A.1 Proposal Title

VESUVIUS - CAMPI FLEGREII SUPERSITE

A.2 Supersite Point-of-Contact (PoC)

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A.3 Core Supersite Team and organization

The core Supersite team is the **Istituto Nazionale di Geofisica e Vulcanologia (INGV)**, which is the largest Italian research institution in Earth Sciences with headquarter in Rome and offices in many cities all over Italy (Milano, Pisa, Bologna, Napoli, Palermo and Catania) with about 1.000 personnel units. INGV main mission is monitoring and study of geophysical phenomena in both solid and fluid components of the Earth. INGV runs surveillance networks, laboratories and observatories and collects, studies and disseminates data in the field of seismology, volcanology, geodesy, geochemistry and marine sciences. It is the reference scientific institution for the Italian government in the field of geo-hazard. INGV works in close coordination with civil protection authorities at national (DPC, Dipartimento della Protezione Civile) and local level. INGV manages 24hours/7days nationwide seismic surveillance service and early warning based on monitoring infrastructures. The INGV seismic and volcanic surveillance networks and the laboratories fit into the European Plate Observing System (EPOS), one of the research infrastructures listed in the roadmap of ESFRI, also included in the Italian research infrastructures roadmap. INGV has a relevant experience in coordinating research activities both in national and international projects. INGV participated both as coordinator and partner in several past and ongoing projects funded by international bodies such as EU (e.g. EXPLORIS, ITN NEMOH, SHARE, MIAVITA, SAFER, NERIES, NERA). INGV now leads the Preparatory Phase projects of two ESFRI research infrastructures of the environmental sector, namely EPOS and EMSO (EMSO, European Multidisciplinary Seafloor Observatory).
Future activities for the next three years for the Vesuvius - Campi Flegreii Supersite will be modulated by the MED-SUV (MEDiterranean SUpersite Volcanoes) project, funded within the Environment program of the 7th Framework Programme of the European Commission (Theme ENV.2012.6.4-2 "Long-term monitoring experiment in geologically active regions of Europe prone to natural hazards: the Supersite concept"), in which INGV is the project Coordinator.

The INGV core supersite team includes researchers which have experience working with a wide range of ground and space-based monitoring techniques, data analysis and research into volcanic process.
Following the list of the researchers involved on the team with their role and expertise.

- **Sven Borgstrom** (PoC, Point of Contact), PhD geologist from the University of Naples "Federico II", Italy (Degree in 1983, PhD in 1990), now at INGV-OV as a Technical Researcher. His field of interest

is in SAR Interferometry since 2002, where he worked/works also jointly with other Italian and international institutions (IREA-CNR, TUDelft, ESA, DLR) on SAR data processing, interpretation and integration with classical geodetic data for ground deformation studies in active volcanic areas. Responsible of WPs/Tasks in national and international projects (e.g. MINERVA ESA-DUP, GLOBVOLCANO ESA-DUE). Author of more than 60 papers on national, international and peer-reviewed journals**.**

- **Giuseppe Puglisi** is a Director of Research and Leader of the "Ground Deformation" unit of the INGV Section of Catania, Osservatorio Etneo. His research activity has concerned investigation in the dynamics of the volcanic and surrounding areas by geodetic techniques, mainly GPS and SAR interferometry. He also deals with researches working on ground deformation data inversion mainly using numerical optimization techniques. He is the coordinator of the EC-FP7 Project entitled Mediterranean Supersite Volcanoes (MED-SUV).
- **Francesco Guglielmino** is a Researcher at the INGV Section of Catania, Osservatorio Etneo. Since 2001, he has been developing research activity on deformation studies to achieve better knowledge of dynamic processes in tectonic and volcanic areas. He works on: acquisition, processing and analysis of InSAR data to monitor large-scale and small-scale ground deformations; modelling of ground deformation in volcanic and tectonic areas; inversion of intrusive processes and magma storage at depth. He also deals with development of new techniques to integrate geodetic data with information derived for EO InSAR processing.

- **Salvatore Stramondo** Laurea degree (M.S.) in electronic engineering in 1996, Ph.D. in Geoinformation in 2007; he joined the INGV in 1997 where he is currently Senior Researcher. Since 2004 he is Adjunct Professor at the University of Calabria, Italy. He was Invited Researcher at the CNR-IRECE (Naples, Italy), IPGP (Paris, France), JPL (Pasadena, CA), IIT (Bombay, India). He is author of 70 international papers, several contributions to National and International conferences and some book chapters. He is actually the PI of APhoRISM - Advanced PRocedures for volcanIc and Seismic Monitoring and MIUR "Progetto Premiale INGV Studio multidisciplinare della fase di preparazione di un terremoto"; WP Leader and task leader in National (MIUR PRIN 2009; Abruzzi Project; PON Calabria) and International (FP7 MarSite; FP7 SAFER) projects, and chair of the Satellite Information Data WG8 of EPOS European Project. Since 2009 he is Editor of Remote Sensing journal and Associate Editor of IEEE GRS Letters and International Journal of Applied Earth Observation and Geoinformation. He is Senior Member of IEEE.

- **Maria Fabrizia Buongiorno i**s researcher Manager at INGV. At INGV, she is the leader of the Remote Sensing Unit at CNT and coordinator of INGV Remote Sensing Activities. She is an expert in the remote sensing field. In 2005-2007 she coordinated the Earthquake and Volcanoes application platform in the European Community Project FP6 EURORISK-PREVIEW, in 2009-2011 European Community Project FP7 SAFER, European Community Project FP7-MIA-VITA. At national level, she coordinated the Italian Pilot project ASI-SRV funded by Italian Space Agency.

Other INGV researchers involved in the Supersite activities are:

- **V. Siniscalchi, P. De Martino, C. Del Gaudio, C. Ricco, G. Berrino, G. Macedonio, G. Chiodini, F. Bianco, L. D'Auria, F. Giudicepietro, R. Peluso, M. Musacchio, M. Silvestri, C. Bignami.**

The list includes researchers not only from the "Osservatorio Vesuviano" INGV-Naples section, with a strong expertise in SAR and optical data processing, geodetical (e.g. GPS, optical levelling, titlmetry, etc.), seismological and geochemical methodologies, data integration and interpretation, modelling.

A.4 Other Supersite Research Teams

The supersite Point of Contact will coordinate interaction with other research teams, and in particular with the participants of the consortium of the European Commission funded by MED-SUV (MEDiterranean SUpersite Volcanoes) project. The project addresses a call in the Environment program of the 7th Framework Programme of the European Commission ("ENV.2012.6.4-2: Long-term monitoring experiment

in geologically active regions of Europe prone to natural hazards: the Supersite concepts"). The consortium is formed by 20 leading academic and research institutions and 4 SMEs from 10 countries, which will implement a long-term monitoring experiment aimed at fitting the rationale of the "Supersite" initiative to a large geographical key region prone to hazards including Mt. Etna.
Following the institutions involved in MED-SUV project and the names of the most relevant persons involved in the project activities.

The **Consiglio Nazionale delle Ricerche (CNR)** is the main public research entity in Italy, which is organized in more than 100 Institutes grouped in 11 Departments. The Institute for Electromagnetic Sensing of the Environment (CNR-IREA) and the Institute of Atmospheric Pollution Research (CNR-IIA) are involved in MED-SUV project. CNR-IREA incorporates a Microwave Remote Sensing Group that is active since 1987. Their main research interest is Differential SAR interferometry (DInSAR), with two main goals: (a) development of tools to detect and monitor Earth surface deformations and (b) demonstration of applicability of the proposed techniques in real scenarios. CNR-IREA has a high level expertise in scientific SAR and DInSAR algorithm development and large experience in scientific software development. IREA has also implemented its DInSAR processing chain into the G-POD and GENESI-DEC framework of ESA, allowing to process automatically satellite data. It has also been involved in a number of National and International Project in the SAR related field, as coordinator or participant. CNR-IIA attends the project with the Earth and Space Science Informatics Laboratory (ESSI-Lab) whose main research topics are relevant to the application of information science and technologies to manage, harmonize, and share Earth & Space Science resources and develop Spatial Information Infrastructures. The research interests of the group are inherent the study of atmospheric pollution in urban and industrial areas, the development of global and regional atmospheric modelling and the treatment of geospatial information. These activities are also pursued as member of the OGC (Open Geospatial Consortium), IEEE ICEO, GEO SIF, as well as an affiliated organization to the US UCAR (University Corporation for Atmospheric Research).
Key personnel involved: Dr. **A. Pepe**, Research Scientist with CNR-IREA, in the DInSAR field. Dr. **M. Manzo**, Research Scientist with CNR-IREA, DInSAR data processing and applications for the monitoring of surface displacements. Dr. **G. Solaro** and Dr. **P. Tizzani**, CNR-IREA Research Scientists, processing SAR data acquired by the C- and X- band sensors, and integration of geophysical numerical modelling of volcanic sources. Dr. **S. Nativi**, Research Scientist with CNR-IIA, coordinator of the Earth and Space Science Informatics Laboratory of CNR-IIA, member of the GEOSS Infrastructure Implementation Board (IIB), co-chair of the GEO Science & Technology Committee, and coordinator of the CNR Inter-departmental project GIIDA. Dr. **P. Mazzetti**, researcher at CNR-IIA, design and development of infrastructures and services for geo-spatial data sharing in the context of national, European (FP7) and global initiatives, member of the 2011 GEOSS Evaluation Team. Dr. **L. Bigagli**, researcher at CNR, ICT applications for geographic information management, addressing the gap between the scientific community and the society/decision makers.

AMRA S.c.a r.l. is an entirely public, no-profit company, established in 2005 as a result of an EU funded project. The leading partner of AMRA is the University of Naples "Federico II", the other partners being four public Universities, CNR, INGV and the "Anton Dohrn" Zoological Station. AMRA operates in the fields of natural and anthropogenic risk assessment and mitigation, with early warning methods for natural hazards and quantitative probabilistic multi-risk assessment as its core activities. AMRA, the owner of the ISNET EEW network installed in Irpinia, works in close partnership with the National Department of Civil Protection. AMRA, currently involved in several FP7 Projects, is now coordinating the REAKT (Towards real-time earthquake risk reduction) and the CLUVA (CLimate change and Urban Vulnerability in Africa) projects. Among the others, it is partner of the following projects: SYNER-G (Systemic Seismic Vulnerability and Risk Analysis for Buildings, Lifeline Networks and Infrastructures Safety Gain); SAFELAND (Living with Landslide Risk in Europe); GEISER (Geothermal Engineering Integrating Mitigation of Induced Seismicity in Reservoirs); MATRIX (New Multi-HAzard and MulTi-RIsK Assessment MethodS for Europe); NERA (Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation).
Key personnel involved: Prof. **R. Moretti**, Department of Civil Engineering of the Second University of Naples and associate researcher at INGV-OV.

The **Italian Civil Protection Department (Dipartimento della Protezione Civile, DPC)** of the Presidency of the Council of Ministers (http://www.protezionecivile.it) is the focal point of the Civil Protection National System, which includes Research Institutes, Private Companies, Volunteers and all Italian operative Forces. The main activities are: (a) forecasting, in order to analyse causes of disaster events, to identify risks and detect risky areas; (b) prevention, to reduce disaster damages; (c) assistance, to ensure elementary aid to the population and (d) management and overcoming of the emergency situations. DPC is involved in many National and International activities related to the evaluation and mitigation of natural risks and crises management (i.e. volcanic, earthquake, landslide).
Key personnel involved: Dr. **V. Bosi**, DPC team Leader.

DLR is the German Aerospace Center. Its extensive research and development work in Aeronautics, Space, Transportation and Energy is integrated into national and international cooperative ventures. The Earth Observation Centre (EOC) at DLR consists of the German Remote Sensing Data Centre (DFD) and the Remote Sensing Technology Institute (IMF) and it is the centre of competence for earth observation in Germany. The IMF is focused mainly on developing sensor-specific algorithms and methodologies, whereas DFD concentrates on developing user-oriented products and services. IMF scientists have been involved in SAR data processing since the early days of SEASAT, the first SAR satellite launched by NASA in 1978. They have had and continue to play leading roles in all civil German SAR missions (SIR-C/X-SAR in 1994, SRTM in 2000, TerraSAR-X in 2007 and TanDEM-X in 2010) and they accompanied ESA in all European SAR missions. The SAR Signal Processing Department (IMF-SV) at IMF is involved in MED-SUV project. They carry out research on data from spaceborne and airborne SAR instruments, developing algorithms and software for the focusing and interferometric processing of SAR signals. They develop and operate generic, interferometric and D-InSAR processors for purposes such as deriving digital elevation models and determining the rates of ground deformation.
Key personnel involved: Dr. **M. Eineder**, Head of the SAR Signal Processing Department at IMF and Dr. **C. Minet** expert in SAR processing for ground deformation monitoring.

Ludwig-Maximilians-University (LMU) is one of only three universities that achieved elite status in the first round of the German Excellence Initiative. The volcanology group has 6 permanent staff members, 2 junior professors, 5 PostDocs and 9 PhD students. It has a strong background in field and experimental volcanology. Instrumentation includes shock tubes for decompression experiments, rock characterisation and grain-size analysis, rheology, thermal analysis, geochemistry, petrology, high-speed filming, high-performance computer facilities. LMU involvement in EU-projects consists in the ITN participation (FP6: 12 RTNs, 5 as coordinator; FP7: 9 ITNs, 2 as coordinator). The volcanology group was involved in EXPLODE, MULTIMO and Volcano Dynamics and is part of the ongoing networks MeMoVolc, NEMOH (both FP7 ITNs) and VUELCO (FP7 Cooperation).
Key personnel involved: Prof. **D. Dingwell**, Chair of Mineralogy and Petrology, Research Professor of Experimental Volcanology, and Director of Earth and Environment Department. Dr. **U. Kueppers**, geologist specialised in experimental volcanology.

GFZ was founded in 1992 as the national research institution for geosciences in Germany and is ab initio member of the Helmholtz Association of National Research Centres. With currently more than 1.100 staff, GFZ combines all solid earth science fields including geodesy, geology, geophysics, mineralogy, palaeontology and geochemistry in a multidisciplinary scientific and technical environment. Research is accomplished using a broad spectrum of methods, such as in-situ monitoring and observations, satellite geodesy and remote sensing, deep geophysical sounding, scientific drilling and the experimental and numerical modelling of geo-processes. In order to provide its activities around the globe and in space, GFZ maintains massive scientific infrastructure and platforms, including observatories, a modular Earth science infrastructure, the home base of the International Continental Scientific Drilling Programme (ICDP) with the Operational Support Group, the novel drilling InnovaRig and the Centre for GeoInformation Technology CEGIT, to mention the most relevant for MED-SUV project.
In 2012 a BubbleLab will start its activity, allowing the simulation of earthquake waves and their effect on various types of fluid reservoirs. GFZ has a relevant experience in coordinating and participating into

international projects, e.g. TRIDEC, Collaborative, Complex and Critical Decision-Support in Evolving Crises (FP7); GEISER, Geothermal Energy Integrating Mitigation of Induced Seismicity in Reservoirs (FP7); CO2CARE, CO2 Site Closure Assessment Research (FP7); GITEWS German Indonesian Tsunami Early Warning System Project; SAFER, Seismic Early Warning for Europe (FP6); SHARE, Seismic hazard harmonization in Europe (FP7); MATRIX, New Multi-Hazard and Multi-Risk Assessment Methods for Europe (FP7); REAKT, Strategies and Tools for Real Earthquake Risk Reduction (FP7).
Key personnel involved: Dr. **H. Woith**, earthquake hydrogeology and monitoring of thermal waters. Dr. **T.R. Walter**, Head of the Research Group "VolcanoTectonics". Dr. **E. Rivalta**, physical modelling of magma-filled dikes and hydrofractures, general physical modelling of volcanic processes.

The **University of Durham**, in the United Kingdom, was founded in 1832. It has over 15.000 undergraduate and postgraduate students (3.500 postgraduates and 1.900 international students from over 120 countries) and employs over 3.000 staff. Its academic teaching and research programmes are delivered through departments organised within three faculties: Arts and Humanities, Science, and Social Sciences and Health. Durham University is one of the UK's leading research universities and has been successfully involved, both as partner and coordinator, in a large number of Framework Programme projects and networks.
The University is engaged in several aspects of activity such as high-quality teaching and learning, advanced research and partnership with business, regional and community partnerships and initiatives. The University's strategy is directed at creating the future through internationally recognised research, scholarship and learning within a distinctive collegiate environment.
Key personnel involved: Dr. **G.R. Foulger**, seismic tomography.

University of Bristol (UNIBRIS). With about 16.000 full-time students and more than 5.000 staff, the University organises its academic activities in 34 departments and 15 research centres arranged in six faculties. League tables generally place Bristol within the top ten universities in the United Kingdom and within the top 30 in the world. The School of Earth Sciences was ranked in the top 5 UK Earth and Environmental Sciences for research by the HEFCE in 2008. The school includes five research groups covering the spread of Earth Sciences topics. The Volcanology group is a global leader in the area of field and laboratory investigations of active and young volcanoes, theory development and modelling. All group members are associated with the Cabot Institute, a world-class multidisciplinary institute for research on all aspects of global environmental change, from basic science and social science to technological and policy solutions. It brings together some of Bristol's most outstanding research - in natural hazards and risk, Bayesian statistics, uncertainty and decision-making, climate modelling, poverty, global insecurities and governance, and systems engineering.
Key personnel involved: Dr. **J. Gottsmann** currently holds a Royal Society University Research Fellowship, senior lecturer at the School of Earth Sciences.

Centre national de la recherche scientifique (CNRS) [IPGP, ISTO, ISTERRE, ENS].
IPGP (Institut de Physique du Globe de Paris) will be leader of the French consortium in MED-SUV project. IPGP is a mixed research Unit (UMR7154) of CNRS and Paris Diderot University. It hosts 330 permanent researchers, engineers and technicians, 65 on contracts, and 90 doctorate students. Scientists are grouped in 13 research teams working in various fields of Earth and Planetary Sciences. Three of those teams have strong international expertise in geophysics, field and physical volcanology, gas geochemistry and remote sensing, magma petrology and geochemistry, and numerical/ analogue modelling of geological fluid dynamics. IPGP is the Institute responsible for monitoring French active volcanoes and shares the management of Montserrat Volcano Observatory.
Key personnel involved: Dr. **P. Allard**, Director of research in French CNRS, attached to IPGP. Dr. **F. Beauducel**, geophysicist (equivalent Professor) at the IPGP, Volcanol. And Seismol. Observatories Department.

ISTO (Institut des Sciences de la Terre d'Orléans) is a mixed research Unit (UMR7327) of CNRS, Orléans University and BRGM. It hosts 70 permanent researchers, engineers and technicians, 35 doctorate students and 15 postdoc. Scientists are grouped in 4 research teams working in various fields of Earth and Planetary

Sciences. One of those teams is involved in volcanology studies, with strong international expertise in experimental petrology aimed at defining pre-eruptive conditions, volatile solubility, physical properties of magmas.
Key personnel involved: Dr. **B. Scaillet**, Director of research at French CNRS, unravelling of magmatic and volcanic processes. Dr. **M. Pichavant**, Director of research at French CNRS, experimental petrology.

ISTerre (Institut des Sciences de la Terre) is a laboratory dedicated to Earth and Environmental Sciences. It was created in 2010 by merging LGIT and LGCA. It belongs to the CNRS (National Centre for Scientific Research), the University "Joseph Fourier" in Grenoble (UJF), the Université de Savoie in Chambery (UdS), to IRD and LCPC. It hosts about 250 people, including 92 academics, 50 technical and administration staffs, 19 postdocs and 90 Ph.D. students. The annual budget is 4.9 M€ (without salaries for permanent staff and academics). 55% of this budget comes from contracts, and 16% from the CNRS. 10% of the budget is dedicated to observation activities. ISTerre hosts 9 research groups covering the major fields in following disciplines: Seismic cycle and transitory movements, Geochemistry 4D, Geodynamo, Volcanoes geophysics, Faults mechanics, Mineralogy and environments, Waves and structures, Tectonics reliefs and basins, and Seismic Risks. The laboratory has produced 836 articles in international journals between 2005 and 2009 (162 per year on average), including 24 in journals with Impact Factor > 5. As a member of the OSUG (Observatoire des Sciences de l'Université de Grenoble), ISTerre is responsible for a number of national facilities for permanent (OMIV, RAP, RENAG, RENASS, RLBP) and mobile (SISMOB) observations in geophysics and data centers (FOSFORE, RAP). It is involved in research infrastructures for European seismology (NERIES, RESIF which is part of EPOS). ISTerre scientists have close connections with beamlines at synchrotron and neutron facilities in Grenoble (ESRF and ILL), Paris (SOLEIL) and abroad.
Key personnel involved: Dr. **V. Pinel**, researcher at IRD, is specialized in mechanical modelling of magmatic systems (magma storage and transport through the crust and volcanic edifice behaviour) and expert of deformation studies using SAR data. Prof. **J. Vandemeulebrouck**, associate professor at Université de Savoie, is an expert on the physics and imagery of hydrothermal systems.

Ecole Normale Supérieure (ENS). The Laboratoire de Géologie (http://www.geologie.ens.fr) is specialized in the study of the Earth deformation at all ranges of timescale, from second (seismology) to million years (mantle rheology). One of its research axes is Earth dynamics and earthquakes. The laboratory has worked and is working on the several large earthquakes that occurred in the last decades and in particular the three giant earthquakes of Sumatra (2004), Chile (2010) and Japan (2011), with particular focus on ground deformations observed with GPS and SAR interferometry. The laboratory is involved in field GPS monitoring with campaign and permanent GPS in Chile, Indonesia, Greece, Bulgaria, Guatemala. It has a leading position in two observatories, the Laboratoire International Associé "Montessus de Ballore" (https://www.lia-mb.net/) in Chile and the Corinth Rift Laboratory (http://crlab.eu) in Greece. It is also one of the leading institutions in the GPSCOPE project (http://gpscope.fr and https://gpscope.dt.insu.cnrs.fr) which is a national initiative gathering various CNRS laboratories involved in Geophysical GPS. ENS participates in various national and international R&D projects, in collaboration with several research institutions, in particular in the countries where ENS installed sensors in the field. The Ecole Normale Supérieure has participated and currently participates into several EU projects relevant to the hazard theme (EU projects CORSEIS, AEGIS, ASSEM, 3HAZ, SISCOR, REAKT for Greece, ANR projects for Chile and Indonesia).
Key personnel involved: Dr. **P. Briole**, senior CNRS researcher, is expert in geodesy and remote sensing applied to volcanoes and seismic zones.

Bureau de Recherches Géologiques et Minières (BRGM). BRGM is a French public institution providing R&D and expertise for public policies, decision making and citizen information in different fields of the Earth Sciences. Activities at BRGM cover areas such as observation, mapping and databases, development and modelling for surface and subsurface processes, natural risks evaluation, management and mitigation and the protection of the environment. BRGM also provides support for EU policies in partnership with other geological surveys (EuroGeoSurveys). The Risks division (RIS), which will be involved in the MED-SUV project, features teams of renowned international experience in the fields of geotechnical, earthquake,

landslide, coastal and structural engineering, emergency management with activities related to geophysical monitoring, numerical modelling, natural hazards evaluation, vulnerability assessment and risk mitigation. BRGM has coordinated or contributed to many EC research projects in risk and vulnerability evaluation fields, including MIAVITA on volcanic risk management and many others like RISK-BASE, LESSLOSS, ORCHESTRA (FP6); ENSURE, SHARE, SAFELAND, PERPETUATE, SYNER-G, MATRIX, ENVISION, REAKT, EuroGEOSS (FP7).
Key personnel involved: Dr. **M. De Michele**, researcher in remote sensing. **A. Vagner**, Specialist in Systems and Automation Engineering, she is currently involved as Project manager of FP7 MIAVITA and works on technical activities related to vulnerability assessment (ENSURE, SYNER-G).

European Space Agency (ESA). ESRIN, the ESA EO centre located in Italy, is responsible for collecting, storing and distributing EO satellite data. Major EO activities today are related to the exploitation of the ERS and ENVISAT missions. ESA actively supports projects aimed at optimising the accessibility and use of these data. Examples of relevant ESA-funded EO Programmes are the Data User (DUP/DUE), the Marked Development and the GMES (Global Monitoring for Environment and Security) Service Element Programme. Through these programmes and via the participation to EC-funded projects, ESA gained excellent contacts with the EU Earth science and EO user community. ESA is also active in promotion of relevant technology (Grid, digital libraries, portals, web-services) for various space-related applications, including Earth science & EO.
Key personnel involved: Dr. **R. Cossu**, working in ESA since 2005, has been working in several projects dealing with different aspects of EO applications and related innovation technologies.

Agencia Estatal Consejo Superior de Investigaciones Científicas (CSIC). The Agencia Estatal Consejo Superior de Investigaciones Científicas (CSIC) is the largest public multidisciplinary research organisation in Spain. CSIC collaborates with national and international universities, public RTD organisations, SMEs companies and other institutions of scientific/technological nature. It has a staff of more than 13.500 employees, among these about 3.500 are permanent researchers and more than 4.000 are pre- and post-doctoral researchers. The CSIC has 135 institutes/centres distributed throughout Spain, including 51 Joint Research Units with universities or other research institutions. CSIC has also a delegation in Brussels. It has considerable experience in both participating and managing RTD projects and training of research personnel. Under the 6th Framework Programme CSIC has signed 404 actions (37 coordinated by CSIC). CSIC has been the 5th organisation in Europe in project execution and funding in the 6th FP. Under the 7th FP CSIC has signed as of today more than 459 projects (including 51 coordinated by CSIC as well as 22 ERC). The Institute of Geosciences (IGEO) is the largest Earth Sciences Institute in Spain. The MED-SUV participant team has a great experience in geodetic research, applying ground and space-based geodetic techniques to the monitoring of volcanic hazards, data integration (GPS, InSAR, optical, etc.) to obtain 3D displacement field, as well as theoretical modelling (direct and inverse problem), being able to carry out simultaneous interpretation of terrestrial and space data of deformation and gravity changes. This team has taken part in a wide range of national and international projects, including several EU and ESA projects in which the members have been actively involved.
Key personnel involved: Dr. **J. Fernández**, Research Scientist, expert in Geodesy applied to natural and anthropogenic hazards, including ground and space base techniques.

University of Granada (UGR). The UGR research group is composed by professors and researchers from the Andalusian Institute of Geophysics. This group has broad experience in analysis of seismic signals in different volcanoes like Etna, Stromboli, Vesuvius, Campi Flegrei, Teide, Azores, Colima, Popocatepelt, Arenal, Telica, San Cristóbal, Copahue, Kilauea and Deception Island. Among different research lines, array analysis, seismic tomography, volcanic signal source location and analysis or automatic signal recognition are the most productive from the scientific point of view. The group has participated in several European and National research projects, and it has managed, in the last 10 years, a few millions of Euros. In the last 5 years the group has published more than 35 high quality scientific papers, presented more than 60 communications in international meetings, presented more than 10 doctoral thesis and other scientific products. The group is the responsible of the use and management of a broad portable seismic network,

focused on the study of volcano seismicity. The net is composed by 10 modules of 12 channels seismic array and 15 broad band seismometers. Some of the seismic arrays are, at the present, deployed in active volcanoes as Colima, Copahue or Deception island. Many of the results of the group are directly applied to the early warning alert of different volcanoes, and some of the members of the group are permanent advisors of different Civil Protection organizations of Spain, Italy, Mexico and Argentina. The group has a large experience in active seismic experiments on volcanoes, being responsible of two of them, one developed in the Antarctica (Deception Island) and the second one in Tenerife Island (Canary Island, Spain).
Key personnel involved: Dr. **J. Ibañez**, Director of Instituto Andaluz de Geofisica, Campus de Cartuja s/n, Universidad de Granada.

CVARG (Centre for Volcanology and Geological Risk Assessment) is a multidisciplinary research unit of the Universidade dos Açores (UAc) belonging to the portuguese national research system. The CVARG activities are developed in the Earth Sciences branch and are mainly directed to prevention and forecast of natural disasters. It develops its main activities in the volcanology domain and associated phenomena, including among others volcanic activity, earthquakes, ground deformation, landslides and tsunamis. In the research component, CVARG integrates various national and international networks and consortia and its research team has a considerable experience in international UE funded projects from the FP5, FP6 and FP7, namely, RETINA, FORESIGHT, EXPLORIS, VOLUME, ESONET, EMSO and EPOS among others. In a more operational component CVARG gives a strong emphasis to multi-parametric monitoring of geological hazards in the Azores region running in association with CIVISA (Centre for Information and Seismovolcanic Surveillance of the Azores) seismic, geodetic, geochemical and meteorological networks for seismovolcanic, landslide and environmental surveillance. It makes part of the Volcano Observatory and provides scientific advice to the Azorean Civil defence.
Key personnel involved: Dr. **T. Ferreira**. Assistant Professor, Head of the board of directors of the CIVISA (Centre for Information and Seismovolcanic Surveillance of the Azores).

University of Malta (UoM). The University of Malta has about 10.000 students. The Atmospheric research unit of the Physics department (Faculty of Science) includes 5 full time employees. The Research Unit has instruments based in Giordan Lighthouse on Gozo for monitoring trace gases and climate change in the Mediterranean. Both Shipping and Volcanic emissions are detectable and work is underway to install further equipment specific for Volcanic emissions. Noteworthy is the participation of the UoM in the VAMOS-SEGURO project.
Key personnel involved: Dr. **R. Ellul**, Project leader with 30 years experience in trace gas monitoring.

University of Western Ontario (Western). The University of Western Ontario (Western) is one of the top 10 leading research universities in Canada, with annual research funding in excess of $225 million.
Key personnel involved: **K. Tiampo** is a Professor in Earth Sciences at Western and has extensive experience in the modelling and inversion of geodetic data.

United States Geological Survey – Hawaiian Volcano Observatory (USGS-HVO). The Hawaiian Volcano Observatory (HVO) was established on the rim of Kilauea caldera in Hawaii in 1912. The Observatories mission is to monitor the activity of Hawaiian volcanoes as a means of assessing and forecasting volcano and earthquake hazards, as well as to gain insights into volcanic and earthquake processes that will help to better understand such hazardous phenomena.
Key personnel involved: Dr. **M. Poland**, expert in deformation monitoring, particularly radar interferometry, inferring magma plumbing system geometry, and monitoring flank instability.

Università degli Studi di Milano (UMIL). The University of Milan, established in 1924, is a public teaching and research-intensive university, the only Italian among the 21 prestigious members of LERU (League of European Research Universities) and an internationally high-ranked university. With a teaching staff of about 2.200 tenured professors and with almost 60.000 students, the University of Milan offers a number of study programmes which can be grouped into three macro-disciplinary areas: Humanities, Social Sciences and Law; Medicine and Healthcare; Natural Sciences. Research activities are conducted in 31 Departments,

among which the Dipartimento di Scienze della Terra “A. Desio” (Department of Earth Science "A. Desio") and 29 Inter-departmental Research Centres. With its wide spectrum of basic and applied research activities, covering scientific disciplines such as stratigraphy, paleontology, structural geology, geomorphology, mineralogy, petrography, geophysics and engineering geology, the Department of Earth Science has been involved in numerous national and international research projects, often as a coordinator. In particular the Engineering Geology research group focuses its interest on three topics: i) Management of landslide hazard and risk mitigation (also applied to volcanic environment, at different scale, slope landslides or volcano flank collapses); ii) geotechnical and geomechanical studies applied to civil-engineering; iii) advanced techniques for groundwater management. The group has gained proven experience in the use of modern statistical techniques for spatial analysis of geological data and the application of numerical modelling to simulate hazard scenarios. The geotechnical, geomechanical and hydrogeological characterization of materials and geological media involved in the phenomena, is a strategic requirement for all the thematic studies. The Engineering Geology Laboratory for Testing Material of the Department has supported 40 years of research, through the characterization of soils, rocks and discontinuities, applied to the assessment of slope stability, civil engineering works, and to the exploitation of water resources.
Key personnel involved: Dr. **T. Apuani**, Geologist. Associate Professor in Engineering Geology; responsible of the Engineering Geology Laboratory for Testing Material of the Department of Earth Science.

Université Blaise Pascal - Laboratoire Magmas et Volcans (UBP-LMV). The Laboratoire Magmas et Volcans (LMV) is a joint research unit of the Blaise Pascal University (UBP), the Centre National de la Recherche Scientifique (CNRS) and the Institute of Research and Development (IRD). It is also one of the laboratories of the Observatoire de Physique du Globe at Clermont-Ferrand (OPGC) and one of the Auvergne Regional Centres of Excellence. The LMV coordinates the Laboratory of Excellence CLERVOLC funded by the French government and aimed at bringing a global and multidisciplinary response to volcanism and volcanic risk issues. It hosts over a hundred people, including 62 permanent researchers and 21 PhD students grouped in 3 teams: Volcanology, Geochemistry and Petrology. The main scientific focus is the study of all magmatic and volcanic processes, from melting in the earth's mantle to the eruption of magma at the surface, by combining state-of-art methods and techniques. To achieve this goal, it has developed a large range of analytical and experimental equipments and methods for observation and modelling. The LMV has strong international expertise in remote sensing, geophysics, field and physical volcanology, gas geochemistry and magma petrology and geochemistry, and numerical/analogue modelling of deformation.
Key personnel involved: Dr. **F. Donnadieu**, expert in radar remote sensing of volcanic plumes. He is in charge of the OPGC Doppler radar monitoring Etna (INGV-UBP-CNRS research agreement) and of the VOLDORAD service at OPGC.

Other research teams, potentially interested in Vesuvius–Campi Flegreii Supersite (mainly in the field of SAR Interferometry)

- **University of Miami, USA (**reference person: **Falk Amelung)**; The University of Miami Geodesy and Seismology Laboratory (UMGSL) is an active research group consisting of 3 faculty members and 10-15 students and postdocs addressing diverse topics in volcanology, tectonics and climate change. UMGSL receives funding from the U.S. National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA). UMGSL depends on excellent in-situ and space data collected by the monitoring and space agencies to develop winning research proposals. F. Amelung is already Co-Investigator in a TSX Proposal on Campi Flegreii (GEO1649), together with INGV (reference person: the Supersite Point-of-Contact) and GFZ (reference person: Thomas Walter); Principal Investigator: IREA-CNR (reference person: Paolo Berardino);

- **JPL/Caltech, USA** (reference person: **Paul Lundgren**, Eric Fielding); the Jet Propulsion Laboratory (JPL), California Institute of Technology (Caltech), is managed by Caltech for the U.S. National Aeronautics and Space Administration (NASA). It is the lead NASA institution for the robotic exploration of the solar system and a leading institution for a large number of Earth satellites

related to climate change and other geoscience objectives. JPL was the original developer of synthetic aperture radar (SAR) interferometry (InSAR) during the 1980's and continues to develop and apply InSAR techniques to scientific problems using both international SAR satellite data and the JPL/NASA developed airborne InSAR, the UAVSAR project.;

- **University of Rome 3, Italy** (reference person: **Valerio Acocella**); The Department of Science at the University of Roma Tre, Italy, is actively involved in the study of the deformation of volcanic areas, at the regional and local scale, and in any setting, including divergent, convergent, transform plate boundaries and hot spots. In addition to the field analysis, we use analogue and numerical models and InSAR analysis. Using these tools, the researchers of the Department have been studying also the recent evolution of Mt. Etna and, subordinately, the Campi Flegrei Caldera. At Mt. Etna, they have investigated the volcanic activity of the last decades in relation to the instability of the eastern flank of the volcano. At Campi Flegrei Caldera, after defining the fracture pattern, they are now studying the recent surface deformation within the caldera, also providing a comparison with that observed during the unrest of other calderas in the world in the last 25 years.

- **University of Leeds, UK** (Reference person: Andrew Hooper and Tim Wright). The University of Leeds is one of the largest universities in the UK with an income of € 5000m, over 30,000 students and 8,000 staff. The School of Earth and Environment was ranked second in the UK for research power in the 2008 Research Assessment Exercise. The Institute of Geophysics and Tectonics within the school is the largest grouping of geophysicists in the UK and a centre of excellence for geodynamcs and tectonics. Researchers in the institute have been active in the field of radar interferometry (InSAR) since 1997 and have been at the forefront of developing the use of InSAR for measuring tectonic and volcanic deformation. The group has developed dedicated InSAR software packages, which have been made available to the scientific community, and today hundreds of users from all over the world use these softwares. Leeds led the international Afar Rift Consortium and is leading the work package on magma migration in the European FUTUREVOLC project.

A.5 Supersite description and justification

The following subsections provide an overview of the main objectives and characteristics of the Supersite.

A.5.1 How does the Supersite support the objectives of the Geohazard Supersites?

The activities in the framework of Vesuvius - Campi Flegreii Supersite will support the objectives of the Geohazard Supersites, facilitating new scientific discoveries through the joint exploitation of large archive and new unprecedent datasets.

Also development and transfer of new scientific knowledge, in particular towards the national and local civil protection authorities, will be a key point for updating the already existing Emergency Plans of Vesuvius and Campi Flegreii.

The development of sustainable long-term EO strategies will be also crucial in terms of scientific knowledge/monitoring of Vesuvius - Campi Flegreii Supersite: this is the main objective of MED-SUV project, from which we expect clear indications/suggestions for future work after the end of the project.

A.5.2/A.5.3 Geological processes characterizing the Vesuvius–Campi Flegreii Supersite and how the geohazard can be characterized

Southern Italy is linked to the geodynamic context of the Central Mediterranean area, characterized by active tectonics related to the diachronic convergence of the boundary between the Eurasian and African plates. The local tectonic setting of the Campanian and Sicilian regions produces different magmas feeding Mt. Etna, Vesuvius and Campi Flegreii, which has reflected in different eruptive behaviours controlled by *open* or *closed* conduit conditions, and covered almost the entire spectrum of threatening and possibly disruptive/destructive volcanic phenomena.

Nowadays, the Neapolitan Volcanic District (NVD: Vesuvius, Campi Flegreii and Ischia Island) is in a quiescence phase. In the case of Vesuvius, currently no clear deformation signals related to volcano dynamics are detected by InSAR/geodetic measurements, apart from some small gravitational collapses in

the upper part of the crater. Nonetheless, it is crucial to continue this joint InSAR/geodetical monitoring activity to highlight a possible reactivation of the volcano, which had its last eruption only in 1944.
Vice versa, in the case of Campi Flegreii (last eruption in 1538), an uplift phase has been recorded since 2005 with an overall deformation of about 23 cm to date. Analysis of historical optical levelling measurements dating back to the fifties have proven that a phase of unrest is underway in the Campi Flegreii caldera. Unrest is supported also by the two significant bradyseismic crises that occurred between 1969-72 and 1982-84 producing an overall uplift of more than 3 metres. At the end of 2012, the ongoing uplift phase at deformation rates up to 3 cm/month, suggested the National Civil Protection Department to pass from the alert level of the Campi Flegreii Emergency Plan from *base* (green) to *attention* (yellow) level.
The change did not involve the population but INGV-OV, in charge for monitoring the NVD. National Civil Protection Department, in fact, asked INGV-OV to increase considerably the monitoring activities at Campi Flegreii area and surroundings, considering also the metropolitan area of Naples with more than 1 million people. The city has grown within the Campi Flegreii caldera and around Vesuvius volcano's flanks, two volcanoes that showed highly explosive volcanism throughout their geological history and historical times. Based on the historical eruptive behaviour, statistics, and modelling of the volcano supply system, a new eruption is expected to produce 10-30 km-high volcanic columns, ash cloud dispersal over substantial portions of Europe and beyond, depending on wind directions, and devastating pyroclastic flows. For this reason, the Naples area is one with the highest level of volcanic risk worldwide with volcanic eruptions that might cause a crisis of European proportions.

A.5.4 Research questions, application developments or operational system enhancements pursued at Vesuvius – Campi Flegreii Supersite

Vesuvius and Campi Flegreii areas are nowadays also test sites for the application of cutting-edge technologies/methodologies in the field of volcanology. For instance, since a couple of years, an innovative study on the internal structure of Vesuvius has begun using an experimental telescope exploiting space-sourced particle beams (muons). These particles, originating from the interaction of cosmic rays with the layers in the upper part of the atmosphere, are able to penetrate considerable rock layers, up to a thickness of about 1-2 km, thus allowing the implementation of a kind of CAT *(Computerized Axial Tomography)* of the volcano. Such a technique has been employed till now only at a few small volcanoes in Japan and French Antilles. The telescope, called *Mu-Ray* (MUonic RadiographY) and set up by a group of Italian researchers from INFN (Istituto Nazionale di Fisica Nucleare), INGV-OV and the University of Naples "Federico II", has innovative features compared with previous sensors, and will be located at the base of Mt. Somma (the old crater), allowing therefore to detect the muons movement across the volcanic cone.
With regard to Campi Flegreii, another interesting activity is currently carried out by a team of INGV-OV researchers. The activity focuses on extending the geophysical monitoring system to the sea, as the Campi Flegreii caldera is partially submerged and therefore, traditional geophysical methodologies cannot be applied as measurements would be extremely difficult and expensive. For the purpose, in the last years a multiparametric station (buoy) has been installed in the Pozzuoli Gulf. The buoy is connected to a submarine module via an electric wire. The module is located at the bottom of the sea at a depth of 100 metres and is equipped with a broadband seismic sensor, a triaxial accelerometer, a low-frequency hydrophone, and a pressure sensor. From the end of 2011, on the emerged part of the buoy a continuous-recording GPS station has been installed in order to verify the possibility to exploit the technique for the estimate of (the only) vertical ground deformations at the base of the buoy. This consists of a ballast located at the bottom of the sea, "rigidly" connected with its emerged part by a mechanical cable. The cable, always in traction, allows possible vertical ground movement to be rigidly transferred to the emerged part of the buoy, and therefore to the GPS station for its measurements. A first test period of about 5 months has allowed to verify that, in spite of possible errors due to the tilting of the emerged part of the buoy related to meteomarine conditions, monitoring of vertical deformations of the sea floor seems to be possible with a centimetre accuracy, thus giving promising results. This study will therefore continue even for the next years.
A further project concerning the Campi Flegreii site is the Campi Flegreii Deep Drilling Project (CFDDP). CFDDP is an international scientific research project focussed on the understanding of volcano dynamics at Campi Flegreii caldera and of the mechanisms causing the unrest phenomena associated with the large

uplift and subsidence (bradyseism) observed. The project involves two drillings: the first one, already finished, has reached depths of 500 metres (pilot hole), while the second one, to be planned, should reach a depth of about 3.500 metres. The pilot hole is mainly aimed to detail the stratigraphy and eruptive history of the easternmost caldera border, which is the less known at depth for lack of previous drillings. This area is also the highest risky one, due to the strong urbanisation and population density. The deep drilling will be mainly conceived to study the mechanisms generating volcanic eruptions and unrests in the area, by in-situ measurement of the main mechanical and fluid-dynamical parameters of deep rocks. Furthermore, in order to infer the depth of the magma chamber, measurements of the temperature gradients in the deeper part of the drilling should be carried out.
A more general goal of CFDDP is to focus the international interest on the volcanic risk and on the environmental, cultural and energy resources of Campi Flegreii. Thus, this area has the potential to become a large natural laboratory to plan and testing innovative technologies also for environmental monitoring and sustainable development such as: mitigation of volcanic and natural hazards, environmental monitoring, sustainable and clean exploitation of geothermal energy.

A.5.5 What data and observation systems and models are available for this site? Who operates them? Can these data/systems/models be accessed readily by the research team? and local support to the Supersite proposal

The monitoring of Vesuvius and Campi Flegreii includes a seismic network continuously recording and linked in real-time to the national seismic network, a mobile network and a laboratory for data analysis and processing, which is able to locate earthquakes with M < 1 under low noise conditions. Seismic events are classified and data are stored in a large database. The permanent network consists of short-period and broadband seismometers, infrasound sensors, hydrophones, borehole strain meters, accelerometers and an OBS station, while the mobile network is equipped with three-components broadband sensors. The optical levelling network has 325 benchmarks for Vesuvius and 370 benchmarks for the Campi Flegreii. 9 Tide-gauge stations in the Naples and Pozzuoli Gulfs were also set up. The GPS network consists of 22 GPS vertices for continuous monitoring of the whole area (8 Vesuvius, 14 Campi Flegreii), besides 60 benchmarks for discrete gravity measurements (32 at Vesuvius, 28 at Campi Flegreii), continuous gravity measurements (1 Vesuvius, 1 Campi Flegreii) and a tiltmetric continuous network of 9 tiltmeters (2 at Vesuvius, 7 at Campi Flegreii).
INGV-OV is currently managing also equipments for geochemical monitoring and infrastructures for research on volcanology (petrological and isotopic analysis (Sr and Nd) of magmas, analysis of volcanic sediments, grain size distributions, fluid inclusions analysis (FTIR), visible and IR monitoring of active volcanoes, microscopy laboratory for component and petrographic analysis).

A.5.5.a Mission of the organization providing the in-situ data

The mission of the INGV is to observe, monitor and understand the geophysical phenomena in both the fluid and solid components of our planet. In this framework, INGV is in charge of the surveillance of the seismicity and volcanic activity of the whole Italian national territory through state-of-the-art observations systems (e.g. instrumental networks covering the national territory or concentrated around the active volcanoes, laboratories, etc.). As far as this application to CEOS is concerned, INGV is the provider of the in-situ data collected on Mt. Etna and Campi Flegrei/Vesuvius Supersites.

A.5.5.b Relationship to decision makers

The INGV belongs to the Italian Civil Protection system. Its relationship with the National Department of the Civil Protection is organized in the context of a decennial Framework Program, which outlines the guidelines for implementing and maintaining the monitoring system, sharing of the information between INGV and DPC, defining of the procedures for the alerts in case of volcanic or seismic events and as well as any issue related to the organization of the surveillance system in Italy. INGV organizes and maintains the complex volcano and seismic monitoring system in Italy through periodic agreements (annual, triennial, etc.) with the DPC, regional and local authorities.

A.5.5.c Data policy and vision for data access

INGV data policy is inspired to GEO and EC directives for the data sharing and dissemination (INSPIRE, etc.). Furthermore, thanks to the wide spectrum of the kinds both of the available data and participants (data providers and data users), the MED-SUV project - as whole - is the ideal forum to find worldwide enforceable data policies aimed at promoting retrieval and systematic access to the EO and the in-situ data for Supersites. This Task deals with the definition of such a data policy, by implementing specific deliverables (at months 6 and 36 of the project) which test and propose a specific data policy. Currently, data sets are shared through INGV web portals. However, during the MED-SUV project, a specific e-infrastructure will be designed and implemented to allow data interoperability and sharing. To this aim this e-infrastructure will consider concepts and solutions introduced and adopted by the GEOSS Common Infrastructure (GCI), as well as the standards recognized by the GEO Standard and Interoperability Forum (SIF-INSPIRE) and GMES. The activities of GEOWOW project will be taken into account through the partners involved in the MED-SUV project. For data archiving and sharing, the supersite digital infrastructure will also consider the experience and best practices developed by previous relevant projects (e.g., DIVO, ASI-SRV, PREVIEWS). The e-infrastructure will be developed using a Service-oriented approach. In this context, added value processing services for exploiting the information contained in low level ESA satellite data will be implemented. The added value products will include integrated parameters and maps obtained merging satellite and in situ data.

Data and data products will be classified according to the level of processing, starting from raw data, i.e. data that keep unchanged the original format of the sensors (e.g. seismic waveform, raw GPS data, etc.) or the original information (e.g., rock samples), to quality controlled data, to data products coming from automated or nearly automated procedures, to data products coming form scientific investigations. Furthermore, according their availability on the data storage, data from permanent stations can be classified as “real-time” or “near real-time”, depending on the delay needed to upload the acquired data on the data storage and make them sharable.

As general rule, the access to the data and data products can be open, restricted or embargoed. Open data and data products are freely available to any users; they will be available under appropriate licences, which regulate observation intellectual properties and copyrights. Restricted data and data products are available to registered authorized users after signing an agreement for accepting the INGV data policy; they are available according to an appropriate license, that regulate observation IP and copyrights. Embargoed data and data products are available only after a specific time (embargo period) has passed since collection/generation. During the embargo period they will be only available to specific authorized users (usually, only to components of the national Civil Defence system). Once the embargoed period has passed they may become open or restricted.

A.6 Current or future use of requested data

InSAR/geophysical data integration

The Earth Observation community considers the Southern Italy volcanoes particularly appealing and Space Agencies have run background missions for both Vesuvius - Campi Flegreii and Mt. Etna over a long time (since the 1980s), so that the current EO database, for both SAR and optical data, is probably the largest in the world for active volcanoes, including EO time series starting from 1984 (LANDSAT) and 1992 (ERS1), respectively.

Moreover, the integration between ground-based networks and InSAR data is an added value for monitoring, as InSAR is able to extract the information on wide areas, not available from classical networks due to their poor space coverage. Conversely, ground-based networks routinely used for surveillance are usually permanent stations (e.g. GPS, tiltmetric, etc.), giving a *continuous* information not detectable from space-borne SAR sensors.

Geodetic monitoring of Vesuvius and Campi Flegreii areas, historically carried out through classical geodetic networks, has been complemented at the end of the nineties with space-borne InSAR techniques, exploiting the C-band sensors onboard the ERS1/2 and ENVISAT ESA satellites.

After the launch of the Japanese ALOS satellite, also L-band data were exploited for studying the NVD, but likely resulting in not really interesting data, considering the amount of (geodetical) information retrieved

with an L-band sensor compared with the low deformation typical of the investigated areas; anyway, if ground deformation grows in time, as it was recently in Campi Flegreii, also L-band data exploitation will become of interest.
In the very last years, C-band monitoring has been therefore complemented by high-resolution X-band (TerraSAR-X, COSMOSkyMed) investigations, in order not only to point out also small deformations, but to extract also an information with an higher sampling rate, compared with ALOS, ERS and ENVISAT revisiting times.
In general, SAR data processing in the NVD was very effective in detecting, for instance, not only the Campi Flegreii 2000 uplift event and, more recently, the ongoing deformation started in 2005, but also in pointing out over the last years an extended ring-like subsidence area around the Vesuvius volcanic edifice (still a matter of scientific debate), besides the deformation in the upper part of the crater.
In 2009, a TerraSAR-X High Resolution Spotlight analysis over Campi Flegreii area close to Solfatara crater, highlighted a small but clear deformation signal consistent with geochemical observations carried out there; this opened new scenarios for InSAR applications, not only in terms of InSAR/geodetical comparison for ground deformation studies, but indicating also a new *non-conventional* way of data integration for volcano monitoring, focussed on detecting very local and small phenomena, likely due to geochemical activity.

Optical data needs

The volcanic phenomena require techniques of synoptic-scale observations that only remote sensing platform can provide. In order to evaluate the real suitability of spatial data to monitor the system of Italian volcanoes and in different application scenarios (e.g. Pre / During / post-crisis), the adequacy of different satellite sensors, was evaluated according to: the technical characteristics (e.g. spatial resolution, geographical coverage, etc.), instrumental performances (e.g. radiometric resolution), main orbital characteristics, and observational such as the temporal resolution. For monitoring of the thermal state of volcanic areas, it is necessary to use TIR sensors with high spatial resolution so as to obtain detailed information even small areas where there might be significant thermal anomalies.

The main disadvantage of this type of sensors is represented by the interference of the weather clouds that make the data completely unusable and poor temporal resolution.

Advanced Spaceborne Thermal Emission and Reflection (ASTER) is one of the five sensors on-board the Terra platform satellite launched in December 1999 as part of the NASA Earth Observing System (EOS). ASTER consists of three different subsystems operating in the visible and near infrared (VNIR, 3 bands), short wave infrared (SWIR, 6 bands) and thermal infrared (TIR, 5 bands) regions of the electromagnetic spectrum. The ASTER spatial resolution varies from 15 m (VNIR), 30 m (SWIR), to 90 m (TIR). ASTER is an on-demand instrument. This means that data over a location are acquired only following the submission of a request aimed to observe that area. Any data that ASTER has already acquired, are available by searching and ordering them from the Earth Observing System Data Gateway (EDG) or from the Japanese GDS system.

LANDSAT 8 Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images, launched in February 2013, consist of nine spectral bands with a spatial resolution of 30 metres for Bands 1 to 7 and 9. New band 1 (ultra-blue) is useful for coastal and aerosol studies. New band 9 is useful for cirrus cloud detection. The resolution for Band 8 (panchromatic) is 15 metres. Thermal bands 10 and 11 are useful in providing more accurate surface temperatures and are collected at 100 metres. Approximate scene size is 170 km north-south by 183 km east-west. The Landsat 8 satellite images the entire Earth every 16 days in a 8-day offset from Landsat 7. Data collected by the instruments onboard the satellite are available for download at no charge from GloVis, EarthExplorer, or via the LandsatLook Viewer within 24 hours of reception.

PLEIADES

Pleiades is the optical component of the ORFEO system developed in cooperation with Italy. Pleiades is an optical observation system with a metric resolution designed to offer a high acquisition capability with a revisit lower than 24 hours to satisfy both civilian and military needs. For this aim, the Pleiades system is constituted of a constellation of two optical satellites (visible and near infrared domain) on a Sun-synchronous orbit at 694 km. This number of satellites is essential to guarantee the accessibility and revisit frequency required to operationally answer to defence and civil security missions. The Pleiades system offers daily access to every point on Earth, resolution of 0.7 m in vertical viewing in panchromatic, acquisition of a 120 km x 120 km image mosaic in the same orbit, and field of view of 20 km corresponding to about 44 images per year (each frame 22 images/yr).

HYPERION

Hyperion is an imaging sensor payload of the Earth Observing (EO-1) platform. Hyperion provides a high resolution hyperspectral imager capable of resolving 220 spectral bands (from 0.4 to 2.5 µm) with a 30-metre resolution. The instrument can image a 7.5 km by 100 km land area per image, provide detailed spectral mapping across all 220 channels with high radiometric accuracy and with a 16-day repeat cycle on Mt. Etna, corresponding to about 22 images per year.

AVHRR

The National Oceanic and Atmospheric Administration (NOAA) series of satellites carries the Advanced Very High Resolution Radiometer (AVHRR). The AVHRR sensor provides imagery in the visible, near infrared and thermal infrared wave length bands. The NOAA satellites have a circular, polar, sun-synchronous orbit with an altitude of 850 km and a period of about 100 min. A sun-synchronous orbit means that each satellite overpasses a same point always at the same local time. As a matter of fact for the NOAA satellite, this characteristic allows up to 10 overpassing using all the available satellite. The imagery data from a NOAA AVHRR sensor can be recorded and/or directly transmitted to a receiving station at a nominal nadir resolution of 1.1 km. In this case, the across track swath width is about 2400 km. The temporal coverage of Vesuvius and Campi Flegreii is at least four passes by day. The constellation of NOAA allows high repetition rate with a daily repeat cycle, corresponding to 1460 images per year. The combination with spatial resolution and spectral capabilities makes this sensor useful and widely used for monitoring volcanic activity.

MSG

The Meteosat Second Generation (MSG) satellites produce Spinning Enhanced Visible & InfraRed Imager (SEVIRI) image data in the form of both High and Low Rate SEVIRI image data. The spatial coverage of imager includes the whole Europe, Africa and locations at which the elevation to the satellite is equal or greater than 10°. The different channels provide measurements with resolution of 3 km at the sub-satellite point. The 12 SEVIRI channels consist of 8 InfraRed (IR) detector packages (3 detectors each), and 1 High Resolution in the Visible (HRV) channel (9 detectors), 2 Visible and 1 Near-IR (3 detectors each), with a baseline repeat cycle of 15 min (that can be reduced in 5 minutes in 'Rapid Scan' mode Service, RSS).

MODIS

The Moderate Resolution Imaging Spectrometer (MODIS) is a multispectral instrument with 36 spectral bands in the wavelength range from visible to thermal infrared. MODIS is aboard the NASA Terra and Aqua polar satellites launched in 1999 and 2002 respectively, as part of the Earth Observing System (EOS) mission (Barnes et al., 1998; http://modis.gsfc.nasa.gov/). MODIS spatial resolution varies from 250 m (channels 1 and 2), 500 m (channels from 3 to 7) and 1000 m for all the remaining channels. The sensor scans ±55 across-track about the nadir from the EOS orbit altitude of 705 km, resulting in a 2330 km swath and full global coverage every one to two days. Campi Flegreii is actually covered by 2 Terra frames (at 10:30 and at 21:30 UTC) by 2 Aqua frames (at 00:00 and at 12:00 UTC), with a daily repeat cycle, corresponding to 1460 images per year (each polar satellites 730 images/yr).

A.7 Schedule

The requested data will be used in the framework of the MED-SUV project. Hence the milestones for setting up the Vesuvius-Campi Flegreii Supersite, as an infrastructure available for the interested Scientific Community, will be suggested by the timetable of the three year-lasting MED-SUV project (1 June 2013-31 May 2016).

A.8 Detailed geographic region of interest

The Campania Province represents the southernmost sector of the Plio-Quaternary volcanic belt along the Italian peninsula. It includes the active volcanoes of Somma-Vesuvius, Ischia and Campi Flegrei (Phlegraean Fields; Fig. 1). The volcanic centres of the Campania Province developed inside Quaternary extensional basins along the Tyrrhenian Sea border at the intersection between NE-SW and NW-SE fault systems. Vesuvius is younger than the 79 AD eruption that destroyed Pompeii and Herculaneum, and probably started to grow after the 472 AD eruption, inside the Somma caldera (Santacroce 1987; Rolandi et al. 1998; Santacroce et al. 2003). Starting from about 18 ka up to 79 AD, the style of volcanic activity at Mt. Somma became more explosive, and plinian eruptions took place. Plinian activity was preceded by long periods of volcanic quiescence, and was accompanied by volcano collapses that formed the Somma caldera; emissions of lavas and pyroclastics by strombolian, vulcanian and subplinian eruptions also occurred during inter-plinian phases. After the 79 AD eruption, Vesuvio has been characterised by strombolian and effusive activity alternating with periods of 200-500 years of volcanic quiescence (e.g. 472 AD and 1631 AD), each closed by large explosive eruptions. The eruption of Mt. Vesuvius of March 1944, is the last eruption occurred at Vesuvius. Since then the volcano has been in a quiescent stage without any major sign of activity.

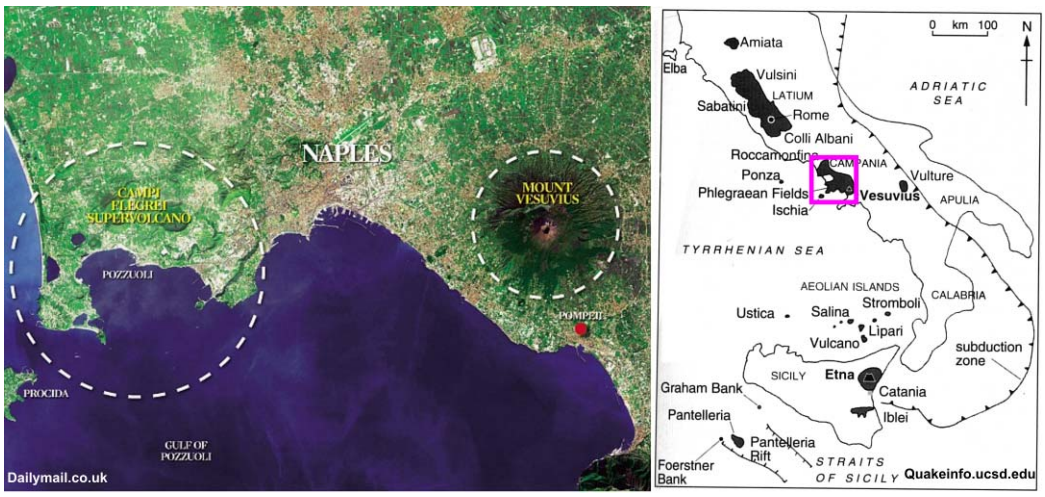

Figure 1: Figure showing the geographic location and the main features of the central-south Italy geodynamic setting.

The Campi Flegrei is a large, 13-km-wide nested caldera located under the western outskirts of the city of Naples and under the Gulf of Pozzuoli. It contains many volcanic centres (cinder cones, tuff rings, calderas) that have been active during the past 30-40,000 years. The volcanic field has been the site of some extremely violent eruptions in the past, although the few ones that occurred during historic times were relatively small events. Currently, the Campi Flegrei is in unrest since about ’50 years.

The satellite data requested for the Vesuvius and Campi Flegreii Supersite fall within 40° - 42° N and 13° - 15° E region.

A.9 Data requirements

The availability of Synthetic Aperture Radar (SAR) data from different sensors exploiting different bands of the electromagnetic spectrum (tipically X, C and L-band for space-borne sensors) allows to evaluate different phenomena occurring at different scales.
In order to quantitatively compare satellite-derived data with ground-based geodetic networks (e.g. optical levelling, GPS), the availability of SAR data from different sensors exploiting different bands and from different tracks (ascending and descending) is critical. Such data will allow, in fact, not only the evaluation of diverse phenomena at different scales but also to reconstruct ascending and descending datasets covering large time spans, resulting in the opportunity to split the data into vertical and easting components of ground motion, when the information on common pixels from both viewing geometries is available. Typically, the *Stripmap* and *Spotlight* acquisition modes have proven suitable for investigating Vesuvius and Campi Flegreii areas with an areal extent of about 150 Km^2 each, very close (a few tens of km) one another so as to be, for instance, in the same ASAR-ENVISAT frame.
A separate discussion shall be done for acquisitions by X-band sensors, for which, due to the reduced areal coverage, different frames for the two different areas are needed,.
Data requirements are listed below, although the list should be considered a preliminary one being revisited at regular intervals, depending on the evolution in time and space of the geodynamics of the investigated areas, and the subsequent related volcanic hazard.

Limited snow coverage of Vesuvius, the higher relief (1281m a.s.l.) in the area of interest, is not a critical issue, as it lasts only a few days during the year, so data for the whole period of the year are usable.

TerraSAR-X (about 132 StripMap per year, angle: flat, product type: SSC)
As regard to TerraSAR-X acquisitions, planning of data has been already fixed in the DLR TSX Proposal "GEO1649" (approval date: November, 2012), which established tasking for TerraSAR-X over Campi Flegreii caldera and Vesuvius volcano as part of the Group of Earth Observation (GEO) Supersites initiative for natural hazards.

COSMO-SkyMed (200 acquisition per year suggested)
The advanced capabilities of the SAR sensors aboard COSMO-SkyMed allow to achieve high resolution products (<1 meter, to 3 meters) in short repeat time intervals (1 to 4 days). At Campi Flegrei caldera, COSMO-Skymed data are acquired with different modes (i.e. spotlight, stripmap) and with different geometries. The quite short revisiting time of CSK data is essential to detect and image the transient caldera activity, which is characterized by high deformation gradients and other dangerous phenomena like the bradyseism. In the Campi Flegrei area CSK data have been covering the time span from 2011 to 2013 (two dataset in Stripmap-mode along both ascending and descending orbit). The ascending orbit dataset covers a time interval from March 2013 to September 2013 and is characterized by an incidence angle of 40° and an orbit inclination with respect to the geographic north (heading) of -9°. In the other side, the descending one spans from February 2011 to March 2013 and is acquired with an incidence angle of 27° whereas the heading is equal to -168°. A background acquisition strategy will be needed in order to update the archives created during the projects ASI-SRV and SAR4VOLCANOES..

Radarsat-2 (30 acquisitions per year suggested)
The availability of Radarsat-2 data is crucial to fill the gap between ENVISAT and Sentinel-1 missions, as Radarsat-2 is at present the only C-band operating mission.
Vesuvius - Campi Flegreii Supersite is actually covered by one ascending and one descending Radarsat-2 frame having a 24 day revisiting time and acquisition in S3 beam mode, corresponding to about 30 images per year. For observation of the Vesuvius - Campi Flegreii Supersite:

- Ascending Beam S3 , H/H+V polarization
- Descending Beam S3, H/H+V polarization**,**

are requested.

FUTURE MISSIONS

Sentinel-1 (about 100 acquisitions per year suggested)
Sentinel-1, to be launched at the beginning of 2014, will have a 12-day revisiting time and operate in the interferometric Wide Swath mode with a swath width of 250 km and ground resolution of 5 × 20 m. In agreement with the Sentinel-1 ESA data policy, the opportunity to get high quality data without any charge will be crucial for the reconstruction of the whole C-band dataset of the ESA satellites, that started in 1992 with ERS1 and stopped at the end of 2010 with ASAR-ENVISAT (apart from the 2010-2012 ENVISAT *drifting phase*).

ALOS-2 (about 20 acquisitions per year suggested)
ALOS-2 has a 14-day revisiting time and is the follow-on JAXA L-band SAR satellite mission of ALOS (Daichi) with the overall objective to provide data continuity to be used for cartography, regional observation, disaster monitoring, and environmental monitoring.
As regard to L-band data from the next ALOS-2 SAR sensor, although data are less affected by a loss of coherence over time compared to X and C-band data, their actual usefulness will be clear only as a function of the amount of ground deformations we will record in the next future.
Anyway, considering the ground deformations we have recently recorded in Campi Flegreii area, we are now likely considering of interest the L-band data of the future PALSAR-2 SAR sensor.

PRISMA
Concerning the optical sensor, in terms of future mission, PRISMA (PRecursore IperSpettrale of the application mission) is an Earth observation system with innovative electro-optical instrumentation which combines a hyperspectral sensor with a panchromatic, medium-resolution camera. The advantages of this combination are that in addition to the classical capability of observation, based on the recognition of the geometrical characteristics of the scene, there is the one offered by hyperspectral sensors which can determine the chemical-physical composition of the objects present on the scene. This characteristic offers the scientific community and users many applications in the field of environmental monitoring. The satellite will have space resolution of 30 m (Hyp) / 2.5-5m (PAN), swath width of 30-60 km, spectral range of 0.4 - 2.5 µmm (Hyp) / 0.4 - 0.7 µm (PAN), and continuous coverage of spectral ranges with 10 nm bands.

SENTINEL 2 and SENTINEL 3
The European Space Agency (ESA) Sentinel-2 and Sentinel-3 satellite platforms will each host four science instruments, supporting primarily oceanographic and global land applications. Data will be delivered in near real time to support a wide range of operational systems and applications. The design lifetime of the Sentinel-2 and Sentinel-3 platform and their instruments is seven and a half years (with consumables for twelve years of operations). Each Sentinel will move in a sun-synchronous orbit with repeat cycle of 10 day with one satellite and 5 days with 2 satellites for Sentinel-2, and 27 days for Sentinel-3. The first satellite is expected to be launched in 2013/14, probably on a Vega launch vehicle from the European Spaceport in Kourou, French Guyana. The Sentinel missions are designed for the specific needs of the GMES programme.

SAR data archive
Almost the entire archive dataset of ASAR-ENVISAT and ERS1/2 data is currently available online on the Supersites website (http://supersites.earthobservations.org/Vesuvius_index.html), This will represent a remarkable heritage for the whole Scientific Community, allowing to reconstruct the geodynamic evolution of the area almost in the last 20 years. Data from the ENVISAT *drifting phase* (end 2010 - beginning 2012), successfully exploited for Vesuvius - Campi Flegreii latitudes, although for the only descending tracks, should be also considered, as well as ALOS-PALSAR, JERS, Radarsat-1/2, TerraSAR-X and COSMOSky-Med historical data archives. for the Vesuvius - Campi Flegreii Supersite area.

Optical data archive
Also for optical sensors, data collected over Vesuvius and Campi Flegreii would stimulate research on recording of time-series data for achieve new insights for a more reliable interpretation of the geophysical

phenomena and for monitoring significant volcanogenic hazards. For the purposes, we ask the archive data of ASTER, HYPERION, MERIS, ATSR, AVHRR, MSG, MODIS, LANDSAT.

A.10 Available resources

The research activities that will benefit of the requested data, will be funded by the FP7 MED-SUV project (6 million Euros) until May 2016, in addition to the resources coming from the individual partners listed above (research grants from other ongoing projects, HW/instrumental and SW resources owned by participant/interested institutions).

A.11 Additional comments

N/A.

A.12 Comprehensive list of in situ data

Below the list of the current and historical monitoring networks of Campi Flegrei and Vesuvius areas and the map with the location of each of the stations.

CAMPI FLGREI

Network	Continuous	Campaigns
Cameras	2 Thermal IR cameras	
Tilt	7 tiltmeters	
Geochemical	4 permanet stations	
GPS	14 permanent stations	36 benchmarks
Gravimetric	1 permanent station	28 benchmarks
Seismic	16 permanent stations	
Levelling		370 benchmarks
Tide gauge	5 stations	

VESUVIUS

Network	Continuous	Campaigns
Cameras	1 Thermal IR camera	
Tilt	2 tiltmeters	
Geochemical	2 permanet station	
GPS	11 permanent stations	36 benchmarks
Gravimetric	1 permanent station	32 benchmarks
Seismic	21 permanent stations	
Levelling		325 benchmarks
Tide gauge	3 stations	

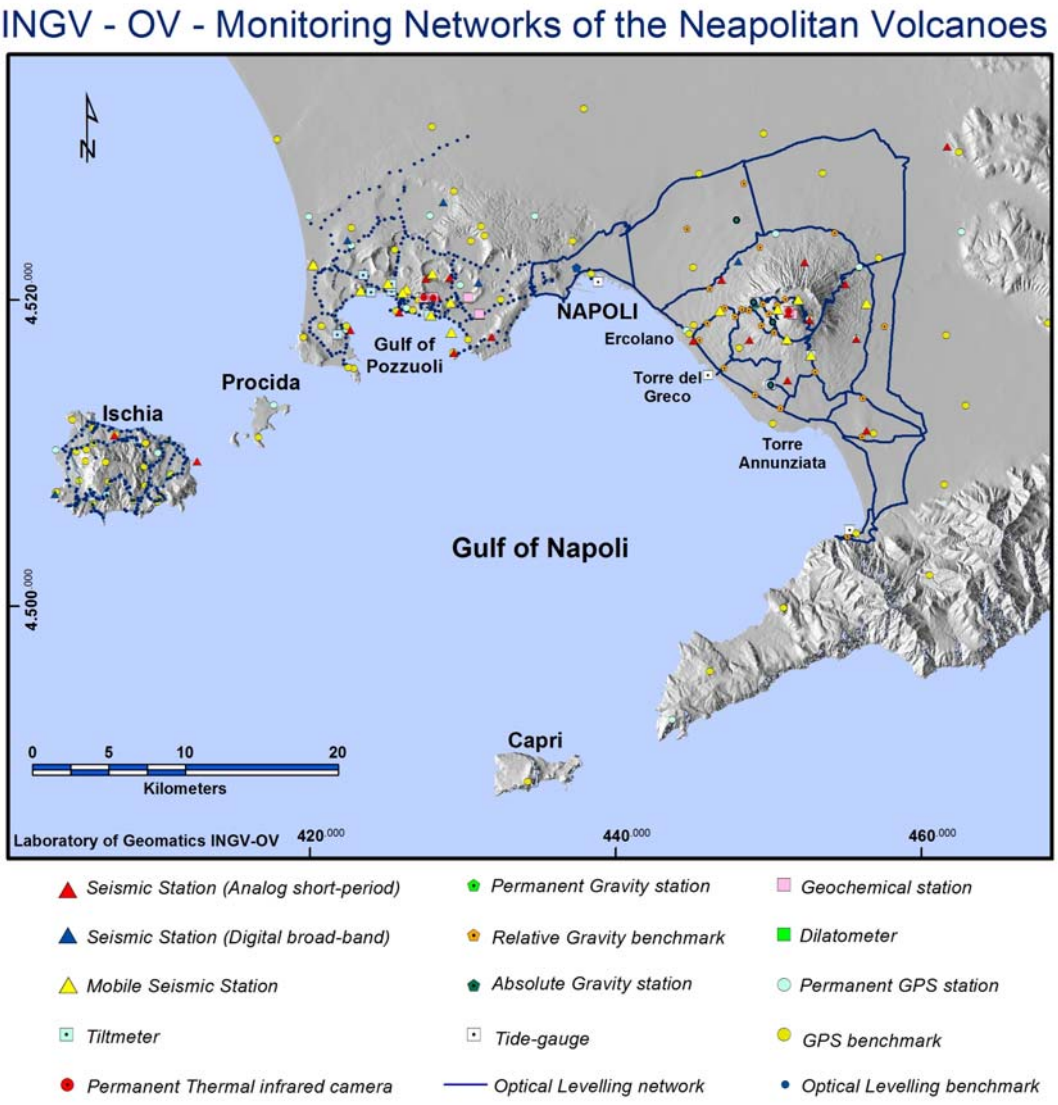

Figure 2: Distribution of the Campi Flegrei and Vesuvius monitoring stations.