CARIBBEAN BIOGEOCHEMISTRY, GLOBAL CHANGE AND OCEAN OBSERVING

Biogeochemical processes, vital for sustaining healthy marine ecosystems in near-surface Caribbean water, are modulated by meso-scale features occurring at spatial scales of a few hundred kilometers and temporal scales on the order of weeks to months. Such phenomena respond readily to climate forcing, but fortunately, a newly arising ocean observing capability now allows unprecedented means for their characterization, tracking and forecasting.

Wind-driven coastal upwelling along the southern margins of the Caribbean Sea and Gulf of Mexico brings cold, salty, nutrient-laden waters to the surface detected and visualized by sea surface temperature (SST) and/or sea surface salinity (SSS) sensors aboard satellites in near-earth orbit. Nutrient subsidy results in blooms of micro-phytoplankton, notably diatoms and dinoflagellates, at the expense of the smaller nano- and pico- fractions prevalent in warm nutrient-poor surface waters. Such blooms, readily detected by satellite-borne ocean color radiometers, maintain highly productive fisheries as well as the remaining famed pearl oyster beds of Margarita, Cubagua and the Guajira Peninsula.

Continental runoff from major rivers (such as the Orinoco and Amazon) spreads throughout the Caribbean from eastern South America (SA) as far as the south coast of Hispaniola; distances of over 1,000 km. Buoyant freshwater plumes are laden with colored dissolved organic matter (CDOM) which is slowly diluted and lost through UV photo-oxidation on timescales of months. While these plumes carry more modest nutrient loads resulting in modest blooms, discrimination between the bloom and the CDOM load is difficult at best with the currently available radiometers. Rainfall patterns over SA respond readily to climate forcing affecting runoff as is apparent in time series observations that reflect virtual absence of the plumes in the northern Caribbean during El Niño years, a harbinger of climate change.

Ten to fifteen Meso-scale eddies of ~200 km diameter and depths to 1 km annually traverse the Caribbean Basin. Cyclonic eddies promote upwelling while anticyclones result in downwelling. Large anticyclonic eddies thus result in deep warm water pools that provide a heat source to fuel hurricanes. Cyclonic eddies, on the other hand, may dampen hurricane force. Ocean eddies are detected and tracked using radar-assisted satellite altimetry for which sea surface height (SSH) anomalies are on the order of centimeters; positive for anti-cyclonic and eddies negative for the cyclonic. Land-based surface current- tracking high-frequency radar (HFR) now also allows eddy tracking along nearby coastal waters.

Tidally generated internal waves propagate along density discontinuities, thermoclines and haloclines. Like eddies, these wave trains cause alternating deepening and shoaling of water masses with excursions of up to 40 m thus exposing deep water phytoplankton communities to enhanced solar irradiance. Phytoplankton productivity may be promoted or retarded depending on the magnitude of vertical excursions and the time of day. Autonomous ocean gliders have successfully characterized wave trains.

Emerging regional anomalies are likely forced by global change. Sahara dust storms are on the rise, decreasing solar irradiance and changing optical and chemical properties of surface waters throughout the greater Caribbean. Similarly unprecedented, are the blooms of sargassum (a pelagic macroalga) arising in the current millennium and now seen to extend from the African coast to the Caribbean and Mesoamerica.

Autonomous ocean observing instruments and platforms have burgeoned in the last few decades allowing powerful new capabilities for sustained detection, quantification and visualization of these important phenomena. Numerical models that assimilate these data streams allow forecasting of their development, progress and demise.

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