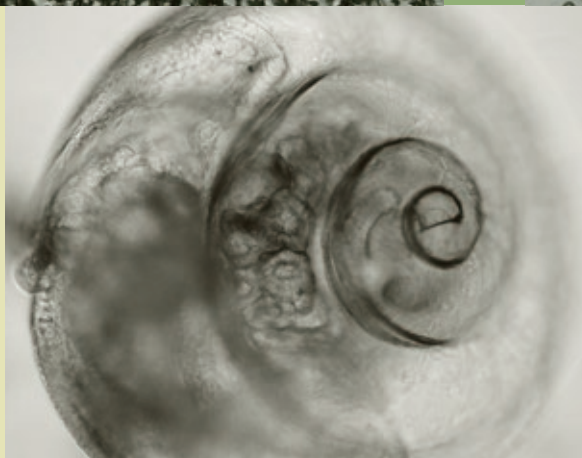




Research and Development on Marine and Global Environmental Change Annual Report FY2017



**Research and Development on Marine and Global
Environmental Change Annual Report FY2017
(April 2017-March 2018)**

Research and Development on Marine and Global Environmental Change Annual Report FY2017

Contents

I. Research Activities and Results

Research and Development Center for Global Change (RCGC)	5
Marine Functional Biology Group / Research and Development Center for Marine Biosciences	23
Application Laboratory (APL)	27
Institute of Arctic Climate and Environment Research (IACE)	33
Department of Coupled Ocean-Atmosphere-Land Processes Research (DCOP)	39
Department of Integrated Climate Change Projection Research (ICliP) & Project Team for Advanced Climate Modeling	45
Department of Seamless Environmental Prediction Research (DSEP)	53
Department of Biogeochemistry	57
Mutsu Institute for Oceanography (MIO)	61

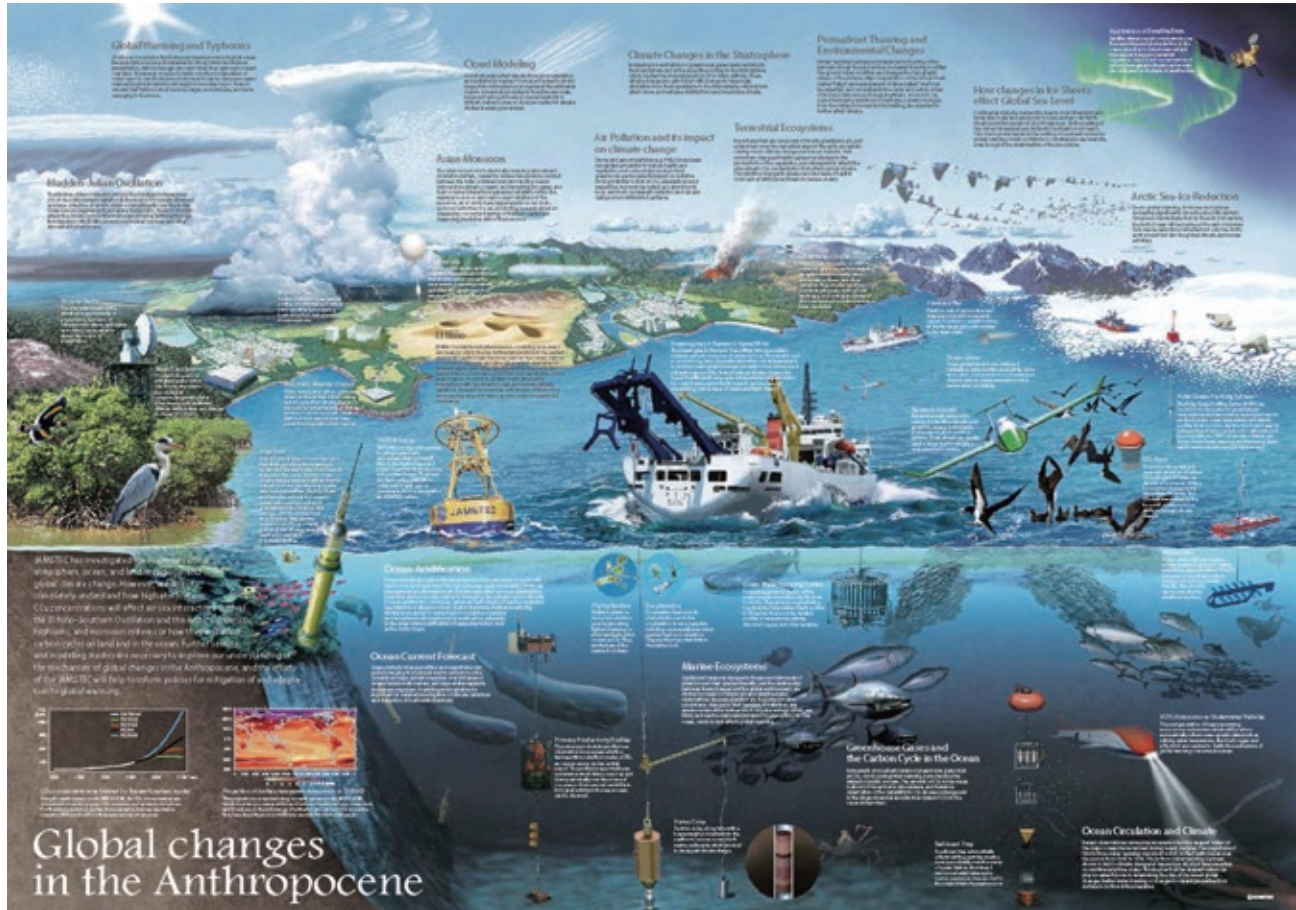
II. Related Activities

Research Collaboration	65
Funded Research Projects	72
Awards	76

I. Research Activities and Results

Changing Oceans and Global Environment – Research and Development Center for Global Change –

Research and Development Center for Global Change (RCGC), established in April 2014, aims to explore the oceans to know their state and to detect signal of global environmental changes. During this fiscal year, Environmental Geochemical Cycle Research Group (formerly a department) was added to RCGC to strengthen a link from our studies to societal issues. Using multidisciplinary approach, including physics, chemistry, biogeochemistry, and ecology, we challenge to the unresolved issues from local to global scales. Several major achievements in this fiscal year are highlighted.



ENSO-scale sea surface salinity variation around the northern edge of the western Pacific warm pool

The western Pacific warm pool, an anomalously high sea surface temperature region in the western tropical and equatorial region, is considered to play a critical role in the ocean-atmosphere interactions in the low latitudes such as El Niño and the Southern Oscillation (ENSO) and to affect the ocean and atmosphere variations in the midlatitudes. Nagano *et al.* [2014] found a significant sea surface salinity (SSS) variation on the timescale of ENSO in the Kuroshio and Kuroshio Extension (KE) region. The ENSO-scale SSS variation is originated in the region east of the Philippines, the northern edge of the western Pacific warm pool, and is advected to the KE region by the Kuroshio current and the Ryukyu Current System [Nagano *et al.*, 2014]. We examined the relationship between SSS and freshwater flux, i.e., evaporation minus precipitation rates, by analyzing Grid Point Value of the Monthly Objective Analysis using Argo data (MOAA GPV, Hosoda *et al.*, 2008) and evaporation (E) and precipitation (P) rates derived from U.S. National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) reanalysis products [Kalnay *et al.*, 1996]. Freshwater flux is evaluated by $F=E-P$.

I. Research Activities and Results

Research and Development Center for Global Change

As a result of a canonical correlation analysis (CCA) of SSS and F in the region of 10°S - 40°N , 120°E - 160°E , we obtained statistically significant coupled patterns of SSS and freshwater flux occurred in El Niño and La Niña as the heterogeneous regression field of SSS (psu) against the F variation of the first (accounting 27.2% of the total variance) and second (12.8%) CCA modes, respectively (Figs. 1a and 1b). The first CCA mode represents high SSS anomaly (red region in Fig.1a) due to the reduced precipitation in the region east of the Philippines in El Niño. The high SSS anomaly is advected northward and reaches to the Kuroshio and KE region after approximately 9 months (Fig.2), as illustrated by Nagano *et al.* [2014]. The reduction of precipitation is caused by the eastward shift of the Walker Circulation associated with an occurrence of El Niño.

The second CCA mode represents low SSS anomaly (blue region in Fig.1b) due to the enhanced precipitation in La Niña. Contrary to the case of El Niño, the enhancement of precipitation is caused by the westward shift of the Walker Circulation associated with an occurrence of La Niña. However, due to the excessive evaporation in the subtropical region, the low SSS anomaly attenuates and disappears during the northward advection and does not reach the Kuroshio and KE region.

The results provide us important knowledge about sea surface water mass modification in the northern edge of the western Pacific warm pool. Based on this knowledge, we designed moored buoy observation at 13°N , 137°E and initiated since December 2016. The data collected until now by the moored buoy demonstrated that a peculiar upper ocean structure with a significant deeper isothermal layer than the mixed layer, so-called the barrier layer, exists in the winter.

In addition, the first and second CCA modes (Fig.1) indicate substantial amplitudes of the ENSO-scale SSS variation coupled with the freshwater flux variation in the eastern edge of the Pacific warm pool. The indication of the relationship between the SSS and freshwater flux variations is important to determine plans of future observations in the eastern edge of the warm pool by research vessels.

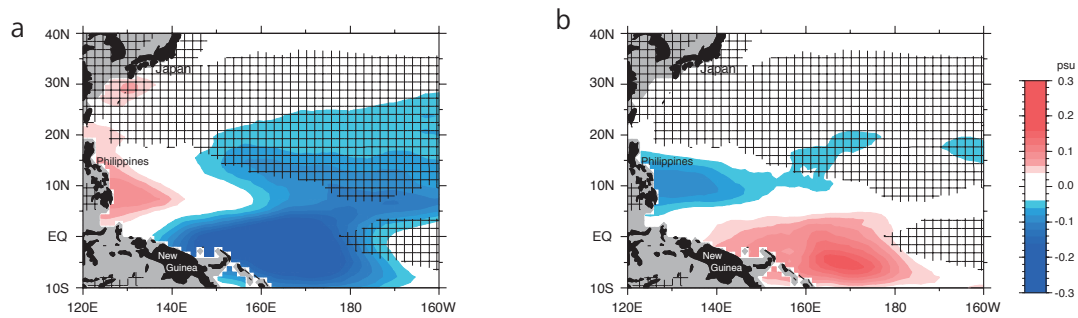


Fig.1 Heterogeneous regression fields of SSS(psu) on the freshwater flux of the (a) first and (b) second CCA modes. Mesh shows regions where annual mean evaporation rate exceeds annual mean precipitation rate [Nagano *et al.*, 2017].

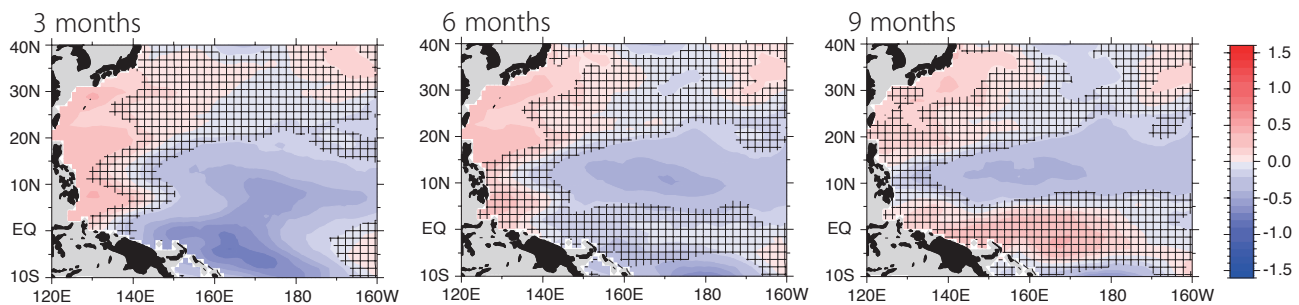


Fig.2 Covariance between the first CCA mode and SSS with time lags from 3 to 9 month. Mesh shows regions of correlation lower than the 95% significance level [Nagano *et al.*, 2017].

References

- Hosoda, S., T. Ohira, and T. Nakamura (2008), A monthly mean dataset of global oceanic temperature and salinity derived from Argo float observations, *JAMSTEC Report of Research and Development*, 8, 47–59, doi:10.5918/jamstecr.8.47.
- Kalnay, E., et al. (1996), The NCEP/NCAR 40-year reanalysis project, *Bulletin of the American Meteorological Society*, 77, 3, 437–471, doi:10.1175/1520-0477(1996)077<0437:TNYRP>2.0.CO;2
- Nagano, A., K. Uehara, T. Suga, Y. Kawai, H. Ichikawa, and M. F. Cronin (2014), Origin of near-surface high-salinity water observed in the Kuroshio Extension region, *Journal of Oceanography*, 70, 389–403, doi:10.1007/s10872-014-0237-5.
- Nagano, A., T. Hasegawa, I. Ueki, and K. Ando (2017), El Niño–Southern Oscillation-time scale covariation of sea surface salinity and freshwater flux in the western tropical and northern subtropical Pacific, *Geophysical Research Letters*, 44, 6895–6903, doi:10.1002/2017GL073573.

Global sea level changes in an ocean state estimation of ESTOC

Global sea level change is a direct and an important climate index associated with a change in the global water mass budget due to global warming and other long-term changes in climate. Lots of literatures show almost monotonous increase of the global mean sea level on the basis of satellite and in-situ observations [e.g., Church and White, 2011]. Further, recent datasets by using global Argo array and NASA's Gravity Recovery and Climate Experiment (GRACE) satellites revealed that the increase came both from water mass increase and rise in the steric height during the recent decade [e.g., IPCC, 2014]. However, there is room for clarification of the mechanism.

This research group intends to make a dynamically self-consistent ocean state estimation to investigate various aspects of basin-scale oceanic changes including a long-term global sea level changes. We carried out the numerical calculation with the Earth Simulator to integrate available ocean observations. A data synthesis experiment was conducted for the period 1957–2014 by using a 4-dimensional variational data assimilation approach based on the data synthesis system named ESTOC (Estimated State of Global Ocean for Climate Research; Osafune et al., 2015; Doi et al., 2015). ESTOC has been used for some climate researches [e.g., Kawai et al., 2018]. The system is newly improved from Osafune et al. to be able to integrate global mean sea level data consistently. The obtained product is a valuable 4-dimensional oceanographic dataset covering from surface to bottom. The overall characteristics of the resulting global ocean state estimate, which does not include any artificial sources or sinks for heat and salt, are in basic agreement with previous studies in some aspects of climate phenomena (not shown).

We will apply our new dataset to investigate the role of steric-height change and water-mass budget change in the long-term global sea level change over 40 years. Figure 3 shows temporal development of estimated global mean sea level (blue) from 1967 to 2014 and two components of it, that is, water mass (green) and steric-height (red). Our system works well to better represent a familiar gross feature of GMSL changes.

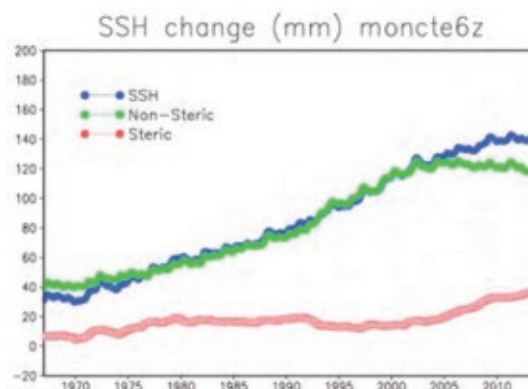


Fig.3 Global mean sea level estimated by a new ESTOC system (blue curve). Red and green curves denote components due to mass change and steric-height change, respectively.

We have investigated a decadal change of the global mean sea level and uncovered that water mass changes are vital to the rate of the change of global mean sea level responsible for a 10-year cycle. This implies global water budget can be modified on a 10-year time scale, which is largely consistent with the intimation of Hosoda *et al.* [2009].

References

- Church, J.A. and N.J. White (2011), Sea-Level Rise from the Late 19th to the Early 21st Century, *Surv Geophys*, 32, 4, 585–602, 32: 585. <https://doi.org/10.1007/s10712-011-9119-1>.
- Doi, T., S. Osafune, N. Sugiura, S. Kouketsu, A. Murata, S. Masuda, and T. Toyoda (2015), Multi-decadal change in the dissolved inorganic carbon in a long-term ocean state estimation, *Journal of Advances in Modeling Earth Systems*, 7, 4, 1885–1990.
- Hosoda, S., T. Suga, N. Shikama, K. Mizuno (2009), Global surface layer salinity change detected by Argo and its implication for hydrological cycle intensification, *J. Oceanogr.*, 65, 579–586, <https://doi.org/10.1007/s10872-009-0049-1>.
- IPCC (2014), Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.
- Kawai, Y., S. Osafune, S. Masuda, and Y. Komuro (2018), Relations between salinity in the northwestern Bering Sea, the Bering Strait throughflow and sea surface height in the Arctic Ocean, *J. Oceanogr.*, 74, 239–261, doi: 10.1007/s10872-017-0453-x.
- Osafune, S., S. Masuda, N. Sugiura, and T. Doi (2015), Evaluation of the applicability of the Estimated Ocean State for Climate Research (ESTOC) dataset, *Geophys. Res. Lett.*, 42, 12, 4903–4911, 2015.

Basin-scale distribution of NH_4^+ and NO_2^- in the Pacific Ocean

The inorganic nitrogenous nutrients, nitrate (NO_3^-), nitrite (NO_2^-), and ammonium (NH_4^+), play an important role in biogeochemical cycles and the productivity of the ocean because their shortage is one of the main factors that limit primary production. The distribution of NO_3^- concentrations and their seasonal variations are well known. In contrast, those of NH_4^+ and NO_2^- have not been presented yet, except for along several one-time sections or at a few ocean time-series stations. Concentrations of NH_4^+ and NO_2^- are generally much lower than those of NO_3^- ; however, their behavior, as well as that of NO_3^- , is important, because these reduced forms of nitrogen are easier than NO_3^- for phytoplankton to assimilate.

We collected more than 25,000 nutrient measurements by many research agencies, and carefully controlled and validated their qualities. As a result, we elucidated basin-scale distributions and seasonal variations of NH_4^+ and NO_2^- concentrations along with those of NO_3^- and satellite chlorophyll-a (CHL) concentrations in the Pacific Ocean. The basin-scale distributions and seasonal variations of NH_4^+ and NO_2^- concentrations corresponded well with geographical features of biological production and nitrogen cycles shown by the previous local observational studies. The highest NH_4^+ , NO_2^- , and NO_3^- concentrations were observed north of 40°N, in the coastal upwelling region off the coast of Mexico, and in the Tasman Sea (Fig.4). NH_4^+ concentrations were elevated during May–October in the western subarctic North Pacific, May–December in the eastern subarctic North Pacific, and June–September in the subtropical South Pacific. NO_2^- concentrations were highest in winter in both hemispheres (Fig.5). The seasonal cycle of NH_4^+ was synchronous with NO_2^- , NO_3^- , and satellite CHL concentrations in the western subtropical South Pacific, whereas it was synchronous with CHL but out of phase with NO_2^- and NO_3^- in the subarctic regions (Fig.5).

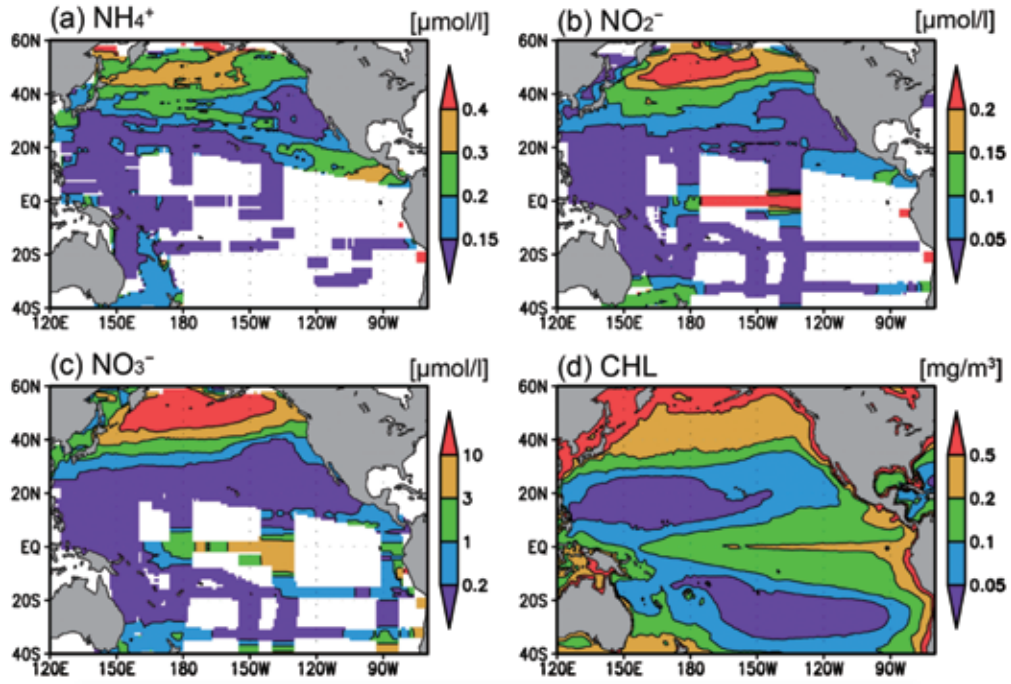


Fig.4 Annual average of (a) NH_4^+ , (b) NO_2^- , (c) NO_3^- , and (d) satellite CHL in the surface layer of the Pacific Ocean. Averaged nutrient concentrations in the window of $\pm 2^\circ$ in latitude and $\pm 5^\circ$ in longitude are plotted at the center of $1^\circ \times 1^\circ$ grid boxes if the number of samples in the window was more than seven in (a–c).

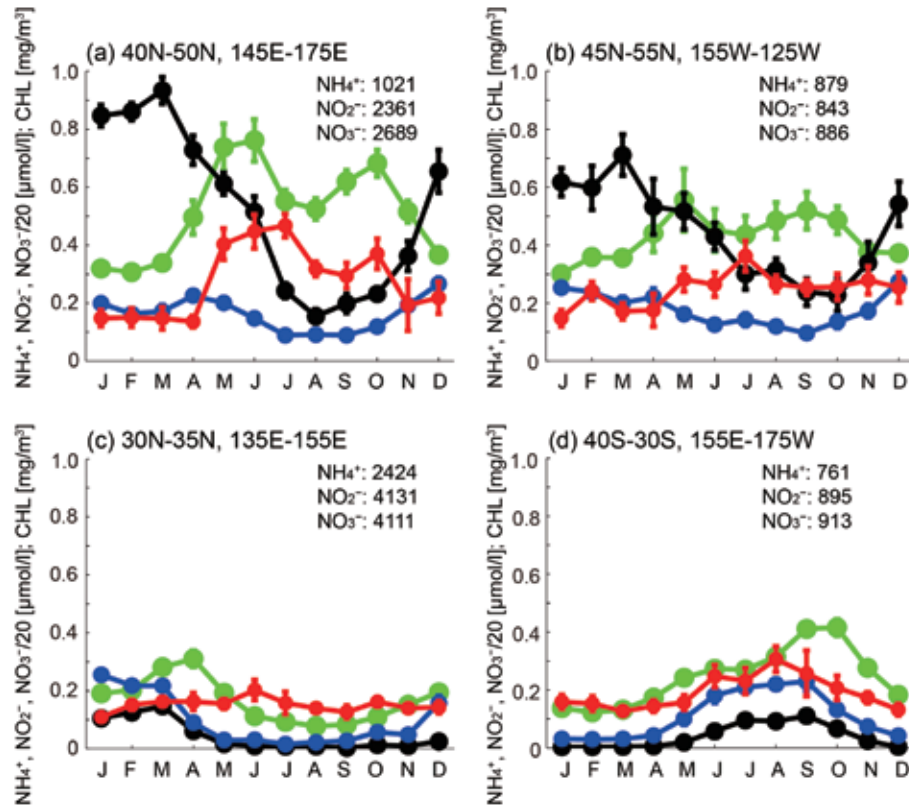


Fig.5 Seasonal changes of areal averaged NH_4^+ (red), NO_2^- (blue), $\text{NO}_3^-/20$ (black), and satellite CHL (green) concentrations in the surface layer of the Pacific Ocean. Error bars denote the 95% confidence intervals of the means. Numbers of samples are shown in each panel.

This is the first report of basin-scale distributions and seasonal variations of NH_4^+ and NO_2^- concentrations based on the observations. Our results provide useful validation data for these models and should therefore facilitate further development of the models.

A new provenance tracing method using cathodoluminescence spectra of single quartz grains

Provenance study of suspended detrital grains in the western subarctic Pacific is critically important to examine the transport process (through atmosphere or riverine input) of iron, a limiting factor for phytoplankton growth of the western subarctic Pacific. In this study, we developed a new provenance tracing method using cathodoluminescence (CL) spectra of single quartz grains, which is applicable to suspended/sinking grains in the western subarctic Pacific (Fig.6). CL spectroscopy can detect crystal-chemical features in quartz such as impurities and intrinsic imperfections that depend on the conditions affecting quartz from its formation onward. As a first step, systematic CL analysis was performed on quartz grains representing two major East Asian deserts, the Gobi Desert in southern Mongolia and the Taklimakan Desert in northwestern China, to evaluate differences in CL spectral features. Such Asian deserts have been considered as potential sources of iron in the subarctic Pacific [Uematsu *et al.*, 2003].

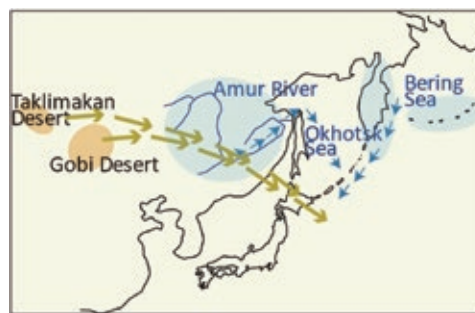


Fig.6 Potential sources of suspended/sinking grains in the western subarctic North Pacific.

Most quartz grains from both deserts showed two CL emission bands in red and blue regions, which were deconvolved to at most five emission components, each representing a specific defect due to an impurity or imperfection. Statistical analysis using the ratios of emission components obtained different compositions of clusters between the quartz grains from the two deserts, probably reflecting the lower abundance of volcanic rocks in the Taklimakan Desert compared to the Gobi Desert (Fig.7) [Nagashima *et al.*, 2016]. Consequently, the CL analysis is useful to identify single grains from Asian Deserts, and probably from other potential sources although we need further CL analysis using samples from additional source areas. This new method will make it possible to estimate provenance of detrital grains in the western subarctic Pacific and relative abundance of iron supply through atmosphere versus river/ocean.

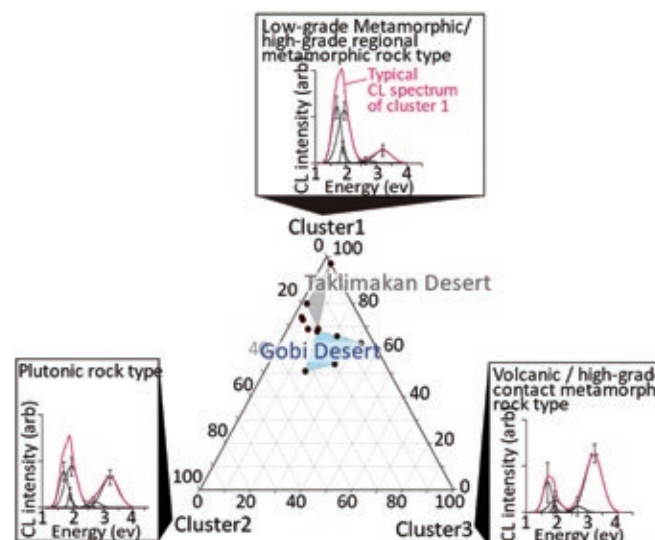


Fig.7 Relative abundance of the three clusters for quartz grains in samples from the Taklimakan and Gobi Deserts. Modified after [Nagashima *et al.*, 2016].

Wildfire Likely to Have Larger Impacts on Climate Change

Pollutants emitted from wildfires in boreal Eurasia can be transported to the Arctic, accelerating global warming by inducing melting of sea-ice and glaciers. Based on a validation of burned areas using ultra-high-resolution images from commercial satellites, we found that burned areas in boreal Eurasia are likely to be underestimated, which implies that the atmospheric transport of fire-emitted pollutants, such as black carbon particles, have larger impacts on global warming than currently thought [Zhu *et al.*, 2017].

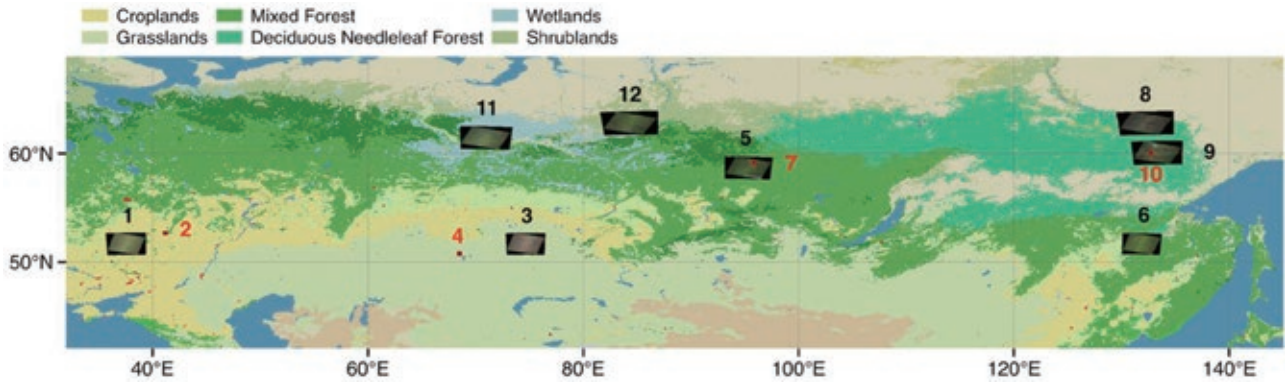


Fig.8 Distributions of 12 validation regions in boreal Eurasia over a wide range of vegetation types. High-resolution satellite products, Landsat 7 ETM+ reference images, are numbered in black. Reference images from commercial satellite products are numbered in red. Only the major vegetation types studied in this work are labeled. The vegetation type data are from the MODIS MCD12Q1 product.

Boreal Eurasia is a region in which large areas of land burn every year. Forest fires in Russia are one of the largest contributing factors to Arctic surface temperature change. The moderate-resolution imaging spectroradiometer (MODIS) is generally used to estimate fire emission products; however, its moderate resolution of 500 m results in uncertainties. As a new approach, we carried out a size-dependent validation of the MODIS data with reference to data from three commercial satellites, RapidEye, WorldView-2, and GeoEye-1, which provide ultra-higher resolutions of 2–5 m, as well as Landsat 7 satellite data with a high resolution of 30 m for six ecotypes over 12 regions of boreal Eurasia in 2012 (Fig.8). During the year, the area experienced severe wildfires, while the sea ice extent in Arctic reached a historic low. We suggest that the MODIS data presents only 13% of burned areas in croplands because of the inadequate detection of small fires in areas smaller than 100 ha (Fig.9).

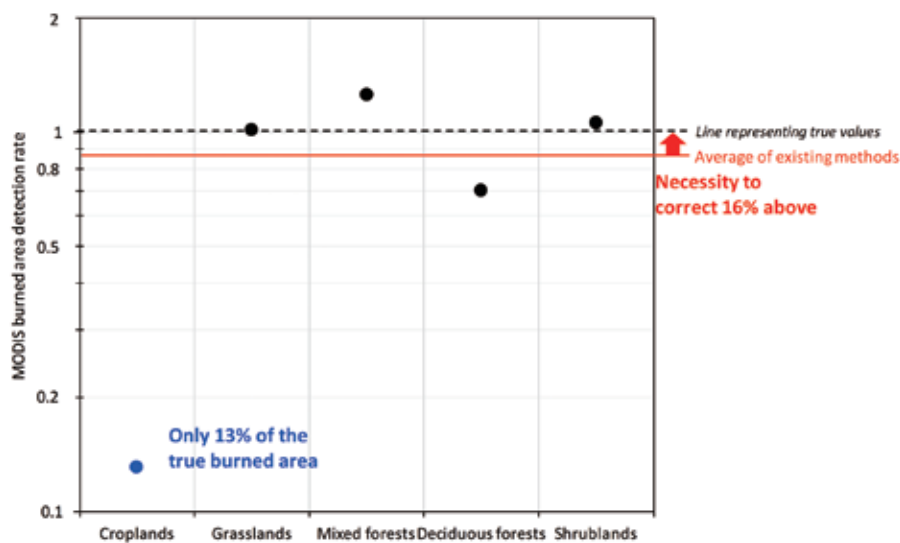


Fig.9 MODIS detection rate of burned areas in major vegetation types in northern Eurasia during 2012. Burned areas detected by ultra-high- and high-resolution satellite images are used as the true values. The figure shows that existing methods detect only 13% of burned areas in croplands compared to the true values. Over all ecotypes, the actual burned area in boreal Eurasia (15,256 km²) may have been ~16% greater than the area suggested by the MCD64A1 (13,187 km²).

I. Research Activities and Results

Research and Development Center for Global Change

In other words, 87% of burned areas have yet to be validated.

These results indicate that burned area data and quantities of pollutants such as black carbon require revision, and should be reflected in simulation models of global warming. New insights would be introduced for discussion at the Arctic Council and the Intergovernmental Panel on Climate Change (IPCC).

References

Zhu, C., H. Kobayashi, Y. Kanaya, and M. Saito (2017), Size-dependent validation of MODIS MCD64A1 burned area over six vegetation types in boreal Eurasia: Large underestimation in croplands, *Scientific Reports*, 7, 4181, doi:10.1038/s41598-017-03739-0.

Publication List

Publication with Peer Review (Published)

- Anderson, D. C., J. M. Nicely, G. M. Wolfe, T. F. Hanisco, R. J. Salawitch, T. P. Canty, R. R. Dickerson, E. C. Apel, S. Baidar, T. J. Bannan, N. J. Blake, D. X. Chen, B. Dix, R. P. Fernandez, S. R. Hall, R. S. Hornbrook, L. G. Huey, B. Josse, P. Jockel, D. E. Kinnison, T. K. Koenig, M. Le Breton, V. Marecal, O. Morgenstern, L. D. Oman, L. L. Pan, C. Percival, D. Plummer, L. E. Revell, E. Rozanov, A. Saiz-Lopez, A. Stenke, K. Sudo, S. Tilmes, K. Ullmann, R. Volkamer, A. J. Weinheimer, and G. Zeng (2017), Formaldehyde in the Tropical Western Pacific: Chemical Sources and Sinks, Convective Transport, and Representation in CAM-Chem and the CCMI Models, *J. Geophys. Res.-Atmos.*, 122(20), 11201–11226, doi:10.1002/2016jd026121.
- Annamalai, H., B. Taguchi, J. P. McCreary, M. Nagura, and T. Miyama (2017), Systematic errors in South Asian monsoon simulation: Importance of equatorial Indian Ocean processes, *J. Climate*, 30, 8159–8178, doi:10.1175/JCLI-D-16-0573.1.
- Aoyama, M., Y. Hamajima, Y. Inomata, Y. Kumamoto, E. Oka, T. Tsubono, and D. Tsumune (2018), Radiocaesium derived from the TEPCO Fukushima accident in the North Pacific Ocean: surface transport processes until 2017, *Journal of Environmental Radioactivity*, 189, 93–102, doi: 10.1016/j.jenvrad.2018.03.014.
- Asahi, H., K. Takahashi, Y. Okazaki, and J. Onodera (2018), Paleooceanography of the Bering Sea advanced by IODP Expedition 323: significant roles playing for global circulation and climate change, *The Journal of Geological Society of Japan*, 124(1), 17–34 (in Japanese), doi:10.5575/geosoc.2017.0066.
- Bian, H. S., M. Chin, D. A. Hauglustaine, M. Schulz, G. Myhre, S. E. Bauer, M. T. Lund, V. A. Karydis, T. L. Kucsera, X. H. Pan, A. Pozzer, R. B. Skeie, S. D. Steenrod, K. Sudo, K. Tsigaridis, A. P. Tsimpidi, and S. G. Tsyro (2017), Investigation of global particulate nitrate from the AeroCom phase III experiment, *Atmos. Chem. Phys.*, 17(21), 12911–12940, doi:10.5194/acp-17-12911-2017.
- Boreddy, S. K. R., K. Kawamura, K. Okuzawa, Y. Kanaya, and Z. F. Wang (2017), Temporal and diurnal variations of carbonaceous aerosols and major ions in biomass burning influenced aerosols over Mt. Tai in the North China Plain during MTX2006, *Atmospheric Environment*, 154, 106–117, doi:10.1016/j.atmosenv.2017.01.042.
- Bruhwyler, L. M., S. Basu, P. Bergamaschi, P. Bousquet, E. Dlugokencky, S. Houweling, M. Ishizawa, H.-S. Kim, R. Locatelli, S. Maksyutov, S. Montzka, S. Pandey, P. K. Patra, G. Petron, M. Saunois, C. Sweeney, S. Schwietzke, P. Tans, and E. C. Weatherhead (2017), US CH₄ emissions from oil and gas production: Have recent large increases been detected?, *J. Geophys. Res.-Atmos.*, 122(7), 4070–4083, doi:10.1002/2016jd026157.
- Cady-Pereira, K. E., V. H. Payne, J. L. Neu, K. W. Bowman, K. Miyazaki, E. A. Marais, S. Kulawik, Z. A. Tzompa-Sosa, and J. D. Hegarty (2017), Seasonal and spatial changes in trace gases over megacities from Aura TES observations: two case studies, *Atmospheric Chemistry and Physics*, 17, 9379–9398, doi:10.5194/acp-17-9379-2017.
- Chandra, N., S. Hayashida, T. Sacki, and P. K. Patra (2017), What controls the seasonal cycle of columnar methane

- observed by GOSAT over different regions in India?, *Atmos. Chem. Phys.*, *17*(20), 12633–12643, doi:10.5194/acp-17-12633-2017.
- Chen, B., and S. L. Smith (2018), CITRATE 1.0: Phytoplankton continuous trait-distribution model with one-dimensional physical transport applied to the North Pacific, *Geoscientific Model Development*, *11*(1), 467–495, doi:10.5194/gmd-11-467-2018.
- Chen, J., S. H. Budisulistiorini, M. Itoh, W. C. Lee, T. Miyakawa, Y. Komazaki, L. D. Q. Yang, and M. Kuwata (2017), Water uptake by fresh Indonesian peat burning particles is limited by water-soluble organic matter, *Atmos. Chem. Phys.*, *17*(18), 11591–11604, doi:10.5194/acp-17-11591-2017.
- Chiba, S., H. Saito, R. Fletcher, T. Yogi, M. Kayo, S. Miyagi, M. Ogido, and K. Fujikura (2018), Human footprint in the abyss: 30 year records of deep-sea plastic debris, *Marine Policy*, *96*, 204–212.
- Ding, J., K. Miyazaki, V. R. Johannes, B. Mijling, J. I. Kurokawa, S. Cho, G. Janssens-Maenhout, Q. Zhang, F. Liu, and P. F. Levelt (2017), Intercomparison of NO_x emission inventories over East Asia, *Atmos. Chem. Phys.*, *17*(16), 10125–10141, doi:10.5194/acp-17-10125-2017.
- Fisher, R. A., C. D. Koven, W. R. L. Anderegg, B. O. Christoffersen, M. C. Dietze, C. E. Farrior, J. A. Holm, G. C. Hurtt, R. G. Knox, P. J. Lawrence, J. W. Lichstein, M. Longo, A. M. Matheny, D. Medvigy, H. C. Muller-Landau, T. L. Powell, S. P. Serbin, H. Sato, J. K. Shuman, B. Smith, A. T. Trugman, T. Viskari, H. Verbeeck, E. S. Weng, C. G. Xu, X. T. Xu, T. Zhang, and P. R. Moorcroft (2018), Vegetation demographics in Earth System Models: A review of progress and priorities, *Global Change Biology*, *24*(1), 35–54, doi:10.1111/gcb.13910.
- Francisco, J. J.-E., A. García-Alix, N. Harada, A. Bahr, S. Sakai, K. Iijima, Q. Chang, K. Sato, K. Suzuki, and N. Ohkouchi (2018), Changes in detrital input, ventilation and productivity in the central Okhotsk Sea during the marine isotope stage 5e, penultimate interglacial period, *Journal of Asian Sciences*, *156*, 189–200, doi:10.1016/j.jseaes.2018.01.032.
- Fujiwara, A., S. Nishino, K. Matsuno, J. Onodera, Y. Kawaguchi, T. Hirawake, K. Suzuki, J. Inoue, and T. Kikuchi (2018), Changes in phytoplankton community structure during wind-induced fall bloom on the central Chukchi shelf, *Polar Biology*, *41*(6), 1279–1295, doi:10.1007/s00300-018-2284-7.
- Ganachaud, A., S. Cravatte, J. Sprintall, C. Germineaud, M. Albery, C. Jeandel, G. Eldin, N. Metzl, S. Bonnet, M. Benavides, L.-E. Heimbürger, J. Lefèvre, S. Michael, J. Resing, F. Quéroué, G. Sarthou, M. Rodier, H. Berthelot, F. Baurand, J. Grelet, T. Hasegawa, W. Kessler, M. Kilepak, F. Lacan, E. Privat, U. Send, P. Van Beek, M. Souhaut, and J.E. Sonke (2017), The Solomon Sea: Its Circulation, Chemistry, Geochemistry and Biology Explored During Two Oceanographic Cruises, *Elementa Science of the Anthropocene*, *5*(33), 1–27, doi:10.1525/elementa.221.
- Goto, D., S. Morimoto, S. Aoki, P. K. Patra, and T. Nakazawa (2017), Seasonal and short-term variations in atmospheric potential oxygen at Ny-Alesund, Svalbard, *Tellus B*, *69*, doi:10.1080/16000889.2017.1311767.
- Guan, K. Y., S. P. Good, K. K. Caylor, D. Medvigy, M. Pan, E. F. Wood, H. Sato, M. Biasutti, M. Chen, A. Ahlstrom, and X. T. Xu (2018), Simulated sensitivity of African terrestrial ecosystem photosynthesis to rainfall frequency, intensity, and rainy season length, *Environ. Res. Lett.*, *13*(2), doi:10.1088/1748-9326/aa9f30.
- Honda, M. C., M. Wakita, K. Matsumoto, T. Fujiki, E. Siswanto, K. Sasaoka, H. Kawakami, Y. Mino, C. Sukigara, M. Kitamura, Y. Sasai, S. L. Smith, T. Hashioka, C. Yoshikawa, K. Kimoto, S. Watanabe, T. Kobari, T. Nagata, K. Hamasaki, R. Kaneko, M. Uchimiya, H. Fukuda, O. Abe, and T. Saino (2017), Comparison of carbon cycle between the western Pacific subarctic and subtropical time-series stations: highlights of the K2S1 project, *Journal of Oceanography*, *73*(5), 647–667, doi:10.1007/s10872-017-0423-3.
- Hori, M., K. Shirai, K. Kimoto, A. Kurasawa, H. Takagi, A. Ishida, N. Takahata, and Y. Sano (2018), Chamber formation and trace element distribution in the calcite walls of laboratory cultured planktonic foraminifera (*Globigerina bulloides* and *Globigerinoides ruber*), *Marine Micropaleontology*, *140*, 46–55, doi:10.1016/j.marmicro.2017.12.004.

I. Research Activities and Results

Research and Development Center for Global Change

- Hoshiba, Y., T. Hirata, M. Shigemitsu, H. Nakano, T. Hashioka, Y. Masuda, and Y. Yamanaka (2018), Biological data assimilation for parameter estimation of a phytoplankton functional type model for the western North Pacific, *Ocean Sci.*, *14*, 371–386, doi:10.5194/os-14-371-2018.
- Houweling, S., P. Bergamaschi, F. Chevallier, M. Heimann, T. Kaminski, M. Krol, A. M. Michalak, and P. K. Patra (2017), Global inverse modeling of CH₄ sources and sinks: an overview of methods, *Atmos. Chem. Phys.*, *17*(1), 235–256, doi:10.5194/acp-17-235-2017.
- Hu, W., K. Murata, S. Fukuyama, Y. Kawai, E. Oka, M. Uematsu, and D. Z. Zhang (2017), Concentration and Viability of Airborne Bacteria Over the Kuroshio Extension Region in the Northwestern Pacific Ocean: Data From Three Cruises, *Journal of Geophysical Research-Atmospheres*, *122*(23), doi:10.1002/2017JD027287.
- Huang, M., G. R. Carmichael, R. B. Pierce, D. S. Jo, R. J. Park, J. Flemming, L. K. Emmons, K. W. Bowman, D. K. Henze, Y. Davila, K. Sudo, J. E. Jonson, M. T. Lund, G. Janssens-Maenhout, F. J. Dentener, T. J. Keating, H. Oetjen, and V. H. Payne (2017), Impact of intercontinental pollution transport on North American ozone air pollution: an HTAP phase 2 multi-model study, *Atmos. Chem. Phys.*, *17*(9), 5721–5750, doi:10.5194/acp-17-5721-2017.
- Ichii, K., M. Ueyama, M. Kondo, N. Saigusa, J. Kim, M. C. Alberto, J. Ardo, E. S. Euskirchen, M. Kang, T. Hirano, J. Joiner, H. Kobayashi, L. B. Marchesini, L. Merbold, A. Miyata, T. M. Saitoh, K. Takagi, A. Varlagin, M. S. Bret-Harte, K. Kitamura, Y. Kosugi, A. Kotani, K. Kumar, S. G. Li, T. Machimura, Y. Matsuura, Y. Mizoguchi, T. Ohta, S. Mukherjee, Y. Yanagi, Y. Yasuda, Y. P. Zhang, and F. H. Zhao (2017), New data-driven estimation of terrestrial CO₂ fluxes in Asia using a standardized database of eddy covariance measurements, remote sensing data, and support vector regression, *J. Geophys. Res.-Bioge.*, *122*(4), 767–795, doi:10.1002/2016jg003640.
- Ikedo, K., H. Tanimoto, T. Sugita, H. Akiyoshi, Y. Kanaya, C. M. Zhu, and F. Taketani (2017), Tagged tracer simulations of black carbon in the Arctic: transport, source contributions, and budget, *Atmos. Chem. Phys.*, *17*(17), 10515–10533, doi:10.5194/acp-17-10515-2017.
- Inoue, R. (2017), A review of wind-induced near-inertial gravity waves: Their generation and propagation in the ocean, *Oceanography in Japan*, *26*(5), 217–225, doi: 10.5928/kaiyou.26.5_217 (in Japanese with English abstract).
- Inoue, R. (2017), A review of wind-induced near-inertial gravity waves propagating in background flows, *Oceanography in Japan*, *26*(5), 227–237 (in Japanese with English abstract).
- Inoue, R., M. Watanabe, and S. Osafune (2017), Wind-Induced Mixing in the North Pacific, *Journal of Physical Oceanography*, *47*(7), 1587–1603, doi:10.1175/JPO-D-16-0218.1.
- Itahashi, S., I. Uno, K. Osada, Y. Kamiguchi, S. Yamamoto, K. Tamura, Z. Wang, Y. Kurosaki, and Y. Kanaya (2017), Nitrate transboundary heavy pollution over East Asia in winter, *Atmos. Chem. Phys.*, *17*(6), 3823–3843, doi:10.5194/acp-17-3823-2017.
- Jiang, Z., B. C. McDonald, H. Worden, J. R. Worden, K. Miyazaki, Z. Qu, D. K. Henze, D. B. A. Jones, A. F. Arellano, E. V. Fischer, L. Zhu, and K. Folkert Boersma (2018), Unexpected slowdown of US pollutant emission reduction in the past decade, *Proceedings of the National Academy of Sciences of the United States of America*, *115*(20), 5099–5104, doi:10.1073/pnas.1801191115.
- Jieying D., K. Miyazaki, R. J. van der A, B. Mijling, J. Kurokawa, S. Y. Cho, G. Janssens-Maenhout, Q. Zhang, F. Liu, and P. F. Levelt (2017), Intercomparison of NO_x emission inventories over East Asia, *Atmospheric Chemistry and Physics*, *17*, 10125–10141, doi:10.5194/acp-17-10125-2017.
- Jung, M., M. Reichstein, C. R. Schwalm, C. Huntingford, S. Sitch, A. Ahlstrom, A. Arneeth, G. Camps-Valls, P. Ciais, P. Friedlingstein, F. Gans, K. Ichii, A. K. J. Ain, E. Kato, D. Papale, B. Poulter, B. Raduly, C. Rodenbeck, G. Tramontana, N. Viovy, Y. P. Wang, U. Weber, S. Zaehle, and N. Zeng (2017), Compensatory water effects link yearly global land CO₂ sink changes to temperature, *Nature*, *541*(7638), 516–520, doi:10.1038/nature20780.
- Kaizer, J., M. Aoyama, Y. Kumamoto, M. Molnar, L. Palcsu, and P. P. Povinec (2018), Tritium and radiocarbon

- in the western North Pacific waters: post-Fukushima situation, *Journal of Environmental Radioactivity*, 184-185, 83–94, doi:10.1016/j.jenvrad.2018.01.015.
- Kanaya, Y., H. Matsui, F. Taketani, X. L. Pan, Y. Komazaki, Z. F. Wang, L. Chang, D. Kang, M. Choi, S. Y. Kim, C. H. Kang, A. Takami, H. Tanimoto, K. Ikeda, and K. Yamaji (2017), Observed and Modeled Mass Concentrations of Organic Aerosols and PM_{2.5} at Three Remote Sites around the East China Sea: Roles of Chemical Aging, *Aerosol Air Qual Res.*, 17(12), 3091–3105, doi:10.4209/aaqr.2016.12.0573.
- Kashimura, H., M. Abe, S. Watanabe, T. Sekiya, D. Y. Ji, J. C. Moore, J. N. S. Cole, and B. Kravitz (2017), Shortwave radiative forcing, rapid adjustment, and feedback to the surface by sulfate geoengineering: analysis of the Geoengineering Model Intercomparison Project G4 scenario, *Atmos. Chem. Phys.*, 17(5), 3339–3356, doi:10.5194/acp-17-3339-2017.
- Katsumata, K. (2017), Eddies observed by Argo floats. Part II: form stress and streamline length in the Southern Ocean, *Journal of Physical Oceanography*, 47(9), 2237–2250, doi:10.1175/JPO-D-17-0072.1.
- Kawai, Y., M. Katsumata, K. Oshima, M. E. Hori, and J. Inoue (2017), Comparison of Vaisala radiosondes RS41 and RS92 launched over the oceans from the Arctic to the tropics, *Atmospheric Measurement Techniques*, 10(7), 2485–2498, doi:10.5194/amt-10-2485-2017.
- Kawai, Y., Q. Moteki, A. Kuwano-Yoshida, T. Enomoto, A. Manda, and H. Nakamura (2017), Impact Propagation of Radiosonde Data Assimilation over the Kuroshio and Kuroshio Extension: Case Study on the Early Summer (Baiu) in 2012, *Journal of the Meteorological Society of Japan*, 95(2), 71–90, doi:10.2151/jmsj.2017-004.
- Kawai, Y., S. Osafune, S. Masuda, and Y. Komuro (2018), Relations between salinity in the northwestern Bering Sea, the Bering Strait throughflow and sea surface height in the Arctic Ocean, *J. Oceanogr.*, 74(3), 239–261, doi:10.1007/s10872-017-0453-x.
- Kitamura, M., M. C. Honda, Y. Hamajima, Y. Kumamoto, M. Aoyama, H. Kawakami, T. Aono, M. Fukuda, and Y. Mino (2017), Temporal changes in radiocesium contamination derived from the Fukushima Dai-ichi Nuclear Power Plant accident in oceanic zooplankton in the western North Pacific, *Journal of Environmental Radioactivity*, 172, 163–172, doi:10.1016/j.jenvrad.2017.03.024.
- Kohler, P., L. Guanter, H. Kobayashi, S. Walther, and W. Yang (2018), Assessing the potential of sun-induced fluorescence and the canopy scattering coefficient to track large-scale vegetation dynamics in Amazon forests, *Remote Sensing Environment*, 204, 769–785, doi:10.1016/j.rse.2017.09.025.
- Kondo, M., K. Ichii, P. K. Patra, J. G. Canadell, B. Poulter, S. Sitch, L. Calle, Y. Y. Liu, A. I. J. M. van Dijk, T. Saeki, N. Saigusa, P. Friedlingstein, A. Arneeth, A. Harper, A. K. Jain, E. Kato, C. Koven, F. Li, T. A. M. Pugh, S. Zaehle, A. Wiltshire, F. Chevallier, T. Maki, T. Nakamura, Y. Niwa, and C. Rodenbeck (2018), Land use change and El Nino-Southern Oscillation drive decadal carbon balance shifts in Southeast Asia, *Nature Communications*, 9, doi:10.1038/s41467-018-03374-x.
- Kondo, M., T. M. Saitoh, H. Sato, and K. Ichii (2017), Comprehensive synthesis of spatial variability in carbon flux across monsoon Asian forests, *Agricultural and Forest Meteorology*, 232, 623–634, doi:10.1016/j.agrformet.2016.10.020.
- Kouketsu, S. (2017), A review of observational studies of circulation in intermediate and deep layers in the North Pacific, *Oceanography in Japan*, 26(5), 189–201, doi: 10.5928/kaiyou.26.5_189 (in Japanese).
- Kouketsu, S., S. Osafune, Y. Kumamoto, and H. Uchida (2017), Eastward salinity anomaly propagation in the intermediate layer of the North Pacific, *Journal of Geophysical Research-Oceans*, 122(2), 1590–1607, doi:10.1002/2016JC012118.
- Kumamoto, Y., M. Aoyama, Y. Hamajima, H. Nagai, T. Yamagata, Y. Kawai, E. Oka, A. Yamaguchi, K. Imai, and A. Murata, Fukushima-derived radiocesium in the western North Pacific in 2014, *Journal of Radioanalytical and Nuclear Chemistry*, 2017, doi:10.1007/s10967-016-5055-3.
- Lin, Y., T. Wei, B. Yang, Y. Knyazikhin, Y. H. Zhang, H. Sato, X. Fang, X. L. Liang, L. Yan, and S. L. Sun (2017), TLS-bridged co-prediction of tree-level multifarious stem structure variables from worldview-2 panchromatic imagery: a case study of the boreal forest, *International Journal of Digital Earth*, 10(7),

- 701–718, doi:10.1080/17538947.2016.1247473.
- Liu, X. Y., A. Kohl, D. Stammer, S. Masuda, Y. Ishikawa, and T. Mochizuki (2017), Impact of in-consistency between the climate model and its initial conditions on climate prediction, *Climate Dynamics*, 49(3), 1061–1075, doi:10.1007/s00382-016-3194-4.
- Manno, C., N. Bednarsek, G. A. Tarling, V. L. Peck, S. Comeau, D. Adhikari, D. C. E. Bakker, E. Bauerfeind, A. J. Bergan, M. I. Berning, E. Buitenhuis, A. K. Burridge, M. Chierici, S. Flöter, A. Fransson, J. Gardner, E. L. Howes, N. Keul, K. Kimoto, P. Kohnert, G. L. Lawson, S. Lischka, A. Maas, L. Mekkes, R. L. Oakes, C. Pebody, K. T. C. A. Peijnenburg, M. Seifert, J. Skinner, P. S. Thibodeau, D. Wall-Palmer, and P. Ziveri (2017), Shelled pteropods in peril: Assessing vulnerability in a high CO₂ ocean, *Earth-Science Reviews*, 169, 132–145, doi:10.1016/j.earscirev.2017.04.005.
- Masuda, S. (2017), Improved ocean state estimation by controlling ocean-mixing: toward synthesis of ocean-mixing observations, *Oceanography in Japan*, 26(5), 209–215, doi:10.5928/kaiyou.26.5_209 (in Japanese with English abstract).
- Miyakawa, T., N. Oshima, F. Taketani, Y. Komazaki, A. Yoshino, A. Takami, Y. Kondo, and Y. Kanaya (2017), Alteration of the size distributions and mixing states of black carbon through transport in the boundary layer in east Asia, *Atmos. Chem. Phys.*, 17(9), 5851–5864, doi:10.5194/acp-17-5851-2017.
- Miyazaki, K., and K. Bowman (2017), Evaluation of ACCMIP ozone simulations and ozonesonde sampling biases using a satellite-based multi-constituent chemical reanalysis, *Atmospheric Chemistry and Physics*, 17, 8285–8312, doi:10.5194/acp-17-8285-2017.
- Miyazaki, K., H. Eskes, K. Sudo, K. F. Boersma, K. Bowman, and Y. Kanaya (2017), Decadal changes in global surface NO_x emissions from multi-constituent satellite data assimilation, *Atmos. Chem. Phys.*, 17(2), 807–837, doi:10.5194/acp-17-807-2017.
- Mochizuki, T., K. Kawamura, S. Nakamura, Y. Kanaya, and Z. F. Wang (2017), Enhanced levels of atmospheric low-molecular weight monocarboxylic acids in gas and particulates over Mt. Tai, North China, during field burning of agricultural wastes, *Atmospheric Environment*, 171, 237–247, doi:10.1016/j.atmosenv.2017.10.026.
- Nagai, S., and K. N. Nasahara (2017), Seasonal leaf phenology data for 12 tree species in a cool-temperate deciduous broadleaved forest in Japan from 2005 to 2014, *Ecological Research*, 32(2), 107–107, doi:10.1007/s11284-017-1439-2.
- Nagai, S., K. N. Nasahara, S. Yoshitake, and T. M. Saitoh (2017), Seasonality of leaf litter and leaf area index data for various tree species in a cool-temperate deciduous broad-leaved forest, Japan, 2005–2014, *Ecological Research*, 32(3), 297–297, doi:10.1007/s11284-017-1452-5.
- Nagai, S., T. M. Saitoh, K. Kajiwara, S. Yoshitake, and Y. Honda (2018), Investigation of the potential of drone observations for detection of forest disturbance caused by heavy snow damage in a Japanese cedar (*Cryptomeria japonica*) forest, *J. of Agricultural Meteorology*, 74(3), 123–127, doi:10.2480/agrmet.D-17-00038.
- Nagai, T., D. Hasegawa, T. Tanaka, H. Nakamura, E. Tsutsumi, R. Inoue and T. Yamashiro (2017), First Evidence of Coherent Bands of Strong Turbulent Layers Associated with High-Wavenumber Internal-Wave Shear in the Upstream Kuroshio, *Scientific Reports*, 7, doi:10.1038/s41598-017-15167-1.
- Nagano, A., T. Hasegawa, I. Ueki, and K. Ando (2017), El Niño–Southern Oscillation-time scale covariation of sea surface salinity and freshwater flux in the western tropical and northern subtropical Pacific, *Geophysical Research Letters*, 44, 6895–6903, doi:10.1002/2017GL073573.
- Nagashima, K., H. Nishido, M. Kayama, Y. Kurosaki, S. Ohgo, and H. Hasegawa (2017), Composition of Asian dust from cathodoluminescence spectral analysis of single quartz grains, *Geology*, 45(10), 879–882, doi:10.1130/G39237.1.
- Nagashima, T., K. Sudo, H. Akimoto, J. Kurokawa, and T. Ohara (2017), Long-term change in the source contribution to surface ozone over Japan, *Atmos. Chem. Phys.*, 17(13), 8231–8246, doi:10.5194/acp-17-8231-2017.

- Nagura, M., and M. J. McPhaden (2018), The shallow overturning circulation in the Indian Ocean, *Journal of Physical Oceanography*, 48(2), 413–434, doi:10.1175/JPO-D-17-0127.1.
- Nagura, M., J. P. McCreary, and H. Annamalai (2018), Origins of coupled-model biases in the Arabian-Sea climatological state, *Journal of Climate*, 31(5), 2005–2029, doi:10.1175/JCLI-D-17-0417.1.
- Noguchi, M., S. Chiba, and K. Tadokoro (2018), Response of lower trophic level ecosystems to decadal scale variation of climate system in the North Pacific Ocean, *Oceanography in Japan*, 27(1), 43–57.
- Ogata, T., M. Nagura, and Y. Masumoto (2017), Mean subsurface upwelling induced by intraseasonal variability over the equatorial Indian Ocean, *Journal of Physical Oceanography*, 47, 1347–1365.
- Ogino, S.-Y., P. Wu, M. Hattori, N. Endo, H. Kubota, T. Inoue, and J. Matsumoto (2018), Cold surge event observed by radiosonde observation from the research vessel "Hakuho-maru" over the Philippine Sea in December 2012, *Progress in Earth and Planetary Science*, 5, doi:10.1186/s40645-017-0163-4.
- Oka, E., M. Ishii, T. Nakano, T. Suga, S. Kouketsu, M. Miyamoto, H. Nakano, B. Qiu, S. Sugimoto, and Y. Takatani (2018), Fifty years of the 137°E repeat hydrographic section in the western North Pacific Ocean, *Journal of Oceanography*, 74(2), 115–145, doi:10.1007/s10872-017-0461-x.
- Oo, A. Z., S. Sudo, K. Inubushi, M. Mano, A. Yamamoto, K. Ono, T. Osawa, S. Hayashida, P. K. Patra, Y. Terao, P. Elayakumar, K. Vanitha, C. Umamageswari, P. Jothamani, and V. Ravi (2018), Methane and nitrous oxide emissions from conventional and modified rice cultivation systems in South India, *Agriculture, Ecosystems & Environment*, 252, 148–158, doi:10.1016/j.agee.2017.10.014.
- Osafune, S., and Y. Tanaka (2018), Bidecadal variability in ocean related to the 18.6-year modulation of tide-induced vertical mixing, *Oceanography in Japan*, 27(1), 19–30, doi:10.5928/kaiyou.27.1_19 (in Japanese with English abstract).
- Palmer, M. D., C. D. Roberts, M. Balmaseda, Y. S. Chang, G. Chepurin, N. Ferry, Y. Fujii, S. A. Good, S. Guinehut, K. Haines, F. Hernandez, A. Kohl, T. Lee, M. J. Martin, S. Masina, S. Masuda, K. A. Peterson, A. Storto, T. Toyoda, M. Valdivieso, G. Vernieres, O. Wang, and Y. Xue (2017), Ocean heat content variability and change in an ensemble of ocean reanalyses, *Climate Dynamics*, 49(3), 909–930, doi:10.1007/s00382-015-2801-0.
- Pan, X. L., Y. Kanaya, F. Taketani, T. Miyakawa, S. Inomata, Y. Komazaki, H. Tanimoto, Z. Wang, I. Uno, and Z. F. Wang (2017), Emission characteristics of refractory black carbon aerosols from fresh biomass burning: a perspective from laboratory experiments, *Atmos. Chem. Phys.*, 17(21), 13001–13016, doi:10.5194/acp-17-13001-2017.
- Patra, P. K., D. Crisp, J. W. Kaiser, D. Wunch, T. Saeki, K. Ichii, T. Sekiya, P. O. Wennberg, D. G. Feist, D. F. Pollard, D. W. T. Griffith, V. A. Velasco, M. De Maziere, M. K. Sha, C. Roehl, A. Chatterjee, and K. Ishijima (2017), The Orbiting Carbon Observatory (OCO-2) tracks 2-3 peta-gram increase in carbon release to the atmosphere during the 2014-2016 El Niño, *Scientific Reports*, 7, doi:10.1038/s41598-017-13459-0.
- Peters, E., G. Pinardi, A. Seyler, A. Richter, F. Wittrock, T. Bosch, M. Van Roozendaal, F. Hendrick, T. Drosoglou, A. F. Bais, Y. Kanaya, X. Y. Zhao, K. Strong, J. Lampel, R. Volkamer, T. Koenig, I. Ortega, O. Puentedura, M. Navarro-Comas, L. Gomez, M. Y. Gonzalez, A. Piter, J. Remmers, Y. Wang, T. Wagner, S. S. Wang, A. Saiz-Lopez, D. Garcia-Nieto, C. A. Cuevas, N. Benavent, R. Querel, P. Johnston, O. Postlyakov, A. Borovski, A. Elokhor, I. Bruchkouski, H. R. Liu, C. Liu, Q. Q. Hong, C. Rivera, M. Grutter, W. Stremme, M. F. Khokhar, J. Khayyam, and J. P. Burrows (2017), Investigating differences in DOAS retrieval codes using MAD-CAT campaign data, *Atmospheric Measurement Techniques*, 10(3), 955–978, doi:10.5194/amt-10-955-2017.
- Piret, L., S. Bertrand, E. Vandekerckhove, N. Harada, C. Moffat, and A. Rivera (2017), Gridded bathymetry to the Baker-Martinez fjord complex (Chile, 48°S) v1, *Figshare*, doi:10.6084/m9.figshare.5285521.v3.
- Ryu, Y., C. Jiang, H. Kobayashi, and M. Detto (2018), MODIS-derived global land products of shortwave radiation and diffuse and total photosynthetically active radiation at 5 km resolution from 2000, *Remote Sensing of Environment*, 204, 812–825, doi:10.1016/j.rse.2017.09.021.

I. Research Activities and Results

Research and Development Center for Global Change

- Saeki, T., and P. K. Patra (2017), Implications of overestimated anthropogenic CO₂ emissions on East Asian and global land CO₂ flux inversion, *Geoscience Letters*, 4, 9, doi:10.1186/s40562-017-0074-7.
- Sasakawa, M., T. Machida, K. Ishijima, M. Arshinov, P. K. Patra, A. Ito, S. Aoki, and V. Petrov (2017), Temporal Characteristics of CH₄ Vertical Profiles Observed in the West Siberian Lowland Over Surgut From 1993 to 2015 and Novosibirsk From 1997 to 2015, *J. Geophys. Res.-Atmos.*, 122(20), 11261–11273, doi:10.1002/2017jd026836.
- Sasaki, H., P. Klein, Y. Sasai, and B. Qiu (2017), Regionality and seasonality of submesoscale and mesoscale turbulence in the North Pacific Ocean, *Ocean Dynamics*, 67(9), 1195–1216, doi:10.1007/s10236-017-1083-y.
- Sato, H., and H. Kobayashi (2018), Topography Controls the Abundance of Siberian Larch Forest, *J. Geophys. Res.-Biogeo.*, 123(1), 106–116, doi:10.1002/2017jg004096.
- Saunio, M., P. Bousquet, B. Poulter, A. Peregon, P. Ciais, J. G. Canadell, E. J. Dlugokencky, G. Etiope, D. Bastviken, S. Houweling, G. Janssens-Maenhout, F. N. Tubiello, S. Castaldi, R. B. Jackson, M. Alexe, V. K. Arora, D. J. Beerling, P. Bergamaschi, D. R. Blake, G. Brailsford, L. Bruhwiler, C. Crevoisier, P. Crill, K. Covey, C. Frankenberg, N. Gedney, L. Hoglund-Isaksson, M. Ishizawa, A. Ito, F. Joos, H. S. Kim, T. Kleinen, P. Krummel, J. F. Lamarque, R. Langenfelds, R. Locatelli, T. Machida, S. Maksyutov, J. R. Melton, I. Morino, V. Naik, S. O'Doherty, F. J. Parmentier, P. K. Patra, C. H. Peng, S. S. Peng, G. P. Peters, I. Pison, R. Prinn, M. Ramonet, W. J. Riley, M. Saito, M. Santini, R. Schroeder, I. J. Simpson, R. Spahni, A. Takizawa, B. F. Thornton, H. Q. Tian, Y. Tohjima, N. Viovy, A. Voulgarakis, R. Weiss, D. J. Wilton, A. Wiltshire, D. Worthy, D. Wunch, X. Y. Xu, Y. Yoshida, B. W. Zhang, Z. Zhang, and Q. A. Zhu (2017), Variability and quasi-decadal changes in the methane budget over the period 2000–2012, *Atmos. Chem. Phys.*, 17(18), 11135–11161, doi:10.5194/acp-17-11135-2017.
- Seiki A., Y. N. Takayabu, T. Hasegawa, and K. Yoneyama (2017), Lack of westerly wind bursts in unmaterialized El Niño years, *Journal of Climate*, 31(2), 593–612, doi:10.1175/JCLI-D-17-0291.1.
- Sekiya, T., K. Miyazaki, K. Ogochi, K. Sudo, and M. Takigawa (2018), Global high-resolution simulations of tropospheric nitrogen dioxide using CHASER V4.0, *Geoscientific Model Development*, 11(3), 959–988, doi:10.5194/gmd-11-959-2018.
- Shi, L., O. Alves, R. Wedd, M. Balmaseda, Y. Chang, G. Chepurin, N. Ferry, Y. Fujii, F. Gaillard, S. Good, S. Guinehut, K. Haines, F. Hernandez, T. Lee, M. Palmer, K. A. Peterson, S. Masuda, A. Storto, T. Toyoda, M. Valdivieso, G. Vernieres, X. Wang, and Y. Yin (2017), An assessment of upper ocean salinity content from the Ocean Reanalyses Inter-comparison Project (ORA-IP), *Climate Dynamics*, 49(3), 1009–1029, doi:10.1007/s00382-015-2868-7.
- Shigemitsu, M., Y. Yamamoto, A. Oka, and Y. Yamanaka (2017), One possible uncertainty in CMIP5 projections of low-oxygen water volume in the Eastern Tropical Pacific, *Global Biogeochemical Cycles*, 31(5), 804–820, doi:10.1002/2016GB005447.
- Shimizu, K., K. Kimoto, K. Noshita, M. Wakita, T. Fujiki, and T. Sasaki (2017), Phylogeography of the pelagic snail *Limacina helicina* (Gastropoda: Thecosomata) in the subarctic western North Pacific, *Journal of Molluscan Studies*, 84(1), 30–37, doi:10.1093/mollus/eyx040.
- Shinoda, T., W. Han, L. Zamudio, R.-C. Lien, and M. Katsumata (2017), Remote ocean response to the Madden-Julian Oscillation during the DYNAMO field campaign: Impact on Somali current system and the Seychelles–Chagos thermocline ridge, *Atmosphere*, 8, 171.
- Shiozaki, T., D. Bombar, L. Riemann, F. Hashihama, S. Takeda, T. Yamaguchi, M. Ehama, K. Hamasaki, and K. Furuya (2017), Basin scale variability of active diazotrophs and nitrogen fixation in the North Pacific, from the tropics to the subarctic Bering Sea, *Global Biogeochemical Cycles*, 31(6), 996–1009, doi:10.1002/2017GB005681.
- Silva, R. A., J. J. West, J. F. Lamarque, D. T. Shindell, W. J. Collins, G. Faluvegi, G. A. Folberth, L. W. Horowitz, T. Nagashima, V. Naik, S. T. Rumbold, K. Sudo, T. Takemura, D. Bergmann, P. Cameron-Smith, R. M. Doherty, B. Josse, I. A. MacKenzie, D. S. Stevenson, and G. Zeng (2017), Future global mortality from

- changes in air pollution attributable to climate change, *Nature Climate Change*, 7, 647–651, doi:10.1038/Nclimate3427.
- Siswanto, E., H. J. Ye, D. Yamazaki, and D. L. Tang (2017), Detailed spatiotemporal impacts of El Niño on phytoplankton biomass in the South China Sea, *J. Geophys. Res.-Oceans*, 122(4), 2709–2723, doi:10.1002/2016jc012276.
- Son, T. P. H., T. V. Chung, N. H. Huan, N. M. Tien, V. V. Tac, N. H. T. Khang, N. T. T. Hoi, M. Herrmann, and E. Siswanto (2017), Abnormal features of oceanographic characteristics in upwelling Vietnam waters under impact of El Niño events, *Vietnam Journal of Earth Sciences*, 39(3), 225–239, doi:10.15625/0866-7187/39/3/10268.
- Storto, A., S. Masina, M. Balmaseda, S. Guinehut, Y. Xue, T. Szekely, I. Fukumori, G. Forget, Y. S. Chang, S. A. Good, A. Kohl, G. Vernieres, N. Ferry, K. A. Peterson, D. Behringer, M. Ishii, S. Masuda, Y. Fujii, T. Toyoda, Y. H. Yin, M. Valdivieso, B. Barnier, T. Boyer, T. Lee, J. Gourrion, O. Wang, P. Heimbach, A. Rosati, R. Kovach, F. Hernandez, M. J. Martin, M. Kamachi, T. Kuragano, K. Mogensen, O. Alves, K. Haines, and X. C. Wang (2017), Steric sea level variability (1993–2010) in an ensemble of ocean reanalyses and objective analyses, *Climate Dynamics*, 49(3), 709–729, doi:10.1007/s00382-015-2554-9.
- Sugie, K., and K. Kuma (2017), Change in the elemental composition and cell geometry of the marine diatom *Attheya longicornis* under nitrogen- and iron-depleted conditions, *Diatom Research*, 32(1), 11–20, doi:10.1080/0269249X.2017.1301999.
- Sugie, K., and K. Suzuki (2017), Characterization of the synoptic-scale diversity, biogeography and size distribution of diatoms in the North Pacific, *Limnology and Oceanography*, 62(3), 884–897, doi:10.1002/lno.10473.
- Sugiura, N. (2017), The Onsager-Machlup functional for data assimilation, *Nonlinear Processes in Geophysics*, 24(4), 701–712, doi:10.5194/npg-24-701-2017.
- Suzuki, K., M. Zupanski, and D. Zupanski (2017), A case study involving single observation experiments performed over snowy Siberia using a coupled atmosphere-land modelling system, *Atmospheric Science Letters*, 18(3), 106–111, doi:10.1002/asl.730.
- Takahata, N., Y. Tomonaga, Y. Kumamoto, M. Yamada, and Y. Sano (2018), Direct tritium emissions to the ocean from the Fukushima Dai-ichi nuclear accident, *Geochemical Journal*, 52(2), 211–217, doi:10.2343/geochemj.2.0499.
- Takata, K., P. K. Patra, A. Kotani, J. Mori, D. Belikov, K. Ichii, T. Saeki, T. Ohta, K. Saito, M. Ueyama, A. Ito, S. Maksyutov, S. Miyazaki, E. J. Burke, A. Ganshin, Y. Iijima, T. Ise, H. Machiya, T. C. Maximov, Y. Niwa, R. Oishi, H. Park, T. Sasai, H. Sato, S. Tei, R. Zhuravlev, T. Machida, A. Sugimoto, and S. Aoki (2017), Reconciliation of top-down and bottom-up CO₂ fluxes in Siberian larch forest, *Environmental Research Letters*, 12(12), doi:10.1088/1748-9326/aa926d.
- Tanimura, Y., C. Shimada, H. Ozawa, K. Kimoto, Y. Tanaka, and H. Itoh (2017), Seasonality and cell-size structure of diatoms in the Tsugaru Strait, northwest Pacific Ocean, *Diatom*, 33, 1–11, doi:10.11464/diatom.33.1.
- Tatebe, H., and S. Osafune (2018), Possible relationship between Pacific interdecadal climate variability and the periodic 18.6-year tidal oscillation in the ocean, *Oceanography in Japan*, 27(1), 3–18, doi:10.5928/kaiyou.27.1_3 (in Japanese with English abstract).
- Tei, S., A. Sugimoto, M. C. Liang, H. Yonenobu, Y. Matsuura, A. Osawa, H. Sato, J. Fujinuma, and T. Maximov (2017), Radial Growth and Physiological Response of Coniferous Trees to Arctic Amplification, *J. Geophys. Res.-Bioge.*, 122(11), 2786–2803, doi:10.1002/2016jg003745.
- Tei, S., A. Sugimoto, H. Yonenobu, Y. Matsuura, A. Osawa, H. Sato, J. Fujinuma, and T. Maximov (2017), Tree-ring analysis and modeling approaches yield contrary response of circumboreal forest productivity to climate change, *Global Change Biology*, 23(12), 5179–5188, doi:10.1111/gcb.13780.
- Toyoda, T., Y. Fujii, T. Kuragano, M. Kamachi, Y. Ishikawa, S. Masuda, K. Sato, T. Awaji, F. Hernandez, N. Ferry, S. Guinehut, M. J. Martin, K. A. Peterson, S. A. Good, M. Valdivieso, K. Haines, A. Storto, S. Masina, A. Kohl, H. Zuo, M. Balmaseda, Y. H. Yin, L. Shi, O. Alves, G. Smith, Y. S. Chang, G. Vernieres,

- X. C. Wang, G. Forget, P. Heimbach, O. Wang, I. Fukumori, and T. Lee (2017), Intercomparison and validation of the mixed layer depth fields of global ocean syntheses, *Climate Dynamics*, 49(3), 753–773, doi:10.1007/s00382-015-2637-7.
- Toyoda, T., Y. Fujii, T. Kuragano, N. Kosugi, D. Sasano, M. Kamachi, Y. Ishikawa, S. Masuda, K. Sato, T. Awaji, F. Hernandez, N. Ferry, S. Guinehut, M. Martin, K. A. Peterson, S. A. Good, M. Valdivieso, K. Haines, A. Storto, S. Masina, A. Kohl, Y. H. Yin, L. Shi, O. Alves, G. Smith, Y. S. Chang, G. Vernieres, X. C. Wang, G. Forget, P. Heimbach, O. Wang, I. Fukumori, T. Lee, H. Zuo, and M. Balmaseda (2017), Interannual-decadal variability of wintertime mixed layer depths in the North Pacific detected by an ensemble of ocean syntheses, *Climate Dynamics*, 49(3), 891–907, doi:10.1007/s00382-015-2762-3.
- Uno, I., K. Osada, K. Yumimoto, Z. Wang, S. Itahashi, X. L. Pan, Y. Hara, Y. Kanaya, S. Yamamoto, and T. D. Fairlie (2017), Seasonal variation of fine- and coarse-mode nitrates and related aerosols over East Asia: synergetic observations and chemical transport model analysis, *Atmos. Chem. Phys.*, 17(23), 14181–14197, doi:10.5194/acp-17-14181-2017.
- Wakita, M., A. Nagano, T. Fujiki, and S. Watanabe (2017), Slow acidification of the winter mixed layer in the subarctic western North Pacific, *Journal of Geophysical Research – Oceans*, 122(8), 6923–6935, doi:10.1002/2017JC013002.
- Watanabe, E., J. Onodera, M. Itoh, S. Nishino, and T. Kikuchi (2017), Winter transport of subsurface warm water toward the Arctic Chukchi Borderland, *Deep-Sea Research Part I-Oceanographic Research Papers*, 128, 115–130, doi:10.1016/j.dsr.2017.08.009.
- Watanabe, M., M. Noguchi, and T. Hajima (2018), Development of a marine ecosystem model to be embedded into an Earth system model, *The Journal of Geological Society of Japan*, 27(1), 31–41 (in Japanese), doi:10.5928/kaiyou.27.1_31.
- Wu, J., H. Kobayashi, S. C. Stark, R. Meng, K. Y. Guan, N. N. Tran, S. C. Gao, W. Yang, N. Restrepo-Coupe, T. Miura, R. C. Oliveira, A. Rogers, D. G. Dye, B. W. Nelson, S. P. Serbin, A. R. Huete, and S. R. Saleska (2018), Biological processes dominate seasonality of remotely sensed canopy greenness in an Amazon evergreen forest, *New Phytologist*, 217(4), 1507–1520, doi:10.1111/nph.14939.
- Yasunaka, S., Y. Nojiri, T. Hashioka, C. Yoshikawa, T. Kodama, S. Nakaoka, S. Chiba, F. Hashihama, M. Wakita, K. Furuya, D. Sasano, A. Murata, H. Uchida, and M. Aoyama (2018), Basin-scale distribution of NH_4^+ and NO_2^- in the Pacific Ocean, *Journal of Oceanography*, 74(1), 1–11. doi:10.1007/s10872-017-0433-1.
- Yasunaka, S., E. Siswanto, A. Olsen, M. Hoppema, E. Watanabe, A. Fransson, M. Chierici, A. Murata, S. K. Lauvset, R. Wanninkhof, T. Takahashi, N. Kosugi, A. M. Omar, S. van Heuven, and J. T. Mathis (2018), Arctic Ocean CO_2 uptake: an improved multiyear estimate of the air-sea CO_2 flux incorporating chlorophyll a concentrations, *Biogeosciences*, 15(6), 1643–1661, doi:10.5194/bg-15-1643-2018.
- Ye, H. J., J. Y. Sheng, D. L. Tang, E. Siswanto, M. A. Kalhor, and Y. Sui (2017), Storm-induced changes in pCO_2 at the sea surface over the northern South China Sea during Typhoon Wutip, *J. Geophys. Res.-Oceans*, 122(6), 4761–4778, doi:10.1002/2016jc012643.
- Yokoi, N., Y. Abe, M. Kitamura, M. C. Honda, and A. Yamaguchi (2018), Comparisons between POC and zooplankton swimmer flux from sediment traps in the subarctic and subtropical North Pacific, *Deep-Sea Research Part I-Oceanographic Research Papers*, 133, 19–26, doi:10.1016/j.dsr.2018.01.003.
- Yokoi, S., S. Mori, M. Katsumata, B. Geng, K. Yasunaga, F. Syamsudin, Nurhayati, and K. Yoneyama (2017), Diurnal cycle of precipitation observed in the western coastal area of Sumatra Island: Offshore preconditioning by gravity waves, *Monthly Weather Review*, 145, 3745–3760, doi:10.1175/MWR-D-16-0468.1.
- Yoshioka, H., H. Fudeyasu, T. Enomoto, M. Katsumata, A. Yamazaki, S. Yokoi, S. Tsujino, A. Masuda, and R. Shirooka (2017), The analysis of the initial data dependence on forecast experiments for the tropical cyclogenesis: The case study of typhoon Leepi (1304) observed by PALAU2013, *Tenki*, 64(12), 873–885 (in Japanese).
- Zhu, C. M., H. Kobayashi, Y. Kanaya, and M. Saito (2017), Size-dependent validation of MODIS MCD64A1

burned area over six vegetation types in boreal Eurasia: Large underestimation in croplands, *Scientific Reports*, 7, doi:10.1038/s41598-017-03739-0.

Publication with Peer Review (In-Press)

- Kamikawaji, Y., H. Matsuyama, K. Fukui, S. Hosoda, and S. Ono (2017), Quality control of ocean observation data using conditional random field, *Jinkochino gakkai ronbunshi*, 33, 3, 1–11 (in Japanese with English abstract).
- Hayashi, S., S. Ono, S. Hosoda, M. Numao, and K. Fukui (2017), Error Detection in Ocean Data considering Spatial Autocorrelation, *Jinkochino gakkai ronbunshi*, 33, 3, 1–10 (in Japanese with English abstract).

Publication without Peer Review (Published)

- Birchenough, S., T. Ono, and N. Harada (2017), Report of the Workshop on Understanding the Impacts and Consequences of Ocean Acidification for Commercial Species and End-Users (WKACIDUSE), *ICES WKACIDUSE Report 2016*.
- Chen, B., and S. L. Smith (2017), Modeling phytoplankton size structure and diversity using the "adaptive dynamics" approach, *Kaiyo monthly*, 49(8), 446–456 (in Japanese).
- Clayton, S., P. Gaube, T. Nagai, M. M. Omand, and M. Honda (2017), Fine-scale biophysical controls on nutrient supply, phytoplankton community structure, and carbon export in Western Boundary current regions, *US CLIVAR Variation*, 15(4), 17–22.
- Inoue, R. (2017), Strategic Observation at the Western North Pacific for Global Change, *POGO news letter*, 29, 1–1.
- García-Comas, C. (2017), Review and future perspectives of observational zooplankton functional trait studies, *Kaiyo Monthly*, 49(8), 457–463.
- Herman, R. (editor), D. Fu, S. Kulawik, K. Miyazaki, G. Osterman, K. Bowman, J. Worden, and TES team (2017), AIRS/OMI Validation Report, Version 1.0, *Jet Propulsion Laboratory, California Institute of Technology*.
- Hosoda, S. (2017), monitoring of oceanic change and current by global array "Argo", *Nagare*, 36, 5, 321–326 (in Japanese).
- Kanaya, Y. (2018), Field observations and numerical model analysis of air pollutants in the marine atmosphere: From Asia to the Arctic, *Journal of the Japan Institute of Marine Engineering*, 53(2), 172–176, doi: 10.5988/jime.53.172 (Japanese article).
- Kasai, Y., S. Hayashida, Y. Kanaya, K. Kita, H. Irie, N. Saitoh, and R. Imasu (2017), Chapter 7 Atmospheric Chemistry, Analysis of global trends related to future vision of Earth Observation, *Meteorological Research Note*, 234, 39–46, The Meteorological Society of Japan (Japanese article).
- Katsumata, K. (2017), Cold wind warms Southern Ocean, *Nature Climate Change*, 8, 16–18, doi:10.1038/s41558-017-0046-0.
- Katsumata, K. (2018), Antarctic Bottom Water and global ocean meridional overturning circulation, *Low Temperature Science*, 76, 1–12, doi:10.14943/lowtemsci.76.1 (in Japanese with English abstract)
- Kobayashi, T. (2017), Monitoring of deep sea, *Keisoku to seigyō*, 56, 5, 355–360 (in Japanese).
- Matsuoka, A., N. Suzuki, T. Ito, K. Kimoto, A. Tuji, R. Ichinohe and X. Li (2017), Excursion guide to the radiolarians of the East China Sea near Sesoko Island, Okinawa, Japan: An important research station for living radiolarian studies, *Science reports of Niigata University (Geology)*, 32, 103–123.
- Nagai, S., T. M. Saitoh, and K. N. Nasahara (2018), Development of phenology observations and land uses and land cover classification by integrating analysis of remote sensing and open-access data, *Journal of the Remote Sensing Society of Japan*, 38(2), 99–104, doi:10.11440/rssj.38.99 (Japanese article with English abstract).
- Noguchi, M., and E. Wada (2017), Tracing marine ecosystem dynamics and biogeochemical cycles using stable

I. Research Activities and Results

Research and Development Center for Global Change

isotope ratios, *Kaiyo monthly*, 49(8), 430–436 (in Japanese).

Patra, P. K. (2017), Study of the global cycle of greenhouse gases using atmospheric chemistry-transport model, *Tenki*, 64(11), 769–785 (Japanese article).

Zhang, D., M. F. Cronin, X. Lin, R. Inoue, A. J. Fassbender, S. P. Bishop, and A. Sutton (2017), Observing air-sea interaction in the western boundary currents and their extension regions: Considerations for OceanObs 2019, *US CLIVAR Variations*, 15, 4, 23–30.

Publication without Peer Review (In-Press)

Nagai, S., H. Kobayashi, and R. Suzuki (2018), Remote sensing of vegetation. Water-Carbon Dynamics in Eastern Siberia, Eds. T. Ohta, T. Hiyama, Y. Iijima, A. Kotani, TC. Maximov, *Springer*, in press.

Microbiological process in pelagic ecosystems

– Marine Functional Biology Group /

Research and Development Center for Marine Biosciences –

Microbes play important roles in major marine biogeochemical processes, such as nutrient cycles and inorganic/organic matter fluxes. However the dynamics of microbes are not used as parameters in global matter cycle models. To embed the contribution of microbes into a global matter cycle model, it is necessary to determine high-resolution geographical variations of their abundance, production and community composition of functional groups in the global pelagic systems. In this project, we examined both prokaryotic and viral abundance, prokaryotic community composition, and prokaryotic activity with depth and across regions to clarify prokaryote-mediated carbon flux mechanisms in the pelagic systems.

In FY2017, we conducted prokaryotic community analysis in the water columns of the Southern Ocean along 126 degrees west line from 68 degrees to 52 degrees south in MR16-09 cruise, in order to reveal geochemical and geophysical impacts of this pelagic realm on microbial ecosystems as follows.

- 1) To determine the microbial community composition and diversity throughout the water columns.
- 2) To estimate the impacts of biogeochemical cycles in the epipelagic layer to the abyssopelagic layer.

Microbiological processes throughout water column of the Southern Ocean

Prokaryotes play a major role in marine biogeochemical fluxes. Microbially mediated biogeochemical transformation rate is one of the major research topics in marine microbial ecology. However the linkages between prokaryotes activity and biogeochemistry in the epi-, meso-, bathy- and abyssopelagic layers are not systematically investigated despite of the efforts that highlighted the role of microbes in the cycling of inorganic/organic matter. In FY2017, we determined prokaryotic compositions in water samples taken along the water columns in the Southern Ocean transect of MR16-09 cruise (Fig.1). We here highlight a part of results of FY2017 research that distribution pattern of prokaryotic composition throughout water column of the Southern Ocean.

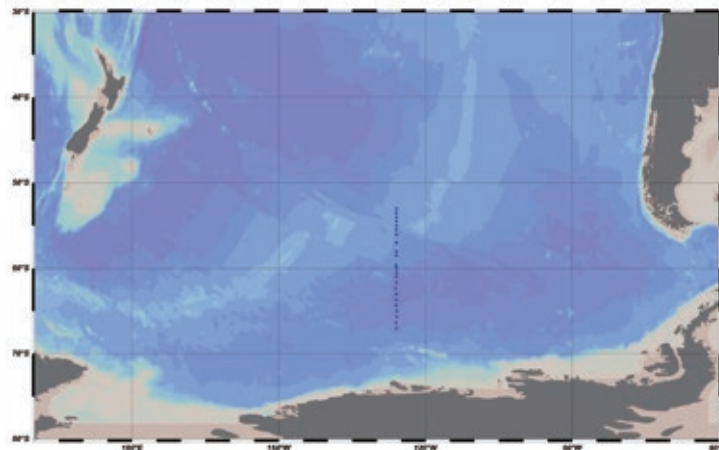


Fig.1 Sampling stations (blue dots) during MR16-09 cruise. This figure was created using Ocean Data View (<http://odv.awi.de/>).

Distribution patterns of prokaryotic diversity and community composition in the surface, meso-, bathy- and abyssopelagic layers of the Southern Ocean along the 125 degrees west.

The results showed that depth profiles of prokaryotic abundance and diversity in the Southern Ocean display similar vertical patterns of general pelagic ocean systems (Fig.2). The abundance of prokaryotes exponentially decreased with increasing water depth, from an average of 2.9×10^5 cells mL⁻¹ in the epipelagic layer to 1.8×10^4 cells mL⁻¹ in the abyssopelagic layer (Fig.2a). Number of OTUs of prokaryotes increased from the epipelagic layer to abyssopelagic layer, and presented more latitudinal variation below the mesopelagic layer (Fig.2b). Diversity index (Shannon) also increased with increasing water depth and harbored more latitudinal variation below the mesopelagic layer (Fig.2c).

The predominant prokaryotic phylotypes (94 OTUs out of 9369 OTUs) were identified by SSU rRNA gene amplicon sequencing. A clustering analysis of the predominant phylotypes showed depth-dependent distribution pattern (Fig.3). Prokaryotic community in the epipelagic layer were distinct from the other layers, and the other communities also showed the depth dependent clustering pattern.

The data set revealed the distinct patterns of both prokaryotic diversity and community composition along the depth, and substantial variations of latitudinal pattern of prokaryotic diversity in the Southern Ocean realm.

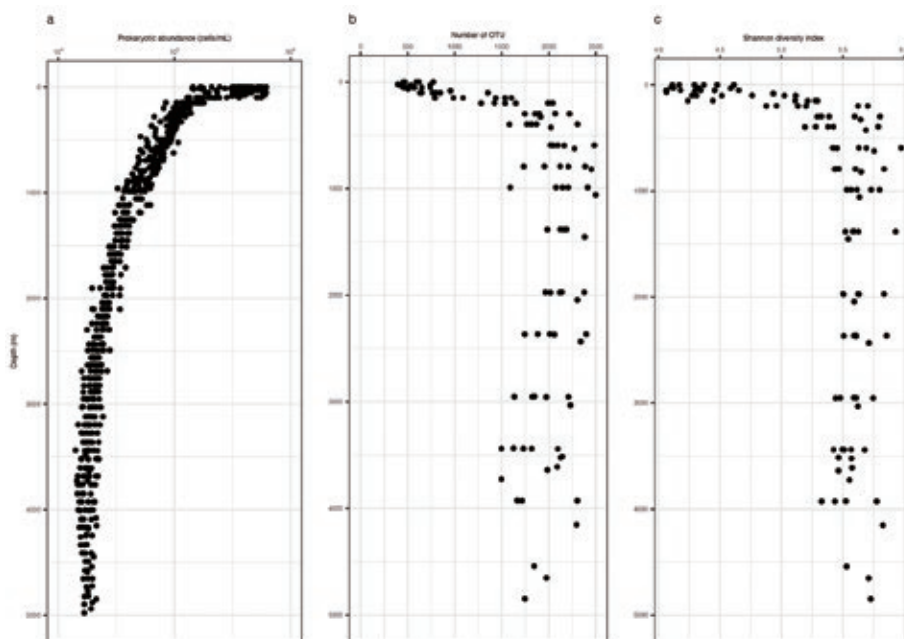


Fig.2 Depth profiles of prokaryotic abundance (a), Number of phylotypes ($\geq 97\%$ similarity, UNOISE3) (b) and Shannon diversity index (c) in the Southern Ocean through the water column.

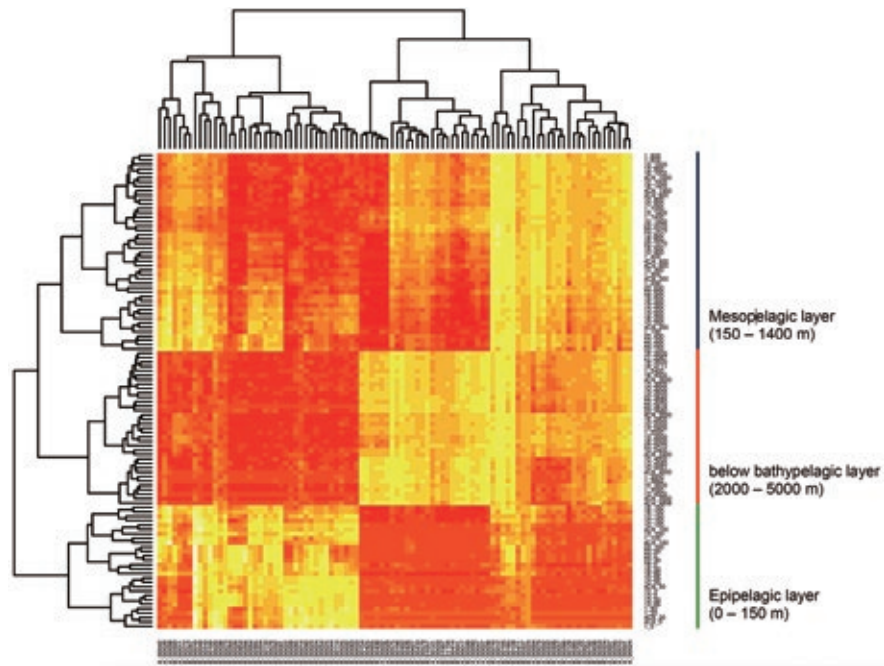


Fig.3 Heatmap representing the abundance (number of reads) of the dominant phylotypes (columns) among the sampling stations (rows).

Climate and ocean variability and predictability studies for societal applications

– Application Laboratory –

Research studies are carried out in the laboratory to improve our understandings of the ocean and climate processes and to improve the predictability of the ocean and climate variations. Researchers at the laboratory have been developing various kinds of ocean/climate models, data analysis tools, and data assimilation techniques to help in the analysis and predictions of ocean and climate variations on times scales of days to decades.

Seasonal to interannual climate predictions based on the SINTEX-F coupled model are regularly produced by the Climate Variability Prediction and Application Research Group (CVPARG). The SINTEX-F model of CVPARG has successfully predicted the occurrence of a positive IOD in the summer of 2017. On the other hand, though the model, initialized in spring and summer, has also predicted a moderate El Niño that condition did not evolve after an initial warming observed in early summer. Nevertheless, initialized in fall, the model successfully predicted a weak La Niña that was observed toward the end of the year.

Our ocean weather forecasts, similarly to atmospheric weather forecasts, are regularly produced by the Environmental Variability Prediction and Application Research Group (EVPARG) in the lab based on the Japan Coastal Ocean Prediction Experiment (JCOPE) system developed at EVPARG. The JCOPE has predicted a Kuroshio large meander in August 2017. The meander was predicted to intensify in September 2017 (Fig.1) before reaching its peak in October 2017. This prediction was reported in several in-house blogs (e.g. <http://www.jamstec.go.jp/aplinfo/kowatch/?p=5076>). A large meander did appear finally in the summer/autumn of 2017, for the first time in the last 13 years. That time, the meander was seen in the August of 2004 and lasted for almost a year. The 2017 Kuroshio meander is reported to have a significant impact on the fisheries, ship routing and local weather in the region and has, therefore, drawn a lot of media and public attention.

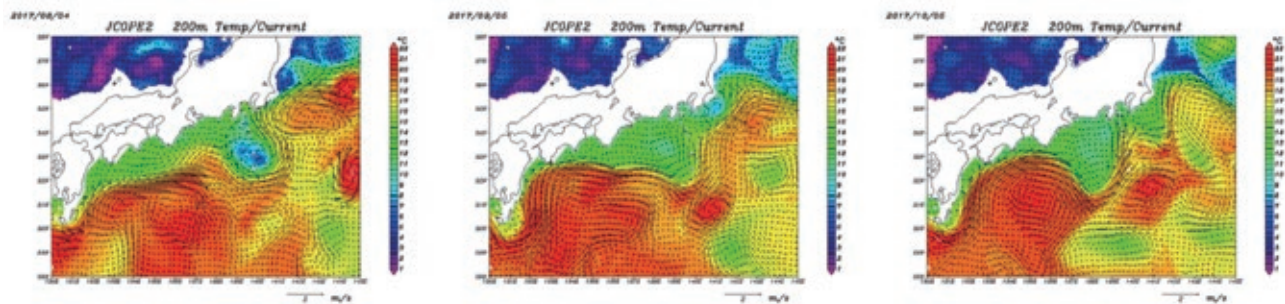


Fig.1 (a) JCOPE subsurface current and temperature at 200m depth showing the boreal-autumn evolution of Kuroshio meander during August-October 2017 (from left to right), predicted on 3 August 2017. <http://www.jamstec.go.jp/jcope/>

Several fascinating research studies were also reported by CVPARG and EVPARG researchers. For example, by conducting atmospheric general circulation model (AGCM) experiments with the AFES model, *Yoshida and Minobe* [2017] reported impact of sea surface temperature (SST) front on the extra-tropical storm tracks. Using the results of the SINTEX-F coupled model, *Morioka et al.* [2018a] have found that the sea ice in the Weddell Sea has a significant impact on the atmospheric and climate variability of that region. The SINTEX-F coupled model also exhibited high skills in the prediction of decadal climate variations in the southern Atlantic and Indian Oceans [*Morioka et al.* 2018b]. Further, by assimilating subsurface ocean data into the prediction system, *Doi et al.* [2017] reported better skills in the predictions of the Indian Ocean Dipole (IOD). In other studies, *Richter et al.* [2017] discussed the role of seasonal migration of the ITCZ in equatorial Atlantic variability, *Sasaki et al.* [2017] explored the seasonality of sub-mesoscale and mesoscale turbulence in the North Pacific Ocean, *Behera et al.* [2017] reported a quasi-asymmetric Indian monsoon rainfall response to the IOD, *Zhang et al.* [2017] studied East China Sea water exchange and *Chang et al.* [2017] explored the formation processes of phytoplankton growth and decline in mesoscale eddies in the western North Pacific Ocean.

Climate link to malaria incidence in South Africa

Malaria poses a great challenge to public health and the sustenance of human wellbeing in many parts of the world. It affects several hundred million people, every year. Apparently, anthropogenic global warming is expanding the spatio-temporal extent of the disease; incidences are now reported beyond the tropics and in non-endemic seasons. This emerging trend of climate change has increased the malaria risk factor for millions more across the globe. While global warming remains a key factor to address future adaptation and mitigation measures, the existing association between climate variation and malaria prevalence needs careful observation and analysis, in addition to non-climatic factors.

In a study conducted under the SATREPS framework, supported by JICA and AMED and in collaboration with Nagasaki University, ACCESS and several other institutions in South Africa, Ikeda *et al.* [2017] investigated the impact of climate variations on the interannual variability of malaria incidence in South Africa. In South Africa, malaria is endemic in the northeastern provinces of Limpopo, KwaZulu-Natal, Mpumalanga. Incidence is particularly high in the northeastern districts of Limpopo province, which neighbor Mozambique, Zimbabwe and Botswana. Malaria prevalence in those districts is distinctly seasonal, with most of the cases reported during the warm and rainy months of September- May, with the seasonal peak in temperature and rainfall coinciding with that in malaria incidence. Results from Ikeda *et al.* [2017] suggest that climate anomalies in the tropical Pacific (La Niña) and the southern Indian Ocean (subtropical dipole) bring changes in precipitation and temperature in South Africa, which then affect malaria incidence a few months later. Taking advantage of this delayed effect, a malaria prediction model was developed based on statistical relationships and by utilizing artificial intelligence and machine learning techniques. These predictions are expected to be extended for a lead time of a couple of seasons by utilizing the SINTEX-F climate predictions. The malaria model forecast will then be utilized in an early warning system to mitigate malaria outbreaks in the affected regions of South Africa.

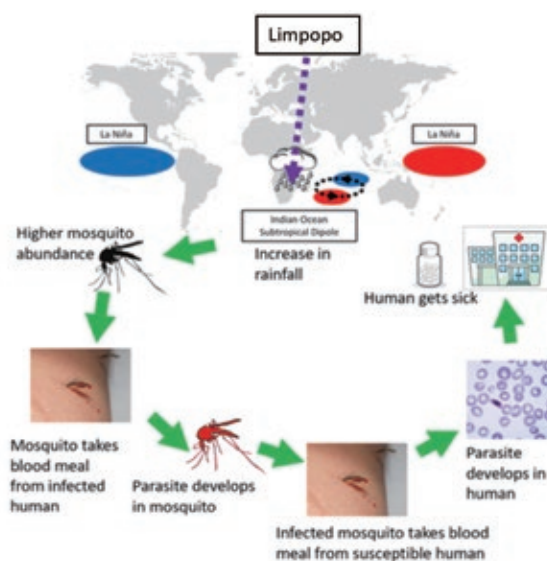


Fig.2 Schematic diagram showing climate the impact of climate conditions on malaria incidence in South Africa. La Niña or Indian Ocean subtropical dipole events increase rainfall in South Africa, which leads to increased mosquito abundance. When a female mosquito takes a blood meal from an infected human, the parasite develops in the mosquito. Subsequently, the infected mosquito can spread the disease when it takes a blood meal from another human. The parasite then develops in the human, making him/her sick requiring medical treatment.

Role of mesoscale eddies in the migration of Japanese eel larvae

The relationship of oceanic mesoscale eddies to marine animals has been recognized for decades. Mesoscale eddies have been observed to be a favorable habitat for marine organisms such as fish larvae and penguins due to their abundant bioproductivity. Particularly, it is suggested that migratory fishes display affinities for fronts and eddies.

Chang et al. [2017] have examined the dynamical role of mesoscale eddies in the migration of Japanese eel larvae in the western North Pacific by taking the example of fish larvae migration associated with eddies in the Subtropical Counter Current. An idealized experiment is conducted to isolate the effects of eddies, and use a three-dimensional particle-tracking method to simulate virtual eel larvae (v-larvae) migration, including swimming behavior.

It is found that the impact of eddies strongly depends on the swimming speed of v-larvae relative to the eddy speed. v-larvae speeds are accelerated by the eddies when they swim slower than the propagation speed of the eddy. On the other hand, v-larvae are dragged by eddies when they swim faster than eddies.

The non-uniform trapping of v-larvae in mesoscale eddies are explained by a modified stream function that incorporates biological swimming ability. A high swimming speed and/or a small eddy rotation speed results in a weak trapping capacity. Simulations of v-larvae migration in realistic eddy fields indicate that the abundance of eddies significantly affects the duration of larval migration, the effect being largely dependent on the larvae swimming speed. A negative relationship is noted between the observed annual eel recruitment index in Taiwan and the eddy index of the subtropical countercurrent region, which suggests a potentially important role of mesoscale eddies in eel larvae migration.

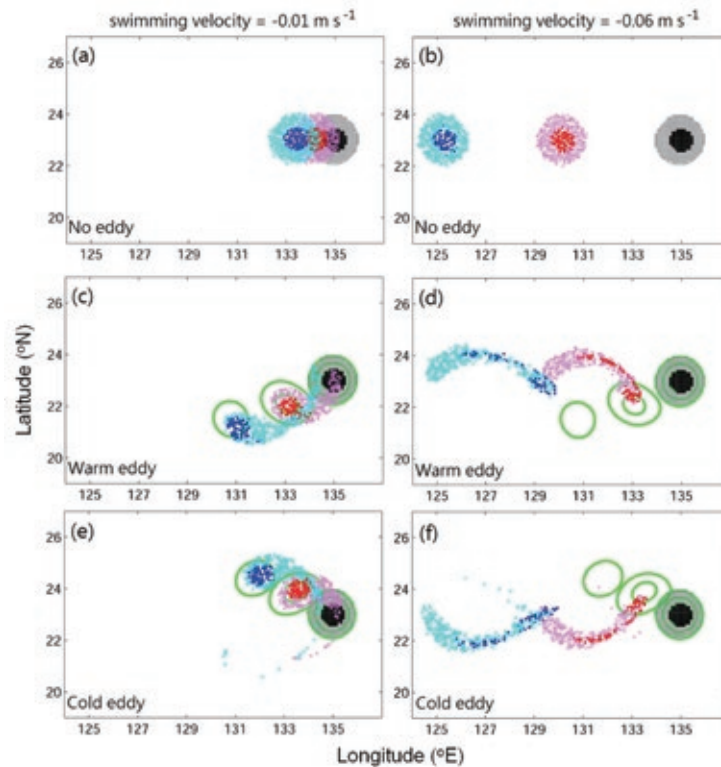


Fig.3 Distributions of v-larvae on day 0 (black, gray), day 100 (red, pink), and day 200 (blue, cyan) for swimming speeds of (left) 0.01 m s^{-1} and (right) 0.06 m s^{-1} , under conditions of (a, b) no eddy, (c, d) warm eddy, and (e, f) cold eddy based on the idealized experiments. Green contours are the sea surface height anomalies, showing the positions of eddies. Dark and light colors indicate v-larvae originating from the inner and outer core of the eddy, respectively.

Publication List

Publication with Peer Review (Published)

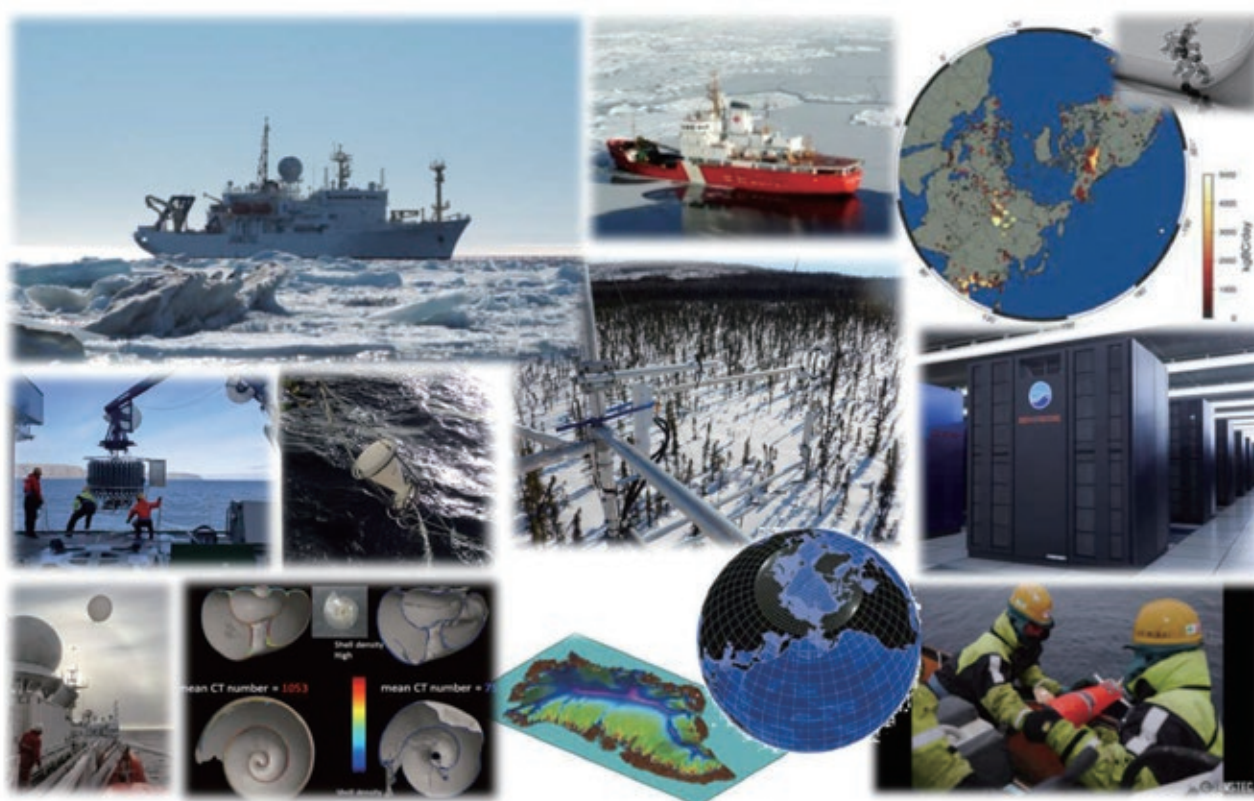
- Annamalai, H., B. Taguchi, J. P. McCreary, M. Nagura, and T. Miyama (2017), Systematic Errors in South Asian Monsoon Simulation: Importance of Equatorial Indian Ocean Processes, *Journal of Climate*, 30(20), 8159–8178, doi:10.1175/JCLI-D-16-0573.1.
- Behera, S. K., and J. V. Ratnam (2018), Quasi-asymmetric response of the Indian summer monsoon rainfall to opposite phases of the IOD, *Scientific Reports*, 8, doi:10.1038/s41598-017-18396-6.
- Chang, Y.-L., Y. Miyazawa, and M. Beguer-Pon (2017), The dynamical impact of mesoscale eddies on migration of Japanese eel larvae, *PLOS ONE*, 12(3), doi:10.1371/journal.pone.0172501.
- Chang, Y.-L., Y. Miyazawa, L. Y. Oey, T. Kodaira, and S. M. Huang (2017), The formation processes of phytoplankton growth and decline in mesoscale eddies in the western North Pacific Ocean, *Journal of Geophysical Research-Oceans*, 122(5), 4444–4455, doi:10.1002/2017JC012722.
- Doi, T., A. Storto, S. K. Behera, A. Navarra, and T. Yamagata (2017), Improved Prediction of the Indian Ocean Dipole Mode by Use of Subsurface Ocean Observations, *Journal of Climate*, 30(19), 7953–7970, doi:10.1175/JCLI-D-16-0915.1.
- Furue, R., K. Guerreiro, H. E. Phillips, J. P. McCreary, and N. L. Bindoff (2017), On the Leeuwin Current System and Its Linkage to Zonal Flows in the South Indian Ocean as Inferred from a Gridded Hydrography, *Journal of Physical Oceanography*, 47(3), 583–602, doi:10.1175/JPO-D-16-0170.1.
- Ikeda, T., S. K. Behera, Y. Morioka, N. Minakawa, M. Hashizume, A. Tsuzuki, R. Maharaj, and P. Kruger (2017), Seasonally lagged effects of climatic factors on malaria incidence in South Africa, *Scientific Reports*, 7(2458), doi:10.1038/s41598-017-02680-6.
- Kataoka, T., T. Tozuka, and T. Yamagata (2017), Generation and Decay Mechanisms of Ningaloo Niño/Niña, *Journal of Geophysical Research-Oceans*, 122(11), 8913–8932, doi:10.1002/2017JC012966.
- Kuwano-Yoshida, A., and S. Minobe (2017), Storm-Track Response to SST Fronts in the Northwestern Pacific Region in an AGCM, *Journal of Climate*, 30(3), 1081–1102, doi:10.1175/JCLI-D-16-0331.1.
- Kuwano-Yoshida, A., H. Sasaki, and Y. Sasai (2017), Impact of explosive cyclones on the deep ocean in the North Pacific using an eddy-resolving ocean general circulation model, *Geophysical Research Letters*, 44(1), 320–329, doi:10.1002/2016GL071367.
- Miyazawa, Y., S. M. Varlamov, T. Miyama, X. Y. Guo, T. Hihara, K. Kiyomatsu, M. Kachi, Y. Kurihara, and H. Murakami (2017), Assimilation of high-resolution sea surface temperature data into an operational nowcast/forecast system around Japan using a multi-scale three-dimensional variational scheme, *Ocean Dynamics*, 67(6), 713–728, doi:10.1007/s10236-017-1056-1.
- Morioka, Y., T. Doi, and S. K. Behera (2018), Decadal climate predictability in the southern Indian Ocean captured by SINTEX-F using a simple SST-nudging scheme, *Scientific Reports*, 8 (1029), doi:10.1038/s41598-018-19349-3.
- Morioka, Y., F. Engelbrecht, and S. K. Behera (2018), Role of Weddell Sea ice in South Atlantic atmospheric variability, *Climate Research* 74(2), 171–184, doi:10.3354/cr01495.
- Ogata, T., M. Nagura, and Y. Masumoto (2017), Mean Subsurface Upwelling Induced by Intraseasonal Variability over the Equatorial Indian Ocean, *Journal of Physical Oceanography*, 47(6), 1347–1365, doi:10.1175/JPO-D-16-0257.1.
- Ratna, S. B., J. V. Ratnam, S. K. Behera, F. T. Tangang, and T. Yamagata (2017), Validation of the WRF regional climate model over the subregions of Southeast Asia: climatology and interannual variability, *Climate Research*, 71(3), 263–280, doi:10.3354/cr01445.
- Ratnam, J. V., S. K. Behera, R. Krishnan, T. Doi, and S. B. Ratna (2018), Sensitivity of Indian summer monsoon simulation to physical parameterization schemes in the WRF model, *Climate Research*, 74(1), 43–66, doi:10.3354/cr01484.
- Richter, I., S. P. Xie, Y. Morioka, T. Doi, B. Taguchi, and S. K. Behera (2017), Phase locking of equatorial Atlantic

- variability through the seasonal migration of the ITCZ, *Climate Dynamics*, 48, 3615–3629, doi:10.1007/s00382-016-3289-y.
- Sahu, N., A. W. Robertson, R. Boer, S. K. Behera, D. G. DeWitt, K. Takara, M. Kumar, and R. B. Singh (2017), Probabilistic seasonal streamflow forecasts of the Citarum River, Indonesia, based on general circulation models, *Stochastic Environmental Research and Risk Assessment*, 31(7), 1747–1758, doi:10.1007/s00477-016-1297-4.
- Sasaki, H., P. Klein, Y. Sasai, and B. Qiu (2017), Regionality and seasonality of submesoscale and mesoscale turbulence in the North Pacific Ocean, *Ocean Dynamics*, 67(9), 1195–1216, doi:10.1007/s10236-017-1083-y.
- Taguchi, B., N. Schneider, M. Nonaka, and H. Sasaki (2017), Decadal Variability of Upper-Ocean Heat Content Associated with Meridional Shifts of Western Boundary Current Extensions in the North Pacific, *Journal of Climate*, 30(16), 6247–6264, doi:10.1175/JCLI-D-16-0779.1.
- Yamazaki, D., D. Ikeshima, R. Tawatari, T. Yamaguchi, F. O'Loughlin, J. C. Neal, C. C. Sampson, S. Kanae, and P. D. Bates (2017), A high-accuracy map of global terrain elevations, *Geophysical Research Letters*, 44(11), 5844–5853, doi:10.1002/2017GL072874.
- Zhang, J., X. Y. Guo, L. Zhao, Y. Miyazawa, and Q. Sun (2017), Water Exchange across Isobaths over the Continental Shelf of the East China Sea, *Journal of Physical Oceanography*, 47(5), 1043–1060, doi:10.1175/JPO-D-16-0231.1.

Changing Arctic

– Institute of Arctic Climate and Environment Research –

The decrease of Arctic sea ice is attributed to the effects of “global warming.” The Arctic is the world region that is warming the most. Warming in the Arctic will proceed at least twice as fast as the world average. Such rapid change will not only reduce sea ice, but also drive the melting of permafrost, glaciers, and ice sheets. Further, this is having impacts on not only the Arctic Ocean and its surrounding region, but also on oceans and countries around the world, including Japan. Change in the Arctic climate will bring about change in the ecosystems of marine organisms living there. In fact, changes occurring in the Arctic Ocean, where the effects of global warming are quickly manifested, could at some time occur in the world’s other oceans. Arctic problems are no longer confined to countries bordering the Arctic Ocean; so, we must think of these problems as global, affecting the whole world. The Japan Agency for Marine-Earth Science and Technology (JAMSTEC), which had been conducting Arctic research since the 1990s, established the Institute of Arctic Climate and Environment Research (IACE) in April 2015 to further expedite its Arctic research and to broadly benefit international society.



Winter transport of subsurface warm water toward the Arctic Chukchi Borderland

The Arctic sea ice retreat is remarkable, particularly in the Pacific side. Changes in wind-driven export of the Arctic sea ice to the North Atlantic and atmospheric heat fluxes are known to be important factors for sea ice reduction. In addition, ocean heat transport from sub-arctic seas is another candidate to decrease sea ice volume. It has been indicated that the subsurface temperature maximum in the Canada Basin reflected intrusion of the Pacific summer water. Substantial parts of upper ocean heat have a potential to affect sea ice freezing/melting. However, spatial and temporal variabilities in the corresponding warm water transport still remain uncertainties.

In the present study, winter transport of subsurface warm water toward the Arctic Chukchi Borderland was investigated by mooring measurements and modeling analyses [Watanabe *et al.*, 2017]. In mid-winter or spring of 2011–2014, subsurface warming signals under sea ice were detected by the multi-year bottom-tethered mooring data in the Chukchi Abyssal Plain (CAP) of the western Chukchi Borderland. Lateral advection of shelf-origin ocean heat is a key process for the subsurface warming. To address the detailed pathways and processes of subsurface warm water transport, an interannual experiment for 2001–2014 was performed using a pan-Arctic sea ice–ocean model “COCO (Center for Climate System Research Ocean Component Model) version 4.9” configured in a high-resolution framework. The horizontal grid size was set to approximately 5 km so that narrow intense currents along complex sharp topography could be resolved. The model result captured the similar seasonality of subsurface temperature in the CAP region and produced interannual variability in the ocean heat content associated with the shelf-origin water distribution around the Chukchi Borderland. In addition to the Barrow Canyon throughflow, westward jet streams along the steep flank of the Chukchi shelf break constituted a primary pathway for the subsurface warm water transport toward the Chukchi Borderland. Since the shelf break jet was much faster than main streams of the Beaufort Gyre, its individual role as an efficient ocean heat conveyor should be considered separately. Whereas ocean heat in the Chukchi shelf break region was partly lost via wind-driven turbulent mixing into upper halocline depths, a substantial amount of the subsurface warm water remained even after mid-winter. The highly stratified condition due to anomalous sea ice meltwater was further preferable for the winter heat transport.



Fig.1 IACE mooring locations of Stations Chukchi Abyssal Plain (CAP), Northwind Abyssal Plain (NAP), and Barrow Canyon (BC) are indicated by red, blue, and green dots, respectively.

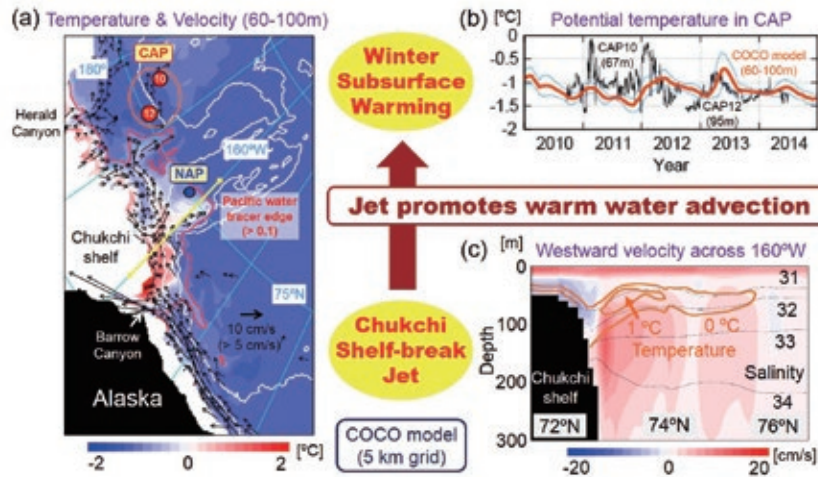


Fig.2 (a) The simulated ocean (shade) temperature [°C] and (vectors) horizontal velocity faster than 5 cm/s at 60–100 m in January 2013. White contours show the seafloor depths of 1,000 and 3,000 m. Red contours show the Pacific water tracer edge defined by the concentration of 0.1. (b) Interannual time series of potential temperature (black) measured by mooring and (orange) produced by the COCO model in the Chukchi Abyssal Plain from 2010 to 2014. (c) Vertical profiles of the simulated (shade) westward ocean velocity [cm/s], (orange contours) potential temperature, and (black contours) salinity across the Chukchi shelf break in January 2013.

Reference

Watanabe, E., J. Onodera, M. Itoh, S. Nishino, and T. Kikuchi (2017), Winter transport of subsurface warm water toward the Arctic Chukchi Borderland, *Deep Sea Res. I*, 128, 115–130.

Technology development for under-ice measurement in the Arctic Ocean

We started development of an underwater smart drone (USD) for under-ice measurement in this fiscal year, a year earlier than originally planned. This drone will enable us to extend its observation range over 10 km from ice edge, and be equipped with a camera and a multi-beam sonar for observation of ice bottom shape, a CTD meter and a fluoro-turbidity meter. The first test run in ice-covered sea will be launched as early as FY2019. A great difficulty in drone operation under ice is measurement of position of the drone. Traditional acoustical positioning from a support vessel is only available in range of a few kilometers from ice edge. We have thus proposed a new under ice positioning method using low frequency (LF) electromagnetic wave (EMW), addressing the study of underwater antennas and propagations since 2016. In March, 2018, we carried out an under-ice propagation test in Saroma Lake which is a brackish-water lake and found that LF EMW can travel distance of over 50 m under-ice in a lateral direction. A part of the works was awarded from the International Symposium on Antennas and Propagation [Sato *et al.*, 2017]. In the work, simulation and experiment were performed for the antennas: 1) an electrode antenna, 2) a full sheath antenna, and 3) a half-sheath antenna as shown in Fig.3. The result realizes that the half sheath antenna has the best performance in impedance matching and transmission efficiency (Fig.4).

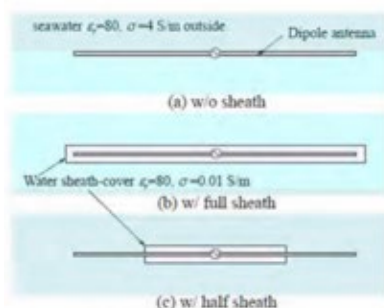


Fig.3 Underwater antenna configurations. (a) sheath less or electrode antenna, (b) full sheath antenna, and (c) half sheath antenna.

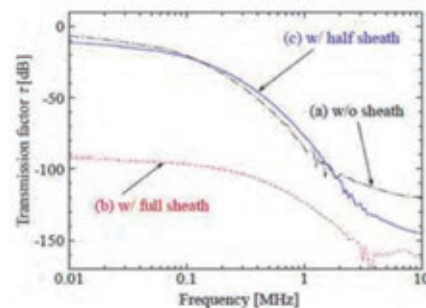


Fig.4 Efficiency of underwater transmission obtained by the simulation for each antenna.

Reference

Sato, H., et al., Dipole antenna with sheath-cover for seawater use, Proc. ISAP 2017, POS1, 1376, Phuket, Thailand, Oct. 2017.

Publication List**Publication with Peer Review**

- Fisher, R. A., C. D. Koven, W. R. L. Anderegg, B. O. Christoffersen, M. C. Dietze, C. E. Farrior, J. A. Holm, G. C. Hurtt, R. G. Knox, P. J. Lawrence, J. W. Lichstein, M. Longo, A. M. Matheny, D. Medvigy, H. C. Muller-Landau, T. L. Powell, S. P. Serbin, H. Sato, J. K. Shuman, B. Smith, A. T. Trugman, T. Viskari, H. Verbeeck, E. Weng, C. Xu, X. Xu, T. Zhang, and P. R. Moorcroft (2017), Vegetation Demographics in Earth System Models: a review of progress and priorities, *Global Change Biology*, 24(1), 35–54, doi:10.1111/gcb.13910.
- Fujiwara, A., S. Nishino, K. Matsuno, J. Onodera, Y. Kawaguchi, T. Hirawake, K. Suzuki, J. Inoue, and T. Kikuchi (2018), Changes in phytoplankton community structure during wind-induced fall bloom on the central Chukchi shelf, *Polar Biology*, 41(6), 1279–1295, doi:10.1007/s00300-018-2284-7.
- Gourmelen, N., D. N. Goldberg, K. Snow, S. F. Henley, R. G. Bingham, S. Kimura, A. E. Hogg, A. Shepherd, J. Mougnot, J. T. M. Lenaerts, S. R. M. Ligtenberg, and W. J. van de Berg (2017), Channelized Melting Drives Thinning Under a Rapidly Melting Antarctic Ice Shelf, *Geophysical Research Letters*, 44(19), 9796–9804, doi:10.1002/2017GL074929.
- Guan, K., S. P. Good, K. K. Caylor, D. Medvigy, M. Pan, E. F. Wood, H. Sato, M. Biasutti, M. Chen, A. Ahlström, and X. Xu (2017), Simulated sensitivity of African terrestrial ecosystem photosynthesis to rainfall frequency, intensity, and rainy season length, *Environmental Research Letters*, 13(2), doi:10.1088/1748-9326/aa9f30.
- Ichii, K., M. Ueyama, M. Kondo, N. Saigusa, J. Kim, M. C. Alberto, J. Ardö, E. S. Euskirchen, M. Kang, T. Hirano, J. Joiner, H. Kobayashi, L. B. Marchesini, L. Merbold, A. Miyata, T. M. Saitoh, K. Takagi, A. Varlagin, M. S. Bret-Harte, K. Kitamura, Y. Kosugi, A. Kotani, K. Kumar, S.-G. Li, T. Machimura, Y. Matsuura, Y. Mizoguchi, T. Ohta, S. Mukherjee, Y. Yanagi, Y. Yasuda, Y. Zhang, and F. Zhao (2017), New data-driven estimation of terrestrial CO₂ fluxes in Asia using a standardized database of eddy covariance measurements, remote sensing data, and support vector regression, *Journal of Geophysical Research – Biogeosciences*, 122(4), 767–795, doi:10.1002/2016JG003640.
- Kawai, Y., M. Katsumata, K. Oshima, M. E. Hori, and J. Inoue (2017), Comparison of Vaisala radiosondes RS41 and RS92 launched over the oceans from the Arctic to the tropics, *Atmospheric Measurement Techniques*, 10(7), 2485–2498, doi:10.5194/amt-10-2485-2017.
- Kimura, S., A. Jenkins, H. Regan, P. R. Holland, K. M. Assmann, D. B. Whitt, M. V. Wessem, W. J. van de Berg, C. H. Reijmer, and P. Dutrieux (2017), Oceanographic Controls on the Variability of Ice-Shelf Basal Melting and Circulation of Glacial Meltwater in the Amundsen Sea Embayment, Antarctica, *Journal of Geophysical Research – Oceans*, 122(12), 10131–10155, doi:10.1002/2017JC012926.
- Kobayashi, H., H. Nagano, Y. Kim, and R. Suzuki (2018), Comparison of Gap Fraction and Leaf Area Index Measurements Under Clear and Cloudy Sky Conditions in Alaska Spruce Forests, *Journal of The Remote Sensing Society of Japan*, 38(1), 44–50, doi:10.1144/rssj.38.44 (in Japanese).
- Köhler, P., L. Guanter, H. Kobayashi, S. Walther, and W. Yang (2017), Assessing the potential of sun-induced fluorescence and the canopy scattering coefficient to track large-scale vegetation dynamics in Amazon forests, *Remote Sensing of Environment*, 204, 769–785, doi:10.1016/j.rse.2017.09.025.
- Kosugi, N., D. Sasano, M. Ishii, S. Nishino, H. Uchida, and H. Yoshikawa-Inoue (2017), Low pCO₂ under sea-ice melt in the Canada Basin of the western Arctic Ocean, *Biogeosciences*, 14, 5727–5739, doi:10.5194/bg-14-5727-2017.
- Kudo, K., K. Yamada, S. Toyoda, N. Yoshida, D. Sasano, N. Kosugi, M. Ishii, H. Yoshikawa, A. Murata, H. Uchida, and S. Nishino (2018), Spatial distribution of dissolved methane and its source in the western

- Arctic Ocean, *Journal of Oceanography*, 74(3), 305–317, doi:10.1007/s10872-017-0460-y.
- Kumamoto, Y., M. Aoyama, Y. Hamajima, S. Nishino, A. Murata, and T. Kikuchi (2017), Radiocesium in the western subarctic area of the North Pacific Ocean, Bering Sea, and Arctic Ocean in 2013 and 2014, *Applied Radiation and Isotopes*, 126, 88–92, doi:10.1016/j.apradiso.2017.02.036.
- Landeira, J. M., K. Matsuno, A. Yamaguchi, T. Hirawake, and T. Kikuchi (2017), Abundance, development stage, and size of decapod larvae through the Bering and Chukchi Seas during summer, *Polar Biology*, 40(9), 1805–1819, doi:10.1007/s00300-017-2103-6.
- Nagano, H., H. Ikawa, T. Nakai, M. Matsushima-Yashima, H. Kobayashi, Y. Kim, and R. Suzuki (2017), Extremely dry environment down-regulates nighttime respiration of a black spruce forest in Interior Alaska, *Agricultural and Forest Meteorology*, 249, 297–309, doi:10.1016/j.agrformet.2017.11.001.
- Natsuike, M., R. Saito, A. Fujiwara, K. Matsuno, A. Yamaguchi, N. Shiga, T. Hirawake, T. Kikuchi, S. Nishino, and I. Imai (2017), Evidence of increased toxic *Alexandrium tamarense* dinoflagellate blooms in the eastern Bering Sea in the summers of 2004 and 2005, *PLoS One*, 12(11), 1–13, doi:10.1371/journal.pone.0188565.
- Ono, J., H. Tatebe, Y. Komuro, M. I. Nodzu, and M. Ishii (2018), Mechanisms influencing seasonal-to-interannual prediction skill of sea ice extent in the Arctic Ocean in MIROC, *The Cryosphere*, 12(2), 675–683, doi:10.5194/tc-12-675-2018.
- Oshima, K., and K. Yamazaki (2017), Atmospheric hydrological cycles in the Arctic and Antarctic during the past four decades, *Czech Polar Reports*, 7(2), 169–180, doi:10.5817/CPR2017-2-17.
- Park, H., Y. Yoshikawa, D. Yang, and K. Oshima (2017), Warming Water in Arctic Terrestrial Rivers under Climate Change, *Journal of Hydrometeorology*, 18(7), 1983–1995, doi:10.1175/JHM-D-16-0260.1.
- Ryu, Y., C. Jiang, H. Kobayashi, and M. Detto (2017), MODIS-derived global land products of shortwave radiation and diffuse and total photosynthetically active radiation at 5 km resolution from 2000, *Remote Sensing of Environment*, 204, 812–825, doi:10.1016/j.rse.2017.09.021.
- Saito, K., J. Mori, H. Machiya, S. Miyazaki, T. Ise, T. Sueyoshi, T. Yamazaki, Y. Iijima, H. Ikawa, K. Ichii, A. Ito, R. O’ishi, T. Ohta, G. Katata, A. Kotani, T. Sasai, A. Sato, H. Sato, A. Sugimoto, R. Suzuki, K. Tanaka, T. Nitta, M. Niwano, B. Eleanor, H. Park, and S. Yamaguchi (2018), Energy-water budget analysis of an Arctic terrestrial models intercomparison GTMIP, *Journal of the Japanese Society of Snow and Ice*, 80(2), 159–174 (in Japanese).
- Sato, H., and H. Kobayashi (2017), Topography controls the abundance of Siberian larch forest, *Journal of Geophysical Research – Biogeosciences*, 123(1), 106–116, doi:10.1002/2017JG004096.
- Sekiya, T., K. Miyazaki, K. Ogochi, K. Sudo, and M. Takigawa (2018), Global high-resolution simulations of tropospheric nitrogen dioxide using CHASER V4.0, *Geoscientific Model Development*, 11, 959–988, doi:10.5194/gmd-11-959-2018.
- Sumata, H., F. Kauker, M. Karcher, B. Rabe, M.-L. Timmermans, A. Behrendt, R. Gerdes, U. Schauer, K. Shimada, K.-H. Cho, and T. Kikuchi (2018), Decorrelation scales for Arctic Ocean hydrography - Part I: Amerasian Basin, *Ocean Science*, 14, 161–185, doi:10.5194/os-14-161-2018.
- Suzuki, K., K. Matsuo, D. Yamazaki, K. Ichii, Y. Iijima, F. Papa, Y. Yanagi and T. Hiyama (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(3), doi:10.3390/rs10030402.
- Suzuki, T., D. Yamazaki, H. Tsujino, Y. Komuro, H. Nakano, and S. Urakawa (2017), A dataset of continental river discharge based on JRA-55 for use in a global ocean circulation model, *Journal of Oceanography*, 74(4), 421–429, doi:10.1007/s10872-017-0458-5.
- Takata, K., P. K. Patra, A. Kotani, J. Mori, D. Belikov, K. Ichii, T. Saeki, T. Ohta, K. Saito, M. Ueyama, A. Ito, S. Maksyutov, S. Miyazaki, E. J. Burke, A. Ganshin, Y. Iijima, T. Ise, H. Machiya, T. C. Maximov, Y. Niwa, R. O’ishi, H. Park, T. Sasai, H. Sato, S. Tei, R. Zhuravlev, T. Machida, A. Sugimoto, and S. Aoki (2017), Reconciliation of top-down and bottom-up CO₂ fluxes in Siberian larch forest, *Environmental Research Letters*, 12(12), doi:10.1088/1748-9326/aa926d.

I. Research Activities and Results

Institute of Arctic Climate and Environment Research

- Tei, S., A. Sugimoto, M. Liang, H. Yonenobu, Y. Matsuura, A. Osawa, H. Sato, J. Fujinuma, and T. Maximov (2017), Radial Growth and Physiological Response of Coniferous Trees to Arctic Amplification, *Journal of Geophysical Research – Biogeosciences*, 122(11), 2786–2803, doi:10.1002/2016JG003745.
- Watanabe, E., J. Onodera, M. Itoh, S. Nishino, and T. Kikuchi (2017), Winter transport of subsurface warm water toward the Arctic Chukchi Borderland, *Deep Sea Research Part I: Oceanographic Research Papers*, 128, 115–130, doi:10.1016/j.dsr.2017.08.009.
- Wu, J., H. Kobayashi, S. C. Stark, R. Meng, K. Guan, N. N. Tran, S. Gao, W. Yang, N. Restrepo-Coupe, T. Miura, R. C. Oliveira, A. Rogers, D. G. Dye, B. W. Nelson, S. P. Serbin, A. R. Huete, and S. R. Saleska (2017), Biological processes dominate seasonality of remotely sensed canopy greenness in an Amazon evergreen forest, *New Phytologist*, 217(4), 1507–1520, doi:10.1111/nph.14939.
- Yamashita, Y., M. Takigawa, K. Ishijima, H. Akiyoshi, C. Kodama, H. Yashiro, and M. Satoh (2017), Resolution dependency of numerically simulated stratosphere-to-troposphere transport associated with mid-latitude closed cyclones in early spring around Japan, *SOLA*, 13, 186–191, doi:10.2151/sola.2017-034.
- Yamada, Y., T. Yokokawa, M. Uchimiya, S. Nishino, H. Fukuda, H. Ogawa, and T. Nagata (2017), Transparent exopolymer particles (TEP) in the deep ocean: full-depth distribution patterns and contribution to the organic carbon pool, *Marine Ecology Progress Series*, 583, 81–93, doi:10.3354/meps12339.
- Yang, W., H. Kobayashi, X. Chen, K. Nishida Nasahara, R. Suzuki, and A. Kondoh (2017), Modeling three-dimensional forest structures to drive canopy radiative transfer simulations of bidirectional reflectance factor, *International Journal of Digital Earth*, 11(10), 981–1000, doi:10.1080/17538947.2017.1353146.
- Yasunaka, S., E. Siswanto, A. Olsen, M. Hoppema, E. Watanabe, A. Fransson, M. Chierici, A. Murata, S. K. Lauvset, R. Wanninkhof, T. Takahashi, N. Kosugi, A. M. Omar, S. van Heuven, and J. T. Mathis (2018), Arctic Ocean CO₂ uptake: an improved multiyear estimate of the air-sea CO₂ flux incorporating chlorophyll a concentrations, *Biogeosciences*, 15(6), 1643–1661, doi:10.5194/bg-15-1643-2018.
- Yoshikawa, Y., H. Park, K. Oshima, and H. Yokoyama (2018), Examination of Simple Ice Jams Calculation Model, *Journal of Japan Society of Civil Engineers, Ser.BI Hydraulic Engineering*, 74(4), 1351–1356 (in Japanese).
- Zhu, C., H. Kobayashi, Y. Kanaya, and M. Saito (2017), Size-dependent validation of MODIS MCD64A1 burned area over six vegetation types in boreal Eurasia: Large underestimation in croplands, *Scientific Reports*, 7(4181), doi:10.1038/s41598-017-03739-0.

Publication without Peer Review

- Ono, J., H. Tatebe, and Y. Komuro (2018), Predictability of Arctic sea ice in a climate model MIROC: toward skillful seasonal forecasts, *Proceedings of the 33rd International Symposium on the Okhotsk Sea & Polar Oceans 2018*, 33, 18–19.
- Watanabe, E. (2017), Progress and future works in the Arctic marine ecosystem modeling: Outcomes of the FAMOS activity, *Kaiyo Monthly*, 561, 423–429 (in Japanese).

Chasing what's happening in the tropics

– Department of Coupled Ocean-Atmosphere-Land Processes Research –

The Maritime Continent (MC) and adjacent seas host a source of the global atmospheric circulation owing to the huge amount of heat release from active cumulus convections. Since this region is characterized with complicated topography with steep mountains and surrounding warm waters, interactions among ocean, land, and atmosphere are thought to play a critical role in regulating weather and climate systems, which have impacts onto not only the tropics but also higher-latitudes. Our research goal is to improve our understanding of weather and climate in this region through observations from the viewpoints of ocean-atmosphere-land interactions. While we deploy our observation network for long-term monitoring at various sites in the MC region based on the collaboration with local agencies including the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) of the Republic of the Philippines and Aero-Meteorological Observatory of National Hydro-Meteorological Service (AMO/NHMS) of the Socialist Republic of Viet Nam, we have organized an international field campaign, Years of the Maritime Continent (YMC), as one of core institutes. YMC is a multi-national effort, which aims to expedite the progress of improving understanding of local multi-scale variabilities of the MC weather-climate system and its global impact. Its observation phase has started since July 2017 and is scheduled to continue until early 2020. During this campaign period, we at JAMSTEC have conducted several intensive observations with Indonesian Agency for the Assessment and Application of Technology (BPPT) and Indonesian Agency of Meteorology Climatology and Geophysics (BMKG) in addition to PAGASA and AMO/NHMS in their respective countries in 2017 and 2018. More detailed information about the YMC can be found in YMC JAMSTEC site at <http://www.jamstec.go.jp/ymc/>. Figure 1 summarizes our major land-based observation sites.

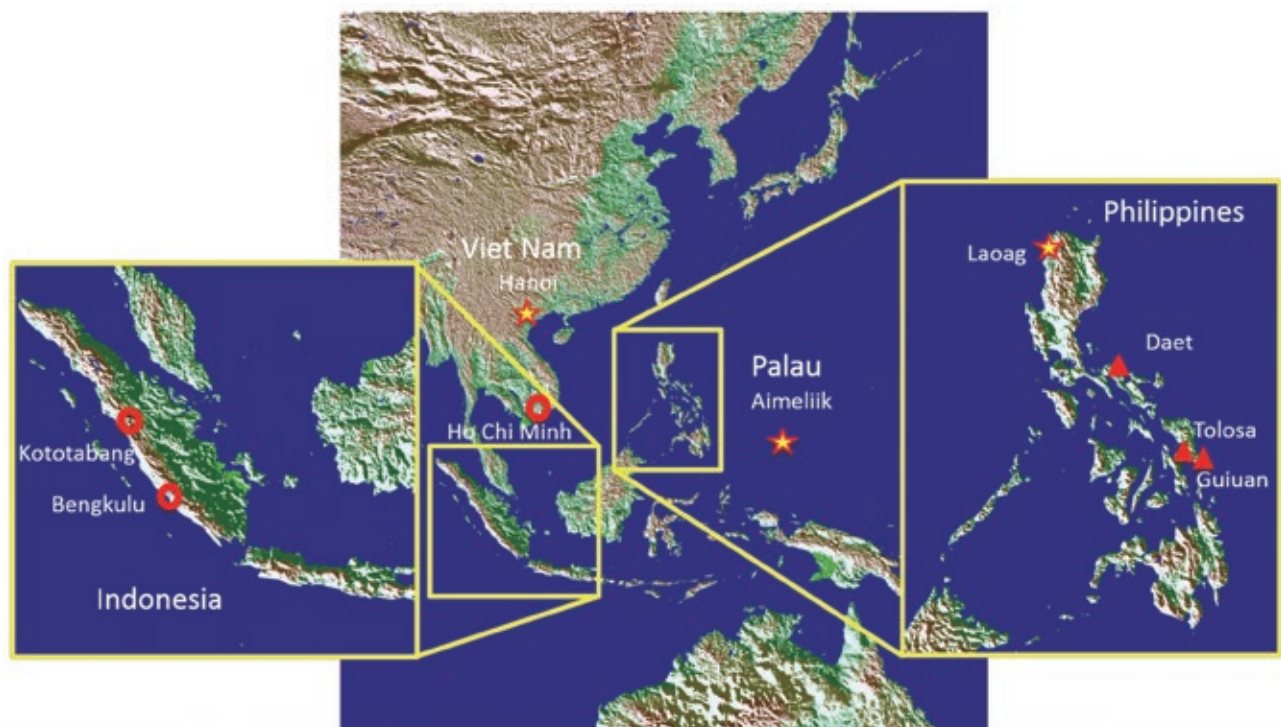


Fig.1 Major observation sites, where DCOP deploys their own instruments for long-term monitoring and/or conducts intensive observations under the YMC project. Red circle/triangle indicate YMC-IOP/long-term monitoring sites, while star indicates both have been carried out.

Coastlines in the tropics act as a key player for regulating global atmospheric water circulation through dehydration process?

Many previous studies on rainfall over the MC region pointed out that much precipitation occurs along the coastline (Fig.2). In particular, diurnal cycle of rain is dominant, and they are usually associated with land-sea breeze. For example, *Ogino et al.* [2016] showed that tropical precipitation amount peaks at the coastline, and precipitation within 300 km from the coastline accounts for about 34% of the total amount over the entire tropics using satellite-based 13 years data. Thus, the first YMC intensive observation, which aimed at studying interaction between diurnal cycle of rain and the Madden-Julian oscillation, was taken place at/off Bengkulu in the southwest coast of Sumatra Island, Indonesia from November 2017 through January 2018.

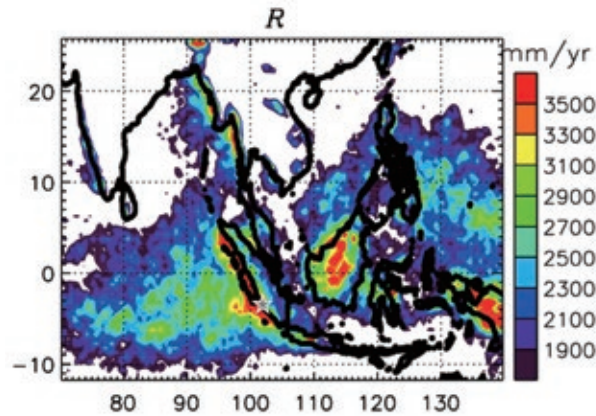


Fig.2 Annual mean precipitation observed by satellite TRMM during December 1997 through January 2011 [*Ogino et al.*, 2016]. Star indicates the YMC intensive observation site around Bengkulu, Sumatra.

Ogino et al. [2017] extended their previous work mentioned above to the entire the globe using the Japanese 55-year reanalysis (JRA-55) product [*Kobayashi et al.*, 2015] for 30 years from 1981 to 2010. They calculated water vapor flux divergence, and then expressed them as a function of distance from the coastline for different latitudinal bands (the northern extra-tropics: 20.625°N-90°N, the tropics: 20.625°S-20.625°N, and the southern extra-tropics: 20.625°S-90°S). The results as a quantity of “landward water vapor transport,” which is expressed as “ T_L ” for brevity, are shown in Fig.3. Global mean behavior of T_L (Fig.3a) shows increase over the ocean toward the land and decrease with distance inland region. In particular, their peak is not found at the coastline, but 150 km off the coastline. This asymmetric pattern indicates that much precipitation occur over the coastal region and they do not reach over the land but return to the ocean through rivers or groundwater discharge. When the same variation is examined in the different latitudinal bands, only the case of tropics shows the similar variation (Fig.3c). In other words, Fig.3 indicates that the coastline in the tropics acts as a “dehydrator”, which consumes water vapor before reaching the inland, and regulates large portion of global water circulation.

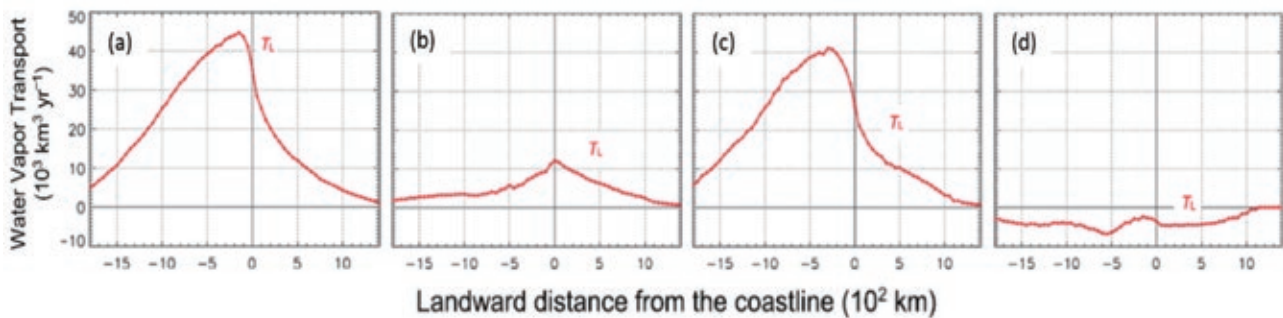


Fig.3 Variation of landward water vapor transport as a function of distance from the coastline for (a) the entire globe, (b) the northern extra-tropics, (c) the tropics, and (d) the southern extra-tropics. Adapted from *Ogino et al.* [2017].

Based on this result, Ogino *et al.* [2017] proposed that water circulation over the entire globe is captured precisely by classifying three regions: open ocean, coastal region (within 150 km from the coastline), and inland region. In addition, this result suggests that ocean surface salinity distribution near the coast is not determined only by the amount of freshwater supply through the rivers and groundwater discharge, but also coastal rain. Influence from the coastline onto precipitation should be considered to improve the numerical model.

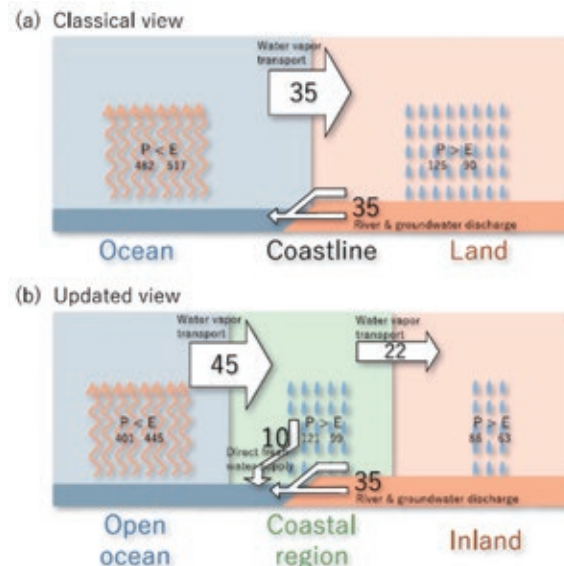


Fig.4 Schematic view of water circulation over ocean and land. (a) classical two-region concept. (b) proposed three-region concept. The numbers inside indicate the amount of water vapor or water transport in $10^3 \text{ km}^3 \text{ yr}^{-1}$. Here, coastal region is defined as that within 150 km from the coastline. Taken from Ogino *et al.* [2017].

References

- Kobayashi, S., Y. Ota, Y. Harada, A. Ebita, M. Moriya, H. Onoda, K. Onogi, H. Kamahori, C. Kobayashi, H. Endo, K. Miyaoka, and K. Takahashi (2015), The JRA-55 reanalysis: General specifications and basic characteristics, *J. Meteor. Soc. Japan*, 93, 5–48, doi:10.2151/jmsj.2015-001.
- Ogino, S.-Y., M. D. Yamanaka, S. Mori, and J. Matsumoto (2016), How much is the precipitation amount over the tropical coastal region?, *J. Climate*, 29, 1231–1236, doi:10.1175/CLI-D-15-0484.1.
- Ogino, S.-Y., M. D. Yamanaka, S. Mori, and J. Matsumoto (2017), Tropical coastal dehydrator in global atmospheric water circulation, *Geophys. Res. Lett.*, 44, 11636–11643, doi:10.1002/2017GL075760.

Publication List

Publication with Peer Review (Published)

- Akasaka I., H. Kubota, J. Matsumoto, E. O. Cayan, R. D. Guzman, and F. D. Hilario (2018), Seasonal march patterns of the summer rainy season in the Philippines and their long-term variability since the late 20th century, *Prog. Earth Planet. Sci.*, 5, 20, doi:10.1186/s40645-018-0178-5.
- Bellenger, H., R. Wilson, J. L. Davison, J.-P. Duvel, W. Xu, F. Lott, and M. Katsumata (2017), Tropospheric turbulence over the tropical open-ocean: Role of gravity waves, *J. Atmos. Sci.*, 74, 1249–1271, doi:10.1175/JAS-D-16-0135.1.
- Chen, T.-C., J. Tsay, J. Matsumoto, and J. Alpert (2017a), Forecast advisory for the cold-season heavy rainfall/flood event developed from multiple interactions of the cold surge vortex with cold surge flows in the South China Sea, *Wea. Forecasting*, 32, 797–819, doi: 10.1175/WAF-D-16-0148.1.
- Chen, T.-C., J. Tsay, J. Matsumoto, and J. Alpert (2017b), Impact of the summer monsoon westerlies on the

I. Research Activities and Results

Department of Coupled Ocean-Atmosphere-Land Processes Research

- South China Sea tropical cyclone genesis in May, *Wea. Forecasting*, 32, 925–947, doi:10.1175/WAF-D-16-0149.1.
- Fathrio, I., S. Iizuka, A. Manda, Y.-M. Kodama, S. Ishida, Q. Moteki, H. Yamada, and Y. Tachibana (2017), Assessment of western Indian Ocean SST bias of CMIP5 models, *J. Geophys. Res. Oceans*, 122, 3123–3240, doi:10.1002/2016JC012443.
- Hasebe, F., S. Aoki, S. Morimoto, Y. Inai, T. Nakazawa, S. Sugawara, C. Ikeda, H. Honda, H. Yamazaki, Halimurrahman, N. Komala, F. Putri, A. Budiyo, M. Soedjarwo, S. Ishidoya, S. Toyoda, T. Shibata, M. Hayashi, N. Eguchi, N. Nishi, M. Fujiwara, S. Ogino, M. Shiotani, and T. Sugidachi (2018), Coordinated Upper-troposphere-to-stratosphere Balloon Experiment in Biak (CUBE/Biak), *Bull. Amer. Meteor. Soc.*, 99, 1213–1230, doi:10.1175/BAMS-D-16-0289.1.
- Huang, G., X. Liu, K. Chance, K. Yang, P. K. Bhartia, Z. Cai, M. Allaart, B. Calpini, G. J. R. Coetzee, E. Cuevas-Agull, M. Cupeiro, H. De Backer, M. K. Dubey, H. E. Fuelberg, M. Fujiwara, S. Godin-Beekmann, T. J. Hall, B. Johnson, E. Joseph, R. Kivi, B. Kois, N. Komala, G. Konig-Langlo, G. Laneve, T. Leblanc, M. Marchand, K. R. Minschwaner, G. Morris, M. J. Newchurch, S.-Y. Ogino, N. Ohkawara, A. J. M. Piter, F. Posny, R. Querel, R. Scheele, F. J. Schmidlin, R. C. Schnell, O. Schrems, H. Selkirk, M. Shiotani, P. Skrivanova, R. Stubi, G. Taha, D. W. Tarasick, A. M. Thompson, V. Thouret, M. Tully, R. van Malderen, G. Vaughan, H. Vomel, P. von der Gathen, J. C. Witte, and M. Yela (2017), Validation of 10-year SAO OMI Ozone Profile (PROFOZ) Product Using Ozone Sonde Observations, *Atmos. Meas. Tech.*, 10, 2455–2475, doi:10.5194/amt-10-2455-2017.
- Kawai, Y., Q. Moteki, A. Yoshida-Kuwano, T. Enomoto, A. Manda, and H. Nakamura (2017), Impact propagation of radiosonde data assimilation over the Kuroshio and Kuroshio Extension: Case study on the early summer (Baiu) in 2012, *J. Meteor. Soc. Japan*, 95, 71–90, doi:10.2151/jmsj.2017-004.
- Kubota, H., R. Shirooka, J. Matsumoto, E. O. Cayan, and F. D. Hilario (2017), Tropical cyclone influence on the long-term variability of Philippine summer monsoon onset, *Prog. Earth Planet. Sci.*, 4, 27, doi:10.1186/s40645-017-0138-5.
- Matsumoto, J., F. Fujibe, and H. Takahashi (2017), Urban climate in the Tokyo metropolitan area in Japan, *J. Environ. Sci.*, 59, 54–62, doi:10.1016/j.jes.2017.04.012.
- Nodzu, M. I., S.-Y. Ogino, and J. Matsumoto (2018), Full access development and decay processes of dual inversion layers in winter over the northwest coast of the South China Sea, *J. Climate*, 31, 1245–1266, doi:10.1175/JCLI-D-16-0907.1.
- Ogino, S.-Y., M. D. Yamanaka, S. Mori, and J. Matsumoto (2017), Tropical coastal dehydrator in global atmospheric water circulation, *Geophys. Res. Lett.*, 44, 11636–11643, doi:10.1002/2017GL075760.
- Ogino, S.-Y., P. Wu, M. Hattori, N. Endo, H. Kubota, T. Inoue, and J. Matsumoto (2018), Cold surge event observed by the radiosonde observation from the research vessel "Hakuho-maru" over the Philippine Sea in December 2012, *Prog. Earth Planet. Sci.*, 5, 9, doi:10.1186/s40645-017-0163-4.
- Seela, B. K., J. Janapati, P.-L. Lin, K. Krishna Reddy, R. Shirooka, and P. Wang (2017), A comparison study of summer season raindrop size distribution between Palau and Taiwan, two Islands in Western Pacific, *J. Geophys. Res. Atmos.*, 122, 11787–11805, doi:10.1002/2017JD026816.
- Seiki, A., Y. N. Takayabu, T. Hasegawa, and K. Yoneyama (2018), Lack of westerly wind bursts in unmaterialized El Niño years, *J. Climate*, 31, 593–612, doi:10.1175/JCLI-D-17-0291.1.
- Thompson, A. M., J. C. Witte, C. Sterling, A. Jordan, B. J. Johnson, S. J. Oltmans, M. Fujiwara, H. Vomel, M. Allaart, A. Piter, G. J. R. Coetzee, F. Posny, E. Corrales, J. A. Diaz, C. Felix, N. Komala, N. Lai, H. T. Ahn Nguyen, M. Maata, F. Mani, Z. Zainal, S.-Y. Ogino, F. Paredes, T. L. B. Penha, F. R. da Silva, S. Sallons-Mitro, H. B. Selkirk, F. J. Schmidlin, R. Stubi, and K. Thiongo (2017), First Reprocessing of Southern Hemisphere Additional Ozone Sondes (SHADOZ) Ozone Profiles (1998–2016): 2. Comparisons with satellites and ground-based instruments, *J. Geophys. Res. Atmos.*, 122, 13000–13025, doi:10.1002/2017JD027406.
- Witte, J. C., A. M. Thompson, H. G. J. Smit, M. Fujiwara, F. Posny, G. J. R. Coetzee, E. T. Northam, B. J. Johnson,

- C. W. Sterling, M. Mohammed, S.-Y. Ogino, A. Jordan, and F. R. da Silva (2017), First reprocessing of Southern Hemisphere ADditional OZonesondes (SHADOZ) profile records (1998-2015) 1: Methodology and evaluation, *J. Geophys. Res. Atmos.*, *122*, 6611–6636, doi:10.1002/2016JD026403.
- Wu, P., S. Mori, and F. Syamsudin (2018), Land-sea surface air temperature contrast on the western coast of Sumatra Island during an active phase of the Madden-Julian oscillation, *Prog. Earth Planet. Sci.*, *5*, 4, doi:10.1186/s40645-017-0160-7.
- Yamanaka, M. D., S.-Y. Ogino, P. Wu, J.-I. Hamada, S. Mori, J. Matsumoto, and F. Syamsudin (2018), Maritime continent coastlines controlling Earth's climate, *Prog. Earth Planet. Sci.*, *5*, 21, doi:10.1186/s40645-018-0174-9.
- Yokoi, S., S. Mori, M. Katsumata, B. Geng, K. Yasunaga, F. Syamsudin, Nurhayati, and K. Yoneyama (2017), Diurnal cycle of precipitation observed in the western coastal area of Sumatra Island: Offshore preconditioning by gravity waves, *Mon. Wea. Rev.*, *145*, 3745–3761, doi:10.1175/MWR-D-16-0468.1.
- Yoshioka, H., H. Fudeyasu, T. Enomoto, M. Katsumata, A. Yamazaki, S. Yokoi, T. Tsujino, A. Masuda, and R. Shiroyaka (2017), The analysis of the initial data dependence on forecast experiments for the tropical cyclogenesis: The case study of Typhoon Leepi (1304) observed by PALAU2013, *Tenki*, *64*, 873–885 (in Japanese).

Toward Comprehensive Projection of Global Change

– Department of Integrated Climate Change Projection Research & Project Team for Advanced Climate Modeling –

Department of Integrated Climate Change Projection Research works on researches on mechanism for oceanic and atmospheric variations including water and biogeochemical cycles, and assessment of human impacts on those variations. Our main research tools include an atmosphere-ocean coupled model dealing with physical variables such as temperature and precipitation, and an earth system model (ESM) incorporating oceanic and terrestrial biogeochemical dynamics important for formation of the global environment. Activities also include observational research on permafrost, in order to develop a land process module to be a part of the ESM. It is hoped that our researches lead to contribution to the society in addition to improved understanding on how the nature works.

From FY2017, JAMSTEC started undertaking “Integrated Research Program for Advancing Climate Models”, or TOUGOU (abbreviation taken from its Japanese name) funded by Ministry of Education, Culture, Sports, Science and Technology (MEXT) by establishing a dedicated project team. Under this program and based on the protocol for global change projection experiments being discussed by scientists from across the world (CMIP6 protocol), we perform experiments using the models developed at JAMSTEC. This annual report includes results obtained under this program.

In FY 2017, an idealized global warming experiment with 2000-year integration was performed using our earth system model in order to make comprehensive evaluation on irreversibility of the global environment. Results were analyzed focusing on carbon cycle response. Last Millennium experiment was also conducted for estimating impacts of human activities on climate variations in historical data.

Part of CMIP6 experiments have been started after finishing fine tuning for the climate model that has been developed toward next round of IPCC and preparing boundary condition data such as aerosol emissions. Completed experiments include the historical experiment that reproduces climate variations since mid-nineteenth century. Earth system version of our climate model has also been set up for operation and preliminary experiments toward CMIP6 have been performed.

An improved scheme, which calculates processes of cloud microphysics more accurately with lesser computational demand, has been incorporated into our global cloud resolving model. As a result, it is now possible to apply the model for CMIP6 protocol. Some of the achievements have been reported to the public by the media. Furthermore, impacts of terrain resolution and vertical resolution on the cloud behaviors have been investigated, which led to important perceptions for precisely representing cloud-radiation feedbacks.

Millennium time-scale experiments using an Earth system model

More attention to climate stabilization has been paid after Paris agreement. If atmospheric CO₂ concentration can be reduced and stabilized, some subsystems in the Earth, like ocean circulation and the biogeochemistry, are expected to continue to respond to the forcing change with some time-lag, from centennial to millennium time scale. In order to investigate how long such subsystems of the Earth can continue to respond behind the anthropogenic forcing change, global warming experiment with millennium time scale are executed in this study, by using an Earth system model. In order to focus on the time-lag, the scenario applied to the simulation is simplified: only CO₂ concentration is abruptly doubled from pre-industrial level and held constant. Figure 1 shows the results: global mean temperature anomaly is shown by black line in the upper left pane. Two more idealized experiment were also conducted: experiments where CO₂ concentration is doubled but only carbon cycle sees the change, and that where only radiation process sees (blue and red lines, respectively). The model projected that climate stabilization is achieved within 2000 years, while the ocean continues to the carbon uptake.

In addition, a last millennium experiment (A.D. 850-1850) is executed using an AOGCM: this serves as the test of the physical core of our new Earth system model. We first confirmed that the spin-up procedure (i.e.

I. Research Activities and Results

Department of Integrated Climate Change Projection Research & Project Team for Advanced Climate Modeling

stabilizing model variables with fixed forcing and making an initial condition for simulations) was successful: global temperature didn't show long-term trend (gray line of lower panel in Fig.2). Then, the last millennium experiment was executed by applying natural (solar, orbital parameter, and volcano) and anthropogenic (land-use change and GHGs) forcing to the model (red line). By this, it is confirmed timing (and duration) of global cooling induced by volcanic eruptions were adequately captured by the physical core of the new Earth system model.

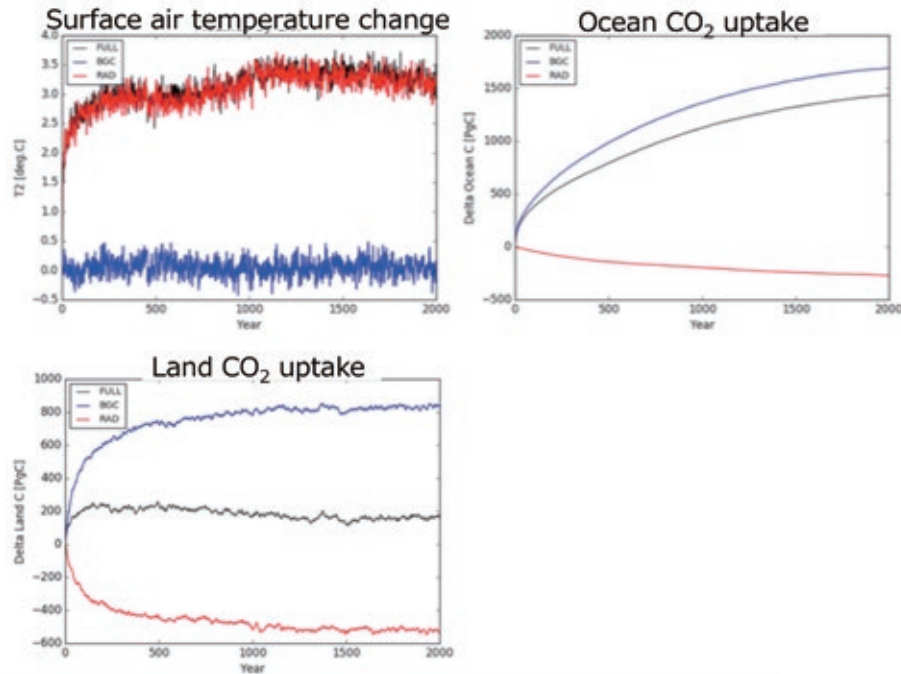


Fig.1 Global surface temperature change where atmospheric CO₂ concentration is abruptly doubled and then fixed during 2000 years (black lines). Red lines represent the simulation where CO₂ concentration is doubled but only radiation process detect the change, while blue lines for the experiments where only carbon cycle sees the change.

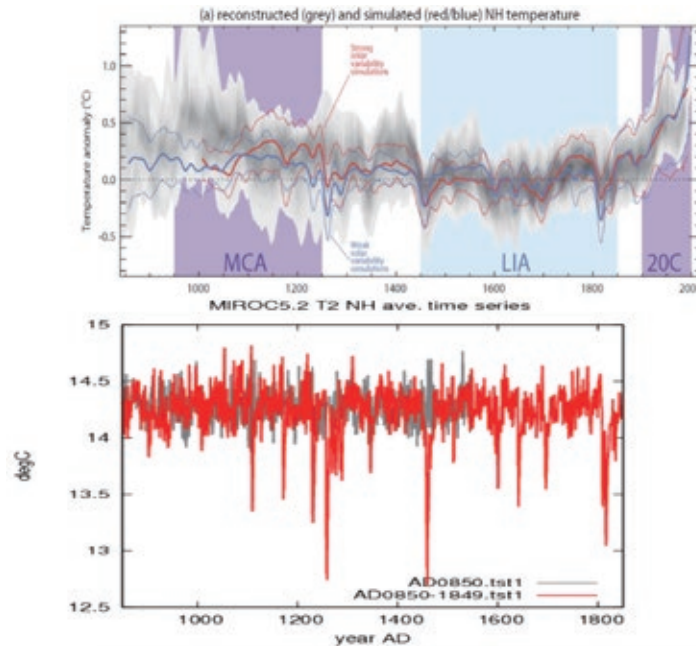


Fig.2 Surface temperature change in Northern hemisphere during A.D. 850-1850, from IPCC-AR5 report (upper panel) and MIROC5.2, which is a physical core of our new Earth system model (lower panel). Note the lines in upper panel are the result smoothed by 30 years averages, while lines in lower panel are annual values.

CMIP6 experiments using the latest version of ESM and MIROC6

The latest version of our Earth System Model (ES2L) and its physical core climate model (MIROC6) had been developed up to the last fiscal year. In this fiscal year, we conducted several sets of climate simulations which had been designed by the sixth phase of the international collaborative framework, the Coupled Model Intercomparison Project (CMIP6). Climatic-mean states and typical internal climate variations on intraseasonal-to-decadal timescales, such as winter/summer East Asian Monsoon, Madden-Julian Oscillation, and the Pacific decadal oscillations, are better represented in MIROC6 than in MIROC5 which was an official climate model for the fifth-phase of the CMIP. For example, as shown in Fig.1, the observed northwesterly wind anomaly on the 300 hPa pressure height and a meridional dipole structure of the 300 hPa pressure height anomalies around Japan, which are occurred associated with the winter East Asian Monsoon variability, are consistently represented in MIROC6. Underestimation of amplitude of the interannual activity of sub-weekly atmospheric disturbances in MIROC5 is much alleviated in MIROC6. As well as internal climate variations and climatic mean states, a centennial global surface air temperature variation including the rapid warming after the 1970s is generally well reproduced in the historical simulations from 1850 to 2014 where external forcing of green-house-gas concentrations, aerosol emissions, the incoming solar irradiance and so on are prescribed based on observations (Figs. 4 and 5). Although the future climate projections and the seasonal-to-decadal scale climate predictions are still in preparation due to the delay of forcing data provision from the CMIP6, the better representation of the present climate in the ES2L and MIROC6 may promise more reliable information on the future climate change. After the future climate projection and prediction experiments are done, by publishing the data to domestic and international societies and science communities, we are aiming to contribute to risk assessment studies on climate changes. Also by analyzing the data by ourselves, we will be tackling a wide range of climate science issues for deeper understanding on the physical processes which cause errors and uncertainties of future climate predictions, which gives us insight on imperfection of simulation models, what processes are needed to the models, and development directions towards more advanced, sophisticated, and versatile comprehensive environment prediction system.

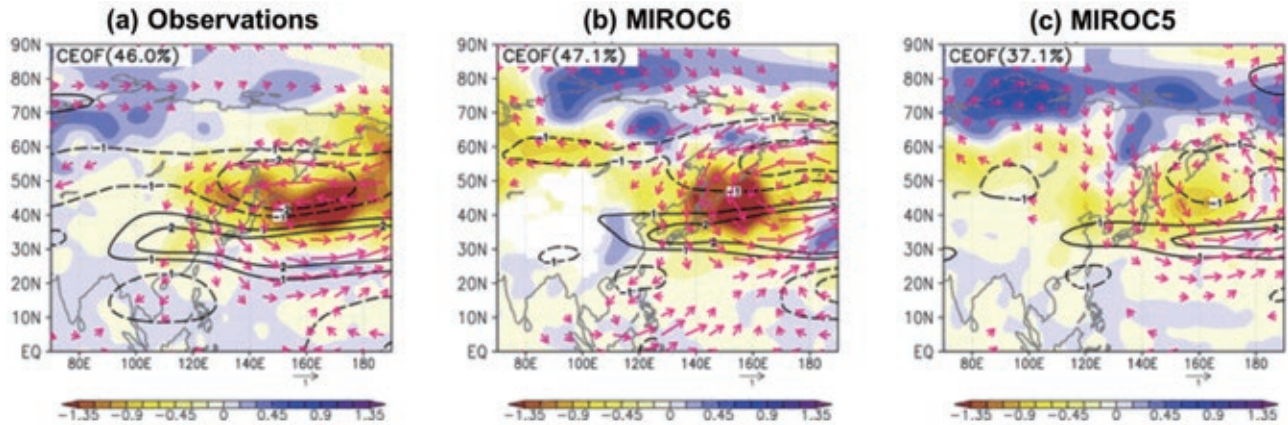


Fig.3 Wintertime East Asian Monsoon patterns for the storm track activity (shades; K m s^{-1}), the 300 hPa pressure height (contours; m), and the 300hPa wind (vector; m s^{-1}). Note that the storm track activity is defined as the atmospheric meridional heat transport associated with sub-weekly disturbances on the 850hPa pressure height.

I. Research Activities and Results

Department of Integrated Climate Change Projection Research & Project Team for Advanced Climate Modeling

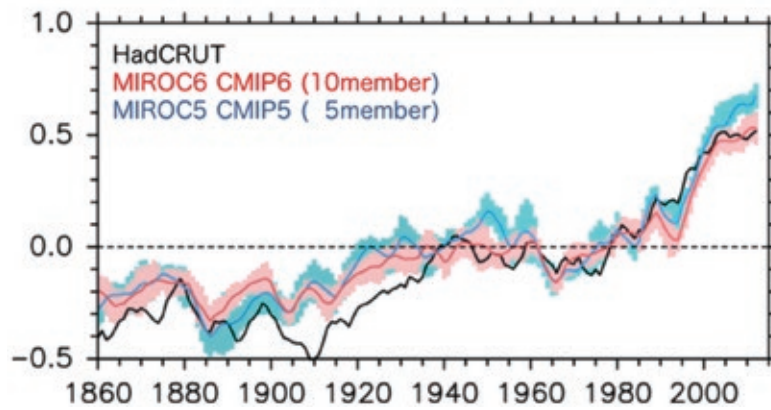


Fig.4 Timeseries of the global-mean surface air temperature anomalies with respect to the 1961-90 mean (°C). The black line indicates observations, the red line MIROC6, and the blue line MIROC5, respectively. A five-year running-mean filter is applied to all the timeseries. Shades indicate 1 standard deviation of ensemble simulations with slightly different initial conditions at the year 1850.

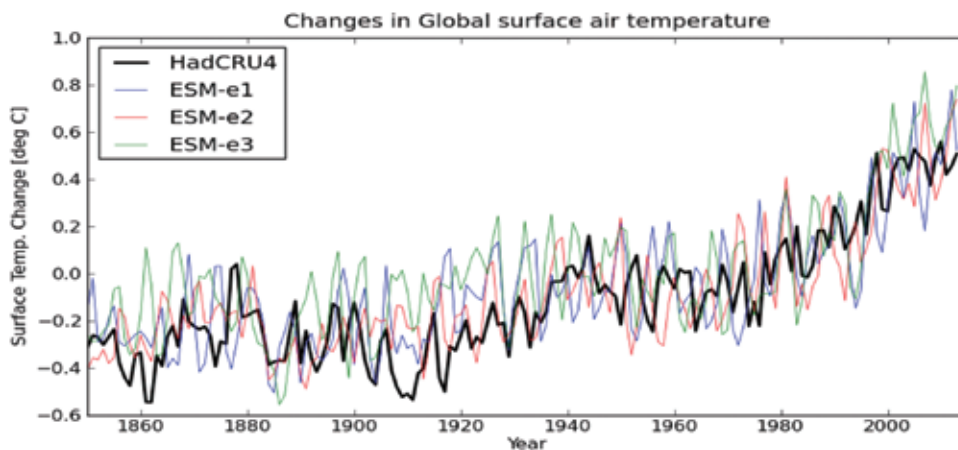


Fig.5 Same as Fig.2, but for the ES2L. The red, blue, and green lines indicate individual ensemble simulations with slightly different initial conditions at the year 1850.

Activity of the NICAM research: Model Improvement and analysis of cloud changes due to global warming

We improved especially the microphysics component to make it allow a larger time step for numerical integration with suppressing numerical errors. In the previous scheme, the productions of cloud condensates strongly depend on a sequential order of their tendency terms, and the influence becomes larger with a time step. A newly introduction of a scheme to reduce such dependency enables to use a larger time step, leading to a reduced computational cost of NICAM simulations. We are planning to apply the improved NICAM to CMIP6 simulations, and to open the high-resolution datasets to the international climate research community.

Additionally, NICAM data analysis from various perspectives in the present fiscal year revealed followings. A study of horizontal resolution dependency confirmed the improved simulation of orographic cirrus clouds due to, for example, steep mountain ranges including the Andes with improving the resolution. We also conducted dependency of vertical resolution on changes of clouds due to global warming, and revealed behavior of high clouds can changes even qualitatively in different resolutions. Such a systematic investigation has not been done previously in the GCM community, and thus will provide useful knowledge to the climate research filed. Detailed changes of an internal structure of typhoons in future climate are also investigated using NICAM to reveal a more expansion of strong-wind regions due to a more slant eye-wall clouds.

Publication List**Publication with Peer Review (Published)**

- Abe, M., K. Takata, S. Watanabe, and M. Kawamiya (2017), Vegetation masking effect on future warming and snow albedo feedback in a boreal forest region of northern Eurasia according to MIROC-ESM, *Journal of Geophysical Research-Atmospheres*, *122*(17), 9245–9261, doi:10.1002/2017JD026957.
- Asayama, S., S. Emori, and K. Masuda (2017), Toward reflective advocacy in climate controversy: complex boundaries between science and policy, *Sociotechnica*, *14*, 21–37 (in Japanese).
- Butchart, N., J. A. Anstey, K. Hamilton, S. Osprey, C. McLandress, A. C. Bushell, Y. Kawatani, Y.-H. Kim, F. Lott, J. Scinocca, T. Stockdale, O. Bellprat, P. Braesicke, C. Cagnazzo, C.-C. Chen, H.-Y. Chun, M. Dobrynin, R. R. Garcia, J. G.-Serrano, L. J. Gray, L. Holt, T. Kerzenmacher, H. Naoe, H. Pohlmann, J. H. Richter, A. A. Scaife, V. Schenzinger, F. Serva, S. Versick, S. Watanabe, K. Yoshida, and S. Yukimoto (2017), Overview of experiment design and comparison of models participating in phase 1 of the SPARC Quasi-Biennial Oscillation initiative (QBOi), *Geoscientific Model Development*, *11*(3), 1009–1032, doi:10.5194/gmd-11-1009-2018.
- Chen, Y.-W., T. Seiki, C. Kodama, M. Satoh, and A. T. Noda (2017), Impact of Precipitating Ice Hydrometeors on Longwave Radiative Effect Estimated by a Global Cloud-System Resolving Model, *Journal of Advances in Modeling Earth Systems*, *10*(2), 284–296, doi:10.1002/2017MS001180.
- Cherry, M., D. Yamazaki, K. Hyungjun, C. Adisorn, V. Jai, and T. Oki (2017), Impacts of spatial resolution and representation of flow connectivity on large-scale simulation of floods, *Hydrology and Earth System Sciences*, *21*, 5143–5163, doi:10.5194/hess-21-5143-2017.
- Du C., M. Shinoda, K. Tachiiri, B. Nandintsetseg, H. Komiyama, and S. Matsushita (2017), Mongolian herders' vulnerability to Dzud: A study of record livestock mortality levels during the severe 2009/2010 winter, *Natural Hazards*, doi:10.1007/s11069-017-2893-4.
- Frieler, K., S. Lange, F. Piontek, C. P. O. Reyer, J. Schewe, L. Warszawski, F. Zhao, L. Chini, S. Denvil, K. Emanuel, T. Geiger, K. Halladay, G. Hurtt, M. Mengel, D. Murakami, S. Ostberg, A. Popp, R. Riva, M. Stevanovic, T. Suzuki, J. Volkholz, E. Burke, P. Ciais, K. Ebi, T. D. Eddy, J. Elliott, E. Galbraith, S. N. Gosling, F. Hattermann, T. Hickler, J. Hinkel, C. Hof, V. Huber, J. Jagermeyr, V. Krysanova, R. Marce, H. M. Schmied, L. Mouratiadou, D. Pierson, D. P. Tittensor, R. Vautard, M. van Vliet, M. F. Biber, R. A. Betts, B. L. Bodirsky, D. Deryng, S. Frolking, C. D. Jones, H. K. Lotze, H. Lotze-Campen, R. Sahajpal, K. Thonicke, H. Tian, and Y. Yamagata (2017), Assessing the impacts of 1.5°C global warming-simulation protocol of the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP2b), *Geoscientific Model Development*, *10*(12), 4321–4345, doi:https://doi.org/10.5194/gmd-10-4321-2017.
- Goelzer, H., S. Nowicki, T. Edwards, M. Beckley, A. Abe-Ouchi, A. Aschwanden, R. Calov, O. Gagliardini, F. Gillet-Chaulet, N. R. Golledge, J. Gregory, R. Greve, A. Humbert, P. Huybrechts, J. H. Kennedy, E. Larour, W. H. Lipscomb, S. Le clec'h, V. Lee, M. Morlighem, F. Pattyn, A. J. Payne, C. Rodehacke, M. Ruckamp, F. Saito, N. Schlegel, H. Seroussi, A. Shepherd, S. Sun, R. van de Wal, and F. A. Ziemann (2017), Design and results of the ice sheet model initialisation experiments initMIP-Greenland: an ISMIP6 intercomparison, *Cryosphere*, *12*(4), 1433–1460, doi:10.5194/tc-12-1433-2018.
- Hirota, N., T. Ogura, H. Tatebe, H. Shiogama, M. Kimoto, and M. Watanabe (2017), Roles of shallow convective moistening in the eastward propagation of the MJO in MIROC6, *Journal of Climate*, *31*(8), 3033–3047, doi:10.1175/JCLI-D-17-0246.1.
- Hirota, N., H. Shiogama, H. Akiyoshi, T. Ogura, M. Takahashi, Y. Kawatani, M. Kimoto, and M. Mori (2017), The influences of El Nino and Arctic sea-ice on the QBO disruption in February 2016, *npj Climate and Atmospheric Science*, *1*, 10, doi:10.1038/s41612-018-0020-1.
- Ikeuchi, H., Y. Hirabayashi, D. Yamazaki, S. Muis, P. Ward, H. Winsemius, M. Verlaan, and S. Kanae (2017), Compound simulation of fluvial floods and storm surges in a global coupled river-coast flood model: Model development and its application to 2007 Cyclone Sidr in Bangladesh, *Journal of Advances in Modeling Earth Systems*, *9*(4), 1847–1862, doi:10.1002/2017MS000943.

I. Research Activities and Results

Department of Integrated Climate Change Projection Research & Project Team for Advanced Climate Modeling

- Inoue, R., M. Watanabe, and S. Osafune (2017), Wind-Induced Mixing in the North Pacific, *Journal of Physical Oceanography*, 47, 1587–1603, doi:10.1175/JPO-D-16-0218.1.
- Ito, A., and J. F. Kok (2017), Do dust emissions from sparsely vegetated regions dominate atmospheric iron supply to the Southern Ocean?, *Journal of Geophysical Research: Atmospheres*, 122(7), 3987–4002, doi:10.1002/2016JD025939.
- Iwahashi, J., I. Kamiya, M. Matsuoka, and D. Yamazaki (2017), Global terrain classification using 280m DEMs: segmentation, clustering, and reclassification, *Progress in Earth and Planetary Science*, 5(1), doi:10.1186/s40645-017-0157-2.
- Kageyama, M., S. Albani, P. Braconnot, S. P. Harrison, P. O. Hopcroft, R. F. Ivanovic, F. Lambert, O. Marti, W. R. Peltier, J.-Y. Peterschmitt, D. M. Roche, L. Tarasov, X. Zhang, E. C. Brady, A. M. Haywood, A. N. LeGrande, D. J. Lunt, N. M. Mahowald, U. Mikolajewicz, K. H. Nisancioglu, B. L. Otto-Bliesner, H. Renssen, R. A. Tomas, Q. Zhang, A. Abe, P. J. Bartlein, J. Cao, Q. Li, G. Lohmann, R. Ohgaito, X. Shi, E. Volodin, K. Yoshida, X. Zhang, and W. Zheng (2017), The PMIP4 contribution to CMIP6-Part 4: Scientific objectives and experimental design of the PMIP4-CMIP6 Last Glacial Maximum experiments and PMIP4 sensitivity experiments, *Geoscientific Model Development*, 10(11), doi:10.5194/gmd-10-4035-2017.
- Kageyama, M., P. Braconnot, S. P. Harrison, A. M. Haywood, J. H. Jungclauss, B. L. Otto-Bliesner, J.-Y. Peterschmitt, A. Abe-Ouchi, S. Albani, P. J. Bartlein, C. Brierley, M. Crucifix, A. Dolan, L. Fernandez-Donado, H. Fischer, P. O. Hopcroft, R. F. Ivanovic, F. Lambert, D. J. Lunt, N. M. Mahowald, W. R. Peltier, S. J. Phipps, D. M. Roche, G. A. Schmidt, L. Tarasov, P. J. Valdes, Q. Zhang, and T. Zhou (2017), The PMIP4 contribution to CMIP6 - Part 1: Overview and over-arching analysis plan, *Geoscientific Model Development*, 11, 1033–1057, doi:10.5194/gmd-11-1033-2018.
- Kataoka, T., T. Tozuka, and T. Yamagata (2017), Generation and Decay Mechanisms of Ningaloo Niño/Niña, *Journal of Geophysical Research: Oceans*, 122(11), 8913–8932, doi:10.1002/2017JC012966.
- Matsumoto, K., and M. Takagi (2017), Climate change Impacts on rice production and adaptation, *Environmental Science*, 30(6), 346–356, doi:doi.org/10.11353/sesj.30.346 (in Japanese).
- Miyakawa, T., H. Yashiro, T. Suzuki, H. Tatebe, and M. Satoh (2017), A Madden-Julian Oscillation event remotely accelerates ocean upwelling to abruptly terminate the 1997/1998 super El Niño, *Geophysical Research Letters*, 44(18), 9489–9495, doi:10.1002/2017GL074683.
- Nakano, M., H. Kubota, T. Miyakawa, T. Nasuno, and M. Satoh (2017), Genesis of Super Cyclone Pam (2015): Sea Surface Temperature Anomalies and Modulation of Large-Scale Environmental Circulation and the Madden Julian Oscillation, *Monthly Weather Review*, 145(8), 3143–3159, doi:10.1175/MWR-D-16-0208.1.
- Niwa, Y., Y. Fujii, Y. Sawa, Y. Iida, A. Ito, M. Satoh, R. Imasu, K. Tsuboi, H. Matsueda, and N. Saigusa (2017), A 4D-Var inversion system based on the icosahedral grid model (NICAM-TM 4D-Var v1.0) Part 2: Optimization scheme and identical twin experiment of atmospheric CO₂ inversion, *Geoscientific Model Development*, 10, 2201–2219, doi.org/10.5194/gmd-10-2201-2017.
- Ogura, T., H. Shiogama, M. Watanabe, M. Yoshimori, T. Yokohata, J. D. Annan, J. C. Hargreaves, N. Ushigami, K. Hirota, Y. Someya, Y. Kamae, H. Tatebe, and M. Kimoto (2017), Effectiveness and limitations of parameter tuning in reducing biases of top-of-atmosphere radiation and clouds in MIROC version 5, *Geoscientific Model Development*, 10(12), 4647–4664, doi:10.5194/gmd-10-4647-2017.
- Ono, J., H. Tatebe, Y. Komuro, M. Nodzu, and M. Ishii (2017), Mechanisms influencing seasonal-to-interannual prediction skill of sea ice extent in the Arctic Ocean in MIROC, *Cryosphere*, 12(2), 675–683, doi:10.5194/tc-12-675-2018.
- Otto-Bliesner, B. L., P. Braconnot, S. P. Harrison, D. J. Lunt, A. Abe-Ouchi, S. Albani, P. J. Bartlein, E. Capron, A. E. Carlson, A. Dutton, H. Fischer, H. Goelzer, A. Govin, A. Haywood, F. Joos, A. N. LeGrande, W. H. Lipscomb, G. Lohmann, N. Mahowald, C. Nehrbass-Ahles, F. S. R. Pausata, J.-Y. Peterschmitt, S. J. Phipps, H. Renssen, and Q. Zhang (2017), The PMIP4 contribution to CMIP6- Part 2: Two interglacials,

- scientific objective and experimental design for Holocene and Last Interglacial simulations, *Geoscientific Model Development*, 19, 3979–4003, doi:10.5194/gmd-10-3979-2017.
- Paltan, H., D. Waliser, W. H. Lim, B. Guan, D. Yamazaki, R. Pant, and S. Dadson (2017), Global Floods and Water Availability Driven by Atmospheric Rivers, *Geophysical Research Letters*, 44(20), 10387–10395, doi:10.1002/2017GL074882.
- Saito, K., J. Mori, H. Machiya, S. Miyazaki, T. Ise, T. Sueyoshi, T. Yamazaki, Y. Iijima, H. Ikawa, K. Ichii, A. Ito, R. O'ishi, T. Ohta, G. Katata, A. Kotani, T. Sasai, A. Sato, H. Sato, A. Sugimoto, R. Suzuki, K. Tanaka, T. Nitta, M. Niwano, E. Burke, H. Park, and S. Yamaguchi (2017), Energy-water budget analysis of an Arctic terrestrial models intercomparison GTMIP, *Journal of the Japanese Society of Snow and Ice*, 80(2), 159–174 (in Japanese).
- Siswanto, E., H. Ye, D. Yamazaki, and D. Tang (2017), Detailed spatiotemporal impacts of El Niño on phytoplankton biomass in the South China Sea, *Journal of Geophysical Research: Oceans*, 122(4), 2709–2723, doi:10.1002/2016JC012276.
- Suzuki, K., K. Matsuo, D. Yamazaki, K. Ichii, Y. Iijima, F. Papa, and T. Hiyama (2017), Hydrological variability and changes in the Arctic circumpolar tundra and the Three largest pan-Arctic river basins from 2002 to 2016, *Remote Sensing*, 10(3), 402, doi:10.3390/rs10030402.
- Suzuki, T., D. Yamazaki, H. Tsujino, Y. Komuro, H. Nakano, and S. Urakawa (2017), A dataset of continental river discharge based on JRA-55 for use in a global ocean circulation model, *Journal of Oceanography*, doi:10.1007/s10872-017-0458-5.
- Tachiiri, K., H. Komiyama, Y. Morinaga, and M. Shinoda (2017), Application of a livestock weight model to the 2009–2010 winter disaster in Mongolia, *Rangeland Journal*, 39(3), 263–277, doi:10.1071/RJ16113.
- Takata, K., P. K. Patra, A. Kotani, J. Mori, D. Belikov, K. Ichii, T. Saeki, T. Ohta, K. Saito, M. Ueyama, A. Ito, S. Maksyutov, S. Miyazaki, E. J. Burke, A. Ganshin, Y. Iijima, T. Ise, H. Machiya, T. C. Maximov, Y. Niwa, R. O'ishi, H. Park, T. Sasai, H. Sato, S. Tei, R. Zhuravlev, T. Machida, A. Sugimoto, and S. Aoki (2017), Reconciliation of top-down and bottom-up CO₂ fluxes in Siberian larch forest, *Environmental Research Letters*, 12, 125012, doi: <https://doi.org/10.1088/1748-9326/aa926d>.
- Tatebe, H., M. Kurogi, and H. Hasumi (2017), Atmospheric Responses and Feedback to the Meridional Ocean Heat Transport in the North Pacific, *Journal of Climate*, 30, 5715–5728, doi:10.1175/JCLI-D-16-0055.1.
- Tatebe, H., and S. Osafune (2017), Possible relationship between Pacific interdecadal climate variability and the periodic 18.6-year tidal oscillation in the ocean, *Oceanography in Japan*, 27(1), 43177 (in Japanese).
- Tsuyuzaki, S., G. Iwahana, and K. Saito (2017), Tundra fire alters vegetation patterns more than the resultant thermokarst, *Polar Biology*, 41(4), 753–761, doi:10.1007/s00300-017-2236-7.
- Uchida, J., M. Mori, M. Hara, S. Satoh, D. Goto, T. Kataoka, K. Suzuki, and T. Nakajima (2017), Impact of Lateral Boundary Errors on the Simulation of Clouds with a Nonhydrostatic Regional Climate Model, *Monthly Weather Review*, 145(12), 5059–5082, doi:10.1175/MWR-D-17-0158.1.
- Watanabe, M., and T. Hibiya (2017), A near-inertial current event in the homogeneous deep layer of the northern Sea of Japan during winter, *Journal of Oceanography*, 74(2), 209–218, doi:10.1007/s10872-017-0451-z.
- Watanabe, M., and M. Kawamiya (2017), Remote effects of mixed layer development on ocean acidification in the subsurface layers of the North Pacific, *Journal of Oceanography*, 73(6), 771–784, doi:10.1007/s10872-017-0431-3.
- Watanabe, M., M. Noguchi, and T. Hajima (2017), Development of a marine ecosystem model to be embedded into an Earth system, *Model Oceanography in Japan*, 27(1), 31–41 (in Japanese).
- Watanabe, S., K. Hamilton, S. Osprey, Y. Kawatani, and E. Nishimoto (2017), First Successful Hindcasts of the 2016 Disruption of the Stratospheric Quasi-biennial Oscillation, *Geophysical Research Letters*, 45, doi:10.1002/2017GL076406.
- Wing, A. A., K. A. Reed, M. Satoh, S. Bjorn, B. Sandrine, and T. Ohno (2017), Radiative-Convective Equilibrium Model Intercomparison Project, *Geoscientific Model Development*, 11(2), 793–813, doi:10.5194/gmd-11-793-2018.

I. Research Activities and Results

Department of Integrated Climate Change Projection Research & Project Team for Advanced Climate Modeling

- Yamazaki, D., D. Ikeshima, R. Tawatari, T. Yamaguchi, F. O'Loughlin, J. C. Neal, C. C. Sampson, S. Kanae, and P. D. Bates (2017), A high-accuracy map of global terrain elevations, *Geophysical Research Letters*, 44(11), 5844–5853, doi:10.1002/2017GL072874.
- Yamazaki, D., S. Watanabe, and Y. Hirabayashi (2017), Global flood risk modeling and projections of climate change impacts, *Global Flood Hazard: Applications in Modeling, Mapping, and Forecasting/AGU Wiley*, 185–203, Chapter 11, doi:10.1002/9781119217886.ch11.
- Yoshimori, M., A. Abe-Ouchi, H. Tatebe, T. Nozawa, and A. Oka (2017), The importance of ocean dynamical feedback for understanding the impact of mid-high latitude warming on tropical precipitation change, *Journal of Climate*, 31, 2417–2434, doi:10.1175/JCLI-D-17-0402.1.
- Zhao, F., T. Veldkamp, K. Frieler, J. Schewe, S. Ostberg, S. Willner, B. Schauburger, S. Gosling, H.-M. Schmied, F. Portmann, G. Leng, M. Huang, X. Liu, Q. Tang, N. Hanasaki, H. Biemans, D. Gerten, T. Satoh, Y. Pokhrel, T. Stacke, P. Ciais, J. Chang, A. Ducharne, M. Guimberteau, Y. Wada, H. Kim, and D. Yamazaki (2017), The critical role of the routing scheme in simulating peak river discharge in global hydrological models, *Environmental Research Letters*, 12, 75003, doi:10.1088/1748-9326/aa7250.

Publication without Peer Review (Published)

- Goelzer, H., S. Nowicki, T. Edwards, M. Beckley, A. Abe-Ouchi, A. Aschwanden, R. Calov, O. Gagliardini, F. Gillet-Chaulet, N. R. Golledge, J. Gregory, R. Greve, A. Humbert, P. Huybrechts, J. H. Kennedy, E. Larour, W. H. Lipscomb, S. Le clec'h, V. Lee, M. Morlighem, F. Pattyn, A. J. Payne, C. Rodehacke, M. Ruckamp, F. Saito, N. Schlegel, H. Seroussi, A. Shepherd, S. Sun, R. van de Wal, and F. A. Ziemann (2017), Design and results of the ice sheet model initialisation experiments initMIP-Greenland: an ISMIP6 intercomparison, *Cryosphere Discussion*, doi:10.5194/tc-2017-129.
- Ohgaito, R., A. Abe, R. O'ishi, T. Takemura, A. Ito, T. Hajima, S. Watanabe, and M. Kawamiya (2017), The effect of high dust amount on the surface temperature during the Last Glacial Maximum: A modelling study using MIROC-ESM, *Climate of the Past Discussions*.
- Ono, J., H. Tatebe, and Y. Komuro (2017), Predictability of Arctic sea ice in a climate model MIROC: toward skillful seasonal forecasts, *The 33rd International Symposium on the Okhotsk Sea & Polar Oceans, 2018*, 33, 18–19.
- Saito, F., and R. Greve (2017), Brief introduction to ice-sheet modeling, Giant Reservoirs - Antarctic Low Temperature Science/Institute of Low Temperature Science, *Hokkaido University*, 76, 179–186, doi:10.14943/lowtemsci.76.179 (in Japanese).
- Suzuki, T., and T. Yasuda (2017), Ocean warming, the changing oceans and the influence of human activity, *Asakura Publishing Co., Ltd.*, 34–40 (in Japanese).
- Tachiiri, K., K. Takahashi, Y. Ito, N. Takayama, and K. Sugimura (2017), 1.5°C and 2°C: implication of the targets in the Paris Agreement on climate change and the pathways to achieve them, *Environmental Information Science*, 46(3), 64–70 (in Japanese).

Toward better understanding of the multi-scale processes in the Tropical Atmosphere

– Department of Seamless Environmental Prediction Research –

Better prediction of the severe weather events that may induce meteorological disaster is a socially demanding problem. Understanding of the interaction between the large-scale environment and the local weather events is essential to this problem. To achieve this, we have been developing a global high-resolution atmospheric model that is capable of simulating the local to global scale convective phenomena in a seamless framework. Subseasonal to seasonal variability is one of our major targets, which gives great impacts on the local weather over the globe. In FY2017, by making use of the global cloud-system-resolving simulations, we demonstrated the multi-scale processes within the intraseasonal oscillation events, which occurred during the JAMSTEC field campaign. This makes a stepping-stone toward more comprehensive understanding of the scale interactions and its proper representation in the model.

Quantification of the effects of high-frequency variability in the ISO events by global cloud-system-resolving simulations

The Madden-Julian Oscillation (MJO; [Madden and Julian, 1971]), or intraseasonal oscillation (ISO) is a dominant tropical variability accompanied with a large-scale (i.e., several thousand kilometers) envelope of organized convection. Because of its global impacts on weather and climate, such as tropical cyclogenesis, heavy rain events, and extreme surface air temperature, the ISO is receiving much attention from operational forecast centers. In JAMSTEC, the ISO has been intensively investigated by international field campaigns [e.g., Yoneyama *et al.*, 2013], as well as by global cloud-system-resolving simulations using Nonhydrostatic ICosahedral Atmospheric Model (NICAM; [Satoh *et al.*, 2014]) [e.g., Miura *et al.*, 2007; Miyakawa *et al.*, 2014; Nasuno *et al.*, 2017].

Recent researches emphasize the importance of moisture variability in the dynamics of the ISO. The convective envelope of the ISO consists of cloud system with various spatio-temporal scales, of which the basic component is cumulonimbus (~10 km, 1 hour). The moisture transport and condensational heating within these cloud systems are a key to understand and predict the ISO. The global cloud-system-resolving simulation has a merit that the vertical motion and condensational heating data are available at dense, broad coverage. This is difficult by field observations or low-resolution simulations. Making use of this merit, we quantify the effects of high-frequency variability (i.e., cumulonimbus) on the large-scale, including the ISO, by using the near real-time forecast dataset for the Cooperative Indian Ocean experiment on Intraseasonal variability in the year 2011 (CINDY2011; Yoneyama *et al.*, [2013]) [Nasuno *et al.*, 2017]. The target region here is the equatorial Indian Ocean domain (60°-90°E, 10°S-10°N).

Figure 1a shows the vertical profile of the simulated vertical advection of moisture, which accounts for a major part of moistening, nearly in balance with condensation. The advection associated with the low-frequency variability (e.g., ISO) and that associated with the high-frequency variability (e.g., cumulonimbus) were separated by applying time filtering (7-day average) to each variable. It was found that the low-frequency advection induced bottom-heavy moistening. The lower tropospheric moistening supported the large-scale convective envelope of the ISO through cloud formation, and was maintained by intensification of circulation by condensational heating. In contrast, the high-frequency advection induced drying in the lower troposphere, unfavorable to form the large-scale convective envelope. This is owing to strong upward transport of moisture by short-lived vigorous clouds. Such effects of high-frequency variability was not evident In European Center for Medium-Range Weather Forecasts Reanalysis (ERA)-Interim (Fig.1b) because the analysis is based on operational model that implicitly represent the effects of cumulonimbus with a coarser horizontal resolution.

I. Research Activities and Results

Department of Seamless Environmental Prediction Research

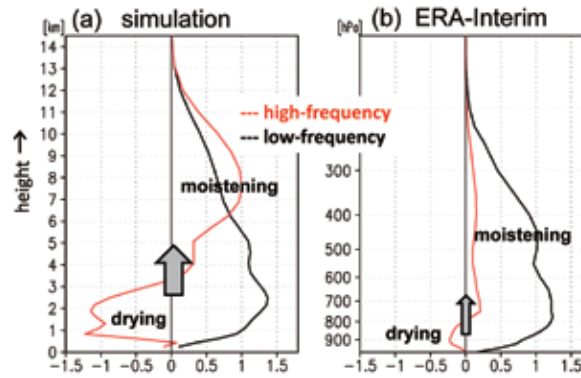


Fig.1 Vertical profiles of period-mean vertical advection of moisture over the equatorial Indian Ocean (60° - 90° E, 10° S- 10° N) in (a) the simulation and (b) ERA-Interim. Advection associated with the low-frequency (7-day mean) variability (black) and that associated with the high-frequency (<7 day) variability (red) are plotted.

In order to clarify the role of the high-frequency variability in the life cycle of the ISO, time evolution of the moisture advection was examined (Fig.2). It was found that the deep moistening by vertical advection due to the low-frequency variability well synchronized with the active period of the ISO (Fig.2a). During the active period, the upward transport of moisture due to high-frequency variability, as seen in the mean profile (Fig.1a), was more enhanced (Fig.2c). This helped deepening of the convection in the ISO, as well as limiting the duration of the moisture supply to the ISO convective envelope. An important finding is that moistening associated with the high-frequency advection was pronounced in the lower to middle troposphere during the inactive to preconditioning periods of the ISO (Fig.2c), together with the moistening due to horizontal transport of moisture in the middle troposphere due to the low-frequency variability (Fig.2b).

This study demonstrates the possible role of high-frequency variability in the preconditioning and mature stages of the ISO over the Indian Ocean. The results suggest that a better representation of these effects may lead to a correct prediction of the onset timing and subsequent development of the ISO. The effects of the high-frequency variability and its impacts on ISO is expected to be more significant over the maritime continent. This issue is under investigation as a part of the Years of the Maritime Continent (YMC) project (cf. DCOP).

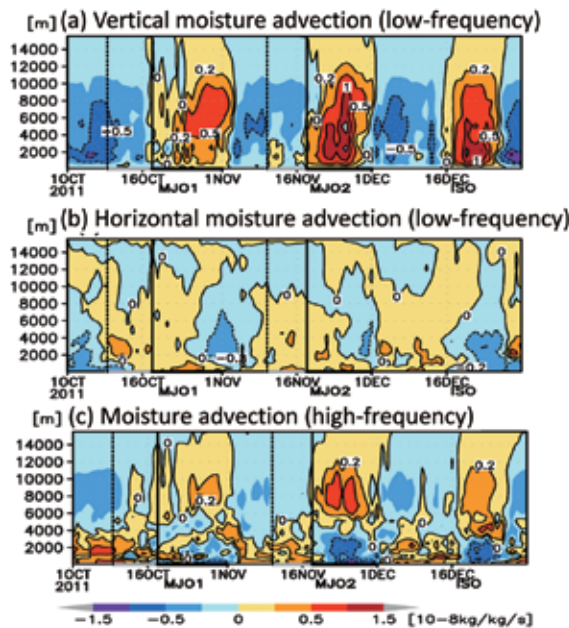


Fig.2 Time-height section of the anomalous advection of moisture over the equatorial Indian Ocean (60° - 90° E, 10° S- 10° N) in the simulation. (a) Vertical and (b) horizontal component associated with low-frequency (7-day mean) variability and (c) horizontal and vertical advection associated with high-frequency (<7 day) variability. The deviations from period-mean profiles are plotted. The gray and black bars at the bottom indicate the preconditioning and active periods of the ISO (Reproduced from Fig.11a, b, and d of [Nasuno *et al.*, 2017]).

References

- Madden, R. and P. Julian (1971), Detection of 40-50 day oscillation in the zonal wind in the tropical Pacific, *J. Atmos. Sci.*, **28**, 702–708.
- Madden, R. and P. Julian (1972), Description of global-scale circulation cells in the tropics with a 40-50 day period, *J. Atmos. Sci.*, **29**, 1109–1123.
- Miura, H., M. Satoh, T. Nasuno, A. T. Noda, and K. Oouchi (2007), A Madden-Julian Oscillation event realistically simulated by a global cloud-resolving model, *Science*, **318**, 1763–1765.
- Miyakawa, T., M. Satoh, H. Miura, H. Tomita, H. Yashiro, A. T. Noda, Y. Yamada, C. Kodama, M. Kimoto, K. Yoneyama (2014), Madden-Julian Oscillation prediction skill of a new-generation global model, *Nature Commun.*, **5**, 3769.
- Nasuno, T., K. Kikuchi, M. Nakano, Y. Yamada, M. Ikeda, H. Taniguchi (2017), Evaluation of the Near real-time Forecasts Using a Global Nonhydrostatic Model during the CINDY2011/DYNAMO, *J. Meteor. Soc. Japan*, **95**, 345–368.
- Satoh, M., H. Tomita, H. Yashiro, H. Miura, C. Kodama, T. Seiki, A. T. Noda, Y. Yamada, D. Goto, M. Sawada, T. Miyoshi, Y. Niwa, M. Hara, Y. Ohno, S. Iga, T. Arakawa, T. Inoue, H. Kubokawa (2014), The Non-hydrostatic Icosahedral Atmospheric Model: Description and Development, *Progress in Earth and Planetary Science*, **1**, 18.
- Yoneyama, K., C. Zhang, and C. N. Long (2013), Tracking pulses of the Madden-Julian Oscillation, *Bull. Amer. Meteor. Soc.*, **94**, 1871–1891.

Publication List

Publication with Peer Review (Published)

- Dado, J. M., and H. Takahashi (2017), Potential impact of sea surface temperature on rainfall over the western Philippines, *Progress in Earth and Planetary Science*, **4**(23), doi:10.1186/s40645-017-0137-6.
- Fujita, M. and T. Sato (2017), Observed behaviors of precipitable water vapour and precipitation intensity in response to upper air profiles estimated from surface air temperature, *Scientific Reports*, **7**, 4233, doi:10.1038/s41598-017-04443-9.
- Ikeda, M., and T. Nasuno (2018), Construction of near real-time forecast system using global nonhydrostatic model and actual uses at JAMSTEC intensive observations, *JAMSTEC Rep. Res. Dev.*, **27**, 47–56 (in Japanese).
- Kawazoe, S. and W. J. Gutowski (2018), Evaluation of regional very heavy precipitation events during the summer season using NARCCAP contemporary simulations. *Int. J. Climatol.* **38** (Suppl.1): e832–e846, doi:0.1002/joc.5412.
- Kikuchi, K., G. N. Kiladis, J. Dias, and T. Nasuno (2018), Convectively coupled equatorial waves within the MJO during CINDY/DYNAMO: Slow Kelvin waves as building blocks, *Clim. Dyn.*, **50**, 4211–4230, doi: 10.1007/s00382-017-3869-5.
- Kilpatrick, T., S. -P. Xie, and T. Nasuno (2017), Diurnal convection-wind coupling in the Bay of Bengal, *J. Geophys. Res. Atmosphere*, **122**, 9705–9720, doi:10.1002/2017JD027271.
- Nasuno, T., K. Kikuchi, M. Nakano, Y. Yamada, M. Ikeda, and H. Taniguchi (2017), Evaluation of the Near real-time Forecasts Using a Global Nonhydrostatic Model during the CINDY2011/DYNAMO, *J. Meteor. Soc. Japan*, **95**, 345–368, doi:10.2151/jmsj.2017-022.
- Wang, L., T. Li, L. Chen, S. K. Behera, and T. Nasuno (2018), Modulation of the MJO intensity over the equatorial western Pacific by two types of El Niño. *Clim. Dyn.*, **51**(1-2), 687–700, doi:10.1007/s00382-017-3949-6.
- Watanabe, S., K. Hamilton, S. Osprey, Y. Kawatani, and E. Nishimoto (2017), First successful hindcasts of the 2016 disruption of the stratospheric quasi-biennial oscillation, *Geophys. Res. Lett.*, **44**, doi:10.1002/2017GL076406.
- Zhao, C., T. Li, S. Yao, T. Nasuno, and S. K. Behera (2017), Intraseasonal Variability of Air Temperature over East Asia in Boreal Summer, *Front. Earth Sci.* **5**(63), doi:10.3389/feart.2017.00063.

Understanding of marine nitrogen cycle based on stable isotope analysis and modeling

– Department of Biogeochemistry –

The purpose of this group is to understand key processes and regulation mechanisms of nitrogen cycle in the ocean. For this purpose, we made various kinds of water sampling for nitrogen isotope analysis and measured nitrogen isotope ratios of each component of marine nitrogen cycle, such as phytoplankton, chlorophylls, nitrate, ammonium, particulate organic nitrogen, and so on, with our elemental analyzer–isotope ratio mass spectrometers. Based on these measured values, we developed 1 dimensional (1D) marine nitrogen isotope models (Fig.1) to comprehensive and quantitative understand the marine nitrogen cycle. In this year we newly measured nitrogen isotope ratios of nitrate along the east-west transect in the subarctic and subtropical North Pacific. Based on these measured values, we will extend our 1D isotope model to a 3D isotope model in the future.

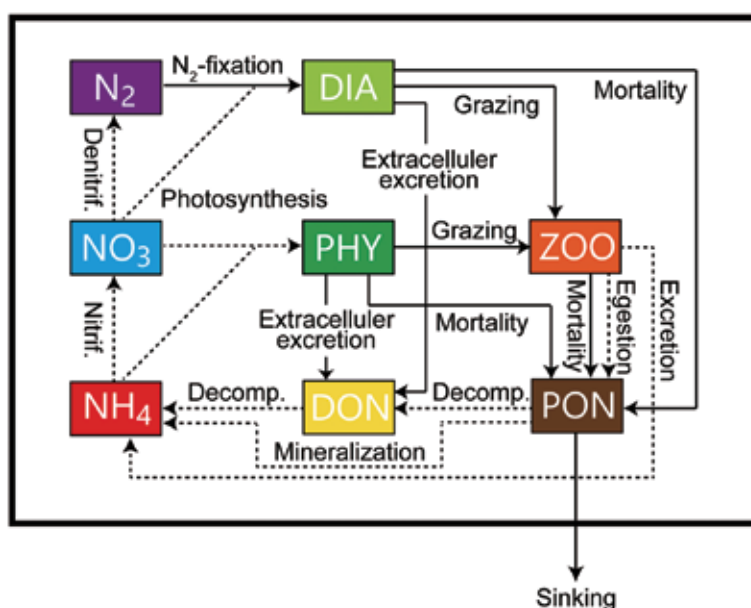


Fig.1 A schematic representation of the marine nitrogen isotope model. The symbols NO_3^- , NH_4^+ , N_2 , PHY, DIA, ZOO, PON, and DON represent the nitrate, ammonium, dinitrogen, phytoplankton, diazotroph, zooplankton, particulate organic nitrogen, and dissolved organic nitrogen concentrations, respectively. The N_2 fixation based on Yoshikawa *et al.* [2013] and denitrification based on Shigemitsu *et al.* [2016] were added to a marine nitrogen isotope model developed by Yoshikawa *et al.* [2005]. The dashed and solid arrows indicate nitrogen flows with and without isotopic fractionation, respectively.

Nitrate Isotope Distribution in the Subarctic and Subtropical North Pacific

The nitrogen isotopic composition of nitrate ($\delta^{15}\text{N}_{\text{Nitrate}}$) is widely used as a tracer of ocean-internal nitrogen cycling (consumption and regeneration) and ocean-external nitrogen inputs and losses. These inputs and losses include N_2 fixation, which is the fixation of N_2 gas into bioavailable nitrogen, such as ammonia by diazotrophs, and denitrification, including microbial respiration using nitrate as an electron acceptor. The oxygen isotopic composition of nitrate ($\delta^{18}\text{O}_{\text{Nitrate}}$) aids the interpretation of $\delta^{15}\text{N}_{\text{Nitrate}}$ [e.g., Casciotti *et al.*, 2008, Rafter *et al.*, 2013, Sigman *et al.*, 2009]. Here we report the $\delta^{15}\text{N}_{\text{Nitrate}}$ and $\delta^{18}\text{O}_{\text{Nitrate}}$ values in the subarctic and subtropical North Pacific (Fig.2) and discuss the nitrogen cycle there (Fig.3).

Water sampling was conducted along 47°N in the subarctic North Pacific and 149°E in the western North Pacific during the MR14-04 cruise of the R/V *Mirai* during July–August 2014. For samples with nitrate concentrations above $1.0 \mu\text{M}$, the $\delta^{15}\text{N}_{\text{Nitrate}}$ and $\delta^{18}\text{O}_{\text{Nitrate}}$ values were measured using the bacterial method of Sigman *et al.* [2001] and Casciotti *et al.* [2002]. $\delta^{15}\text{N}_{\text{Nitrate}}$ and $\delta^{18}\text{O}_{\text{Nitrate}}$ values were determined using a

I. Research Activities and Results

Department of Biogeochemistry

ThermoFinnigan GasBench + PreCon trace gas concentration system interfaced with a ThermoScientific Delta V Plus isotope-ratio mass spectrometer at JAMSTEC.

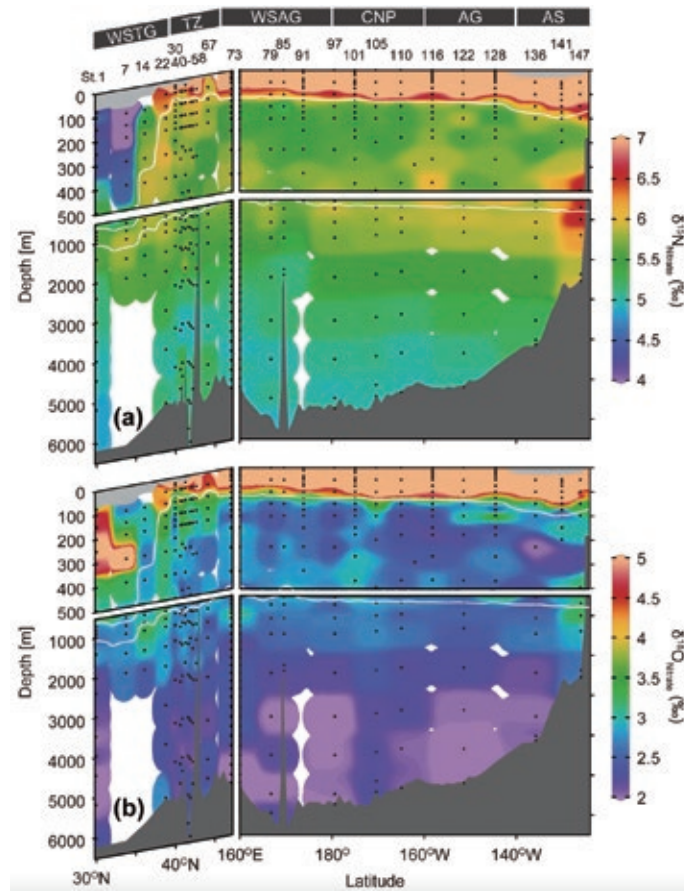


Fig.2 Horizontal distributions of (a) $\delta^{15}\text{N}_{\text{Nitrate}}$ values (‰) and (b) $\delta^{18}\text{O}_{\text{Nitrate}}$ values (‰) along the cruise track. Black dots indicate sampling points. White lines represent the isopycnal surfaces for $\gamma\text{N} = 26.5$ and $\gamma\text{N} = 27.4$. The surface gray areas indicate nitrate concentrations below $1.0 \mu\text{M}$. WSTG = western subtropical gyre; TZ = transition zone; WSAG = western subarctic gyre; CNP = central subarctic North Pacific; AG = Alaska gyre; AS = Alaska stream.

In the western subarctic gyre, known as a high-nutrient, low-chlorophyll region, the $\delta^{15}\text{N}_{\text{Nitrate}}$ and the differences between $\delta^{15}\text{N}_{\text{Nitrate}}$ and $\delta^{18}\text{O}_{\text{Nitrate}}$ (herein $\Delta(15-18)$) in the intermediate water were significantly lower than in the surrounding area. The ^{15}N -depleted nitrate was generated by nitrified nitrate from the remineralization of organic matter produced by the partial consumption of the surface nitrate pool. Between the western subarctic gyre and the Alaskan gyre, there was a 0.2‰ increase in $\delta^{15}\text{N}_{\text{Nitrate}}$ and a 0.3‰ increase in $\Delta(15-18)$ in the intermediate water associated with a $7.2 \mu\text{M}$ decrease in the nitrate concentration at the surface. Assuming Rayleigh distillation kinetics, the increase in utilization of the surface nitrate pool between the western subarctic gyre and the Alaskan gyre (from 29% to 85%) corresponds to a change in $\delta^{15}\text{N}$ of organic matter from 2.6‰ to 4.9‰. The ^{15}N enrichment of intermediate nitrate toward the east resulted from the increase in utilization. Moreover, the ^{15}N -depleted nitrate in the mixed-layer water of the western subtropical gyre was affected by N_2 fixation in the Kuroshio water, whereas the ^{15}N -enriched nitrate in the intermediate water at the western margin of North America was affected by water column denitrification. The $\delta^{15}\text{N}$ sediment record in the western subarctic North Pacific likely reflects past changes in the high-nutrient, low-chlorophyll region but may also be controlled by water column denitrification and N_2 fixation.

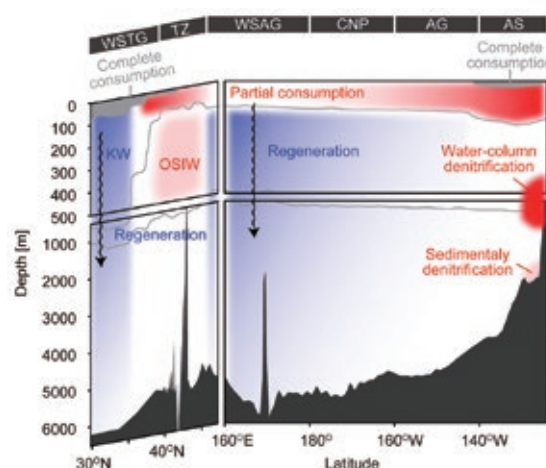


Fig.3 Schematic diagram showing how the $\delta^{15}\text{N}_{\text{Nitrate}}$ signals were generated and propagated in the study area. The red and blue shaded regions designate the intensity of ^{15}N enrichment and depletion, respectively. The gray shaded regions designate nitrate-deficient areas. The wavy arrows show the sinking of ^{15}N -depleted organic matter generated in the mixed-layer water. KW and OSIW indicate the water masses originating in the Kuroshio water and the Okhotsk Sea intermediate water areas, respectively. WSTG = western subtropical gyre; TZ = transition zone; WSAG = western subarctic gyre; CNP = central subarctic North Pacific; AG = Alaska gyre; AS = Alaska stream.

Publication List

Publication with Peer Review (Published)

- Honda, M. C., M. Wakita, K. Matsumoto, T. Fujiki, E. Siswanto, K. Sasaoka, H. Kawakami, Y. Mino, C. Sukigara, M. Kitamura, Y. Sasai, S. L. Smith, T. Hashioka, C. Yoshikawa, K. Kimoto, S. Watanabe, T. Kobari, T. Nagata, K. Hamasaki, R. Kaneko, M. Uchimiya, H. Fukuda, O. Abe, and T. Saino (2017), Comparison of carbon cycle between the western Pacific subarctic and subtropical time-series stations: highlights of the K2S1 project, *Journal of Oceanography*, 73(5), 647–667, doi:10.1007/s10872-017-0423-3.
- Sakai, S., S. Matsuda, T. Hikita, A. Shimono, J. B. McManus, M. Zahniser, D. Nelson, D. L. Dettman, D. Yang, and N. Ohkouchi (2017), High-precision simultaneous $^{18}\text{O}/^{16}\text{O}$, $^{13}\text{C}/^{12}\text{C}$ and $^{17}\text{O}/^{16}\text{O}$ analyses for μg -quantities of CaCO_3 by tunable infrared laser absorption spectroscopy, *Analytical Chemistry*, 89, 11846–11852.
- Yasunaka, S., Y. Nojiri, T. Hashioka, C. Yoshikawa, T. Kodama, S. Nakaoka, S. Chiba, F. Hashihama, M. Wakita, K. Furuya, D. Sasano, A. Murata, H. Uchida, and M. Aoyama (2018), Basin-scale distribution of NH_4^+ and NO_2^- in the Pacific Ocean, *Journal of Oceanography*, 74(1), 1–11, doi:10.1007/s10872-017-0433-1.

Research of Coastal Environment Change

– Mutsu Institute for Oceanography –

The aims of research program of the Mutsu institute for oceanography (MIO) are to investigate coastal environment changes and to understand biogeochemical cycle in coastal area which area might be affected by the global warming and the increasing carbon dioxide concentration. For this purpose, MIO is conducting observational studies around the eastern Tsugaru Strait under the collaborative agreements with the Hokkaido University and the Aomori Prefectural Industrial Technology Research Center.

Methods of our main researches are the measurement of surface current speed and direction using High frequency ocean radar system (HF radar), and the hydrographic observation in the eastern area of Tsugaru strait. The hydrographic observation by the training ship of Hokkaido University was started in 2009 and it has been conducted about 4 times a year. The surface water temperature off port of Sekinehama which was requested from the Aomori Prefectural Fisheries Experiment Station has been measured from 2002 to distribute for fishermen. The high frequent observation on the pier of Sekinehama Port was also added to detect seasonal and annual environmental changes after we observed the cold Oyashio Water in 2014. The in-situ observation using the continuous measuring pH device was enhanced in 2017 for understanding acidification effect on the coastal organisms in the Tsugaru Straight area.

The HF radar has been installed and operated since April 2014. The current pattern maps obtained from HF radar are distributed to fishermen and others through website, MORSETS (MIO Ocean Radar data Site for Easter Tsugaru Strait, <http://www.godac.jamstec.go.jp/morsets/e/top/>) on September 2015. This website is accessed mostly from Aomori area early morning. Probably a lot of fishermen check this site before fishing. In FY 2017, we arranged to add the coastal seawater temperature on the distributing image of MORSETS website for more convenient. We also started discussing to refer the sea surface temperature image obtained from the satellite on the MORSTES.

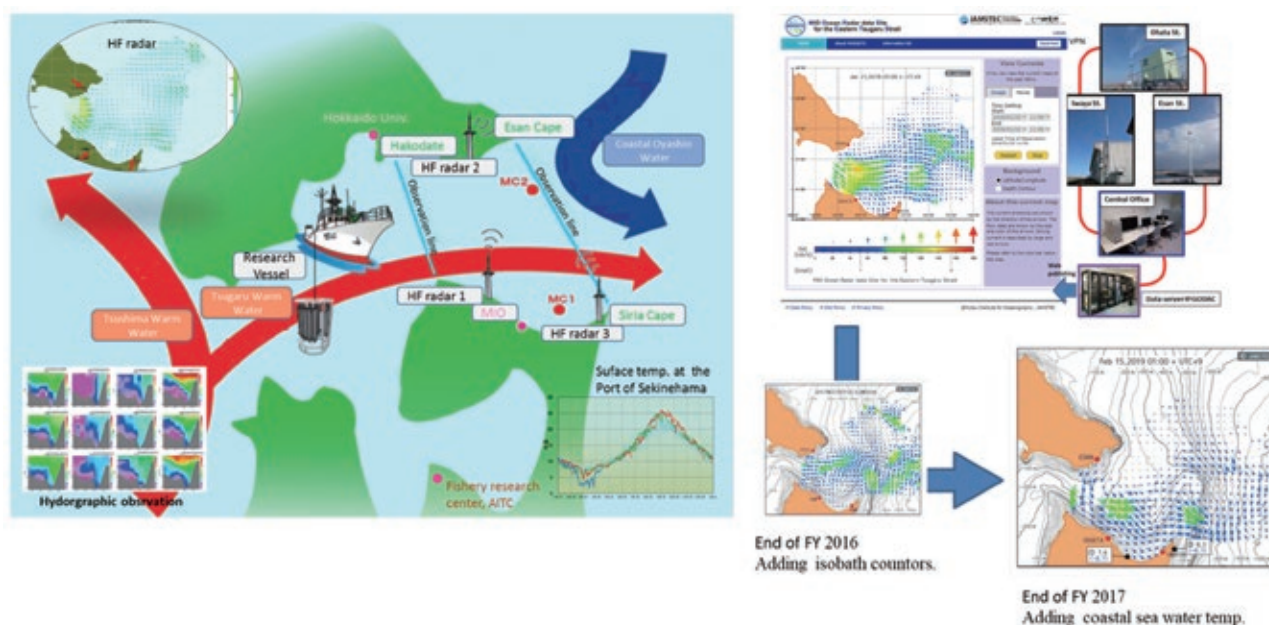


Fig.1 Schematic of MIO research program and website of MORSETS.

II. Related Activities

Research collaboration

1. Domestic research collaboration

(1) Institute of Low Temperature Science, Hokkaido University

Theme: Study of mechanism to sustain primary productivity and biogeochemical cycle in the subarctic North Pacific including its marginal seas such as Okhotsk and Bering Seas

Program: Research and Development Center for Global Change

(2) National Institute for Environmental Studies (NIES)

Theme: Improvement of observation using shipboard lidar for water vapor, cloud and aerosol over ocean

Program: Research and Development Center for Global Change

(3) Kyushu University, Institute for Advanced Study

Theme: Deposition of aerosol particles on the North Pacific and the Arctic region

Program: Research and Development Center for Global Change

(4) National Institute of Advanced Industrial Science and Technology (AIST)

Theme: Evaluation of a densitometer based on refractive index measurement

Program: Research and Development Center for Global Change

(5) The Tsurumi-Seiki Co., Ltd.

Theme: A study on development of the next-generation deep profiling float equipped with the high-accuracy dissolved oxygen sensor

Program: Research and Development Center for Global Change

(6) JFE Advantech Co., Ltd.

Theme: Evaluation of pressure dependency of the dissolved oxygen sensor used for the next-generation deep profiling float

Program: Research and Development Center for Global Change

(7) Research Institute for Sustainable Humanosphere, Kyoto University / Metro Weather Co., Ltd.

Theme: Observational study of wind characteristics over ocean using shipboard Doppler Lidar

Program: Research and Development Center for Global Change

(8) Graduate School of Maritime Sciences, Kobe University

Theme: Integration of observational and modeling studies of atmospheric ozone, precursors, and aerosols (SLCPs) over oceans around Japan

Program: Research and Development Center for Global Change

(9) The Center for Academic Resources and Archives, Tohoku University

Theme: Development of ultra-microscale skeletal density quantification of marine calcifiers by the Microfocus X-ray Computed Tomography

Program: Research and Development Center for Global Change

II. Related Activities
Research collaboration

(10) Institute of Tropical Medicine, Nagasaki University (NEKKEN)

Theme: Establishment of an early-warning system for infectious diseases in Southern Africa incorporating climate predictions

Program: Application Laboratory

(11) Center for Frontier Medical Engineering, Chiba University / School of Engineering, Tohoku University / Faculty of Engineering, Niigata University / Information Technology R&D Center, Mitsubishi Electric Corporation

Theme: Technology development for under-ice measurement in the Arctic Ocean

Program: Institute of Arctic Climate and Environment Change Research

(12) National Agriculture and Food Research Organization (NARO) / National Research Institute for Earth Science and Disaster Resilience (NIED) / Akita University

Theme: Domestic observations on thermal and hydrological states on and below surface

Program: Department of Integrated Climate Change Projection Research

(13) Meteorological Research Institute (MRI), Japan Meteorological Agency (JMA)

Theme: Improvement of mesh meteorological data accuracy using a regional climate model

Program: Department of Seamless Environmental Prediction Research

2. International research collaboration

A. Interagency agreement (*extracted based on the areas of cooperation related to Research and Development on Marine and Global Environmental Change)

(1) Woods Hole Oceanographic Institution (WHOI), USA

Theme:

- Arctic Research
Program: Institute of Arctic Climate and Environment Research
- Physical Oceanography and WOCE Hydrographic Lines Revisits
Program: Research and Development Center for Global Change
- Biogeochemistry and the Carbon Cycles
Program: Mutsu Institute for Oceanography
- Extra-tropical Ocean-Atmosphere variability and predictability
Program: Application Laboratory

(2) Scripps Institution of Oceanography (SIO), USA

Theme:

- Study of Ocean General Circulation and Climate
Programs: Research and Development Center for Global Change, and
Application Laboratory
- Research into Marine Biogeochemical Cycles
Program: Research and Development Center for Global Change

(3) The Trustees of Columbia University in New York, Lamont-Doherty Earth Observatory (LDEO), USA

Theme: Climate Change in Relation to Dynamics of Marine Ecosystem and Biogeochemical Cycles
Program: Research and Development Center for Global Change

(4) The Office of Oceanic and Atmospheric Research (OAR) of the National Oceanic and Atmospheric Administration (NOAA), USA

Theme:

- Indo-Pacific Tropical Ocean and Climate Research and IndOOS (Scientific and Technology Development Cooperation)
Program: Research and Development Center for Global Change
- Ocean and Climate Research in the North Pacific; Cooperation in Developing and Maintaining JAMSTEC and PMEL Contributions to the North Pacific Surface Mooring Network
Program: Research and Development Center for Global Change
- Arctic Observation and Research
Program: Institute of Arctic Climate and Environment Research
- CO₂ and other Autonomous Biogeochemical Sensors and Platforms including autonomous surface vehicles and autonomous underwater vehicles
Program: Research and Development Center for Global Change
- Computer Modeling for Global Environment Research
Program: Department of Integrated Climate Change Projection Research
- Ocean Acidification Observation and Research
Program: Research and Development Center for Global Change

II. Related Activities

Research collaboration

(5) University of Hawaii (UH), USA

Theme: Study on Climate Change and Variability in the Asia-Pacific region

Program: Application Laboratory

(6) University of Alaska Fairbanks (UAF), USA

Theme:

- Greenhouse Gas Dynamics of Boreal Forest and Tundra Ecosystems Vulnerability to Arctic Warming

Program: Research and Development Center for Global Change

- Arctic Ocean Observation Research

Program: Institute of Arctic Climate and Environment Research

- Northern Fresh Water Cycle and Changing Atmospheric Pattern

Program: Research and Development Center for Global Change

(7) The National Oceanography Centre (NOC) and The University of Southampton (UoS), UK

Theme:

- Geology and Geophysics (Palaeoceanography)

Program: Department of Biogeochemistry

- Physical Oceanography (The Argo Programme, Global Ocean Circulation)

Program: Research and Development Center for Global Change

(8) The Agency for the Assessment and Application of Technology of the Republic of Indonesia (BPPT), Indonesia

Theme:

- Tropical Ocean Climate Observational Studies

Program: Research and Development Center for Global Change

- Climate Dynamics Research over the Maritime Continent

Program: Department of Coupled Ocean-Atmosphere-Land Processes Research

(9) The Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia

Theme:

- Heat, Carbon and other Material Transports through Ocean Circulation and their Variability

- Planktonic Community Comparisons, including those of the Continuous Plankton Recorder, in Australasian and Japanese regions

- Ocean Modelling and Data Assimilation

- Real-time Monitoring of the Global Ocean, including Polar and Deep-water Extensions

- Indo-Pacific Ocean and Atmosphere Dynamics

Program: Research and Development Center for Global Change

(10) Department of Fisheries and Oceans (DFO), Canada

Theme:

- Observing and Modeling Ocean Climate Variability in the upper 200-300m layer of the Arctic Ocean

- Observing and Modeling Physical, Chemical and Biological Processes of Shelf/Basin Interaction

- Determining the Freshwater and Chemical Budgets of the Bering, Chukchi and Beaufort Seas

- Monitoring and Modeling the Evolution of Ice-Thickness Variability in both Shelf and Offshore Domains

Program: Institute of Arctic Climate and Environment Research

(11) Korea Institute of Ocean Science and Technology (KIOST), Korea

Theme:

- Western Pacific Ocean Circulation and Air-Sea Interaction
Program: Research and Development Center for Global Change
- Nonlinear Wave Interaction
Program: Application Laboratory

(12) Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI), Germany

Theme:

- Polar Research and Technology
Program: Institute of Arctic Climate and Environment Research
- Atmospheric Research
Program: Application Laboratory

(13) L'Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), France

Theme:

- Ocean Monitoring
Program: Research and Development Center for Global Change
- Simulation Research with the Earth Simulator
Program: Application Laboratory

(14) Council of Scientific and Industrial Research – National Institute of Oceanography (NIO), India

Theme:

- Upper Ocean Dynamics and Air-Sea Interactions in the Tropical Indian Ocean
- Ocean Biogeochemistry in the Indian Ocean and Impact on Ocean Climate
Program: Research and Development Center for Global Change

(15) The Agency for Meteorology, Climatology and Geophysics of the Republic of Indonesia (BMKG), Indonesia

Theme: Marine Meteorology and Climate Studies over the Maritime Continent

Program: Department of Coupled Ocean-Atmosphere-Land Processes Research

(16) Institute of Marine Research (IMR), Norway

Theme: Marine Research (e.g. Carbonate chemistry and Biogeochemistry, Ocean dynamics and Climate variability)

Programs: Research and Development Center for Global Change, and Institute of Arctic Climate and Environment Research

(17) The Ministry of Earth Sciences (MOES), India

Theme:

- Observation System for Ocean Climate Variability
Program: Research and Development Center for Global Change
- Modeling of Climate Variability and its Application
Program: Application Laboratory

II. Related Activities
Research collaboration

B. Research cooperation agreement between each research program and foreign institute on specific theme

(1) University of Alaska Fairbanks (UAF), USA

Theme:

- Greenhouse Gas Dynamics of Boreal Forest and Tundra Ecosystems Vulnerable to Arctic Warming
Programs: Research and Development Center for Global Change, Department of Integrated Climate Change Projection Research, and Institute of Arctic Climate and Environment Research
- Observational Research of Black Carbon in Alaska relevant to Climate and Environmental Changes in the Arctic
Program: Institute of Arctic Climate and Environment Research

(2) University of Hawaii (UH), USA

Theme:

- Sub-seasonal Predictability of Tropical and Extratropical Climate Modes
Programs: Department of Coupled Ocean-Atmosphere-Land Processes Research, and Application Laboratory
- Mid-Latitude Ocean-Atmosphere Variability
Program: Application Laboratory
- Unraveling the Coupled Air-Sea Interaction Processes in CFES in Shaping the Monsoon-Indian Ocean Basic States
Program: Application Laboratory

(3) Department of Fisheries and Oceans (DFO), Canada

Theme: Pan-Arctic Climate Investigation

Program: Institute of Arctic Climate and Environment Research

(4) The Agency for the Assessment and Application of Technology of the Republic of Indonesia (BPPT), Indonesia

Theme:

- Research Collaboration in Climatology, Meteorology, and Hydrometeorology over Indonesian Maritime Continent
Program: Department of Coupled Ocean-Atmosphere-Land Processes Research
- Tropical Ocean Climate Observational Studies
Programs: Research and Development Center for Global Change, and Department of Coupled Ocean-Atmosphere-Land Processes Research

(5) Anhui Institute of Optics and Fine Mechanics (AIOFM), Chinese Academy of Sciences, China

Theme: Research Cooperation of Atmospheric Composition Change related to Environmental and Climate Change

Program: Research and Development Center for Global Change

(6) Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences, China

Theme: Research Cooperation of Atmospheric Composition Change related to Environmental and Climate Change

Program: Research and Development Center for Global Change

- (7) **Advanced Environmental Monitoring Research Center (ADEMRC), Gwangju Institute of Science and Technology, Korea**
Theme: Research Cooperation of Atmospheric Composition Change related to Environmental and Climate Change
Program: Research and Development Center for Global Change

- (8) **Universidad de Concepción (UDEC), Chile**
Theme: Basic Research on Paleoceanography, Biogeochemistry, Biology, Physical Oceanography and Geophysics in the Coastal Area off Chile
Program: Research and Development Center for Global Change

- (9) **Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) of the Department of Science and Technology (DOST), The Philippines**
Theme: Monsoon Experiment in the Republic of the Philippines
Program: Department of Coupled Ocean-Atmosphere-Land Processes Research

- (10) **Aero-Meteorological Observatory of National Hydro-Meteorological Service (AMO/NHMS), Vietnam**
Theme: Research Collaboration on Asian Monsoon Observation over Vietnam
Program: Department of Coupled Ocean-Atmosphere-Land Processes Research

- (11) **A.M. Obukhov Institute of Atmospheric Physics (IAP), Russian Academy of Sciences, Russia**
Theme: Research Cooperation of Atmospheric Composition Change related to Environmental and Climate Change
Program: Research and Development Center for Global Change

- (12) **Departement Oceanographie et Dynamique des Ecosystemes, L'Institut Français de Recherche pour l'Exploitation de la Mer (ODF/IFREMER), France**
Theme: Scale Interactions and Material Transport using Output from High-resolution Ocean Simulations
Program: Application Laboratory

- (13) **The Agency for Meteorology, Climatology and Geophysics of the Republic of Indonesia (BMKG), Indonesia**
Theme: Weather and Climate over the Indonesian Maritime Continent
Program: Department of Coupled Ocean-Atmosphere-Land Processes Research

- (14) **The National Institute of Water and Atmospheric Research (NIWA), New Zealand**
Theme: Investigation of Climate Predictability and Applicability over New Zealand using Statistical Downscaling Method
Program: Application Laboratory

- (15) **Korean Polar Research Institute (KOPRI), Republic of Korea**
Theme: Marine Research in the western Arctic Ocean
Program: Institute of Arctic Climate and Environment Research

- (16) **The University of Oxford, United Kingdom Le Centre National de la Recherche Scientifique, France Indian Institute of Tropical Meteorology, India Potsdam Institut für Klimafolgenforschung, Germany, and Institute of Atmospheric Physics, China**
Theme: Globally Observed Teleconnections in Hierarchies of Atmospheric Models
Program: Department of Seamless Environmental Prediction Research

Funded research projects

(1) Development of a New Ecosystem Model to Represent the Adaptive Capacity of Plankton Communities in the North Pacific (FY2012-2017)

Fund: Core Research for Evolutional Science and Technology (CREST)

Funding institution: Japan Science and Technology Agency (JST)

Program: Research and Development Center for Global Change

(2) Research on use and improvement of ocean database (FY2015-2017)

Fund: Environment Research and Technology Development Fund (ERTDF)

Funding institution: Meteorological Research Institute (MRI), Japan Meteorological Agency (JMA)

Program: Research and Development Center for Global Change

(3) Estimation of Asian CH₄ emission and evaluation of emission reduction by inverse modeling (FY2015-2017)

Fund: Environment Research and Technology Development Fund (ERTDF)

Funding institution: Nara Women's University

Program: Research and Development Center for Global Change

(4) Effective utilization of new satellite observations on air pollution at km-class spatial resolution for frontier science and policy on ozone and PM_{2.5} issues (FY2015-2017)

Fund: Coordination Funds for Promoting AeroSpace Utilization

Funding institution: Ministry of Education, Culture, Sports, Science and Technology (MEXT),

Program: Research and Development Center for Global Change

(5) Impacts of Short-Lived Climate Pollutants from Asia on the Arctic Climate and Environment (FY2015-2017)

Fund: Environment Research and Technology Development Fund (ERTDF)

Funding institution: National Institute for Environmental Studies (NIES)

Program: Research and Development Center for Global Change

(6) C budget of ecosystems and cities and villages on permafrost in eastern Russian Arctic (COPERA) (FY2015-2019)

Fund: Strategic International Research Cooperative Program “Belmont Forum”

Funding institution: Japan Science and Technology Agency (JST)

Program: Research and Development Center for Global Change

(7) Validation of GPM/DPR on the oceanic precipitating clouds by utilizing the data from R/V Mirai onboard instruments (FY2016-2018)

Fund: Precipitation Measuring Mission (PMM)

Funding institution: Japan Aerospace Exploration Agency (JAXA)

Program: Research and Development Center for Global Change

(8) Detection of temporal variation in marine primary production (FY2016-2018)

Fund: Environment Research and Technology Development Fund (ERTDF)

Funding institution: National Institute for Environmental Studies (NIES)

Program: Research and Development Center for Global Change

- (9) Acquisition of ground truth data for mapping of biophysical parameters of forest (FY2016-2018)**
Fund: Global Change Observation Mission (GCOM)
Funding institution: Japan Aerospace Exploration Agency (JAXA)
Program: Research and Development Center for Global Change
- (10) Ocean Deployment of drifting buoys with pCO₂ Sensor – Toward Resolving Data Gap Area – (FY2016-2020)**
Fund: Global Environment Research Account for National Institutes
Funding institution: Ministry of Education, Culture, Sports, Science and Technology (MEXT)
Program: Research and Development Center for Global Change
- (11) Top-down model development for estimation of total carbon (CO₂,CH₄,CO) sources and sinks (FY2017-2019)**
Fund: Environment Research and Technology Development Fund (ERTDF)
Funding institution: National Institute for Environmental Studies
Program: Research and Development Center for Global Change
- (12) Establishment of an Early-warning System for Infectious Diseases in Southern Africa Incorporating Climate Predictions (FY2014-2018)**
Fund: Science and Technology Research Partnership for Sustainable Development (SATREPS)
Funding institution: Japan Agency for Medical Research and Development (AMED)
Program: Application Laboratory
- (13) Assimilation of high-resolution satellite sea surface temperature data, including Himawari-8, into numerical ocean models and validation of the products (FY2015-2018)**
Fund: A contract research funded by Japan Aerospace Exploration Agency
Funding institution: Japan Aerospace Exploration Agency (JAXA)
Program: Application Laboratory
- (14) Arctic Challenge for Sustainability (ArCS) (FY2015-2019)**
Fund: National flagship project funded by the Ministry of Education, Culture, Sports, Science and Technology
Funding institution: Ministry of Education, Culture, Sports, Science and Technology (MEXT)
Program: Institute of Arctic Climate and Environment Research
- (15) Improvement of forest radiative transfer model (FY2016-2018)**
Fund: Environment Research and Technology Development Fund (ERTDF)
Funding institution: Hokkaido University
Program: Institute of Arctic Climate and Environment Research
- (16) Research algorithm development of GCOM-C1 LAI/FAPAR, and NPP (FY2016-2018)**
Fund: Global Change Observation Mission (GCOM)
Funding institution: Japan Aerospace Exploration Agency (JAXA)
Program: Institute of Arctic Climate and Environment Research

II. Related Activities

Funded research projects

(17) Studies on effects of large-scale tropical disturbances upon climate in East Asia (FY2015-2017)

Fund: Environment Research and Technology Development Fund (ERTDF)

Funding institution: Atmosphere and Ocean Research Institute (AORI), The University of Tokyo

Program: Department of Coupled Ocean-Atmosphere-Land Processes Research

(18) Elucidating variability of stratospheric circulations associated with a global warming (FY2015-2017)

Fund: Environment Research and Technology Development Fund (ERTDF)

Funding institution: Atmosphere and Ocean Research Institute (AORI), The University of Tokyo

Program: Department of Integrated Climate Change Projection Research

(19) Assessing dynamic permafrost degradation mechanism and vulnerability (FY2016-2018)

Fund: Environment Research and Technology Development Fund (ERTDF)

Funding institution: Ministry of the Environment

Program: Department of Integrated Climate Change Projection Research

(20) Investigation of the possibility to improve an Earth system model utilizing GCOM-C data (FY2016-2018)

Fund: Global Change Observation Mission (GCOM)

Funding institution: Japan Aerospace Exploration Agency (JAXA)

Program: Department of Integrated Climate Change Projection Research

(21) Research on methane – climate feedback (FY2017-2019)

Fund: Environment Research and Technology Development Fund (ERTDF)

Funding institution: National Institute for Environmental Studies

Program: Project Team for Advanced Climate Modeling

(22) Sophisticated Earth system model for evaluating emission reductions needed (FY2017-2021)

Fund: Integrated Research Program for Advancing Climate Models (TOUGOU)

Funding institution: Ministry of Education, Culture, Sports, Science and Technology (MEXT)

Program: Project Team for Advanced Climate Modeling

(23) Prediction and Projection of Large-Scale Climate Changes Based on Advanced Model Development (FY2017-2021)

Fund: Integrated Research Program for Advancing Climate Models (TOUGOU)

Funding institution: Atmosphere and Ocean Research Institute, The University of Tokyo

Program: Project Team for Advanced Climate Modeling

(24) Impact of Short Lived Climate Pollutants on Global Water Cycle (FY2014-2018)

Fund: Environment Research and Technology Development Fund (ERTDF)

Funding institution: Kyushu University

Program: Department of Seamless Environmental Prediction Research

(25) Meteorological and Agricultural Information System (FY2014-2018)

Fund: Cross-ministerial Strategic Innovation Promotion Program

Funding institution: Central Region Agricultural Research Center (CARC), National Agriculture and Food Research Organization (NARO)

Program: Department of Seamless Environmental Prediction Research

(26) Globally Observed Teleconnections and their Role and Representation in the Hierarchies of Atmospheric Models (FY2016-2019)

Fund: Strategic International Research Cooperative Program “Belmont Forum”

Funding institution: Japan Science and Technology Agency (JST)

Program: Department of Seamless Environmental Prediction Research

(27) Development and improvement of the method for isolation and purification of various organic compounds to evaluate the dynamics of marine ecosystems and material cycling (FY2013-2018)

Fund: Core Research for Evolutional Science and Technology (CREST)

Funding institution: Japan Science and Technology Agency (JST)

Program: Department of Biogeochemistry

Awards

- **PEPS The Most Cited Paper Award**

Dr. Chihiro Kodama, Dr. Tatsuya Seiki, Dr. Akira Noda (Department of Seamless Environmental Prediction Research)

The Non-hydrostatic Icosahedral Atmospheric Model: description and development
(April 2017)

- **The Okada Prize of the Oceanographic Society of Japan**

Dr. Takeshi Doi (Application Laboratory)

Understanding and predicting variation in tropical and coastal ocean upwelling
(May, 2017)

- **The Okada Prize of the Oceanographic Society of Japan**

Dr. Koji Sugie (Research and Development Center for Global Change)

Impact of ocean acidification on phytoplankton dynamics and bioelement cycling
(May, 2017)

- **Nishida Prize for Promotion of Geo-and Planetary Science**

Dr. Shingo Watanabe (Department of Seamless Environmental Prediction Research)

Studies on general circulation of the atmosphere based on high resolution GCM and earth system model
(May, 2017)

- **The Award of the Meteorological Society of Japan**

**Dr. Shingo Watanabe (Department of Seamless Environmental Prediction Research),
Dr. Yoshio Kawatani (Department of Integrated Climate Change Projection Research)**

Studies on the middle atmosphere general circulations using gravity wave resolving models
(May, 2017)

- **ESPEC Prize for the Encouragement of Environmental Studies**

Dr. Takuma Miyakawa (Research and Development Center for Global Change)

Studies on PM2.5 aerosol characterization using next-generation unmanned observation platforms
(August, 2017)

- **NASA Group Achievement Award**

Dr. Kazuyuki Miyazaki (Research and Development Center for Global Change)

For his contributions to the KORUS-AQ projects using a multi-constituent data assimilation system developed at JAMSTEC
(September, 2017)

- **Extraordinary Scientist Award of the Paleosciences Society**

Dr. Naomi Harada (Research and Development Center for Global Change)

Study on the subarctic North Pacific paleoenvironment in late Quaternary
(November, 2017)

- **Hydrographic Technology Encouragement Award of the Japan Hydrographic Association
Institute of Arctic Climate and Environment Research**

Development of under-ice AUV for the Arctic Ocean
(February, 2018)

- **Ecological Research Paper Award of the Ecological Society of Japan
Dr. Shin Nagai (Research and Development Center for Global Change)**

Seasonality of leaf litter and leaf area index data for various tree species in a cool-temperate deciduous broad-leaved forest, Japan, 2005-2014
(March, 2018)

* Papers in this Annual Report may be overlap across groups or fiscal years.

Published by: Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Publication Date: February 2019

ISBN: 978-4-901833-45-5



Research and Development on Marine and Global Environmental Change

-
- | | |
|---|---|
| ● Headquarters | 2-15 Natsushima-cho, Yokosuka-city, Kanagawa 237-0061, Japan
PHONE : +81-46-866-3811 |
| ● Yokohama Institute for Earth Sciences | 3173-25 Showa-machi, Kanazawa-ku, Yokohama-city, Kanagawa 236-0001, Japan
PHONE: +81-45-778-3811 |
| ● Mutsu Institute for Oceanography | 690 Kitasekine, Sekine, Mutsu-city, Aomori 035-0022, Japan
PHONE : +81-175-25-3811 |
| ● Contact | rsd-pr@jamstec.go.jp |
| ● URL | http://www.jamstec.go.jp/ |