Carbon cycling across the land–ocean aquatic continuum of North America

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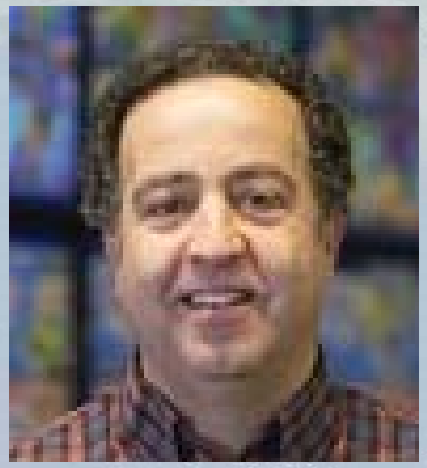

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US Dept. Agriculture Forest Service

Lisamarie Windham-Myers

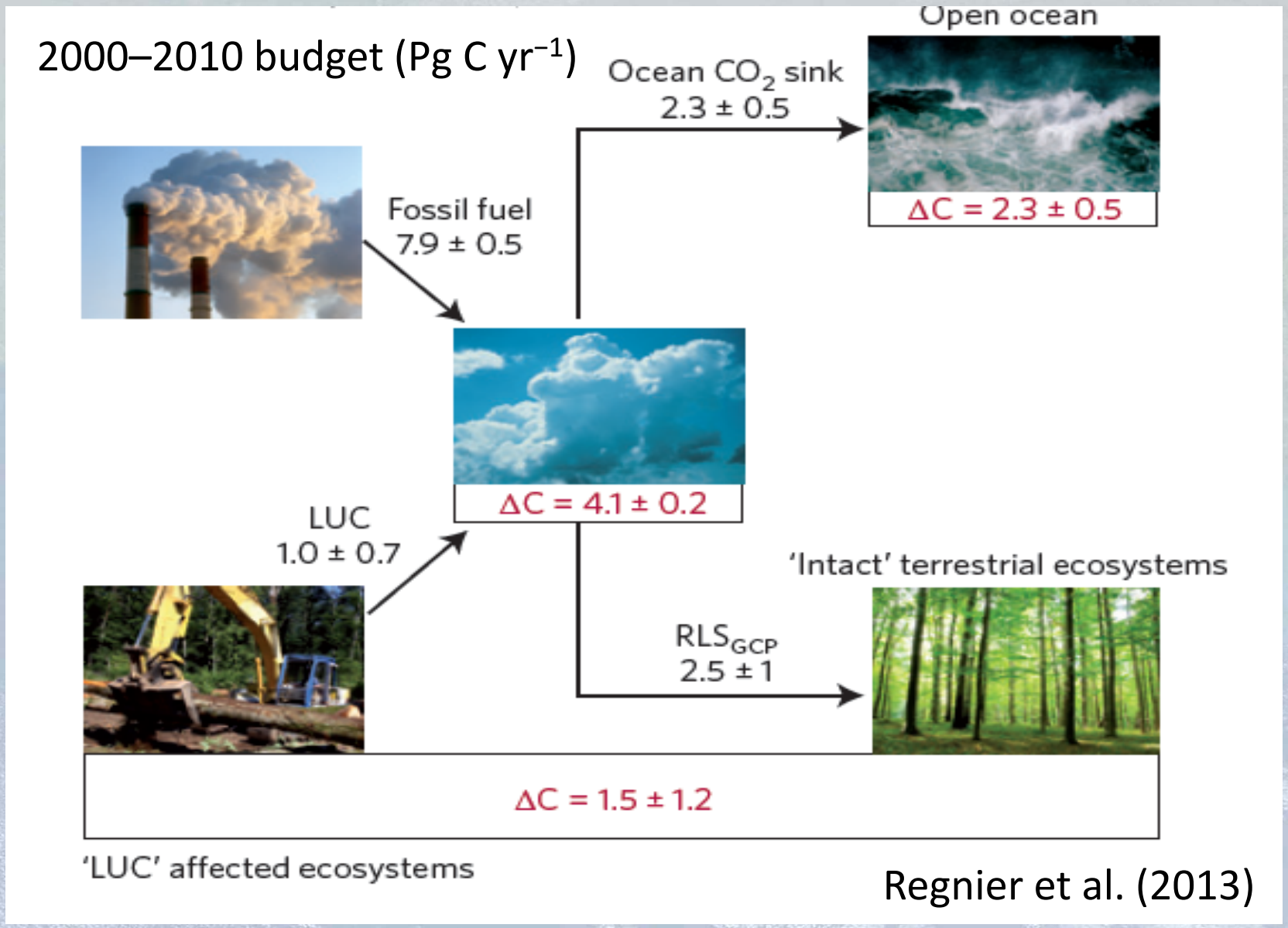
US Geological Survey

OneNOAA Science Seminar, “From Science to Solutions: The State of the Carbon Cycle (SOCCR2) Seminar Series,” March 19, 2019

Why is the carbon cycle important?

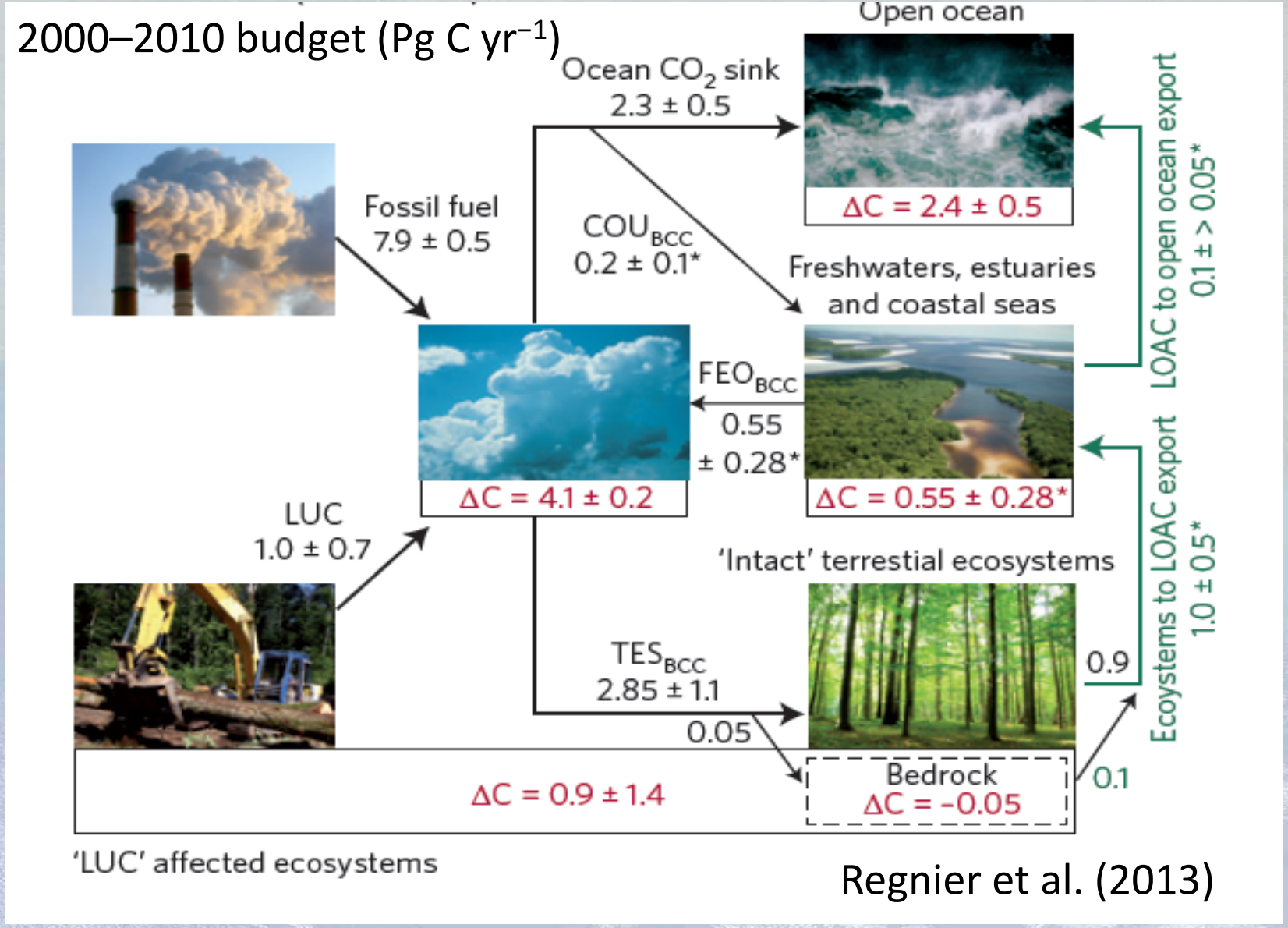
- Regulates the abundance of the most important non-condensable greenhouse gases: carbon dioxide and methane
  - The natural greenhouse effect warms the planet by 33 ^{o}C
- Carbon dioxide stimulates plant growth
- Carbon dioxide acidifies the ocean
- Carbon is the main currency for quantifying the productivity of the biosphere, including
  - Forests
  - Fisheries
  - Agriculture

In the traditional view of the global carbon cycle, land and ocean are <u>not connected</u>



Regnier et al. (2013)

In the modern view of the global carbon cycle, land and ocean are linked via an aquatic continuum



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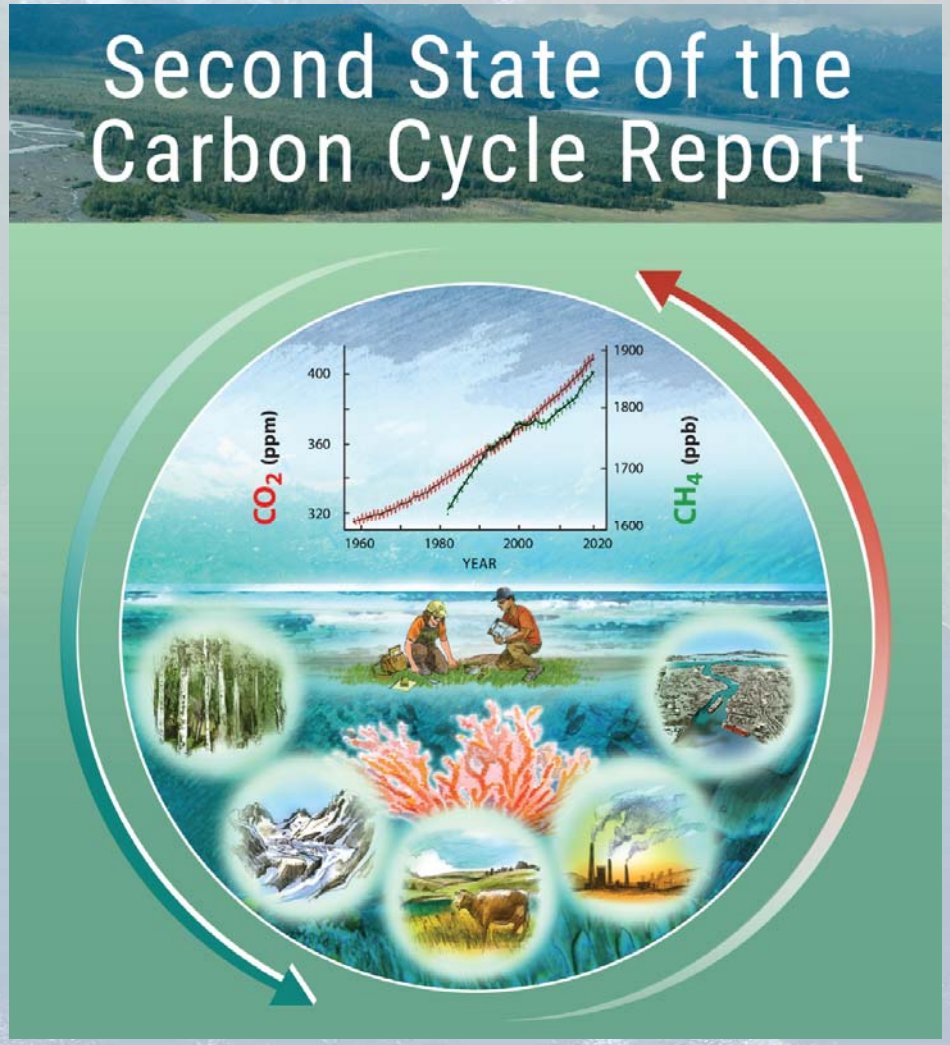

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https://www.globalchange.gov/content/about-soccr-2

13 Terrestrial Wetlands

14 Inland Waters

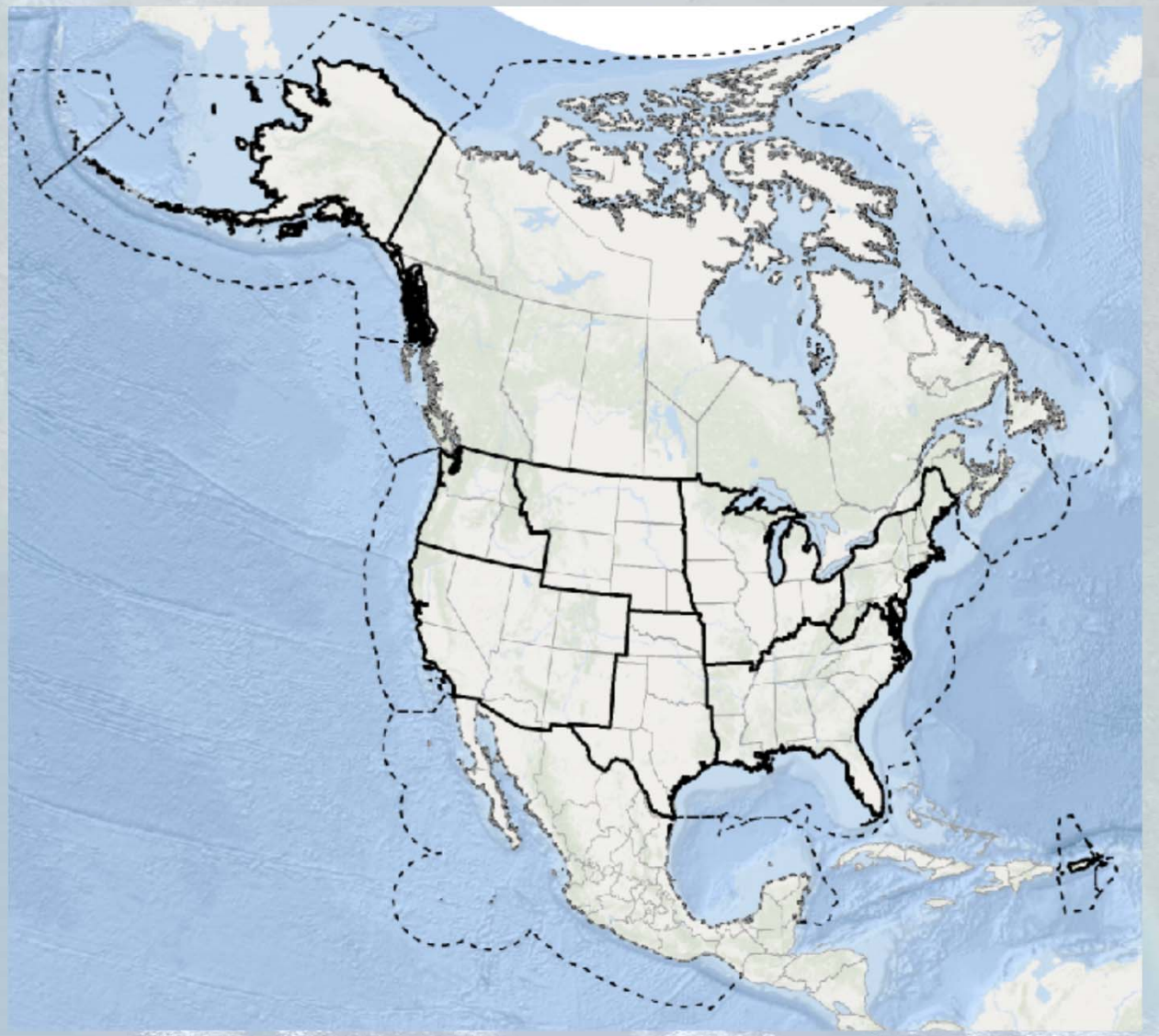
15 Tidal Wetlands and Estuaries

16 Coastal Ocean and Continental Shelves

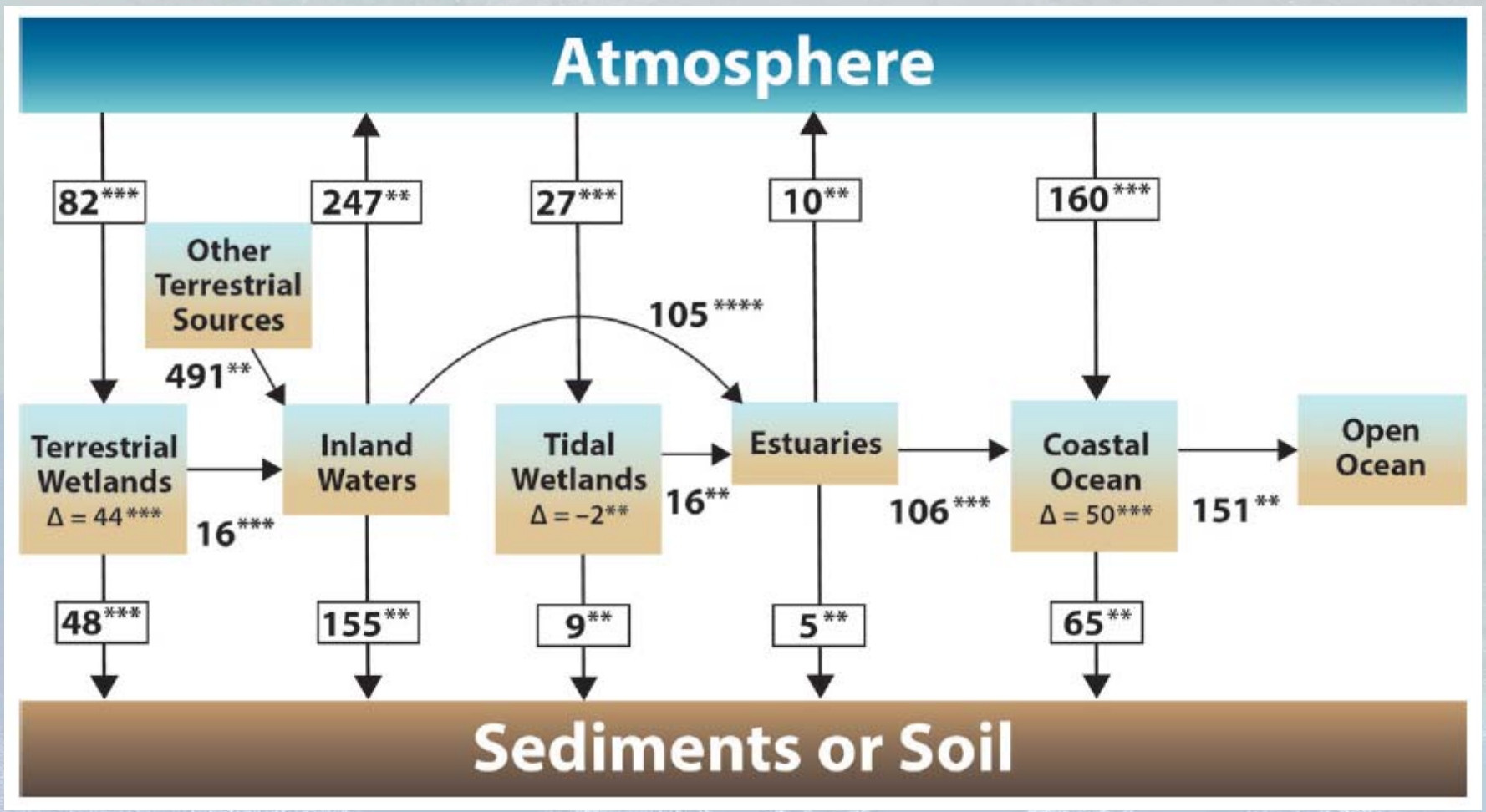
A difficult problem … boundaries are messy

SOCCR2 aquatic chapters used a combination of literature review, data synthesis, and models (process-based, inversion, and empirical)

Coastal ocean domain defined as the Exclusive Economic Zone—typically 200 nautical miles from shore

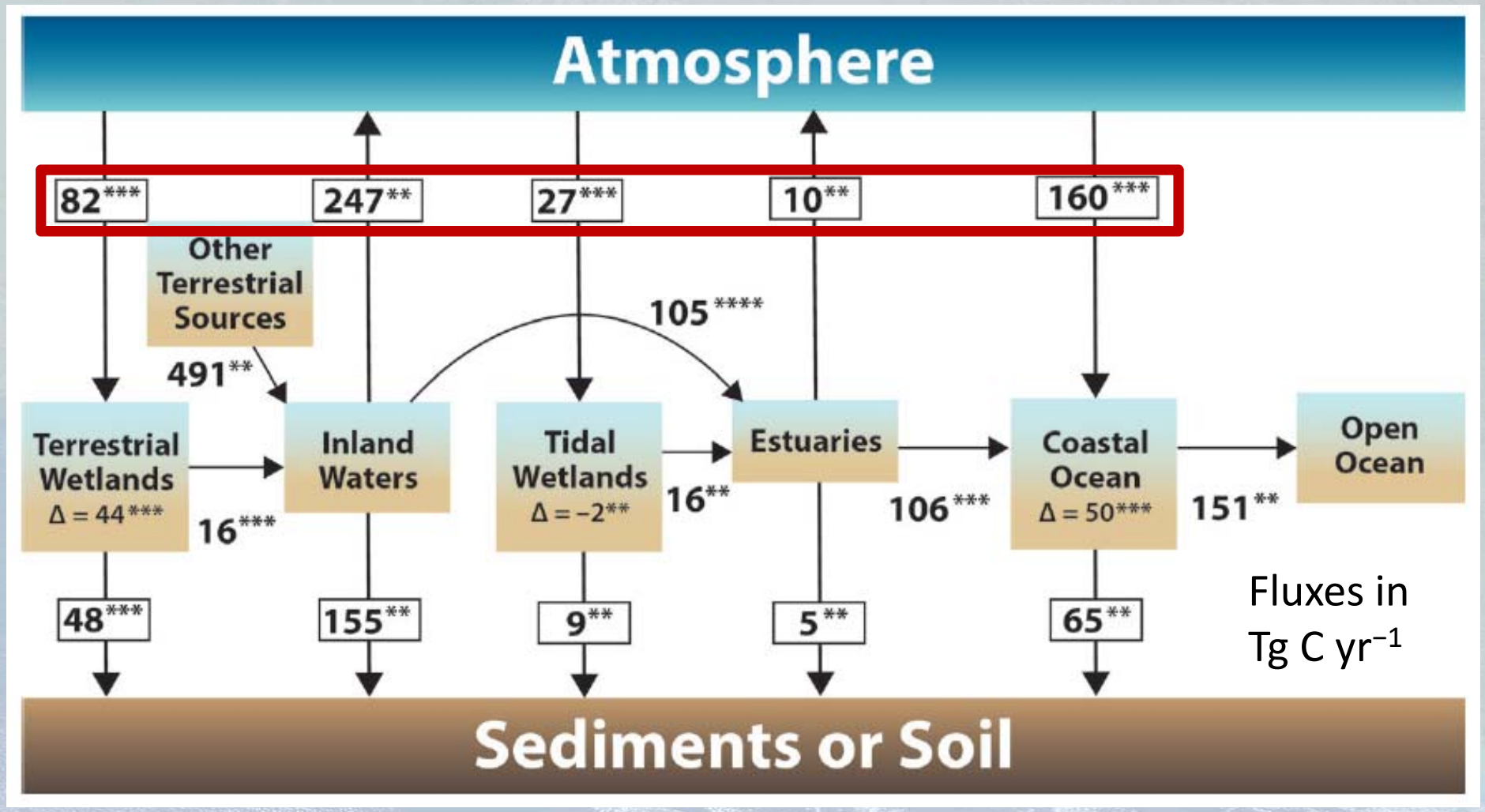


Total Carbon Budget of North American Aquatic Ecosystems (Tg C yr^{-1})



95% confidence actual value is within 25% (****), 50% (***), or 100% (**) of reported value

Large compensating exchange fluxes with atmosphere: 269 Tg C yr^{-1} uptake, 257 Tg C yr^{-1} release



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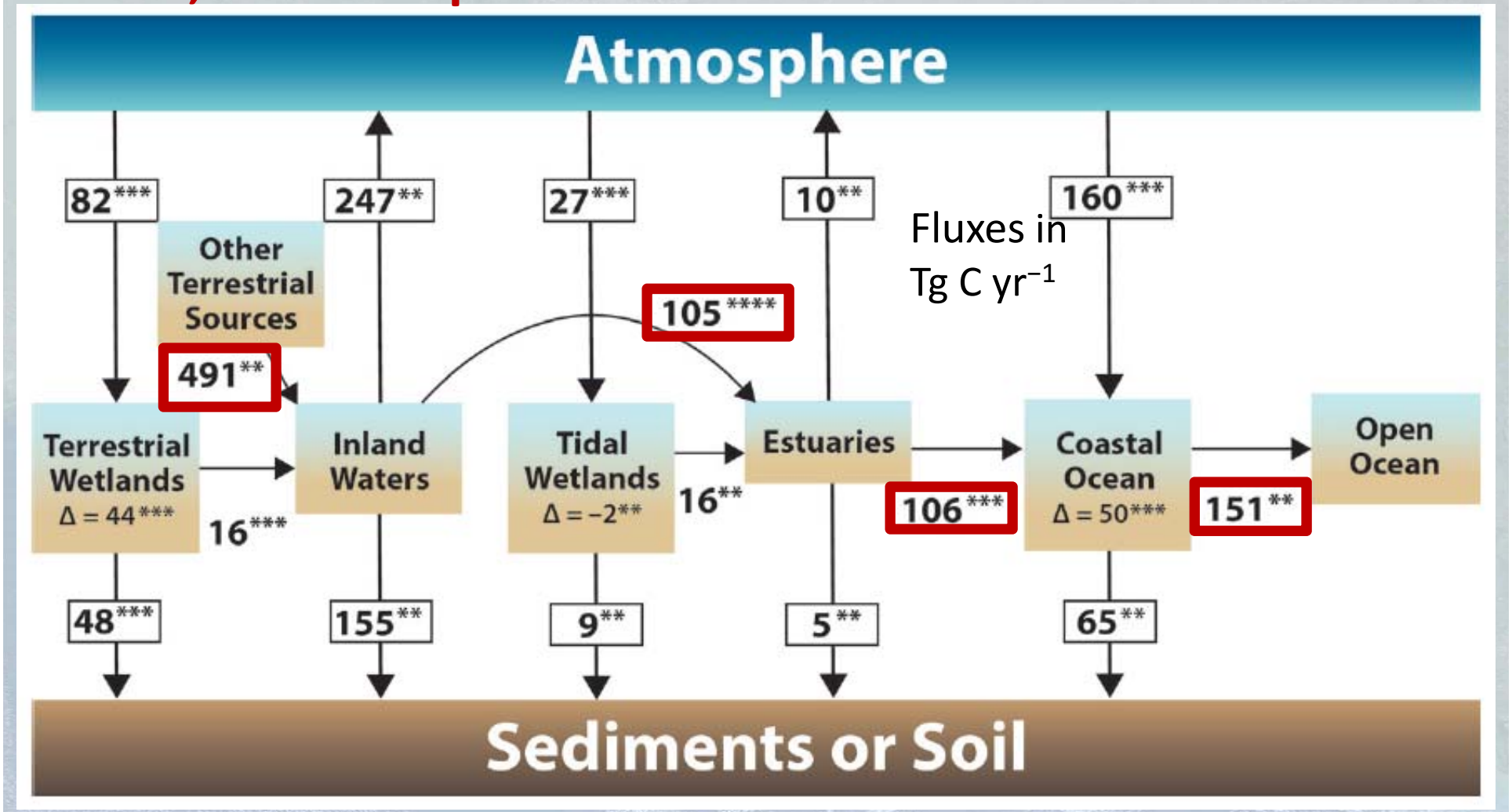
Large lateral fluxes to inland waters, estuaries, the coastal ocean, and the open ocean



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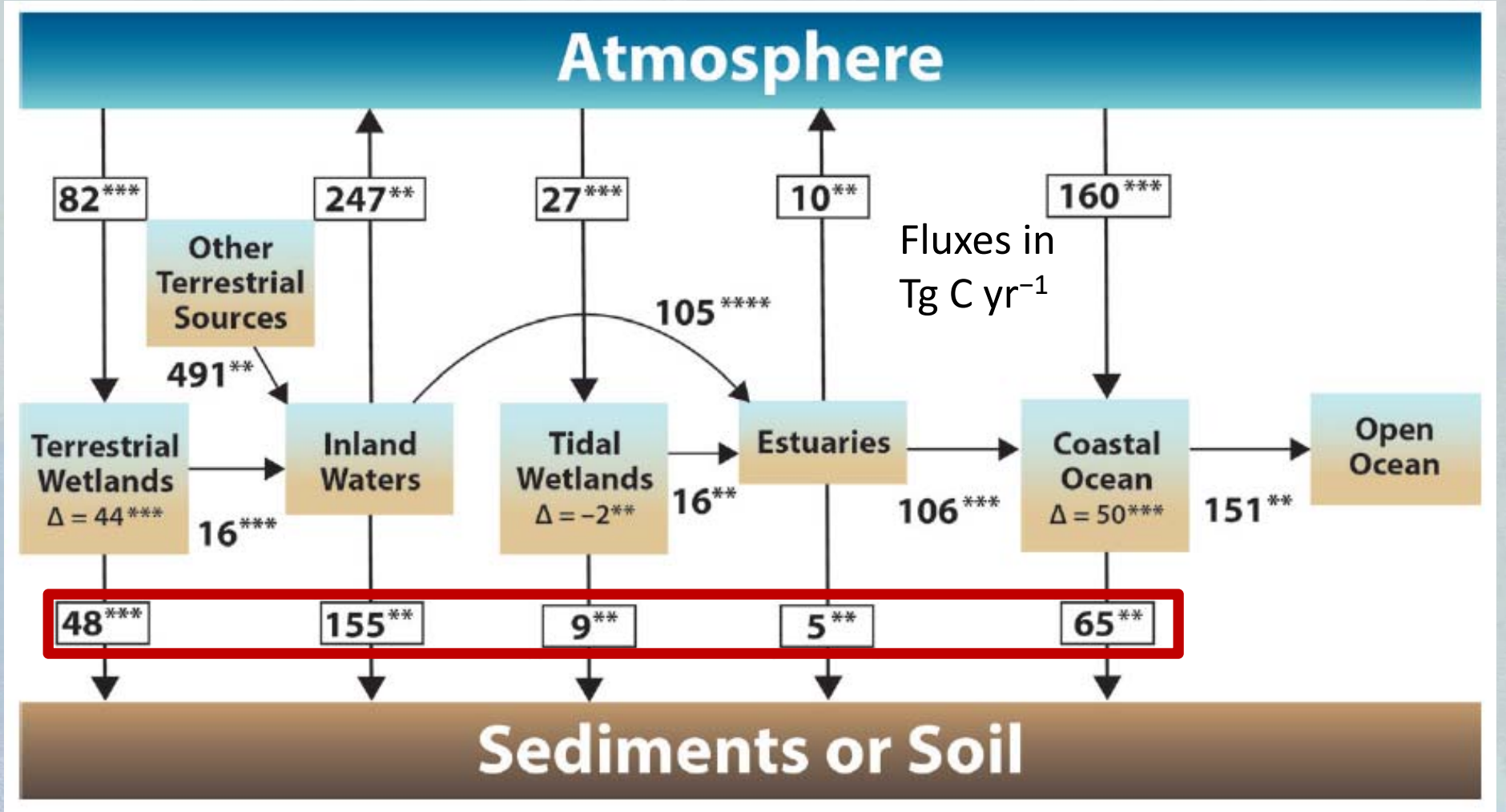
Large burial: 282 Tg C yr^{-1}



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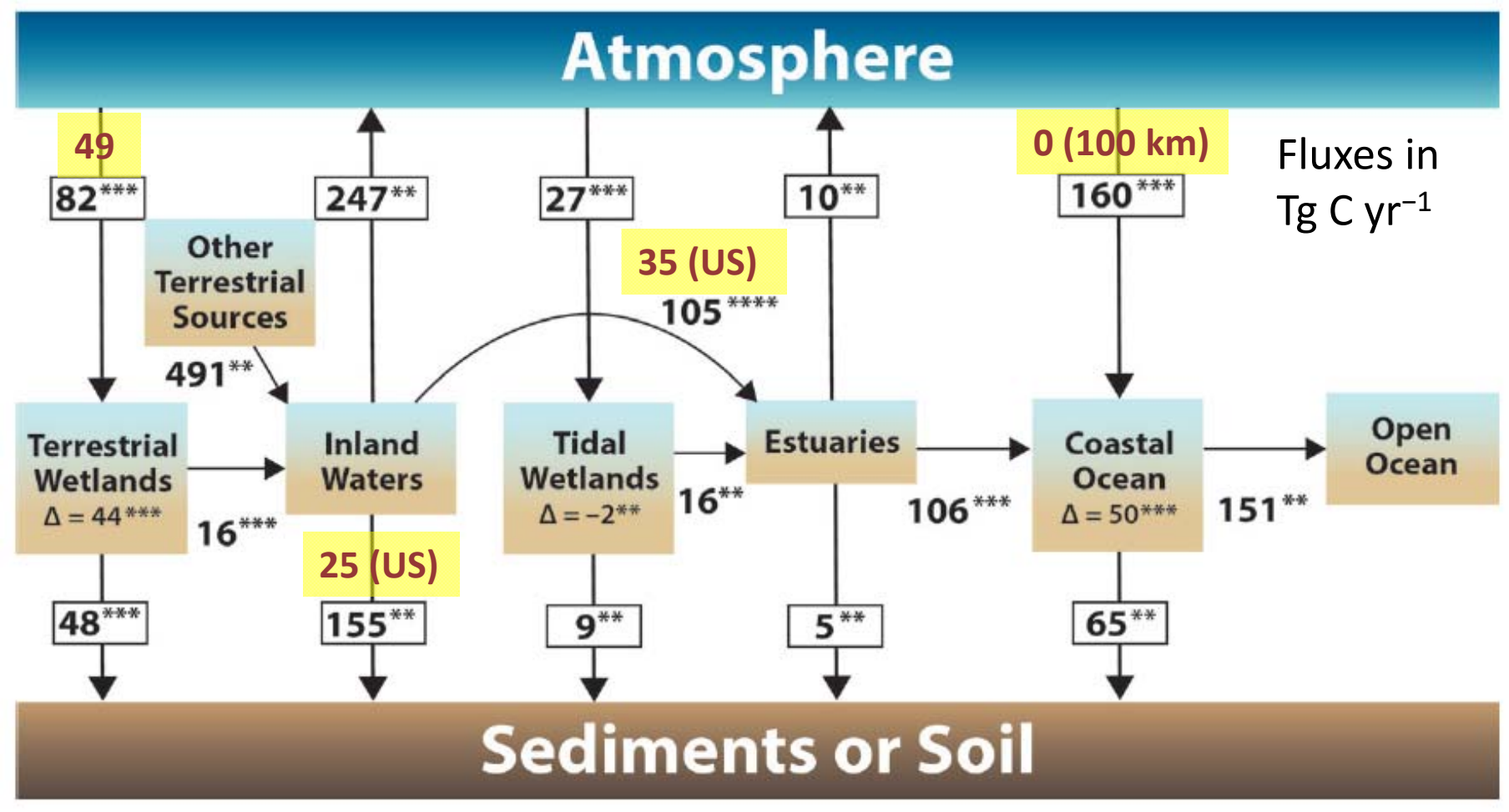
There have been major advances in the North American aquatic carbon budget since SOCCR1



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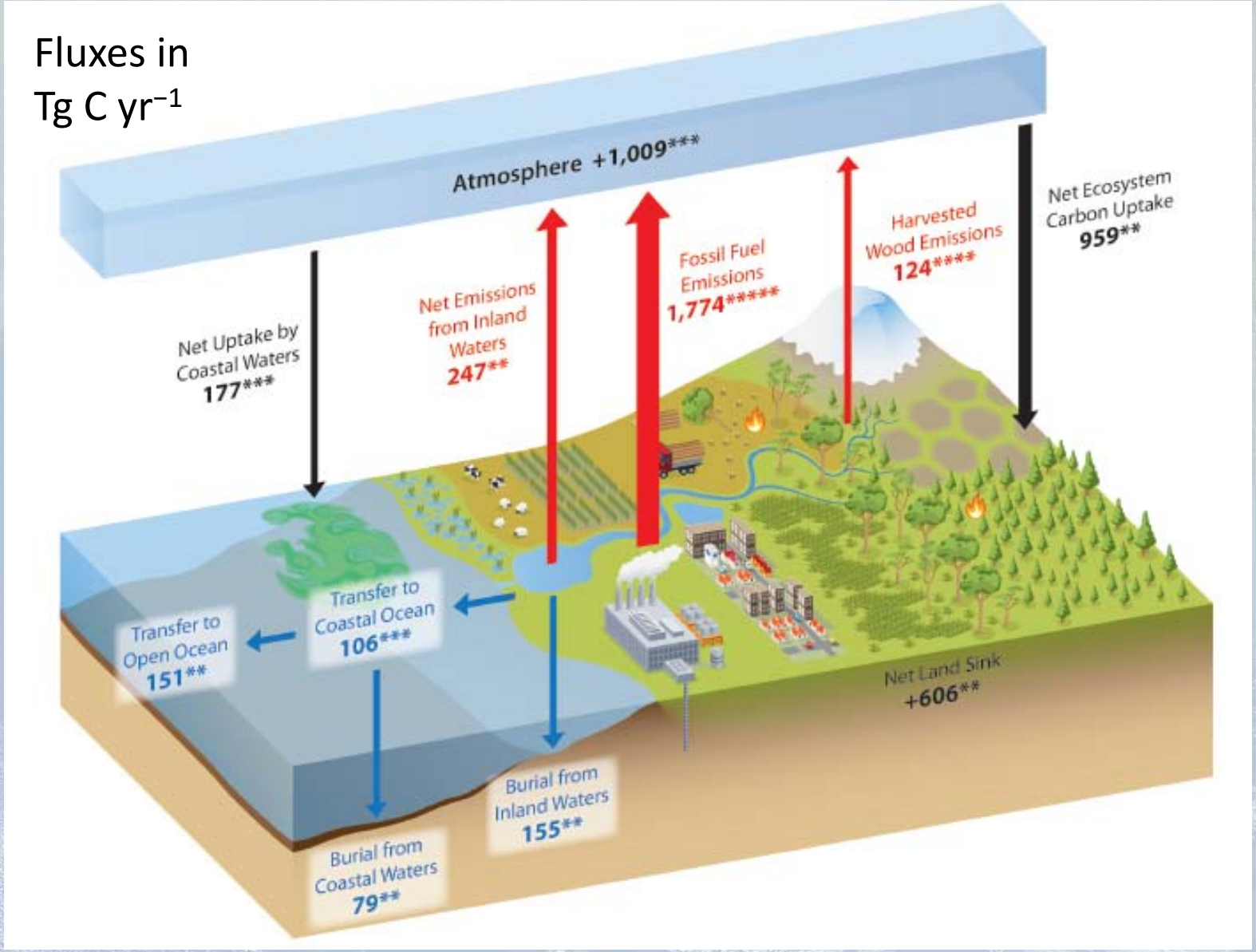
Putting the land–ocean aquatic continuum of North America into context



Other Chapter 13 highlights

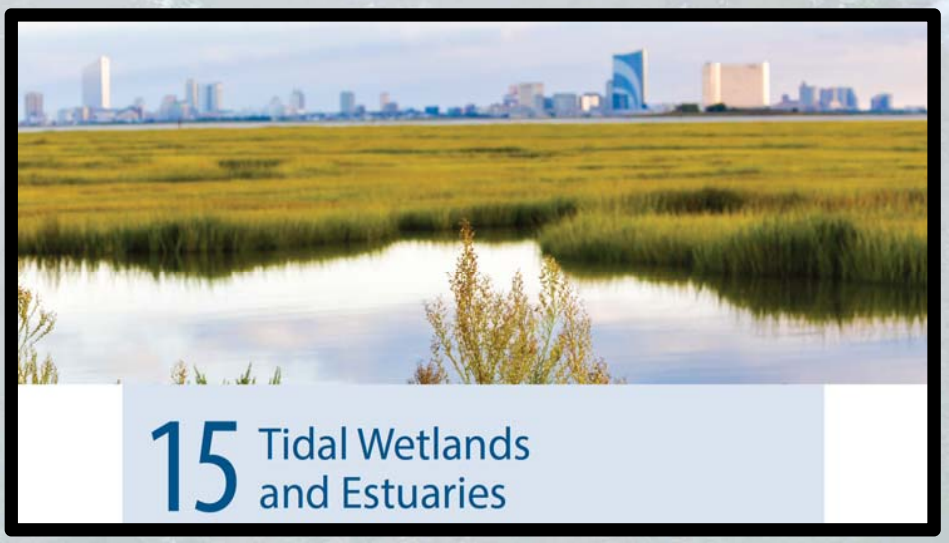
- Wetland methane emissions offset about 1/3 of wetland CO_2 uptake
- North America wetlands about 1/3 of global wetland emissions
- Current rate of wetland loss much less than historical rates, with restoration and creation nearly offsetting natural wetland loss
- Created and restored wetlands are not functionally equivalent to natural wetlands

Other Chapter 14 highlights

Future research should

- Quantify methane emissions
- Better represent storms and other extreme events
- Standardize measurement techniques and protocols, similar to what has been done by the International Ocean Carbon Coordination Project

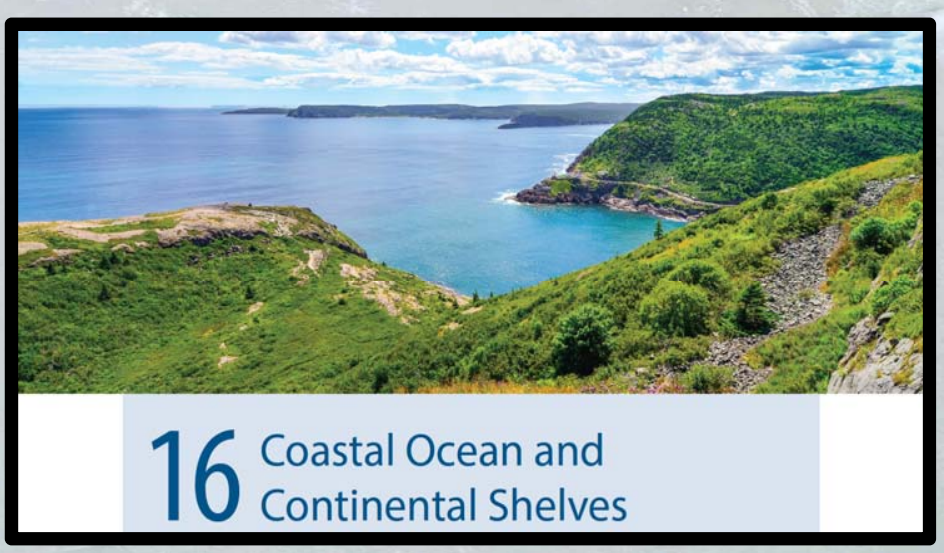
Other Chapter 15 highlights



Future research should

- Understand responses to accelerated sea level rise
- Map tidal wetland and estuarine extent
- Quantify carbon dioxide and methane exchange in large, undersampled, and rapidly changing regions

Other Chapter 16 highlights



- The net uptake of atmospheric CO_2 by the coastal ocean is driven primarily by high-latitude regions
- Low pH conditions occur in Arctic and North Pacific coastal waters and have been exacerbated by anthropogenic CO_2
- Expanded monitoring, synthesis, and modeling required to provide more reliable coastal carbon budgets and future projections of the coastal ocean

What have we learned?

- Aquatic systems play a prominent role in the North American carbon budget
- Exchanges with the atmosphere are large but offsetting (± 200 – 300 Tg C yr^{-1})
- Lateral transfers and burial are large and exclusive to aquatic systems:
  - Lateral transfer ≈ 500 Tg C yr^{-1} to inland waters and ≈ 100 Tg C yr^{-1} to estuaries, coastal waters, and the open ocean
  - Burial ≈ 300 Tg C yr^{-1}

More information

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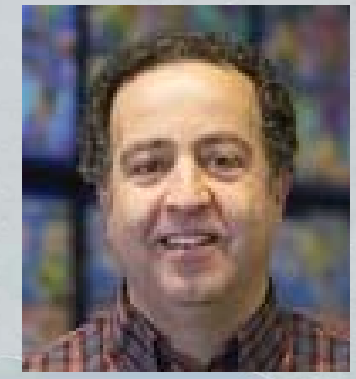
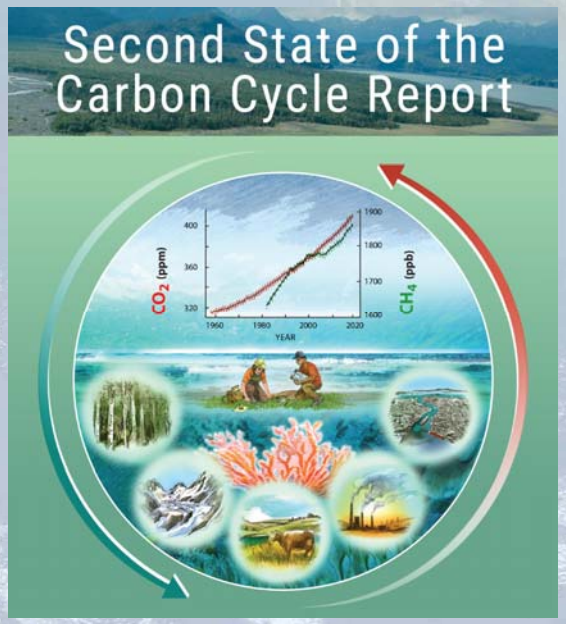


- About the 2nd State of the Carbon Cycle Report (SOCCR2):
  - https://www.globalchange.gov/content/about-soccr-2



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