Critical Zone studies in Benin, West Africa

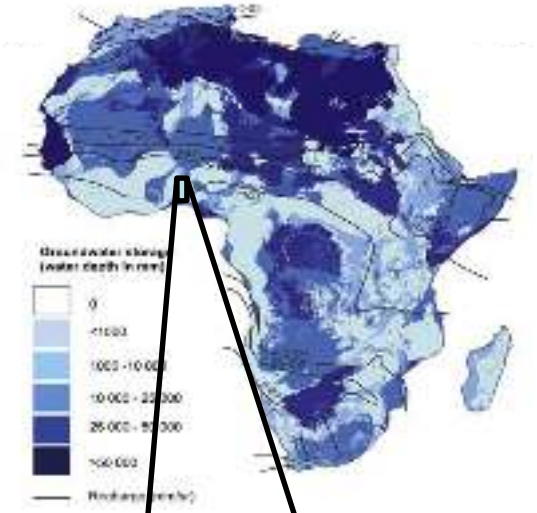
Coupling scintillometry, electrical resistivity, Magnetic Resonance Sounding, gravimetry and modelling

Descloitres, M., Cohard, J.M., Vouillamoz, J.M., Legchenko, A., Hector, B., Boucher, M., Galle, S., Vandervaere, J. P., Séguis, L., Peugeot, C., Favreau, G., Hinderer, J., Wubda, M., Allé, C., Lawson, M., Kotchoni, V., Yalo , N., Adjomayi, P., Lawin , E., Agbossou, E., Boukari, M., Mamadou, O., Guyot, A., Robert, D., Richard, A.

West Africa soudanian zone: Societal issues

- Water ressources (ODD6)
  - Location
  - Quantification
  - Evolution

Surface water: intermitent…



MacDonald et al., 2012

Basement rocks

Sedimentary area

Difficult access to groundwater (30% of boreholes are unsuccesfull…)

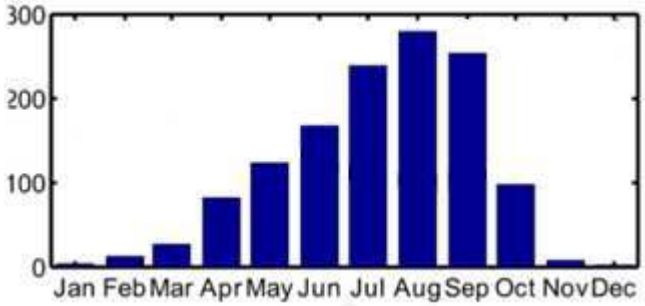
- Environnemental risques (ODD13)
  - flooding
  - pollution

Periodic flooding near the coast…

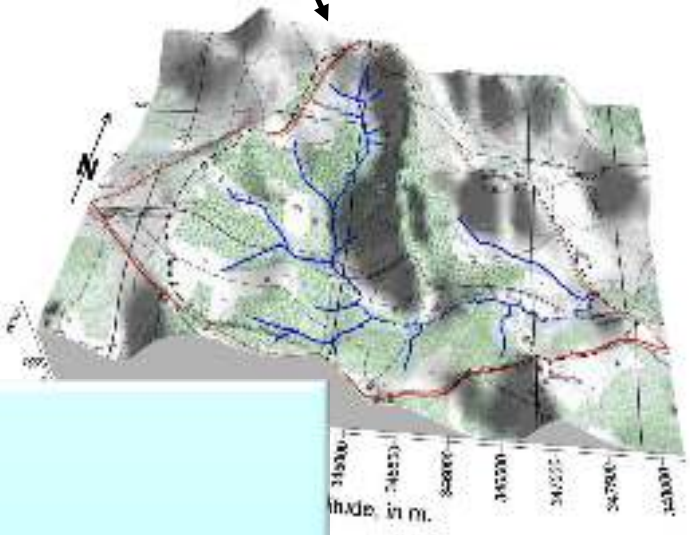
AMMA-Catch observatory in Bénin

Upper Ouémé region

- Soudanian climate
- Végétation: cropping, savana and forests
- Hard rock basement



Pluviométrie à Djougou (mm)



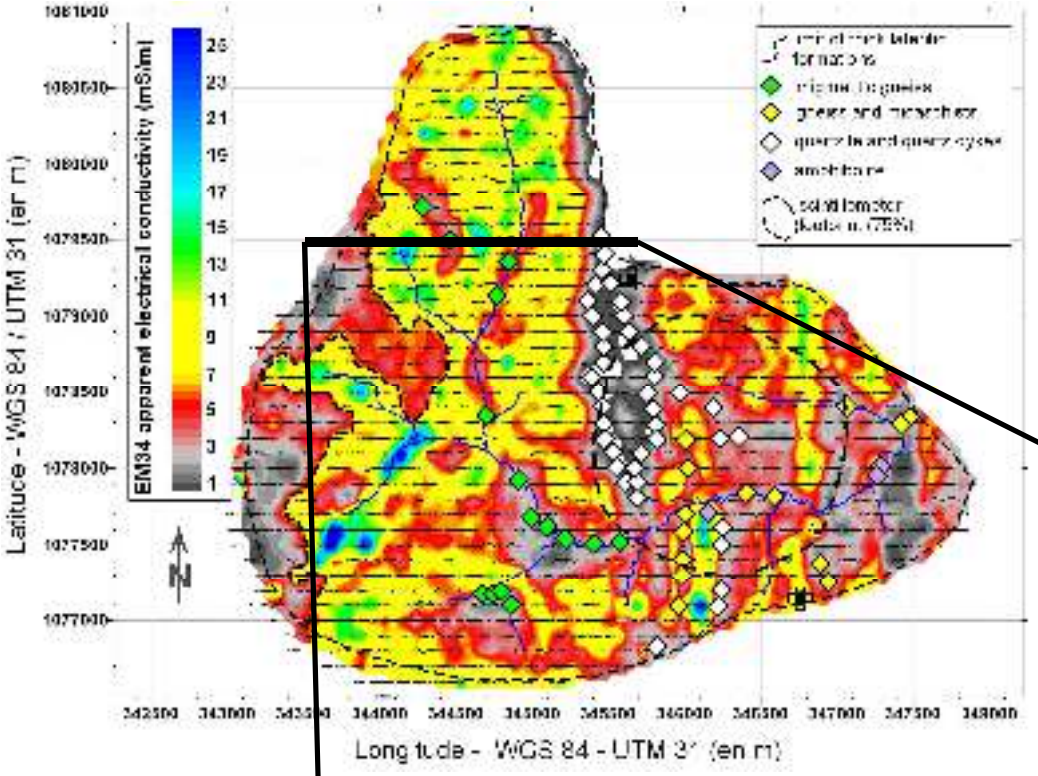
Cultures dans la région de Djougou, mars 2013

Savane dans la région de Djougou, mars 2013

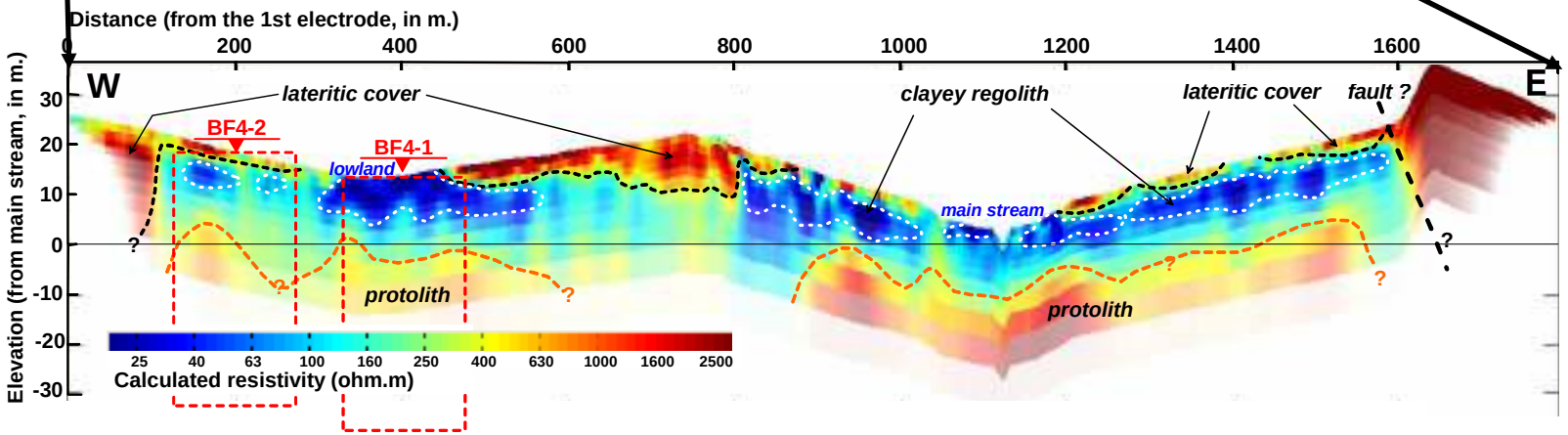
Ara Watershed

- 13 km²
- Contrasted geology: gneis/micaschist/quartzite
- Various land uses

Geophysical properties of the sub-surface

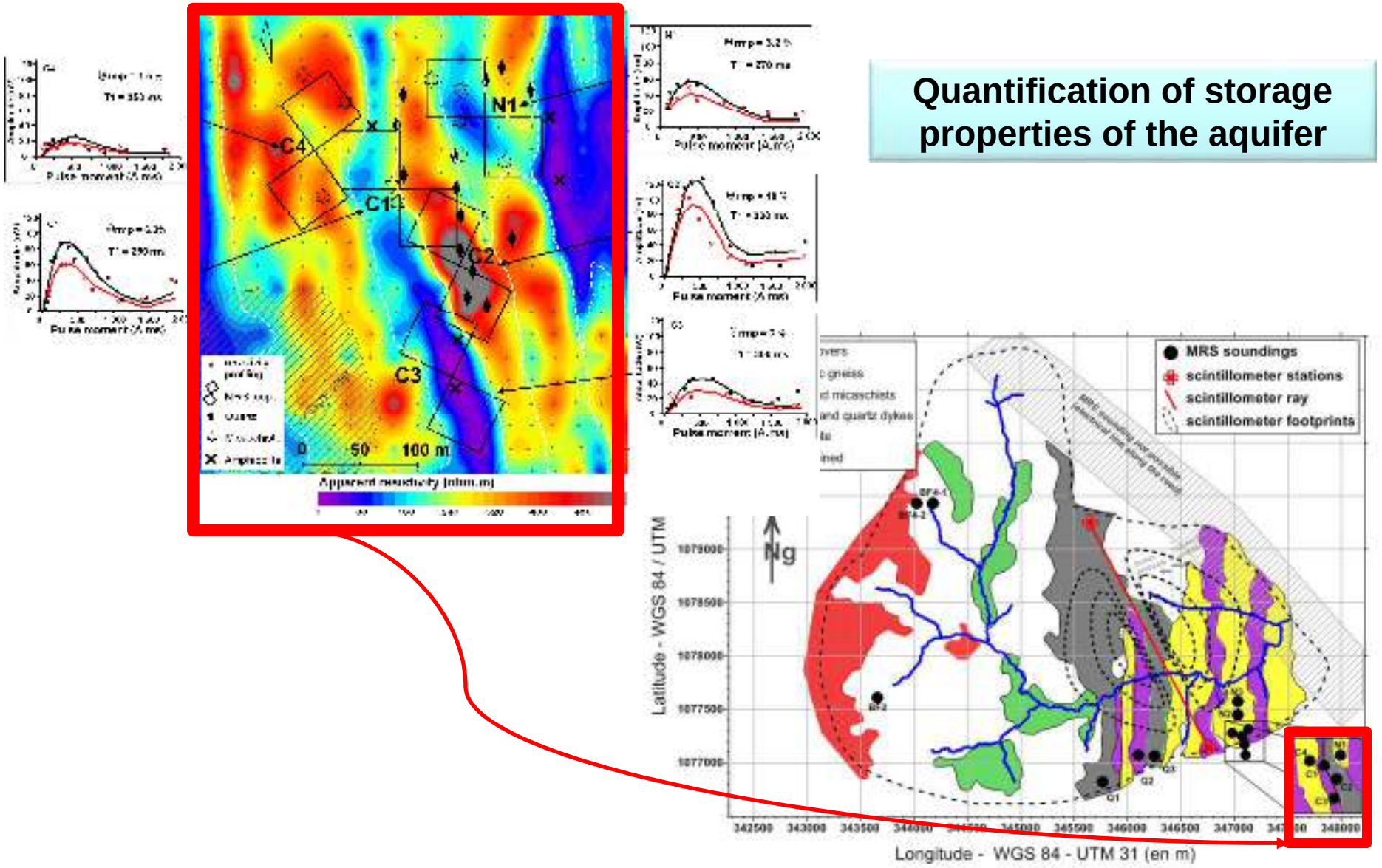


- **Getting geometrical information for modelling**
- **Processes studies**



Wubda, M, 2013. Mémoire de DESS, LGA, Paris VI - IRD

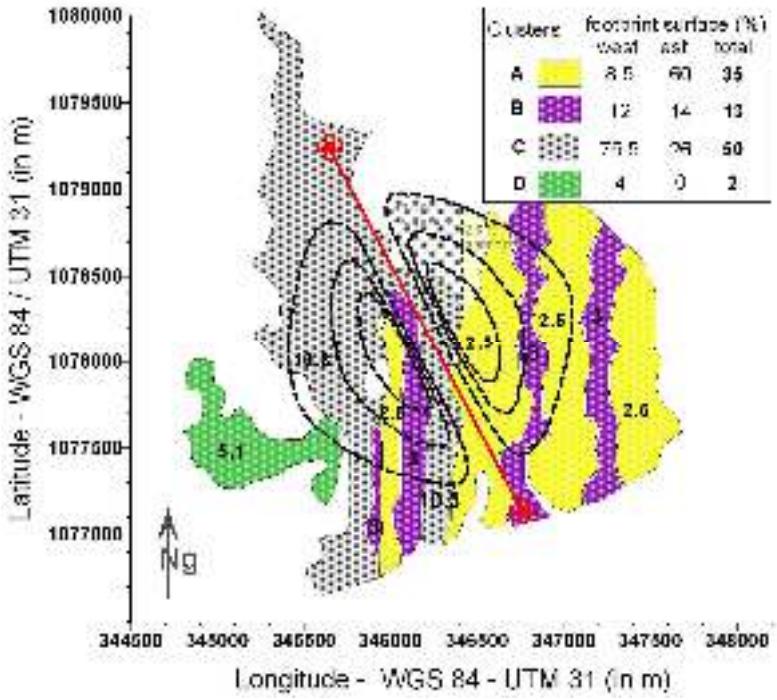
Coupling electrical resistivity and Magnetic Resonance Sounding (MRS)



Quantification of storage properties of the aquifer

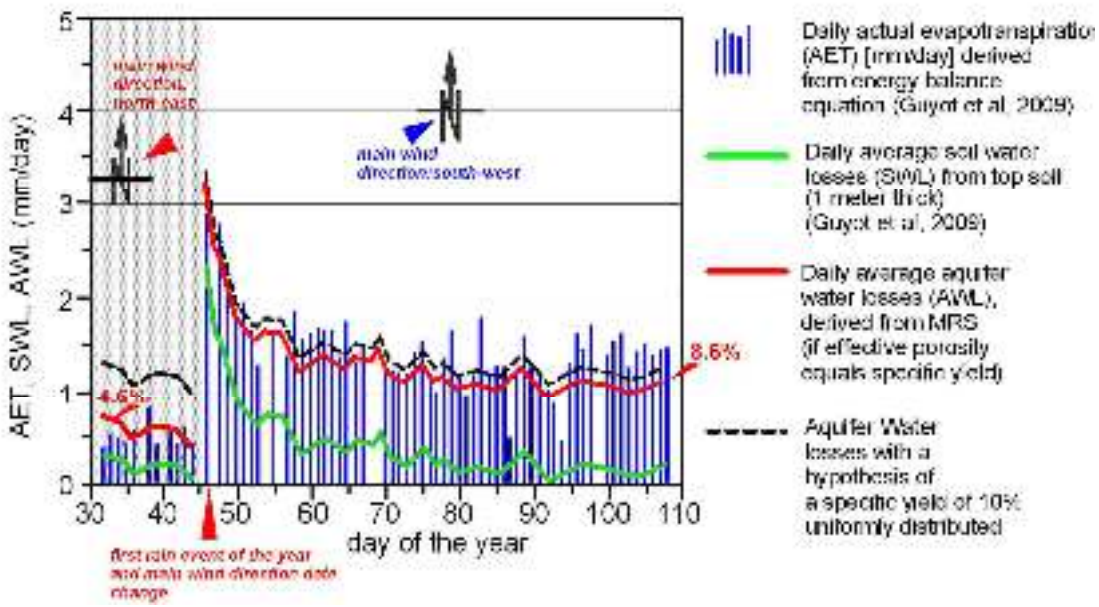
Descloitres, M., Séguis, L Legchenko, A., Wubda, M, Guyot, A., Cohard, J.M., 2011. Near Surface Geophysics.

Coupling scintillometry and geophysical measurements (ERT and MRS)



Descloitres, M., Séguis, L Legchenko, A., Wubda, M, Guyot, A., Cohard, J.M., 2011. Near Surface Geophysics.

Evapo-transpiration fluxes quantification at the Ara watershed scale

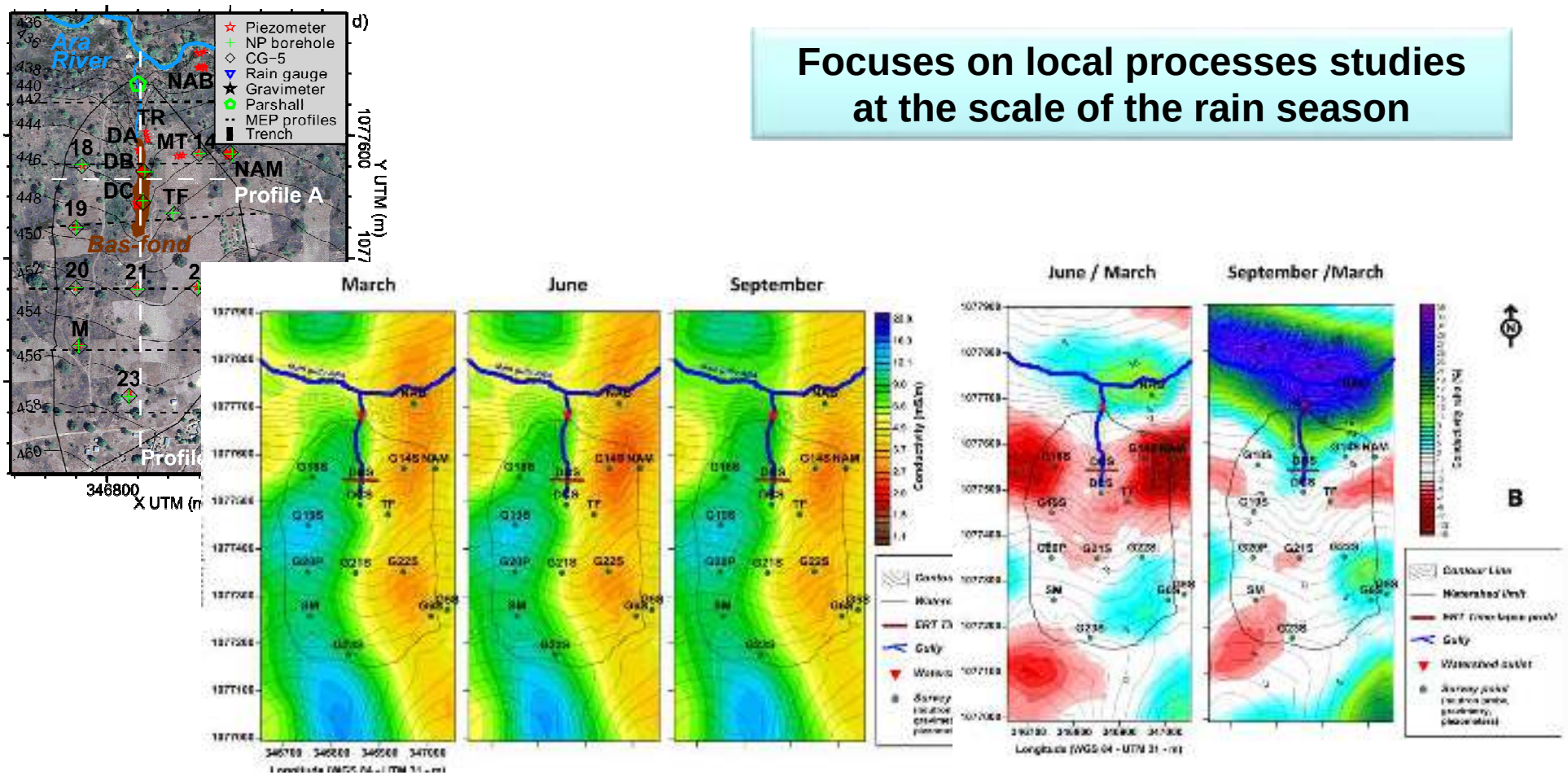


Guyot,A., Cohard, J.M., Anquetin, S., Galle, S., Lloyd, C. R., 2009. Journal of hydrology

→ **Scintillometer data better explained**

→ **Evidence of the crucial role of aquifer for evapotranspiration fluxes**

Time-lapse resistivity surveys: electromagnetic mapping



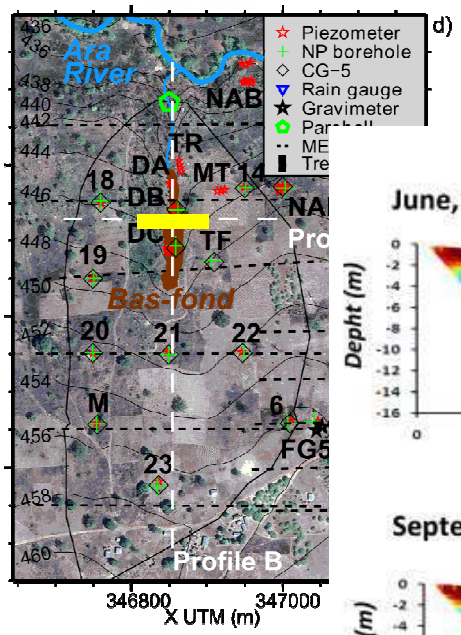
Focuses on local processes studies at the scale of the rain season

→ **Differential maps point out groundwater chemical changes in the subsurface.**

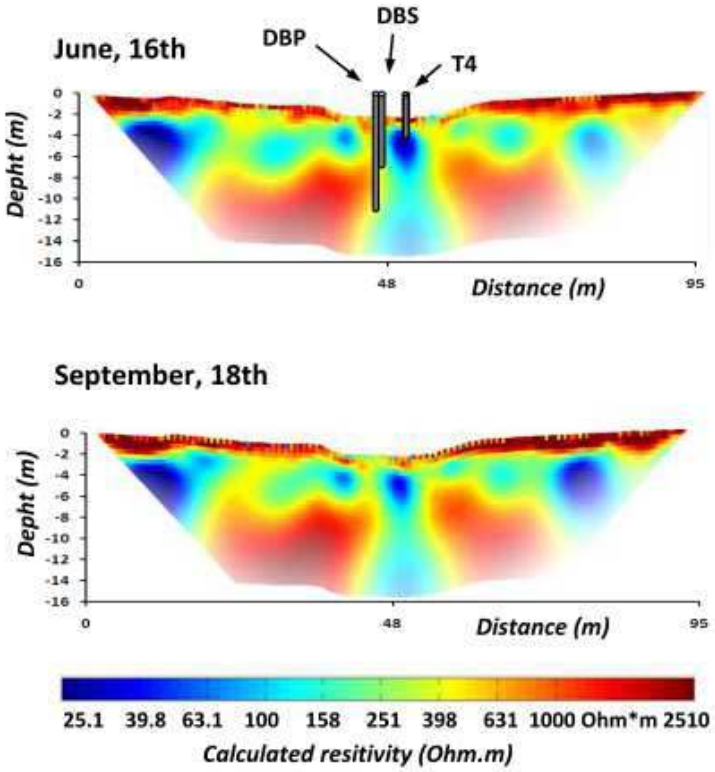
→ **Necessity to get in-situ data to interpret time lapse resistivity**

Wubda, M., Descloitres, M., Yalo, N., Ribolzi, O., Vouillamoz, J.M., Boukari, M.,, Hector, B., Séguis, L., 2017. Journal of Applied Geophysics, in press

Time-lapse resistivity surveys: differential electrical resistivity tomography

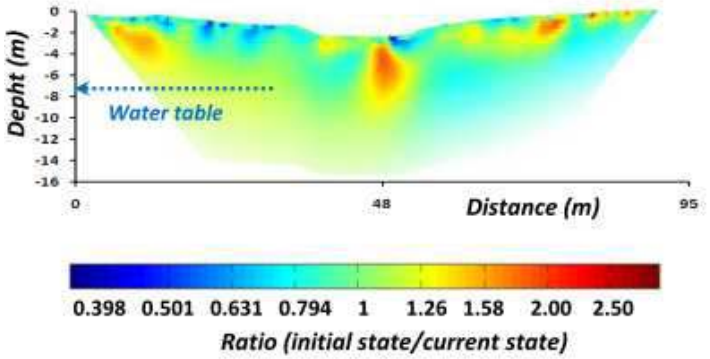


Time-lapse ERT surveys
Across the small low-land



Where does groundwater infiltrate?

Seasonal variations (september<> june)



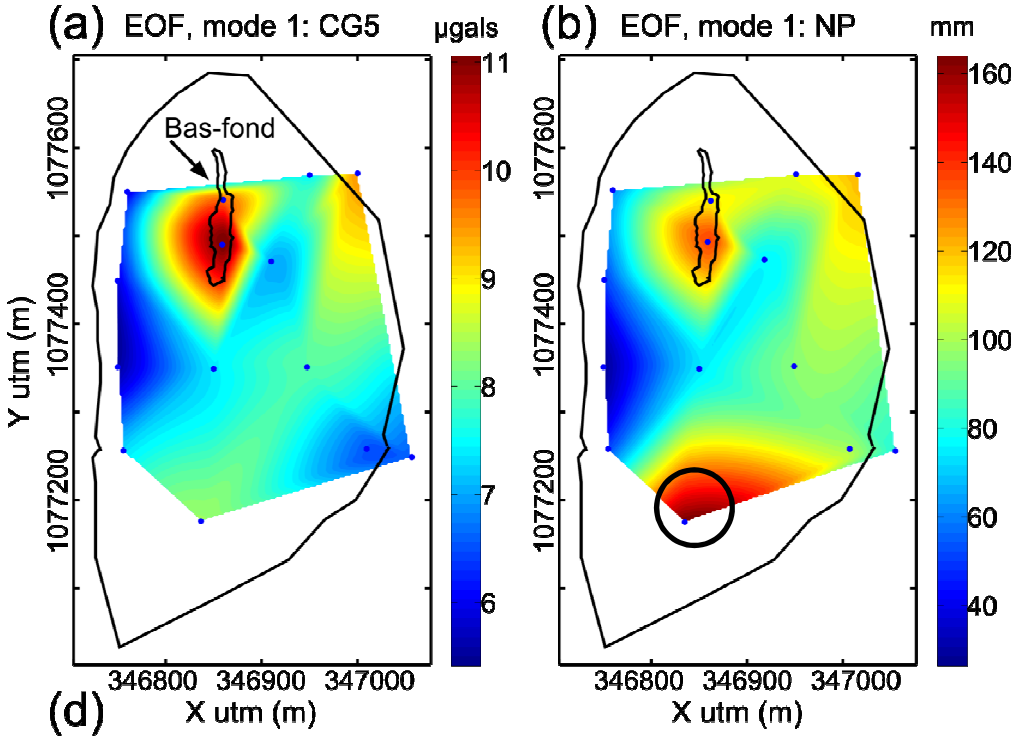
→ **A unique way to track groundwater infiltration throught the first 10 meters**
→ **Delicate interpretation without external in-situ data: test site required**

Wubda, M., Descloitres, M., Yalo, N., Ribolzi, O., Vouillamoz, J.M., Boukari, M.,, Hector, B., Séguis, L., 2017. Journal of Applied Geophysics, in press

Coupling gravimetry and hydrological measurements (neutron probes)

Time lapse gravimetry

Storage variations calculated from neutron probe data



Differential gravimetry to quantify hydric storage differences along the year

→ A very interresting possibility to quantify yearly variations of water content

Hector, B., Séguis, L., Hinderer, J., Cohard, J.-M., Wubda, M., Descloitres, M., Benarrosh, N. and Boy, J.-P., 2015: Water Resour. Res.

Coupling gravimetry and hydrological measurements (neutron probes)

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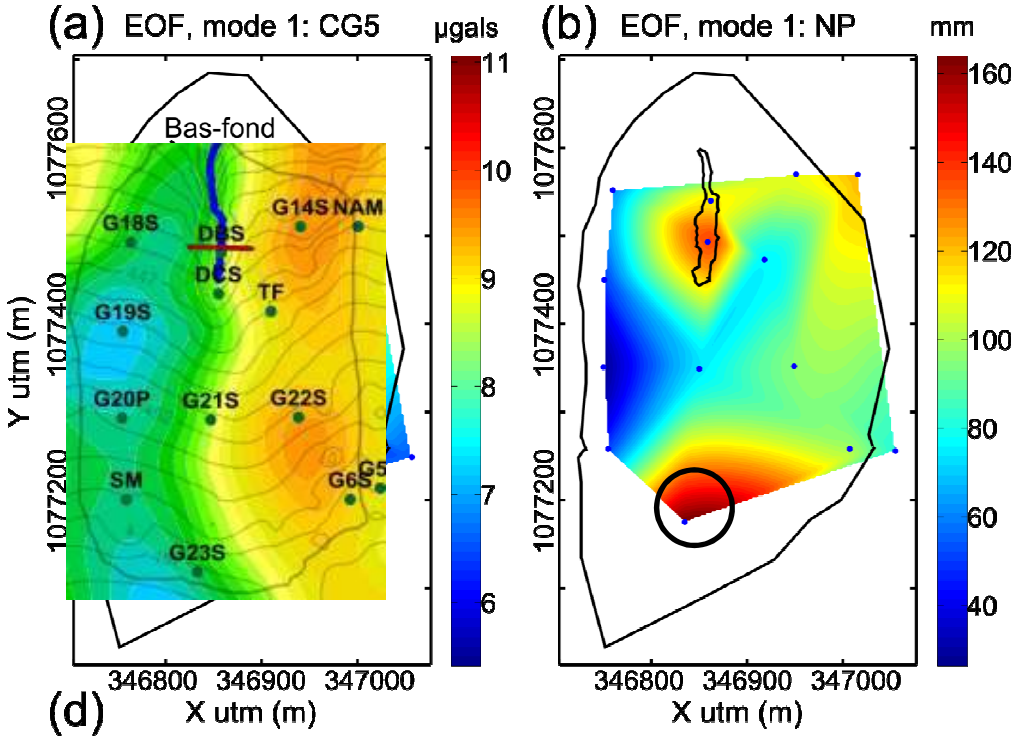

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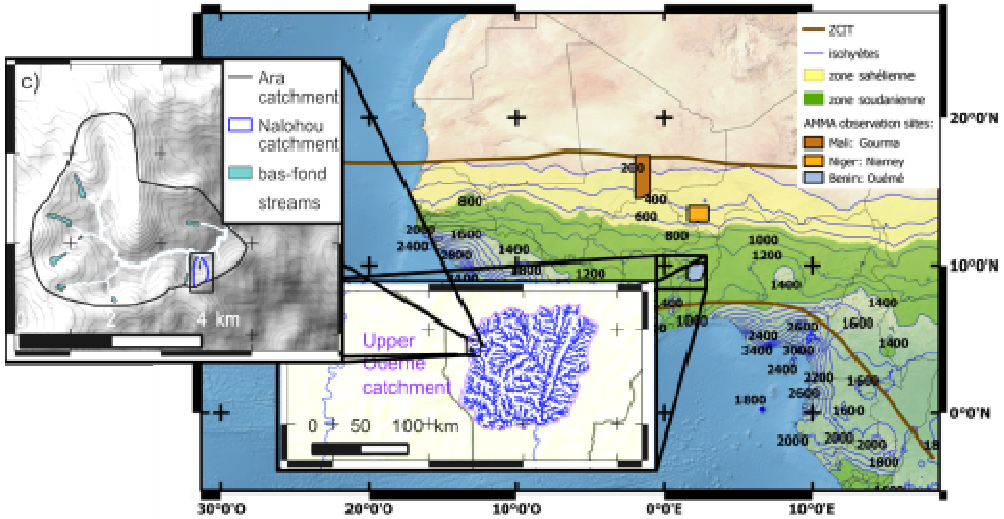
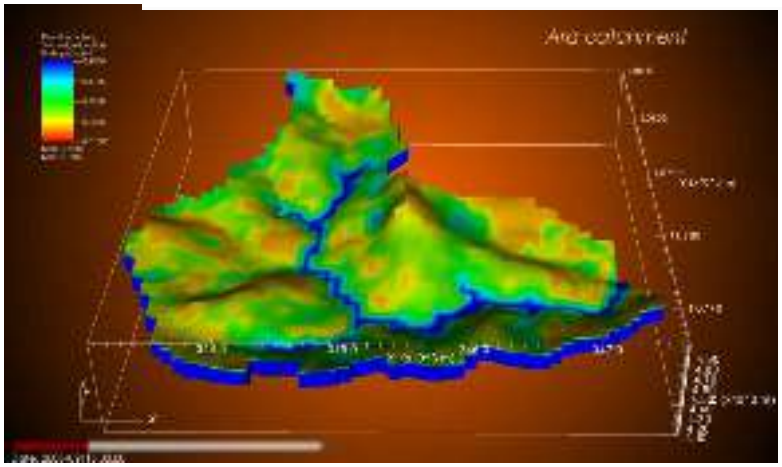
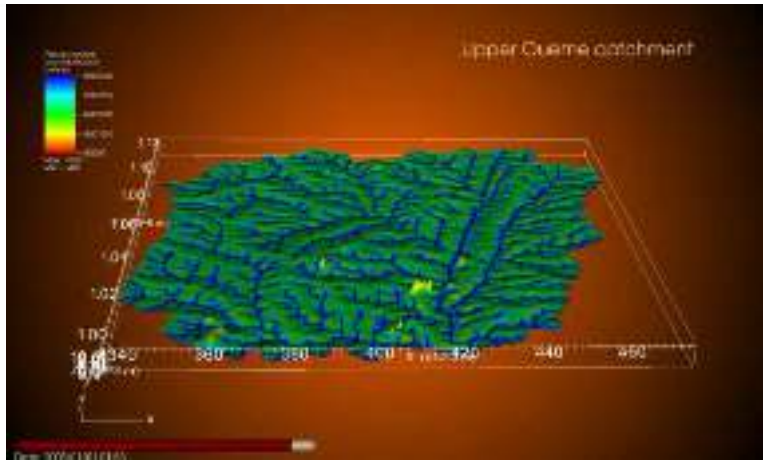
Towards a physically based modelling



PARFLOW CLM: An efficent tool for physically based hydrological modelling,



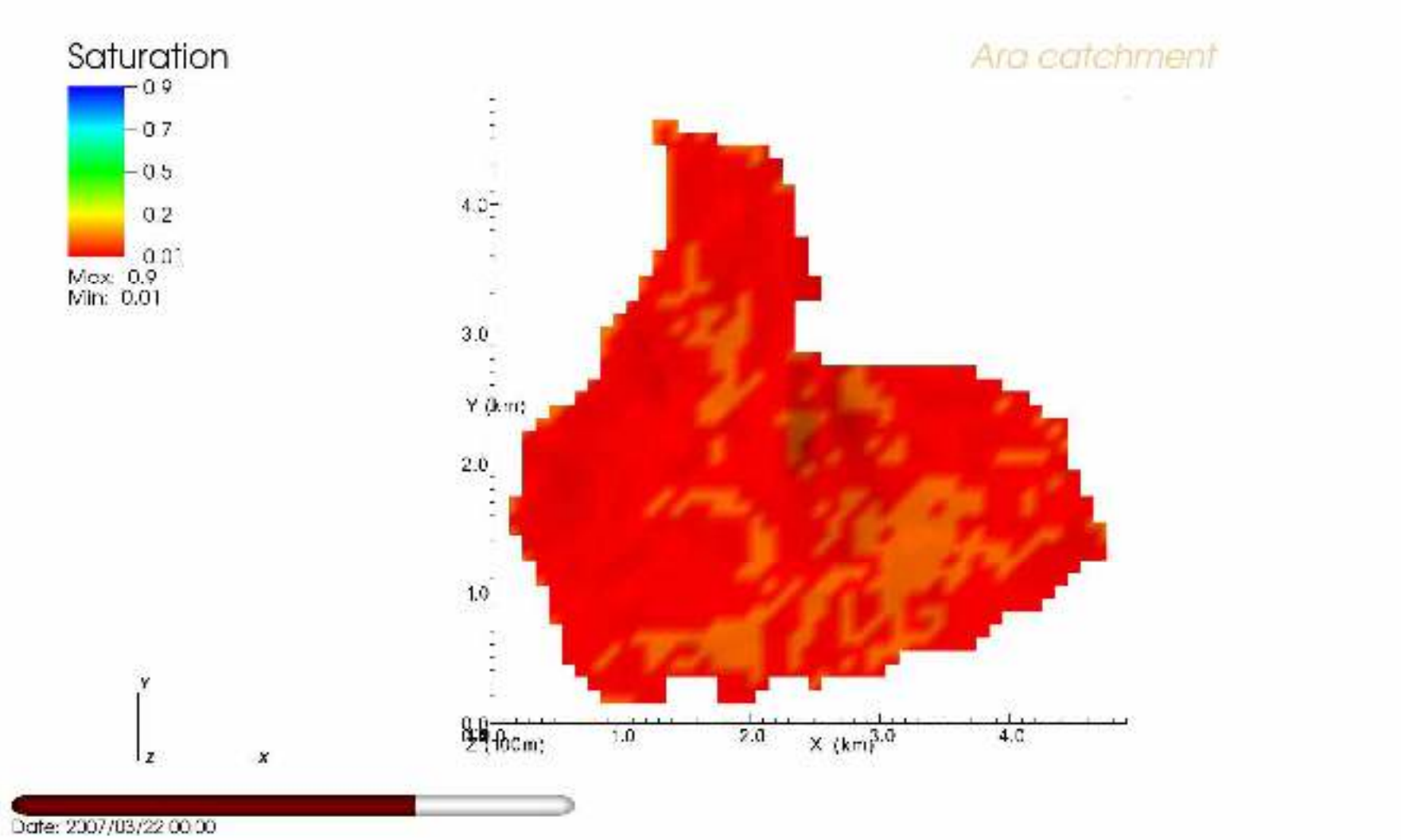


→ **Interresting possibilities to study scale changes**

→ **A strong challenge for geophysicist to fill the grid with useful information**

Travaux cours, équipe PhyREV, IGE, 2017

→ **As a conclusion, to illustrate that the dream is not so far…**

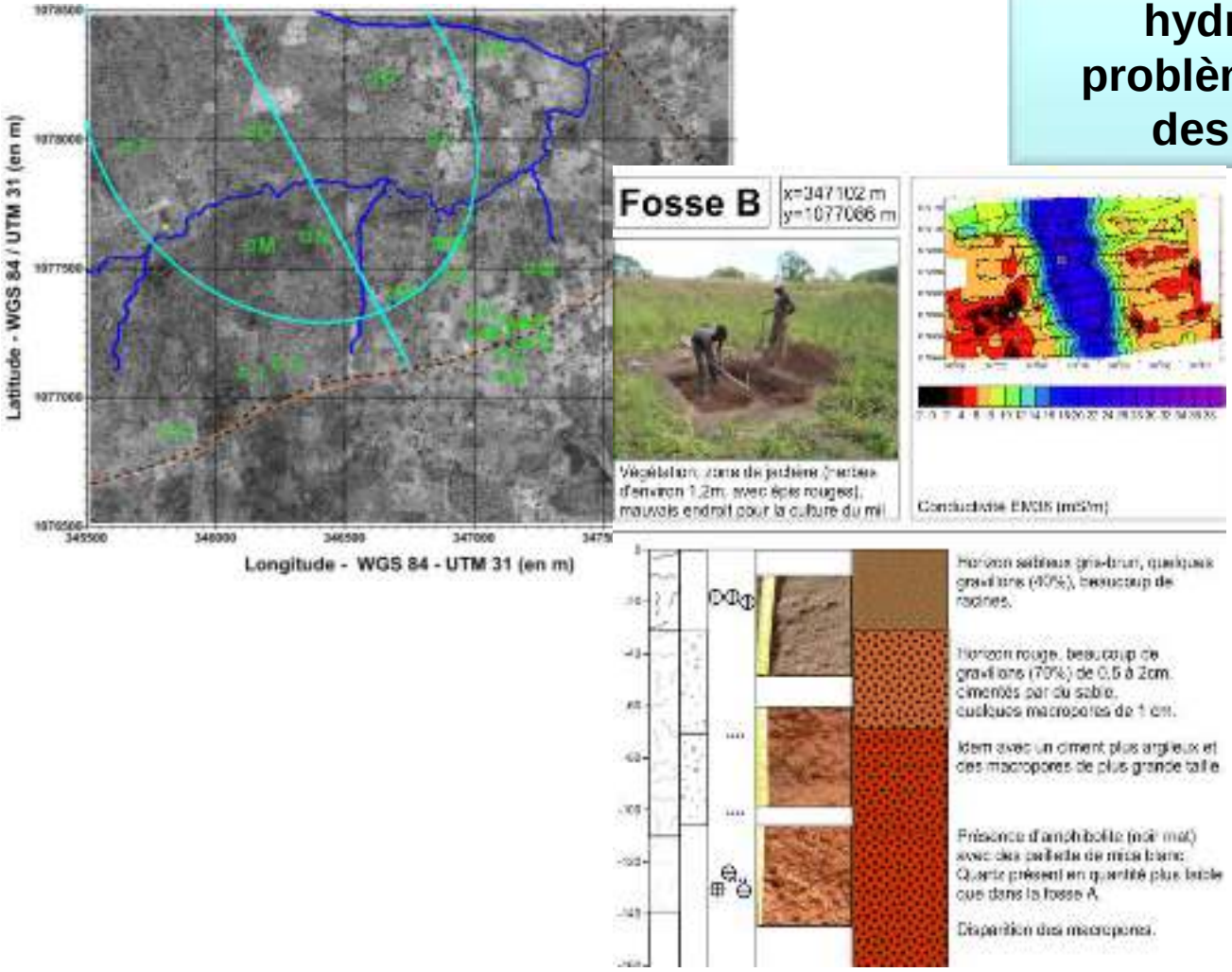


→ **Thank you for your attention**

Simulation PARFLOW CLM, travaux cours, Basile Hector et équipe PhyREV, IGE, 2017

Couplage entre résistivité et infiltrométrie

Etudes des propriétés hydriques des sols: un problème de positionnement des fosses d'analyses

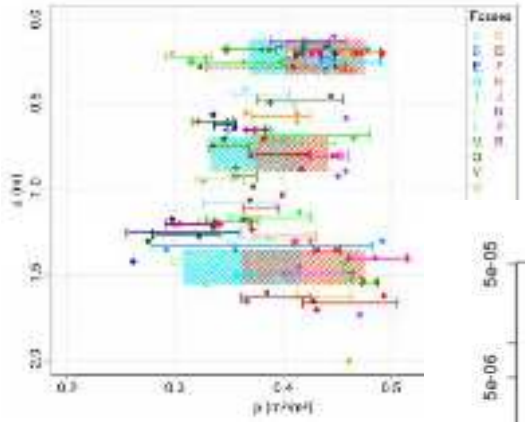


→ Meilleur positionnement des fosses

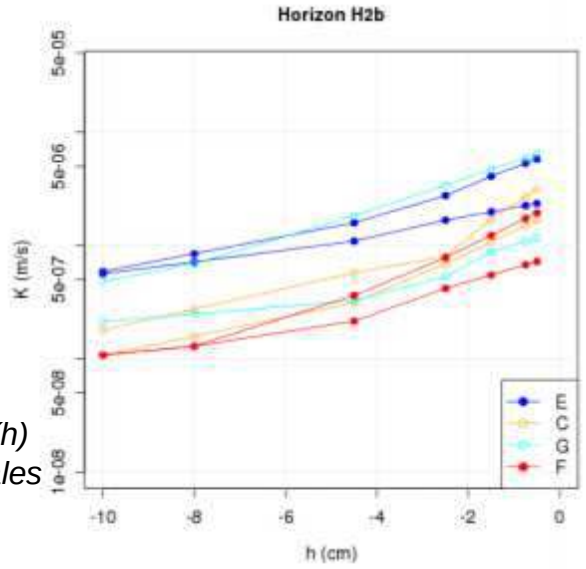
D. Jabot Robert, 2011. Thèse LTHE

Couplage entre résistivité et infiltrométrie

Compréhension des variations de propriétés hydriques en 1D: une première étape vers une modélisation distribuée.

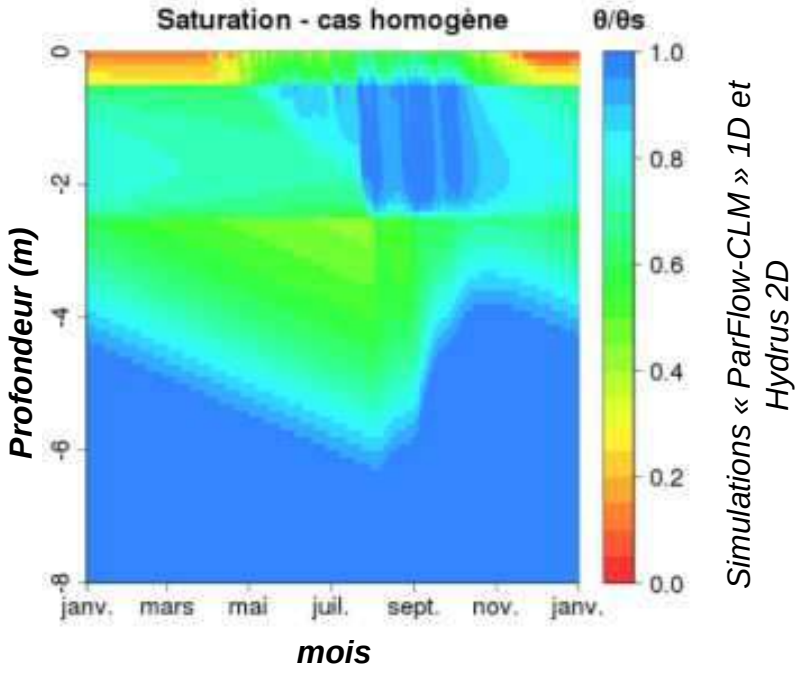


Variation des porosités en fonction de la profondeur pour l'ensemble des fosses



Courbes K(h) expérimentales

D. Jabot Robert, 2011. Thèse LTHE.



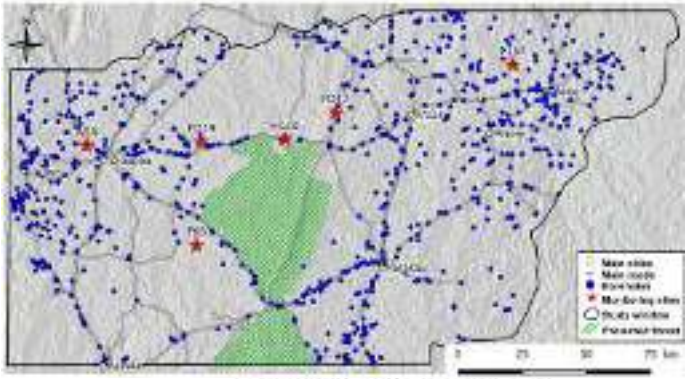
Simulations « ParFlow-CLM » 1D et Hydrus 2D

Richard, A., Galle, S., Descloitres, M., Cohard, J. M., Vandervaere, J. P., Séguis, L., and Peugeot, C., 2013Hydrol. Earth Syst. Sci.

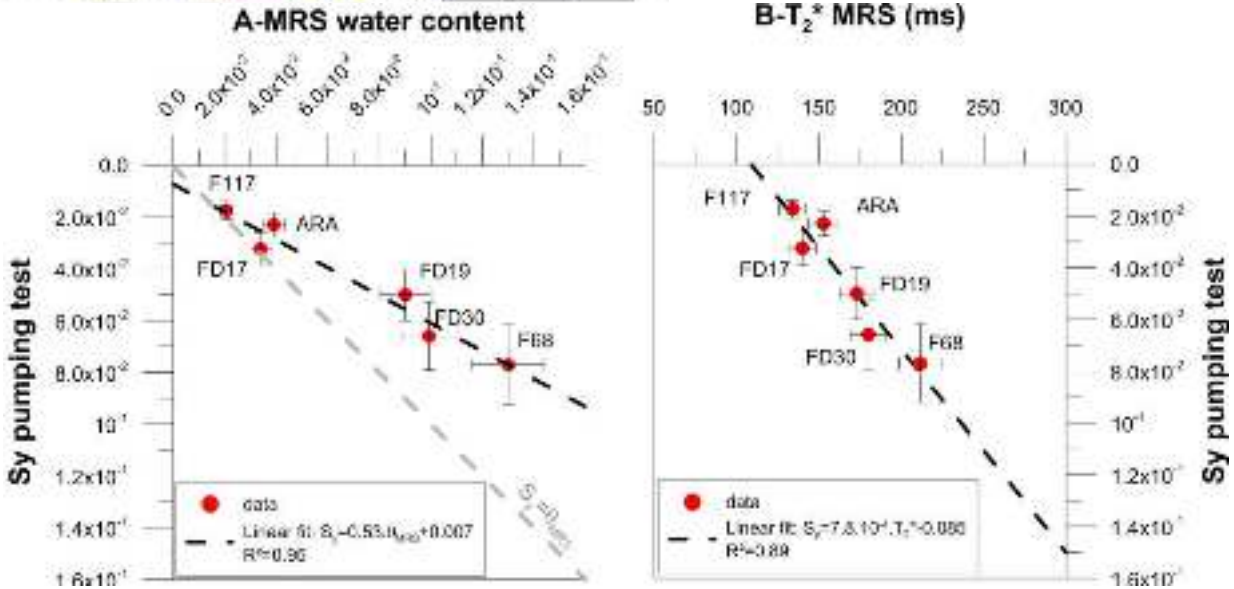
→ Degré de confiance accru sur la représentativité des mesures in situ

→ Une modélisation mieux étayée

Ressources en eau souterraine Projet UE-UA « GRIBA » . IRD/QUB/INE/2IE



Une possibilité de mieux connaitre les ressources en eau souterraine



→ **Ressource moyenne par mètre carré: 400 litres**

→ **4 à 6 ans de réserve : capacité d'amortissement des variations clim.**

Vouillamoz, J.M., Lawson, F.M.A., Yalo, N., Descloitres, M., 2015. Journal of Hydrology

Vouillamoz, J. M., Lawson, F. M. A., Yalo, N., Descloitres, M., 2014. Journal of Applied Geophysics