8. Strengthening resilience to natural multi-hazards and extreme events

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8.1. Scope and Context

8.1.1. Definitions

For the purposes of this document, the definitions of natural hazards, resilience and extreme events follow the established glossary[1] of the United Nations Office for Disaster Risk Reduction (UNDRR) terminology for disaster risk reduction and the multi-hazard and multi-risk terminology adopted by the MYRIAD-EU project[2]. UK Government relevant definitions are also indicated for further contextualization. The IPCC (2022) defines a **hazard** as “any natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources.” Here we have adopted the broader UNDRR definition of hazard: “A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption, or environmental degradation”, which is not limited to only physical but also includes biogeochemical. Hazards that are predominantly associated with natural processes and phenomena are referred to here and by the UNDRR as **natural hazard**. The UK Government Resilience Framework (2022) defines **resilience** as “the ability to anticipate, assess, prevent, mitigate, respond to, and recover from natural hazards, deliberate attacks, geopolitical instability, disease outbreaks, and other disruptive events, civil emergencies or threats to our way of life.” There is not a generalised UK government definition for an **extreme event**, so we follow the definition of extreme weather events, defined in the Government Resilience: Extreme Weather report (2024), “events that are significantly different from the average or usual pattern” and add the NOAA definition[3], “a time and place in which weather, climate, or environmental conditions—such as temperature, precipitation, drought, or flooding—rank above a threshold value near the upper or lower ends of the range of historical measurements.” To acknowledge that a single hazard might not be extreme but still be considered part of an extreme event, we have adopted the definition of **multi-hazard** provided by the UNDRR as “the selection of multiple major hazards that the country faces, and the specific contexts where hazardous events may occur simultaneously, cascadingly or cumulatively over time, and taking into account the potential interrelated effects.”

8.1.2. Natural hazards and extreme events in the marine environment

The ocean covers more than 70% of the Earth's surface and plays a fundamental role in the modulation of climate and weather, meaning its impact on hazards, multi-hazards and extreme events is not limited to the ocean environment. However, marine hazards and extreme events present a particular group of hazards with broad ranges of impacts and unique challenges to forecast, monitor and study. Marine natural hazards are often connected, with the initial event triggering secondary hazards that may present more of a risk to communities or ecosystems than the initial event, for example, an earthquake may trigger an underwater landslide that then triggers a tsunami, and it is the tsunami that presents the primary hazard. If hazards occur simultaneously or in quick succession, they can interact with each other and lead to cascading, far-reaching socio-economic impacts. The timescales and triggers of these events are also poorly understood for many hazards, making forecasting of these events difficult and inaccurate, and limiting the ability of governments and communities to plan for them. The impact of the hazard will also depend on the vulnerability of the ecosystems or communities that it intersects. Thus, to improve resilience, marine hazards research must be cross disciplinary, covering oceanography, geology, geophysics, meteorology, biology, spatial planning, policy, and the social sciences.

Marine hazards are increasingly being recognised as a blind spot in regional and national risk assessments. Two European Marine Board reports (Kopp et al., 2021; European Marine Board, 2022) have highlighted the significance of marine hazards for Europe and their potential impact on the blue economy and the resilience gaps and help frame what is included in both deep ocean and coastal hazards. The hazards covered in these reports provide a comprehensive summary of marine hazards and extreme events and are outlined in Table 5.4.1. Many of these natural hazards may present hazards to (marine) infrastructure, which then becomes a technological hazard. The topics of eutrophication, deoxygenation, and invasive species are covered by other Grand Challenges in this chapter and so are not discussed here.

Table 8.1: Overview of the hazards across oceans and coastal zones highlights by recent EU Marine Board reports into marine hazards, the blue economy and resilience. *Scope to be redefined to reflect topics covered by other Grand Challenges and crosscutting issues.*

Hazard	**Description**
Earthquakes	Earthquakes are the sudden release of strain in the Earth's crust, typically in the form of a brittle rupture. This will generate waves of shaking and, in shallow earthquakes, may cause substantial deformation of the overlying ground or seafloor, which may generate secondary hazards, particularly tsunamis. The largest earthquakes occur at or near the plate tectonic boundaries, particularly in transform or destructive plate margins.
Volcanoes	Volcanoes are formed where the mantle melts and these melts are able to reach the Earth's surface. They occur predominantly at constructive or destructive plate boundaries, but also in the centre of plates at hot spots.

	Volcanoes present variable hazards, strongly linked to the composition of magma they erupt, though explosions may also be driven by steam. The most explosive volcanoes are typically found in arc settings, but all volcanic eruptions may present hazards to communities and infrastructure.
Tsunamis	A tsunami is a succession of waves of long wavelength generated by an underwater disturbance that causes a sudden displacement of a large volume of water from the sea floor. Tsunamis may be triggered by a host of processes, including earthquakes, volcanic eruptions, submarine landslides, onshore landslides in which debris fall into the water, and meteorite impacts. The size of the wave will depend on the volume of the original displacement, the proximity of the coastline impacted to the source, and the shape of the seafloor up to the coastline.
Submarine mass movements	Submarine slopes are often composed of unconsolidated, water-saturated soft-sediment. The homogeneity of the seafloor over large areas means that large regions may fail at one time, creating huge mass movements, which travel for long distances. The triggers for submarine landslides are poorly constrained, but include overpressure between grains, earthquakes, tidal cycles, over-steepening, large sediment inputs and anthropogenic activity. There may be time lags between triggering events and landslides and often more than one process will combine to create conditions for a submarine mass movement.
Fluid activity	Fluid flow through marine sediment is common but may be caused by a variety of different processes including burial, fluid migration, biogeochemical processes, and hydrothermal activity. On land high fluxes of fluid flow may generate mud volcanoes, while in the oceans the hazards posed by fluid flow are primarily due to direct contact with infrastructure or marine drilling or trenching operations.
Migrating bedforms	In areas with a strong currents or tidal regimes, where the seafloor is covered by loose material, sand waves may form and migrate. They may be found in many environments, including shallow coastal seas, straights, canyons and channels. Migrating bedforms impact oceanographic processes and impact habitat suitability, but primarily pose a threat to seafloor infrastructure, such as submarine cables and pipelines.
Ocean temperature *To be linked to Climate GC*	Global mean sea surface temperature has changed by 0.6°C since 1980, though regional variability means this is more or less extreme in some locations. Warming affects ecosystems in different ways including changes in species composition, changes in the range of mobile species, loss of kelp forests and time of reproduction and migration of species. These changes have poorly understood consequences for the functioning of ecosystems.
Marine heatwaves	Marine heatwaves (MHWs) have increased in intensity and frequency globally over the last decades. This trend is expected to continue into the future, with the Arctic Ocean being one of the regions to experience the

	largest increase in frequency of MHWs. MHWs are characterised by discrete periods of anomalously high ocean temperatures that last for more than five days with temperatures > 90% higher than the 30-year historical baseline. They have detrimental ecological implications, including mass mortalities, harmful algal blooms, shifts in species' ranges, and altering food webs and species interactions.
Sea-level rise	Sea-level rise is a result of thermal expansion due to ocean warming and the loss of land-based ice from glaciers and ice sheets. Between 1901 and 2018, global mean sea level increased by 20 ± 5 cm, with increasing rates over the past couple of decades. Uncertainty in future projections make it difficult to understand exactly where and how severe impacts will be. Potential impacts include flooding, coastal erosion, landslides, submergence, and the displacement or collapse of intertidal flats, tidal salt marshes, low subtidal foreshores, and dune ecosystems.
Flooding, storm surges, waves	Rising sea levels increase the exposure of coastal communities to episodic flooding due to tides, storms, and waves. The interaction between storm surges, waves and mean sea-level changes are an evolving research area. The co-occurrence of other multiple hazards is also not well studied. Higher flood levels increase the risk to communities and infrastructure, with potential impacts on tourism, recreation, and transportation.
Ocean acidification *To be linked to Climate and Biodiversity GCs*	Ocean surface pH has declined globally from 8.2 to below 8.1 since the industrial revolution. Local and seasonal variations in ocean acidification, particularly in coastal regions, make predictions of acidification and its impacts difficult A decline in pH has broad consequences including reduced calcification rates in species with shells, biodiversity losses and the associated loss of their ecosystem services. It may impact the metabolism, reproduction, behaviour, and survival of marine organisms, altering food webs, causing biodiversity loss and loss of complexity of marine ecosystems. Ocean acidification also reduces the future ability of the ocean to act as a carbon sink.
Extraction of biomass *To be linked to Economy and Biodiversity GCs*	Commercial and recreational fishing are the leading cause of biodiversity loss and altered ecosystem functions. Negative impacts include directly removing animals, removing specific sized individuals, changing the reproductive ability of a stock, and damaging habitat-forming organisms and benthic ecosystems.
Contaminants and litter *To be linked to Pollution GC*	Through the interaction of currents, tides and winds, some coastal areas are prone to the deposition and accumulation of pollutants and natural and plastic floating debris. Contaminants can cause reduction in ecosystem function or collapse and can impact sectors including fisheries, tourism, and aquaculture.
Coastal erosion	Coastal erosion is the physical reduction of land mass at the coast that results from the interfacing of marine, fluvial and landsliding processes

	with the coast (Mentaschi et al., 2018). Shoreline change is a broad descriptor that is often used as a proxy for coastal erosion. The definition of shoreline varies considerably depending on the scale and purpose of the study, but it is a term that generally refers to the interface between land and sea (Burningham and Fernandez-Nunez, 2020).
Rip currents	Rip currents are strong flows of seawater travelling perpendicular to the shoreline and out towards the sea; they can shift quickly due to changing bed morphology. They are the most common hazard to coastal recreation users as they appear calm on the surface yet pull people out to sea. The majority of UK lifeguard incidents involve individuals caught in rip currents[4].

8.1.3. State of the art in marine hazards and extreme events in the UK

The United Kingdom is a world leader in marine hazards and extreme events with world class infrastructure and observatories. Internationally important research is already occurring in the UK across the spectrum of marine hazards and extreme events, including into the impacts of human infrastructure on marine ecosystems to help spatial planning and marine engineering, climate modelling and forecasting to e.g. predict marine heatwaves and changes to ocean processes, (sub)seafloor sampling, mapping and modelling to e.g. predict earthquakes, cable failures and tsunami generation. The use of machine learning and digital twinning plays an important part in this data-intense research.

The Natural Hazards Partnership (NHP) offers expert insights on various natural hazards, developing advanced hazard impact models and supporting technology. Its research provides consistent, authoritative information to improve policies, communication, and services for UK civil contingencies, government, and emergency responders. By uniting public bodies, the NHP promotes a holistic, integrated approach to natural hazard risk management, focusing on risk reduction and prevention. The NHP aims to facilitate knowledge exchange and best practices; provide timely, reliable advice to the government and responder community; and foster the development of new disaster response services. The new UK National Climate Science Partnership (UKNCSP[6]) will provide the foundations to enable the UK to be a global leader in climate science for climate solutions to tackle climate change and its impacts. We will do this by combining the UK's wide-ranging capabilities in climate observing and prediction to shape a world-leading, strategic partnership that will work with the public and private sectors to ensure decision-makers and businesses have access to the climate information they need, in order to build urgent resilience and adapt to the pressing challenges of the coming decades.

Currently sustained ocean observatories in the UK feed into meteorological models used to forecast storms and weather, and experts across the scientific spectrum contribute to the National Risk Register. For example, to enhance our ability to assess compound events, the Met Office has invested in a Regional Environmental Prediction (REP) modelling approach, the framework for which will provide multivariate information from the atmosphere, land, waves and ocean around the UK[5]. Investment in science and computing has made the UK a world leader in climate change research, but as we see from recent extreme weather events worldwide, understanding and predicting climate change is not enough. To respond to the threats posed by a rapidly changing climate, climate science needs to move from defining the problem to enabling solutions.

8.2. Anticipated scientific developments by 2040

One of the key priorities identified by groups across the scientific spectrum was the need to define baselines appropriately so that the impacts of hazards, including climate change, can be accurately measured and monitored. Indeed, for climate change there is a pressing urgency to do this now, before major disruptions and/or damage are caused. Due to an accelerated need for marine resources (minerals and energy), there is an urgent need for sound ecological baselines and understanding of Earth's internal processes to underpin assessments of impacts, risks and opportunities for marine net gain and security for infrastructure and energy. Ongoing work in this field, both in the deep and shallow marine environments, has led to a scientific consensus that not enough is known about marine ecosystems and natural geohazards to underpin marine planning with confidence. A strategic and regional approach is often needed to understand ecological functions and sub-sea processes, with hazards often caused indirectly and/or from processes in the far-field.

The international Seabed 2030 effort is a more strategic approach with the ambition to map the entire planet's ocean floors at a minimum resolution of 100 x 100 m. This low resolution is not fit for all hazards and extreme events studies, especially not in shallower and coastal waters, and not all seafloors may be surveyed by 2040. Regardless, by 2040, more high-resolution seafloor bathymetry data will provide an improved dataset of not only snapshots in time, but importantly temporal seabed evolution (e.g. pre- and post- event data and seabed morphodynamics) to help determine the exact scale and size of the hazards and plan future strategic work. We expect significant technological development by 2030, particularly in ocean observatories, communications and sensors. There are several seabed observatories currently in existence; these are the pilot projects that will identify the most efficient and useful ways to measure parameters in the deep and are likely to enable more and better observatories in the future. The development in communications, particularly the likely existence of global Wi-Fi internet coverage by 2030, would make transmitting data from sensors at observatories both possible and inexpensive and increase the current capability for real-time monitoring of hazardous regions. Increased satellite coverage and resolution, along with an increasing diversity of satellite-derived products and processing algorithms are also expected over the next few decades. In this context, Destination Earth (DestinE[7]) is an ambitious initiative of the European Union to create a digital model of Earth that will be used to monitor the effects of natural and human activity on our planet, anticipate extreme events and adapt policies to climate-related challenges. Using innovative Earth system models, cutting-edge computing, satellite data and machine learning, Destination Earth will allow its users to explore the effects of climate change on the different components of the Earth system, together with possible adaptation and mitigation strategies; "By 2030: A 'full' digital replica of Earth through the convergence of the digital twins available through the platform."

Linked to technology, the recent advances in cable sensing, including those which allow for the detection of signals of ocean and geological processes on existing telecommunications cables, are providing some of the first time-series measurements in the deep ocean ever to have been recorded. While limited to regions served by subsea cables, these measurements are likely to allow the first real-time monitoring of currents, seismicity and volcanic activity in the deep oceans, and will provide some of the first constraints on the most hazardous regions, enabling better targeting of future data collection efforts.

8.3. Key future Science Questions, knowledge gaps and uncertainties

The diversity of topics covered by this theme make it impossible to highlight all the specific scientific questions that will be a priority in 2040 in this document because there are so many of them. Across the workshops many topics were raised, including but not limited to: earthquake precursory conditions, submarine volcanic monitoring, higher resolution coastal measurements to enable climate impact forecasting, the impact of climate change on essential ocean processes (e.g. the Atlantic Meridional Overturning Circulation), enhancement of existing hazards by climate change, threats from infrastructure to the natural environment, tsunami risk and modelling and ocean drivers for non-marine regimes.

However, three general priority themes emerged across the workshops that crosscut individual scientific disciplines:

i) **Identification of multi-hazards and extreme events:** the ocean is a blind spot when it comes to identifying potential future hazards or extreme events, due to the lack of high-resolution mapping (particularly in near coastal zones and the deep oceans), ocean monitoring and the fact than many of these hazards have not occurred yet (emerging hazards) or have not been experienced or recorded on recent timescales. There has also historically been a focus on the largest and most catastrophic events, however, smaller events that occur regularly are much less well characterised or recorded, even though cumulatively they may have a larger impact overall. There is also a knowledge gap in understanding the, often complicated, connections and triggers between primary and secondary hazards in order to predict the impact they may have and a lack of models that connect the land to the marine realm.

ii) **Timing and frequency of hazards and extreme events:** key to understanding the risks of hazards and extreme events is knowing their likely recurrence intervals and forecasting when events might occur. For almost all of the hazards in Table X.1, this is currently not possible. We lack an understanding of both of the fundamental earth processes that drive catastrophic events, for example major volcanic eruptions, and the processes and preconditioning that may prime and trigger events, for example, submarine landslides. Our ocean models are also not high enough resolution, or lack the appropriate constraining data, to allow accurate forecasting of extreme events like marine heatwaves, and we do not have enough observations to understand the impacts of these events on the natural environment.

iii) **Resilience:** Resilience depends both on the exposure to hazards or extreme events, as well as the impacted community or ecosystem's ability to survive and recover from it. In terms of ecosystems, we lack the detailed understanding of community thresholds and tipping points, making the impacts of events hard to predict or quantify. For communities, we do not collect as standard the types of data essential for understanding vulnerability to specific hazards uniformly across the planet, and we expect the ways in which communities are vulnerable to change, for example as more services move online, or as transport mechanisms change. We also lack an understanding of the interaction of hazards or extreme events that may amplify or alter one another, with most studies focussing on single events rather than compound or cumulative impacts.

To achieve these objectives requires a combination of sustained and individual experimental data acquisition, as well as the potential to install infrastructure then communicate data in real time to land (for monitoring of hazards). Sustained observation is essential for monitoring but will mean different things in different situations. For example, sustained seismic and deformation monitoring are likely to be the most useful for volcanic settings, while repeated photographic surveys alongside geochemical and ocean measurements would be the most important for understanding ecosystem impacts of a marine heatwave or anthropogenic disturbance. Much of this work will also require the physical sampling of ocean waters, organisms and the seafloor, so there is a requirement for both individual sampling campaigns as well as sustained return sampling in some situations.

It was also highlighted that with increased amounts of data, particularly with sustained observations, there would need to be increases and changes in data storage, sharing and accessibility in future. Not all data types are currently supported by standard repositories like the British Oceanographic Data Centre, and with increasingly diverse and new datasets and types, there would either need to be an expansion of existing data sharing capability and platforms or the development and support of new platforms. For forecasting, warning and scenario analysis of hazards, new connections with national agencies would need to be established where these do not currently exist.

8.4. Future Observation/Product Requirements

The diversity of hazards in the oceans require diverse measurements on variable time and spatial scales as well as bespoke platforms for data sharing and modelling future plausible hazards and scenarios. Marine geohazards are those that are specifically associated with the seafloor and geological processes.

Table 8.2: Overview of the future observation and product requirements for natural hazards.

Topic:	**Requirements:**	**Purpose:**
Forecasting	Geophysical characterization of the subsurface. Active and passive seismic data with improved resolution. Controlled source electromagnetic characterization. Gravity and magnetics surveys. Geological sampling (coring and drilling) to characterise the development of hazardous conditions and define recurrence rates. Geological mapping for spatial extents and impacts.	To characterise the subsurface conditions that generate these hazards and to identify their precursors.
Modelling	Improved boundary conditions. Higher resolution measurements of processes triggering and acting within hazardous events. Require higher spatial and temporal resolution measurements of deep ocean and coastal processes, including temperature, currents, turbulence and waves. Increased global sensor coverage, particularly in sensitive locations, and satellite-derived data needed.	Predicting marine geohazard occurrences and impacts of climate, storms, waves, flooding, and marine heatwaves.
Understanding ecosystem impacts, especially in data sparse regions	Physical observations, long-term sampling, innovative habitat mapping, and AI predictions. In-situ observations of community response to disturbances, including anthropogenic hazards.	Better characterization of marine ecosystems, thresholds, and tipping points. Enhanced understanding of ecosystem connectivity. Predict community structure and vulnerability.

Across all of these topics, in order to improve resilience, monitoring and anticipation is critical. Monitoring involving the sustained measurement of fundamental parameters will allow forecasting of hazards on longer timescales, enabling us to develop more resilient infrastructure, will provide warnings of imminent hazards allowing either the cessation of an activity before it develops, or the evacuation of regions likely to be impacted where the source cannot be controlled, and will improve our understanding of the precursors and triggers of hazardous phenomena so they can be mitigated.

8.5. General description of key capabilities required

Capability of Table 8.2 to be drawn out here (sampling, modelling etc.)

The hazards covered by UK researchers are so diverse they will require a broad range of future infrastructure. There is an enthusiasm to embrace autonomy, for the increased range and survey extents possible as well as the reduced cost and environmental impact of using a vessel. However, there is also a recognition from the community that many activities, in particular some geophysical surveys and physical sampling, cannot be achieved without a vessel. For example, to better understand the frequency of past events, deeper paleo records need to be observed, which often involve bigger monitoring equipment that impose constraints on the size of the vessel that can be used.

8.5.1. Observational Infrastructure

Mobile autonomous platforms are likely to form a large part of the effort to acquire better spatially distributed measurements and may, alongside traditional measurements with buoys, provide monitoring capability for some hazardous phenomena, particularly those associated with climate impacts on the ocean, while deeper submergence vehicles will contribute to better mapping and characterising the ocean floor if no physical samples are required.

Research Vessels will continue to be required for most physical sampling (some autonomous water sampling is possible) and geophysical surveys. For monitoring, repeat measurements made with either autonomous platforms or vessels may prove enough for some hazards, while others are likely to require a combination of dedicated observatories in high-risk zones, combined with remote observations from satellites and potentially measurements made using the existing subsea cable infrastructure.

Earth Observation (EO) is the gathering of information about planet Earth's physical, chemical and biological systems via remote sensing technologies, usually involving satellites carrying imaging devices (definition by the EU Scientific Commission). It is essential for understanding natural hazards, particularly in multi-(hazard-)risk contexts. Data from EO has rapidly become widely available and substantially easier to use due to the steep decline in the cost of imagery and the deployment of machine learning algorithms. By leveraging this EO data, we can address complex interactions between hazards and enhance resilience. Products derived from the Global Navigation Satellite System underpin many hazard risk assessments: e.g. Monitoring deformation of the solid Earth, monitoring Earth rotation, ionosphere and troposphere and variations in the hydrosphere.

8.5.2. Digital Infrastructure

To better anticipate plausible future hazards scenarios, we will need to develop a **new generation of models** to help interpret and provide robust and innovative methods for long-term hazard assessments and short-term forecasting of marine geohazards. This approach needs to cover all time scales, from seconds to hours (landslides, earthquakes, tsunamis), days to years (volcanic eruptions, migrating bedforms, fluid activities), and years to millions of years (e.g. seafloor deformation).

The deployment of widespread 5G technology can significantly enhance flood detection systems by enabling faster, more reliable communication between sensors and monitoring systems. With its low latency and high bandwidth, 5G allows real-time transmission of large volumes of data from remote sensors, improving the accuracy and timeliness of warnings. Additionally, 5G technology supports the integration of cutting-edge technologies such as Internet of Things (IoT), Artificial Intelligence (AI), and edge computing, enabling more in-depth analysis and prediction models that can better assess flood risks and provide timely alerts to local communities and authorities.

8.5.3. People, Skills and Partnerships[8]

The environmental change is at such scale and pace, that we must face the increased risk of natural hazards as an extraordinary challenge. To strengthen resilience to natural multi-hazards and extreme events, communities need to recognise their role in this, and take responsibility. That can be achieved by better science and better science communication (e.g., Frontiers for Young Minds: Natural Hazards in the Ocean; Hillman et al., 2023) to make people more aware, better prepared and more confident in their own understanding of marine hazards. That requires better skills training (incl. at sea) for both scientists and for the wider communities: a better understanding of e.g. statistics (the likelihood of events – short-term variations vs long-term change), of the complexity of Earth processes in the marine world, and of the complexity in roles of local and national authorities (e.g. who makes policy frameworks for which hazard management, who manages the risks?). There are tools we can use easily (using EO data, for example), as the improved EO data access for empirical research should act to democratise and diversify science and the scientific community (Nagaraj et al., 2020). Other tools are more challenging, like providing access to training at sea.

FOOTNOTES

[1] https://www.undrr.org/drr-glossary/terminology

[2] https://disasterriskgateway.net/index.php/Definitions

[3] https://www.climate.gov/news-features/climate-qa/what-extreme-event-there-evidence-global-warming-has-caused-or-contributed#:~:text=An%20extreme%20event%20is%20a,the%20range%20of%20historical%20measurements

[4] https://www.metoffice.gov.uk/weather/warnings-and-advice/seasonal-advice/travel/out-and-about/understanding-rip-currents#:~:text=Rip%20currents%20are%20a%20major,lifeguard%20incidents%20involve%20rip%20currents.

[5] https://committees.parliament.uk/writtenevidence/43524/html/

[6] https://www.metoffice.gov.uk/research/approach/collaboration/uk-national-climate-science-partnership

[7] https://www.esa.int/Applications/Observing_the_Earth/Destination_Earth

[8] https://access-national-risk-register.service.cabinetoffice.gov.uk/individuals-communities

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