

CSEP Italy

Giuseppe Falcone

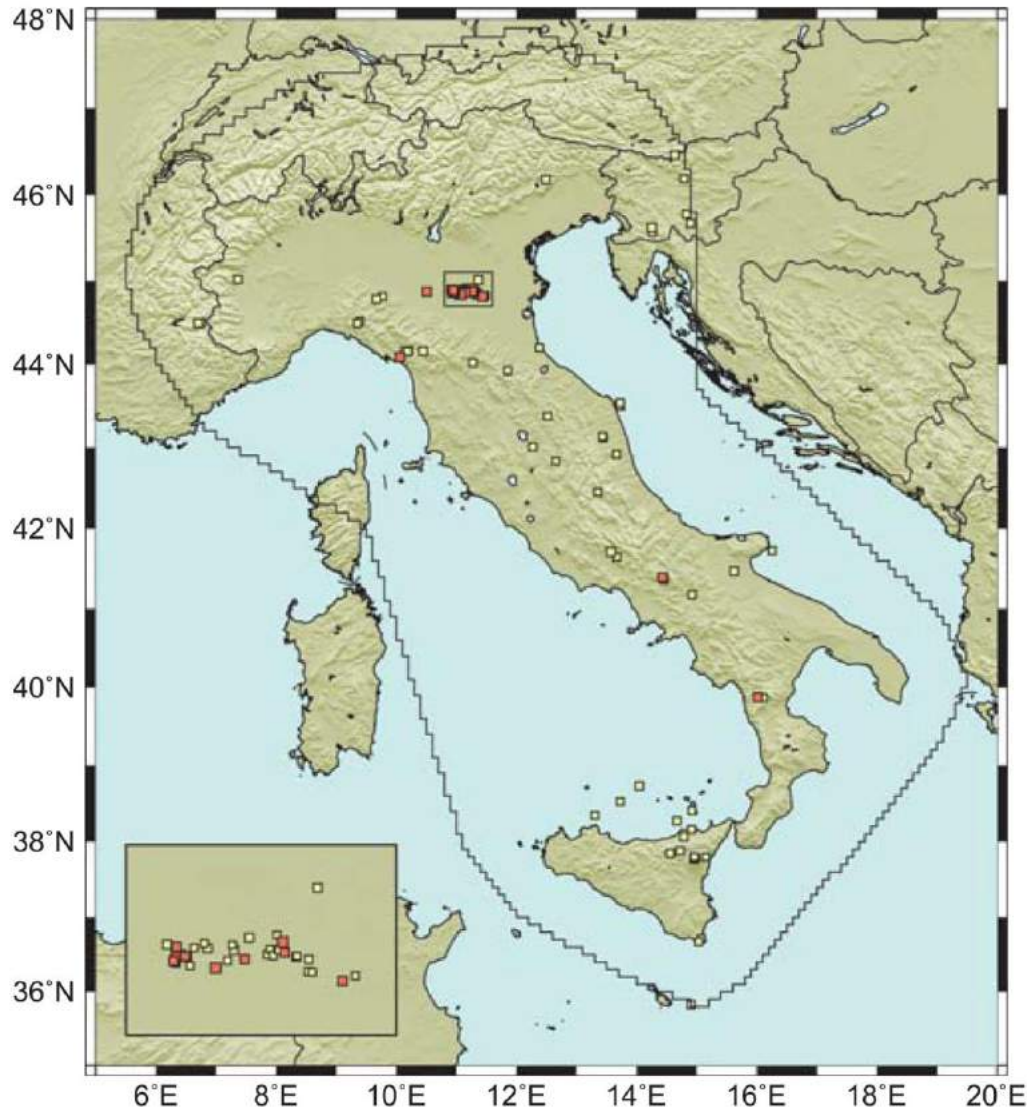
Istituto Nazionale di Geofisica e Vulcanologia

Contributions by **W. Marzocchi, M. Taroni**

Outline of the talk

- ❑ CSEP Italy Results
- ❑ The importance of CSEP in OEF
- ❑ OEF in Italy, new perspectives

CSEP Italy Results



Test

Time: 1 August 2009 – 31 July 2014

1-day forecasts: 1826

Space: Italy inside the black area

Target events (M 3.95+): 97

Model Submitted

ETAS LM

ETES FMC

STEP NG

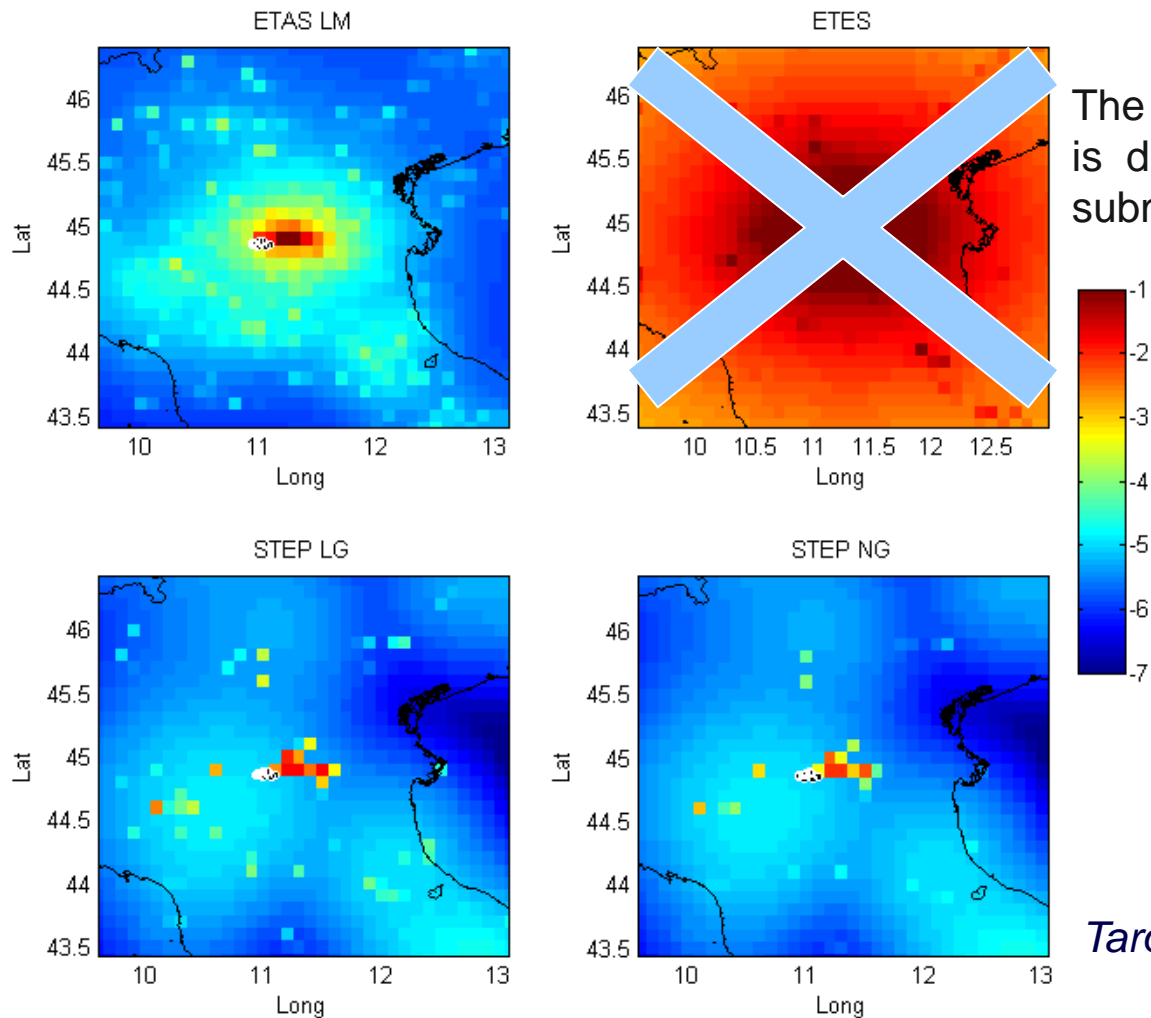
STEP LG

Sequence

2012 Emilia Romagna

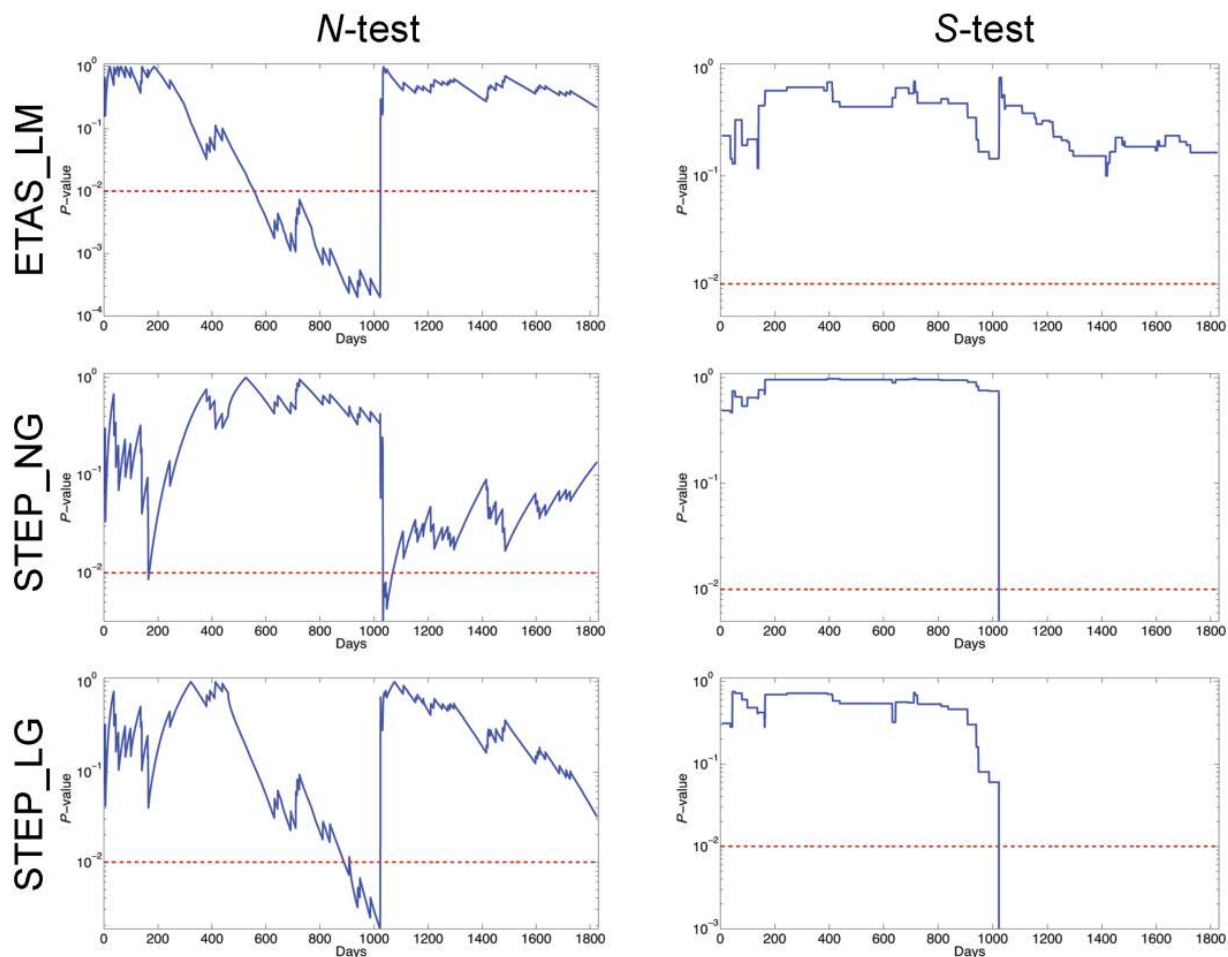
Taroni et al. (2018)

One-day forecasts for 29 May 2012



The overprediction of the ETES model is due to a bug in the software code submitted in the test center.

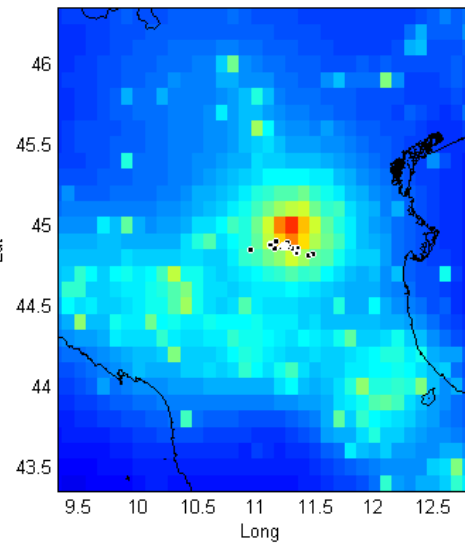
Taroni et al. (2018)



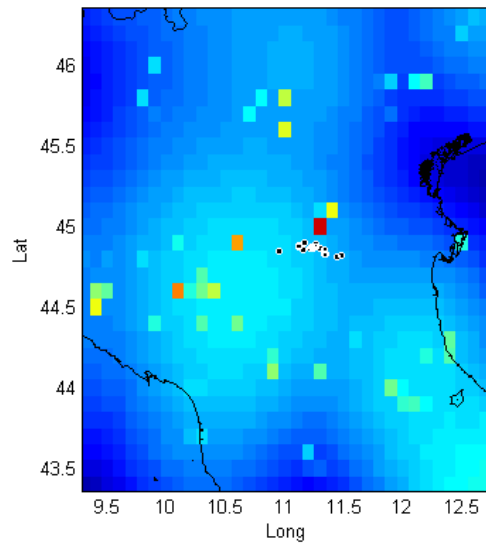
Emilia sequence
Taroni et al. (2018)

CSEP Italy Results

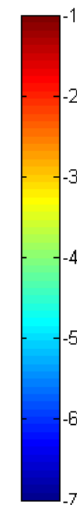
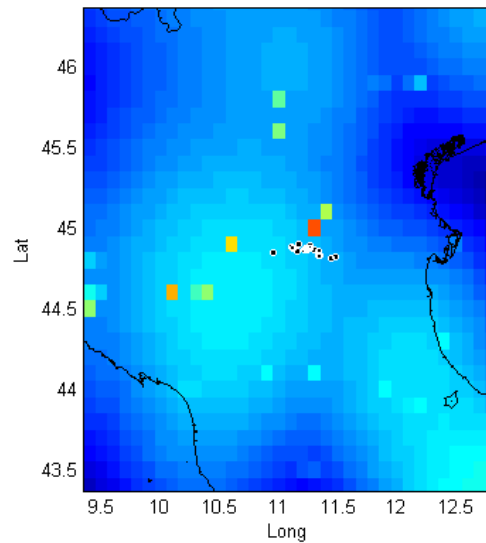
ETAS LM



STEP LG

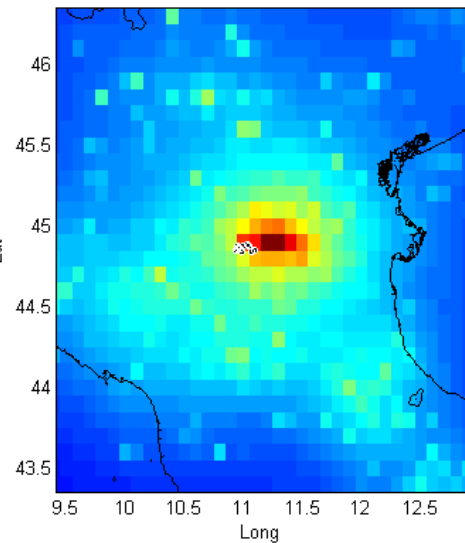


STEP NG

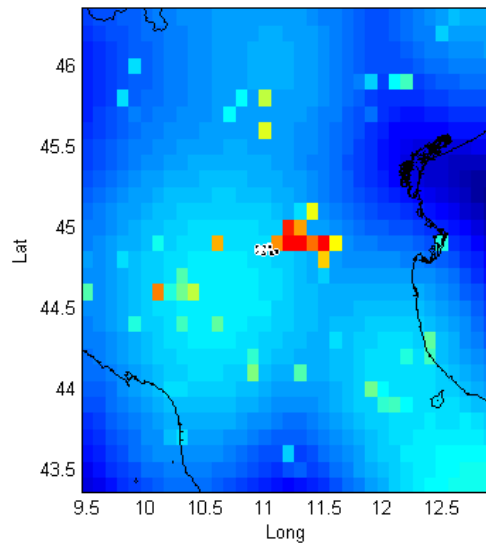


May, 20 2019
Mw 6.1

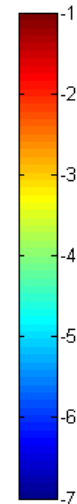
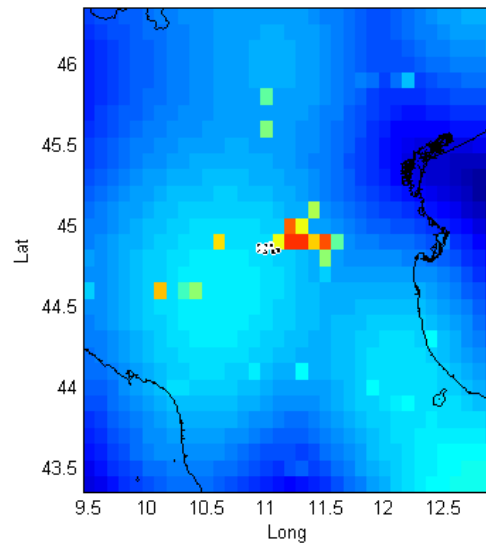
ETAS LM



STEP LG



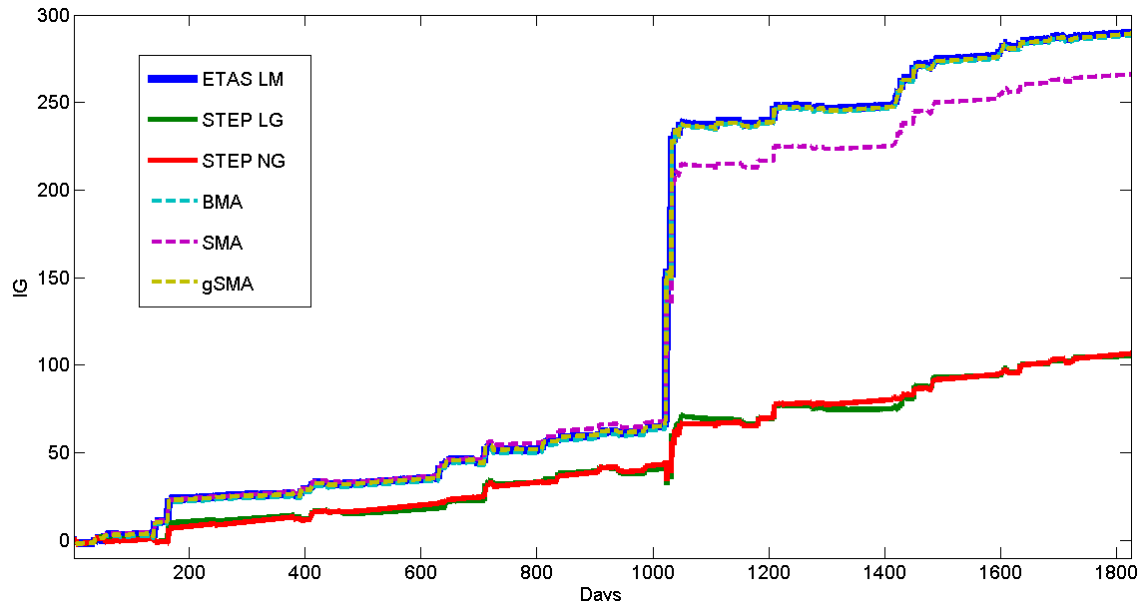
STEP NG



May, 29 2019
Mw 5.9

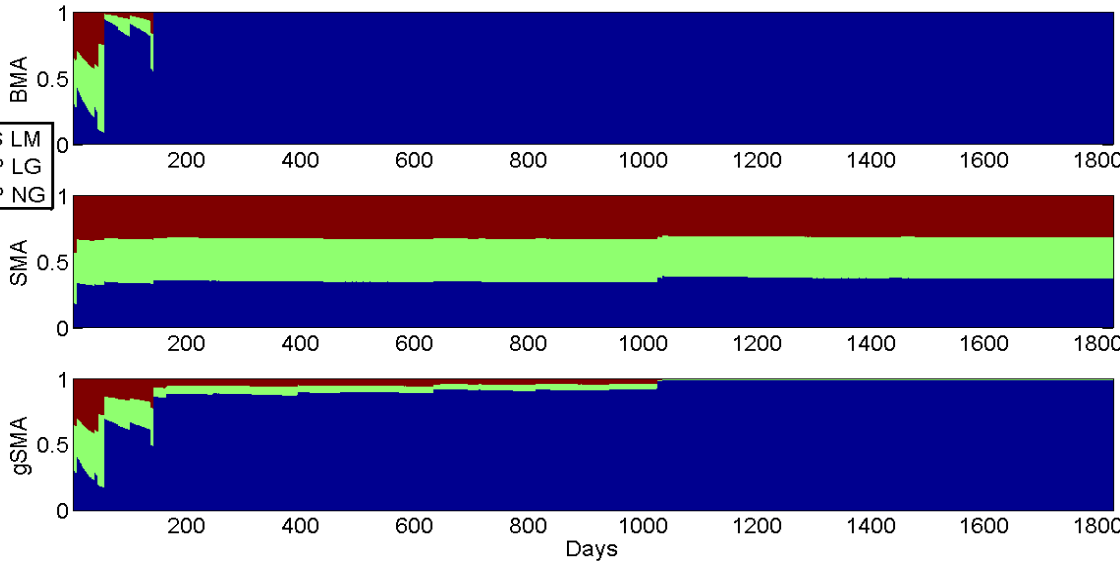
Taroni et al. (2018)

CSEP Italy Results



ensemble models

Cumulative information gain



Weight of each model as function of the time

Taroni et al. (2018)

The importance of CSEP in OEF Italy

The importance of CSEP in OEF Italy

ANNALS OF GEOPHYSICS, 53, 3, 2010; doi: 10.4401/ag-4848

The ETAS model for daily forecasting of Italian seismicity in the CSEP experiment

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Article history
Received October 30, 2009; accepted August 16, 2010.
Subject classification:
Earthquake probability, Forecasting, Italian seismicity, Hypothesis test, Aftershocks.

ABSTRACT
This study investigates the basic properties of the recent shallow seismicity in Italy, through stochastic modeling and statistical methods. Assuming that earthquakes are the realization of a stochastic point process, we have modeled the occurrence rate density in space, time and magnitude using an epidemic type aftershock sequence model. By applying the maximum likelihood procedure, we estimated the parameters of the model that best fit the Italian instrumental catalog, as recorded by the Istituto Nazionale di Geofisica e Vulcanologia (INGV) from April 16, 2005, to June 1, 2009. Then we applied the estimated model to a second independent dataset (June 1, 2009, to September 1, 2009). We show that the model performed well on this second database, through the relevant statistical tests. The model proposed

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ANNALS OF GEOPHYSICS, 53, 3, 2010; doi: 10.4401/ag-4812

Building self-consistent, short-term earthquake probability (STEP) models: improved strategies and calibration procedures

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² Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, USA
³ GNS Science, Avalon, Lower Hutt, New Zealand

Article history
Received October 23, 2009; accepted April 13, 2010.
Subject classification:
Earthquake statistics, Earthquake forecasting, Likelihood testing, Aftershock model, Seismicity analysis.

ABSTRACT

We present two self-consistent implementations of a short-term earthquake probability (STEP) model that produces daily seismicity forecasts for the area of the Italian national seismic network. Both implementations consider a time-varying and a time-invariant contribution, for which we provide the best fit to documented global seismicity in time-varying

frameworks such as epidemic type aftershock sequence (ETAS) models and short-term earthquake probability (STEP) models are used for automated, near-real-time applications (e.g., Console et al. 2003, Gerstberger et al. 2005, Helmstetter et al. 2006, Mazzocchi and Lombardi 2008). Both of these frameworks can adapt to ongoing earthquake sequences by re-estimating model parameter values and automatically generating forecasts that account for the most recent seismicity. Physics-based models that combine calculations of stress changes with a rate-and-state friction

ANNALS OF GEOPHYSICS, 53, 3, 2010; doi: 10.4401/ag-4710

Short-term and long-term earthquake occurrence models for Italy: ETES, ERS and LTST

Giuseppe Falcone^{1,*}, Rodolfo Console¹, Maura Murru¹

¹ Istituto Nazionale di Geofisica e Vulcanologia, sezione di Roma, Italy

Article history
Received October 1, 2009; accepted April 22, 2010.
Subject classification:
Earthquake interactions and probability, Statistical analysis, Stress, Historical seismology, Earthquake faults.

ABSTRACT

This study describes three earthquake occurrence models as applied to the whole Italian territory, to assess the occurrence probabilities of future (M > 3.0) earthquakes: two as short-term (24 hours) models, and one as long-term (1 and 10 years). The first model, for short-term forecasts is a purely stochastic epidemic type earthquake sequence (ETES) model. The second (short-term) model is an epidemic rate state (ERS) forecast based on a model that is physically constrained by the application to the earthquake clustering of the Dieterich's rate state constitutive law. The third forecast is based on a long-term stress transfer (LTST) model that considers the perturbations of earthquake probability for interacting faults by static Coulomb's stress changes. These models have been submitted to the Collaborative for the Study of Earthquake Predictability (CSEP) for forecast testing for Italy (ETH Zurich), and they were tested down to test their validity on real data in a future setting starting from August 1, 2009.

Helmstetter et al. 2006]. These models were proposed to answer the most common questions of the general public and the media that arise in particular after sizable events, such as «What will happen next?» and, «What is the chance that another large earthquake will occur?».
Stochastic short-term models describe seismicity as a random point process, for which a continuous space-time density distribution of the earthquake occurrence can be defined. A best-fit procedure based on the maximum likelihood criterion has been used for statistical analysis of random processes. In particular, Kagan and Knopoff (1976, 1987), Kagan (1993), Cigato (1999), Kagan and Jackson (2000), Cecceile and Murru (2001), Imoto (2004), Ribiccioli and Fritson (2006), and Helmstetter et al. (2006) have applied the

No singles models are used!

ENSEMBLE forecasting model. Each model is **weighted** according to its forecasting performances)

Selected models (constraints)

The models must be submitted to at least one **CSEP** experiment.

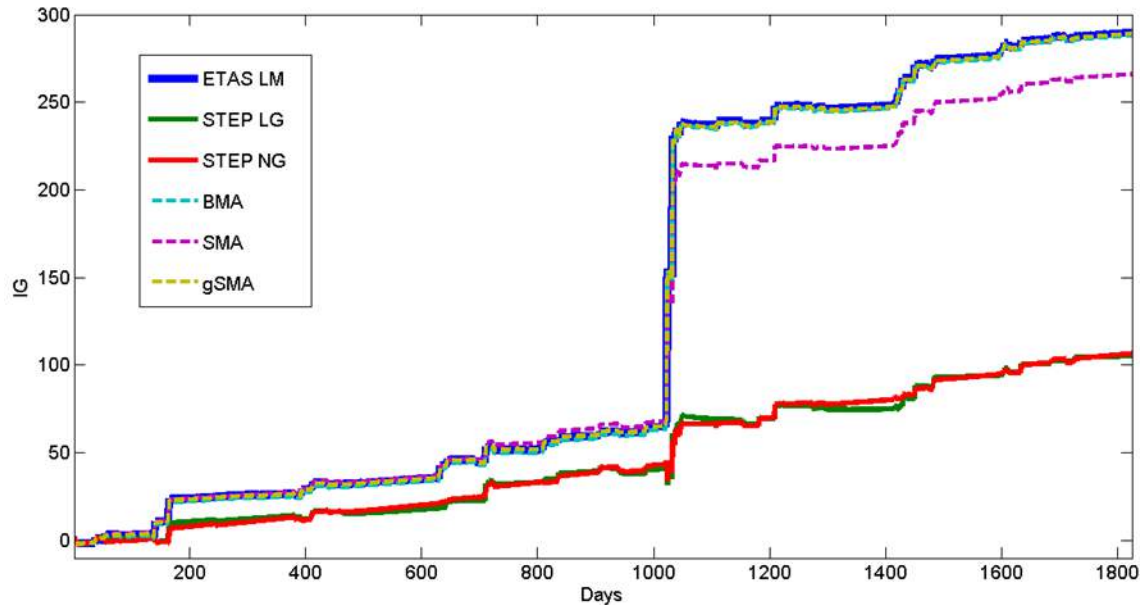
The test in CSEP experiment indicates the scientific robustness of these models for the potential uses in operational earthquake perspective.

The importance of CSEP in OEF Italy

The OEF without the CSEP



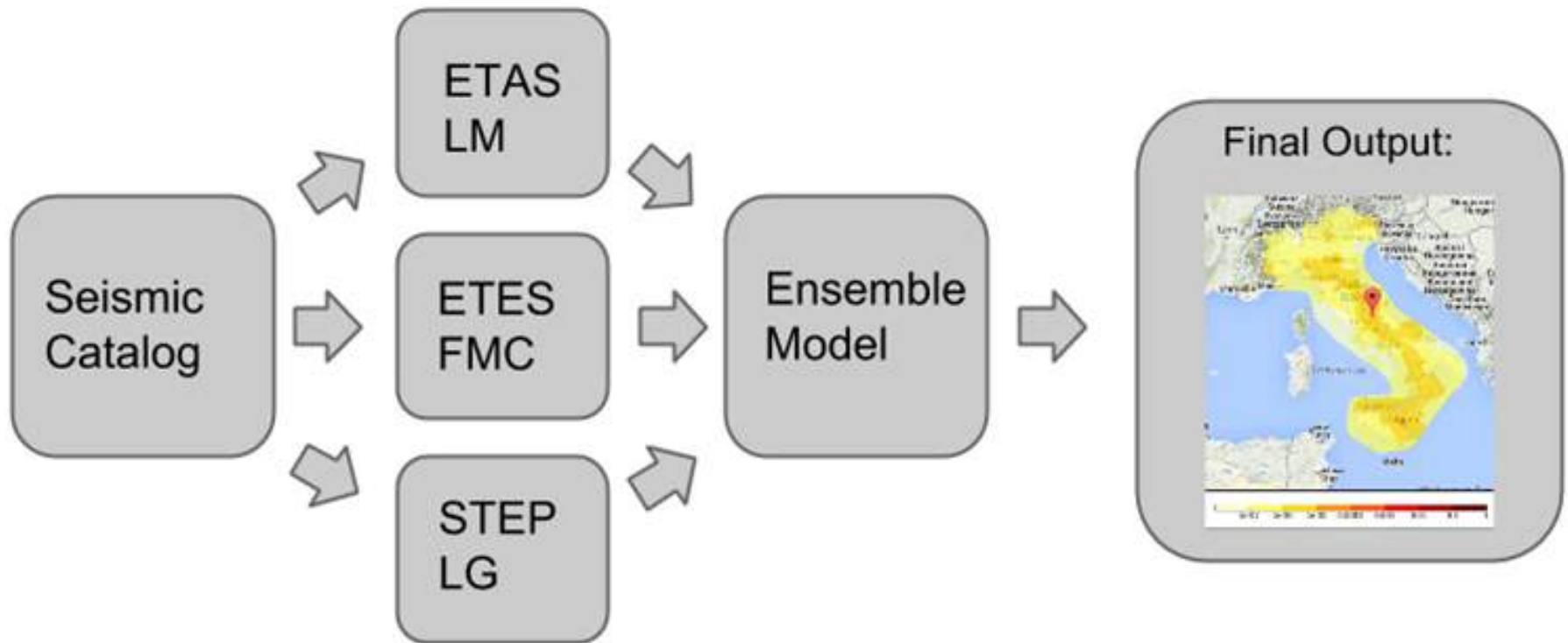
The importance of CSEP in OEF Italy



Ensamble models

The ensemble models perform well in the 1-day testing class; they pass the N- and S-Test and show IG comparable to the best performing model (ETAS_LM)

OEF in Italy, new perspectives



OPERATIONAL EARTHQUAKE FORECAST 4 - Italy

Current weekly Probability :

MMI 6+ **MMI 7+** MMI 8+ MI 4+ MI 5.5+

Lat / Long /

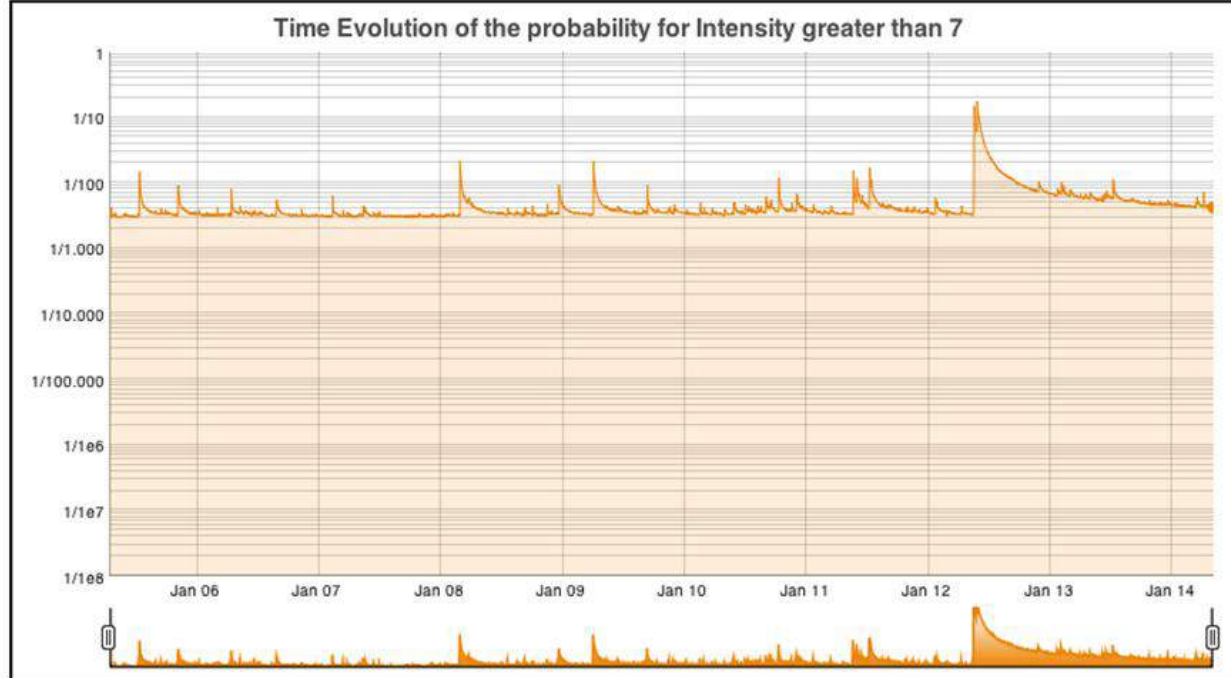
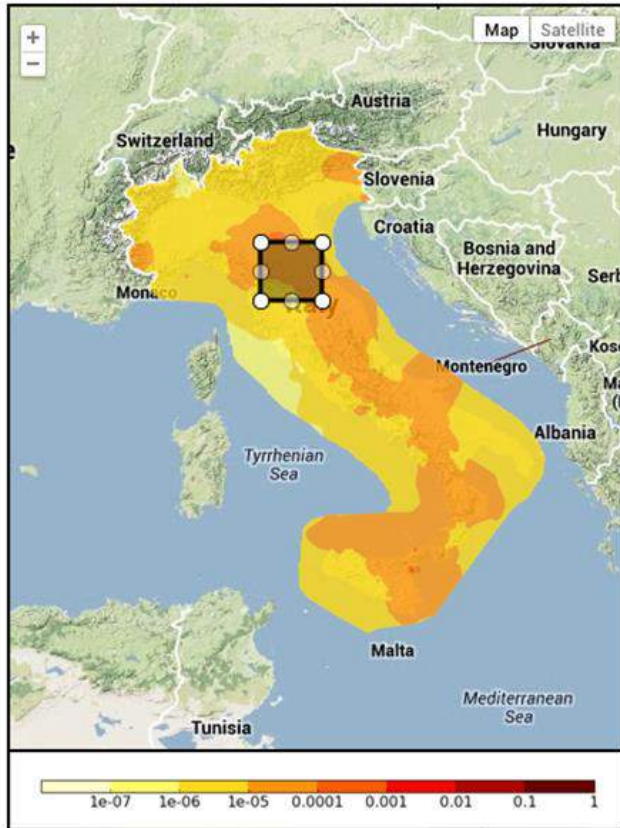
get the time evolution of the weekly probability in the selected area

last run: 2014/05/08 00:00
area probability 4.22e-3

Center (Location): Dimension (km):

get the time evolution of the weekly probability in the selected area

2014/05/08:
area probability:0.004



OEF products

Every day at midnight:

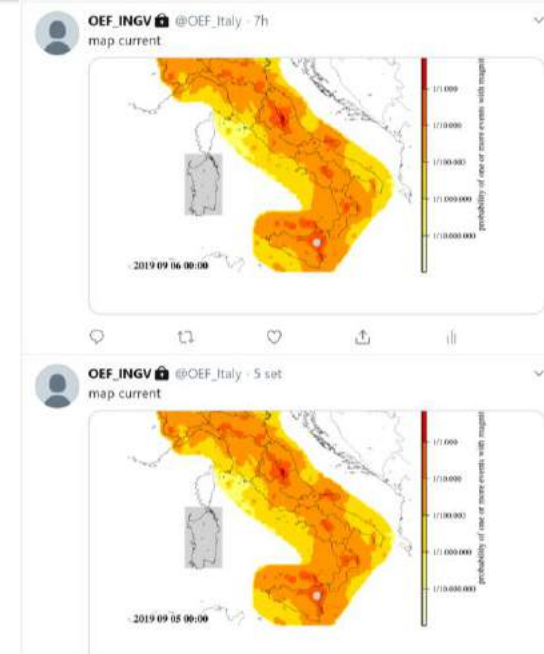
- calculates the weight of the model with the seismicity occurred in the previous week;
- provides the new probability (MI 4+, MI 5.5+, MMI 6+, MMI 7+, MMI 8+) values for the next week;
- send the map with the probability of one or more events with MI 4+ in a private tweet

When occurred an event with MI 3.5+:

- provides the new probability (MI 4+, MI 5.5+, MMI 6+, MMI 7+, MMI 8+) values for the next week;
- send the map with the probability of one or more events with MI 4+ in a private tweet

When occurred an event with MI 5.0+:

- provides the new probability (MI 4+, MI 5.5+, MMI 6+, MMI 7+, MMI 8+) values for the next week;
- send the map with the probability of one or more events with MI 4+ in a private tweet
- send an email with an pdf attached (earthquake notification report)



Mercoledì 18 Gennaio 2017 ore 14:01:58 UTC

SEQUENZA SISMICA IN CORSO

Centro di Protezione Sismica (CPS)

Istituto Nazionale di Geofisica e Vulcanologia

Operazioni Funzionali al Dipartimento di Fisica e Astronomia

Versione Predefinita

Realtà Virtuale 3D Geo-2017 16/10/06/UTC

Terremoto

Magnitudo 2.8 MS

Tempo origine: 18 Gen 2017 15:41:58 (ora locale)

18 Gen 2017 14:01:58 UTC

Coordinate sismocentrale: 11.47, 42.82°N 13.31, 42°E

Profondità: 7.0 km

Comuni interessati

MS 2.5 - 3.0

ACQUOLA

ANAGNINO

STIME PER I PROSSIMI 7 GIORNI (in un'area di 30 km dall'epicentro)

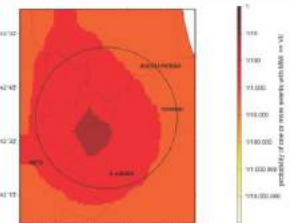
Probabilità di accadimento per intensità superiore al grado VII della scala Mercalli

2.1% (ovale 2%)

Probabilità di accadimento per intensità superiore al grado VIII della scala Mercalli

47.6% (ovale 3.4%)

Valore medio superiore agli 11 minuti dopo terremoto di magnitudo superiore a 5.5



OEF in Italy, new perspectives

In the 2020 the map will be public and posted in a dedicated webpage. In the page will be present:

- a Italian map with the probability of one or more events with MI 4+;
- a video that shows the evolution of the probability (starting from 1 January 2018 up to last map created for the system);
- A link for the earthquake notification report for the events with MI 5.0+;
- a section about the information that the map and video provide.

In this moment the webpage is evaluated to check the impact of the information to different level of the society (housewives, workers, students, researchers ecc.....).

The screenshot displays the INGV CPS website interface. At the top, there are four tabs for seismic hazard: "Pericolosità sismica a rischio sismico", "Pericolosità sismica a lungo termine in Italia", "Pericolosità sismica a medio termine in Italia", and "Pericolosità sismica a breve termine in Italia". The main content area features a large map titled "Pericolosità sismica a breve termine in Italia" showing hazard levels across Italy. To the left, there is a sidebar with sections for "NEWS", "CPS", "APPROFONDIMENTI", and "LINK UTILI".

Cosa mi mostra questa mappa?

Questa mappa mostra la probabilità, per ogni zona d'Italia (PI) che nei prossimi 7 giorni si verifichi uno scuotimento del terreno tali da produrre effetti del VI grado di intensità Mercalli o superiori. Sono questi scuotimenti che possono danneggiare gli edifici, per lo meno quelli non costruiti in terra e più vulnerabili. Ogni punto rappresenta approssimativamente un quadrato di una decina di km di lato, e le gradazioni di colore rappresentano diverse probabilità. La mappa somministra alcuni elementi fondamentali: la probabilità di una calamità sismica di intensità VI o superiore non è mai zero da nessuna parte. Ciò significa che un terremoto può avvenire ovunque e in un qualunque momento. Tale probabilità non è costante nello spazio: ci sono cioè aree dove la probabilità è più alta che in altre. E non è costante nel tempo: in caso di attività sismica in corso, la mappa di oggi è diversa da quella di giorni scorsi e sarà diversa fra pochi giorni.

FOCUS: Sequenza sismica In zampo - 18 gennaio 2017

Cosa mi mostra questo video?

Questo video contiene una collezione temporale di mappe: ogni mappa mostra la probabilità, per ogni zona d'Italia (PI) che nei 7 giorni successivi si verifichi uno scuotimento del terreno del VI grado di intensità Mercalli o superiore. Questa probabilità è calcolata in celle con approssimativamente 10 km di lato, e le gradazioni di colore rappresentano diverse probabilità. Le mappe sono prodotte ogni giorno oppure dopo un terremoto di magnitudine 3.5 o superiore.

Si noti che tale probabilità non è mai zero da nessuna parte: ciò significa che un terremoto può avvenire ovunque e in un qualunque momento. Tale probabilità non è costante nello spazio: ci sono cioè aree dove la probabilità è più alta, talmente si può vedere anche che questa probabilità non è costante nel tempo: la probabilità settimanale in un'area interessata da una sequenza sismica cambia nel tempo.

PI La Sardegna e la zona dell'Etna appaiono in grigio perché i modelli attuali non sono in grado di fornire stime accurate per queste aree. La Sardegna perché è una zona con una attività sismica molto bassa e con poche informazioni storiche. La zona dell'Etna perché è un vulcano molto attivo con l'attività sismica complessa e perché ha necessita di una modellazione ad hoc. Il CPS sta lavorando per sviluppare modelli adeguati anche per queste aree.

Perché la probabilità a breve termine cambia frequentemente?

Future work:

CSEP

- test the models for the period 2014-2019;
- introduce new testing tool (RISE Project);
- develop new earthquake forecast models (RISE Project);

OEF

- synthetic events replishment in the hours after the mainshock (incompleteness catalog);
- insert new models in the ensemble;
- change the actual model weight procedure (from SMA to gSMA or BMA);
- insert in result of the hybrid model the uncertainties to each single model;
- migrate all system code in Python and sharing it in GitHub.

Thanks for your attention