INTERNATIONAL WORKSHOP ON WATER SCARCITY
TAKING ACTION IN TRANSBOUNDARY BASINS AND REDUCING HEALTH IMPACTS
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Impact of droughts on water quality: data and risk analysis

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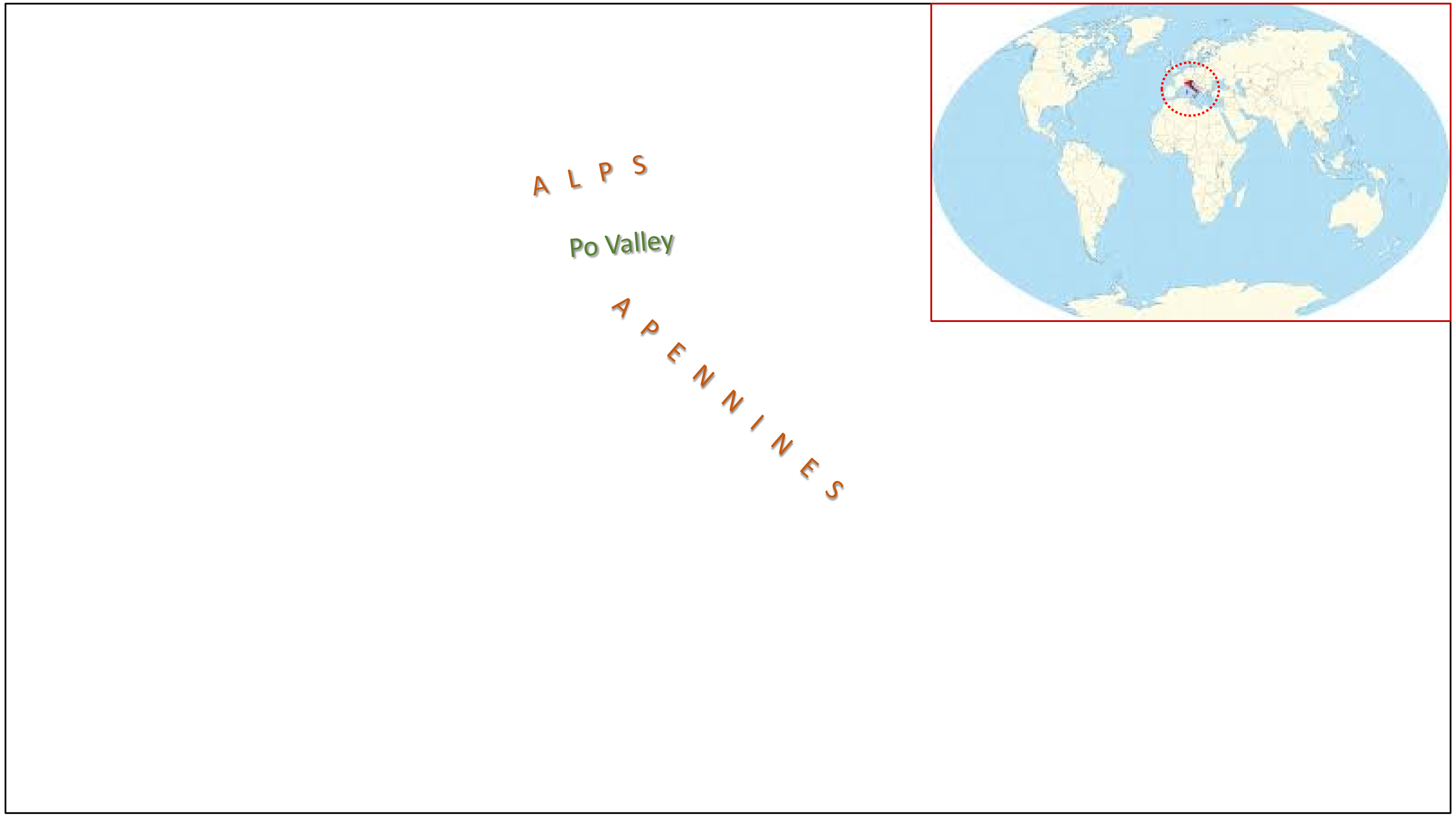
Climate changes in Europe: Italy as a testing laboratory



Latitudes:
between 35.5°N and 47.1°N

Length:
1,350 Km

Elevation:
between -3 m and 4.8 Km

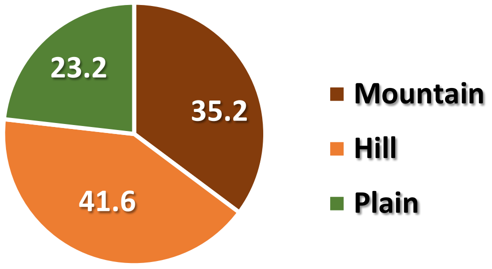
Orography:
Alps as northern boundary;
Apennines as backbone;
Po Valley (largest plain: 70%of plains)

Surrounded by sea for 80% of the border line (2 semi-closed sea basins: Tyrrhenian and Adriatic Seas)

Micro-climate influenced by recent decrement in cold seawater supply

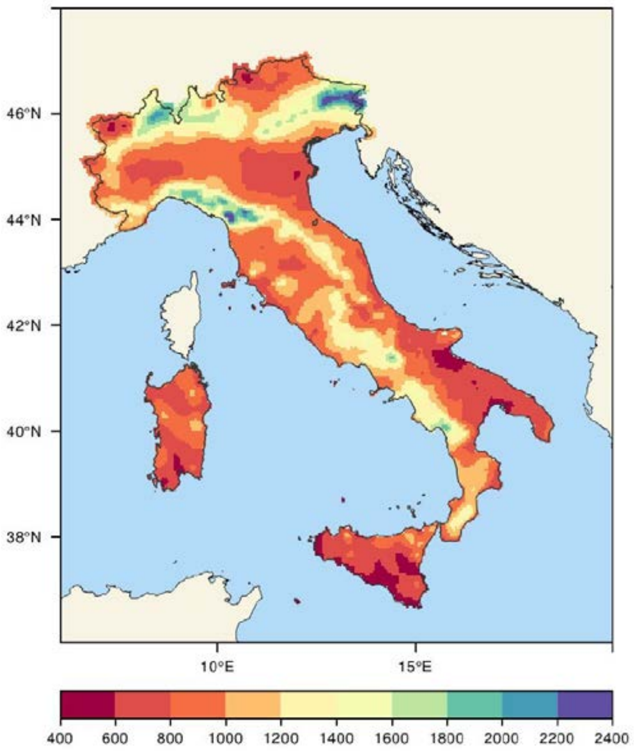
Coastline erosion boosted by urbanization

Italy (301,000 Km^2)



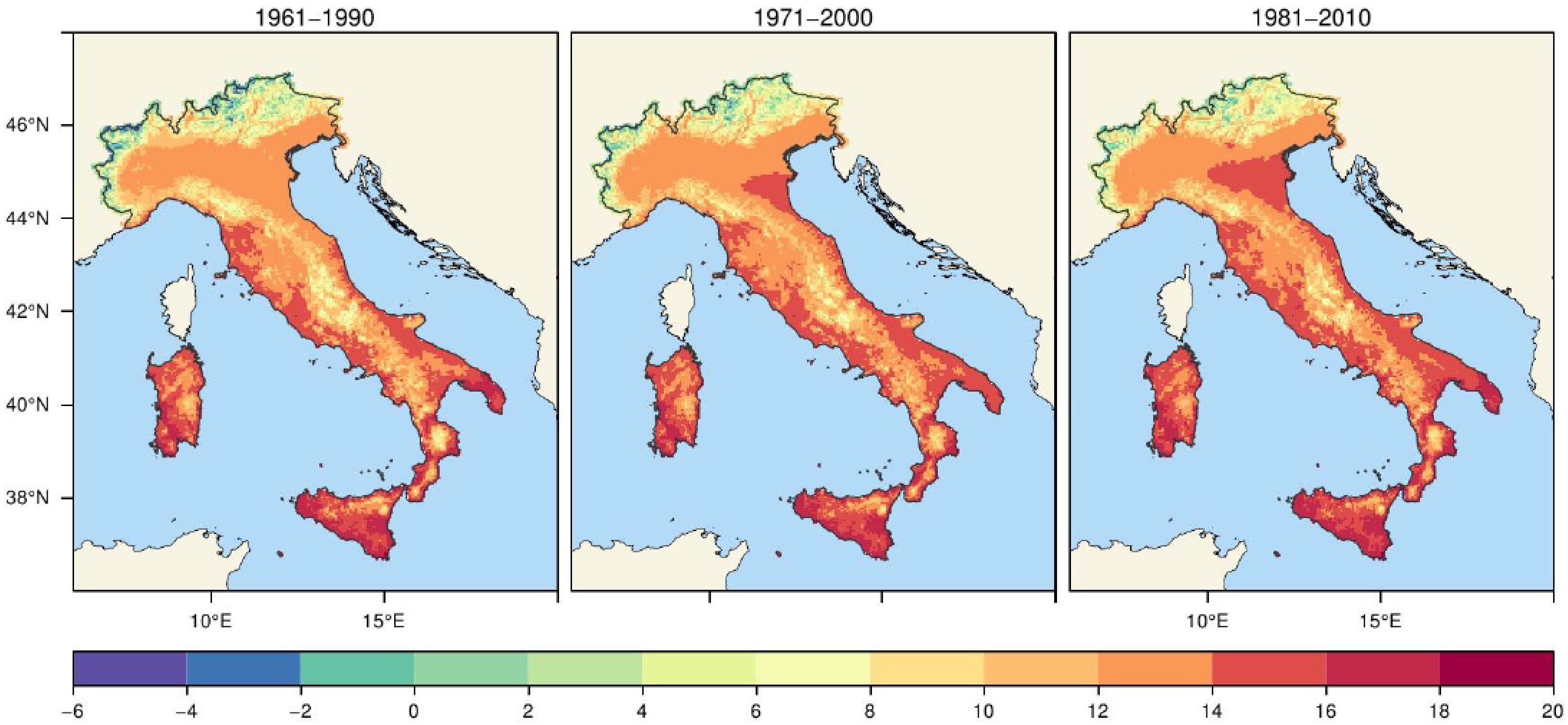
Climate variability in Italy

Average annual rainfall (1951-80)



By ISPRA 2005

Average annual mean temperature



By ISPRA 2005

Proposed 6 different climate areas

Italian national project on

"Climate changes and health in the vision of planetary health"

- In Mar2017 project financed by Italian MoH and co-ordinated by Italian National Institute of Health
- Participants: 7 national bodies/institutes + WHO
- Goals:
  - Actions to support health decisions during Italian Presidency of G7 in 2007
  - Specific research activities on 7 impact areas at national level with a vision of 5-30 yrs. (in particular: impact on quality of water bodies under stress and integrated water cycle in relation to emerging and persistent pollutants)
  - Resilience of national water systems to climate changes (WHO/UNECE protocol)
  - Training for general practitioners to promote scientific evidence on health impact of environmental pollution
  - Final workshop on acquired data and possible follow-ups

How to measure drought severity-duration-frequency

Droughts are complex phenomena usually related to long and sustained periods in which water availability becomes scarce

Their development is slow: the moment in which they start and finish is very difficult to identify

Impacts are generally non-structural and difficult to quantify as affected by the time scale over which precipitation deficits accumulate

Different drought indices (at least 51 according to WMO) have been proposed to quantify spatial and temporal extent of droughts using one or more indicators (precipitation, temperature, streamflow, groundwater/reservoir levels, soil moisture, snowpack, etc.)

Drought index used in the present survey

Standardized Precipitation Evapotranspiration Index (SPEI) by *Vincente-Serrano et al.* (2010) based on the climatic water balance D:

$D = P - PET$

where:

P = monthly precipitation (mm)

PET = potential evapotranspiration (mm) according to Thornthwaite (using mean monthly temperature and geographical location)

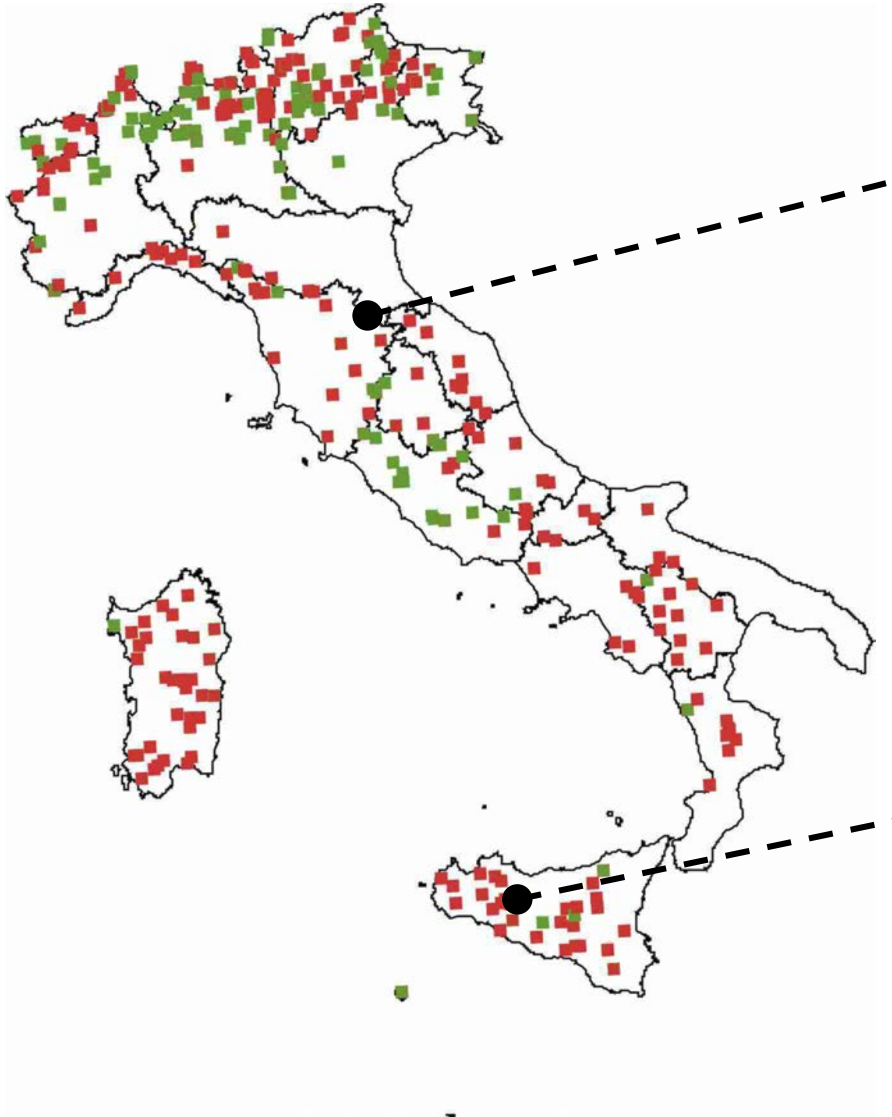
Calculated D are aggregated at various time scales (1 ÷ k months) and fitted with a log-logistic probability distribution function

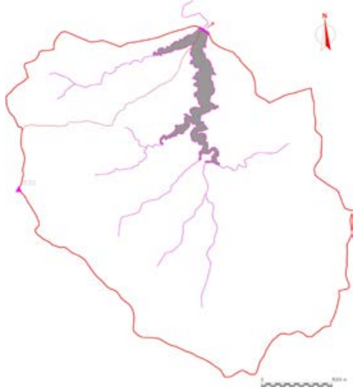
SPEI is a standardized Gaussian variate with a mean of 0 and a SD of 1

SPEI represents the degree of deviation from the normal conditions recorded at a given site (allows comparing droughts across sites with very different climatology)

User is required to find the time scale at which the response to drought is highest

The investigated areas





Lake of Ridracoli

Artificial basin

Max volume: 33.1 million m^3

Max depth: 82 m

Catchment basin: 1035 Km^2

Water supplier: *Romagna Acque - Società delle Fonti*

Lake Fanaco

Artificial basin

Max volume: 20.7 million m^3

Max depth: 48 m

Catchment basin: 46 Km^2

Water supplier: *Siciliacque*

Input data

SPEI

obtained from Spanish PEI Global Drought Monitor (http://spei.csic.es/map/maps.html; drought conditions at global scale with 0.5° spatial resolution and monthly time resolution)

original data from US Climate Prediction Center for mean temperatures and German Global Precipitation Climatology Centre for monthly precipitations

calibration period: Jan 1950 to Oct 2017

Reservoir storages and analytical data

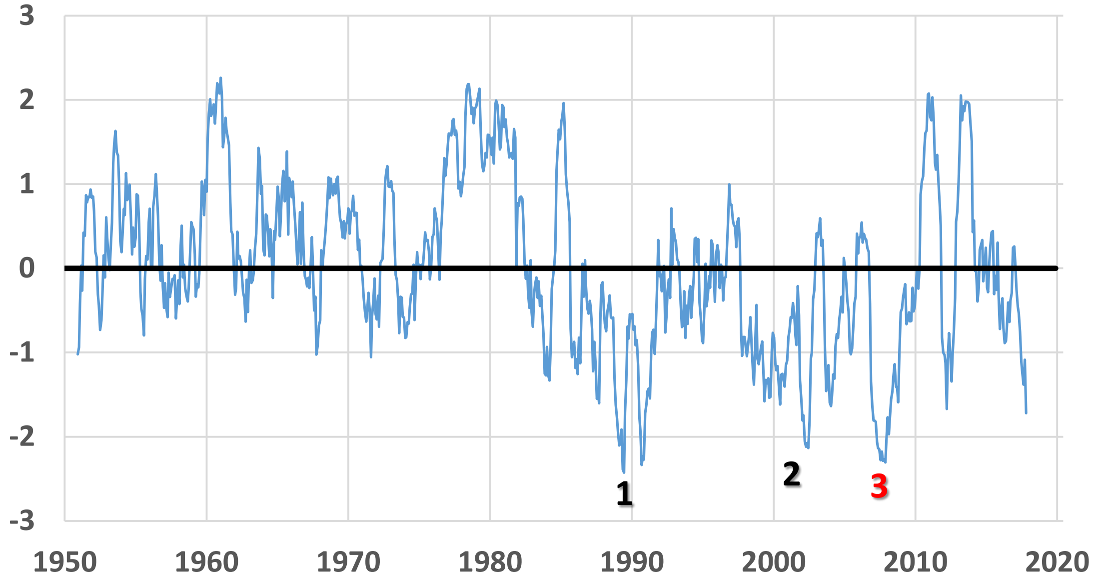
provided by the two water suppliers (last 23 yrs. for Ridracoli; last 13 yrs. for Fanaco)

preliminarily standardized by first applying a lognormal distribution (skewness correction) to the monthly medians

correlated with SPEI at different time scales

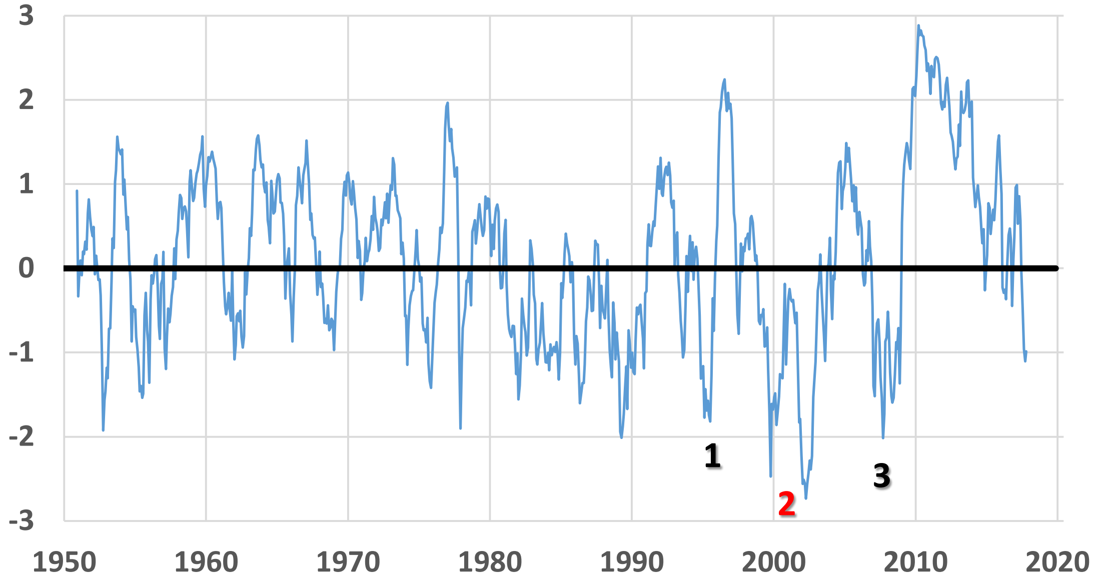
Drought severity-duration-frequency in the investigated areas

Lake of Ridracoli
SPEI time scale: 12 months



Relevant events	From/to	Duration (months)	Magnitude (months)	Intensity
1	Oct 1986 Oct 1991	61	67	1.11
2	Sep 1997 Nov 2002	63	70	1.11
3	Oct 2006 Jan 2010	40	51	1.28

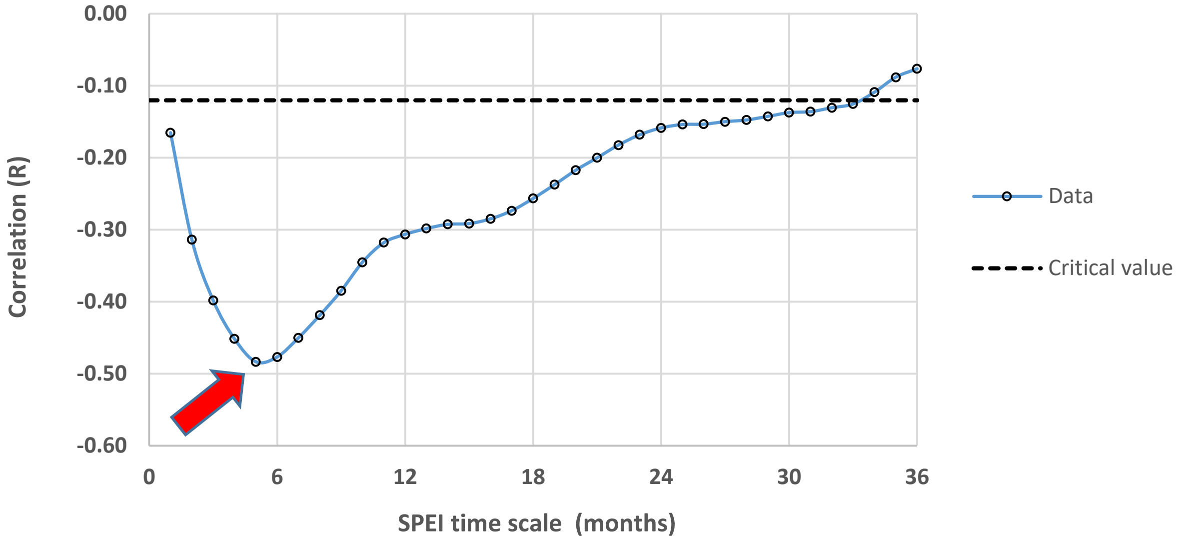
Lake Fanaco
SPEI time scale: 12 months



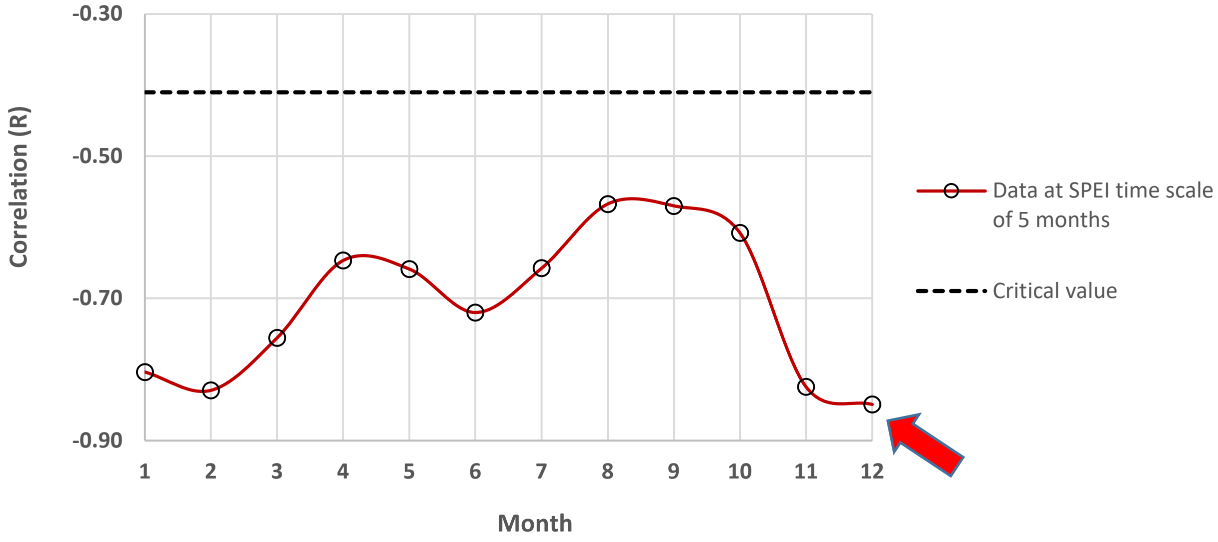
Relevant events	From/to	Duration (months)	Magnitude (months)	Intensity
1	Sep 1994 Nov 1995	15	17	1.13
2	Nov 1998 Mar 2003	53	67	1.26
3	Dec 2006 Dec 2008	25	28	1.11

Basin storage reduction versus Drought index 1/2

Lake of Ridracoli:
correlation between continuos series

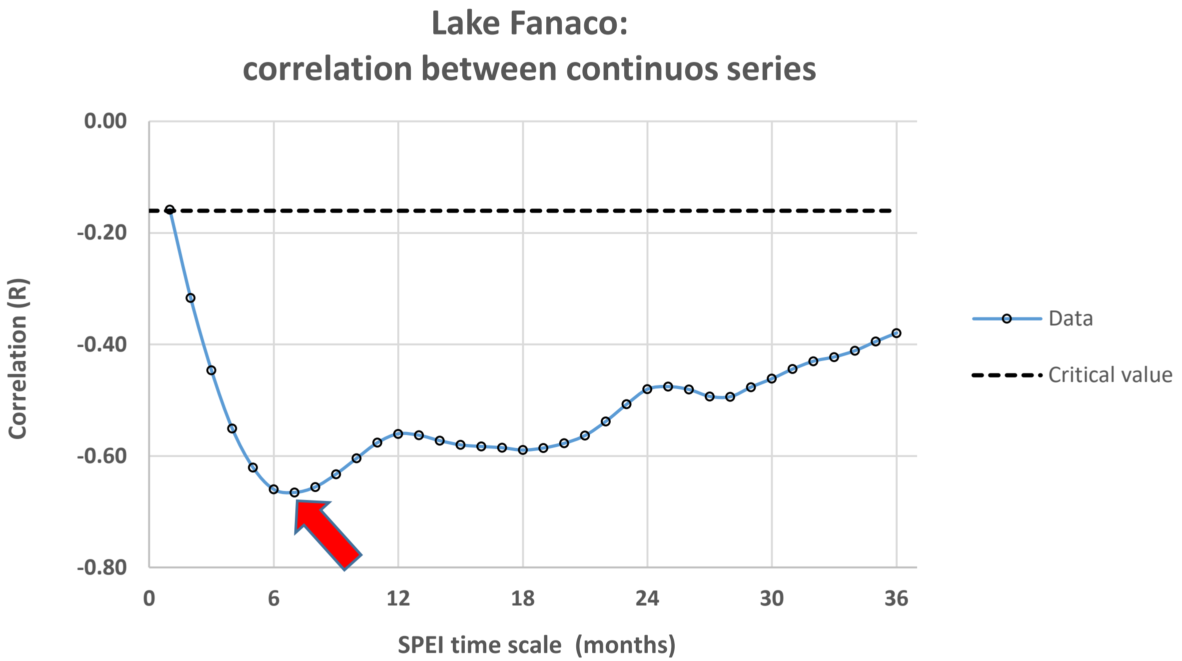


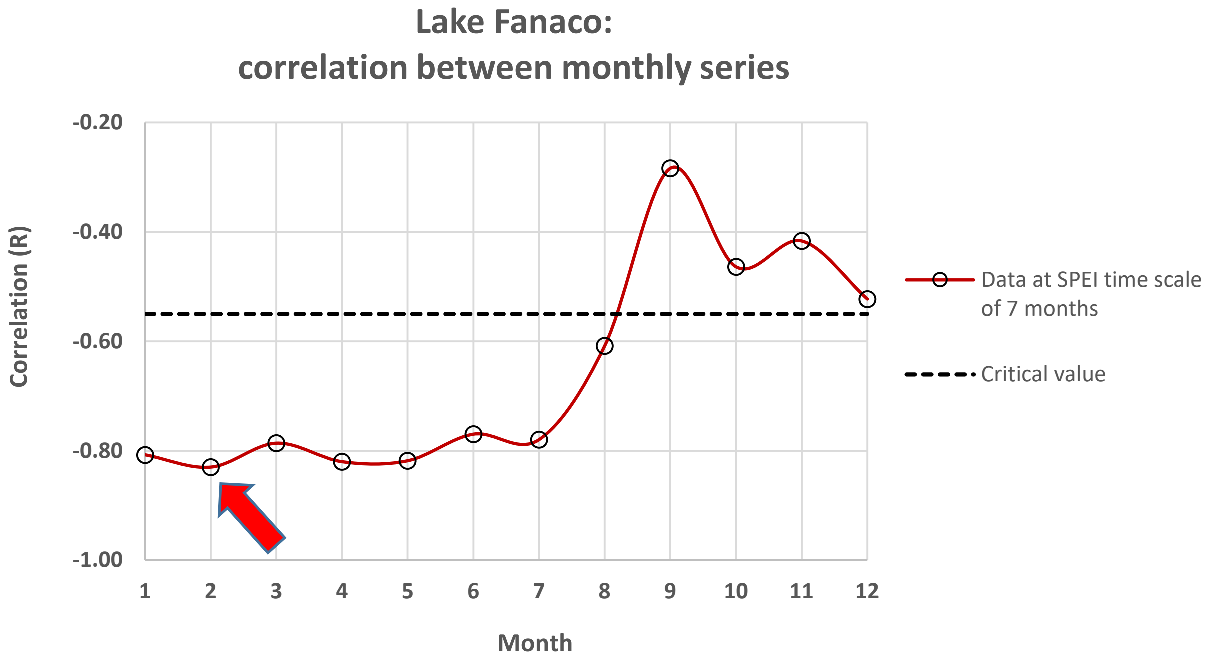
Lake of Ridracoli:
correlation between monthly series



Max negative correlation at medium time scale (5 months: Aug – Dec). Storage reduction increases as drought severity increases

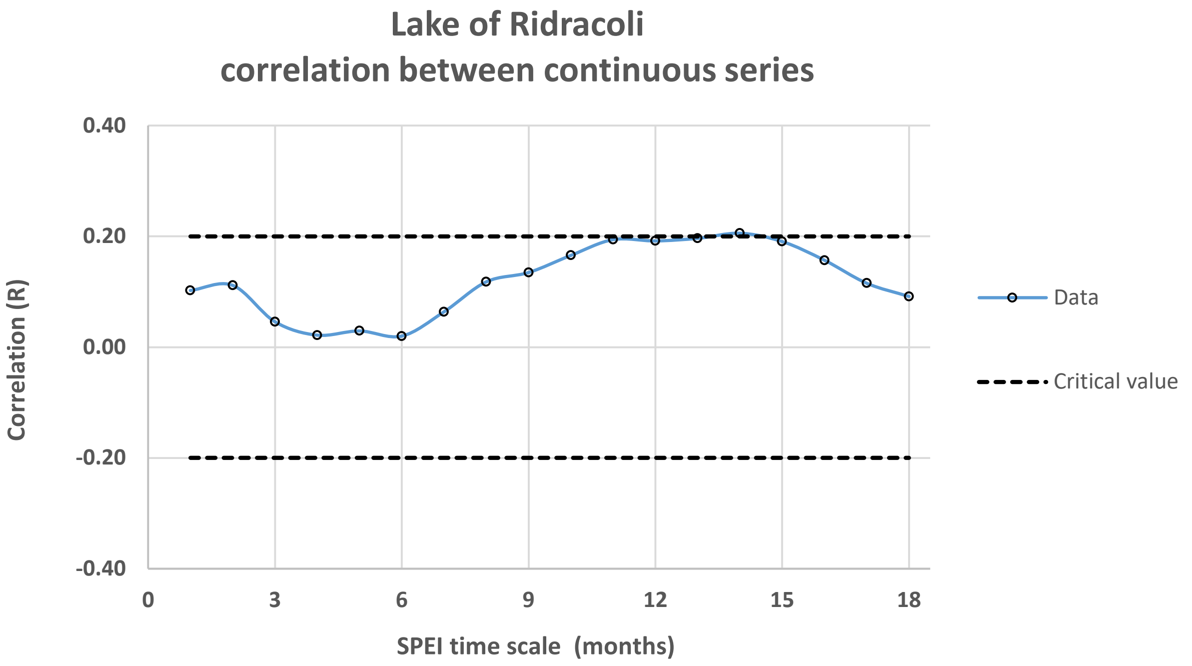
Basin storage reduction versus Drought index 2/2

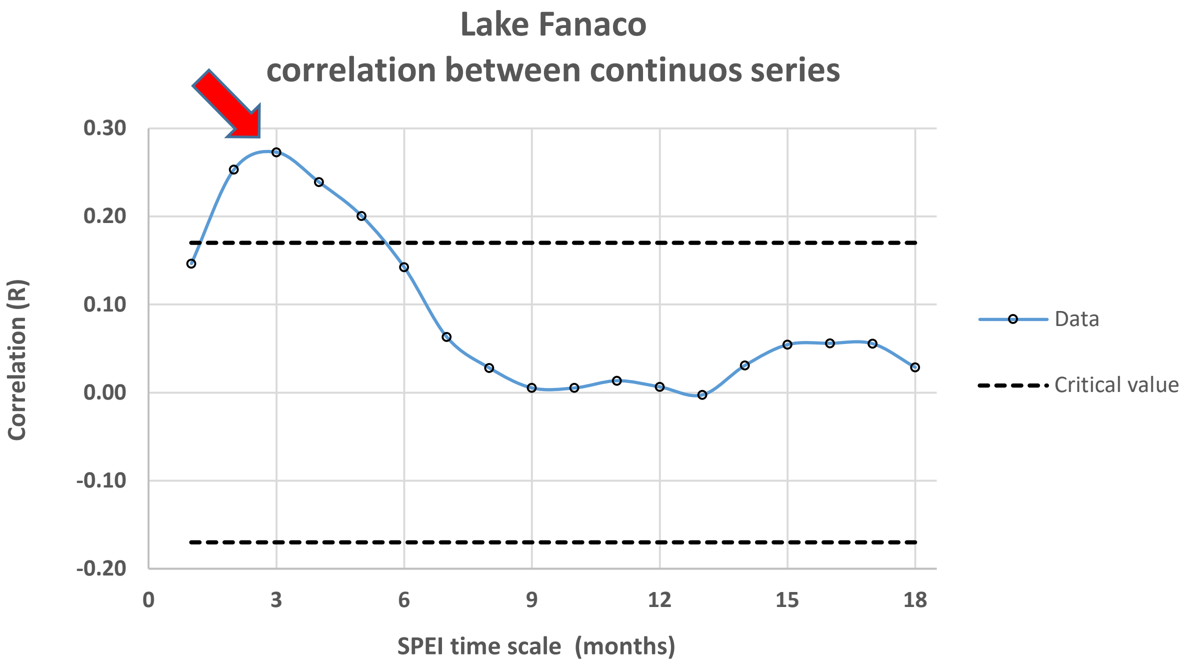




Max negative correlation at medium time scale (7 months: Aug – Feb). Storage reduction increases as drought severity increases

Water turbidity versus Drought index

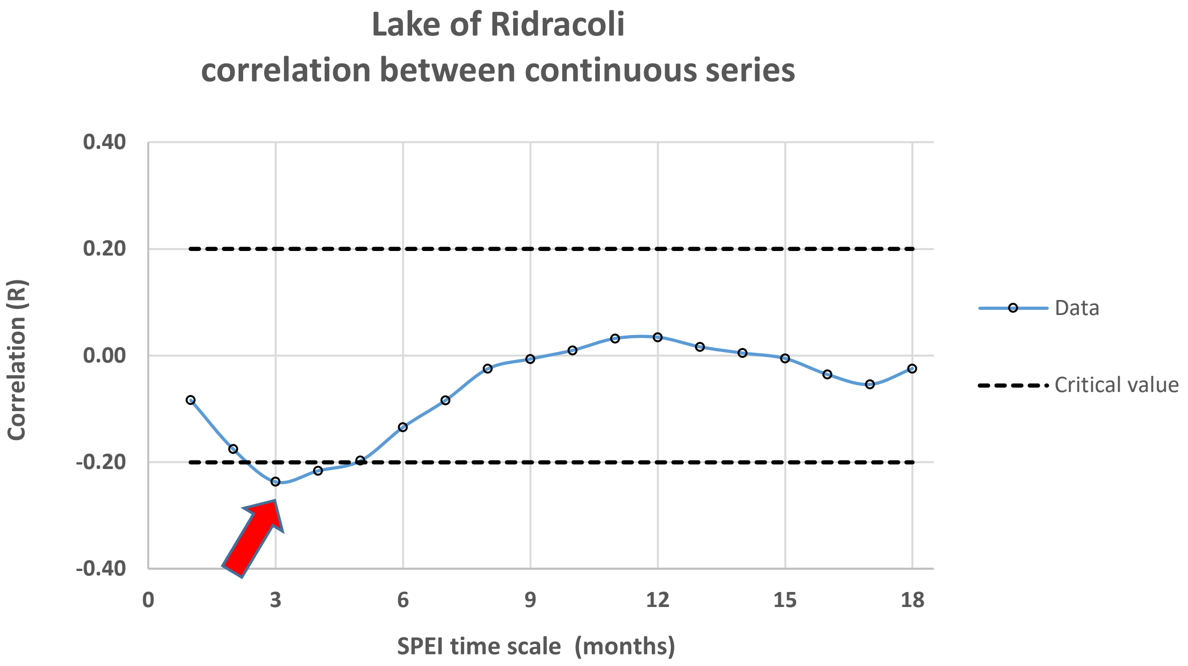


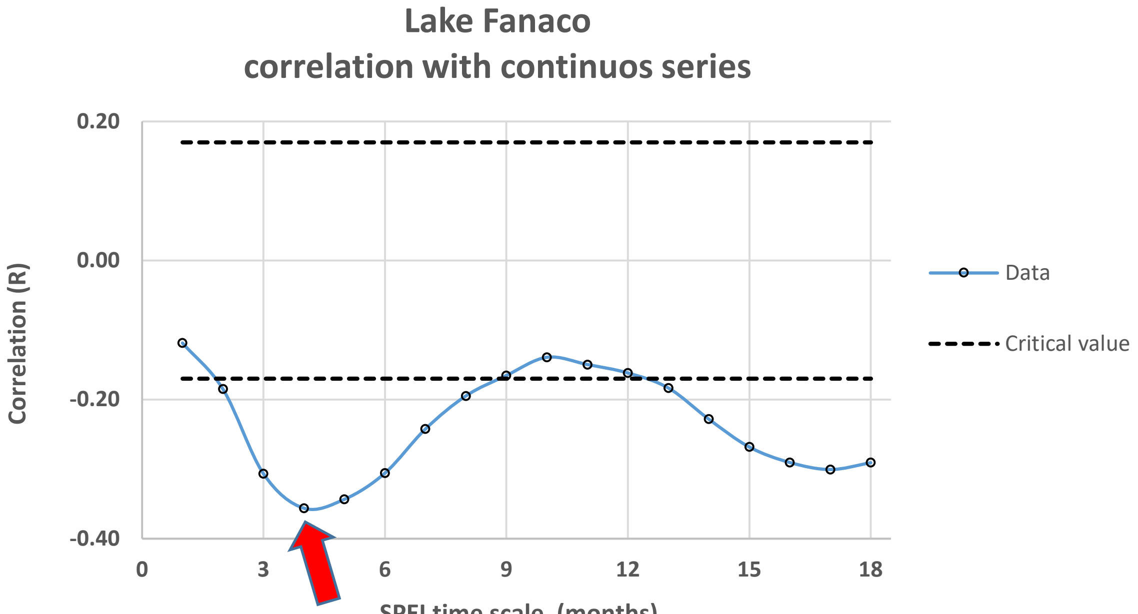


No relevant correlation

Max positive correlation at short time scale
(3 months: Apr - Jun)
Turbidity increases as rainfall increases

Manganese in water versus Drought index





Max negative correlation at short time scale
(3 months: Nov - Jan)
Mn increases as drought severity increases

Max negative correlation at short time scale
(4 months: Feb - May)
Mn increases as drought severity increases

Correlations between other parameters and Drought index

Parameter	Lake of Ridracoli		Lake Fanaco	
Ammonium			- (6 months)	Feb-Jul
Nitrate	None		+ (8 months)	Jan-Aug
Free chlorine			+ (5 months)	Aug-Dec
Total Organic Carbon	+ (12 months)	Sep-Oct		
Iron	None		None	

Lessons learned and recommendations

- Correlation analysis between drought indices and reservoir storages or analytical results is a powerful tool to highlight basins vulnerability to drought events
- Time-scale correlation analysis is useful to identify period, duration and frequency of the effects produced by relevant drought events
- This kind of information is relevant to Risk Analysis (RA) within Water Safety Plan activities
- Water treatment should be modulated according to RA outcomes