plots? (You maybe have to look into the analyzeFit() function).

*Upper plot is the residuals of the predicted variable yTi lower plot is the standarized residuals (residuals / sd(yTi))*

5

What is indicated by the blue lines in the upper plot? Step back in the plots and compare the results, and look at the summary output.

*The blue lines in the upper plot are the standard deviation of the predicted variable (yTi) by which the residuals are divided to be standarized*

Which of the two models will you prefer and why? *The one with sigma level because it allows the variance to change with time and captures better the variability of the process and that is shown in its residuals. When comparing their Log-Likelihood, also the model with sigma-levels has a larger likelihood.*

# References

JJ Allaire, Yihui Xie, Jonathan McPherson, Javier Luraschi, Kevin Ushey, Aron Atkins, Hadley Wickham, Joe Cheng, and Winston Chang. *rmarkdown: Dynamic Documents for R*, 2018. URL https://CRAN.R-project.org/package=rmarkdown. R package version 1.10.

Peder Bacher and Henrik Madsen. Experiments and data for building energy performance analysis: Financed by the danish electricity saving trust. 2010.

Peder Bacher and Henrik Madsen. Identifying suitable models for the heat dynamics of buildings. *Energy and Buildings*, 43(7):1511–1522, 2011.

Dirk Eddelbuettel. *digest: Create Compact Hash Digests of R Objects*, 2018. URL https://CRAN.R-project.org/package=digest. R package version 0.6.15.

Keith R Godfrey. Correlation methods. In *System Identification*, pages 527–534. Elsevier, 1981.

Rune Juhl. *ctsmr: CTSM for R*, 2018. R package version 0.6.17.

Henrik Madsen. *Time series analysis*. Chapman and Hall/CRC, 2007.

R Core Team. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria, 2018. URL https://www.R-project.org/.

Hadley Wickham. *tidyverse: Easily Install and Load the 'Tidyverse'*, 2017. URL https://CRAN.R-project.org/package=tidyverse. R package version 1.2.1.

Yihui Xie. *knitr: A General-Purpose Package for Dynamic Report Generation in R*, 2018. URL https://CRAN.R-project.org/package=knitr. R package version 1.20.