CLE15 COMPLETE RADIAL PROFILE MODEL DOCUMENTATION

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1. Model description

This model outputs a complete tropical cyclone radial profile of the azimuthal wind, given a set of physical parameters as input. This model is described in full in [1]. This profile is the merger of a profile for an inner convecting region (i.e. where it is raining heavily) and an outer non-convecting region (i.e. where it is not raining), both of which are models for the gradient wind at the top of the boundary layer. The validity of the merged model is also in principle for the gradient wind, but its parameters as presented here have been tuned to match data for the full wind near the surface from the HWind and QuikSCAT databases.

The model run time is approximately one-tenth of a second on a professional laptop for most model parameters, with the exception of very weak and/or large storms, for which convergence is slower. Note that the code for this model is quite elaborate – it is not a simple parametric equation with a couple of lines of code.

The model requires as input three storm parameters and three environmental parameters. The three storm parameters are

- V_{max}: maximum azimuthal-mean wind speed,
- A radial length scale, such as radius of $V = V_{max}$ (r_{max}), the outer radius of $V = 0$ (r_0), or any other intermediate wind radius (r_{fit}),
- f: local Coriolis parameter value at storm center.

The three environmental parameters are

- C_d: surface momentum exchange (i.e. drag) coefficient; used in the outer model only,
- w_{cool}: radiative-subsidence rate in the rain-free tropics above the boundary layer top; used in the outer model only,
- $\frac{C_k}{C_d}$: ratio of surface exchange coefficients of enthalpy and momentum; used in the inner model only.

Default settings define C_d to be a function of V following the data of [2]; $w_{cool} = 2\ mm\ s^{-1}$ constant based on data from [1]; and $\frac{C_k}{C_d}$ to be a function of V_{max} that increases from 0.5 at low intensity to above 1 at high intensity based on data from [1]. Note that $\frac{C_k}{C_d}$ is capped at 2 for extremely high intensities that lie beyond the observational range to which it has been fit, and thus these high values are essentially an untested extrapolation. If desired,

the user has the option to set C_d and $\frac{C_k}{C_d}$ as constants (typical values are .0015 and 1, respectively).

Lastly, an optional eye adjustment can be made that slightly reduces the wind speed for $r < r_{max}$ by a factor of $\left(\frac{r}{r_m}\right)^{\alpha}$. The exponent α can also be adjusted; it's default value is set to 0.15 based on results of [1]. This modification is purely empirical and is subject to change in the future.

Note: For extremely weak/large storms, the solution will not converge for low values of $\frac{C_k}{C_d}$. In such cases, the model will increase the value of $\frac{C_k}{C_d}$ in increments of 0.1 until it does converge. This acts effectively as an "error tolerance" for such anomalous cases, for which the model physics are not really expected to be valid anyways.

2. Using the model

There are three options for input parameters to run the model. All three require as input the maximum azimuthal-mean wind speed, V_{max}. In addition, a radial length scale is needed, each of which has its own file to maximize computational speed:

(1) r_{max} (**CLE15_plot_rmaxinput.m**),
(2) r_0 (**CLE15_plot_r0input.m**),
(3) r_{fit} (**CLE15_plot_rfitinput.m**).

Each of these files are set up to produce an example solution and plot for default parameters, as is shown in Figure 1. Use these files as the basis for understanding how the model works and extracting the necessary code relevant to your needs. For full scientific details of the model, see [1].

References

[1] Daniel R Chavas, Ning Lin, and Kerry A Emanuel. A model for the complete radial structure of the tropical cyclone wind field. part i: Comparison with observed structure. *Journal of Atmospheric Sciences*, Accepted, 2015.

[2] MA Donelan, BK Haus, Nicolas Reul, WJ Plant, M Stiassnie, HC Graber, OB Brown, and ES Saltzman. On the limiting aerodynamic roughness of the ocean in very strong winds. *Geophysical Research Letters*, 31(18), 2004.

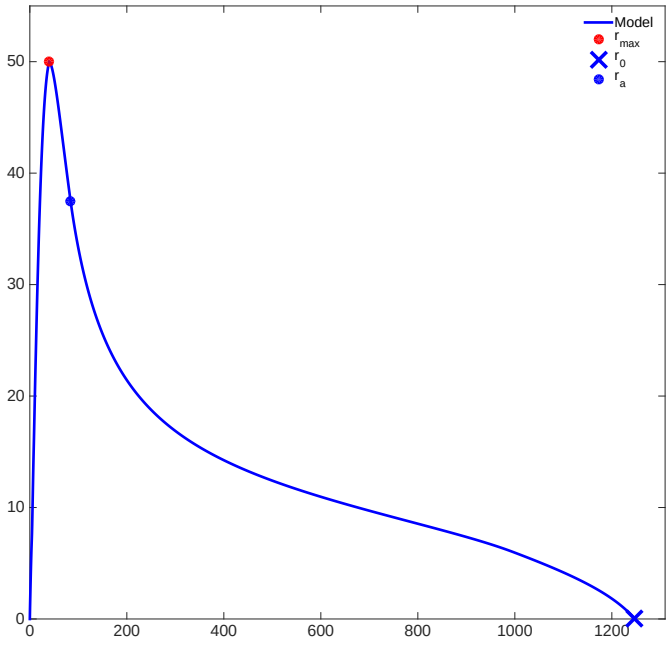

FIGURE 1. Example complete model solution with $(r_m, V_m) = (30\ km, 50\ ms^{-1})$, for default parameter values.