Quarterly Report ending 31 March 2002

Development of a Tropical Cyclone Rainfall Climatology and Persistence (R-CLIPER) Model

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During the second quarter we started evaluating the tropical cyclone (TC) rain climatology and persistence (R-CLIPER) model on five storms selected through discussion with members of TPC/NHC and HPC:

Andrew (1992); fast moving major hurricane
Fran (1996): classical mature hurricane making landfall
Danny (1997): small, weak, slow-moving hurricane
Floyd (1999): major trough interaction with weakening hurricane
Allison (2001): strong slow-moving tropical storm.

The R-CLIPER was modified to use the 6-h best track positions for each of the storms shown in Fig. 1, and was run here at HRD. The TMI-climatology version of the R-CLIPER was used for all five cases. Fig. 2 shows the storm total rain for all five cases and Table 1 lists the R-CLIPER peak storm-total rainfall after landfall for each case along with the gauge estimated peak storm-total rainfall.

The results from the five cases in Fig. 2 give good examples of the distribution of storm total rainfall that the R-CLIPER produces. It is clear from Fig. 2 that when storms move slowly, as in Danny, the rainfall increases, while as a storm intensifies the swath of rain is slighter narrower as in the Andrew and Floyd examples. Even though Allison was moving slowly, the rainfall was still relatively light because it was so weak. Figure 2 and Table 1 also show that while the storm total distributions make sense in terms of the storm speed and intensity, the R-CLIPER performs relatively poorly when compared to a single measure of the rain distribution such as the peak storm-total rainfall. Using this measure of the rainfall distribution the R-CLIPER often produces less than half the gauge-estimated peak storm-total rainfall, and in the case of Allison less than 15%. This tendency to underestimate the storm-total rainfall is also evident when comparing the probability distribution of it from gauges and the R-CLIPER.

Figure 3 show a comparison of the probability of storm-total rainfall from the R-CLIPER and the gauge data available from the NCDC archives for the five cases. The Andrew and Fran cases contained only the gauge totals >2" and 5", respectively. Hence, they are not the best to compare with. However, comparisons with the Danny, Floyd and Allison gauge storm-total rainfall distributions show that the R-CLIPER storm-total rainfall is roughly a factor of two less than that from the gauges for each percentile. This result is not that surprising, as the mean rainfall rate used in the R-CLIPER is not the best measure of the natural rain distribution, which is log-normally distributed, not normally distributed.

Figure 4 shows the probability distribution of the occurrence of rain within 500 km of the storm center from the TRMM TMI climatology for the three storm intensity classes (Lonfat et al 2000). The abscissa is in log coordinates demonstrating the log-normal shape of the distribution. This shape holds for the probability distribution of the total rain flux within 500 km of the storm, as well as that for each 10 km annuli (not shown). Hence, a better measure of the natural rain distribution is the mean of the log of the rain amount, or possibly the median (50%) value of the total storm rainfall. However, that will not increase the storm total rainfall by a factor of two, more like an increase of 25%. If one wants to know the peak storm-total rainfall it may be better to forecast the tail of the probability distribution of rain, such as the 95%, which varies little with storm intensity (Fig. 4). The tail of the rain distribution is determined by the convective processes, which don't vary much from storm to storm, or by radius from the storm center. This observation fits with Kraft's "rule of thumb" which doesn't include a variation in peak storm-total rainfall with intensity, i.e., you can get just as much rain from a tropical storm or as from a major hurricane of the same speed of motion.

The above discussion brings up an interesting question: what does the forecaster need to predict? Is the forecaster interested in a good measure of the storm-total rain distribution to insure the area and rough mean amounts are correct? On the other hand, is the forecaster interested in the likelihood the storm total rainfall has some probability of exceeding some amount? The answer to these questions would determine what type of products the R-CLIPER should produce. Because the TRMM TMI TC rain climatology includes information about the probability distribution of rain by occurrence, rain amount, radius form the storm, and storm intensity we can tailor the products to address a number of forecast needs. The type of products the forecasters want needs to be addressed before we can attempt to improve R-CLIPER to produce a more meaningful product. This effort needs to be started as soon as possible. As a means of starting the dialogue, we plan to present a seminar on this material at TPC/NHC in the next month. If travel funds are available Frank Marks will try to do the same at HPC. A discussion of the type of TC precipitation forecasts needed was also brought up as an action item at the end of the IHC for a future workshop or breakout session.

Over the next quarter, we will continue the validation effort of the current R-CLIPER. We plan to work with HPC to get the 6-h rain products for comparison to the R-CLIPER 6-h rain totals. We also plan to work with Mark DeMaria to improve the rain gauge storm-total rainfall archive for Andrew and Fran. The current version of the model will remain in use for this hurricane season at TPC while we continue our evaluation of the products. We plan to generate a new version of the R-CLIPER to use the mean log of the rain amount rather than the mean rain amount currently used.

A transition problem identified with the current operational R-CLIPER for use this season is its dependence on the ATCF forecast for the storm track. Currently, the ATCF contains no track forecast information after the storm makes landfall, when TPC/NHC stops producing them. HPC continues to follow the storm's remnants, however, no track forecast is produced from which to run the R-CLIPER. This issue has to be addressed by TPC/NHC and HPC before inland R-CLIPER forecasts can be generated this season.

The R-CLIPER model was presented at an AOML informal seminar in February 2002[1], and some of the results were shown during the panel discussion on tropical cyclone quantitative precipitation forecasting at the Interdepartmental Hurricane Conference in March 2002. Results from these tests will also be presented at the 25th Conference on Hurricanes and Tropical Meteorology in May 2002 (Marks et al 2002).

References:

Lonfat, M., F. D. Marks, S. Chen, 2000: Study of the rain distribution in tropical cyclones using TRMM/TMI. Reprints *24th Conference on Hurricanes and Tropical Meteorology*, AMS, Ft. Lauderdale, FL, 480-481.

Marks, F. D., G. Kappler, M. DeMaria, 2002: Development of a Tropical Cyclone Rainfall Climatology and Persistence (R-CLIPER) Model. Reprints of the 25th *Conference on Hurricanes and Tropical Meteorology*, AMS, San Diego, CA. (ftp://ftp.aoml.noaa.gov/hrd/pub/marks/7D2_Marks.pdf)

Table 1.

Storm	R-CLIPER maximum rainfall (in)	Location of R-CLIPER maximum rain	Gauge Maximum rainfall (in)	Location of gauge maximum rain
Andrew 1992	7.0	Louisiana coast	11.9	Hammond, LA
	4.0	Florida coast	7.8	Broward, FL
Fran 1996	8.2	N of Puerto Rico		
	4.0	Carolina coast	14.2	Luray, VA
Danny 1997	12.3	Alabama coast	27.0	Theodore, AL
Floyd 1999	7.3	Bahamas	11.9	Clinton, NC
	3.0	Carolina coast	14.5	Williamsburg, VA
Allison 2001	6.4	SE Texas	36.9	Houston, TX

[1] ftp://ftp.aoml.noaa.gov/hrd/pub/marks/rcliper/R-CLIPER.pdf

Figures

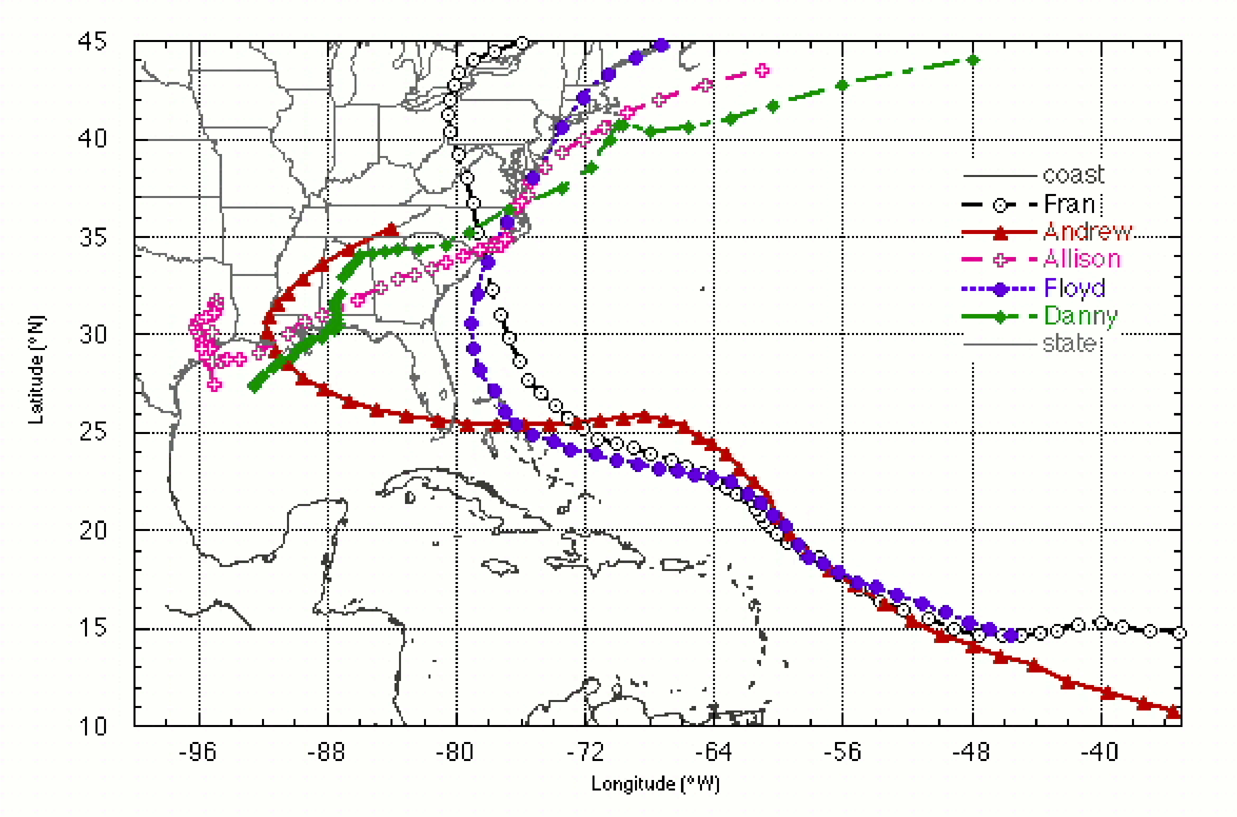

Fig. 1. Best track for the five cases used for the R-CLIPER validation.

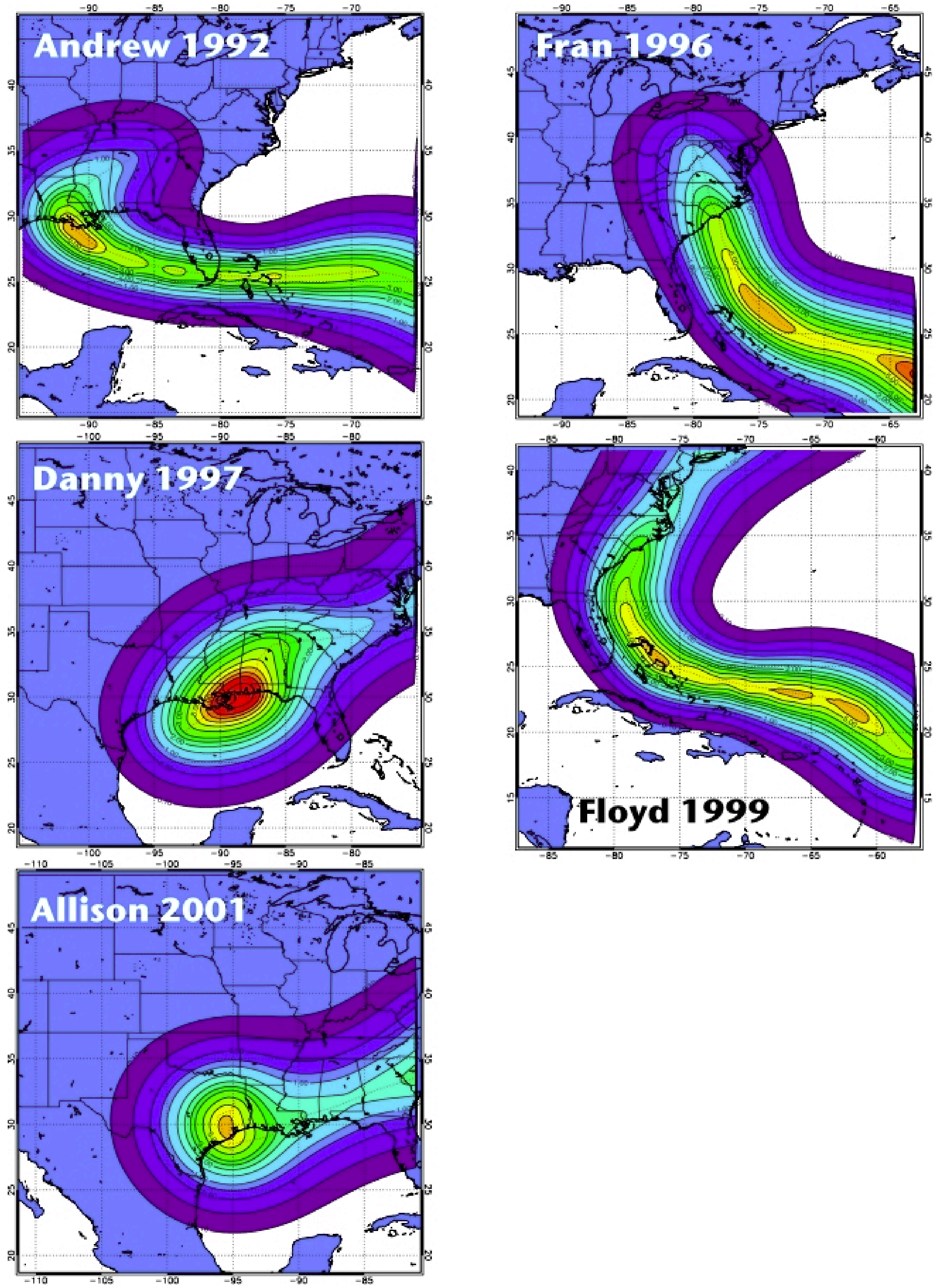

Fig. 2. Storm-total rainfall (inches) for the five cases in Fig. 1. Rainfall totals are denoted by color shading and contours, whereas the storm best-track is denoted by a red dotted line.

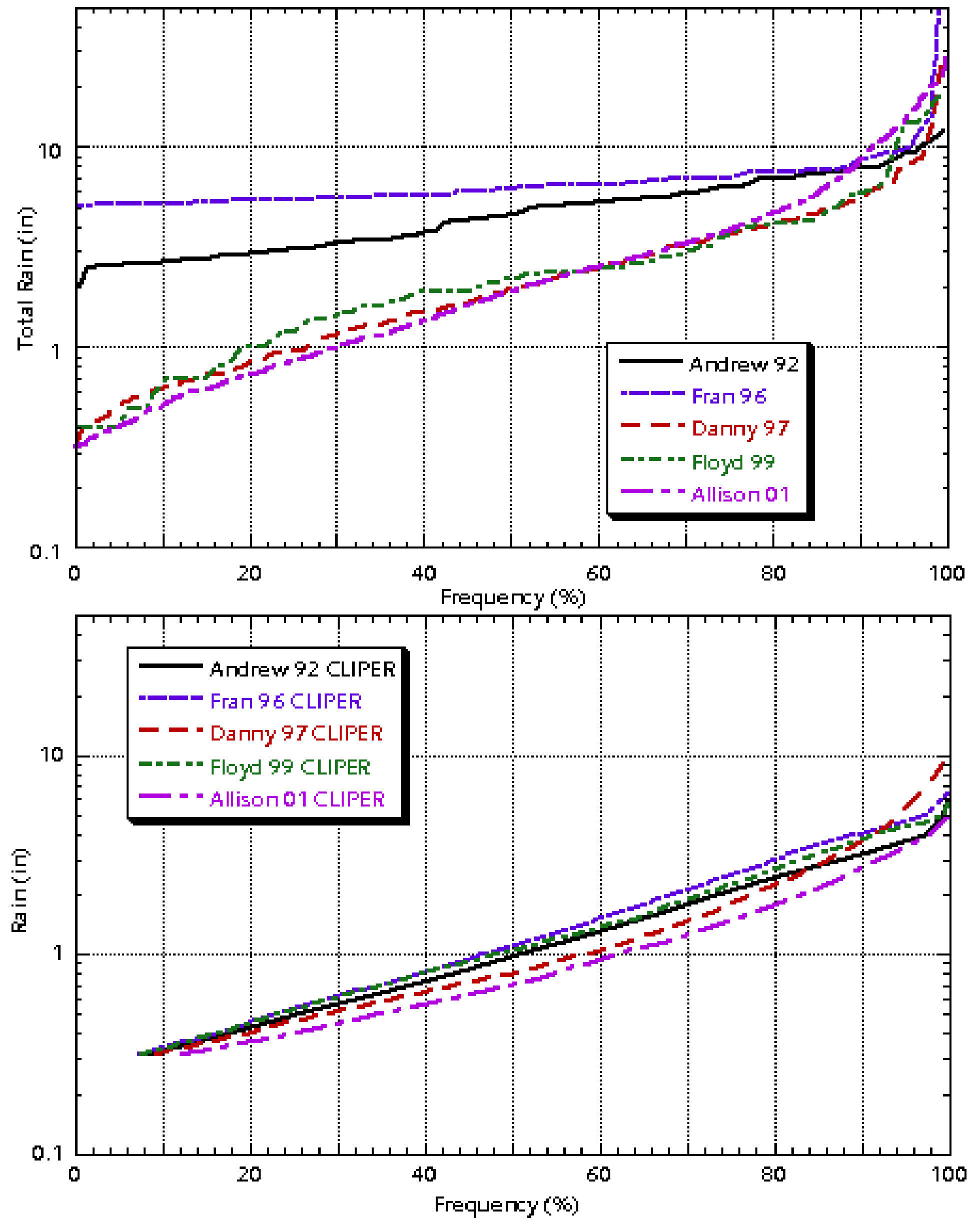

Fig. 3. Cumulative probability distributions of gauge and R-CLIPER storm-total rainfall (inches) for the five cases.

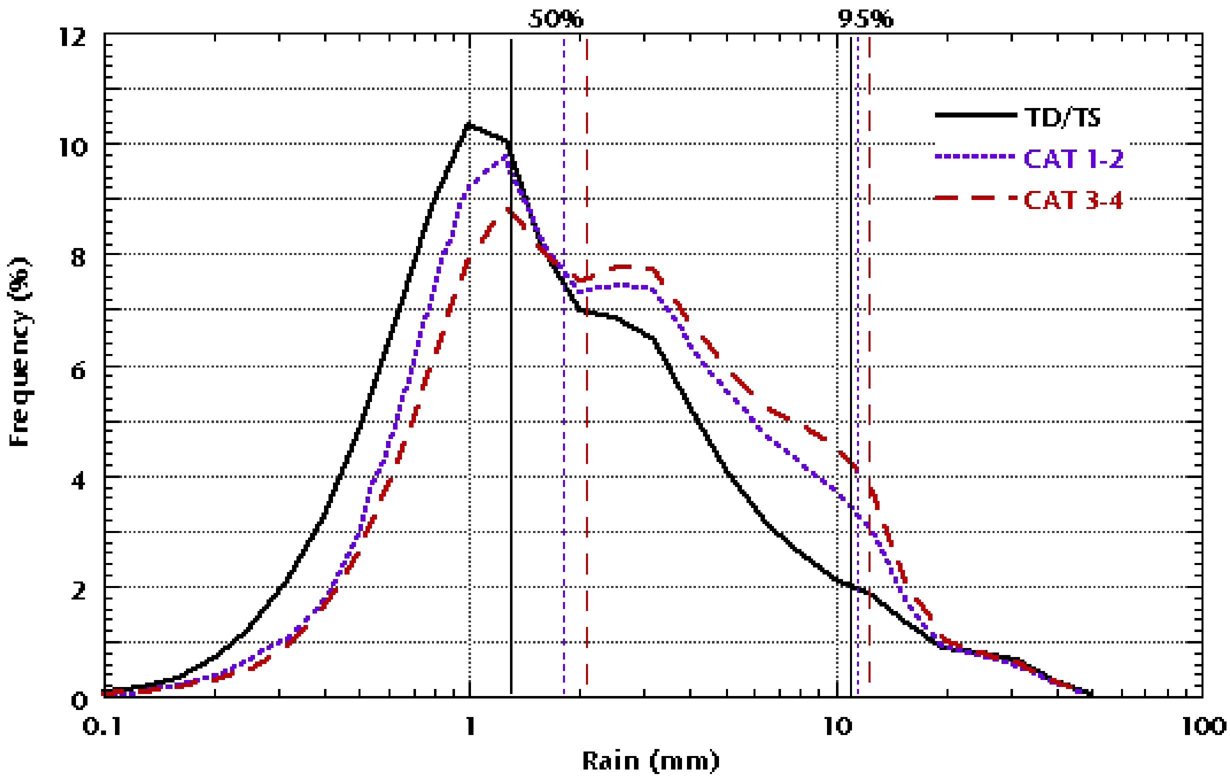

Fig. 4. Probability distribution occurrence of rain (mm) within 500 km of the storm center from the TRMM TMI climatology for the three intensity classes (Lonfat et al 2000). The median (50%) and 95% rain values for each class are denoted by vertical lines.

Second Year Work Plan

The development of the R-CLIPER, while technically simple once the TC rain climatology was developed, has generated a number of forecast issues that need to be addressed before the rain forecasts can be used effectively. These issues are fundamental to quantitative precipitation forecasting, and not isolated to the R-CLIPER. One of the biggest problems in the area of quantitative precipitation forecasting seems to be a lack of understanding of what we are trying to predict. In my opinion, the TC rain climatology and R-CLIPER provide a perfect vehicle to use to frame these questions and attempt to answer them. We need to strive to make the best use of the TC rain climatology and R-CLIPER to provide useful rain forecasts for the NOAA forecast team. The approach proposed here is to continue the evaluation of the R-CLIPER using different measures of the rain distribution, and to work with the forecasters to determine the best measures of the rain distribution to use for the different forecast products they may need.

Work Plan

The second year will be dominated by the task of validating the R-CLIPER to give the forecasters a good feel for what part of the storm rainfall distribution the R-CLIPER best represents. This effort will be focused on two key areas: (1) the validation of the R-CLIPER using the mean rain amount that was developed in year 1; and (2) expanding the R-CLIPER to forecast other, more appropriate measures of the rainfall distribution, i.e., the mean log rainfall, or the 95% for use in flash-flood forecasts.

Under the first area we will continue our evaluation of the current, and any newer versions of the R-CLIPER with HPC's 6-h areal average rainfall amounts on a 1°X1° grid. Comparisons with storm-total rainfall data from gauges will also be performed. A University of Miami undergraduate (Gretchen Kappler) will work with Frank Marks on these evaluations, with software support from Peter Dodge.

The second area of effort will entail working with the NOAA TC precipitation forecast community to come up with the best R-CLIPER generated products. Frank Marks plans to work closely with the TPC/NHC and HPC to come up with the best suite of products. The most useful products can be coded and tested with the five cases already chosen, and put into the operational suite.

During this timeframe we will also be updating the TRMM TMI rain climatology with another year of TRMM data. This work plus the addition of wavenumber one asymmetry information from the climatology will be undertaken as part of Frank Marks' TRMM funded research.

Timeline

31 December 2002 complete evaluation of the 2002 TC R-CLIPER forecasts compared to storm-total rainfall.

January 2003 work with OFCM to organize and conduct workshop to establish useful TC rain forecast products.

February 2003 present R-CLIPER results to IHC

31 March 2002 complete validation of the five cases using the HPC 6-h rainfall amounts.

15 May 2003 provide new versions of the R-CLIPER to produce various rain forecasts, such as the mean log rainfall or the 95% of the rain distribution.

Budget

The budget for year two includes 1 month of Frank Marks' time to work on the validation issues and the development of new products based on the probability distribution to address different measures of the rain distribution. The budget also includes 1 month of Peter Dodge's time to help with processing of the gauge and HPC data sets. We have never used the HPC data sets before and it will take some software development to work with these data sets. I have also included 0.5 month of the division secretary's time for clerical support. The remainder of the salary covers the University of Miami undergraduate's time to process the data. I have also included funds for travel to cover trips to the IHC and USWRP Science meeting to present the results from this work, to publish the results of the work, purchase a larger disk drive to store all of the data sets, and for computer support at AOML.

Budget for Year 2

		Total mm	Estimated Cost ($K)
Salaries and Fringe Benefits			
Senior Personnel			
	Frank Marks	1	10.1
Support Personnel			
	Peter Dodge	1	6.1
	Secretary	0.5	1.9
Other Labor (CIMAS etc..)			
	UM undergraduate (Kappler)	6	8.7
	Total Salaries		**26.7**
Fringe Benefits (NOAA=23%, UM=0%)			4.2
	Total Salaries and Benefits		**30.9**
Travel	IHC, USWRP science meeting		1.5
Publications	paper on R-CLIPER to AMS Journal		1.5
Equipment	10 Gbyte Hard drive		0.2
Other	Computer maintenance (hardware/software)		2.0
Indirect Costs (34.1% NOAA; 8% student)			**8.3**
	Total		**44.4**