Enhancing the policy relevance of scenarios through a dynamic analytical approach

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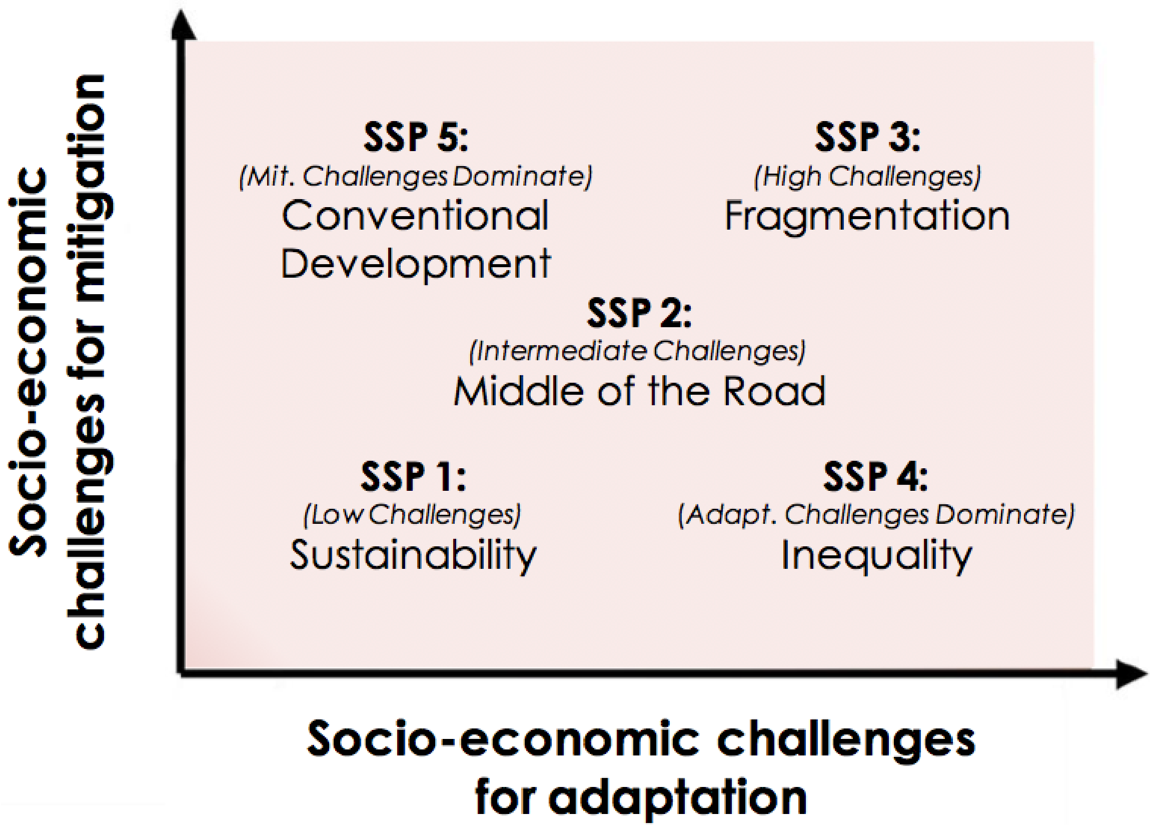
The Framework for the Development of New Socio-economic Scenarios for Climate Change Research



The SSP scenario space and five scenario typologies (from O'Neill et al. 2011)

SSP = « Shared Socio-economic Pathways »

A story and simulation approach, and intuitive logics for the “SSPs”

- **SSP 4: Inequality** (or Unequal World, or Divided World)

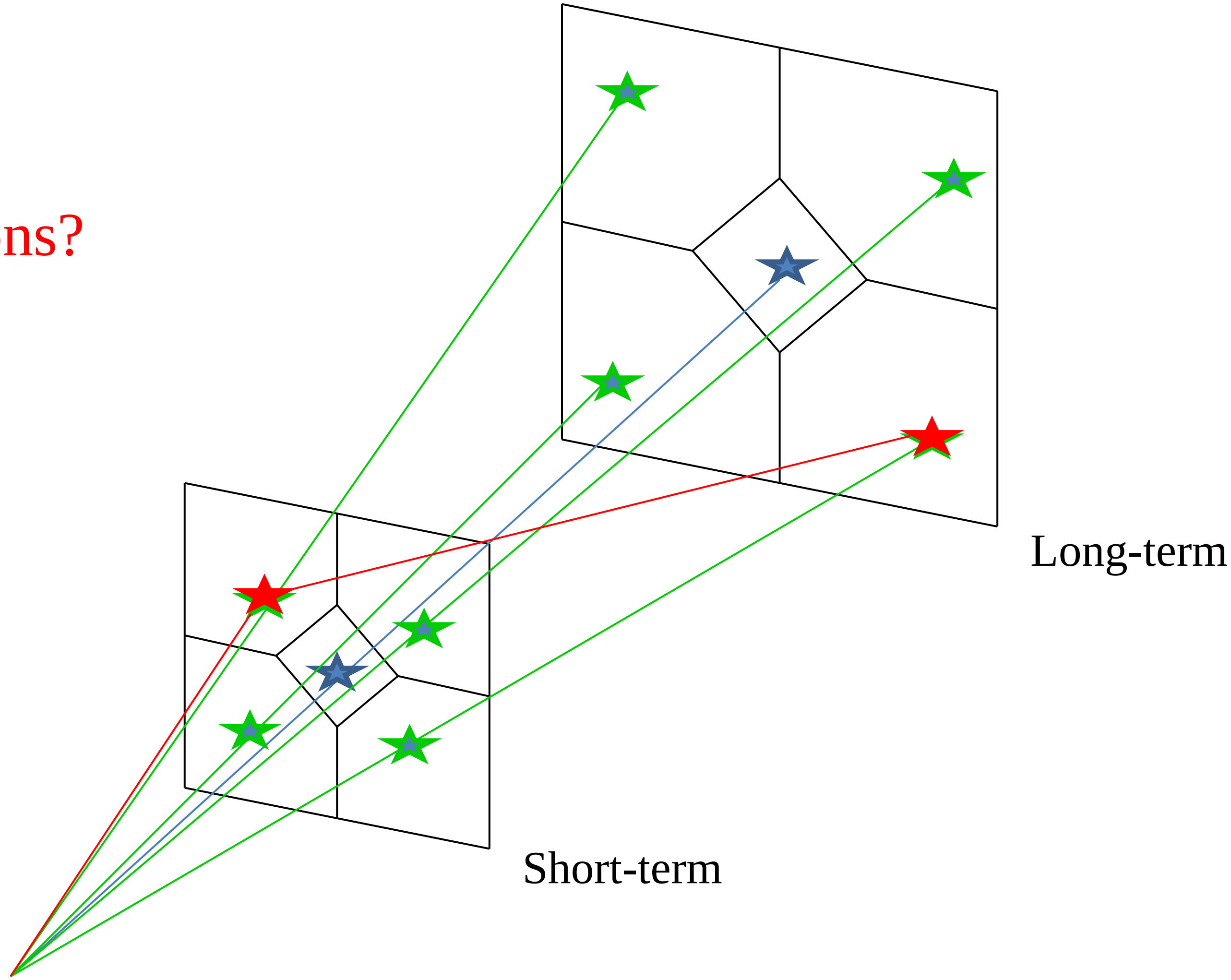
Summary: This pathway envisions a highly unequal world both within and across countries. A relatively small, rich global elite is responsible for much of the emissions, while a larger, poorer group contributes little to emissions and is vulnerable to impacts of climate change[…].

- **SSP 5: Conventional Development**

Summary: This world stresses conventional development oriented toward economic […]. The preference for rapid conventional development leads to an energy system dominated by fossil fuels, resulting in high GHG emissions and challenges to mitigation. Lower socio-environmental challenges to adaptation result from attainment of human development goals, robust economic growth, highly engineered infrastructure with redundancy to minimize disruptions from extreme events, and highly managed ecosystems.

Parallel future universes?

Or shifts?
Bifurcations?



A model to explore the "scenarios space" of socio-economic uncertainties

- An economy-energy-environment model, Imaclim-R
  - Hybrid global model (12 regions, 12 sectors)
  - Endogenous GDP and structural change
  - Endogenous energy markets
  - Endogenous and induced technical change
  - Explicit representation of energy technologies
  - Exogenous:
    - Demography
    - Labour productivity growth
    - Maximum potential of technologies (renewable, nuclear, CCS, EV…)
    - Learning rate decreasing the cost of technologies
    - Fossil fuel reserves
    - Parameters of the functions representing energy-efficiency in end-uses
    - Parameters of the functions representing behaviors and life-styles (motorization rate, residential space, evolutions in consumption preferences…)

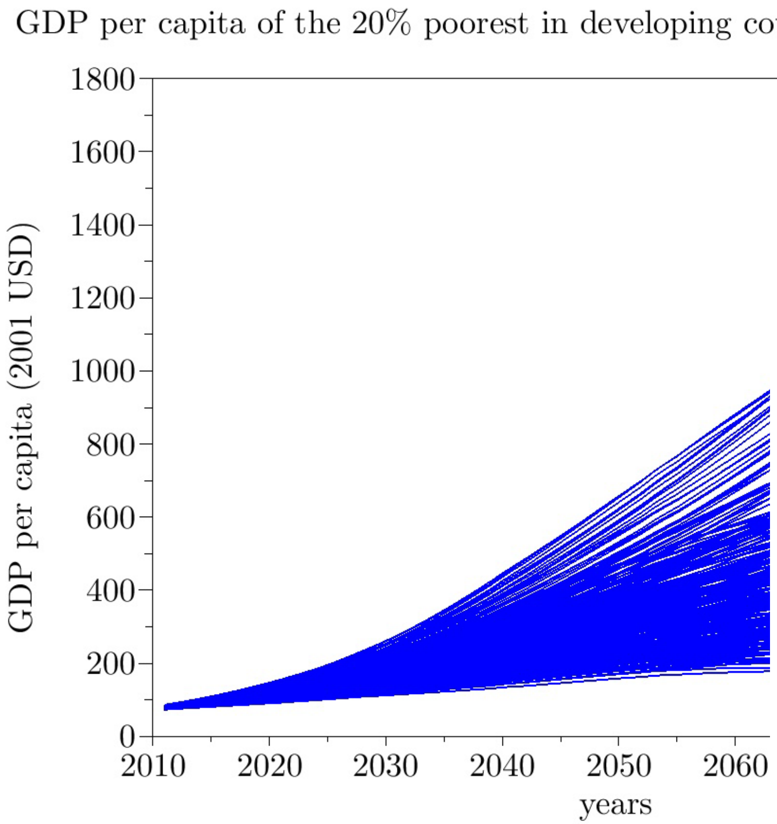
A model to explore the “scenarios space” of socio-economic uncertainties

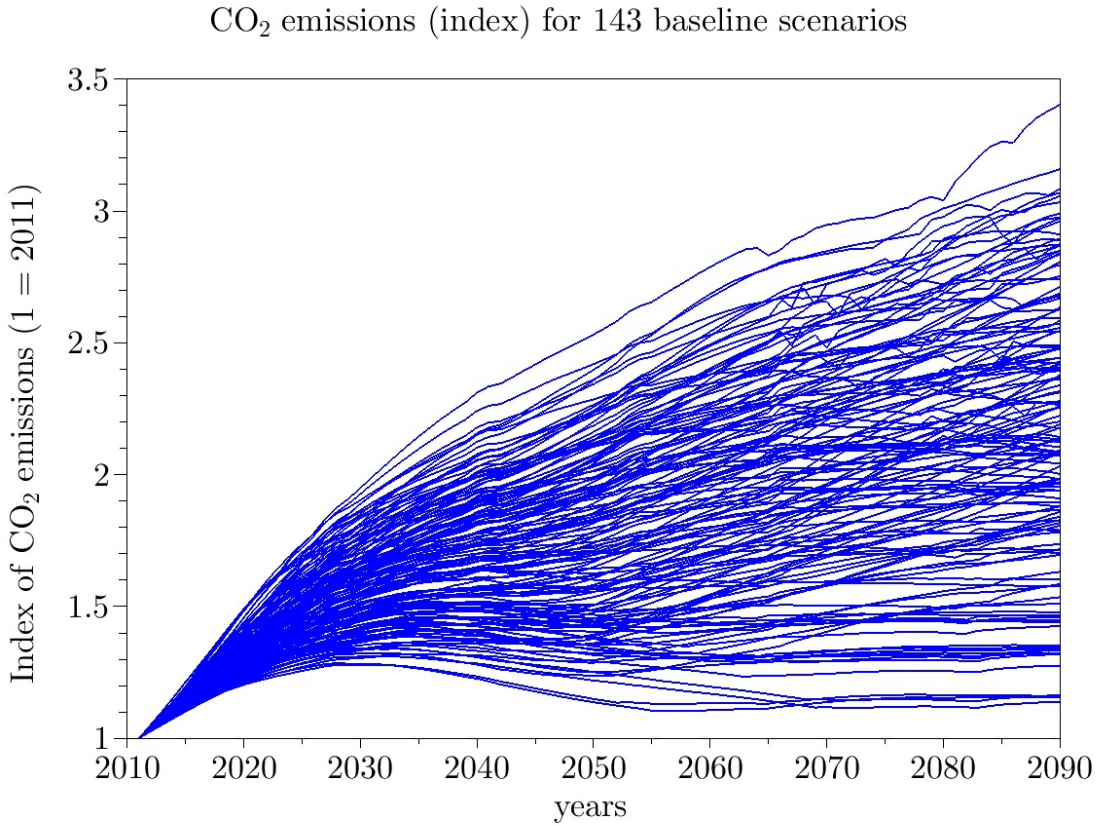
- A database of scenarios combining alternative assumptions on a large number of model parameters (Rozenberg et al., 2012)
  - Growth drivers (active population and labour productivity growth) of rich countries (slow; medium or fast)
  - Growth drivers (active population, productivity catch-up) of low income countries (slow; medium or fast)
  - Labour markets rigidities in developing countries (low or high)
  - Availability and costs of coal and unconventional oil/gas (low availability or high availability)
  - Evolution of consumption preferences (energy sober or energy intensive)
  - Speed of induced energy efficiency (slow globally; fast in rich countries but slow catch-up in low-income countries; fast globally)
  - Costs and potentials of low carbon technologies (low availability or high availability)

→432 scenarios over 2001-2100

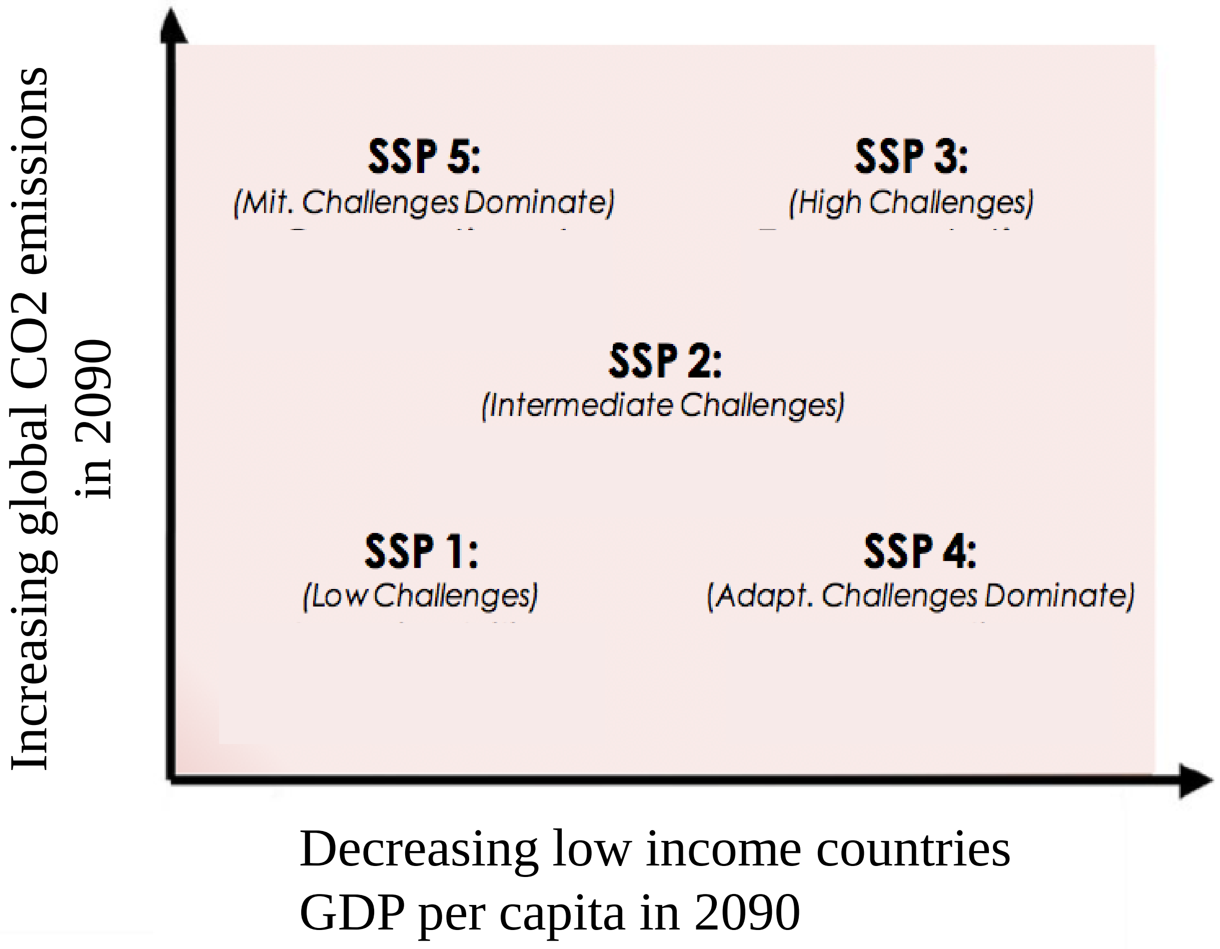
A database of socio-economic scenarios

Some illustrative results (extractions from the database of scenarios):

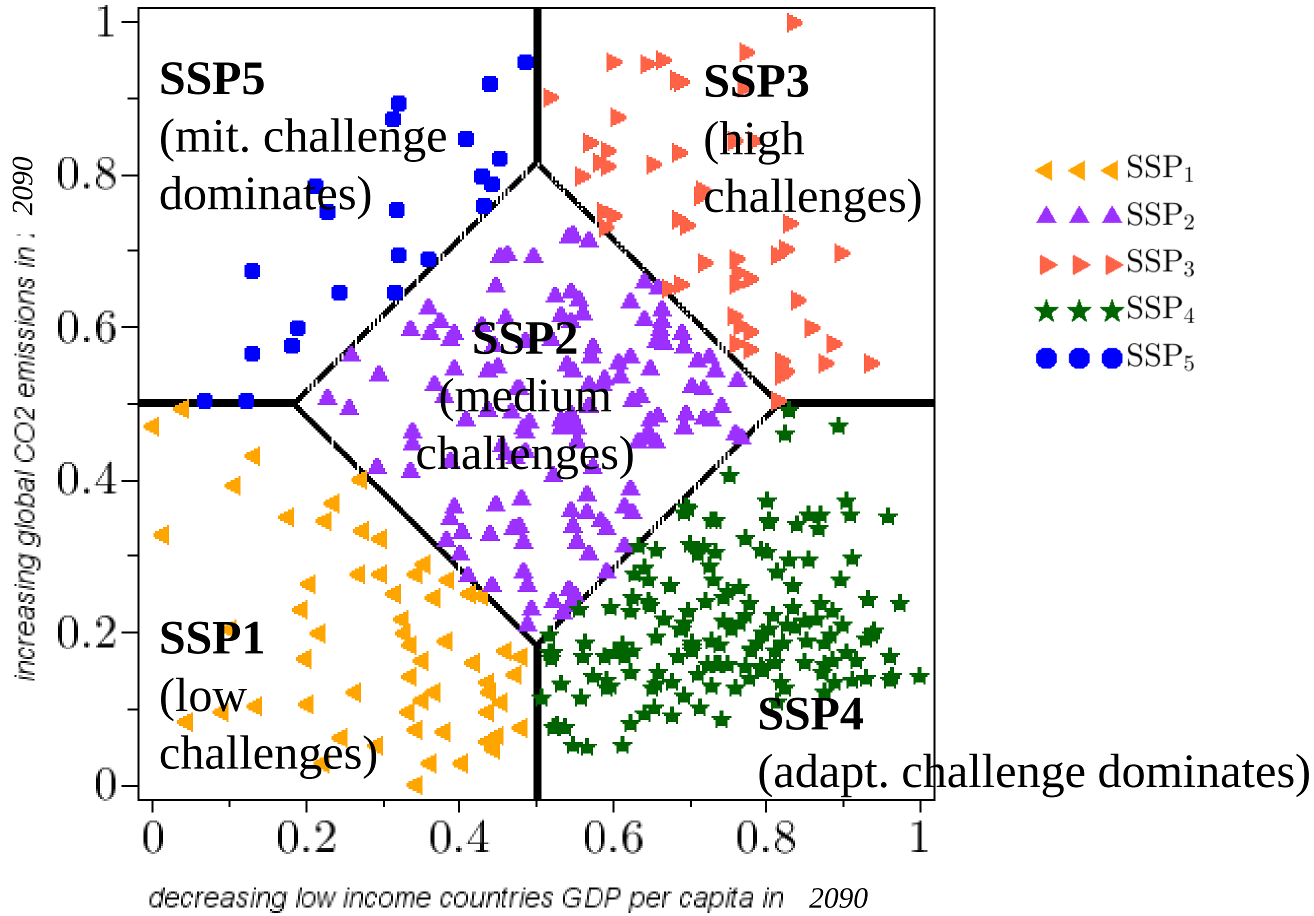




Mapping the scenarios into the « SSP space »



Mapping the scenarios into the « SSP space »



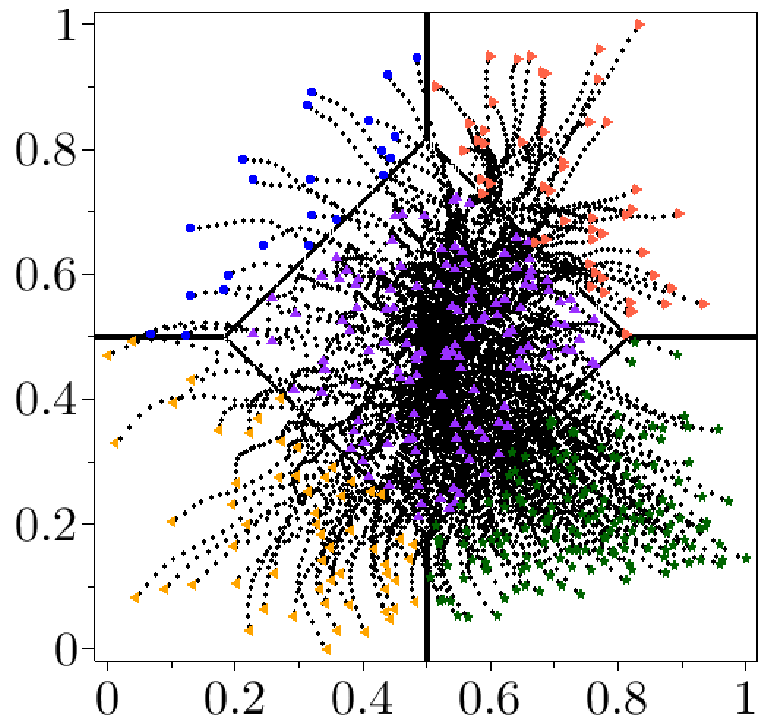
Distribution of 432 IMACLIM-R scenarios in the SSP scenario space

Visualizing the scenarios dynamics

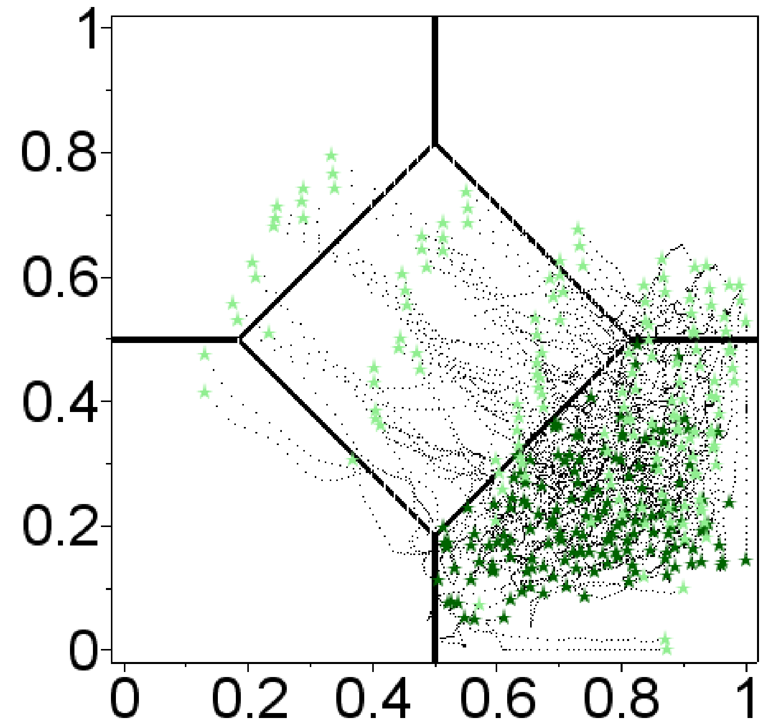
- Compare the performance of any individual model run against the ensemble mean

Visually, one can trace these pathways by performing the transformation :

$$\forall t, X_t = \frac{x_t - \overline{x_t}}{\max(x_T) - \min(x_T)} + \frac{\overline{x_T} - \min(x_T)}{\max(x_T) - \min(x_T)}$$

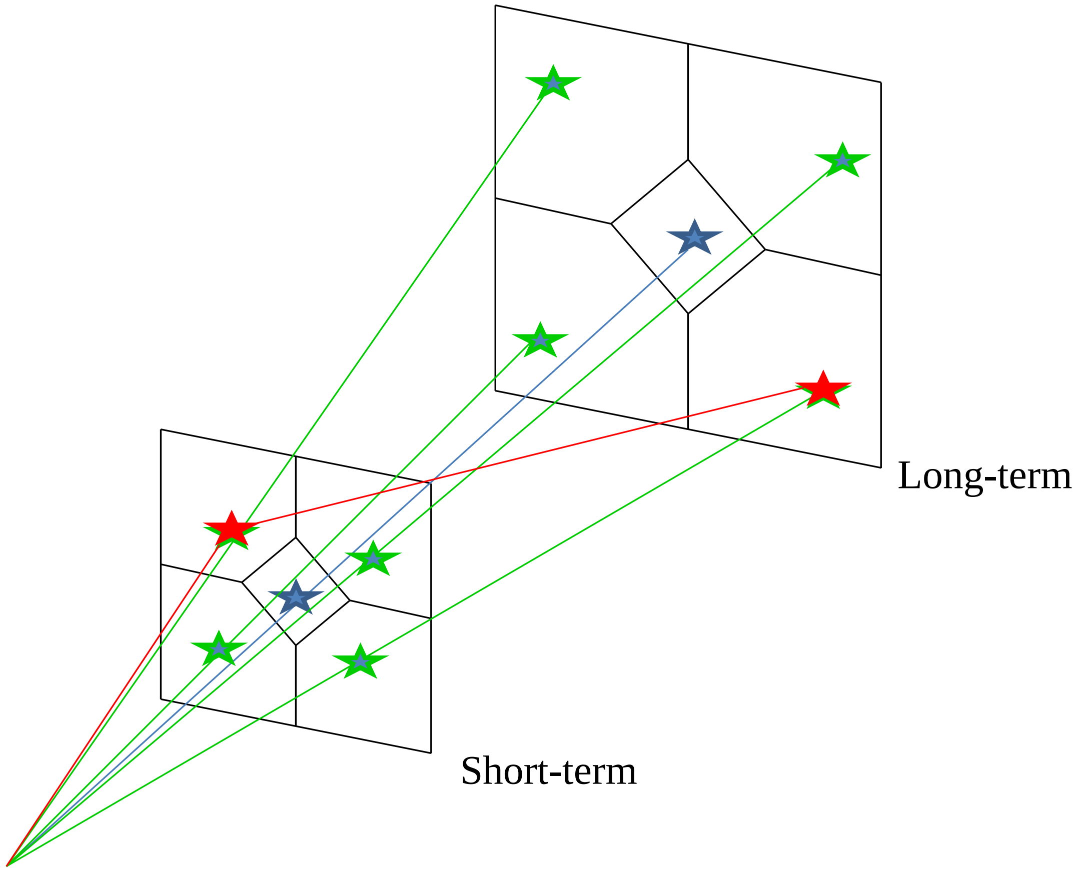


$$\forall t \in [2020 - 2090],\ Y_t = \frac{x_t - \min(x_t)}{\max(x_t) - \min(x_t)}$$



Scenarios (in)stability

A scenario, classified as a particular type of SSP in the short term (through 2025), is stable if it retains its classification over the long-term (through 2090).



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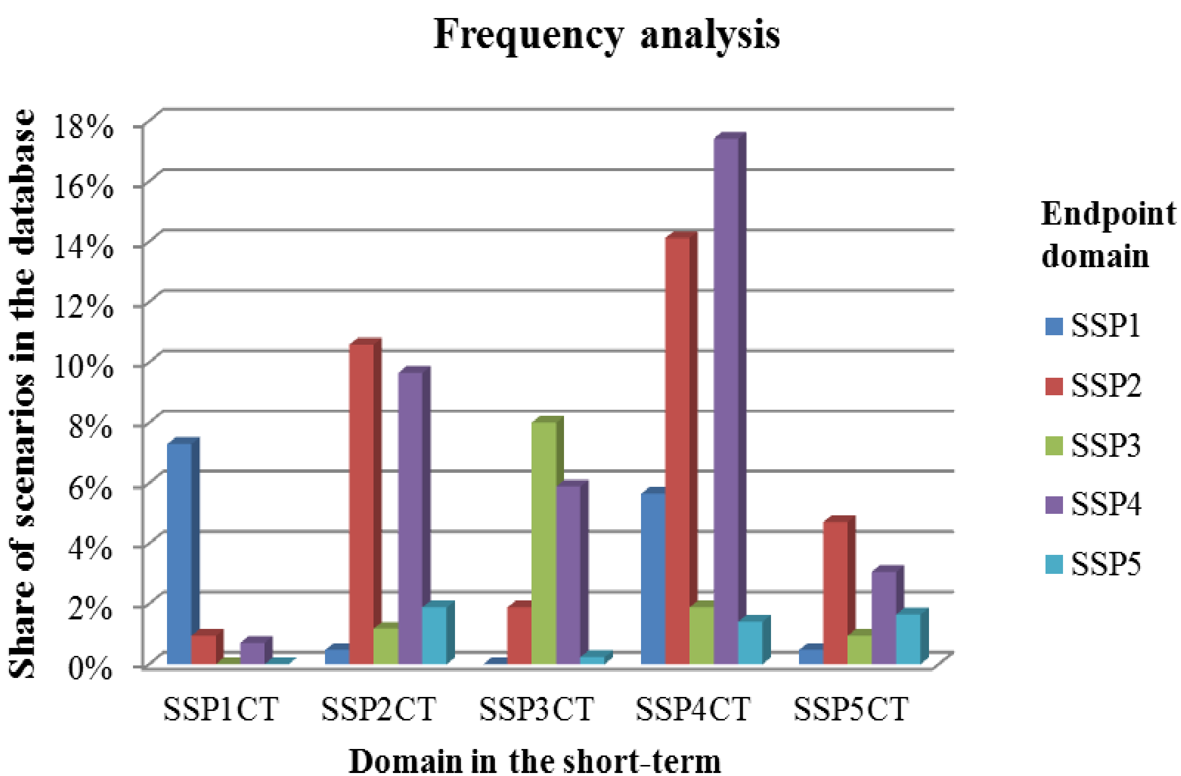
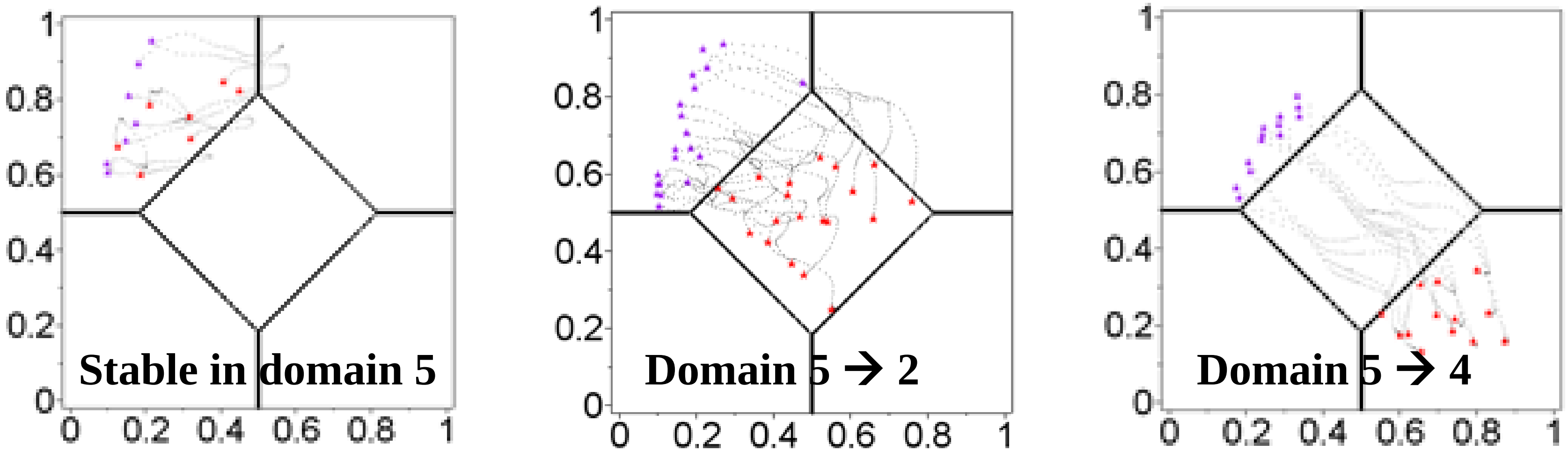


A majority (55%) of scenarios are unstable.

- Low challenges scenarios (SSP1) are very stable (82%)
- High mitigation challenges and low adaptation challenges scenarios (SSP5) are very unstable (15%)

Understanding scenarios (in)stability

PRIM analysis to uncover the main scenarios drivers



	Leader growth	Low income countries catch up	Unconventional fossil fuels	Behaviors	Energy efficiency	Availability of low carbon technologies	Labour rigidities in low income countries
5→2	Low or medium	Fast	High	(Energy intensive)			Low
5→4		Fast	Low	Energy intensive	Low or mixed		Low
Stable 5	High	Fast	High				Low

To conclude:
1. A few take-away messages

- A new **dynamic analytical approach** for investigating a **large number of scenarios** generated by an IA model.

- Address two principal shortcomings of how **uncertainty** is traditionally handled in **IA scenario studies**, result of the prevailing practice of investigating **a small number of scenarios**:

1. the *ad hoc* nature of exploring vast socioeconomic uncertainties with only a small number of scenarios;
2. the conventional representation of alternative scenario typologies as “parallel universes”.

- A **majority** of scenarios in our database are **unstable** (move over time from one domain of the uncertainty space to another).

- Scenarios with high growth and high emissions in the short-term are particularly unstable: archetypes of the **“carbon lock-in” risk**.

To conclude:
2. Some limits to keep in mind

- It is only a model
- Only a small sub-space of « future pathways » was explored
- No « surprises » were included

- The difficulty to deal with « policies »
  - The alternative assumptions made for model parameters can be interpreted as policy levers/choices
  - Still, no explicit climate change mitigation policies included (e.g. no carbon price)

To conclude:
3. Areas for further work/collaborations

Work in progress…

- Further exploration of the "carbon lock-in" issue with the scenarios database
  - Dates when given "carbon budgets" are exhausted in these reference pathways

- With the dynamic approach new policy relevant research questions become possible for investigation:
  - Can we know if we are on a desirable (e.g. the SSP1 domain) or undesirable (e.g. the SSP3 domain) scenario trajectory?
  - How can we change from an undesirable scenario trajectory to desirable one?

- Other databases of scenarios (policy scenarios, multi-model databases…), other questions

Thank you !

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