TRACCS

TRansformative Advances in Climate modelling for Climate Services

TRAnsformer
la modélisation du Climat
pour les services ClimatiqueS

Wébinaire d'information - 29 novembre 2022

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https://climeri-france.fr/pepr-traccs/

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Qu’est-ce qu’un PEPR ?

TRACCS

PEPR: Programme et équipements prioritaires de recherches exploratoires, instrument du Programme d’investissements d’avenir (PIA4), dans le contexte France2030, pour « construire ou consolider un leadership français dans des domaines scientifiques liés ou susceptibles d’être liés à une transformation technologique, économique, sociétale, sanitaire, environnementale, etc., et considérés comme prioritaires aux niveaux national ou européen ».

PIA: Programme d’investissements d’avenir (PIA), piloté par le Secrétariat général pour l’investissement (SGPI), mis en place par l’État pour financer des investissements innovants et prometteurs sur le territoire, afin de permettre à la France d’augmenter son potentiel de croissance et d’emplois. De l’émergence d’une idée jusqu’à la diffusion sur le marché d’un produit ou service nouveau, le PIA intervient sur tout le cycle de vie de l’innovation et fait le lien entre la recherche publique et le monde de l’entreprise.

https://climeri-france.fr/pepr-traccs/

Qu'est-ce qu'un PEPR ?

- **PEPR Exploratoires :** budget de 1 milliard d'euros décidé dans le cadre de France 2030, financement Etat (MESR), gestion confiée à l'ANR. Il y aussi 2 milliards pour les PEPR « accélération des stratégies nationales ».

- Appels à projets au printemps 2021 (1ère vague, 4 projets dont OneWater et FairCarbon, total 200 M€), hiver 2021-2022 (2ème vague, 13 projets retenus donc TRACCS, IRIMA, 600 M€) et une 3ème vague est prévue (200 M€).

- **Concept** : identifier des sujets demandant des moyens et une coordination nationale, confiée aux organismes (EPST, EPIC, EPA etc.) et établissements (universités), chargés de piloter les PEPR.

- Le budget d'un PEPR se décompose en actions de pilotage (« **projet de gouvernance** »), **projets ciblés**, et d'**appels à projets**, en proportions variables selon les domaines de chaque PEPR (maturités, besoins de la communauté).

TRansformative Advances in Climate modelling for Climate Services

Motivations à déposer un projet dans le domaine climat, impacts et services climatiques

- Plusieurs constats:
  - Forte motivation à développer les activités dans le domaine de l'étude du climat afin de continuer à faire progresser les outils et connaissance, produire les informations climatiques attendues et assurer expertise scientifique vis-à-vis de nombreux interlocuteurs.

Key societal demand for climate information is unmet by current approaches

TRACCS

Stakeholders

Governments, local authorities, NGOs, Industries, …

Demand for climate change information for decision making & climate action (adaptation, mitigation, interventions)

Health

Land management

Agriculture

Energy

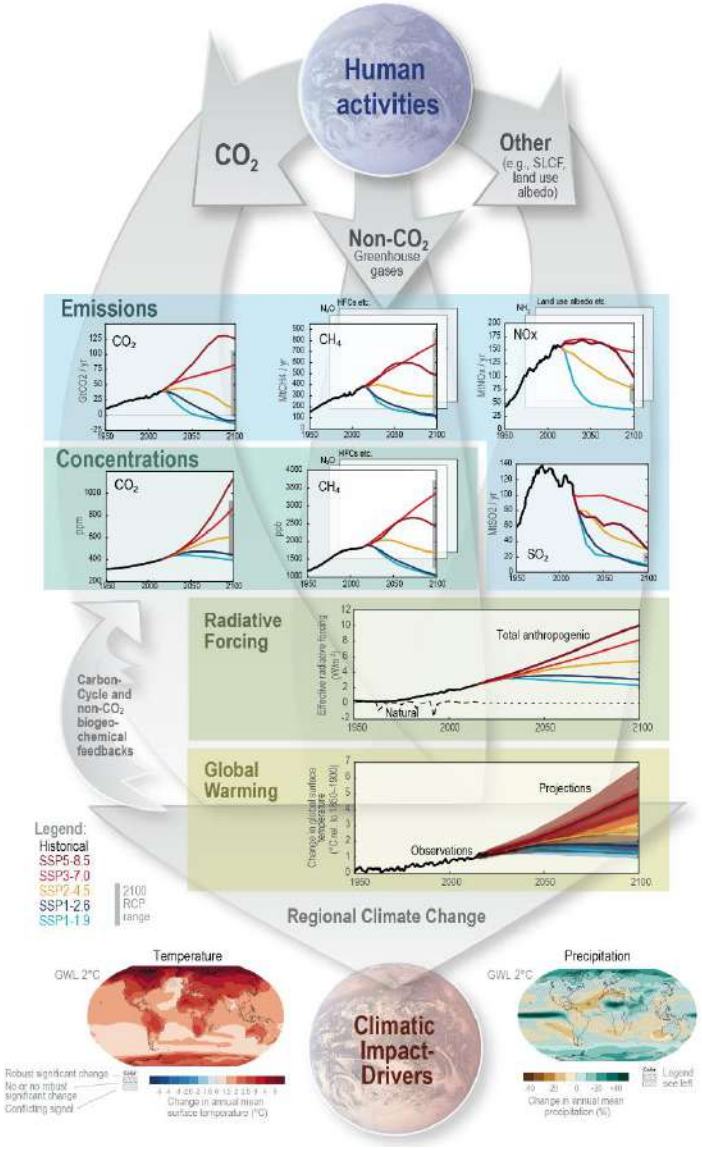
Insurance

Diversity of demands

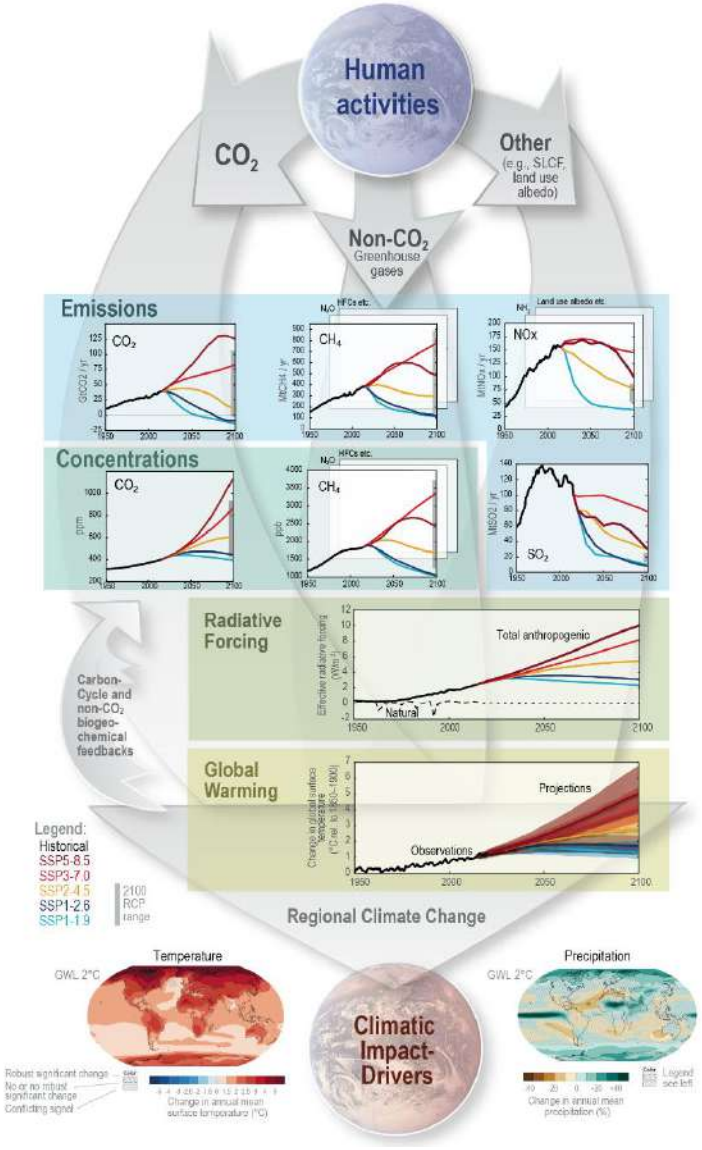
- local, regional
- decadal, centennial
- statistics, worst case scenarios
- sectoral, territorial

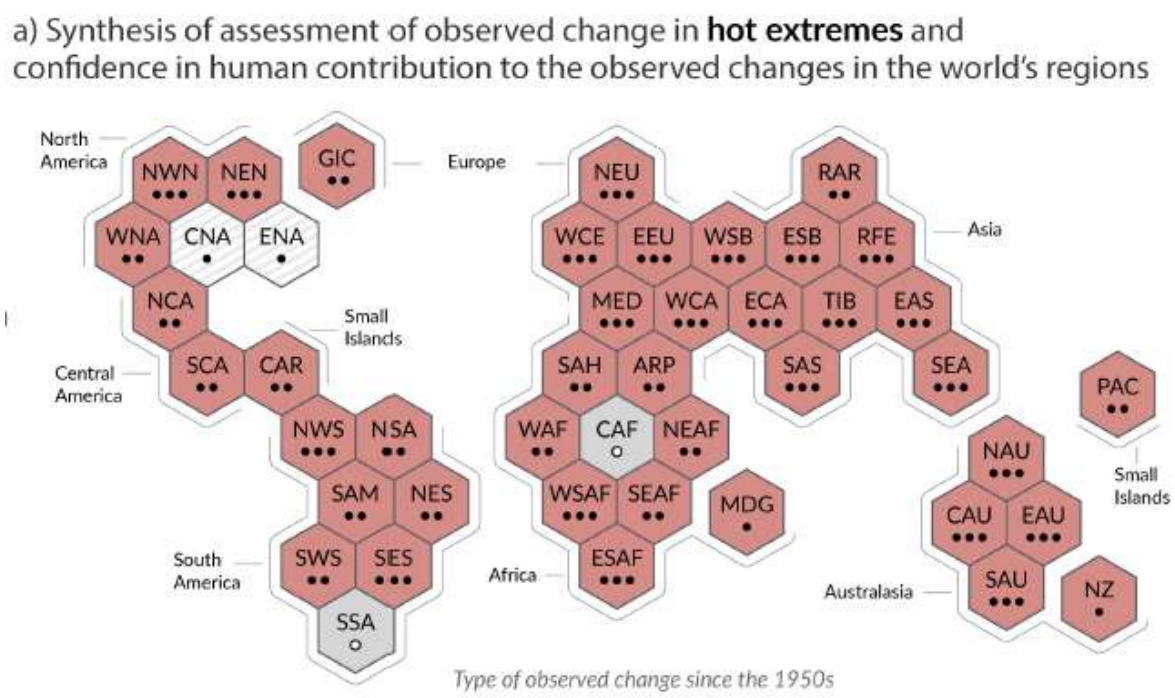
- not only data, but also expertise & trust

Climate modelling is the bedrock of climate science knowledge, climate projections & climate policies…



Climate modelling is the bedrock of climate science knowledge, climate projections & climate policies… yet many uncertainties remain, especially at local/regional scale





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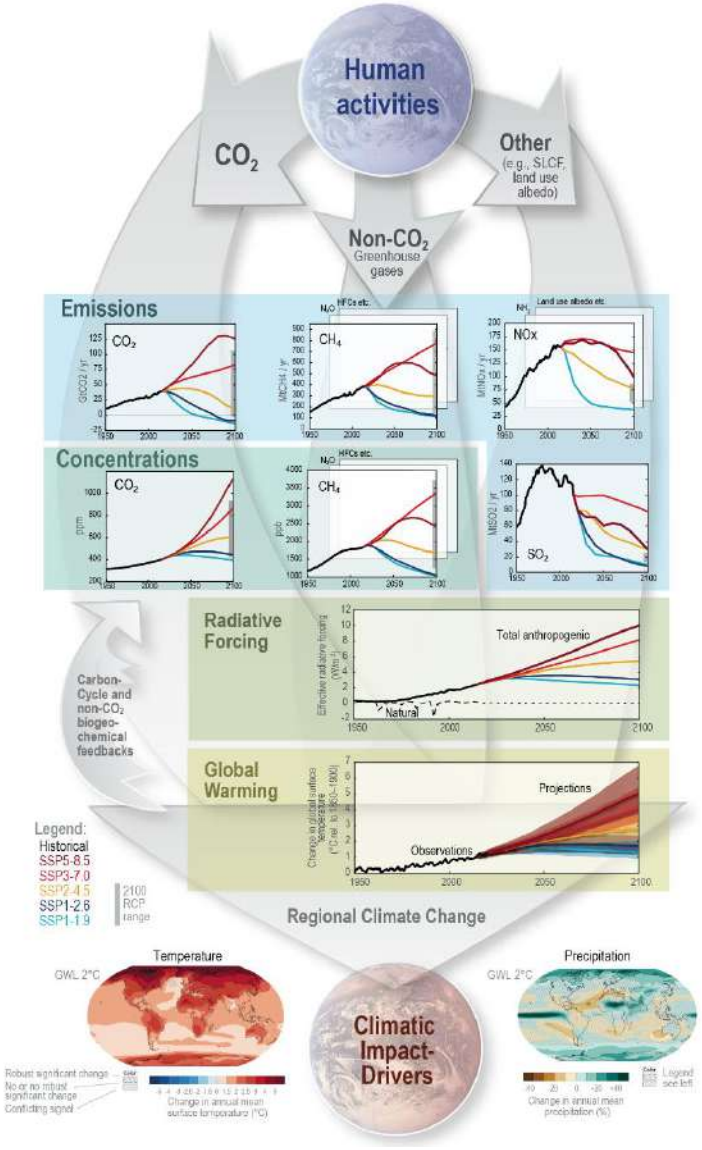
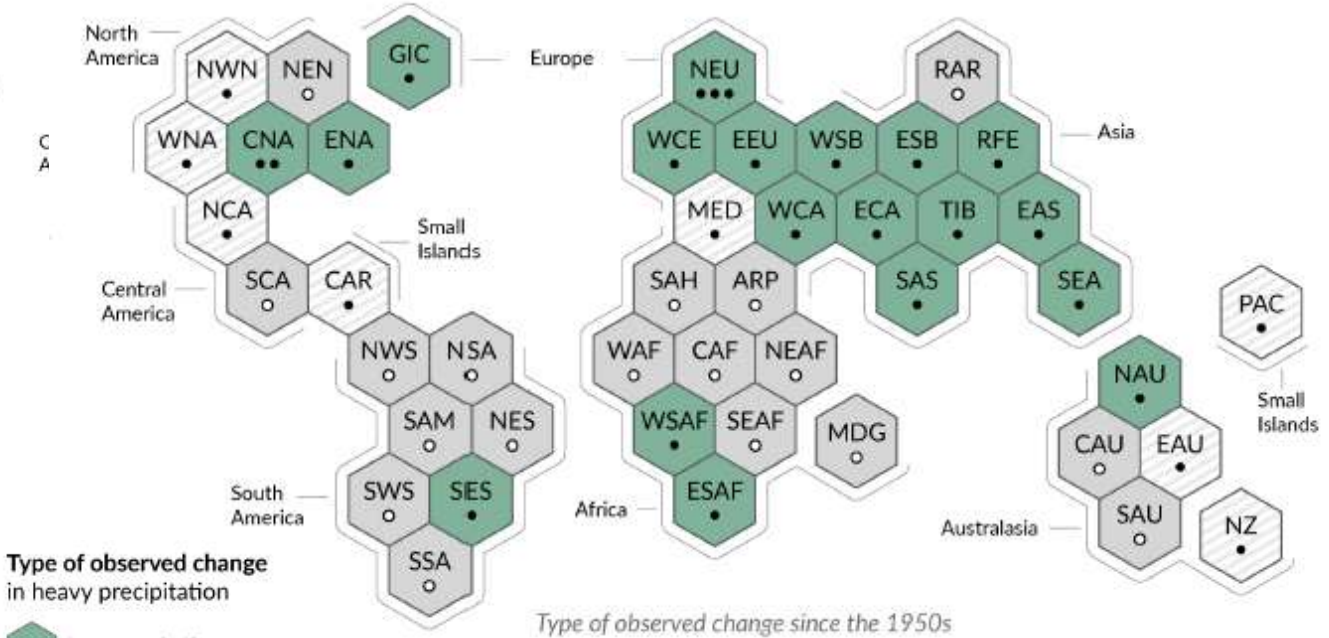


a) Synthesis of assessment of observed change in **hot extremes** and confidence in human contribution to the observed changes in the world's regions

b) Synthesis of assessment of observed change in **heavy precipitation** and confidence in human contribution to the observed changes in the world's regions



Type of observed change in heavy precipitation

- Increase (19)
- Decrease (0)
- Low agreement in the type of change (8)
- Limited data and/or literature (18)

Type of observed change since the 1950s

Confidence in human contribution to the observed change

- ●●● High
- ●● Medium
- ● Low due to limited agreement
- ○ Low due to limited evidence

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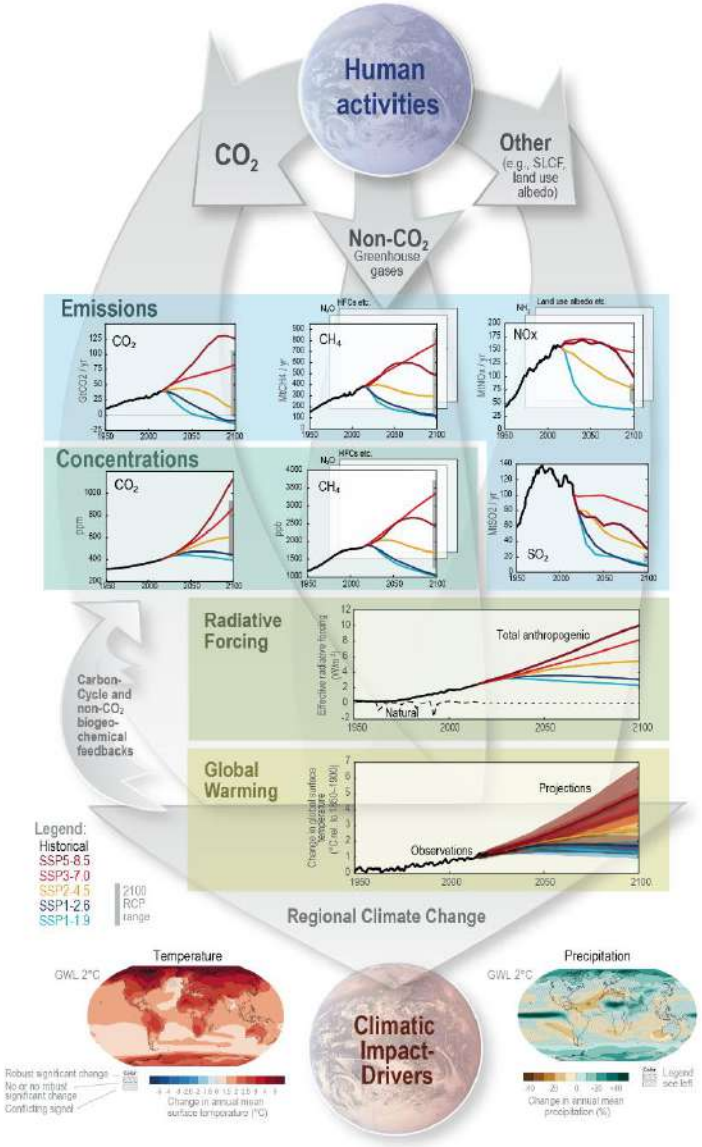
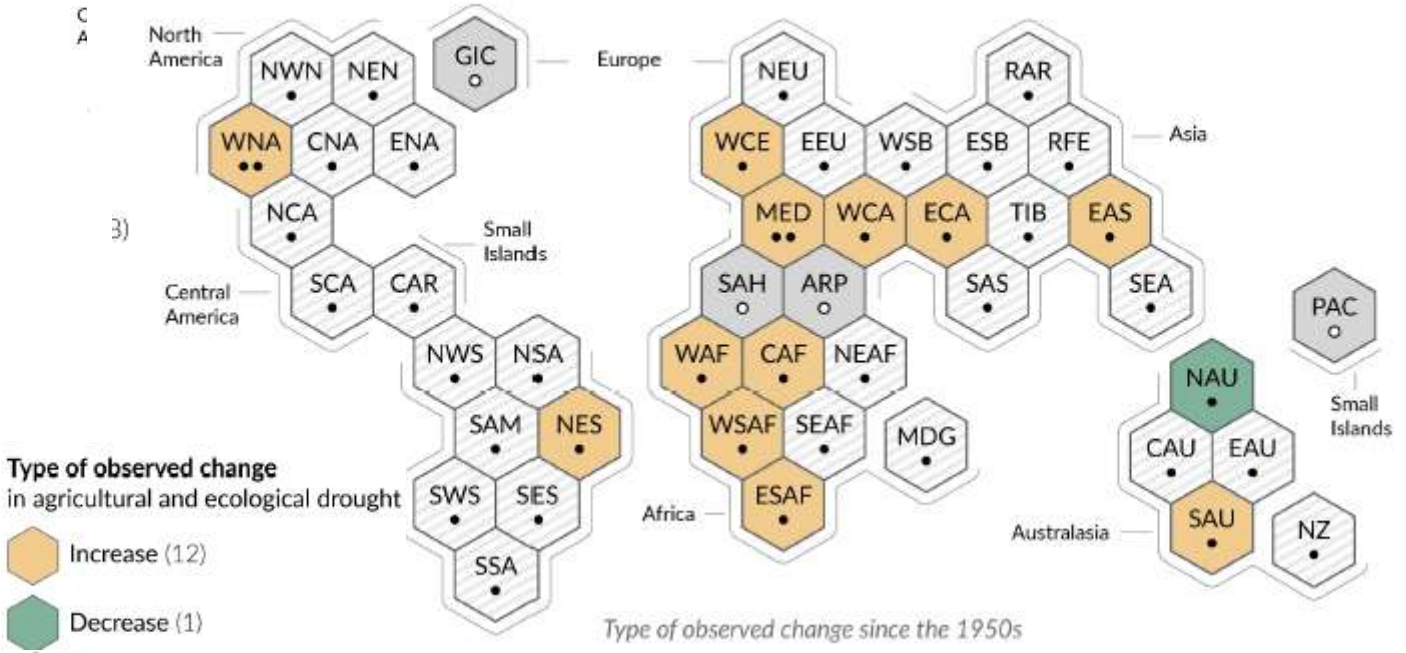


a) Synthesis of assessment of observed change in **hot extremes** and confidence in human contribution to the observed changes in the world's regions

b) Synthesis of assessment of observed change in **heavy precipitation** and confidence in human contribution to the observed changes in the world's regions

c) Synthesis of assessment of observed change in **agricultural and ecological drought** and confidence in human contribution to the observed changes in the world's regions



Key societal demand for climate information is unmet by current approaches

Stakeholders

Governments, local authorities, NGOs, Industries, …

Demand for climate change information for decision making & climate action (adaptation, mitigation, interventions)

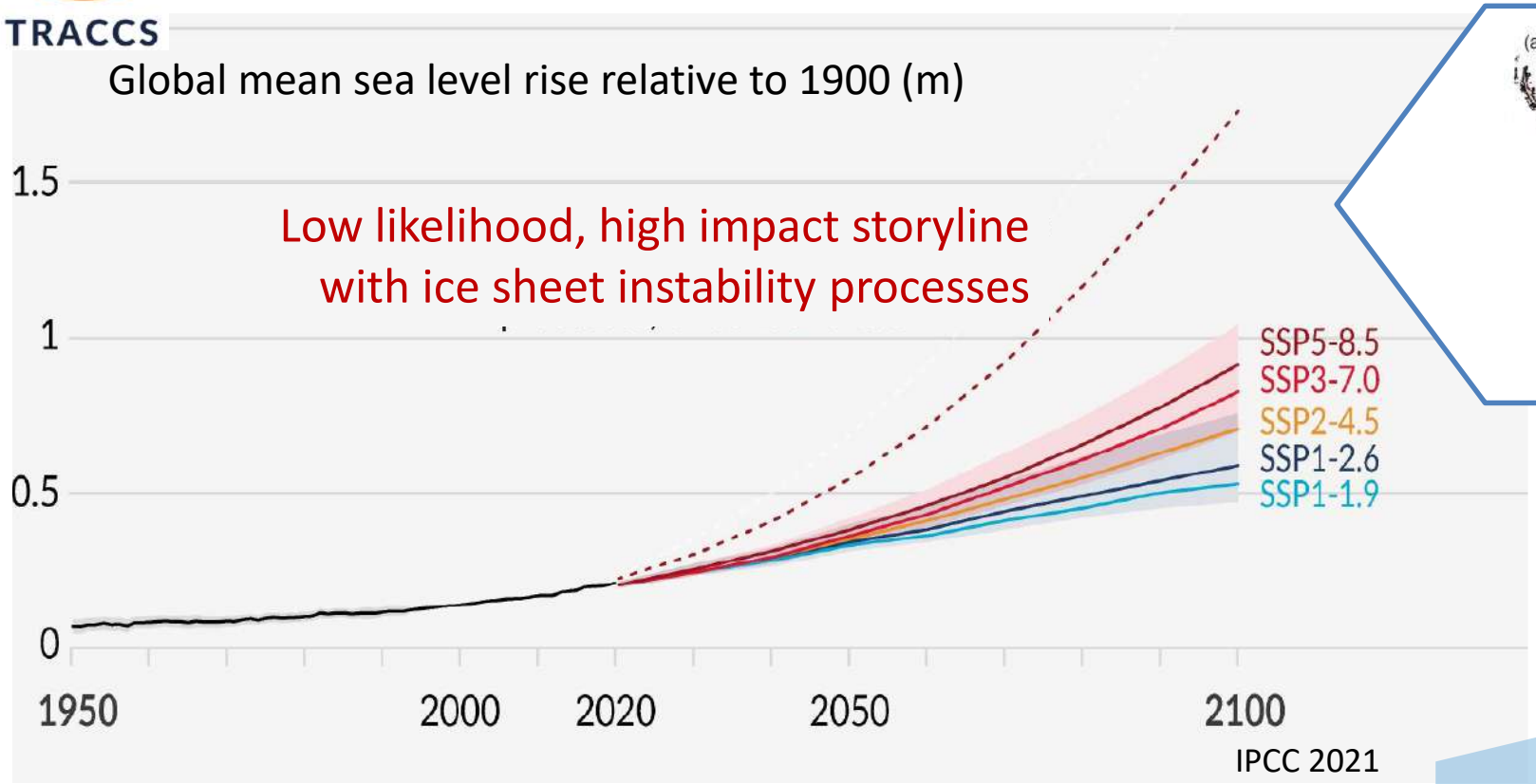
Physical science basis

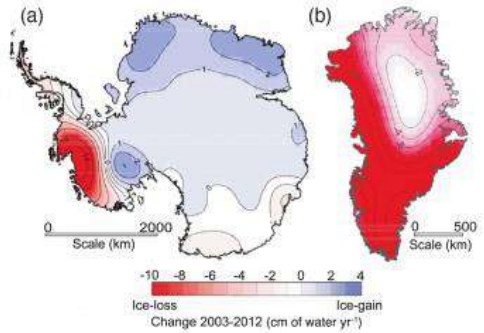
Climate models

➔ knowledge on climate change at global and regional scales

Missing components in climate models

TRACCS

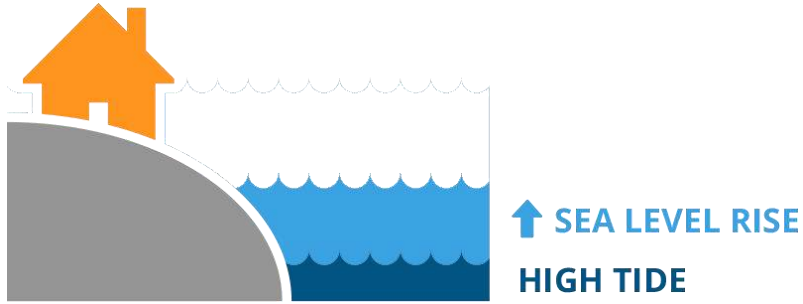




Ice sheets
+ glaciers
+ ocean
thermal
expansion

IPCC 2013

Threats related
to sea level rise



Climate models

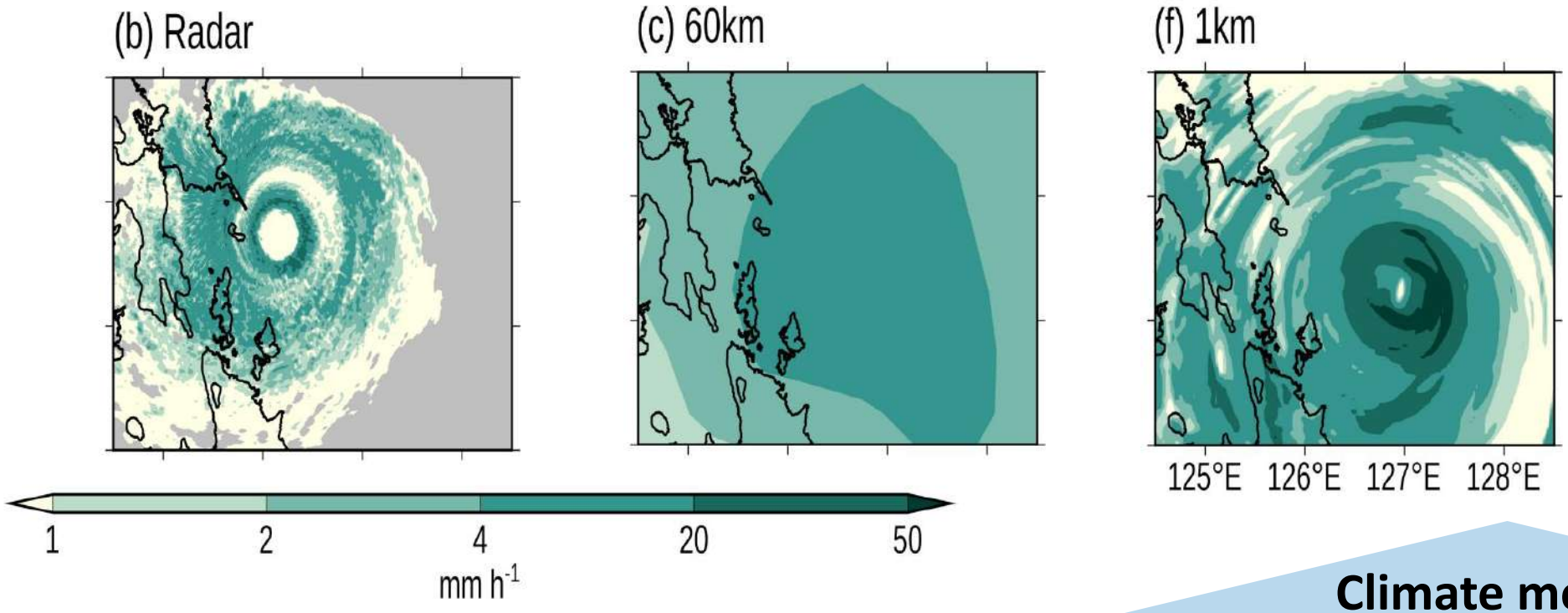
➔ knowledge on climate change at global and regional scales

But currently

- miss key components

Missing small scale phenomena in climate models

observations **models**

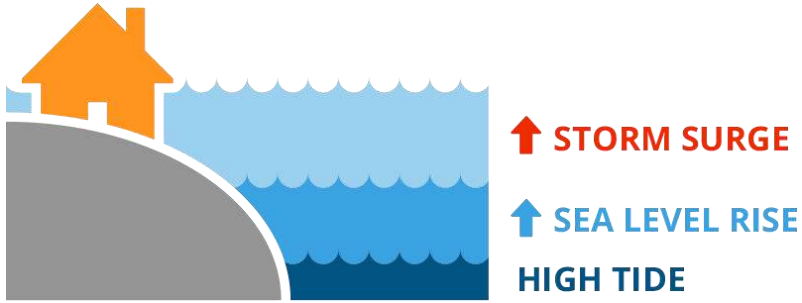


Haiyan super typhoon 8/11/2013

Philippines 4Mpersons displaced

IPCC 2021

Threats related to sea level rise



Climate models

➔ knowledge on climate change at global and regional scales

But currently

- miss key components
- misrepresent local scale phenomena and extremes

Key societal demand for climate information is unmet by current approaches

Stakeholders
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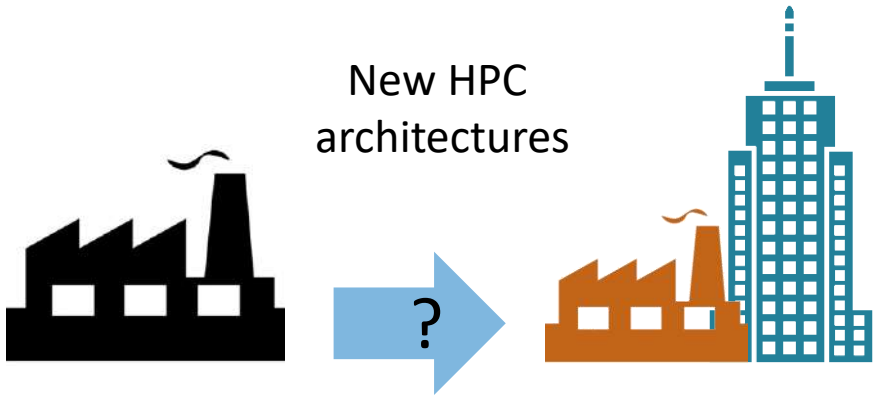
Demand for climate change information for decision making & climate action (adaptation, mitigation, interventions)

Physical science basis
- Met. services
- Research scientists (physics, model developers)
- …

New HPC architectures



now

Post 2025

Climate models

➔ knowledge on climate change at global and regional scales

But currently
- miss key components
- misrepresent local scale phenomena and extremes
- need major rewriting to benefit from new computing architectures

Key societal demand for climate information is unmet by current approaches

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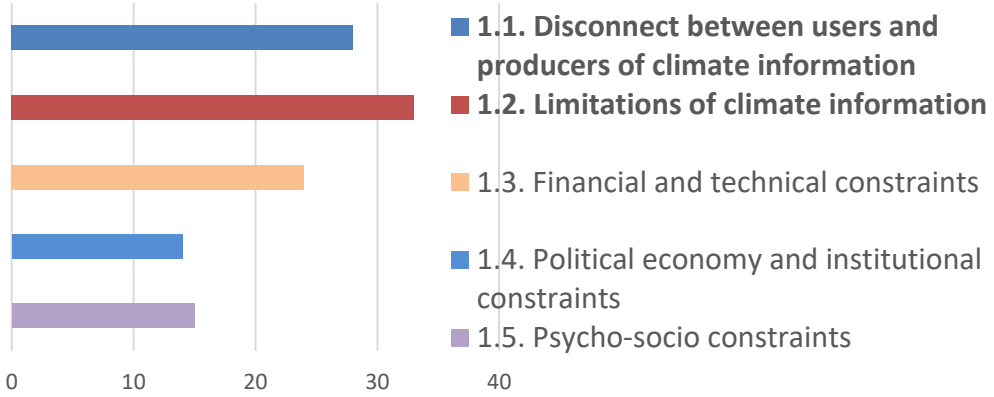
Demand for climate change information for decision making & climate action (adaptation, mitigation, interventions)

Physical science basis
- Met. services
- Research scientists (physics, model developers)
- …

Impacts, vulnerability and adaptation
- Research scientists
- Consultancy
- …

Communication challenges between the producers and users of climate information



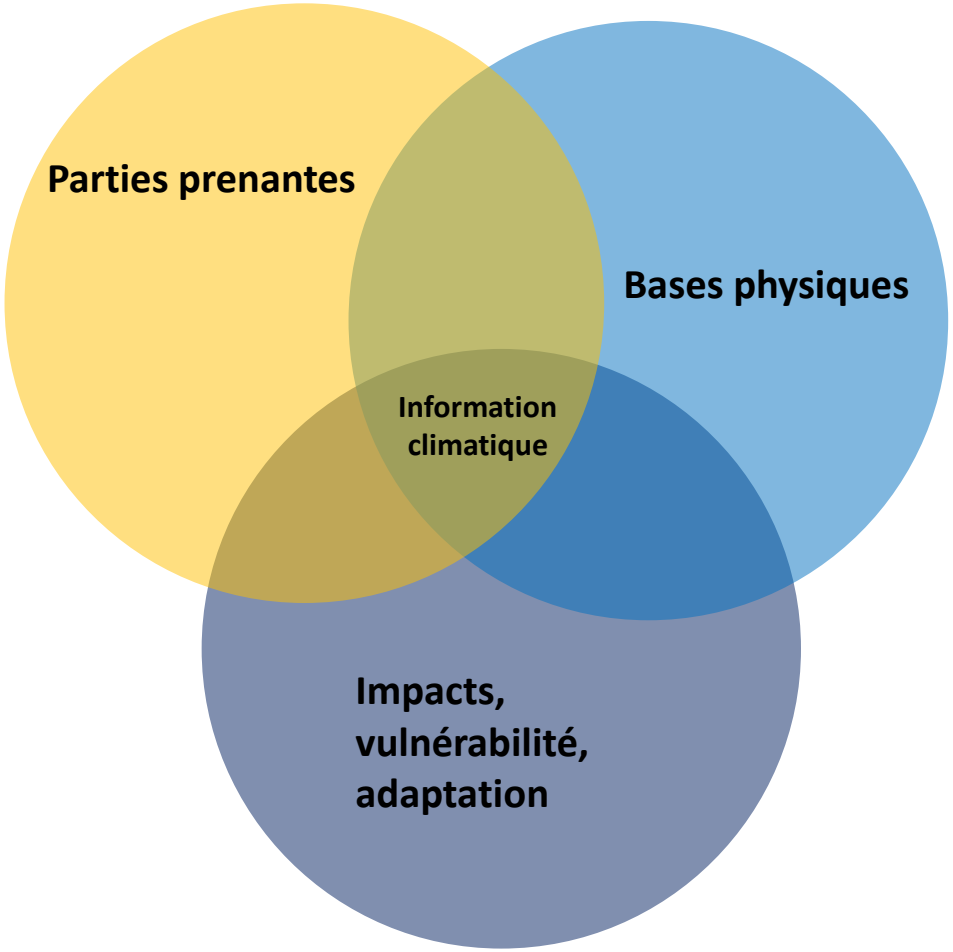
Jones et al., 2016, meta-analysis, 31 publications

Climate data alone is not enough for stakeholders

- Disconnection between users and producers
- Quality/appropriateness of data and information

➔ **Problem for decision making**

TRACCS : TRansformative Advances in Climate modelling for Climate Services



Principaux objectifs

1/ encourager la co-construction d'informations climatiques exploitables par les parties-prenantes et les experts sur le climat

pour répondre aux besoins des utilisateurs, des décideurs politiques aux industries, aux services et au grand public.

2/ améliorer les connaissances et les outils sur les processus, les impacts et les risques du changement clim., de l'échelle mondiale à locale.

pour fournir les meilleures informations climatiques possibles pour la prise de décision.

3/ Former la prochaine génération de professionnels du développement de modèles, de la distribution de données, de la coproduction de services climatiques, de l'utilisation et soutien des services climatiques.

pour assurer la durabilité de cet écosystème élargi de la science du climat.

TRansformative Advances in Climate modelling for Climate Services

Motivations à déposer un projet dans le domaine climat, impacts et services climatiques

- Plusieurs constats:
  - Forte motivation à développer les activités dans le domaine de l'étude du climat afin de continuer à faire progresser les outils et connaissance, produire les informations climatiques attendues et assurer expertise scientifique vis-à-vis de nombreux interlocuteurs.
  - Fin de la « convention service climatiques », arrêt du GICC etc. -> difficultés de contexte pour le développement des services climatiques.
  - Difficultés structurelles de la communauté de modélisation climatique française (manque de RH pérennes, recrutements très limités, renouvellements à organiser)
  - Contexte de Destination Earth (DestinE), besoin de développer une alternative à des approches centrées sur la modélisation planétaire haute résolution, en exploitant le bénéfice d'une panoplie d'outils de modélisation à plusieurs échelles et degrés de couplage.

TRACCS : Objectives, challenges, structural entities

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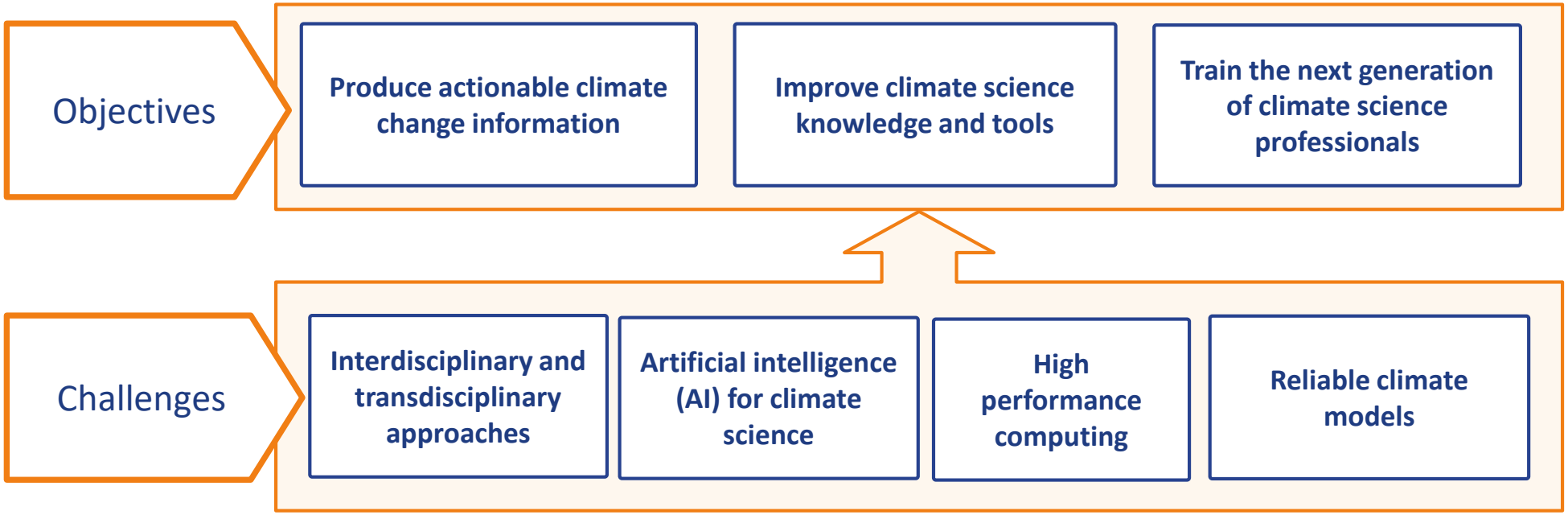
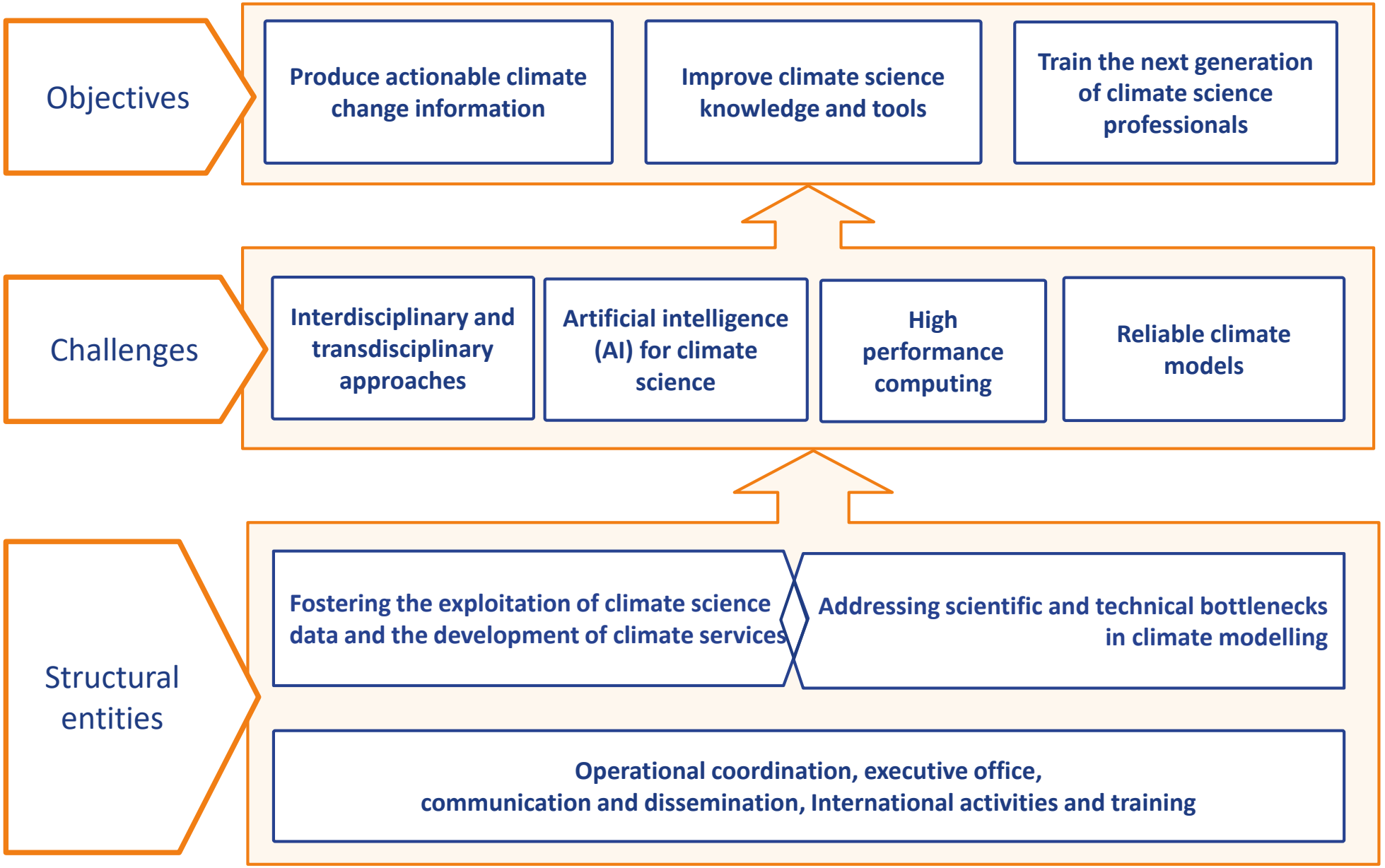


TRACCS : Objectives, challenges, structural entities



TRACCS ; 8 ans ; **51 M€ (budget révisé à la baisse par rapport au dépôt)**

GOUV

Operational coordination, executive office, communication and dissemination
International activities, training – 6.1 M€ ***CNRS INSU, Météo-France***

PC

Fostering the exploitation of climate science data and the development of climate services
« Impacts, adaptation and vulnerabilities »

PC 1 to 4 – 10.1 M€

Addressing scientific and technical bottlenecks in climate modelling
« The physical science basis »

PC 5 to 10 – 24.7 M€

Calls for projects (2 rounds)

10 M€

- Interdisciplinary approaches for climate change impacts, adaptation and services
- Evaluation of climate interventions
- AI for climate sciences
- Model evaluation

TRACCS : Précisions scientifiques, admininstratives et financières

Pilotage : CNRS et Météo-France
9 partenaires au niveau national.

Le budget global est fixé (51 M€), ainsi que les partenaires des projets de gouvernance (CNRS et MF) et des projets ciblés, et la répartition financière macroscopique.

Les **projets ciblés** ont pour objectif de renforcer et structurer la communauté scientifique nationale dans le domaine de l'étude du climat (modélisation climatique notamment), des impacts du changement climatique (interdisciplinarité indispensable) et le prototypage de services climatiques.

Ils répondent à des objectifs généraux de la communauté scientifique. Les moyens de TRACCS viennent, dans les laboratoires, en soutien d'une stratégie nationale, en complément des ressources des organismes/établissements et des autres sources de financement (nationaux, européens). Dans TRACCS, il s'agit principalement de recrutements de postes relativement longs par rapport aux projets traditionnels, visant à attirer et stabiliser de nouveaux collègues.

Les **appels à projet** ont vocation à contribuer aux objectifs de TRACCS en élargissant le périmètre des acteurs impliqués et des domaines d'application abordés.

TRACCS : Importance de la formation

TRACCS vise à contribuer au passage à l'échelle de la formation dans le domaine de l'étude du climat, des impacts, des services climatiques.

Formation par la recherche de nouveaux collègues (stages, doctorant.e.s, personnes recruté.e.s) par l'échange de savoirs et de bonnes pratiques.

Inventaire des cours et formations post-bac avec une composante concernant l'étude du climat.

Inventaire des ressources de formation dans le domaine du climat et mise en place d'un outil permettant de les partager plus efficacement.

Organisation d'ateliers d'échanges (réunions régulières, écoles d'été etc.) entre enseignant.e.s dans le domaine climat, impacts, services afin de partager expériences, difficultés rencontrées, ressources, bonnes pratiques.

Liens avec l'Office for Climate Education pour la transmission avec l'enseignement primaire et secondaire

A compléter !

TRACCS

Operational coordination, executive office, communication and dissemination, international activities, training

M. Kageyama, S. Morin, L. Bouilloud, P. Braconnot

Fostering the exploitation of climate science data and the development of climate services

S. Anquetin, L. Terray, N. De Noblet

« Impacts, adaptation and vulnerabilities »

- PC 1 Co-design with stakeholders
- PC 2 Brokerage of data & methods
- PC 3 Territorial information
- PC 4 Extreme events

Addressing scientific and technical bottlenecks in climate modelling

O. Boucher, J. Deshayes, G. Durand, D. Salas y Melia

« The physical science basis »

- PC 5 New computing paradigms
- PC 6 Calibration & uncertainties
- PC 7 Physical processes
- PC 8 Biogeochemistry
- PC 9 Polar ice sheets
- PC 10 km-scale climate information

Calls for projects / AAP

- Interdisciplinary approaches for climate change impacts, adaptation and services
- Evaluation of climate interventions
- AI for climate sciences
- Model evaluation

TRACCS : Liste des projets ciblés

https://climeri-france.fr/pepr-traccs/

PC#	Titre du projet	Responsables initiaux du projet ciblé	Organisme coordinateur du projet ciblé
PC-1	Co-design with stakeholders	Sandrine Anquetin (IGE), Nathalie De Noblet (IPSL), D. Salas y Mélia (CNRM)	CNRS
PC-2	Brokerage of data and methods	J.-M. Soubeyroux (Météo-France/DCSC), C. Pagé (CERFACS CECI), G. Levavasseur (IPSL), M. Kerdoncuff (Météo-France/DCSC)	Météo-France
PC-3	Territorial information	Benjamin Sultan (ESPACE-DEV), Benoît Hingray (IGE), Nathalie de Noblet (IPSL)	IRD
PC-4	Extreme events	Mathieu Vrac (ISPL-LSCE), Aurélien Ribes (CNRM)	CNRS
PC-5	New computing paradigms	Julien Le Sommer (IGE), Sophie Valcke (CERFACS CECI), Thomas Dubos (IPSL), Yann Meurdesoif (IPSL-LSCE)	UGA
PC-6	Calibration & uncertainties	Julie Deshayes (IPSL-LOCEAN), Aurore Voldoire (CNRM), Romain Roehrig CNRM)	CNRS
PC-7	Physical processes	Romain Roehrig (CNRM), Nicolas Jourdain (IGE), Martin Vancoppenolle (IPSL-LOCEAN)	Météo-France
PC-8	Biogeochemistry	Yves Balkanski (IPSL-LSCE), Virginie Marécal (CNRM), Roland Séférian (CNRM)	CNRS
PC-9	Polar ice sheets	Gaël Durand (IGE), Sylvie Charbit (IPSL-LSCE), Christophe Dumas (IPSL-LSCE)	CNRS
PC-10	km-scale climate information	Samuel Somot (CNRM), Mathieu Vrac (IPSL-LSCE)	Météo-France

Fostering the exploitation of climate science data and the development of climate services

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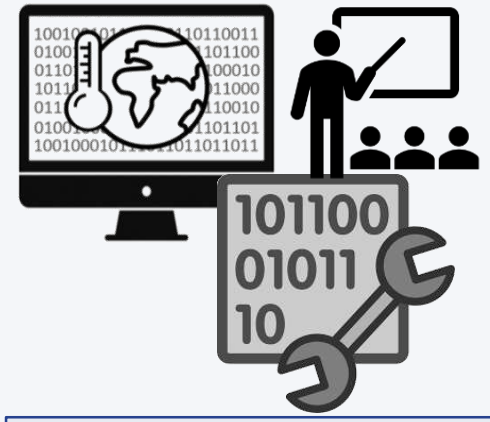
TRACCS

PC1. Co-design with stakeholders

PC2. Brokerage of data & methods



PC3. Territorial information

PC4. Extreme events

Future climate risks in France and elsewhere

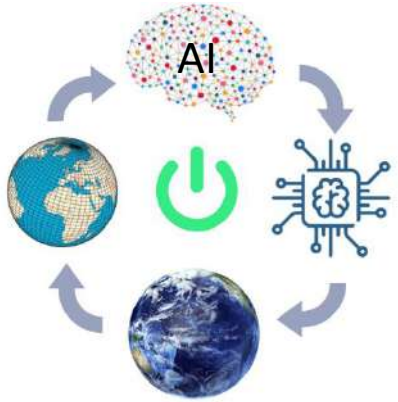
- **Actionable climate change information** for key sectors and territories (France mainland & overseas, foreign countries)
- **Special focus on extreme events**: quantification, attribution, compounds, future evolution
- Transformative, **interdisciplinary and transdisciplinary** advances towards climate services

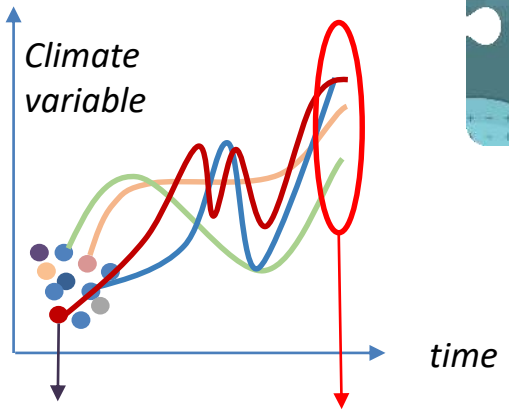
Addressing scientific and technical bottlenecks in climate modelling

TRACCS

PC5. New computing paradigms	PC6. Calibration & uncertainties	PC7. Physical processes	PC8. Biogeo-chemistry	PC9. Polar ice sheets	PC10. km-scale climate information

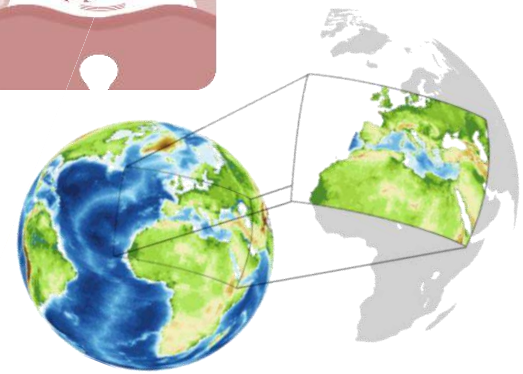
Transformative advances
in model design
- increased use of IA,
- addressing new HPC frameworks,
- quantifying confidence levels





Calibration, parameter secltion

Distribution of values,including extremes

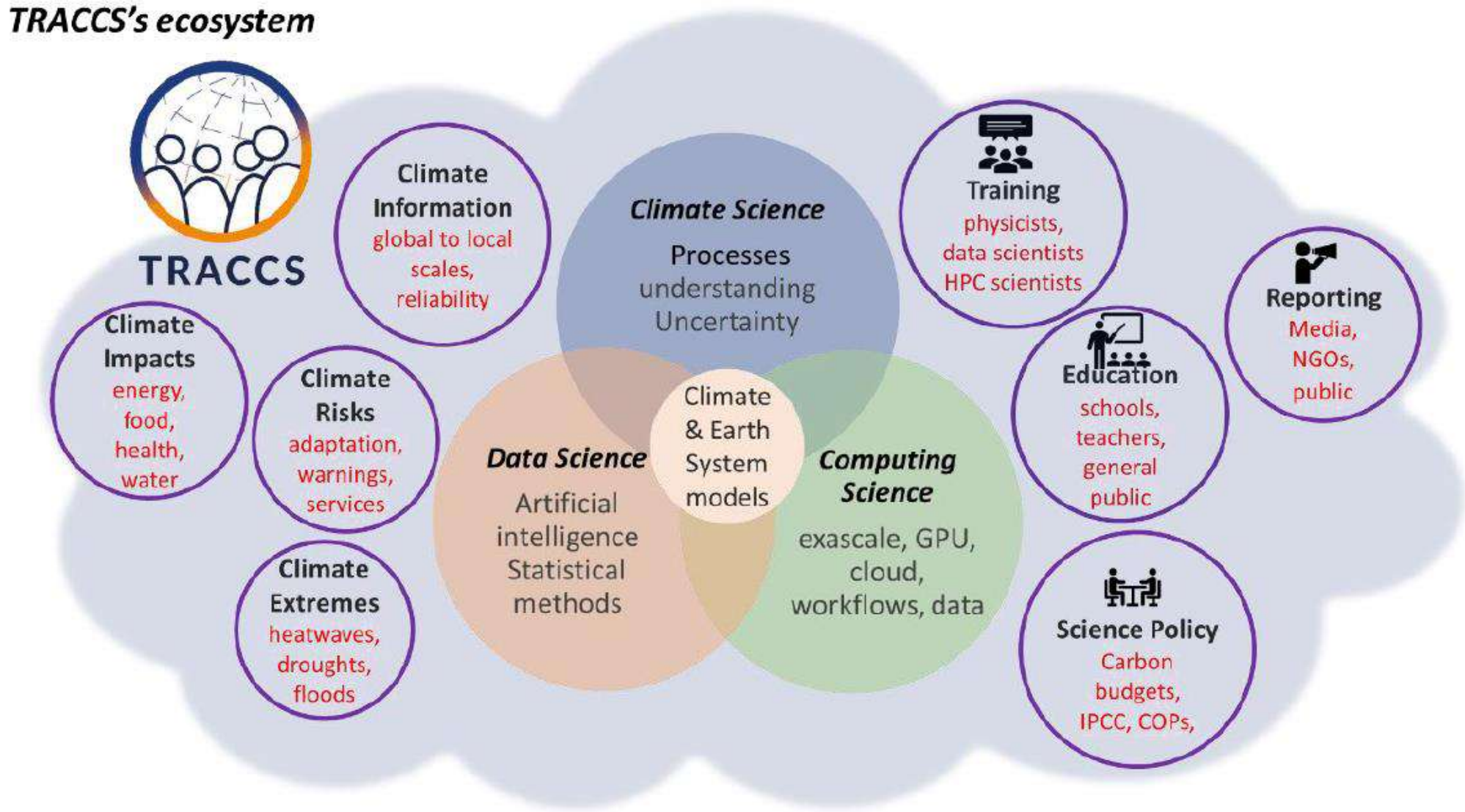


TRACCS will develop and contribute
- a consistent set of improved climate models
- operating across all spatial (100-1 km scale) and temporal scales of the climate system,
- enabling long simulations & large ensembles.

Robust basis for science and climate services

TRansformative Advances in Climate modelling for Climate Services

TRACCS



TRACCS in a nutshell

Climate services **adapted** to users' needs

↑

Trusted methods and products

↑

Robust scientific basis Knowledge & models

TRACCS is:

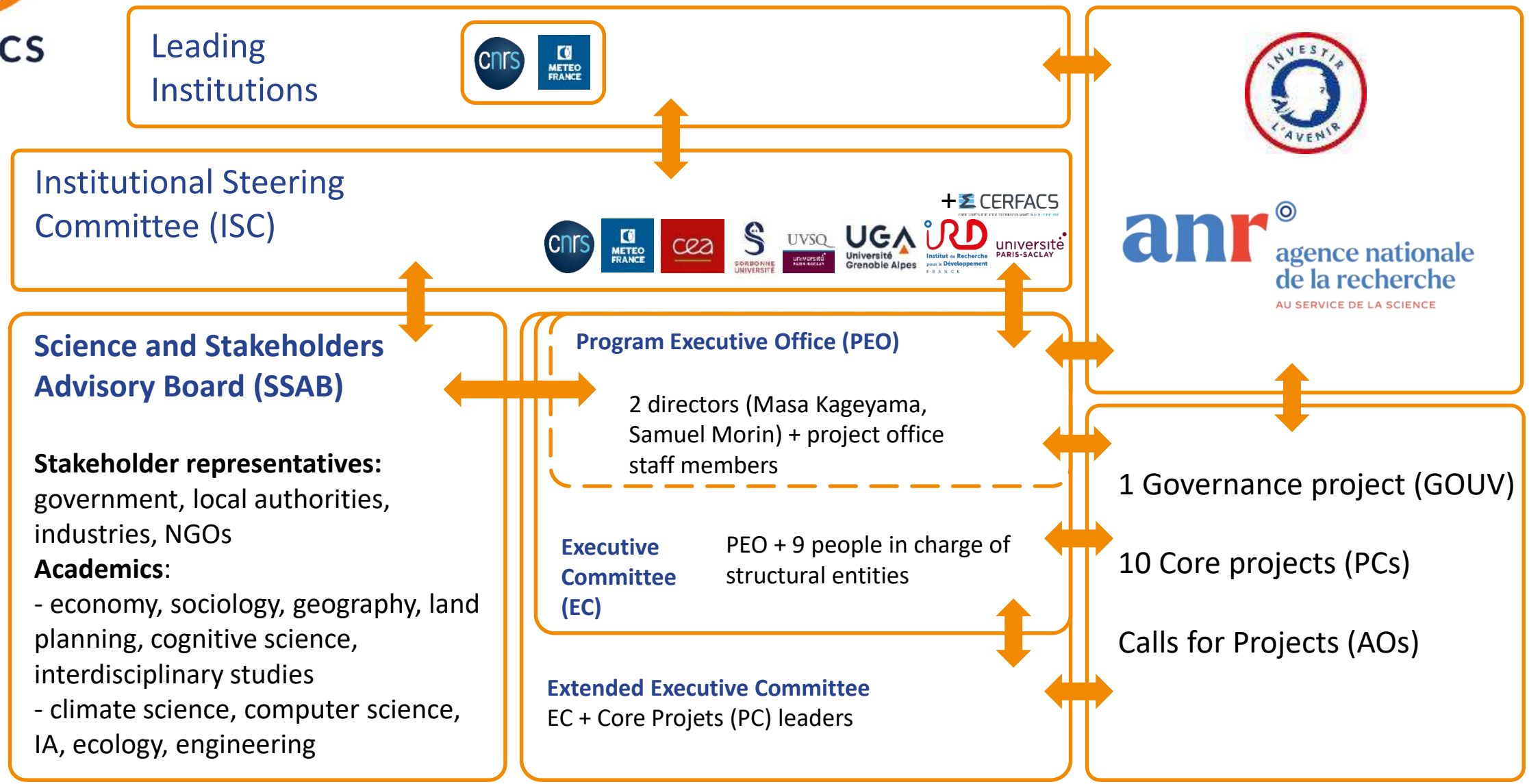
- a 8 year programme (51 M€ total cost)
- an unprecedented effort by the French climate research organizations to join forces and develop **a strategic roadmap for transforming climate modeling frameworks and unleash the development of genuine and actionable climate services.**
- a **cornerstone PEPR** interacting with other PEPRs and research & operational initiatives requiring trustable and fit-for-purpose climate change information much beyond the current state-of-the-art (OneWater, FAIRCarbon, IRIMA, NUMPEX, SOLUBIOD, others to come)

Relevant to national frameworks (National Low Carbon Strategy SNBC, National Adaptation Plans PNACC) and **institutions** (ONERC, High Council for Climate, relevant ministries and agencies)

Strong international dimension (connections & complementarities with Copernicus C3S, DestinE, WMO/WCRP).

TRACCS Organization and governance

https://climeri-france.fr/pepr-traccs/



Prochaines étapes

https://climeri-france.fr/pepr-traccs/

Travail en cours de finalisation de la description des projets de gouvernance et projets ciblés, en vue de lancer les projets au 1er semestre 2023.

Construction des liens avec les autres PEPR, les entités partenaires (autres PEPR, infrastructures de recherches dont CLIMERI et DataTerra, projets, initiative, réseaux etc.) afin de concrétiser l'aspect transformant, structurant et de soutien de TRACCS.

Il est évidemment possible de venir contribuer aux objectifs des projets ciblés de TRACCS en s'impliquant dans les travaux prévus, et de continuer à établir et renforcer les articulations entre TRACCS et les projets déjà en cours au niveau national et international.

La première vague d'appels à projets est prévue pour 2024 au plus tôt (afin de préciser l'articulation avec les projets ciblés et maximiser les interactions). Sujets identifiés :

- **Interdisciplinary approaches for climate change impacts, adaptation and services**
- **Evaluation of climate interventions**
- **AI for climate sciences**
- **Model evaluation**

Pour en savoir plus : https://climeri-france.fr/pepr-traccs/

TRACCS

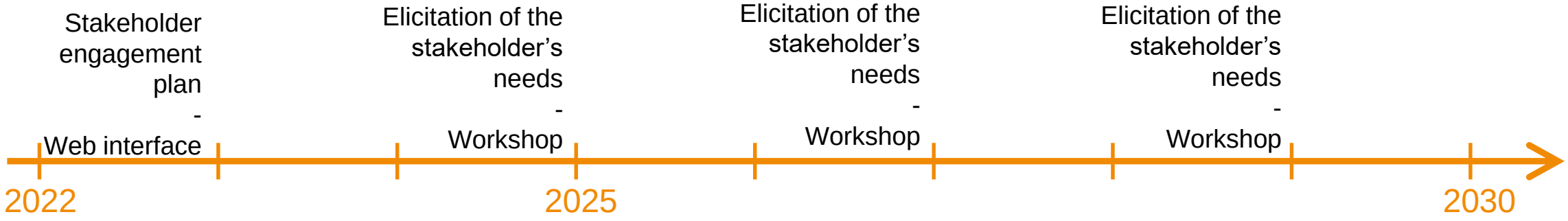
TRACCS Projets ciblés

PC1: Stakeholder interaction platform

Develop a dialogue platform **to translate stakeholder's needs into scientific questions**, taking into account up-to-date knowledge about the models' capacities and performance.

Engage a wide range of stakeholders: local and regional authorities; governmental and international agencies; industry; NGOs; water-agriculture-forestry management (Europe and tropical countries).

Co-design new climate services – Strengthen science with and for society



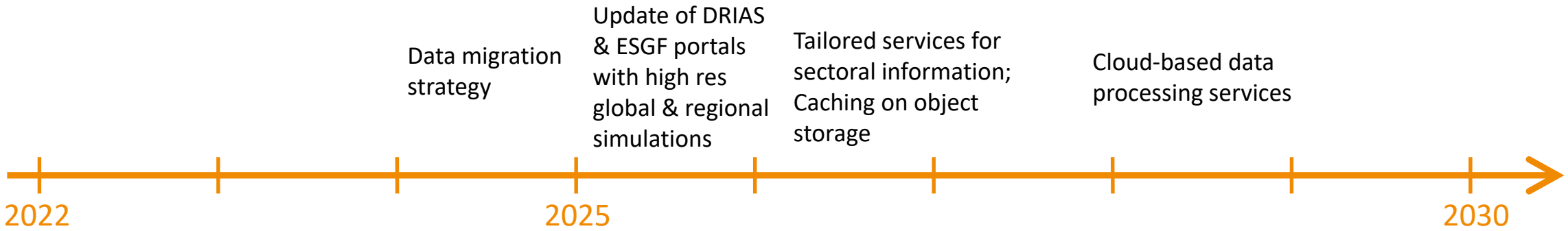
PC2: Brokerage of data and methods

The amount of data generated by climate models will increase tremendously with the advent of exascale computing. These large volumes of data to be shared will **require** paradigm changes.

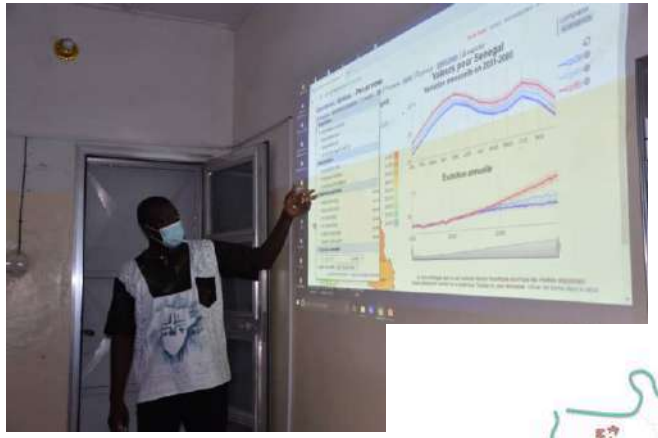
Provide a robust and sustainable infrastructure to distribute climate data and software for scientific and societal stakeholders

- New actionable datasets , redesign of DRIAS portal to better meet sectorial needs
- First-class services for advanced users to access innovations developed in TRACCS, build upon the national GAIA-DATA infrastructure and interfaced with generic European Infrastructures EOSC, EGI, Copernicus, DestinE and EUDAT
- Preparation of data-ready analyses for ‘less advanced’ users, relying on cloud-based technologies and formats.

Provide access to very high resolution datasets with on-demand analytics – Support adjusted and actionable climate change data



PC3: Territorial climate services demonstrators – the added value of integrated climate information



Stakeholders'values should be the starting point of climate information and service development, not the end point.

1) Engage multi-disciplinary teams of stakeholders to co-construct and co-produce decision-relevant and scale-relevant information,
2) Foster co-designed information portals and climate services,
3) Perform inter-disciplinary and multi-sectoral analyses.

Climate services demonstrators prototyped in France, and two highly vulnerable countries, Senegal and Ivory Coast

The French network of Regional Groups of Climate Expert (GRECs) supported

Regular meetings with GRECs

Regular meetings with Senegal and Ivory Coast Authorities

2022 2025 2030

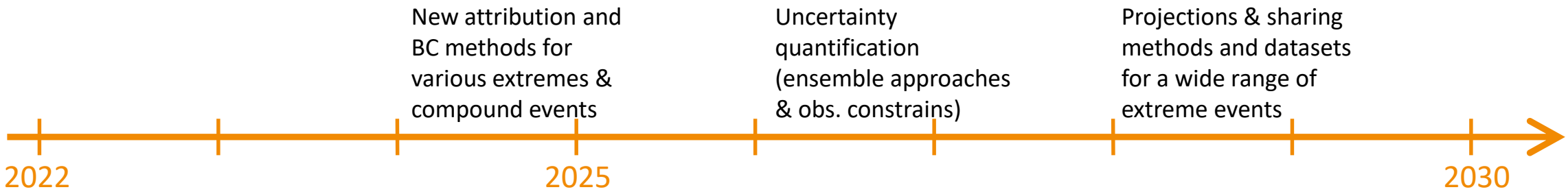
PC4: Extreme events under climate change – statistical methods, attribution, projections

- Extreme events are very **impactful** for many activities and ecosystems
- Projected to be **more frequent** in the future

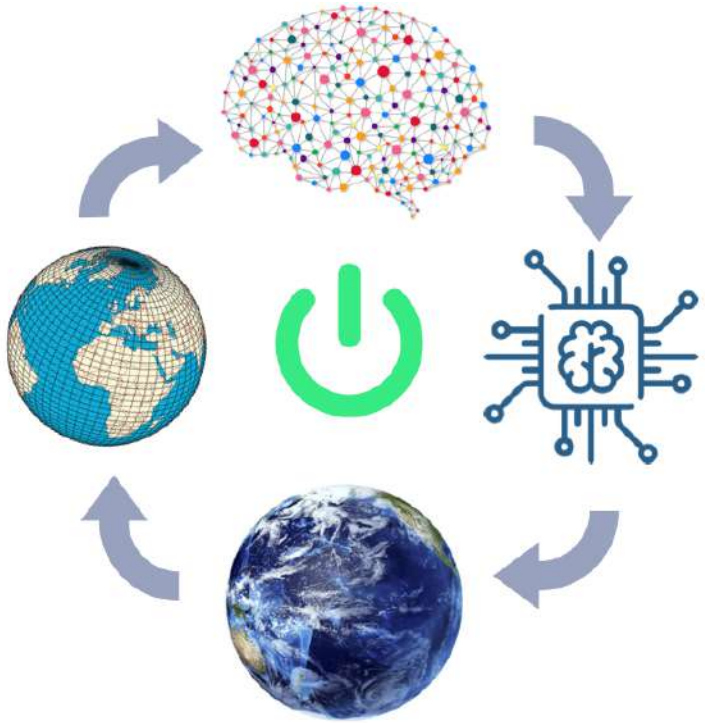
=> Need of **robust hazard projections** for a large range of extremes:

- ✓ e.g., heat/cold waves, heavy rainfall, droughts, storms, etc.
- ✓ including **more unusual events** and "***Compound events***"

New statistical & ML methods (bias correction/obs. constraints/attribution/uncertainties) & projections



PC5: New computig paradigms – designing efficient, modular & trainable climate models



Climate models : key **numerical tools** for climate services.

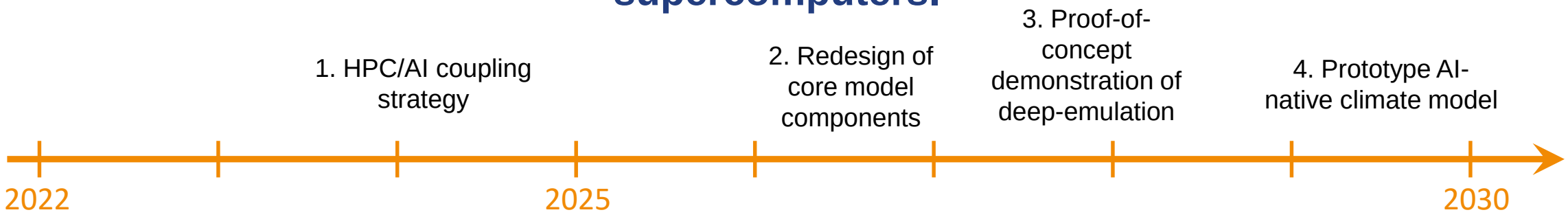
Challenges : exascale, km-scale, AI/ML, uncertainties, fit-for-purpose

=> Need to redesign models and prepare their (R)evolution

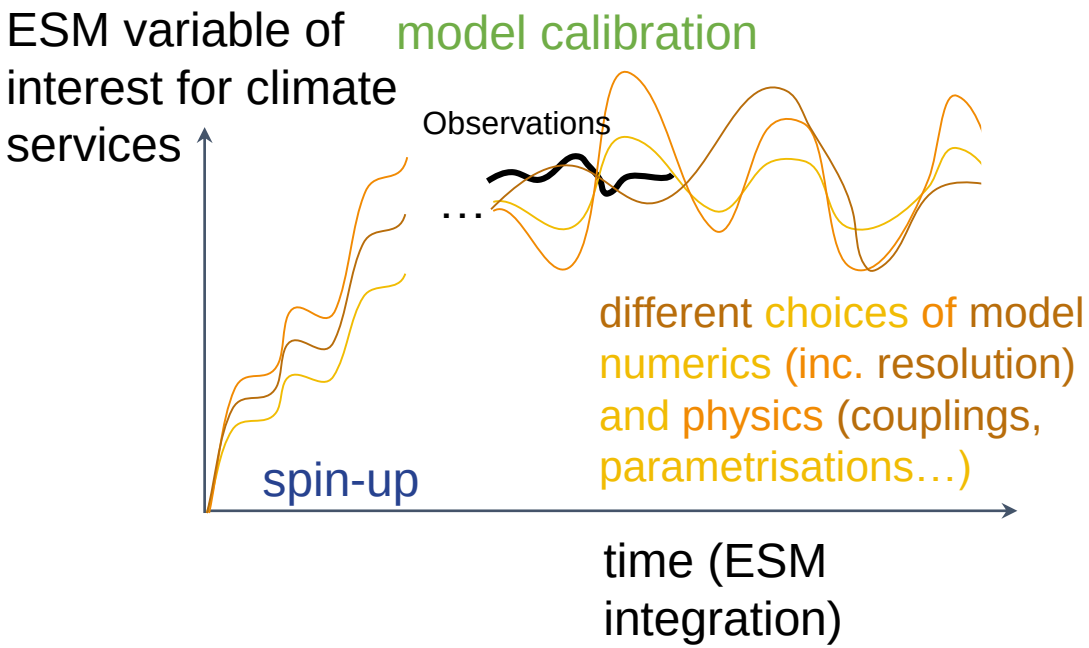
Objectives

- develop robust protocols for leveraging AI in climate models
- redesign compute-intensive model components and interfaces
- explore disruptive paradigms for longer-term evolutions

Core technologies for leveraging AI in climate models and exploiting upcoming supercomputers.



PC6: Exploring uncertainties – advancing model development for climate services



Model calibration: a long-standing bottleneck in Earth system modelling

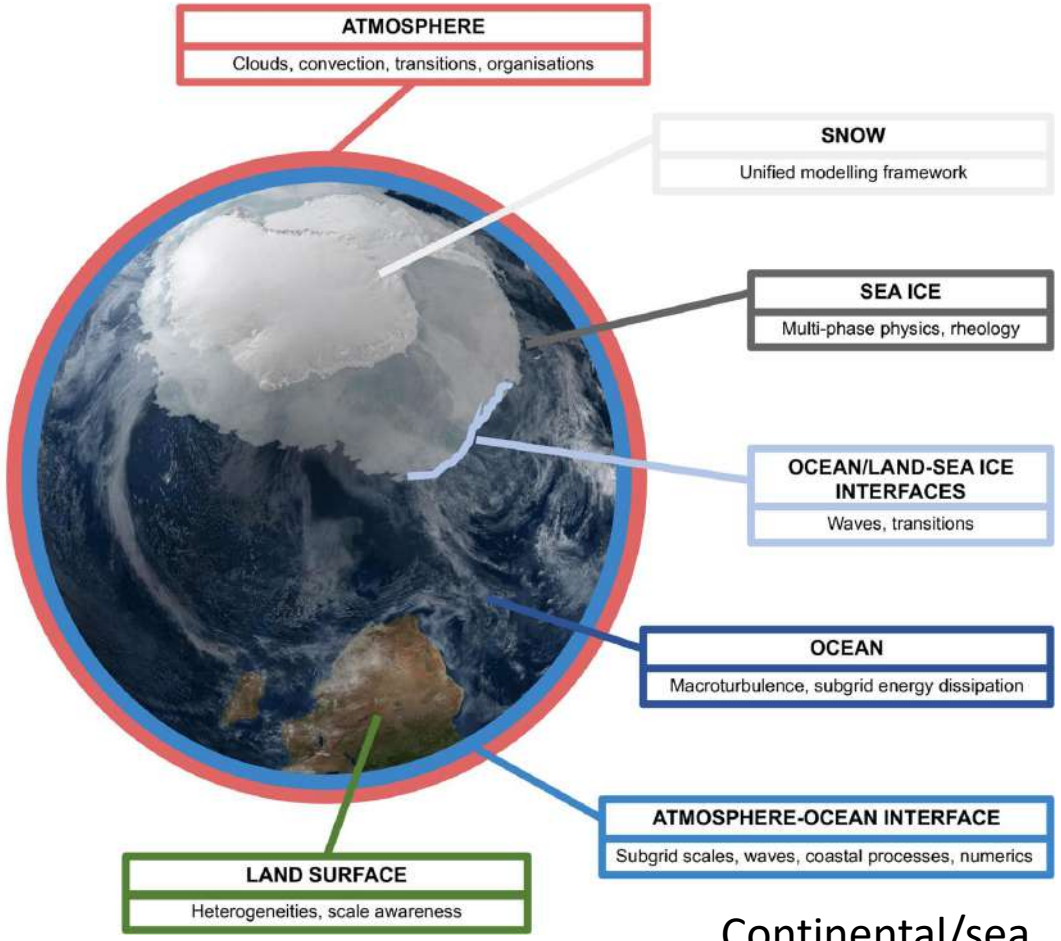
Need to tackle all modelling uncertainties to deliver appropriate climate information

Recent and original scientific advances from the French community

- **Develop innovative strategies for ESM spin-up**
- **Objective and efficient ESM calibration, benefiting from AI**
- **Fully address ESM parametric uncertainty**
- **Narrow projections with observational constraints**

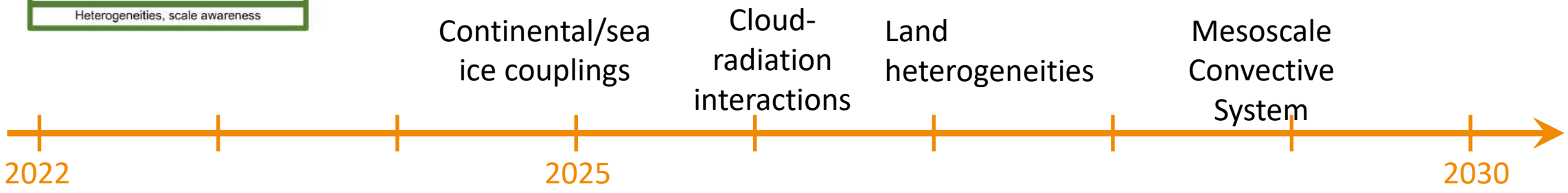
Accelerating feedbacks between model development/validation/climate services
Solid basis to coordinate model hierarchies (resolution, complexity)

PC7: Enhanced representation of physical processes – Increasing the ESM reliability for climate studies and projections

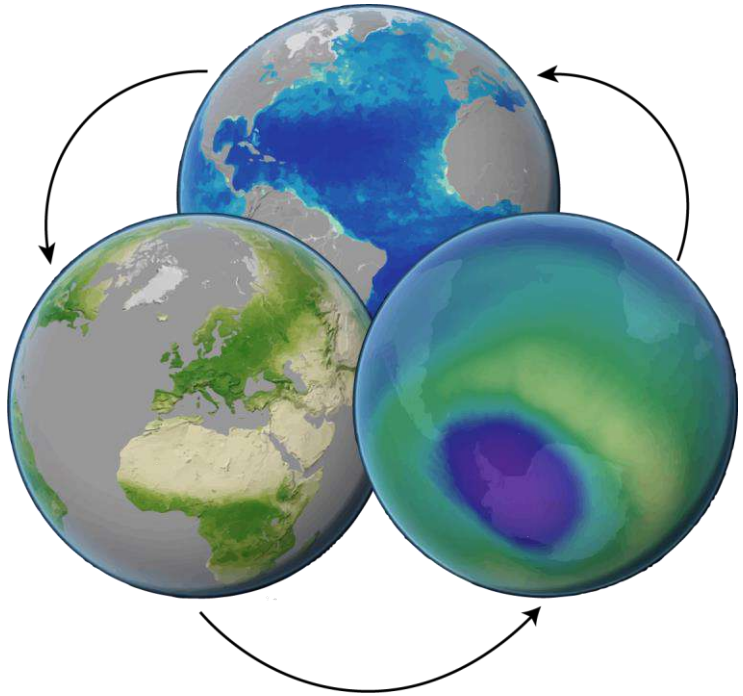


- **Advance theoretical models of physical processes**
- **Fully benefit from process/high-resolution models and most recent observations**
- **Explore the potentiality of AI-based techniques**

Novel, consistent and scale-aware representations of Earth system processes



PC8: Enhanced treatment of biogeochemical processes – climate feedbacks, impacts and vulnerabilities

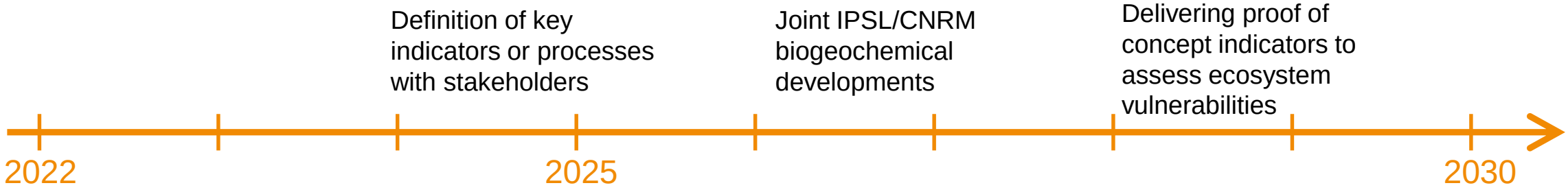


The current level of integration of these processes is lagging behind the most up-to-date knowledge, limiting our ability to deliver information on climate/Earth system feedbacks, impacts and vulnerabilities.

The aim is to explore a wider range of approaches to make a step change in the representation of biogeochemical responses in ESMs and analyze their interactions.

The focus will be on components of high level of interest for their impacts on the Earth system: P, N, C, and Fe cycles and their isotopes, fires, biogenic volatile organic compounds, and the dynamics of semi-arid ecosystems.

Transformative aspects include co-developing new inter-operable biogeochemical process modules between IPSL /CNRM ESMs, making use of advanced tools such as emulators to speed up biogeochemical processes



PC9: Polar Ice Sheets in the climate system – addressing high-end sea-level scenarios

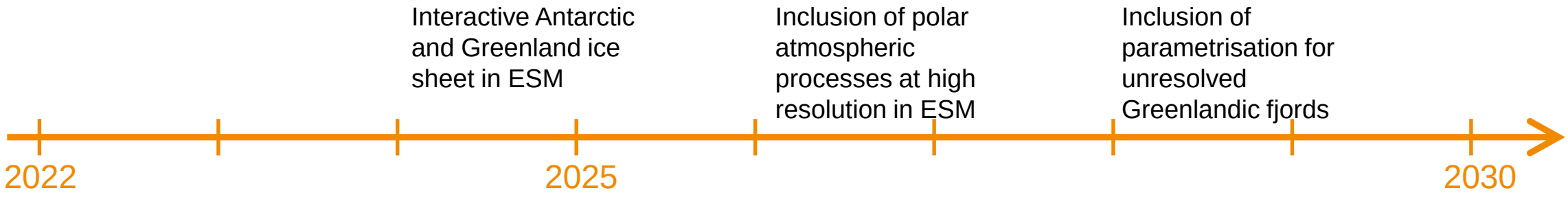
Greenland and Antarctica mass loss: the main uncertainty in the projections of the forthcoming mean sea-level rise.

The national community: a recognized leader in ice sheet model developments.

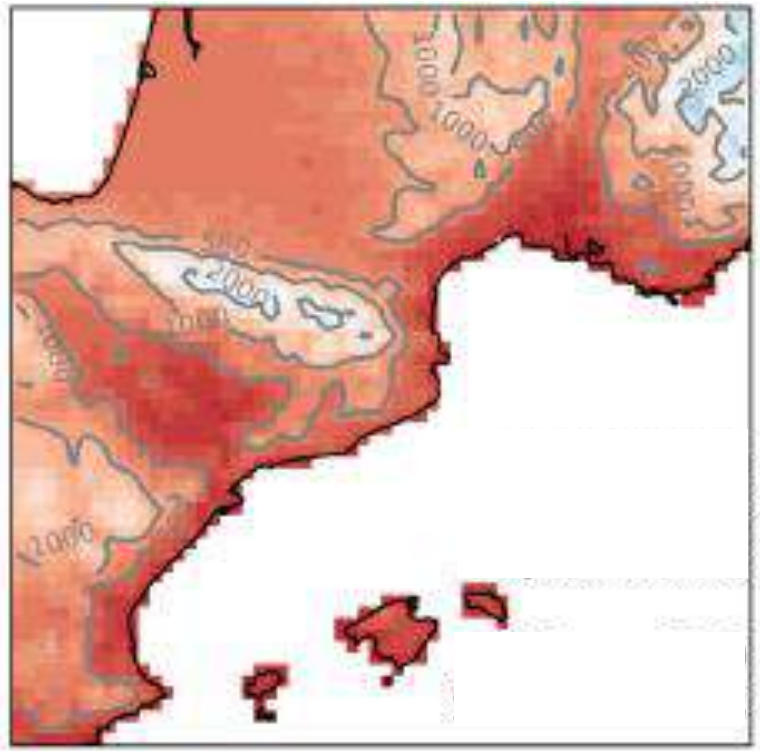
Include ice sheet model in ESM, the last missing climate component not represented in ESMs worldwide.

Ice sheets in IPSL ESM Implemented -

Improved understanding of ice sheets tipping points



PC10: Reaching the local scale in climate studies – towards reliable climate information for local adaptation strategies



- Reliable local-scale (~1 km) climate projections and information = unreached (technical & scientific) challenge so far
- Needed for specific areas (eg, mountains, cities, islands coasts) & climate services (eg, for institutions, citizens, companies)

=> We need to:

- ✓ increase the resolution while preserving consistency b/ scales
- ✓ add new HR processes parametrization and coupling (eg, aerosol-cloud radiation, city-climate, etc), including w/ machine learning techniques
- ✓ better understand local phenomena for risk assessment

Beyond current local-scale climate modelling – integration of the French communities & projections