EXPERIMENTAL LONG-LEAD FORECAST BULLETIN

This Bulletin is issued quarterly by the Climate Prediction Center and is intended to present experimental long-lead forecasts of short-term climate fluctuations in real time. Accompanying each forecast is a brief discussion of the forecast method and its estimated skill. More detail about the type of forecasts acceptable for publication in this Bulletin is given under "Purpose" and "Editorial Policy."

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SUMMARY OF FORECASTS

For ENSO Condition:

Dynamical methods: The standard and the new Lamont Doherty Earth Observatory models predict continuing cold conditions through winter 1996-97.The NCEP coupled model calls for some weakening of the current cold SSTA east-central Pacific between now and boreal fall 1996. The Australian BMRC low order coupled model forecasts current cool Niño 3 to switch to warm for the second half of '96, further strengthening by late winter and spring '97. The Oxford coupled model calls for cool SST to continue for remainder of '96. The COLA coupled model predicts dissipation of cool SST conditions by summer 1996, warming to >1°C by winter '96-97.

Statistical methods: CDC's inverse modeling predicts dissipation of below normal east-central Pacific SST by summer '96, with possible positive anomalies emerging in the southeastern tropical Pacific. The Australian BMRC non-linear analogue predicts somewhat decreasing SOI by May 1996. UCLA's SSA-MEM predicts near to slightly below normal SST through '96, with near normal SOI. JPL/Utah State's CSSA/MARS "analog" system predicts a La Nina period peaking in early 1997. Univ. of British Columbia's neural net model predicts a warm episode for Niño 3 for fall-winter '96-'97. NCEP/CPC's CCA predicts current below normal Niño 3.4 (120°-170°W) SST dissipating by June and becoming moderately warm by Jan '97. NOAA's constructed analog predicts dissipation of cool Niño 3.4 SST by late spring 1996, warming to ~0.5°C for fall and winter 1996-97. NCEP's 4-model consolidated forecast projects cool SST through 1996, switching to warm after March 1997.

For United States/Canadian Temperature:

Dynamical methods: The NCEP coupled model forecasts cool in northern tier for spring and summer '96.

Statistical methods: NCEP/CPC's optimal climate normals scheme predicts warm Pacific Northwest, Northeast, Mid-Atlantic, cool Florida panhandle for Apr-May-Jun '96; warm Southwest and much of eastern half Jul-Aug-Sep. NCEP/CPC's CCA predicts positive anomalies parts of Texas, the Southwest, far West and Hawaii Apr-May-Jun, warm California, Mid-Atlantic, southern Alaska, Hawaii Jul-Aug-Sep. NCEP/CPC's screening multiple regression predicts above normal parts of southern tier and Maine, cool in Northwest and upper Great Lakes for Apr-May-Jun '96; above normal Southwest, part of Southeast, Maine, Montana in Jul-Aug-Sep. The Environment Canada CCA predicts cold near and west of Hudson Bay, warm British Columbia in Apr-May-Jun '96.

For United States/Canadian Precipitation:

Dynamical methods: The NCEP coupled model forecasts some enhanced wetness Great Lakes for Apr-May-Jun.

Statistical methods: NCEP/CPC's optimal climate normals predicts wet in Pacific Northwest Apr-May-Jun '96; wet Michigan and Great Basin, dry North Carolina Jul-Aug-Sep. NCEP/CPC's CCA calls for wetness in Pacific Northwest, near normal Honolulu for Apr-May-Jun '96; dry central Alaska, wet Hilo for Jul-Aug-Sep. NCEP/CPC's screening multiple regression predicts dryness in south-central Texas and parts of eastern seaboard for Apr-May-Jun '96. The Environment Canada CCA calls for wet along east coast of Canada and central British Columbia, dry Saskatchewan for Apr-May-Jun '96.

For Tropical/Subtropical Rainfall:

Dynamical methods: The Scripps/MPI ECHAM3.2 atmospheric GCM indicates drier than normal conditions in the Nordeste of northeast Brazil for boreal spring 1996.

Statistical methods: The Univ. of Wisconsin multiple regression and discriminant analysis forecasts call for near-average rainfall for the Nordeste for Mar-Apr-May-Jun '96. The UK Meteorological Office multiple regression and discriminant analysis forecasts indicate dry to average rainfall for the Nordeste for Mar-Apr-May. NCEP/CPC's CCA predicts weak anomalies at most tropical Pacific islands this boreal spring, and some enhancement of rainfall at Johnston Island in summer.

For 1996 Tropical Storm Activity:

Statistical methods: The CSU LAD regression approach (see previous Bulletin issue) forecasts slightly negative Atlantic storm anomalies for most aspects of '96 tropical storm activity. The FSU Poisson and tropical/baroclinic approach (see previous issue) predicts approx. average '96 season for Atlantic hurricanes, somewhat below average for intense hurricanes. FSU's Bayesian probabilistic model (this issue) indicates 1.25 (~60% of normal) intense Atlantic hurricanes for 1996. The Australian BMRC SOI-based regression (see previous issue) calls for near to slightly below normal Australian region storm activity for the southern fall 1996 season.

EL NIÑO/SOUTHERN OSCILLATION (ENSO) DIAGNOSTIC ADVISORY

Issued by the Climate Prediction Center
March 13, 1996

Cold episode conditions have steadily intensified in the tropical Pacific since mid-1995. During this period negative sea surface temperature (SST) anomalies have expanded westward from the eastern equatorial Pacific into the central equatorial Pacific. This cooling has been associated with substantially weaker-than-normal convective activity over the central equatorial Pacific (positive OLR anomalies), a feature that has become especially pronounced during the last four months. Consistent with the changes in SST and convective activity, the equatorial low-level easterlies have been stronger than normal over the western and central equatorial Pacific.

During February 1996, SSTs were more than 1°C below normal along the equator from the date line eastward to 130°W. In addition, convection was weaker than normal in the equatorial band from 160°E eastward to 130°W, and stronger-than-normal easterlies covered nearly the entire equatorial Pacific. Although the Southern Oscillation Index (SOI) was near zero in February, the overall pattern of sea level pressure anomalies (negative anomalies over Indonesia and positive anomalies over the eastern tropical Pacific) is consistent with the cold episode patterns of anomalous low-level winds, SST and convection.

Cold episode conditions are likely to continue for the next few months, but the long-term outlook is unclear due to the considerable variability between statistical and numerical model predictions. For example, the statistical techniques (CCA and linear inverse modeling) indicate a rapid return to near-normal SST by mid-year. Thereafter, the CCA indicates a continuation of the warming trend and the development of positive SST anomalies, while the linear inverse modeling technique maintains near-normal conditions through the end of 1996. One version of the NCEP coupled model indicates an evolution similar to that shown by the CCA. The other version of the NCEP model predicts a somewhat weaker warming trend. In contrast, the two versions of the Lamont Doherty Earth Observatory model show continued cold episode conditions through early 1997.

The ENSO advisories are available on the World Wide Web via Mosaic or Netscape at http://nic.fb4.noaa.gov. Since our resources to produce and distribute the advisories are limited, we are forced to restrict the hard copy distribution. Therefore, we are requesting that users obtain the advisories electronically from the World Wide Web. However, if you require a hard copy version of the advisories, please contact the Climate Prediction Center using the e-mail address:

wd52vk@hp31.wwb.noaa.gov

EXPERIMENTAL LONG-LEAD FORECAST BULLETIN

PURPOSE

This Bulletin, issued by the Climate Prediction Center (CPC), is intended as an opportunity to present experimental forecasts with a long lead time. In the process we hope to achieve an exchange of ideas on long lead forecasting, which would serve as a mechanism to stimulate research in this area. The frequency of issuance is quarterly. The forecasts are mainly intended for the surface climate in the United States, such as a forecast of winter U.S. surface temperature 6 months or a year in advance. Forecasts for other aspects of climate, such as ENSO, the hurricane season severity, or surface climate in other parts of the world are also welcome.

Long range forecasting, with or without a lead time, is in an embryonic stage of development. In general, forecasting skill is currently at a minimal level. Some recent progress has been made with dynamical approaches to such forecasts, using either simple or complex, coupled ocean-atmosphere or uncoupled atmospheric GCMs. A comparable level of achievement has also been attainable using empirical methods.

It is our goal that the next several decades will bring a major improvement in understanding and in forecast skill. In the process of this progressive advancement in knowledge and ability, a bulletin such as this can help focus new ideas and disseminate information that will keep interested researchers abreast of the latest developments. It will also encourage collaboration among researchers and forecasters in this field. The real-time forecasts that appear in this Bulletin will serve as examples of what can be done now, and add some reality and suspense to what otherwise could only be an academic research discussion.

The contents of this Bulletin are not routine; i.e. some of the forecasts presented are expected to vary widely in their methodology, lead time, and specific predicted quantity from issue to issue.

This Bulletin is distributed to researchers as well as those with more applied interests. Persons wishing to participate in, or offer comments on, the Experimental Long-Lead Forecast Bulletin should contact Tony Barnston (editor) or Huug van den Dool at 301-763-8155 (fax 301-763-8395), or write to Climate Prediction Center, W/NMC51 Room 604, Washington, DC 20233. Technical Assistant: Paul Sabol

EDITORIAL POLICY

Researchers from other research and academic centers, both within NOAA and extramural, who are interested in contributing to this Bulletin are invited to do so. A variety of forecasting techniques would add value and interest to the Bulletin. Prospective participants should read the following guidelines to determine if their contribution meets a minimum standard of credibility.

GUIDELINES FOR CONTRIBUTIONS

A. Time Scale, Lead, and Real-Time Nature of Forecasts

For the purposes of this Bulletin, we define the forecast averaging time scale as at least one month in duration, and extending to as much as 3 or more months. Thus, daily weather variability is to be essentially excluded, and short-term climate variability emphasized. Occasionally, very long time-averages such as one year or longer would be interesting (e.g., effects of greenhouse gases, volcanoes).

The long-lead aspect means that the forecast target period will not begin at the time of the forecast, but at a future time at which numerical weather prediction skill would, on average, be minimal. Two weeks of lead time appears to be a reasonable minimum for satisfaction of this condition. Leads of much longer duration are heartily encouraged, if warranted.

Forecasts are to be of real-time nature, i.e., the target period must not yet have occurred. This is in contrast to hindcasts, for which observed data for the target period are available at the time of the forecast.

B. Acceptability

In order that the forecasts be acceptable, they must ideally satisfy the following criteria:

(1) **Reproducibility:** The method must be describable in terms such that others could generate an identical forecast by following the method description—at least in principle.

(2) **Skill:** A track record is required! The skill of the method, as evaluated in a manner that accounts for artificial skill must be available, and should be better than that of random forecasts beyond reasonable doubt.

(3) **Documentation:** The method must have been presented in at least a non-refereed publication, in the current general context.

(4) **Presentation Standards:** The forecast should be cast in unambiguous terms. When using anomalies and/or classes the base period must be stated. (We prefer the 1961-90 normals.)

A limited number of forecasts will appear in any individual issue. The editors at the Climate Prediction Center will make a selection from among the contributed forecasts, based on which ones best meet the above criteria.

C. Forecast Target

Forecasts for temperature or precipitation over the United States mainland are especially encouraged. More localized forecasts, such as for surface climate for New England, California, or outside the U.S. are acceptable on a more occasional basis. Forecasts for fields clearly related to U.S. surface temperature or precipitation, such as geopotential height or tropical sea surface temperature, are also acceptable. All forecasts must be long-lead and on a climate time scale, as defined in item (a).

D. Narrative Summary of Method, and Its Estimated Skill

Accompanying a long-lead forecast, there should appear a brief description or explanation of the method employed, which may be either ongoing or new. While a few specific formulations or other technicalities are appropriate, references to refereed or informal publications should be made in most instances. Estimates of forecast skill must be reported, using tools that minimize artificial skill (e.g., cross-validation, or independent forecast testing). Dynamical, empirical or hybrid forecasting techniques are eligible.

E. Verification

The Climate Prediction Center will not be responsible for verifying forecasts appearing in the Bulletin, except its own. It is the contributor's duty to verify his/her own forecasts using one or more common methods.

CONTENTS

Forecasts of Tropical Pacific SST Using a Simple Coupled Ocean-Atmosphere Dynamical Model

contributed by Stephen Zebiak and Mark Cane

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Since the middle to late 1980s, forecasts of the Nino 3 SST anomaly have been regularly made at Lamont-Doherty Earth Observatory of Columbia University using a simple coupled ocean-atmosphere dynamical model (Cane et al. 1986, Cane and Zebiak 1987, Zebiak and Cane 1987). This represented the beginning of a strong movement toward physical approaches to the diagnosis and prediction of climate and its short-term fluctuations. Here, we present a few details of this model's current forecasts of Niño 3 and the tropical Pacific basin. Forecasts using a new version of the model with improved initialization are now additionally available; these will be highlighted following a discussion of the forecasts of the standard version of the model.

Figure 1 shows forecasts of the SST anomaly in Niño 3 for 3 to 15 months lead using data through January 1996, and the observed Niño 3 SST over the past 2 years. These forecasts are actually ensemble means of forecasts from six consecutive months ranging from August 1995 to January 1996. Forecasts are adjusted to have the same mean and standard deviation as the observed data for each calendar month and lead time. The vertical bars show the error standard deviations. These do not necessarily become larger with increasing lead time, because even with an unchanging expected fraction of SST variance explained by the forecasts, the natural interannual SST variability changes with season. (The vertical axis is in anomalous °C as opposed to standardized anomaly in which case the size of the error bars would reflect only the skill of the forecasts.) In this case the forecasts describe a continuation of somewhat below normal Nino 3 conditions, with strongest negative anomalies for winter 1996-97.

A closer look at the forecast integrations is provided in Fig. 2, where six individual SST forecasts beginning from 1-month-apart initial conditions from August 1995 to January 1996 are shown along with the ensemble mean which is used in Fig. 1. The forecasts shown in Fig. 2 may not correspond exactly to those shown in Fig. 1, because in Fig. 2 the forecasts are adjusted to have the same mean and standard deviation as observed data only on an overall basis rather than for each calendar month and lead time. The spread among the individual ensemble members is small from the initialization times to boreal fall 1996, but becomes large from that point onward.

Figure 3 shows 6, 9 and 12 month lead SST anomaly forecasts for the tropical Pacific Basin, verifying in July and October of 1996 and January of 1997, respectively. These forecasts are adjusted to have the same mean and standard deviation as observed data on an overall basis (not for each calendar month and lead time), so they are exactly comparable with those shown in Fig. 2 but not necessarily Fig. 1. Like those for other target periods or for just Niño 3, the forecasts are adjusted for systematic biases. One such bias is an underestimation of amplitude of anomalies in the central (but not eastern) Pacific, which causes anomaly maxima to be placed too far east or prevents the central Pacific from fully participating. A statistical correction using singular value decomposition (SVD) is carried out to do the adjustment. The 6, 9 and 12 month lead forecast shown in Fig. 3 indicate a continuation of the present cool conditions without abatement through winter 1996-97.

Recent research at Lamont has shown that the skill of the SST forecasts can be increased significantly by improving the intialization system (Chen et al. 1995). The existing system has used wind stress anomalies (derived at Florida State University) to initialize the forecast runs, without current analyzed SST data. A newly developed system allows observed SST data to participate in the intialization process. Skill is found to increase not only in the early part of a forecast run but at intermediate and long leads as well. The "spring barrier" in skill that is present in the existing initialization scheme is substantially reduced using the improved system.

When the new initialization system is applied to the current SST forecast, the result is as shown in Fig. 4. The improved scheme produces a forecast generally similar to the customary Lamont forecast. This has not always been the case, however; e.g. several months ago the new scheme's forecast was for considerably colder conditions than the old. Now, both schemes favor a cold forecast.

Cane, M., S.E. Zebiak and S.C. Dolan, 1986: Experimental forecasts of El Nino. *Nature*, **321**, 827-832.

Cane, M. and S.E. Zebiak, 1987: Prediction of El Nino events using a physical model. In *Atmospheric and Oceanic Variability*, H. Cattle, Ed., Royal Meteorological Society Press, 153-182.

Chen, D., S.E. Zebiak, A.J. Busalacchi and M.A. Cane, 1995: An improved procedure for El Nino forecasting: *Implications for predictability*. *Science*, **269**, 1699-1702.

Zebiak, S.E. and M.A. Cane, 1987: A model El Nino-Southern Oscillation. *Mon. Wea. Rev.*, **115**, 2262-2278.

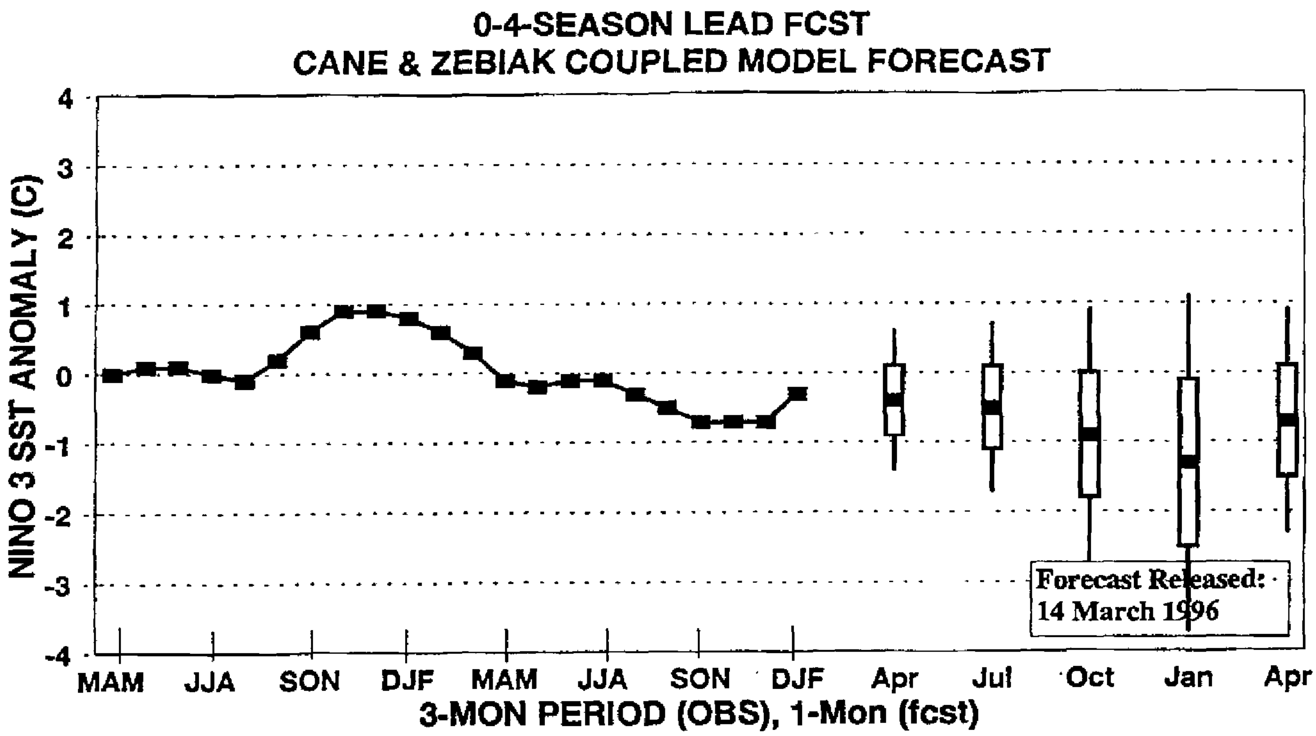

Fig. 1. *Forecasts for the SST anomaly (°C) in the Niño 3 region (5°N–5°S, 90°–150°W), based on the simple coupled model of Cane and Zebiak. Filled squares at the midpoints of the vertical forecast boxes represent the predictions, and the vertical boxes (lines) show the one (two) error standard deviations. The solid line represents the observed three month mean SST anomaly in Niño 3 up to the most recently available data. The bars show forecasts for 1 month mean SST anomalies at leads of 3, 6, 9, 12 and 15 months. See text for additional detail.*

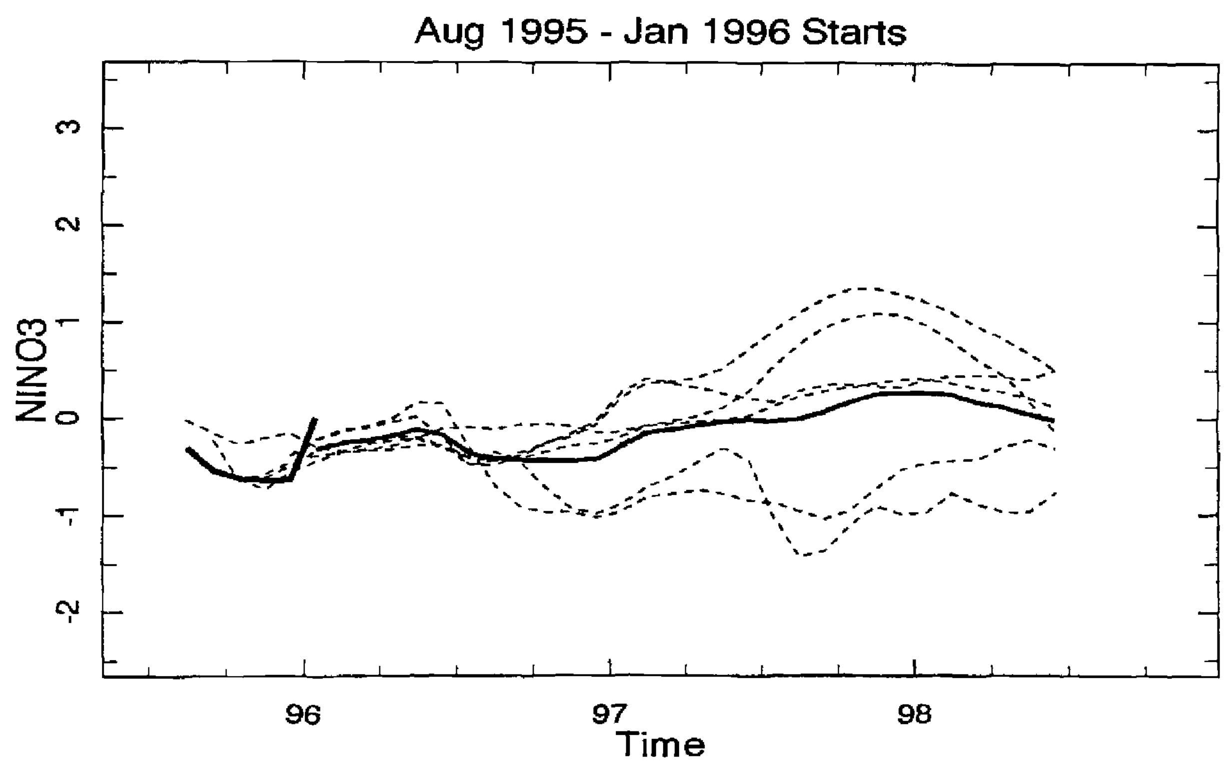

Fig. 2. *Time series of forecasts of Niño 3 SST from the Cane and Zebiak coupled model, for individual 1-month-apart initial conditions from August 1995 to Janaury 1996 (dashed lines) and the ensemble mean (solid line) used to form Fig. 1. However, an overall adjustment for the mean and standard deviation is used rather than lead- and season-specific adjustments as was done for Fig. 1. The thick solid line on left side shows the observed one month mean SST over the temporal range of the initial conditions.*

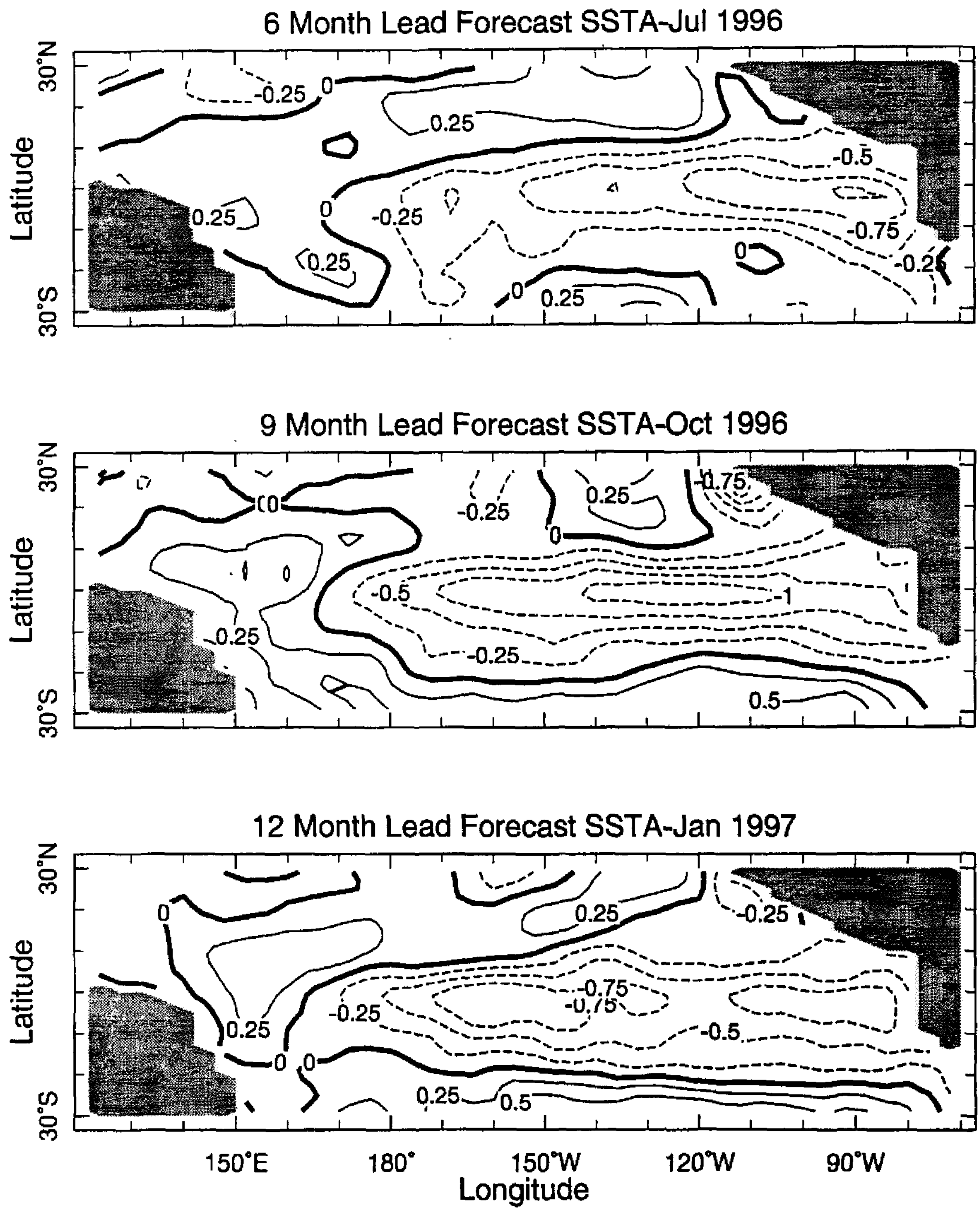

Fig. 3. *Cane and Zebiak coupled model SST anomaly forecast fields for July and October 1996, and January 1997, made at 6, 9 and 12 month lead times, respectively. The forecasts are ensemble averages of 6 forecasts with 1-month-apartinitial conditions ranging from August 1995 to January 1996. Adjustments for the mean and standard deviation are applied, based on lead time but independent of start time.*

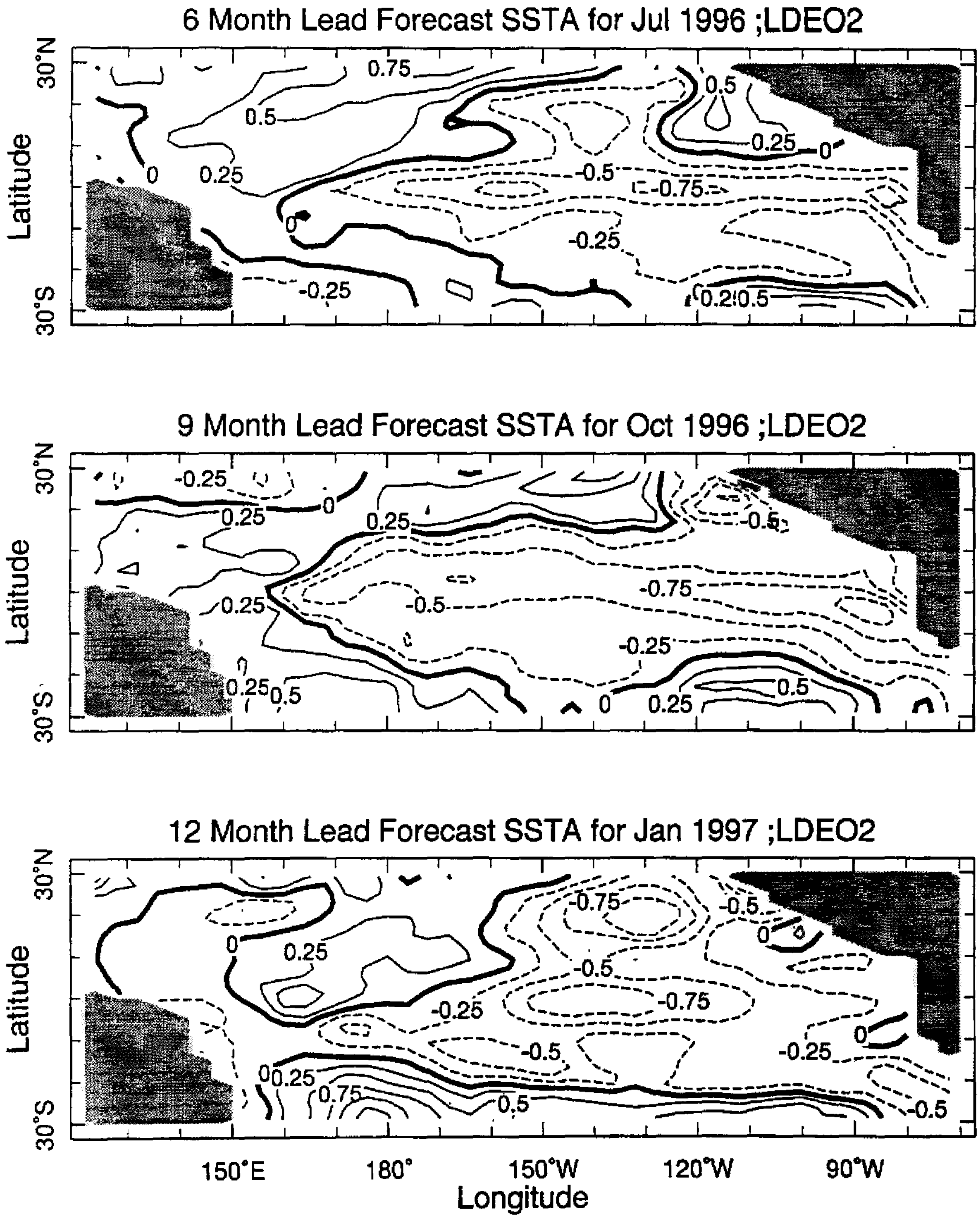

Fig. 4. *As in Fig. 3 except for the forecast made using the new initialization procedure (LDEO2) (Chen et al. 1995).*

Prediction of Precipitation in Northeast Brazil for Boreal Spring 1996 Using an Atmospheric GCM with Persisted SST Anomalies

contributed by Nicholas Graham

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Interannual rainfall variability has long been a concern to agricultural and water management interests in northeastern Brazil. The Nordeste is climatologically dry much of the year, with significant rainfall concentrated mainly in February, March and April. Some of the interannual variance of this rainfall has been found to be predictable using statistical methods (Hastenrath and Greischar 1993, Ward and Folland 1991; the forecasts of which are shown in the Greischar and Colman sections of this issue, respectively). Here we predict this rainfall using a dynamical approach.

Since 1993, forecasts of precipitation in northeastern Brazil have been prepared using a general circulation model forced with persisted or model-forecast SST anomalies from the beginning of the Feb-Mar-Apr-May wet season. The forecasts are made using the Max-Planck Institute for Meteorology (MPI)/University of Hamburg ECHAM3.2 atmospheric GCM, configured with T42 truncation (giving a physical grid resolution of approximately 2.5 degrees) and 19 vertical layers. The forecasts of most value to planners in northeastern Brazil are those produced in early January, early February and early March.

Figure 14 of the March 1994 issue of this Bulletin shows the spatial distribution of estimated correlation skill in predicting South American precipitation from near-simultaneous SST for boreal spring (Mar-Apr-May) over the 1970-93 period. Skill maxima were found on the west coast of equatorial South America and in northeast Brazil, with the latter value 0.69. Still higher skills are produced when only the wettest and driest years are forecast (Graham 1994). Skill would be somewhat lower for persisted previous SST rather than near-simultaneous SST. On the other hand, the ECHAM3 model was used in 1994; an improved ECHAM3.2 version is now used. An updated and more realistic estimate of skill is discussed below, following presentation of this year's forecast.

Fig. 1 shows predicted percent of normal precipitation for Feb-Mar-Apr 1996, using persisted global SST anomalies for January 1995 as boundary forcing (added to the climatologies for the respective months) for the ECHAM3.2 atmospheric GCM. While this is a zero-lead forecast, the integrations extend several months into the future. An ensemble of 6 simulations was used, covering January through April, each member using different atmospheric initial conditions (chosen at random from restart files for the same time of year). Evaluation of the results from retrospective forecasts over the period 1970-91 (in this case with ensembles of 3 simulations each year) using this approach resulted in correlations of up to 0.4 to 0.6 for the individual grid squares over the central portion of the Nordeste region of Brazil and north of the Amazon. Elsewhere, correlation skills typically range from 0 to 0.4. The **forecast map depicts dry (~50% of normal) conditions over the Nordeste**, with wetter than normal conditions to the north and south. This pattern is consistent with the current SST anomaly patterns in the tropical Atlantic: There are more positive SST anomalies in the north tropical Atlantic than in the south and near-equatorial tropical Atlantic, a pattern that is statistically not favorable for Nordeste precipitation. However, it is inconsistent with current conditions in the Pacific: Typically, cool SSTs in the tropical central and eastern Pacific are associated with wetter than normal conditions in the Nordeste.

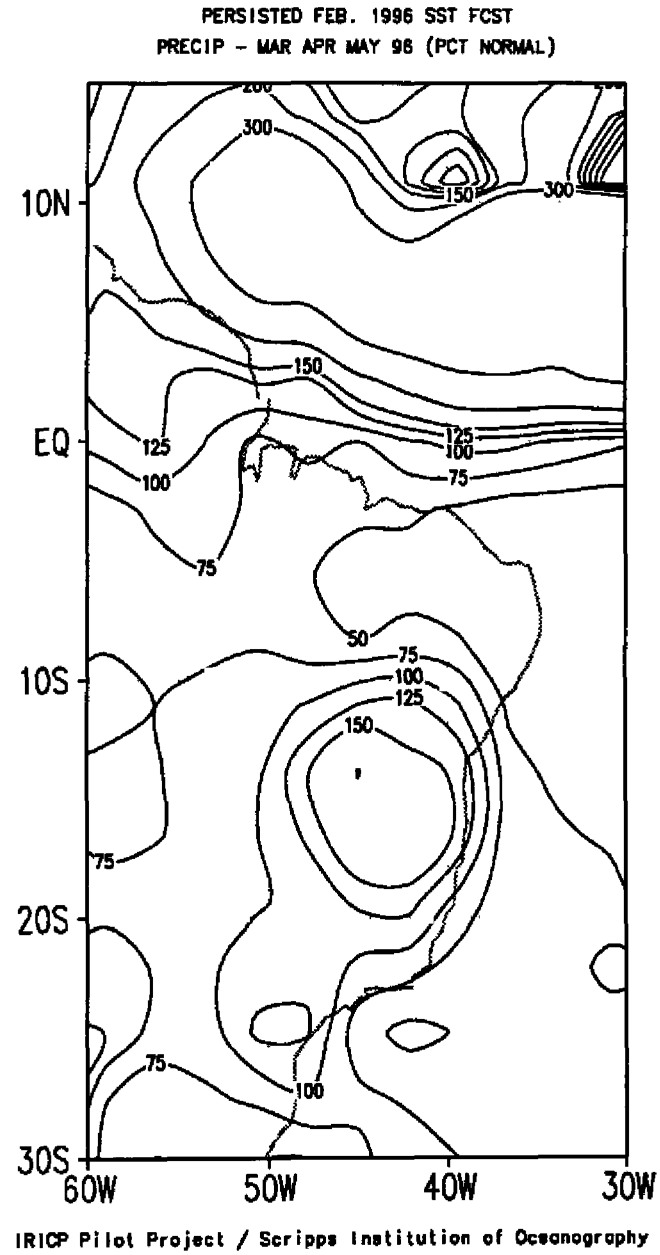
Fig. 2 shows a similarly derived forecast using February 1996 SSTs to make a prediction for Mar-Apr-May 1996. The distribution of predicted precipitation is similar to that for Feb-Mar-Apr, suggesting that any May precipitation will not greatly alter the wet season totals.

Forecasts such as these have proven very useful to regional agencies (e.g. FUNCEME in the state of Ceara) responsible for managing water resources and for providing crop selection and planting guidance. For example, based on a forecast of continued severe drought in 1993, construction of hydrologic facilities was instituted that prevented severe water shortages later in the year. In 1994, a forecast of normal to slightly wetter than normal conditions allowed agricultural managers to devise a planting strategy that resulted in record agricultural production in the state of Ceara.

Ward, M.N. and C.K. Folland, 1991: Prediction of seasonal rainfall in the North Nordeste of Brazil using eigenvectors of sea surface temperature. *Int. J. Climatol.*, **11**, 711-743.

Hastenrath, S. and L. Greischar, 1993: Further work on the prediction of northeast Brazil rainfall anomalies. *J. Climate*, **6**, 743-758.

Graham, N.E., 1994: Experimental predictions of wet season precipitation in northeastern Brazil. *Proceedings of the 18th Annual Climate Diagnostics Workshop*, Boulder, Colorado, November 1-5, 1993, 378-381.



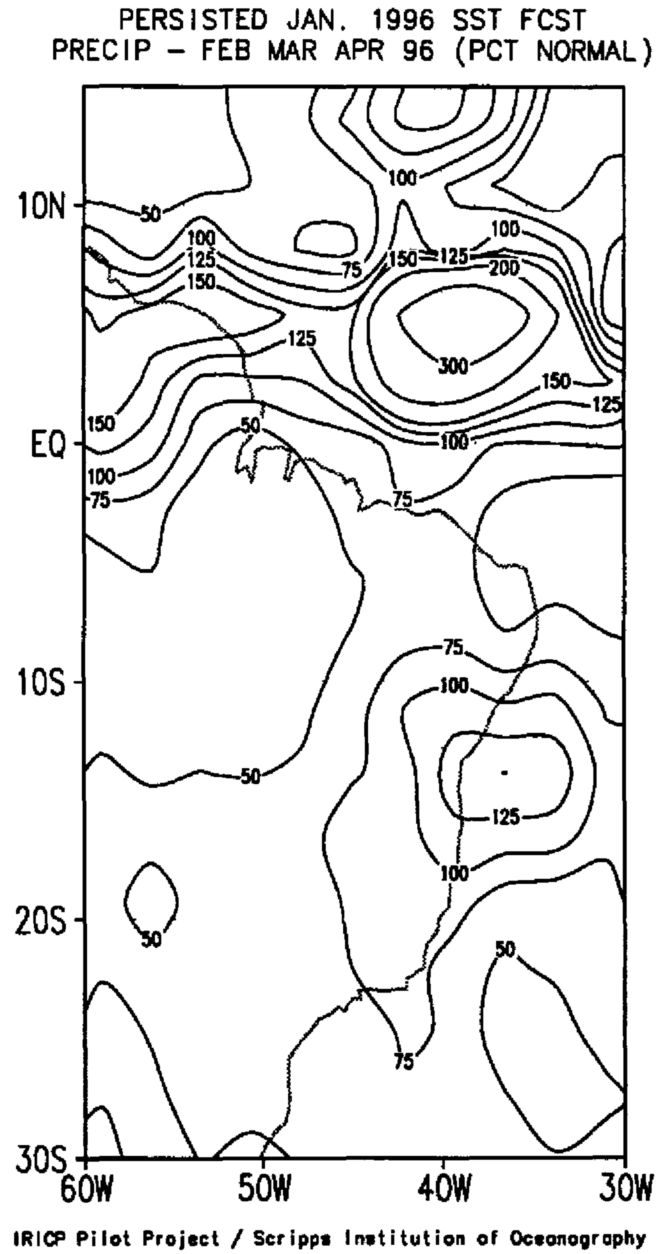


Fig. 1 *ECHAM3.2 atmospheric GCM precipitation forecast for vicinity of northeastern Africa for Feb–Mar–Apr1996, based on persisted January 1996 SST anomaly field. The forecast is the mean of six ensemble members. The forecast is expressed in terms of percentage of normal.*

Fig. 2 *As in Fig. 1, except for Mar–Apr–May 1996 based on persisted February 1996 SST anomaly field.*

Forecasts of Tropical Pacific SST Using a Comprehensive Coupled Ocean-Atmosphere Dynamical Model

contributed by Ming Ji and Ants Leetmaa

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A non-simple coupled ocean-atmosphere model has been developed for use for long-lead climate forecasts in the Coupled Model Project at NOAA's National Centers for Environmental Prediction (Ji et al. 1994a,b). The NCEP Medium Range Forecast (MRF) atmospheric model is used with a dynamic Pacific Basin ocean model originated at the Geophysical Fluid Dynamics Laboratory. The MRF has a reduced spatial resolution and is tuned for more realistic tropical circulation. The ocean thermal field, including SST and subsurface temperature, is initialized using an ocean data assimilation system (Ji et al. 1995) Research has shown that when observed SST fields are prescribed, this coupled model's atmospheric response is fairly reliable in the tropics but considerably less so in the extratropics. The extratropical response is best during the warm or cold phase of ENSO as reflected in the SST. Much attention has in fact been given to the prediction of ENSO itself--the tropical Pacific SST anomaly. Such a forecast is presented here.

In the September and December 1993 issues of this Bulletin, the expected forecast skill of the coupled model version used in 1993 (called CMP6) was shown. A tendency for a horseshoe-shaped spatial pattern of maximum model skill was noted, with highest equatorial skill near the date line and higher skill just north or south of the equator than immediately along it to the east of 165°W. Mean skill for the Nino 3 and Nino 4 regions was shown as a function of season and lead time. The model generally outperformed persistence by a substantial margin. A seasonal dependence in skill was noted, where forecasts were affected by a "spring barrier" as found both in other dynamical as well as statistical predictive models.

Starting with the forecasts presented in the September 1994 issue, the NCEP coupled model was upgraded in several ways, including a refinement of the flux climatology and the installation of a MOS correction for the stress anomalies produced by the atmospheric model. Thus, skills became higher than those cited above; e.g. the high skill horseshoe "thickened" along the equator, extending farther eastward into the western part of the Niño 3 region. Figures 2-1 and 2-2 of the September 1994 issue show a comparison of hindcast skills between the newer (called CMP9) and the previous model versions as a function of lead time for Niño 3 and Niño 4, respectively.

During the last few months, a still newer version of the NCEP model has been developed, called CMP10 (Ji et al. 1996). A major difference between CMP9 and CMP10 is in the heat flux coupling: CMP9 contained a negative feedback procedure for coupling the anomalous net heat flux, while CMP10 uses anomaly coupling for the net heat flux forcing. While mean skills are not as different between CMP9 and CMP10 as they are for CMP6 and CMP9. CMP10 behaves more realistically for high amplitude SST anomalies. CMP9, with its negative feedback mechanism, ran the danger of damping strong ENSO events too much and/or too soon.

The CMP9 and CMP10 coupled model forecasts for the SST anomaly field averaged over Mar-Apr-May 1996 (no lead), Jun-Jul-Aug 1996 (3 months lead) and Sep-Oct-Nov 1996 (6 months lead) are shown in Fig. 1, where the systematic model bias for hindcasts over the 1983-95 period has been subtracted. This forecast is actually the mean of an ensemble of 7 to 11 individual cases, each based on a different one- to two-week-apart initial ocean condition ranging from early January through early March, 1996. The CMP9 and CMP10 forecasts are similar, indicating some weakening and meridional narrowing of the present cool equatorial anomalies. Near dissipation of the cold episode is implied going into winter 1996-97. Fig. 2 shows the Nino 3 forecast in the form of a time series for the three lead times used to form the 3-month forecast averages used in Fig. 1 for both versions of the model.

The observed anomalous SST and subsurface equatorial temperature field for the week centered on February 28 (Fig. 3) include a region of negative subsurface sea temperature anomalies in the central and especially the eastern tropical Pacific Basin. Positive subsurface anomalies appear in the western Pacific, which may presage a return to warm conditions farther east at the surface in 12-18 months (Smith et al. 1995).

Ji, M., A. Kumar and A. Leetmaa, 1994a: A multi-season climate forecast system at the National Meteorological Center. *Bull. Am. Meteor. Soc.*, **75**, 569-577.

Ji, M., A. Kumar and A. Leetmaa, 1994b: An experimental coupled forecast system at the National Meteorological Center: Some early results. *Tellus*, **46A**, 398-418.

Ji, M., A. Leetmaa and J. Derber, 1995: An ocean analysis system for seasonal to interannual climate studies. *Mon. Wea.* Rev., **123**, 460-481.

Ji, M., A. Leetmaa and V.E. Kousky, 1996: Coupled model forecasts of ENSO during the 1980s and 1990s at the National Meteorological Center. *J. Climate*, 9, submitted.

Smith, T.M., A. G. Barnston, M. Ji and M. Chelliah, 1995: The impact of Pacific Ocean subsurface data on operational prediction of tropical Pacific SST at the NCEP. *Wea. Forecasting*, **10**, 708-714.

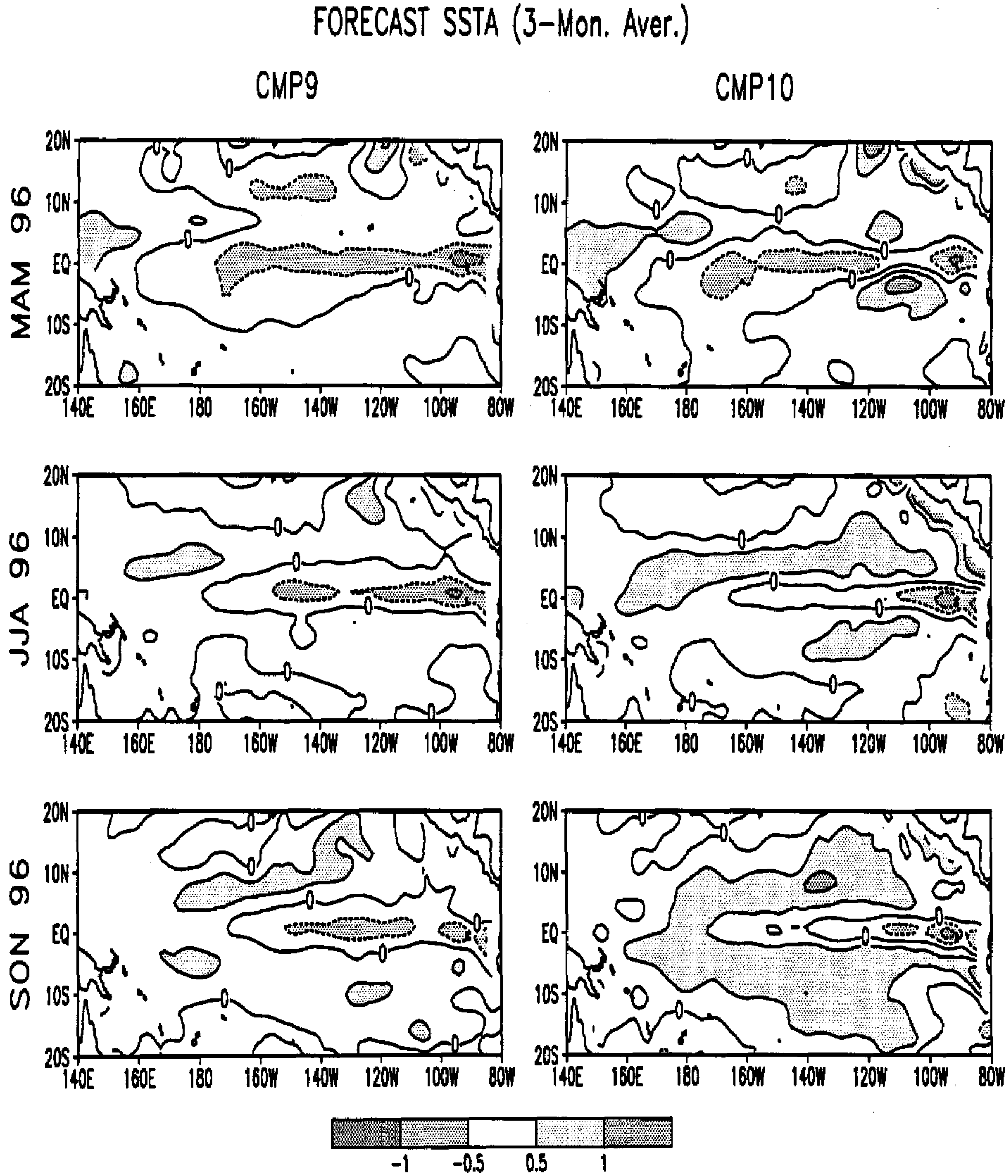

Fig. 1. *NCEP (formerly NMC) coupled model SST anomaly forecast fields for Mar–Apr–May, Jun–Jul–Aug, and Sep–Oct–Nov 1996. Each forecast is an average of three individual month ensemble averages, which in turn are composed of 2 to 4 individual forecasts from 1 to 2–week–apart initial SST conditions. Forecasts from both the CMP9 and CMP10 are shown.*

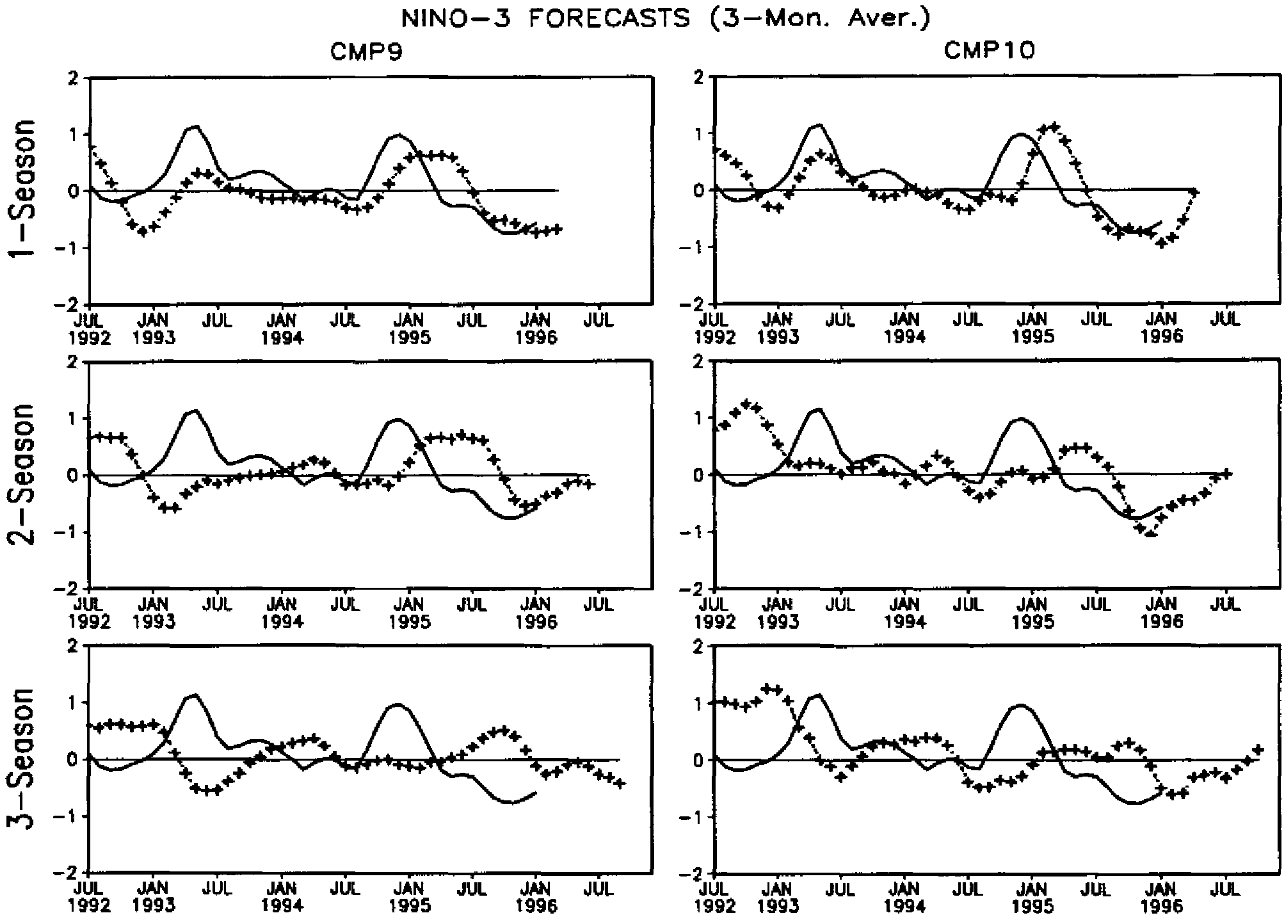

Fig. 2. *NCEP coupled model SST anomaly forecast time series for Niño 3 for Mar–Apr–May, Jun–Jul–Aug, and Sep–Oct–Nov 1996, as well as intermediate 3–month periods at 1–month increments. The broken line in each panel represents the SST anomaly forecast (°C), and the solid line the observed SST anomaly. The predictions represent the mean of three ensemble mean forecasts, each for one of the 3 most recent months, produced by forecasts from two to three individual 1 to 2–week–apart initial conditions per month.*

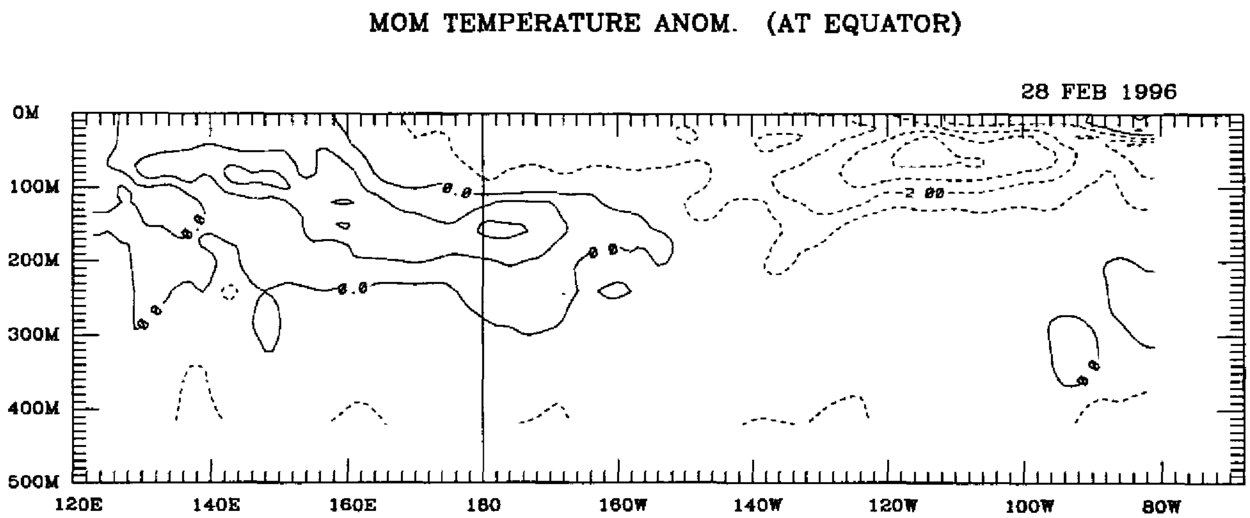

Fig. 3. *Equatorial depth–longitude section of ocean temperature anomaly with respect to the 1983–92 mean for the week centered on February 28, 1996.*