

# "SeismoSAT" project results in connecting seismic data centres via satellite

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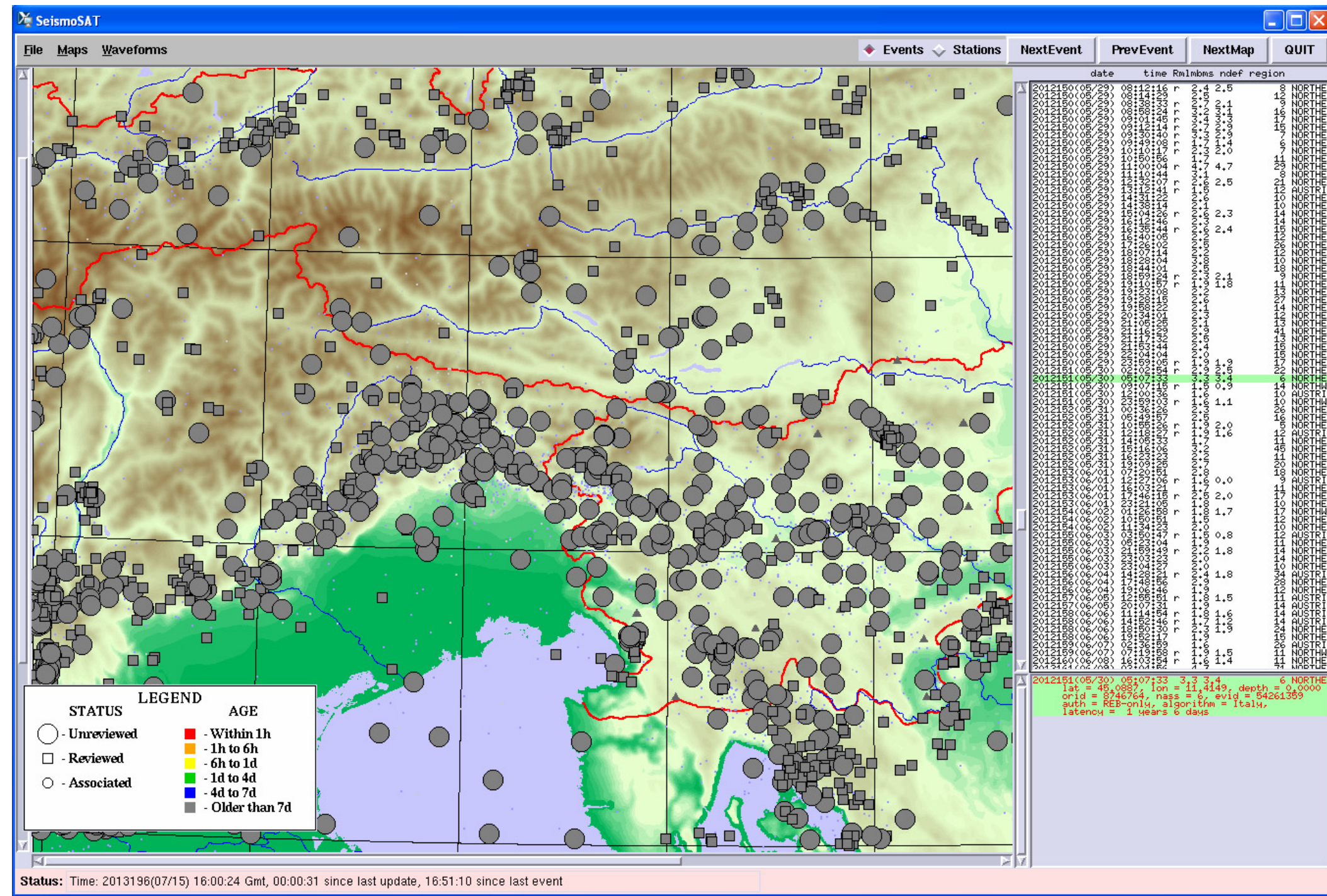
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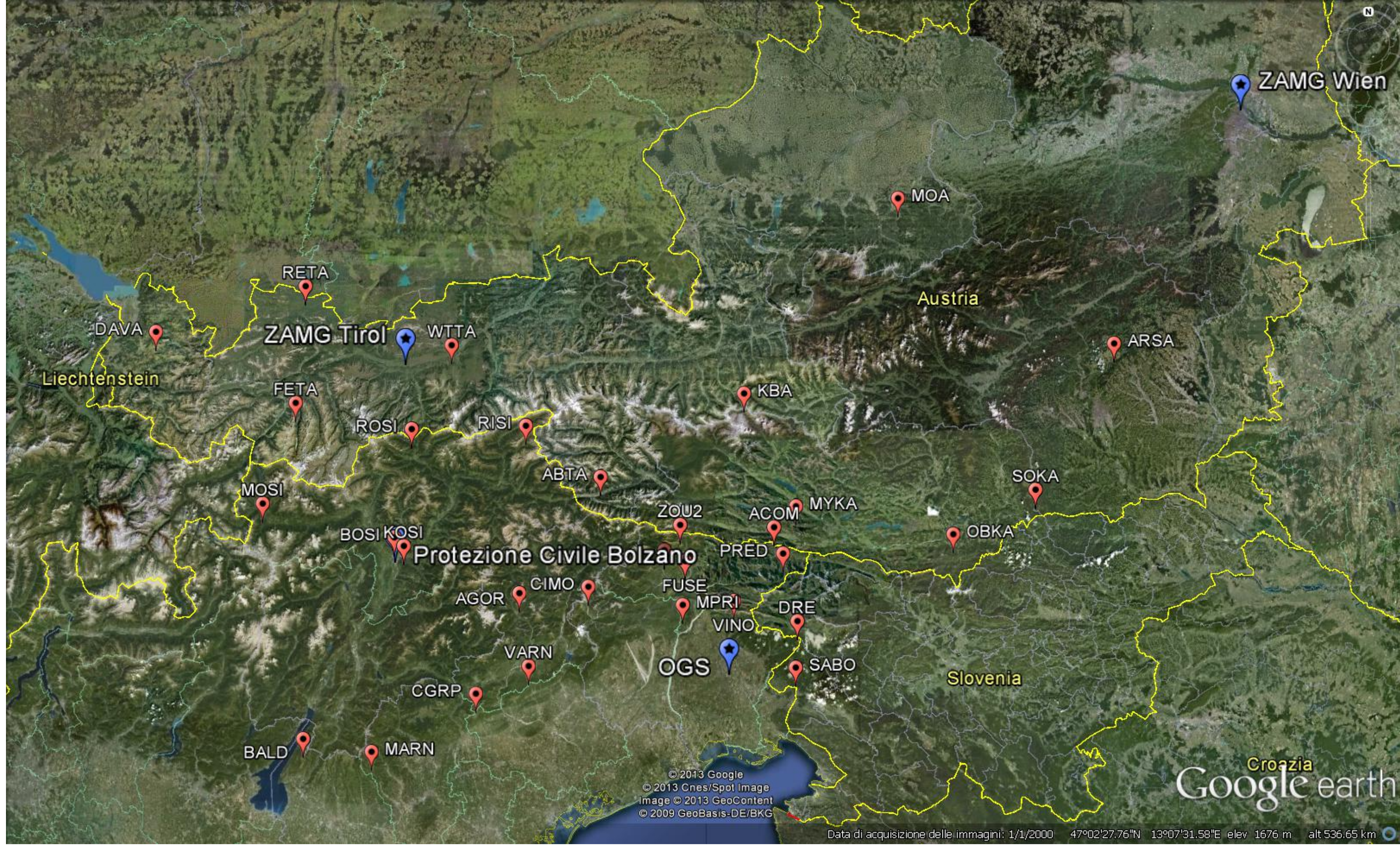


**ABSTRACT.** Since 2002 the OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale) in Udine (Italy), the Zentralanstalt für Meteorologie und Geodynamik (ZAMG) in Vienna (Austria), and the Agencija Republike Slovenije za Okolje (ARSO) in Ljubljana (Slovenia) are using the Antelope software suite (Bragato et al., 2010) as the main tool for collecting, analyzing, archiving and exchanging seismic data in real time, initially in the framework of the EU Interreg IIIa Italia-Austria project "Trans-national seismological networks in the South-Eastern Alps" (Bragato et al., 2004). The data exchange has proved to be effective and very useful in case of seismic events near the borders between Italy, Austria and Slovenia, where the poor single national seismic networks coverage precluded a correct localization, while the usage of common data from the integrated networks improves considerably the overall reliability of real time seismic monitoring of the area. Up to now the data exchange between the seismic data centres relied on internet: this however was not an ideal condition for civil protection purposes, since internet reliability is poor. For this reason in 2012 the Protezione Civile della Provincia Autonoma di Bolzano in Bolzano (Italy) joined OGS, ZAMG and ARSO in the Interreg IV Italia-Austria project "SeismoSAT" (Progetto SeismoSAT, 2014) aimed in connecting the seismic data centres in real time via satellite. As already presented in the past, the general technical schema of the project has been approved, data bandwidths and monthly volumes required have been quantified, the common satellite provider has been selected and the hardware has been purchased and installed. We will here illustrate the SeismoSAT project final tests and results.

The border region of Slovenia, Austria and NE Italy has experienced several destructive earthquakes in the past. Different seismic networks are operating in the area supporting monitoring, alerting and research. The occurrence of recent strong earthquakes demonstrated that the integration of services provided by the neighbouring networks is essential for a rapid and efficient intervention.



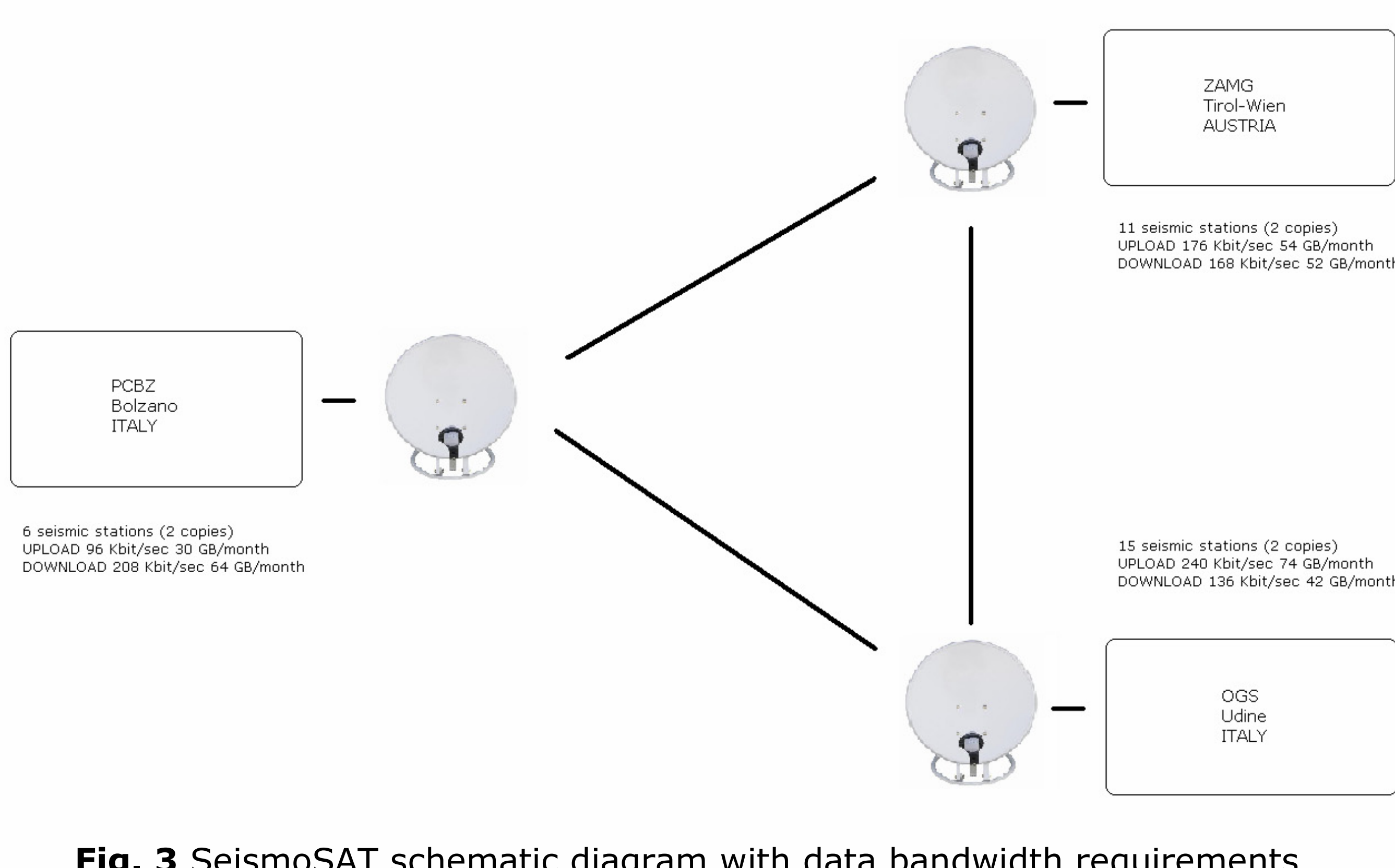
**Fig. 1** 2011-2012 seismicity map of the border region between Northeast Italy, Austria and Slovenia. Grey dots are events with magnitude ML > 1.5.



**Fig. 2** SeismoSAT map with seismic stations in red and data centres in blue

| Source            | Thread | #pkts | Oldest         | Latest       | Average | Latency      |                    |
|-------------------|--------|-------|----------------|--------------|---------|--------------|--------------------|
| IV_ZDZ_HZ/SEED    | 0      | 2322  | 1221.4 1296811 | 000 12:57:55 | 797050  | 000 15:03:40 | 1.1 1.04 hours     |
| IV_TLZ_HZ/SEED    | 0      | 1936  | 1001.1 1297318 | 000 12:58:05 | 797418  | 000 15:03:44 | 1.1 1.04 hours     |
| IV_TLZ_HZ/SEED    | 0      | 1831  | 963.1 1297306  | 000 12:58:05 | 796907  | 000 15:03:41 | 1.0 1.04 hours     |
| IV_TLZ_HZ/SEED    | 0      | 1831  | 963.1 1297306  | 000 12:58:04 | 796901  | 000 15:03:38 | 1.0 1.04 hours     |
| IV_TLZ_HZ/SEED    | 0      | 1864  | 902.2 1296703  | 000 12:58:02 | 796343  | 000 15:03:45 | 1.0 1.04 hours     |
| IV_NLCAON_HZ/GENC | 44     | 11373 | 1311.9 1296650 | 000 12:58:06 | 796381  | 000 15:03:37 | 0.9 2.834 seconds  |
| IV_NLCAON_HZ/GENC | 0      | 1832  | 963.6 1297119  | 000 12:58:04 | 798410  | 000 15:03:45 | 1.0 1.04 hours     |
| IV_NLMD_HZ/GENC   | 0      | 7549  | 1215.1 1296707 | 000 12:57:59 | 800538  | 000 15:03:47 | 1.3 1.04 hours     |
| IV_NLMD_HZ/GENC   | 44     | 11373 | 1295.5 1296593 | 000 12:58:06 | 1296313 | 000 16:07:38 | 0.9 3.122 seconds  |
| IV_NLCAE_HZ/GENC  | 44     | 11373 | 1218.9 1296725 | 000 12:58:06 | 1296490 | 000 16:07:38 | 0.9 3.122 seconds  |
| IV_NLCAE_HZ/GENC  | 0      | 11373 | 1268.3 1296572 | 000 12:58:06 | 1296328 | 000 16:07:38 | 0.9 2.834 seconds  |
| IV_NLMD_HZ/GENC   | 0      | 11373 | 1268.3 1296572 | 000 12:58:03 | 797421  | 000 15:03:40 | 0.9 1.04 hours     |
| IV_NLMD_HZ/GENC   | 0      | 7533  | 822.5 1299514  | 000 12:57:58 | 798939  | 000 15:03:30 | 0.9 1.04 hours     |
| IV_NLRE_HZ/GENC   | 44     | 11373 | 1277.7 1296650 | 000 12:58:06 | 1296391 | 000 16:07:38 | 0.9 2.834 seconds  |
| IV_NLRE_HZ/GENC   | 0      | 1831  | 963.1 1297023  | 000 12:58:02 | 797626  | 000 15:03:41 | 1.0 1.04 hours     |
| IV_FUSE_HZ/GENC   | 44     | 11373 | 1268.3 1296650 | 000 12:58:06 | 1296372 | 000 16:07:38 | 0.9 2.834 seconds  |
| IV_FUSE_HZ/GENC   | 0      | 1831  | 963.1 1297113  | 000 12:58:04 | 797700  | 000 15:03:44 | 1.0 1.04 hours     |
| IV_NLMD_HZ/GENC   | 0      | 7600  | 1050.7 1303449 | 000 12:58:06 | 800674  | 000 15:03:39 | 1.1 1.04 hours     |
| IV_NLMD_HZ/GENC   | 44     | 11373 | 1315.7 1296554 | 000 12:58:06 | 1296310 | 000 16:07:38 | 0.9 2.834 seconds  |
| IV_NLRE_HZ/GENC   | 0      | 7472  | 972.9 1304722  | 000 12:58:05 | 793151  | 000 15:03:36 | 1.2 1.05 hours     |
| IV_NLRE_HZ/GENC   | 0      | 2861  | 1504.9 1297103 | 000 12:58:05 | 796236  | 000 15:03:47 | 1.6 1.04 hours     |
| IV_NLMD_HZ/GENC   | 44     | 11373 | 1277.8 1296553 | 000 12:58:06 | 1296337 | 000 16:07:38 | 1.0 2.834 seconds  |
| IV_NLMD_HZ/GENC   | 0      | 2304  | 1211.9 1296515 | 000 12:58:02 | 798436  | 000 15:03:47 | 1.3 1.04 hours     |
| IV_NLMD_HZ/GENC   | 44     | 11373 | 1381.8 1296651 | 000 12:58:06 | 1296346 | 000 16:07:38 | 1.0 2.834 seconds  |
| IV_NLMD_HZ/GENC   | 44     | 11373 | 1126.7 1296584 | 000 12:58:06 | 1296356 | 000 16:07:38 | 0.9 2.834 seconds  |
| IV_NLMD_HZ/GENC   | 44     | 11377 | 1220.6 1296462 | 000 12:58:01 | 1296400 | 000 16:07:37 | 0.9 2.834 seconds  |
| IV_NLMD_HZ/GENC   | 54     | 1297  | 627.7 1297286  | 000 12:58:01 | 1295510 | 000 16:07:23 | 0.4 18.182 seconds |
| IV_NLMD_HZ/GENC   | 54     | 1341  | 649.0 1296984  | 000 12:57:59 | 1296460 | 000 16:07:38 | 0.5 13.765 seconds |
| IV_NLMD_HZ/GENC   | 54     | 11376 | 1125.7 1296459 | 000 12:58:01 | 1296386 | 000 16:07:36 | 0.8 4.834 seconds  |
| IV_NLMD_HZ/GENC   | 54     | 1278  | 610.0 1297107  | 000 12:58:01 | 1296981 | 000 16:07:35 | 0.4 36.493 seconds |
| IV_NLMD_HZ/GENC   | 54     | 1430  | 692.1 1297120  | 000 12:58:01 | 1296508 | 000 16:07:24 | 0.5 16.504 seconds |
| IV_NLMD_HZ/GENC   | 54     | 11377 | 1179.6 1296452 | 000 12:58:01 | 1296463 | 000 16:07:37 | 0.8 3.834 seconds  |
| IV_NLMD_HZ/GENC   | 54     | 11377 | 1171.8 1296450 | 000 12:58:01 | 1296409 | 000 16:07:37 | 0.8 3.834 seconds  |
| IV_NLMD_HZ/GENC   | 185    | 11346 | 1234.6 1296665 | 000 12:58:05 | 1296299 | 000 16:07:37 | 0.9 3.834 seconds  |
| IV_NLMD_HZ/GENC   | 185    | 11346 | 1234.6 1296665 | 000 12:58:05 | 1296312 | 000 16:07:37 | 1.0 3.834 seconds  |
| IV_NLMD_HZ/GENC   | 185    | 11345 | 1279.8 1296671 | 000 12:58:05 | 1296302 | 000 16:07:37 | 0.9 3.834 seconds  |
| IV_NLMD_HZ/GENC   | 185    | 11346 | 1241.0 1296465 | 000 12:58:01 | 1296419 | 000 16:07:37 | 1.0 3.834 seconds  |
| IV_NLMD_HZ/GENC   | 185    | 11346 | 1248.9 1296447 | 000 12:58:04 | 1296385 | 000 16:07:37 | 0.9 3.834 seconds  |
| IV_NLMD_HZ/GENC   | 185    | 11346 | 1317.7 1296561 | 000 12:58:01 | 1296269 | 000 16:07:36 | 0.9 4.834 seconds  |
| IV_NLMD_HZ/GENC   | 0      | 2647  | 1281.1 1297109 | 000 12:58:06 | 798227  | 000 15:03:47 | 1.4 1.04 hours     |
| IV_NLMD_HZ/GENC   | 0      | 4110  | 1086.2 1296518 | 000 12:58:05 | 798233  | 000 15:03:48 | 1.1 1.04 hours     |
| IV_NLMD_HZ/GENC   | 0      | 2421  | 1171.8 1296772 | 000 12:58:05 | 798442  | 000 15:03:48 | 1.2 1.04 hours     |
| IV_NLMD_HZ/GENC   | 0      | 2204  | 1066.7 1296767 | 000 12:58:04 | 798627  | 000 15:03:47 | 1.1 1.04 hours     |
| IV_NLMD_HZ/GENC   | 0      | 2421  | 1171.8 1296772 | 000 12:58:04 | 798627  | 000 15:03:47 | 1.2 1.04 hours     |
| IV_NLMD_HZ/GENC   | 0      | 2412  | 1167.4 1296514 | 000 12:58:01 | 798002  | 000 15:03:47 | 1.2 1.04 hours     |
| IV_NLMD_HZ/GENC   | 0      | 2450  | 1185.8 1296778 | 000 12:58:05 | 797973  | 000 15:03:45 | 1.3 1.04 hours     |
| IV_NLMD_HZ/GENC   | 0      | 3190  | 1344.0 1296550 | 000 12:58:01 | 798380  | 000 15:03:47 | 1.6 1.04 hours     |
| IV_NLMD_HZ/GENC   | 0      | 2756  | 1313.9 1296511 | 000 12:58:03 | 798414  | 000 15:03:48 | 1.4 1.04 hours     |
| IV_NLMD_HZ/GENC   | 0      | 2497  | 1208.5 1296727 | 000 12:58:01 | 798224  | 000 15:03:45 | 1.3 1.04 hours     |
| IV_NLMD_HZ/GENC   | 0      | 2676  | 1295.2 1297121 | 000 12:58:06 | 798188  | 000 15:03:46 | 1.4 1.04 hours     |
| IV_NLMD_HZ/GENC   | 0      | 7546  | 913.3 1296614  | 000 12:58:06 | 800903  | 000 15:03:51 | 1.0 1.04 hours     |
| IV_NLMD_HZ/GENC   | 0      | 7546  | 913.3 1296614  | 000 12:58:06 | 801009  | 000 15:03:51 | 1.0 1.04 hours     |
| IV_NLMD_HZ/GENC   | 0      | 2264  | 1198.9 1296732 | 000 12:58:05 | 798418  | 000 15:03:47 | 1.3 1.04 hours     |

**Tab. 1**  
Data latency during internet outage



**Fig. 3** SeismoSAT schematic diagram with data bandwidth requirements

## REFERENCES

- European Regional Development Fund (ERDF): [http://ec.europa.eu/regional\\_policy/index.cfm/en/funding/erdf/](http://ec.europa.eu/regional_policy/index.cfm/en/funding/erdf/), last access: 3 April 2015, 2014.
- Interreg IV Italia-Austria: <http://www.interreg.net/>, last access 3 April 2015, 2014.
- Progetto SeismoSAT: <http://www.crs.inogs.it/seismosat/>, last access: 3 April 2015, 2014.
- Bragato, P.L., Costa, G., Fitzko, F., Horn, N., Priolo, E., Kobal, M., Suhadolc, P., and Živčić, M.: The INTERREG IIIA Project: "Trans-National Seismological Networks in the South-eastern Alps", ESC XXIX General Assembly, Potsdam, Germany, 13-17 September 2004, 2004.
- Bragato, P.L., Costa, G., Horn, N., Pahor, J., Pesaresi, D., Lenhardt, W., and Živčić, M.: The usage of Antelope for acquiring end exchanging data in South-Eastern Alps: present configuration and future perspectives, ESC XXXII General Assembly, Montpellier, France, 6-10 September 2010, 2010.
- Pesaresi, D., Lenhardt, W., Rauch, M., Živčić, M., Steiner, R., Fabris, P., and Bertoni, M.: The Interreg IV Italia-Austria "SeismoSAT" project: connecting seismic data centres via satellite, Adv. Geosci., 36, 57-60, doi:10.5194/Adv. Geosci.-36-57-2014, 2014.
- Pesaresi, D., Lenhardt, W., Rauch, M., Živčić, M., Steiner, R., and Bertoni, M.: "SeismoSAT" project state of the art: connecting seismic data centres via satellite, EGU General Assembly 2014, Vienna, Austria, 27 April – 2 May 2014, doi:10.13140/RG.2.1.1382.6089, 2014.

In Pesaresi et al. (2014a) we indicated the bandwidth requirements, the choice of the satellite provider and the installations of the satellite antennas, in Pesaresi et al. (2014b) we indicated the choice of the Cisco 2921 routers for the SeismoSAT project with Virtual Private Network (VPN) capabilities.

The automatic switching between the default internet and the back-up satellite data links is then realized with the usage of several VPN tunnels between the SeismoSAT data centers: 2 between each couple of data centers, one via internet and one via satellite. The Cisco 2921 router, by constantly checking which of the two IP connections has the best metrics, choose automatically internet when available and switches also automatically to the back up satellite links when internet is down.

**Fig. 4** on the right shows the final schematic of the IP connections topology of the SeismoSAT project.

**Fig. 5** bottom right shows the results of the final stress test at LP OGS data center in Udine. During a general internet outage lasting more than 1 hour, real time data acquisition from P1 ZAMG (code OE\_\*) and P2 PCBZ (code SI\_\*) seismic stations was guaranteed by the satellite connections of the SeismoSAT project.

Latencies during the same internet outage are listed in **Tab. 1** bottom left.

## Note

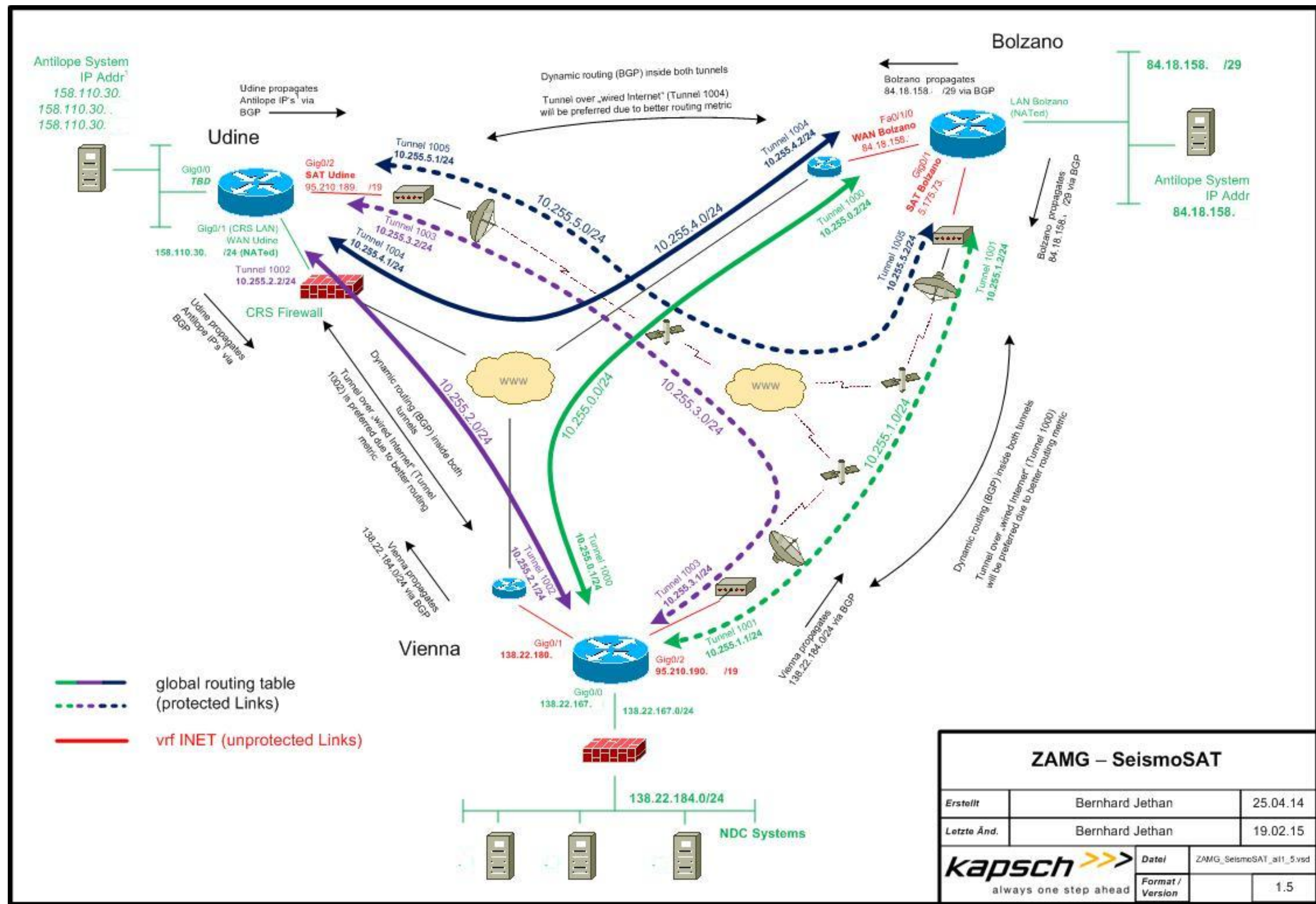
ARSO is an "associated partner" of the SeismoSAT project. ARSO benefits from the improved robustness of the data exchange between the other data centres, while eventually fully taking part in the project if other sources of funding will be available.

## Conclusions

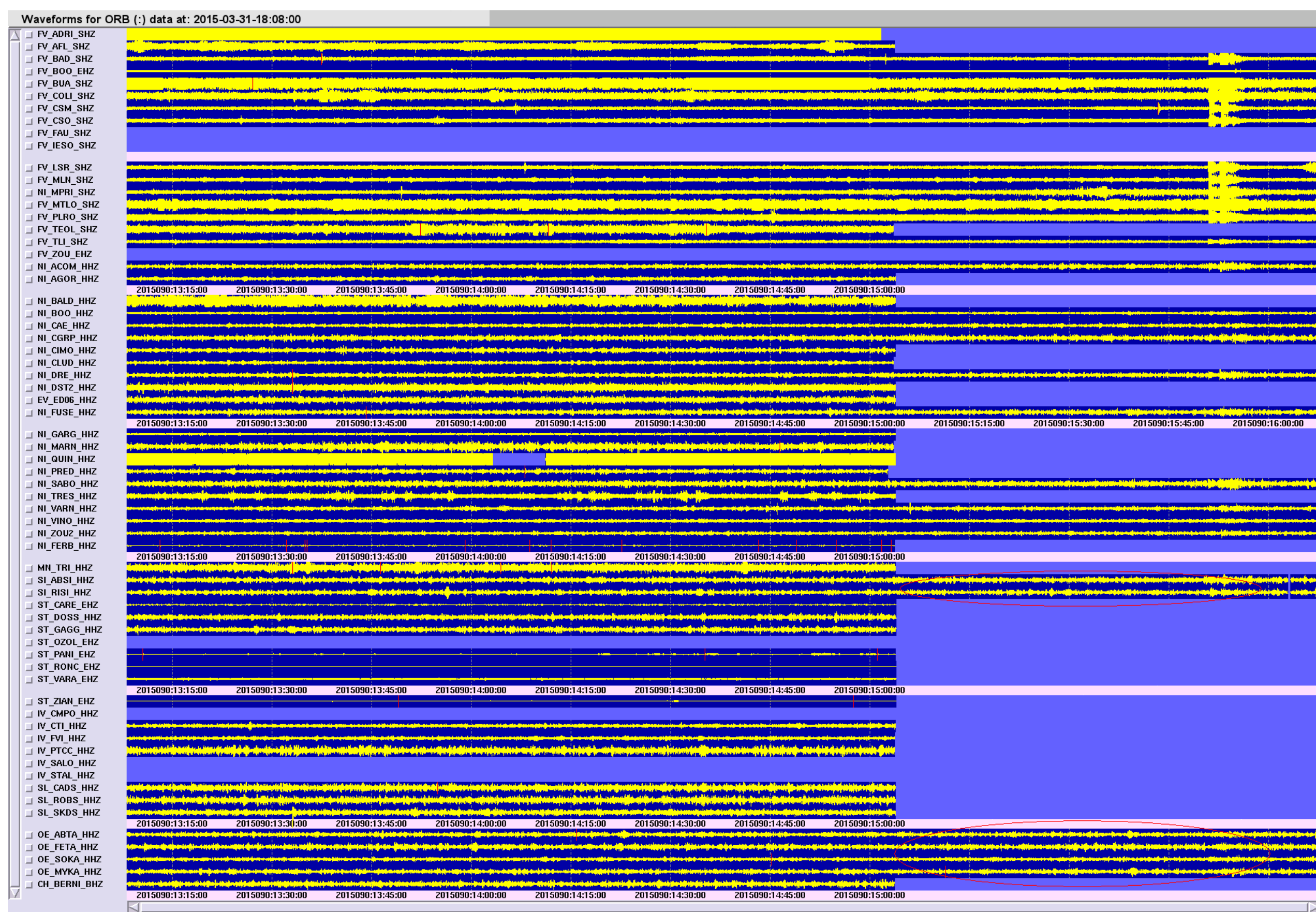
The Interreg IV Italia-Austria SeismoSAT project ended successfully on 31<sup>st</sup> March 2015. Discussions are undergoing with the Civil Defence of the Friuli-Venezia Giulia region to extend the SeismoSAT project to its headquarters in Palmanova and to guarantee the future sustainability of the project.

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**Fig. 4** SeismoSAT IP connections schematic



**Fig. 5** Stress test. With internet down, P1 ZAMG (code OE\_\*) and P2 PCBZ (code SI\_\*) seismic stations acquired at LP OGS data centre

