OC 3570 Final Project LCDR Jim Rocha

Identifying cloud layers on Rawinsondes and IR satellite images

The planned objective of the project was to gain experience in the following areas of interest: 1) Operation of Rawinsondes to include interpreting the data received, 2) Analyzing images from the NOAA-14 (16) satellites, 3) Use of Teravision satellite image processing software, and 4) Learn a little more about the structure of the atmosphere.

The original idea had been to compare the cloud top temperatures received from the NOAA satellites with the interpreted cloud top temperatures identified on the Rawinsonde data. The plan needed to be changed after realizing that the meteorological time scale did not permit accurate co-location of the Rawinsonde flight with the time of the satellite over pass. Though every attempt was made to match the times as close as possible, it was not possible to remove all the sources of error. The errors in co-locating the data samples in time and space were caused by a combination of the following sources: 1) The duration of the satellite overpass (time to complete the image) is approximately 16 minutes, 2) The Rawinsonde flights lasted as long as 45 minutes, and 3) The movement of the Rawinsonde itself was as much as 90 km at speeds ranging from 10 to 120 knots. These numerous variables made it impossible to locate a specific point in space and time to compare the two data sources. Once this became known, it was necessary to alter the plan and try to compare general cloud layers, in the local area, between the two data sources.

The procedure used was to first identify the Rawinsonde flights that actually did correspond to satellite over passes. There were four cases where good balloon flights matched with a good satellite images. The source of the satellite images was the NOAA-14 or 16 AVHRR channel 4. This channel was chosen due to the characteristics of 11µm IR wavelength within the atmosphere and in clouds. The terrestrially emitted 11 µm photons are only slightly affected by the gaseous portion of the atmosphere, but are entirely absorbed into any clouds which measure more than a few meters thick. By looking at this wavelength, it is possible to collect information from just the top few meters of the highest layer of clouds. Only those photons coming from the very top few meters reach the satellite by direct path. The information received from the AVHRR is in brightness temperature and is very close to the actual temperature of the top few meters of the cloud. There is the possibility that a very thin layer could allow some background photons through and the temperature would appear higher than the actual temperature and/or higher than one might expect for a specific type of cloud (see figure one attached). The cloud layers in the Rawinsonde data were determined by looking for peaks in the relative humidity profile (with respect to altitude). For each of the four cases, three distinct layers were chosen, and upper and lower temperatures for the layer determined from the corresponding temperature profile. Data profiles, images and interpretive comments for three of the four cases have been included as attachments following this discussion. The included data profiles and images are from Rawinsonde flights 18, 19, and 20, from the second cruise period. The other studied case was from Rawinsonde flight 11. However this data did not show any more revealing features than the chosen three and was thus not included.

Rawinsonde flight 18 revealed a humidity profile which was not as variable, with respect to altitude, compared to flights 19 and 20, which appeared to have a much more complicated structure. This did not, however, make it any easier to try to determine individual layers. In fact, it made it more difficult and ultimately, it was left to the discretion of the examiner to determine levels without the aid of having sharp humidity gradients. The individual layers chosen from the Rawinsonde data and the corresponding temperatures can be found on the first page of each of the sets of images. In nearly every case, an attempt was made to identify a low, mid, and high layer and identify the type of clouds found. Stratoform and cumuloform clouds seemed to be the order of the day. Cumulus congestus seemed to be apparent in data from flights 18 and 19. In each case, it was clear that the choice of layers could have been made differently, which would have resulted in filtered satellite images that would have had a different appearance. The printed satellite images were composed by isolating the temperature range of the desired layer and filtering out all other temperatures. The areas that appear white in the images are the areas with the corresponding temperatures. In all three cases, there are areas where rings can be seen, which are a result of the outer edges of a colder cloud being falsely warmed by background photons penetrating the thin edge.

The conclusion drawn following the review and analysis of the data was that it is very difficult, if not impossible to identify specific clouds between the two data sources for comparison. There is too much variability in the retrieval of the data to accurately link a particular cloud in time and space. It seems that it would be possible to draw some better comparisons if the cloud layers were solid, thick Stratoform clouds or some type of marine layer, but with complicated frontal dynamics this seems impossible. In the end, the objectives of the project were met. Considerable knowledge of Rawinsonde operations and valuable experience using Teravision was obtained.