The potential of medium resolution satellite imagery to estimate regional yields of cotton, wheat and rice in irrigated cropping systems in Uzbekistan

Sebastian Fritsch[1], Christopher Conrad[1], Ahmad M. Manschadi[2], Stefan Dech[3]

Introduction and background

Arid regions like **Central Asia** are most vulnerable to climate change. There is **pressure on water resources**, but precise predictions of impacts are not available. Regional **food security and cropland productivity** are threatened by these developments. **Information** and **data** (on water and land parameters) **at the regional level** can be provided by **satellite remote sensing**. **This work** aimed at the **prediction and analysis of regional crop yields** of irrigated cotton, winter wheat and rice using **MODIS data** coupled with a **light-use efficiency model** and is part of the project on 'ecological and economical restructuring of land and water use in **Khorezm, Uzbekistan'** (www.zef.de/khorezm). The rural Khorezm district (fig. 1 and 2) is located in the upper Amudarya delta and subject to large environmental problems.

Fig. 1: The study area, located in the Aral Sea Basin (Source: MODIS imagery, ESRI data and maps).

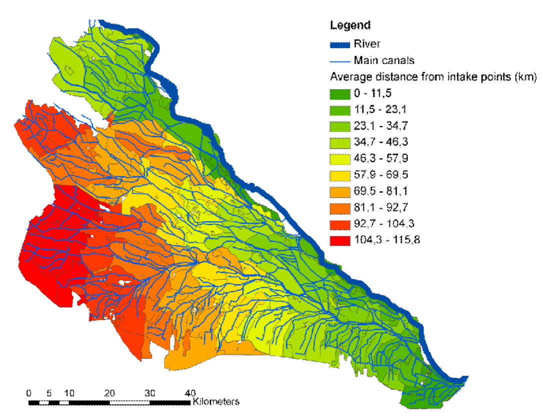

Fig. 2: Khorezm displays an extensive irrigation system. Main canals receive water via intake points at the Amudarya river.

Data and methods

The main input to the model is the fraction of photosynthetic active radiation absorbed by the plants (**FPAR**), which was derived from the Terra MODIS sensor. Additional required input consisted of **meteorological**, **crop-specific** and **landuse** data. The **conceptual framework** of the approach can be seen in figure 3.

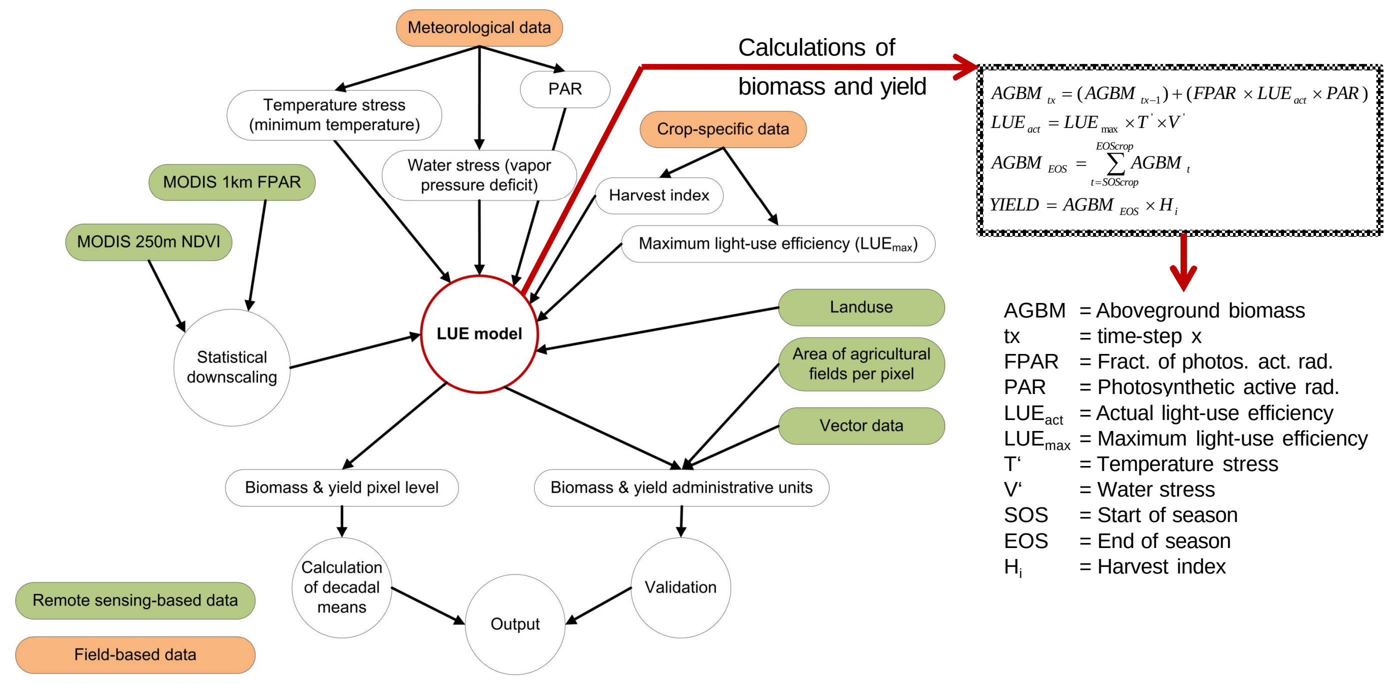

Fig. 3: Components of the LUE model used for regional crop yield mapping and prediction.

The LUE model calculates biomass accumulation on a daily basis and final yield. Pixel-based results were used to calculate 10-year averages of biomass and yield and afterwards aggregated on administrative levels (WUA/Rayon). This allowed validation and identification of **year-to-year as well as within-season deviations** from the mean.

Results and discussion

1 Yield calculations

• **Model vs. stats** (**2004 & 2005**)

Model results were aggregated and compared to official statistics (fig. 4). R^2 amounted to 0.81. Further validation on finer scale has yet to be conducted.

• **Pixel – based** (**2000-2009, in t/ha**)

	Mean	Standard deviation
Cotton	1,9	0,24
Wheat	2,79	0,54
Rice	2,81	0,44

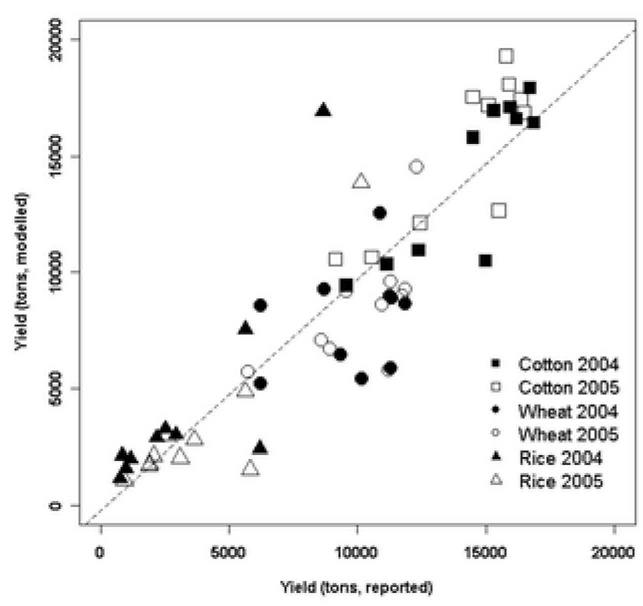

Fig. 4: Comparison between modeled and reported yield for 2004 and 2005 on Rayon level (total RMSE: 2423 t).

Wheat and WUAs closer to the river and major intake points show higher performance in years with low water availability (compare fig. 2).

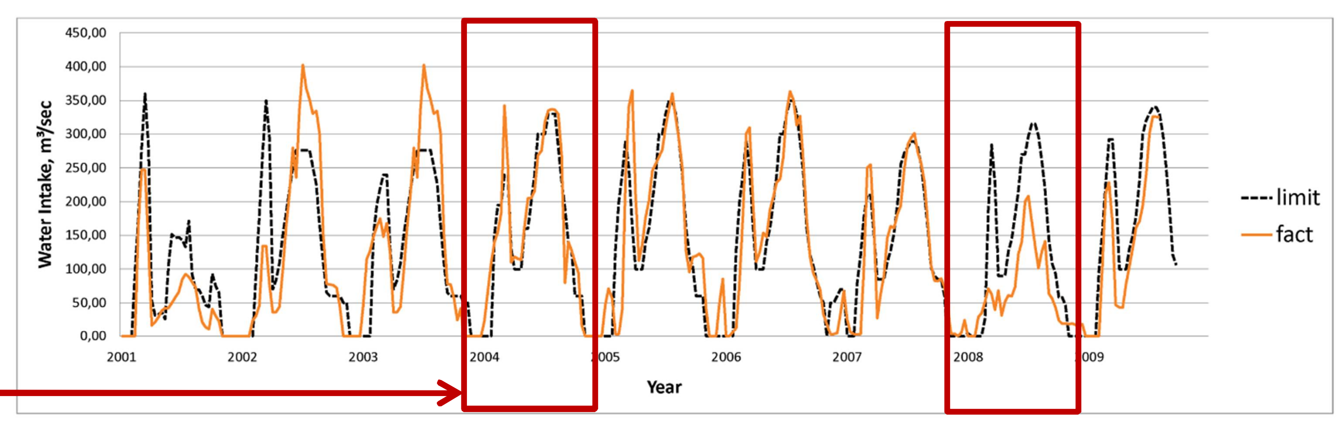

Fig. 6: Comparison of estimated (limit) and actual (fact) water availability in the Khorezm province from 2001 – 2009 (source: www.cawater-info.net).

compare

2 Performance assessment

Crop yields for 2004 and 2008 were analyzed with regard to deviations from the 10-year mean. Resulting patterns of crop yield above and below average (fig. 5) can be explained by regional water availability, which varies from year to year (fig. 6) and mainly determines crop growth.

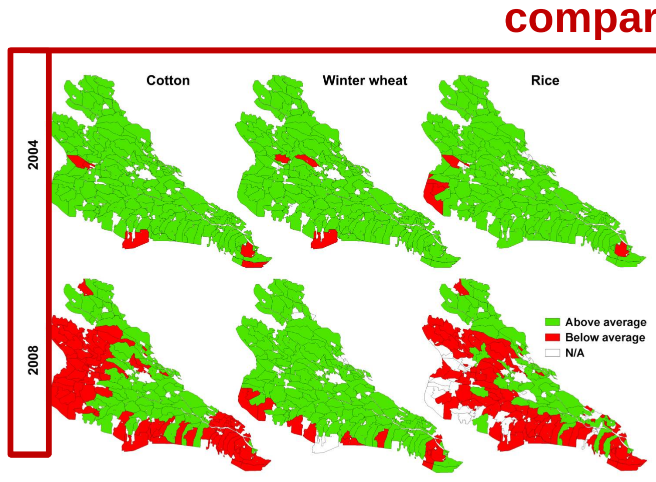

Fig. 5: Deviations from decadal average yield of major crops for the years 2004 (high water availability) and 2008 (low water availability).

3 Within-season anomalies

Average decadal biomass production was also calculated and analyzed. Results indicate this approach can be used for within-season detection of underperforming areas (fig. 7). However, it seems only possible from a specific point in time onwards and further research is necessary.

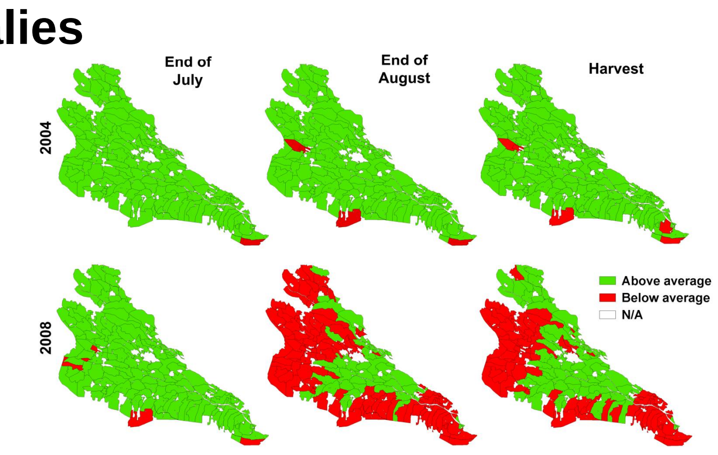

Fig. 7: Deviations from the decadal mean of cotton biomass for specific dates of the season in 2004 and 2008. Patterns at the end of August correspond to that of final yield, indicating the potential of within-season crop monitoring.

Conclusions

The presented approach is well suited for regional crop yield mapping and prediction. Drawbacks are mainly due to the coarse resolution of the remote sensing data and lead to a trade-off between accurate area and per-pixel yield estimates. **Results suggest that it is possible to monitor year-to-year as well as within-season crop growth variability.**

Open questions and issues that still need to be solved include:
• Validation of the MODIS FPAR input data used for the model
• Upscaling of in situ FPAR data via high-resolution satellite images
• Model validation using in-situ data and high-resolution yield modeling

If this will be achieved the approach can contribute to an improved management of environmental resources in the study region.

Affiliations

1: Remote Sensing Unit, Department of Geography, University of Würzburg, Am Hubland, 97074 Würzburg, Germany
Emails: sebastian.fritsch@uni-wuerzburg.de; christopher.conrad@uni-wuerzburg.de
2: Department of Ecology and Natural Resource Management, Center for Development Research (ZEF), University of Bonn, Walter-Flex-Str. 3, 53113 Bonn, Germany
Email: manschadi@uni-bonn.de
3: German Remote Sensing Data Center (DFD), Germany Aerospace Agency (DLR), Oberpfaffenhofen, 82234 Weßling, Germany
Email: stefan.dech@dlr.de
For further information please contact: **sebastian.fritsch@uni-wuerzburg.de**

GERMAN-UZBEK KHOREZM PROJECT
Zentrum für Entwicklungsforschung
Center for Development Research
University of Bonn
Federal Ministry of Education and Research
DAAD Deutscher Akademischer Austausch Dienst German Academic Exchange Service
universitätbonn