Name	Last commit	Last update
Commons	first upload from /scratch/projects/cat/SPT...	6 days ago
IO/earlyEst	first upload from /scratch/projects/cat/SPT...	6 days ago
Step1_EnsembleDef	first upload from /scratch/projects/cat/SPT...	6 days ago
Step2_RunSimulations	Upload last script from CINECA	6 days ago
Step3_HazardAggregation	first upload from /scratch/projects/cat/SPT...	6 days ago
Step4_AlertLevels	first upload from /scratch/projects/cat/SPT...	6 days ago
Step5_Visualization	first upload from /scratch/projects/cat/SPT...	6 days ago
Description_of_steps.txt	Update Description_of_steps.txt	4 days ago
README.md	Update README.md	4 days ago
run.sh	first upload from /scratch/projects/cat/SPT...	6 days ago

ChEESE-PTF

PROBABILISTIC TSUNAMI FORECASTING (PTF) FOR EARLY WARNING AND RAPID POST EVENT ASSESSMENT

Earthquakes, Tsunamis

This service provides rapid probabilistic forecasting of tsunami inundation, following an earthquake offshore or close to the coast, before it actually occurs or before tsunami observations are available. For near-field tsunami early warning (EW) purposes, the large uncertainty about earthquake location and magnitude, as available in the first minutes, are reflected into forecasting uncertainty. For the purpose of supporting rapid post-disaster intervention, for which more time is available, additional source and even tsunami information in the subsequent phases can be exploited to eventually narrow down the tsunami forecast uncertainty. The service also provides an early estimate of the earthquake parameters with their uncertainty when they are not yet available, as a by-product.

Based on real-time seismic parameters, the workflow either uses pre-calculated tsunami scenarios, or prepares par-files to run large ensembles of numerical simulations with the Tsunami-HySEA Monte Carlo version. It then produces the tsunami forecast combining the ensemble simulation output with source probabilities.

It works in near-real time at the CAT-INGV Tsunami Warning Centre (https://www.ingv.it/cat/en/), which is a NEAMTWS Tsunami Service Provider (http://www.ioc-tsunami.org/). There are millions of pre-calculated tsunami scenarios that were run on a 30 arc-sec grid for 8 hours of simulation. It is embedded in the operational data/information flow of the CAT-INGV . It is in the Calibration/Validation + External Review phase towards the fully Operational Phase (from TRL 3: TRL 8 to 9). It deals with potentially tsunamigenic earthquakes anywhere in the entire Mediterranean Sea (offshore and inland close to the coast). In this configuration, PTF output provides exceedance probabilities for tsunami heights just off the coastline for almost equally spaced points of interest every 20 km along the

coasts of the Mediterraean Sea. It was run for example for the recent Ierapetra and Samos-Izmir earthquakes and tsunamis in 2020. Using the pre-calculated scenarios, the computing time can be limited to the order of seconds, which is suitable for early warning purposes.

The version based on simulation ensembles to be run from scratch on large enough HPC clusters in urgent computing mode was already tested with: a suite of more than 10 recent events in the Mediterranean Sea, that is all those for which the CAT-INGV issued a tsunami alert message in recent years; the 2003 Zemmouri-Boumerdes Mw 6.8 earthquake and tsunami in the western Mediterranean; the 2020 Samos-Izmir Mw 7.0 in the eastern Mediterranean; the NEAMWave17 Mw 8.5 synthetic scenario; the 2010 Mw 8.8 Maule Chile earthquake and tsunami.

For the Samos Mw 7.0 Earthquake PTF a single exercise was conducted with uncertainty exploration up to 2 sigma. This resulted in about 38 000 scenario simulations with Tsunami-HySEA; 1981x1321 cells (5x5 deg domain at 30 arcsec; 4 hours propagation) which were run with a reservation of ~800 nodes x 4 V100 = ~ 3200 GPUs.

Also in this configuration, PTF output provides exceedance probabilities for tsunami heights in front of the coastline, but for denser almost equally spaced points of interest every 2 km along the coasts. It also provides exceedance probabilities for tsunami heights just off the coastline as it doesn't require linearity.For the Maule event, the output is also retrieved in correspondence of the deep sea DART sensors that measured the tsunami.

The number of scenarios in the ensemble depends on the magnitude of the earthquake and on the desired level of accuracy (how many standard deviations are explored). Typical numbers are tens of thousands scenarios for 2 standard deviations.

The computing time of a single simulation on 1 GPU (V100) is for example about 300 s for 8 hours of tsunami propagation within the entire Mediterranean at 30 arcsec (900 m) spatial resolution, or ~2 hours for 40 hours of propagation within the entire Pacific Ocean at 1 arcmin resolution; the total time to run the whole ensemble depends on the ensemble size and on the number of GPUs available.

In this configuration, the PTF is then suitable for rapid post-event assessment but in principle can be exploited also for early warning if enough resources are available. For example, it constitutes a prototype for applications in ARISTOTLE, event analysis at CAT-INGV and potentially other Tsunami Service Providers worldwide. It has in fact a Global scope.

Achieved high Technology Readiness Level (From TRL 3 to TRL 7-8).