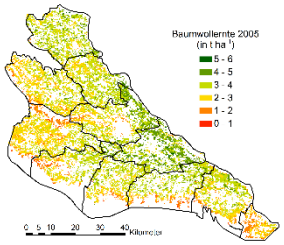
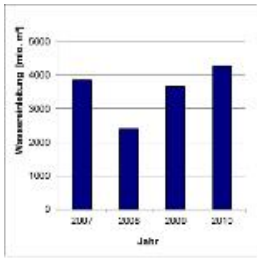
Estimation of actual evapotranspiration to derive irrigation efficiency indicators in the Aral Sea Basin, Central Asia

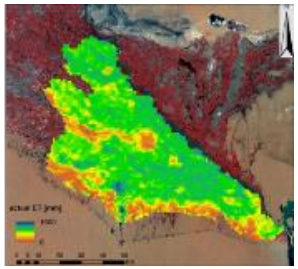
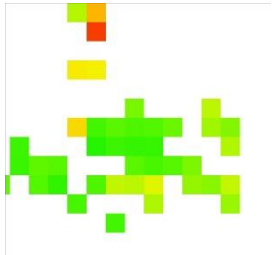
Tagung „Landschaftsprozessmonitoring mittels Multisensordaten “

5. Gemeinsamer Workshop der AKs

„Auswertung von Fernerkundungsdaten“ der DGPF e.V. und „Fernerkundung“ der DGfG e.V.

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About the project

Work package III (University of Wuerzburg):

WUEMoCA (Water Use Efficiency Monitor in Central Asia):

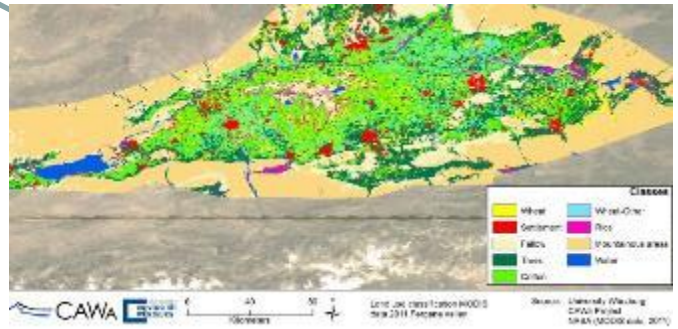
→ automated monitoring and visualization instrument addressing sustainable land management, decision making, and planning processes

CAWa was designed to **support scientific cooperation and communication between the CA countries** (and Germany) in the sector of water resource management

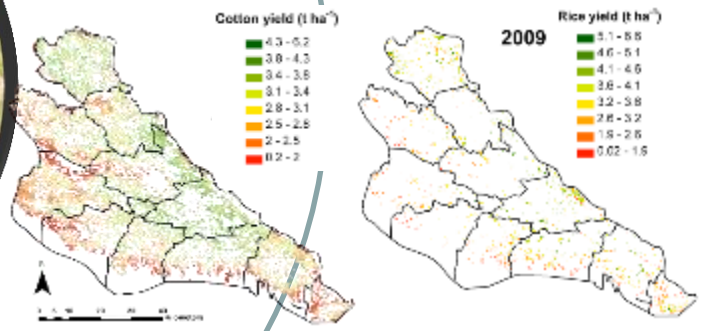
Aims and Partners

Use of satellite remote sensing (multi-temporal multi-sensor mapping), Information about crops for each field parcel

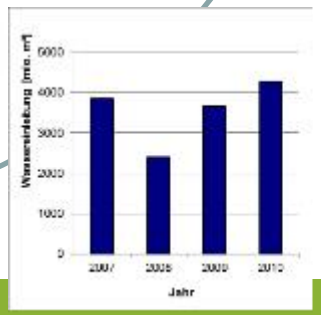
Land use (cotton, rice, wheat, fallow, etc.)

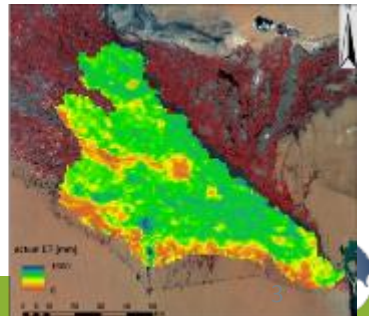


Crop yield/biomass development



Water flow / use efficiency





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UNIVERSITÄT
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KRASS
Khorezm Rural Advisory Support Service

Water Use Efficiency Indicators:

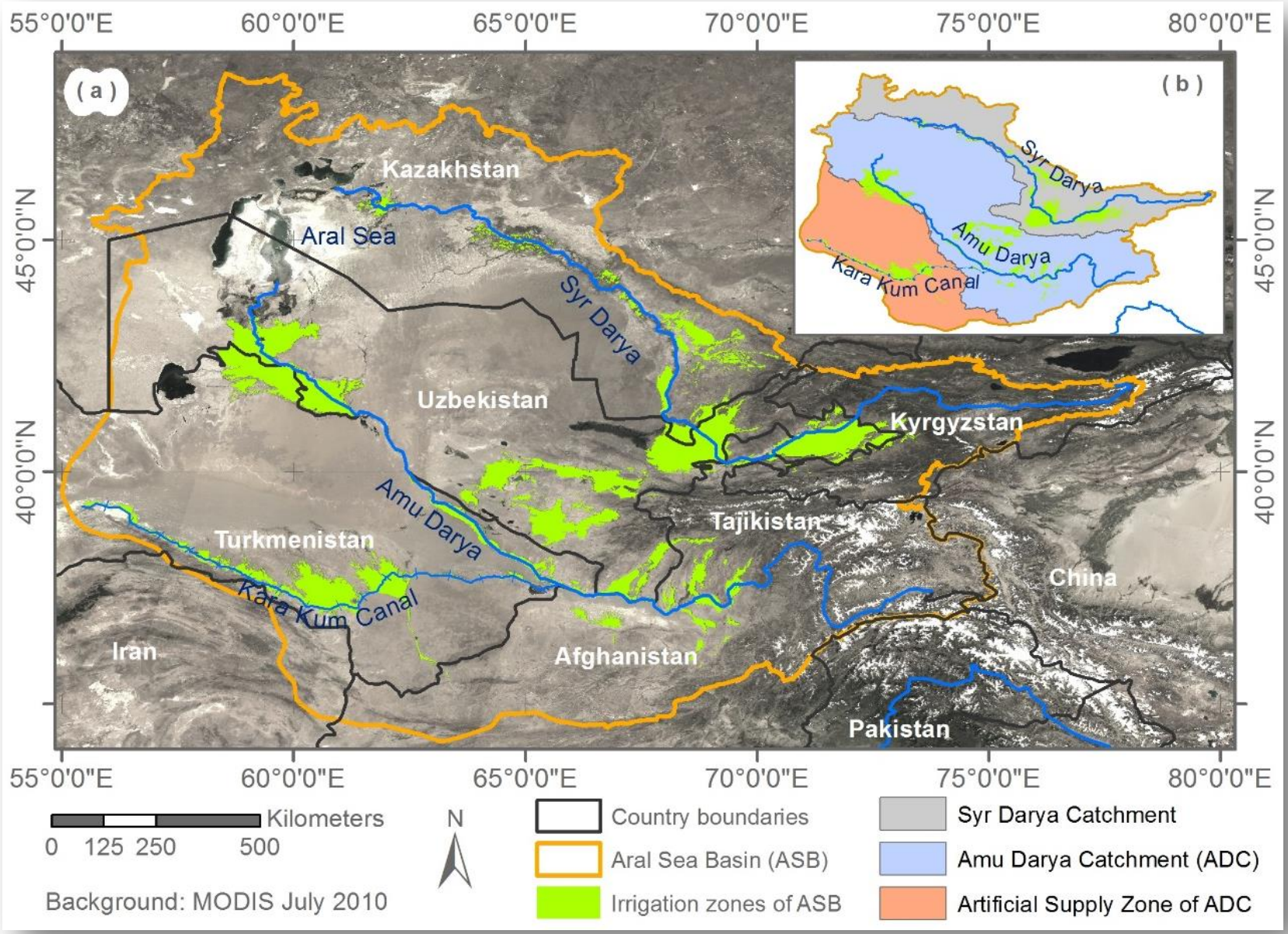
Irrigation Efficiency: ET_a/W

ET_a : actual Evapotranspiration
W : water withdrawal at the boundary of district

Crop water productivity : Y/ET_a in kg/m^3

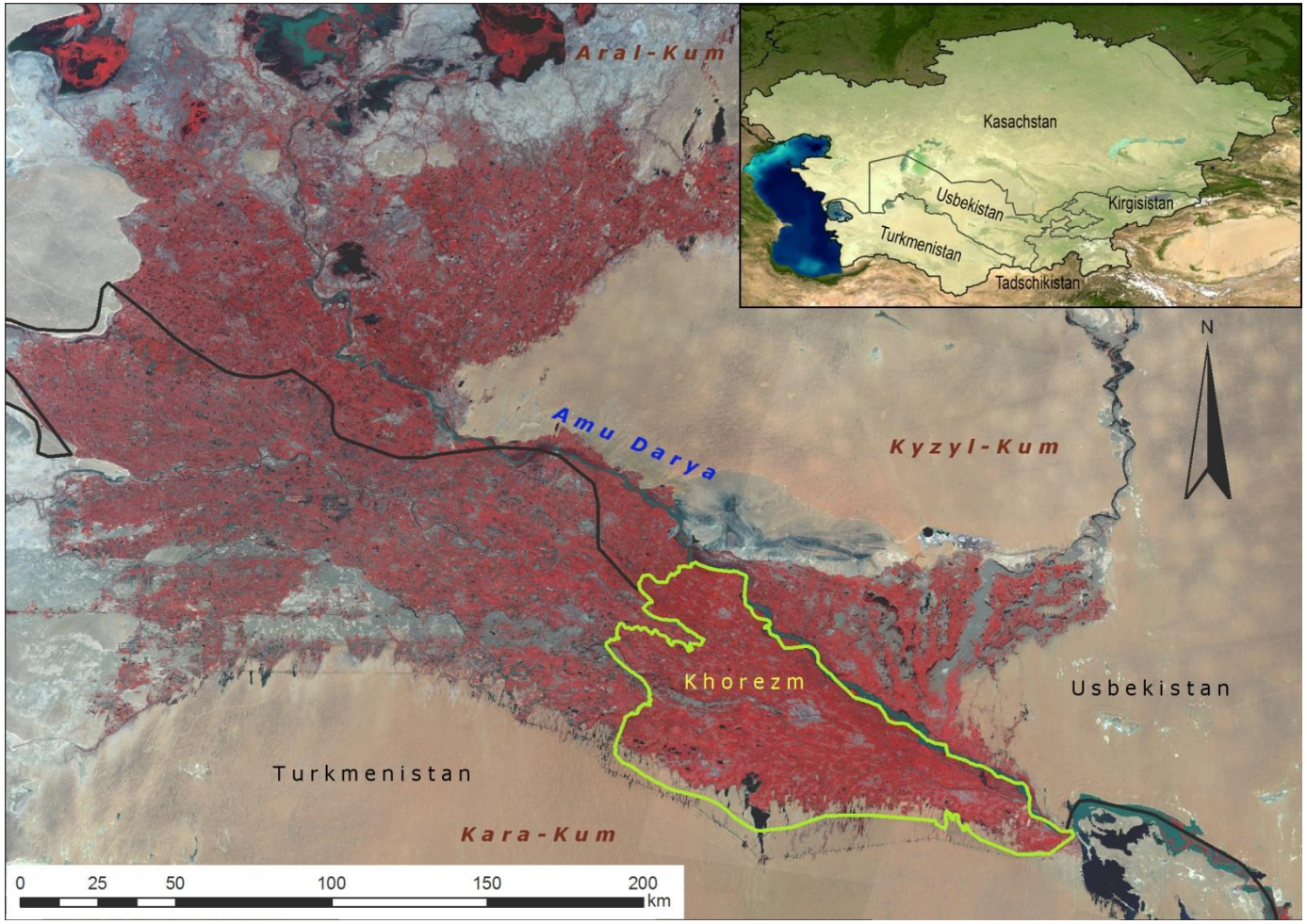
Y: Crop specific yield

Non-sustainable irrigation water use in the Aral Sea Basin



Focus area

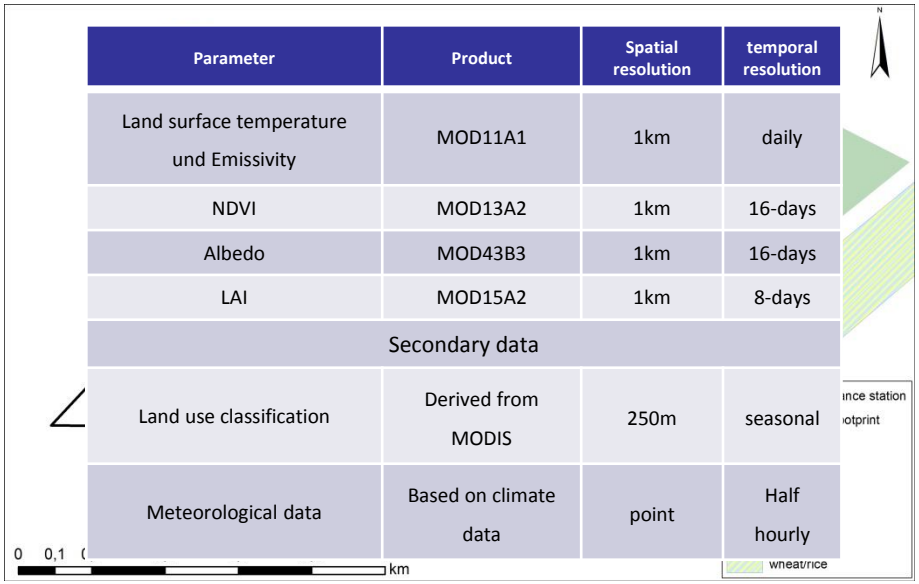
Khorezm is a textbook example of the problems of irrigated agriculture in the Aral Sea Basin (Vlek et al., 2012)

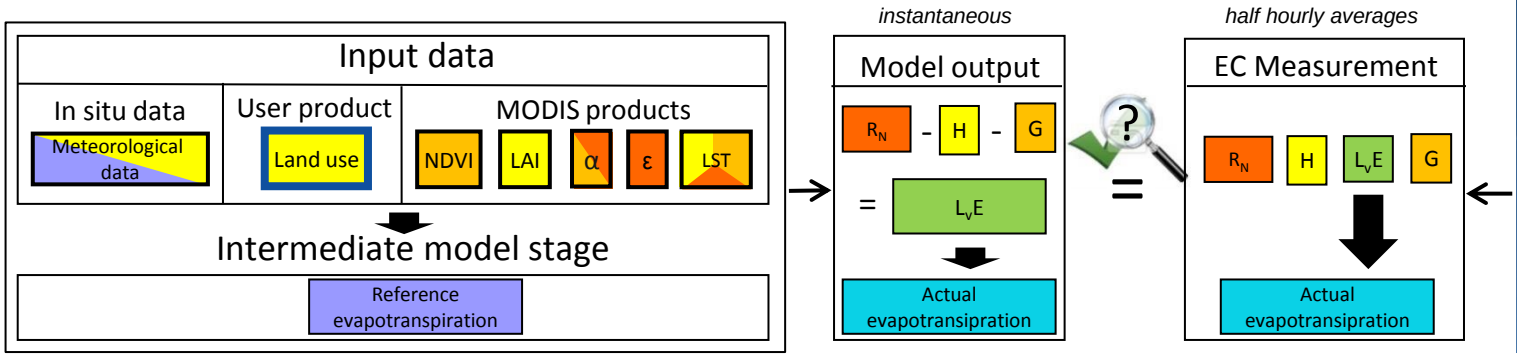


ET modelling and validation

Test fields

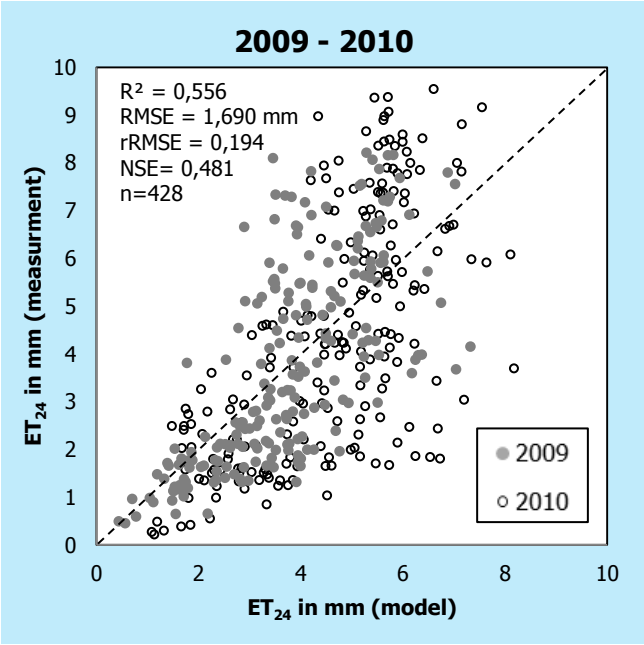
Parameter	Product	Spatial resolution	temporal resolution
Land surface temperature und Emissivity	MOD11A1	1km	daily
NDVI	MOD13A2	1km	16-days
Albedo	MOD43B3	1km	16-days
LAI	MOD15A2	1km	8-days
Secondary data			
Land use classification	Derived from MODIS	250m	seasonal
Meteorological data	Based on climate data	point	Half hourly

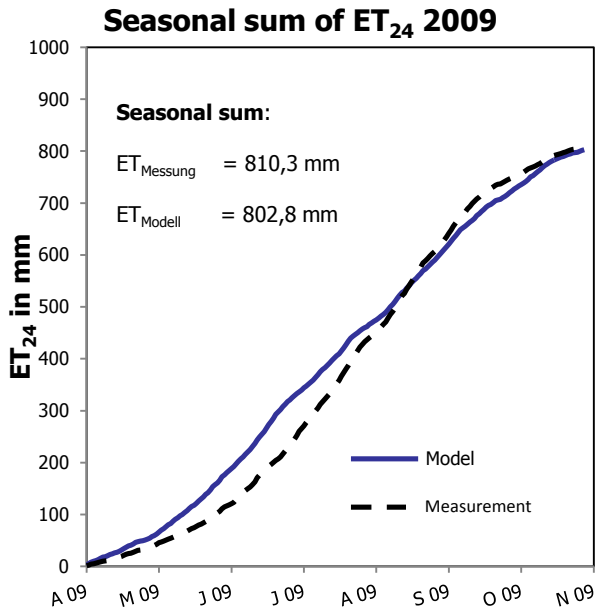




R_N: Net radiation
λET: latent heat flux
H: sensible heat flux
G: soil heat flux

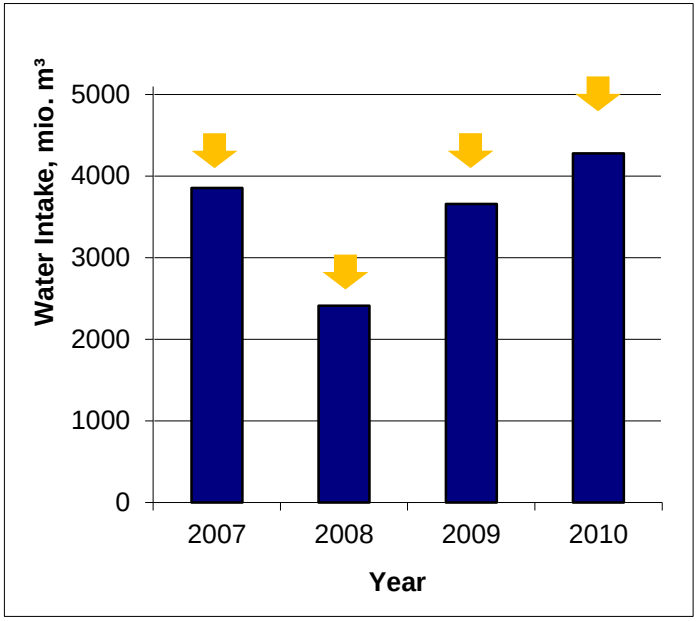
Evaluation of the ET model





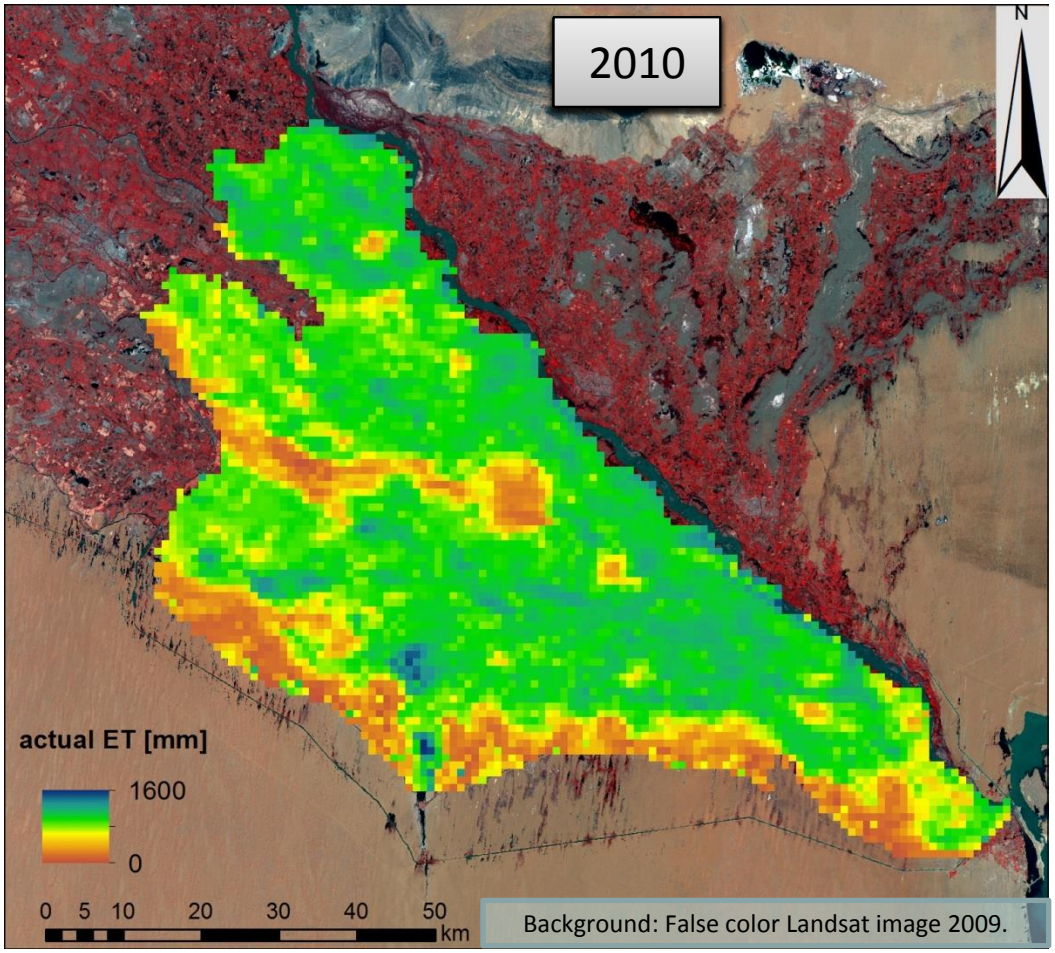
Irrigation efficiency (ET_a/W)

Water intake into Khorezm irrigation system*



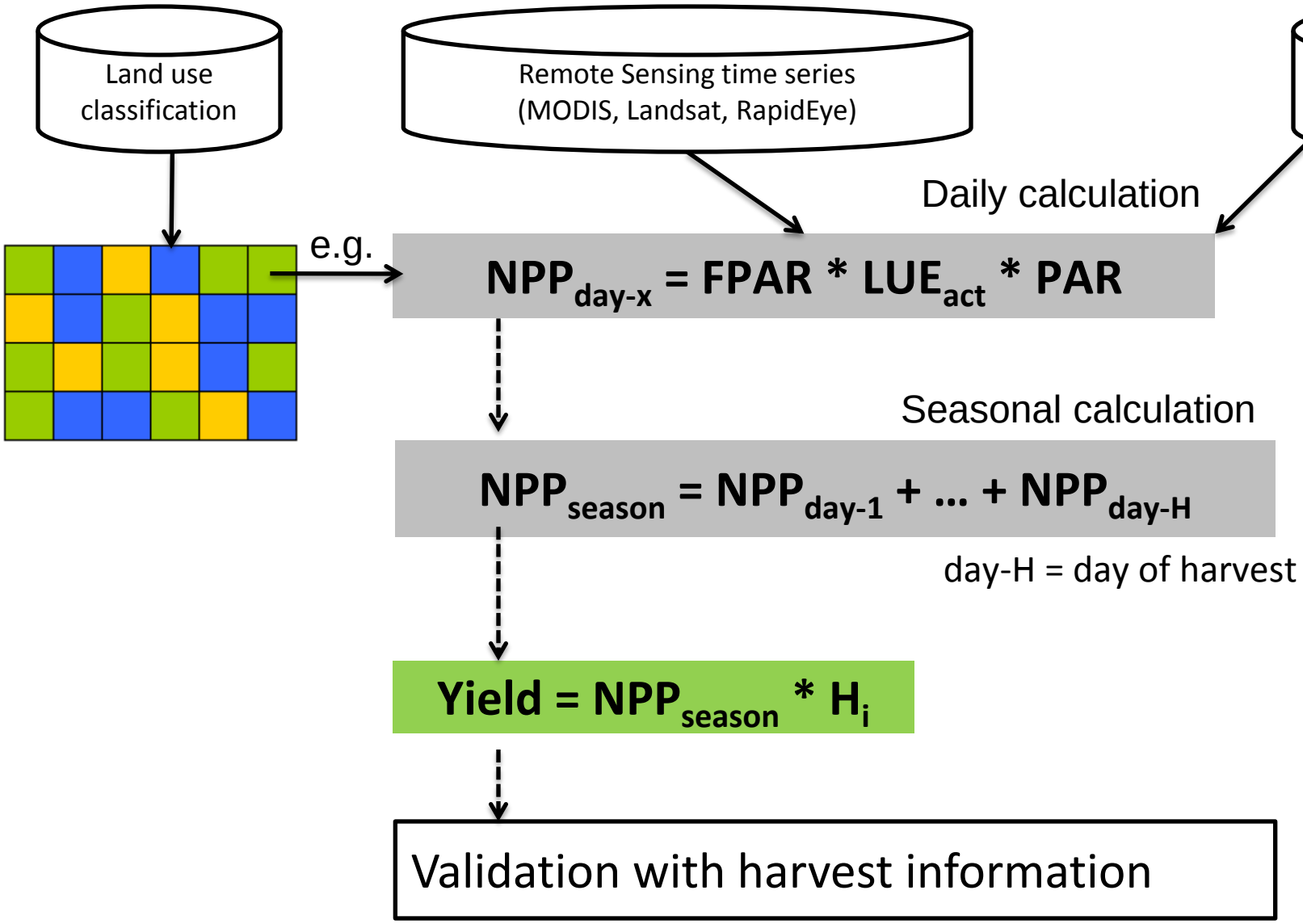
Year	Seasonal ET in km³	Water intake* in km³	Irrigation efficiency
2003			
2004	4.04	**5.94**	**0.67**
2005	3.60	**5.47**	**0.65**
2006			
2007			
2008			
2009			

*http://www.cawater-info.net



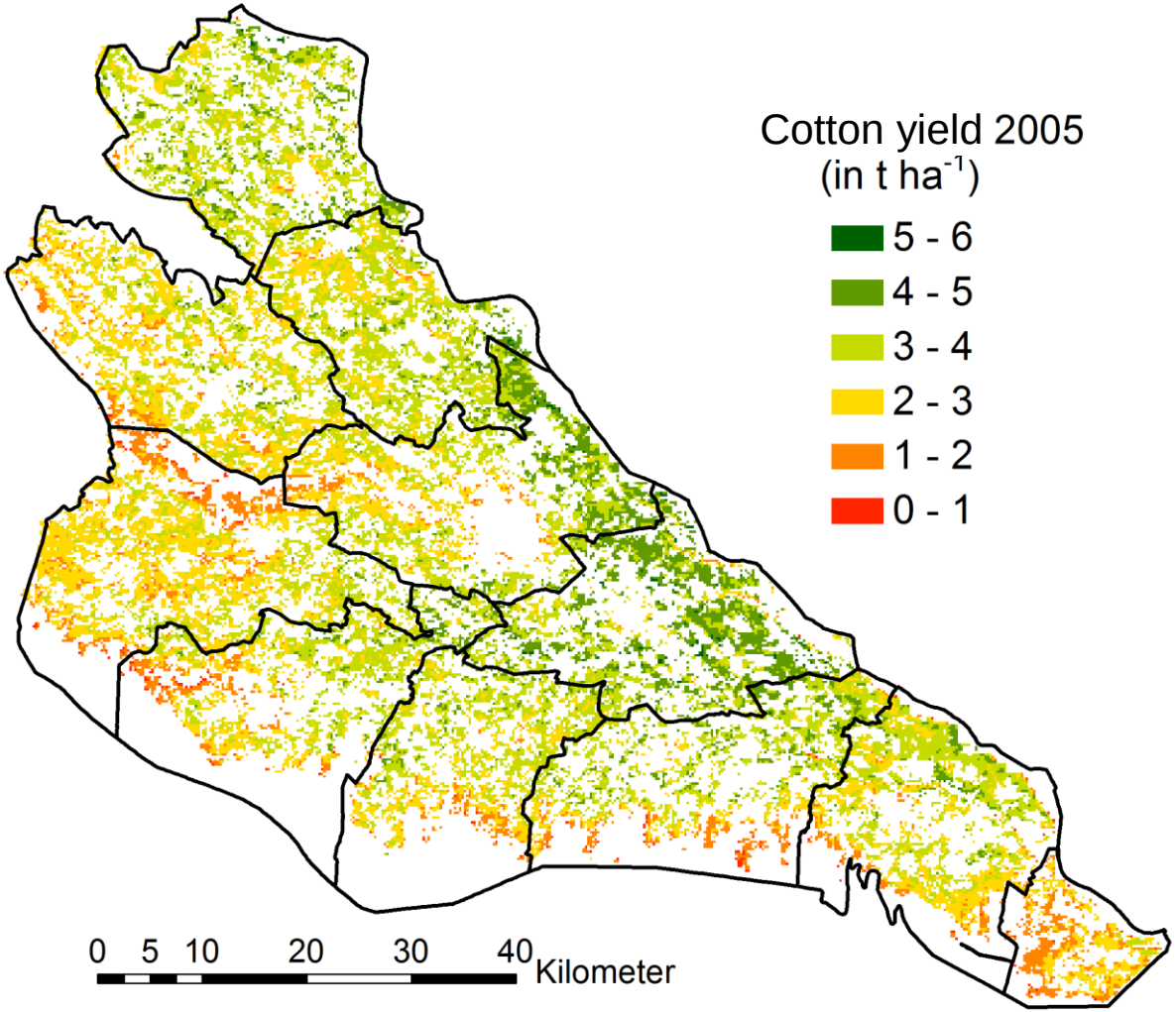
→ Statistics of water intake are underestimated by 37% in 2004 and 2005 (Conrad 2006)

Yield modeling – Light Use Efficiency



Fritsch, 2013

Yield results MODIS 250m for 2005 and 2008



Source : Fritsch et al. 2013

Water productivity

Due to spatial resolution of input data the "***water productivity***" is calculated based the coarse resolution → 1km pixel with homogenous land use (threshold: 80% of same land use)

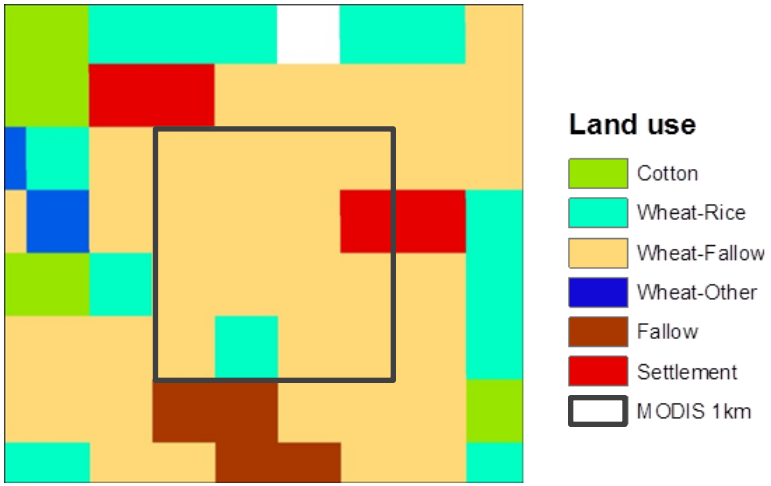
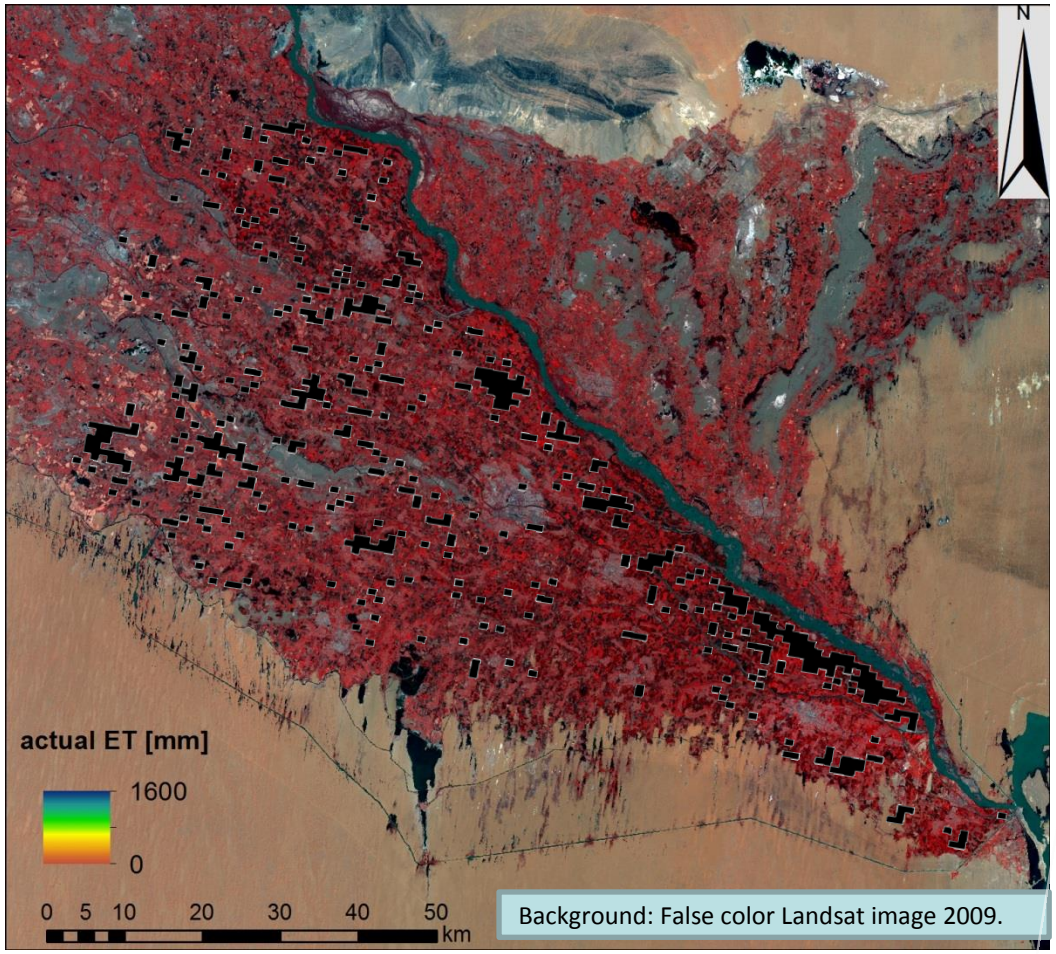


Table: Number of homogeneous pixel per year

	2003	2004	2005	2006	2007	2008	2009
Cotton	486	659	661	573	672	366	629
Wheat-Rice	0	0	0	2	1	1	8
Wheat-Fallow	0	6	1	2	0	0	0
Wheat-Other	46	29	58	67	37	48	46
Rice	101	58	34	31	25	12	6
Fallow	461	485	458	475	518	821	563

Results: Water productivity (cotton)

Year	mean water productivity cotton
2003	0.28
2004	0.25
2005	0.27
2006	0.28
2007	0.31
2008	0.22
2009	0.30



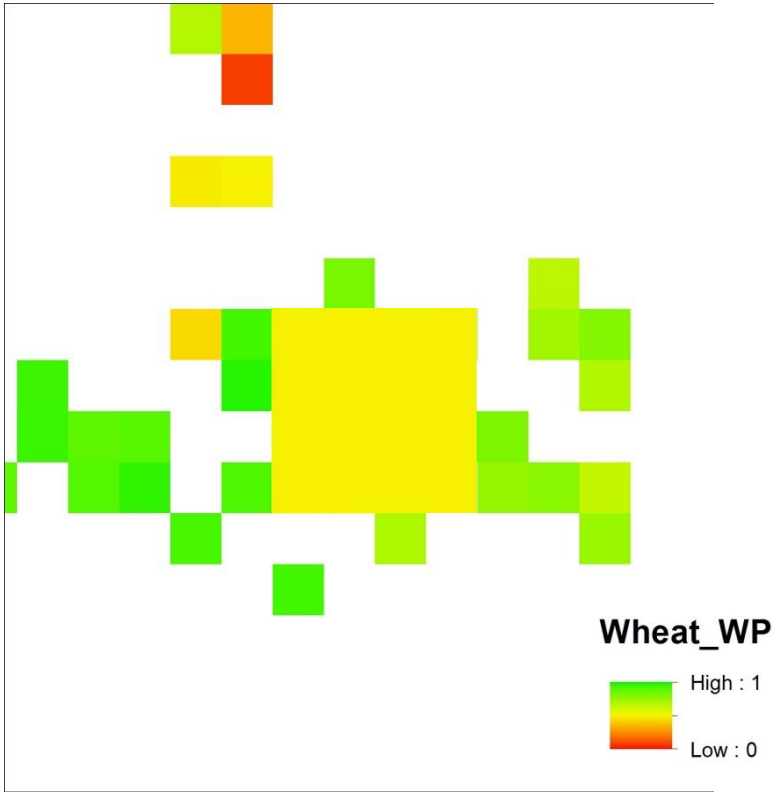
Results – Indicator calculation

Analysis of cotton water productivity based on 1km homogenous pixel is suitable, but for other crop this approach is insufficient.

→ test of disaggregation method MODIS 1km to 250m of evaporative fraction ETF based on ETF - NDVI relation for 2006 (Eswar et al., 2013)

Year	wheat WP 1km	wheat WP 250m
2003	-	-
2004	0.340	-
2005	0.385	-
2006	0.449	0.388
2007	-	-
2008	-	-
2009	-	-

Wheat WP 2006



Summary

- Medium irrigation efficiency in Khorezm 0.66 (well>80%, poor<50%) in 2004 and 2005. Official water withdrawal statistics are not suitable for calculation due to underestimation.
- Problems of ET modelling in dry years.
- Regions mean CWP is 0.26 kg/m³ (literature for CA: 0.22–0.46) for cotton and 0.41 kg/m³ (CA: 0.44-1.02) for winter wheat
- to evaluate wheat CWP 1km resolution was insufficient
  → disaggregated approach is more suitable
- CWP is small compared to other irrigation systems of the world.

Crop	CWP* in kg/m³	world mean CWP* in kg/m³
Wheat	2.23 (China) 1.72 (USA)	1.09
Cotton	0.84 (Argentina) 0.59 (Turkey)	0.65

*Zwart SJ, Bastiaanssen WGM (2004) Review of measured crop water productivity values for irrigated wheat, rice, cotton and maize. Agric Water Manage 69:115–133

Thanks for your attention

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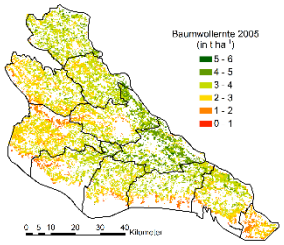


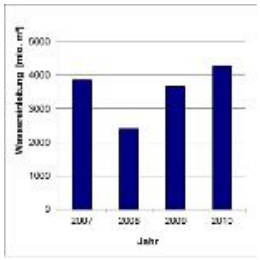

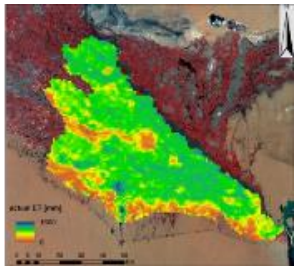
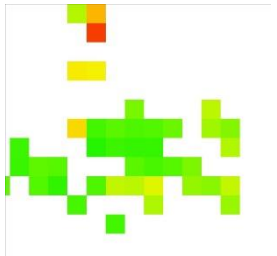

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