**“Adapt your future: let’s talk about climate change”**

4th October 2022

# CLIMATE CHANGE’S IMPACT IN GROUNDWATER RESOURCES AND HYDROGEOLOGICAL RISK ASSESSMENT


Prof. Chiara Calligaris

Dipartimento di Matematica e Geoscienze

Università degli Studi di Trieste

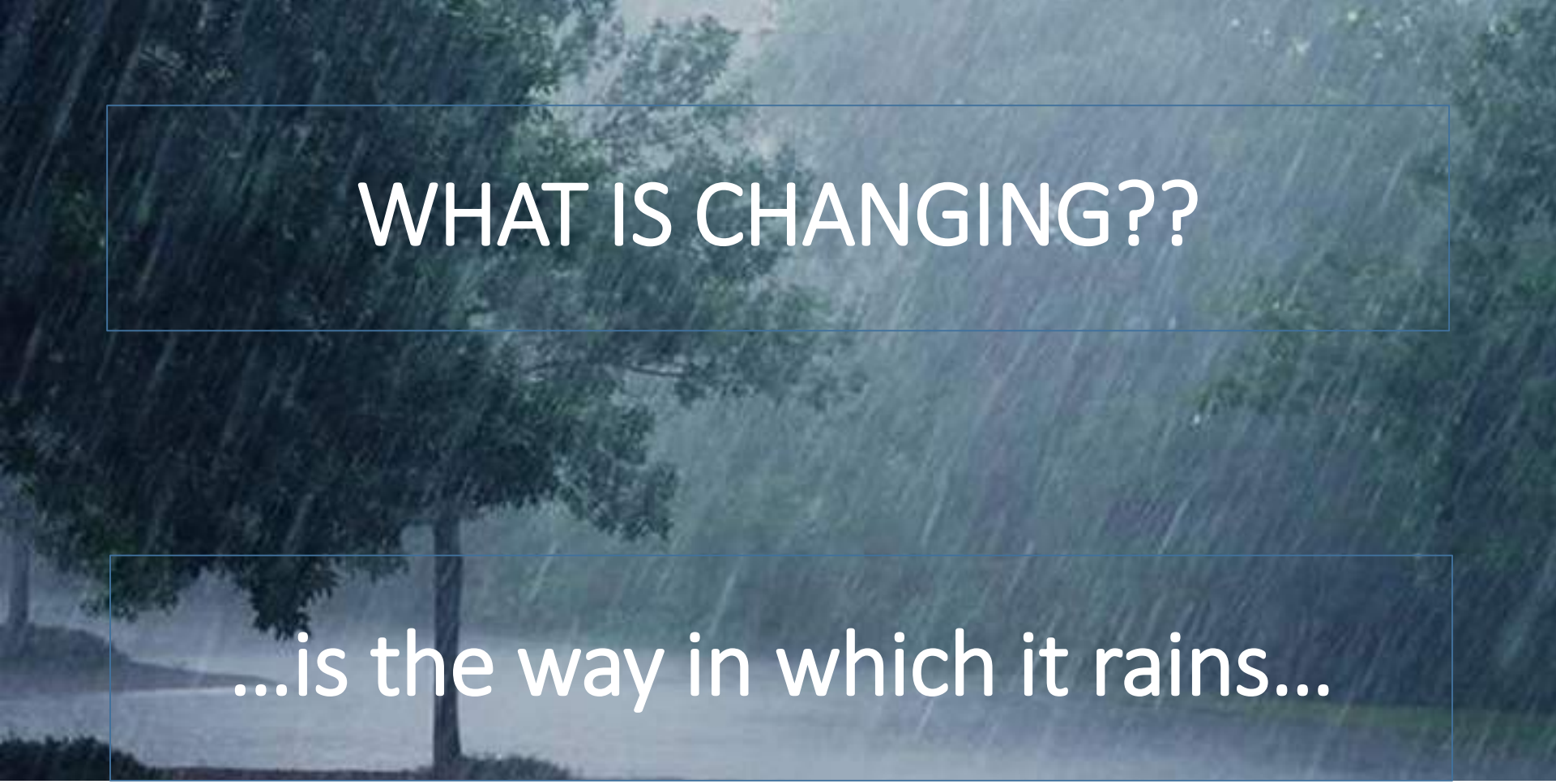
# CLIMATE CHANGE

## GROUNDWATER RESOURCES

## HYDROGEOLOGICAL RISK ASSESSMENT

# WHAT'S GOING ON TO THE GROUNDWATER RESOURCES??

## 2022 has been a very dry year….but….on 9 September 2022…



# WHAT IS CHANGING??

…is the way in which it rains…

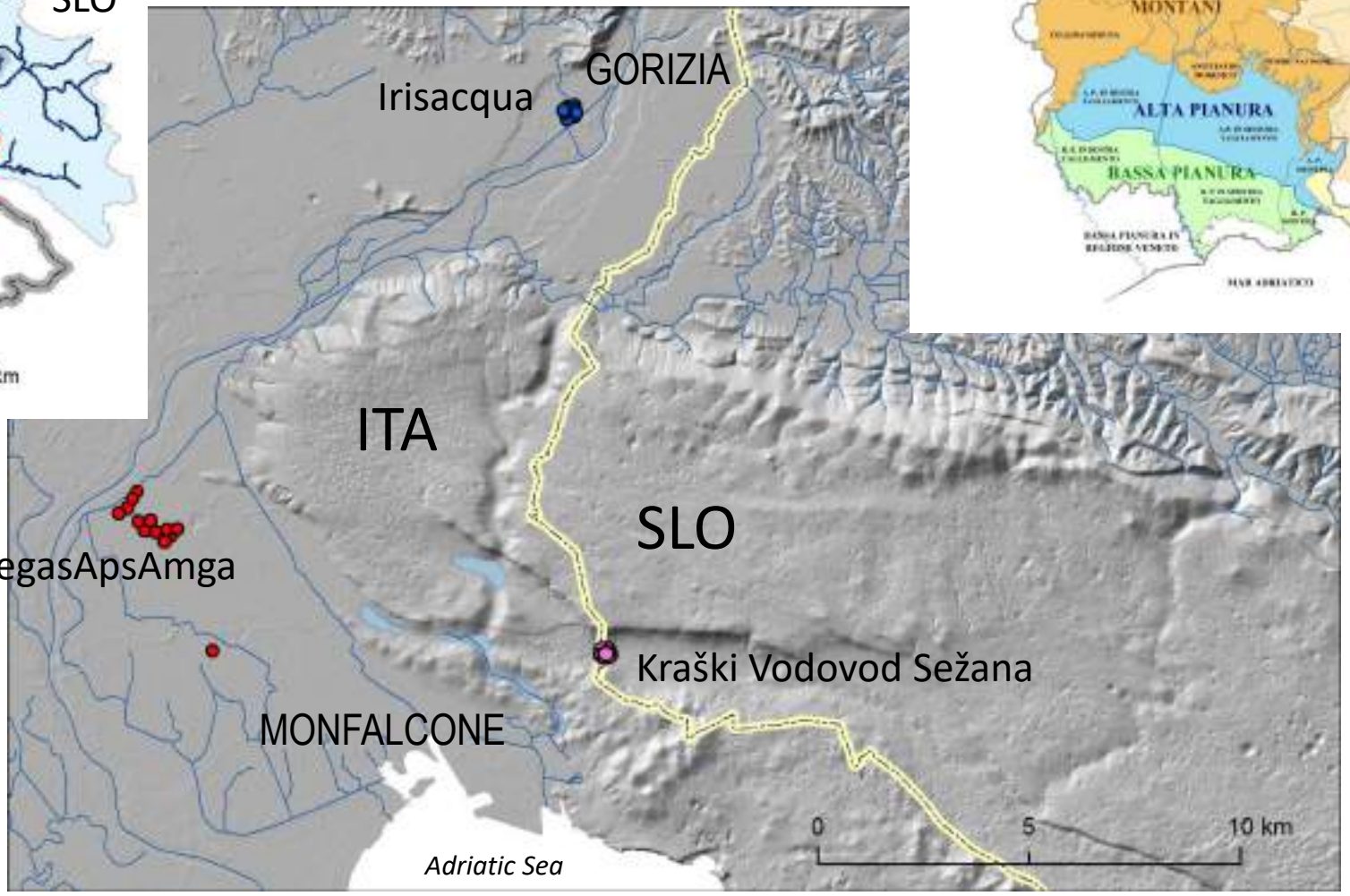
THIS HAS AN IMPACT ON THE GROUNDWATER RECHARGE

# DRY SOIL WITH CRACKS, how water infiltrates

https://messaggeroveneto.gelocal.it/udine/cronaca/2022/03/26/news/siccita-i-consorzi-di-bonifica-manca-l-acqua-dobbiamo-razionarla-semine-di-mais-e-soia-posticipate-1.41329570

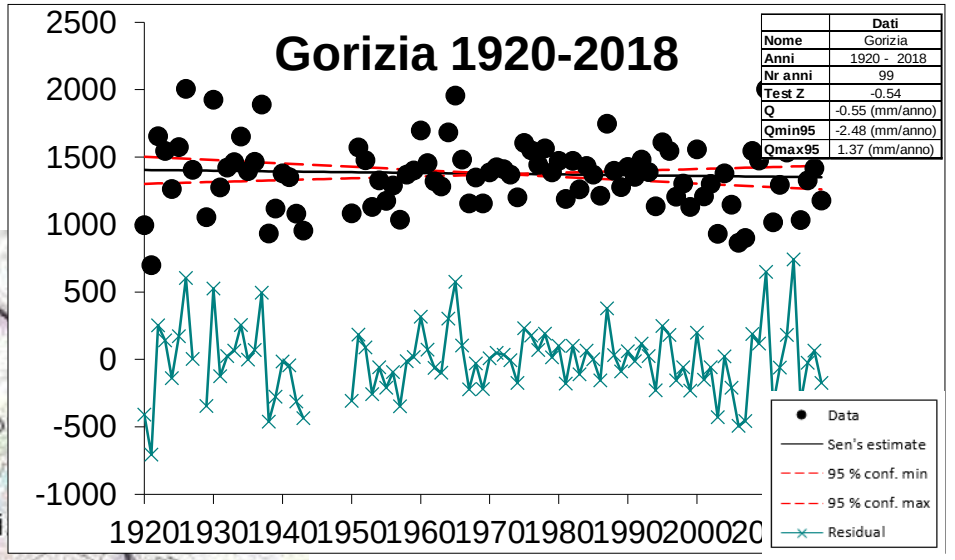
# AN EXAMPLE.....



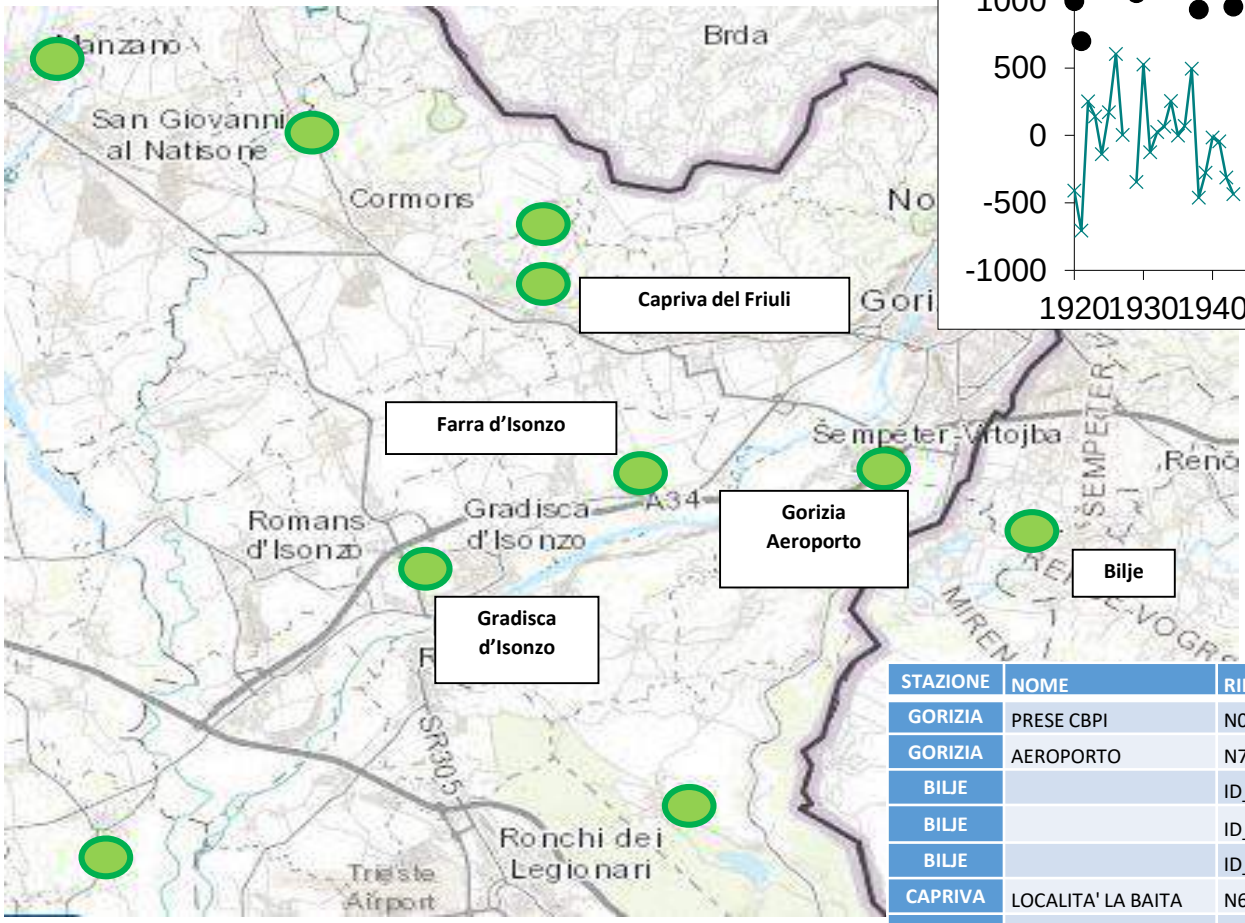



The aquifers of the Isonzo Plain provide freshwater to more than 390.000 persons considering the towns of Gorizia (Irisacqua), Trieste (AcegasApsAmga) and part of the inhabitants of the Slovenian karst (Kraški Vodovod Sežana).

# PLUVIOMETRIC STATIONS LONG-TERM TIME SERIES

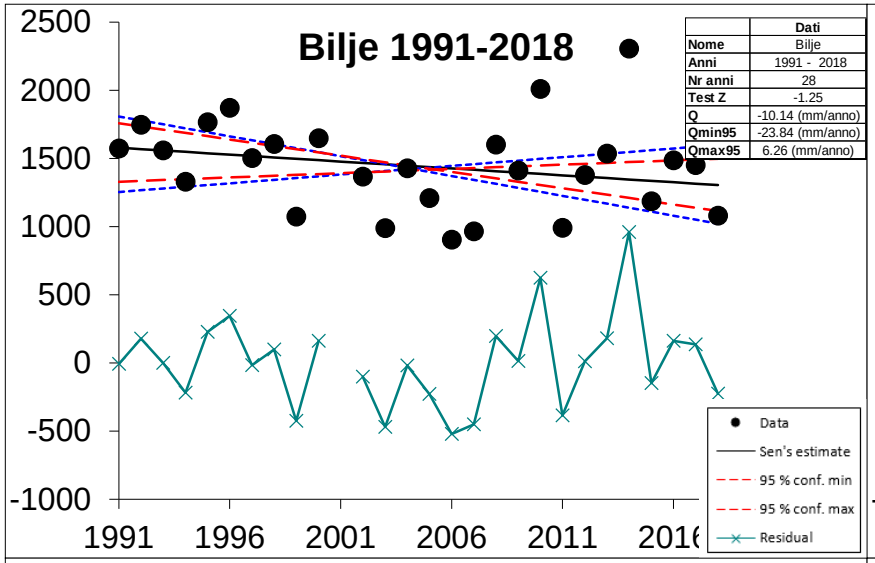


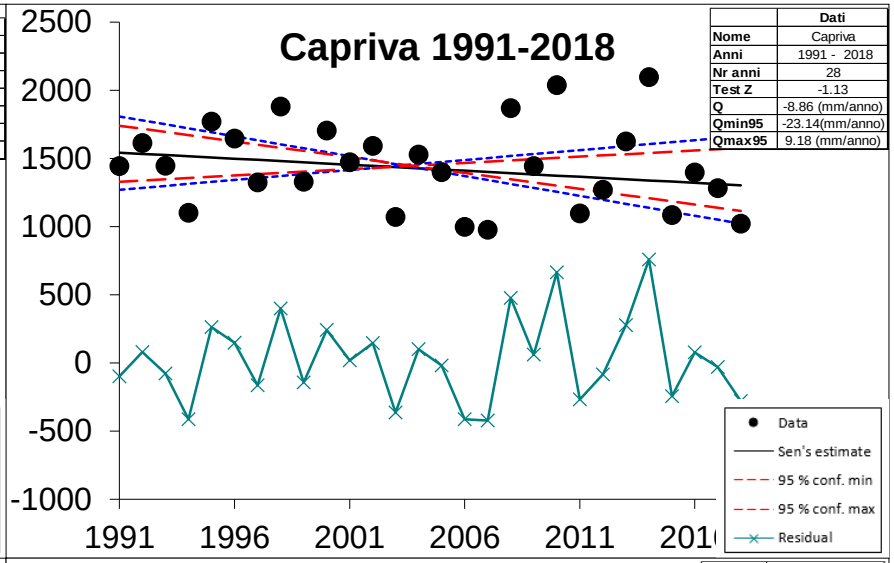

| | Dati |
|---|---|
| Nome | Gorizia |
| Anni | 1920 - 2018 |
| Nr anni | 99 |
| Test Z | -0.54 |
| Q | -0.55 (mm/anno) |
| Qmin95 | -2.48 (mm/anno) |
| Qmax95 | 1.37 (mm/anno) |

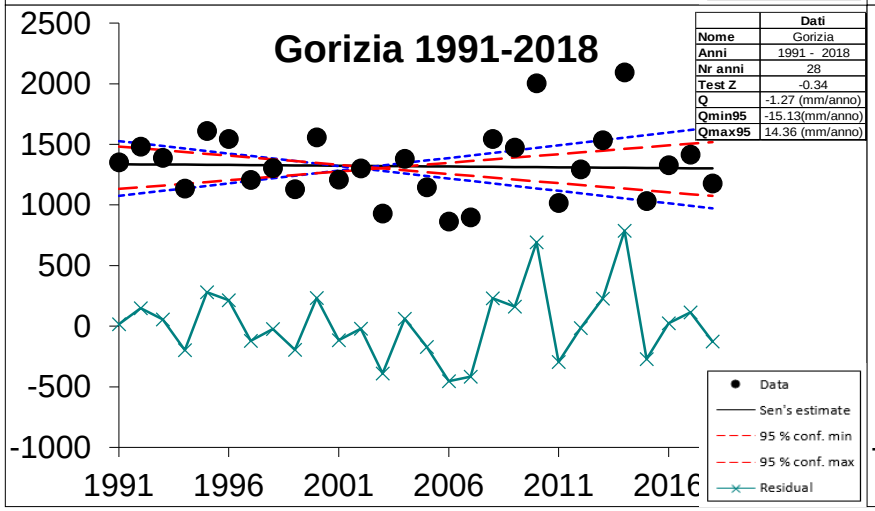


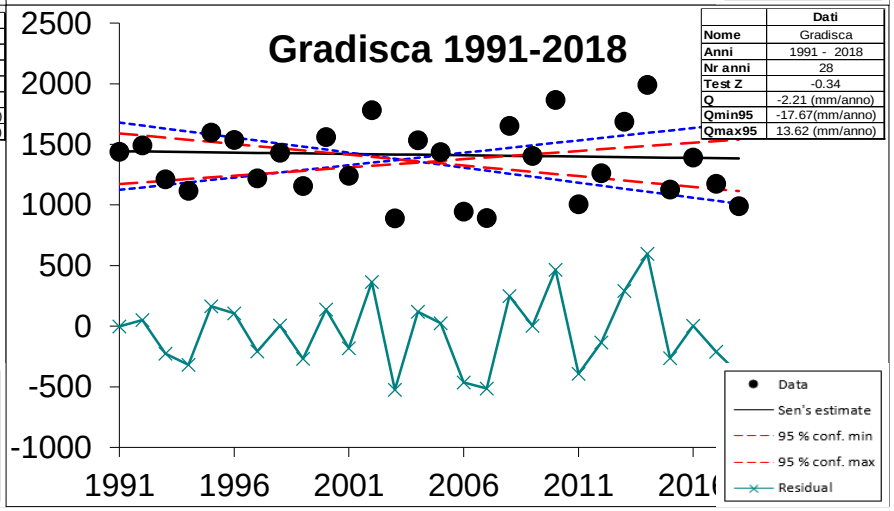

| STAZIONE | NOME | RIFERIMENTO FVG | DATE MONITORAGGIO | FONTE |
|---|---|---|---|---|
| GORIZIA | PRESE CBPI | N022 | 01/10/1919 - 02/01/2012 | OSMER |
| GORIZIA | AEROPORTO | N701 | 01/01/1995 - 2018 | OSMER |
| BILJE | | ID_232 | 01/04/1962 - 21/12/1982 | ARSO (SLO) |
| BILJE | | ID_2249 | 22/12/1982 - 31/03/1991 | ARSO (SLO) |
| BILJE | | ID_1923 | 01/04/1991 - 2018 | ARSO (SLO) |
| CAPRIVA | LOCALITA' LA BAITA | N606 | 01/01/1991 - 2018 | OSMER |
| GRADISCA | | N026 | 01/01/1950 - 2018 | OSMER+RAFVG |
| FARRA | FORTIN | N024 | 01/01/1994 - 02/01/2012 | RAFVG |

# PLUVIO TIME SERIES ANALYSES AND TRENDS

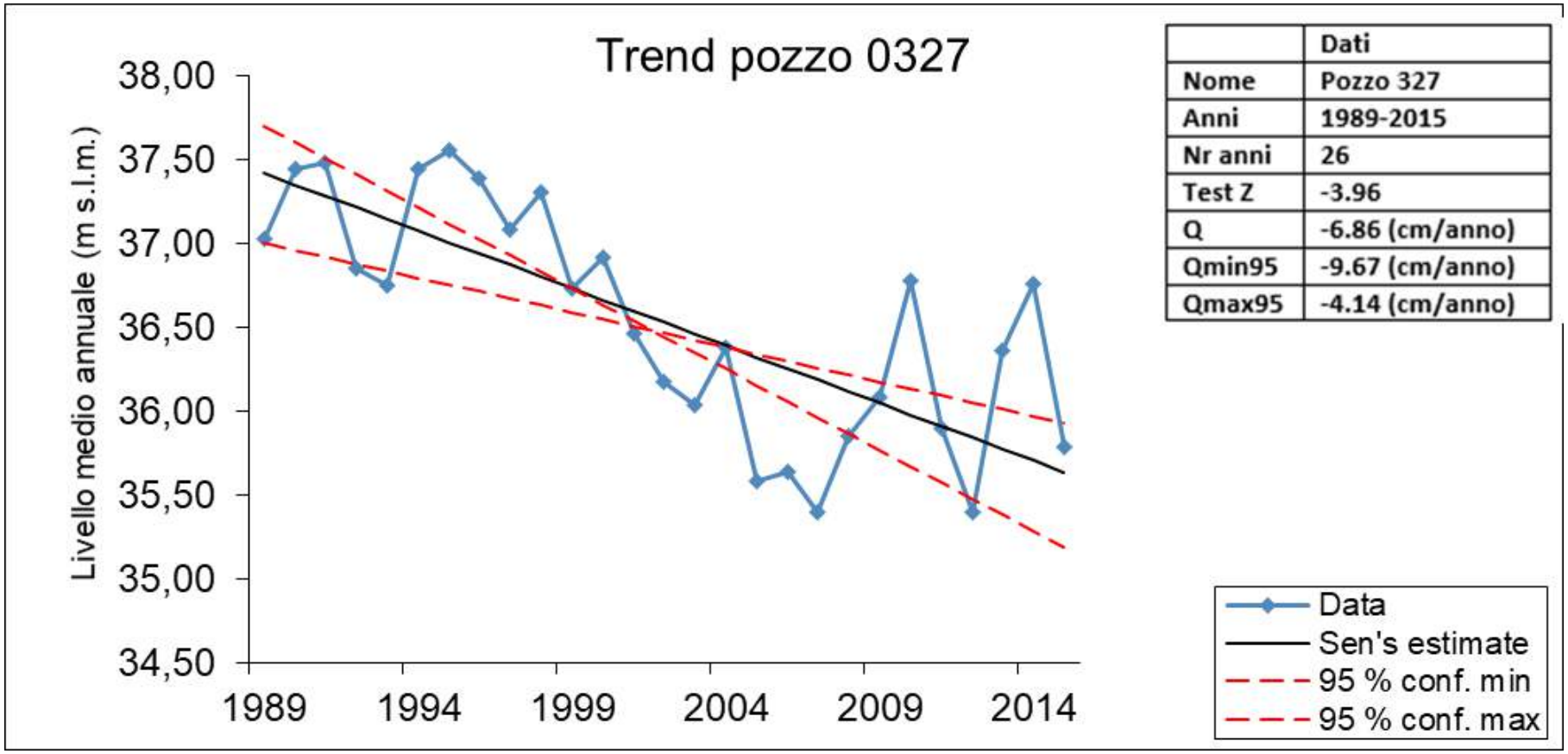


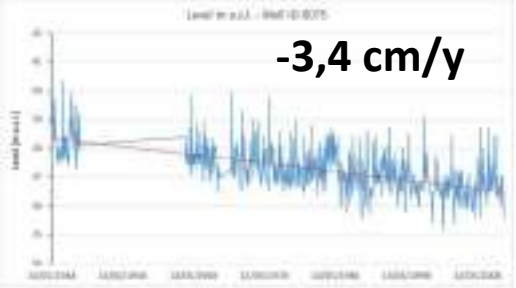



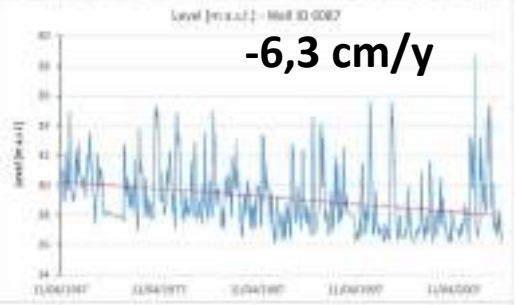
# What can we use to monitor the groundwater levels??
# THE PIEZOMETERS

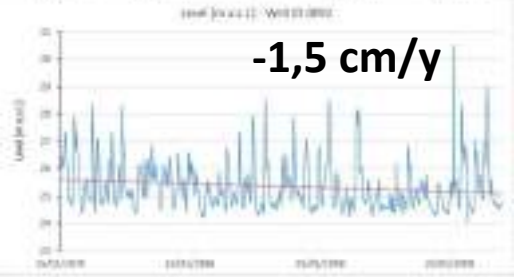


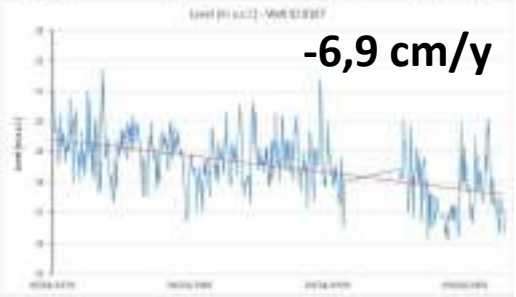

| | Dati |
|---|---|
| Nome | Pozzo 327 |
| Anni | 1989-2015 |
| Nr anni | 26 |
| Test Z | -3.96 |
| Q | -6.86 (cm/anno) |
| Qmin95 | -9.67 (cm/anno) |
| Qmax95 | -4.14 (cm/anno) |

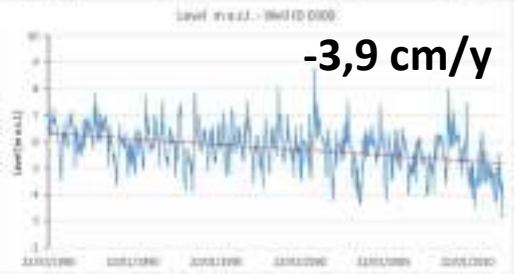
Average annual groundwater level data for the period 1989-2015. For piezometer 327 the value of Q, which therefore expresses the lowering of the groundwater level, is equal to -6.86 cm/y.



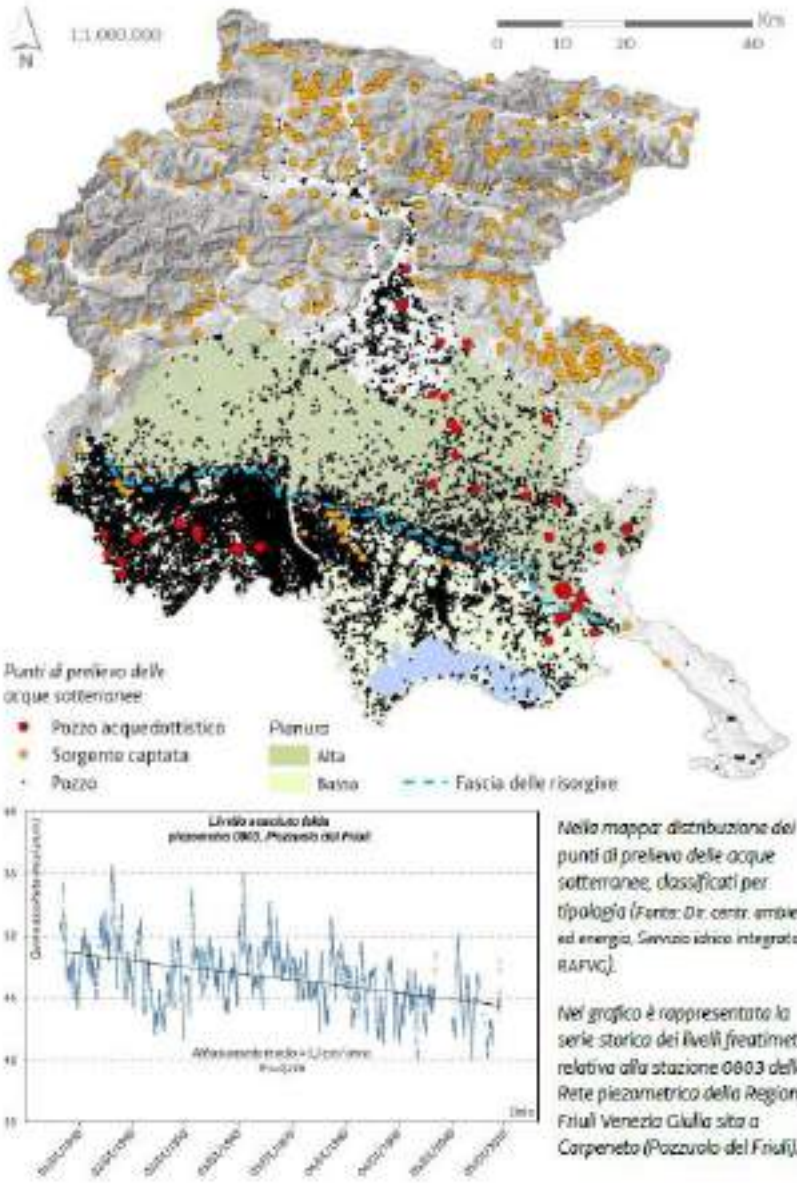




In 2017, Calligaris et al., analysed five wells located in the Isonzo/Soča River Plain in accordance with the available longer time series. Data series, for some wells, covered a period from 1948 to 2012.

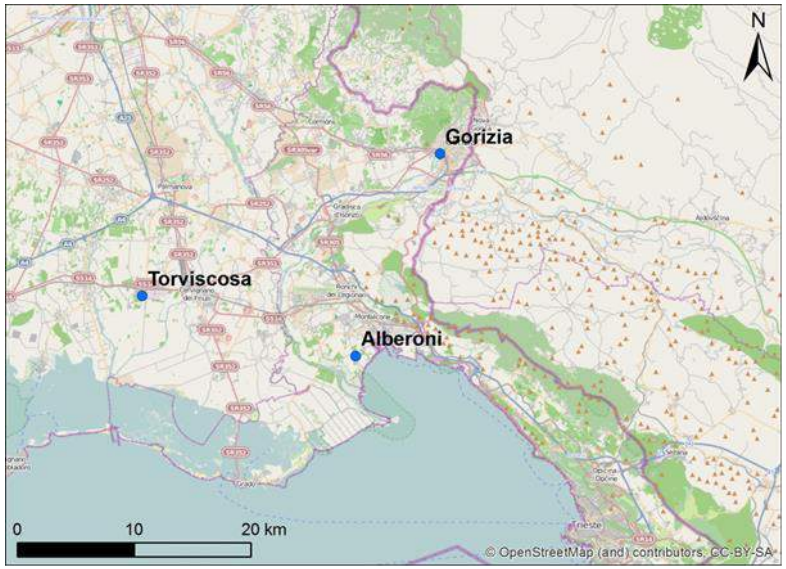
As defined also by Gerdol (2013), the data highlighted different but always decreasing trends also according to the location of the considered well, but between **-1,5 cm/y** and **-6,9 cm/y**, definitively in accordance with what discovered in the FVG low plain with a lowering of **-5,2 cm/y** in a well at Pozzuolo del Friuli as said by Bezzi et al. (2018).




*Nella mappa: distribuzione dei punti di prelievo delle acque sotterranee, classificati per tipologia (Fonte: Dir. centr. ambiente ed energia, Servizio idrico integrato, RAFVG).*

*Nel grafico è rappresentata la serie storica dei livelli freatimetrici relativa alla stazione 0803 della Rete piezometrica della Regione Friuli Venezia Giulia sita a Carpeneto (Pozzuolo del Friuli).*

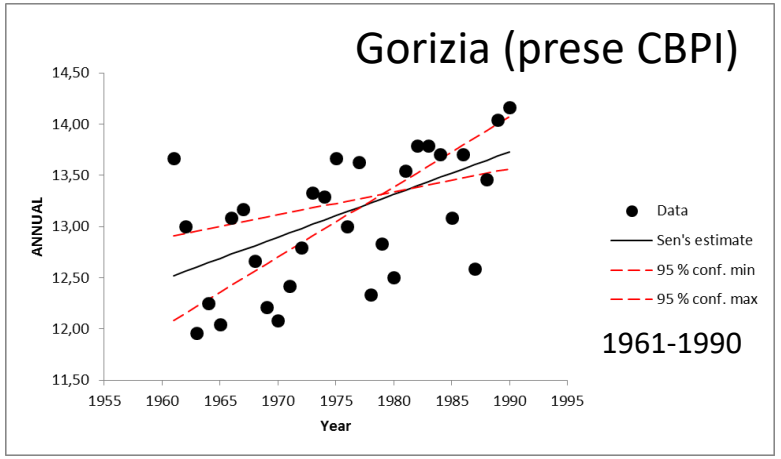
# THE TEMPERATURES

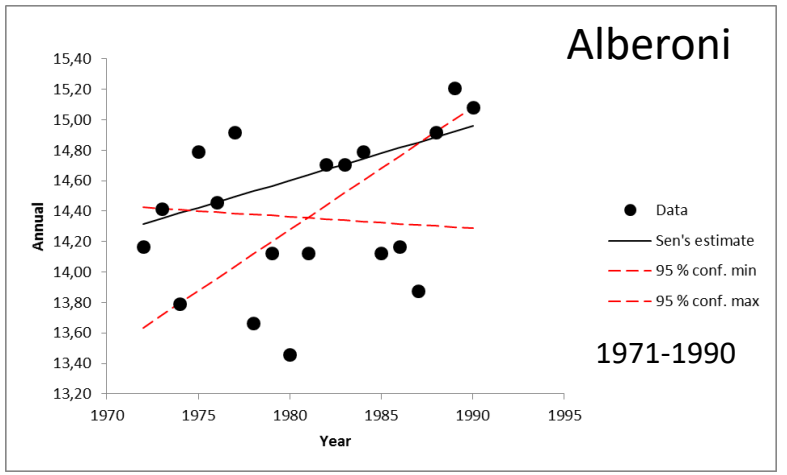


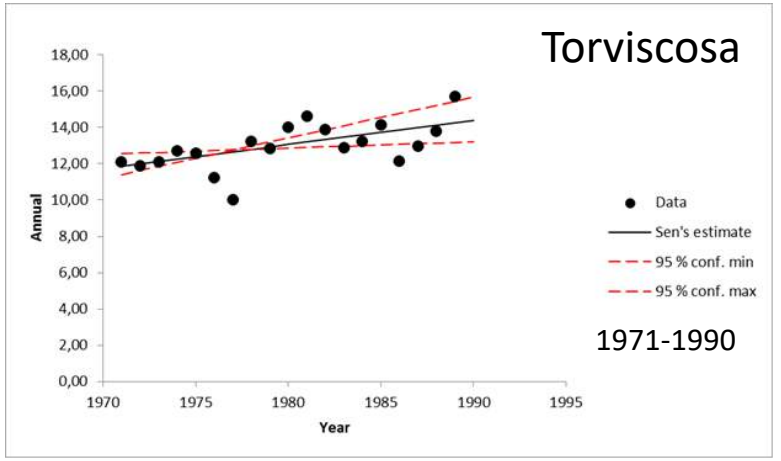

The debate on global warming has in fact ceased for many years within the scientific world as there is now full agreement that it is unequivocal.
Since 1950, many of the observed changes are unprecedented on a millennial scale. The increase in the global average temperature of the earth's surface and oceans of 0.85° C for the period 1880-2012 corresponds to an increasing forecast for the end of the 21st century, with values between 0.3 and 4.8° C depending on the greenhouse gas emission scenarios (IPCC, 2014).

**Value computed on the whole dataset**

**GORIZIA (prese CBPI)** Trend= **+0,2°C/10y**, t(1941-2011)=13,4°C
**ALBERONI** Trend= **+0,4°C/10y**, t(1972-2011)=14,4°C
**TORVISCOSA** Trend= **+0,6°C/10y**, t(1941-2011)=13,5°C



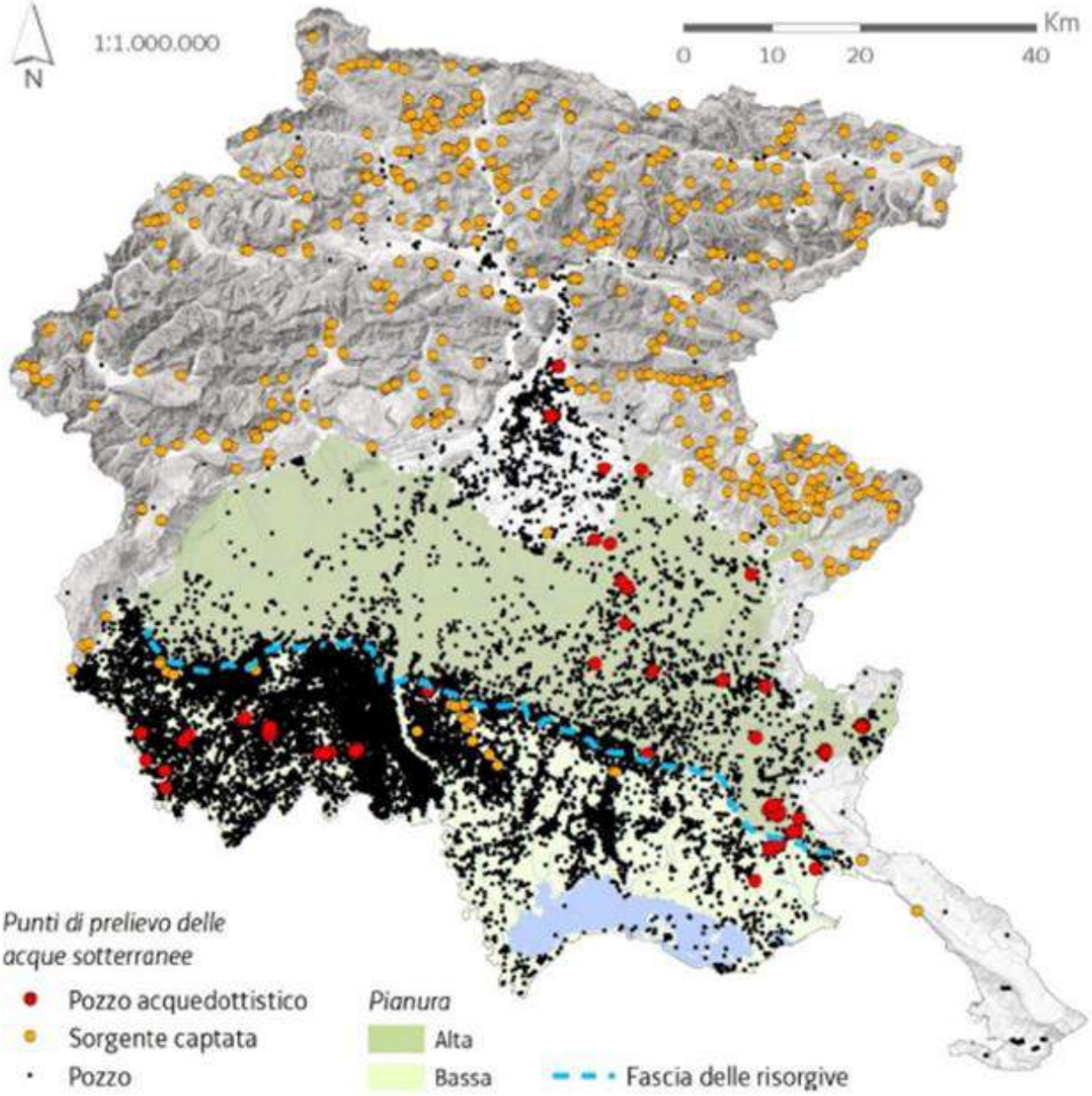



There is a **variation in the rainfall regime** with longer periods of drought, more frequent extreme events and an **increase in the average temperatures**.

In the summertimes, there is an **increasing evapotranspiration** and an **increase in the groundwater withdrawals** with a consequent reduction in the groundwater availability.

There is a general **lowering of the groundwater levels** observed from the 1970s up to today.

The analyses done on the area are capturing an image of the actual state of the art in order to be able to monitor in the future the ongoing situation.




*Bezzi et al., 2018*

# AND IF WE HAVE A LOOK AT THE HYDROGEOLOGICAL RISK AS FLOODS AND LANDSLIDES…

*TriestePrima, 2022*

## SEA LEVEL RISE JOINTLY WITH AN IMPORTANT RUNOFF DUE TO THE RAIN BOMB

# RAIN BOMB

Watch a massive ‘rain bomb’ descend over Dallas
Footage showed a microburst engulfing downtown Dallas in June 2017 (The Washington Post).

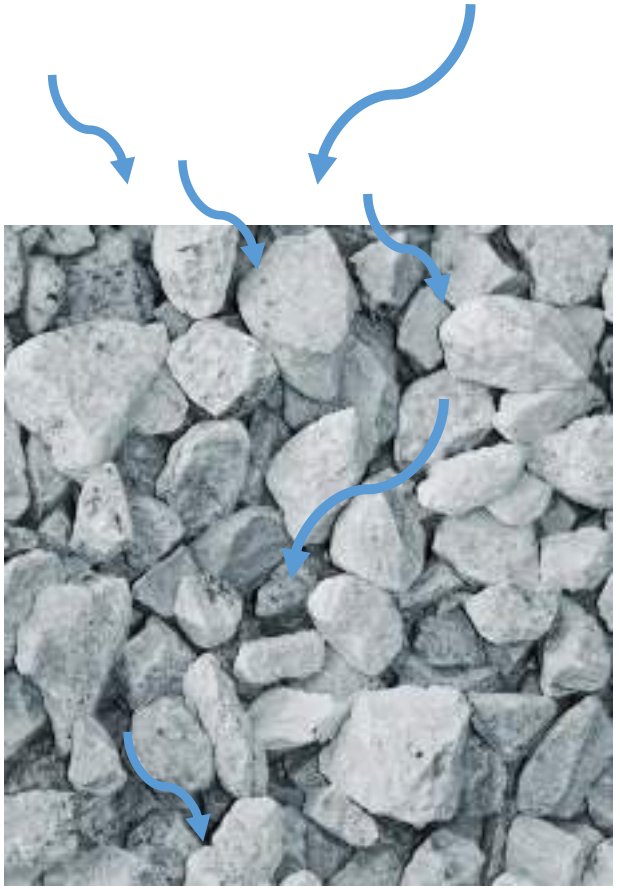
# AND IN THE MOUNTAIN??
# ONE EXAMPLE…

# DEBRIS FLOW

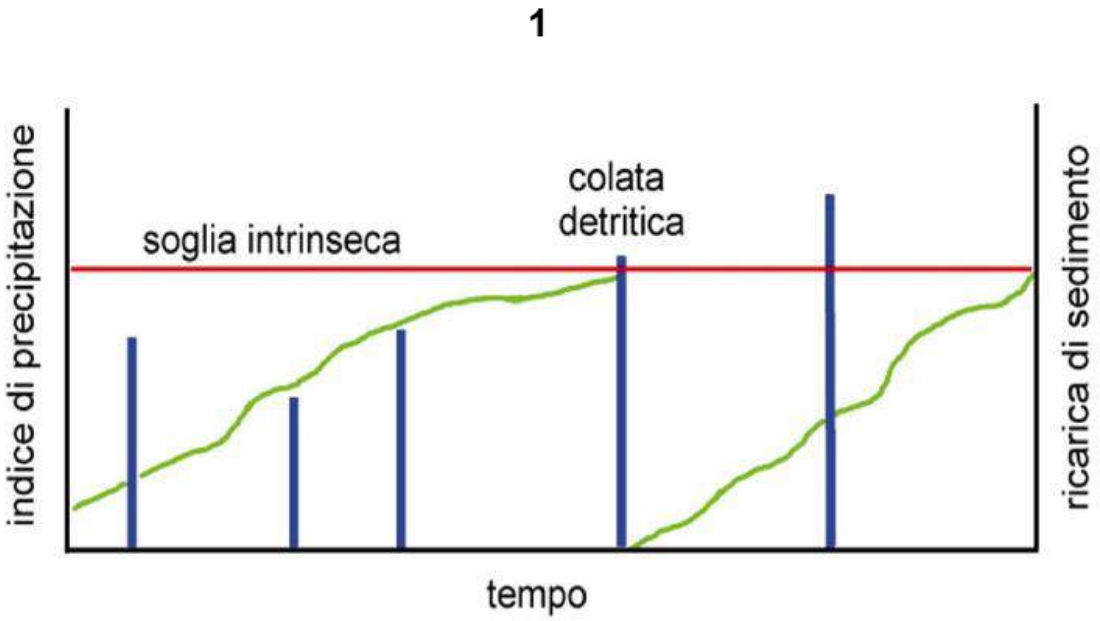
TRIGGERING ZONE

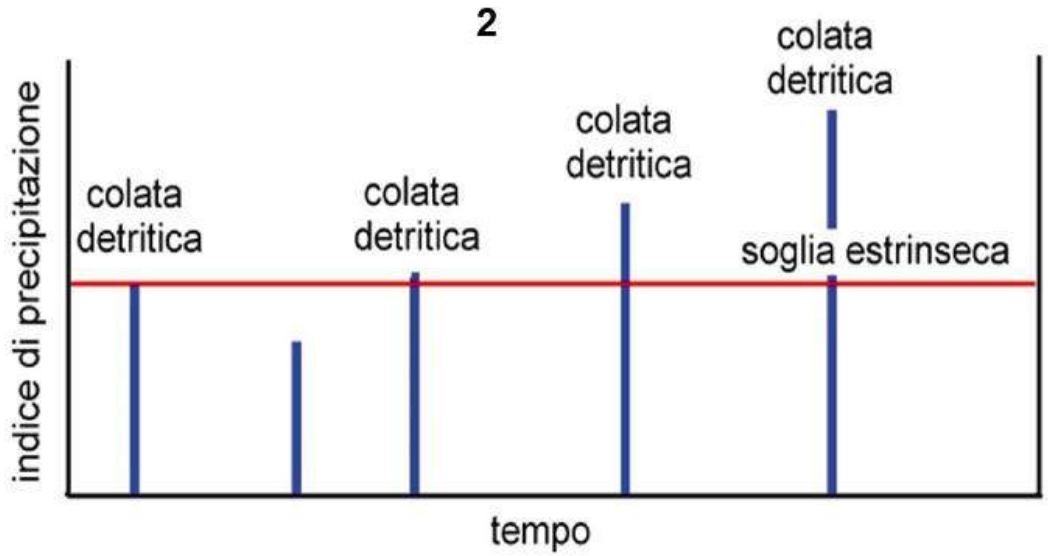
TRANSPORT CHANNEL

DEPOSITIONAL AREA



DEBRIS




Blue bars indicate the rainfalls, green lines the cumulated debris recharge, red horizontal lines, the tresholds over which a debris flow can occur.

Bovis e Jakob, 1999

# CAN WE PREVENT ALL THIS?

*Photo courtesy: Protezione Civile FVG, 2003*

## VALCANALE 2003

# THESE PHENOMENA CAN BE MODELLED TO PREVENT DISASTERS AND TO ADAPT TO LIVE WITH THEM

*Photo courtesy: Protezione Civile FVG, 2003*

Overview of the Cucco hamlet (Malborghetto-Valbruna Municipality)
Photo taken just after the alluvial event of 29$^{th}$ August 2003 from Mt. Due Pizzi

# HYDRAULIC MODELING

Cortina d'Ampezzo



Flow depth (m)

- 0.0 - 0.1 (m)
- 0.1 - 0.5 (m)
- 0.5 - 1.0 (m)
- 1.0 - 2.5 (m)
- 2.5 - 5.0 (m)
- >5.0 (m)

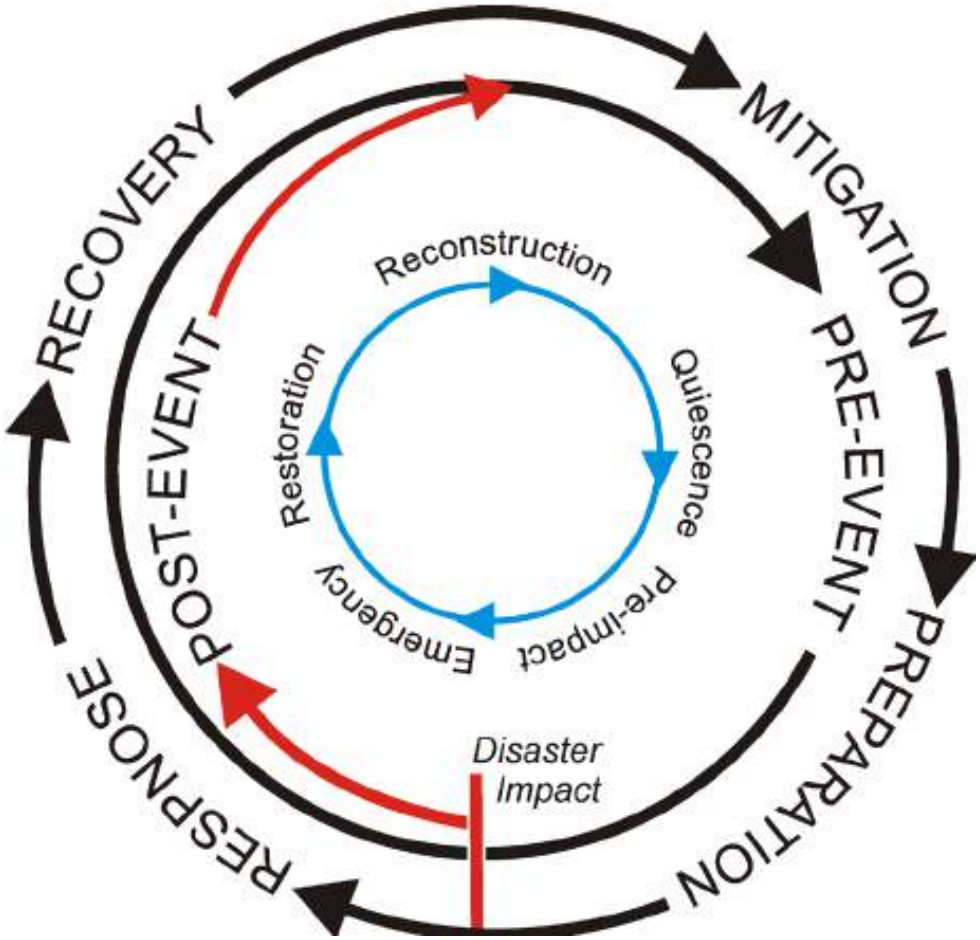
Deposits (green) and erosion (red) (m)

- < -5.00 (m)
- -5.00 - -2.50 (m)
- -2.00 - -1.00 (m)
- -1.00 - -0.50 (m)
- -0.50 - 0.00 (m)
- 0.00 - 0.50 (m)
- 0.50 - 1.00 (m)
- 1.00 - 2.50 (m)
- 2.50 - 5.00 (m)
- > 5.00 (m)

*Courtesy of Prof. Carlo Gregoretti - UNIPD*

# TO CONCLUDE: THE CYCLE OF DISASTER

There is an imminent need to improve natural disaster management capacity in to reduce disaster impacts. Given that disasters are spatial phenomenon, the application of geospatial information technology (GIT) is essential to the natural disaster management process. Disaster management practitioners could harness this potential in an attempt to reduce hazard vulnerability and improve disaster management capacity. But only **WE CAN ADAPT OURSELVES** to cohabit with what is occurring around us working hard within the PREPARATION PHASE of the cycle.




*Herold S. and Sawada M., International Journal of Applied Geospatial Research, 3(2), 24-62, April-June 2012*

# THANKS FOR YOUR ATTENTION!

Esemon di Sopra (RAVEO FVG), sinkhole, April 2022