Reconciling information from alternative climate-economic models: a posterior integration approach

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Background

Studies of complex systems are non-separable from the analysis of partial and imprecise information received from alternative sources. A system analysist deals with a set of ensemble outcomes which needs to be integrated into one estimate in order to install the ensemble into the modelling chain or provide support for the informed decision making.

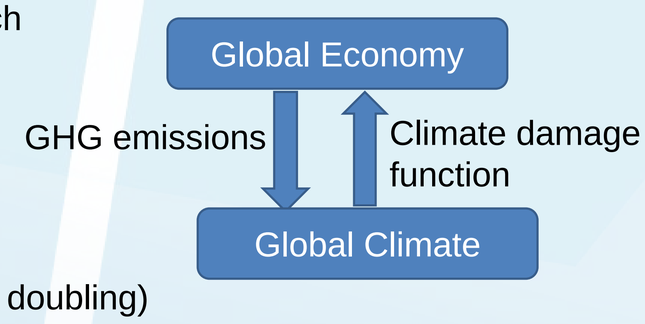
Integration Method

We suppose that several independent models $1, \dots, n$ are used to estimate a deterministic element z (the true value of the output variable of a complex system) and give some probability π_i to z on Z. The **posterior integration method** (Kryazhimskiy, 2013) is based on the assumption that model outcomes are mutually compatible, i.e. we should observe identical outcomes after the use of model ensemble. Formally, the **product probability distribution** of original estimates is

$$\pi(z) = \frac{\pi_1(z) \cdot \pi_2(z) \cdot \dots \cdot \pi_n(z)}{\sum_{z' \in Z} \pi_1(z') \cdot \pi_2(z') \cdot \dots \cdot \pi_n(z')}, \qquad z \in Z$$

Structural Dynamic Economic Model (SDEM)

- SDEM is an actor-based climate-economy model
- it does not require substantial computational resources in simulations
- *climate module*: dynamic equations for CO_2 concentration and global mean surface air temperature
- *economic module*: system dynamic approach



Input

(sensitivity of climate system to CO_2 doubling)

- **Model 1**: a log-logistic distribution (fat-tailed)
- **Model 2**: a triangular distribution (thin-tailed)

Scenarios

- **Business-as-usual scenario**: without introducing carbon tax or mitigation
- **Mitigation scenario**: under global carbon tax 15 EUR/tCO_2 (in 2010 prices; harmonized worldwide; constant over time)

Output

- atmospheric **CO2 concentration**, ppmv
- global mean surface air **temperature** increase, °*C*
- global carbon **emissions**, $GtCO_2$/year
- the output of the global **economy** corrected by the Weitzman climate damage function, trln EUR2010/year

Findings

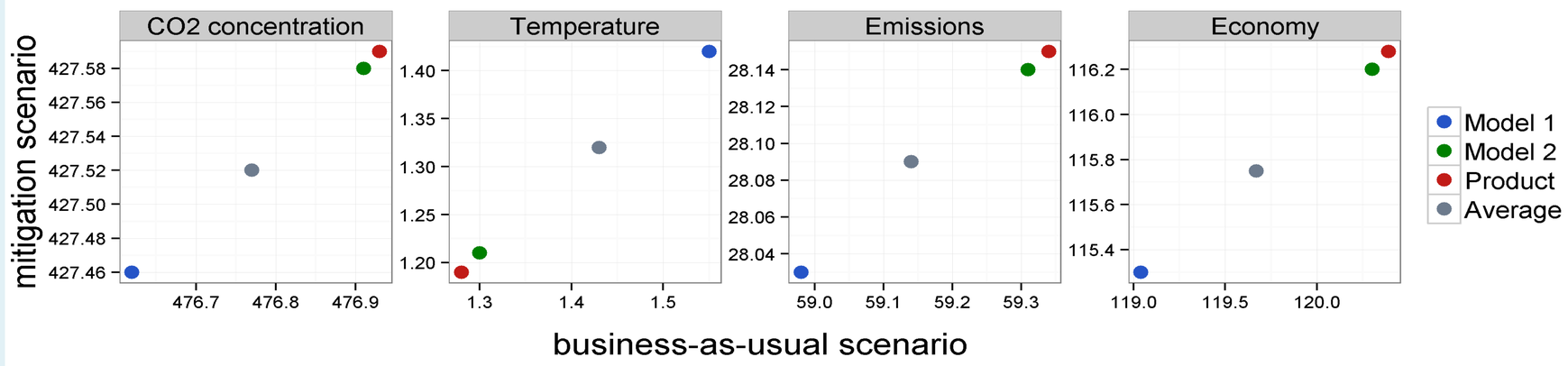
- **Product of original estimates shows that models reconcile to less extreme predictions on the development of the climate-economic system**

  Original model-based distributions are harmonized by posterior integration method. In the integrated model mean estimate of the global temperature increase is reduced, CO_2 concentration and emissions are expected to grow. Along with this, expected economy growth is higher than each individual model predicts. These effects hold in both scenarios - with and without introduction of carbon tax.

- **The range of predictions can expand after integration of original estimates, depending on the way how these estimates were combined**

  Taking average from the model-based distributions can be viewed as an alternative method. It's not necessary that qualitative results will coincide with results from the posterior integration method

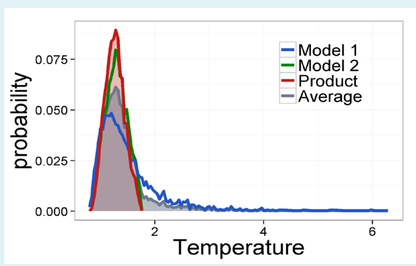
Mean estimates of output variables in 2050



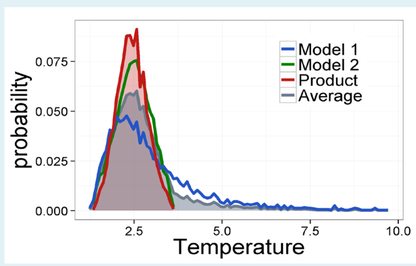
- **Product of original estimates is more informative**

  The standard deviation of the product distribution is less than in the original model-based estimates in both scenarios. This means that original probability distributions complement each other (in the context of posterior integration method). From the assumption of posterior integration method original models should be mutually compatible and reconciled on the identical outcomes, consequently their product distribution is not skewed.

Business-as-usual scenario,



Business-as-usual scenario,



References
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Kovalevsky, D.V., Hasselmann, K. (2014): Assessing the transition to a low-carbon economy using actor-based system-dynamic models. Proceedings of the 7th International Congress on Environmental Modelling and Software (iEMSs), 15-19 June 2014, San Diego, California, Vol. 4, 1865-1872

Acknowledgements
This work received support from the EU FP7 project COMPLEX (grant no. 308601)

COMPLEX
Knowledge Based Climate Mitigation Systems for a Low Carbon Economy