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

ESA-CCI collocation meeting

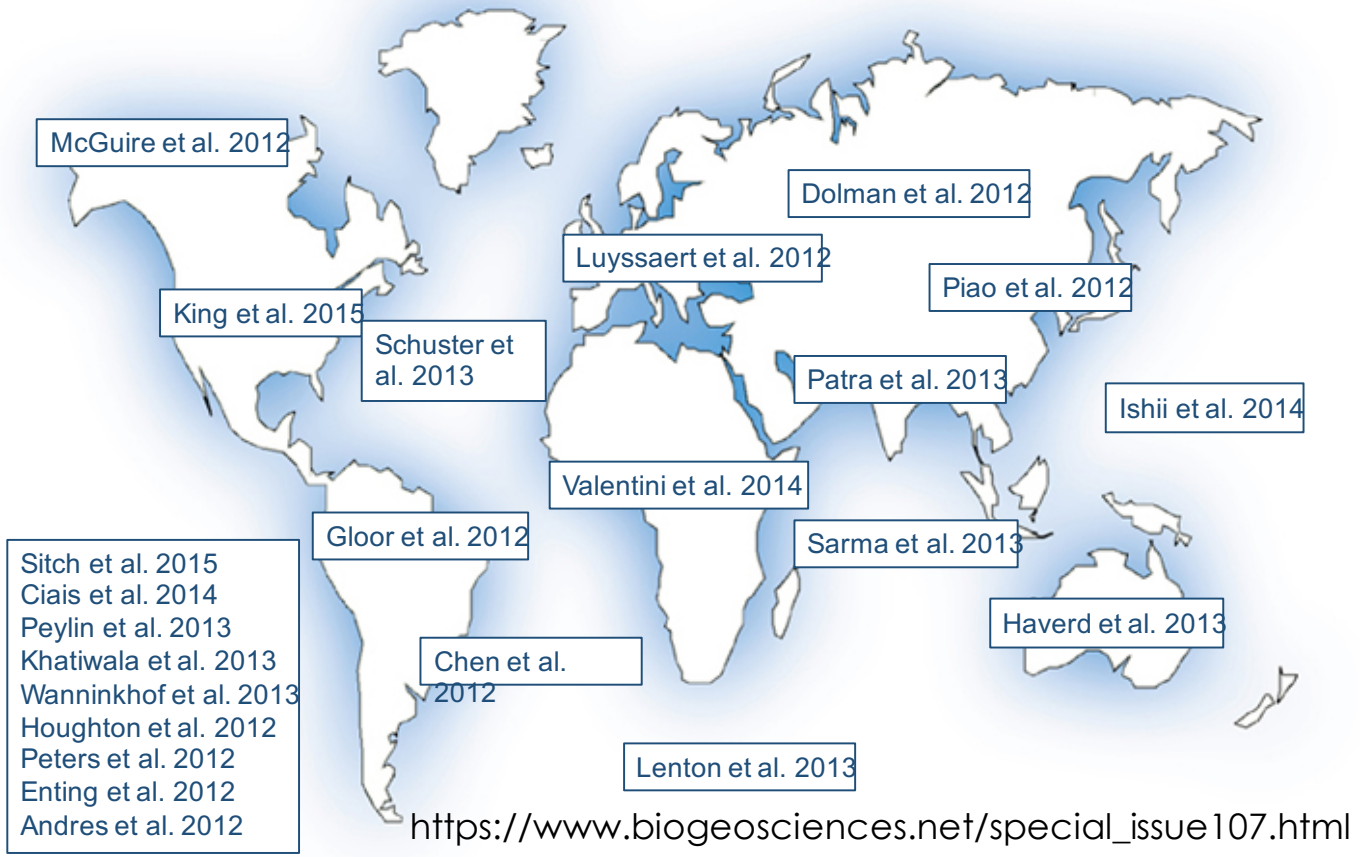
A.Bastos, P.Ciais, F.Chevallier, C.Yue, W.Li,
P.Friedlingstein, S.Sitch, M.Jung,M.Reichstein,P.Canadell

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.



https://www.biogeosciences.net/special_issue107.html

What is RECCAP?

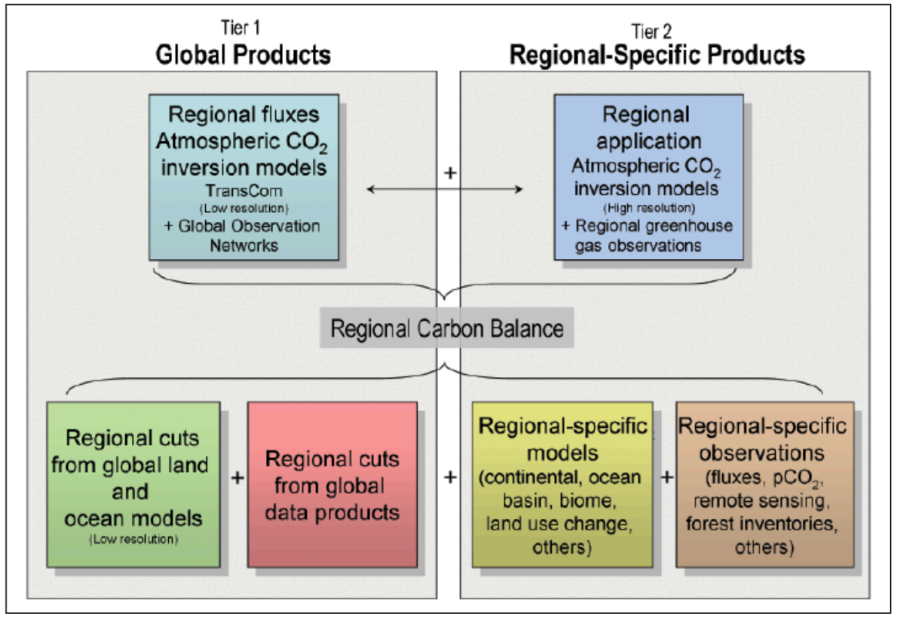
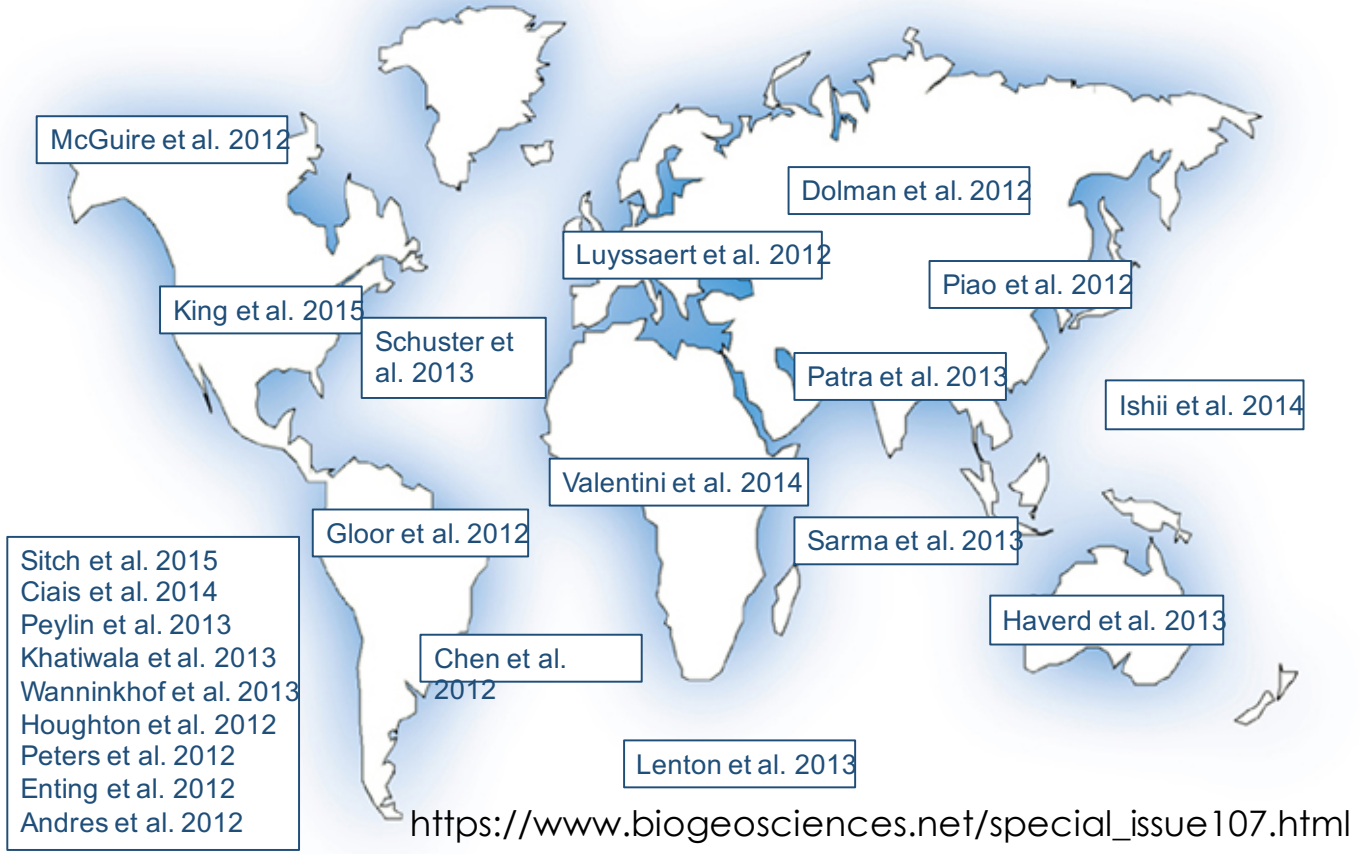


Fig. 1. Two-tier methodological approach ensuring that all regions, regardless of the level of information available to them, can develop a consistent top-down and bottom-up carbon balance.

Canadell et al., 2011



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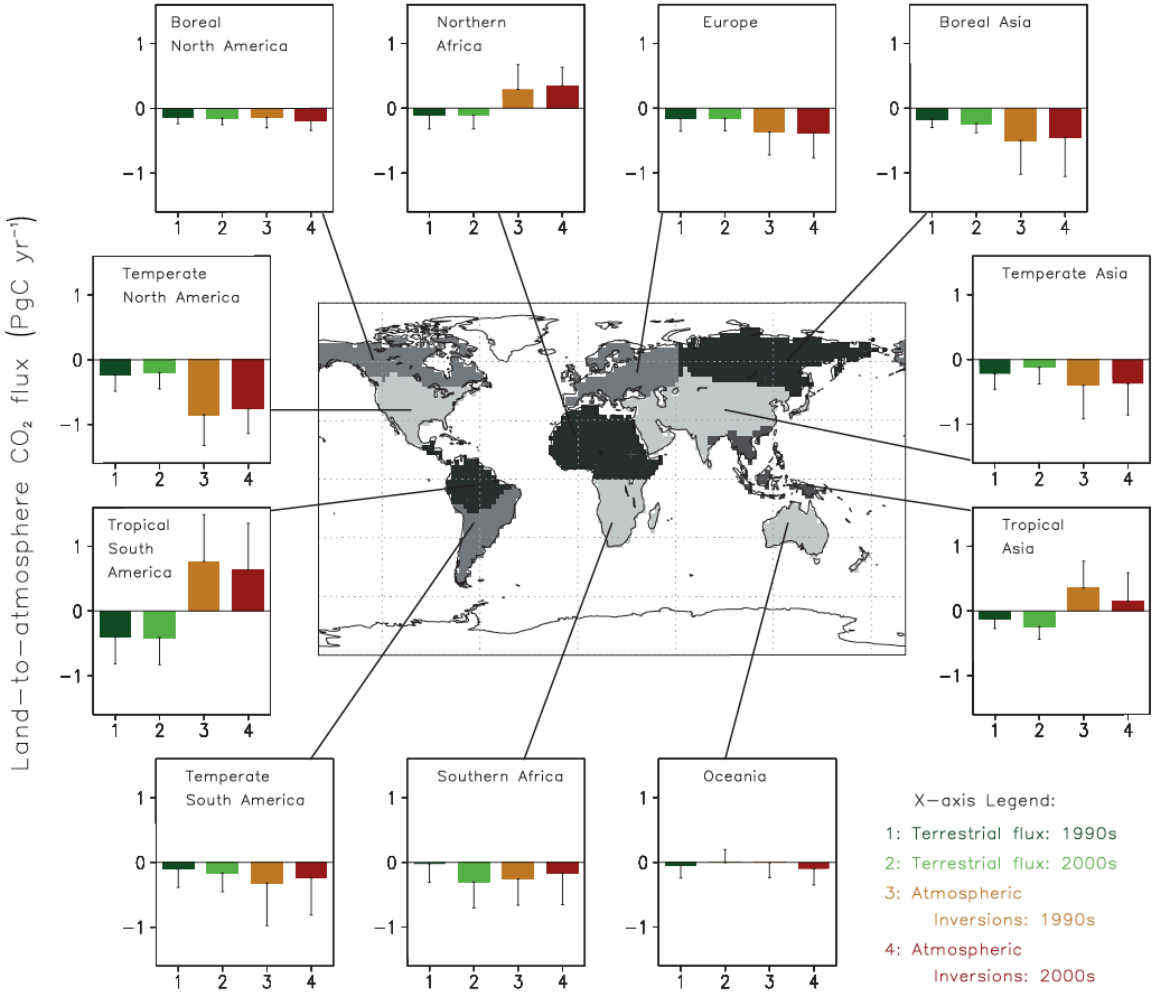
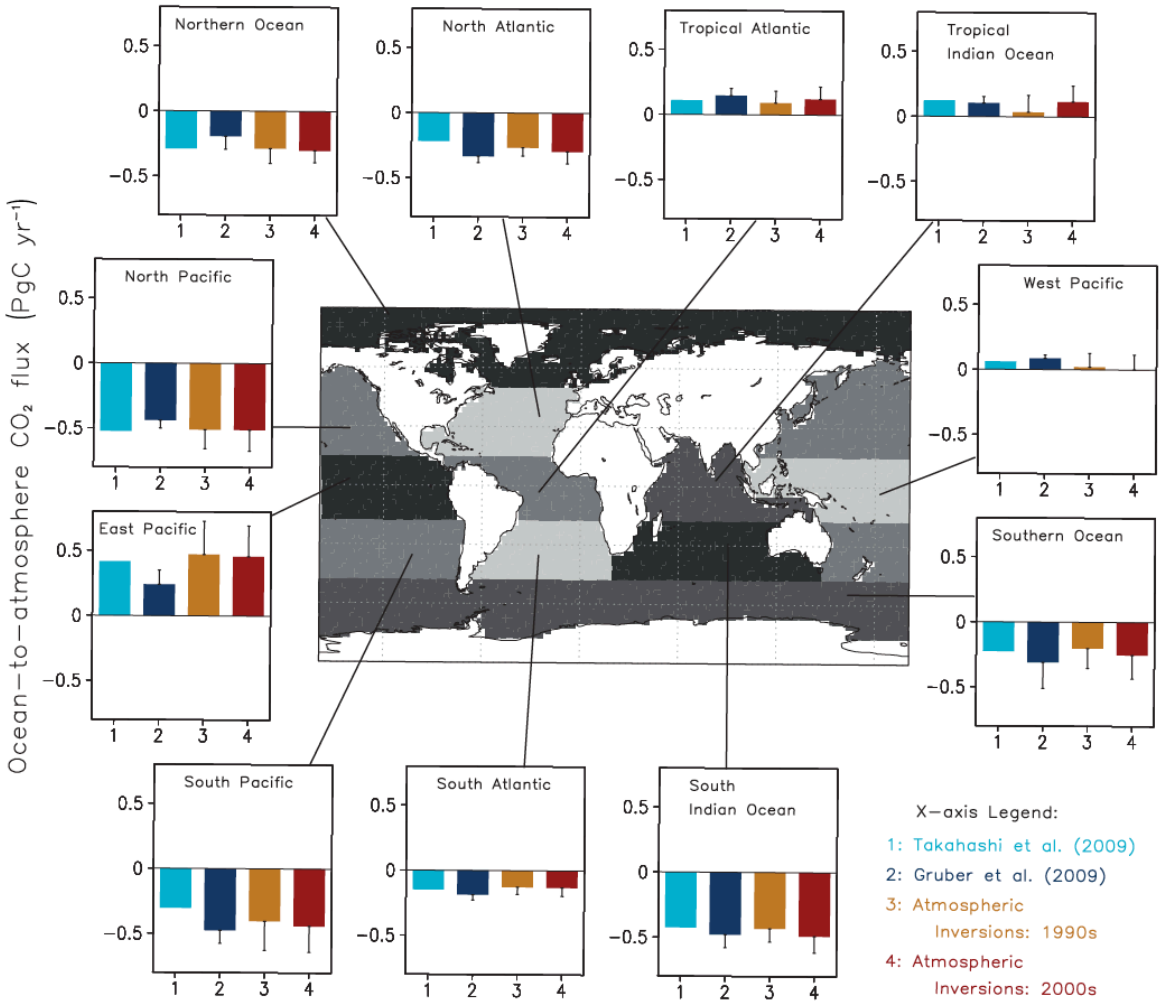
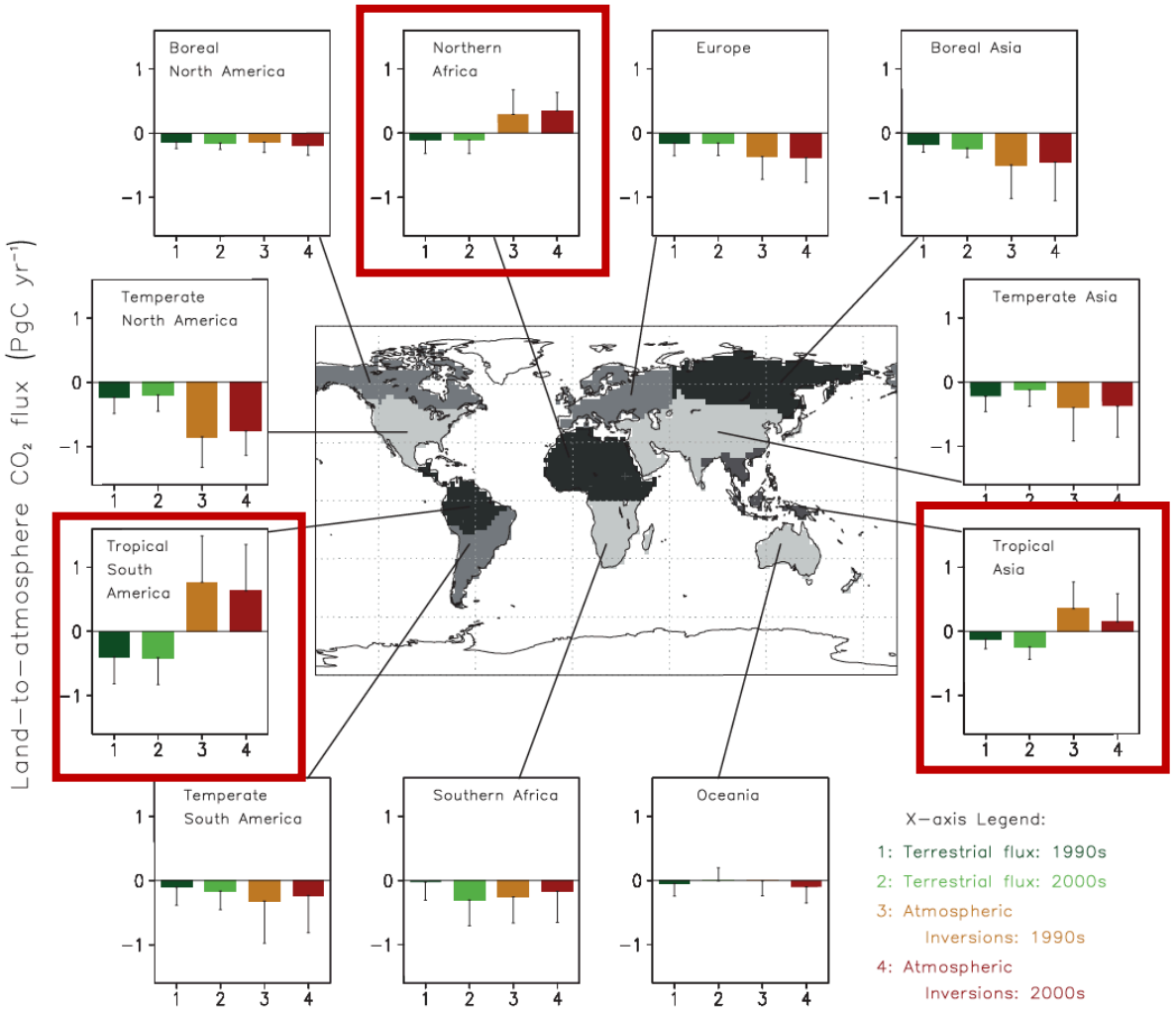
What is RECCAP?

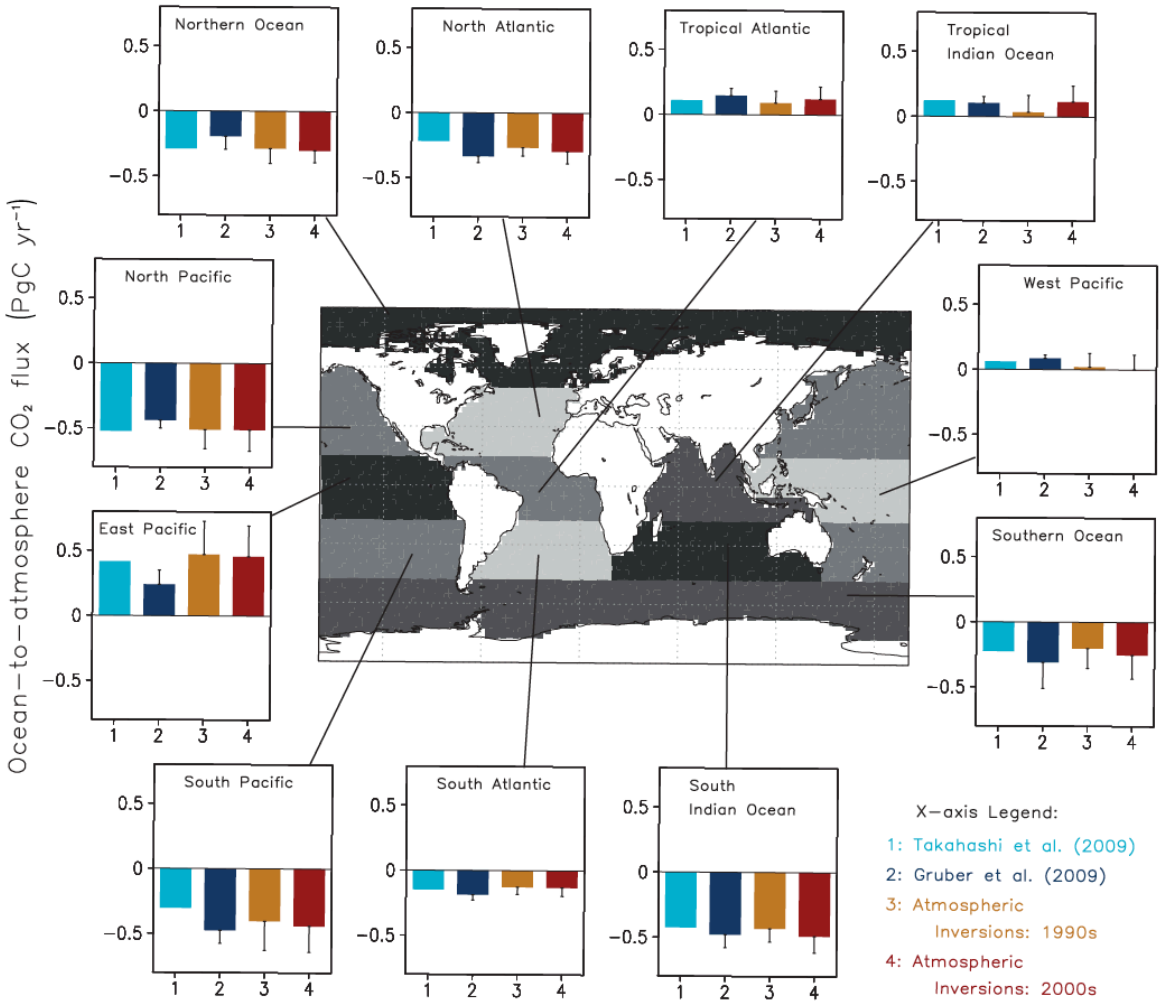




Ciais et al. 2013, IPCC AR5

What is RECCAP?





Ciais et al. 2013, IPCC AR5

Why RECCAP-2?

Earth Syst. Sci. Data, 10, 405–448, 2018
https://doi.org/10.5194/essd-10-405-2018

Open Access Earth System Science Data

Latest Global Carbon Budget

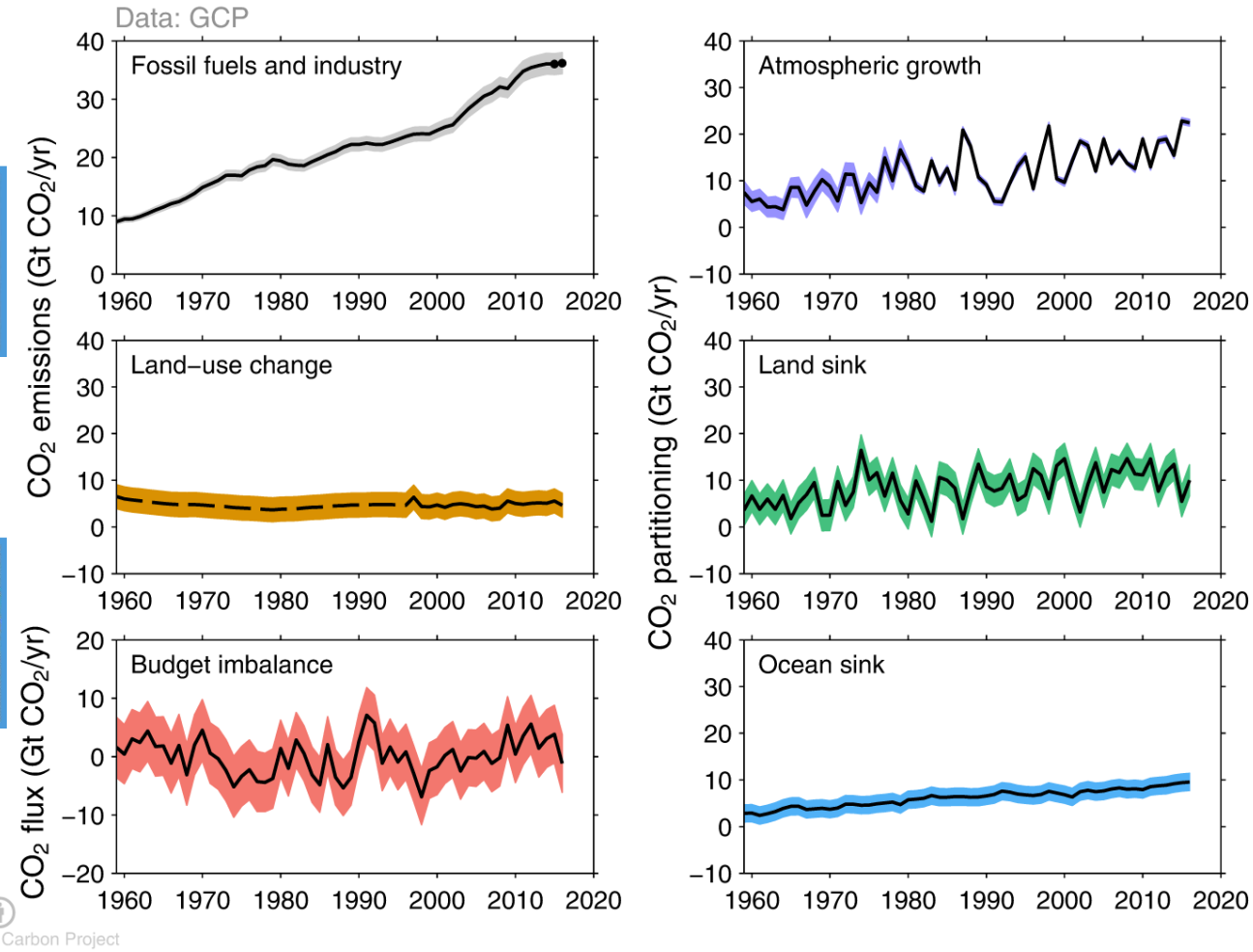
(LeQuéré et al., 2017)

Global Carbon Budget 2017

Corinne Le Quéré[1], Robbie M. Andrew[2], Pierre Friedlingstein[3], Stephen Sitch[4], Julia Pongratz[5], Andrew C. Manning[6], Jan Ivar Korsbakken[2], Glen P. Peters[2], Josep G. Canadell[7], Robert B. Jackson[8], Thomas A. Boden[9], Pieter P. Tans[10], Oliver D. Andrews[1], Vivek K. Arora[11], Dorothee C. E. Bakker[6], Leticia Barbero[12,13], Meike Becker[14,15], Richard A. Betts[16,4], Laurent Bopp[17], Frédéric Chevallier[18], Louise P. Chini[19], Philippe Ciais[18], Catherine E. Cosca[20], Jessica Cross[20], Kim Currie[21], Thomas Gasser[22], Ian Harris[23], Judith Hauck[24], Vanessa Haverd[25], Richard A. Houghton[26], Christopher W. Hunt[27], George Hurtt[19], Tatiana Ilyina[5], Atul K. Jain[28], Etsushi Kato[29], Markus Kautz[30], Ralph F. Keeling[31], Kees Klein Goldewijk[32,33], Arne Körtzinger[34], Peter Landschützer[5], Nathalie Lefèvre[35], Andrew Lenton[36,37], Sebastian Lienert[38,39], Ivan Lima[40], Danica Lombardozzi[41], Nicolas Metzl[35], Frank Millero[42], Pedro M. S. Monteiro[43], David R. Munro[44], Julia E. M. S. Nabel[5], Shin-ichiro Nakaoka[45], Yukihiro Nojiri[45], X. Antonio Padin[46], Anna Peregon[18], Benjamin Pfeil[14,15], Denis Pierrot[12,13], Benjamin Poulter[47,48], Gregor Rehder[49], Janet Reimer[50], Christian Rödenbeck[51], Jörg Schwinger[52], Roland Séférian[53], Ingunn Skjelvan[52], Benjamin D. Stocker[54], Hanqin Tian[55], Bronte Tilbrook[36,37], Francesco N. Tubiello[56], Ingrid T. van der Laan-Luijkx[57], Guido R. van der Werf[58], Steven van Heuven[59], Nicolas Viovy[18], Nicolas Vuichard[18], Anthony P. Walker[60], Andrew J. Watson[4], Andrew J. Wiltshire[16], Sönke Zaehle[51], and Dan Zhu[18]

Changes in the budget over time

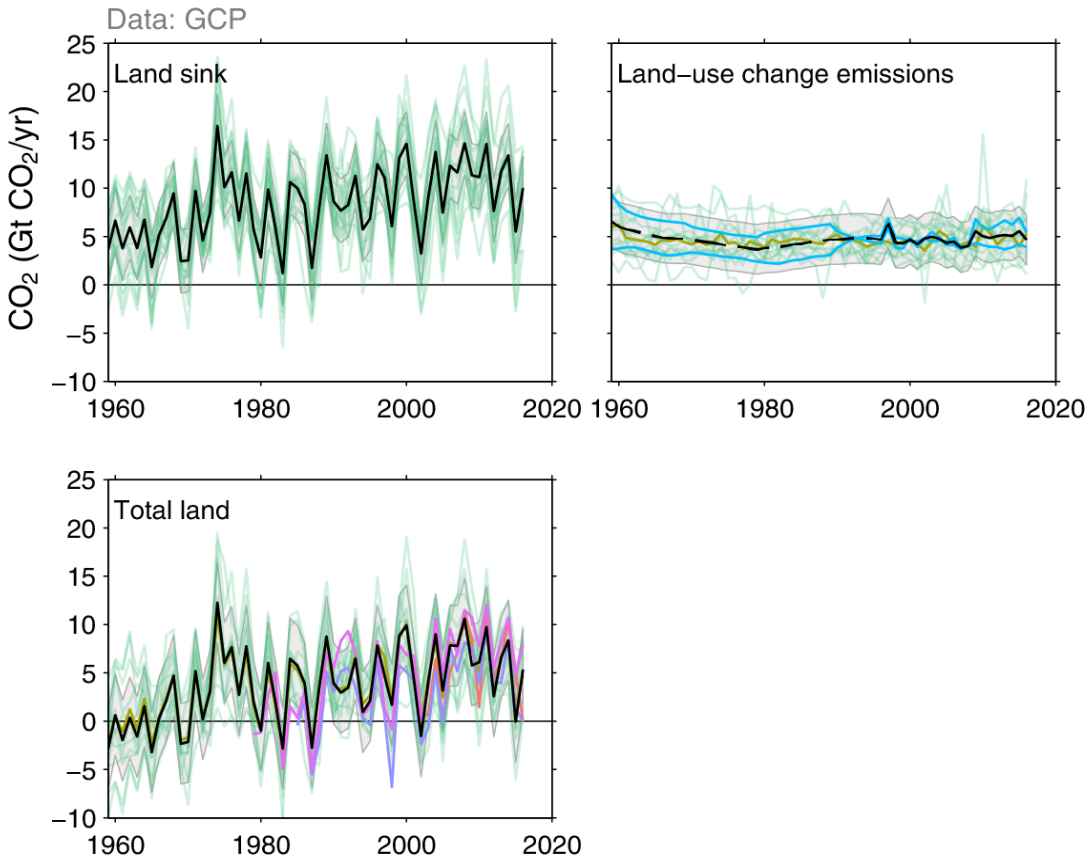
The sinks have continued to grow with increasing emissions, but climate change will affect carbon cycle processes in a way that will exacerbate the increase of CO_2 in the atmosphere



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

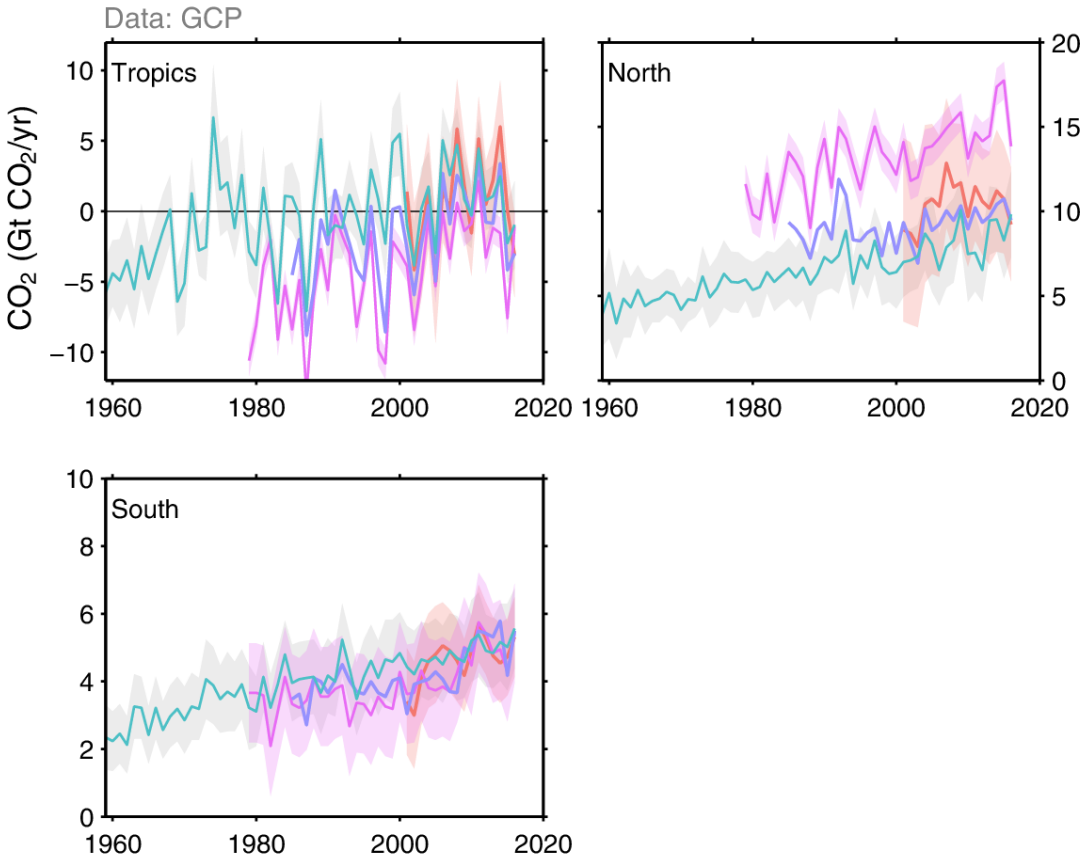
(LeQuéré et al., 2017)

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); Melton and Arora (2016); Oleson et al. (2013); Reick 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 CO_2 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

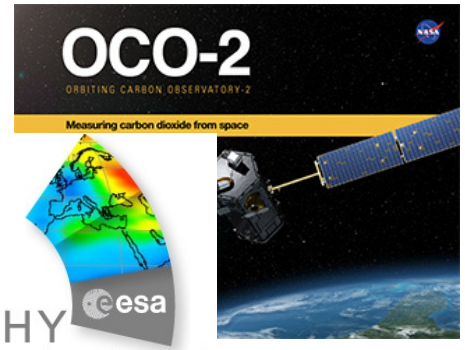
Individual estimates from: Aumont and Bopp (2006); Buitenhuis et al. (2010); Chevallier et al. (2005); Clarke et al. (2011); ; Doney et al. (2009); Guimberteau et al. (2017); Hauck et al. (2016); Haverd et al. (2017); Ilyiana et al. (2013); Jain et al. (2013); Kato et al. (2013); Keller et al. (2017); 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

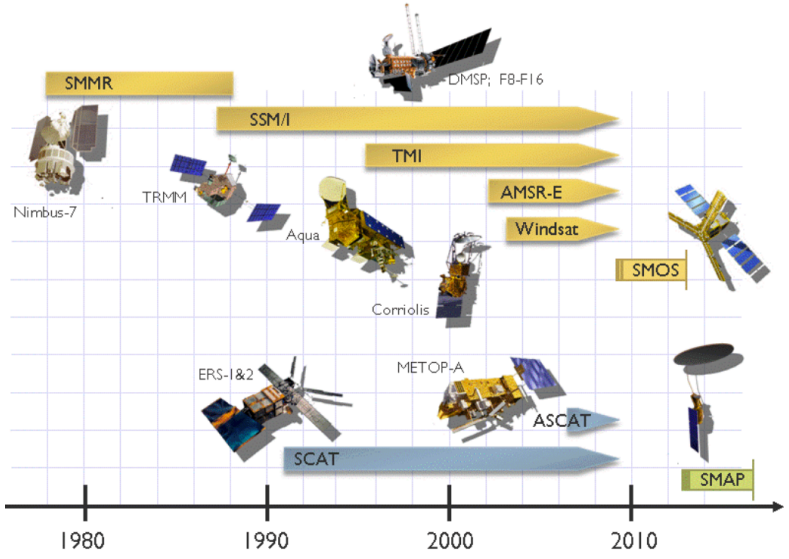
esa

SOCAT · SURFACE OCEAN CO_2 ATLAS ·

MERIS
Medium Resolution Imaging Spectrometer



SCIAMACHY
Scanning Imaging Absorption Spectrometer for Atmospheric Cartography



Copernicus
Europe's eyes on Earth

Atmosphere Monitoring Service

Jena CarboScope
Data-based estimates of carbon cycle variability

CarbonTracker

WAGENINGEN UNIVERSITY & RESEARCH

fire cci

land cover cci

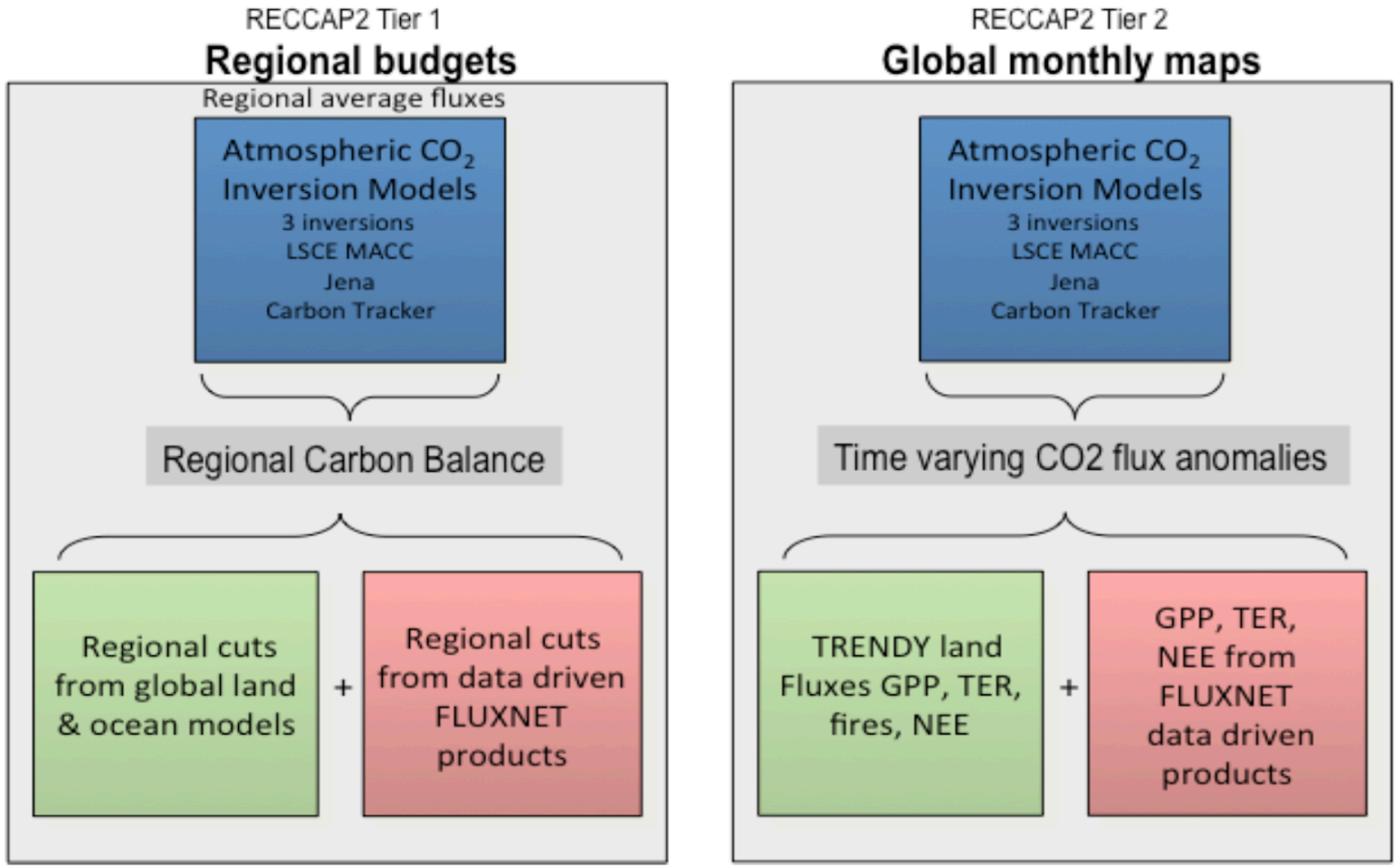
soil moisture cci

ghg cci

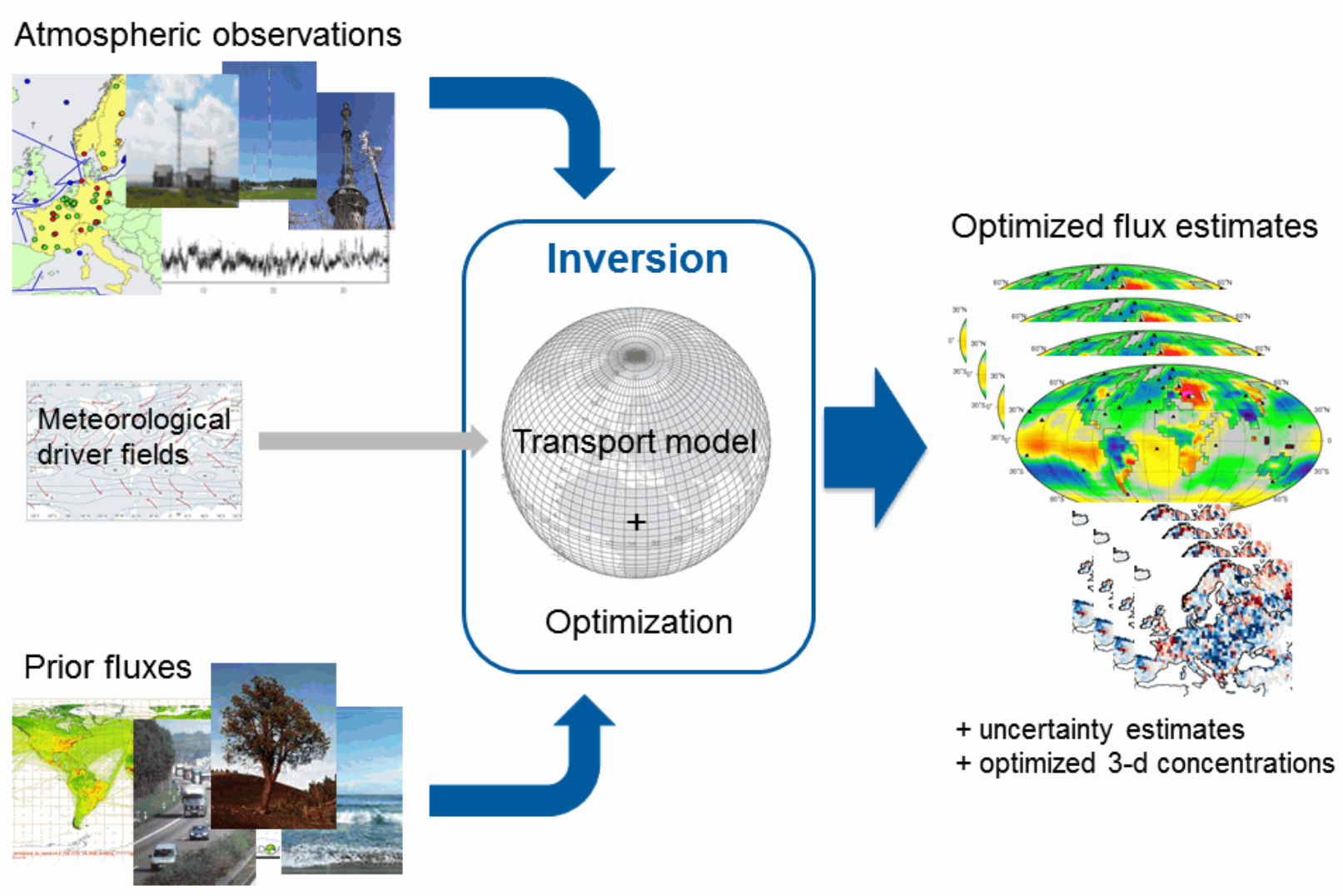
FluxCom

TRENDY

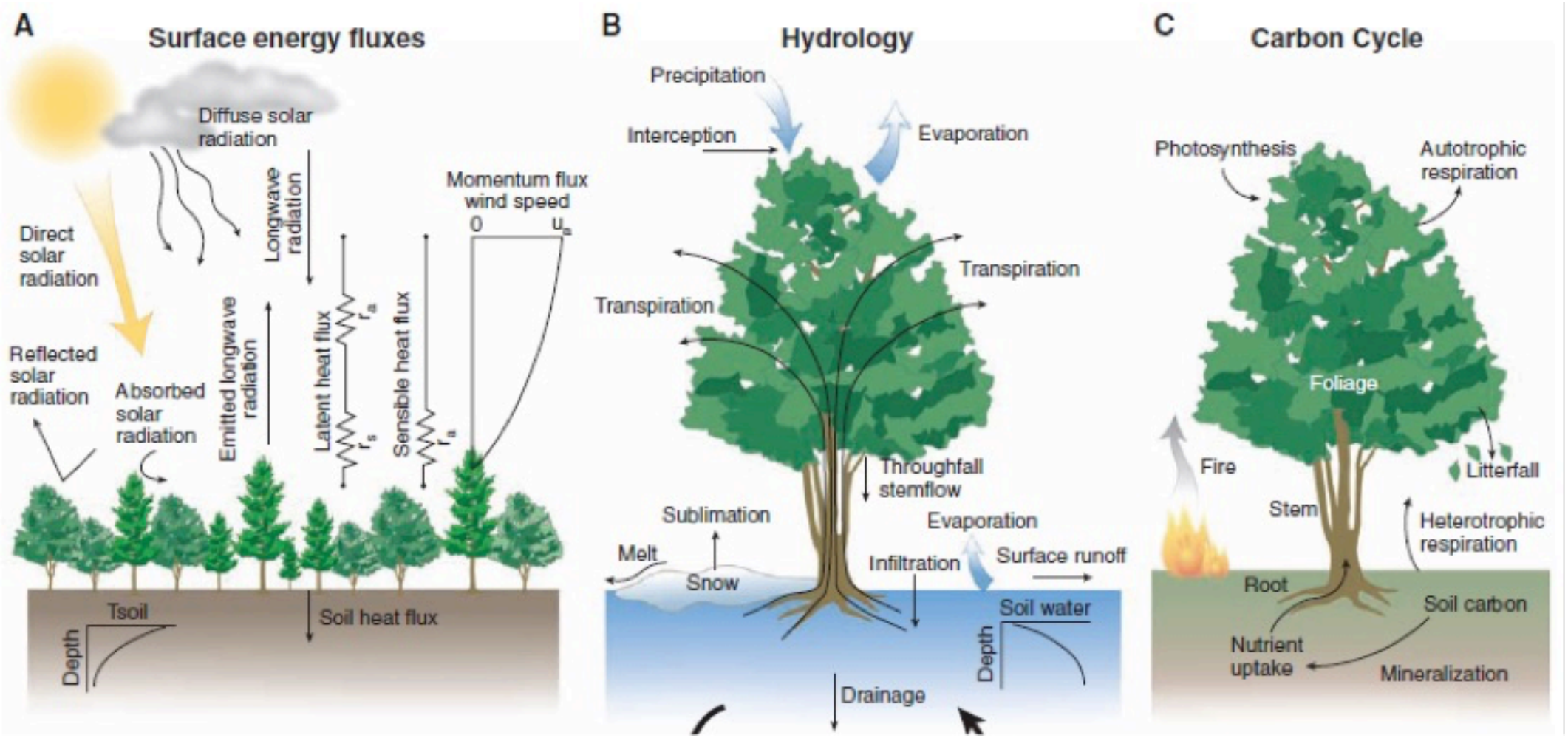
Towards RECCAP-2



Atmospheric Inversions

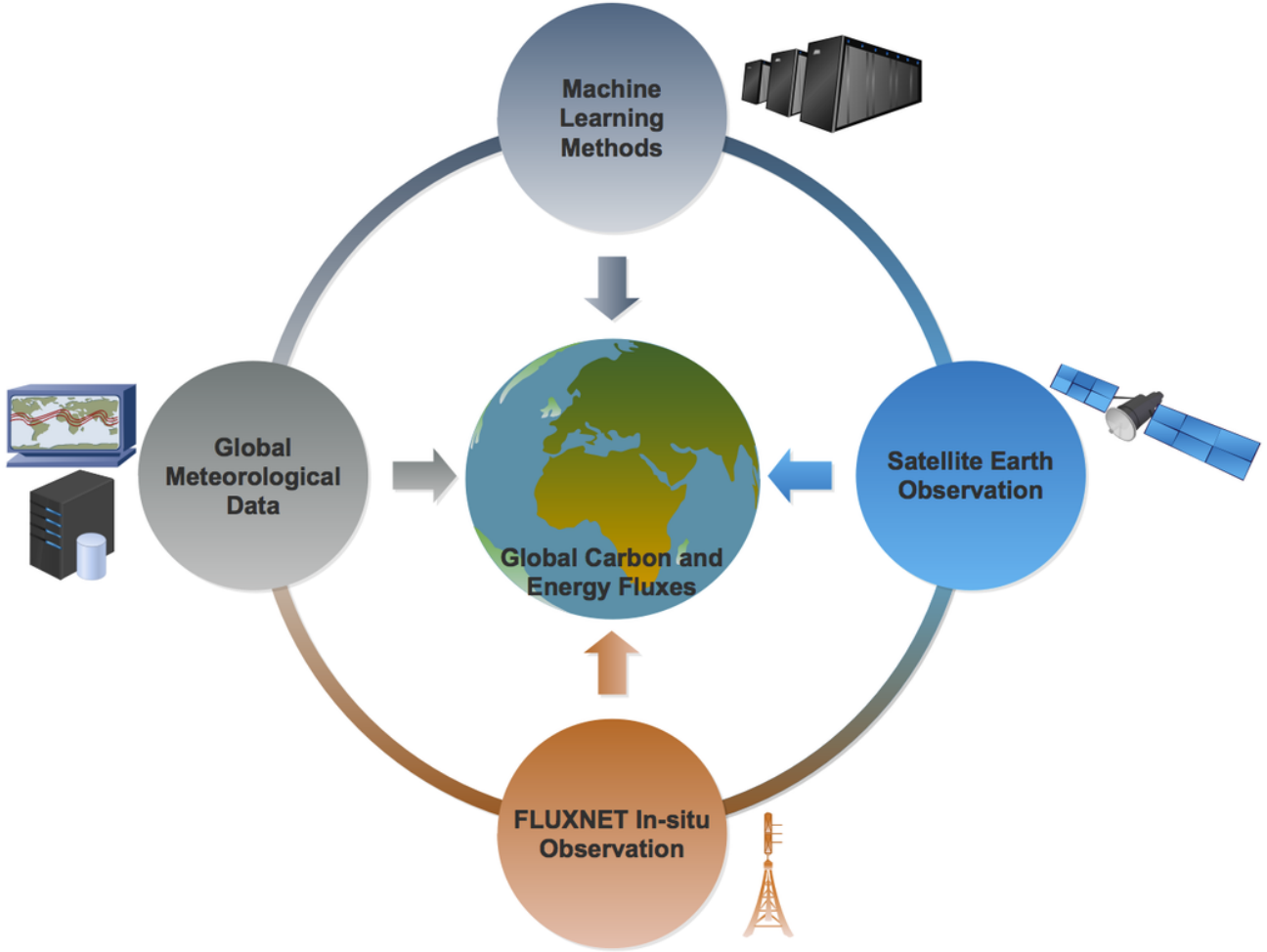


Land-surface models



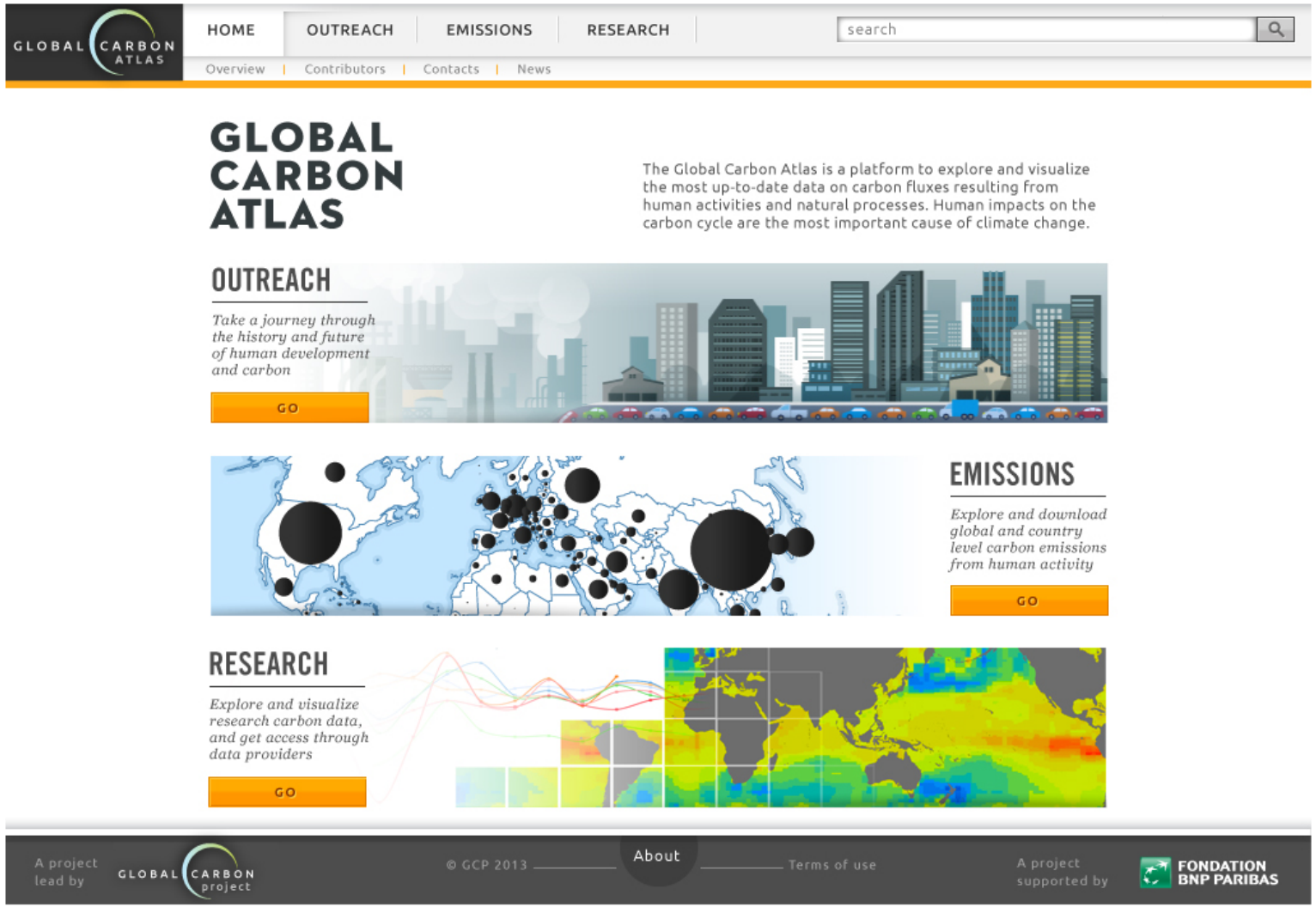
Bonan et al. 2008

Data-driven ML products



Fluxcom.org

Engaging the community



Project overview

Teams and workplan

September each year → GLOBAL CARBON project

LSCE – Laboratoire des Sciences du Climat & de l'Environnement

futurearth – research for global sustainability

LSCE – Atmospheric CO_2 inversions
- Annual updates of global and regional CO_2 budgets & uncertainties (CAMS, CarboScope, CarbonTracker)
- Comparison of in-situ based and satellite CCI GHG based budgets
- Analysis of global and regional inter-annual anomalies and drivers

University of Exeter – 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)

Max Planck Institute for Biogeochemistry – Data-driven* models
* ESA-CCI & EO data
- Annual production of data-driver estimates of GPP, TER, NEE since 1982
- Uncertainties and biases of data-driven estimates
- Systematic synthesis of uncertainty (predictors, algorithms, network)

Synthesis
- Synthesis of top-down & bottom-up estimates
- Open access to regional CO2 fluxes
- Engage the modelling & users' community (Workshop)

ESA-CCI & RECCAP-2

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

fire cci

land cover cci

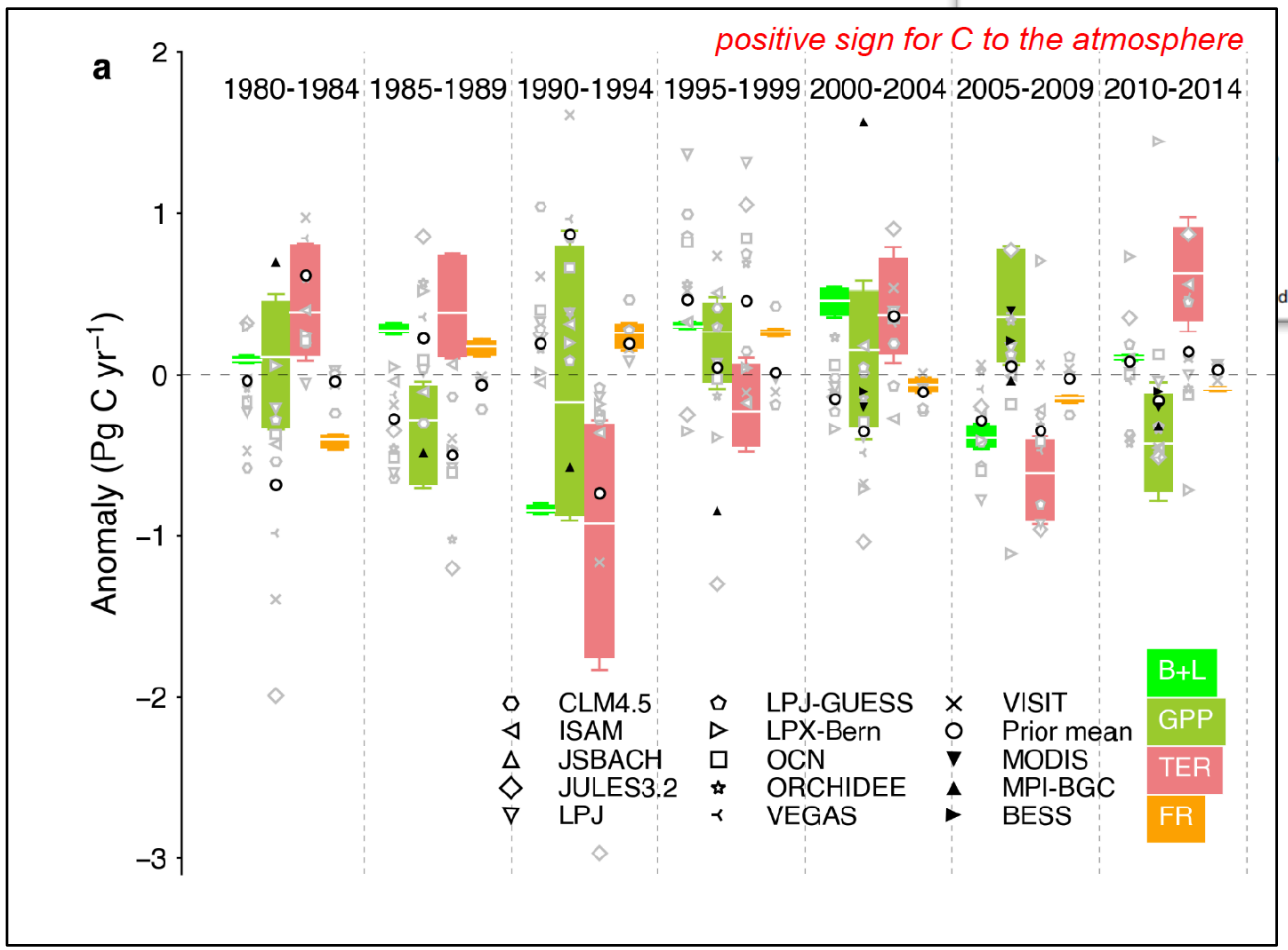
soil moisture cci

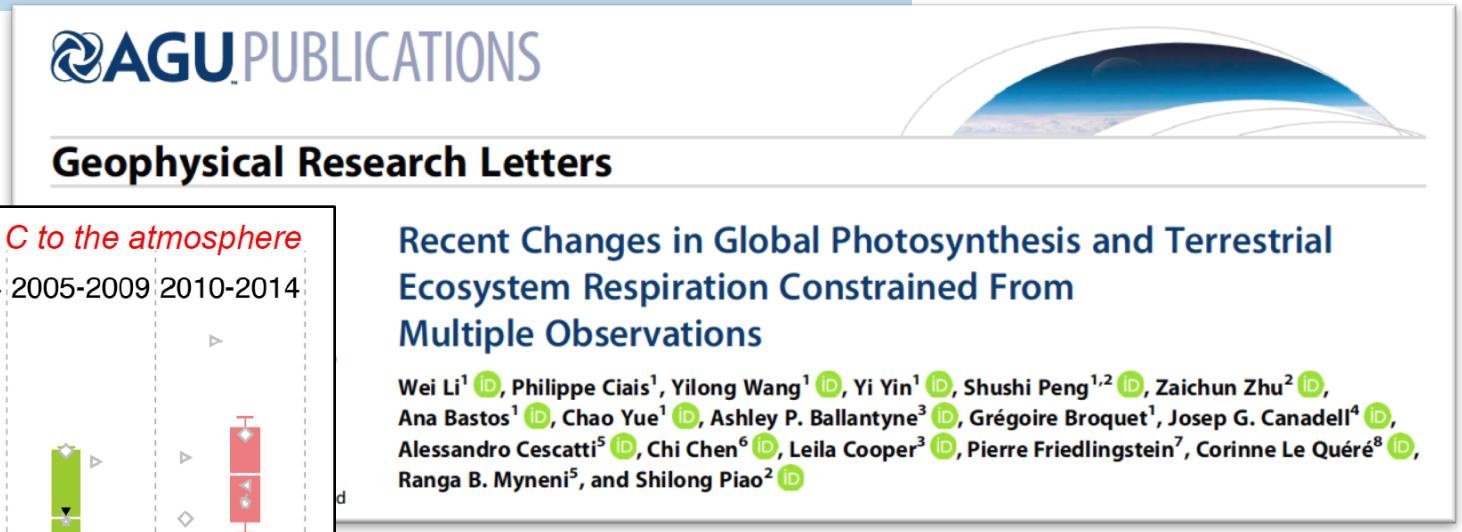
ghg cci

+ Recently funded **Biomass CCI**

TIMING IS CRUCIAL!

New opportunities




AGU PUBLICATIONS

Geophysical Research Letters

Recent Changes in Global Photosynthesis and Terrestrial Ecosystem Respiration Constrained From Multiple Observations

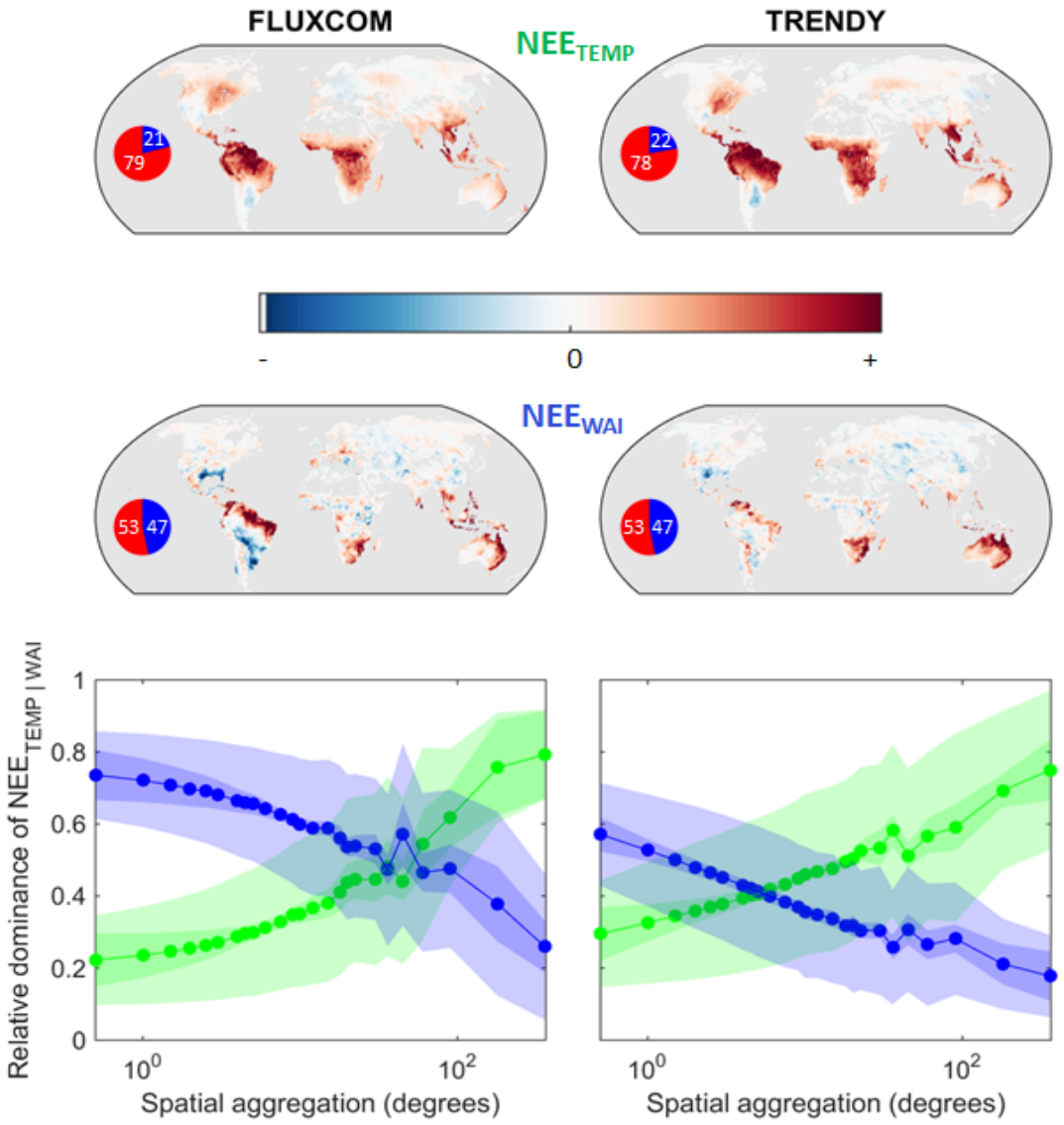
Wei Li[1], Philippe Ciais[1], Yilong Wang[1], Yi Yin[1], Shushi Peng[1,2], Zaichun Zhu[2], Ana Bastos[1], Chao Yue[1], Ashley P. Ballantyne[3], Grégoire Broquet[1], Josep G. Canadell[4], Alessandro Cescatti[5], Chi Chen[6], Leila Cooper[3], Pierre Friedlingstein[7], Corinne Le Quéré[8], Ranga B. Myneni[5], and Shilong Piao[2]

Constraining multi-annual variability in terrestrial CO_2 fluxes from model-data integration

Li et al. GRL, 2017

New opportunities

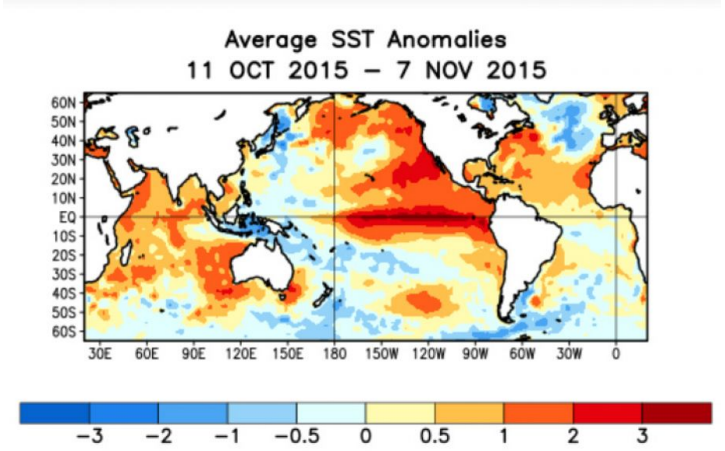
Compensating moisture effects make temperature dominate global land carbon sink variations

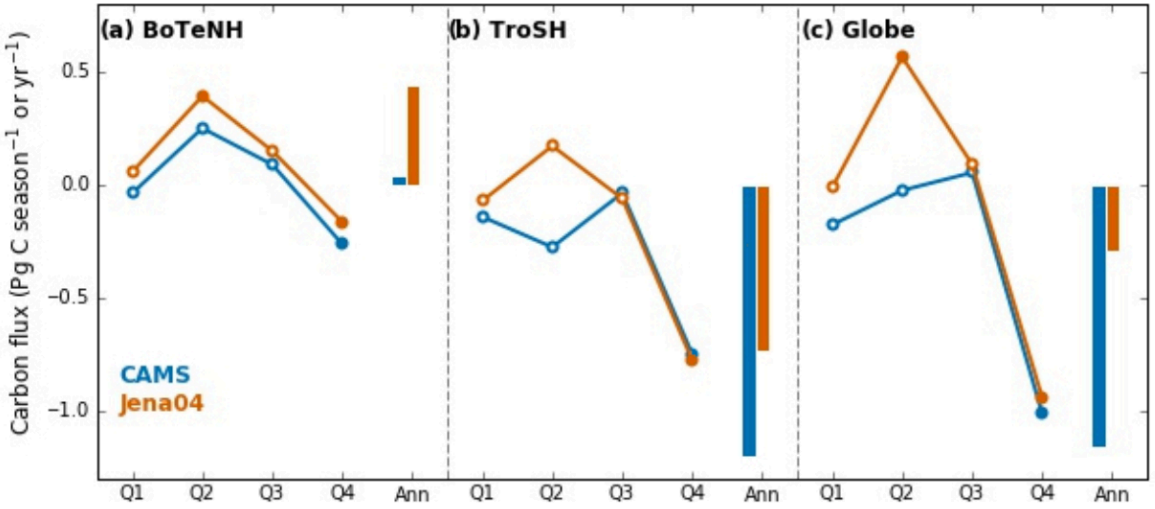


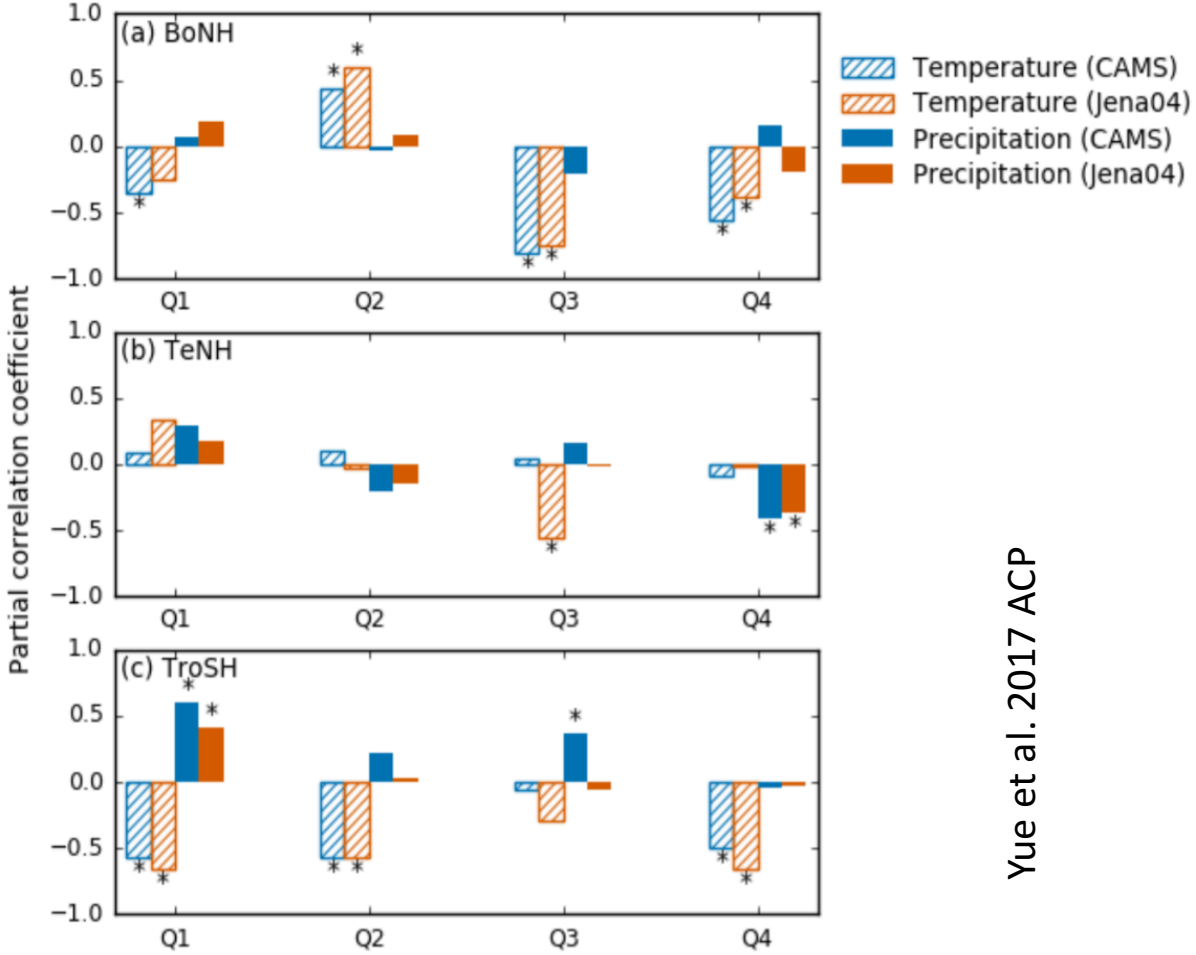
Jung et al. Nature, 2017

New opportunities

NOAA-CPC

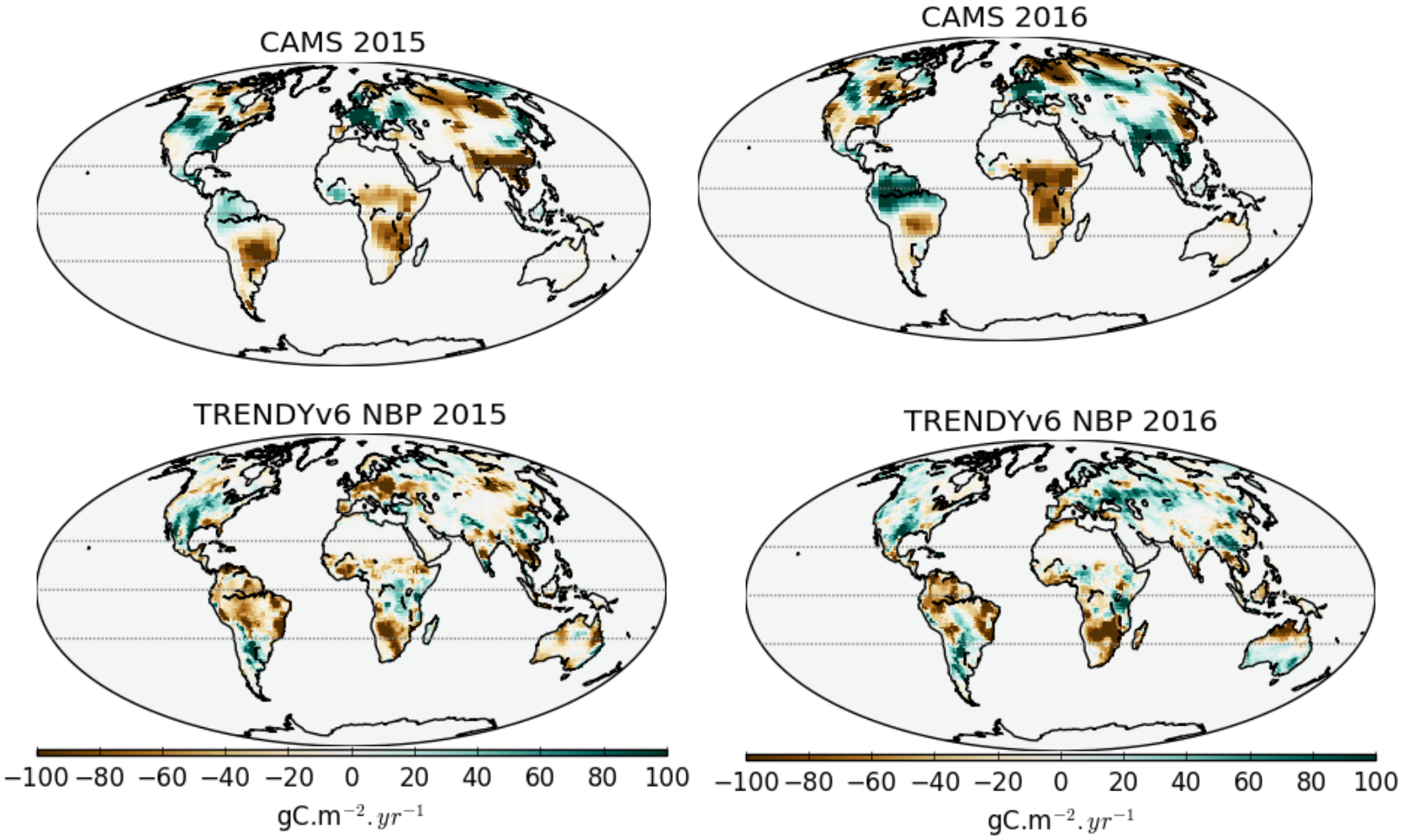






Yue et al. 2017 ACP

New opportunities



Friedlingstein et al. *in prep*

Thanks!