Understanding the Origin of Paris Agreement Emission Uncertainties

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General context

The Paris Agreement establishes a long-term temperature goal of holding global-mean temperature increase well below 2°C and pursuing efforts to limit it to 1.5°C relative to preindustrial levels. This climate goal is accompanied by a legally binding review architecture: every five years countries submit national climate plans, or **nationally determined contributions (NDCs)**, which themselves are not legally binding. These NDCs cover aspects of mitigation and adaptation, together with issues related to means of implementation, comparability and fairness, or sustainable development.

Alternating with the five-yearly submission cycle of NDCs, periodical **stocktaking** exercises of implementation progress will be carried out by the Parties to the Paris Agreement. These stocktaking exercises will assess the **collective progress towards the achievement of the agreement's goals** in light of the **best available science**. Here we provide new science presenting a systematic analysis of one of the key components of such a stocktaking exercise: estimating implied greenhouse gas (GHG) emissions under the current NDCs and assessing potential sources of uncertainty.

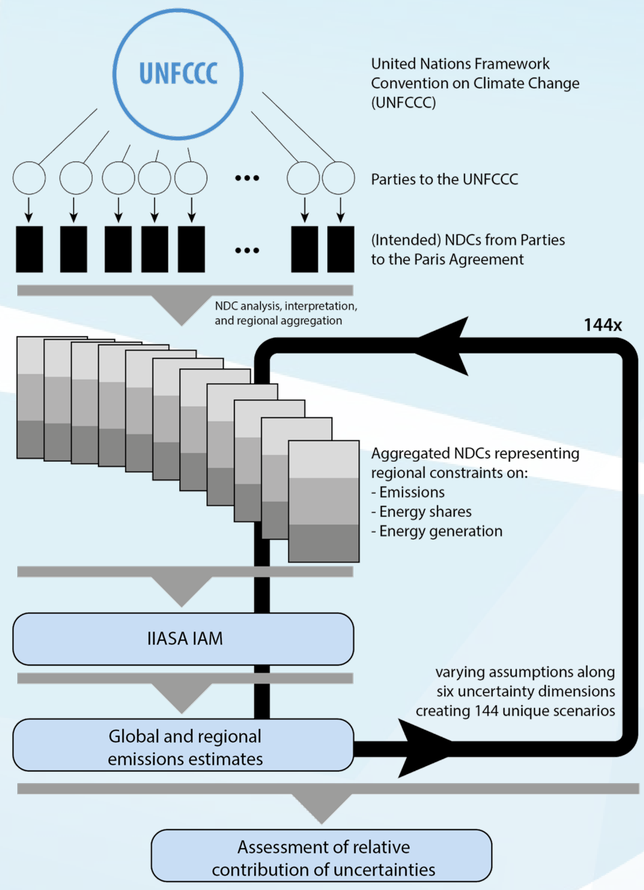
Approach & implementation

Six dimensions of uncertainty have been identified which influence emissions estimates under the NDCs (see Table on the right):

- **Socioeconomic baseline variation**
- **Uncertainty in historical emission inventories**
- **Uncertainty due to conditionality of NDCs**
- **Range specifications of targets**
- **Alternative energy accounting methods**
- **Attribution of non-commercial biomass**

Mitigation actions specified in the NDCs are identified and interpreted at the national level in light of these six uncertainty dimensions and then aggregated and analysed at the level of eleven world regions. Structured variation of the six uncertainty dimensions results in 144 unique interpretations of the NDCs mitigation targets.

The global and regional assessment of uncertainties was carried out with the IIASA Integrated Assessment Modelling (IAM) framework, which has the energy system model MESSAGE at its core. Three general types of constraints are imposed within MESSAGE based on how mitigation actions have been defined by NDCs themselves: (1) emission constraints, (2) energy share constraints, and (3) energy generation constraints.



SIX DIMENSIONS OF UNCERTAINTY

Socioeconomic baseline variation:
NDCs are assessed under three socio-economic futures from the Shared Socio-economic Pathways (SSPs). These three futures represent a quantification of a sustainable green-growth world (SSP1), a world with regional rivalry (SSP3), and a middle-of-the-road world following historical experience (SSP2).

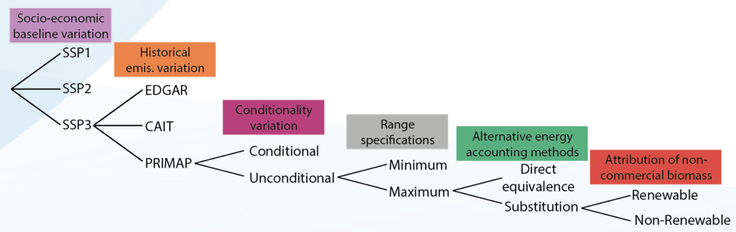
Historical emission inventories:
NDCs are assessed under three different historical emission datasets (PRIMAPHIST, EDGAR, CAIT).

Uncertainty due to conditionality of NDCs:
Two cases, one in- and the other excluding conditional actions, are assessed

Range specifications of targets:
Instead of providing one single target number, some NDCs propose a target range.

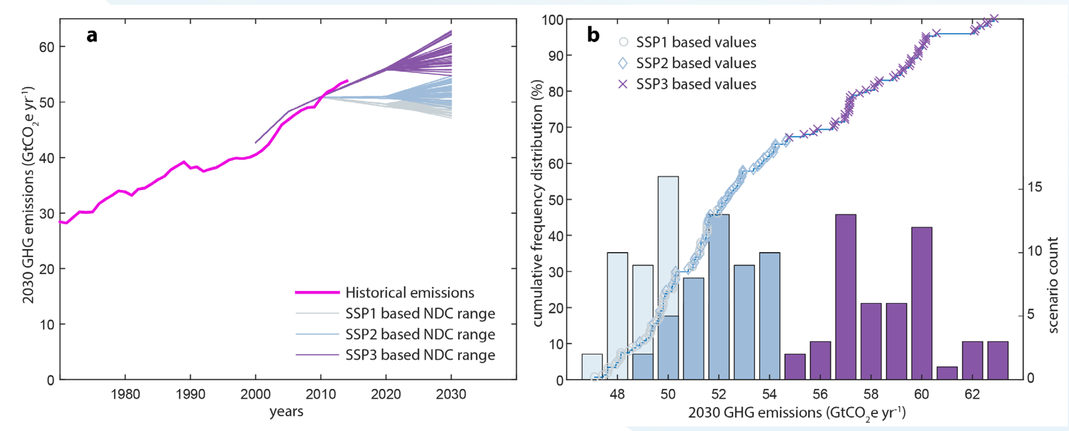
Alternative energy accounting methods:
The contributions of renewable and fossil energy sources can be compared by expressing renewable energies in 'primary energy equivalence'. Several methods exist to make this conversion. NDCs are assessed assuming two primary energy equivalence methods: the direct equivalence method, and the partial substitution method.

Attribution of non-commercial biomass:
Non-commercial biomass covers an important share of the overall energy demand in some regions. Whether this non-commercial biomass is counted towards renewable energies can influence how easily a country can meet an NDC target which aims at achieving a specific share of renewable energies. Two cases are assessed: either counting non-commercial biomass towards renewable primary energy or not.



Results

Estimated emissions for 2030 range from 47 to 63 $GtCO_2e\ yr^{-1}$, or -10% to +20% around our global median estimate of 52 $GtCO_2e\ yr^{-1}$ in 2030.



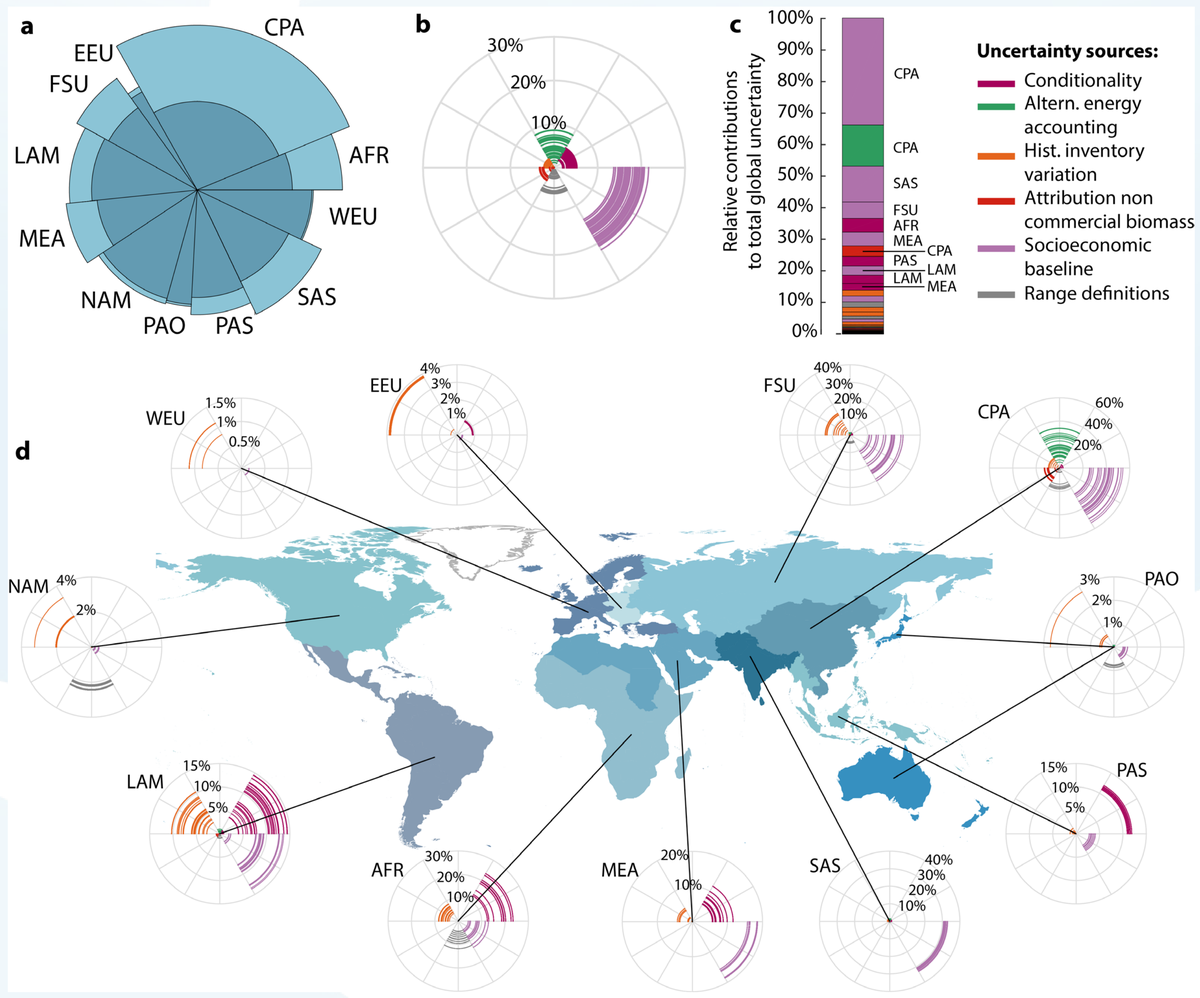
Ranking of uncertainty sources:

1. Socioeconomic baseline variation (ca. 15-20%)
2. Alternative energy accounting methods (ca. 0-10%)
3. Uncertainty due to conditionality of NDCs (ca. 0-5%)
4. Range specifications of targets (ca. 0-5%)
5. Attribution of non-commercial biomass (<2%)
6. Uncertainty in historical emission inventories (<2%)

With important variations across regions (see Figure on the right)

Options to reduce uncertainty:

The overall uncertainty can be reduced by about 10% through simple, technical clarifications regarding energy accounting rules or uncertainties in historical inventories. Remaining uncertainties depend to a large extent on politically valid choices about how NDCs are expressed, for example, climate actions expressed as intensity improvements. Because of uncertainty in economic development they appear to a large degree irreducible for as long as countries choose to express their actions in this way. Some uncertainties, like the conditions attached to particular NDC actions can be reduced by improving clarity of whether and when conditions are met. Providing greater clarity about the future availability of funding and other types of support by developed countries can limit this uncertainty. The wide range of irreducible uncertainties highlights that a thorough and robust process that keeps track of where emissions are heading becomes increasingly important.



*Overview figure: Regional contributions of uncertainty sources to overall NDC emission projection uncertainty. **a**, regional emissions contributions to global emissions and uncertainty under full implementation of current NDCs. Shadings show the minimum-maximum range per region; **b**, magnitude of uncertainty in 2030 per source relative to the median estimate; **c**, average contribution to full uncertainty range in 2030 per uncertainty source with the 10 most important contributions identified by region; **d**, as panel **b** but per geographical region.*

References

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