Joint Hurricane Testbed first year accomplishments and second year proposal

Project: Development of a Rapid Intensification Index for the Eastern Pacific Basin

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1. First year accomplishments (July 1, 2003-May 1, 2004)

a. Derivation of the Eastern Pacific rapid intensification index

The software that was previously employed to derive a rapid intensification (RI) index for the Atlantic was modified so that it could be utilized to derive an RI index for the Eastern Pacific basin utilizing the SHIPS (DeMaria and Kaplan 1999) and TPC/NHC best track databases. Following the methodology that was utilized for the Atlantic basin (Kaplan and DeMaria 2003), RI was defined as the 95th percentile of all of the over-water 24-h intensity changes for the tropical and sub-tropical cyclones that comprised the database. For the Eastern Pacific, this corresponded to a 24 h intensity change of 19 ms^{-1} for the period 1989-2002. However, RI was defined as a 24 h intensity change of $\geq$18 ms^{1} (35 kt) for the purpose of this study. The Eastern Pacific sample was divided into RI and non-RI cases to choose the predictors for which statistically significant differences existed between the RI and non-RI samples at the 99.9% level following the methodology described in Kaplan and DeMaria (2003). The RI thresholds were then defined as the mean values of all of the RI cases for each of the statistically significant predictors. It is important to note that all available data were used to compute the RI thresholds. Thus, the RI thresholds of the synoptic and climatological predictors were computed for the period from 1989-2002 since those data were available for that entire time period. In contrast, the RI thresholds for the GOES predictors were determined for the period 1995-2002 since the GOES data were not available prior to 1995.

Sensitivity tests were performed to determine which sets of predictors should be included in the final version of the Eastern Pacific RI index. This was done objectively by choosing the predictors that yielded probability of RI estimates that produced the highest Brier Skill Score (Wilks 1995) for a homogenous set of cases that comprised the developmental sample. The Brier Skill Score (Wilks 1995) was evaluated by comparing the probability of RI estimates of the various versions of the RI index to the climatological probability of RI (i.e. ~6%) to assess which method more accurately reflected whether or not RI occurred during any given 24-h period. These tests showed that combining the five predictors that were employed previously by Kaplan and

DeMaria (2003) to obtain the standard version of the Atlantic RI index (i.e., previous 12-h intensity change, 850-700 hPa relative humidity, 850-200 hPa vertical shear, sea-surface temperature, potential intensity) and two inner-core GOES predictors (area-averaged infrared brightness temperature and the standard deviation of the GOES infrared brightness temperature) produced the most skillful version of the RI index for the Eastern Pacific basin. Both of the GOES predictors and the previous 12-h intensity change were evaluated at t=0 h, while the remaining four predictors were averaged for the 24 hour period commencing at t=0 h.

To allow for comparisons between both versions of the RI index, the Atlantic version was re-derived utilizing the Atlantic SHIPS database for the period 1989-2002. Interestingly, the predictors in the re-derived version of the Atlantic RI index were identical to those that were utilized in the recently developed Eastern Pacific version of the index save for a slight difference in the area over which the standard deviation of the brightness temperature was computed. Figure 1 shows a comparison of the performance of both versions for the 1995-2002 developmental samples. Although some of the RI thresholds were determined using cases prior to 1995, the probabilities could only be computed for the period from 1995-2002 since the GOES data were unavailable prior to 1995. The probability of RI estimates shown are for the 24 h period that begins at t=0 h and ends at t=24 h. Thus, if RI was observed to have occurred, but just not for that 24 h period (i.e. it took place for the 6-h period just prior to or after the period beginning at t=0) then it was assumed that RI did not occur for the purpose of computing the RI probabilities shown in the figure.

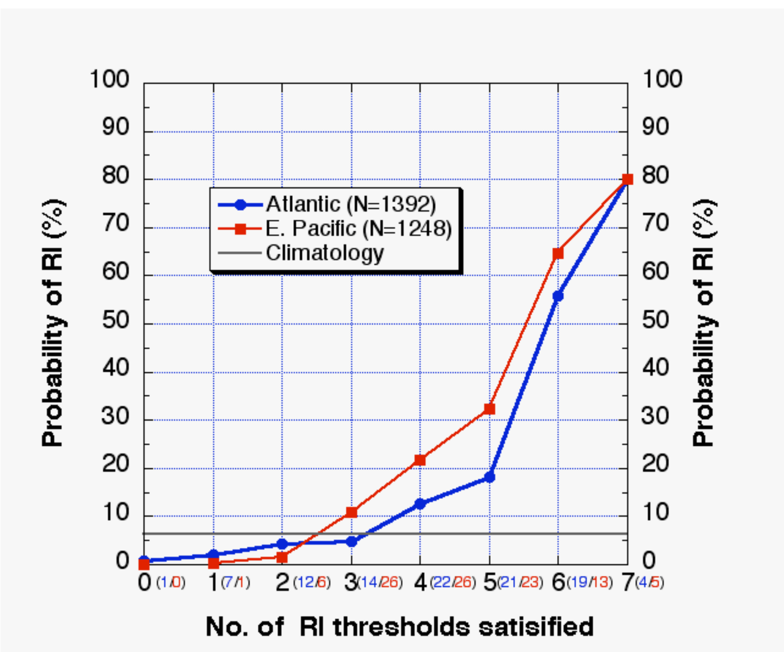

Fig. 1. The probability of RI estimates obtained using the Atlantic (blue) and E. Pacific (red) versions of the RI index for the 1995-2002 developmental samples. The climatological probability of RI (6%) is also provided. The percentage of the sample total number of RI cases is provided beside the number of RI thresholds satisfied.

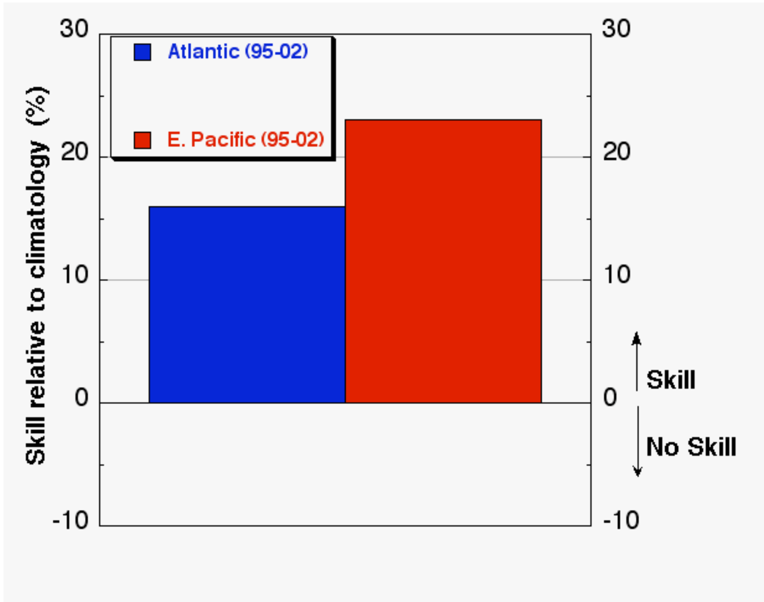

Fig. 2. The corresponding Brier skill scores computed relative to climatology utilizing the probability of RI estimates that are depicted in Fig.1 for the Atlantic and E. Pacific versions of the RI index.

Although the maximum probability of RI estimates obtained for each of the two versions were similar, the higher Brier skill scores obtained for the Eastern Pacific sample (Fig. 2) suggests that the RI index derived for that basin is somewhat superior to that derived for the Atlantic basin. Also, while the probability of RI was found to be fairly high (~80%) when all 7 RI thresholds were satisfied this occurred for 5% or less of the RI cases. Nevertheless, approximately 20% of all of the RI cases occurred for the 24-h period when the estimated probability of RI was 50% or more (i.e. when 6 or 7 of the RI thresholds were satisfied) for the 1995-2002 Atlantic and Eastern Pacific developmental samples.

b. Performance of the RI index for the 2003 Eastern Pacific hurricane season

Since derivation of the Eastern Pacific version of the RI index was not complete until after the 2003 hurricane season had ended, it was not possible to test the RI index in real-time. However, all of the operational data necessary to run the index was saved and the RI index was re-run for the entire season. Figure 3 shows the results of the re-run cases for the 2003 Eastern Pacific hurricane season. The figure shows that the RI index did not perform well for the Eastern Pacific re-runs. There appear to be a few factors that contributed to the somewhat disappointing performance during the 2003 season. First, the sea-surface temperature estimates that were employed in SHIPS and hence in the RI index may not have been representative of the underlying ocean temperature for some storms. To illustrate, Gentemann et al. (2004) showed that employing the AMSR-E deduced sea-surface temperatures in place of those obtained from the Reynolds analysis yielded improvement of up to 8% (~6% at 24 h) in the magnitude of the SHIPS forecast errors. Gentemann et al. (2004) hypothesized that these improvements were due to the more accurate SSTs that were obtained using the AMSR-E measurements. Specifically, they cited the capability of AMSR-E to capture the lowered sea-surface temperatures that were produced in the cool wake regions of previous cyclones as the primary reason for the observed improvements. Since, two of the seven predictors (i.e. sea-surface temperature and potential) that are used in the RI index are dependent on sea-surface temperature the RI index was likely adversely affected by the inaccuracy of the Reynolds values. To test the sensitivity of the index to the use of different sea-surface temperature measurements, the RI index was re-run using the AMSR-E sea-surface temperatures instead of the Reynolds values. As can be seen in Fig. 3, the use of the AMSR-E values greatly improved the performance of the RI index, although the index still was not skillful relative to climatology.

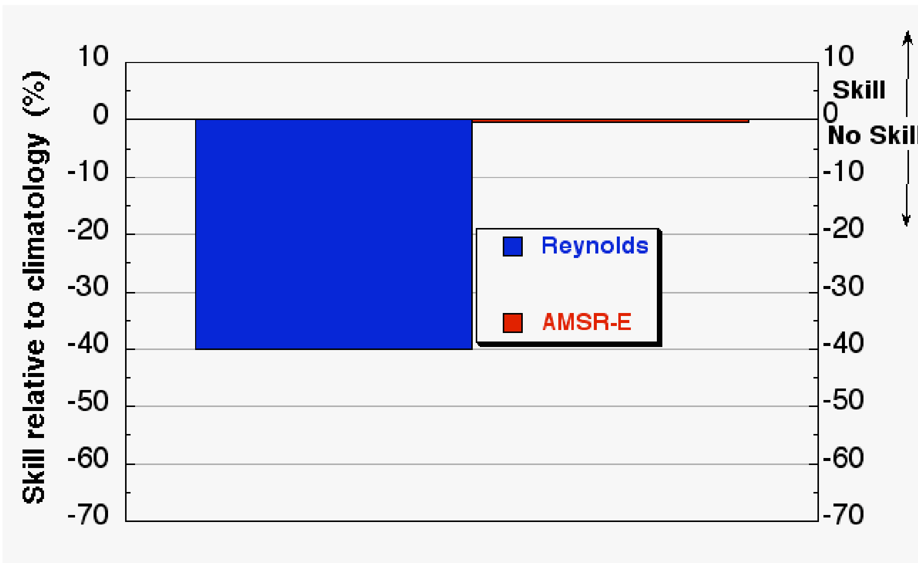

Fig. 3. The Brier skill scores of the Eastern Pacific version of the RI index for a homogeneous sample of the 2003 re-run cases (N=196). The results are shown for the version that used Reynolds sea-surface temperatures as well as for the version that used AMSR-E values.

Another factor that likely contributed to the lack of skill of the RI index for the 2003 Eastern Pacific season is that the season was less active than normal. Figure 4 shows the average Brier skill score for the entire 1995-2002 sample as well as those computed for each individual year. It can be seen that in years when the overall probability of RI was lower than the total sample average of 6% the RI index tended not to perform as well as it did when the probability of RI was near or above the sample average. This result may simply reflect the difficulty of having skill relative to climatology when the overall probability of RI is very low in any given year. However, it is also likely that the poorer performance during the less active years is the result of the overall conditions being more suppressed than that of the mean long-term conditions for which the RI index was originally developed. In any event, the Eastern Pacific RI index performance during 2003 appears to be within the range of the possible performance for any given year, particularly when the RI index was run using the AMSR-E sea-surface temperatures in place of the Reynolds values.

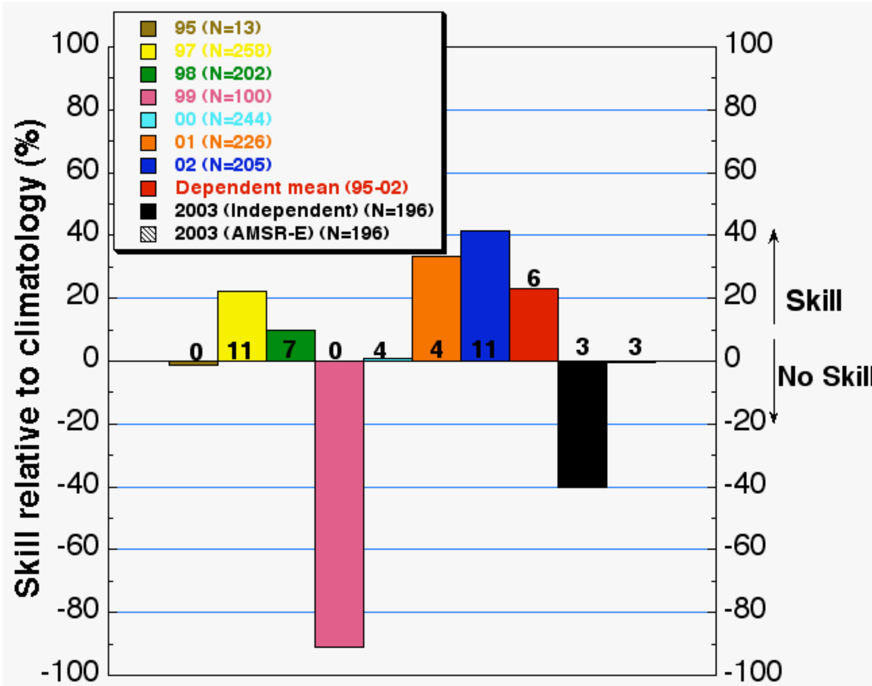

Fig. 4. The Brier skill scores of the Eastern Pacific version of the RI index obtained for the entire developmental sample (1995-2002) as well for each of the individual years that comprised that sample. Also shown on each of the bars (in black) is the probability of RI for any given year or y ears. These probabilities were computed by simply dividing the number of RI cases by the total number of cases that occurred during that year (or years). The number of cases for each of the individual years is also provided.

c. Preparation of the rapid intensification index for the 2004 Hurricane season

In preparation for real-time (Eastern Pacific version) and operational (Atlantic version) testing during the upcoming 2004 hurricane season, both versions of the RI index were updated by including data from the 2003 hurricane season as well as some additional cases from previous years. Figure 5 shows the updated probabilities that will be used for the 2004 season. The probabilities and Brier scores (Fig. 6) for the updated versions of the index decreased somewhat from the values cited previously which reflects the difficulties encountered when employing the RI index during the 2003 hurricane season. It is worth noting that the E. Pacific version still outperformed the Atlantic version for the updated sample.

The subroutine that was used to compute the RI index in the operational SHIPS model during previous hurricane seasons was modified so that it can be used to compute the probability of RI for both the Eastern Pacific and Atlantic basins. The output from both the Atlantic and Eastern Pacific versions of the RI index will be included on the log sheet that is printed out each time the SHIPS model is run in either basin.

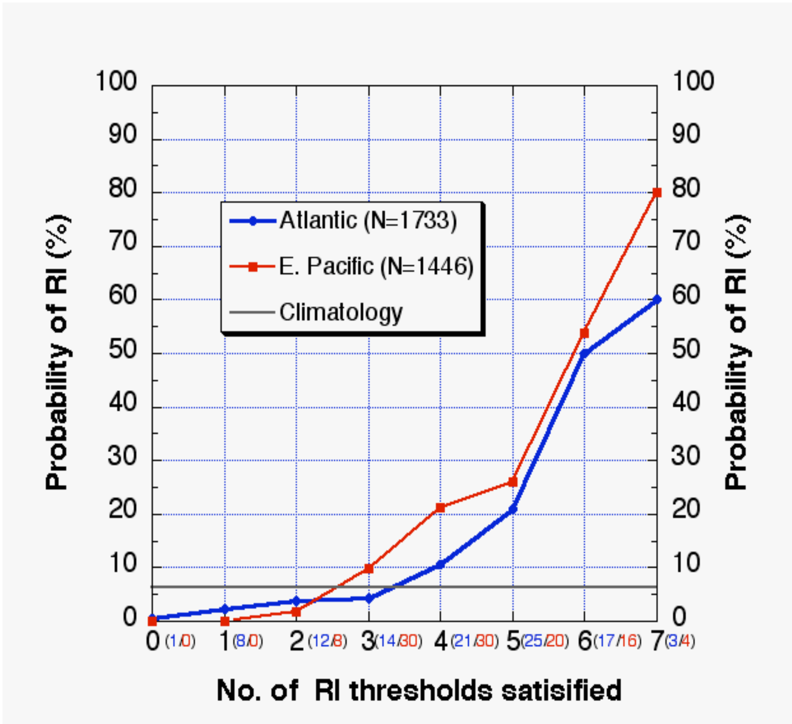

Fig. 5. Same as in Fig.1 except for the1995-2003 developmental samples.

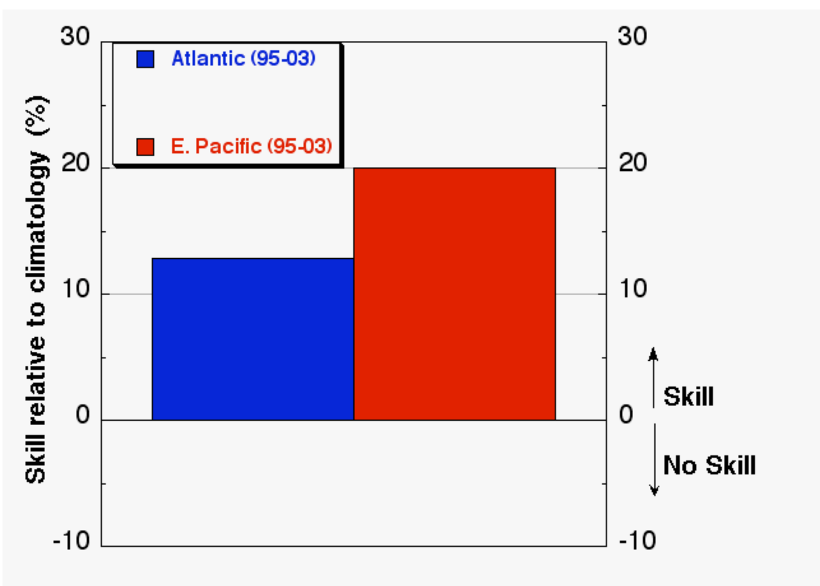

Fig. 6. Same as in Fig. 2 except based upon the probabilities depicted in Fig. 5.

d. Development of a scaled version of the RI index

One of the current weaknesses of the RI index is that it uses fixed thresholds when assessing the probability of RI which often results in relatively large variations in the RI probabilities between 6-hourly forecast times. Thus, work has begun to develop an index that combines each of the RI predictors into a single value that can then be used to estimate the probability of RI. To accomplish this task, the scaled magnitude of each of the seven predictors was computed. These values were scaled between 0 and 1 where the magnitude of each of the values was determined by the range of values within which RI occurred. These scaled values were then summed together and then binned so that the RI probabilities could be determined for a given range of the scaled RI index values. Figure 7 shows the variation of the probability of RI as a function of the magnitude of the RI index obtained for the 1989-2002 Eastern Pacific developmental sample. The scaled index was multiplied by ten so that the index may range from 0 to 70. It can be seen that the maximum value of any of the binned groups was 50. While, the maximum probability attained using the standard and scaled version of the RI index are similar, the variation of the scaled version as a function of the probability of RI is smoother. Also, a much larger fraction of the RI cases occur for large values of the RI index. Specifically, the probability of RI exceeded 43% for a total of 47% of the RI cases for the scaled version of the RI index. In contrast, the probability of RI was 32% or greater for 40% of the RI cases for the standard version of the RI index (see Fig. 1). Thus, higher probabilities of RI were obtained for a larger fraction of the RI cases when using the scaled version of the index. These results are encouraging and continued refinements will be made to the scaled version of the index. A comparison of the performance of the standard and scaled versions of the RI index will also be performed on an independent sample of cases from the upcoming Eastern Pacific hurricane season.

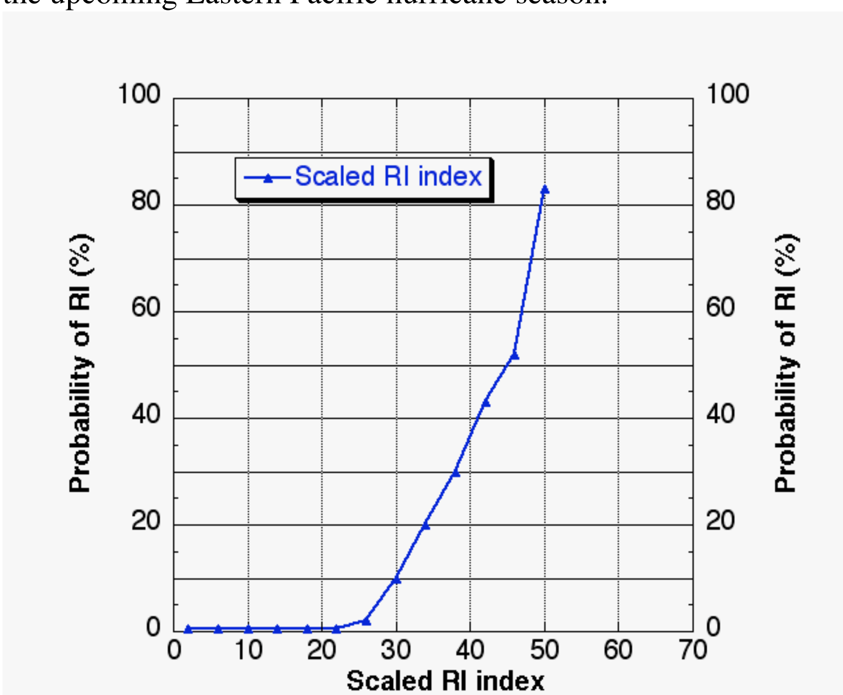

Fig. 7. The probability of RI as a function of the magnitude of the scaled RI index for the 1989-2002 Eastern Pacific developmental sample.

e. References

DeMaria, M., and J. Kaplan, 1999: An updated statistical Hurricane Intensity Prediction Scheme (SHIPS) for the Atlantic and eastern North Pacific basins. *Wea. Forecasting*,**14**, 326-337.

Gentemann, C, M. DeMaria, and F.J. Wentz:, 2004: Near real time global optimum

interpolated microwave SSTs: Applications to hurricane intensity forecasting. Preprint, 26th Conf. on Hurricanes and Tropical Meteorology.
Kaplan, J. and M. DeMaria, 2003: Large-scale characteristics of rapidly intensifying tropical cyclones in the North Atlantic basin. *Wea Forecasting*, **18**, 1093-1108.
Wilks, S.D.,1995: *Statistical methods in the atmospheric sciences*. Academic Press, 467 pp.

2. Second year proposal (July 2004- July 2005)

The overall outline for the second year of this proposal is nearly identical to that which was provided in the original proposal. Therefore, we will just provide a brief summary of what we propose to do with emphasis placed upon what is new as was requested by the JHT.

a. Work plan

The tasks and the associated timeline for the second year of the proposal are provided below**.** Note that any text that is shown in red represents a slight deviation from that originally proposed

- Run the standard (7 predictor) Eastern Pacific RI index operationally during the 2004 Eastern Pacific Hurricane season. (June 2004-Nov 2004)

- Employ the1989-2003 Eastern Pacific SHIPS database to continue to develop the scaled version of the RI index and to compare its performance to that of the standard (7 predictor) version by re-running both versions for the 2004 Eastern Pacific hurricane season (July 2004-January 2005).

- Employ 1989-2003 SHIPS database to continue to refine the standard (7 predictor) version of the Eastern Pacific RI index for use during the 2005 season (July 2004 - January 2005).

- Present comparison of the 2004 performance of the standard (7 predictor) and scaled versions of the Eastern Pacific RI index at the Interdepartmental Hurricane Conference. (March 2005)

- Employ 1989-2004 Eastern Pacific SHIPS database to update the Eastern Pacific RI index in preparation for the 2005 Hurricane season (April 2004 – May 2004)

- Modify code used to compute Eastern Pacific RI index in the operational SHIPS model for use during the 2005 season. (May 2005)

- Run Eastern Pacific RI index for 2005 Eastern Pacific hurricane season (May 2004-November 2005)

- Update code that is used to re-derive the Atlantic version of the RI index so that it may used by NHC to re-derive the standard Eastern Pacific version of the index for future seasons. Provide training of TPC personnel so that they may use the updated RI code to re-derive the RI index. (June 2005 -July 2005).

b. Schedule and needs for expected travel

No significant changes to those outlined in the original proposal are anticipated.

c. JHT staff requirements

No significant changes to those outlined in the original proposal are anticipated.

d. Budget

No changes are requested from the budget that was submitted in the original proposal. However, we have included the budget as an appendix for convenience.

APPENDIX

Year 2 Budget

		mm	JHT Yr 2 Requested Amount
Personnel			
AOML	Kaplan	4.0	27.6
AOML	Griffin	0.5	4.4
Total Salaries			32.0
Fringe Benefits	23.5% NOAA		7.5
Total Salaries and Fringe Benefits			39.5
Indirect Costs	39% NOAA		15.4
Total Labor Costs			54.9
Equipment			0.0
Travel	IHC meeting		1.5
	Ft Collins/DeMaria		1.7
Publications			0.0
Other	Computing/Communications		6.0
Total			64.1

The year 2 budget includes a request for four months of support for the PI in year 2 to complete the work outlined in section 2a. The budget also includes 0.5 months of support in year 2 for a computer programmer to assist with the updating of the code that will be used to re-derive the RI index on TPC computers. The computing/communications costs are for maintaining and supporting computer hardware, software, and communications links (LAN) to TPC that meet NWS security specifications. The travel costs are to cover expenses for the presentation of JHT related results at the Interdepartmental Hurricane Conference and to work with Dr. Mark DeMaria of NOAA/NESDIS to assist with the development and testing of Eastern Pacific RI index. The budget does not include the cost of contributions by Dr. Mark DeMaria since they will be covered by NESDIS base funds.