INTREV-WetEco: INterception-TRanspiration-Evaporation - interdependencies of hydrological processes in WETland ECOsystems, finansed by the Polish National Centre of Sciences

Integration and Validation of Remote Sensing derived Interception Storage into distributed Rainfall-Runoff model

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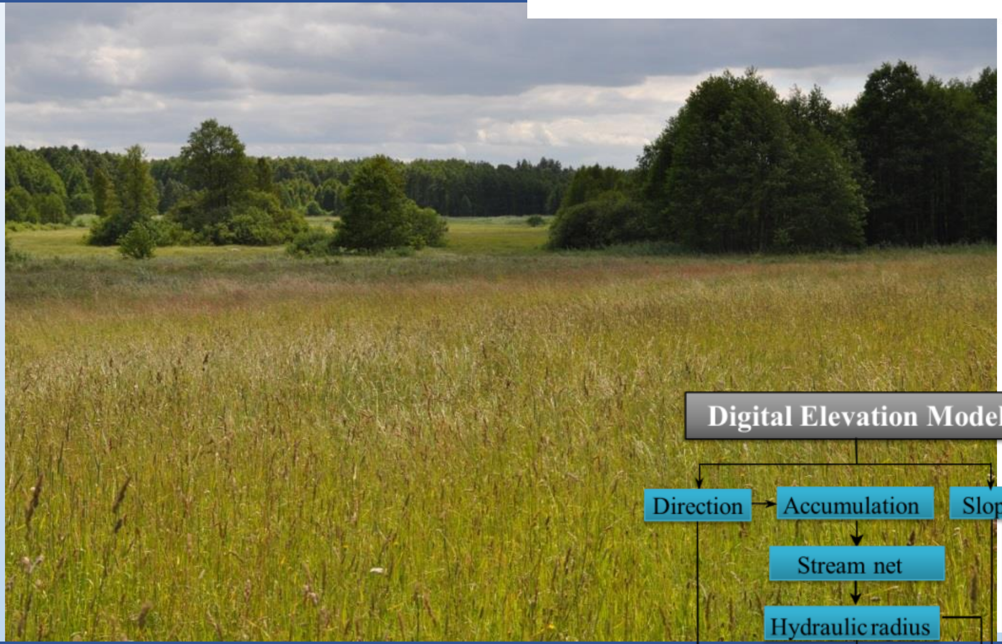
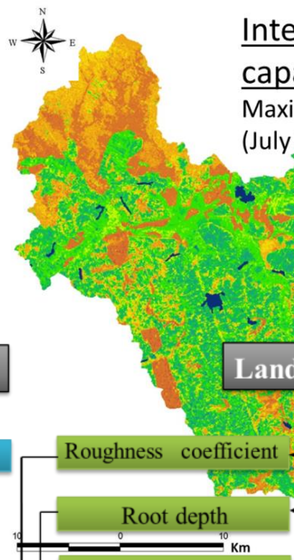
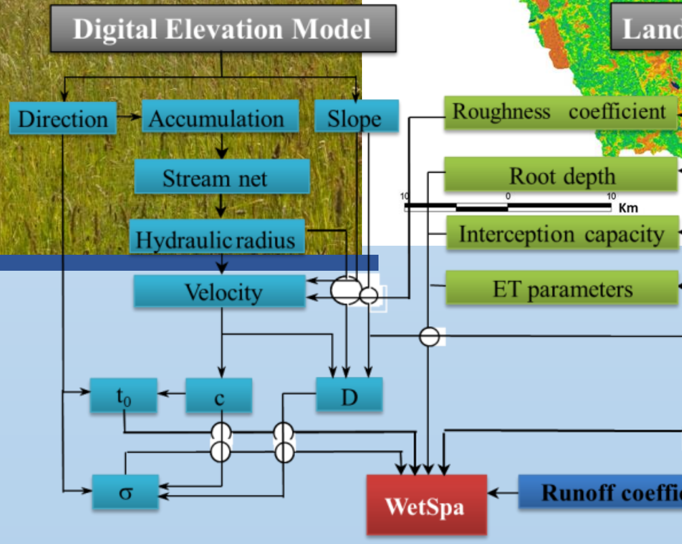






Int

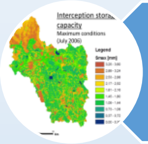
The extensive floodplain and riverine marshes, forms the big river valley peatland, with an unique diversity of wetland ecosystems. Interception storage capacity of these mostly sedges is a clue of our study.

Intro

- **Distributed models of catchments with significant wetland coverage have to focus on wetland-specific issues such as the hydrological response of natural vegetation, i.e. parameterisation and dynamics of vegetation.**
- **This study focuses on improving the interception capacity calculation in the distributed hydrological model WetSpa and SWAT based on phisical parameters**
- **Leaf Area Index (LAI) is an useful, phisical parameter describing vegetation canopy structure in terrestrial ecosystems closely related to e.g. biomass and interception storage capacity.**
- **The one of the objectives is to integrate seasonal LAI data: field measurements and remote sensing**
- **The upper Biebrza basin selected for testing**

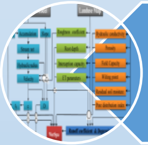
Scheme of the conducted research

Remote Sensing data
(LAI-Landsat relation)

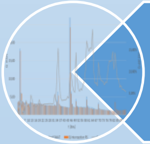


Interception maps –LAI based equations

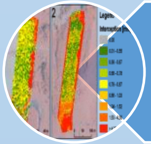
Verification of the interception maps - field sampling and laboratory analysis



Model set up - GIS zonal statistics or distributed GRID

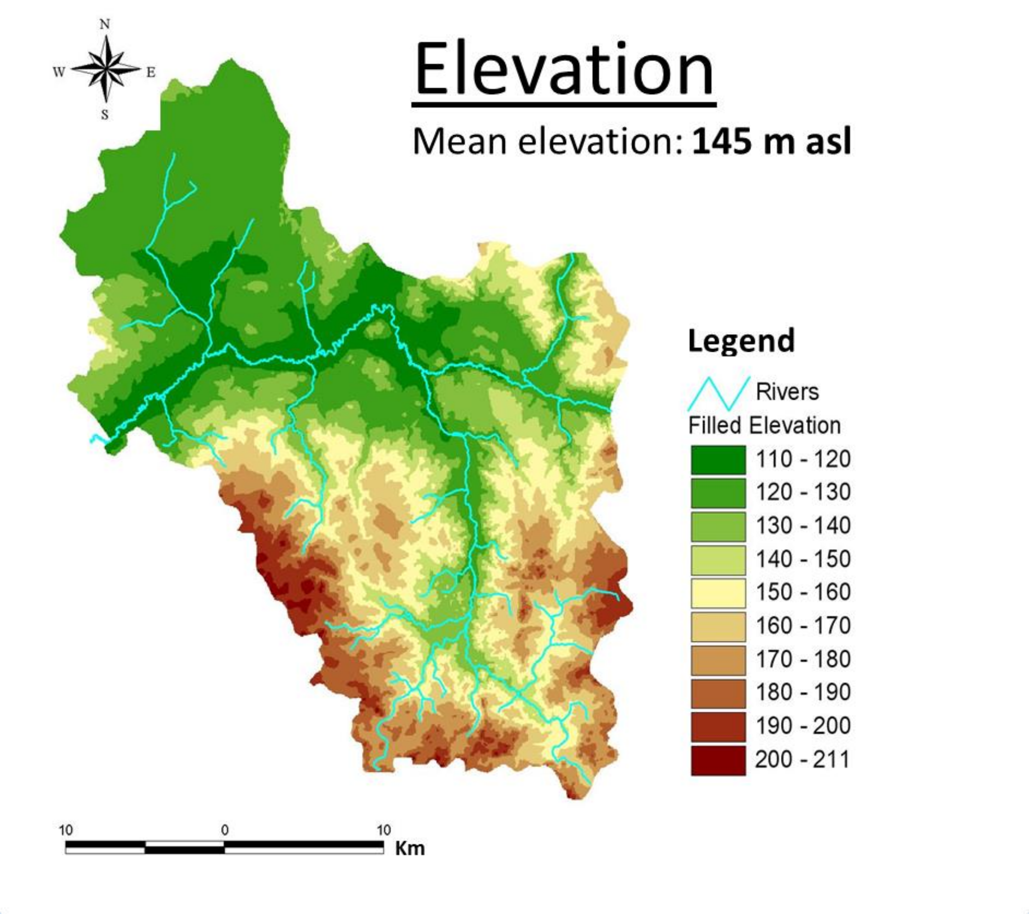


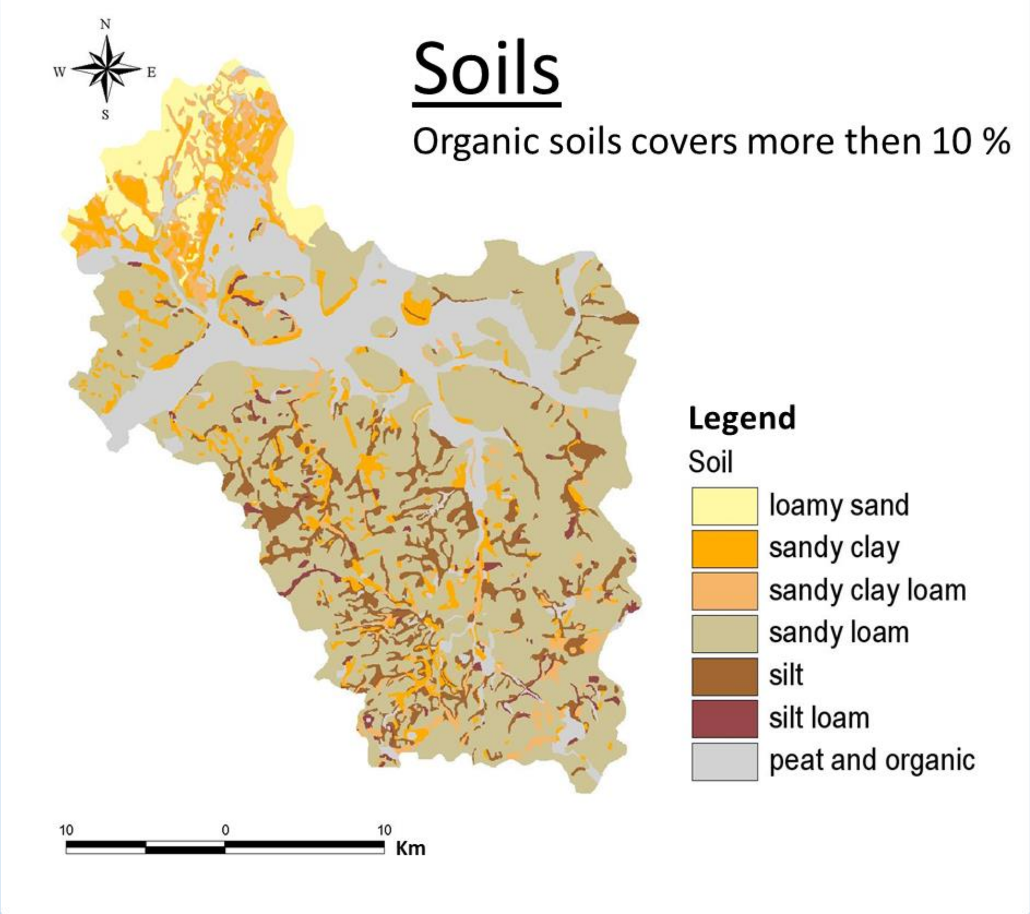
Results



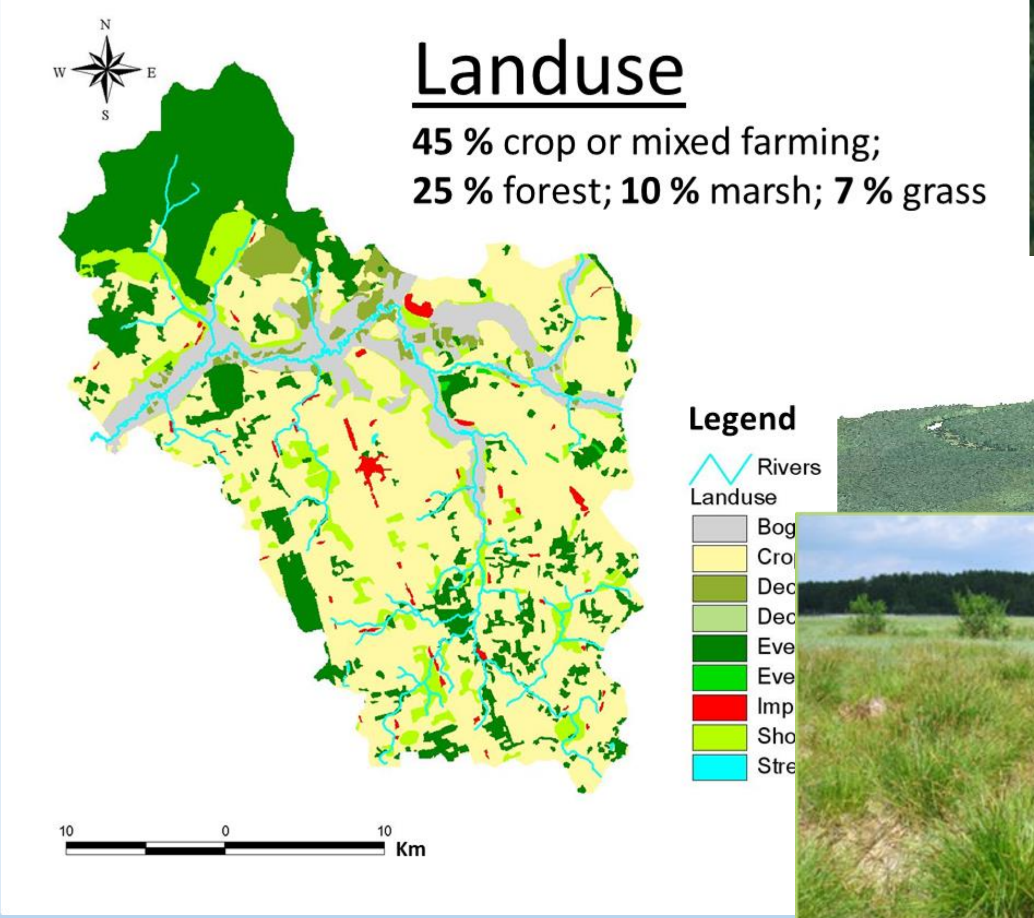
Discussion of different RS interception options

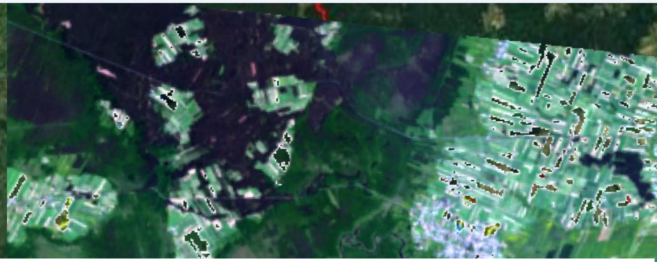
Input maps: DEM and soil

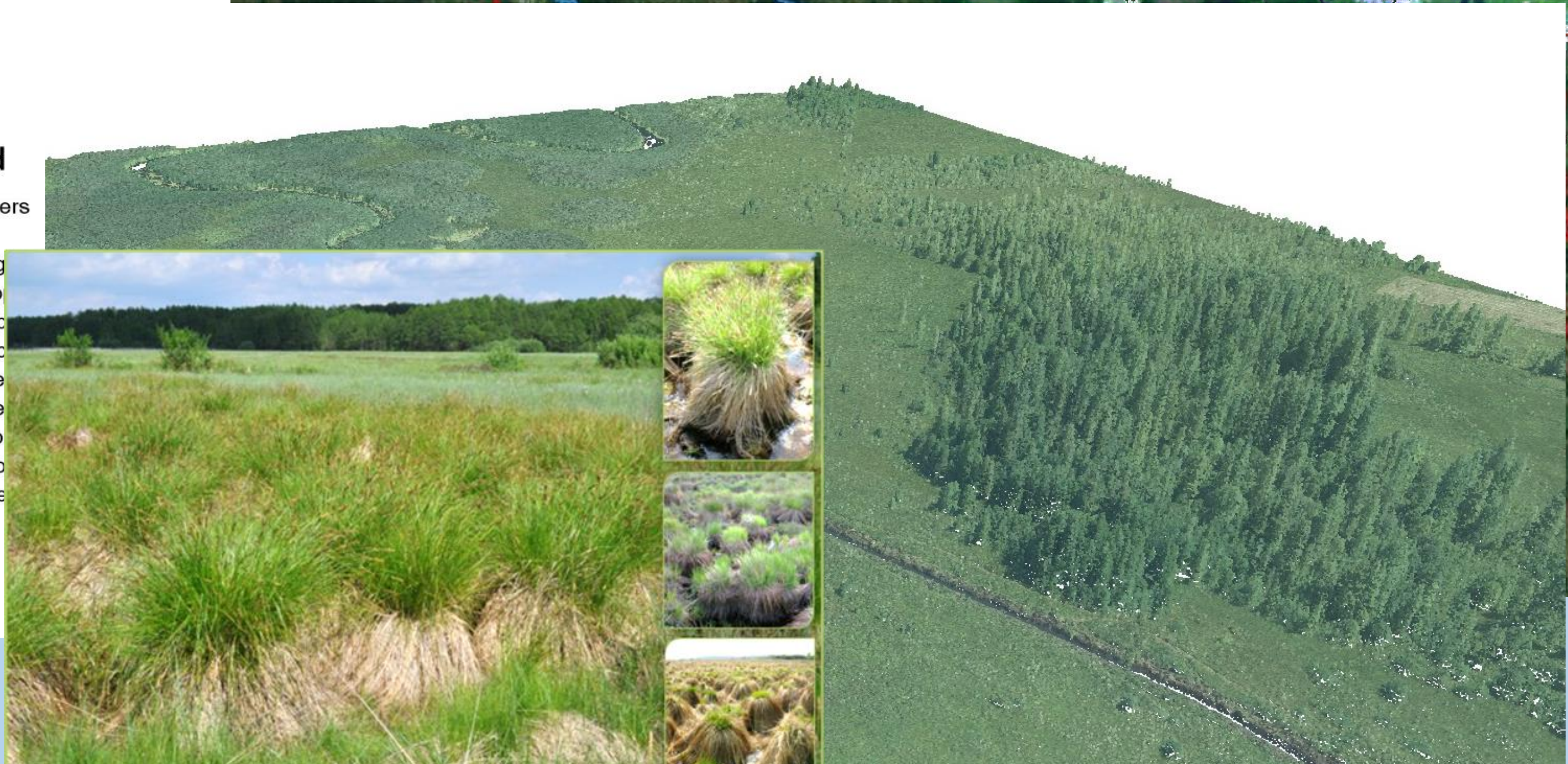




Input maps: CLC Land use and RS-LC (Landsat, ChrisProbe, ALS Point cloud)



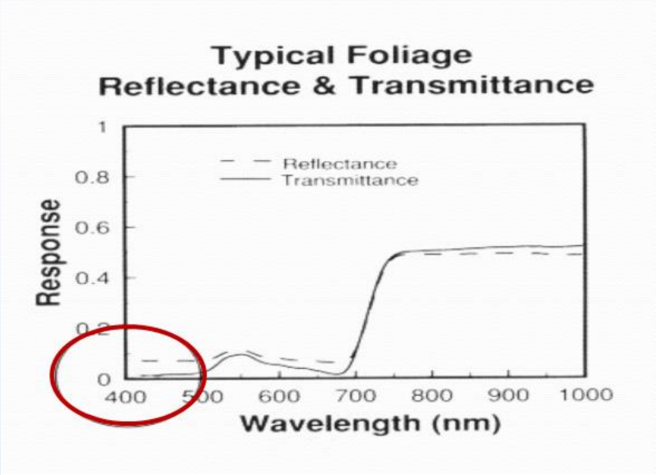


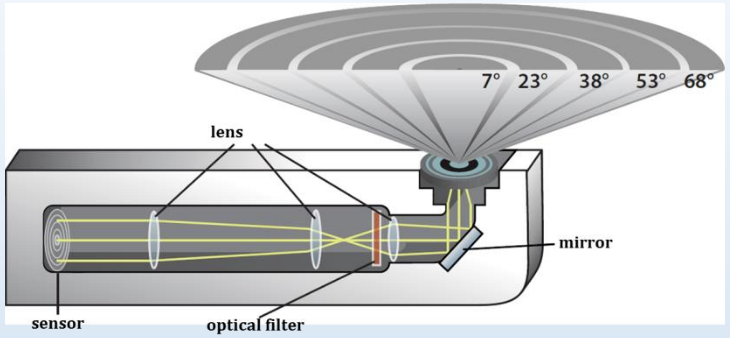


Interception storage capacity estimation

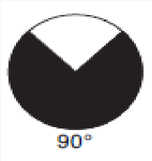
- LAI of different plant communities has been measured in a seasonal using LAI-2000 Plant Canopy Analyzer.
- Landsat images are used to represent the different vegetation stages during the growing season (near LAI minimum and LAI maximum).
- Empirical relationships between these measurements and several spectral vegetation indices were tested.
- The highest correlation and the strongest linear relationship regarding LAI has TM *Atmospherically Resistant Vegetation Index* ARVI (R^2=0.79).
- The minimum/maximum LAI maps are combined with the existing equations to calculate spatially distributed hydrological parameter maps, i.e. minimum and maximum interception storage capacity.

Measurement equipment – LICOR LAI-2000

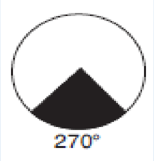




Willow shrubs



Sedges and grass



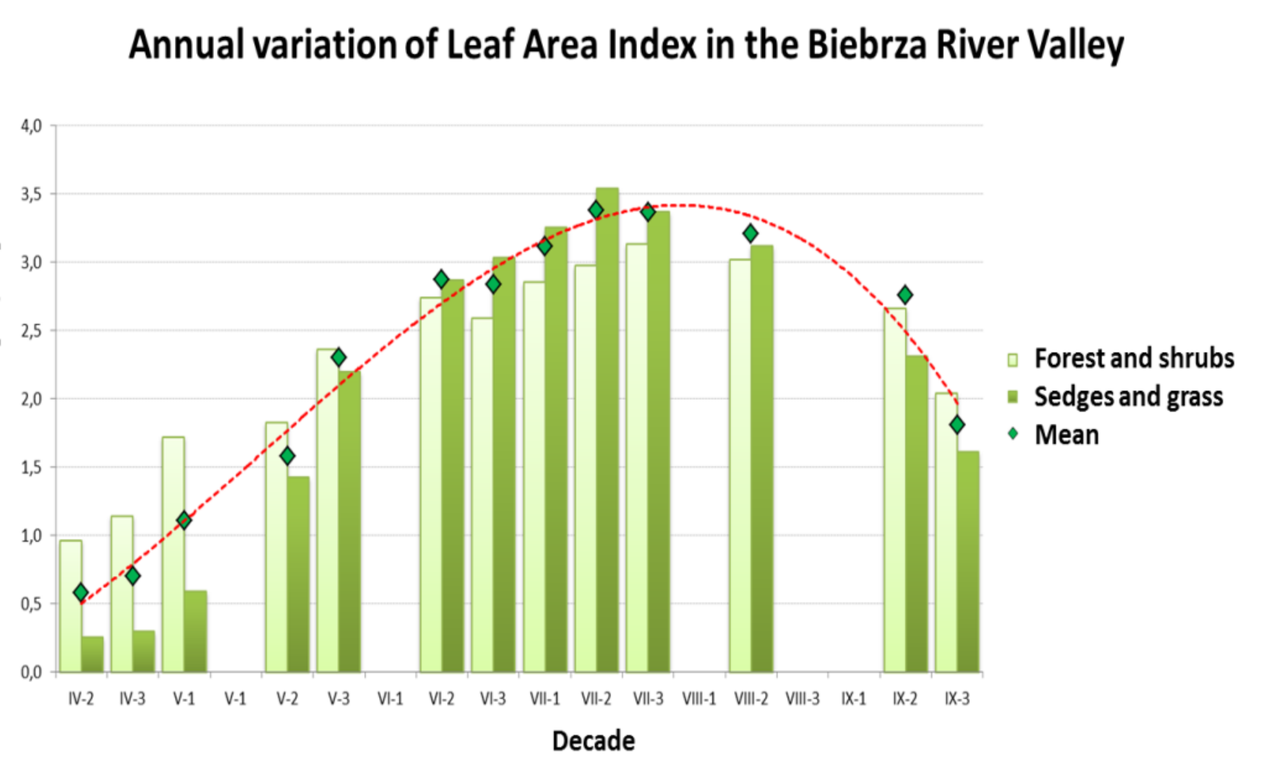
Stable sky conditions

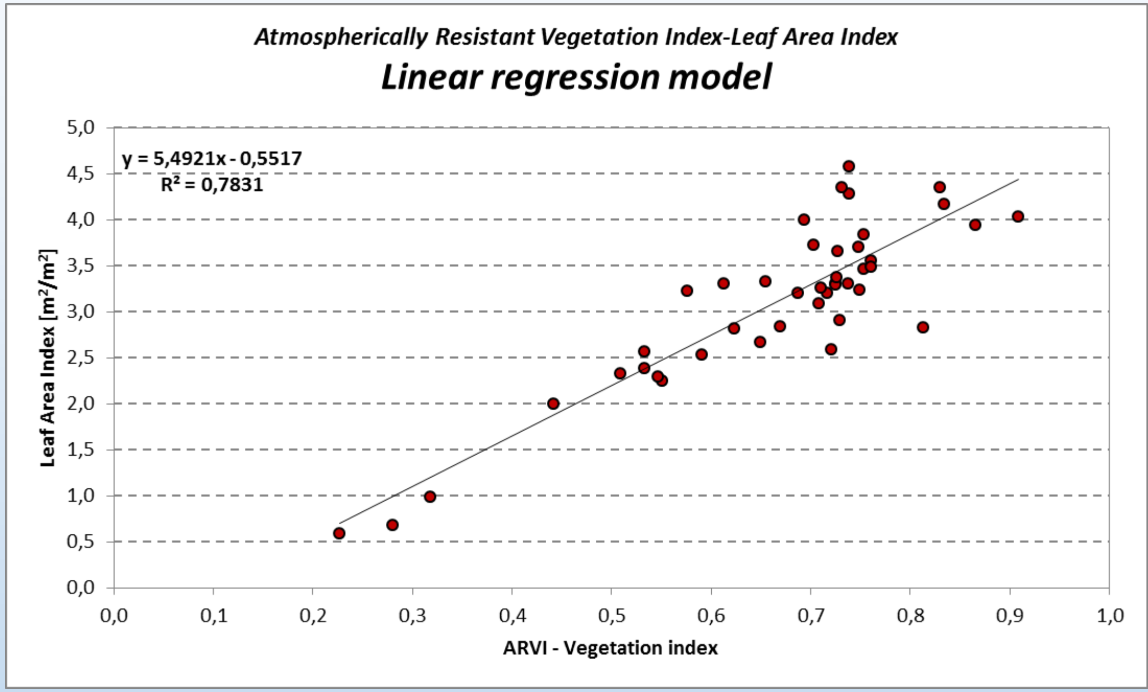
↑↓↓↓↓↓↓↓↓↓↓↓

Unstable sky conditions

↑↓↓↓↓↓↑↓↓↓↓↓

LAI sesonal variation and its regression to Landsat





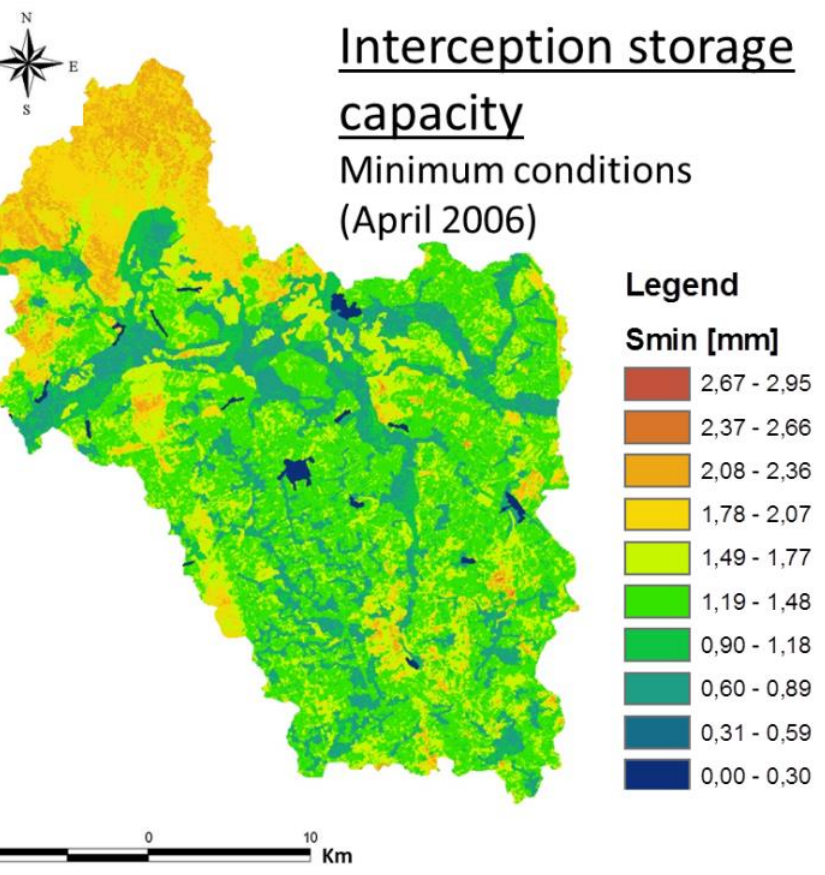
Interception storage capacity calculation based on LAI (Based on methodology De Jong & Jetten, 2007):

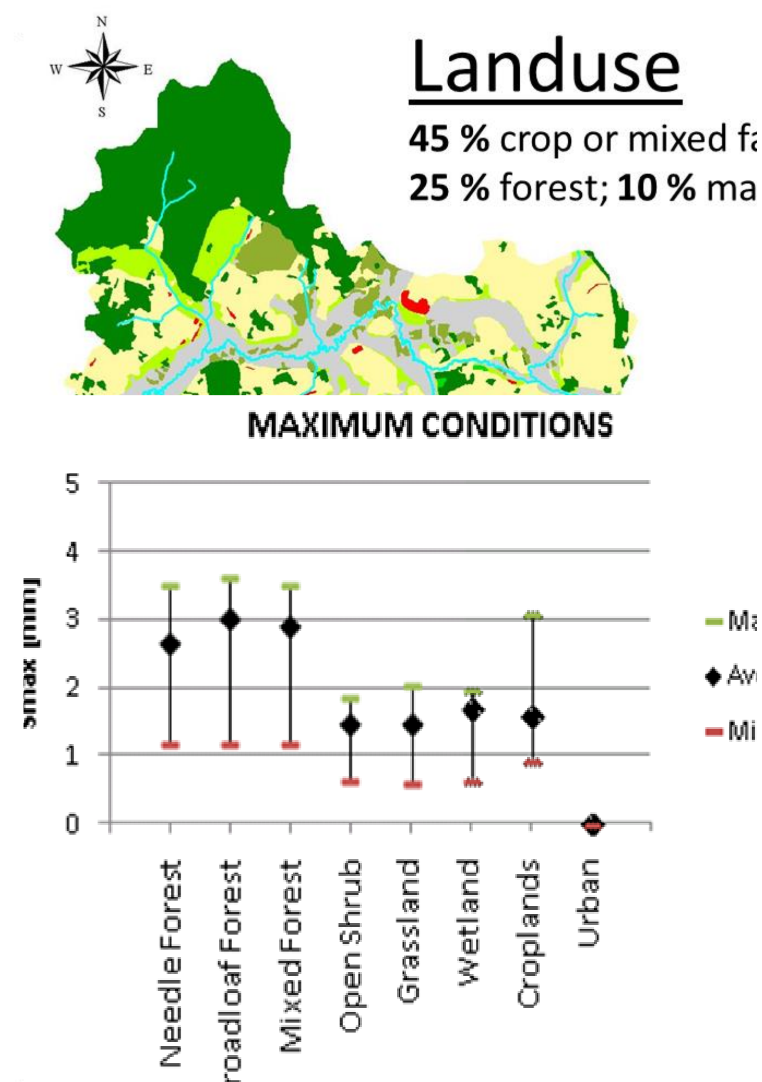
- **Agricultural crops (Hoyningen – Huene ,1981):**
- Smax_crops_min = 0.935+(0.498*LAIMIN65)-(0.00575*(LAIMIN65^2))

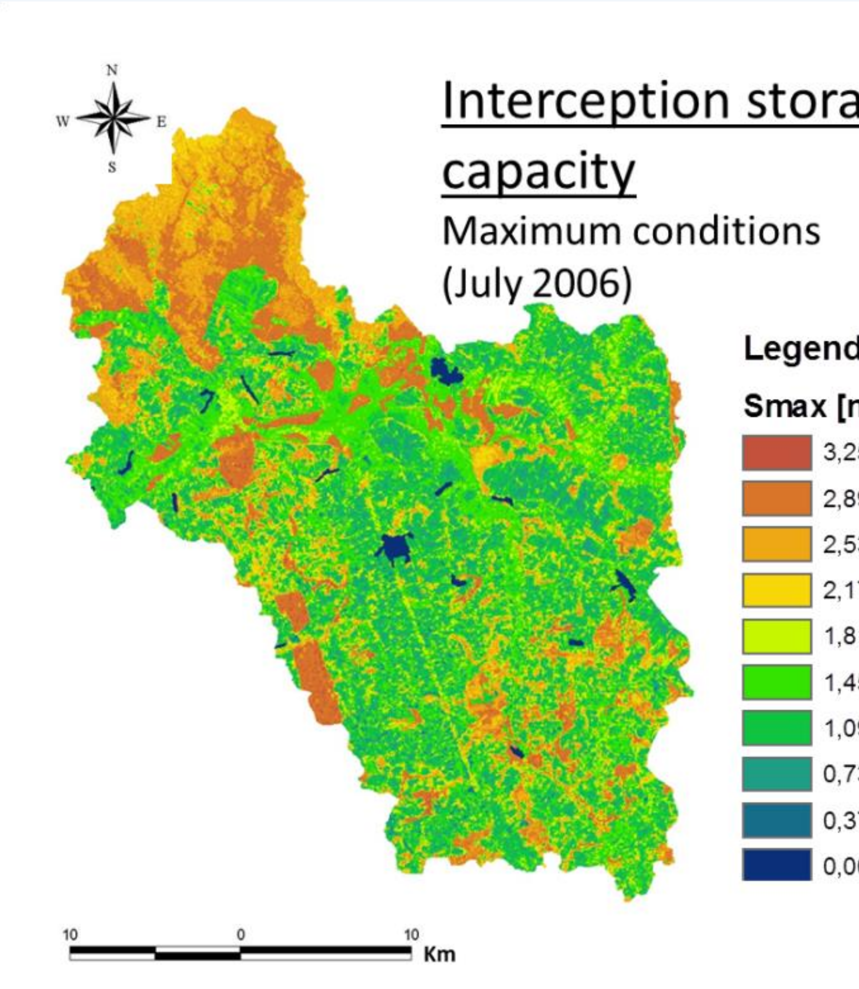
- **Grass and shrubs (Amongst others Gomez et al., 2001):**
- Smax_grass_min = 0.3063*LAIMINCORR65)+0.5753

- **Broadleaf forest (Gomez et al., 2001):**
- Smax_forest_min = 1.1840(0.490*LAIMINCORR65)

Min and Max Interception storage capacity based on Landsat







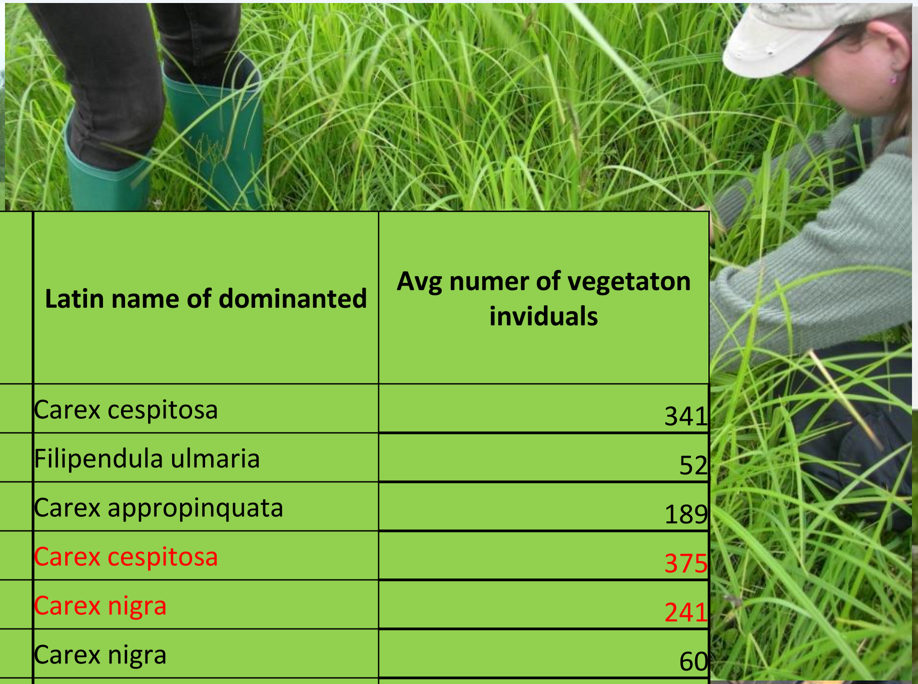
Interception map verification

Sedge ecosystems as dominated habitats in riparian wetland

Interception canopy water storage estimation

- Sedge interception water capacty (Int) estimation by measurement of leafs water storage capacity (Wohlfahrt et al., 2006)
- Sampling (60-100 pieces per dominated vegetation type)
- Counting: pieces of dominated vegetation species pes sq m (n)
- Isolation (wax)
- Weight:
  - Dry (d)
  - After wetting and spraying (w)
  - The water storage as a average difference between wet and dry: avg(w-d)
- Interception capacity calculation: Int = avg(w-d)*n
- Biomass estimation (Wet (3 h after sampling), Dry (dring 24h in 70 C degree)
- Tansley relevee and leaves counting per sq meter

Sampling and counting, Biomass and relevee



Carex appropinquata – 3

Rumex acetosa – 1

Filipendula almaria – 2

Ranunculus repens – 2

Valeriana officinalis – 1

Carex cespitosa – 4

Geum rivale – 2

Menyanthes trifoliata – 2

Lysimachia thyrsiflora – 2

Carex nigra – 1

Viola pumila – 1

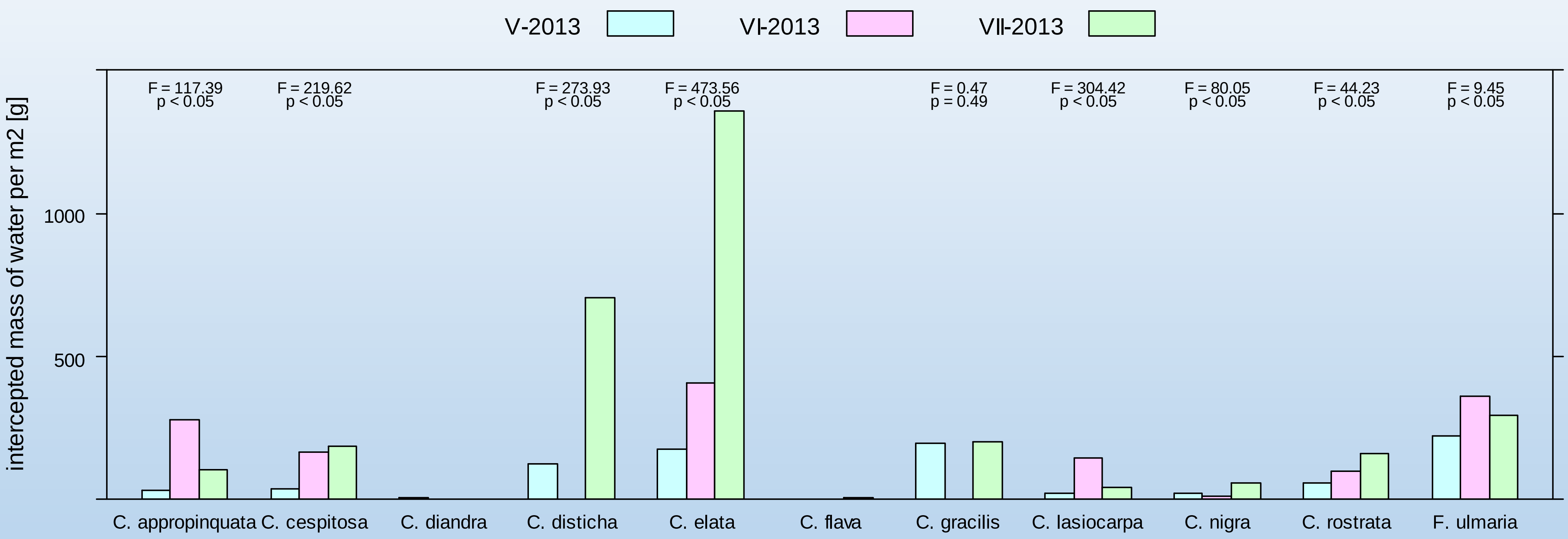
Circium sp. – 1

Polygonum bistor ta – 1

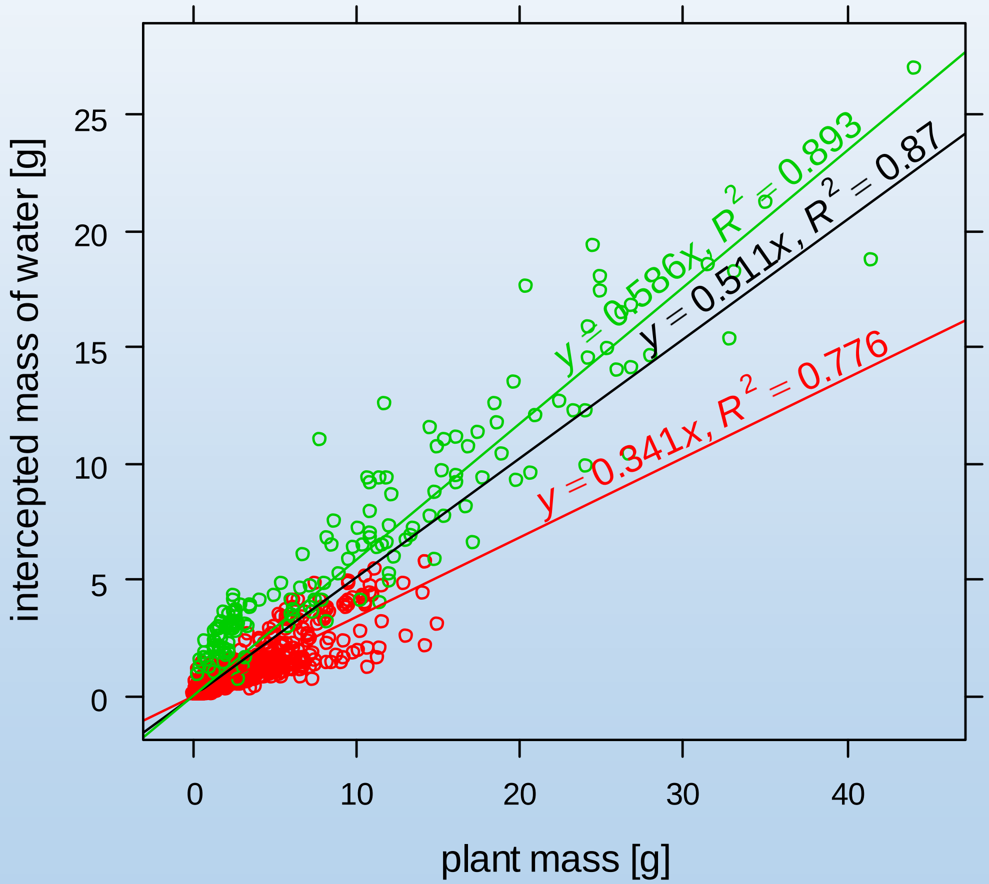
No	Name of ecosystem	Polish name	Latin name of dominanted	Avg numer of vegetaton inviduals
1	Caricetum caespitosa	Turzyca darniowa	Carex cespitosa	341
2	Philipendulatum	Wiązówka błotna	Filipendula ulmaria	52
3	Caricetum appropinquata	Turzyca tunikowa	Carex appropinquata	189
4	Caricetum caespitosa	Turzyca darniowa	Carex cespitosa	375
5	Caticetum nigrae	Turzyca pospolita	Carex nigra	241
6	Caricetum paniceae	Turzyca pospolita	Carex nigra	60
7	Caricetum caespitosa	Turzyca darniowa	Carex cespitosa	378
8	Caricetum appropinquata	Turzyca tunikowa	Carex appropinquata	350
9	Caricetum lasiocarpae	Turzyca nitkowata	Carex lasiocarpa	278
10	Caricetum diandrae	Turzyca łuszczkowata	Carex lepidocarpa	45
11	Caricetum elatae	Turzyca dzióbkowata	Carex rostrata	120
12	Caricetum elatae	Turzyca sztywna	Carex elata	254
13	Caricetum distichae	Turzyca dwustronna	Carex disticha	546
14	Caricetum gracilis	Turzyca zaostrzona	Carex gracilis	229
15	Caricetum gracilis	Turzyca zaostrzona	Carex gracilis	138

Isolating, wetting and spraying, weighting

Results per square meter



Mass of water stored on versus plant mass



- High correlation between interception and mass of individual plants of Carex genus (red), Filipendula genus (green) and both (black).
- Values of interception obtained for measured locations shows also good agreement with Landsat-LAI based maps

Interception model sensitivity and simulation

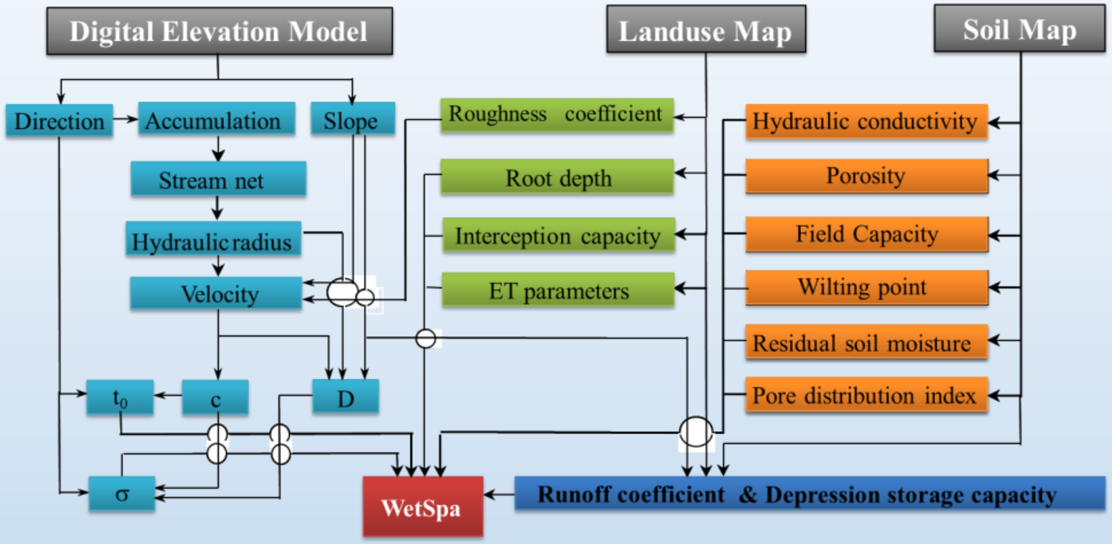
WetSPA water balance

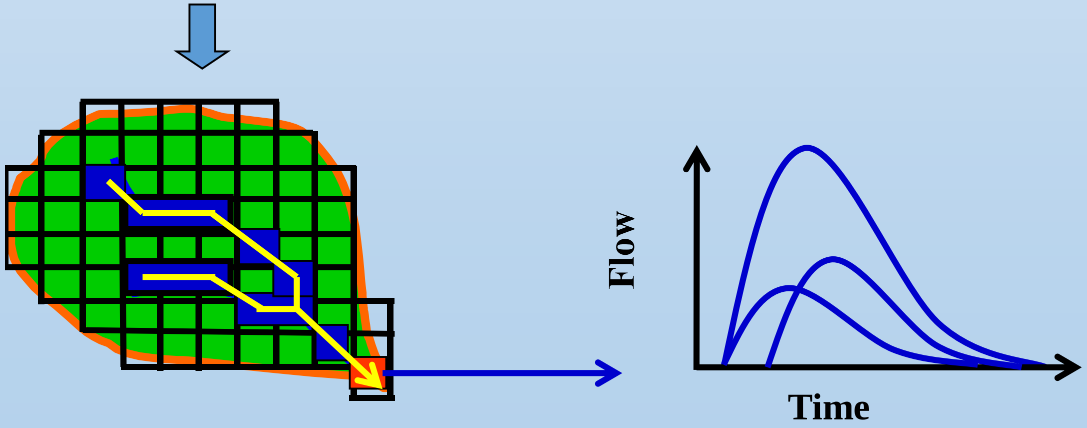
SWAT discharge

WETSPA - raster based rainfall-runoff model

Input to the model:

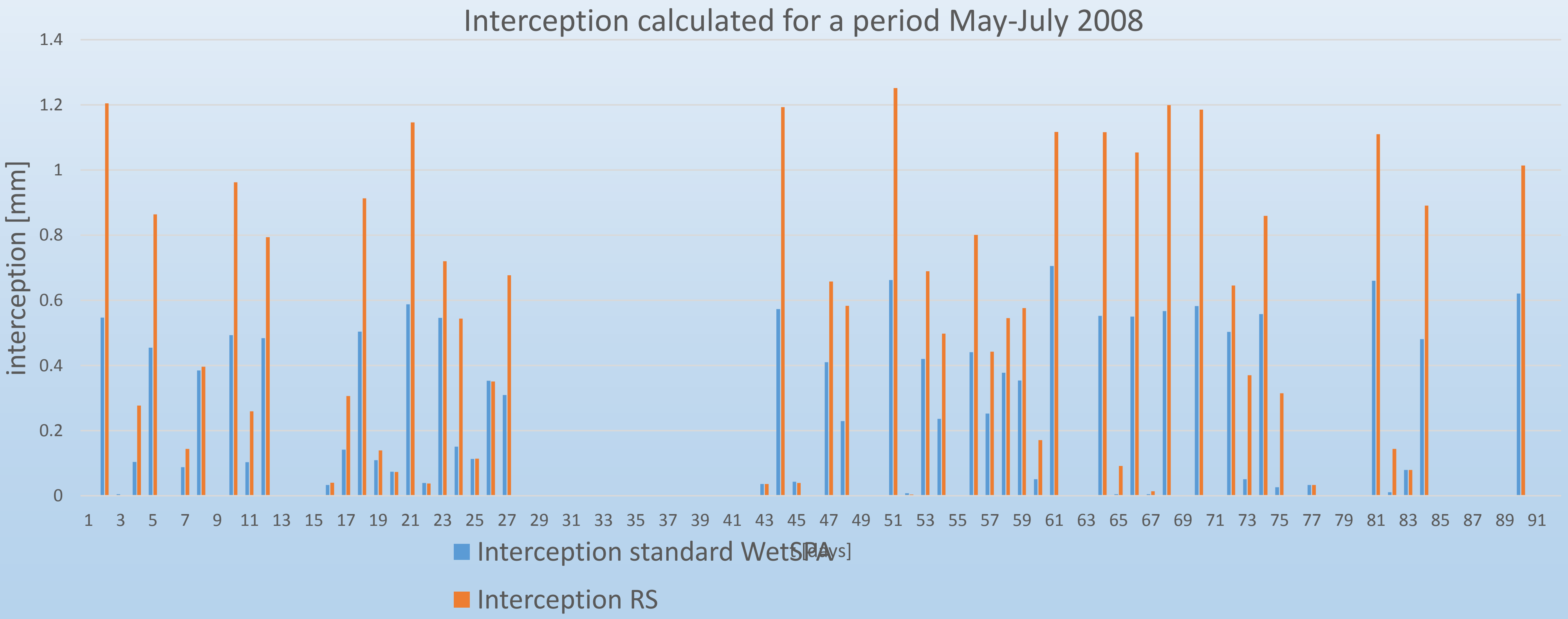
- GIS maps: Digital Elevation Model, land use and soil
- Meteo data: Precipitation, Temperature, Potential Evapotranspiration
- Modeling period:
    - 01.11.2007 – 31.10. 2009
    - interval step: daily
- **Interception maps in distributed form per GRID**





Water balance results from WetSPA for the period of 2007-2009 –in catchment scale

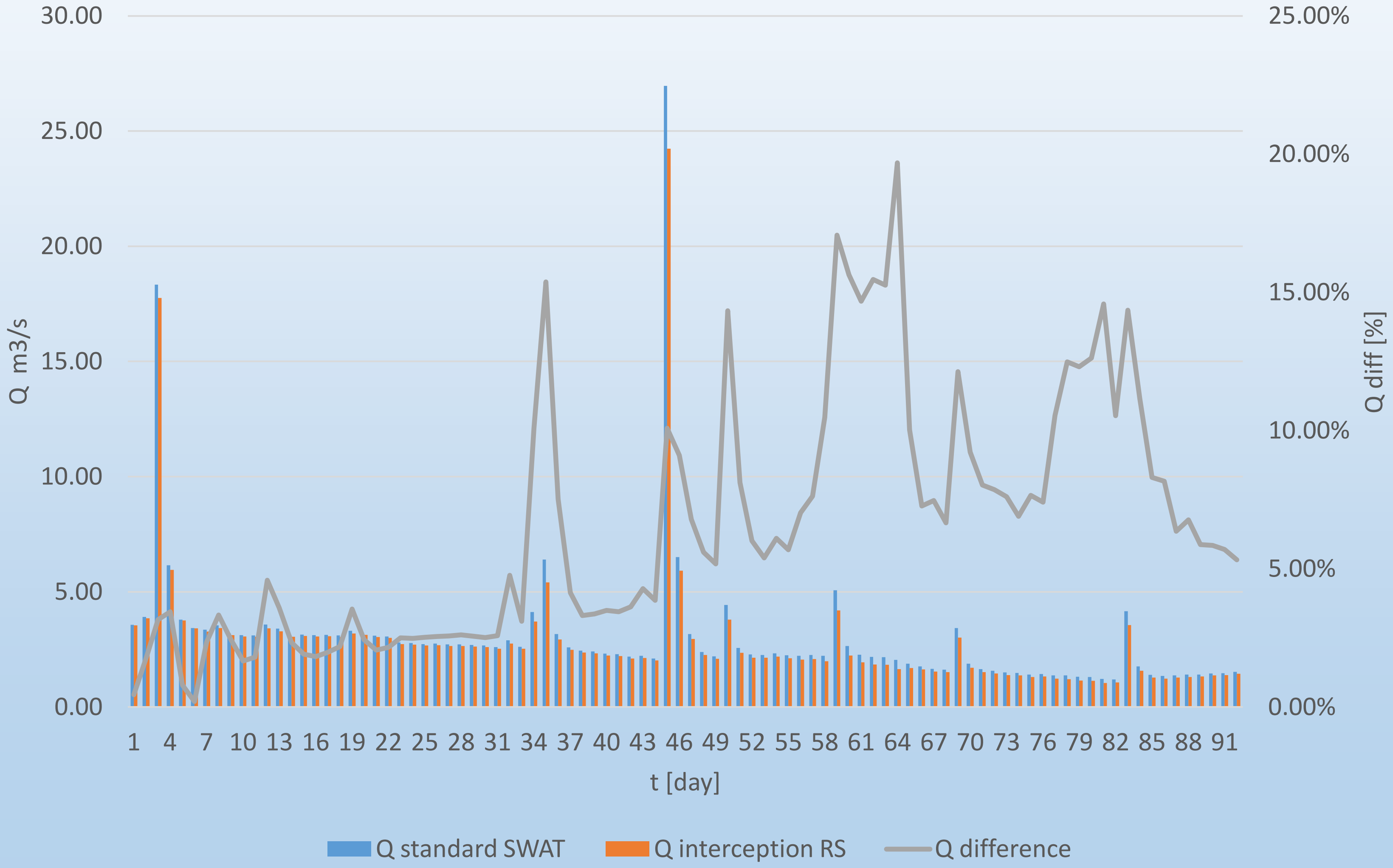
- Yearly rainfall: 676 mm
- Yearly interception standard : 37 mm   and interception RS: 68 mm



Soil & Water Assessment Tool | SWAT

- Same digital and hydr-meteo input like for WetSpa;
- 76 subbasins (area 513-2331 ha)
- 1342 HRU
- **Maximum condition interception map** (Maximum canopy interception parameter in SWAT) included as
  - Scenario 1 - average value per landuse type (e.g. 0 – urban; 1,66 – wetland, 3,02 leafy forest)
  - Scenario 2 average per subbasin
- Total av. yearly runoff diference between observed and simulated not calibrated discharge in standard SWAT data: ca.100%

Soil & Water Assessment Tool SWAT results (period: May-July, daily)

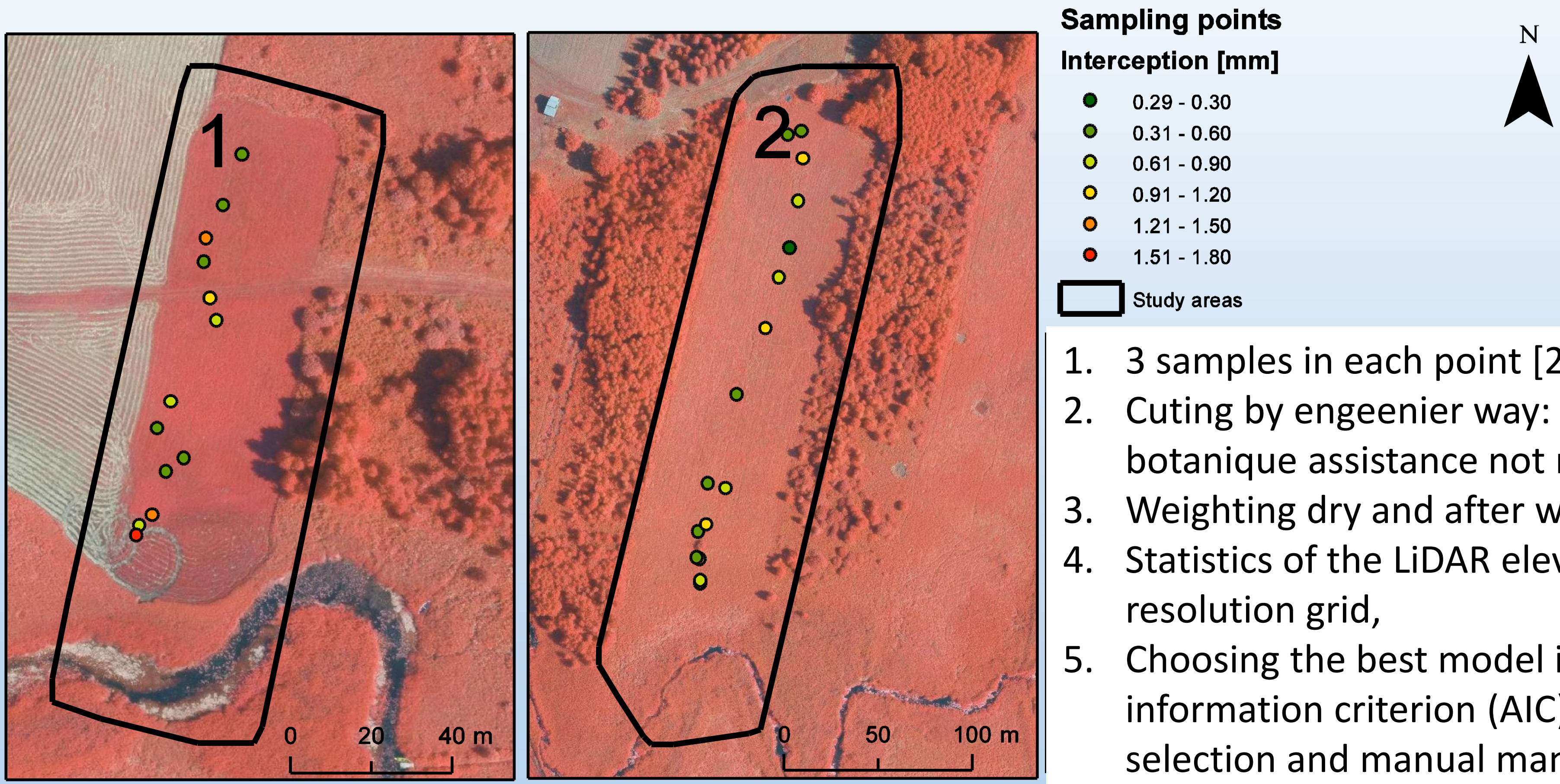


RS local upscaling models of riparian vegetation (sedge, reed, sedge-moss)

Hiperspectral – Chris Probe reflectance model of LAI

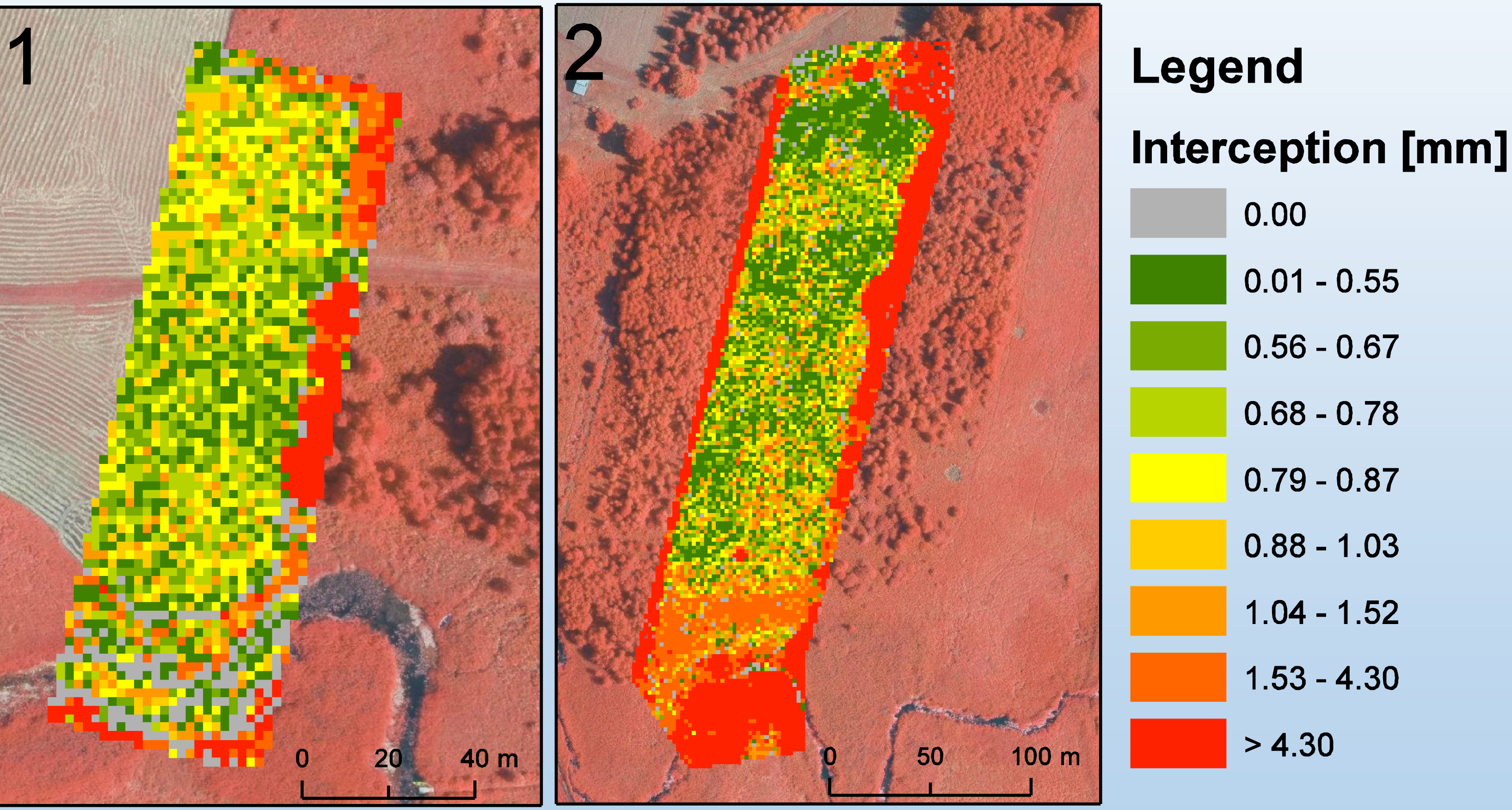
Airborne Laser Scanning density model of bomass and interception

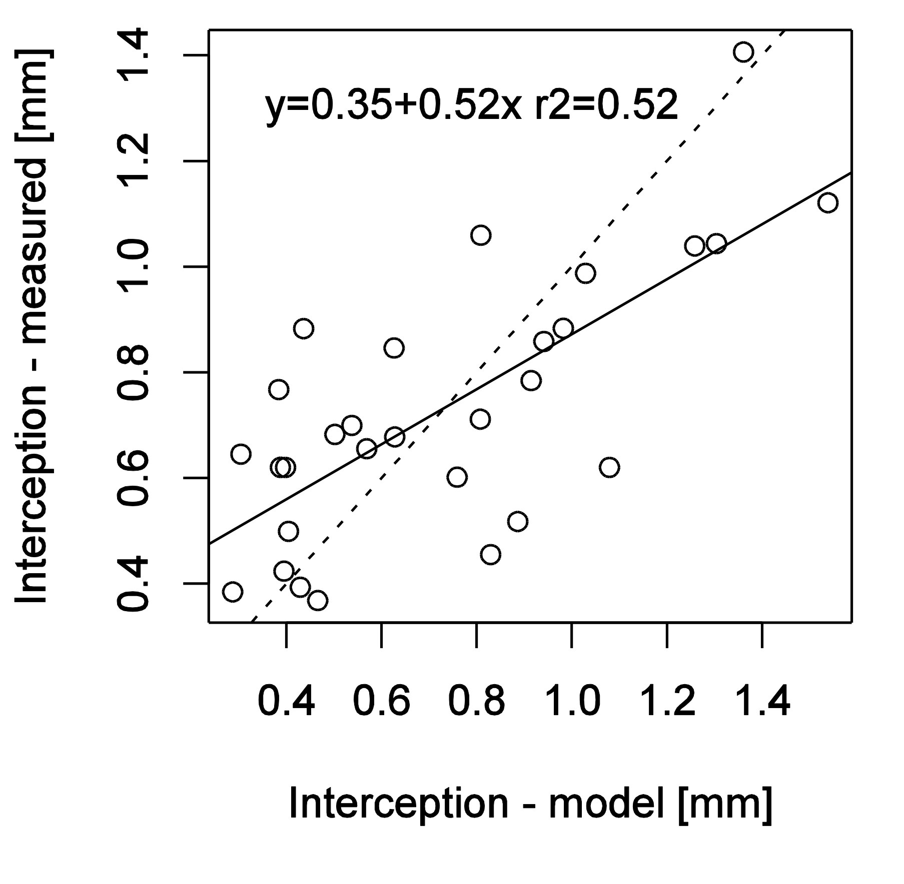
Interception directly linked to the ALS point cloud
1. Sampling of biomass and statistical analysis



1. 3 samples in each point [25x25 cm]
2. Cuting by engeenier way: all vegetaton in square, botanique assistance not needed.
3. Weighting dry and after wetting
4. Statistics of the LiDAR elevations in a 2 m spatial resolution grid,
5. Choosing the best model in terms of Akaike information criterion (AIC) using stepwise model selection and manual manipulation of the independent variables

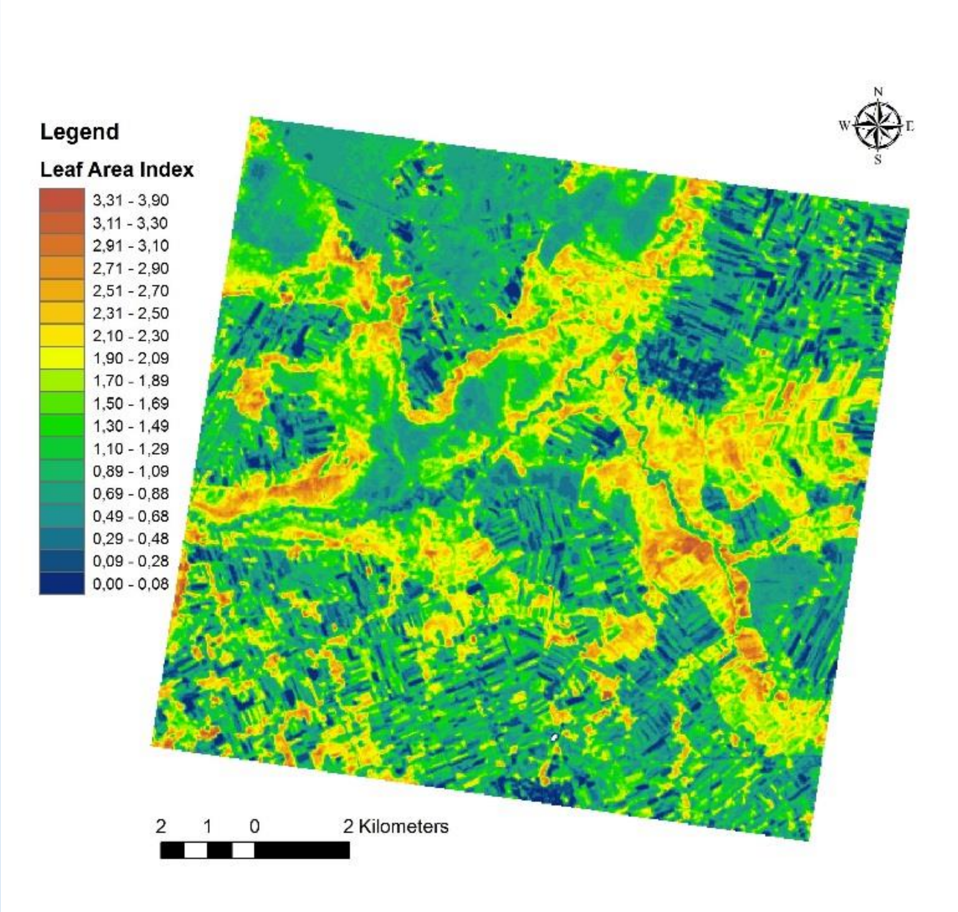
Interception directly linked to the ALS point cloud
2. interception storage capacity maps





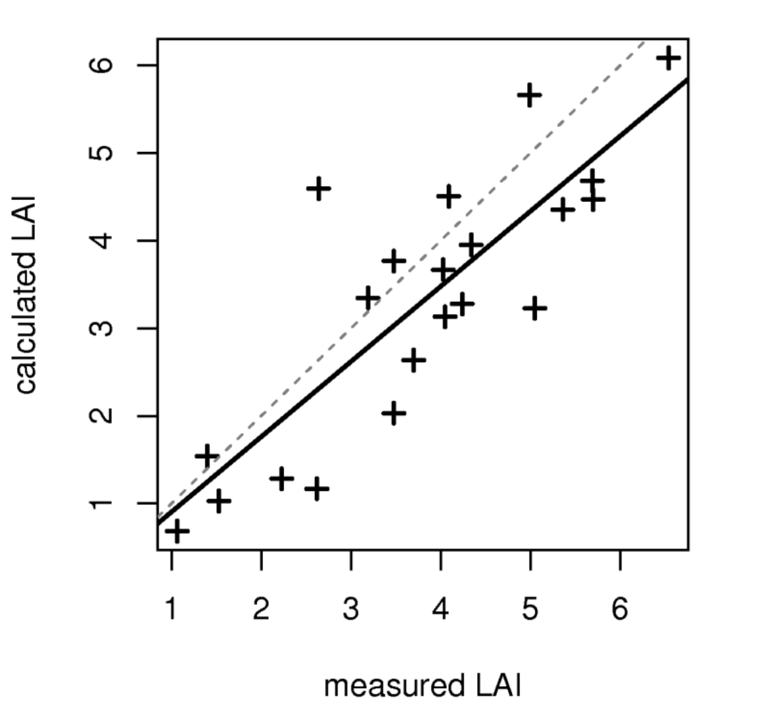
the best model with the rainfall interception

LAI model based on Chris Probe satellite



LAI = 14.508 * *index11-52* [6.245]

- *index11-52* = (*b11* - *b52*) / (*b11* + *b52*)
- R^2 = 0.69 *RMSE* = 0.84[-]
- b11 = 530 nm; b52 = 886 nm (10nm bands)



Validation plot

Conclusion

- The interception estimation in the *rainfall-runoff models* (WetSpa, SWAT) was improved by integrating remote sensing data
- The minimum/maximum LAI maps are combined with the interception equations to calculate spatially distributed hydrological parameter maps, i.e. minimum and maximum interception storage capacity.
- The model application yields considerable spatio-temporal differences in interception estimates for scenarios using interception maps calculated based on LAI measurements and remote sensing data, compared to the CLC.
- **The water balance calculation shows significant results in total basin interception storage (90%)**
- **SWAT model was found as sensitive for remote sensing interception scenarios (up to 20% difference in daily discharge)**
- The interception storage capacity based on ALS (SAR in global scale) data is promissing method for develop in the future as one which directly indicate vegetation structure