

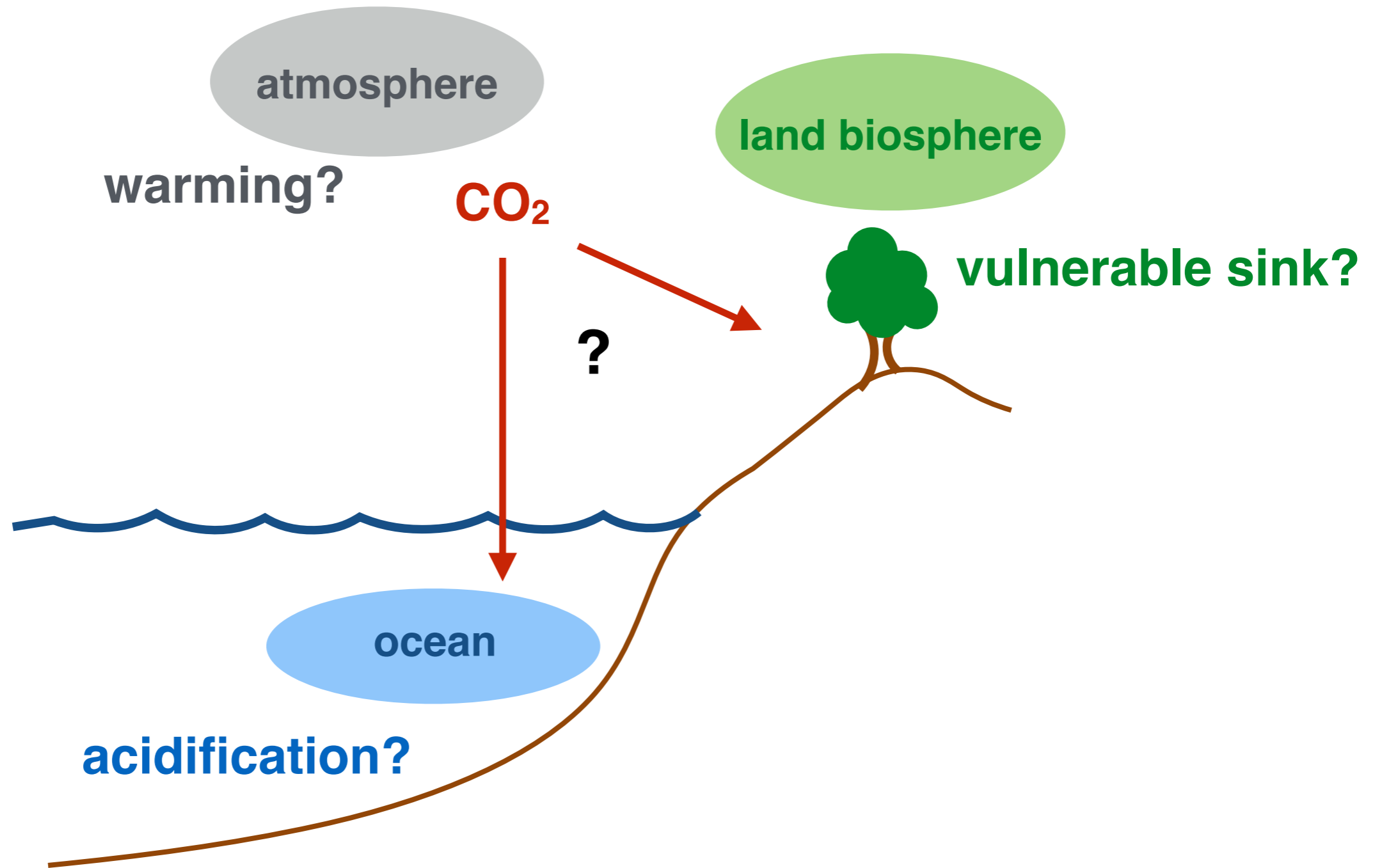
Global reconciliation of land, ocean, and river carbon fluxes

Laure Resplandy

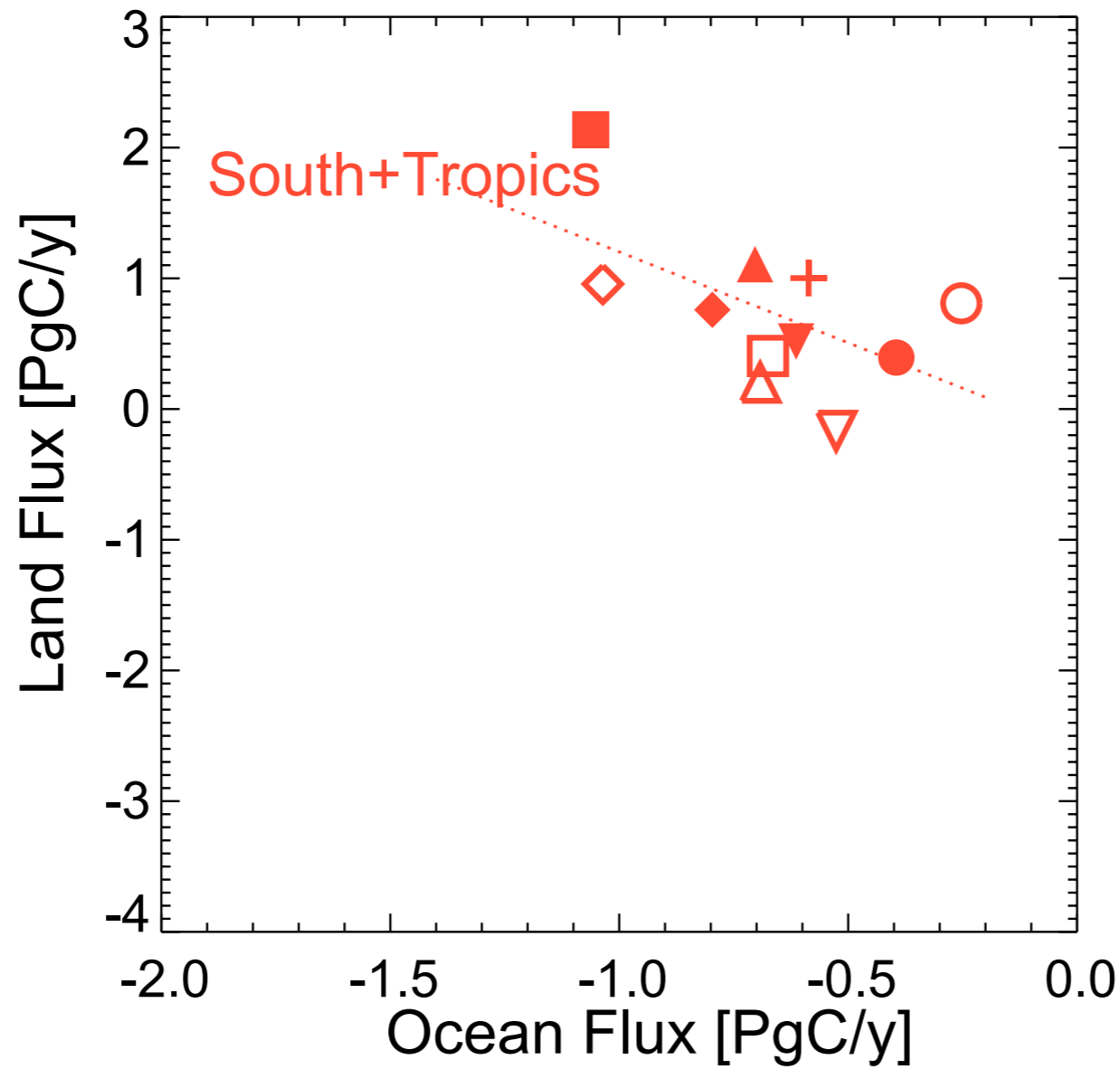
Scripps Institution of Oceanography, UC San Diego

R. Keeling (Scripps); B. Stephens, J. Bent (NCAR); A. Jacobson (NOAA)
C. Rödenbeck (MPI, Germany); S. Khatiwala (Oxford, UK)

Why should we care where carbon is stored?

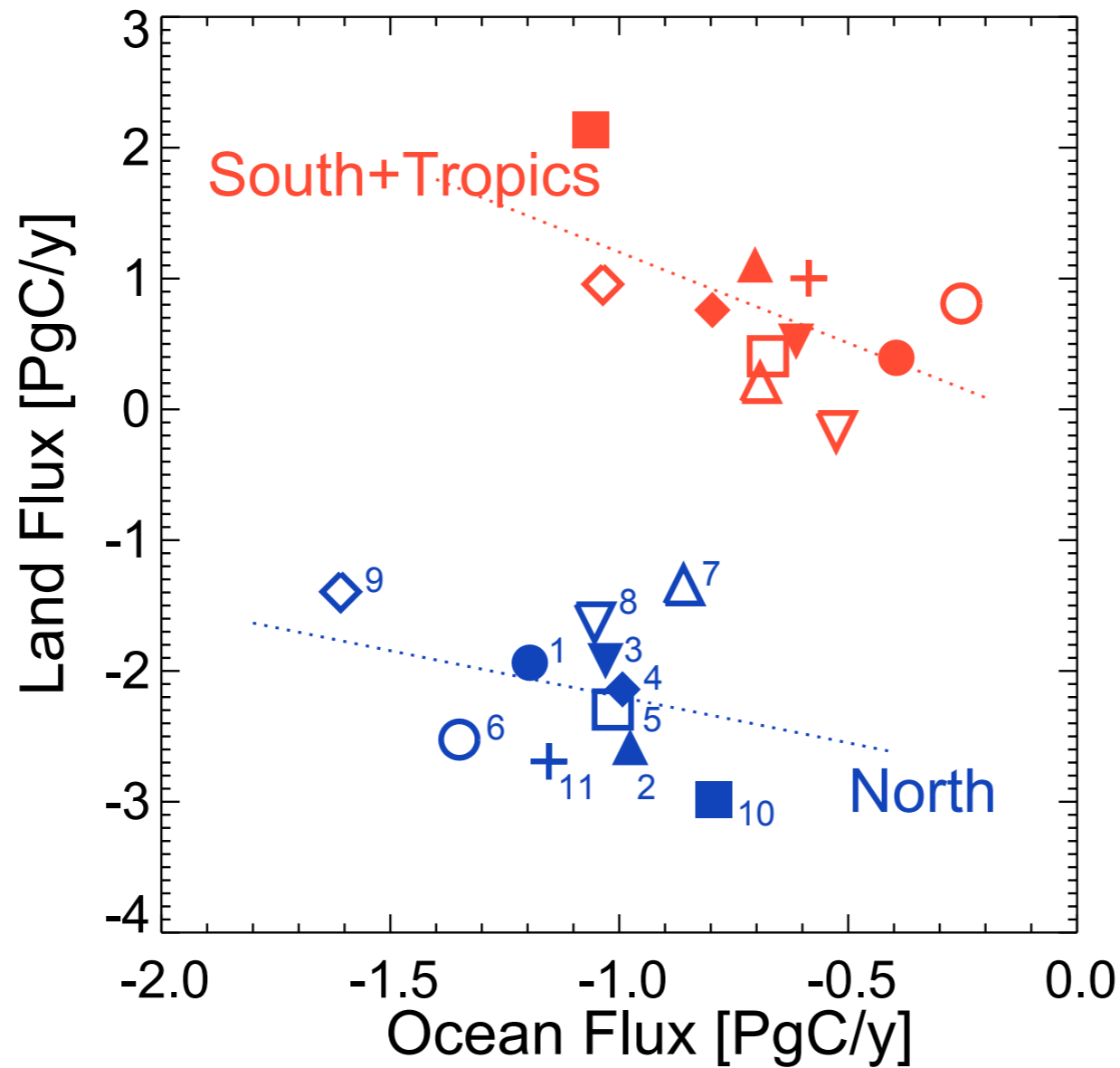


Land sink depends on our knowledge of ocean sink



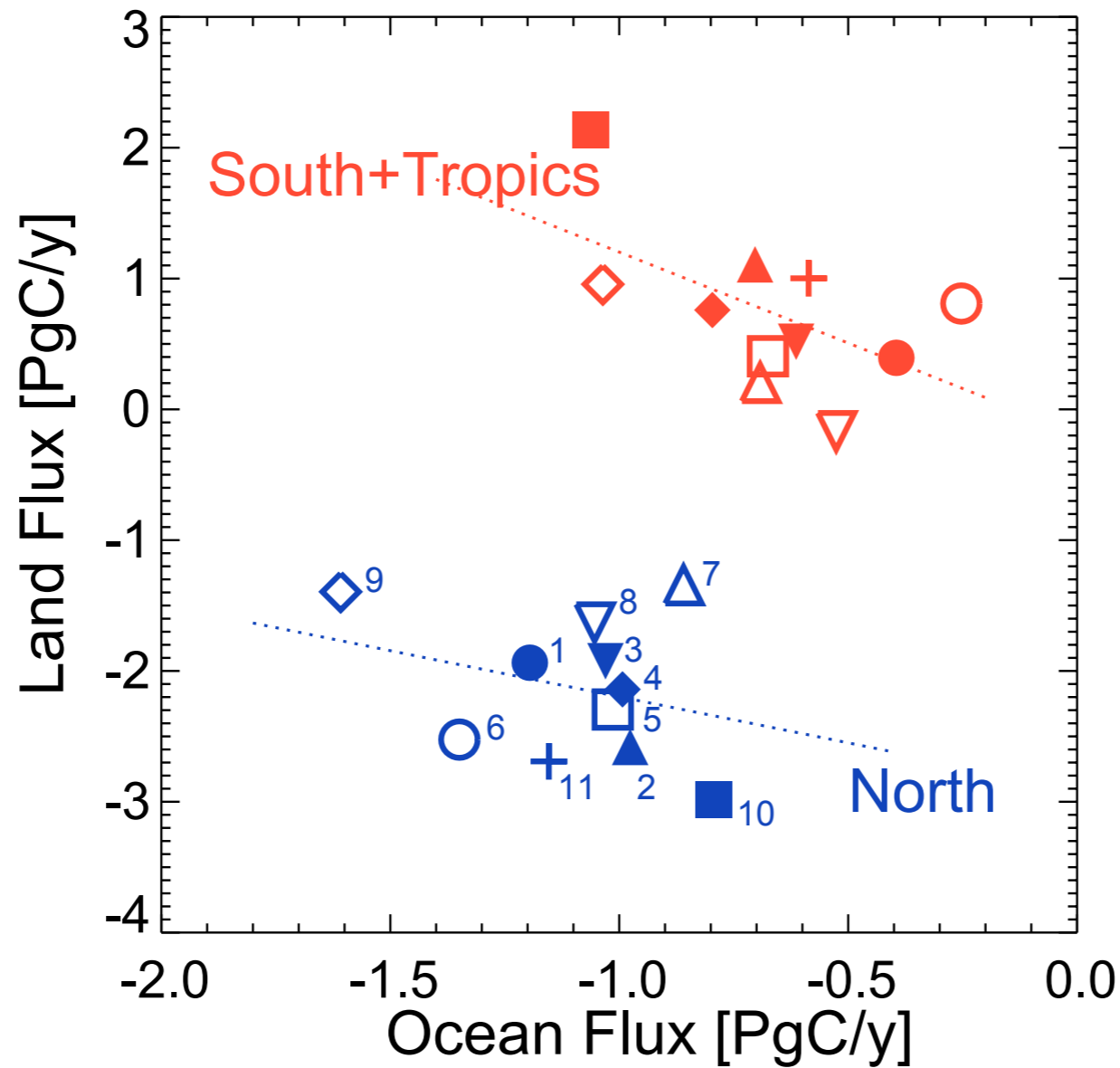
based on RECCAP results
(Peylin et al., 2013)

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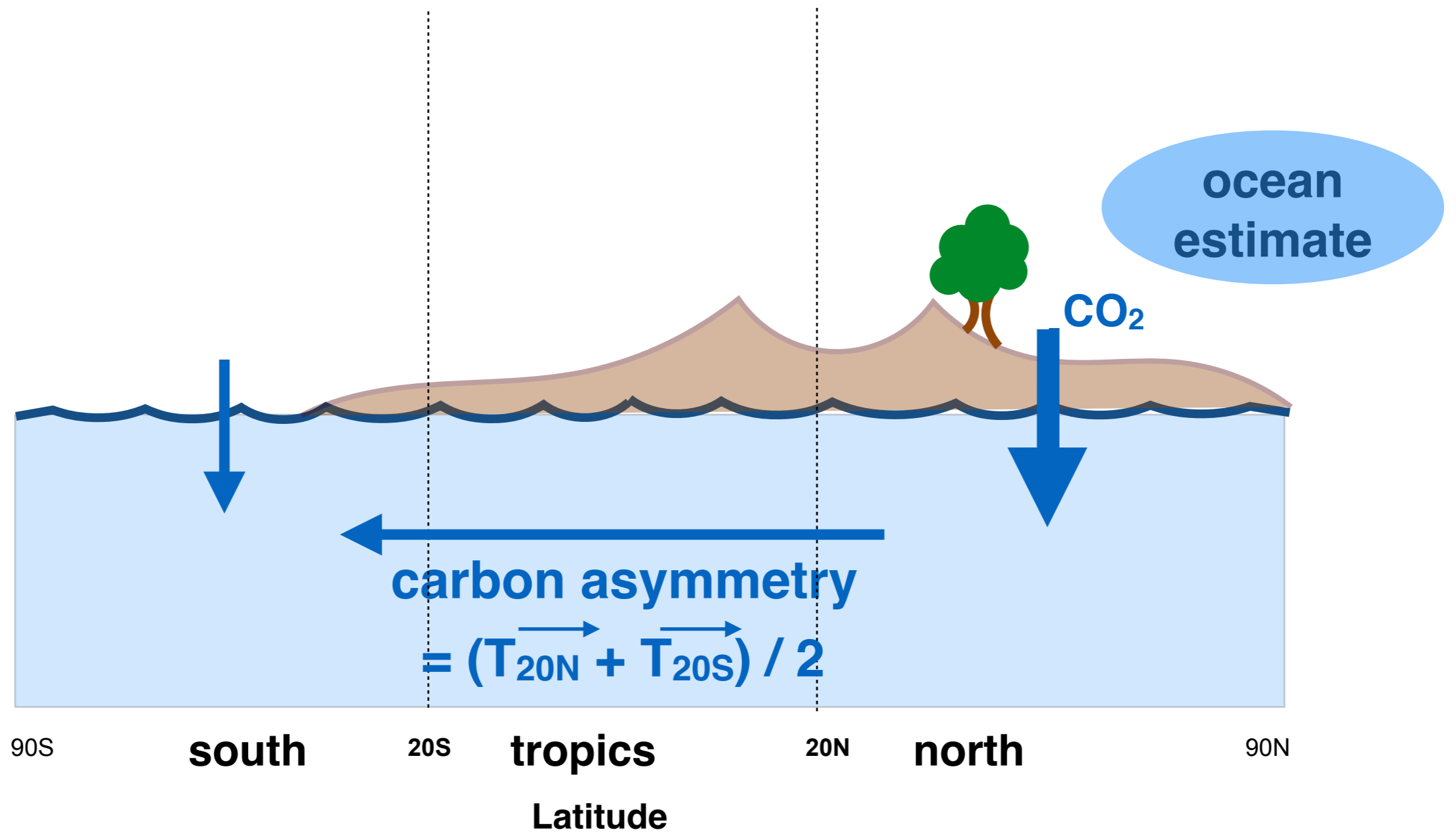
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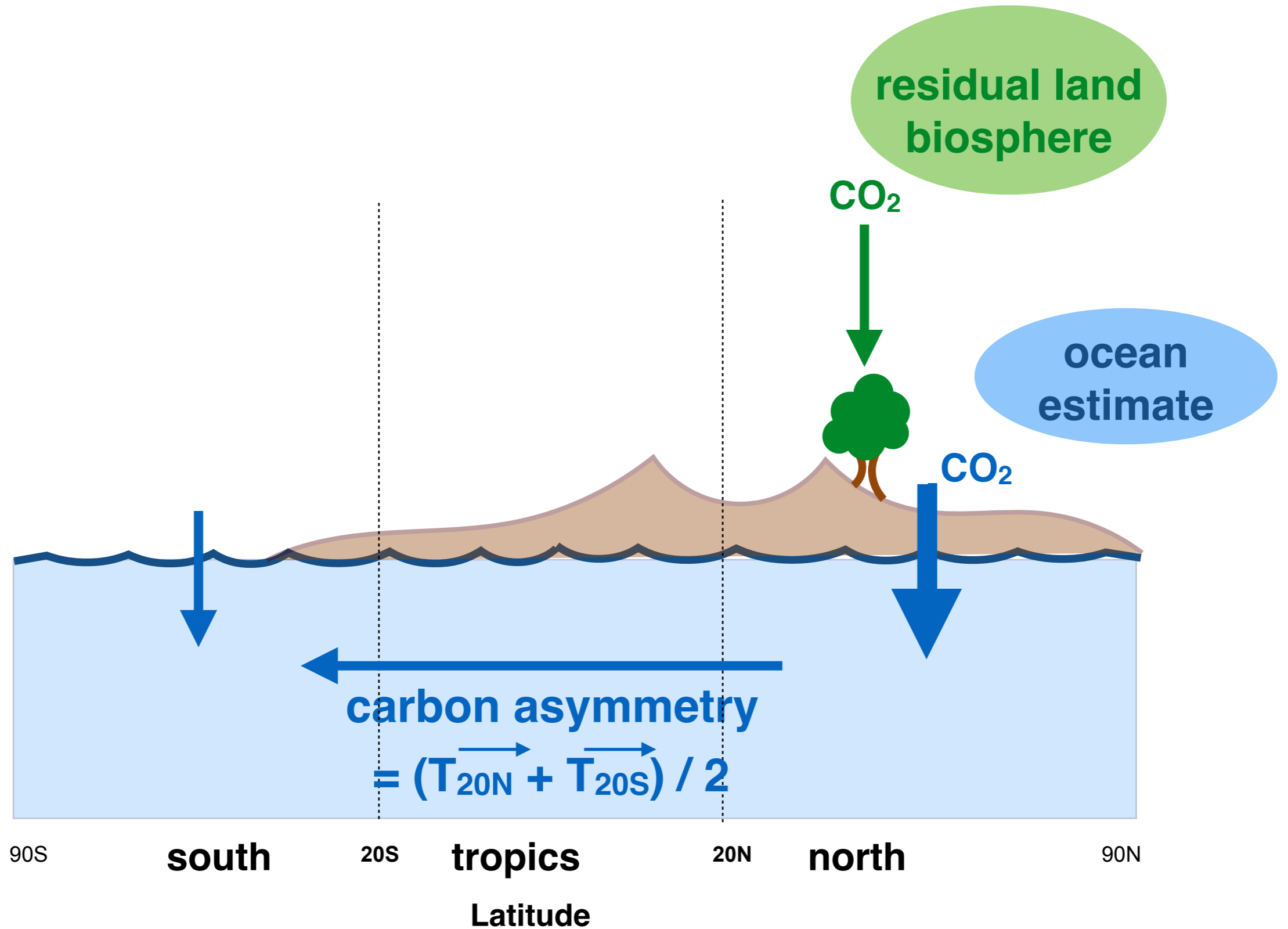
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- ▶ New constraints on ocean?
- ▶ Implications for land sink?

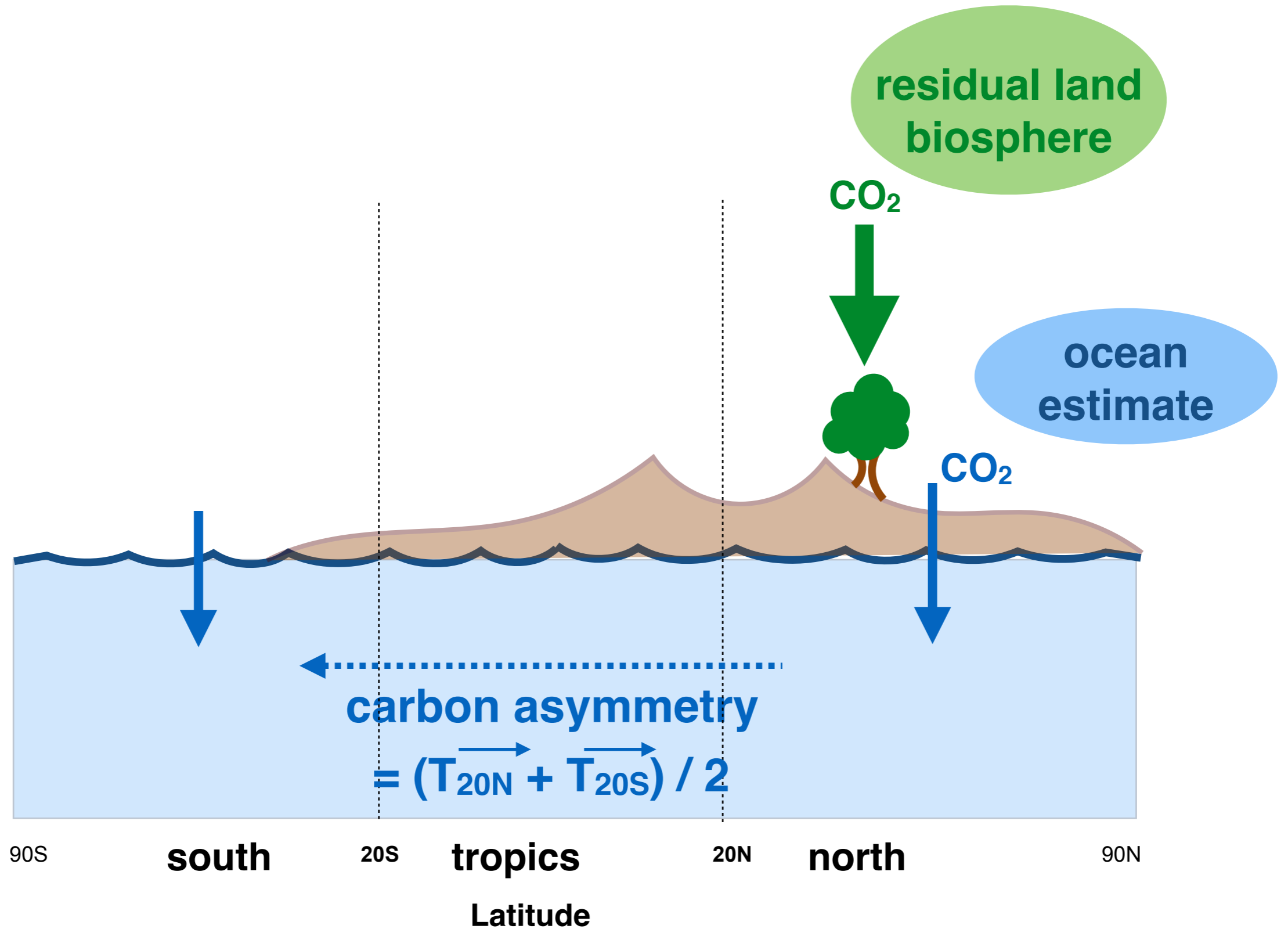
Ocean carbon asymmetry & implications for land sink



Ocean carbon asymmetry & implications for land sink



Ocean carbon asymmetry & implications for land sink



2 state-of-the-art ocean sink estimates

ocean sink = air-sea flux + rivers

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ocean sink = air-sea flux + rivers

**ocean inversions
(data + model)**

**pCO₂ data
+ revised river
estimate**

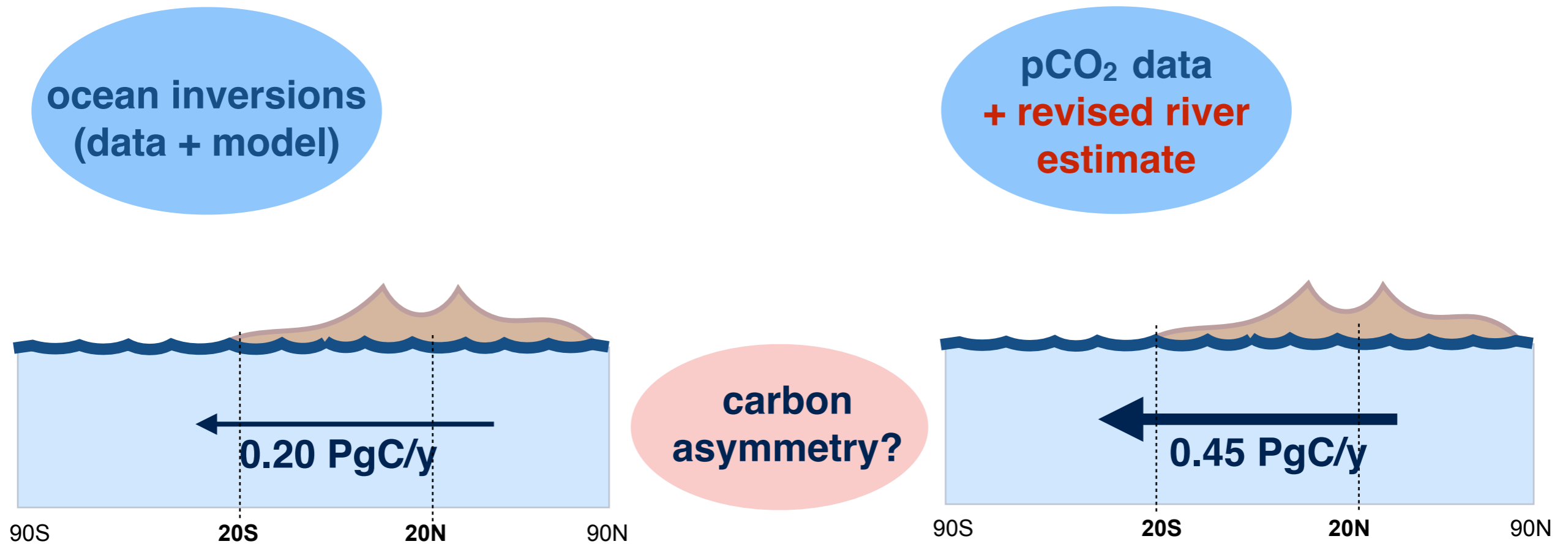
Mikaloff Fletcher et al., 2006, Jacobson et al. 2007;
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Resplandy et al., in prep

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Controversy on carbon asymmetry started in 1989...

previous
state-of-the-art

Atmospheric CO₂ data
Mauna Loa - South Pole

1 PgC/y

(Keeling et al., 1989)

Models/Inversions

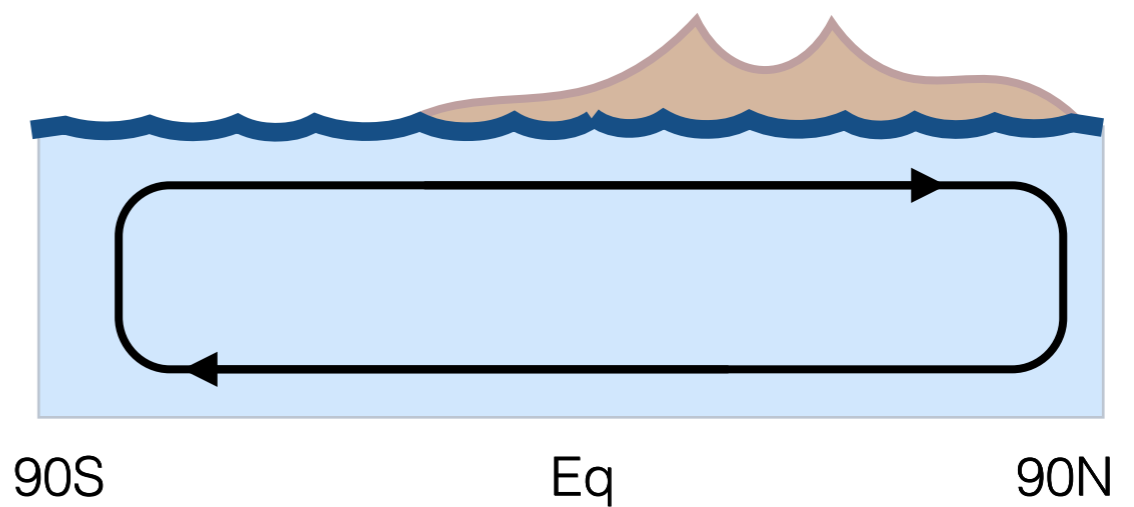
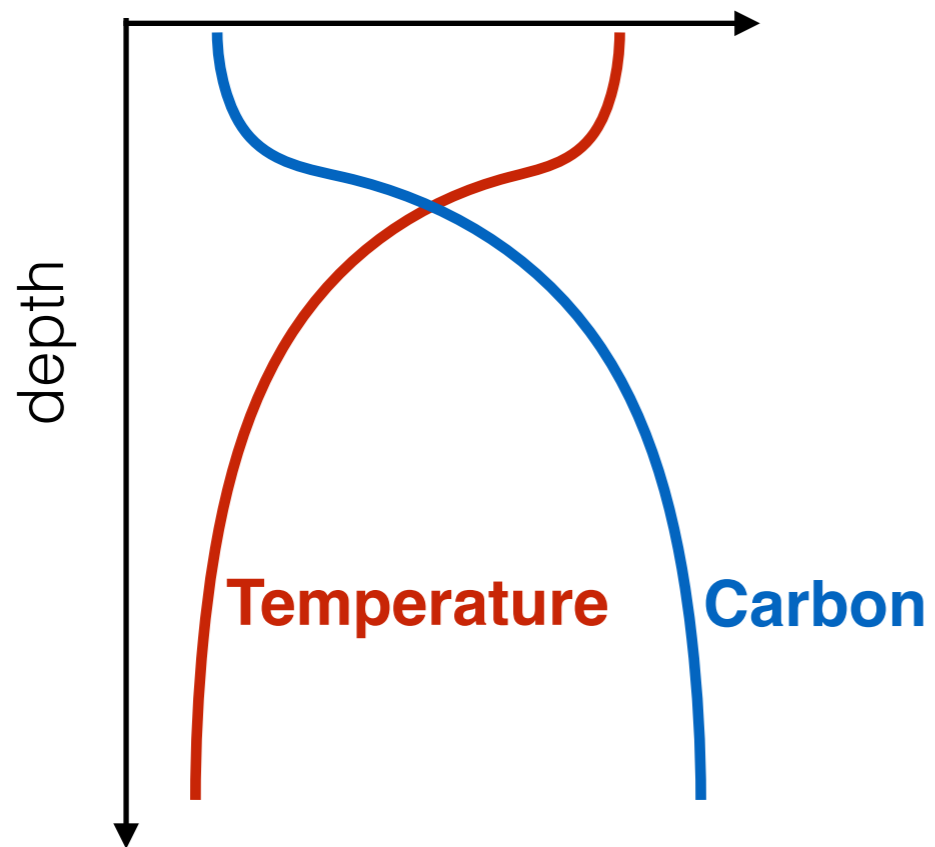
< 0.3 PgC/y

(Murnane et al., 1999; Aumont et al.
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Controversy on carbon asymmetry started in 1989...

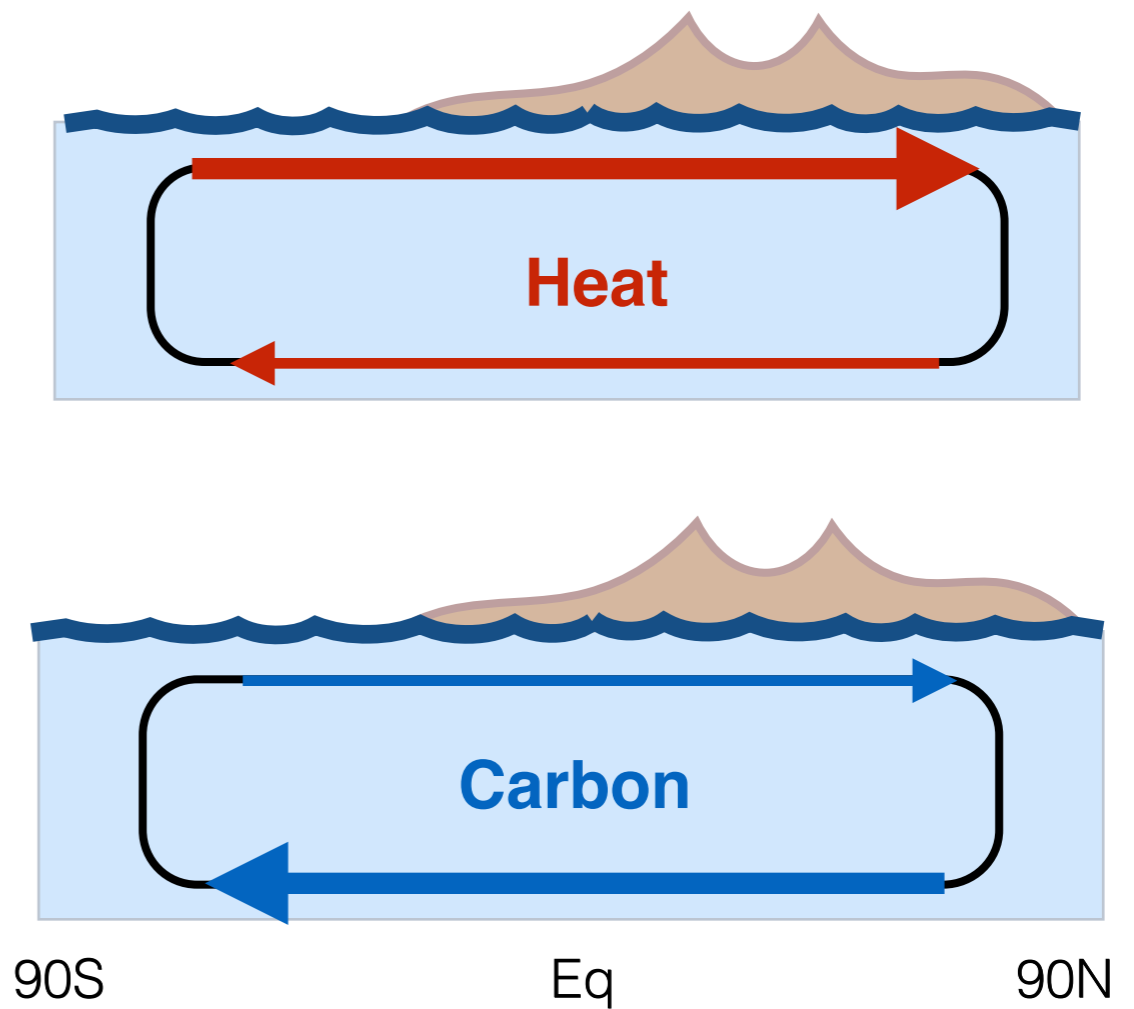
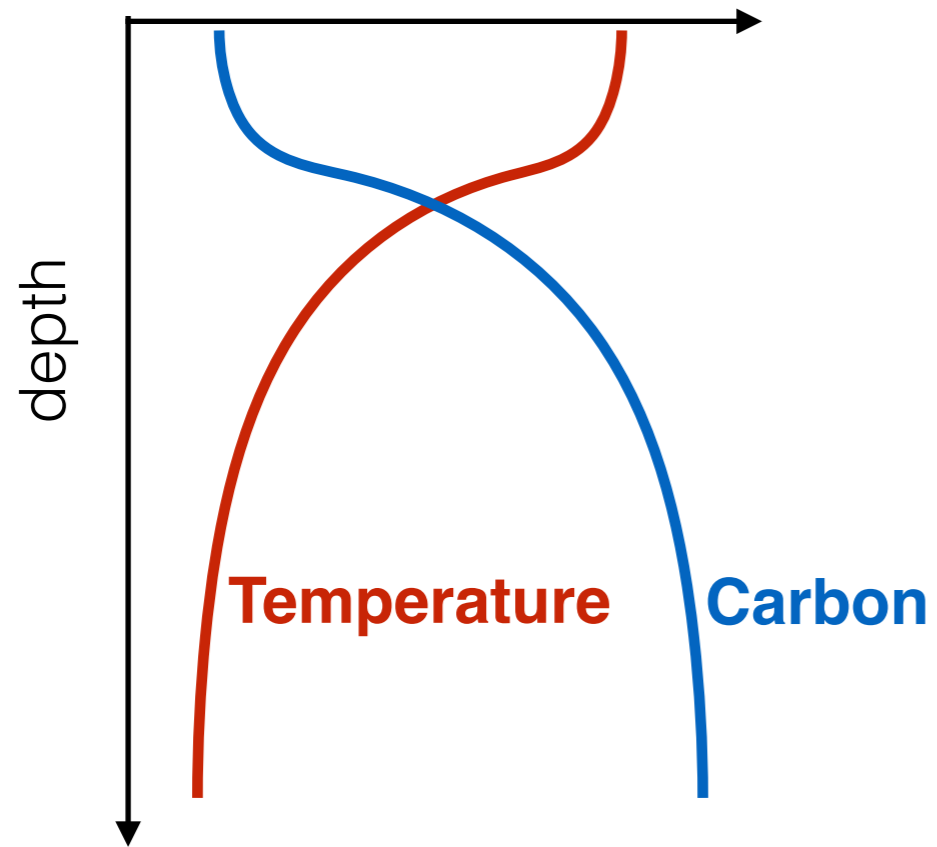
| | previous state-of-the-art | This study |
|--|--|--|
| Atmospheric CO ₂ data Mauna Loa - South Pole | 1 PgC/y (Keeling et al., 1989) | 55 years atmospheric CO₂ |
| Models/Inversions | < 0.3 PgC/y (Murnane et al., 1999; Aumont et al. 2001; Gloor et al., 2003; Mikaloff Fletcher et al., 2007...) | recent generation |
| Heat-based constraint (Atmospheric APO) | | new heat constraint |

Heat an indicator of carbon transport



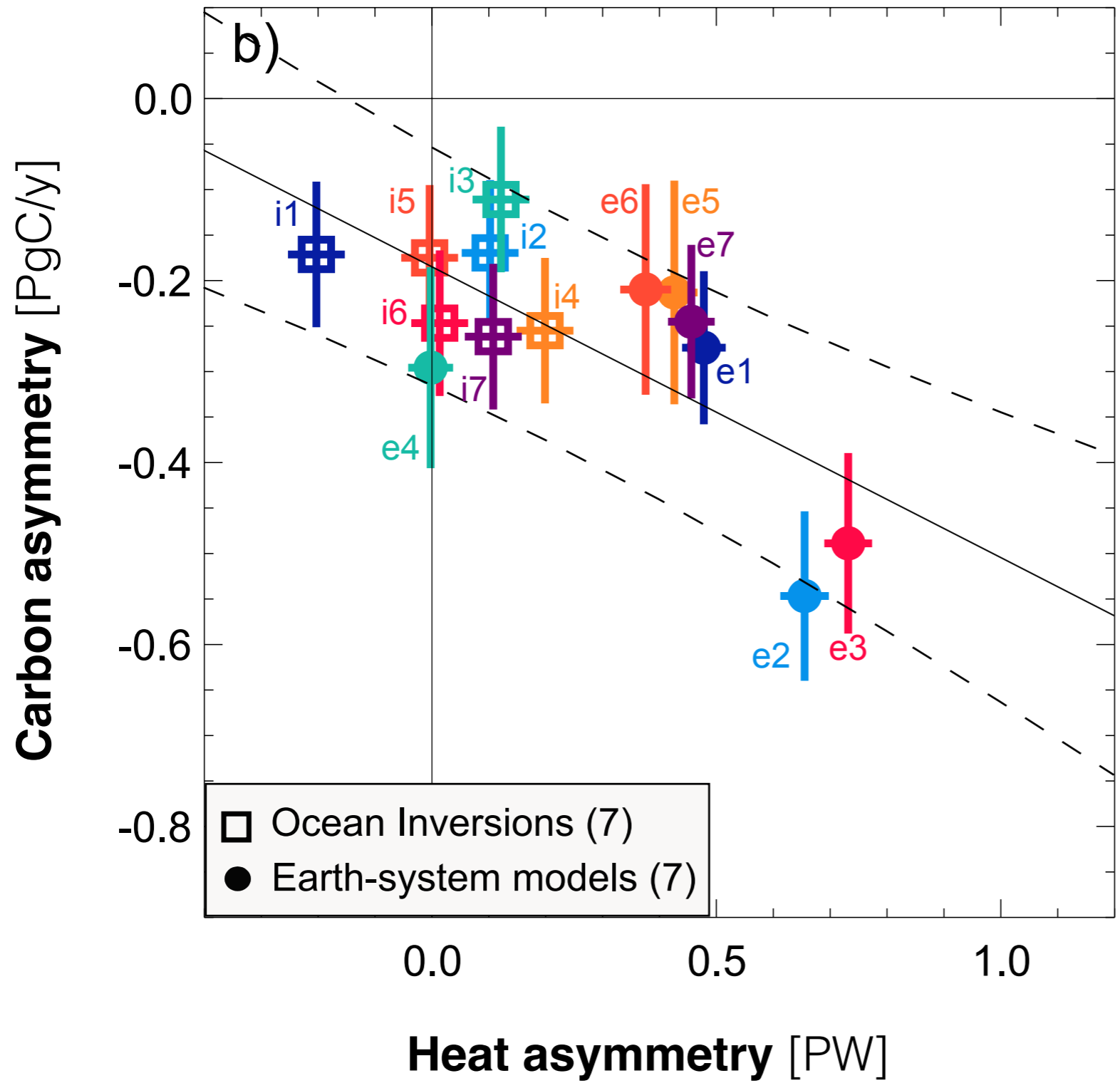
Global Ocean

Heat an indicator of carbon transport



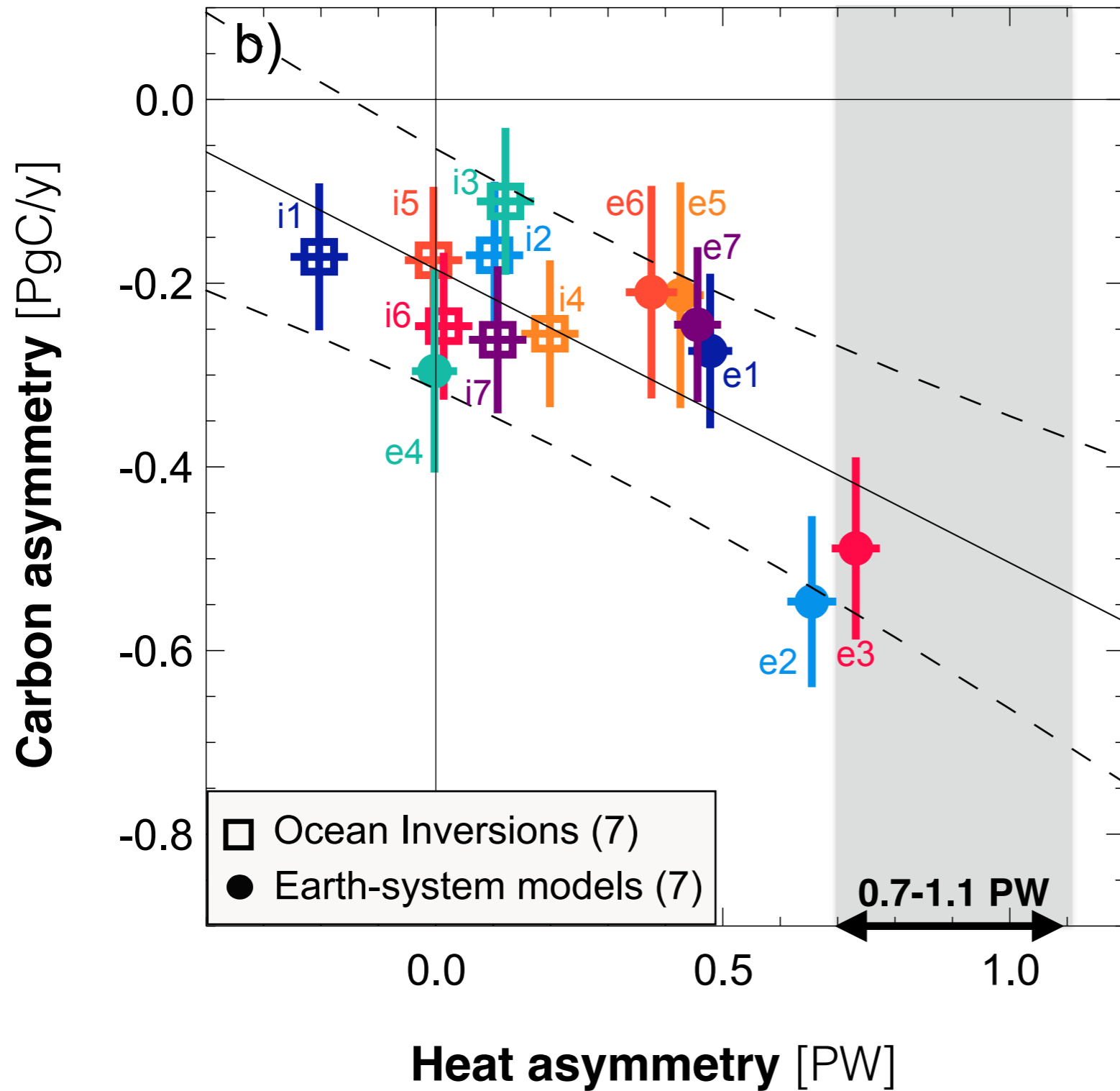
Global Ocean

New heat-based constraint on carbon asymmetry



Suite of 14 models

New heat-based constraint on carbon asymmetry

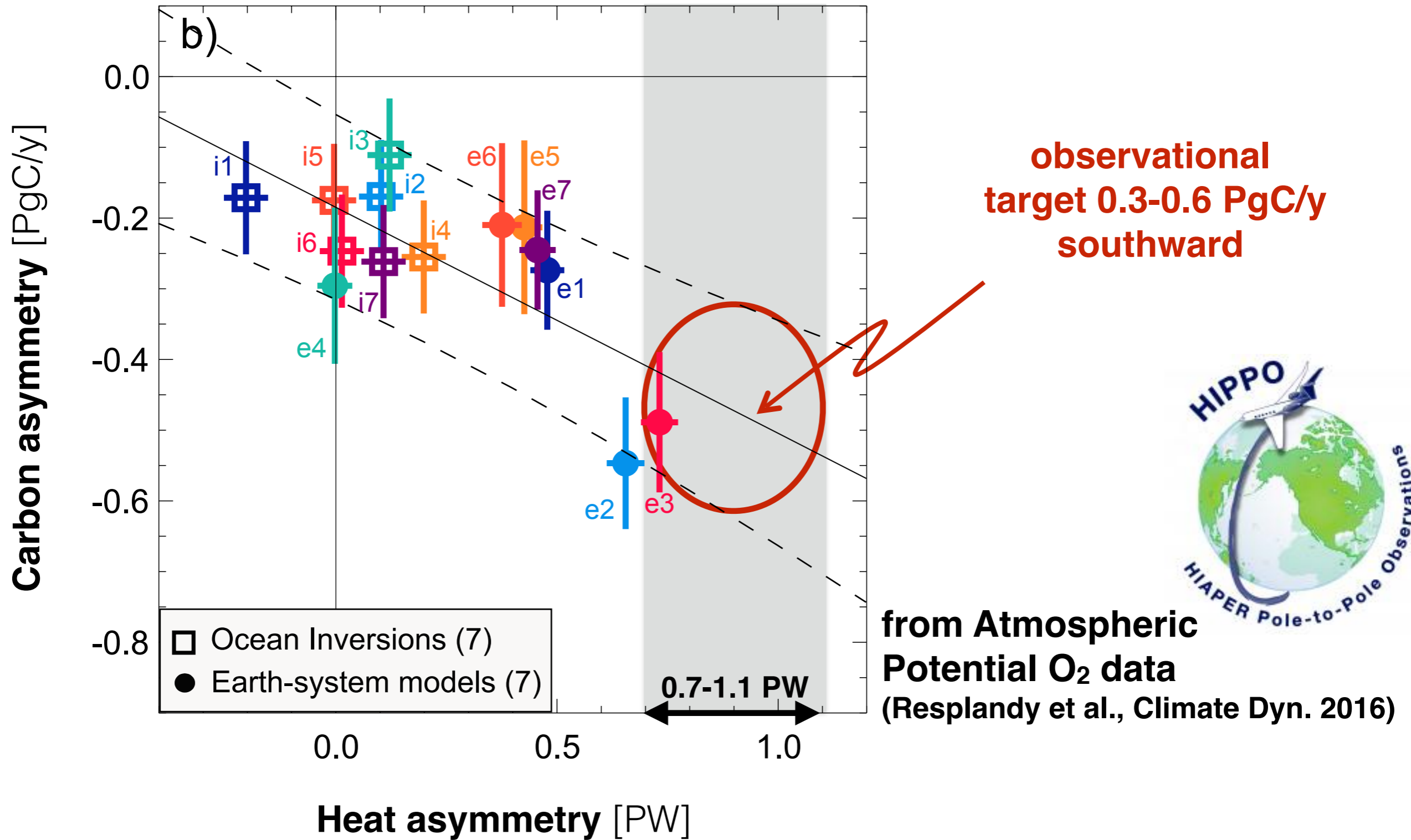


Suite of 14 models underestimates asymmetry



from Atmospheric Potential O₂ data
(Resplandy et al., Climate Dyn. 2016)

New heat-based constraint on carbon asymmetry



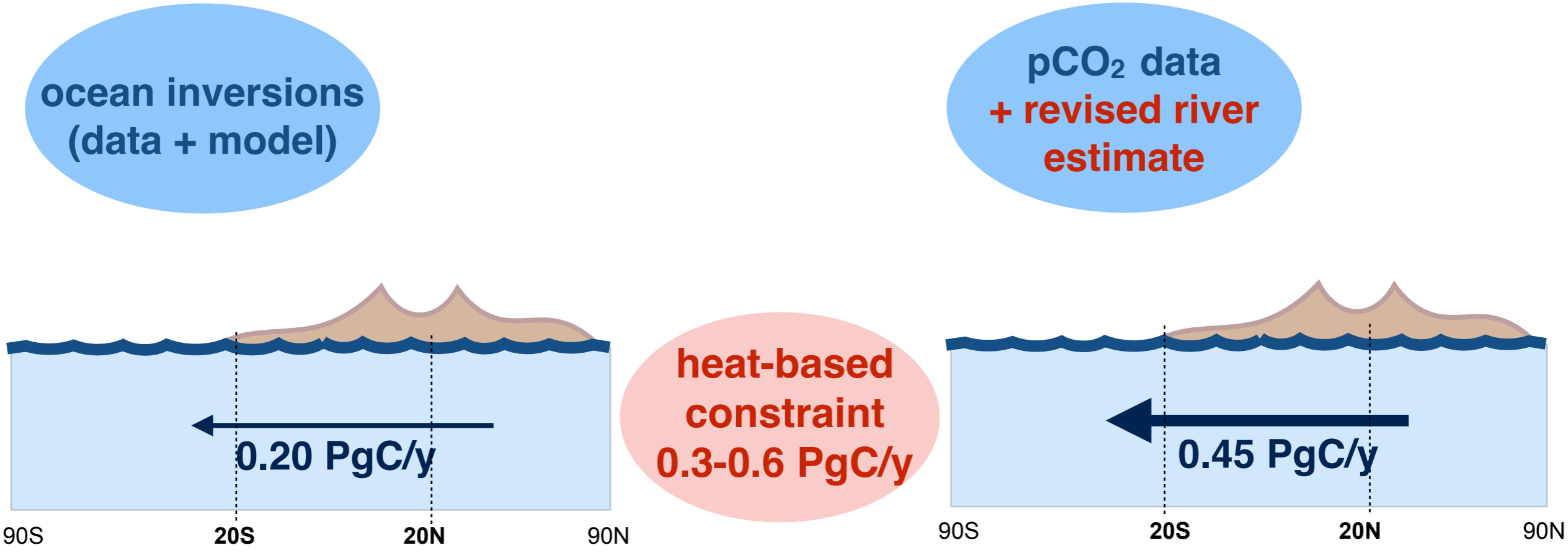
New constraint on carbon asymmetry

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| Heat-based constraint (Atmospheric APO) | | 0.3-0.6 PgC/y |

Towards the reconciliation on carbon asymmetry...

| | previous state-of-the-art | This study |
|--|--|----------------------|
| Atmospheric CO ₂ data Mauna Loa - South Pole | 1 PgC/y (Keeling et al., 1989) | ~0.5 PgC/y |
| Models/Inversions | < 0.3 PgC/y (Murnane et al., 1999; Aumont et al. 2001; Gloor et al., 2003; Mikaloff Fletcher et al., 2007...) | 0-0.5 PgC/y |
| Heat-based constraint (Atmospheric APO) | | 0.3-0.6 PgC/y |

Revised ocean-river agrees with heat-based constraint

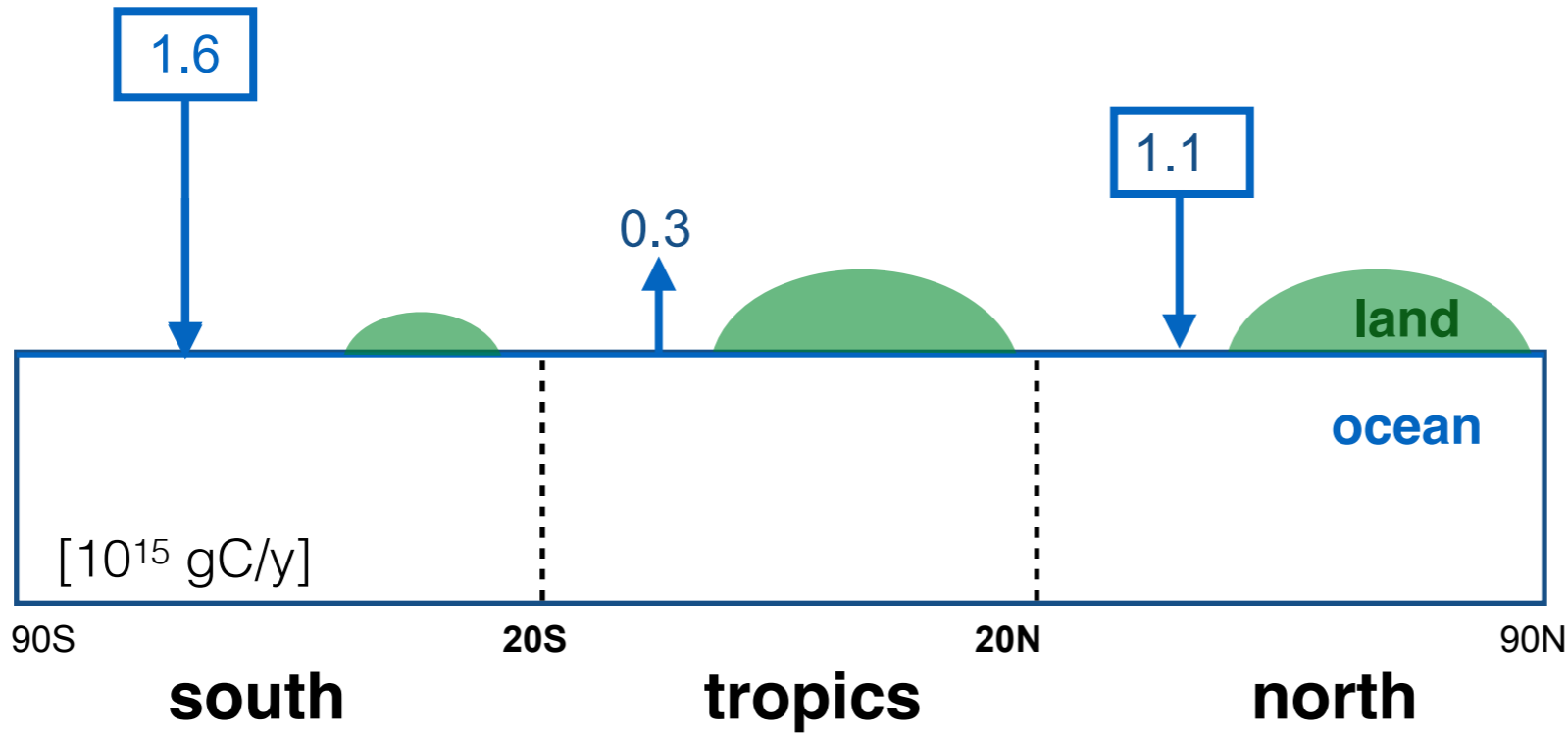
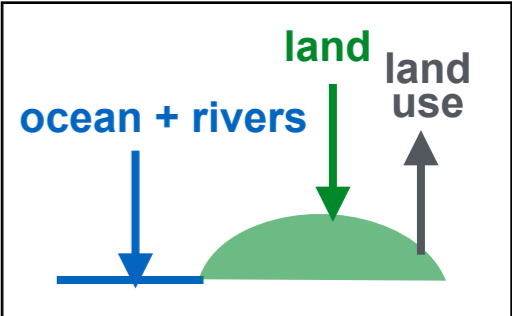


Mikaloff Fletcher et al., 2006, Gruber et al., 2009

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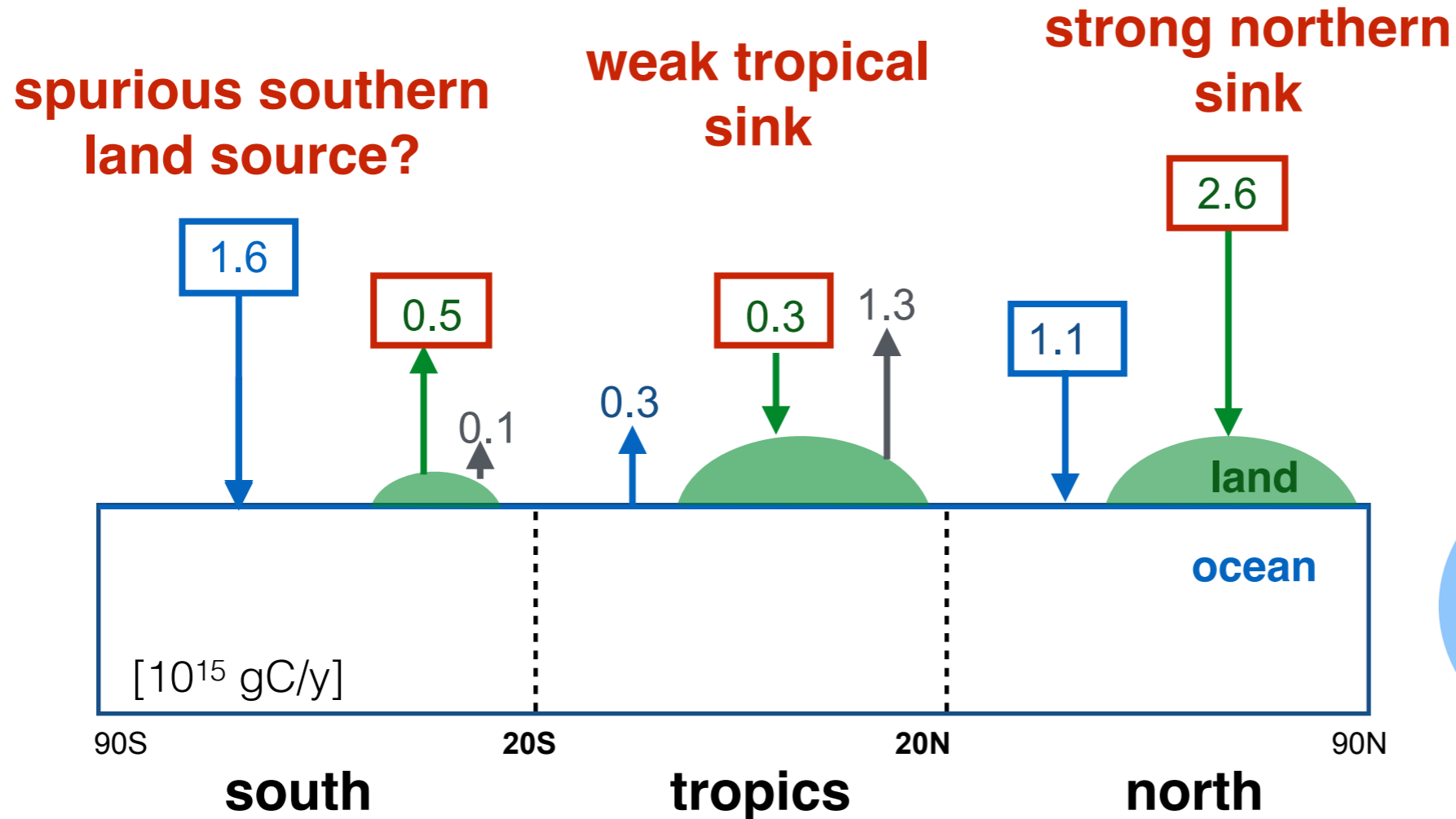
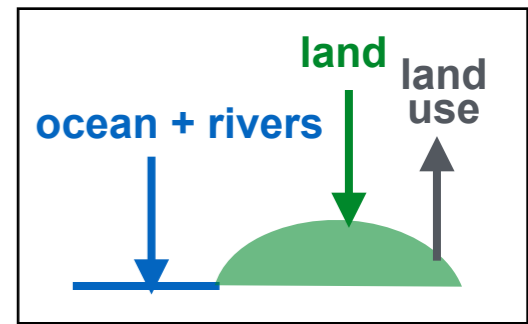
Implications for land sink?



ocean inversion
Gruber et al., 2009
(1990-2010 period)

Implications for land sink?

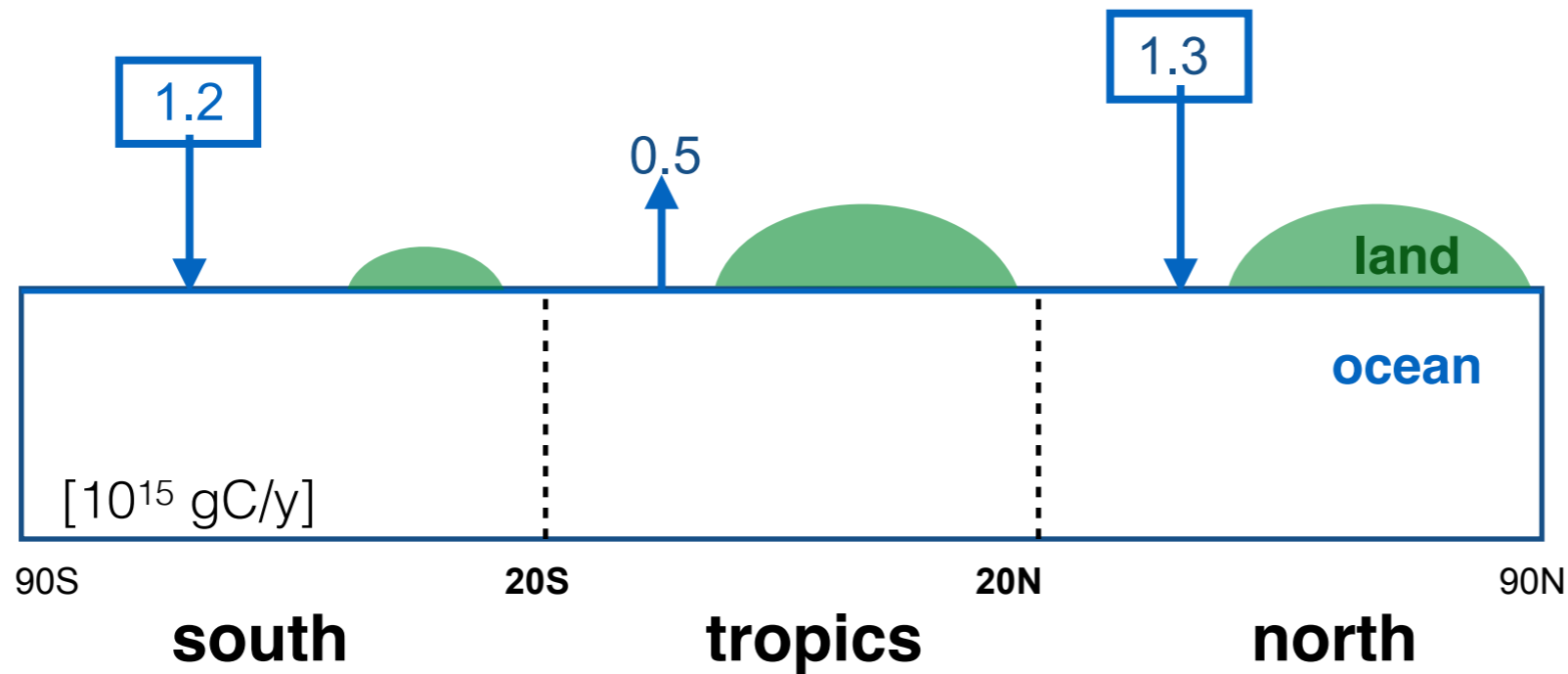
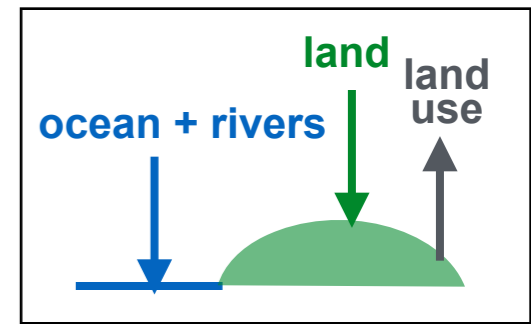
Atmospheric CO₂ inversion (MPI-Jena, Roedenbeck)



ocean inversion
Gruber et al., 2009
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Implications for land sink?

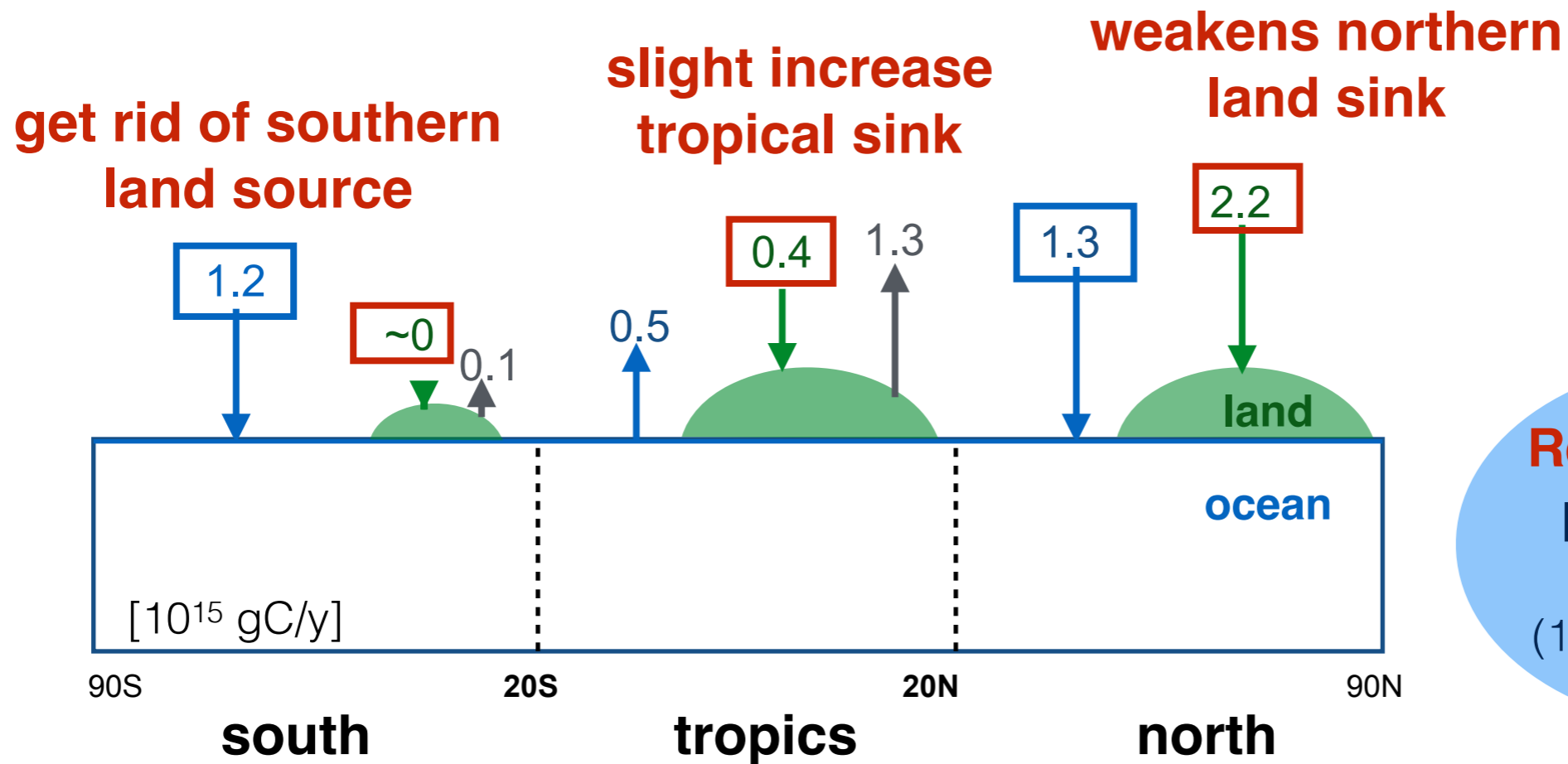
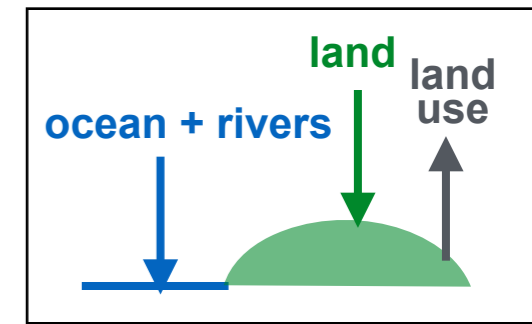
Atmospheric CO₂ inversion (MPI-Jena, Roedenbeck)



**Revised ocean
pCO₂-based
+ rivers**
(1990-2010 period)

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Revised ocean pCO₂-based + rivers
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Summary

New observational constraints on carbon/heat budget

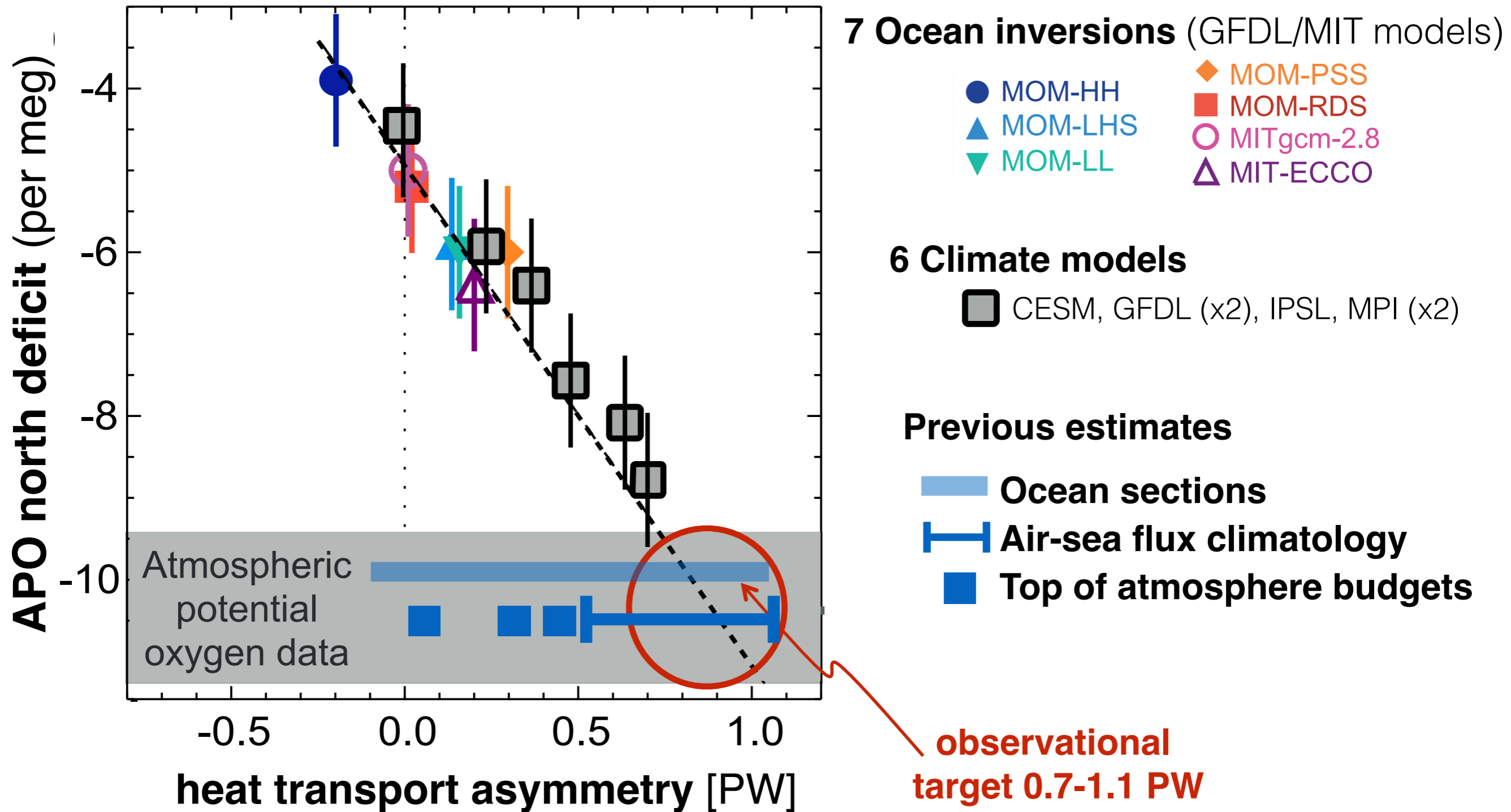
Revised carbon budget impacts land sink magnitude & distribution

Ocean/climate models underestimate carbon & heat transport

Implications for climate system

land sink, tropical precipitations,
Arctic sea ice, glacial-interglacial transitions etc.

How do state-of-the-art climate models do?



Controversy on carbon asymmetry

Atmospheric data: Keeling et al., 1989

