Evaluation of noise related to physical processes in estimates of estuary metabolism

Marcus Beck

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Points to remember:

- What is broader significance, why do we care about this?
- Megaphone approach - broad to large, i.e., use simple examples to explain concept, then just a logical extension to 'all' the data
- Hourly production estimates during the day can be negative, they are net estimates and do not account for respiration

Outline:

- Introduction
  - Estimates of ecosystem metabolism - what it is, why we need it, basic methods
  - State of the science for measuring ecosystem metabolism using open-water method - Caffrey 2004, Caffrey et al. 2013, Staehr et al. 2010, others
  - Violation of assumptions or complications using Open-water method in estuaries - causes, lit review (Nidzieko et al. 2014), mostly anecdotal to date and site-specific, summary of assumptions in table 7 Staehr et al. 2010
  - Management concerns in monitoring and ecosystem assessment – limited resources
    - Questions of where, frequency, and duration for deployment of sondes (see Staehr et al. 2010) with limited resources
    - Can we evaluate the extent to which monitoring provides an accurate assessment of actual DO, with relevance for standards/hypoxia criteria? What if we only sample during periods of increasing tide?
    - We have x number of estuaries and y $<<$ x water quality monitors, let's put them in set locations for 10 days. What's wrong with this or what kind of bias could be expected?
  - Management concerns in monitoring and ecosystem assessment – high frequency data
    - NERRS monitoring – other extreme, ample data but no noise characterization

    - Potential approaches to estimate magnitude/direction of bias from existing datasets, contrast with explicit experimental design to answer same question
  - Study objective, goals, questions
    - Objective – Characterize effects of physical processes on DO signal to improve estimates of metabolism with multi-year time series of high frequency water quality data for US estuaries
    - Can we describe the magnitude of the noise or bias in estimates of ecosystem metabolism?
    - Can stations be categorized as to the expected types of noise or bias?
    - If so, can this noise or bias be removed?
      - For example, what is minimum averaging window or minimum sampling time required to remove noise or bias (e.g., can we reduce the noise to +/- 10% of expected)?
      - Can empirical correction models be developed on a site-level basis that accounts for noise or bias?
    - The approach is meant to characterize existing noise/bias but also outline strategies for obtaining estimates of wq trends with more accuracy – What kinds of strategies give us high quality information?

- Methods - Simple to complex
  - Data source
    - NERRS SWMP overview
    - Data processing (e.g., combination of nut, wx, and wq time series, data qa/qc, filters, which sites were excluded, etc.)
  - Basic overview and application of open-water method to SWMP data - including air-sea gas exchange estimation via Thiebaut 2008, Caffrey et al. 2013
  - Emphasis on noise/bias eval, not trends in metab – this is for another project
  - Theoretical equation

$$\frac{DO_{obs}}{dt} = \frac{DO_{bio}}{dt} + D + \frac{DO_{adv}}{dt} + \epsilon \tag{1}$$

$$\frac{DO_{bio}}{dt} = \frac{DO_{obs}}{dt} - D - \frac{DO_{adv}}{dt} - \epsilon \tag{2}$$

    - Break out advection term into separate components related to season, day/night, spring/neap, etc.
    - Error term could include any other effects that violate assumptions of method, e.g., meteorological effects, assumed to be less important for this analysis but still an issue
  - Evaluation of potential sources of bias/noise
    - Simulated DO advection gradients/tides and solar periods to illustrate effects on DO signal and metabolism

  - Flowchart description – situations leading to bias/not all sites are equal
    * Categorization of time series observation - syn, ant, null
    * Exemplary cases but keep it simple (3 or 4 sites) - geom_ribbon plots and example of phase characterizations, interaction plots of mean inst. DO flux by categories (season, spring/neap, day/night, synchrony)
  - Characterization of all SWMP sites - for generalization of patterns
    * Ordination and clustering using tidal components - well-studied, do not overemphasize but describe as basis for characterizing tidal effects
    * Same methods as above for categorization of obs as syn/ant
    * Quantification of bias signal by category
    * Aggregation/averaging over increasing window to remove signal - relate to magnitude of bias/noise, note that aggregation is not ideal
  - Model for bias/noise correction - obs DO is a function of metab DO, air-sea gas exchange, tidal forcing, and error as above
    * Estimate relative bias for each station given spring/neap, season, etc. - assumes midpoint between antagonistic/synergistic observations are unbiased
    * Relative magnitude of bias used as site-specific correction factors
    * Validate correction model by showing no tidal signal in metabolism after correction

- Results
  - Site-level categorization - ordination/clusters
  - Types of bias/noise associated with site-level categories
  - Minimum averaging windows by categories, sites
  - Functions for removing noise by categories, site
    * How well does it work?
    * Include all as supplementary

- Discussion
  - Recommendations – results useful for evaluation of high frequency data and use of limited resources
    * e.g., If site is macrotidal semidiurnal, do not sample less than x number of days
    * If SWMP, use correction factors
    * If long-term time series available, id bias and estimate correction factors
  - Geographic similarity not equal to site-level similarity – site-specific characteristics could dominate DO signal
  - Emphasis on tidal advection – other factors contribute to bias/noise
  - tidal height not always coincident with tidal excursion
  - Conclusions