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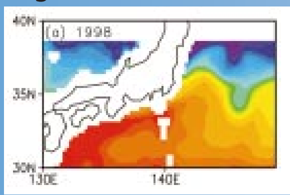

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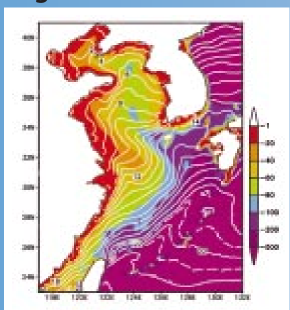

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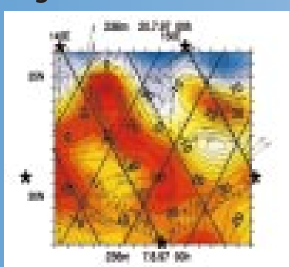

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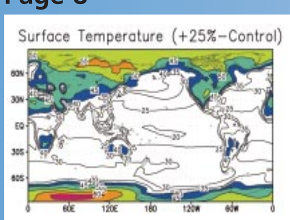

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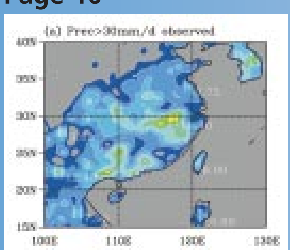

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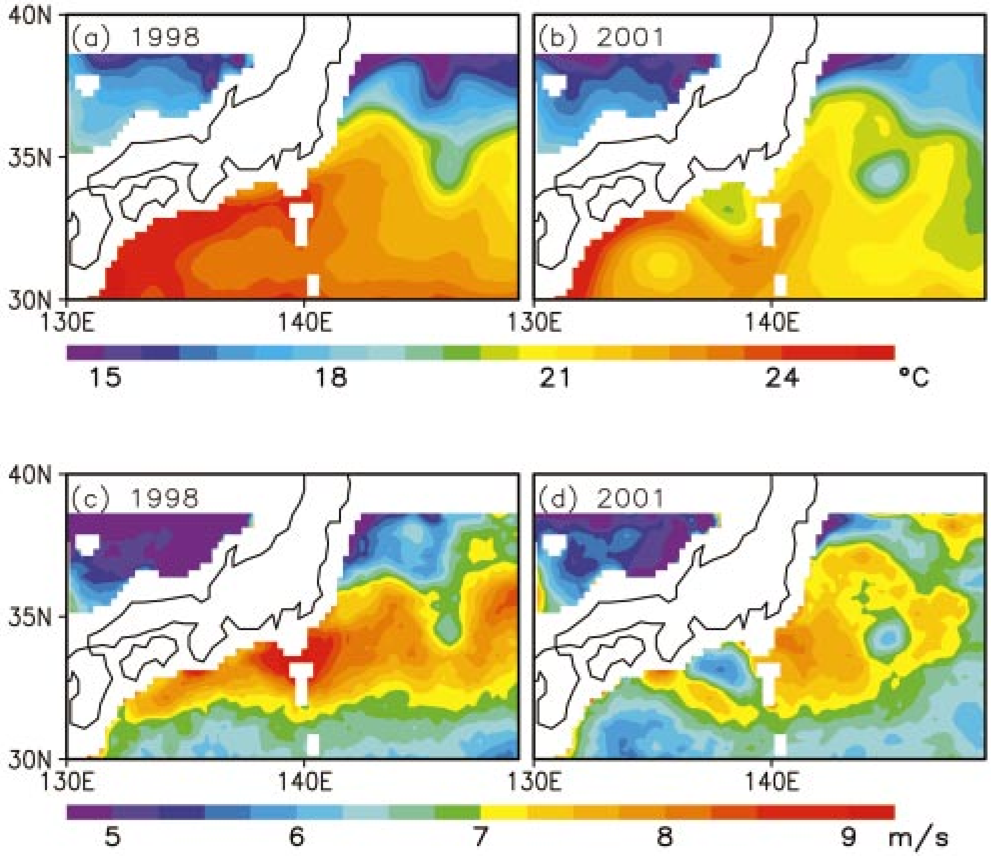


Figure 1: *April to June mean fields in SST and surface wind speed for 1998 (panels a and c) and for 2001 (panels b and d) based on TRMM Microwave Imager data sets. The shift between Kuroshio's straight (panel a) and meandering path (panel b) is accompanied by large differences in SST. The high wind speed over the straight warm SST path is markedly reduced when the warm water is replaced by cool water in the meandering path.*

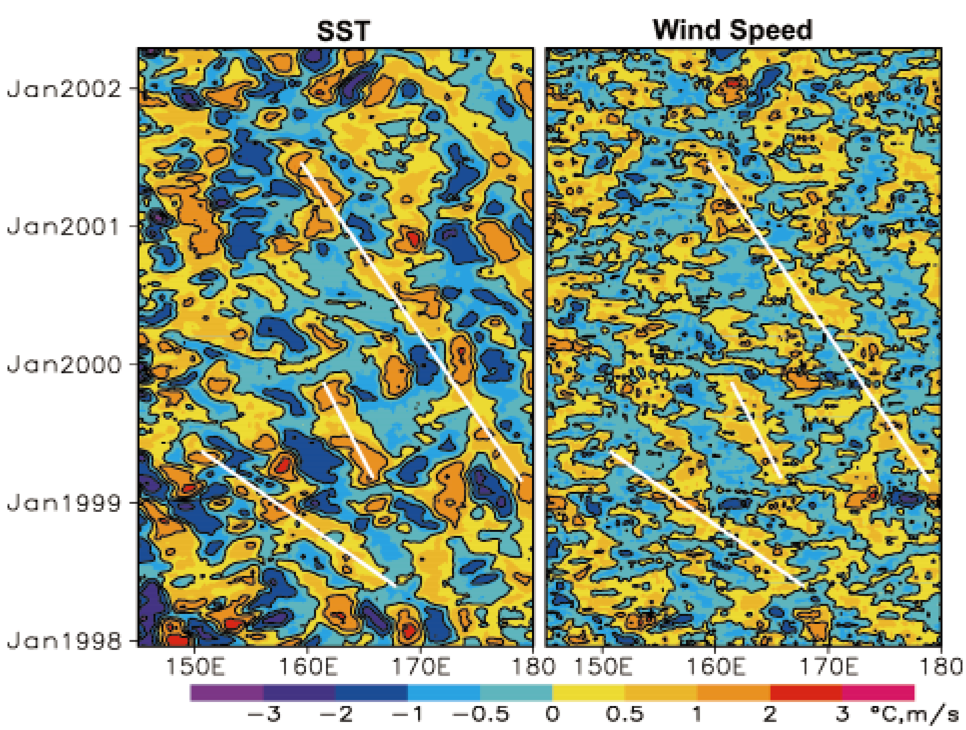


Figure 2: *Longitude-time sections of high-pass zonally filtered SST (left panel) and surface wind speed along 35°N (right panel), smoothed with a 3-week running-mean filter. For both SST and wind speed, weekly TRMM Microwave Imager datasets were used. Contour intervals for SST and for wind speed are 1°C and 1 m/s, respectively. Constant phase lines are plotted in white to facilitate comparison between the panels.*

Kuroshio's Surprising Effect on Winds

The Kuroshio Current of the western North Pacific carries large amounts of warm and salty tropical water northward at average speeds of over 1 m per second (over 2 miles per hour). In winter, when cold and dry continental air blows over this warm current, intense convection takes place in the ocean, and huge amounts of heat and moisture are released to the atmosphere. Because of this heat transport, the Kuroshio is an important element of the Pacific climate system. Furthermore, the strong subsurface fronts that form along the Kuroshio have been known as fertile fishing grounds to Japanese fishermen for generations. In fact, the name Kuroshio, which means the 'Black Current' in Japanese, tells us that ancient fishermen used its dark color to identify the current and its fertile temperature front.

It is well established that the Kuroshio is driven by the basin-scale wind system over the North Pacific. Now, **Masami Nonaka** and **Shang-Ping Xie** have detected that the Kuroshio, in turn, has a distinct effect on the winds. Taking advantage of new satellite microwave observations that can see through clouds, they have drawn a map detailing the structure of the surface winds and how they are associated with the Kuroshio. The Kuroshio's effect on the winds has not been observed before because sea-wind measurements in the past have had to rely on sparse ship-based observations.

In images of the sea surface taken by the Tropical Rain Measuring Mission (TRMM) satellite, the Kuroshio can now be easily tracked and appears as a band of warm water. Its influence on the winds is detected in the region south of Japan, where the current shifts between alongshore and offshore paths. In 1998, the Kuroshio took an alongshore path and the TRMM sea surface temperature (SST) image in Figure 1a shows the warm current hugging the south coast of Japan. In 2001, the Kuroshio was in an offshore path, and Figure 1b shows the warm band flowing away from the coast for as far as 400 km around 139˚E.

The TRMM wind-speed measurements reveal an association between wind speed and the Kuroshio: The region of maximum wind speed tends to follow the Kuroshio's path, remaining right on top of the warm current (Figures 1c and d). This tendency is especially clear in 2001 when the bands of maximum SST and wind speed are collocated off the coast from 135˚ to 140˚E. In contrast, wind speed is markedly reduced over the cold-water pool left behind by the Kuroshio's offshore meander between 136˚–140˚E. In addition, a local wind speed minimum can be seen in 2001 over a pinched-off cold ring centered at 145˚E, 34˚N.

This SST-wind coupling persists further east along the Kuroshio Extension, all the way to the international dateline. The white lines in the left panel of Figure 2 show the evolution of unusually warm current flows as they propagate westward from January 1998 to 2002; the white lines in the right panel show the regions of higher winds, which propagate westward along with the regions of higher SST.

The wind co-variations seem to result from an adjustment of vertical wind shear to changes in static stability of the atmosphere near the surface. Analysis of the Japan Meteorological Agency's buoy measurements east of Japan indicate that when the sea surface is anomalously warm, the near-surface atmosphere is more unstable than usual. This greater vertical mixing brings down the high winds from above (see p. 5 on the winds over the Yellow and China Seas). The wind-stress anomalies induced by the Kuroshio account for only 20-30% of the mean stress. Yet, because this strong current is so narrow, the effect on upwelling is large, impacting the circulation and the ecosystems significantly.

The positive SST-wind correlation over the Kuroshio Current and its extension is opposite to what is usually found in regions of weak currents, such as those south of the Aleutian low. There, the ocean responds to the atmosphere, the higher wind speeds cool the ocean surface.

Whether and how the atmosphere reacts to changes in extratropical sea surface temperature has been under intense debate, and this missing piece has been a major obstacle in understanding how climate varies. This study establishes beyond a doubt that the ocean can significantly influence the atmosphere and the winds in the extratropics. The implication of this new evidence for climate modeling is far-reaching.

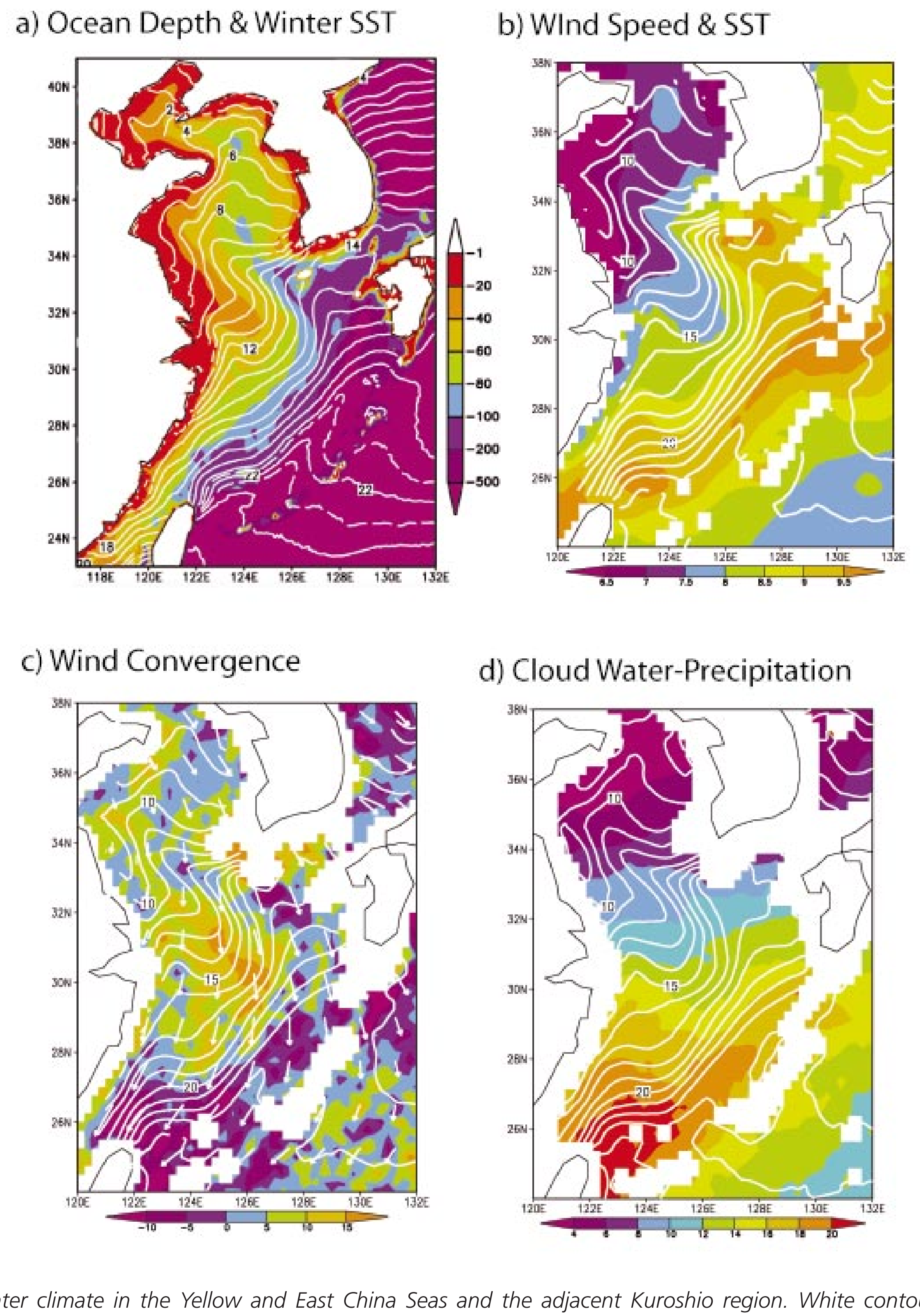


Figure 3: *Winter climate in the Yellow and East China Seas and the adjacent Kuroshio region. White contours represent sea surface temperatures (in °C): (a) Bottom depth (color: in m); (b) speed (color: in m/s); (c) convergence of surface wind (color: in* $10^{-6}s^{-1}$*); and (d) cloud liquid water (color: in* 10^{-2}*mm).*

Ocean Depth Affects Local Climate

It is well known that topography of the land surface affects weather and climate. For example, the Pacific Coast of South America is desert, while Amazonia on the other side of the Andes is rich in rainfall and hosts the largest rain forest of the world. On the global scale, the Tibetan Plateau is a controlling element in Northern Hemisphere climate. Even the tall mountains of the tiny Hawaiian Islands have been shown to exert far-reaching effects on the Pacific Ocean and atmosphere.

The influence of the shape of the ocean bottom on climate, however, has been studied less widely. To many, it may even sound absurd that submerged bottom topography can change winds and clouds. A team of scientists at the IPRC (**S.-P. Xie, J. Hafner,** and **H. Xu**), the Jet Propulsion Laboratory (**W.T. Liu**), and Hokkaido University (**Y. Tanimoto** and **H. Tokinaga**) has detected such an improbable bathymetric effect on the winter climate of the Yellow and East China Seas.

These seas, located between China, Korea and Japan, together form one of the largest shelf seas of the world. They are shallow, ranging in depth from a few meters to not much more than 100 m; but their bottom topography is uneven with deeper and shallower tongue-like regions. The team has discovered that during winter the sea surface over the deep channels is warmer than over the shallow parts (Figure 3a). They propose the following mechanism to account for this relationship. The northerly monsoon winds carry the frigid and dry continental air over the seas, cooling their surface. Heat is transferred from the ocean bottom upward through convection. The deeper the area, the more heat it contains, and the slower the surface cools so that the cooling rate of the water column is determined by its thickness. In other words, shallow regions cool much faster than the deep channels. This mechanism may combine with the advection of warm Kuroshio water (see p. 3) by shelf currents. A quantitative assessment of how much the warm Kuroshio water contributes to the warm SST tongues during winter in the Yellow and East China Seas must await further observations in this, as yet, little charted region.

The bathymetric effect of the seas does not stop with causing variations in the sea surface temperature (SST). New measurements with the QuikSCAT and TRMM satellites reveal remarkable spatial co-variations in wind speed and SST. High winds and increased cloudiness are found over the bathymetric-induced warm tongues. One such band of ocean-atmosphere co-variation meanders through the Yellow Sea between China and Korea, following a deep channel for 1000 km (Figure 3b). The mechanism for this ocean effect on the winds is thought to be the convectively induced vertical mixing in the atmosphere over the warm tongue, similar to that over the Kuroshio (see p. 3).

The Kuroshio is steered northeastward along the shelf break, where there is another bathymetric effect (Figure 3a). A sharp SST front forms in winter between the warm Kuroshio and the cold shelf water. Examining ship logs of the past 30 years, the team found that the static instability of the atmosphere near the surface—measured by the difference between air and sea surface temperatures—peaks at the Kuroshio (Figure 3c). This instability causes strong vertical mixing that brings down swift winds from aloft to the surface, producing a local maximum in surface wind speed on the warmer flank of the Kuroshio front, as observed by the QuikSCAT satellite (Figure 3b). The strong atmospheric convection further manifests itself as a band of precipitating clouds that is fueled by the moisture supply from converging surface winds (Figure 3d). The wind convergence appears to result from both the hydrostatic pressure and the convectively induced accelerations of cross-frontal flow at the surface. Satellite images capture both this cloud band and the wind convergence.

Suggested Further Readings:

Ichikawa, H. and R.C. Beardsley, 2002: The current system in the Yellow and East China Seas. J. Oceanogr., 58, 77-92.

Xie, S.-P., J. Hafner, Y. Tanimoto, W.T. Liu, H. Tokinaga and H. Xu, 2002: Bathymetric effect on the winter sea surface temperature and climate of the Yellow and East China Seas. *Geophys. Res. Lett.,* DOI 10.1029/2002GL015884R, in press.

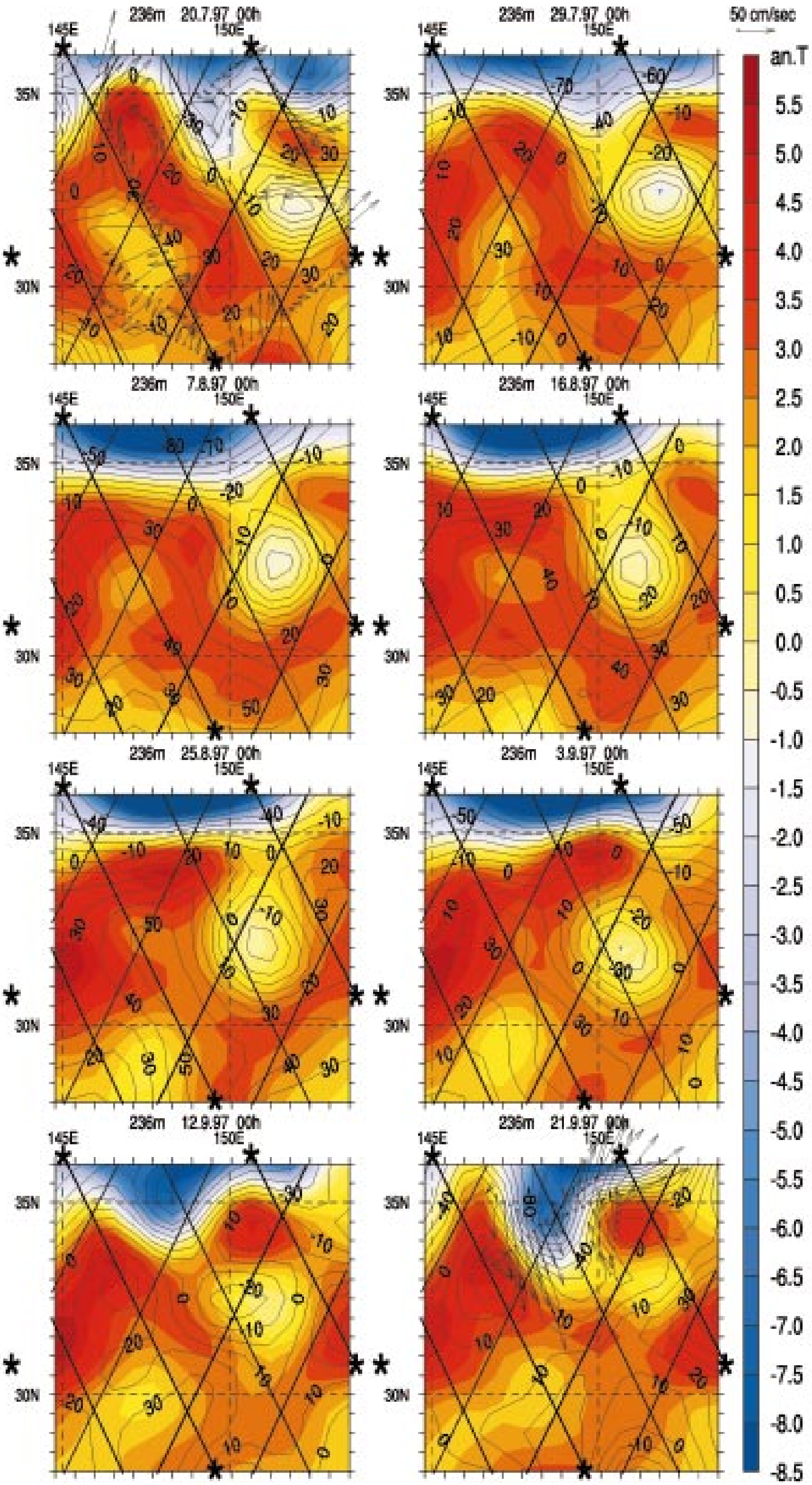


Figure 4: *Evolution of the optimized streamfunction (contours) and temperature anomalies (color) at 236 m depth retrieved by means of four-dimensional variational data assimilation technique. Positions of the acoustic transceivers are denoted by stars, satellite tracks by solid slanted lines. Results of the acoustic Doppler current profiler measurements are shown by arrows (first and last panels).*

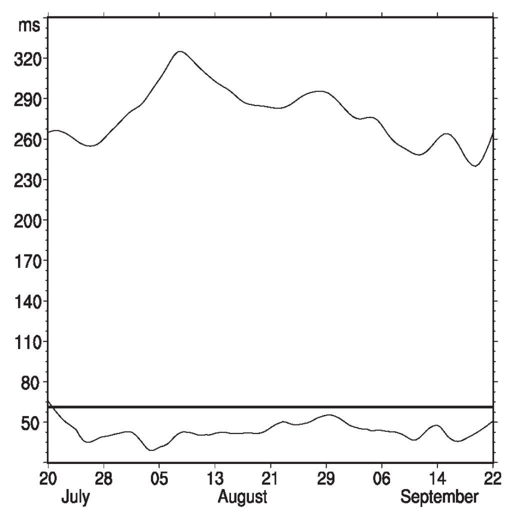


Figure 5: *Evolution with time of data misfits in the tomography model. Upper curve shows the errors of the "first-guess" solution (i.e., before assimilation); lower curve shows the errors after assimilation. The horizontal line represents the observational error variance level.*

A New Method for Tracking Ocean Dynamics

The Kuroshio Current transports large amounts of warm and salty water from the tropics northward, whereas the Oyashio Current transports cold and fresh water from the Bering Sea and the Sea of Okhotsk southward. Where they meet in the western North Pacific, they form the Kuroshio Extension and the Oyashio Front, a region of very complicated currents and eddies. Large decadal variations that strongly affect Pacific climate have been found in the area. What happens in these currents is, therefore, of particular interest for climate study and climate prediction.

It is difficult in this region to chart in any detail mesoscale features that evolve over several weeks, and information about them has been sparse. This lack of observations has been an obstacle to gaining an understanding of how such features might determine or affect Pacific Ocean climate. Now **Max Yaremchuk, Konstantin Lebedev,** and **Humio Mitsudera** at the IPRC have developed a method that makes the detection and tracking of significant features easier, not only for this region, but also for the rest of the world's oceans.

Figure 4 illustrates the kinds of information that can be obtained by applying their method, showing the evolutions of mean transport velocity (contours) and temperature anomalies (color) in the Kuroshio Extension at a depth of 236 m, every nine days from July 20 to September 21, 1997. The sharp temperature difference between the warm Kuroshio (red shades) and the subarctic ocean (blue shades) is clearly visible in the figure and as large as 12˚C in some places. The sequence of eight panels shows intense eddy activity. A cold meander (yellow shades) at the Kuroshio Extension front is present in the top, left panel at 150–152˚E and 32–33˚N. This meander turns into a mid-sized cold-core eddy as it moves westward at a speed of 4 cm/s. Anomalously warm water reaches the latitude of 35˚N by the end of August and interacts with the cold eddy. The warm anomaly detaches itself in the second half of September at 34˚N, 151˚E, forming an eddy with a warm core. Both the temperature and streamfunction fields show this event. The detachment of the eddy from the western warm-water tongue was possibly triggered by the cold core anomaly further south at 30–32˚N, 147–148˚E. Qualitative analyses of the flow dynamics beyond those shown above reveal a current that sometimes exceeds 1.2 m/s (nearly 3 miles per hour) and that advects density anomalies.

These results were obtained by assimilating five variables into a numerical model: sea surface height data from the satellite TOPEX/Poseidon (solid slanted lines); acoustic travel-times observed along the ray paths connecting five autonomous acoustic transducers at a depth of 1075 m (positioned at the stars); differential acoustic travel-time observations (differences between direct and reciprocal travel-time, which contain information about currents); and hydrographic temperature and velocity measurements obtained during deployment and recovery of the transducers (arrows denote observed velocity).

Using acoustic travel-time as an indirect measure of water temperature in numerical models would be very helpful in studying the evolution of mesoscale ocean processes, but has not been very feasible, as the travel-times cannot be easily incorporated into models. The new strategy adopted here has dealt with this problem by assimilating the travel-times using a variational data algorithm. Since the model solution depends on both the initial and the boundary conditions, the evolution of an event changes when the values of these conditions are changed. The variational data assimilation procedure can find "best-fit" initial and boundary conditions, those that produce a model solution that is as close as possible to all the data measured during the time of model integration.

The graph in Figure 5 illustrates the large error reduction after assimilation: The straight horizontal line shows the mean error of acoustic travel-time measurements; the upper curve represents travel-time errors in a model solution without assimilation, while the lower curve shows the deviations of the model solution from measured data after assimilation. The deviations obtained with the assimilated data fall well below the measurement error, indicating how much this technique improves the usefulness of acoustic travel-times as a measure of ocean temperature.

This method for assimilating acoustic travel-times into an ocean model greatly facilitates charting week-long ocean processes that occur over large distances. The present data sets together with the dynamical information provided by the model are sufficient to detect and track how eddies form and decay. The evolution of eddies such as those seen in the panels is particularly important in estimating the ocean’s heat and salinity budgets—the controlling forces in ocean circulation and its impacts on global climate.

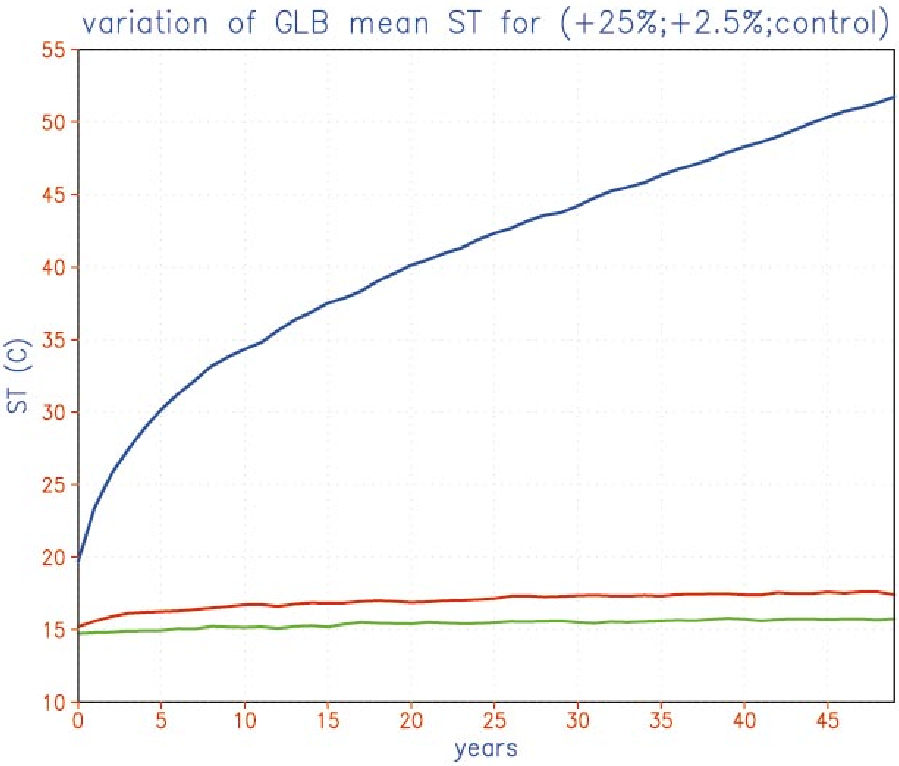
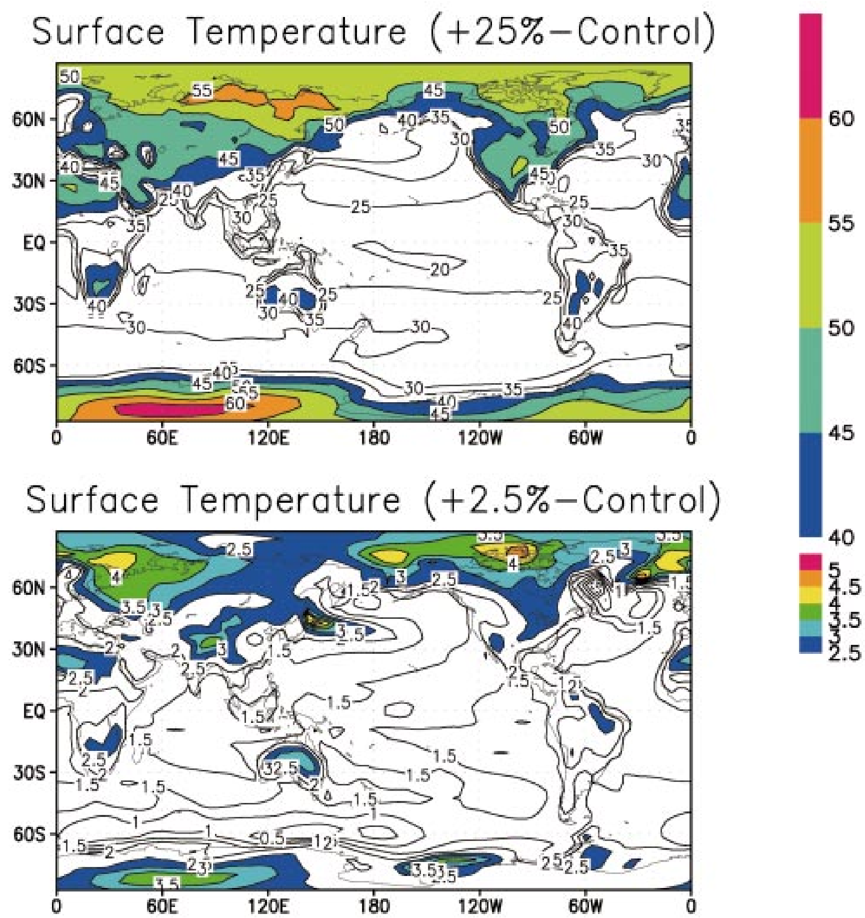


Figure 6: *Annual-mean global surface temperature in integrations of the NCAR coupled atmosphere-ocean general circulation model in the control run (green), and in runs with the solar constant increased over the standard value by 2.5% (red) and by 25% (blue).*

Figure 7: *Surface temperature in °C averaged over years 41–50 in the +25% solar constant run minus that in the control run (top panel). Surface temperature averaged over years 41–50 in the +2.5% solar constant run minus that in the control run (bottom panel). Contours labeled in °C.*



Climate Response to Strong Global Perturbations

Researchers interested in modeling the sensitivity of climate to changes in atmospheric composition have overwhelmingly focused on predicting the response to relatively modest external forcing—typically the kind of changes in concentration of long-lived greenhouse gases that are likely to be seen in the next 50 to 100 years. The likelihood that atmospheric carbon dioxide (CO_2) concentrations will reach twice pre-industrial levels sometime in the 21st century has led to the "double CO_2" scenario as a standard case that many modeling groups have simulated.

The doubling of CO_2 concentration leads to a net direct forcing of the troposphere of about 5 W/m^2, and the effects are thought to be similar to those that would be caused by about a 2% increase in the solar constant. The various current state-of-the-art models predict that the increase in global mean surface temperature due to a doubling of CO_2 concentration will reach equilibrium between 2˚C to 5˚C.

Unfortunately for mankind, it is very likely that in the next few centuries the climate forcing from human activities will reach at least 10 W/m^2 (corresponding to a four-fold increase in CO_2 levels), quite possibly 15 W/m^2 (an eight-fold increase in CO_2 levels), and conceivably even much higher, given the human capability to influence the atmospheric concentrations of other important greenhouse gases such as nitrous oxide, methane, hydrofluorocarbons, hydrochlorofluorocarbons and chlorofluorocarbons. The question of whether the surface climate response to such forcings saturates with increasing forcing or grows nonlinearly will determine how serious such perturbations could be for future generations. This is also an issue of interest to planetary scientists, since the very high temperature observed in the Venusian atmosphere has been attributed to the so-called "runaway greenhouse (RG) effect." The RG effect is the strongly nonlinear response of surface temperature on an earth-like planet when radiative forcing exceeds a hypothesized threshold. The RG effect has been studied in very simple climate models, but the existence of the RG instability threshold has not yet been demonstrated in a comprehensive general circulation model.

At the IPRC, **Weijun Zhu** and **Kevin Hamilton** (Theme 4 Leader and Professor of Meteorology) are examining the nature of the response to large climate perturbations using the NCAR Climate System Model (CSM). To keep matters as simple as possible, the climate perturbations were introduced by changing the solar constant while the concentrations of long-lived atmospheric constituents were kept constant at near present-day values. Figure 6 shows the evolution of the annual-mean global surface temperature in a control version, and in versions in which the solar constant was instantaneously increased by 2.5% and 25%. The temperature in the +2.5% run appears to reach equilibrium at about 2˚C above the control run. This is roughly the same warming that has been found by other investigators when the CO_2 in this model is doubled. The CSM is thus one of the least sensitive of the current comprehensive climate models.

The +25% solar constant run shows a continuously rising temperature through the full 50 years of integration. It is not clear if the climate in this case will reach equilibrium, but the temperature increase over the control by year 65 already exceeds 40˚C, suggesting that the response has become extremely nonlinear. It is possible that the continued warming in this experiment indicates that the model with +25% is close to the RG instability boundary. Figure 7 shows the annual-mean surface temperature change (relative to control) averaged over years 41 to 50 of the +2.5% and +25% runs. The extreme warming in the +25% experiment is evident, and is almost everywhere much more than 10 times the warming in the +2.5% run. It should be emphasized that this model includes only water vapor and cloud feedback processes, since concentrations of long-lived greenhouse gases are held fixed.

Hamilton and Zhu are now conducting experiments to characterize the sensitivity of the model climate to changes in the solar constant of +5%, +10% and +15%, and to determine at what temperature the nonlinearity in the equilibrium climate response to radiative forcing perturbations becomes significant. They are analyzing the results of these model experiments to see how transient eddies in both the tropics and extratropics respond to very large changes in the mean climate.

Probing into the Workings of Climate with the IPRC Regional Climate Model

Introduction

General circulation models (GCMs) of the global atmosphere are a key tool for climate research. They represent atmospheric dynamics, physics, and chemistry with mathematical equations, which are then solved on a three-dimensional grid that spans the globe. Computer capabilities currently limit the grid resolutions in the global GCMs that are used to simulate Earth's climate and make warming predictions and that are integrated over several decades (such as those reviewed in the latest report by the Intergovernmental Panel on Climate Change). As a consequence, they have a longitudinal grid spacing of only about 300 km, which is insufficient to resolve many important features of the atmospheric circulation. To deal with this limitation, scientists are turning to regional atmospheric models. Covering a smaller region, the available computing power in such models can be applied to represent climate-related processes and their interactions with Earth's geographic and vegetation features in finer detail.

The IPRC Regional Climate Model

At the IPRC, scientists have developed the IPRC Regional Climate Model (IPRC–RegCM; Y.Wang, O. Sen, and B. Wang, see *IPRC Climate*, Vol. 1, Fall 2001). The model was originally designed for application to East Asia, a region where climate variability is extremely difficult to simulate. Dominated by the monsoon, the large-scale atmospheric circulation is driven mainly by the heat contrast between the Eurasian continent and the tropical ocean to the south, and as such, East Asian climate is a result of complex interactions between the tropics and the higher latitudes. Furthermore, its highly varied topography—the highest mountain range on Earth, land surfaces ranging from tropical forests to deserts, and extensive coastlines—affects climate in many different ways. Developed from a mesoscale tropical cyclone model (Wang 1999, 2001, 2002), the IPRC–RegCM now includes a mass-flux cumulus parameterization scheme, a sophisticated and accurate radiation scheme, and a biosphere-atmosphere transfer scheme for land-surface processes that allows the representation of complex atmospheric interactions with high mountains, coastlines, and vegetation covers. The model is run with a horizontal grid spacing of 25–50 km.

The model has been tested in seasonal simulations for the East Asian region using ECMWF data for initial conditions and (continuously updated) horizontal boundary conditions, and Reynolds SST data for the lower boundary condition over the ocean. The model has successfully simulated the 1998 summer monsoon season, realistically reproducing the area-averaged daily rainfall, the daily minimum and maximum air temperatures and their monthly mean geographic patterns, and the extreme flooding observed in China that year—the worst since 1955. It also captured the distribution of the frequency of occurrence of heavy daily rainfall (Figure 8), something that other models have failed to do (Y.Wang, O. Sen, and B. Wang). This is a necessary capability for a model that is to be used for studying the climate system's response to changes and fluctuations in the atmosphere, land, and ocean, and for assessing the impact of global change on regional climate.

Long-Term Goals

The long-term goal of the IPRC scientists is to develop a grid-point GCM into which the IPRC–RegCM is nested, with explicit two-way interaction between the global atmospheric and the regional atmospheric circulations. This approach is new compared with the current common strategy in which conditions in the GCM affect conditions in the regional model but not *vice versa*. The two-way approach has the advantage that improved regional-scale simulation can feed back into the global model, improving global simulation, which then, in turn, may improve the regional climate simulation.

To reach this stage in development, however, the IPRC–RegCM must first be used for, and tested, on diverse climate regimes. Below are two examples of how the IPRC scientists are applying the model to probe into the workings of climate.

Cold Meanders in the Equatorial Eastern Pacific

One investigation with the IPRC–RegCM studies the effects of meanders called tropical instability waves (TIWs). The TIWs travel along cold-warm SST fronts to the north and south of the cold tongue in the eastern tropical Pacific, have periods of about one month and wavelengths of around 1,000 km, and are stronger to the north than to the south of the cold tongue (Figure 9a). They affect the thickness of the atmospheric boundary layer (the first 2 km or so above Earth's surface), which can be as much as 500 meters lower over the cold water than over the warm water, resulting in large atmospheric pressure differences.

The surface winds are notably weaker on the cold tongue and the cold meanders. This is shown more clearly in the observed regression coefficients of SST and wind vector onto a TIW index (Figure 9b). Anomalously high southeasterly trade winds can be seen to occur over the warmer SSTs and weaker trade winds over the cold SSTs.

What physical mechanism is causing such an atmospheric response at these ocean fronts? One idea is that, as air crosses from cold to warm SST, the air becomes unstable and mixes. This leads to a more homogeneous air column over the warm water, resulting in more uniform temperatures and stronger winds there. Conversely, as warm air crosses from warm to cold SST, the air becomes stable, mixing is reduced, and the air becomes more stratified, resulting in stronger wind shear that weakens the surface winds. Another idea is that similar temperature anomalies develop in the atmosphere as on the ocean surface and, as a hydrostatic response, low pressure develops over the warm SST and high pressure over the cold SST. The near-surface winds are then directed from high to low pressure regions and are strongest over the SST gradients.

Which of these mechanisms actually occurs? The IPRC model with its very good representation of mixing processes makes it ideal for looking at these possibilities. Model simulations (R.J. Small, S.-P. Xie, and Y. Wang) result in a near-surface wind response that is similar to observations (Figure 9c). Detailed analysis of these simulations suggests that both vertical mixing and pressure-gradient are important, and that horizontal advection by the mean flow plays a role. In the simulation, the surface-pressure anomalies lie downstream of the SST anomalies, and the pressure-driven wind is strongest over the warmest SST, just as the observations indicate.

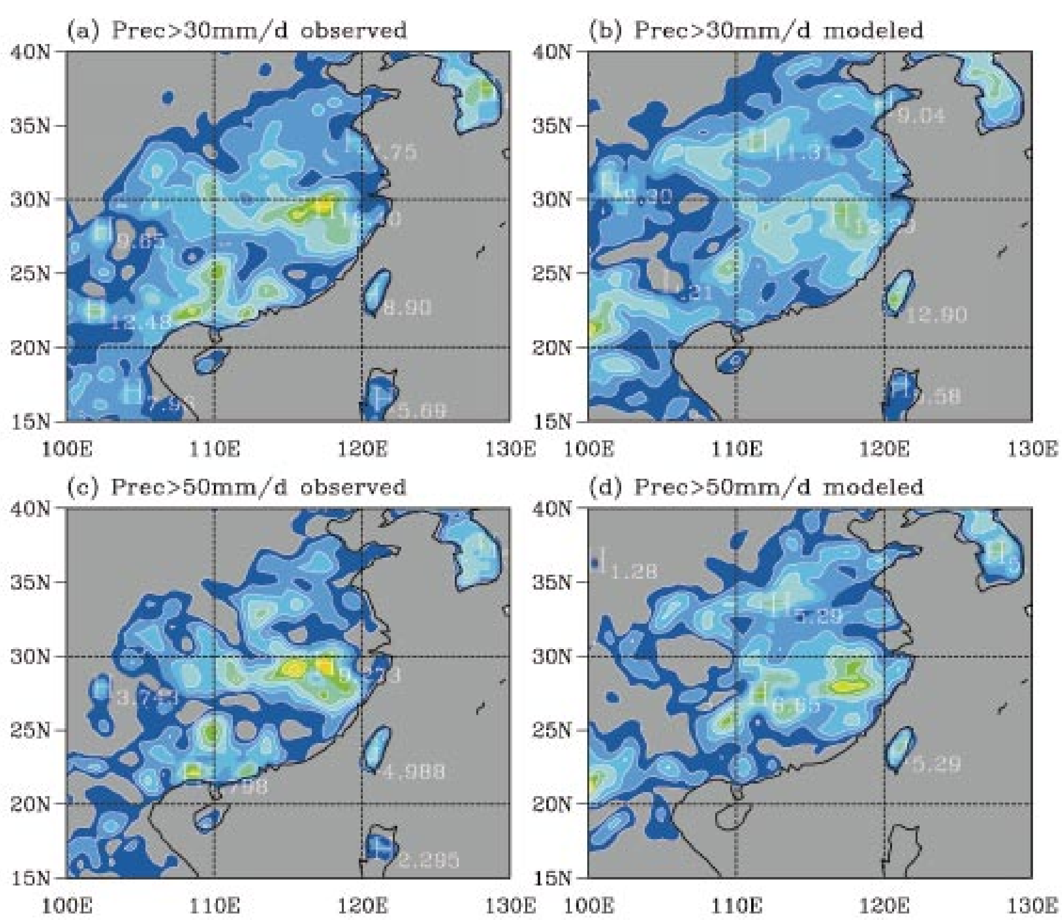


Figure 8: *Observed (left) and modeled (right) distributions of frequency of occurrence (percentage of days in June 1998) of daily rainfall greater than 30 (top), and 50 (bottom) mm.*

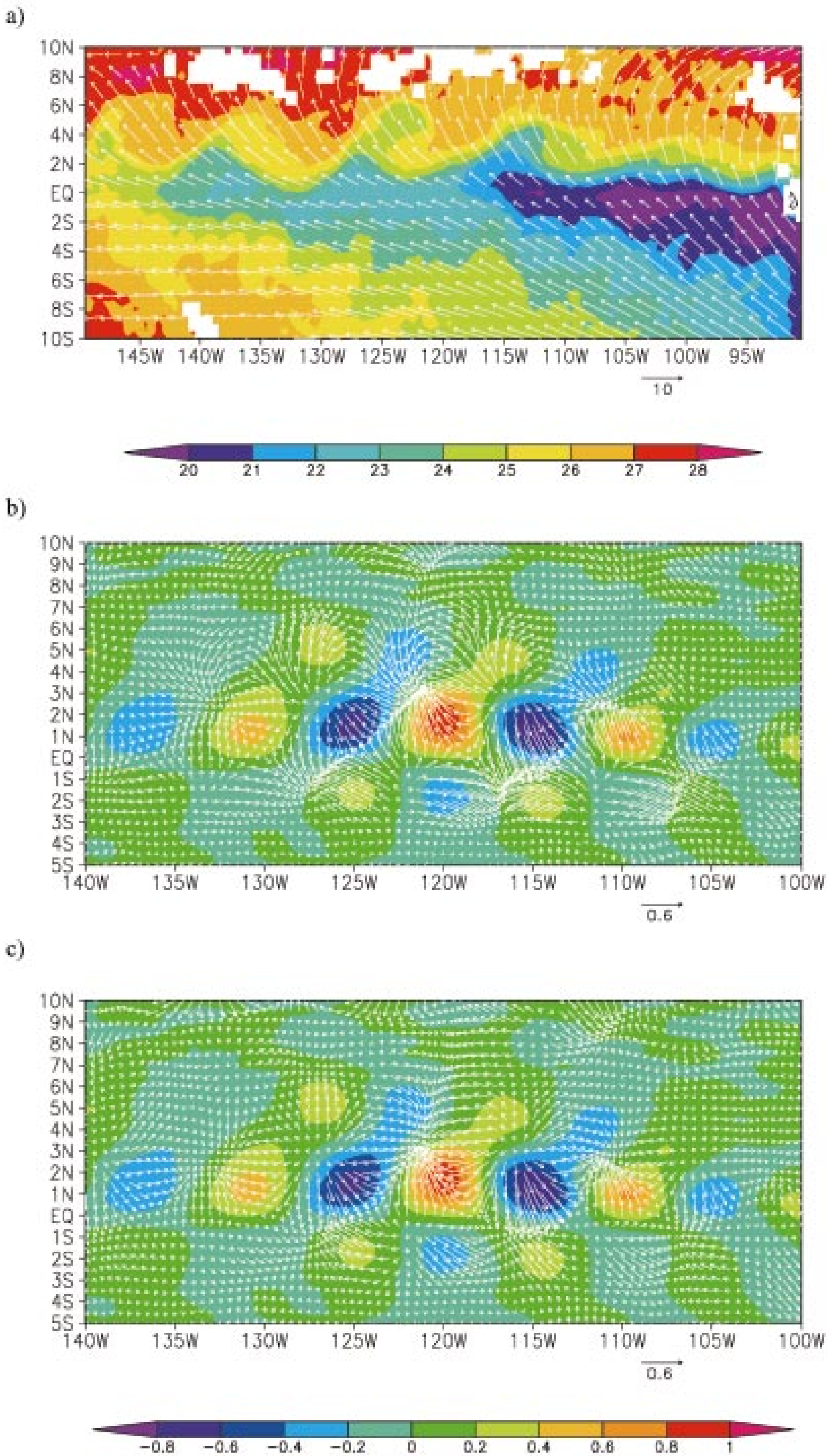


Figure 9: *(a) SST variations (color; Tropical Rainfall Measuring Mission Microwave Imager measurements) associated with tropical instability waves (TIWs) and their effect on surface winds (vectors; QuikSCAT scatterometer measurements). White areas denote data gaps, which occur primarily in the ITCZ region due to precipitation. (b) Regression coefficients of observed SST and surface wind onto a TIW index. (c) Corresponding regression coefficients obtained from a run of the IPRC–RegCM. A comparison of (b) and (c) shows similar features, suggesting the model is capturing the appropriate boundary-layer response.*

Deforestation and Rainfall Patterns

Although it is accepted that deforestation affects climate, its influence on the atmosphere is unclear: Are the effects local or global? Are they suppressed or enhanced by large-scale atmospheric circulation? Is rainfall increased or reduced? Indochina is of particular interest because the strong summer-time monsoon winds that flow over the peninsula may interact in unusual ways with different land-surface covers. Using the IPRC–RegCM, IPRC scientists are investigating how the recent deforestation in the region may have affected the monsoon flow, and what impact it may have downstream on rainfall over China, which can be plagued by both droughts and floods during the monsoon season (O. Sen, Y. Wang, and B. Wang).

Simulations with the model were run under two land-surface conditions: the current agricultural land cover and a forested cover. The experiment was conducted for the period of April through September of 1998—the summer of the severe flooding in China mentioned above. Results (based on the average of 5 ensemble runs for each condition) show that deforestation can have remote effects as well as local effects on climate, even appearing to modify the monsoon flow. The area downstream of the deforestation gets more rainfall in the model, whereas part of the area over and upstream of the deforestation gets less (Figure 10). The extent of the change in modeled rainfall, particularly in the area of deforestation, however, depends upon the strength of the monsoon. Next steps in understanding the workings of the region's climate will be to investigate how the wind and rainfall changes that are seen in the present simulations are influenced by summers less wet than 1998, and then to determine the physical mechanisms responsible for the changes.

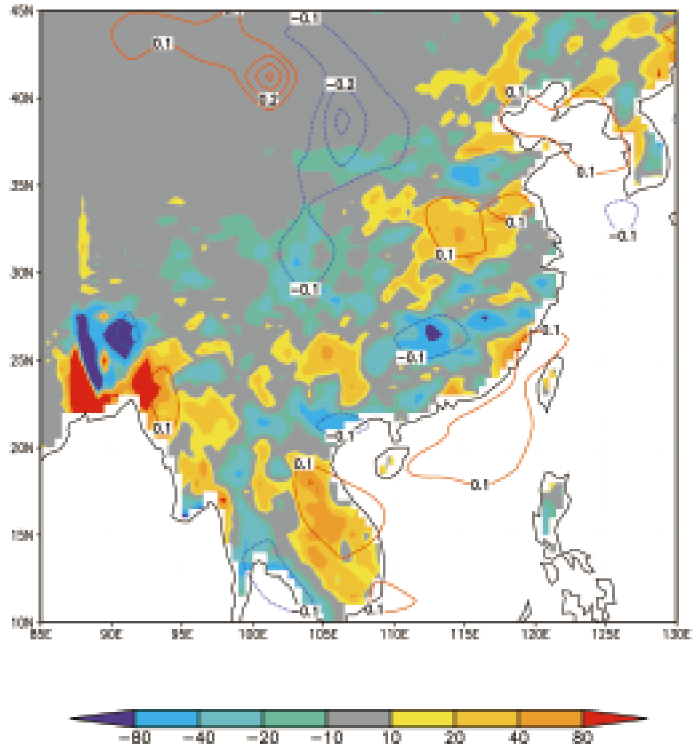


Figure 10: *Differences in June-July-August 1998 Indochina rainfall between the current vegetation and a forested vegetation cover, as simulated with the IPRC–RegCM. Absolute differences in mm/month are shown in color, relative differences are represented by contours. Results are based on a 5-member ensemble simulation for each condition.*

Conclusion

These are only two examples of how the IPRC–RegCM is being used to probe into the climate system, and some of the above findings are already useful in regional climate predictions. A wide range of similar experiments with the model is now either being conducted or planned at the IPRC. The experiments focus on understanding the mechanisms responsible for such widely different climate phenomena as intraseasonal oscillations in the tropical Indian and western Pacific Oceans and their role in generating tropical cyclones, and events in the eastern Pacific that affect convective activity in the intertropical convergence zone. The climate picture that will emerge from these studies should significantly advance the quality of simulations in general circulation models and their global warming predictions.

The next issue of the *IPRC Climate* will report research with the IPRC–RegCM on the eastern Pacific atmosphere and ocean climate and how it is affected by the Andes.

Will Curbing Air Pollution Reduce Global Warming?
Air Pollution as a Climate Forcing Workshop

Tropospheric ozone (O_3), black carbon (BC) aerosols, and methane (CH_4) together may contribute more to global-mean surface warming than carbon dioxide (CO_2). These pollutants also have short atmospheric lifetimes compared to CO_2, and their control might have visible positive effects within a short period of time. In addition, O_3 and BC cause significant health problems. Understanding both the climate and health concerns of these pollutants should enable the formulation of more rational and cost-effective regulatory controls. To address these issues, the workshop *Air Pollution as a Climate Forcing* was organized by a committee headed by NASA Goddard Institute for Space Studies scientist **James Hansen,** and hosted by the IPRC at the East-West Center April 29–May 3, 2002.

Workshop participants came from a variety of communities (atmospheric science, air pollution control technology, societal impact, and policy) and countries to discuss such questions as: What actions need to be taken to reduce the emission of these pollutants? Can the climate and health benefits from a given emission reduction in a particular pollutant be quantified? The presentations focused on the sources of the pollutants, estimated magnitude of emissions, atmospheric chemical and physical responses to the emissions and their sinks, impacts on climate and health, currently available and future technologies for reducing emissions, and policies needed to curb emissions.

The climate effects of changes in concentrations of different trace gases have often been quantified by computing the "climate forcing"—the change in the global mean radiative heating rate for the troposphere when a particular perturbation is introduced into a model with set temperatures. This definition was critically reviewed at the meeting, and although participants noted its limitations, they felt that the climate-forcing concept was useful for evaluating different perturbations within the same framework.

Reports on methane showed that the post-industrial increase in CH_4 has led to a climate forcing of $0.55 W/m^2$ (with an uncertainty of ±20%), but the rate of increase appears to have slowed over the last decade. The impact of a specific reduction in CH_4 concentrations on the heat budget can be predicted fairly accurately. The actual sources and sinks of CH_4, however, are not understood well enough to reliably quantify the effects of particular emission reductions. Future reductions might be possible through recapturing CH_4 emissions from coal burning and from landfills, and through controlling carbon monoxide (CO) and volatile organic carbon (VOC) emissions in landfills, biofuel use, and waste treatment.

Tropospheric O_3 forms through lightning and through the interaction of other pollutants. Our ability to predict a greenhouse impact of O_3 reduction, therefore, depends on our ability to predict a specified reduction in its precursors. The ability to model the chemistry of these precursors ranges from good (for CH_4) to fair (for NOx, CO, and VOC emissions). Verification of reductions in O_3 from precursor emissions in atmospheric observations is difficult and not likely to improve greatly. Possibilities for reducing tropospheric O_3 are found in road transport, biofuel use, power plants, air and ship transport, fossil fuel production and handling of the products. The existing pollution regulations in Europe and North America are examples of how midlatitude O_3 can be curbed in the free troposphere.

Black Carbon (BC) was the aerosol given most attention at the workshop. BC absorbs sunlight and has a net warming effect on the atmosphere. Observations suggest that BC contributes significantly to climate forcing, amounting to $+ 0.5 W/m^{-2}$ or more. BC is emitted during incomplete combustion. Among the main sources of BC

worldwide are residential coal and biofuels for heating and cooking (~40%), diesel motors (~10%), coal plants (~5%), while open burning of fields and forests contributes about 50%. These percentages all have fairly large uncertainties, as it is very difficult to inventory the many sources of BC, especially in the developing world, where dung, grasses and wood are used for heating and cooking.

BC emissions can be reduced through improved combustion, switching to fuels that emit less BC in combustion, and capturing BC through filters. Though these actions sound straightforward, the interplay between fuel efficiency and emissions complicates decision making. For example, using diesel fuel reduces fuel consumption, because it is more efficient than gasoline, but it also emits much more BC, especially if it is not of high-grade. The huge increase in fuel projected for transportation in the developing world, which uses mainly low-quality diesel, makes this question particularly relevant.

Determining the general effects of aerosols—of which some have a cooling and others a warming effect—on global temperatures and on health is extremely complex. As aerosols move away from their source, they react chemically with each other and atmospheric gases; as a consequence they may change their nature and their interaction with light, and thus their effect on the heat budget. Aerosol dynamics models are being developed that describe the ways in which aerosols interact with each other and develop in size, depending upon their concentrations and distance from their source.

Evidence was presented on the long-range transport of ozone and other pollutants. North American pollutants travel to Europe, particularly during times of strong westerlies. The meteorological conditions favoring long-range travel are linked to the North Atlantic Oscillation and mid-latitude cyclones. Asian pollutants travel to Hawaii and California. The change in pollutants as they travel can significantly alter their effects on incoming solar radiation. For example, as the sand lofted during storms in the Gobi Desert passes over industrial areas with BC and other pollutants in China, it changes its properties and absorbs more sunlight in the higher atmosphere, making the atmosphere warmer and more stable; clouds burn off and don't form as readily, changing the water cycle. Modeling results suggest that the higher BC content in northern China may contribute to droughts in that region. Another modeling study suggests that controlling BC emissions would have a rapid effect on temperature, while the effects of reducing CO_2 would take much longer to appear.

The technology speakers provided a thought-provoking twist to the workshop. Our energy supply comes mainly from fossil fuels and biomass burning, which are not only major sources of CH_4, and BC emissions, and tropospheric O_3 precursors, but also of CO_2 emissions. The technology sector, therefore, views the control of both air pollutants and CO_2 under the topic of *carbon management.* Carbon management must consider three things: energy efficiency, carbon filtering or decarbonization of energy sources, and CO_2 sequestration from the atmosphere.

The sources of greatest carbon emissions in the U.S. are the burning of fuel for electricity production and for transportation. Electricity, itself, is clean, and switching to electricity for energy in the developing world will greatly curb the growth rate of air pollution; the generation of electricity, however, can emit much CO_2. In 2000, electricity generation was the source of 40% of CO_2 emissions in the US. By increasing energy efficiency and changing the energy source, the emissions related to electricity can be curbed. For instance, the generation of electricity can be made much more efficient: Central power stations now use about 3 units of energy for every unit delivered, but new technologies can lower this to a 2:1 ratio. Even better, electricity can be generated by using procedures that emit little or no CO_2. For example, the use of coal emits 900g CO_2 per kilowatt-hour, natural gas 400g, photovoltaic cells 200g (with technological improvements only 100g), and wind a negligible amount.

There is also room for more efficient electricity use. For instance, refrigerators today use between 4 to 5 times less energy than 30 years ago, even though they have become bigger. Air-conditioning is a good candidate for greater efficiency in the US. In the developing world, greater efficiency can be found with cooking stoves.

Transportation fuel is another large source of CO_2, accounting for 33% of CO_2 emission in the US. Global CO_2 emissions from transportation are projected to increase 75% over the next 25 years (International Energy Agency), most of the increase coming from the developing world. Transportation fuel is also a major source of BC and O_3. Achieving a cleaner atmosphere requires vehicles powered by energy other than fossil fuels, for instance, hydrogen. Renewable energy sources such as solar and wind power are well suited for producing hydrogen and, as mentioned above, emit little CO_2.

The technologies for more efficient energy use and for sources of non-carbon based energy, such as hydropower, turbines without dams, geothermal, wind, and solar,

Continued on page 16

Second IPRC Annual Symposium

The Second Annual IPRC Symposium was held on May 16 and 17, 2002, at the East-West Center in Honolulu. This symposium allows the IPRC scientists to present their research highlights to each other in a formal setting. It is a time to pause and reflect upon the progress of the IPRC as a whole and to identify areas for future research. This sharing makes common research threads visible, encouraging future collaborations and the solicitation of helpful suggestions.

A total of 39 talks were given by each of the IPRC researchers, as well as by Fei-Fei Jin (University of Hawaii, School of Ocean and Earth Science and Technology) and Ming Feng (Commonwealth Scientific & Industrial Research Organisation, Australia). There were eight sessions, covering the following topics: Atmosphere-Ocean Interactions, Pacific Climate Variability, Oceanic Processes in the Kuroshio, Dynamics of the Western Boundary Currents, Oceanic Processes and Modeling, Global Climate Change and Variability, Regional and Global Atmospheric Modeling, the Asia-Pacific Data-Research Center, and the Computer Network. The list of symposium talks and their presenters can be found under *Seminars and Workshops* at the IPRC website: http://iprc.soest@hawaii.edu.

IPRC researchers assembled in front of the Imin Conference Center, East-West Center.

Curbing Air Pollution *(continued from page 15)*

exist—a point often mentioned at the workshop. This technology, however, is not making an inroad because coal and oil are still so cheap. Other reasons for not adopting new technologies are that shoppers tend to go for the low purchase price rather than the long-term savings through energy efficiency, that current regulations in the US favor central power station generation over distributed and renewable generation, and that implementation of such technologies as hydrogen-fueled motors, requires huge and costly changes in infrastructure.

In sum, reducing air pollution will curb global warming and much technology for such reduction is already available. To bring about the needed changes, though, individuals, industry, and especially governments must take vigorous action.

The full workshop report is available at www.giss.nasa.gov/meetings/pollution02/. Workshop sponsors were the National Aeronautics and Space Administration, the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, the National Science Foundation, the Goddard Space Flight Center, Earth Sciences Directorate, the Hewlett Foundation, the California Air Resources Board, the California Energy Commission, the International Pacific Research Center, and the East-West Center.

New IPRC Staff

Saichiro Yoshimura, chosen by JAMSTEC and NASDA as the new liaison officer between the Frontier Research System for Global Change and the IPRC, joined the IPRC in July 2002. For most of his professional career, thirty years now, he has been an administrative officer in the Japanese government.

Yoshimura's professional life began with an undergraduate degree in engineering, electronics to be specific, from The University of Tokyo. The next step led him to the United States on a fellowship of the Japanese government for administrators and to two years of graduate study in business administration at the Wharton Graduate School of Business, University of Pennsylvania, in Philadelphia, where he obtained a master's degree in business administration. There he was exposed to US scientific-management philosophies, decision-making procedures, and their application to the real business world. He recalls, "The kind of theoretical problem-solving methods I learned about at Wharten were rejected at the time by Japanese industry on the pretext that life in Japan with its long history and unique traditions would not allow the efficient application of theories created in the United States." He adds, "It is interesting to note that now, 30 years later, many sectors of Japanese industries have learned that they are not exempt from such universal theories."

Yoshimura moved to Paris as a scientific attaché, stationed with the Japanese delegation to the Organization of Economic Co-operation and Development (OECD), an international organization of developed countries. He tells of how he enjoyed his three years there … particularly the diplomatic privileges that translated into no parking tickets. He returned to France, to Strasbourg, in 1991 as Deputy Secretary-General of the Human Frontier Science Program Organization, an international granting agency for brain and molecular biology study. The organization was supported by the then G7 countries and was given an annual budget on the scale of $60 million. He recalls, "It was a rare opportunity to observe real-life, active, first-rate, international scientists working on the peer-review panels during this five-year assignment. I was impressed that even Nobel laureates on the panel were easily voted down during the scientific reviews, which was, and still is, inconceivable in Japan."

His administrative work with the Japanese government has included such different fields as nuclear energy, space development, information sciences, brain research and robotics. He says that after these varied experiences he is curious about climate research and is looking forward to the opportunity of meeting and working with the IPRC scientists. As liaison officer, Yoshimura will facilitate communication and coordination between the IPRC and JAMSTEC, NASDA, and Frontier. He likens his mission to that of a diplomat.

Kelvin Richards joined the IPRC in September 2002 as a professor of oceanography. He received his Ph.D. in 1978 from the University of Southampton, England. He recalls, "My thesis was on the formation of sand ripples. But, having developed a theory for their formation, I decided it was time to quit the field. The problem of the interaction of turbulence and moving sand grains was just too difficult. Now I wonder, is climate any easier?"

After completing his Ph.D., Richards worked as a Royal Society Research Fellow in the Department of Applied Mathematics and Theoretical Physics, University of Cambridge. There he studied atmospheric boundary-layer problems, principally stratified turbulent flow over hills and the dispersion of pollutants. In 1980, he moved to the Institute of Oceanographic Sciences at Wormley, in the leafy countryside of Surrey. Working for the institute, he had his first experience in taking scientific measurements at sea, deploying 'Swallow' floats in the Madeira Abyssal plain.

In 1985, Richards returned to Southampton as a faculty member in the then Department of Oceanography. He taught courses in basic fluid dynamics, geophysical fluids, and physical oceanography. To date, he has seen 16 graduate students get their Ph.D.

His research interests, though broad, have the underlying theme of how stirring and mixing affects the dynamics of Earth's environment system. They include turbulent boundary layers, eddy–mean flow interaction, the dynamics of gyres, equatorial flows and the Antarctic Circumpolar Current, plumes from hydrothermal vents, the transport of tracers, and the impact of physical processes on the marine ecosystem. Recently, he has started to look at the role oceanic processes play in the interaction between the fluid environments of the ocean and atmosphere.

"What I enjoy about oceanographic research," he confides, "is that it allows me to mix theory, numerical modeling, and getting my hands dirty at sea. Last spring, I was on a cruise of the UK Marine Productivity program investigating the effects of the changing physical environment on the zooplankton *Calanus finmarchicus* in the subpolar gyre of the North Atlantic. This involved taking measurements amongst the ice floes on the east Greenland Shelf."

Richards is looking forward to working with colleagues both within the IPRC and the broader SOEST community. "My first work-day at the IPRC coincided with the arrival of the *Kilo Moana,* the new UH research ship," he recalls. "I hope the coincidence is prophetic, and it is not too long before I have the chance to sail with her to the tropical Pacific." His immediate plans are to consider the impact of mixing processes in the equatorial ocean on the ocean's response to atmospheric forcing, and the coupling between the ocean and atmosphere. "My philosophy," he says, "is to tackle a problem from both ends, looking closely at the mixing processes themselves as well as with GCMs to quantify their larger-scale effect. I hope to extend my studies in biogeochemical modeling, looking at what controls 'patchiness' and changes to basin-scale ecosystem dynamics induced by the ever-changing climate."

Niklas Schneider joined the IPRC as an associate professor of oceanography in October 2002. Growing up on a tiny island in the North Sea, he was intrigued already as a child by the power and moods of the ocean, and when he entered the University of Hamburg, he knew from the start that he wanted to become an oceanographer. After spending his undergraduate years at the University of Hamburg and completing his "Vordiplom," something between a bachelor's and a master's degree, he turned to the University of Hawaii (UH) and a balmier ocean for graduate studies in oceanography.

Upon receiving his Ph.D. in 1992 from UH, he moved to Scripps Institution of Oceanography (SIO), La Jolla, California. There he first worked as postdoctoral fellow with T. Barnett and, using ocean and atmosphere models, he studied the role of buoyancy forcing in the dynamics of El Niño and the western Pacific warm pool.

In 1995, he joined the staff at the Climate Research Division of SIO as an assistant researcher, and in 2001, he became an associate researcher and permanent member. His work, in collaboration with colleagues at SIO, the National Center for Atmospheric Research, and the Max-Planck Institute for Meteorology in Hamburg, has spanned tropical coupled ocean-atmosphere dynamics, the dynamics and role of the Indonesian Throughflow in the climate system, and decadal climate variability of the Pacific. The latter research has documented, with observations and model simulations, the generation and subsurface evolution of decadal temperature anomalies. Among other things, he has found that decadal variability in a coupled-model solution appeared to rely on advection of water-mass anomalies from within the tropics to the equator.

Recently, he has studied decadal dynamics and the predictability of the wind-driven circulation of the North Pacific. This work involved the analysis of long integrations of a coupled model and its comparison with the short instrumental record. A highlight was finding that winter-temperature anomalies in the ocean off the Japan coast appear predictable from simple oceanic Rossby-wave dynamics and measurements of Pacific-wide wind-stress anomalies.

At the IPRC, Schneider plans to continue his quest to understand the ocean's role in decadal climate variability and change. In particular, he plans to study the role of water-mass anomalies, the role of the southern Pacific and Indian Oceans (which includes a return to studies of the Indonesian Throughflow), and the role of ocean heat transports on the atmosphere.

Fumiaki Kobashi joined the IPRC in August 2002 as an assistant researcher from the Frontier Research System for Global Change. He received his Ph.D. in physical oceanography in March 2002 from Tohoku University, Japan.

His dissertation research focused on mesoscale sea-surface-height (SSH) variability in the regions of the North Pacific Subtropical Countercurrent (STCC) and the Hawaiian Lee Countercurrent (HLCC), and on how this variability may impact Kuroshio variability, such as its path and volume transport. An analysis of altimeter data showed SSH varied greatly in the STCC and HLCC regions. Results of a linear stability analysis based on newly constructed climatological monthly-mean hydrographic datasets suggest that mesoscale variability in SSH is generated by baroclinic instability and by their nonlinear interactions with the resulting eddies. Kobashi noted that such mesoscale disturbances propagate westward in the STCC region and sometimes cause fluctuations in the volume transport in the upstream Kuroshio, with cyclonic eddies being related to transport decreases and anticyclonic eddies to transport increases. These variations in transport have the same period as the disturbances. He also found evidence to suggest that when anticyclonic disturbances approach the Kuroshio, warm water is advected from the STCC to the Kuroshio.

At the IPRC, Kobashi is working with **Humio Mitsudera** (IPRC Theme 2 Co-Leader) on the dynamics of the North Pacific subtropical ocean with a focus on the STCC. He plans to analyze a combination of satellite remote-sensing data and in-situ data to obtain insights into how the STCC is formed and to examine the seasonal-to-interannual STCC variability and its relationship to changes in the large-scale atmospheric and oceanic circulations. Kobashi is also planning to examine Japan Marine Science and Technology Center (JAMSTEC) mooring data in the Tokara Strait, in order to investigate further the effects of mesoscale disturbances on the Kuroshio.

Shinya Yarimizo joined the IPRC as a computer systems engineer in April 2002. Born and raised in Yokohama, Japan, Yarimizo came to the US in 1991. Until he was well into his third year in college, he didn't have a clue about computers—he literally hadn’t used a computer!

"Upon transferring from a junior college to the University of California at Davis," he says, "I somehow managed to slip myself into the College of Engineering, majoring in Computer Science and Engineering. This is where I was dragged into the computer world. From then until I graduated in 1997 with a Bachelor of Science, I spent more time in front of the computer screen than I care to think about. I spent my college days as a hard-core nerd," he admits, but likes to think it has paid off.

After earning his degree, Yarimizo worked as a software engineer for a computer graphics production company called *Square USA*, where he was involved in producing the fully computer-generated feature film *Final Fantasy: The Spirits Within.* At the company, he was a " jack-of-all-trades," doing everything from moving furniture to writing serious amounts of code. One of his significant software contributions was the development of a batch-job-queuing system, which controlled thousands of CPU-intensive jobs every day on a thousand-node Linux cluster. Besides writing and maintaining his (and often others') software, he was responsible for managing the users' computing environments, and he worked closely with the systems administration team. It was from this experience that he learned so much about working with computer systems, and about helping people with their computer and software frustrations.

Now at the IPRC, Yarimizo works with **Ronald Merrill** in computer systems administration, assisting in planning and purchasing computers and related equipment, the configuration of new equipment, and the maintenance and upgrading of installed hardware and various software. This translates into working with anyone at IPRC who uses a computer—that is, everyone. He has turned himself into a one-stop computer help department, a miracle worker in solving the many varied and complex computer problems of the IPRC staff. He says he enjoys working with people—and his ever-willing, patient way with people and their computer puzzles confirms this. His wide knowledge and intuition on how software programs work are a most valuable asset for this role.

In spite of the very time-consuming everyday tasks at IPRC, Yarimizo maintains his interests in computer graphics and entertainment, open-source and collaborative development, and computer-based automation.

Visitors

Professor **Akimasa Sumi,** Director of the Center for Climate System Research, University of Tokyo, and Mr. **Tsuguhiko Katagi**, Assistant Executive Director of the Office of Satellite Technology, Research and Applications at the National Space Development Agency of Japan (NASDA), visited the IPRC on July 22, 2002. They paid a courtesy call to IPRC Director **Jay McCreary**. Liaison Officer **Saichiro Yoshimura** and Dr. **Riko Oki**, Associate Senior Engineer at the Satellite Program and Planning Department of the NASDA Office of Satellite Technology, joined the meeting.

The visitors also had the opportunity to come together with several IPRC researchers and with the young scientists from NASDA and JAMSTEC (Japan Marine Science and Technology Center), who are currently working at the IPRC, as well as with graduate students from Japan who are studying with Professor Shang-Ping Xie and are supported by the IPRC. **Peter Hacker**, Manager of the Asia-Pacific Data-Research Center (APDRC), described the mission and activities of the APDRC, which links data-management and data-preparation activities to research and provides one-stop shopping of climate data and climate products to the IPRC researchers and collaborators and to the national and international climate research communities (see *IPRC Climate*, Vol. 2, No.1). **Shang-Ping Xie**, Theme 1 Co-Leader and Professor of Meteorology at the University of Hawaii, presented his research that deals with the far-reaching effects of the tall mountains of the Hawaiian Islands on the ocean and atmosphere. **Masami Nonaka** from NASDA reported on changes in the Kuroshio paths and associated regional changes in the winds (see p. 3, this volume); **Takahiro Endoh** from JAMSTEC described his modeling research on the Kuroshio.

From left to right, back row: Saichiro Yoshimura, Tsuguhiko Katagi, Akimasa Sumi, Jay McCreary, Takahiro Endoh, Masami Nonaka, Riko Oki, Yuko Okumura; front row: Toru Miyama, Bunmei Taguchi, Shang-Ping Xie, and Hideki Okajima.

Visiting Scholars

The IPRC has an active visitor program. Our visiting scholars give seminars and work with IPRC research staff. From April 2002 to October 2002, the IPRC sponsored the scientists named below for visits of one week or longer.

Ming Feng
Commonwealth Scientific and Industrial Organization, Marmion Marine Laboratories, Marmion, Australia

Wolf-Dieter Grossmann
Center for Environmental Research Leipzig/Halle and GKSS-Forschungszentrum Geesthacht, Germany

Silvio Gualdi
Istituto Nazionale di Geofisica e Vulcanologia, Bologna, Italy

Leland Jameson
Lawrence Livermore National Laboratory, Livermore, California

Mu Mu
Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijin, China

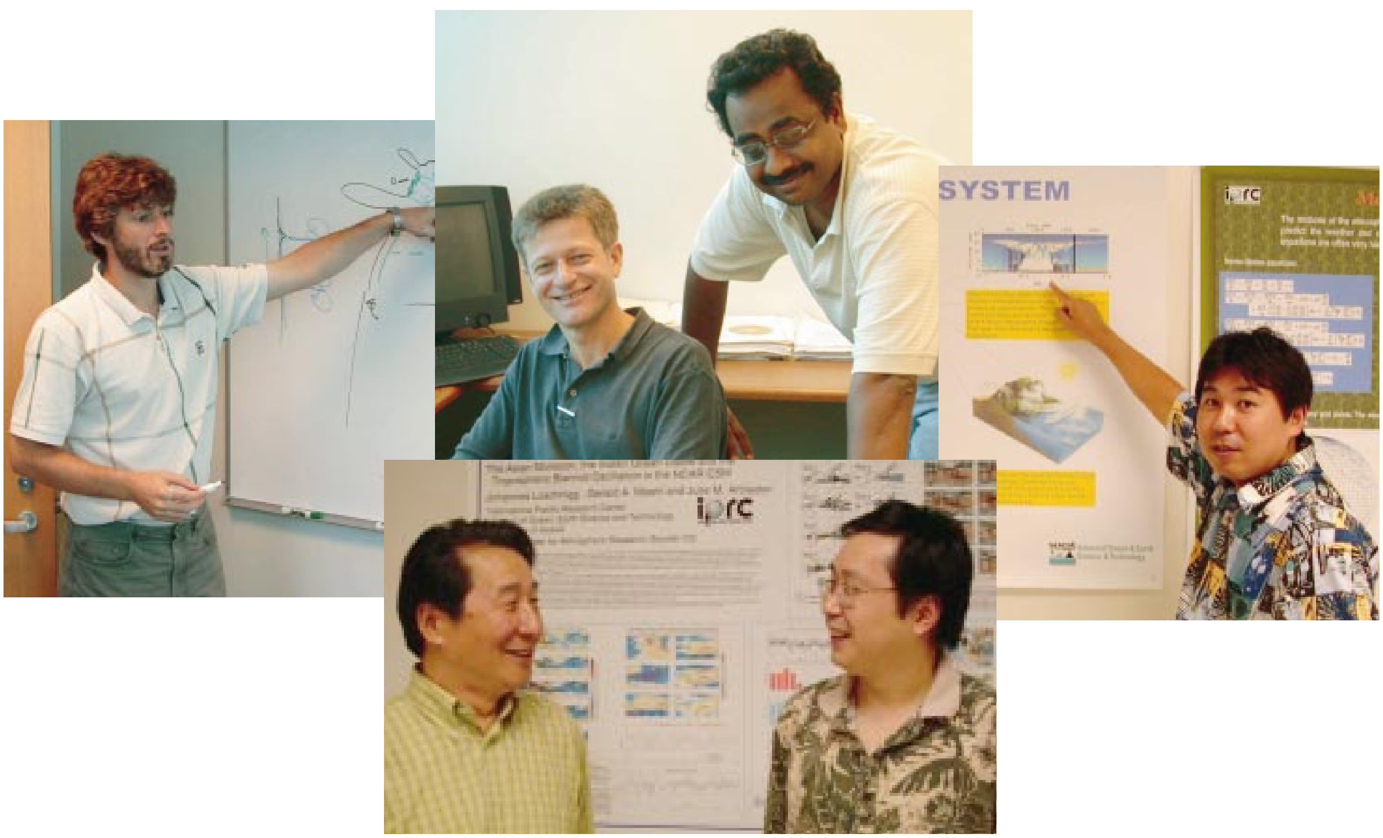
Dmitri Nechaev
Department of Marine Science, Stennis Space Center, Mississippi

Tomohiko Tomita
Department of Environmental Science, Kumamoto University, Kumamoto, Japan

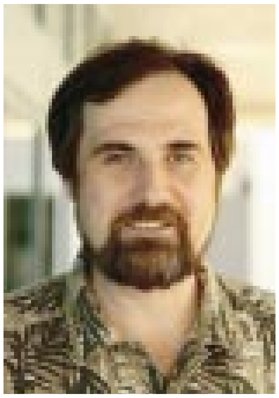
Willie Soon
Harvard-Smithsonian Center for Astrophysics, Cambridge, Massachusetts

Quian Xie
South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China

Yong-Ti Zhu
Shanghai Meteorological Bureau, Shanghai, China



News of IPRC Scientists



Kevin Hamilton, IPRC Theme 4 Leader and Professor of Meteorology, is serving on the editorial board of a new and innovative scientific journal, *Atmospheric Chemistry and Physics,* published by the European Geophysical Society. The journal consists of two parts: a web-based electronic journal, *Atmospheric Chemistry and Physics Discussions (APCD)*, and a standard, hardcopy journal. Papers are submitted electronically and are given a rapid anonymous peer review. Papers that pass this initial review are posted on the web in the *APCD*, and an eight-week period is opened on the website for comments from the official reviewers, the general scientific community, and for responses from the authors. The original papers and comments are preserved permanently on the *APCD* web site, so this provides an ideal forum for discussion of controversial ideas. After this comment period, papers judged by the editors to merit hardcopy publication are scheduled to appear in the journal's paper version.

The journal started accepting papers late in 2001, and the first paper issues have recently appeared. The journal is currently meeting very ambitious targets in terms of rapid publication, with an average of 8 weeks from submission to appearance on the APCD web site, and 25 weeks from submission to appearance in the hardcopy journal. Even more impressive has been the volume and quality of the discussions that have appeared on the APCD web site, far outstripping the typical "comment and discussion" sections in traditional journals.

A subscription is required to receive the hardcopy journal, but access to the APCD web site will hopefully remain free of charge. More details are available at http://www.copernicus.org/EGS/acp.

At the recent meeting of the Pacific Congress on Marine Science and Technology (PACON International) in Chiba, Japan, **Lorenz Magaard,** Professor of Oceanography and Executive Associate Director of the IPRC, was chosen as the president-elect for 2002 to 2004, with his presidential term running from 2004 to 2006. Magaard has been an active member of PACON from its inception and at the 2000 Congress in Honolulu, he received the prestigious International Award of the Pacific Congress on Marine Science and Technology for his significant contribution to the advancement of ocean science and technology.

PACON International is a dynamic network of marine scientists, engineers and policy makers organized for the purpose of sharing insights and breakthroughs in ocean scientific research, and in state-of-the-art marine technology. The members of this international, nonprofit organization are active in promoting scientific, technical, and environmentally sound use of ocean resources in a developmentally sustainable way. While the organization is Honolulu based, it concerns itself with the entire Asia-Pacific marine environment, and its membership and sponsors are worldwide.

The Making of a Climatologist

As part of its collaboration with Japan, the IPRC educates young climate researchers. Below is the story of Bunmei Taguchi, who came to the University of Hawaii in Fall 2000 as a graduate student with financial support from the IPRC.

There seems nothing unusual about **Bunmei Taguchi,** a graduate meteorology student at the University of Hawaii (UH) at Manoa. He fits right in with both the local and the many foreign students. But how he came to be at UH, doing climate research in the meteorology Ph.D. program is worth a story.

After majoring in applied physics in Japan, Taguchi wanted to study something more real—meteorology. "You can feel the wind, the rain, and see the clouds." Thus, for his master's research, he investigated the heat exchange between the atmosphere and land covered by snow. Upon completing his master's meteorology degree, Taguchi worked for a private company in Japan as a scientific computer programmer. He was assigned to help researchers in government institutions develop codes for their computer programs on environmental simulations, usually to address the environmental impact of construction projects (e.g., power plants). Among his projects was determining the possible destructive effect of a tsunami on a planned power plant.

His tsunami work experience must have been the reason that his company dispatched Taguchi to the Japanese Marine Science and Technology Center (JAMSTEC) to work with **Humio Mitsudera** (now IPRC Theme 2 Co-leader), who was developing ocean models for his research. Taguchi's task was to configure the Princeton Ocean Model (POM) as a high-resolution model of the Kuroshio and its extension. It took two to three years until the adaptation of POM as a high-resolution model for the Kuroshio region began to yield realistic simulations. "Fixing the codes to get reasonable results was painful," Taguchi recalls. And just as the model became useful to study interesting phenomena, Mitsudera left for Honolulu and for the IPRC. This departure, however, did not stop their collaboration.

Bunmei Taguchi "hanging out" with his international graduate-student friends.

When visiting Honolulu and the IPRC in 1999, Taguchi got the idea that he would like to work at the IPRC. His company, though, wanted him back to work on another project. Taguchi then did much soul searching: Should he leave the security of a good job to follow his research interests? The wish to understand the workings of the Kuroshio and to do his own research tipped the scale. He resigned, and in June 2000, he came to Honolulu to continue his work with Mitsudera.

The financial support of the IPRC allowed him to apply as a graduate student to the UH and to pursue a Ph.D. in meteorology with **Shang-Ping Xie** (Theme 1 Co-leader and Professor of Meteorology). The transition from a computer engineer in Japan to a graduate student in the US was not easy. Learning English was a challenge. The first months at UH, he took English courses. Sharing his experiences with the many other students from Japan helped. "Best of all," he thinks, "is the friendship with international students in meteorology and oceanography. They are special for me because we share the same wish to study the ocean and atmosphere and have the same language and cultural difficulties."

About his course work, Taguchi says, "I found graduate work very difficult and challenging, the courses tough and time-consuming, but enjoyable. The classes are excellent and very useful in getting a solid foundation in both oceanography and meteorology, and I get to attend the lectures of famous researchers." Now, after two years, he feels much more comfortable in Hawaii. He still takes every opportunity to expand his knowledge of English, realizing that English is the universal scientific language and mastering it will help him read and publish in international scientific journals and stay on top of cutting-edge science in his field.

Although life has been tough in graduate school, Taguchi has no regrets about leaving his good job: He is now able to continue to pursue his real interest—scientific research. He is excited about his current research project that investigates how the fine structure of the Kuroshio varies with variations in the large-scale ocean circulation and how this variability can affect North Pacific climate.

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For inquiries and address corrections, contact Gisela Speidel at gspeidel@hawaii.edu. Should you no longer wish to receive this newsletter, please let us know.

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