

A strategy to build a unified data set of moment magnitude (Mw) estimates for low-to-moderate seismicity regions based on European-Mediterranean data: Application to metropolitan France

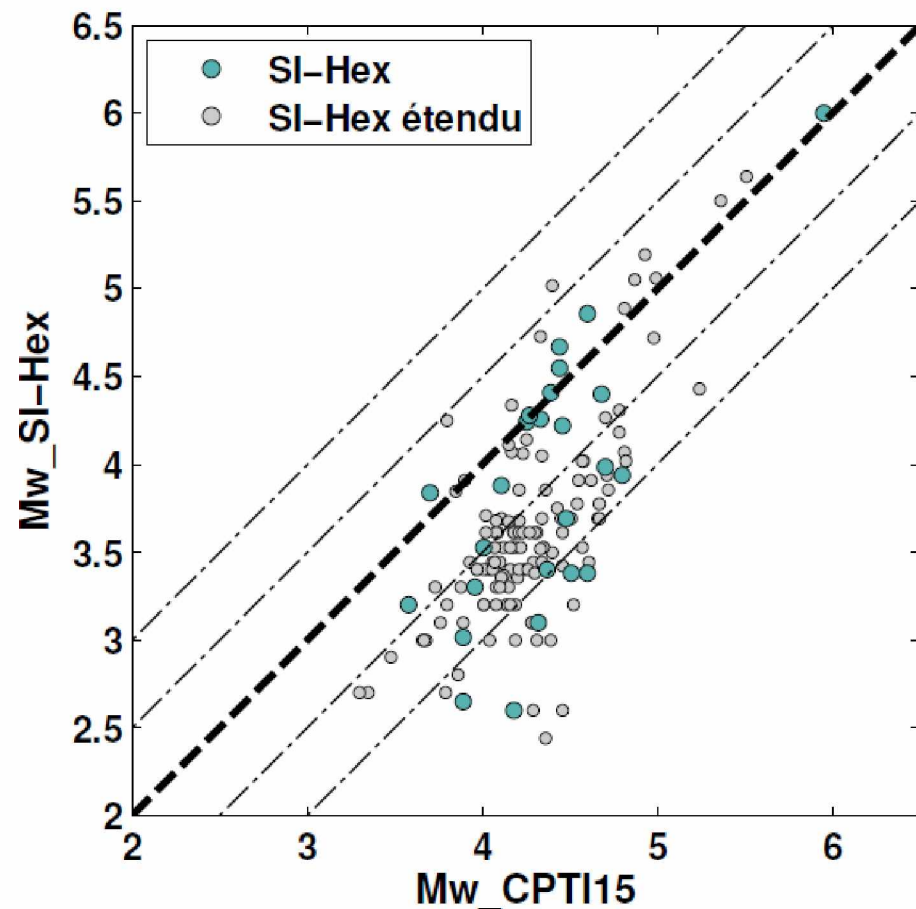
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The issue

- The M_w values of the French instrumental seismicity catalog [SI-Hex] are not consistent with the M_w values of the other catalogs
 - ⇒ *e.g., with the Italian catalog [CPTI15] large differences are observed for $M_w < 5.0$ earthquakes*
- Thus, they are not also consistent with the M_w values in the ground motion flatfiles used to develop GMM



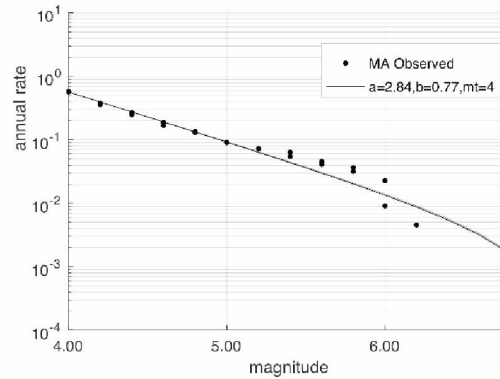
Laurendeau et al. (2019)

The motivation – need to have consistent Mw values

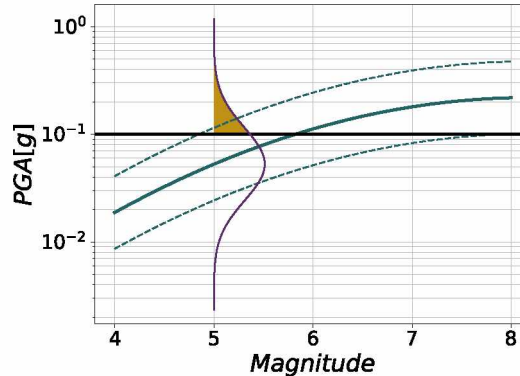
PSHA

Earthquake
catalogs

GMMs



PSHA Matlab (Visini)



The magnitude (**Mw**)-frequency
probability distribution of
earthquakes

$$\log_{10} \lambda_m = a - bm$$

The probability of exceeding a
certain level of motion for a
given scenario
(**Mw**, Distance, Site)

How to deal with different M_w estimates?

- « **Direct** » **Mw estimates**: based on waveform inversions in time or in frequency domain

2005/09/08 11:27:17 Vallorcine eqk

Sources	Published Mw
GCMT	4.60
RCMT	4.50
INGV-TDMT	4.16
SED-TDMT	4.40
Delouis et al. (2009)	4.47
IRSN RAP	4.37

} ΔM_w of 0.44

M_w estimates provided by different sources may differ due to differences:

- in computation methods,
- input data,
- or seismic networks.

→ especially among small-moderate sized events

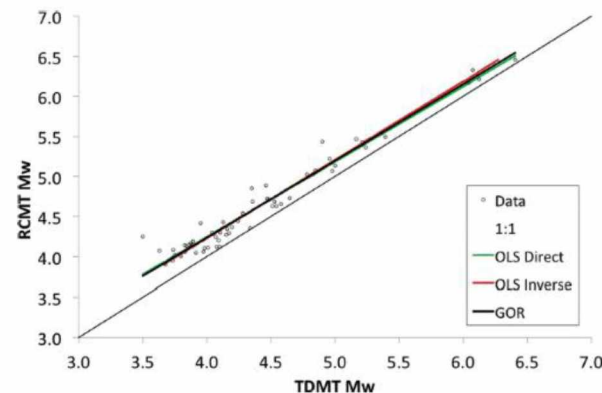
Existing strategies to define a unique Mw (mainly for Mw>4.5)

Ranked in a priority scheme

- ❑ **Europe - EMEC** (Grünthal & Wahlström, 2012) used in the ESM data set
 - a) Specific studies
 - b) SMTS
 - c) RCMT
 - d) Regional catalogs (e.g., CPTI15, ECOS09)
- ❑ **Global - ISC-GEM** (Storchak et al., 2013; 2015; Di Giacomo et al., 2018)
 - a) GCMT
 - b) Specific studies

Unification

- ❑ **Italy - CPTI15 v2.0** (Gasparini et al., 2012; Rovida et al., 2016)
 - reference: GCMT and RCMT and corrections: +0.05 to Mw NEIC, -0.05 to Mw ETHZ, +0.2 to Mw INGV-TDMT
 - Mw in the catalog: weighted average of Mw
- ❑ **Greece** (Konstantinou 2015)
- ❑ **Taiwan** (Kishida et al., 2018)



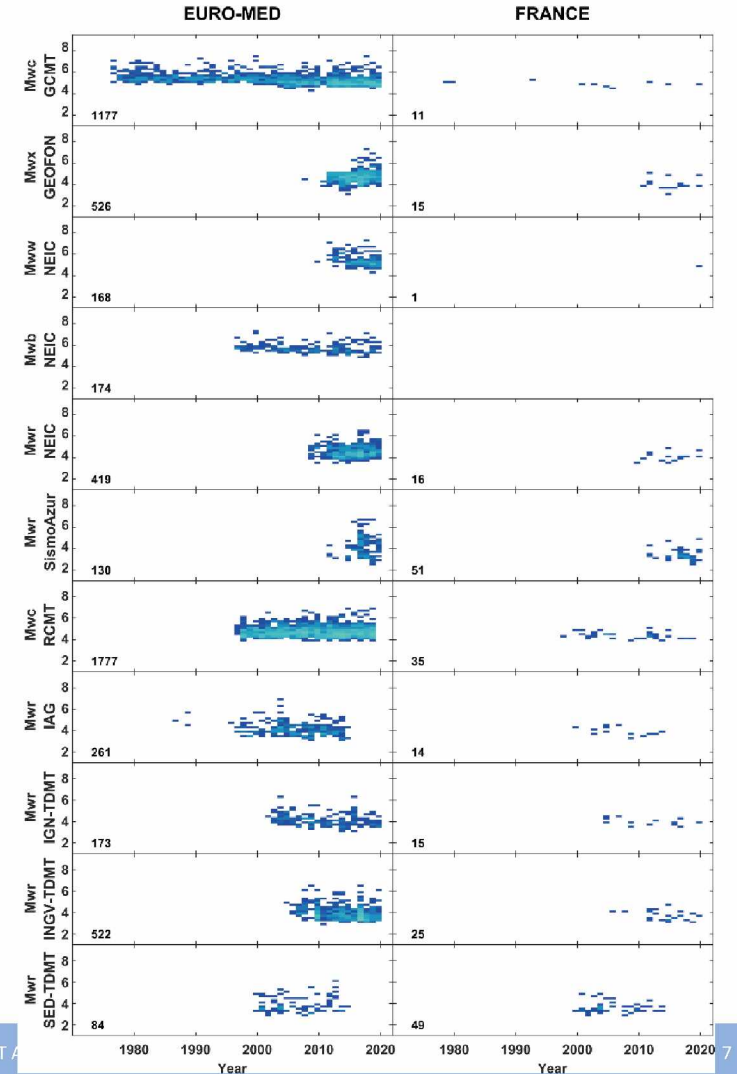
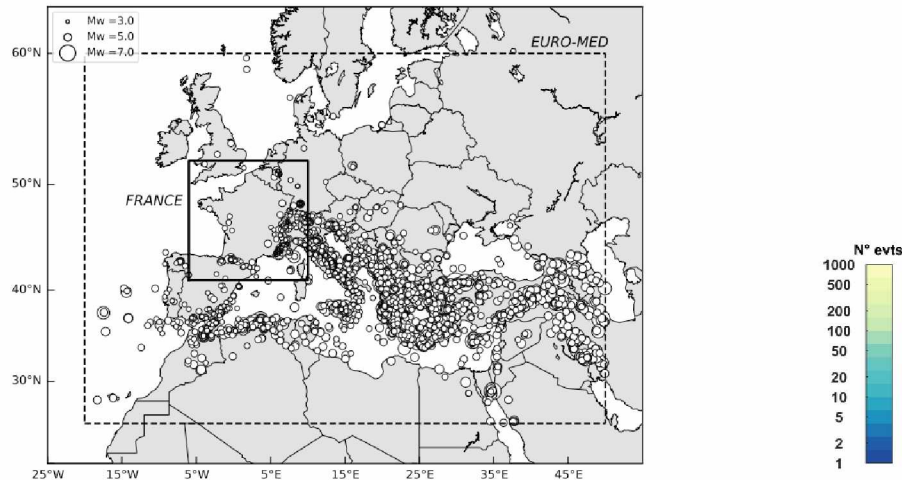
Gasparini et al. (2012)

Our approach aimed at unifying low-to-moderate Mw

- **STEP 1:** Collecting all available Mw directly computed by the seismological services or by specific studies in the Euro-Mediterranean region
- **STEP 2:** Applying a procedure to have a unique and unified Mw value to describe the earthquakes

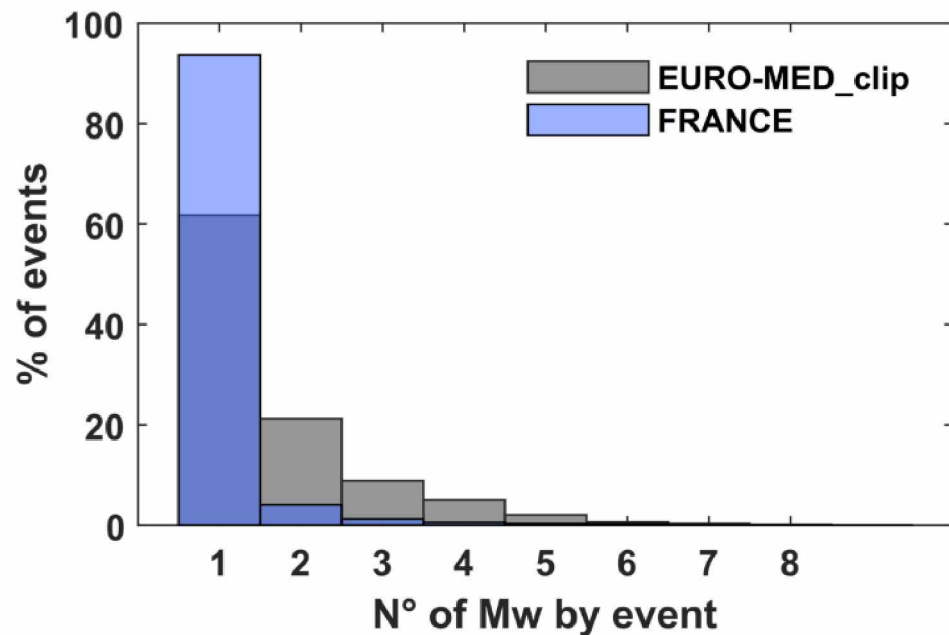
STEP 1: Collection of direct Mw

- From international and regional agencies + specific studies
 - No French agency estimates Mw systematically
 - Few Mw are computed by seismological services for metropolitan France ($M_w \geq 5.5$)
 - In order to compare Mw estimates between sources, we had work at the European scale (EURO-MED)



STEP 1: Collection of direct Mw

- The final data set



6752 direct Mw for 4454 shallow events

(1288 events in France region,
248 events with $M_w \geq 2.5$)

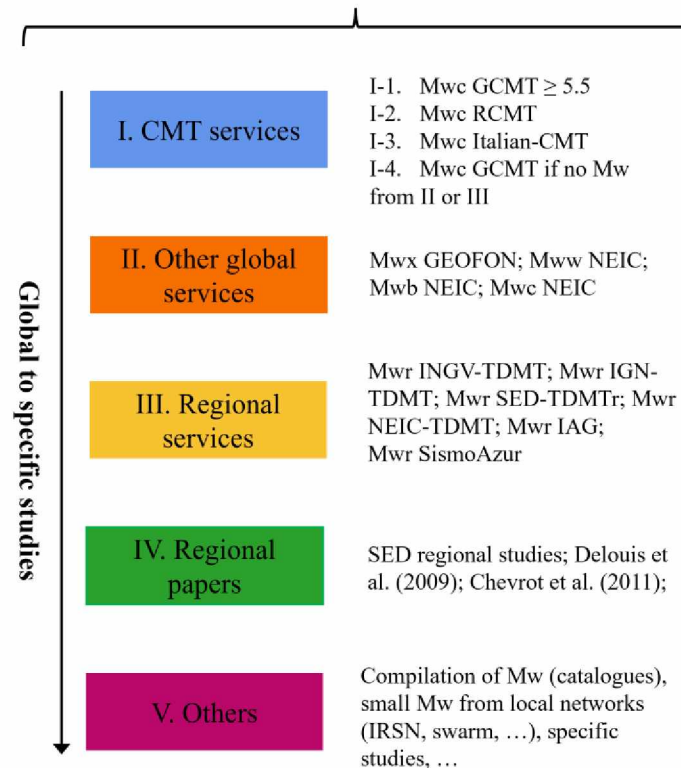
Most events are associated with
only 1 source of Mw,
but from various sources!

And for the other events, we had
to deal with several Mw values.

STEP2: Definition of a unique and unified Mw value

▪ Development of a hybrid strategy

Ranking



Ranking of the sources according to additional criteria based on:

- the method used to compute M_w
- the spatial and temporal coerture
- the metadata it published (reproducibility)

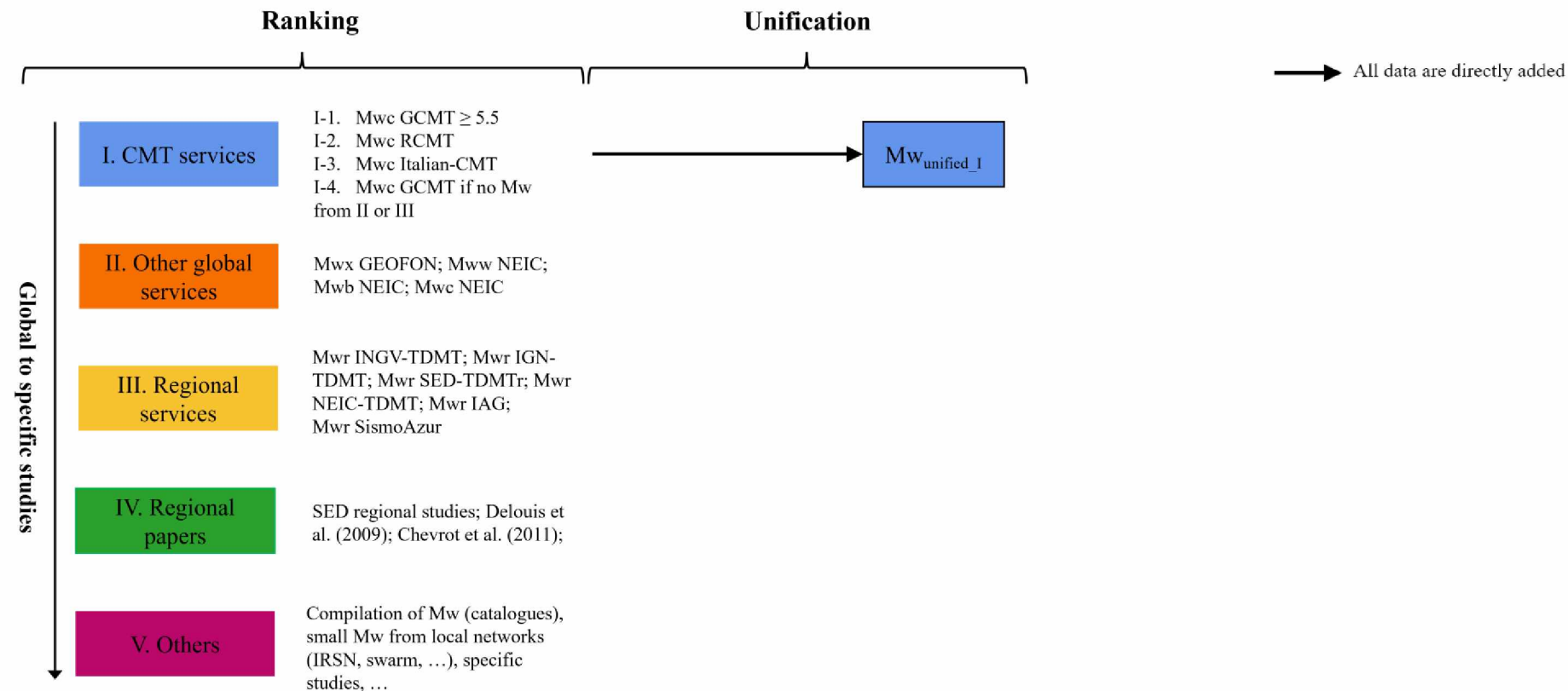
Estimation of M_w following the GCMT standard

$$M_0 = \frac{1}{2} (|\lambda_1| + |\lambda_2|)$$

$$M_W = \frac{2}{3} (\log_{10}(M_0) - 9.1)$$

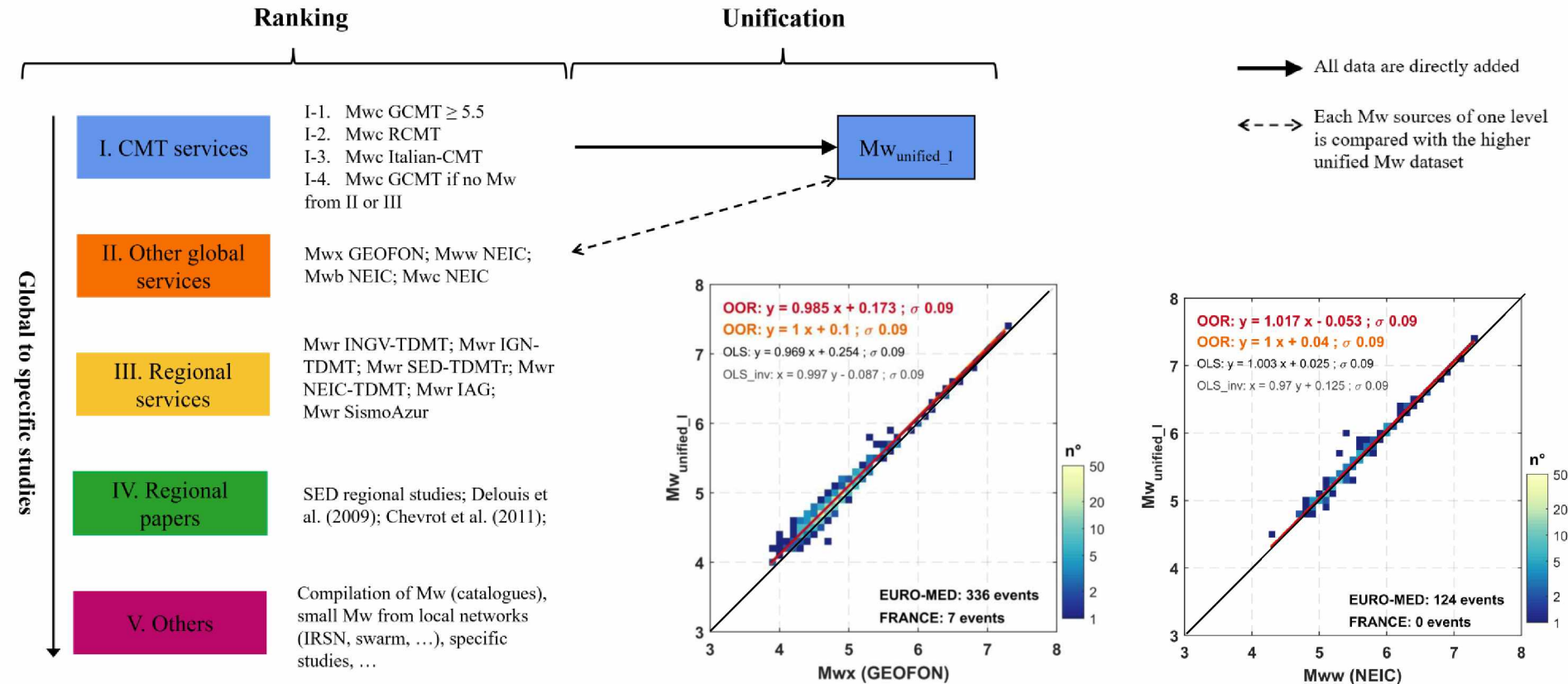
STEP2: Definition of a unique and unified Mw value

▪ Development of a hybrid strategy



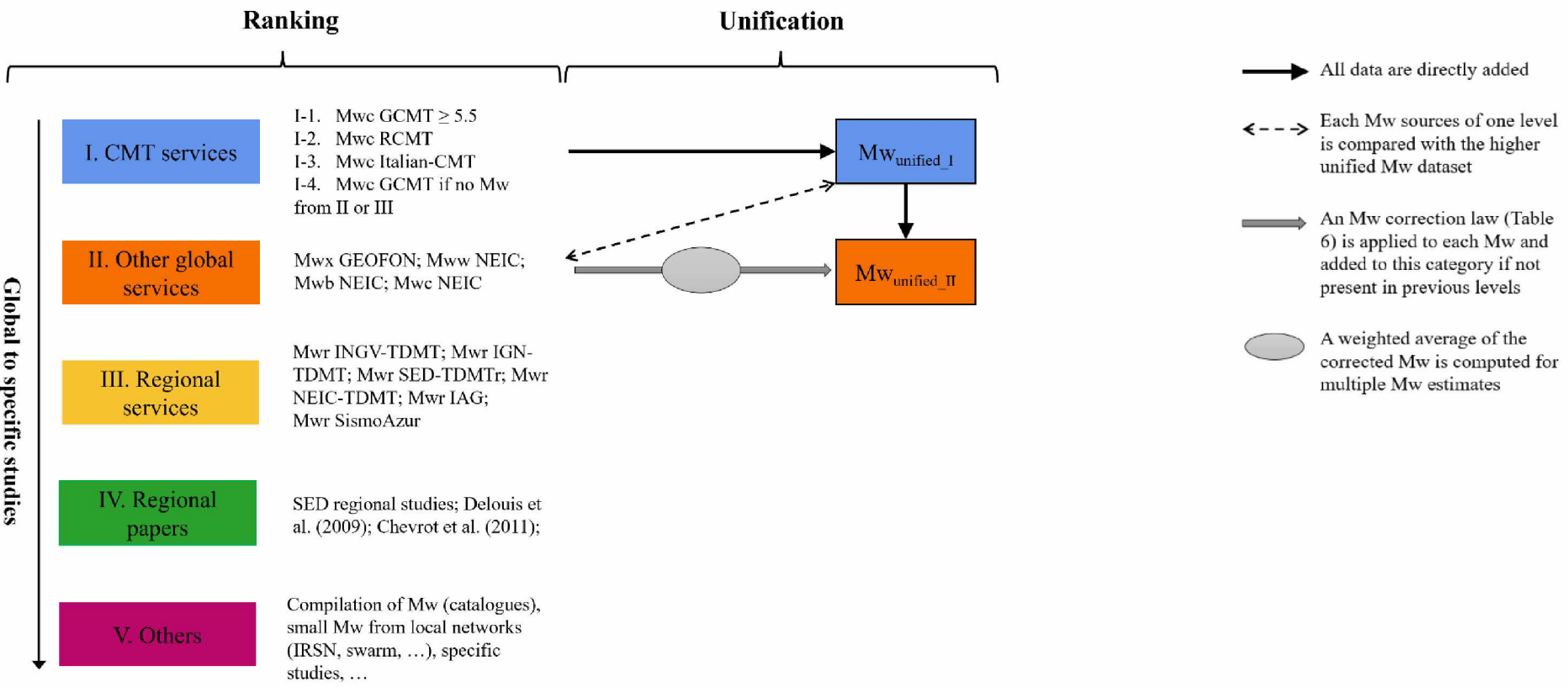
STEP2: Definition of a unique and unified Mw value

Development of a hybrid strategy



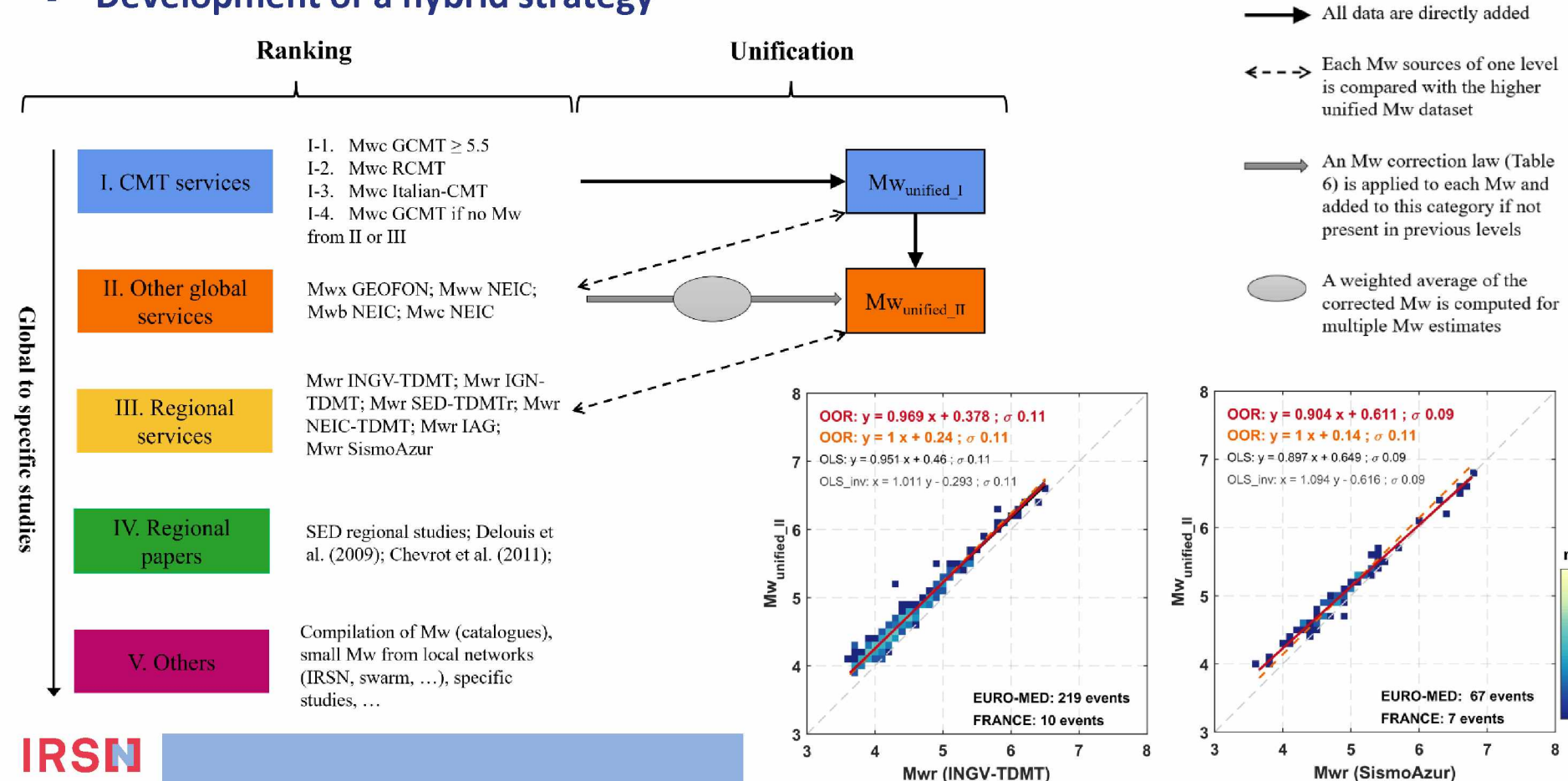
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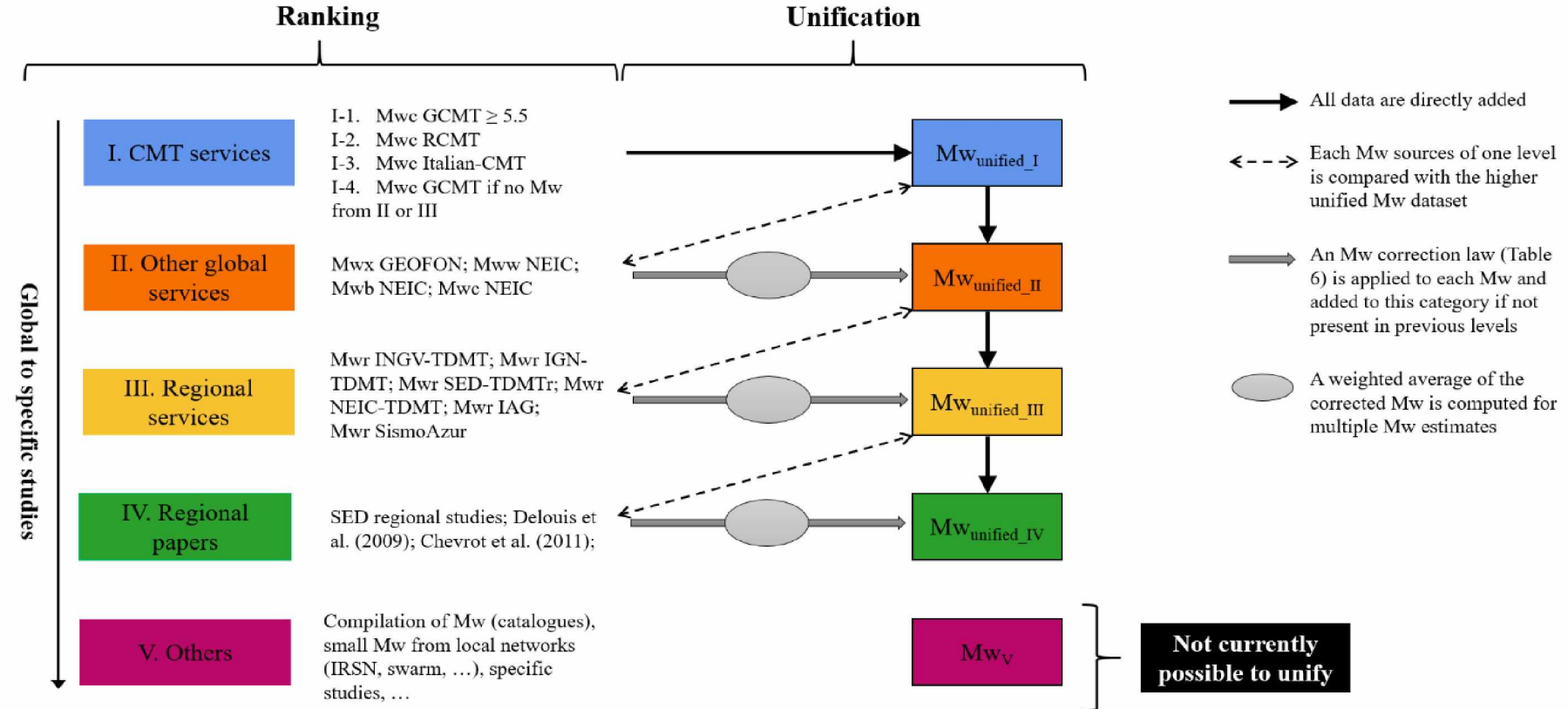
STEP2: Definition of a unique and unified Mw value

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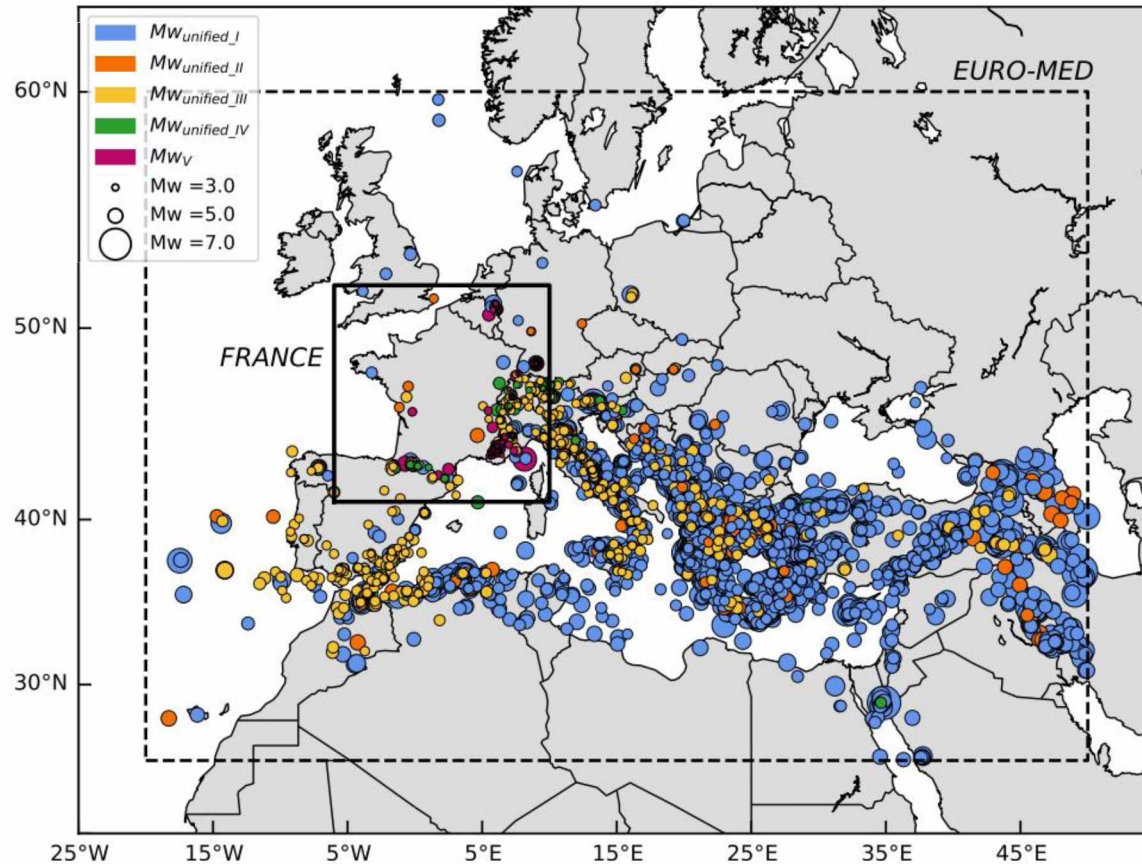
STEP2: Definition of a unique and unified Mw value

Development of a hybrid strategy



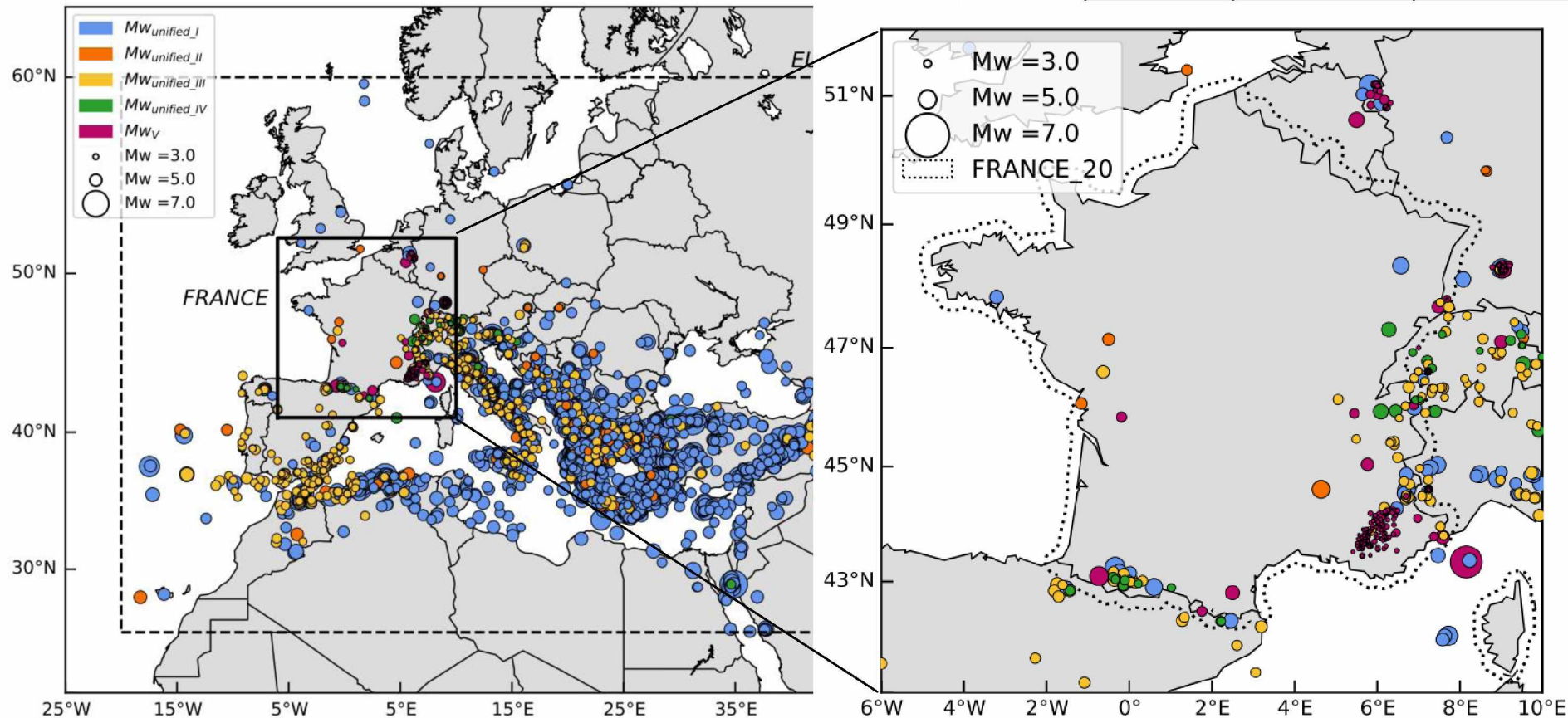
The final unified Mw data set

FRANCE_20	FRANCE	EURO-MED
82	185	3351



The final unified Mw data set

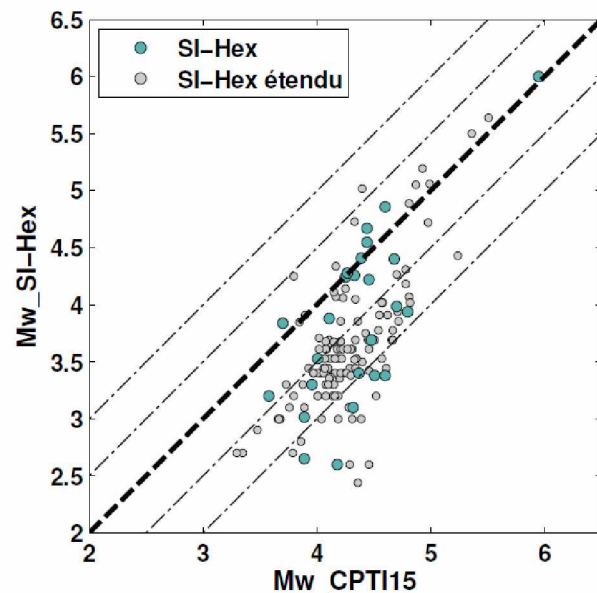
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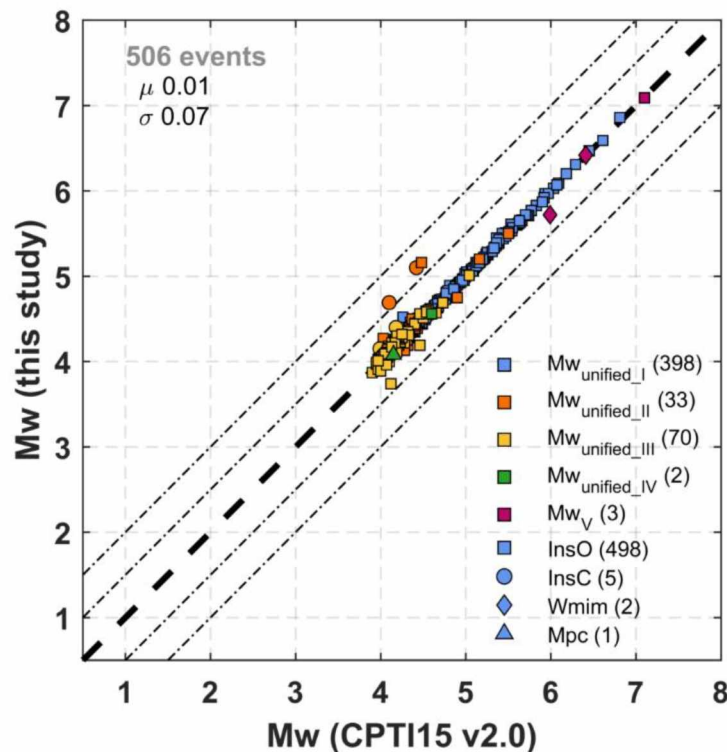
The final unified Mw data set

- Comparing with the Italian catalogue CPTI15 v2.0

PREVIOUSLY



OUR STUDY

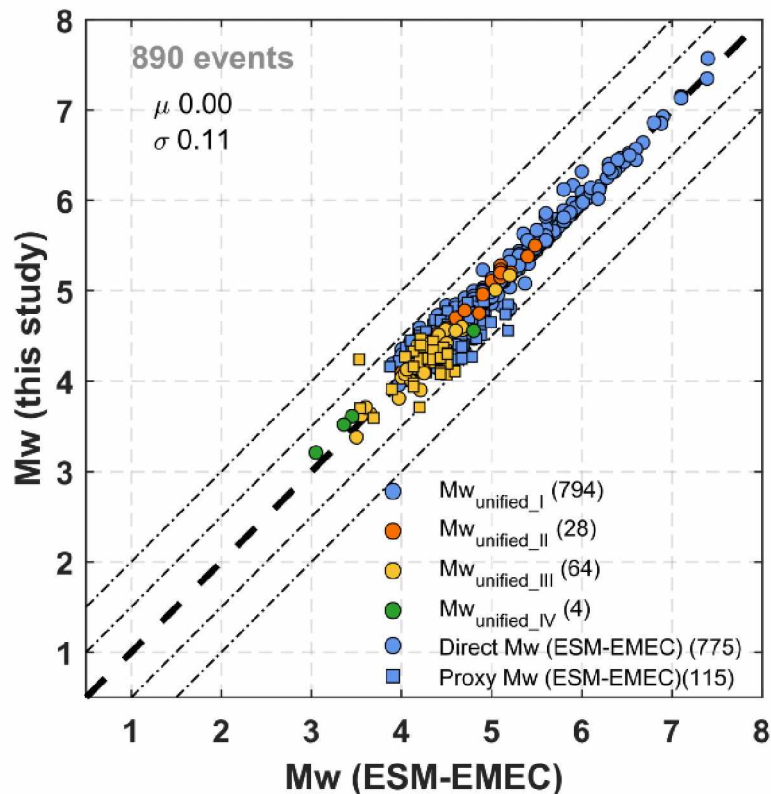


We observe a good fit with the Mw of the CPTI15.

The consistency of the Mw between countries can thus be improved.

The final unified Mw data set

- Comparing with flatfiles of GMMs: ESM-EMEC



- On average, we have a good agreement between the two data sets.
- A larger dispersion is observed for $Mw < 5.0$, especially when Mw are defined from proxies, up to ± 0.5 unit of Mw .
- The ranking of the sources seems to have a greater impact on the differences between data sets than the corrections applied to unify the data.

Conclusions

- We developed a new strategy to associate a unique and unified Mw values for low-to-moderate earthquakes.
- We have built and provided a dataset of 6752 direct Mw from 34 sources (bulletins, publications) concerning 4454 shallow events (depth < 40 km) that occurred between 1963 and 2019 in the Euro-Mediterranean region.
- A unified Mw value could be assigned to 3351 events ($3.1 \leq M_w \leq 7.6$) in the Euro-Mediterranean region and 185 events ($2.4 \leq M_w \leq 5.4$) in the FRANCE region.
- Need to reduce differences in Mw estimates between sources for $M_w < 5.0$ earthquakes
➔ responsible for significant discrepancies between data sets.

Future works

- To develop new magnitude scale conversion laws for France for the events without direct Mw estimates in order to provide a new instrumental earthquake “Mw” catalog for metropolitan France.
- To analyze the impact of the choice of the Mw data set on the GMMs and especially the between-event variability of GMM.

See S. Kotha's talk (at 5pm) for
the model development
AND
see our poster 108 for the
impact study