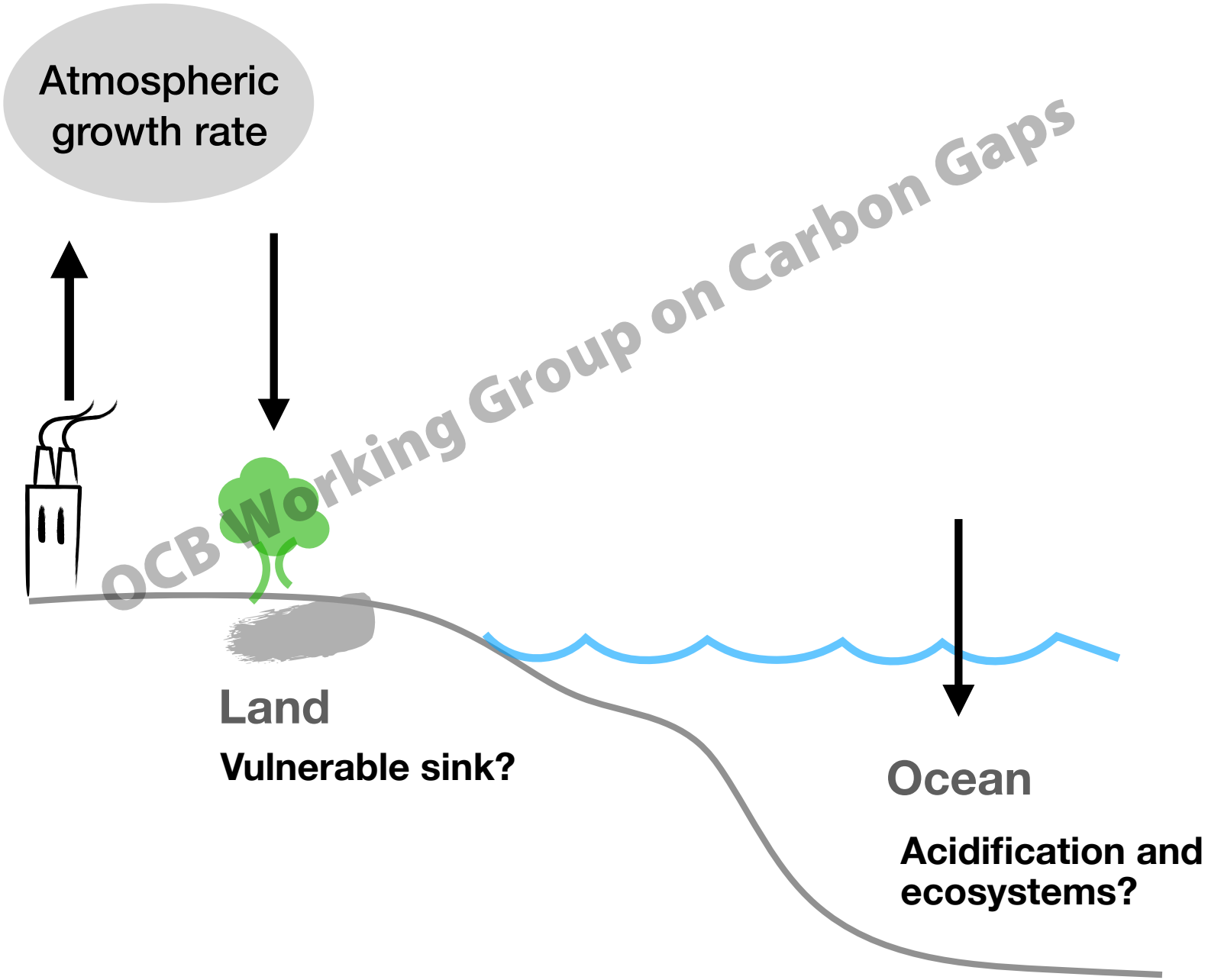
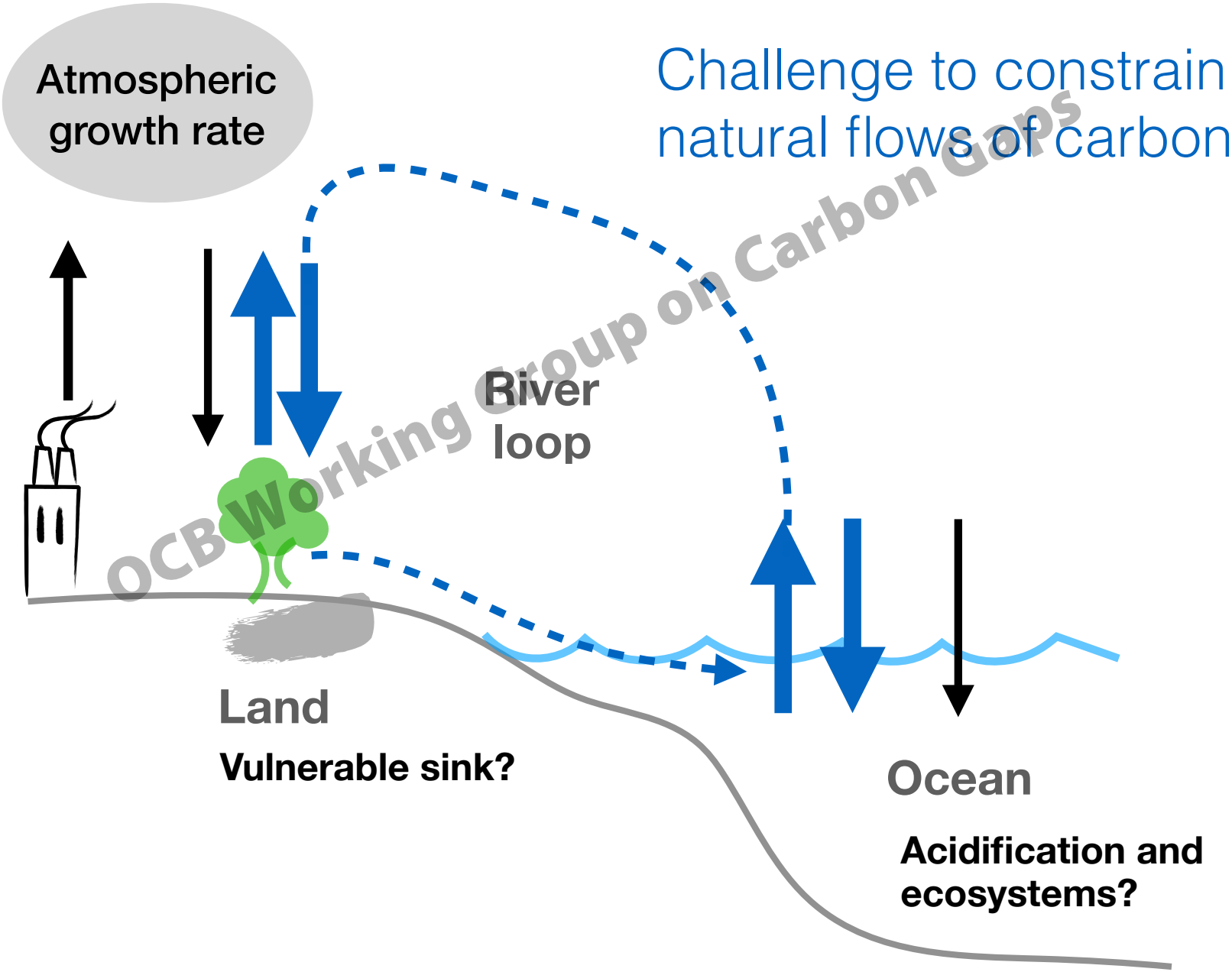
River loop and natural ocean outgassing

Laure Resplandy
Princeton University

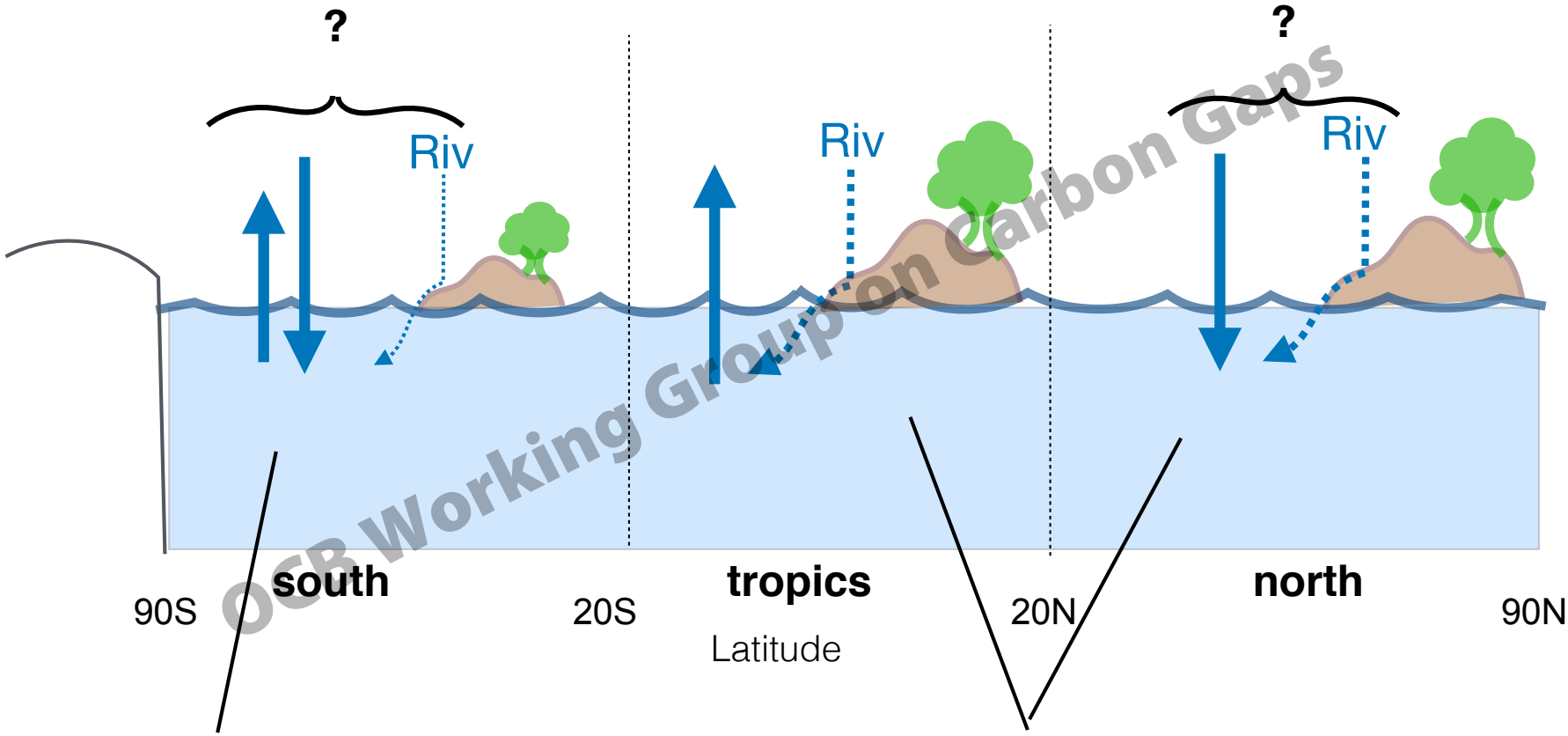
Partition between land and ocean key to assess impacts and carbon-climate feedbacks



Natural carbon flows introduce large uncertainties in ocean/land partition and global carbon budget



Constraint on natural ocean/river carbon flux: north/south asymmetry & river loop contribution



Mismatch up to 1 PgC/y in ocean sink between estimates

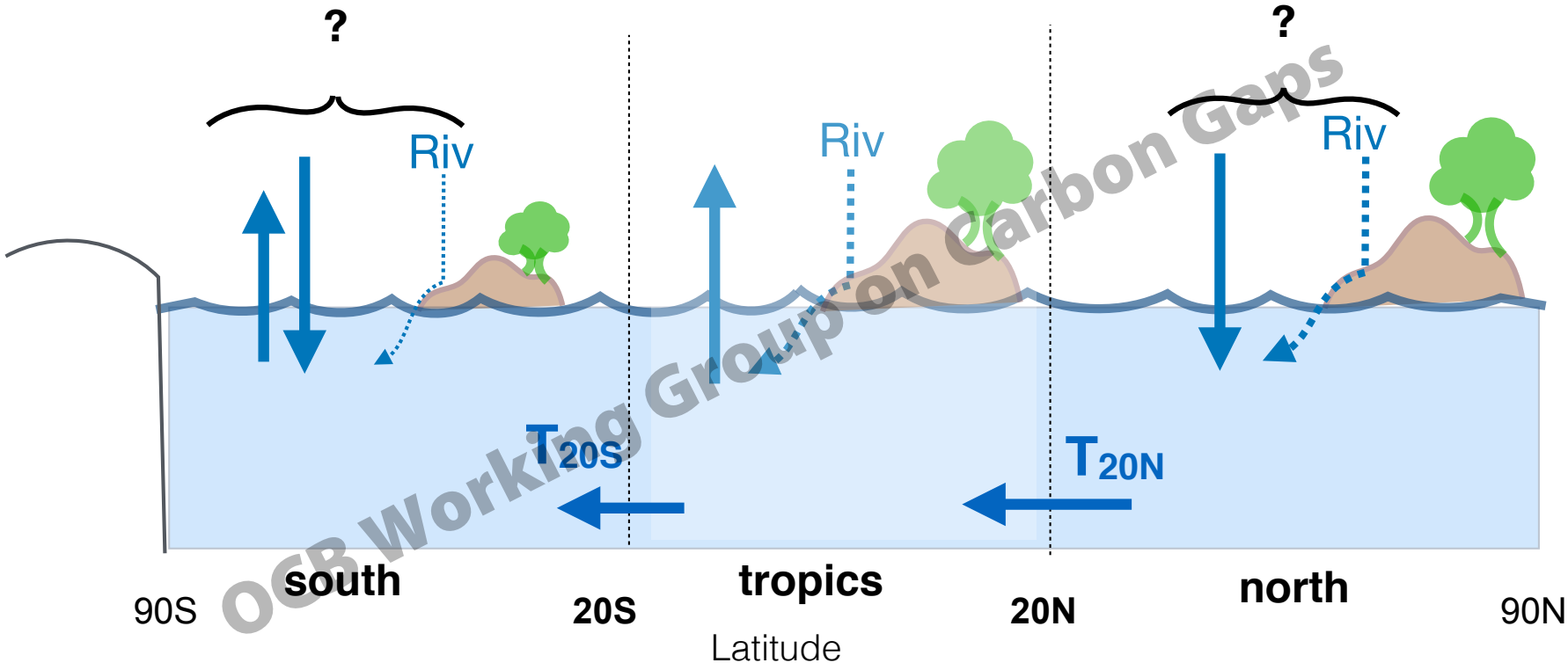
Le Quéré et al., 2018

Uncertainties in river loop

0.45 ± 0.18 PgC/y (Jacobson et al., 2007)

0.75 ± 100% PgC/y (Regnier et al. 2013; Bauer et al, 2013)

Hemispheric asymmetry quantifies north/south imbalance in ocean/river fluxes

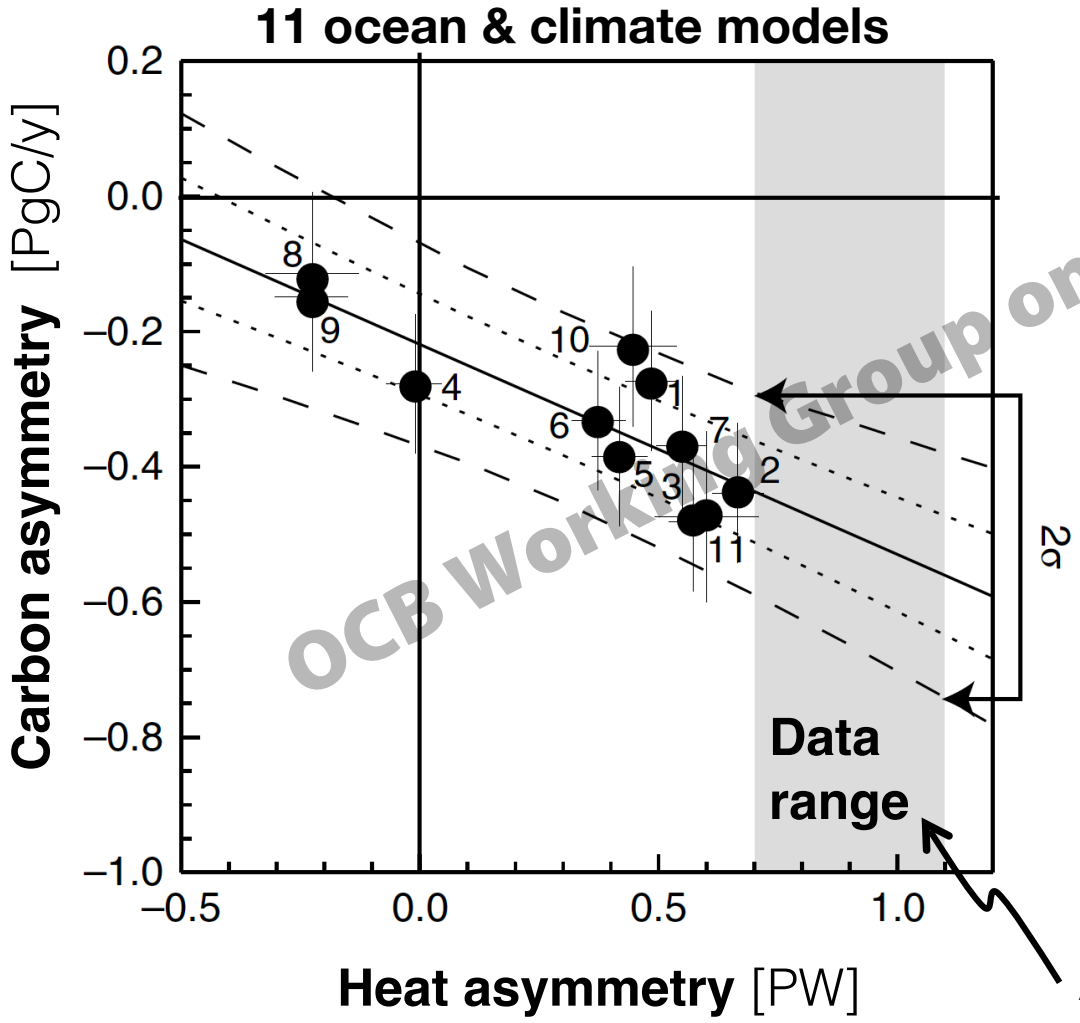


Hemispheric asymmetry

$$A = (T_{20N} + T_{20S}) / 2$$

Carbon north-south transport scales with heat transport

Heat asymmetry explains **60%** of differences in carbon transport
Heat + Bio pump asymmetry explain **85%** of carbon transport



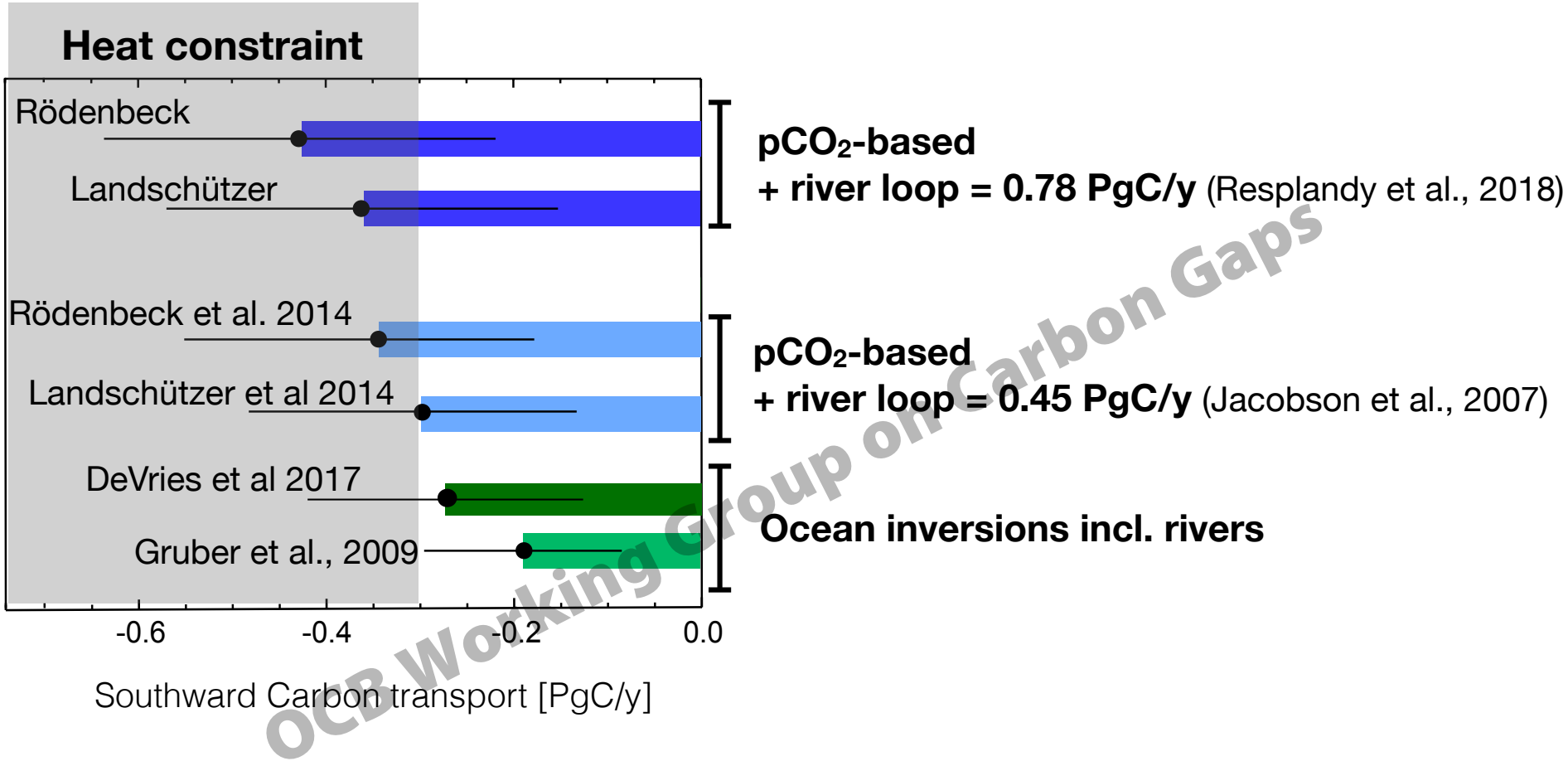
1) Models **biased low in heat** and **carbon transports**

2) Southward carbon transport **= 0.30 to 0.75 PgC/y**

Heat fluxes (Large and Yeager, 2009)
Atmospheric data (Resplandy et al., 2016)
Hydrography (Ganachaud and Wunsch, 2003)

Resplandy et al., Nat Geo 2018

Heat constraint on carbon transport



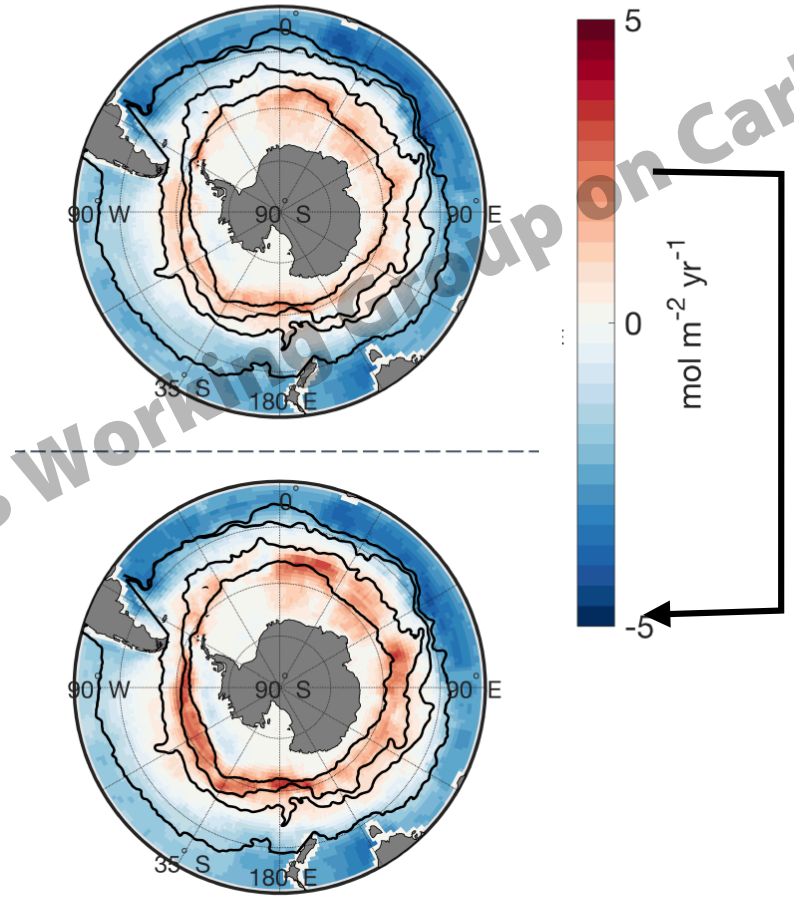
- Estimates **agree within large uncertainties** but **systematic differences in north-south balance**
- ocean inversions incompatible with heat constraint
- stronger river loop improve match to heat constraint
- Implies strong outgassing of CO_2 offsets uptake in the South

Resplandy et al., Nat Geo 2018

SOCCOM float data suggests stronger winter outgassing in Southern Ocean

Winter pCO_2-based air-sea CO_2 flux

SOCAT database only



SOCAT database + SOCCOM floats

Adding SOCCOM float data reduces annual uptake by 0.4 PgC/y

SOCCOM
Southern Ocean Carbon and Climate Observations and Modeling

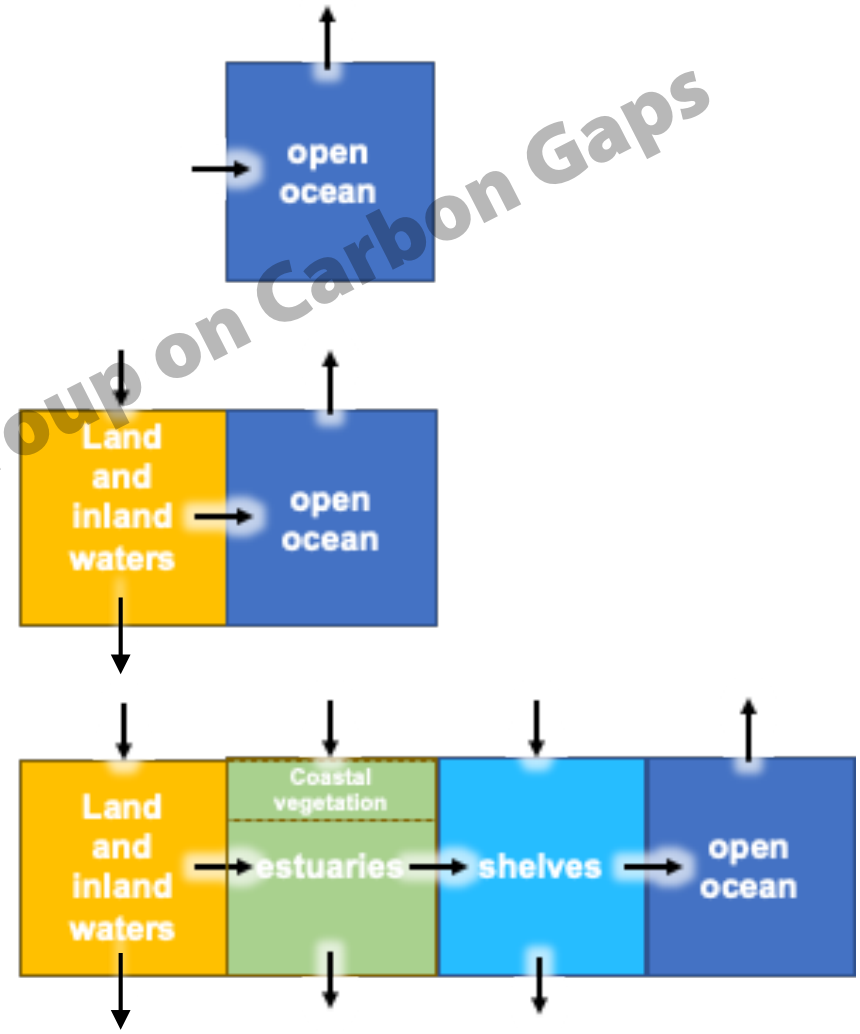
Bushinsky et al, 2019

Constraints on river loop including recent research on estuaries, coastal vegetation and shelves

Top-down ocean heat
Resplandy et al 2018

Bottom-up estimate
Jacobson et al 2007

Revised bottom-up estimate
Regnier, Resplandy and Ciais in prep



Multiple line of evidence support large natural carbon flow to the ocean leading to a natural outgassing of 0.7 PgC/y

- Top down heat constraint
- Stronger winter outgassing in the Southern Ocean
- Revised bottom up estimates of estuaries including carbon fixation by coastal vegetation

Influence partition between land/ocean sink and understanding of carbon feedbacks