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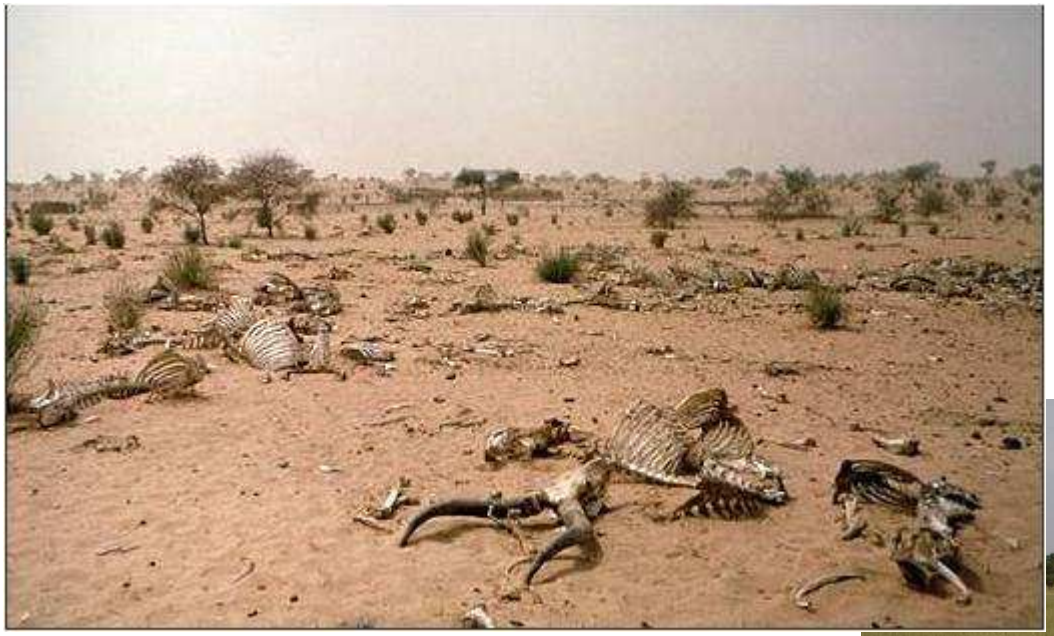
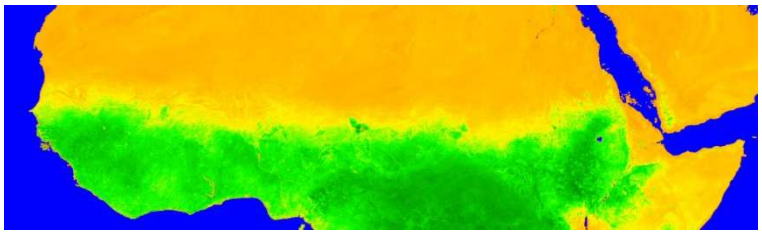
POTENTIALS FOR DETECTING CANOPY WATER STRESS USING GEOSTATIONARY MSG-SEVIRI SWIR DATA





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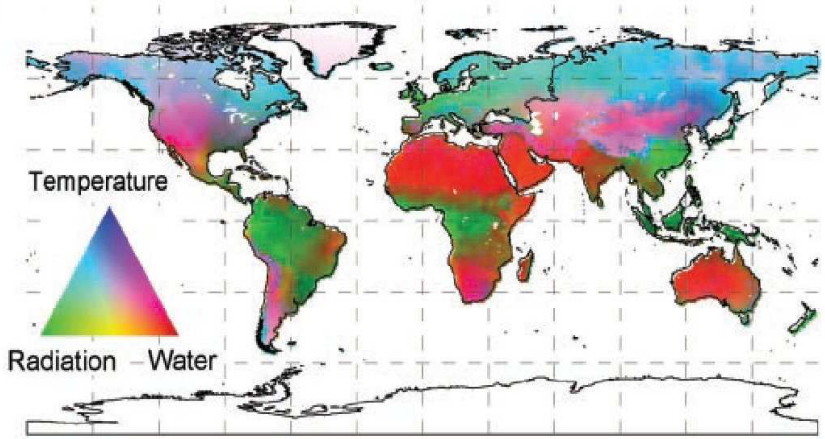
University of Copenhagen, Denmark

Co-workers; Silvia Huber*, Simon R. Proud*, Mads O. Rasmussen*, Inge Sandholt, Simon Stisen**, Cheikh Mbow, UCAD Senegal

Water; primary potential climatic constraint to plant growth (40% of Earth's Terrestrial Surface)



Potential climatic constraints to plant growth. Nemani *et al*. (2003)

Outline:

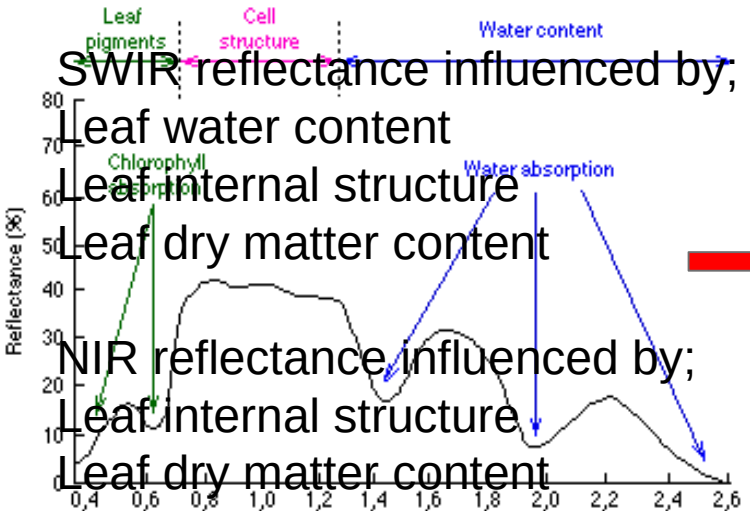
- EO-based Canopy Water Stress detection
- In situ measured Canopy Water Stress
- Results & validation
  - from point observations
  - validation in the spatial domain

EO-based Canopy Water Stress detection

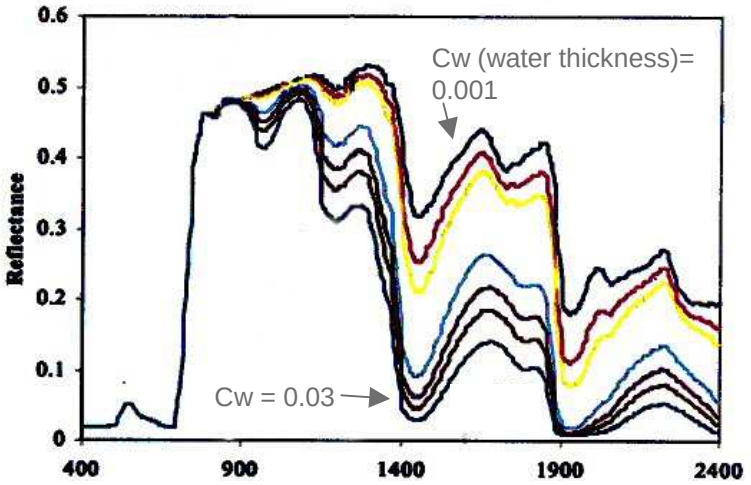
Absorption by leaf water occurs in SWIR
- Shortwave infrared reflectance is negatively related to leaf water content
- Increased reflectance in SWIR is the most consistent leaf reflectance response to plant stress in general, including water stress.

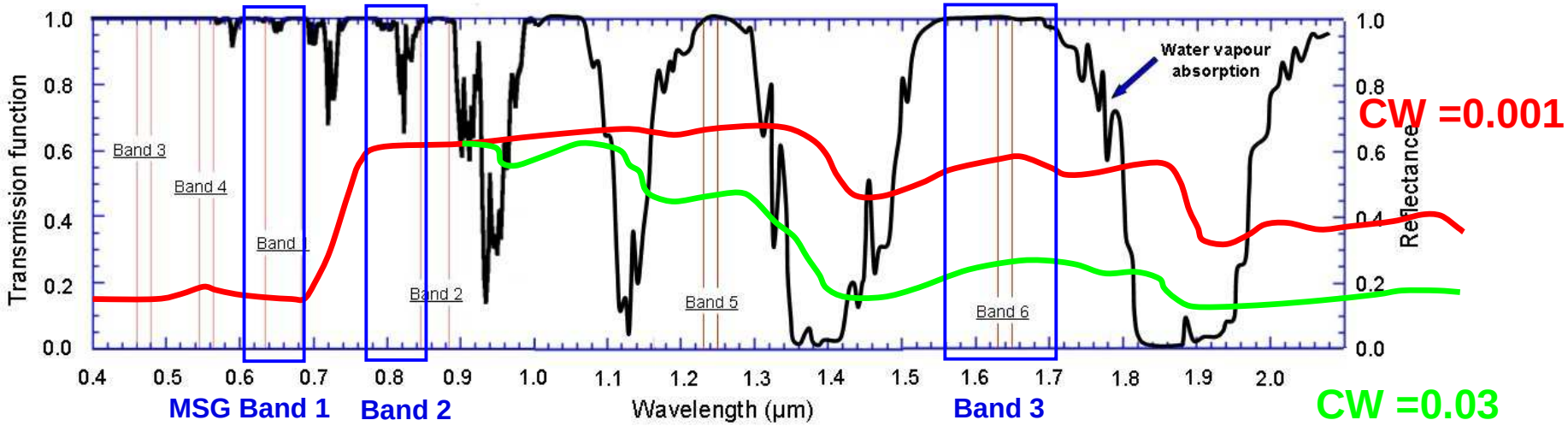
SWIR reflectance influenced by;
Leaf water content
Leaf internal structure
Leaf dry matter content

NIR reflectance influenced by;
Leaf internal structure
Leaf dry matter content



Prospect+Sail models; Zarco-Tejada and Ustin 2001





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EO-based Canopy Water Stress detection
- Water Stress index development

Physically based studies;
Tucker, 1980;
Fourty and Baret, 1997

Laboratory measurements;
Hunt, Rock, & Nobel, 1987
Carter, 1994

Physically – Emperically applied to sat sensors…

Hunt and Rock, 1989 – Landsat TM	Moisture Stress Index	$\mathrm{MSI} = \frac{\mathrm{Band\ 6}}{\mathrm{Band\ 4}}$
Gao, 1996 - AVIRIS	Normalized Difference Water Index	$\mathrm{NDWI} = \frac{\mathrm{Band\ 4} - \mathrm{Band\ 5}}{\mathrm{Band\ 4} + \mathrm{Band\ 5}}$
Serrano, Ustin, Roberts, et al., 2000 - AVIRIS		
Zarco-Tejada and Ustin, 2003 - MODIS	Simple Ratio Water Index	$\mathrm{SRWI} = \frac{\mathrm{Band\ 4}}{\mathrm{Band\ 5}}$
Ceccato et al., 2001; 2002 - SPOT VGT.		
Fensholt and Sandholt, 2003 - MODIS	Shortwave Infrared Water Stress Index	$SIWSI = \frac{Band\,6 - Band\,2}{Band\,6 + Band\,2}$
Rubio et al., 2006 - MODIS	Normalized Difference Water Index 7	$\mathrm{NDI7} = \frac{\mathrm{Band\ 4} - \mathrm{Band\ 7}}{\mathrm{Band\ 4} + \mathrm{Band\ 7}}$
Trombetti et al., 2008 – MODIS	Shortwave Infrared Ratio	$\mathrm{SWIRR} = \frac{\mathrm{Band\ 6}}{\mathrm{Band\ 7}}$
Fensholt et al. 2010 – SEVIRI MSG	Shortwave Infrared Water Stress Index	$SIWSI = \frac{Band\,3 - Band\,2}{Band\,3 + Band\,2}$

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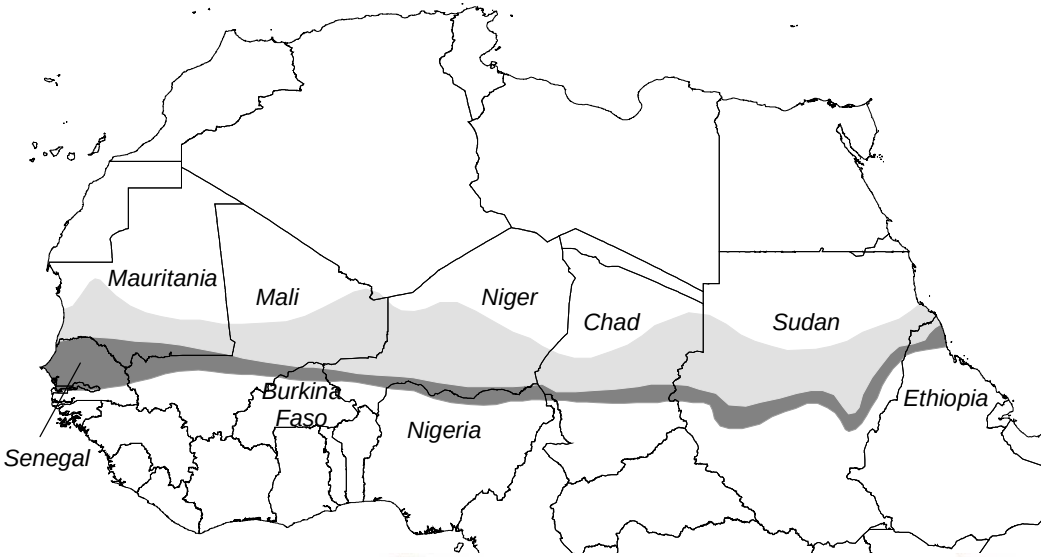
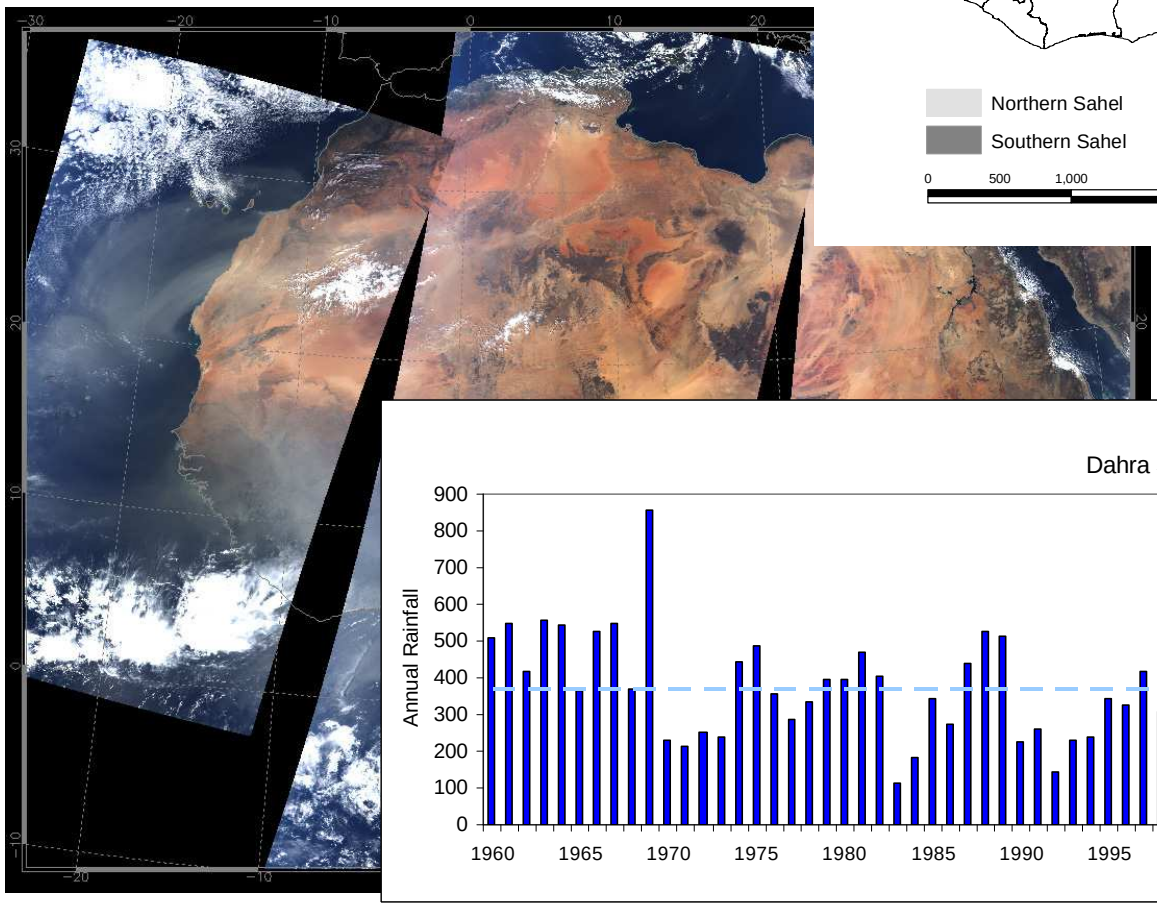
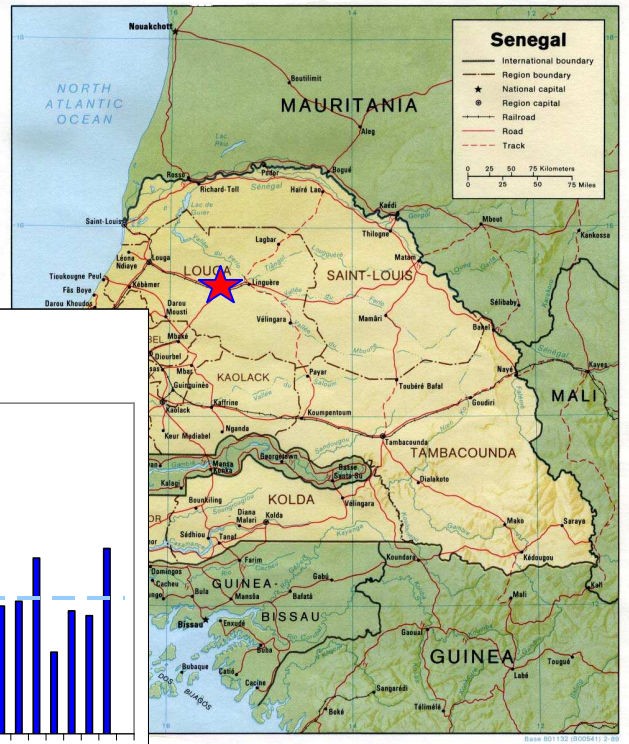
Variable performance validation

From the Dahra test site in semi-arid Senegal





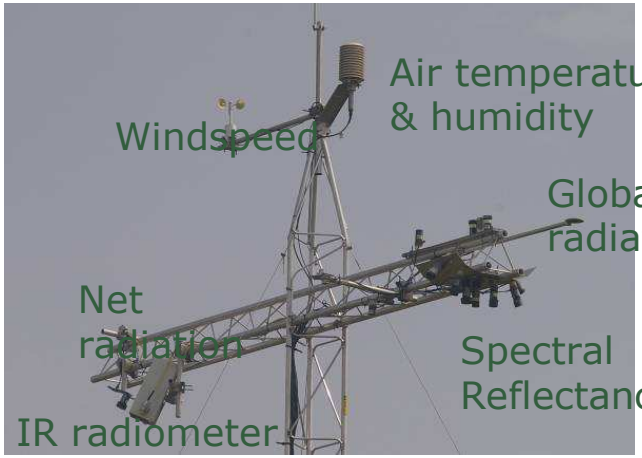


Dahra test site setup

Since 2004

- Air temperature,
- Relative humidity
- Wind speed
- Net radiation
  Global radiation
- Ground heat flux

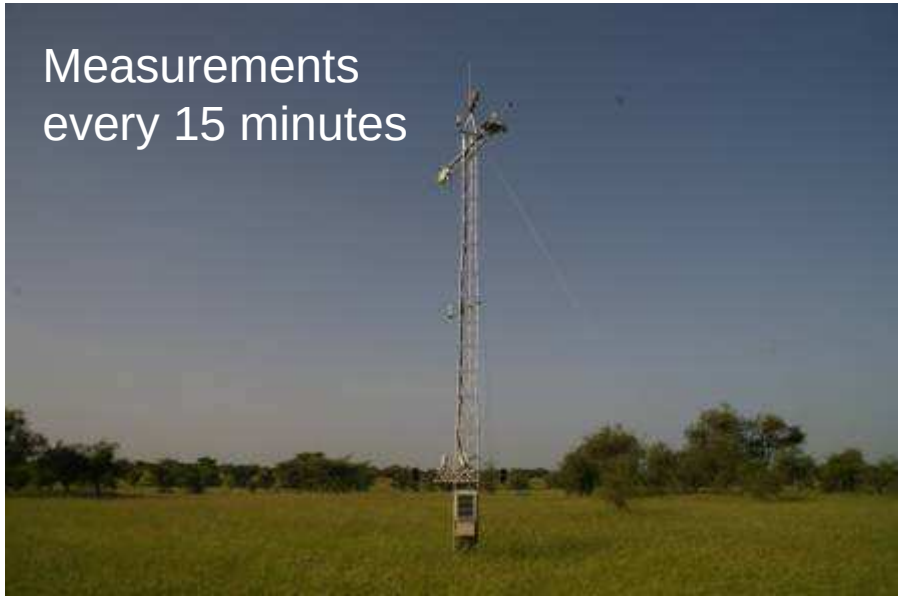
Full surface energy balance
Flux profile estimates of latent and sensible heat



Since 2002

- Precipitation & surface temperature
- Soil moisture & soil temperature profiles
- Sensor specific reflectances, matching various sensors for estimation of spectral vegetation indices & fAPAR.

Ancillary sampling:
biomass, vegetation height, root depth etc.



Dahra test site setup

Since 2008

- LST (collaboration with

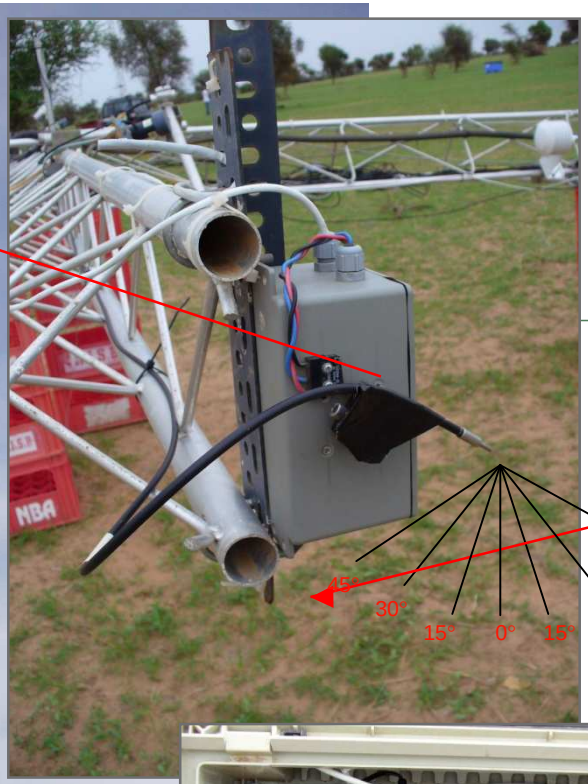
Institute of Technology (KIT)
Institute for Meteorology and Climate Resarch (IMK)
Atmospheric Trace Gases and Remote Sensing (ASF)

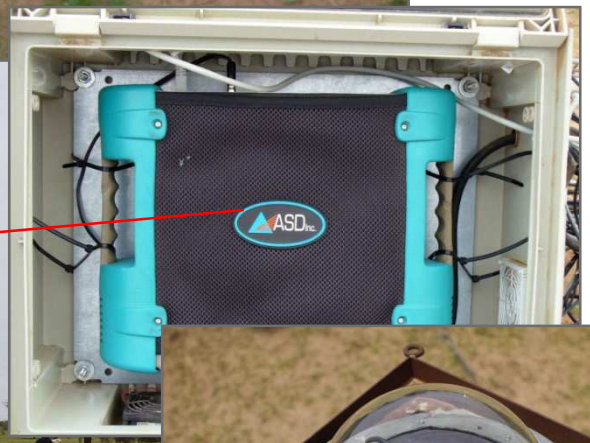
- Poster: Rasmussen, Mads, O. et al.

Intercomparison between SEVIRI LST-products
And comparison with *in situ* LST measurements

East West

Eddy Flux Tower





Since 2010

- ASD spectroradiometers (350-1800 nm)

- Eddy covariance fluxes (water and carbon)
  Collaboration with University of Lund

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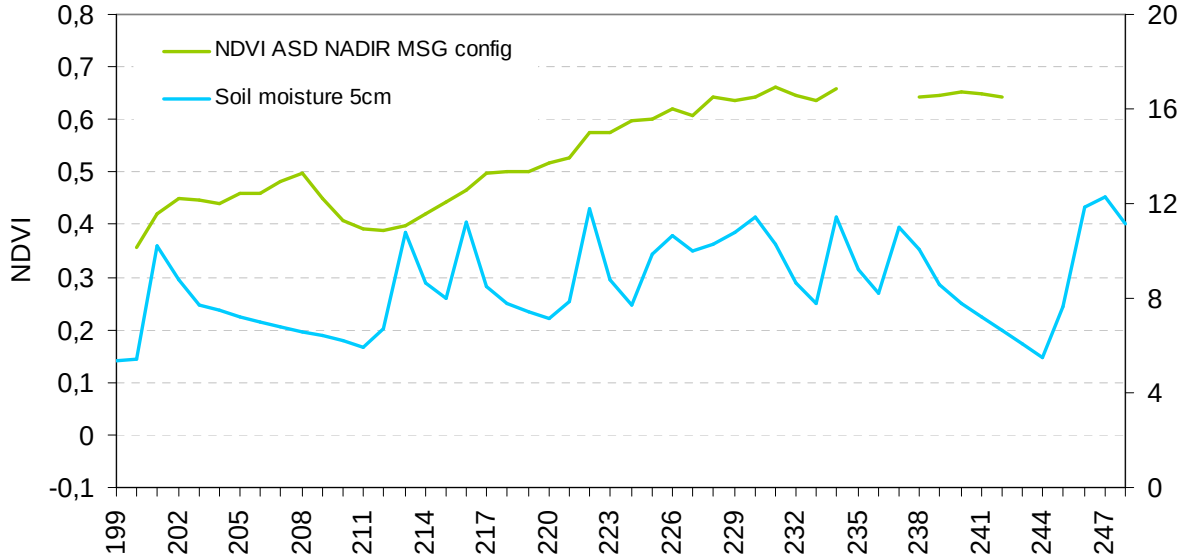
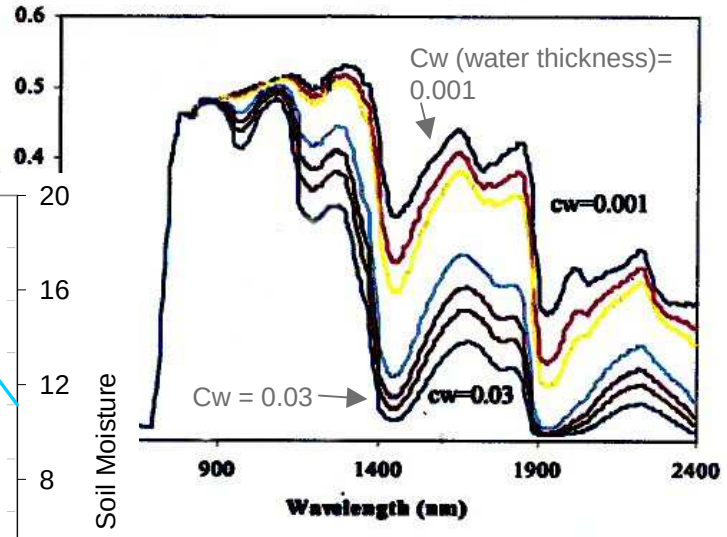
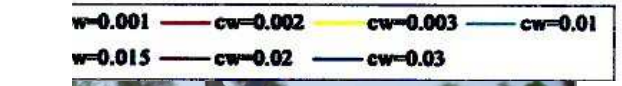
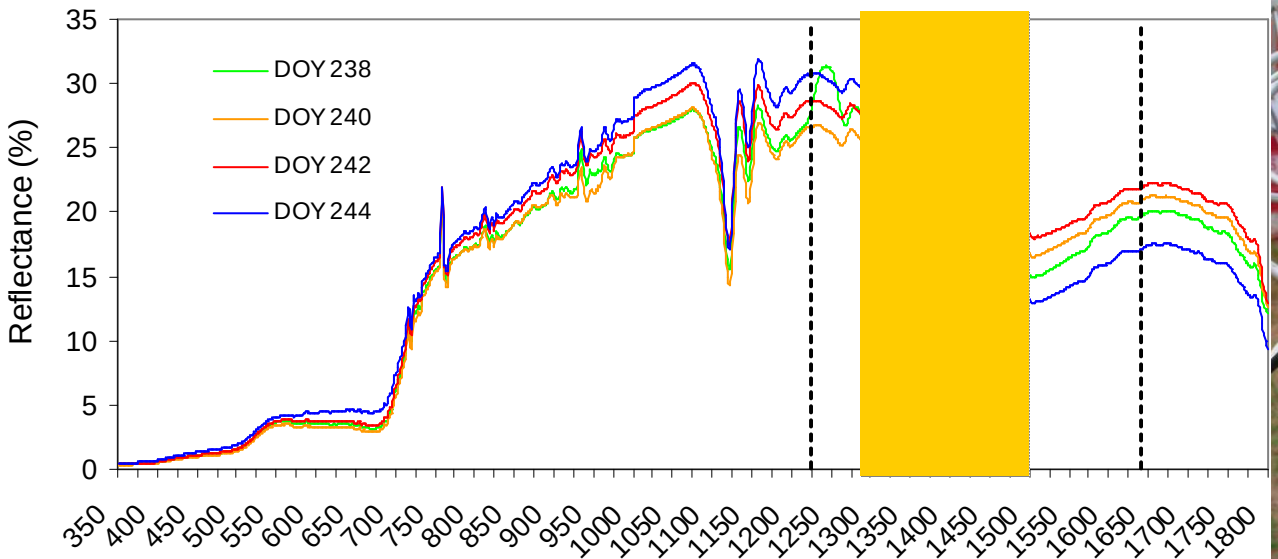
Can SWIR based canopy water statu

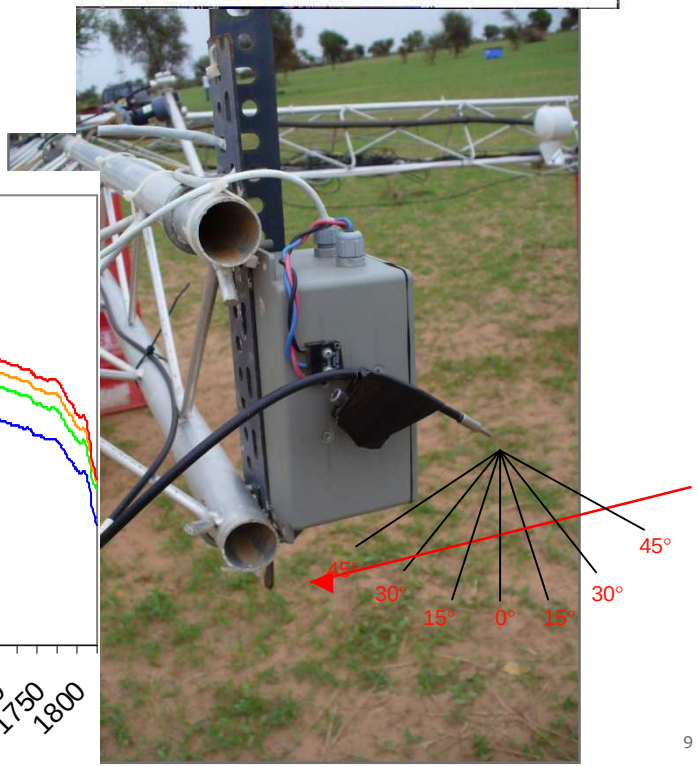


Prospect+Sailh models; Zarco_Tejada and Ustin 2001









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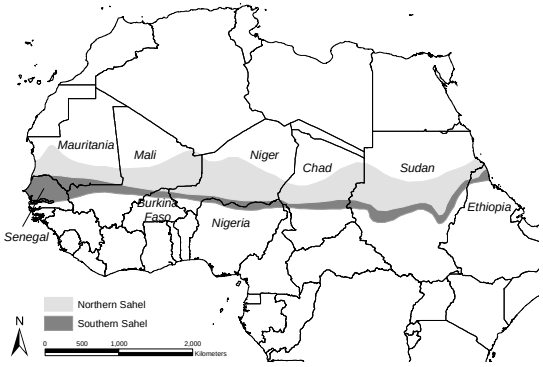
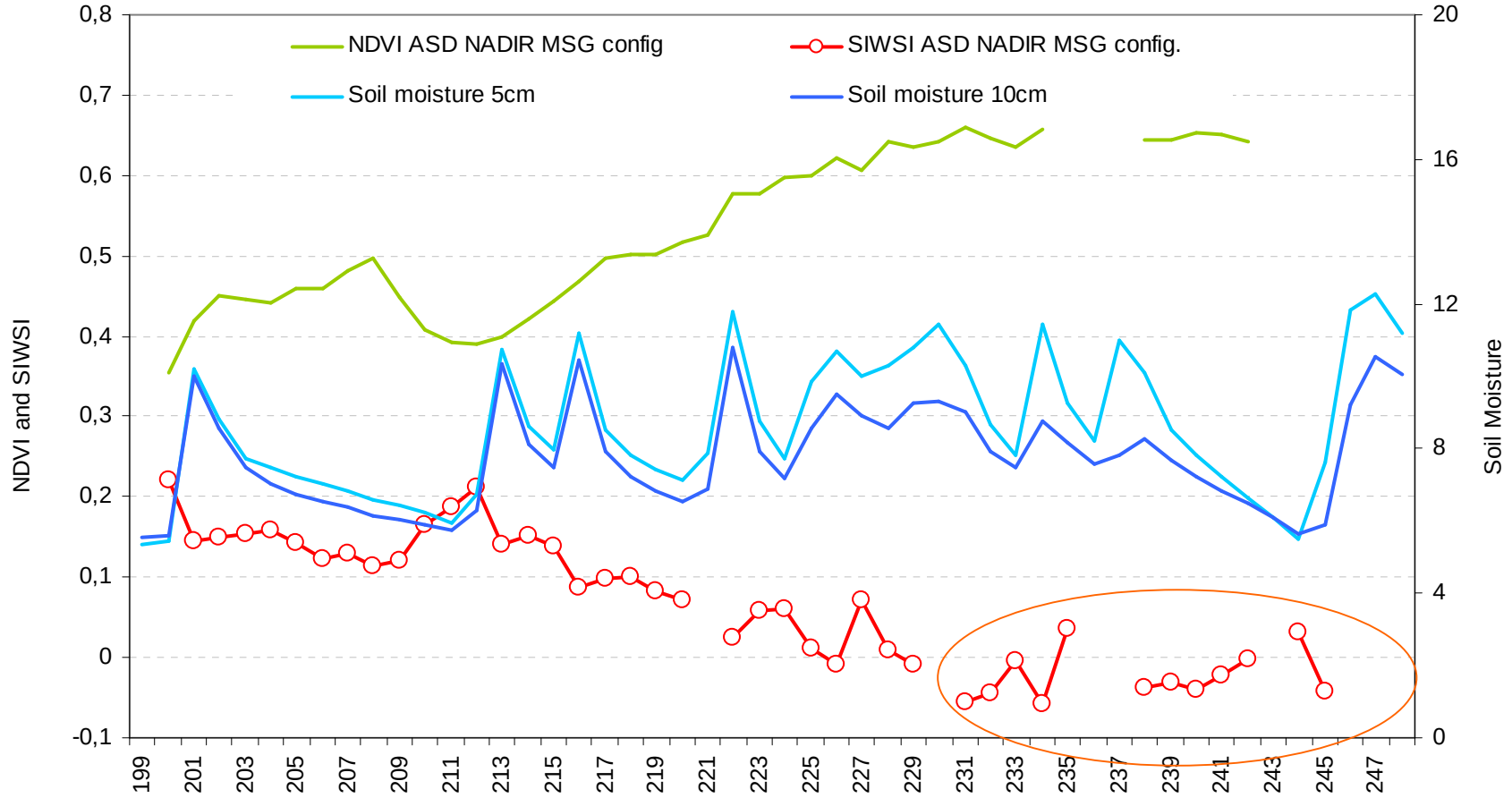
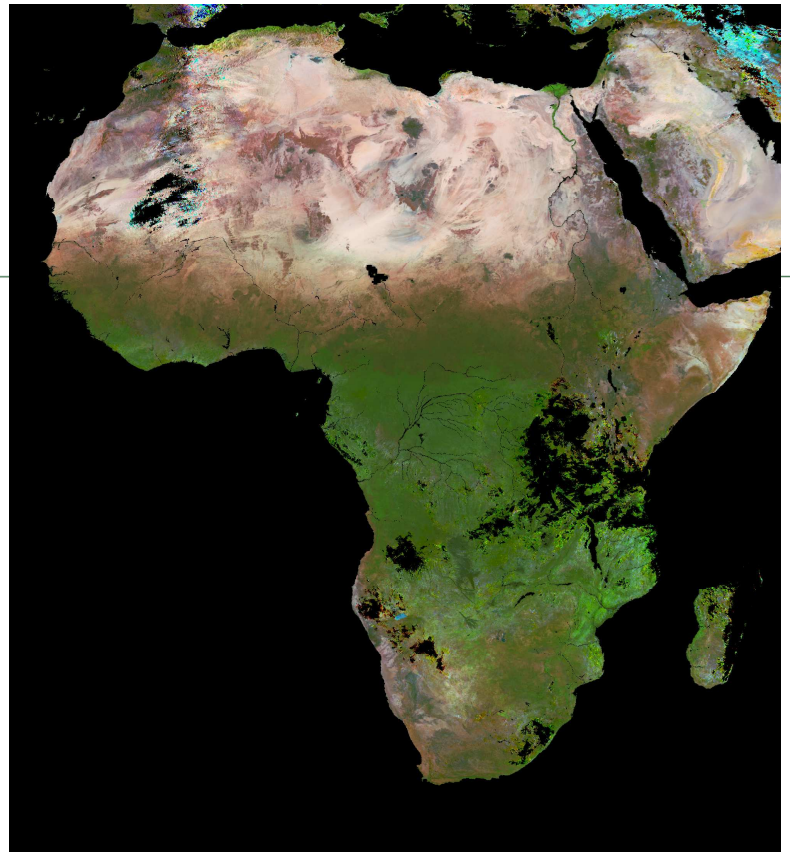
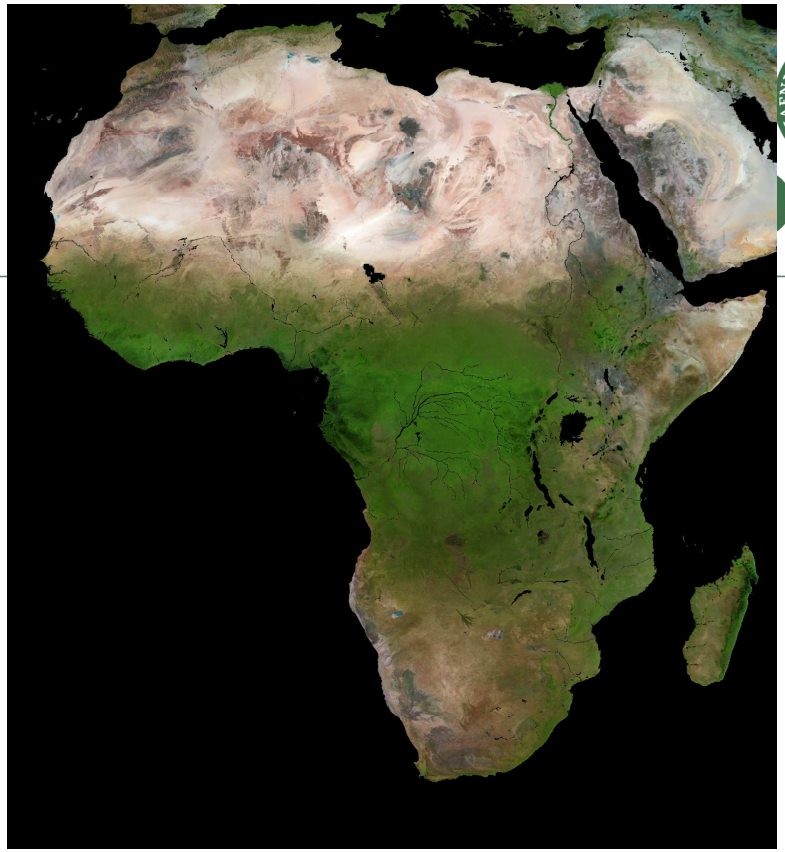






4-day BRDF corrected reflectances Febr. 2008

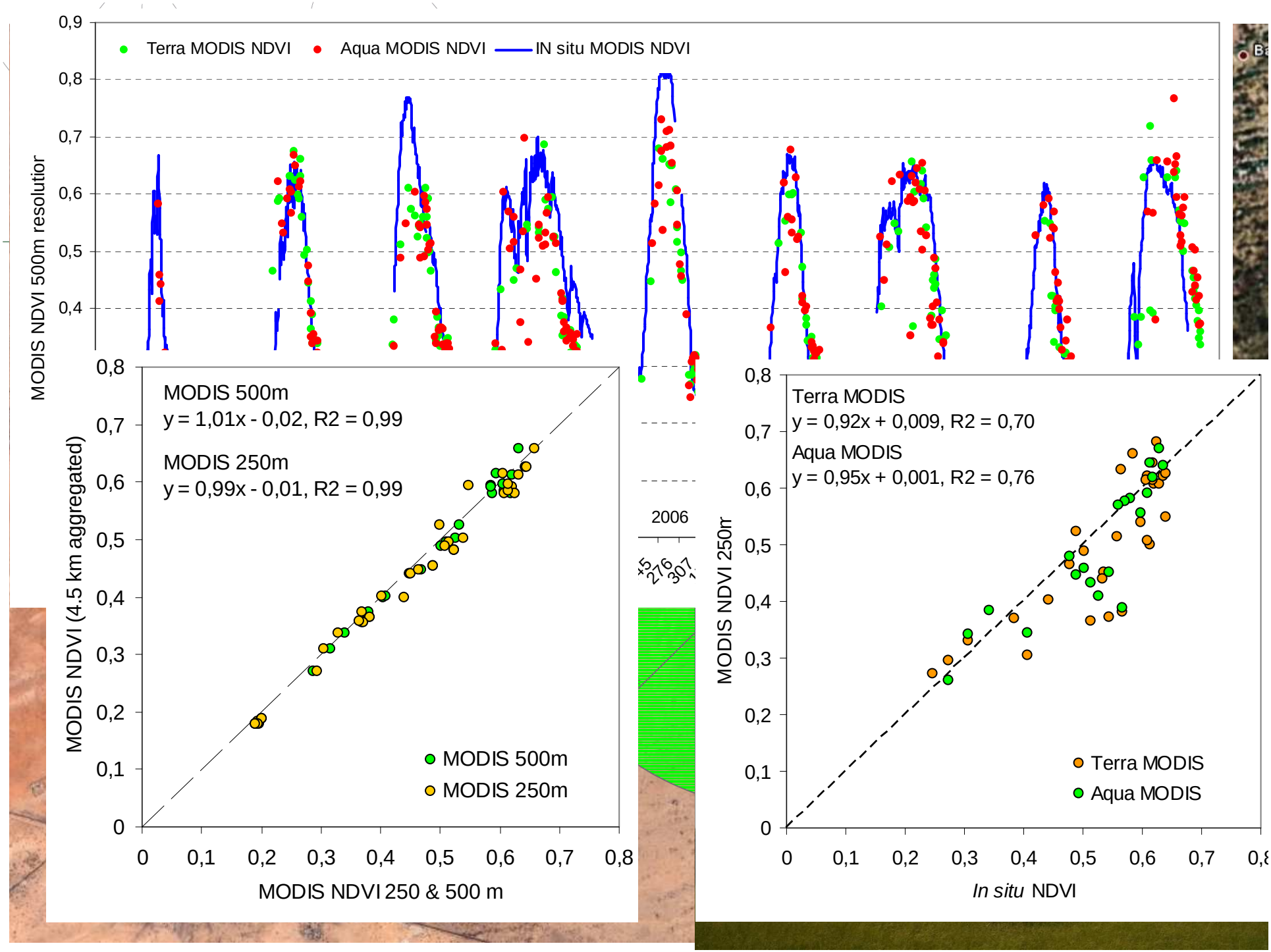


Annual BRDF corrected reflectances avg. 2008

MSG SEVIRI data University of Copenhagen
SMAC corrected (MOD08 input), reflectances BRDF (NBAR)

Proud, S. R. 2010…

Poster: Evaluating the effectiveness of producing BRDF models from SEVIRI surface reflectance data.


Terra MODIS NDVI
Aqua MODIS NDVI
IN situ MODIS NDVI
MODIS NDVI 500m resolutior
0,9
0,8
0,7
0,6
0,5
0,4
2006
MODIS 500m
y = 1,01x - 0,02, R2 = 0,99
MODIS 250m
y = 0,99x - 0,01, R2 = 0,99
MODIS NDVI (4.5 km aggregated)
MODIS 500m
MODIS 250m
MODIS NDVI 250 & 500 m
Terra MODIS
y = 0,92x + 0,009, R2 = 0,70
Aqua MODIS
y = 0,95x + 0,001, R2 = 0,76
MODIS NDVI 250m
Terra MODIS
Aqua MODIS
In situ NDVI

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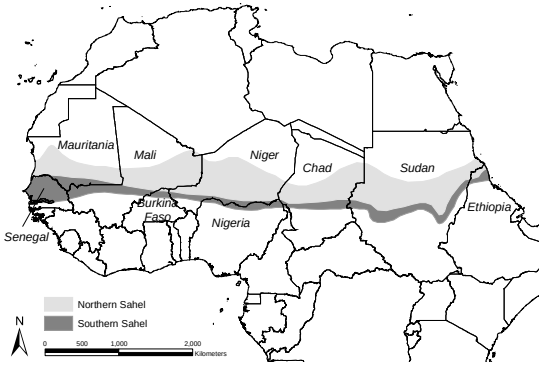
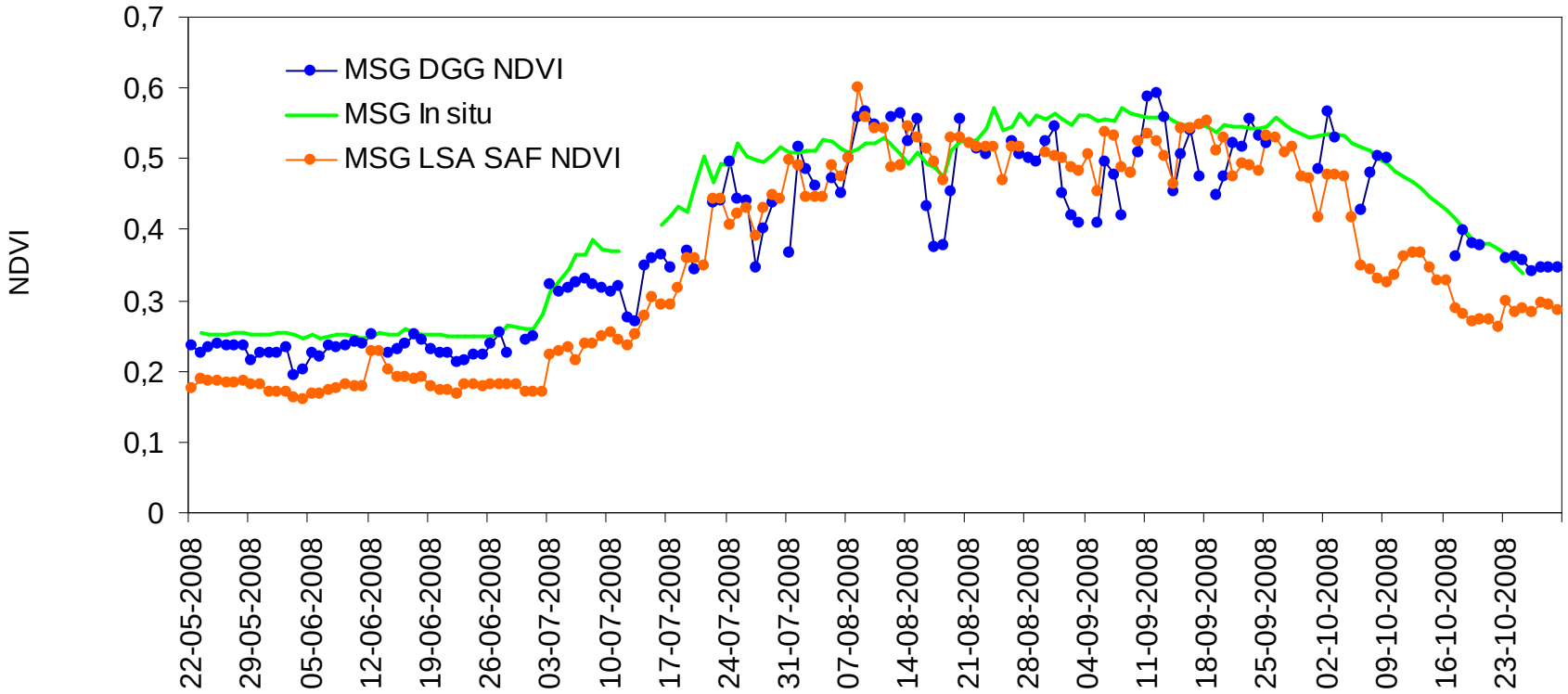


Comparing MSG SEVIRI vegetation indices with in situ measuremets



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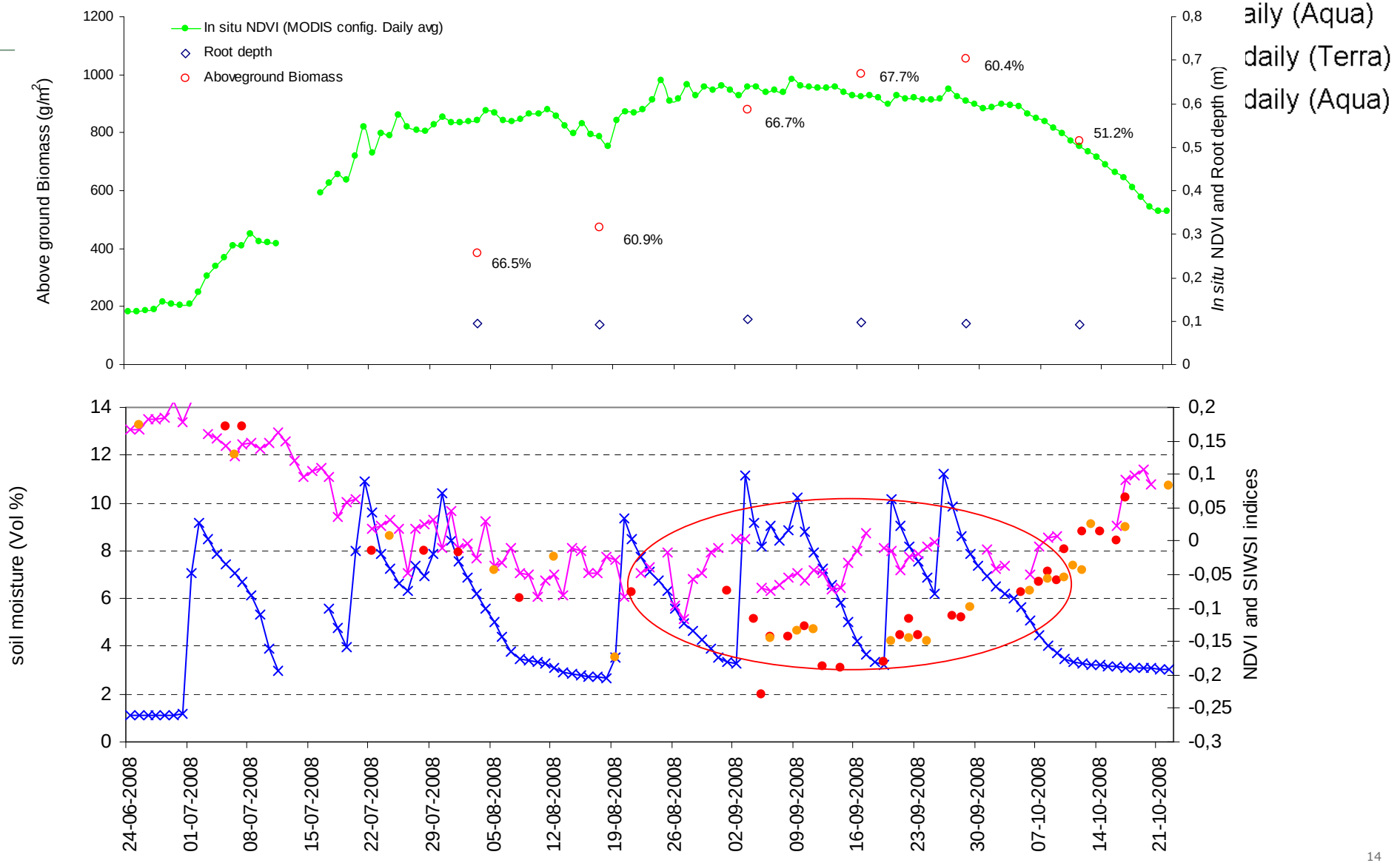
Evaluation of EO-based SIWSI from in situ measuremets - 2008



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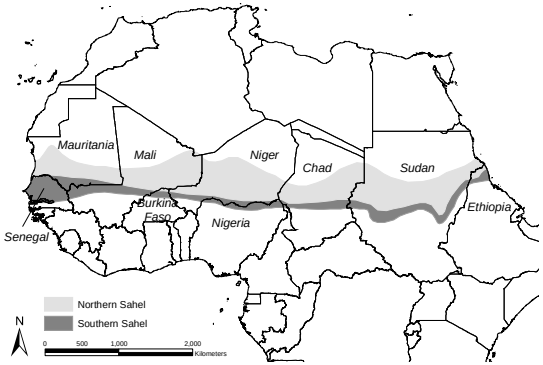
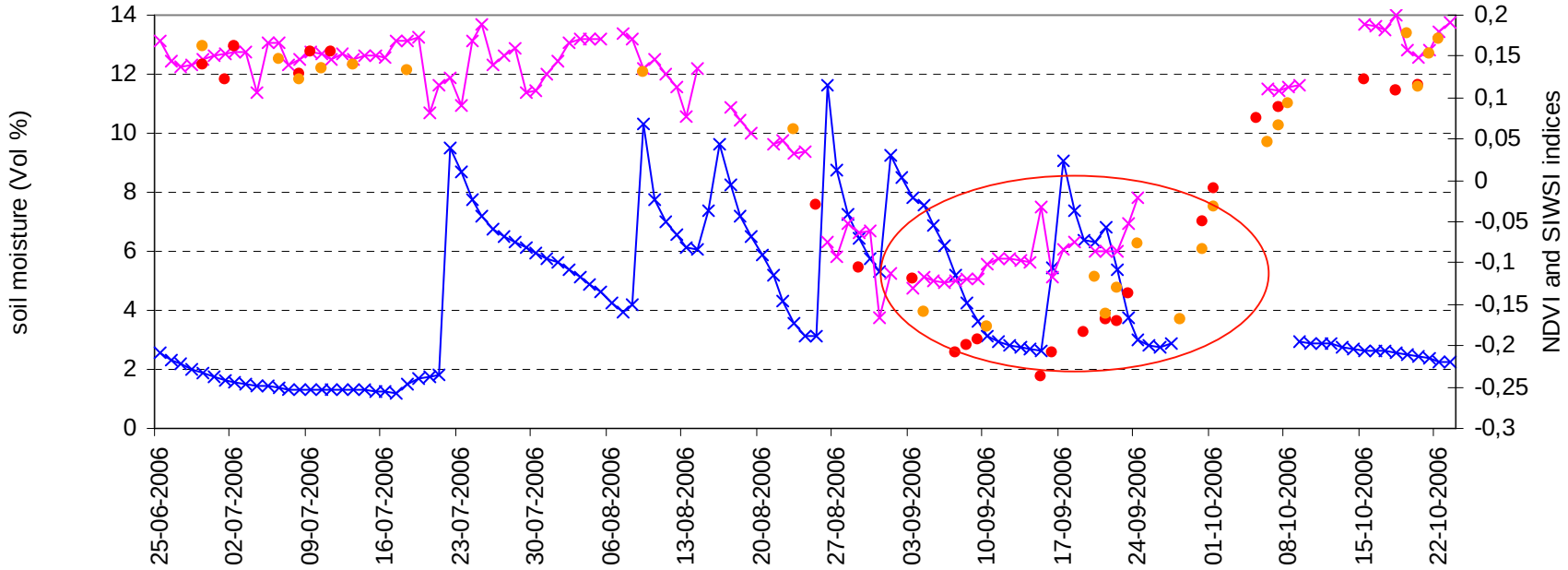
Evaluation of EO-based SIWSI from in situ measuremets – 2006



- In situ soil moisture 10cm
- MSG NDVI (daily BRDF)
- MSG SIWSI (daily BRDF)
- MODIS NDVI daily (Terra)
- MODIS NDVI daily (Aqua)
- MODIS SIWSI daily (Terra)
- MODIS SIWSI daily (Aqua)



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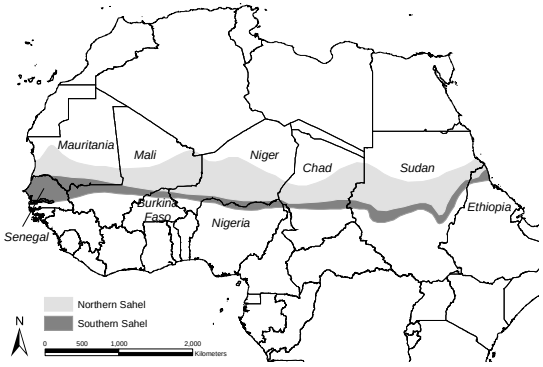
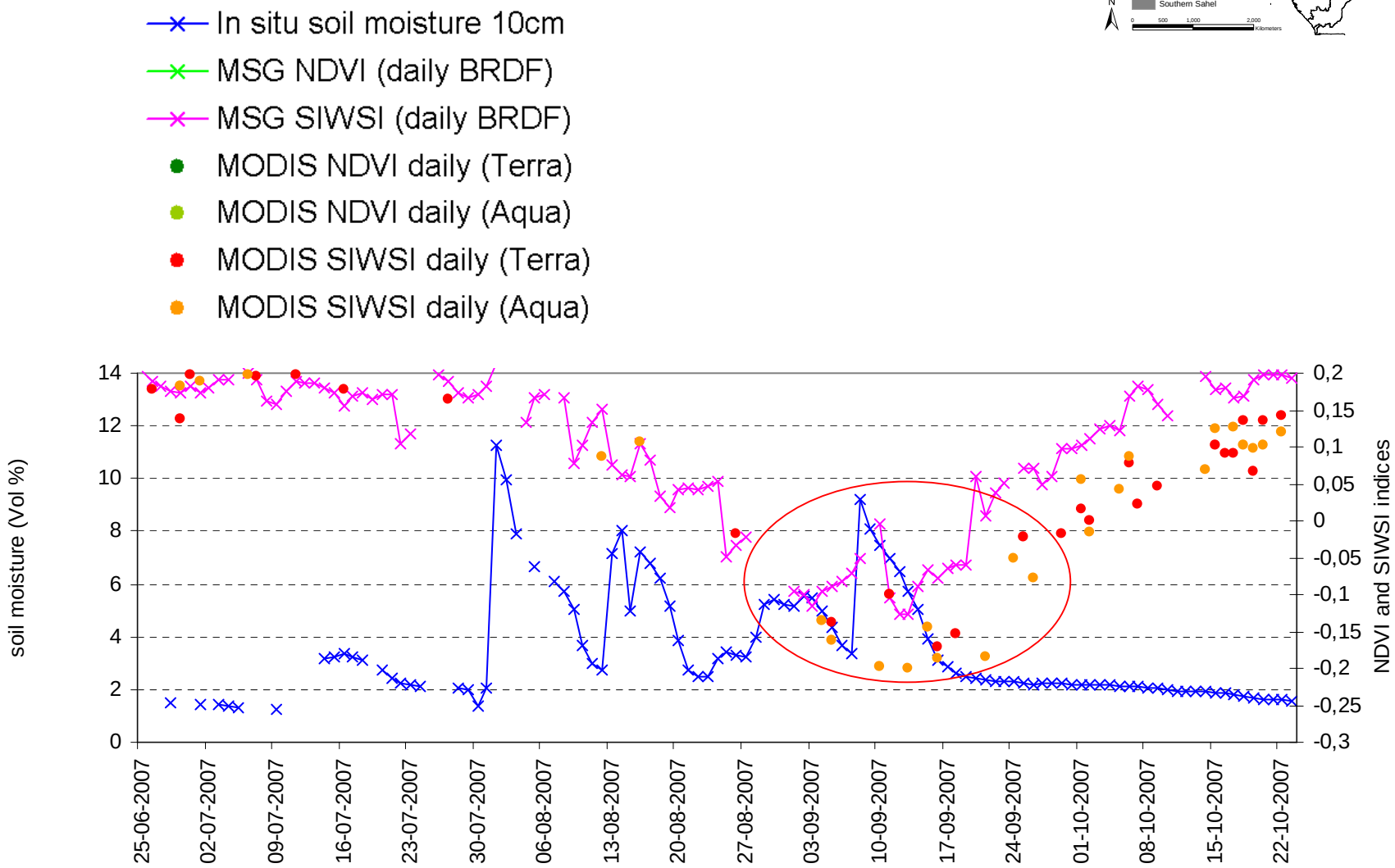
Evaluation of EO-based SIWSI from in situ measuremets - 2007





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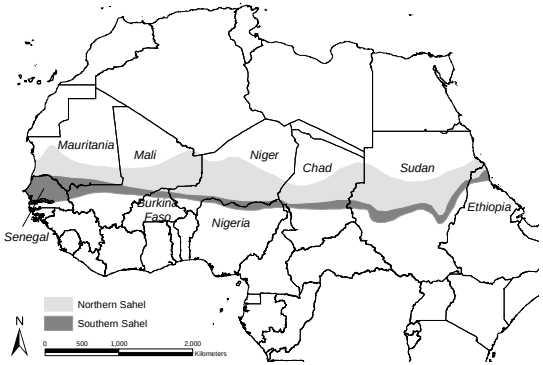
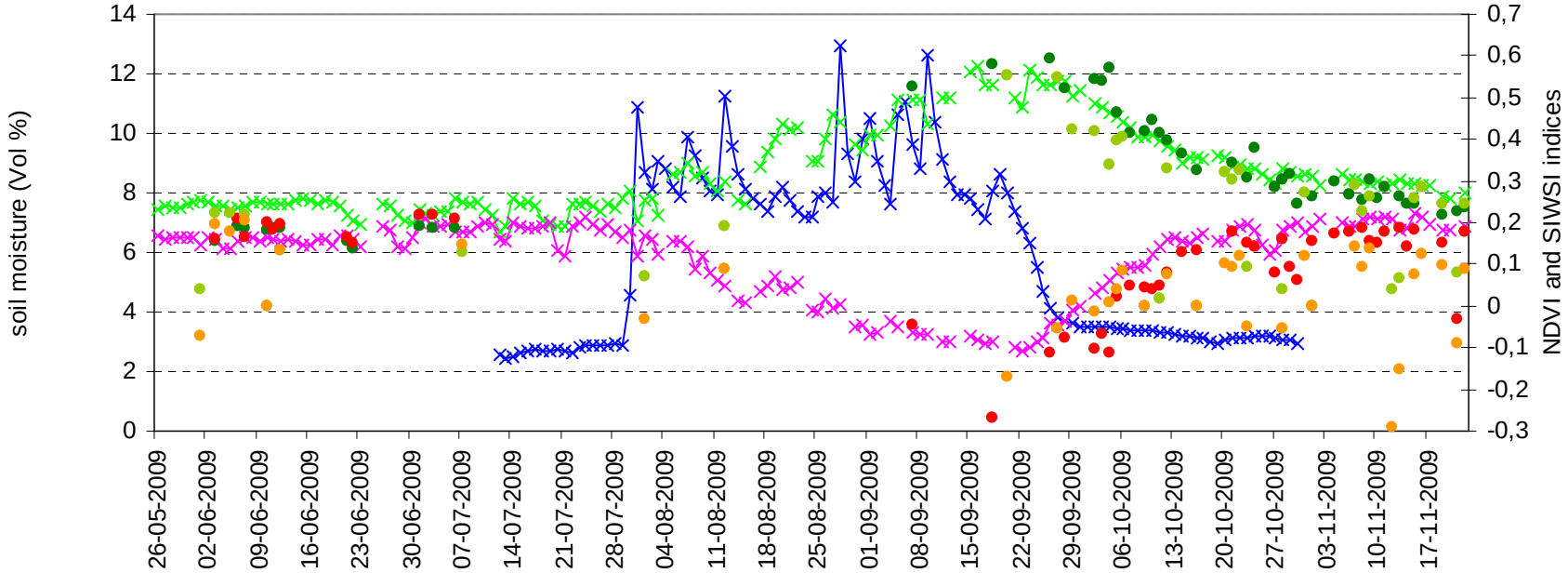
Evaluation of EO-based SIWSI from in situ measuremets - 2009



- In situ soil moisture 10cm
- MSG NDVI (daily BRDF)
- MSG SIWSI (daily BRDF)
- MODIS NDVI daily (Terra)
- MODIS NDVI daily (Aqua)
- MODIS SIWSI daily (Terra)
- MODIS SIWSI daily (Aqua)



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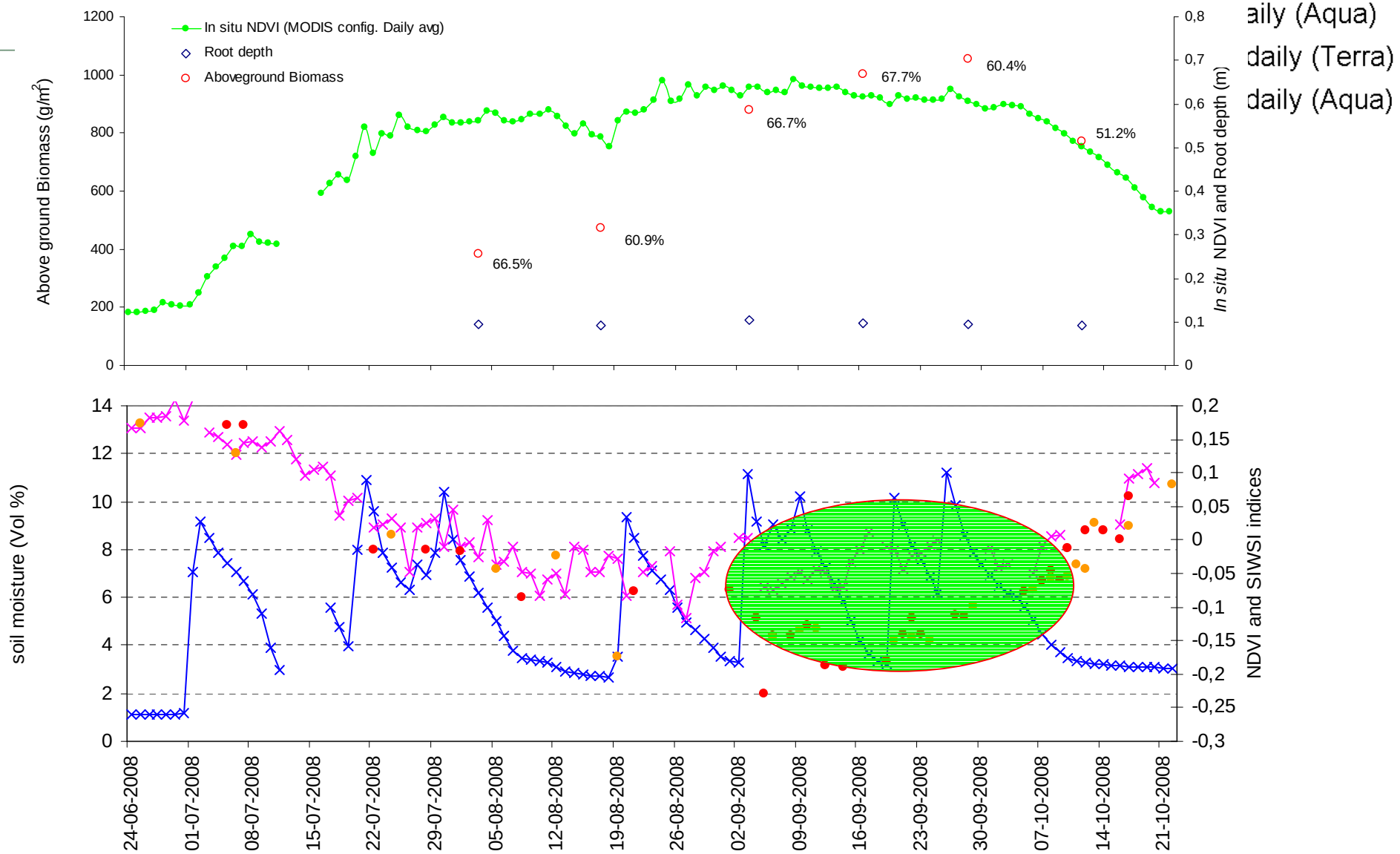
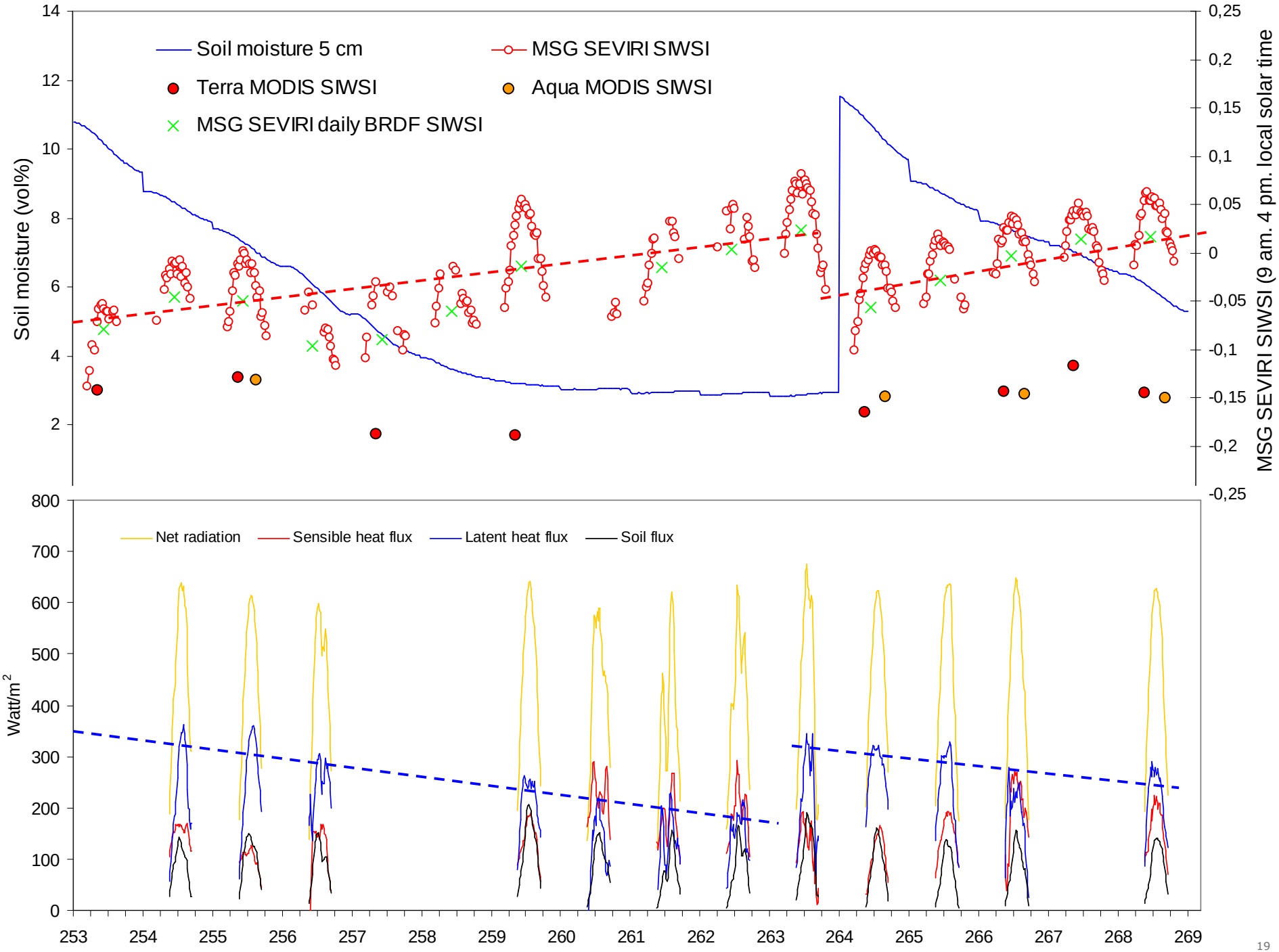
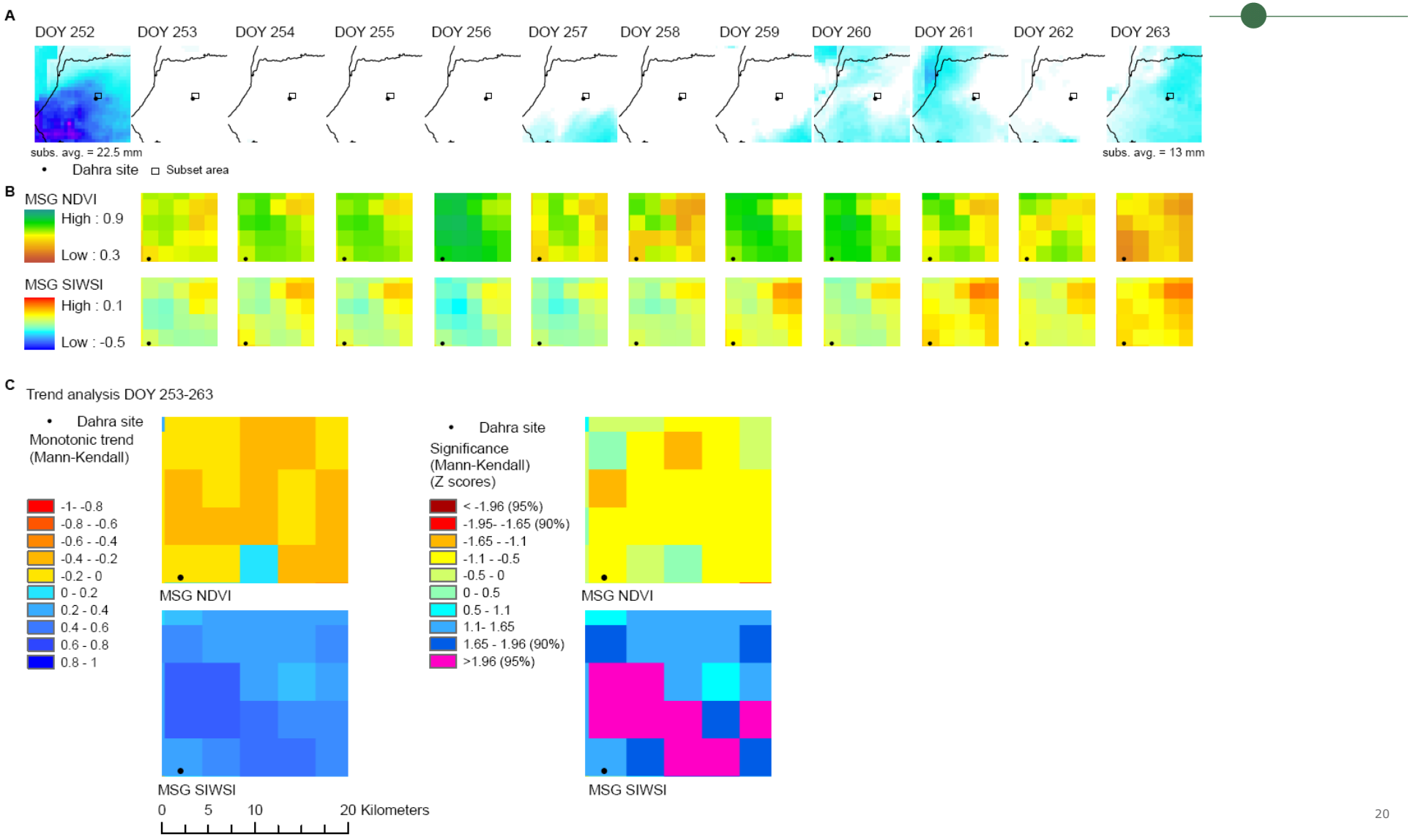
Evaluation of EO-based SIWSI from in situ measuremets - 2008

In situ soil moisture 10cm
MSG NDVI (daily BRDF)
MSG SIWSI (daily BRDF)
MODIS NDVI daily (Terra)
aily (Aqua)
daily (Terra)
daily (Aqua)




Soil moisture 5 cm
MSG SEVIRI SIWSI
Terra MODIS SIWSI
Aqua MODIS SIWSI
MSG SEVIRI daily BRDF SIWSI
Soil moisture (vol%)
MSG SEVIRI SIWSI (9 am. 4 pm. local solar time
Net radiation
Sensible heat flux
Latent heat flux
Soil flux
Watt/m2

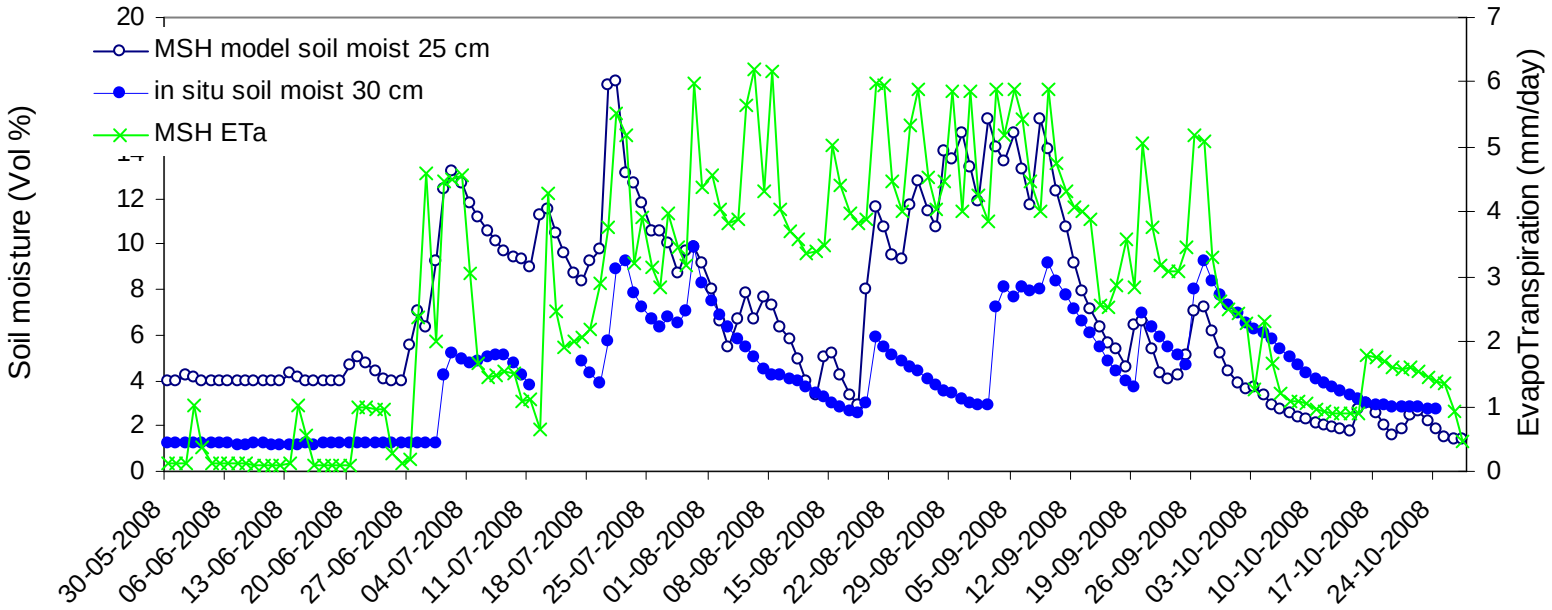
- Spatio-temporal Evaluation of SIWSI (20 pixels, 320 km²) using NOAA RFE rainfall as surface water status indicator



- Spatio-temporal evaluation of MSG SIWSI using a hydrological model (Mike-She distributed model)

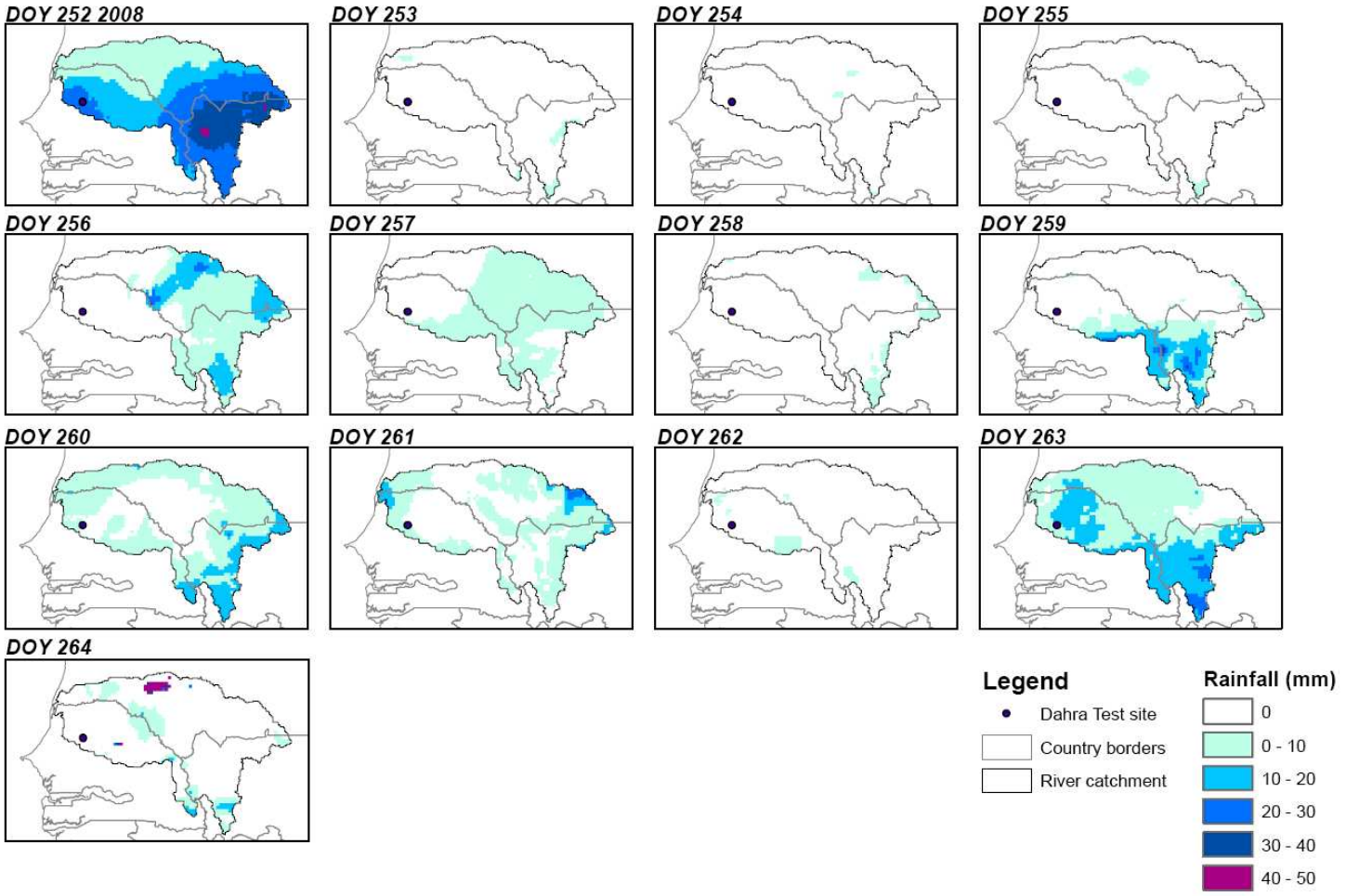
- Is the model able to simulate water status at the Dahra test site?

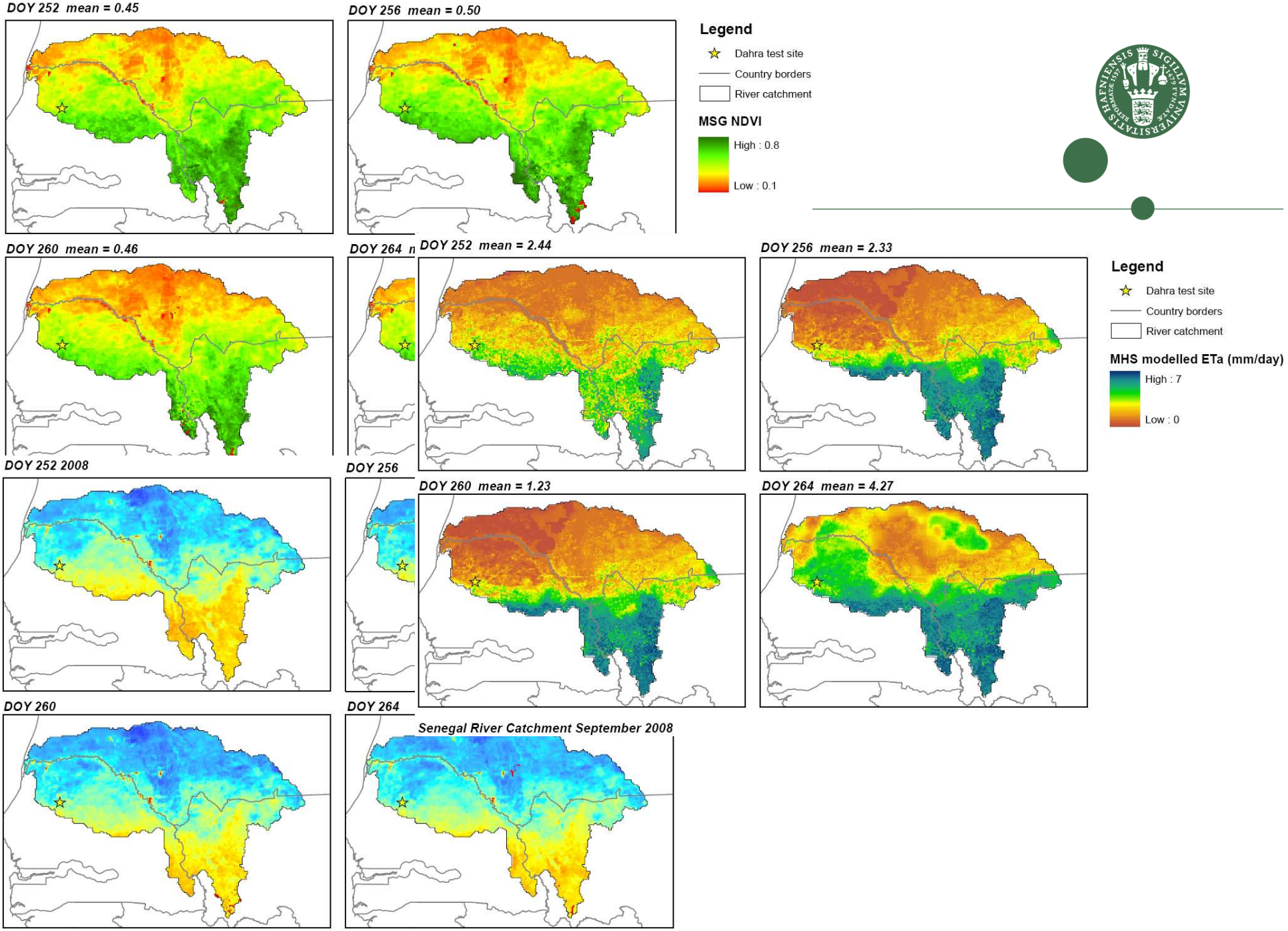
- Are model inputs (RFE rainfall) reliable?

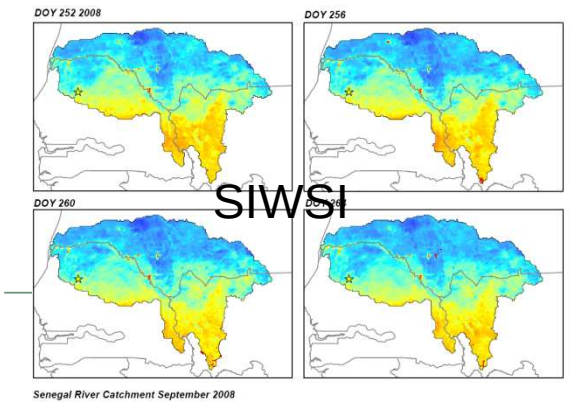


- Spatio-temporal evaluation of MSG SIWSI using a hydrological model (Mike-She distributed model)

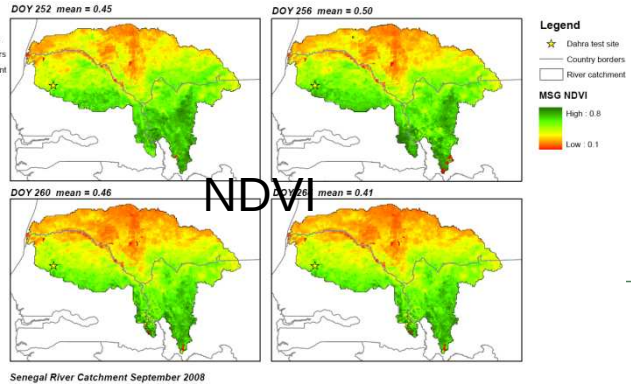
Preliminary data analysis…



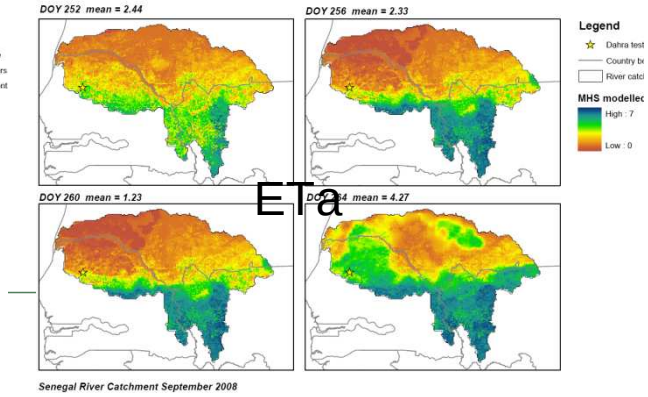

DOY 252 mean = 0.45
DOY 256 mean = 0.50
Legend
Dahra test site
Country borders
River catchment
MSG NDVI
High : 0.8
Low : 0.1
DOY 260 mean = 0.46
DOY 264 n
DOY 252 mean = 2.44
DOY 256 mean = 2.33
Legend
Dahra test site
Country borders
River catchment
MHS modelled ETa (mm/day)
High : 7
Low : 0
DOY 252 2008
DOY 256
DOY 260 mean = 1.23
DOY 264 mean = 4.27
DOY 260
DOY 264
Senegal River Catchment September 2008
Senegal River Catchment September 2008



SIWSI

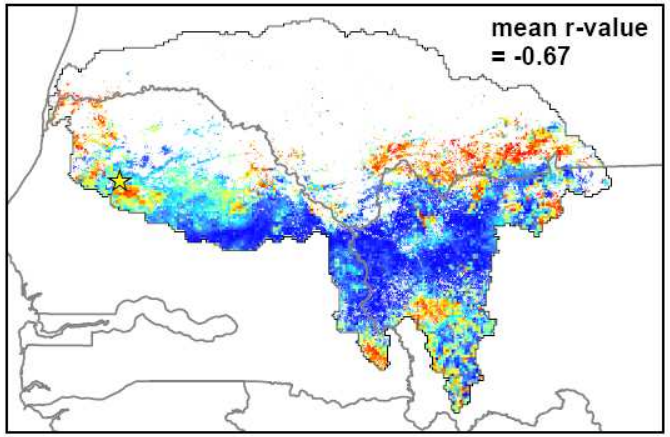


NDVI

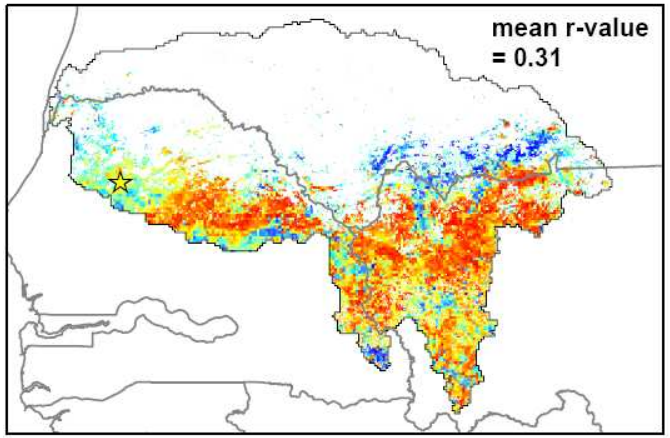


ETa

Correlation beween MSG SIWSI and MSH ETa (DOY 252-264)



Correlation beween MSG NDVI and MSH ETa (DOY 252-264)



Senegal River Catchment September 2008

LAI (MODIS) <0.8 masked out

Legend

- Dahra test site
- Country borders
- River catchment

r value

High : 1

Low :-1

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Conclusions and perspectives

- SWIR sensitivity to Canopy water content (semi-arid grass land)
- MSG sensitivity on a daily scale

- Biomass dependancy
- SWIR based indices complementary to VIS/NIR approaches
- SWIR based indices more robust to atm correction than VIS/NIR