Design of modelling case-studies framed by observations

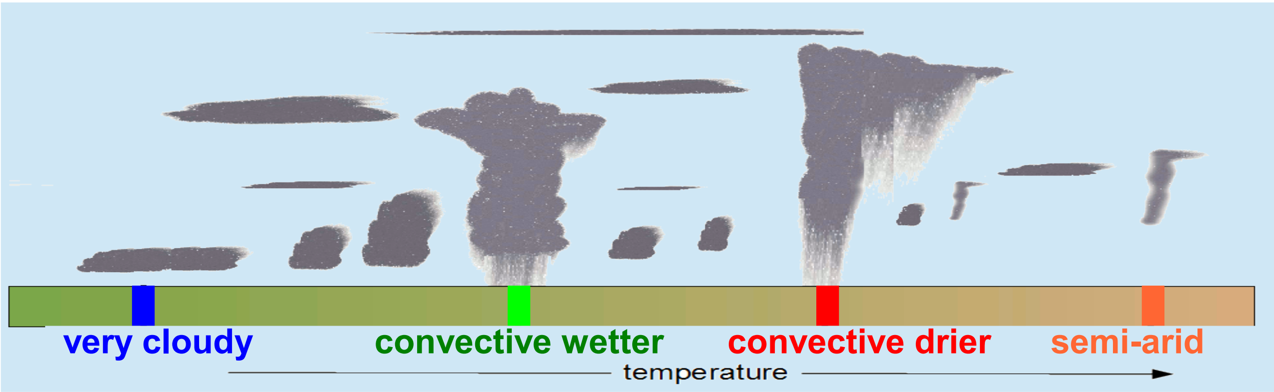
designed to be run by LES/CRM and SCM
process understanding and guidance for parametrizations

(Gounou et al. 2012, Couvreux et al. 2014)

aim : analyze how interactions between clouds, convection, boundary-layer and surface processes vary among different climates/regimes (meridional gradient)

Use observations/AMMA ECMWF reanalysis to first build a set of 4 'realistic' 10-day cases (with diurnal cycle, synoptic fluctuations...)

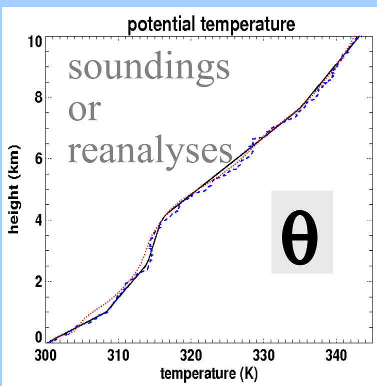
Simplify the set up in a way that preserve robust features of the model behaviour



Guinean coast
Soudanian (deep convection)
Sahelian monsoon (deep convection)
Sahel in late spring (moist but not wet, no rain)

modelling set up

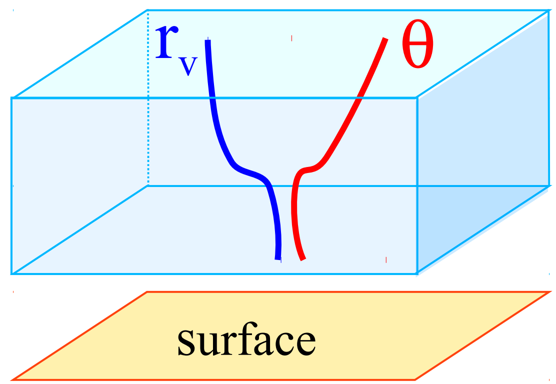
Atmospheric profiles



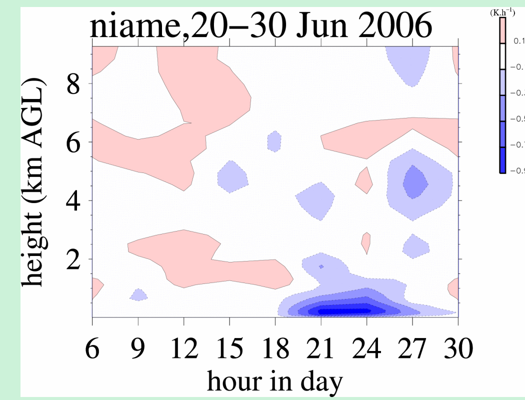
r_v U

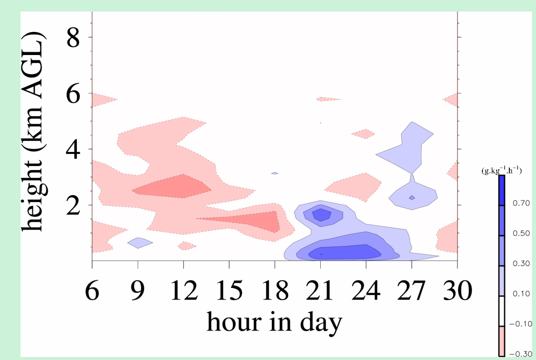
atmospheric initial conditions

atmos. boundary conditions
larger-scale advection



ECMWF AMMA reanalysis (3h) used a broad guide (sensitivities & corrections)





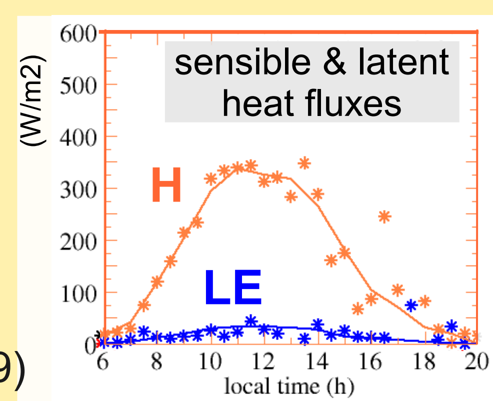
Surface initial & boundaryconditions

Surface properties and/or state

albedo, emissivity...

soil moisture, soil temperature

Local data & ALMIP, Boone et al BAMS 2009)



Simulations performed with MesoNH
10x 1 day or
1 x 10 days

larger-scale advection

diagnosed from the ECMWF AMMA reanalysis

limitations: deep convection, low-level monsoon bursts (too weak)... drifts
but still usually able to capture synoptic variability in convective activity

high cloud top often coincides with *local strong max of omega in ERA-AMMA (omega<0 equiv. to positive vertical velocity)*

no high cloud top *corresponds to periods with enhanced subsidence in ERA-AMMA (red)*

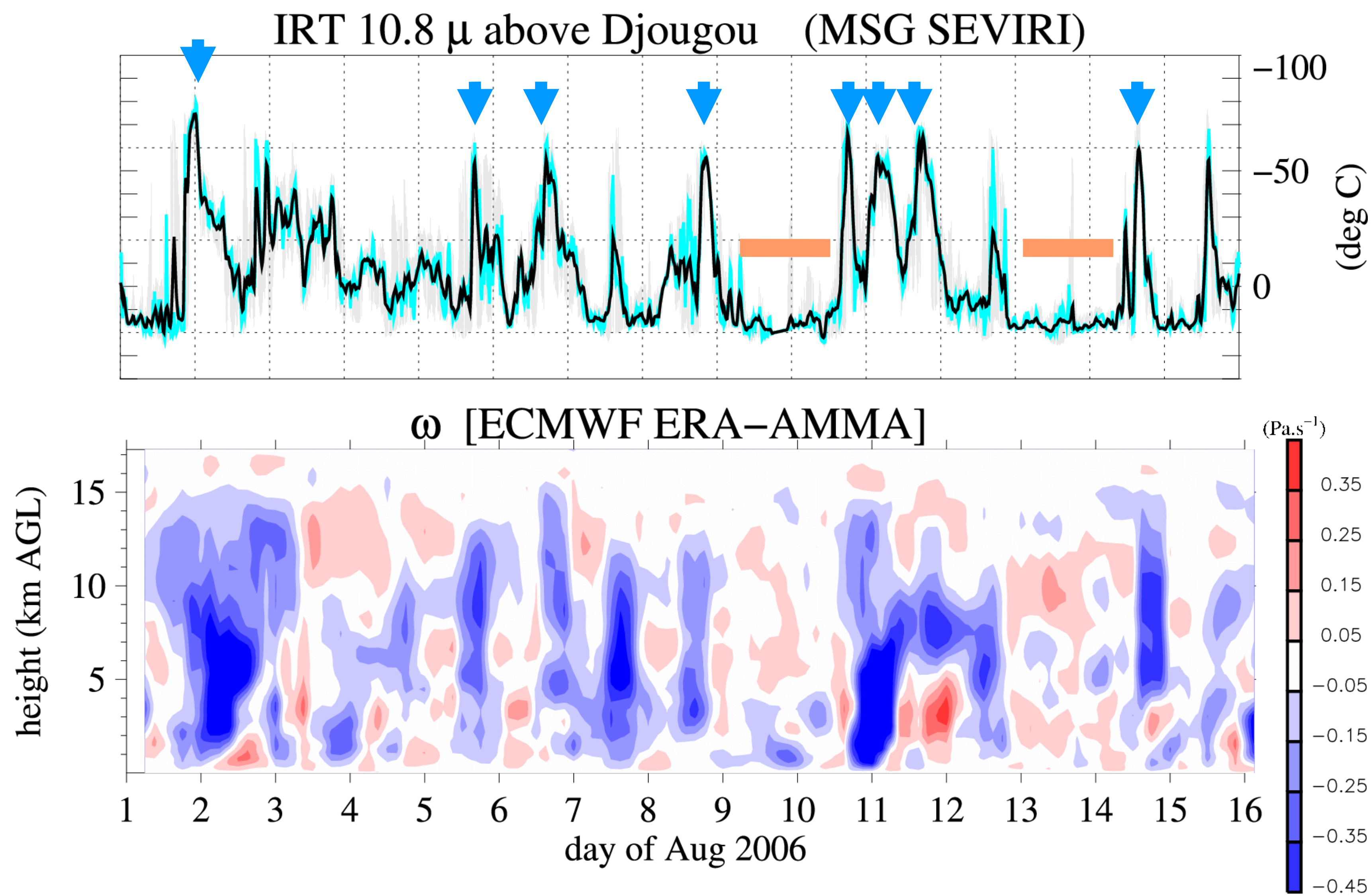
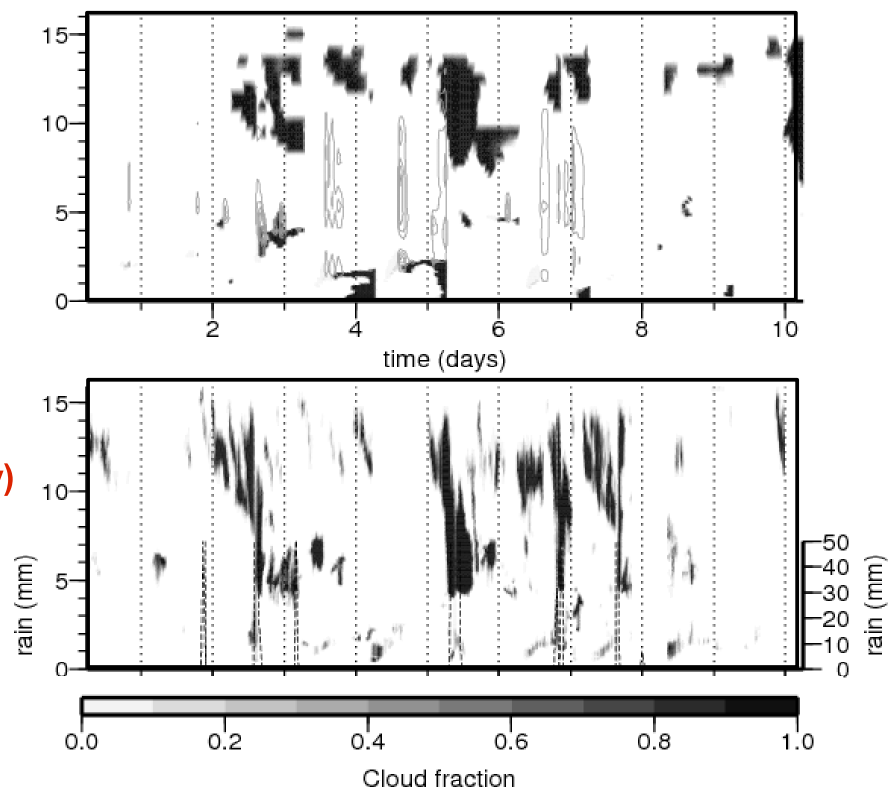


Illustration of modelling results

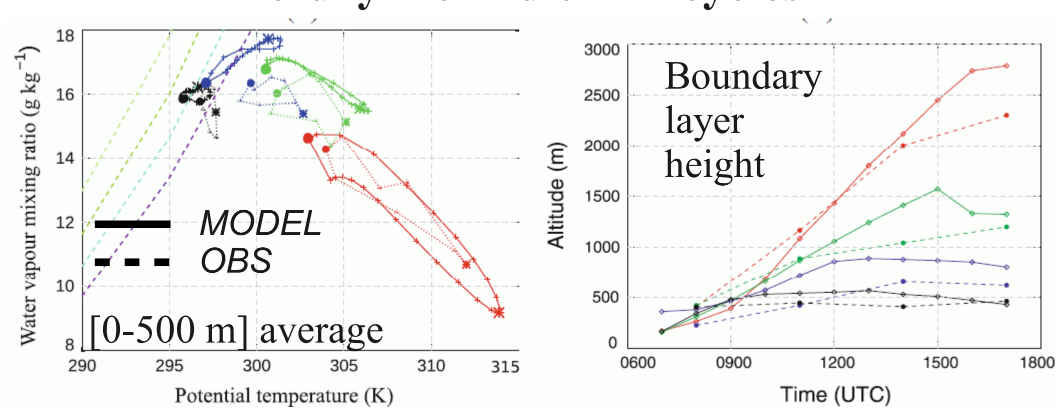
Evaluation of simulations

MODEL SCM MesoNH

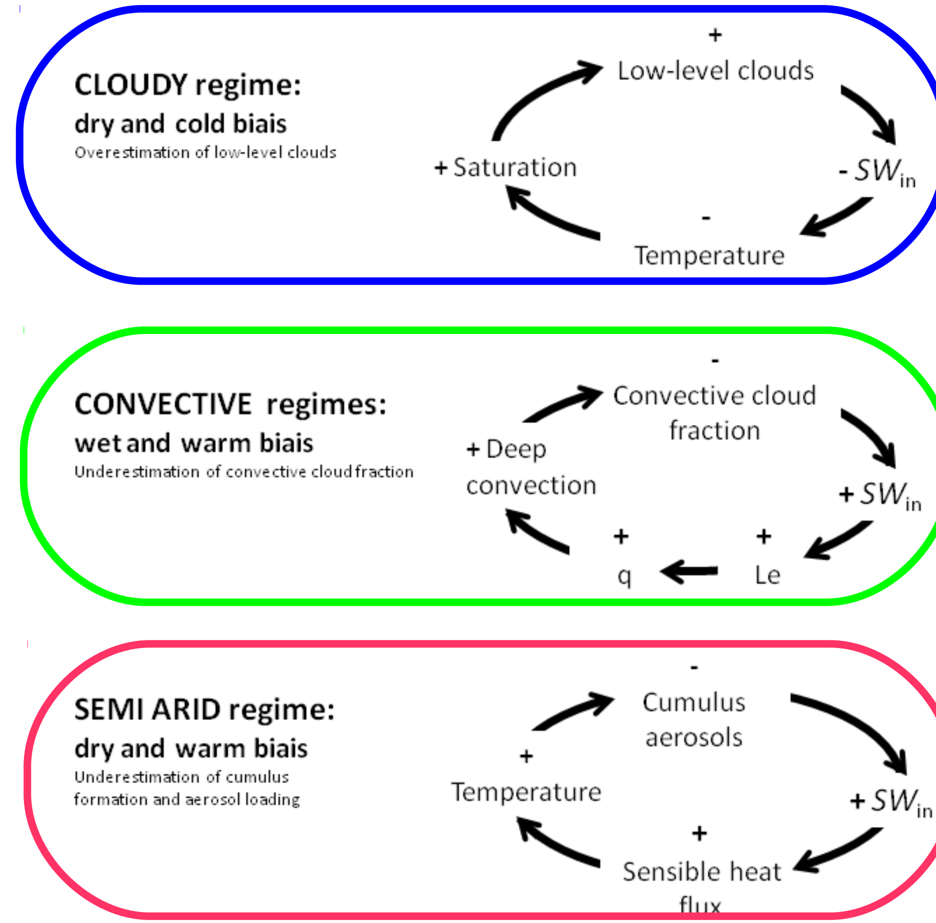
OBS (Niamey)



10-day mean diurnal cycles

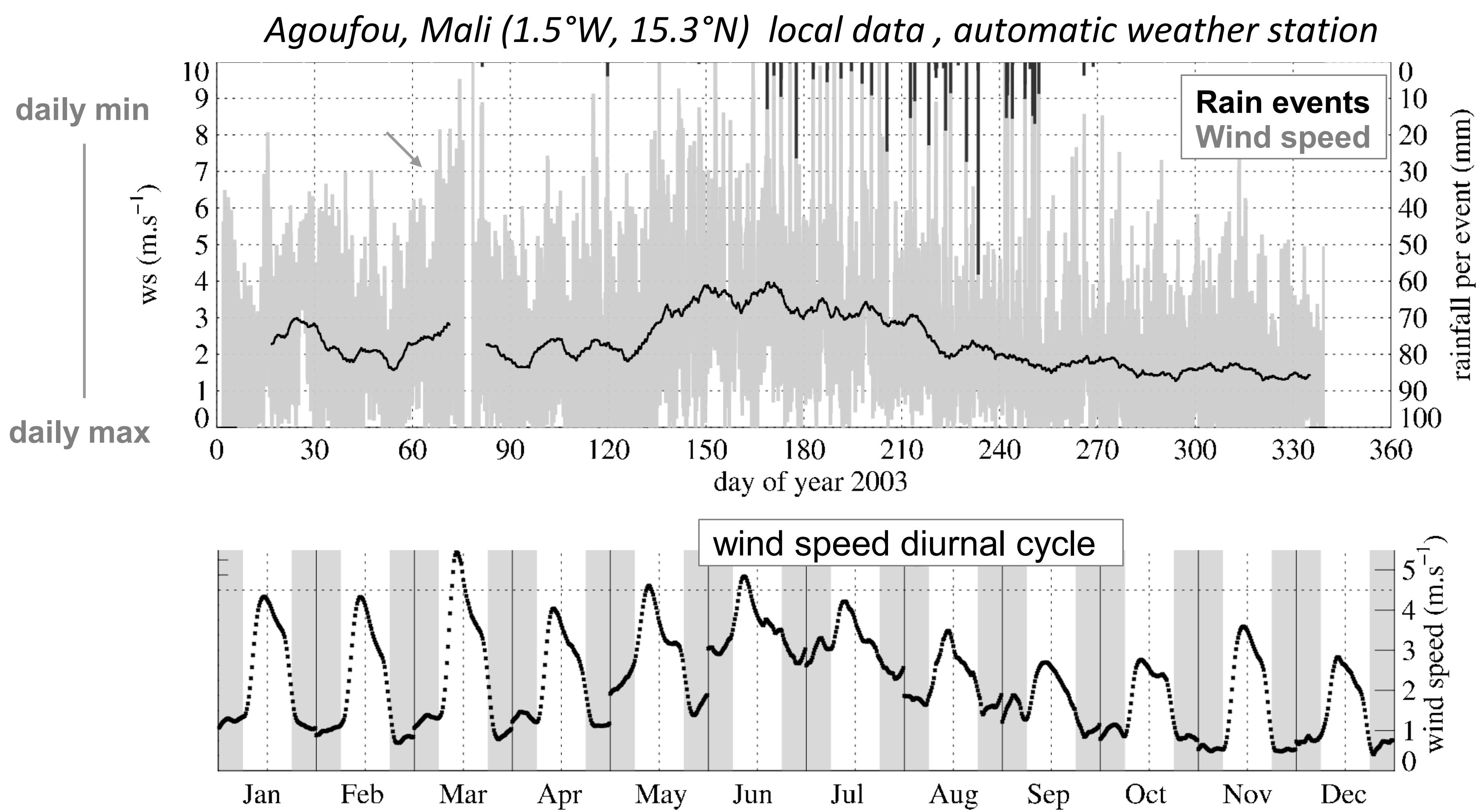


Mechanisms behind simulation biases



Couvreux et al. (BLM 2014)

Important characteristics of the surface wind in the Sahel



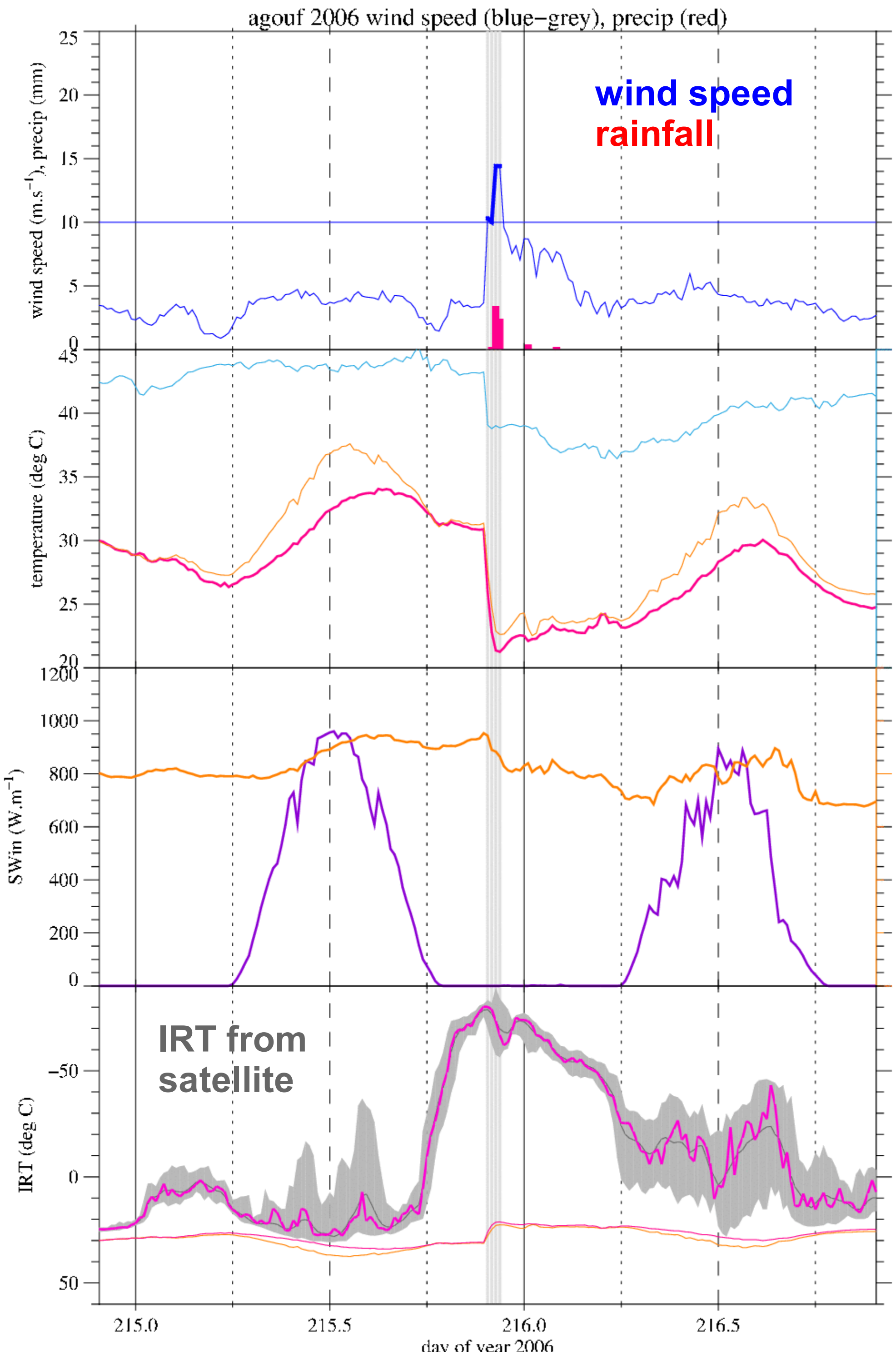
Guichard et al. J. Hydrology (2009)

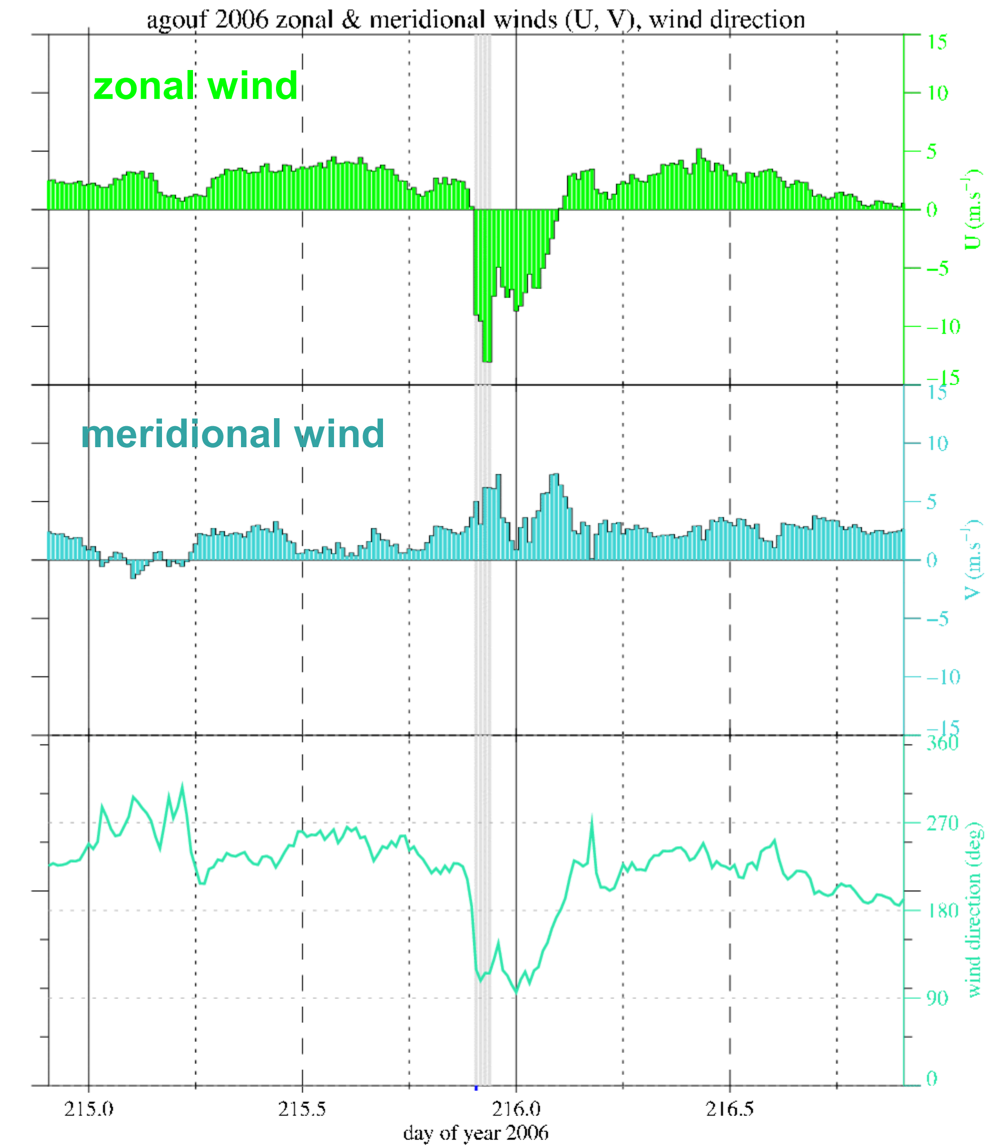
Strong wind gusts associated with rainfall

morning maximum (mixing of low level nocturnal jet)

weak nocturnal wind outside of the monsoon season (dry air)

Zoom on a typical example of convective event as seen locally in the Sahel





first wind event on doy 215 [3 Aug at 21.75 h]

vertical grey lines : occurrences of wind speed > 10 m.s^{-1}

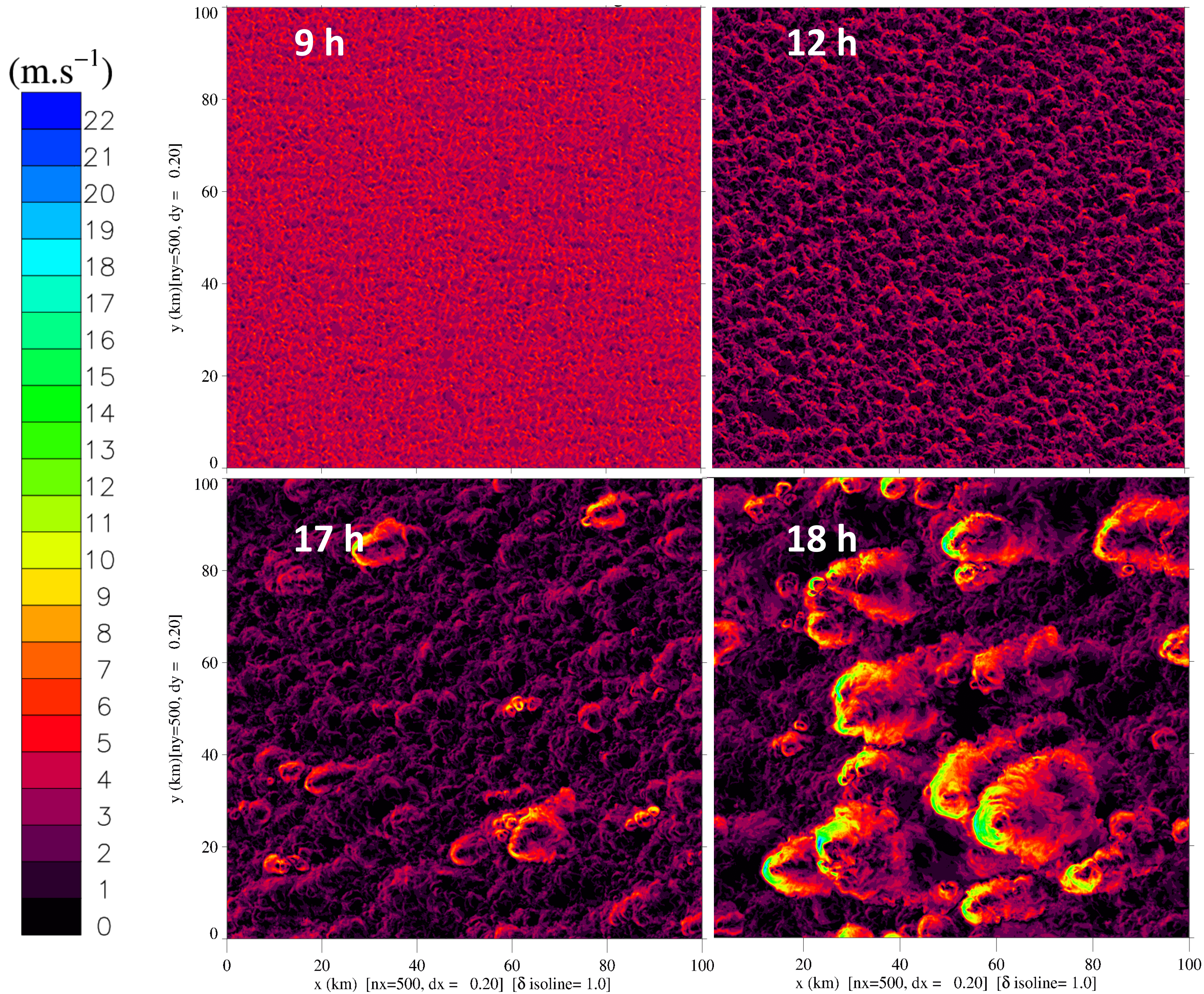
IRT above agouf

IRT 50 km x 50 km centred on agouf pixel: average

IRT 50 km x 50 km centred on agouf pixel: min and max

Most strong wind events involve rainfall (different from the Sahara)

Zoom on an example of convective event as simulated with LES

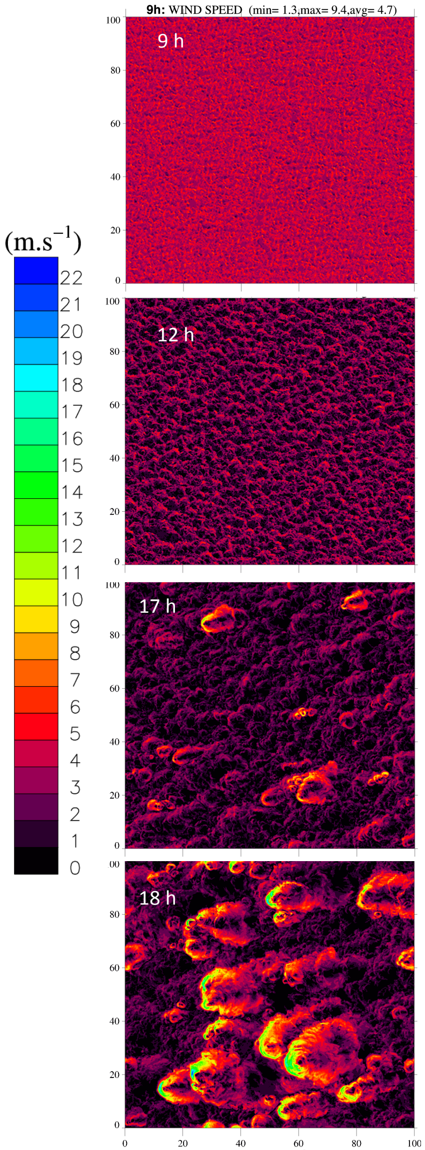


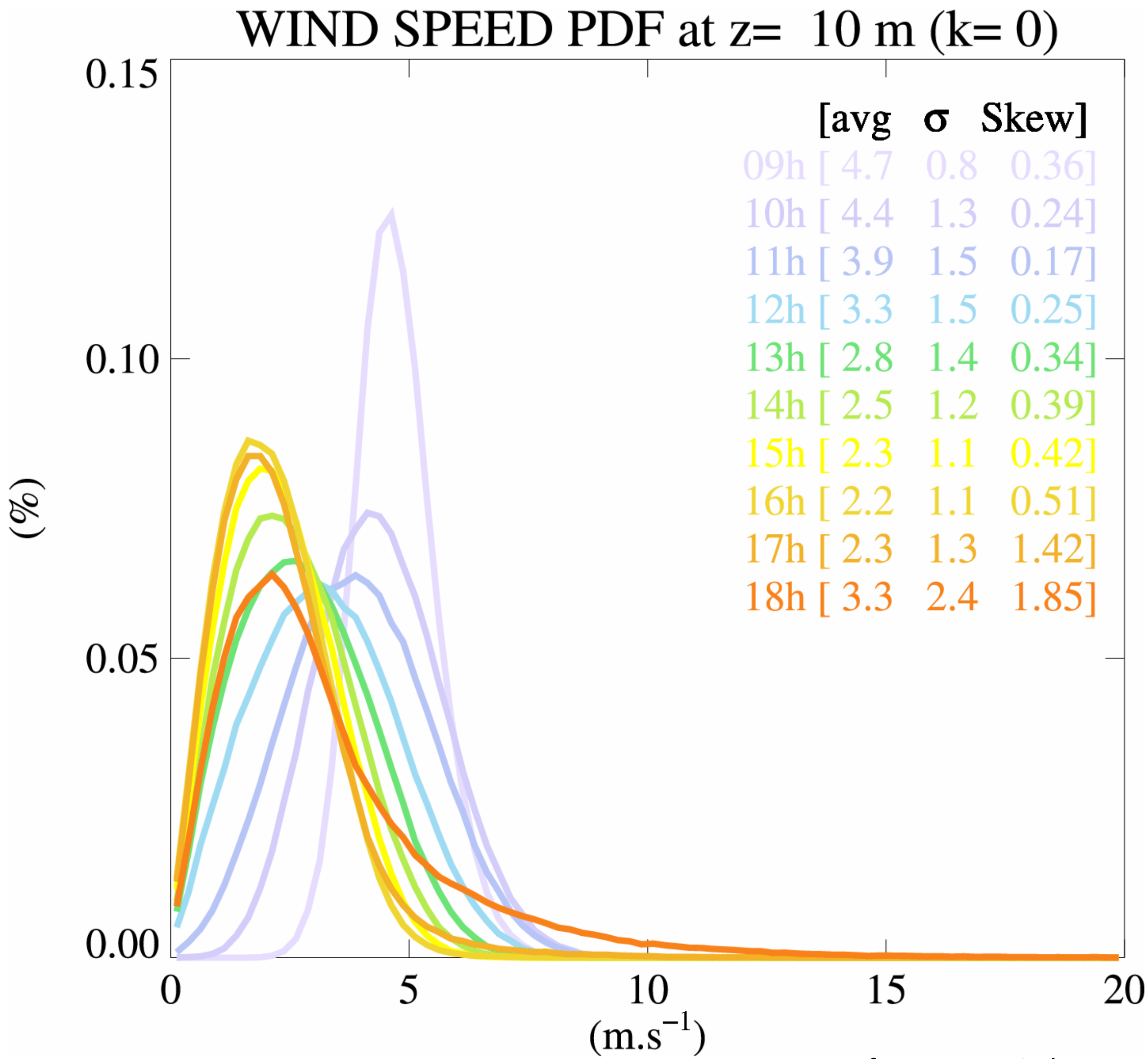
Daytime growth of the convective boundary layer

Mean wind speed weakens

Cold pools spreading at the surface with strong winds at their leading edges

Zoom on an example of convective event as simulated with LES

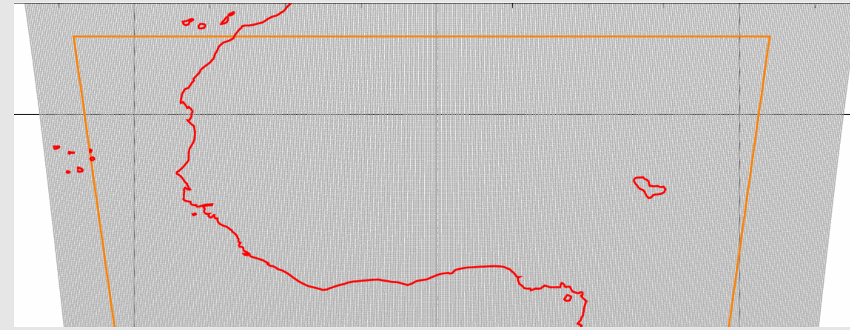


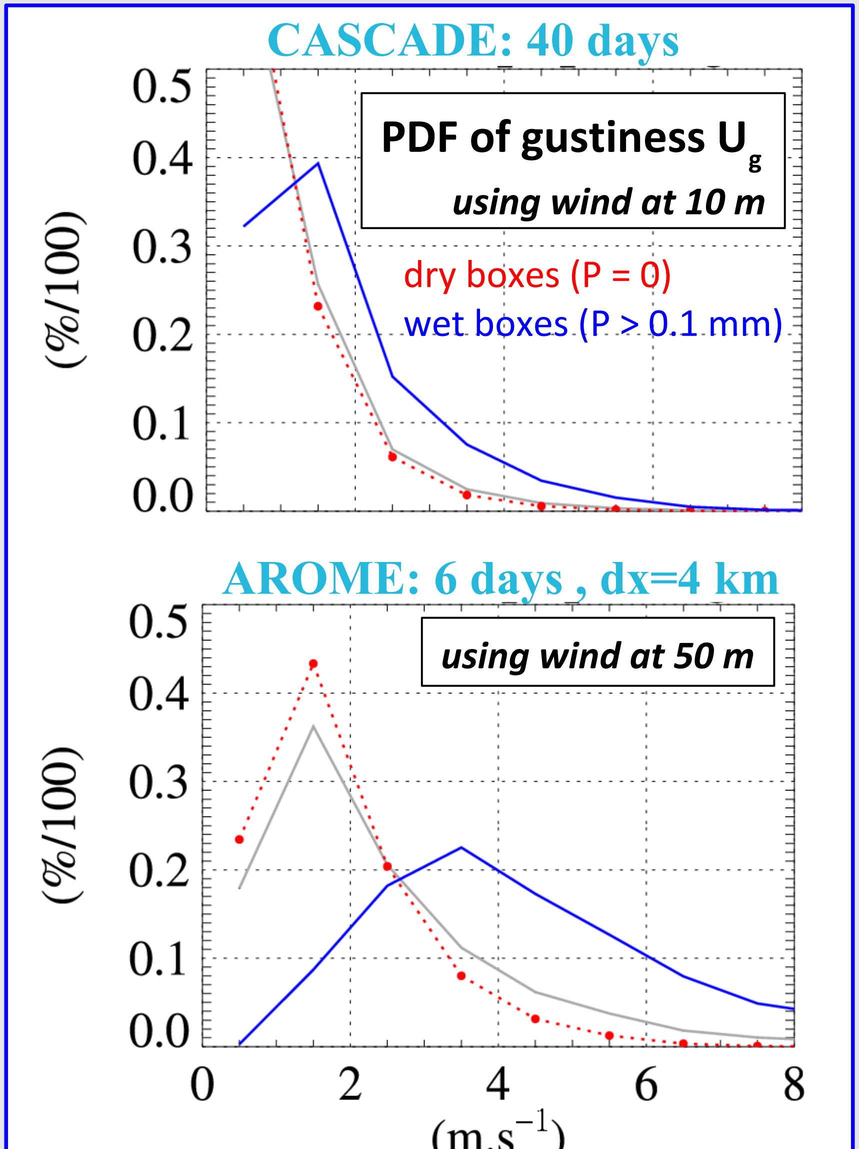


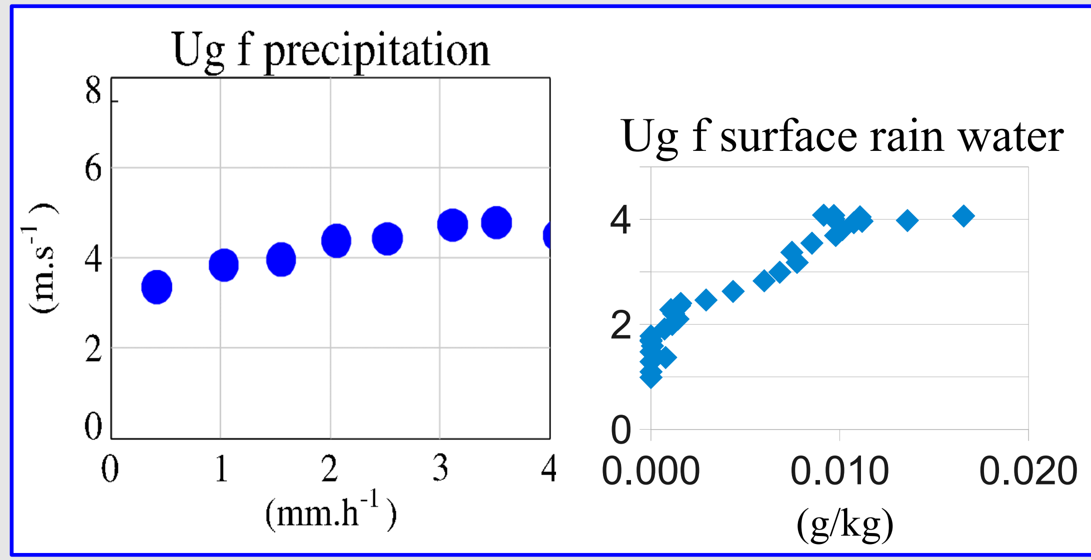
Increase of strongest winds

A few preliminary results

Monsoon season [10°W-10°E , 10°N-20°N]
time sampling = 1 h
boxes A_i ~ 100 km x 100 km : compute U_g (A_i , t)







caution

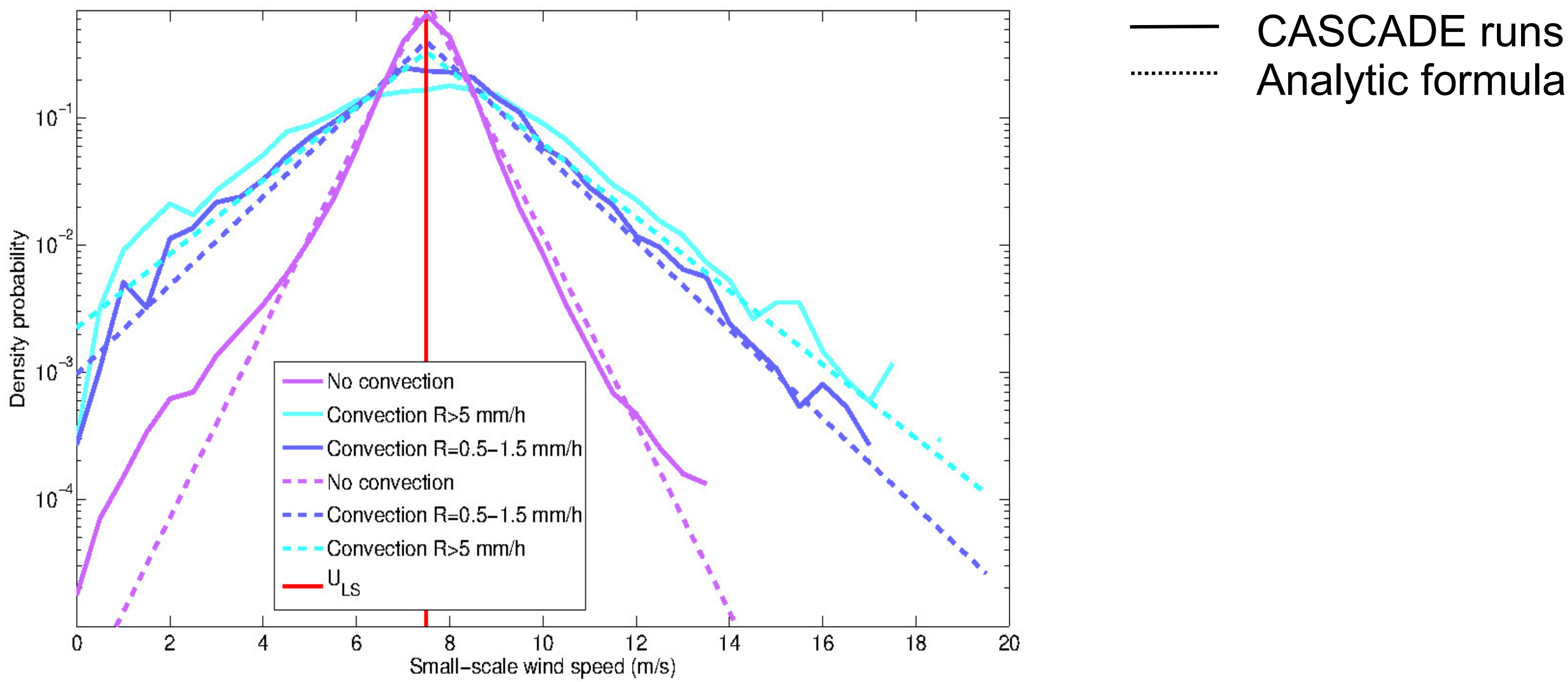
substantial scatter (exploration of DCAPE, shear)
quantitative differences among models

still, in the Sahel (south of 16°N at least),
rainfall appears as informative at 1st order
(consistent with local and MIT data)
most gust cases occur close to where rain is falling

both models generate convectively-driven gust winds, as opposed to models with convective parametrizations which do not display any - consistent with previous CASCADE studies

A few preliminary results

parametrizing wind speed PDF



source: Largeron

$$f(u,\sigma_*,\mu_*) = \frac{\sqrt{2}}{2\sigma_*}\exp\left(-\frac{\sqrt{2}|u-\mu_*|}{\sigma_*}\right)$$
$$\mu_* = U_{LS}$$
$$\sigma_* = A \cdot U_{LS}^{\alpha}$$

with A & $\alpha = f(rainfall)$