Identification of potential groundwater recharge using 3D-spatial soil moisture observations in the Ad-Dahna desert, Saudi Arabia

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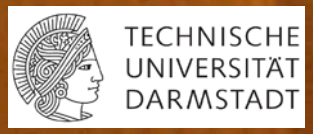
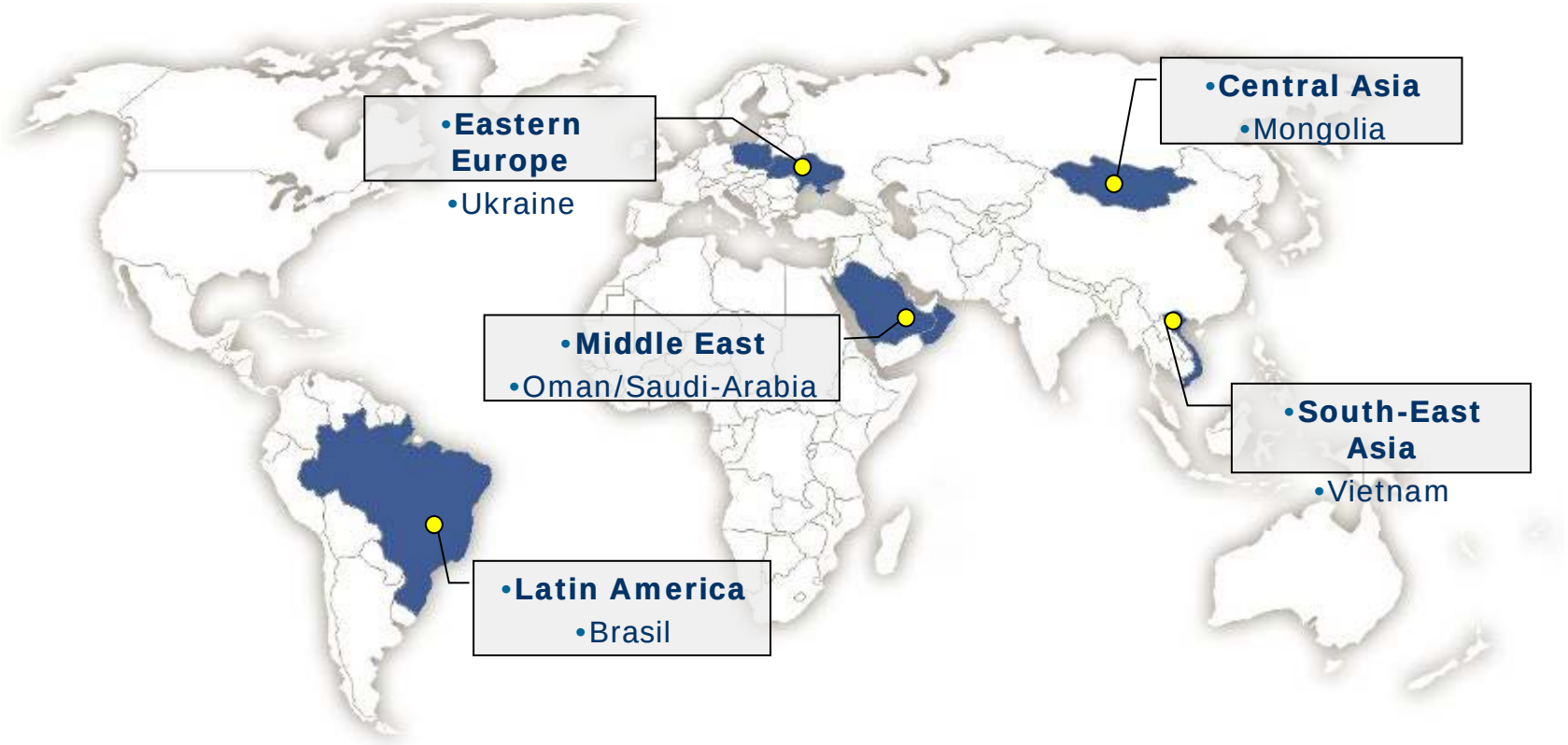


Motivation

IWAS: specific contributions to develop IWRM approaches in hydrologically sensitive regions

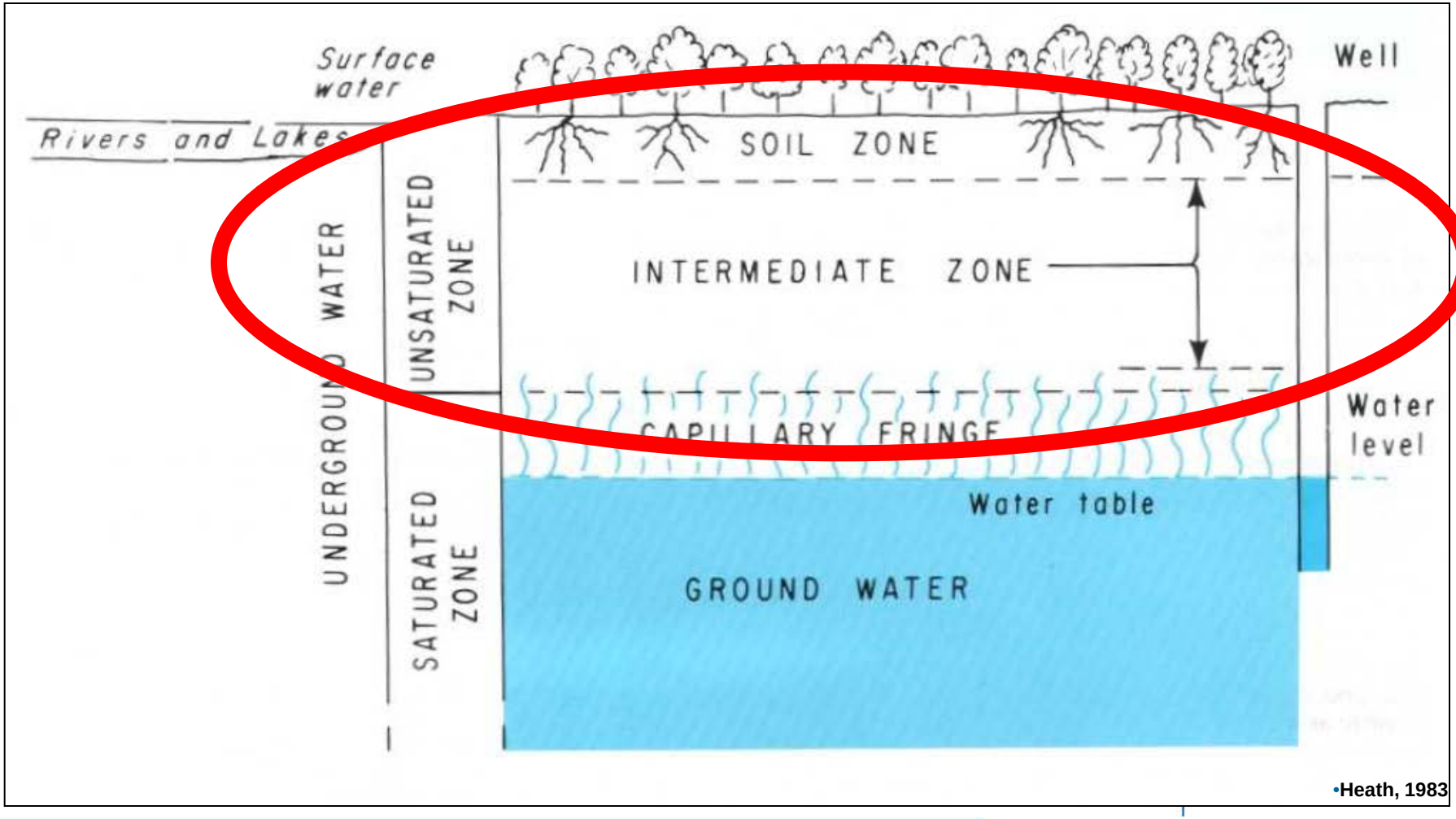


Challenge in arid areas:

High and further increasing stress on the water resources !

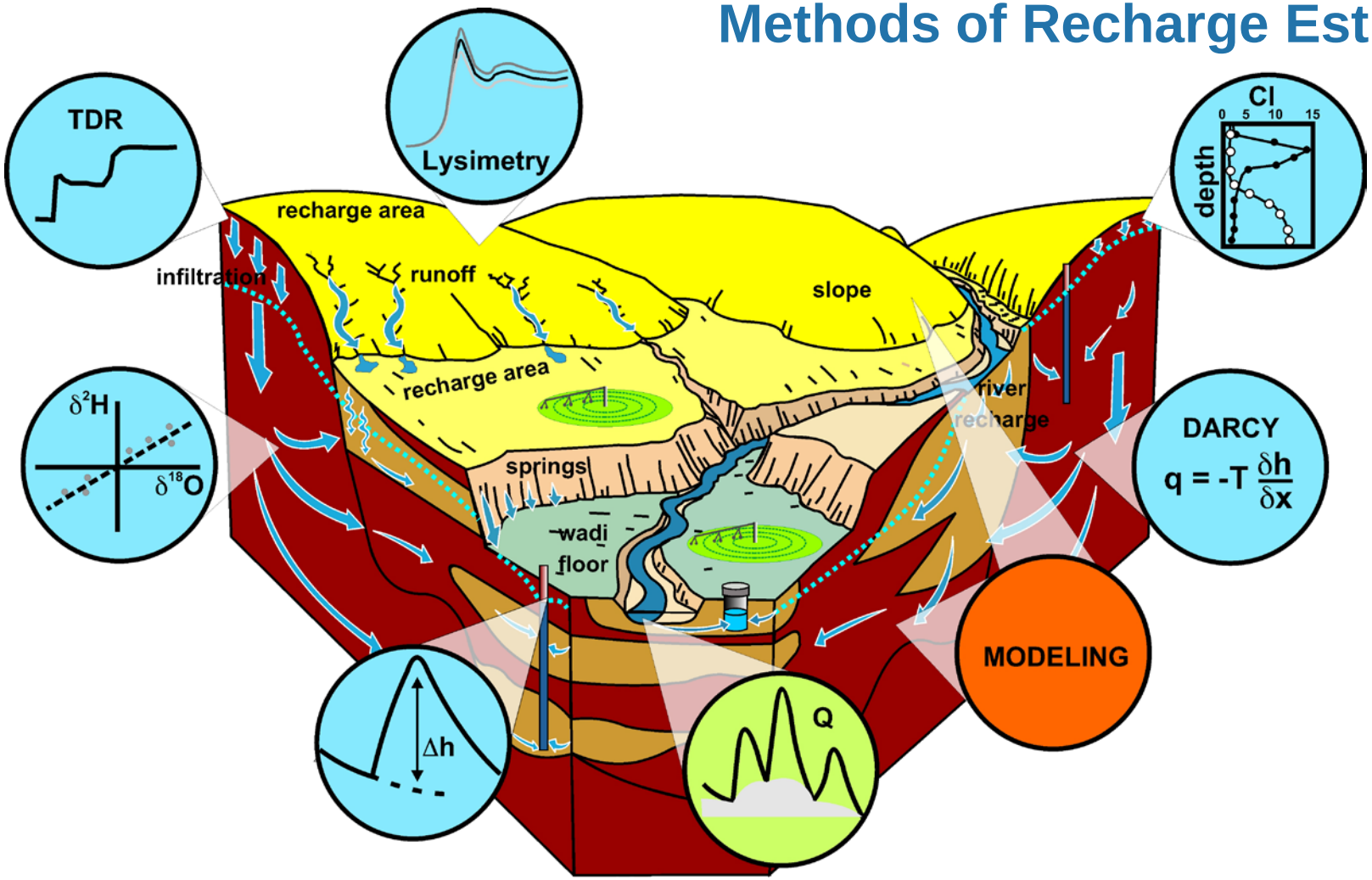
Groundwater recharge

to understand groundwater recharge is to understand water fluxes in the unsaturated zone



•Heath, 1983

Methods of Recharge Estimation



from precipitation

- Lysimetry
- neutron / TDR probe
- Chemical tracer (Isotopes, Cl)
- Water-budget methods

from intermittent flow

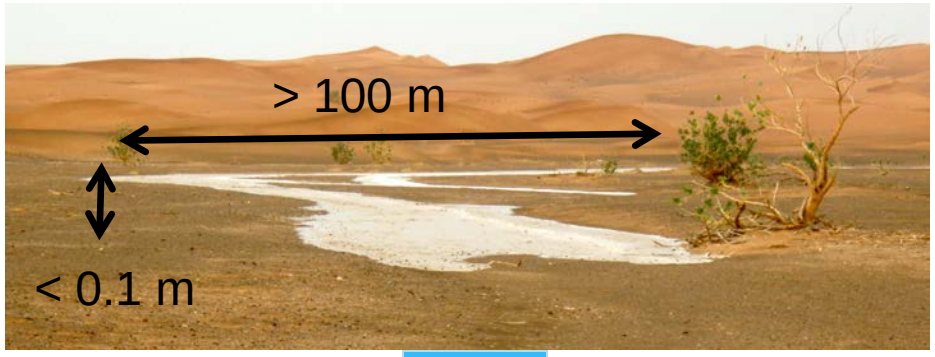
- Stream water-budget methods
- Streamflow hydrograph analysis
- Chemical analysis

Modeling methods

- Soil water budget models
- Watersheds models
- Groundwater-Flow models
- Combined models

from intermittent flow

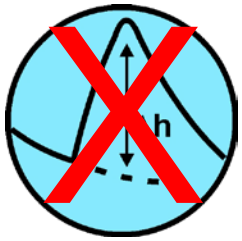
discharge



In search of suitable methods

unsuitable wadi geometry

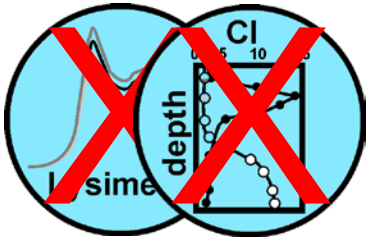
Water table fluctuation



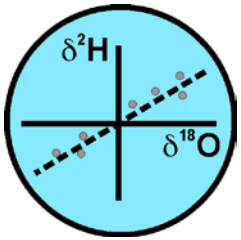
unsuitable depth to water table (> 300m)

from precipitation

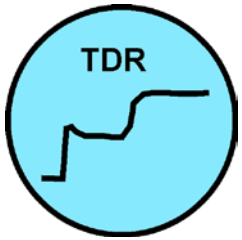
Lysimetry, Chemical tracer, …



unsuitable geogenic background or cost



Combination of chemical tracer (Isotope) and water content TDR measurements



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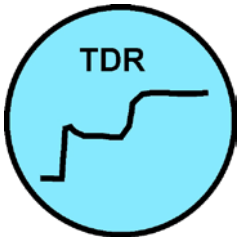


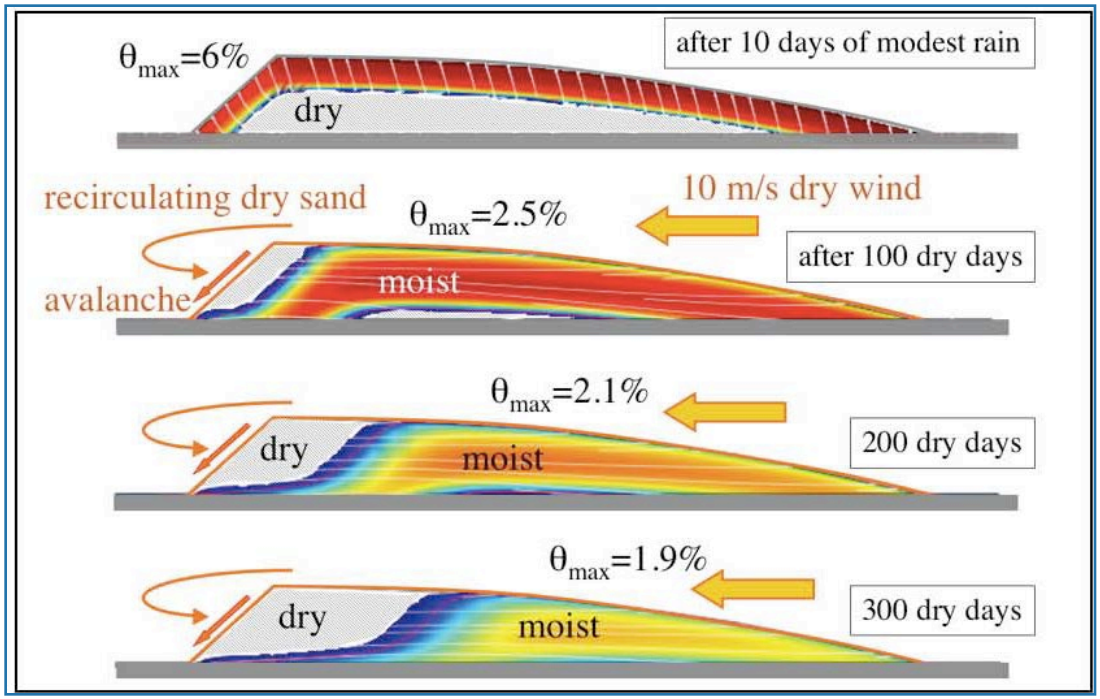
Water content measurement

TDR - Time Domain Reflectometry

Method are used to determine moisture content in soil and porous media.

Interest: Does recharge occurs under sand cover and aridity?

Different studies show the availability of moisture under Sand dunes, e.g. Dincer, 1974



Cornell University; College of Engineering, Sibley School of Mechanical and Aerospace Engineering (2009)

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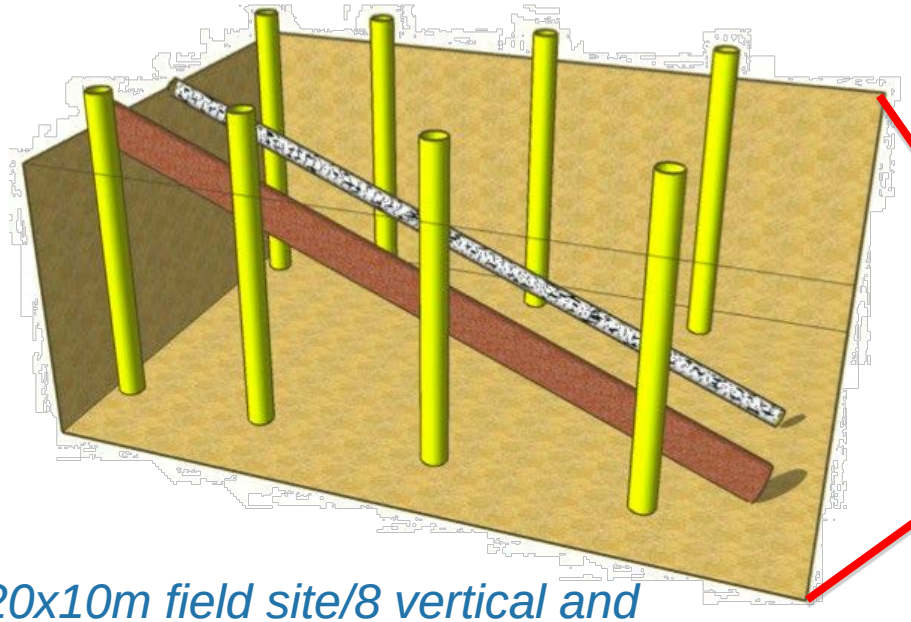
Observation from precipitation to recharge;

Experimental field site in the Kingdom Saudi Arabia

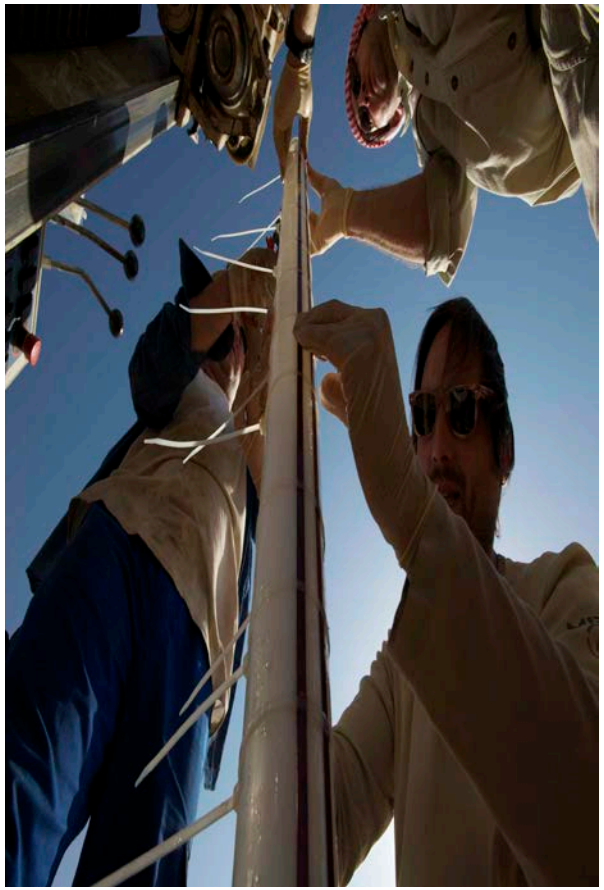
- *installation of TDR monitoring system, climate station, temperature loggers and an experimental irrigation plot in the Ad Dhana sand sea*
- ***Monitoring** of water infiltration over an extended period of time (years)*
- *chemical / isotopic fractionation*



20x10m field site/8 vertical and one sloped TDR sensors

Installation of monitoring equipment

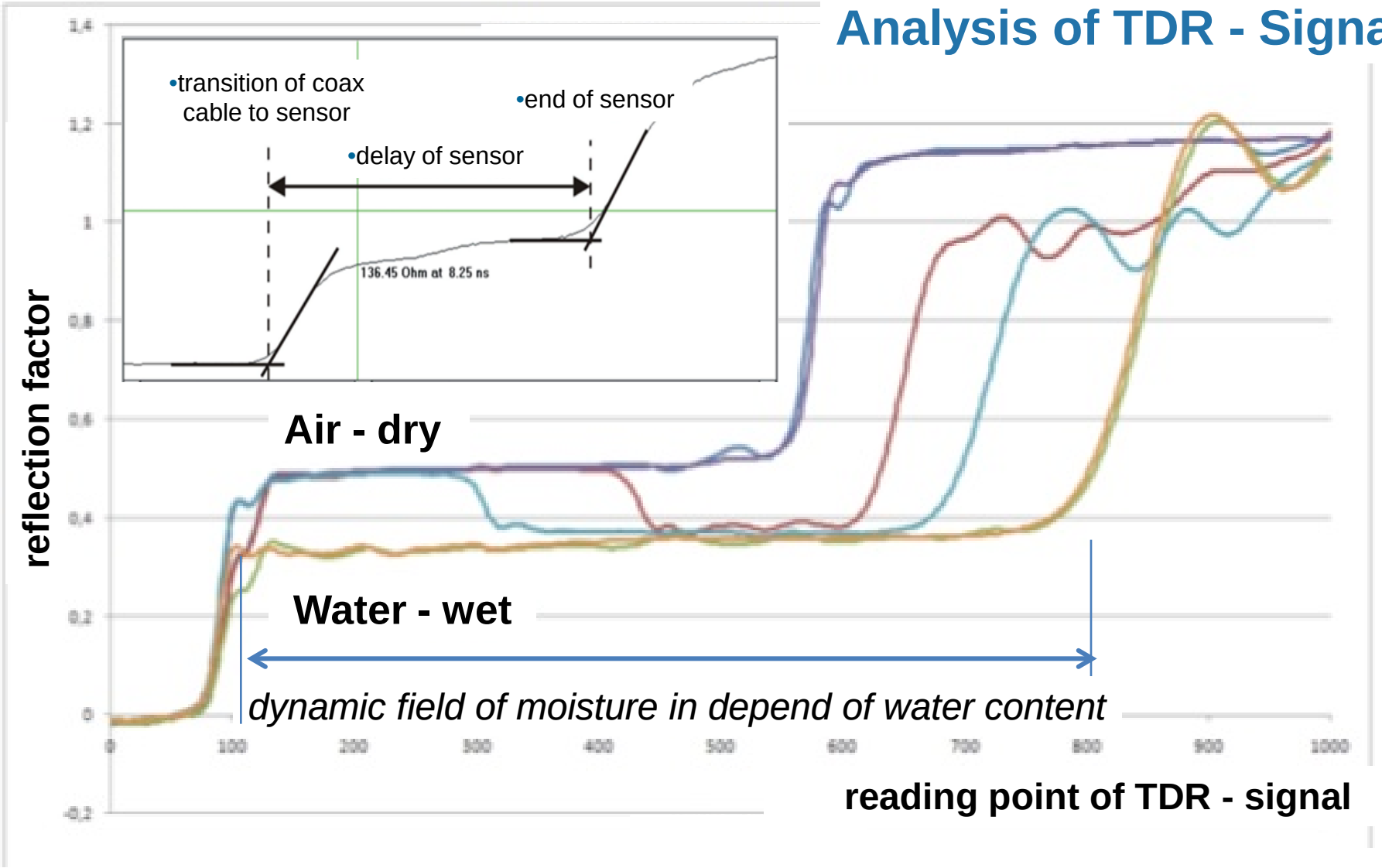
Retrieval of moist sand samples (from 3 to 14m deep in the unsaturated zone)



Installation of Tube-TDR Sensor (down to 13 m deep in the unsaturated zone)

Installation of sucktion caps

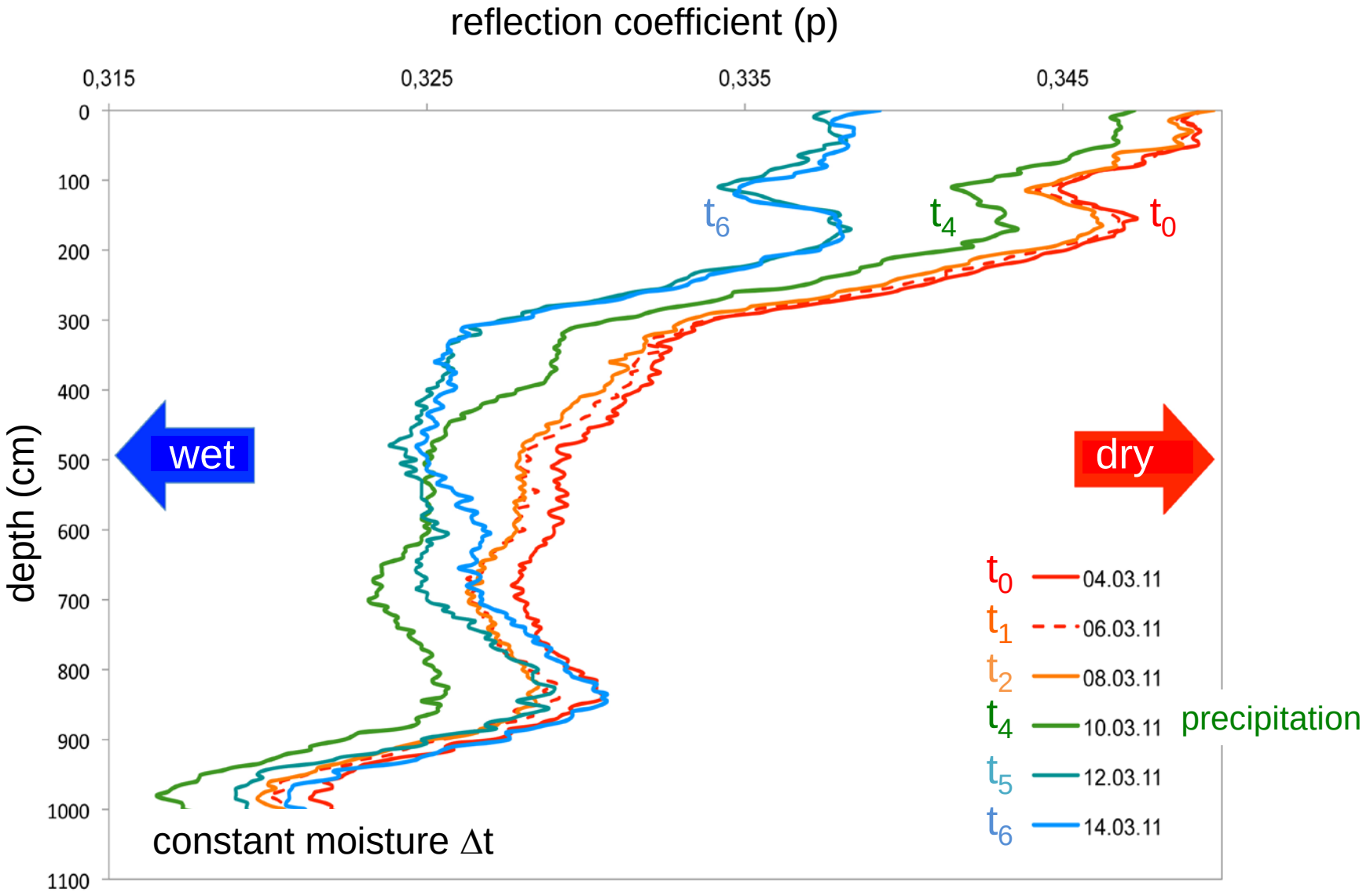
Analysis of TDR - Signal



Estimation of volumetric water content, e.g. Topp et al., 1984:

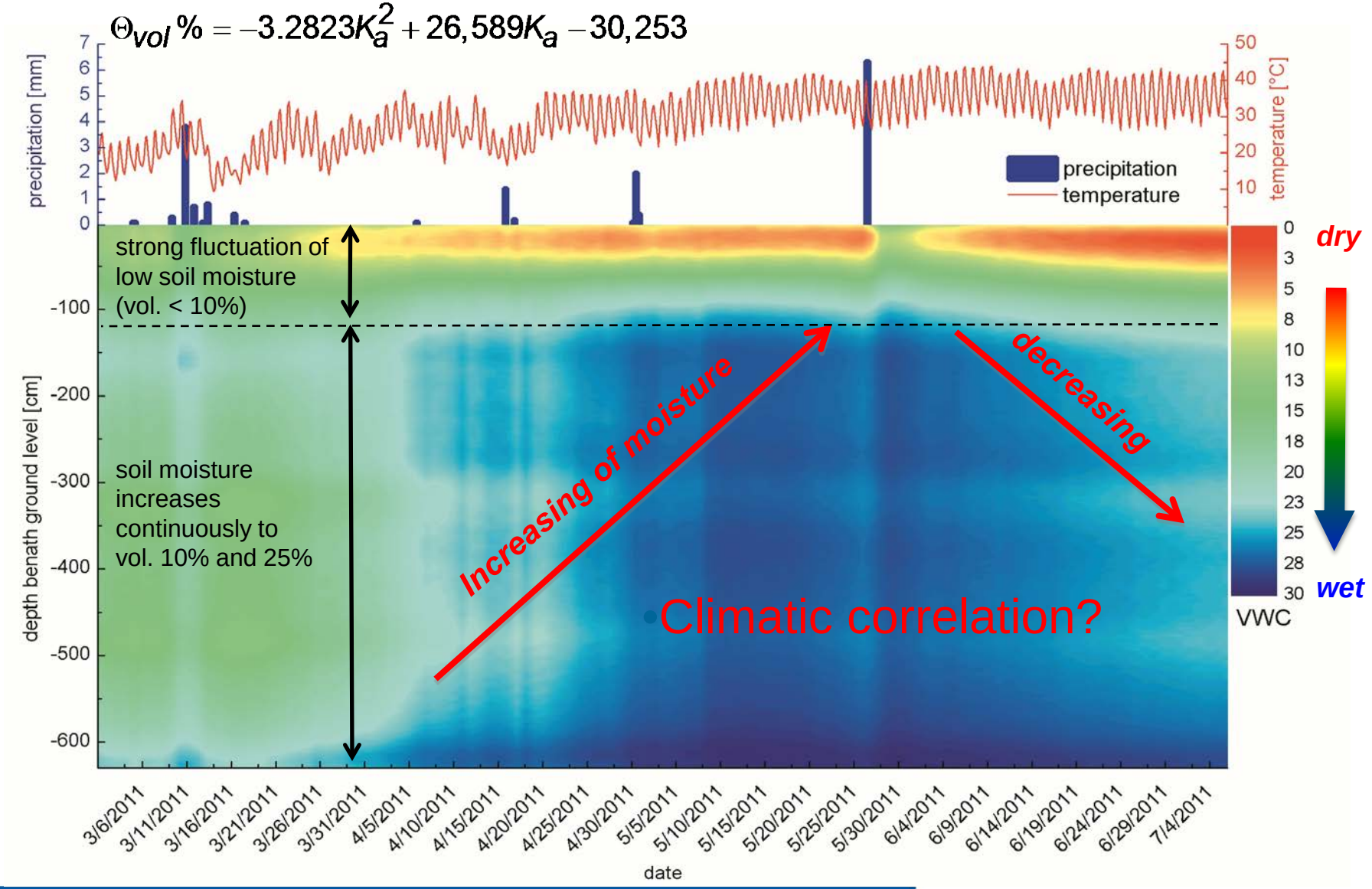
$$\Theta_{vol}\,\% = -5.3\cdot 10^{-2} + 2.92\cdot 10^{-2} K_a - 5.5\cdot 10^{-4} K_a^2 + 4.3\cdot 10^{-6} K_a^3$$

Results of infiltrations front in Ad Dhana Sand dunes



Continuous and high resolution monitoring of vol. water content

- *Preliminary result of volumetric water content (vol.%)*
- converted in VWC (Meier, 2011) by a modified Topp et al. (1984) equation (error 3-5%)

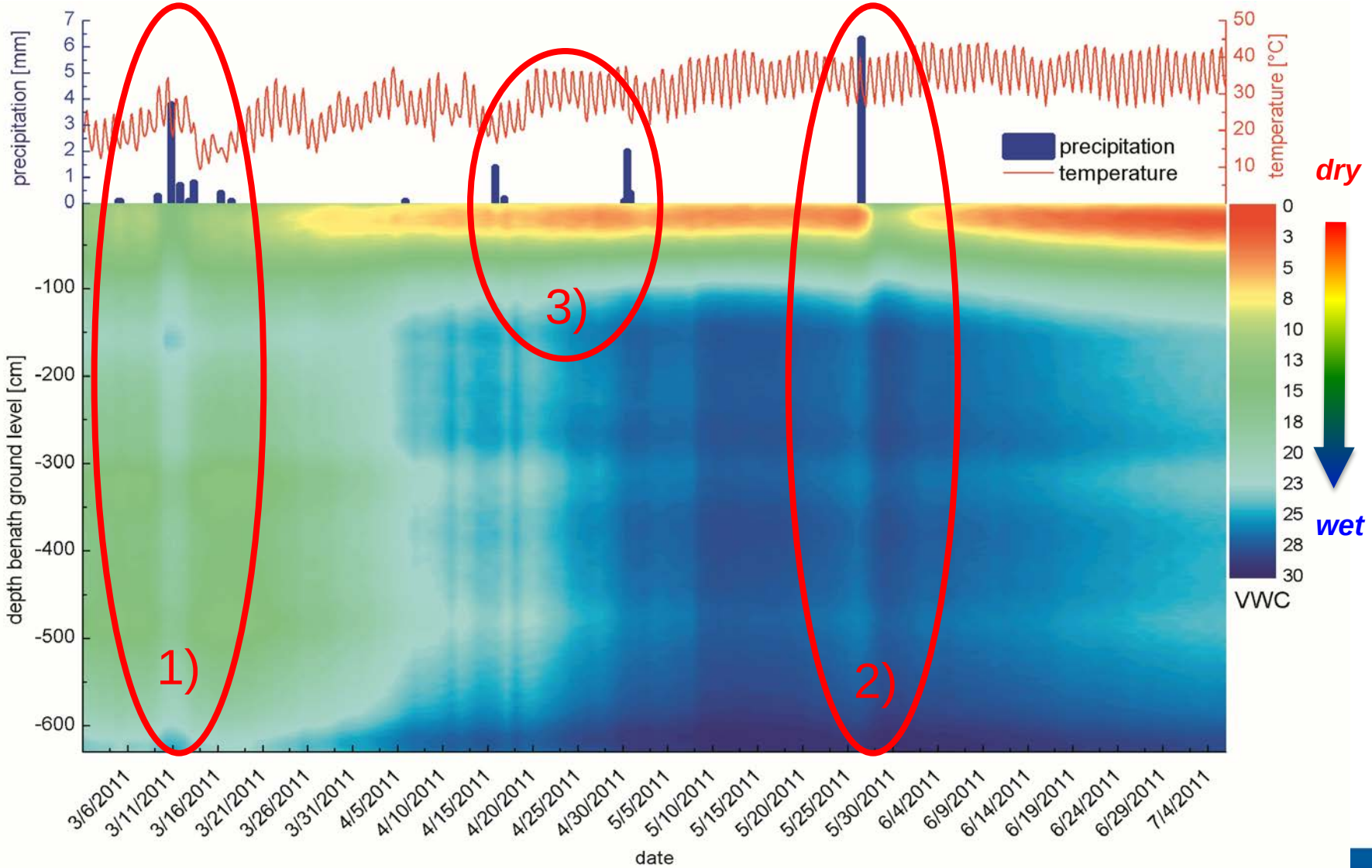


Continuous and high resolution monitoring of vol. water content

1) rain events of less 4 mm/d lead to a slight increase of the moisture content within the first 0.5m

2) rain events of > 4 mm/d lead to a fast downward water infiltration process within the soil column

3) Rain events < 3mm/d lead to no response



Conclusion

- detected moisture down to 14m depth
- observed infiltration fronts as result of precipitation
- continuous high resolution monitoring of vol. water content (VWC)
- solved the estimation of volumetric water content (vol.%) by modified Topp equation (error 3-5%)
- threshold estimation: rain of > 4 mm/day seem to show a fast downward water infiltration process

Acknowledgements

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