PACE Mission Development

Antonio Mannino
antonio.mannino-1@nasa.gov
NASA Goddard

Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) Overview

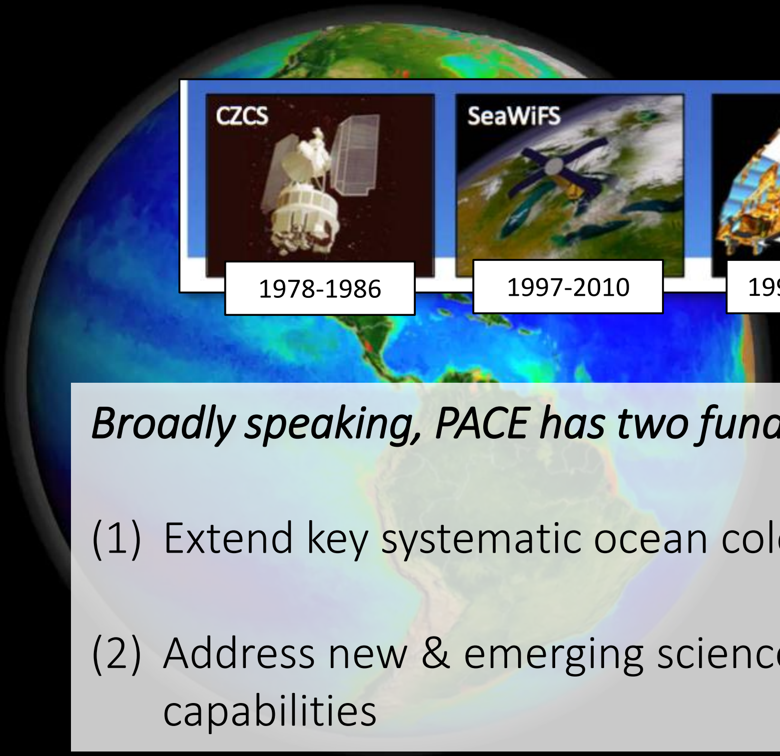
Antonio Mannino, Deputy Project Scientist

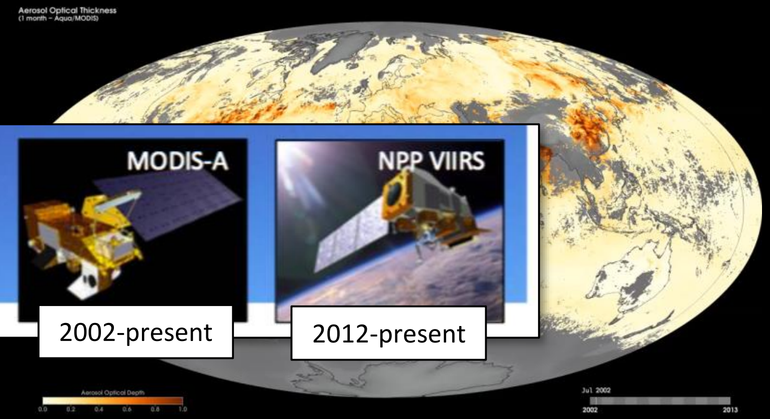
Jeremy Werdell, Project Scientist

Paula Bontempi, Program Scientist

ocean chlorophyll
normalized land vegetation index

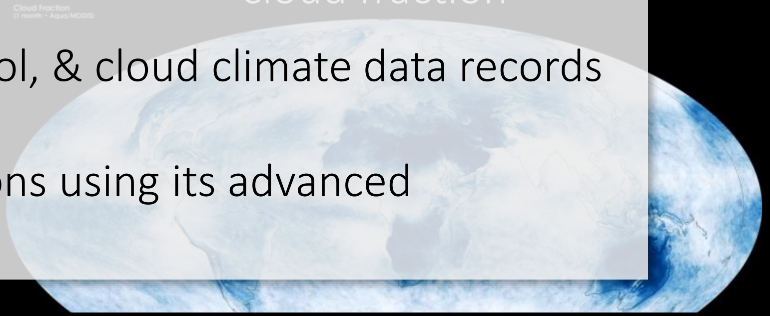
aerosol optical thickness





Broadly speaking, PACE has two fundamental science goals:

cloud fraction



(1) Extend key systematic ocean color, aerosol, & cloud climate data records

(2) Address new & emerging science questions using its advanced capabilities

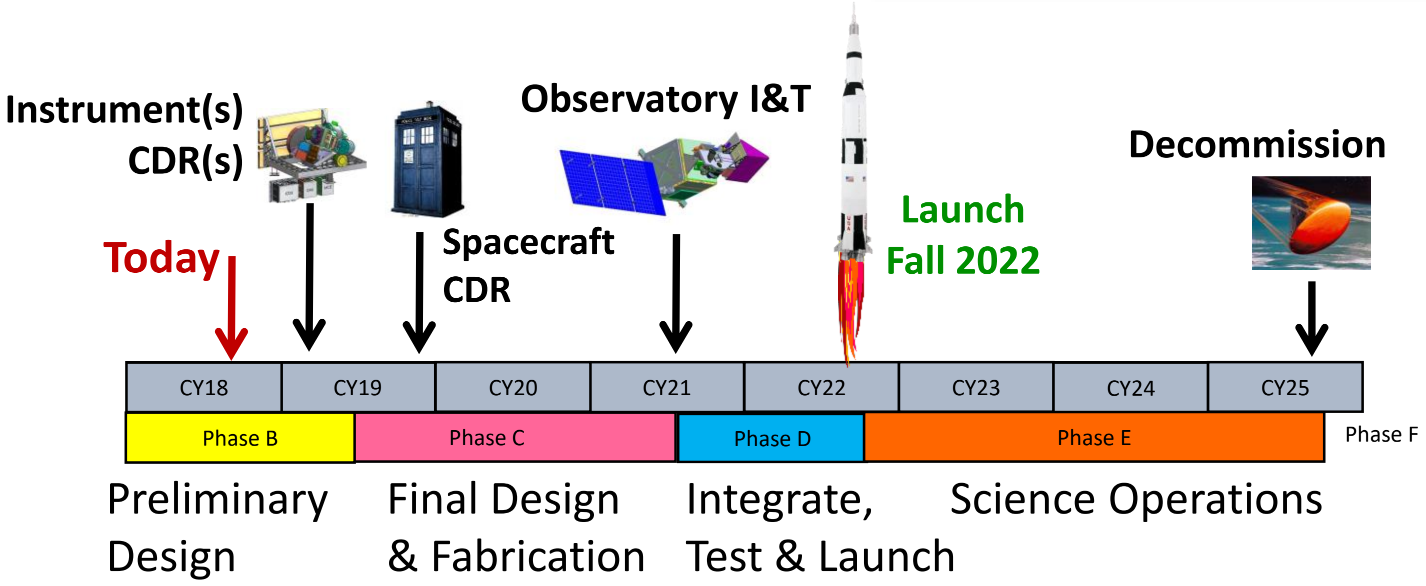
"Majority of Americans say a top priority for NASA should be monitoring key parts of the Earth's climate system (63%) …"

Citation: Pew Research Center, June 2018, "Majority of Americans Believe It is Essential That the U.S. Remain a Global Leader in Space."

PACE Mission characteristics

Key Mission Elements	
Mission management	NASA Goddard SFC
Ocean Color Instrument	NASA Goddard SFC
HARP2 polarimeter	UMBC
SPEXone polarimeter	SRON (Netherlands)
Spacecraft/Mission Ops	NASA Goddard SFC
Science data processing	NASA Goddard OBPG
Competed science teams	NASA Earth Sciences Div.

Key Mission Features	
Cost	$805M, DTC
Life	3-yr, Class C, 10-yr fuel
Orbit	676.5 km, Sun sync, 1-pm
Coverage (OCI)	2-day global
RF Communications	Ka direct to ground 600Mbps



Science Goals, Challenges, & Capabilities of OCI

Extend key systematic **ocean** biological, ecological, & biogeochemical climate data records, as well as **cloud** & **aerosol climate data records**

Make **new global measurements of ocean color** that are essential for understanding the global carbon cycle & ocean ecosystem responses to a changing climate

Collect **global observations of aerosol & cloud properties**, focusing on reducing the largest uncertainties in climate & radiative forcing models of the Earth system

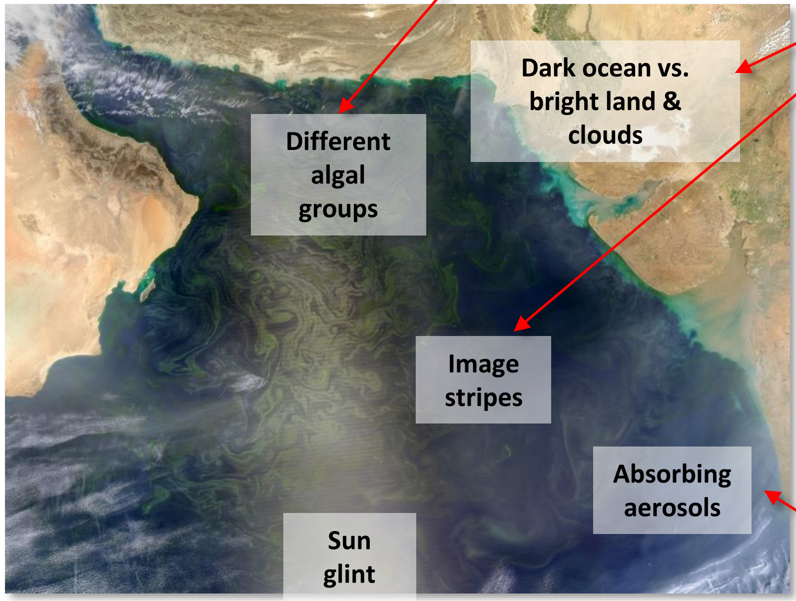
GSD of 1 ± 0.1 km^2 at nadir

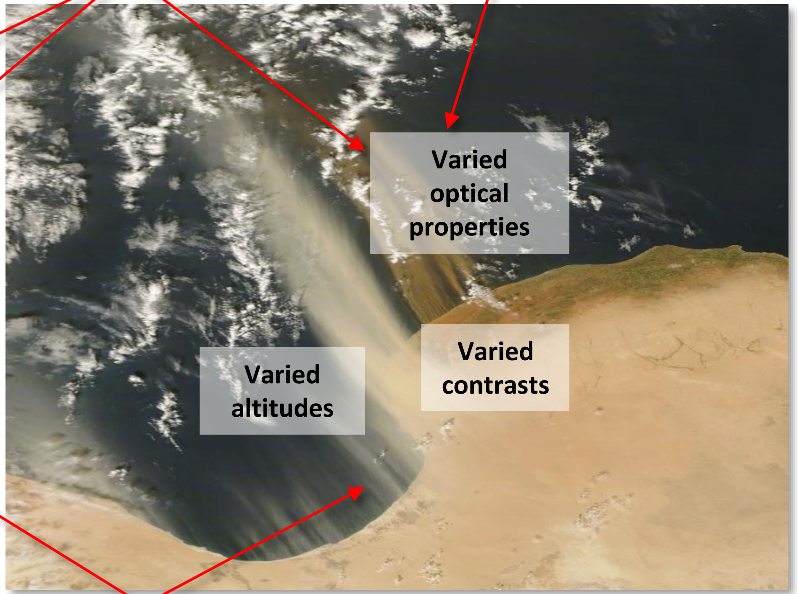
Spectral range from 350-865 @ 5 nm

Lunar calibration & onboard solar calibration (daily, monthly, dim)

Instrument performance requirements

940, 1038, 1250, 1378, 1615, 2130, 2260 nm



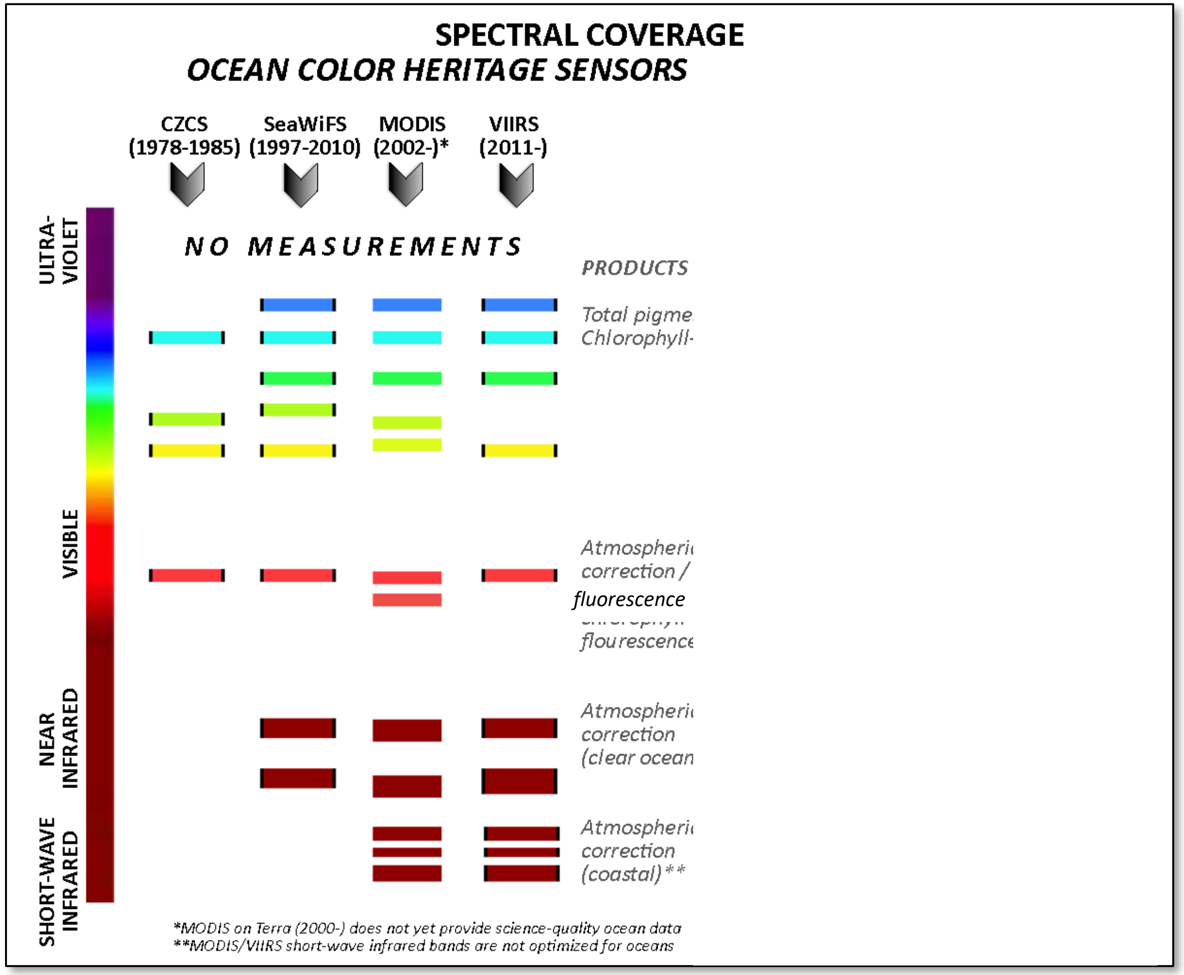


Tilt ± 20^o

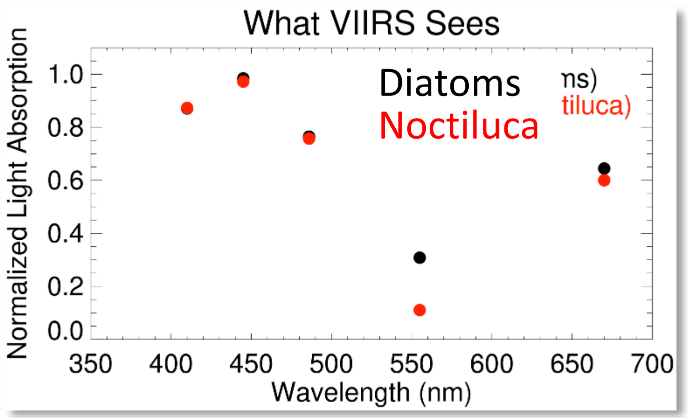
Spectral range goal of 320-865 @ 5 nm

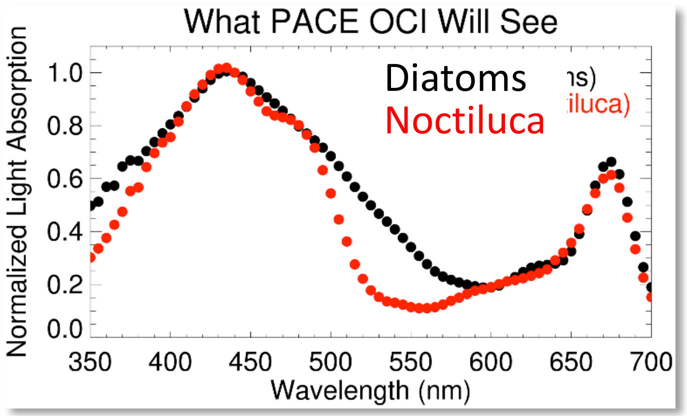
Improve our understanding of how **aerosols influence ocean ecosystems & biogeochemical cycles** and how **ocean biological & photochemical processes affect the atmosphere**

From multi-spectral radiometry to spectroscopy



differentiating between constituents requires additional information relative to what we have today





Multi-Angle Polarimetry on PACE

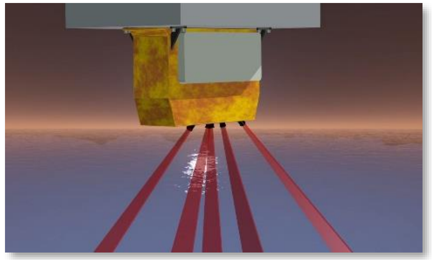
Two cubesat-sized *contributed* instruments

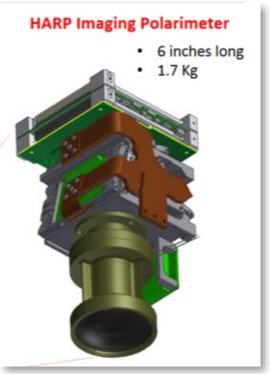
Spectro-Polarimeter for Planetary Exploration (SPEXone)

Contribution from the Netherlands (SRON, NSO, Airbus; TNO optics)

POC: Otto Hasekamp

Hyperspectral (UV) + narrow swath





Hyper Angular Rainbow Polarimeter (HARP-2)

Contribution from University of Maryland Baltimore County

POC: Vanderlei Martins

Hyperangular + wide swath

	SPEXone	**HARP-2**
Spectral range (resolution)	385-770 nm (hyperspectral 2 nm)	440, 550, 670 nm (10) + 870 nm (40 nm)
# viewing angles	5 (-52^{o}, -20^{o}, 0^{o}, 20^{o}, 52^{o})	20 for 440, 550, 870 nm + 60 for 670 nm (114^{o})
Swath width	9^{o} (100 km)	94^{o} (1550 km)
Ground sample distance	2.5 x 2.5 km	3 x 3 km
Heritage	AirSPEX	AirHARP, cubesat HARP for ISS

Required science data products (OCI)

Required data products & additional expected data products:

Level 1 required (~threshold) products

Water-leaving reflectance	Aerosol optical thickness
Chlorophyll-a	Aerosol fine mode fraction
Phytoplankton absorption	Liquid / ice cloud optical thickness
NAP+CDOM absorption	Liquid / ice cloud effective radius
Particulate backscattering	Cloud layer detection ($\tau < 0.3$)
Diffuse attenuation	Cloud top pressure ($\tau > 3$)
Fluorescence line height	Shortwave radiation effect

Building capabilities to produce this full suite of OCI products from proxy data using preliminary/heritage algorithms by the end of 2018

Advanced & evaluation science data products

Required data products & additional expected data products:

Incomplete list of advanced (~baseline) products

Carbon stocks & fluxes	Liquid / ice cloud water path
Phytoplankton pigments	Polarimeter-specific products
Phytoplankton physiology	Applied sciences-specific products
Community structure (PFTs)	Land data products (TBD)
Productivity	Your very favorite data product that
PAR, light attenuation, water quality	we forgot to list

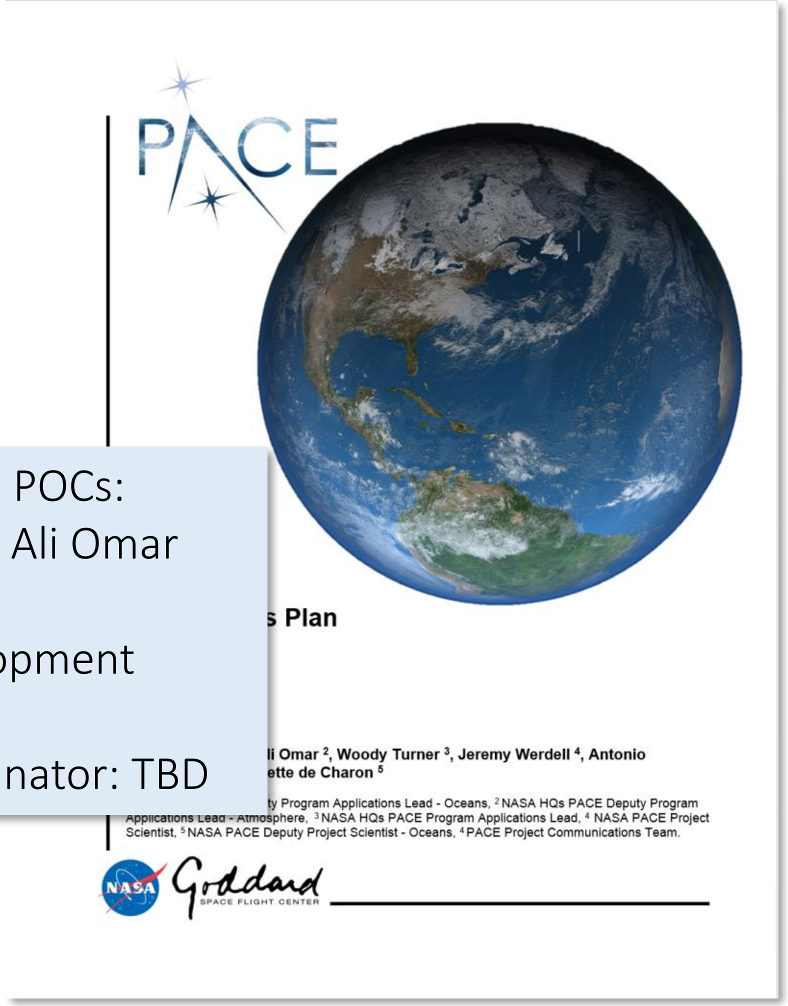
General expectations for future PACE science teams:

- *Novel* methods for required products (exploit spectral capabilities)
- Methods for advanced products + scientific applications

Looking forward: applied sciences

New NASA directive on Applied Sciences within missions

Mission Phase	Applications Activity
Pre-phase A	• Assessment of the community of practice. • Description of potential applications from the PACE data using the requirements established by the Science Definition Team (SDT).
Phase A	• Applications website establishment. • Database of user community individuals begins. • Applications Plan written and posted to website. • Applications white papers developed and posted to the website. • Applications Traceability Matrices developed and posted to the website. • Applications Working Group established.
Phase B	• Workshop conducted with targeted science communities to communicate key model, observation and Applied Sciences opportunities and requirements. • Newsletters, articles, posters, and other communications developed to expand the community of pote • Early Adopters Prograr
Phase C/D	• Annual workshop focu • Description of validatic • Conference presentati interaction to expand t • Data workshops, short • Interaction with NASA
Phase E	• Documenting decision • Newsletter, journal articles, conference presentations of applications of data. • Community interaction and support of data reprocessing and improvement. Calibration/validation of data quality, format, issues. • Conduct Impact Workshop to assess success of Applications implementation. • Conduct a Quantitative PACE Data Societal Benefit Value Assessment. • Information for Senior Review Submissions.


PACE

s Plan

li Omar [2], Woody Turner [3], Jeremy Werdell [4], Antonio
ette de Charon [5]

ty Program Applications Lead - Oceans, [2] NASA HQs PACE Deputy Program Applications Lead - Atmosphere, [3] NASA HQs PACE Program Applications Lead, [4] NASA PACE Project Scientist, [5] NASA PACE Deputy Project Scientist - Oceans, [4] PACE Project Communications Team.

Goddard SPACE FLIGHT CENTER

PACE Applied Sciences program POCs:
Woody Turner, Maria Tzortziou, Ali Omar

A/S Program currently in development

Project Applied Sciences Coordinator: TBD

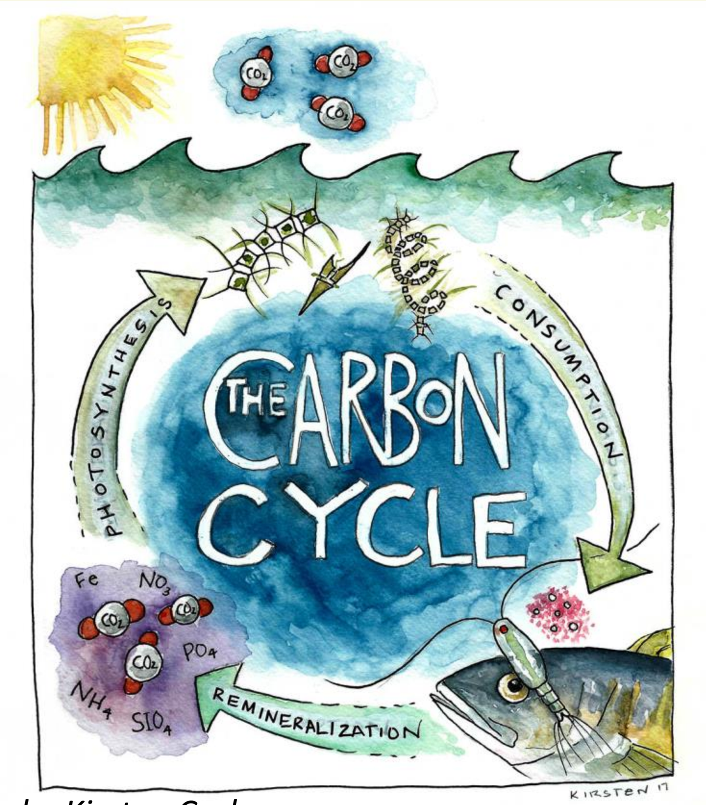
Learn more about PACE

https://pace.gsfc.nasa.gov
@NASAOcean (Twitter)
@NASA.Ocean (Facebook)
Technical Memo. series

Chesapeake Bay Research Activities

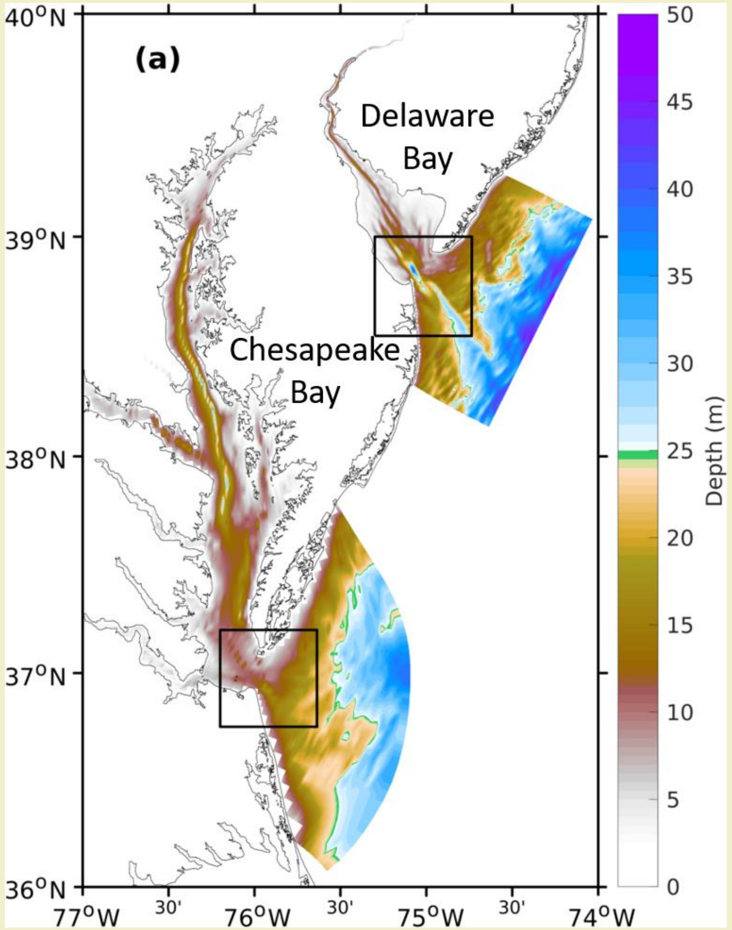
abridged version

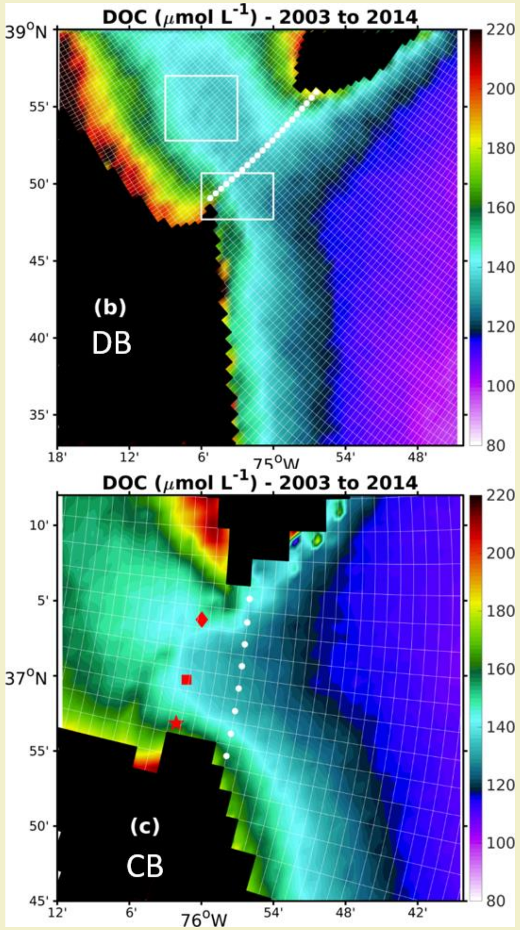
Antonio Mannino, NASA GSFC
and many others



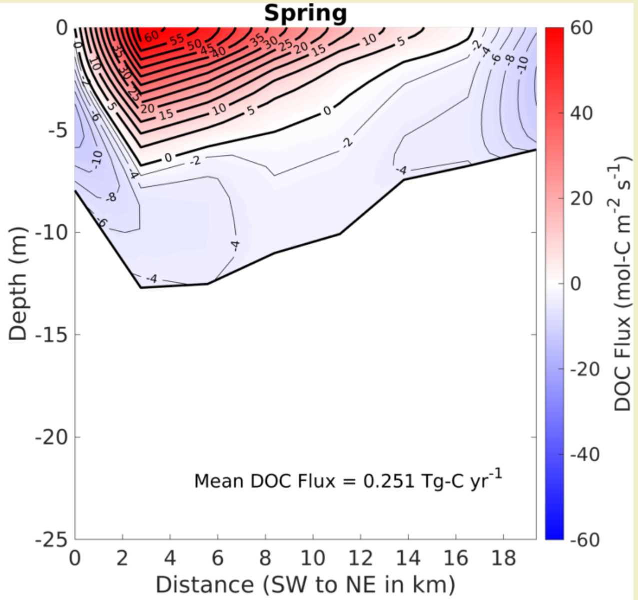
by Kirsten Carlson

DOC Fluxes from Chesapeake Bay and Delaware Bay from Satellite DOC and Estuarine Model Physics





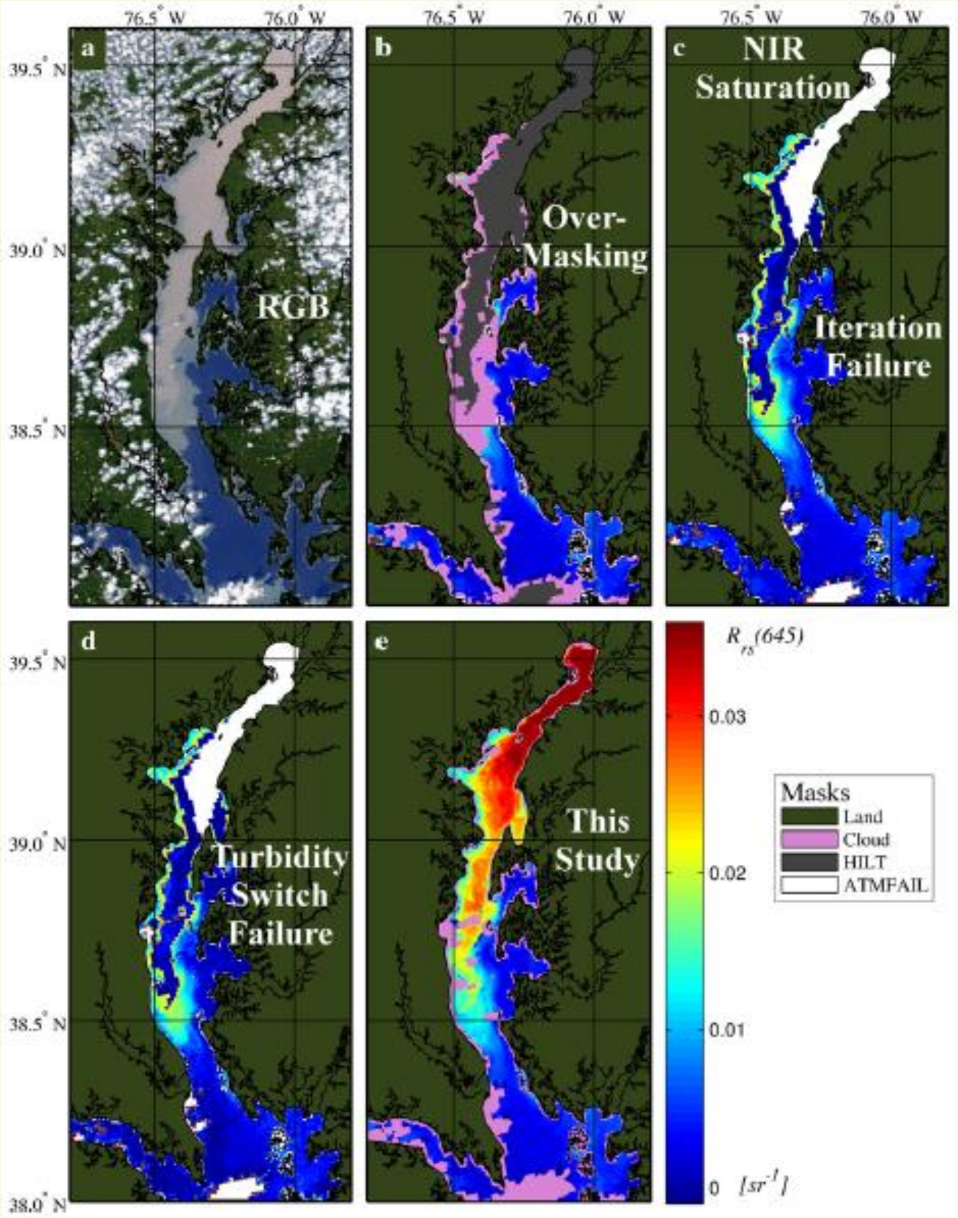
2007-2011 Mean Annual Flux from CB mouth to MAB = 0.21 Tg C yr^{-1}



ROMS with ECB & DB grids

Signorini, Mannino et al. in prep.

Improved Coverage and Data Quality for Turbid Waters



- Improved masking in high turbidity waters
- Applied SWIR bands to enable turbid water retrievals

MODIS image from Sept. 11, 2011 following Hurricane Irene and Tropical Storm Lee

Aurin et al. 2013 RSE

Future Plans

- Satellite- and ROMS-based Carbon budget for lower Chesapeake Bay and Middle Atlantic Bight
  - POC, DOC and DIC
  - fluxes, standing stocks and Net Community Production
  - Terrestrial DOM fluxes
- Satellite-derived Phytoplankton community composition for Chesapeake Bay (lower) and Middle Atlantic Bight
- Potentially Satellite-derived water quality parameters
- Improvements in data products with PACE (2024)