



2016 Progetto Firenze

L'alluvione
Le alluvioni



L'alluvione, le alluvioni

Memoria e azione

BARI BOLDIGNA BRESCIA CAGLIARI CATANIA
CASSINO COSENZA FIRENZE GENOVA LATINA
MILANO NAPOLI PADOVA PALERMO PERUGIA
POTENZA ROMA SALERNO TORINO TRENTO

Seminario diffuso
4 novembre 2016

Vito IACOBELLIS

Andrea Gioia, Noemi Saraò, Si Mokrane Siad, Vincenzo Totaro

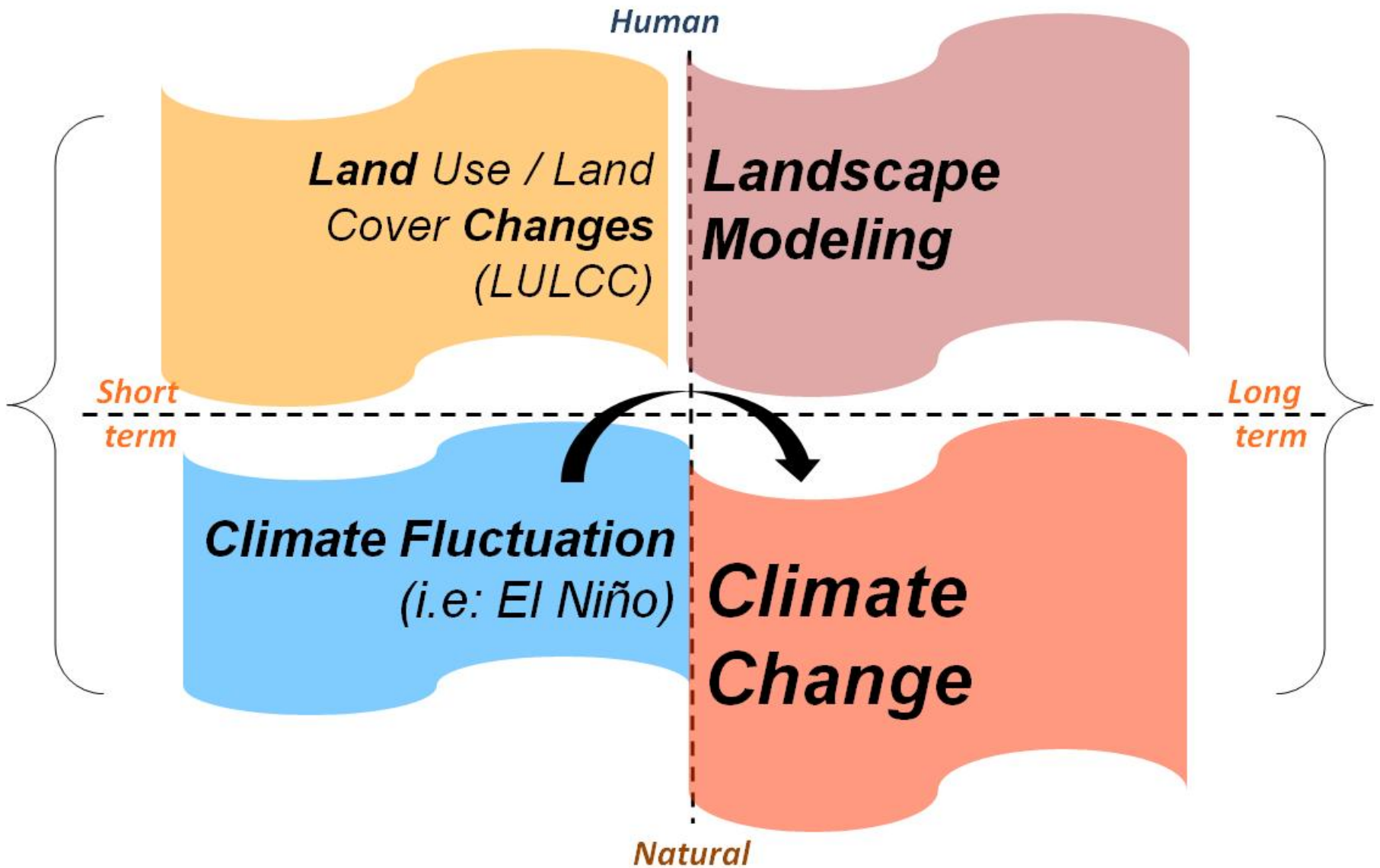


Politecnico
di Bari



OIBA
ORDINE DEGLI INGEGNERI
della Provincia di Bari





XXXIII Convegno Nazionale di Idraulica e Costruzioni Idrauliche
Brescia, 10-15 settembre 2012

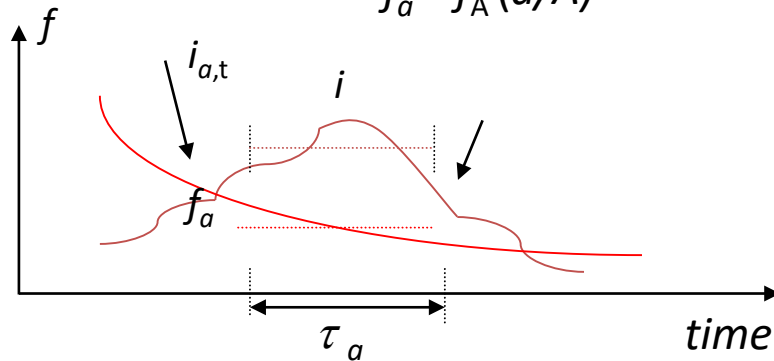
DOPO IL VAPI: LA VALUTAZIONE DELLE MASSIME PORTATE AL COLMO DI PIENA NELL'ESPERIENZA DEL POR CALABRIA

*D. Biondi⁽¹⁾, P. Claps⁽²⁾, F. Cruscomagno⁽¹⁾, D.L. De Luca⁽¹⁾, M. Fiorentino⁽³⁾, D.
Ganora⁽²⁾, A. Gioia⁽⁴⁾, V. Iacobellis⁽⁴⁾, F. Laio⁽²⁾, S. Manfreda⁽³⁾, P. Versace⁽¹⁾*

Distribuzioni stazionarie derivate

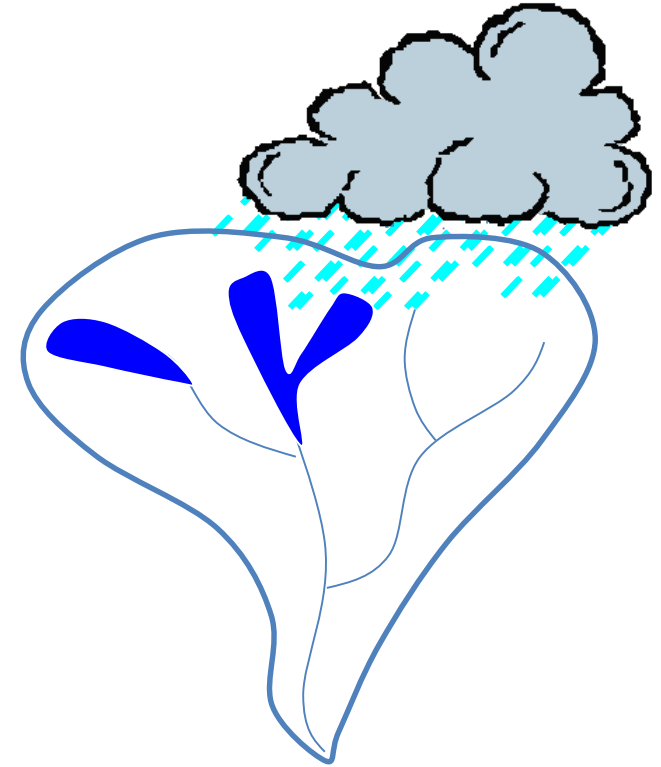
$$u_a = \xi (i_{a,\tau} - f_a)$$

$$f_a = f_A (a/A)^{-\varepsilon'}$$



u_a = portata specifica per unità di area
contribuente

a = area contribuente al picco di piena



La cdf della portata di deflusso diretto

$$G_Q(q) = \int_0^A \int_0^q g(u|a)g(a)du da$$

Si ottiene un TCIF ipotizzando che le piene siano legate a due differenti processi:

- *L-type (frequente), si verifica al superamento di una soglia di ruscellamento bassa e dall'attivazione di una piccola parte di bacino.*
- *H-type (raro), si verifica al superamento di una soglia di ruscellamento più alta ed sono caratterizzate da una più ampia area contribuyente.*

$$F_{Q_p}(q_p) = \exp\left\{-\Lambda_L [G_{Q,L}'(q_p)] - \Lambda_H [G_{Q,H}'(q_p)]\right\}$$

$$\Lambda_q = \Lambda_L + \Lambda_H = \Lambda_p \exp\left(-\frac{f_{A,L}^k}{E[i_{A,\tau}^k]}\right) \quad \Lambda_H = \Lambda_p \exp\left(-\frac{f_{A,H}^k}{E[i_{A,\tau}^k]}\right)$$

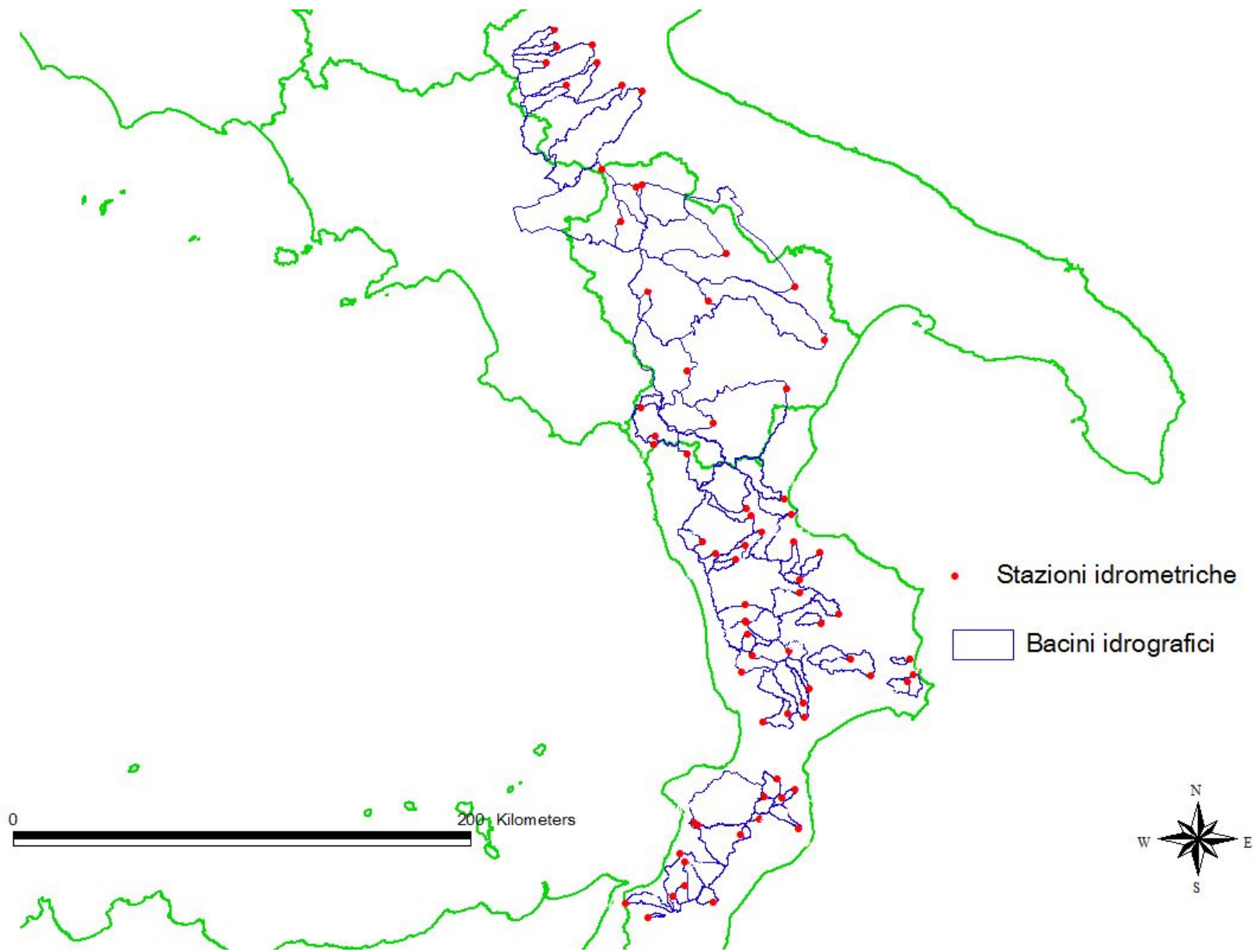
$$f_{a,L} = f_{A,L} (a_L / A)^{-\varepsilon_L}$$

$$f_{a,H} = f_{A,H} (a_H / A)^{-\varepsilon_H}$$

$$r_L = E[a_L] / A$$

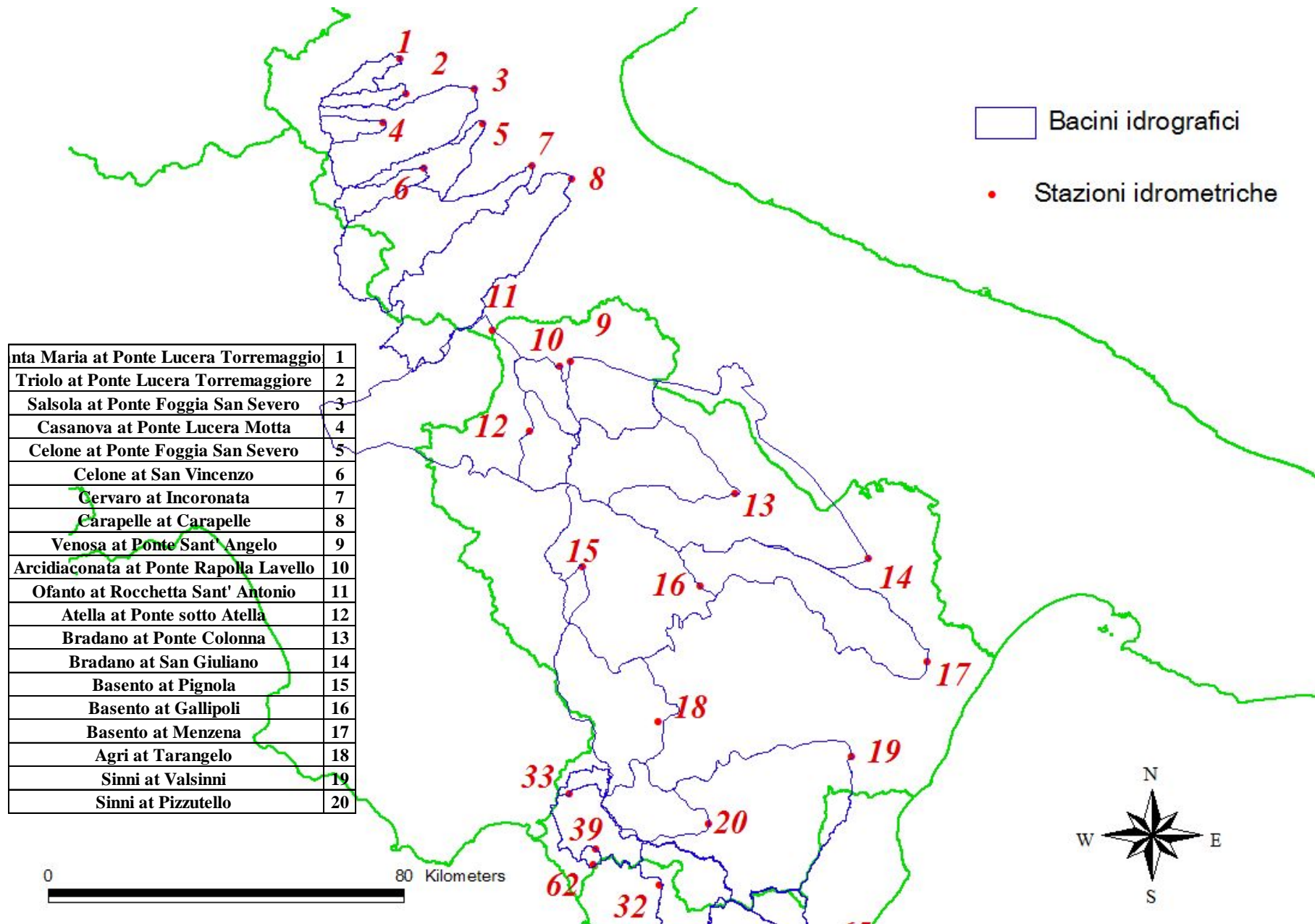
$$r_H = E[a_H] / A$$

Il caso di studio



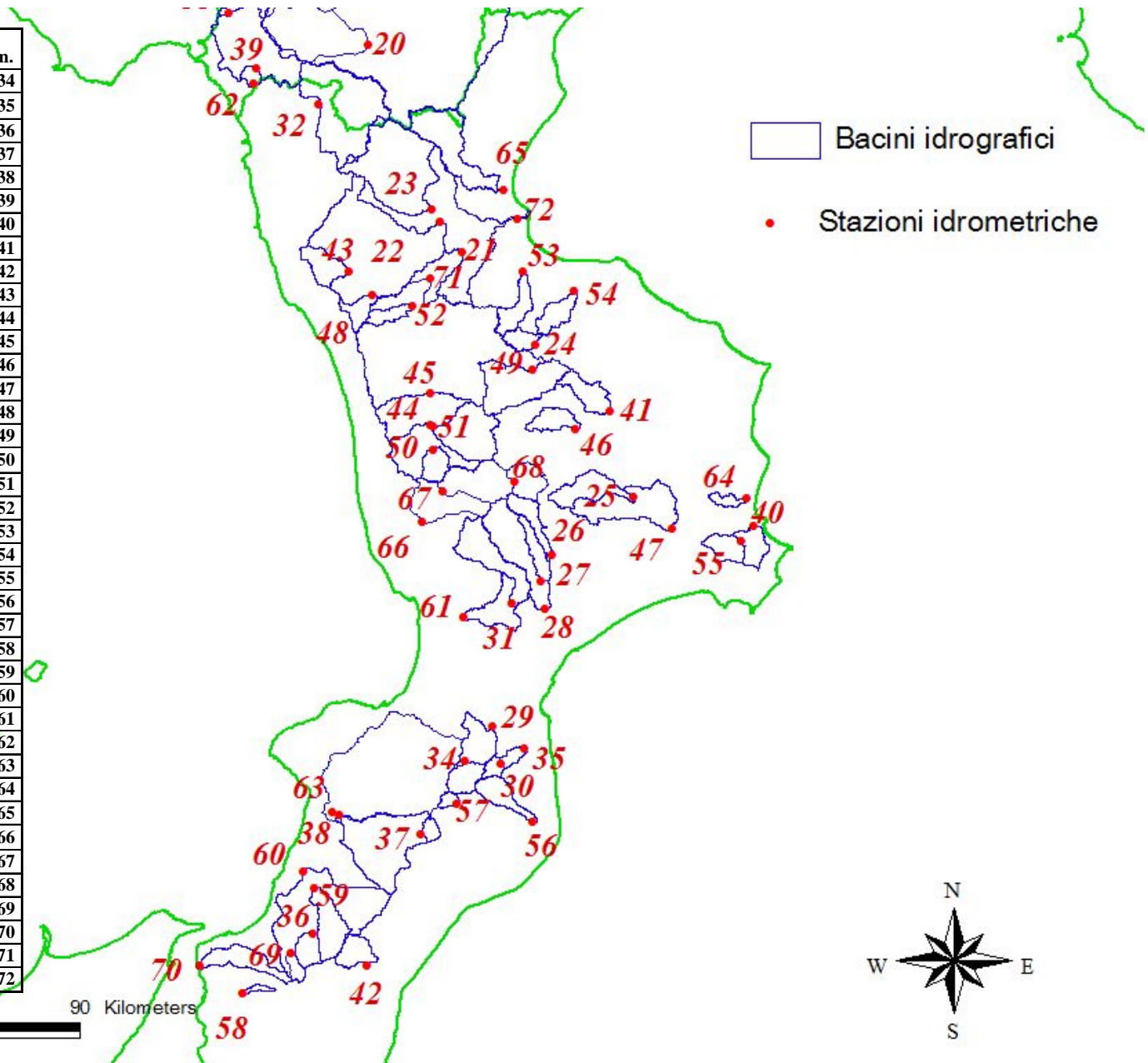
I bacini hanno superficie variabile tra 8 e 1654 km².

Il caso di studio

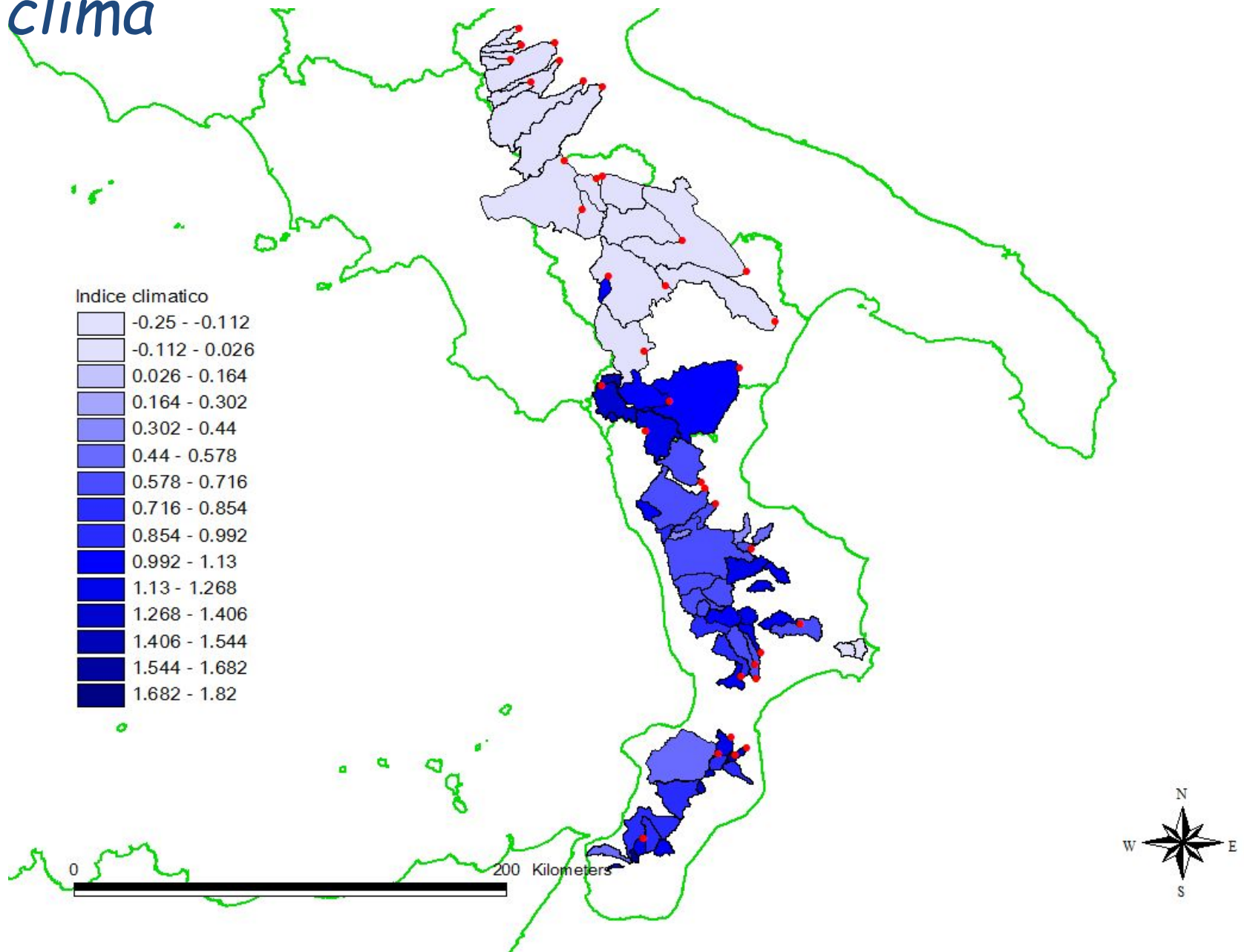


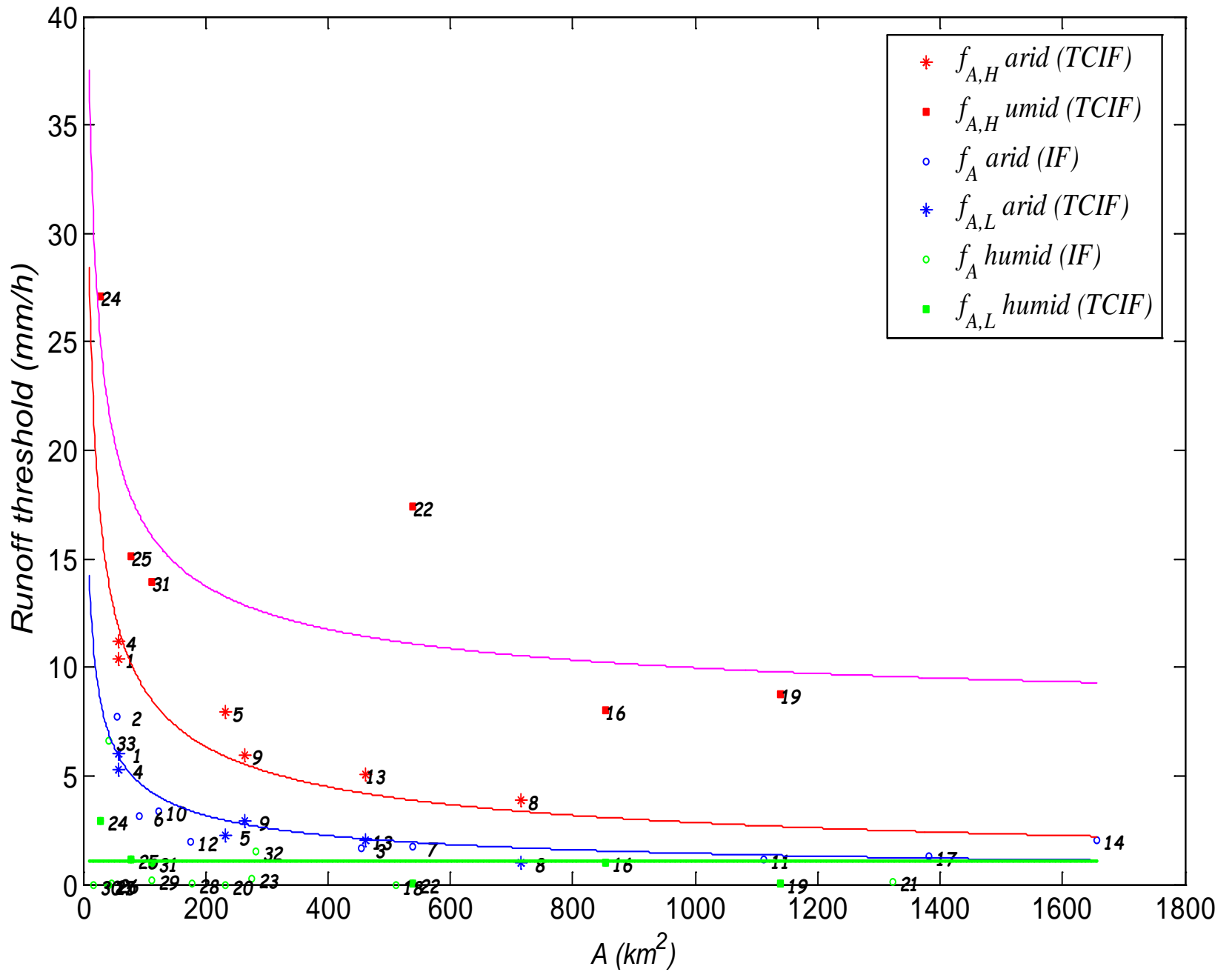
Il caso di studio

	n.
Ancinale at Spadola	34
Alaco at Pirrella	35
Duverso at santa Giorgia	36
Metramo at Castagnara	37
Metramo at Carmine	38
Noce at Le Fornaci	39
Esaro at Crotone San Francesco	40
Lese at Schiena d'asino	41
Careri at Bosco	42
Esaro at cameli	43
Busento at Cosenza	44
Crat at castiglione	45
Garga at Torre Garga	46
Tacina at Serrarossa	47
Follone at San Marco Argentano	48
Mucone at Cecita	49
Issa at Vizza	50
Crati at Cosenza	51
Turbolo at Mongrassano	52
Coriglianeto at Corigliano	53
Colognati at Pizzuto	54
Esaro at Ponte Forcosa	55
Assi at Botteria	56
Allaro at Ponte Mongiana	57
Annunziata at straorino	58
Calabro at Puzзара	59
Rizziconi	60
Amato at Licciardi	61
Noce at castrocucco	62
Mesima at Sbarretta	63
Ponticelli at Ponte SS. 106	64
Raganello at Terzeria	65
Savuto at Persico	66
Savuto at Ponte Savuto	67
Savuto at Poverella	68
Vasi at Scifà	69
Catona at Reggio Calabria	70
Crati at Santa Sofia d'Epiro	71
Crati at Sibari	72



Il clima





La parametrizzazione del modello

$$r_H = 2.51 C_{\text{runoff}} - 7.56 P(\text{WI} > \mu_{\text{WI}} + \sigma_{\text{WI}}) - 2.22 I P(\text{WI} > \mu_{\text{WI}} + \sigma_{\text{WI}}) \quad R^2 = 0.925,$$

runoff coefficient proposed by De Smedt et al. (2000)

wetness index WI (Beven and Kirkby, 1979)

in Puglia:

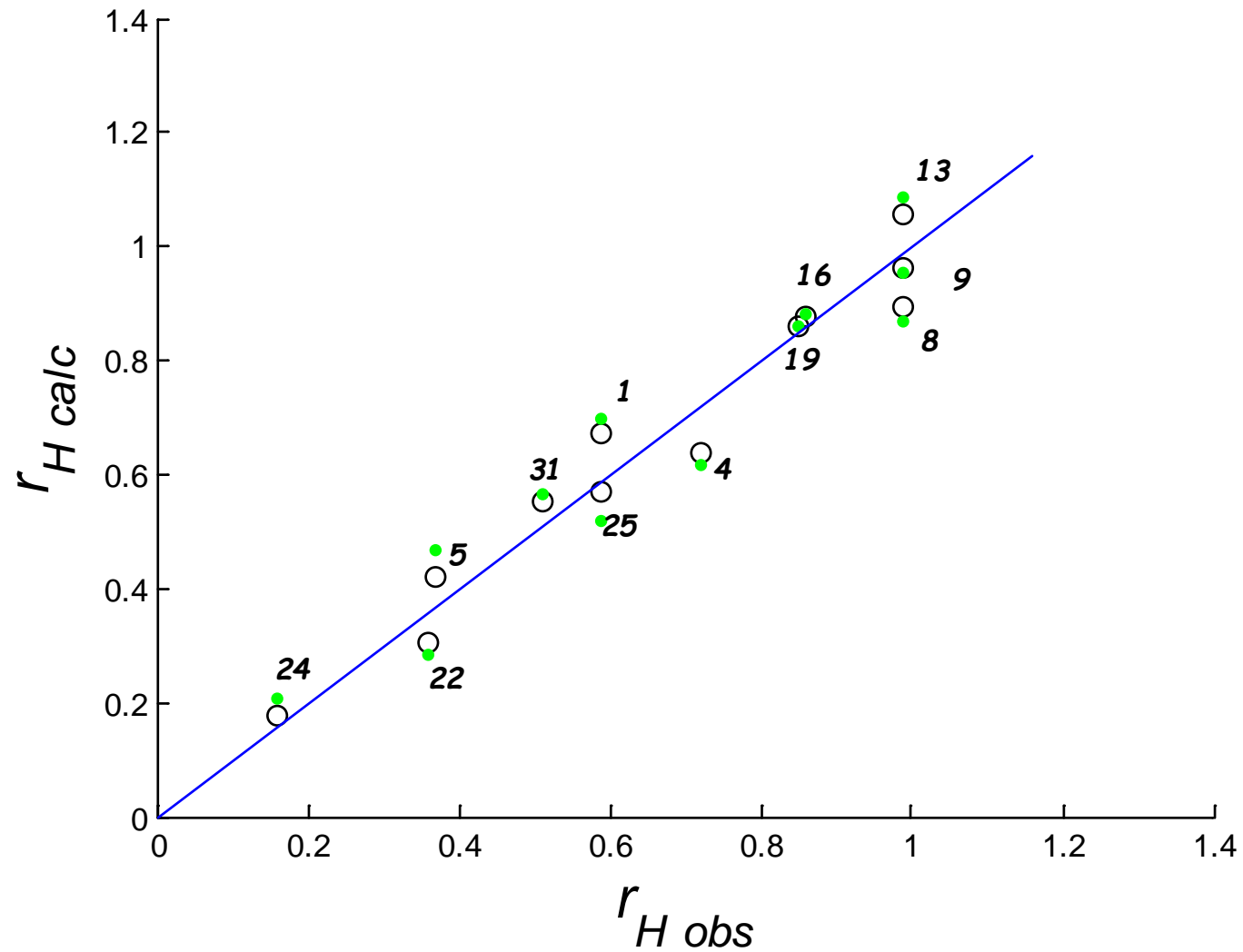
$$\log r = \log r_L = 31.46 \text{Sl} - 86.35 I P(\text{WI} > \mu_{\text{WI}} + \sigma_{\text{WI}}) - 3.50 \psi - 2.6515, \quad R^2 = 0.86.$$

Sl is the mean slope of the river basin

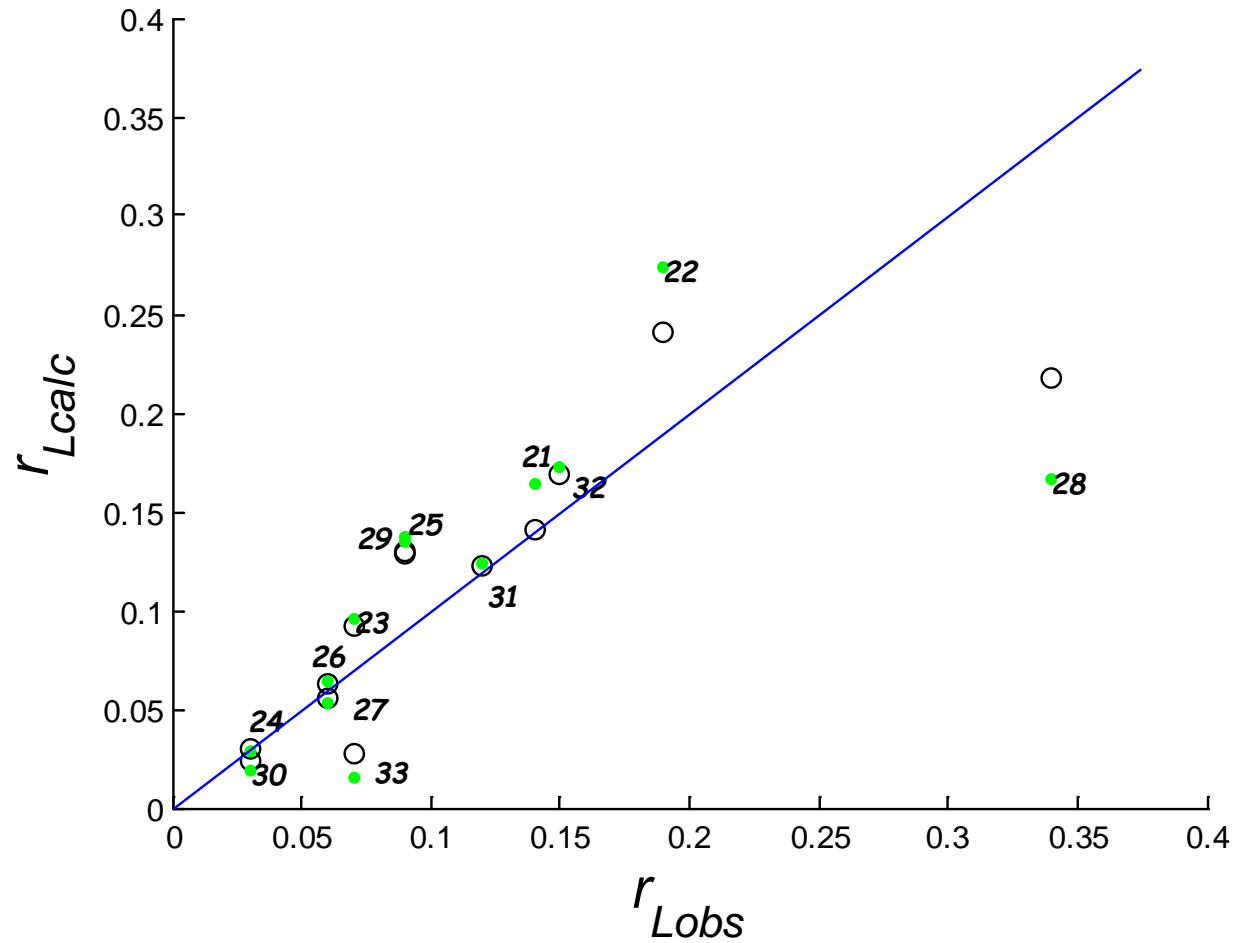
$$\psi = 1 - (\psi_{\text{v.low}} + 0.1 \psi_{\text{low}})$$

$\psi_{\text{v.low}}$ and ψ_{low} are the fractions of the total basin area with bedrock characterized respectively by very low ($\psi_{\text{v.low}}$) and low permeability (ψ_{low});

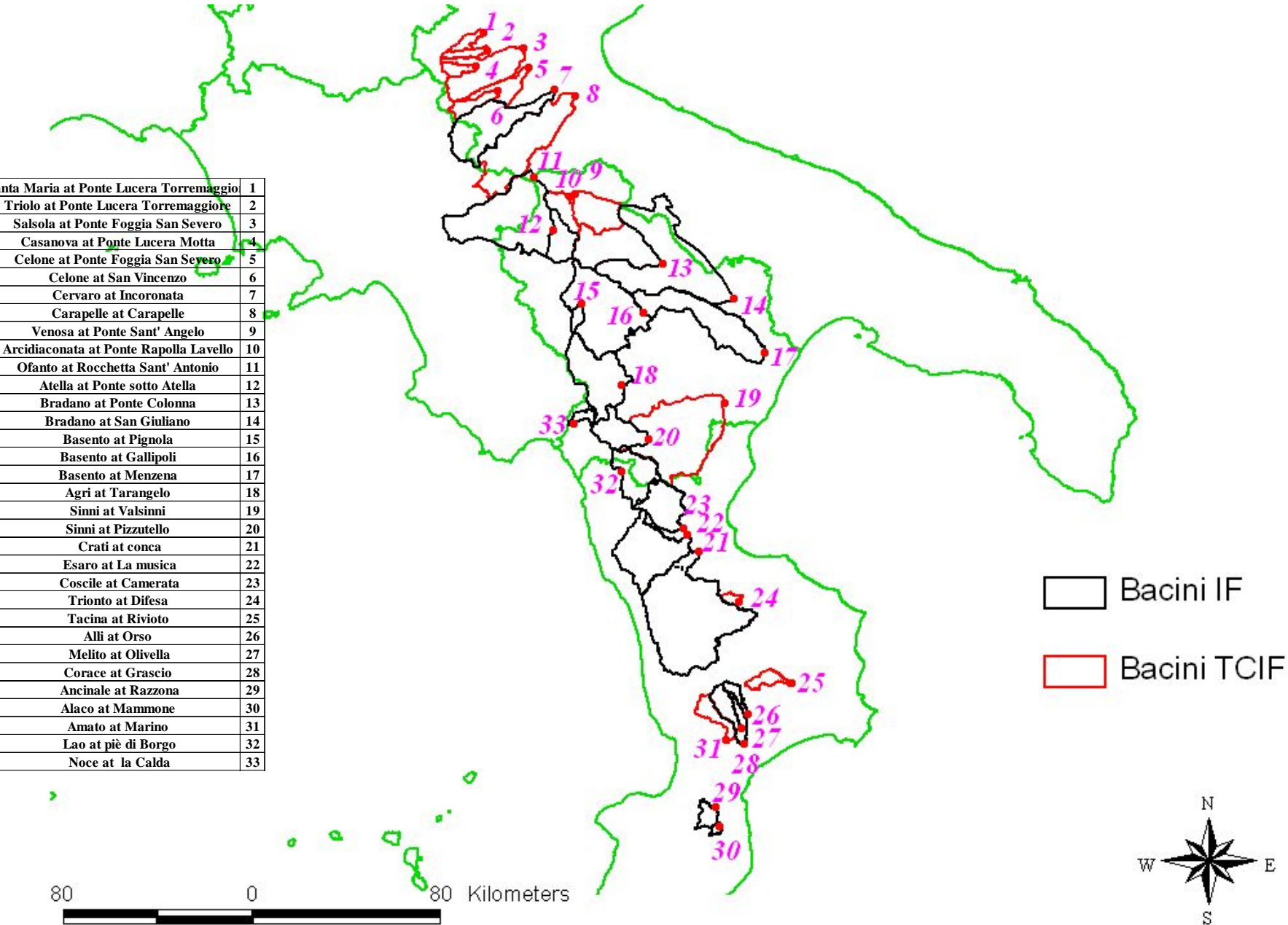
La verifica del modello regionale



La verifica del modello regionale

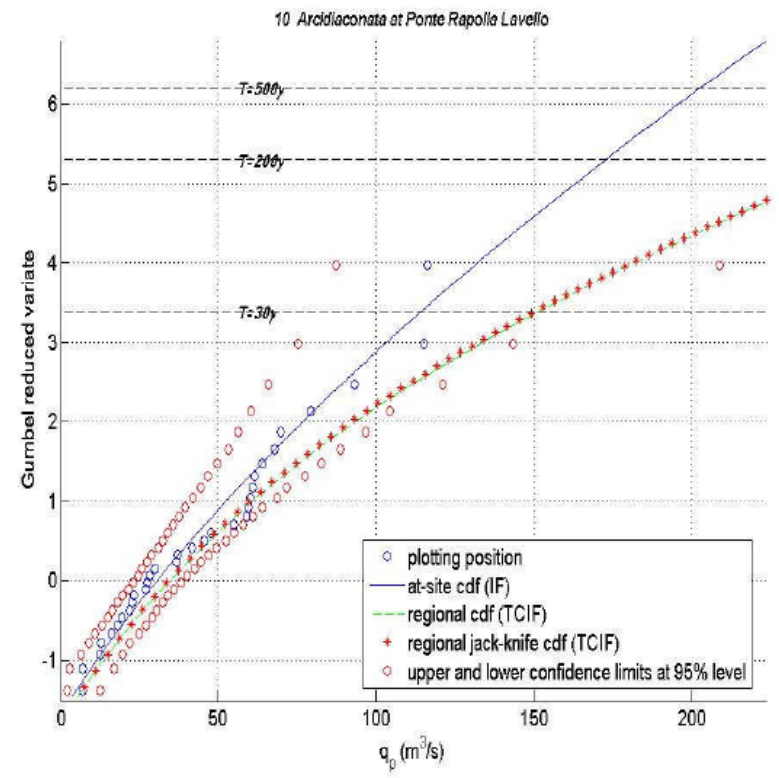
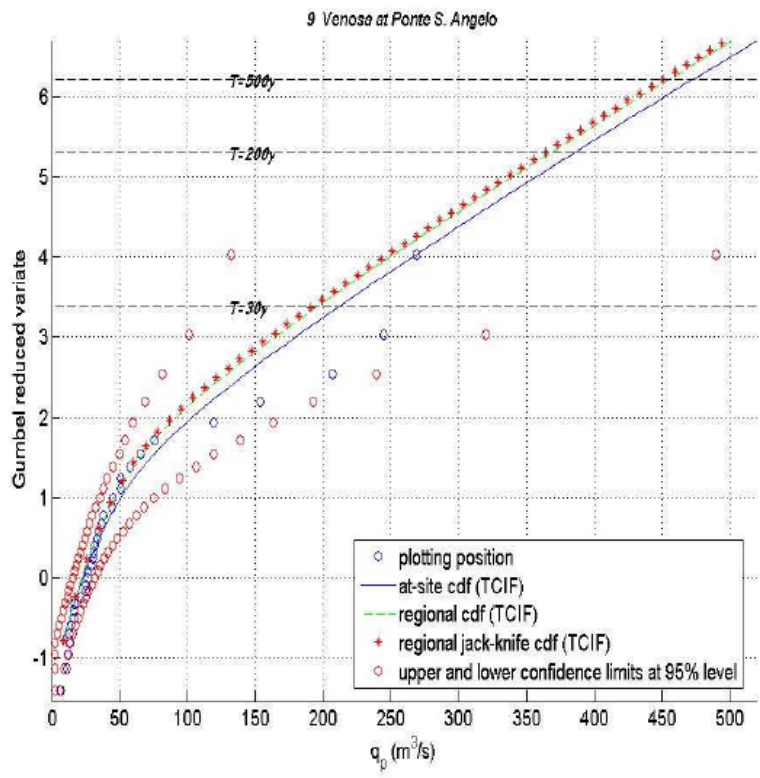


Il caso di studio: individuazione del modello

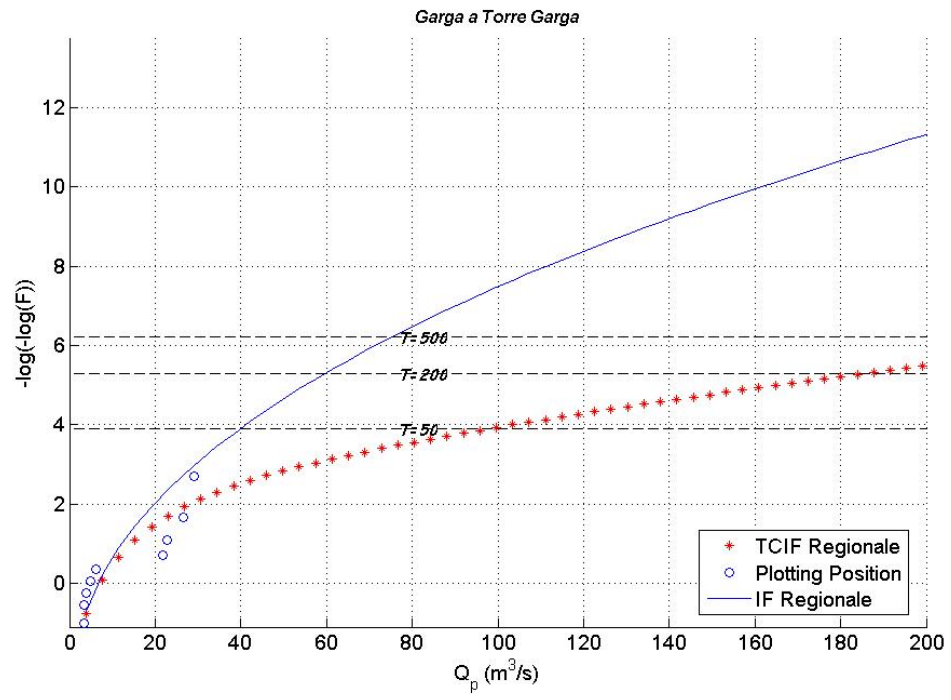
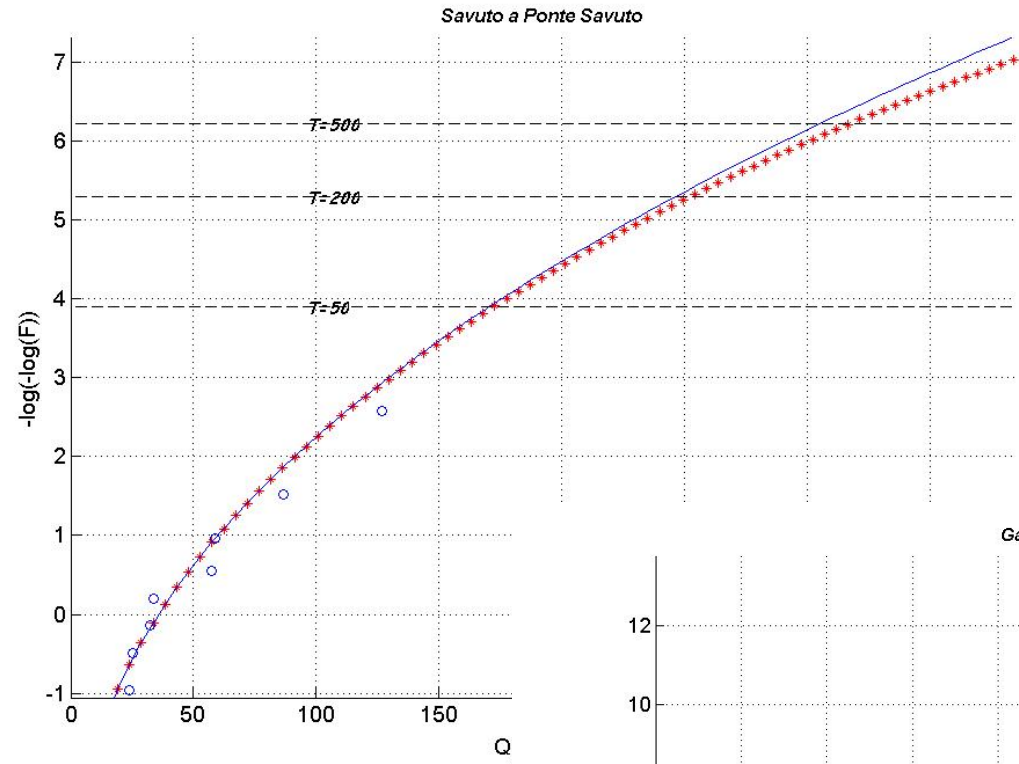


Monte Maria at Ponte Lucera Torremaggiore	1
Triolo at Ponte Lucera Torremaggiore	2
Salsola at Ponte Foggia San Severo	3
Casanova at Ponte Lucera Motta	4
Celone at Ponte Foggia San Severo	5
Celone at San Vincenzo	6
Cervaro at Incoronata	7
Carapelle at Carapelle	8
Venosa at Ponte Sant' Angelo	9
Arcidiaconata at Ponte Rapolla Lavello	10
Ofanto at Rocchetta Sant' Antonio	11
Atella at Ponte sotto Atella	12
Bradano at Ponte Colonna	13
Bradano at San Giuliano	14
Basento at Pignola	15
Basento at Gallipoli	16
Basento at Menzена	17
Agri at Tarangelo	18
Sinni at Valsinni	19
Sinni at Pizzutello	20
Crati at conca	21
Esaro at La musica	22
Coscile at Camerata	23
Trionto at Difesa	24
Tacina at Riviotto	25
Alli at Orso	26
Melito at Olivella	27
Corace at Grascio	28
Ancinale at Razzona	29
Alaco at Mammone	30
Amato at Marino	31
Lao at piè di Borgo	32
Noce at la Calda	33

Risultati

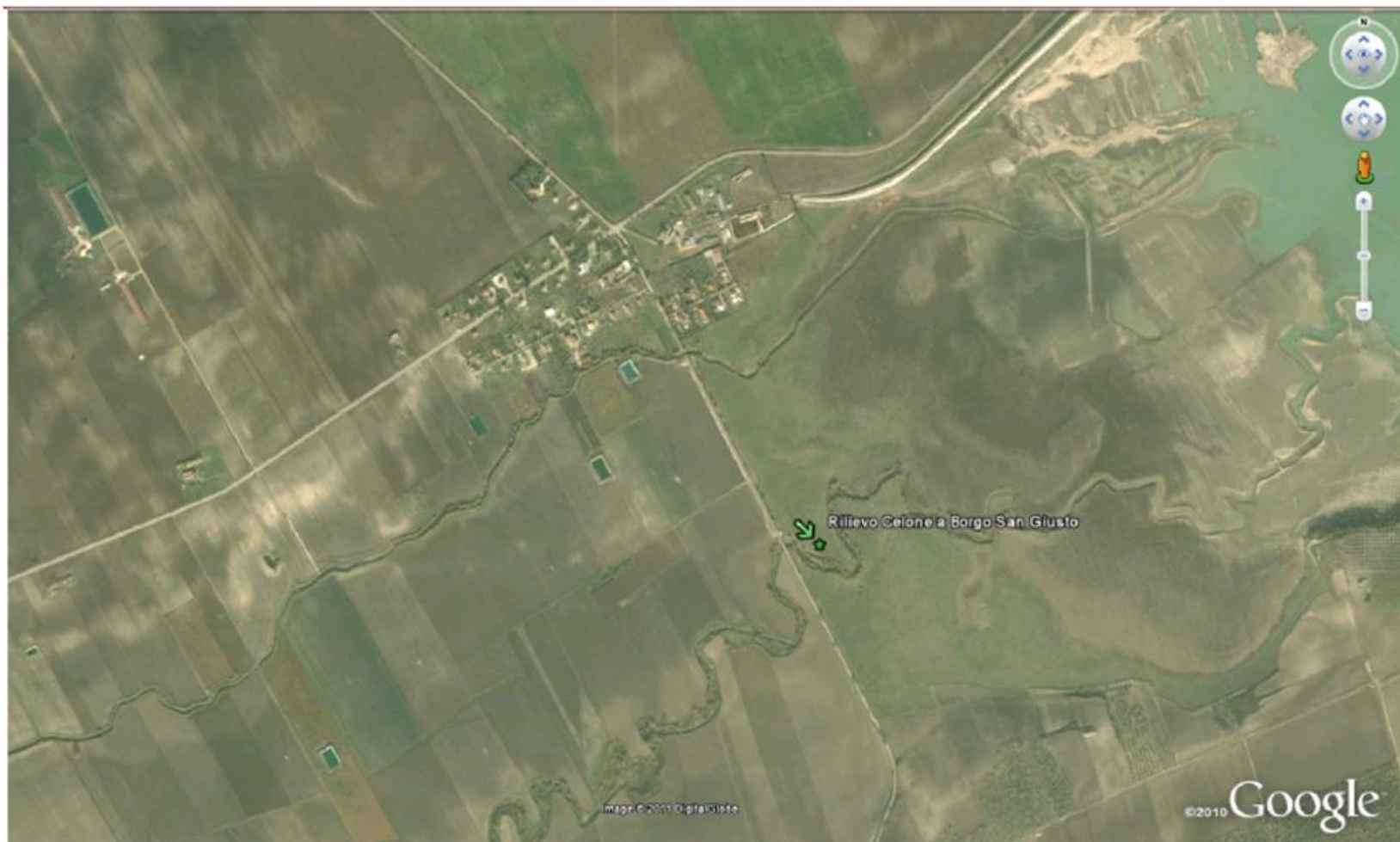


Risultati





INSTALLAZIONE E CALIBRAZIONE DI UN SENSORE SPERIMENTALE PER LA MISURA DELLA VELOCITÀ E PORTATA DEL TORRENTE CELONE A SAN GIUSTO (FG)



Rilievo Celone a Borgo San Giusto

Image © 2011 DigitalGlobe

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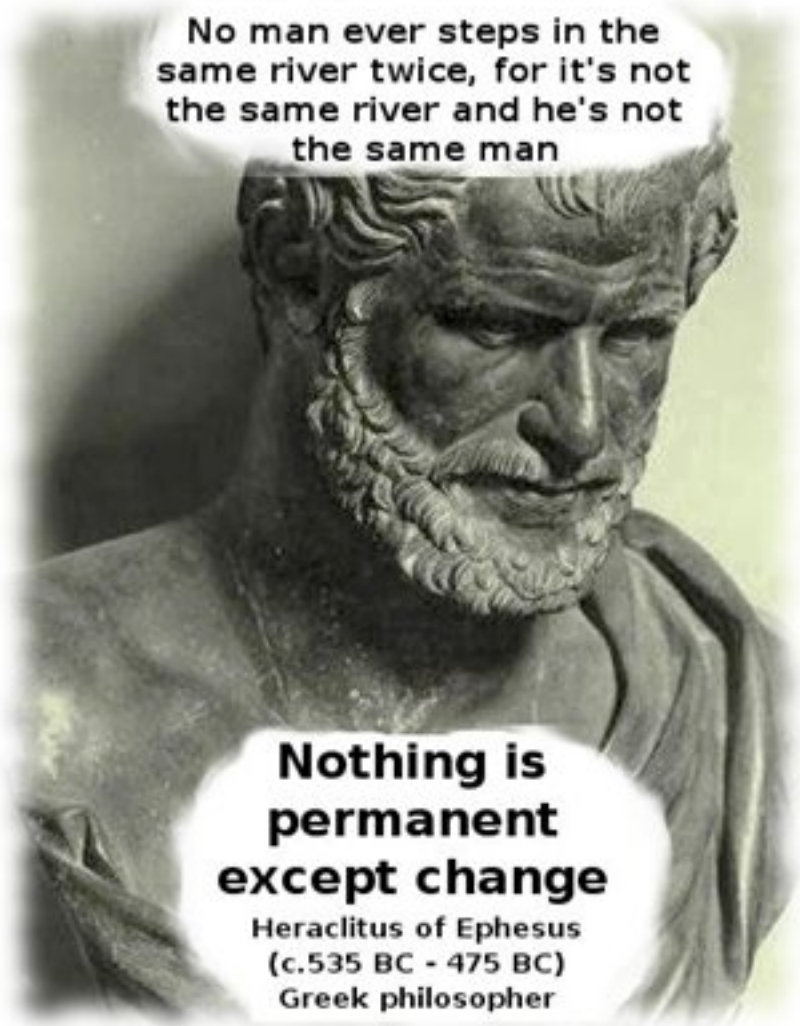


Il sensore è un correntometro acustico che utilizza l'Effetto Doppler per misurare la velocità dell'acqua lungo le componenti X e Y del piano tramite la misura degli echi riflessi dai sedimenti trasportati in sospensione.





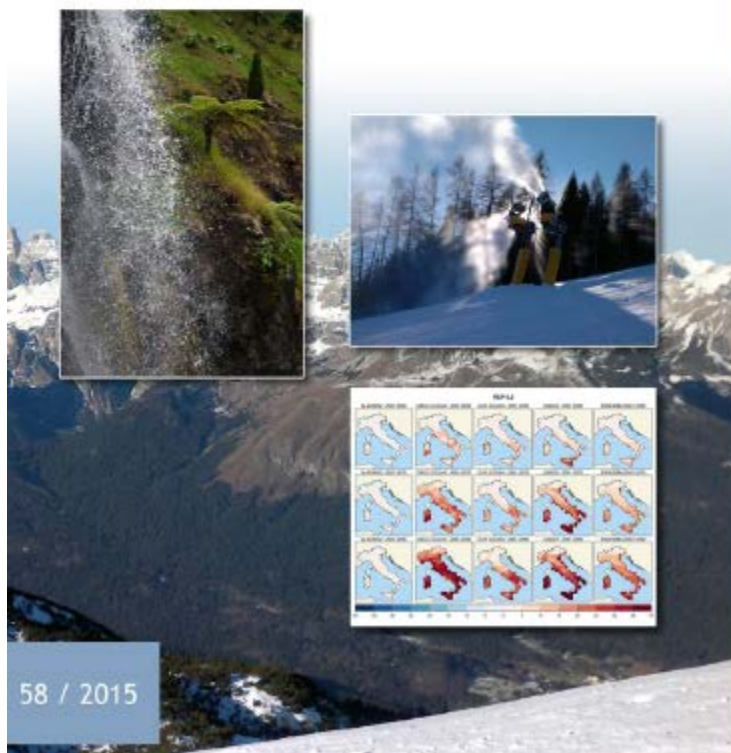
No man ever steps in the same river twice, for it's not the same river and he's not the same man



Nothing is permanent except change

Heraclitus of Ephesus
(c.535 BC - 475 BC)
Greek philosopher

Il clima futuro in Italia: analisi delle proiezioni dei modelli regionali



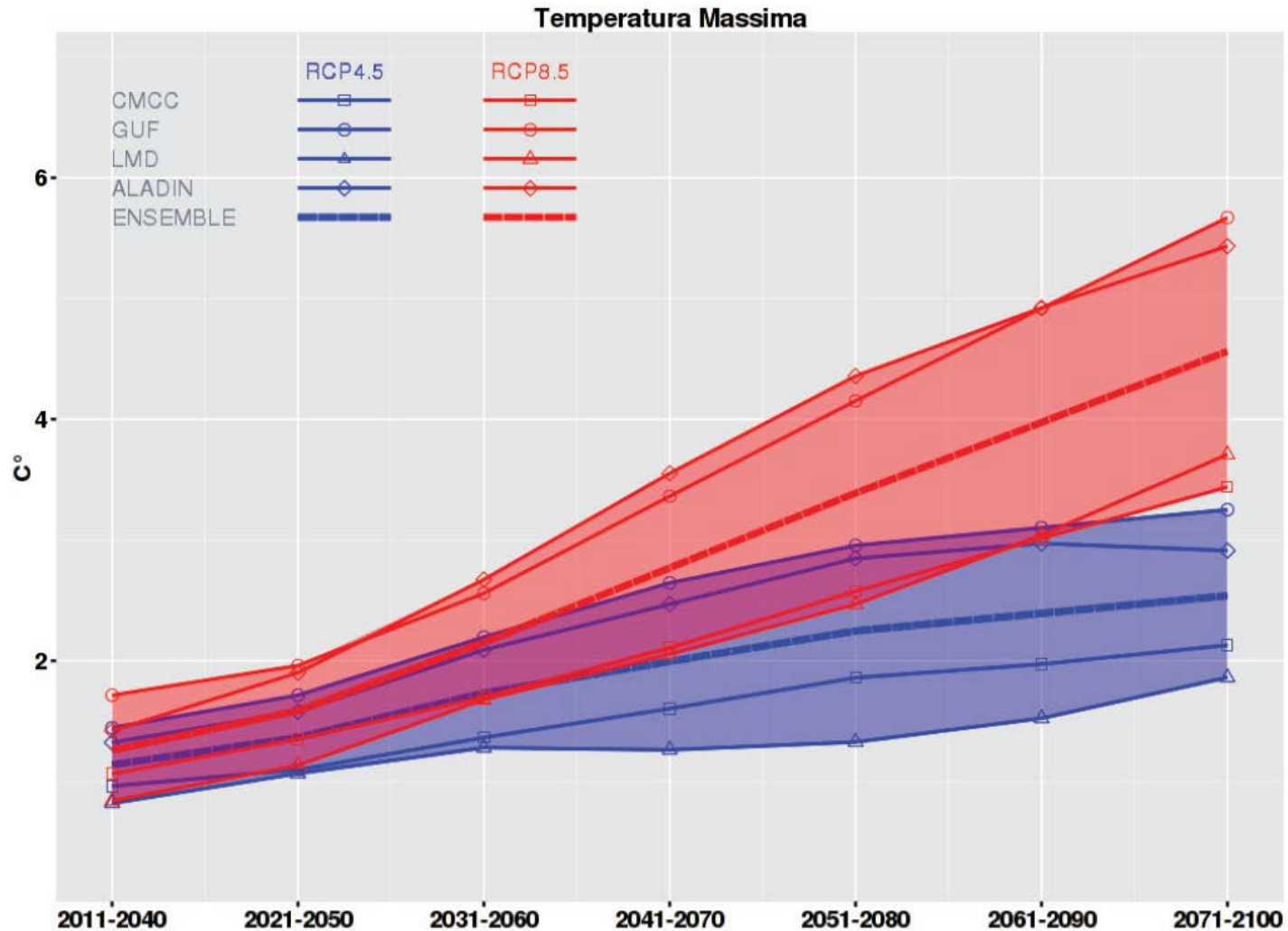


Figura 3.1 – Temperatura massima. Variazioni rispetto alla media 1971-2000 dei valori previsti dai quattro modelli (media su periodi di 30 anni) nei due scenari RCP4.5 (blu) e RCP8.5 (rosso). L'area colorata rappresenta lo spread delle previsioni dei modelli mentre la linea tratteggiata indica la media delle variazioni previste dai modelli (ensemble mean).

IPCC - Representative Concentration Pathways – RCP - scenario intermedio RCP 4.5

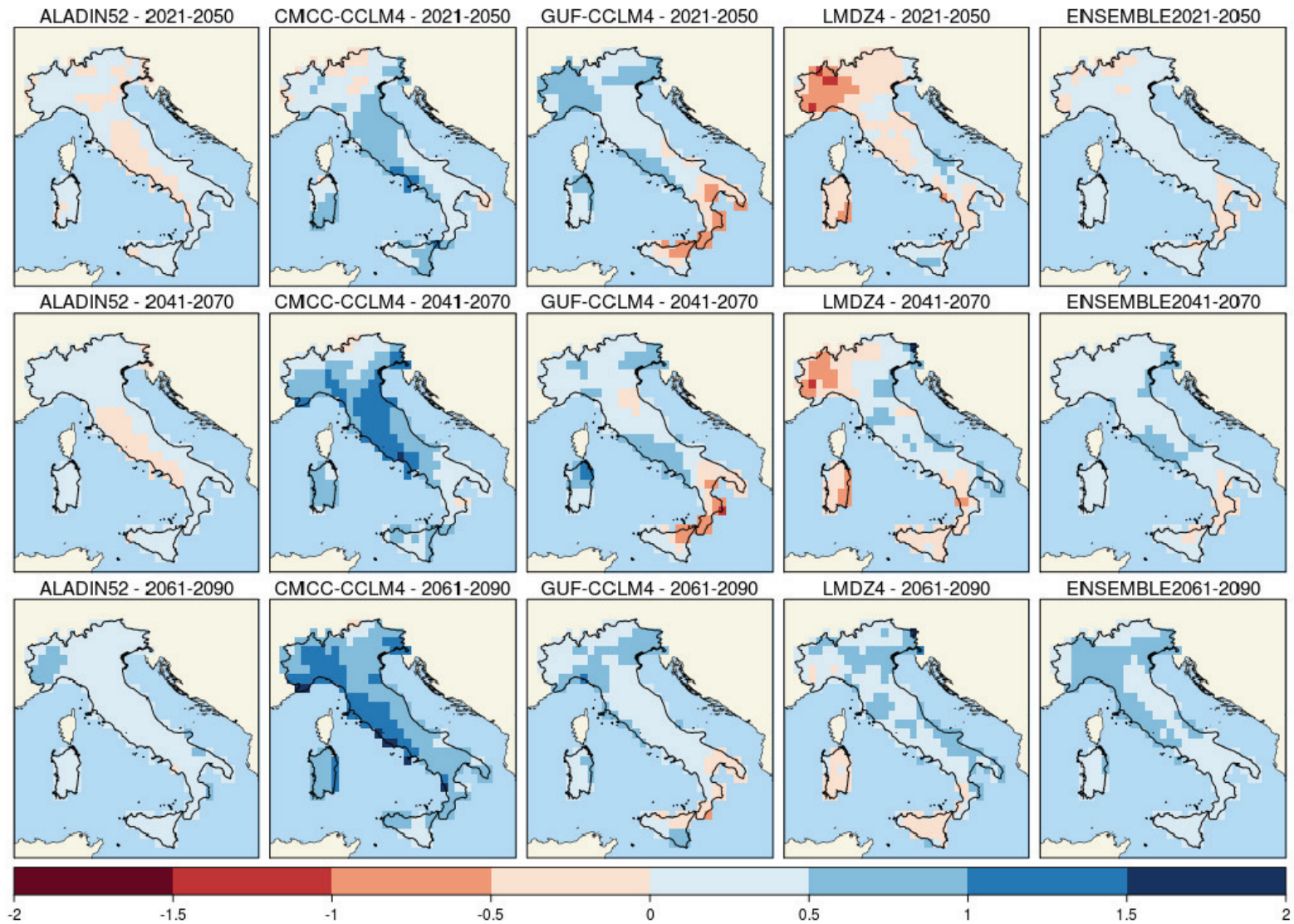
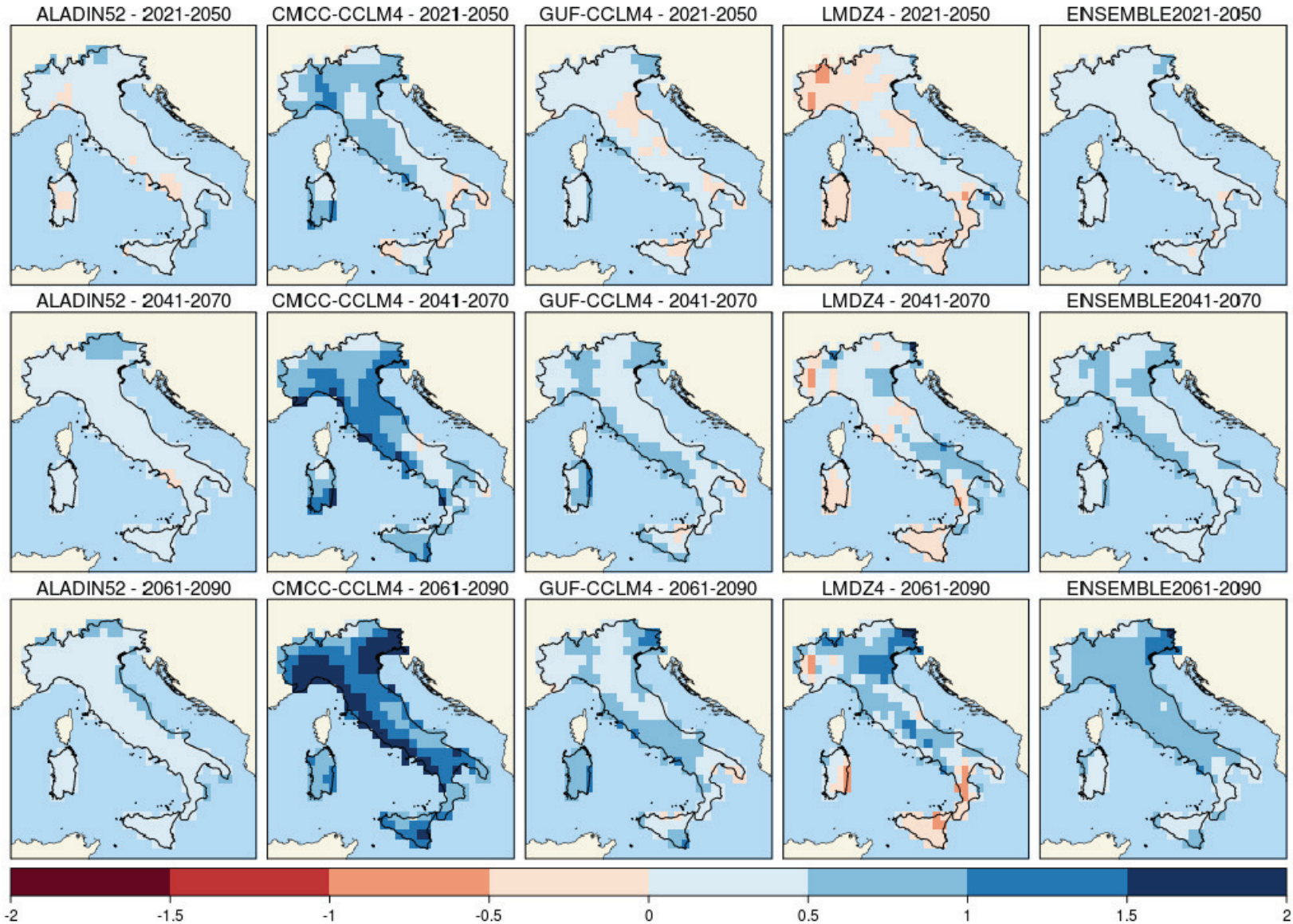


Figura 4.6 – Intensità di precipitazione giornaliera (mm/giorno), scenario RCP4.5. Mappe delle variazioni previste dai modelli e dall'ensemble mean ai tre orizzonti temporali 2021-2050 (prima riga), 2041-2070 (seconda riga), 2061-2090 (terza riga).

scenario caratterizzato da un'elevata emissione e da un elevato valore della forzante radiativa

RCP 8.5



STIMA DELL'EFFETTO DEI CAMBIAMENTI CLIMATICI SUI FENOMENI DI DISSESTO GEO-IDROLOGICI: IL CASO STUDIO DELLA CAMPANIA CENTRALE

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¹ Divisione di Ricerca Regional Modeling and geo-Hydrological Impacts,
Fondazione CMCC Centro Euro-Mediterraneo sui Cambiamenti Climatici – Capua (Italia).

² Autorità di Bacino della Campania Centrale, Napoli (Italia).

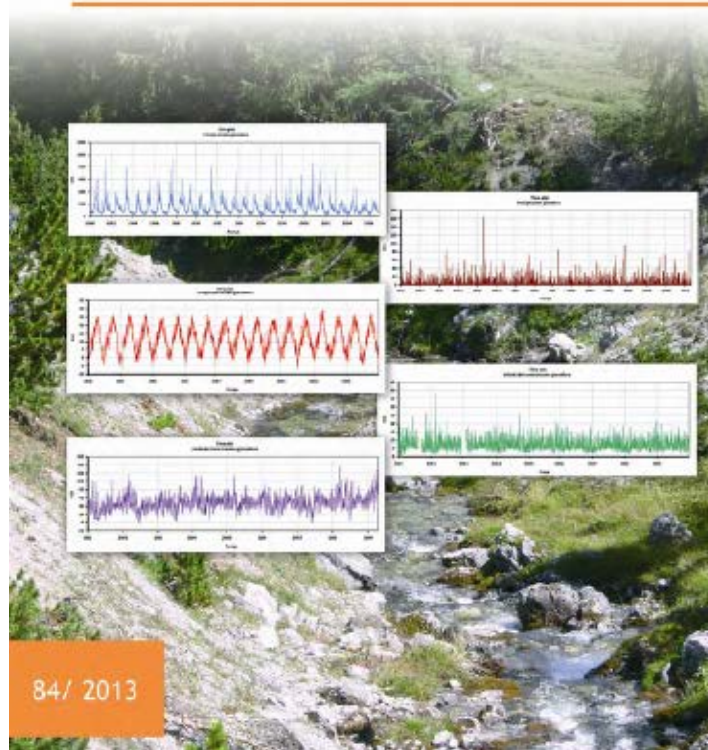
³ Laboratorio di Meteorologia, Centro Italiano Ricerche Aerospaziali (CIRA) – Capua (Italia).

La Direttiva Europea 2007/60/CE ed il relativo decreto legislativo di recepimento (D.Lgs. 49/2010) richiedono una esplicita stima degli effetti dei cambiamenti climatici sull'occorrenza e magnitudo dei fenomeni di dissesto idro-geologico.

Tuttavia il Decreto Legislativo 49/2010 stabilisce che, relativamente alla valutazione dell'effetto dei CC, essa diventi obbligatoria per i successivi riesami dei dispositivi (2018-2021 – secondo ciclo e successivamente ogni 6 anni) permettendo che, nella prima fase (la cui chiusura era prevista per il dicembre 2015), possa essere opzionale o limitarsi ad analisi di tipo qualitativo.

Purtroppo, come riportato in numerosi studi, su tali scale temporali sub-giornaliere (soprattutto per i valori estremi), a causa delle risoluzioni oggi permesse e delle conseguenti parametrizzazioni fisiche adottate, i risultati delle simulazioni climatiche sono caratterizzate da incertezze (ed errori associati) sensibilmente superiori a quelli restituiti fino alla scala giornaliera limitandone in molti casi l'utilizzo; d'altro canto, è bene ricordare che, per tali scale temporali, spesso scarseggiano anche le serie di dati di adeguata lunghezza e densità spaziale per una congrua validazione delle prestazioni dei modelli climatici.

Linee guida per l'analisi e l'elaborazione statistica di base delle serie storiche di dati idrologici

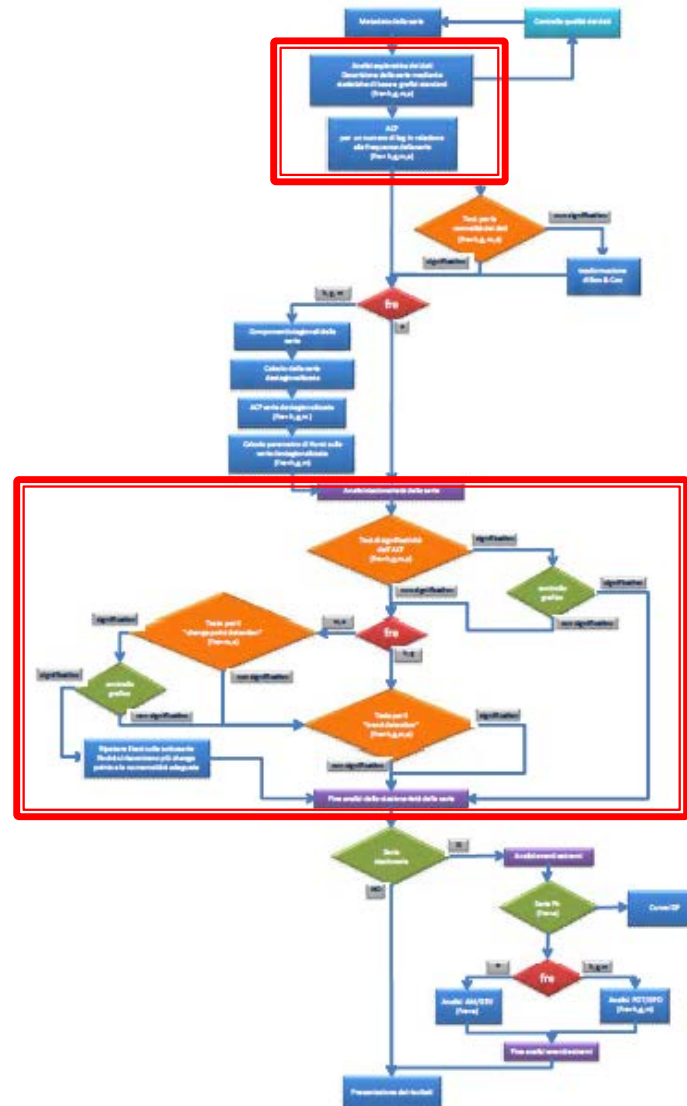


84/ 2013

Diagramma di flusso della procedura di analisi di una serie storica di dati idrologici (da ISPRA, 2013)

ANALISI ESPLORATIVA DELLA SERIE

ANALISI DELLA STAZIONARIETA' DELLA SERIE



**Diagramma di flusso della procedura di analisi di una serie storica di dati idrologici
(da ISPRA, 2013)**

**ANALISI ESPLORATIVA
DELLA SERIE**

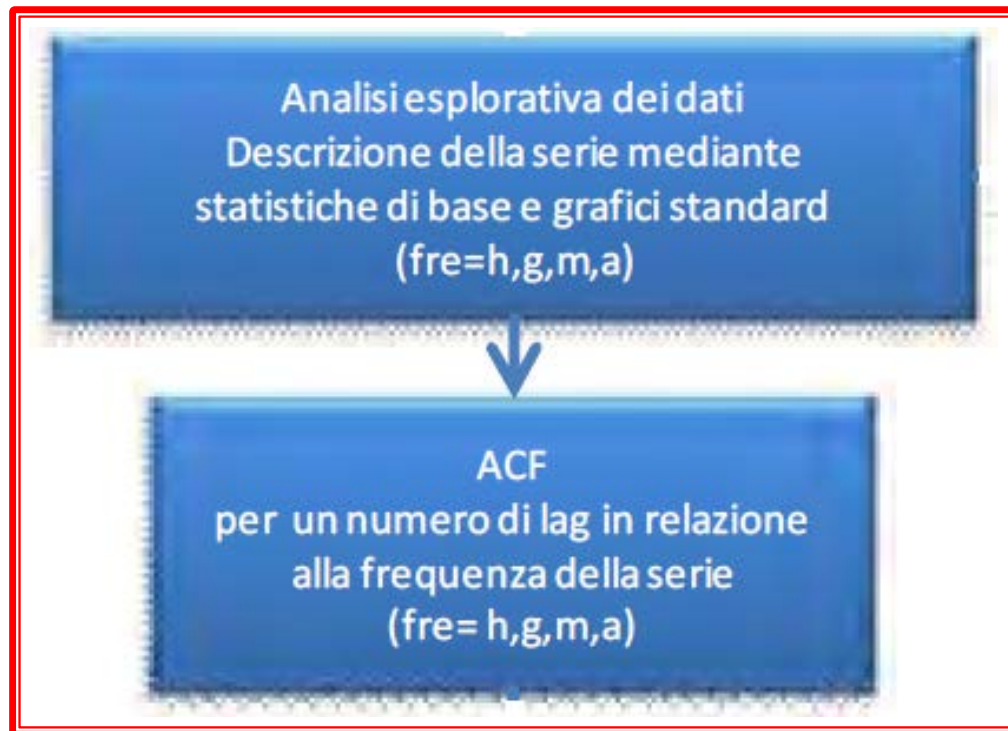
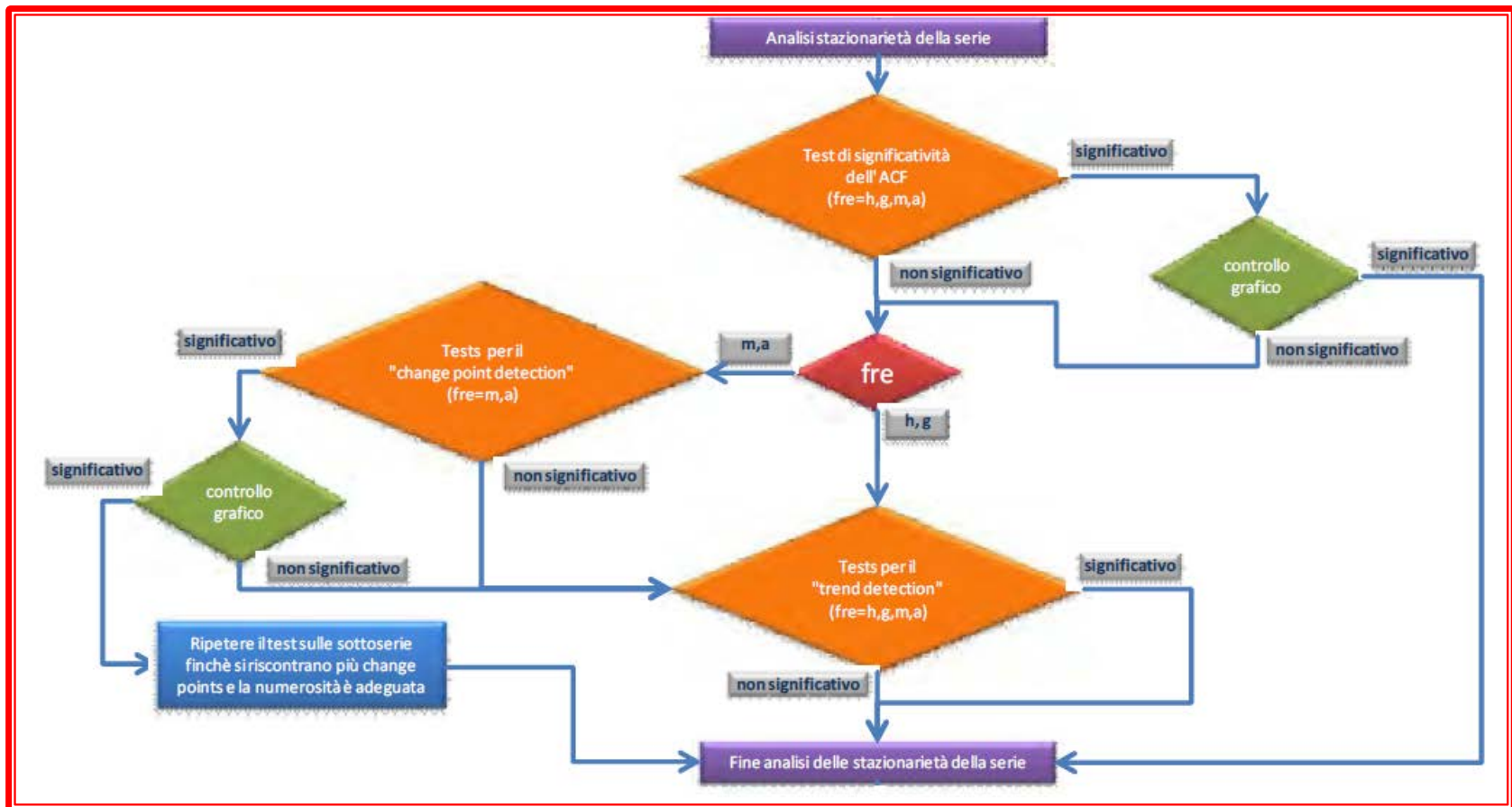


Diagramma di flusso della procedura di analisi di una serie storica di dati idrologici (da ISPRA, 2013)

ANALISI DELLA STAZIONARIETA' DELLA SERIE



Indice di Qualità della Serie di dati Idrologici (iQuaSI) (da Ispra, 2013)

$$iQuaSI = a_L \times \left(\frac{L_A}{L}\right) + b_L \times \left(\frac{L_B}{L}\right) + c_L \times \left(\frac{L_C}{L}\right) + d_L \times \left(\frac{L_D}{L}\right)$$

Tabella 6.1 - Coefficienti per la determinazione dell'indice di qualità della serie

		Lunghezza della serie (anni)			
		L ≥ 30	15 ≤ L < 30	5 ≤ L < 15	L < 5
Classe dei dati	A	1	3/4	1/2	0
	B	3/4	1/2	1/4	0
	C	1/2	1/4	0	0
	D	0	0	0	0

Tabella 6.2 - Indice di qualità della serie iQuaSI

Qualità della serie	iQuaSI
Elevata	$0.90 < iQuaSI \leq 1$
Buona	$0.70 < iQuaSI \leq 0.90$
Sufficiente	$0.30 < iQuaSI \leq 0.70$
Scadente	$0.10 < iQuaSI \leq 0.30$
Pessima/Inutilizzabile	$0 \leq iQuaSI \leq 0.10$

Il test di Mann-Kendall

E' un test parametrico per l'individuazione di trend monotoni. La statistica del test si può esprimere come:

$$S = \sum_{k=1}^{T-1} \sum_{j=k+1}^T \text{sgn}(X_j - X_k)$$

Il test è condotto sulla statistica Z che segue ha una distribuzione normale standard

$$Z = \begin{cases} (S - 1)/V^{0.5} & \text{se } S > 0 \\ 0 & \text{se } S = 0 \\ (S + 1)/V^{0.5} & \text{se } S < 0 \end{cases}$$

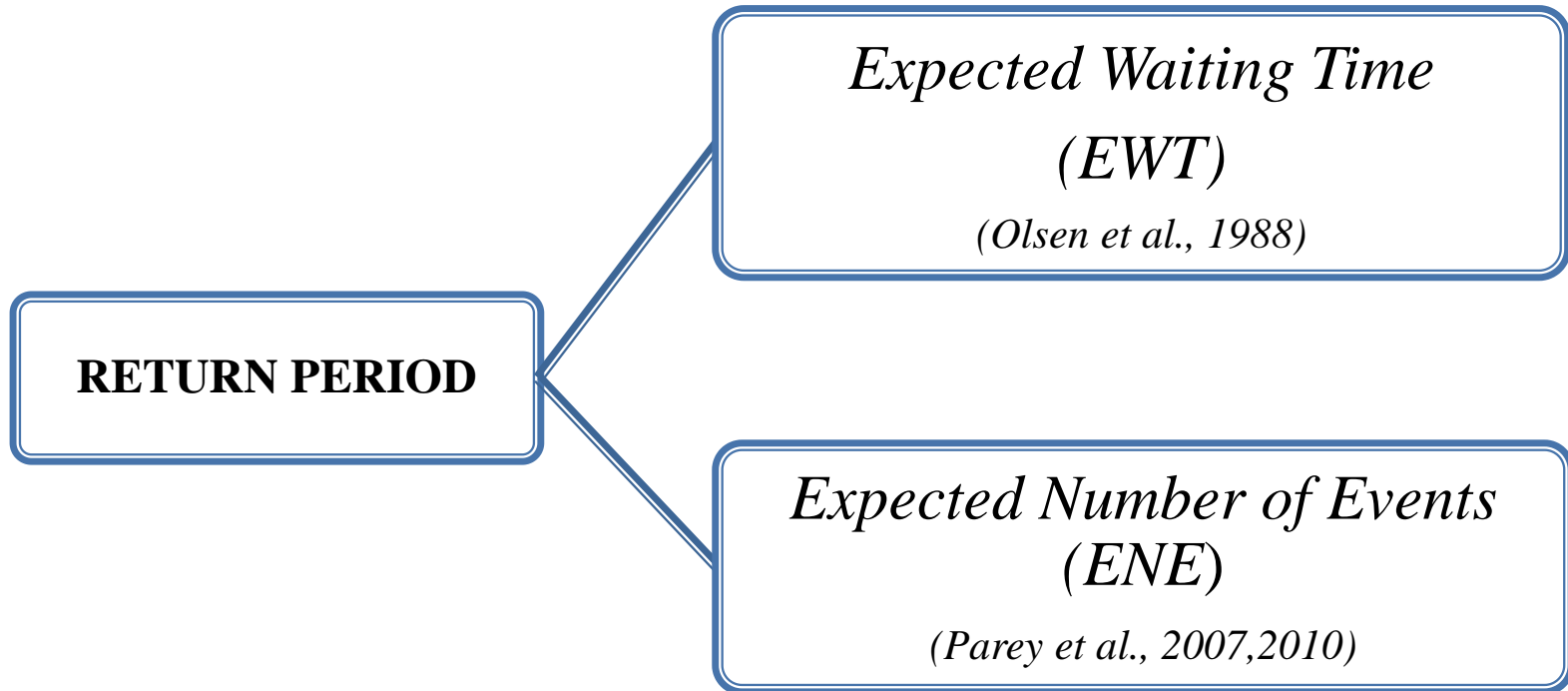
essendo V la varianza di S .

Revisiting the Concepts of Return Period and Risk for Nonstationary Hydrologic Extreme Events

Jose D. Salas, M.ASCE¹; and Jayantha Obeysekera, M.ASCE²

Abstract: Current practice using probabilistic methods applied for designing hydraulic structures generally assume that extreme events are stationary. However, many studies in the past decades have shown that hydrological records exhibit some type of nonstationarity such as trends and shifts. Human intervention in river basins (e.g., urbanization), the effect of low-frequency climatic variability (e.g., Pacific Decadal Oscillation), and climate change due to increased greenhouse gasses in the atmosphere have been suggested to be the leading causes of changes in the hydrologic cycle of river basins in addition to changes in the magnitude and frequency of extreme floods and extreme sea levels. To tackle nonstationarity in hydrologic extremes, several approaches have been proposed in the literature such as frequency analysis, in which the parameters of a given model vary in accordance with time. The aim of this paper is to show that some basic concepts and methods used in designing flood-related hydraulic structures assuming a stationary world can be extended into a nonstationary framework. In particular, the concepts of return period and risk are formulated by extending the geometric distribution to allow for changing exceeding probabilities over time. Building on previous developments suggested in the statistical and climate change literature, the writers present a simple and unified framework to estimate the return period and risk for nonstationary hydrologic events along with examples and applications so that it can be accessible to a broad audience in the field. The applications demonstrate that the return period and risk estimates for nonstationary situations can be quite different than those corresponding to stationary conditions. They also suggest that the nonstationary analysis can be helpful in making an appropriate assessment of the risk of a hydraulic structure during the planned project-life. DOI: 10.1061/(ASCE)HE.1943-5584.0000820. © 2014 American Society of Civil Engineers.

Tempo di ritorno in condizioni non stazionarie



Expected Waiting Time interpretation (EWT)

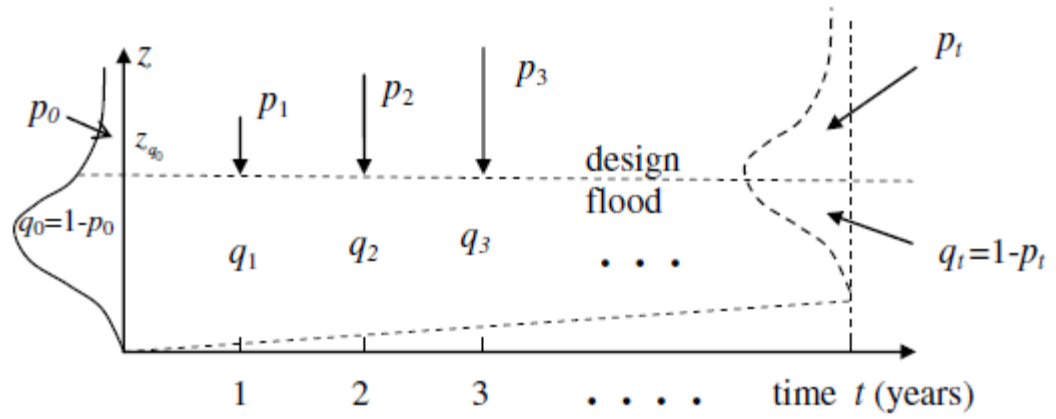
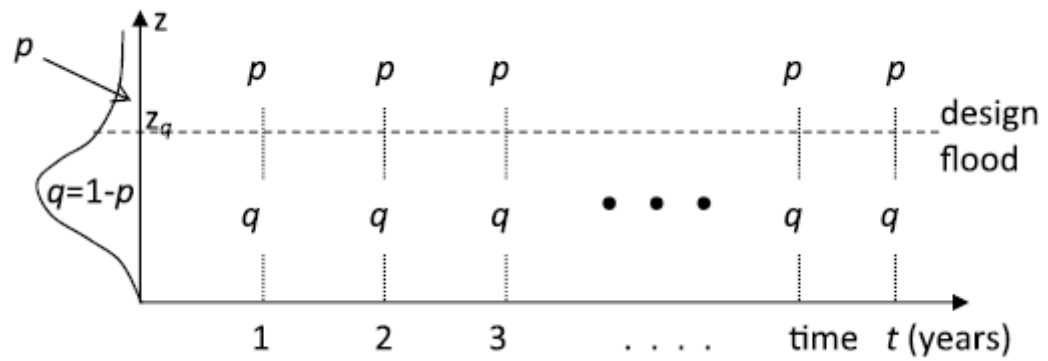
“Expected waiting time until an exceedance occurs”

$$T = \sum_{x=1}^{\infty} x p_x \prod_{t=1}^{x-1} (1 - p_t)$$

Expected Number of Events interpretation (ENE)

“Numbers of years for which the expected number of exceedance is equal to 1.”

$$\sum_{t=1}^T (1 - p_t) = 1$$



Expected Waiting Time interpretation (EWT)

$$f(x) = P(X = x) = (1 - p_1)(1 - p_2)(1 - p_3) \dots (1 - p_{x-1})p_x$$

$$f(x) = p_x \prod_{t=1}^{x-1} (1 - p_t) \quad x = 1, 2, \dots, x_{\max}$$

$$T = E(X) = \sum_{x=1}^{x_{\max}} x f(x) = \sum_{x=1}^{x_{\max}} x p_x \prod_{t=1}^{x-1} (1 - p_t)$$

Generalized Extreme Value distribution (GEV)

$$F(z, \underline{\theta}_t) = \exp \left\{ - \left[1 + \varepsilon \left(\frac{z - \mu_t}{\sigma_t} \right) \right]^{-1/\varepsilon} \right\}$$

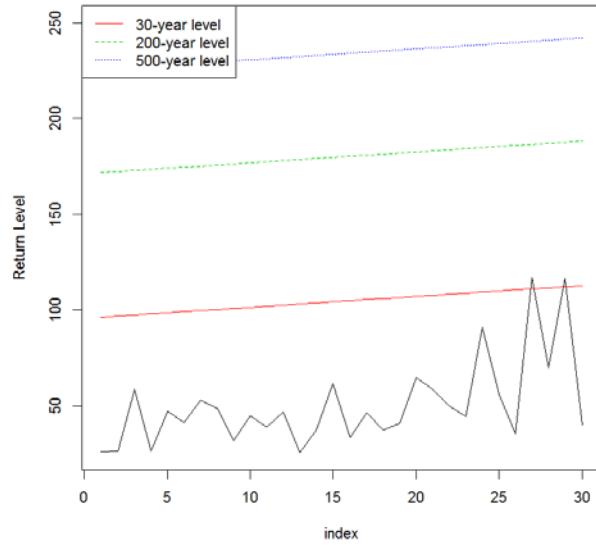
$$\mu = \mu_0 + a \cdot t$$

$$\sigma = \sigma_0 + b \cdot t$$

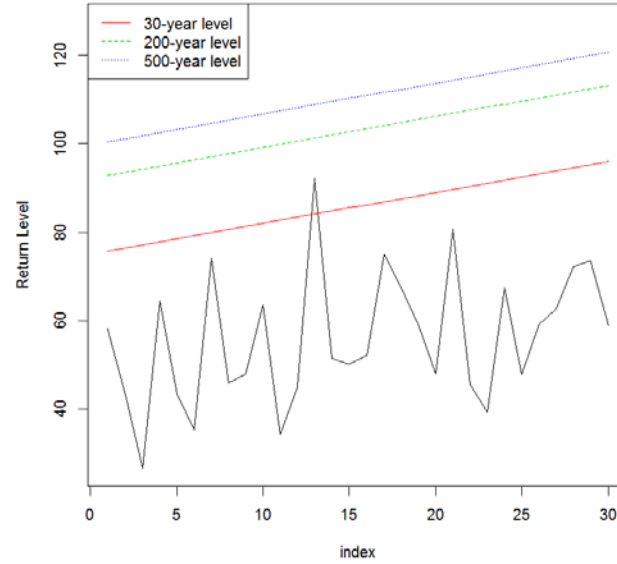
$$p_t = 1 - \exp \left\{ - \left[1 + \varepsilon \left(\frac{z_{q_0} - \mu_t}{\sigma_t} \right) \right]^{-1/\varepsilon} \right\}$$

$$z_{q_0} = \mu_0 - \frac{\sigma_0}{\varepsilon} \left\{ 1 - [-\ln(1 - p_0)]^{-\varepsilon} \right\}$$

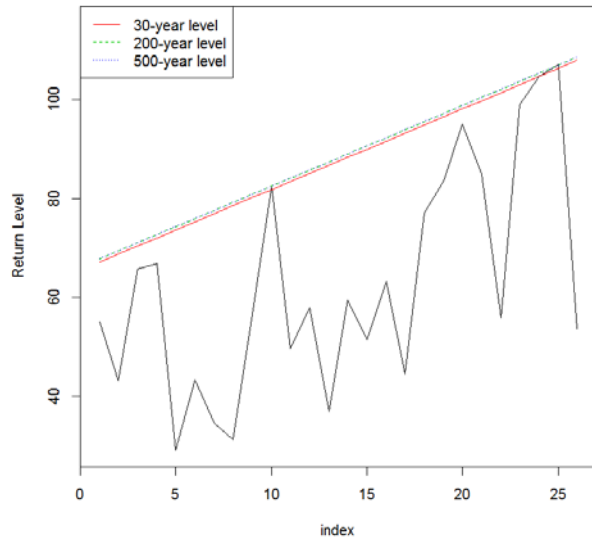
Barletta (1984-2012)



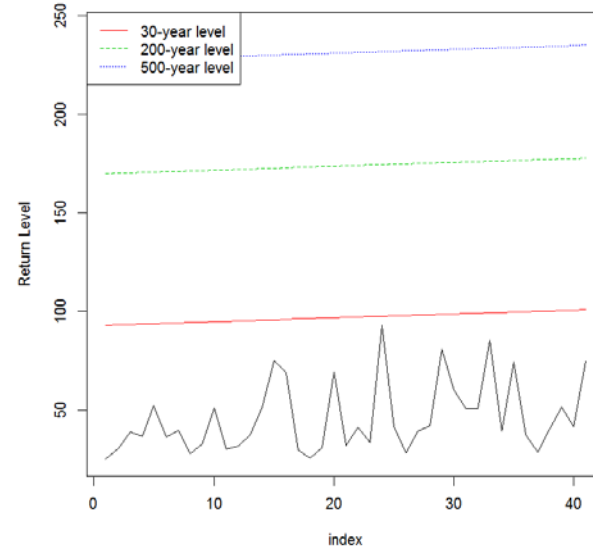
Corato (1980-2012)



San Marco in Lamis (1984-2012)

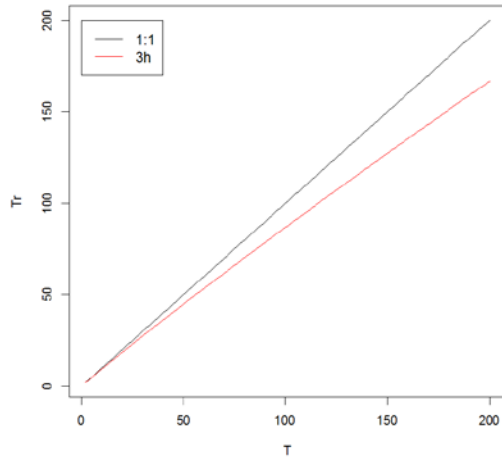


Castelluccio dei Sauri (1970-2012)

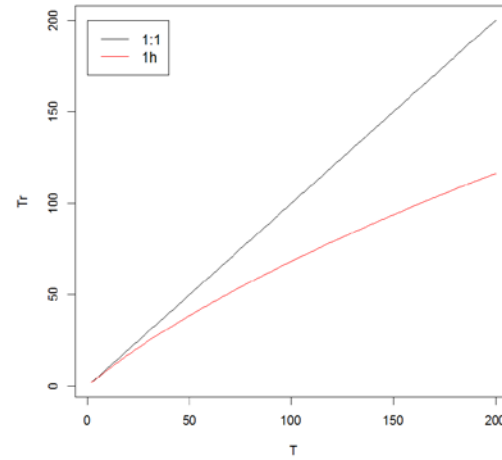


Grafici T-Tr

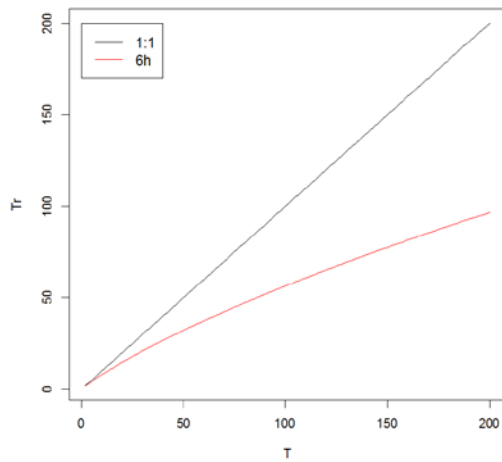
Stazione di Barletta



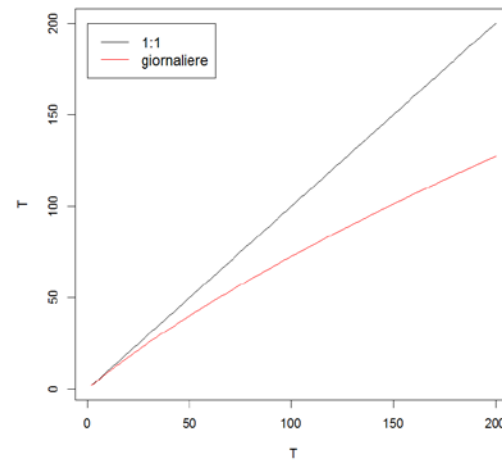
Stazione di Corato



Stazione di San Marco in Lamis



Stazione di Castelluccio dei Sauri



Akaike Information Criterion (Akaike, 1974)

E' un indice di selezione di selezione tra modelli diversi, la cui espressione analitica è:

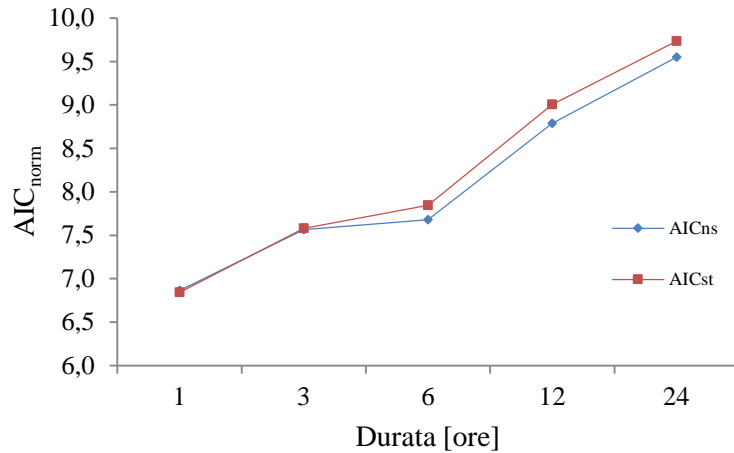
$$\text{AIC} = -2 \ln(L) + 2(k)$$

dove L indica il valore massimizzato della funzione di verosimiglianza del modello stimato e k il numero di parametri del modello.

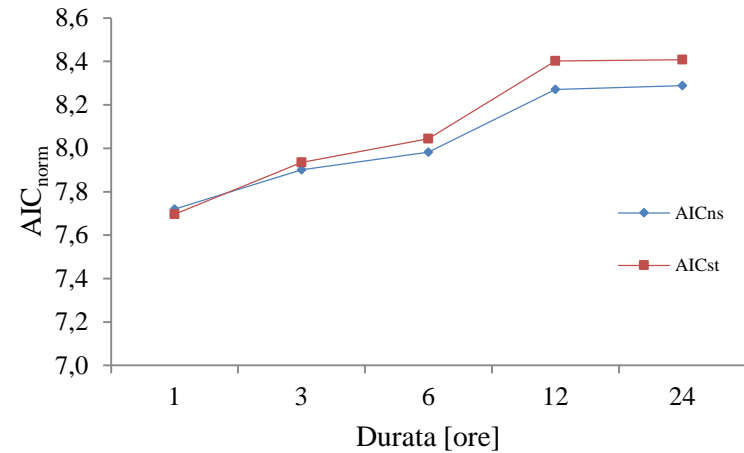
Il modello migliore è quello cui corrisponde un valore di AIC minore.

Andamenti temporali orari dell'indice AIC normalizzato

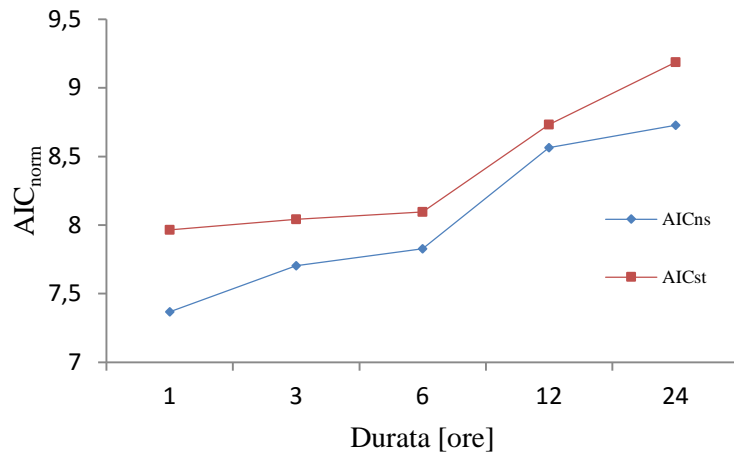
Stazione di Barletta (1984-2012)



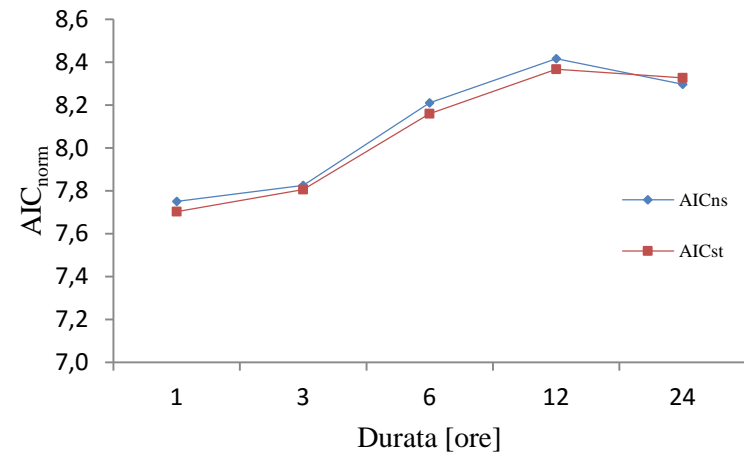
Stazione di Corato (1980-2012)



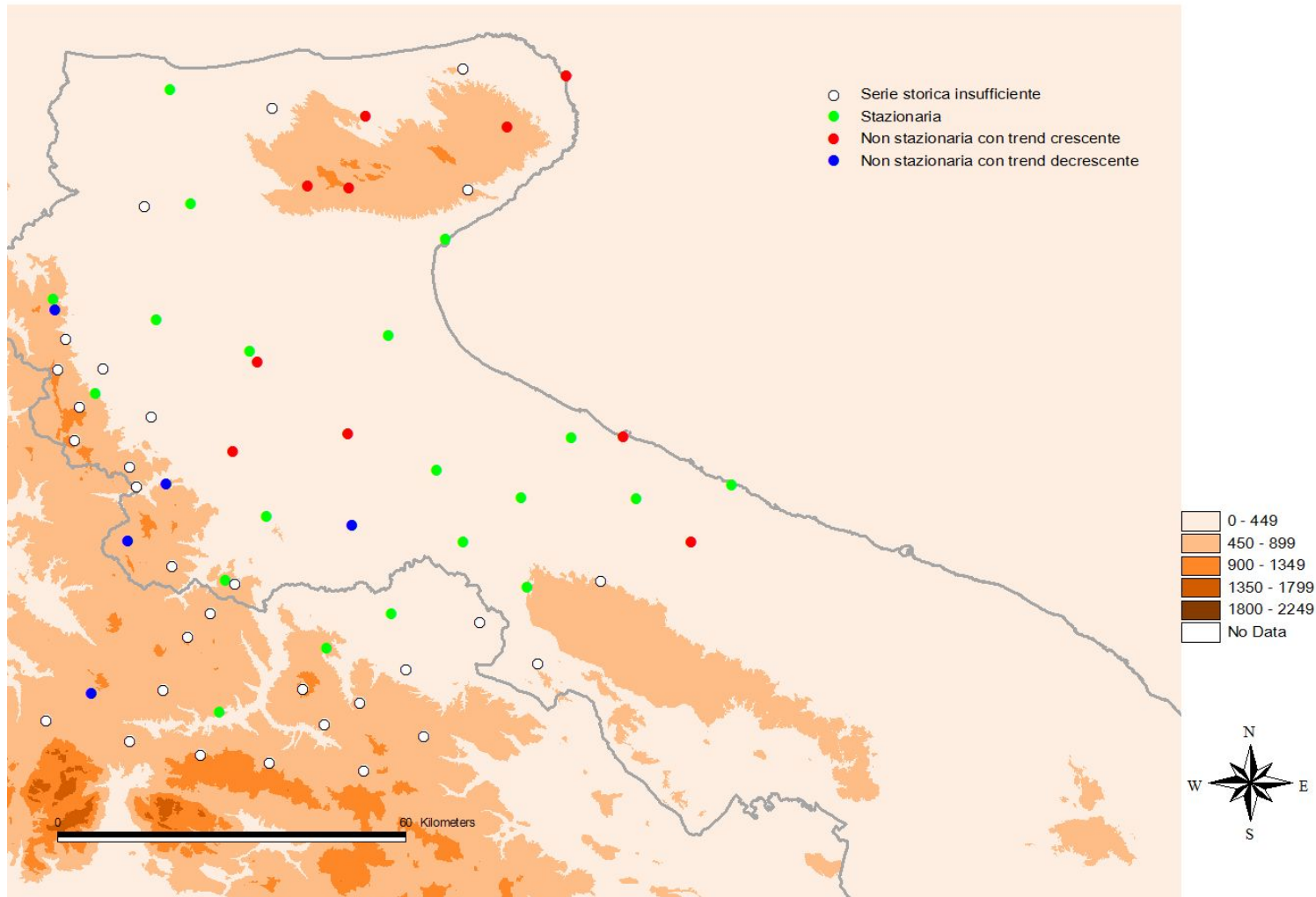
Stazione di San Marco in Lamis (1984-2012)



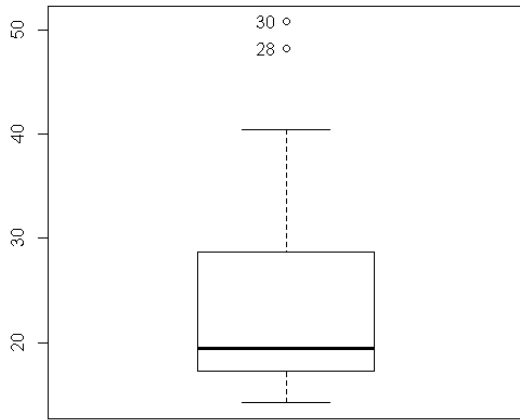
Stazione di Castelluccio dei Sauri (1970-2012)



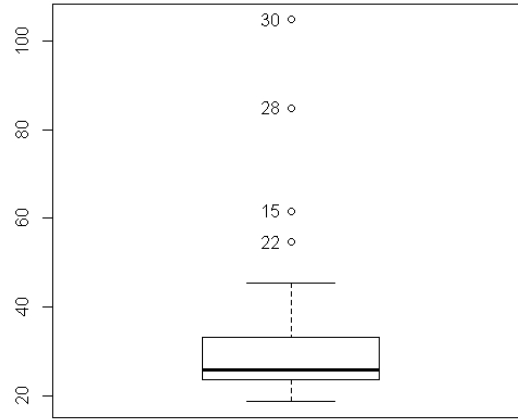
Analisi di non stazionarietà



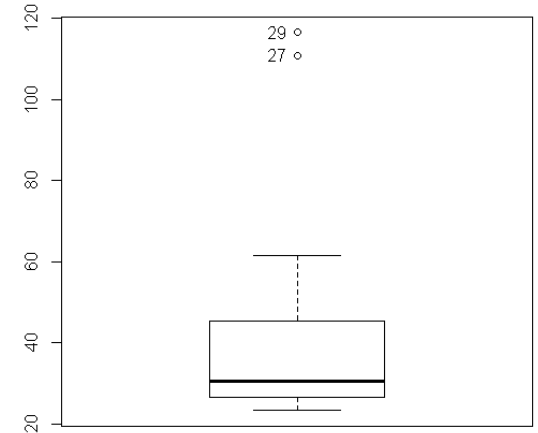
Stazione di Barletta (1984-2012)



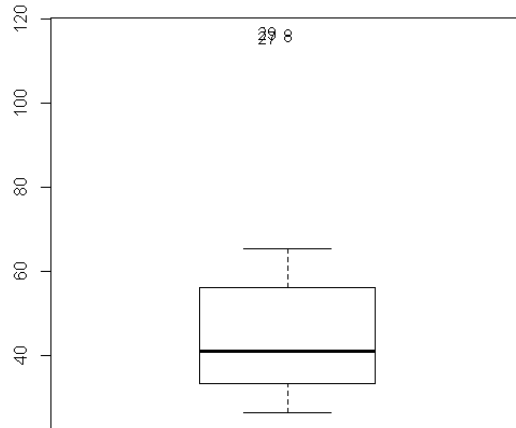
1 h



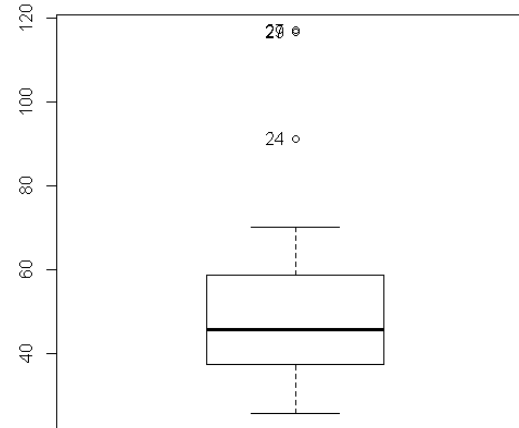
3 h



6 h

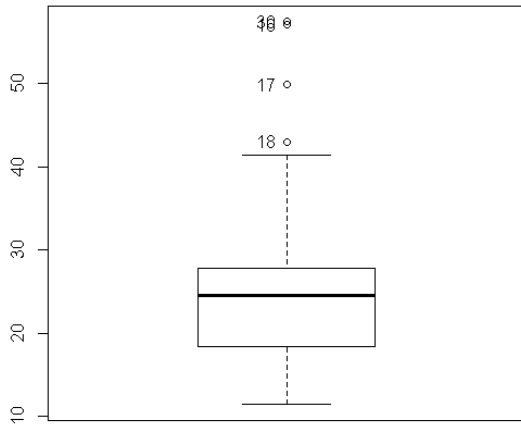


12 h

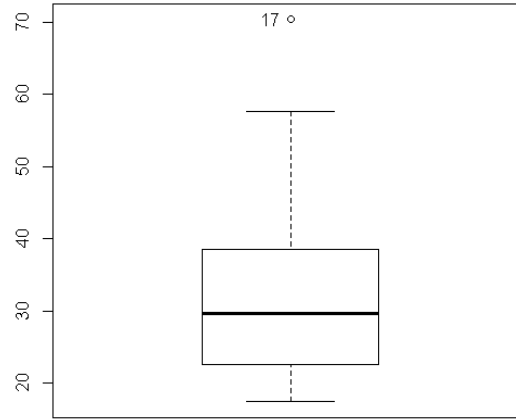


giornaliera

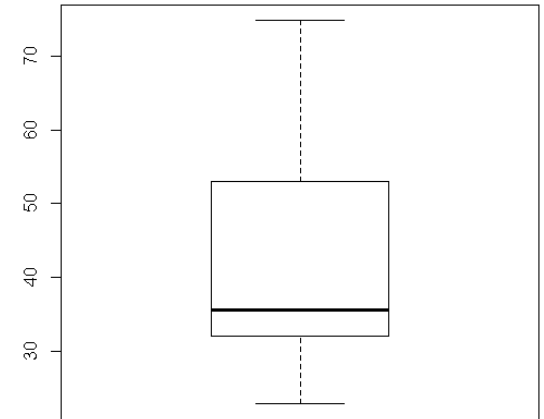
Stazione di Corato (1980-2012)



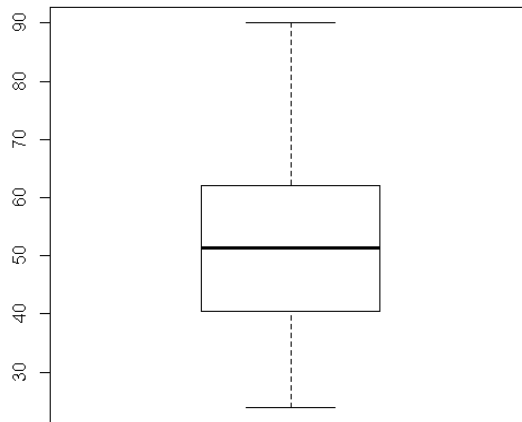
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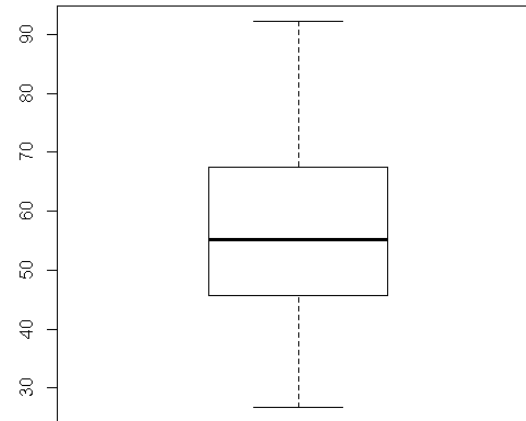
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6 h

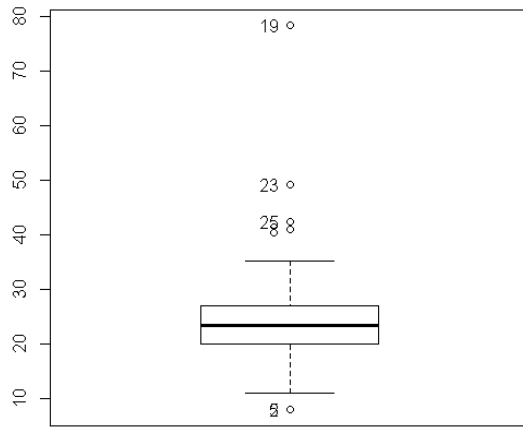


12 h

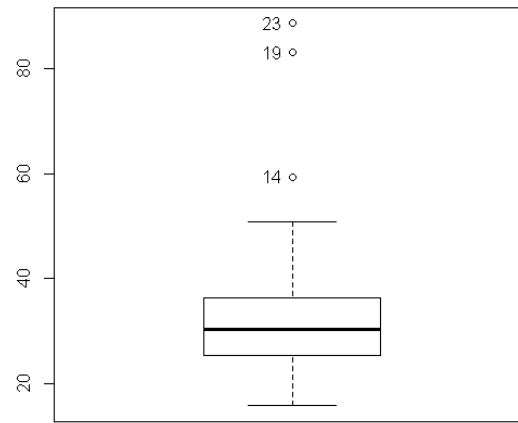


giornaliero

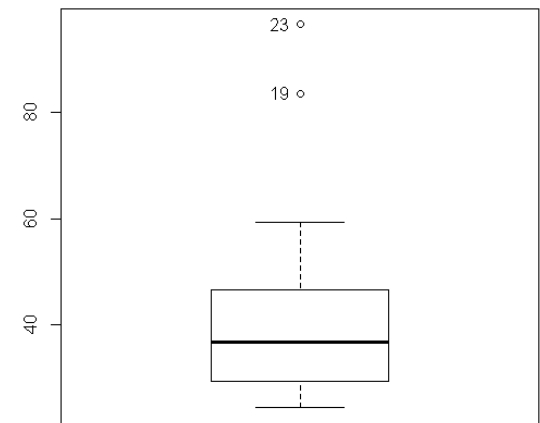
Stazione di San Marco in Lamis (1984-2012)



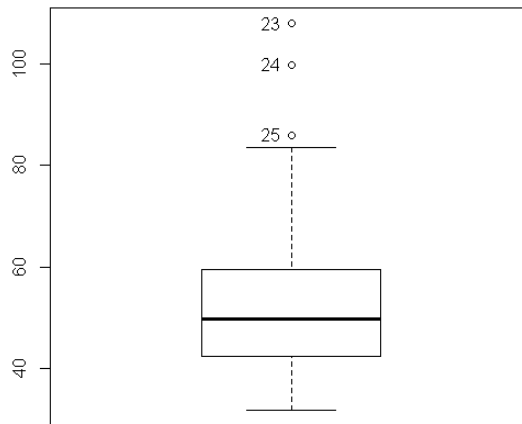
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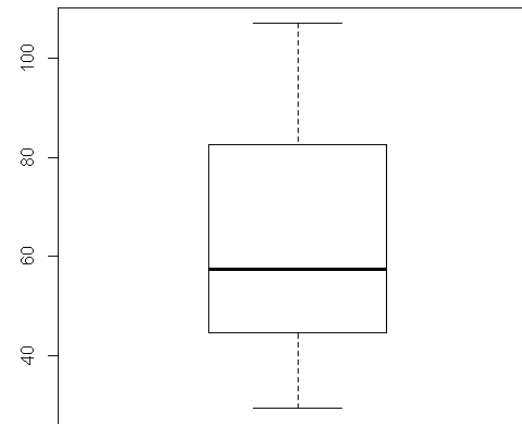
3 h



6 h

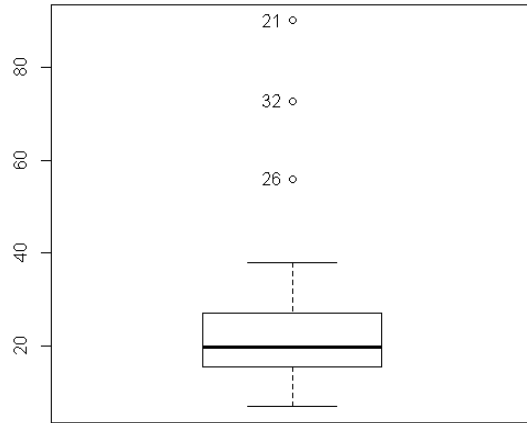


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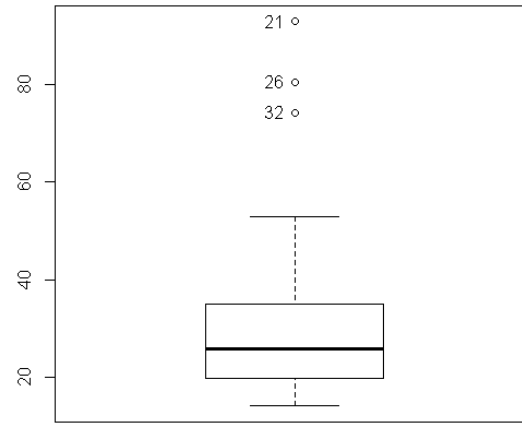


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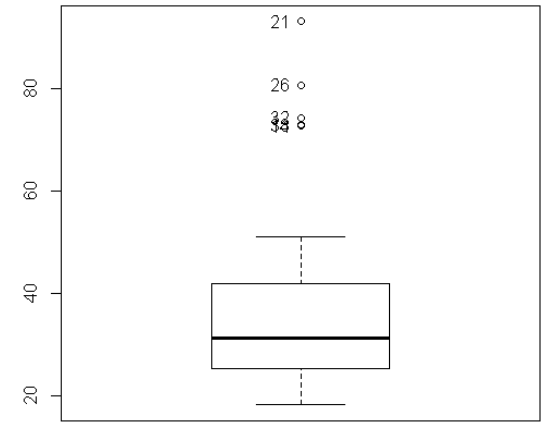
Stazione di Castelluccio dei Sauri (1970-2012)



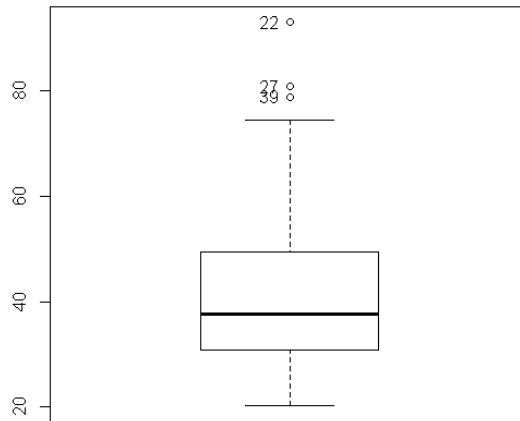
1 h



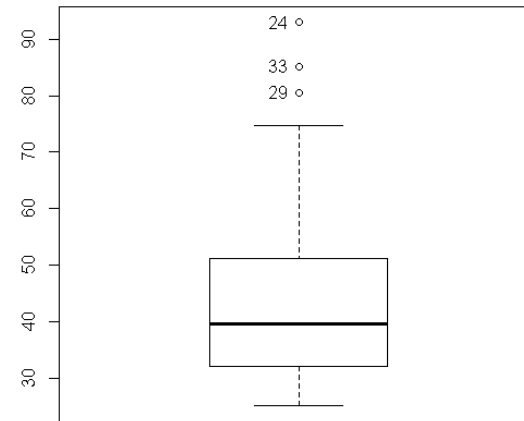
3 h



6 h

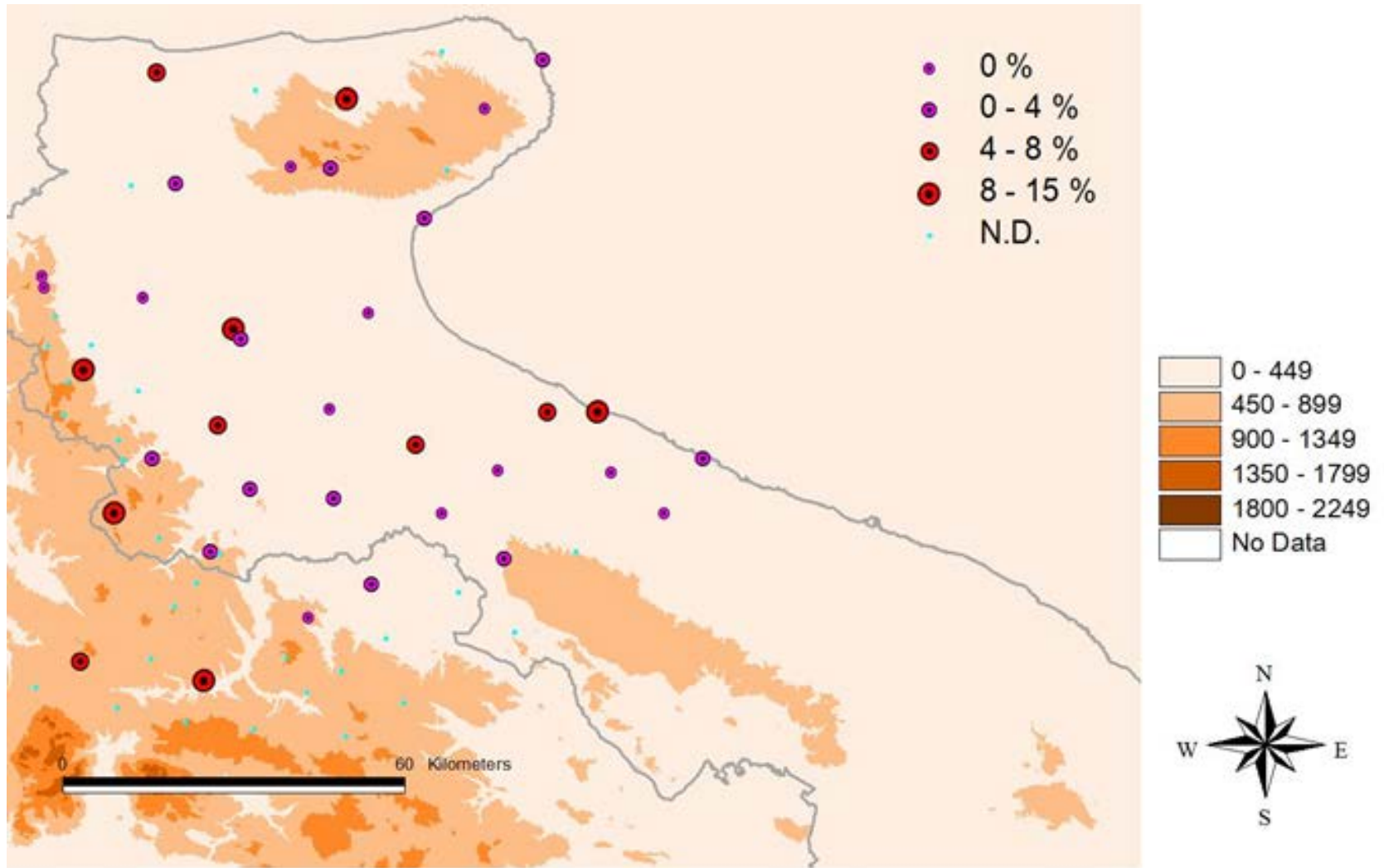


12 h




giornaliero

Analisi degli outliers



Hydrol. Earth Syst. Sci., 18, 649–671, 2014
www.hydrol-earth-syst-sci.net/18/649/2014/
doi:10.5194/hess-18-649-2014
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Hydrology and
Earth System
Sciences Open Access 

Advancing catchment hydrology to deal with predictions under change

U. Ehret , H. V. Gupta , M. Sivapalan , S. V. Weijs , S. J. Schymanski , G. Blöschl , A. N. Gelfan , C. Harman ,
A. Kleidon , T. A. Bogaard , D. Wang , T. Wagener , U. Scherer , E. Zehe , M. F. P. Bierkens ,
G. Di Baldassarre , J. Parajka , L. P. H. van Beek , A. van Griensven , M. C. Westhoff , and H. C. Winsemius

*International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM)
Mediterranean Agronomic Institute of Bari (IAMB)*

Master of Science Program

Final Presentation



Research
topic

Continuous land use/land cover changes impacts on stream flow discharge modelisation and driving factors investigation



MSc. Student:

• *Si Mokrane SIAD (Algeria)*

Supervisors:

• *Prof. Pandi ZDRULI (IAM of Bari)*

Study Area

Choice criteria

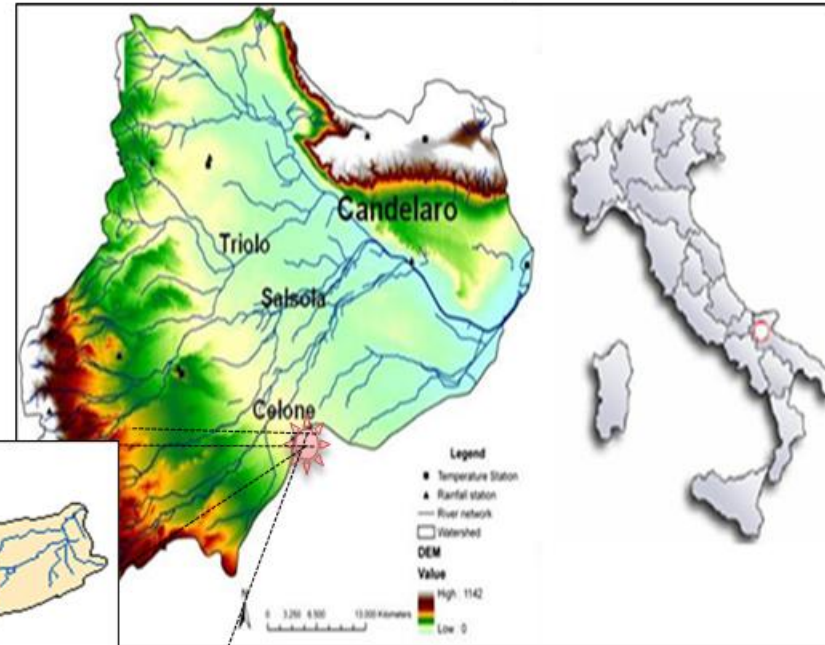
Data availability: complete weather database | Small size: minimize the spatial heterogeneity | Significant of LULCC

Distinctive feature:

- *Intensive agricultural activity*

Land allocation:

- Durum wheat (75% of the total basin area)
- Broad-leaved forest (5%),
- Annual crops (4%),
- Natural vegetation (3%)
- Olive groves (2.7%)
- The residential area (<5%)



Data collection and processing

Raw	Satellite	Processed
Weather (Daily rainfall, Monthly Min/Max temperatures, Monthly wind) Protezione Civile di Apuglia	LANDSAT images (Land use)	$K_c = f(\text{NDVI})$
Soil hydraulic properties (porosity, FC, WP, saturation, depth, permeability) ACIA database	MODIS HDF's 594 HDF's (LAI, NDVI)	LAI spatial processing

Data processing

- **LAI:** Images at **8 days** times and **90 m** spatial resolutions (increase the resolution from **1 Km to 90 m** using a bi-square interpolation in ArcGIS)
- **K_c :** Matrix generated from the NDVI images ($K_c = 2.219 * \text{NDVI} - 0.38$, $R^2 = 0.94$) (Milella, Bisantino et al. 2012)
- **ET:** Monthly maximum and minimum temperatures using **FAO Penman Monteith**
- **Land Use:** processed **LANDSAT** images from a previous study , conducted by (Novelli et al., 2014),

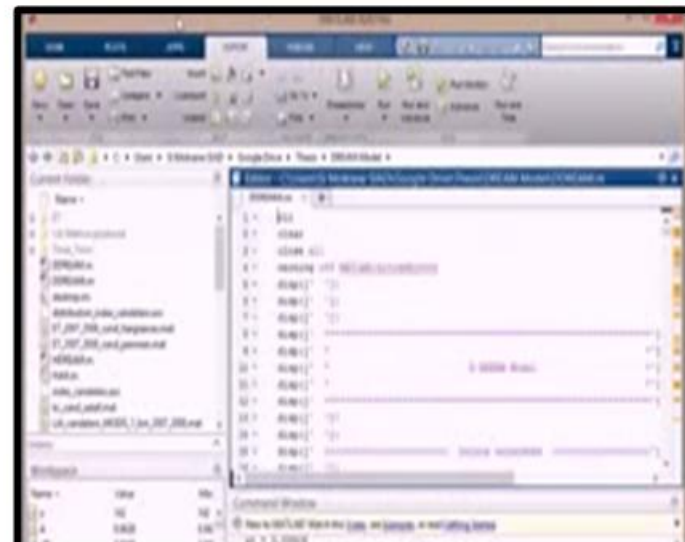
Study period

According to the data collected, the period **2000-2012** of study is determined to have a complete set of data in order to run the DREAM model

DREAM model

DREAM: Distributed Runoff, Evaporation and Antecedent soil Moisture

- Distributed model
- Daily-DREAM (D-DREAM) : daily runoff and soil dynamics
- Hourly-DREAM.(H-DREAM): reproducing the flood event at an hourly step
- Vegetation coverage, soil texture, local slope, etc., are required for each cell
- The hydrological processes are computed on a grid-base



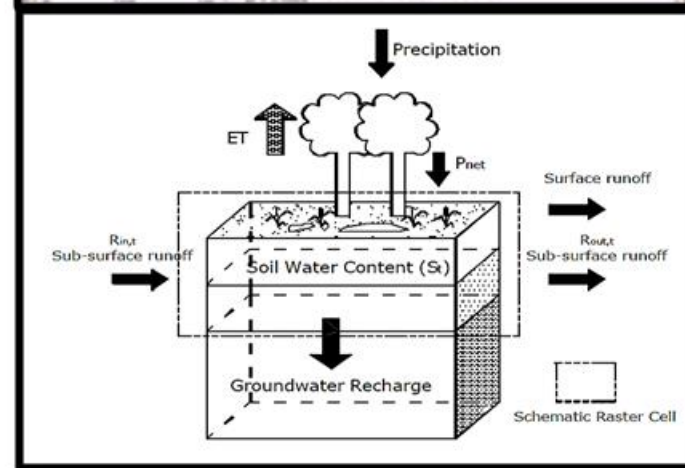
Base tool for LULCC impacts assessment

DREAM data needs:

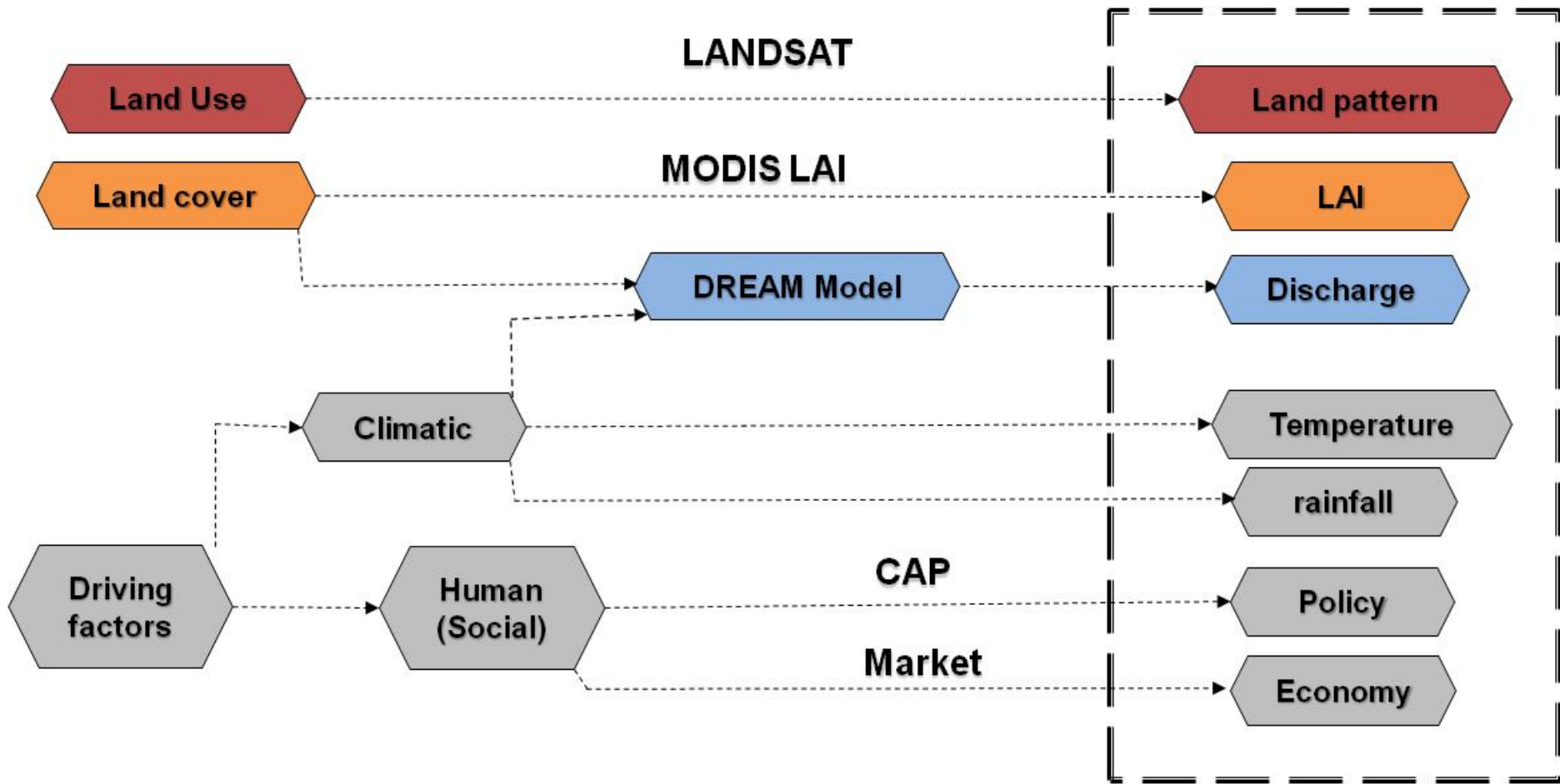
- Daily rainfall and discharge
- Monthly wind, Min/Max Temperatures
- Leaf Area Index
- Crop coefficient (K_c)
- Soil matrix and hydraulic properties

Data organisation:

- Vectors
- Matrices

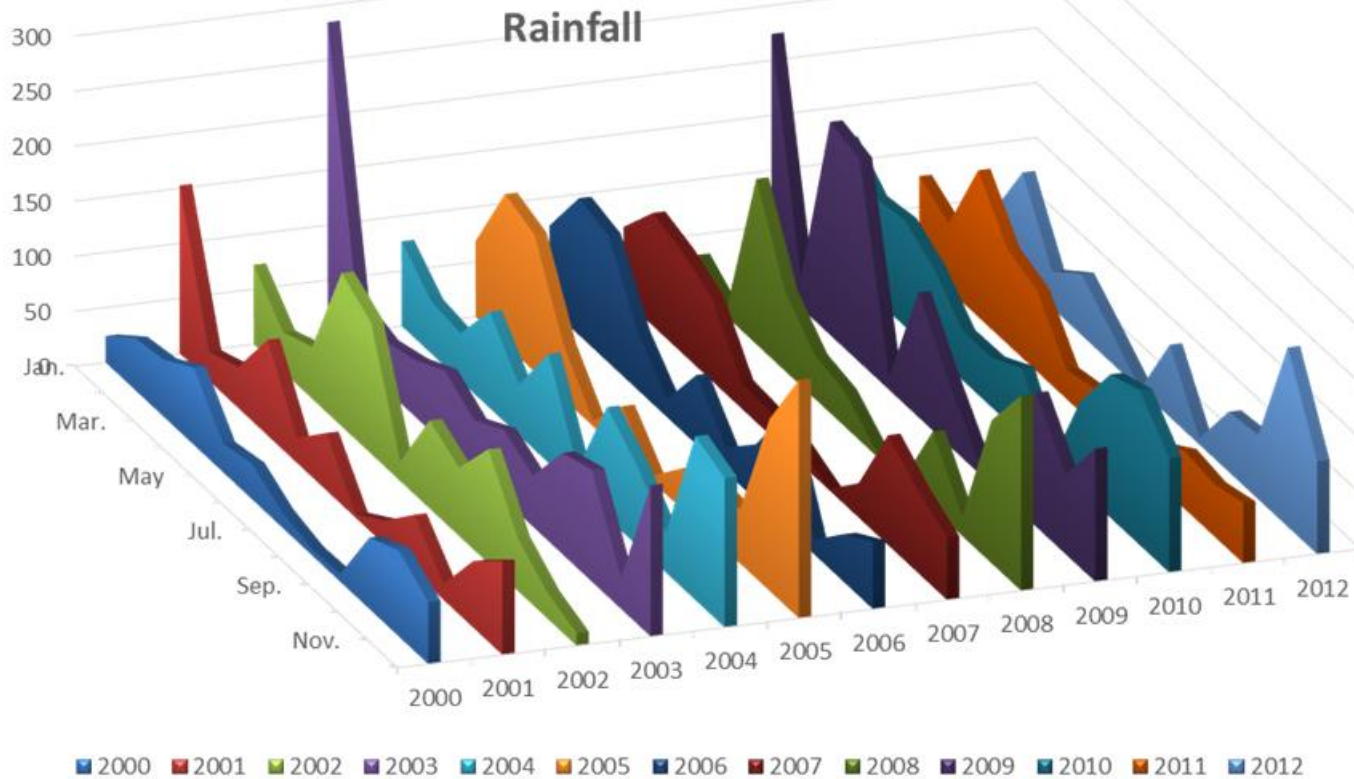


Procedure



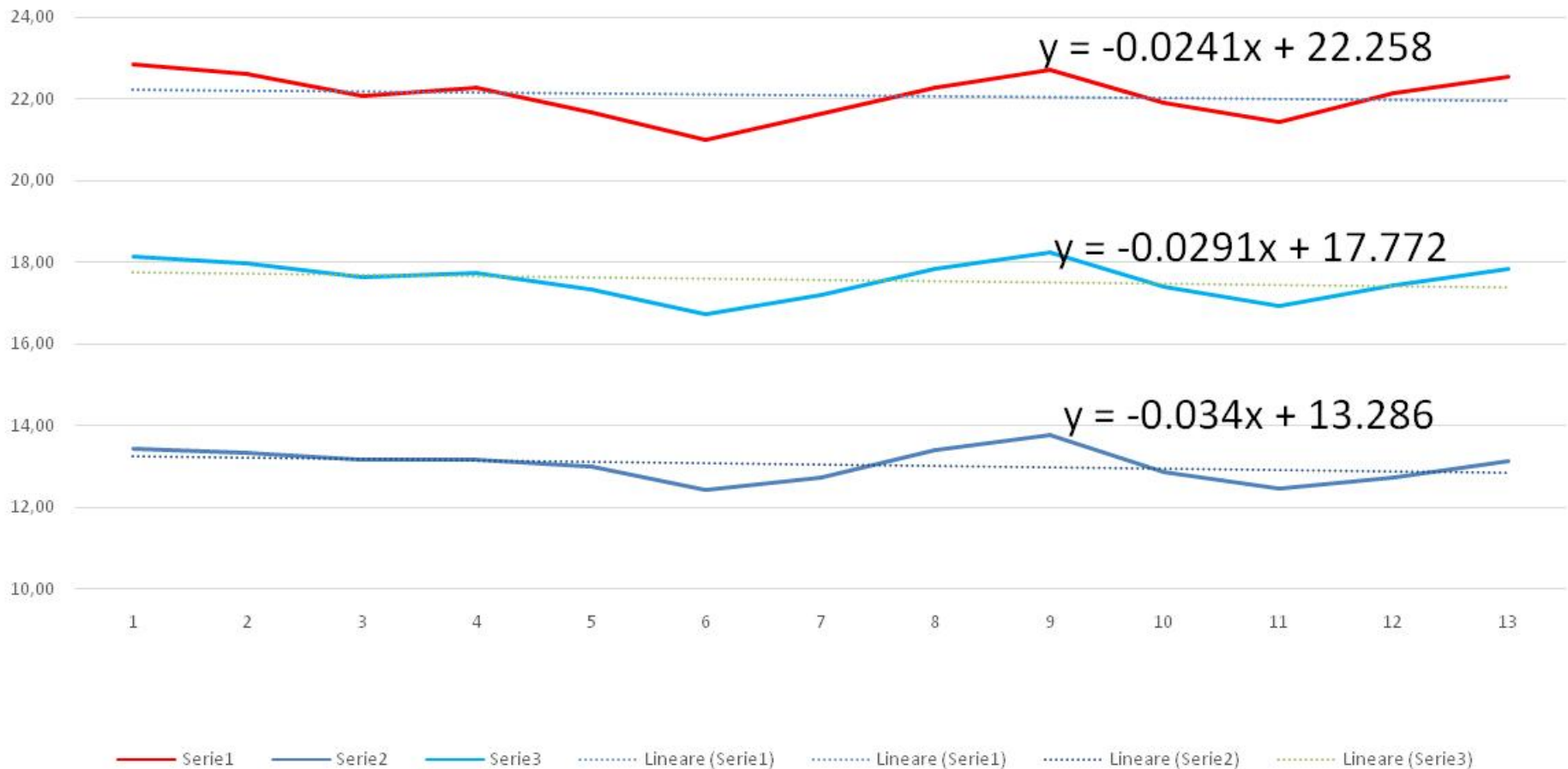
Climatic factors (rainfall and temperature)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ann,
Mean	101	66	90	84	40	46	35	27	62	62	90	100	801
STD	77	41	51	39	31	31	27	31	29	40	51	56	197



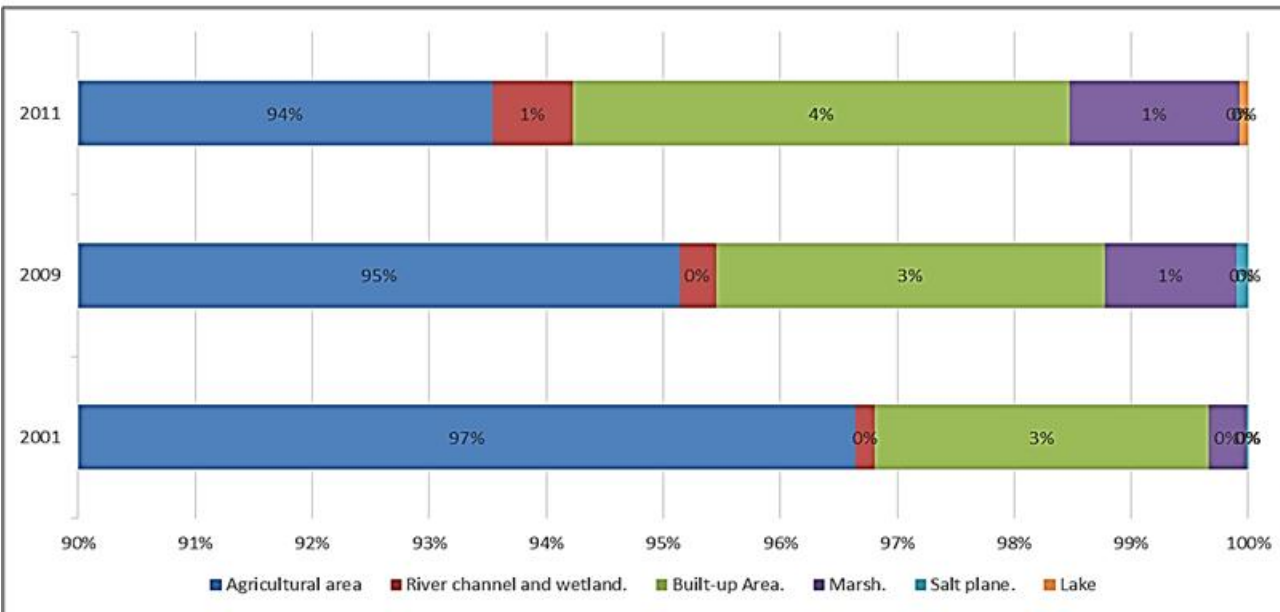
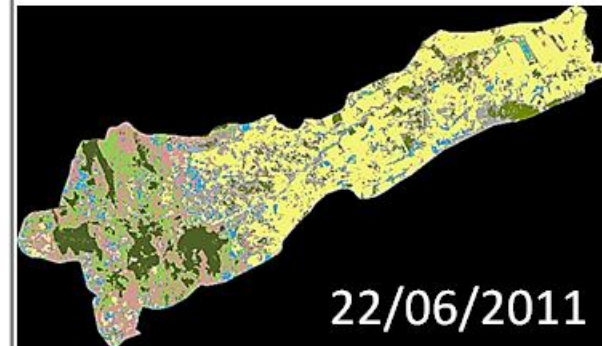
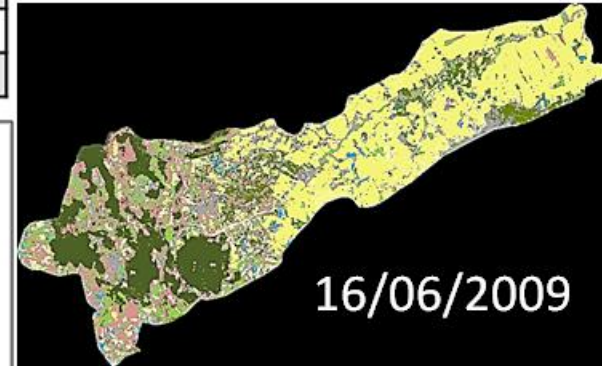
Climatic factors (rainfall and temperature)

Temperature



Land Use changes

Year	2001		2009		2011	
	Area (Km ²)	%	Area (Km ²)	%	Area (Km ²)	%
Agricultural and forests area	98.345	97	96.812	95	95.182	94
River channel and wetland	0.164	00	0.316	00	0.703	01
Built-up Area	2.907	03	3.38	03	4.322	04
Marsh	0.321	00	1.148	01	1.473	01
Salt plane	0.021	00	0.102	00	0.002	00
Lake	0.000	00	0.000	00	0.076	00

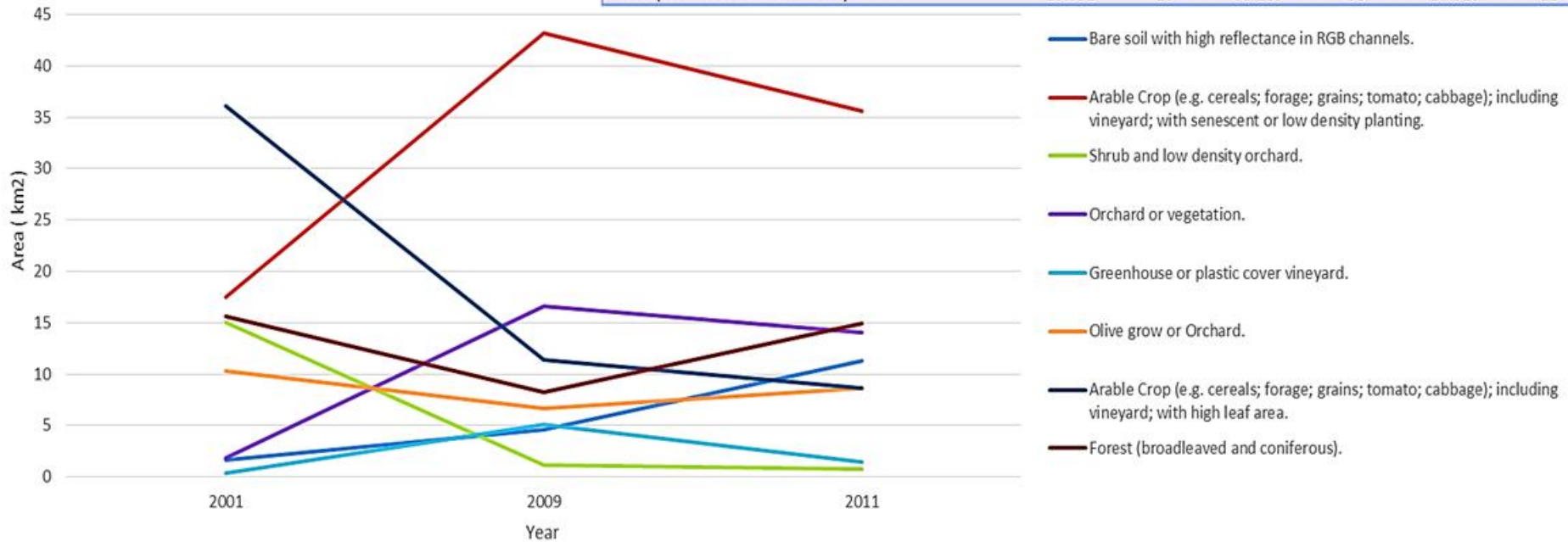


Land Use changes

Year	2001		2009		2011	
	Area (Km ²)	%	Area (Km ²)	%	Area (Km ²)	%
Bare soil with high reflectance in RGB channels	1.616	02	04.579	05	11.295	12
Arable Crop (e.g. cereals; forage; grains; tomato; cabbage); including vineyard; with senescent or low density planting	17.499	18	43.218	45	35.565	37
Shrub and low density orchard	15.061	15	01.13	01	00.732	01
Orchard or vegetation	01.801	02	16.568	17	14.01	15
Greenhouse or plastic cover vineyard	00.360	00	05.072	05	01.433	02
Olive grow or Orchard	10.28	10	06.69	07	08.646	09
Arable Crop (e.g. cereals; forage; grains; tomato; cabbage); including vineyard; with high leaf area	36.136	37	11.366	12	08.588	09
Forest (broadleaved and coniferous)	15.592	16	08.189	08	14.913	16

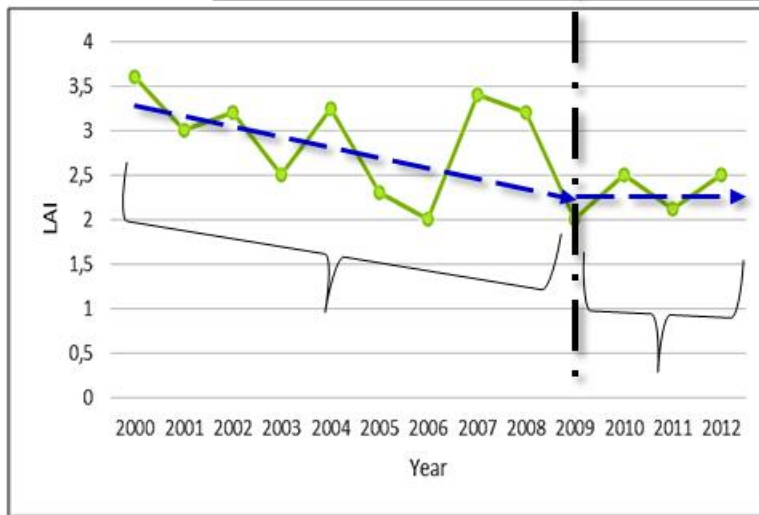
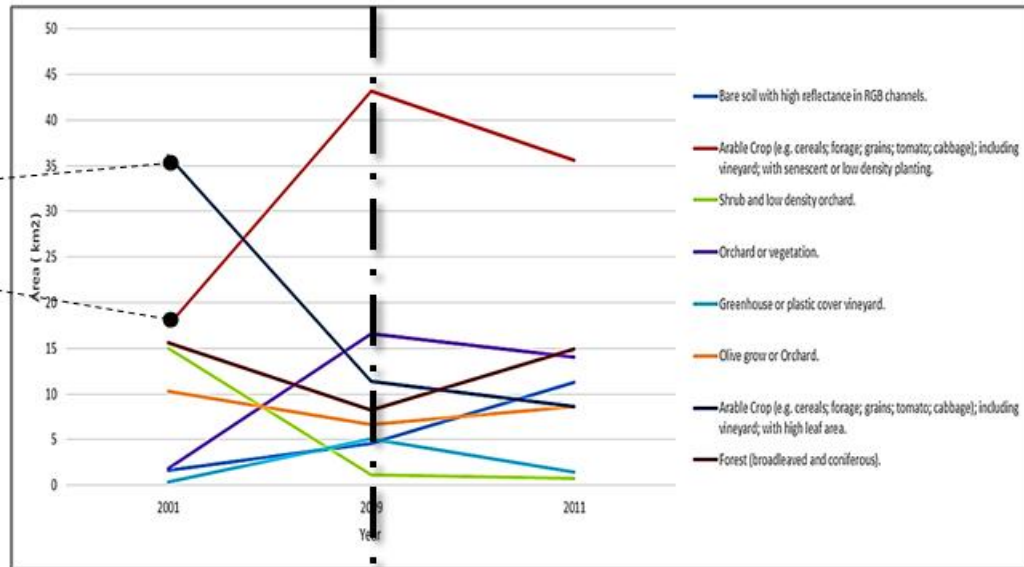


“Agricultural and forest area” sub-classes



Land Use Vs. Land Cover (LAI)

Shift between culture with:
high leaf area index
low leaf area index



Two trend with a **gradually decrease** in the LAI

Application

Model assessment

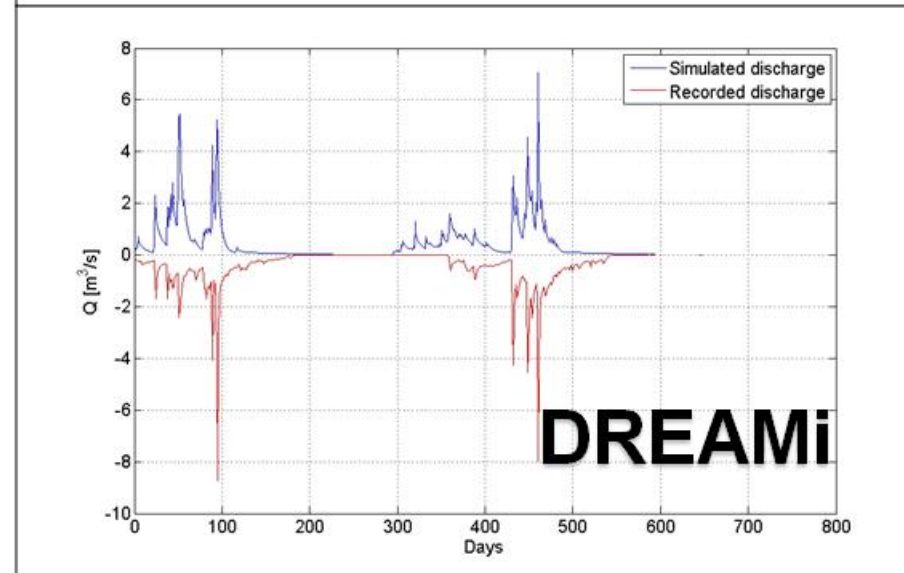
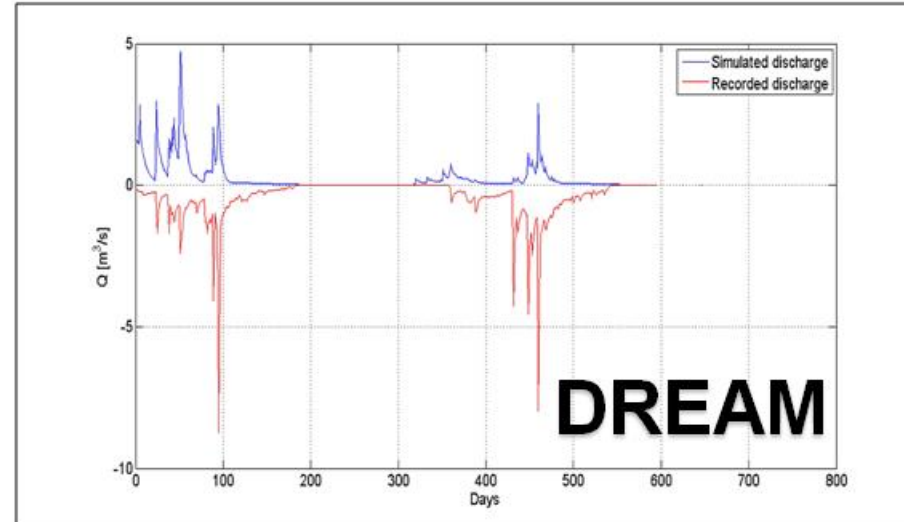
Improvements

DREAM	Before improvement	After improvement
Leap years consideration	Not for evapotranspiration	Yes
LAI temporal resolution	monthly	Any
LAI resolution control	No	Yes
Control over LAI series	No	Yes
Accounting for Leap years	No for ET	Yes
Code organization	By section modeled	Start by the parameters
Execution time	Slower	Faster

DREAMi VS. DREAM

Period of application: 2007-2008

Same input data, except LAI:
8 days (DREAMi) VS. Monthly (DREAM)

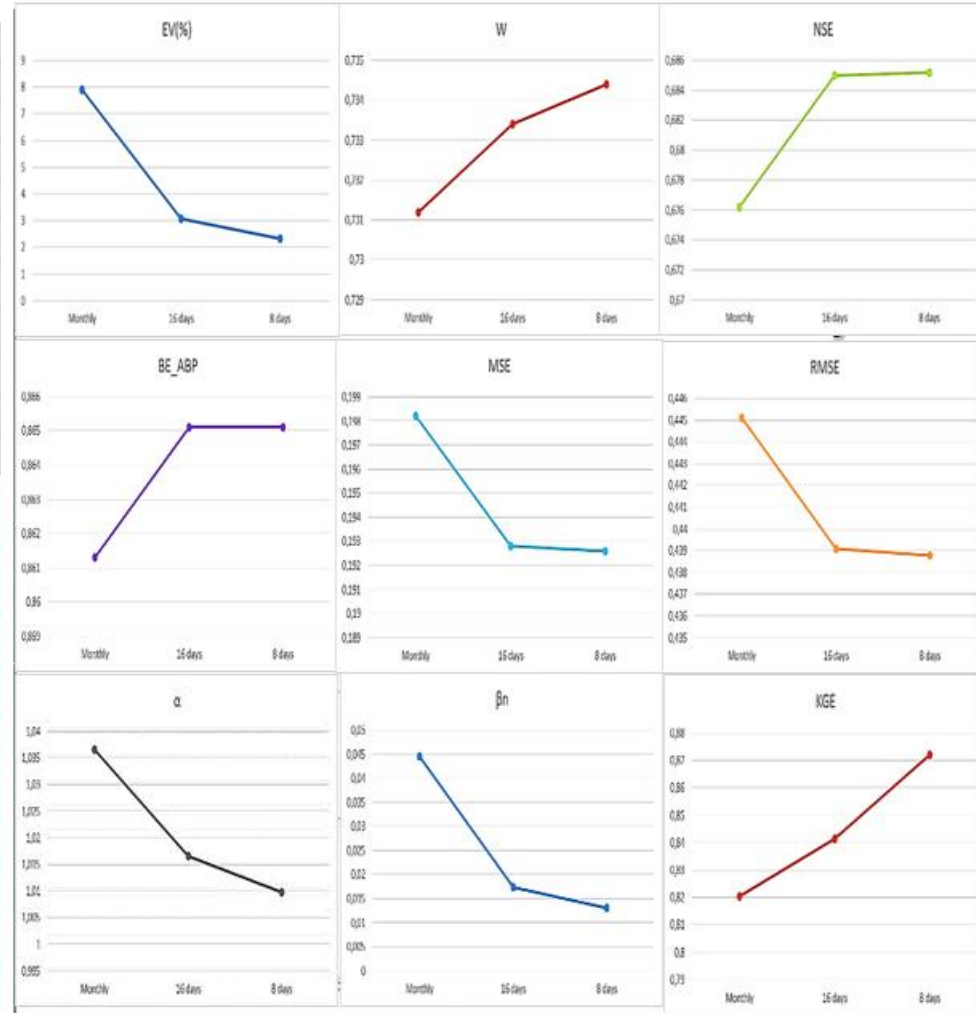


Model LAI sensitivity analysis

Application

Efficiency criteria	Description
NSE	Nash Sutcliffe efficiency
MSE	Mean square error
RMSE	Root mean square error
W	Index of agreement
BE _{APB}	Normalized benchmark efficiency using the adjusted precipitation benchmark model
r	Linear correlation coefficient between simulations and observations
a	Measure of relative variability in the simulated and observed values
β_n	Bias normalized by the standard deviation in the observed values
EV _%	Volumetric error
KGE	Kling-Gupta efficiency

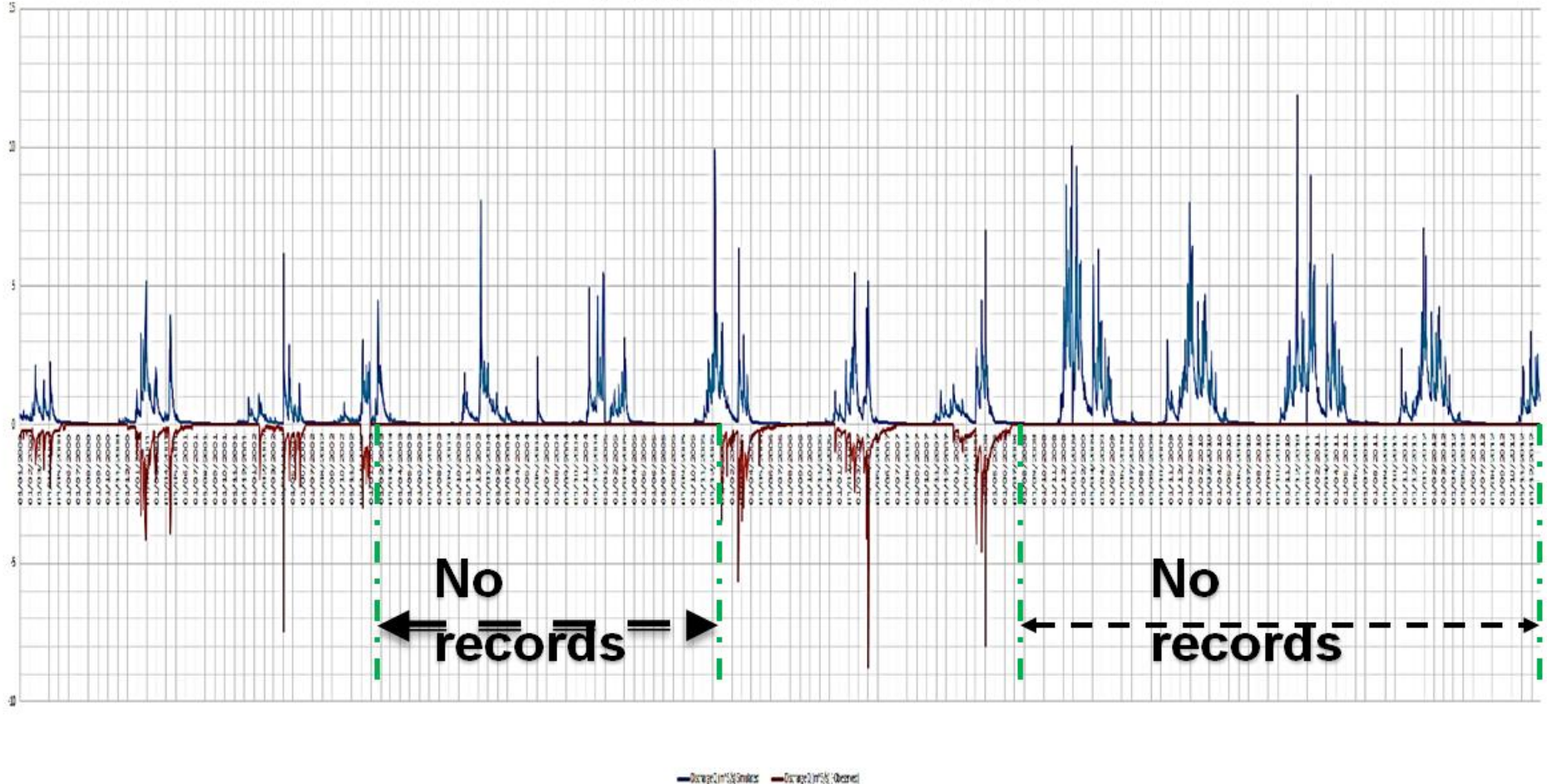
PARAMETER	MONTHLY	16 DAYS	8 DAYS	OPTIMAL VALUE
EV _%	7.9227	3.0802	2.3186	0
W	0.7312	0.7334	0.7344	1
NSE	0.6762	0.6850	0.6852	1
BE _{APB}	0.8613	0.8651	0.8651	1
MSE	0.1982	0.1928	0.1926	0
RMSE	0.4451	0.4391	0.4388	0
a	1.0366	1.0166	1.0098	1
β_n	0.0446	0.0173	0.0130	0
KGE	0.8205	0.8415	0.8722	1



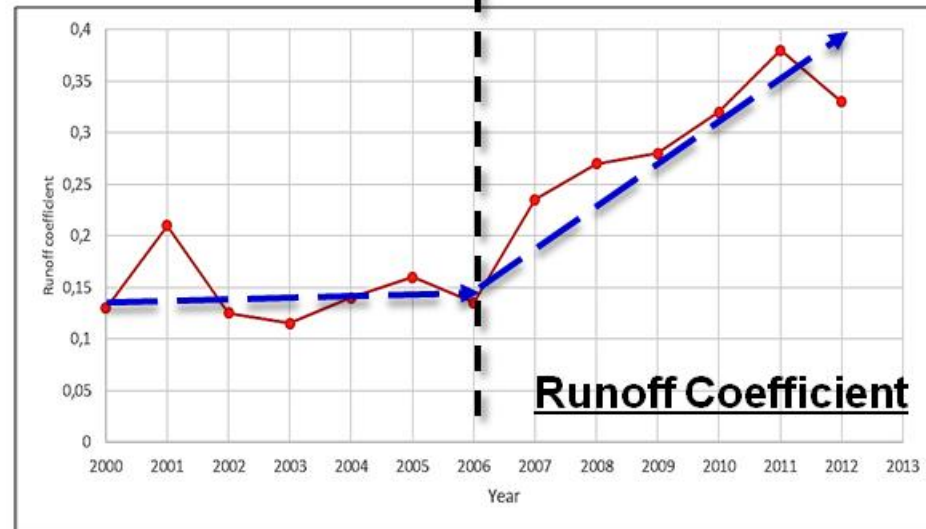
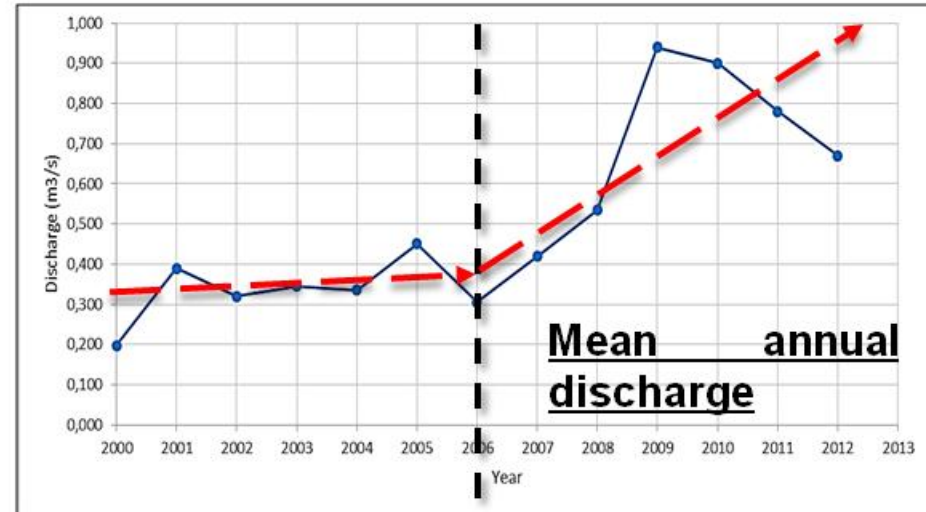
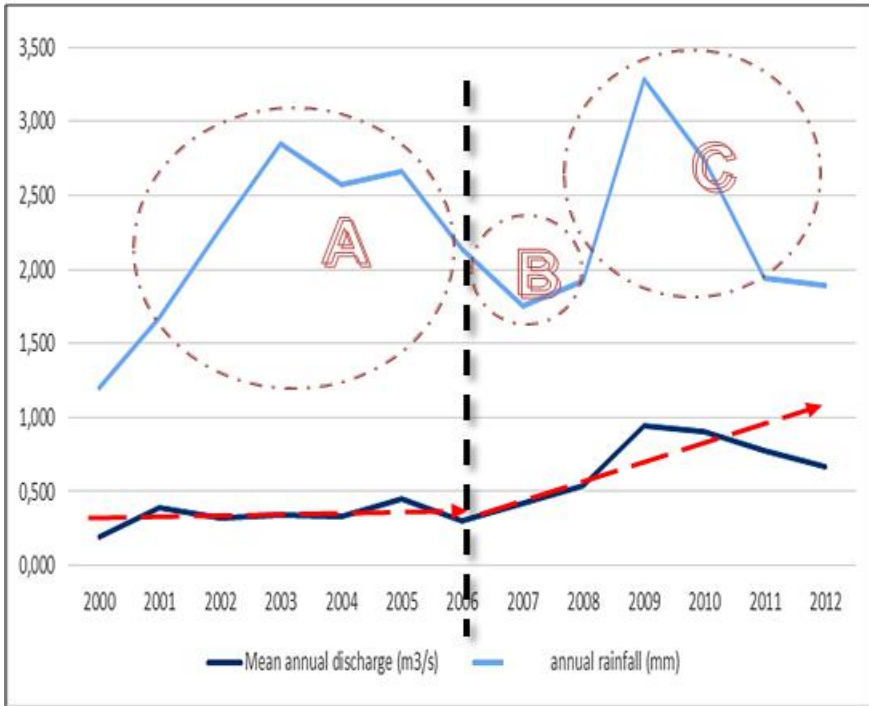
Continuous simulation

Continuous discharge simulated vs. recorded

Period 2000-2012



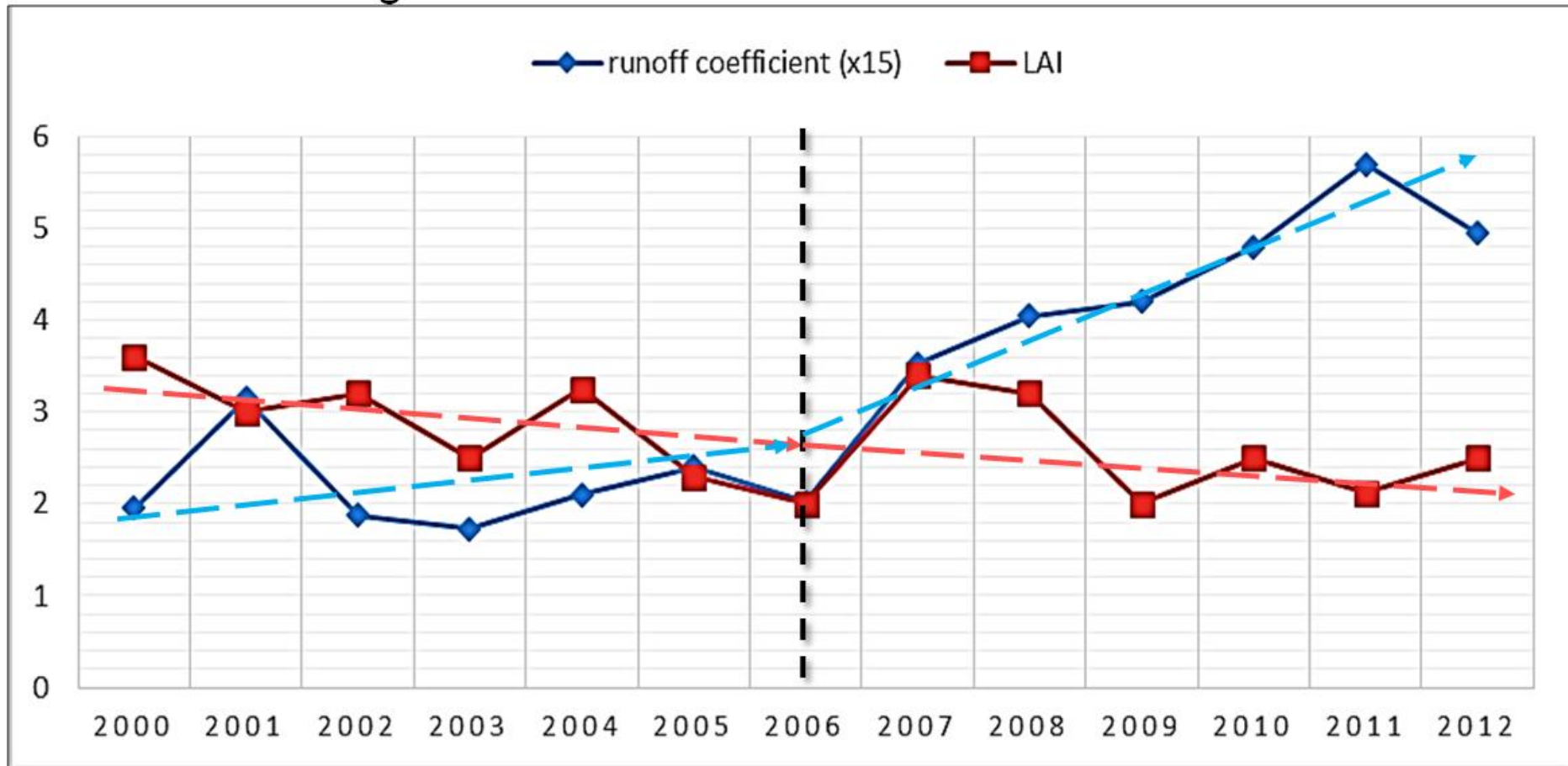
Hydrometric analysis



Increase of the watershed to rainfall in generating runoff

Runoff coefficient Vs. Leaf Area Index

Area densely covered with vegetation, yields less runoff than bare ground



Conclusioni

La valutazione degli impatti climatici sulla previsione di piena di medio-lungo periodo richiede:

- Una rigorosa valutazione dei trend osservati;
- Una efficace analisi regionale sulla presenza di outliers
- Una modellazione idrologica utile a comprendere gli aspetti essenziali della trasformazione afflussi deflussi e la sua evoluzione nel tempo
- L'adozione di modelli probabilistici idonei alla rappresentazione dei fenomeni non stazionari
- La capacità di sfruttare l'enorme mole di dati rivenienti dalla osservazione della terra
- La necessità di rivitalizzare la misura delle precipitazioni e delle portate di piena.

Grazie per l'attenzione!

