

Preface

The Changing Earth Science Network Projects 2011–2013

To better understand the various processes and interactions that govern the Earth system and to determine whether the recent human-induced changes could ultimately destabilise its dynamics, both the natural system variability and the consequences of human activities have to be observed and quantified.

In this context, the European Space Agency (ESA) published in 2006 the document “The Changing Earth: New Scientific Challenges for ESA’s Living Planet Programme” as the main driver of ESA’s new Earth Observation (EO) science strategy. The document outlines 25 major scientific challenges covering all the different aspects of the Earth system, where EO technology and ESA missions may provide a key contribution.

In this framework, and aiming at enhancing the ESA scientific support towards the achievement of “The Challenges”, the Agency has launched the “Changing Earth Science Network”, an important programmatic component of the new Support to Science Element (STSE) of the Earth Observation Envelope Programme (EOEP). In this preface, the objectives of this initiative are summarised and the list of the projects selected in the second call of the programme is provided. An in-depth overview of such projects will be provided in the following book chapters.

ESA EO Science Strategy and the Support to Science Element (STSE)

Since their advent, satellite missions have become central in the Earth monitoring and understanding, resulting in significant progresses in a broad range of scientific areas. Although the Earth has undergone significant changes in the past, there is mounting evidence that those occurring during the last 150 years are affecting the various interactions and processes among the different components of the Earth

system. Understanding those changes, their impacts on human lives and how anthropogenic activities affect the Earth system and its climate represent a major scientific endeavour where EO technology is already playing a key role.

In the mid-1990s, ESA set up its Living Planet Programme (LPP) working in close cooperation with the international scientific community to define, develop and operate focused satellite missions addressing some of the key questions at the core of Earth system science.

Moreover, realising the importance of further understanding the Earth and its response to these recent changes, the ESA published “The Changing Earth: New Scientific Challenges for ESA’s Living Planet Programme” as the main driver of ESA’s new EO science strategy. The document outlines 25 major scientific challenges faced today covering all the different aspects of the Earth system and climate (oceans, atmosphere, cryosphere, land surface, solid Earth), where EO technology and ESA missions may provide a key contribution namely:

The Challenges of the Oceans

1. Quantify the interaction between variability in ocean dynamics, thermohaline circulation, sea level, and climate.
2. Understand the physical and biochemical air/sea interaction processes.
3. Understand the internal waves and the mesoscale in the ocean, its relevance for heat and energy transport, and its influence on primary productivity.
4. Quantify the marine-ecosystem variability, and its natural and anthropogenic physical, biological and geochemical forcing.
5. Understand the land/ocean interactions in terms of natural and anthropogenic forcing.
6. Provide the reliable model- and data-based assessments and predictions of the past, present and future state of the ocean.

The Challenges of the Atmosphere

1. Understand and quantify the natural variability and the human-induced changes in the Earth’s climate system.
2. Understand, model and forecast the atmospheric composition and air quality on adequate temporal and spatial scales, using ground-based and satellite data.
3. Better quantify the physical processes determining the life cycle of aerosols and their interaction with clouds.
4. Observe, monitor and understand the chemistry–dynamics coupling of the stratospheric and upper tropospheric circulations, and the apparent changes in these circulations.
5. Contribute to the sustainable development through interdisciplinary research on climate circulation patterns and extreme events.

The Challenges of the Cryosphere

1. Quantify the distribution of sea-ice mass and freshwater equivalent, assess the sensitivity of sea ice to climate change and understand thermodynamic and dynamic feedbacks to the ocean and atmosphere.

2. Quantify the mass balance of grounded ice sheets, ice caps and glaciers; partition their relative contributions to global eustatic sea-level change; and understand their future sensitivity to climate change through dynamic processes.
3. Understand the role of snow and glaciers in influencing the global water cycle and regional water resources, identify the links to the atmosphere and assess likely future trends.
4. Quantify the influence of ice shelves, high-latitude river run-off and land ice melt on global thermohaline circulation, and understand the sensitivity of each of these fresh-water sources to future climate change.
5. Quantify the current changes taking place in permafrost and frozen-ground regimes, understand their feedback to other components of the climate system and evaluate their sensitivity to future climate forcing.

The Challenges of the Land Surface

1. Understand the role of terrestrial ecosystems and their interaction with other components of the Earth system for the exchange of water, carbon and energy, including the quantification of the ecological, atmospheric, chemical and anthropogenic processes that control these biochemical fluxes.
2. Understand the interactions between biological diversity, climate variability and key ecosystem characteristics and processes, such as productivity, structure, nutrient cycling, water redistribution and vulnerability.
3. Understand the pressure caused by anthropogenic dynamics on land surfaces (use of natural resources, and land-use and land-cover change) and their impact on the functioning of terrestrial ecosystems.
4. Understand the effect of land-surface status on the terrestrial carbon cycle and its dynamics by quantifying their control and feedback mechanisms for determining future trends.

The Challenges of the Solid Earth

1. Identification and quantification of physical signatures associated with volcanic and earthquake processes—from terrestrial and space-based observations.
2. Improved knowledge of physical properties and geodynamic processes in the deep interior, and their relationship to Earth-surface changes.
3. Improved understanding of mass transport and mass distribution in the other Earth system components, which will allow the separation of the individual contributions and a clearer picture of the signal due to solid-Earth processes.
4. An extended understanding of core processes based on complementary sources of information and the impact of core processes on Earth system science.
5. The role of magnetic field changes in affecting the distribution of ionised particles in the atmosphere and their possible effects on climate.

To reinforce this strategy, in 2008, it was established the Support to Science Element—STSE (www.esa.int/stse), to provide scientific support for both future and on-going missions, by taking a pro-active role in the formulation of new

mission concepts and products, by offering support to the scientific use of ESA EO multi-mission data and promoting the achieved results.

In this Context, STSE main pillars aim at:

- Developing novel mission concepts in preparation for the next generation of European scientific missions;
- Developing advanced algorithms and innovative products that exploit the increasing ESA multi-mission capacity;
- Reinforcing ESA collaboration with the major international scientific programmes and initiatives in Earth system sciences;
- Support the Next Generation of Earth System European Scientists (The Changing Earth Science Network).

The Changing Earth Science Network

As one of the main programmatic components of the STSE, ESA launched in 2008 a new initiative—the Changing Earth Science Network—to support young scientists to undertake leading-edge research activities contributing to achieve the 25 scientific challenges of the LPP by maximising the use of ESA data.

The initiative is implemented through a number of research projects proposed and led by early-stage scientists at postdoctoral level for a period of two years. Projects undertake innovative research activities furthering into the most pressing issues of the Earth system, while exploiting ESA missions data with special attention to the ESA data archives and the new Earth Explorer missions.

Specifically, the Initiative Aims at:

- Contributing to the scientific advancement in Member States towards the achievement of the new 25 strategic challenges of the LPP;
- Fostering the use of ESA EO data by the Earth Science community maximising the scientific return (in terms of scientific results and publications) of ESA EO missions;
- Contributing to consolidate a critical mass of young scientists in Europe with a good scientific and operative knowledge of ESA EO missions, assets and programmes;
- Promoting the development of a dynamic research network in ESA Member States addressing key areas of relevance for ESA missions and the ESA science strategy;
- Enhancing interactions, exchanging know-how and allowing cross fertilisation between ESA and Earth science laboratories, research centres and universities.

The first call for proposals, issued in 2008, resulted in the selection of 11 postdoctoral scientists from the Agency's Member States based on the scientific merit of the individual projects. A second call for proposals was issued in early

2010 to be implemented between 2011 and 2013, resulting in a further selection of 10 leading-edge research activities. New calls took place in early 2012 and 2014.

This volume collects some of the results obtained by eight of the second set of projects started in 2011 and completed in 2013. They describe research activities exploiting data coming from several remote sensors on-board a wide suite of ESA and non-ESA satellites. In summary, the projects described in the following provide cutting-edge advanced exploitation of satellite data relevant to a broad range of scientific applications, towards an improved monitoring of the integrated Earth system.

Acronym	Full project title	Researcher	Institute
CHIMTEA	Chemical Impact of Thunderstorms on Earth's Atmosphere	Enrico Arnone	Istituto di Scienze dell'Atmosfera e del Clima, ISAC-CNR, Bologna, Italy
TIBAGS	Tropospheric Iodine Monoxide and Its Coupling to Biospheric and Atmospheric Variables—A Global Satellite Study	Anja Schönhardt	Institute of Environmental Physics (IUP), University of Bremen, Bremen, Germany
GreenSAR	Greenland and Antarctic Grounding Lines from SAR Data	Noel Gourmelen	School of GeoSciences, University of Edinburgh, UK
MESO3D	Sensor Synergies for Studies of Mesoscale and Sub-Mesoscale Ocean Dynamics	Nicolas Rascle	Laboratoire d'Océanographie Spatiale, IFREMER, Plouzané, France
SMOSPROC	Study of Ocean Surface Processes and Their Impact on the Retrievals of Salinity from SMOS	Kieran Walesby	National University of Ireland, Galway
SMASPARES	SMOS Data Assimilation for Parameter Estimation in Radiative Transfer Models	Carsten Montzka	Institute of Bio- and Geosciences: Agrosphere (IBG-3), Forschungszentrum Jülich, Jülich, Germany
PROgRESSIon	PROtotyping the Retrievals of Energy Fluxes and Surface Soil Moisture	George P. Petropoulos	University of Aberystwyth, Aberystwyth, UK
GEMMA	Crustal Modelling and Moho Estimation with GOCE Gravity Data	Daniele Sampietro	Politecnico di Milano—Polo Territoriale di Como, Como, Italy

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