Adapting our parameterisations for the grey zone

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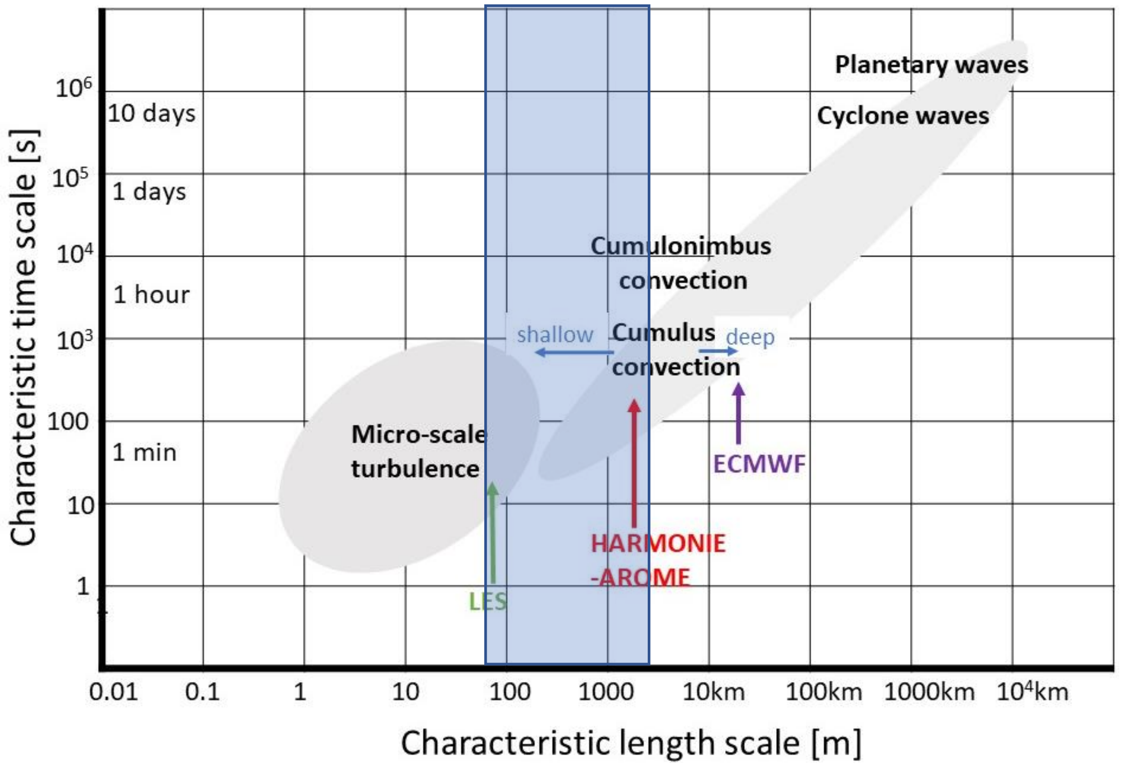
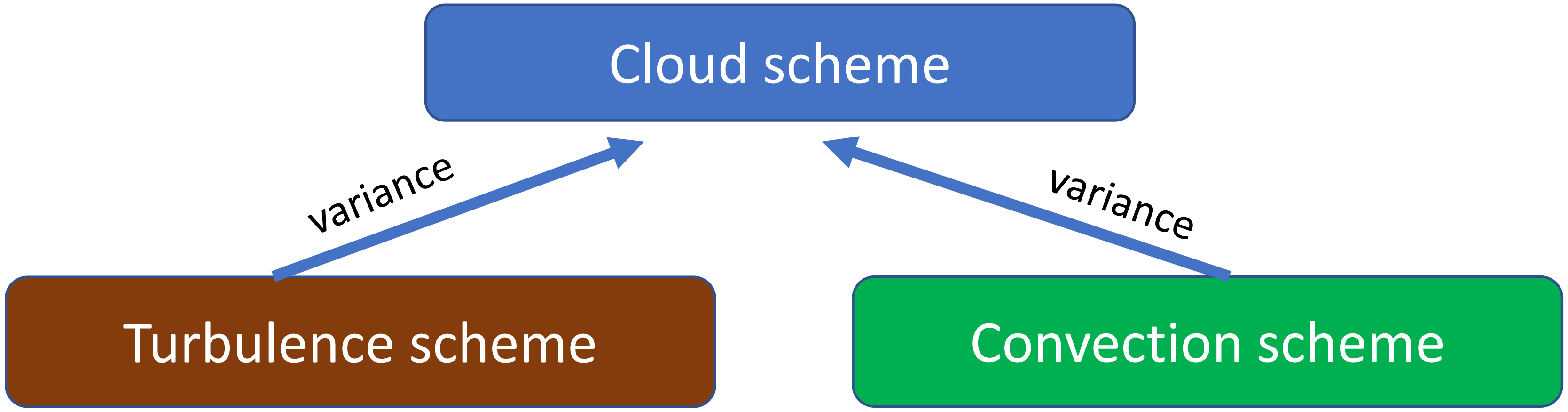
Fundamental question: Processes become partly resolved, what to do?

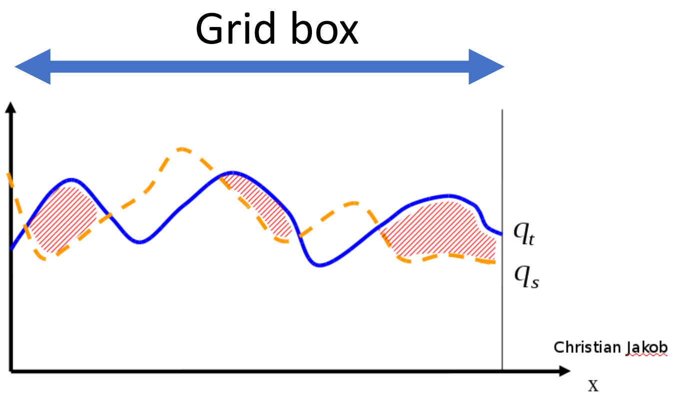


Here considering 3 schemes:

- convection
- turbulence
- cloud (!?)

Statistical cloud scheme → grey zone??

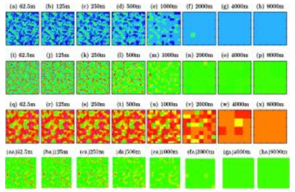




However, in Arome and Harmonie-Arome there is a third contribution from the extra variance term! (see de Rooy et al., 2022 GMD)

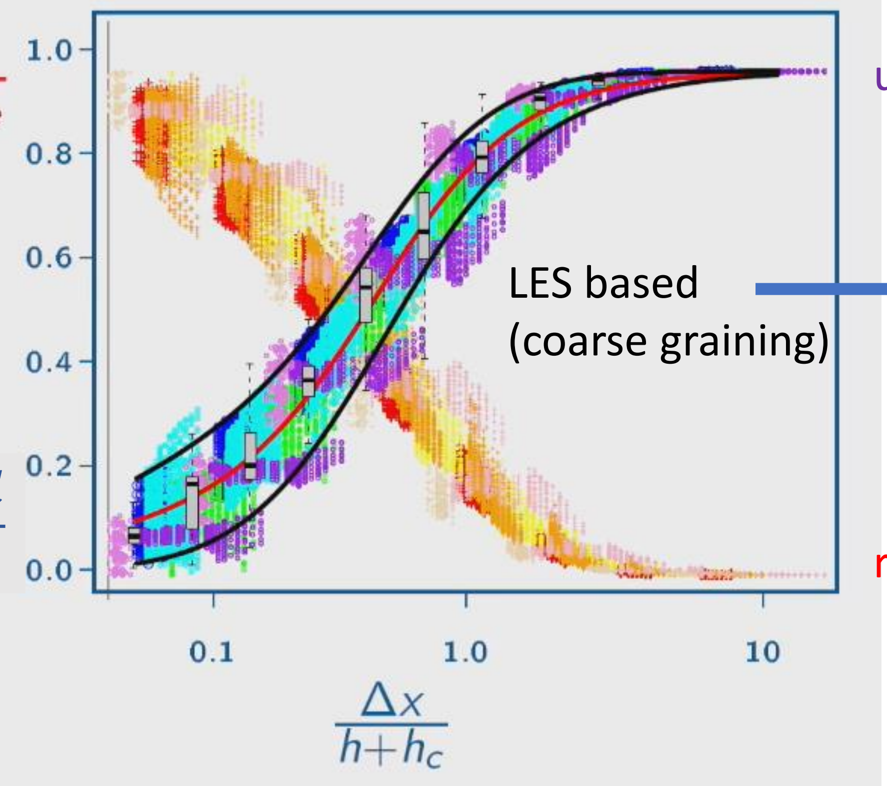
Suggestion: linear decrease from current value at 2.5km to 0 at 100m resolution (LES)

Convection and turbulence in the grey zone



Rachel Honnert plot (e.g. Honnert 2011, JAS)

$$\frac{humidity\ flux\ resolved}{total\ humidity\ flux}$$



$$\frac{humidity\ flux\ subgrid}{total\ humidity\ flux}$$

unresolved

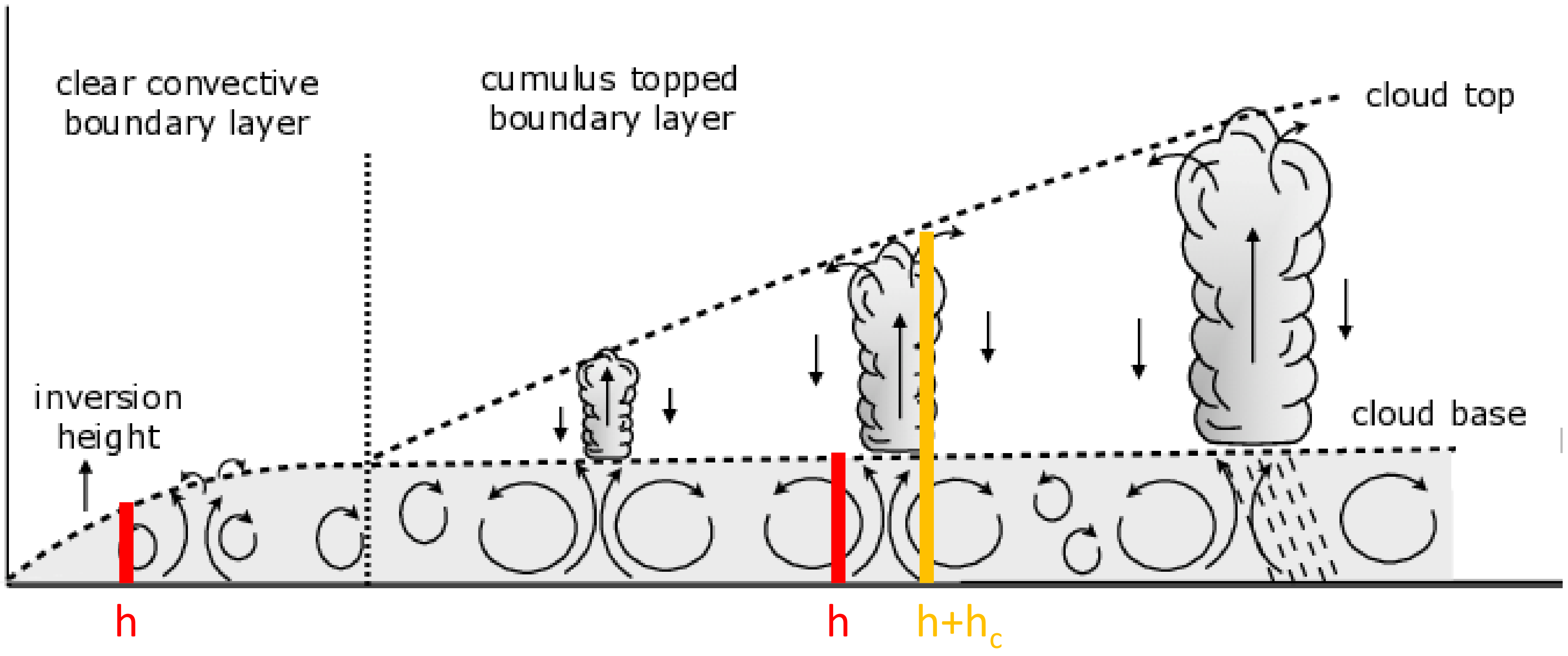
resolved

LES based (coarse graining)

We want similar behavior in NWP

$h+h_c$ is an estimate of the relevant (dominant) scales

Boundary layer height h or $h+h_c$ as an estimate of the scales

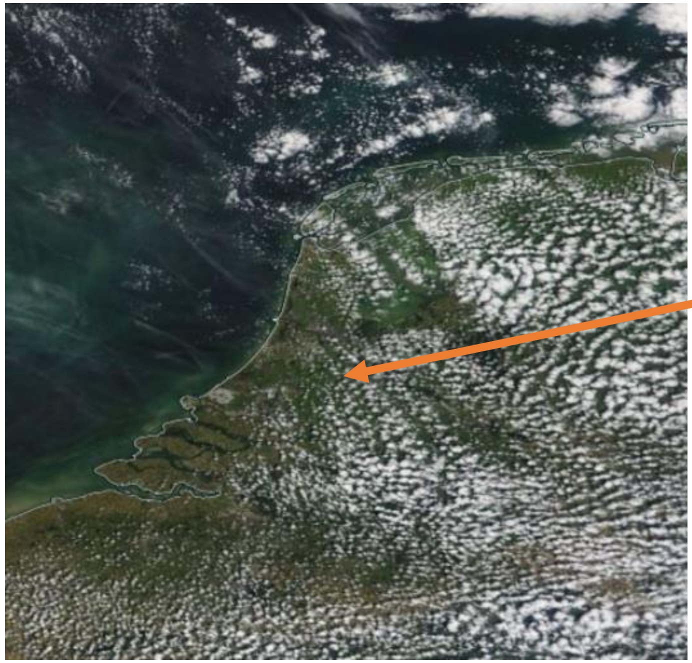


LES: h or $h+h_c$ less trivial.
Several options tried but best:
Top level with $q_l>0$ or if no q_l height with minimum $w'\theta_v'$

Harmonie-Arome: h or $h+h_c$
Very simple: Termination height moist and/or dry updraft.
Moist ↔dry → New possibilities!

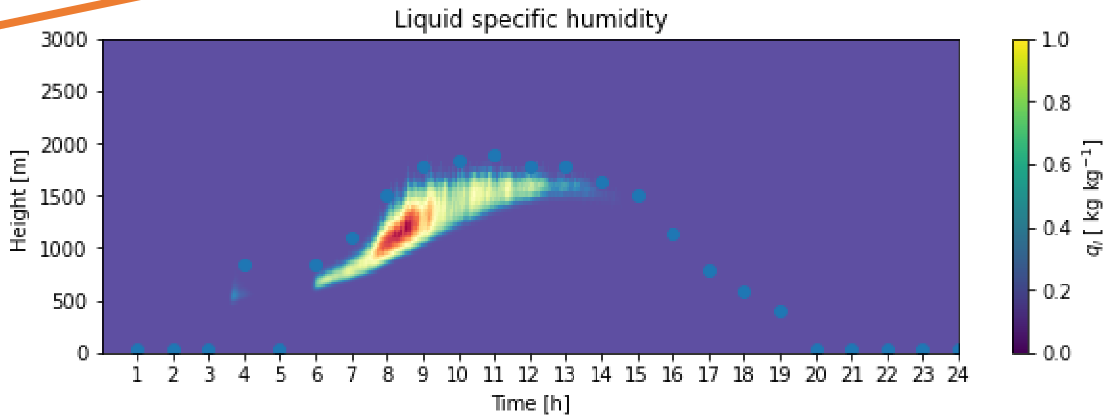
Decrease Mass flux with $f(\Delta x/h)$ *(Lancz et al. 2018)*
But
Now separately for dry (h) and moist ($h+h_c$)

Start with a simple case of (very) shallow convection
16th July 2022



LES

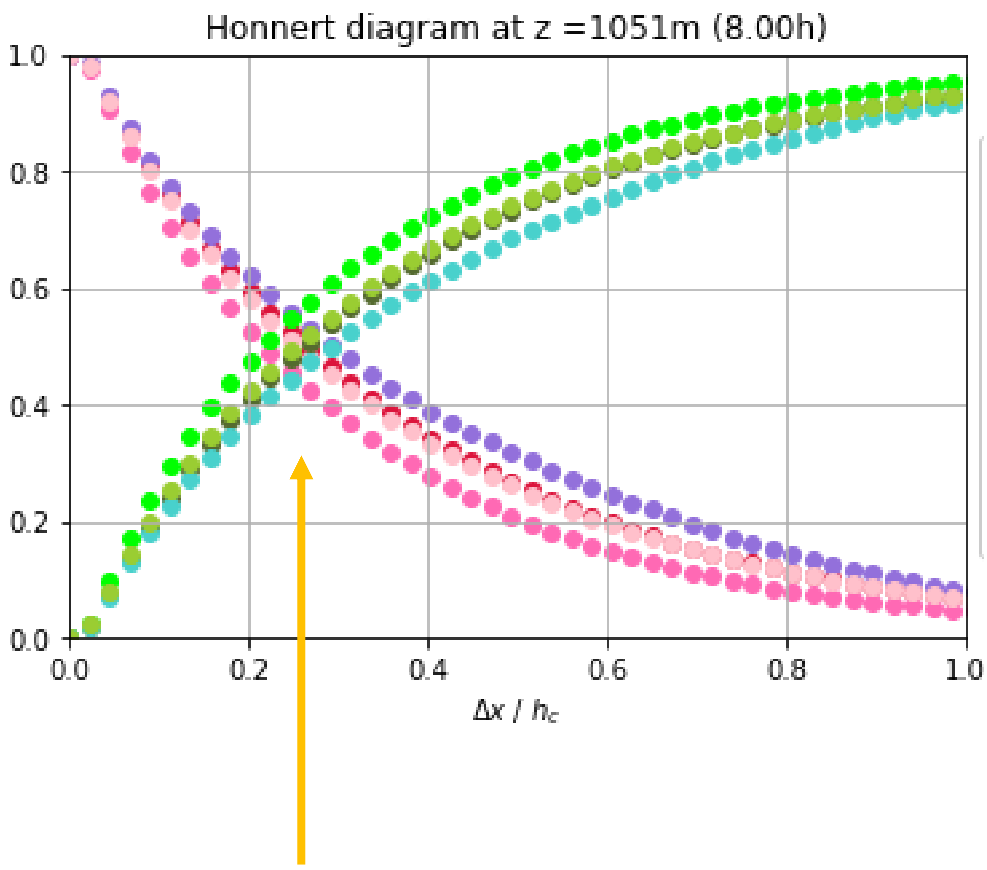
Cabauw

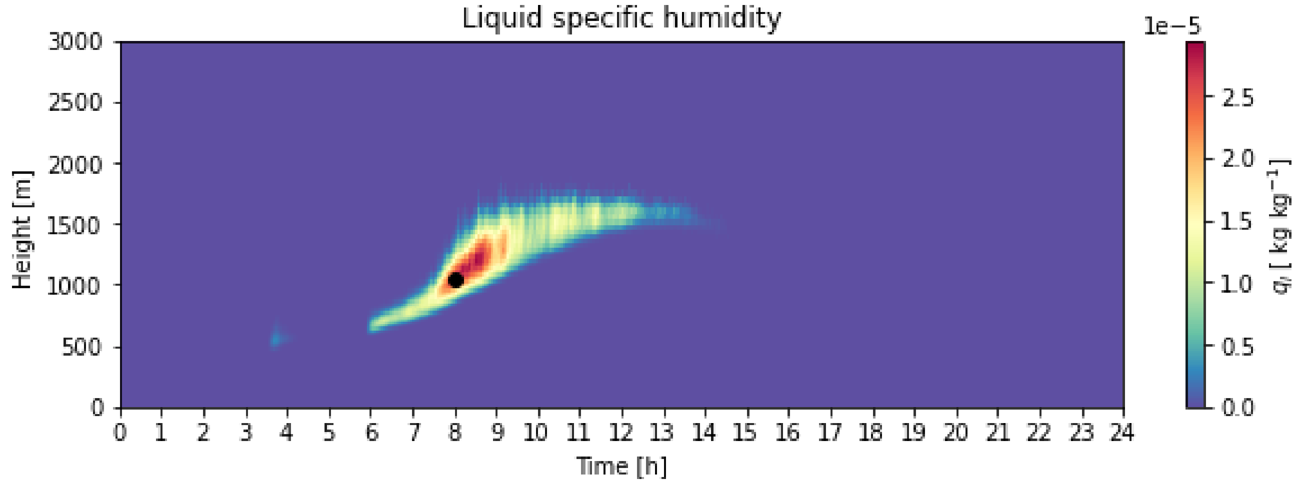


h or h_c generally okay with q_l or $w'\theta_v'$ criteria

In the cloud (LES results)

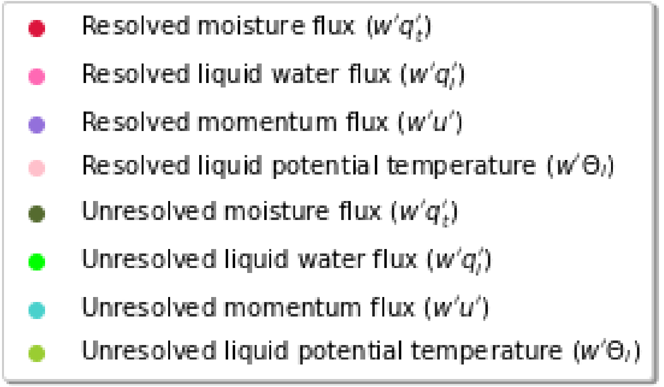
LES domain =15x15km2





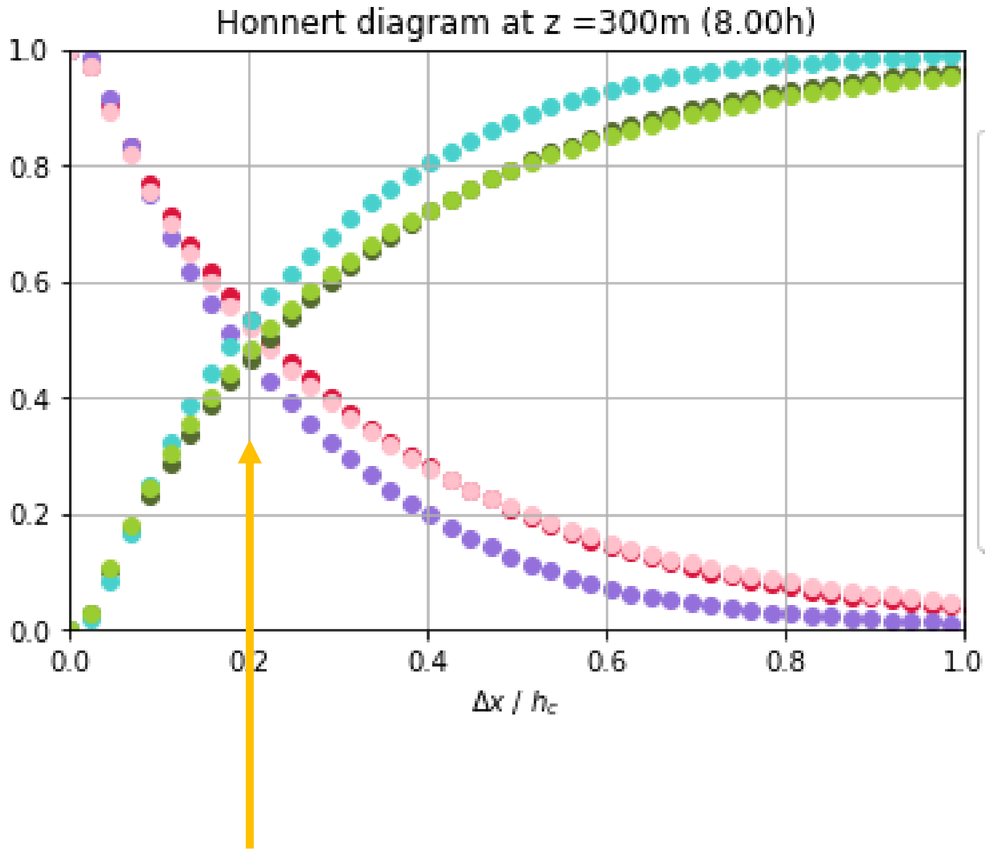
z = 1051 m

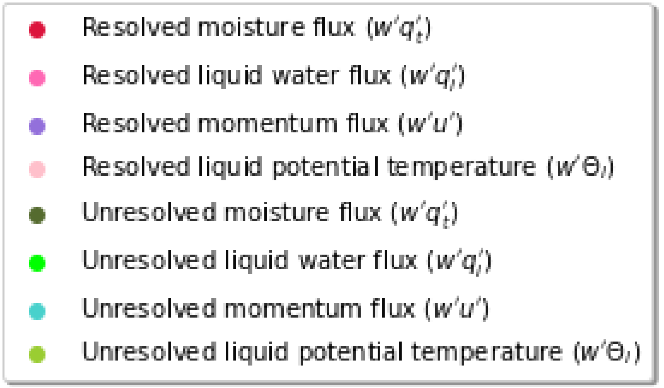
T = 8.00 h

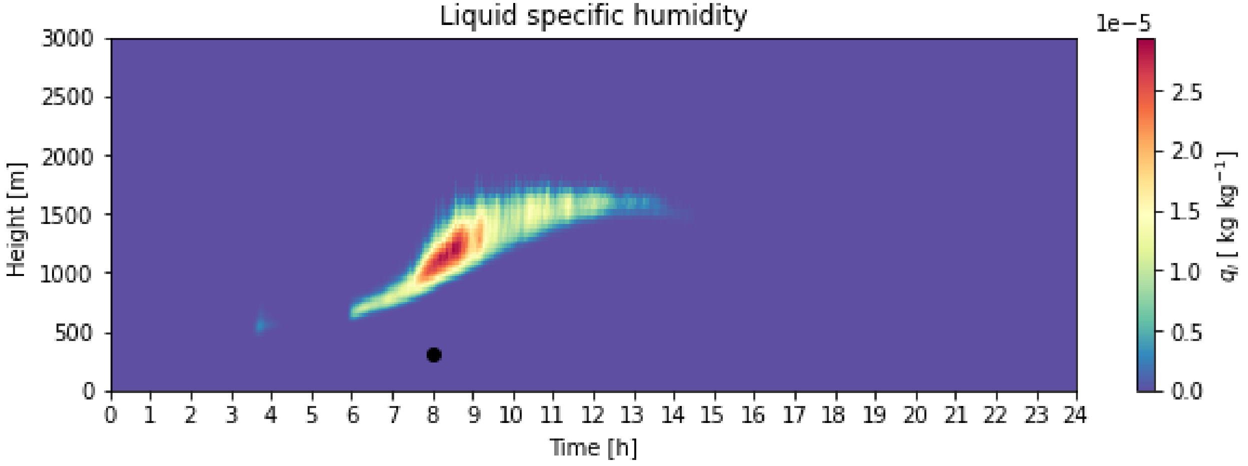


Scales in cloud layer:
momentum larger
q_l smaller

Dry boundary layer (LES results)







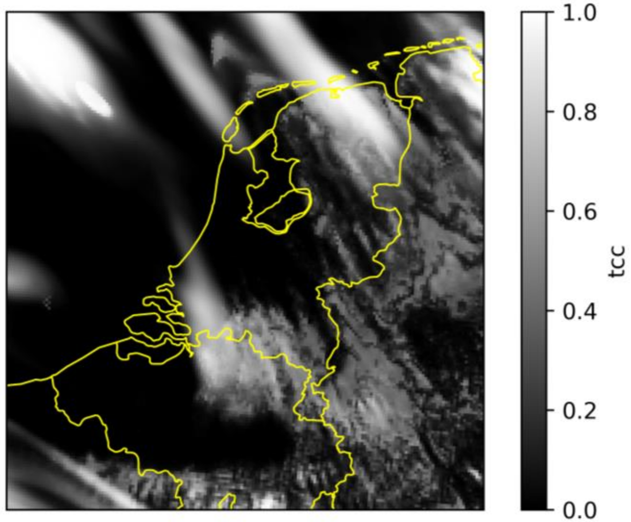
z = 300 m
T = 8.00 h

Scales in sub-cloud:

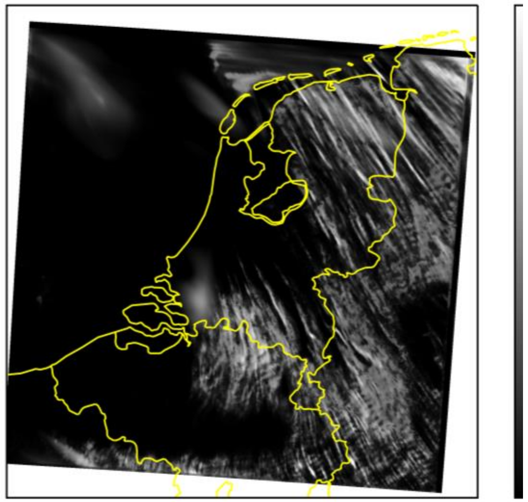
- momentum smaller
- In general sub-cloud smaller scales

Preliminary results with HARMONIE-AROME with scale-aware convection scheme

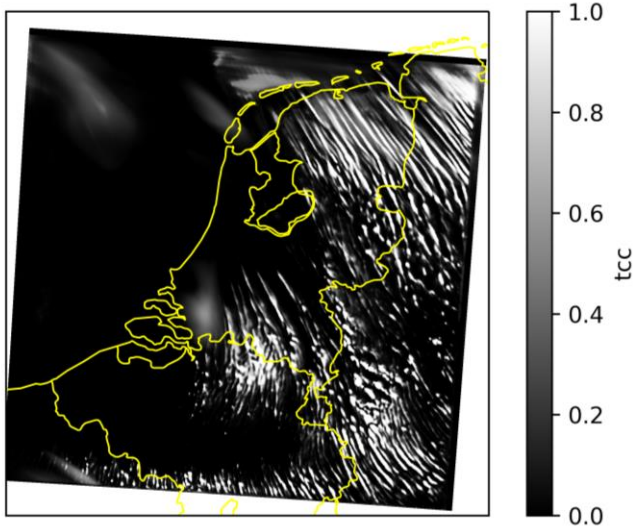
HARMONIE-AROME 500x500m^2 resolution total cloud cover



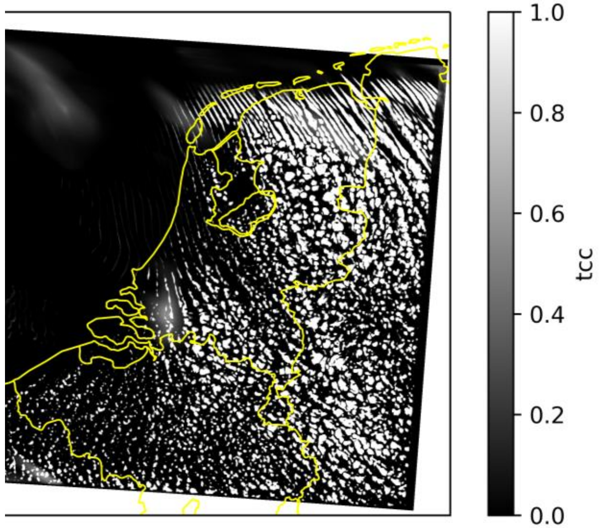
2.5km run (conv. on)



convection scheme on



scale-aware convection



convection scheme off

- To be checked with observations!
- Default UVmix=off but small impact this case.

Preliminary results with HARMONIE-AROME with scale-aware convection scheme

HARMONIE-AROME 500x500m^2 resolution
resolved vertical velocity

convection scheme on | scale-aware convection | convection scheme off

Scale aware scheme positioned in between full and no convection

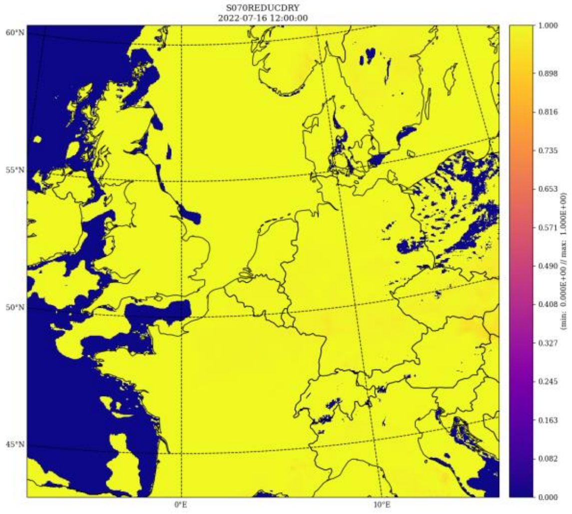
- First impression: scale aware scheme behaves as expected (also for energy spectrum)

Mass flux reduction factor 16th July run in scale aware runs

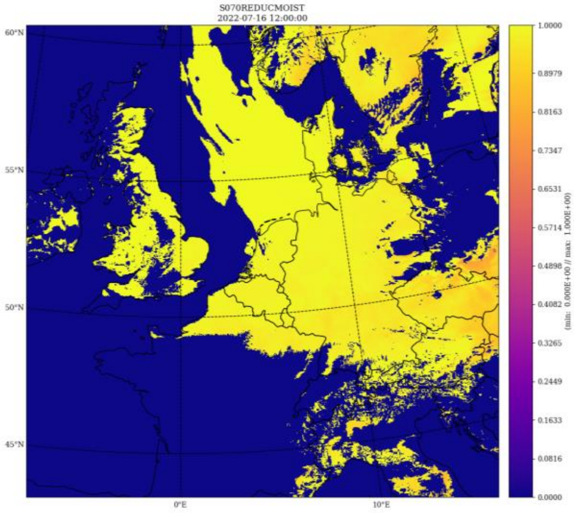
2500m run

- Even at this resolution some attenuation! (mostly for moist MF)
- Tests also for typical operational resolutions?

Reduction dry mass flux



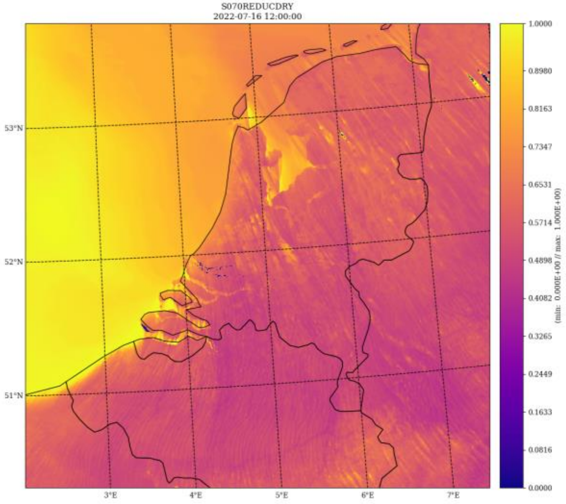
Reduction moist mass flux



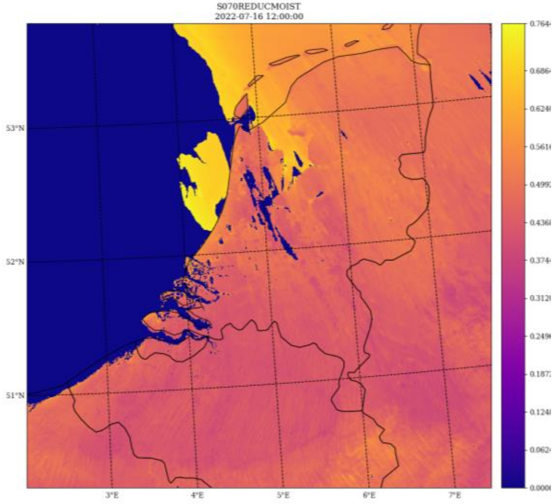
500m run

- More substantial attenuation
- Small scale structures also for dry MF!

Reduction dry mass flux

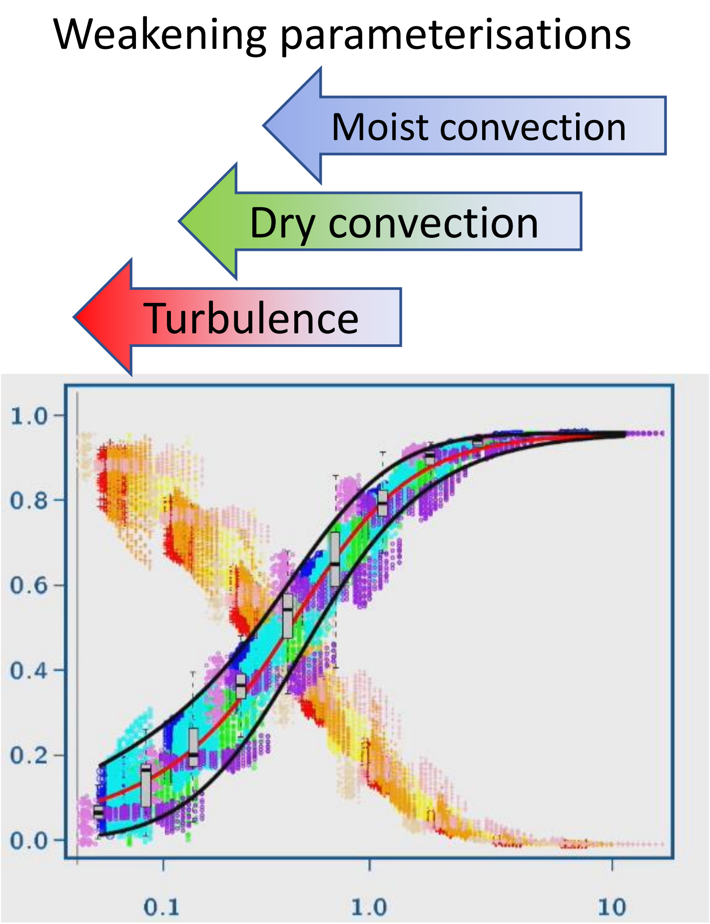


Reduction moist mass flux



NB scale! max=0.76

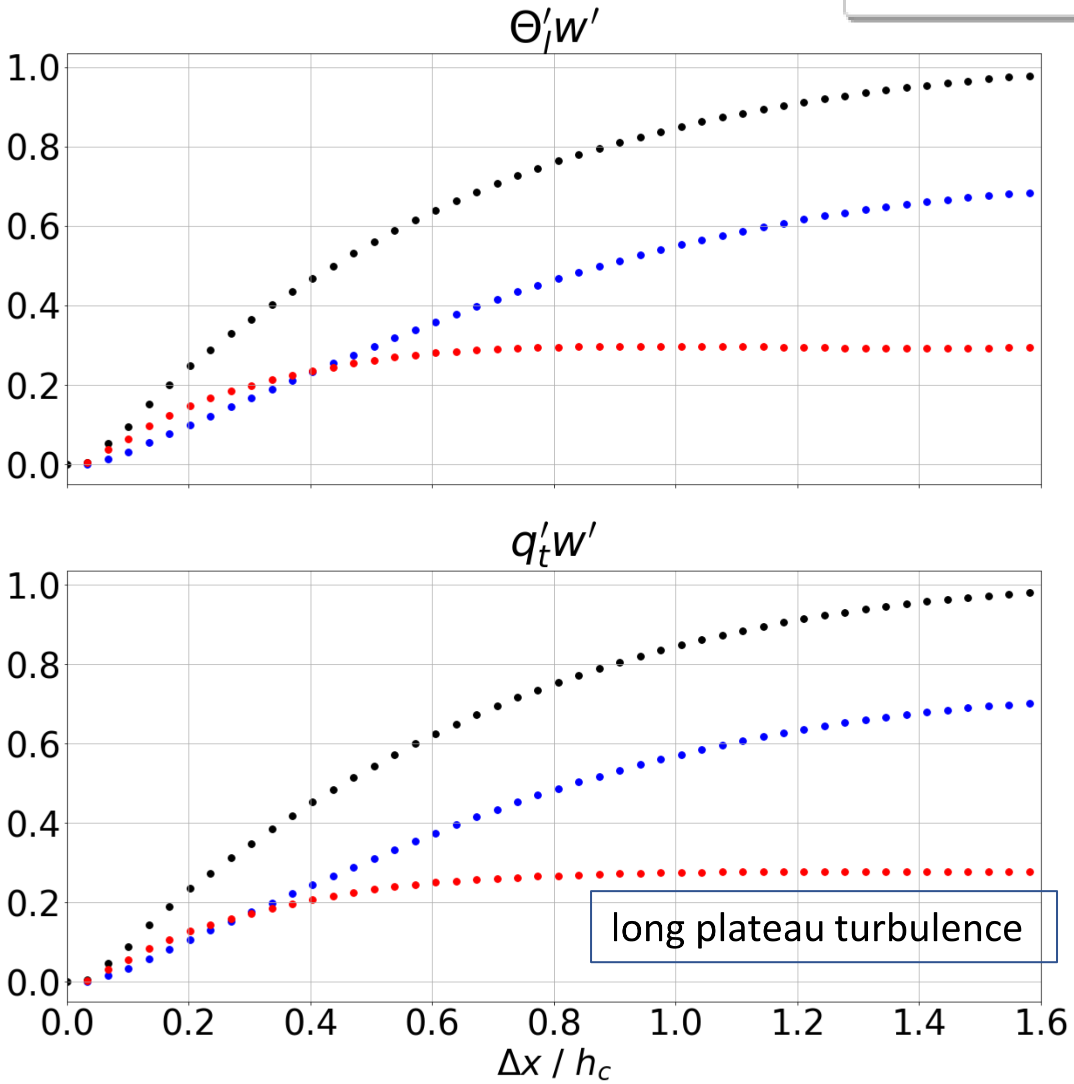
So far only convection considered but especially at higher resolutions also turbulence needs to be scale-aware

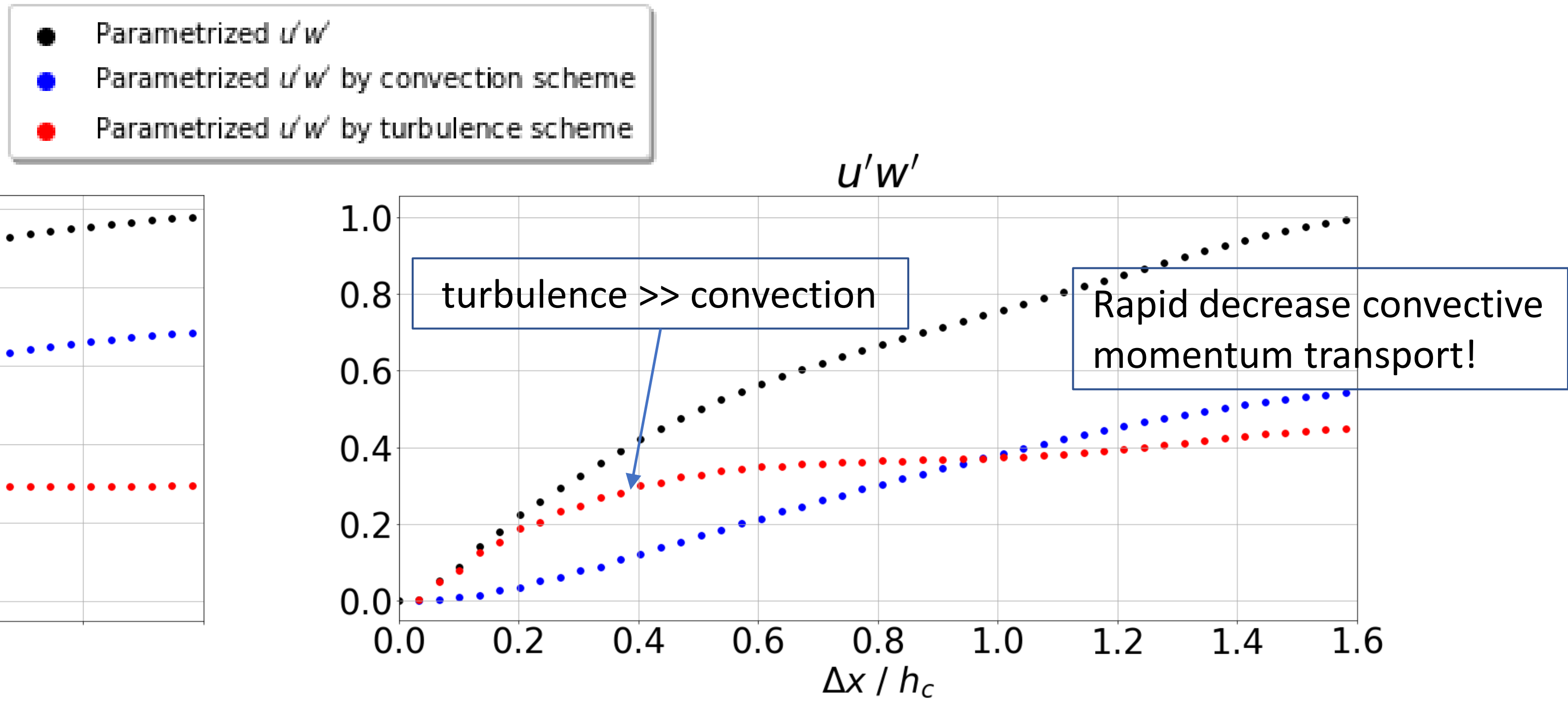


Applying conditional sampling in LES we can divide that part of the total transport to be done by the convection and by the turbulence scheme!

LES result: partitioning total transport in convection and turbulence (simple case)

at 1051m (middle cloud layer) , 8h





Similar behavior θ_l and q_t but momentum different!

Remake these plots with HARMONIE-AROME!

Discussion, outlook

- LES are an important tool to develop scale-awareness in our models (Honnert)
- Many exciting topics like: differences q, T, uv, (un)organized convection, etc.
- preliminary results, like:
  - -first results simple case promising for scale-aware convection
  - -momentum is different from T, q
- what about intrinsically stochastic? (important for high resolutions)
- Simple start is important but EUREC4A gives unique opportunity to extend to robust, more generic model developments. (Horizontal) organization complicates things (Alessandro Savazzi et al.).

Aitäh
Küsima?

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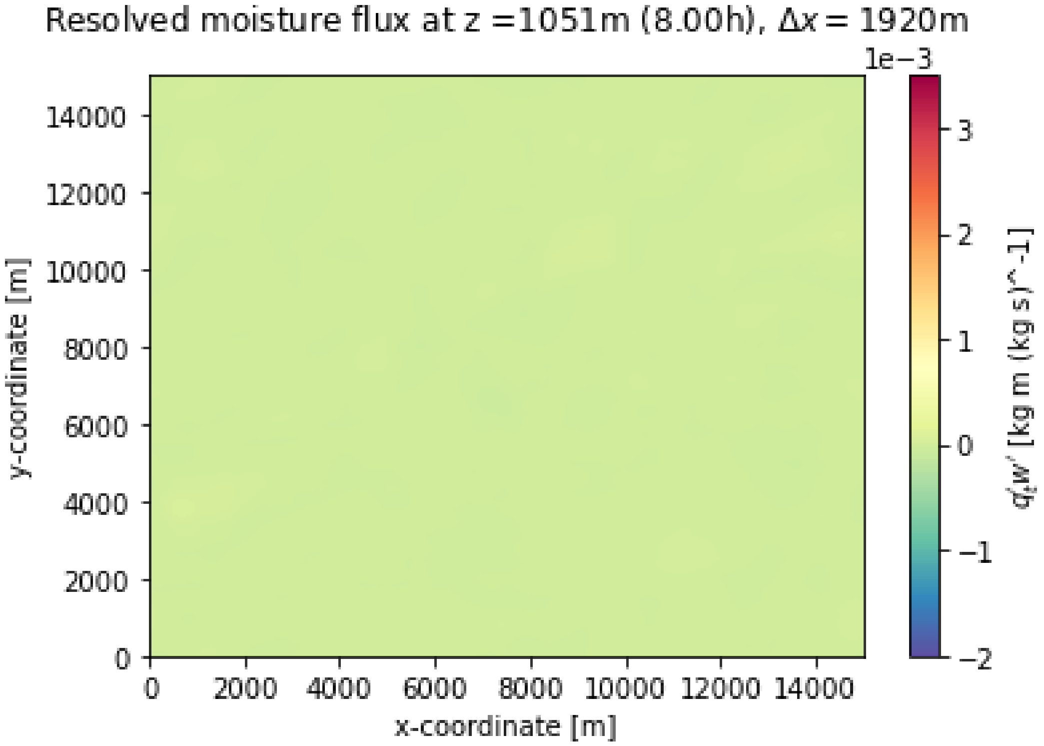
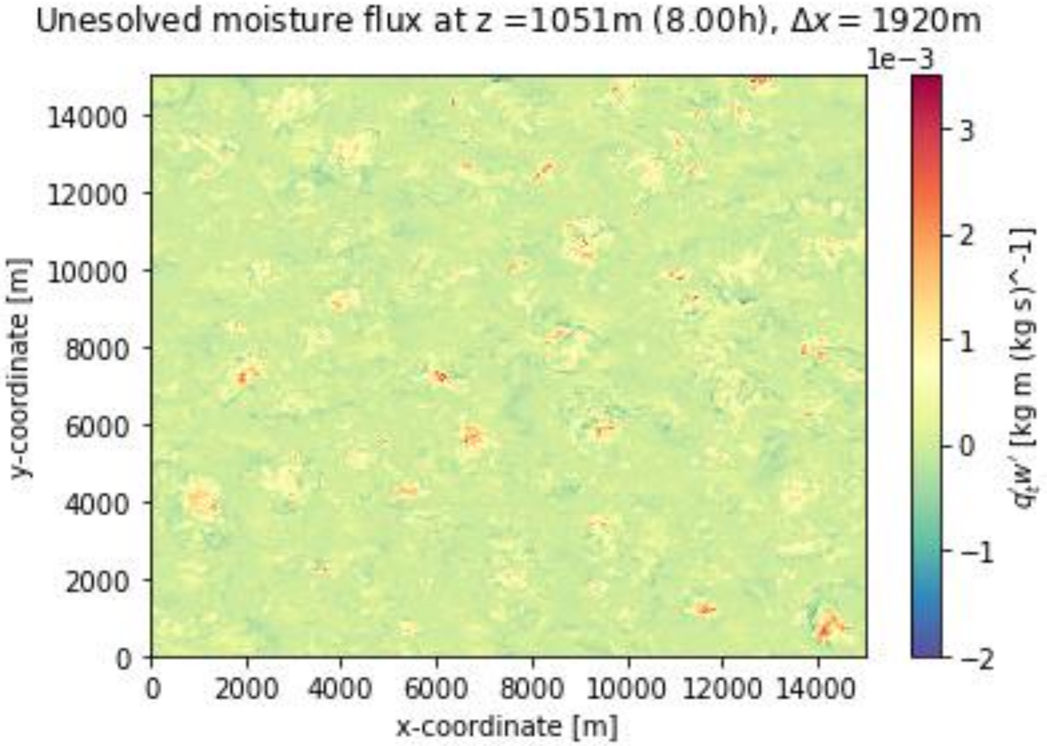
DALES

Coarse graining with running mean





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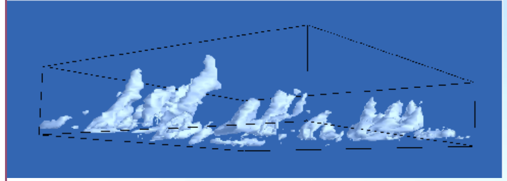
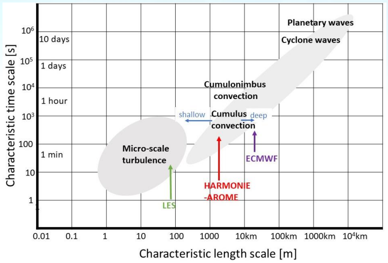
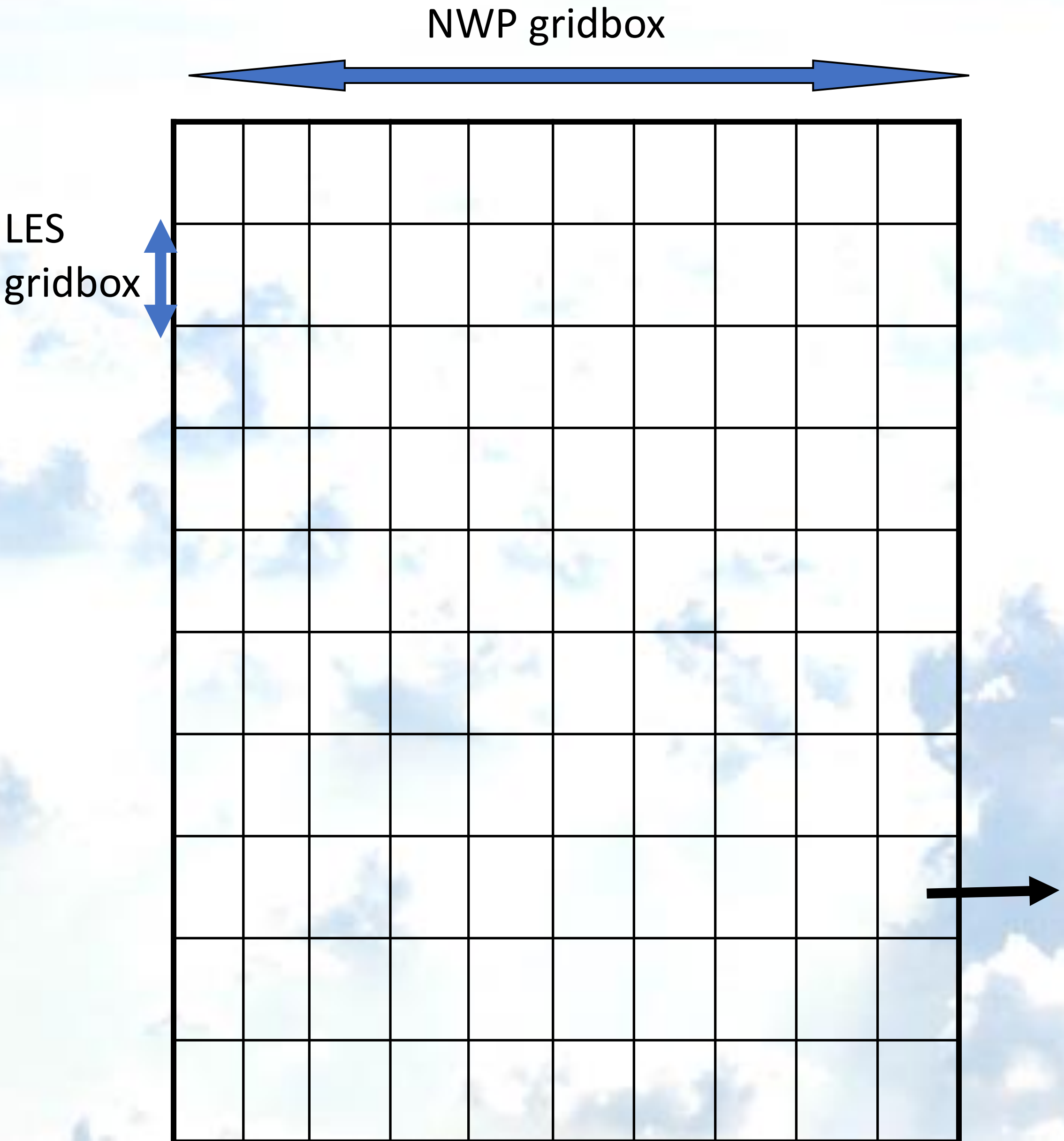


The importance of LES models

(that resolve convection)



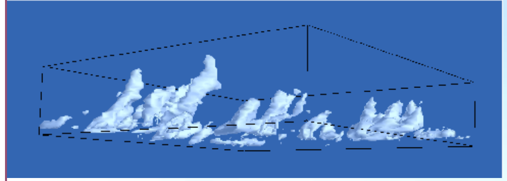


NWP- or Climate model:

$$\frac{D\overline{\phi}}{Dt} = -\frac{\partial(\overline{w'\phi'})}{\partial z} + F_{\phi}$$

$\overline{w'\varphi'}$ = total turbulent transport (sub grid for NWP or climate models)

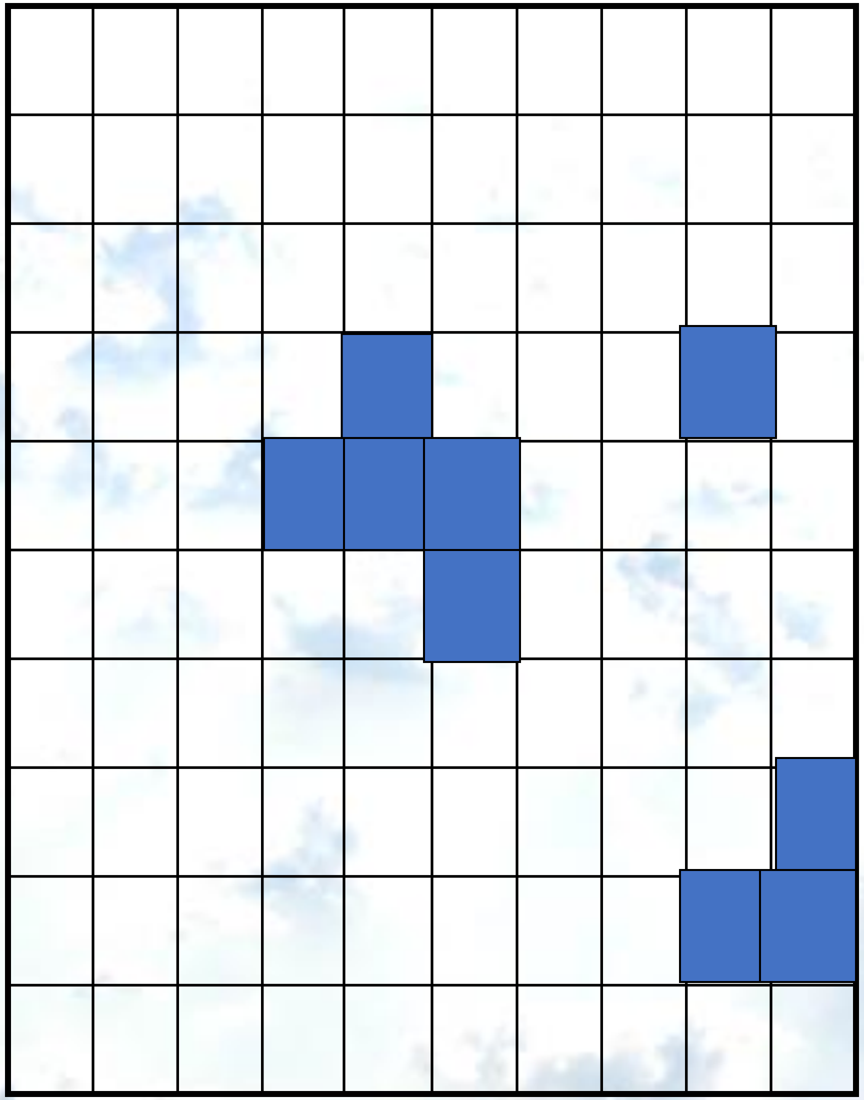
$$\left.\begin{aligned} w' &= w - \overline{w} \\ \varphi' &= \varphi - \overline{\varphi} \end{aligned}\right\} \Rightarrow \overline{w'\phi'}^{\,LES\ total}$$



Convective transport LES

$$\overline{w'\phi'}^{total} = a_c\overline{w'\phi'}^{c} + (1-a_c)\overline{w'\phi'}^{e} + a_c(1-a_c)(w_c-w_e)(\phi_c-\phi_e)$$

■ = cloudy LES gridbox



Define cloud with a conditional sampling, e.g.: $\theta_v > \overline{\theta_v}$ $\quad q_l > 0 \quad w > 0$

$$\overline{\varphi}^{c} \equiv \varphi_c \equiv \frac{1}{A_c}\iint_{\substack{cloudy\\ area}} \varphi\, dxdy$$

$$\approx a_c w_c(\varphi_c - \varphi_e) \equiv \frac{M}{\rho}(\varphi_c - \varphi_e) = \overline{w'\phi'}^{LES\ convection,total}$$

Convective transport (major part of total)

Investigate (bulk) mass flux approach in LES including its parameters!