

Metodi di interpolazione spaziale della temperatura

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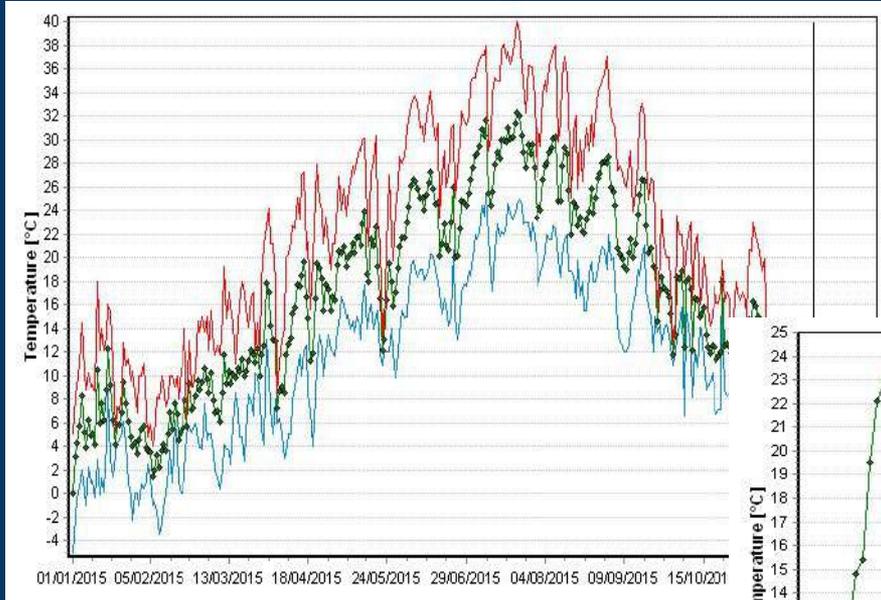


Osservatorio clima
<https://www.arpae.it/clima>

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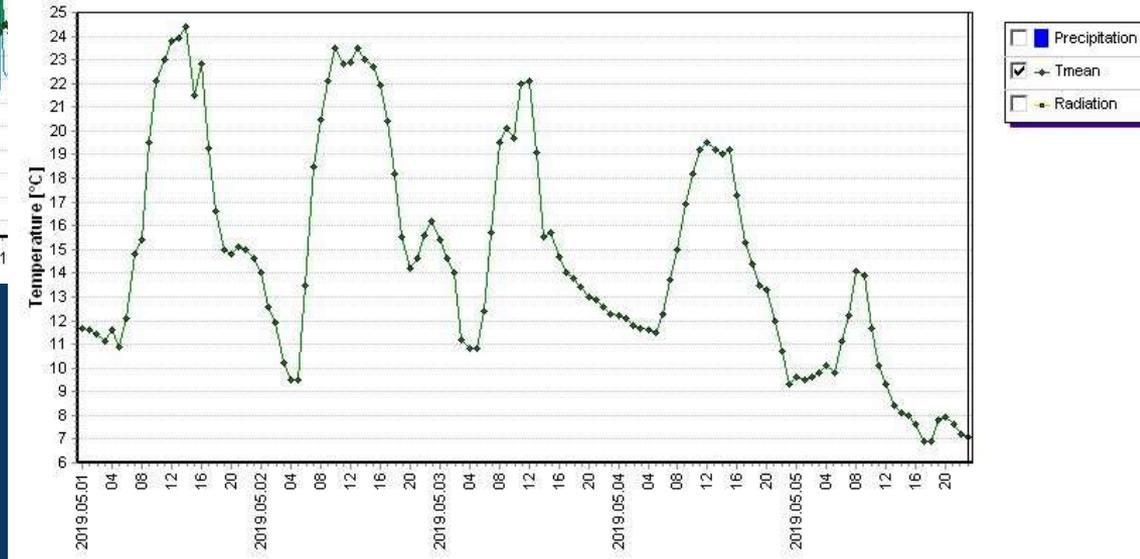
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Variabilità temporale

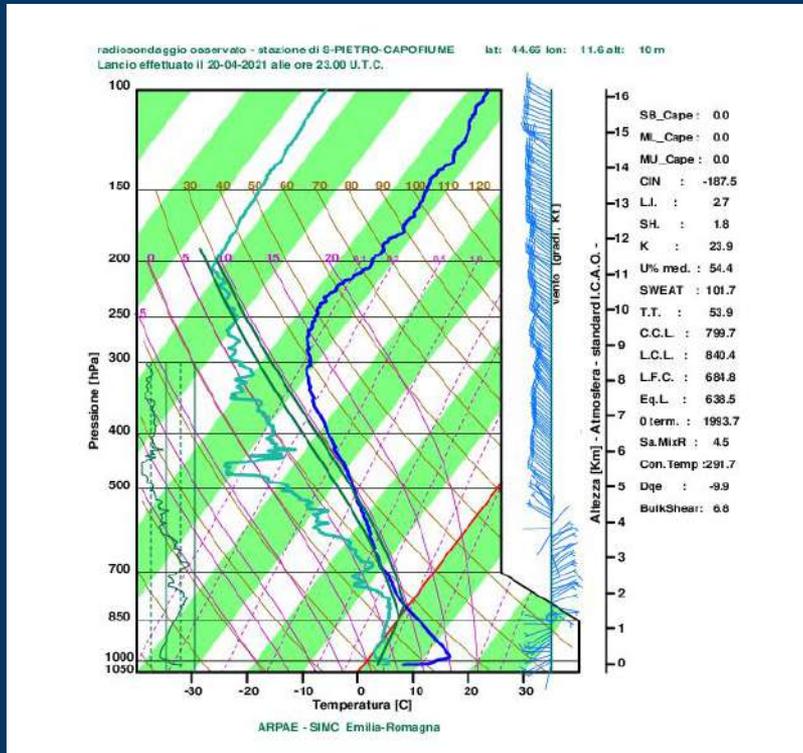


dati Arpae

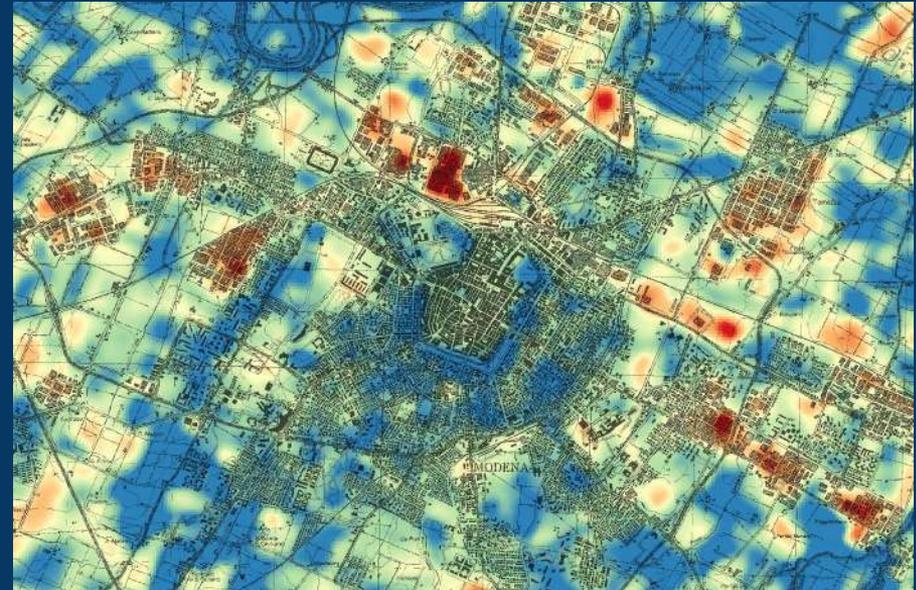
dati Arpae



Variabilità spaziale



dati Arpae (radiosondaggio San Pietro Capofume)



dati Modis

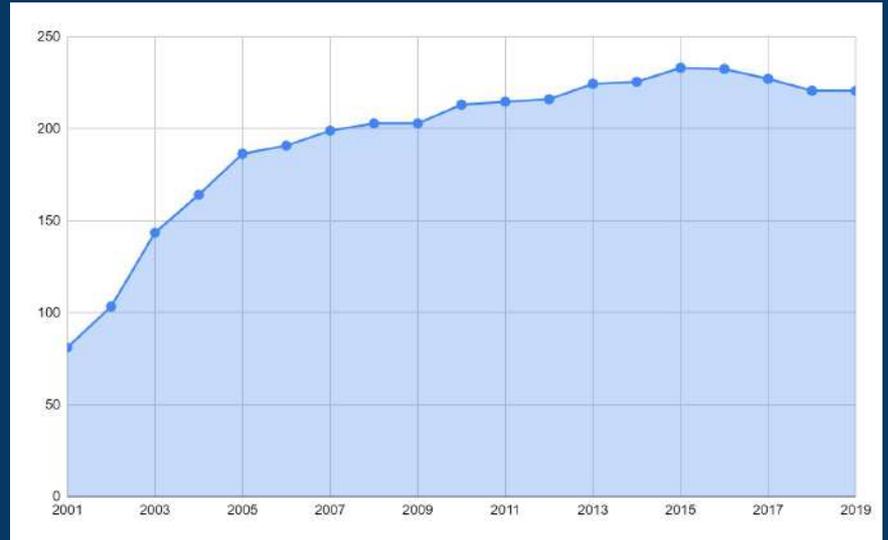
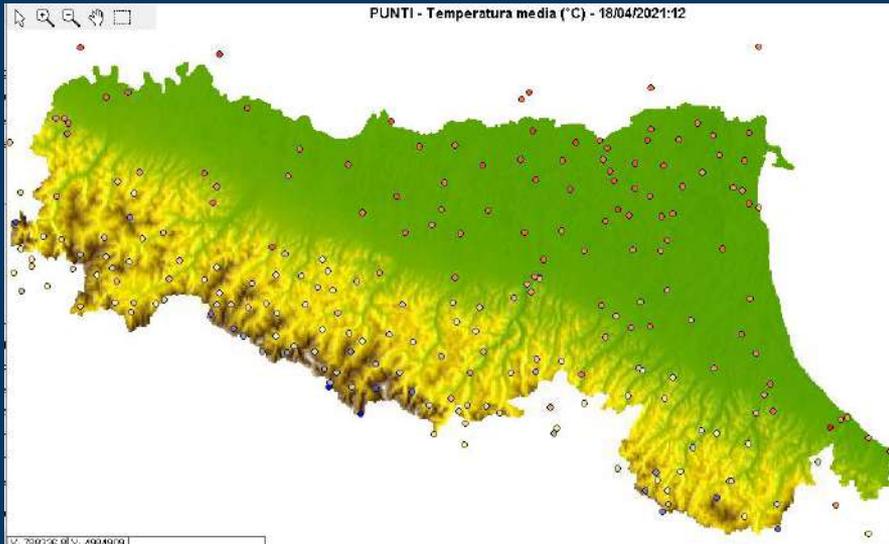
Perché interpolare

1. monitoraggio meteorologico/ambientale
2. monitoraggio climatico
3. modellistica
 - a. dataset completo per input modellistici
 - b. dataset completo per validazioni modellistiche

Perché interpolare: monitoraggio meteo

✓ dettaglio spaziale (massima densità)

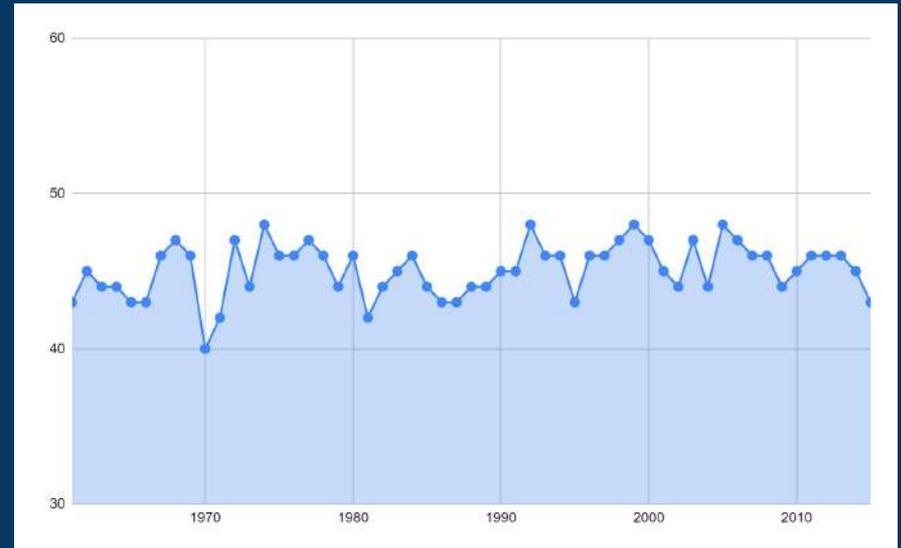
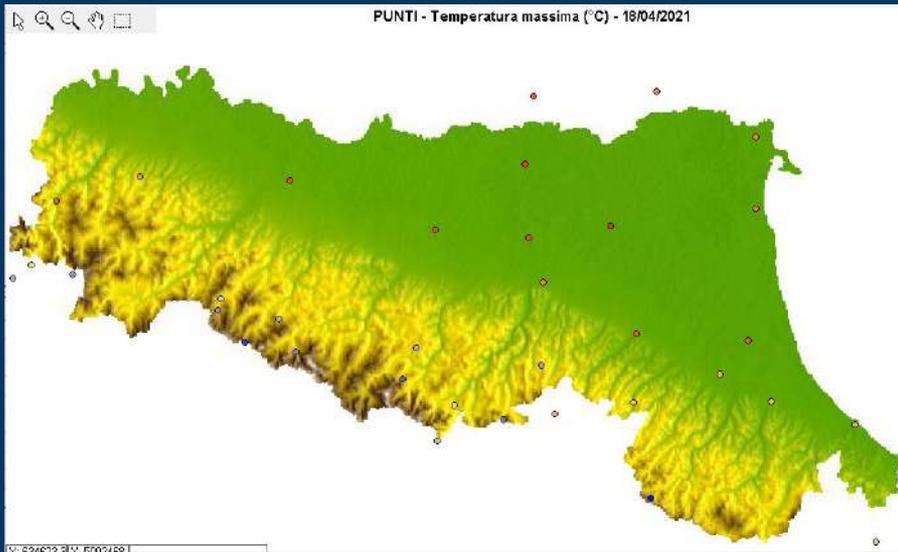
uniformità temporale (densità costante)



Perché interpolare: monitoraggio clima

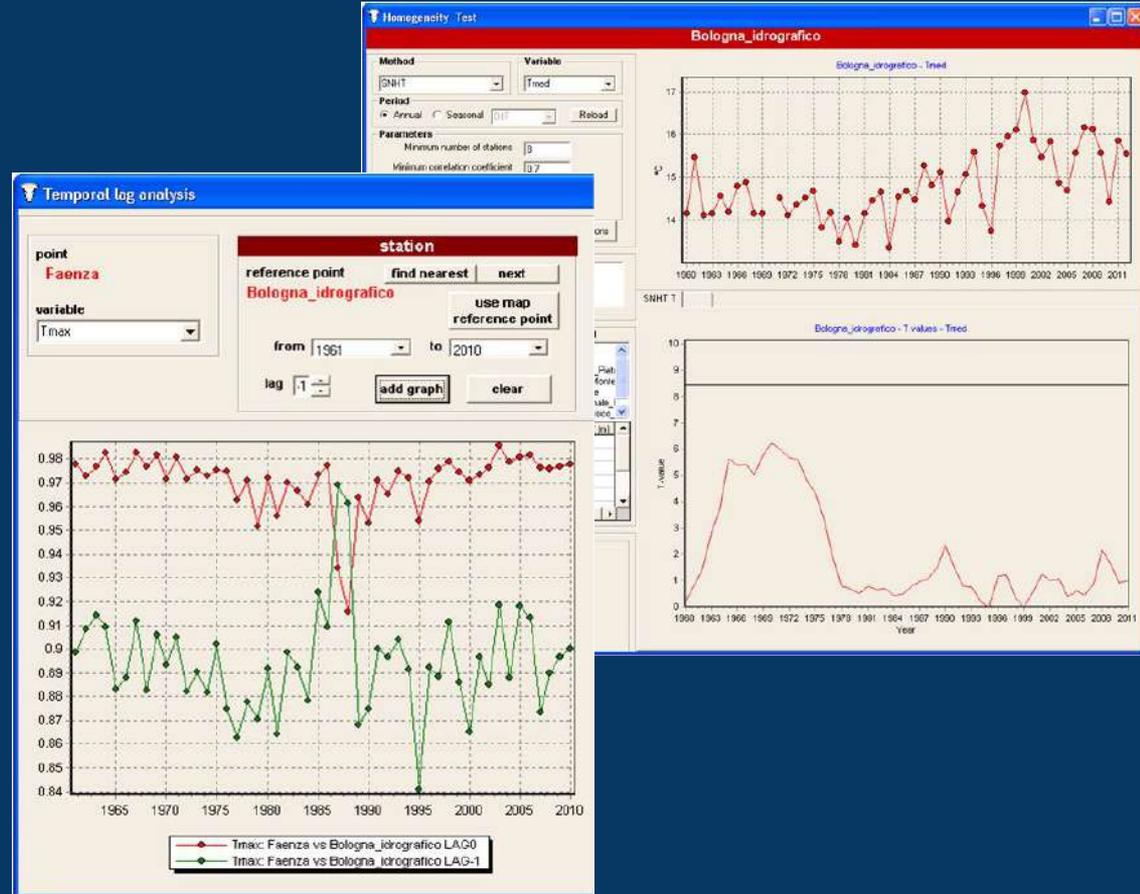
dettaglio spaziale (massima densità)

✓ uniformità temporale (densità costante)



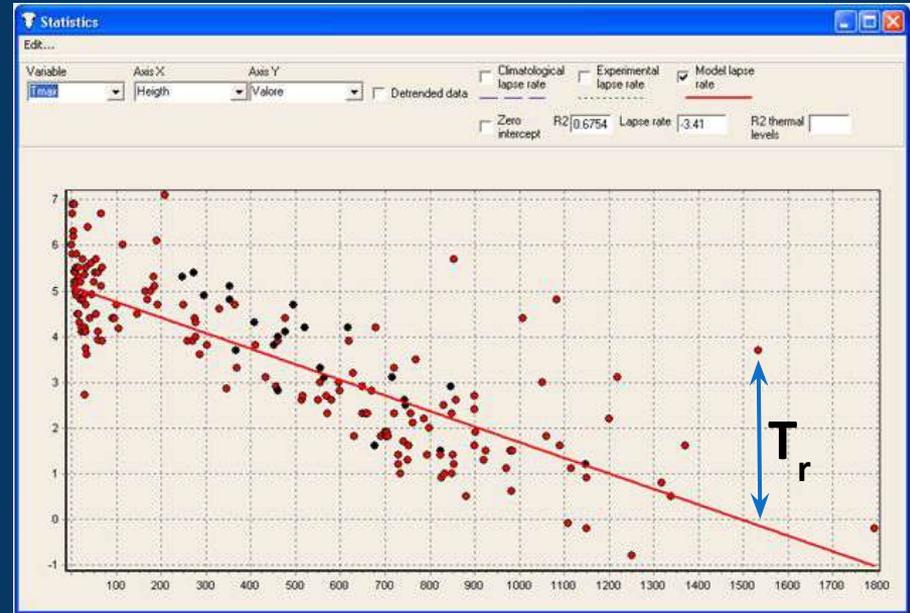
Come interpolare: controlli qualità

- omogeneità temporale
- sincronicità
- controlli “on the fly”
- controllo valori annuali in cross-validation (solo temp)



Detrending: aspetti generali

- interpolazione della variabile fisica (non dell'indicatore)
- utilizzo di variabili geografiche come predittori, in base alla conoscenza fisica e del territorio
- costruzione di un campo di "background" e interpolazione dei residui



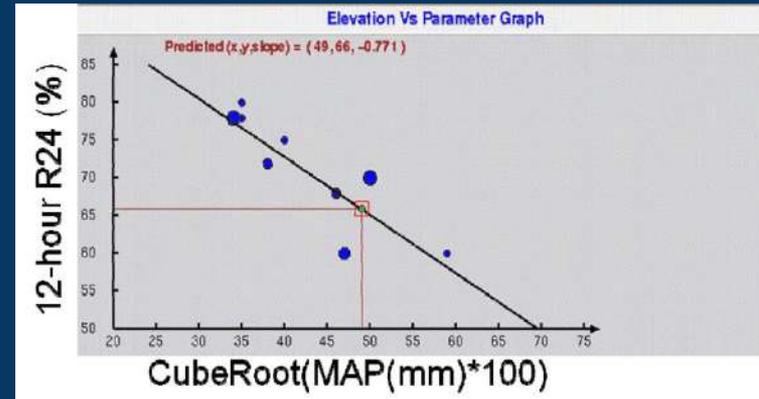
$$T = T^* + T_r$$

T^* : background

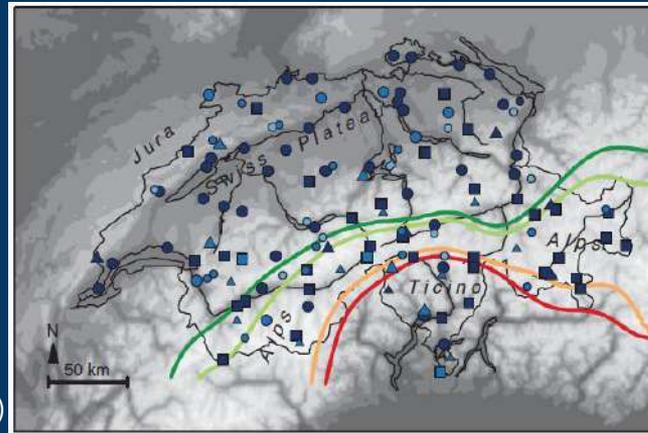
T_r : residuo (anomalia)

Detrending: problematiche

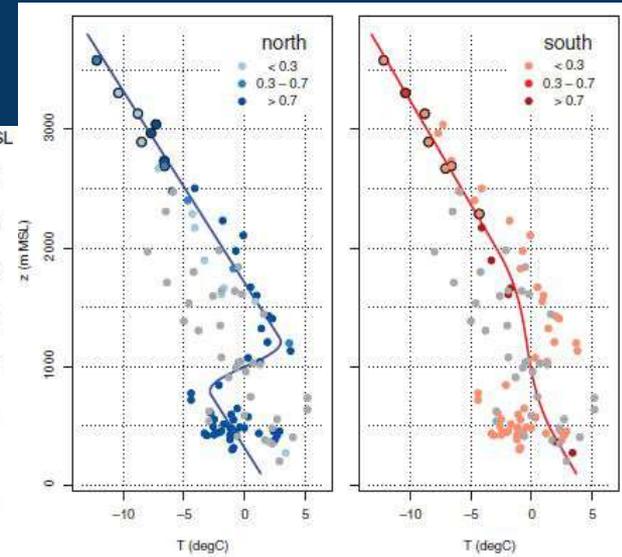
- scala temporale
- scala spaziale
 - analisi della correlazione
 - scala di output
- metodi per il detrending multiplo



Perica et al., 2012



Frei (2014)



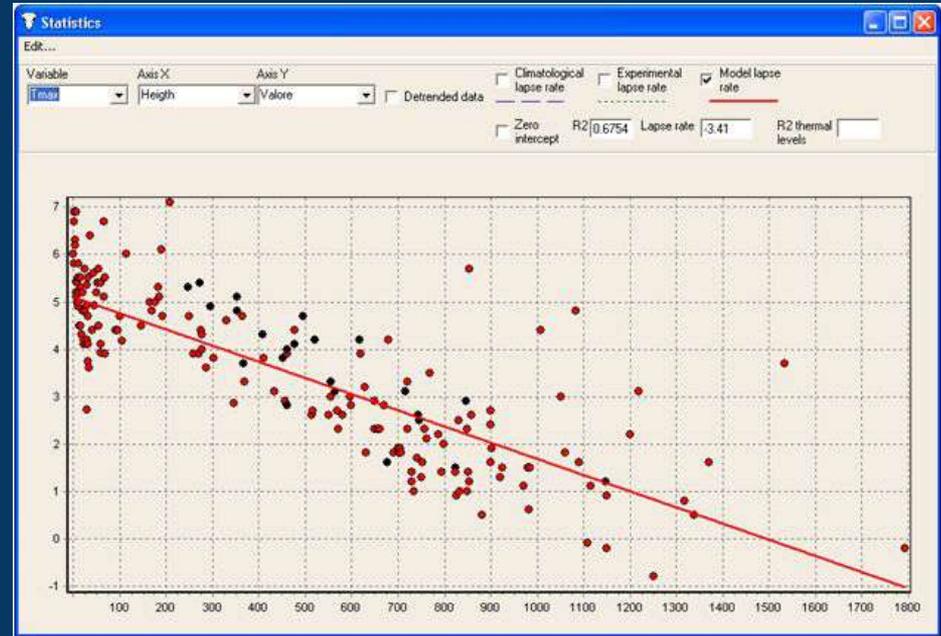
Detrending: cosa abbiamo scelto

Detrending multiplo (successivo) con i seguenti predittori:

- Distanza dal mare
- Quota s.l.m. (double lapse rate, stepwise regression)
- Frazione urbana
- Posizione topografica relativa

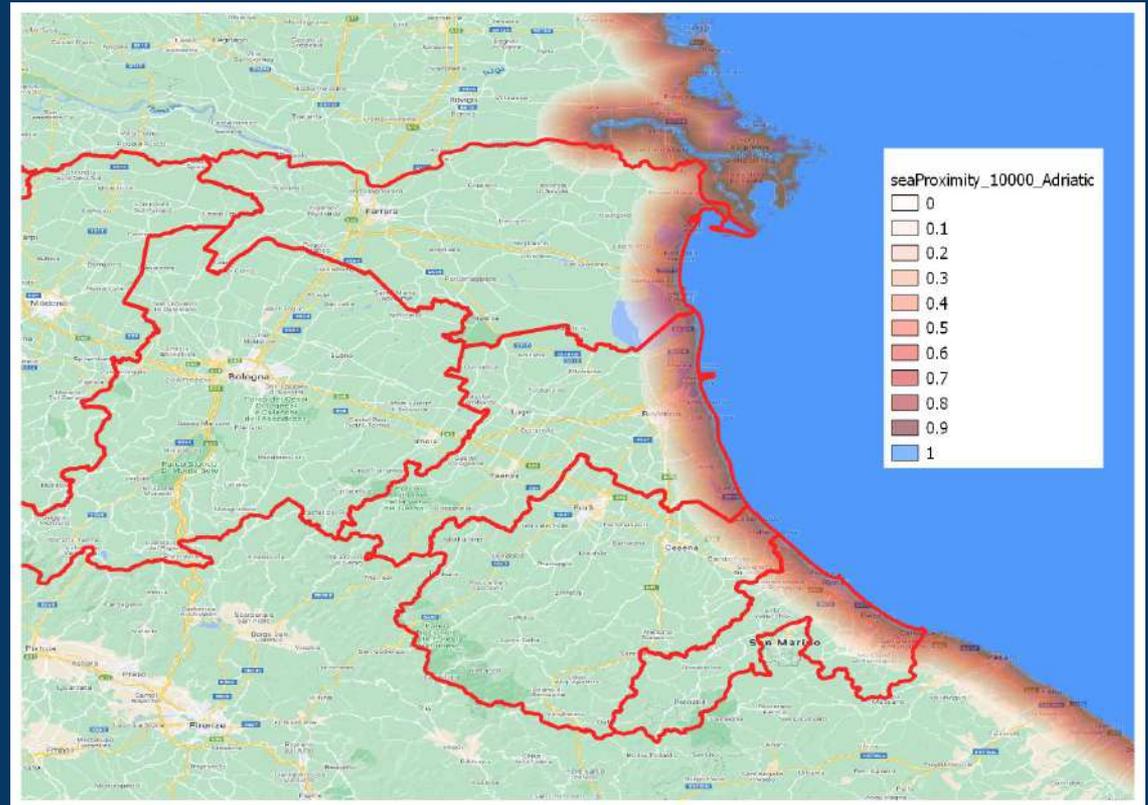
Interpolazione su risoluzione DEM, poi aggregazione a 5 km

Utilizzo anche per temperatura di rugiada



Detrending (distanza dal mare)

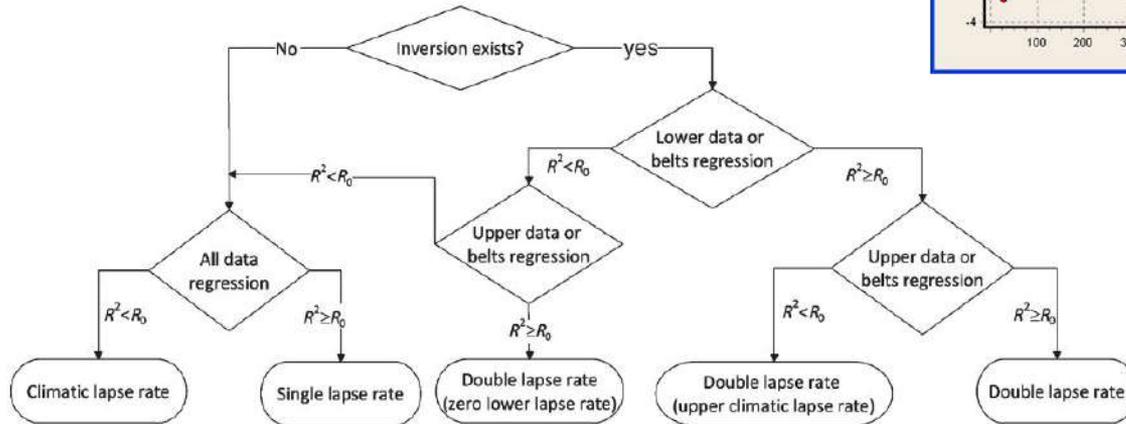
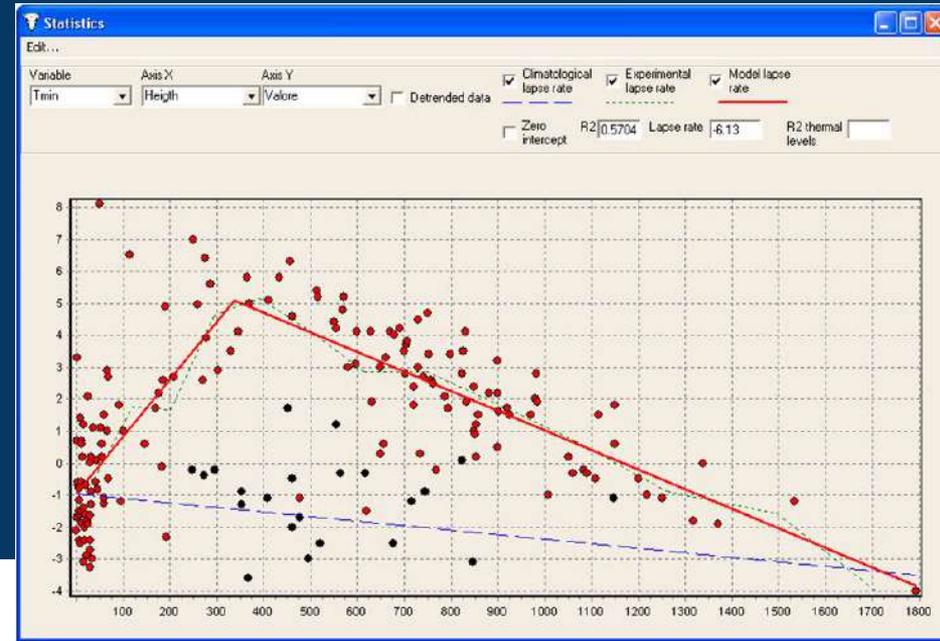
distanza massima effettiva (10 km)



Detrending (quota)

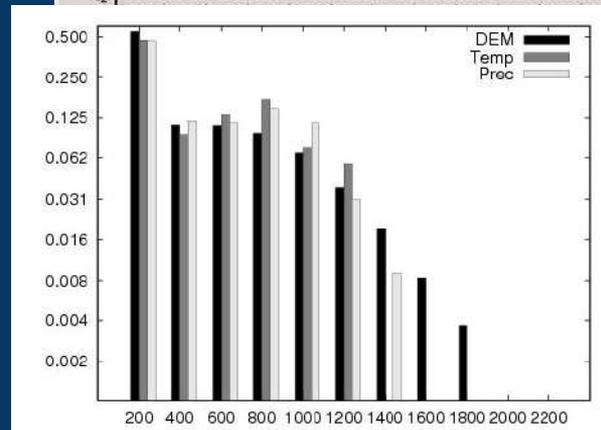
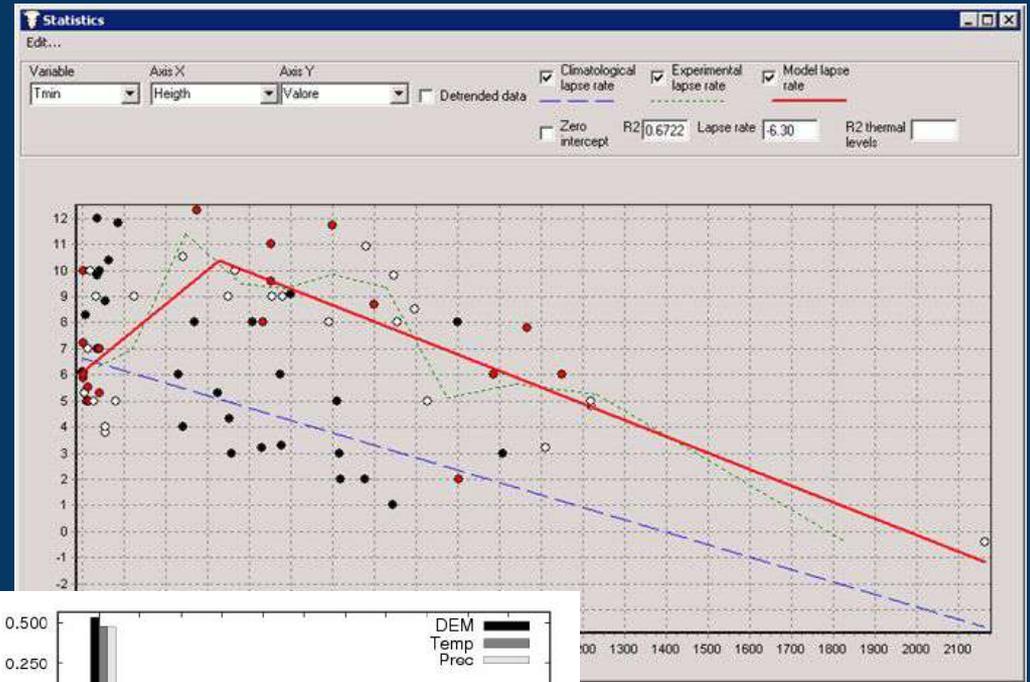
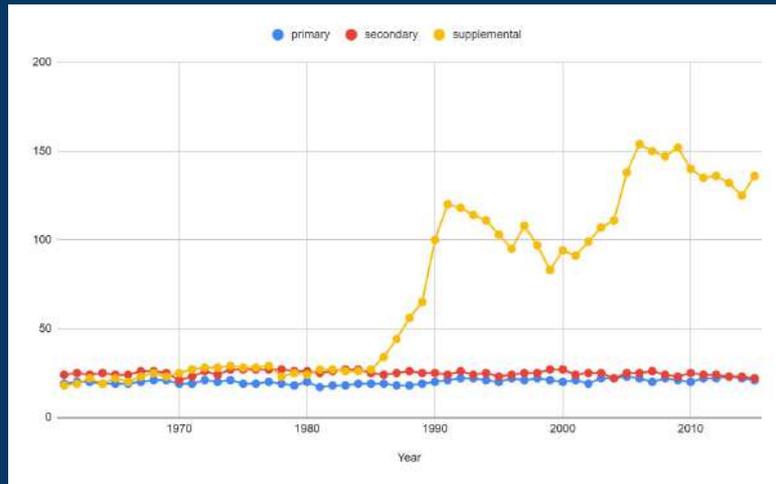
Ruolo stazioni (primarie e secondarie)

Stepwise regression (per punti e fasce)



Detrending (quota)

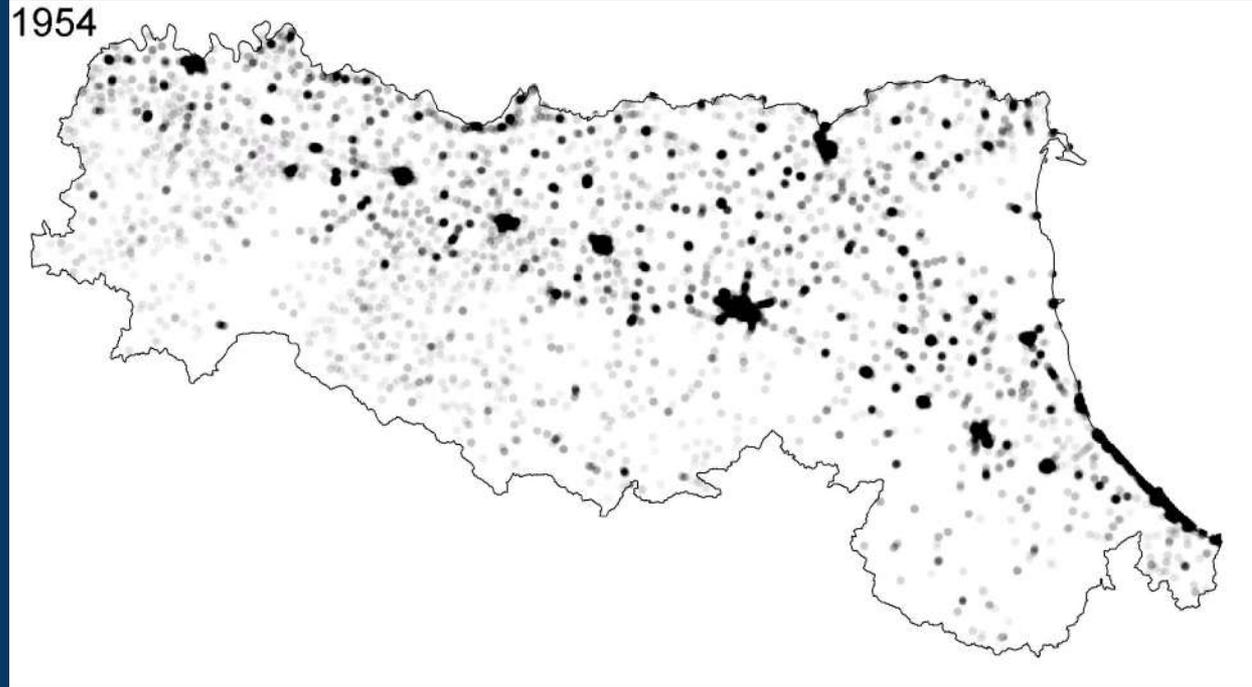
Ruolo stazioni (primarie, secondarie, supplementari) in dataset climatologici



Detrending (frazione urbana)

rappresentazione urbano

densità abitativa

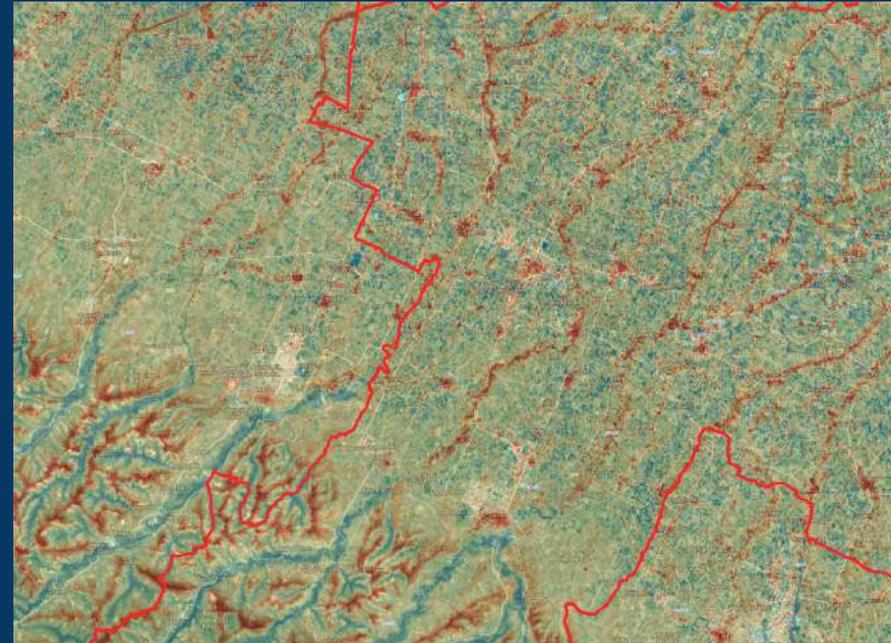
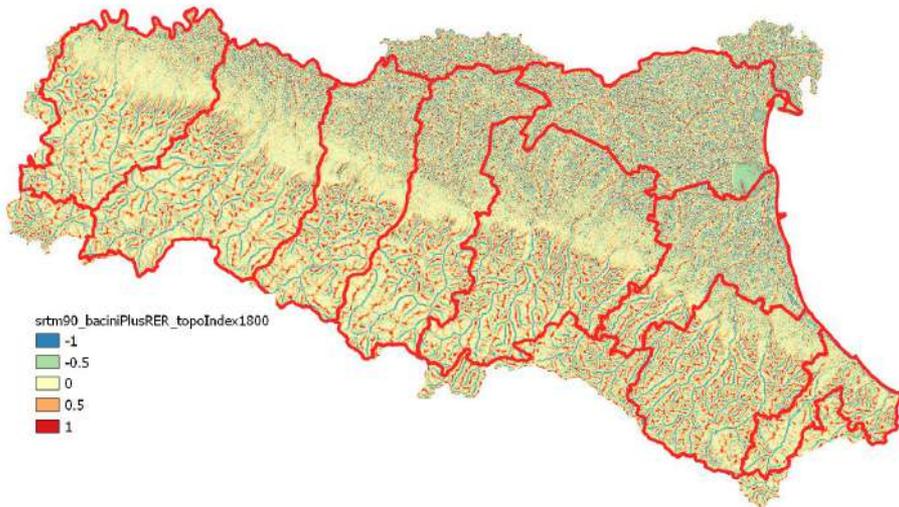


Detrending (indice topografico)

- descrizione accumulo aria fredda (anche per micro-variazioni di quota)
- rappresentazione “idrologica”

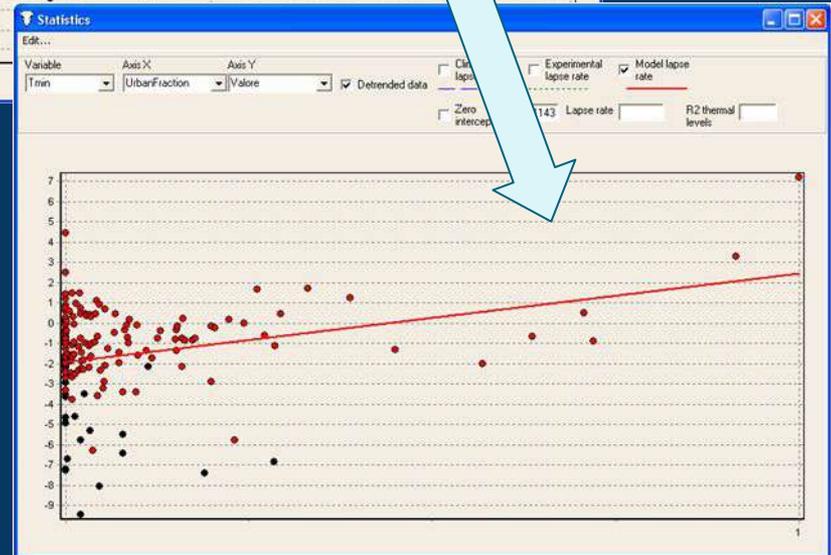
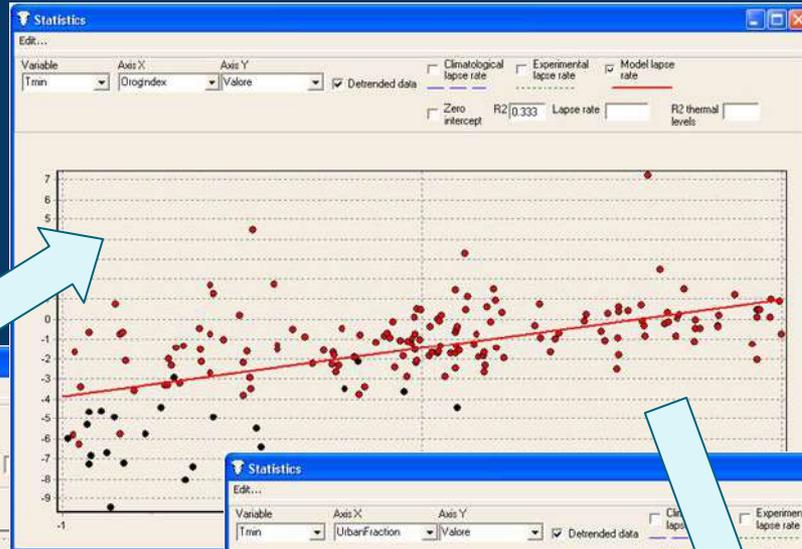
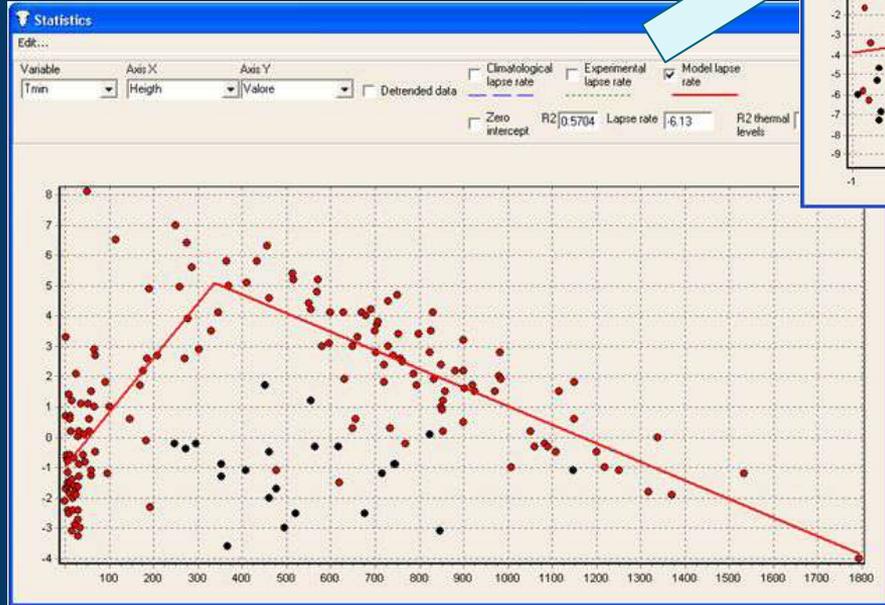
$$\text{TRP} = \frac{\sum_i w_i - \sum_j w_j - \frac{1}{2} \sum_k w_k}{\sum_i w_i + \sum_j w_j + \sum_k w_k}$$

$$w_x = 1 - \frac{r_x}{r_{\max}} \quad (x = i, j, k)$$



Detrending

detrending multiplo e separazione di scala



Interpolazione dei residui

metodo Shepard

$$f(P) = \frac{\sum_{i=1}^N w_i x_i}{\sum_{i=1}^N w_i}$$

$$w_i = \frac{1}{d(P, P_i)} (1 + t_i)$$

$$t_i = \frac{\sum_{j=1}^N d_j (1 - \cos \alpha_j)}{\sum_{j=1}^N d_j}$$

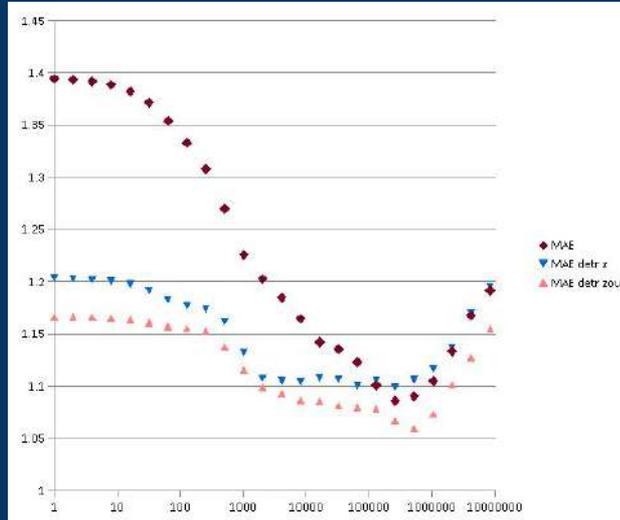
$$d_i = d_c + k_z d_z + k_h d_h$$

d_i : distanza topografica

d_c : distanza cartesiana

d_z : distanza verticale (differenza di quota)

d_h : "ostruzione" topografica

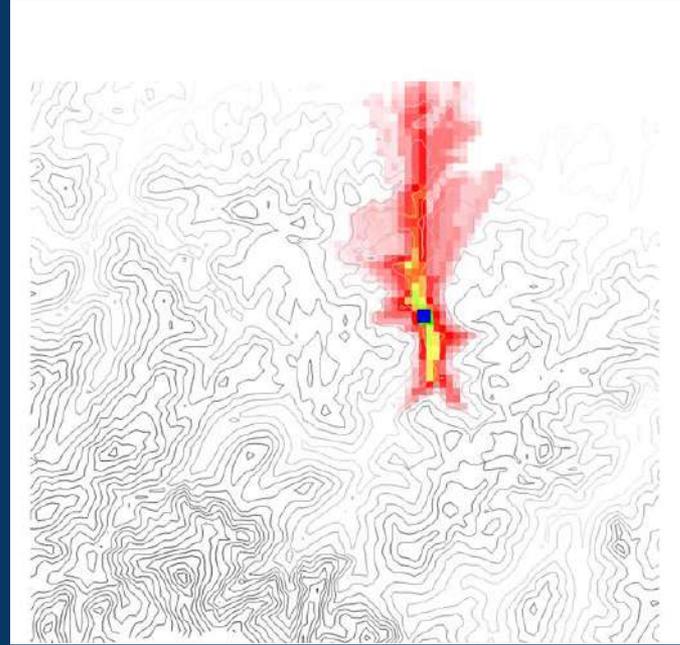
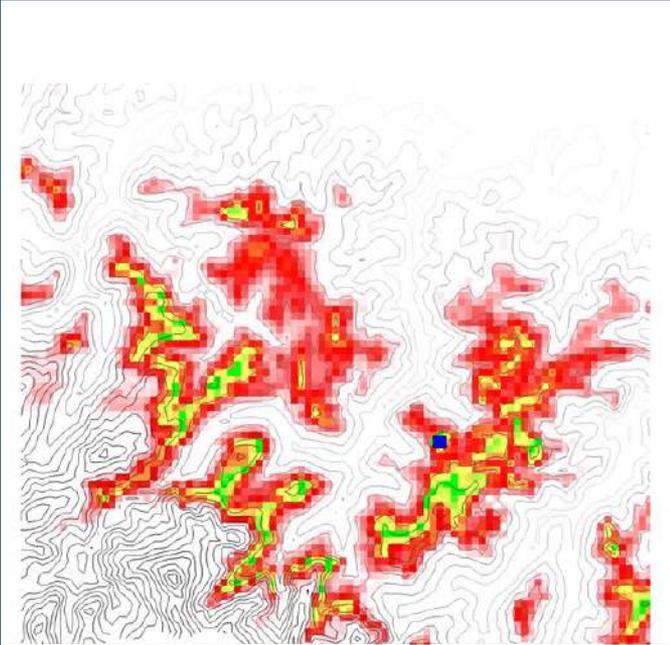


2ⁿ combinazioni di detrending (scelta in base a MAE)

ottimizzazione dei parametri k in base a MAE

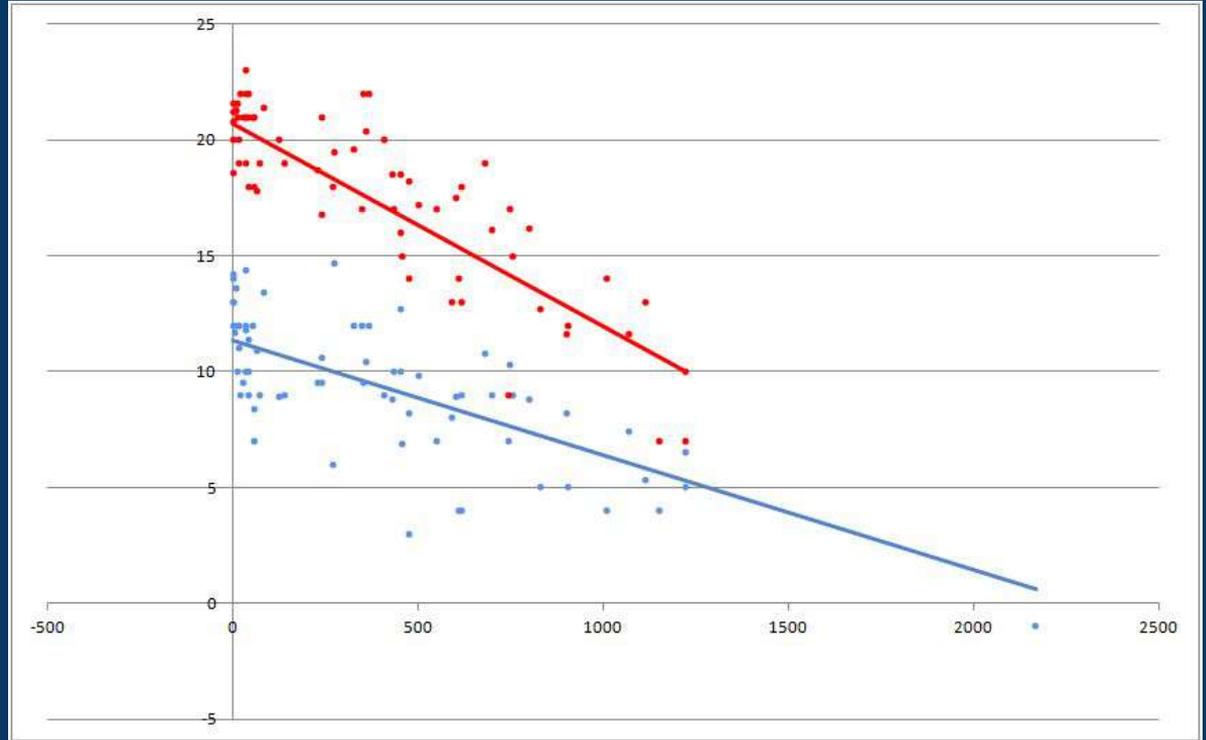
Distanze topografiche

informazione dei residui da detrending più “conservata” in ambiti topografici simili



Controllo coerenza temporale (giornalieri)

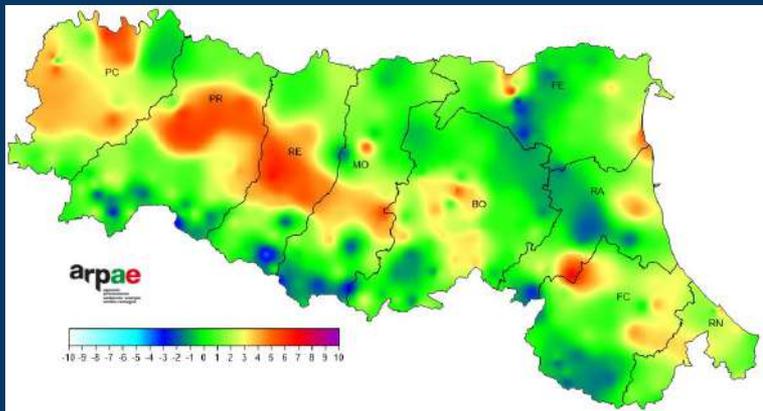
con dati di bassa qualità,
possibili incongruenze in alta
quota per incrocio lapse rate



Esempi

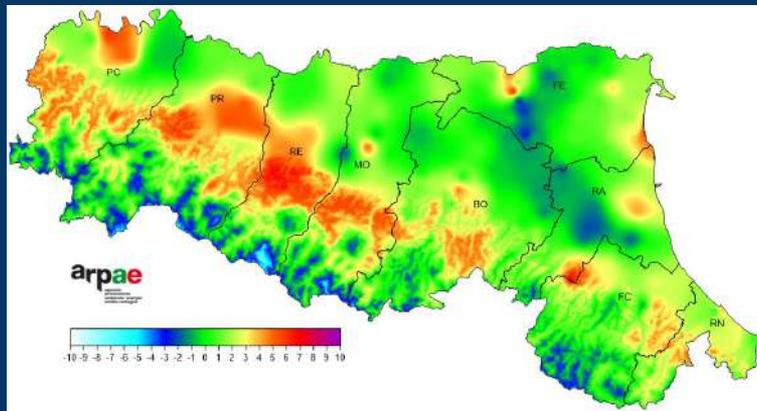
shepard

MAE: 1.72 °C



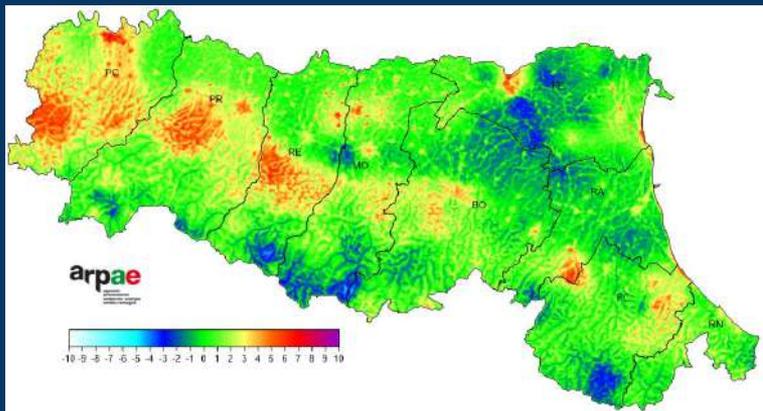
shepard + alt detr

MAE: 1.78 °C



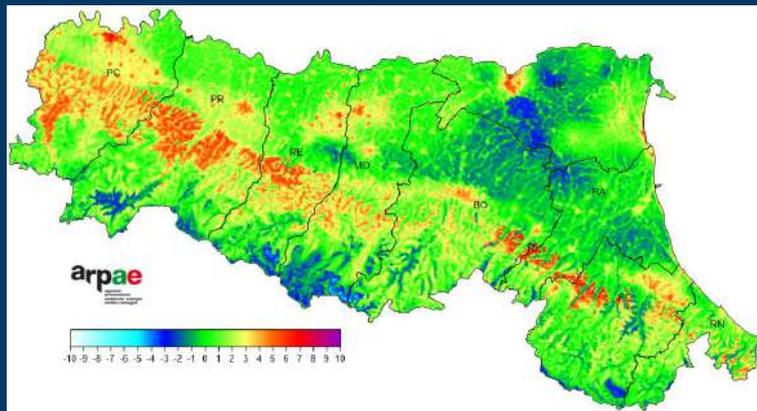
shepard + best detr

MAE: 1.43 °C



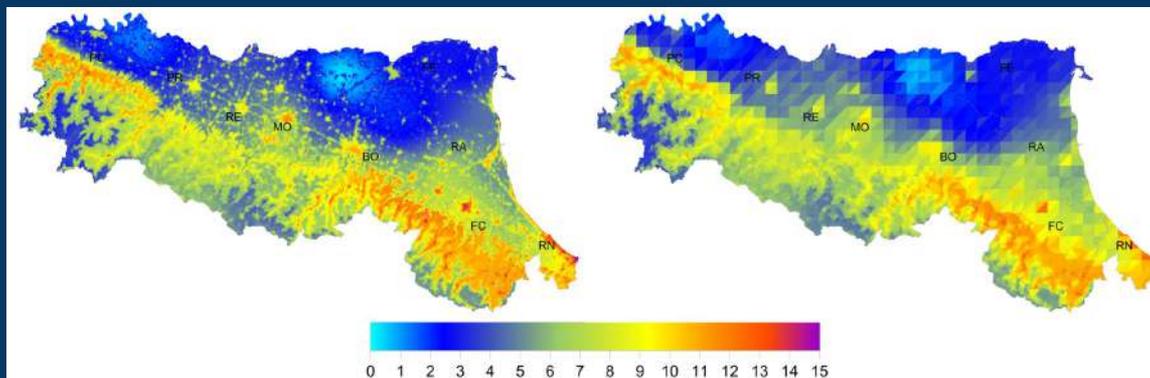
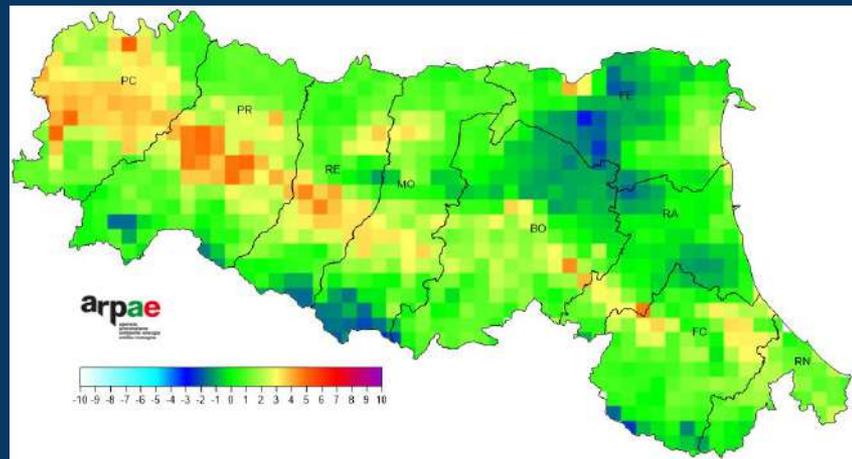
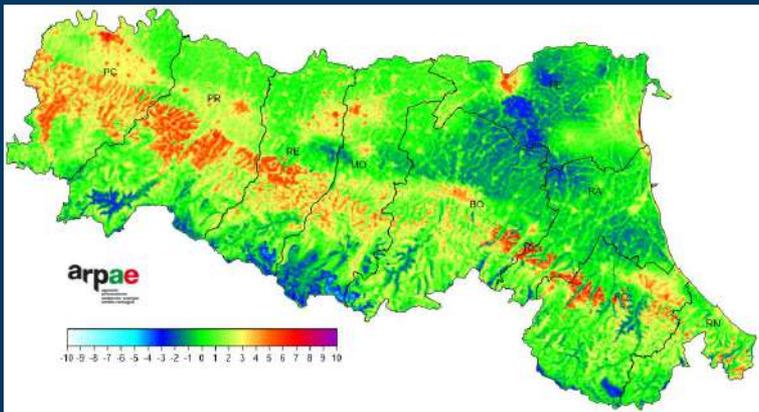
shepard + best detr + topo dist

MAE: 1.32 °C



Esempi

aggregazione su grid



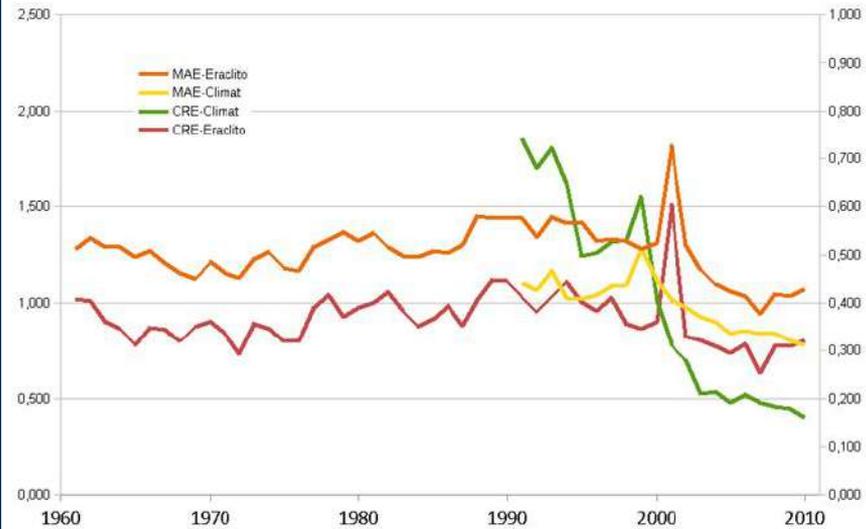
esempio di TIN

Valutazione dell'errore (cross validation)

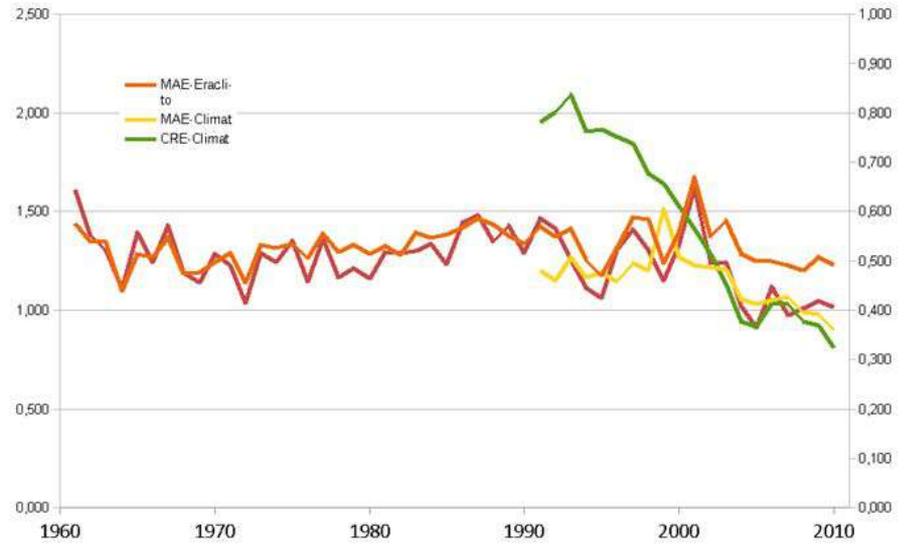
MAE: Mean Absolute Error (°C) [0, ∞[

CRE: Compound Relative Error (-) [0, ∞[

Tmax - Average annual error

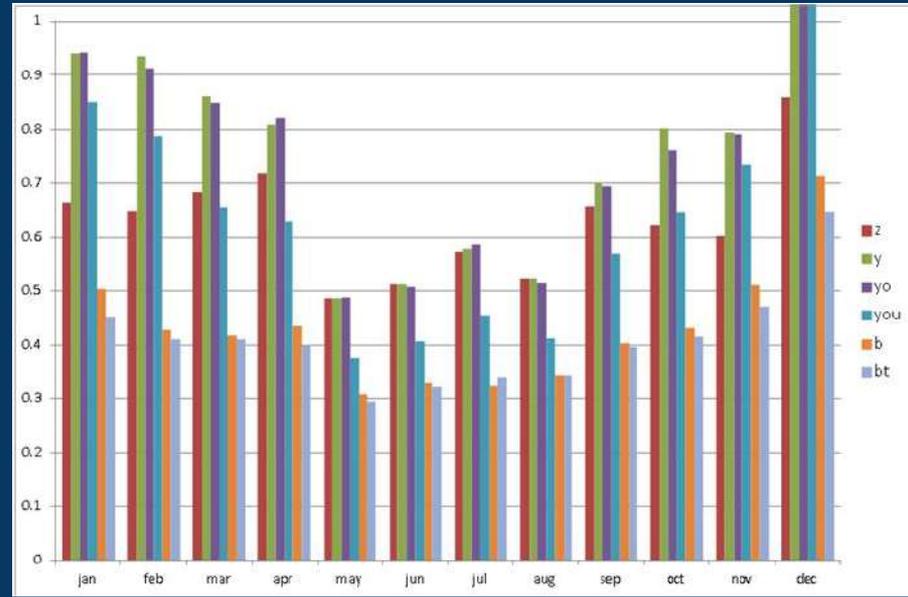
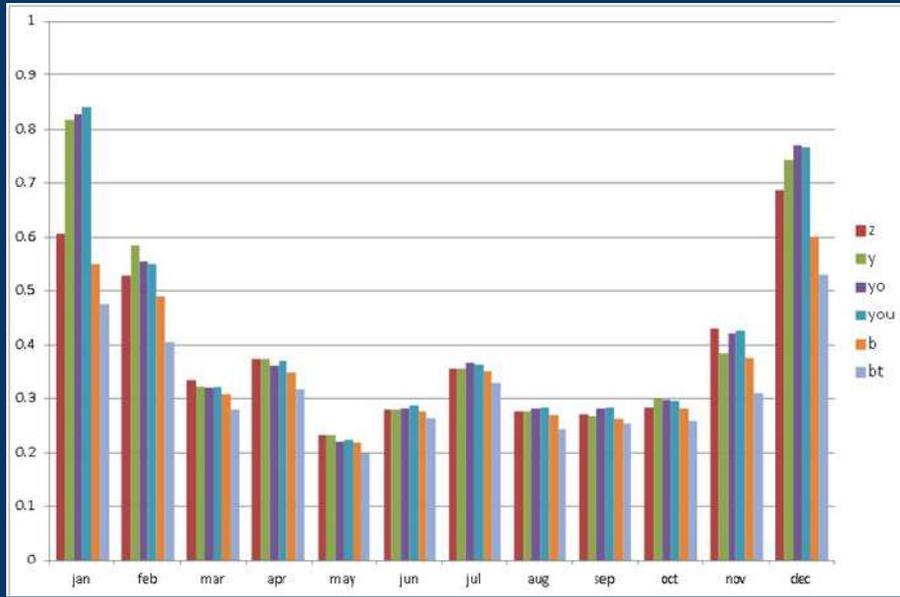


Tmin - Average annual error

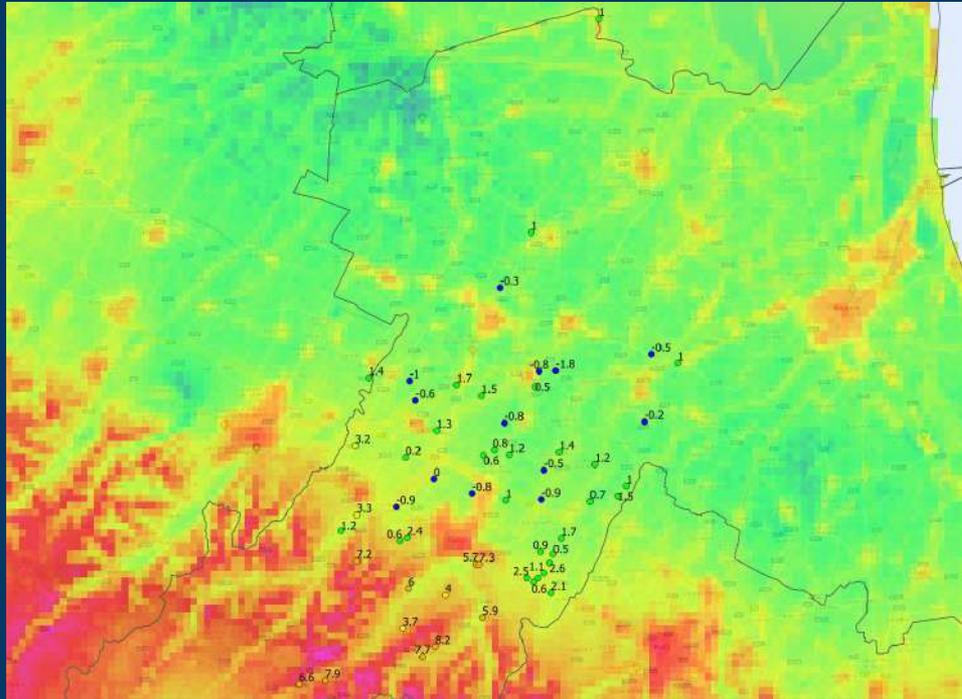


Valutazione dell'errore (cross validation)

CRE: Compound Relative Error (-) $[0, \infty[$



Valutazione dell'errore (campioni indipendenti)

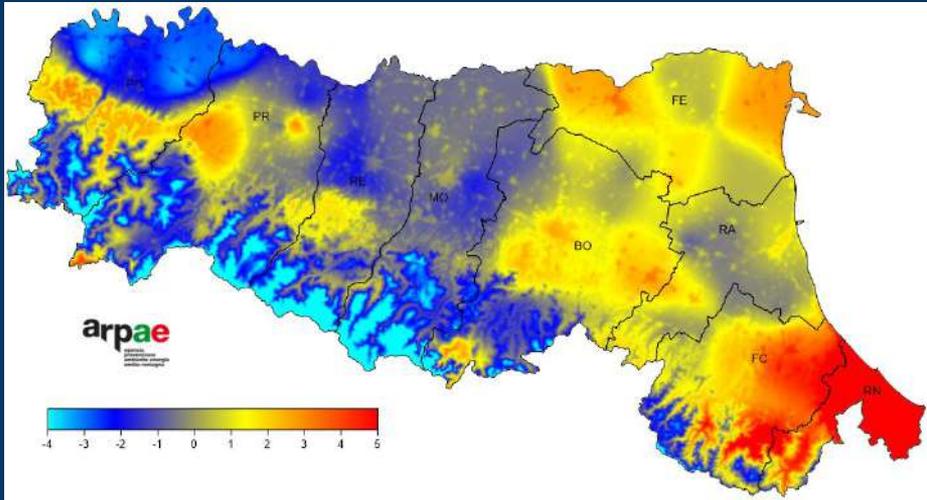


Data e ora	MAE	MBE	RMSE	R ² (-)
05/04/2021 05:00 UTC	1.37	1.02	2.10	0.12
07/04/2021 05:00 UTC	1.10	0.26	1.30	0.33
08/04/2021 05:00 UTC	1.42	1.11	2.27	0.12
09/04/2021 05:00 UTC	1.52	1.16	2.29	0.57
Complessivo	1.25	0.58	1.59	0.49

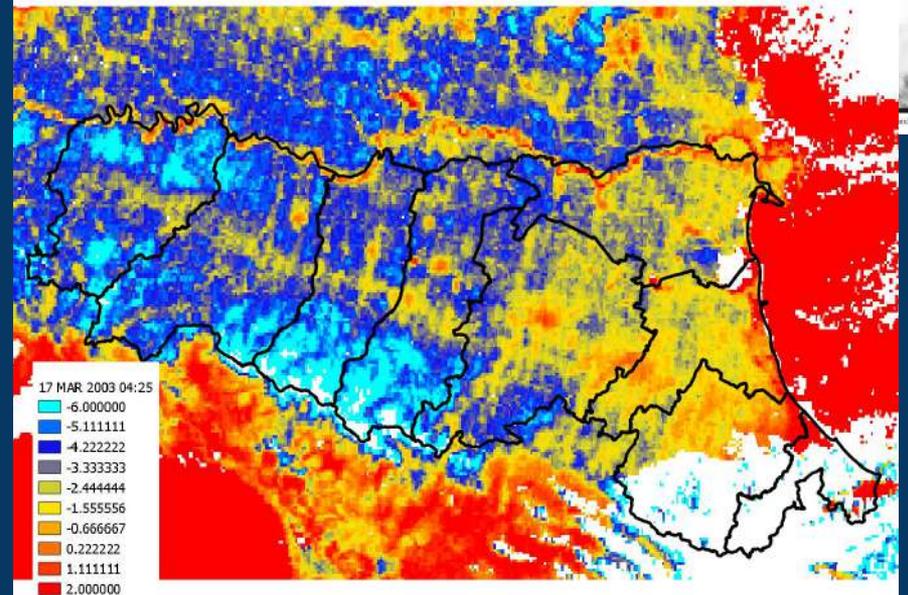
Validazione qualitativa

Land Surface Temperature (da dati NOAA-AVHRR)

17 Mar 2003 05:00



17 Mar 2003 04:25



Problematiche

UTILIZZO

- indicare sempre incertezza e uso consigliato dei dataset
- le piante possono risentire di temperature molto diverse da quelle a 2 m (schermatura, altezza)
- risoluzione effettiva

SVILUPPO

- utilizzo predittori specifici per zona (es. vicinanza a corpi idrici, uso del suolo, esposizione)
- frazione urbana o DPM?
- lapse rate variabile

Bibliografia



- ★ ERG5_Eraclito - Dataset climatico dal 1961
- ★ ERG5 - Dataset meteo orario e giornaliero dal 2001
<https://dati.arpae.it/>

Software PRAGA

<https://github.com/ARPA-SIMC/PRAGA>

Antolini et al., 2016. A daily high-resolution gridded climatic data set for Emilia-Romagna, Italy, during 1961-2010. *International Journal of Climatology*, 36(4), 1970–1986. <https://doi.org/10.1002/joc.4473>

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