CHAPTER FOUR

TALLAHASSEE FOG CLIMATOLOGY

4.1 Fog Occurrence

A total of 188,803 hourly surface observations were analyzed over the 20 year study period (1976-1997) to develop a dense fog climatology for TLH. Figure 2 shows the percent occurrence of observed visibilities at TLH based on all available hourly surface visibility observations. It is clear that visibility generally is quite good at TLH. Approximately 70% of the hourly visibilities are ≥ 11 km (6.8 miles). On the other hand, restricted visibilities, i.e., those ≤ 1 km (0.62 miles), account for only 2.4% of the total observations (Fig. 2b). Observations with dense fog, i.e., visibility ≤ 0.45 km (0.25 miles) comprise only a small percentage (1.4 %) of the observed visibility at TLH.

Only 789 dense fog days were observed over the 20 year study period, averaging approximately 39 per year. The set of dense fog days used in this study can be found in the appendix. The winter season, December through February (DJF), contains 37.9% of the dense fog days (Fig. 3). The spring season, March through May (MAM), is second with 29% of the observations. The fall season, September through November (SON), is third with 20.9%, and summer, June through August (JJA), contains the smallest number of dense fog days (12.2%).

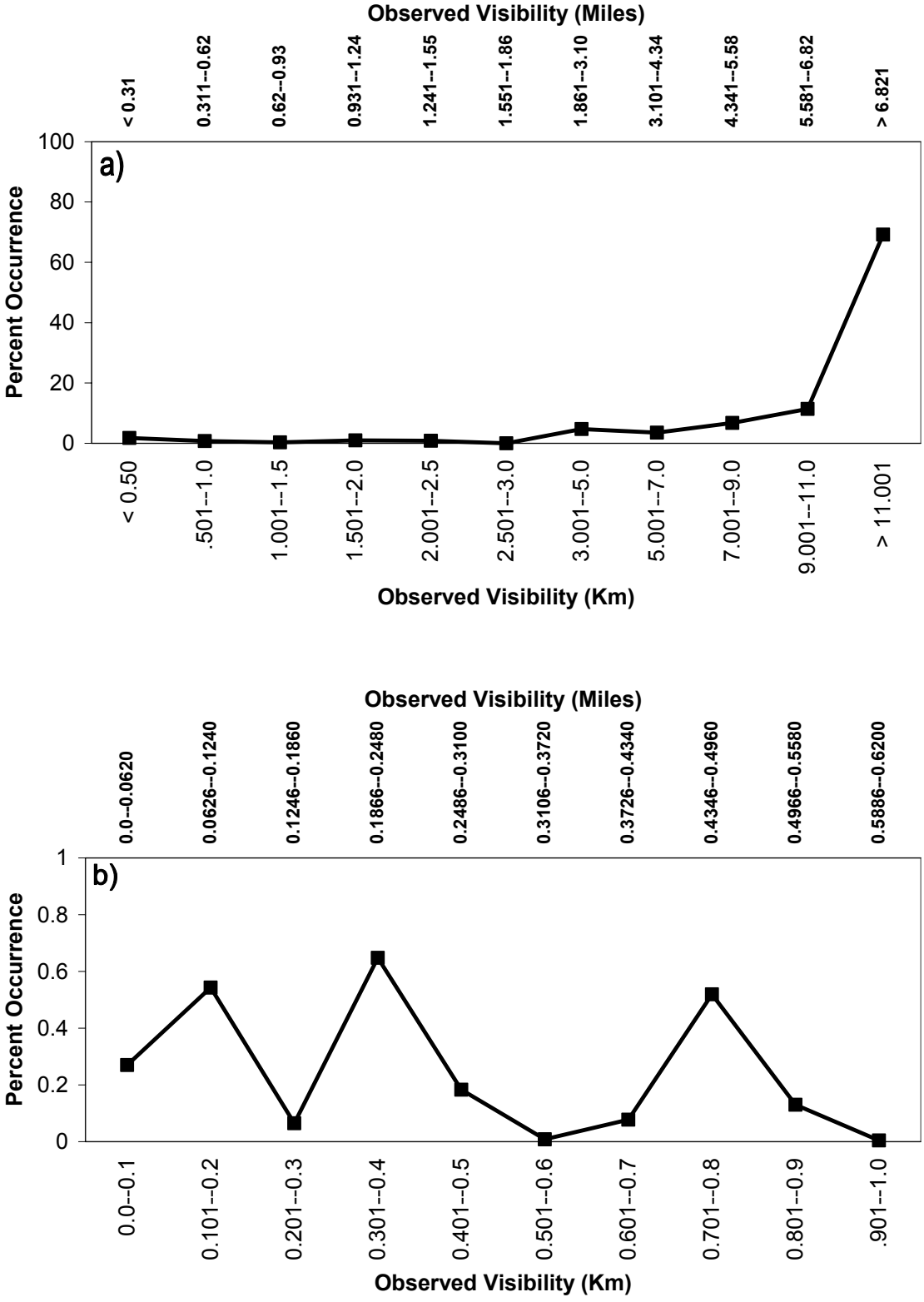

Fig. 2. Percent occurrence of a) all surface visibilities and, b) visibilities ≤ 1 km (0.62 miles) at TLH for the period 1976-1997.

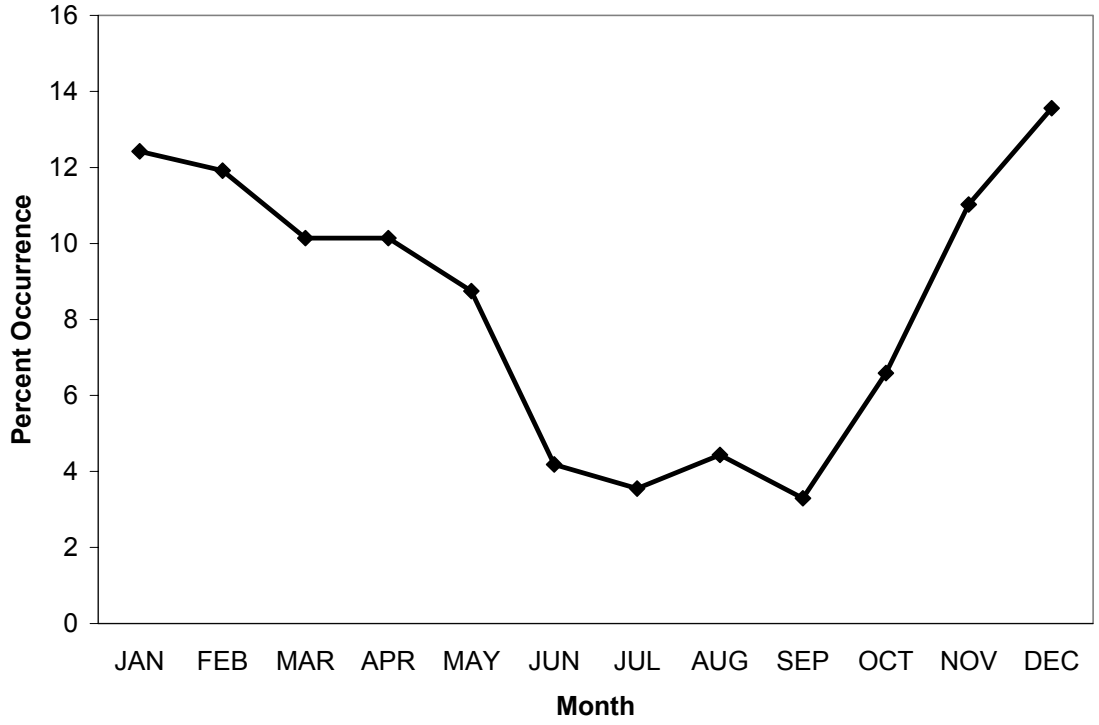

Fig. 3. Percent occurrence of dense fog days (visibilities ≤ 0.45 km) at TLH during the period 1976-1997.

Fog has been observed at all hours of the day at TLH. However, most dense fog (Fig. 4) occurs between approximately 0400 and 1300 UTC. Very little dense fog is observed during the early or late afternoon hours. Dense fog occurs most frequently near sunrise, which is near 1100 UTC during the spring and summer and near 1200 UTC during the fall and winter seasons. The range of times with dense fog is most narrow during summer (JJA) and broadest during winter (DJF).

The first observation of fog, i.e., the first occurrence of fog (with visibility ≤ 9.6 km or ≤ 6 miles) reported in the present weather section of the hourly observation, occurs rather uniformly throughout the seasons (Fig. 5). During the spring, summer, and fall, the most common time of first fog is between 1100-1200 UTC. During the winter, the most common first fog is 0000 UTC, with a secondary maximum at 1300 UTC. During all seasons, the percentage increases greatly between 2300 and 0000 UTC, with the range of times being relatively narrow during the summer and broader during the winter. The first hourly observation of fog is rarely of the dense variety.

Hourly precipitation data indicate that precipitation occurs some time during the 18 hour period prior to fog events (Fig. 6). Approximately 23% of fog cases occur within one hour after precipitation during the winter months. In the spring, summer, and fall months, only 12-14% of all fog cases occur within one hour of precipitation. One not so surprising feature is that during the summer months, early to late afternoon precipitation precedes many fog events. This precipitation often is a result of sea breeze convection, which is common during the summer months in the Florida panhandle.

For operational forecasters, the most difficult forecast is the duration of a fog event. Table 3 shows the percent of occurrence at various duration times. In general,

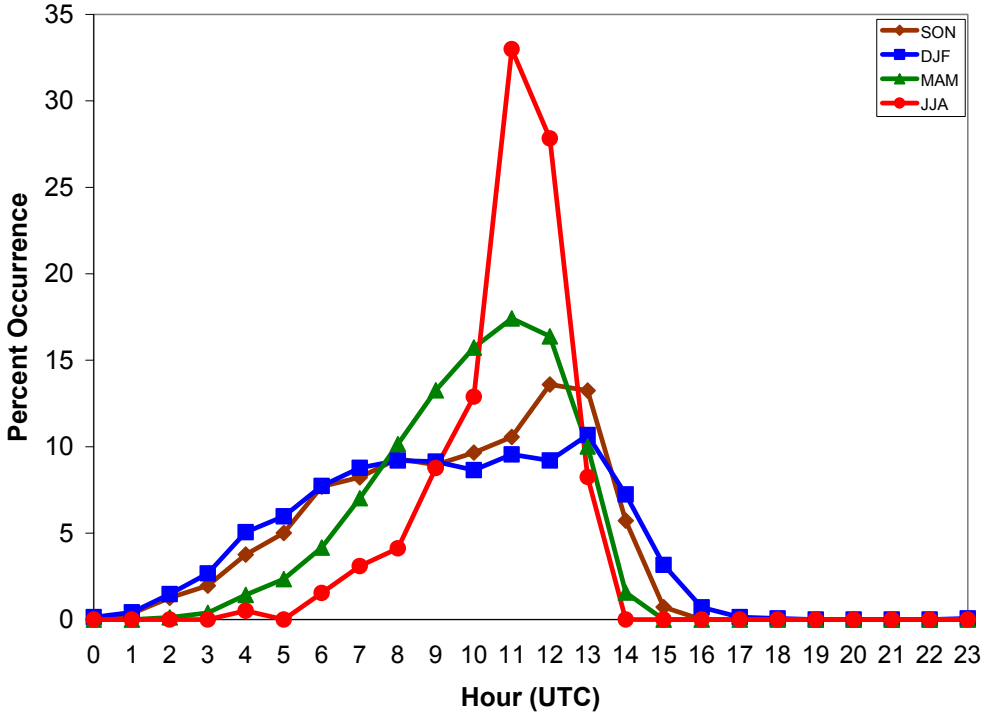

Fig. 4. Percent occurrence of dense fog (visibility ≤ 0.45 km (0.25 miles)) by hour for each season at TLH for the period 1976-1997.

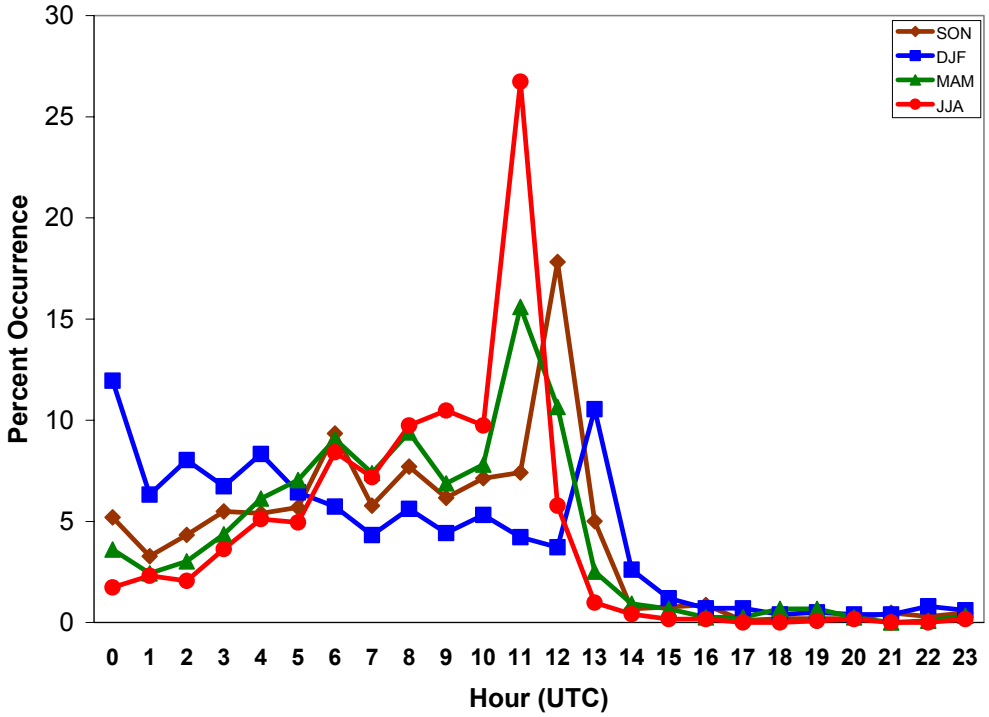

Fig. 5. Percent occurrence of the first observation of fog for all seasons at TLH for the period 1976-1997.

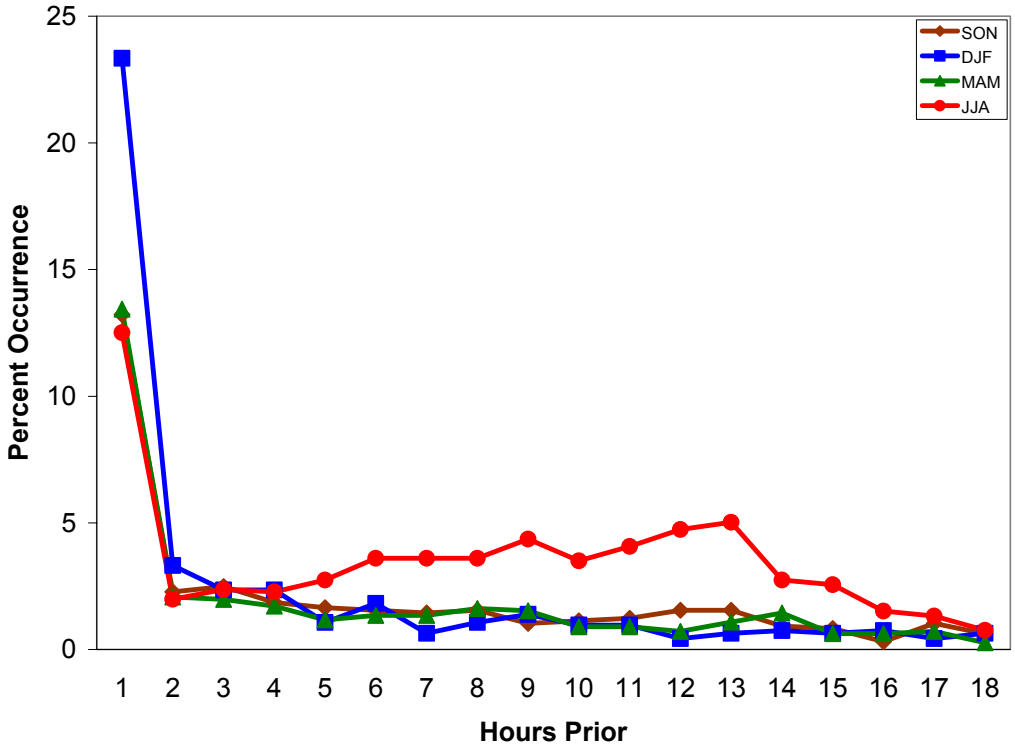

Fig. 6. Percent occurrence of precipitation prior to fog events at TLH.

Table 3. Duration of all fogs observed at TLH during the period 1976-1997.

Duration of Fog	Percent Occurrence
Less than 1 hour	20.8%
Less than 2 hours	35.7%
Less than 3 hours	48.0%
Less than 4 hours	57.9%
Less than 5 hours	65.9%
Less than 6 hours	72.2%
Less than 7 hours	78.9%
Less than 8 hours	84.1%
Less than 9 hours	88.1%
Less than 10 hours	91.9%

results show that fog at TLH does not persist long. Approximately 58% of fog events last ≤ 4 hours. However, the data do contain a 39 hour fog event (not all dense). Fog generally dissipates a few hours after sunrise due to turbulent mixing in response to atmospheric radiational warming.

4.2 Surface Data Climatology

It is useful to relate the occurrence of fog to other surface parameters. Surface parameters were examined for the four seasons, i.e., fall (September-November), winter (December-February), spring (March-May), and a 6 month warm season (April-September). Only variables from the winter (December-February) and warm seasons (April-September) will be shown since they allow one to examine the two seasons having the opposite extremes of dense fog occurrence in TLH. The winter season contains the largest number of dense fog events, while the warm season contains the least. Original plans called for a summer season (JJA); however, very few dense fog events were observed during that season. Therefore, the six month warm season (April-September) was created to gain more dense fog events.

Wind direction may be an important variable in determining whether or not dense fog will develop. To gain a better understanding of how wind direction affects the incidence of dense fog, diagrams of percentage occurrence have been calculated for all dense fog observations (visibility ≤ 0.45 km (0.25 miles)), fog observations (with 0.45 km (0.25 miles) < visibility ≤ 9.6 km (6 miles)), observations of no fog, and all observations between 0000 and 1200 UTC (Fig. 7). All hourly observations during the 24 h period were examined. Figure 7a illustrates the surface wind directions observed

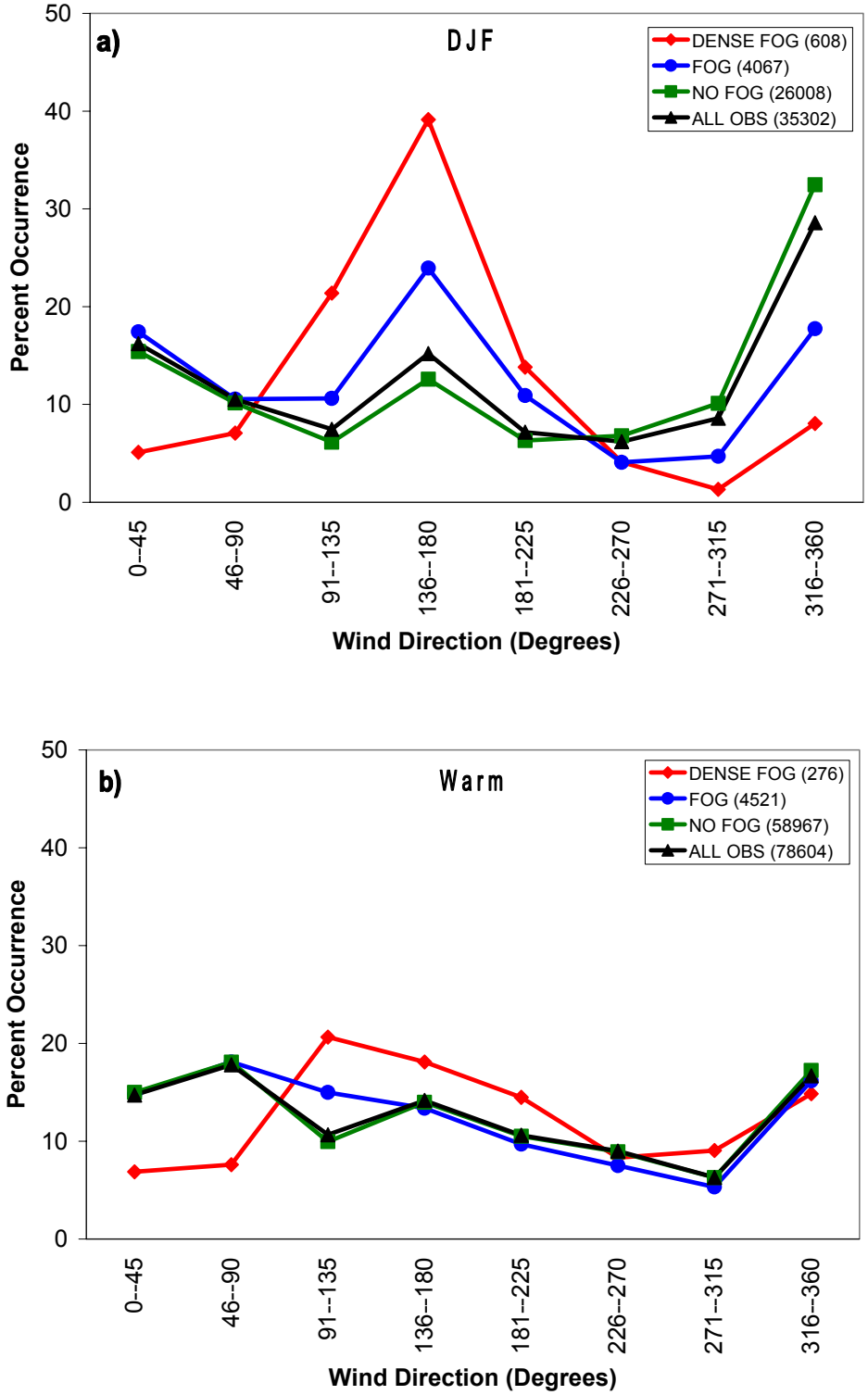

Fig. 7. Observed surface wind directions during dense fog (visibility ≤ 0.45 km (0.25 miles)), fog (0.45 km (0.25 miles) < visibility ≤ 9.6 km (6 miles)), no fog, and all observations during a) winter (DJF) and b) the warm season at TLH.

during the winter season. A total of 35,302 observations were available during the 20 year period. Of those observations, 608 were dense fog observations, 4,067 were fog observations, and 26,008 were no fog observations. The most striking feature is that approximately 78% of the dense fog observations and approximately 50% of the fog observations occur with a southerly wind (south of the range 90°-270°) component. A southerly component at TLH produces onshore flow from the Gulf of Mexico, which can advect moisture into the area for possible dense fog development. The all observations category shows that wind direction in TLH varies greatly during the winter season, with the most common directions being from the northwest (30%).

During the warm season (Fig. 7b), wind directions during observations of dense fog and no fog are rather similar. There were a total of 78,604 observations during this season, of which 276 were dense fog, 4,521 were fog observations, and 58,967 were no fog. The winds show a large range of directions in all of the categories. However, there is a slight tendency for dense fog events to occur during a southerly wind component.

Surface wind speeds observed during dense fog, fog, no fog, and all observations were examined (Fig. 8). Wind speeds during the winter season are similar to those during the warm season. During the winter (Fig. 8a), approximately 60% of the dense fog observations (approximately 30% of the fog observations) occur with wind speeds < 1 m s^{-1}. Similarly, nearly 70% of the dense fog observations (nearly 54% of the fog observations) during the warm season (Fig. 8b) are associated with wind speeds < 1 m s^{-1}. The overall distributions of both seasons show that speeds are relatively weak during the dense fog events suggesting that the fogs may be radiational in nature.

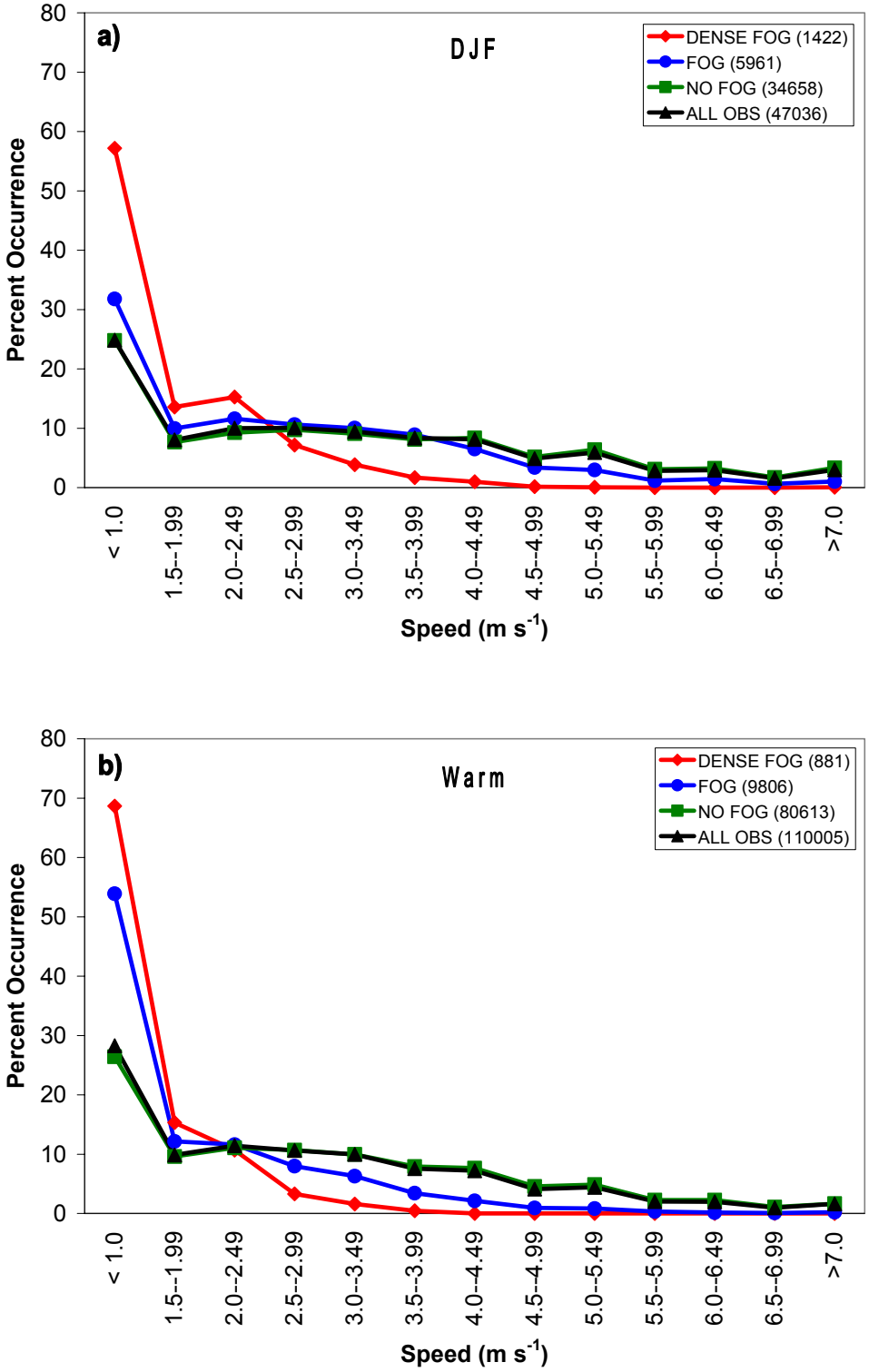

Fig. 8. Observed wind speeds during dense fog (visibility ≤ 0.45 km (0.25 miles)), fog (0.45 km (0.25 miles) < visibility ≤ 9.6 km (6 miles)), no fog, and all observations for a) DJF and b) the warm season at TLH.

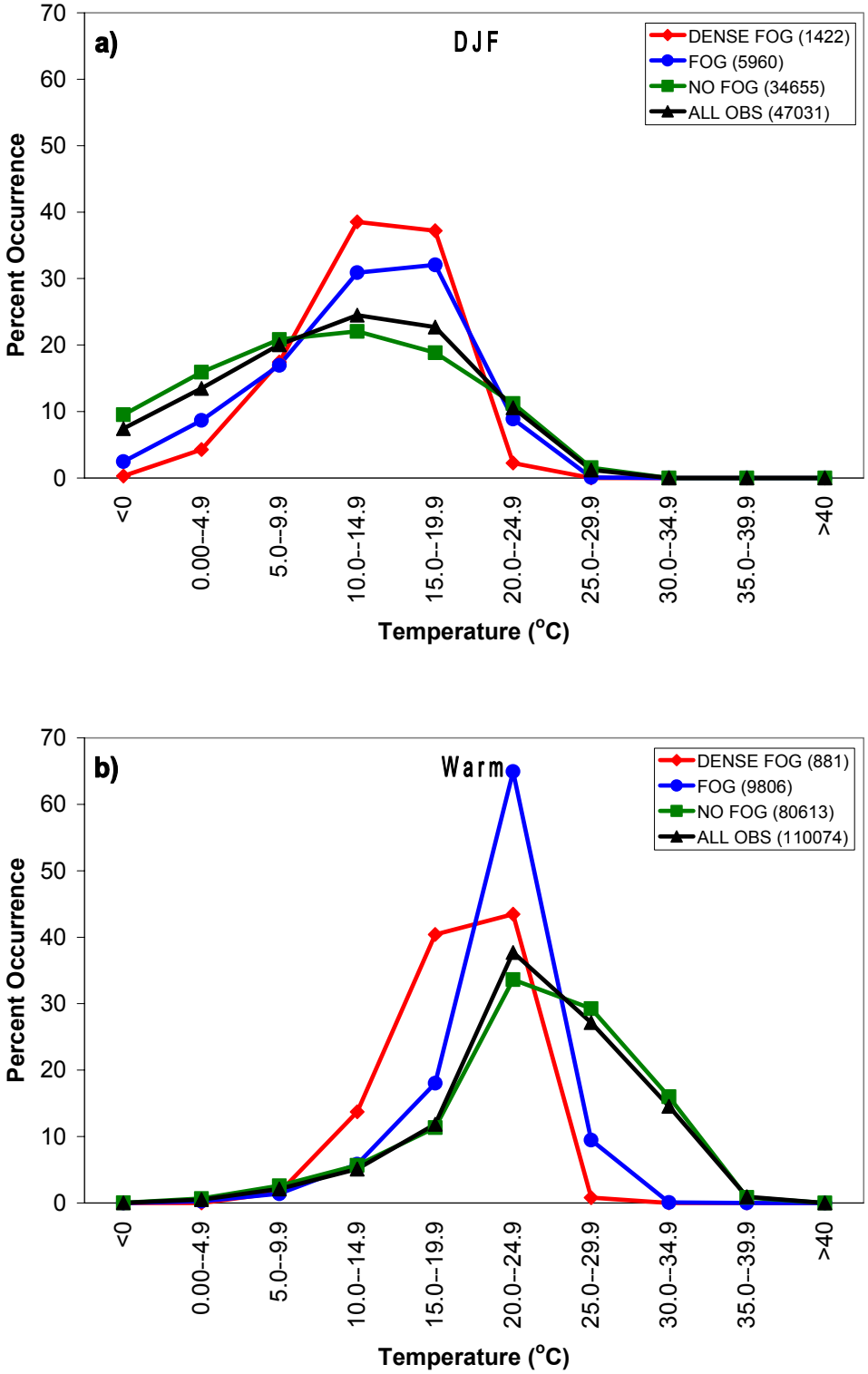

Fig. 9. Observed surface temperatures during dense fog (visibility ≤ 0.45 km (0.25 miles)), fog (0.45 km (0.25 miles) < visibility ≤ 9.6 km (6 miles)), no fog, and all observations for a) DJF and b) the warm season at TLH.

Surface temperatures observed during dense fog events also were examined (Fig. 9). During the winter (Fig. 9a), approximately 75% of the surface temperatures observed with dense fog and nearly 63% of the surface temperatures observed with fog are between 10 and 19.9° C. Compared to the no fog and all observations, dense fog appears to occur on slightly warmer than average nights. This may be due to the southerly wind component that was mentioned earlier. Additionally, the development of dense fog may inhibit outgoing longwave radiation from Earth. This would tend to keep surface temperatures warmer than on a clear night.

During the warm season (Fig. 9b), nearly 85% of the surface temperatures observed with dense fog range between 15 to 24.9° C. Approximately 65% of the surface temperatures observed during fog (non-dense) range between 20 to 24.9° C. Compared to the no fog and all observation groups, dense fogs during the warm season tend to be observed on somewhat cooler nights—opposite to that found during the cold season. One should note that warm season temperatures occur over a relatively narrow range.

Surface dewpoints observed during dense fog, fog, no fog, and all observations are shown in Fig. 10. During the cold season (DJF), dewpoint temperatures observed with dense fog events are somewhat warmer (more humid) than those during all observations. Together with the wind and temperature distribution noted earlier, this again suggests the role of advection from the Gulf of Mexico. However, during the warm season, dense fog is associated with relatively cool (i.e., dry) dew point temperatures.

Surface cooling is an important variable related to fog formation during the night. Cooling of the atmosphere near the ground involves two phases. Studies by Bergot

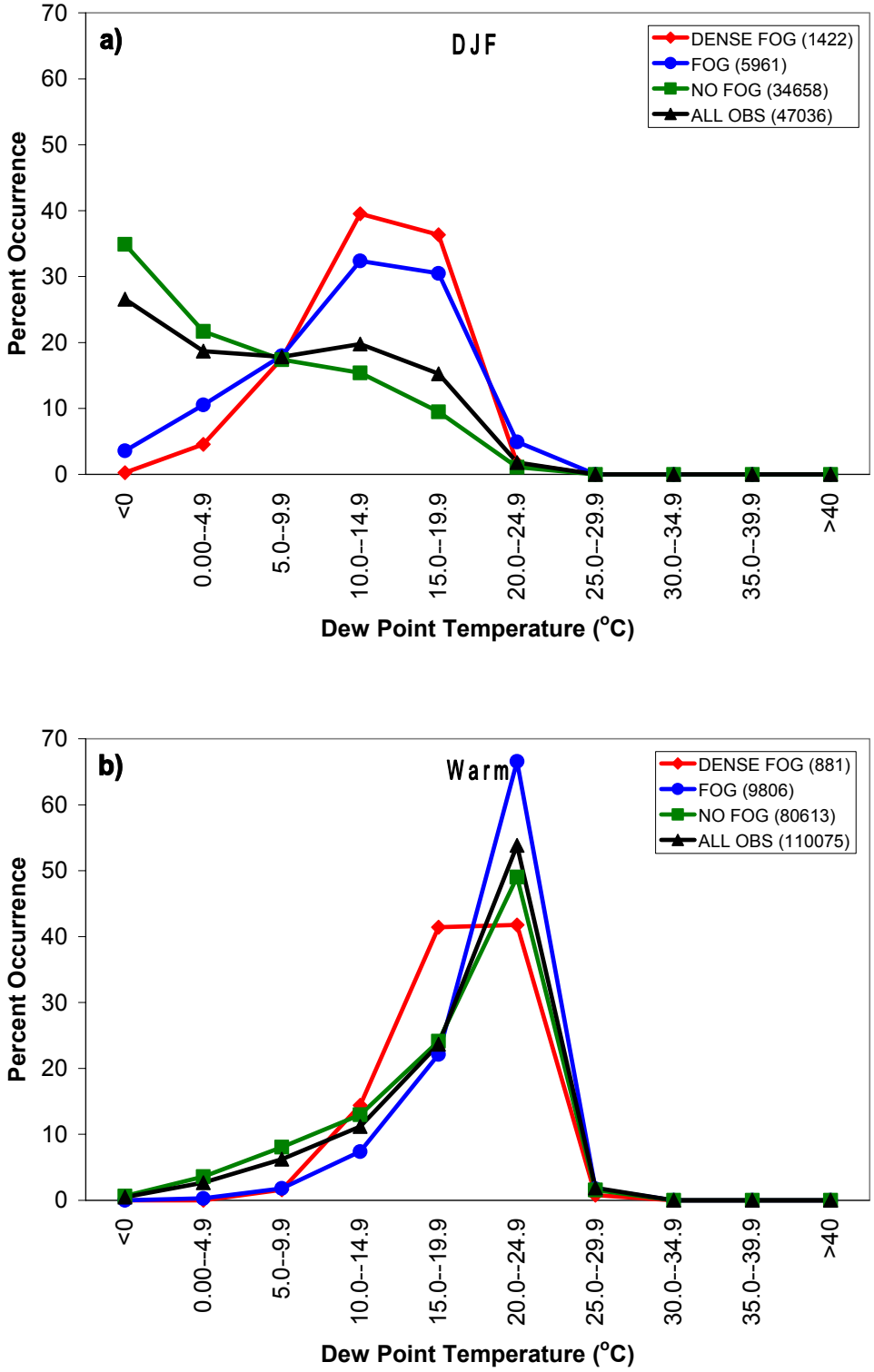

Fig. 10. Observed surface dewpoints during dense fog (≤ 0.45 km (0.25 miles)), fog (0.45 km < visibility ≤ 9.6 km (6 miles)), no fog, and all observations for a) DJF and b) the warm season at TLH.

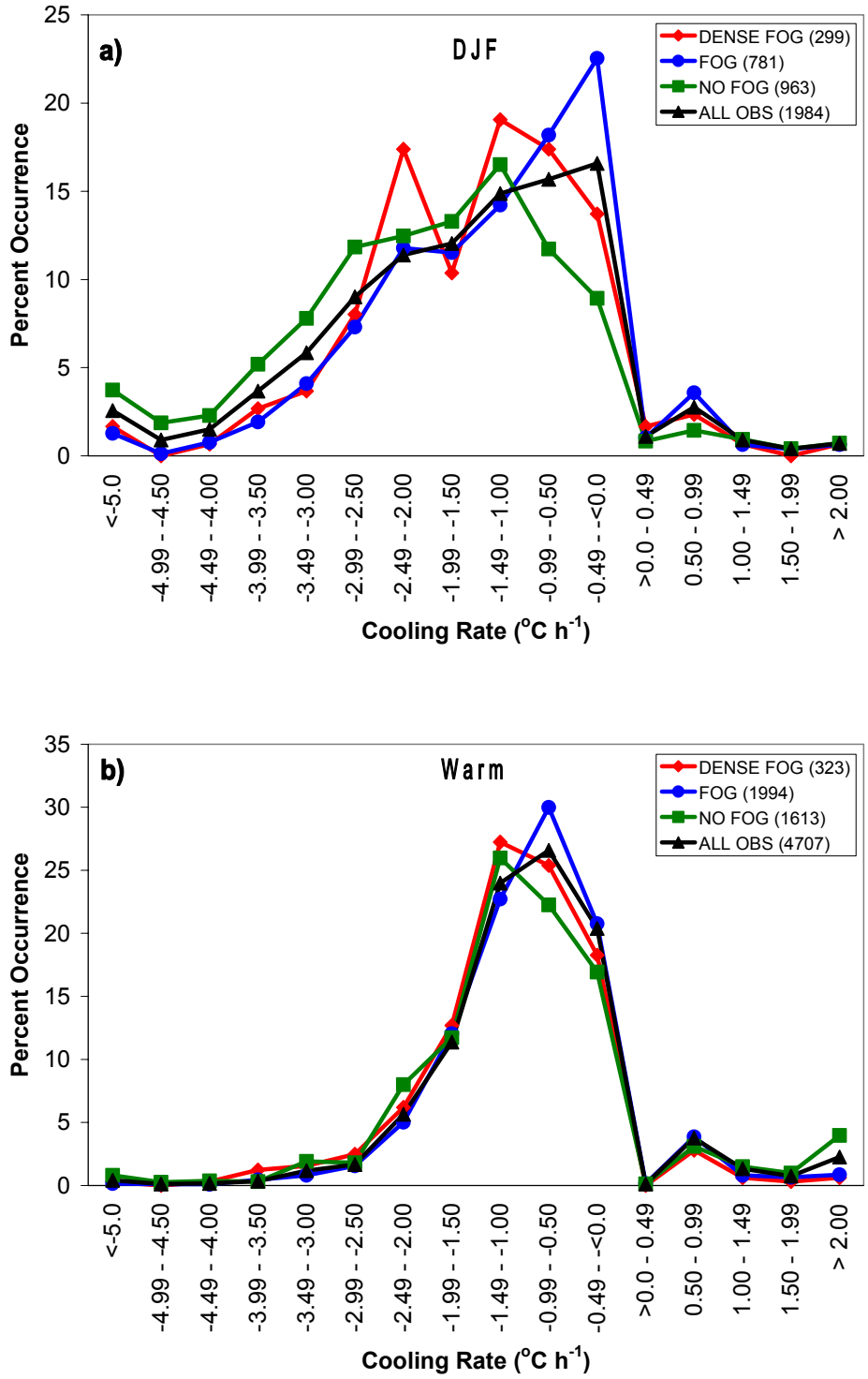

Fig. 11. a) Observed 0000 to 0100 UTC surface cooling prior to dense fog (visibility ≤ 0.45 km (0.25 miles)), fog (0.45 km (0.25 miles) < visibility ≤ 9.6 km (6 miles)), no fog, and all observations for DJF and b) 0200 to 0300 UTC cooling rates prior to dense fog, fog, no fog, and all observations for the warm season at TLH.

and Guedalia (1994) indicated that cooling is significant (-2 to -5° C h^{-1}) during the first few hours after sunset. During the rest of the night, the cooling is much smaller. In the current study, cooling rates during the winter (DJF, Fig. 11a) were examined between 0000-0100 UTC (a few hours after sunset). Values are slightly larger (more negative) than those observed with no fog events as well as all observed events (all nights). These cooling rates prior to dense fog events generally are between –0.5 and –2.5° C h^{-1}. Current results agree with those of Bergot and Guedalia (1994).

Cooling rates during the warm season also were examined (Fig. 11b). However, since the sun sets at a later time (0000-0100 UTC), cooling rates between 0200-0300 UTC were examined. Cooling rates prior to dense fog events are similar to those observed prior to no fog events, but slightly more negative than those observed in all events. Cooling rates prior to dense fog events during the warm season generally are between -0.5 and –1.5° C h^{-1}.

4.3 Upper Air Climatology

It is informative to relate fog occurrence to parameters measured above the surface. The 0000 UTC radiosonde data used in this climatology were available from 1991 through 1997. This data set is substantially smaller than the surface set because radiosonde observations were not always taken at TLH. During the 1970s and 1980s, radiosonde observations were taken at Apalachicola, FL (AQQ, now AAF). The radiosonde observation site was relocated to TLH during June 1991. A total of 1205 radiosonde observations (211 prior to dense fog, 893 prior to fog events (non-dense), and 101 prior to no fog events) were used to complete this climatology. Although the original

radiosonde data were interpolated to 25 hPa levels when preparing the climatology, they were not interpolated to initialize the PBL model. Since fog is confined to the lowest levels of the atmosphere, only selected meteorological variables from levels near the surface will be presented. In particular, the 1000 hPa level (~90 to 120 meters above the surface) and the 925 hPa (~800 meters above the surface) will be investigated.

During the cold season (DJF), the majority of temperature observations at 1000 hPa preceding dense fog are between 11 and 25.9° C, with the peak between 16 and 20.9° C (Fig. 12a). 0000 UTC 1000 hPa temperatures preceding fog (non-dense) events were similar with approximately 52% of the temperatures between 16 and 20.9° C. 0000 UTC temperatures on no fog days are cooler, with 80% of the temperatures between 0.0 and 15.9° C. Temperatures prior to dense fog tend to be relatively warm, with just over 60% of the observations between 16 to 20.9° C. Similar results can be seen at the 925 hPa level (Fig. 13a) where 0000 UTC temperatures prior to dense fog events are warmer than those observed on nights when fog does not form.

During the warm season (Fig. 12b) 1000 hPa temperatures observed at 0000 UTC prior to dense fog events are relatively cool, with just under 60% of the observations between 21 and 25.9° C. This is opposite to that observed during the cold season (Fig. 12a), but consistent with the surface temperatures (Fig. 9). At 925 hPa (Fig. 13b), 0000 UTC temperatures are relatively cool during the warm season prior to dense fog events. Temperatures occurring prior to dense fog events occur in a somewhat narrow range between 16 to 25.9° C. 0000 UTC temperatures observed prior to fog (non-dense), no

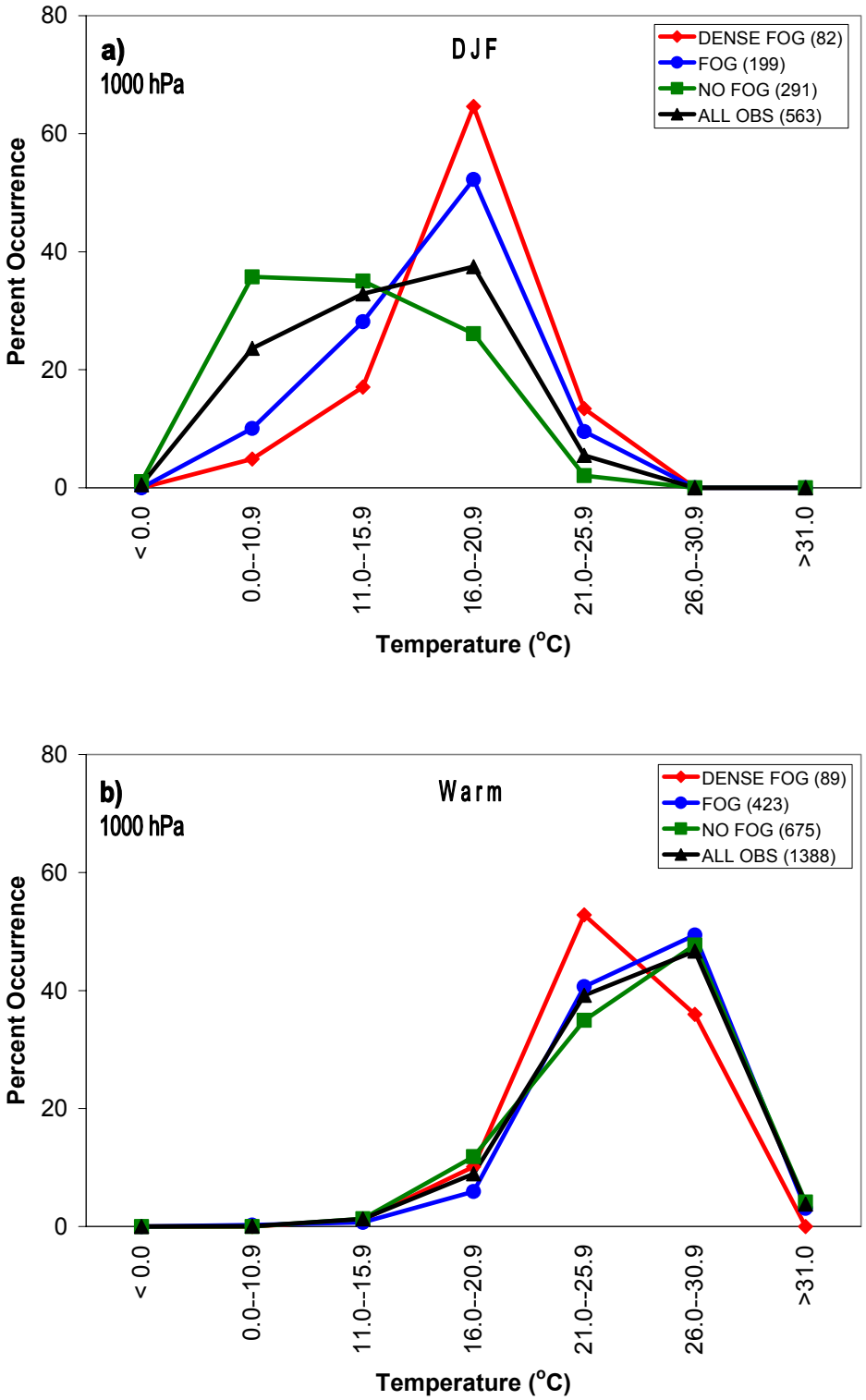

Fig. 12. Temperatures at 1000 hPa at 0000 UTC observed prior to dense fog (visibility ≤ 0.45 km (0.25 miles)), fog (0.45 km (0.25 miles) < visibility ≤ 9.6 km (6 miles)), no fog, and all cases during a) DJF and b) the warm season at TLH.

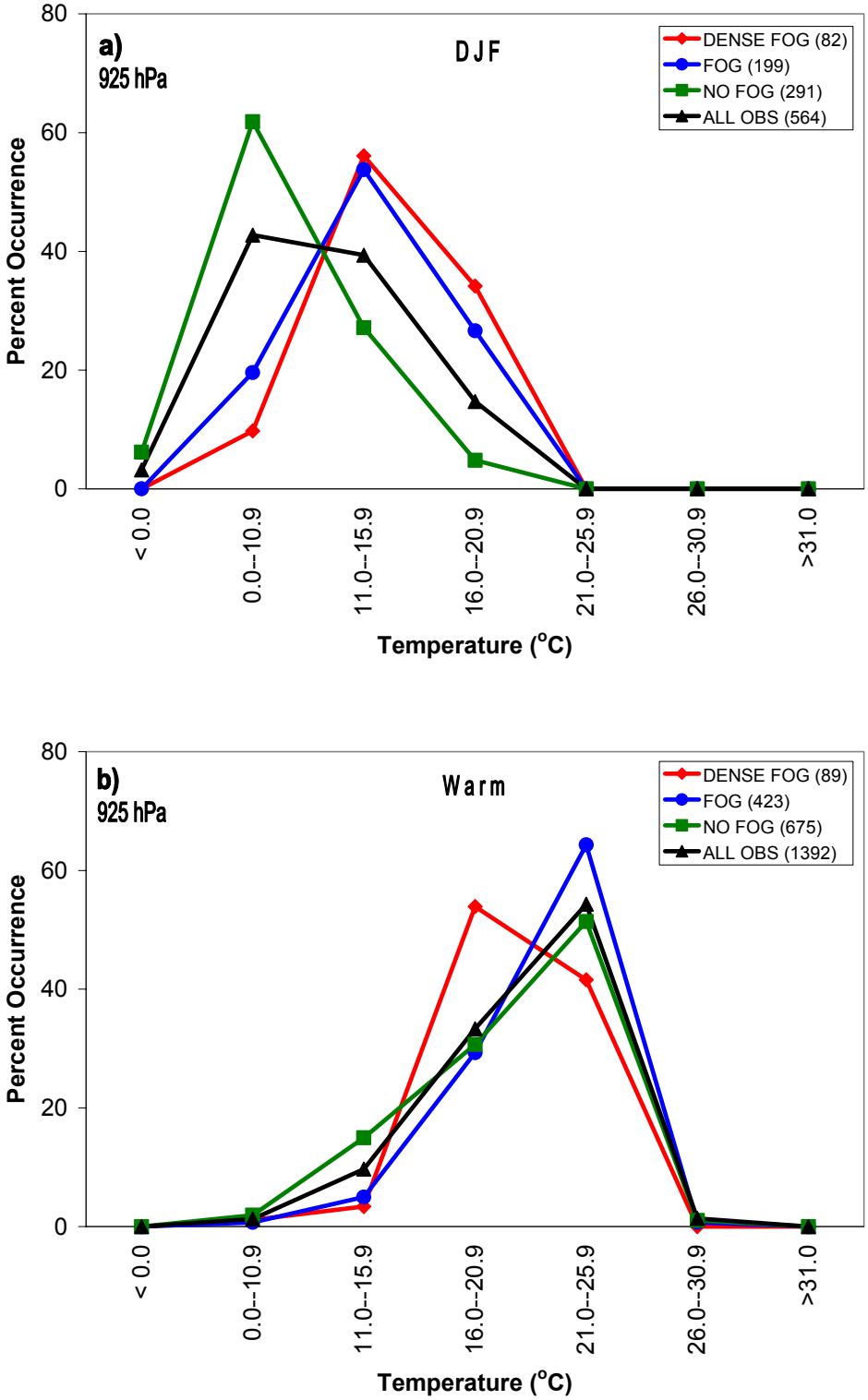

Fig. 13. Temperatures at 925 hPa at 0000 UTC observed prior to dense fog (≤ 0.45 km (0.25 miles)), fog (0.45 km (0.25 miles) < visibility ≤ 9.6 km (6 miles)), no fog, and all events during a) DJF and b) the warm season at TLH.

fog and all events are slightly warmer with 60% of the observations falling in the 16 to 25.9° C range.

Distributions of relative humidity (RH) at 1000 and 925 hPa also were examined. During the winter season (Fig. 14a), the RH values span a wide range, especially for the no fog and all observation categories. However, just over 70% of the 1000 hPa RH observations taken before a dense fog event and just over 68% of the 1000 hPa RH observations taken before a fog event during winter are ≥ 71%, compared to only 14% exceeding 71% for the no fog cases. Although this value may seem small, RH tends to increase during the night as the atmosphere cools due to radiational cooling. RH values at 925 hPa also cover a wide range during the winter season (Fig. 15a). However, approximately two-thirds of the values are ≥ 71% before dense fog events compared to only 27% exceeding 71% for the no fog cases. Thus, RH values at 925 hPa preceding dense fog events are somewhat smaller than those found at 1000 hPa. This may be attributed to the impending fog layer being located below the 925 hPa level.

Turning to the warm season, RH values at 1000 hPa (Fig. 14b) preceding dense fog and fog (non-dense) events are somewhat greater than those of the no fog and all observation categories. RH values at 925 hPa during the warm season (Fig. 15b) are greater than during the winter season (Fig. 15a). Additionally, the dense fog events tend to be preceded by greater values than the other categories. Just under two-thirds of the 925 hPa RH values preceding a dense fog event during the warm season are ≥ 71%; compared to 44% exceeding 71% for the no fog cases.

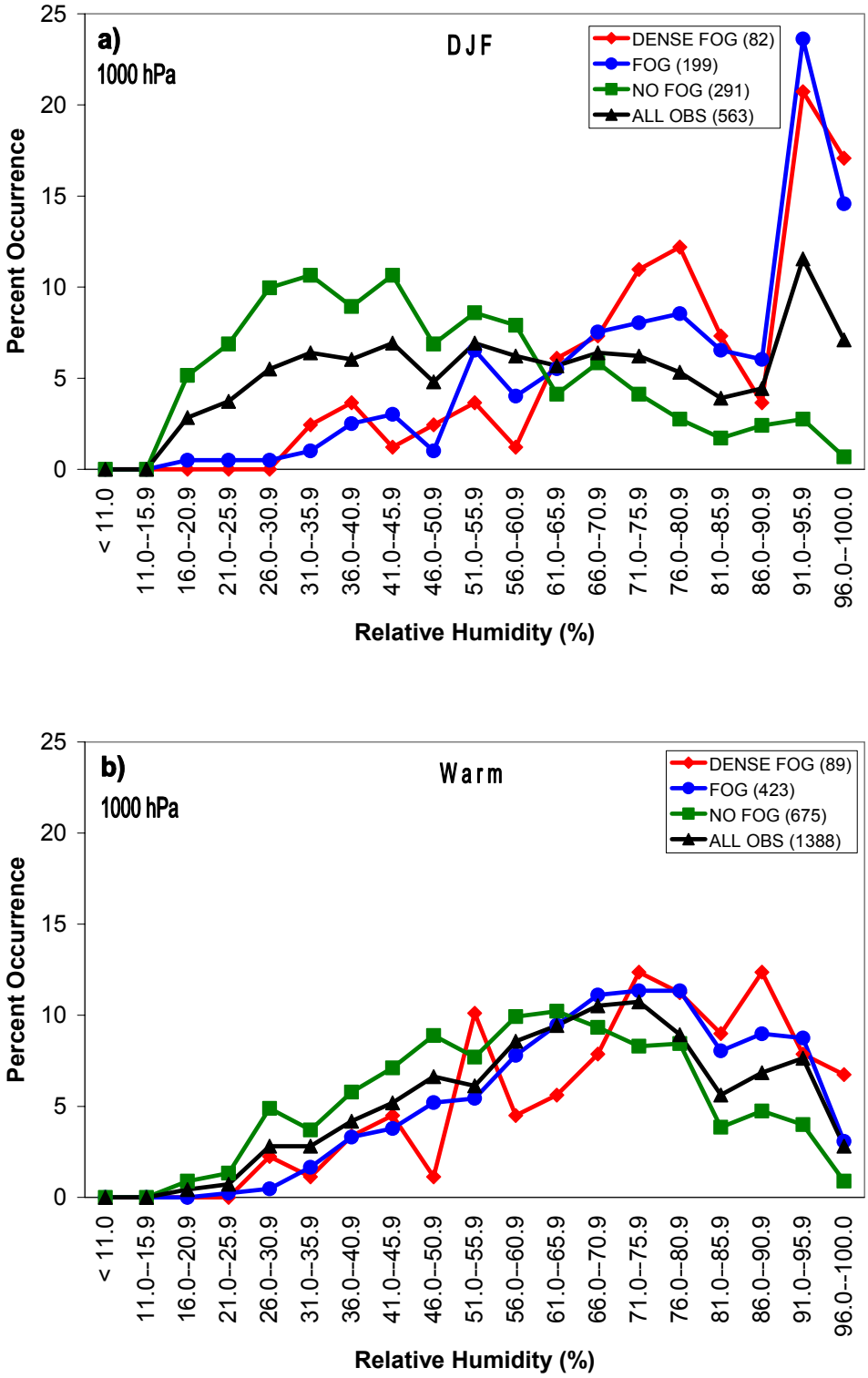

Fig. 14. Relative humidity at 1000 hPa at 0000 UTC observed prior to dense fog (visibility ≤ 0.45 km (0.25 miles)), fog (0.45 km (0.25 miles) < visibility ≤ 9.6 km (6 miles)), no fog, and all cases during a) DJF and b) the warm season at TLH.

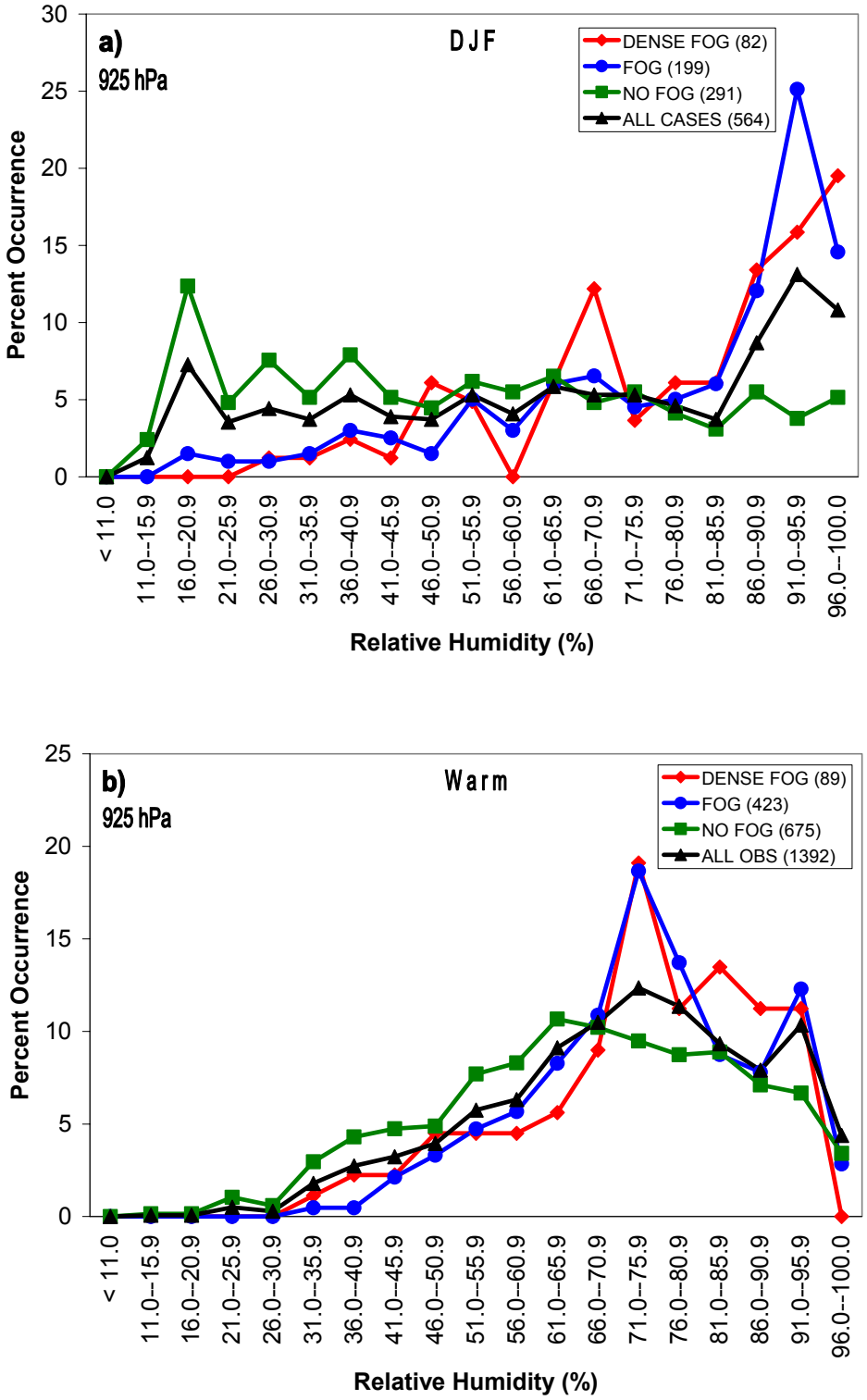

Fig. 15. Relative humidity at 925 hPa at 0000 UTC observed prior to dense fog (visibility ≤ 0.45 km (0.25 miles)), fog (0.45 km (0.25 miles) < visibility ≤ 9.6 km (6 miles)), no fog, and all cases during a) DJF and b) the warm season at TLH.

Unlike surface wind speeds (Fig. 8), speeds at 1000 hPa are not dominated by the calm categories during the winter (Fig. 16a). In fact, approximately 48% of the 1000 hPa wind speeds prior to dense fog events are between 6 and 9.9 m s^{-1}. Values preceding fog events (non-dense varieties) are similar to those found prior to dense fog events. Additionally, values preceding dense fog events are somewhat weaker than those of the composite category. During the warm season (Fig. 16b) the four categories exhibit similar distributions.

Wind speeds preceding fog at 925 hPa are stronger than those at 1000 hPa. This is not surprising since the atmosphere decouples during the night. This decoupling results in higher wind speeds aloft than at the surface. During the winter season (Fig. 17a), approximately 34% of all the 925 hPa wind speeds are ≥ 14 m s^{-1}. Speeds observed prior to dense fog and fog (non-dense) are somewhat weaker than the composite category. During the warm season (Fig. 17b), all four categories exhibit similar distributions. However, speeds generally are weaker than those observed in the winter.

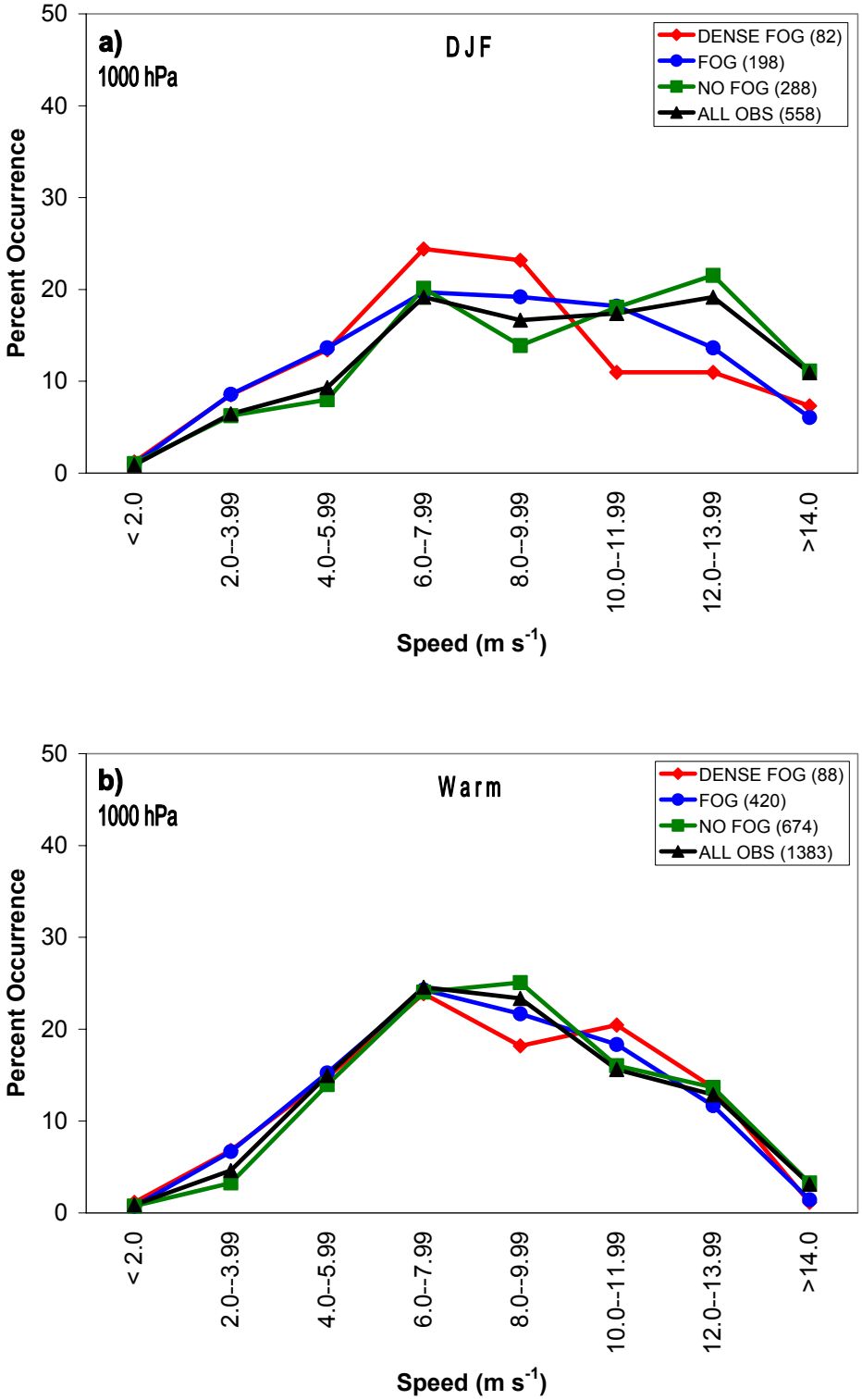

Fig. 16. Wind speed at 1000 hPa at 0000 UTC prior to dense fog (visibility ≤ 0.45 km (0.25 miles)), fog (0.45 km (0.25 miles) < visibility ≤ 9.6 km (6 miles)), no fog, and all events for a) DJF and b) the warm season at TLH.

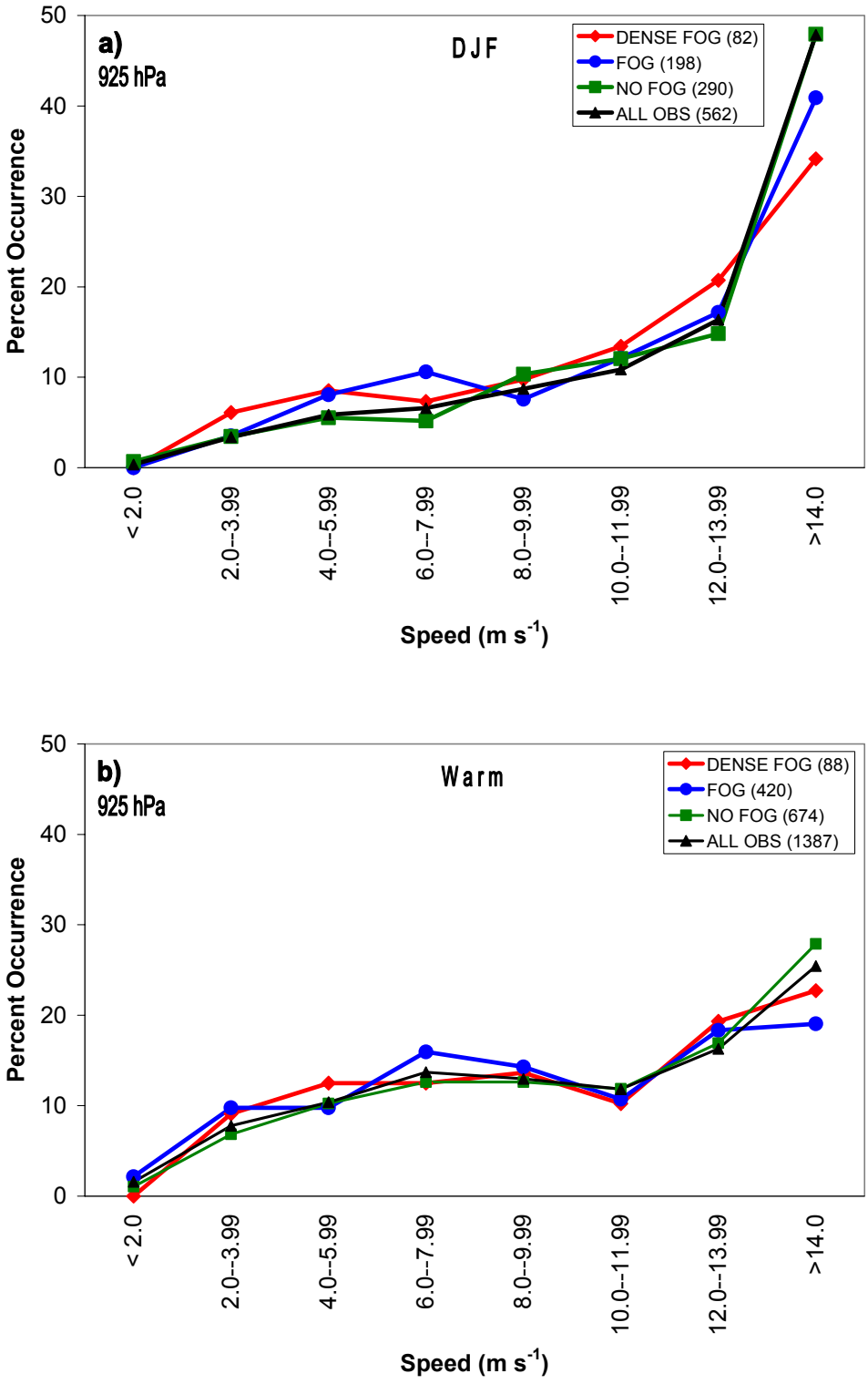

Fig. 17. Wind speed at 925 hPa at 0000 UTC prior to dense fog (visibility ≤ 0.45 km (0.25 miles), fog (0.45 km (0.25 miles) < visibility ≤ 9.6 km (6 miles)), no fog, and all cases during a) DJF and b) the warm season at TLH.