A time dependent model of elastic stress in the Central Apennines, Italy

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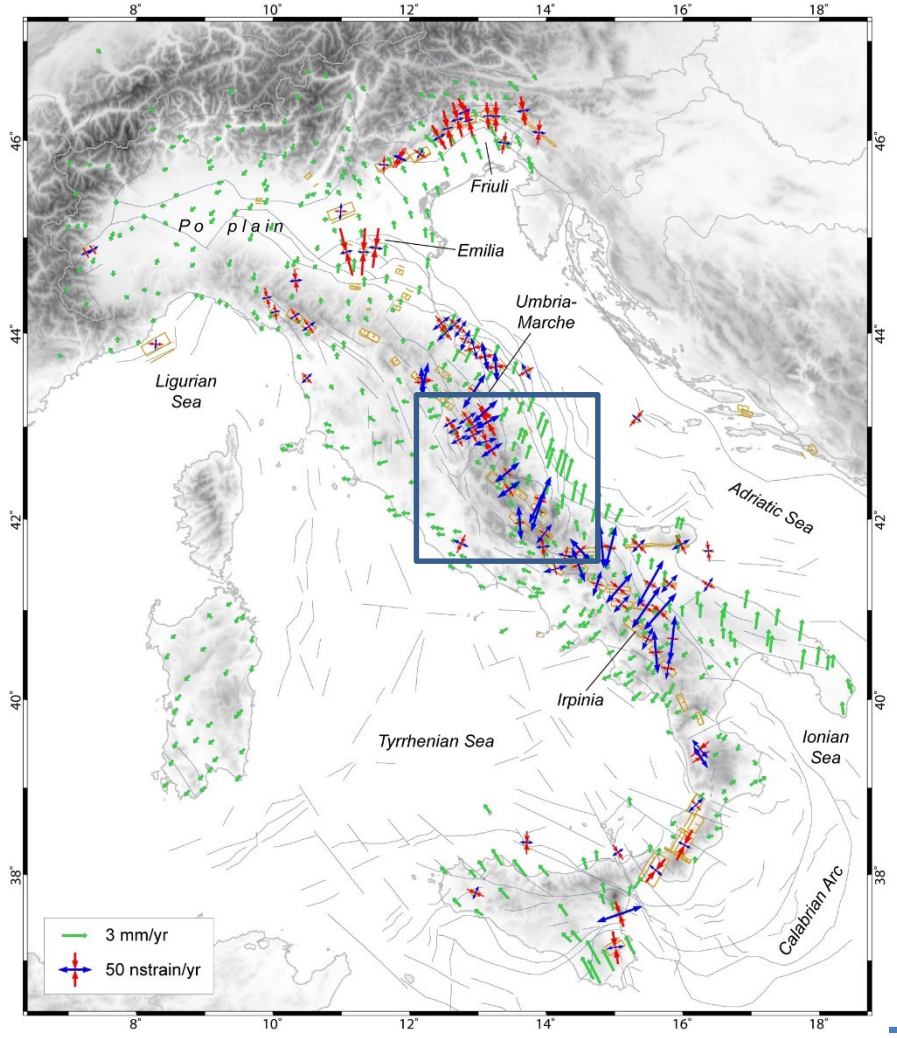
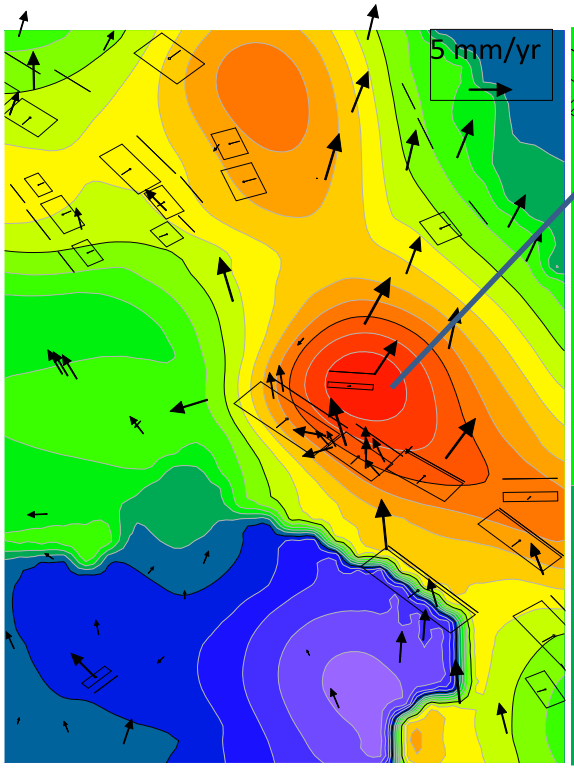
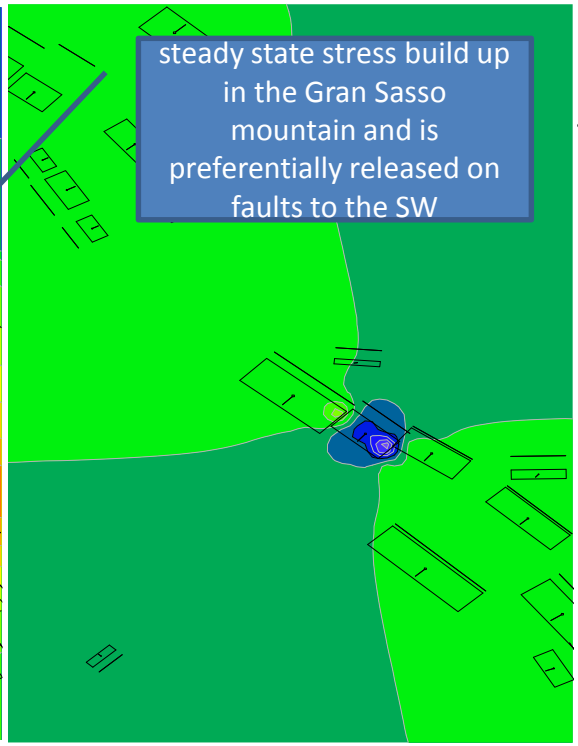
- GNSS inferred stress buildup on active faults in central Apennines
- Stress balance requires stress release
- Seismic catalogue + Okada: stress released by earthquakes in the past 700 years can be estimated
- Calibrate regional stress rate so that the faults are in a state of stress consistent with observed moment tensor of recent earthquakes
- Identify potential seismic gaps, where stress has increased but not yet released



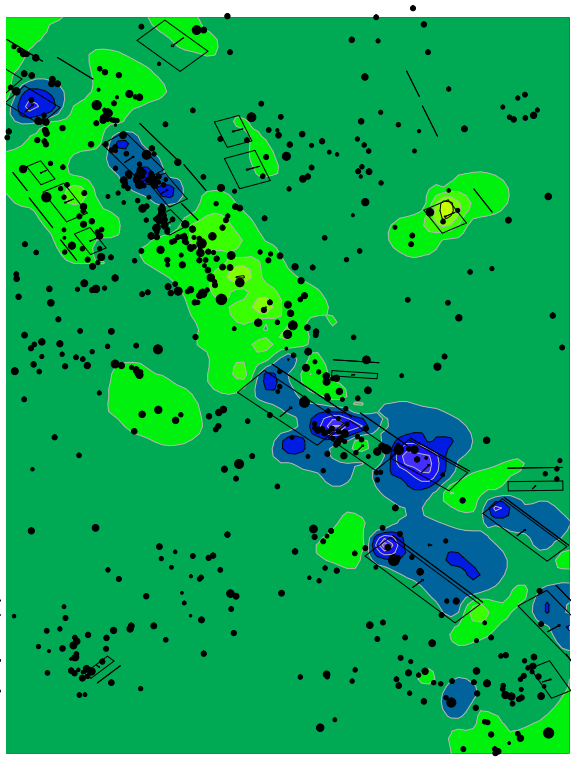
- The Central Apennines are in a state of extensional stress, with the tension orthogonal to the belt (NE to SW)
- Most earthquakes (e.g. Colfiorito, L'Aquila, Amatrice-Norcia) mirror this state of stress
- Geophysical data (in situ stress measurements) point to extensional stress
- GNSS velocities are divergent in a ETRF2000 frame → extensiona strain rate
- Question: can we calibrate the geodetic strain/stress rate so that we maintain the region in a state of tensional stress?



Calibrated regional stress: GPS stressrate*2000yrs

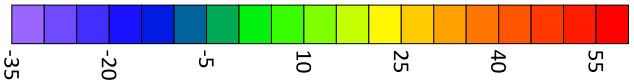


Stress released by current event (L'Aquila 2009)



Stress released by 33 previous events (1315-2009-)

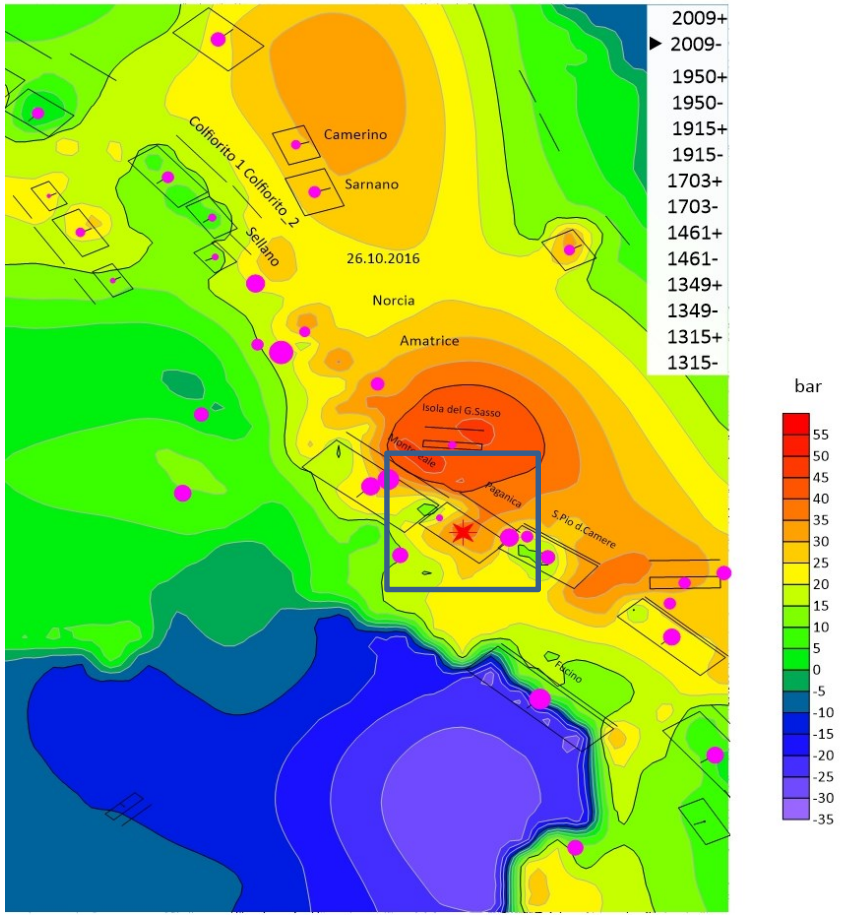
bar



L'Aquila test case

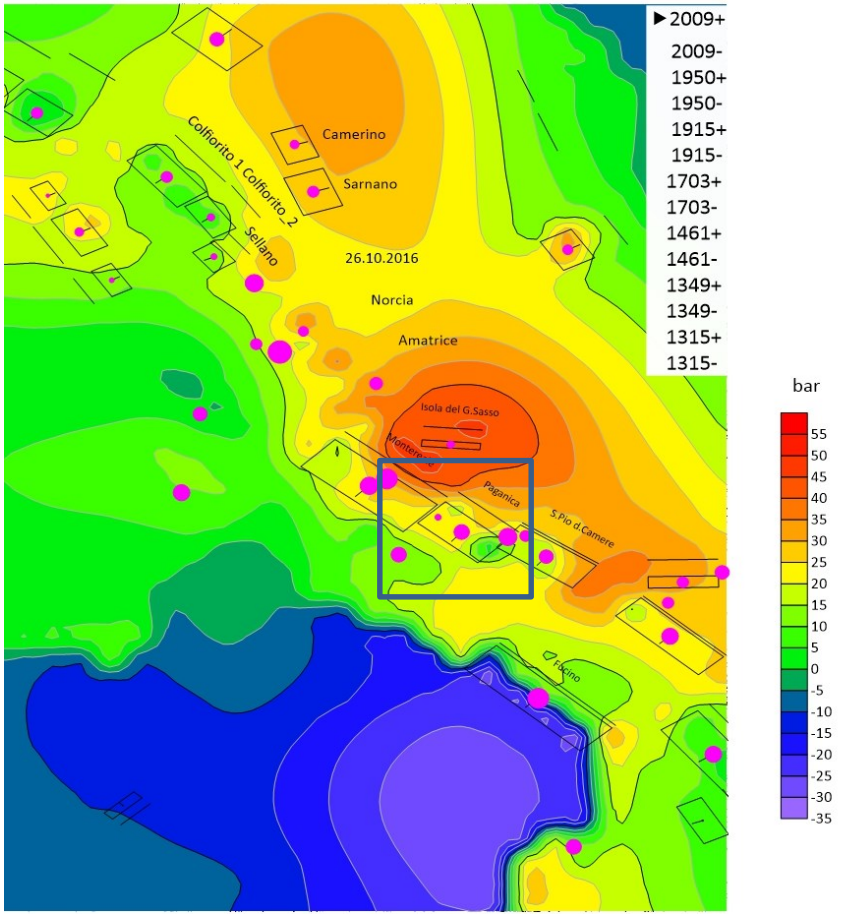
Multiply the geodetic stress rate by an empirical time constant + Coulomb stress released by events from 1315 to 2009-: is the resulting stress aligned with the moment tensor of the 2009 L'Aquila earthquake? Yes if the time constant is at least 2kyrs

Coulomb stress at Aquila mapped on faults with:
strike=133; dip=43; slip=-85; Mw=6.3;refz_qk=-6.25; FRIC=0.4



Estimated state of Coulomb stress before L'Aquila 2009

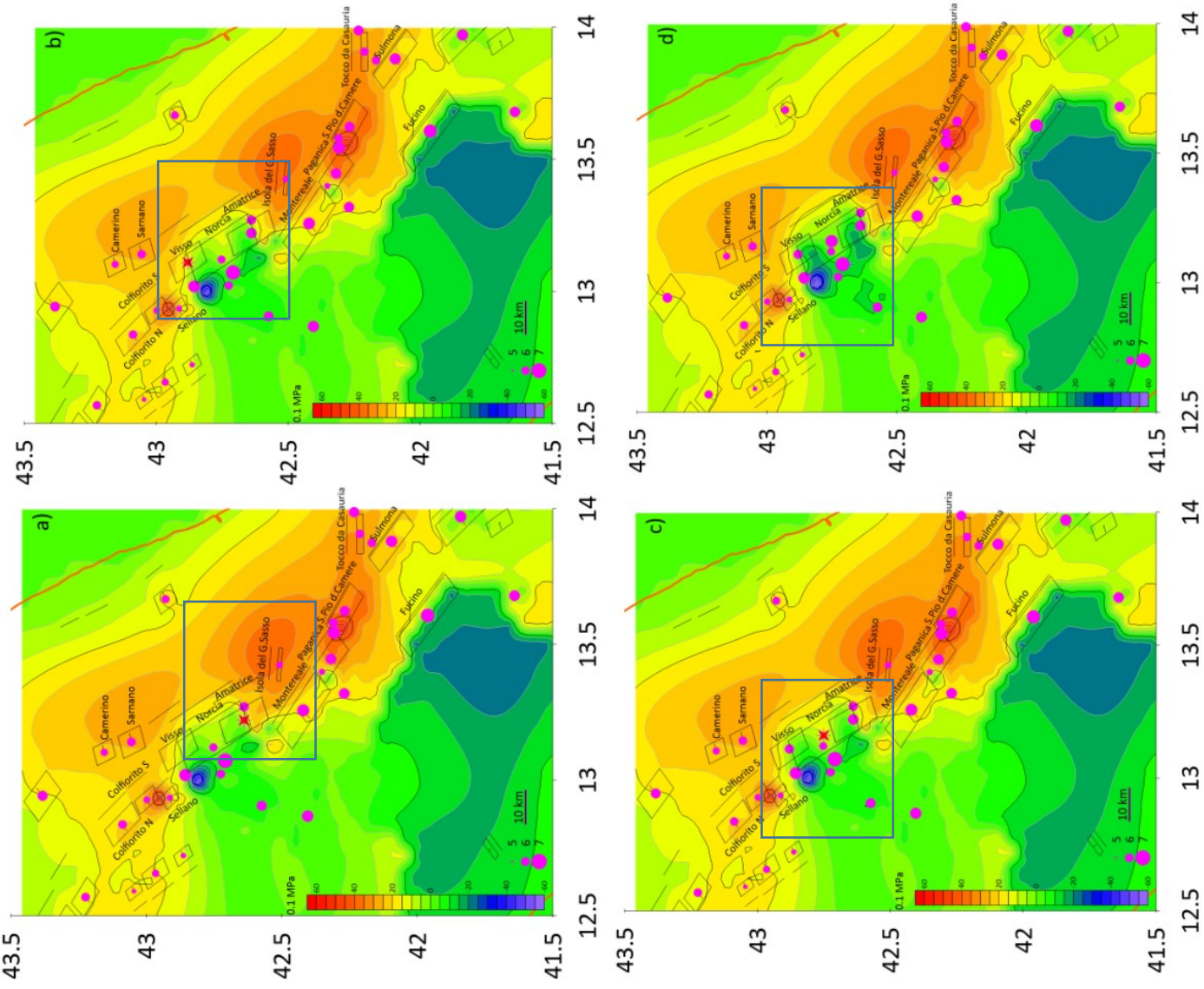
Coulomb stress at Aquila mapped on faults with:
strike=133; dip=43; slip=-85; Mw=6.3;refz_qk=-6.25; FRIC=0.4



Estimated state of Coulomb stress after L'Aquila 2009

24.08.2016 – 28.10.2016 (Amatrice - Visso)

< 30.10.2016 (Norcia)



<24.08.2016 (Amatrice)

28.10.2016 – 30.10.2016 (Visso- Norcia)

Conclusions

- GNSS geodesy provides surface strain rate only
- To estimate the stress on a fault system such as the Central Apennines we sum the elastic stress released by historical earthquakes with the geodetic stress rate multiplied by an empirical time constant
- We calibrate the time constant in such a way that the total stress is always tensional
- The resulting time history of the Coulomb stress in the past 700 years shows that stress has accumulated mostly in the Gran Sasso area and has episodically been released on faults to the SW, at times when the Coulomb stress was particularly high
- At this time the area SE of the Gran Sasso seems to have a higher Coulomb stress: could it be a seismic gap?