Remote sensing-based agricultural early drought detection system for Aral Sea Basin: *development and applications*

Muhammad Usman, Matthias Völkel, Christopher Conrad

10. Jahrestreffen des Arbeitskreises Fernerkundung der Deutschen Gesellschaft für Geographie (DGfG) – 06-07 October, Halle - Germany

Schafft Wissen. Seit 1502.

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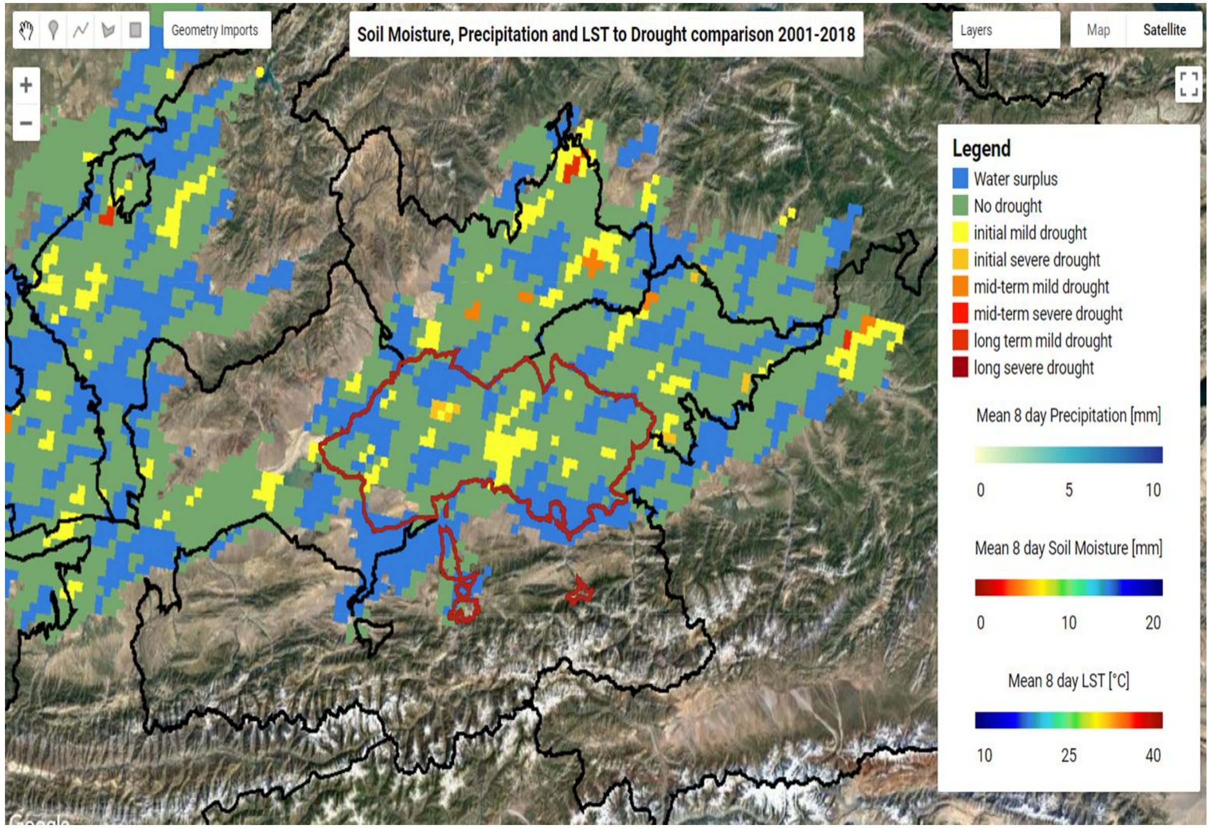
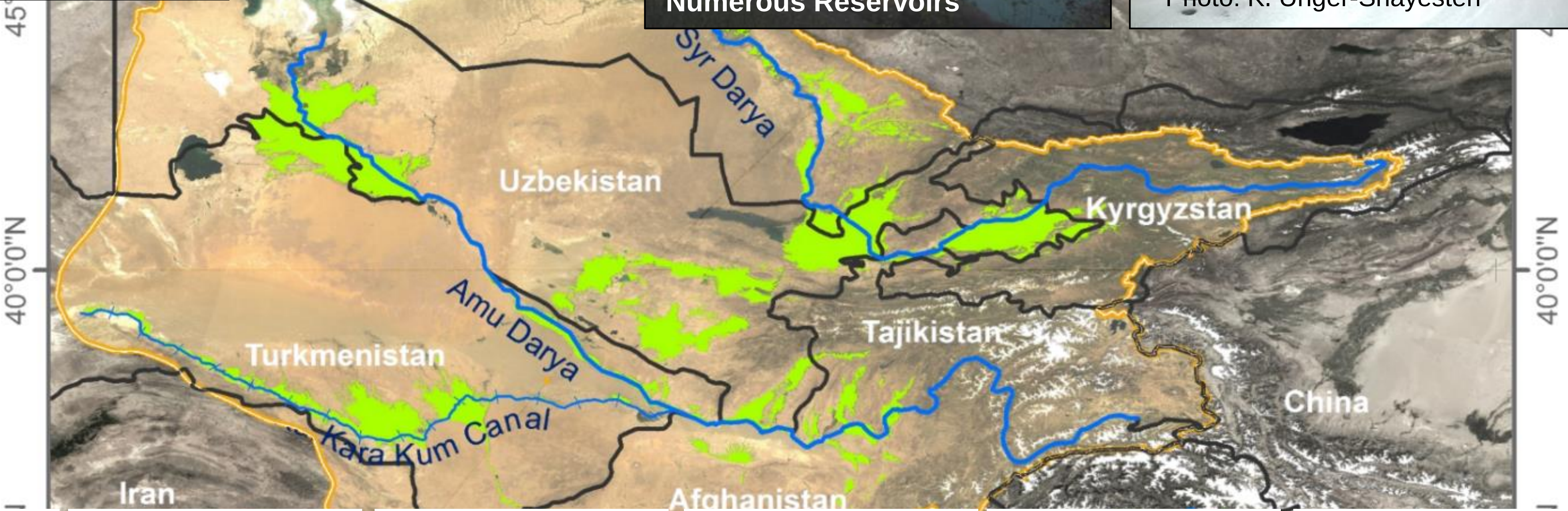


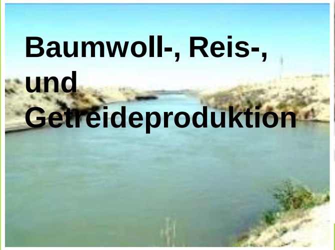
The Aral Sea Basin


Aralseeboden
Photo: Pool Filmverleih/lotus Film




Numerous Reservoirs


Pamir: Abramovgletscher
Photo: K. Unger-Shayesteh


Baumwoll-, Reis-, und Getreideproduktion


Photos aus dem Archiv des Khorezm-Projekts

Climate Impact: A serious threat

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GEO ECOLOGY

CLIMATE

Central Asian drought highlights water vulnerability

Ryskeldi Satke
July 12, 2021

A severe drought in Central Asia is causing mass livestock die-offs and shortages of water for irrigation. In two provinces of Kazakhstan, more than 2,000 domesticated animals have died due to lack of water and forage. In Kyrgyzstan, farmers have staged multiple protests in the northern region of Chui because of a lack of water to irrigate their crops. The farmers say they are on the verge of losing this season's harvest if the authorities do not supply them with water.

Distressing videos, such as this one sourced from the news portal Lada.kz, and used with their permission, show the difficult state of livestock in the region.

Similarly, water shortages in Uzbekistan have resulted in lost harvests and rising prices for seasonal vegetables. The drought in Uzbekistan's Samarkand region has disrupted the supply of drinking water: lack of precipitation and the low water level of the Zarafshan River caused a drop in the groundwater level. The Uzbek authorities have enforced water rationing in Samarkand city, limiting public consumption to prevent a greater supply crisis.

In Turkmenistan, a regional weather website reported that this year's drought in the southern and southeastern districts of the Ahal region is already the worst extreme weather event in 13 years. This is causing low pasture yields and a reduction in fodder for livestock.

https://www.preventionweb.net/news/central-asian-drought-highlights-water-vulnerability

RadioFreeEurope RadioLiberty

June 24, 2021 10:11 GMT
By Bruce Pannier

Central Asian Heat Wave And Drought Creating Water Shortages, Crop Failures

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https://www.rferl.org/a/central-asian-drought-water-shortages/31324012.html

The Central Asian drought has led to the deaths of thousands of domesticated animals (image: Alamy file picture)

Green Central Asia
Enhancing environment, climate and water resilience

Federal Foreign Office

GREEN CAWA

Implemented by

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

PIK

DKI

GFZ Helmholtz Centre Potsdam

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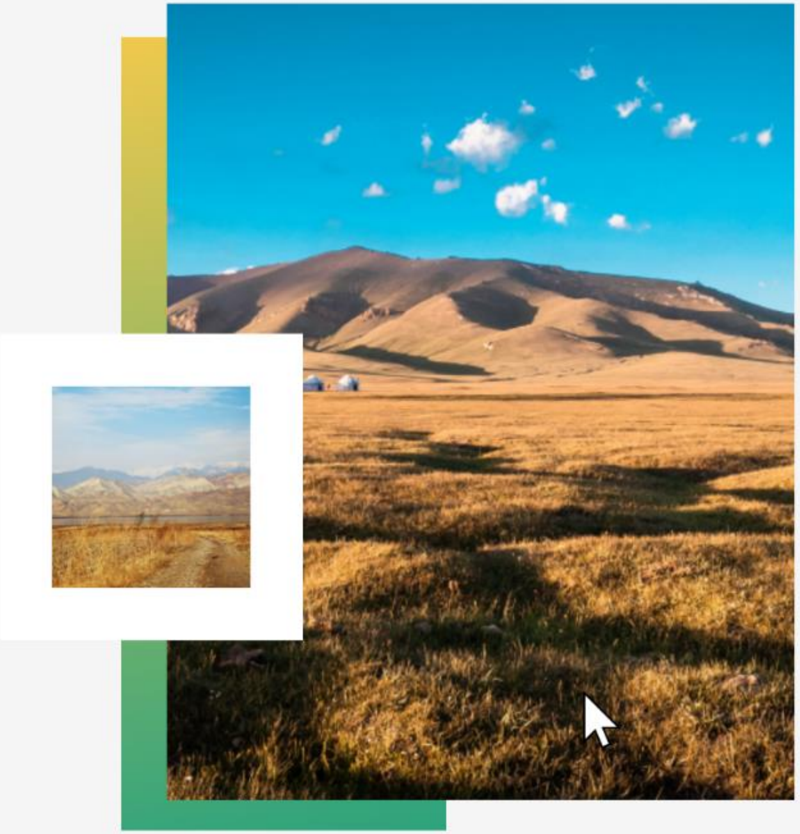


German Initiative

Green Central Asia: Transboundary dialogue on climate, environment and security in Central Asia and Afghanistan

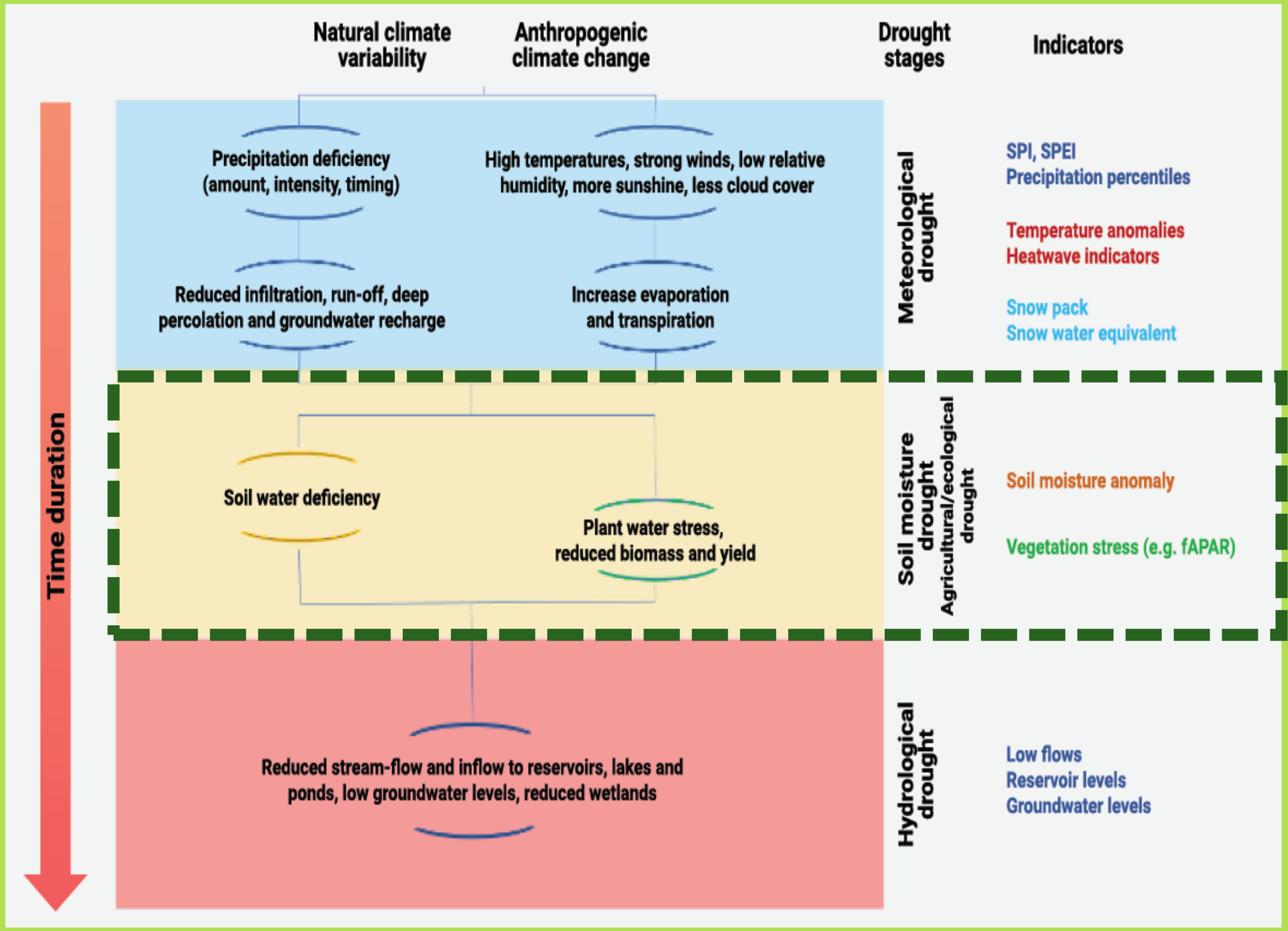
The aim of 'Green Central Asia' is to develop a political dialogue and consequently create better access to information and data in order to enable countries to assess the impact of climate change more accurately and to develop cooperative preventive measures. The target group of the Initiative consists of the foreign ministries (and, through them, the respective institutions responsible for climate and environmental resources, including educational and research institutions) of Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan and Uzbekistan as well as Afghanistan.

DISCOVER MORE

http://greencentralasia.org/en

Foreign Minister Maas and his counterparts from Central Asia and Afghanistan in Berlin, 28.01.2020, © Florian Gaertner/photothek.net

http://www.cawa-project.net/welcome-to-the-cawa-green-project/



Source: Wilhite et al. (2014), GAR Report (2021)

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GEO ECOLOGY

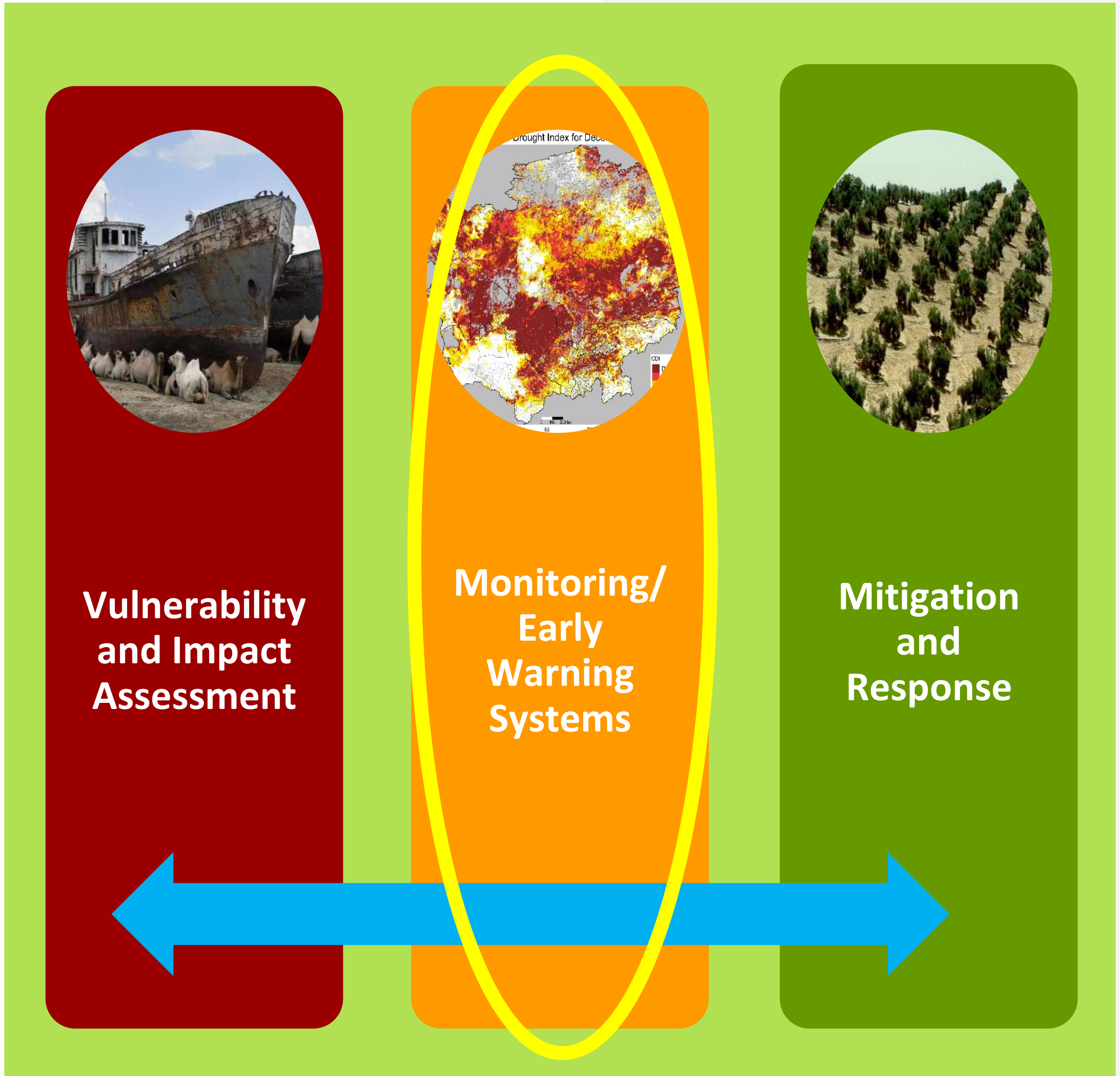
Drought and Impacts

→ Both natural and human-induced factors affect the climate behavior

→ The result could be either increase in temperature or a decrease in precipitation

→ Every drought type is measured/ quantified in form of different indicator(s)

→ Hydrological drought is the last to appear on the time scale



Source: WMO and GWP

Drought Management

→ Vulnerability and impact assessment: who is at risk and when?

→ Monitoring and early warning systems: which area is impacted and how?

→ Mitigation and response: what to do, when and who to target?

Global Drought Systems Available

System	Index used	Resolution	Type of information	Open source
https://iridl.ldeo.columbia.edu/maproom/Global/Drought/Global/CPC_GOB/Analysis.html	3-month SPI	1°x1°	Global map and time series at locations	No
https://gdis-noaa.hub.arcgis.com/pages/drought-monitoring	SPI, SPEI, ESI, Soil Moisture, CDI for Europe only	Various resolutions	Static maps	No
https://www.apcc21.org/ser/global.do?lang=en	1, 3, 6 and 12 months SPI	2.5°x2.5°	Static maps	No
http://drought.eng.uci.edu/	SPI, SSI and MSDI	Various resolutions	Static maps (last map available February 2016)	No
https://spei.csic.es/map/maps.html#months=1#month=4#year=2022	SPEI for selected regions	1 degree spatial resolution	1950 to date	Yes

SPI = Standardised Precipitation Index; SPEI = Standardised Precipitation-Evapotranspiration Index; ESI = Evaporative Stress Index; CDI = Combined Drought Index; SSI = standardised Soil Moisture Index, MSDI = Multivariate Standardised Drought Index

- → Mainly covering meterological drought i.e. SPI & SPEI
- → Very coarse resolution, mainly useful for regional/ global studies
- → Information is not updated often
- → Not covering all regions of the world
- → Limited applicability for agricultural drought

Agricultural Drought Monitoring in CA

Remote Sensing Based Drought Monitoring

Index Name	Symbol	Calculation formula
Normalized Differential Vegetation Index [28]	NDVI	$NDVI = \frac{NIR - RED}{NIR + RED}$
Vegetation Index [29]:	VCI	$VCI = \frac{NDVI_i - NDVI_{min}}{NDVI_{max} - NDVI_{min}}$
Integral Vegetation Index	IVI	$IVI = \sum_{i=1}^{18} NDVI_i$
Integral index of vegetation conditions	IVCI	$IVCI = \frac{IVI_i - IVI_{min}}{IVI_{max} - IVI_{min}}$

Source: Meshcherskaya A.V. (1981), Kogan F.N. (1990)

→ Only crop phonological / biomass response based indicators

→ Not directly catering the fact of limited water supply in the region

→ Only supporting spatial variation of drought situation at a time ignoring its temporal variation

Proposed Drought Indicators – Droughtmap ASB tool

Evaporative Stress Index (ESI) ~ Evaporative Fraction (Supply side)

$$ESI = \frac{ET_a}{ET_o}$$

ET_a = Actual ET (from SSEBI surface Energy Balance algorithm)

ET_o = Potential ET

→ ESI can represent the water shortage for agriculture from irrigation and/or precipitation

Data: MODIS Based NDVI & LST

Normalized Difference Vegetation Index (NDVI) (Response side)

→ Plant response to drought conditions can be seen directly in term of NDVI values and vice versa (i.e. Lower values than normal represent stress conditions)

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

NIR = Near infrared

RED = Visible Red

Data: MODIS NDVI (Aqua and Terra) @ 250m

Conceptual Framework for Drought Monitor

a) Value 10day-ETact within [mean (10_year-ETact) – standdev (10_year-ETact), mean (10_year-ETact) + standdev (10_year-ETact)] = -1,0,1
b) Value 10day-ETact within [20% percentile (15_year-ETact), 80% percentile (15_year-ETact)] => -1,0,1

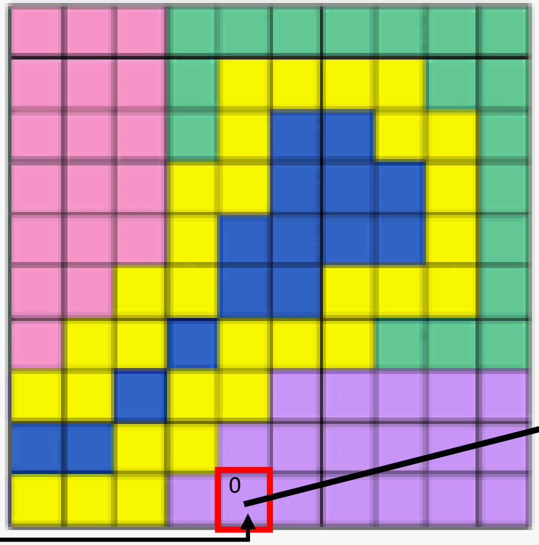
Aggregation Level:

- 5kmx5km
- Province (Oblast)
- District (Rayon)
- Country
- Aral Sea Basin

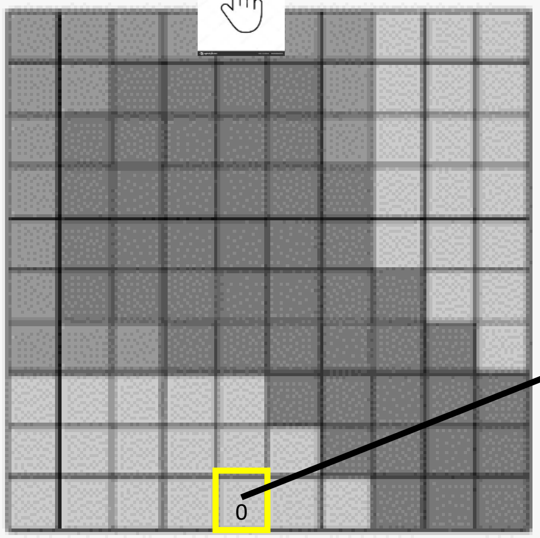
Drought Early Warning - Indicators:

Indicator 1 NDVI

Indicator 2 ESI

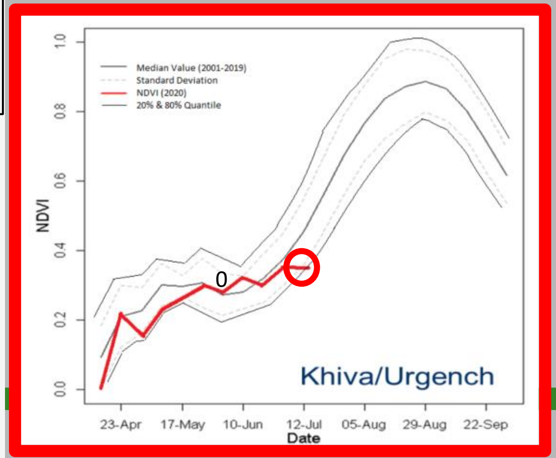


Legend
-1 = Drought signs
0 = normal development
+1 = excellent vegetation development

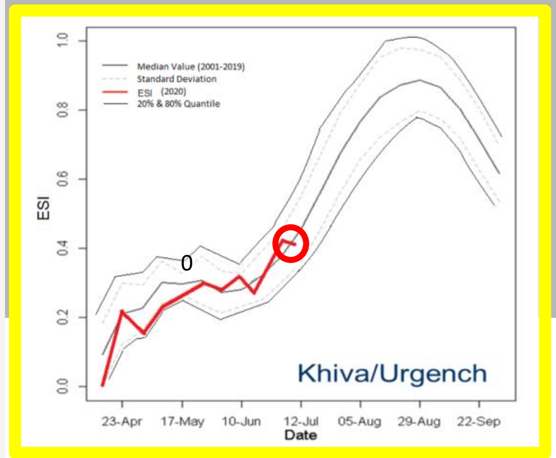


Legend
-1 = Drought
0 = No drought
+1 = Excess Water

Indicator 1



Indicator 2



Representation of Key Drought Parameters

Duration

if duration < 1	=> „no drought“
if 1<= duration <=2	= > „initial drought“
if 2< duration <= 3	= > „mid-term drought“
if duration > 3	=> „long-term drought“

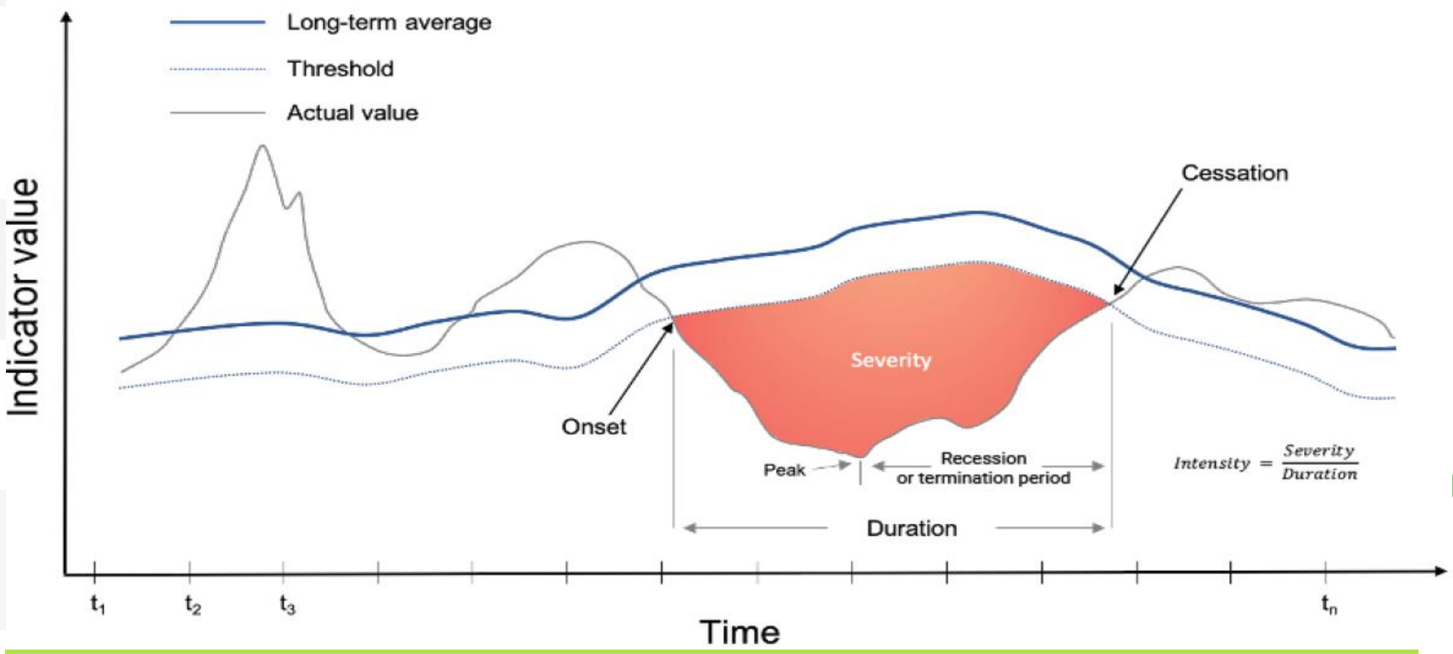
Severity

If |sum(DSI)| => Severity Factor*	... „Severe drought“
|sum(DSI)| < Severity Factor	... „Mild drought“
|sum(DSI)| = 0	... „No drought“

Drought Classification

1	Water surplus
2	No drought
3	Mild drought
4	Initial severe
5	Mid-term mild
6	Mid-term severe
7	Long-term mild
8	Long-term severe

*Severity factor ∫ (Duration)



Frequency = No of drought events per time duration

Severity (Magnitude) = Related to the water deficit; computed as the sum of the differences, in absolute values, between the drought indicator (DI) values and the threshold used to define the level of dryness

Intensity = Severity divided by duration of the event

Duration = No of days, month, or time steps of the event

Plausibility analysis

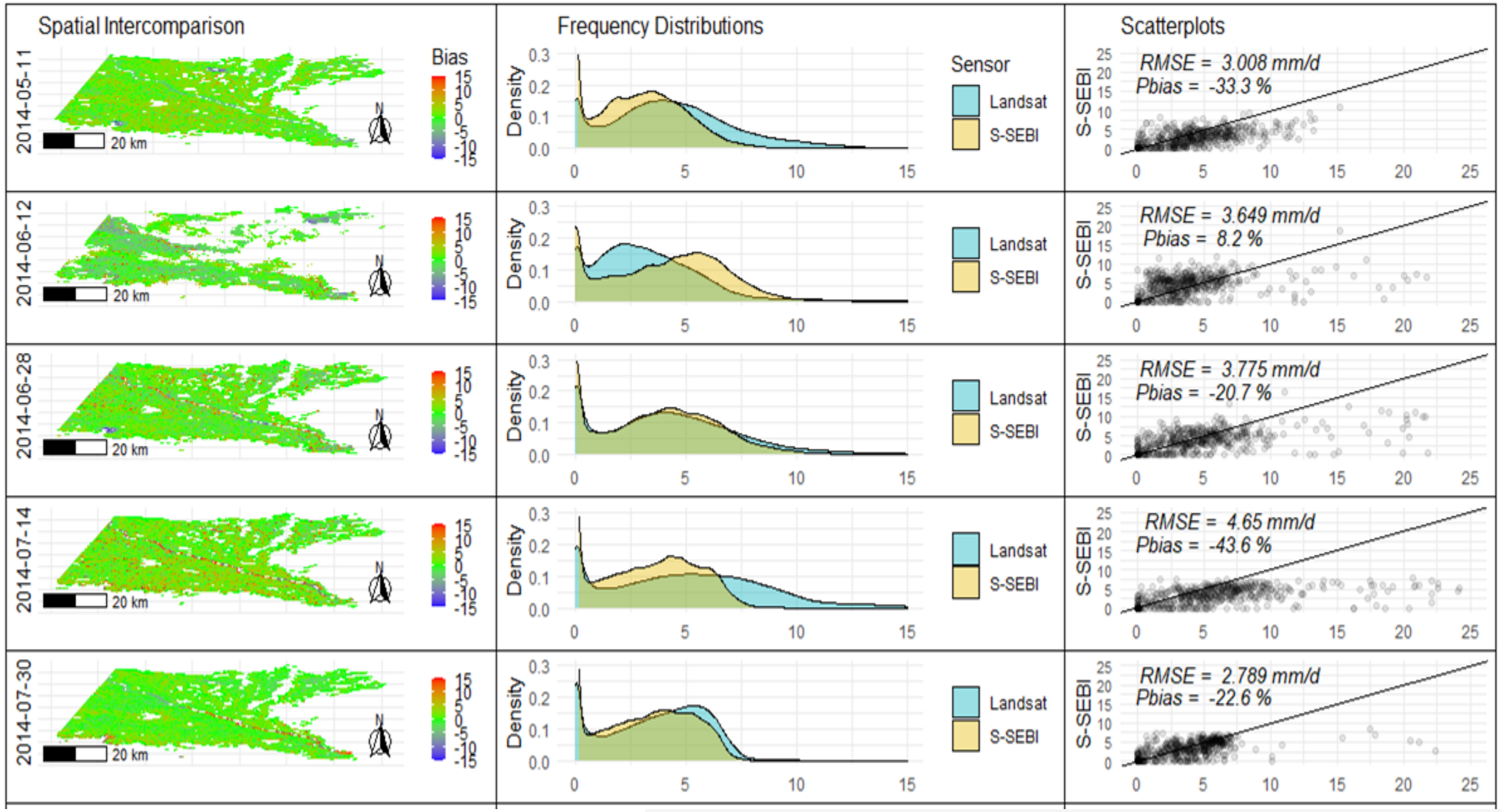
→ The comparison was done between S-SEBI and EEFLUX (i.e. Landsat) actual ET results

→ The results show that S-SEBI is overall underestimating ET (i.e. See Bias)

→ The frequency distribution chart shows comparatively least scatter ability (i.e. variation in values) in the case of S-SEBI

→ The data scattering is higher for Landsat with more pixels showing higher ET

→ Possible explanations include different algorithms, the different spatial resolution of used data



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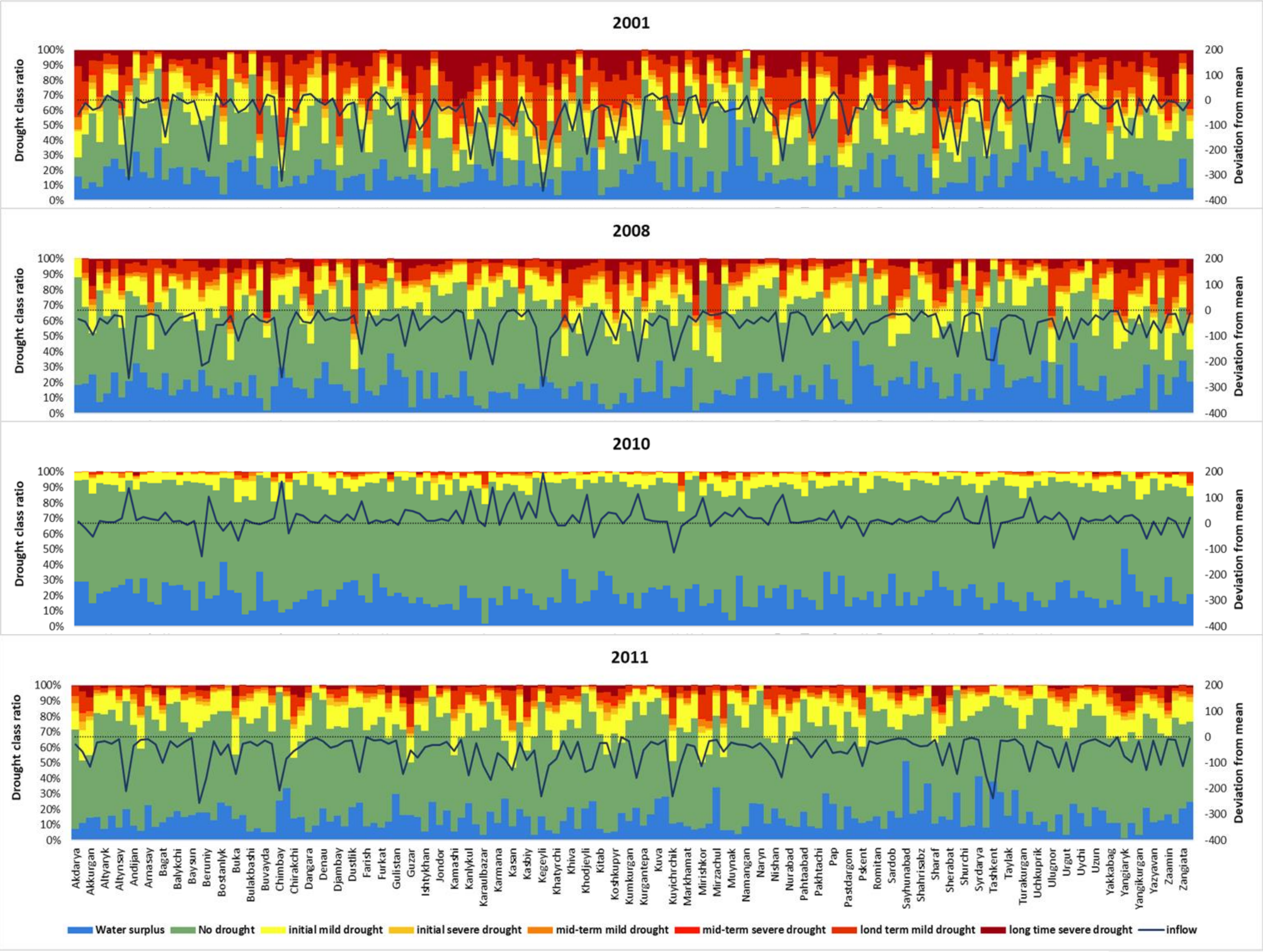
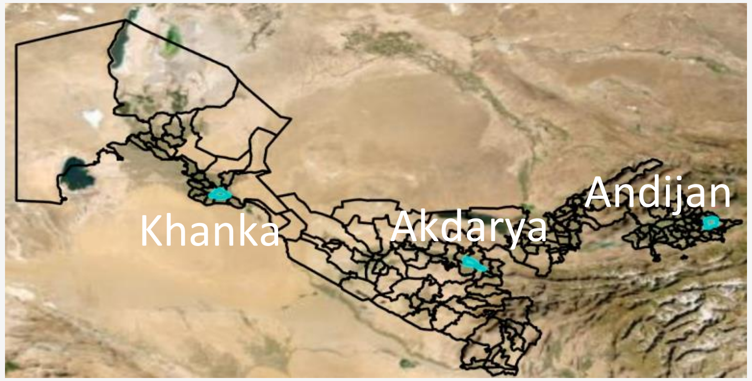


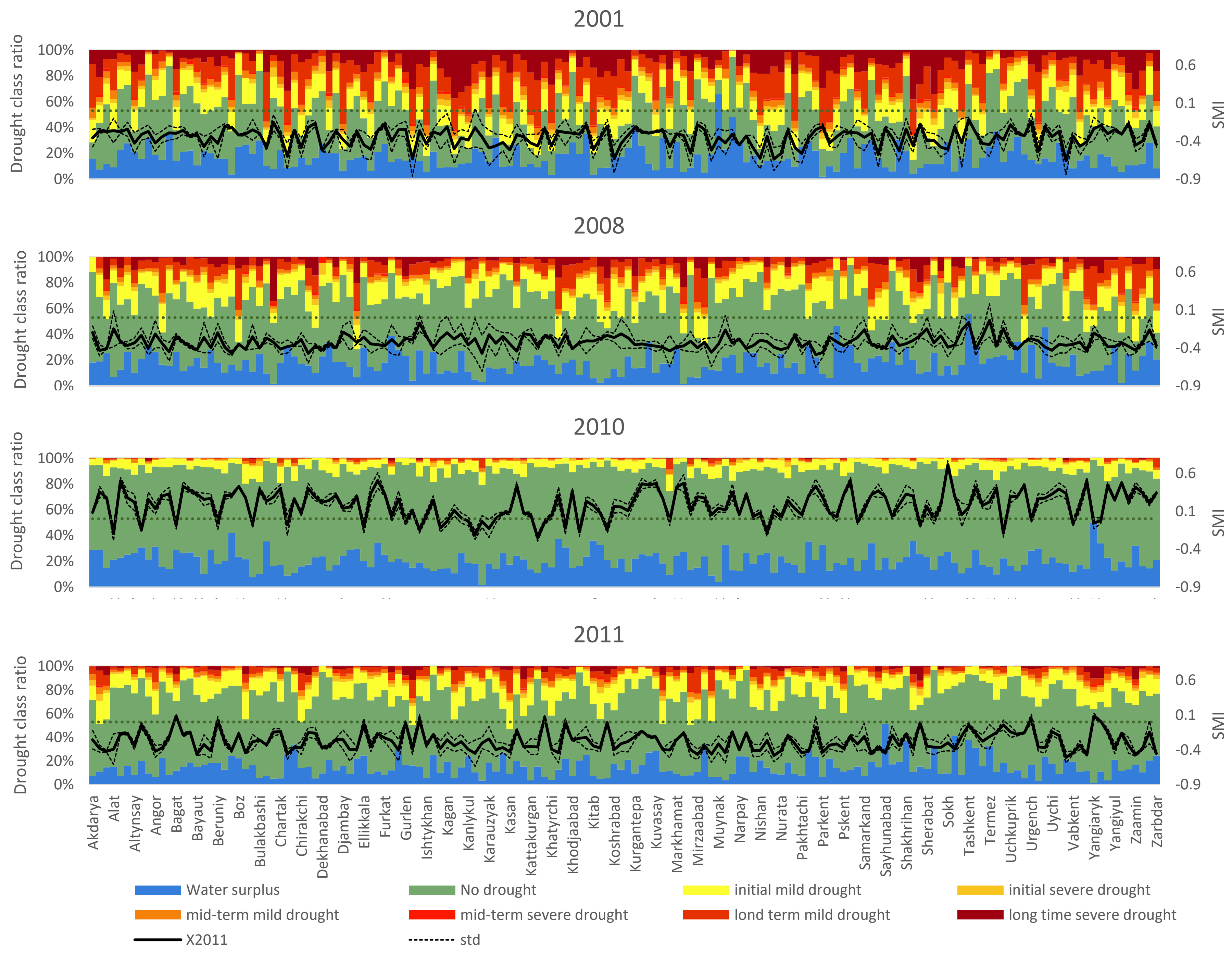
Plausibility analysis: Inflow

- → The charts demonstrate relationship of various drought situations with river water inflow in rayons of Uzbekistan in annual resolution
- → The effects of low/ higher irrigation flow on drought development can be seen
- → Years 2001, 2008 were dry and year 2010 was a wet year. Drought conditions can be well represented through the patterns

Inflow – Temporal comparison for selected regions

- Three rayons in Uzbekistan





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Plausibility analysis – Standardized Soil Moisture Index (SMI)

→ Data Source: FLDAS Soil Moisture from 0-100 cm (spat. res. 11132 m)

→ FLDAS data are simulated for research by combination of MERRA-2 and CHIRPS 6-hourly rainfall data

→ FLDAS reference period: 1982-01-01 until now in monthly resolution

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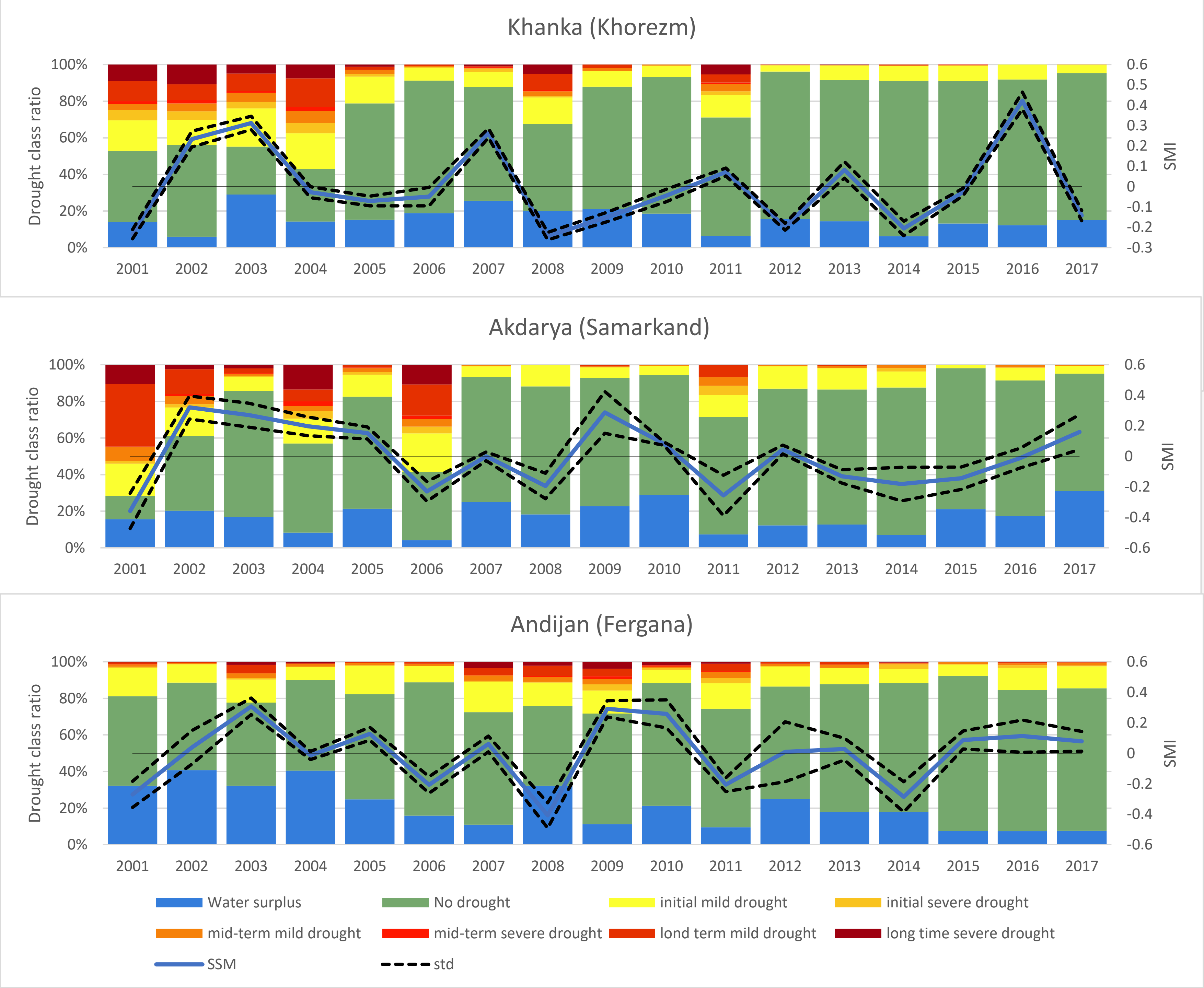
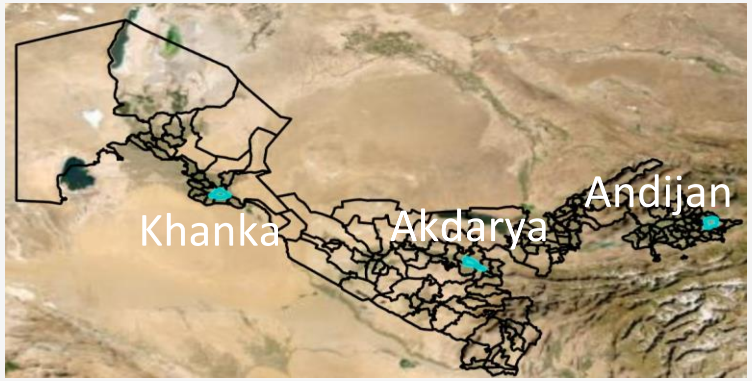
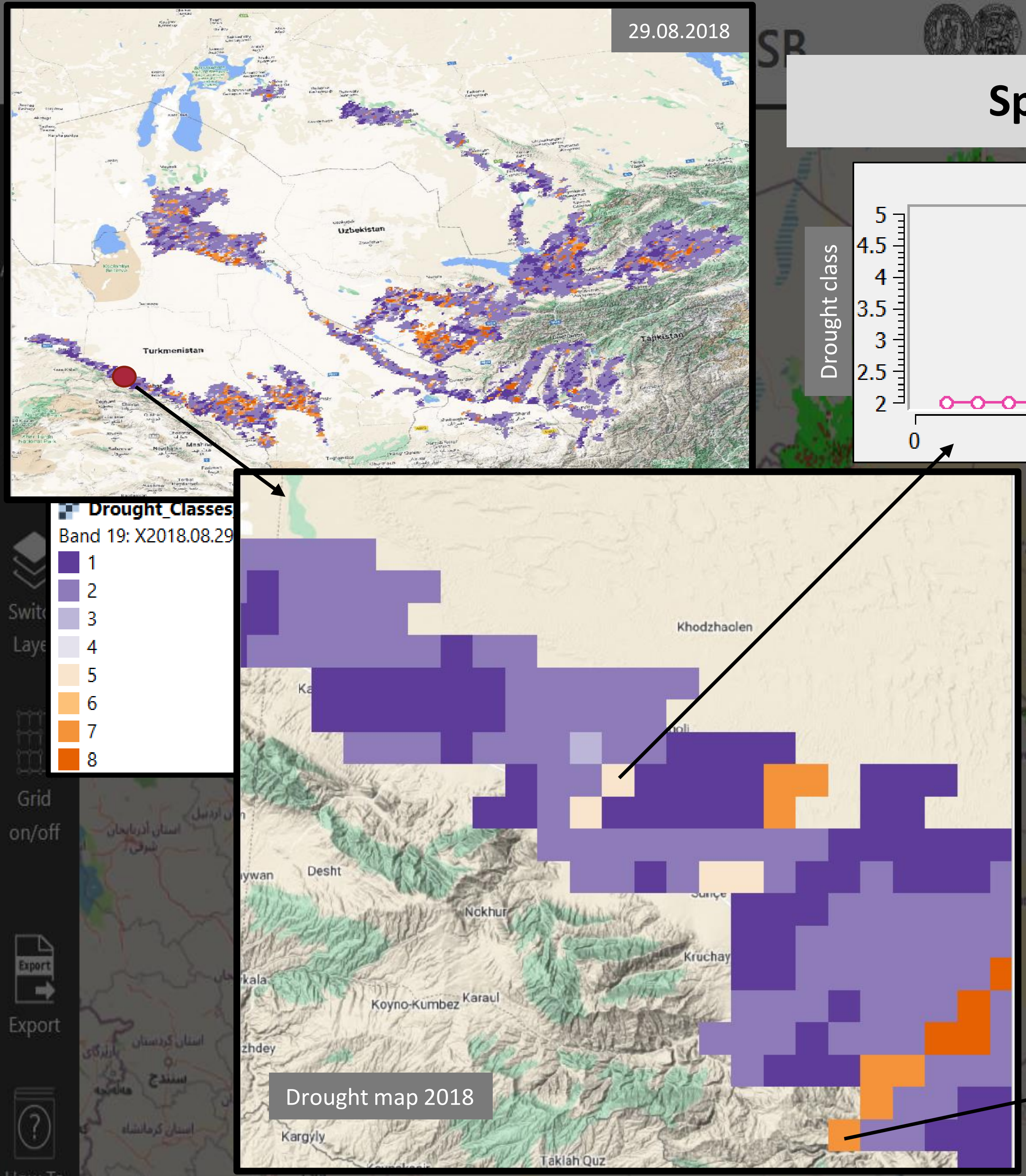


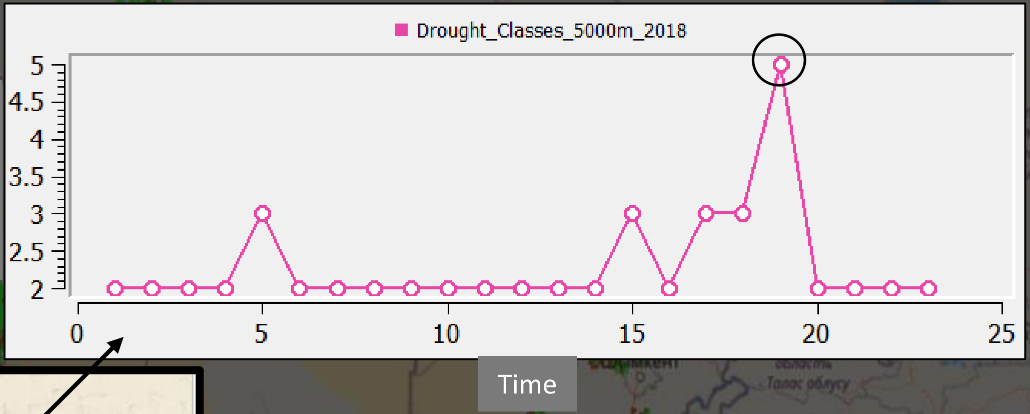
SMI – Temporal comparison for selected regions

- Three rayons in Uzbekistan

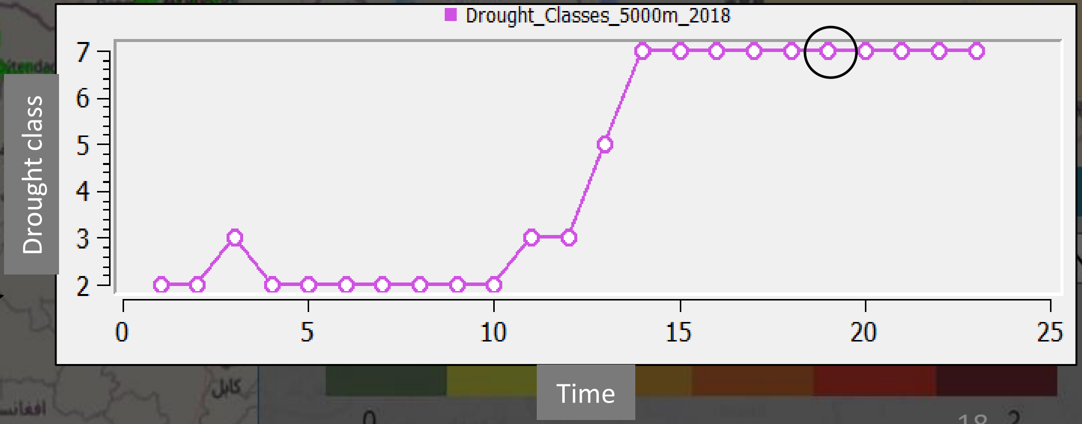


Spatio-temporal Representation of Results





- X-axis = Time (Image)
- Y-axis = Drought situation (Class)



Potential Applications

→ Drought bulletins through email subscriptions

→ Drought information could be coupled with crop-specific critical growth stages for optimum water management and yield enhancement

→ Areas that require urgent actions could be prioritized based on crop and drought information

→ Various geographical and climate-driven variables could be coupled with spatio-temporal drought information for hotspot area analyses

→ Spatial planning of mitigation and response centers for socio-environmental projects

Consent Letters For Cooperation

КАЗАҚСТАН РЕСПУБЛИКАСЫ ЭКОЛОГИЯ, ГЕОЛОГИЯ ЖӘНЕ ТАБИҒИ РЕСУРСТАР МИНИСТРЛІГІ

«ҚАЗГИДРОМЕТ» ШАРУАШЫЛЫҚ ЖҮРГІЗУ ҚҰҚЫҒЫНДАҒЫ РЕСПУБЛИКАЛЫҚ МЕМЛЕКЕТТІК КӘСІПОРНЫ

МИНИСТЕРСТВО ЭКОЛОГИИ, ГЕОЛОГИИ И ПРИРОДНЫХ РЕСУРСОВ РЕСПУБЛИКИ КАЗАХСТАН

РЕСПУБЛИКАНСКОЕ ГОСУДАРСТВЕННОЕ ПРЕДПРИЯТИЕ НА ПРАВЕ ХОЗЯЙСТВЕННОГО ВЕДЕНИЯ «КАЗГИДРОМЕТ»

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факс: 8(71 72) 79-83-44, info@meteo.kz

010000 г. Нур-Султан, проспект Мәңгілік Ел, 11/1
Тел: 8(7172) 79-83-93, 79-83-84
факс: 8(7172) 79-83-44, info@meteo.kz

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14.09.2022

Министерство экологии, геологии и природных ресурсов Республики Казахстан

Департамент экологической политики и устойчивого развития

Копия: Германское общество по международному сотрудничеству (GIZ)

Ответ на письмо № 16670 от 12.09.2022 года

РГП «Казгидромет» рассмотрев письмо Германского общества по международному сотрудничеству (GIZ) касательно иницативы «Зеленая Центральная Азия» **подтверждает свою заинтересованность и готов вести дальнейшее сотрудничество по разработке инструмента**, который посредством раннего предупреждения будет способствовать предотвращению и смягчению рисков засухи, а также адаптации и реагированию на засушливые ситуации.

Кроме того, в целях координации и реализации проводимых работ, связанных с разработкой вышеуказанного инструмента Национальными координаторами РГП «Казгидромет» назначаются специалисты, принимавшие непосредственное участие 18-20 июля т.г. в техническом семинаре, который состоялся в г.Ташкент, Узбекистан.

1.Салиева Камар Сапабековна - Ведущий инженер Управления агрометеорологического прогнозирования Департамента агрометеорологического мониторинга и прогнозирования, *saliyeva_k@meteo.kz;*

2.Каратай Маншук Атагоныскызы - Ведущий инженер Управления климатических исследований Научно-исследовательского центра, *karatay_m@meteo.kz.*

Генеральный директор **Д. Алимбаева**

КЫРГЫЗ РЕСПУБЛИКАСЫНЫН ТЫШКЫ ИШТЕР МИНИСТРЛИГИ

MINISTRY OF FOREIGN AFFAIRS OF THE KYRGYZ REPUBLIC

№ 19-011/3563

Кыргыз Республикасынын Тышкы иштер министрлиги Кыргыз Республикасындагы Германия Эл аралык Кызматташуу Коомуна (GIZ) өз урматын билдирүү менен бирге, 2022-жылдын 25-августундагы №GCA-033 катка жооп катары "Жашыл Борбордук Азия" демилгесинин алкагында кургакчылык тобокелдигин алдын алууга жана жумшартууга, ошондой эле алдын ала билдирүү системасы аркылуу кургакчылык кырдаалдарына ыңгайлашууга жана чараларды көрүүгө салым кошо турган инструмент иштеп чыгуу жаатында мындан ары кызматташууга кыргыз тарап кызыкдар экендигин билдирет.

ГЕРМАНИЯ ЭЛ АРАЛЫК КЫЗМАТТАШУУ КООМУНУН КЫРГЫЗ РЕСПУБЛИКАСЫНДАГЫ ӨКҮЛЧҮЛҮГҮНӨ
Бишкек ш.

КУМИТАИ ҲИФЗИ МУҲИТИ ЗИСТИ НАЗДИ ҲУКУМАТИ ҶУМҲУРИИ ТОҶИКИСТОН

АГЕНТИИ ОБУҲАВОШИНОСӢ

КОМИТЕТ ОХРАНЫ ОКРУЖАЮЩЕЙ СРЕДЫ ПРИ ПРАВИТЕЛЬСТВЕ РЕСПУБЛИКИ ТАДЖИКИСТАН

АГЕНТСТВО ПО ГИДРОМЕТЕОРОЛОГИИ

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№___________
аз « » ________ соли 2022
Ба №________________
аз « »_________ соли 2022

Кумитаи ҳифзи муҳити зисти назди Ҳукумати Ҷумҳурии Тоҷикистон

Агентии обуҳавошиносӣ мактуби Вазорати корҳои хориҷии Ҷумҳурии Тоҷикистон аз 19.08.2022, №6/16-2(22403) оид ба абзори мусоидат ба пешгирии хатарҳои Осиёи Марказиро мавриди баррасӣ қарор дод.

Агентӣ ба саволҳои саволномаи ҷамъияти Олмон оид ба ҳамкории байналмилалӣ (GIZ)-ро пурра ҷавоб гардонида, барномаи аз тарафи Донишгоҳи Мартин-Лютер Ҳолле Виттенберг таҳия гардидаистодаро барои истифода дар самти баҳодиҳии вазъи хушксолӣ ва пешгӯикунии он дар кишвар муҳим арзёбӣ менамояд.

Ҳамзамон, Агентӣ бо мақсади беҳтар намудани фаъолияти соҳаи агрометеорология ҳавасмандии худро ҷиҳати дастрас ва ҷории барномаи мазкурро иброз менамояд.

Замима дар ҳаҷми 16 саҳифа.

Бо эҳтиром,
Директор — Қурбонзода А.Ҳ.

Иҷр:Маркази яхшиносӣ
Тел:+992901055540

Fotos: GIZ

Literature cited

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Thank you very much for listening!

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