IOCCG Trevor Platt Memorial Scholarship

Fellowship Training and Outcome Report

Home Institute

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES(INCOIS), INDIA

Host Institues

NASA-Godard Space Flight Centre (GSFC)
Ocean Ecology Laboratory
Maryland, USA

Columbia Climate School
Lamont-Doherty Earth Observatory (LDEO)
Columbia University, New York

Supervised by

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NASA-GSFC

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Lamont-Doherty Earth Observatory
Columbia University

Duration of Visit: 1st June – 28th June

Title: Advancing Marine Optics and Remote Sensing

Summary – NASA Goddard Space Flight Center (GSFC)

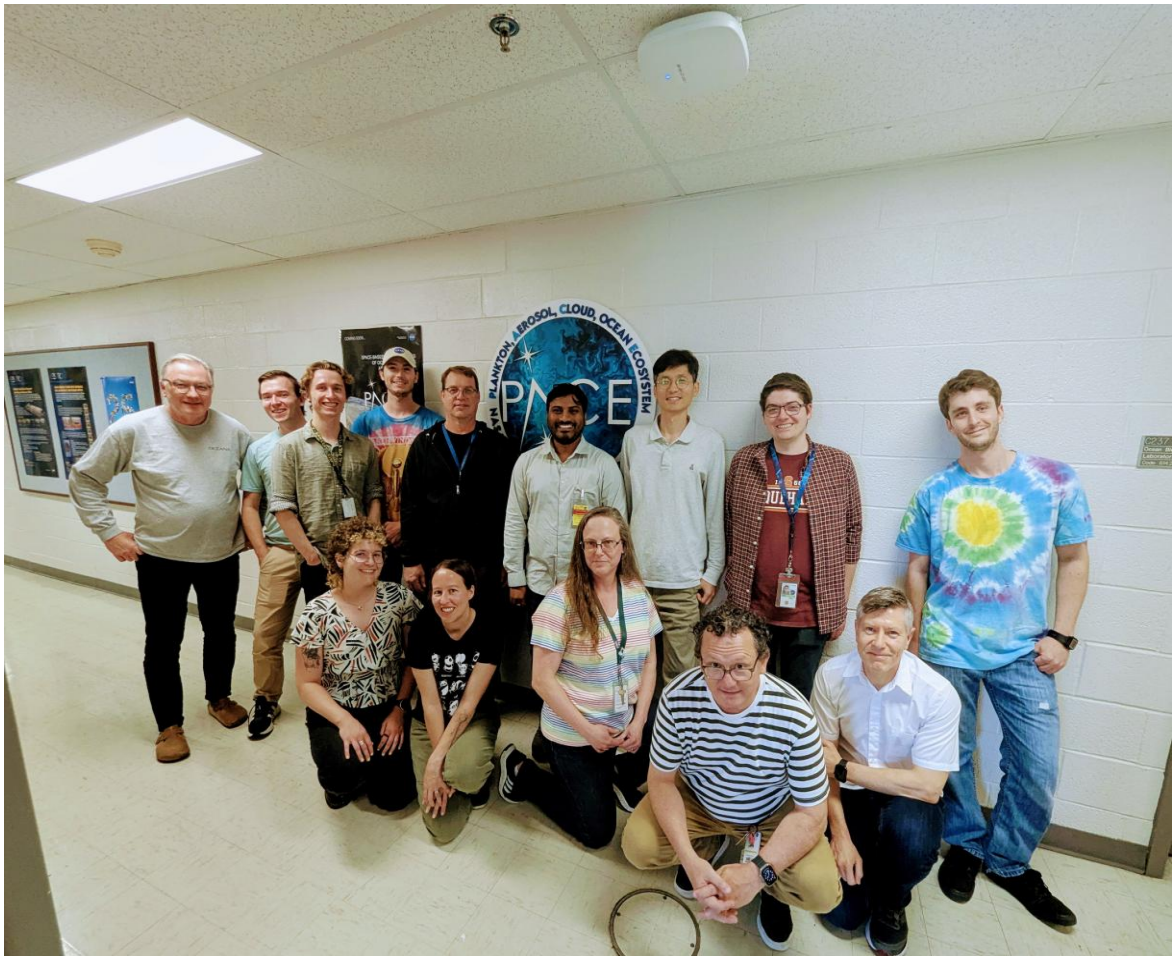
As part of the collaborative research and training initiative, a comprehensive hands-on training program was undertaken at NASA's Goddard Space Flight Center (GSFC), with a focus on advanced bio-optical methods and ocean color remote sensing. The visit was aimed at gaining practical exposure to laboratory instrumentation, sample processing workflows, and data calibration techniques vital for improving satellite-based assessments of ocean biogeochemical properties.

The initial days of the visit involved orientation, familiarization with the Ocean Ecology Laboratory, and detailed discussions to plan the two-week training schedule. Activities commenced with a focus on Total Organic Carbon (TOC), Particulate Organic Carbon (POC), and Colored Dissolved Organic Matter (CDOM) analyses. Standard methods were reviewed, including filtration, sample storage protocols, and instrumentation details. For CDOM measurements, both spectrophotometric scanning and waveguide-based systems were demonstrated. A high level of precision and control over sample handling was emphasized, particularly for maintaining accuracy in optical absorption measurements.

Significant time was devoted to the High-Performance Liquid Chromatography (HPLC) techniques used for pigment analysis. Detailed demonstrations included pigment extraction protocols, column handling, solvent preparation, and gradient programming. The training highlighted the importance of internal standard preparation and calibration strategies to ensure accuracy and reproducibility. Considerable attention was given to optimizing pigment resolution, particularly for critical pairs such as chlorophyll-a and its degradation products. The role of various solvents, buffer preparation (notably with TBAA), and sonication conditions was thoroughly covered. The training also included protocols for quality control, such as conducting blank runs, optimizing injection buffers, and developing pigment libraries using both individual and mixed standards.

In parallel with laboratory work, several sessions focused on in situ measurements of inherent optical properties (IOPs). A range of optical instruments such as AC9, Hyper bb, LISST, and VSF systems were used to assess absorption, backscattering, and particle size distributions. The data acquisition involved careful control of MilliQ water baselines, sample dilution with artificial seawater, and radiometric simulations using radiometers. Special experiments were conducted on known phytoplankton species to examine their spectral responses, contributing to algorithm development for satellite discrimination of phytoplankton functional types. The training also included exposure to flow-through optical systems and real-time culture sample processing. Detailed procedures were shown

for sample collection, storage, and cytometric analysis, focusing on phytoplankton groups such as *Synechococcus*. Imaging Flow Cytobot (IFCB) processing techniques were also introduced, along with its deployment and data capture capabilities, which enhance plankton community assessments over extended monitoring periods.



Group picture with working members of Ocean Ecology Laboratory, NASA-GSFC, Maryland, USA

Radiometric techniques were another key area of focus, particularly above-water radiometry using TRIOS systems. Challenges in obtaining accurate remote sensing reflectance due to surface effects were addressed. Calibration procedures, viewing geometries, and quality flags for deriving Level-2 satellite products such as normalized water-leaving radiance (nLw) and remote sensing reflectance (Rrs) were thoroughly discussed. Processing techniques for radiometry data into SeaBASS-compatible formats

were also demonstrated. The training further included pigment purity assessment, chromatographic resolution checks, and calibration equation development. Spectrophotometric measurements served as cross-validation tools for HPLC pigment results. Concepts such as pigment degradation, elution timing, spectral overlaps, and internal standard normalization were essential components of the calibration workflow. The extraction efficiency and repeatability of chromatographic methods were discussed at length, and advanced methods for preparing and optimizing mixed standards were practiced.

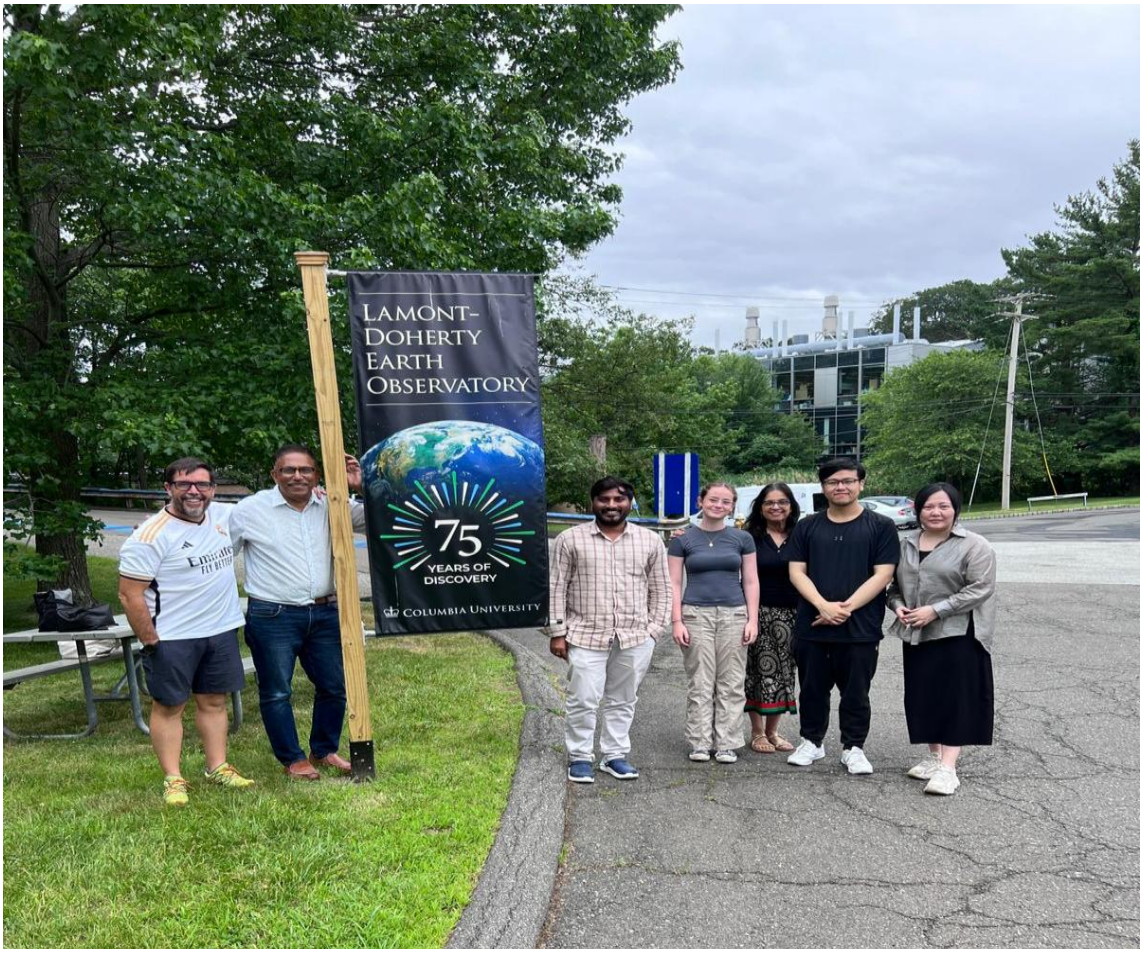
Towards the conclusion of the training, discussions on standard NASA protocols for sampling of parameters like CDOM, POC, and DOC were held. Protocol sheets were reviewed and cross-compared with field practices. Additional insights were shared regarding spectral libraries, pigment retention times, baseline corrections, and software-based chromatogram interpretation.

Summary – Lamont-Doherty Earth Observatory, Columbia University

As part of an international academic engagement and capacity-building initiative, a two-week training program was undertaken at the Lamont-Doherty Earth Observatory (LDEO), Columbia University. The visit aimed to enhance expertise in satellite ocean color interpretation, bio-optical algorithm development, and the application of pigment-based chemotaxonomic techniques for phytoplankton community analysis. The training also served to strengthen collaboration on ongoing research activities concerning phytoplankton functional types and marine primary productivity.

A significant focus of the training was on the application of chemical taxonomy using the CHEMTAX program, a robust statistical tool that utilizes high-performance liquid chromatography (HPLC) pigment data to infer the abundance and distribution of various phytoplankton groups. This method offers a powerful approach for linking pigment profiles to phytoplankton taxonomy, thereby improving the ecological interpretation of satellite ocean color data. The training involved detailed calibration of pigment ratios and the development of matrix input files tailored to regional phytoplankton assemblages, with a focus on pigment markers such as fucoxanthin, zeaxanthin, and divinyl chlorophyll-a, among others. In conjunction with chemotaxonomic analysis, extensive sessions were held on the application and refinement of satellite-based bio-optical models. These included the Quasi-Analytical Algorithm (QAA) and the Generalized Inherent Optical Properties (GIOP) model, which are widely used for deriving inherent optical properties (IOPs) such as absorption (a), backscattering (bb), and attenuation (c) from remote sensing reflectance (Rrs) data. The training provided insight into parameter tuning, region-specific adaptation, and spectral optimization for these models, allowing a more accurate retrieval of bio-optical properties from multispectral satellite observations.

A key highlight was the exposure to an in-house absorption-based model developed by the host research group, which further refines the estimation of phytoplankton absorption coefficients and enables a more accurate mapping of phytoplankton functional types in global and regional oceans. This model complements the CHEMTAX output by integrating pigment data with spectral absorption features, enhancing satellite algorithm validation and ecological monitoring capacity. The training also covered the Vertical Generalized Productivity Model (VGPM), a well-established satellite-based model used to estimate net primary productivity (NPP) in the ocean. The VGPM utilizes satellite-derived chlorophyll-a, light availability, and temperature to provide large-scale estimates of ocean productivity. Training sessions included parameter sensitivity analyses, comparison of VGPM outputs with in situ productivity data, and discussions on how such productivity estimates can be regionally calibrated using field measurements.



Group picture with working members of LDEO group, Columbia University, New York USA

Throughout the training, significant time was allocated to independent research activities. These included the refinement of a research manuscript focusing on the optical characterization of winter phytoplankton blooms in the northeastern Arabian Sea. Using insights gained from model training, the manuscript was restructured to incorporate more advanced interpretations of satellite-derived IOPs and functional group variability.

In summary, the visit to LDEO provided an intensive and intellectually stimulating environment that facilitated both technical training and scientific collaboration. It offered unique opportunities to interact with leading scientists, gain familiarity with high-level analytical tools, and integrate advanced satellite and pigment data approaches for marine biogeochemistry. The skills and insights gained during this visit are expected to play a pivotal role in advancing future research efforts on phytoplankton ecology, satellite algorithm development, and regional productivity modelling.

Outcome & Future Directions

The training experience at NASA-GSFC enabled the practical implementation of unified IOCCG-recommended protocols in the field of marine bio-optics, particularly in the collection, processing, and analysis of optical and pigment data. A significant portion of the training was dedicated to the development and standardization of HPLC methodologies for phytoplankton pigment analysis. These refined protocols ranging from sample digestion to internal standard calibration and mixed pigment standard preparation will now be adopted and implemented at the home institute (INCOIS) to improve the accuracy and consistency of pigment-based studies in the Indian Ocean region.

During the course of the visit at Columbia University (LDEO), preliminary work was initiated on a new research concept that emerged through collaborative discussions. This concept focused on linking satellite retrievals with in situ pigment-based phytoplankton classifications—is being developed into a full abstract for submission to the upcoming Ocean Sciences Meeting in Glasgow, Scotland, scheduled for February 2026. The goal is to present comparative results from satellite algorithms (QAA, GIOP, VGPM) and chemotaxonomic data to advance discussions on improving satellite-driven phytoplankton assessments in dynamic oceanic regions.

Personal Experience

"As a fellow of the IOCCG Trevor Platt Memorial Scholarship, I had the incredible opportunity to train at NASA Goddard Space Flight Centre and Columbia University's Lamont-Doherty Earth Observatory. The experience was truly transformative from learning satellite ocean color validation and radiometric techniques to hands-on work with HPLC pigment analysis and bio-optical algorithms. Beyond the technical learning, what made this journey memorable was the welcoming and collaborative environment. Working alongside experts, exchanging ideas, and seeing how global

teams tackle marine science challenges was inspiring. These interactions even helped shape a new research idea that I'm now preparing to present at the Ocean Sciences Meeting 2026.This fellowship has not only boosted my skills and confidence but also strengthened my belief in the power of international collaboration. I'm deeply grateful to IOCCG for supporting early-career scientists like me and for opening such exciting doors in the world of ocean color remote sensing."

R Chandra Sekhar Naik

INCOIS, INDIA

THANK YOU

IOCCG
International Ocean Colour Coordinating Group

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