ICOS | INTEGRATED CARBON OBSERVATION SYSTEM

SOCIO-ECONOMIC IMPACT, RI SERVICES AND ACCESS TO DATA

Werner Kutsch

ESFRI EoE Workshop 15.11.2021

ESFRI White paper 2020

MAIN MESSAGES

ESFRI considers that the following are needed for a stronger Europe:

Reinforce the position of Research Infrastructures as an essential pillar of the European Research Area, forming a healthy, sustainable and integrated Research Infrastructure ecosystem that strives for scientific excellence with impact, and provides transnational services, supporting education and skills development.

Enhance the role of Research Infrastructures as truly strategic investments across borders of sectoral domains, contributing to European strategic agendas and enabling European research and innovation to address pressing and complex societal challenges.

Develop and exploit the potential of European Research Infrastructures as knowledge and innovation hubs, integrated into local communities, forming the basis of European competitiveness, with regional impact and global outreach.

Further strengthen the coherence between European, national and regional priorities and policies for Research Infrastructure development and funding.

Exploit the potential of Research Infrastructures as major promoters of Open Science providing FAIR (data which meet principles of findability, accessibility, interoperability, and reusability) and quality certified Open Data, supporting their contribution to the success and impact of the European Open Science Cloud and so strengthening their capacity to serve their users.

Better use the potential of the ESFRI to contribute to the development of coherent Research Infrastructure policy and investment in Europe, ensuring its appropriate capacity to that end.

- Scientific excellence with impact,
- Research and innovation to address pressing and complex societal challenges,

"Looking to the future, Europe's citizens are demanding that their investments in science help to bring solutions to the global challenges of the 21st century: the impact of climate change, the harnessing of industrial change and the digital transition, the threat of social inequality and its impact on our democracies – all of which require a new approach and present the opportunity for scientific disciplines to join forces in helping address them. To meet these challenges in an effective manner, the ERA requires clearer prioritisation and better coordination combined with a more cohesive engagement with global opportunities."

ICOS' contributions to the SDGs

A focus on SDG 13: by providing harmonised, high quality greenhouse gas (GHG) measurements across Europe, ICOS contributes directly to SDG 13 'Climate Action'. Monitoring GHG emissions and removals is vital to achieve carbon neutrality. Our data along with excellence climate science and active international dialogue enable informed decision-making for global climate strategies.

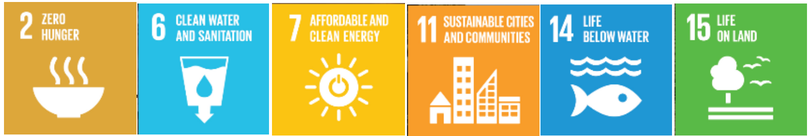
In addition, ICOS ERIC contributes to several other SDGs in two key impact areas :

Scientific excellence

ICOS provides FAIR data for scientists, students, citizens and policy makers. They support research and innovation to adapt agriculture, water management, energy provision and city planning to the challenges related to climate change and its impacts.

Societal impact

Reliable data on GHG fluxes support evidence-based policy making around climate adaptation and mitigation. Direct cooperation with UN organisations such as WMO and UNFCCC and science partnerships around the world support education and strong institutions.



Science generates

more societal impact

The excellence of the ICOS Science case

KUNGL. VETENSKAPS-AKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

5 OCTOBER 2021

Scientific Background on the Nobel Prize in Physics 2021

"FOR GROUNDBREAKING CONTRIBUTIONS TO OUR UNDERSTANDING OF COMPLEX PHYSICAL SYSTEMS"

The Nobel Committee for Physics

THE ROYAL SWEDISH ACADEMY OF SCIENCES has as its aim to promote the sciences and strengthen their influence in society.

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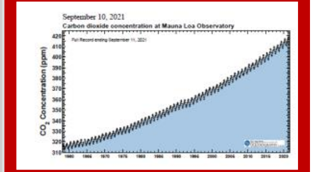

FIG. 4. The Keeling Curve, named after the late Charles Keeling who began the monitoring program. The curve shows monthly mean CO_2 concentration from Mauna Loa, 1958-2021. (Data from Scripps Institution of Oceanography; https://keelingcurve.ucsd.edu.)

ory of climate must rely on the challenging edifice of explicitly time dependent differential equations to capture the time-evolution of climate subsystems on many timescales. On the other hand numerical modeling, which marches forward the coupled equations of the entire system in the modality of weather forecasting, can incorporate time dependent forcing in a variety of ways. It is self-evident that the atmosphere, ocean, cryosphere, land masses and biosphere must obey the laws of thermodynamics. However, the myriad of time scales in the globally coupled system make determination of which subsystems are in what balance on a given time scale a challenging theoretical exercise.

The canonical class of energy balance models, now referred to as "Budyko-Sellers models" [15, 28, 78, 101], pits the incoming shortwave and outgoing longwave radiative fluxes against each other. In a mean annual, globally averaged sense we can write

$$C_P \frac{\partial T}{\partial t} = S_0(1-\alpha) - \epsilon\sigma T^4, \quad (1)$$

where T is the temperature of the surface, C_P is its effective heat capacity, S_0 and α are the solar shortwave radiative flux and surface albedo respectively, σ is the Stefan-Boltzmann constant and ϵ the emissivity. The fixed point for this simple model is

$$\epsilon\sigma T_{BP}^4 = S_0(1-\alpha) \Longleftrightarrow F_G{}^{\uparrow} = F_{\odot}{}^{\downarrow}, \quad (2)$$

or that the incoming solar flux ($F_{\odot}{}^{\downarrow}$) is balanced by the upward surface flux ($F_G{}^{\uparrow}$), which gives us the steady state temperature $T_{BP} = \sqrt[4]{S_0(1-\alpha)/\epsilon\sigma}$. The atmosphere only enters into this result through the use of the planetary albedo α, which is approximately 0.3 as determined from satellites, thereby including both highly reflective clouds (up to 0.9) and absorbing oceans (0.2). Hence, T_{BP} *does not include* the infrared contribution of the atmosphere and hence does not deal with the greenhouse effect. In consequence, this is often referred to as a "bare planet" temperature and it is cold; $T_{BP} \approx -15°C$ [5, 91].

Now, the simplest means to see the infrared effects of the atmosphere is shown in Figure 5. In steady

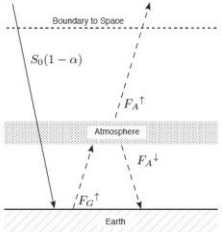

FIG. 5. Approximately as envisioned by Svante Arrhenius in 1896 [6], a "one-layer atmosphere" over Earth that absorbs and emits the outgoing infrared radiation from the surface $F_G{}^{\uparrow}$. We assume the outgoing atmospheric infrared emission is the same as the incoming, and that the atmosphere is isothermal, so that $F_A{}^{\downarrow} = F_A{}^{\uparrow} \equiv F_A$. Modified from [5].

state, balancing the fluxes in the atmospheric layer we have $F_G = 2F_A$, and using this at the surface we find $F_{\odot}{}^{\downarrow} = F_A$ at the top of the atmosphere. The two key consequences are (a) the top of the atmosphere radiates to space at the (cold) bare planet temperature $T_A = T_{BP}$, and hence (b) the surface temperature is now a balmy $T_G = 2^{1/4} T_{BP} \approx 34°C$.

Generalizing this to an N-layer atmosphere one finds that $T_G = (1+N)^{1/4} T_{BP}$ with the top of the atmosphere radiating to space at T_{BP}, with the clear implication of a runaway greenhouse effect that ignores the subtleties of the spectral absorption of greenhouse gases, feedbacks and many other effects. These leading order processes were understood by the polymath Svante Arrhenius. In 1896 [6], in a pioneering study of how absorption by CO_2 would influence T_G, he built the scientific framework central to the atmospheric column models used in successively more complex treatments that have developed since then.

The effect now known as *band-saturation* was also understood by Arrhenius, who was using the then available state of the art spectroscopic data on CO_2 and water vapor, and in particular that from the experiments of Tyndall [109]. In band-saturation the absorption increases linearly with temperature at low gas concentrations (or pressures) but with increasing concentration all infrared radiation entering a gas is absorbed. Not only did Arrhenius determine that the atmosphere is not sat-

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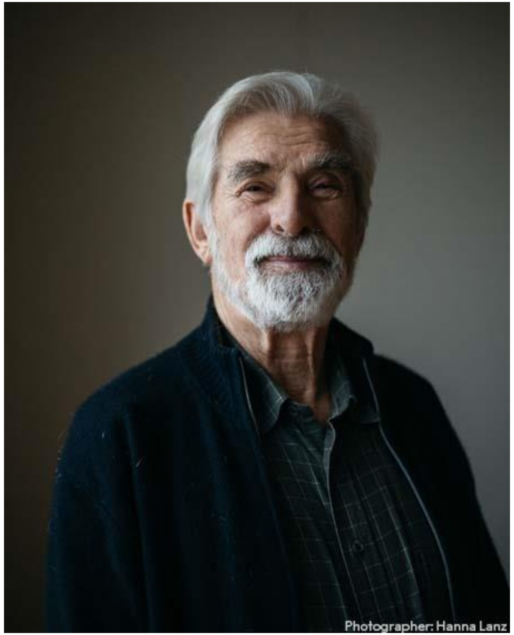
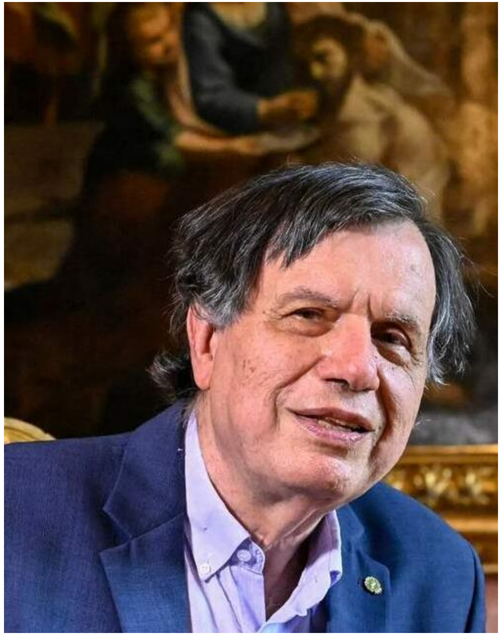
First of all: congratulations to the Physics Nobel laureates in 2021

Syukuro Manabe



Klaus Hasselmann



Giorgio Parisi

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For groundbreaking contributions to our understanding of complex physical systems.
They found hidden patterns in the climate and in other complex phenomena.

Two quotes

- **»Model calculations provide patterns; when we find these patterns in observations, we have recognised the human fingerprint.«   (J Marotzke).**

- **»I would rather have no global warming and no Nobel Prize.«**

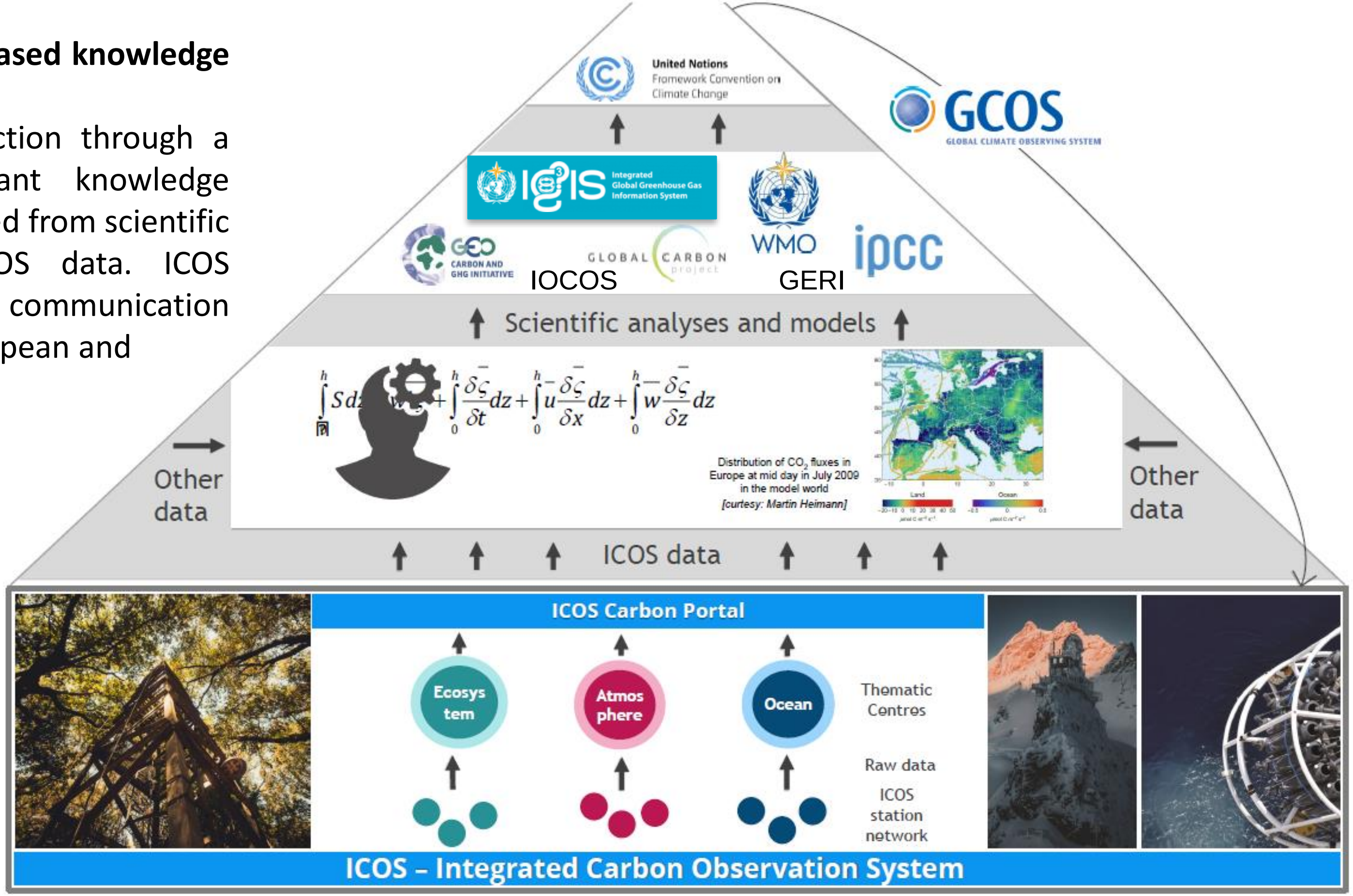
  (K Hasselmann)

ICOS value chain towards scientific and societal services

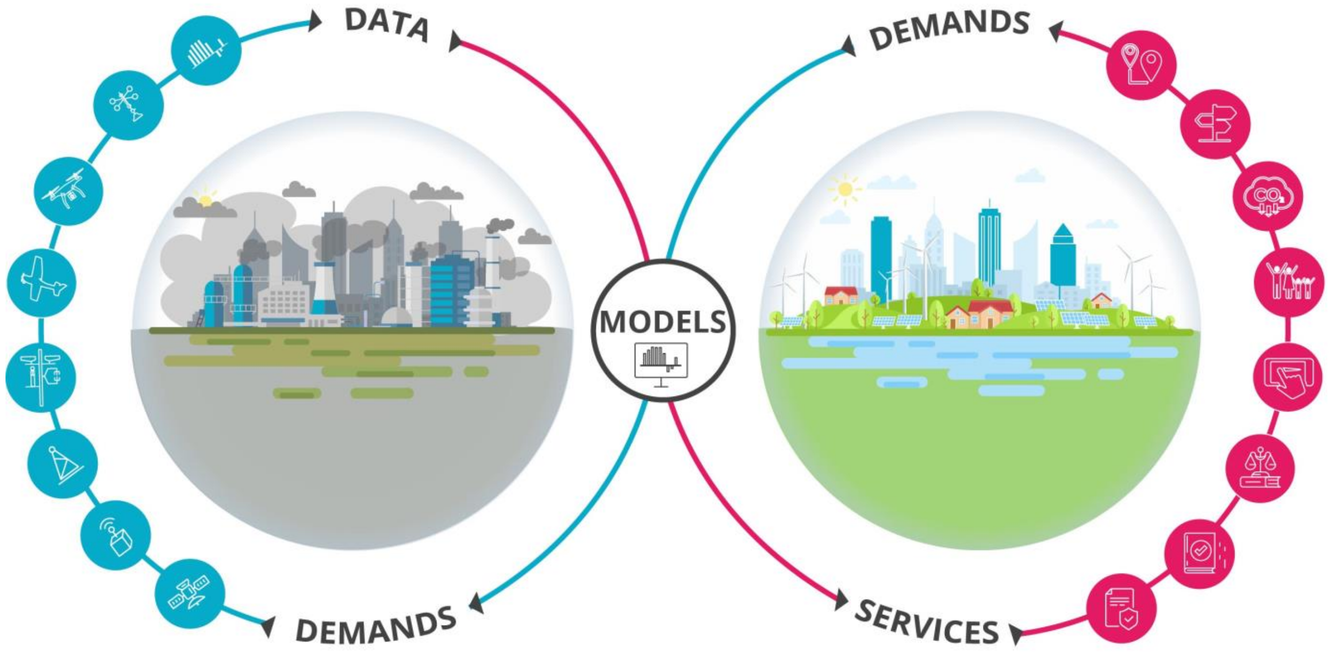
Communicating science-based knowledge towards society

ICOS supports climate action through a number of policy-relevant knowledge products that are generated from scientific activities based on ICOS data. ICOS provides respective communication channels on national, European and global level.

- Good practise
- Data harmonisation
- Compilation of global data sets
- Regional and global scientific initiatives
- Common services



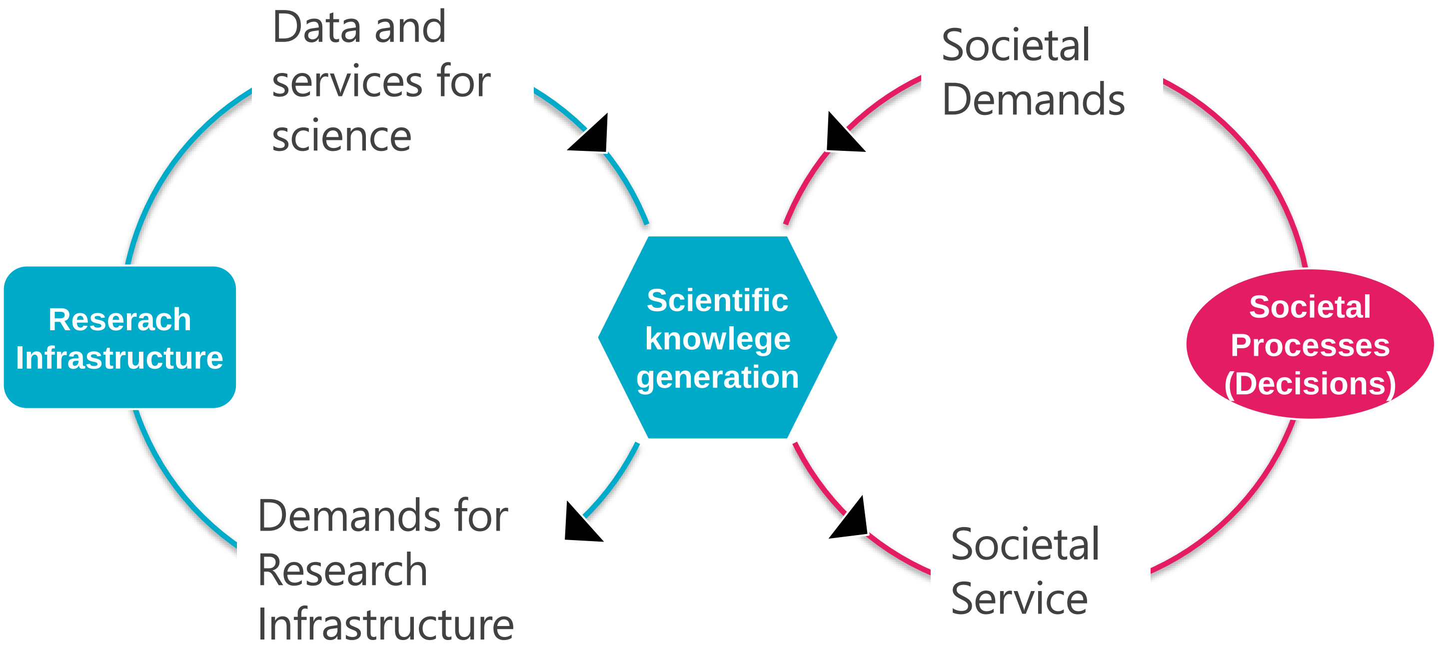
The PAUL project

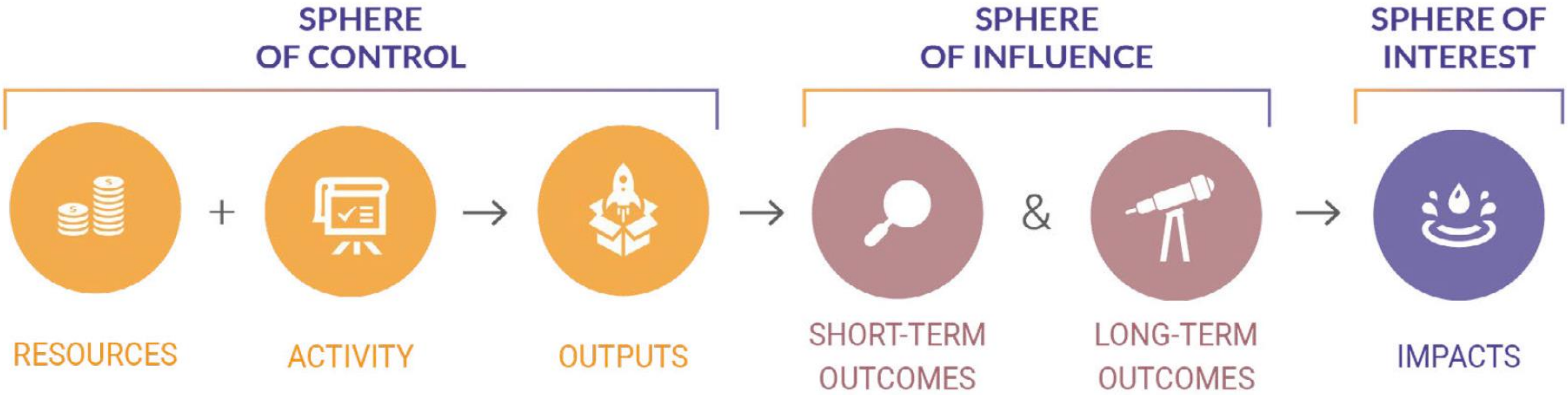


- Demands of the cities
- Demands of the policy-makers
- Behavioural aspects and attitudes of citizens

- Based on high-quality observation data and climate models
- Using the latest service design methods
- Services for cities, policy-makers and industry

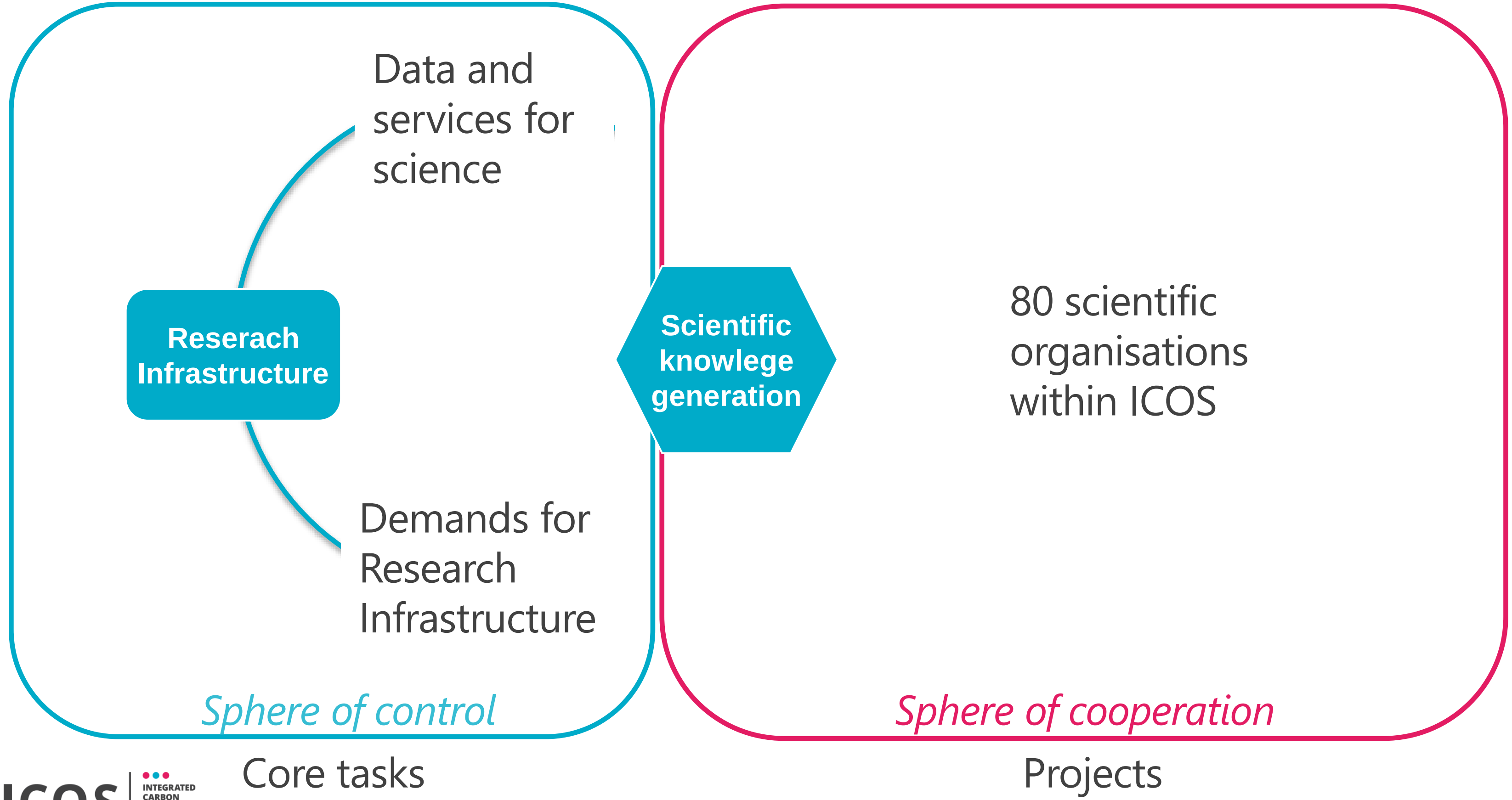
Suggestion for a new approach of societal value generation





Source: RI-PATHS project

ICOS RI as part of something bigger



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Services 1: services for scientists

- Standardisation of distributed observations
- Standardisation of data processing and quality control
- FAIR data
- Data usage tracking
- Services for scientific data usage
  - Jupyter notebooks
  - Library of algorithms
  - Footprint analyses
  - Data pipelines to integrative models and to the COPERNICUS Monitoring and Verficiation Support System

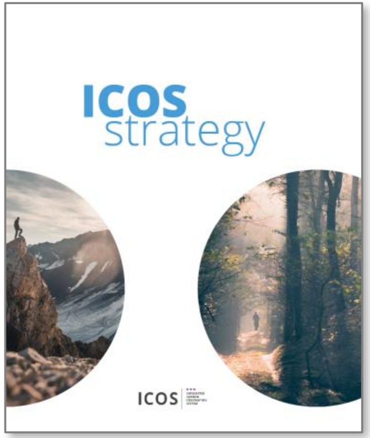
ENVRI community

Services 2: services for societies

- Communication
- Services for manufacturers
- Support for global data compilation and presentation
- Support for Assessment (IPCC)
- Specific Climate Services to Cities, Regions, Countries
  - Verification support for inventories
  - Quantification (and perhaps certification) of natural sinks
  - …
- Global cooperation (from continental to global observatories)
- Science Diplomacy

GLOBAL CARBON PROJECT

Evaluation of your service efforts



Define strategic goals

- Define the services you want to provide (and why)
- Define the respective users/stakeholders
- Connect to the respective users/stakeholders

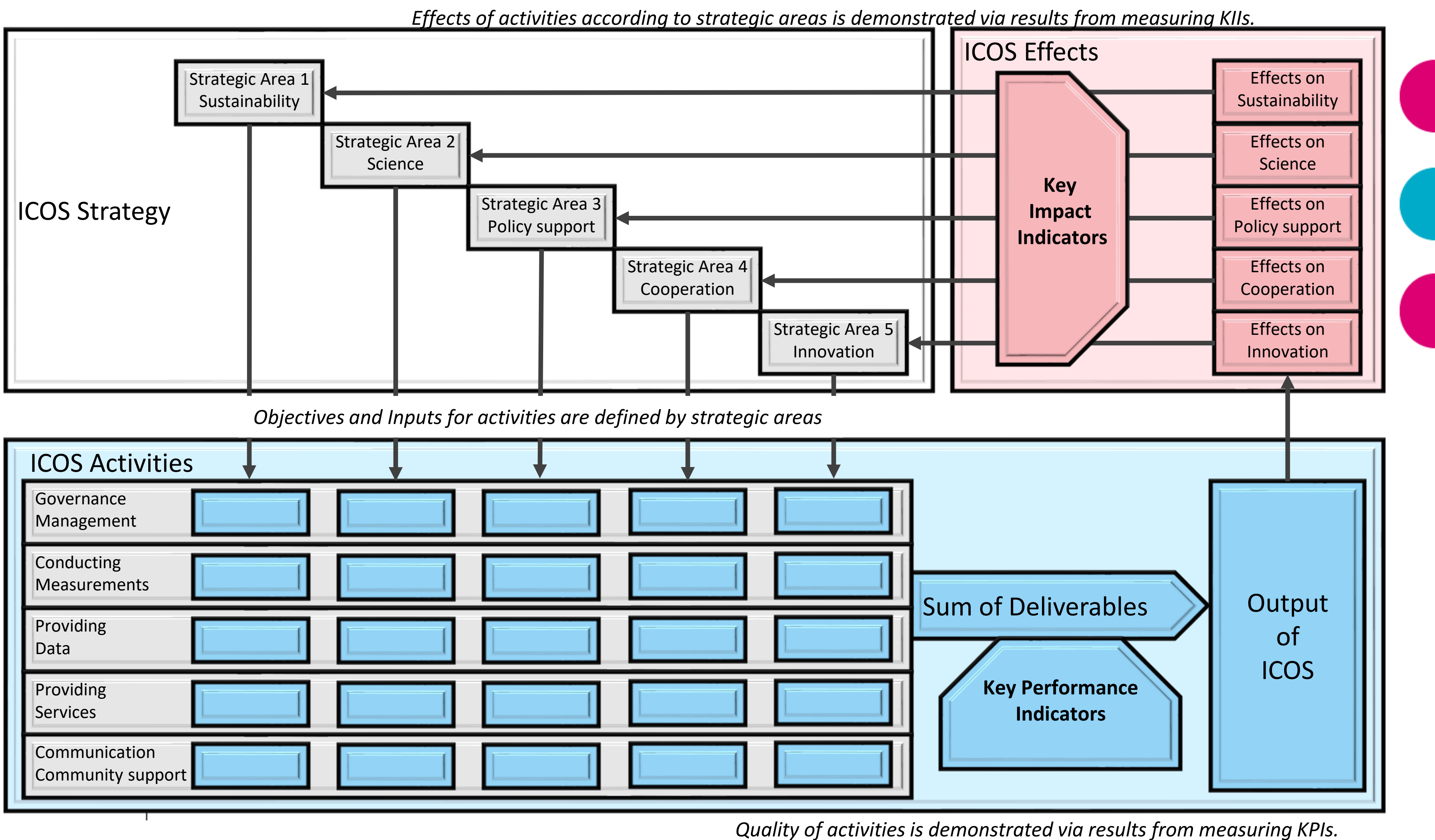
Connect the strategic goals to your activities

- Define deliverables and outcome for annual and five-year reporting (KPIs)

Close the circle by describing and evaluating your impact

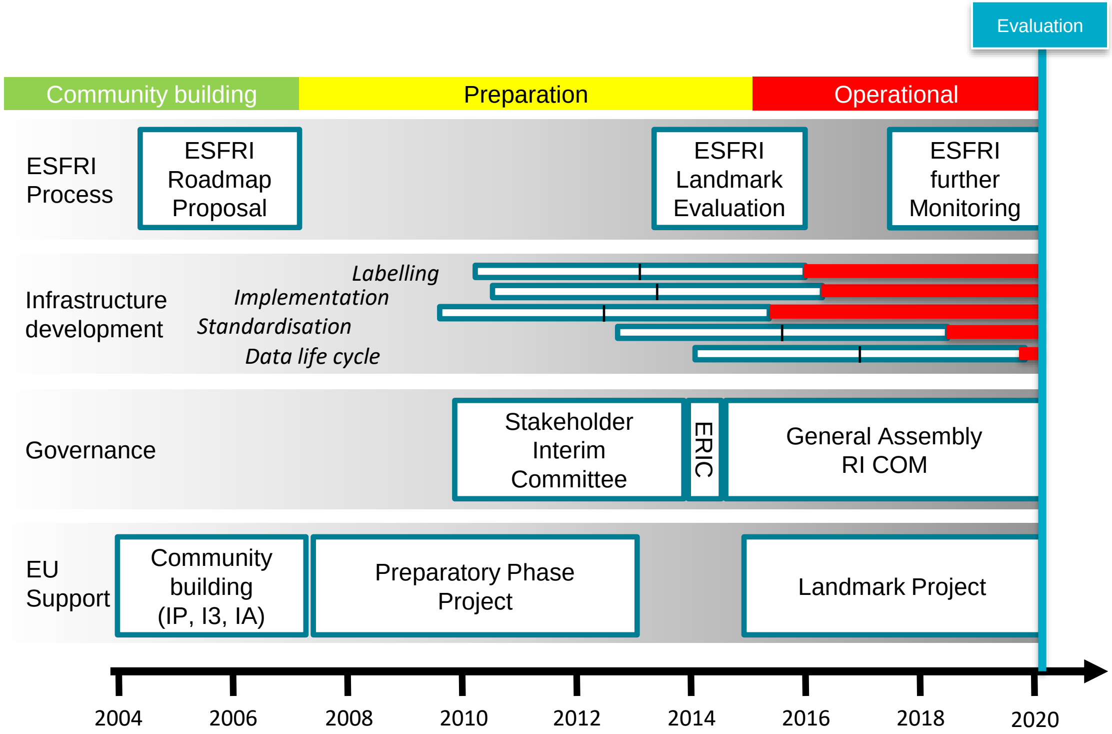
- Define key impact indicators (KIIs)

https://www.icos-cp.eu/sites/default/files/cmis/ICOS%20Strategy.pdf



Effects of activities according to strategic areas is demonstrated via results from measuring KIIs.
ICOS Strategy
Strategic Area 1 Sustainability
Strategic Area 2 Science
Strategic Area 3 Policy support
Strategic Area 4 Cooperation
Strategic Area 5 Innovation
ICOS Effects
Key Impact Indicators
Effects on Sustainability
Effects on Science
Effects on Policy support
Effects on Cooperation
Effects on Innovation
Objectives and Inputs for activities are defined by strategic areas
ICOS Activities
Governance Management
Conducting Measurements
Providing Data
Providing Services
Communication Community support
Sum of Deliverables
Key Performance Indicators
Output of ICOS
Quality of activities is demonstrated via results from measuring KPIs.

The ICOS situation



36 KPIs in five main fields

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https://www.icos-cp.eu/sites/default/files/2021-05/ICOS%20Evaluation%202020%20Report%20_online%20low.pdf
https://www.icos-cp.eu/sites/default/files/cmis/ICOS%20Impact%20Assessment%20Report%202018.pdf

Thank your for your attention

www.icos-ri.eu

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