DIPARTIMENTO DI SCIENZE
Department of Earth and Environmental Sciences E DELLA TERRA

EXPLORING CLIMATE CHANGE IMPACT ON GROUNDWATER SUPPORTING A MEDIUM STUDY AND LONG TERM WATER MANAGEMENT PLANNING, A CASE STUDY IN NORTHERN ITALY

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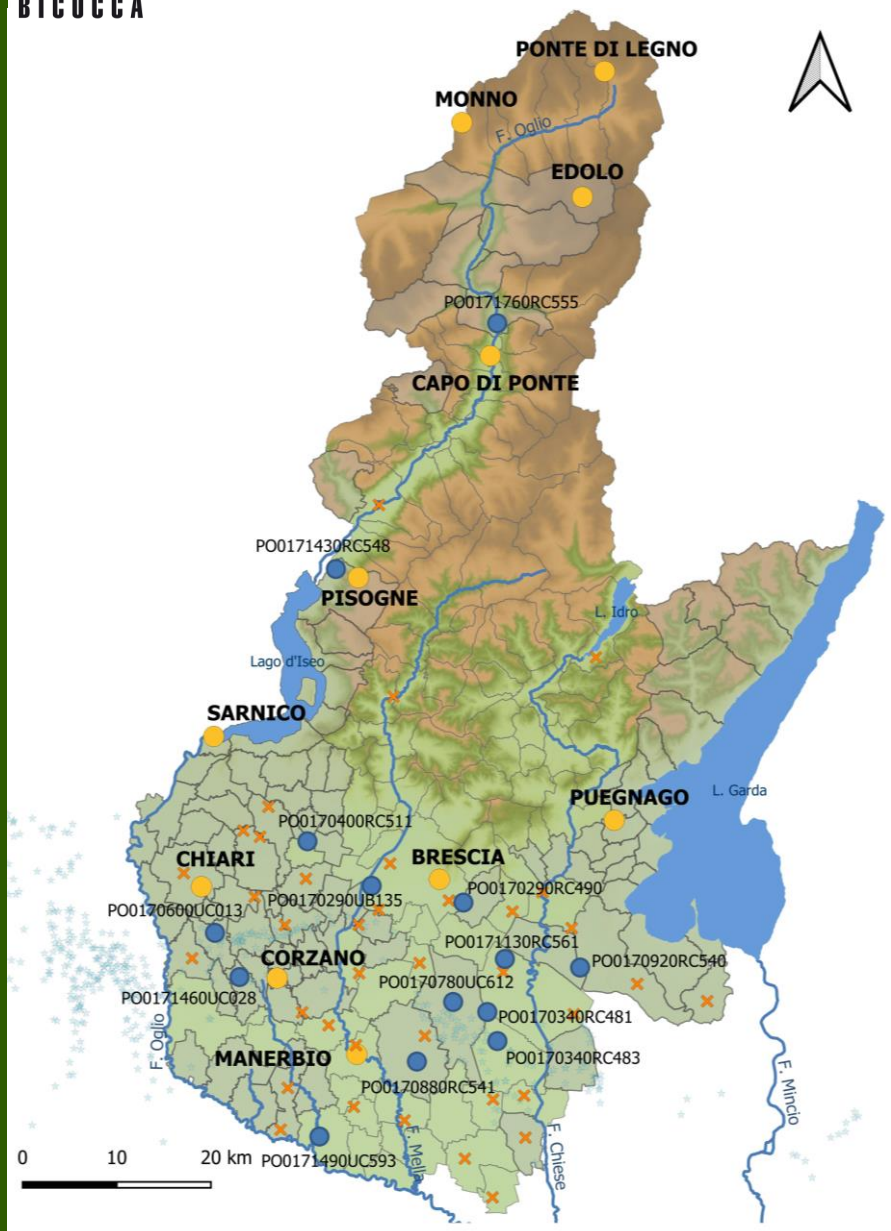
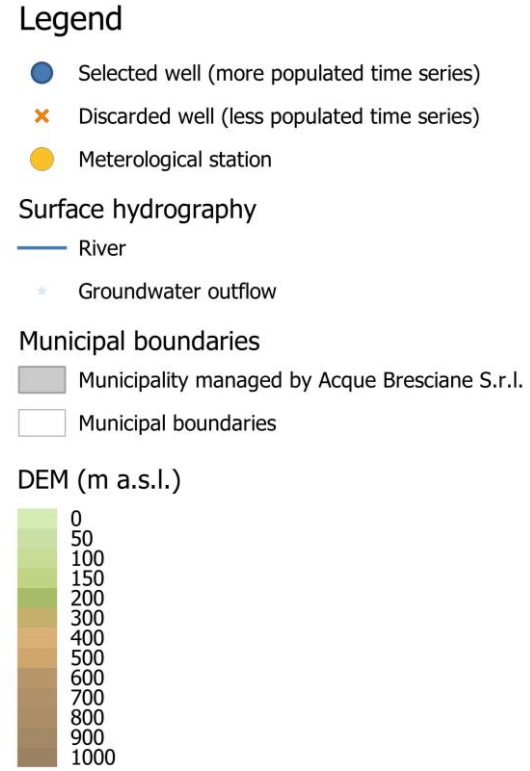
EGU – Vienna, 23-27 May 2022

STUDY AREA





Province of **Brescia,** northern Italy:

- Alpine area
- Plain area
  - Higher plain
  - Lower plain
  - Morainic area

Climate: temperate continental, with cold winters and wet and warm summers.

Precipitation: usually higher in spring and autumn than in winter or summer.

Available data	Source	Period covered
Precipitation data	ARPA* meteorological station	2009 – 2020 (monthly data)
Groundwater data	ARPA* monitoring network	2009 – 2020 (monthly data)

*ARPA Lombardy, Regional Agency for the Environment.

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METHODOLOGY

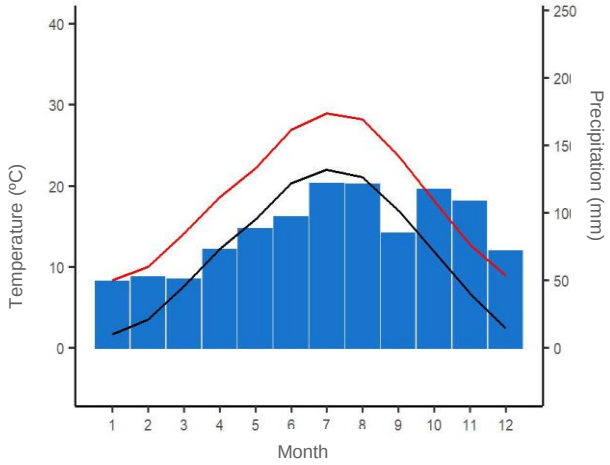
Precipitation and Temperature data

- **Climograph**
- **SPI** (Standardized Precipitation Index)
- Annual/quarterly/monthly precipitation and temperature counts
- Number of quarterly dry days
- Quarterly cumulative precipitation
- Average quarterly temperature
- Time series decomposition

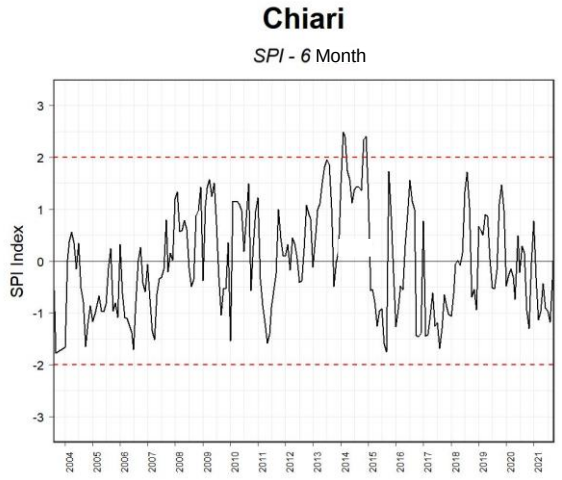
Groundwater data

- Outliers removing
- **Missing value treatment (with Seasonally Decomposed Imputation vs. Monthly average)**
- Trend analysis (Mann-Kendall test and Pettitt's test)
- Time series decomposition
- Autocorrelation – Cross correlation

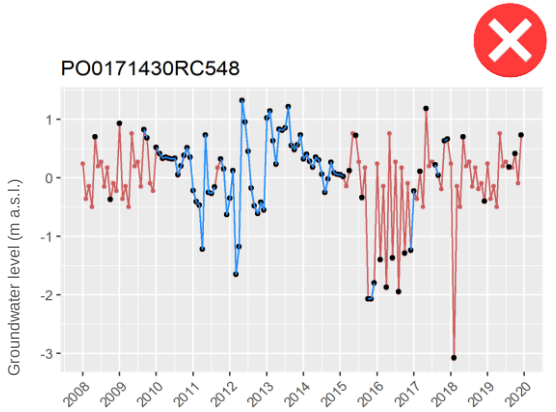
Climograph



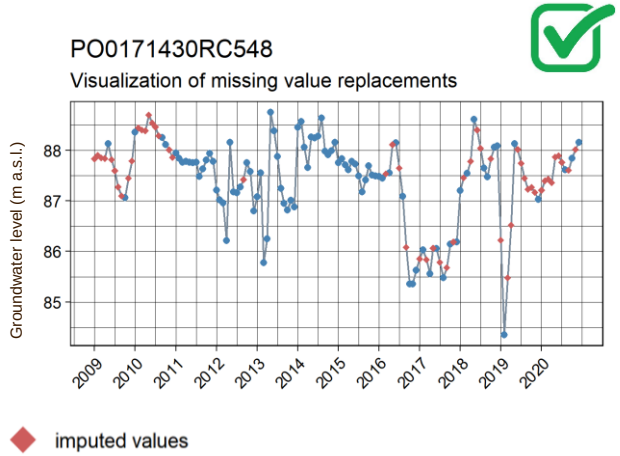
SPI



Monthly average



Seasonally decomposed imputation



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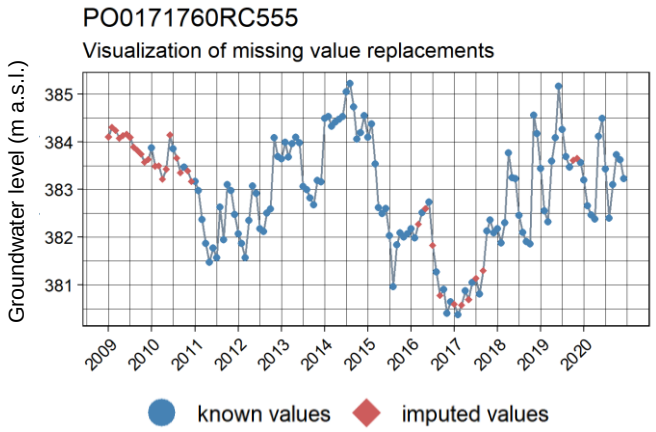
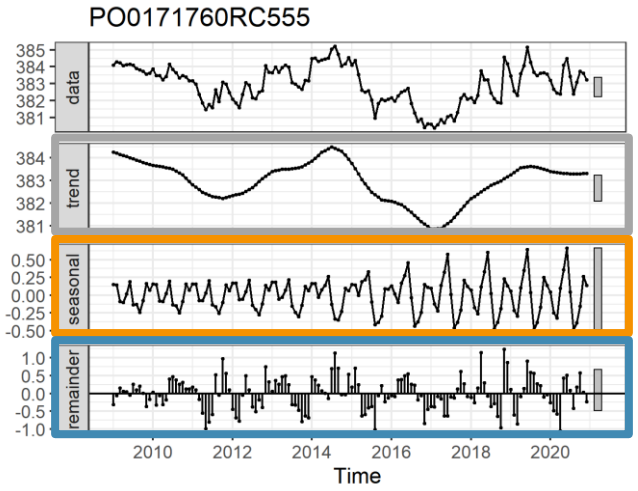
1. Alpine area

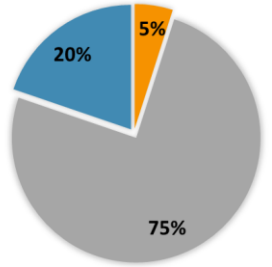
Complete time series



Time series decomposition



Decomposition components



Pluri-annual trend

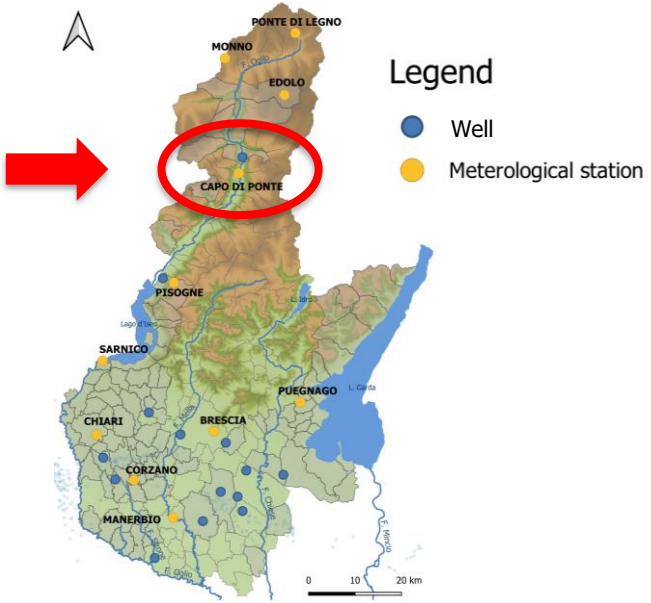
Seasonality - two yearly peaks:

- Snowmelt - summer
- Precipitation - autumn

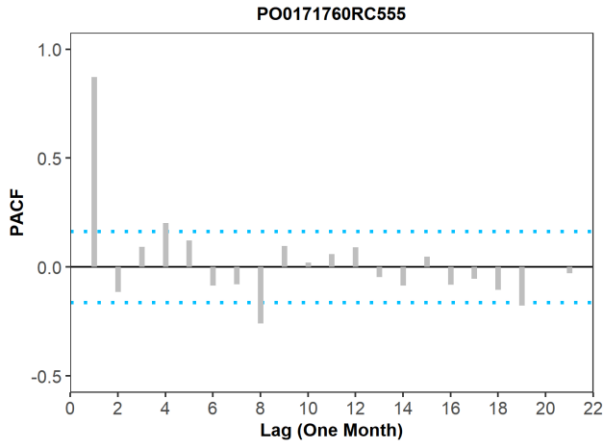
Reminder

Climate change vulnerability

Possible shifting in the **snowmelt period** and changing in the **precipitation type** (from snow to rain).

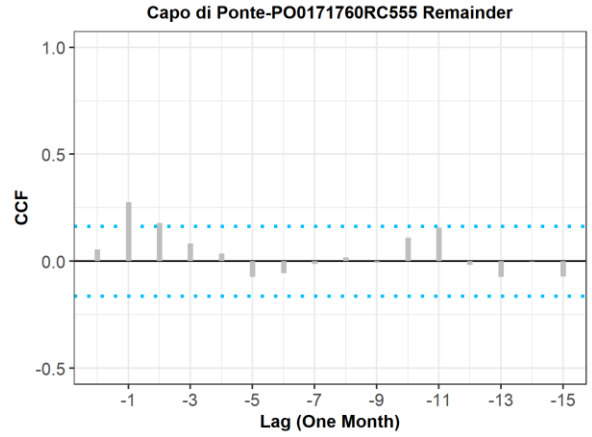


Partial Autocorrelation



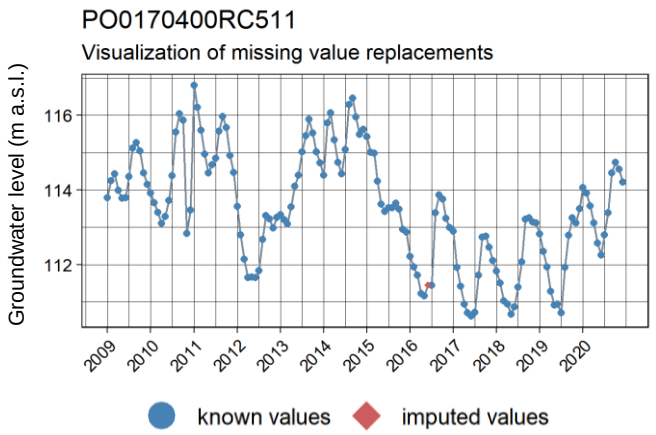
Cross correlation

Reminder component vs precipitation

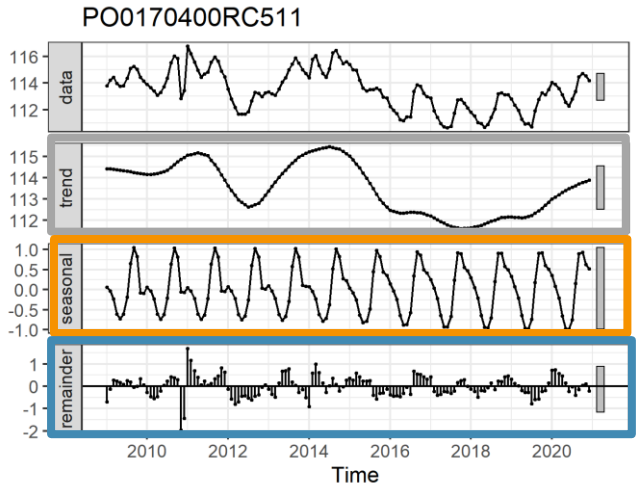


2. Higher plain – unconfined aquifer

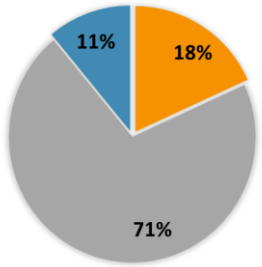
Complete time series



Time series decomposition



Decomposition components



Pluri-annual trend

Seasonality - two yearly peaks:

- Irrigation return flow from surface water - summer
- Precipitation - autumn

Reminder

Climate change vulnerability

Change of **irrigation source** form surface water to groundwater

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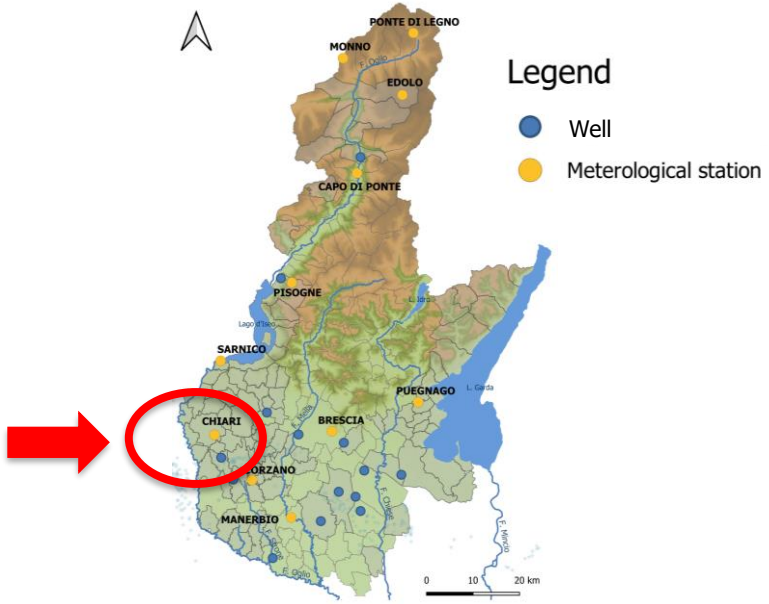
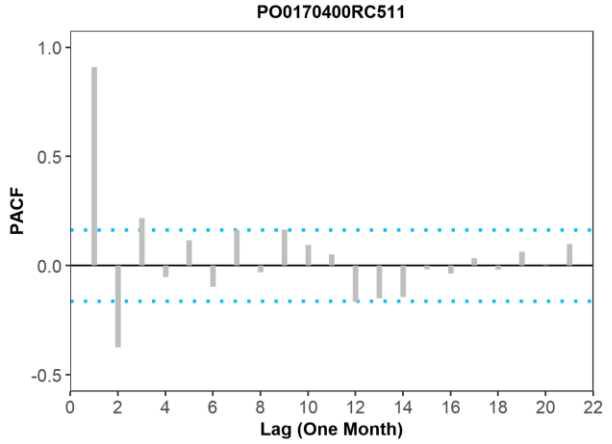
reduced input and increased output

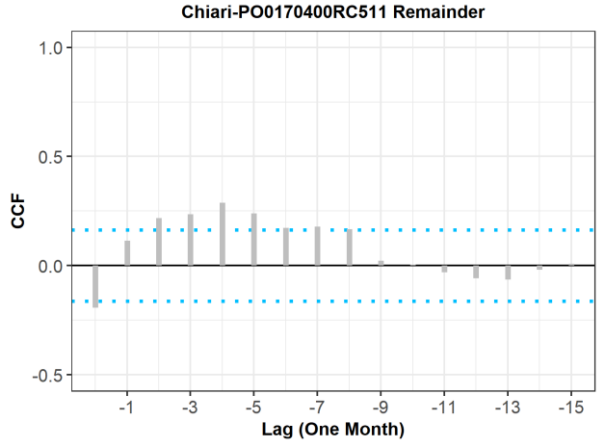


Partial Autocorrelation



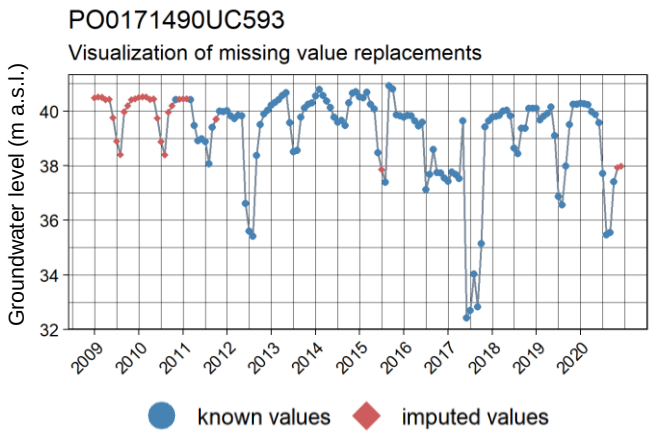
Cross correlation

Reminder component vs precipitation

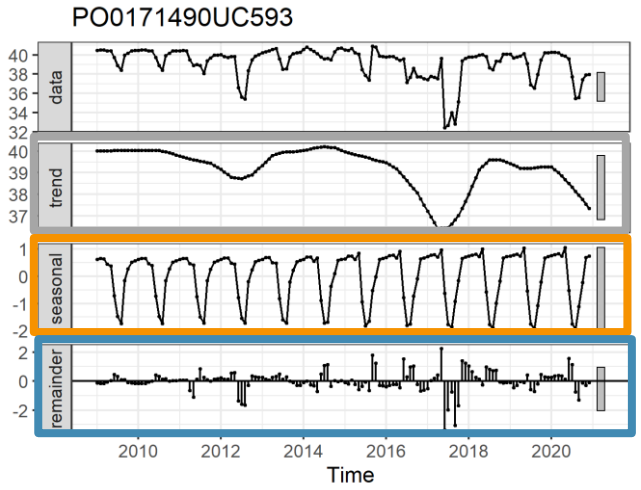


3. Lower plain – confined aquifer

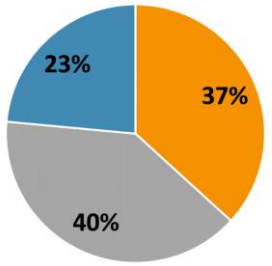
Complete time series



Time series decomposition



Decomposition components



Pluri-annual trend

Seasonality - one yearly minimum:
- Abstraction - summer

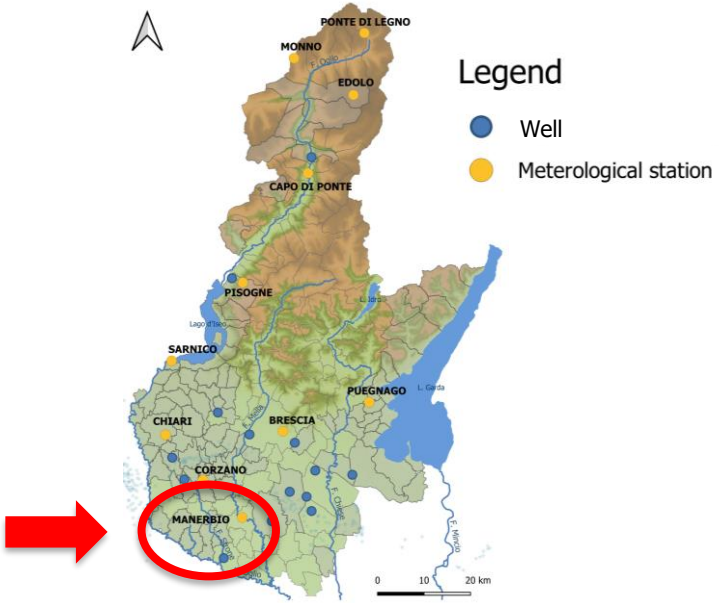
Reminder

Climate change vulnerability

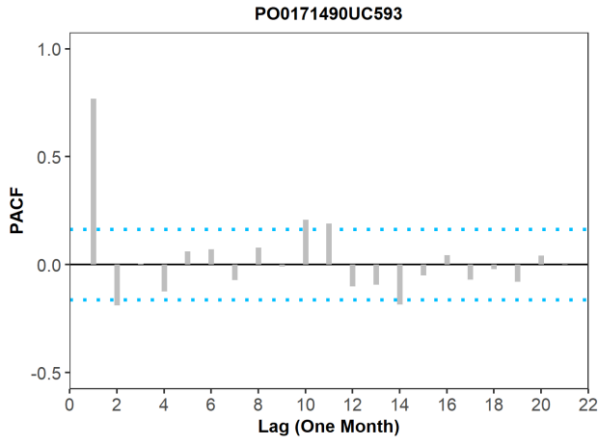
Increased **demand for irrigation** purposes

↓

increased abstraction

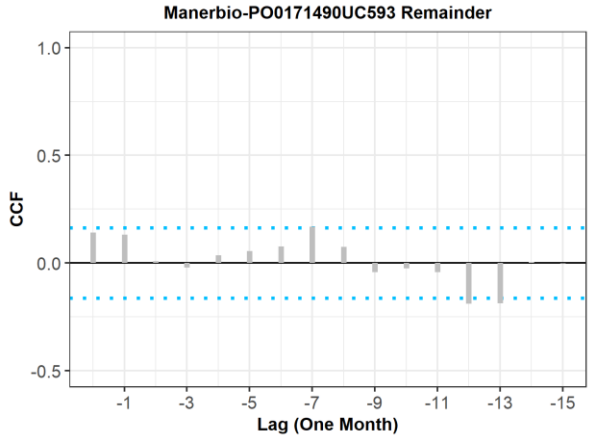


Partial Autocorrelation



Cross correlation

Reminder component vs precipitation



CONCLUSIONS

As one of the most significant water sources, **groundwater is going to play an increasingly important role in facing climate change**;

Climate change could affect groundwater system both directly and indirectly and their effects differ according to the groundwater bodies considered;

This variability highlights that a study based only on the possible variation of precipitation and temperature are too simplistic and the consequent **necessity to consider all the inputs and the outputs**, e.g., changing source for irrigation (from surface water to groundwater) in the higher plain can cause a variation in the groundwater balance;

Further analyses will lead to the identification of actions to resiliently respond to changes.

Thanks for paying attention!

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