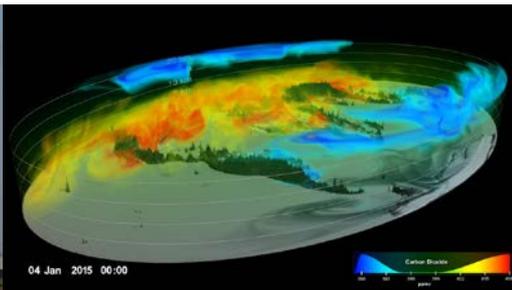


*Global carbon budget accounting following
the State of the Carbon Cycle Report 2:
The REgional Carbon Cycle Assessment and
Processes study (RECCAP-2)*

Ben Poulter, & the RECCAP-2 Steering Committee:

Ana Bastos, Pep Canadell, Philippe Ciais, Nicolas Gruber, Judith Hauck, Masao Ishii, Rob Jackson, Prabir Patra, Nobuko Saigusa



Acknowledgements



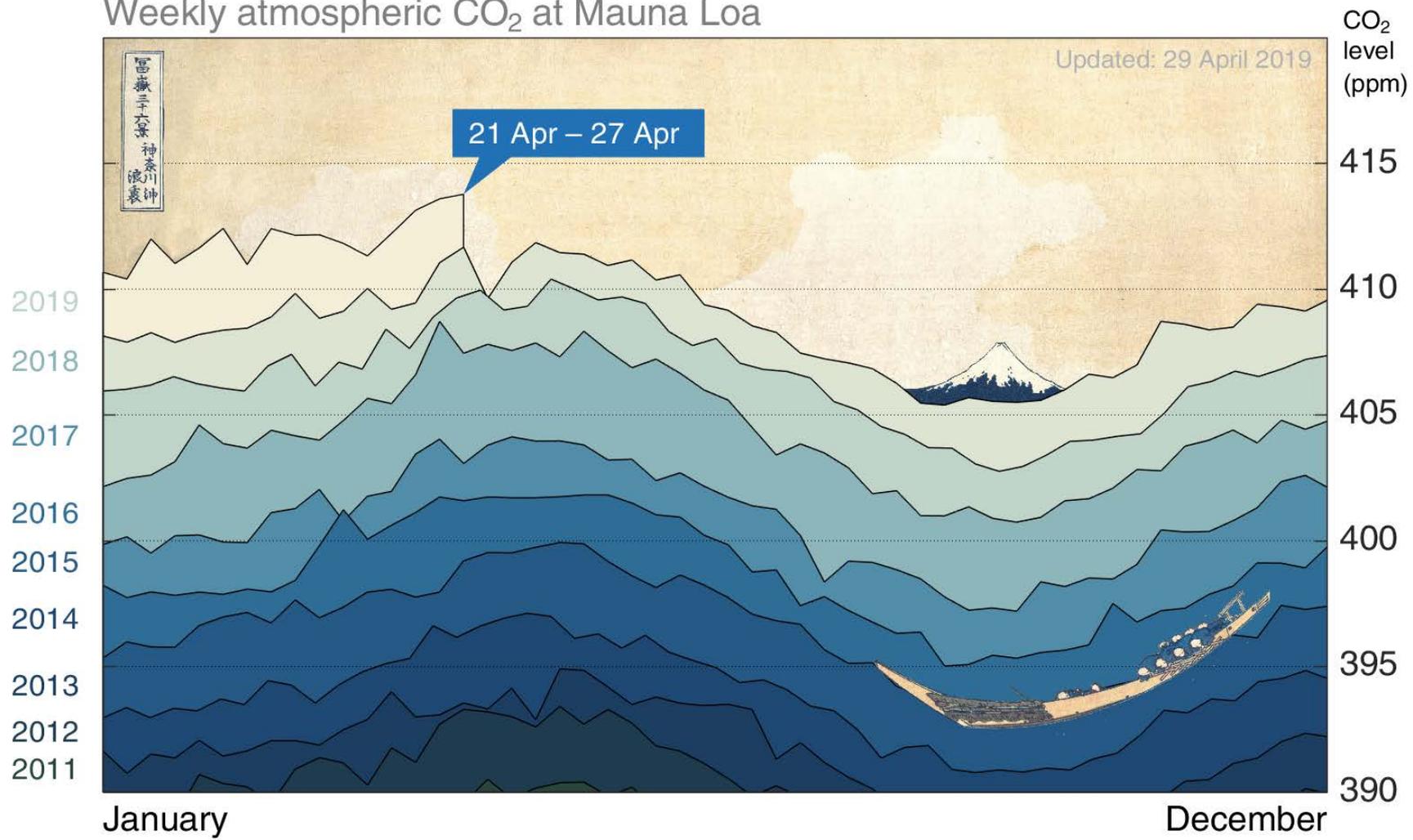
RECCAP-2 Kick Off
March 2019
Gotemba, Japan



National Institute for
Environmental
Studies

Regional Carbon Cycle Assessment and Processes study

Weekly atmospheric CO₂ at Mauna Loa



@robbie_andrew • Data: Tans & Keeling (2019)

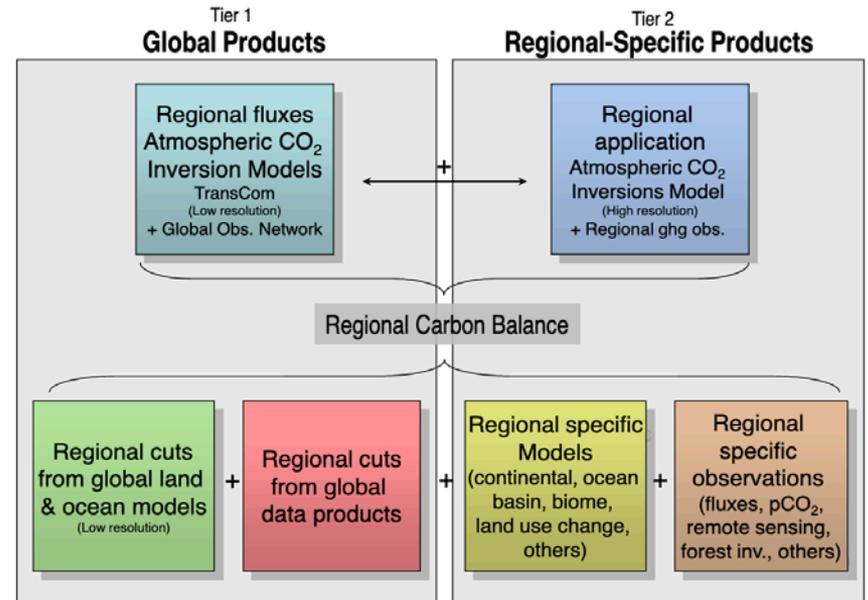
OneNOAA Science Seminar Series, April 2019

1. The Road to RECCAP-2

The first REgional Carbon Cycle and Processes study, RECCAP

- Coordinated by the Global Carbon Project between 2007-2012
- Carbon budgets were developed for the time period 1990-2008
- Used existing model data/observations, with new and traceable analyses
- Mandate was:
 - Establish mean carbon balance of large regions (continents and ocean basins)
 - Compare independent TD and BU budgets to assess uncertainties
 - Evaluate interannual variability, trends, and underlying processes

RECCAP (2007-2012)



1. The Road to RECCAP-2

The Global Carbon Project is a global research project of Future Earth - RECCAP, carbon budget, methane budget, nitrous oxide budget, urbanization...



Research projects

AIMES — Analysis, Integration and Modelling of the Earth System

bioDISCOVERY

bioGENESIS

CCAFS — Climate Change, Agriculture and Food Security (Partner)

ecoSERVICES

ESG — Earth System Governance

Future Earth Coasts (formerly LOICZ)

GCP — Global Carbon Project

GECHH — Global Environmental Change and Human Health (2006 - 2014)

GLP — Global Land Programme

GMBA — Global Mountain Biodiversity Assessment

IGAC — International Global Atmospheric Chemistry

IHOPE — Integrated History and Future of People on Earth

ILEAPS — Integrated Land Ecosystem-Atmosphere Processes Study

IMBeR — Integrated Marine Biosphere Research (formerly IMBER)

IRG — Integrated Risk Governance Project

MAIRS-FE — Monsoon Asia Integrated Research for Sustainability - Future Earth

oneHEALTH (formerly ecoHEALTH)

PAGES — Past Global Changes

PECS — Programme on Ecosystem Change and Society

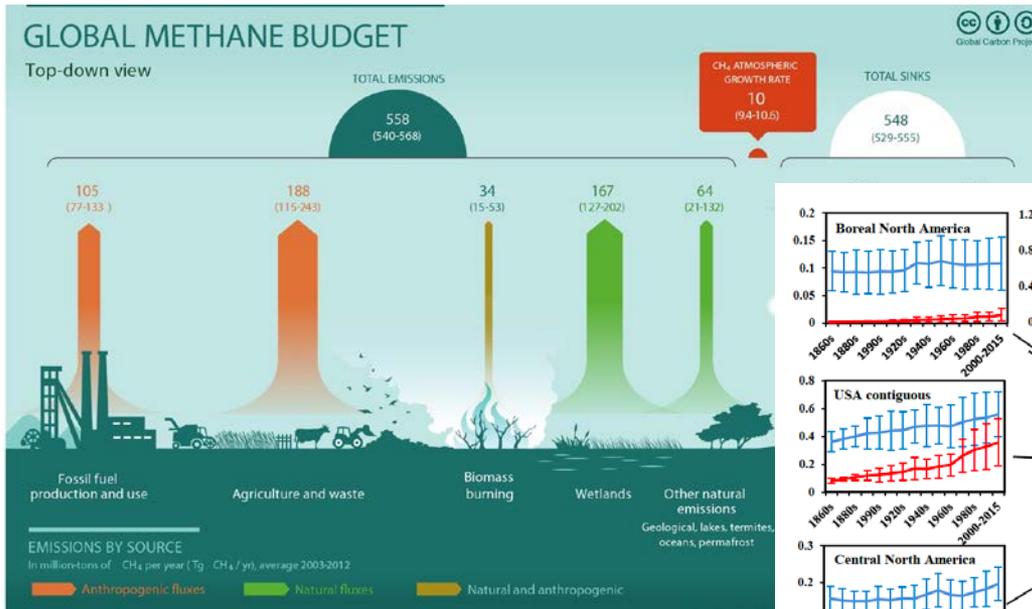
SOLAS — Surface Ocean-Lower Atmosphere Study

UGEC (no longer in operation)

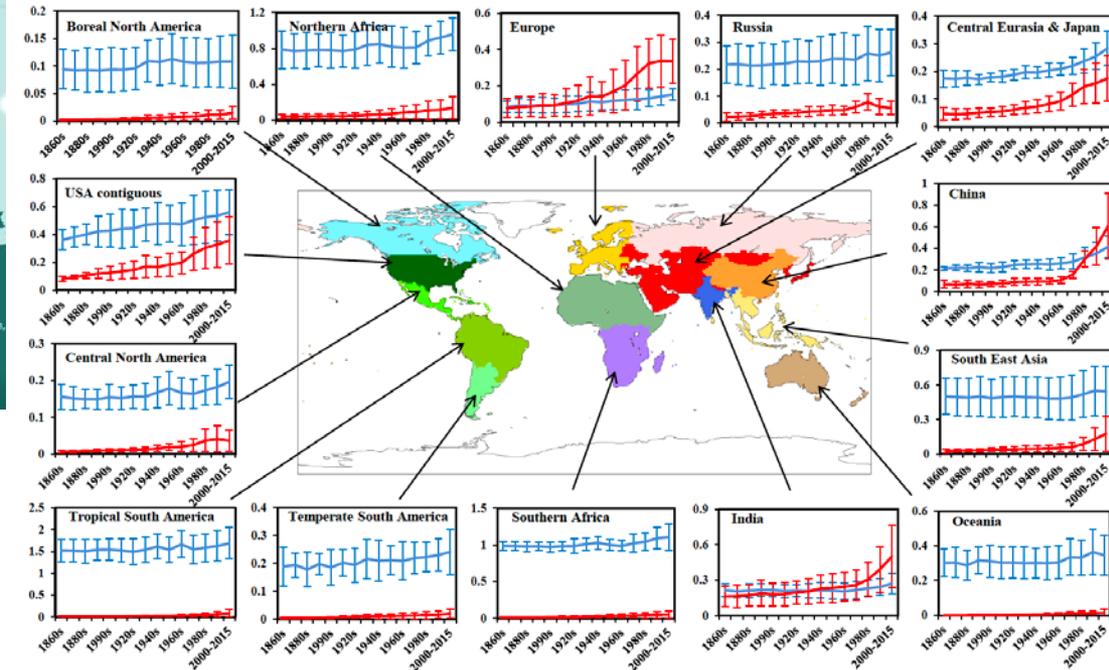
Water Future — Sustainable Water Future Programme

1. The Road to RECCAP-2

Since RECCAP-2, the global methane (2000-2017) and nitrous oxide budgets have been developed (2000-2015)



Saunois et al. 2016

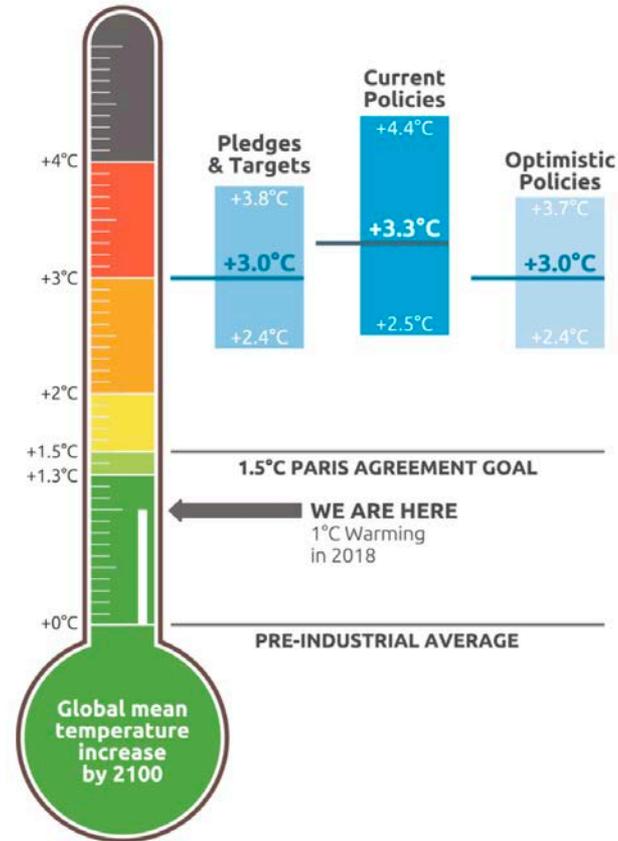


Tian et al. 2019

1. The Road to RECCAP-2

The Paris Agreement & IPCC Special Report on 1.5 degrees

- A 1.5-degree pathway requires 45% reduction of CO₂ emissions by 2030
- Paris Agreement, Article 4, states Parties shall reach peak emissions as soon as possible, and achieve a balance of anthropogenic GHG emissions and removals by sinks in second half of century.
- Paris Agreement, Article 14, periodic global 'stocktake' of implementation of Agreement to assess collective progress...



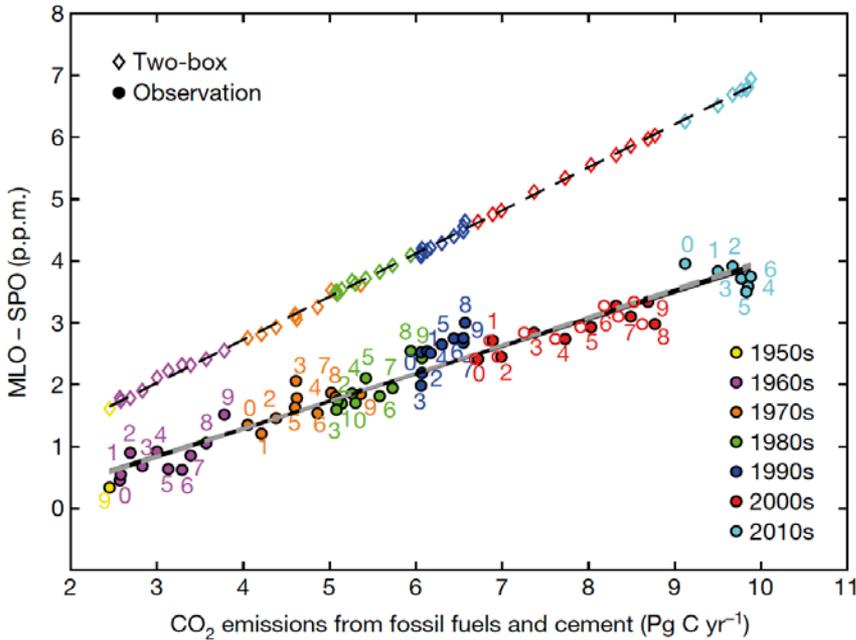
CAT warming projections
Global temperature increase by 2100

December 2018 Update

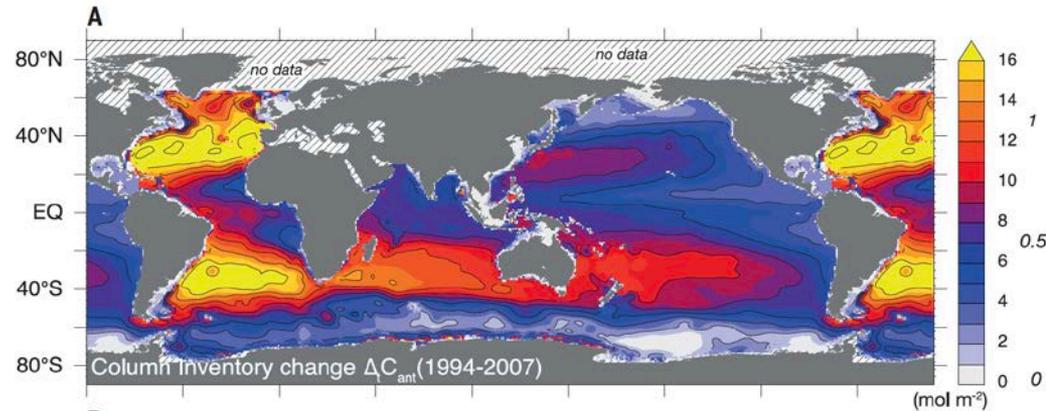
1. The Road to RECCAP-2

State of Carbon Cycle Science

- Increasing rates of land carbon uptake, and divergence between TD and BU methods
- Ocean carbon uptake increasing, lower uptake in N Atlantic (AMOC slowdown)
- Airborne fraction has remained constant over past five decades



Ciais et al. 2019

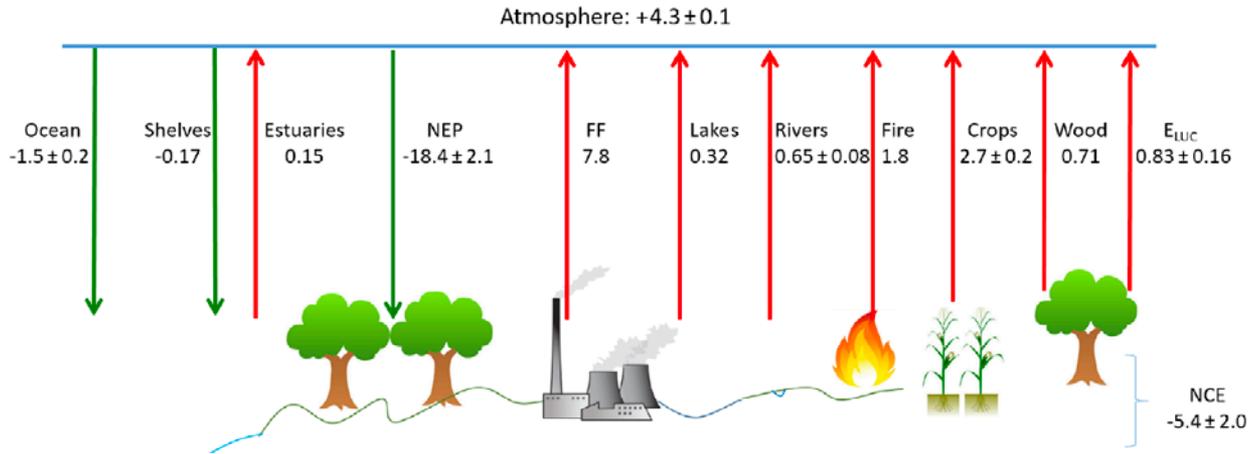


Gruber et al. 2019

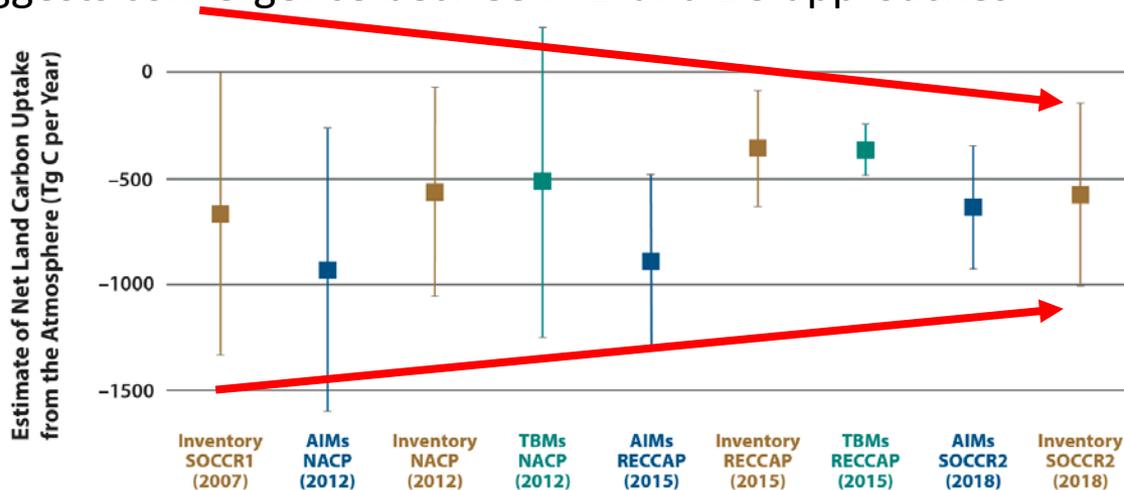
1. The Road to RECCAP-2

Reconciling Top-Down and Bottom-Up Budgets

- BU reveals $\sim 10 \text{ PgC yr}^{-1}$ imbalance, explained by biases in upscaling of flux towers



- SOCCR2 suggests convergence between TD and BU approaches



Hayes et al. 2018 (SOCCR2)

2. Goals for RECCAP-2

Charter for RECCAP-2

RECCAP2 will design and perform a set of global syntheses and regional GHG budgets of all lands and oceans, and explore mechanisms by which to deliver regular updates of these regional assessments based on scientific evidence, considering uncertainties, understanding of drivers, and retrospective analysis of recent trends. Gotemba, Japan, 2019



2. Goals for RECCAP-2

Features of the RECCAP-2 activity (2019-2022)

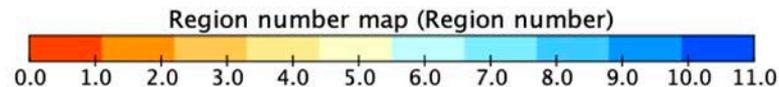
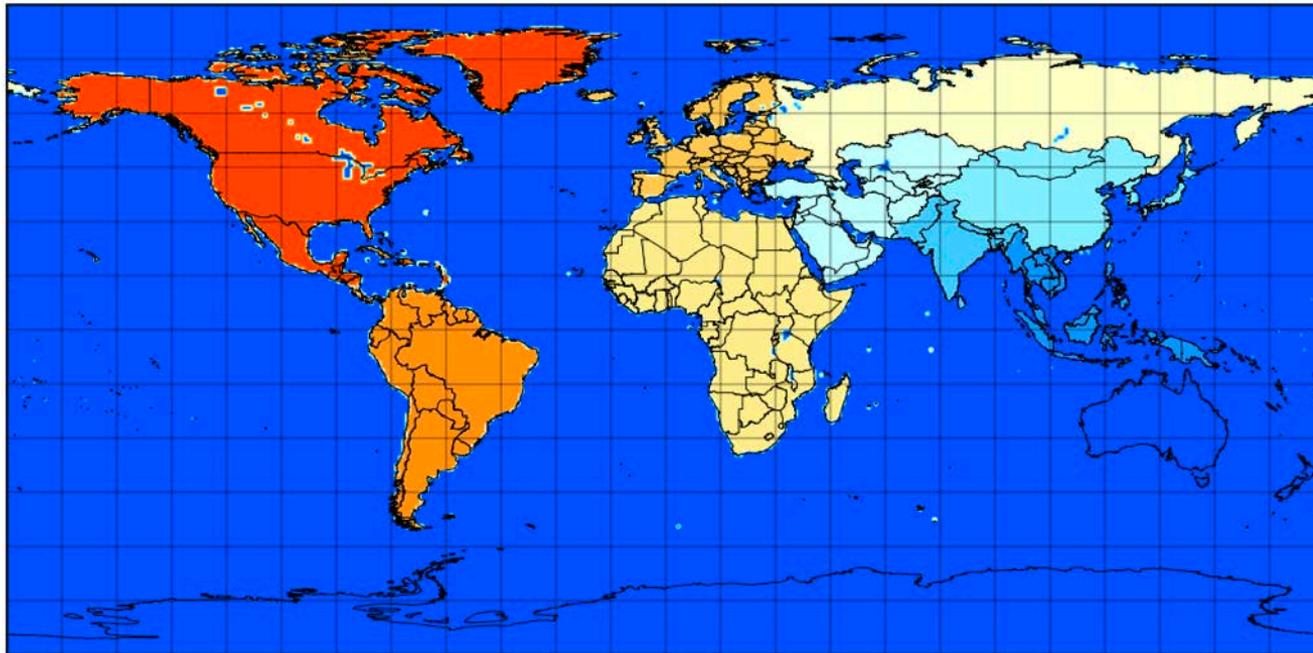
- Will cover the 2009-2018 time period
- Bridge Tier 1 and Tier 2 GHG accounting
- Includes 3-GHGs (CO₂, CH₄, N₂O)
- New regions, special interest hotspots
- Accounting framework based around stock change and fluxes
- Accounts for uncertainties within Bayesian framework
- Integration of novel / emerging datasets (TD/BU/inventory)
- Provides constraints on 'future' on climate-carbon feedbacks
- Establishes a framework for semi-regular annual/biannual updates



2. Goals for RECCAP-2

RECCAP-2 New regions, special interest hotspots

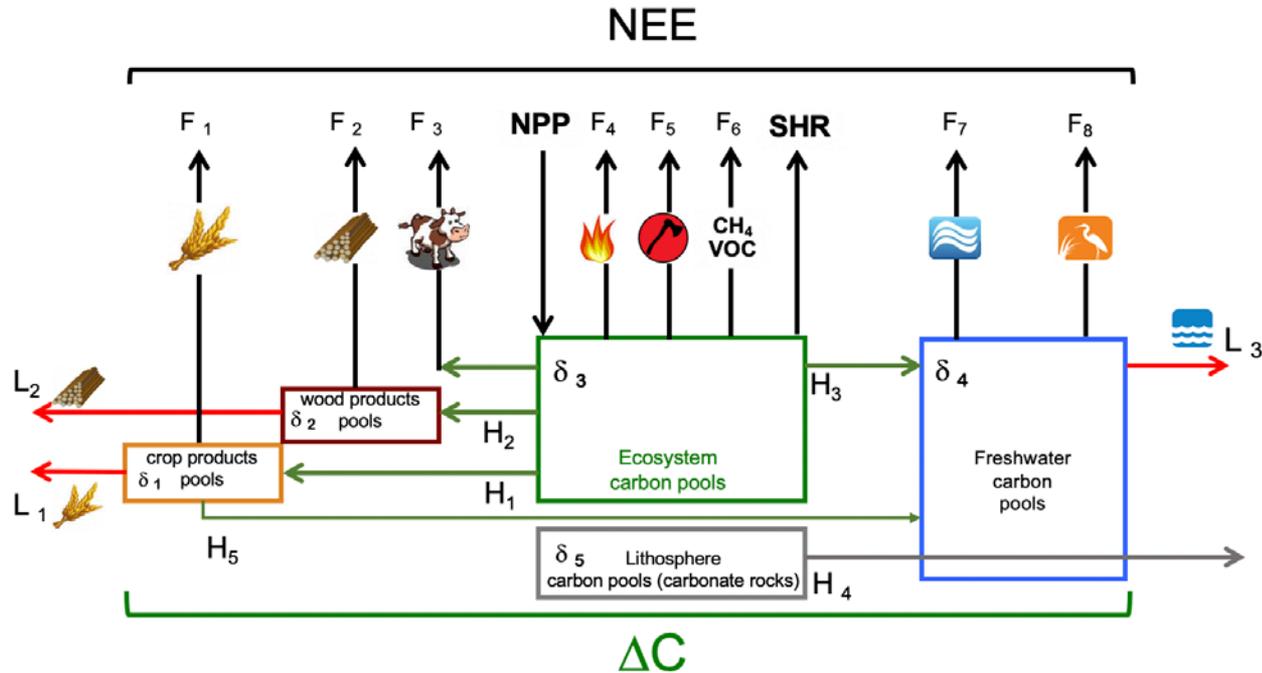
- 11 Land Regions
- 4 Ocean Basins (Arctic/Atlantic split)
- Special interest (permafrost, semi-arid, coastal zone “blue carbon”, global synthesis)
- Maintain balance between biomes and policy-relevance using hierarchical approaches



OneNOAA Science Seminar Series, April 2019

3. The RECCAP-2 Approach

RECCAP-2 stock change versus fluxes (P Ciais, R Andrews)



1. Fluxes derived from inversions

$$NEE_C = NEE_{CO_2} + E_{CO} + E_{CH_4} + E_{VOCs}$$

2. Stock change from biogeochemical models and inventories

$$\Delta C = \Delta C_{\text{biomass}} + \Delta C_{\text{soil}} + \Delta C_{\text{inland water burial}} + \Delta C_{\text{wood products}} + \Delta C_{\text{crop products}} + \Delta C_{\text{fossil}}$$

3. The RECCAP-2 Approach

Examples of RECCAP-2 datasets

Fluxes

- Atmospheric inversions for CO₂, CH₄, N₂O (from GCP activities, OCO-2 MIP, etc.)
- Biogeochemical models (prognostic/diagnostic) for biogenic CO₂, CH₄, N₂O fluxes (e.g., TRENDY)
- Inventories (EPA, IEA, FAO, EDGAR, GAINS) for anthropogenic (fossil fuel, agriculture)
- GHG observing networks (NOAA-ESRL, TCCON, AGAGE) for concentration changes, additional sinks

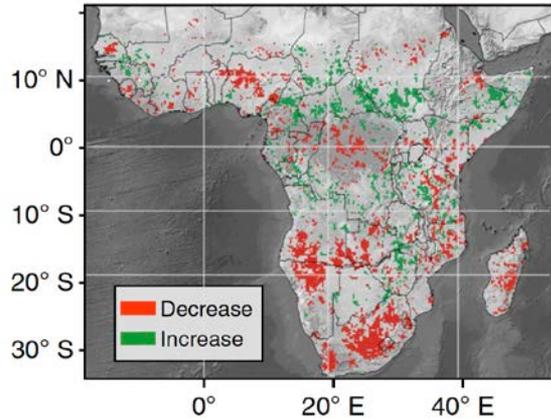
Stock change

- Aboveground biomass datasets (lidar-based, microwave based, e.g., Vegetation Optical Depth)
- Land-use land cover change mapping (Landsat, MODIS, Sentinel)
- Soil carbon data/models/long-term experiments

3. The RECCAP-2 Approach

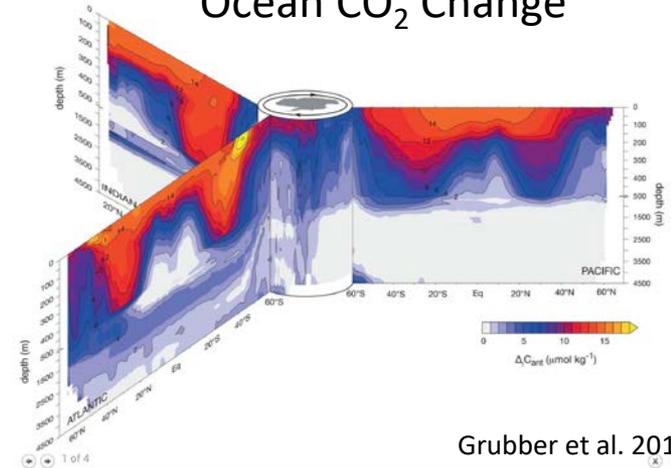
New / novel datasets to be incorporated

VOD-L Band Biomass



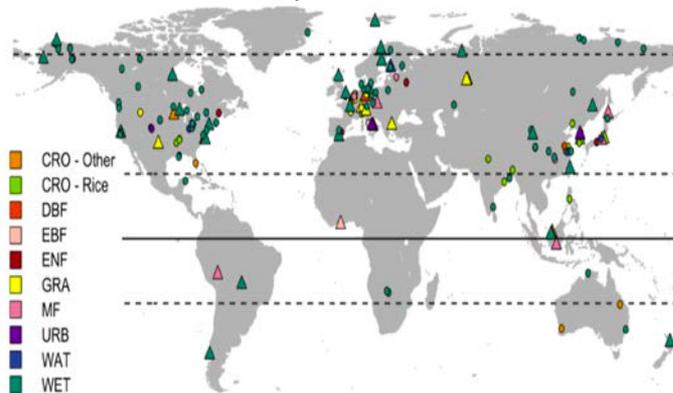
Brandt et al. 2018, NatureE&E

Ocean CO₂ Change



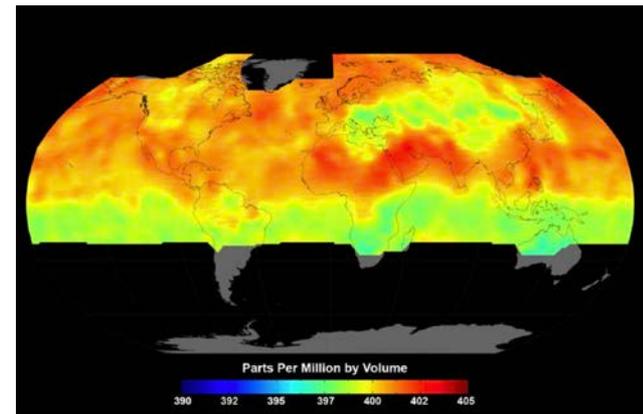
Grubber et al. 2019, Science

FLUXNET-CH₄



Knox et al. 2019, BAMS

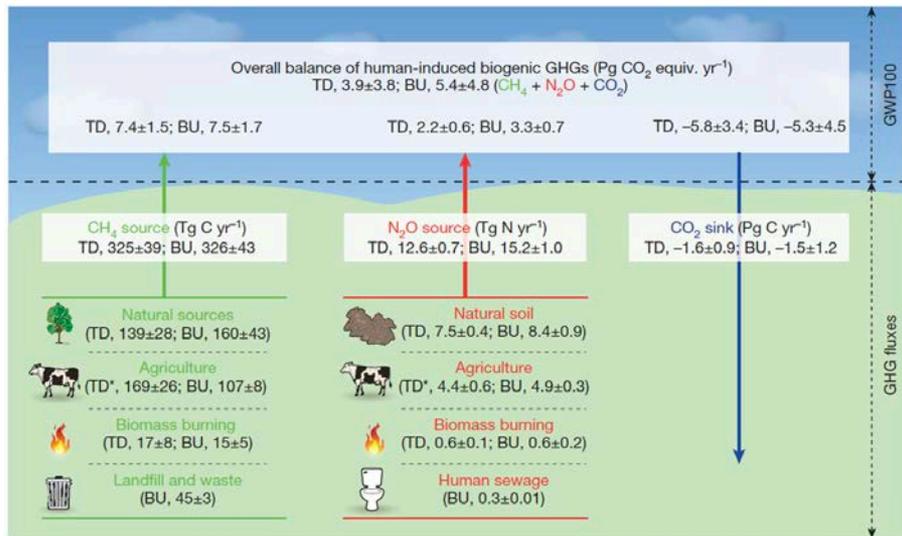
Column GHG – GOSAT-OCO-2



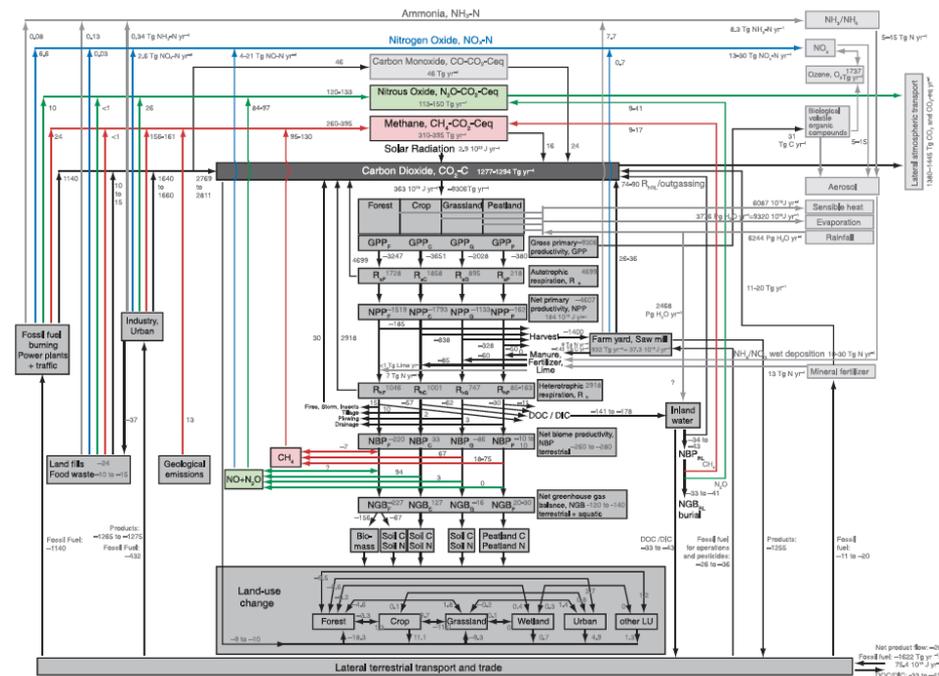
3. The RECCAP-2 Approach

RECCAP-2 communication of budgets

- Balancing simple/transparent budgets with underlying complexity
- Communications with policy makers versus scientific audiences
- Addressing uncertainties with ensembles, TD vs BU, global synthesis



(Tian et al. 2016)



(Schulze et al. 2010)

3. The RECCAP-2 Approach

Take home points

RECCAP-2 will be carried out as:

- a multi-GHG gas assessment for period 2009-2018
- chapters will encompass 11 land regions, 4 ocean basins, and ~3-5 'special interest' themes (permafrost, blue carbon, semi-arid regions)
- develop a consistent workflow to compare stock change and flux-based approaches to assess sink/source status
- use BU and TD approaches to assess uncertainties and research gaps
- provide a framework for semi-regular GHG budgeting within context of international climate mitigation, i.e., Paris Agreement (Article 4, and Article 14)

4. Engaging with RECCAP-2

RECCAP-2 contact information, upcoming meeting, job announcement

1. Global Carbon Project

1. RECCAP(1) : <https://www.globalcarbonproject.org/reccap/>
2. RECCAP-2: <https://www.reccap2-gotemba2019.org/>

2. Upcoming meetings

1. AGU Chapman Conference
(<https://connect.agu.org/aguchapmanconference/upcoming-chapmans/carbon-climate>)

3. RECCAP-2 Post Doctoral Scientist Position (w Ben Poulter, Lisamarie Wyndham Myers, and Anna Michalak):

1. Mendenhall Fellowship (<https://www.usgs.gov/centers/mendenhall>)

4. Contacts

1. Ben Poulter (benjamin.poulter@nasa.gov), twitter: @poulterlab
2. Pep Canadell (pep.Canadell@csiro.au), twitter: @pepcanadell
3. Rob Jackson (rob.jackson@stanford.edu)