

→ MEASUREMENTS AND OBSERVATIONS IN THE 21st CENTURY CONFERENCE

Soil water content assessment by means of optical and thermal remote sensing: an analysis of advantages and limits of the "Triangle Method"

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21 November 2016 | ESA-ESRIN | Frascati (Rome) Italy

BACKGROUND

Among indirect estimations of soil water content (U) indexes in the upper soil layer, the **triangle method** is based on the analysis of optical and thermal features sensed *via* EO.

- **Hypotheses:**

2.0 vegetation stress is due to U ;

2.1 meteorological conditions are fairly constant in space → not too wide area;

2.2 the full range of U occurs: i) from dry to wet limits ii) under the full range of vegetation coverage (bare soil ↔ dense vegetation). → not too small area.

These hyps. cannot be met easily, thus researchers have started looking at **multi-temporal approaches** (e.g., Wang *et al.* 2004).

- **Extra challenges:** periodic fluctuations of atmosphere meteorological forcing (*i.e.*, air temperature and humidity, solar radiation) influence the thermal regime of the soil vegetation system.
- **Needs:** the contribution of U fluctuations on the LST need to be isolated from the other forcing or results have to be interpreted.

The IMERA MERIDIONALE Catchment

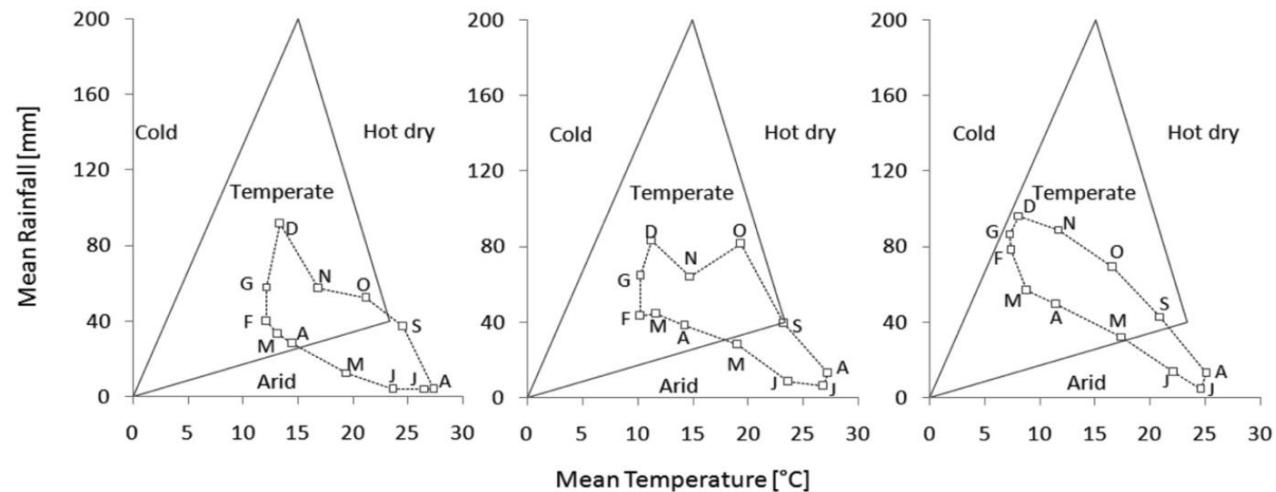
Surface	2014 Km ²
Land use	Mainly crop plots
Total annual rainfall	520 mm

Drasi gauge station	
Altitude	56 m s.l.m.
Sub-catchment surface at Drasi	1782 Km ²

Licata [70m s.l.m.]

Delia [384m s.l.m.]

Ganci [970m s.l.m.]



Péguy climograph: thermo-pluviometric conditions at selected gauge stations.

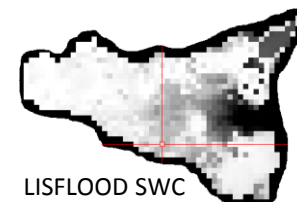
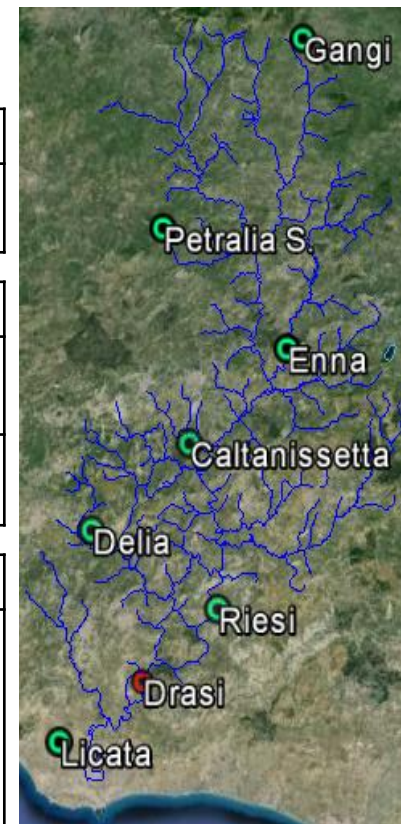
DATASET

(1/1/2001 - 31/12/2012)

Gauge data	Meteorological variables
SIAS meteorological data	Air temperature and humidity, Solar radiation, daily total rainfall

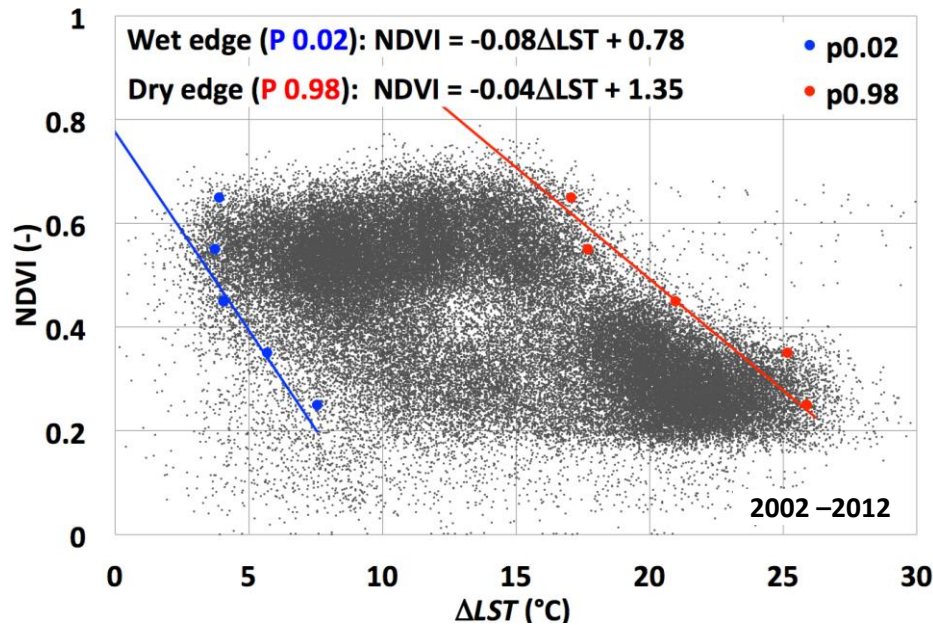
EO products	Resolutions
LST: MOD11A2	R_S : 1 Km - R_T : 8 days
NDVI: MOD13Q1	R_S : 250 m - R_T : 16 days

Hydrological products	Resolutions
LISFLOOD^(*) daily topsoil SWC (U)	R_S : 5 km - R_T : 1 day



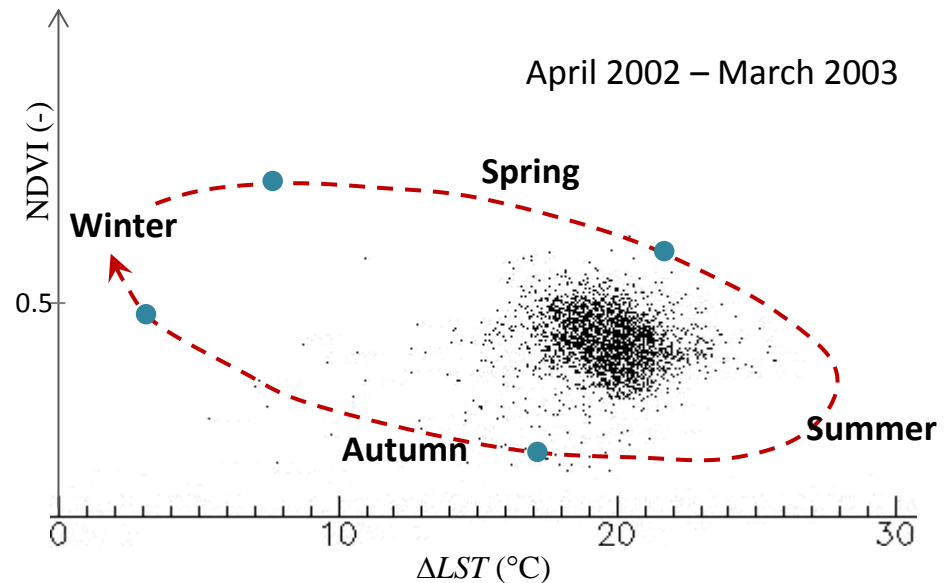
(*) LISFLOOD reproduces the hydrology of large European catchments. It runs within the European Flood Awareness System.

TRIANGLE METHOD *admittance version*

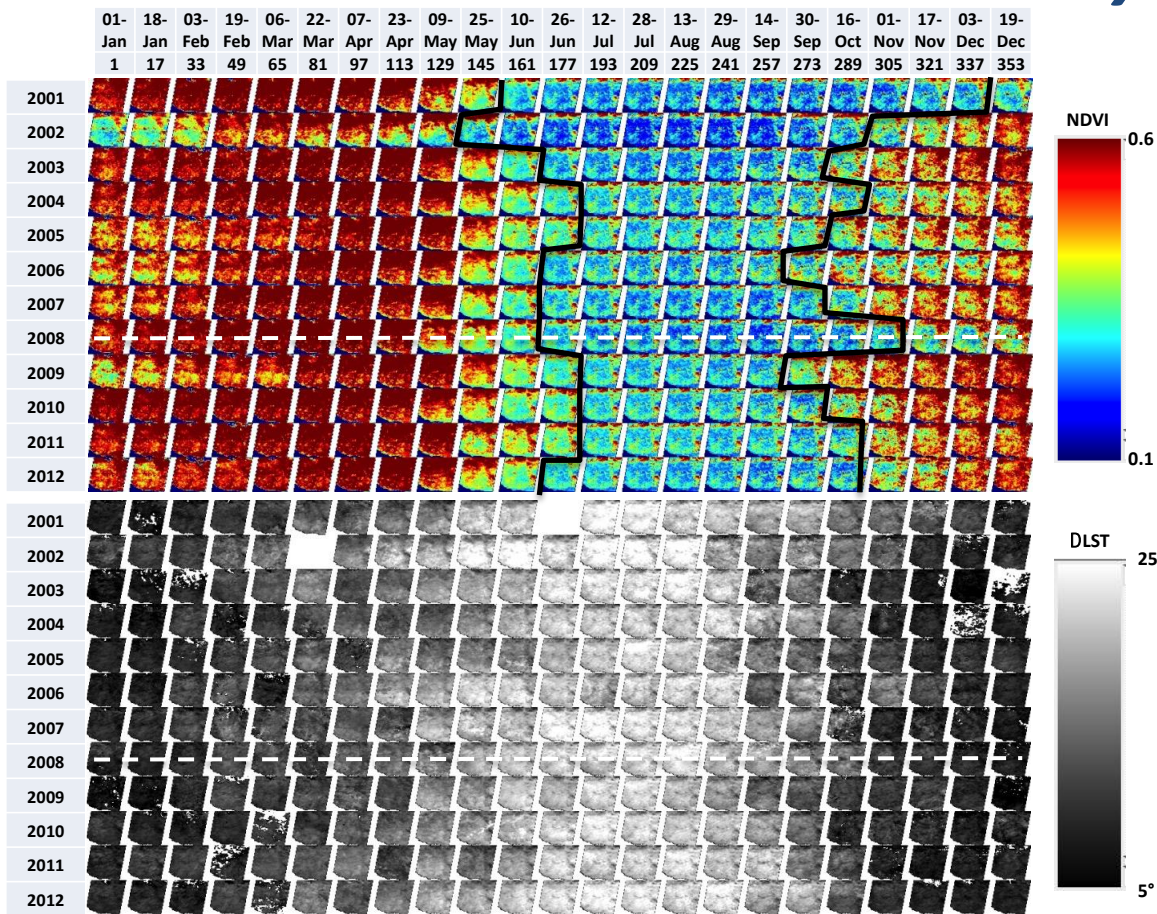


$$\Delta LST = LST_{\text{day}} - LST_{\text{night}}$$

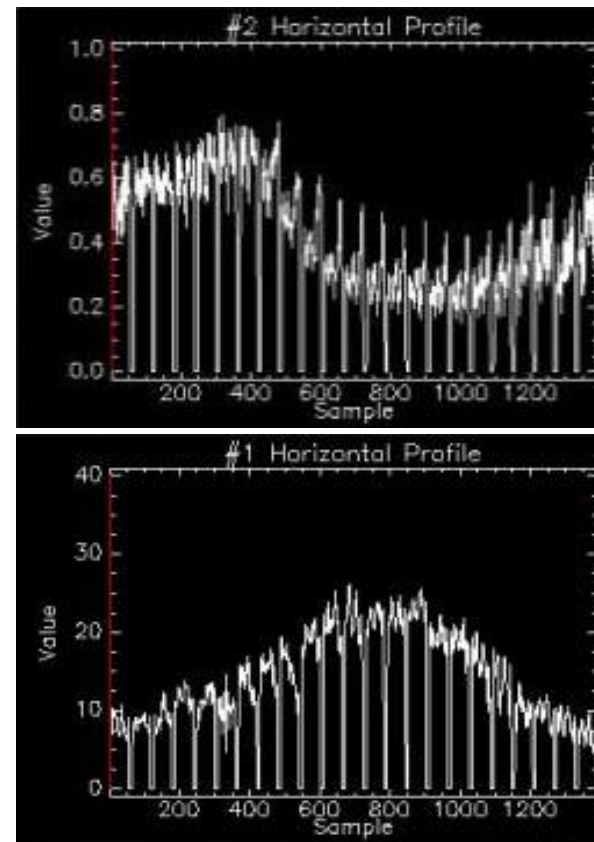
NDVI- ΔLST pairs move clockwise during the year, concordantly with the Péguy climograph



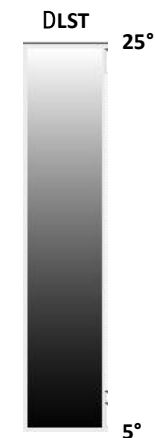
Diachronic analysis



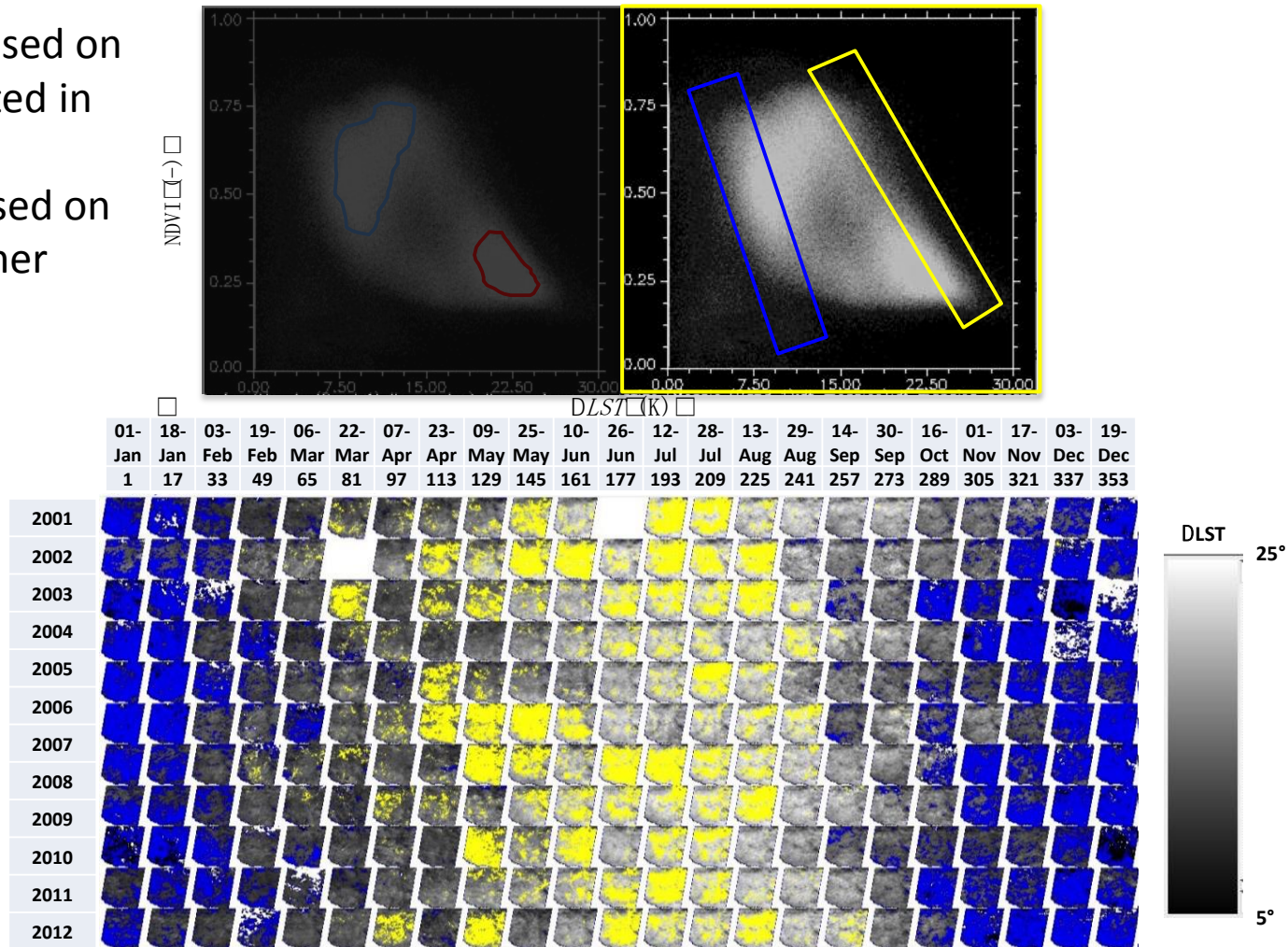
NDVI (upper p.) and day – night LST (lower p.)

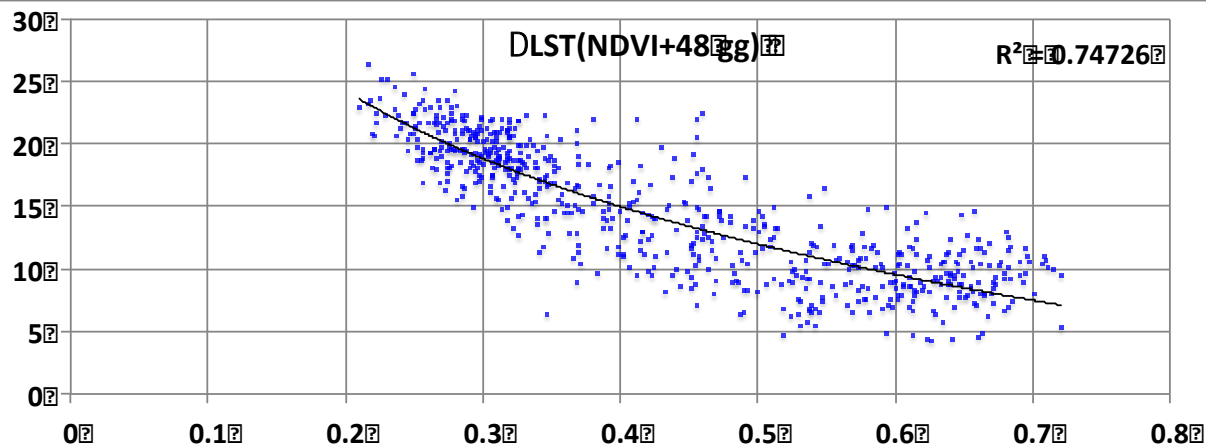
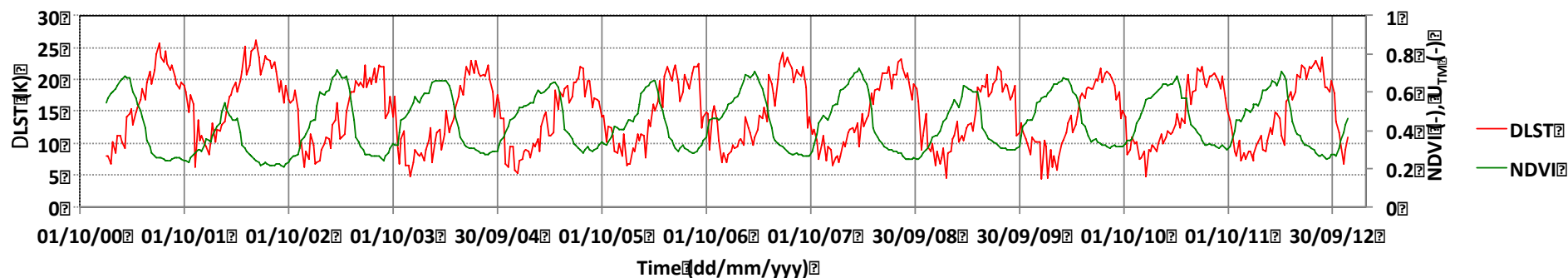


NDVI vs. Δ LST phase shift



Wet edge based on
pixels collected in
winter;
Dry edge based on
spring-summer
pixels.



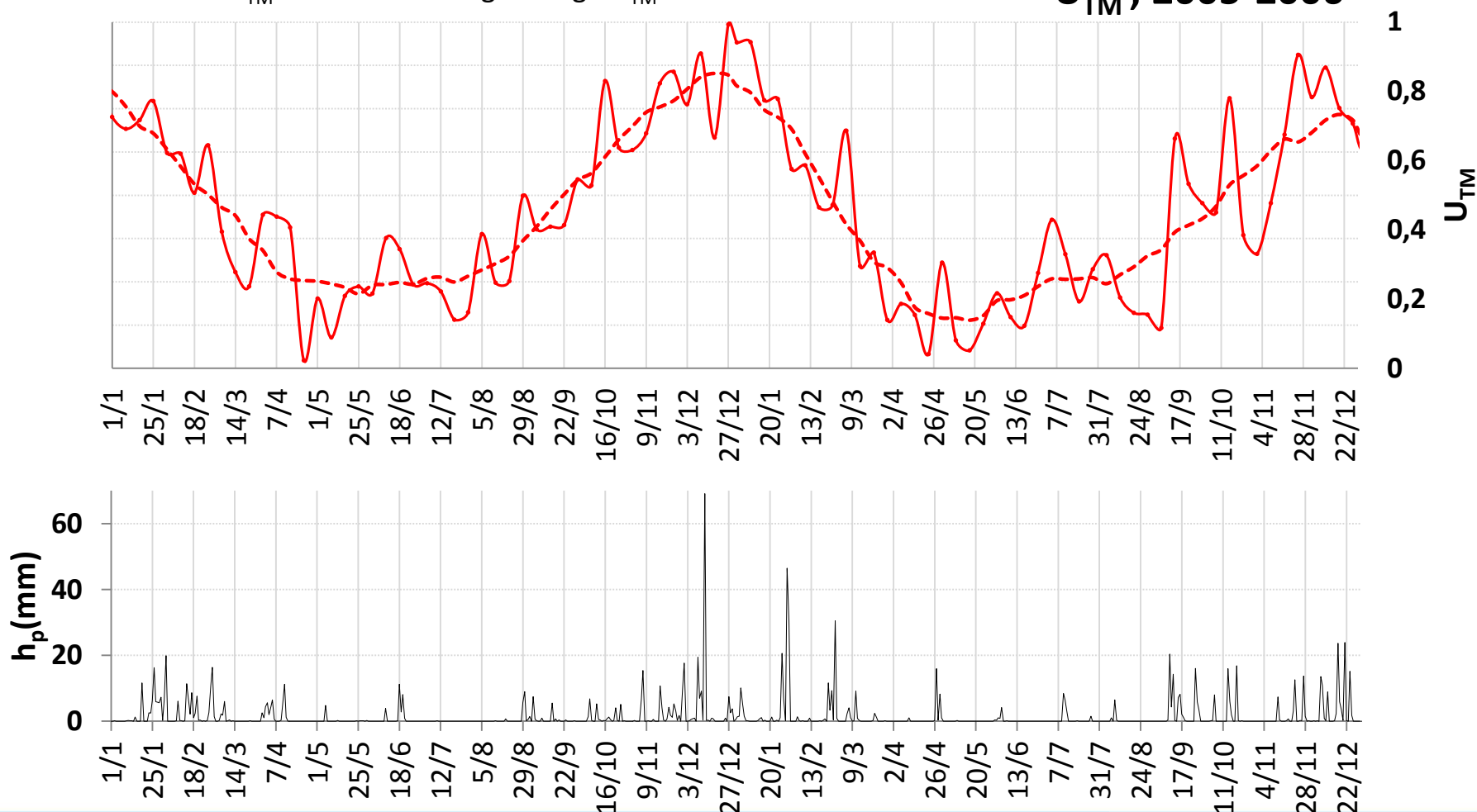


- NDVI vs. ΔLST hysteresis
- ≈ 1.5 months phase shift

U_{TM} has a sinusoidal behaviour, changes are almost in accordance with rainfall events

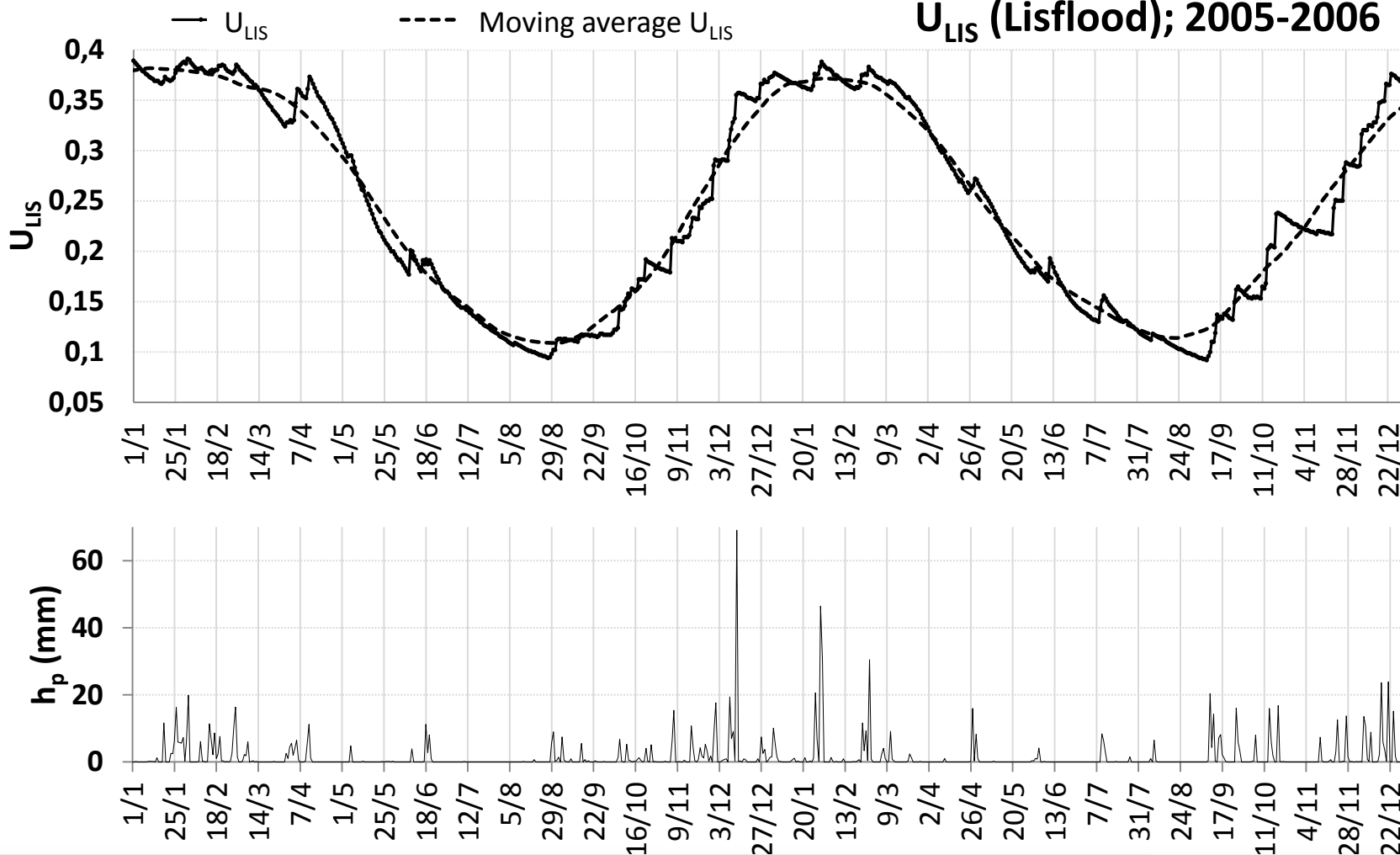
— U_{TM} - - - Moving average U_{TM}

U_{TM} ; 2005-2006

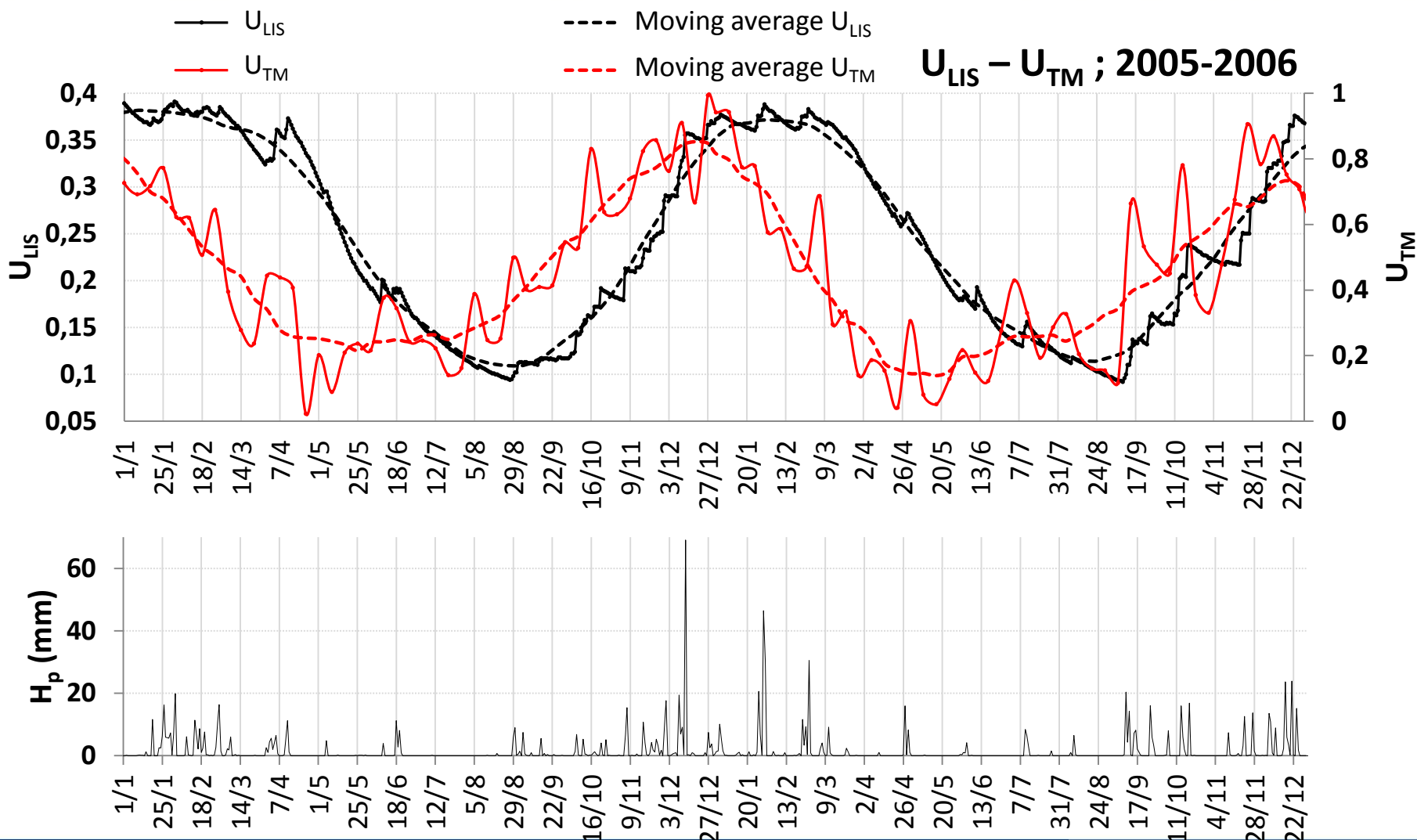


Also U_{LIS} shows a sinusoidal behaviour, shifted in time if compared to U_{TM}

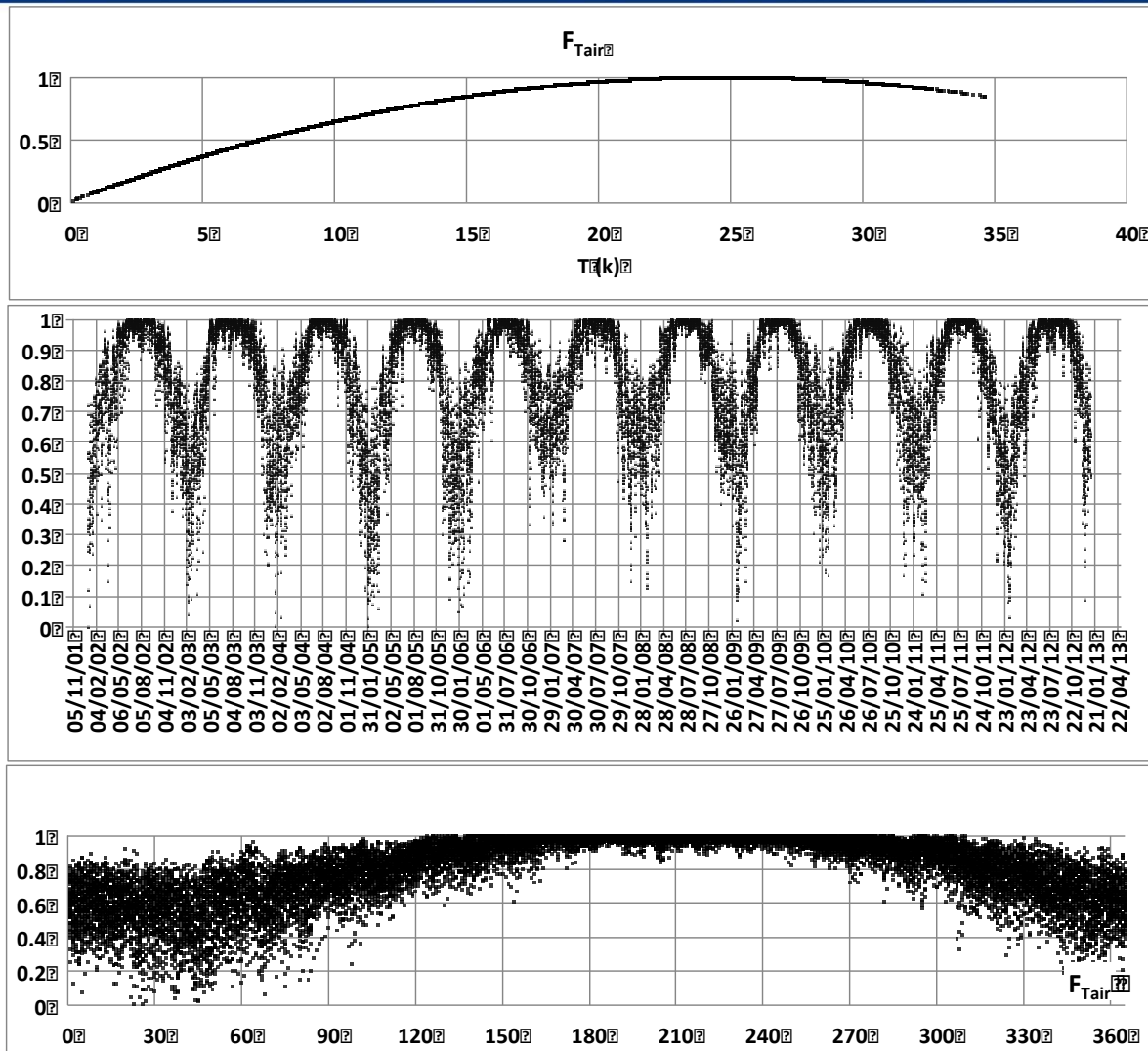
U_{LIS} (Lisflood); 2005-2006

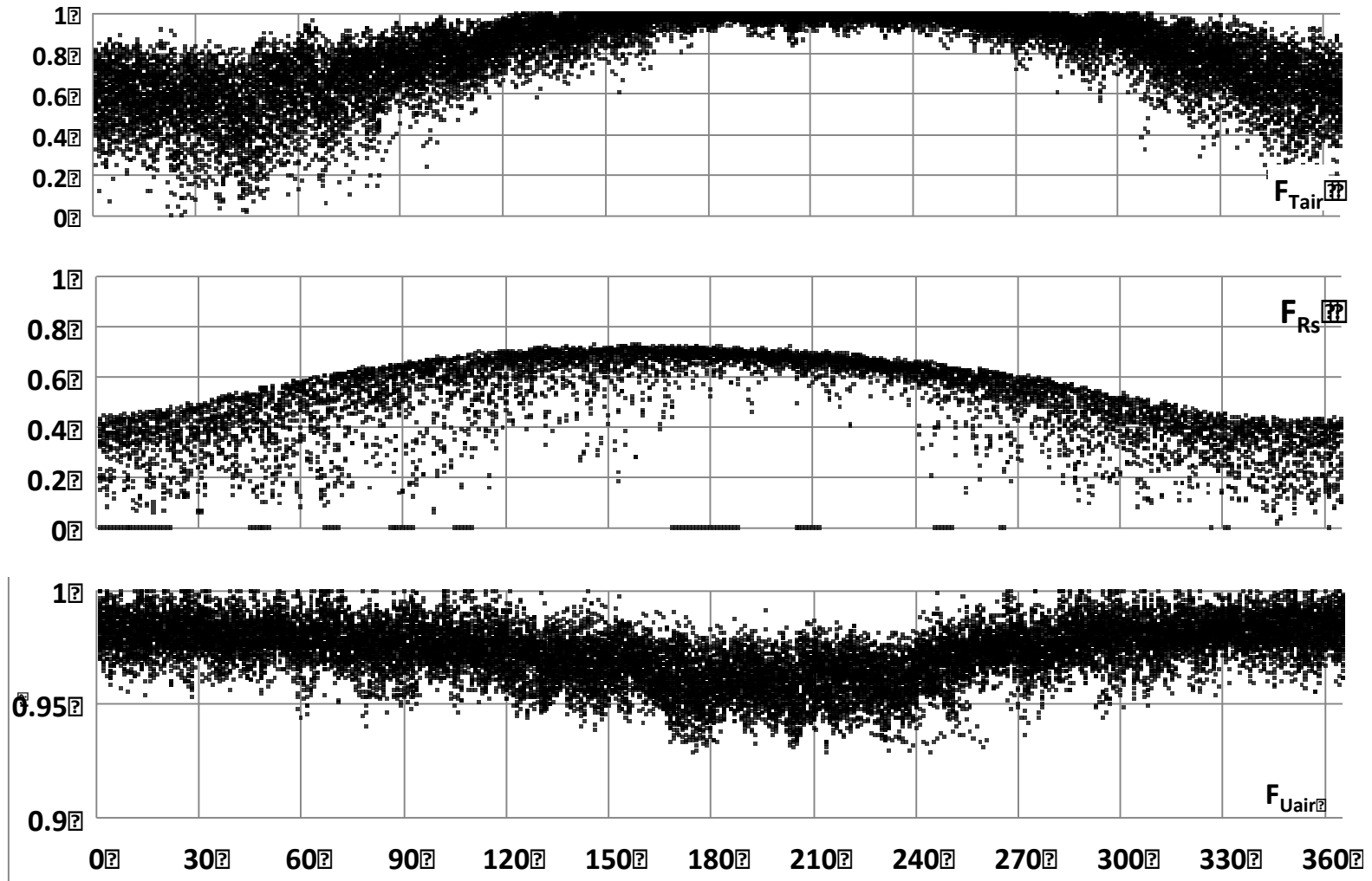


Why a different behaviour?

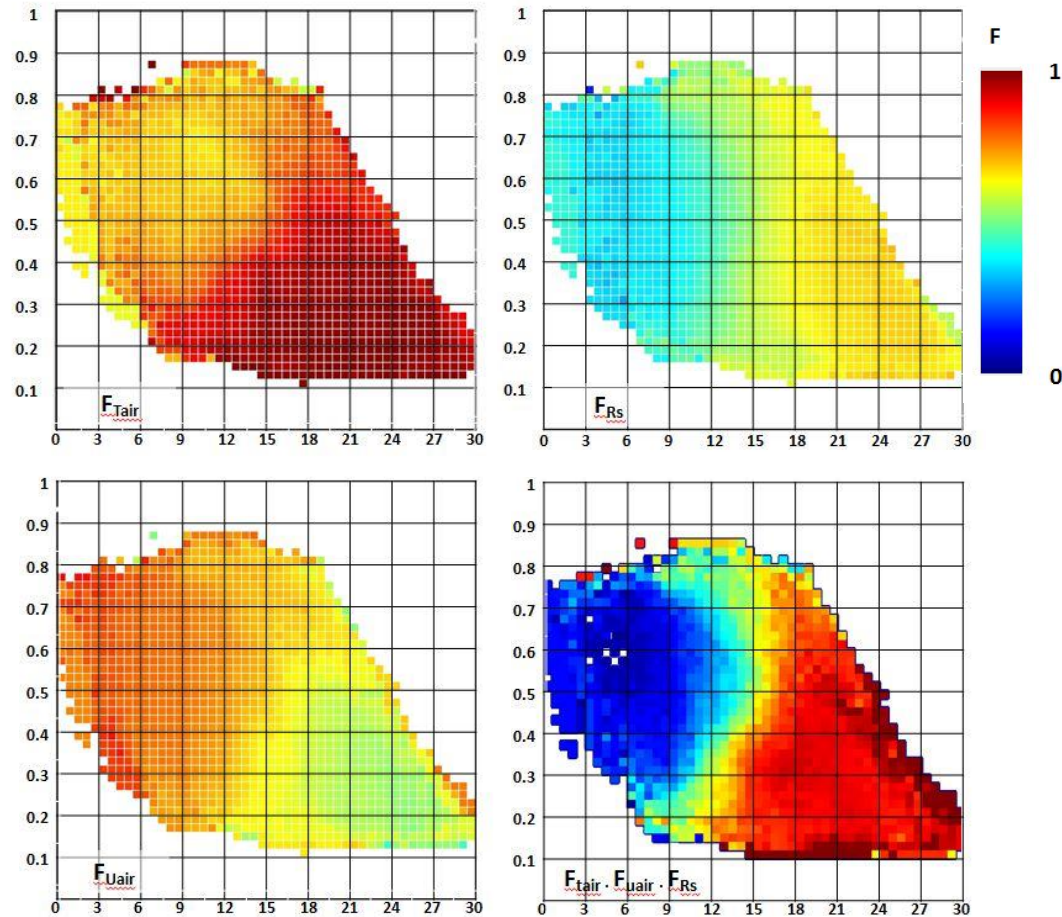


Environmental stress
reduction factors, F ,
of stomata
conductance (Jarvis,
1976).



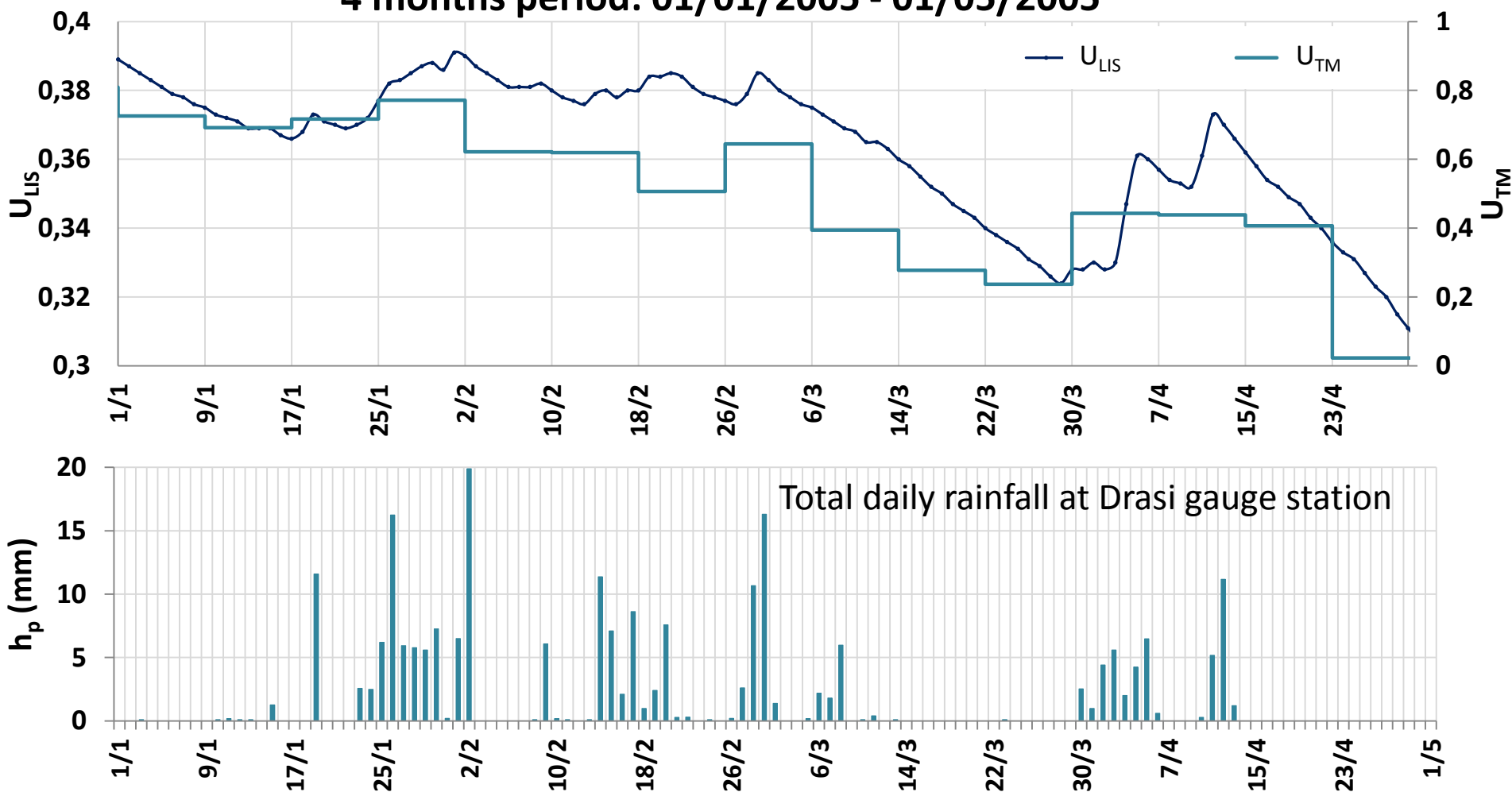


F are evaluated within the NDVI vs. LST space



Changes in U_{TM} are explained with θ variations, do we expect a uniform distribution of F in the NDVI vs. ΔLST space?

4 months period: 01/01/2005 - 01/05/2005



CONCLUDING REMARKS

- Mediterranean climate exhibits both **arid and temperate periods** (arid for $\approx 3-7$ months varying mainly with altitude from April-May to August-October; remaining months show a temperate climate - Péguy climograph).
- In accordance, the temporal analysis reveals that **the boundaries of the triangle move** during the seasons following a **circular behavior**.
- The assumption that the temperature vs. vegetation index features space is mainly controlled by θ availability is **not physically realistic**, at least in Mediterranean climate.
- Indeed, the position of ΔLST -NDVI pairs, and wet and dry edges as well, depends not only on root zone water stress but also for **environmental stress factors** (difference with optimal air temperature, excessive incident solar radiation, air humidity).
- U_{TM} should be interpreted as a **vegetation stress index**.
- **Quick response** in U_{TM} after rainfall events.

ACKNOWLEDGEMENTS

Soil water content products from LISFLOOD model were gently furnished by the water and floods research group of the JRC of the European Commission.