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SOME EMPIRICAL RULES FOR FORECASTING FOG AND STRATUS OVER NORTHERN FLORIDA, SOUTHERN GEORGIA AND ADJACENT COASTAL WATERS

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Editor's Note

This report, by an operational forecaster with considerable experience in aviation-related weather problems, typifies the original intent of the Regional Technical Memorandum series. That is, to provide an informal medium for the documentation and quick dissemination of results not necessarily appropriate for more formal publication. Technical Memoranda are a means for describing technical procedures and practices which may be of limited applicability, but nonetheless valuable. We encourage greater participation in this series by field forecasters as a means of sharing significant techniques and valuable experience.

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I. SEA FOG AND STRATUS NEAR THE NORTHWEST FLORIDA COAST

When forecasting the occurrence of sea fog over the eastern Gulf of Mexico and adjacent coastal sections, satellite imagery has proven to be one of the most useful tools available. This is especially true in the absence of either direct visual observations, or reports from boaters and pilots, that sea fog is present or is forming offshore. Since sea fog tends to persist offshore throughout the daylight hours and, in most instances, is easily detectable on presently available satellite pictures, we rely heavily on this tool at the Miami WSFO. Therefore, when sea fog is known to be offshore, it can be expected to move rapidly inland soon after sunset, or even earlier, as the land surface temperatures decrease, if the low-level wind has an onshore component (southerly in the case of the Florida panhandle). Even if the low-level winds are light and variable or calm - with no apparent on shore component - there is a likelihood of fog forming inland during the night when sea fog is present offshore. However, it usually forms several hours later than when there is an onshore wind component. The exceptions would be those cases during which there is advection of drier air from the north near the surface, or when radiational cooling is inhibited by a cloud cover aloft at night.

In some instances, sea fog and ground fog (due to radiational cooling) form simultaneously at night. However, the ground fog will usually dissipate after sunrise but the sea fog will persist offshore. It may even persist along the coast if there is a sufficient onshore wind component, or if there is sufficient cloud cover aloft to inhibit surface heating and burnoff. Under other conditions, such as sufficient surface heating to cause burnoff, and/or an offshore wind component, sea fog may recede several miles offshore - even beyond the horizon. Nevertheless, as the ground cools and the surface winds diminish after sunset, fog is likely to develop inland again.

Satellite imagery has shown that sea fog tends to form along or behind slow moving cold fronts during the late fall and winter months. This is primarily true after a succession of cold fronts have moved into the northern Gulf of Mexico within a relatively short period of time. These successive invasions of cold arctic or polar air may eventually lower the underlying water temperature by several degrees. Subsequently, evaporation from the sea surface saturates the overlying cold air near the surface along and behind the front. Sea fog is the result.

In some instances, the fog will form and move southward with the front into the southeastern Gulf of Mexico. In other instances, the fog will remain about stationary in the region that it formed, and will remain independent of the frontal movement. This is apparently related to the sea surface temperature and the overlying air dew point temperature. The fog will persist or advect into regions in which the sea surface temperature is equal to or nearly equal to the air dew point temperature. At any rate, in the latter case, sea fog should be forecast to move inland when the winds are favorable for onshore advection. Even when the wind component is not onshore, and there is no dry air advection or cloud cover, there seems to be a strong positive correlation between ground fog formation at night and the presence of sea fog offshore. It should be forecast in those situations.

Sometimes sea fog formation in the northeast Gulf of Mexico is not directly related to a recent cold frontal passage. During the winter or late fall, after a series of cold outbreaks over the northeast Gulf of Mexico, the water temperature may be lowered several degrees. After this has happened, occasionally, a synoptic flow pattern which advects warm, moist air from the southeast Gulf, or even the northwest Caribbean, into the northeast Gulf and over Florida (See Fig. 1). The dew points of this warm, moist air can be equal to or higher than the sea surface and land temperatures. When this is the case, sea fog and stratus are likely to form over the northeast Gulf of Mexico. Also, fog and stratus are likely to form over Florida during the night, especially over the central and northern sections. In fact, the entire state, as well as southern Georgia, may experience fog and stratus under these conditions.

Burnoff usually occurs over land by late morning or early afternoon. Offshore, complete burnoff sometimes does not occur. Therefore, fog and stratus are likely to move inland again soon after sunset where the onshore wind component is favorable. Advection coupled with radiational cooling after dark may spread fog and stratus over Florida, southern Georgia and the northeast Gulf of Mexico for several consecutive nights when the above mentioned conditions exist.

With the aid of satellite pictures, another sequence of events has been observed to be involved in the origin of sea fog. Sometimes extensive dense radiational fog forms at night over central and northern Florida while none forms offshore. Around sunrise, as the fog inland begins to burn off, some of it near the west coast of the peninsula is advected offshore into the northeast Gulf by a light east to southeast wind (See Fig. 2). When the dewpoint temperatures in the fog over the peninsula are approximately the same as the water temperature in the Gulf, the fog may persist offshore. Insolation during the day may be insufficient to completely burn off the fog over water. In this situation, the fog (now sea fog) has been observed to advect northwestward during the day and move onshore over the panhandle just after sunset. This, coupled with radiational fog, may completely blanket the panhandle - or all of north Florida and southern Georgia for that matter - with very low ceilings and visibilities during the night.

II. FOG AND STRATUS NEAR FRONTS OR TROUGHS OVER NORTH FLORIDA

Fog and stratus over north Florida appears to be highly correlated with the presence of slow moving or stationary fronts or troughs in the area at night (See Figs. 3 and 4). Usually, the fog and/or stratus form in the vicinity of the frontal zone or trough (both in advance and behind) between midnight and sunrise. It occasionally will form before midnight, especially when considerable rainfall has occurred during the late afternoon and evening, and skies become relatively clear soon after dark. This situation frequently produces very low visibilities and partial or total obscurations in fog before sunrise.

After sunrise, as visibilities begin to improve, definite stratus ceilings frequently develop before burnoff is completed. Usually, burnoff occurs by late morning (around 1500 GMT). If a thick, broken to overcast ceiling (Sc, Ac, As or Cs) develops over the area after the fog and/or stratus have formed, and persists for several hours after sunrise, then burnoff may not occur until early afternoon or later. Therefore, when fronts or troughs, especially slow moving or stationary ones, are expected in or near the forecast area at night, fog and stratus should be forecast.

The amount and extent of the fog and stratus will depend upon several factors. Some of the more prominent factors that must be considered are the moisture content within the frontal zone or trough and of the surrounding air mass over the forecast area, the soil moisture, low-level stability, the presence or absence of inversions, and the low-level winds (velocity and shear). Recent rainfall and saturated soil and air mass conditions correlate well with the occurrence of heavy fog and low stratus. Additionally, local moisture sources, such as rivers, large or numerous lakes, and extensive swampy areas must be considered.

III. STRATUS AND FOG ASSOCIATED WITH ANTICYCLONES OVER THE SOUTHEASTERN UNITED STATES

Whenever a low-level anticyclone or ridge moves into the southeastern United States - especially into northern Georgia or Alabama, eastern Tennessee and/or the western Carolinas - a northeast to east wind pattern is established in the lower 3000 - 5000 feet over southern Georgia and northern Florida (see Fig. 5). As a general rule, the low-level winds are northeasterly near the Atlantic coast and easterly over the Florida panhandle. Also, there usually is an inversion below 6000 feet associated with the ridge. This is a synoptic situation that is frequently favorable for stratus formation, and sometimes for both stratus and fog over southern Georgia and northern Florida. In general, the stronger the winds and/or greater the vertical wind shear below the inversion, and especially below 3000 feet, the higher the cloud base is likely to be and the less likelihood there is for a significant visibility restriction in fog. The weaker the winds are (speed and shear), the lower the cloud base will be, and the greater will be the chance for low visibilities in fog. If the winds gradually decrease, so do the ceilings and visibilities. Very low ceilings and visibilities can occur if the winds weaken enough between sunset and sunrise.

If the winds below 3000 feet remain strong, for instance, 15 to 20 knots, the ceilings usually will not drop below 1000 feet. On the other hand, when the winds decrease to less than 15 knots, ceilings may drop below 1000 feet. With winds around 10 knots or less, ceilings below 500 feet are likely and visibilities may be reduced to below 1 mile. It is not uncommon for ceilings and visibilities to lower to near zero/zero when the winds at all levels below 2000-3000 feet decrease to below 10 knots before sunrise.

The moisture source seems to be not only advection from the Atlantic Ocean, but also from the swampy marsh regions of southeast Georgia. Often, Valdosta and/or Alma, Georgia are the first locations to report the formation of stratus or fog. Within about two hours of these first reports Tellahassee frequently, and Albany sometimes, will begin to report stratus and/or fog.

Usually, the ceilings and visibility restrictions that develop at Tallahassee and over the eastern section of the Florida panhandle closely parallel those that developed over southeast Georgia a few hours earlier. By sunrise, these conditions may have spread well into the Florida panhandle and southwest Georgia. Burnoff usually occurs by late morning (155 GMT).

It should be noted that specific values expressed above in this paper, such as ceiling heights and visibilities as related to given ranges of wind speed, are rough at best, and are based upon empirical rules. No definitive case studies have been carried out in this regard here at the Miami WSFO.

In summary, strong low-level winds, especially strong vertical wind shear, generate and maintain enough mixing below the subsidence inversion over southern Georgia and northern Florida to counteract, or inhibit, low stratus and fog formation. Weaker northeast and east winds favor low stratus and fog formation over southern Georgia and northern Florida when the trajectory is from the Atlantic coast. In closing, it should be pointed out that the same rules seem to apply over the Florida panhandle and southwest Georgia under a southerly wind regime with a trajectory from the Gulf of Mexico.

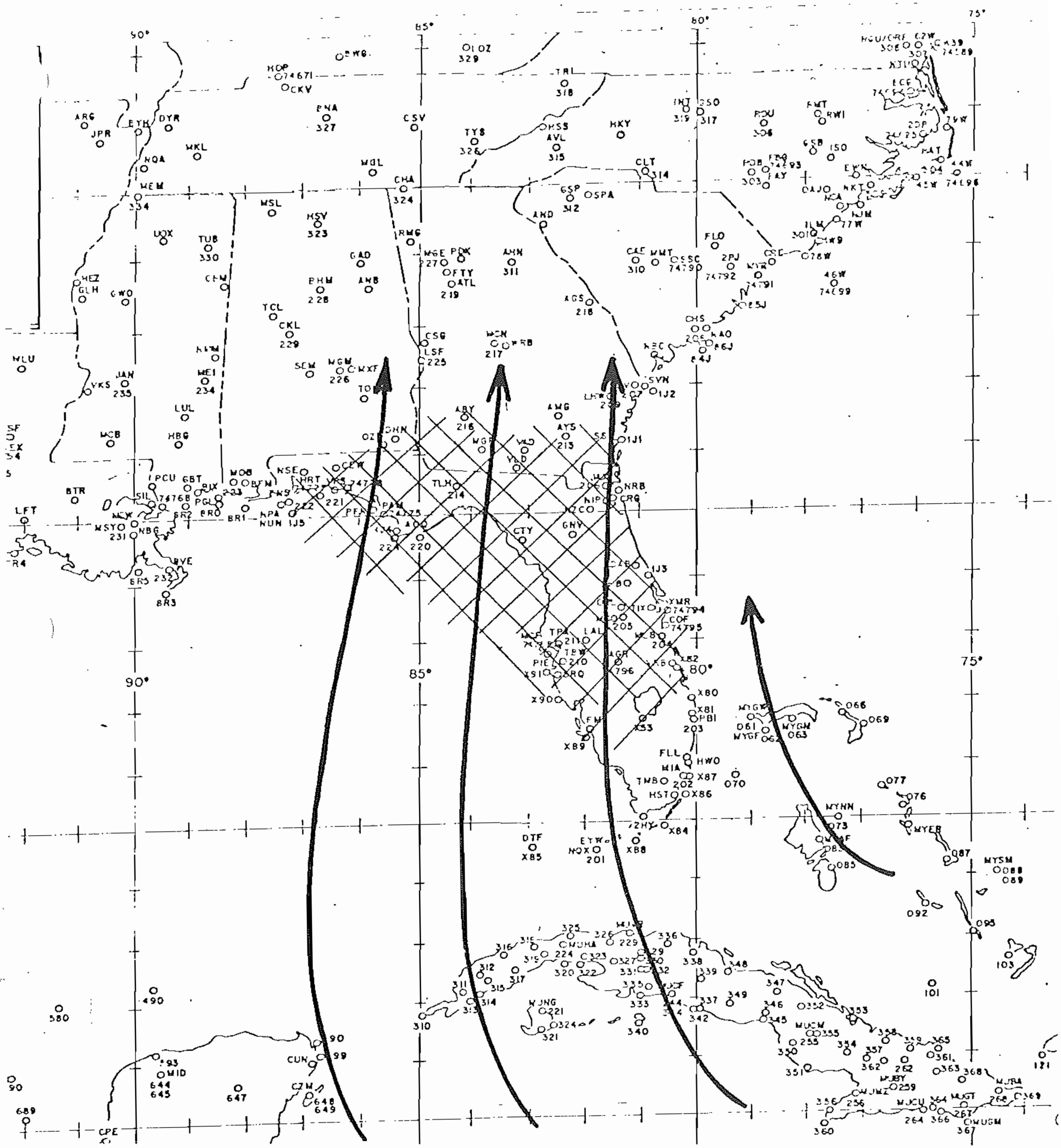

Figure 1. Deep southerly flow (surface to 10,000 feet or higher) associated with extensive formation of sea fog, fog, and stratus (hatched area) over much of southern Georgia and Florida.

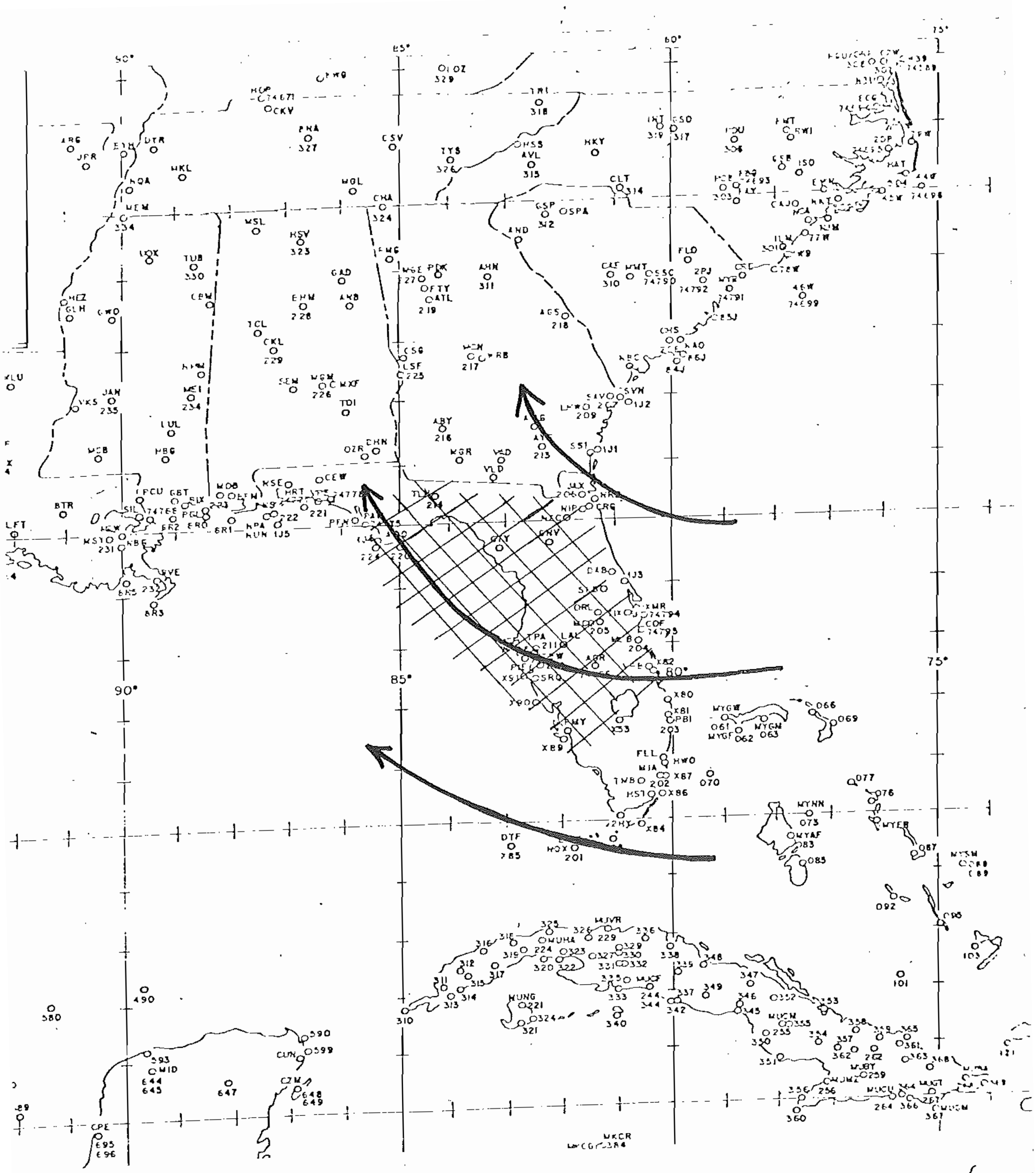

Figure 2. Advection of radiation fog (hatched area) over peninsular Florida into northeast Gulf of Mexico and subsequently the Florida panhandle. See text for details.

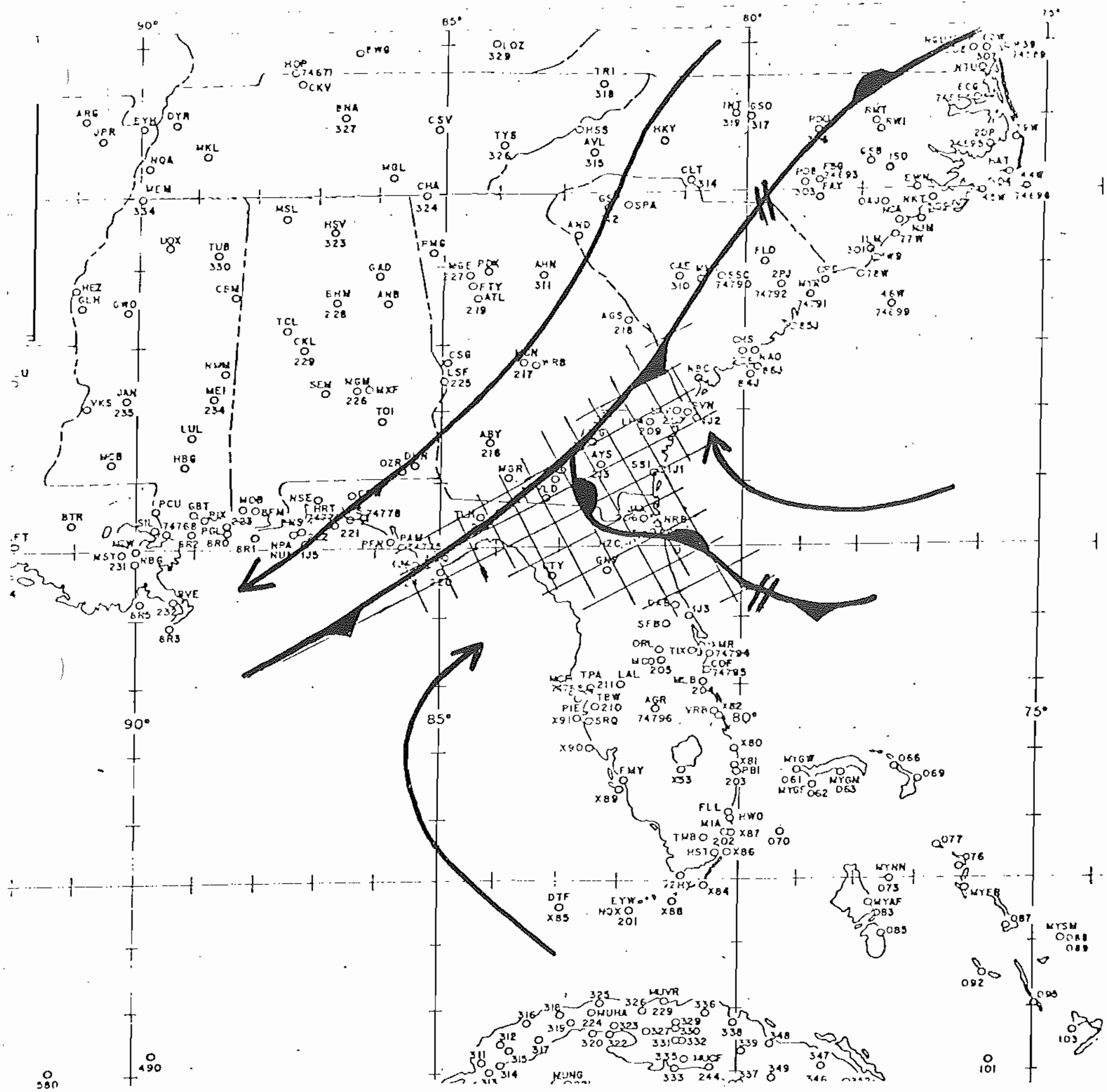

Figure 3. Hypothetical slow moving frontal system associated with primary fog/stratus (hatched area) usually occurring between 0600 GMT and 1500 GMT.

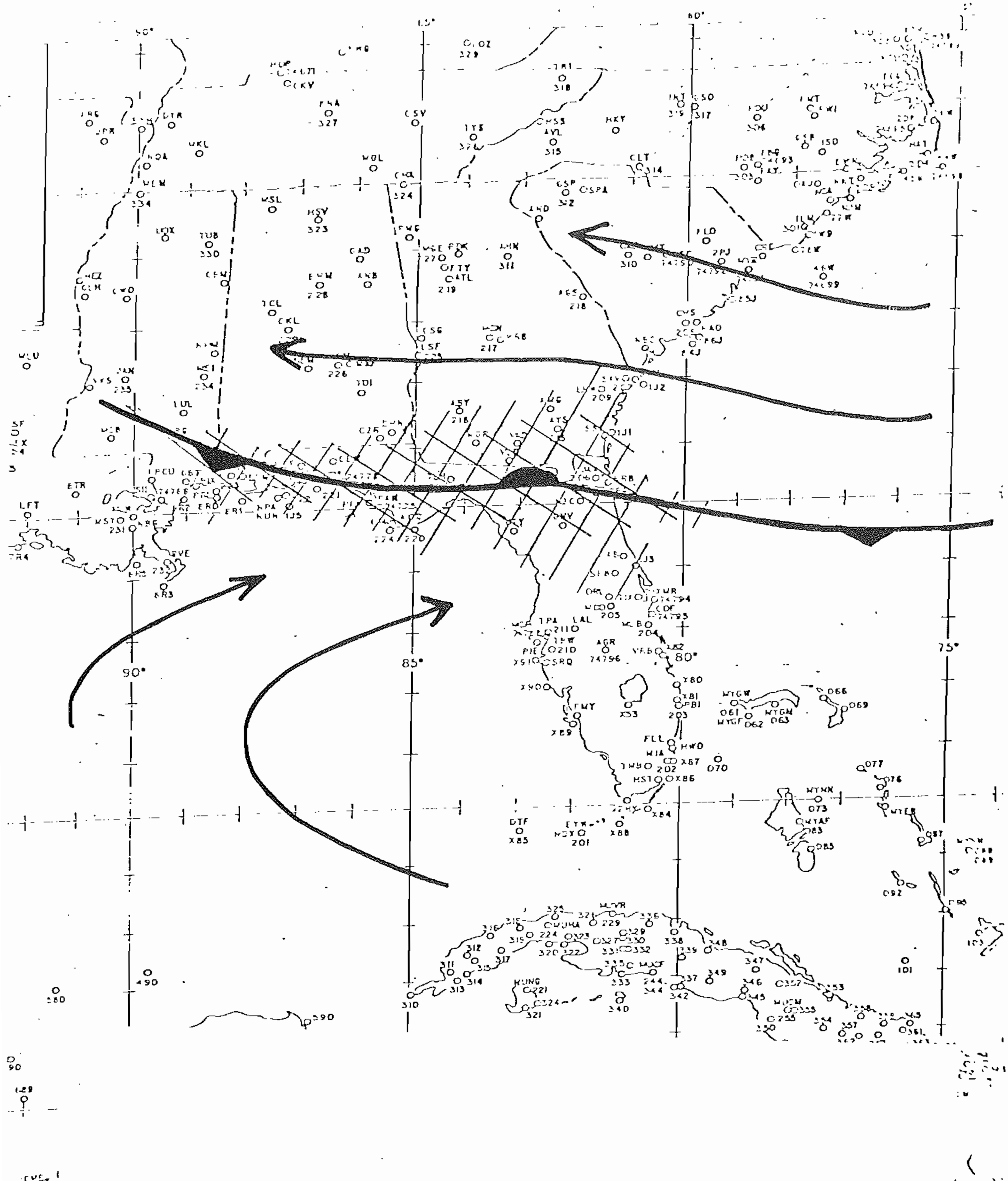

Figure 4. Hypothetical stationary front over north Florida with primary zones of fog/stratus (hatched area) usually occurring between 0600 GMT and 1500 GMT.

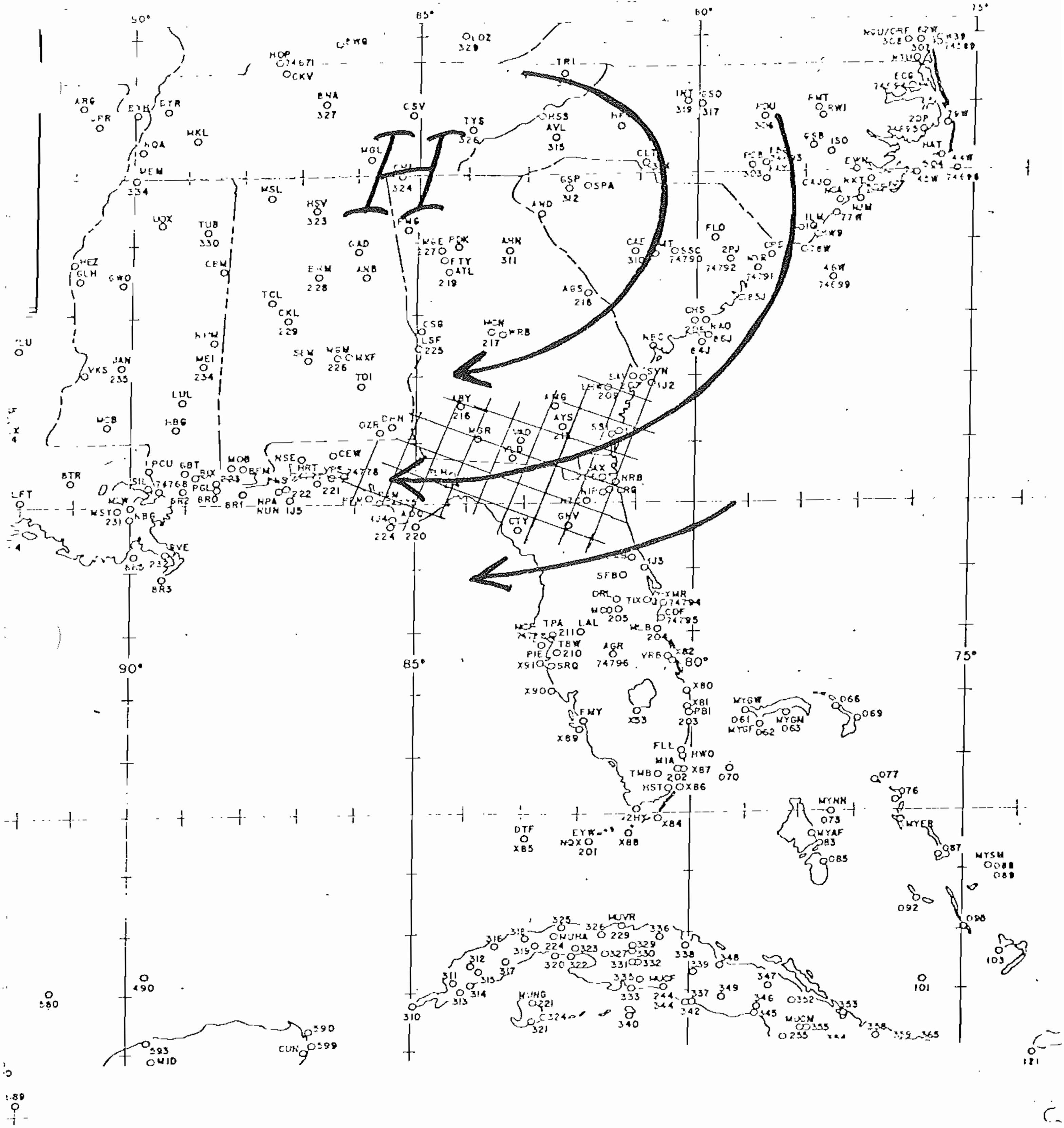

Figure 5. Stratus /fog over southern Georgia and northern Florida (hatched area) associated with anticyclones over the southeastern United States and mean low level flow easterly from surface to 3000 feet.