⟶ Taking into account the gustiness due to free and deep convection for the representation of air-sea fluxes

- in the LMDZ model -

Alina Găinuşă-Bogdan, Frédéric Hourdin, Catherine Rio, Jean-Yves Grandpeix, Jean-Louis Dufresne

What is gustiness?

Small-scale wind variability

↑

Subgrid

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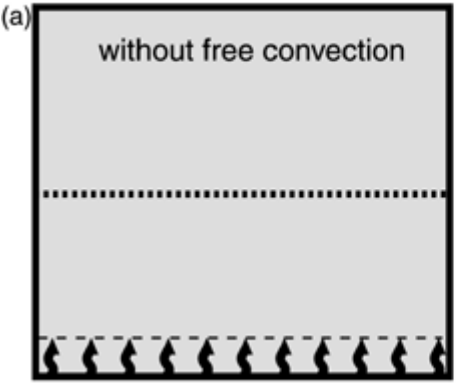
Subgrid

Redelsperger et al. (2000)

ENHANCEMENT OF SURFACE FLUXES FOR UNDISTURBED PBL



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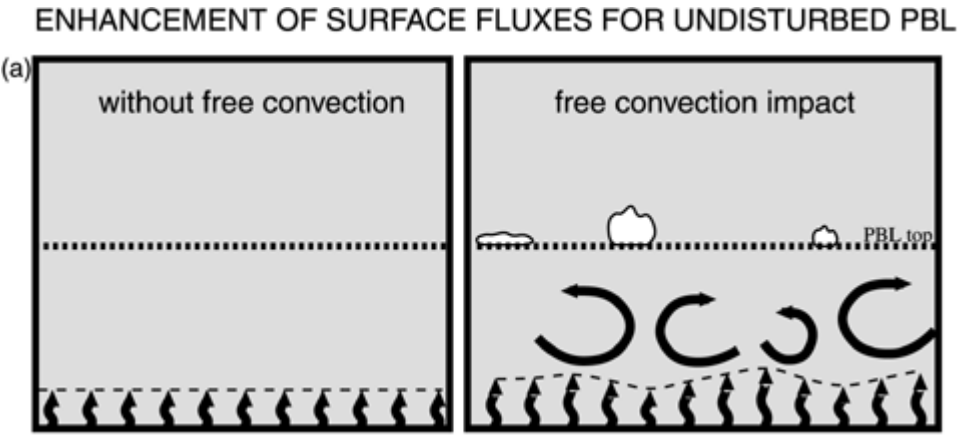

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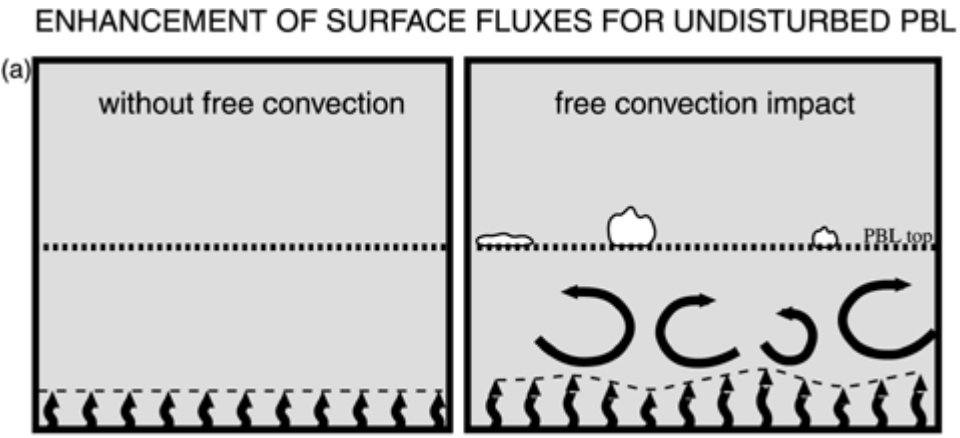
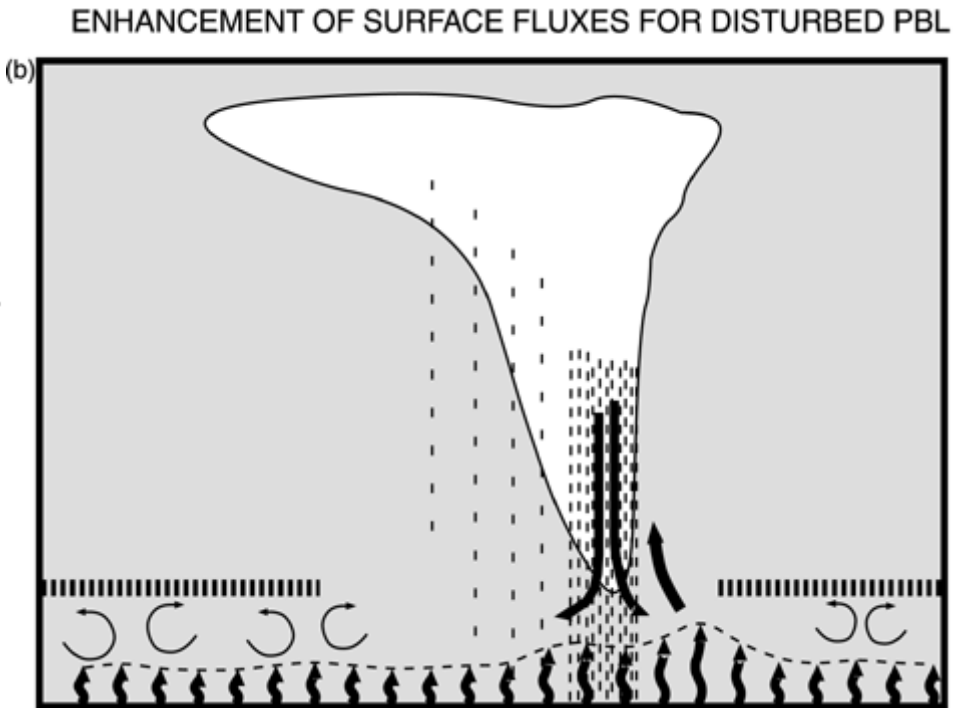




How can we parameterize gustiness?

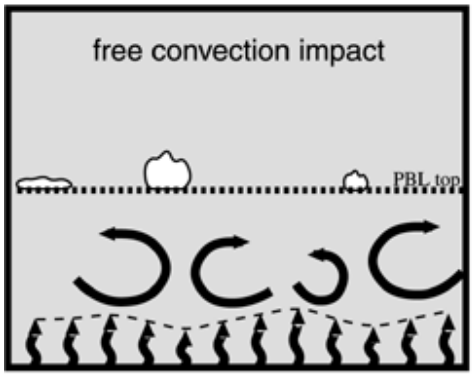
→ Free convection:

Godfrey&Beljaars (1991):

$$U_{eff}^2 = U_0^2 + (\beta w_*)^2$$

Redelsperger et al. (2000):

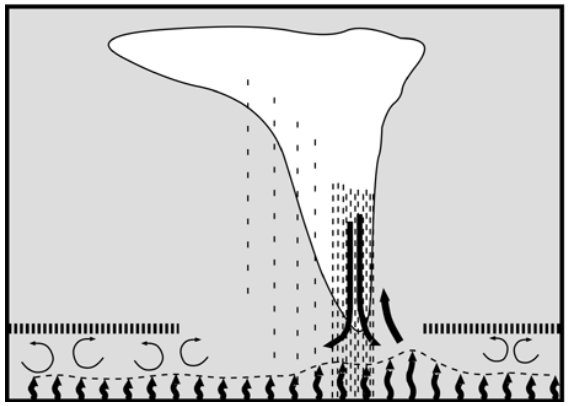
$$\beta = 0.65$$



→ Deep convection:

Redelsperger et al. (2000):

$$U_g = \left(\frac{19.8\, R^2}{1.5 + R + R^2} \right)^4$$



How important is gustiness?

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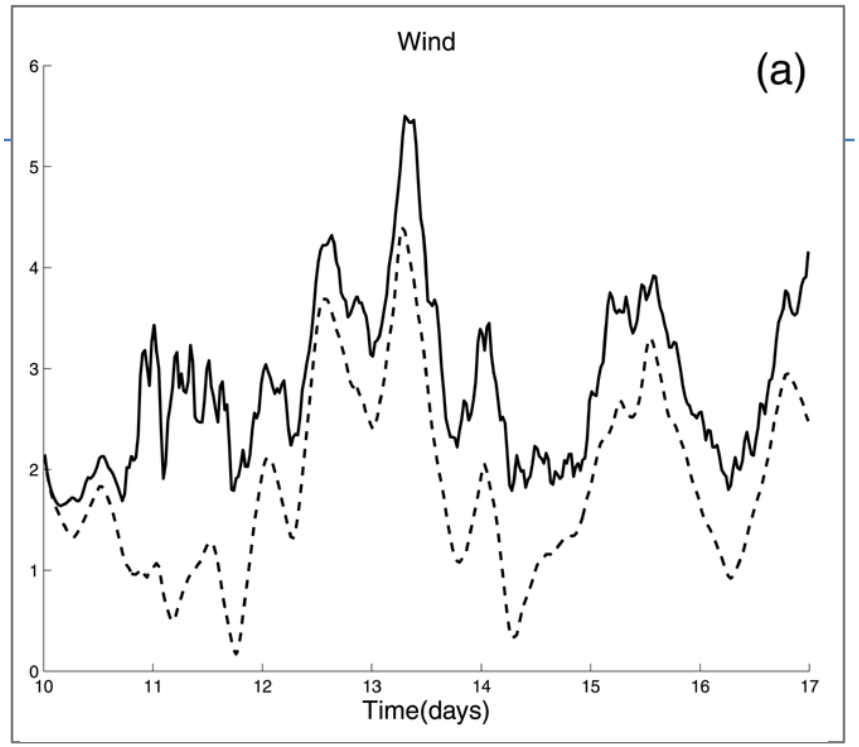
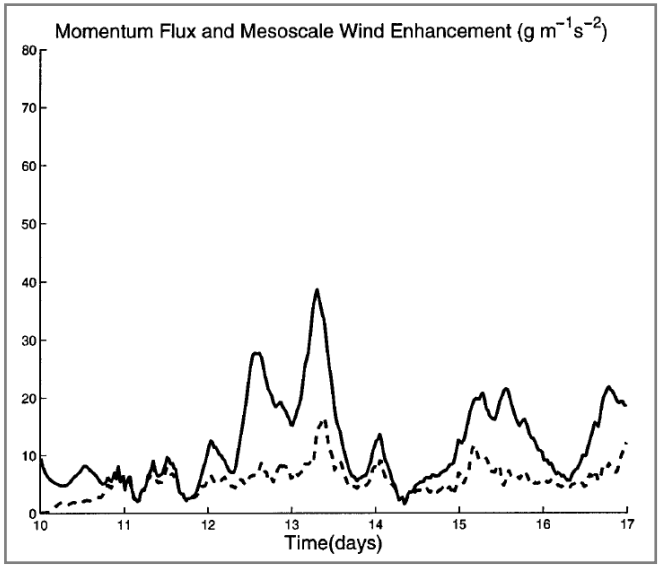
At low wind speeds, quite!



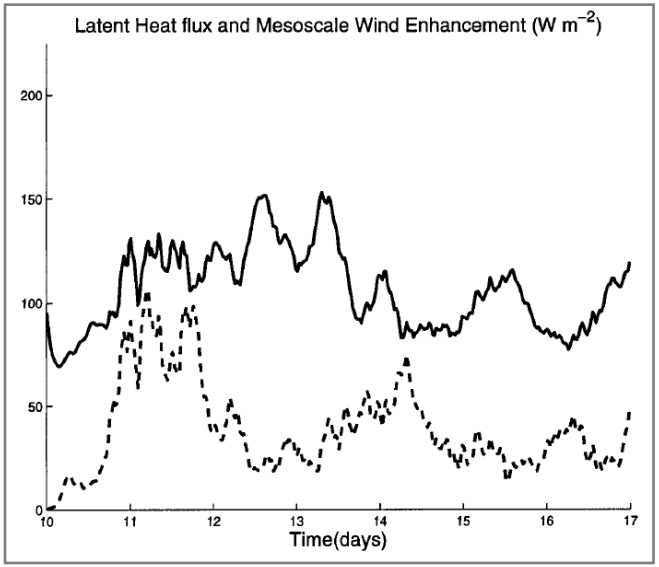
How important is gustiness?

Wind stress

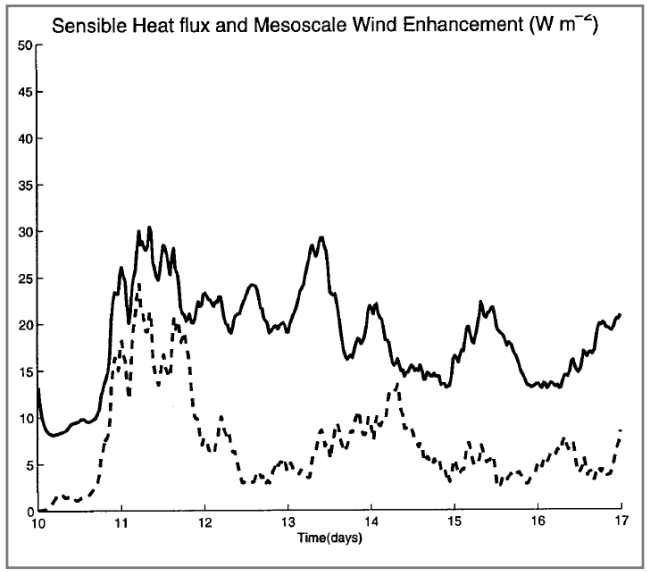


At low wind speeds, quite!

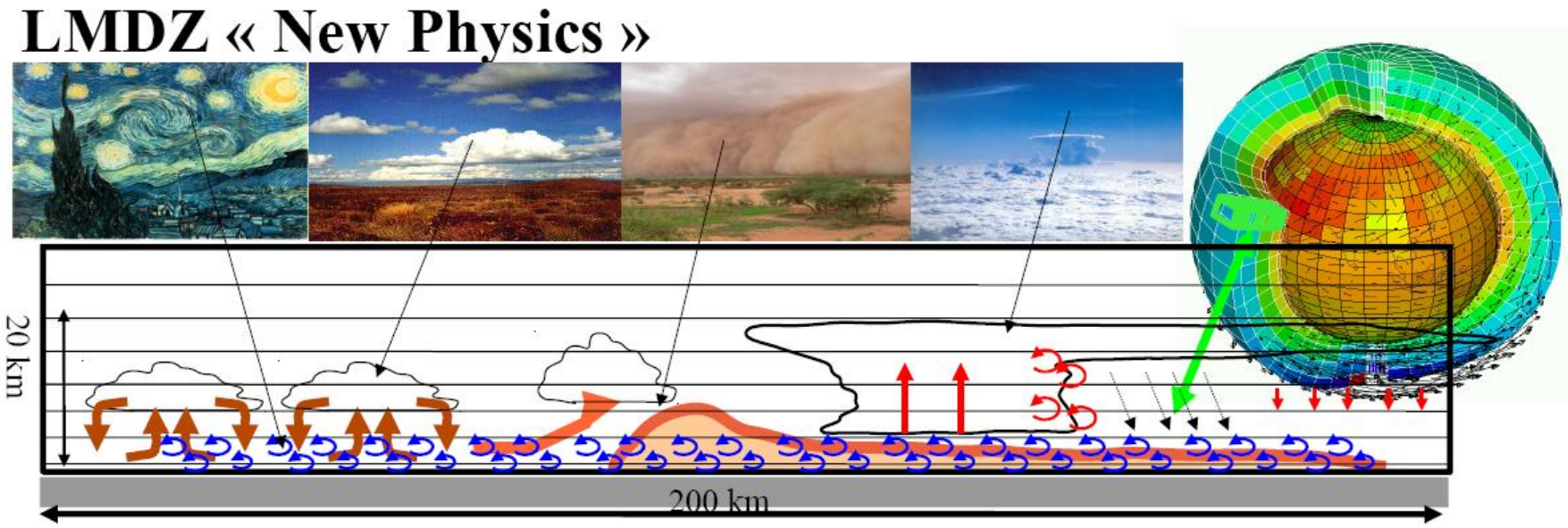
Latent heat flux



Sensible heat flux

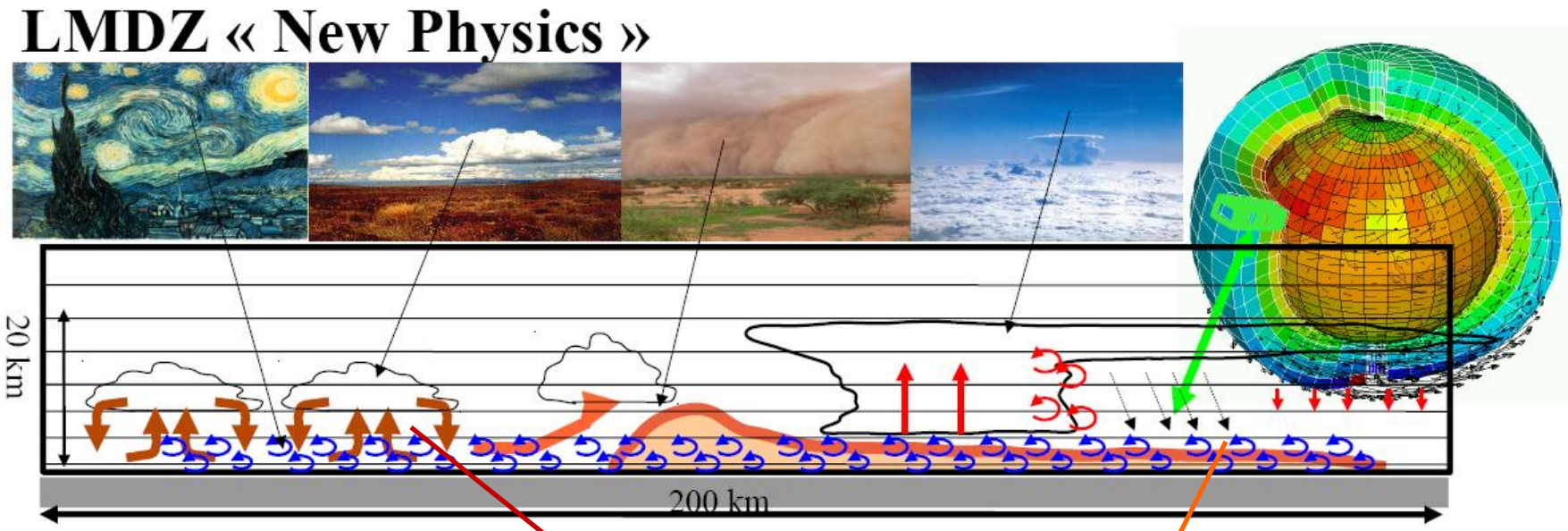


How can we parameterize gustiness?



ALE = Available lifting energy

How can we parameterize gustiness?



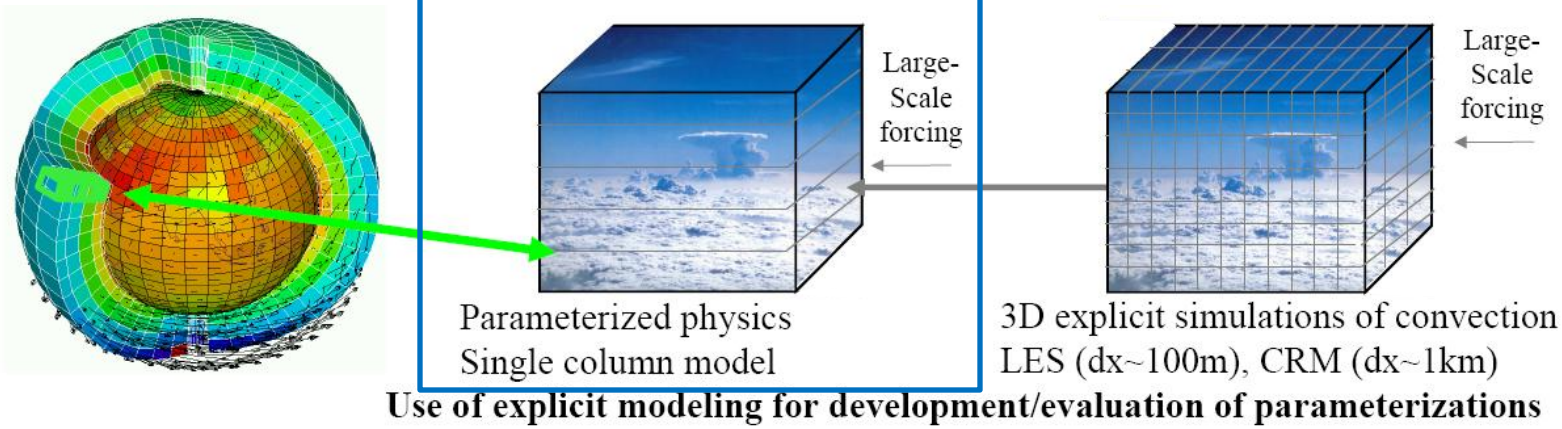
Redelsperger et al. (2000): $(\beta w_*)^2$ $f(R)$

$$U_{eff}^2 = U_0^2 + \beta^2 \zeta\, 2ALE_{BL} + \alpha\, 2ALE_{WK}$$

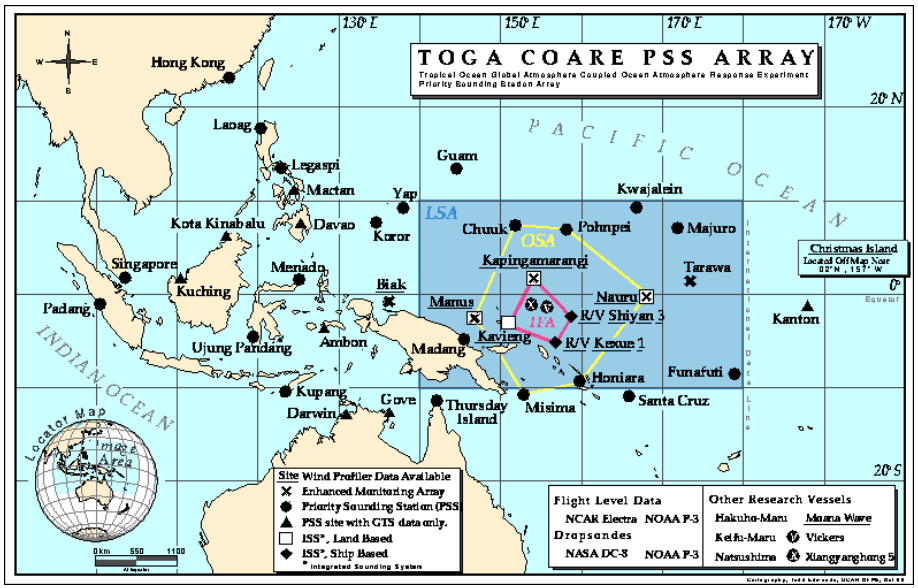
ALE = Available lifting energy

What can we use for development?

TOGA



Use of explicit modeling for development/evaluation of parameterizations



The TOGA-COARE campaign:

- Nov. 1st, 1992 – Feb. 28, 1993
- Succession of active and suppressed convection events

How do we parameterize gustiness?

$$U_{eff}^2 = U_0^2 + \beta^2 \zeta^2 2ALE_{BL} + \alpha 2ALE_{WK}$$

$\beta = 0.65$, $\zeta = 1$, $\alpha = ?$

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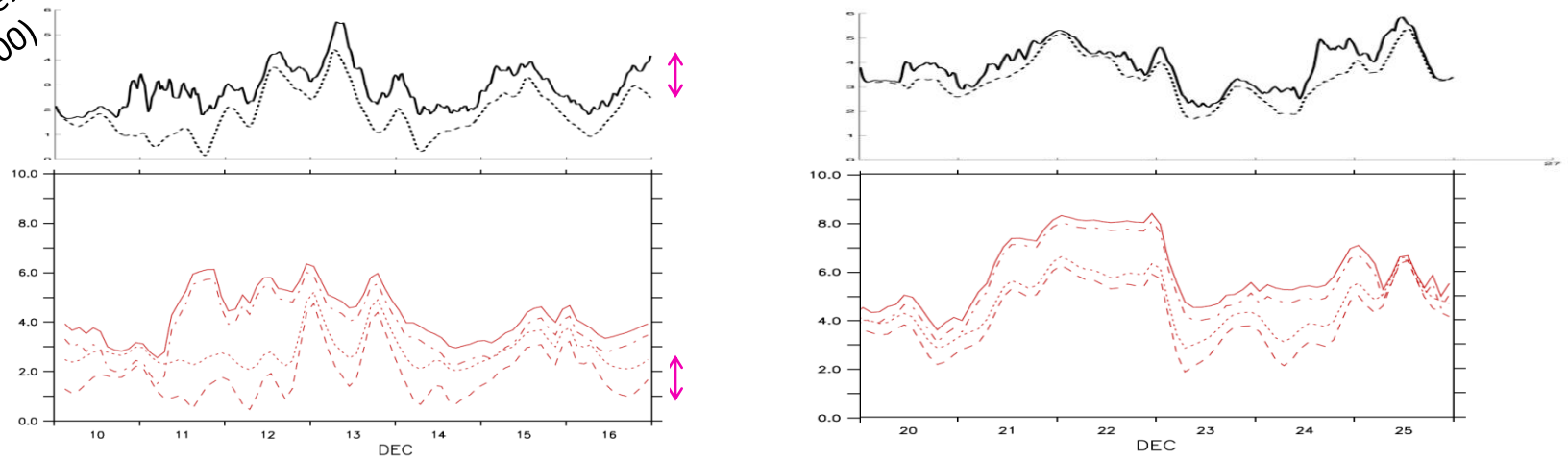
Redelsperger et al. (2000)

LMDZ1D CTRL



Scalar mean of the wind speed (Redelsperger et al., 2000) = U_0 + resolved deep convection gustiness

Magnitude of the mean vector wind (Redelsperger et al., 2000) = U_0

U_0, CTRL + BL gust + WK gust

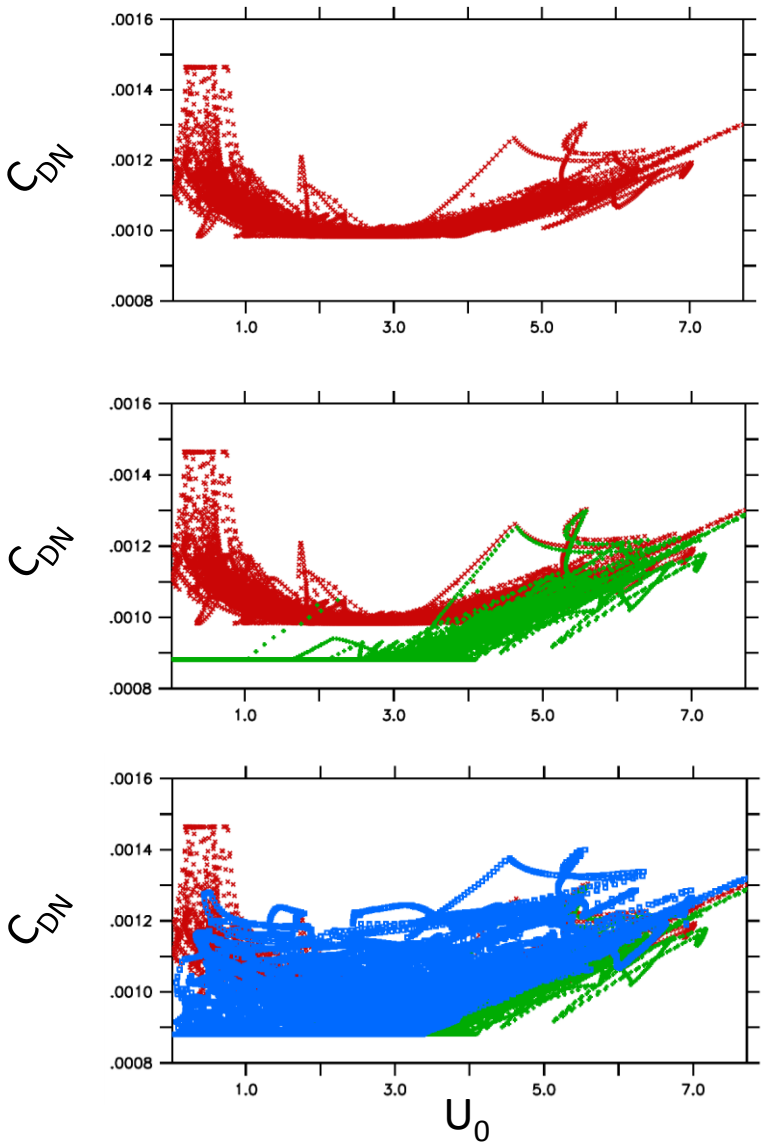
U_0, CTRL + BL gust

U_0, CTRL + WK gust

Magnitude of the mean vector wind = U_0, CTRL

- ✓ comparable magnitudes
- ✓ lower gustiness for U_0 peaks, higher for low U_0
- ✓ wind enhancement higher in 10-16 Dec than 20-25 Dec 1992

1D simulations



$$C_{DN} = \left[\frac{\kappa}{ln(z/z_0)}\right]^2$$

CTRL

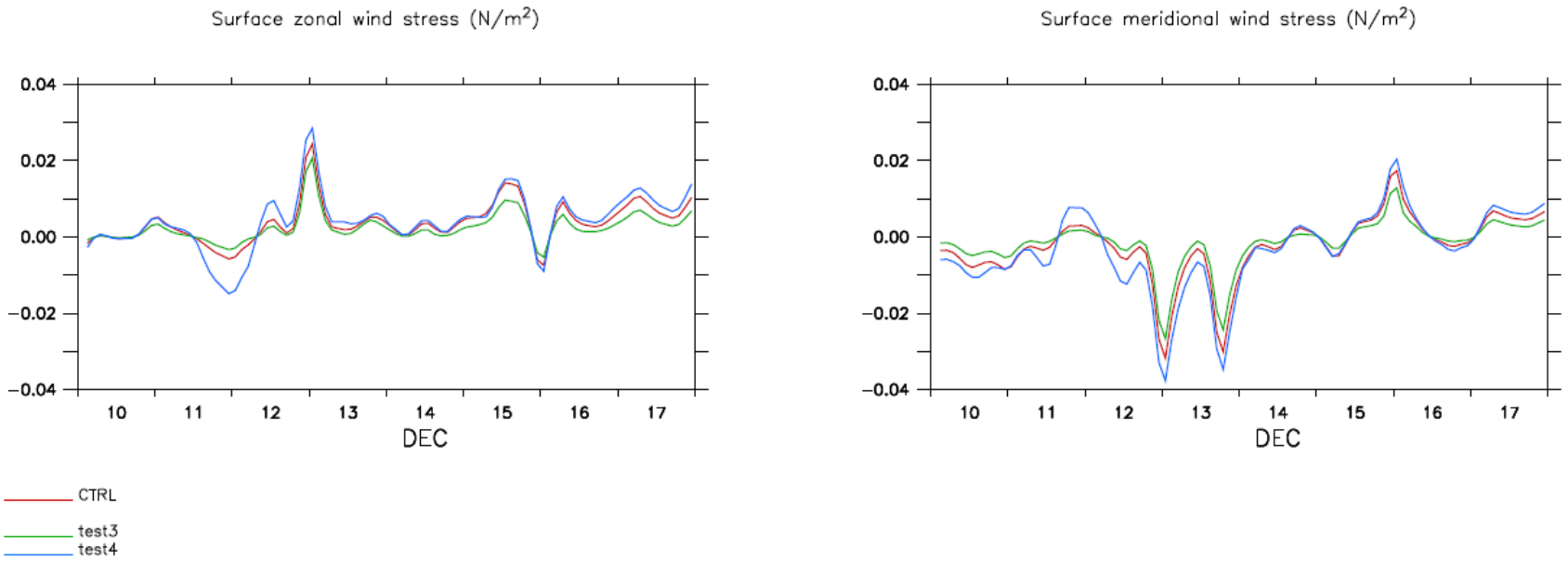
Remove C_{DN} increase at low wind speeds

test3

Add gustiness parameterization

test4

Results - fluxes

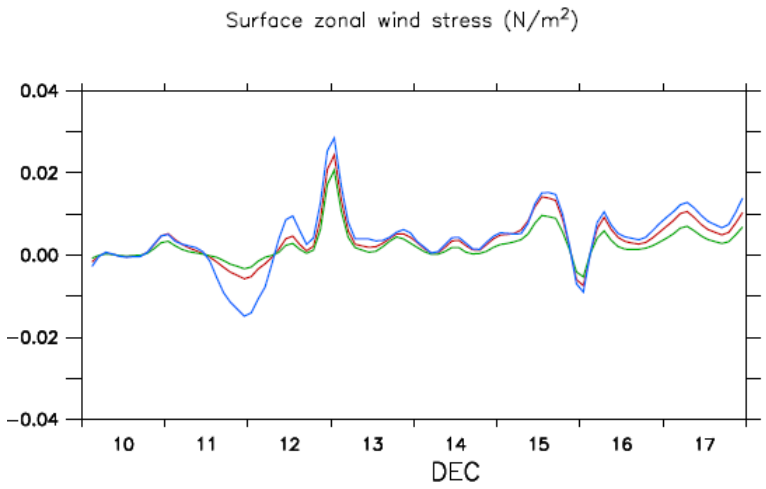


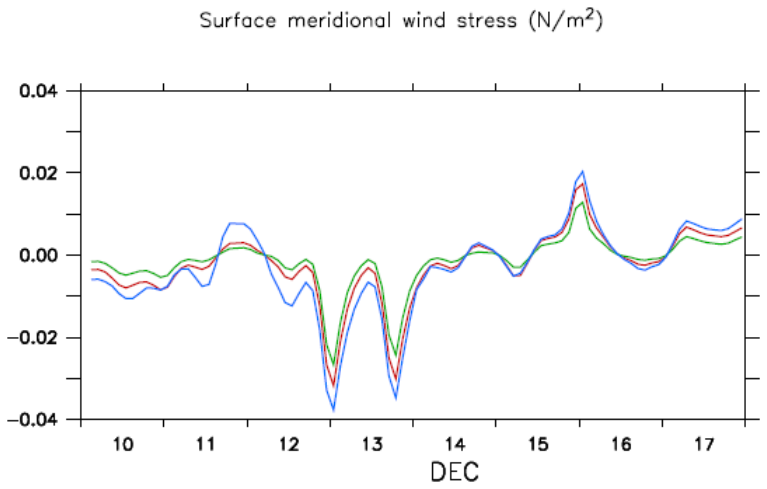
The results are what we expect for the wind stress:

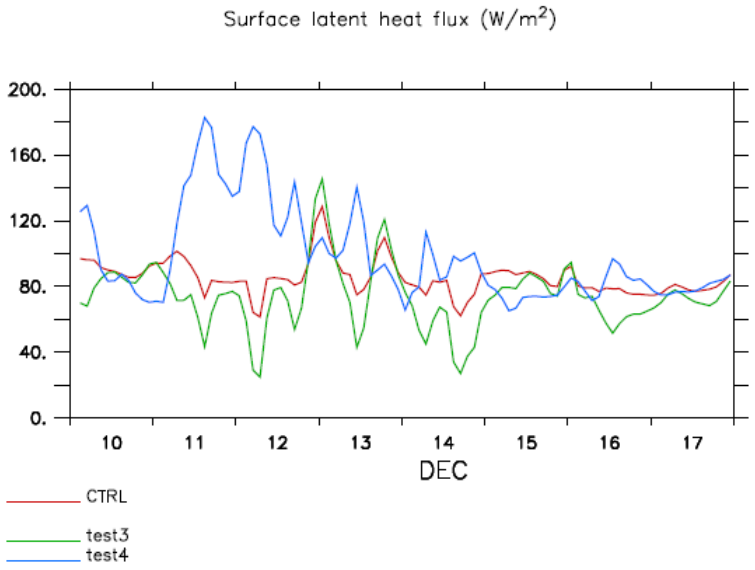
- remove C_{DN} increase at low wind speeds => mostly reduced wind stress
- add gustiness => enhanced wind stress

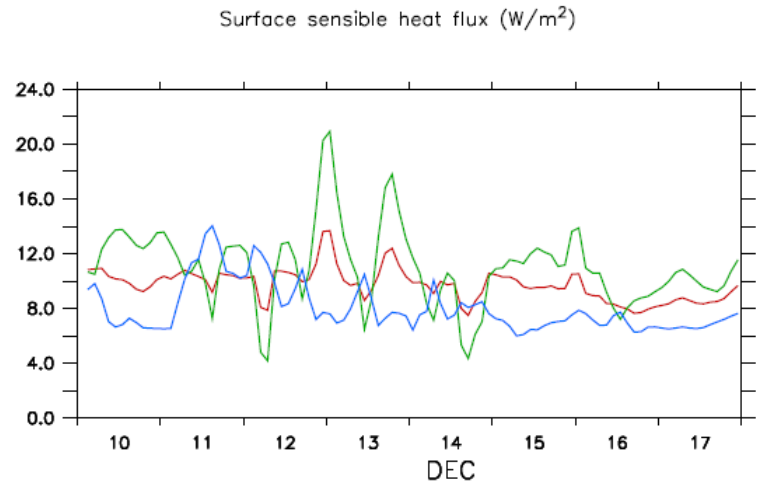
+ Gustiness-enhanced wind stress higher than in CTRL

Results - fluxes

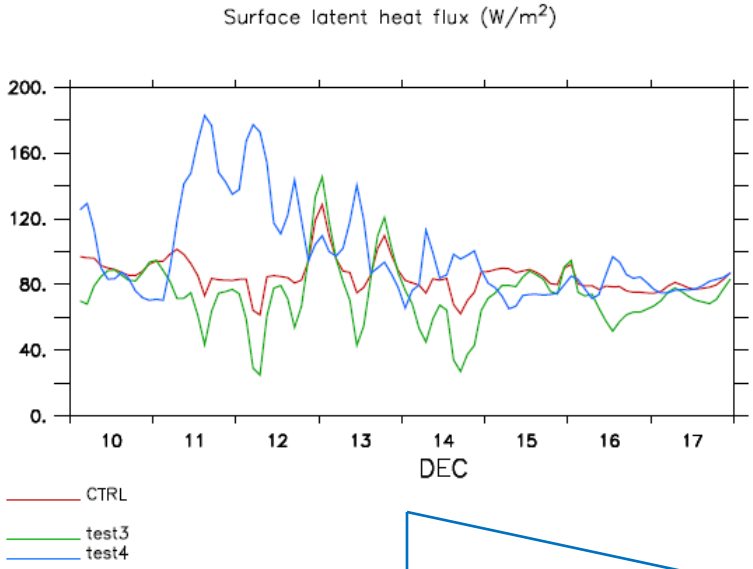


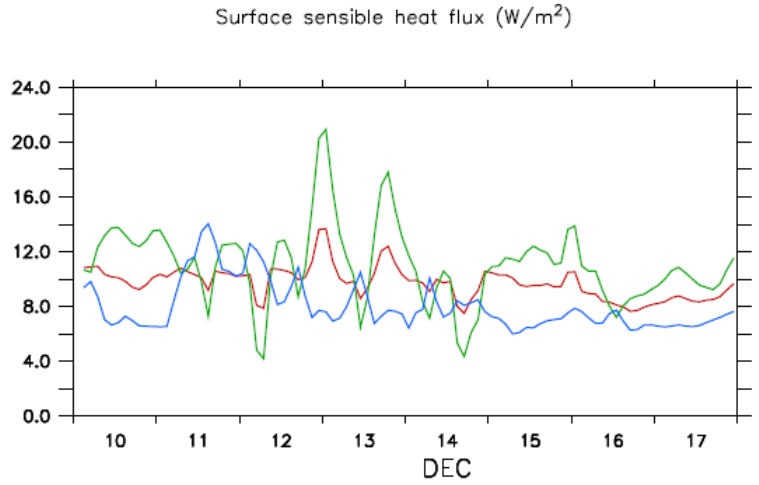


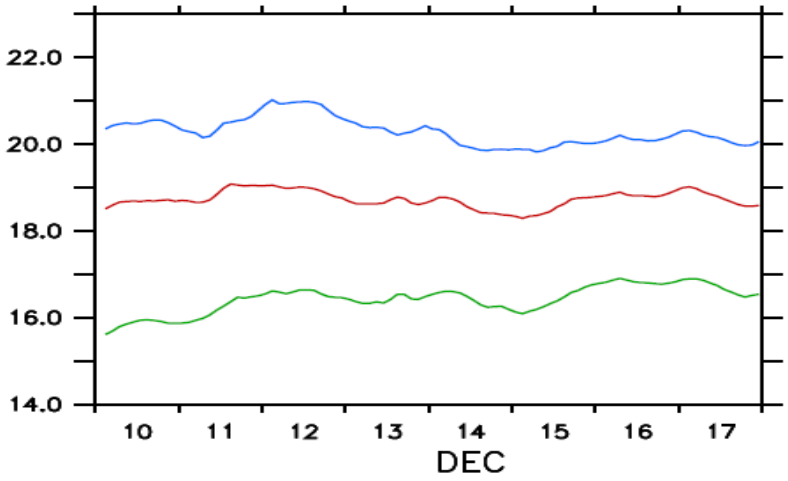


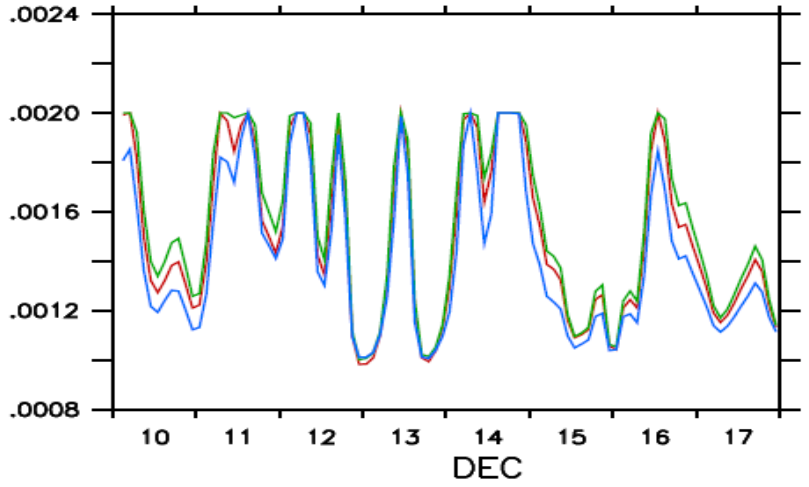


Results – fluxes and state variables









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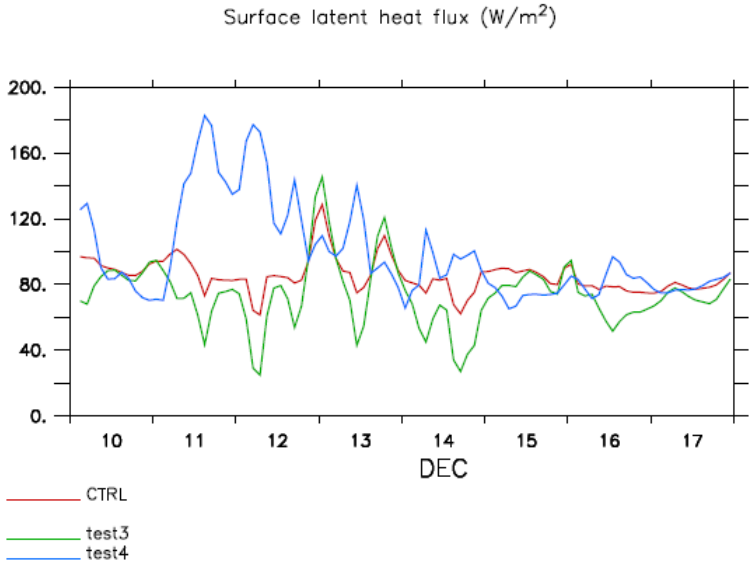
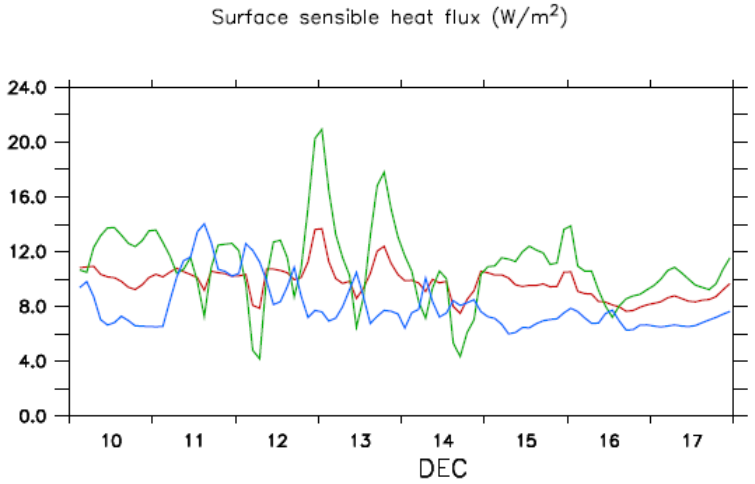
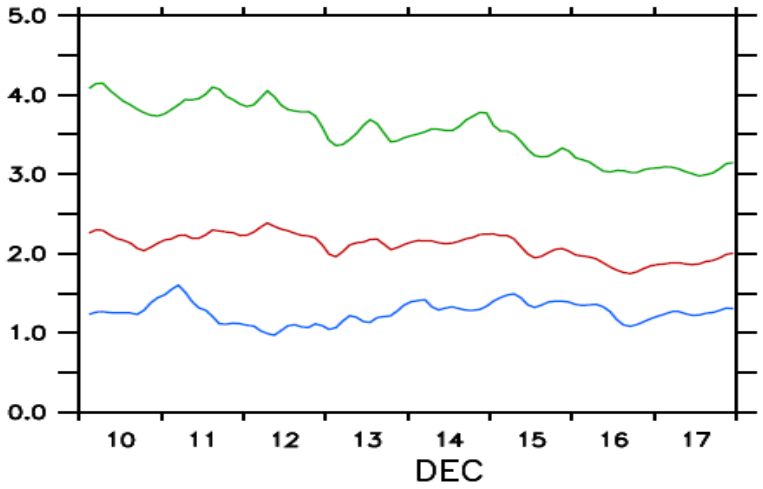
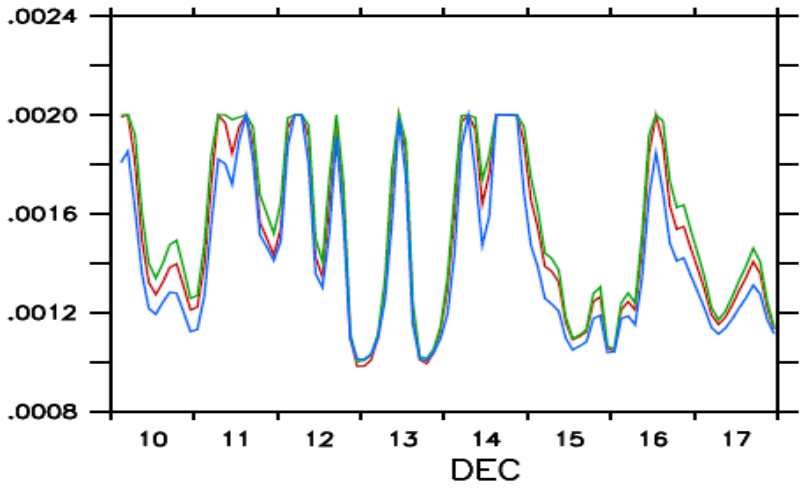


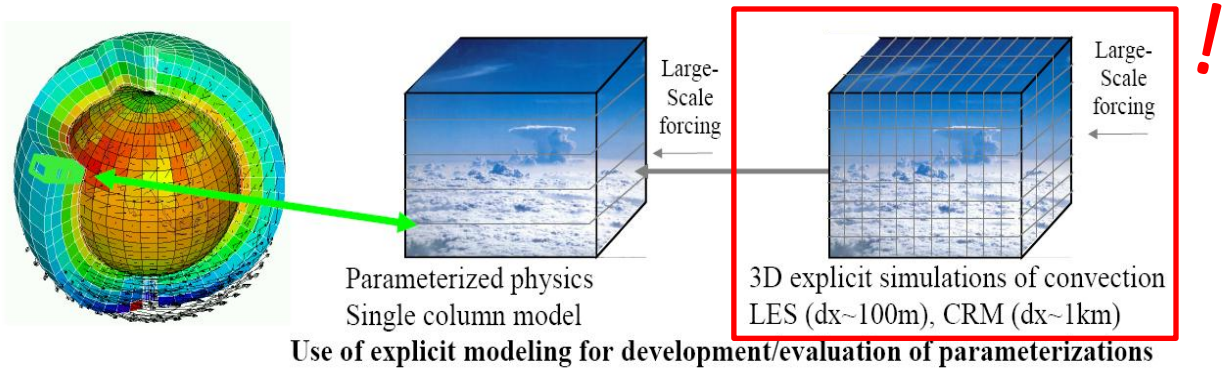






Ending remarks

- This is promising
- This is also very preliminary – much analysis needed
- Tuning
  - $\alpha_{WK} \sim 0.03 \rightarrow 0.3$
  - add variation with wake size - ?
  - ζ – slightly tunable around *1*
  - would need very good reason to change β
- OBS, LES, CRM data needed for fine-tuning the parameterization



Use of explicit modeling for development/evaluation of parameterizations

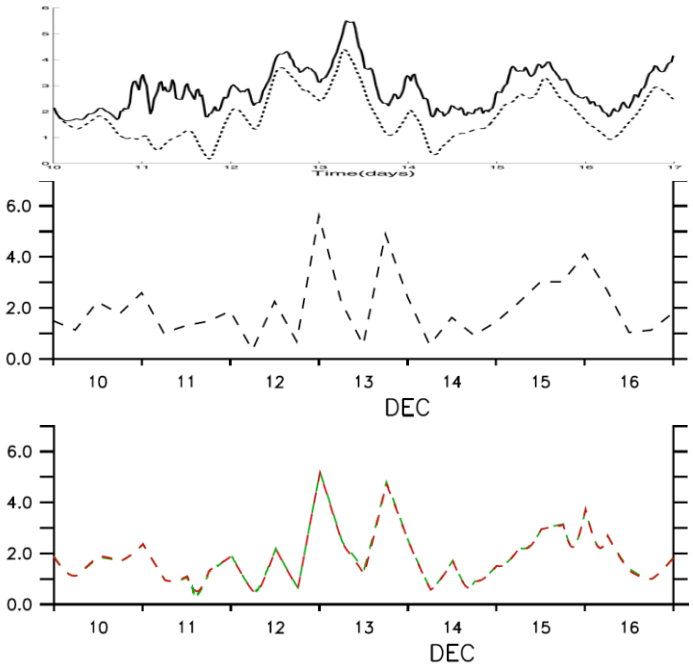
Thank you!

How do we parameterize gustiness?

$$U_{eff}^2 = U_0^2 + \beta^2 \zeta 2ALE_{BL} + \alpha 2ALE_{WK}$$

$\beta = 0.65$, $\zeta = 1$, $\alpha = ?$

Horizontal wind speed



↕ deep convection gustiness

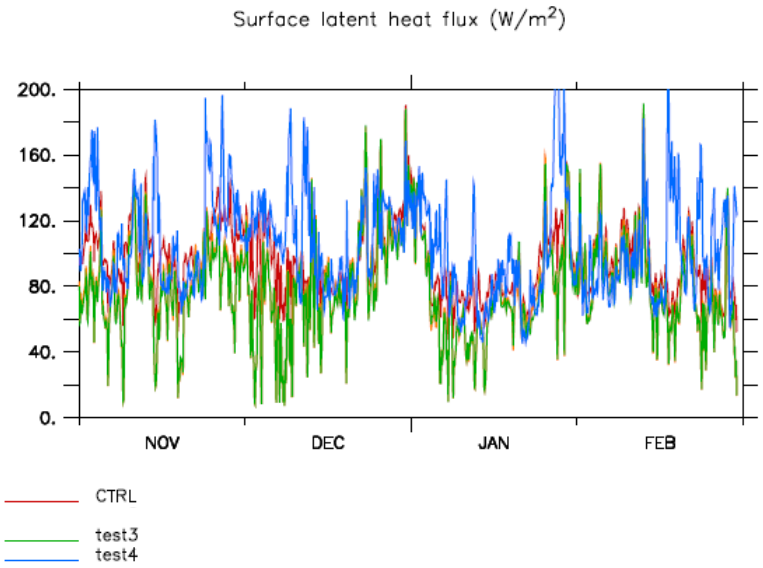
——— Scalar mean of the wind speed (Redelsperger et al., 2000) = U_0 + resolved deep convection gustiness

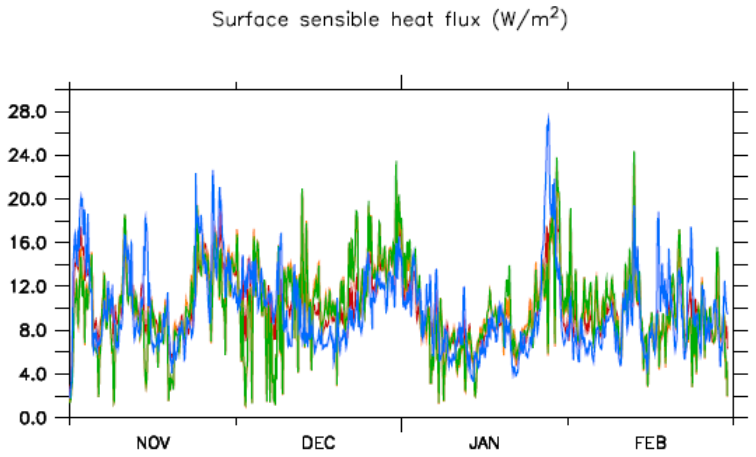
····· Magnitude of the mean vector wind (Redelsperger et al., 2000) = U_0

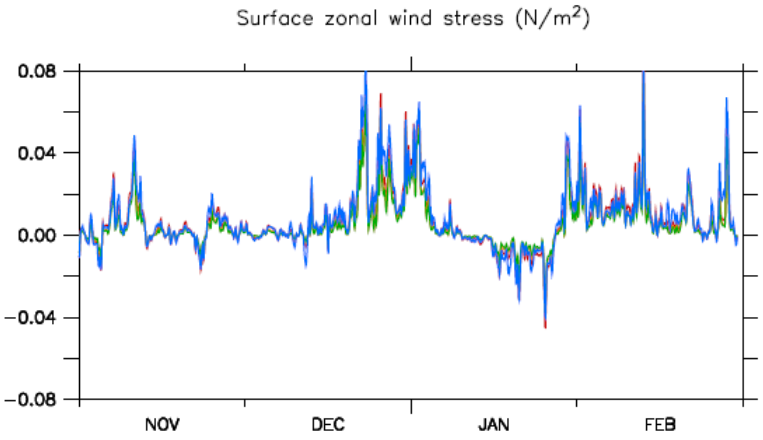
- - - - - Magnitude of the mean vector wind = U_0, 'OBS'

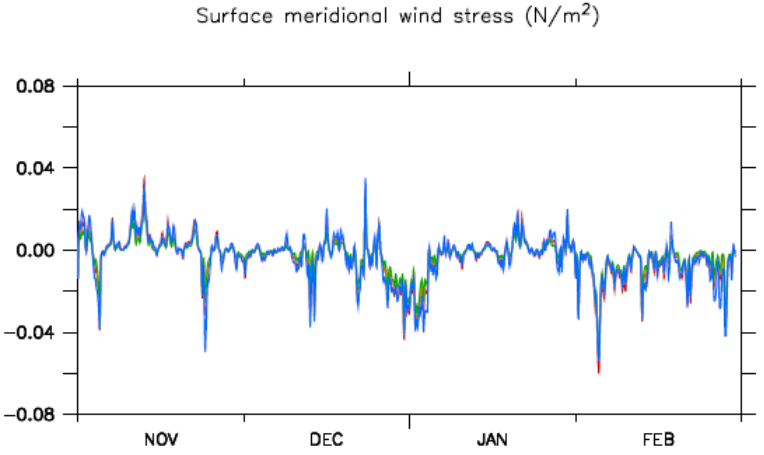
- - - - - Magnitude of the mean vector wind = U_0, CTRL

Results - fluxes









→ Results not quite as crystal-clear as we would like. Let's take a closer look...