Contribution of the MCS anvils to radiative, heat and water budgets : a strategy for quantification at different scale

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Goal : to derive radiative, heat and water budgets at different scale only from multiscale observations collected during AMMA field experiment

Why ? Redistribution and transformation of water over West Africa
Associated processes and their efficiency
Impact of water transports and phase changes on monsoon variability and dynamics
Help improve forecast of water availability

Principle : computation of Q1 and Q2

$$Q1=\overline{\pi}\frac{\overline{D}\overline{\theta}}{Dt}\approx-\frac{\overline{\pi}}{\overline{\rho}}\frac{\overline{\partial\overline{\rho}\theta' w'}}{\partial z}+Qr+\frac{1}{c_p}\left[Lv(\overline{c}-\overline{e})+Ls(\overline{d}-\overline{s})+Lf(\overline{f}-\overline{m})\right]$$

$$Q2=-\frac{L}{c_p}\frac{\overline{D}\overline{q}}{Dt}\approx-\frac{L}{c_p\overline{\rho}}\frac{\overline{\partial\overline{\rho}q' w'}}{\partial z}+\frac{L}{c_p}\left[(\overline{c}-\overline{e})+(\overline{d}-\overline{s})\right]$$

$$R=C-E-T$$

Need : basic fields (temperature, specific humidity, wind...) implied in the computation and their spatial derivatives at the different scales

Tool : MANDOPAS (3D/4D)

Variational method with physical constraint

MANDOPAS (3D/4D)

Principle : $I_{ana} = f(x)\, g(y)\, h(z)\, k(t)$

with $f(x) \ldots k(t)$ = Legendre polynomials truncated at a given order of expansion

Retrieval of I : minimization in least-squares sense of the difference between measurements F(I) and the analytical expression of these measurements $F(I_{ana})$ computed with the analytical form I_{ana}.
The addition of physical constraints is possible

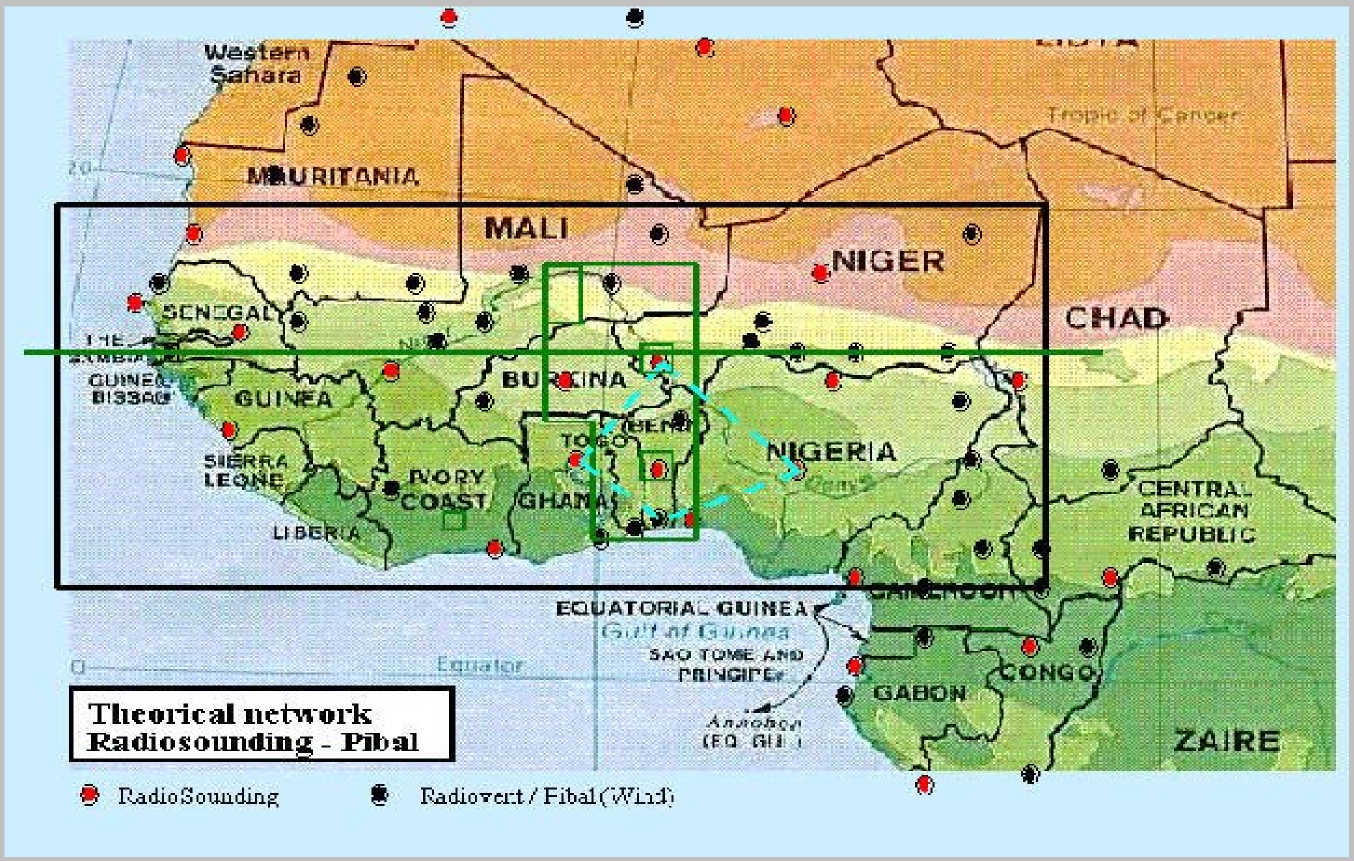
Objective : no parameterization, no model analyses or diagnostics, only observations.

Example : I = WIND
Measurements : Doppler radar velocities F1(I), radiosounding F2(I), Meteosat cloud winds F3(I), ...

Physical constraints : air mass continuity equation, vertical air velocity nil at ground.

At the scale of the West Africa

Input data : 6 / 12 hours RS + surface stations + satellite measurements + IOP dropsondes + driftsondes + radars at Niamey, Djougou.



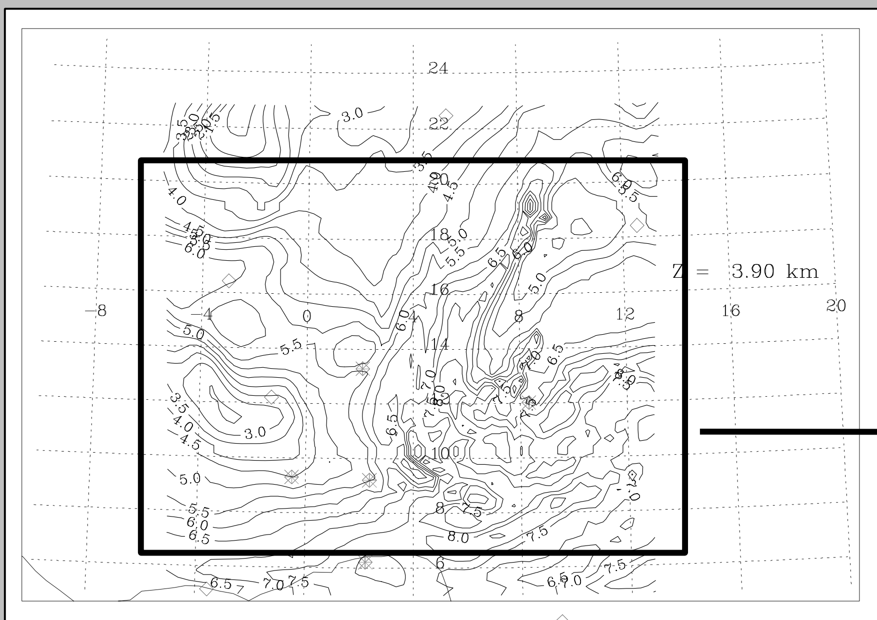
Present work : observations are being simulated using ECMWF model outputs and satellite orbitography in order to mimic the AMMA observations and assess the accuracy of the derived water budgets.

At the scale of West Africa (smaller domain, with Meso-NH)

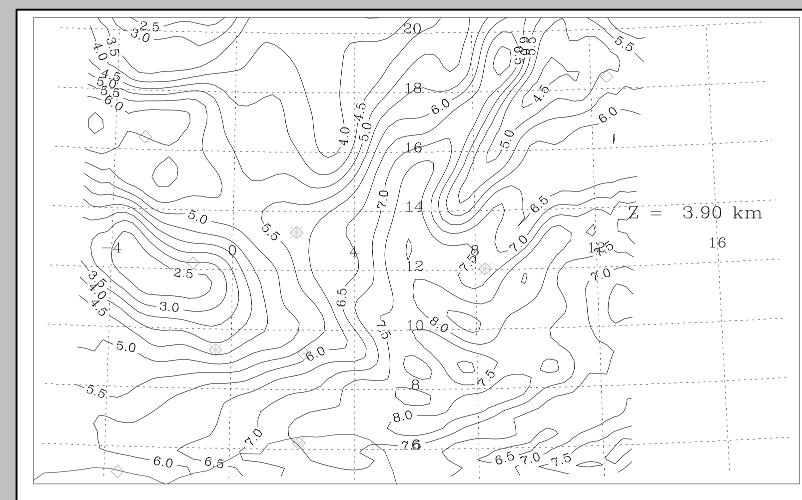
Illustration of the performance of MANDOPAS (3D) : wind and qv

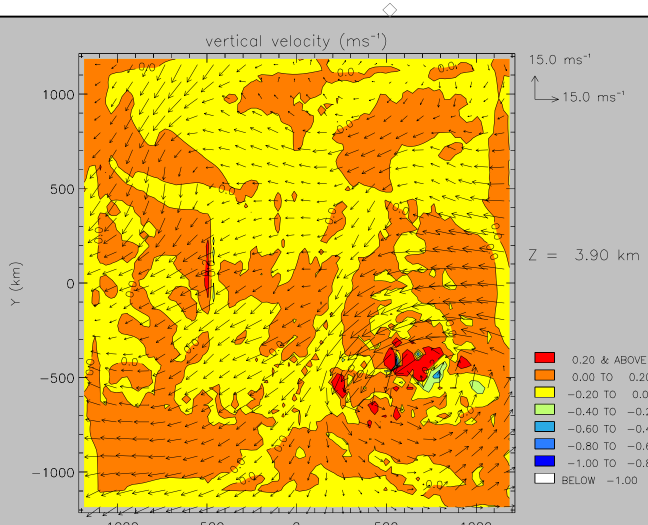
Synthetic observations included : all water vapour satellite products, 6h RS, MSG cloud winds, GPS EOP/SOP stations

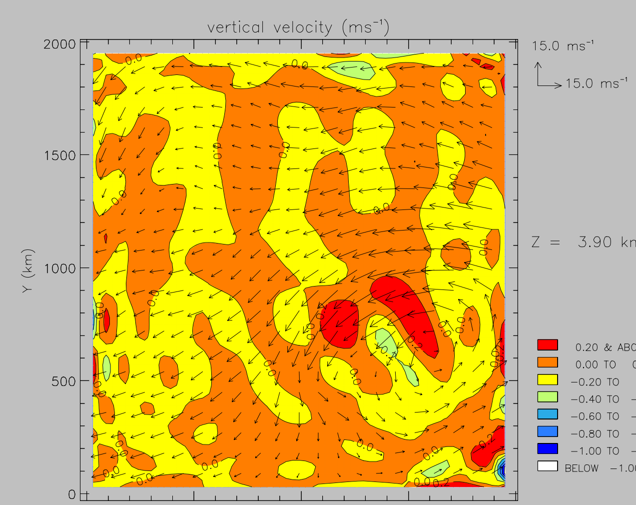
Reference qv field (model)



Retrieved qv field (MANDOPAS)







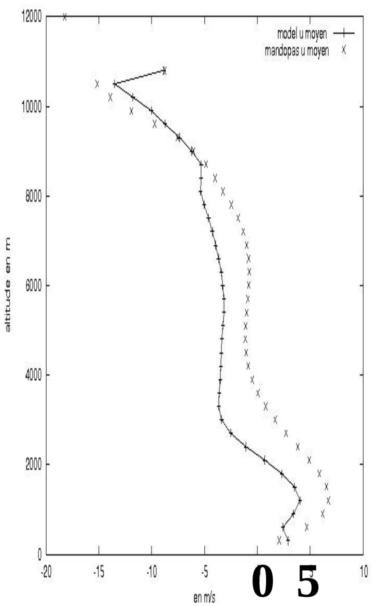
At the scale of the CATCH bassin

Input data : 6 / 12 hours RS + surface stations + radars at Djougou + airborne 94 GHz Doppler radar + IOP dropsondes + driftsondes + satellite measurements.

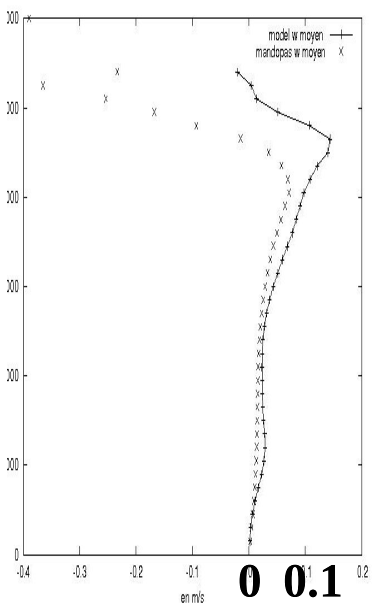
Present work : Investigate if water budgets can be computed with reasonable accuracy with the SOP instrumentation in the CATCH area. For this we use a MESO-NH simulation as a reference, simulate the CATCH observations, retrieve wind and qv from the synthetic observations using MANDOPAS, and then Q2.

Illustration of the first results : Q2 (in MCS area) with the RS quadrilateral + surface stations + MSG winds). Results are reasonable, but radar data will be necessary for more quantitative estimation.

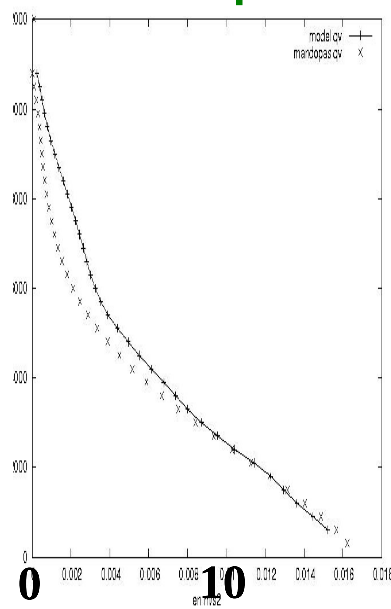
Horizontal wind



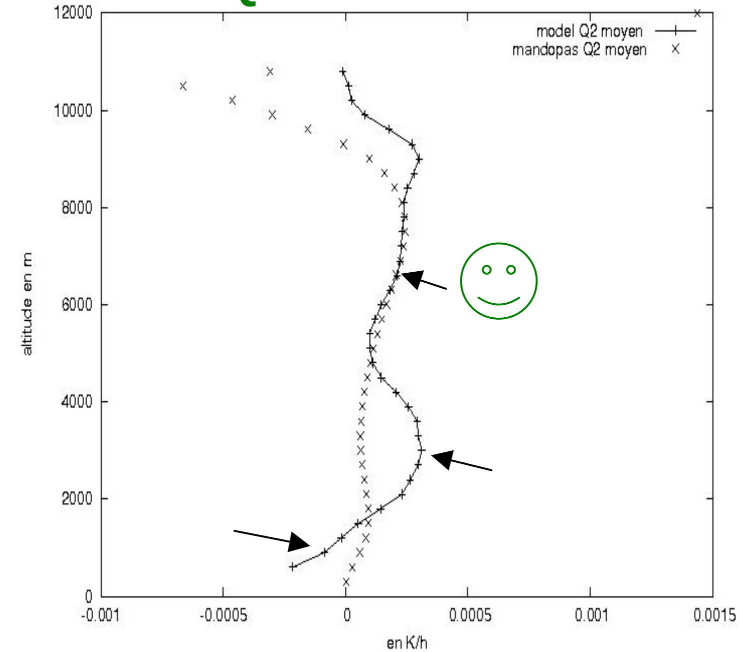
Vertical wind



Water vapour



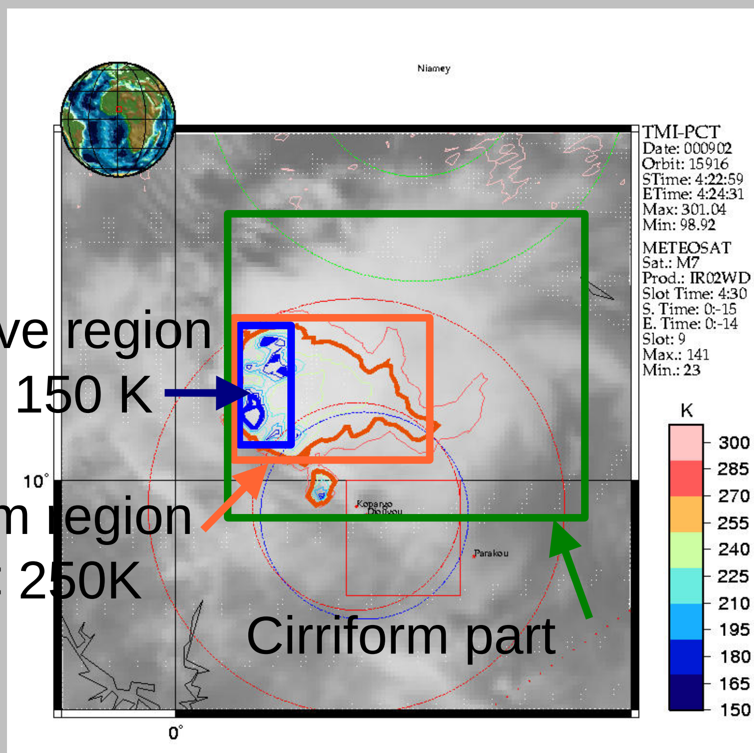
Q2

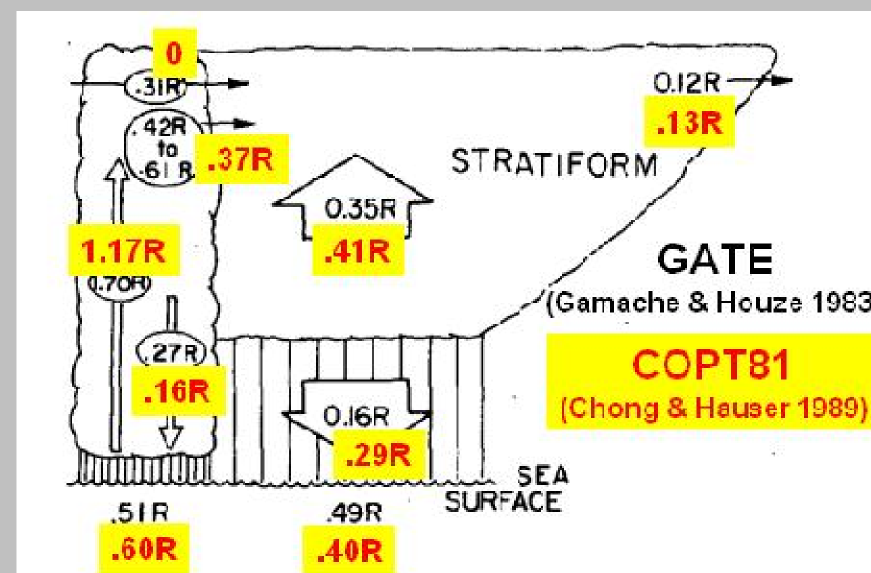


At the scale of the MCSs and their different parts

Input data : Airborne 94GHz Doppler radar data , dropsondes,
Ground-based C band Doppler polarimetric radar data

Water budget in each part of the system including the cirriform part
(including the cirriform part)





During SOPD (dedicated to microphysics) : improve the estimation of source terms at the different stage of the system life cycle.

Future work and strategy :

Prior to the field experiment :

Perform sensitivity tests on 3D / 4D using synthetic observations

Following the field experiment :

Systematic quantification of budget at the different scales.

How can a better quantification of budgets at local scale can improve the budget computation at larger scale ?

How the heating and moistening profiles interact with the different Monsoon components ?