Using satellite observations to model net carbon dioxide emissions from AFOLU (REgional Carbon Cycle Assessment and Processes (RECCAP) under the Global Carbon Project

Yohanna Villalobos, Pep Canadell, and the Australasia RECCAP2 team

IPCC TFI Expert Meeting on Use of Atmospheric Observation Data in Emission Inventories

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Presenter: Yohanna Villalobos
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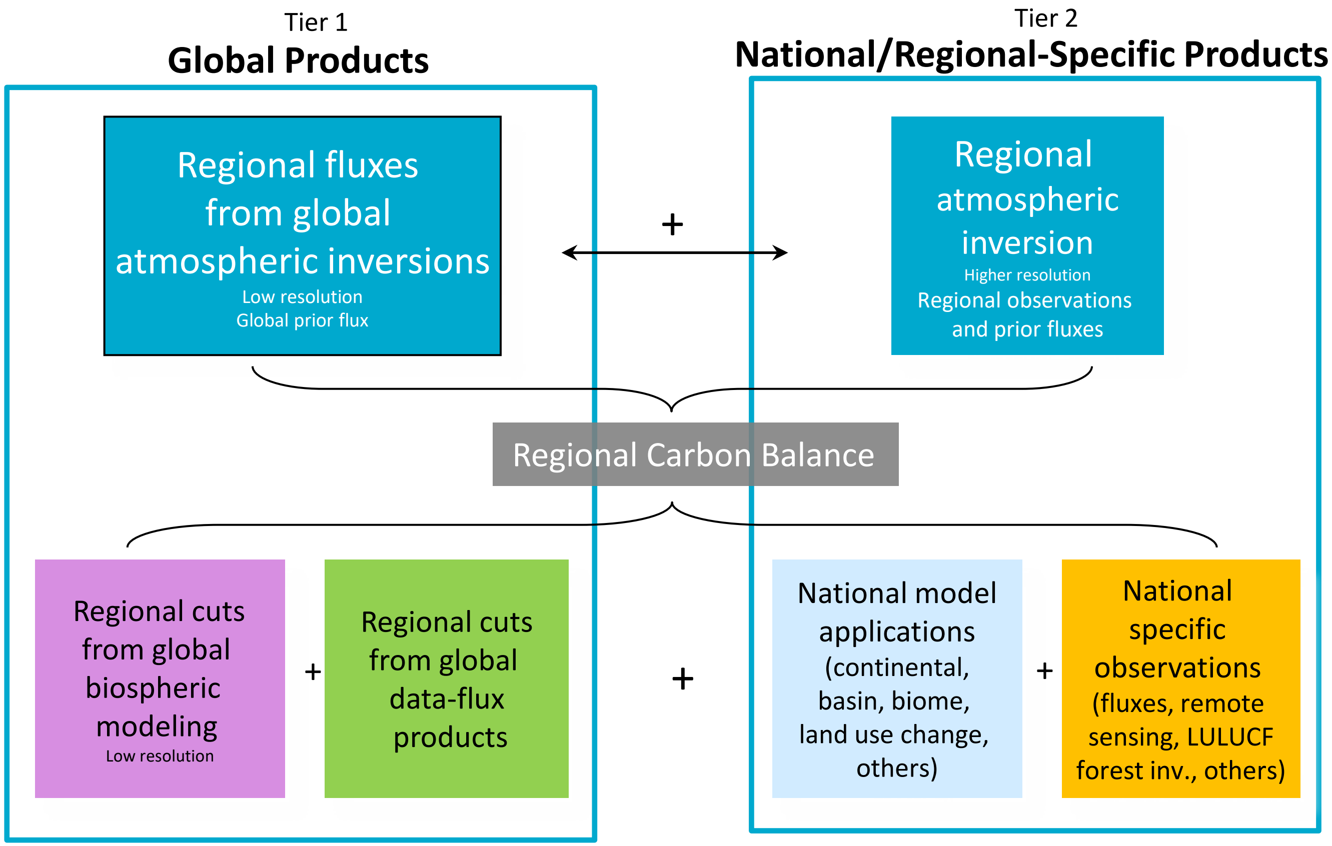
What is RECCAP-2?

- RECCAP-2 is a global assessment to develop regional and national (for big countries) carbon, methane and nitrous oxide budgets.
- To contribute to the Paris Agreement global stocktake and tracking towards net zero emissions of anthropogenic and natural GHG sources and sinks.
- To quantify and further constrain anthropogenic greenhouse gas emissions and thus support the improvement of National greenhouse gas inventories (NGHGIs).

Figure 1: The RECCAP2 budget considers ten land regions and five ocean regions that together cover the entire globe (Kondo et al., 2021)

Two-tier approach for national/regional GHG balance



GCP, RECCAP1

How we compare AFOLU/LULUCF from NGHGI with inversions?

National GHG inventory (NGHGI)
(IPCC guidelines, 2006, 2019)

National/Regional
Carbon Budget

Agriculture, Forestry and Other Land Use **(AFOLU/LULUCF)**

→

National/Regional
Atmospheric Inversion

Satellite-based inversion
Provides best estimate of net C balance

In Australia, all lands are considered managed lands (except 8 per cent from desert areas).

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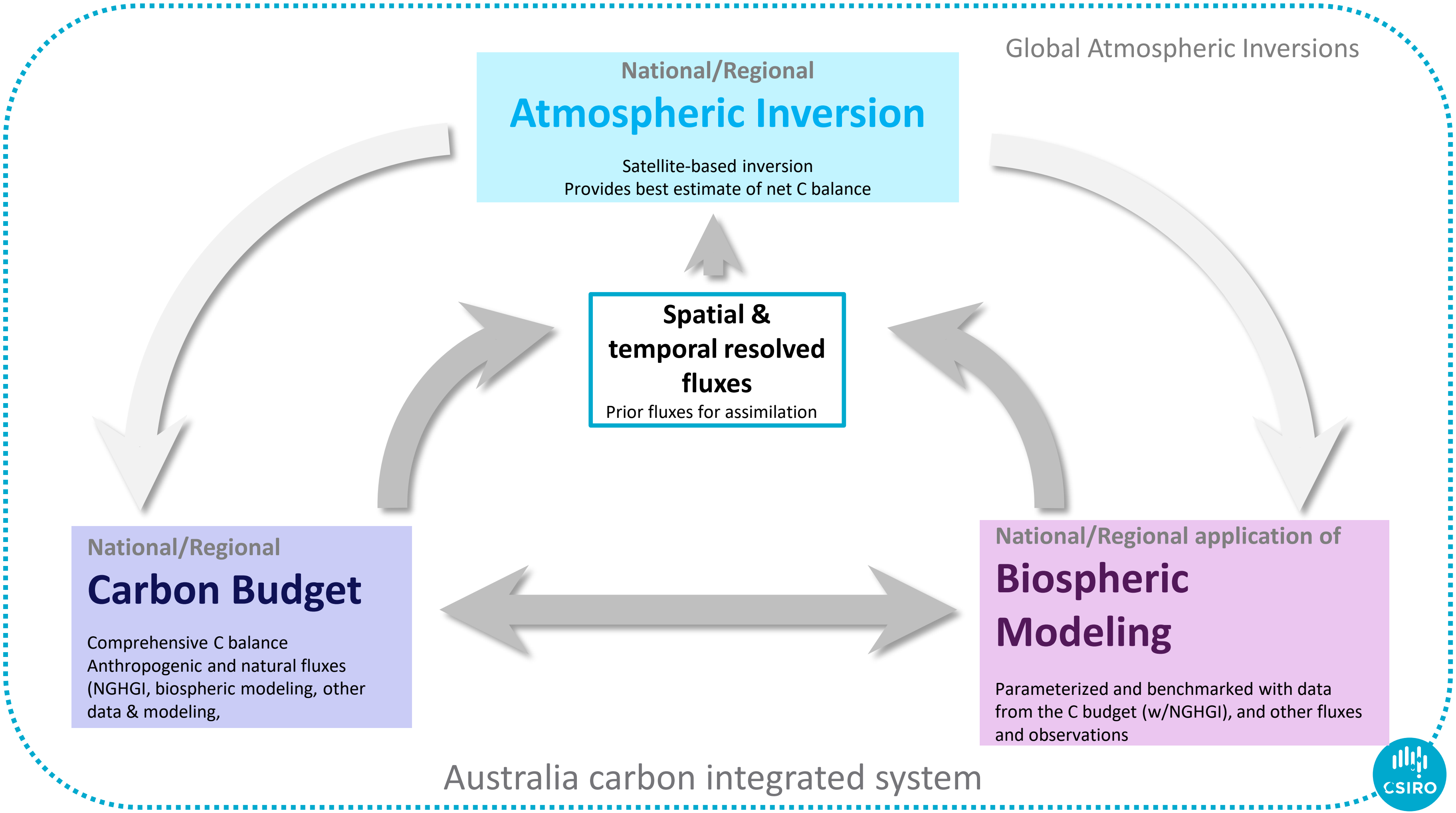
Global Atmospheric Inversions
National/Regional
Atmospheric Inversion
Satellite-based inversion
Provides best estimate of net C balance
Spatial & temporal resolved fluxes
Prior fluxes for assimilation
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Anthropogenic and natural fluxes
(NGHGI, biospheric modeling, other data & modeling,
National/Regional application of
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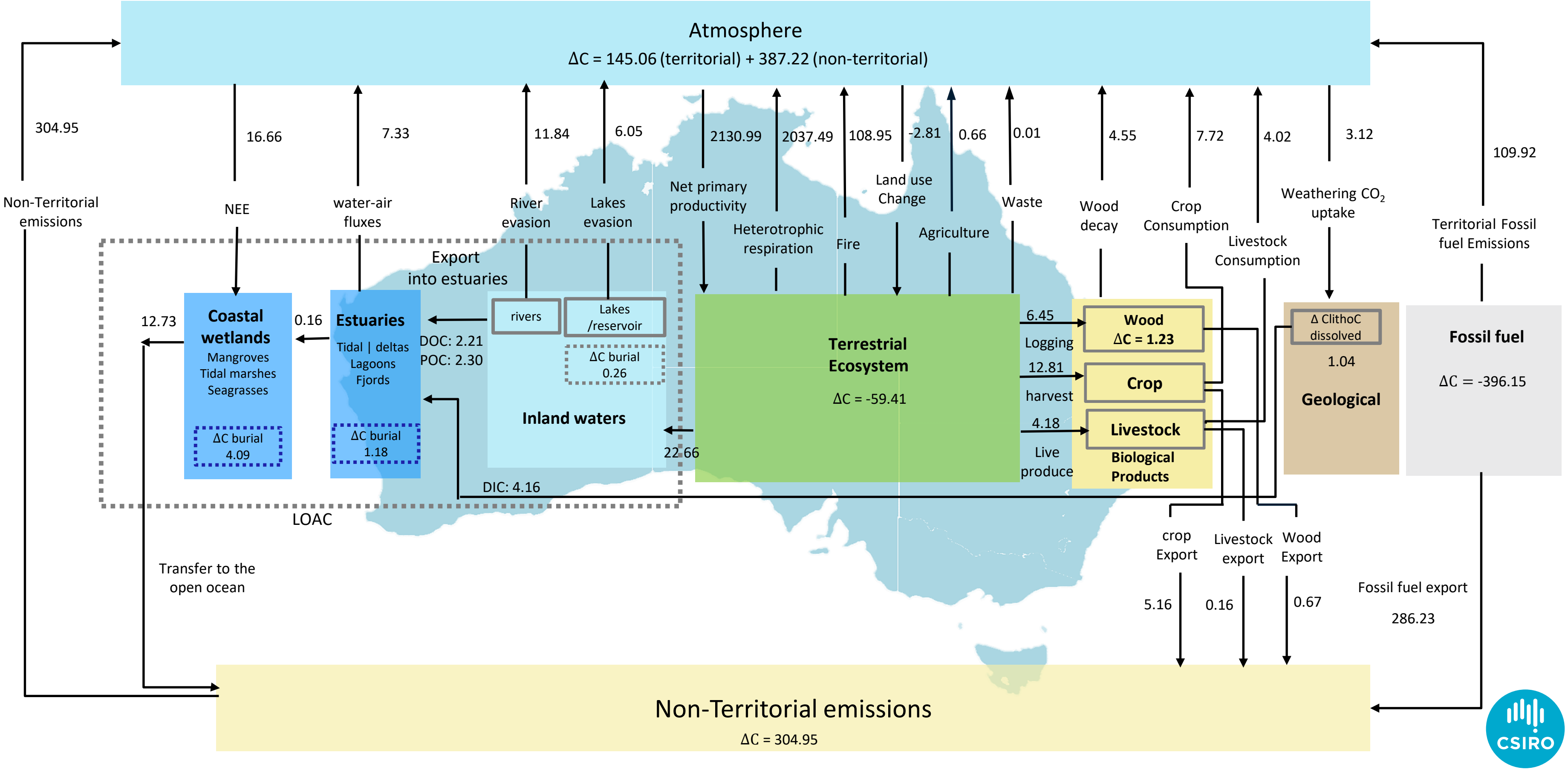
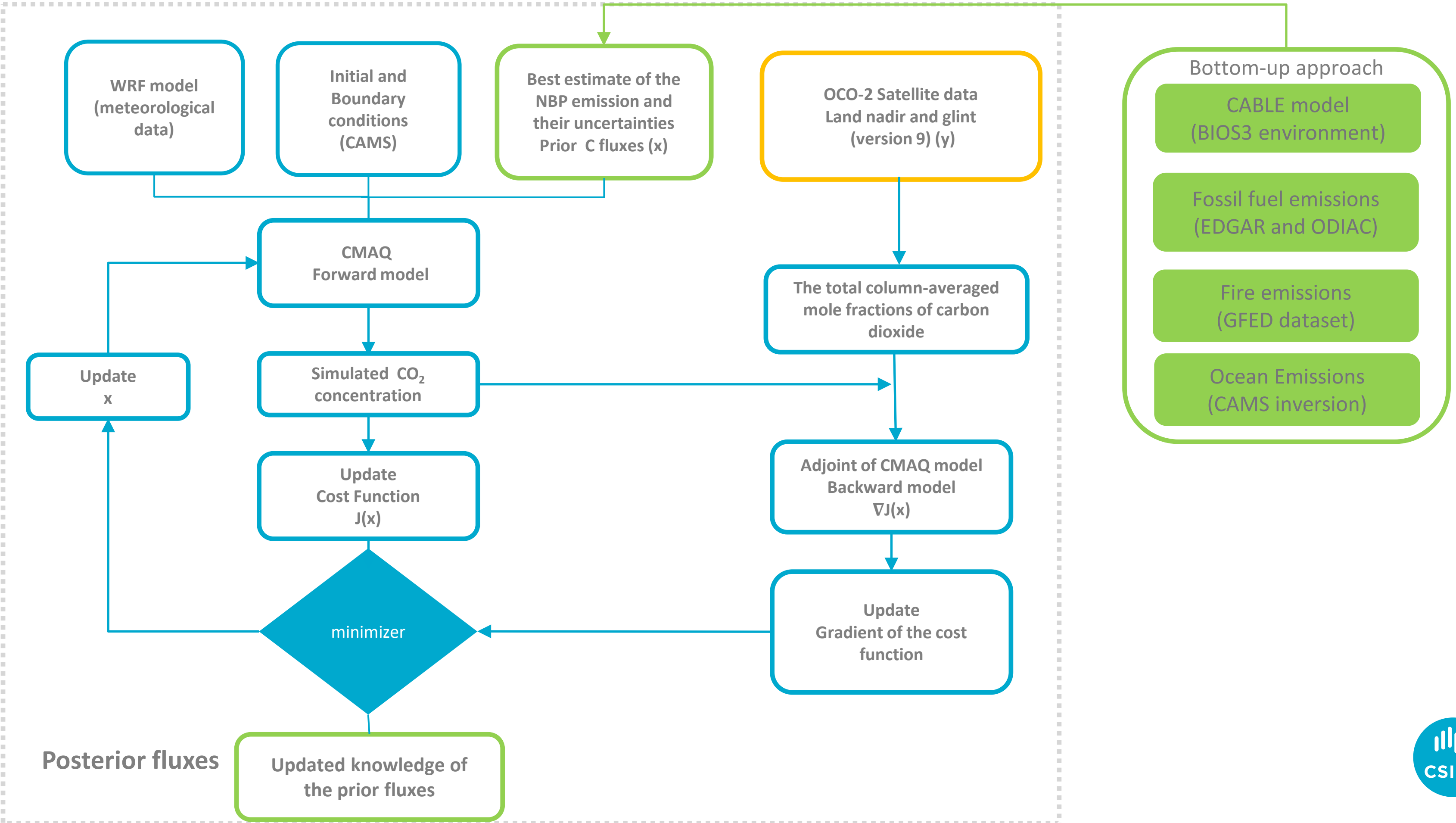
Parameterized and benchmarked with data from the C budget (w/NGHGI), and other fluxes and observations
Australia carbon integrated system
CSIRO

Regional Australia carbon Budget (2010-2019) (Units Tg C yr^{-1})

- Work in Progress -



Australia regional inversion (2015-2019)



The importance of prior fluxes in the regional inversion

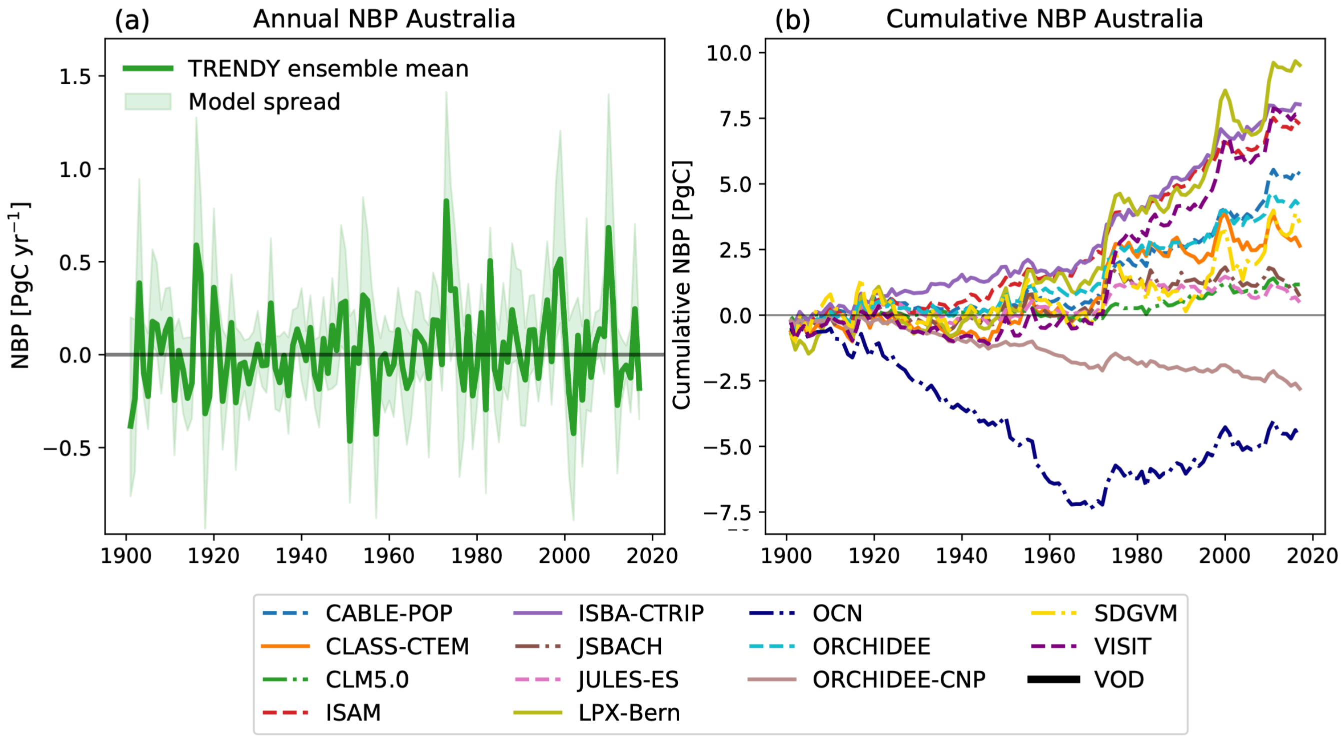
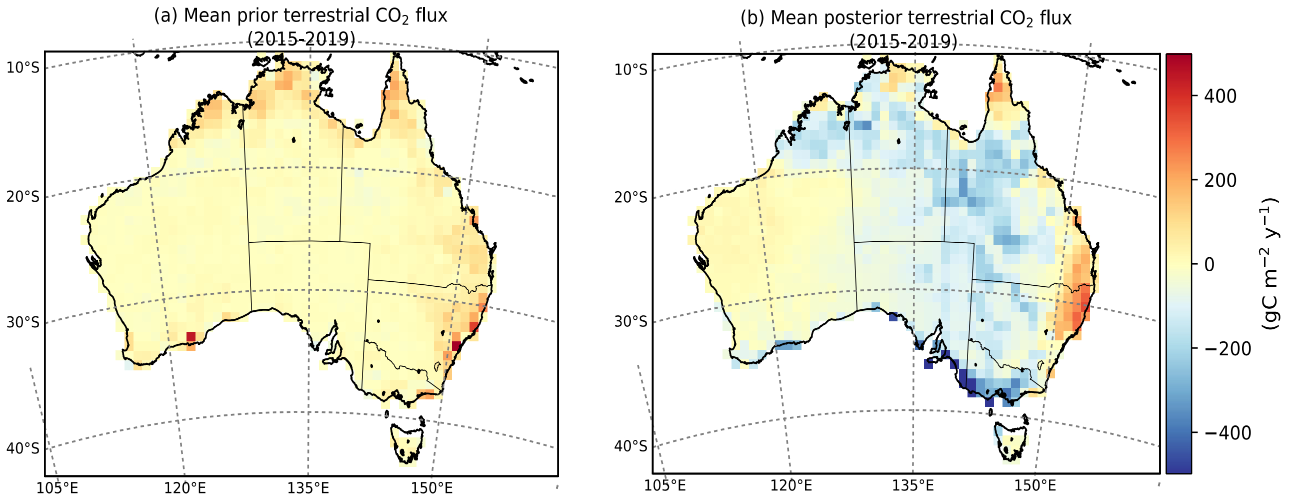


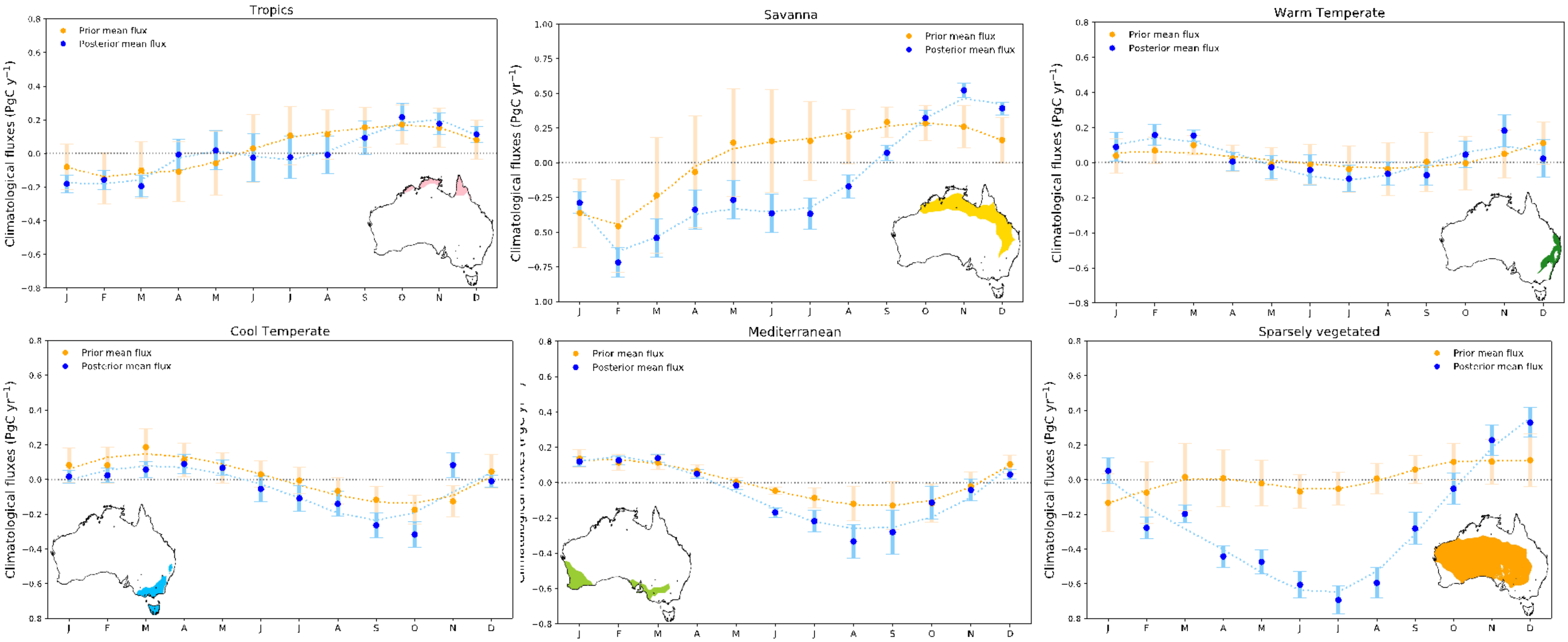
Figure 1. Net Biome Production (NBP). Positive indicates a terrestrial carbon sink (Teckentrup et al., 2021).

Long-term mean 2015-2019



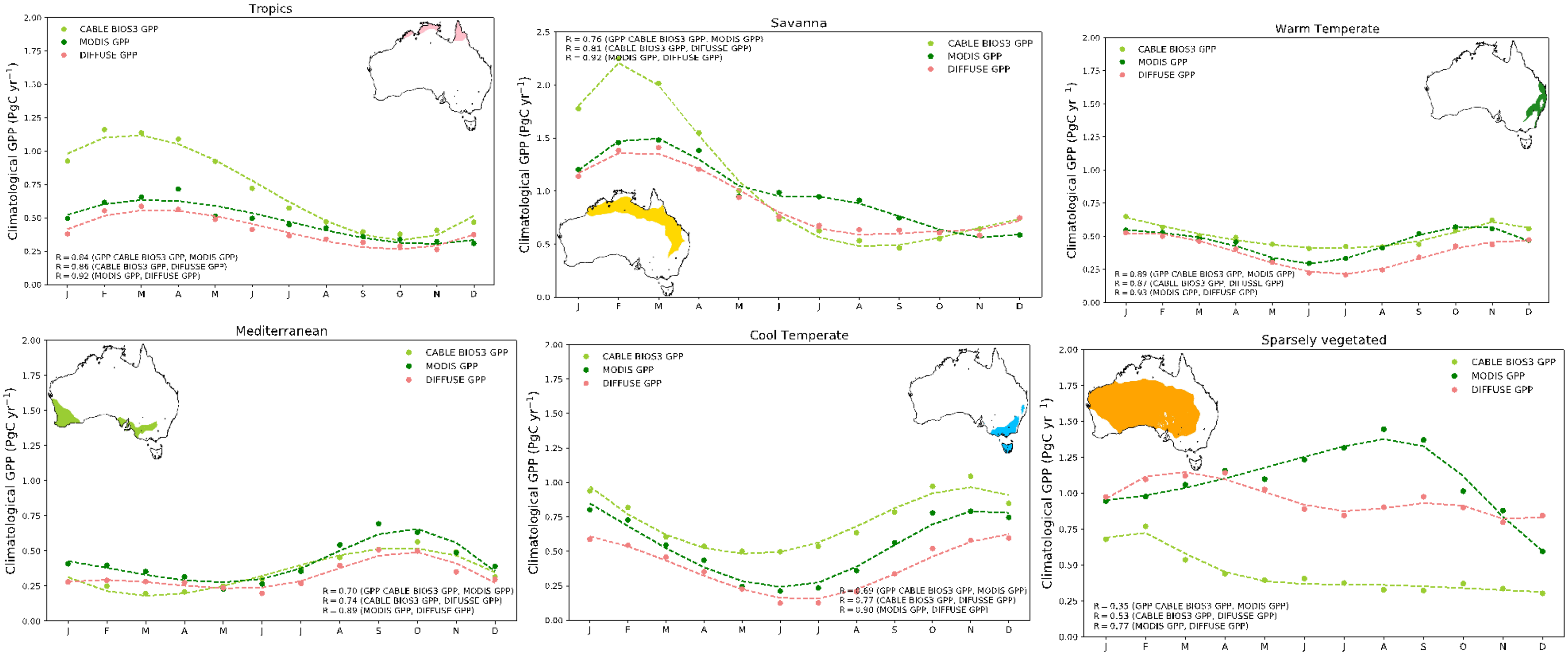
The long-term mean of our posterior terrestrial CO_2 flux indicate that Australia was a carbon sink of -0.46 +- 0.08 PgC y^{-1} compared to the prior flux estimate which was 0.11 +- 0.20 PgC y^{-1} (excluding fossil fuel emissions). (Villalobos et al., 2022)

Climatological seasonal carbon cycle 2015-2019



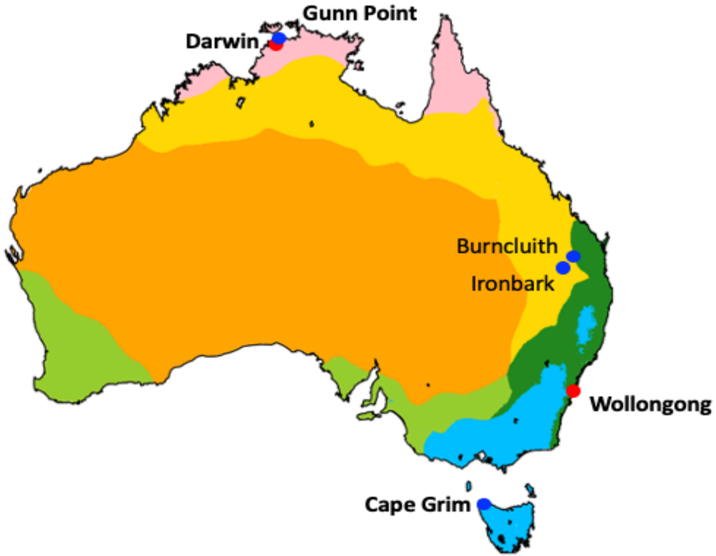
Climatological seasonal cycle of prior (orange points) and posterior (blue points) terrestrial carbon fluxes (2015–2019). The dashed orange and blue lines represent a smooth line for the prior and posterior fluxes respectively.

Climatological GPP 2015-2019



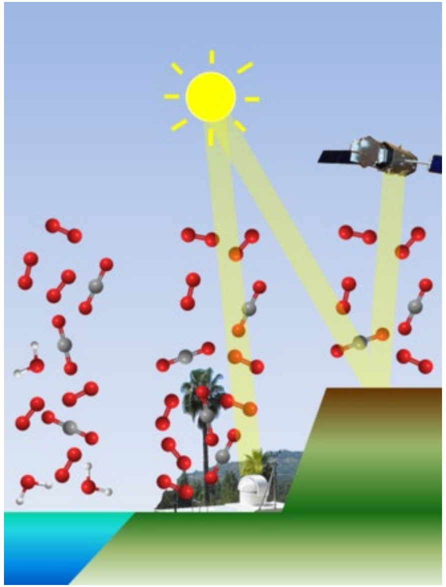
Climatological seasonal cycle of prior (orange points) and posterior (blue points) terrestrial carbon fluxes (2015–2019). The dashed orange and blue lines represent a smooth line for the prior and posterior fluxes respectively. (Villalobos et al., (2022).

Validation with independent data



- In-situ measurements (blue dots)

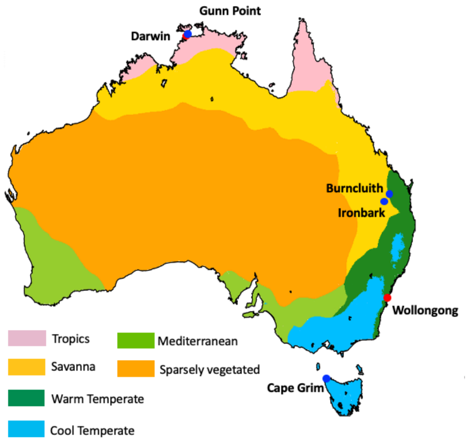
- The Total Carbon Column Observing Network (TCCON) records direct solar spectra in the near-infrared spectral region (red dots).

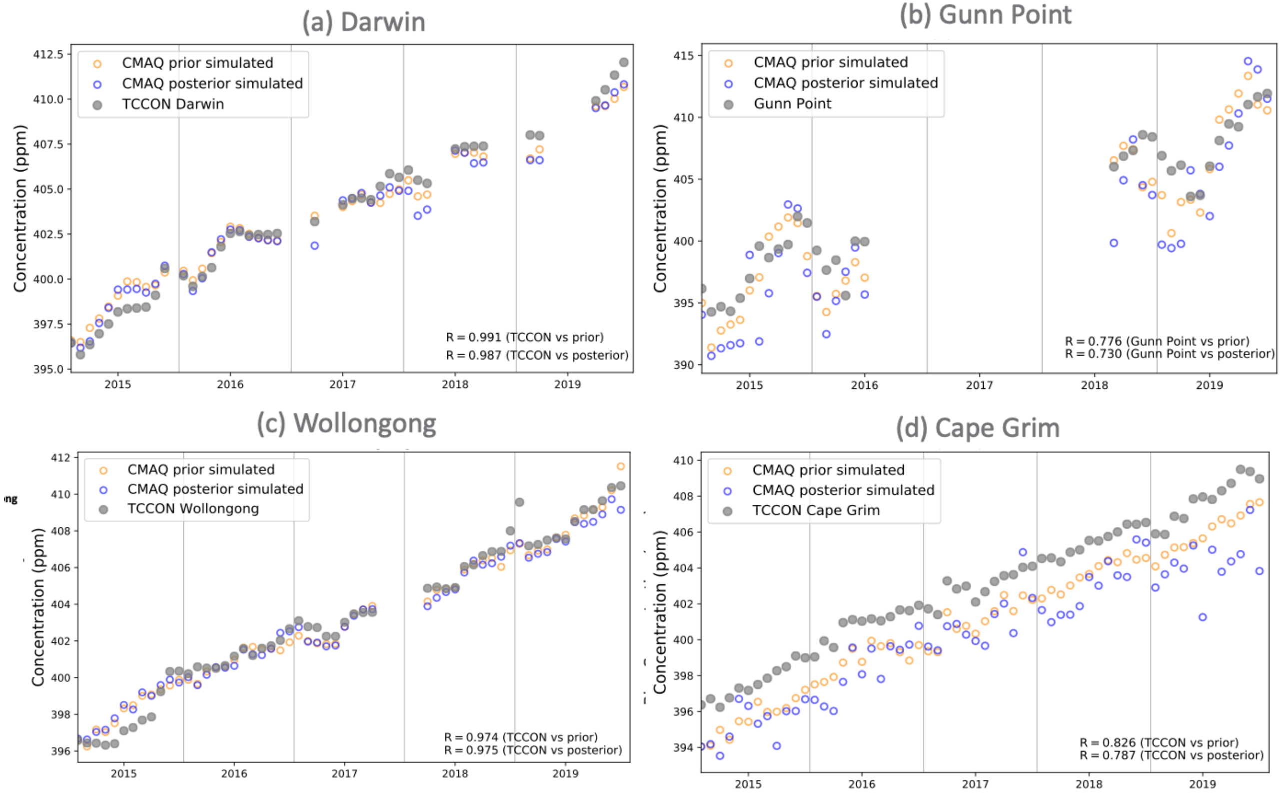


Validation

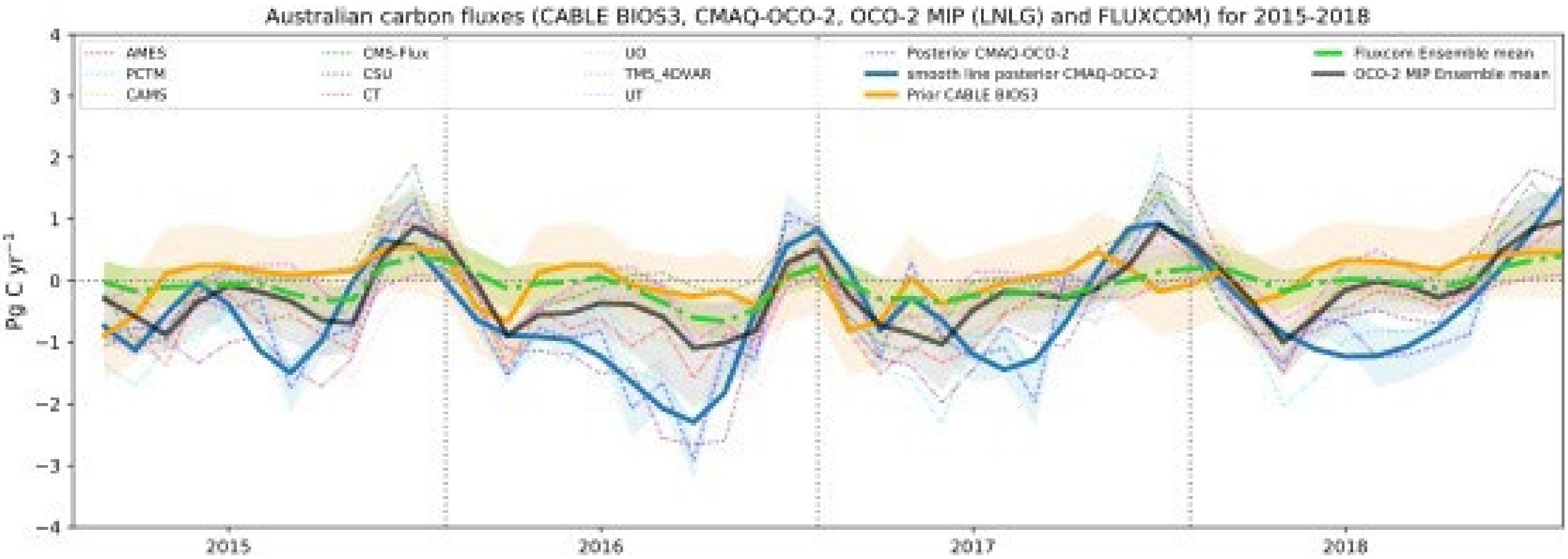
TCCON observations

in-situ observations



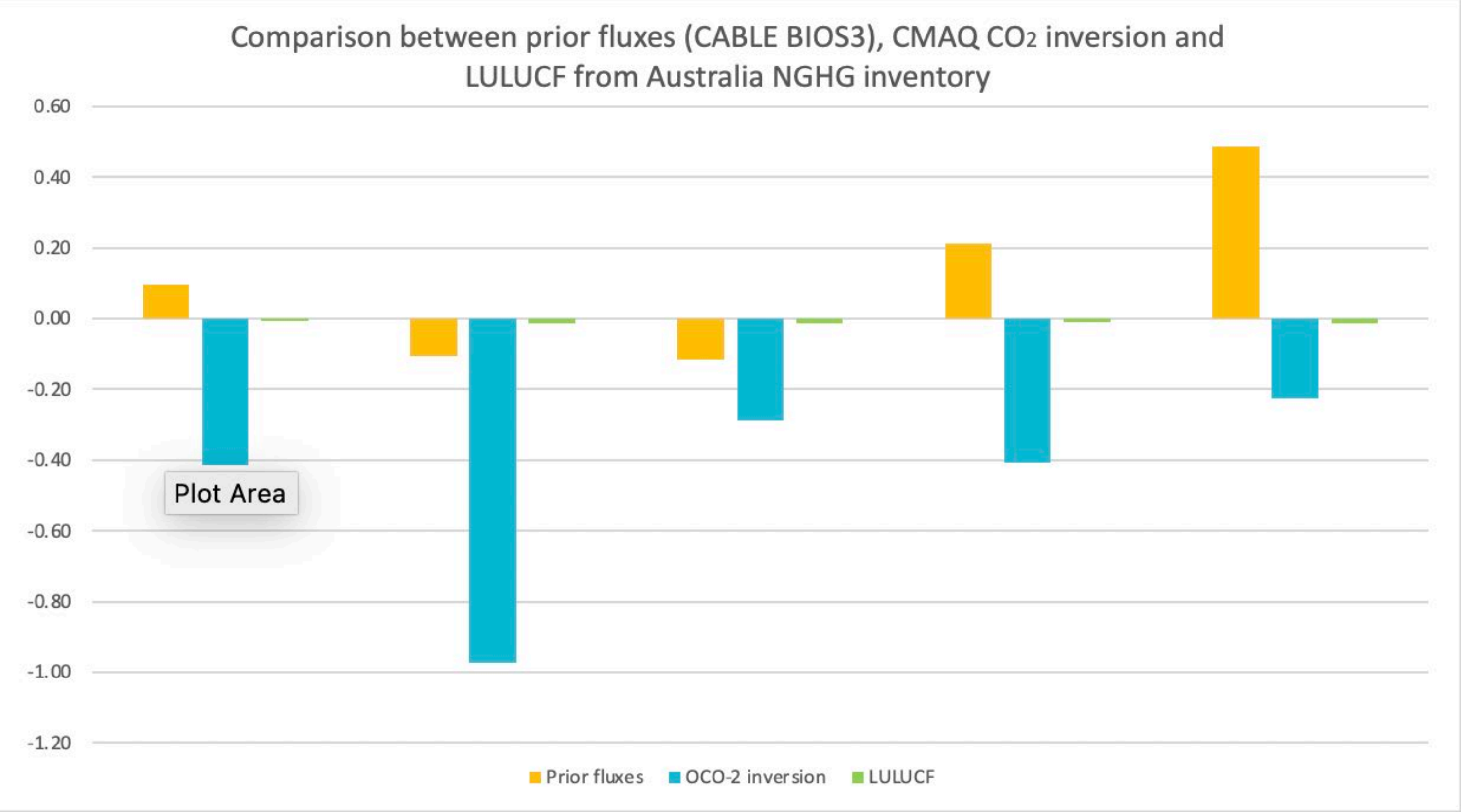


Comparison:
Regional OCO-2, Global OCO-2 MIP, TBM (prior, CABLE) and FluxCom



Comparison between monthly mean posterior (blue line), prior (orange line), FLUXCOM ensemble mean (green line), OCO-2 MIP ensemble (black line) carbon fluxes, and the monthly carbon fluxes from the nine models that participate in OCO-2 MIP: AMES, PCTM, CAMS, CMS-Flux, CSU, CT, OU, TM5-4DVAR, and UT (in PgC yr−1).

OCO-2 inversion results against what is reported in the LULUCF From Australian NGHGI (2015-2019)



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Reconciling OCO-2 inversion results with LULUCF From Australian NGHGI

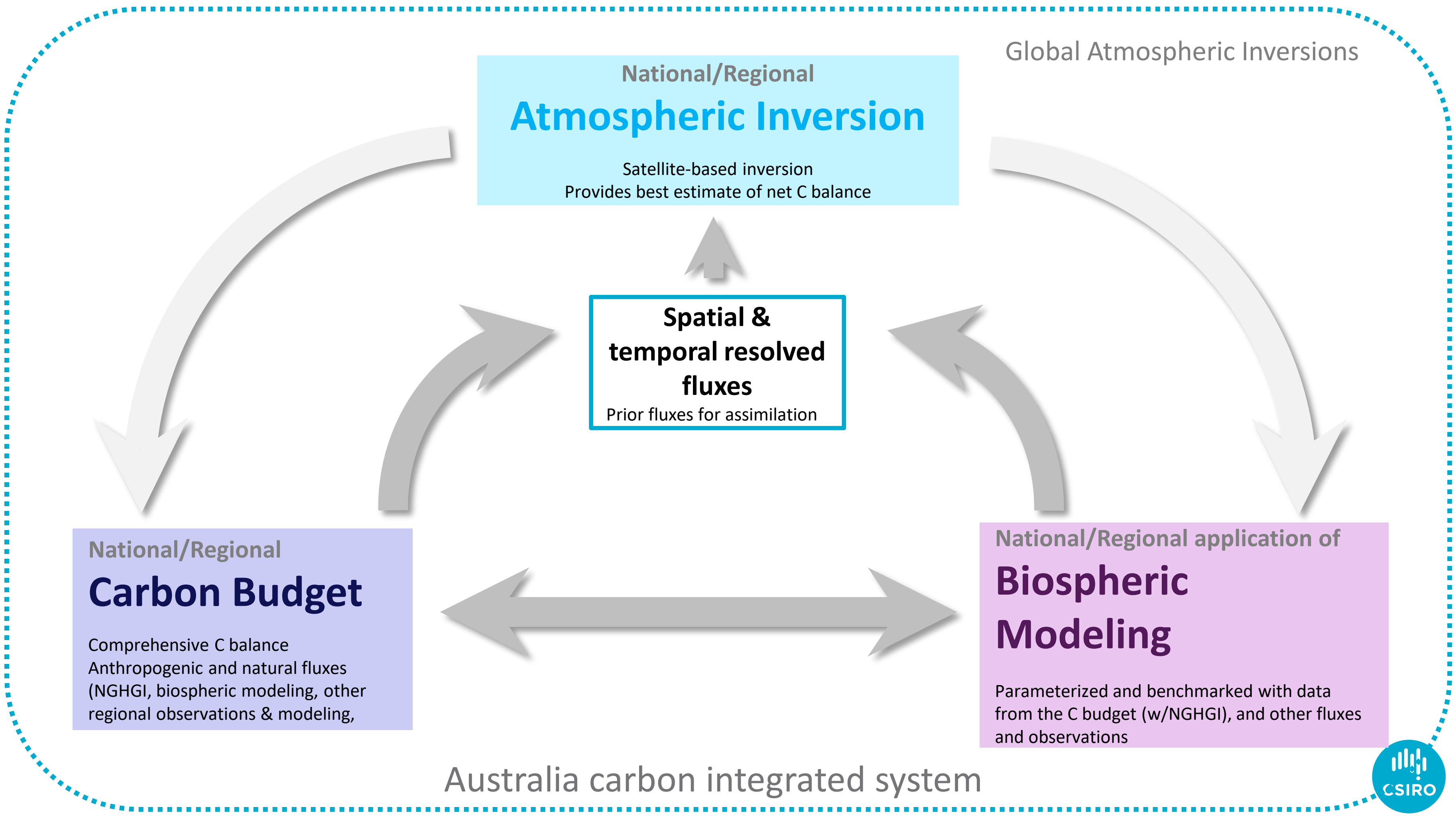
1. Sort out any definitional inconsistencies and system boundaries on what is included and not in each of the two approaches, and identify any clear missing fluxes, particularly natural fluxes which might not be included in the NGHGI.

2. Assess how sinks and sources are created from the strong inter-annual climate variability in Australia, and therefore not part of the long-term trend driven by direct human activities.

3. Implications from using static empirical growth models, yield curves, and biomass maps in the NGHGI versus processes modeling or forest inventory approaches that include the indirect effects of a changing climate and atmospheric CO_2 (the CO_2 fertilization effect).

4. As the NGHGI focuses primarily on anthropogenic forest-to-no-forest (and back again) conversions, carbon sinks/sources from arid and semi-arid ecosystems could be missing in the inventory.

5. What do we learn from any remaining gaps once the above has been sort out? Have we identified new sources or sinks, key processes, hot spots, etc?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Australia carbon integrated system
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RECCAP2-Australasia contributions

- **Atmospheric Inversions & land surface modelling in Australia**
  - Yohanna Villalobos, CSIRO, coordinating lead author
  - Peter Rayner, University of Melbourne.
  - Peter Briggs, land surface modeling, data analysis
  - Ian Harman, land surface modeling
  - Juergen Knauer, CSIRO, land-surface modeling
  - Ben Smith, WSU, CABLE-BIOS
  - Pabrir Patra (CO_2, NO_2 and CH_4)
  - Hanqin Tian, and Naiqing Pan (N_2O),
- **Atmospheric Inversions & land surface modelling in NZ**
  - Liz Keller, GNS, New Zealand
  - Timothy W. Hilton, GNS New Zealand
  - Beata Bukosa, NIWA
  - Sara Mikaloff-Fletcher, NIWA

LOAC (Land to ocean aquatic continuum)

- **inland waters**:
  - Ronny lauerwald
- **Coastal ecosystem**:
  - Judith Rosentreter, Yale University
  - Thomas Wernberg, UWA: blue carbon, kelp forest
  - Oscar Serrano, ECU: blue carbon, seagrass
- **Shelf fluxes**
  - Laure Resplandy, Princeton University
- **Flux Inventories**:
  - DAWE, DISER (Australian LUC, Agriculture, Fossil fuel)
  - Yohanna Villalobos, CSIRO, coordinating lead author
  - Pep Canadell, CSIRO, coordinating lead author
- **Future projections**:
  - Tilo Ziehn, CSIRO: CMIP6, Earth System modelling
  - Liz Keller, GNS, New Zealand