Dissolved Organic Carbon and Colored Dissolved Organic Matter distribution in the Long Island Sound ecosystem, from Sentinel-3/OLCI observations

Fang Cao[1,2] (fcao@sklec.ecnu.edu.cn), Maria Tzortziou [2](mtzortziou@ccny.cuny.edu)

[1] State Key Laboratory of Estuarine and Coastal Research, East China Normal University, 500 Dongchuan Rd., Shanghai 200241,China

[2] The City College of New York, The City University of New York, Center for Discovery and Innovation,85 St Nicholas Terrace, New York, NY 10031,USA

Background & Introduction

Long Island Sound (LIS) - one of the largest estuaries and most important natural resources of North America - is a **biogeochemical transformer of autochthonous and allochthonous dissolved organic carbon (DOC)** that shapes estuarine ecological functioning and biological diversity. Here, we developed a new algorithm to retrieve, for the first time, the dynamics of DOC and colored dissolved organic matter (CDOM) across this important and complex ecosystem from space.

We first evaluated the applicability of five atmospheric correction (AC) approaches (Baseline Atmospheric Correction (BAC), C2RCC, ACOLITE, MUMM, and POLYMER) for OLCI using in situ radiometric data we collected across the estuary and AERONET-OC time series data collected at the Long Island Sound Coastal Observatory (LISCO). We found that POLYMER was the optimal AC method, with mean APD of 11.86%, RMSE of 0.00061 sr^{-1} and bias of -5.63%. A multiple-linear regression (MLR) algorithm we previously designed for complex estuarine systems (Cao et al., 2018, RSE) was optimized for the LIS estuary using more than four years of bio-optical data we collected in this system, and measurements collected by the Connecticut Department of Energy and Environmental Protection (CT-DEEP) as part of their long-term water quality monitoring program. End-to-end validation gave good performance of the LIS-DOC algorithm with a mean APD of less than 20%. This work represents the first comprehensive description of DOC dynamics across the Sound from satellite observations.

Data & Methods

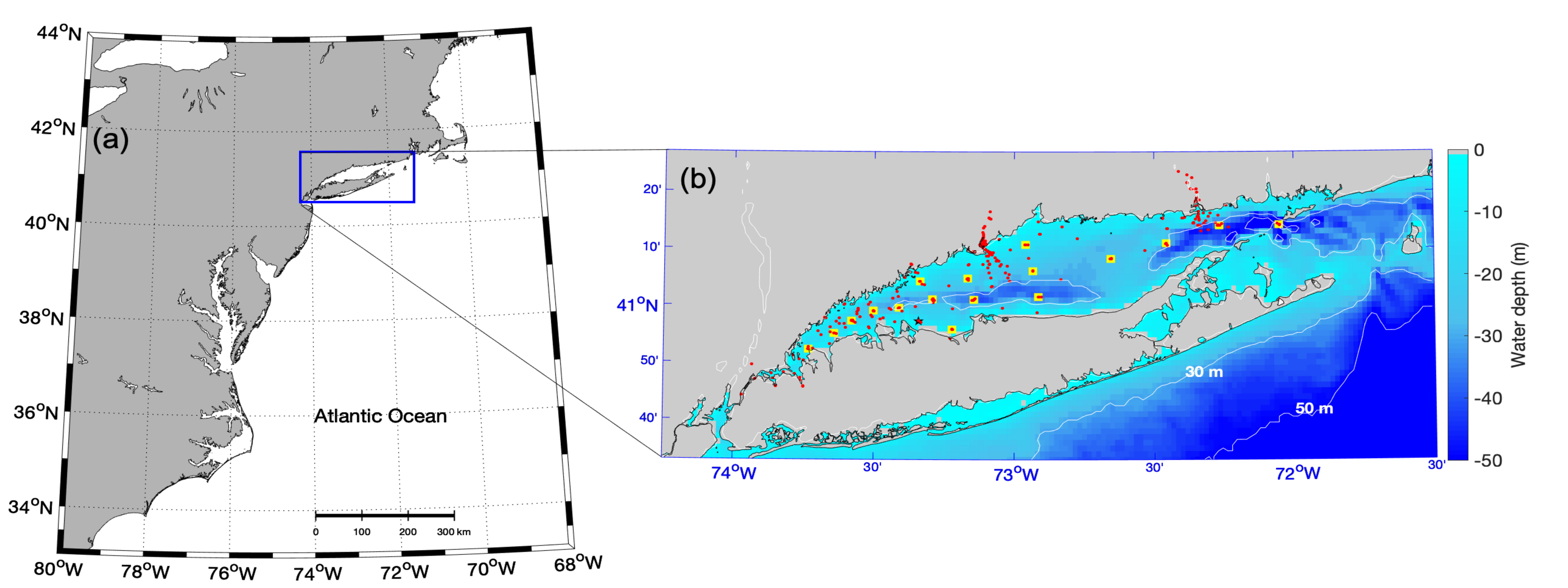

Fig. 1. Sampling stations in the Long Island Sound. Yellow squares indicate CT-DEEP monthly water quality (WQ) data from 2002-present; red dots indicate CDOM, DOC, Rrs dataset collected by our lab from Sept 2017- Mar 2021; black star indicates Rrs data at the fixed AERONET-LISCO station.)

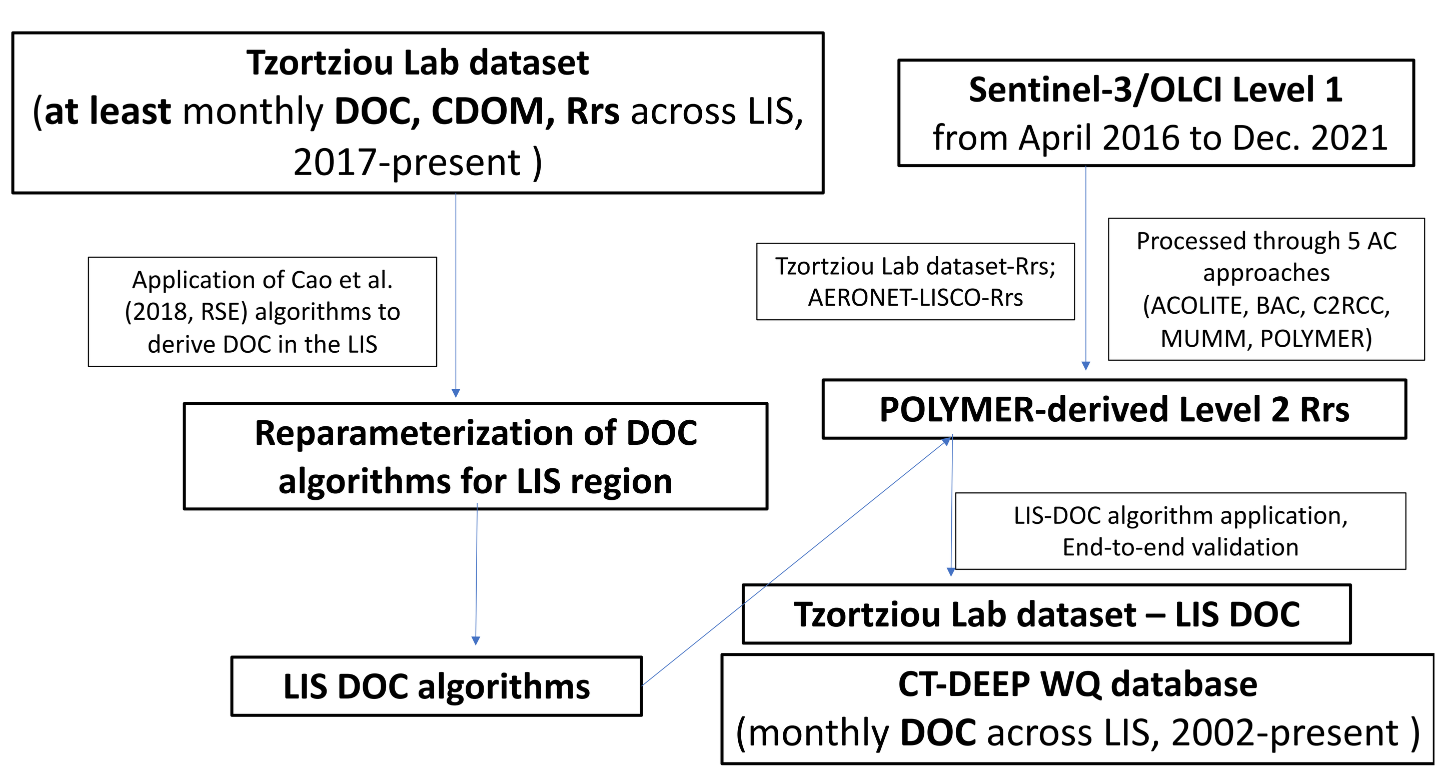

Fig. 2. Flow chart showing three steps: (1) Development of the LIS-DOC algorithm using our in-situ measurements collected in 2017-2021; (2) Processing of OLCI L1 data using different atmospheric approaches; and (3) end-to-end validation of LIS- DOC algorithms using CT-DEEP measurements of DOC concentrations and our in-situ measurements of both DOC concentrations and CDOM optical properties.

Next step

- Apply the LIS CDOM and DOC algorithms to long term measurements from the MERIS sensor.
- Merge almost two decades of satellite data from Envisat/MERIS and Sentinel-3/OLCI, to examine spatial patterns, seasonal cycles, and decadal variability in DOC and CDOM optical signature, and assess the key factors driving biogeochemical variability in dissolved organic carbon at seasonal and interannual scales.

Preliminary results and Discussions

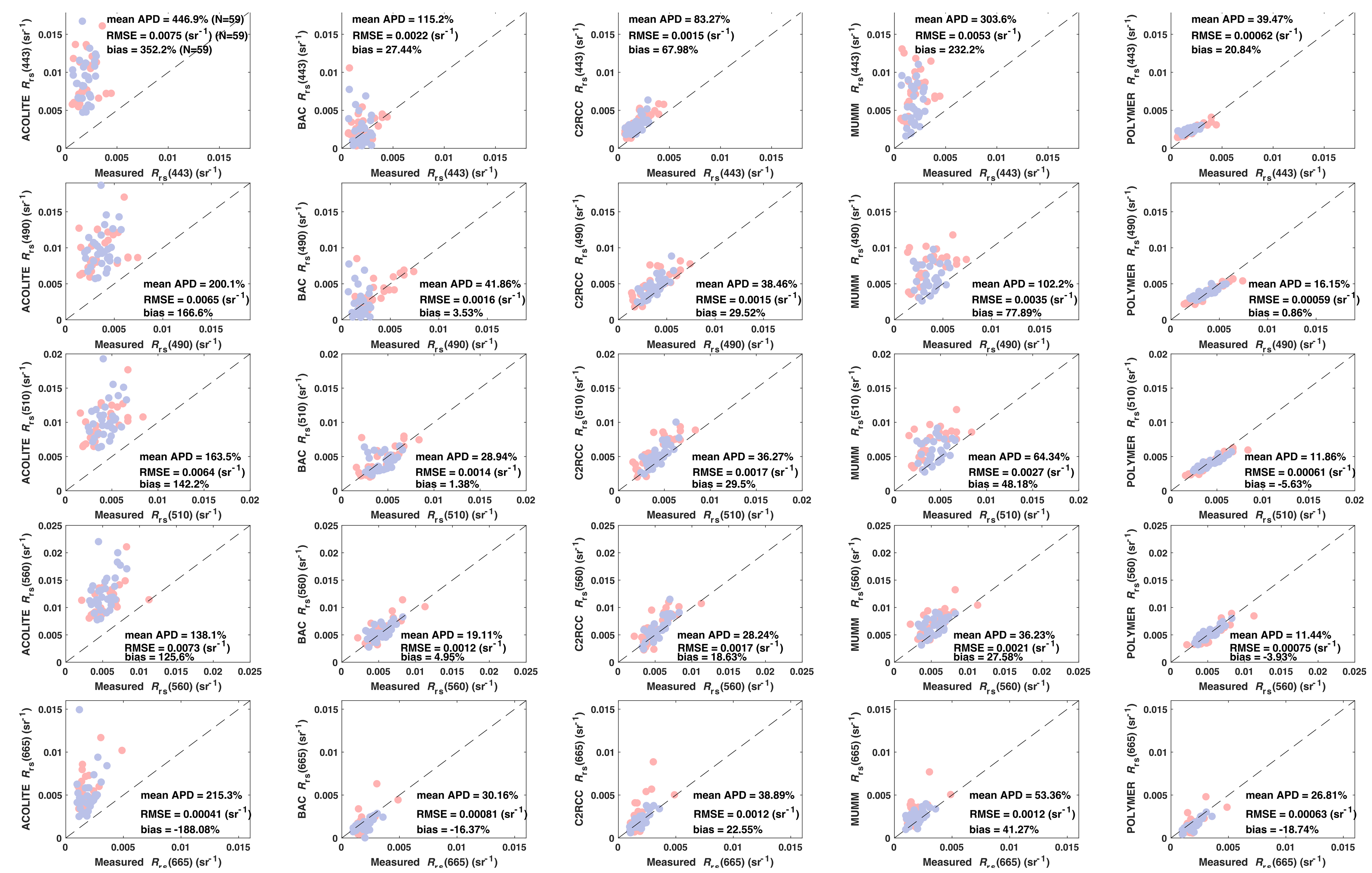

Fig. 3. Result of the five atmospheric correction approaches applied to the LIS region. Red symbols indicate time series Rrs data obtained from AERONET-LISCO fixed station (from 2016 to 2018) ; blue symbols indicate in situ Rrs data collected by our group (2018-now).

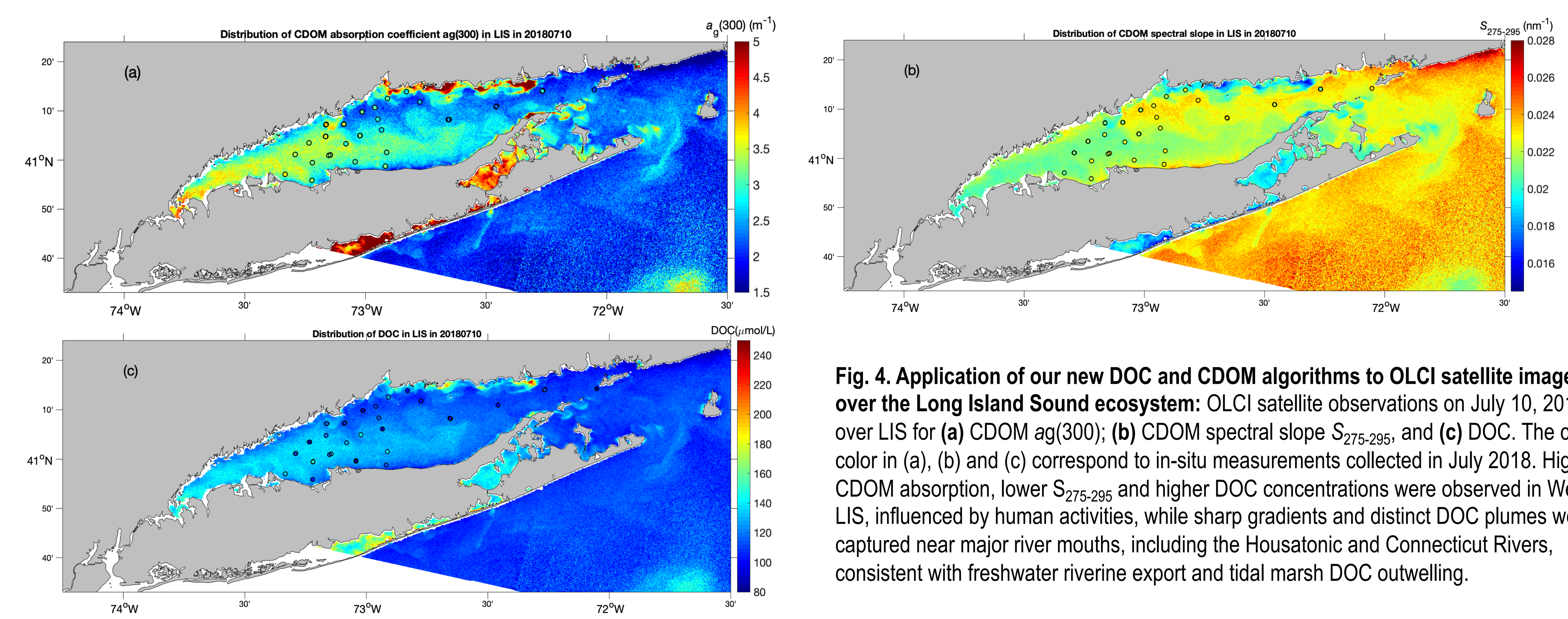

Fig. 4. Application of our new DOC and CDOM algorithms to OLCI satellite imagery over the Long Island Sound ecosystem: OLCI satellite observations on July 10, 2018 over LIS for **(a)** CDOM ag(300); **(b)** CDOM spectral slope $S_{275-295}$, and **(c)** DOC. The circle color in (a), (b) and (c) correspond to in-situ measurements collected in July 2018. Higher CDOM absorption, lower $S_{275-295}$ and higher DOC concentrations were observed in Western LIS, influenced by human activities, while sharp gradients and distinct DOC plumes were captured near major river mouths, including the Housatonic and Connecticut Rivers, consistent with freshwater riverine export and tidal marsh DOC outwelling.

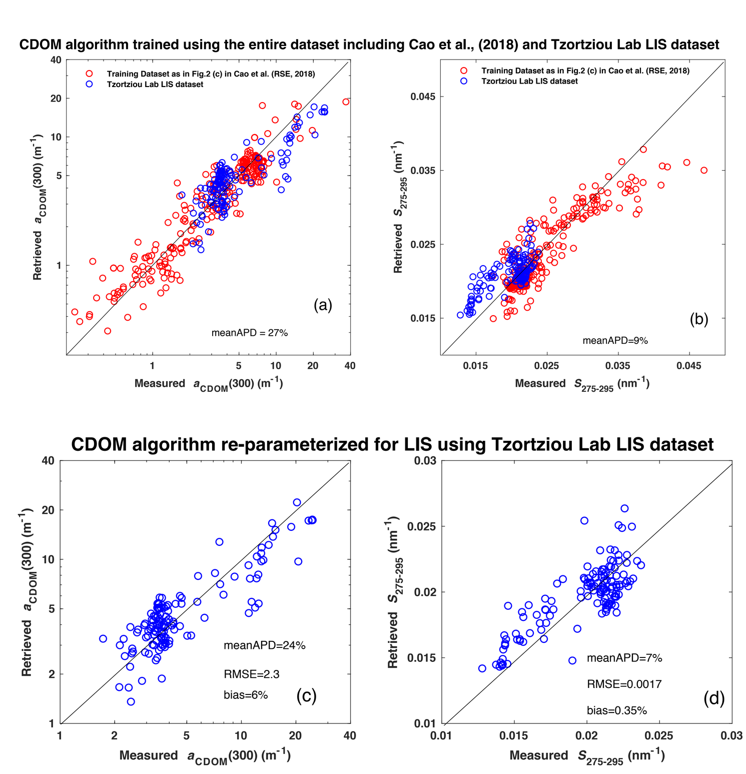

Fig. 6. CDOM algorithm performance: (a&b) Performances of the CDOM algorithms re-parameterized using the training dataset published in Cao et al., (2018, RSE) and our in-situ measurements in LIS. (c&d) Performances of the regionally tuned DOC algorithms optimized for the Long Island Sound ecosystem.

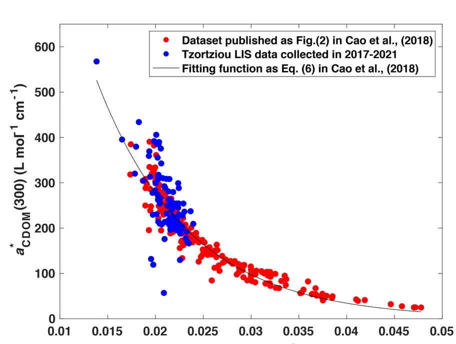

Fig. 5. Fitness of the relationship between CDOM spectral slope $S_{275-295}$ versus DOC-specific ag(300), as published in Cao et al., 2018) for the LIS newly collected data (blue dots).

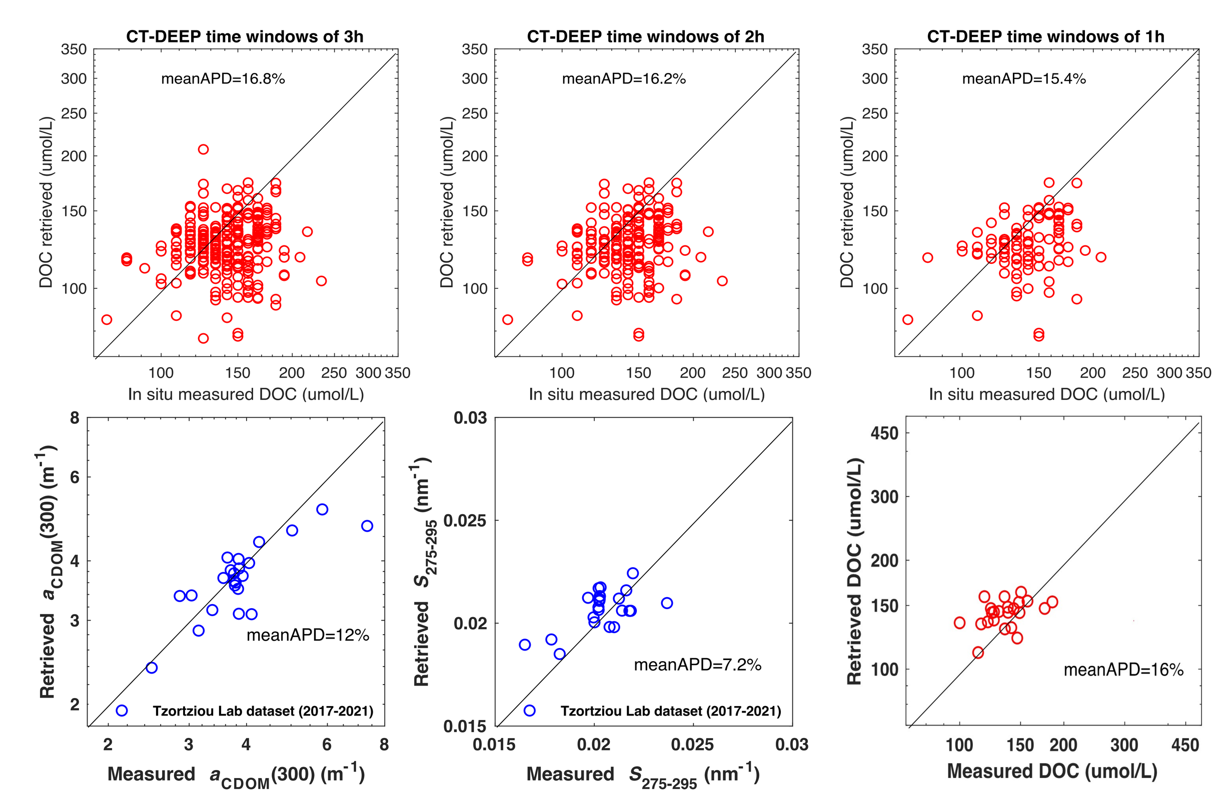

Fig. 7. End-to-end validation of the LIS regionally tuned CDOM and DOC algorithms. Upper panels: Comparison of retrieved DOC versus measured DOC for the CT-DEEP data (2016 to 2021), for different match up time windows (±1-3 hrs); **Lower panels**: Retrieved CDOM, $S_{275-295}$ and DOC compared to our in-situ measurements in LIS (± 1hr).