Subgrid-scale fluxes at the PBL top in CRMs

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In a typical CRM, “clouds”, “rainy area” and “cold pools” are resolvable features.

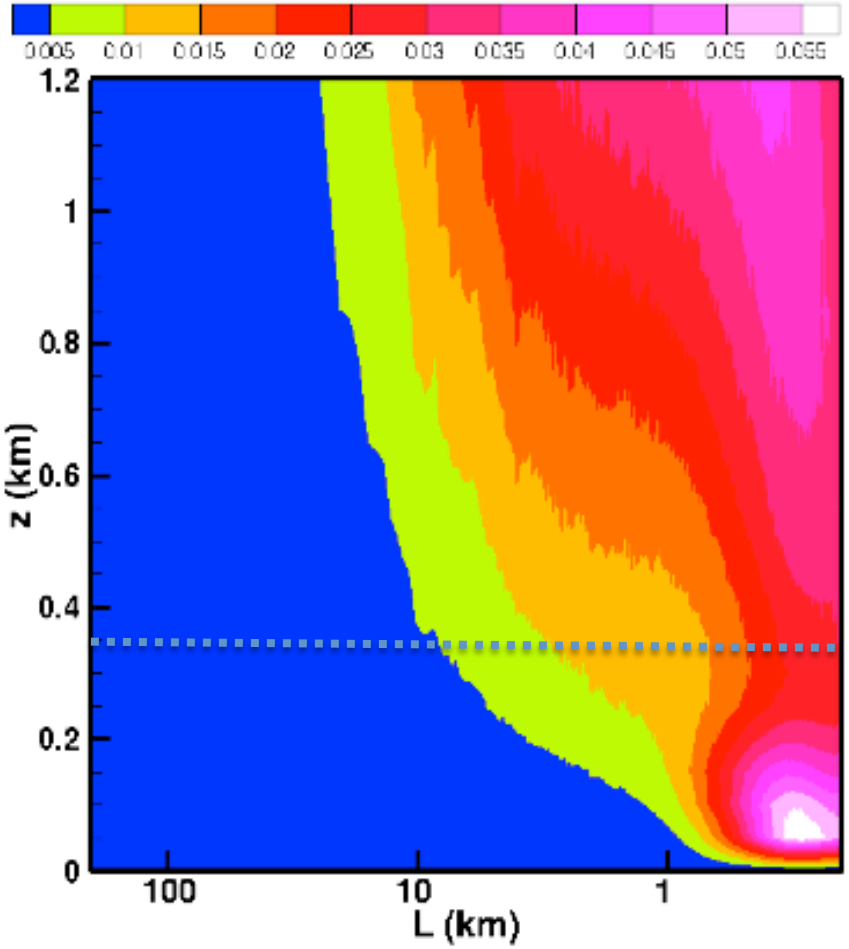
The PBL in a CRM varies at various regions.

My goal is to model SGS fluxes for CRMs, focusing on fluxes at the PBL top in this talk.

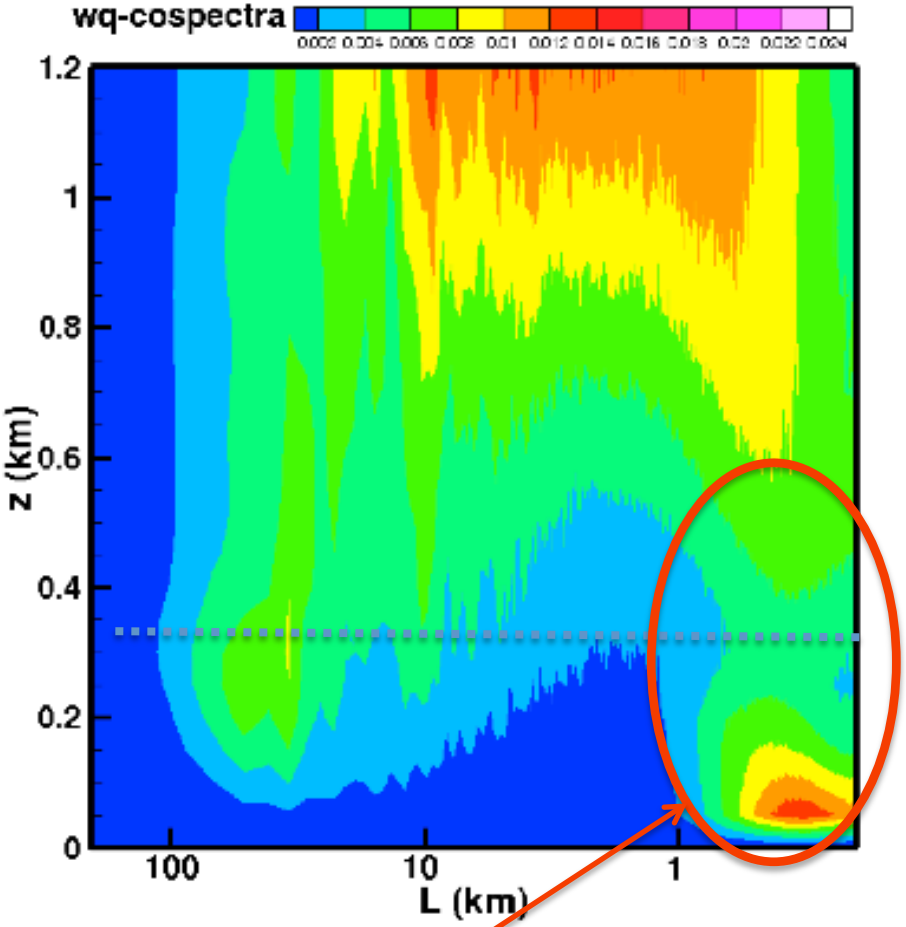
I will use the Giga-LES as database.

Why do we need to model SGS fluxes in CRMs?

contours of w-spectra



wq-cospectra



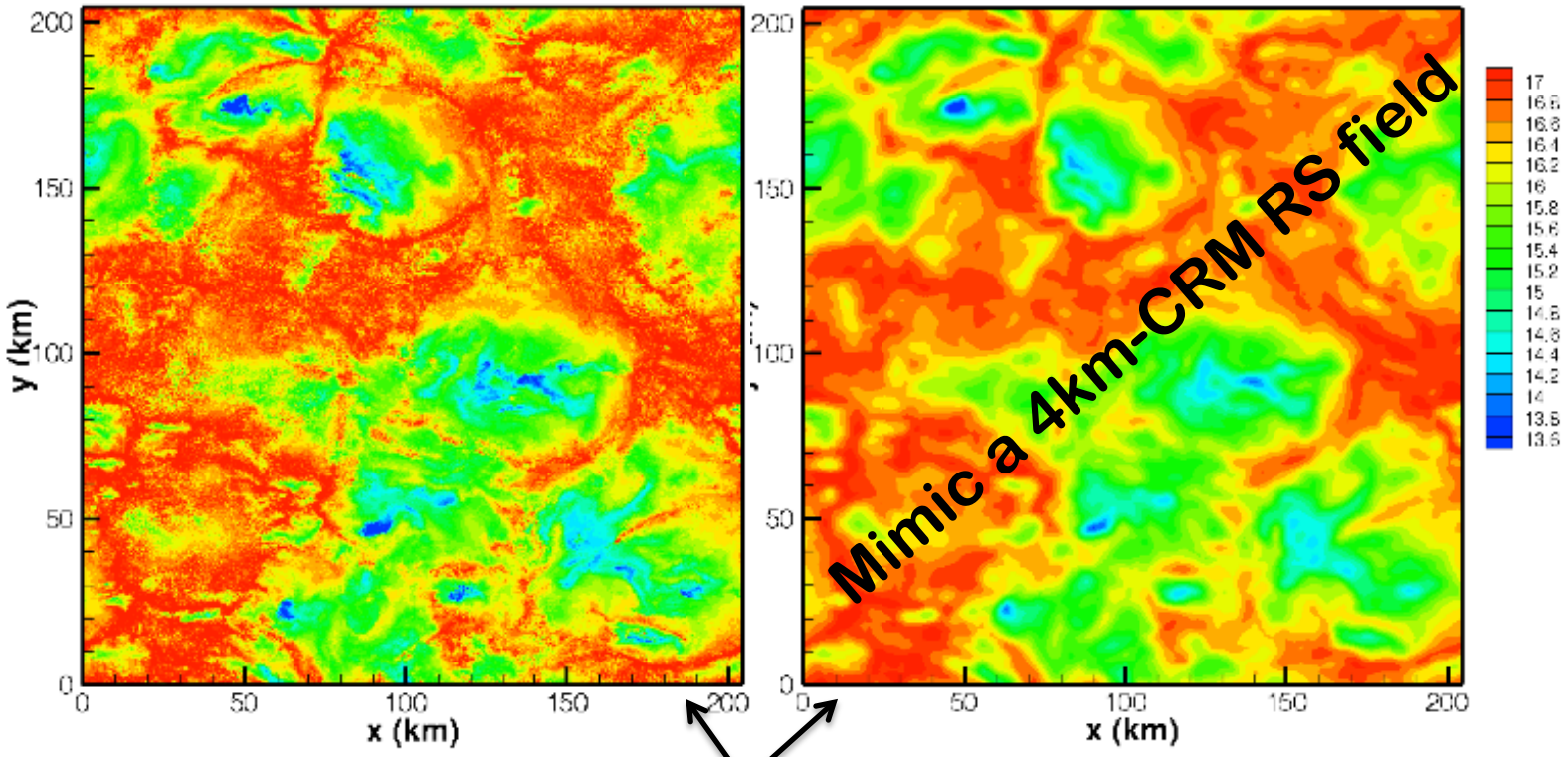
Most flux resides on small scales (SGS in CRMs)!

(Step 1) Split the Giga-LES field to CRM resolvable (RS) & SGS components.

moisture field at z ~ 300 m

before filter

after filter; filter width of 4 km; smoothed field



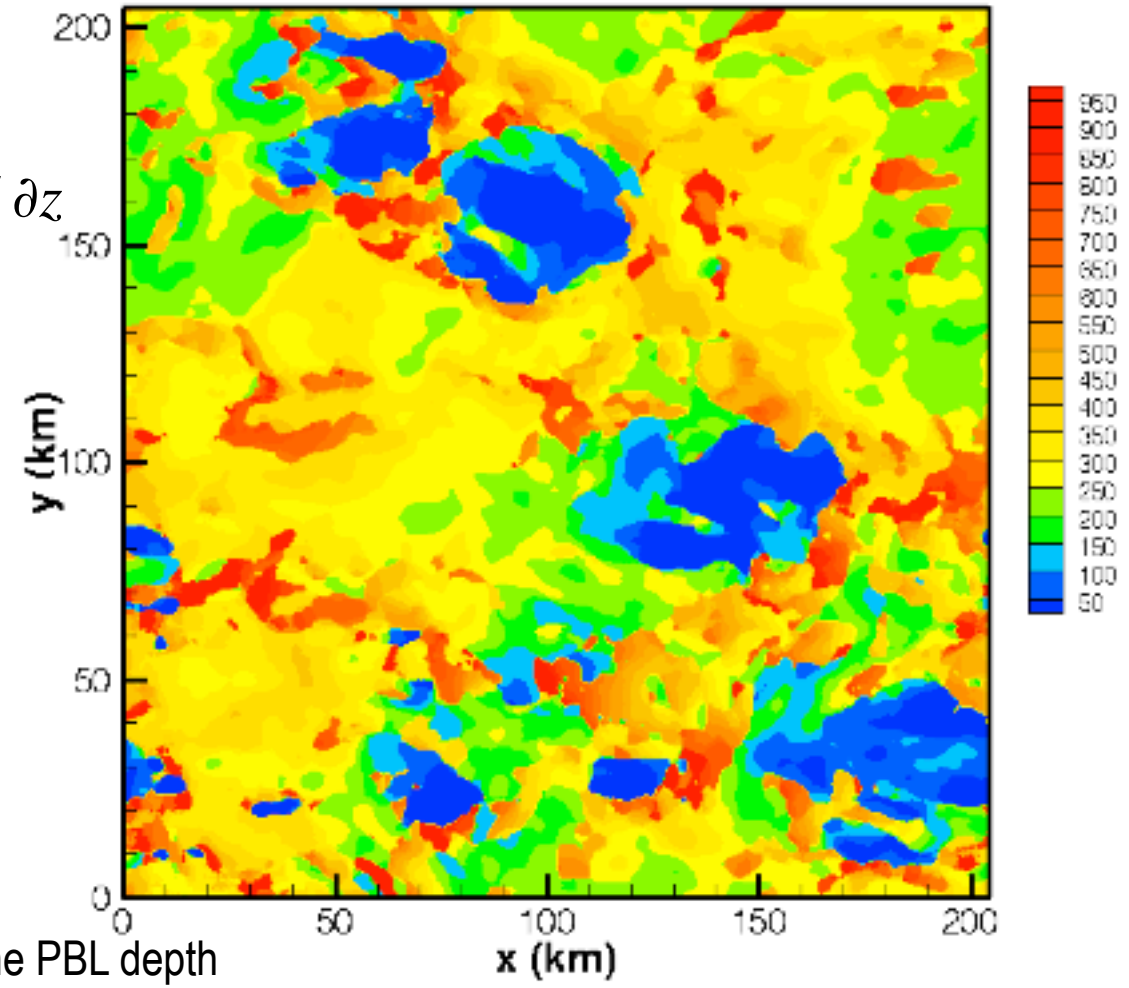
The difference is the CRM SGS field.

(Step 2) Find the PBL height from the RS_4km field

1. Search for max $\partial\theta_\ell / \partial z$ and min $\partial q / \partial z$ below 1 km.

2. Choose the min. of the two.

distribution of the inversion (PBL) height

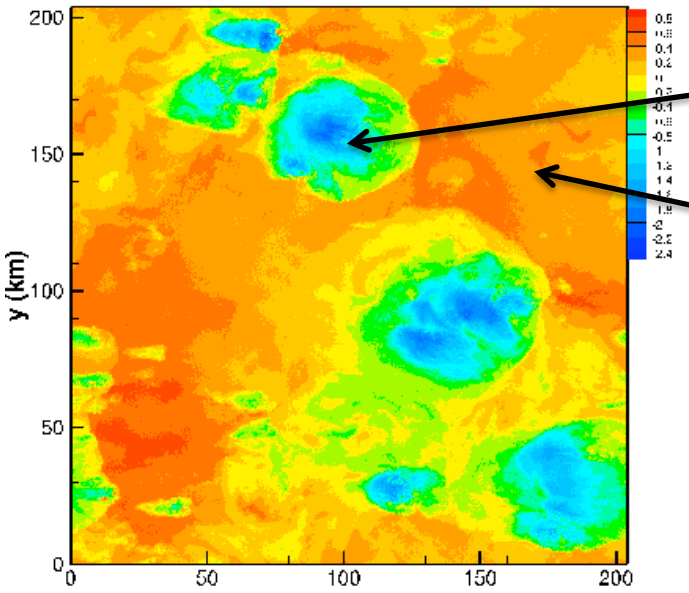


•Will not consider pts where the PBL depth reaches 1 km in my analysis.

(horizontal mean of zinv ~ 336 m)

(Step 3) Conditionally sample the PBL into 4 regimes.

temp. near the surface

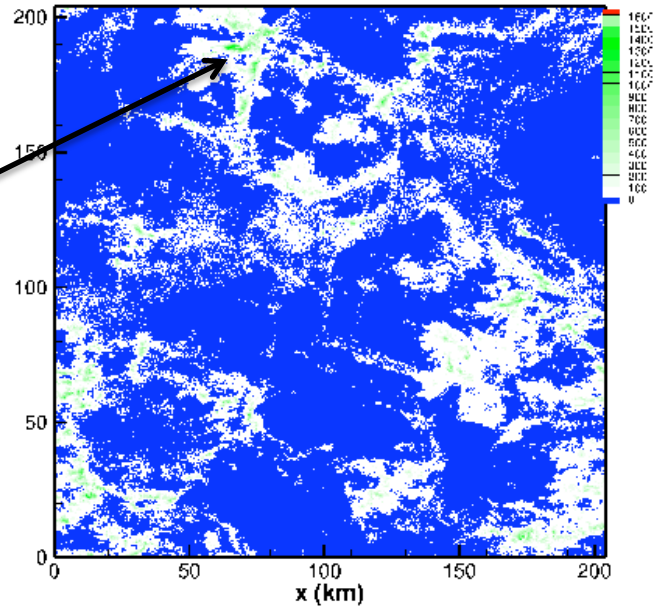


1. cold-pool

2. recovered (environmental) PBL

3. cloudy region

vertically integrated condensed water (g/m2) **LWP**



4. rainy area

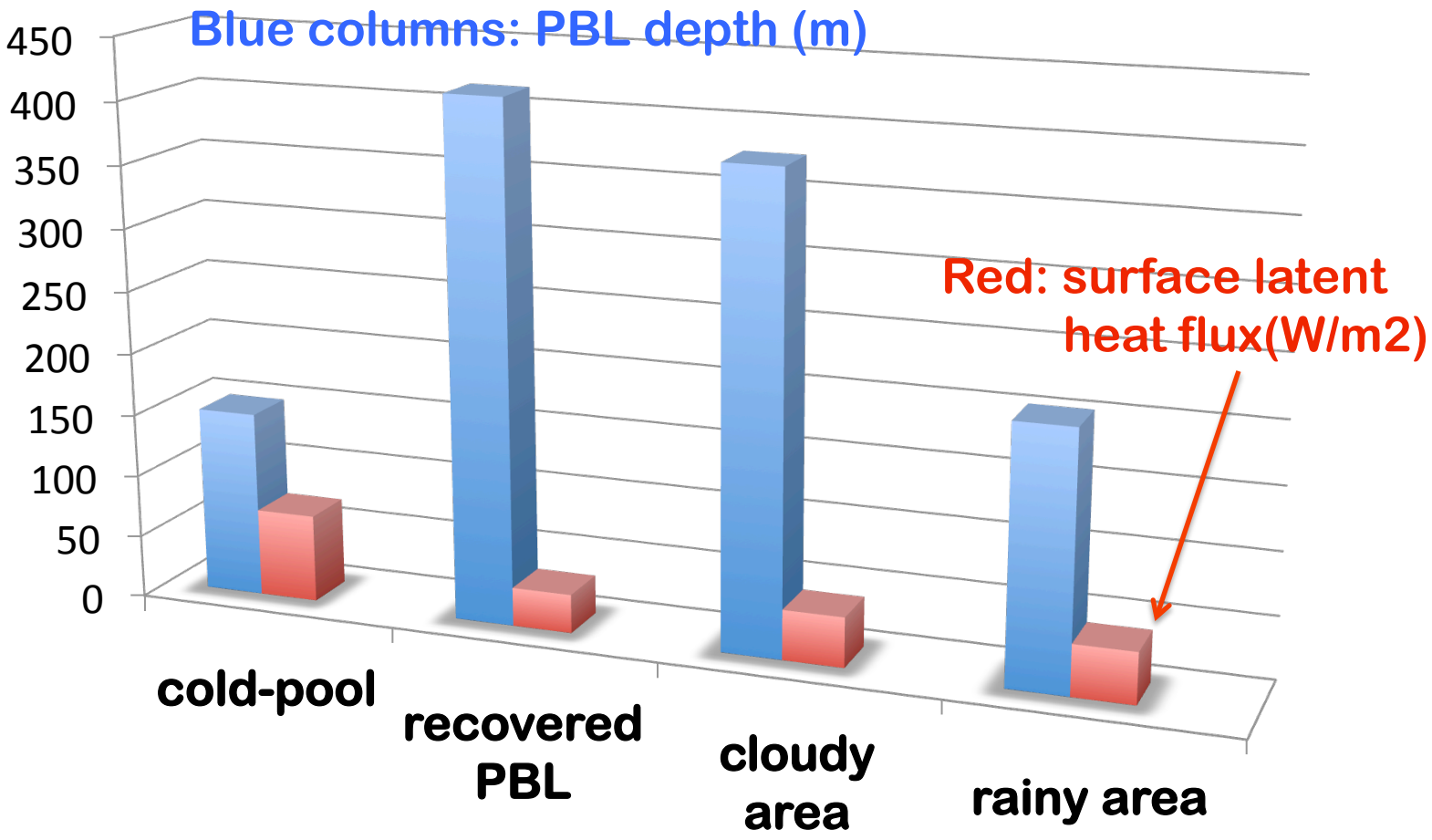
Criteria for sampling the four regimes from the RS_4km (smoothed) field:

1. **Cold-pool region**: sfc latent heat flux > 2 times of its xy-mean
2. **Recovered PBL**: [t(i,j,1) – mean T] > 0.5C and LWP < 80 g/m2
3. **Cloudy region**: LWP > 0.05 x (max of LWP) (excluding small cld)
4. **Rainy region**: first-grid rain amount > 0.1 g/kg

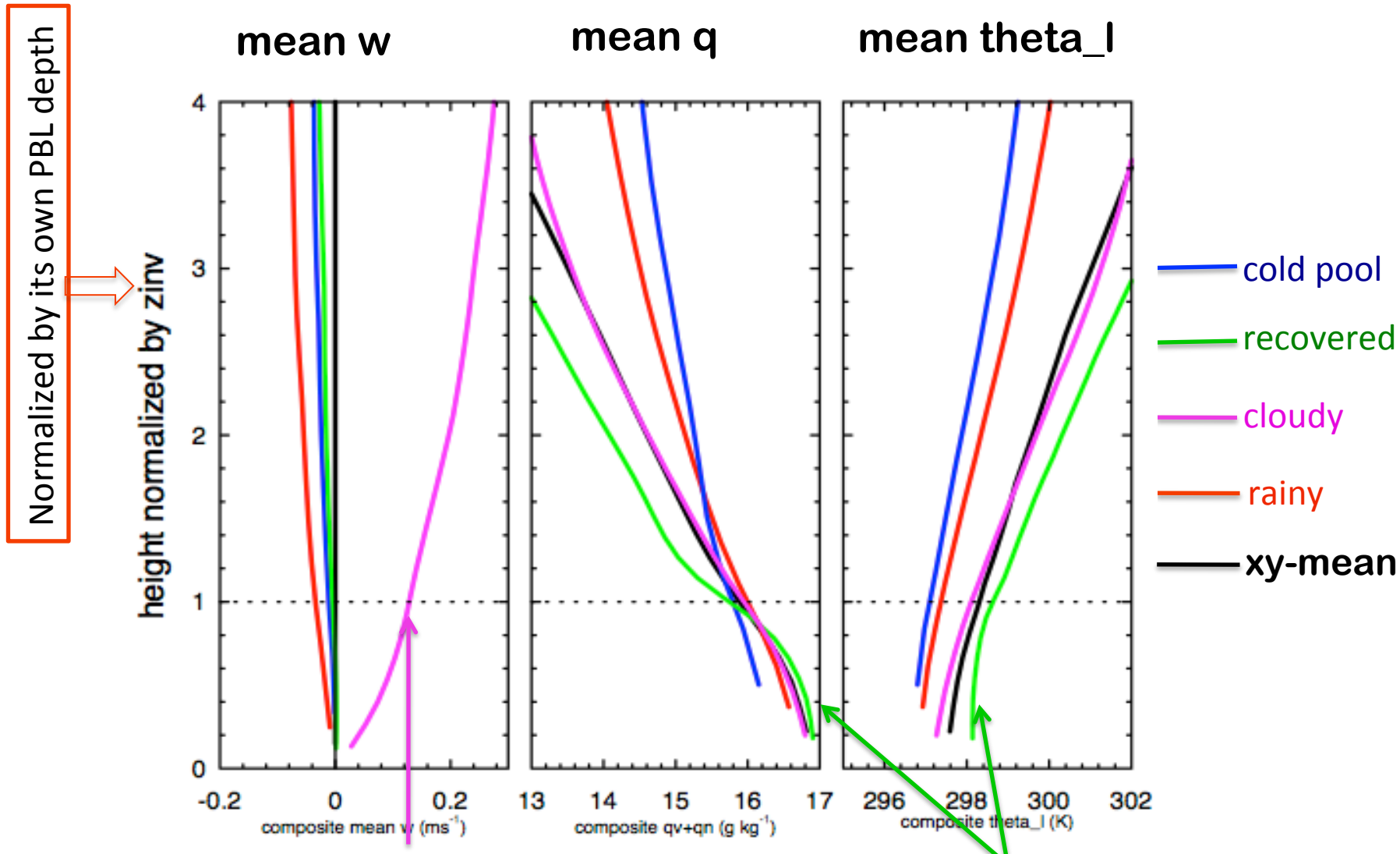
# of sampled grid columns	
cold-pool:	56,000 (1.3%)
recovered:	187,000 (4.5%)
cloudy:	58,000 (1.4%)
rainy:	152,000 (3.6%)

(max of LWP ~ 17330 g/m2
assuming rho=1 kg/m3)

Averaged parameters over each region



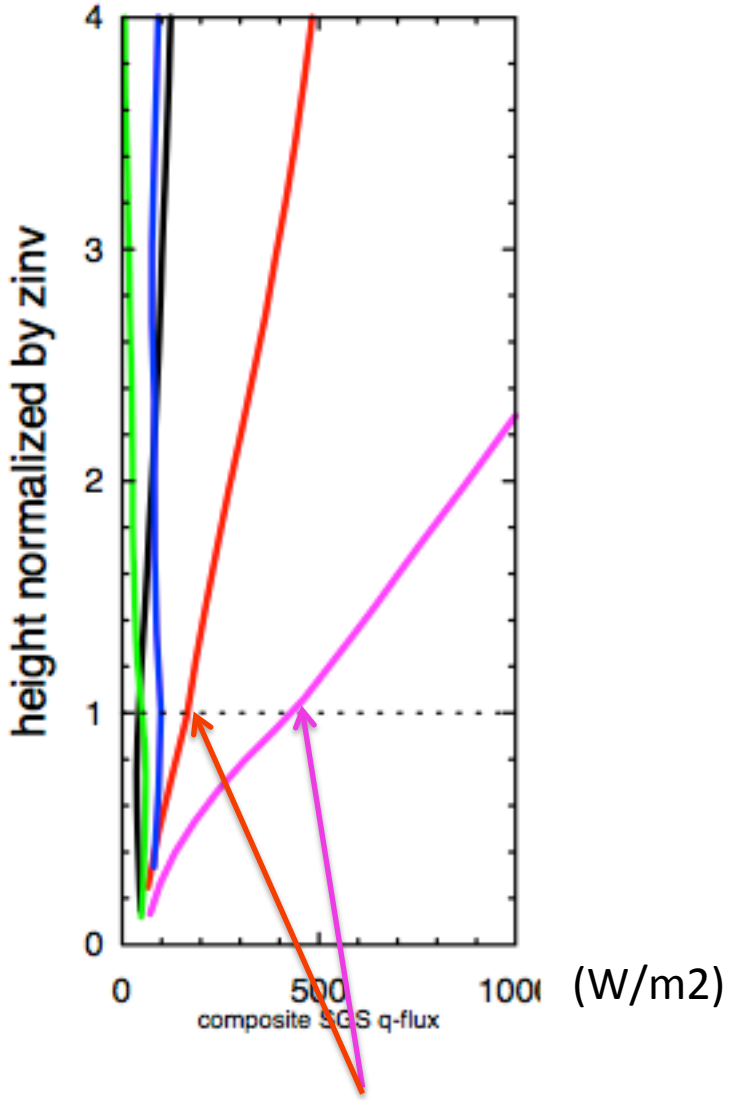
Composite vertical profiles: mean fields



mean W>0 in cloudy area

Only "recovered" PBL shows a "well-mixed" layer.

Composite vertical profiles: SGS flux



cold-pool area

recovered area

cloudy area

rainy area

xy-mean (whole domain average)

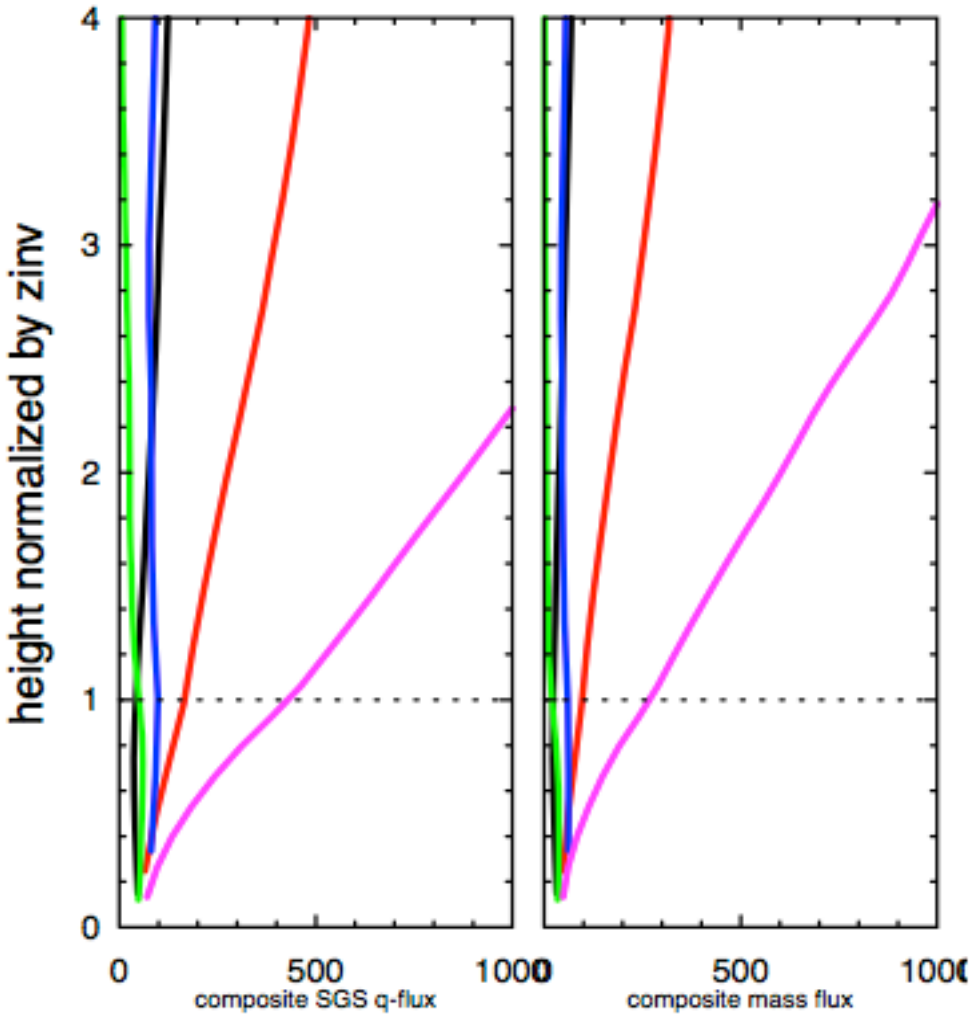
Significant amounts of SGS turbulent flux at the PBL top in cloudy and rainy areas.

How to model the SGS flux: "top-hat" flux?

top-hat flux

retrieved τ_{wq} $(w^U_{SGS} - w^D_{SGS})(q^U_{SGS} - q^D_{SGS})/4$

If Gaussian JPDF



cold-pool

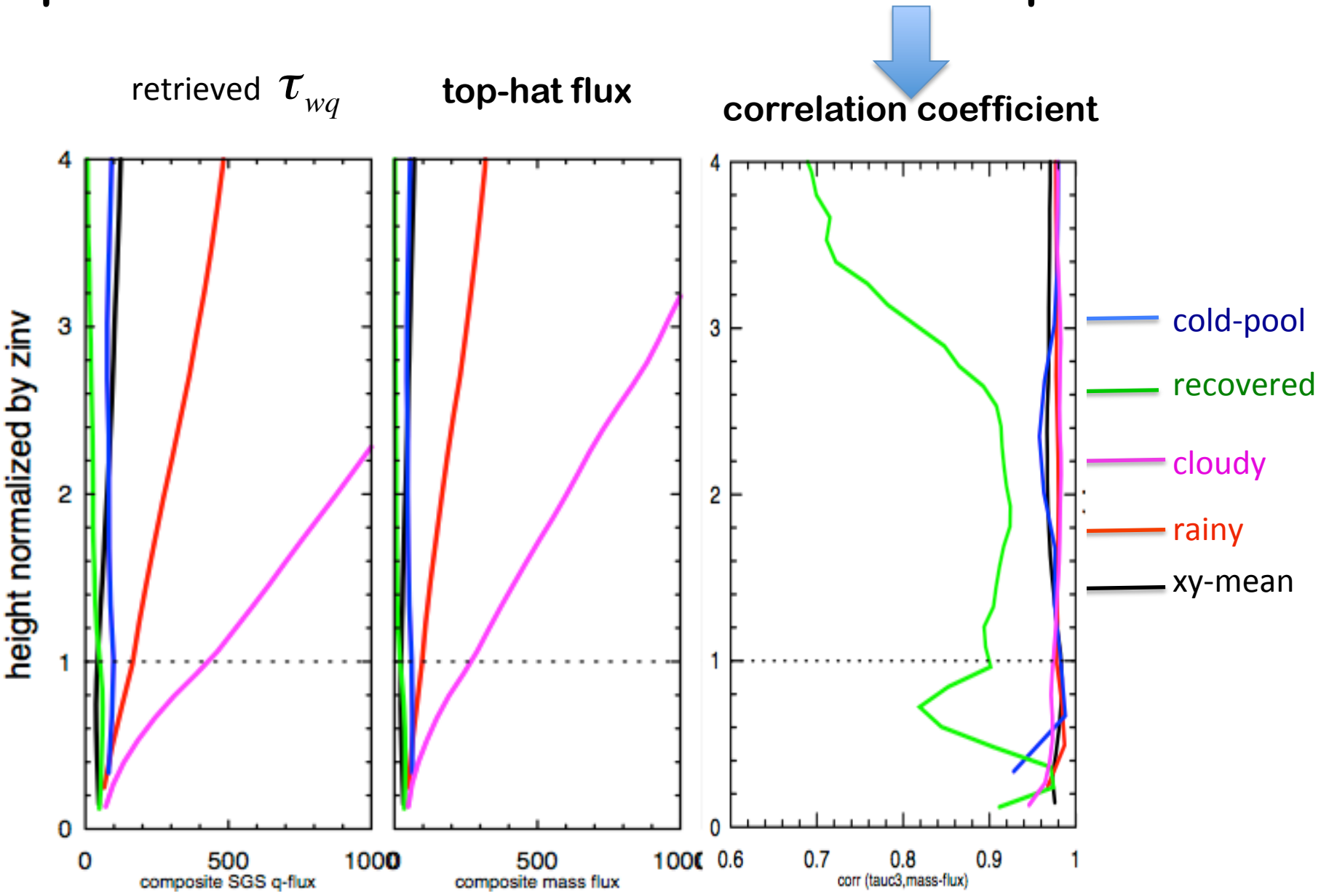
recovered

cloudy

rainy

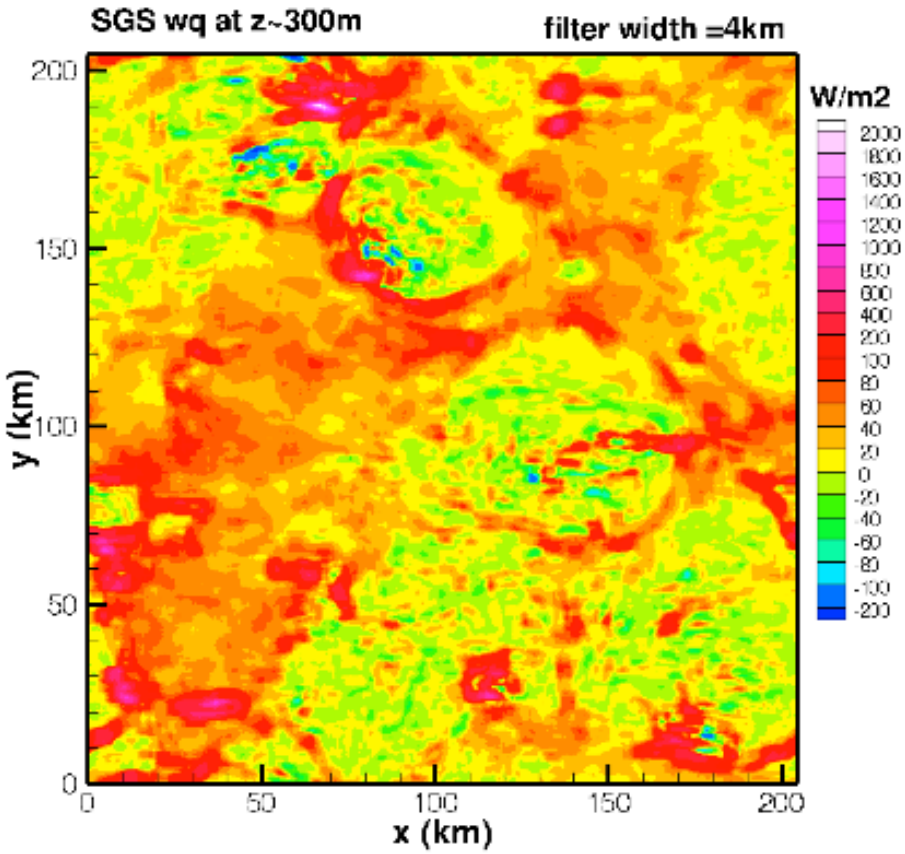
xy-mean

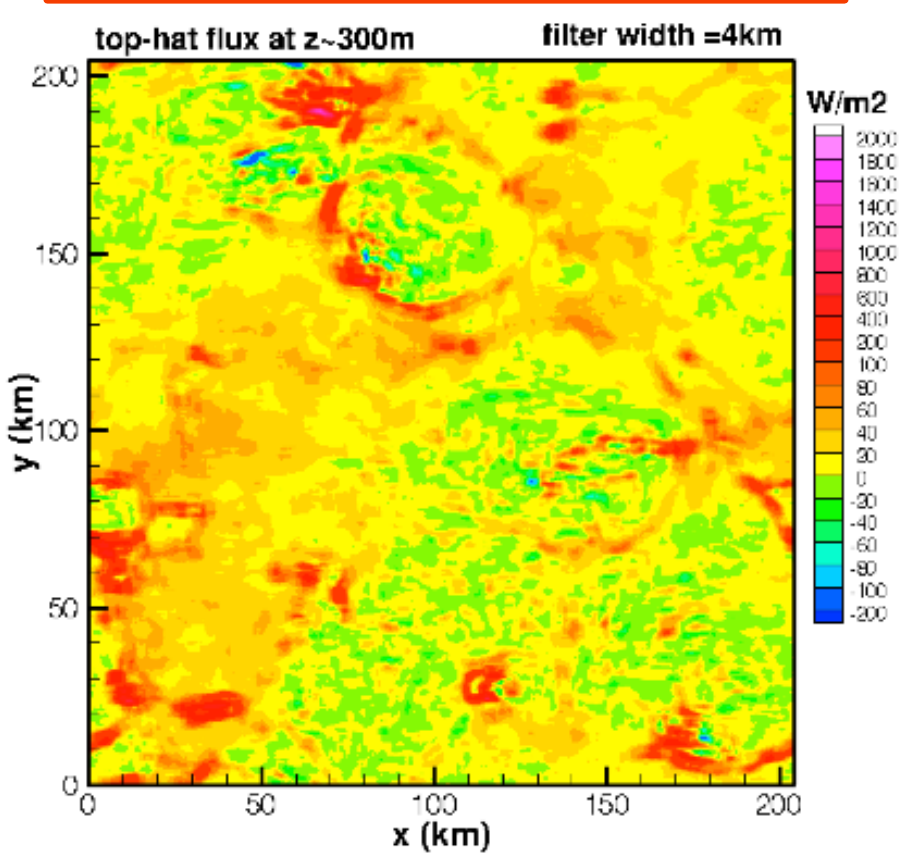
Spatial correlation between SGS flux and top-hat flux



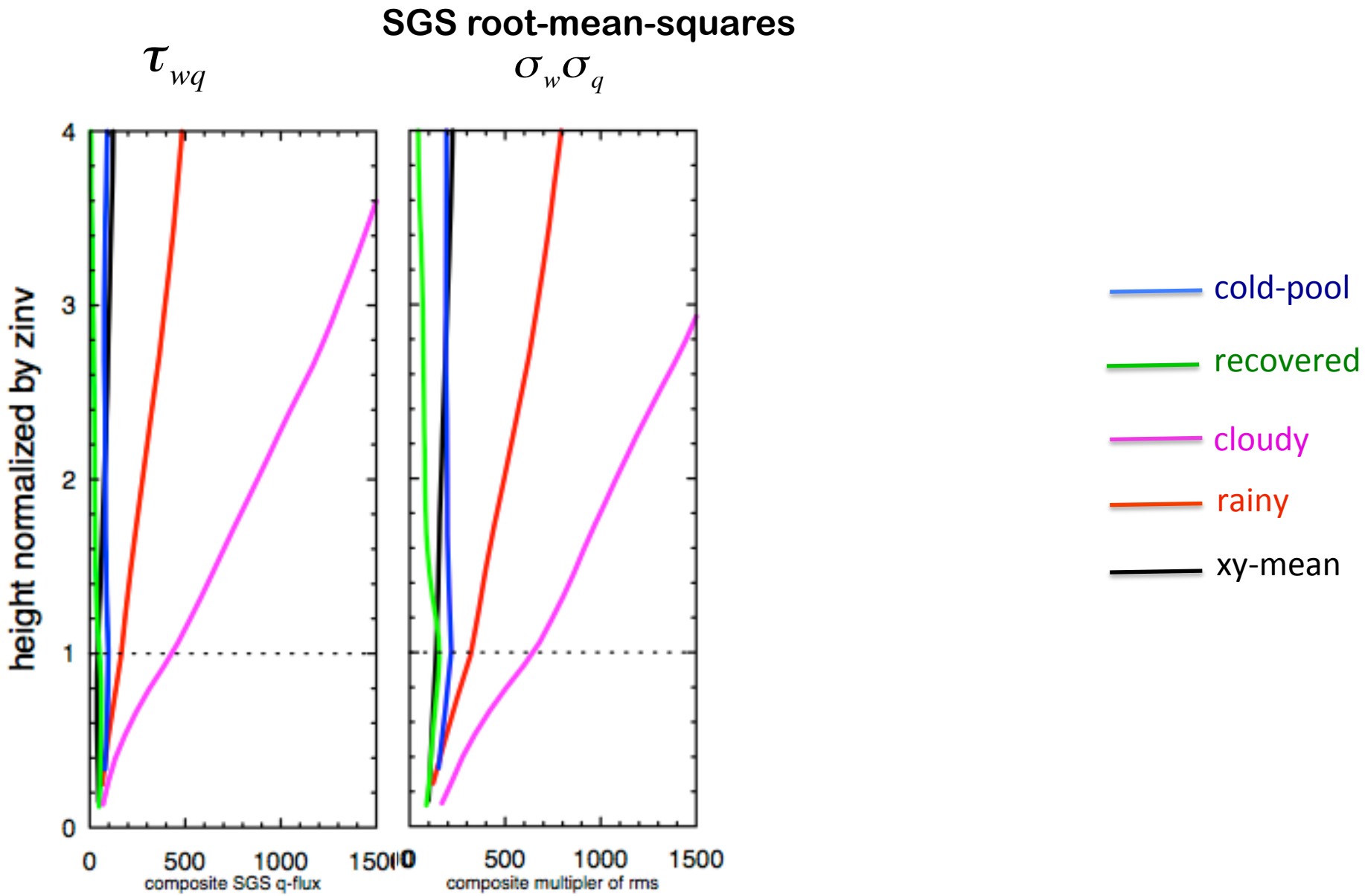
Horizontal distribution of SGS flux at z~ 300 m

$$(w^U_{SGS} - w^D_{SGS})(q^U_{SGS} - q^D_{SGS}) / 4$$

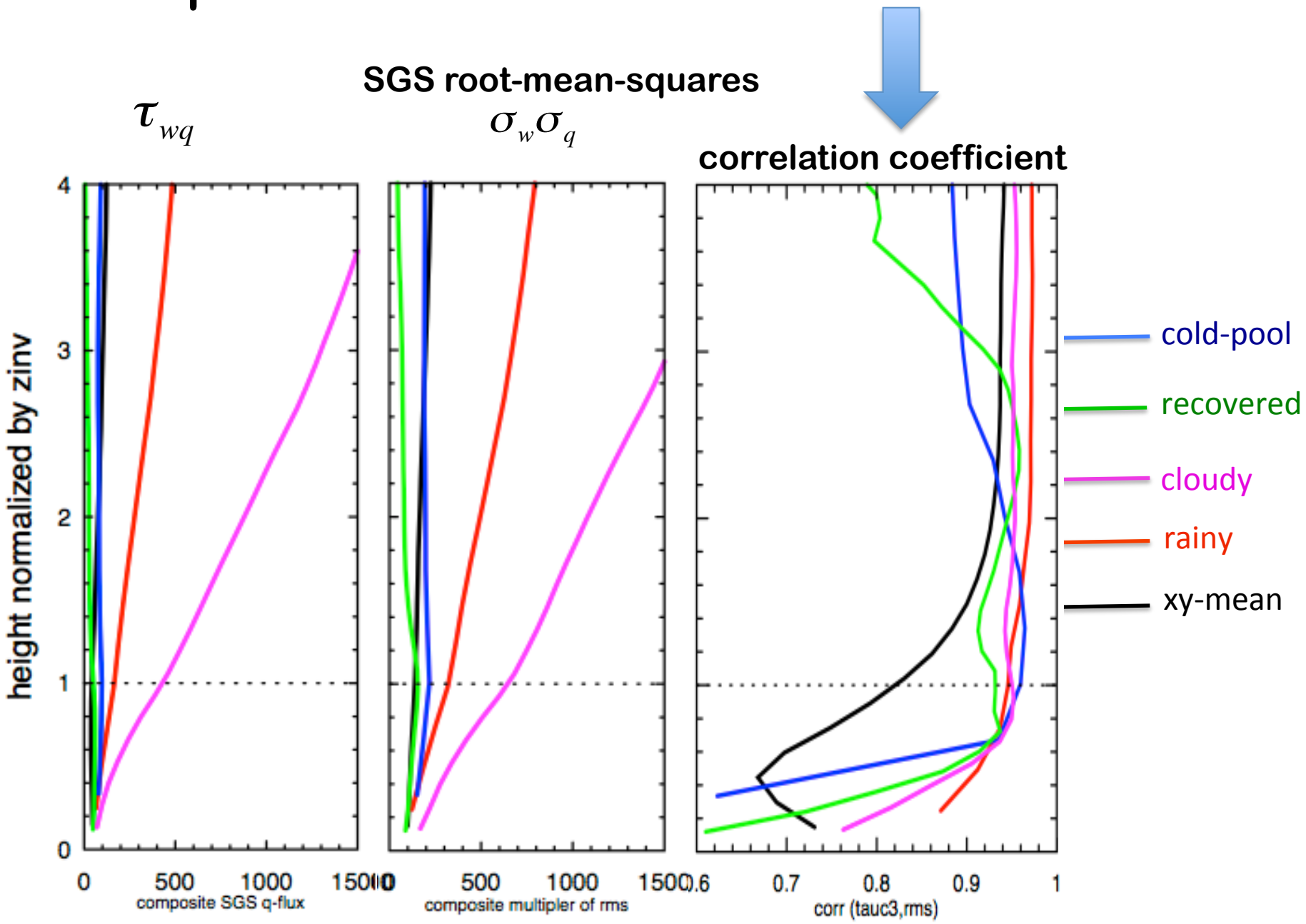




Can SGS variances represent SGS flux?

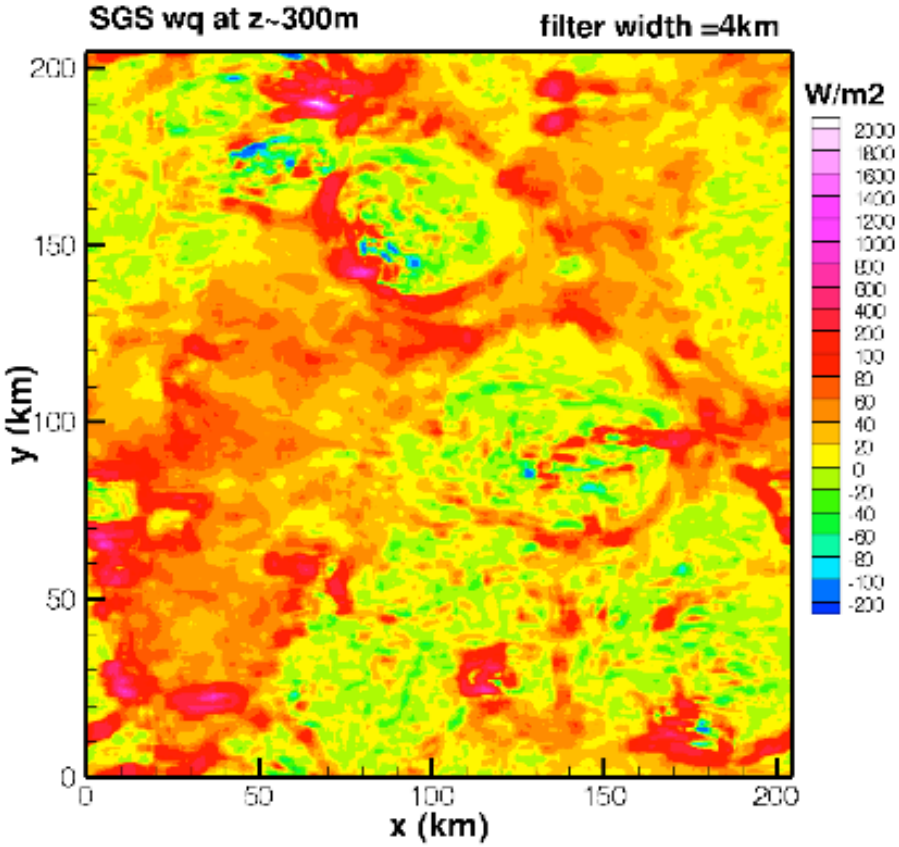


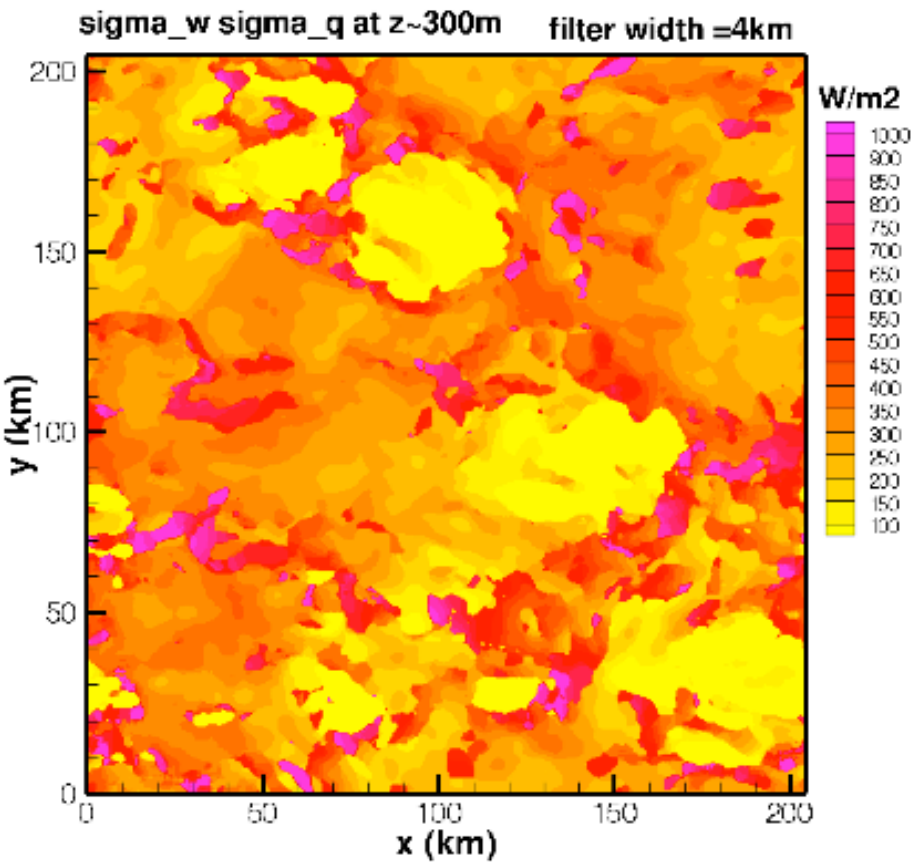
Spatial correlation between them?



Horizontal distribution of SGS flux at z~ 300 m

$$\sigma_w \sigma_q$$





Summary

- Only the PBL in the recovered area looks familiar: "well-mixed" PBL & small turbulence flux above.
- Large SGS flux at the PBL top in cloudy & rainy areas, signifying strong interaction as expected.
- SGS flux correlates well with SGS "top-hat" flux & also reasonably with the multiple of SGS root mean squares.
- Next: is it easier to model SGS up/down-drafts properties or SGS variances?