# REgional Carbon Cycle Assessment and Processes (RECCAP)

*Version 12*

## Mandate

1. Establish the mean carbon balance of large regions of the globe at the scale of continents and large ocean basins, including their component fluxes, using a combination of bottom up data and models from regional carbon cycle programs and global analyses.

2. Compare these bottom-up estimates with the results of regional top-down atmospheric inversions, and thereby test the compatibility of regional bottom-up estimates with global atmospheric constraints.

3. Evaluate the regional 'hot-spots' of interannual variability and possibly the trends and underlying processes over the past decades by combining available long-term observations and model results.

## Products

1. Special issue (and possibly published also as a book), including papers on regional land and ocean C budgets, papers assessing overall state, trends and variability in carbon fluxes, and synthesis papers testing compatibility of regional bottom-up estimates with global atmospheric constraints (pdfs should be available shortly after publication for wide distribution). We will explore Online Open Access journals to ensure that publication after submission of individual papers is not delayed by late submissions. Examples of Journals that will be explored are Biogeosciences and Earth Interactions. Suggestions are welcome.

2. High-level synthesis paper/s reporting key results in Science, Nature or Nature-Geoscience. Possibility for 2-3 high-level synthesis papers as special feature in Nature-Geosciences.

3. Database (updatable in the future) of C fluxes from regional and global estimates

## Global and Regional Syntheses

### Principle

A group of scientists will take responsibility for assembling a synthesis of the C balance of their region, using an ensemble of methods and data. This synthesis should broadly follow the IPCC principles:

- draw mostly on existing research work and tools, although specific new data analysis or model simulations will be welcome,
- give a fair account of representative results obtained by different groups which can be reflected in the multiple authorship of the synthesis,
- provide traceable and referenced information about the data and model sources,
- provide a clear assessment of uncertainties and methods, including remaining areas of discrepancy, or uncharted areas. We do not expect an even distribution of knowledge and uncertainties over each region of the globe, given the contrasting density of regional C observation networks.

**Guidelines for synthesis scope, content and lengths**
No more than 15 pages of text double spaced + additional figures and references. The text should consist of synthesis work for a general scientific readership, summarizing the various existing streams of data or model results, and focusing on analyzing the results and their uncertainties (length and formats will change based on the election of journals)

**Global Syntheses G1-G5**
Each of these syntheses will cover and analyze the globe subdivided into large regions (e.g. the TRANSCOM land and ocean regions) using a globally homogeneous approach global analysis of fossil fuel and cement emissions from harmonized energy-related statistics. Synthesis work in each of these 'global' syntheses should begin with a summary description of the approach and data used, focus primarily on discussing regional differences in C balance and uncertainties, possibly in light of the underlying mechanisms. Each region will be analyzed both for its long term mean C budget over the target period 1990-2008, but also wherever possible for their rate of interannual variability and trends. Regions poorly constrained by data should be identified

**Regional Land Syntheses (L1-L10)**
Each regional land syntheses should at least provide:

- Estimate of the long-term mean C budget, over the past 18 years (1990-208) excluding anthropogenic emissions that will be treated in a separate synthesis.
- Provide estimate of the average (monthly) seasonal cycle of ecosystem fluxes and (if possible) of disturbance-related emissions.
- Provide a simple breakdown, e.g. in a summary table, of the long term mean C budget into component gross fluxes of GPP, NPP, RH, and Disturbance emissions for major land cover types including at least croplands, grassland and forests (themselves possibly separated if necessary into types such as deciduous vs. conifers).
- Provide estimation of the interannual flux anomalies over the past 16 years
- Give an overview of the dominant underlying processes causing sources and sinks and, if relevant, of sub-regional 'hot spots'.

**Regional Ocean Syntheses O1-O7**
Each regional ocean synthesis should at least provide:

- Estimate of the long-term mean C budget, over the past 18 years (1990-2008), including interior ocean.
- Provide an estimate of the natural and anthropogenic $CO_2$ fluxes
- Provide estimate of the average (monthly) seasonal cycle of $CO_2$ fluxes
- Provide a simple breakdown, e.g. in a summary table, of the long term mean C budget into component gross fluxes of primary production, export production, thermal component and physical transport.
- Provide estimation of the interannual flux anomalies since 1983.
- Give an overview of the dominant underlying processes causing sources and sinks and, if relevant, of sub-regional 'hot spots'.

**Final Syntheses S1-6**
These Synthesis Of Synthesis (= S syntheses) will be drafted during the meeting, drawing upon the results of syntheses above. To facilitate this process, a spreadsheet with the main regional results from these syntheses will be prepared and distributed short before the meeting. Four SOS syntheses are foreseen that will integrate top-down inversions results with state of the art bottom-up long-term mean fluxes, and their interannual variability, possibly also in key regions the long term trends. Areas where both approaches converge or differ will be identified, as well as uncertainties assessed into a coherent framework. A discussion of the different processes contributing regionally (eg $CO_2$ fertilization versus legacy from past land use change and climate change) will be provided in synthesis S3. Finally, synthesis S4 will make essential recommendations for reducing errors in the future (e.g. organizing data exchange protocols, tailored model intercomparisons or model-data comparison, identify regions where key information is missing and ways to reduce uncertainties in a 5-10 years time frame, including the forthcoming advent of remotely sensed $CO_2$ columns from new sensors)

## List of Syntheses

Whenever possible and appropriate, there will be two lead authors/coordinators with one being an observationlist and the other a modeler. This balance also needs to be taking into account in the list of contributors.

### Global Introductory Syntheses

| Global Introductory Synthesis | Topic | Lead authors | Suggested contributing authors |
|---|---|---|---|
| G1 | Fossil fuel emissions | tba | Gregg Marland, Mike Raupach, Kevin Gurney, Peter Rayner et al. |
| G2 | Land use change emissions | Skee Houghton (Woods Hole, USA)<br>Guido van Werf (The Netherlands) | Ruth DeFries, Hanson, Stephen Stitch, Jim Randerson, others |
| G3 | Global atmospheric budget | Kevin Gurney (USA)<br>Rachel Law (Australia)<br>Philippe Peylin (France) | Andy Jacobson, Christian Rödenbeck, TransCom, others |

### Terrestrial Regional Syntheses

| Terrestrial Regional Syntheses | Topic | Lead authors | Suggested contributing authors |
|---|---|---|---|
| L1 | Africa | Riccardo Valentini (Italy)<br>Bob Scholes (South Africa)<br>Yadvinder Mahli (UK) | Niall Hanaan, Christopher A. Williams, Dario Papale, Joerg Kaduk, Markus Reichstein, others |
| L2 | Arctic tundra | David McGuire (Alaska, USA)<br>Torben Christensen (Sweden) | |
| L3 | Australia | Vanessa Haverd (CSIRO, Australia)<br>Mike Raupach (CSIRO, Australia) | Rachel Law, NCAS-Gary Richards, Yingping Wang, Pep Canadell, others |
| L4 | East Asia (Two Koreas, Mongolia, China, Japan) | Shilong Piao (Peking University, Ming Xu (CAS, China), Japanese co-author, Korean co-author | Tian-TEM, Xaao Purdue University, Shaoqiang Wang, Jingyun Fang, Yao Huang, Mei Huang, Guangsheng Zhou et al., Ito, Yoshi Yamagata, Korean colleagues. |
| L5 | Southeast Asia | tba | |
| L6 | South Asia (India) | tba | |
| L7 | Europe | Sebastiaan Luyssaert (Belgium)<br>Philippe Ciais (France) | Detlef Schulze, Markus Reichstein (MPI-Jena), Dario Papale (U. Tuscia who did the global fluxnet synthesis), S. Luyssaert (U. Antwerp); A. Cescatti (JRC), N. Vuichard (LSCE ), Gert-Jan Nabuurs (inventories), Detlef Schulze, Riccardo Valentini, |

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|---|---|---|---|
| | | | Galina Churkina. |
| L8 | North America | Mac Post (USA), Ken Davis (USA)<br>Werner Kurz (Canada)<br>Ben de Jong (Mexico) | Proposed by Ben for Mexican contribution: Fernando Paz Pellat (remote sensing of land use and land-use change); Jorge Etchevers Barra (soil scientist, expert on soil carbon dynamics in terrestrial ecosystems); Marcela Olguin (carbon density assessments in forest ecosystems and modelling);<br>Carlos Cruz Gaistardo (expert on soils and soil carbon, land use and land-use change) |
| L9 | Russia | Han Dolman (The Netherlands)<br>Anatoly Shvidenko | Mattias Jonas,. Involve Russians and Japanese. Ask him Inoue. Christian Wirth (forests), Usoltsev, David Archard or Mollicone (remote sensing, Lapshina (forest bogs), tundra: Kuhry (tundra ), Hubberto, Belelli (Grassland),), Luca Belelli et al., Guy from NIES (works with Anatoly, asked me in Jena). |
| L10 | South America | Emanuel Gloor (UK)<br>Umberto Roach (Brazil) | Jean Ometto, Chris Jones (modeler), Yadvinder Malhi (eddy fluxes, forest inventories), Scott Denning (atmospheric inverse modeling), Simon Lewis (forest inventories), Esteban Jobbagy et al. |

**Global Oceans Syntheses**

| Global Introductory Syntheses | Topic | Lead authors | Suggested contributing authors |
|---|---|---|---|
| O1 | Global ocean surface $CO_2$ | Taro Takahashi (Columbia University, USA)<br>Rik Wanninkhof (NOAA, USA) | G. Mckinley To compare multiple products providing mean and seasonal estimates of air-sea $CO_2$ fluxes. That includes Taro's new 2000 climatology, Wanninkhof's seasonal flux maps (these can be used to convert the climatology to a real assessment of fluxes between the stated years), oceanic inversions of Niki's group, and other work as available (possibly the product from CASIX if ready on time). |
| O2 | Global ocean carbon storage | Samar Khatiwala (Columbia University, USA)<br>Toste Tanhua (Kiel, Germany) | C. Sabine, R. Schlitzer, (Others: Toste Tanhua (CarboOcean, CARINA etc.), Are Olsen et al. (SOCAT) et al., Robert M. Key (Princeton, GLODAP data set), Reiner Schlitzer (AWI, Bremerhaven) and Joos/Gerber (Univ. Bern), M. Ishii (JMA), A. Murata (JAMSTEC) for ocean inversions and data assimilation |

**Regional Oceans**
Regional syntheses below discuss the contribution of anthropogenic $CO_2$ and DIC, an estimate of the contributing processes, and interannual variability or trend as appropriate.

| Ocean Syntheses | Topic | Lead authors | Suggested contributing authors |
|---|---|---|---|
| O3 | Pacific | M. Ishii (Tsukuba, Japan),<br>Richard Feeley (NOAA, USA) | F. Chai, McKinley, Nojiri, Y. Watanabe et al. |
| O4 | Atlantic and Arctic | Ute Schuster (University East Anglia, UK)<br>Second co-lead, tba | Doug Wallace, Andy Watson, Mick Follows (MIT) Leif Anderson/Sara Jutterström (Gothenburg, essential for Arctic), Stefanie Dutkiewicz (MIT), Nick Bates (Arctic ocean), et al. |
| O5 | Southern Ocean | Andrew Lenton (CSIRO, Australia)<br>Bronte Tilbrook (CSIRO, Australia) | Richard Matear, Nikki Lovenduski (US), Nicolas Metzl, Marta Alvarez, et al. |
| O6 | Indian | Nicolas Metzl (France)<br>V. Sharma (India) | Claire Lo Monaco |
| O7 | Coastal Ocean and marginal sea | Alberto Borges (Belgium) | Arthur Chen, Casper Plattner (modeller), Helmuth Thomas, Wei-Jun Cai et al. |

| Global Lateral Fluxes Syntheses | Topic | Lead authors | Suggested contributing authors |
|---|---|---|---|
| G4 | Rivers fluxes (globe). | Peter Raymond (USA) | Abril, Sundquist, Michel Meybeck (Paris), Hans Dürr (Utrecht) (aquatic carbon cycle in naure geo, see authors). We need both the gross flux (2gt) and the one that is sequestered in the oceans (0.6) Pierre Regnea (world best on estuaries). |
| G5 | Embedded carbon in trade | Glen Peters (Norway)<br>Steven Davis (USA) | Ken Caldeira, others |

**Global Syntheses of Syntheses**
All Authors above would contribute to the global syntheses.

| Global Syntheses Syntheses | Topic | Lead authors | Suggested contributing authors |
|---|---|---|---|
| S1 | Comparison of atmospheric & bottom up fluxes (mean decadal). | Wolfgang Knorr, others | Marco Scholze; Ning Zeng, et al. (include atmospheric inversions, flux studies, book-keeping methods (inventories), and combined methods (data assimilation) |
| S2 | Inter-annual variability at regional scale. | Markus Reichstein (Germany) | Rachel Law (CSIRO, Australia) Kevin Gurney, Corinne Le Quere, Joerg Kaduk, Guido van Werf, Karen Assmann (Bergen, as for Atlantic) |

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|---|---|---|---|
| S3 | Attribution to regional processes over the globe | Niki Gruber (Switzerland)<br>Pep Canadell (Au)<br>Stephen Sitch (UK) | Rob Jackson (USA)-Chris Sabine, Ying ping, Federico Magnani (Italy). Use a few models that have done factorial runs (no need all models, it would be too much work). Relationship between carbon sink and climate change, land management, etc. |
| S4 | Future trends | Mike Raupach (CSIRO, Australia)<br>Pierre Friedlingstein (France) | Jae Edmonds (biofuels). Ciais, Stephen Sitch, ocean forward modeler, Chris Sabine, et al. Meta-analysis of C4mip and other datasets and other future model projects. The carbon-climate feedback. Carbon sensitivity of carbon to temperature by reccap regions. This also should have the kaya type of results. Extrapolate drivers of land use from integrative assessment. How land use may change. Summary:<br>1) Biophysical change, carbon-climate feedback by region, 2) kaya for ff for each region, 3) kaya luc for each region. |
| S5 | Methods (protocols and uncertainty analyses) | | Ian Enting, Riccardo Valentini, Ciais, Canadell, others |
| S6 | Final recommendations | Multi-author | |

Glossary of all terms (eg, GPP, NEP).

**Time line**

August 2007
Draft of mandate and scope

April 2008
"Sign-in" on synthesis scope ; regional programs are contacted and will provide a quick feedback to Pep on the initiative + help to identify a list of key persons (= regional representatives, on the order of up to 3 persons per region responsible for representing their science communities).

May 2008
Synthesis framework (list of questions to be addressed) and time window (spatial & temporal resolution)

September 2009 (ICDC8)
Information and consultation session at the ICDC8 in Jena, Germany

November 2009
Invitations to lead authors
Detailed soft protocol for the production of regional syntheses.

May 2010
Global datasets and model runs available to the regional groups:

- Ocean inversions: Niki Grubber
- Ocean biogeochemical models: Corinne Lequere
- Atmospheric inversions: Kevin Gurney, Philippe Peylin, Rachael Law
- Terrestrial biogeochemical models: Stephen Stitch
- Fire emissions: Guido van Werf

October 2010
First RECCAP workshop to review progress towards the regional full carbon balances. 6-8 October 2009, Viterbo, Italy.

December 2010-January 2011
Regional synthesis are submitted for review

January-March 2011
Internal review of the syntheses & model results output is collected.

March-June 2011
Hold 2nd Workshop: Final Synthesis meeting over 4 full days to draft the Global synthesis papers. Revised regional papers are submitted.

March to December 2011
Finalizing syntheses of syntheses papers, reviewing, submissions, publication

## Committees and Engagement

**Steering Scientific Committee**
Philippe Ciais, *Chair* (France), Pep Canadell (Australia), Han Dolman (The Netherlands), Kevin Gurney (USA), Niki Gruber (Switzerland), Corinne Le Quere (UK), Mac Post (USA), Mike Raupach (Australia), Chris Sabine (USA), Piao Shilong (China), Stephen Stitch (UK), Ming Xu (China).

**RECCAP Partners**
The following organizations and projects have either become partners (involved in the running of RECCAP) or endorsed RECCAP with the commitment to contribute:

- COordination action Carbon Observation System (COCOS), Europe
- US Carbon Cycle Science Program USA
- Chinese Science Academy (CAS), China
- CSIRO Marine and Atmospheric Research, Australia
- National Institute for Environmental Studies (NIES), Japan
- Quantifying and Understanding the Earth System (QUEST), UK
- International Ocean Carbon Coordination Project (IOCCP)
- CarboAfrica

Additional partners and sponsorship are actively sought.

**Contact**
For further information, feedback on the document and interest in getting involved please contact: Pep Canadell <pep.canadell@csiro.au>