Second Split Workshop in Atmospheric Physics and Oceanography

# PREDICTABILITY OF SEVERE HYDROMETEOROLOGICAL EVENTS IN THE MEDITERRANEAN AREA

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**PREDICTABILITY**

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# SEVERE HYDROMETEOROLOGICAL EVENTS

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Their level of predictability is strongly dependent on the degree of constraints on their spatial-temporal evolution set from large scale dynamics and boundary processes.

# EQUILIBRIUM AND NON-EQUILIBRIUM

HIGH degree of predictability → Equilibrium conditions

↓

The rate of creation of CAPE by forcing is balanced by its consumption by convection

←

Large scale forcing determines the statistical properties of convection and the spatio-temporal behavior of the corresponding severe rainfall events

# EQUILIBRIUM AND NON-EQUILIBRIUM

LOW degree of predictability → Non-Equilibrium conditions

↓

CAPE is build up from large scale processes over long timescales and removed by sudden triggering of deep moist convection

←

Triggering condition determines the spatio-temporal behavior of the corresponding severe rainfall events

# A convective time scale for equilibrium and non-equilibrium conditions (Done et al., 2006)

Convective timescale

$$\tau_c = \frac{CAPE}{dCAPE/dt}$$

$$\sim \frac{CAPE}{Precip.\ rate}$$

Equilibrium expected when $\tau_c$ small compared to forcing timescale

$$\frac{dCAPE}{dt} = \frac{1}{3600}\frac{i_R L_v g}{T_0 \rho_0 c_p} \approx 0.045 \times i_R$$

where

$i_R$ is the rainfall intensity [mm/h]

$L_V$ is the latent heat of vaporization

$g$ is the gravity acceleration

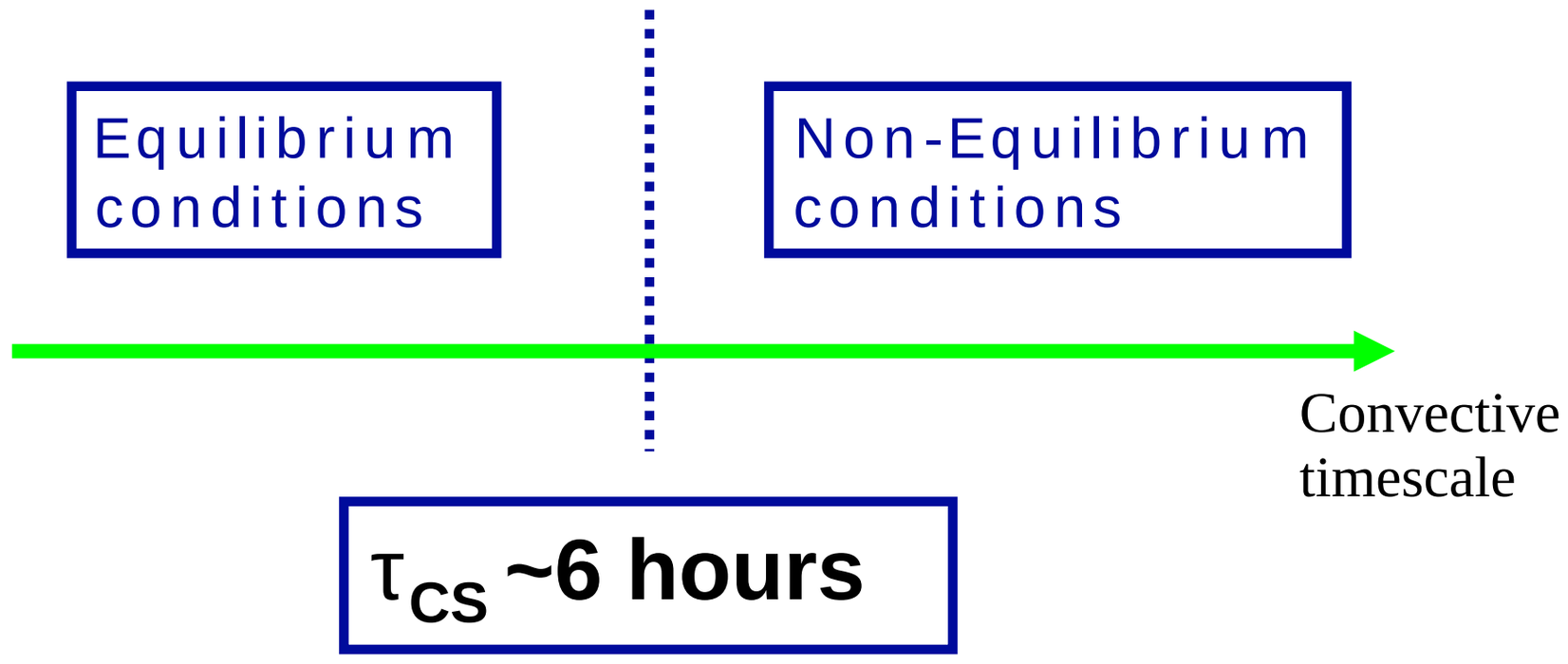
$c_p$ is the specific heat at constant pressure

$T_0$ is the air temperature

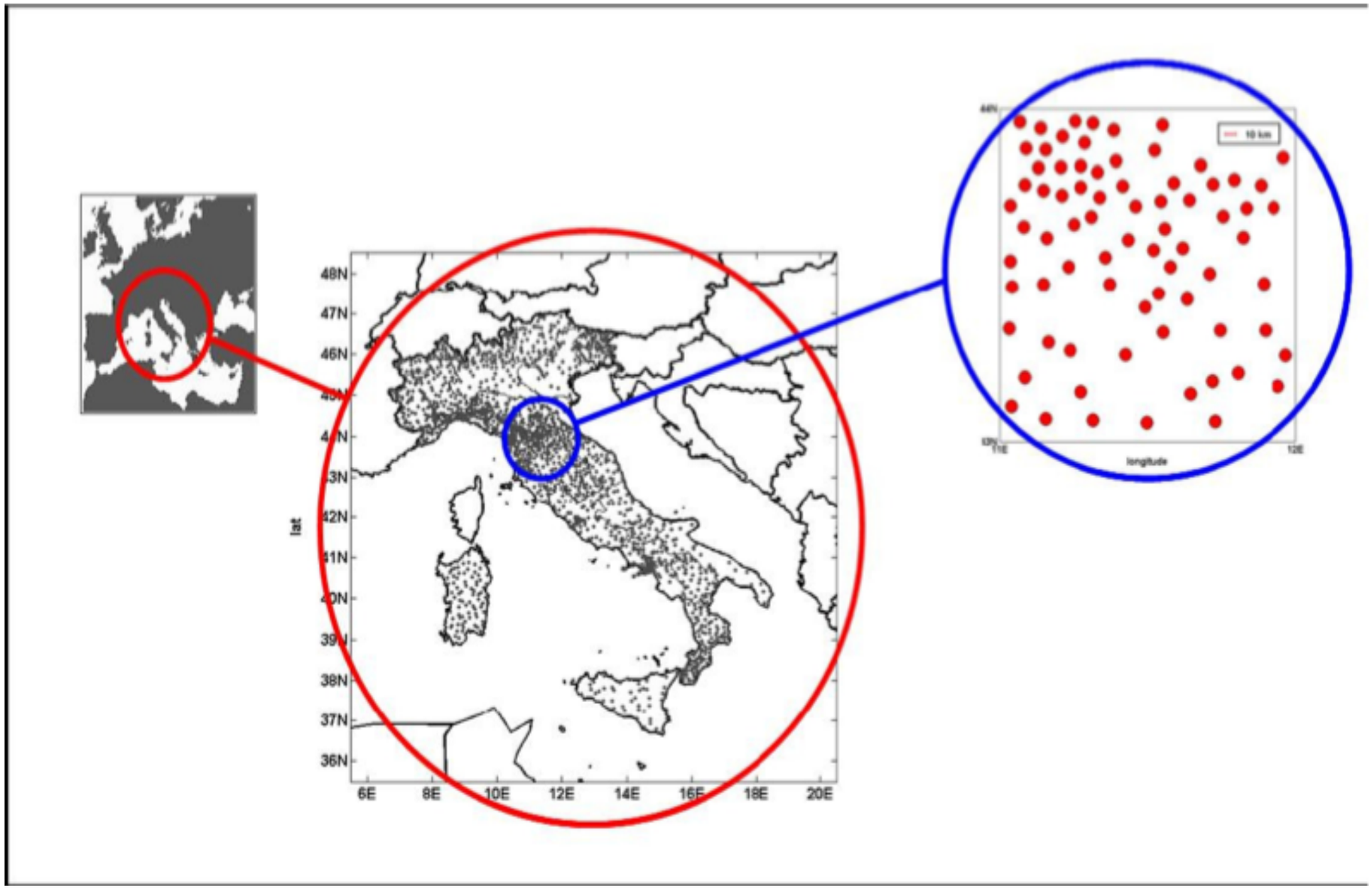
$\rho_0$ is the air density

# A convective time scale for equilibrium and non-equilibrium conditions

$$\tau_C = \frac{CAPE}{\frac{dCAPE}{dt}} = \frac{CAPE}{0.045 \times i_R}$$



# Italian Raingauge network



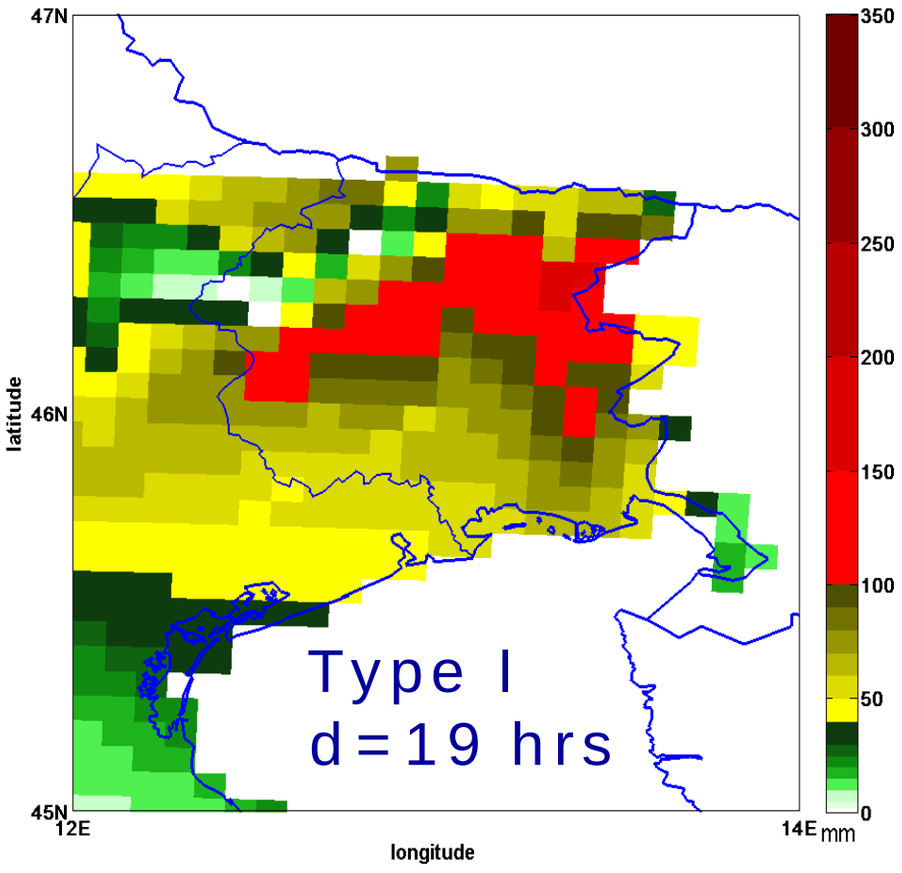

network density:
between 1gauge/50km$^2$ and 1 gauge/200km$^2$

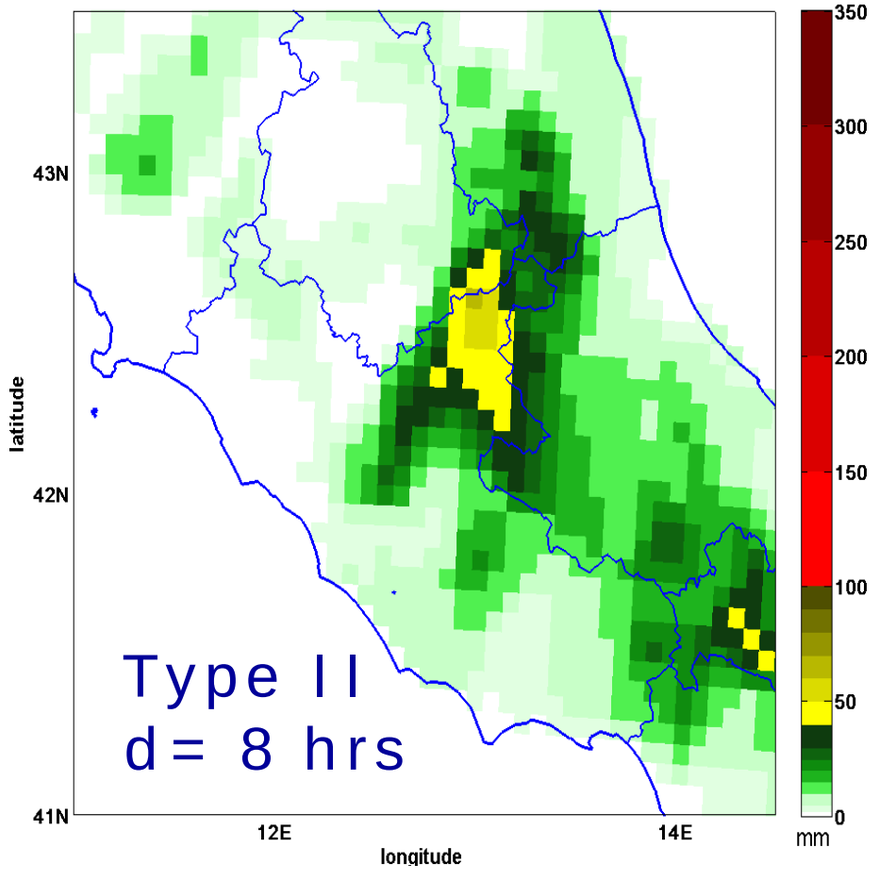
# Severe rainfall events classification

Molini et al. (2009) developed a procedure to single out heavy rainfall events and to classify them on the basis of:

1. Duration;
2. Spatial extent,
3. Large/small-scale triggering mechanism

# Severe rainfall events classification




Type I events:

- Long-lived (lasting more than 12 hours)
- Spatially distributed (more than 50x50 km$^2$)

Type II events:

- Brief and localized (lasting less than 12 hours)
- Spatially concentrated (less than 50x50 km$^2$)

# Severe rainfall events classification

The event classification procedure was applied to the Italian Raingauge Network observations from January 2006 to December 2008.

81 severe events:

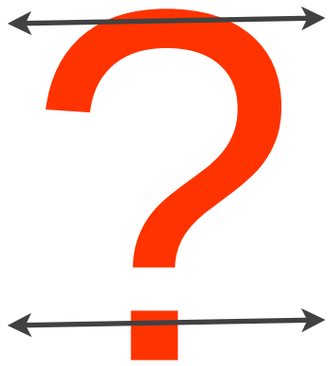
- **51** events **Type I** events lasting more than 12 hours and striking an area bigger than 50x50 km$^2$;
- **30** events **Type II** events lasting less than 12 hours and striking an area smaller than 50x50 km$^2$.

# Predictability and event characterization

Are the differences between these two types of event associated with different mechanisms of control of the precipitation by dynamical processes in the atmosphere?

Short values of $\tau_c$
- Equilibrium conditions

Long values of $\tau_c$
- non-Equilibrium conditions



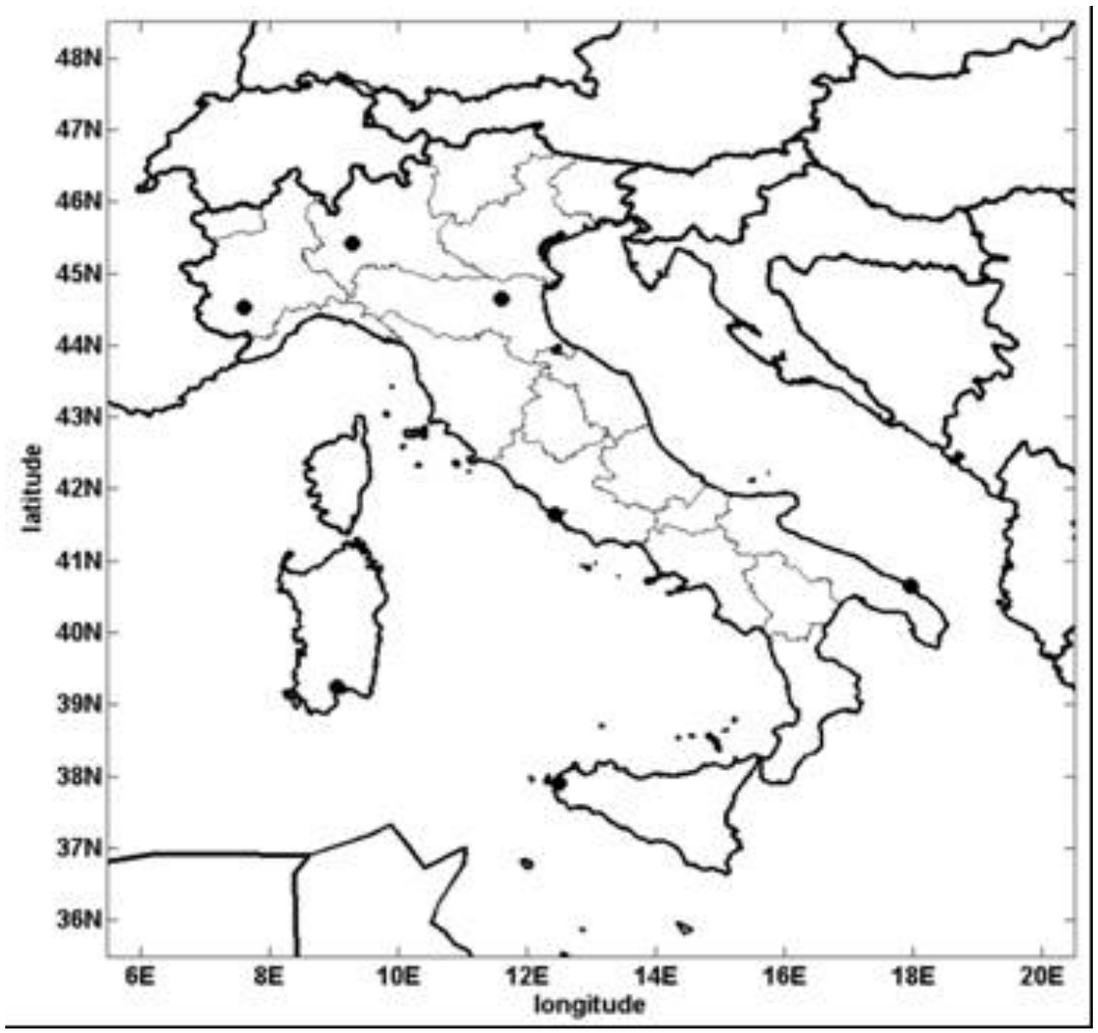
Type I events

Type II events

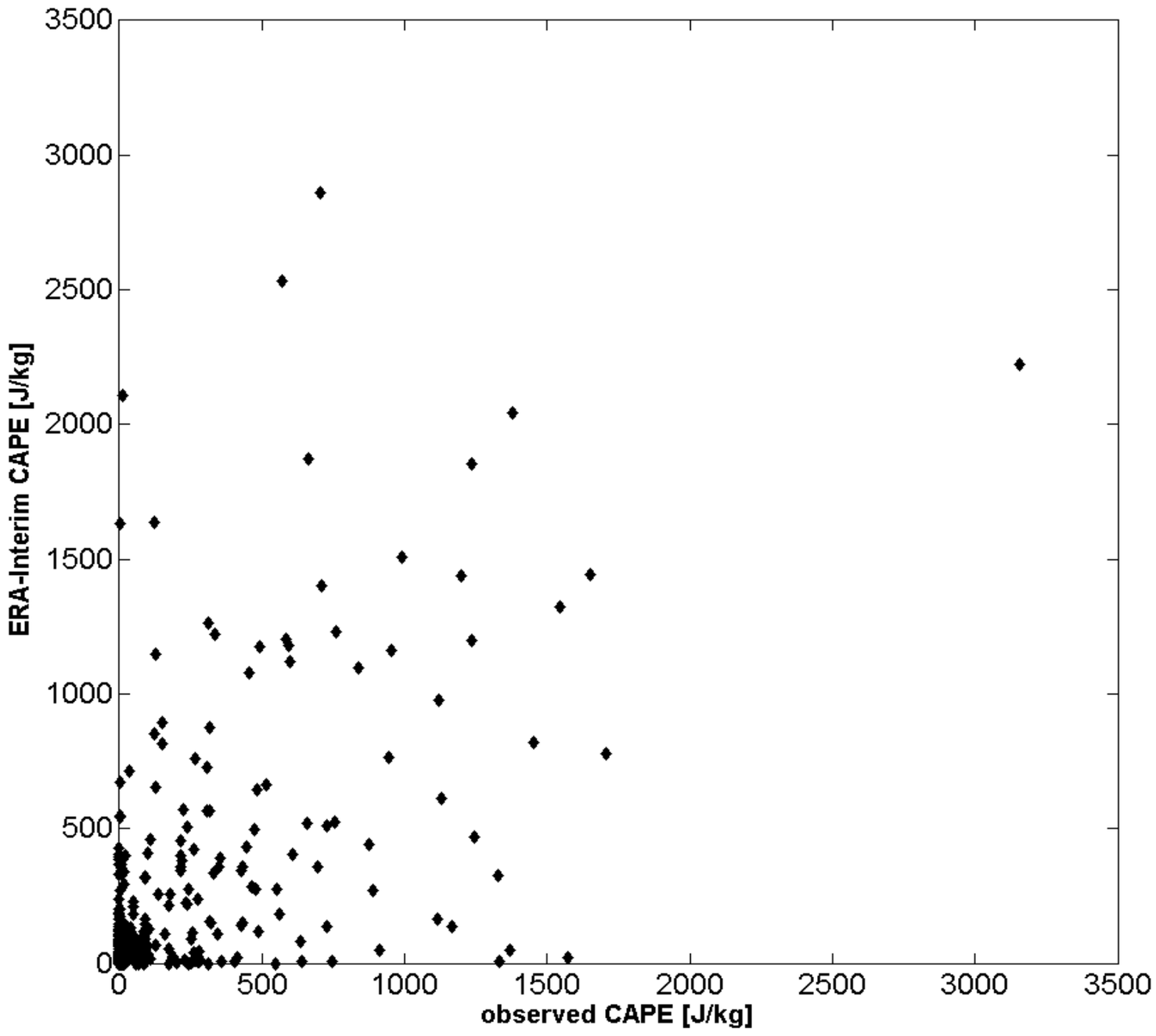
# Radiosounding network

To calculate CAPE and $\tau_c$ for the events classified we cannot use Italian radiosoundings due to the coarseness of the network

We resort to the use of ERA-Interim products to estimate CAPE values over the area and for the duration corresponding to each event classified for the period 2006-2009



# CAPE VALUE COMPARISON




BIAS = 50 J/kg
MAE = 200 J/kg

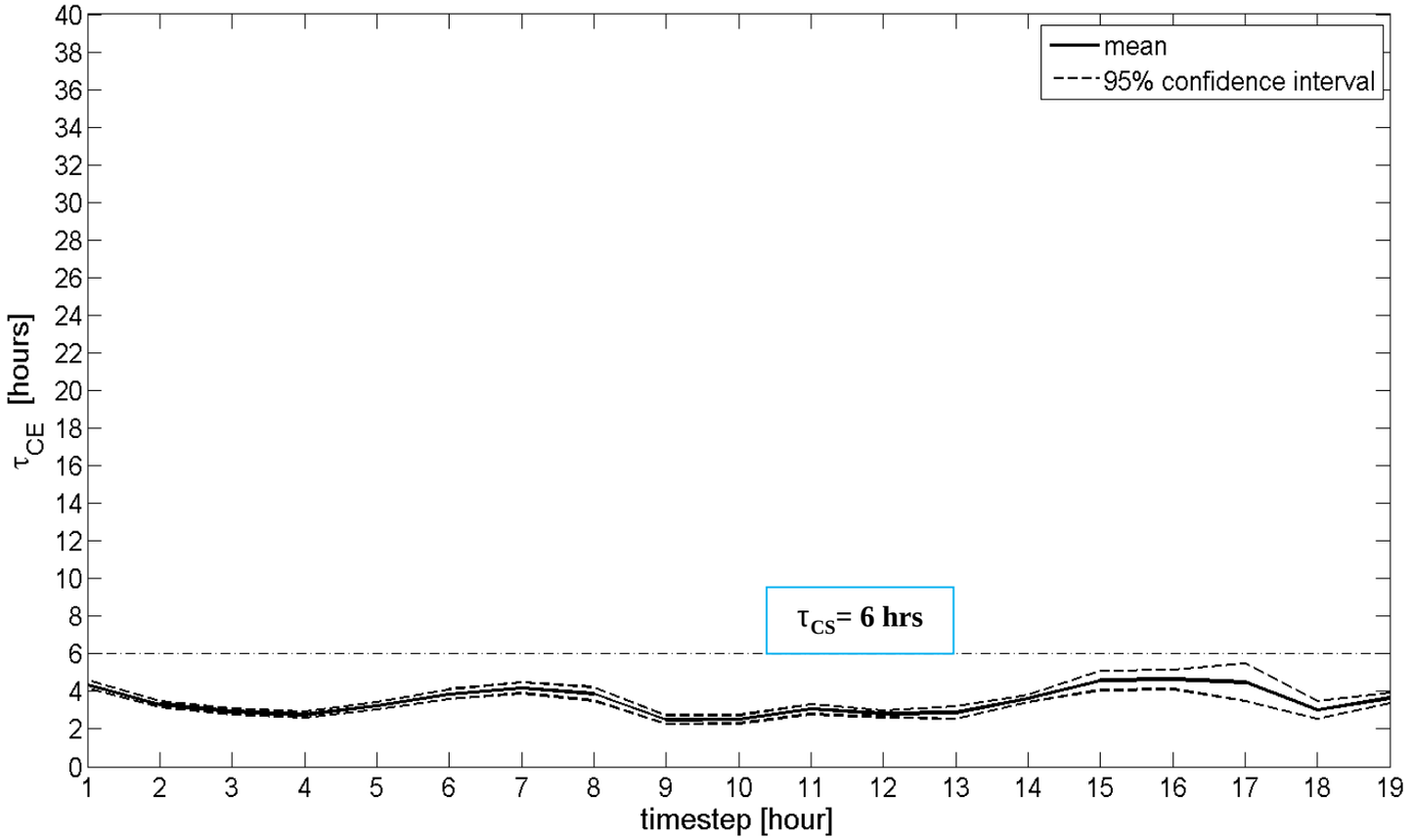
# $\tau_C$ computation

1. ERA-Interim CAPE values were interpolated on the same grid ($\Delta x = \Delta y \sim 10$ km) adopted for the interpolation hourly rainfall observations;

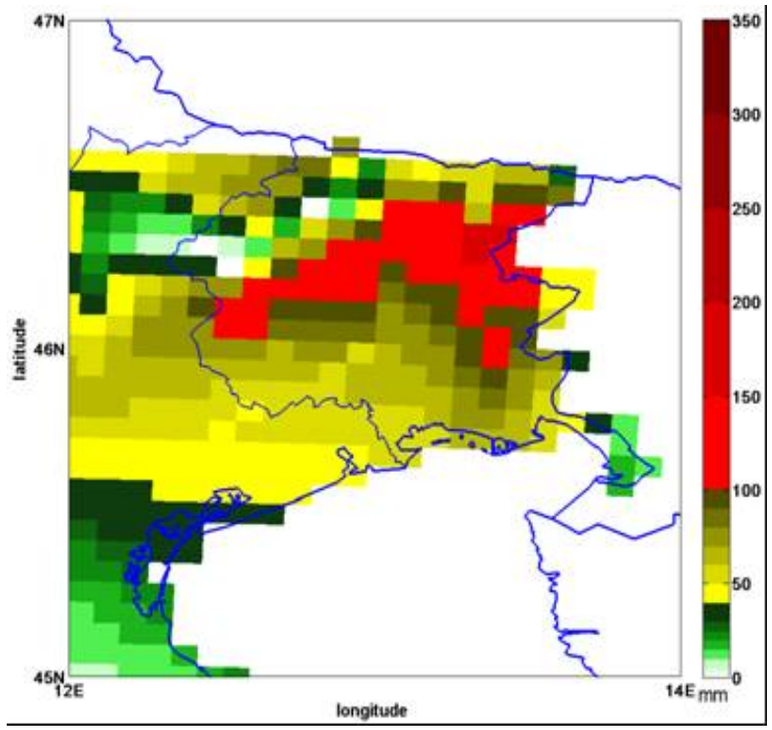
2. Grid points belonging to each severe event spatial domain were selected and the computation of pixel-values of $\tau_C$ was performed only over rainy grid (hourly rainfall intensity > 2 mm/h).

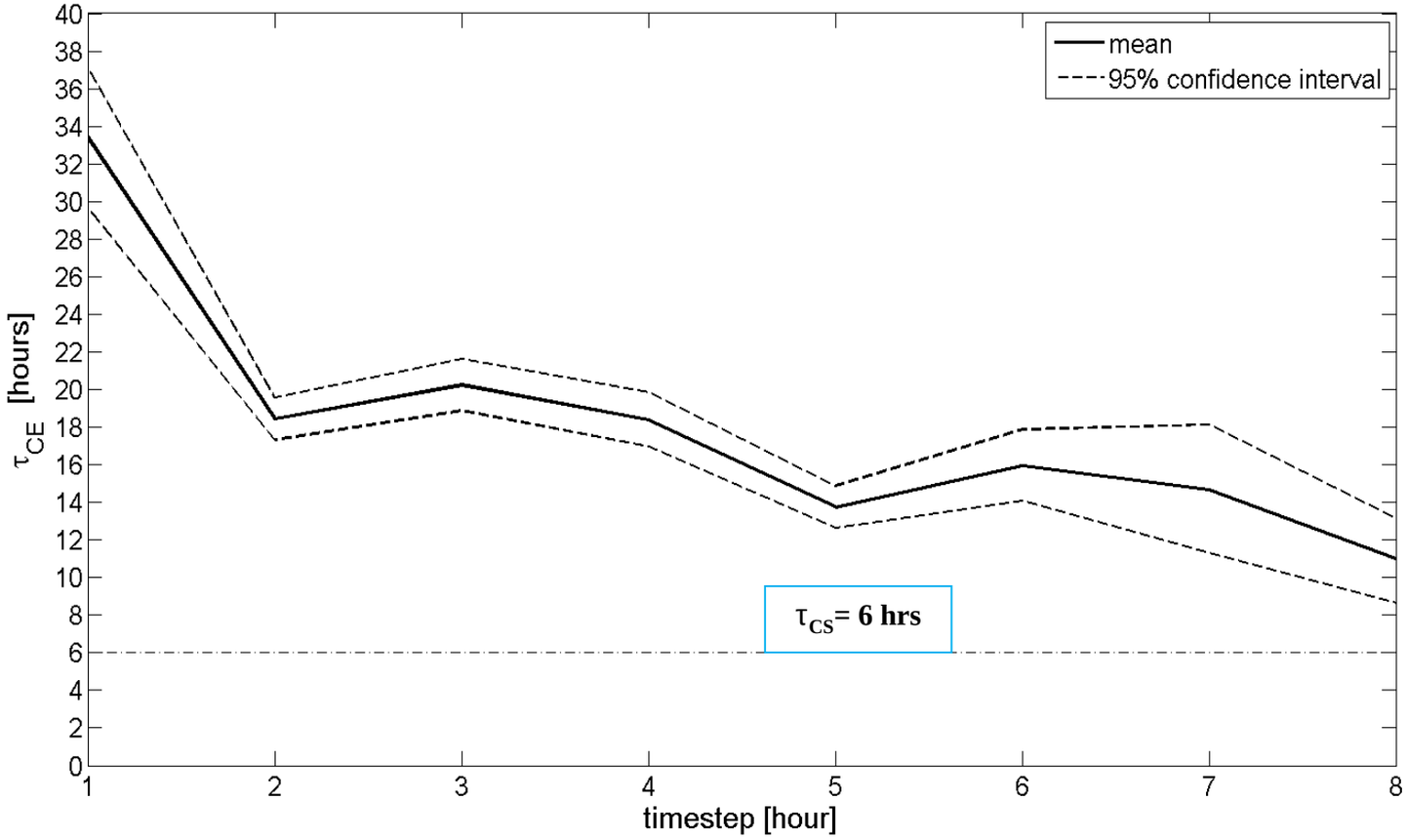
3. At each hourly time step, a spatial mean value of the adjustment convective timescale $\tau_{CE}$ was computed over the aforementioned rainy points. In this way it was also possible to study the temporal evolution of $\tau_{CE}$ over the whole duration and area of each event.

4. As a measure of the equilibrium or non-equilibrium nature of each extreme event, we adopted the average value $\tau_{CM}$ of each $\tau_{CE}$ time series.

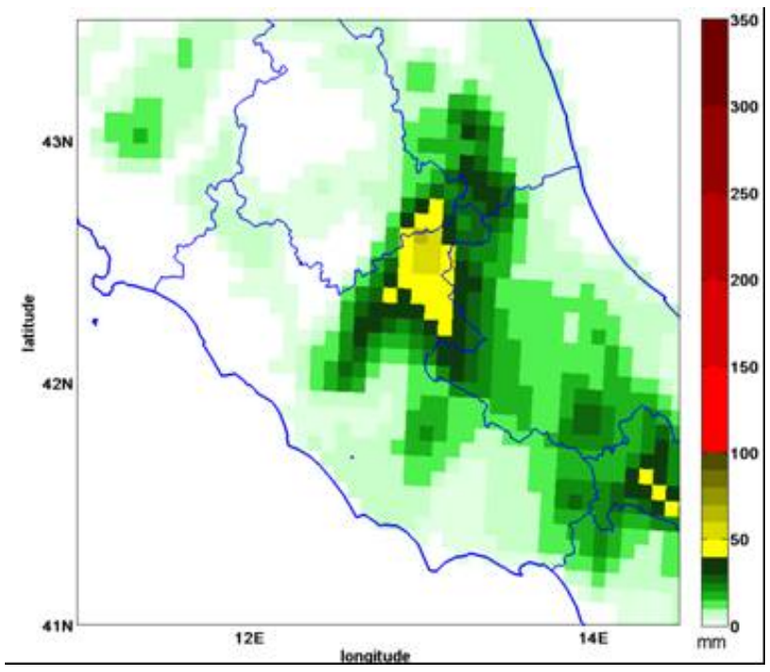



## Type I event

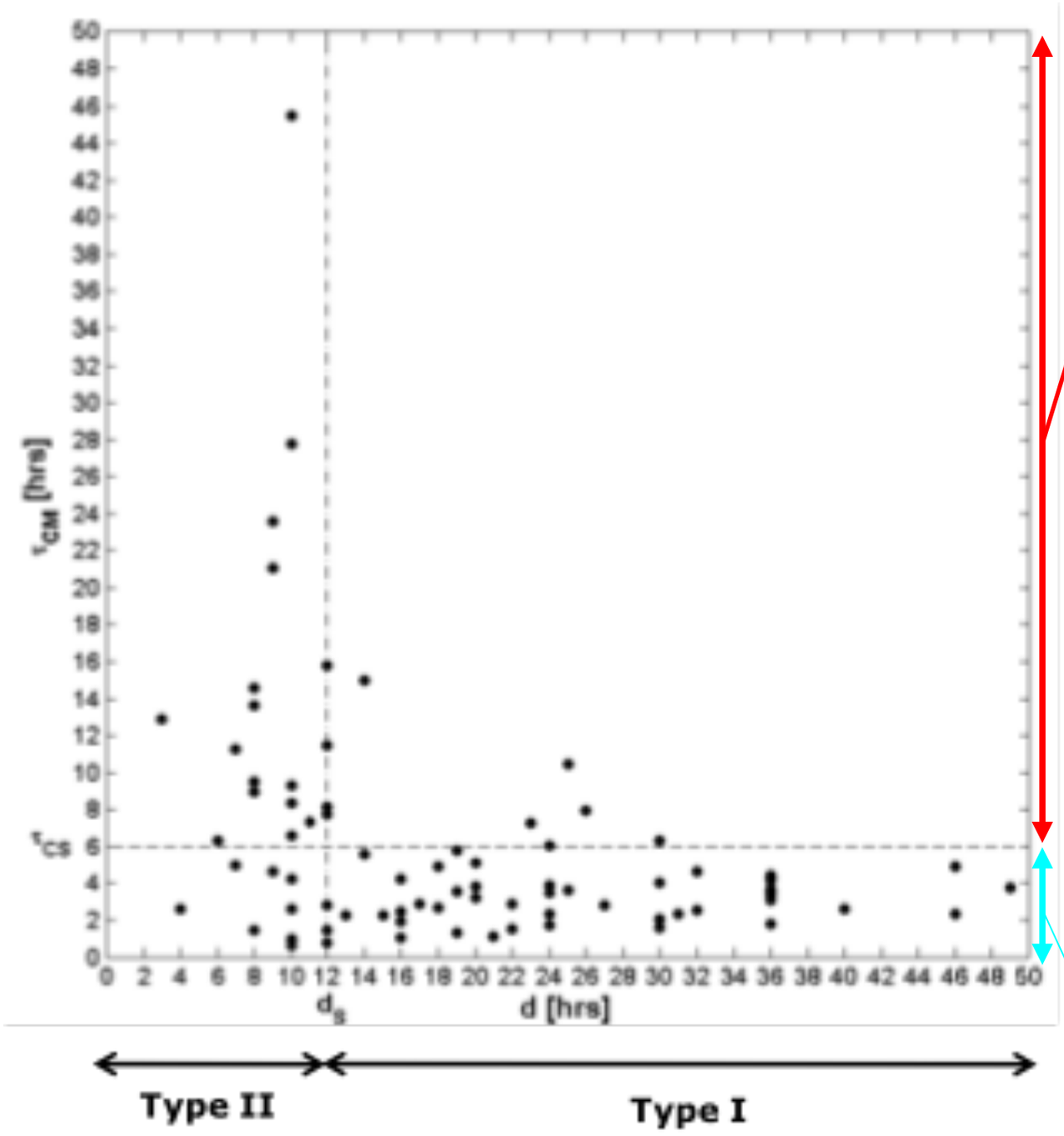



## Type II event



# Event Distribution




**NON Equilibrium**

$\tau_{CS}$= 6 hrs

**Equilibrium**

# SUMMARY AND CONCLUSIONS

Type I: 45 events out of 51 (about 90%) are characterized by $\tau_{CM}$ values lower than 6h, thus corresponding to equilibrium conditions;

Type II: 20 events out of 30 (about 66%) are characterized by $\tau_{CM}$ values higher than 6h, thus corresponding to non-equilibrium conditions.

The underlying hypothesis of this study seems to be supported by these findings:

- Type I events are largely associated with equilibrium conditions and thus more predictable

- Type II events are characterized by non-equilibrium condition and consequently are expected to be hardly predictable.

# New Data

The event classification procedure was applied to the Italian Raingauge Network observations from January 2009 to December 2009.

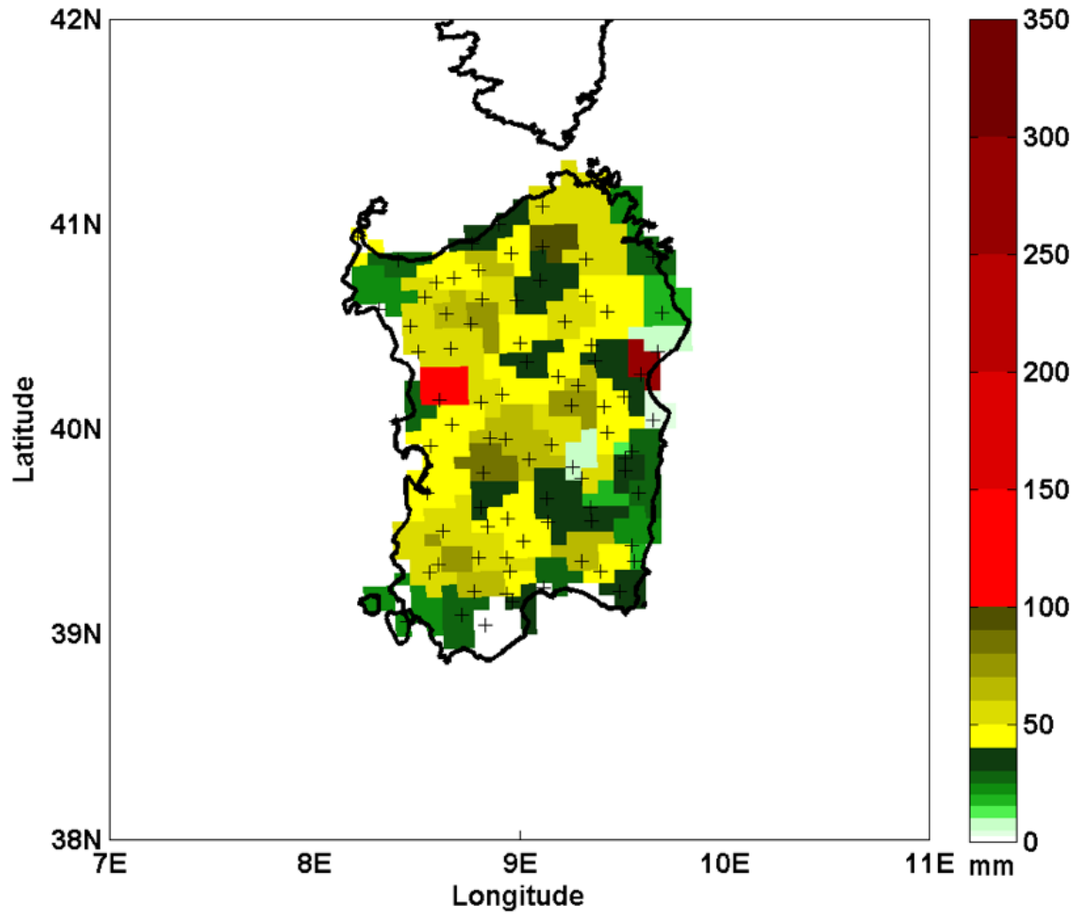
severe events:

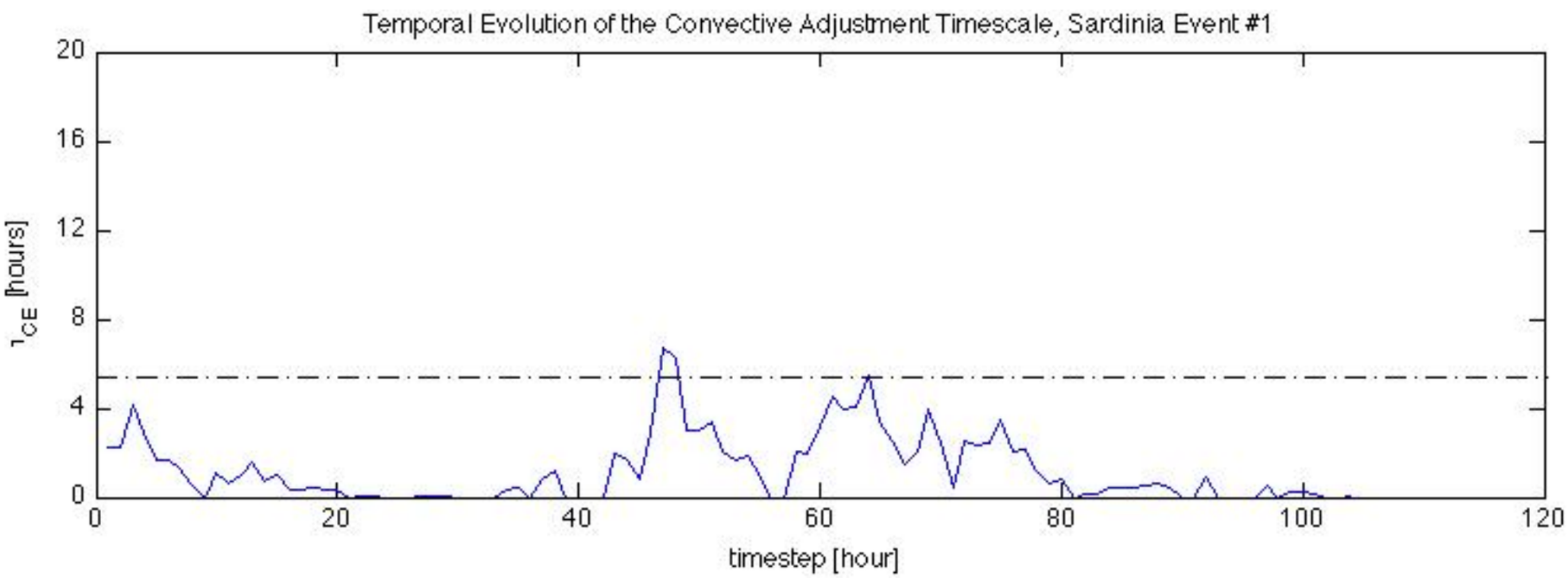
- **<u>51</u>** events **<u>Type I</u>** events lasting more than 12 hours and striking an area bigger than 50x50 $km^2$;
- **<u>30</u>** events **<u>Type II</u>** events lasting less than 12 hours and striking an area smaller than 50x50 $km^2$.

# New Results

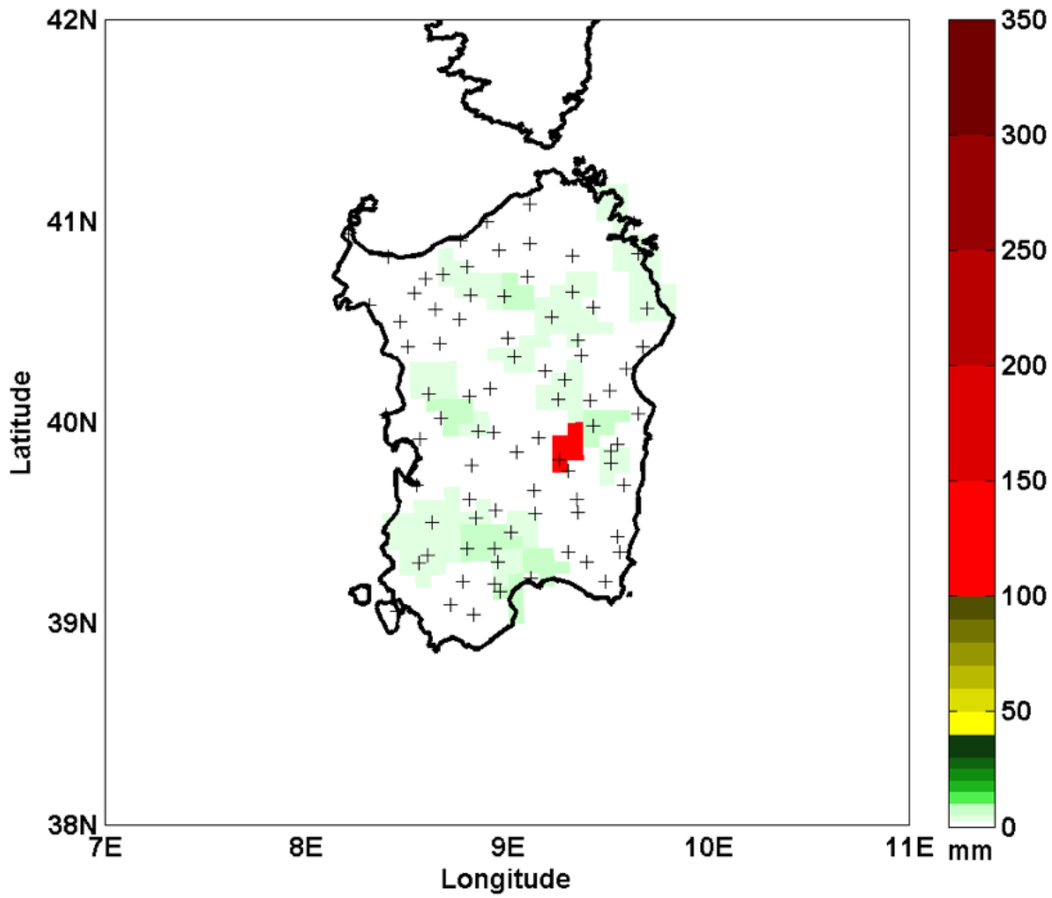

Trentino-Alto Adige \ Südtirol
Lombardia
Valle d'Aosta
Vallée d'Aoste
Friuli - Venezia Giulia
Veneto
Piemonte
Emilia-Romagna
Marche
Liguria
Toscana
Abruzzo
Molise
Umbria
Lazio
Puglia
Sardegna
Campania
Basilicata
Calabria
Sicilia

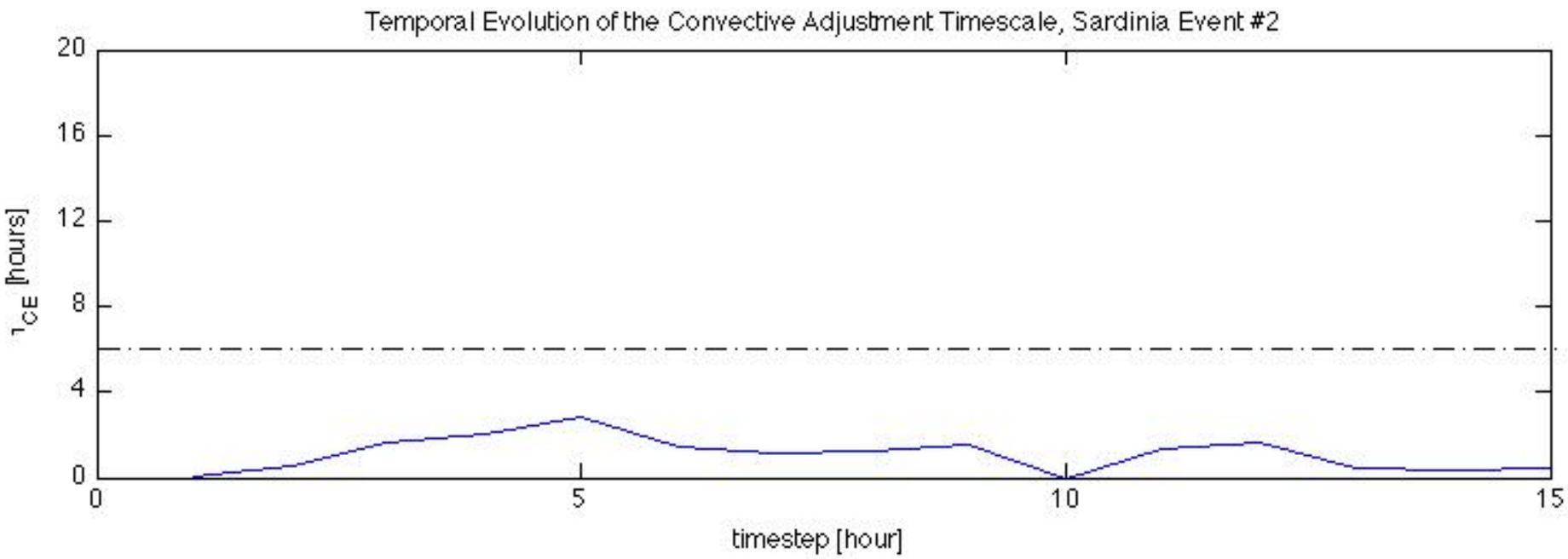
# New Results - Sardinia 1



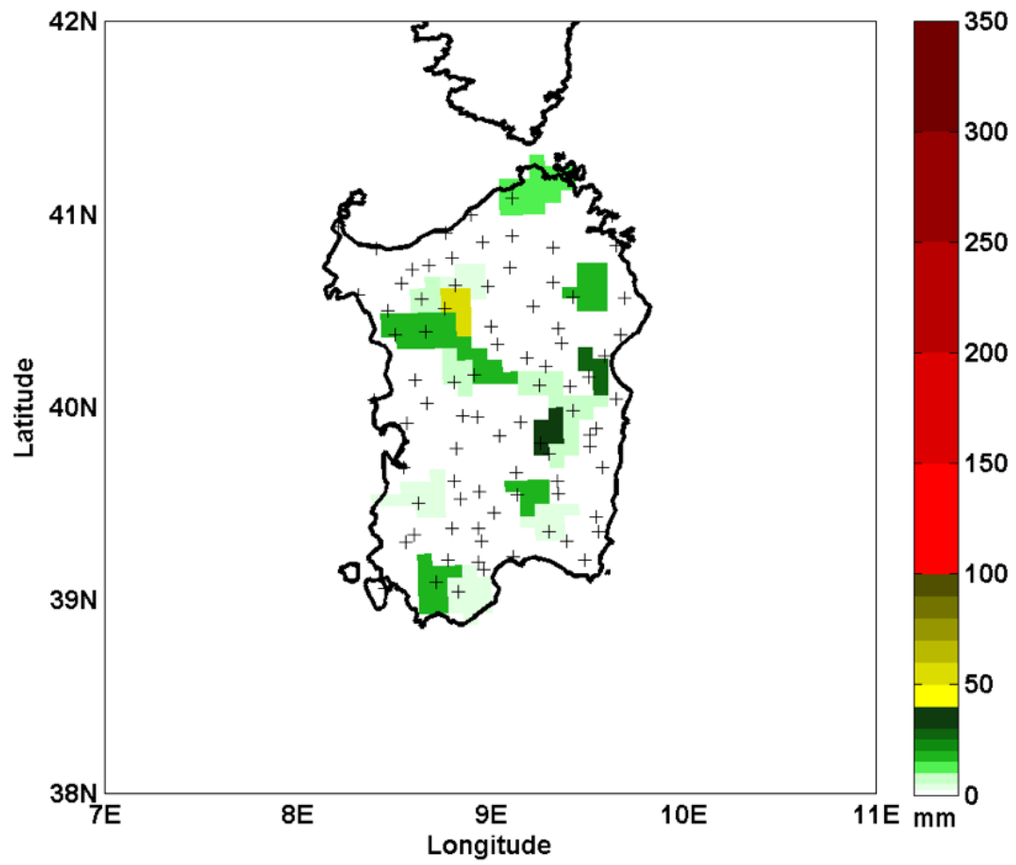



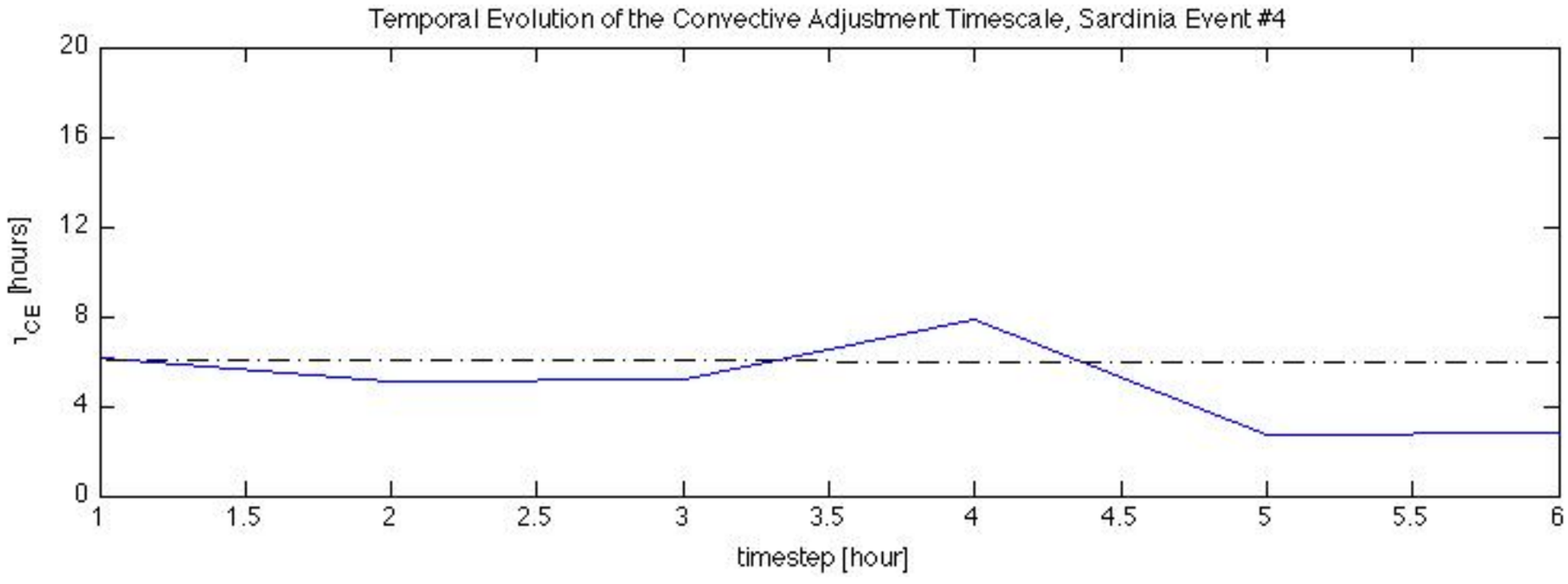
# New Results - Sardinia 2



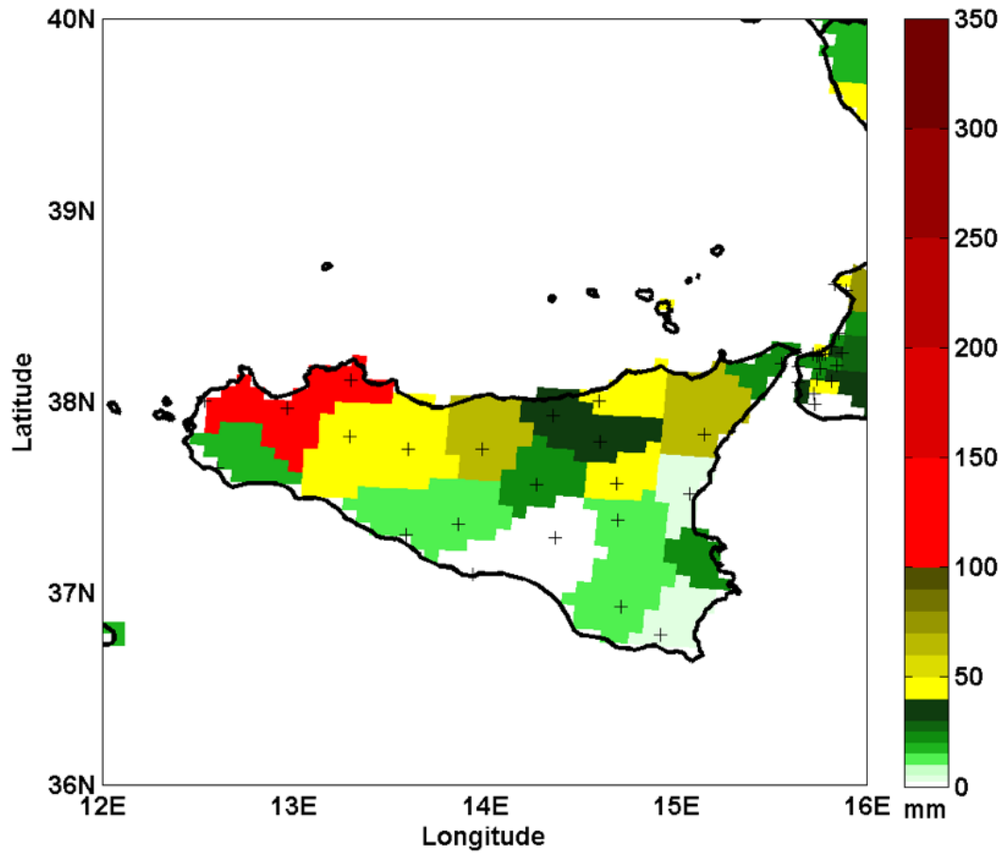



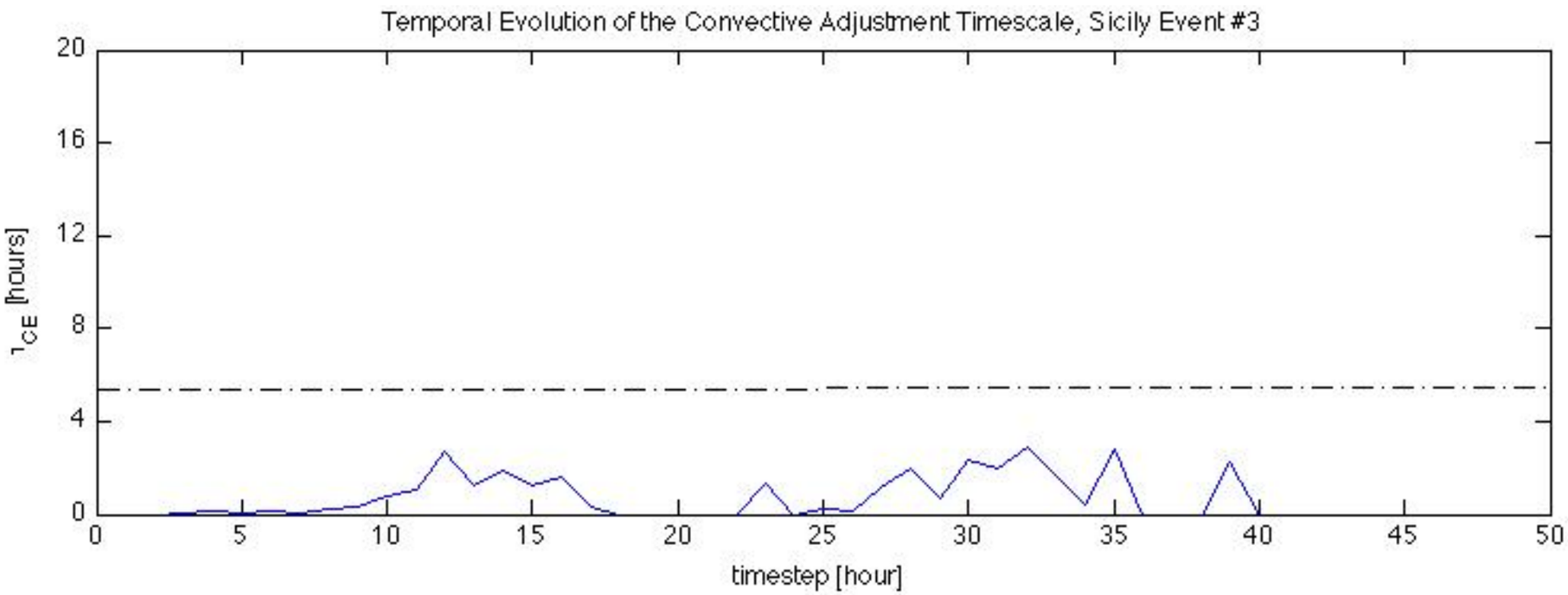
# New Results - Sardinia 4



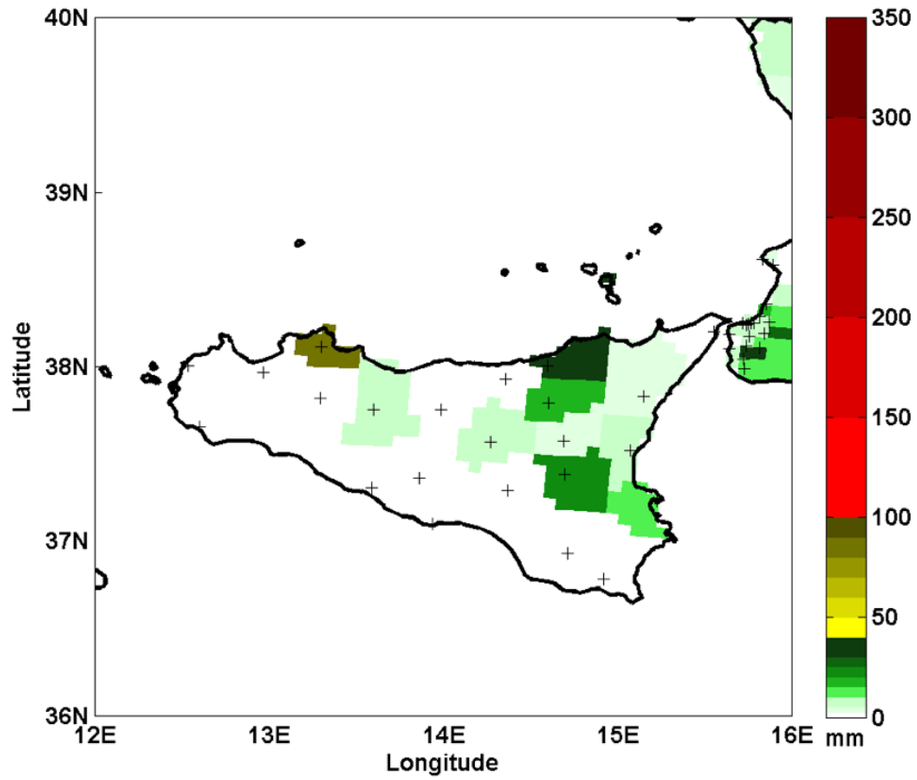



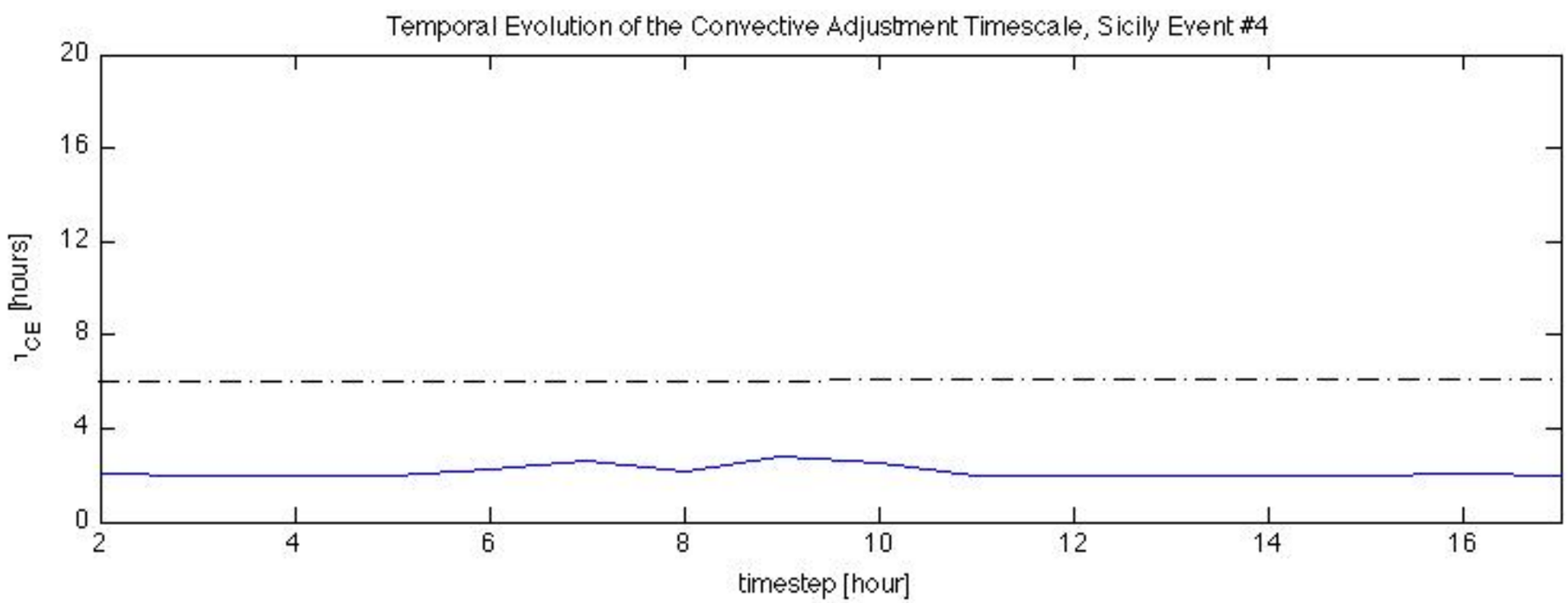
# New Results - Sicily 3



# New Results - Sicily 4

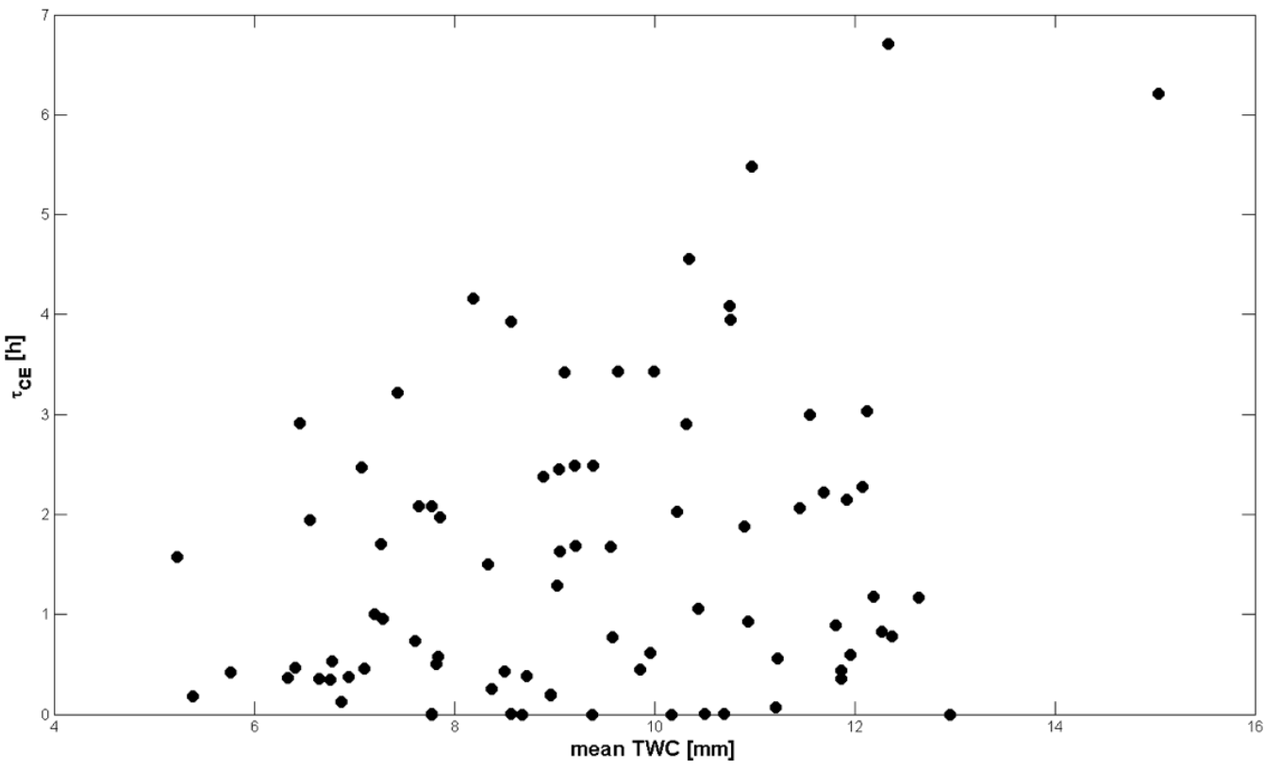


# Correlations?




Sicily 3




Sardinia 1

# Thank you!