

Surface Weather Climatology for Juan Santa Maria Airport (JSM) and Tocumen-Panama Airport (TCM or TMP). [These are not the airport codes – sorry]

This brief report is based on 6 years (2000-2006) of hourly surface observations at Costa Rica's Juan Santamaria Airport near San Jose (JSM) and Panama's Tocumen International Airport near Panama City(TCM or TMP) during the 32 day period 7/15-8/15 inclusive. Our goal is to investigate the likelihood of weather hazards to the B-57 and ER-2 aircraft, when they occur, and, to a lesser extent, whether they can be forecasted.

The first two figures are overall frequency of the different weather hazards as a function of time of day, the first for JSM and the second for TCM

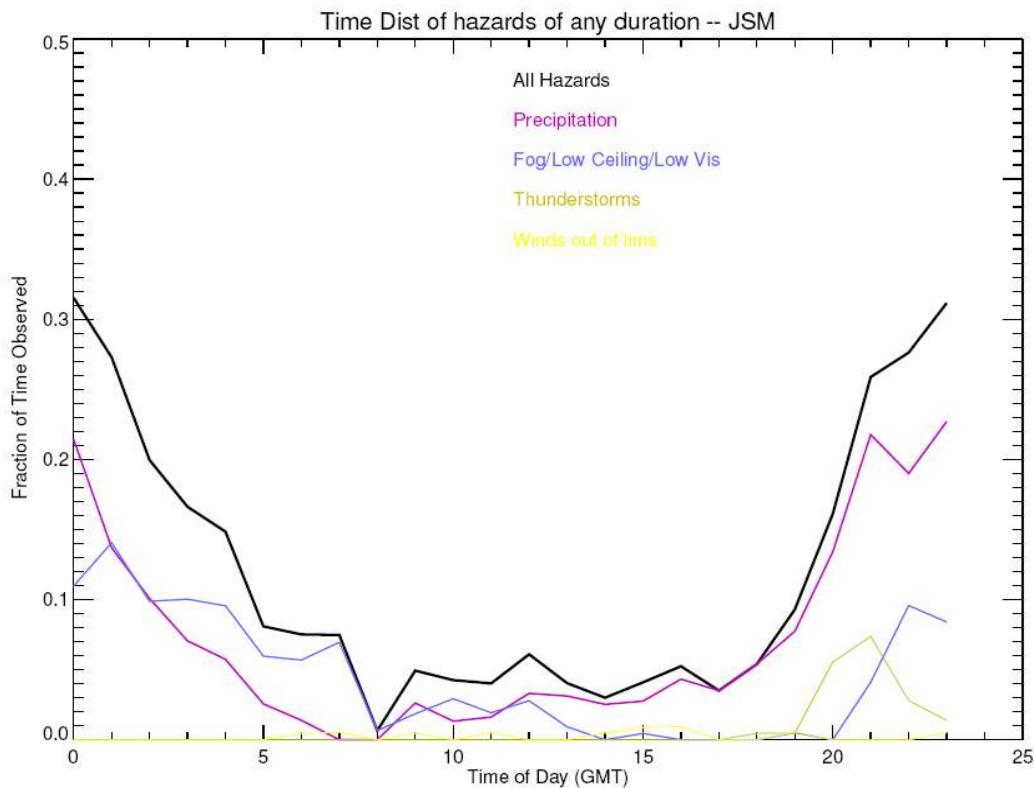


FIGURE 1

These plots simply show the fraction of time at each hour that a given weather hazard is observed in the standard hourly weather report. The faint yellow is winds out of limits (max wind 35 knots, max cross 15), while the blue visibility curve applies if there is EITHER fog, or low ceilings (500 feet) or low visibility (less than .5 miles). The ordinate is simply the proportion of the 224 (7 years times 32 days) hourly obs (at that hour) that have a particular hazard. Of note are: (1) the fairly broad peak at around 3-

6PM in the overall hazards at JSM; (2) the lingering incidence of fog/low ceiling/low visibility(FVC) into the evening; (3) the near-absence of any incidence of high winds/cross winds at either station; (4) the very low incidence of weather hazards

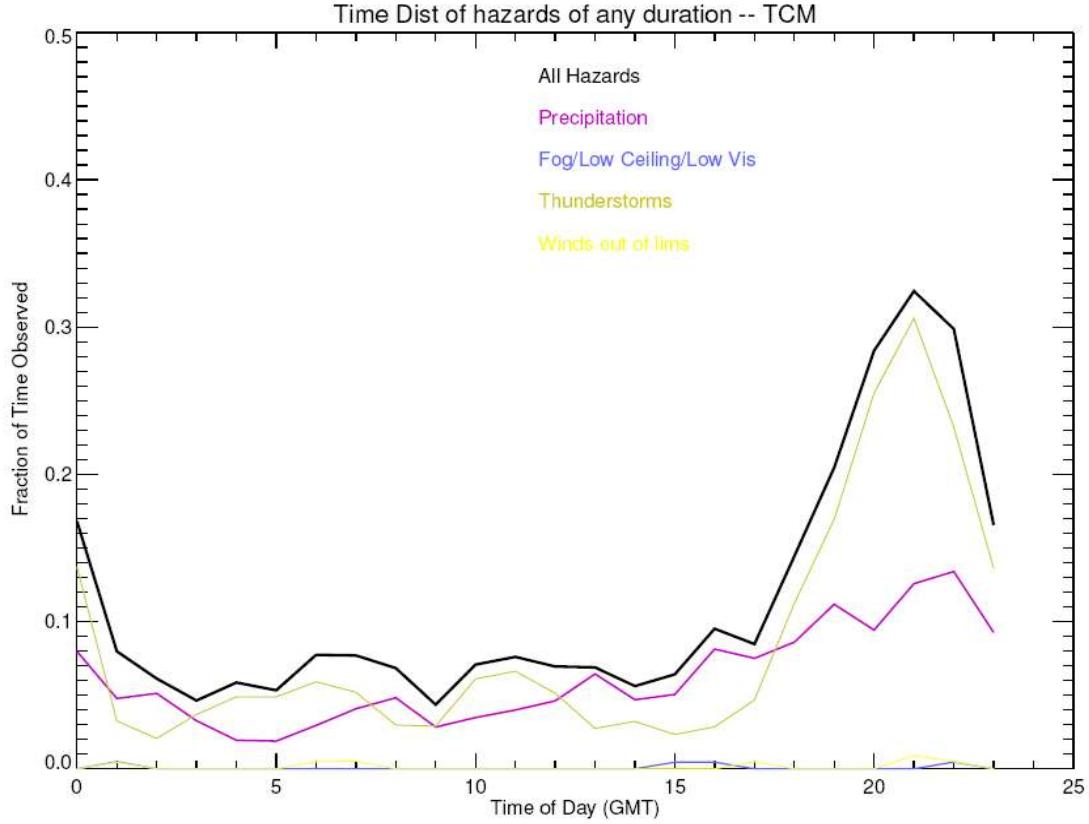


FIGURE 2

for a substantial period at JSM between 2 AM and 1 PM; (5) the sharper if somewhat higher peak of weather hazards at TCM; (6) the higher incidence of thunderstorms at TCM than at JSM; (7) the lower incidence of both precipitation and FVC at TCM than at JSM; and (8) an enhancement of weather hazards during the morning “quiet period” at TCM relative to JSM. Though the nature and timing of the weather hazards differ, these simple statistics suggest a similar level of operational difficulty for the two sites. In particular, both have the same number of days (out of the 224 sampled) with NO hazards observed at all at any time – about 50 for each station.

To explore this in a bit more detail, we next look at weather hazards that last 2 hours or more. This is based on the idea that an aircraft may be able to wait one hour while conditions improve. Waiting two hours or more, however, puts too many constraints on the science return. Figure 3 shows the starting and ending times (black and magenta,

respectively) of 2 hour or longer periods of weather hazards of any kind at JSM. The ordinate is the number of occurrences of a 2 or more hour weather hazard period starting (or ending) at a particular hour. The start curve peak is [obviously] shifted to an earlier time than the all hazards black curve in Figure 1. The mean duration of these incidences is 3.25 hours. Ending times are not until well into the evening. Notably, these greater than 2 hour periods of weather hazard do not start until 1-2PM. A significant number do not end until 10 PM. There is some evidence that the evening weather hazards are a bit shorter than the ones in the late afternoon (viz the 3 hour separation between the 21Z start and 0Z ending peaks, and the 1 hour separation between the 3Z start and 4Z ending peaks). Out of 224 days, 116 had at least one incident of a weather hazard of some kind lasting more than 2 hours.

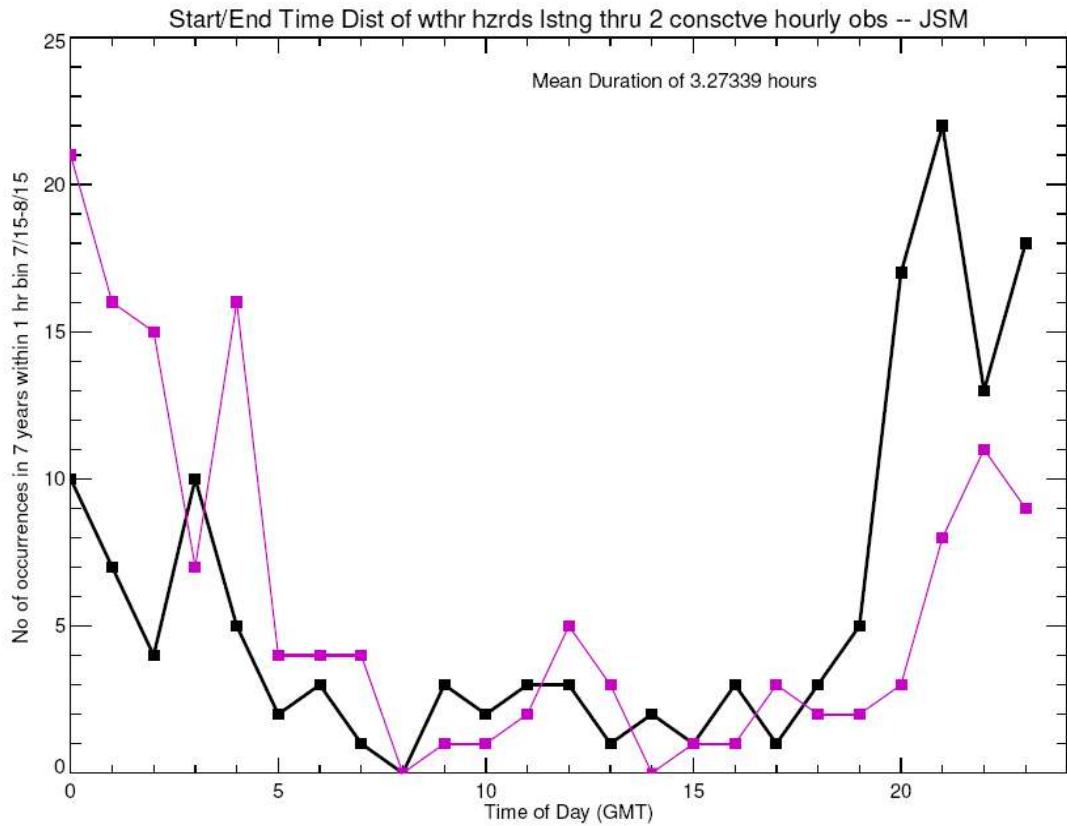


FIGURE 3

Figure 4 shows the same curve for TCM. In terms of number of days with 2 hour or more weather hazards, there are actually more in Panama (131 vs 116 in Costa Rica). However, there is no tail into the evening at Panama. Also, the trouble starts sooner, about 11AM-12noon instead of 1-2PM. Duration of these weather hazards (average) is about the same as at JSM. The enhancement of weather hazards during the morning quiet

period at Panama is also apparent.

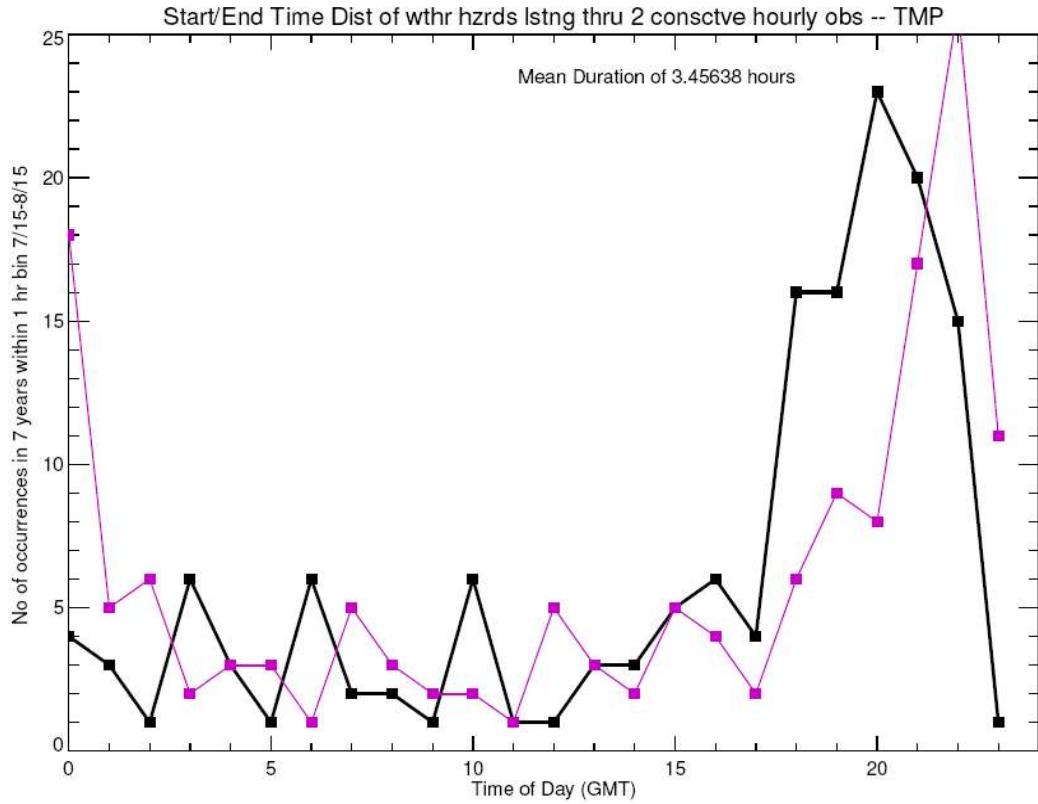


FIGURE 4

Figures 5 and 6 show the precipitation and FVC (fog, visibility, ceiling) 2 hour hazard curves for JSM, respectively. The point of showing this is to point out the onset of the precipitation between 1 and 2 PM, which is followed by FVC about an hour later. Most of the visibility problems are after sunset, as the moist ground cools off. There is significant rain into the evening as well. It should be noted that the overall incidence of 2 hour or more precip is larger than the incidence of FVC (also clear from the raw stats in Figure 1). So, not all lengthy precip results in subsequent lengthy fog.

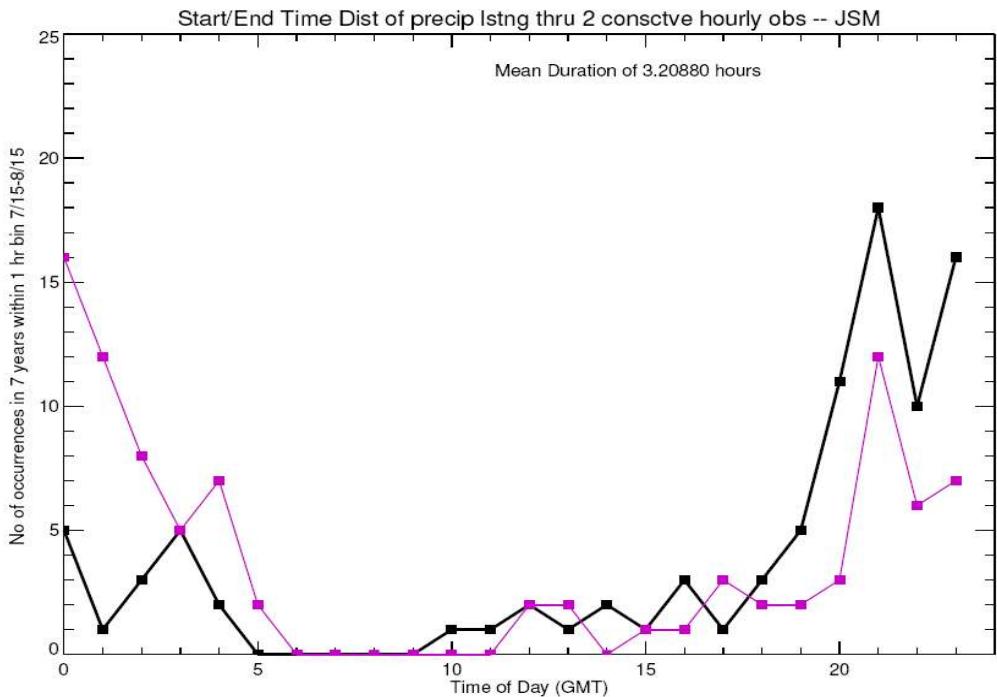
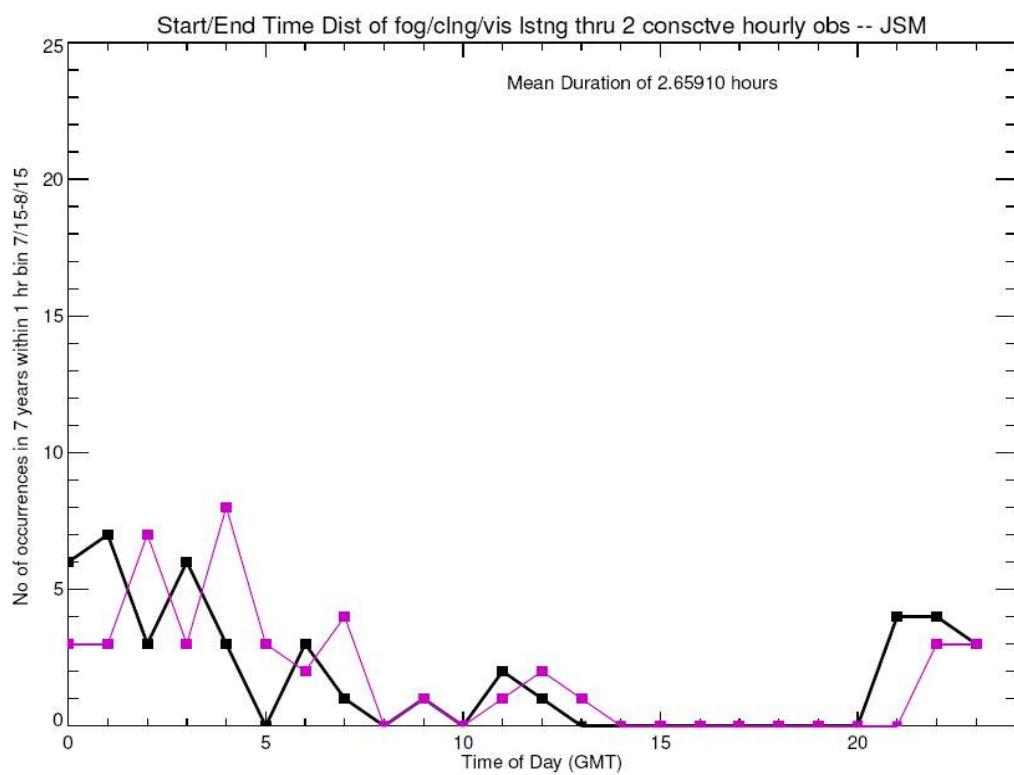


FIGURE 5 (above)

FIGURE 6 (below)



Figures 7 and 8 show the same type of diagram for precipitation and thunderstorms at Panama. An interesting point is that the incidence of precipitation is substantially less at Panama than at JSM – borne out by the lower rainfall (5 inches/month in Panama vs 9 at JSM during this time of year). Most of the hazards are thunderstorms, and I believe many do not have rainfall associated with them.

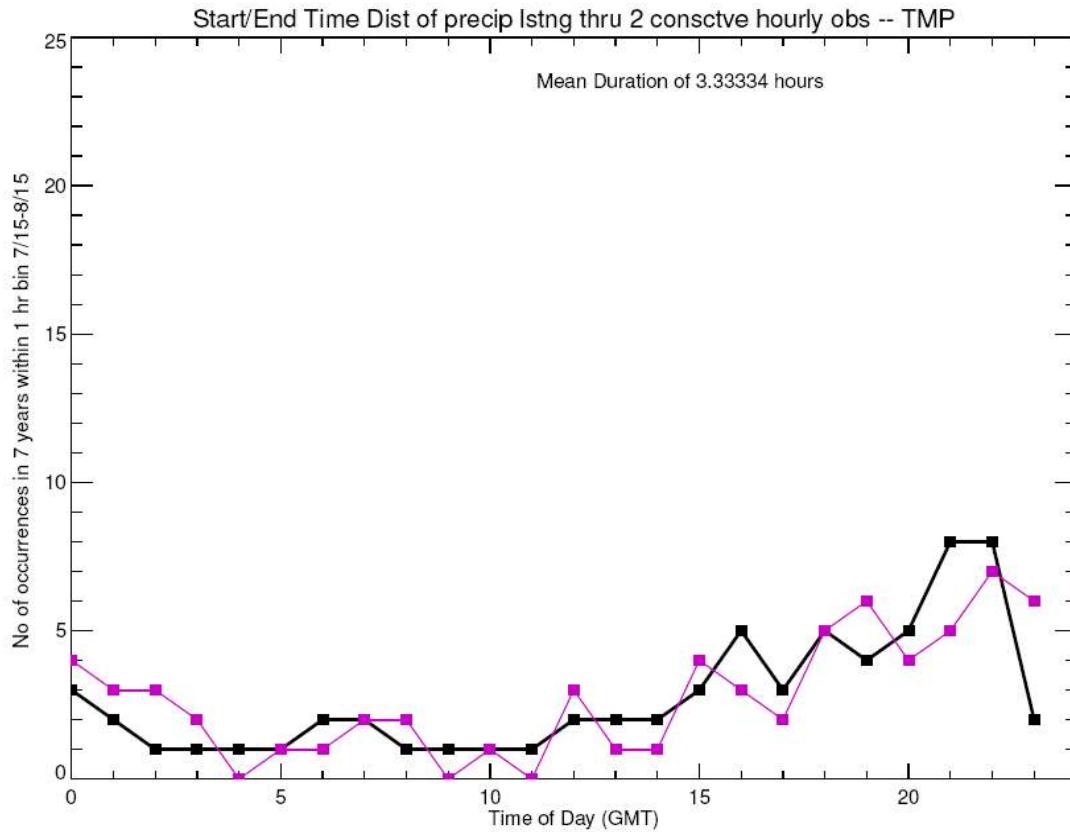


FIGURE 7

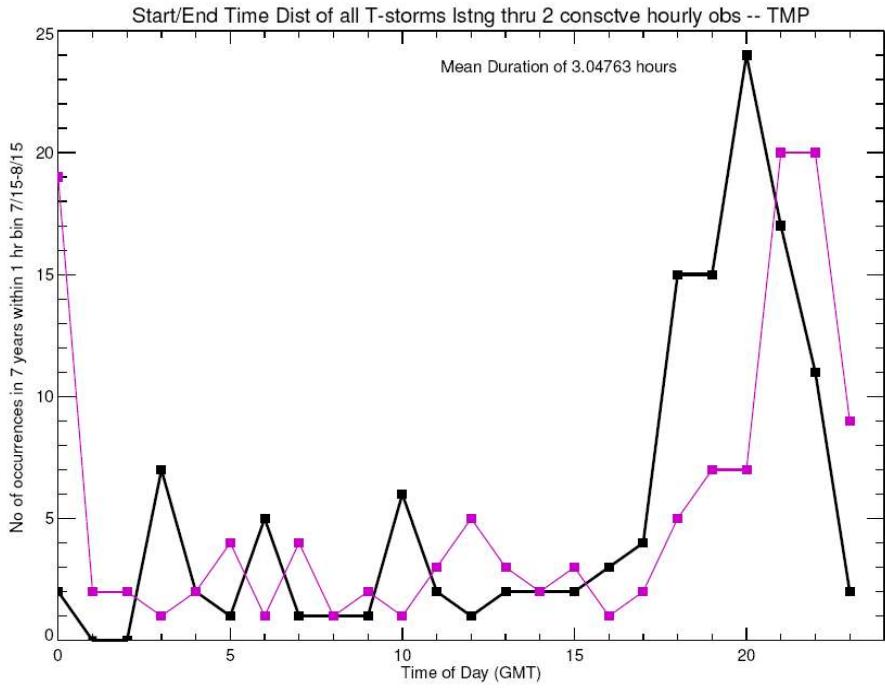


Figure 8

It appears that landing an aircraft in the early evening hours will be more of a challenge at JSM than at TCM. It should be noted, however, that the morning period (3 AM to 11 AM) is significantly quieter at JSM than at TCM (and longer). Comparing the incidences of weather hazards during this period at JSM and TCM, we find the following. There are 38 days with at least 1 hourly report of a weather hazard between 3 and 11 AM at JSM, vs 57 at TCM. There are 17 days with at least 2 hourly reports of weather hazards between 3 and 11 AM at JSM, vs 32 at TCM (nearly a factor of two). Another way of saying this is that about one quarter of the time, there is a weather hazard at Panama during the 3 to 11 AM quiet period. In San Jose, the times when mornings are bad are probably forecastable, these being due to so-called “temporales” where there is a strong persistent southwesterly flow due to persistent convection in the Caribbean (associated in some cases with tropical cyclones). The incidences of bad mornings in Panama are not necessarily related to this (they did not happen at the same time as the bad mornings in Costa Rica). They are more likely due to a northward displacement of the ITCZ. Whether this is forecastable is not known.

It is worth examining the relationship of winds to hazardous weather at JSM. This can give us an understanding of its cause, and, perhaps, some forecasting skill (emphasis on

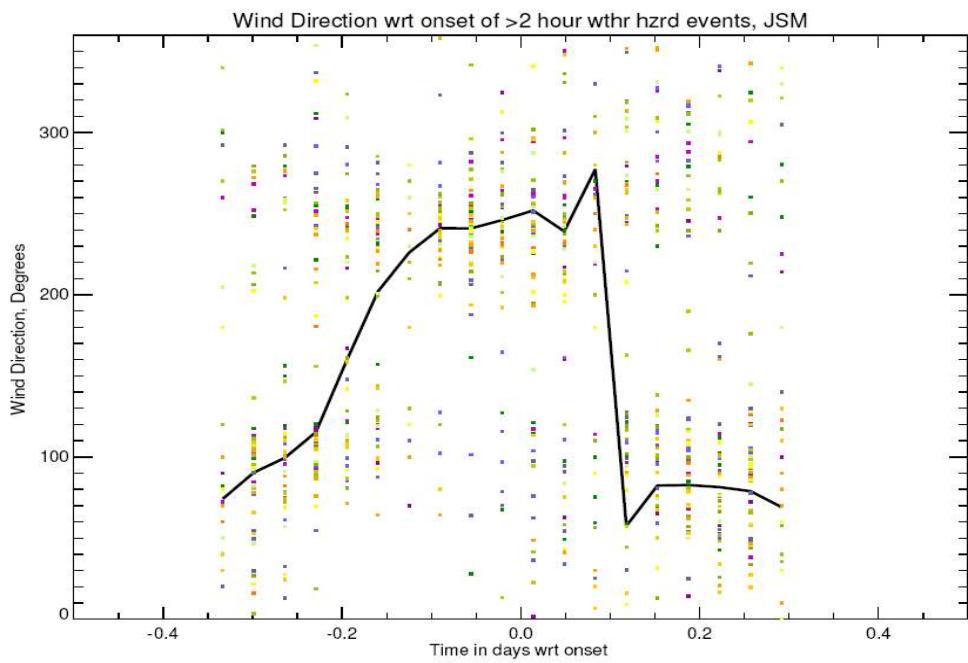
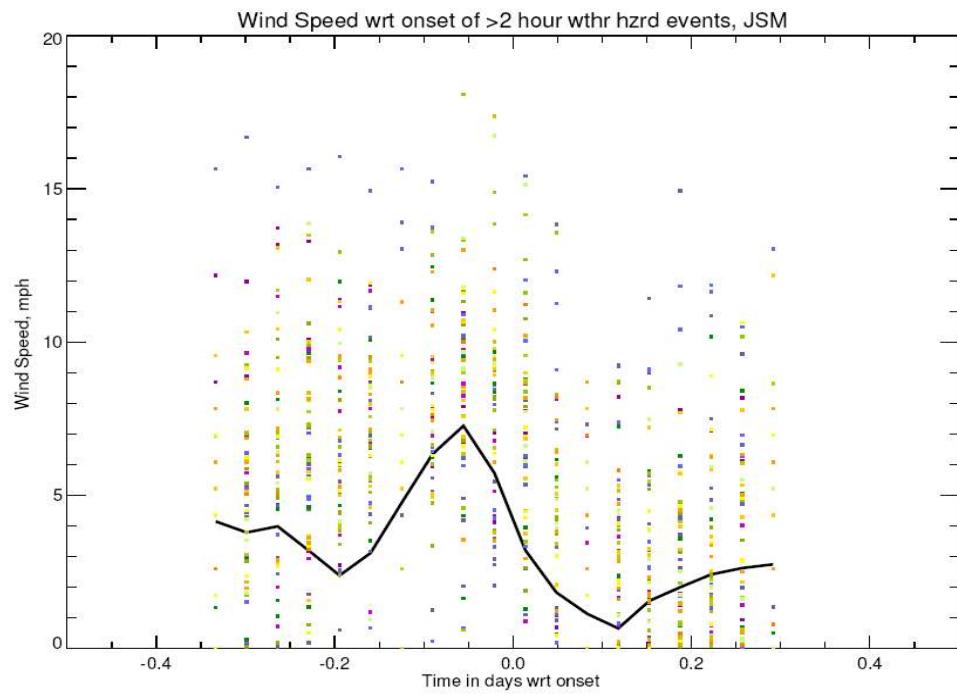


FIGURE 9 (above)

FIGURE 10 (below)



perhaps). Figures 9-12 show composite diurnal evolutions of wind direction and speed for days with weather hazards lasting 2 or more hours that start at 20-22Z (figures 9 and 10), and composite diurnal evolutions for days with NO weather hazards lasting 2 or more hours (figures 11 and 12). The abscissa is the time, in units of days, with respect to the weather hazard start (Figures 9 and 10) and 21Z (Figures 11 and 12).

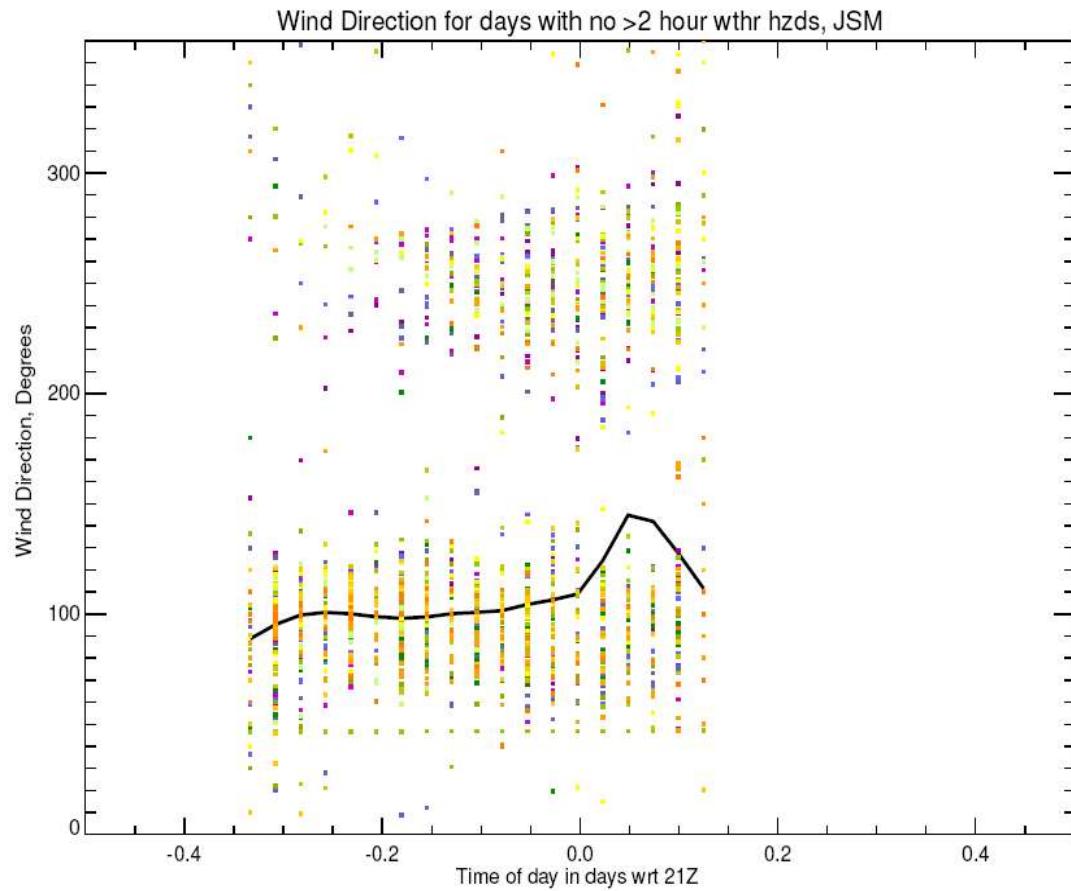


Figure 11

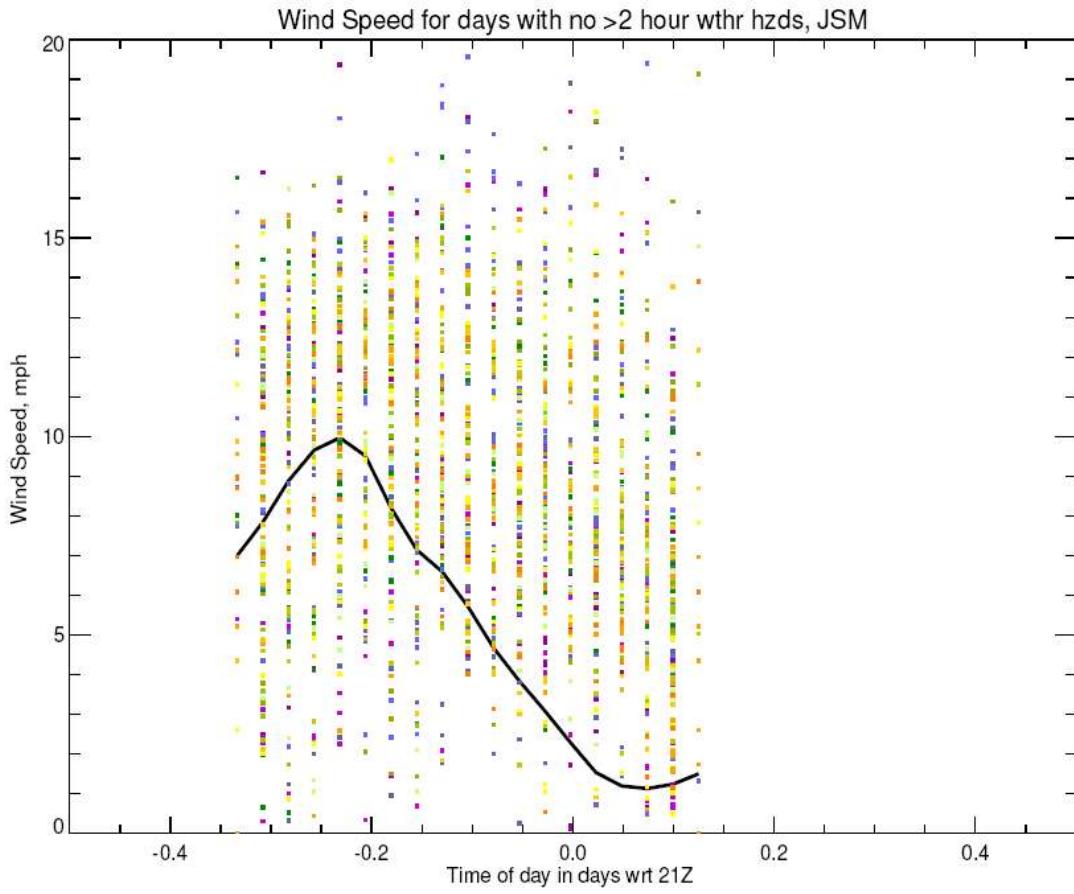


Figure 12

The colored dots are all the samples, and the black line is the mean. The mean curve for the weather hazard days shows a wind shift from easterly to westerly about four hours before the onset of inclement weather, with weak winds after onset, returning to easterlies later in the evening. This wind shift is absent, at least in the mean, for the non-hazard days. However, looking at the colored dots, you can see a population of westerly winds starting four hours or so before 21Z in the non-hazard plot. As Rennie said in his e-mail, a sea breeze frequently develops (from the west) with the solar heating. The role of topography in blocking the trades and allowing a westerly sea breeze to come in underneath is also important. However, it does not rain every day, i.e., a wind shift does not mean it will rain. It IS clear that the morning easterlies are much weaker on hazard days. If easterlies are greater than 10 mph, a no-hazard day is very likely.

I have also looked at the overall weather statistics during the Daytime AuRa VAlidation

LAnder WindowS from 4 PM to 8 PM and from 5 PM to 8 PM. This is arguably on the late side, but the previous graphs suggest that trying to do it much sooner on a regular basis is asking for trouble. I looked at the incidence of 2 hour (or more) consecutive hourly reports of a weather hazard. For JSM, we had 70 days with these weather hazards out of 224 for 4-8 PM, and 63 days for 5-8PM. At TCM, these numbers are 40 and 29 days, respectively. The difference is significant, and probably greater than these numbers would indicate. Even if the ceiling is not below limits, there may be some broken clouds at JSM in the evening after rainfall which can complicate a landing in the dark.

Liberia is an airport some 5 hours drive from Juan SantaMaria (JSM). It is near sea level, and its overall weather characteristics are significantly different from those of JSM. Figure 13 shows the diurnal distribution of weather hazards for Liberia. It should be compared with Figures 1 and 2 for Juan SantaMaria and Tocumen, respectively.

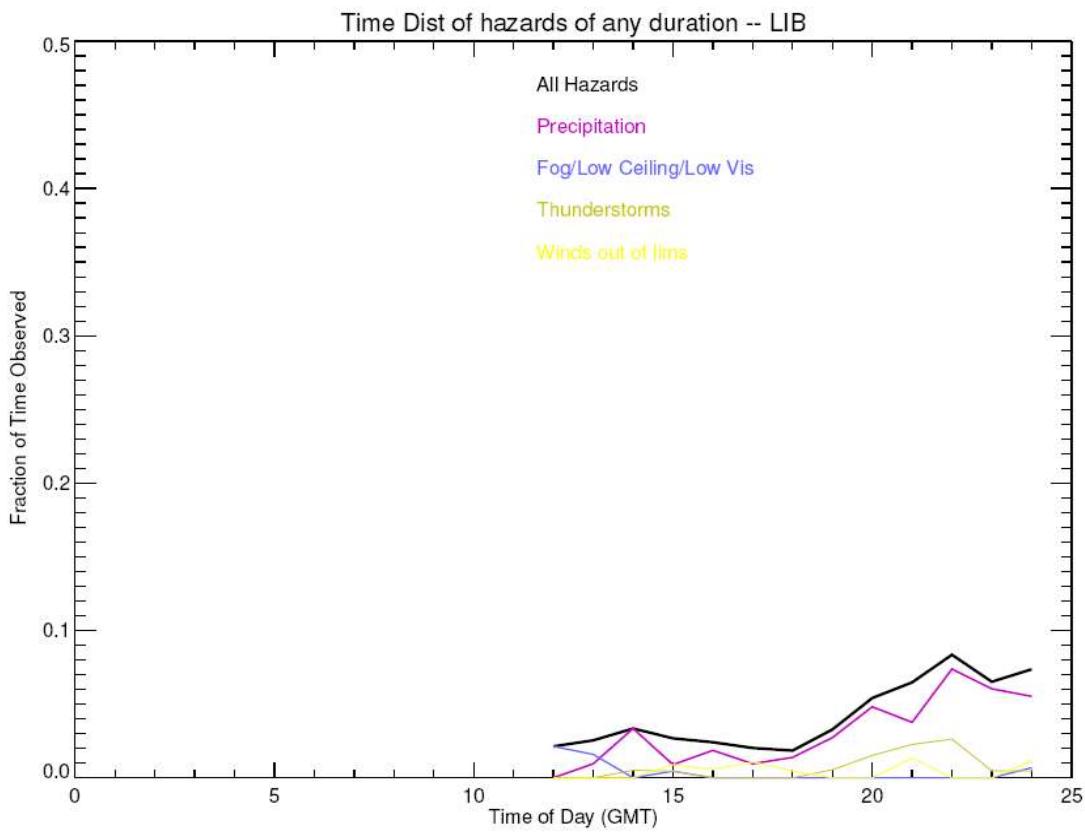


Figure 13

Note that Liberia has no observations during the night. Liberia also has no weather forecaster on site. TAFS are available, but are issued from JSM. The weather hazards

peak at a similar time as JSM, but are much less frequent (a factor of 3-3.5 lower. Also, there are no observations of fog/low ceiling/low visibility conditions in the afternoon. Of course, Liberia's utility as an alternate airport might be compromised if there is strong coupling between the weather at the two airfields. The sites are quite different, of course, with JSM in a mountain valley and Liberia at sea level on the other side of a mountain range. One can see one obvious difference in the nature of the weather (other than the frequency of hazards) just by the absence of significant fog/lowvis/lowceiling in the afternoon. Still, it is worth looking at the statistics to see whether a hazard at Liberia is more likely if there is a hazard at JSM.

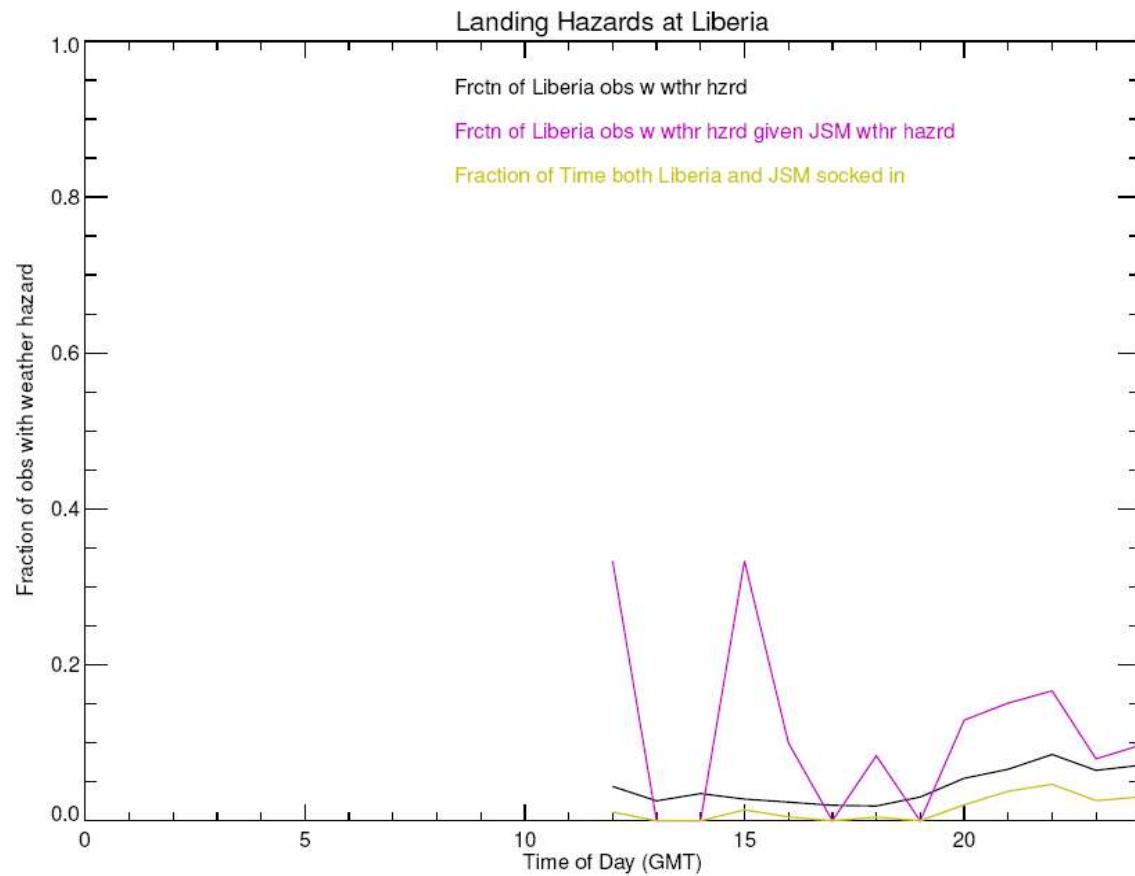


Figure 14

Figure 14 shows the fraction of observations (black curve) in Liberia with any weather hazard as a function of time of day. The curve is essentially the same as the black curve in Figure 13. The purple curve is the same as the black curve, except only observations where there is a simultaneous hazard at JSM have been considered. The pea soup colored curve is the fraction of time both JSM and Liberia are socked in. It should be noted that the coupling statistics (purple curve) are worthless before 20Z (2 PM) because of the low incidence of JSM weather hazards at those times. However, between 2 and 4 PM, there is definitely some coupling. Essentially what this says is that if there is bad weather at JSM between 2 and 4 PM inclusive, the probability for bad weather at Liberia is doubled from its usual low value. At 5 and 6 PM, however, bad weather at JSM has no statistical effect on the likelihood of bad weather at Liberia (and these are probably the most critical landing times for the ER-2). A reasonable explanation for what is happening is that conditions that favor convection at JSM have some tendency to favor convection in Liberia. In fact, the probability enhancement between 2 and 4 PM (purple curve higher than black curve) follows the thunderstorm curve for both Liberia (Figure 13) and JSM (Figure 1). Later on, the upslope flow at JSM's mountain location produces low ceilings and fog. Liberia's sea level location does not produce these conditions. We could pursue this further, but the green curve, which shows the probability of both JSM and Liberia being unuseable in the afternoon is quite small, comparable to values in the quiet morning hours at JSM. Yes, there is coupling, but it is not strong. If there is bad weather at JSM, the probability of bad weather at Liberia (purple curve) is still less than 20% (not 100% -- which would be the case for complete coupling).

