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**– A center for the study of climate in Asia and the Pacific at the University of Hawai'i**

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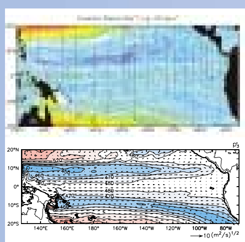

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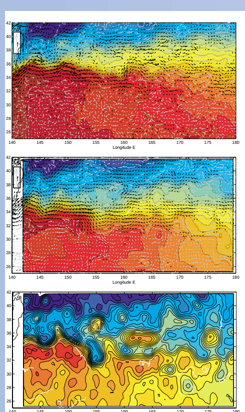

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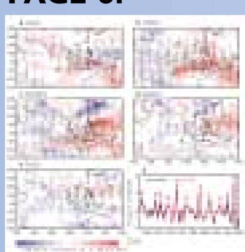

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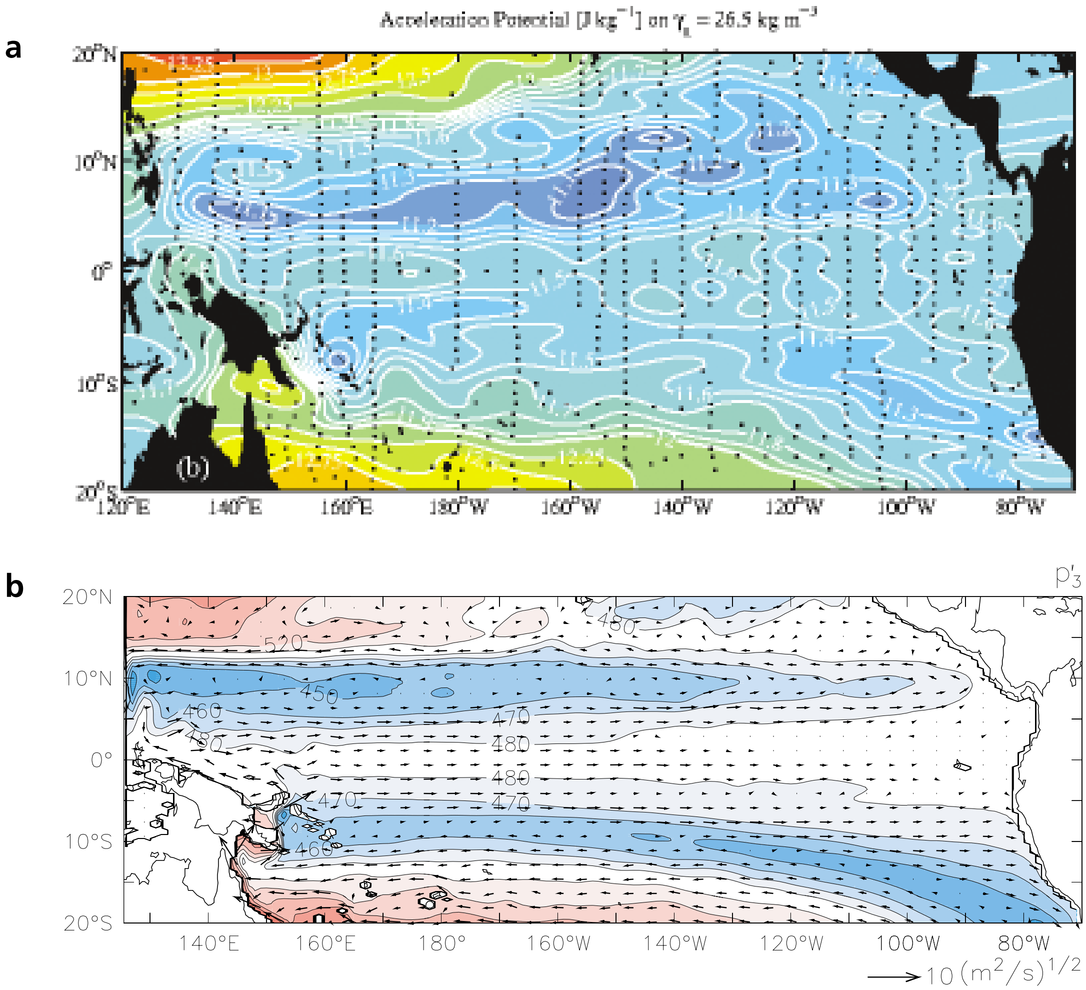


***Figure 1.*** *(a) Acceleration potential (dynamic meters) relative to 900 dbar on the 26.5 kg/m³ neutral density surface, which lies at a depth range from about 300 m to 400 m in the tropical Pacific Ocean. Isolines tend to recirculate in the northern hemisphere but to intersect the eastern boundary in the southern hemisphere. (After Johnson and McPhaden,1999.)*

*(b) Horizontal distributions of $p'_3 = p_3/g_{35}$ fields for the main run. The contour interval is 10 m.*

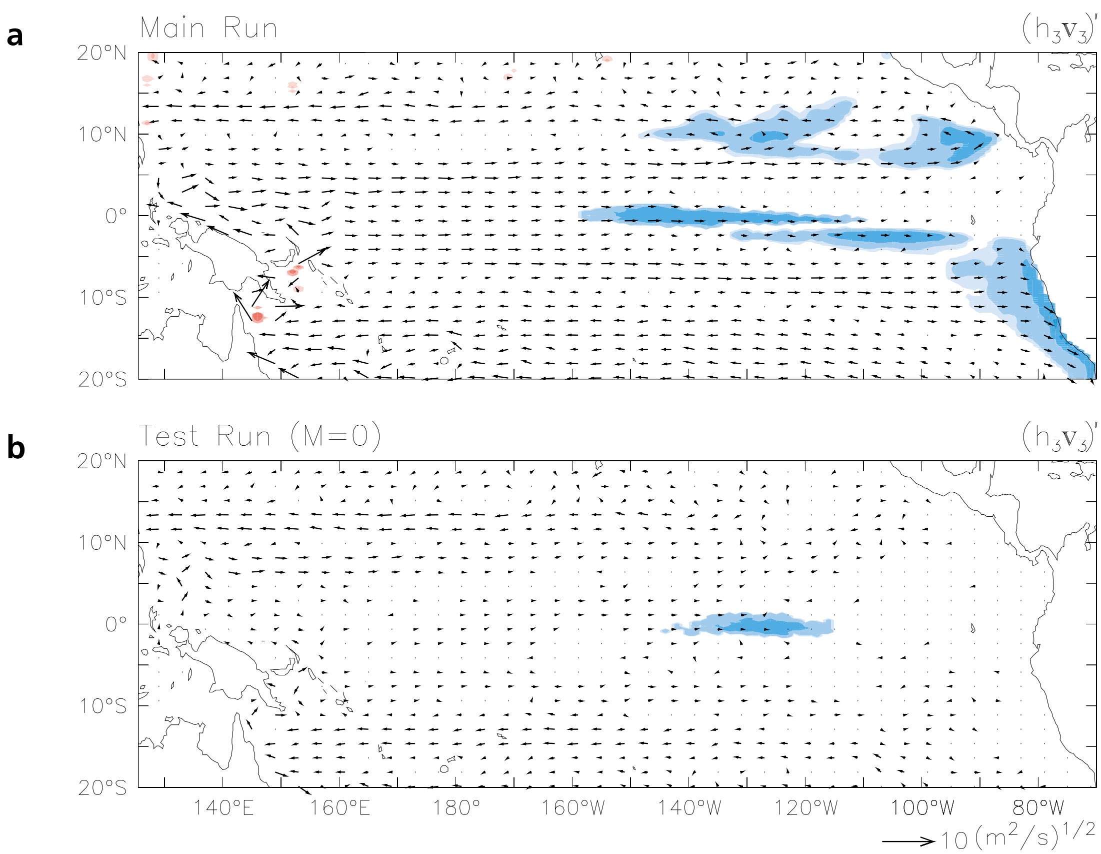


***Figure 2.*** *Solutions in the 4.5-layer model. (a) With realistic inflow and outflow of transport = M. Horizontal distributions of $(h_3\mathbf{v}_3)'$ (shading) fields from the main run. To emphasize weaker flow, arrows are of the vector field $(h_3\mathbf{v}_3)' \equiv h_3\mathbf{v}_3/|h_3\mathbf{v}_3|^{1/2}$. Positive (negative) values of $w_2$ are show by blue (red) shading, and the lightest shadings indicate where $w_2$ is greater than 0.1 cm/day or less than -0.1 cm/day. (b) Test run with M=0. Notice the changes in upwelling regions and the disappearence of the TJs.*

# Unraveling the Dynamics of the Tsuchiya Jets

A few degrees north and south off the equator, just beneath the thermocline, two narrow currents or jets, the Pacific Subsurface Countercurrents, flow eastward. The two jets carry a significant amount of water (about 14 Sv) across the basin, with the northern jet being somewhat stronger than the southern one. First reported by Tsuchiya in the 1970s, these currents are also called Tsuchiya Jets (TJs). As they cross the basin, the jets rise in the water column and their cores shallow from about 300 m in the western ocean to 150 m in the east.

Adapted from observations of Johnson and McPhaden (1999), Figure 1a illustrates the horizontal structure of the TJs. The contours can be viewed as streamlines along which the currents flow; the closer the contours are, the faster the flow. The blue areas indicate regions of cyclonic flows in each hemisphere; the TJs are the eastward flows near the equator. Toward the east, the TJs shift away from the equator, a property first noted by Tsuchiya. The northern TJ does not appear to extend to the eastern boundary but rather to recirculate in the interior ocean. In contrast, the southern TJ does extend to the eastern boundary, the 11.5 J/kg line intersecting the coast near 12ºS. Although the TJs themselves are confined to the tropics, their cool temperature indicates that their source water lies well outside the tropics. Less clear are the sink regions of the jets. The dynamics of the TJs has been one of the least understood of any of the equatorial currents: Neither the processes that maintain the jets, nor their role in the Pacific general circulation has been clear.

**Jay McCreary,** IPRC Director and Professor of Oceanography, began to study the TJs with **Peng Lu** more than five years ago, while both were at Nova Southeastern University in Florida. After several years of work, they obtained solutions of the TJs in both analytical and numerical models with idealized half-basins (from 30ºS to 0º and from 0º to 30ºN) and winds: These solutions reveal that not only wind forcing is needed to sustain the TJs, but also a Pacific interocean circulation with inflow of water from the Antarctic Circumpolar Current and an outflow of water in the Indonesian passages with a transport *M*. In 2000, **Zuojun Yu**, associate researcher at the IPRC, joined their effort. Together, they obtained solutions to numerical models of the realistic Pacific Ocean basin forced by climatological winds and by an interocean circulation with transport $M = 10$ Sv. Their work, based on a hierarchy of models varying from 2.5-layer to 4.5-layer systems, is now in press in *Journal of Physical Oceanography*.

Their analytic solutions to the 2.5-layer model suggest that the TJs are geostrophic currents along arrested fronts. Such fronts are generated when Rossby-wave characteristics, carrying information about the ocean's density structure away from boundaries, converge or intersect in the interior ocean. The solutions indicate the following dynamics: (1) the southern TJ is driven by upwelling along the South American coast and the northern TJ by upwelling in the band of the Intertropical Convergence Zone and strengthened by a recirculation gyre extending across the basin; and (2) the TJ pathways are sensitive to parameters controlling the density structure. Numerical solutions to the 2.5- and 4.5-layer models confirm the analytic results. They demonstrate that the northern TJ is strengthened considerably by unstable waves along the eastward branch of the recirculation gyre, that the TJs are an important branch of the Pacific interocean circulation, and that their pathways are sensitive to vertical-mixing parameterizations and to the structure of the driving wind. A rather striking similarity can be seen when comparing Figure 1b derived from the 4.5-layer numerical solution with the observations in Figure 1a.

To demonstrate that the TJs are a part of the Pacific interocean circulation, the researchers tested the sensitivity of the TJs to the strength of the interocean circulation transport. When the inflow from the Antarctic Circumpolar Current and the outflow through the Indonesian Throughflow are blocked ($M = 0$), both TJs vanish in the 4.5-layer model (compare Figures 2a and 2b). Thus, the TJs exist because of the Indonesian Throughflow—a remarkable example of remote forcing on a basinwide scale.

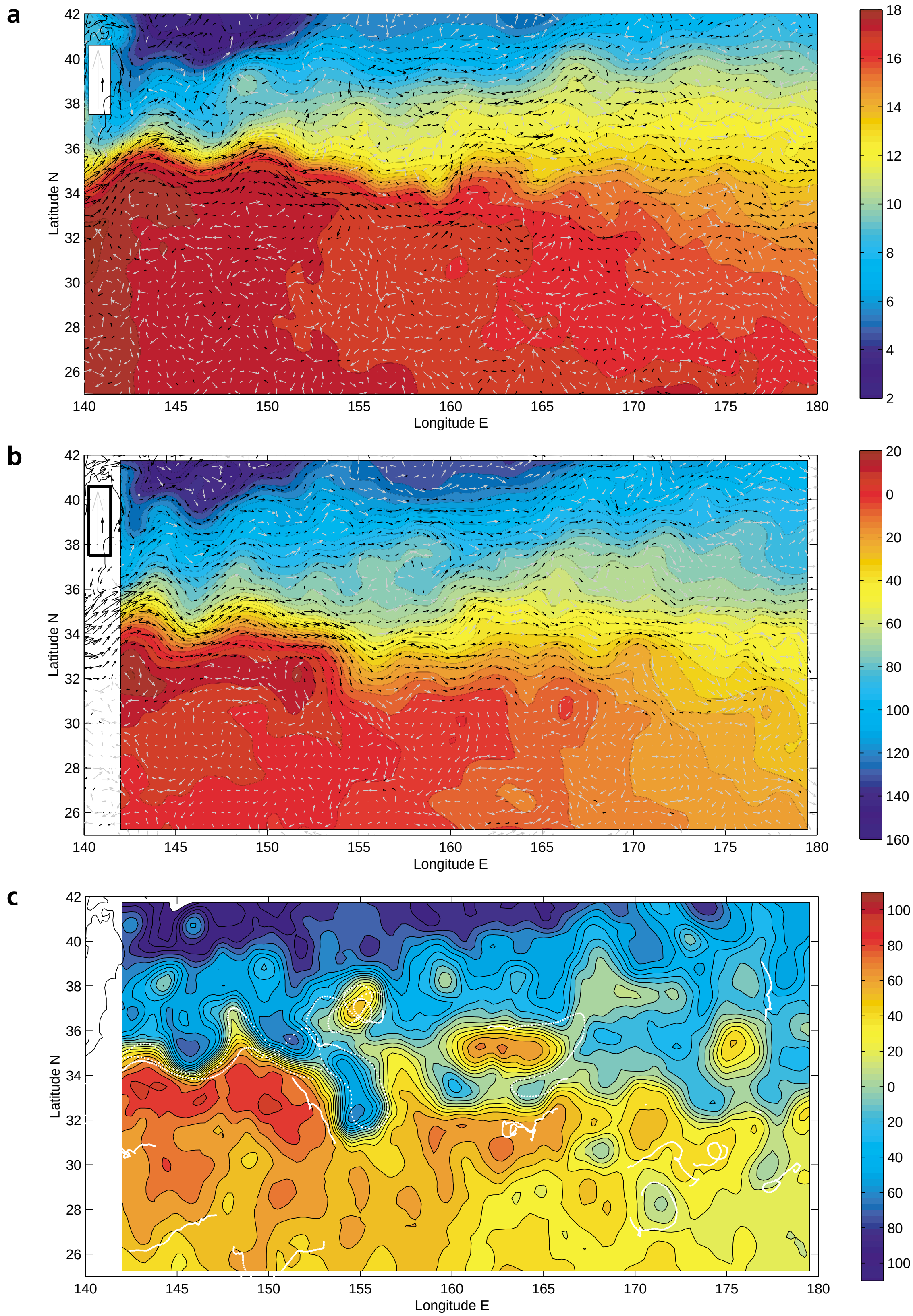


***Figure 3.*** *Kuroshio Extension Region: (a) Mean temperature at 200 m depth with contour interval 1°C. Vectors are 1/4 degree-mean drifter velocities smoothed to 1/2 degree spatial resolution. Velocities larger/smaller than 10 cm/s are shown in black/grey color. In the box, 50 cm/s scales are shown. (b) Mean sea level at contour interval 5 cm and mean unbiased velocities at 15 m depth scaled as in panel a. (c) Absolute sea level on December 6, 1993 computed from AVISO MSLA data referenced to mean sea level shown in panel b. Contour interval is 10 cm. White dots mark 6-hourly positions of all drogued drifters from November 16, 1993, through January 15, 1994.*

# Absolute Sea Level Maps for the Kuroshio Extension

The extension of the Kuroshio Current lies at the crossroad of processes that govern the dynamics of one of the strongest western boundary currents of the World Ocean and that control the large-scale interannual variability in the North Pacific. The tremendous complexity of currents in this region stems from the strong interaction between an active eddy field and narrow wind-driven, inertial jets with their associated sharp fronts and steep bottom topography. This makes for a region with the largest mesoscale variability in the North Pacific.

In order to develop ¼° spatial resolution maps of the mean and the eddy circulations that existed in the Kuroshio Extension (KE) from 1992 to 2000 (25–42ºN, 142–180ºE) and a mean, absolute sea-level map, **Nikolai Maximenko** (IPRC) and **Peter Niiler** (Scripps Institution of Oceanography) used Argo fixes from 804 Surface Velocity Programme drifters, merged sea level anomaly data from the Centre National d'Etudes Spatiales – Archivage Validation et Interprétation des données des Satellites Océanographiques (AVISO), and hydrographic data from the 1998 World Ocean Dataset of NOAA's National Oceanographic Data Center. The mean absolute sea level map that has been developed by these scientists provides an important reference for satellite altimetry.

Measurements of drifter velocity at 15 m and temperature at 200 m depths (Figure 3a) show three nearly stationary meanders (at 143, 149 and 153.5ºE) in the KE jet that end in a 300-km northward deflection east of the Shatsky Rise at 160ºE. (The interannual trends in mesoscale variance in the AVISO data noticed earlier by Ducet and LeTaon, 2001, are absent along the path of the meandering KE jet). The drifter mean-eastward surface transport between 28ºN–40ºN at 152ºE is 12.2 (+/-2.6) Sv/100 m and agrees with the geostrophic estimates of 10 Sv/100 m in the 1980–1982 current meter data at 4000 m and 1200 m depths. Three anticyclonic circulations are found in a larger area south or southeast of the Kuroshio (20–45ºN, 120–180ºE); the most southern eddies near Daito Island (not shown; approximately at 26.5ºN, 130ºE) is a new discovery. Very few drifters with drogues attached have crossed the Kuroshio front—5 out of 337 released south of 35ºN crossed into the subpolar gyre water, and 3 of the 182 released north of 35ºN or in the East China Sea crossed into the subtropical gyre. This finding indicates little mixing of these water masses.

The geostrophic currents observed in the AVISO data of the KE region and the drifter velocities (from which high-frequency motions were filtered out and Ekman drift subtracted) correlate at r = 0.8. Two main error sources in the mean fields were (1) the non-uniform temporal distribution of drifter data in the area of strong interannual variability; and (2) the difference between the eddy-kinetic energies computed from the AVISO and the drifter data, which reached ±20%. The latter problem results from the fact that the eddies on either side of the KE tend to be of opposite sign. The eddies south of the KE were mainly cyclonic with a pronounced sea-level depression; those north of the KE were mainly anticyclonic. The most energetic eddies formed by separating from the meandering KE jet. In general, the eddies have rotational velocities about 20% larger in the north and 20% smaller in the south than estimated from geostrophy.

The absolute sea level map shown in Figure 3b was developed as follows: The amplitudes of the AVISO geostrophic currents were adjusted with concurrent drifter observations and used to compute an unbiased mean geostrophic circulation and quasi-geostrophic Reynolds' stresses in the KE region. (The principal axes of the eddy Reynolds' stresses were found to be oriented along the unbiased mean velocity vectors within the meandering KE jet.). The time-mean horizontal momentum balance equation, which includes both the mean and eddy momentum convergences, was then solved to compute the map in Figure 3b and its uncertainty (which has a mean value of 2.4 cm). Statistical analysis revealed an important contribution to the momentum balance from the Bernoulli and eddy terms at particular locations.

Figure 3c illustrates a good correspondence between drifter trajectories and concurrent absolute sea level, the drifters appearing to follow sea level contours. A mean absolute sea level map of the KE region, supplemented by 10-day maps of the same fields, will shortly be available to the public on the APDRC server (see p. 19).

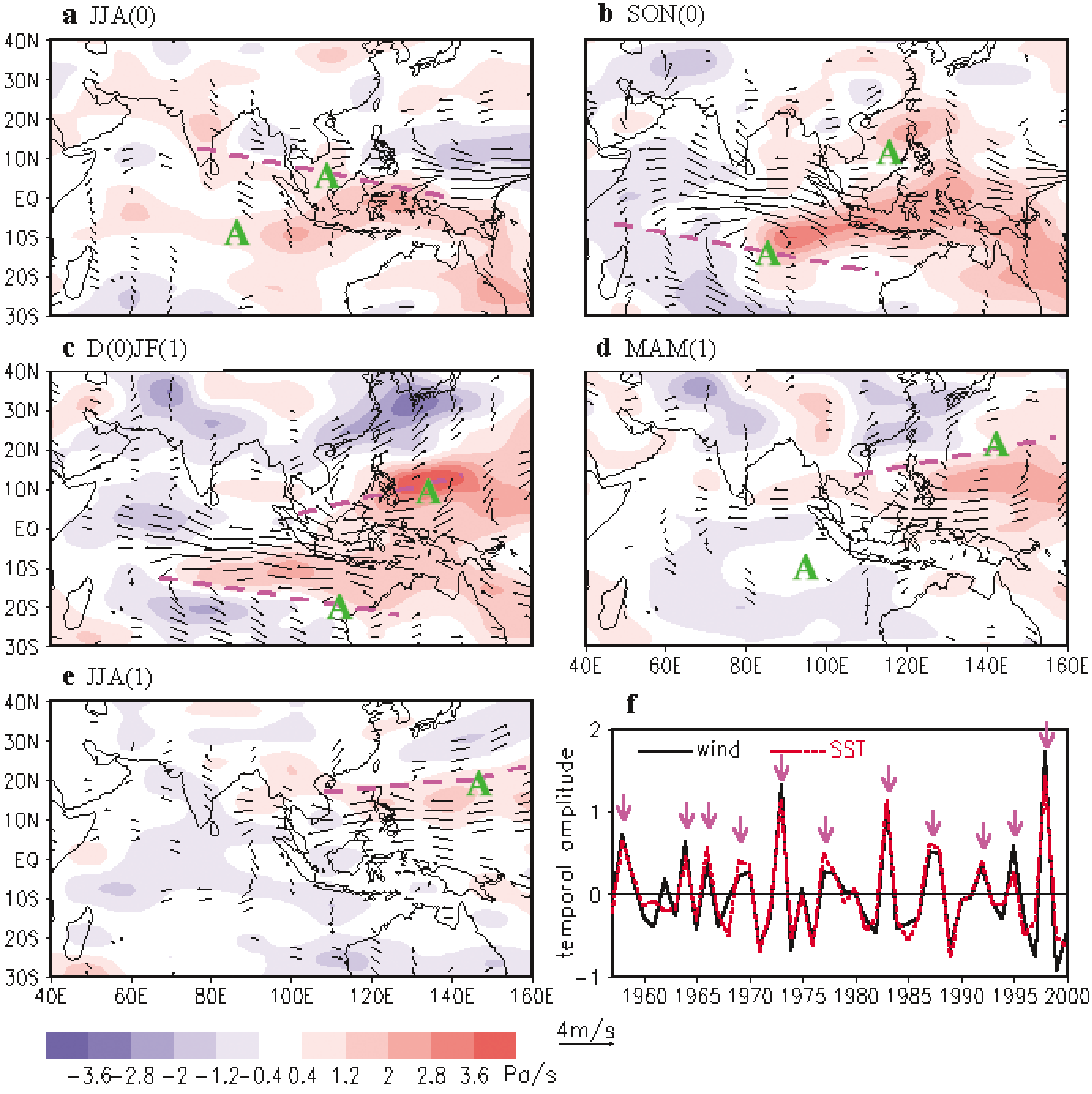


***Figure 4.*** *Results of the ESVD analysis. (a – e) The anomalous seasonal mean winds at 850 hPa (vectors) and vertical p-velocities at 500 hPa (shaded area) during El Niño events. (a and b) Conditions in the summer and fall before the mature El Niño; (c) during the mature El Niño; and (d and e) in the following spring and summer; (f) the time evolution of the 850 hPa wind anomalies over the Asian-Australian monsoon region and the SST anomalies over the Indian and Pacific Oceans during the mature phase of El Niño events.*

# El Niño and Anomalous Asian–Australian Monsoons: Remote Forcing or Local Air–Sea Interaction?

Monsoon rainfall over the Asian continent has been monitored for over a century because of its importance to agriculture. Both unusually high rainfall and drought are related to ocean–atmosphere conditions, particularly conditions in the eastern Pacific. The precise nature of the ocean–atmosphere influence, however, is still under debate. **Bin Wang** and his IPRC colleagues **Renguang Wu** and **Tim Li** studied the evolution of the Asian–Australian monsoon anomalies over five consecutive seasons during El Niño events by performing an extended singular value decomposition on NCEP/NCAR reanalysis sea-surface temperature, wind, and vertical motion data from 1956 through 2000.

Figure 4 shows the anomalous seasonal mean winds at 850 hPa (vectors) and vertical *p*-velocities at 500 hPa (colored area) during El Niño events. Panels *a* and *b* show the anomalies during the developing El Niño, panel *c* during the mature phase, panel *d* during the decaying phase, and panel *e* when conditions in the eastern Pacific are "normal"again. Panel *f* displays the temporal evolution of Asian–Australian wind (850 hPa) and Indian–Pacific Ocean SST over the 46 years. The anomalous winds and SST are closely related (r = 0.94), with the most significant wind anomalies occurring during an El Niño fall.

The low-level wind anomalies in Figure 4 are characterized by two off-equatorial anticyclones—one located over the South Indian Ocean (SIO), the other over the western North Pacific (WNP). The SIO anticyclone, which is responsible for unusual climate conditions over India, the Indian Ocean, and East Africa, originates in boreal summer while an El Niño is developing, amplifies rapidly, reaches its height in fall, and decays before El Niño matures. On the other hand, the WNP anticyclone, which is responsible for unusual climate in East and Southeast Asia, forms in fall, attains its maximum intensity when El Niño matures, and persists through the next spring and summer while El Niño decays.

Remote El Niño forcing *alone* cannot explain the extraordinary amplification of the SIO anticyclone in the developing stage of El Niño nor the maintenance of the WNP anticyclone in the decaying phase of El Niño. Wang and his colleagues show that the ocean–atmosphere conditions in the two regions of the anticyclones are very similar, namely, *a SST dipole with cold water to the east and warm water to the west of the anticyclone center* (see Figures 5*a* and *b*). These conditions, according to the authors, result from positive ocean–atmosphere feedback intensifying and maintaining the anticyclones. They conclude that although the anomalies are often triggered by El Niño conditions in the Pacific, the interaction is controlled by the monsoon seasonal cycle and perhaps induced by other local or remote forcing. Their hypothesis receives support in a study of a series of experiments in which the Max-Planck atmospheric model, ECHAM-4, is coupled to the Wu-Li-Fu ocean model.

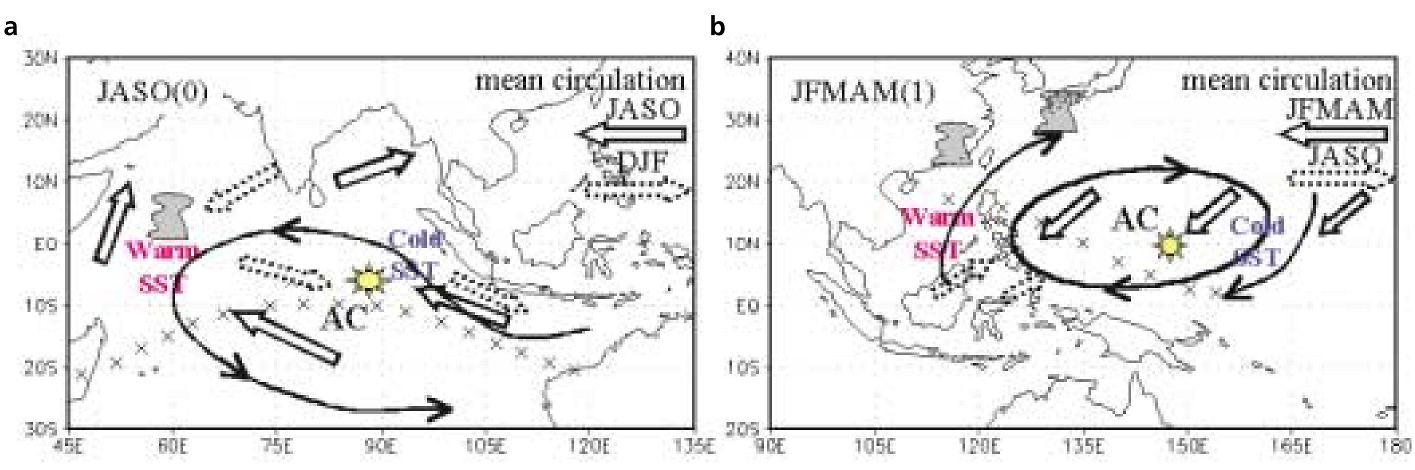


***Figure 5.*** *Schematic of the monsoon-ocean interaction (a) in the Indian Ocean in the summer and fall before the mature El Niño and (b) in the western North Pacific in the winter and spring of the mature and decaying El Niño.*

# The Role of the Stratosphere in Tropospheric Climate Variability and Climate Change

*Kevin Hamilton*

## Review of Recent Developments

The stratosphere contains less than 15% of the total mass of the atmosphere. Thus the traditional view has been that weather and climate in the stratosphere are controlled strongly by processes in the troposphere and that stratospheric influences on the troposphere are minor. In recent years, however, scientists have become increasingly interested in the possible effects of changes in the stratospheric circulation on the troposphere (e.g., Robock, 2001; Wallace and Thompson, 2002). One reason for this interest is the recognition that some of the strongest radiative perturbations that have affected climate in the recent past have occurred in the stratosphere. In particular, the rapid change in stratospheric ozone concentrations over about the last 20 years associated with anthropogenic input of chlorine compounds has greatly influenced the climate system. Moreover, the sulfate aerosols injected into the stratosphere by large explosive volcanic eruptions (such as those of El Chichon in 1982 and Mt. Pinatubo in 1991) persist for at least two years and have strong effects on both the shortwave and longwave components of the radiative balance. Given the relatively large stratospheric perturbations caused by such phenomena, even a fairly modest interaction with tropospheric circulation could affect surface climate in interesting ways (e.g., Robock, 2001).

A second reason for this new interest comes from a recent spate of studies claiming to find a tendency for stratospheric perturbations in the Northern Hemisphere winter circulation to propagate downward to the troposphere (e.g. Baldwin and Dunkerton, 2001). This means that knowledge of the stratospheric circulation could be used as the basis for seasonal forecasts of tropospheric circulation, at least in Northern Hemisphere winter.

A similar tendency for perturbations to propagate downward has been noted in some comprehensive atmospheric general circulation models (GCMs). Figure 6 illustrates results obtained using a "troposphere-stratosphere-mesosphere" GCM as part of a collaborative project between the author and **Mark Baldwin** (Northwest Research Associates). The calculation begins by deseasonalizing and low-passing daily time series of the Northern Hemisphere three-dimensional geopotential height field over 34 years of a control model simulation. An empirical orthogonal function (EOF) analysis is applied independently to the time series of anomalies at each height. Figure 6 shows the time series of the coefficient of the first EOF, contoured in the height-time plane. The blue and yellow-red areas correspond to opposite phases of this EOF—the blue colors indicate times when the polar vortex is more westerly than normal, with correspondingly cold high-latitude temperatures, and the yellow-red areas indicate heights and times with a more easterly (or less westerly) vortex and anomalously warm high-latitude temperatures.

Figure 6 displays interesting anomalies in each winter (anomalies are much smaller in other seasons). The tendency for the anomalies to propagate downward is evident within the stratosphere, but is less consistent between the stratosphere and troposphere—sometimes anomalies appear first in the troposphere and then in the stratosphere, sometimes the other way around. Overall, however, the mean tendency is for the tropospheric perturbations to follow those in the stratosphere, in basic agreement with the recent observational studies. This statistical tendency is the basis for suggesting that skillful seasonal tropospheric forecasts can be made based on knowledge of the state of the large-scale stratospheric circulation.

The interest in stratospheric influence on tropospheric seasonal weather patterns has even reached the major governmental agencies with practical forecasting responsibilities. Several recent issues of the *Monthly Report on the Climate System*, published by the Japan Meteorological Agency, have featured cover figures showing aspects of stratospheric circulation. Seasonal forecasts at the US National Center for Environmental Prediction use aspects of the stratospheric circulation as inputs.

There is no guarantee, however, that the tendency for downward propagation of anomalies across the tropopause reflects an actual physical effect of the stratospheric flow on tropospheric flow. Geophysics has many examples of phenomena showing a phase progression actually opposite to the physical propagation of disturbances (for example, the opposite vertical components of the phase and group velocities for internal gravity waves). It could, thus, even be that the causality is entirely from troposphere to stratosphere and that the development of anomalies in the troposphere, on average, happens to follow a predictable course with a passive (and incidental) effect on the stratospheric flow.

If, however, the causality is really downward, the implications for modeling climate change are great. The strong radiative effects of changes in ozone and other greenhouse gasses should change the stratospheric circulation, which would lead to a mean trend in tropospheric circulation. Wallace and Thompson have argued that this sequence may be needed to explain the observed pattern in surface temperature increase over the last few decades. The warming has been enhanced particularly over northern Europe and northern Asia (NENA). While there are straightforward reasons for expecting greater surface warming at high latitudes (stronger mean atmospheric stratification

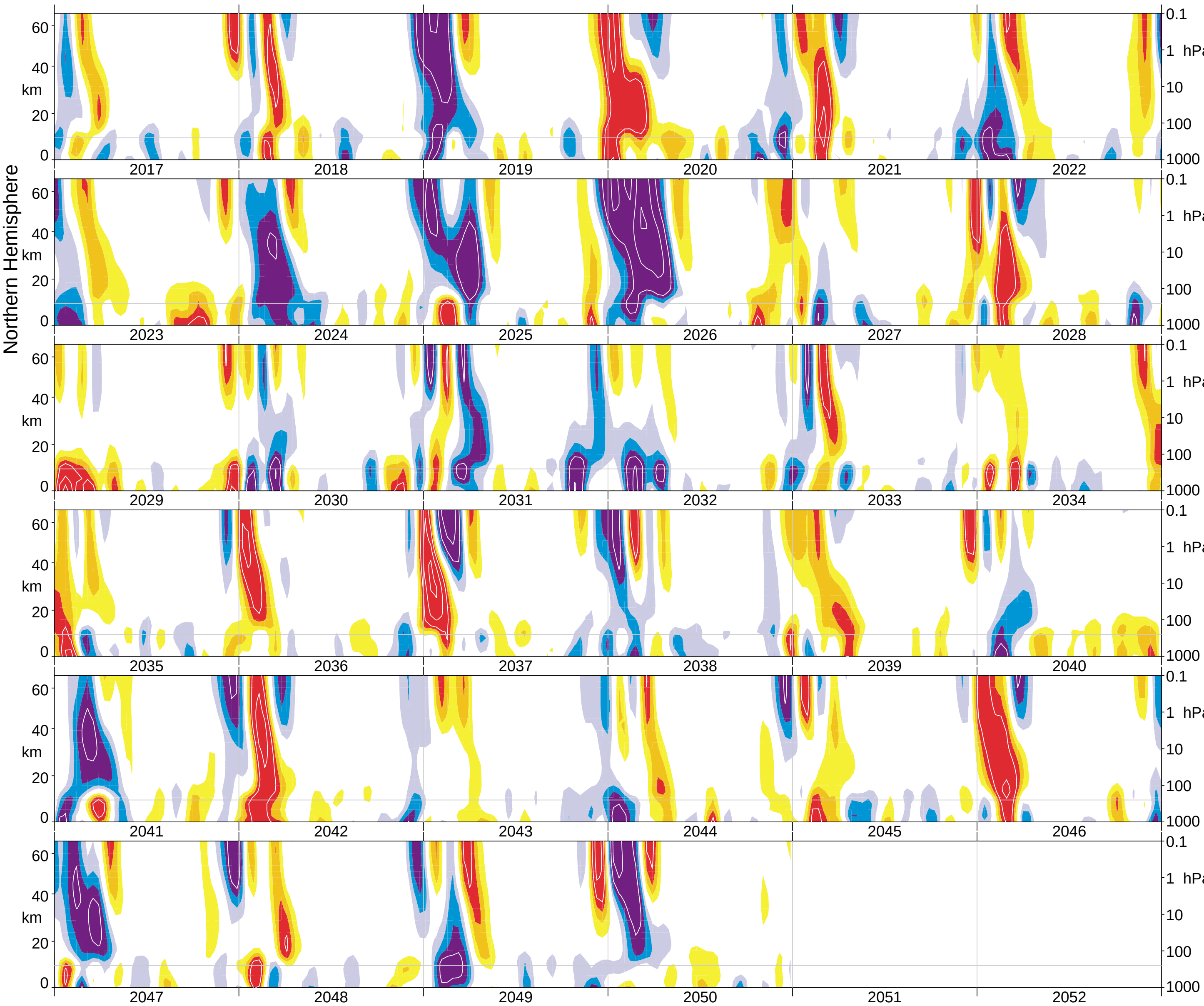


***Figure 6.*** *Height-time section of anomalies in the coefficient of the first EOF of Northern Hemisphere geopotential variation from 34 years of control integration with the SKYHI general circulation model. The EOF analysis is performed independently at each level. The blue areas correspond to cases with anomalously westerly polar vortex and cold polar conditions and the red/yellow areas to opposite anomalies. The values at each level are normalized by the standard deviation at that level and the contour interval is unity. Only anomalies greater than one standard deviation are shaded. The thin vertical lines show the beginning of each calendar year. The years are labeled arbitrarily starting in "2017." The thin horizontal lines show the approximate height of the extratropical tropopause.*

which confines the warming near the surface, and snow-albedo feedback), and over land (less surface heat storage than over the ocean), the actual observed warming in NENA regions seems higher than would be expected from these effects alone. Wallace and Thompson (2002) suggest that the changes in the winter-mean near-surface circulation associated with changes in the stratospheric circulation could account for the strength of the NENA-region warming. Interestingly, the long-term trend in the geographical warming pattern is similar to the patterns of anomalous surface temperature generally seen after major volcanic eruptions, which produce their most direct radiative effects in the stratosphere.

Other investigators have found that the surface warming predicted by global GCMs in response to increasing greenhouse gas concentration can differ depending on whether the model includes adequate resolution in the stratosphere. Shindell et al. (1999) found that they could get their model to simulate a realistically enhanced warming over NENA regions when their model included several levels extending through the entire stratosphere, but not when it had a more typical configuration for climate models (i.e., a model top near 30 km).

Several investigators have taken these indications of significant stratospheric influence in the troposphere to speculate about solar influence on surface climate. There has been a long and controversial history of investigations into a possible correlation between the 11-year cycle in solar activity and surface climate. While various claims of empirical correlations have been made, it has generally seemed implausible that the very small (~0.1%) modulation of the total solar flux over the solar cycle could have much influence on climate. However, the solar minimum versus solar maximum contrast is much larger at the very shortwave end of the solar spectrum. These very short wavelength photons are almost completely absorbed before they reach the troposphere, and their modulation can be expected to directly produce significant solar cycle temperature changes in the upper atmosphere (perhaps of the order of 2ºC near the stratopause, even more at higher levels). If the large-scale dynamics couples the tropospheric circulation to the stratospheric circulation, the physical link from the solar variations to surface climate variations is plausible.

## Work Underway at IPRC

All these new developments are certainly provocative and may, in fact, point to features that are of great importance in understanding and modeling climate changes. However, despite the many papers published on this subject in the last few years, some very basic questions remain. One difficulty, even in GCM studies, lies in unambiguously detecting the effects of stratospheric climate forcing. The winter stratosphere is a region with strong internal variability on interannual timescales, and in some GCMs at least, stratospheric circulation varies spontaneously on decadal or even longer timescales (Hamilton, 1995, 2000; Butchart et al., 2000).

A second problem is understanding the mechanisms that can exert a quantitatively significant effect at the surface. To date, the record among GCMs that have actually produced significant tropospheric effects of stratospheric volcanic aerosol or stratospheric ozone changes is mixed.

As part of the work on global change at IPRC, the author is involved in several related modeling efforts to clarify the role of the stratosphere in tropospheric weather and climate. This work, which is conducted in collaboration with colleagues at the NOAA Geophysical Fluid Dynamics Lab (GFDL), Rutgers University, Northwest Research Associates, and Laboratoire Meteorologie Dynamique in France, uses the SKYHI model, a troposphere-stratosphere-mesosphere model developed over the last quarter century at GFDL. This model is a full climate GCM with a serious treatment of the atmospheric circulation to heights near 80 km. The model has been tested extensively and many features of the simulated stratospheric circulation have been shown to be realistic. In particular, the overall level of interannual variability in the extratropical Northern Hemisphere circulation and the response of the extratropical circulation to ocean temperature variations and to tropical circulation variations are all reproduced fairly well (Hamilton, 1995, 1998).

One test with the current SKYHI looks at how realistic the unforced variability is (e.g., the present Figure 6) and how the model responds to the well-observed stratospheric aerosol input following the 1991 Mt. Pinatubo eruption (see the 2001/Fall issue of *IPRC Climate*). This research has many aspects, including (a) understanding how the model simulation depends on numerical resolution (Hamilton et al., 1999, 2001; Koshyk and Hamilton, 2001), (b) how the tropical stratosphere interacts with the extratropical stratosphere (Hamilton, 1998), and (c) the nature of long period of unforced variability in the stratospheric circulation. The model is also being applied to some very direct studies of the dynamical effects of stratospheric circulation on the underlying troposphere. In these experiments, the control version of the SKYHI model is applied in a series of winter seasonal integrations. The initial conditions for each run are taken from the early winter in one year of a long control run, but with a strong zonally symmetric perturbation arbitrarily added to the stratospheric polar vortex. This amounts to suddenly adding a blue or red perturbation in Figure 6 to the simulation, but only in the stratosphere. The subsequent evolution of the tropospheric circulation will then be compared to that in the control run. If the stratosphere does dynamically affect the troposphere, the imposed stratospheric perturbation should show a systematic effect in the troposphere. Such an outcome would establish, in the simplest context, the significance of downward dynamical interactions.

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# Climate and Society:
## A New Research Area at IPRC

A new project, led by IPRC Executive Associate Director **Lorenz Magaard**, is starting at the IPRC. After meeting with **Wolf Grossmann**—a mathematician, socio-economist, and system scientist at the UFZ Center for Environmental Research in Leipzig and Halle, Germany—Magaard realized the significance of developing models that consider interactions between societal parameters and climate change. He invited Grossmann to spend five weeks this spring at the IPRC and SOEST. The third partner in this emerging effort is **Hans von Storch**, Director of the Institute for Coastal Research of the GKSS Research Center, Geesthacht, Germany, who visited the IPRC at the same time.

The key role in their project is played by Grossmann's ISIS model (Information Society Integrated Systems). This model describes interactions between such societal elements as economy, environment, human knowledge, and human attitude. It provides an analysis of past economic developments and transitions: an economy based on a new discovery begins, gathers steam, matures, and finally declines when another economy starts to take its place. The model considers how the evolution of an economy and the transition from a mature economy to a new one change human knowledge, human attitude, and the physical environment; it includes issues such as quality of life, education, training, and policies for support of the new economy. A past example of such an economic cycle and its impact on man and nature is the steam engine development. The model provides information to guide policy on how to best facilitate and support the economical and social transformation, while maintaining a healthy environment.

Recognizing that ISIS was missing an important element—the climate and climate change—Grossmann, Magaard, and von Storch are now working on integrating elements of climate risks (such as storms or flooding) and climate change (such as sea level rise) into the model. This effort is particularly timely. According to Grossmann, we are now in a process of economic transformation from a mature industry to a new, information-based economy (*information society*) that is evolving out of the new information and communication technologies (new ICTs). With the advent of ICTs, a large-scale demand for information and information-producing "machines" is emerging, together with many new types of jobs. This is accompanied by significant changes in social organization. The current transition is comparable only to the transition from the agricultural to the industrial age when, due to the steam engine, a big supply of energy could be accessed: fossil coal.

ISIS differs from other concepts of the society–climate interaction, in that society is not passively responding to climate and climate change, but is in the driver's seat. Environmental change is relevant as a constraint within which certain social and economic developments may emerge more, or less, favorably.

The project team is working on a pilot study of a world with two hypothesized regions: Region 1 is preferred—it has the mature industry, the new economy is sprouting here, people like to live here—but it is threatened by environmental extremes and changes. People don't like living as much in Region 2, it has little thriving mature industry and, therefore, almost no new-economic activity but it is less vulnerable to climate extremes. Business as usual would mean that the social and economic developments are mainly limited to Region 1, while Region 2 remains undeveloped. If an extreme climate event occurs, however, Region 1 would suffer greatly. The ISIS model helps policy makers and governments, for example, to compare the costs of such an extreme event in Region 1 with directing the ongoing course of economic development to the less dangerous Region 2. The model shows people the risks of setting up the new industries in Region 1 and reasons for encouraging them in Region 2. The team intends to expand this pilot study with more complex and realistic set-ups.

If ISIS is to be a policy tool that guides response to the new economy in an environmentally sound way, it must be developed now while the infrastructure for these new industries is still in its infancy.

*Lorenz Magaard, Wolf Grossmann, and Hans von Storch*

# Understanding Stratospheric Processes and their Role in Climate

## The Ninth Annual Meeting of the SPARC Scientific Steering Group

*Kevin Hamilton*

The IPRC played host to the 9th annual meeting of the Scientific Steering Group (SSG) of the SPARC (Stratospheric Processes and their Role in Climate) program last December. SPARC is one of the six main initiatives of the World Climate Research Programme and focuses on understanding and modeling the circulation and chemistry of the stratosphere, and how these influence and are influenced by tropospheric climate and climate change.

The meeting participants discussed a range of current issues relating to stratospheric circulation and climate. In the 1990s, SPARC undertook major assessments of trends observed in stratospheric temperature, ozone, and water vapor over the last few decades. The SSG considered how to update these assessments and formulated plans for assessing the observed trends in stratospheric aerosol concentration. Preliminary plans were discussed for a more integrative assessment of the consistency of the observed temperature trends and the coincident changes in atmospheric composition.

In addition to these assessment efforts, the SSG reviewed some other activities SPARC has undertaken in order to advance understanding of certain key physical processes. A notable example among these is the effort to apply routinely collected, operational upper-air weather data to the study of the gravity-wave field in the upper troposphere and lower stratosphere. Modern radiosonde systems actually record data at quite fine vertical resolution (~100 m, or better). Unfortunately, the standard practice has been to archive only the data at the levels mandated by the World Meteorological Organization (WMO). By saving only the WMO-mandated data, the national meteorological services are discarding potentially important information about the atmosphere. For some years now, **Kevin Hamilton** (IPRC) with his colleague **Robert Vincent** (Adelaide University) have led a SPARC-sponsored working group to “rescue,” archive, and analyze the very fine vertical resolution wind and temperature data from operational balloon-borne radiosondes. They have coordinated the accumulation and analysis of the raw data, and through their effort, suitable data have been obtained from over 190 stations provided by the national meteorological services of 12 countries. The SSG reviewed these achievements along with preliminary scientific analyses that have examined the geographical and seasonal variability in the wave-like fluctuations seen in these data. The activities of other SPARC working groups were reviewed, including one devoted to understanding the dynamical and chemical structure of the tropopause region, and another that is conducting a series of intercomparisons of results from several global simulation models with substantial resolution of the stratospheric circulation.

*From left to right: Kevin Hamilton, Roger Newson (WMO), SPARC Co-chair Alan O’Neill, head of the SPARC Office Marie-Lise Chanin, and SPARC Co-chair Marvin Geller*

The participants concluded the meeting with a discussion of how SPARC should react to the recent surge of interest in the relationship between large-scale stratospheric and tropospheric circulations (see Hamilton's review article in this issue). This is a particularly challenging issue and will require substantial efforts in both modeling and observation to reach clear conclusions.

Kevin Hamilton, IPRC Theme-4 leader and SPARC SSG member, acted as local host for this SSG meeting, which was held December 3–6, 2001, at the Tokai University Honolulu campus. **Marvin Geller** (Stony Brook University) and **Alan O'Neill** (University of Reading) were co-chairs. The 26 participants included the members of the SSG, the SPARC working group leaders, some personnel from the SPARC Office in Paris, and representatives of other international organizations and national funding agencies.

# Linking Pacific Climate and Fisheries

## The Pacific Climate and Fisheries Workshop

Fish make up over 15 percent of the animal protein in the world's food supply, and in many countries, fisheries are a major part of the economy. Fish populations have large swings, however, as witnessed by the Peruvian anchovy fishery in the early part of the 1970s, when the annual yield fell from about 13 to less than 2 million metric tons within 3 years. This collapse was devastating to Peru's economy and dealt a blow to the worldwide food supply.

Overfishing is one obvious cause of a shrinking fish population. Another candidate is variation or change in ocean climate. This latter link, though, is not well understood yet, and to shed more light on the climate–fish ecosystem question, the IPRC hosted the Pacific Climate and Fisheries Workshop at the East-West Center, November 14–17, 2001. Climate scientists, social scientists, ecologists, fish biologists, and fisheries managers worked together at the workshop to lay the foundations for new research approaches that integrate climate knowledge and marine ecology with sustainable fishery management and social and political concerns.

"The time is now ripe for such an interaction, as physical oceanographers and climate researchers are making great strides in describing and understanding ocean climate variations using numerical models," according to **Claude Roy** (IRD, French–South African IDYLE Project).

Coming from very diverse backgrounds, a challenge for these experts is to learn to talk to each other, develop common terminologies, common goals, and common frameworks. The workshop was therefore unusual in that it had no pre-set presentations. Rather, all the available time was reserved for discussion and communication among the scientists, and the program alternated between plenary discussions of central questions and smaller focus groups. **Jürgen Alheit** (Baltic Sea Research Institute) as the plenary discussion leader created an environment that stimulated lively, all-around participation. A synopsis of the most important discussion points follows below.

The question *what climate information is useful to fisheries management* yielded wide-ranging answers. Some participants thought that climate forecasts are not yet good enough to provide fisheries with useful forecasts, and that too little is known about how climate variations affect different species; others pointed out that enough is known on how El Niño affects certain fishes, and this information has already provided helpful forecasts.

The complexity of applying climate information to fisheries was further mirrored in the following concerns: forecasts are given with too short notice; some climate variations, themselves, are too brief for meaningful adjustments; forecast information may be misused by banks; and recommendations for adjusting to climate change may result in oversupply. For example, when governments in South America, noting an impending El Niño, recommended that fisheries shift attention to dolphin fish, the result was an oversupply of dolphin fish and very low prices.

*Defining marine ecoshifts and determining indices of regime shifts* received intense discussion. Basic indices were debated: some argued against using primary productivity saying there is little relationship between primary productivity and number of fish; others were against using cholorophyll, since areas of strong upwelling with lots of nutrients sometimes have few fish (for example, the Benguela Current); still others saw a problem with using zooplankton biomass as an index.

On what spatial scales do shifts occur—local, regional, basinwide, or global? On what timescales do they occur—biennual or decadal, sudden or gradual? Regime shifts in the physical ocean may have different timescales from biological ones. A small shift in the seasonal cycle can sometimes have a significant impact, as for example, the early blooming of zooplankton, on which Cassin's auklets feed while hatching their eggs, may result in abandonment of the nests.

A further question pertaining to the regime shift definition is whether comprehensive or separate indices should be developed for shifts in ocean climate, marine ecosystems, and various fish populations. **Arthur Miller** (Scripps Institution of Oceanography) suggested that an analysis of the last three Pacific Ocean climate shifts might reveal patterns of the similarities and differences accompanying these shifts and could help in developing appropriate indices.

The *mechanisms that drive regime shifts* are also not well understood yet. **Andrew Bakun** (IRI) described a fascinating, rapidly evolving (about 10 – 50 years) adaptive mechanism, the school-mix feedback hypothesis, whereby climate change may trigger a biological change, namely, a change in reproductive habitat selection. If there is such a mechanism, then Bakun believes that we might learn how to take actions to effect the operation of the mechanism in order to avoid the collapse of a fish population, such as the one off the coast of Namibia several decades ago. When large industrial fisheries began to fish in the spawning grounds there, it appears that the sardines shifted their primary spawning site to the adult feeding grounds. It has not been possible to bring the sardine population back to its original abundance. Understanding the mechanisms by which fish may move away from their most favorable spawning habitats because of local overfishing could help to prevent or rectify such happenings.

Participants agreed that much more needs to be learned about the typical migration, feeding, and spawning behaviors of different fish species and how these behaviors are affected by climate variations. The climate–spawning relationship, for instance, may be quite different for different species. Thus, anchovies have a short life-span making them sensitive to high frequency climate events, and they do well in cold water; sardines have a 5 – 10 year life-span, and they do alright in warmer waters.

A major goal of the workshop was to plan an interdisciplinary climate–fisheries project. Three possible topics for such a project emerged by workshop's end:

1) **Andrew Bakun's** school-mix feedback adaptive mechanism in fish populations under strong selective pressures mentioned above. This mechanism may allow a schooling fish population to effectively track longer-period environmental (climatic) variability and so maintain correct adaptation to longer-term variability.
2) **Patrick Lehodey's** approach to researching the interaction between climate and tuna by using different modeling approaches, for example, individual energetics models (IPM), mass-balance models (ECOPATH-ECOSIM), and spatial ecosystem models (SEPODYM), to explore the underlying mechanism by which climate-induced environmental variability affects the pelagic ecosystem and tuna populations.
3) **Alec MacCall's** Flow Hypothesis, which suggests that decadal variations in flow speed (strength) of the three major Pacific boundary currents systems (South America, North America, and Japan) affect the mesoscale structure of the flow patterns and the associated frontal zones, as well as the marine habitat, including nutrient supply and conditions for fish survival and growth. Thus, when the flow of the Kuroshio Current is weaker and slower, it tends to meander, and cooler, nutrient-rich Oyashio water intrudes, providing favorable conditions for sardine spawning and larval retention.

*From left to right: Jay McCreary, Lorenz Magaard, Andrew Bakun, Kenneth Broad, and Jürgen Alheit*

This third project already reflects the desired fruitful interaction among workshop participants: Fishery biologist MacCall developed this hypothesis in discussion with biological oceanographer **Takashige Sugimoto**, physical oceanographer **Don Olson**, and fishery oceanographer Andrew Bakun.

Scientists from the workshop are meeting again at the PICES North Pacific Transitional Areas Symposium held April 2002 in La Paz, Mexico, where they have planned to develop further the framework for this interdisciplinary climate–fisheries research project.

The workshop concept was suggested by Lorenz Magaard (IPRC), who also organized the workshop logistics. The International Research Institute for Climate Prediction (IRI) strongly supported Magaard's suggestion and asked Andrew Bakun (IRI senior research scientist) and Kenneth Broad (University of Miami) to develop and organize the workshop program. The IRI and the IPRC were the primary sponsors of the workshop; co-sponsors included the North Pacific Marine Science Organization (PICES), the Center for Sustainable Fisheries of the University of Miami, the International GLOBEC Project Office and the IDYLE Project of the French Institut de Recherche pour le Developpement (IRD). Moreover, a number of additional organizations and institutions (e.g., the NOAA Office of Global Programs, NASA, IOC, FAO, and others) contributed

# Indian Ocean Dipole Takes Center Stage

## Symposium on the Ocean–Atmosphere Coupled Dynamics in the Indian Ocean

*Shang-Ping Xie*

The Symposium on the Ocean–Atmosphere Coupled Dynamics in the Indian Ocean, jointly organized by the Frontier Research System for Global Change and the IPRC (co-conveners: **T. Yamagata** and **J.P. McCreary**), took place December 17–18, 2001, in Tokyo. Scientists from 5 continents presented 49 papers. Compared to the first International Symposium on Indian Ocean and Monsoon Variability in March 2000, held also in Tokyo, the number of papers on Indian Ocean climate variability increased dramatically, a reflection of the explosion of interest and progress in this topic.

The Indian Dipole Mode (IDM), a contrasting sea surface temperature (SST) pattern in the tropical eastern and western Indian Ocean (see Figure 7), was the central theme of the symposium. There is consensus among scientists that cooling in the eastern equatorial Indian Ocean SST is associated with a major shift in atmospheric convection and ocean circulation; under debate is the significant link between this cooling and western equatorial Indian Ocean SST variability and the mechanism that might be responsible.

Empirical analyses of observations show a significant correlation between the IDM and ENSO in boreal fall, but not during other seasons. The physical explanation for this seasonal correlation is now being debated. One school argues that the IDM variance explained by ENSO is small and hence the IDM is largely an independent mode intrinsic to the Indian Ocean. The other holds that this seasonal correlation is evidence for an ENSO-forced scenario.

While only one coupled general circulation model (GCM) group reported success in reproducing the IDM at the first Tokyo Symposium, five coupled GCM groups presented successful simulations this time. Carefully designed coupled GCM experiments will shed light on the coupled dynamics in the Indian Ocean in general, and on the relation between IDM and ENSO in particular. For example, the GFDL atmospheric GCM, forced by observed history of SST variations in the equatorial Pacific east of the dateline and coupled with a slab-ocean mixed-layer elsewhere, yields an ENSO composite (the average of many ENSO events) resembling the IDM.

The rather short instrumental measurement record during which only a few strong IDM events have occurred limits empirical studies on this topic. **N. Abram** analyzed isotope compositions of modern and Holocene corals off Sumatra, Indonesia, at a subseasonal resolution. Her analysis of fossil corals indicates that the IDM existed at least as early as the mid-Holocene period and that many paleo-IDM events occurred independent of the Pacific ENSO. The synthesis of such high-resolution coral analysis with Pacific paleo-coral records appears promising, and together with coupled GCM experiments, offers hopes of resolving the issues that cannot be answered by the short instrumental records.

There appears to be a consensus that the IDM involves a positive air-sea interaction but that it is a damped mode, requiring external forcing to be excited. Several papers investigated the triggers for a strong IDM, and several papers dealt with the IDM influence on rainfall anomalies over the surrounding continents, on marine biological activity, and on tropospheric ozone.

Besides air–sea interactions and Indo–Pacific Ocean interactions along the equator, papers also dealt with off-equatorial variability. Evidence for links between the IDM and the South Asian summer monsoon was presented. Furthermore, off-equatorial Rossby waves in the tropical South Indian Ocean have large amplitudes, and several observational and modeling studies suggest that these waves induce significant SST anomalies in the west where the mean thermocline is shallow, a unique Indian Ocean feature. These Rossby waves, according to some studies, appear to affect tropical cyclone formation through their effects on SST.

Papers were also presented on oceanic processes causing Indian Ocean climate variability, including cross-equatorial flow, the Indonesian Throughflow, and waves. Given the small horizontal gradient in climatological SST in the Indian Ocean, salinity may have significant effects on ocean dynamics and on SST variability. High-frequency disturbances like the atmospheric Madden-Julian Oscillation may also lead to adjustments in the Indian Ocean climate and affect its variability.

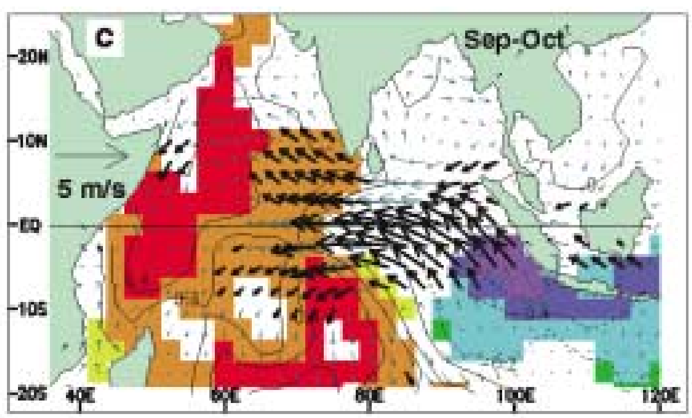



***Figure 7.*** *Evolution of composite SST and surface wind anomalies during the peak of an IDM event (Sep-Oct)*

# CLIVAR's Pacific Focus

## CLIVAR Pacific Implementation Panel

CLIVAR Pacific Implementation Panel's first meeting was hosted by the IPRC at the East-West Center, February 7–9, 2002. Chair, **Kelvin Richards**, School of Ocean and Earth Sciences, University of Southampton, described the Panel's functions, which are to provide an overview of Pacific climate events and projects, spot gaps and weaknesses, convene scientists for discussions on key issues, and provide the community with information on Pacific climate. **John Gould**, International CLIVAR Director, reviewed the panel's charge to understand natural climate variability and human-induced changes, and to study the long-term predictability of climate in order to improve predictions. A better observing system in the Pacific is essential, given the region's influence on global climate.

Panel members reported on CLIVAR-Pacific-related projects in their respective countries. Simulation of climatology with the Australian Commonwealth Scientific & Industrial Research Organization's new coupled model agrees well with observations; the Bureau of Meteorology Research Centre's ENSO prediction model suggests that with global warming, Australia will have less rain. Canada is working with the Japan Marine Science and Technology Center on a system of weather buoys strung across the North Pacific. Chile and Peru are joining forces in the Chili-Peru Oxygen Minimum Circulation Experiment, a study of dynamic and biochemical processes affecting the oxygen minimum content. China is studying causes of variability in the Indo–Pacific warm pool, where huge amounts of water vapor enter the atmosphere, and the movement of SST anomalies from the Indian to the Pacific Ocean. The supply ship for China's two Antarctic stations, traveling once a year to and from Antarctica, can take ocean measurements. France is studying ENSO predictability using an ENSO-observing system that includes data from coral drilling, tide gauges, and timeseries stations. Japan has an extensive $CO_2$ mapping study; climate modeling research on Japan's supercomputer, the Earth Simulator, starts April 2002.

Details on the "Launching of the Argo Armada" were given by **Howard Freeland**. The data collected by the free-drifting profiling Argo floats (measuring ocean temperature and salinity of the upper 2000 m) are made publicly available within hours after collection and allow continuous monitoring of the ocean state. At present 708 floats have been set adrift; over the next three years, 2,373 more are planned for a total of 3,000 floats. By the end of 2002, we can expect good coverage except for the East Pacific from the equator southward. The Argo system is a truly international endeavor. Built by the individual nations, the floats relay data to their national centers. Standardized calibration and quality control are a problem. Also, countries must be willing to deploy floats far away from home for global coverage and to continue funding replacements, the floats having only a 4-year life span.

The new Global Ocean Timeseries Observing System—a mooring system collecting data for marine ecologists, oceanographers, meteorologists and solid earth geophysicist—was presented by **Robert Weller**. A complement to Argo, the moorings are to be long-term and placed at sites with the greatest overlapping scientific interests. Support and funding for this system is now being sought among the scientific community. Weller also reported on the East Pacific Investigation of Climate, which is producing interesting data on the interaction between the ocean–atmosphere boundary layer. A southward extension of buoys is planned and will form the Ocean South East Pacific Array.

The Panel was briefed on several studies being planned, including the Kuroshio Extension System Study and The Hemispheric Observing System Research and Predictability Experiment. **Roger Lukas** described the Pacific Basin Extended Climate Study (PBECS), a long-term experiment to test and improve dynamical models of ocean processes causing climate variability. PBECS is based on the belief that the best hope for climate prediction and assessment lies in models that have sound approximations of important physics and are initialized with accurate observations. The international panel has adopted an implementation and planning strategy closely aligned to PBECS in order to provide a framework for national contributions to CLIVAR Pacific.

**Peter Hacker**, manager of the APDRC (see p. 19), described the activities of the APDRC, which the Panel strongly endorsed. **Daniela Turk** (CLIVAR office) presented the CLIVAR links with biogeochemical/carbon programs. The Panel recognized the benefits for collaboration with these programs, particularly in view of the ENSO impacts on biogeochemical processes in the Pacific Ocean.

For further information on CLIVAR Pacific visit *www.usclivar.org*.

# Closer Japan - US Partnership in Climate Research

The Japan–US partnership in climate research received a boost at the Climate Modeling and Applications Science Meeting in Tokyo, February 25, 2002. This meeting between high-level Frontier Research System for Global Change (FRSGC) scientists and scientists from NOAA Office of Oceanic and Atmospheric Research (OAR) and collaborating programs resulted from President Bush's wish for closer climate research collaboration with Japan. The meeting's aim was to explore specific partnership possibilities. Described below are the participating programs and the projects proposed for collaboration.

Research at Japan's FRSGC focuses on prediction of global environmental change by conducting process studies and developing models to be run on the Earth Simulator. **Taroh Matsuno** (Director-General, FRSGC) described research and the main models being developed at the FRSGC: a coupled atmosphere–ocean GCM for modeling the Baiu front, typhoons, and baroclinic eddies; a very high-resolution (5 km) atmospheric GCM; and an integrated global environment model. Tests on the Earth Simulator supercomputer using the first two models with several horizontal resolutions are underway. **Hirofumi Sakuma** (Group Leader, FRSGC) expects that the very high-resolution models will be able to simulate precipitation patterns, storm tracks, Kuroshio meanders, the Indian Ocean Dipole, and more. **Toshio Yamagata** (Director of the FRSGC's Climate Variability Project and of the Japanese portion of the IPRC) expanded on the FRSGC research on the Indian Ocean Dipole, which appears to have a global effect on midlatitude temperature variability. Discussions are underway with African countries and India to take more measurements in the area. (NOAA is also exploring the extension of moored buoys into the Indian Ocean.)

NOAA's plans for climate services, described by **Ken Mooney** (Deputy Director, Office of Global Programs), are to provide on-demand climate assessments, produce maps of US carbon sources and sinks, develop options for managing greenhouse gases and aerosols, and produce routine state-of-the-atmosphere reports. Earth system models are being developed at the NOAA Geophysical Fluid Dynamics Laboratory (GFDL) to provide knowledge on natural climate variability and man's effects on climate. According to **Ants Leetma** (Director, GFDL), plans include production of forecast products (from future climatologies to seasonal and weather forecasts), development of an ocean model with a $1/10^{\circ}$ resolution and a chemical transport model, and an assessment of the Pacific Ocean impact on the Indian Ocean. A major project is the Earth System Modeling Framework, a $10 million NASA-funded, 5-year project to produce a general modeling framework among US climate modeling efforts. The main US climate modeling institutes have agreed to use the framework.

The current status and plans for IPRC's Asia–Pacific Data–Research Center (APDRC, p. 19) were presented by **Julian McCreary** (Director, IPRC). The APDRC currently receives funds from NASA and NOAA in order to link US data centers to the APDRC, allowing easier access to high-quality data sets and products from many centers. Concerning ocean data assimilation, **Toshiyuki Awaji** reported FRSGC's plans, and **Ming Ji** described GFDL efforts and ECCO (Estimating Circulation and Climate of the Ocean), a joint project between Scripps, JPL, and MIT.

The International Research Institute (IRI) focuses on societal applications of climate research. **Antonio Moura** (Director, IRI) gave examples of the institute's worldwide projects: El Niño forecasts to advise agriculture in Argentina and fisheries management in Peru; a global mosquito population study to predict outbreaks of Dengue; a 10-member ensemble run on 16 PCs in Brazil to predict rainfall. Stephen Zebiak described the IRI applied modeling efforts, which include study of seasonal and longer timescale climate variation, the role of land surface, regional model development, and the Indian Ocean influence on global climate.

As a result of the meeting, the following projects for US–Japan research partnerships are being proposed (institutional programs are listed in parenthesis): 1) study of the Indian Ocean Dipole by application of coupled ocean–atmosphere GCMs, investigating (a) the teleconnections between the Pacific and Indian Oceans, (b) the links between annual and interannual cycles, and (c) the predictive ability of models (FRSGC, IRI, GFDL, and IPRC); 2) ocean data assimilations with the Earth Simulator (FRSGC, NOAA, and GFDL); 3) development of ocean and atmosphere models with a focus on testing parameterizations, reducing biases, and common diagnostics (FRSGC, IRI, IPRC, and GFDL); 4) development of data centers and data sets to improve data coverage and coordination (YIES; FRSGC; APDRC; IPRC; IRI; NOAA-OGP); the IPRC is to hold a workshop on this topic.

# Go Data Shopping!
## The Asia–Pacific Data–Research Center

More and more data for research on climate variability and change are becoming available. International observation programs like Tropical Ocean Global Atmosphere (TOGA) and World Ocean Circulation Experiment (WOCE), as well as advances in satellite technology, have made this increase in data possible. With the additional new monitoring programs such as Argo and time-series stations the data stream will jump again. The data, though are often difficult to access and surprisingly underused.

To remedy this situation, the IPRC has established the Asia–Pacific Data–Research Center, which plans to provide easy, one-stop shopping for climate data and products to local researchers and collaborators, the national climate research community, and the general public. The center's mission is to increase understanding of climate variability in Asia–Pacific by developing the computational, data-management, and networking infrastructure necessary to make data resources readily accessible and usable by researchers, and by undertaking data-intensive research activities that will both advance knowledge and lead to improvements in data preparation and data products. Thus, with the somewhat unusual combination of data management and research, the center takes an important step in making sure data are put into a format useful for research.

The APDRC has four parts: (1) Data Server System (DSS); (2) data management and archive building; (3) value-added, data-intensive research projects; and (4) coordination and collaboration.

The Data Server System uses a distributed approach, that is, the data can reside in many different institutions, but it is provided in a uniform format. One major significant research feature is that both in-situ and gridded data are provided together with convenient comparisons between the two data sets. For example, the Live Access Server (LAS) has gridded data (see Figure 8) and the EPIC server has in-situ data (see Figure 9). With a few clicks, plots such as these can be yours.

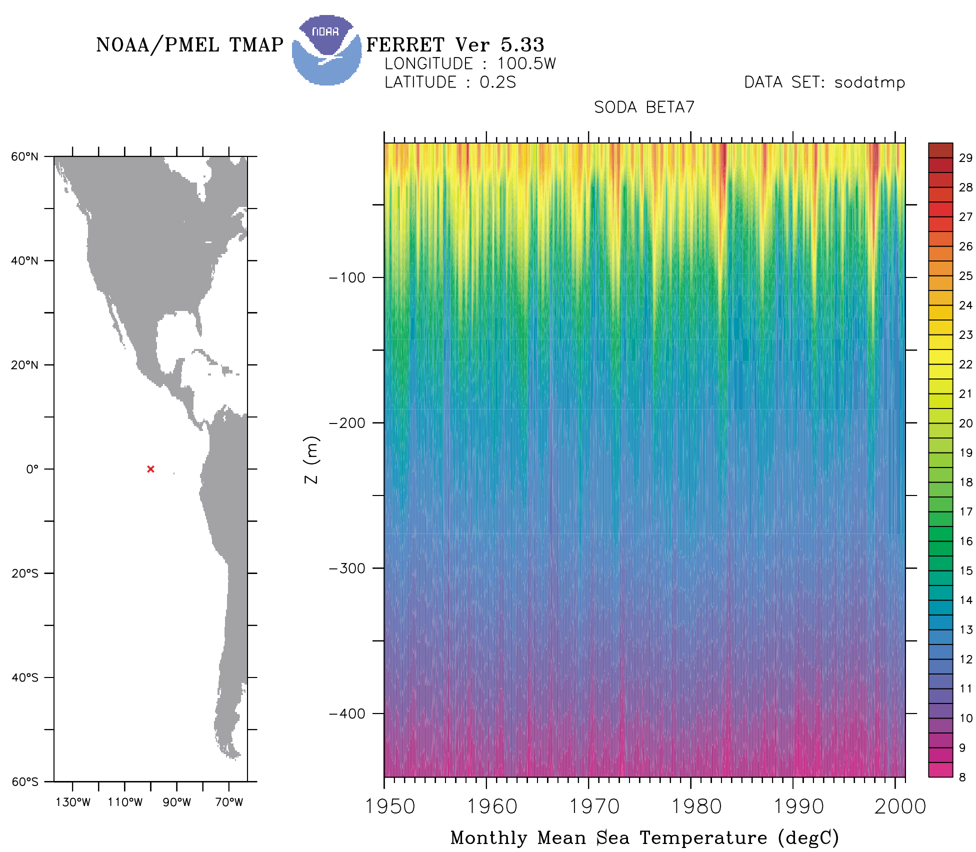



**Figure 8.** *Depth-time graph of assimilated ocean temperature at 100 W at the equator at point x, showing how the thermocline is deeper during El Niño years. Plotted from SODA: Simple Ocean Data Assimilation, Carton et al. 1999. The data are served by LAS in aggregates of 50 files of yearly data compiled by Catalog/Aggregation Server or CAS.*

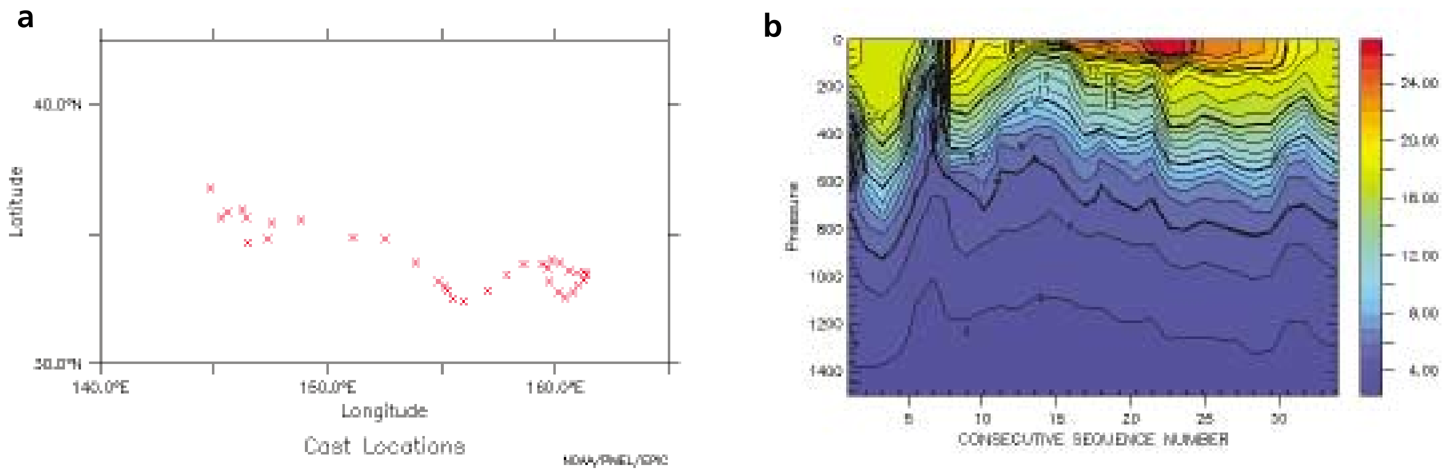
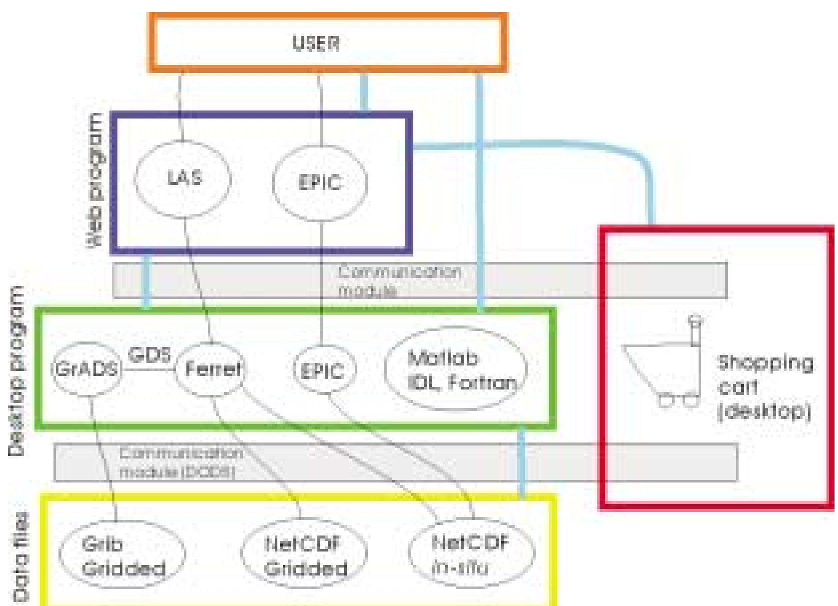



***Figure 9.*** *(a) Trajectory of Argo float no. 29043 selected from 25 Feb. 2001 to 21 Jan. 2002 on the EPIC server. Each x marks the location where the float took measurements. (b) Vertical temperature measurements taken by the float at the 30 measurement points in panel a. Any subset of the measurements taken can be requested for plotting.*

Moreover, you have a choice of software applications. The various levels of the system and the available servers and applications you can already use are shown in Figure 10. There is a shopping cart for your use. This cart, a repository of data location and server information, makes a smooth transition from the servers to your favorite application software. The cart, for example, allows you to view gridded and in-situ data at the same time (Figure 11).




| ***Servers*** | ***Applications*** |
|---|---|
| DODS | JOA |
| CAS | ncBrowse |
| LAS | eWoce |
| EPIC | Matlab |
| CDP | IDL |
| GDS | Ferret |
| | Grads |

***Figure 10.*** *A schematic of the APDRC Server System.*

As this issue of *IPRC Climate* goes to press, you can get the following data at APDRC's data archives: On EPIC you can obtain WOCE CTD and some sample Argo data. On LAS, you can obtain Climatologies (COADS and Levitus), CPC merged precipitation analysis, NCEP reanalysis 1 and 2, Atlas SSMI 5-day ocean winds, NASA JPL SeaWinds QuickSCAT (level3), SODA monthly (1950–2001) and TMI SST (1998–2001). If you don't find what you need for your research, let the APDRC scientists know and check back a few months later.

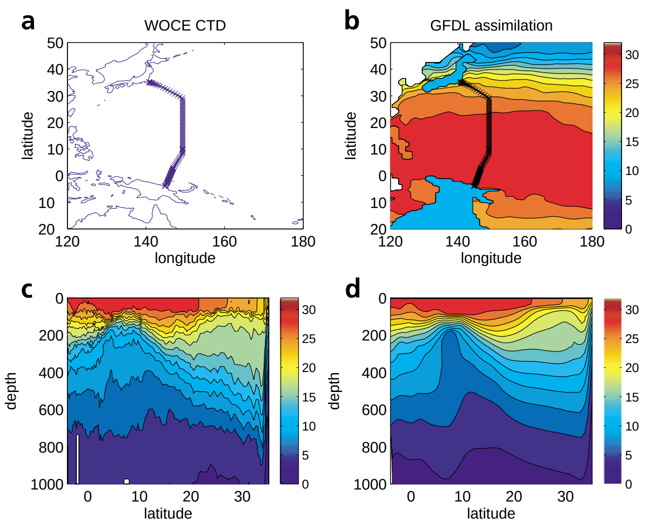



*Figure 11.* *A demonstration of the shopping cart. The user has requested in Matlab format remote and distributed data sets served by EPIC and LAS. The shopping cart serves as the repository of the DODS URLS selected by the two servers. (a) Location of the CTD casts of WOCE P10 line from October to November 1993. (b) Vertical temperature measurements of these casts. (c) Sea surface height of a GFDL assimilation product for November 1993. (d) Vertical temperatures resulting from an interpolation of the GFDL product at the CTD cast points.*

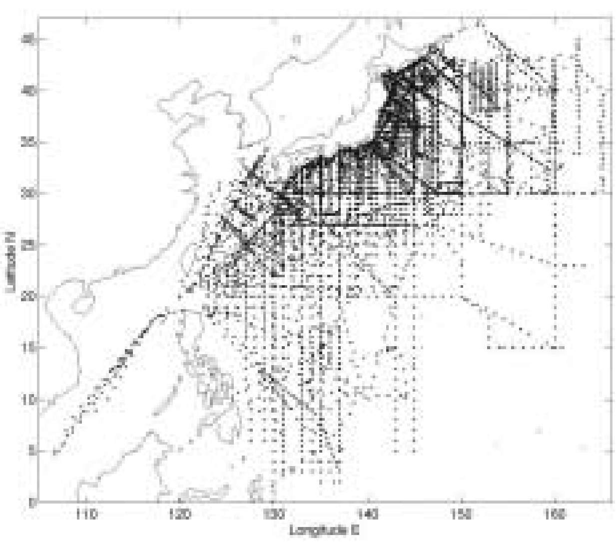


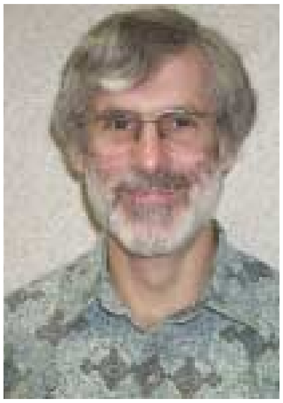

*Figure 12.* *Locations of 18,742 bottle stations from surveys conducted from 1969 to 1993 by the Far Eastern Research Hydrometeorological Institute in Vladivostok, Russia.*

An example of the value-added research project being undertaken at the APDRC is provided by the data from 20,000 Russian bottle stations south and east of Japan (Figure 12). The data set, which the APDRC has recently acquired through a contract with the Far Eastern Regional Hydrometeorological Research Institute, stems mainly from 48 seasonal 1980–1991 surveys and consists of temperature, salinity, and chemical tracer measurements from the surface to 1500 meters. The set represents data with spatial and temporal resolution not available from any other observational data set and covers the three most recent Kuroshio large-meander events (1981–1984, 1986–1988, and 1989–1991). The IPRC staff is combining this data with 1985–1989 satellite altimetry from the US Navy *Geosat* to describe the evolution of the geostrophic velocity field at various depths without an arbitrary reference level, to evaluate dynamic balances, and to determine the three-dimensional circulation patterns during the formation and decay of the 1986–88 Kuroshio large-meander. These studies will contribute to a better understanding of the dynamics of the deep thermohaline circulation and its interaction with bottom topography and wind-driven currents.

So, if you have an Asia–Pacific climate project, go shopping for data at *http://apdrc.soest.hawaii.edu*, the APDRC website. The APDRC team would like your input. Let them know what works for you and what does not!

The APDRC wishes to acknowledge the Pacific Marine Environmental Laboratory for their programming support and help in installing their software and data into the APDRC server. Members of the APDRC staff are **Peter Hacker**, Manager, Data-Intensive Research Projects, Coordination and Collaboration; **Ronald Merrill**, Computer Systems Manager; **Humio Mitsudera**, Data Archives; **Yingshuo Shen**, Data Server Manager; **Takuji Waseda**, Data Server System; and **Gang Yuan**, Assistant Researcher; **Yongsheng Zhang**, Atmospheric Data Specialist.

# News of IPRC Scientists



**Julian P. McCreary**, IPRC Director, has recently been appointed to the Ocean Studies Board of the National Research Council, one component of The National Academies which comprise also the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The National Academies bring together experts from all scientific, health, and technological fields to address critical national issues and give balanced, unbiased advice to the federal government and the public. They provide science and technical advice in various ways: written reports reflecting the consensus reached by an expert study committee, proceedings from conferences and workshops, "white papers" on policy issues of special interests, symposia, roundtables, lectures, and forums on national issues.

Expert study reports on which the Ocean Studies Board (OSB) has recently participated include *Spills of Emulsified Fuels: Risks and Response*, a report on various petroleum hydrocarbon-based fuels and the ecological consequences of their use; *Transforming Remote Sensing Data into Information and Application*, a discussion of recent changes in remote sensing technology and application, and the implications of these changes; and *Abrupt Climate Change: Inevitable Surprises*, a description of, and research recommendations for, understanding recent climate change. Currently the Board is looking at environmental conditions and ecosystem restoration in Florida, particularly concerning the Everglades.

The various projects of The National Academies are supported by external grants rather than by direct funding from the US government. The committee and board members serve without compensation. The Ocean Studies Board meets three times a year, and the Spring 2003 Board meeting will be hosted by the IPRC and held at the East-West Conference Center.

**Masami Nonaka**, Frontier Researcher at the IPRC, was awarded the Frontier Research System for Global Change 2001 Outstanding Scientist Award. **Toshio Yamagata** presented him with the award for "having published and in press four scientific papers during 2001. His studies with Shang-Ping Xie (IPRC) on the Hawaiian Wake, (published in the June 15, 2001, issue of *Science*), have opened a new page in the study of the air–sea interactions in the subtropics." Nonaka's publications deal mainly with the subtropical shallow overturning circulation (subtropical cells) and their decadal variability.

**Shang-Ping Xie,** Associate Professor of Meteorology and researcher at the International Pacific Research Center, School of Ocean and Earth Science and Technology, has been awarded the prestigious 2002 Medal of the Meteorological Society of Japan, the highest honor awarded by the society to a member for meteorological research. Xie, the first non-Japanese member of the society to be thus honored, received the medal for his "contributions to the understanding of ocean–atmosphere interaction that shapes the tropical climate and its variability." The medal was presented at the Spring Meeting, May 22–24, 2002, in Omiya, Japan.

# New Scientific Staff

**Saji Hameed** joined the IPRC in January 2002 as an assistant researcher from Frontier Research System for Global Change (FRSGC). He began his oceanography studies at Cochin University in India, obtaining a B.Sc. in 1990. He continued his education at the Indian Institute of Science in Bangalore, where he received his M.Sc. and Ph.D. in atmospheric sciences in 1994 and 1997, respectively.

Hameed then moved to Japan and worked as a researcher at FRSGC, where his research focused on documenting the features of the newly identified mode of coupled variability in the tropical Indian Ocean referred to as the Indian Ocean Dipole Mode (IDM, see p. 16). Together with **Toshio Yamagata** and colleagues at FRSGC, he has described the salient features of the spatial structure and temporal evolution of the IDM in SST, surface winds and precipitation.

At the IPRC, Hameed will work in Theme 1, the Indo-Pacific Ocean Climate, and continue to pursue his interest in the climate and environment of the Indian Ocean. Currently he is analyzing the teleconnection patterns that are induced by the IDM and its interference with the teleconnection patterns generated by ENSO. In addition to his work on the atmospheric mechanisms involved in IDM teleconnections, he plans to study the seasonal and intraseasonal structures in equatorial Indian Ocean SST, winds, rain, and ocean currents using satellite and *in-situ* data. He also intends to investigate the environmental impacts of extreme events on coral populations in the region.

**Haiming Xu** joined the IPRC as a postdoctoral fellow in January 2002. He obtained his B.Sc. and M. Sc. in synoptic dynamic meteorology from the Department of Atmospheric Sciences, Nanjing University, in 1985 and 1988, respectively. He then worked for three years at the Chinese National Marine Environmental Forecast Center as an assistant engineer. Returning again to Nanjing University in 1991, he studied at the Nanjing Institute of Meteorology (NIM), where he completed his Ph.D. dissertation on the circulation features leading to onset of the East-Asian tropical and subtropical summer monsoons and associated mechanisms. Based on his research, he proposed that the Indochina Peninsula is important in establishing and maintaining the South China Sea summer monsoon, while the Indian Peninsula is important for the course of the Asian summer monsoon. This research also revealed a relationship between the Meiyu onset and the North Atlantic Oscillation and SST over the North Atlantic.

Upon earning his Ph.D., Xu worked as an associate professor at NIM, continuing his research on monsoon dynamics, short-term climate change, and air–sea interaction based on climate models and data analysis. He was also an instructor at NIM's Regional Meteorological Training Center of the World Meteorological Organization.

At the IPRC, Xu is working with **Shang-Ping Xie**, **Yuqing Wang**, and **Tim Li** on air–sea–land interaction in the eastern Pacific. Using the IPRC–Regional Climate Model developed by Yuqing Wang and **Omer Sen** (see *IPRC Climate*, Vol.1, Fall), he is studying the effects of the Andes on atmospheric circulation. He intends to develop this regional climate model into an air–sea coupled model to investigate how the presence of the Andes affects the air–sea interaction and thereby the climate in the eastern Pacific.

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