A Case Study of the Intertropical Convergence Zone

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USS Yorktown (CVS-10)

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1. Introduction

Had it not been for the splashdown of Apollo 8 on the northern fringes of the Intertropical Convergence

Zone (ITCZ), television viewers throughout the world might never have viewed the beauty of a tropical sunrise. As seen in color, the skies of the ITCZ presented

a spectacular setting for the dramatic return of the astronauts to earth after their historic lunar orbit. Even so, it is highly improbable that any of the TV audience that day recognized the background as perhaps one of the last frontiers of tropical meteorology.

It is accepted that the ITCZ tends to be in the region of convergence between the northeasterly winds of the Northern Hemisphere and the southeasterly trades of the Southern Hemisphere. With geography and commerce as it is today, the ITCZ presents a minimal weather problem to the world as it undulates about the equator. Few shipping lanes cross this line, and only a few island weather stations are in the path of the ITCZ, particularly in the mid-Pacific. Due to the paucity of data, and the lack of economic or social pressure for a determined analytic effort, little has been done on the study of the ITCZ. Scientific interest does exist, however, as indicated by the "Line Islands Experiment" conducted in early 1967. Supported by the National Science Foundation, and coordinated by the National Center for Atmospheric Research, a two-month study of the Intertropical Convergence Zone was conducted. Occasionally, additional data are acquired, as was the case with the Lunar Orbiting Mission. It happened that the Pacific Recovery Zone for the end of the December 1968 project was in the equatorial belt, just north of the climatological mean position of the ITCZ, according to the records of the Fleet Weather Central at Pearl Harbor.

2. The ITCZ

While awaiting the return of astronauts Borman, Lovell and Anders, the prime recovery ship *USS Yorktown (CVS-10)*, was assigned to a nearly stationary position at 7N and 165W during the period 23–27 December 1968. This location was initially in the northern fringes of the ITCZ, but during the time on station the system moved northward, and the ship briefly operated just to the south of the ITCZ. This particular movement of the ITCZ appears to be well substantiated not only by observed weather, but also by the cloud patterns detected by the ESSA satellite, as depicted in Fig. 1.

Prior to passage of the ITCZ, the ship experienced variable cloudiness and scattered showers normally expected along the northern periphery of the system. Shower activity was at a maximum in the early morning hours, diminishing about 2 hr after sunrise. During the period of maximum precipitation it was estimated that cumulus cloud tops averaged between 12,000 and 14,000 ft, although isolated buildups to 20,000 feet were in evidence. By midday the predominant clouds were altocumulus, based between 8000 and 10,000 ft, with lower scattered cumulus at 1500–2000 ft with tops to 3000–4000 feet. Typical of the latitude, the air temperature ranged from 78–82F. Sea surface temperatures were near a constant 82F, reaching 83F on only one

FIG. 1. Copy of cloud coverage depicted by ESSA satellite. Original photograph was transmitted by facsimile from the Fleet Weather Central, Pearl Harbor.

occasion. It was interesting to note the relationship of the warm sea surface on cloud development. As the air temperature gradually decreased in the late afternoon and the sea-air temperature differential became more pronounced, marked vertical development commenced in the cumuliform clouds. By 2000 local time, scattered rain shower activity was not uncommon. Although probably not singly responsible for the enhancement of the cumulus, the ensuing cloud development was interesting to observe. Throughout the day, the winds were a persistent east-northeasterly, averaging from 14–18 kt.

The northward passage of the Intertropical Convergence Zone was accompanied by a brief display of cloud-to-cloud lightning. South of the ITCZ the weather regime abruptly changed; sky conditions became scattered, and the mercury reached an "all cruise" high of 88F. In addition, the winds dropped off to light and variable, tending to a southerly component. The sea was characterized by an easterly swell of 3–4 ft. Interestingly enough, there was no extreme drop in pressure, and in general, the weather conditions could be described as pleasant. Within 24 hr the clouds and showers of the ITCZ slipped quietly southward, without benefit of lightning, and the *USS Yorktown* again found herself steaming under the northern fringes of the system.

3. Analysis of movement

The existence of the ITCZ is well supported, and is graphically documented by satellite photographs. However, the explanation for the latitudinal movements has not been completely resolved. In view of the fact that there were no locally apparent causes of the northward migration of the ITCZ as experienced by the *Yorktown*, it is suggested that dynamic external forces were in operation. In view of the following analysis it appears that impetus for movement can be attributed to a deepening low centered at 36N, 167W, as depicted in Fig. 2.

FIG. 2. Surface analysis for 1200 GMT 24 December 1968. The ITCZ is located to the south of 10°N.

Fig. 3 is an analysis of the mean sea level pressure from 10–25°N, along 165°W longitude, for the period 23–27 December. The key point of this analysis is the reversal of the pressure gradient during the period

0000–1200 GMT 24 December. The pressure field is such that lower pressures are observed at higher latitudes than in the lower latitudes. This condition prevailed for less than 12 hr when the pressure gradient returned to the normal state. Data employed in Fig. 3 are derived from locally prepared shipboard analysis and from the surface analysis transmitted by facsimile by the Fleet Weather Central at Pearl Harbor.

The weather of 23–27 December 1968 is depicted in Fig. 4. It can be seen in the plot of the various parameters that pressure is the least obvious of all elements in detecting the movement of the ITCZ. The most conspicuous indicator of change is the surface wind field which experienced a near complete reversal, along with a marked decrease in speed. Temperature appears to provide a reasonable indicator of a change in environmental status, although the increase in temperature is relatively modest. Observed sky conditions were so variable that their use as a single indicator of the ITCZ moving is very limited. Used in conjunction with other observed conditions, however, it becomes a usable tool.

Radiosondes taken by the *Yorktown* provided the data for Fig. 5. The diagram shows that the changes in the thermal structure were in general relatively discrete, except for the period from 25–26 December when mild warming at all levels followed by pronounced cooling took place. At about this time a 500-mb streamline analysis facsimile chart for 0000 GMT 26 December transmitted by the Fleet Weather Central Pearl Harbor was received which depicted a trough penetrating the tropics to 10°N along 165°W.

4. Conclusion

It is suggested that the trough aloft associated with the surface low depicted in Fig. 2 is reflected in the

FIG. 3. Time cross section of the pressure field for the period 23–26 December 1968 from 10–25°N along longitude line 165°W.

FIG. 4. Weather conditions observed by the *USS Yorktown* from 23-26 December 1968 while at 7°N.

FIG. 5. Vertical time cross section of the atmosphere as determined by radiosondes launched from the *USS Yorktown*.

25–26 December portions of the cross sections of Fig. 5, which would signify that the trough aloft extended as far south as 7N. This view is also supported by the cloud patterns of Fig. 1. The correlation between the pressure field (Fig. 3) and the observed ship's surface weather (Fig. 4) seemingly indicates a direct relationship between dynamic midlatitude low-pressure systems and relative movement of the ITCZ. In this case study it appears that the ITCZ was drawn northward from what

is normally considered the mean position. From this relationship it is inferred that the degree of northward movement of the ITCZ is proportional to the intensity of the influencing midlatitude cyclone. Because of the magnitude of the dynamics involved, it is reasonable that the northward movement of the ITCZ would most likely be limited to the winter months when barotropic systems tend to develop and persist at more southerly latitudes.