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Preface to SRL Focus Section on “European Seismic Networks and Associated Services and Products”

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Dear Allison,

we are submitting the Preface to the Focus Section on “European Seismic Networks and Associated Services and Products”.

We are thankful to you and the whole Editorial Staff of Seismological Research Letters for support in the preparation of this Focus Section. We are looking forward to the finalization of this work with the publication of the print issue in May.

Please find below (*) our suggestion for the organization of the papers in the print issue.

Thank you and best regards,
the Guest Editors.

(*)
ORFEUS papers & international collaborations

1. EIDA: the European Integrated Data Archive and service infrastructure within ORFEUS
   by Strollo et al.
2. Accessing European Strong-Motion Data: an update on ORFEUS Coordinated Services
   by Lanzano et al.
3. Exploring Approaches for Large Data in Seismology: User and Data Repository Perspectives
   Quinteros et al.

EIDA nodes

4. Résif-SI: a distributed information system for French seismological data
   by Pequegnat et al.
5. The GEOFON Program in 2020
   by Quinteros et al.
6. German Seismic and Infrasound Networks contributing to the European Integrated Data Archive (EIDA)
   by Stammler et al.
7. Seismic waveform data from Greece and Cyprus: Integration, archival and open access
   by Evangelidis et al.
8. The Italian Node of the European Integrated Data Archive
   by Danecek et al.
9. UiB-NORSAR EIDA node: Integration of seismological data in Norway
   by Ottemöller et al.
10. Seismic monitoring in Eastern Europe: from national to transnational real and near real-time services and products
    by Marmureanu et al.
11. Evolution of the Kandilli Observatory and Earthquake Research Institute (KOERI) Seismic Network and the Data Center Facilities as a Primary Node of EIDA
    by Cambaz et al.

Other networks & temporary deployments

12. The Portuguese National Seismic Network – Products and Services
    by Carrilho et al.
13. Improving cross-border seismic research: The Central and Eastern Europe Earthquake Research Network (CE3RN)
    by Lenhardt et al.
14. Development of the NORSAR network during the last 50 Years
    by Schweitzer et al.
15. The modern Swedish National Seismic Network: 20 years of intraplate microseismic observation
    by Lund et al.
16. The Finnish National Seismic Network: Towards Fully Automated Analysis of Low-Magnitude Seismic Events

by Veikkolainen et al.

17. The OGS - North-Eastern Italy Seismic and Deformation Network: current status and outlook.
    by Bragato et al.
18. A first national seismic network for the Maltese islands – the Malta Seismic Network
    by Galea et al.
19. The StressTransfer seismic network – an experiment to monitor seismically active fault zones in the northern Alpine foreland of southwestern Germany
    by Mader and Ritter
20. Seismic Networks in Poland, Integrating Data Under European Plate Observing System
    by Rudzinski et al.
21. The SWATH-D seismological network in the Eastern Alps
    by Heit et al.

Other monitoring and research products

22. Seismic Surveillance and Earthquakes Monitoring in Italy
    by Margheriti et al.
23. From seismic monitoring to tsunami warning in the Mediterranean
    by Amato et al.
24. Caravel: a new Earthworm based open source development for the Italian seismic monitoring system
    by Bono et al.
25. The transversal seismicity action RESIF: a tool to improve the distribution of the French seismicity products.
    by Masson et al.
26. RAMONES, the Rapid Assessment of MOmeNt and Energy Service in Central Italy: Concepts, capabilities and future perspectives
    by Spallarossa et al.
27. Orientations of Broadband Stations of the KOERI Seismic Network (Turkey) From Two Independent Methods: P and Rayleigh Wave Polarization
    by Büyükakpınar et al

If eventually accepted in due time

28. New Turkish Accelerometric Database and Analysis System (TADAS)
    by Senturk et al.
29. i1-net: Iran Strong Motion Network
    by Shahvar et al.

Preface to SRL Focus Section on "European Seismic Networks and Associated Services and Products"

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Declaration of Competing Interests

The authors acknowledge there are no conflicts of interest recorded.

Observational seismology in Europe is firmly rooted in national and regional observatories in charge of managing more than 100 permanent seismic networks and more than 200 past and present temporary deployments. Primarily driven by governmental mandates to detect local seismicity and provide earthquake information to civil protection agencies and the general public, this monitoring effort results also in a tremendous amount of high-quality data - more than 12,000 stations presently contribute to the European Integrated Data Archive (EIDA) - made available to scientists and practitioners. This lively community of seismic data providers and users is at the core of the success of this Focus Section: thirty groups responded enthusiastically to our Call for Papers providing high-quality contributions describing the state of the art in observational seismology in the greater European region, addressing all components of the life cycle of seismic data, from station design to open dissemination of data and seismological products (Amato et al., 2021; Bono et al., 2021; Bragato et al., 2021; Büyükakpınar et al., 2021; Cambaz et al., 2021; Carrilho et al., 2021; Danecek et al., 2021; Evangelidis et al., 2021; Galea et al., 2021; Heit et al., 2021; Lanzano et al., 2021; Lenhardt et al., 2021; Lund et al., 2021; Marmureanu et al., 2021; Margheriti et al., 2021; Masson et al., 2021; Mader & Ritter, 2021; Ottemöller et al., 2021; Quinteros et al., 2021a; Quinteros et al., 2021b; Rudzinski et al, 2021; Péquegnat et al., 2021; Schweitzer et al., 2021; Senturk et al., 2021; Shahvar et al., 2021; Spallarossa et al., 2021; Stammler et al., 2021; Strollo et al., 2021; Veikkolainen et al., 2021).

This large community is also at the core of the Observatories and Research Facilities for European Seismology (ORFEUS) initiative, which started in 1986 as a working group to establish a coordinated European approach in "broadband instrumentation and experience in deployment of digital broadband networks" (Nolet et al., 1986), and evolved as the coordination, integration, standardization and homogenization forum of seismological observatories across Europe. ORFEUS relies on a bottom-up (with mandate from the seismic networks) and federated approach (van Eck et al., 2004), that allows promoting international collaboration while respecting national and institutional uniquenesses. This is key in the European context characterized by cultural diversities and strong national identities. Decades have elapsed since the inception of ORFEUS and the ORFEUS Data Center (ODC), and the domain of observational seismology has witnessed tremendous technological and methodological innovations worldwide. The number of seismic stations has increased by a few orders of magnitude. Seismic data, originally distributed using CD-ROMs for significant events, are nowadays openly and continuously available using state-of-the-art web services and databases. This is primarily possible thanks to the efforts of seismic networks and seismological observatories, further supported and amplified by international initiatives like

ORFEUS, Incorporated Research Institutions for Seismology (IRIS) and the International Federation of Digital Seismograph Network (FDSN).

The European Integrated Data Archive (EIDA; Strollo et al., 2021) is the federated infrastructure within ORFEUS in charge of the dissemination of raw seismic waveforms and standardized station metadata, i.e., the original focus of the ORFEUS initiative. The EIDA federation presently comprises twelve "nodes" (data centers) based in France (Péquegnat et al., 2021), Germany (Quinteros et al., 2021a; Stammler et al., 2021), Greece (Evangelidis et al., 2021); Italy (Danecek et al., 2021), Netherlands, Norway (Ottemöller et al., 2021), Romania (Marmureanu et al., 2021), Spain, Switzerland, and Turkey (Cambaz et al., 2021). EIDA nodes are being considered for establishment in the coming years, for example in Portugal (Carrilho et al., 2021), Sweden (Lund et al., 2021), Turkey (Senturk et al., 2021) and the United Kingdom. Each EIDA node collects and distributes data at national or regional level; a few of the EIDA nodes (Quinteros et al., 2021a; Péquegnat et al., 2021) integrate data from global networks. Other networks that operate at a local or regional level also provide relevant data, which in many cases are also available through EIDA and ORFEUS (Galea et al., 2021; Heit et al., 2021; Mader & Ritter, 2021; Bragato et al., 2021; Lenhardt et al., 2021; Rudzinski et al., 2021; Shahvar et al., 2021; Schweitzer et al., 2021; Veikkolainen et al., 2021). All open data facilitate the development, calibration and consolidation of innovative research and monitoring products and services (Amato et al., 2021; Bono et al., 2021; Margheriti et al., 2021; Masson et al., 2021; Spallarossa et al., 2021). Co-located with the EIDA node in the Netherlands (networks NL, NR, NA), the ODC is also a node of the EIDA infrastructure (including data from all seismic networks not associated with any other EIDA node), and the central hub of all services and initiatives promoted by ORFEUS. The EIDA federation and the recent addition of a strong-motion program (Lanzano et al., 2021) to the original "broadband seismology" focus of ORFEUS are distinctive features of the European approach to integrated seismological waveform data and services. ORFEUS is indeed the only international organization that simultaneously promotes broadband and strong-motion (processed earthquake data and site characterization metadata) seismology, encouraging synergies between two communities that are often segregated mainly for historical reasons.

Most of the articles of this Focus Section serve as good examples in the Open Science domain, where data are also expected to be "findable, accessible, interoperable, and reusable" (Wilkinson et al., 2016). In many contributions, emphasis is placed on quality: as automated access to seismological archives *via* standardized web services emerges as the preferred user strategy, ensuring high-quality of data and metadata becomes more and

more important (e.g., Büyükakpınar et al., 2021; Cambaz et al., 2021; Carrilho et al., 2021; Evangelidis et al., 2021; Mader & Ritter, 2021; Ottemöller et al., 2021; Péquegnat et al., 2021; Stammler et al., 2021; Strollo et al., 2021). Quality is especially important at a time when very large datasets are increasingly being processed routinely and "blindly" in machine-learning approaches. The vast majority of seismological data centers already manage multi-sensor archives (seismometers, accelerometers, infrasound, amphibian seismological instruments, high-rate global navigation satellite systems, etc.), and the inclusion of new types of data (e.g., rotational sensors, low-cost instrumentation, synthetic waveforms) in seismological archives poses new challenges and prompts for new technical solutions and standards for data archival, metadata preparation, quality checks, data dissemination and processing. A particular challenge over the next few years (Quinteros et al., 2021b) is the upcoming massive growth of data volumes, due in particular to new instruments (large-N experiments and Distributed Acoustic Sensing systems) but also to increased volumes of traditional seismic data. It is expected that multi-sensor experiments will progressively dominate the technical and scientific discussion in geosciences in the coming decade, spurred by the societal need to develop multi-disciplinary, multi-hazard science and research products. Joining forces and competences is therefore key to address future challenges: the EarthScope Consortium was recently established in the USA, and the European Plate Observing System (EPOS) candidates as the framework to integrate all geoscience services in the greater European region. ORFEUS and its seismic network community strongly support the development and consolidation of EPOS by participating in the activities of its Thematic Core Service for Seismology.

Scientists are well aware of the importance of citations of their work. At the same time, research often requires high-quality data that can only be acquired through work by seismic network operators. Just like scientists, these networks also are dependent on proper recognition of their activities through citations. If a journal paper uses data from a seismic network, the seismic network can, and should in our opinion, be cited in a similar manner as scientific papers. As Guest Editors of this Focus Section we encouraged all authors to include international network codes, seismic network Digital Object Identifiers and full network citations (generated using the web interface of the FDSN, "Networks- Generate citations for network data") in their papers. We are glad to have been strongly supported in this initiative by the SRL Chief Editor and the Editorial Boards of SSA journals. The seismic networks mentioned in the papers included in this Focus Section are listed in Table 1 (apologies for any involuntary *omissis*).

We are thankful to the Chief Editor Allison Bent and the whole Editorial Staff of Seismological Research Letters for support in the preparation of this Focus Section. We are thankful to the contributors for having enthusiastically responded to our Call for Papers. Our deepest appreciation goes to seismic networks operation and management staff in Europe and worldwide, whose dedicated technical work allows for the science that we all value.

Table 1 - Network codes (sorted alphabetically in each column) and citations (where available) of seismic networks mentioned in the papers of this Focus Section.

2M (Jordi Diaz, J. A. P., 2015)	FReDnet	LX (Instituto Dom Luiz (IDL)-Faculdade De Ciências Da Universidade De Lisboa, 2003)	SS
3A_2016 (Istituto Nazionale di Geofisica e Vulcanologia (INGV) et al., 2018)	G (Institut De Physique Du Globe De Paris (IPGP), & Ecole Et Observatoire Des Sciences De La Terre De Strasbourg (EOST), 1982)	M1 (Institute Of Physics Of The Earth Masaryk University Brno (IPE), 2017)	ST (Geological Survey-Provincia Autonoma Di Trento, 1981)
4A_2009 (Istituto Nazionale Di Geofisica E Vulcanologia (INGV), 2009)	GB	MD (Geological And Seismological Institute Of Moldova, 2007)	SX (Leipzig University, 2001)
4C_2011	GE (GEOFON Data Centre, 1993)	ME (Sector For Seismology, I. O. H., 1982)	T1 (Institute Of Physics Of The Earth Masaryk University (Czech), 1991)
5J_2014 (Cimini et al., 2018)	GL	ML (University Of Malta, 2014)	TH (Jena, F. S. U., 2009)
6A_2008 (Roessler et al., 2008)	GO	MN (MedNet Project Partner Institutions, 1990)	TK (Disaster And Emergency Management Authority, 1973)

6A_2010 (Heit et al., 2010)	GR (Federal Institute for Geosciences and Natural Resources, 1976)	MT (French Landslide Observatory – Seismological Datacenter / RESIF, 2006)	TL
6A_2019 (Fuchs et al., 2019)	GU (University Of Genova, 1967)	MQ	TU (Disaster And Emergency Management Authority, 1990)
6G_2013 (Ergintav et al., 2013)	HA (University Of Athens, 2008)	NA (KNMI, 2006)	UD (Main Center Of Special Monitoring, 2010)
AB	HC (Technological Educational Institute Of Crete, 2006)	ND (Nouméa-Nouvelle-Calédonie, P. L.-C. I. R. D. D., 2010)	UP (SNSN, 1904)
AC (Institute Of Geosciences, Energy, Water And Environment, 2002)	HE (Institute Of Seismology, U. O. H, 1980)	NI (OGS (Istituto Nazionale Di Oceanografia E Di Geofisica Sperimentale) And University Of Trieste, 2002)	VD (CNR IMAA Consiglio Nazionale Delle Ricerche (Italy), 2019)
AI (Istituto Nazionale Di Oceanografia E Di Geofisica Sperimentale, 1992)	HF	NL (KNMI, 1993)	VI
AM (Raspberry Shake Community et al., 2016)	HI (ITSAK, 1981)	NO (Norsar, 1971)	VR (European Gravitational Observatory, 2019)
BA	HL (National Observatory Of Athens, I. O. G., 1997)	NR (Utrecht University (UU Netherlands), 1983)	VS (University Of Evora, (2000)
BE (Royal Observatory Of Belgium, 1985)	HM (GeoRisk Earthquake Engineering, 1995)	NS (University Of Bergen, 1982)	WI (Institut De Physique Du Globe De Paris (IPGP), 2008)

BN	HP (University Of Patras, G. D., 2000)	OE (ZAMG-Zentralanstalt Für Meterologie Und Geodynamik, 1987)	WC
BQ (Department Of Geosciences, Bensberg Observatory, University Of Cologne, 2016)	HS (Hessian Agency For Nature Conservation, Environment And Geology, 2012)	OL (Istituto Nazionale Di Oceanografia E Di Geofisica Sperimentale (OGS Italy), 2016)	WM (San Fernando Royal Naval Observatory (ROA) et al., 1996)
BS (National Institute Of Geophysics, 1980)	HT (Aristotle University Of Thessaloniki Seismological Network, 1981)	OT (University Of Bari "Aldo Moro", 2013)	X3_2020 (Alparone et al., 2020)
BW (Department Of Earth And Environmental Sciences, Geophysical Observatory, University Of Munchen, 2001)	HU (Kövesligethy Radó Seismological Observatory (Geodetic And Geophysical Institute, Research Centre For Astronomy And Earth Sciences, Hungarian Academy Of Sciences (MTA CSFK GGI KRSZO)), 1992)	OX (OGS (Istituto Nazionale Di Oceanografia E Di Geofisica Sperimentale), 2016)	X5_2015 (Sokos, 2015)
CH (Swiss Seismological Service (SED) At ETH Zurich, 1983)	IB (Institute Earth Sciences "Jaume Almera" CSIC (ICTJA Spain), 2007)	PF (Observatoire Volcanologique Du Piton De La Fournaise (OVPF), & Institut De Physique Du Globe De Paris (IPGP), 1979)	XK_2020
CL (Corinth Rift Laboratory Team And RESIF Datacenter, 2013)	II (Scripps Institution Of Oceanography, 1986)	PL	XO_2018 (EMERSITO Working Group, 2018)

CQ (Geological Survey Department Cyprus, 2013)	IJ (Observatory, K., 2013)	PM (Instituto Português Do Mar E Da Atmosfera, I.P., 2006)	YB_2007 (Sokos, 2007)
CR (University Of Zagreb, 2001)	IP	RA (RESIF, 1995)	YD_2018 (Moretti et al., 2018)
CZ (Institute Of Geophysics, A. O. S. O. T. C. R., 1973)	IT (Presidency Of Counsil Of Ministers - Civil Protection Department, 1972)	RD (RESIF, 2018)	YF_1999 (Lee et al., 1999)
D1 (Institute Of Physics Of The Earth Masaryk University (Czech), 2014)	IU (Albuquerque Seismological Laboratory (ASL)/USGS, 1988)	RF (University Of Trieste, 1993)	Z3_2015 (AlpArray Seismic Network, 2015)
DZ	IV (INGV Seismological Data Centre, 2006)	RN (Ruhr Universitaet Bochum (RUB Germany), 2007)	ZJ_2019 (Hetényi et al., 2019)
EG (Dynamics, R. U. O. S., 1993)	IX	RO (National Institute For Earth Physics (NIEP Romania), 1994)	ZM_2017
ES (Instituto Geografico Nacional, Spain, 1999)	KO (Kandilli Observatory And Earthquake Research Institute, Boğaziçi University, 1971)	SI	ZS (Heit et al., 2018)
EV (Istituto Nazionale Di Oceanografia E Di Geofisica Sperimentale, 2012)	LC (Laboratorio Subterraneo De Canfranc, 2011)	SK (ESI SAS, 2004)	

FR (RESIF, 1995)	LE (Landesamt Fuer Geologie, Rohstoffe Und Bergbau, 2009)	SL (Slovenian Environment Agency, 2001)	

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