ESA's new EO Science Strategy and Earth Action

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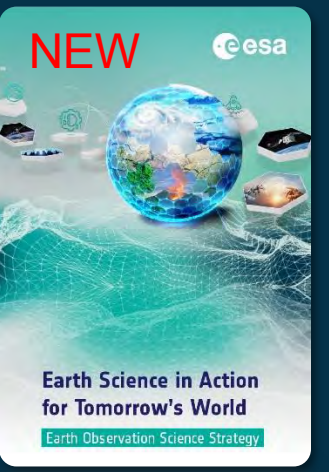
What is the new EO Science Strategy?

- Articulates a **strategic vision** for EO **science** at ESA
- Presents **cross-cutting** science priorities addressable by EO, which respond to scientific **and** societal challenges - and have relevance and beneficial impact
- Coherent with the **2040 horizon** as well as ESA's **Space 2040 strategy** and identifies strategic **Areas of Action** implementable on **different timescales**
- **Focus** on areas where ESA's programmes and activities can address scientific challenges, assemble scientific knowledge with which to **take action**, and with **traceable & beneficial impact**
- Identifies areas of science that ESA may respond to **across the value chain**, from innovative missions, technology development, through scientific excellence to societal benefits
- Involves R&D and innovation, strong partnerships – even beyond the space sector



Why an EO Science Strategy is important?

Calls for mission ideas and selection of future Research missions shall be guided by a Science Strategy

Proposed missions shall respond to the science priorities and questions outlined in the Science Strategy

The Science Strategy provides a framework to guide international partnerships with other Agencies and Institutions

The Science Strategy shall guide priorities for investments in developing the new technologies and observation sensing/platform capabilities required to implement future EO missions

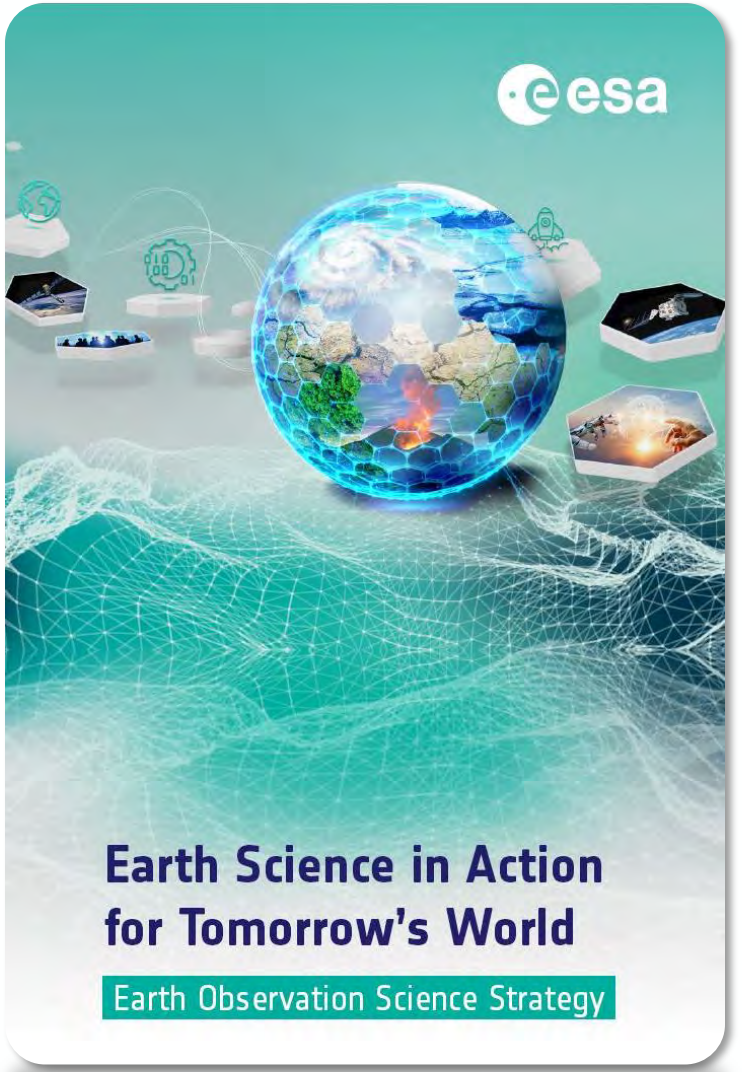
The science strategy shall guide investments and R&D (e.g. FutureEO Programme)

The Science Strategy is a tool to communicate the vision, goals and ambition of ESA's EO Programmes, and provides a means to gauge progress and success, and to guide future programme implementation

EO Science Strategy & Reference Documents

Publicly available online:

- Release version of EO Science Strategy (*Earth Science in Action for Tomorrow's World – Earth Observation Science Strategy*)
- Guiding EO Science Questions document (built also on extensive community)
- In the online library: ESA - Earth observation library under Strategy and Programme Documents
- Each document includes a citation and DOI for easy, consistent and transparent referencing



EO Science Strategy: Essential Building Blocks

6 Overarching Science Themes

- Cover most important themes of integrated Earth system science
- Provide inclusive cross-disciplinary framework to stimulate future missions, guide selection and implementation, and break down disciplinary silos

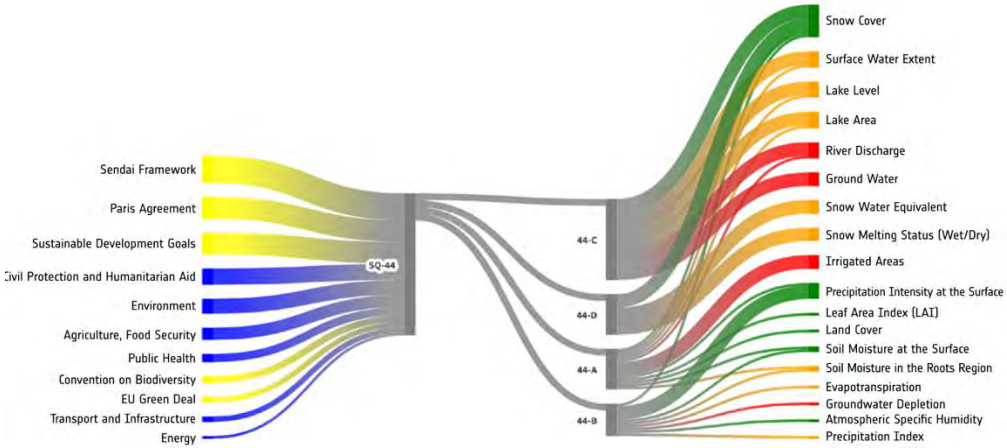
ST-I	ST-II	ST-III	ST-IV	ST-V	ST-VI
The water cycle	The carbon cycle and chemistry	Energy fluxes	Ecosystem health	Extremes and hazards	Interfaces & coupling in the Earth system

4 Strategic Areas of Action

- Provides basis to assess, categorise and prioritise science and programmatic actions and activities

23 Guiding Science Questions

- Identify a non-exclusive series of pressing Earth system science issues that can be addressed by using EO
- Vetted by EO community after wide consultation and integration of extensive community feedback
- Traceable to primary geophysical information needs and to policies and societal benefits

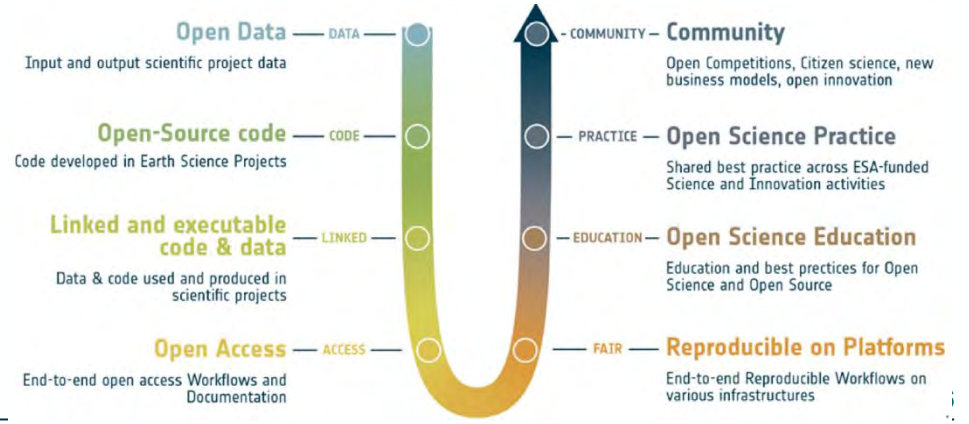


16 Strategic Objectives

- Capture and reinforce important objectives within the science strategy

5 Enabling Tools

- Support, augment and enhance the implementation of activities



Science Themes & Stategic Areas of Action

ST-I	ST-II	ST-III	ST-IV	ST-V	ST-VI
The water cycle	The carbon cycle and chemistry	Energy fluxes	Ecosystem health	Extremes and hazards	Interfaces & coupling in the Earth system

Table 1 Overarching science themes that guide scientific priorities within EO Programmes. A detailed description of each theme can be found in Appendix 1.

A-1: Frontier science and discovery:
a strong foundation

A-2: From science to societal benefits:
meeting society's needs

A-3: Reducing critical knowledge gaps:
taking expedient action

A-4: Filling critical observation gaps:
preparing for tomorrow starts today

Guiding Science Questions and their relevance to International Treaties, Agreements & Conventions

Strategic Areas of EO Action

A1: **Frontier Science and Discovery**

- innovative/blue-skies, novel discovery science
- groundbreaking/technologically challenging
- serving as a foundation for all areas of action
- harnesses science knowledge, technical know-how at European level through ESA

A2: **From Science to Benefits**

- contribution to areas of societal benefits in the domains of international and national policy
- science basis for development of green solutions
- science relevant to informing, assisting, enabling monitoring of compliance, and evaluate policy impact
- support to evidence-based policy implementation

A3: **Reducing Critical Knowledge Gaps**

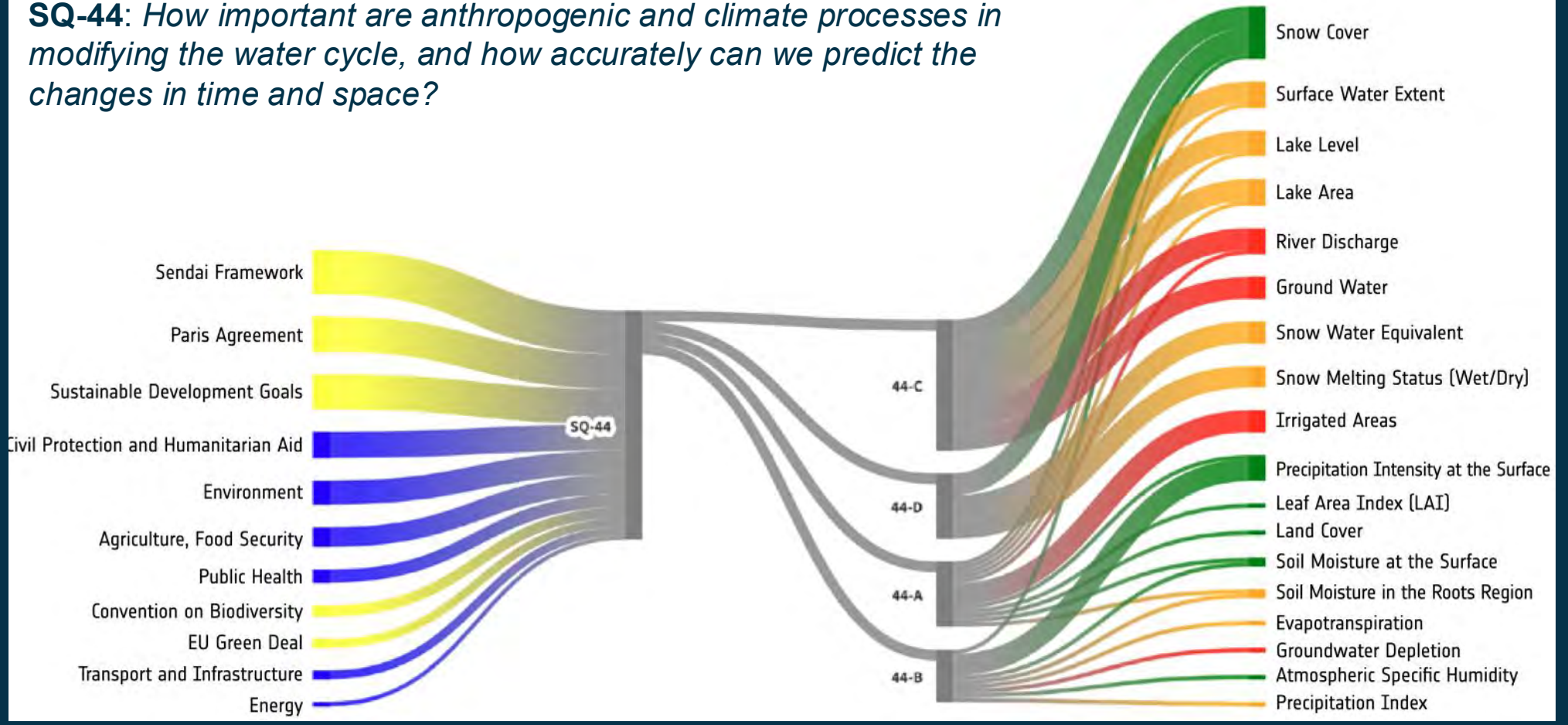
- uptake and contribution of existing/upcoming missions to science questions
- pursuit of multi-mission synergies
- agile Scout research missions for rapid return
- addressing high priority science through partnerships and institutional collaborations
- demonstrable progress made in 6 years

A4: **Filling Critical Observation Gaps**

- addressing crucial observation gaps with new technologies
- study and predevelopment of novel and improved observational capabilities
- requiring sustained science / technology development
- takes into account EO reference architecture

Guiding Science Question 44: Hydrology

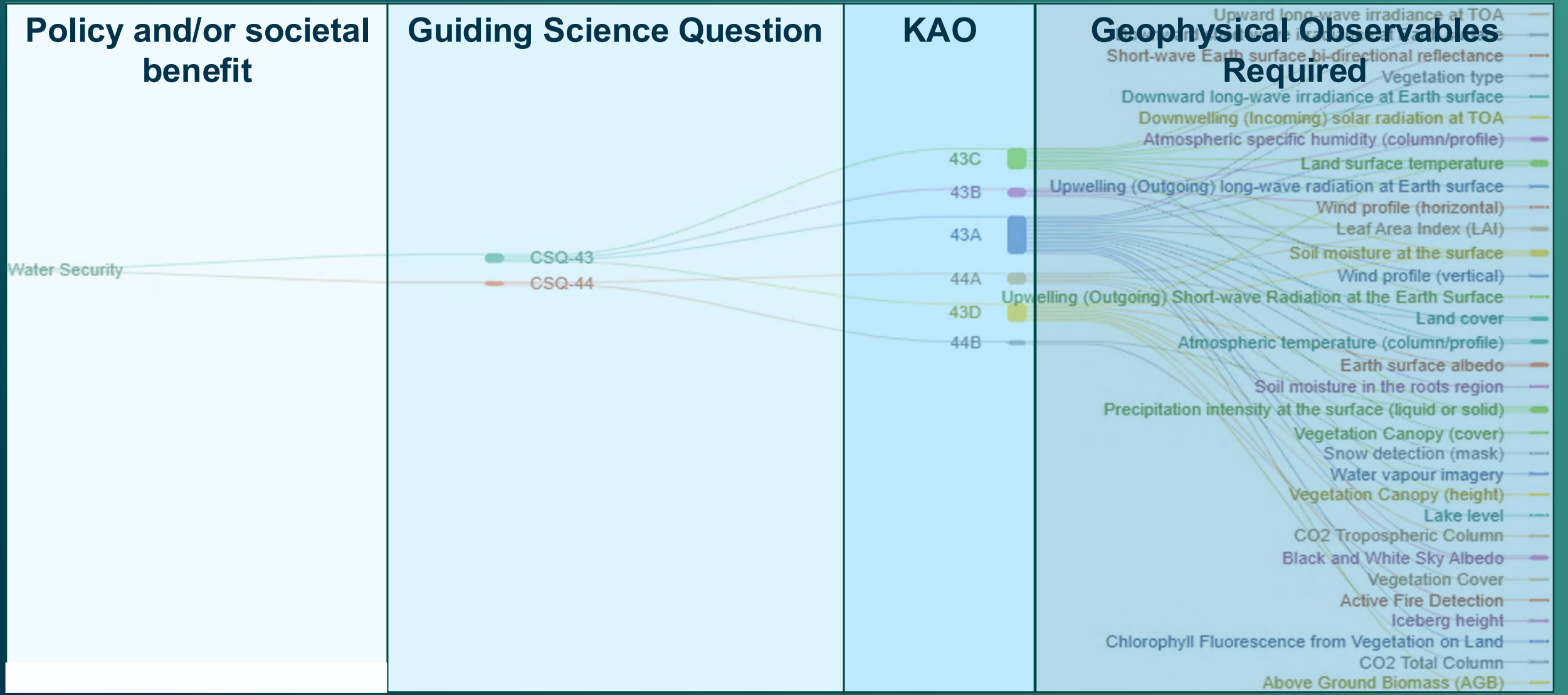
SQ-44: *How important are anthropogenic and climate processes in modifying the water cycle, and how accurately can we predict the changes in time and space?*



Gap Status
Plentiful
Limited
Gaps

Based on sensor availability only, not quality. Number of instruments in the database that provide each observable, and that are operational or approved, and with EoL later than 2024

Example traceability for water security using foundation study database



Criteria Used to Characterise Science Questions

Category	Justification	Scoring Criteria
A1 Frontier Science and Discovery (Novel / discovery science)	Innovative / blue-skies science that is groundbreaking / technologically challenging. can best be addressed via multilateral cooperation through ESA.	**High Score**: Answering the question would deliver fundamentally new knowledge or help to quantify processes, fluxes or stores that are unmeasured, or have large or poorly understood uncertainties. **Low Score**: The science is derivative – delivers incremental gains in already well understood processes.
A2 From Science to Societal Benefits (Policy relevance and benefits, and risk reduction)	Clear benefits to society are an increasingly important driver to the ESA strategy. Need to support greater confidence in actions by governments the private sector and individuals	**High Score**: Makes a unique or leading contribution to an area of societal benefit that is significant in scope, economic impact, or risk. EO data plays a unique or very significant role in delivering **Low Score**: The societal or policy relevance of the SQ is minimal or marginal. EO data makes a minor contribution alongside several other actions by other parties.
A3 Reducing Critical Knowledge Gaps (Scope to reduce critical knowledge gaps in the next 5-6 years)	The updated EO science strategy will have a horizon of 5-10 years, with the associated need to demonstrate significant progress within the first 5-6 years.	**High Score**: Demonstrable progress can be made on specific and scientifically / societally important objectives through R&D and technology development (including with AI/ML) that exploits existing or planned data, particularly from the ESA science programme. **Low Score:** Progress can only be achieved in the long term, possibly because entirely new missions would be needed that are not currently planned
A4 Filling Critical Observation Gaps (Potential to fill critical observation gaps through innovation in space technology)	Filling critical observation gaps through technology development is fundamental to the ESA EO programme.	**High Score**: Represents a critical knowledge gap but advancement is critically / uniquely dependent on new EO technologies. Technology development needed for SQ progress could result in new operational observations in the long term. **Low Score:** Criticality of knowledge gap is low and / or existing data and instrument types are adequate to make progress. Or, conversely, required measurements cannot feasibly be made from space.

Earth Action - the approach

Earth Action: A New Pillar

- ***Combines*** all knowledge/expertise/experience gained over decades!
- ***Addresses*** the full life cycle of data exploitation under a single programmatic umbrella
- ***Responds*** to "most or all" relevant policy frameworks, climate/sustainability legislation & resolutions… and of course the EO science strategy

→ **Earth System and Climate Science** → *frontier science across six over-arching themes; predictive models for digital twins, green solutions; climate science (cross-ECVs, extreme events, tipping points)*

→ **Enabling policies** → ***addressing complex, inter-linked policy framework at all levels***

→ **Readiness for global action and partnerships** → ***strengthens co-design ;*** *DG DEFIS, CLIMA, RTD, ENV, INTPA, AGRI, HOME, JRC, EUROSTAT;* ***UN:*** *UNEP, UNSD; International Financial Institutions, etc.; "geopolitics"*

→ **Industrial competitiveness** → improve **competitiveness** of EO sector**,** ***resilience*** *strong driver*

→ **Enabling elements** → *disruptive/digital innovation, open calls, SUP, knowledge exchange, education and training, open innovation, space for a green future accelerator*

Conclusions

- New ESA EO Science Strategy in place based on a vision towards 2040
- **A**ffects all new research missions and also Earth Action!
- Implementation targets over short, medium and **long-term**
- Strategy revision expected on approx. 5-6 years cadence
- Implementation plan is in progress
    - Big ticket science is much wanted by all
    - …but how do we afford it
    - … and strengthen European leadership (now and forever)
    - … and ?
- EO Ecosystem 2040+ plans shall work hand-in-hand with the EO Science Strategy to achieve a balanced and attractive long-term plan for European EO in a global and competitive context