

Queimadas Reference Satellite: A data analysis

Analysing data for choosing the next reference satellite for the Queimadas Program

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Agenda I

1 Introduction

2 Exploratory Data Analysis

3 Time Series

- NPP-375D
- NPP-375-PM
- AQUA M T
- NOAA 12

4 Forecast

5 Forecast vs observations

6 Future work

7 References



Introduction



What would be the next reference satellite?

- What would be the next reference satellite [1, 3]?



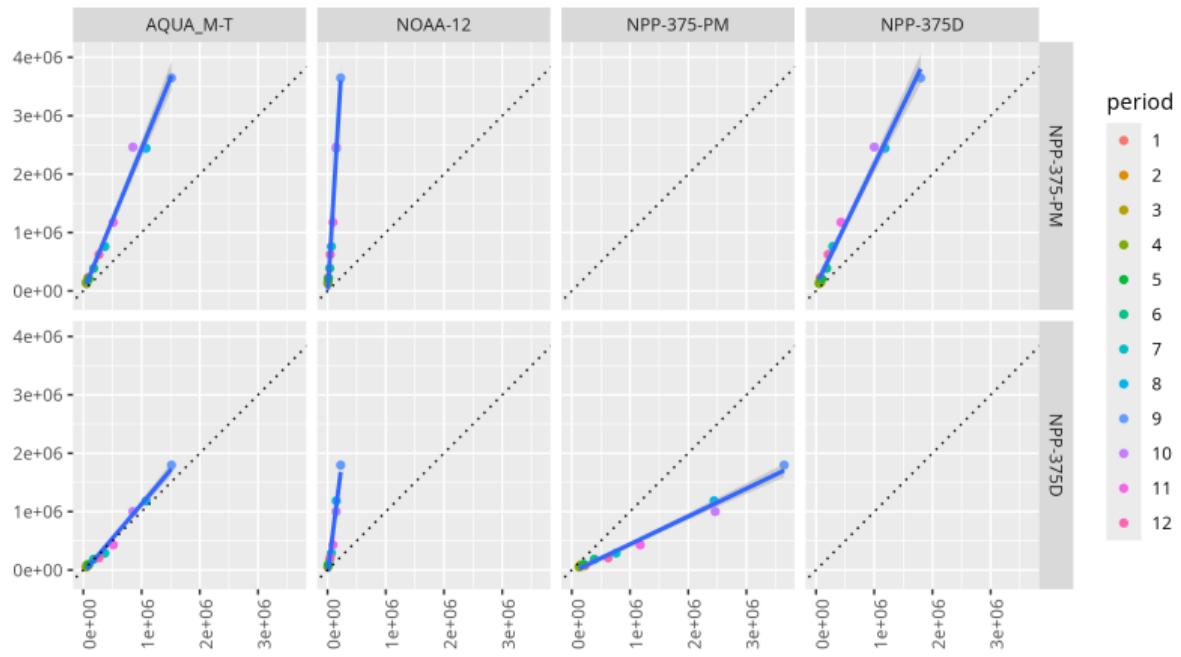
Online resources

- Queimadas portal.
- Queimadas FAQ.
- Source code
 - ▶ Code repository available [here](#).
 - ▶ Slides available [here](#).

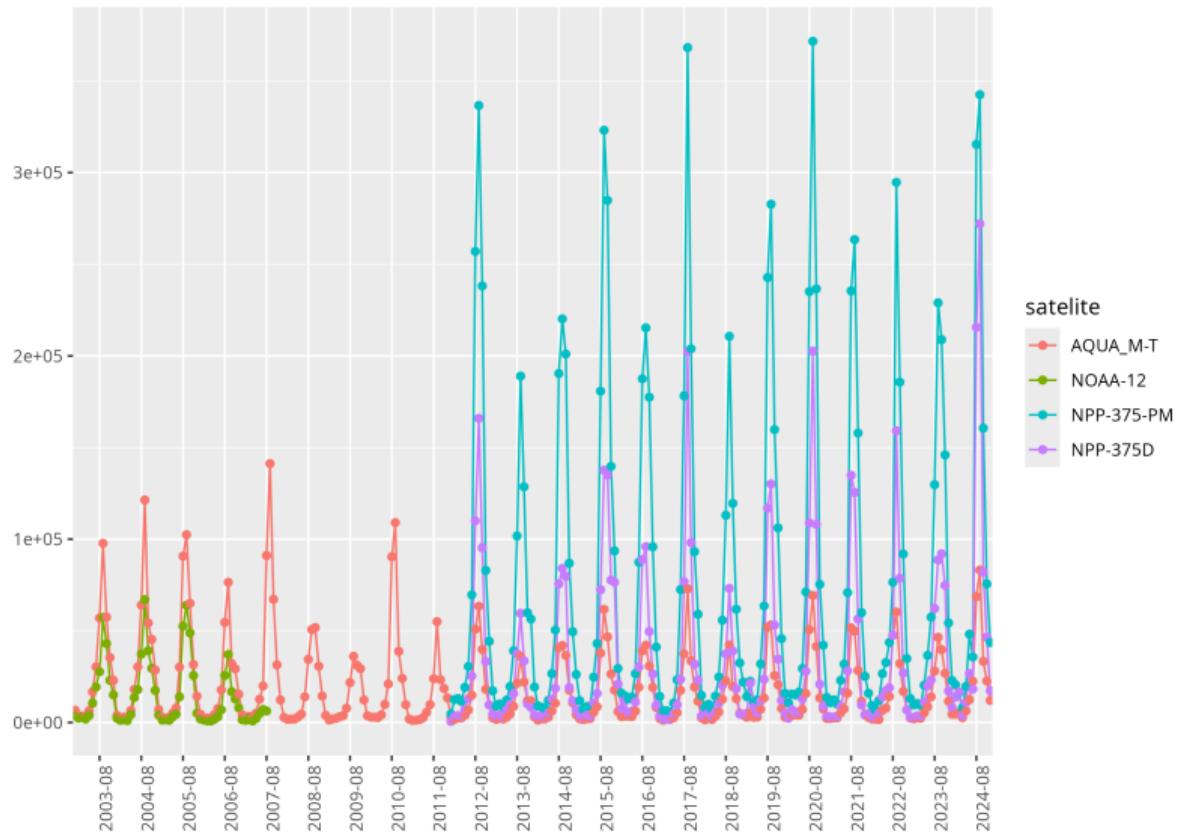


Exploratory Data Analysis

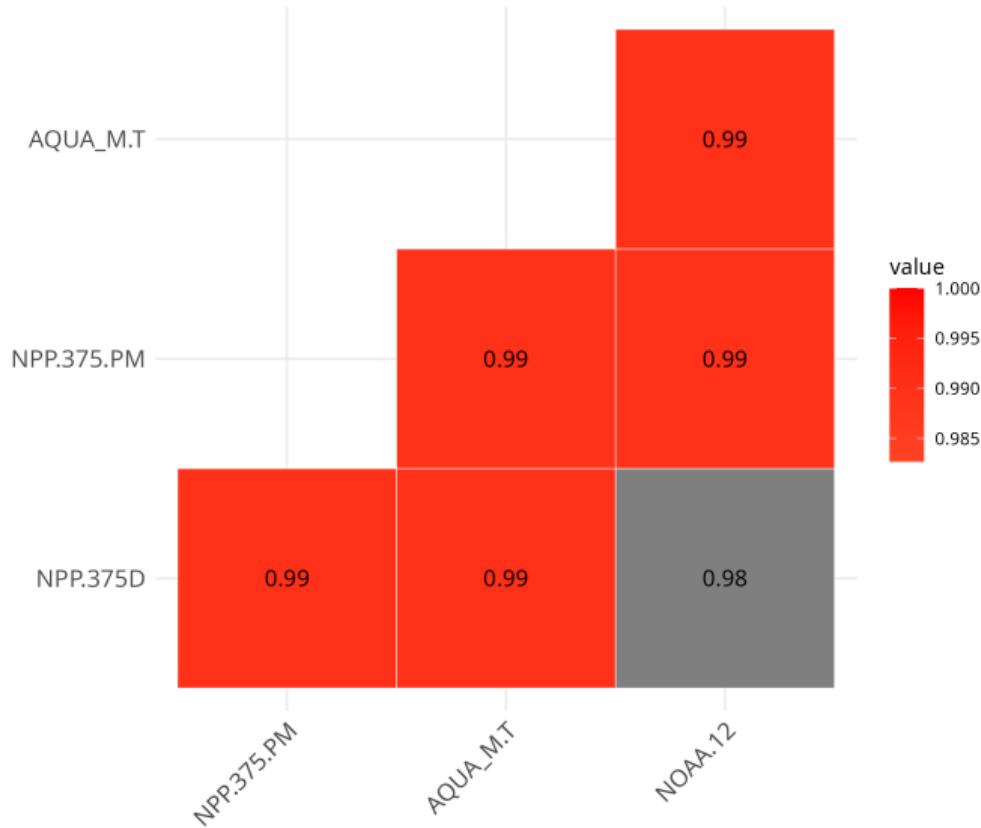
Brazilian fire foci aggregated by month (all years)



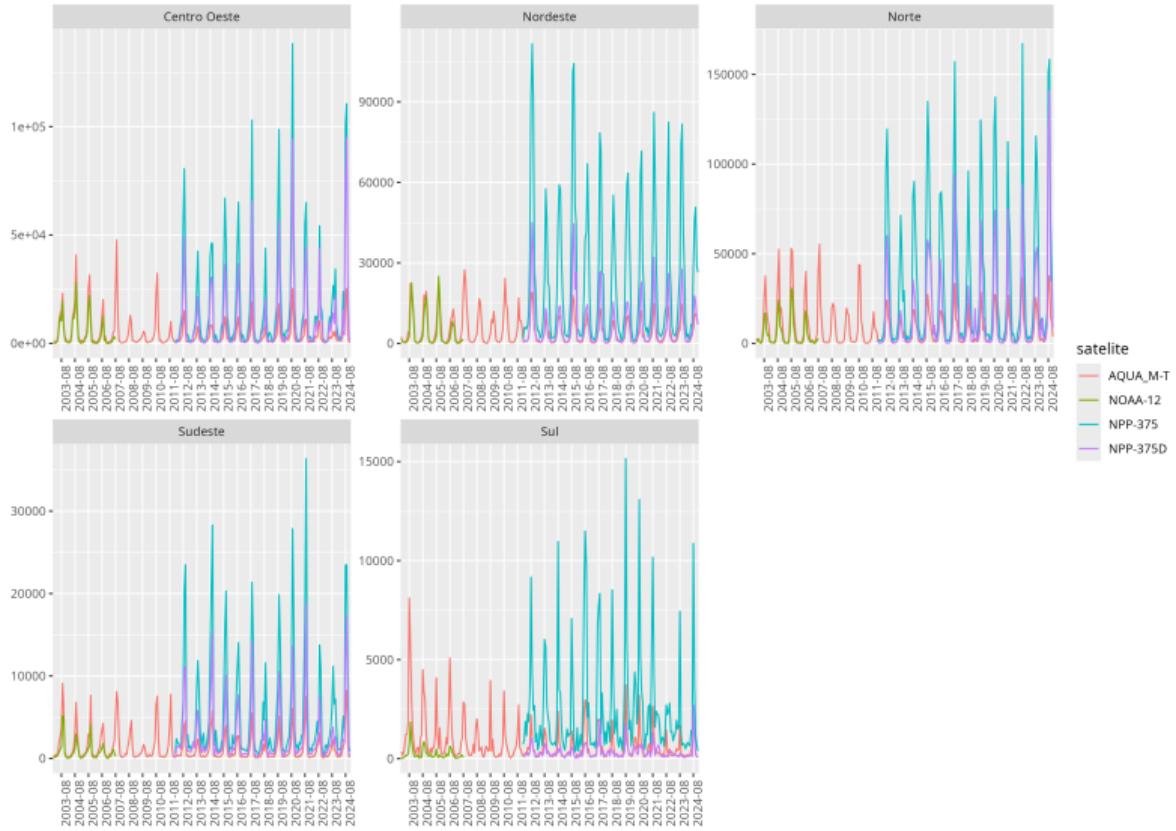
Brazilian fire foci aggregated by year and month



Correlation between fire foci from the reference satellites in Brazil



Brazilian regions by year and month



Time Series

Time series' components

- Structural time series model [2]:

- ▶ Trend $g(t)$.
- ▶ Periodic changes $s(t)$.
- ▶ Effects of holidays $h(t)$.

- **Assumptions:**

- ▶ ϵ_t is normally distributed.
- ▶ Forecasting is a curve-fitting problem; no account for temporal dependence structure in the data [4].

$$y(t) = g(t) + s(t) + h(t) + \epsilon_t$$



Do the models fit?

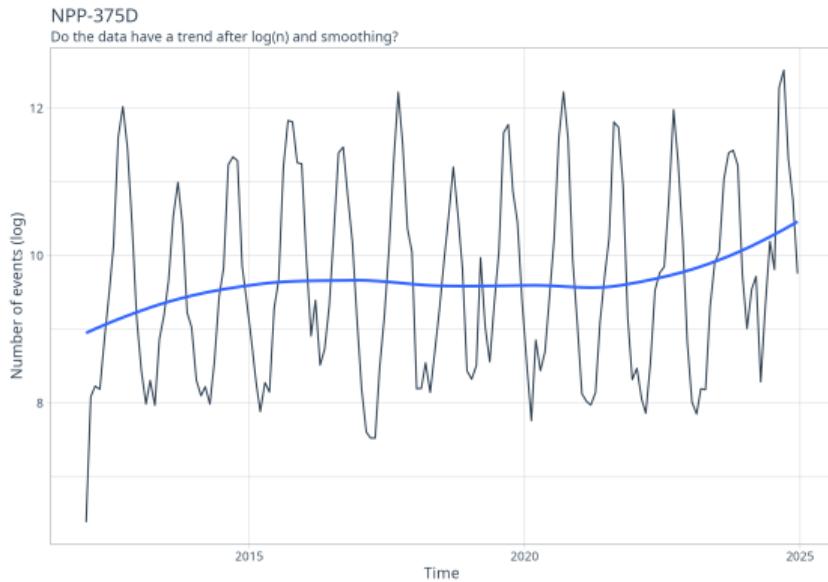
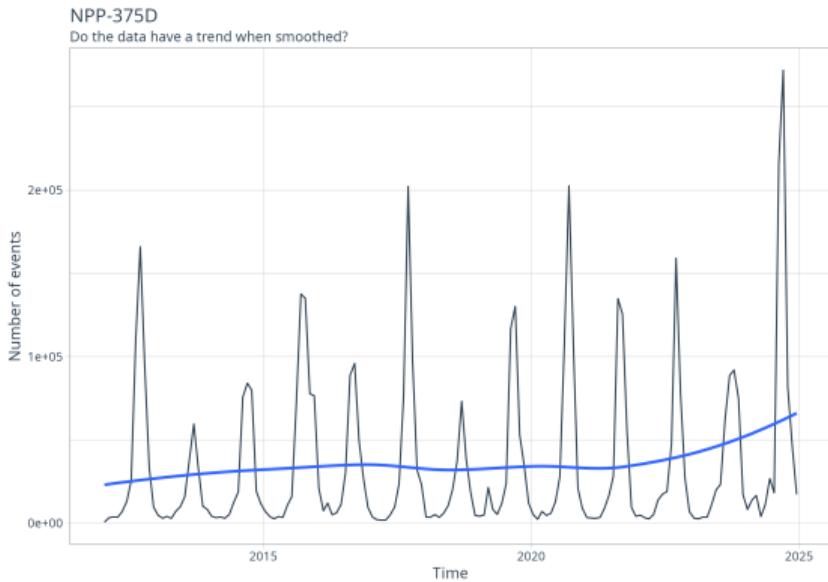
- Do the data have a trend when smoothed?
- Do the data have a trend after applying the logarithm function and smoothing?
- Are the data autocorrelated in the time dimension?
- Do the data have a trend component?
- Do the data have season component?
- How does the model fit its observations?
- How do compare the residuals and the fitted values?
- Do the mode-observations residual have a normal distribution?



NPP-375D



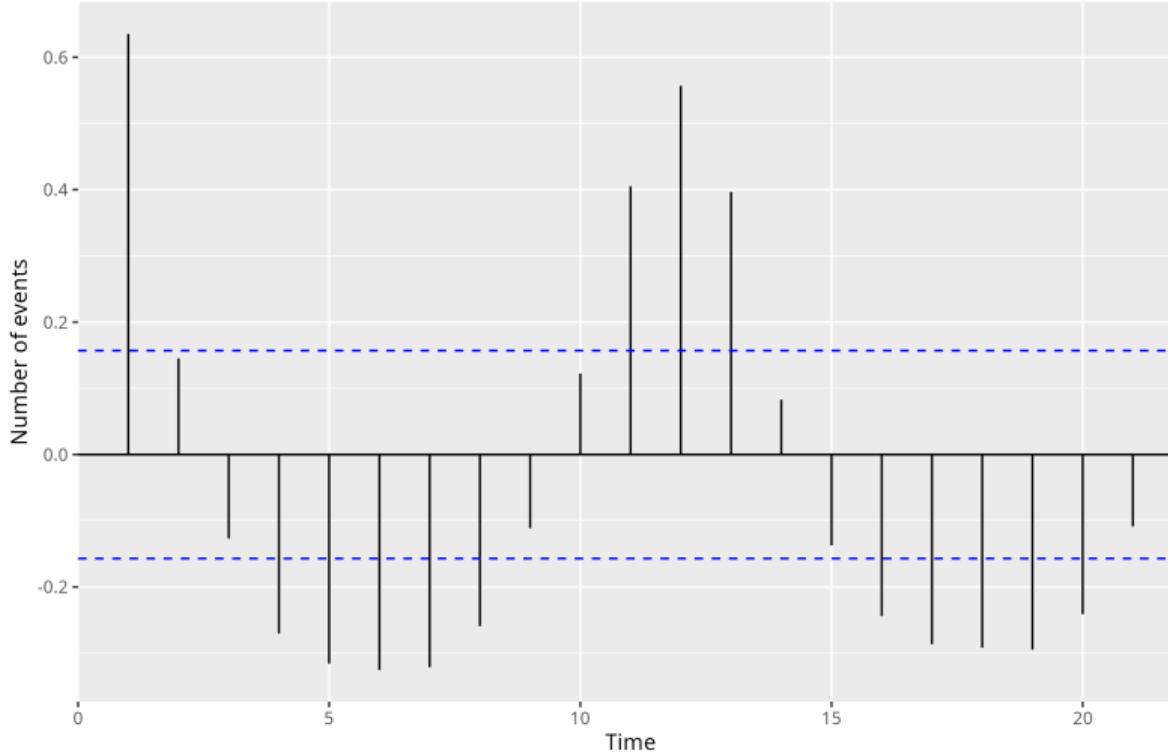
Time series trend (with smoothing)



Time series autocorrelation

NPP-375D

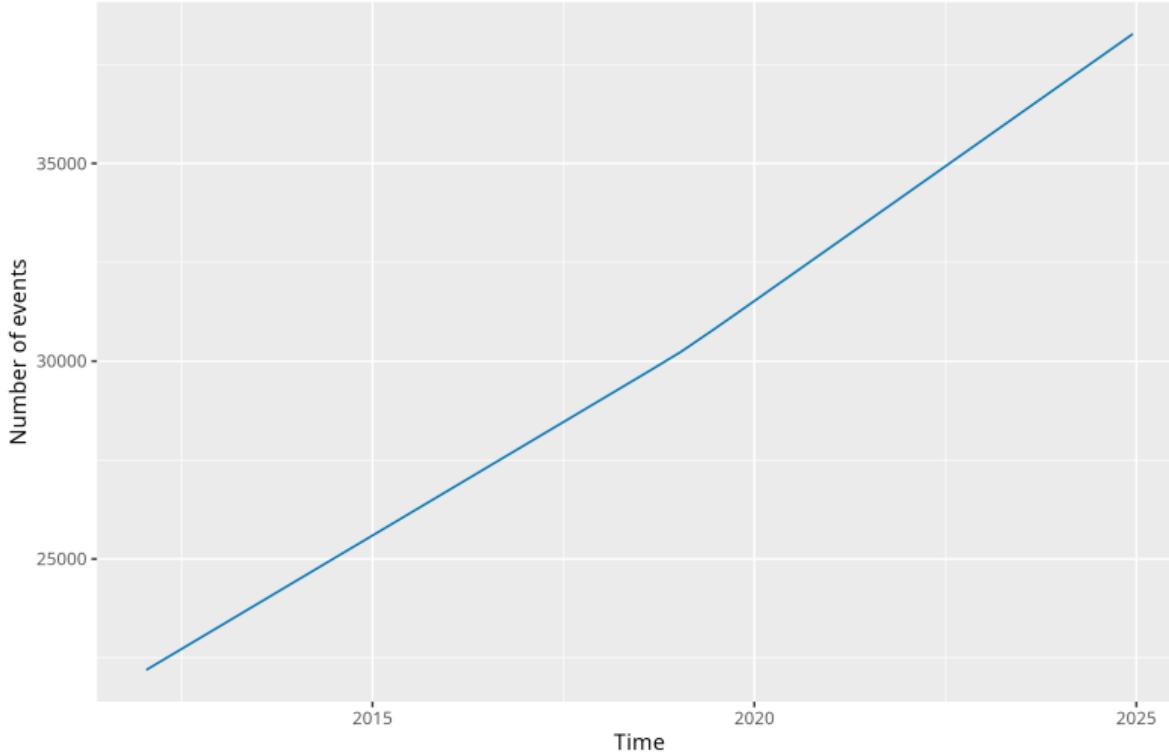
Is the time series autocorrelated?



Time series trend

NPP-375D

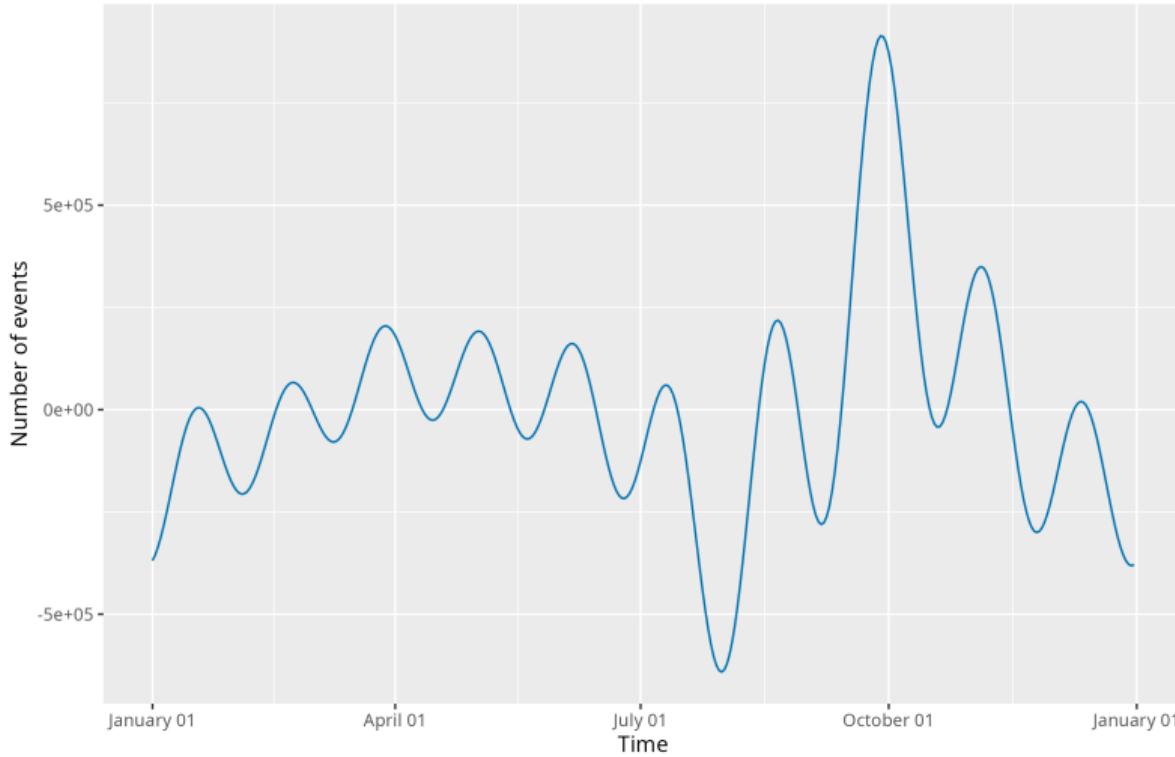
Do the data have a trend component?



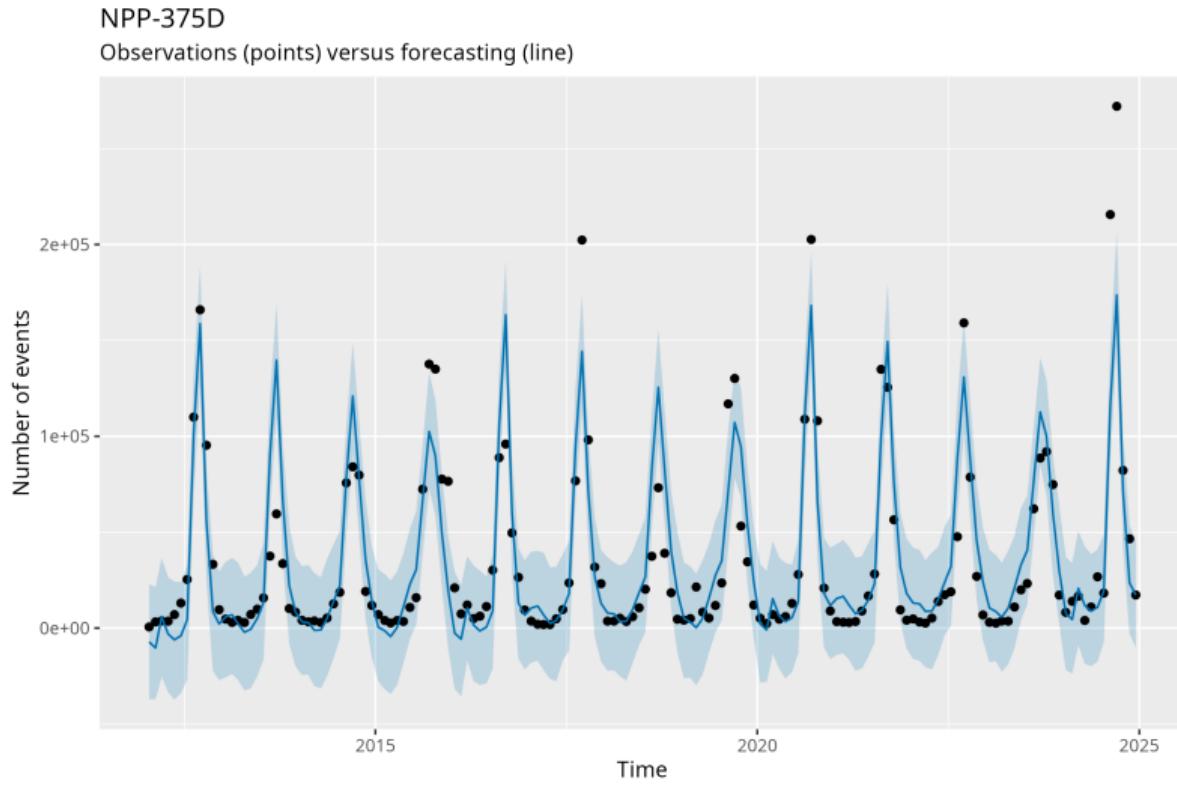
Time series seasonality

NPP-375D

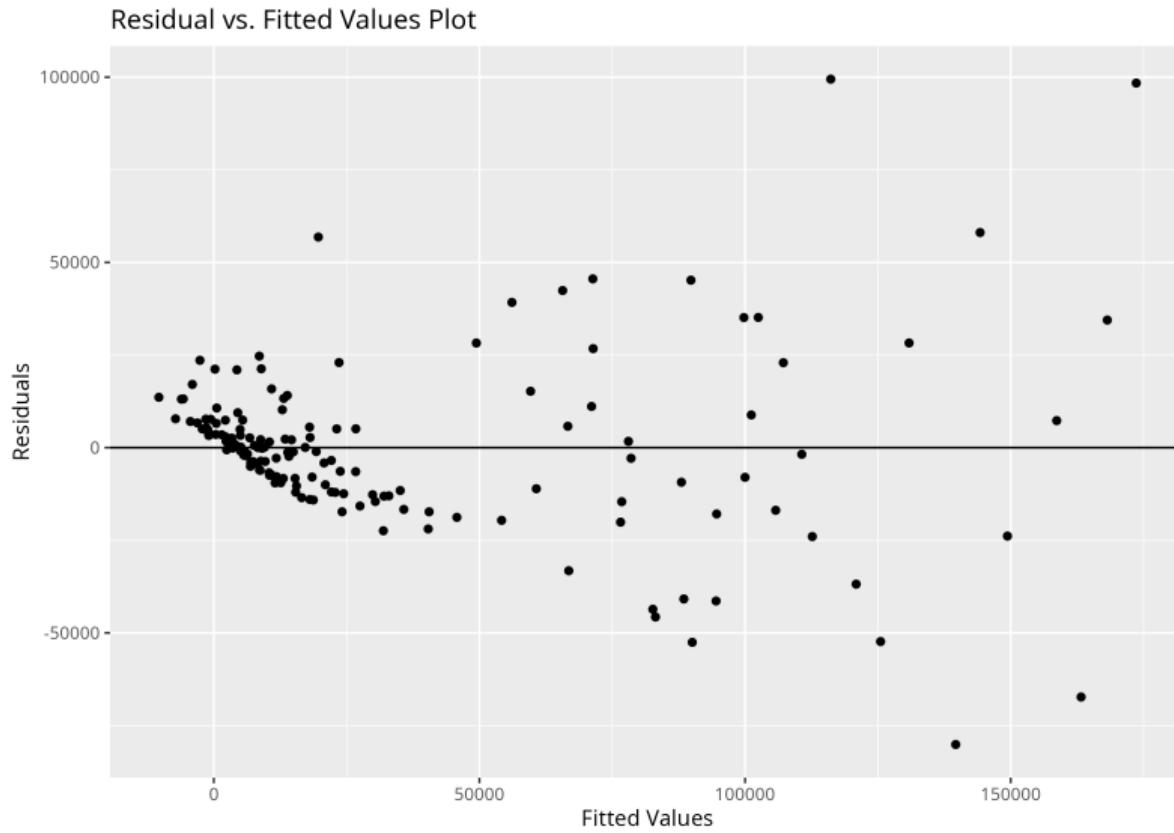
Do the data have a seasonality component?



Time series versus forecast



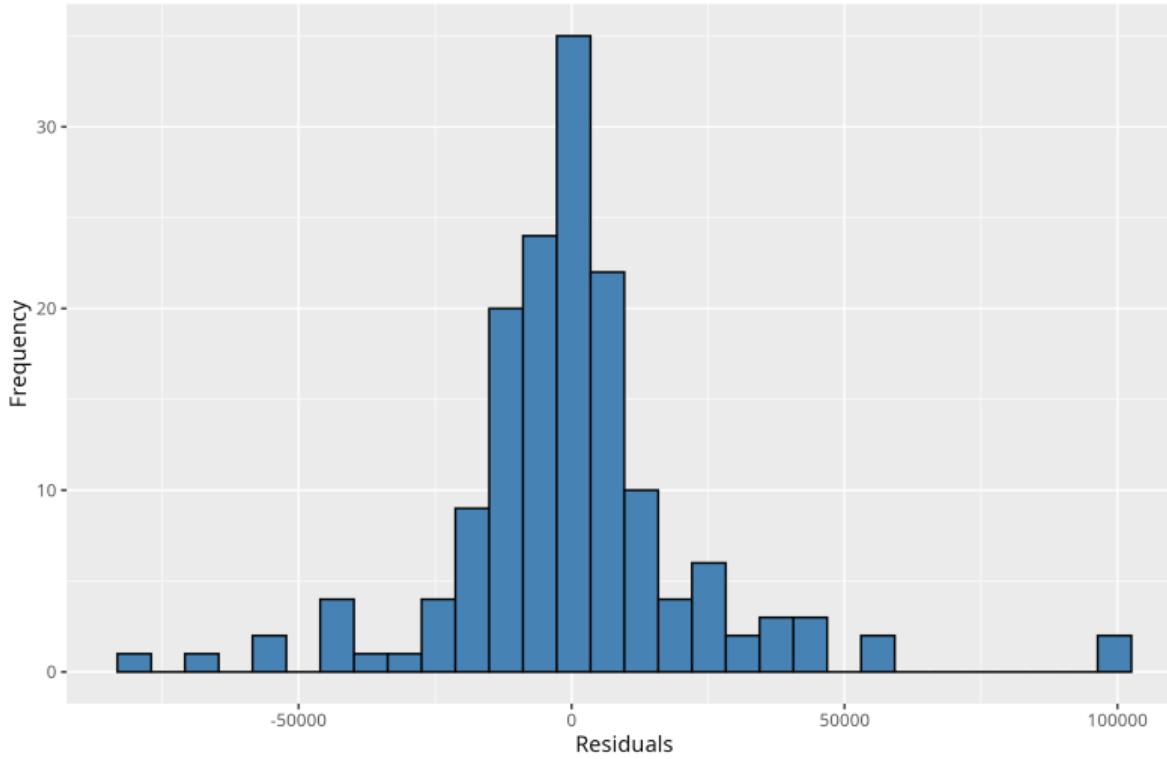
Time series versus forecast



Time series versus forecast

Histogram of Residuals

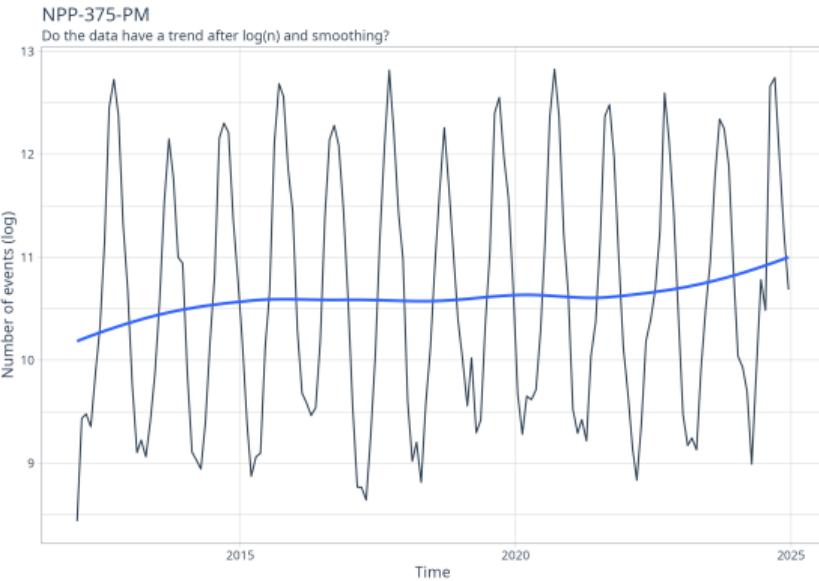
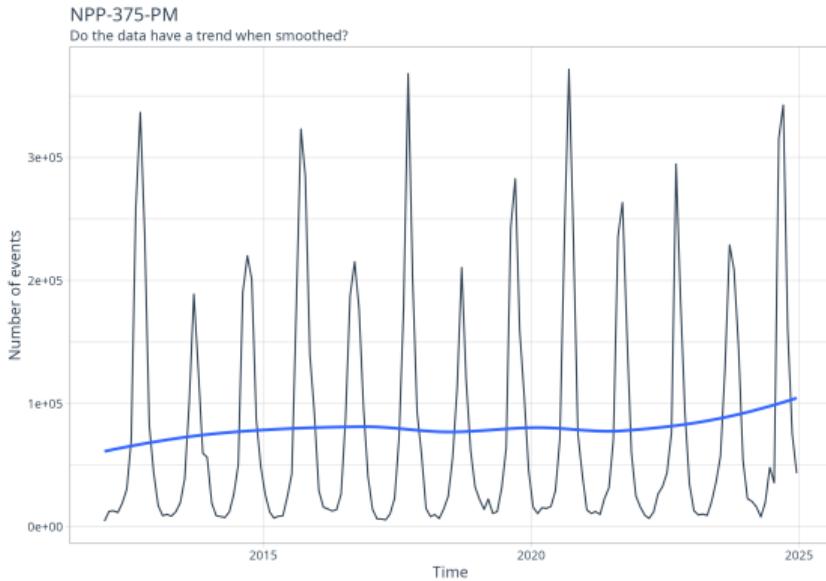
Do the residuals have a normal distribution?



NPP-375-PM



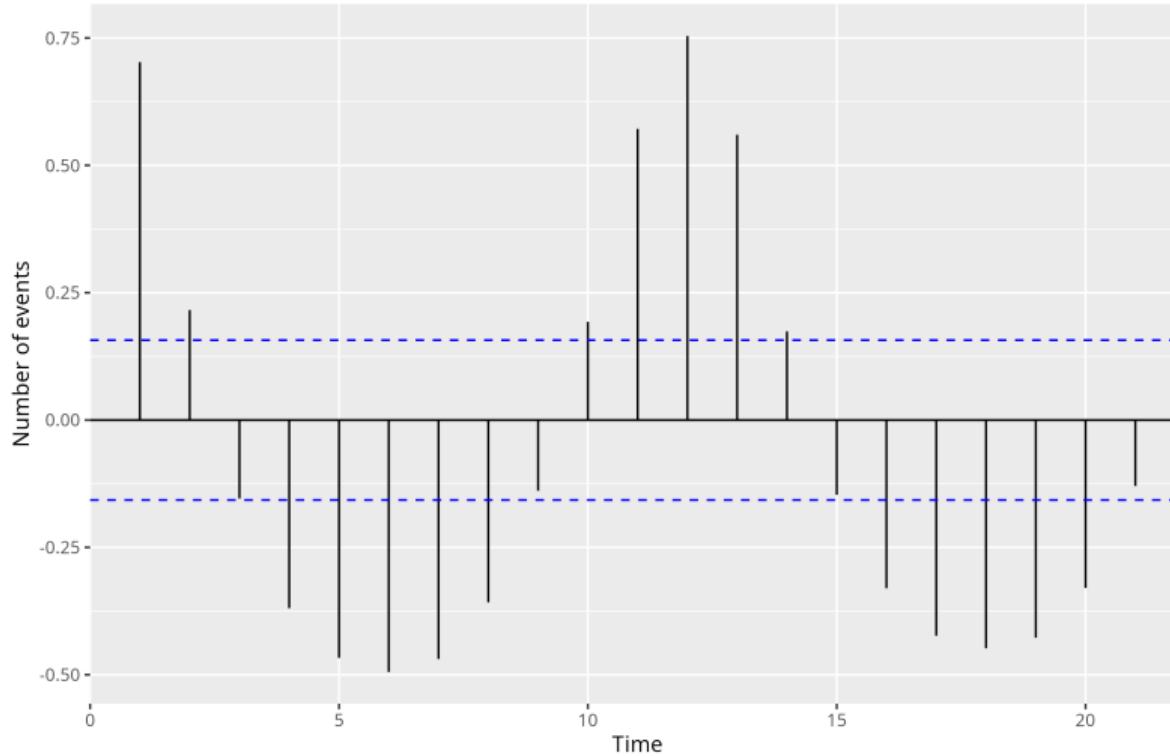
Time series trend (with smoothing)



Time series autocorrelation

NPP-375-PM

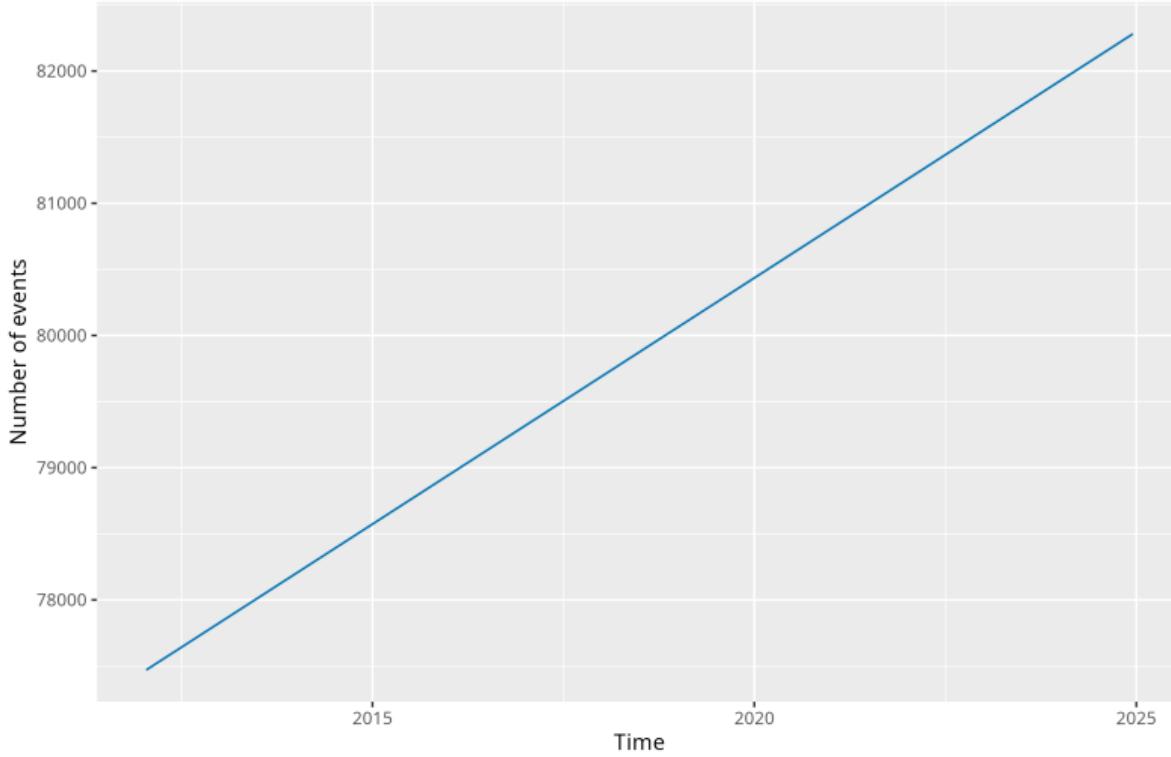
Is the time series autocorrelated?



Time series trend

NPP-375-PM

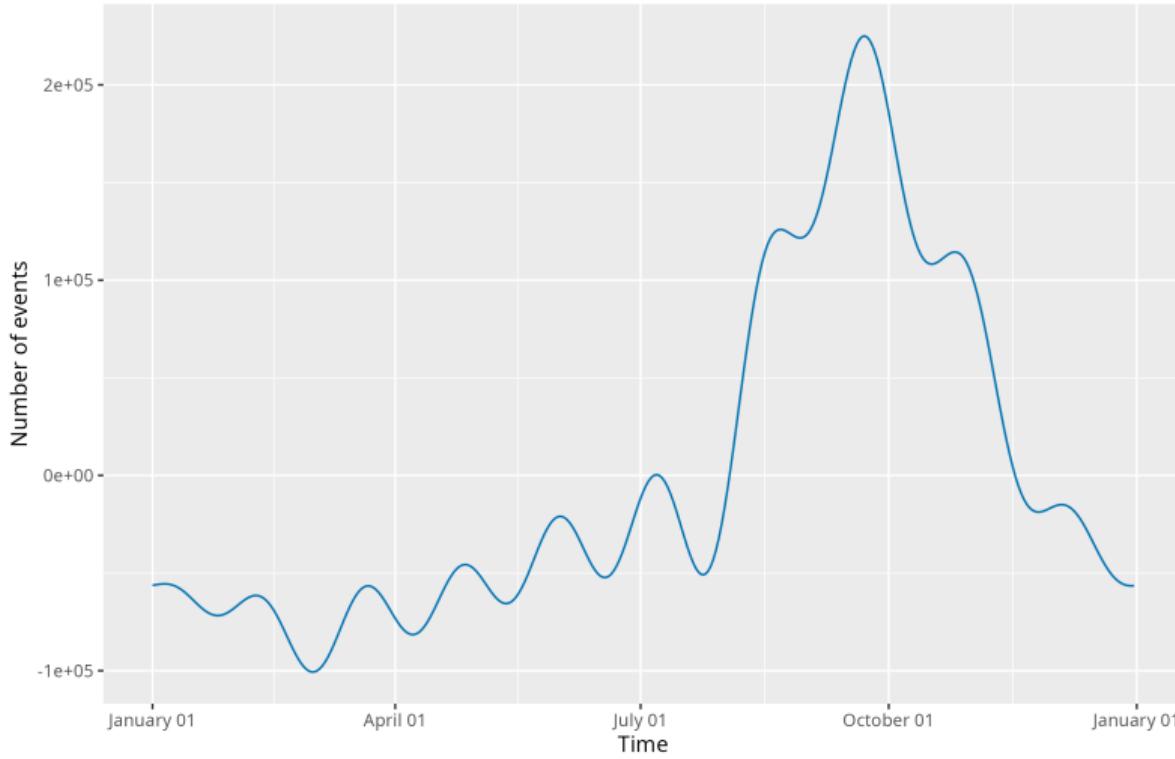
Do the data have a trend component?



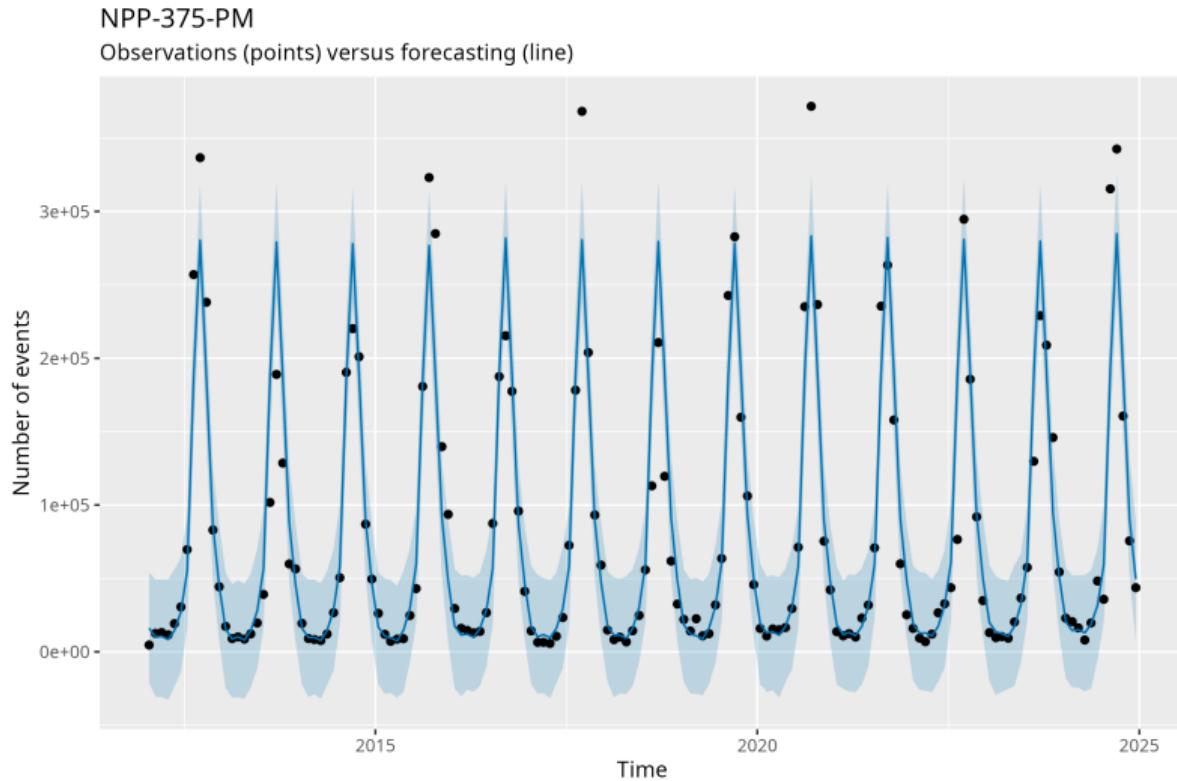
Time series seasonality

NPP-375-PM

Do the data have a seasonality component?

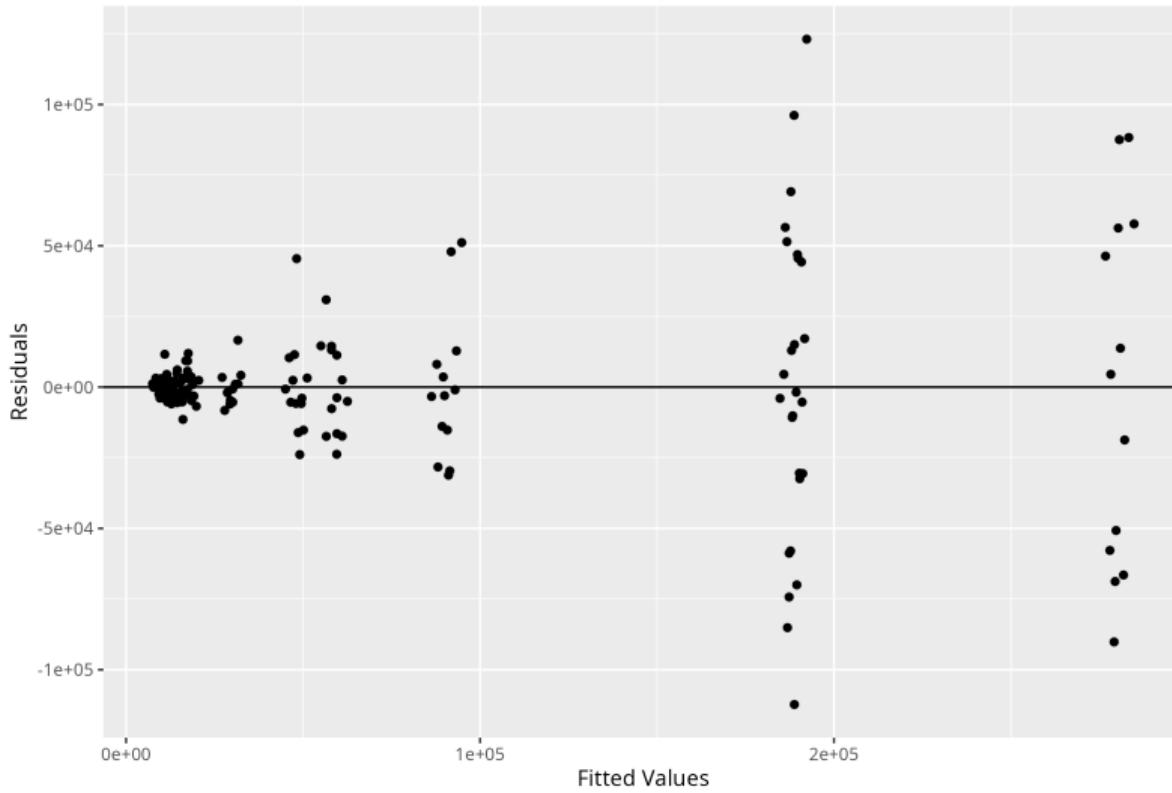


Time series versus forecast

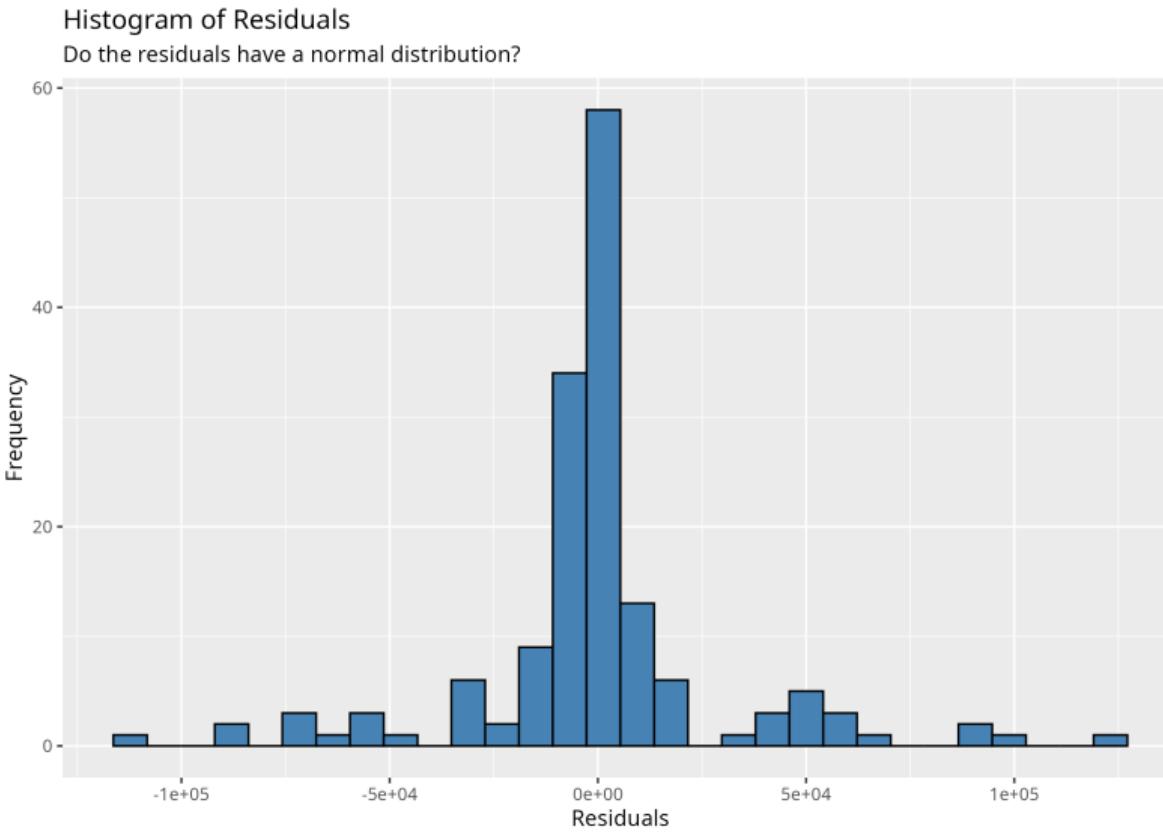


Time series versus forecast

Residual vs. Fitted Values Plot



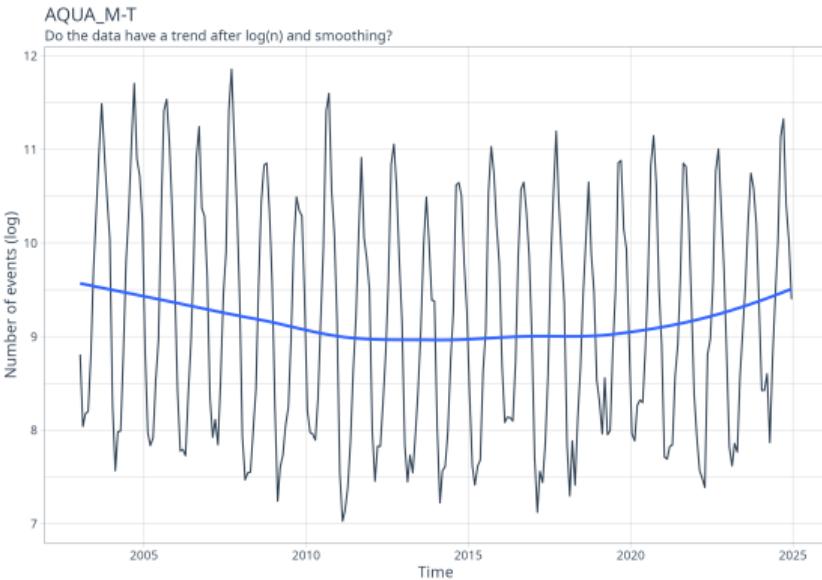
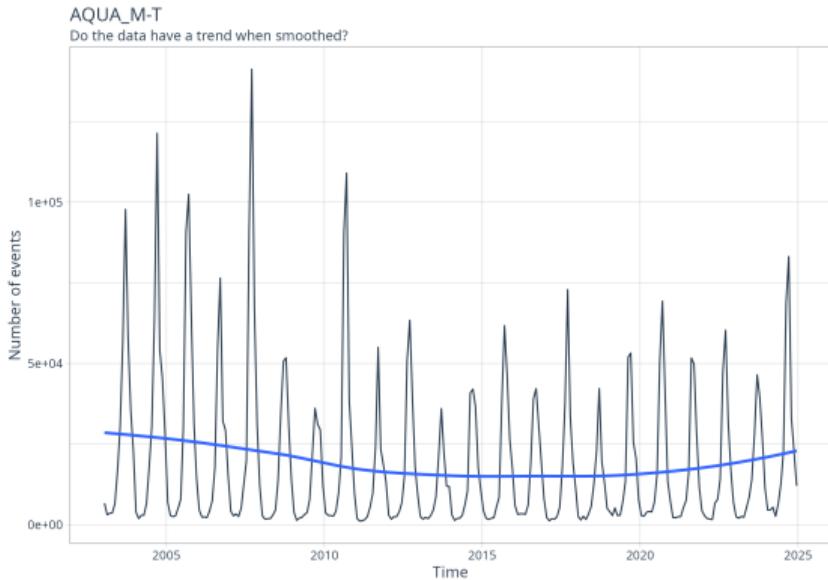
Time series versus forecast



AQUA M T



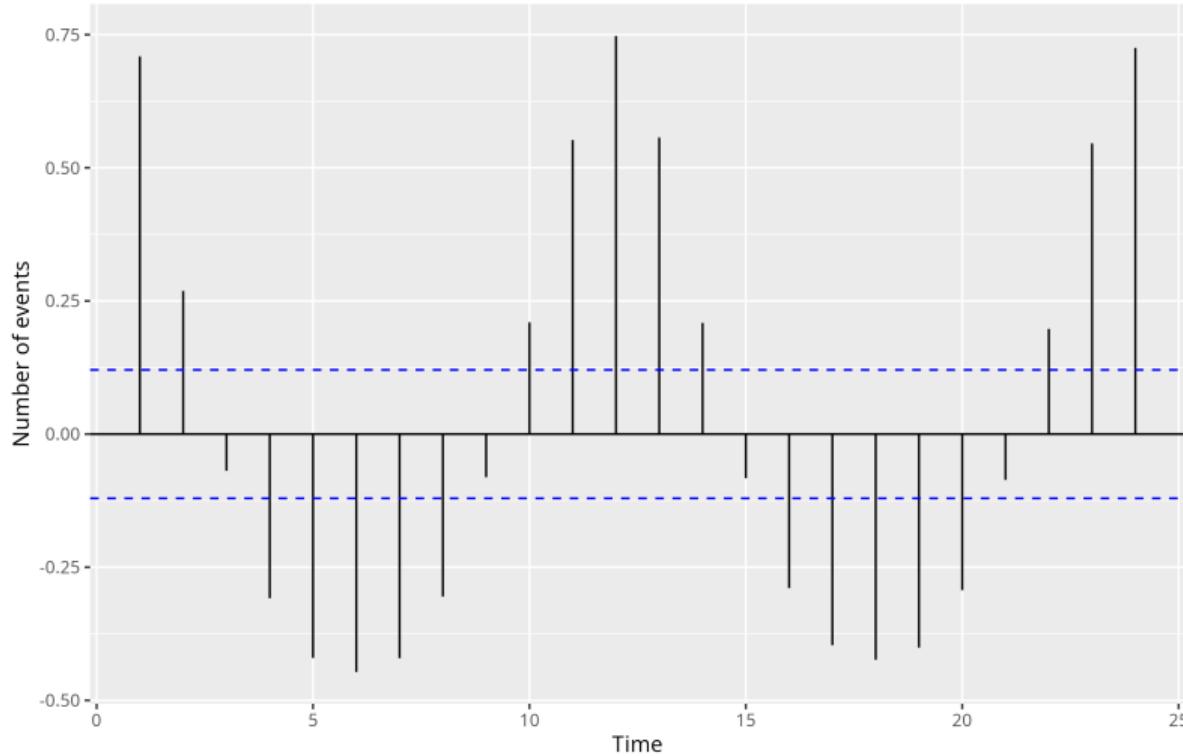
Time series trend (with smoothing)



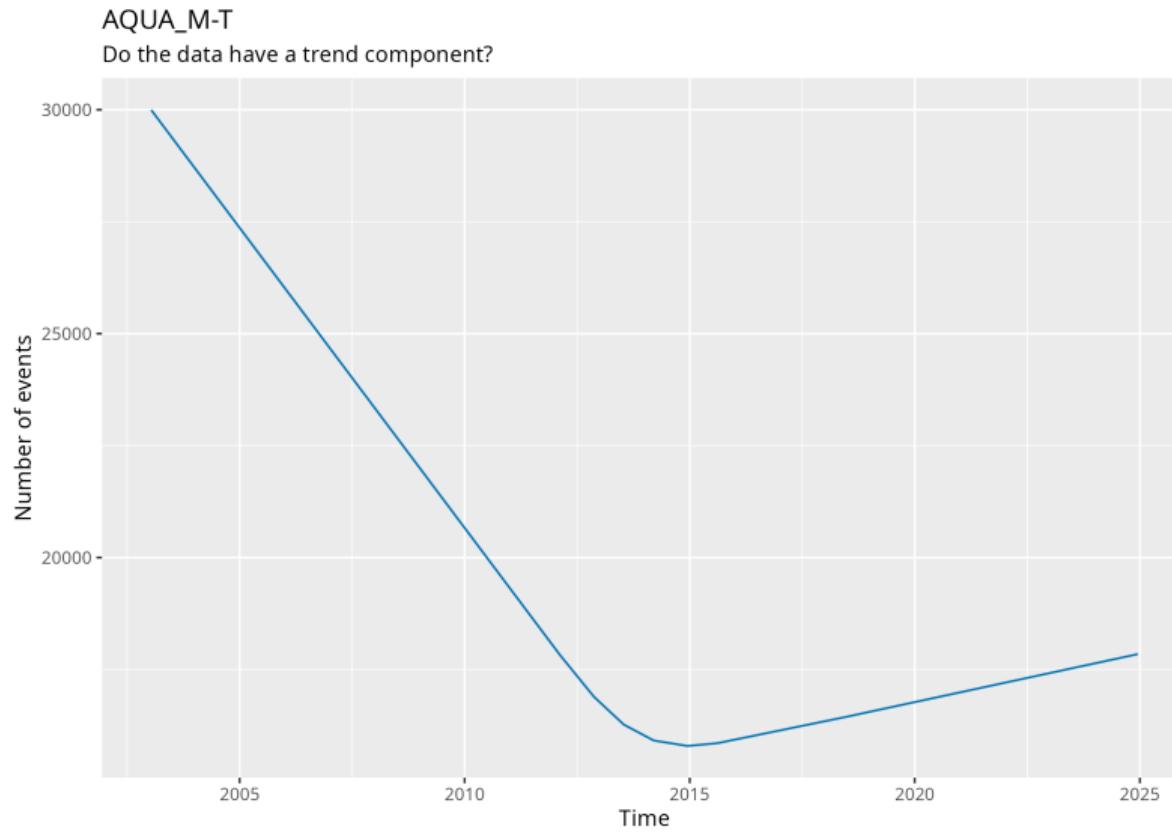
Time series autocorrelation

AQUA_M-T

Is the time series autocorrelated?



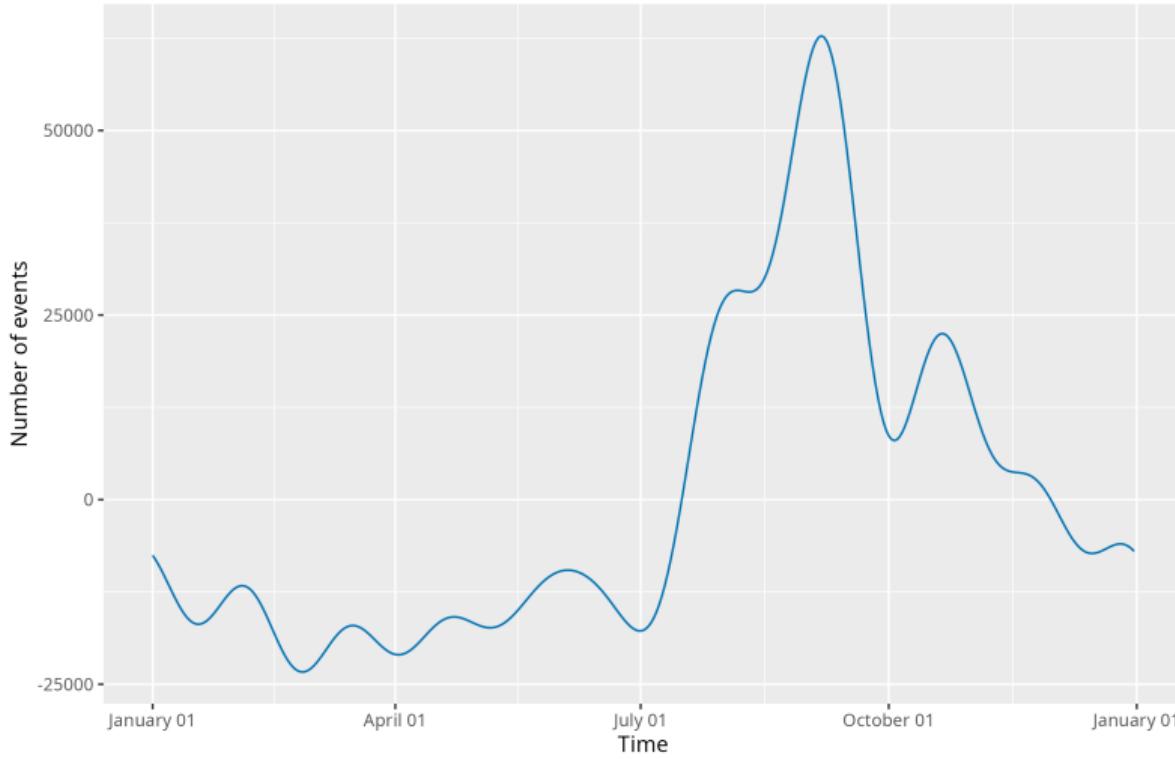
Time series trend



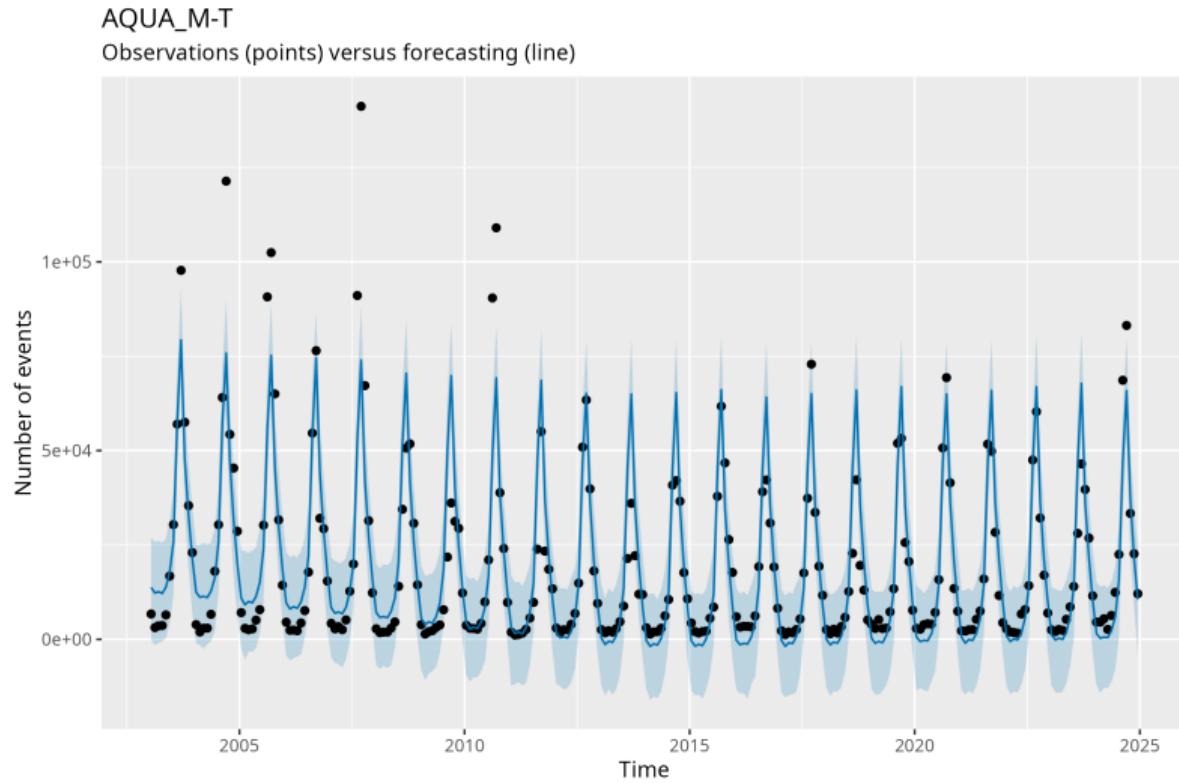
Time series seasonality

AQUA_M-T

Do the data have a seasonality component?

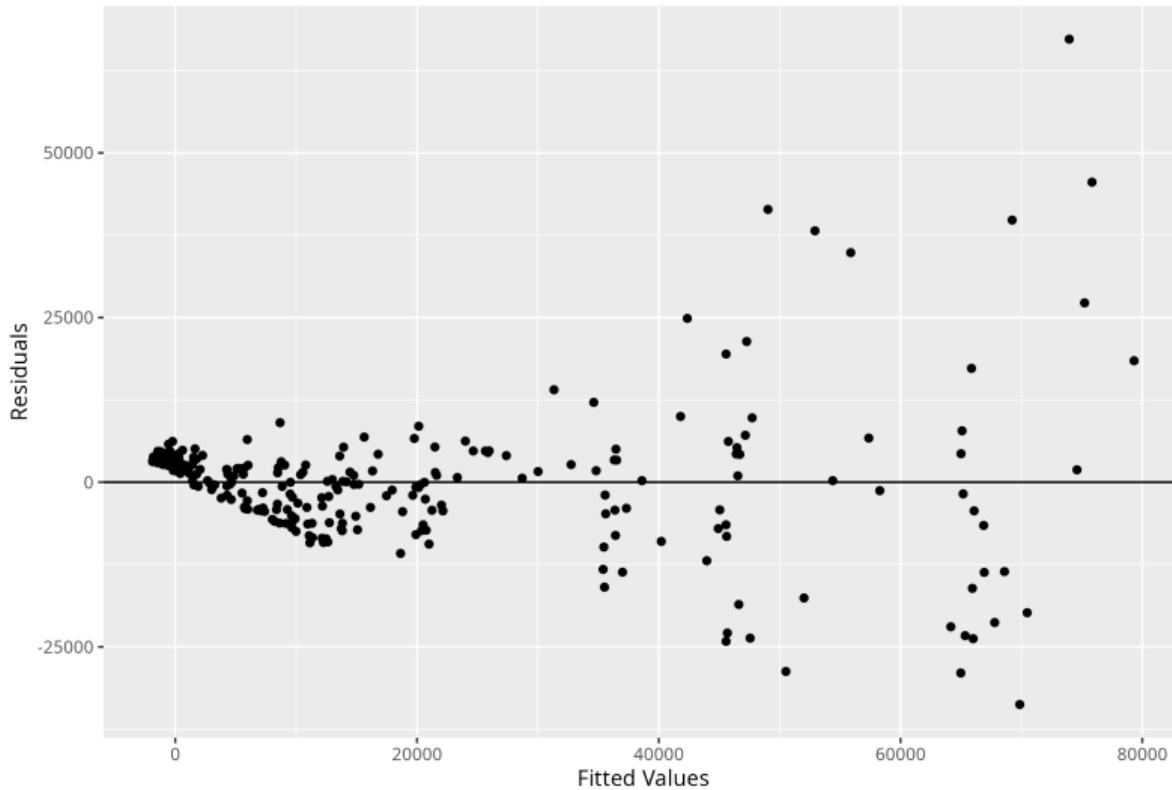


Time series versus forecast



Time series versus forecast

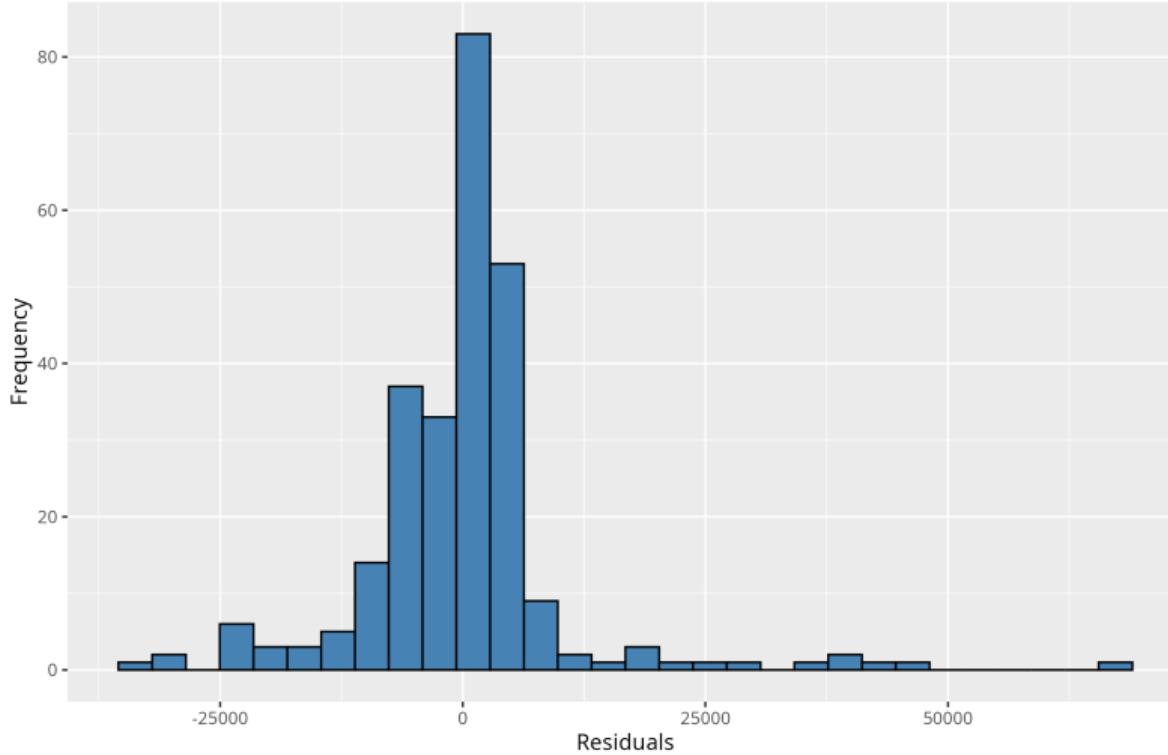
Residual vs. Fitted Values Plot



Time series versus forecast

Histogram of Residuals

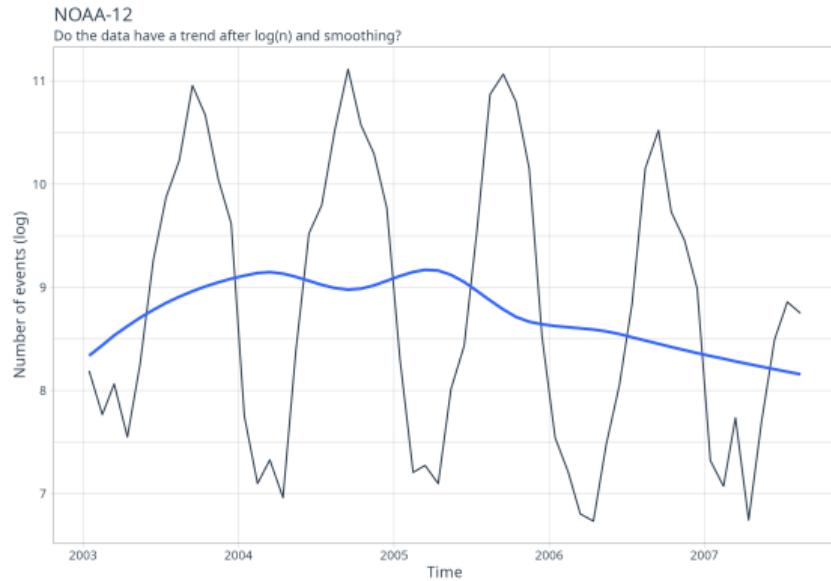
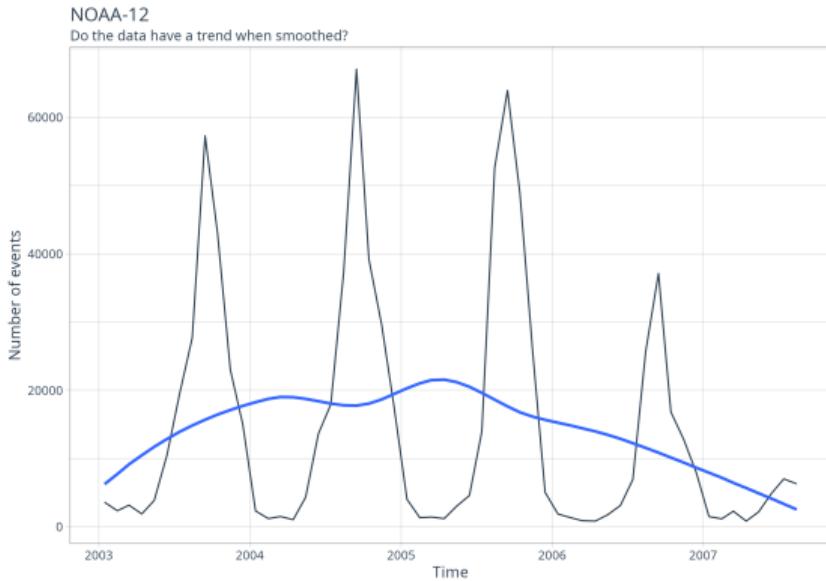
Do the residuals have a normal distribution?



NOAA 12



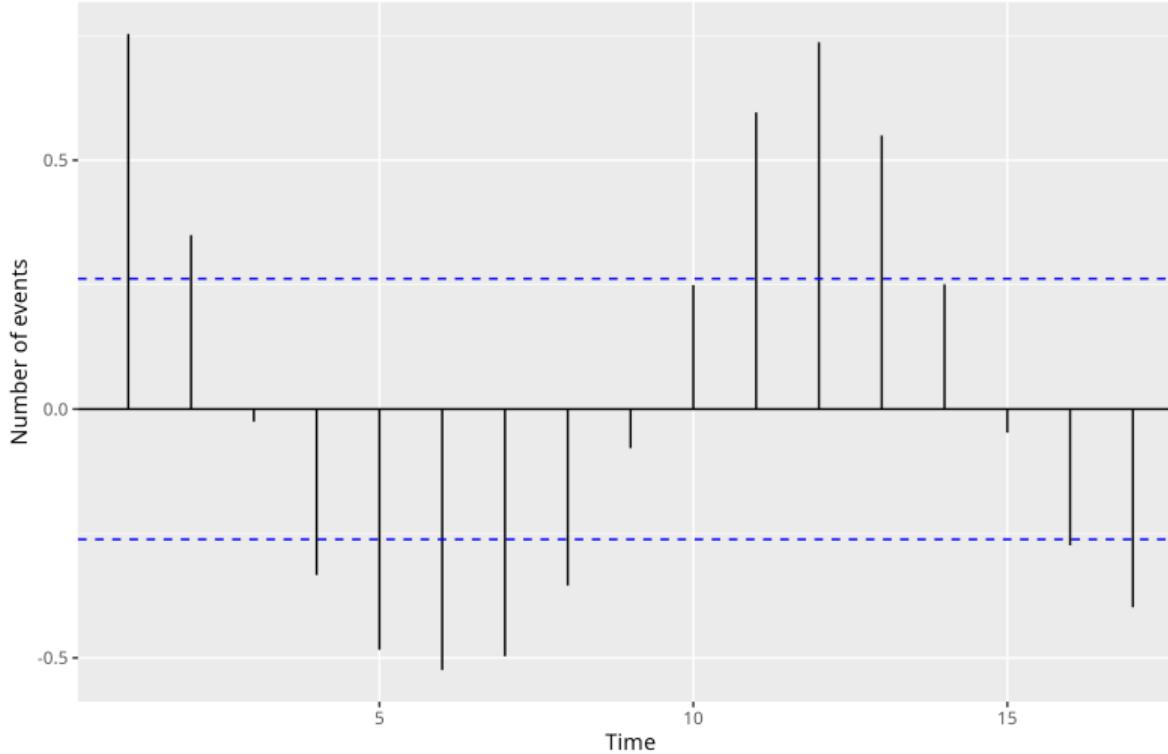
Time series trend (with smoothing)



Time series autocorrelation

NOAA-12

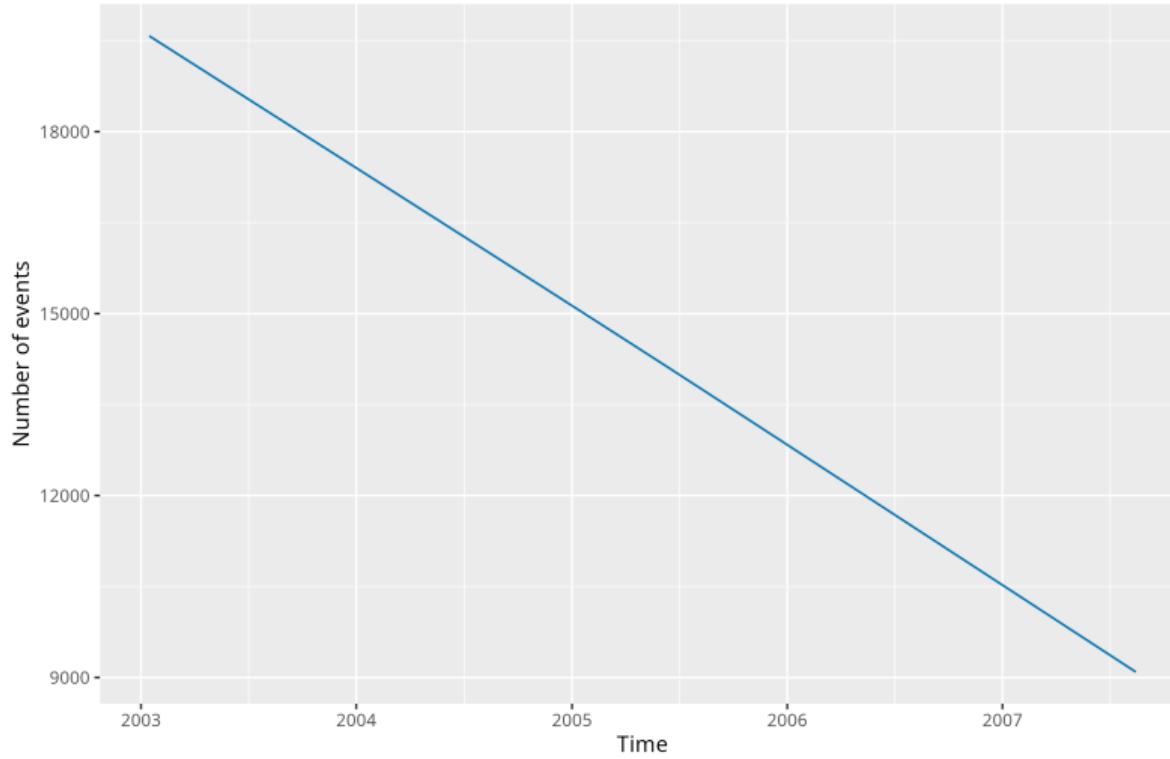
Is the time series autocorrelated?



Time series trend

NOAA-12

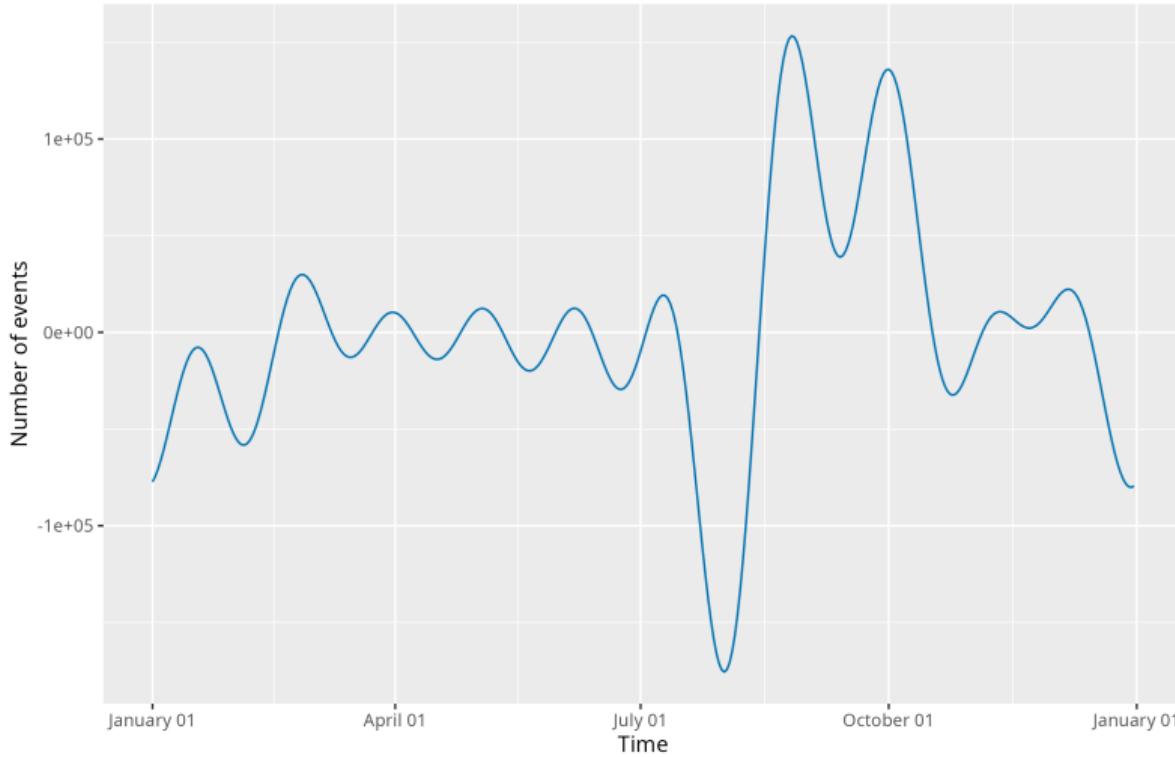
Do the data have a trend component?



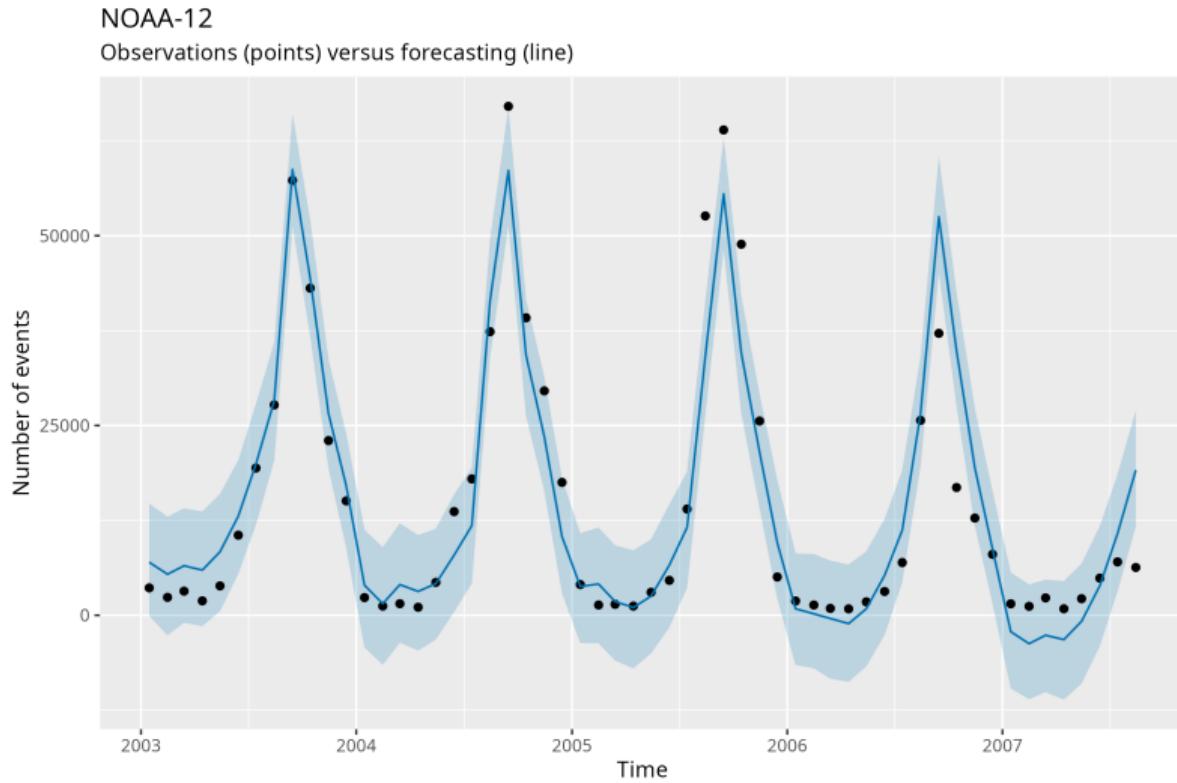
Time series seasonality

NOAA-12

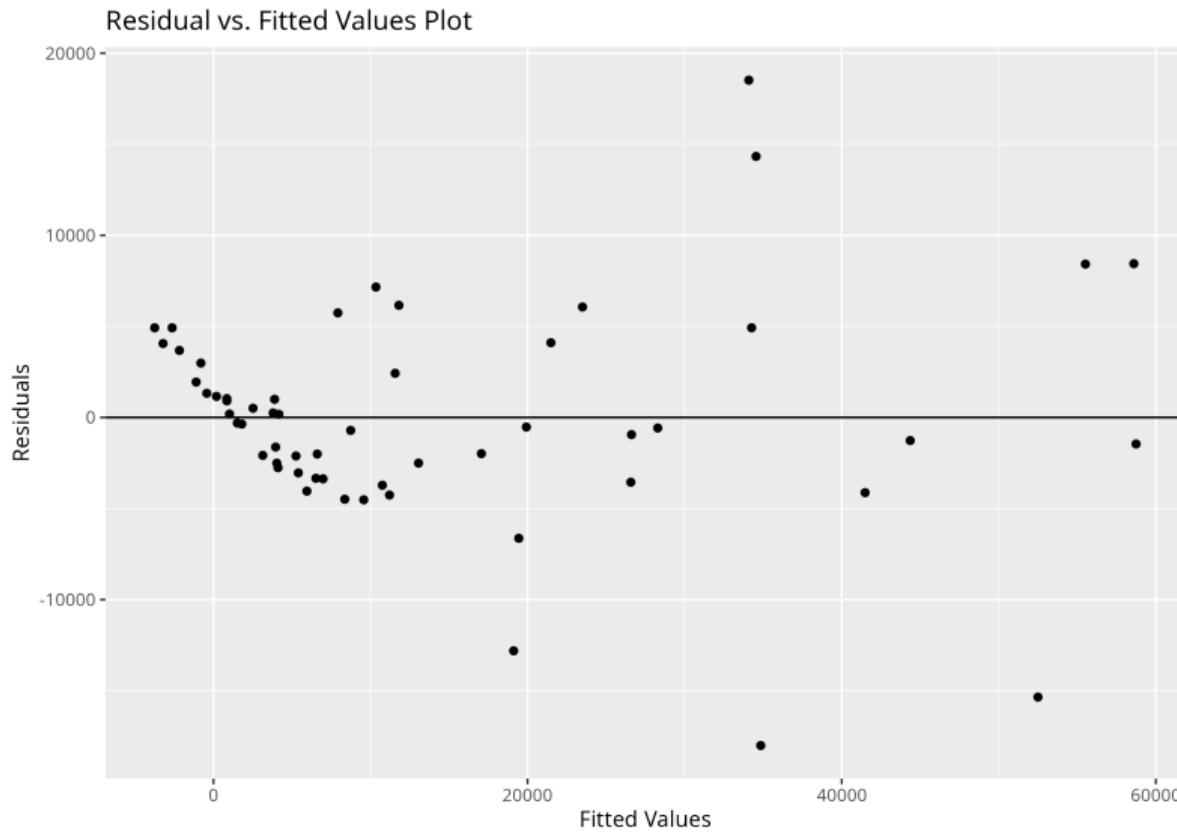
Do the data have a seasonality component?



Time series versus forecast



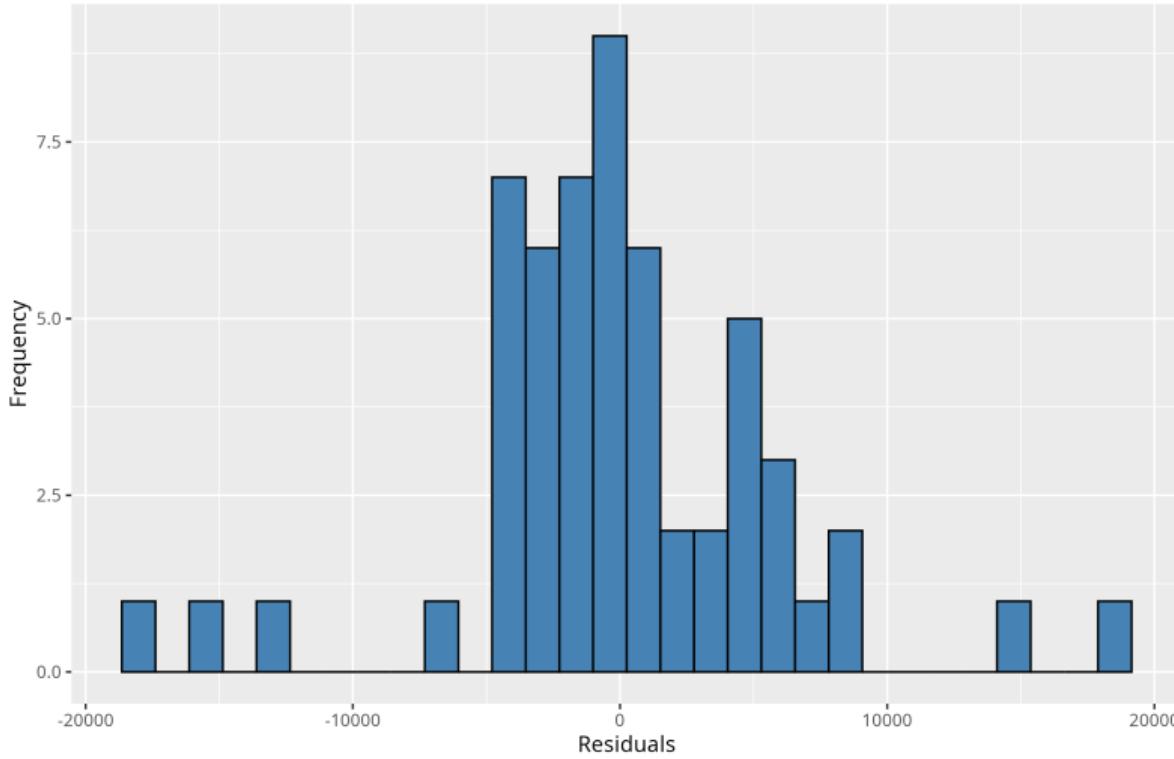
Time series versus forecast



Time series versus forecast

Histogram of Residuals

Do the residuals have a normal distribution?



Summary

Name	Trend	TLog	Autocor	Season	Random Res	Res Dist
NPP-375D	+	+	12 m	yes	TODO	Normal
NPP-375-PM	+	+	12 m	yes	TODO	Normal
AQUA M T	-+	-+	12 m	yes	TODO	Normal
NOAA 12	-	+-	12 m	yes	TODO	Normal

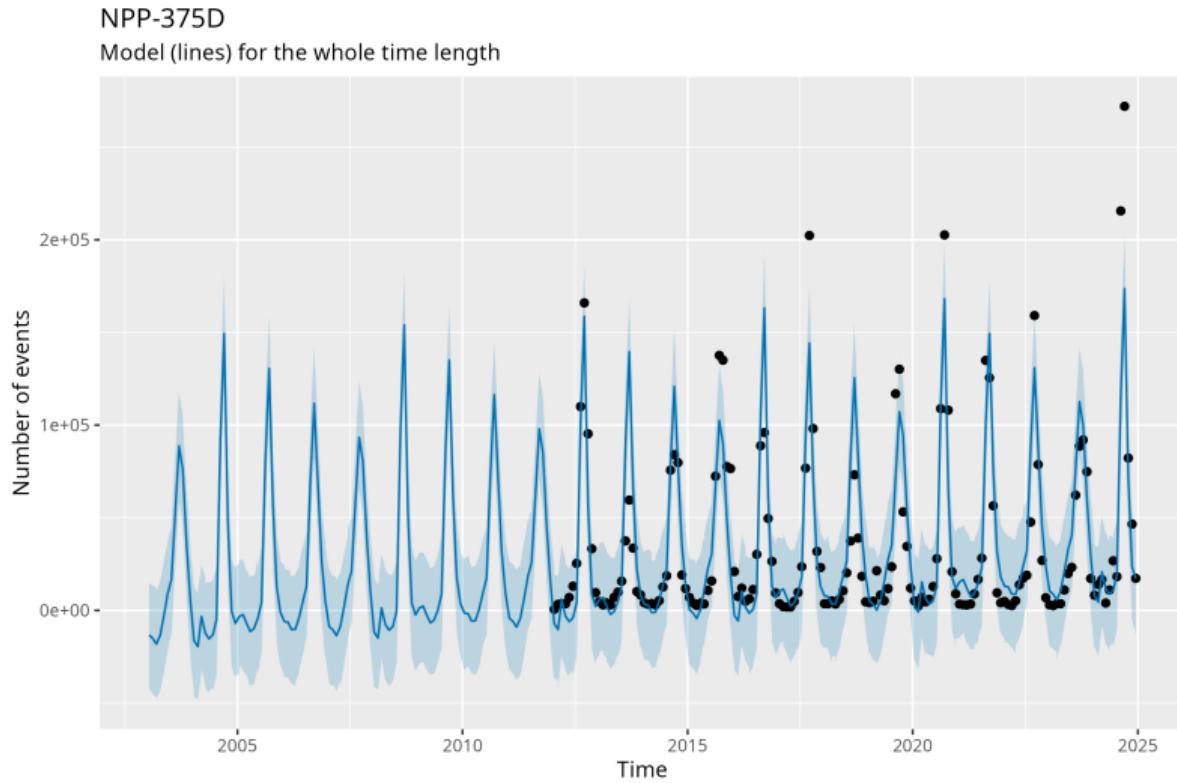
Forecast

Do the forecasts extend well along time?

- Use the models to forecast the time series of the union of data coming from all sources.

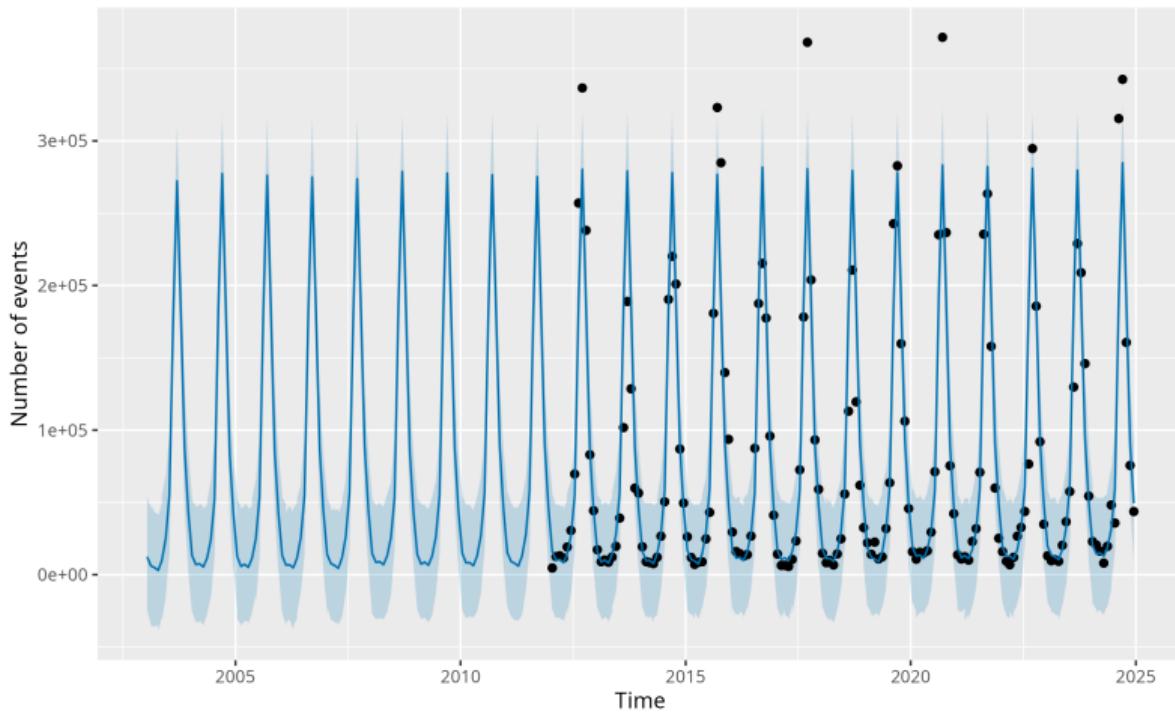


Forecast

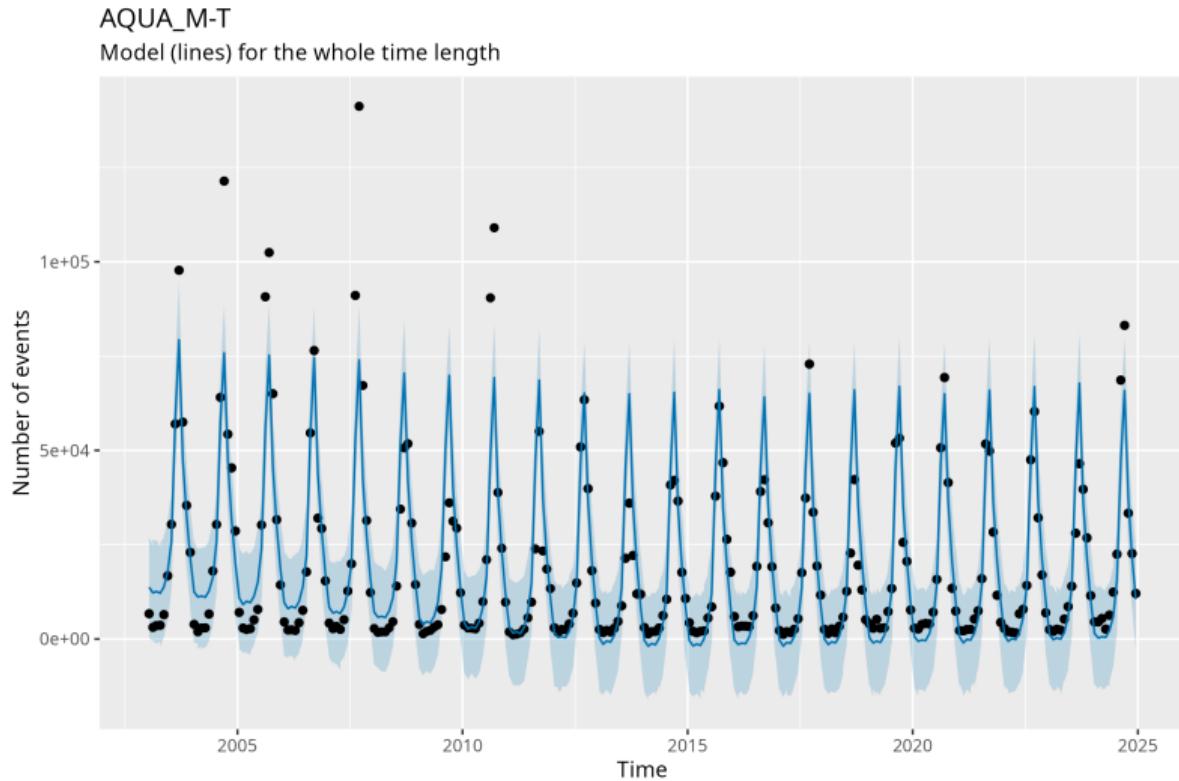


Forecast

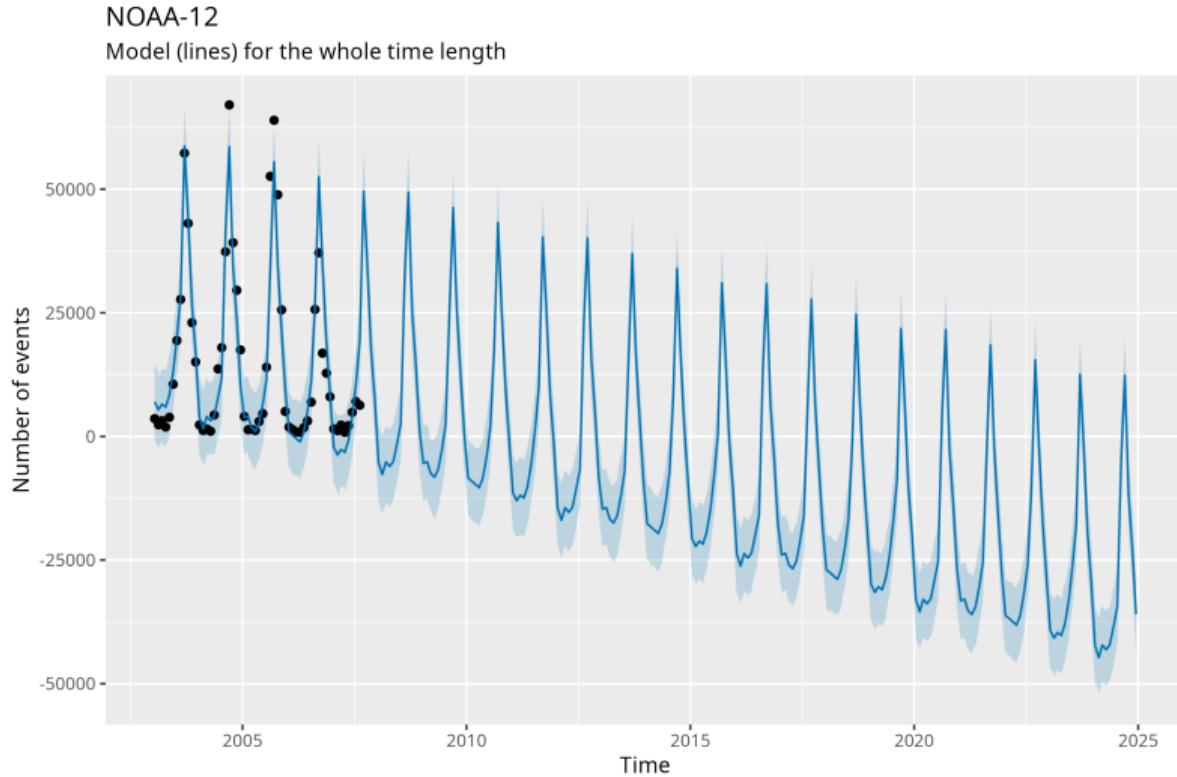
NPP-375-PM
Model (lines) for the whole time length



Forecast



Forecast



NOTES

- The trends causes negative forecastings in NPP-357D and especially in NOAA-12.
- The most well-behaved model correspond to the time series of NPP-375-PM.
- **We are considering NPP-375-PM's model the reference forecast.**



Forecast vs. Observations

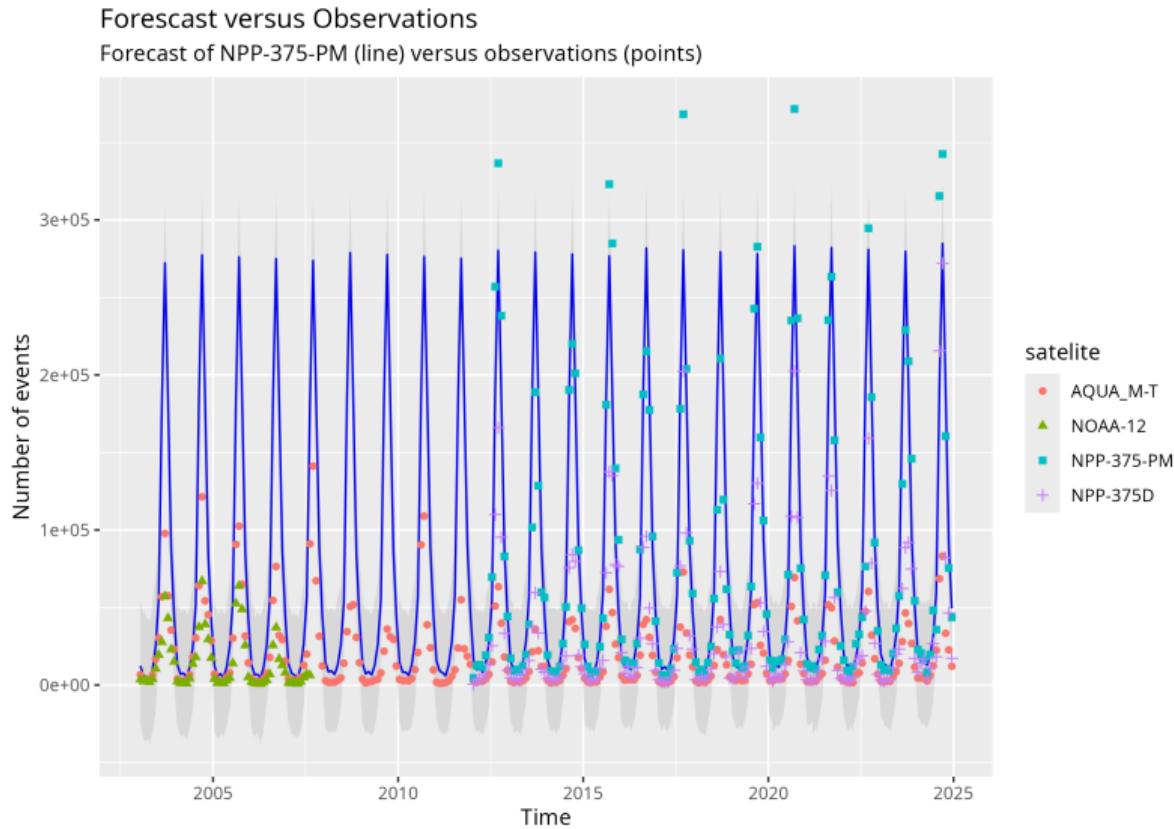


Does the forecast fit other observations?

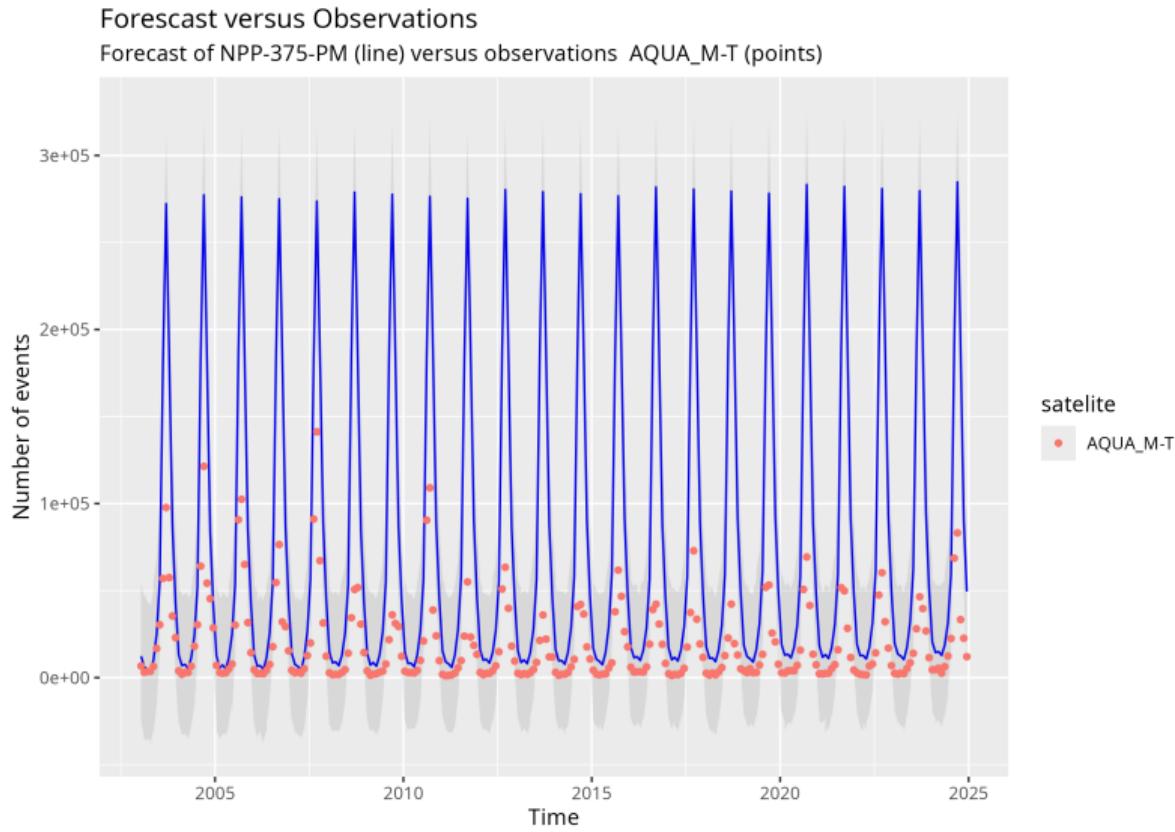
- Considering NPP-375-PM's model as the reference, how does the model fit data from other satellites?



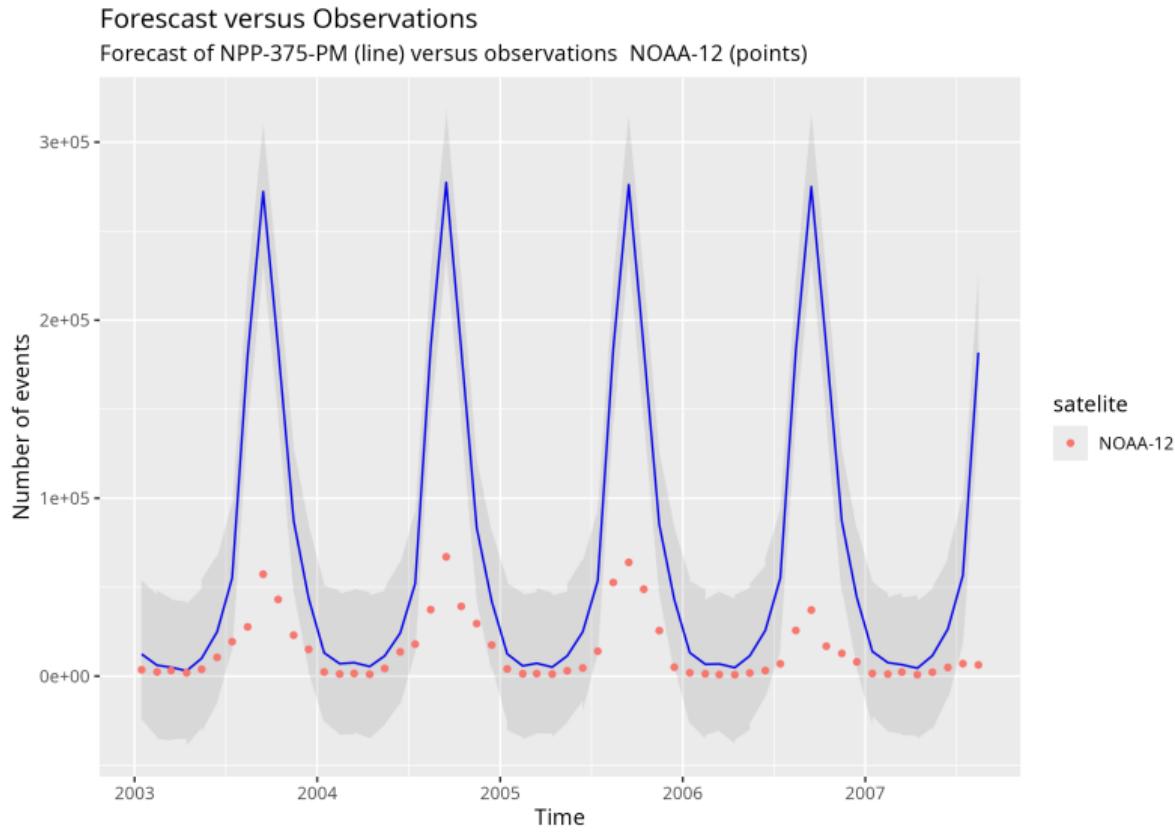
Forecast versus observations



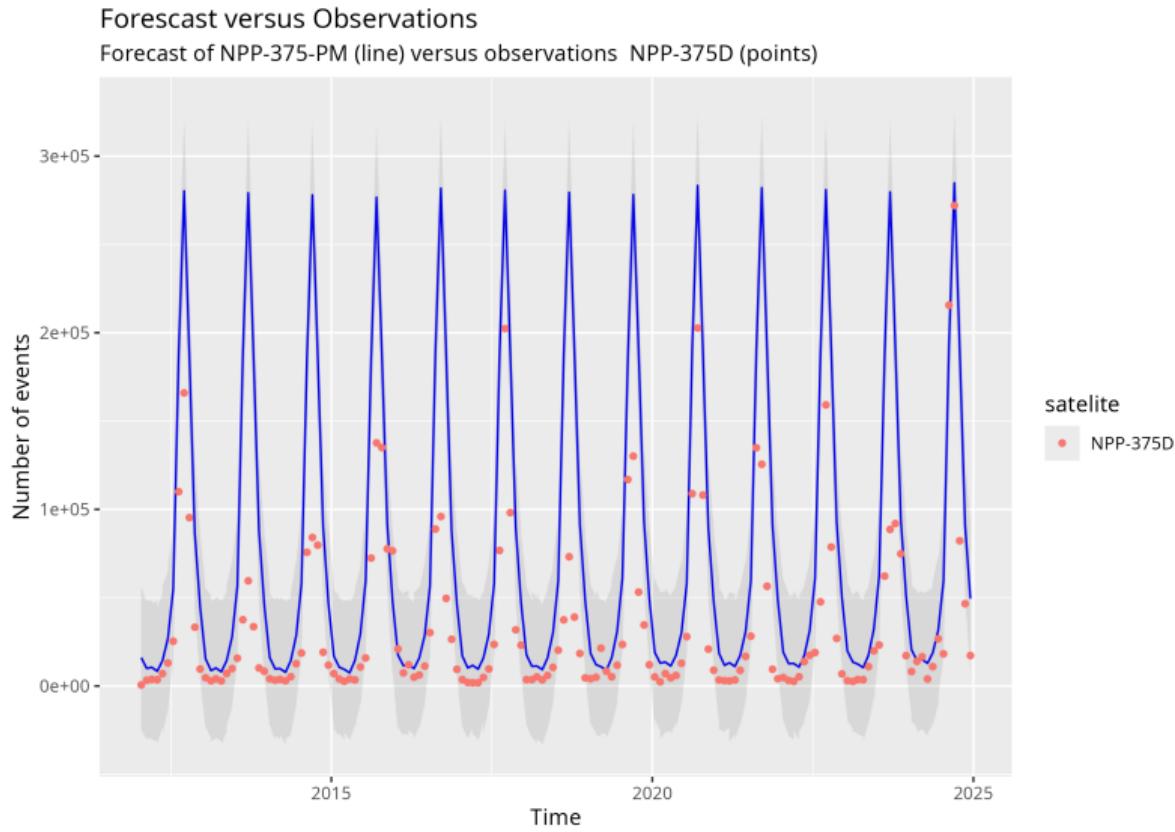
Forecast vs. observations



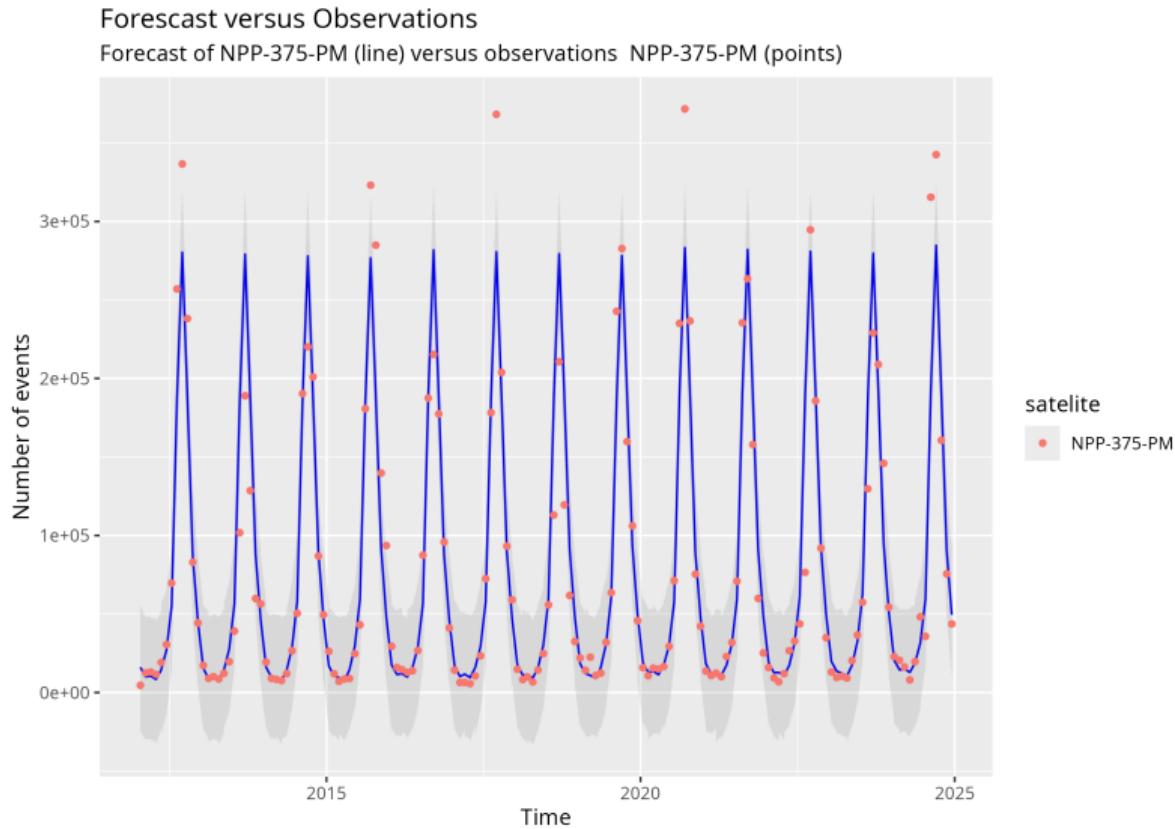
Forecast vs. observations



Forecast vs. observations

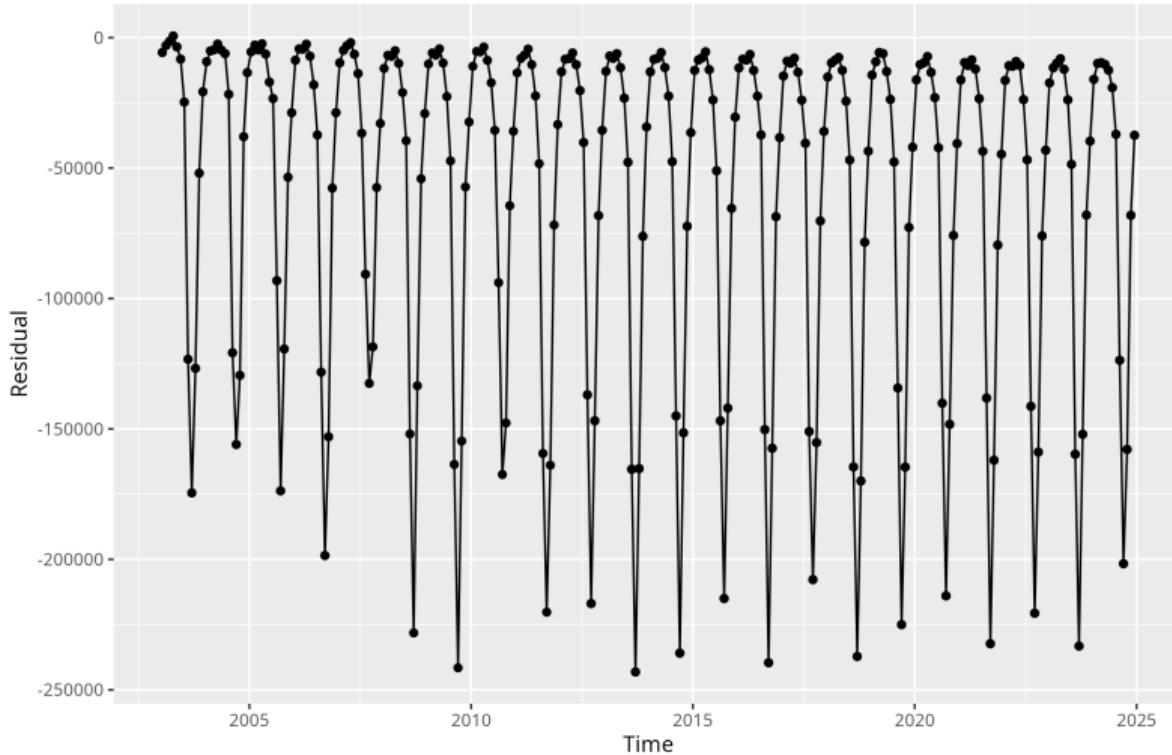


Forecast vs. observations



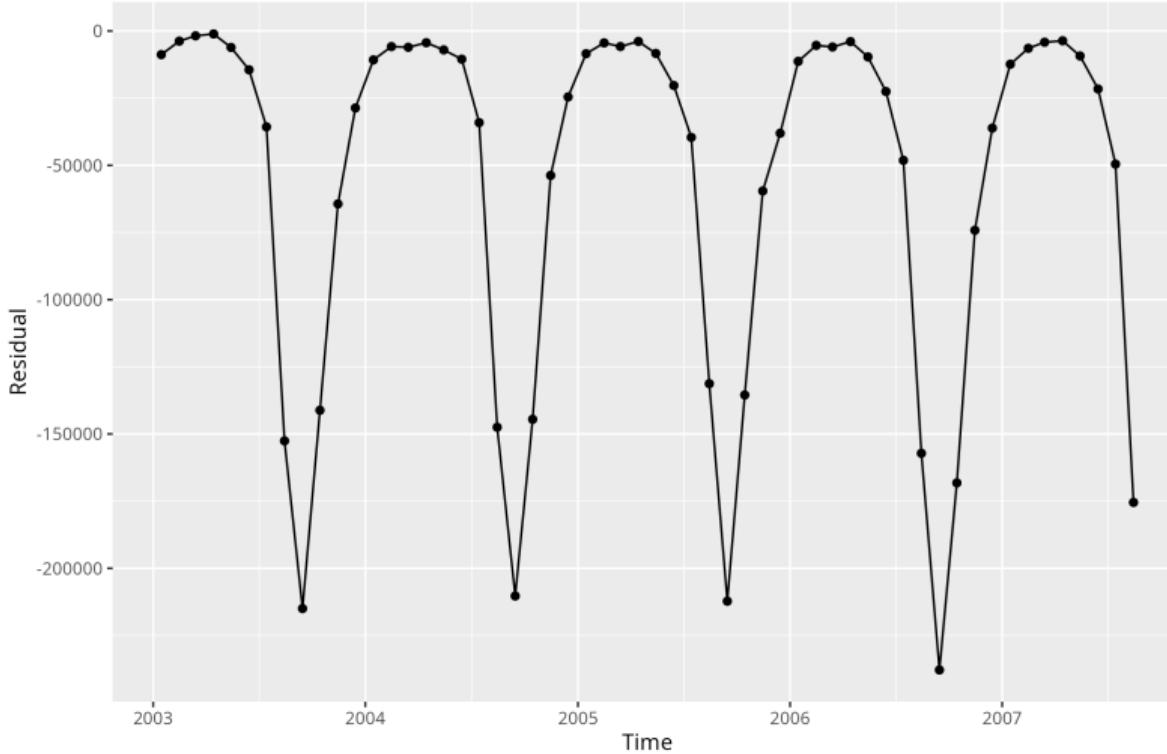
Forecast versus observations (residuals)

Forecast versus Observations (residuals)
Residuals of AQUA_M-T minus the forecast of NPP-375-PM



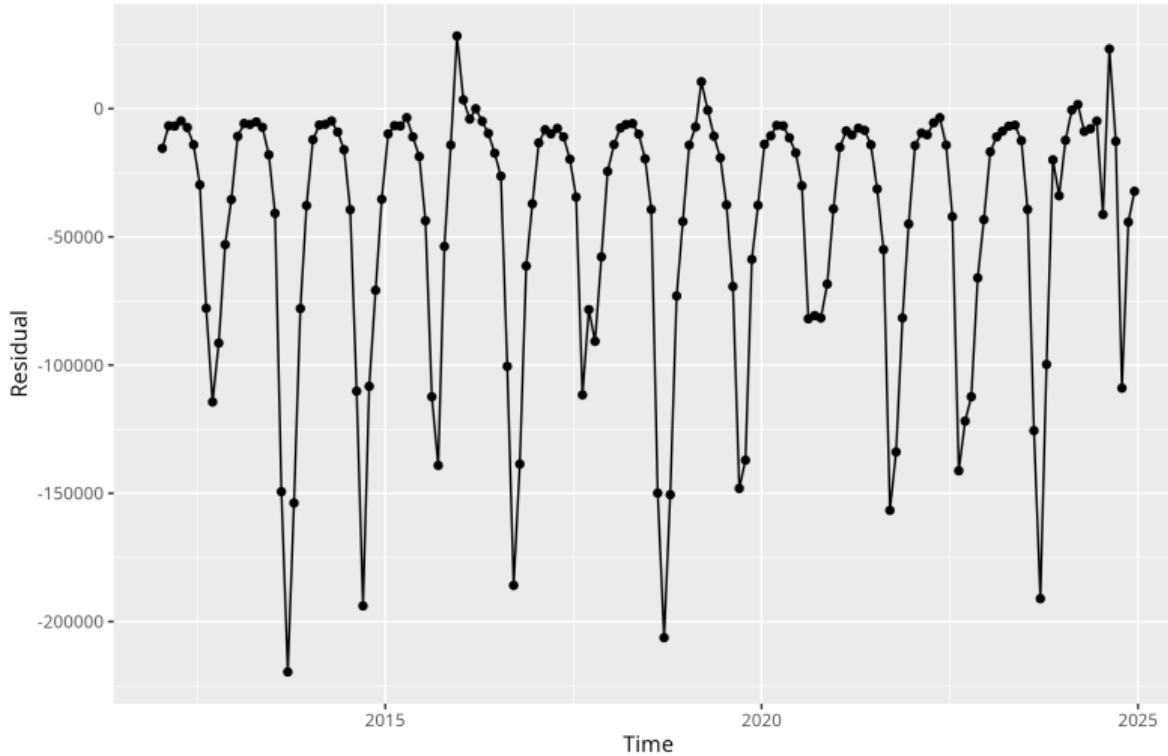
Forecast versus observations (residuals)

Forecast versus Observations (residuals)
Residuals of NOAA-12 minus the forecast of NPP-375-PM



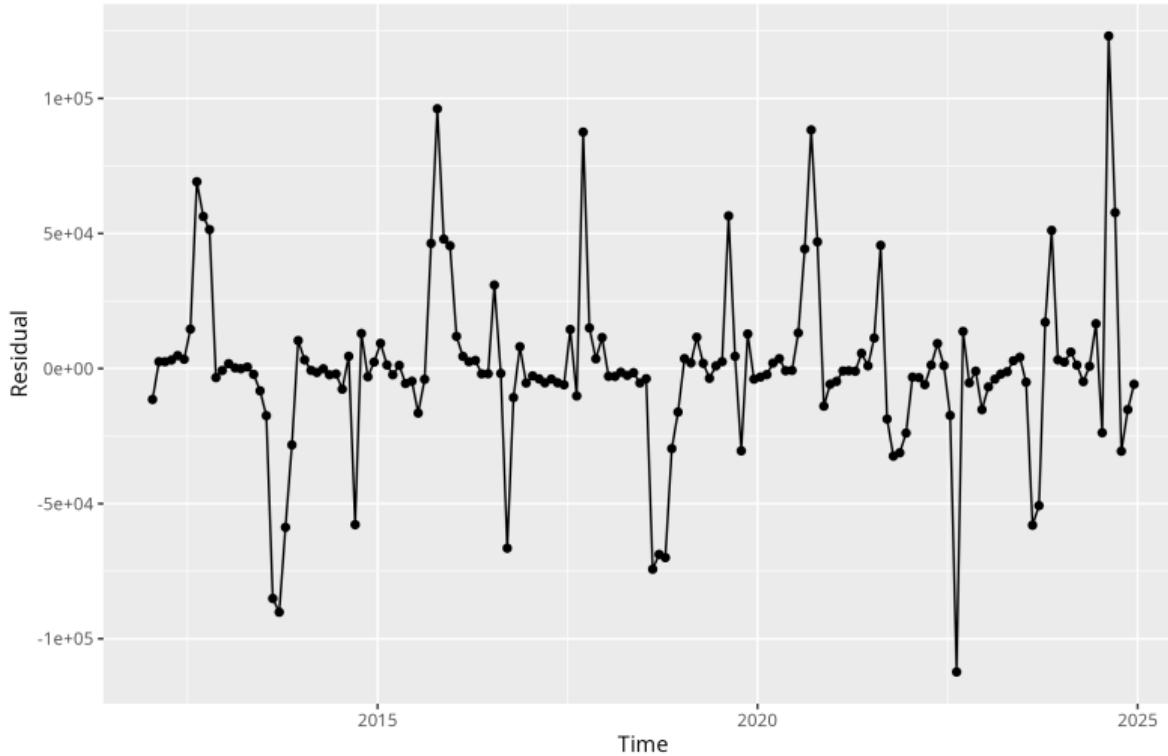
Forecast versus observations (residuals)

Forecast versus Observations (residuals)
Residuals of NPP-375D minus the forecast of NPP-375-PM



Forecast versus observations (residuals)

Forecast versus Observations (residuals)
Residuals of NPP-375-PM minus the forecast of NPP-375-PM



Future Work

Future work

- TODO.



References

References |

- [1] National Institute for Space Research in Brazil. *Banco de Dados de Queimadas*. 2023. URL: <http://www.inpe.br/queimadas/bdqueimadas> (visited on 02/11/2026).
- [2] A. C. Harvey and S. Peters. “Estimation Procedures for Structural Time Series Models”. In: *Journal of Forecasting* 9.2 (Mar. 1990), pp. 89–108. ISSN: 0277-6693, 1099-131X. DOI: [10.1002/for.3980090203](https://doi.org/10.1002/for.3980090203).
- [3] Alberto Setzer, Fabiano Morelli, and Jean Carlos Souza. “O Banco de Dados de Queimadas Do INPE”. In: *Biodiversidade Brasileira* 9.1 (2019), pp. 239–239.
- [4] Sean J. Taylor and Benjamin Letham. “Forecasting at Scale”. In: *The American Statistician* 72.1 (Jan. 2, 2018), pp. 37–45. ISSN: 0003-1305, 1537-2731. DOI: [10.1080/00031305.2017.1380080](https://doi.org/10.1080/00031305.2017.1380080).