Object: Request for Expressions of Interest (EoI) to contribute to the Earth Telescope Initiative and co-creation process (period 2024-2027)

Earth Telescope Research Program

International Call for Expression of Interest

The Istituto Nazionale di Geofisica e Vulcanologia (INGV) invites researchers to express their interest in participating and contributing to one of the three research lines under the Earth Telescope (ET) Research Program. This interdisciplinary initiative aims to address fundamental questions about the dynamics of planet Earth by improving our ability to scrutinize its interior, from the deep Earth to the ionosphere.

Earth Telescope Research Program Overview

The Earth Telescope (ET) program is a continuation of INGV's commitment to fundamental research. The main objective of the ET program is to understand the role of the decoupling region between the mantle and the crust (asthenosphere) in controlling plate dynamics and magma generation. The heterogeneity represented by the asthenosphere significantly influences crustal dynamics and processes, impacting both the hydrosphere and atmosphere. However, the extent of this influence is poorly understood. To address this fundamental question, the program encompasses three key research lines, each tackling pivotal scientific challenges through interdisciplinary approaches and international collaborations (see short descriptions in Appendix):

1. *Studying the Asthenosphere as a Key to Understand the Dynamics of Plates and the Origin of Magmas* (**SAKURA**): This research line aims to investigate the asthenosphere's role in plate tectonics and magma generation, utilizing cutting-edge observational and analytical techniques.
2. *Study of Geospheres Interactions in the Earth System* (**TESI**): This research line focuses on understanding the interactions between Earth's internal processes and surface dynamics, employing seismological and geophysical analyses, modeling, and laboratory experiments to shed light on the complexities of these interactions.
3. *Investigating the Interplay Between Volcanic Activity and Climate Change* (**DEMETRA**): This research line seeks to elucidate the relationship between volcanic activity and climate change, examining how volcanic emissions influence climate systems and contribute to global warming or cooling.

ET aims to investigate geological processes and phenomena across various spatial and temporal scales, develop advanced techniques to enhance Earth monitoring capabilities, and foster collaboration among national and international researchers. For all three research lines, scientists will be asked to propose, design, and plan the technologies and methodologies of tomorrow, enabling a transformative leap in understanding Earth's dynamic systems. By integrating cutting-edge innovations, the ET program aspires to revolutionize our knowledge of Earth's dynamics and push the boundaries of scientific discovery. Furthermore, the program aims to benefit from synergies with key initiatives and projects of INGV, leveraging these advancements to deepen insights into the complex interactions governing our planet's internal and surface processes.

Eligibility

The call is open to researchers of all nationalities with expertise in Earth sciences, geophysics, seismology, volcanology, geology, geochemistry, geodesy, remote sensing, applied mathematics, computer science, and Artificial Intelligence.

Expression of Interest
Interested researchers are invited to submit expressions of interest indicating their willingness to participate in one of the three lines of the Earth Telescope Initiative. Please include the following:

1 – Research line chosen
2 – Short CV (maximum one page, approximately 600 words)
3 – Short proposal (maximum two pages, approximately 1200 words)

In your short proposal, provide a brief overview of your research background, relevant expertise, and potential contributions to the chosen line, addressing the following points:

a) ET Research Line chosen
b) Proposal Title
c) Proposal duration in months
d) Principal Investigator (PI)
e) Participants internal and external to INGV
f) Collaborations with national and international partners (University, Research Center, Industry)
g) Scientific Rationale
h) Objectives and their alignment with the ET project objectives
i) Advancement of knowledge with respect to the State of the Art
j) Innovative technologies applied and/or (preferably) developed
k) Advanced methodologies introduced and/or (preferably) developed
l) Research Plan in work packages and tasks
m) Gantt diagram showing the timing of the work packages and tasks
n) Expected results and their contribution to the ET Project's goals
o) Expected Products and Deliverables
p) Description of the team
q) Proposal cost estimate

Submission Details:
Expressions of interest should be sent via email to cs.progetti@ingv.it no later than 16 October 2024. Please use "Earth Telescope Initiative - Expression of Interest" as the subject line of your email.

Selection Process:
Expressions of interest will be evaluated by the Scientific Programme Board of ET based on the three Horizon Europe Evaluation criteria: (i) Excellence (max 5 points), (ii) Impact (max 5 points), and (iii) Quality and efficiency of the implementation (max 5 points).

APPENDIX 1

Research Line 1

Title. Studying the Asthenosphere as a Key to Understand the dynamics of plates and the oRigin of mAgmas

Acronym: SAKURA

Budget 2024: 2.0 M€

Abstract

- *Objective*: Explore the asthenosphere's contribution to plate dynamics, earthquake generation, and volcanic activity.
- *Methodology*: Integrate geological, geochemical, and geophysical data with advanced physical-numerical models.
- *Research Streams*:
  - Characterization of the asthenosphere's chemical and physical properties.
  - Investigation of subduction processes, oceanic expansion, and tectonic plate transformations.
  - Examination of the deep sources of magmas and development of high-resolution 3D models.

Introduction. The SAKURA project focuses on the asthenosphere, a critically influential region of the Earth's mantle located between 80 and 200 km below the surface. Characterized by lower viscosity, this region enables the movement of tectonic plates and the generation of magma through decompression and fluid-fluxed melting. The project aims to explore the asthenosphere's contribution to plate dynamics, earthquake generation, and volcanic activity through an interdisciplinary approach that integrates geological, geochemical, and geophysical data, with a particular focus on the Central Mediterranean area.

State of the Art. The asthenosphere plays a pivotal role in Earth's geological processes, influencing plate tectonics, magma generation, and volcanic activity. Despite significant advancements, fundamental questions remain regarding its composition, physical properties, heat sources, and regional variations. This research intends to deepen the understanding of these aspects, as well as the asthenosphere's role in mantle convection, plate interactions, and the generation and migration of magmas.

Methodology. The project will employ a comprehensive approach combining seismic and other geophysical data collection with the study of igneous rocks through petrological and geochemical analyses. Advanced physical-numerical models, such as LaMEM, will be utilized to simulate interactions between the asthenosphere, lithosphere, and magmas. This multidisciplinary investigation will involve collaborations with research institutes and universities, integrating disciplines like geology, geophysics, volcanology, physics, and mathematics.

Objectives.

- **Characterization of the Asthenosphere**: Analyze the chemical and physical properties, including viscosity, temperature, and composition, to understand their influence on plate dynamics and magma generation.
- **Role in Plate Dynamics**: Investigate subduction processes, oceanic expansion, and tectonic plate transformations, assessing their impact on magma generation and migration.
- **Origin of Magmas**: Examine geochemical and isotopic evidence to determine the deep sources of magmas, focusing on decompression and fluid-fluxed melting processes.
- **Development of Physical-Numerical Models**: Integrate results into models like LaMEM to simulate mantle flow and lithospheric deformation, enabling high-resolution 3D time-dependent simulations.

Research Streams:

1. Characterization of the Asthenosphere Role in the Central Mediterranean Area:
   - Tyrrhenian subduction zone
   - Ionian Sea area
2. Quantification of Chemical-Physical Properties and Governing Processes:
   - Molten rock fraction and asthenosphere viscosity estimates
   - Thermal models
   - Physical-numerical models
3. Deep Origin of Magmas in the Italian Volcanic Provinces:
   - Quaternary volcanism and geodynamic models
   - Origin of the magmatism of the Campanian province

- Characterization of the plumbing systems at Campi Flegrei and Ischia:
- Magnetotellurics, geodesy, 3D and 4D seismic tomography

Expected Results. The SAKURA project aims to enhance our understanding of the asthenosphere's role in plate dynamics and magma generation. Anticipated outcomes include improved models of asthenospheric flow, better insights into magma generation and transport, and a deeper understanding of earthquake and volcanic processes. These findings could advance earthquake prediction, georesource management, and provide insights into geological cycles relevant to Earth's evolutionary history. The project aspires to significantly contribute to the knowledge of Earth as a dynamic system.

APPENDIX 2

Research Line 2

Title. Study of Geospheres Interactions in the Earth System

Acronym: TESI

Budget 2024: 2.0 M€

Abstract

- *Objective*: Understand the interactions between Earth's internal processes and surface dynamics.
- *Methodology*: Collect and analyze geological, geophysical, and volcanological data, and perform seismological analyses and geophysical modeling.
- *Research Streams:*
  - Role of fluids in earthquake and volcano instabilities.
  - Interactions of the lithosphere with the hydrosphere and atmosphere.
  - Monitoring of lithosphere-atmosphere-ionosphere coupling.
  - Mediterranean Geodynamic Traverse for high-resolution tomographic models.

Introduction. The TESI project aims to study the interactions between the different geospheres, which control surface dynamics and deep Earth processes, to understand the physics underlying these interactions. By examining different spatial and temporal scales, the project seeks to quantify the geosphere interactions, such as those between the deep Earth and lithosphere, lithosphere and hydrosphere, and lithosphere and atmosphere. The study will encompass scales ranging from laboratory to natural environments, focusing on the interaction between deep Earth dynamics and surface processes.
State of the Art. This proposal integrates deep and surface processes to understand Earth's evolution. The interplay between internal dynamics, fluids, and earthquakes is crucial, as fluids affect fault behavior and seismic activity. Surface processes and geophysical signals, such as ambient seismic noise, reveal interactions between Earth's spheres. The interactions of the lithosphere and hydrosphere are crucial for understanding the formation of critical minerals and geothermal areas, essential for geo-sustainability. The coupling of the lithosphere with the outer spheres, including the atmosphere and ionosphere, is essential for understanding earthquake-related phenomena.
Methodology. The project will collect and analyze geological, geophysical, and volcanological data to assess the nonlinear dynamics resulting from geosphere interactions. Seismological analyses and geophysical modeling will be conducted to understand internal processes and their impacts. Laboratory experiments will define rock mechanics and material properties. Numerical and analog modeling will be used to reconstruct internal processes. Additionally, ionospheric data will be included to study interactions with the lithosphere and atmosphere.
Objectives. The primary objective is to gain insights into the dynamics of internal processes, ranging from geodynamics to earthquakes and volcanic instability, and their correlation with surface evolution and outer Earth spheres. The project aims to derive a comprehensive picture of these interactions to innovate future models of the Earth system.
Research Streams:

1. Role of Fluids on Earthquakes and Volcano Instabilities: This activity focuses on understanding fault slip processes within the crust, integrating data from field analogues and monitoring systems. It explores the physical mechanisms and triggers of volcano flank sliding, employing an interdisciplinary approach to model processes and capture precursory signals.
2. Interactions of Lithosphere with the Hydrosphere: This involves ambient noise observations to understand their physical origins, developing numerical models, and improving seismic observations. Monitoring sea waves and terrestrial water storage using low-frequency seismic observations is a key aspect. It also includes geothermal energy, ore formation, and geo-resources.
3. Lithosphere-Atmosphere-Ionosphere Coupling (LAIC): Using ionospheric sounding techniques to study co-seismic ionospheric perturbations. Monitoring vibrations and perturbations in the lithosphere, atmosphere, and ionosphere system is effective in understanding LAIC mechanisms.

4. Mediterranean Geodynamic Traverse: Using data from European actions and new experiments, this activity integrates seismological and geodetic analyses to define the deep structure and kinematics of the Mediterranean system. High-resolution tomographic models, deep interface geometries, and kinematics will be derived using seismological and active seismic data. Deployment of marine fiber systems is crucial for monitoring extreme environments.

Expected Results. The TESI project aims to advance our understanding of the interactions between Earth's internal processes and surface dynamics. Expected results include high-resolution models of the Mediterranean's deep structure and kinematics, insights into the role of fluids in fault slip behavior and volcano instability, improved geophysical methods for monitoring hydrosphere changes, and an enhanced understanding of lithosphere-atmosphere-ionosphere coupling.

APPENDIX 3

Research Line 3

Title. Investigating the interplay between volcanic activity and climate change

Acronym: DEMETRA

Budget 2024: 2.0 M€

Abstract

- *Objective*: Elucidate the relationship between volcanic activity and climate change.
- *Methodology*: Combine geological, geophysical, climatological, and volcanological data with numerical models and satellite monitoring.
- *Research Streams*:
  - Assess the impacts of volcanic eruptions on atmospheric composition and climate.
  - Investigate tectonic degassing in geothermal areas.
  - Develop integrated climate models to predict future impacts of volcanic and tectonic activities on climate.

Introduction. The DEMETRA project addresses the intricate and evolving relationship between volcanic activity and climate change.

State of the Art. While volcanic and tectonic activities release minor amounts of greenhouse gases compared to human emissions, they have modulated Earth's climate throughout geological history. Volcanic eruptions produce aerosols that can cool the Earth by reflecting solar radiation, although the extent of this effect requires further study. The complex feedback mechanisms between volcanic eruptions and climate, including changes in precipitation, atmosphere, and ocean circulation, are not fully understood. Geological records of various climatic proxies and past eruptions help reconstruct their climatic impacts, providing insight into historical climate changes. Developing strategies to mitigate the climatic and societal impacts of volcanic activity remains a critical research focus.

Methodology. The project will employ a comprehensive approach, combining geological, geophysical, climatological, and volcanological data collection with high-performance computing models. Collaborations with research institutes and universities will integrate disciplines such as geology, geophysics, volcanology, climatology, physics, and mathematics.

- Data Collection and Analysis: Gather geological, climatological, geophysical, and volcanological data to assess the past and current influence of volcanic activity on Earth's climate.
- Numerical Modeling: Use numerical models and AI technologies to reconstruct and predict the effects of volcanic and tectonic activities on climate.
- Satellite Monitoring: Employ satellite technology to monitor volcanic emissions and greenhouse gases.

Objectives. The primary goals of DEMETRA are:

- Volcanic Impacts: Assess atmospheric composition changes due to greenhouse gases and aerosols from explosive volcanic eruptions and the formation of large igneous provinces.
- Role of Tectonic Degassing: Investigate how tectonic degassing in geothermal areas influences climate.
- Identify Feedback Mechanisms: Understand the cascading effects of volcanic and tectonic activity on climate, including changes during glacial periods and sea level variations.
- Develop Integrated Climate Models: Create advanced models to predict future impacts of volcanic and tectonic activity on climate.

Research Streams.

1. Role of Volcanic Eruptions on Climate Change:
   - Climatic effects of explosive eruptions throughout geological history, focusing on the Late Antique Little Ice Age (LALIA).
   - Regional and global impacts of volcanic eruptions, including acid rain and ocean fertility effects.
   - Long-term climatic effects during the formation of Large Igneous Provinces, with a focus on the Ethiopian basaltic area.
2. Climate Change and Volcanic Processes:

- Pre-eruptive processes influenced by climate change: effects of isostatic variations in glacial periods, sea level, and precipitation.
- Syn- and post-eruptive processes influenced by climate change: effects of local precipitation variations and glaciers, lahar generation, and implications for volcanic hazard.

3. Tectonic Degassing and Earth's Climate:
   - Quantify and understand the origin of soil CO2 and CH4 fluxes in the Italian peninsula.
   - Quantify and understand the origin of soil CO2 and CH4 fluxes in the African Rift and Great African Lakes region.

Expected Results. The DEMETRA project aims to provide insights into the impact of volcanic eruptions on atmospheric composition and regional and global climate patterns; identify feedback mechanisms linking volcanic and tectonic activity to climate change; develop advanced climate models for predicting the future impacts of volcanic and tectonic activity on climate, aiding in the development of more effective risk mitigation and adaptation strategies. This effort aligns with the EU initiative of Destination Earth (https://digital-strategy.ec.europa.eu/it/policies/destination-earth), which aims to develop a digital twin of the Earth system to monitor, simulate, and predict the impact of climate-related disasters on human activities, focusing on climate change effects, extreme volcanic events, and their socio-economic impacts.