Reenvisioning the Ocean: The View from Space

A RESPONSE

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C
Carbon
Remote Sensing Carbon

- **Stocks**
  - $p\text{CO}_2$, DIC, DOC, POC & PIC
- **Components**
  - Community structure, calcifiers, $N_2$ fixers, etc.
- **Fluxes**
  - Air-sea, export, net community production, etc.

Remote Sensing Carbon

- Ocean color is not perfect for this task
  
  Optical properties are not carbon species
  
  CDOM is not DOC, optical backscattering is not POC

- Need to think like paleo-oceanographers...
  
  Develop “quantitative proxies”
  
  But ... test them using real observations
Some Examples…

- Stocks
  - POC
  - pCO₂
  - CDOM (This is a shameless plug for our CDOM poster!!)

- Components
  - Calcifiers - coccolithophorid bloom occurrence

- Fluxes
  - Air-sea CO₂ fluxes

Remote Sensing of POC

Relate POC to estimates of optical backscattering by particle
Loisel et al. [2002] GRL
Remote Sensing of POC

SeaWiFS chlorophyll concentration  
SeaWiFS POC

April 1998

Remote Sensing of POC

"POC"  
Chlorophyll

Average for the North Atlantic (0 to 60°N)
Remote Sensing of POC

- POC patterns are very different from chlorophyll
- Validation at BATS & HOT is OK, but not great
  - Ratios of satellite to field POC are 1.22 (± 0.37) @ BATS & 0.94 (±0.27) @ HOT
- Enables POC budgets to be assessed
  - Mean POC = 54 mg C m⁻³
- Large uncertainty in conversion from optics to POC
  - Estimated to be ~40% - Improvements are underway

Remote Sensing of Calcifiers

Coccolithophorid bloom classification
Iglesias-Rodríguez et al. [2002] GBC
Remotely Sensing of Calcifiers

- Classification analysis based on observations of coccolithophorid blooms
- Enables space/time characteristics of coccolithophorid blooms to be assessed
- First (& probably easiest) step towards determining phytoplankton community structure remotely

Air-Sea CO$_2$ Fluxes

- Relate observations of pCO$_2$ to SST
- Satellite SST to map pCO$_2$
- Highly variable relationship

Lee et al. [1998] *Nature*
Incorporating winds enables air-sea CO$_2$ fluxes to be estimated.

- Used regional relationships for pCO$_2$ as f(SST)
- Drive with remote estimates of wind & SST
- Approach has promise, but we need a better way to predict pCO$_2$
- What if climate change, alters pCO$_2$ =f(SST)??
Remote Sensing Carbon

- Ocean color is not easily related to carbon
  - Chlorophyll is not carbon

- Key is using “real” observations to build simple models
  - Global data are finally available - more in future
  - The JGOFS legacy is its open data access
  - We are really just at the beginning of this work
The Future is Remotely Sensible

• There are many applications under consideration
  - Primary production & export fluxes
  - Photochemical rxn rates (CO, CO₂, COS, etc.)
  - DMSP/DMS cycling & air-sea DMS fluxes
  - *Trichodesmium* distributions
  - Physiological status from fluorescence
  - and many more ...
Remote Sensing of DOC

Colored Detrital & Dissolved Organic Material Absorption
Siegel et al. [2002] JGR

Remote Sensing of DOC

NH Winter DOC Distribution
Siegel et al. [2002] JGR
Remote Sensing of *Trichodesmium*

Index for *Trichodesmium* occurrence
Toby Westberry [work in progress]

Remote Sensing of DIC & pCO₂

- Empirical approach for the Tropical Pacific
- Model ...
  \[ DIC = f(SST, SSS) \]
  \[ TA = f(SST, SSS) \]

Loukos et al [2000] GRL
Remote Sensing of DIC & pCO₂

- Average from 5°S to 10°N
- 1982 to 1994
- SST, SSS & wind products used

Anomalous evasion is well related to SOI
Remote Sensing of DIC & pCO$_2$

- Empirically model DIC & TA for Tropical Pacific
- Drive this with remote sensing (& other) data
- Find relationship between CO$_2$ evasion & SOI
- BUT, evasion flux uncertainties are $\sim$50%
- More field observations should help
- So would the remote sensing of sea surface salinity