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Full waveform modelling and misfit calculation using the VERCE platform

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In recent years the increasing resolution of seismic imagining by full waveform inversion has opened new research perspectives and practices. These methods rely on harnessing the computational power of large supercomputers and new storage capabilities, to run large parallel codes to simulate the seismic wave field in three-dimensional geological settings. The VERCE platform is designed to make these full waveform techniques accessible to a far wider spectrum of the seismological community.

VERCE empowers a broad base of seismology researchers to harvest the new opportunities provided by well-established high-performance wave simulation codes such as SPECFEM3D. It meets a range of seismic research needs by eliminating the technical difficulties associated with using these codes, allowing users to focus on their research questions. VERCE delivers this power to seismologists through its science gateway, supporting wave simulation codes on each of the provided computing resources. Users can design their waveform simulation scenarios making use of a library of pre-loaded meshes and velocity models, and services for selecting earthquake focal mechanisms, seismic stations and recorded waveforms from existing catalogues, such as the GCMT catalogue, and FDSN data sources. They can also supply their own mesh, velocity model, earthquake catalogue and seismic observations. They can submit the simulations onto different computing resources, where VERCE provides codes that are tuned and supported for those resources. The simulations can currently be run on a range of European supercomputers in the PRACE network, including superMUC at LRZ, GALILEO at CINECA and on selected resources like Drachenfels at SCAI and within the EGI network.

The gateway automates and looks after all these stages, but supplies seismologists with a provenance system that allows them to manage a large series of runs, review progress, and explore the results. The platform automates misfit analysis between simulated and recorded waveforms, enabling seismologists to specify and steer their misfit analyses using existing python tools and libraries such as Pyflex and the dispel4py data-intensive processing library. All these processes, including simulation, data access, pre-processing and misfit calculation, are presented to the users of the gateway as dedicated and interactive workspaces.

The VERCE platform can also be used to produce animations of seismic wave propagation through the velocity model, and synthetic shake maps. We demonstrate the functionality of the VERCE platform with two case studies, using the pre-loaded velocity model and mesh for Chile and Northern Italy. It is envisioned that this tool will allow a much greater range of seismologists to access these full waveform inversion tools, and aid full waveform tomographic and source inversion, synthetic shake map production and other full waveform applications, in a wide range of tectonic settings.