



PDF-Based SGS Parameterizations For MMF

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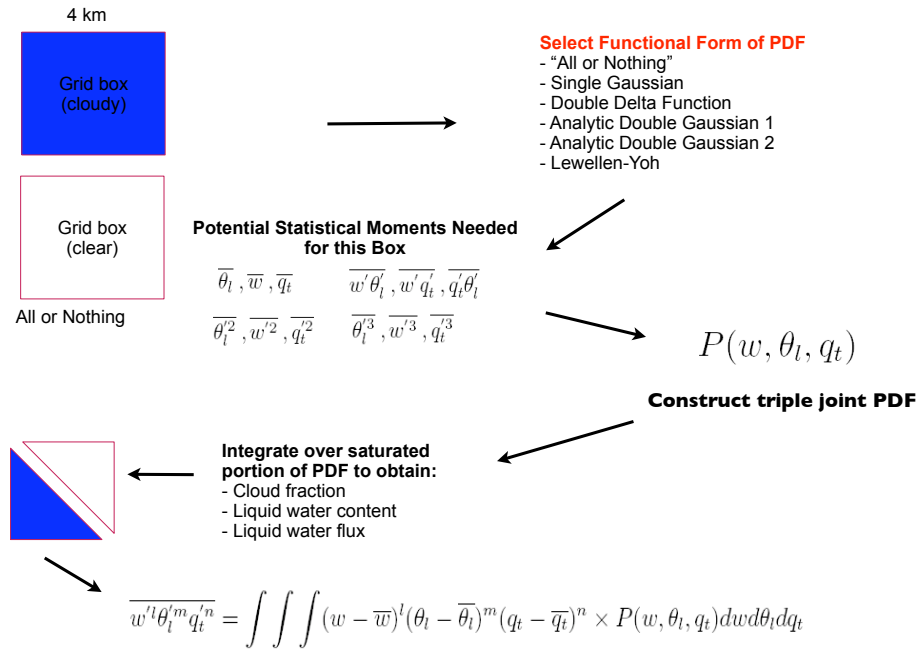


Outline



- Brief overview of assumed PDF method
- Progress since January:
 - Draft paper of assumed PDF testing
 - Test case of transition of stratocumulus to cumulus
 - Implementing the parameterization into SAM

Assumed PDF method





PDF Testing Paper



- Paper drafted on extensive test of PDFs:
 - “All or Nothing” Approach
 - Single Gaussian
 - Double Delta Function
 - Analytic Double Gaussian I
 - Analytic Double Gaussian II
 - Lewellen-Yoh
- Relevant work: Larson et al. 2002
- Range of grid volumes tested (0.2 to 204.8 km)
- Three cases tested from high resolution benchmarks
 - BOMEX (shallow convection)
 - Stratocumulus to cumulus transition
 - Giga-LES (large domain deep & shallow convection, mesoscale organization)



Transition from Stratocumulus to Cumulus

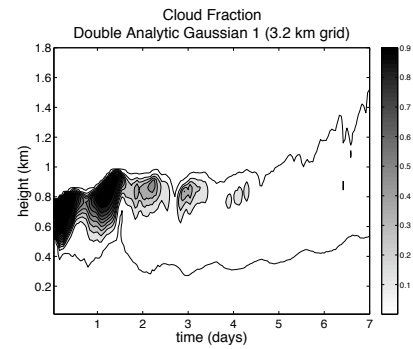
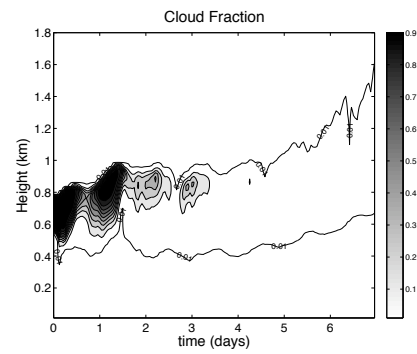
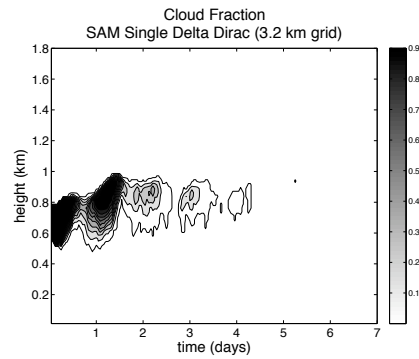


- Based off of profiles from OWN ship
 - ─ Modified for a slightly deeper/drier initial mixed layer
- 50 m horiz. resolution
- Domain: 25.6 km x 25.6 km (145 vertical levels)
- Interactive Radiation
- 7 day simulation
 - ─ Linear increase in SSTs
- Assumed PDFs tested for grid volumes ranging from 0.4 to 25.6 km

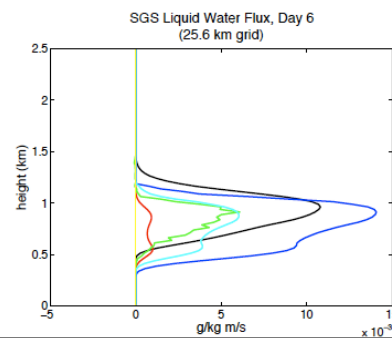
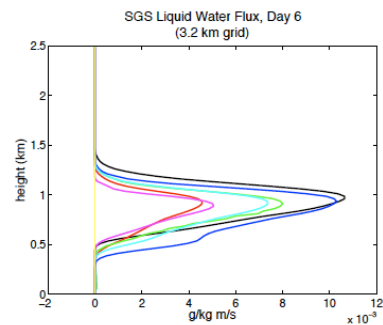
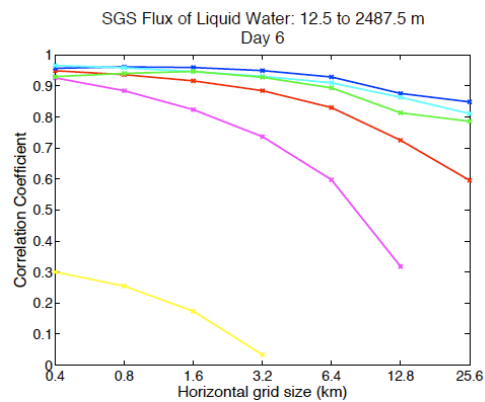
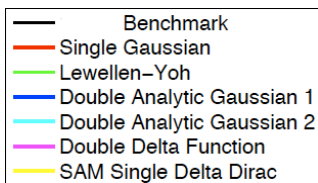
Transition from Stratocumulus to Cumulus (Cloud Structure)

All PDFs realistically diagnose cloud structure of stratocumulus portion of simulation

All three Double Gaussian based PDFs represent cloud structure similarly throughout the entire simulation



Transition from Stratocumulus to Cumulus (Liquid Water Flux)



Moment Equations

(First Try Implementation Into SAM for ADGI)

- Second order moments based off Redelsperger 1986

	$\overline{\theta_l'^2} = C_1 l^2 \frac{\partial \overline{\theta_l}}{\partial x_i} \frac{\partial \overline{\theta_l}}{\partial x_i} \phi_i$	$\overline{\theta_l' q_w'} = C_1 l^2 \left(\frac{\partial \overline{q_w}}{\partial x_i} \frac{\partial \overline{\theta_l}}{\partial x_i} \right) (\phi_i + \psi_i)$
Scalars →	$\overline{q_w'^2} = C_1 l^2 \frac{\partial \overline{q_w}}{\partial x_i} \frac{\partial \overline{q_w}}{\partial x_i} \psi_i$	$\overline{u_i' \theta_l'} = -\frac{2}{3} \frac{l}{C_s} \overline{E}^{1/2} \frac{\partial \overline{\theta_l}}{\partial x_i} \phi_i$
		← Covariances
		$\overline{u_i' q_w'} = -\frac{2}{3} \frac{l}{C_h} \overline{E}^{1/2} \frac{\partial \overline{q_w}}{\partial x_i} \psi_i$

Vertical Velocity →
$$\overline{u_i' u_j'} - \frac{2}{3} \delta_{ij} \overline{E} = -\frac{4}{15} \frac{l}{C_m} \overline{E}^{1/2} \left(\frac{\partial \overline{u_i}}{\partial x_j} + \frac{\partial \overline{u_j}}{\partial x_i} \right)$$

- Prognostic equation for third order moment of w

$$\frac{\partial \overline{w'^3}}{\partial t} = -\overline{w} \frac{\partial \overline{w'^3}}{\partial z} - \frac{\partial \overline{w'^4}}{\partial z} + 3 \overline{w'^2} \frac{\partial \overline{w'^2}}{\partial z} - 2 \overline{w'^3} \frac{\partial \overline{w}}{\partial z} + \frac{3g}{\theta_o} \overline{w'^2 \theta_v'} - \frac{3}{\rho_o} \overline{w'^2 \frac{\partial p'}{\partial z}} - \epsilon_{www}$$

Summary & Future Work

- Summary:
 - Analytic Double Gaussian I being implemented into SAM
 - First look at second/third moments in SAM yields results with high correlation but high RMSE
- Future Work:
 - Get PDF paper out!
 - Turbulent Length Scale in moment equations
 - Re-run benchmarks with coarse resolution with finished parameterization