Task 3: Test site Irpinia

An advanced, real-time, seismic monitoring infrastructure for the detailed imaging and characterization of a complex normal fault system in the southern Apennines

WP3.3: Reflection seismology applied to micro-earthquake data

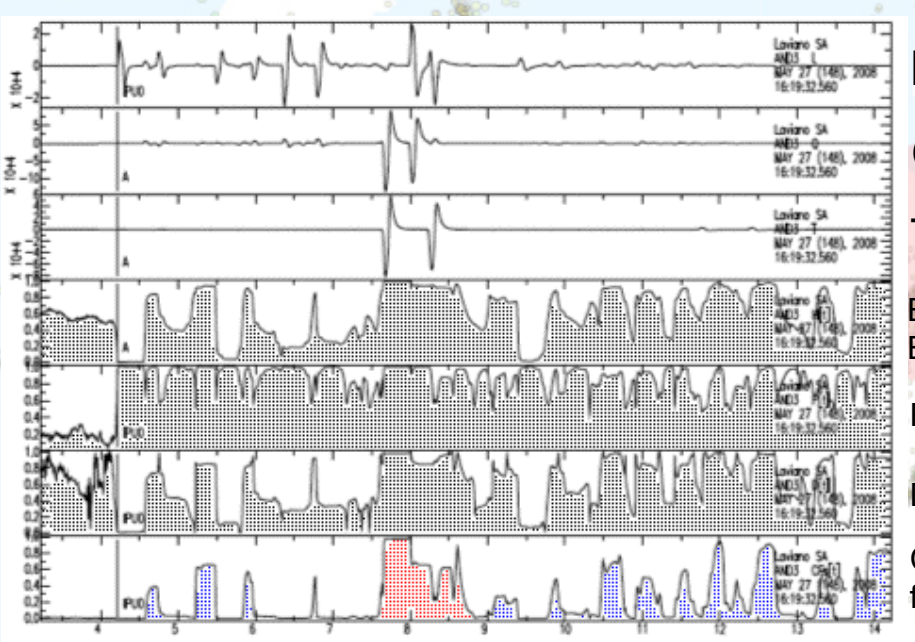
Nils Maercklin

RISSC, Universitá degli Studi di Napoli Federico II, Naples, Italy

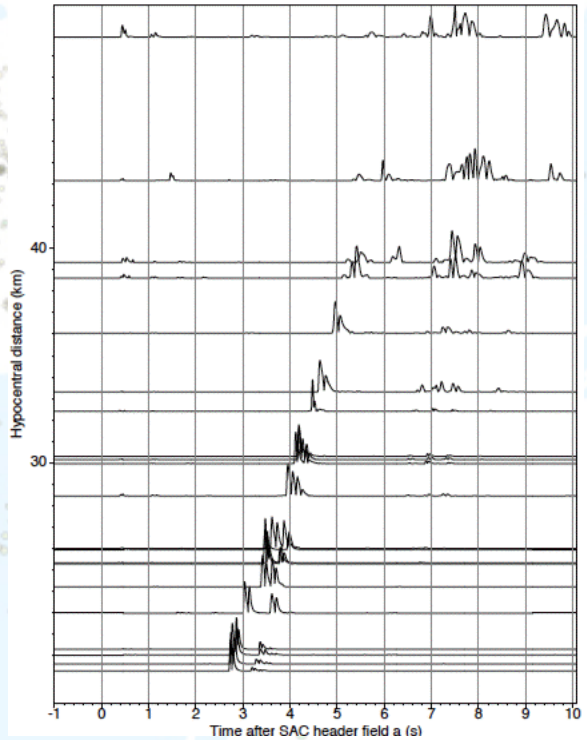
WP3.3 – Multicomponent processing

Objective: Identification of secondary seismic phases, processing tools for signal enhancement.

(1) Polarization analysis based on 3-C covariance matrix,
(2) Selection of suitable polarization attributes, e.g. for S-waves,
(3) Polarization filtering,
(4) Move-out analysis in seismic sections.



Rotated 3-C seismogram and polarization attribute traces (O. Amoroso)



Amplitude of transverse components multiplied by characteristic function for S (hypocentral distance versus time after P)

WP3.3 – Seismic imaging (beamforming, migration)

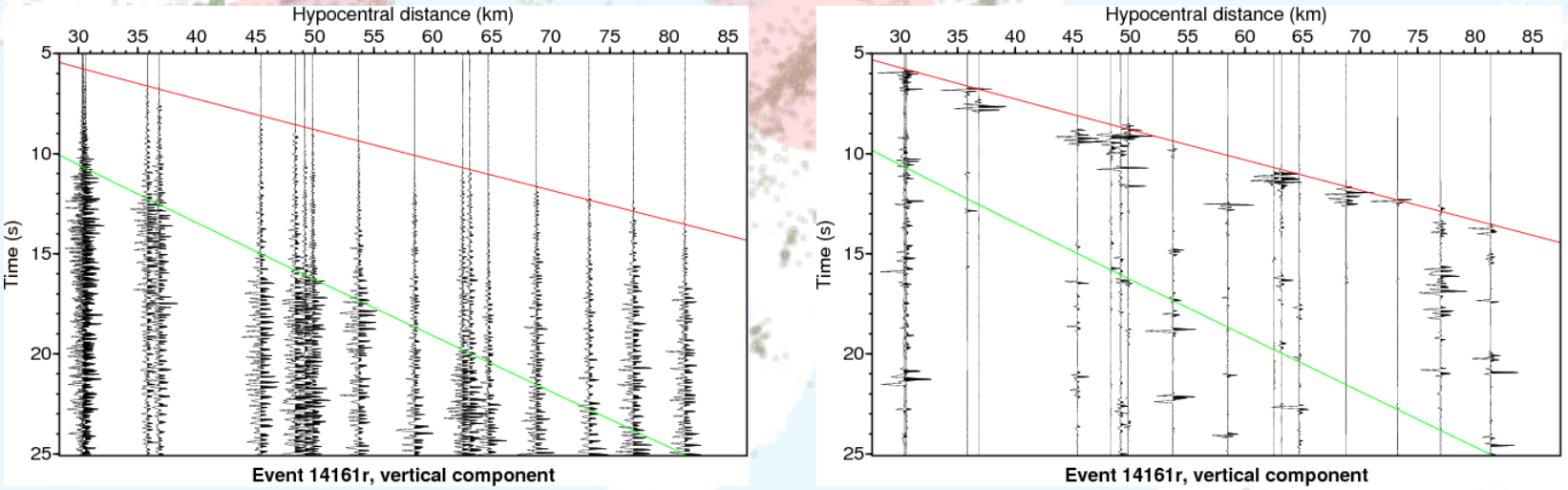
Objective: Image of sources and of subsurface structure (scattered, reflected, converted waves).

Imaging method:

(1) Regular grid of possible source or scatterer locations in target volume,
(2) For each grid point compute the travel time according to the imaging condition,
(3) Stack aligned traces in a time window at computed times (weighted stack for reflections/conversions),
(4) Assign stack amplitude or semblance to current grid point, and repeat process for entire volume,
(5) Source imaging: Repeat this process in a moving time window along the seismogram.

Stack maxima indicate locations of sources or of scatterers/discontinuities.

Data example:

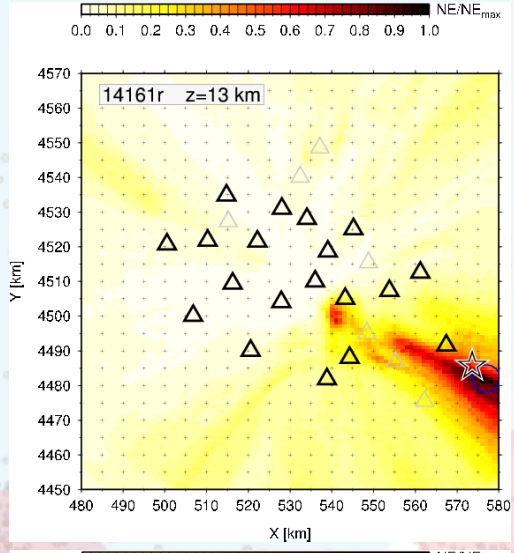


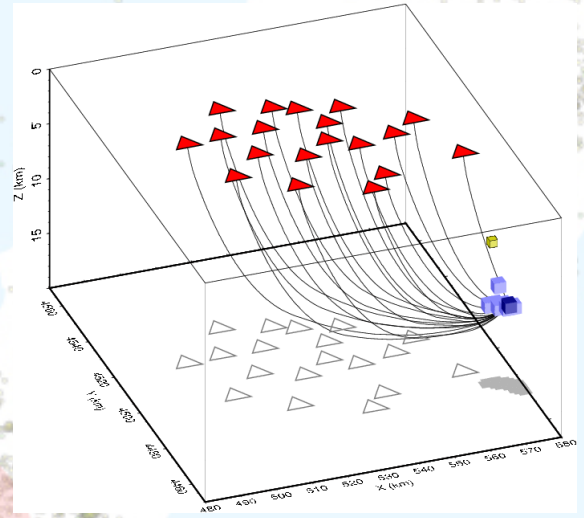
Raw and polarization-filtered seismograms

WP3.3 – Seismic imaging (beamforming, migration)

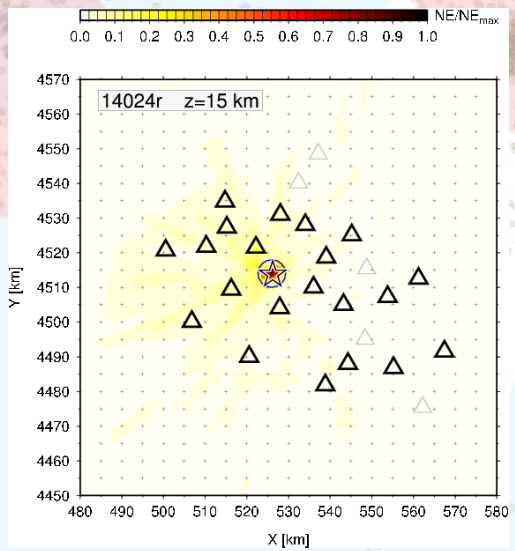
Point-source images from first-arrival P-waves of two local earthquakes

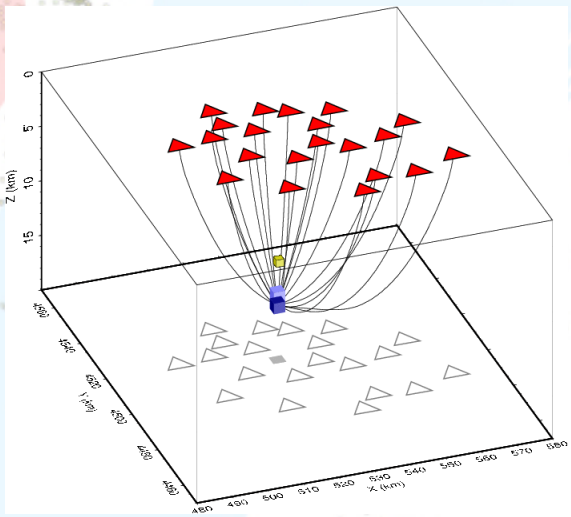
Event outside ISNet (Potenza region)





Event inside ISNet (Laviano)

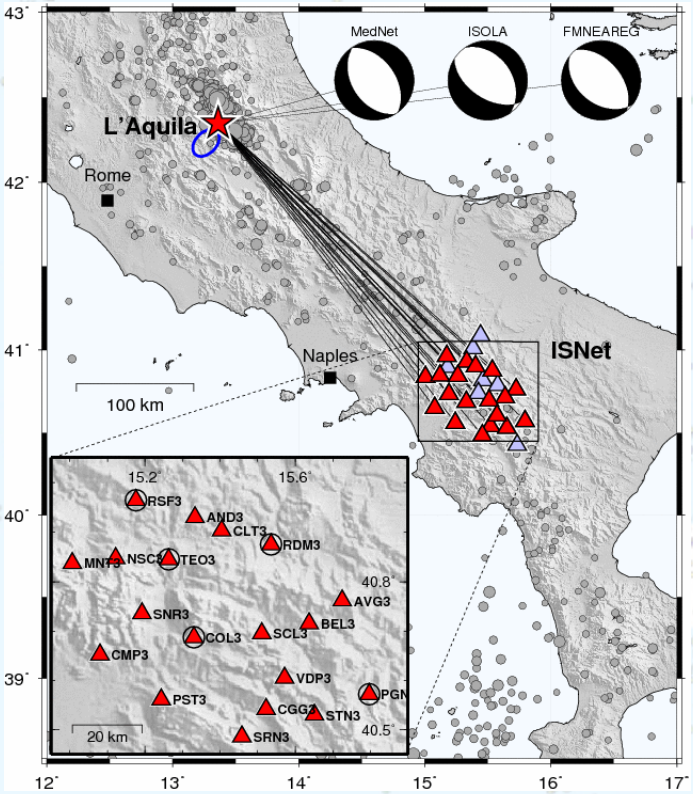




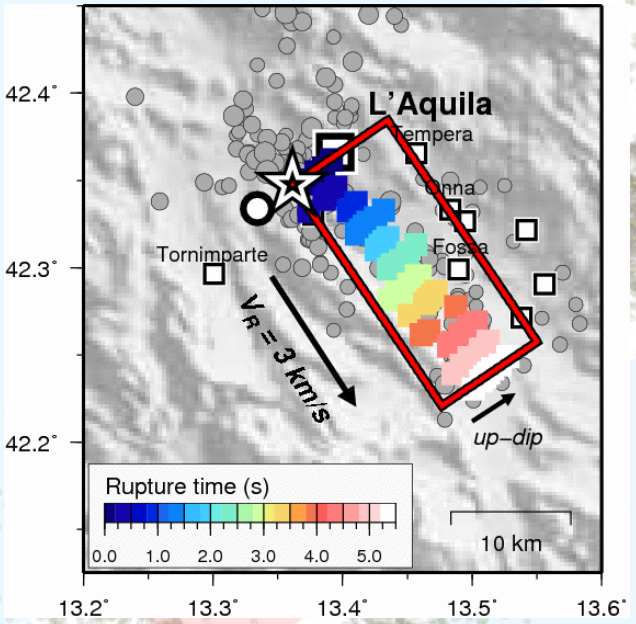
Horizontal depth-slices through image volume, and 3-D views

WP3.3 – Seismic imaging (beamforming, migration)

Extended-source image of the April 2009 L'Aquila earthquake from P-waves recorded at ISNet

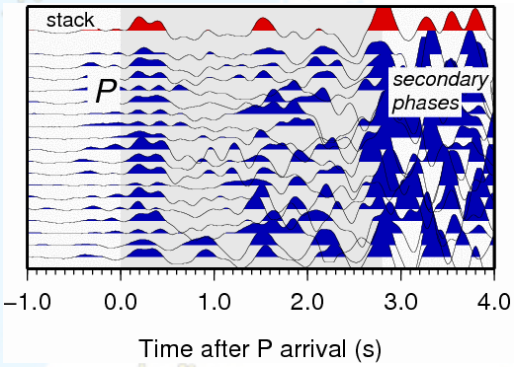


Acquisition geometry



Space-time evolution of the earthquake rupture

(strike, length, rupture velocity)

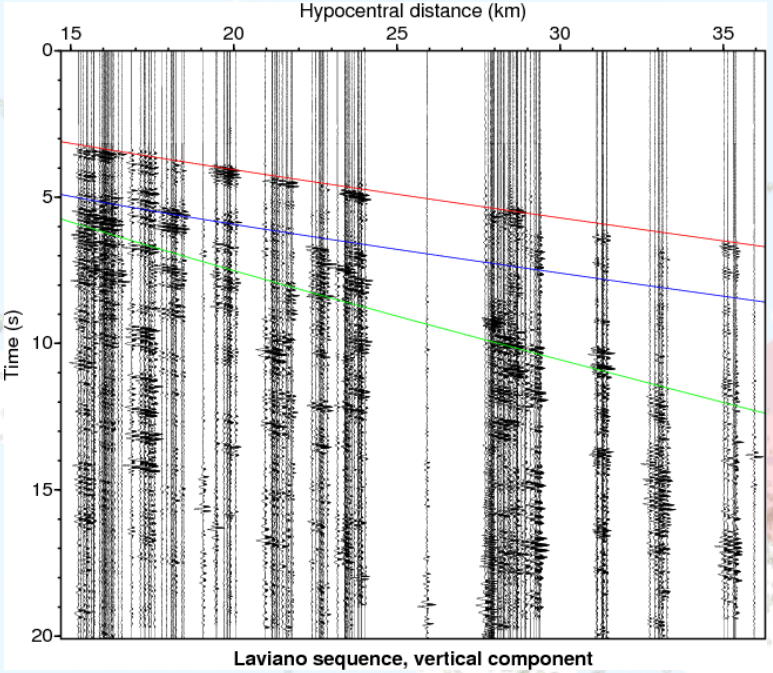


Vertical-component ISNet acceleration records

WP3.3 – Scattered, reflected, and converted phases

Objective: Structural image of the Irpinia region (discontinuities, faults, scatterers).

Data example:

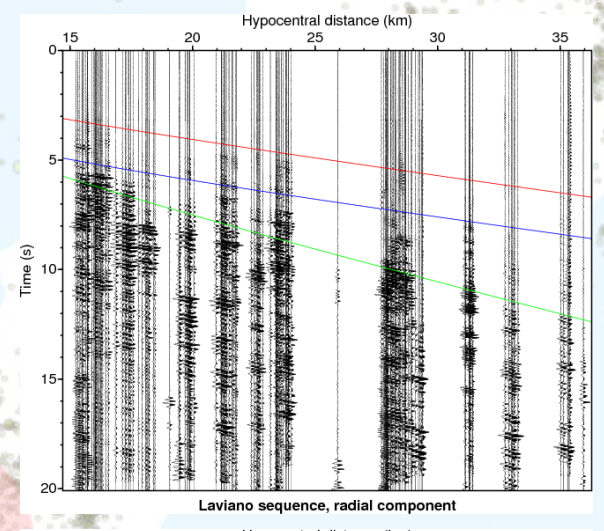


Z

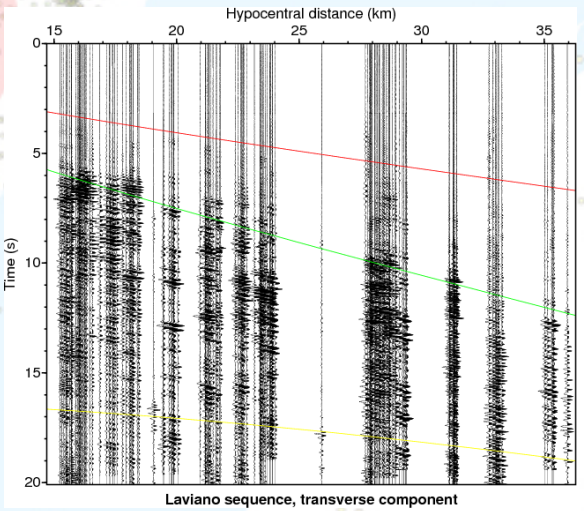
P

PS

S



R



T

Composite seismogram sections of the Laviano sequence in May 2008 (polarization-filtered and normalized).

Lines mark theoretical arrival times for a 1-D layered model (1-D model and statics: E. Matrullo, event locations: T. A. Stabile).

WP3.3 – Summary and outlook

Completed tasks:

Implementation and application of software tools for phase identification and multichannel processing (polarization analysis and filtering, beam analyses, data exchange).

Development and test of beamforming/migration algorithms for source/rupture imaging of earthquakes or noise sources (e.g. WP3.1), and for seismic scatterers (small structures, faults) and discontinuities.

Preliminary results:

Improvement of consistent S-wave identification via multicomponent processing and analysis, relevant also for more accurate event locations and for the development of an S-wave velocity model (WP3.2).

Migration techniques successfully image locations of small local earthquakes within or near ISNet. Source parameters of the L'Aquila earthquake (fault length, strike, rupture velocity) could be estimated from the 250 km distant ISNet array.

Outlook:

Application of migration methods to image subsurface discontinuities or scatterers (before July 2010) and reflection travel time tomography (future perspective).