→ MWBS | MAPPING WATER BODIES FROM SPACE 2015 CONFERENCE

Monitoring Sahelian ponds water quantity and quality by remote sensing

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Motivations : Why monitoring water bodies in the Sahel ?

Surface water critical to people and livestock

- often the only water resource
- domestic use (including drinking…)
- low infrastuctures, significant poverty, high vulnerability

Hydrology: Sahelian hydrology poorly understood

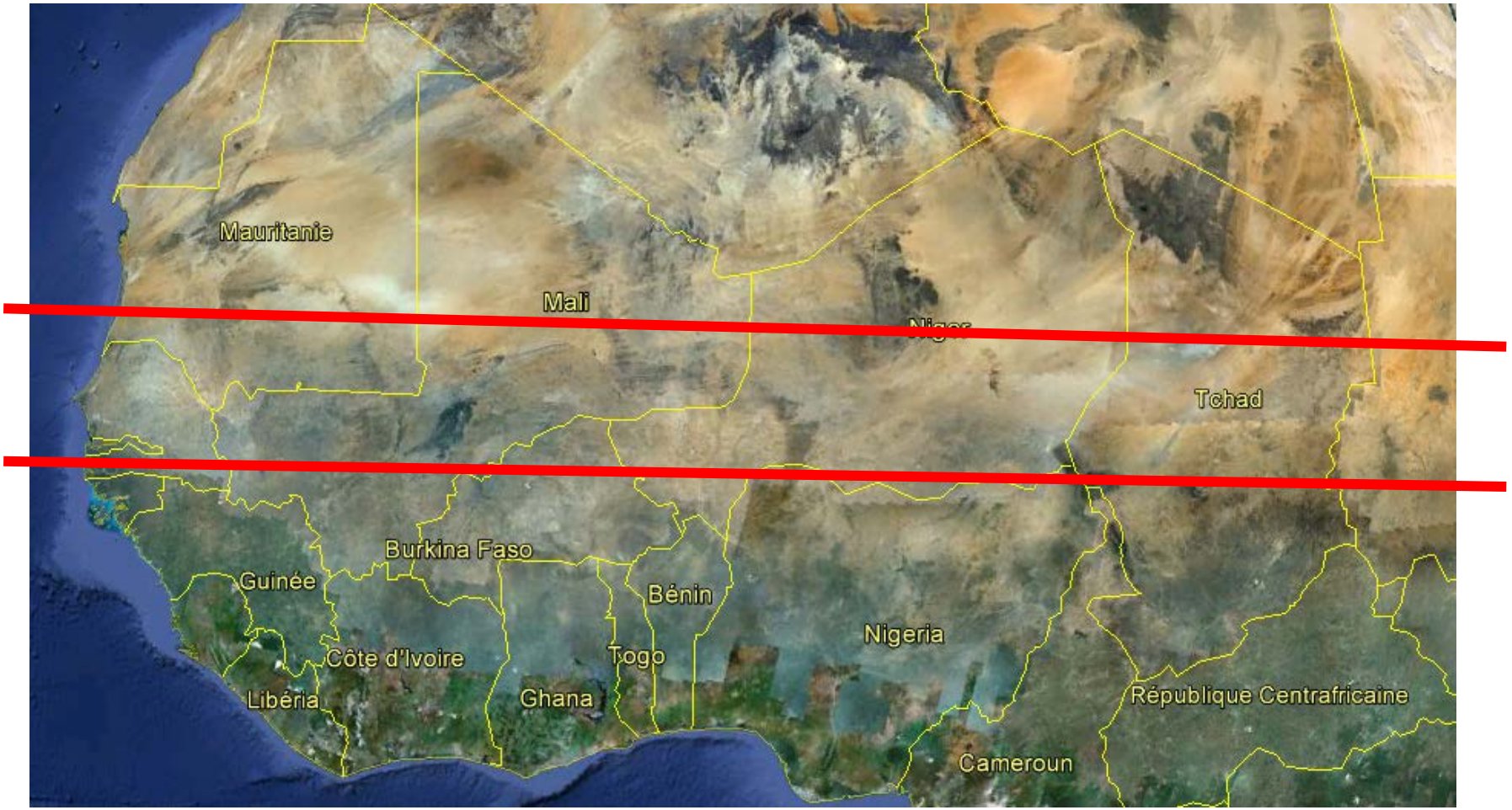
Health: water quality issues, ‘water deseases’

Methane and carbon cycles

Wildlife, various ecosystems services

Low monitoring infrastructures -> remote sensing very useful.

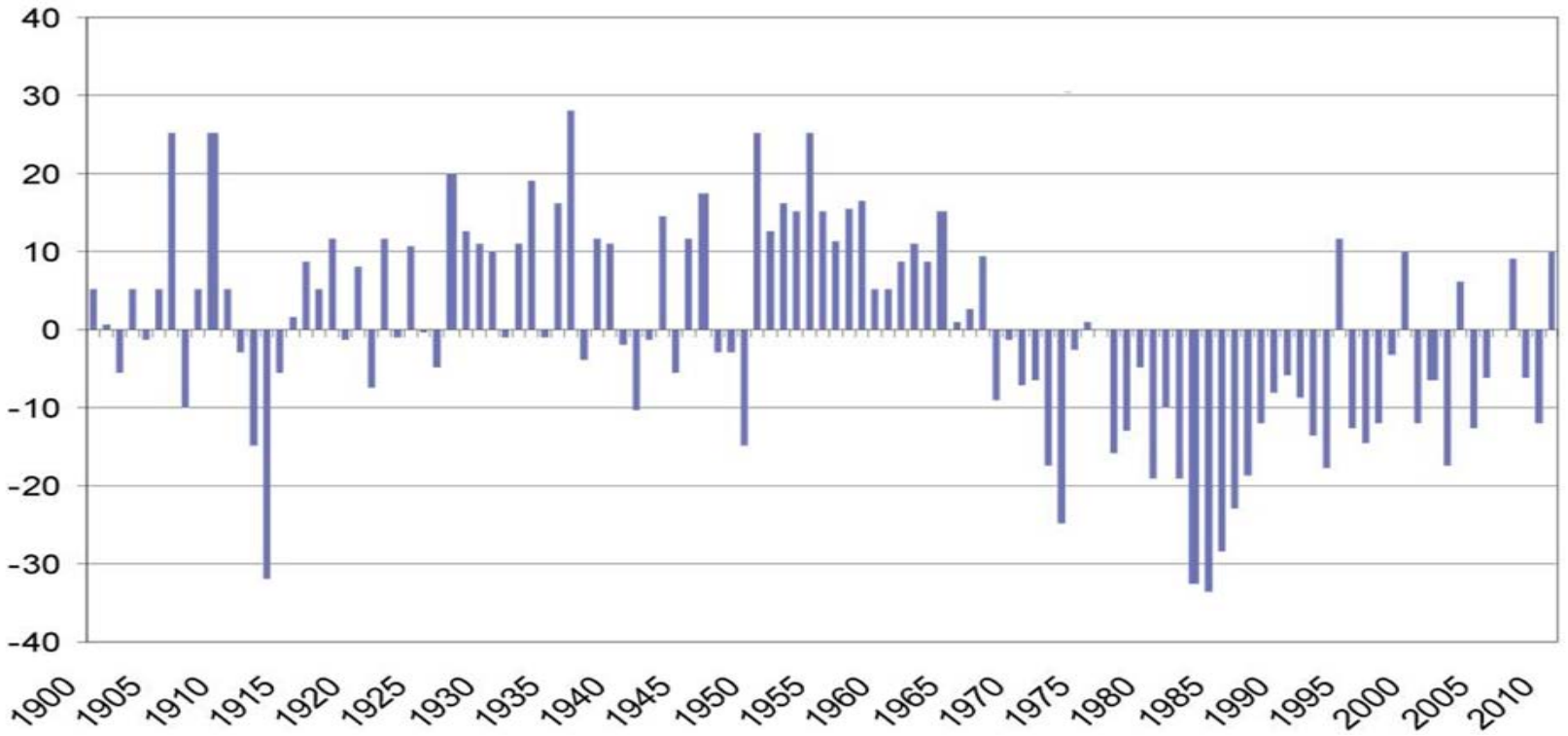
Sahel: 600 to 100 mm/year, 9 month dry season, semi-arid hot area



Largely endorheic (lot's of ponds), a few rivers

Niger and Senegal just 'visit' Sahel, with almost no contribution from Sahel

Sahelian Hydrology :



Largest mutidecadal drought in 20th century

Expected consequence: strong reduction in river flow and water bodies surface beween the wet 50-60 ies and the dry 70-80-90

Sahelian Hydrology :

Expectation WRONG ! (as well as all large-scale models ?)

Less rain, but :

Increased surface runoff (seen as soon as 1985 in Burkina, Albergel)
Rising water table in SouthWest Niger (continuous 1990-present)
because of increase of waterflow in gullies, more infiltration
Increasing river flow and runoff coefficient in all surveyed Sahelian rivers (1980-present)
Increase red flood of the Niger

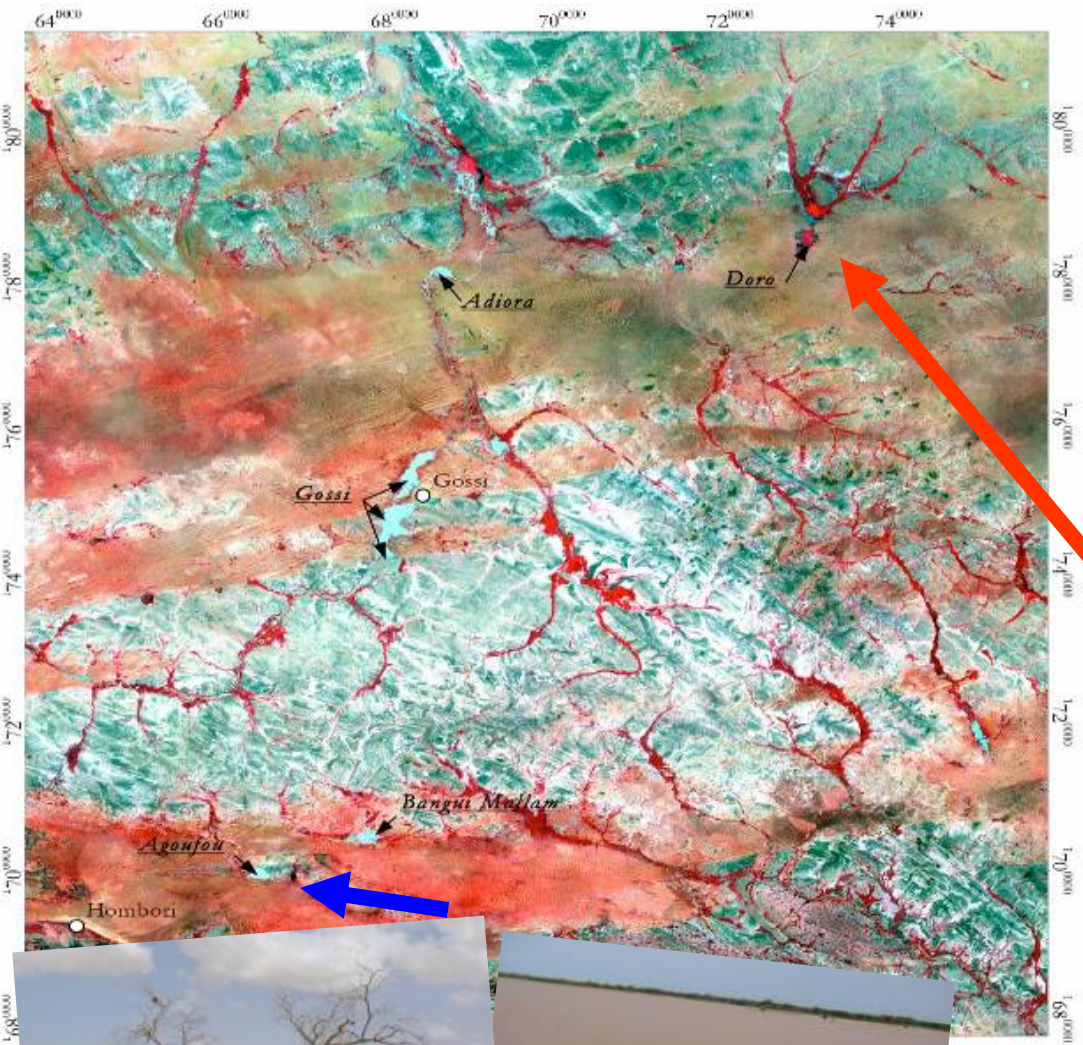
Leduc, Favreau, Descroix Mahé, Amogu et coll.

Generally attributed to increasing crop area.

What happened to water bodies ?

What happened to un-cultivated Sahel ?

What are the processes ?



Rain = 350 mm / year

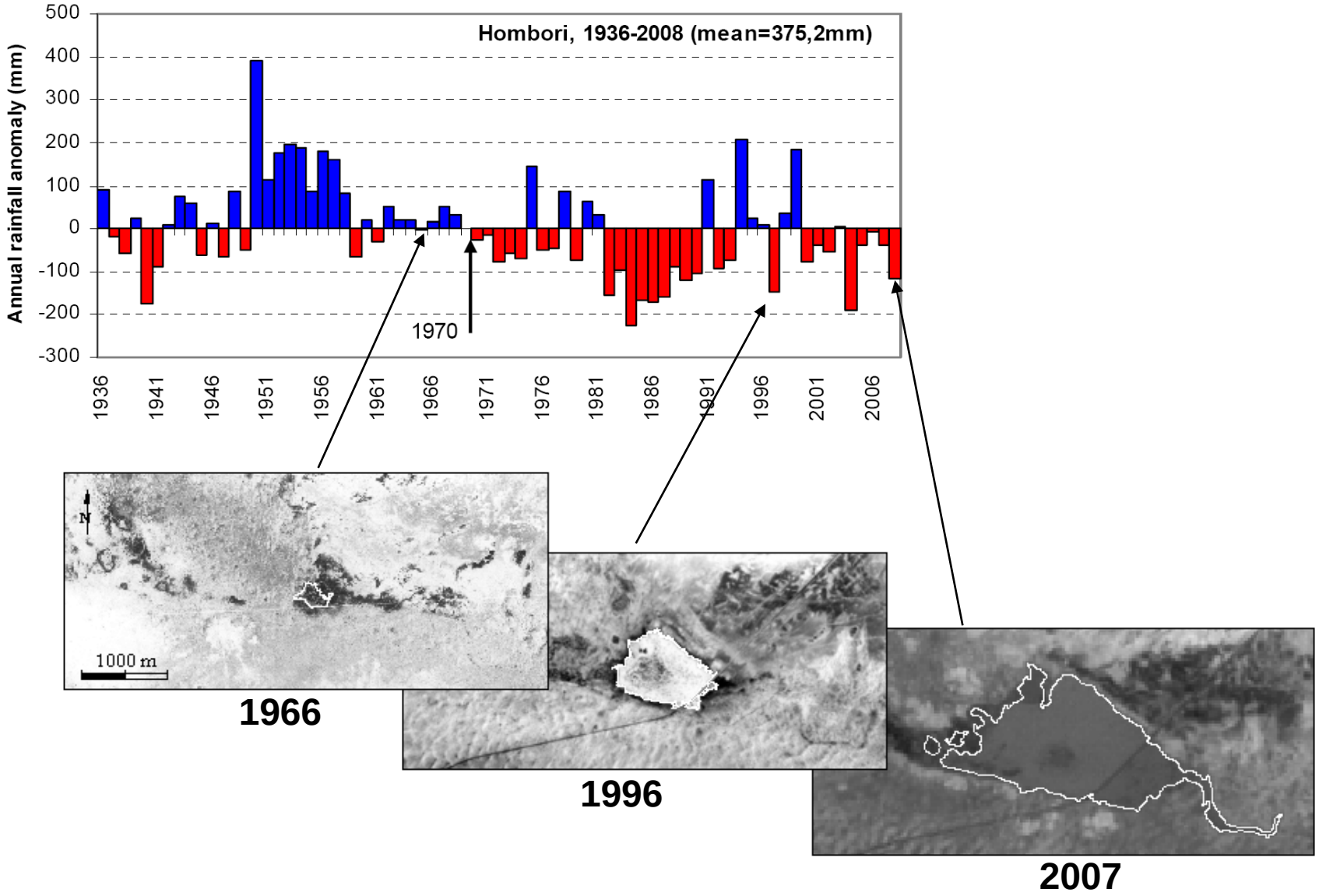
Runoff on shallow soils (35%) feeds ponds

No runoff on deep sandy soils

Shallow ponds of various size, flat terrain

Method: Compilation of (all) remote sensing data, aerial pictures

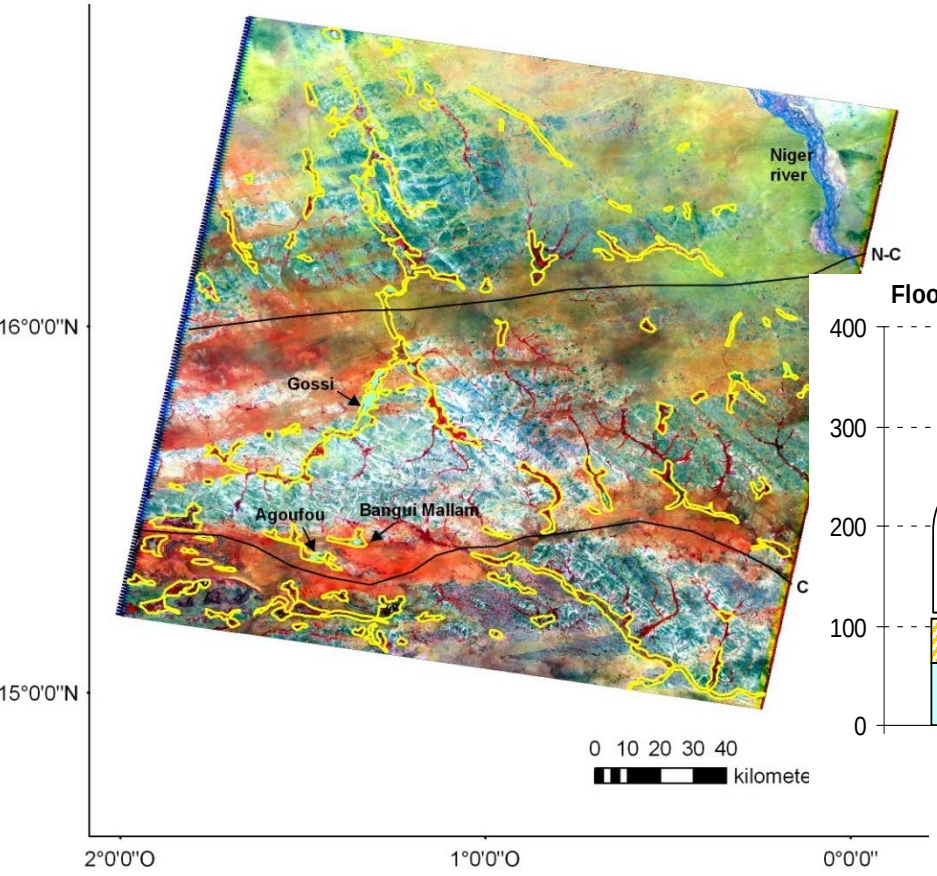
Results: The striking case of the Agoufou pond (AMMA supersite)

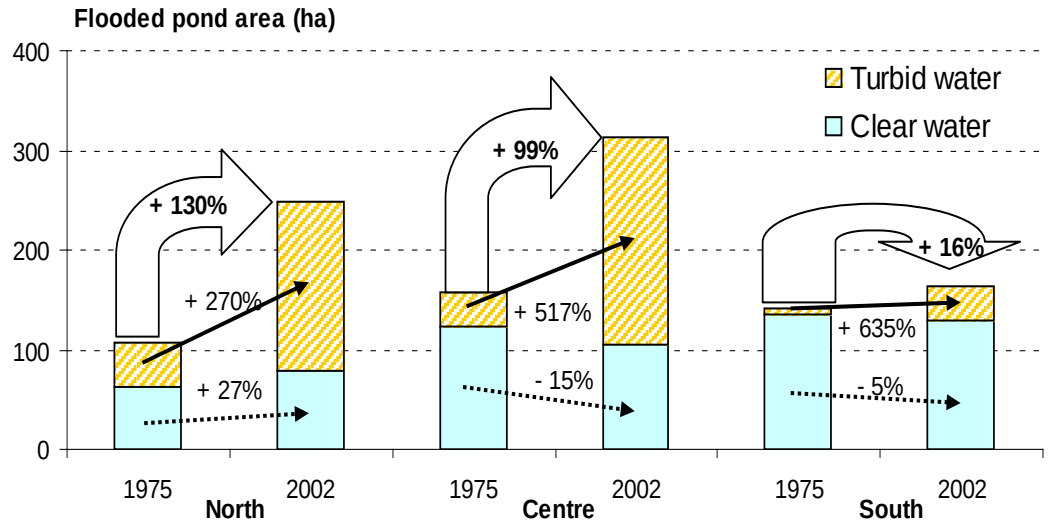


A regional phenomenon

landsat scenes 1975 – 2002

91 ponds classified

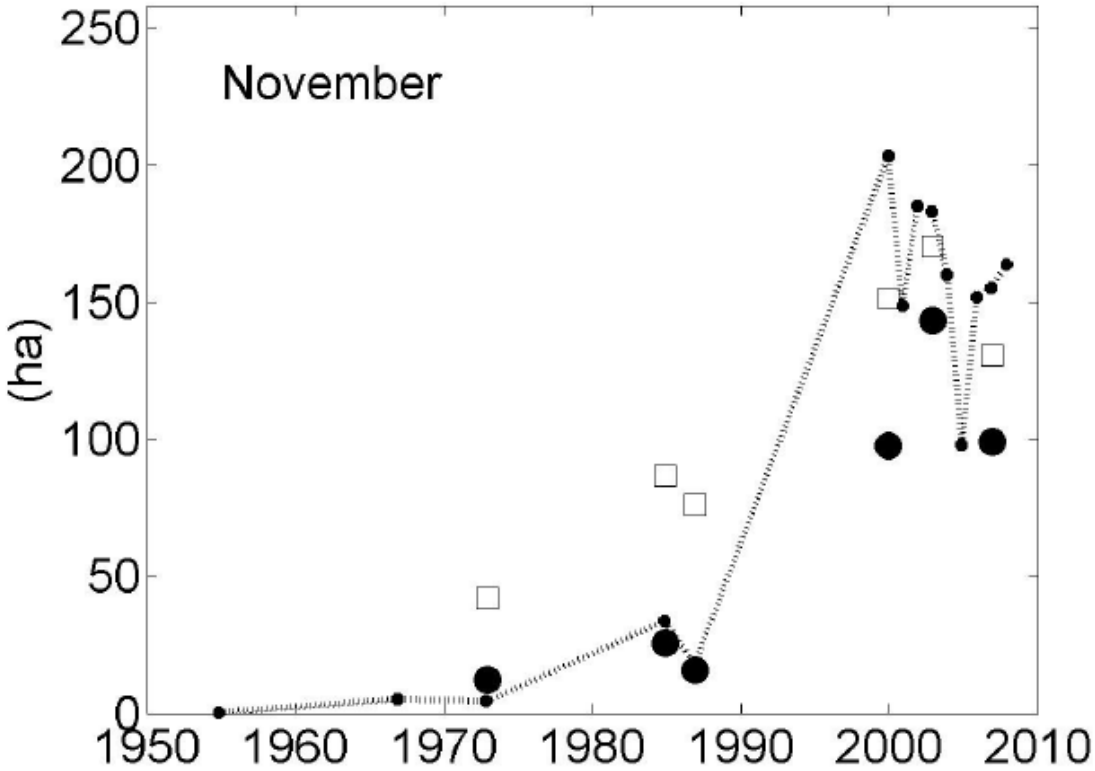




General increase of ponds surface all over the region : + 98 % (Gardelle et al 2010 HESS)

Mostly turbid ponds increased

Results: the Regional view for the Gourma



Strong increase of ponds' surface in the dry last 30 years, compared to the wet 50-60'. Acceleration in the early 90'.

Sahelian paradox holds for uncultivated Sahel

Processes still uncertain, a plant-runoff-gully-erosion story.

Sahelian hydrology: From surface to volume

Need some information on water level

in situ

prior shape equation

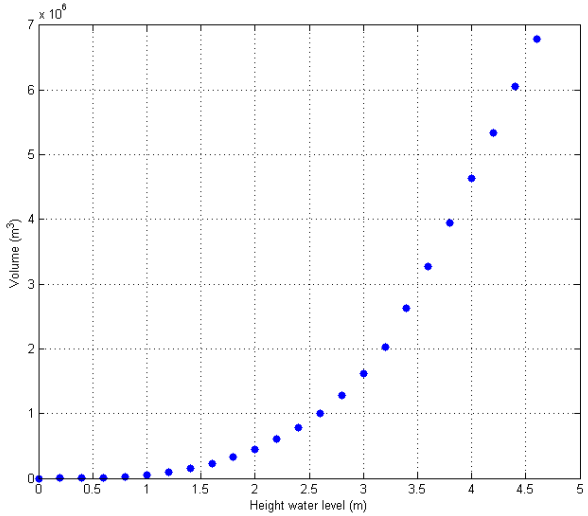
(all ponds are conical, but some more conical than others)

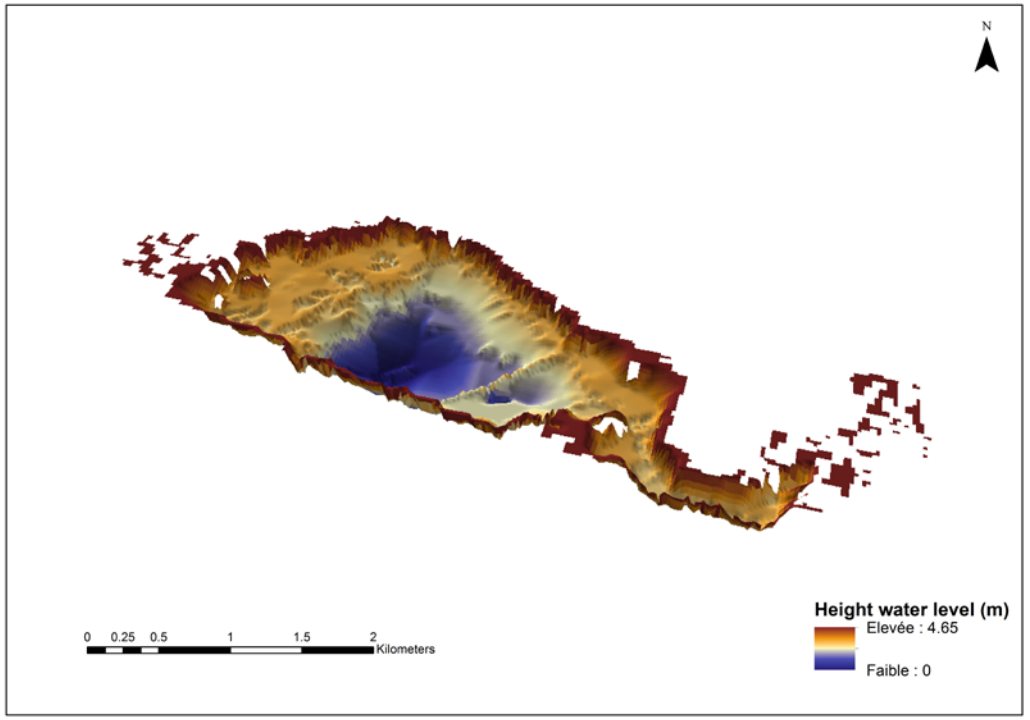
futur wide-swath altimeter (SWOT)

A series of high/moderate resolution images Formosat, Landsat, Spot

-> 3D shape of the pond

H, S, V relations

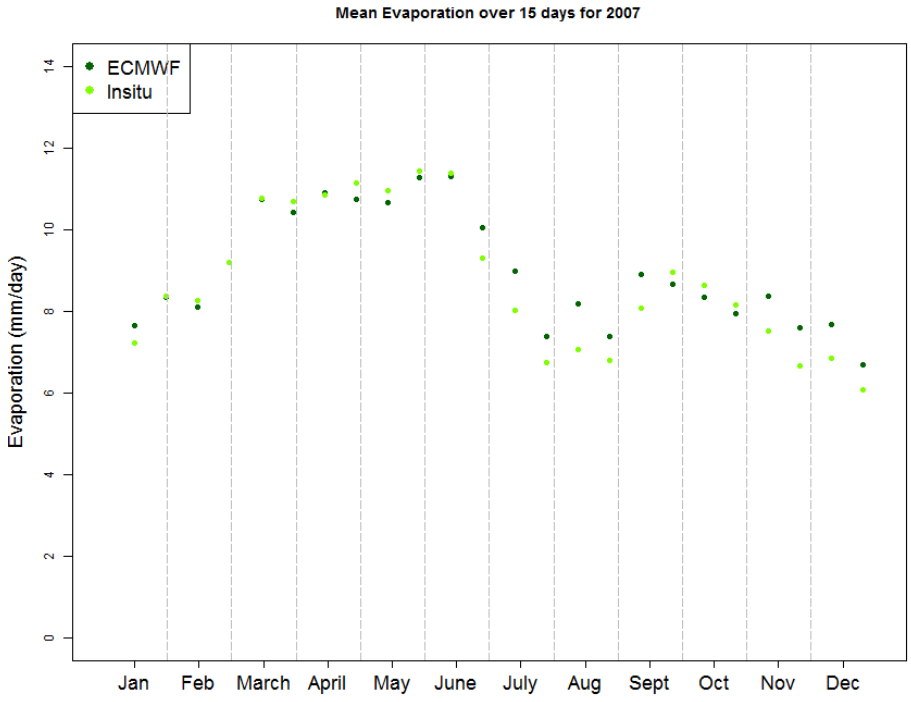


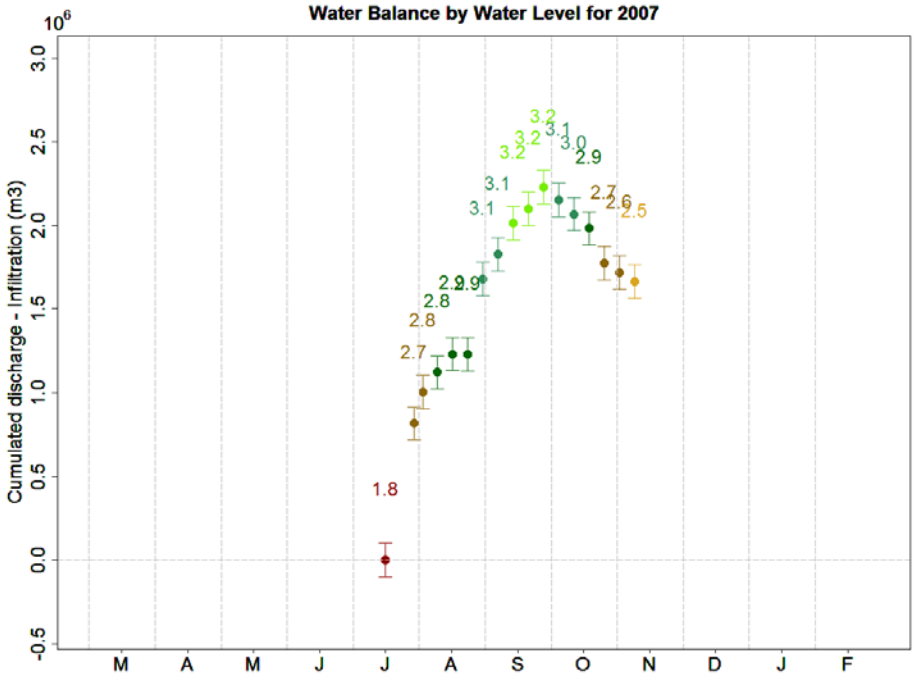


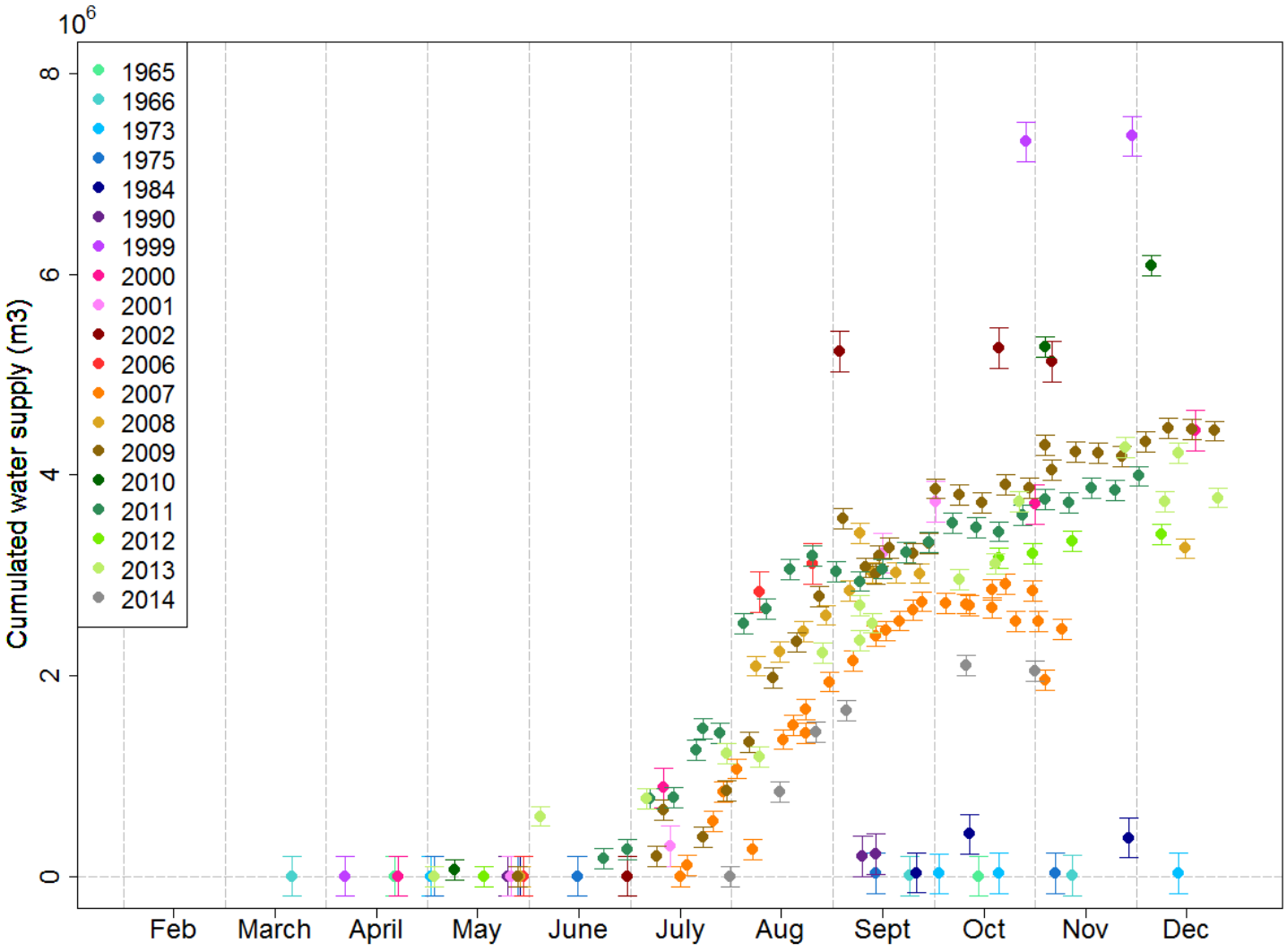
Sahelian hydrology: From volume to discharge

Pond's water balance : dV/dt = P – E + Discharge - Infiltration

Integration between two dates / images gives cumulated discharge to the pond







Laetitia Gal PhD thesis

Some lessons from ponds surface/volume monitoring

Open water surface fairly easy

Flooded vegetation may be tricky.

- - > SWIR helps
- -> high resolution helps (fewer mixed pixels)
- -> frequent data help (shallow flooded vegetation short lived, interpolated)

Sahelian ponds are small: 30 m or less is fine.

1988-1998 large gap in Landsat data (USGS, ESA)

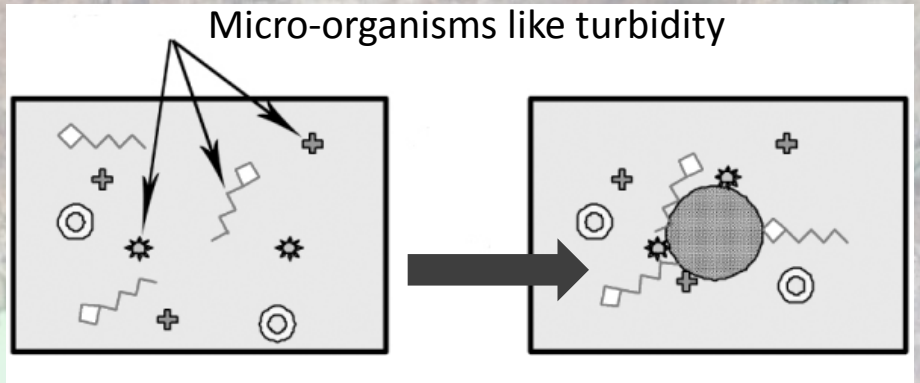
- -> fill with SPOT (ERS for larger ponds ?)
- -> encourage multi-sensor products
- -> are there lost data somewhere ?

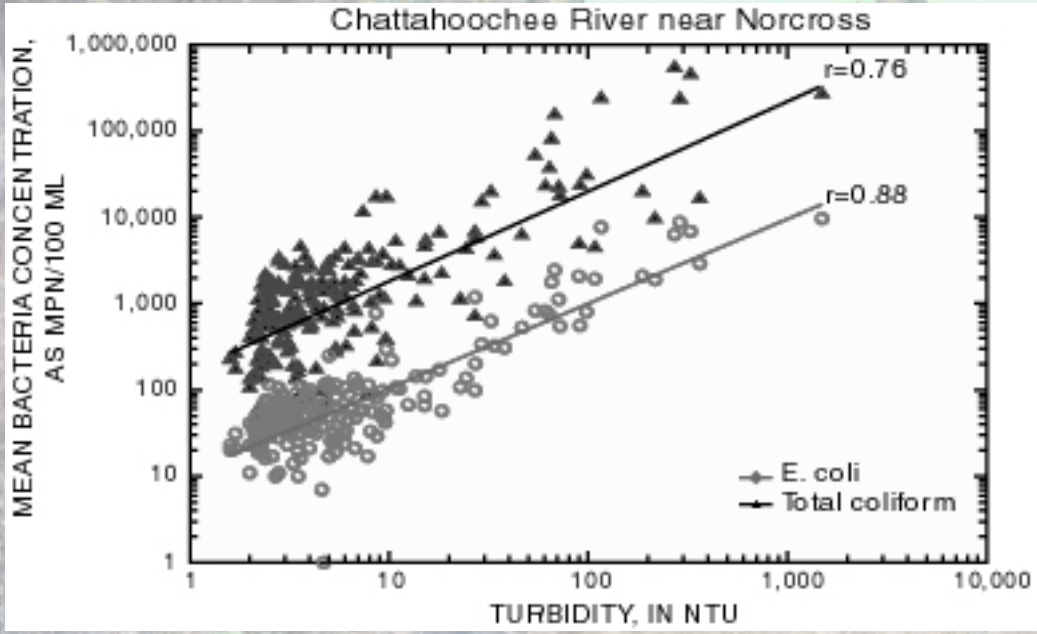
SWOT + S2/L8 ideal for surface + volume assessment !

Sahelian ponds are shallow, forget large-scale DEM …

Water bodies products more numerous than Sahelian validation sites ?

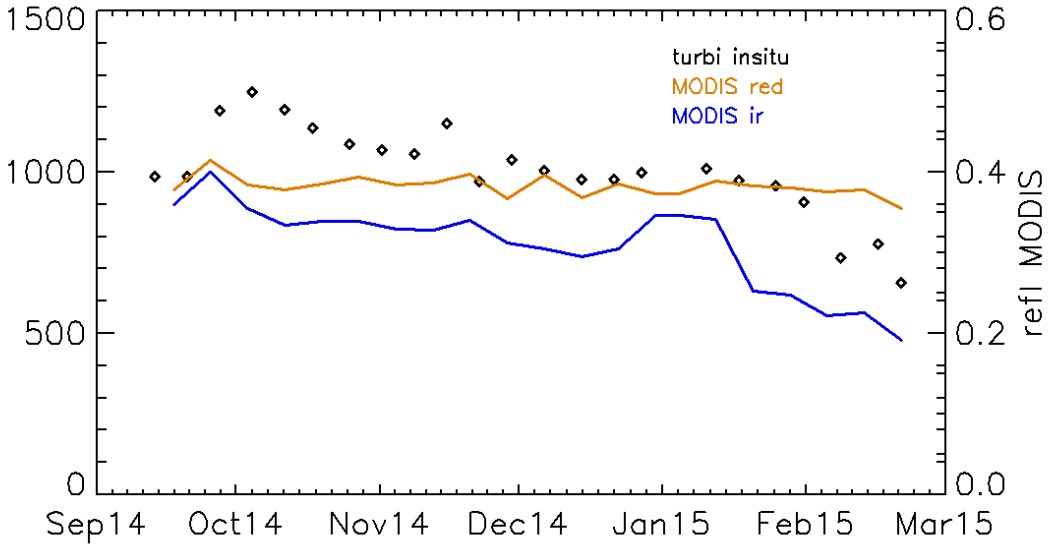
On going research : turbidity and health issues





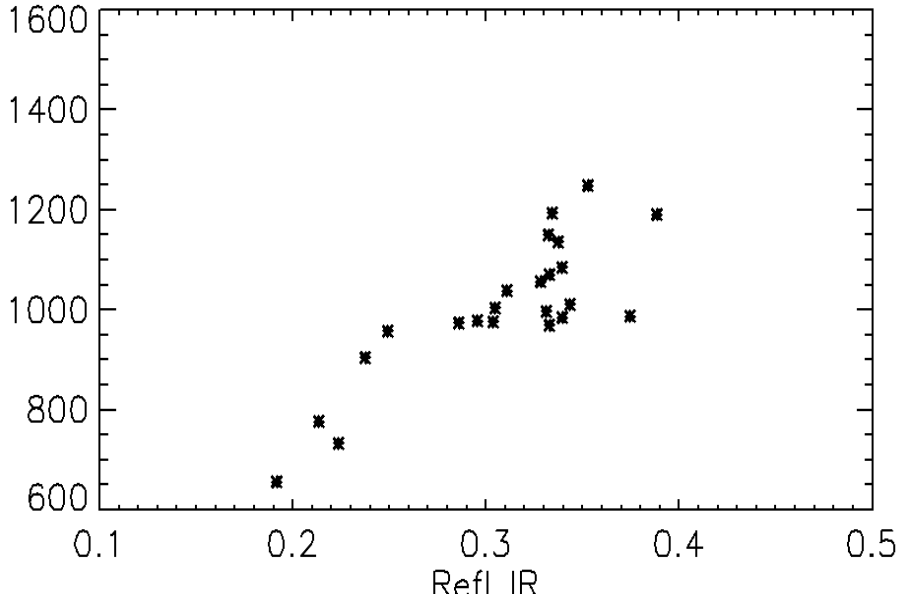
Georgia Water Science Center

Matching in situ turbidity with MODIS, Landsat, SPOT reflectance

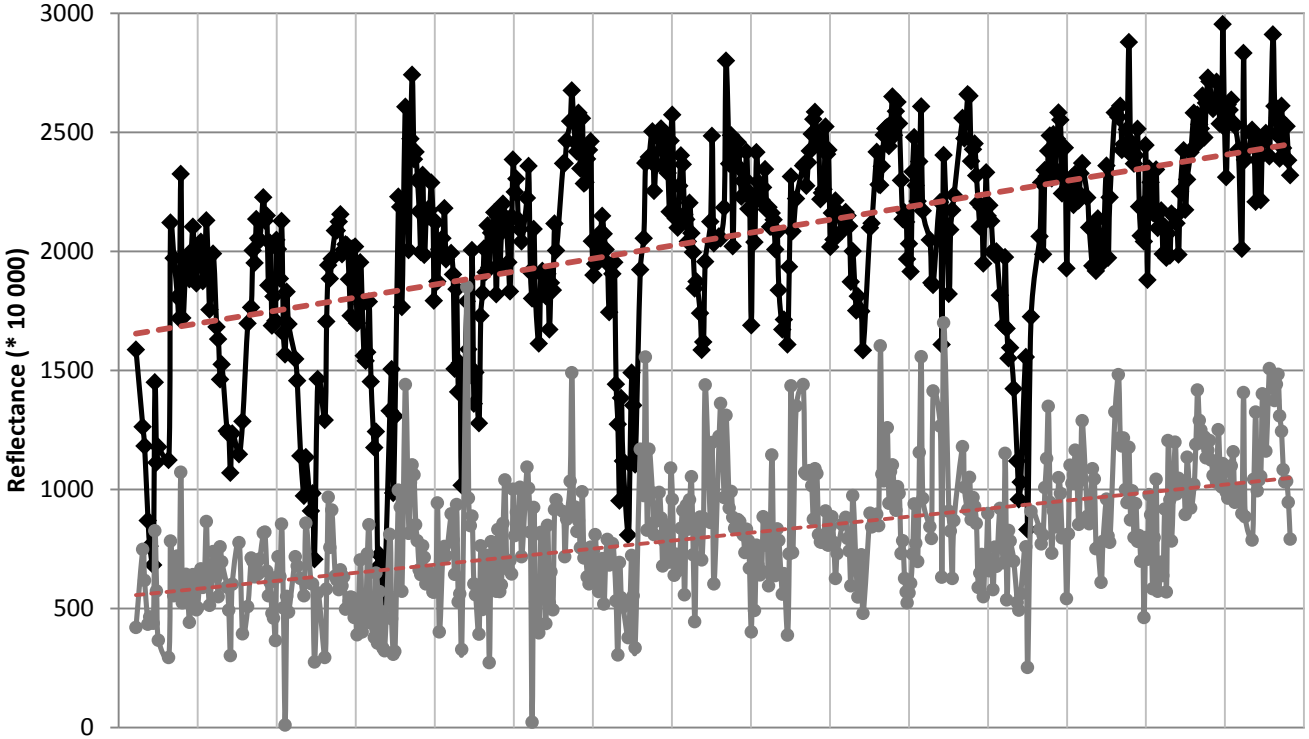


The Very Turbid Agoufou pond

Preliminary results
Grippa, AMMA-CATCH observatory



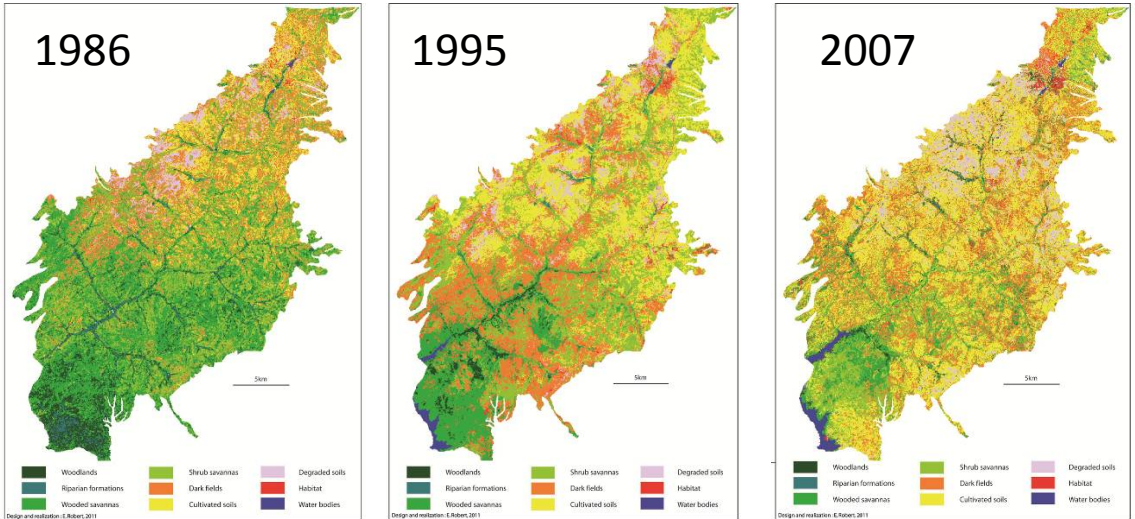
Bagre lake, Red & Infra-red Reflectance



Planned trip July 2015
SPOT take 5

In situ spectrometry
In situ SPM, turbidity
In situ health survey

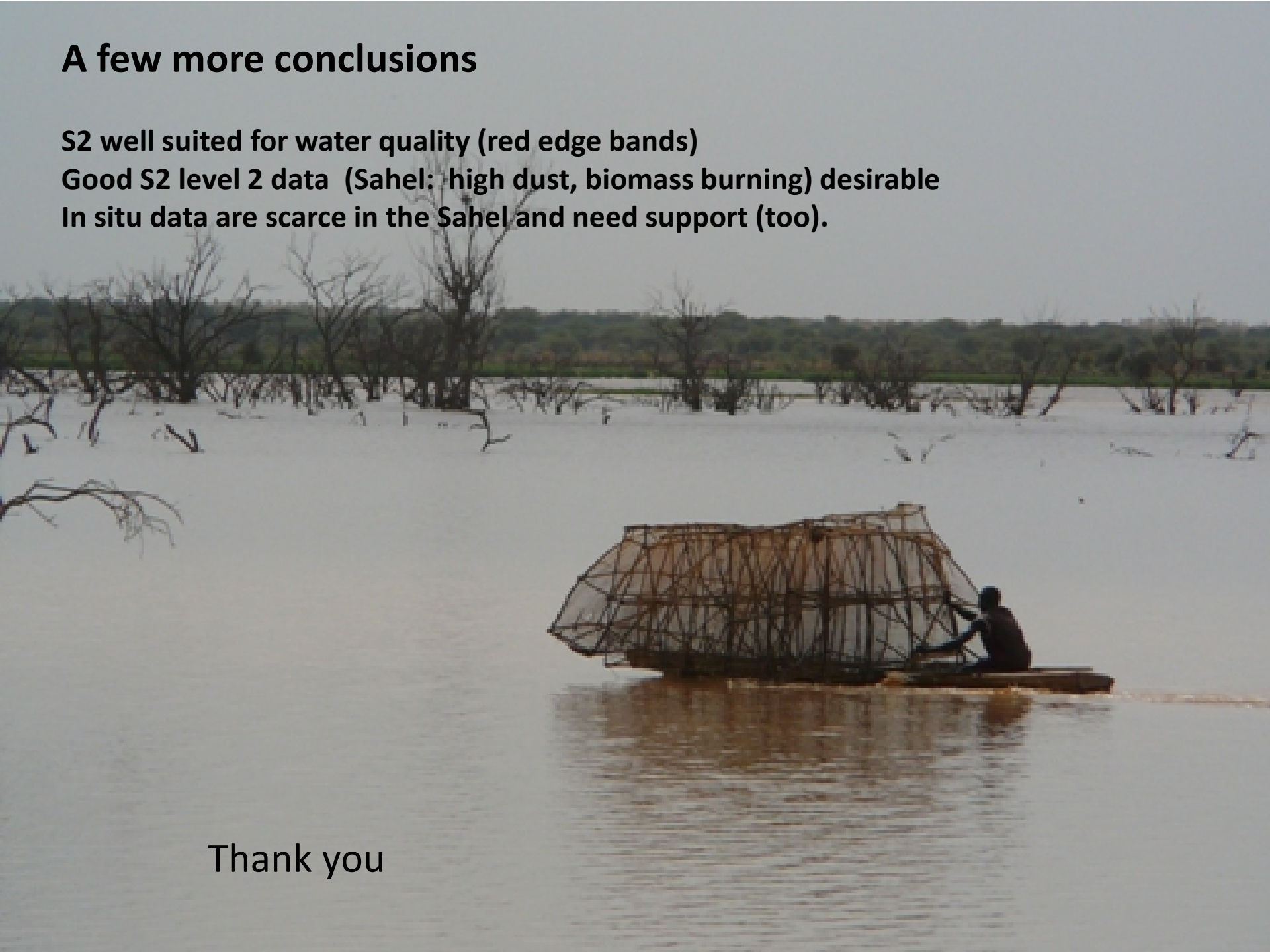
Radiance modeling
Tests of J.M.Martinez algorithm
(Poster)



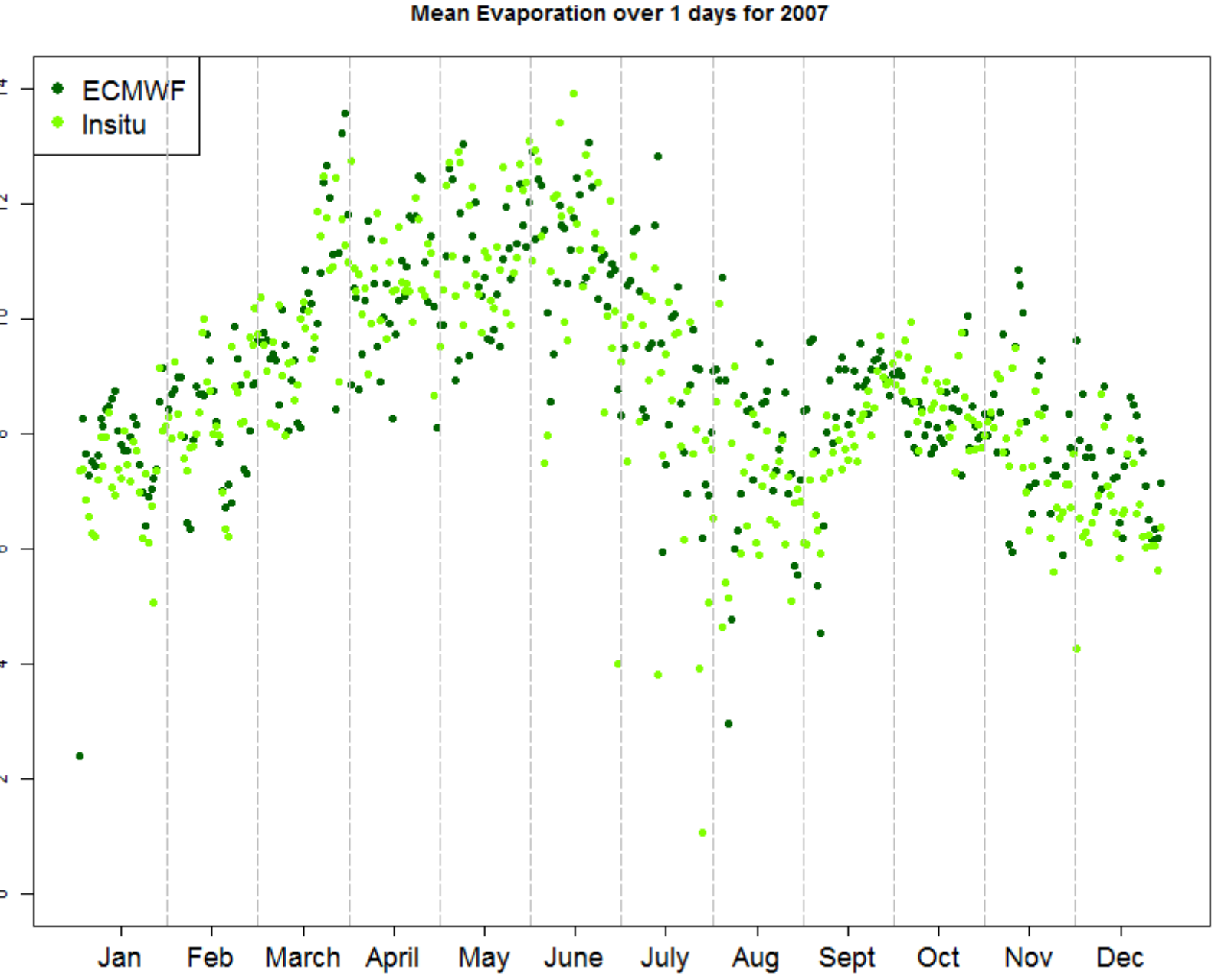
Elodie Robert postdoc. CNES
Support from PNTS

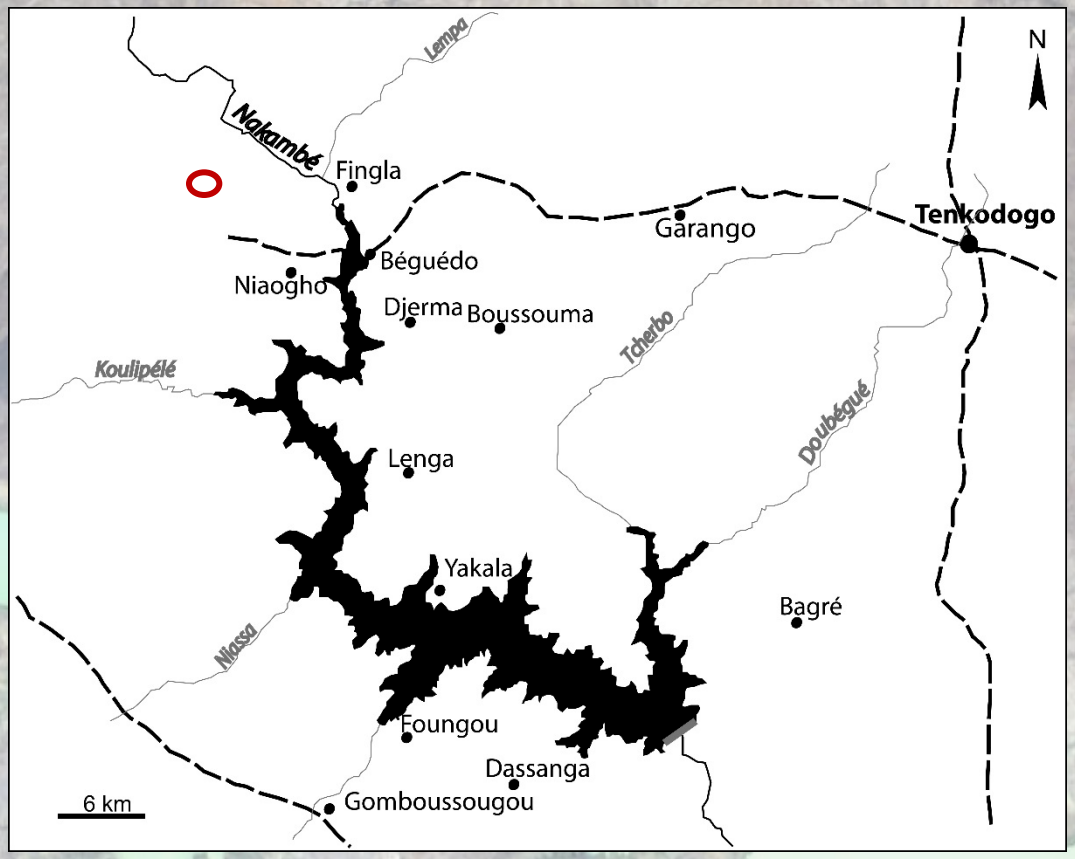
A few more conclusions

S2 well suited for water quality (red edge bands)
Good S2 level 2 data (Sahel: high dust, biomass burning) desirable
In situ data are scarce in the Sahel and need support (too).



Thank you


Mean Evaporation over 1 days for 2007
ECMWF
Insitu
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec


N
Lampa
Nakambé
Fingla
Garango
Tenkodogo
Béguédo
Niaogho
Djerma
Boussouma
Tcherbo
Koulipélé
Doubégué
Lenga
Yakala
Bagré
Niassa
Foungou
Dassanga
Gomboussougou
6 km

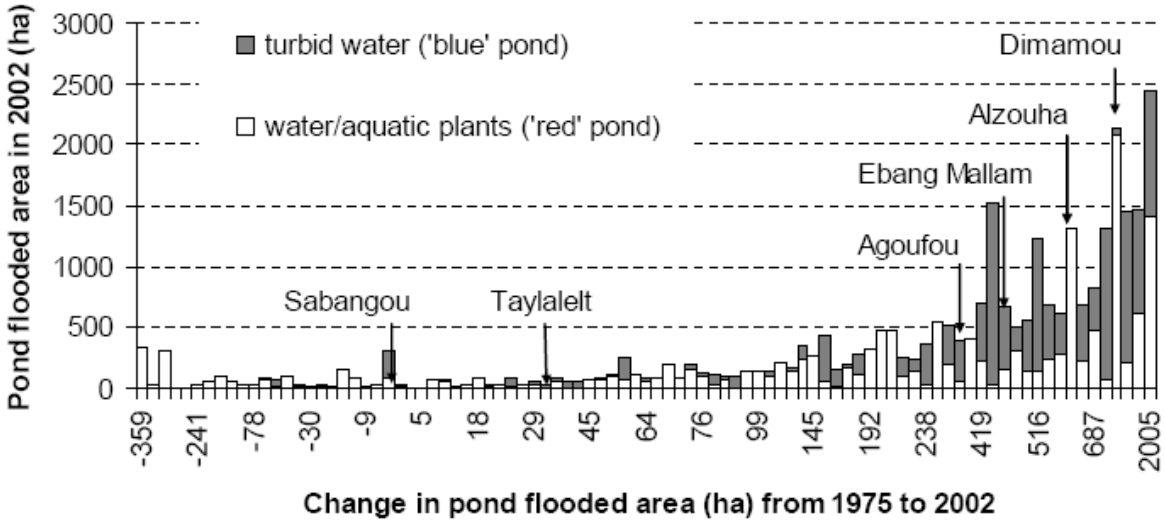


Fig. 10. The 91 ponds of central Gourma ranked by the absolute value of the change in flood area between 1975 and 2002 (x-axis, negative values indicate decrease in flood area, positive value increase), in relation with the area covered by the pond in 2002, separated into turbid water without vegetation ("blue" pond) and less turbid with aquatic vegetation ("red"pond).

Gardelle et al. 2010