An interactive model revived with a new scalable codebase

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[for "Methodological" session 11, also relevant to 16 ("Stakeholder…") and 2 ("Stocktake")]

Longtime participants of IAMC may recall the interactive "Java Climate Model" (JCM). This evolved since year 2000, initially as a graphical web tool enabling people to explore climate stabilisation pathways and within these equitable sharing of emissions. At that time IPCC was only mandated to investigate no-policy scenarios, and used relatively simple models (parameterised to complex models), which could be re-implemented by JCM to fill the gap for lower policy pathways. The model incorporated a full set of gases, land-use change and climate-carbon feedbacks, coupled with regional socioeconomic scenarios.   Development moved via DEA-CCAT Copenhagen, UNEP-GRID Arendal, KUP-U-Bern, TECLIM-U-Louvain, IVIG-UF-Rio deJaneiro, and is continued independently by the author (in Belgium).

While the initial focus was an interactive tool to facilitate stakeholder dialogue, it was discovered that its rapid robust response to diverse combinations of hundreds of parameters was also useful for probabilistic analysis. Iterative algorithms to calculate inverse emissions pathways allowed exploration of how diverse global stabilisation goals - defined by concentration, forcing and temperature, translated to uncertainty in emissions or impacts.   Thus JCM provided the first (in 2003) probabilistic assessment of pathways stabilising at 2C. This facility to vary goals, including forcing "levels", also helped its authors contribute to the IPCC process for developing new scenarios, which led to our current parallel structure of RCPs and SSPs (and also, inter alia to the creation of the IAMC).
Other research applications of JCM included attribution of historical contributions to climate warming, including uncertainty regarding LUC emissions, exploring sensitivity to assumptions within economic risk analyses, and the importance of including international aviation (including non-CO2 forcing) within stabilisation scenarios.

More recently (2016+) JCM was applied to a probabilistic analysis of regional emission pathways within <1.5° or <1.75°C goals, and further developed to include bottom-up demographic and socioeconomic modules for exploring potential future human migration in the context of climate change. Adjusting parameters of these modules interactively also illustrates sensitivity to assumptions regarding changing patterns of future development, and scenarios including SSPs. In reality we don't choose world-views, but cope with a diverse blend, and policy response might be modelled better by "fuzzy control" than optimising foresight (maybe response to the pandemic provides a learning opportunity, given its accelerated timescale compared to climate?), we need flexible structures to model such feedbacks. .

Development of the model stalled, however, as it became increasingly difficult to keep an interactive version publicly available, due to the withdrawal of browser support first for java applets, then later for java "webstart". JCM worked well with that platform, but such complex scientific tools were stranded as the business models of big software companies shifted towards mobile devices and cloud servers.

So to revive the original concept, to enable anybody to quickly explore the sensitivity to diverse options and uncertainties, required a new foundation. This year the codebase is being rewritten in the language Scala-3 (new May 2021). This compiles to both the JVM desktop platform , efficient for systematic analysis such as probabilistic calculations, and in parallel to javascript for running interactively in a web browser. Scala's strong typing and functional style helps the compiler catch errors, thereby retaining the reliability of the model as the complexity of interactions and feedbacks grow, while the dynamic visual response to parameters also assists testing. Scala-3's new syntax aids code readability, including for scientists more familiar with "pythonic" style. A partial prototype is working, and the whole model should be back online this autumn, before this IAMC conference.

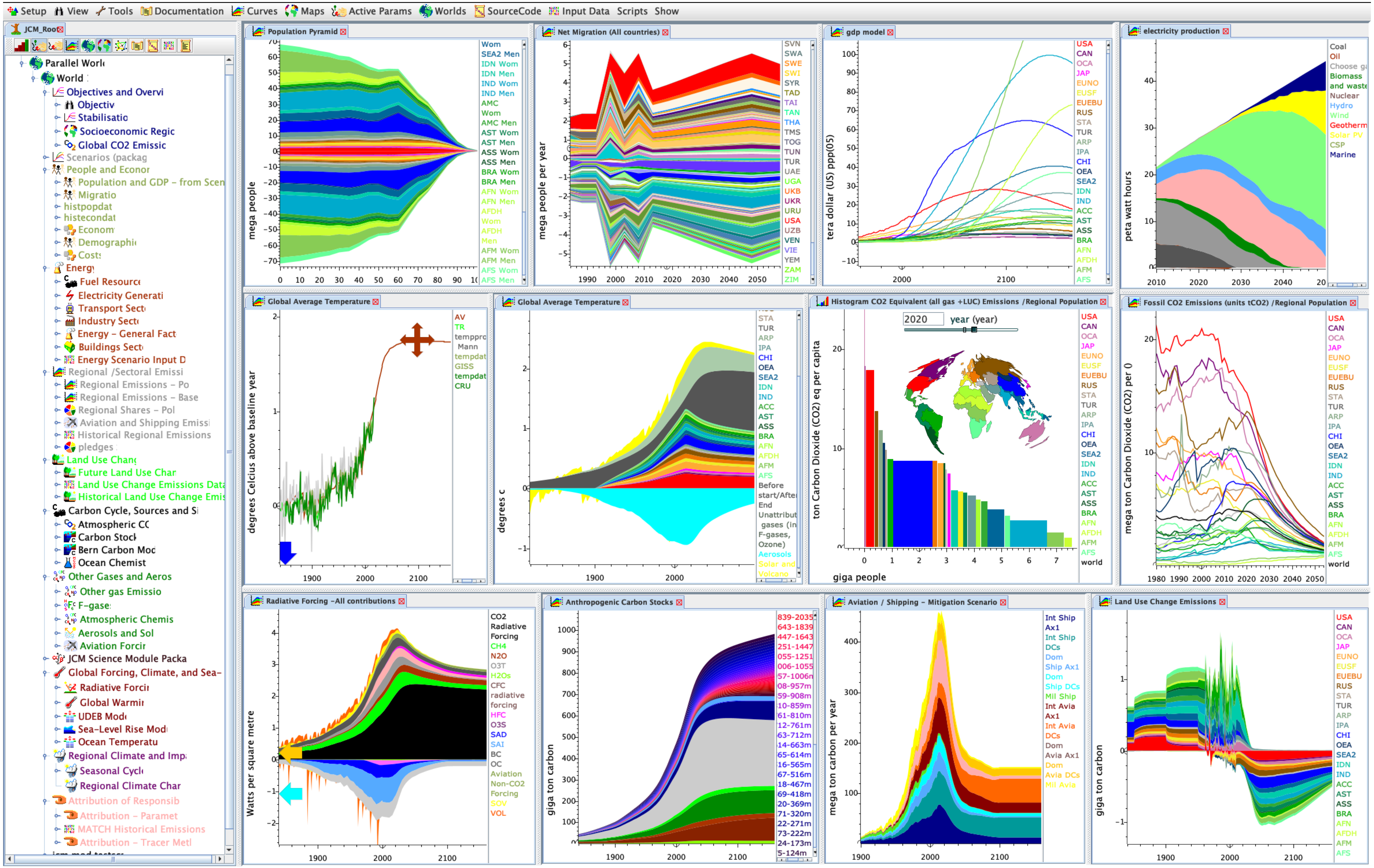

Fig 1: A snapshot of the model to illustrate range of topics. Clockwise from top-left: Demographic pyramid, Migration fluxes, GDP (PPP), Electricity Sources, Fossil CO2 per capita (curves / histogram), Land Use Change emissions, Aviation emissions, Anthropogenic Carbon stocks, Radiative Forcing, Temperature, Attribution of Warming. Most plots are based on a 1.75°C stabilisation scenario. Readers who know this model may observe similarity to older versions - which is a convenient test during conversion to Scala3 (code behind this snapshot is about half rewritten). Before the IAMC workshop plots should be updated and a new web interface online.

With a new language, the model needs a new name. The prototype's working name "Scalable World Interactive Model" adapts the concept "scalable" (reflecting the language) to apply across several dimensions - notably across time, space (regional detail), sectors, and complexity level. JCM always portrayed the future continuing smoothly from the past, with curves from about 1750 to 2300. This is not trivial, as IAM scenarios often differed from reality in the near-term (even without surprises such as COVID). Including both short-term fluctuations and regional socioeconomic detail helps people see how current trends fit (or not) within long-term pathways, but we cannot sensibly model such detail over three centuries neither for past (as we lack data) nor for future (considering society changes), yet longer timescales remain essential for stabilisation of impacts such as sea-level rise, and biogeochemical and demographic systems. For this reason, and for efficiency, the new code structure enables varying time-steps and regional aggregation, so users may "zoom" in and out. Currently it calculates nationally, but larger nations should be subdivided to better represent diversity, both regarding climate and demographics. Considering challenges of interpreting diverse subnational data, a structure should let users incorporate local data to improve extrapolations from global datasets.

Scalability also applies to varying complexity, so the interface supports diverse users from students to experts, and provides filters to focus on specific questions. While scientists are encouraged to concentrate their expertise, we should always recall that any chain (of assessment) is only ever as strong as its weakest link, and sometimes zoom back out to check the whole system. For this reason, interactive models (parameterised using other models), still play an important role despite increased computing power. Such tools help us prototype experiments and projects for more complex models. The ultimate IAM remains the global network of human heads, yet human-model interfaces remain a weak link.

Regarding near-term development, the global stocktake over the next two years suggests reviving the original speciality of this model - equitable pathways towards stabilisation goals. If global negotiations progress well and focus shifts towards regional implementation, such models may help demonstrate how local efforts relate to comparable transitions in other continents. If, alternatively, focus shifts towards adaptation, the topic of climate-related migration may be pertinent, and a scalable regional structure also helps explore this. Other diverse applications can be envisaged, depending inter-alia on your interest and collaboration.