A simple interpretation of the surface temperature/vegetation index space for assessment of surface moisture status

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Hydrological Modeling by EO data

- **GOES/Meteosat and SSM/I are useful for estimating rainfall.**

  Heavy Rain/Snow Estimates (SPENES), Areal Tropical Rainfall Potential (TRaP)

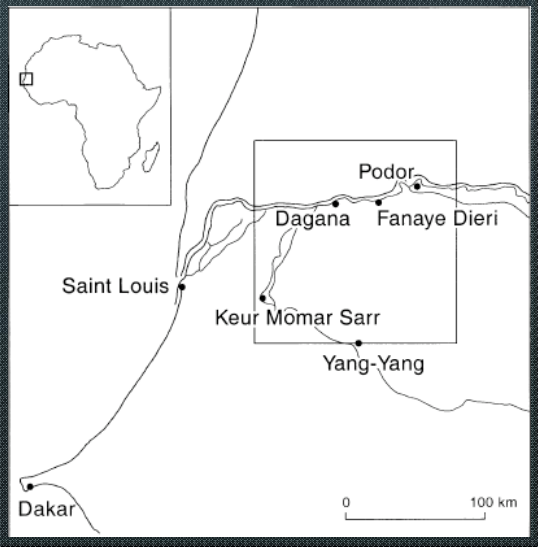
- **SPOT Vegetation, MODIS, MERIS can be use to determine soil moisture content.**

- **NOOA AVHRR measures data on the visible, near, shortwave, and thermal infrared parts of the electromagnetic spectrum. Three key variables in hydrological models: vegetation cover and leaf area index (LAI), albedo and evapotranspiration, or soil humidity.**

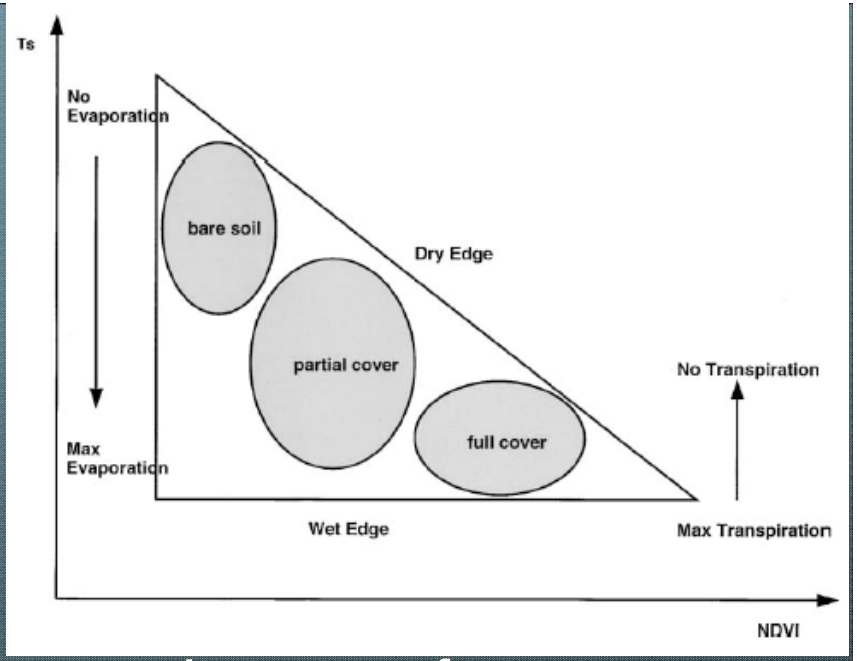
Objectives

- To demonstrate how NOAA AVHRR and other similar data may be used to estimate temporal and spatial patterns of soil moisture (key variable in Distributed Hydrological Models).
- To interpret Ts/NDVI space in terms of surface soil moisture status.
- To compare the results with soil moisture derived from a hydrological model.

140X 140 sq. km in the northern part of Senegal



Ts/NDVI space

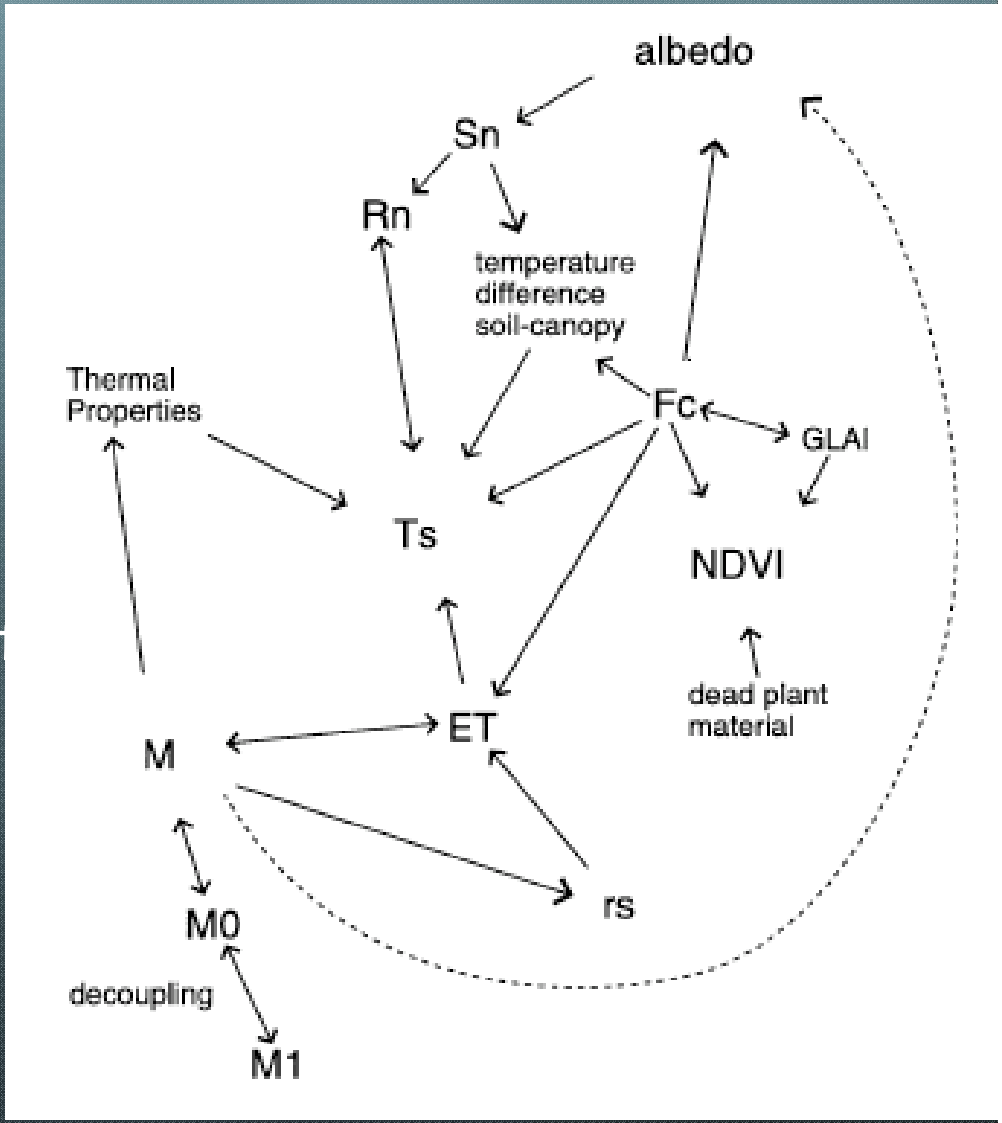


- NDVI and Surface Temperature (Ts) are Indicators of water stress.
- Ts/NDVI slope is related to evapotranspiration and has been used to estimate air temperature.
- Analysis of Ts/NDVI slope has been used to assess information related to areal averaged soil moisture condition.
- The location of a pixel in the Ts/NDVI space (Triangle) is influenced by many factors (soil, vegetation, energy balance, surface soil moisture).

Interpretation of the Ts/NDVI space

- Fractional vegetation cover (FC)
- Evapotranspiration (ET)
- Heat capacity and conductivity of the surface
- Net radiation
- Atmospheric forcing and surface roughness

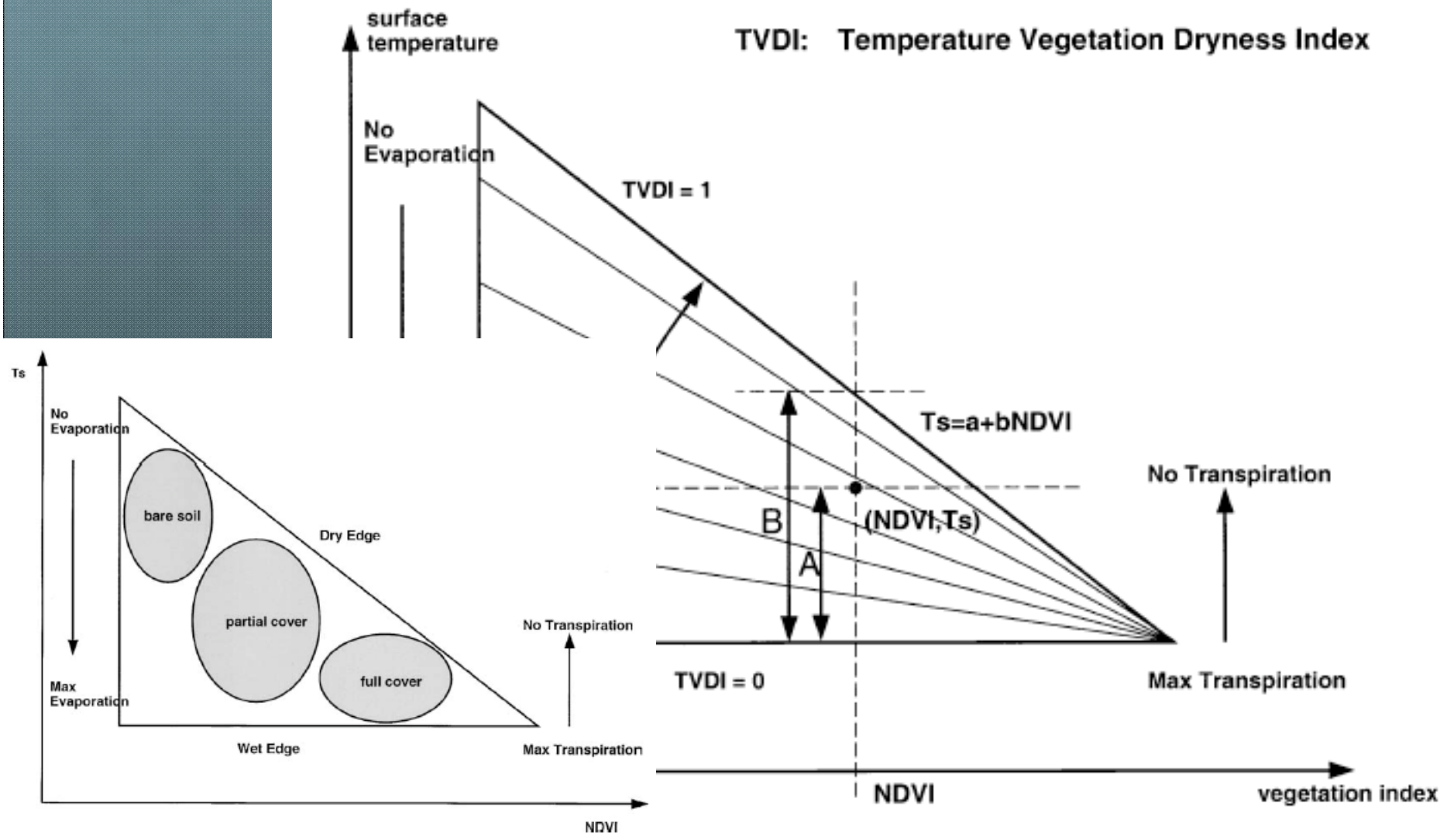
INTERACTIONS



Sn = shortwave net radiation balance; Rn = net radiation balance; GLAI = green leaf area index; Fc = fractional vegetation cover; ET = evapotranspiration; rs = stomatal resistance; M1 = soil moisture content (root zone); M0= top soil moisture content.

Temperature Vegetation Dryness Index

$$\mathrm{TVDI} = \frac{T_s - T_{s_{min}}}{a + b\mathrm{NDVI} - T_{s_{min}}}$$



Assumptions and sources of error

Assumptions

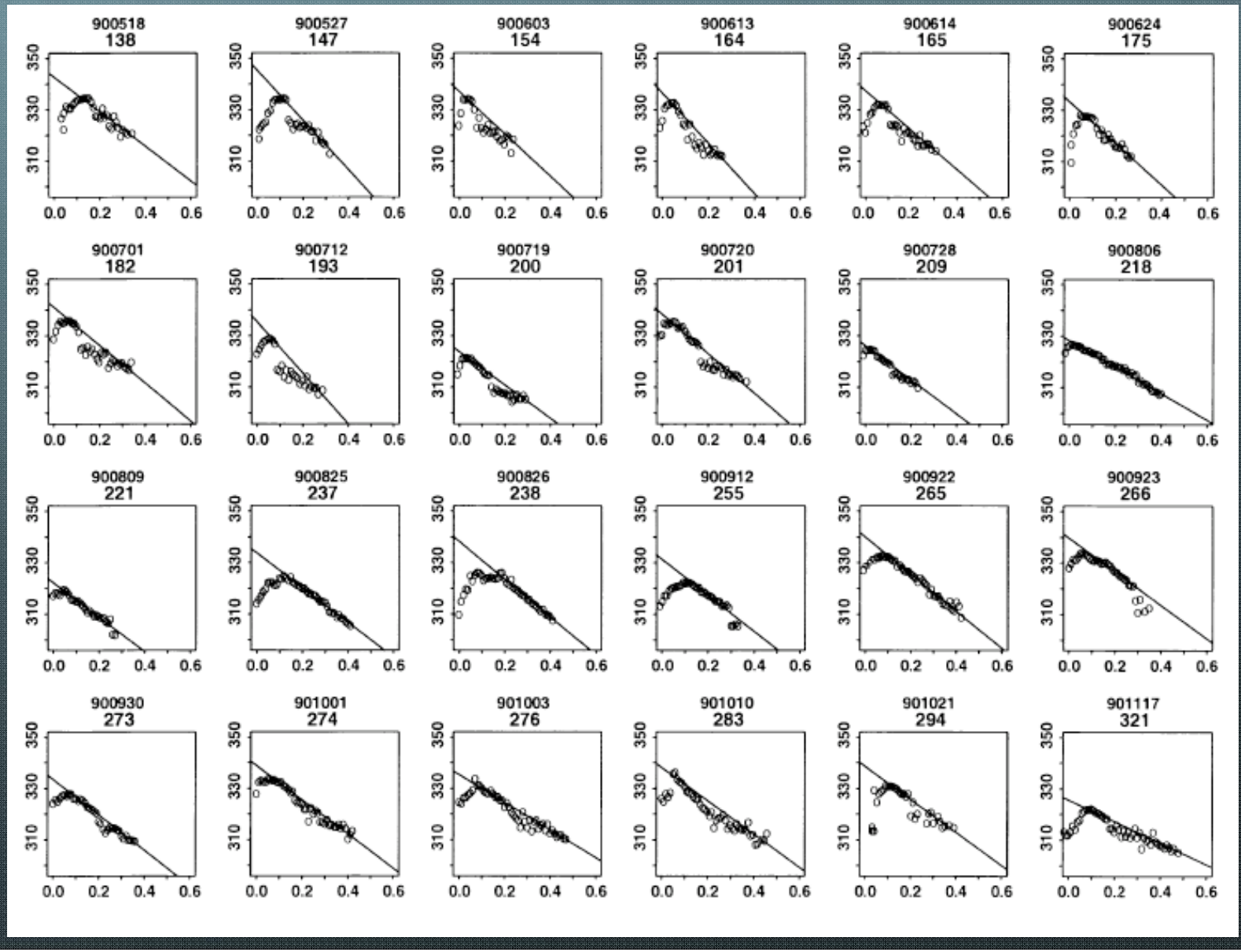
- Soil moisture is the main source of variation for Ts
- TVDI is related to surface soil moisture due to changes in thermal inertia and evaporative control on net radiation partitioning.

Sources of Error

1. No account of view angle effects on Ts and NDVI
2. The "triangle" may not be determined correctly from the EO data, if the area of interest does not include a full range of variability in land surface conditions
3. No account of errors in estimation of Ts (unknown and varying land surface emissivity and atmospheric effects)
4. No account of clouds, shadows, and associated variation in net radiation
5. Decoupling of the top surface soil layer from lower layers
6. Dependence of Ts and NDVI on surface type due to differences in aerodynamic resistance

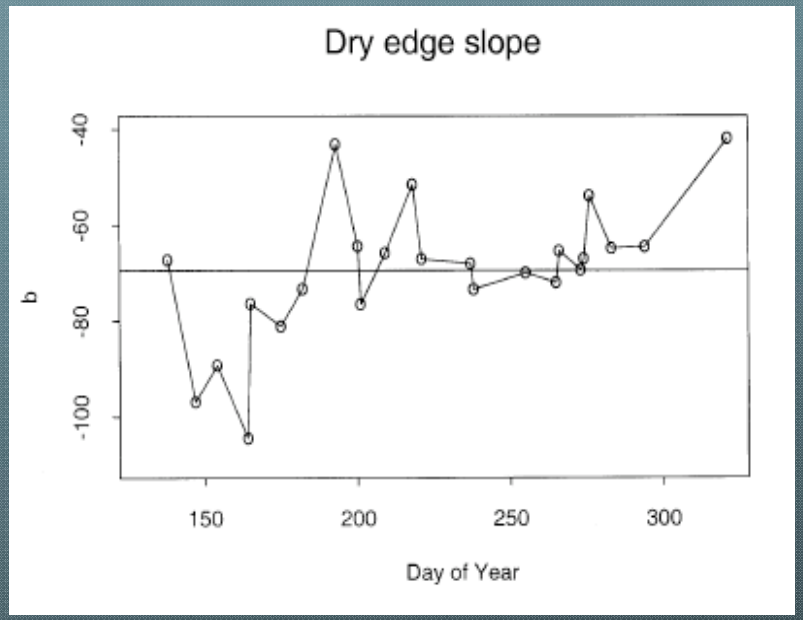
Results

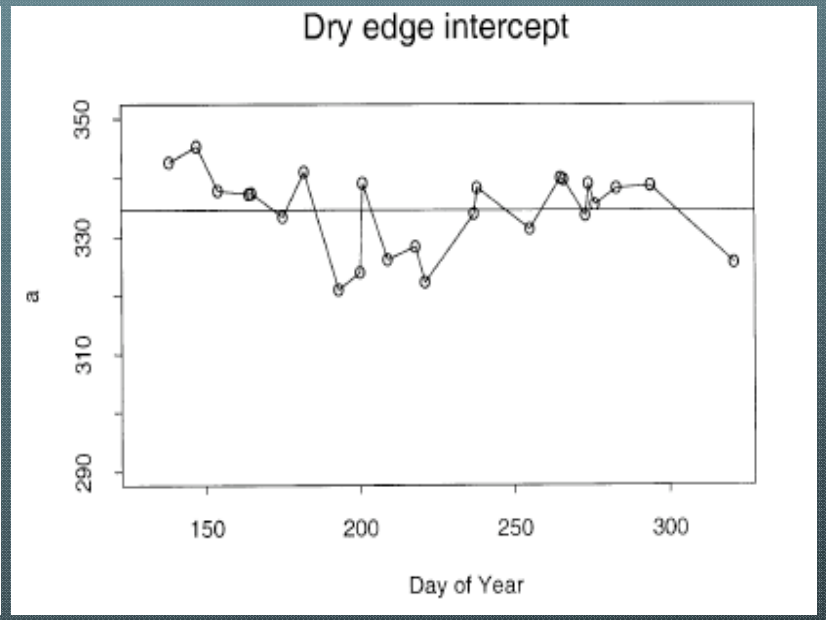
Ts/TVDI space

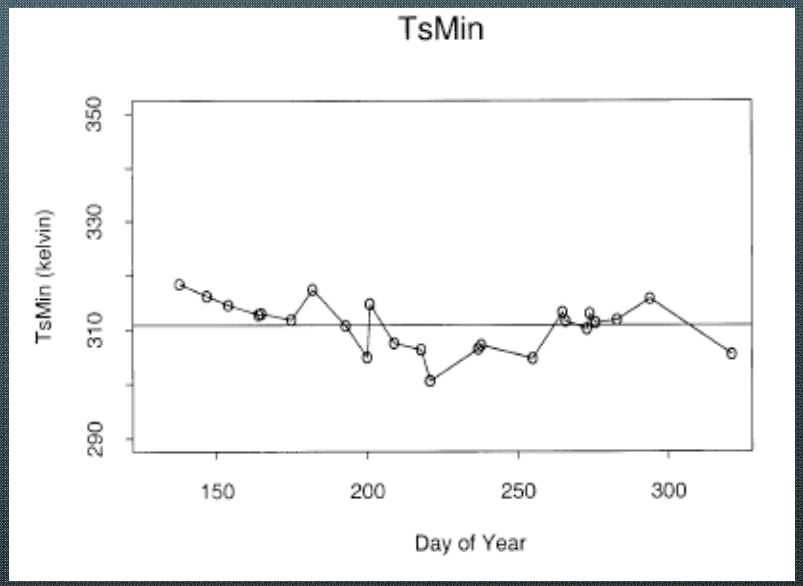


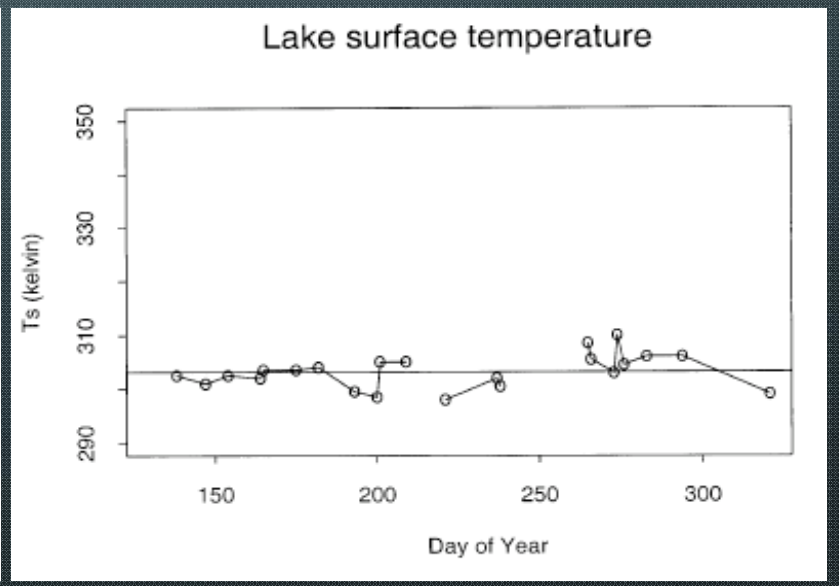
Results

Temporal Evolution in TVDI parameters









TVDI parameters for the 24 images plotted as function of time

Results

Temporal Evolution in TVDI parameters

- TDVI is sensitive to rainfall.
- High values in the dry season and low values in the rainy season with greater variability in dry season

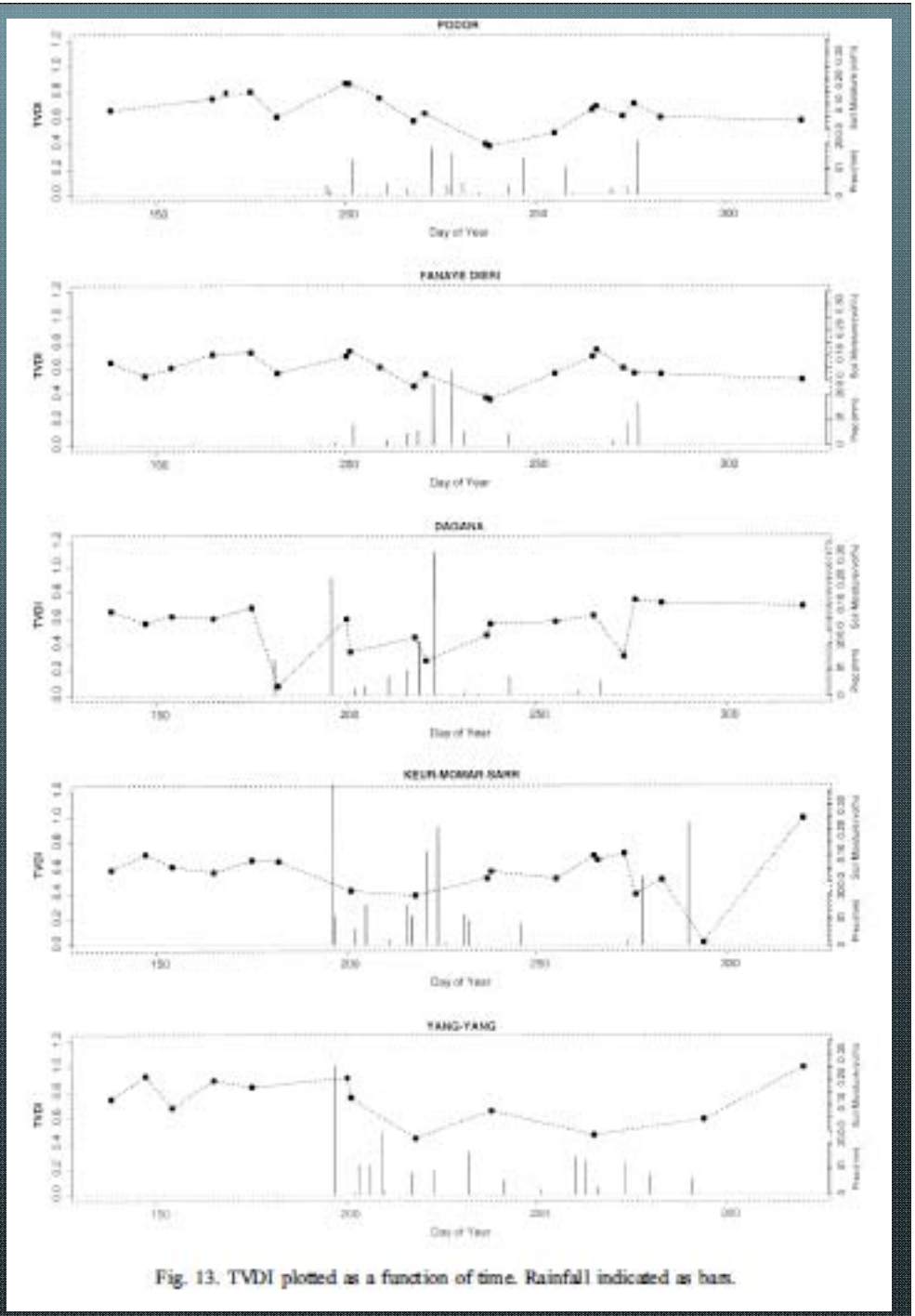
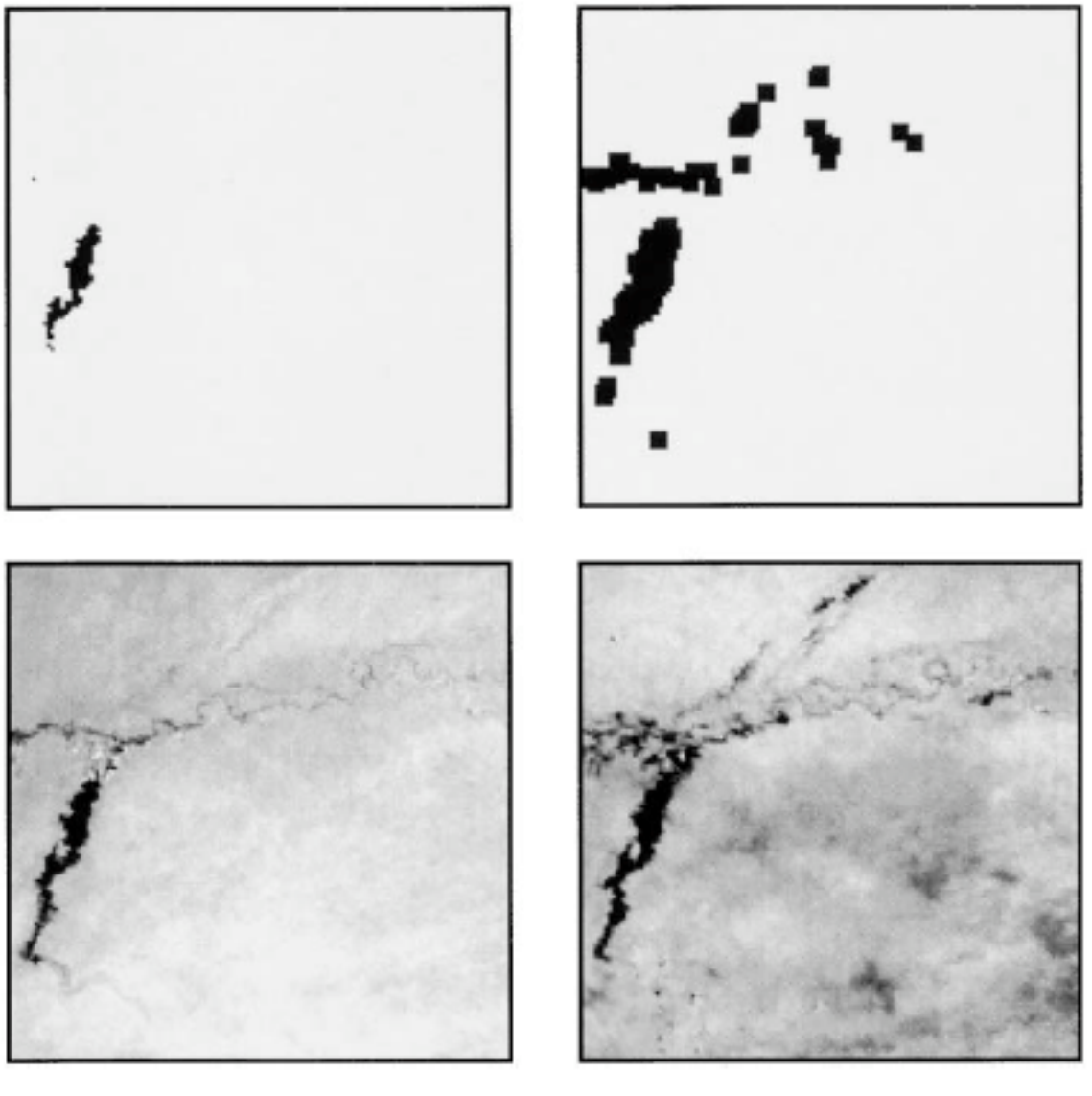


Fig. 13. TVDI plotted as a function of time. Rainfall indicated as bars.

Results

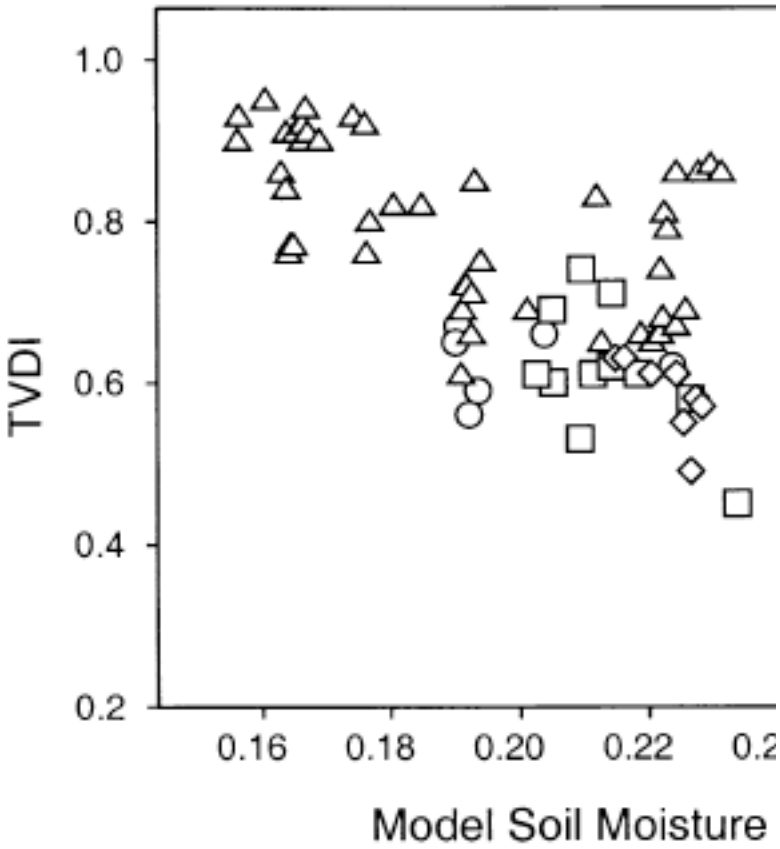
Low-land areas around the river and the moist area close to the lake have low dryness indices.

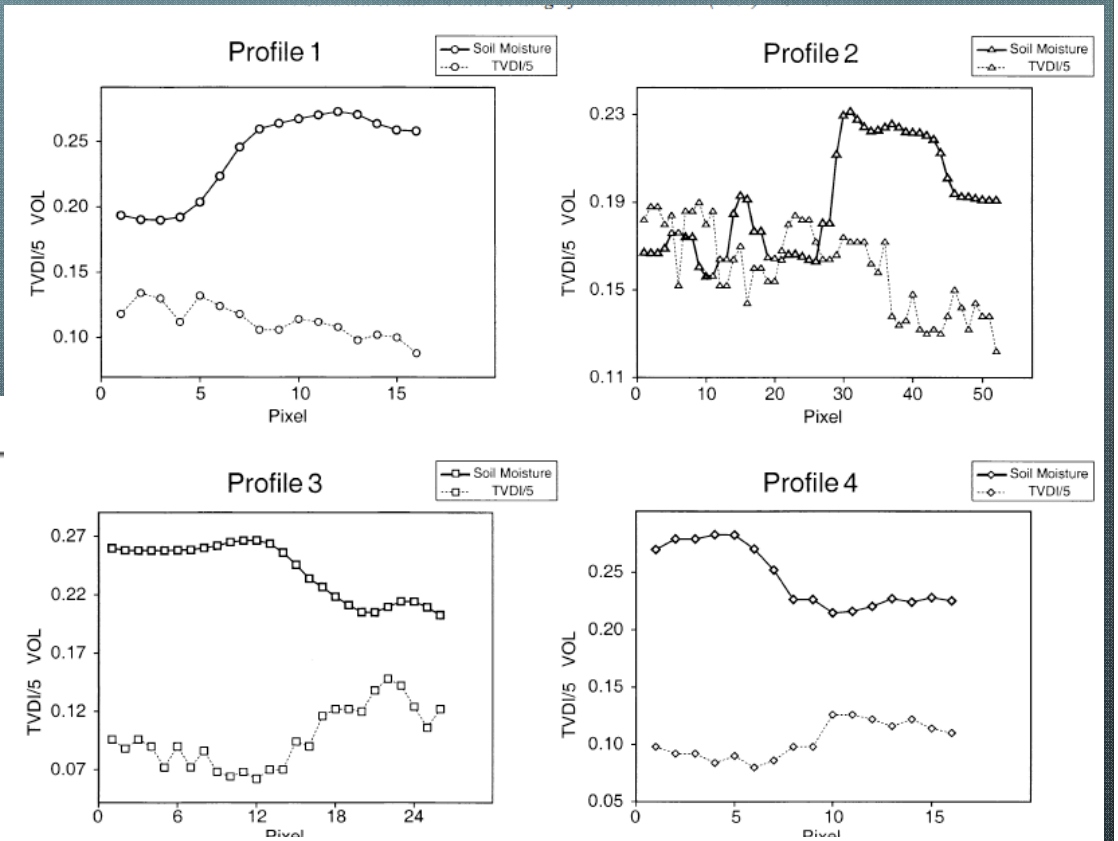
Spatial Variation of TVDI



Results

Comparison to simulated soil moisture





Mean, standard deviations of simulated soil moisture (SM) and TVDI, and R^2 values for linear fit of the data

	SM		TVDI		
Transect	Mean	S.D.	Mean	S.D.	R^2
1	.24	.03	.56	.06	.54
2	.19	.02	.80	.10	.23
3	.24	.02	.49	.13	.81
4	.25	.03	.52	.08	.70
5	.22	.04	.65	.18	.70

Conclusion and Future Directions

- Ts/NDVI is space is well defined in most of the cases
- Estimation of TDVI parameters was most problematic in the dry season
- No Distinct trend in the temporal evolution is found.
- TDVI is closely related to surface soil moisture simulated with MIKE SHE Model R2 = 0.70
- Similar Spatial patterns of TDVI and simulated soil moisture were found.

- Additional work using meteorological data is required to test the robustness of the method over large areas, and the use of TVDI for driving, updating and validating hydrological models.