Enhancing the policy relevance of scenario studies through a dynamic analytical approach using a large number of scenarios

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Motivations

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," which provide little insight on possible socioeconomic conditions that could transform scenarios appearing to match one typology into another;

→These shortcomings may inhibit the policy relevance of IA scenario studies.

→ Develop a **"dynamic" approach** using a **large number of scenarios**.

A methodology for a dynamic approach

Summarized in 4 steps:

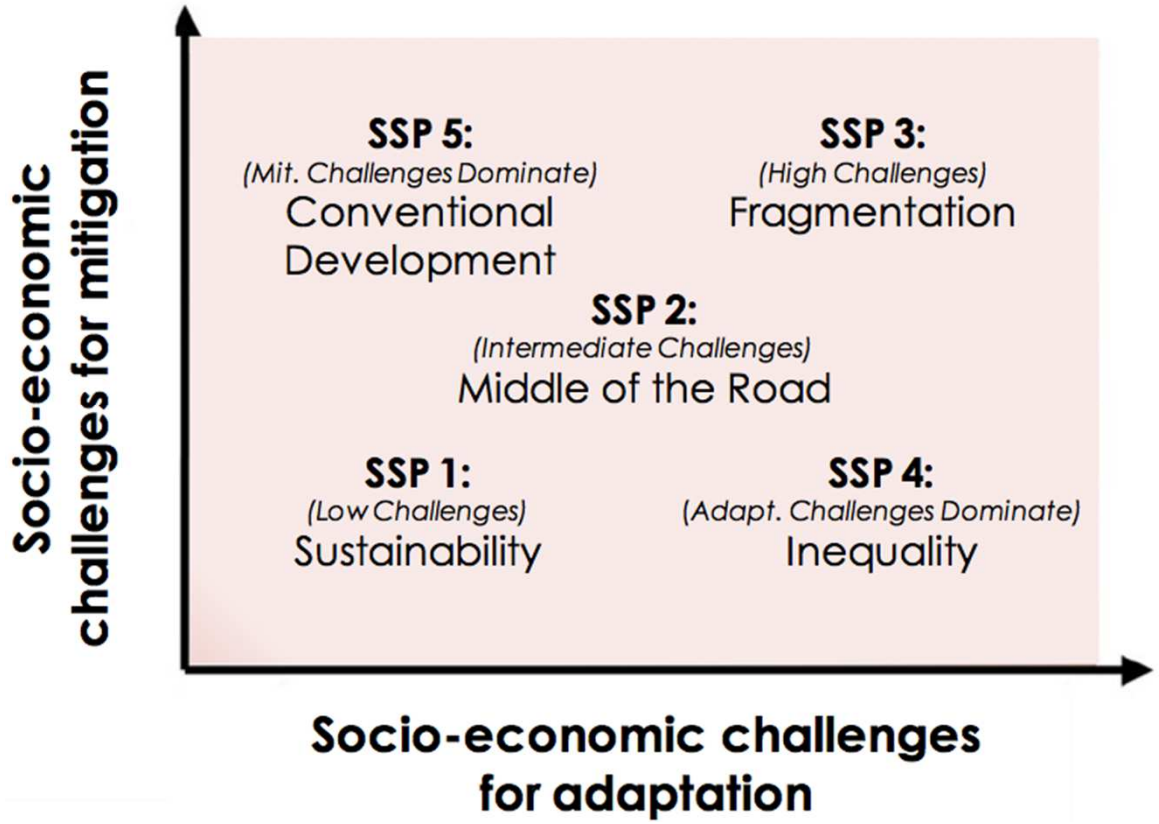
1. Develop or identify a scenario typology scheme

2. Generate a large number of scenarios

3. Develop indicators for classifying scenarios within the typology scheme

4. Develop an approach for inspecting scenario evolution within the typology scheme

1. Development or identification of a scenario typology scheme
2. Generation of a large number of scenarios
3. Development of indicators for classifying scenarios in the typology scheme
4. Development of an approach for inspecting scenario evolution



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

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- An IA model, Imaclim-R
  - Hybrid global CGE (12 regions, 12 sectors)
  - Endogenous energy markets
  - Endogenous and induced technical change
  - Explicit representation of energy technologies

- 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)
  - Labor markets flexilibty (low rigidities or high rigidities)
  - 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 2001-2090

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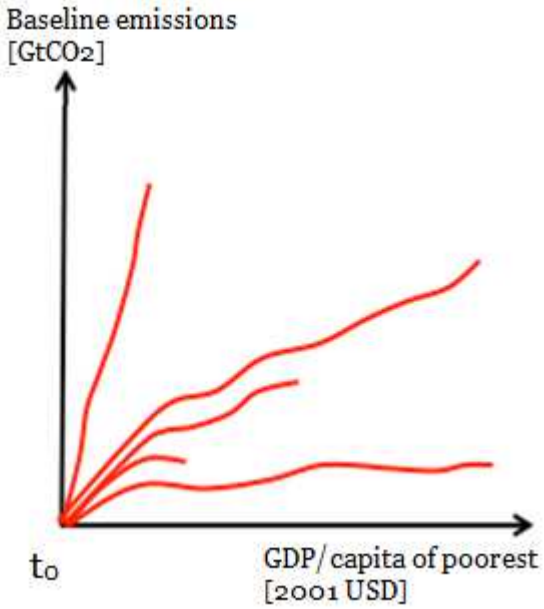
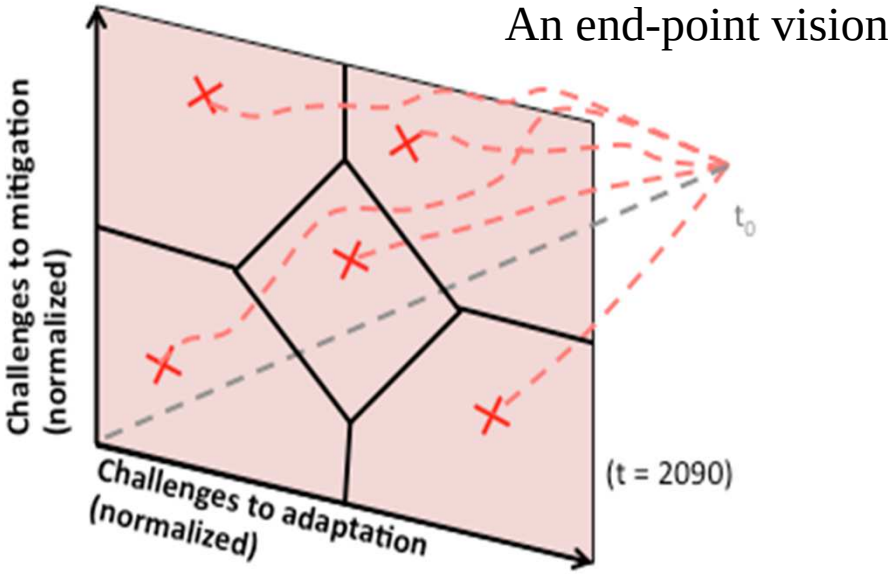
Interpreting the SSPs axes and domains, a possible illustration:

- Challenges to adaptation: the inverse of developing countries' GDP per capita in 2090
- Challenges to mitigation: global CO2 emissions in 2090
- Domains boundaries: relative to distribution of results, same size domains, diamond shaped SSP2 domain
- Normalization of indicators value



An end-point vision



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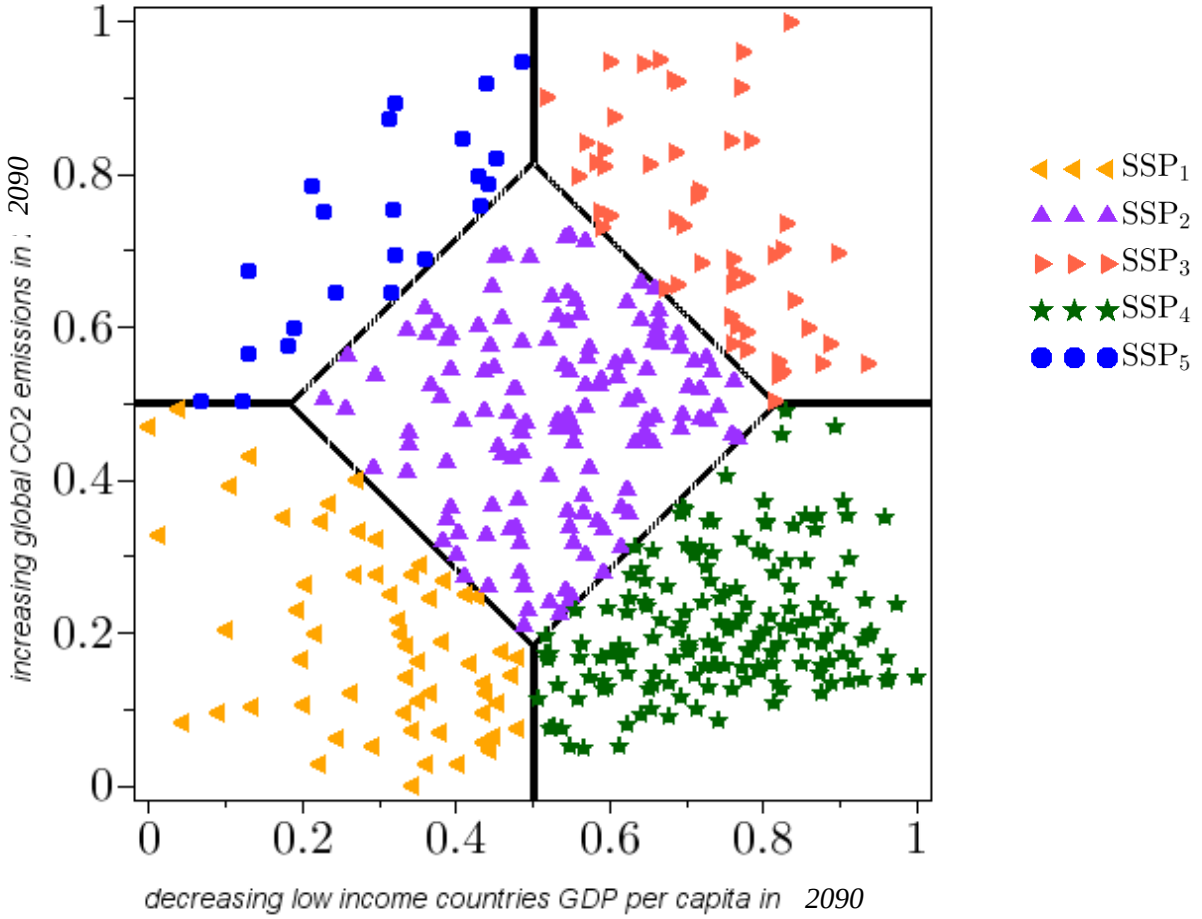

Distribution of 432 IMACLIM-R scenarios in the SSP scenario space

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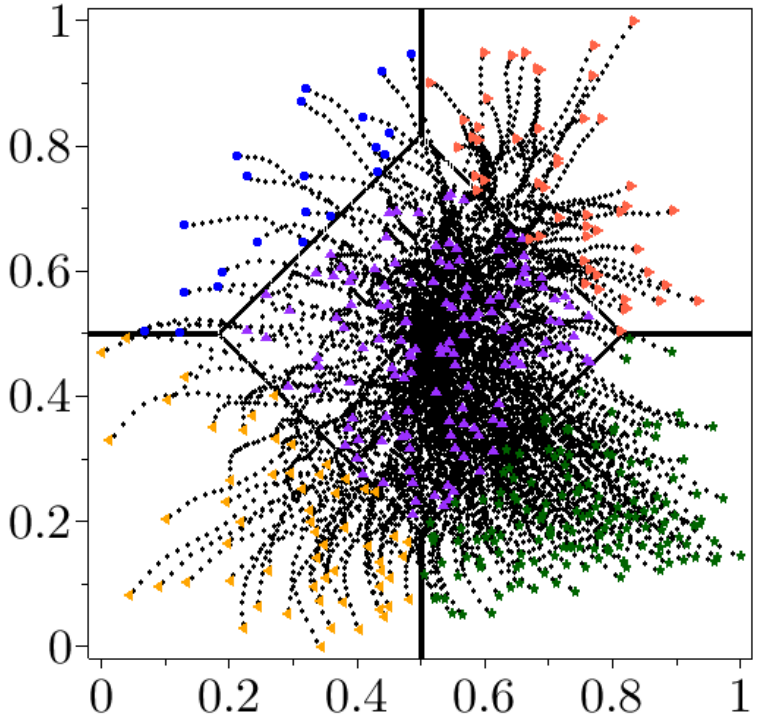
- Compare the performance of any individual model run against the ensemble mean
  - All scenario trajectories have the same starting point
  - With each progressive time step, individual scenario runs spread away from the ensemble mean across the five SSP domains

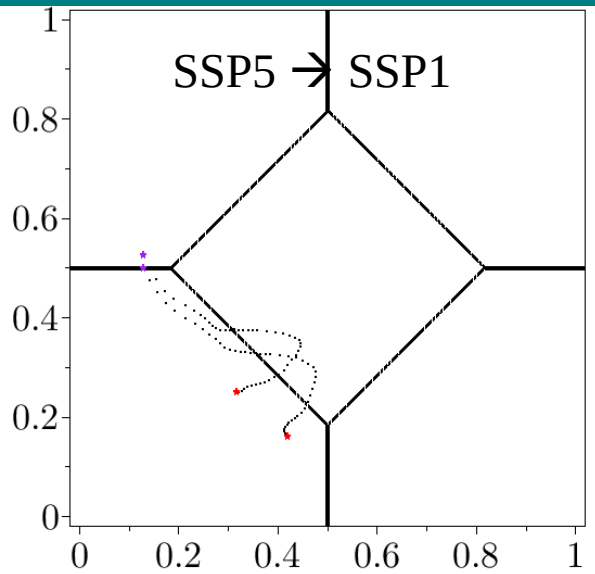
Visually, one can trace this divergence by performing the transformation :

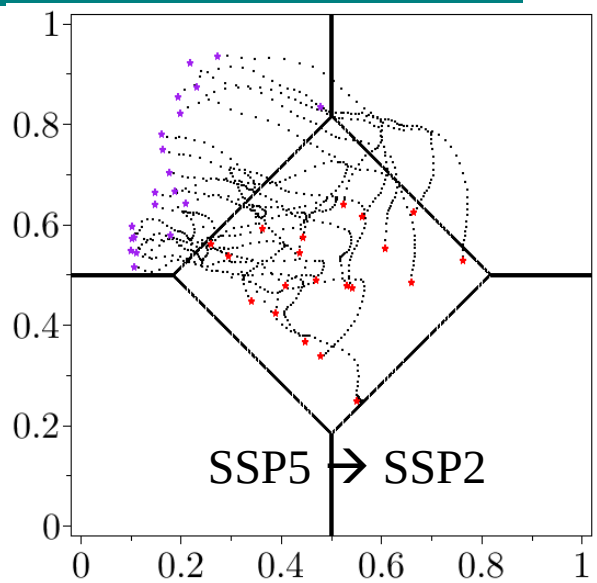
$$\forall t, X_t = \frac{x_t - \bar{x_t}}{\max(x_T) - \min(x_T)} + \frac{\overline{x_T} - \min(x_T)}{\max(x_T) - \min(x_T)}$$

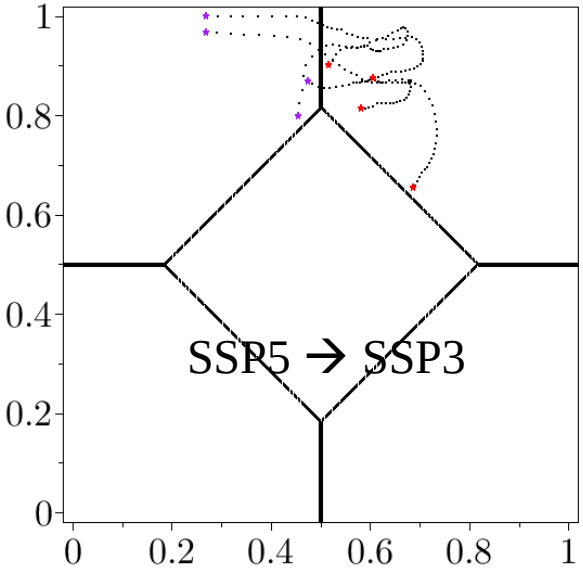


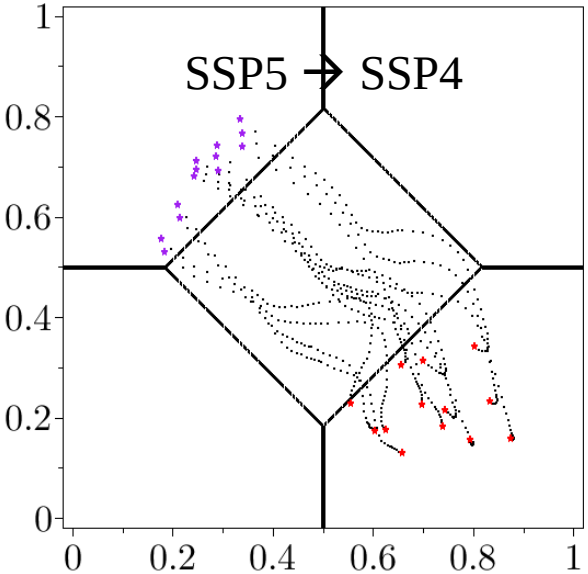
Example application:
The (in)stability of global socioeconomic scenarios

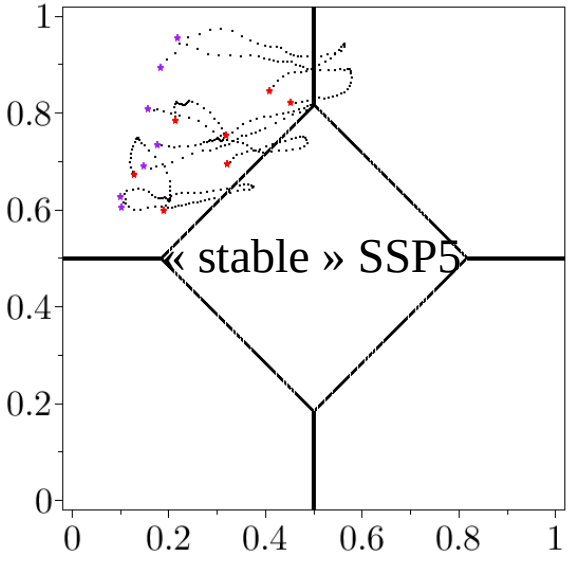
Where do scenarios that are in the SSP5 domain on the short term (2025) end-up in the longer term?











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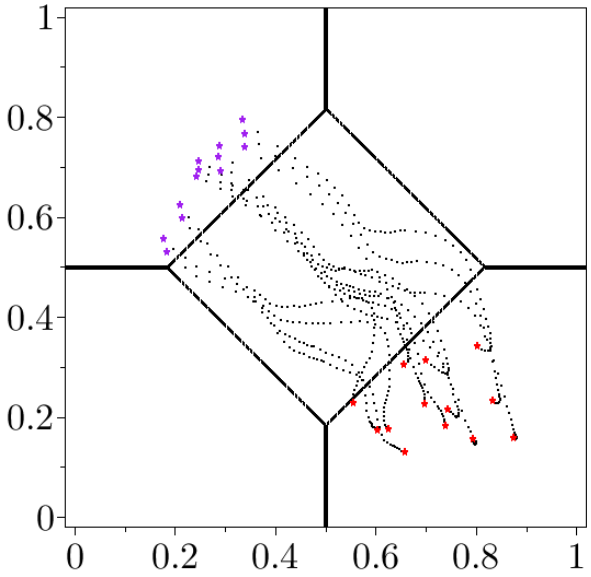

SSP5 → SSP4

- Focusing on scenarios that start with high GDP/capita and high emissions (relatively to the ensemble mean), and where emissions are reduced on the longer term at the expense of GDP/capita in low income countries.

- Using a scenario discovery algorithm (modified version of the Patient Rule Induction Method) to uncover their common drivers:

  - Fast convergence of low income countries;
  - Flexible labor markets;
  - Slow energy efficiency in low income countries;
  - Energy intensive behaviors;
  - Low availability of coal and unconventional fuels.

Conclusion

- A new dynamic analytical approach for investigating a large number of scenarios generated by an IA model.
- Some exploratory results demonstrating that global socioeconomic scenario typologies are not necessarily stable : the typology of some scenarios can change over time.
- This dynamic analytical approach holds promise for addressing the principal shortcomings of traditional IA scenario studies, where uncertainty is explored with a small number of scenarios.
  - The exploration of uncertainties is substantially more comprehensive; the policy-relevance and credibility of IA scenario studies could be enhanced.
  - 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?
- Work in progress…
  - other databases of scenarios (policy scenarios, multi-model databases…), other questions

Thank you !

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