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ON THE PRESSURE-WIND RELATIONSHIP IN TROPICAL CYCLONES

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1. INTRODUCTION

A new model (henceforth referred to as PWRM) for the determination of the pressure-wind relationship in tropical cyclones (TCs) has been developed on the basis of operational storm parameters such as the outermost closed isobar POCI and its radius ROCI, the central pressure PC or its deviation from a given environmental pressure dPC = PC – (POCI + 1 hPa), respectively, the radius of 34-kt wind speed R34, the radius of maximum wind speed RM or the maximum wind speed VM. For any given pair of one size and one intensity parameter (note that ROCI is not really a size parameter, because the wind speed at this radius may vary), e.g. ROCI and PC, and the storm centre latitude, the model computes a consistent and complete set of storm parameters by integration of the f-plane gradient wind equation for an inertially-stable, axi-symmetric, tangential wind profile. Beside the retrieval of a complete set of TC parameters from a parameter pair that can be observed most easily and/or exactly in operational practice, the model allows systematic insights in the general relationship between storm parameters and their range of validity. The model was developed and tested using operational advisories (A-Decks) of 8900 global TC cases 2000-2004 given by the Automated TC Forecasting System (ATCF).

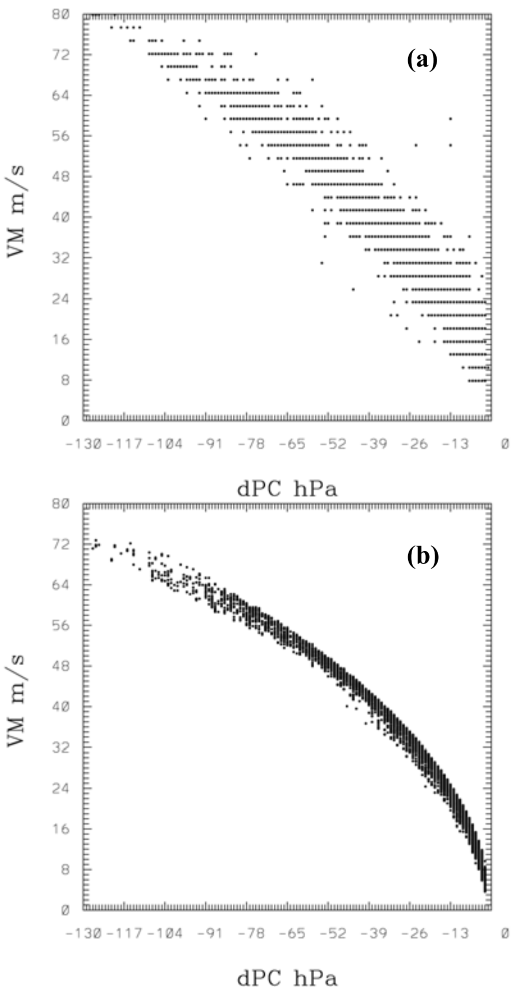

Figure 1: *Pressure-wind relationship: VM as function of dPC of the (a) A-Decks and of (b) PWRM for all TC cases.*

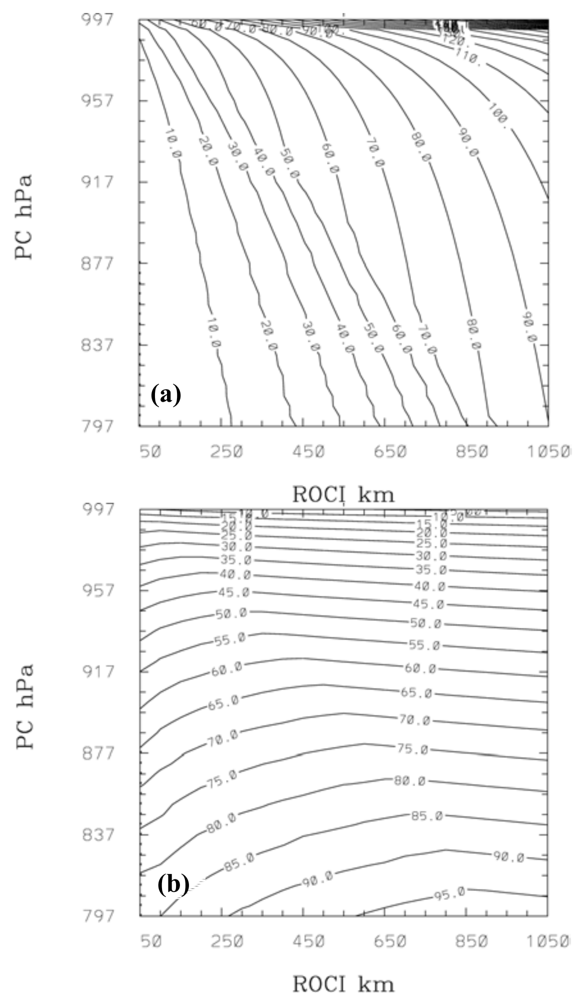

Figure 2: *(a) RM in km and (b) VM in m/s of PWRM as functions of ROCI and PC for a centre latitude of 25° N.*

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Results were verified against ATCF best-track data (B-Decks).

2. RESULTS

Figure 1a shows a scatter diagram of the operational estimates of VM and dPC during the years 2000-2004. The relatively large width of the band relating VM to dPC is mainly a result of the different tables used in different regions to compute VM from PC. The same diagram of PWRM in Fig. 1b, with ROCI and dPC as input, has similar characteristics but a smaller band-width that depends only on the centre latitudes of the storms. In contrast to Fig. 1a, the PWRM relation levels off in the case of very strong storms, with smaller intensities than those observed routinely. This agrees with the finding that, on average, the estimates of VM in the A-Decks are 6.5 m/s higher than the corresponding values measured during aircraft missions through 197 Atlantic hurricanes 1996-2001, with overestimations of VM occurring especially in storms with VM > 40 m/s.

Figure 2 shows examples of RM and VM, computed with PWRM, as functions of the input quantities ROCI and PC at a latitude of 25º N. As expected, stronger dependencies exist between ROCI, R34 (not shown) and RM, with smaller values of RM and R34 for smaller ROCIs, and between PC and VM. The relationships are non-linear, however, and depend also on latitude: for fixed ROCI and PC, RM, R34 and VM become larger at higher latitudes. Note also that the tangential wind speed at ROCI (not shown) varies considerably (1-14 m/s, depending mainly on ROCI and latitude). This rules out ROCI as a storm size parameter.

The values of RM, R34 and VM of PWRM agree well with those operationally-observed, as shown in Fig. 3. Mean errors (8900 cases) are –5.0 km for RM, 12.3 km for R34 and –0.5 m/s for VM, with standard deviations of 29.8 km, 56.8 km and 3.8 m/s, respectively. The last error results mainly from the underestimation of VM in the case of very strong storms (Fig. 3c). A comparison of the tangential wind profiles of PWRM with those measured during 197 aircraft missions through Atlantic hurricanes between 1996 and 2001 shows also good agreement. Using RM, VM of the mean tangential wind profile computed from all individual flight legs of one aircraft mission, the PWRM profile lies within an envelope defined by the profiles of all individual flight legs in about 70% of all cases analysed. Using ROCI and PC of the A-Decks as input, the above percentage reduces to 50% but still represents an astonishing agreement in view of the errors of the operational estimates of storm structure parameters. As a consequence of the results discussed above, PWRM may be used for an automatic, consistent estimation of complete sets of storm parameters as well as for the generation of more realistic synthetic vortices during the initialization of numerical prediction models.

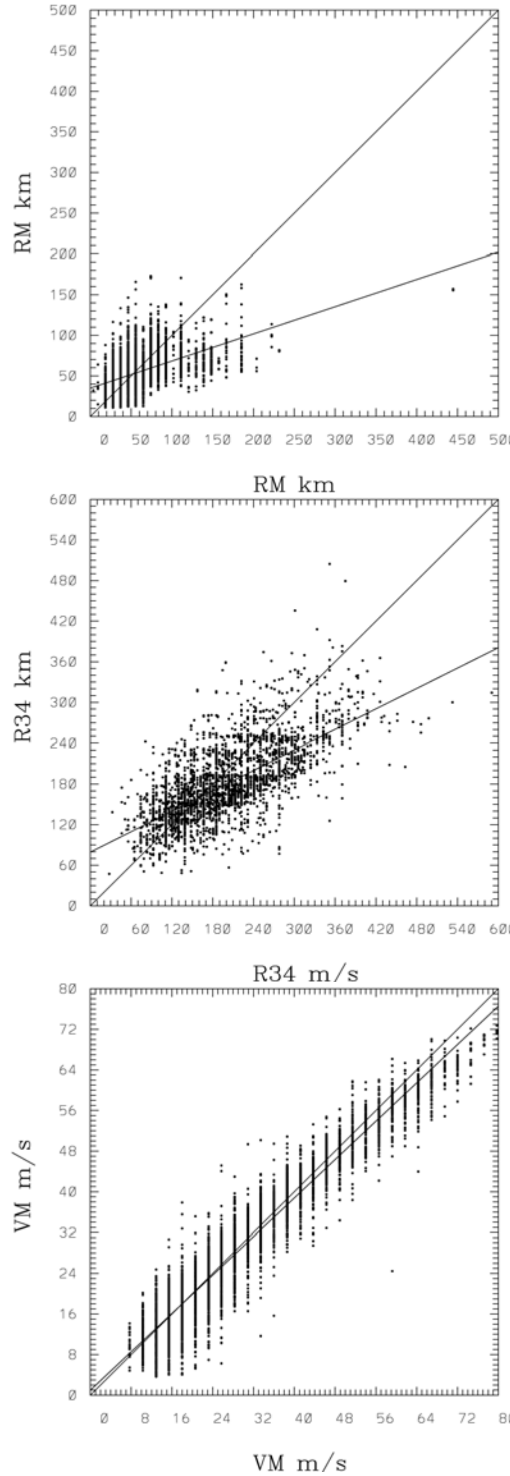

Figure 3: *As Fig. 1, but (a) RM, (b) R34 and (c) VM of PWRM vs. the corresponding best-track parameters.*