Integrating Field Experiments, Remote Sensing, and Process-based Modeling Toward Improved Understanding and Quantification of Watershed Scale Carbon Cycling

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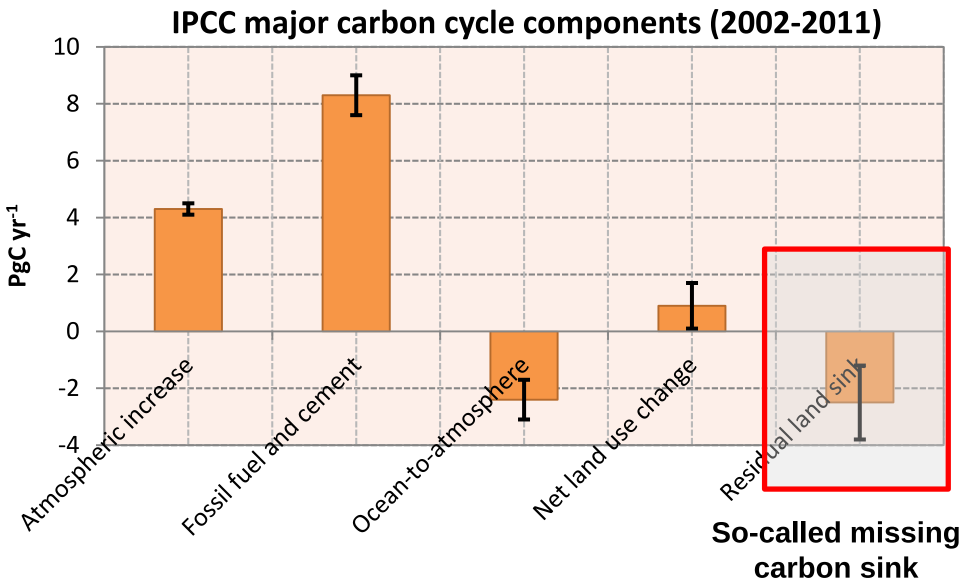
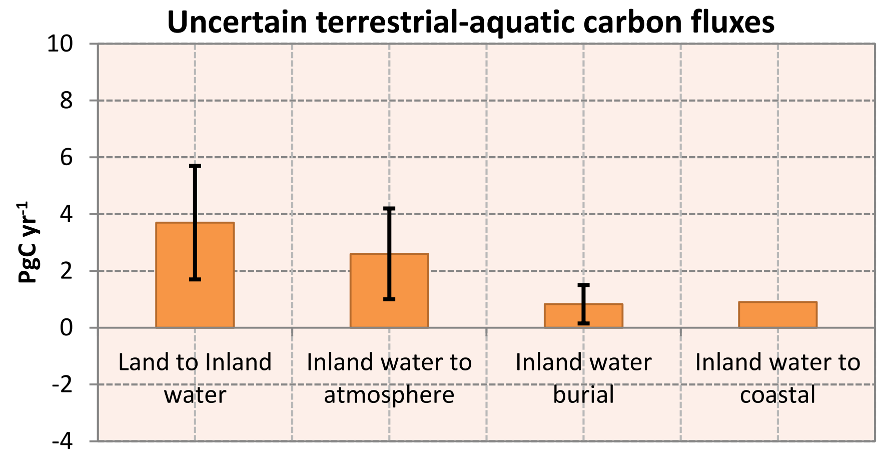
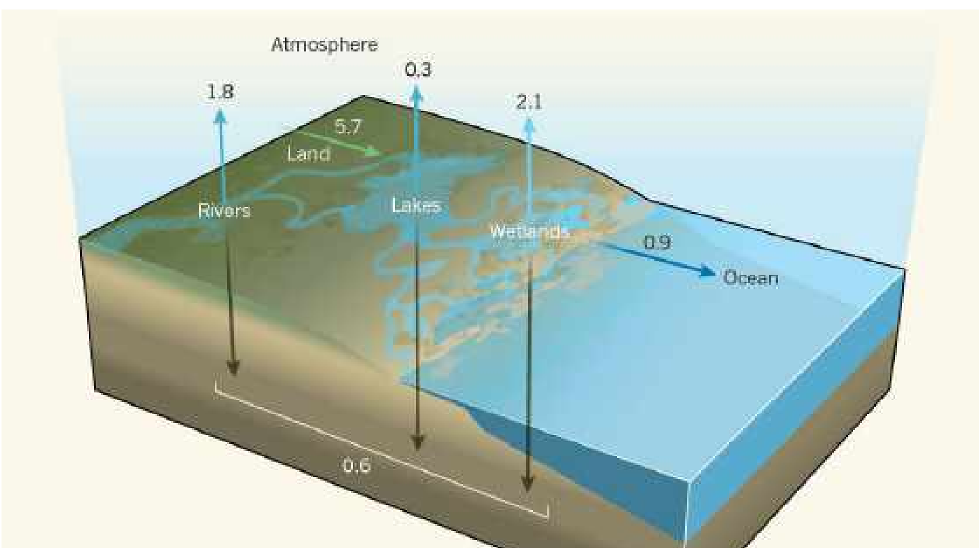
College Park, MD

Significance of terrestrial-aquatic carbon fluxes







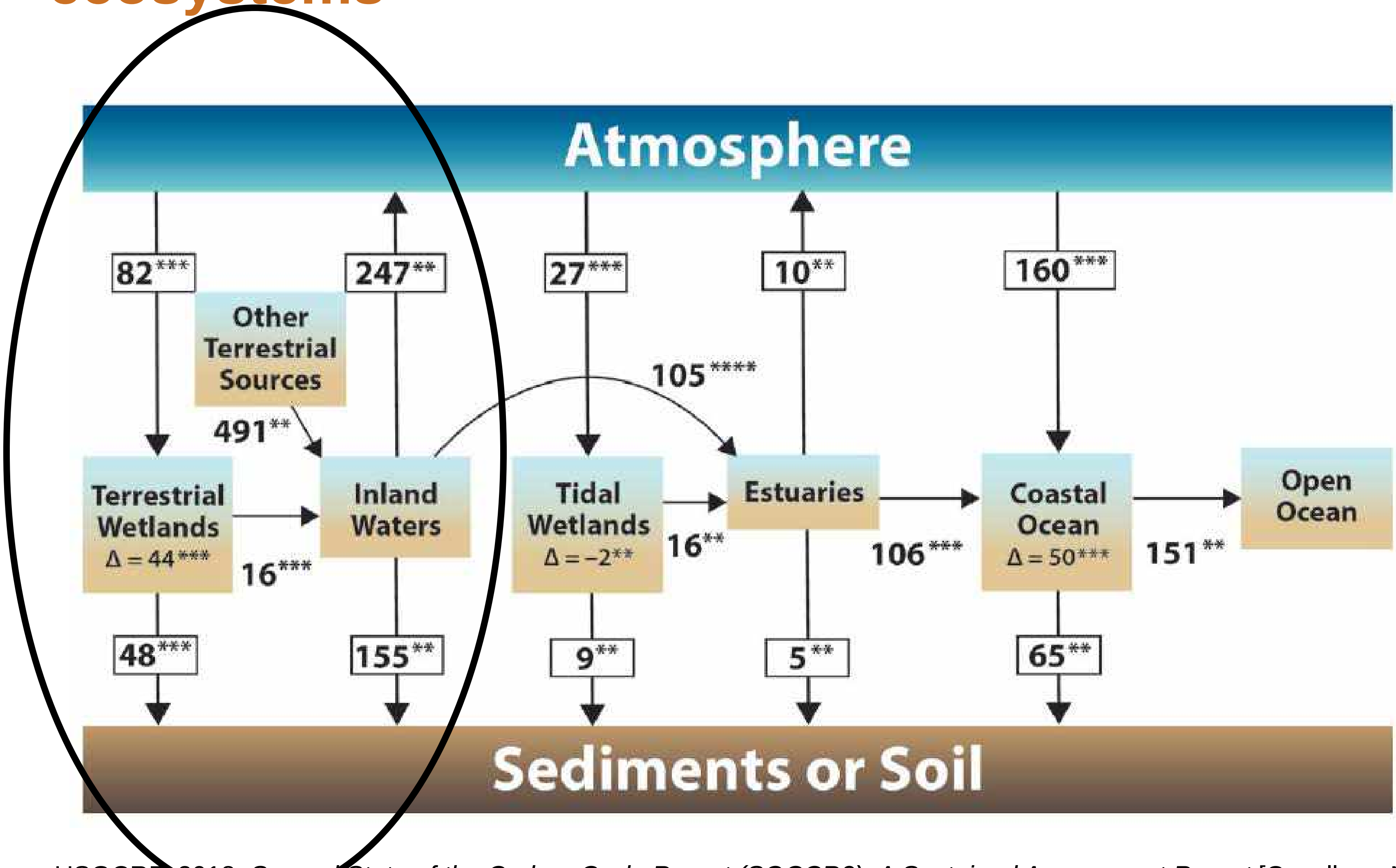
Bernhard Wehrli, 2013

Recent results indicate that aquatic fluxes subject to significant uncertainty:

- Land to Inland water: 1.7 - 5.7 PgC yr^{-1}
- Inland water to atmosphere: 1.0 – 3.88 PgC yr^{-1}
- Inland water burial: 0.15 - 1.6 PgC yr^{-1}

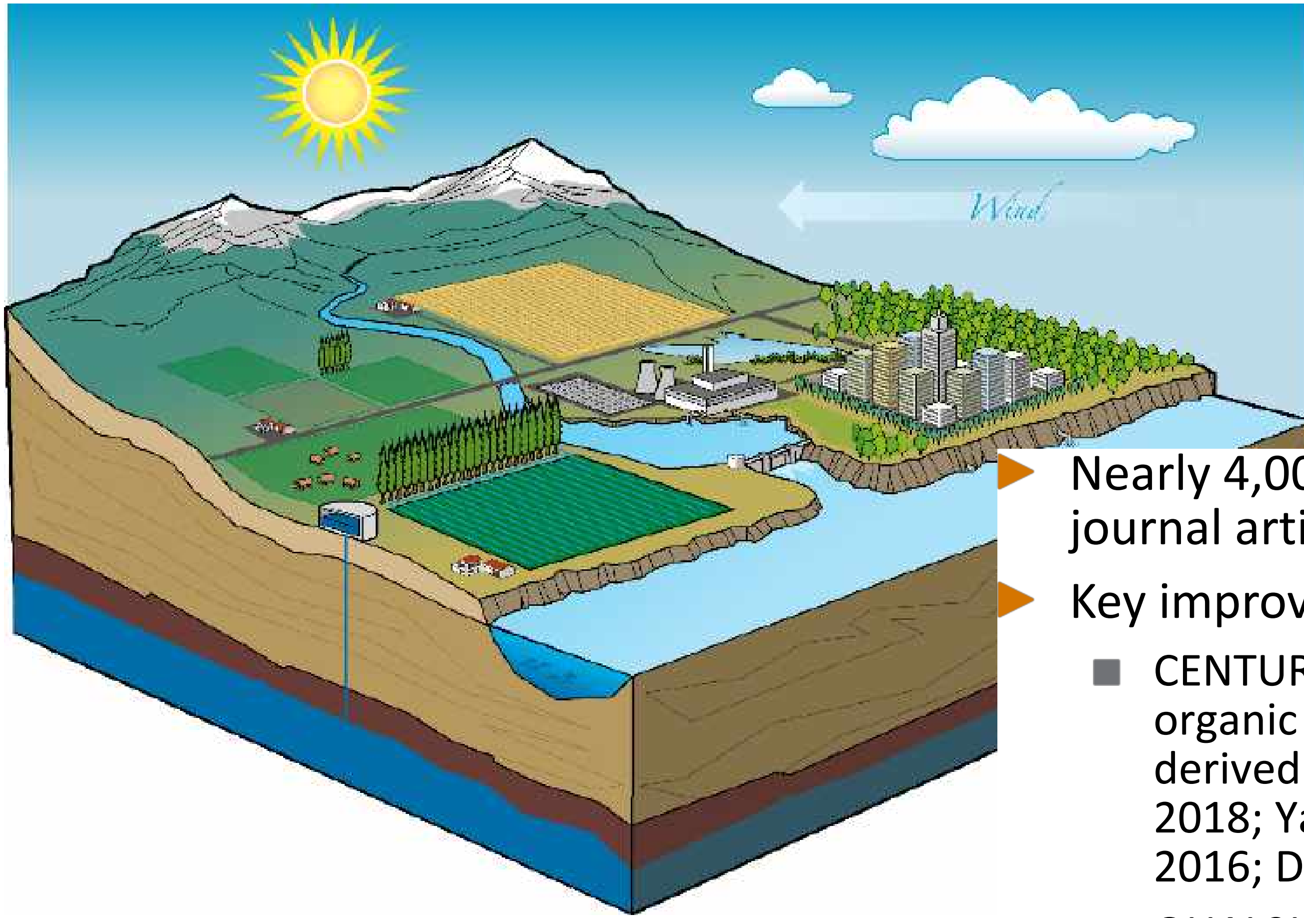
(Ciais et al., 2013, Tranvik et al., 2009, Wehrli, 2013, Aufdenkampe et al., 2011, Mendonça et al., 2017, Stallard, 1998, Bastviken et al., 2011, Cole et al., 2007, Raymond et al., 2013, Sawakuchi et al., 2017, Drake et al. 2018)

Carbon budget of North American aquatic ecosystems



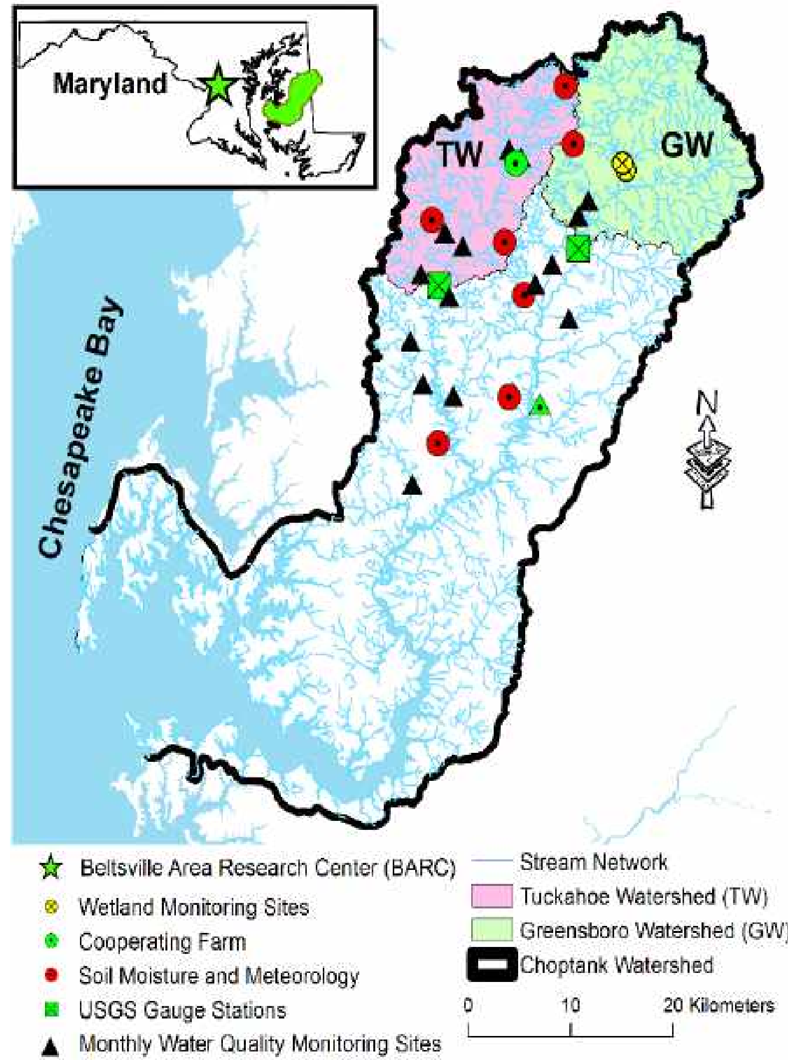
USGCRP, 2018: *Second State of the Carbon Cycle Report (SOCCR2): A Sustained Assessment Report* [Cavallaro, N., G. Shrestha, R. Birdsey, M. A. Mayes, R. G. Najjar, S. C. Reed, P. Romero-Lankao, and Z. Zhu (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 878 pp., https://doi.org/10.7930/SOCCR2.2018.

Watershed approach: the Soil and Water Assessment Tool (SWAT)



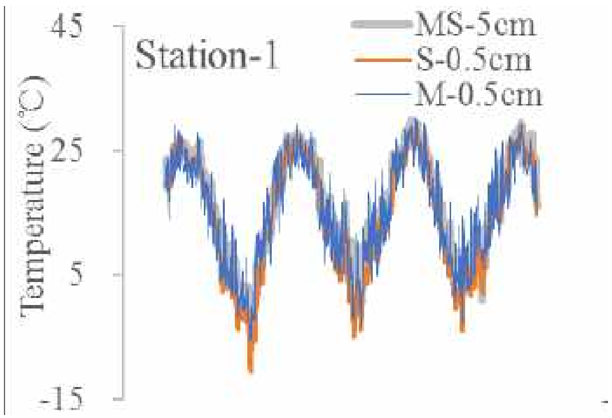
- Nearly 4,000 peer reviewed journal articles
- Key improvements for C cycling:
  - CENTURY and EPIC for soil organic matter and terrestrially-derived C (Zhang et al. 2013, 2018; Yang and Zhang et al. 2016; Du et al. 2019)
  - QUAL2K and CE-QUAL-W2 riverine carbon processes (Du et al. 2019; Qi et al. 2019)

Study region: Tuckahoe Watershed (TW) in lower Chesapeake Bay region

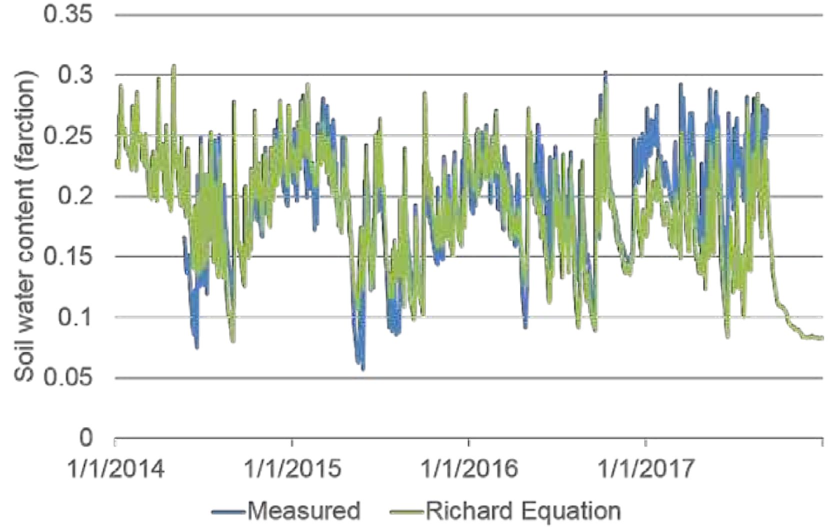


Part of USDA LTAR and CEAP

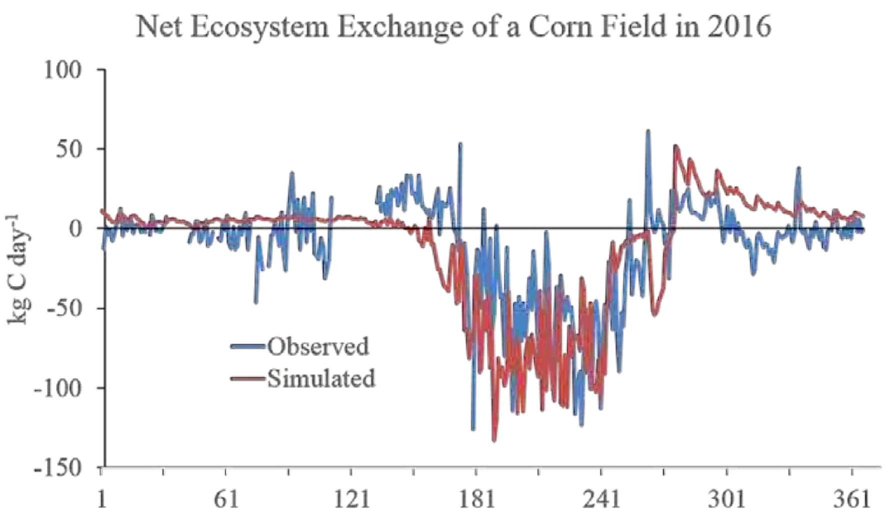
Field scale model evaluation



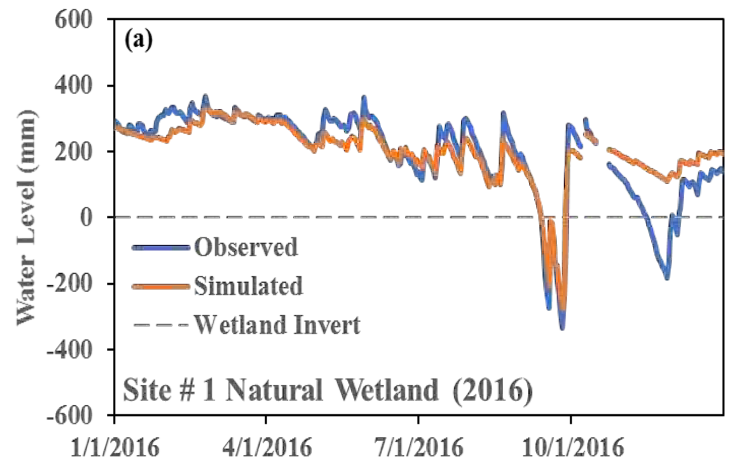
Qi et al. (2018)



Qi et al. (2018)



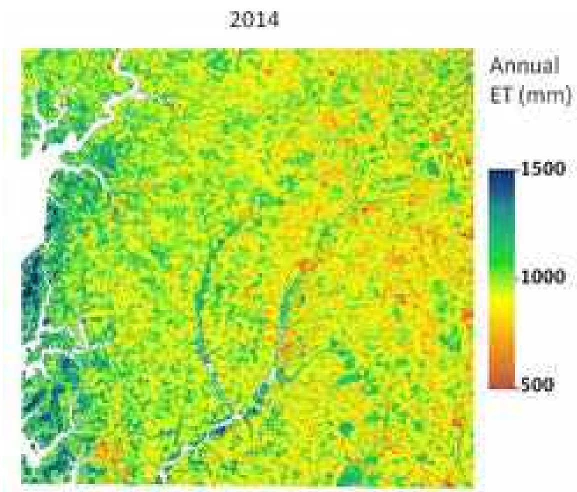
Qi et al. (2019)



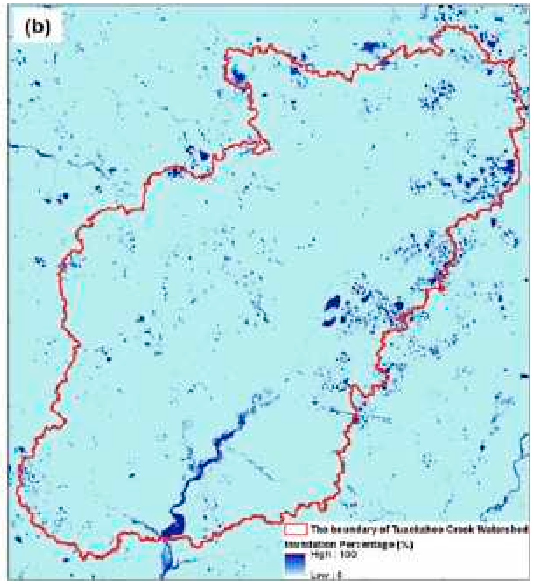
Qi et al. (2018)

In addition, surveyed crop yield (Lee et al. 2018) helped constrain model performance.

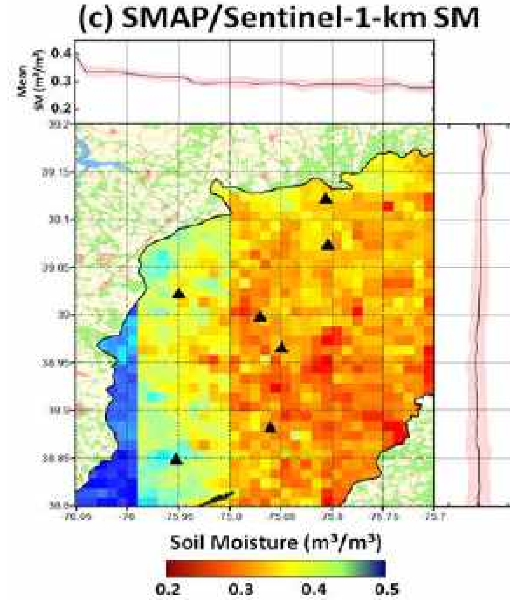
Using remote sensing data to enhance model fidelity



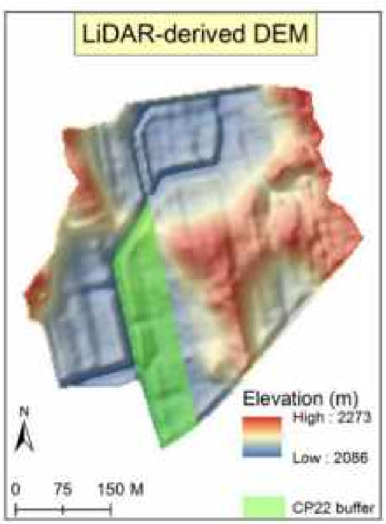
Sun et al. (2017) , Lee et al. (2019) Constrain ET and plant growth using Landsat and MODIS derived ET



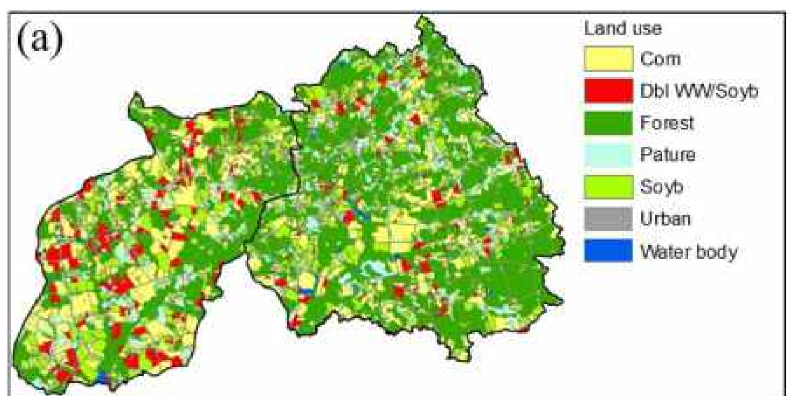
Lee et al. (2017), Huang et al. (2014) Improving modeling of wetland inundation using Landsat derived inundation map.



Kim et al. (2019). Regional Estimates of soil moisture to further constrain regional hydrology processes.

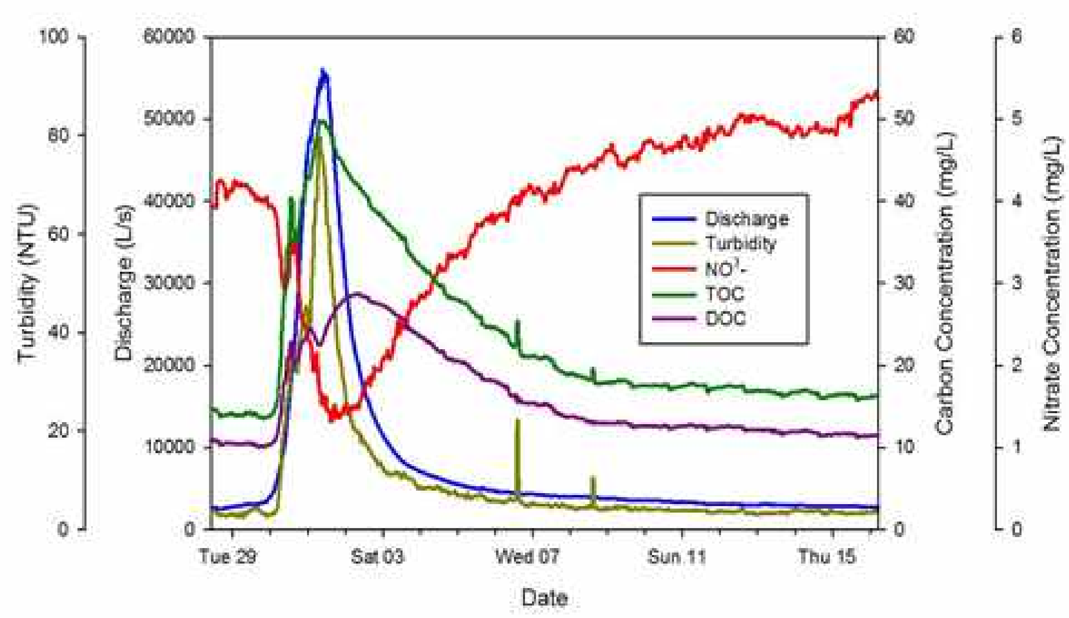


Wallace et al. 2018. Delineating flow paths using high-resolution LiDAR-derived DEM



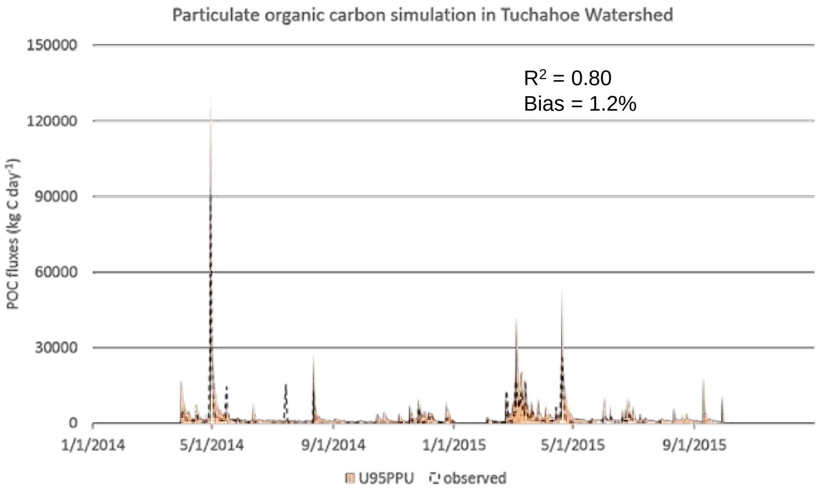
Hively et al. (2014), Yeo et al. (2014), Lee et al. (2016) Using remotely sensed cover crop images for water quality modeling

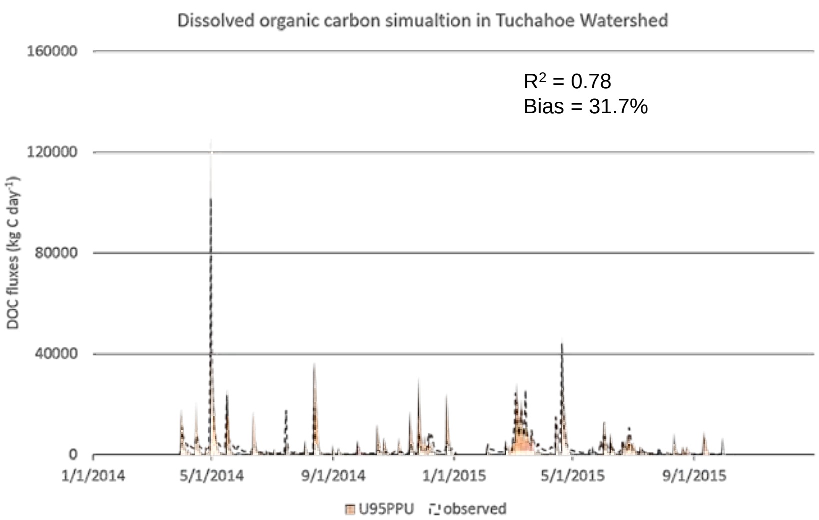
Continuous measurements of POC and DOC at the outlets of Tuckahoe and Greensboro

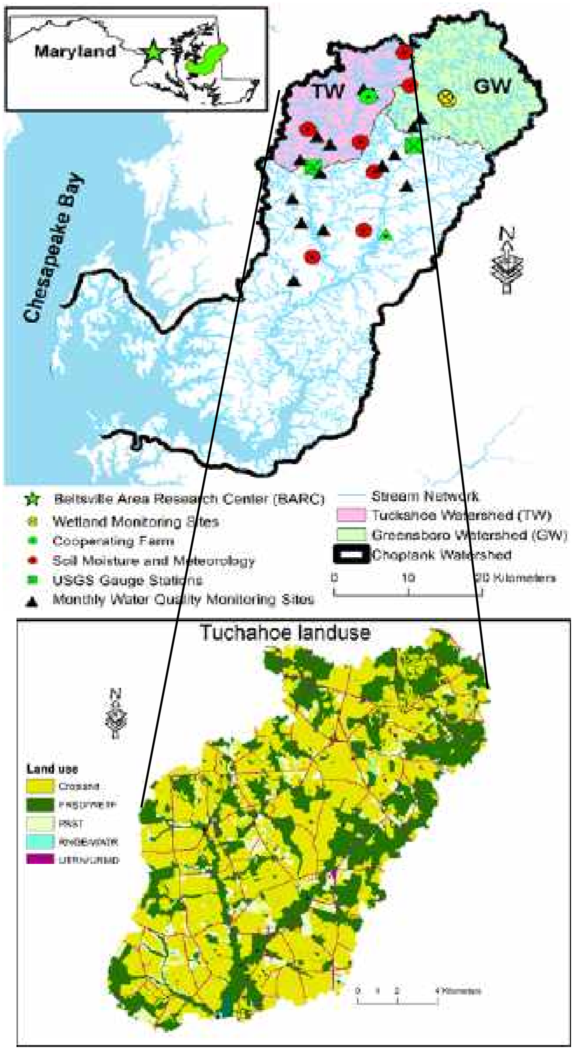


Water quality monitoring include *in-situ* instrument packages containing full spectrum (200 to 700 nm) spectrophotometer probes (S-CAN Instruments, Vienna Austria) for in-situ monitoring of turbidity, nitrate, TOC, and DOC at 30-min intervals. Exemplary measurements of riverine hydrology & biogeochemistry parameters for a continuous period of 18 days are shown Above.

Model Evaluation for POC and DOC fluxes (Tuckahoe)

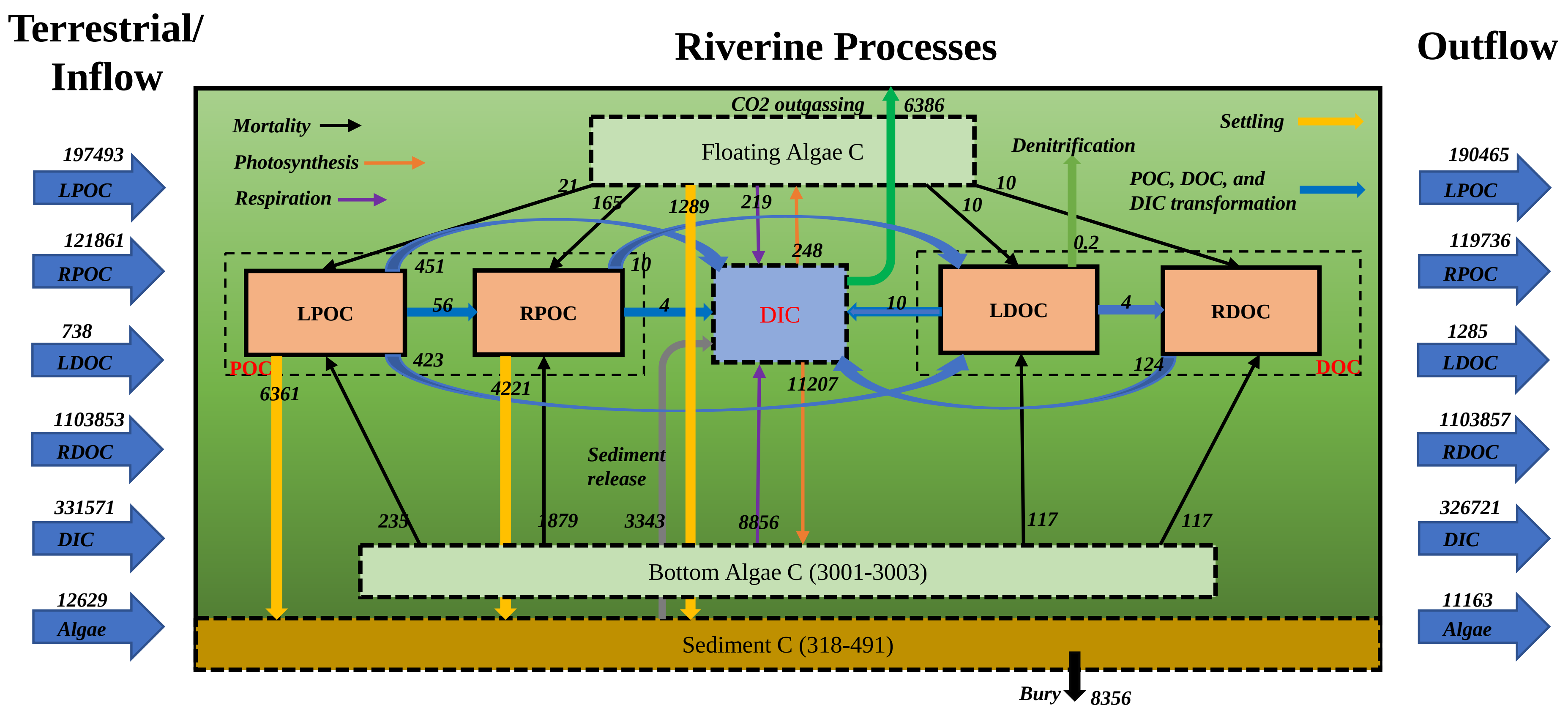






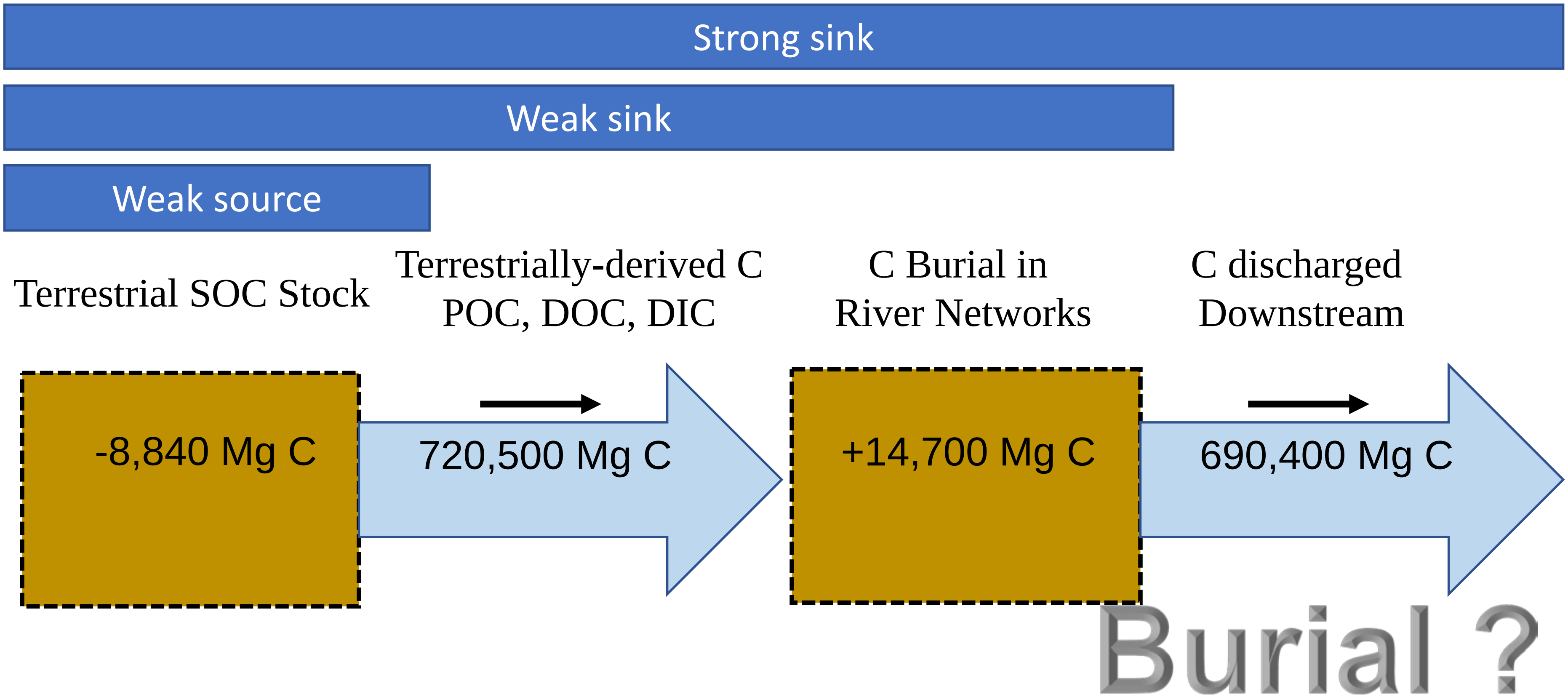
Complex riverine processes

Exemplary carbon pools, transformations, and fluxes at a reach scale.



Can we adequately constrain terrestrially-derived C and the riverine C stocks and flows?

Carbon stocks across terrestrial and aquatic ecosystems

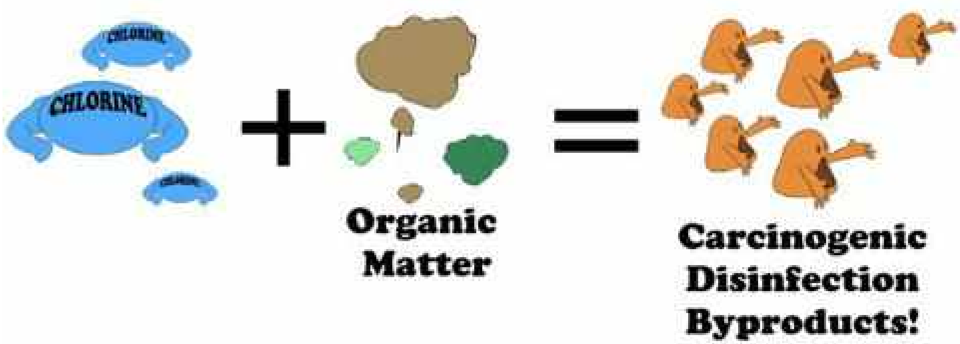


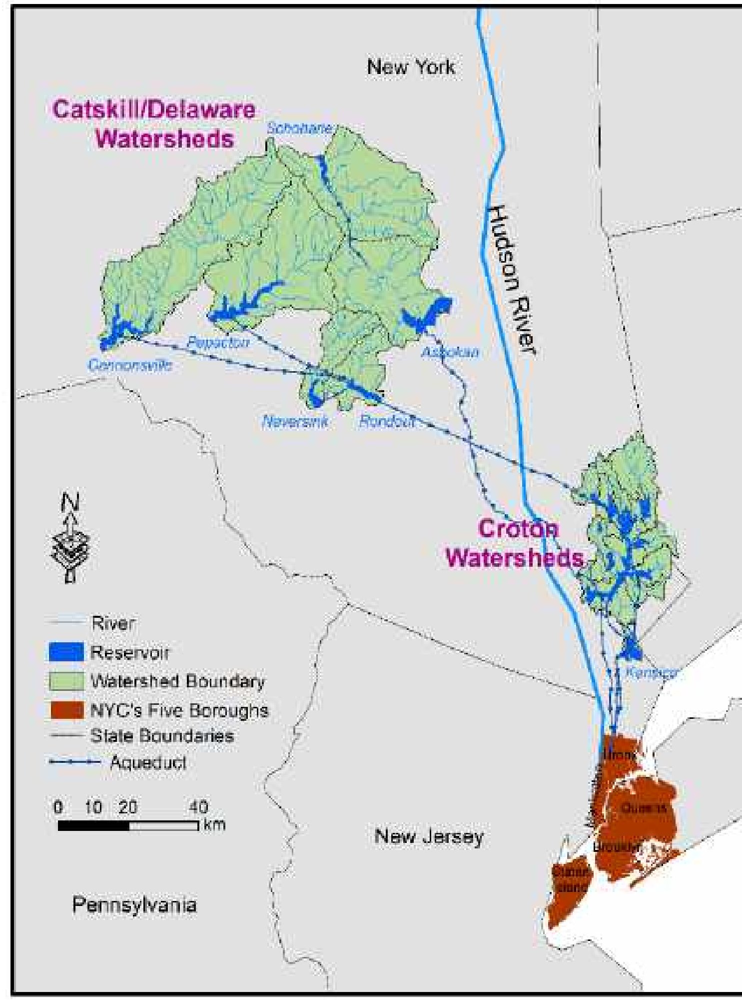
227,678 Mg C

$$\textit{This study} \quad \frac{\text{C Burial}}{\text{Terrestrially-derived C}} = \frac{14{,}700\ \text{Mg C}}{720{,}500\ \text{Mg C}} = 2\%$$

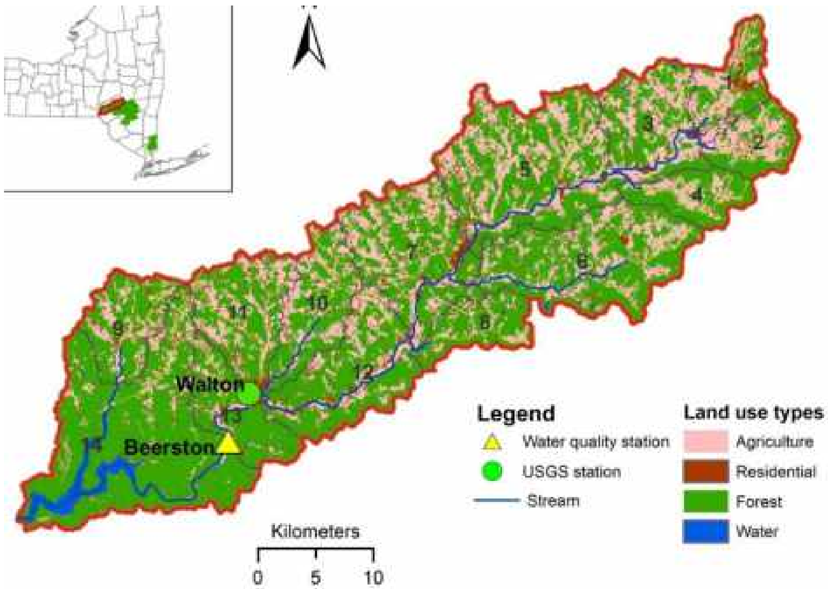
$$SOCCR2 \quad \frac{\text{C Burial}}{\text{Terrestrially-derived C}} = \frac{155\ \text{Tg C}}{491\ \text{Tg C}} = 31.6\%$$

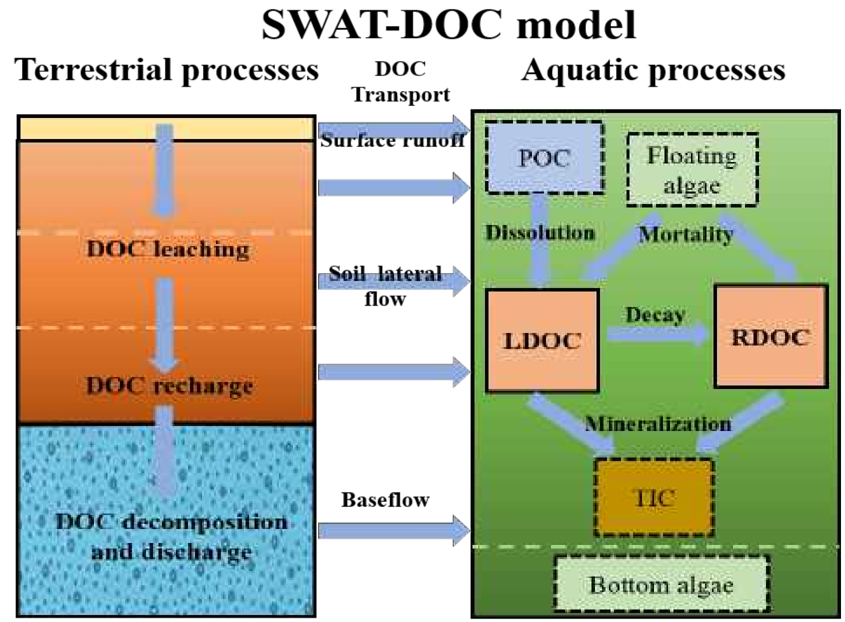
Terrestrial-aquatic carbon cycling relevant to human health

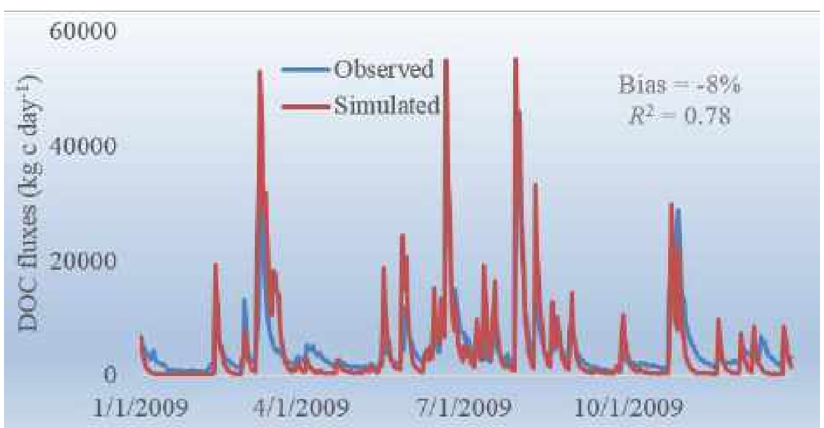




DOC modeling in NYC source watersheds

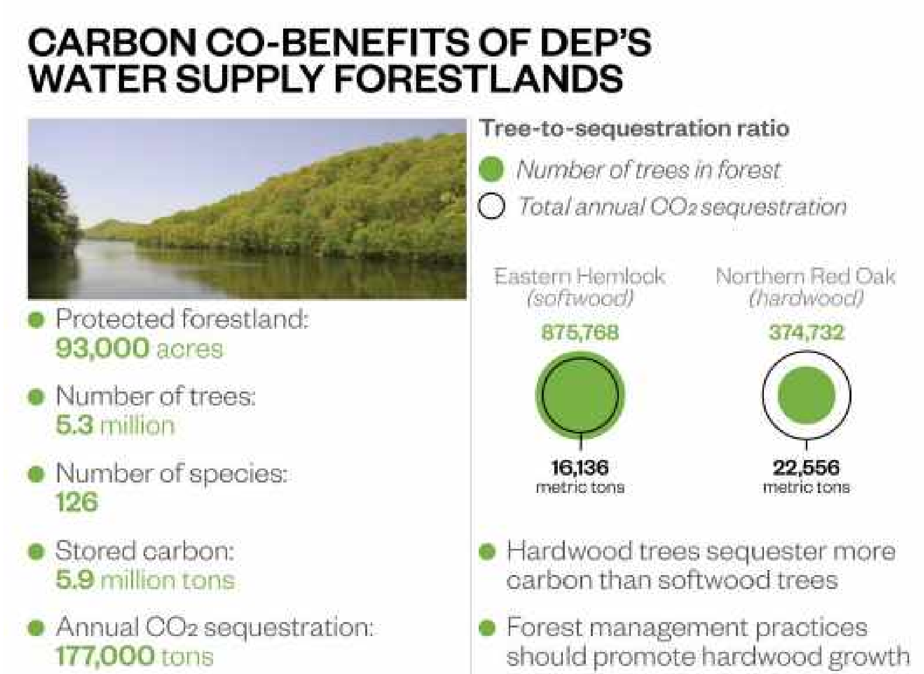






Du, X., Zhang, X., Mukundan, R., Hoang, L. and Owens, E.M., 2019. Integrating terrestrial and aquatic processes toward watershed scale modeling of dissolved organic carbon fluxes. *Environmental Pollution*, *249*, pp.125-135.

Balancing different carbon cycle impacts



www.hazenandsawyer.com/work/projects/nycdep-water-energy-nexus-study/

Filtration Plant:

Upwards of $10 billion for construction +
$200-400 million for operation and maintenance/year

Forest carbon sequestration benefits:

$17.7 million/year
With a carbon price at $100/Ton CO_2
(Jeff McMahon 2019, Forbes)

Conclusions

- Coupled terrestrial-aquatic carbon cycling is not only relevant to carbon balance accounting, but also has direct impact on human health (e.g. drinking water safety).

- Uncertainties associated with terrestrial-aquatic carbon cycling are likely large, and need to be further constrained.

- Addressing the terrestrial-aquatic carbon cycling challenge requires more coordinated efforts across communities and disciplines.

Thank you for your attention!