FORECAST SKILL OF THE NMC GLOBAL MODEL IN THE TROPICS

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ABSTRACT

In support of a newly established International Desk at the United States' National Meteorological Center and in order to improve model guidance for tropical forecasters, a joint project between the National Hurricane Center and the Development Division has investigated the performance of the NMC global analysis/forecast system in the tropics. The analysis system captures most easterly waves and produces realistic large-scale precipitation patterns. Forecasts of tropical winds have skill out to at least 4 days at upper levels and at least 3 days at lower levels; skill is less near the equator than near the subtropics. The analyses and forecasts handle well midlatitude systems moving into the tropics.

1. The Caribbean desk

The United States' National Meteorological Center (NMC) established an International desk in spring 1993. Forecasters from Caribbean and South American countries visit NMC for several months and issue daily discussions of numerical model guidance for the Caribbean and South America. Such visits give the visiting forecasters exposure to and experience in the use of sophisticated model guidance, give NMC forecasters exposure to and experience in forecasting tropical weather, and accelerate NMC model developers' exposure to model performance and model problems in the tropics and Southern Hemisphere. The visiting forecasters also have access to and use forecasts from the European Centre for Medium-Range Weather Forecasts and the United Kingdom Meteorological Office. The International desk is currently in the Meteorological Operations Division in Washington; it is planned to move the desk to the National Hurricane Center in Miami.

In support of the Caribbean desk and in order to improve the model guidance available to the National Hurricane Center (NHC), NMC has begun a cooperative effort between the Development Division and NHC to examine the performance of the NMC global model in the tropics. A workshop on tropical analysis and prediction was held in Miami during April 1993, joint papers have been presented and NHC now has better access to global model products.

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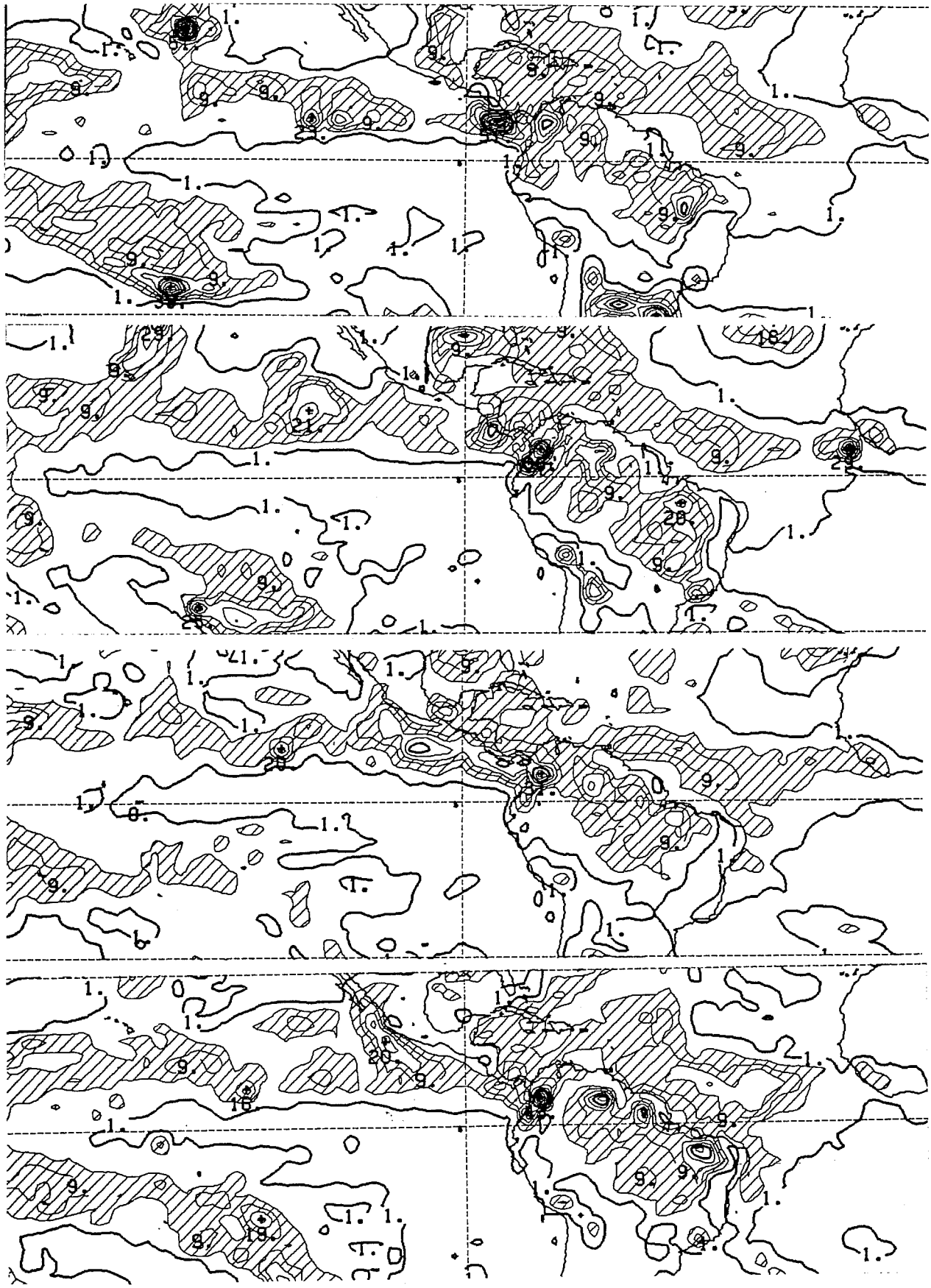


Fig. 1. Five-day mean rainfall over the Western Hemisphere tropics from 0-6 hour forecasts in the NMC operational global data assimilation system (GDAS) for (from the top) Oct. 18-22, Oct. 23-27, Oct. 28-Nov. 1, and Nov. 2-6. 1993. Contour interval 4 mm/day, beginning at 1 mm/day; amounts from 5 to 13 mm/day are shaded.

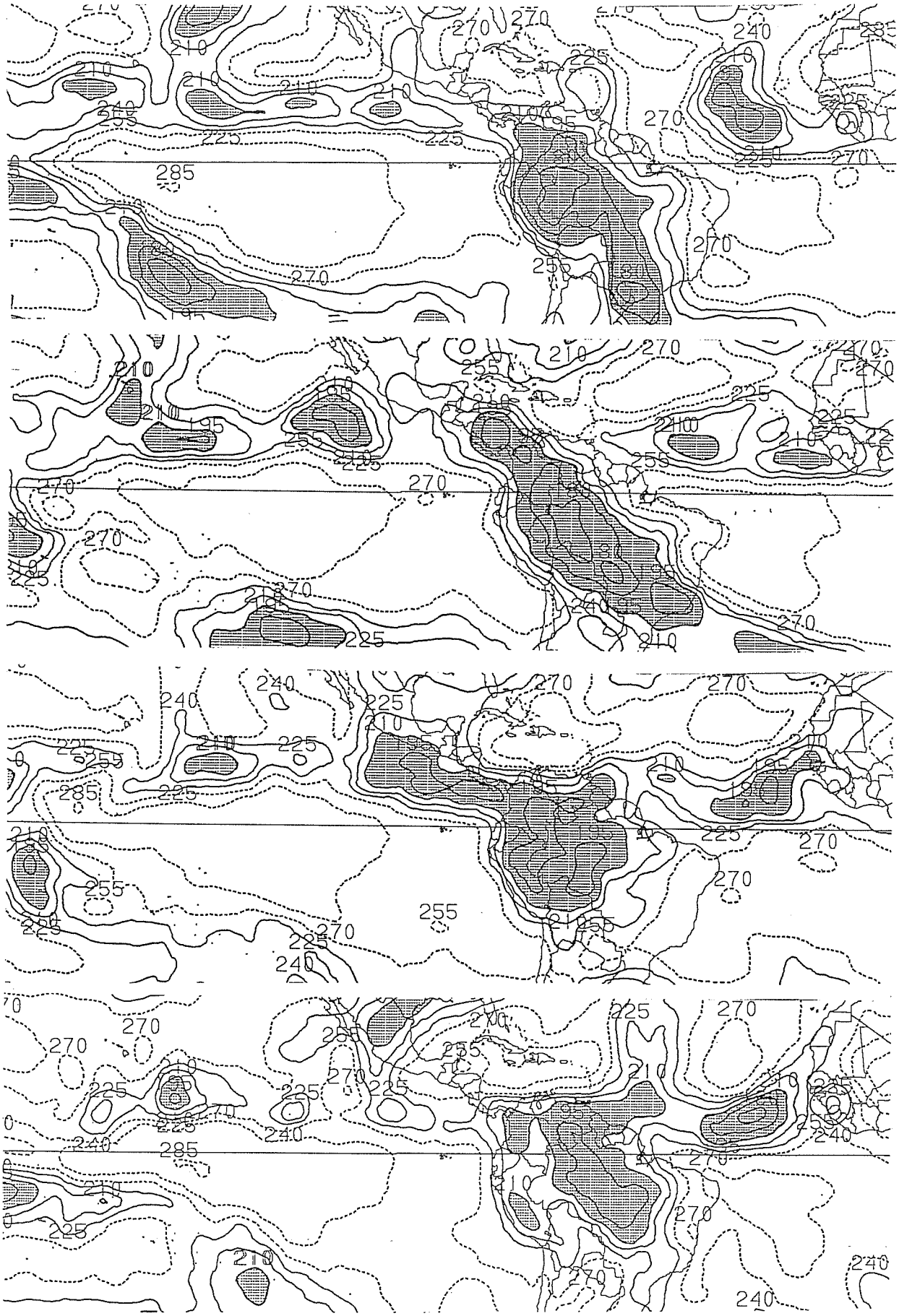


Fig. 2. As in Fig. 1, except that five-day mean outgoing longwave radiation from satellite observations is shown (courtesy of NMC Climate Analysis Center). Contour interval 15 Watts/m^2; values less than 210 Watts/m^2 are shaded.

2. Tropical analyses and precipitation

Since the tropics have far fewer rawinsondes than the Northern Hemisphere midlatitudes and tropical disturbances are often weaker than midlatitude disturbances, the quality of NMC tropical analyses needs to be assessed. Thiao (private communication) has shown that the NMC global analysis/forecast system is able to initialize and forecast the movement of easterly waves over North Africa and the west Atlantic during summer.

Figs. 1 and 2 compare time-mean precipitation from the NMC analysis cycle with satellite-observed outgoing longwave radiation (OLR) for four successive five-day periods. The model precipitation shows in general good agreement with areas of low OLR, where low cloud-top temperatures imply deep convection. Changes in the two fields correlate reasonably well. Problems with precipitation, for example over Brazil, can be seen, but the similarity indicates that NMC analyses assimilate enough data to capture realistically the 5-day mean divergent flow in the tropics.

Fig. 3 compares longitude-time diagrams of precipitation estimates derived from GOES-West satellite observations of cloud-top temperatures (left) with model-based precipitation at 15N in Sept. 1993. (Note that different contour intervals are used in the satellite and model precipitation estimates.) While the precipitation from NMC analyses (center) is noisier than the precipitation index, most of the westward propagating features in the precipitation index also appear in the model analyses. Many also appear in the 1-2 day forecasts (right). The model does less well with standing oscillations in precipitation over tropical continents. Differences between model precipitation and independent satellite-derived estimates of precipitation reflect problems in the model physics and errors in the independent estimates as well as errors in the analysed winds. These results indicate that the NMC global system has skill in analyzing and forecasting easterly waves.

3. Tropical skill

Fig. 4 shows differences between NMC analyses and forecasts and rawinsonde observations. The differences between the observations and the analyses reflect analysis error as well as instrument errors and that part of the observations that are not resolved by the model. In both hemispheres the day 1 error versus observations is considerably larger than the initial difference, indicating that the observations have considerable influence on the analysis. The growth of the error versus observations with forecast length through 5 days implies that the model error is still growing and that the model still has some skill even in 5 day forecasts. The

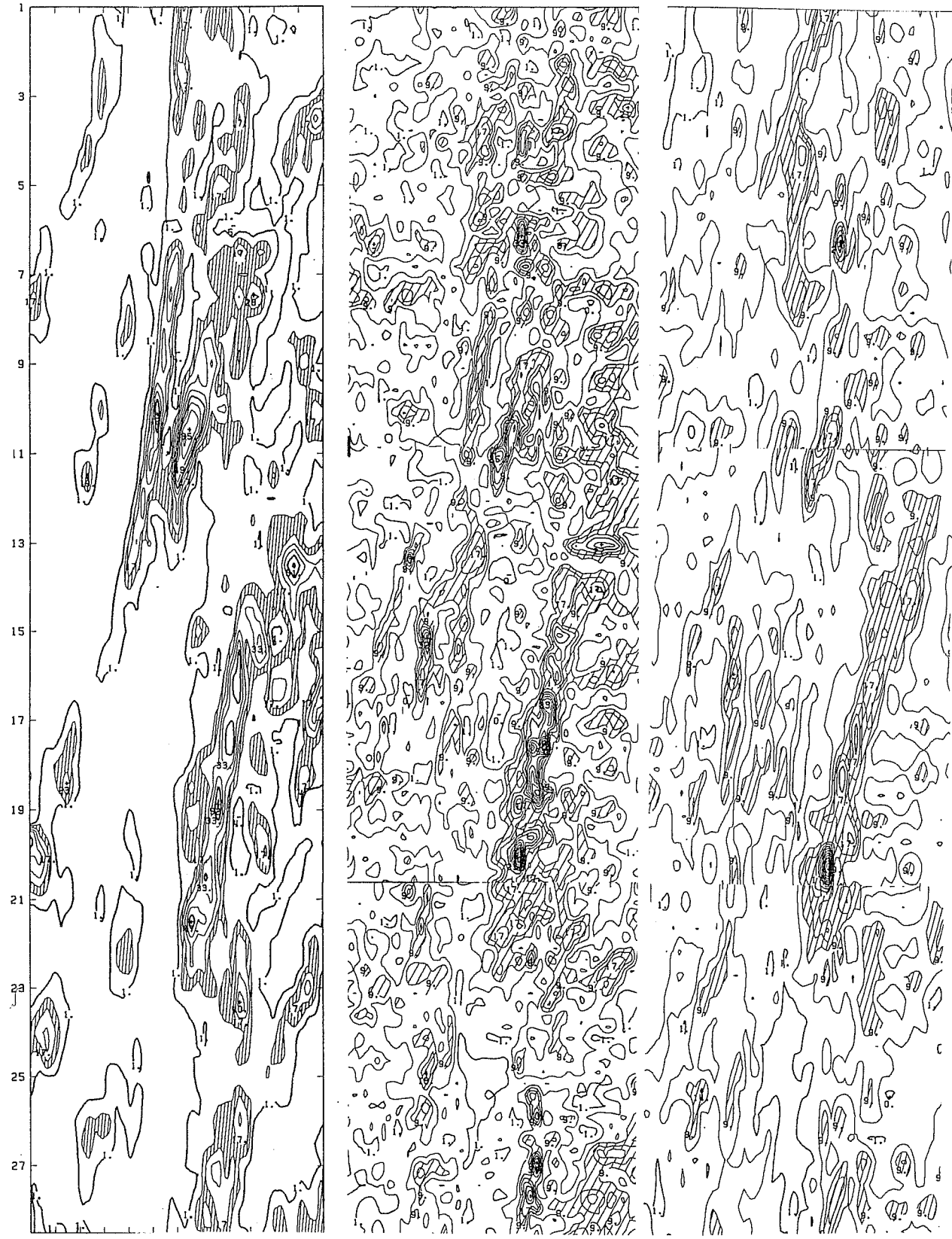


Fig. 3. Longitude-time plots of (left) precipitation index estimates of rainfall rates every 12 hours, (center) rainfall rates from 0-6 hr hr forecasts in the NMC GDAS every 6 hours, and (right) rainfall rates from 24-48 hr forecasts from the NMC global operational model every 12 hours for Sept. 1-28, 1993 for the region 12.5-17.5 N. The longitudinal extent of the plots is from 170W on the left to 50W on the right. Contour intervals (left) 8 mm/day, beginning at 1 mm/day; values between 9 and 17 mm/day are shaded. Contour intervals (center and right) 4 mm/day, beginning at 1 mm/day; values between 9 and 17 mm/day shaded.

plots show a significant growth of model error in the first 24 hours.

The above results indicate that NMC tropical analyses are realistic enough to serve as a valid verification of tropical forecasts. Fig. 5 shows such a verification of 850 and 250 mb wind forecasts compared to the skill of a forecast based strictly on climatology. Two-day forecasts of tropical winds have as much skill as three-day forecasts in the Northern Hemisphere midlatitudes. Skill is less at 850 mb than at 250 mb and is less near the equator than it is near 20N or 20S. Fig. 6 shows the skill of daily 4-day forecasts of 250 mb winds and the skill of climatology. While the difference is small compared to the total error, in only a very few cases are the four-day forecasts worse than climatology. In cases of highly anomalous flow, the difference between day 4 and climatology increases significantly.

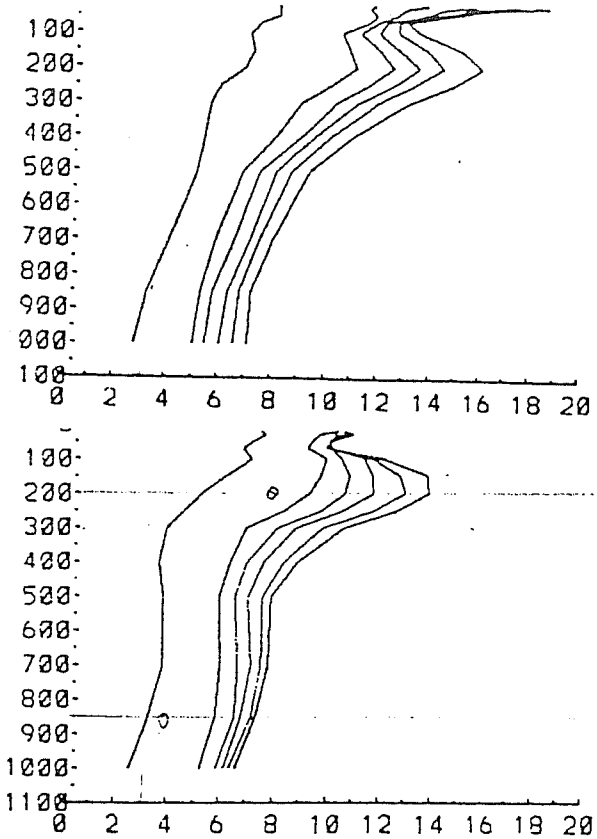
4. Hovmoller plots of v

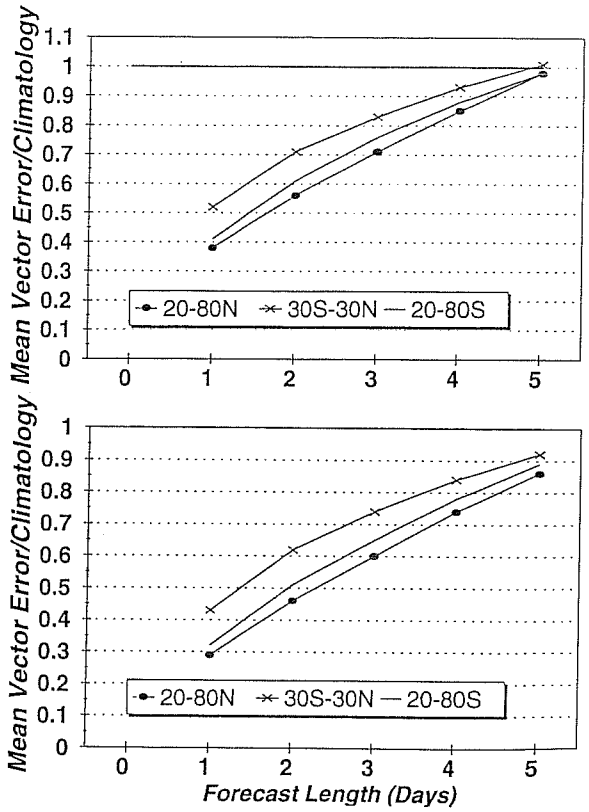
Fig. 7 compares longitude-time diagrams of meridional wind (v) from daily 3-day forecasts and from the verifying analyses for different latitudes, seasons, and levels. At 20 N in Feb. (left) the 200 mb flow shows individual systems propagating eastward, a case of strong downstream development on Feb. 9 and the longer waves propagating slowly westward. The three-day forecasts realistically portray all these, although some mistakes in amplitude can be seen. The evident skill reflects in part the presence of strong midlatitude disturbances. At the equator in Feb. (center) the forecasts perform less well on smaller-scale features, but do predict most features, at least qualitatively. The larger-scale waves in particular appear to be well forecast. At both 20 N and the equator the three-day forecasts display excellent continuity from day to day. Three-day forecasts of 850 mb v for Sept. at 15N (right) do forecast the movement of most easterly waves with some skill, but miss intense features (Hurricanes Kenneth and Lidia) near 105W on Sept. 11. Three-day 850 mb forecasts have less continuity between 180 and 100W over the east Pacific than elsewhere, especially during Sept. 1-15.

5. Conclusions

NMC tropical analyses capture most tropical planetary-scale features quite realistically and also contain many realistic synoptic-scale features. Experience suggests that experienced tropical forecasters can improve upon the model guidance in the analysis as well as the forecast of tropical weather. The NMC model performs well with midlatitude systems that penetrate the tropics and has skill in analysing and forecasting easterly waves.

Acknowledgments. J. Gross of NHC contributed substantially to the success of this project. We also thank Ron McPherson and Eugenia Kalnay for their encouragement and support.





(left) Fig. 4. The RMS vector difference between NMC global analyses and forecasts and rawinsonde observations of winds during the period Dec. 29, 1992-Feb. 19, 1993 for (top) 0-30N and (bottom) 0-30S. The first curve on the left is the difference of the analyses from the rawinsondes, successive curves on the right are the verification of 1 day, 2 day, 3 day, 4 day and 5 day forecasts against the rawinsondes. The horizonal axis is in m/s.

(right) Fig. 5. The skill of daily NMC global model (top) 850 mb and (bottom) 250 mb wind forecasts in the tropics and extratropics averaged over Apr. 15, 1993-Jan. 5, 1994 as measured by mean vector error normalized by the mean vector error of climatology. The forecasts are verified against NMC global analyses.

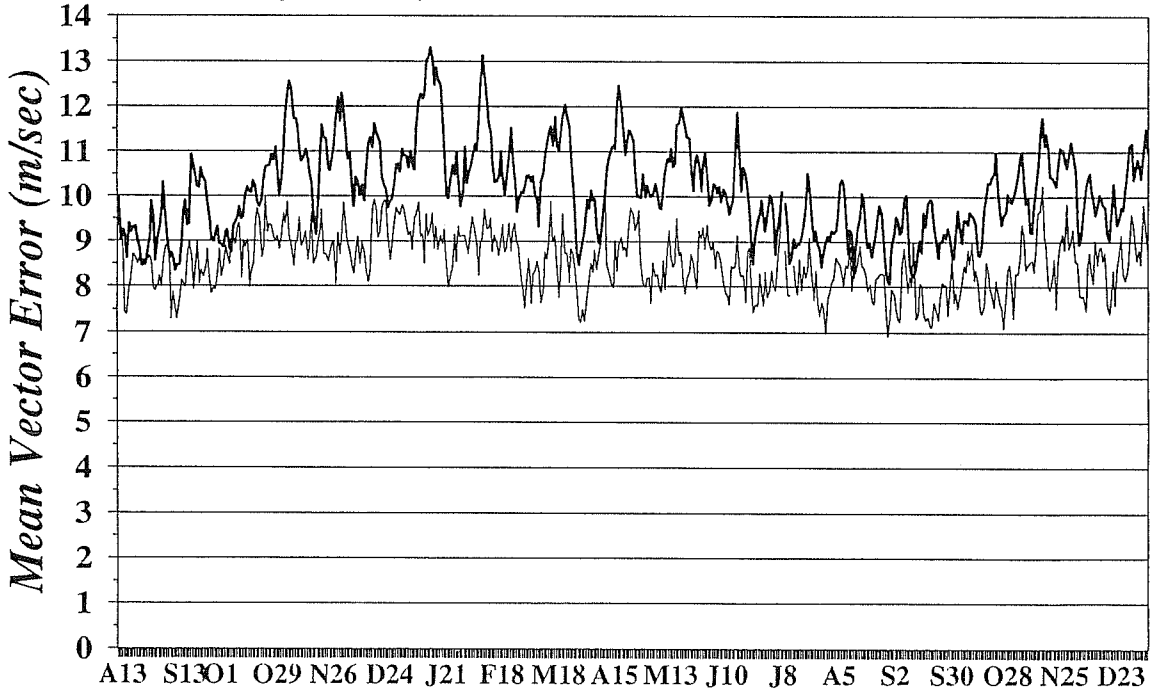


Fig. 6. The daily mean vector error of 4-day forecasts (light line) of 250 mb wind by the NMC global model and of climatology (heavy line) for 30S-30N during the period Aug. 11, 1992- Jan. 5, 1994.

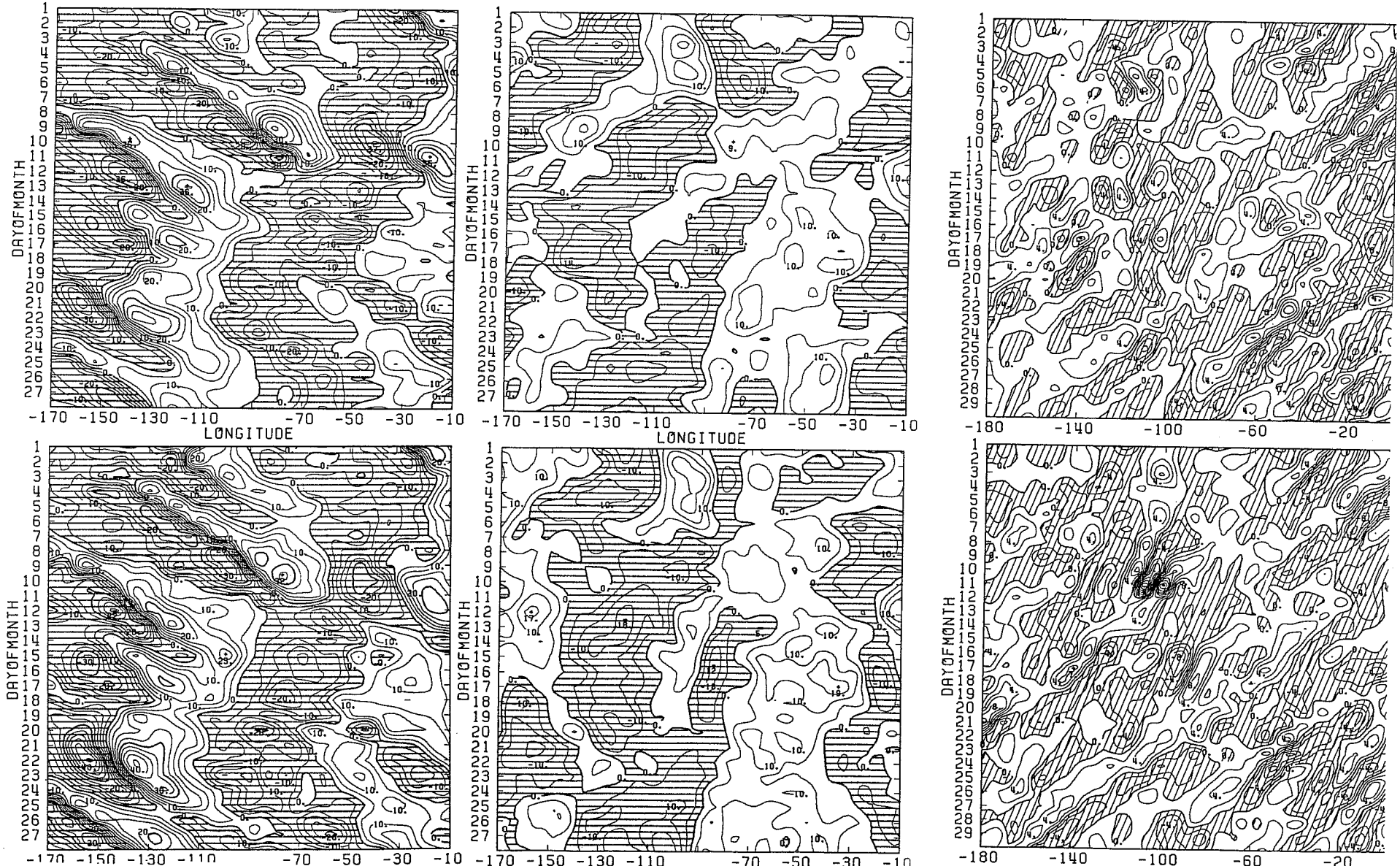


Fig. 7. Longitude-time plots of daily 3-day forecasts (top) and analyses (bottom) of the 250 mb meridional wind by the NMC global analysis/forecast system for Feb. 1993 at 20N (left) and the equator (center) and (right) the 850 mb meridional wind for Sept. 1993 at 15N for the western hemisphere. Contour interval 5 m/s. Shading denotes northerlies.