Exploitation of CCI products in the second Regional Carbon Cycle Assessment and Processes (RECCAP-2)

ESA-CCI collocation meeting

A. Bastos, P. Ciais, F. Chevallier, C. Yue, W. Li, P. Friedlingstein, S. Sitch, M. Jung, M. Reichstein, P. Canadell

20-22 March 2018
Oxford, UK
What is RECCAP?

• To establish the **mean carbon balance of large regions** of the globe at the scale of continents and large ocean basins, including their **component fluxes**.

• To do it by comparing and reconciling multiple bottom-up estimates with the results of regional top-down atmospheric inversions, with attribution to main flux components.

• To evaluate the **regional ‘hot-spots’ of inter-annual variability and possibly the trends** and underlying processes over the past two (or more) decades by combining available long-term observations and modeling.
What is RECCAP?

Fig. 1. Two-tiers methodological approach ensuring that all regions, regardless of the level of information available to them, can develop a consistent top-down and bottom-up carbon balance.

Canadell et al., 2011

https://www.biogeosciences.net/special_issue107.html
What is RECCAP?

X-axis Legend:
1: Terrestrial flux: 1990s
2: Terrestrial flux: 2000s
3: Atmospheric Inversions: 1990s
4: Atmospheric Inversions: 2000s

Gais et al. 2013, IPCC AR5
What is RECCAP?

- Boreal North America
- Northern Africa
- Europe
- Boreal Asia
- Temperate North America
- Temperate Asia
- Tropical South America
- Southern Africa
- Ocean
- North Pacific
- East Pacific
- South Pacific
- North Atlantic
- South Atlantic
- Tropical Atlantic
- Tropical Indian Ocean
- West Pacific
- Southern Ocean

X-axis Legend:
1: Terrestrial flux: 1990s
2: Terrestrial flux: 2000s
3: Atmospheric Inversions: 1990s
4: Atmospheric Inversions: 2000s

Gais et al. 2013, IPCC ARS
Latest Global Carbon Budget
(LeQuéré et al., 2017)
Changes in the budget over time

The sinks have continued to grow with increasing emissions, but climate change will affect carbon cycle processes in a way that will exacerbate the increase of CO$_2$ in the atmosphere.

The budget imbalance is the total emissions minus the estimated growth in the atmosphere, land and ocean. It reflects the limits of our understanding of the carbon cycle.

Source: CDIAC; NOAA-ESRL; Houghton and Nassikas 2017; Hansis et al 2015; Le Quéré et al 2017; Global Carbon Budget 2017
Why RECCAP-2?

Latest Global Carbon Budget
(LeQuéré et al., 2017)

Top-down and bottom-up estimates of surface CO$_2$ fluxes agree quite well at global scale

Source: Le Quéré et al. 2017; Global Carbon Budget 2017

Individual estimates from: Chevallier et al. (2005); Clarke et al. (2011); Guimberteau et al. (2017); Hansis et al. (2015); Haverd et al. (2017); Houghton and Nassikas (2017); Jain et al. (2013); Kato et al. (2013); Keller et al. (2017); Krinner et al. (2005); Meltom and Arora (2016); Oleson et al. (2013); Reich et al. (2013); Rodenbeck et al. (2003); Sitch et al. (2003); Smith et al. (2014); Tian et al. (2015); van der Laan-Luijkx et al. (2017); Woodward et al. (1995); Zaehle and Friend (2010). Full references provided in Le Quéré et al. (2017).
Why RECCAP-2?

Latest Global Carbon Budget
(LeQuéré et al., 2017)

Top-down and bottom-up estimates of surface CO₂ fluxes agree quite well at **global scale** but present large inconsistencies in regional budgets and their inter-annual variability.

Source: Le Quéré et al 2017; Global Carbon Budget 2017

Individual estimates from: Aumont and Bopp (2006); Buitenhuis et al. (2010); Chevallier et al. (2005); Clarke et al. (2011); Doney et al. (2009); Guimberteau et al. (2017); Hauck et al. (2016); Haverd et al. (2017); Illyana et al. (2013); Jain et al. (2013); Kato et al. (2013); Keller et al. (2017); Krinner et al. (2005); Landschützer et al. (2016); Law et al. (2017); Melton and Arora (2016); Oleson et al. (2013); Reick et al. (2013); Rödenbeck et al. (2003); Rödenbeck et al. (2014); Séférian et al. (2013); Schwinger et al. (2016); Sitch et al. (2003); Smith et al. (2014); Tian et al. (2015); van der Laan-Luijkx et al. (2017); Woodward et al. (1995); Zaehle and Friend (2010). Full references provided in Le Quéré et al. (2017).
Towards RECCAP-2
Towards RECCAP-2

RECCAP Tier 1

Regional budgets
Regional average fluxes

- Atmospheric CO₂ Inversion Models
  - 3 inversions
  - LSCE MACC
  - Jena
  - Carbon Tracker

Regional Carbon Balance

Regional cuts from global land & ocean models + Regional cuts from data driven FLUXNET products

RECCAP Tier 2

Global monthly maps

- Atmospheric CO₂ Inversion Models
  - 3 inversions
  - LSCE MACC
  - Jena
  - Carbon Tracker

Time varying CO₂ flux anomalies

- TRENDY land Fluxes GPP, TER, fires, NEE + GPP, TER, NEE from FLUXNET data driven products

::: ESA-CCI Collocation meeting :::: 20-22 March 2018 ::::
Land-surface models

Bonan et al. 2008
Data-driven ML products
Engaging the community
Project overview

Teams and workplan

- **Atmospheric CO₂ inversions**
  - Annual updates of global and regional CO₂ budgets & uncertainties (CAMS, CarboScope, CarbonTracker)

- **Land surface models (LSMs)**
  - Annual update of LSMs’ outputs (GPP, TER, NEE, LAI, C-stocks, etc) for globe and RECCAP regions
  - Evaluation of LSMs against ESA-CCI products (burned-area, biomass, land-cover, soil-moisture)
  - Analysis of LSMs ability to capture inter-annual variability and extremes (e.g. ENSO)

- **Data-driven* models**
  - Annual production of data-driver estimates of GPP, TER, NEE since 1982

- **Comparison of in-situ based and satellite CCI GHG based budgets**

- **Analysis of global and regional inter-annual anomalies and drivers**

- **Synthesis**
  - September each year
  - Synthesis of top-down & bottom-up estimates
  - Open access to regional CO₂ fluxes
  - Engage the modelling & users’ community (Workshop)

---

*: ESA-CCI & EO data

::: ESA-CCI Collocation meeting :::: 20-22 March 2018 ::::
## ESA-CCI & RECCAP-2

### Collocation meeting

20-22 March 2018

---

<table>
<thead>
<tr>
<th>Variable</th>
<th>Project</th>
<th>Years currently covered</th>
<th>Resolution</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burned area (version 4.1)</td>
<td>CCI Fire</td>
<td>2005-2011</td>
<td>0.25 degree, bi-weekly</td>
<td>Chuvieco et al. (2016)</td>
</tr>
<tr>
<td>Land cover (version v.2.0.7)</td>
<td>CCI Land Cover</td>
<td>1992-2015</td>
<td>300m, annual, with dedicated tool available to convert to DGVM resolutions</td>
<td>Li et al. (2016)</td>
</tr>
<tr>
<td>Soil moisture (v02.2)</td>
<td>CCI Soil Moisture</td>
<td>1978-2015</td>
<td>0.25 degree, daily</td>
<td>Dorigo et al. (2015)</td>
</tr>
<tr>
<td>XCO2_SCI_BESD</td>
<td>CCI GHG</td>
<td>2002-2015</td>
<td>60×30 km²</td>
<td><a href="http://ghgcci.physik.uni-bremen.de/">http://ghgcci.physik.uni-bremen.de/</a></td>
</tr>
<tr>
<td>XCO2_GOS_OCFP</td>
<td>CCI GHG</td>
<td>2009-2015</td>
<td>10.5 km</td>
<td><a href="http://ghgcci.physik.uni-bremen.de/">http://ghgcci.physik.uni-bremen.de/</a></td>
</tr>
<tr>
<td>XCO2_GOS_SRFP</td>
<td>CCI GHG</td>
<td>2009-2015</td>
<td>10.5 km</td>
<td><a href="http://ghgcci.physik.uni-bremen.de/">http://ghgcci.physik.uni-bremen.de/</a></td>
</tr>
</tbody>
</table>

---

+ Recently funded **Biomass CCI**

---

**TIMING IS CRUCIAL!**
New opportunities

Positive sign for C to the atmosphere

Constraining multi-annual variability in terrestrial CO₂ fluxes from model-data integration

Li et al. GRL, 2017
New opportunities

Compensating moisture effects make temperature dominate global land carbon sink variations

Jung et al. Nature, 2017
New opportunities
New opportunities

Friedlingstein et al. *in prep*
Thanks!