Workshop Schedule

Day 1: December 9, 2009

9:00-9:20 Registration

9:20-9:30 Opening/Practical Information
Kevin Hamilton and Wataru Ohfuchi

Session 1
Tropical Ocean and Coupled Ocean-Atmosphere Processes
Chair: Akio Ishida

9:30-9:50 Hideharu Sasaki
9:50-10:10 Baoqiang Xiang
10:10-10:30 Ingo Richter

10:30-11:00 Break, Photo Session

Tropical Ocean and Coupled Ocean-Atmosphere Processes (Continued)
Chair: Hideharu Sasaki

11:00-11:20 Yoshikazu Sasai
11:20-11:40 Akio Ishida
11:40-12:00 Yukio Masumoto

12:00-13:20 LUNCH

Session 2

Ocean Dynamics

Chair: Takeshi Enomoto

13:20-13:40 Oleg Melnichenko

13:40-14:00 Shinichiro Kida

14:00-14:20 Patrice Klein

Session 3

Data Assimilation

Chair: Tangdong Qu

14:20-14:40 Gleb Panteleev

14:40-15:10 Break

Data Assimilation (Continued)

15:10-15:30 Takeshi Enomoto

15:30-15:50 Gleb Panteleev

Session 4

Climate Change Modeling

Chair: Kevin Hamilton

15:50-16:10 Axel Lauer

16:10-16:30 H. Annamalai

16:30-16:50 Tim Li

WORKSHOP DINNER starting 18:30

Day 2: December 10

9:00-9:10 Practical Information
Kevin Hamilton and Wataru Ohfuchi

Session 5
Midlatitude Ocean and Coupled Ocean-Atmosphere Processes
Chair: Masami Nonaka

9:10-9:30 Hisashi Nakamura
9:30-9:50 Akira Kuwano-Yoshida
9:50-10:10 Bunmei Taguchi
10:10-10:30 Masami Nonaka

10:30-11:00 Break

Midlatitude Ocean and Coupled Ocean-Atmosphere Processes (Continued)
Chair: Bunmei Taguchi

11:00-11:20 Yoshi N. Sasaki
11:20-11:40 Tangdong Qu

Session 6
Model Development Issues
Chair: Wataru Ohfuchi

11:40-12:00 Nobumasa Komori
12:00-12:20 Ryo Onishi

12:20-13:40 LUNCH

Model Development Issues (Continued)

13:40-14:00 Juanxiong He

14:00-14:20 Don Morton

Session 7

Atmospheric Dynamics

Chair: Hisashi Nakamura

14:20-14:40 Yoshiyuki O. Takahashi

14:40-15:00 Yoshio Kawatani

15:00-15:30 Break

Atmospheric Dynamics (Continued)

15:30-15:50 Wataru Ohfuchi

15:50-16:10 Shang-Ping Xie

16:10-16:30 Hironori Fudeyasu

16:30-16:50 Kevin Hamilton

Session 8

16:50-17:30 Discussion

Seasonal variations of the Hawaiian Lee Countercurrent induced by the meridional migration of the Trade Winds

Hideharu Sasaki (ESC/JAMSTEC), Shang-Ping Xie (IPRC/Univ. of Hawaii),
Bunmei Taguchi (ESC/JAMSTEC), Masami Nonaka (RIGC/JAMSTEC),
Yukio Masumoto (RIGC/JAMSTEC)

Seasonal variations of the Hawaiian Lee Countercurrent (HLCC) are investigated using satellite observations of sea surface height (SSH) and wind stress as well as eddy-resolving ocean simulations using the OFES. The HLCC is strong from summer to winter and weak in spring between the dateline and the Hawaiian Islands. In response to the seasonal migration of the northeast trade winds in the meridional direction, the wind curl dipole lee of Hawaii varies strength, exciting westward-propagating Rossby waves via Ekman pumping. The analyses of both observations and simulations show that the propagation of Rossby waves south of the HLCC, driven by the southern pole of the wind curl dipole in the lee of the islands, contributes the most to the seasonal variations of the HLCC. It seems consistent with the generation mechanism of the HLCC by Xie et al. (2001) and with the seasonal cycle of the trade winds. We further found that the influence of the southern Rossby waves is dominant. Unlike the wind-driven seasonal variations, our analysis suggests that other mechanisms such as mode water intrusion or air-sea interaction may cause the interannual variations of the HLCC.

A newly developed global climate model--Coupled POP and ECHAM model

Baoqiang Xiang 1 Bin Wang 1,2 Qinghua Ding 1, Xiouhua Fu 2

1 University of Hawaii at Manoa, Hawaii
2 International Pacific Research Center, Hawaii

A newly coupled OAGCM is developed based on POP-1.4.3 and ECHAM-4.6 model by using the coupler of OASIS-3.0. Preliminary results of this coupled model climatology and its simulation of the interannual climate modes will be presented and evaluated, such as monsoon, intraseasonal oscillation, ENSO, and so on.

Some common problems of ENSO simulation exhibit in current coupled models with too regular and high frequency, and diverse amplitudes. Our coupled model has a reasonable ENSO frequency but the amplitude is relative weaker compared with observations. This is quite important and fundamental issue about the ENSO simulation. So we will discuss the causes of the weak amplitude of ENSO from the perspective of mean state and feedback processes.

The link between equatorial and southeast Atlantic warm events as inferred from CFES simulations and observations

Ingo Richter[1,4]*, Swadhin Behera[1,4], Yukio Masumoto[1,2], Nobumasa Komori[3], Bunmei Taguchi[3] , Toshio Yamagata[2,4]

[1] *Research Institute for Global Change, JAMSTEC, Yokohama, Japan*
[2] *Graduate School of Science, University of Tokyo, Tokyo, Japan*
[3] *Earth Simulator Center, JAMSTEC, Yokohama, Japan*
[4]*Application Laboratory, JAMSTEC, Yokohama, Japan*

A recent 100-year simulation of CFES is used to analyze the relation between warm events in the eastern equatorial Atlantic (Atlantic Niños) and southeastern Atlantic (Benguela Niños). Unlike large model biases seen in many current general circulation models CFES achieves a very realistic simulation of the tropical Atlantic, particularly in the equatorial region. Both Atlantic and Benguela Niños are simulated with realistic amplitude and phase locking, making the model suitable for analyzing the relation between the two events. The temporal correlation between indices of the Atlantic Niño (ATL3) and Benguela Niño (ABA) is approximately 0.65, which is roughly the same as the correlation calculated from the optimally interpolated (OI) sea surface temperature (SST) dataset. Maximum correlation occurs when the ABA leads the ATL3 by two months. It is found that, in the model context, the close correlation between ABA and ATL3 is due to their common origin from a basin wide weakening of the South Atlantic subtropical anticyclone. The weakening of the anticyclone commences in boreal winter and leads to warming in the ABA through a combination of reduced upwelling due to local weakening of the along-shore winds, and downwelling Kelvin waves initiated in the equatorial region. The latter also provides a precondition to ATL3 warming by depressing the thermocline in that region. The subsurface temperature anomaly thus induced finds its surface expression in boreal summer when the climatological thermocline is shallowest and upwelling most vigorous. The limited satellite observations available at this time appear to confirm the above mechanism.

Seasonal and interannual variability of marine ecosystem in the Eastern Tropical Pacific with an eddy-resolving physical-biological model

Yoshikazu Sasai[1], Akio Ishida[1], Kelvin J. Richards[2], and Hideharu Sasaki[3]

[1] Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology, 3173-25, Showa-machi, Kanazawa-ku, Yokohama, 236-0001, Japan

[2] International Pacific Research Center, SOEST, University of Hawaii, Honolulu, 96822, USA

[3] Earth Simulator Center, Japan Agency for Marine-Earth Science and Technology, Yokohama, 236-0001, Japan

A global eddy-resolving coupled physical-biological model has conducted to investigate the seasonal and interannual variability of marine ecosystem in the eastern tropical Pacific during 2000-2007. The seasonal variability of surface chlorophyll concentration in the model agrees reasonable with the satellite ocean color data, except for the equatorial region. High chlorophyll levels off the Gulf of Tehuantepec, Papagayo, and Panama in winter and in the Costa Rica Dome in summer is well reproduced due to the supplying of nitrate rich-waters by the vertical mixing and coastal and open ocean upwelling. The variability of thermocline depth is strongly connected to the seasonal variability of surface chlorophyll. The El Niño Southern Ocean (ENSO) scale variability has an affect on the marine ecosystem. The model reproduces the variability of chlorophyll is corresponding to the ENSO scale variability. During the cold SST anomalies phase (2000, 2001 and 2007), the chlorophyll concentration is much higher than the other years (2002-2006). When the SST anomalies are cold, the chlorophyll concentrations are high with the supplying of nutrient rich-waters by the shoaling of thermocline and nutricline depths and the strong vertical mixing associated with the trade winds. When the SST anomalies are warm, the chlorophyll concentrations are low because of deepening of thermocline and nutricline

depths.

Water mass transport in the Arabian Sea: an idealized tracer study using OFES

Akio Ishida[1], Yoshikazu Sasai[1], Yasuhiro Yamanaka[1, 2] and Hideharu Sasaki[3]

1. Research Institute of for Global Change, Japan Agency for Marine-Earth Science and Technology

2. Graduate School of Environmental Earth Science, Hokkaido University

3. Earth Simulator Center, Japan Agency for Marine-Earth Science and Technology

The intermediate waters in the Arabian Sea are characterized by a thick layer of low-oxygen water. The outflow from the Red Sea through the Gulf of Aden is considered to partly determine the properties in the intermediate waters. Although mean properties have been investigated through observational and modeling studies, the transient dynamics of the water spreading from the Red Sea has not been fully understood.

In this study, we have performed an idealized tracer experiment using the current velocities from Ocean General Circulation Model for the Earth Simulator (OFES) to investigate the role of variations in currents and eddies in spreading of the Red Sea Water through the Gulf of Aden. The tracer is passive and governed by the advection-diffusion equation with constant source into the Gulf of Aden. To elucidate the controlling factors the velocity field has been decomposed into three components: daily mean, 121-day running mean to remove the eddies, and long term mean. The tracer extends eastward from the Gulf of Aden in the experiments with the long term mean or running mean velocity field. In contrast, the zonal extent is limited and diffusive spreading in the north-south direction appears in the daily velocity experiment. This indicates that the eddy motions even at the intermediate depths play a critical role in spreading of the Red Sea Water into the western Arabian Sea. To quantify the role of eddies and seasonal variation of the current field, the diffusivity in is estimated using the advection flux of tracer.

Decadal variations in the shallow meridional overturning cell in the southern tropical Indian Ocean

Yukio Masumoto (Research Institute for Global Change, JAMSTEC /
Graduate School of Science, the University of Tokyo),
Ayano Tanabe (Graduate School of Science, the University of Tokyo),
Tomomichi Ogata (Graduate School of Science, the University of Tokyo)

A possible mechanism responsible for decadal variation of the shallow meridional overturning cell in the southern tropical Indian Ocean is investigated by analyzing results from a high-resolution ocean general circulation model and by a series of numerical experiments using a simple reduced gravity wave ocean model. Simulated variations demonstrate strong weakening of the cell during 1990's. This weakening of the cell is associated with weakening of the southward Ekman transport due to reduced easterly winds over the southern tropical region. In the subsurface layer, positive (negative) thermocline depth anomaly appears in the eastern (western) part of the region, which generates the southward geostrophic current anomaly. It turns out that this subsurface anomaly field is mainly generated by the wind stress curl anomaly over the southeastern tropical Indian Ocean. Decadal variations and their mechanisms during other periods are also discussed.

QUASI-STATIONARY STRIATIONS IN THE EASTERN SUBTROPICAL PACIFIC: VORTICITY BALANCE.

Oleg Melnichenko[1], Nikolai Maximenko[1], Niklas Schneider[1], and Hideharu Sasaki[2]

[1] International Pacific Research Center, School of Ocean and earth Science and Technology, University of Hawaii, Honolulu, Hawaii

[2] The Earth Simulator Center, Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan

Using 1993-2002 mean dynamic ocean topography, concurrent satellite altimeter observations and output of the Ocean General Circulation Model for the Earth Simulator (OFES), the dynamics of quasi-stationary alternating jet-like structures (striations) in the eastern parts of the subtropical North and South Pacific are examined by assessing individual terms in the time-averaged relative and potential vorticity balances.

We demonstrate that the observed and modeled striations are governed by the same dynamics, in which the transient (eddy) forcing is found to be essential. At the same time, eddies act differently from what one would expect from the two-dimensional turbulence theory or based on results of idealized studies of multiple zonal jets. Using potential vorticity (PV) diagnostics, we show that the time-mean PV is not conserved following the time-mean streamlines on the scale of the striations and that this circulation is sustained by the eddy flux of layer thickness rather than by inertial dynamics. Two linear terms, advection of the striations' PV anomaly by the large-scale flow and advection of the background large-scale PV by the striations, appear in the time-averaged PV budget due to the non-zero angle between the large-scale flow and the striations' axes. In the upper layer, these terms are as large as the eddy forcing term and tend to partially compensate for each other, as if the striations were Rossby waves standing on the large-scale flow. At the same time, these waves seem to be able to organize the eddy field as to sustain them.

The impact of open ocean circulation on marginal sea overflows

Shinichiro Kida
Earth Simulator Center, JAMSTEC

A recently developed non-hydrostatic oceanic model, the Multi-Scale Simulator for the Geoenvironment - Ocean (MSSG-O), is introduced. The model simulates realistic features from basin scale to laboratory scale successfully which will be useful tool for various multi-scale process modelling studies.

Using MSSG-O, we examined how marginal sea overflows may interact with the open oceanic circulation.

Marginal sea overflows are known to determine the global oceanic water mass properties but how susceptible they are to climate variability has not been well investigated.

One of the reason is that it is computationally expensive to resolve marginal sea overflows in General Circulation models (GCMs), since overflows occur on a scale of few kilometers.

Thus the effect of overflows are mostly prescribed in GCMs.

We constructed an overflow resolving 1km high-resolution two basin model (marginal sea + open oceanic basin) separated topographically by a strait and a sill and examined the interaction between marginal sea overflows and open oceanic circulations.

Our experiments show that the transport of marginal sea overflows increases/decreases depending on the sign of open ocean circulation suggesting indirect but strong influence of open oceanic circulation on the production rate of dense water within marginal seas.

Our experiments also suggest that dense water formation occurring on the Antarctic shelves (Antarctic Bottom water) are most sensitive to the climate variability than other major overflows.

Upper-ocean turbulence at meso and submesoscales: new results obtained from high-resolution 3-D simulations

Patrice Klein[1], Bach Lien Hua[1], Guillaume Lapeyre[2], Guillaume Roullet[1], Xavier Capet[1], Sylvie Le Gentil[1], Hideharu Sasaki[3].

[1]LPO/IFREMER Plouzane, FRANCE

[2]LMD/ENS, Paris FRANCE

[3]ESC/JAMSTEC Yokohama, JAPAN

We performed numerical simulations on the Earth Simulator (Japan) with unprecedented high resolution (in both horizontal and vertical directions) that well resolved both the mesoscales (100km) and submesoscales (<10km). The turbulent properties of a baroclinically unstable oceanic flow are examined and are the following. The dynamics in the surface layers involve large Rossby numbers and strong frontogenesis processes. The energetic ageostrophic divergent motions associated with submesoscale surface frontogenesis are shown to significantly alter the nonlinear transfers of kinetic energy. They also affect the cyclone-anticyclone asymmetry, with a dominance of small cyclones in the upper layers and large anticyclones in the deeper layers. At last they increase the stratification of the upper oceanic layers.

However, despite this strong ageostrophic character, some of the main surface properties are surprisingly still close to the surface quasigeostrophic (SQG) equilibrium. This suggests that the validity of some specific SQG relations extends to dynamical regimes with large Rossby numbers.

Toward 20 year reanalysis of the Arctic Ocean circulation.

Gleb PANTELEEV[1], Dmitri NECHAEV[2], Andrey PROSHUTINSKY[3], Takashi KIKUCHI[4] , Rebecca WOODGATE[5], Jinlun ZHANG[5], M.Yaremchuk[6],
[1]*International Arctic Research Center, University of Alaska*
[2]*Department of Marine Science, University of Southern Mississippi*
[3]*Woods Hole Oceanographic Institute,*
[4]*JAMSTEC, Japan,*
[5]*Aplied Physical Laboratory, University of Washington,*
[6] *Naval Research Laboratory, Stennis Space Center, MS*

gleb@iarc.uaf.edu

To reconstruct circulation in the Arctic Ocean we are developing an efficient data assimilation system involving application of several data assimilation approaches: conventional 4Dvar data assimilation for the ocean model and simplified nudging for ice model. In a preliminary effort, the data assimilation system was used to reconstruct circulation in the Chukchi Sea during 1990-1991. The results are in good agreement with available historic observations and provide statistically confidentestimates of the dynamically important features of circulation (oceanic mass, heat, and salt transports and surface fluxes) that are not directly observed.
The approach is now applied for the reconstruction of the entire circulation in the Arctic Ocean. Preliminary results and adjoint sensitivity studies will be presented and discussed.

Precursory signals of significant weather events found in ensemble reanalysis ALERA

Takeshi Enomoto[1], Miki Hattoril[2], Takemasa Miyoshi[3] and Shozo Yamane[4]

Earth Simulator Center, Japan Agency for Marine-Earth and Science and Technology[1]
Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology[2]
University of Maryland[3]
Doshisha University[4]
eno@jamstec.go.jp

An experimental ensemble reanalysis dataset was produced in a collaborative project among the Japan Meteorological Agency, Japan Agency for Marine-Earth Science and Technology and Chiba Institute of Science (Miyoshi et al. 2007, SOLA). Although its duration is limited to about one and a half years from May 2005, this dataset, called ALERA (AFES-LETKF experimental ensemble reanalysis), provides extra information not present in conventional reanalysis datasets: the ensemble spread that represents the analysis error. The ensemble spread not only provides a measure of quality of the analysis but also represents dynamical uncertainty of the flow. It is found that the ensemble spread appears to provide precursory signals of some significant weather events. For example, a region with large ensemble spread in the subtropical anticyclone often develops into a tropical cyclone. It is speculated that the ensemble spread becomes large due to differences in timing and intensity of convections among ensemble members. There are more examples that indicate precursory nature of the ensemble spread in the monsoon onset, westerly bursts in the eastern Indian Ocean and even in the stratospheric sudden warming. These findings would suggest that ensemble reanalysis allow us to explore new aspects of atmospheric phenomena.

4dVar assimilation experiments into highly non-linear models with adjointless technique.

Gleb PANTELEEV[1], Maksim YAREMCHUK[2], Dmitri NECHAEV[3],
[1]*International Arctic Research Center, University of Alaska*
[2] *Naval Research Laboratory, Stennis Space Center, MS*
[3]*Department of Marine Science, University of Southern Mississippi*

Results of the twin-data assimilation experiments into quasigeostrophic and primitive equation sea-ice models are presented. The employed assimilation method does not require development of the tangent linear and adjoint codes fro implementation and based on minimization of the cost function in a sequence of low-dimensional subspaces of the control space. It is shown that convergence rate of the adjointless 4dVar technique is similar to that of the standard 4dVar in case of stable tangent linear model. In the presence of non-liear instabilities in the direct model the new method works better than 4dvar whose performance is deteriorated due to the breakdown of the tangent linear approximation. It is also shown that the adjointless 4dVar becomes advantageous when observations are sparse and noisy. Perspectives for development of the adjointless ice-ocean data assimilation system are discussed.

The Impact of Global Warming on Marine Boundary Layer Clouds over the Eastern Pacific – A Regional Model Study

Axel Lauer[1], Kevin P. Hamilton[1], Yuqing Wang[1], Vaughan T. J. Phillips[2] and Ralf Bennartz

[1] International Pacific Research Center, School of Ocean and Earth Science and Technology, 1680 East-West Rd., Honolulu, Hawaii 96822

[2] Department of Meteorology, School of Ocean Earth Science and Technology, University of Hawaii at Manoa, 2525 Correa Rd., Honolulu, Hawaii 96822

[3] Department of Atmospheric and Oceanic Sciences, University of Wisconsin – Madison, 1225 W. Dayton St., Madison, Wisconsin 53706

Abstract

Clouds play a key role in the Earth's radiation budget and thus climate by reflecting solar radiation and absorbing thermal radiation. The response of clouds to climate forcings imposed by increases in greenhouse gas concentrations as well as the impact of anthropogenic emissions of aerosols and precursor gases on cloud properties is still poorly understood and remains one of the largest uncertainties in our efforts to quantify radiative forcing from anthropogenic activities [*IPCC*, 2007]. Despite the significance of the persistent subtropical stratocumulus decks for the Earth's radiation budget [e.g. *Randall et al.*, 1984], the simulation of these marine clouds have been particular challenges for global and regional models [e.g. *Bretherton et al.*, 2004]. Starting from our successful simulation of marine boundary layer clouds in the eastern Pacific [Lauer et al., 2009], we assess cloud response to climate forcing from increased greenhouse gas concentrations over the East Pacific region with the IPRC Regional Atmospheric Model. We show results obtained by dynamical downscaling of climate projections for the end of the 21st century from IPCC AR4 models using the Pseudo-Global-Warming Method [*Kimura and Kitho*, 2007; *Sato et al.*, 2007]. Our model results suggest that the low marine clouds found frequently over the eastern Pacific are very sensitive to global warming. The positive cloud feedback of 2

W/m^2/K calculated by the IPRC Regional Atmospheric Model is larger than those predicted by the global IPCC AR4 models.

References

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Has the South Asian summer monsoon rainfall responded to anthropogenic forcing?

H. Annamalai, J. Hafner, K.P. Sooraj, P.A. Pillai, and V. Prasanna

International Pacific Research Center, University of Hawaii

Diagnostics performed with rainfall observations suggest that the summer monsoon rainfall (June through September) over India is on a declining tendency over the last five decades. This observational finding is supported by analysis performed on the multi-century integrations conducted with the GFDL coupled model. To identify the reasons for the rainfall reduction, a suite of sensitivity experiments with the GFDL AGCM forced by observed sea surface temperature (SST) warming tendency over the tropical Indo-Pacific warm pool region is performed. The model integrations cover the period 1951-2000. AGCM solutions suggest that it is the SST warming and the associated changes in local rainfall and atmospheric circulation over the tropical west Pacific that is responsible for inducing descent anomalies (through Rossby waves), and subsequent decline in the monsoon rainfall over India. Further analyses with a linear atmosphere model forced with tropical west Pacific SST and available observations confirm the AGCM results. Based on our findings, it is concluded that the south Asian summer monsoon has started to respond to anthropogenic forcing.

Global warming shifts Pacific tropical cyclone location

Tim Li[1], MinHo Kwon[1], Jong-Seong Kug[2], and Jing-Jia Luo[3]

[1]International Pacific Research Center, University of Hawaii, USA

[2]Korea Ocean Research and Development Institute, Korea

[3]Research Institute for Climate Change, JAMSTEC, Japan

Tropical cyclones (hereafter TC), called typhoons in the western Pacific and hurricanes in the Atlantic and the central and eastern Pacific, are among the most devastating weather phenomena that can affect human life and economy. How global warming will affect TC activity is a hotly debated topic. A high-resolution (~40km) atmospheric general circulation model is used to determine whether the frequency of tropical cyclones will change in the Pacific with globe warming. A significant shift is found in the location of tropical cyclones from the western to central Pacific. The shift to more TCs in the central and less in the western Pacific is not attributable to a change in atmospheric static stability, but to a change in variance of tropical perturbations associated with a change in the background vertical wind shear and boundary layer divergence.

Importance of midlatitude oceanic frontal zones in the formation of storm-tracks and westerly jets as revealed in high-resolution climate model simulations

Hisashi Nakamura

Department of Earth, Planetary Science, University of Tokyo, and

It has now started being recognized that meridional SST gradients concentrated on midlatitude oceanic frontal zones are important for recurrent cyclone development necessary for the formation of storm tracks and that high-resolution climate model simulations are useful for studying the importance. The oceanic frontal zones are characterized by tight gradient in surface air temperature and by abundant moisture supply from warm ocean currents, both of which favor cyclone development. The recurrent development of atmospheric disturbances requires effective restoration of surface baroclinicity against the relaxing effect by their heat transport. The restoration is particularly effective in oceanic frontal zones via cross-frontal differential heat supply from the ocean, where SST is insensitive to heat exchanges with the atmosphere due to the presence of a deep mixed layer and the confluent strong ocean currents. The restoration, which may be called "oceanic baroclinic adjustment" and can be confirmed and highlighted through planetary-wave model experiments and idealized AGCM experiments, acts to anchor major storm tracks along the major oceanic frontal zones. As observed and well reproduced in CFES, the major storm track in the Southern Hemisphere is anchored along the prominent oceanic frontal zone in the South Indian Ocean, where atmospheric influences of landmass are weak. A well-defined rain band and an eddy-driven polar-front jet with strong surface westerlies are collocated with the frontal zone. The presence of oceanic eddies in the frontal zone leaves persistent zonal inhomogeneities in surface evaporation, (convective) rainfall and surface wind velocity.

Precipitation response to the Gulf Stream in an atmospheric GCM

Akira Kuwano-Yoshida (Earth Simulator Center, JAMSTEC)
Shoshiro Minobe (Hokkaido University)
Shang-Ping Xie (IPRC, University of Hawaii)

Atmospheric response to sea surface temperature (SST) gradients associated with the Gulf Stream is investigated using an atmospheric general circulation model. Forced by observed SST, the model simulates a narrow band of precipitation, surface convergence, and evaporation that closely follows the Gulf Stream, much like satellite observations. Such a Gulf Stream rain band disappears in the model when the SST front is removed by horizontally smoothing SST. Our analysis shows that it is convective precipitation that is sensitive to SST gradients. The Gulf Stream anchors a convective rain band by creating surface wind convergence and intensifying surface evaporation on the warmer flank. Deep convection develops near the Gulf Stream in summer when the atmosphere is conditionally unstable. As a result, a narrow band of upward velocity develops above the Gulf Stream throughout the troposphere in summer while it is limited to the lower troposphere in other seasons.

Atmospheric response to decadal SST anomalies confined within the North Pacific subarctic frontal zone in a coupled model simulation

Bunmei Taguchi, Masami Nonaka, Nobumasa Komori, Akira Kuwano-Yoshida (JAMSTEC), and Hisashi Nakamura (University of Tokyo/JAMSTEC)

Evidence is mounting that sea surface temperature (SST) gradients associated with midlatitude oceanic fronts exert deep and large-scale influences on the mean state of the atmosphere beyond local responses in the planetary boundary layer. However, it remains to be examined whether oceanic frontal variability may affect time-varying atmospheric state and contribute to enhance the low-frequency variance of the midlatitude climate.

Here we present wintertime North Pacific decadal SST anomalies and their atmospheric influence simulated in a coupled model. Although a half-degree horizontal resolution in its ocean component does not resolve mesoscale eddies, a century-long coupled simulation represents a sharp mean SST front in the North Pacific subarctic frontal zone (SAFZ). Pronounced decadal SST variations are confined within SAFZ and are well correlated with meridional migration of the front, a feature consistent with recent high-resolution OGCM studies that highlight the importance of oceanic frontal variability in generating decadal SST anomalies. Associated with the latitudinally confined SST anomalies, simulated atmospheric storm track in the North Pacific is systematically modulated as it is anchored by near-surface baroclinicity that changes in accordance with the SAFZ variations. When the SST anomalies are positive, the storm track is shifted northward, which induces anti-cyclonic surface mean flow feedback in subpolar central Pacific. The weakened Aleutian low suppresses southward-flowing Oyashio current off Japan coast, and causes northward migration of SAFZ, acting as a positive feedback between the SST anomalies and the atmospheric response, which contributes to persistence of the Pacific decadal SST anomalies.

Decadal variations in heat content and surface heat flux in the western North Pacific in a coupled GCM

Masami Nonaka[1], Bunmei Taguchi[2], and Hisashi Nakamura[1, 3]
[1]Research Institute for Global Change, JAMSTEC
[2]Earth Simulator Center, JAMSTEC
[3]Graduate School of Science, University of Tokyo

Importance of oceanic frontal zones for air-sea interaction in midlatitudes has been revealed by recent studies. We have investigated interannual to decadal variations of the frontal zones in the western North Pacific using an eddy-resolving OGCM, and it is shown that changes in oceanic circulation can induce sea surface temperature (SST) and heat flux (SHF) anomalies in those regions. Also, recent studies have shown that variations in the Kuroshio Current can modify heat content and SHF in the western North Pacific. In this study, we investigate decadal variations in the Kuroshio Current transport and SHF in a coupled GCM that can represent oceanic frontal zones. Consistent with the analysis of observed data by Kawai et al. (2008), intensified Kuroshio transport at 25N is associated with warm SST and enhanced upward SHF to the south of Japan. SST and SHF variations in the entire western North Pacific region are, however, not correlated with the Kuroshio transport. Decadal variations in the Kuroshio Extension and subarctic frontal zones are related not to the Kuroshio transport variations, but to the signals propagating westward from the central North Pacific and the Oyashio Current variations.

Interannual to decadal Gulf Stream variability in an eddy-resolving ocean model

Yoshi N. Sasaki
International Pacific Research Center, University of Hawaii at Manoa, USA
Niklas Schneider
International Pacific Research Center and Department of Oceanography,
University of Hawaii at Manoa, USA

Meridional shifts of the Gulf Stream (GS) jet on interannual to decadal timescales and the corresponding oceanic changes are investigated using a hindcast output of a near global eddy-resolving ocean model from 1960 to 2003. The simulated variability of the GS jet shows good agreement with observations, and is related to the 2-yr leading atmospheric fluctuations, which are characterized by the North Atlantic Oscillation. It is revealed that the lagged response of the GS jet to the atmospheric variations is attributed to the westward propagation of the long-wavelength meander from 45°W to 75°W. These westward propagations of the meander that have a zonal scale of 2000 km can be explained by the thin-jet theory. The meanders are likely induced by wind stress curl fluctuations through the Ekman convergence. Associated with the northward (southward) shift of the jet, sea surface temperature warms (cools) around the jet and over the continental shelf north of the jet. The former warming is consistent with the northward shift of the jet, and reduces the temperature gradient south of the jet. Furthermore, the meridional shifts of the jet accompany the coherent meridional shifts of energetic eddy activity regions around the jet. Therefore, our numerical results indicate that the GS jet acts to bring the atmospheric signals from the central to western North Atlantic, and the resultant meridional shift of the jet induces the notable mesoscale oceanic changes around the GS.

A North Pacific decadal variability in subduction rate identified by OFES

Tangdong Qu and Ju Chen
International Pacific Research Center, SOEST, University of Hawaii at Manoa, Honolulu, HI

Abstract. Analysis of OFES output has revealed the existence of a North Pacific decadal variability in subduction rate. This decadal variability corresponds well with the Pacific Decadal Oscillation (PDO). The zero-lag correlation between the two time series is about 0.6 for the entire period of integration (1950-2003), and reaches as high as 0.8 after the climate shift in the mid-1970s. Much of this decadal variability is due to changes in winter mixed layer depth, which in turn are closely related to changes in surface wind and heat flux. In addition to an enhanced subduction volume, the positive phase of PDO also represents a deepening of winter mixed layer in the central North Pacific and a shift of density in subducted water from the subtropical to the central mode water.

A high-resolution simulation of the global coupled atmosphere-ocean system using CFES

Nobumasa Komori (ESC, JAMSTEC),Bunmei Taguchi (ESC, JAMSTEC),
Akira Kuwano-Yoshida (ESC, JAMSTEC), Hideharu Sasaki (ESC, JAMSTEC),
Takeshi Enomoto (ESC, JAMSTEC), Masami Nonaka (RIGC, JAMSTEC),
Yoshikazu Sasai (RIGC, JAMSTEC), Meiji Honda (RIGC, JAMSTEC & Faculty of Science, Niigata University), Koutarou Takaya (RIGC, JAMSTEC), Akio Ishida (RIGC, JAMSTEC), Yukio Masumoto (RIGC, JAMSTEC & Graduate School of Science, University of Tokyo), Wataru Ohfuchi (ESC, JAMSTEC), and
Hisashi Nakamura (RIGC, JAMSTEC & Graduate School of Science, University of Tokyo)

ESC: Earth Simulator Center
RIGC: Research Institute for Global Change
JAMSTEC: Japan Agency for Marine-Earth Science and Technology

To promote studies on mechanisms and predictability of high-impact phenomena especially in the mid-latitudes and their relation to the global-scale circulations, we have developed a global, high-resolution, coupled atmosphere-ocean general circulation model (GCM) which is designed to achieve efficient computational performance on the Earth Simulator (ES). The model, named CFES (Coupled Atmosphere-Ocean GCM for the ES), consists of AFES and OFES, atmospheric and oceanic component respectively, with multiple program/multiple data technique and fully parallelized coupling schemes.

At this moment, 23 years of integration has been completed using CFES with the resolutions of T239 (about 50 km) and L48 for the atmosphere, and 0.25 degree (about 25 km) and 54 levels for the ocean. With its high-resolution that permits eddies in the oceanic component, the coupled model simulates frontal structures and their variability in the mid-latitude western boundary currents in a realistic manner. In addition, the atmospheric component is fine enough to resolve local orography and to capture ocean surface structures such as meandering fronts and mesoscale eddies, and these oceanic fine-scale signatures are clearly reflected in the surface atmospheric fields as found in high-resolution satellite observations. These results are promising for

researches on frontal-scale air-sea interactions and their role in basin- and global-scale circulations of the ocean and atmosphere.

Spectral-bin cloud microphysics scheme in MSSG and its applications

Ryo Onishi
Earth Simulator Center, JAMSTEC

An original spectral-bin cloud scheme is implemented in the MSSG (Multi-Scale Simulator for the Geoenvironment), which is an atmosphere-ocean coupled model designed for seamless climate and weather simulations. The spectral-bin scheme is based on an Eulerian-in-radius discretization scheme, where several tens of classes (bins) are used to resolve the broad size spectra of cloud droplet. The spectral-bin scheme is therefore able to deal with the size of cloud droplet explicitly, and suitable for discussing the detail processes in cloud microphysics. In this talk, we discuss impacts of (i)turbulent collisions of cloud droplets and (ii)giant CCN (cloud condensation nuclei), which is often seen in urban atmosphere, on cloud development.

Development the coupled WRF within CCSM4

Juanxiong He (Arctic Region Supercomputing Center and International Arctic Research Center), Greg Newby (Arctic Region Supercomputing Center), Tony Craig (The National Center for Atmospheric Research), Jaromir Jakacki (Institute of Oceanology, Polish Academy of Sciences), Chunmei Zhu (University of Washington), Mark Seefeldt (University of Colorado at Boulder)

Developing the coupled WRF within CCSM4 is an important part of a collaborative project to develop a Regional Arctic Climate system model (RACM), which integrates the WRF, the regional Los Alamos National Laboratory POP ocean model and CICE sea ice model and University of Washington Variable Infiltration Capacity (VIC) hydrological model under the framework of CCSM4. As one intermediate step to the RACM, the global WRF coupling with POP, CICE and CLM under the framework of CCSM4 had been obtained. A three months simulation on the global domain had been undertaken to test the technical ability of the coupled WRF to run for a long term. The result fulfills the expectation. Furthermore, by testing the regional WRF coupling with the regional POP and CICE and/or CLM/VIC for a long-term simulation over the Pan-Arctic region, the severe cold feedback between the WRF and the others component models was found. The method to mitigate the phenomena has been developed. Some promising results have been obtained. It is shown that the coupled WRF has an ability to work with other climate component models both in the global scale and regional scale under the framework of CCSM4 and can be used in other region too.

Key words: coupling, WRF, CCSM4

Weather and Climate Activities in Alaska's State-of-the-Art High Performance Computing Environment

Don Morton
Arctic Region Supercomputing Center
University of Alaska Fairbanks
Fairbanks, Alaska, USA

The Arctic Region Supercomputing Center (ARSC) at the University of Alaska Fairbanks has targeted high latitudes environmental modeling as a major thrust area for research activities. With activities ranging from high-resolution real-time weather forecasting to model-coupling to data assimilation, ARSC has amassed a wealth of experience in exploring the bleeding-edge in computationally intensive simulations of weather and climate systems. This presentation will overview ARSC's activities in environmental modeling, emphasizing the presenter's experiences in utilization of the Weather Research and Forecast (WRF) model at fine resolutions, and in pushing WRF to its computational limits. Additionally, joint activities of the International Arctic Research Center (IARC) and ARSC will be highlighted.

Medium and high resolution simulations of Martian atmosphere

Yoshiyuki O. Takahashi (Center for Planetary Science/Kobe University),
Yoshi-Yuki Hayashi (Kobe University),
Masatsugu Odaka (Hokkaido University),
Wataru Ohfuchi (Earth Simulator Center/JAMSTEC)

One of the issues about the Martian atmosphere is to reveal possible circulation features of small and medium scale disturbances ranging between thermal convection and baroclinic waves. In order to obtain some insights into this aspect, medium and high resolution simulations of the Martian atmosphere are performed by using a Mars general circulation model (GCM). It is anticipated that those simulations will also provide some insights into dust cycle in the Martian atmosphere, since small and medium scale disturbances may play important roles on atmospheric dust lifting and transport. The model used in this study is developed by combining a dynamical core of the AFES and physical routines of the Mars GCM which has been developed in our group. In the talk, some of the features of atmospheric disturbances and the dust lifting processes represented in our high resolution GCM simulations are presented.

The roles of equatorial trapped waves and internal inertia-gravity waves in driving the quasi-biennial oscillation

Y. Kawatani[1] ,K. Sato[2], T.J. Dunkerton[3], S. Watanabe[1], S. Miyahara[4], M. Takahashi[5]

[1] Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan

[2] The University of Tokyo, Tokyo, Japan

[3] Northwest Research Associates, Redmond, USA

[4] Kyushu University, Fukuoka, Japan

[5] CCSR, University of Tokyo, Kashiwa, Japan

The roles of equatorial trapped waves (EQWs) and internal inertia-gravity waves (GWs) in driving the QBO are investigated using T213L256 AGCM without gravity-wave drag parameterization. Although the simulated QBO has a shorter period than that of the real atmosphere, its amplitudes and structure in the lower stratosphere are fairly realistic. In the eastward wind shear of the QBO, eastward EQWs including Kelvin waves contribute up to ~25–50% to the driving of the QBO. On the other hand, westward EQWs contribute up to ~10% to driving the QBO during the weak westward wind phase. GWs with zonal wavelength ≤~1000 km are main contributors to the westward wind shear phase of the simulated QBO. Three-dimensional wave forcing of the QBO is also investigated. In both the eastward and westward wind shear phases of the QBO, nearly all EP-flux divergence due to GWs results from the divergence of the vertical component of the flux. On the other hand, EP-flux divergence due to EQWs results from both the meridional and vertical components of the flux in regions of strong vertical wind shear. In the eastward wind shear zone associated with the QBO, the eastward wave forcing due to GWs in the Eastern Hemisphere is much larger than that in the Western Hemisphere, whereas in the westward wind shear zone, westward wave forcing does not vary much in the zonal direction.

Descriptions of Sensitivity of the Zonal Jets and Hadley Circulations in Aqua Planet Experiment Project

Ohfuchi, W.[1], Y. Yamada[2], Y.O. Takahashi[3], T. Sampe[4], M. K. Yoshioka[5],
K. Nakajima[6], M. Ishiwatari[7], and Y. Y. Hayashi[3]

[1]Japan Agency for Marine-Earth Science and Technology,
[2]Japan Ministry of Internal Affairs and Communications,
[3]Kobe U., [4]U. Aizu, [5]Nagoya U., [6]Kyushu U., [7]Hokkaido U.

We have conducted a suite of idealized simulations of various atmospheric general circulation models (AGCM) to understand how resolutions and cumulus parameterizations affect model sensitivity to different sea surface temperatures. In this paper, changes in the zonal jets and Hadley circulations are described. The first part, we have changed resolutions and cumulus parameterizations of an AGCM. In general, changes in cumulus parameterizations causes larger sensitivity than those of resolutions. For some cases, there is a hint of convergence of model results with increasing resolutions. The second part, we describe sensitivity in 11-model intercomparison. Variation in the model intercomparison is as large as an AGCM with different resolution and cumulus parameterization.

Modeling island wakes near Hawaii

Shang-Ping Xie, Yang Yang, Jan Hafner, and Jian Ma
IPRC, University of Hawaii

Satellite-borne microwave observations reveal far-reaching effects of the Hawaiian Islands. Microwave sensors are blinded by land emission near the coast, where orographic effects of these islands are expected to be the greatest. To overcome this problem, we have turned to visible/infrared measurements by satellite and high-resolution modeling with MM5 at 1-3 km resolution. Our results show that surface wind and cloud patterns in the lee vary depending on island elevation.

For islands of elevations below the trade wind inversion (e.g., Kauai and Oahu), a well-defined cloud line develops in the early afternoon in the lee. This cloud line displays a clear diurnal cycle, dissipating during night. The MM5 simulation suggests a thermal wake mechanism in which the downstream advection of warm air from the island in the afternoon creates a belt of low pressure in the wake, where the resultant surface convergence supports a cloud line. During night, the cold advection from the island forces divergence in the wake against cloud formation.

Cloud formation is very different lee of the Big Island where mountains stand above the inversion and block the trade winds in the surface layer. The afternoon lee cloud line is not observed in the middle wake of the Big Island. Instead a southwest slanted cloud line emanates from the southwest corner of the island in the afternoon. The model reproduces this slanted cloud line and shows that it is anchored by surface wind convergence. The southwest convergence line appears due to the Coriolis effect acting on the eastward reverse flow in the wake, inducing a southward wind component with convergence (divergence) to the south (north). This explains a north-south asymmetry without a cloud line from the northern corner of the Big Island. The southwest cloud line displays a pronounced diurnal cycle, dissipating during night with surface wind divergence. The cause of this diurnal cycle remains to be fully resolved.

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Multiscale interactions in the lifecycle of a Tropical Cyclone Simulated in a Global Cloud-System-Resolving Model NICAM

Hironori FUDEYASU[1], Yuqing WANG[1], Masaki SATOH[2, 3],
Tomoe NASUNO[3], Hiroaki MIURA[3] and Wataru YANASE[2]

[1] International Pacific Research Center, Universityof Hawaii, Honolulu, USA
[2] Center for Climate System Research, University of Tokyo, Kashiwa, Japan
[3] Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan

The increasing capability of high-end computers allows numerical simulations with horizontal resolutions high enough to resolve cloud systems in a global model. In this presentation, the results from the global Nonhydrostatic ICosahedral Atmospheric Model (NICAM), used by the Earth Simulator, are highlighted to demonstrate the beginning of a potentially new era for weather and climate predictions with global cloud-system resolving models. The NICAM simulation with a horizontal resolution of about 7 km successfully reproduced the lifecycle of Tropical Storm (TS) Isobel that formed over the Timor Sea in the austral summer 2006. Initialized with the atmospheric conditions 2 weeks before the cyclones genesis, the model captured reasonably not only the timing of the observed cyclone geneses but also their motions and mesoscale structures. The model provides a high temporal/spatial resolution dataset for detailed studies of the multiscale interactions on the lifecycle of the simulated storm as the large-scale and meso-scale aspects. These promising results suggest the predictability of tropical cyclones by high-resolution global cloud-system-resolving models.

Spatial variance characteristics of high resolution atmospheric model simulations

Kevin Hamilton, IPRC, University of Hawaii
Yoshiyuki O. Takahashi, Division of Earth and Planetary Sciences, Kobe University
Wataru Ohfuchi, ESC/JAMSTEC
Masaki Satoh, CCSR, University of Tokyo and JAMSTEC

The observed horizontal and vertical spectra of wind or temperature variance in the atmosphere generally show power law behavior with the spectral slopes depending on scale, altitude, and perhaps latitude. This talk will examine how well current high resolution global models can simulate the key features of observed variance spectra in the atmosphere. Results from versions of the GFDL SKYHI model, the JAMSTEC AFES model and the JAMSTEC/U Tokyo NICAM model will be discussed. Also discussed will be the implications of the results for theories that have been advanced to account for the scale-dependence of atmospheric flow.