Bridging Research and Operations

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Past Accomplishments of the Science

The 1970s

- ❑ Vector super-computing is born
- ❑ Satellite data transforms the field
- ❑ Global warming is simulated

Past Accomplishments of the Science

The 1980's

- Land models are being developed and are coupled to atmospheric GCM

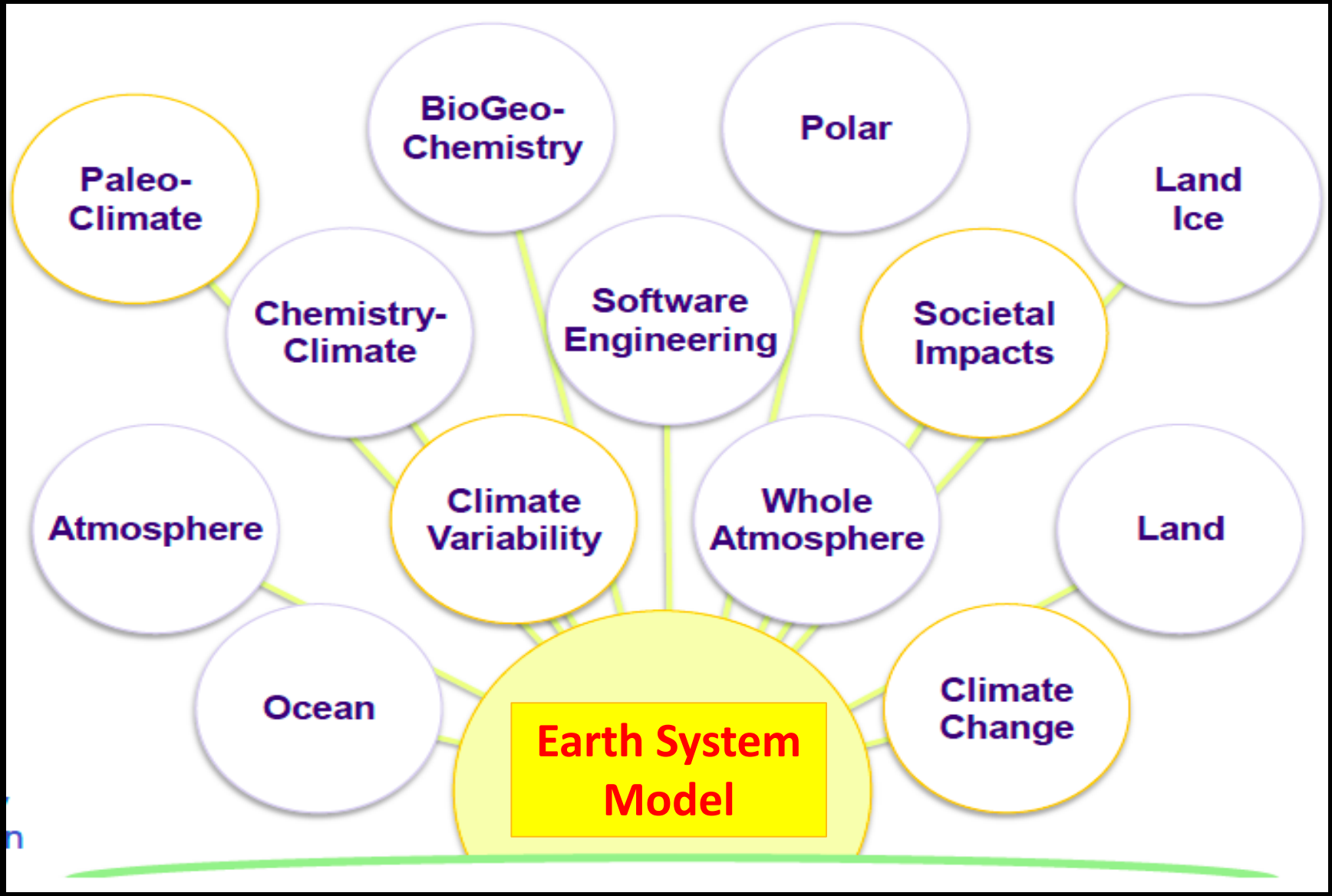
The 1990s

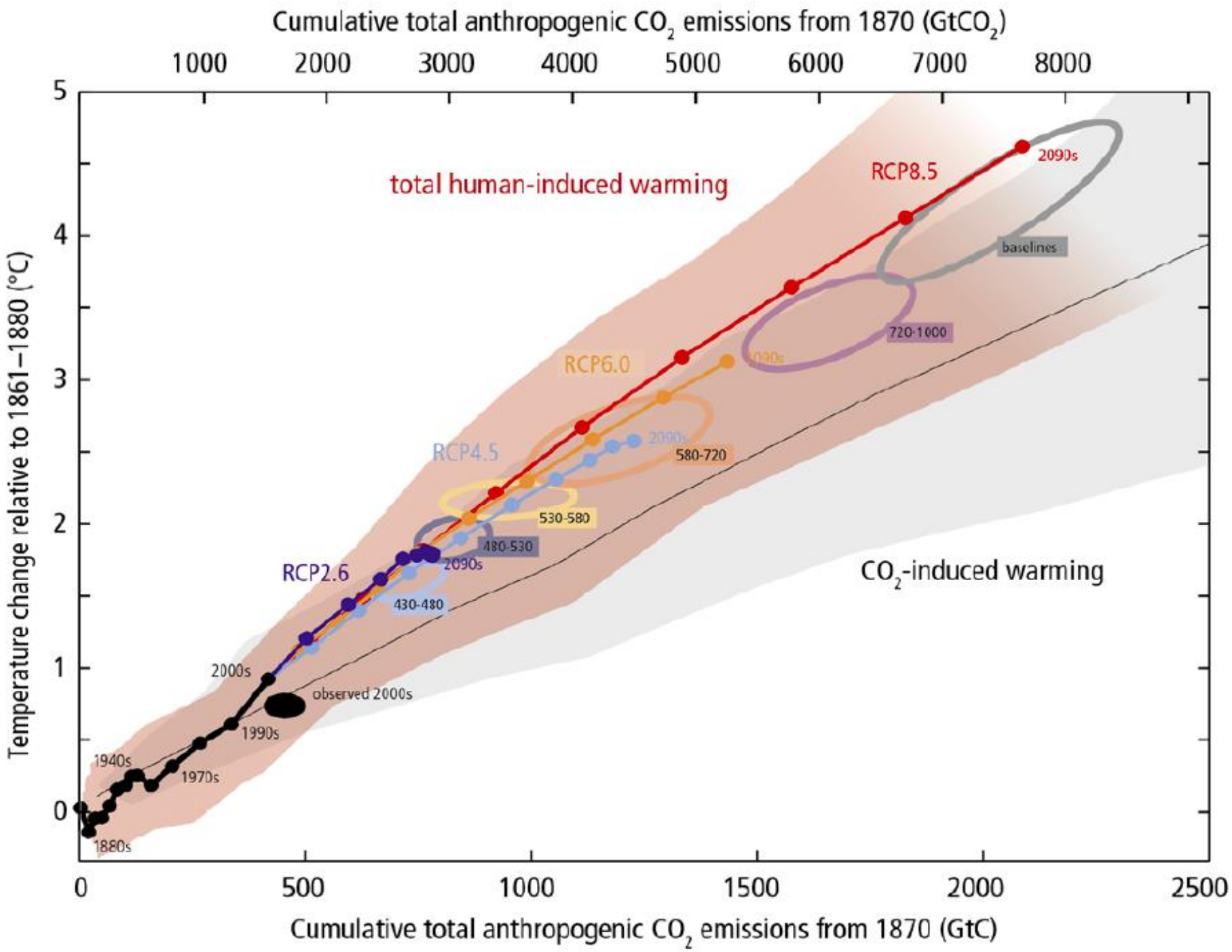
- Parameterization testing becomes organized
- Reanalysis begins
- The carbon cycle enters the models
- Aerosols and chemistry enter the models
- The IPCC Assessments begin
- Operational seasonal prediction begins
- Moving from uncertainties to probabilities

The 2000's

- Ensemble simulations, stochastic approach
- Biogeochemistry is coupled to the physical climate
- Very high resolution global models are integrated
- CMIPs and CORDEX

Earth System Model



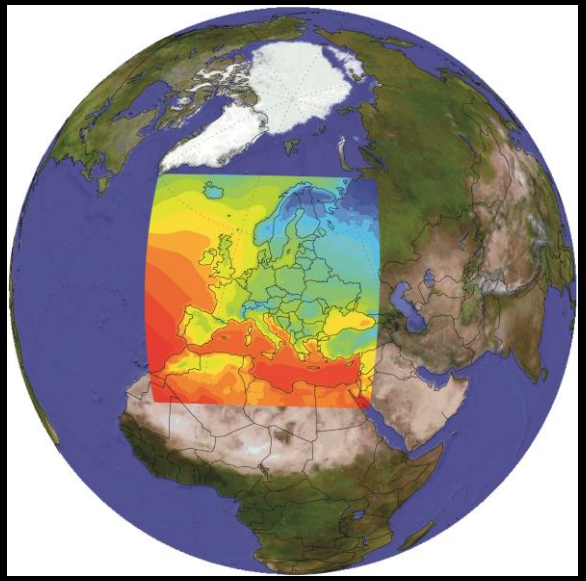

Cumulative total anthropogenic CO_2 emissions from 1870 ($GtCO_2$)
1000
2000
3000
4000
5000
6000
7000
8000
Temperature change relative to 1861–1880 (°C)
0
1
2
3
4
5
total human-induced warming
RCP8.5
2090s
baselines
720-1000
RCP6.0
2090s
RCP4.5
2090s
580-720
530-580
480-530
RCP2.6
2090s
430-480
CO_2-induced warming
2000s
observed 2000s
1990s
1940s
1970s
1880s
0
500
1000
1500
2000
2500
Cumulative total anthropogenic CO_2 emissions from 1870 (GtC)

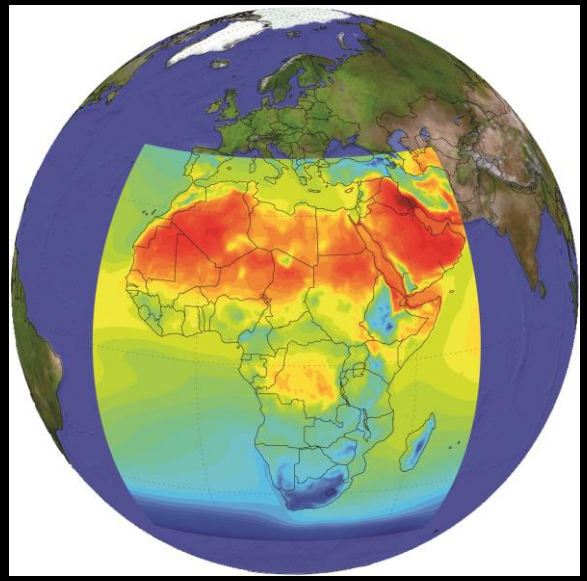
Input to International Negotiations

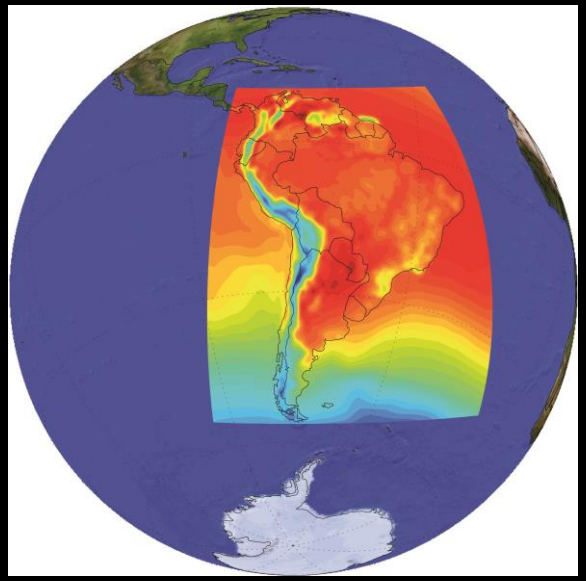
- The research, based largely on climate projections, has found that, to keep warming below 2^0C, the total emission of CO_2 should be limited to 1000 Gt CO_2.
- International negotiations will have to see how to develop an international policy driven by this constraint.
- But, this information is not sufficient to develop regional, national and local mitigation and adaptation policy. Here risks and timeframes are important aspects.

Regional climate downscaling - CORDEX

- Coordination of regional climate modelling
- Evaluate & improve downscaling techniques
- Support vulnerability, impact, adaptation
- Direct engagement with stakeholders

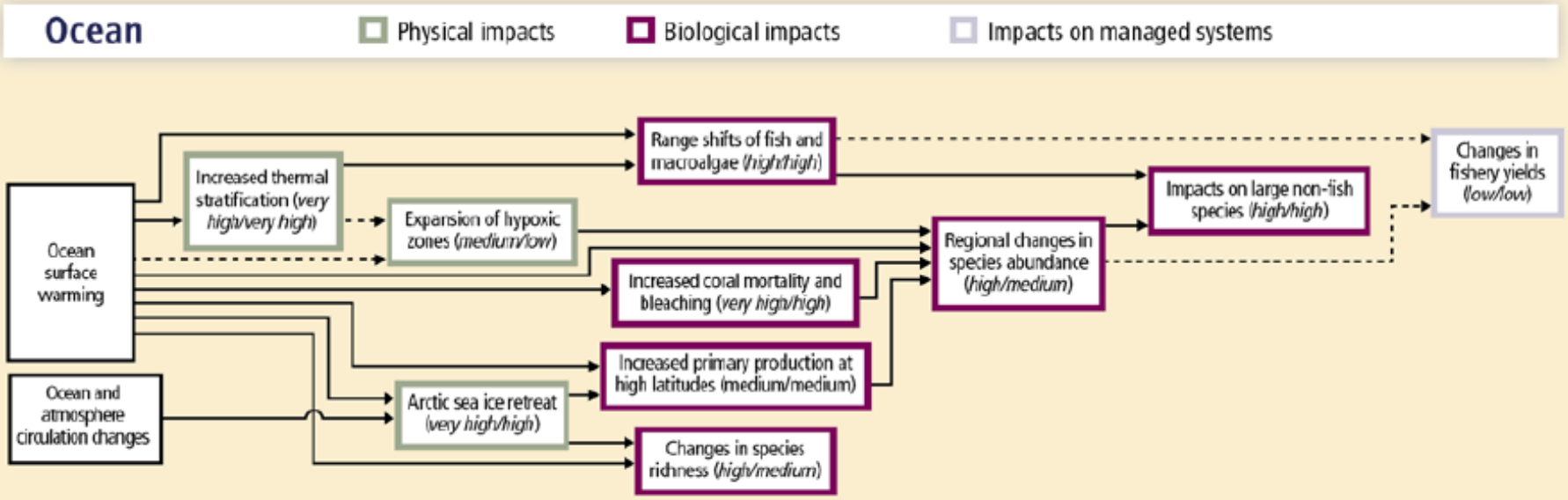


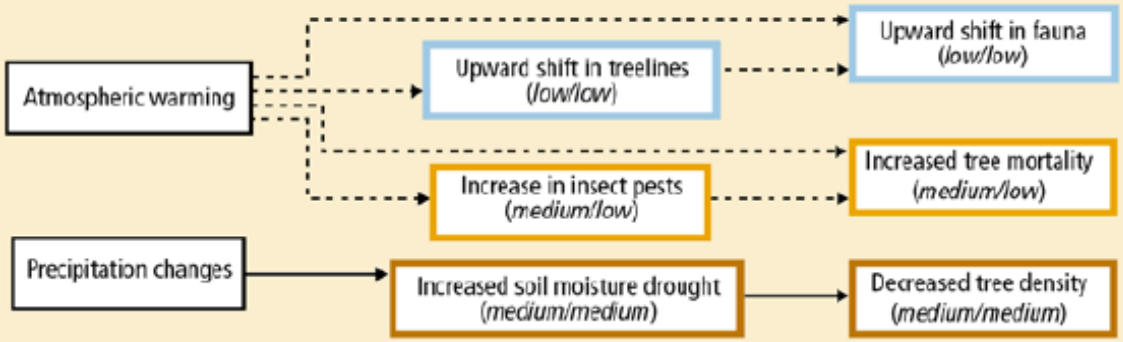




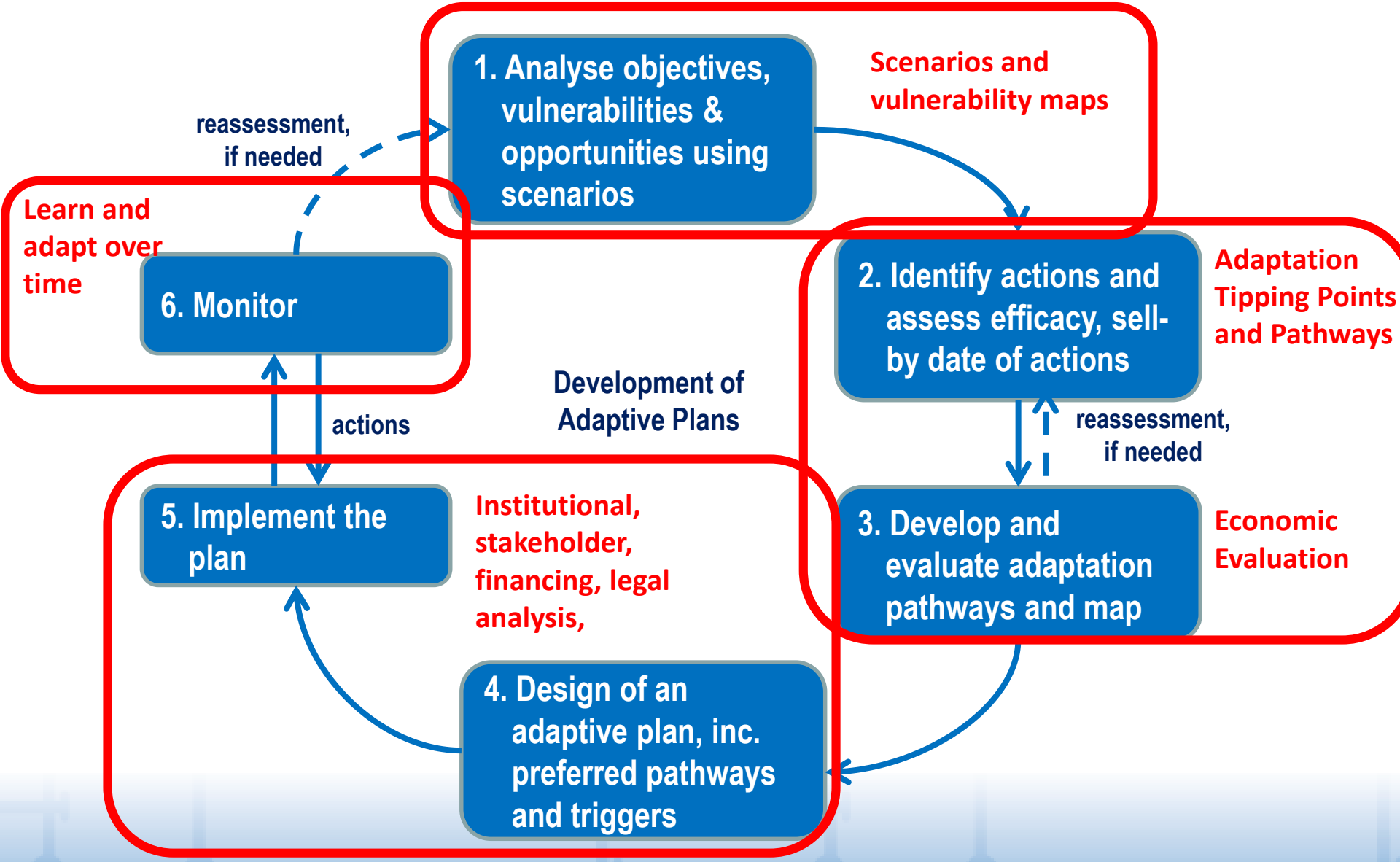
wcrp-cordex.ipsl.jussieu.fr/

Assessing Impacts of Climate Change





Dynamic Adaptive Policy Pathways



After Haasnoot et al. (2013) Glob. Env. Change. 10.1016/j.gloenvcha.2012.12.006

The Example of Water Availability

Water Security: key challenges of the 21st century
Some key facts

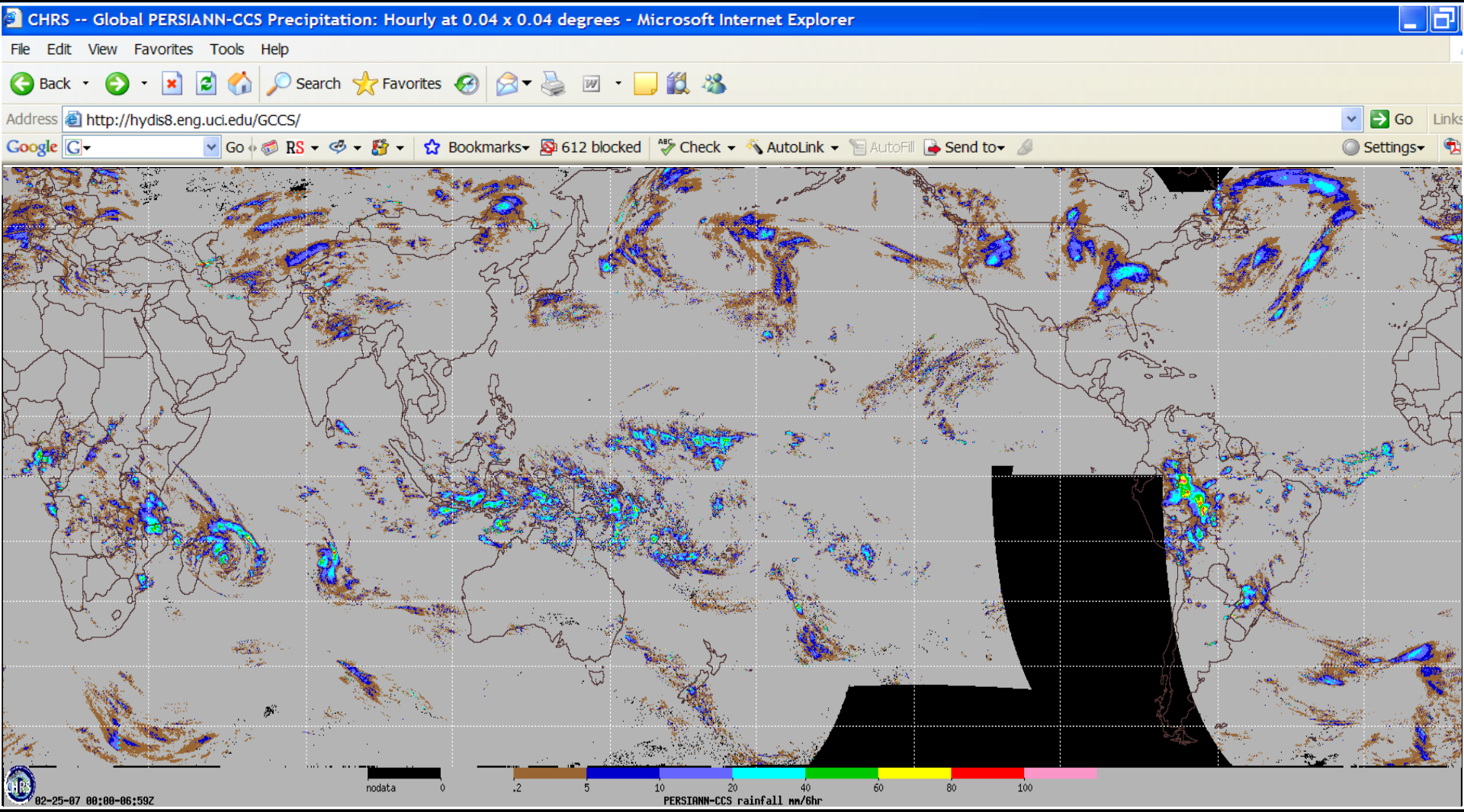
85% of the human population live in arid areas. By 2030, half of the population will be living in areas of high water stress.

6-8 million human beings are killed each year from water-related disasters and diseases.

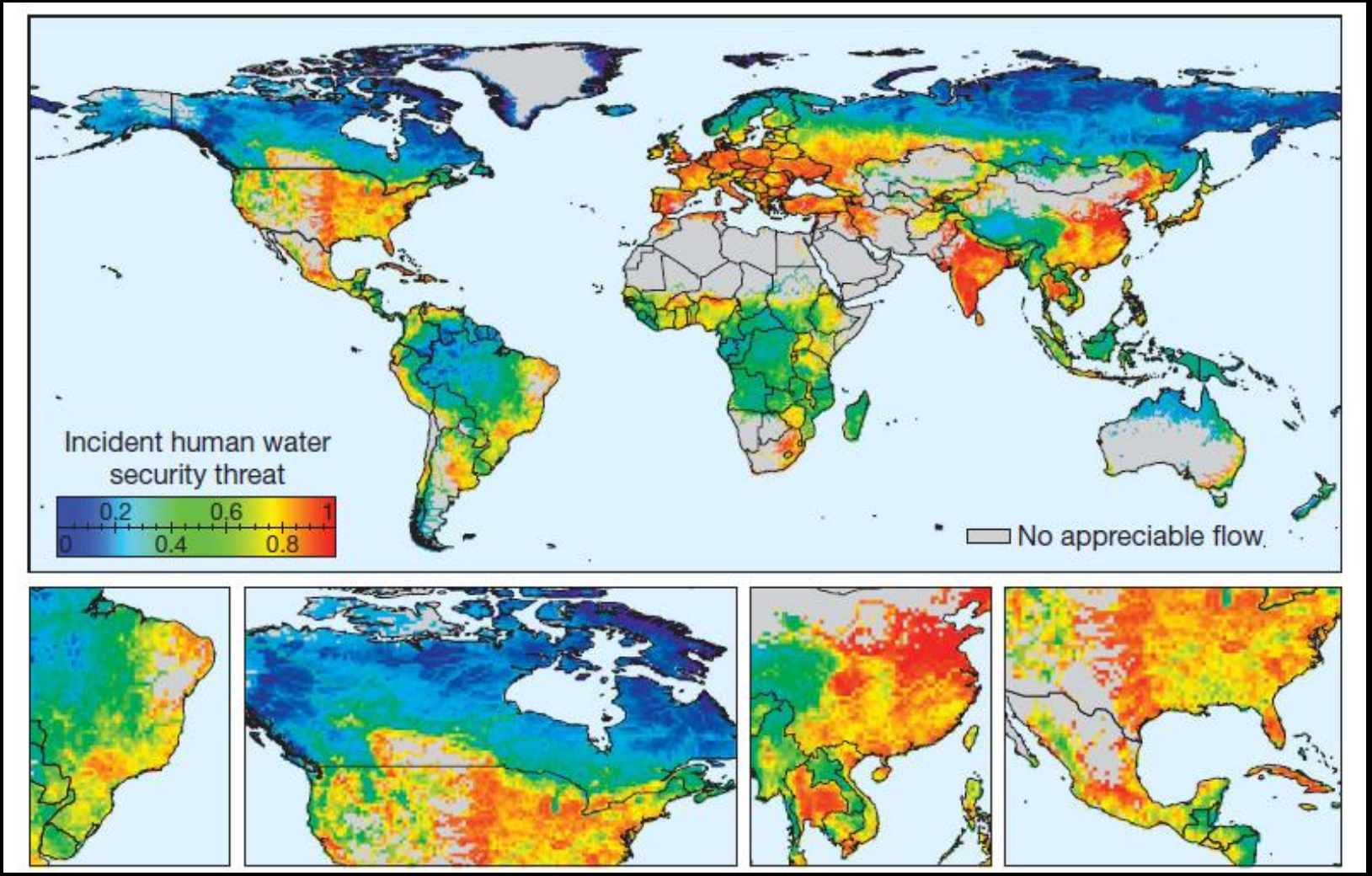
750 million people lack access to safe water, while nearly 2.5 billion people lack access to adequate sanitation.

*Inventoried by UNESCO-IHP

6-hour 0.04^0 x 0.04^0 Rainfall over a 7-day period



Nearly 80% of the world's population is exposed to high levels of threat to water security. Massive investment in water technology enables rich nations to offset high stressor levels without remedying their underlying causes, whereas less wealthy nations remain vulnerable. Vörösmarty et al. (2010):



Global and regional geography of incident threat to human water security (Vörösmarty et al., 2010)

The Responses:
6 Themes, 3 Axes

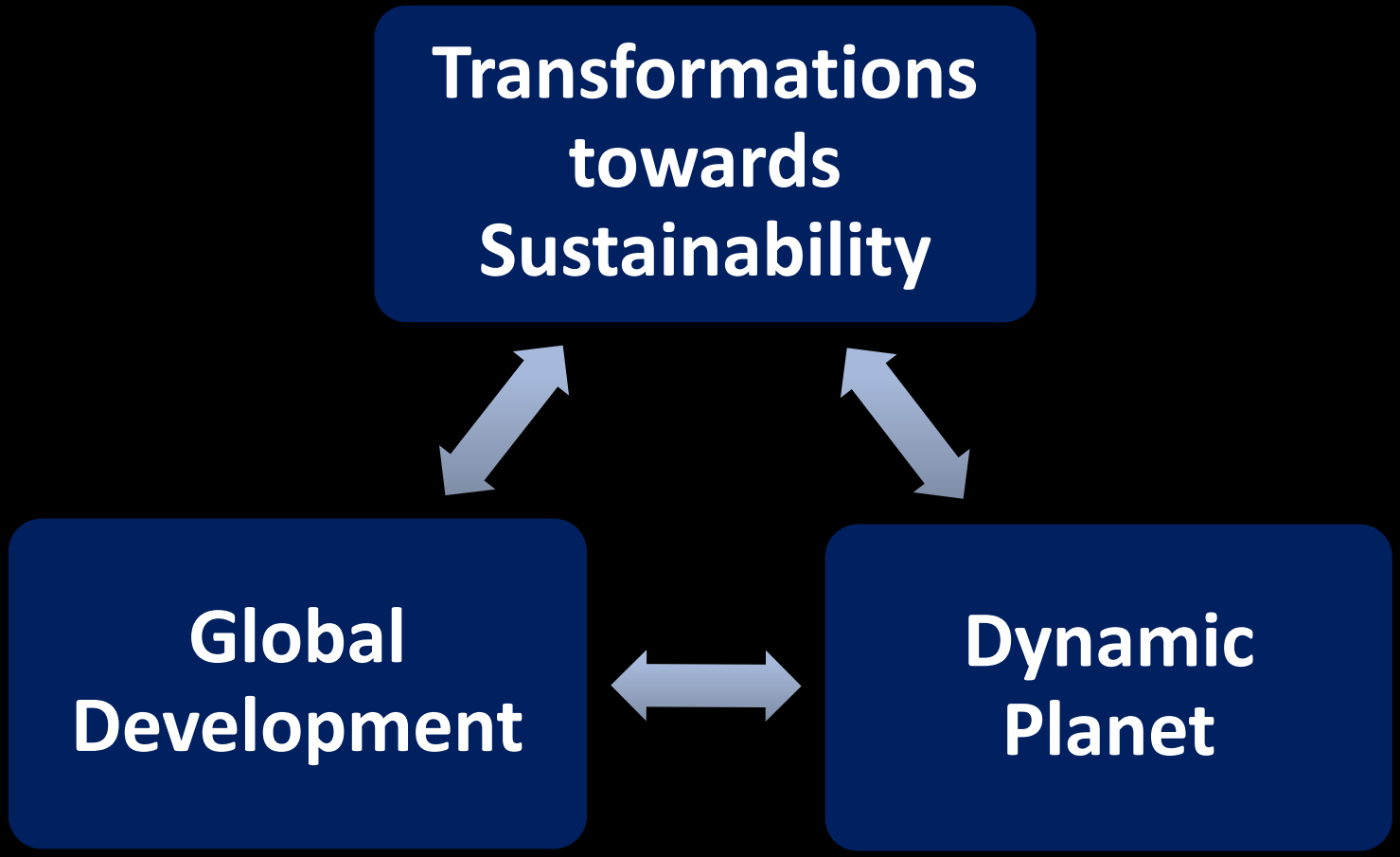
Improve knowledge and innovation to address water security challenges.

Axis 1: Improve knowledge and innovation to address water security challenges

Axis 3: Enhancing policy advice to reach water security at local, national, regional and global levels.

Axis 2: Developing institutional and human capacities for water sustainability innovation

Future Earth Themes

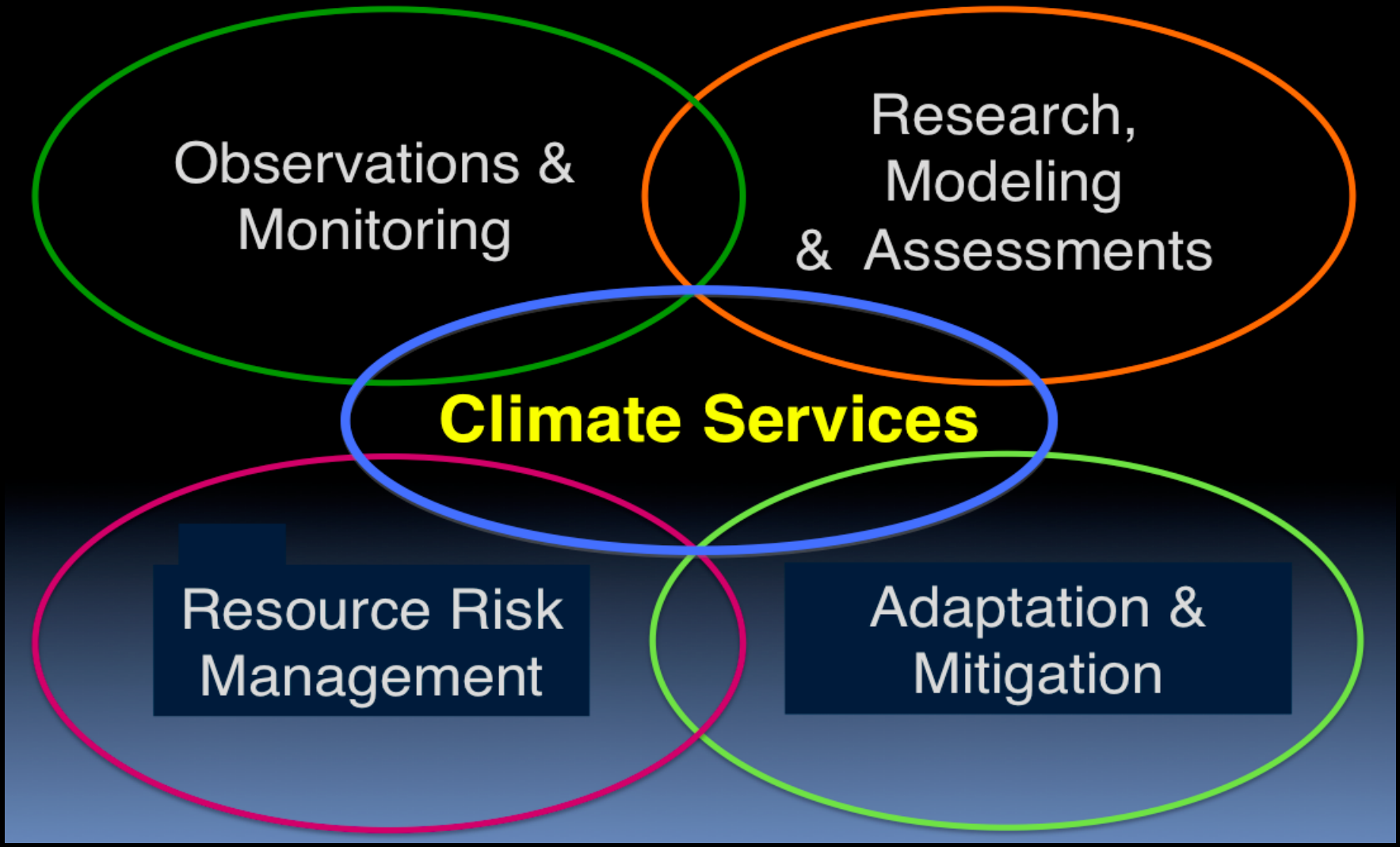


And cross-cutting issues: Observing systems, models, theory development, data management, research infrastructures

Co-Production of Knowledge

- "Local knowledge" should be combined with "scientific knowledge" to constitute relevant information.
- Who is providing the "local knowledge"?
- Are the stakeholders ready to join and really contribute to the development of climate services? It may not fit their business model.

The Elements of a Climate Service



The Chain for Climate Services

International and European initiatives	**Observations and production of climate projections**
National hydro-meteorological services	**Production of downscaled projections**
Sectorial Research organizations (energy, agriculture, water, etc.)	**Value-added sectorial information**
National/Federal Climate Services	**Synthesis and translation for users**
Communication and Boundary organizations (NGOs, unions, media)	**Two-way communication and advisory services**
National users (policymakers, professional organizations)	**Federal government and corporate world use information**
Regional climate services and information providers	**Adapt information to the needs of individual users and advise regional governments**
End-users (Vulnerable communities)	**Individual actors (farmers, industrialists etc.) make use of information.**

The ECMWF CCCS

A Chain of cooperating institutions

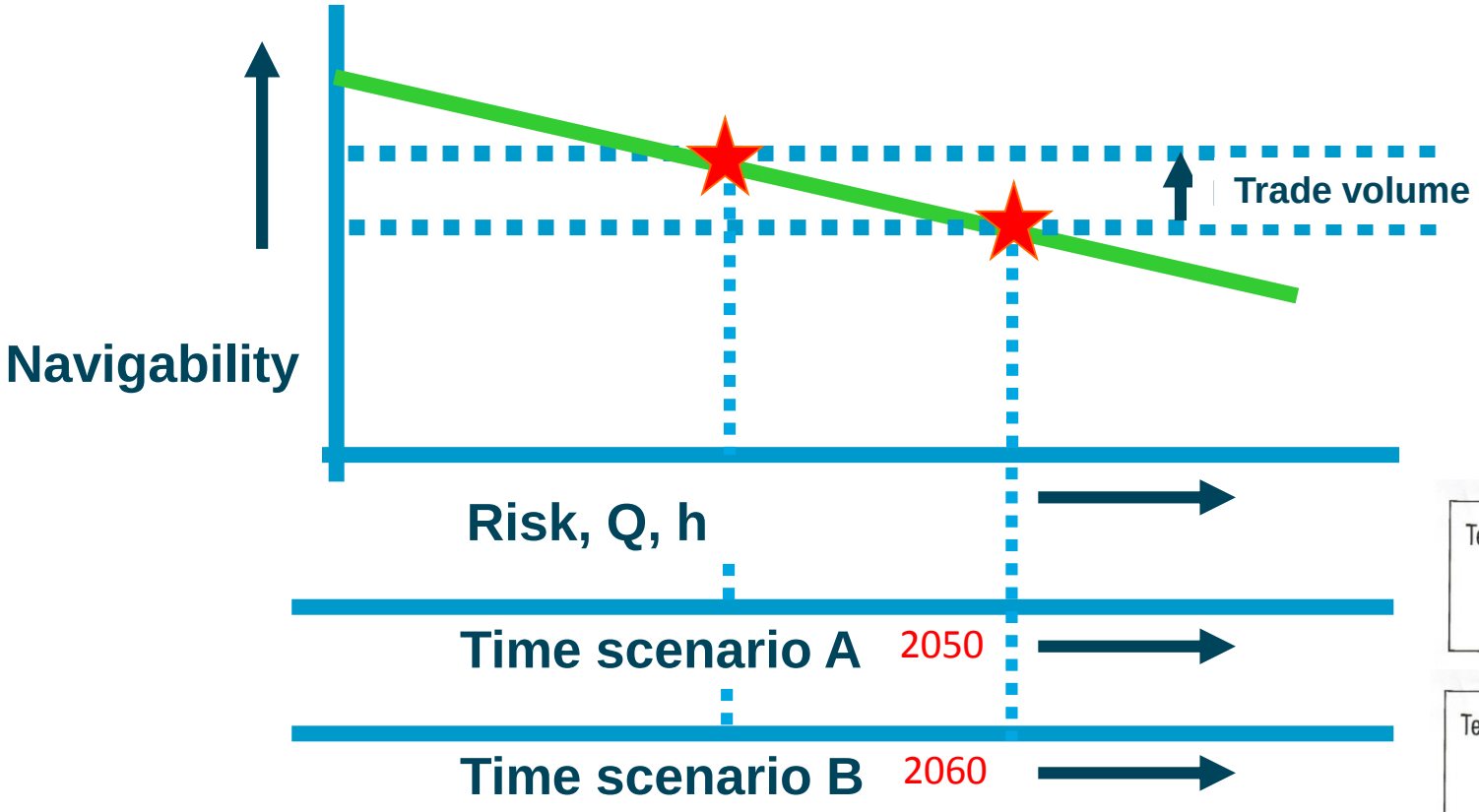
How to transform climate projections into "useful" information

- Stakeholders look at the questions from a different perspective:

- 90 degrees rotation of the climate projection graphs
- How much climate change can society cope with?
- Response planning requires that we estimate in which timeframe climate change will occur.

Adaptation Tipping Point & Use by date of policy action

A stress test: How much (climate) change can we cope with?
When do start to achieve missing our objectives?



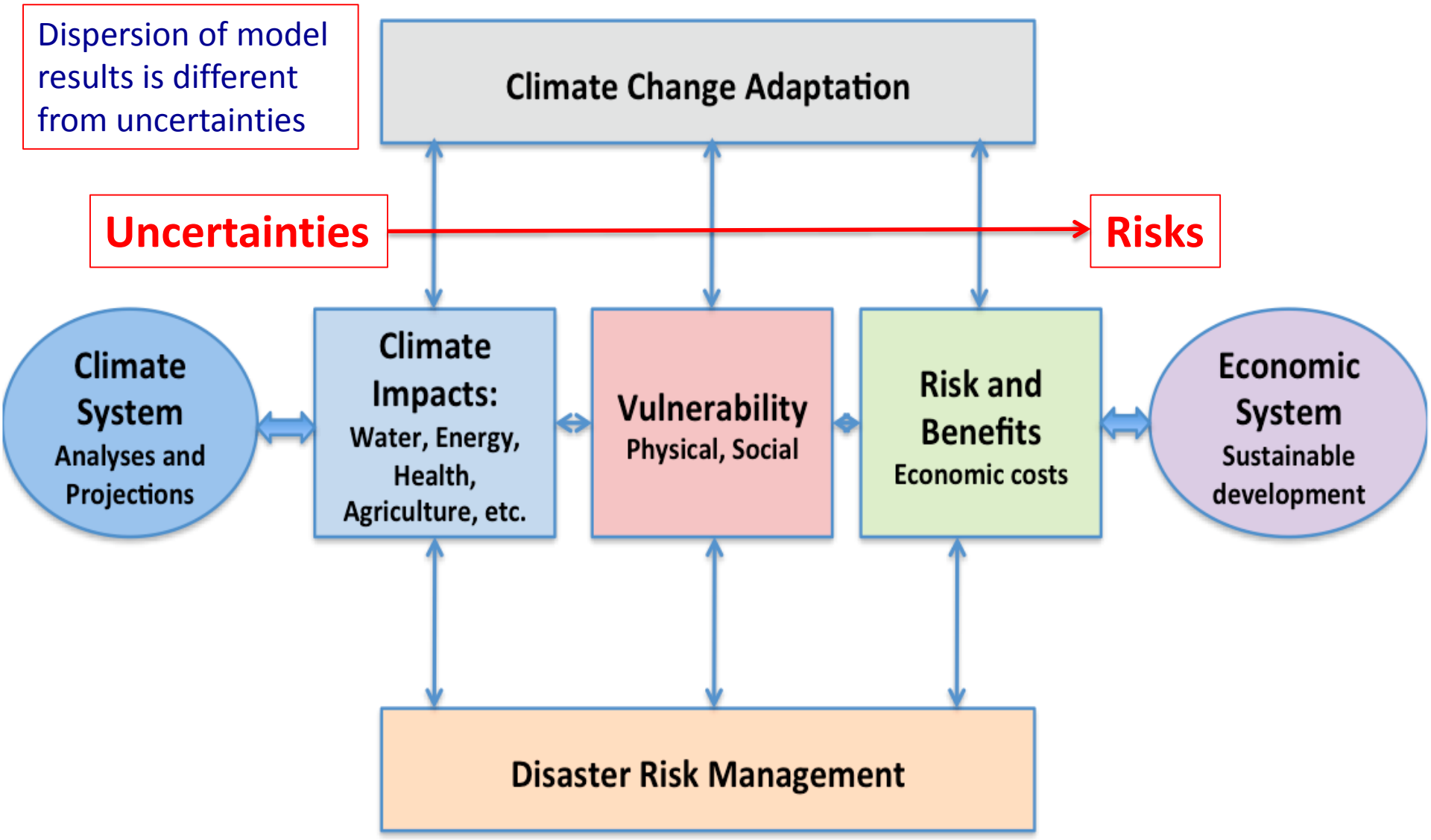
Model based, participatory and/or with expert judgement

Kwadijk, J.C.J. et al 2010 WIRES Climate Change DOI: 10.1002/wcc.64, Haasnoot et al 2012 Climatic Change

How to transform data uncertainty into risk management tool.

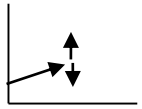
- This is typically the area where a strong consultation and interactions with end-users are required.

From Uncertainties to Risk Management

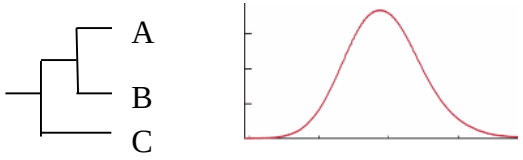


Levels of uncertainty

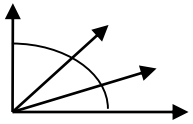
1. Single possibility



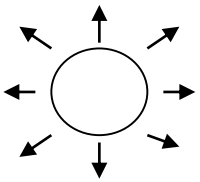
1. Multiple alternatives with likelihoods (probabilities)



2. Multiple alternatives without likelihoods



3. Known unknowns

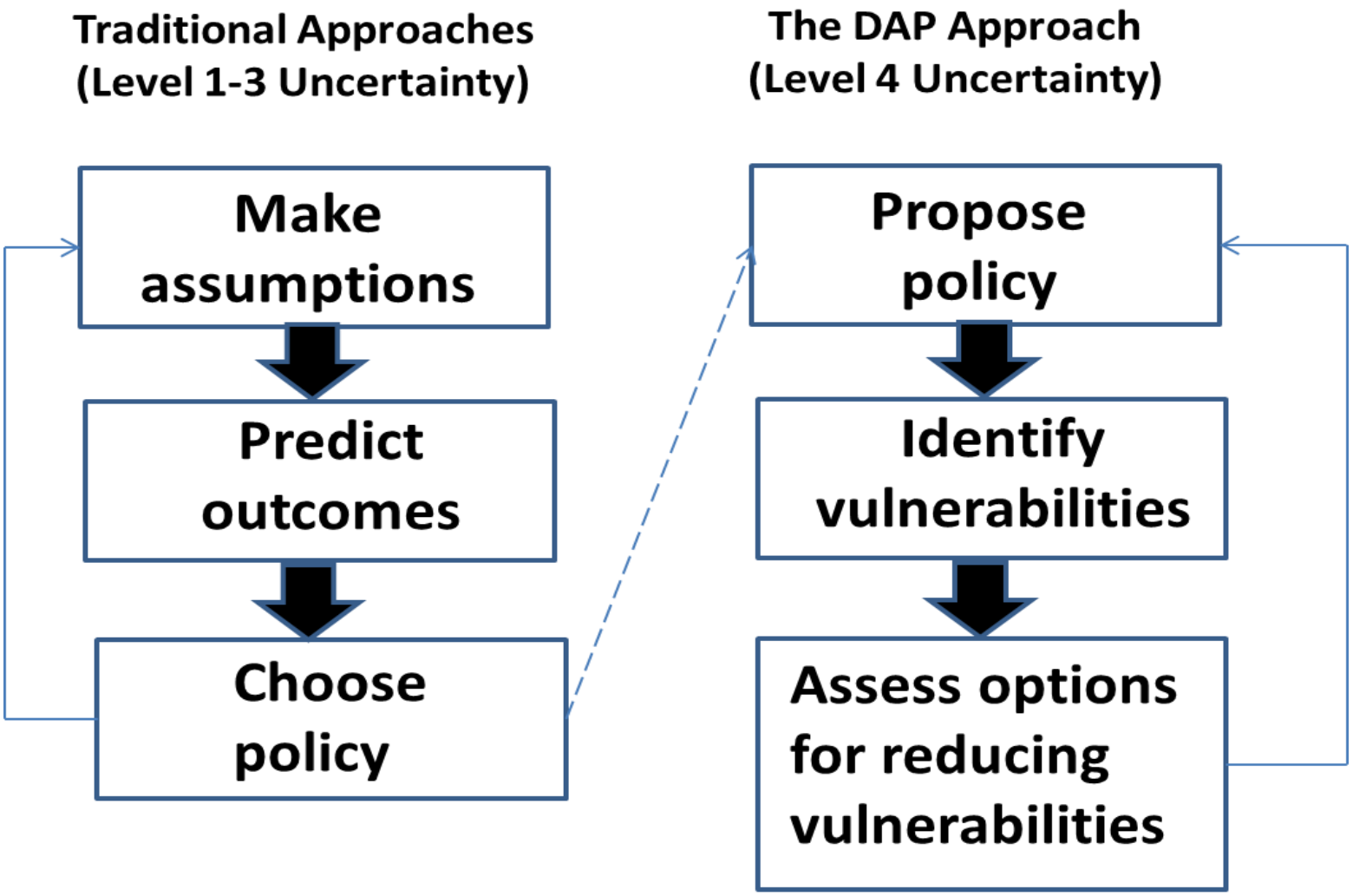


4. Unknown unknowns (the real risk!)

??

Courtesy, Warren Walker, Marjolijn Haasnoot

Extend the Analysis



From Jaap Kwadijk

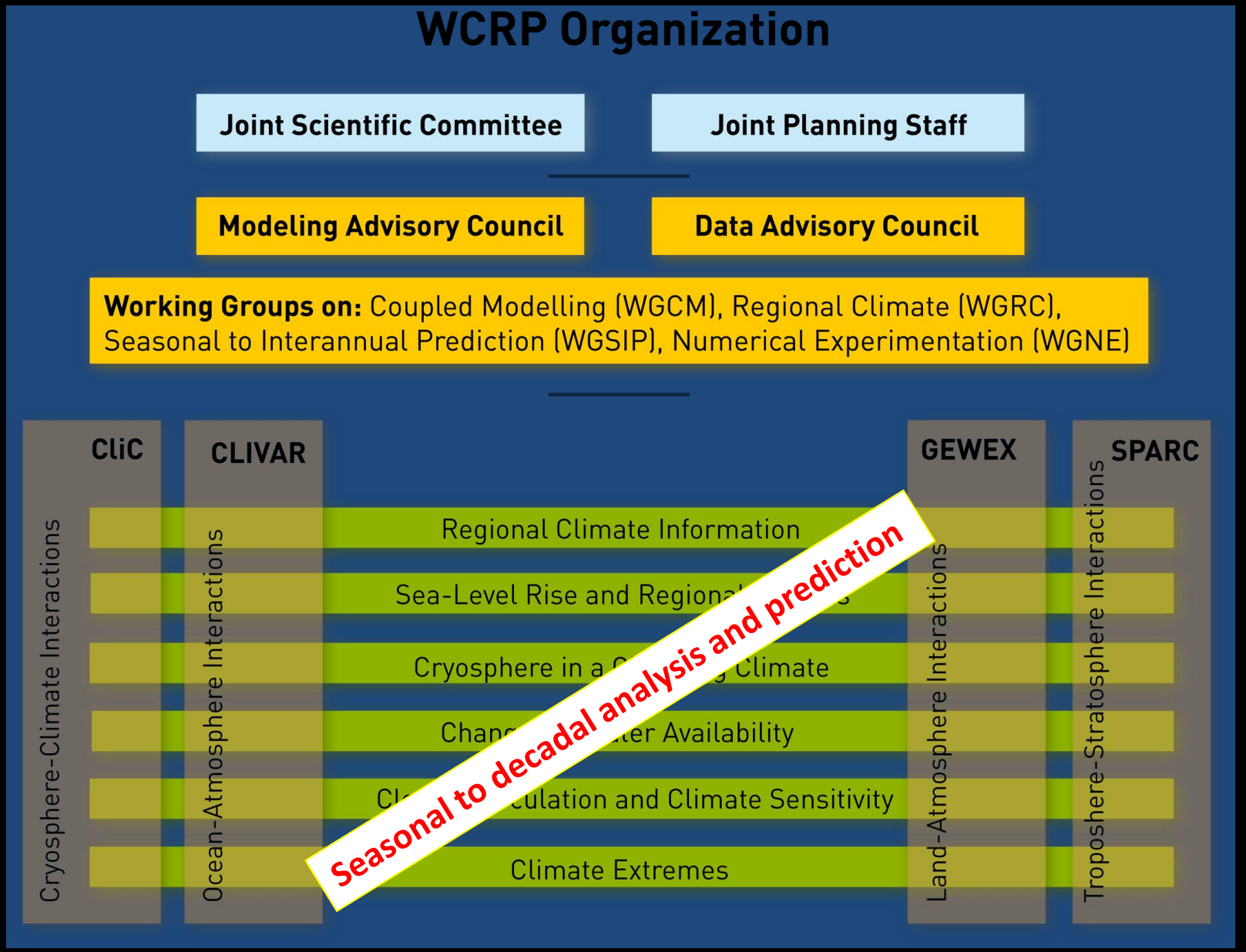
Sectoral and regional policy makers: What is the added value of regional projections?

- High-resolution (regional) climate models are providing more robust results in regions of complex topography and probably in regions of complex land surface. But, basically, climate variability is essentially a global problem (teleconnections, etc.)
- The regional climate community is well organized (CORDEX).
- It is unclear if the uncertainties in the regional models are lower or larger than in the output of the global climate models.

Decision makers work on a 5-10 year timeframe.
What can we offer them?

- There is a strong demand from stakeholders (health, agriculture, tourism, energy, etc.) to receive predictions of interannual variability on the scale of a few years.
- The science on this issue is very young, but it is evolving very rapidly. This question represents a grand scientific challenge with high economic relevance.
- Perturbed Parameter Ensembles (PPE) and Multi-Model Ensembles (MME)

WCRP Organization



Key Words towards Trust

- Available
- Dependable
- Reliable
- Usable
- Credible
- Authentic
- Responsive
- Sustainable

Thank You