Division for Land–Ocean Ecosystem Research

- Global warming and changes in terrestrial water-material cycles in the Arctic circumpolar region
- Effects of climate change and anthropogenic forcing on the terrestrial ecosystem
- Cloud/rainfall variability in Asian monsoon regions
- Dynamics of phytoplankton in marginal seas and coastal areas
- Climate variability and changing open ocean ecosystem dynamics and biogeochemical cycle
- Interaction between oceanic waves and climate variations

The Land–Ocean Ecosystem Research Division investigates regional and global energy, water and material cycles, and physical/biogeochemical processes in the land–ocean ecosystem.

The land research group contributes to advancing our understanding of the mechanisms of how on-going global warming and anthropogenic activity influence the terrestrial water cycle and ecosystem. Using field observations, satellite remote sensing, global meteorological data analysis, laboratory analysis, and model simulation approaches, our group works to understand the impact of global warming on hydrological and greenhouse gas cycles in the Arctic region, the dynamics of the continental scale water cycle, the processes that drive weather and climate over Asia, the interplay between the terrestrial ecosystem and the climate, and the detection of early signs of influence of global warming in Antarctica.

Ocean research is conducting using satellite remote sensing, numerical simulations, and in situ observations. We also performing synthesis studies of physical and biogeochemical processes in the ocean and their interactions with the atmosphere and climate. In particular, we are investigating the manner in which oceanic heat content, circulation, and surface waves interact with atmospheric environments and how they are linked to climate and meteorological phenomena such as tropical cyclones. We are also investigating how variations in ocean circulation, mixing processes, and air–sea fluxes influence marine ecosystems where phytoplankton is a primary producer. Moreover, we are interesting the possible impact of the marine ecosystem on physical processes and climate in the ocean and atmosphere.

Main Activities in FY2018

Hydrological variability in the Arctic circumpolar tundra and the large pan-Arctic river basins

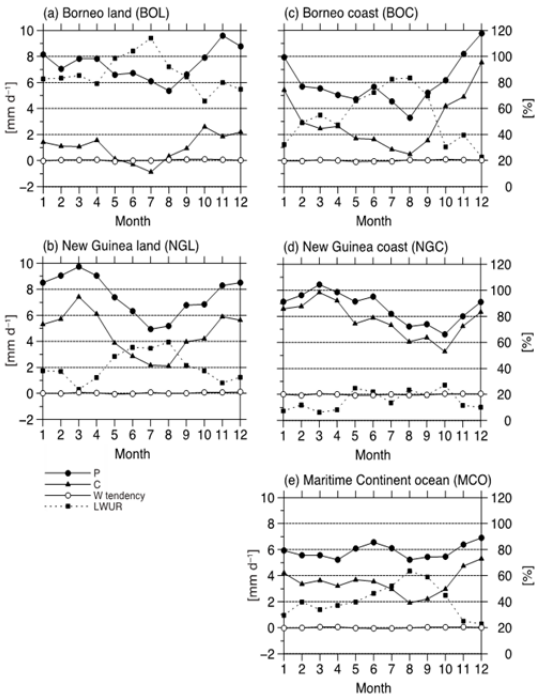
We analyzed spatiotemporal variations in the terrestrial water storage (TWS) of the Arctic circumpolar tundra region (ACTR) and those of the largest pan-Arctic river basins (Lena, Mackenzie, and Yukon), and utilized monthly Gravity Recovery and Climate Experiment data from 2002 to 2016. Together with the global land reanalysis and river runoff data, we identified declining TWS trends throughout the ACTR, mainly owing to increasing evapotranspiration driven by increasing summer air temperatures. In terms of regional changes, large and significant negative trends in TWS were observed mainly over the North American continent. In the Lena River basin, the autumnal TWS signal persisted until the spring of the following year, while in the Mackenzie River basin, the TWS level in the autumn and winter had no significant impact on the following year. These results are important for understanding future TWS trends, with ongoing climate change.

(Reference: Suzuki et al., 2018: Hydrological variability and changes in the Arctic circumpolar tundra and the three largest pan-Arctic river basins from 2002 to 2016. *Remote Sensing*, 10, 402, doi:10.3390/rs10030402.)

Precipitation maintenance mechanism over the Maritime Continent

This study investigated atmospheric water cycles over several time scales to understand the maintenance processes that control heavy precipitation over the islands of the Maritime Continent. Large island regions can be divided into land, coastal, and ocean areas based on the characteristics of both the hydrologic cycle and the diurnal variation in precipitation. Within the Maritime Continent, the major islands of Borneo and New Guinea exhibit different hydrologic cycles. Large-scale circulation variations, such as the seasonal cycle and the Madden–Julian oscillation, have a lesser effect on the hydrologic cycle over Borneo than over New Guinea because the effects depend on their shapes and locations. The impact of diurnal variations on both regional-scale circulation and water exchange between land and coastal regions is pronounced over both islands. The recycling ratio of precipitation, which can be related to stronger diurnal variation in the atmospheric water cycle that results from enhanced evapotranspiration over tropical rain forests, is higher over Borneo than that over New Guinea.

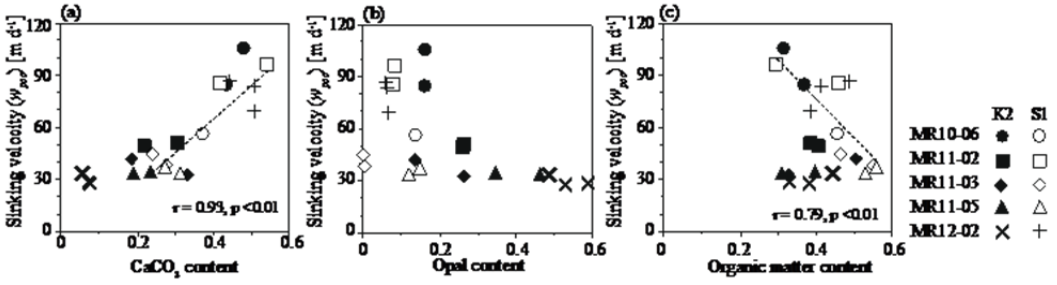
(Reference: Kanamori et al., 2018: Effect of long- and short-term atmospheric water cycles on the water balance over the Maritime Continent. *Journal of Hydrometeor.*, 19, 1413–1427, doi: 10.1175/Jhm-D-18-0052.1)



Monthly precipitation, moisture flux convergence, temporal change in precipitable water content and local water use ratio over Borneo and New Guinea regions.

Sinking velocities of particles in the subarctic and subtropical regions of the western North Pacific

The sinking of particulate matter in the ocean is one of the most important processes by which carbon and other biophilic elements are transported from the surface to the ocean interior, referred to as the "biological pump." Here, we examined sinking velocities of particles exported from the upper layer at two observation sites, K2 and S1, located in the subarctic and subtropical gyres in the western North Pacific, respectively. Sinking particles, collected by drifting sediment traps at 100–200 m, were fractionated in five ranges of sinking velocities between 5 and 1000 m day^{-1} using a elutriation system. The averaged sinking velocities (*wPOC*) calculated from the velocity distributions of POC were 31 ± 16 and 63 ± 26 m day^{-1} at K2 and S1, respectively, i.e., POC was exported faster at S1. For S1 particles, a positive correlation was found between *wPOC* and $CaCO_3$ contents. This indicates that particles containing heavy $CaCO_3$ sink



Relationships between sinking velocity and (a) calcium carbonate ($CaCO_3$) content, (b) opal content, and (c) organic matter content of particles.

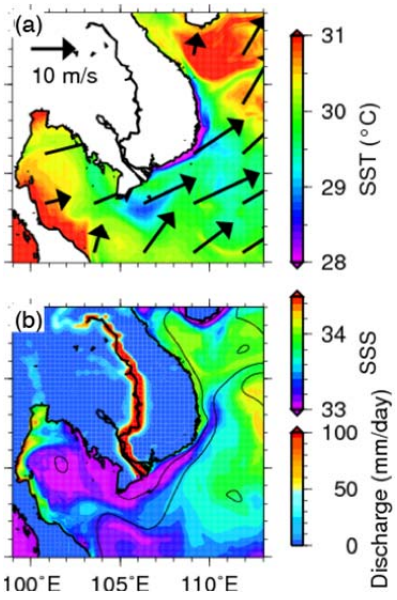
faster than those containing lighter organic matter. Particles at K2, mainly composed of opal and organic matter, did not exhibit a clear relationship between *wPOC* and the denser opal. Instead, *wPOC* had a positive correlation with $\delta^{15}N$ of the sinking particles and was small (large) when the surface layer was stratified (well-mixed). These results implied that the upper water stability/mixing influences the growth/fragmentation of aggregates as well as their chemical composition, thereby affecting *wPOC*.

(Reference: Sukigara et al., 2019: Sinking dynamics of particulate matter in the subarctic and subtropical regions of the western North Pacific. Deep-Sea Res. I, doi: 10.1016/j.dsr.2018.11.004)

LETKF-based high-resolution ocean data assimilation system for the Asia-Oceania region

With the development of satellite observations and numerical models, high spatiotemporal variations in sea-surface temperature, salinity, and height associated with oceanic fronts and eddies have been detected. Satellite observations with infrared and microwave sensors can capture variables at the sea surface except for under cloud and heavy rainfall regions, respectively. In contrast, numerical models can provide 3D gridded outputs without missing values, but do not necessarily have perfect reproducibility because they include parameterizations. Data assimilation estimates statistically best states combining observations and outputs from numerical models, and therefore, may provide outputs with more high reproducibility.

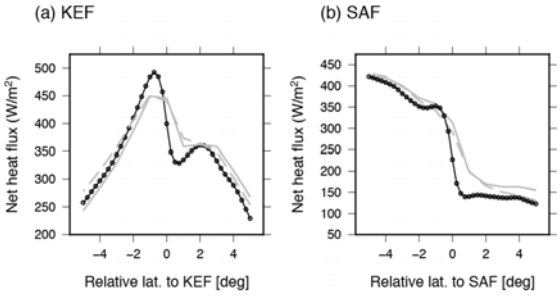
In this study, we established a one-way nest high-resolution ocean data assimilation system in the southeastern Asian coastal region [98°–115°E, 0°–22°N] with a horizontal resolution of 1/36° embedded in the large-scale western Pacific region [95°E–165°W, 50°S–50°N] with that of 1/12°. To consider spatiotemporal salinity variations, freshwater fluxes (the sum of evaporation, precipitation, and river discharge) were incorporated into the ocean model and satellite sea-surface salinity was assimilated. The southeastern Asian coastal system showed that in the summer wet season, when southwestern monsoon blows, the localized cool sea-surface temperatures along the Vietnam coast caused by coastal upwelling and northeastward advection of low-salinity water formed by freshwater discharge from the Mekong River. Thus, the system may enable us to gain insight from the connection between physical and biological oceanography and hydrology.



Monthly mean of (a) sea-surface temperatures and surface wind, (b) sea-surface salinity and river discharge, and sea-surface height in the southeast Asian coastal system in August 2015.

Satellite-derived global surface flux data set: J-OFURO3

Accurate estimations of surface heat, momentum, and freshwater fluxes over the global oceans are needed to understand the air−sea interactions in the climate system. It is difficult to estimate fluxes for global oceans by using in situ observations alone; therefore, it is necessary to estimate satellite-based observation. In this study, we newly developed satellite-derived air-sea flux estimation through multiple satellites, as well as advanced estimation techniques. Furthermore, the obtained estimated values were prepared as a

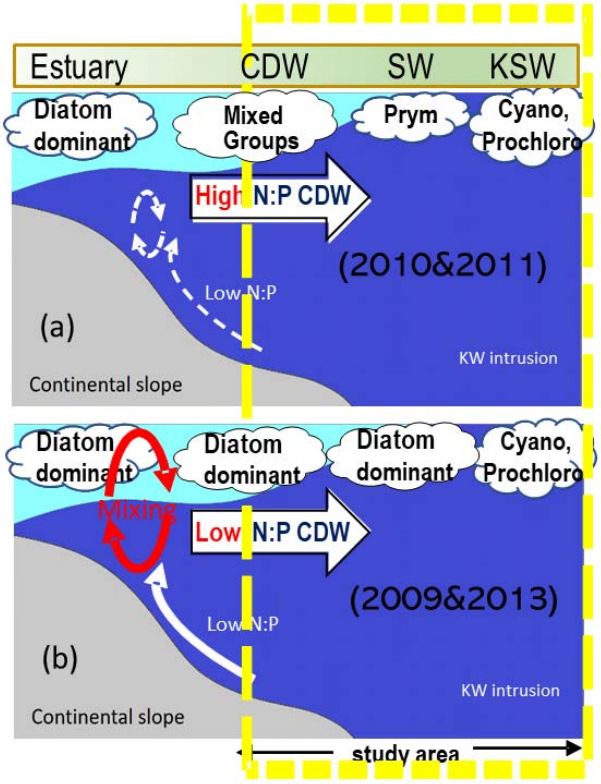


Air-sea flux changes in January climatological monthly mean in the North Pacific, (Left) Kuroshio front, and (right) subarctic front.

dataset and released to the public as J-OFURO3. The new dataset succeeded in more accurately capturing the regional surface flux changes associated with the oceanic meso-scale and fronts that could not be captured clearly in the previous studies (see figure p46). Furthermore, with the development of long-term data for 30 years (1988–2017), various investigations regarding climate change and global warming have started. This is also expected to contribute to research on ocean mixing and the impact on ocean ecosystems that have initiated air−sea interactions.
(Reference: Tomita et al., 2019: *J. Oceanogr.*, 75, 171, doi: 10.1007/s10872-018-0493-x)

Control of Phytoplankton Community Structure in East China Sea by Anthoropogenic Input of Nitrogen

It is indicated that the anthropogenic nutrient input from the large river Changjiang changes the ecosystem of the river mouth in East China Sea. However, the large-scale change in the phytoplankton community was not known in the middle of the East China Sea, which can be important for Japanese fisheries. In July 2009–2011 and 2013, the phytoplankton community structure was studied at the south of Jeju Island, Korea, to the Japanese side by T/V Nagasaki-Maru, Nagasaki University. Large diatoms dominated in 2009 and 2013, whereas small cyanobacteria and green algae dominated in 2010 and 2012. In the diatom-dominated years, the phosphate concentration and N/P ratio were high and low, respectively. Results of statistical analysis with other environmental parameters indicated that the influence of river discharge with high anthropogenic nitrogen was high for low-diatom years, while the phosphate input from non-Changjiang origin water was important in the diatom-dominated year. When upwelling and mixing near the Chinese coastal area supplied phosphate to the Changjiang Diluted Water, the influence of anthropogenic nitrogen became weaker and resulted in lower N/P ratio with diatom dominance. The results contrasted with those of Amazon plume, where diatom dominated with low anthropogenic nitrogen supply.



Influences of Changjiang river and upwelling water on phytoplankton community structure. Top: years with high anthropogenic nitrogen input from Changjiang river, Bottom: years with high influence of upwelling.

(Reference: Xu, Q., et al., 2019: Interannual changes in summer phytoplankton community composition in relation to water mass variability in the East China Sea. *J. Oceanogr.*, 75(1), 61–79, doi:10.1007/s10872-018-0484-y
: Gomes, H.d.R. et al., 2018: The Influence of Riverine Nutrients in Niche Partitioning of Phytoplankton Communities–A Contrast Between the Amazon River Plume and the Changjiang (Yangtze) River Diluted Water of the East China Sea. *Front. Mar. Sci*., doi: 10.3389/fmars.2018.00343)