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# Assessing the contribution of the Climate Space programme to the ESA EO Science Strategy

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# Context and objectives

- The ESA EO Science Strategy launched in 2024 is characterised by 23 Guiding Science Questions (SQs), each of which has specific objectives and requirements for Geophysical Observables
- The study will assess the contribution that the Climate Space programme is making to achievement of ESA's strategic goals through **three mechanisms**:
  - Enhancing the quality, consistency and traceability of Geophysical Observables from EO data through the generation of ECVs
  - Advancing the specific objectives of SQs by improving process understanding
  - Contributing to ESA's Strategic Objectives through education, outreach and promoting the use of EO in the policy domain
- We will develop and implement a methodology that can be extended and adapted to other areas of the ESA EO programme
- The study will also support future assessments by the design of appropriate metrics and templates to record and quantify progress
- The Study kicked-off in February 2026 and will run until September 2026

# EO Science strategy elements

The ESA EO Science Strategy has a number of components through which contributions can be assessed

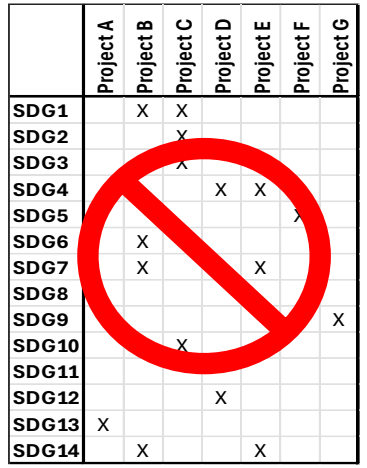
- 23 Science Questions
  - Each with specific objectives (59) and observation requirements (100s), and linked to national and international policy needs
- 4 Strategic areas of action
  - A1 Frontier Science and Discovery: a strong foundation
  - A2 From Science to Benefits: meeting society's needs
  - A3 Reducing Critical Knowledge Gaps: taking expedient action
  - A4 Filling Critical Observation Gaps: preparing for tomorrow starts today
- 6 Over-arching science themes
  - Water cycle, carbon cycle and chemistry, energy fluxes, ecosystem health, extremes and hazards, Interfaces & coupling in the Earth system
- 16 Strategic objectives, Eg.
  - #3 To develop scientific knowledge …information products relevant to … policy frameworks
  - #12 ..communications of ..results towards the general public, policy-makers …
  - #14 To foster ..openness in EO science, … and of a sustainable open innovation ecosystem

# Structure of a Science Question

| Question | Knowledge Advancement Objectives | Geophysical Observables [Links to MIM databases] | MIM Number | Measurement Specifications | Data sets, Methods, Tools & Models | Policies / Benefits |
|---|---|---|---|---|---|---|
| How has the ocean carbon cycle responded to anthropogenic CO2 and climate change? | A) Track changes in ocean uptake and removal of $CO_2$ associated with changes in atmospheric $CO_2$ concentration, sea surface temperature, ocean transport and biological productivity at 1°x1° or higher resolution over the globe? | **1. Critical Parameters** *Precise/accurate estimates of near-surface atmospheric CO2 and its spatial and temporal gradients* | | | Atmospheric GHG retrieval algorithms<br>Atmospheric flux inverse models<br>Global ocean biogeochemical models (GOBMs)<br>Enhanced Cal/val | CC mitigation and adaptation policy |
| | | Atmospheric $CO_2$ dry air mole fraction | CEOS-44 | Precise/accurate (0.1 ppm) $XCO_2$ and $XO_2$ at a resolution of 1°x1° or higher at monthly intervals | | |
| | | *Sea surface temperature (SST) and salinity* | | | | |
| | | Sea Surface salinity | CEOS-152 | SST, salinity at a spatial resolution of 1°x1° or higher at daily intervals | | |
| | | Sea surface temperature | CEOS-144 | | | |
| | | *Surface vector winds* | | | | |
| | | Wind speed over sea surface (horizontal) | CEOS-141 | Ocean wind speed at a spatial resolution of 1°x1° or higher at daily intervals | | |
| | | Wind vector over sea surface (horizontal) | CEOS-143 | | | |
| | | *Ocean colour* | | | | |
| | | Ocean chlorophyll concentration | CEOS-149 | Ocean colour at a spatial resolution of 1°x1° or higher at daily intervals | | |
| | | Ocean suspended sediment concentration | CEOS-150 | | | |
| | | Colour dissolved organic matter (CDOM) | CEOS-151 | | | |
| | | **2. Supporting Parameters** | | | | |
| | | Precipitation | CEOS-116 | precipitation at a spatial resolution of 1°x1° or higher daily | | |

# Overall Approach

- Avoid tick-box syndrome
- Identify meaningful connections and contributions
- Traceability and justification for all contributions



| | Project A | Project B | Project C | Project D | Project E | Project F | Project G |
|---|---|---|---|---|---|---|---|
| SDG1 | | X | X | | | | |
| SDG2 | | | X | | | | |
| SDG3 | | | X | | | | |
| SDG4 | | | | X | X | | |
| SDG5 | | | | | | X | |
| SDG6 | | X | | | | | |
| SDG7 | | X | | | X | | |
| SDG8 | | | | | | | |
| SDG9 | | | | | | | X |
| SDG10 | | | X | | | | |
| SDG11 | | | | | | | |
| SDG12 | | | | X | | | |
| SDG13 | X | | | | | | |
| SDG14 | | X | | | X | | |

Track 1: ECV Projects

EOSS → Science Question → KAO → GO → ECV Product → CS Project

Track 2: Cross-cutting Tipping points, adaptation etc..

EOSS → Science Question → KAO → Earth System process → CS Project

Track 3: strategic, outreach and comms projects

EOSS → Strategic Objectives → CS Project

# Task 1: ECV Projects

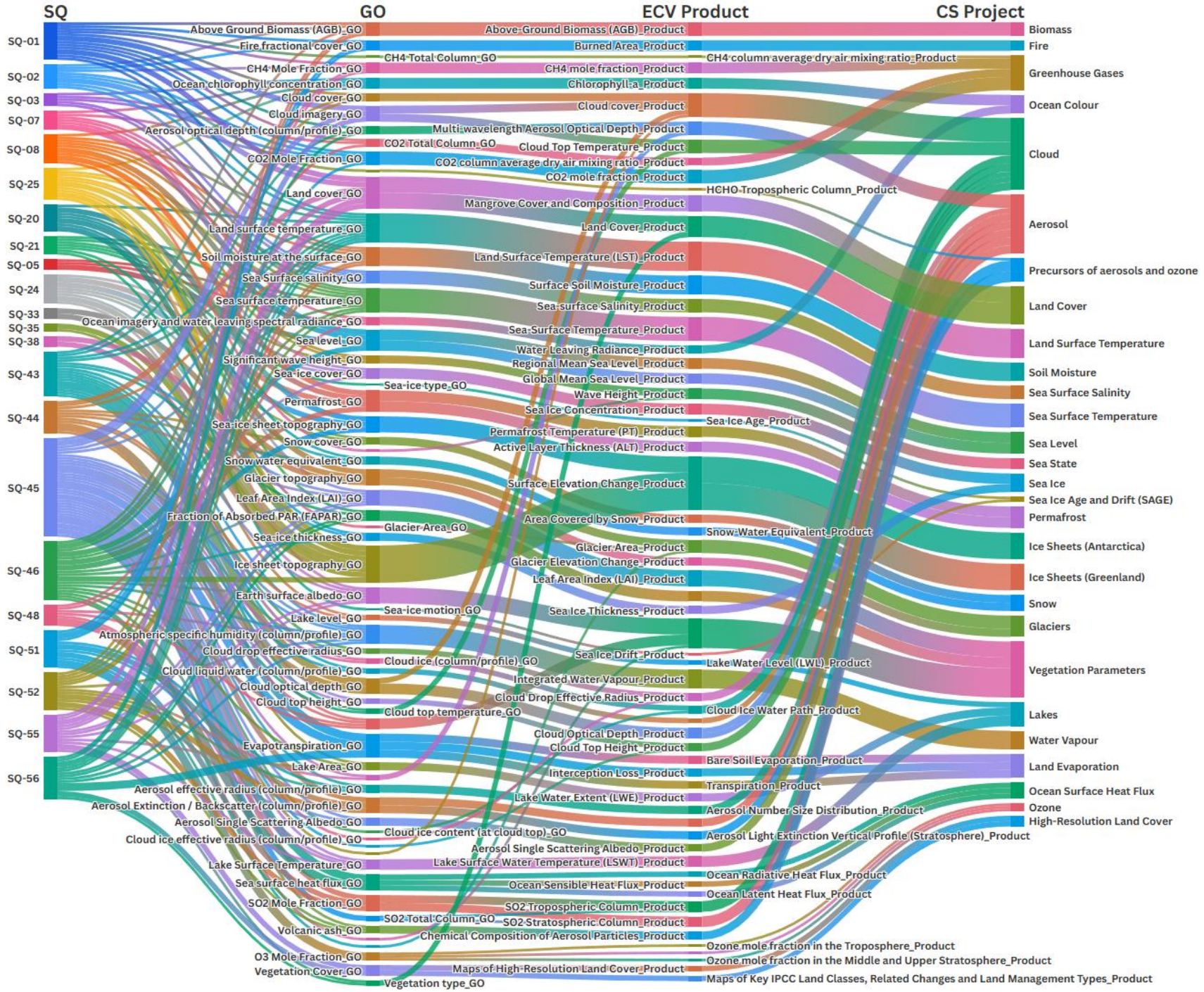

- GO (strictly speaking, CEOS measurements) -> ECV Products
- Some issues / ambiguities in CEOS descriptions
- 209 links identified
- *Note these are the 2022 ECV products

- ECV Products -> Climate Space projects
- Fairly straightforward – project documentation generally good – PUGs have the info if it is not available on the basic www page
- 88 links identified

- In both cases, we documented all the relevant links, even if they were not part of a full end to end chain

# Track 1: Results

- This version contains only the complete links through the chain
- Aggregated at the SQ level (KAOs not shown)
- Line weights are proportional to the sum of the scores of the links between each node
- Takes into account multiple objectives per SQ and “criticality” of GO to the objective



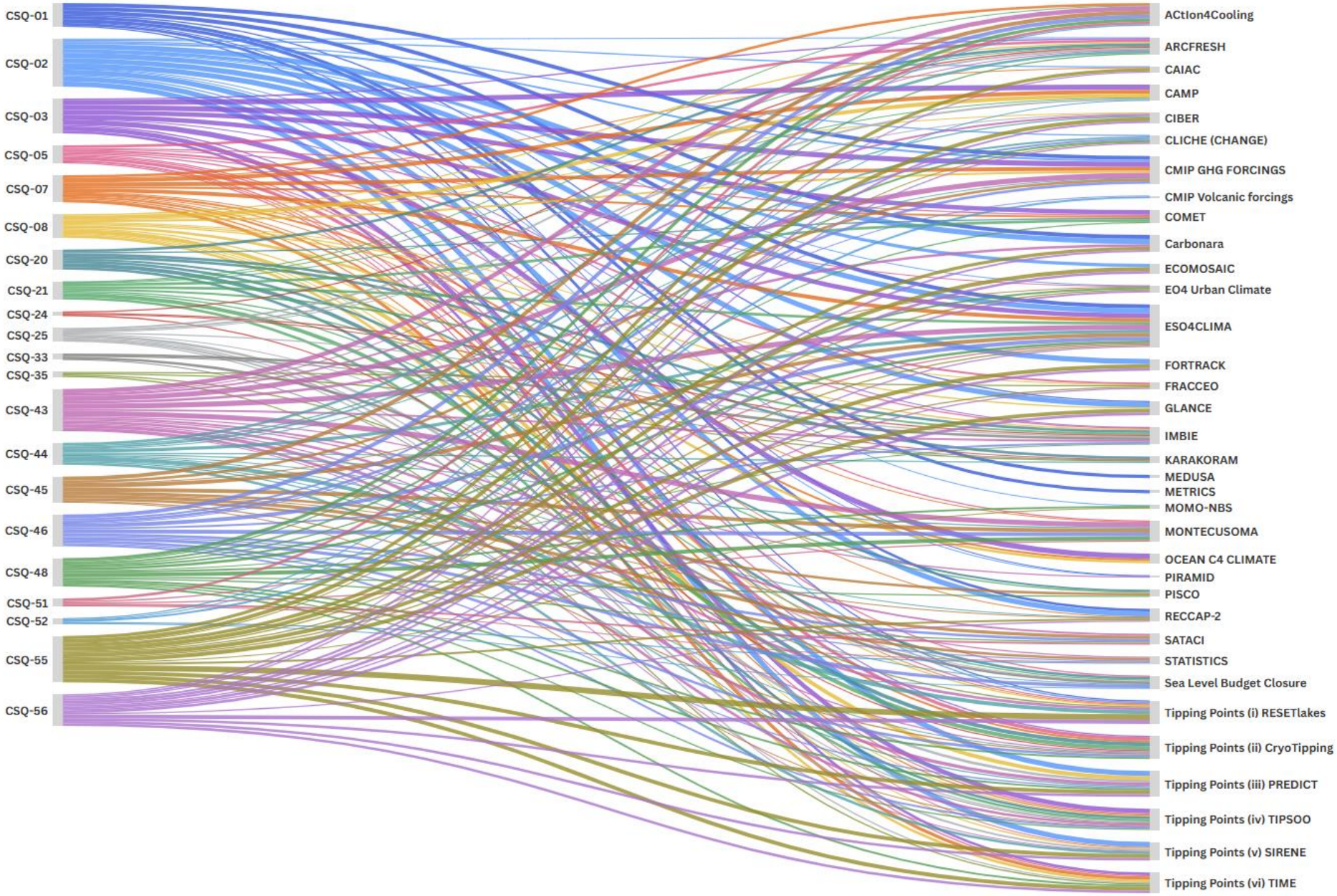
# Task 1 Results: Notes

- Overall, the results are good, showing that the data being generated from the ECV projects are relevant to nearly all of the SQs
- The only missing SQs are solid earth related, so the gap is not surprising
- The diagram only shows the complete links through the chain. Other versions could be constructed that show gaps on one side or the other, but at the moment we are looking to highlight the contributions
- There are a few things to tidy up, for example where a SQ is needing an observation that is not in the CEOS list, but we know is being produced in a climate space project
  - One example is river runoff - this is a requirement of one or more SQs.  It is not in the CEOS DB, but is an ECV product
  - We will need to add some additional nodes in the GO column for these items

# Track 2: Assessment of cross cutting and applications projects

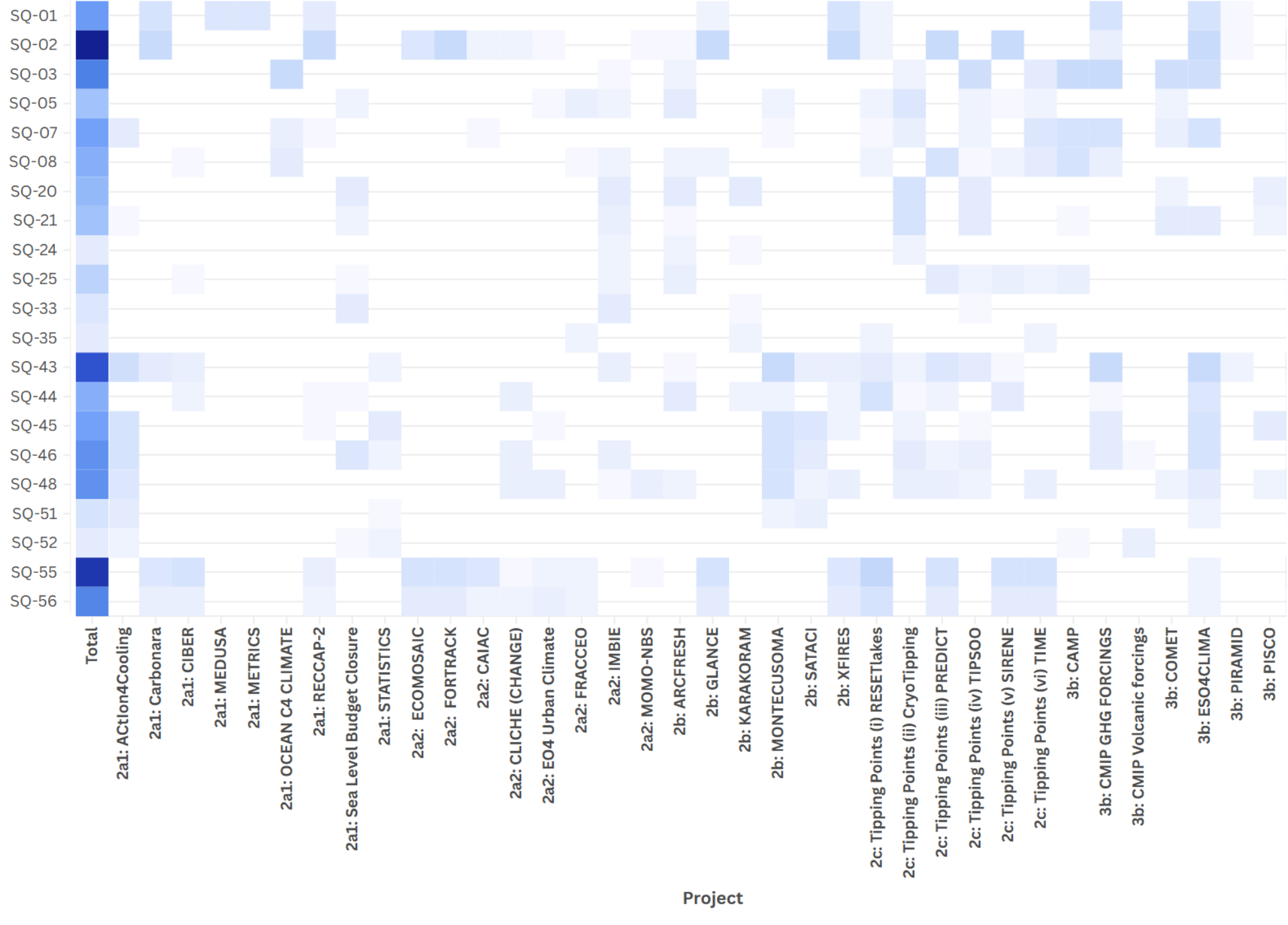

- Need to find common currency between non-ECV specific Climate Space activities and ESA Science Strategy
- Represent the Science Strategy by SQs
- Consider at level of KAOs where specific objectives in terms of process understanding are expressed
- Identify major (2) or minor (1) relevance of each Climate Space Project to each KAO
- Provide short comment as justification of score
- Populate matrix of  about 3,000 elements (44 projects x 68 KAOs) with score/justification for each hit

# Track 2 Preliminary Results: Sankey



# Track 2 Preliminary results heatmap

- Includes projects that can be linked to one or more SQs and for which www / site documents are available
- Consolidated at SQ level



# Track 2 Results notes

- Matrix of projects v KAOs about 10% populated in draft - ~400 Project -> KAO contributions resulting in ~220 Project -> SQ contributions
- Weights (line thickness & heatmap colours)  and are the sum of the links from the projects to the KAOs for each science question
- Fairly evenly distributed, with results intuitively reasonable
  - KAOs related to eg SQs 55/56 (ecosystems in transition) relevant to many projects
  - Sea level budget closure project linked to several SQs
  - SQ 33 (GIA signal of Pleistocene deglaciation) specific to few projects
- 21 of the 23 SQs represented
  - Only two solid Earth SQs not represented
- Next steps
  - Collect data for remaning new projects not yet analysed
  - Review and moderate all the assessments

# Analysis and assessment tools

“Measure what is important, don't make important what you can measure.”

- Objective is to define a set of metrics and templates and to design a meaningful and non-burdensome assessment framework
- Starting point is to examine the assessment we have just done and identify which additional information would have made it more:
  - Efficient
  - Meaningful
  - Robust
- We will design a set of metrics, templates and guidelines suitable for assessment through the whole programme lifecycle: Programme Contents - ITTs – Evaluation – Project execution, and test it on a small number of current projects
- Explore information formatting and AI tools to support ongoing evaluation

# Next steps

**April**

- Tie a up some loose ends in the GO – ECV Product – CS Project mapping

**May-June**

- Collect the remaining CS project information, complete the project assessment, review and moderate the scores and comments
- Complete the assessment for the strategic, cross-cutting projects
- Tying back all of this to the components of the EO Science Strategy (areas of action, strategic objectives …) and summarize assessment and visualizations
- Draft the future assessment metrics, guidelines and templates

**June - Sept**

- Dry run the assessment with a small sub-set of current projects
- Collate all results and assess the utility of AI tools to support interpretation and summarization of the evaluation

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