An updraft-downdraft scheme for SGS transport in cloud-resolving models

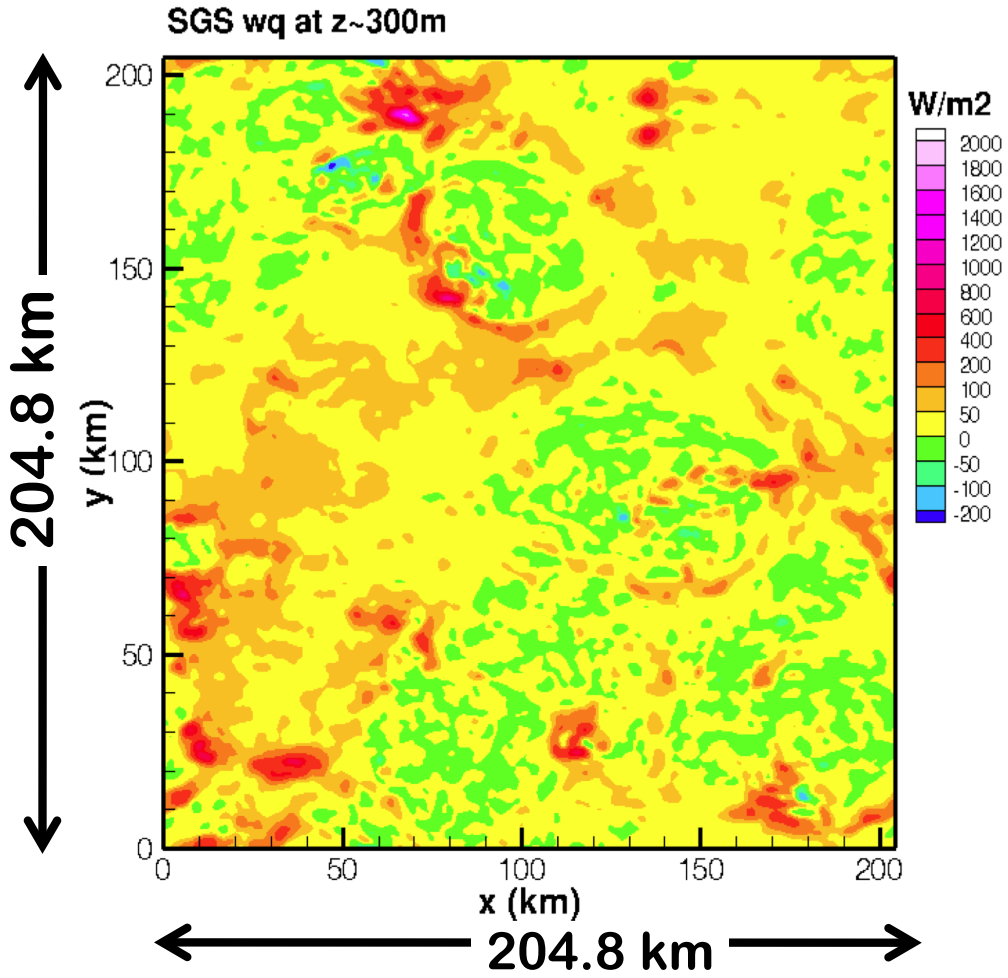
Chin-Hoh Moeng

(Moeng and Arawaka, 2012, MWR, current issue)

NCAR & CMMAP are sponsored by the National Science Foundation

SGS latent heat flux

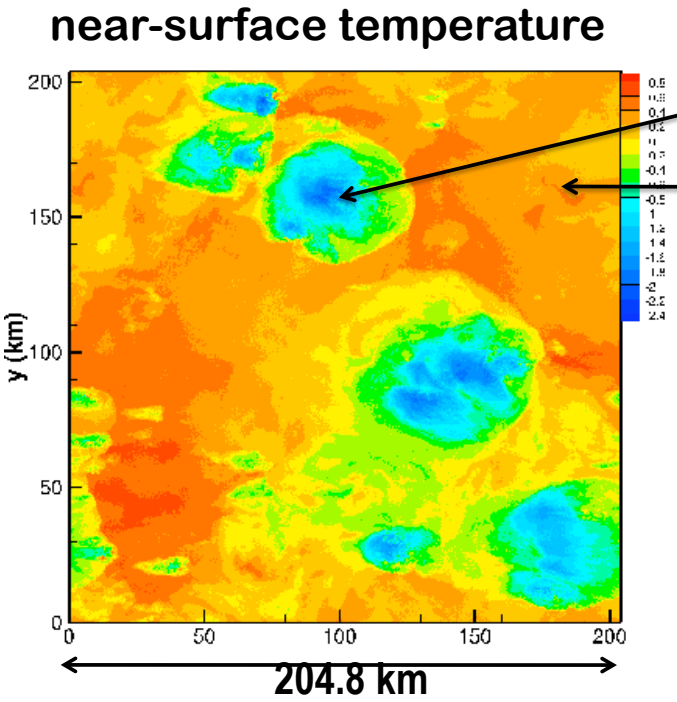
retrieved from the Giga-LES with a cutoff width of 4 km



SGS fluxes vary greatly in space!

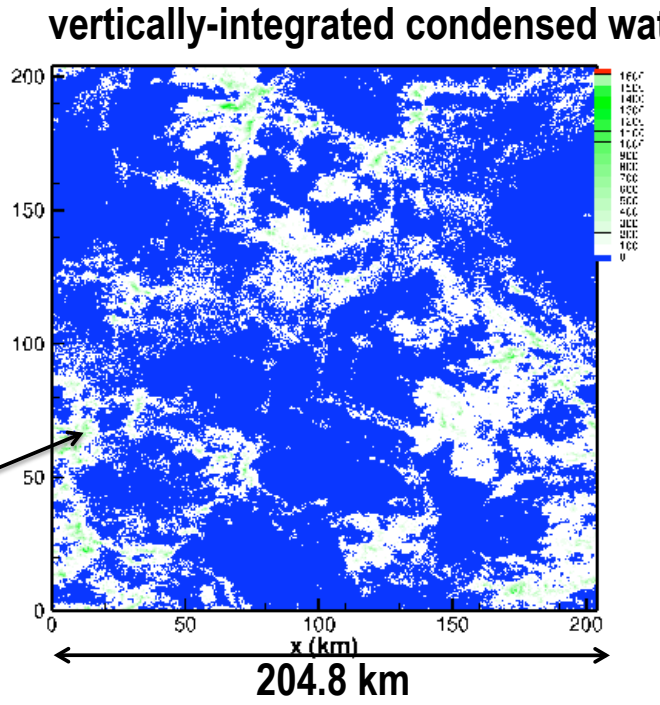
The PBL transport varies in various part of the cloud system.

➡ We select & study six PBL regimes.



1. PBL-cold

2. PBL-envr



3. PBL-cldy

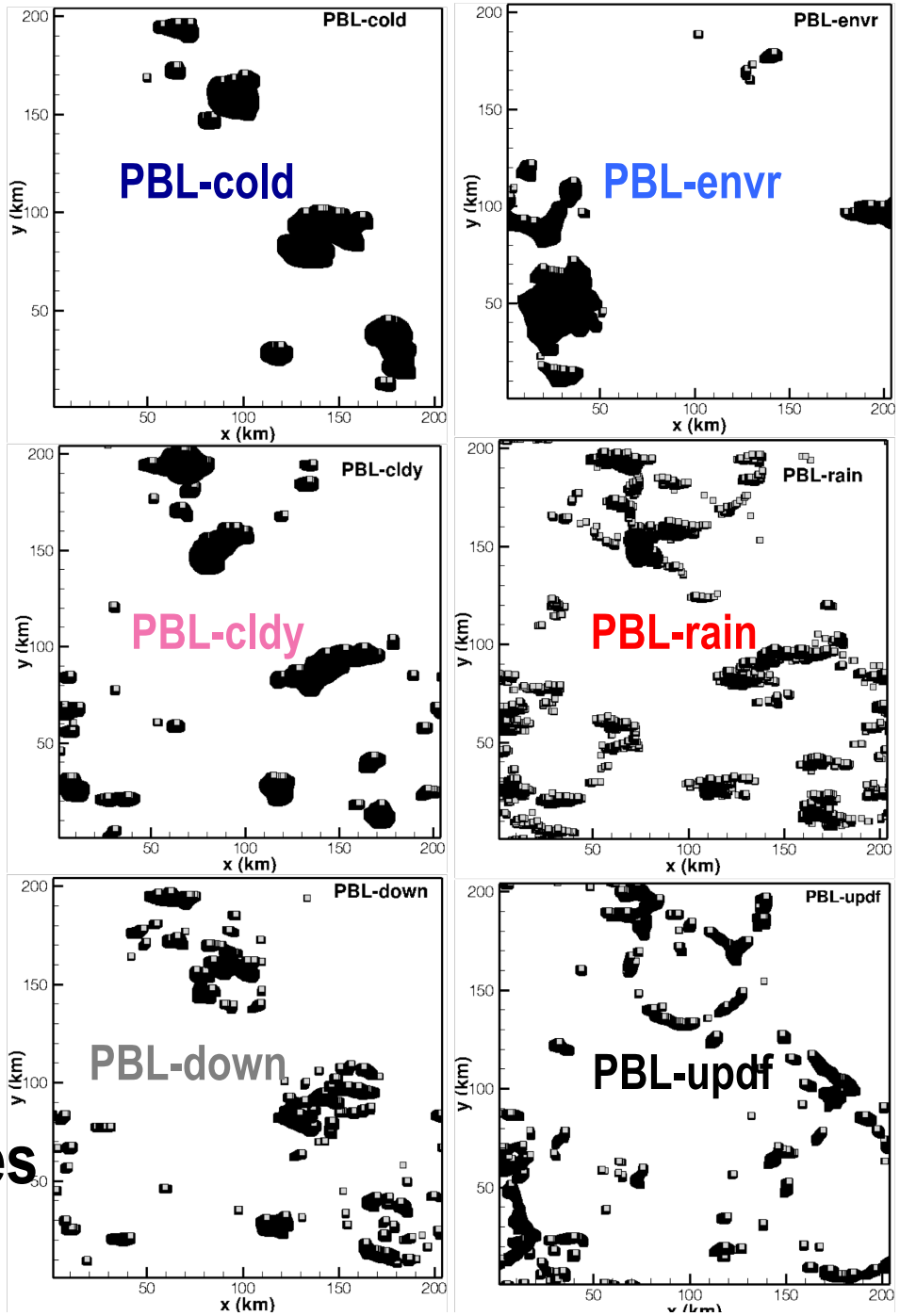
4. PBL-rain

5. PBL-updf

6. PBL-down

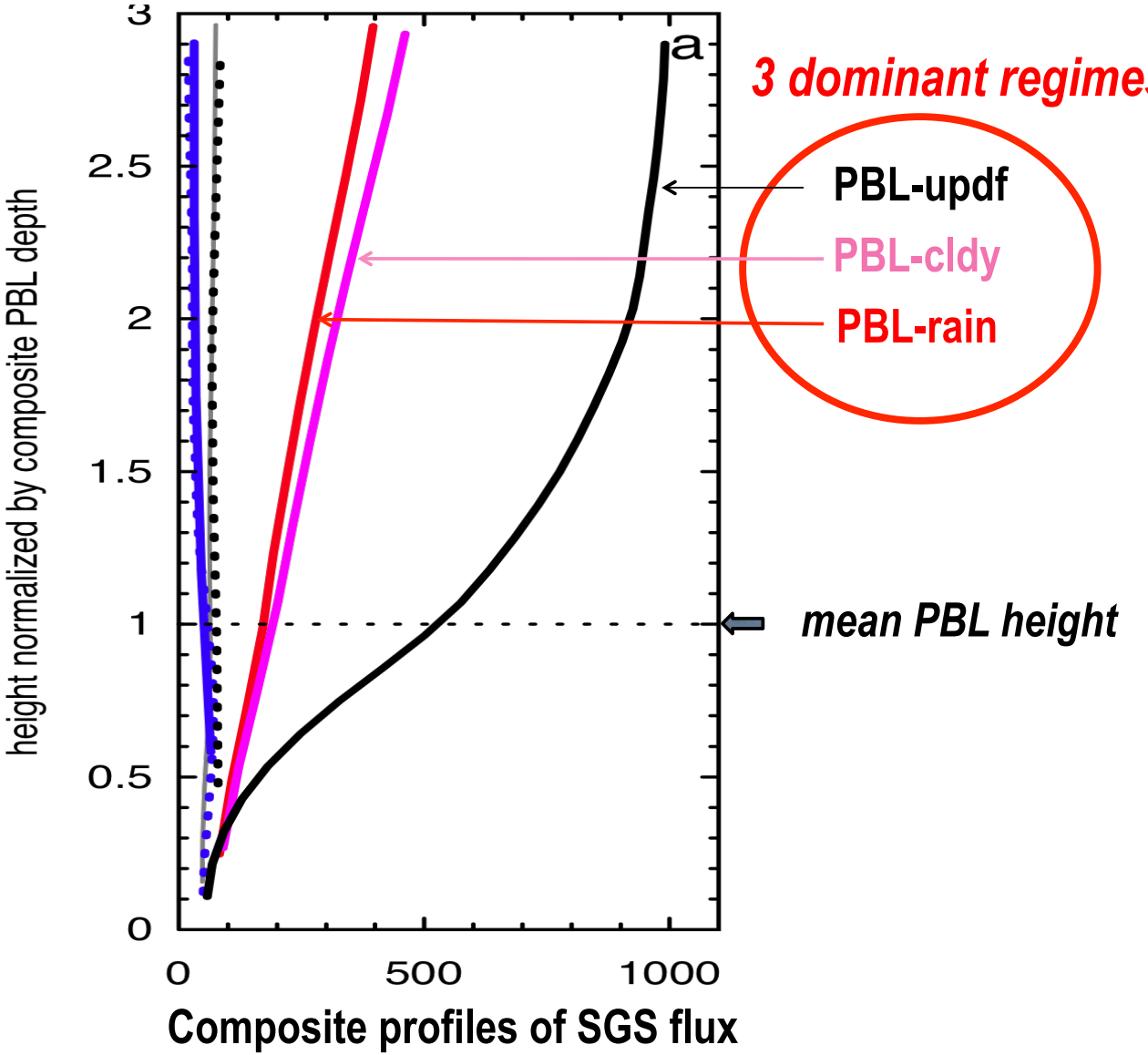
Grid locations of the 6 PBL regimes

Sample sizes:
140,000 - 220,000



Next: Find their composites

The composite SGS-flux profiles show:
PBL-updf, PBL-cldy, PBL-rain carry most of the moisture.



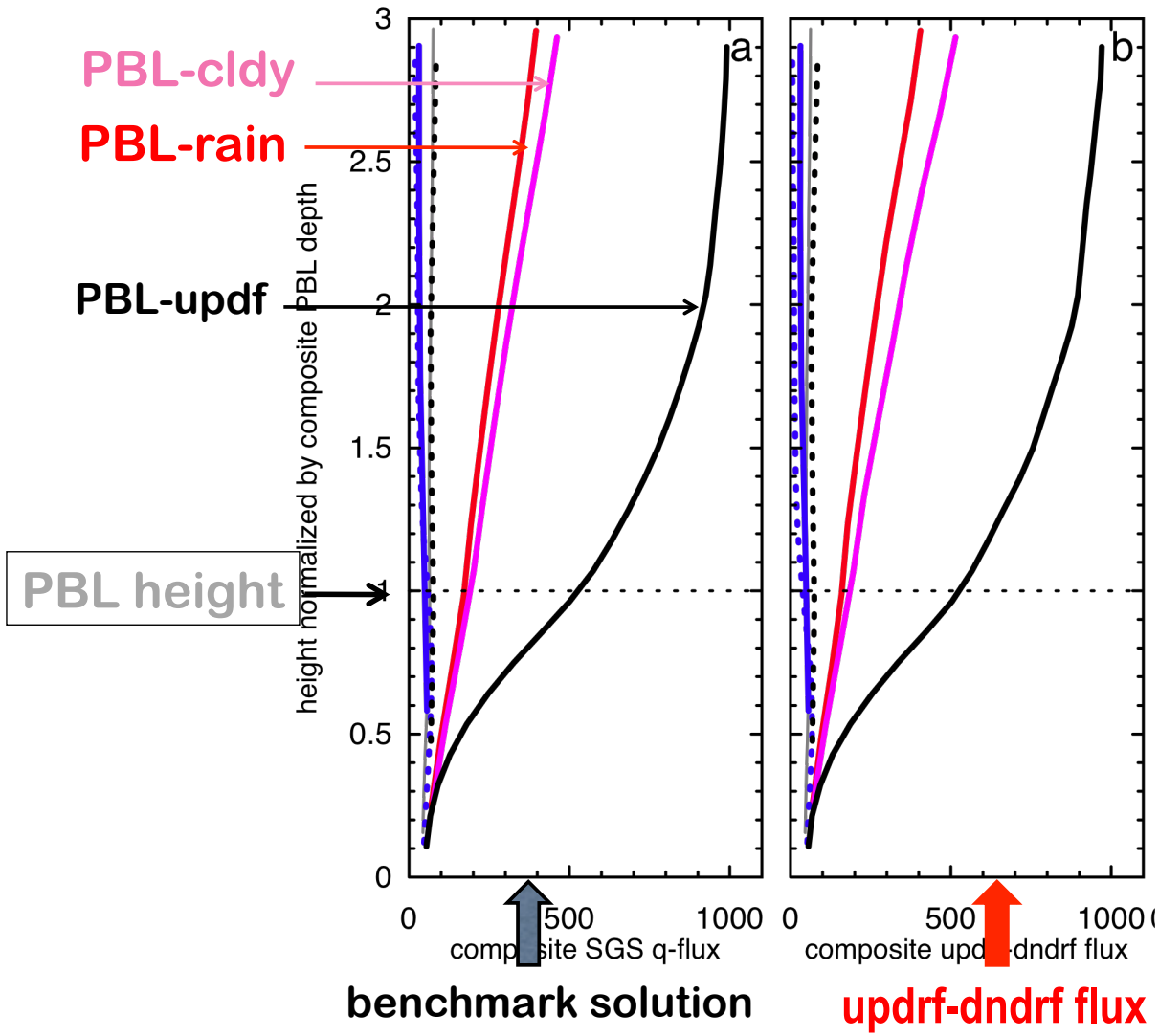
A parameterization scheme for SGS q-flux in CRMs

The updraft-downdraft scheme:

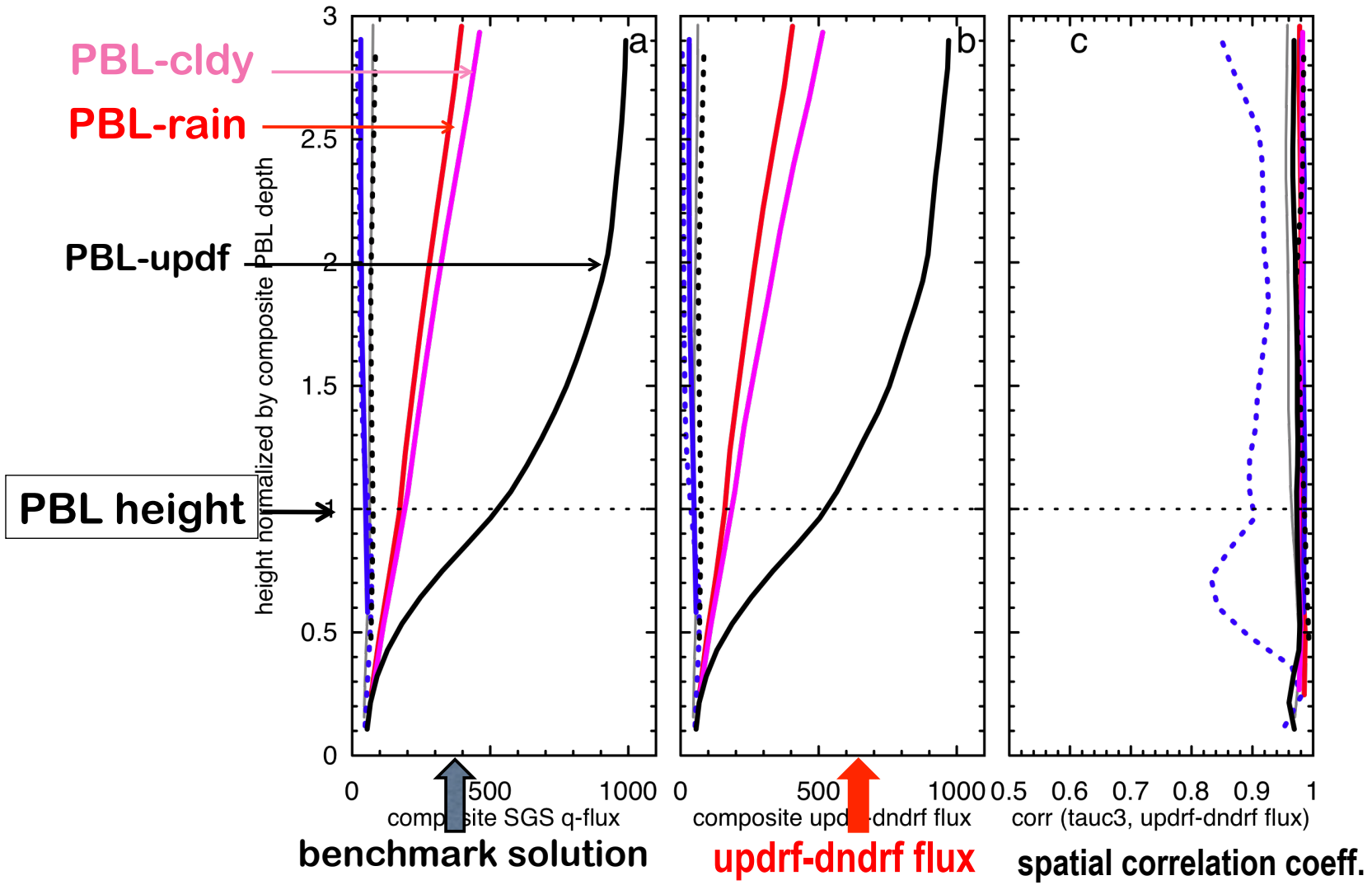
$$\tau_{wq}^{UD} = A_1 (w^{up} - w^{dn})(q^{up} - q^{dn})$$

$w^{up}, w^{dn}, q^{up}, q^{dn}$ are SGS updraft-downdraft mean properties.

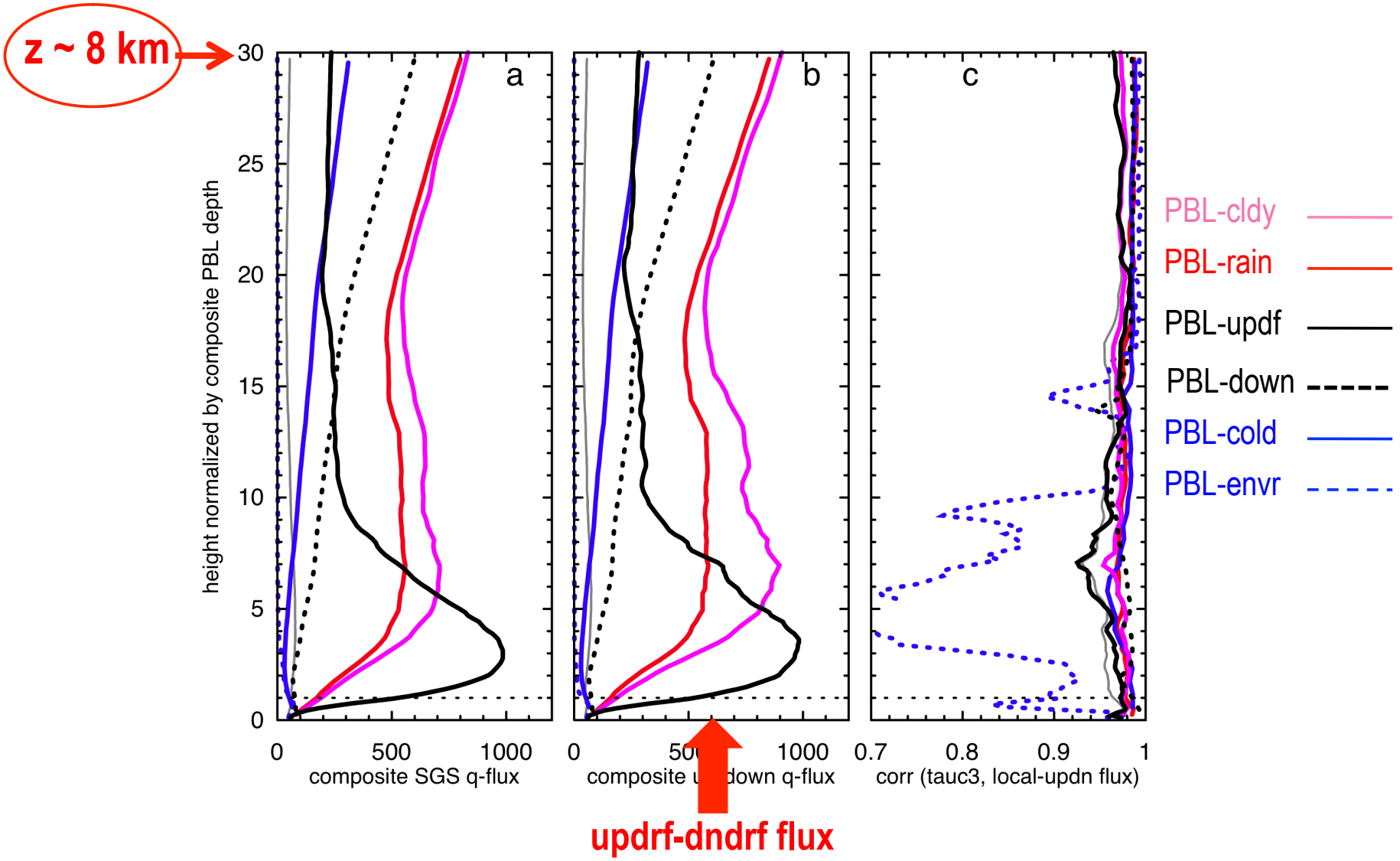
The updraft-downdraft scheme with A1=0.4 for various PBL regimes



The updraft-downdraft scheme with A1=0.4 for various PBL regimes



Updraft-downdraft scheme with A1=0.4 for the entire convection layer



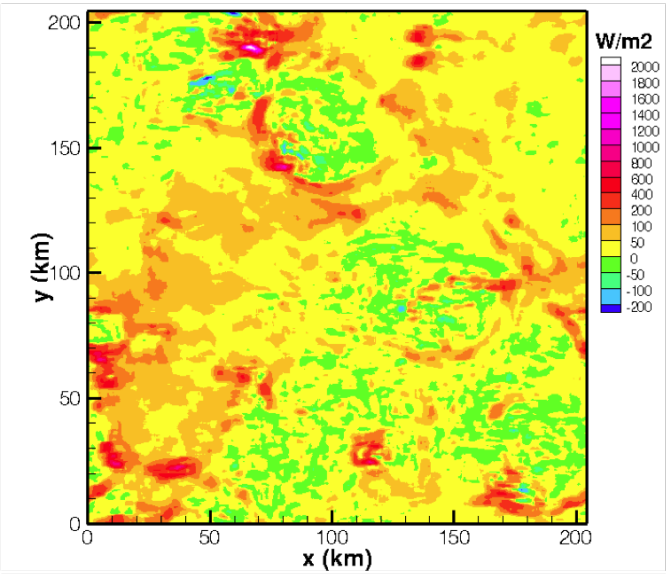
contours at z ~ 300 m

cutoff width = 4 km

$\Delta_f = 4\text{km}$

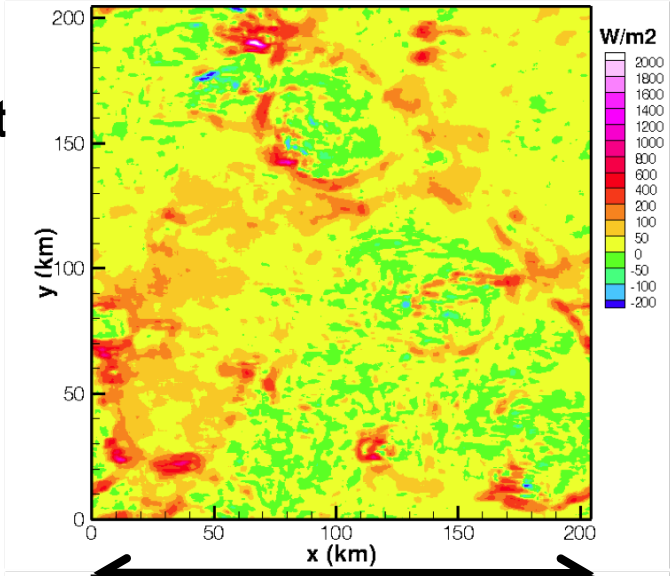
Benchmark

τ_{wq}



updraft-downdraft scheme with A1=0.4

τ_{wq}^{UD}



204.8 km

contours at z ~ 300 m

cutoff width = 4 km

$\Delta_f = 4\text{km}$

cutoff width = 10 km

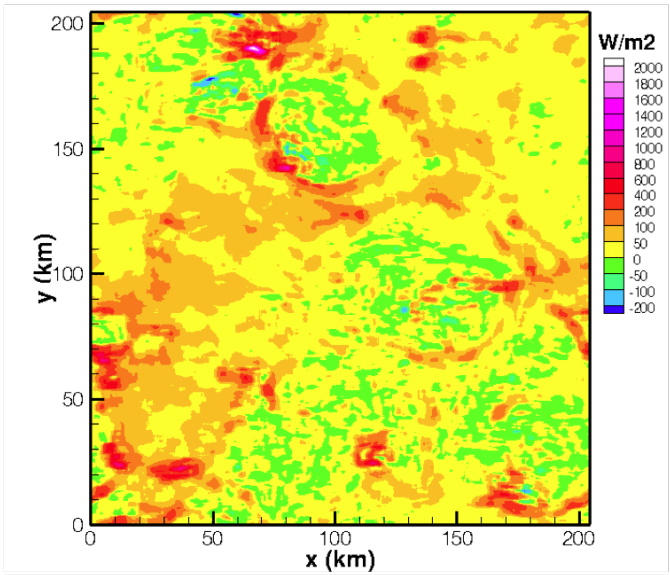
$\Delta_f = 10\text{km}$

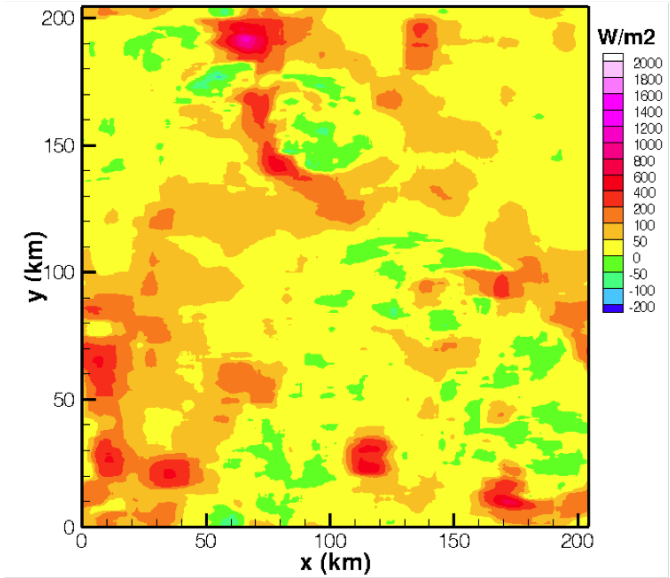
Benchmark

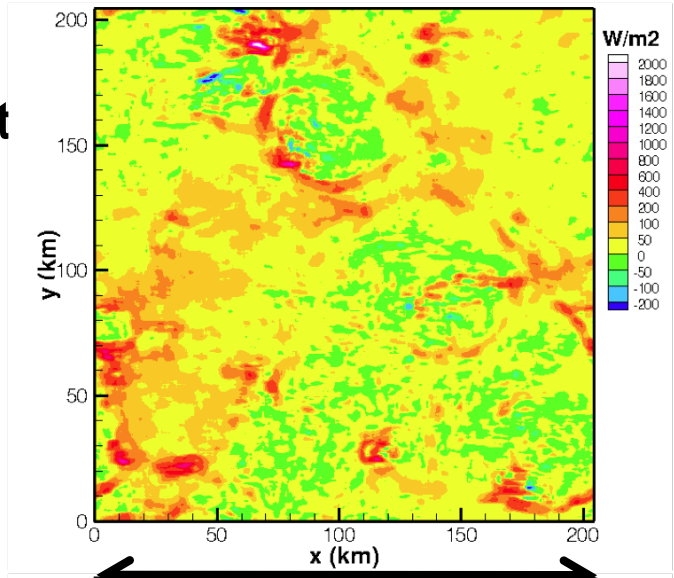
τ_{wq}

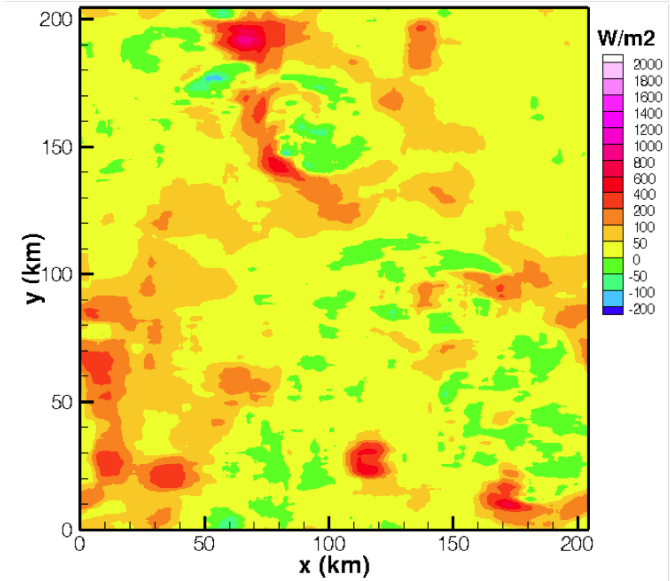
updraft-downdraft scheme with A1=0.4

τ_{wq}^{UD}









Why the updraft-downdraft scheme works so well? Why A1=0.4?

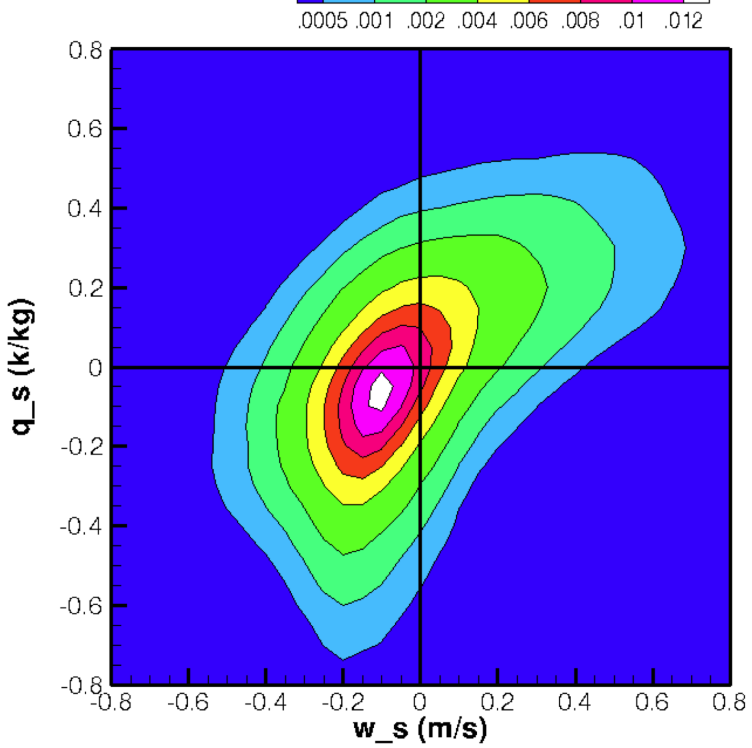
If w & q fluctuations are jointly Gaussian, A1 = $\pi/8 \sim 0.4$ (Wyngaard and Moeng 1992).

Are the CRM-SGS w-q processes nearly jointly Gaussian?

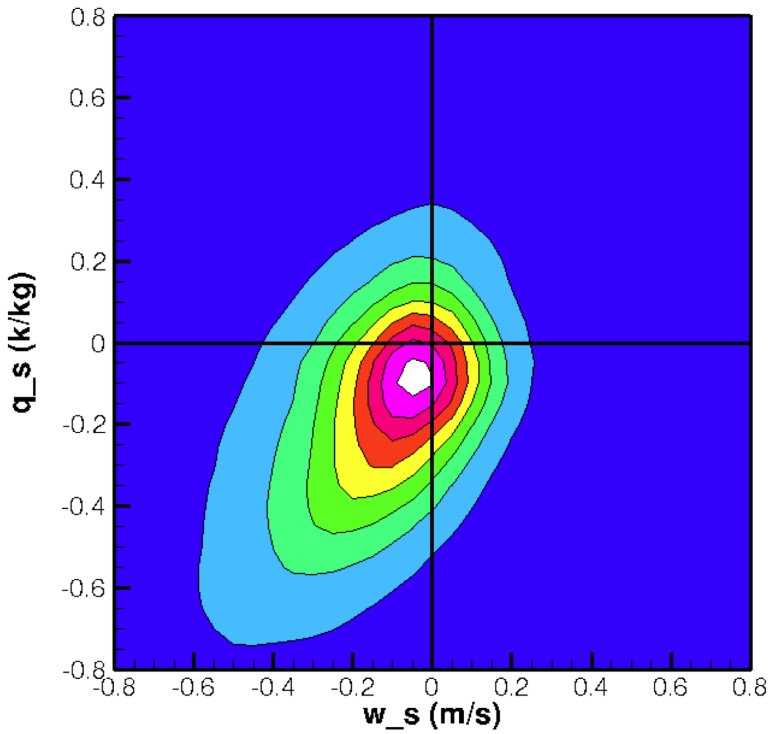
Joint PDF of SGS w & q fluctuations:

averaged over all 4 km x 4 km sub-domains of the PBL-updf regime

at z~ 300m for PBL-updf

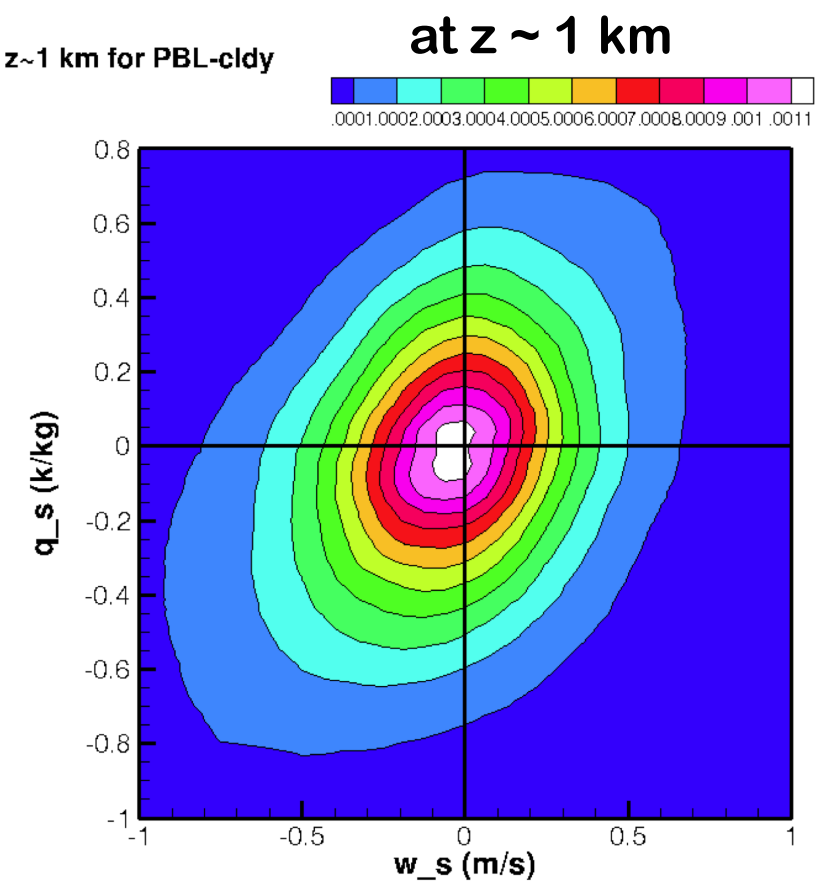


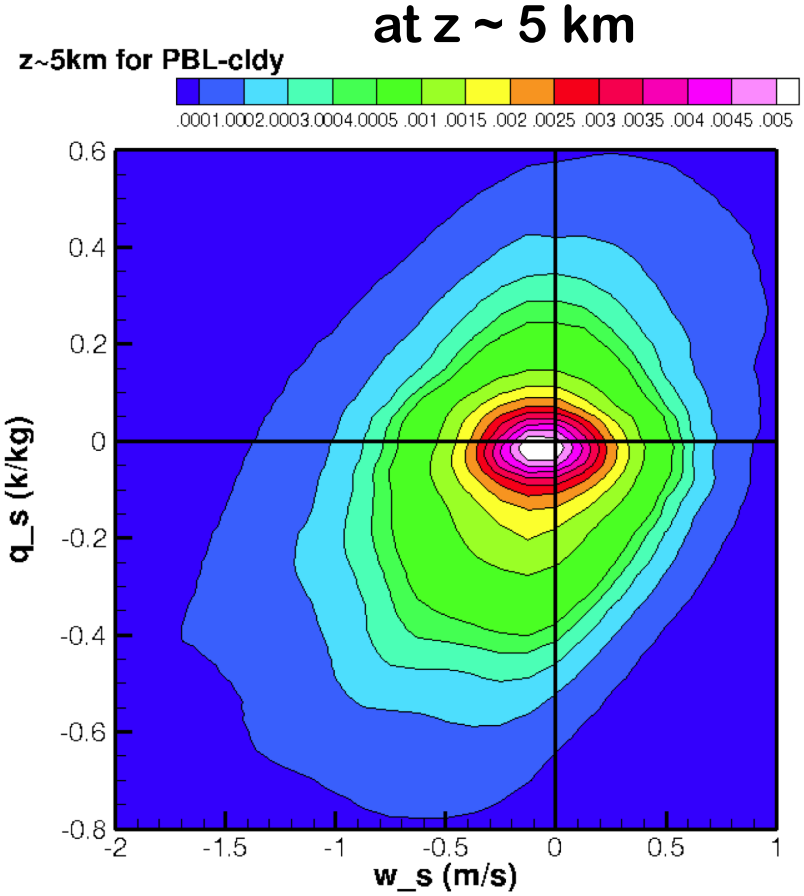
at z ~ 1 km for PBL-updf



Joint PDF of SGS w & q fluctuations:

averaged over all 4 km x 4 km sub-domains of the PBL-cldy regime





Summary and future work

1. PBL-updf, PBL-cldy,PBL-rain dominate the moisture transport to the cloud layer.

2. The updraft-downdraft scheme works well in representing SGS fluxes (q_t & θ_l) in CRMs.

3. Next: Relate the SGS updraft-downdraft mean properties to the CRM-resolved flow fields.