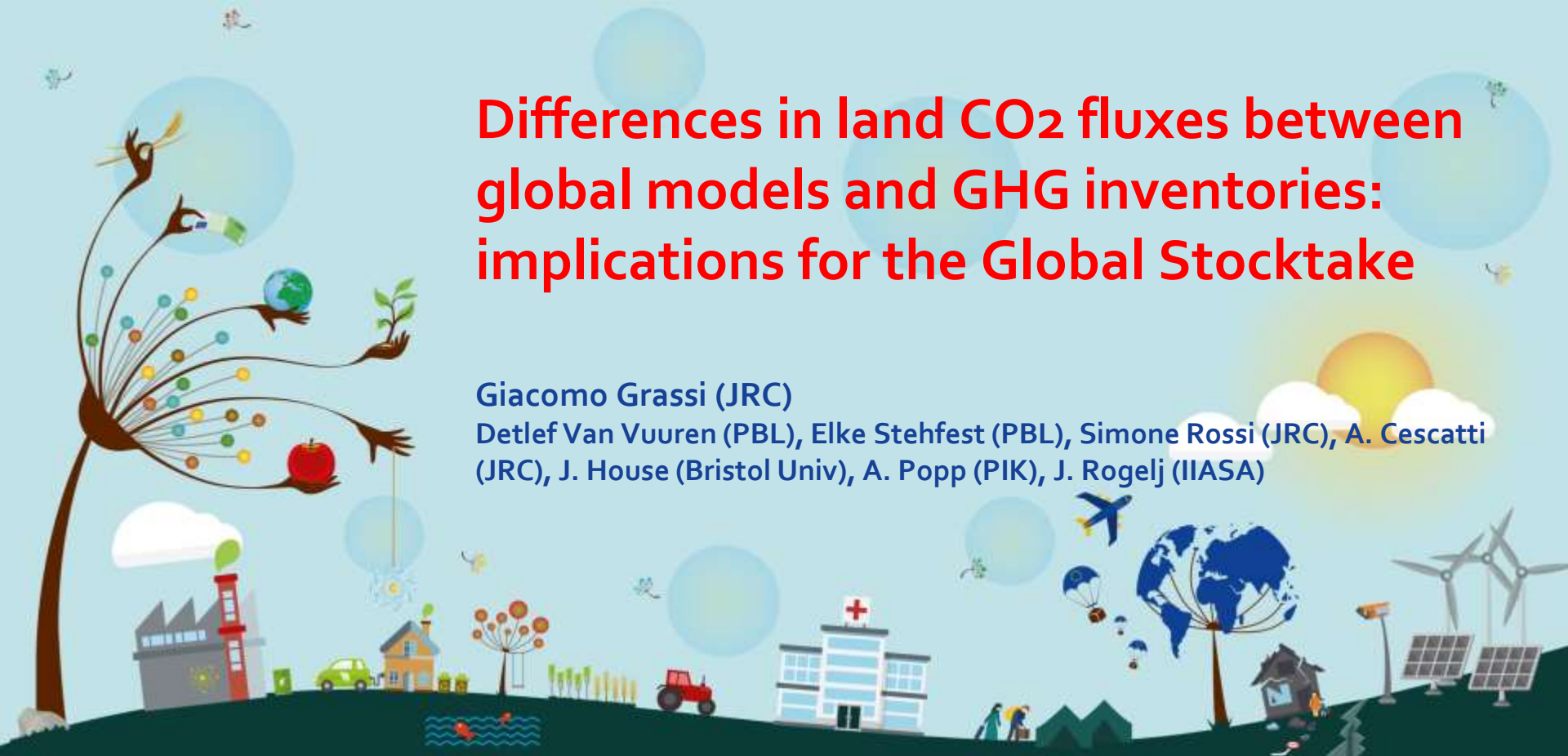


Differences in land CO₂ fluxes between global models and GHG inventories: implications for the Global Stocktake

Giacomo Grassi (JRC)

Detlef Van Vuuren (PBL), Elke Stehfest (PBL), Simone Rossi (JRC), A. Cescatti (JRC), J. House (Bristol Univ), A. Popp (PIK), J. Rogelj (IIASA)



COP25, IPCC SRCCL, 3rd December 2019



Can you tell me where I am? We're lost.

You are at Latitude 50 North and Longitude 4 East, at 100 m above sea level.

You must be a scientist. I asked you a simple question, you gave me too complex information and I'm still lost.

And you must be a policymaker. I gave you an accurate answer, but you don't understand ...



The Global Carbon Budget

(average 2007-2016 from Global Carbon Project 2017)

88%

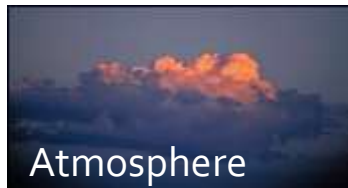
Fossil fuel emissions



Energy,
transport,
etc.

46%

Atmosphere



24%

Oceans



30%

Forests



The forest sink is complex to measure and only partly anthropogenic

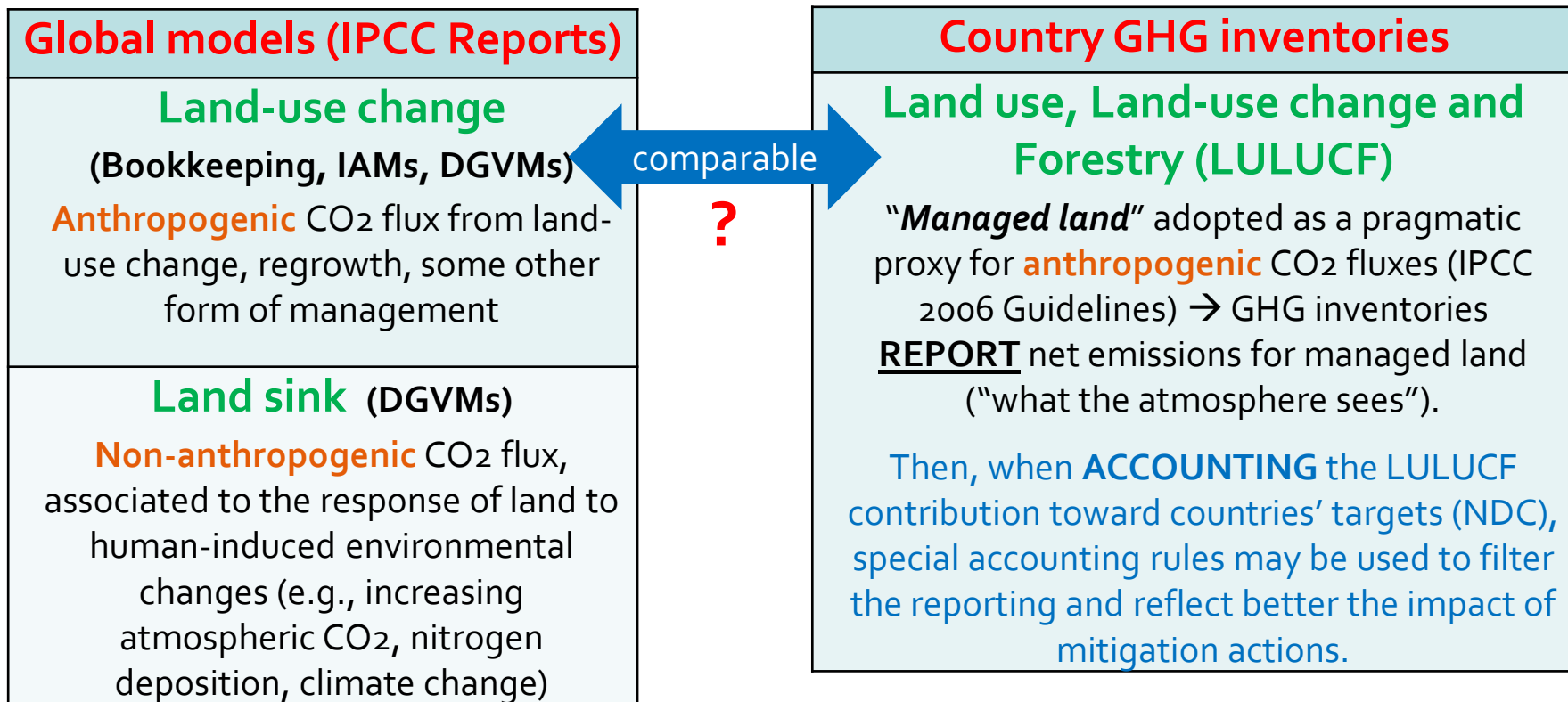
12%

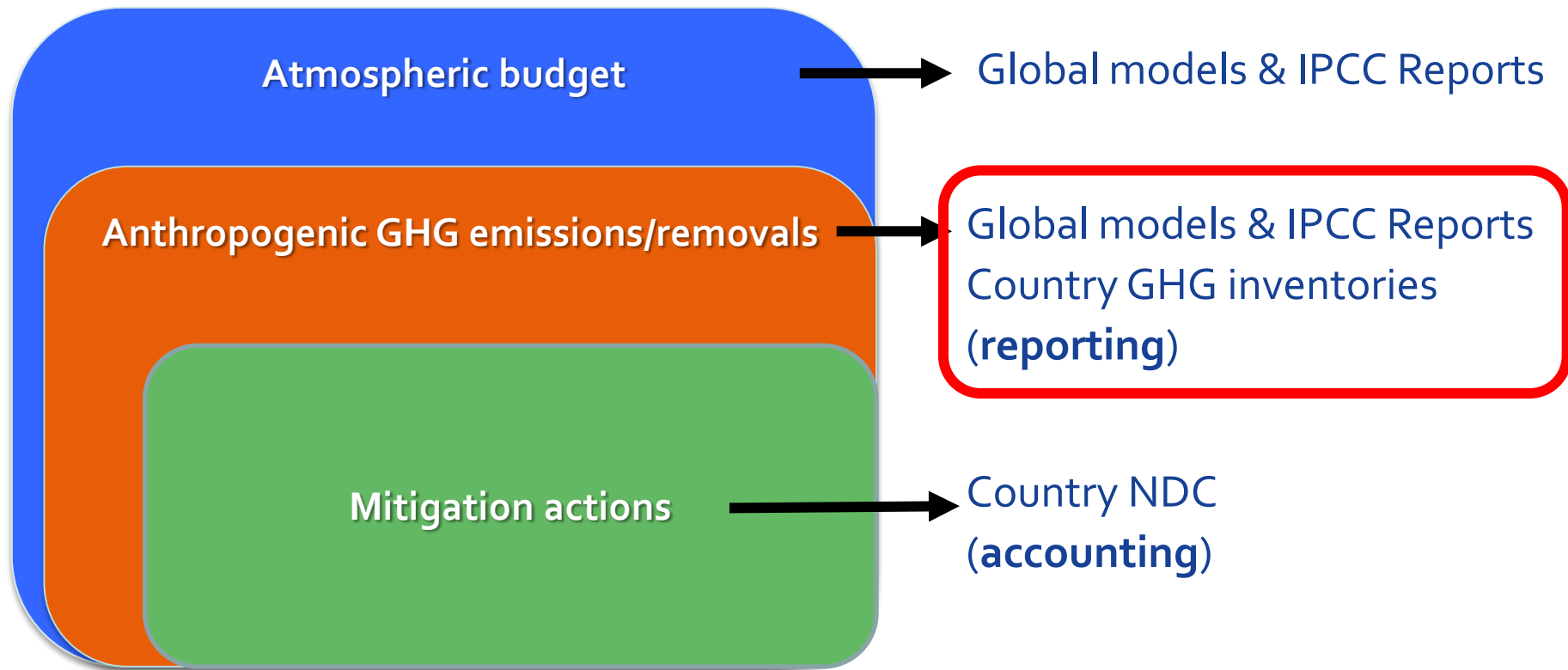
Land use change



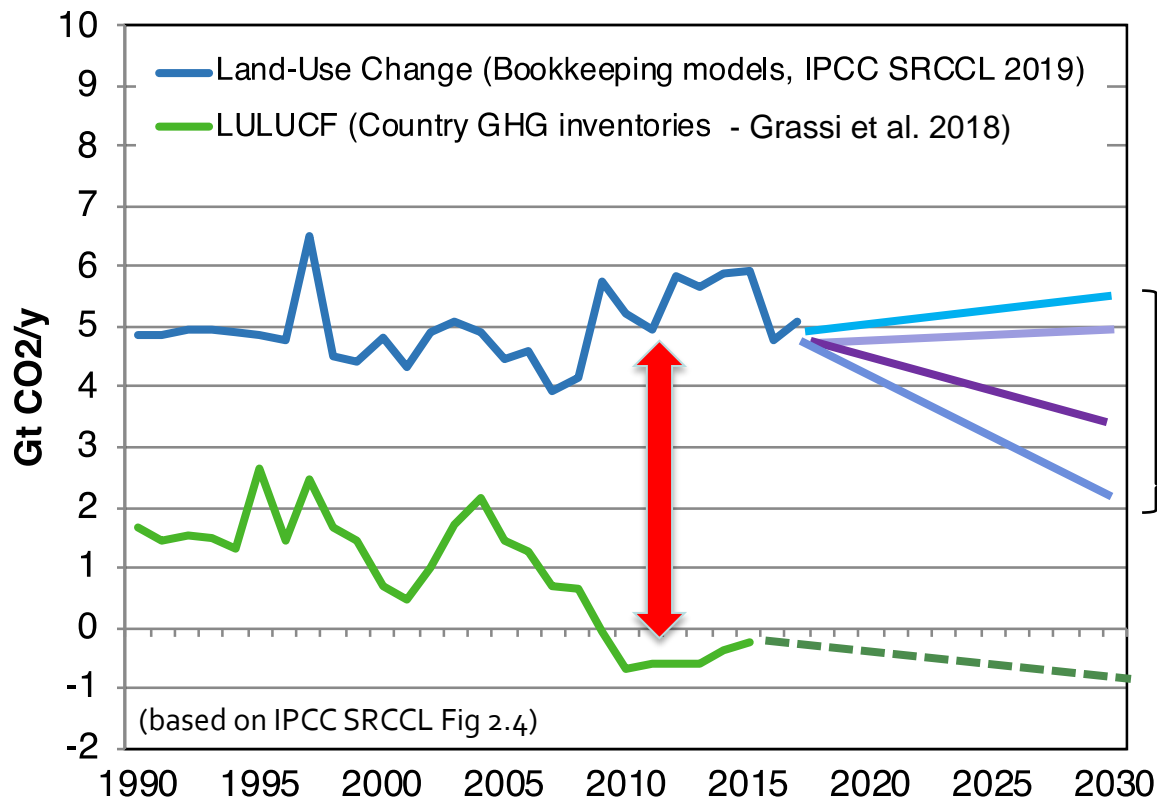
Land Use, Land-Use Change and Forestry (LULUCF)

Land-related Co2 flux categories





Global anthropogenic land CO₂ fluxes: models vs. countries



For 2010, $\approx 5 \text{ GtCO}_2/\text{y}$ gap
(mainly on the forest sink)



This gap holds also for the
future: **is it a problem?**

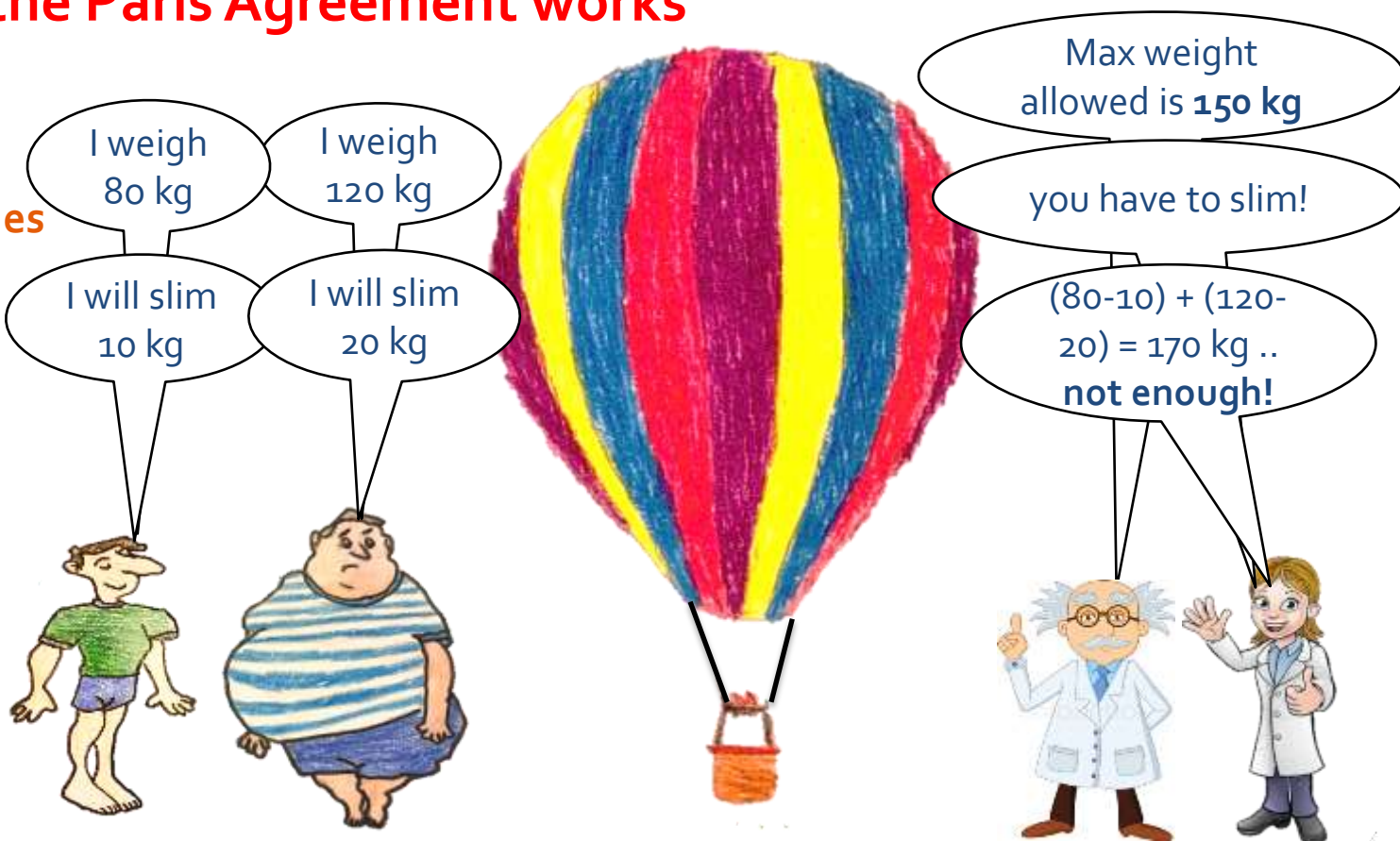
IAMs land mitigation pathways

Country land-related
climate pledges

How the Paris Agreement works

GHG
inventories

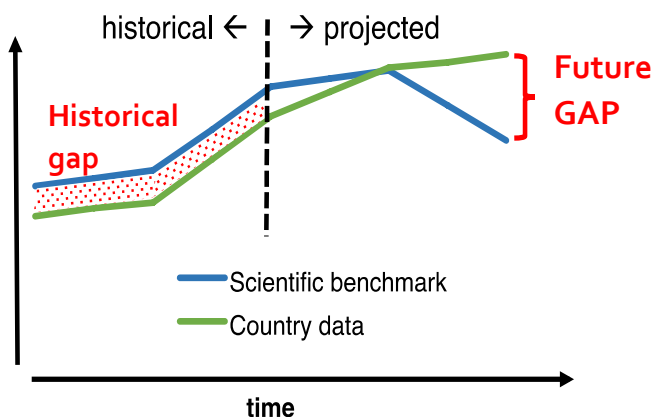
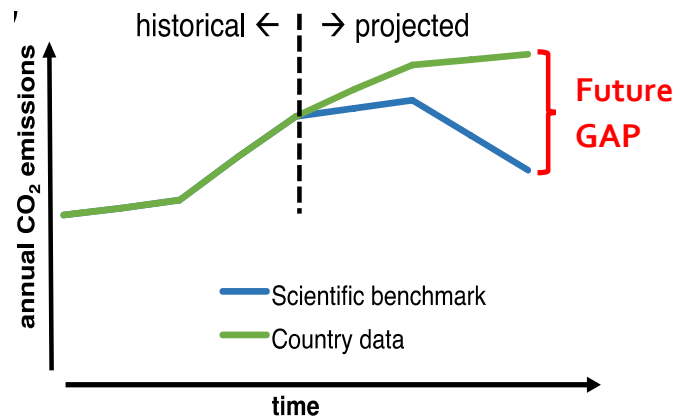
1st NDC



IPCC
ARs

The Global Stocktake (GST) will assess (from 2023, every 5 yrs) the countries' collective progress towards the $< 2^{\circ}\text{C}$ target "in the light of the best available science".

Inputs to the GST: a) Aggregated countries' GHG data
b) IPCC AR6 and other scientific data → compared to assess the future "gap"



The GST requires comparability





Possible causes of the gap between global model and countries

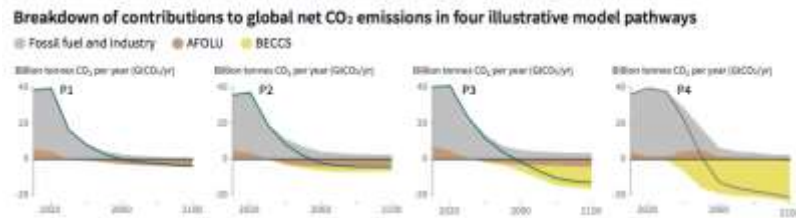
- 1) Coarse & incomplete representation of land-use change / management in global **models** (Pongraz et al. 2018) → *impact difficult to quantify*
- 2) Inaccurate & incomplete estimation of land CO₂ flux in **country GHG inventories**, especially in developing countries (Grassi et al. 2017) → *difficult to quantify*
- 3) **Conceptual differences in estimating «anthropogenic» land CO₂ sink**, which make global models and countries hardly comparable → **>3 GtCO₂/y** (Grassi et al. 2018).

While in the long-term improvements are expected in both models and countries, the **Global Stocktake in 2023** requires **quick fixes** to allow **comparing country pledges with IAMs' mitigation pathways**.

These differences are reflected also in the **SPMs of IPCC SR1.5 and SR CCL:**

ipcc Summary for Policymakers
GLOBAL WARMING OF 1.5 °C

AFOLU estimates reported here are not necessarily comparable with countries' estimates.



ipcc Climate Change and Land Summary for Policymakers

A.3.3. Global models and national GHG inventories use different methods to estimate anthropogenic CO₂ emissions and removals for the land sector. Both produce estimates that are in close agreement for land-use change involving forest (e.g., deforestation, afforestation), and differ for managed forest. Global models consider as managed forest those lands that were subject to harvest whereas, consistent with IPCC guidelines, national GHG inventories define managed forest more broadly. On this larger area, inventories can also consider the response of land to human-induced environmental changes as anthropogenic, while the global model approach treats this response as part of the non-anthropogenic sink. For illustration, from 2005 to 2014, the sum of the national GHG inventories net emission estimates is 0.1 ± 1.0 GtCO₂yr⁻¹, while the mean of two global bookkeeping models is 5.1 ± 2.6 GtCO₂yr⁻¹ (likely range). Consideration of differences in methods can enhance understanding of land sector net emission estimates and their applications.



Global models and countries use **different approaches to estimate anthropogenic land CO₂ fluxes**, due to **differences in:**

- a) attributing the impact of human-induced environmental changes**
- b) forest area considered managed**

a) Differences in attributing the impact of human-induced environmental changes

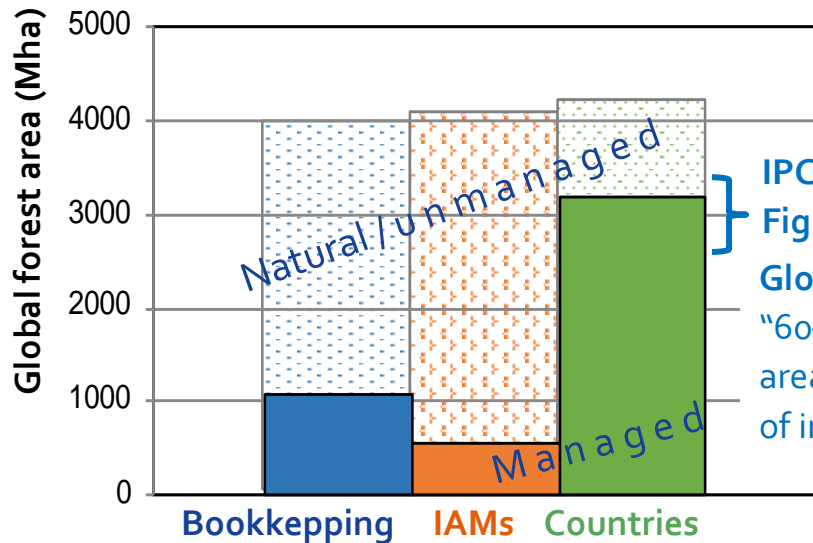
(IPCC SRCCL Fig. 2.6)

| | | Bookkeeping/IAMs <i>Anthropogenic</i> "Land-use change" | | DGVMs <i>Natural</i> "Land Sink" | | Country inventories <i>Anthropogenic</i> "LULUCF" | |
|--------------------------------|------------------------------------------------------------------|---------------------------------------------------------------|--------|----------------------------------------|--------|---------------------------------------------------------|--------|
| | | Managed | Unman. | Managed | Unman. | Managed | Unman. |
| Direct human induced effects | Land use change Management (e.g. harvest) | ✓ | | | | ✓ | |
| Indirect human induced effects | Climate change, atm. CO ₂ increase, N deposition etc. | | | ✓ | ✓ | ✓ | |
| Natural effects | Interannual variability Natural disturbances | | | ✓ | ✓ | ✓ | |
| Averages* for 2005-2014 → | | ≈ 5 GtCO ₂ /y | | ≈ -11 GtCO ₂ /y | | ≈ 0 GtCO ₂ /y | |

Most countries include the impact of "indirect effects" (environmental change)

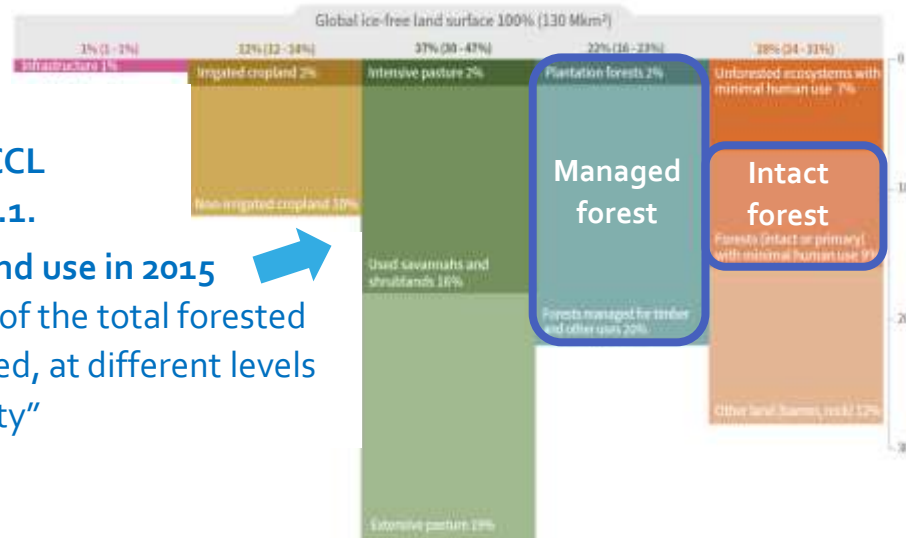
*Bookkeeping and DGVMs: Le Quere et al., 2018; IAMs: average for 2010 of IAM runs in SSP Database. Country GHG Inventories: Grassi et al., 2018

b) Differences in forest area considered managed



IPCC SRCCL
Fig. SPM.1.

Global land use in 2015
"60–85% of the total forested area is used, at different levels of intensity"



- Total forest area similar (around 4000 Mha)
- 'Managed' area in **Bookkeeping** and **IAMs** (i.e. subject to harvest) **much smaller** than **Countries** 'managed' area (where human practices are applied to perform production, ecological or social functions)

Different scopes, two communities → different approaches to identify anthropogenic flux.
Countries include the impact of “**environmental change**” on a larger “**managed**” area.

How to reconcile these differences for the Global Stocktake?

Changing the countries’ approach is difficult.

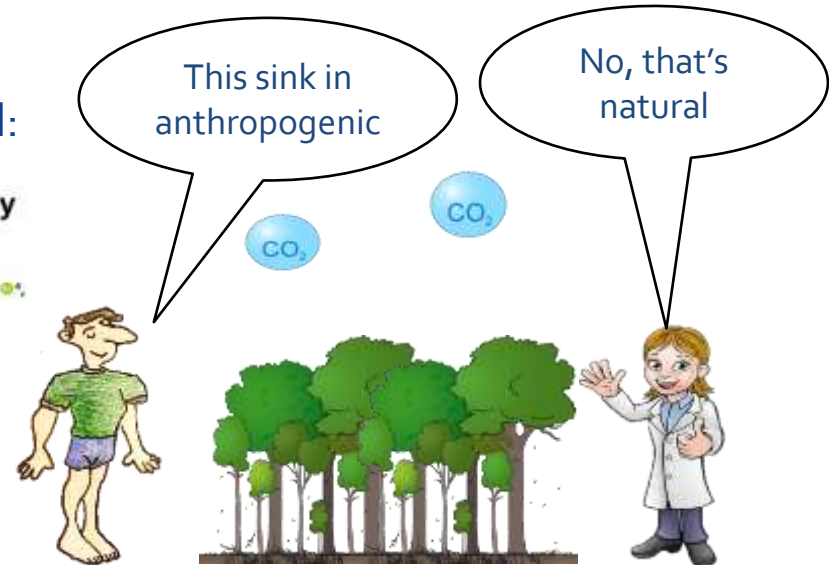
Models’ results may be post-processed →
approach successfully applied to historical period:



Reconciling global-model estimates and country reporting of anthropogenic forest CO₂ sinks

Giacomo Grassi^{1*}, Jo House², Werner A. Kurz³, Alessandro Cescatti¹, Richard A. Houghton⁴

And for the future (IAMs scenarios?)



a) Differences in attributing the impact of human-induced environmental changes

Possible new table to “translate” global model estimates:

| CURRENT Land CO ₂ flux categories | NEW Land CO ₂ flux categories | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|------------------------------------------|
| Land use (Bookkeeping/IAMs): CO ₂ from direct effects in managed land | a) CO ₂ from direct effects in managed land | consistency with previous estimates |
| Natural land sink (DGVMs): response of land to human-induced environmental changes (indirect + natural effects), in both managed and unmanaged land | b) CO ₂ from indirect + natural effects in managed land | |
| | c) CO ₂ from indirect + natural effects in unmanaged lands | |
| | e) Natural “Land sink”: b + c | consistency with country GHG inventories |
| | d) <u>LULUCF</u> in country GHGs: a + b | |

(Grassi et al., in preparation)

b) Differences in managed forest area

→ We need a map of managed areas close to countries' approach

ESA-CCI: 300 m global land cover map 1992-2015 by European Space Agency's Climate Change Initiative

Intact forests
(Popatov et al.)

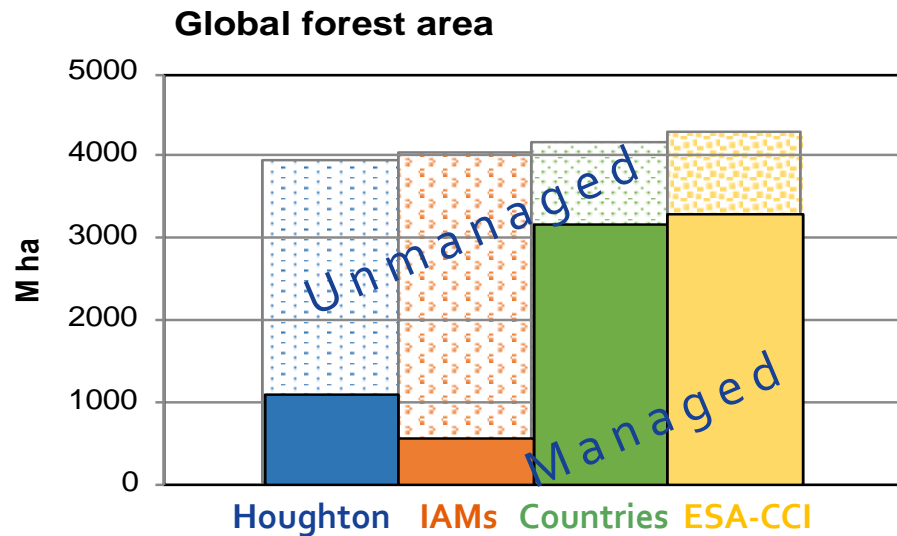


ESA-CCI (total forest classes)

minus

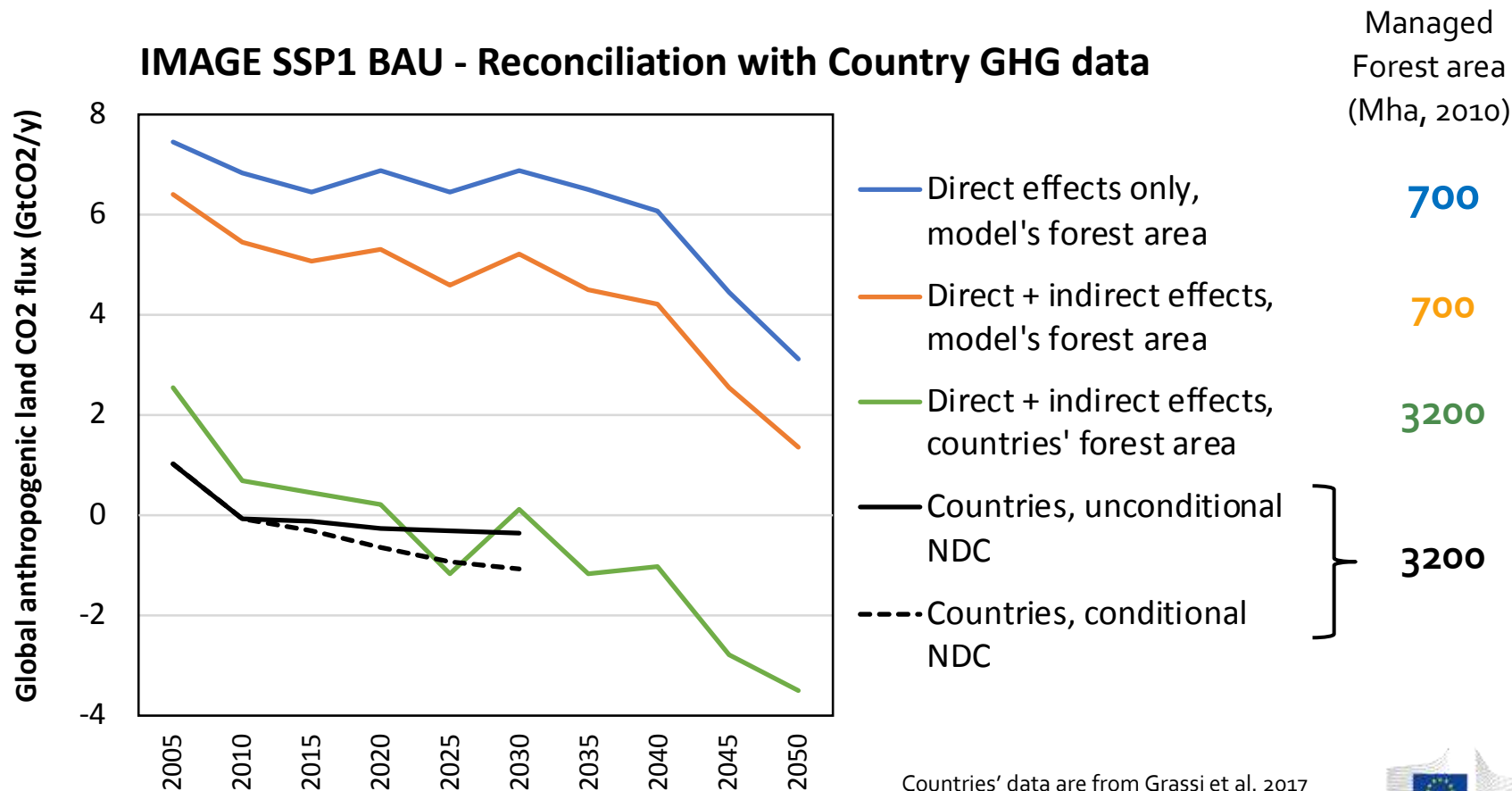
Intact forests (≈unmanaged)

= '*managed*' forest



(Grassi et al., in preparation)

Illustrative results for IMAGE, SSP1- baseline



Conclusions

- Large gap in land CO₂ fluxes between global models and countries, mostly on forests.
- Gap mainly due to a **conceptual difference in estimating “anthropogenic” CO₂ sink**: countries include the impact of “**environmental change**” on a larger “**managed**” area.
- Reconciling these differences is needed to **assess country collective progress towards meeting modelled mitigation pathways** under the Global Stocktake.
- To this aim, preliminary results of an **ex-post processing of IAMs results** are promising.
- Next steps: use data from all IAMs



Thank you!