Initial biogeochemical modeling at NOAA/NCEP: Using VIIRS ocean color data for validation and data assimilation

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3: NOAA/NESDIS/STAR; 4: NASA/GMAO

Project Descriptions

(Background)

• The NOAA Ecological Forecasting Roadmap (EFR) for 2015-2019 states that its objective is "to provide dependable, higher quality forecast products, derived from the successful transition of research and development into useful applications…."

• In support of the NOAA-approved roadmap, this project proposes to evaluate approaches and develop a prototype foundational global biogeochemical modeling capability for NOAA's operational Real-Time Ocean Forecast System (RTOFS) for reliably providing the global modeling fields required to support the ecological forecasts of the EFR technical teams

Project Descriptions
(Background)

- Specifically,
  - ➢ to establish a component for the national modeling ‘backbone’ that will generate global predictions of the common physical and biogeochemical variables used by ecological forecasts

  - ➢ to address key linkages and gaps within the EFR infrastructure framework via JPSS VIIRS ocean color data and physical-biogeochemical numerical modeling because ocean color data from VIIRS provides a unique path toward ecological forecasting through biogeochemical (BGC) analyses and forecasts, facilitating both real-time and scenario-based marine ecosystem applications

Project Descriptions

(Identification of Users)

- Targeted users within NOAA:
  - ➢ Ecological Forecasting Roadmap technical teams (harmful algal blooms, hypoxia, habitats),
  - ➢ Those explicitly involved with numerical modeling and prediction in conjunction with the NOAA Ecological Forecasting Infrastructure and Process team

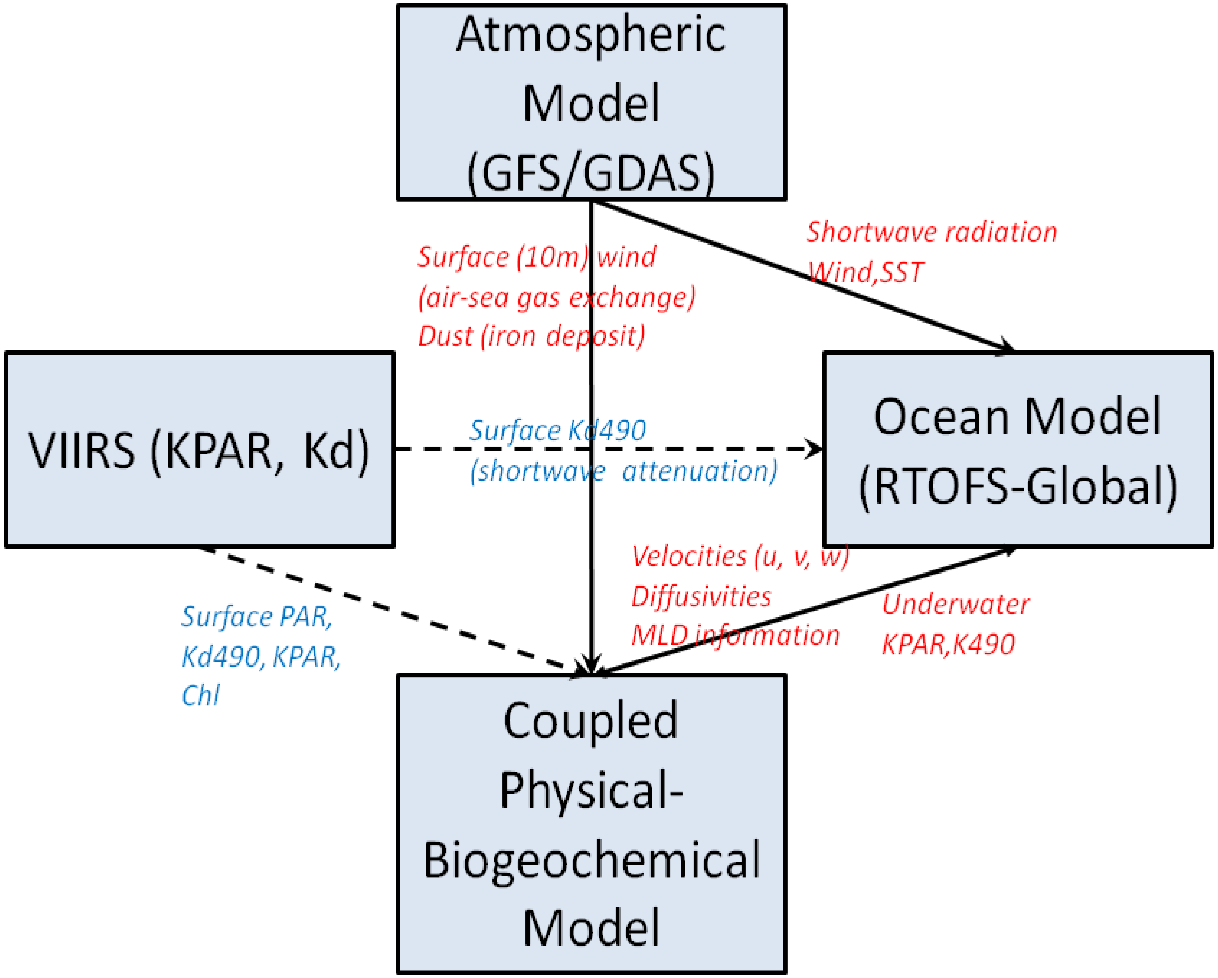
- The external user community:
  - ➢ Local, state, federal governments, non-governmental organizations (NGO's), and academic and industry entities using derivative analyses and predictions.

Scientific Objectives

- Employing coupled BGC-physical modeling to improve NWS forecasting skill at short-term and seasonal scales
  - ➢ by including the effects of biological heating on upper-ocean thermal structure
  - ➢ by exploring the direct assimilation of VIIRS products (K_{d490}) in conjunction with radiative transfer (RT) computations using existing validated algorithms (Lee, 2006; Gregg, 2002).
- Providing scenario-based forecasting
  - ➢ to predict system responses to potential changes by drivers (natural or through ecosystem management decisions)
- Assessing the effects of carbon dynamics between the atmosphere and the ocean and subsequent changes in the acidity of the global ocean
- Exploring BGC model to support for upper-trophic-level modeling

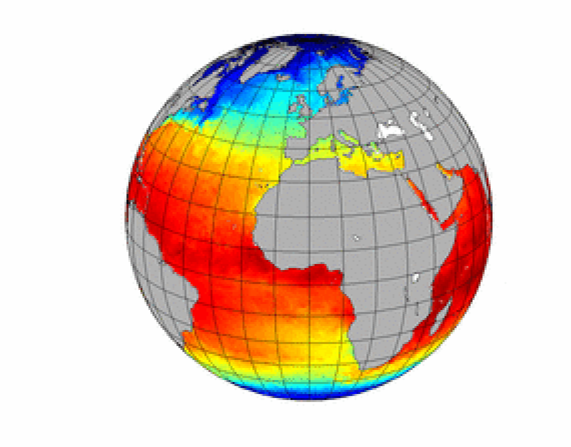
Approaches

(Schematic Diagram)



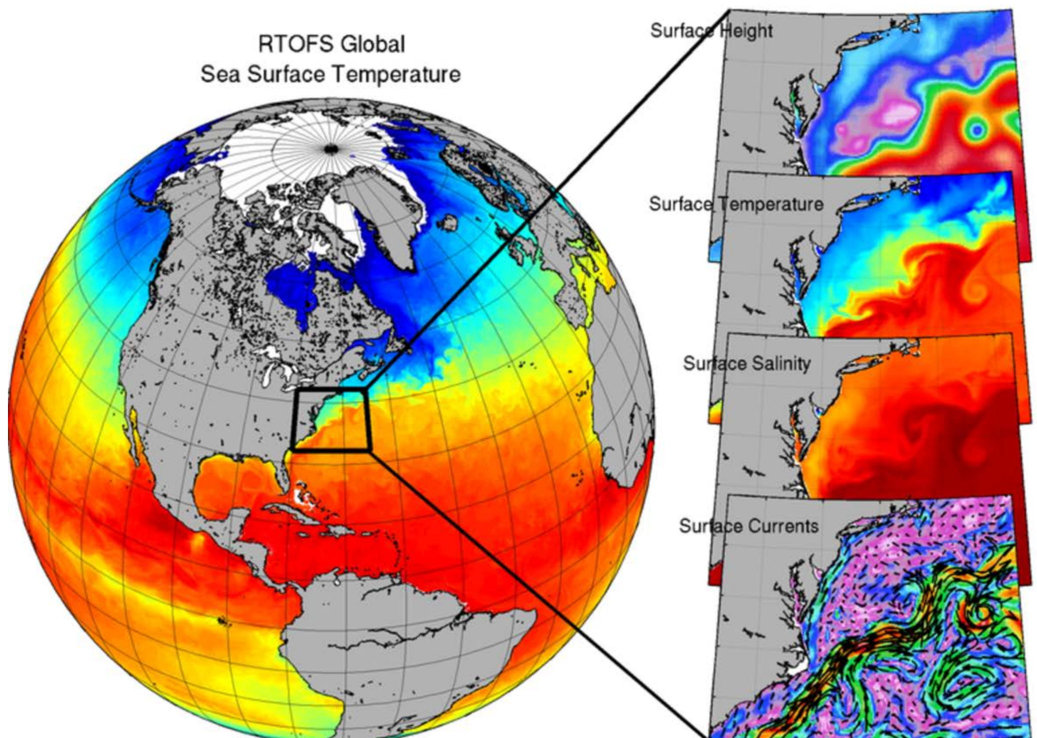
Approaches

(Ocean Model: RTOFS-Global)



- RTOFS-Global
  - ➢ Hybrid Coordinate Ocean Model (HYCOM) based system with 1/12° and 41 layers
  - ➢ iso-pycnal (deep ocean), z-levels (surface), σ (coasts)
  - ➢ Tripole grid (1 at South Pole and 2 from Arctic bipole)
  - ➢ Recti-linear (<47°N) and curve-linear (>47°N)

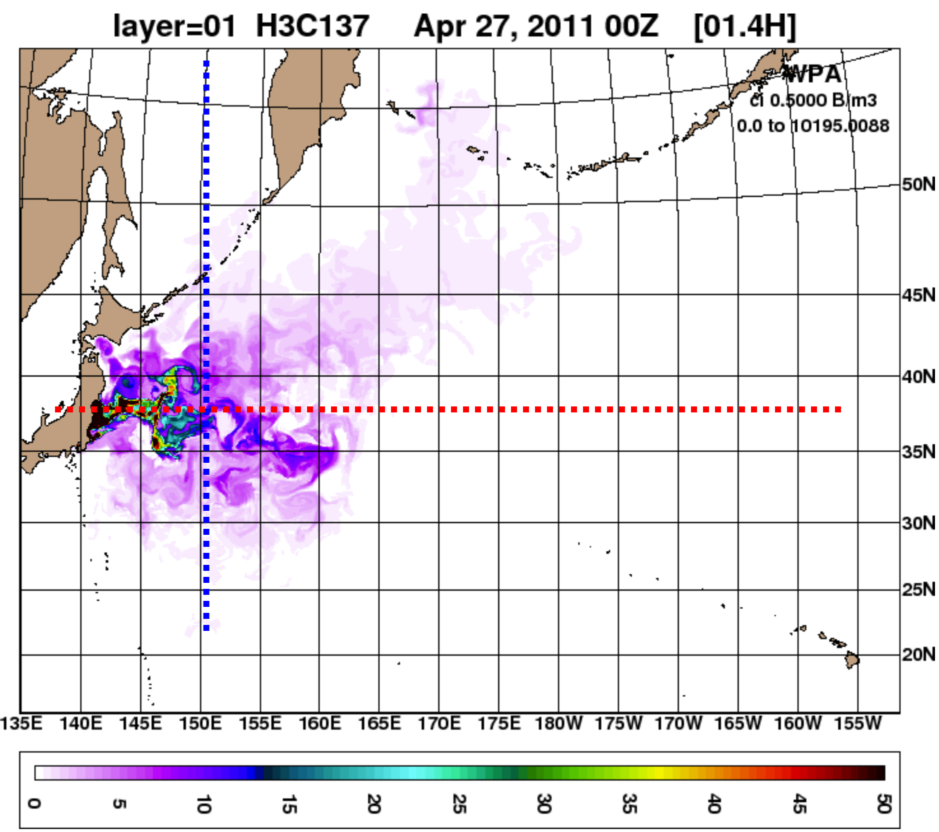
- RTOFS-Global
  - ➢ NAVOCEANO daily initialization with MVOI (now 3DVAR) data assimilation from NCODA (Navy Coupled Ocean Data Assimilation)
  - ➢ KPP for vertical mixing
  - ➢ 2-day nowcast (GDAS) and 6-day forecast (GFS)

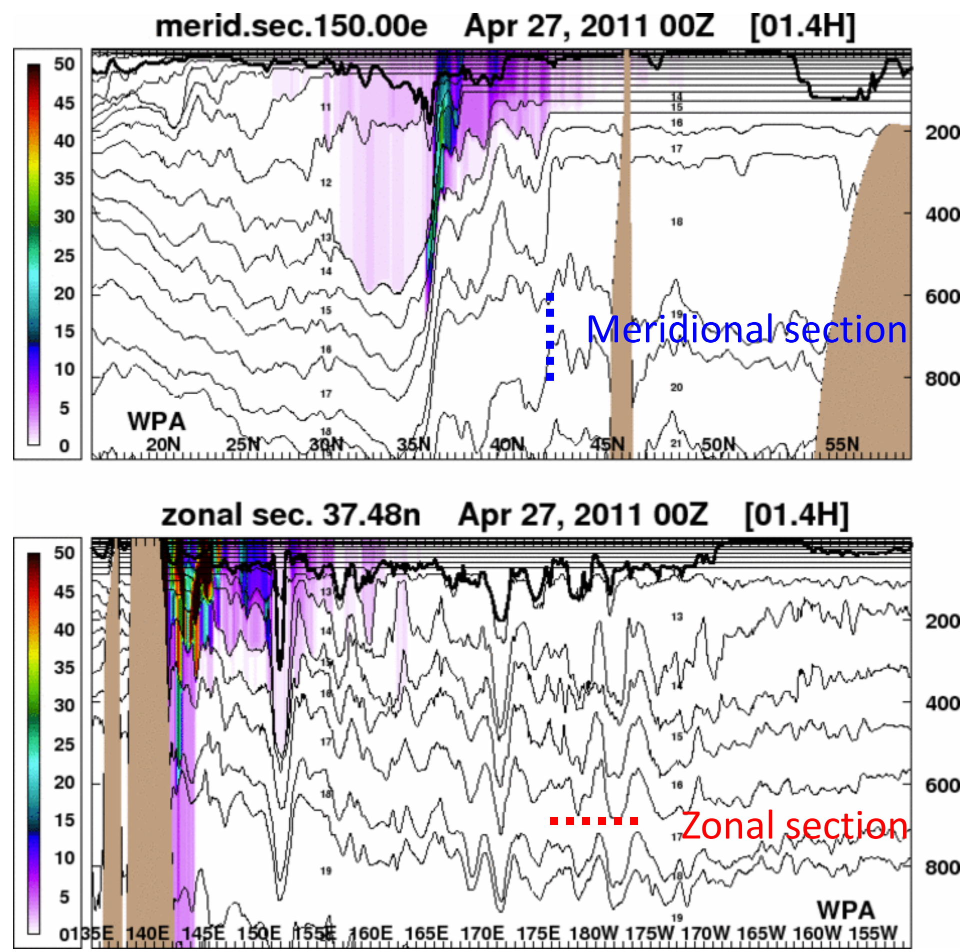


(credit: Spindler)

Approaches

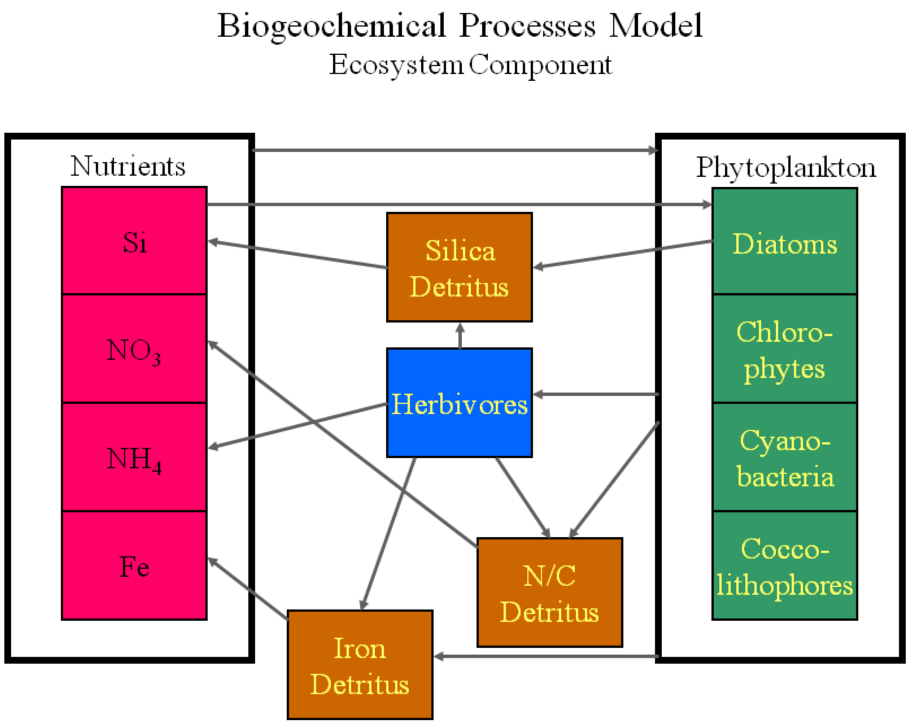
(Ocean Model: RTOFS-Global)

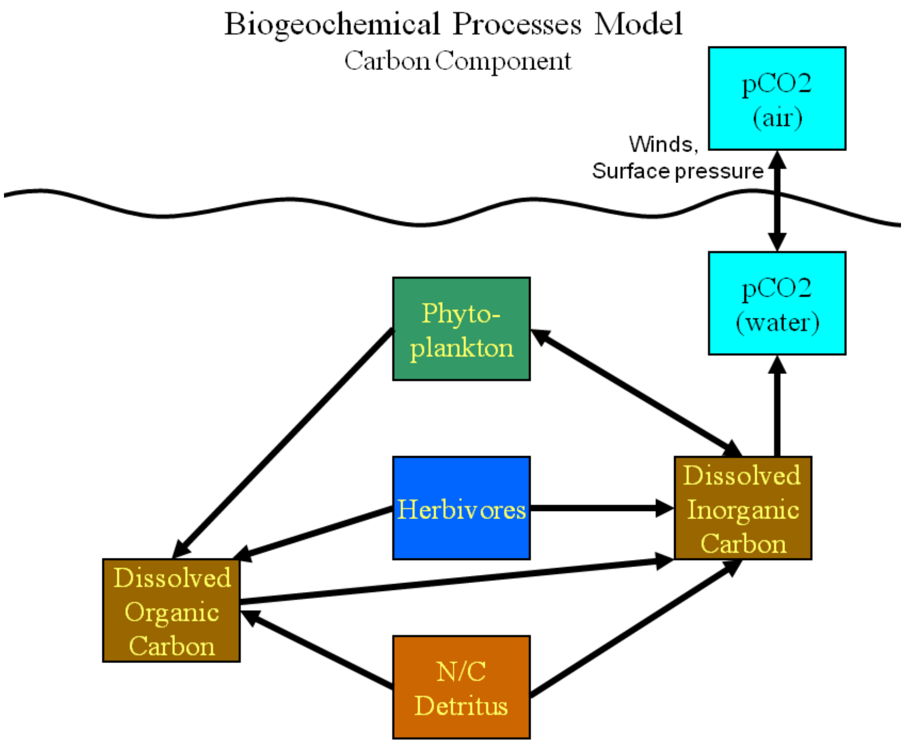




Approaches

(NOBM: NASA Ocean Biogeochemcial Model)





Gregg (2002; http://gmao.gsfc.nasa.gov/research/oceanbiology/description.php)

Approaches

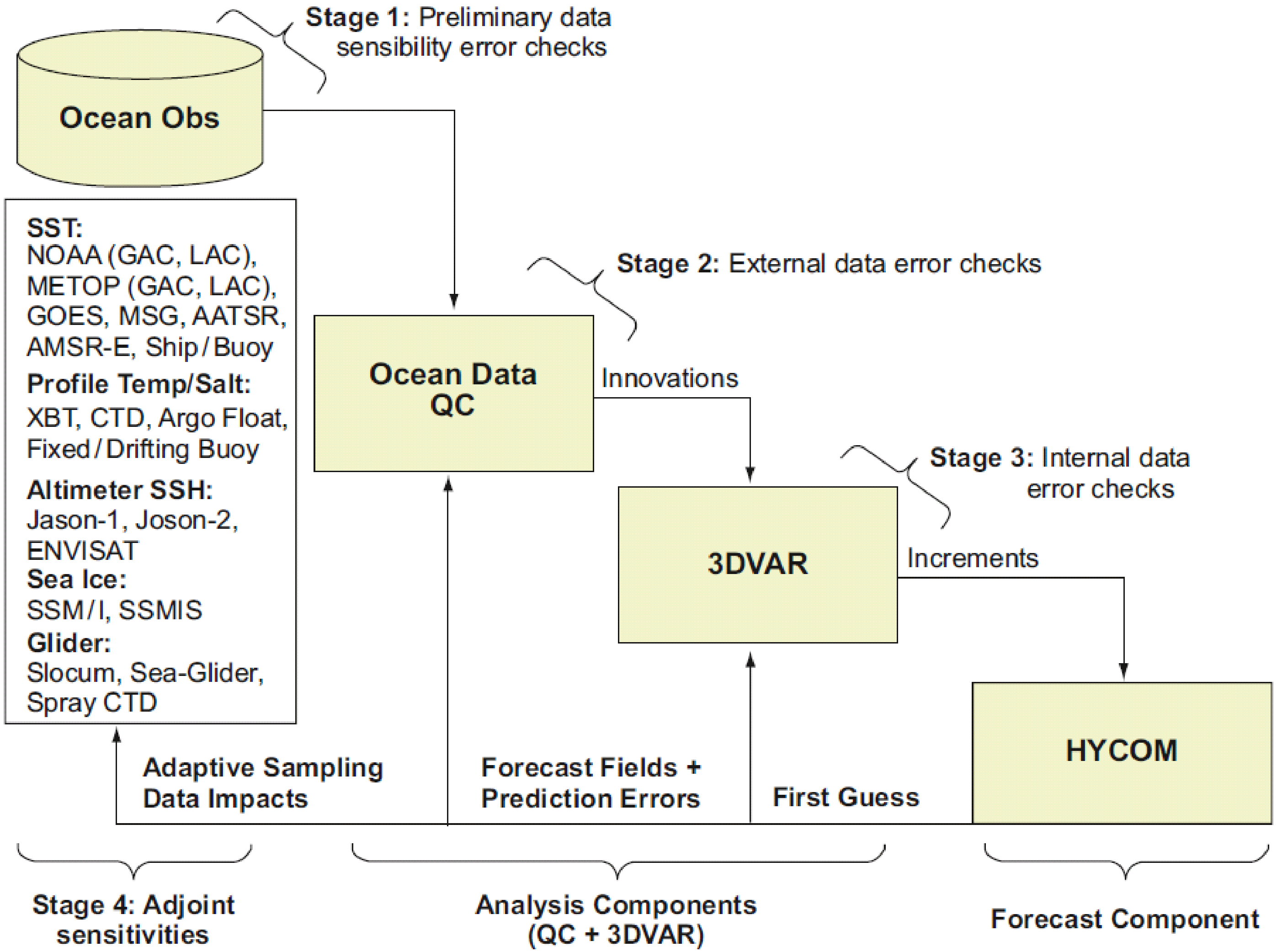
(Data Assimilation: 2DVAR)

- Step 1. Integrate model for a certain period with no nudging from t=0 (beginning of cycle) to t=T. Initial condition is X(t=0). End condition is X(t=T)
- Step 2. Carry out CHL analysis at 0-hr and at T-hr
- Use CHL from X(t) as a background $X_{b.}$
  - $X_a=X_b+K(y_0-H(X_b))$

  where X_a: analysis; X_b: background; K: Kalman gain; y_0: observations (VIIRS); H: observation operator; $[y_0-H(X_b)]$: innovation, distance between model and observation

  - Data points will be assimilated (e.g., VIIRS) with a certain time window for data pooling
- Step 3. Create linearly interpolated CHL field between the two consecutive CHL analyses X_a (t=0) and X_a (t=T).
- Step 4. Integrate model for T hours with nudging from t=0 (beginning of cycle) to t=Thrs. Initial condition is X(t=0). End condition is X(t=T)
- Next cycle: re-label end condition of integration with nudging as the initial condition if the next cycle.

Approaches
(Data Assimilation: NCODA)



Cummings (2011)

Milestones

- *Year 1:*
  - ➢ Use VIIRS-derived K_{dPAR} and K_{d490} with a two-band scheme (Lee et al., 2006)
- *Year 2:*
  - ➢ Implement coupling of the modified BGC model with online HYCOM/RTOFS-Global
  - ➢ Modify NOBM (Gregg, 2002; 2003) biogeochemical module to include air-sea oxygen dynamics
- *Year 3:*
  - ➢ Implement simple data assimilation techniques (2DVAR) to nudge model values to better represent VIIRS observations
  - ➢ Validate model-derived Chl-a against independent *in situ* observations (e.g., BIO-Argo) and VIIRS data.

Thanks!