GTP Visit Description: Dorota Jarecka

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*Geophysical Turbulence Program – 2008 NAR*

*with Wojciech Grabowski (NCAR)*

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Dorota Jarecka, a PhD student from the University of Warsaw (UW, Poland) jointly advised and mentored by Grabowski and his colleague from UW, Prof. Hanna Pawlowska, spent 6 month at NCAR between February and August 2008, supported jointly by GTP, UW, and Grabowski’s NOAA outside funds. Jarecka attended 2008 IMAGE Theme of the Year workshop in May and summer school in July. She also analyzed model simulations of shallow tropical convection with the emphasis on representation of turbulent entrainment and mixing on cloud dynamics. Since these clouds are strongly diluted by entrainment, this has far reaching consequences as discussed, for instance, in Grabowski (J. Climate 2006, pp. 4664-4682). These simulations apply a novel approach to represent the effects of entrainment and mixing on in-cloud buoyancy (Grabowski, J. Atoms. Sci. 2007, pp. 3666-3680; see Figure 1 below for an explanation). Jarecka extended this approach and refers to the improved model as the $\lambda - \beta$ model, where the variables $\lambda$ (the scale of cloudy filaments associated with turbulent mixing introduced by Grabowski) and $\beta$ (the fraction of the gridbox occupied by the cloudy air; added by Jarecka) allow for a better representation of turbulent cloud dynamics. Figure 2 illustrates the impact of the new model by comparing results from simulation of a field of shallow convective clouds using the $\lambda - \beta$ model with results from a traditional bulk cloud model. See figure caption for the explanation. Jarecka will be involved in future development of this model to combine it with a more sophisticated representation of cloud microphysics.

While at NCAR, Jarecka drafted a conference paper for the International Conference on Clouds and Precipitation (Cancun, Mexico, July 7-11 2008) and prepared a poster with her results. This poster received a student poster award at the conference. With help from Grabowski and Pawlowska she extended the conference paper into a journal manuscript that has been submitted to publication in J. Atmos. Sci. These publications are listed below.


Precipitation (ICCP), July 7-11, 2008, Cancun, Mexico.
Figure 1: Evaporation of cloud water as a result of turbulent mixing between cloudy and cloud-free gridboxes. The vertical axis represents time. The two gridboxes are shown at the bottom of the figure, at time $t_0$. During a model time step, from $t_0$ to $t_1$, parameterized turbulent mixing creates a gridbox containing both cloudy and cloud-free air. The traditional bulk model immediately homogenizes the gridbox, resulting in either a saturated and cloudy or a subsaturated and cloud-free gridbox at time $t_1$. In the modified bulk model, homogenization is only possible once turbulent stirring reduces the filament width $\lambda$ from the initial value $\sim \Lambda$ (taken as the model gridlength) to the value corresponding to the microscale homogenization $\lambda_0$. This process may take several time steps as illustrated on the left side of the figure.
Figure 2: Contoured frequency by altitude diagrams (CFADs) of the vertical velocity (calculated with 0.15 m s$^{-1}$ wide bins) for the $\lambda-\beta$ model (right panel) and the traditional bulk model (left panel) in a simulation of a field of shallow convective clouds applying EULAG model with 25 m horizontal and vertical gridlength. Results represent statistics gathered over 4 hour period. The gray-scale bar details the frequency-of-occurrence scale. Only model gridpoints with a cloud water mixing ratio larger than $10^{-2}$ g kg$^{-1}$ are included in the analysis. Clouds in the $\lambda-\beta$ model are slightly deeper than in the bulk approach; this can be argued to result from delayed evaporation of cloud water due to entrainment and mixing, resulting in more in-cloud buoyancy. Also, there are more points with positive vertical velocities in the range of 0 to 1 m s$^{-1}$ in the $\lambda-\beta$ model across most of the depths of the cloud field. This is again consistent with the expectation that cloud evaporation (and thus buoyancy reversal and subsequent downward acceleration) is delayed when the $\lambda-\beta$ approach is used.