Short Project Summary

Vegetation and water dynamics from satellite remote sensing

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Basin-wide land surface information with respect to vegetation cover, land use and flooding are crucial for an effective water resources management. The ever increasing amount of globally available optical and radar satellite data allows the observation of long-term trends and seasonal variability of the land surface cover by means of big-data time-series analysis approaches. The observed trends and dynamics are controlled by the hydro-meteorological regime and human interference. Therefore, the aim of this subproject was to observe land surface dynamics by satellite time-series analysis in relation to observed hydro-meteorological dynamics as well as land and water resources management. Furthermore, observed vegetation dynamics are compared to regional vegetation modeling results to evaluate the suitability for modeling of ecosystems, vegetation states and erosion/sedimentation processes.

Methods and Data

Time series of optical satellite data are utilized to analyze vegetation and water dynamics in different spatial and temporal scales. The MODIS sensor aquires daily imagery of 250m pixel size since February 2000. The Copernicus Sentinel-2 mission allows analysis of higher spatial detail since 2015, with imagery of a pixel size of 10m to 20m taken approx. each 5 days. Both datasets are globally and freely available.

Vegetation indices (VI) such as NDVI and EVI are used to derive quantitative and qualitative parameters of intra- and inter-annual vegetation dynamics. Quantitative parameters are the long-term trend (Fig. 1), annual variations, days of vegetation coverage, number of crop cycles and phenological parameters (e.g. start/peak/length of season). Qualitative parameters can be derived by using land cover specific VI-trajectories and ground truth data to derive e.g. land cover maps and irrigation masks.

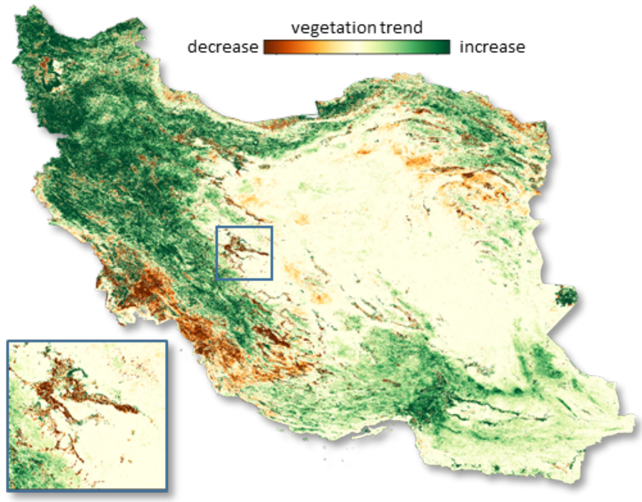

Figure 1 Vegetation trend for Iran (2001-2019) using MODIS

A water index (NDWI) based on Sentinel-2 is further used to derive detailed knowledge about the extent and duration of inundation areas in case of extreme flood events.

Results and Conclusions

For the SaWaM target regions Karun (Iran), Rio São Francisco (Brazil), Tekeze-Atbara and Blue-Nile (Sudan/Ethiopia), Catamayo-Chira (Ecuador) monthly VI parameters and their annual variations from the long-term average were derived. In general, the vegetation signal clearly follows the overall water availability and dry and wet years show a clearly decreased and increased vegetation signal, respectively. In case of meteorological droughts (e.g. 2008 in Iran, 2012-2017 in Rio São Francisco) the vegetation was clearly affected showing a general lower VI signal, especially in grassy vegetation but also in a decreased cultivation due to the lack of water for irrigation. Moreover, in most regions an increase in (irrigated) agricultural areas is observed in the MODIS time span (2000-2019).

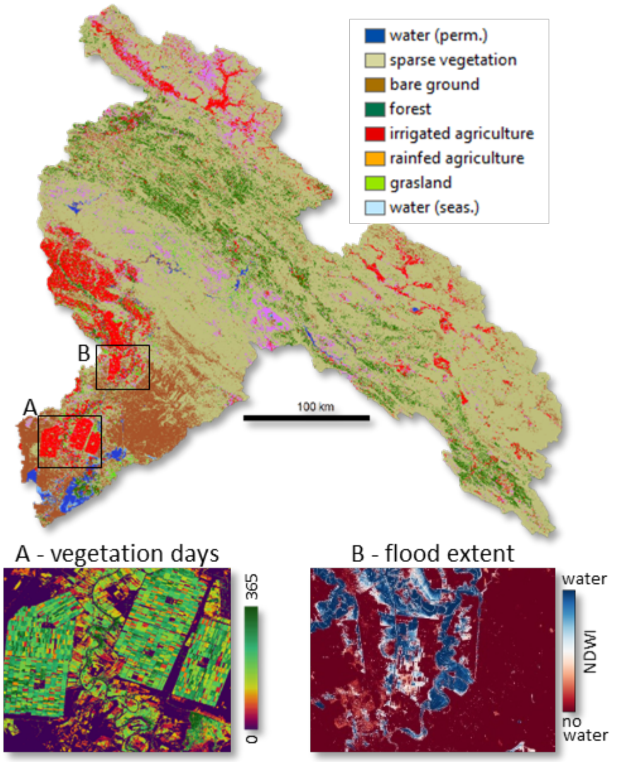

Figure 2 Sentinel-2 based parameter derivation in Karun, Iran. (Land cover, days with vegetation cover, flood extent during 2019 flood.)

Using Sentinel-2 the vegetation and water dynamics are analyzed at higher spatial detail for the Karun catchment, Iran. Using VI-trajectories and ground truth data a catchment wide land cover map at 10m spatial resolution was produced as well as specific parameters such as an irrigation mask or days of vegetation coverage were derived (Fig. 2). Moreover, the Sentinel-2 images allowed a detailed mapping of surface water cover during the extreme flood event in 2019 (Fig. 2) that caused widespread inundation of bare soils and agricultural fields that lasted for several month.

For the entire Iran, the MODIS-based vegetation dynamics are analyzed in regard to the climatic variations (e.g. precipitation, temperature derived by ERA5-Land). Regions were identified where the vegetation signal correlates with climatic variations and thus are more susceptible the predicted climate change towards drier and warmer conditions. Using recently available global land cover maps (Copernicus land cover products), vegetation dynamics and climate dynamics, the sustainability of agricultural water consumptions was evaluated. It could be shown that high percentages of irrigated areas in arid or hyperarid areas are not cultivable anymore because unsustainable water usage resulted in water shortages nowadays (e.g. Isfahan, Shiraz) (Fig. 1, inset).

In conclusion, optical remote sensing time series data can serve as valuable contribution to evaluate water management, e.g. in case of floods, irrigation, and preservation of natural ecosystems. Even though the project aims at making use of globally available data from satellite observations and modelling, for detailed and quantitative derivation of land surface characteristics from satellite data, in-situ information is still indispensable, which is, however, often inconsistent and hard to obtain.

References

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Behling R, Roessner S, Foerster S (2020), Satellite time series analysis of vegetation dynamics for water resources management in semi-arid regions, EGU 2020, doi: 10.5194/egusphere-egu2020-16520