# Monitoring Vegetation Condition in Central Asia: An Overview

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## Q1. Monitoring to achieve what end?

A1. Linkage with Climate Models (FVC, LAI, phenology)

B1. Environmental Assessment (soils, vegetation, water, fire, dust, urban, natural disasters)

C1. Census of Agriculture (cultivated area, production, yield, crop mapping, irrigated area, evapotranspiration)

## Q2. Monitoring at which spatial / temporal / spectral scales?

A2. 1-25km / subdaily to biweekly / Veg Indices (NDVI, EVI, WDRVI)

B2. 10-1000m / daily to biweekly to annual / VNIR, SWIR, TIR, MW

C2. 10-500m / weekly to annual / VNIR, SWIR, TIR

- Monitoring implies an active interest in detecting, quantifying, and assessing the significance of change. Where? When? How much? How significant? What form? What agency?

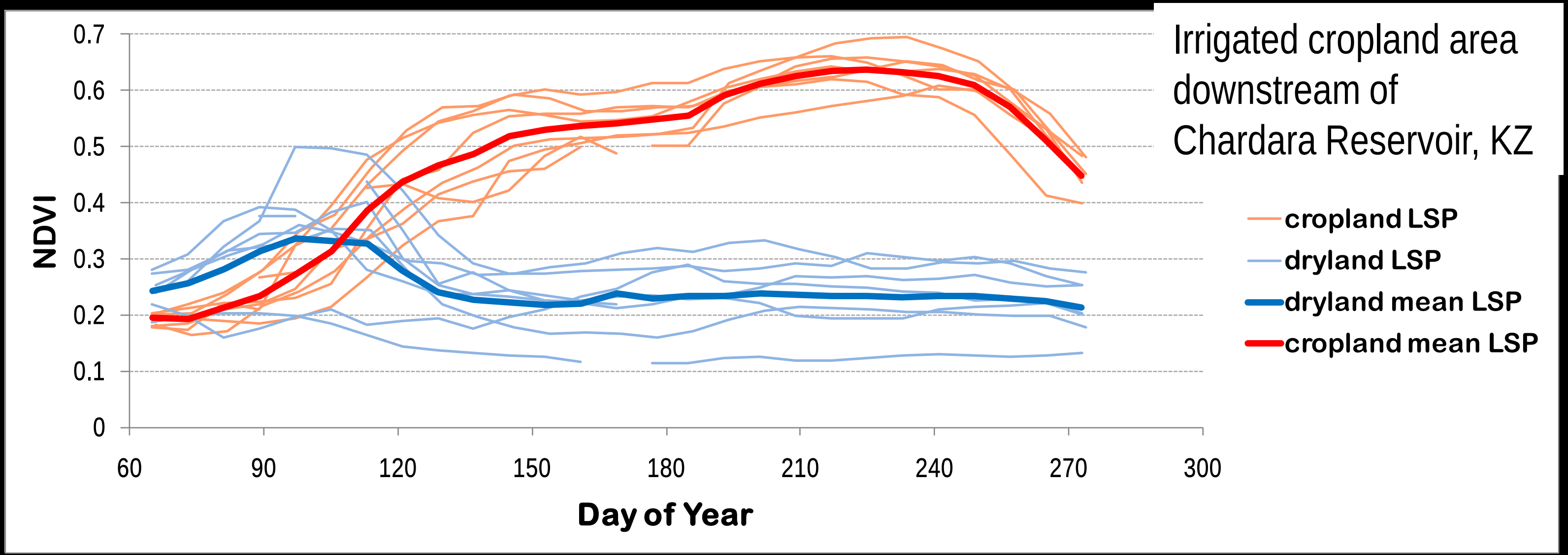
- Analysis of land cover / land use change (LCLUC) has traditionally meant quantifying categorical change, but that is a historical artifact of data scarcity and computational limitations.

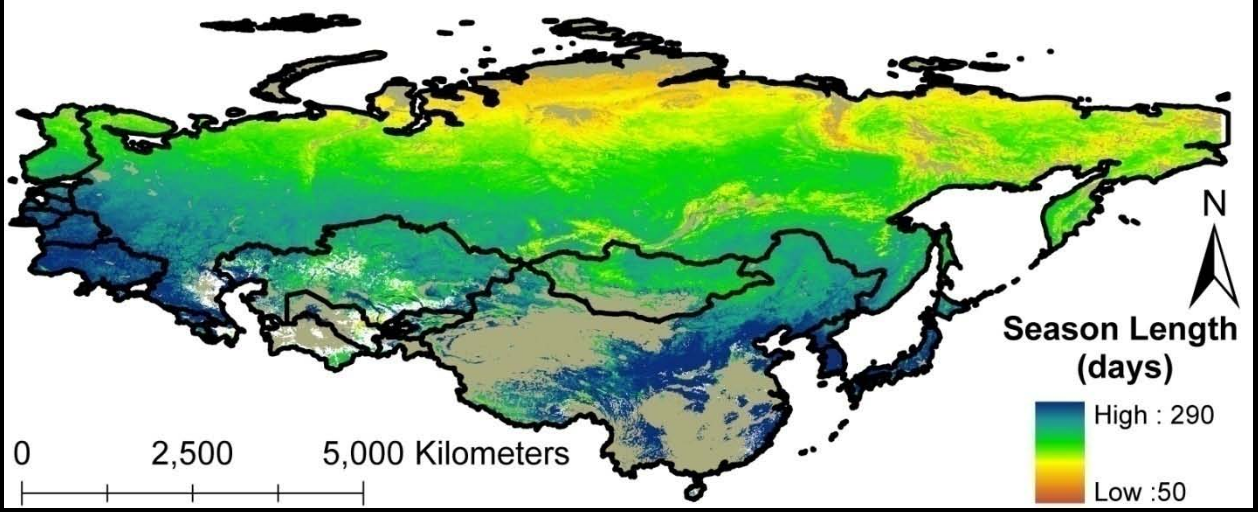
- LCLUC considered in terms of dynamics requires a functional rather than structural representation, focusing on changes in temporal pattern rather than changes in spatial pattern occurring between a couple of time points.

Land Surface Phenologies (LSPs) describe the spatio-temporal development of the vegetated land surface using remote sensing data.

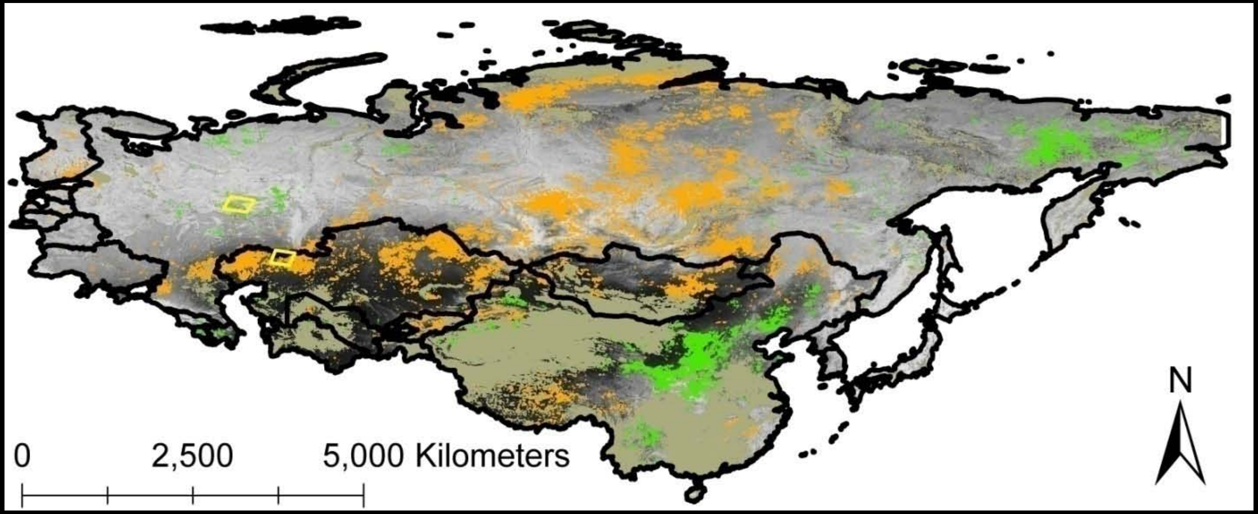
LSPs are *more than* time series of vegetation condition as indicated by vegetation indices (NDVI, EVI, WDRVI) or biogeophysical variables (FVC, LAI, ANPP). LSPs include identification and quantification of phenological phases, e.g., green-up, reproduction, senescence.

We can identify characteristic *phenological endmembers:*





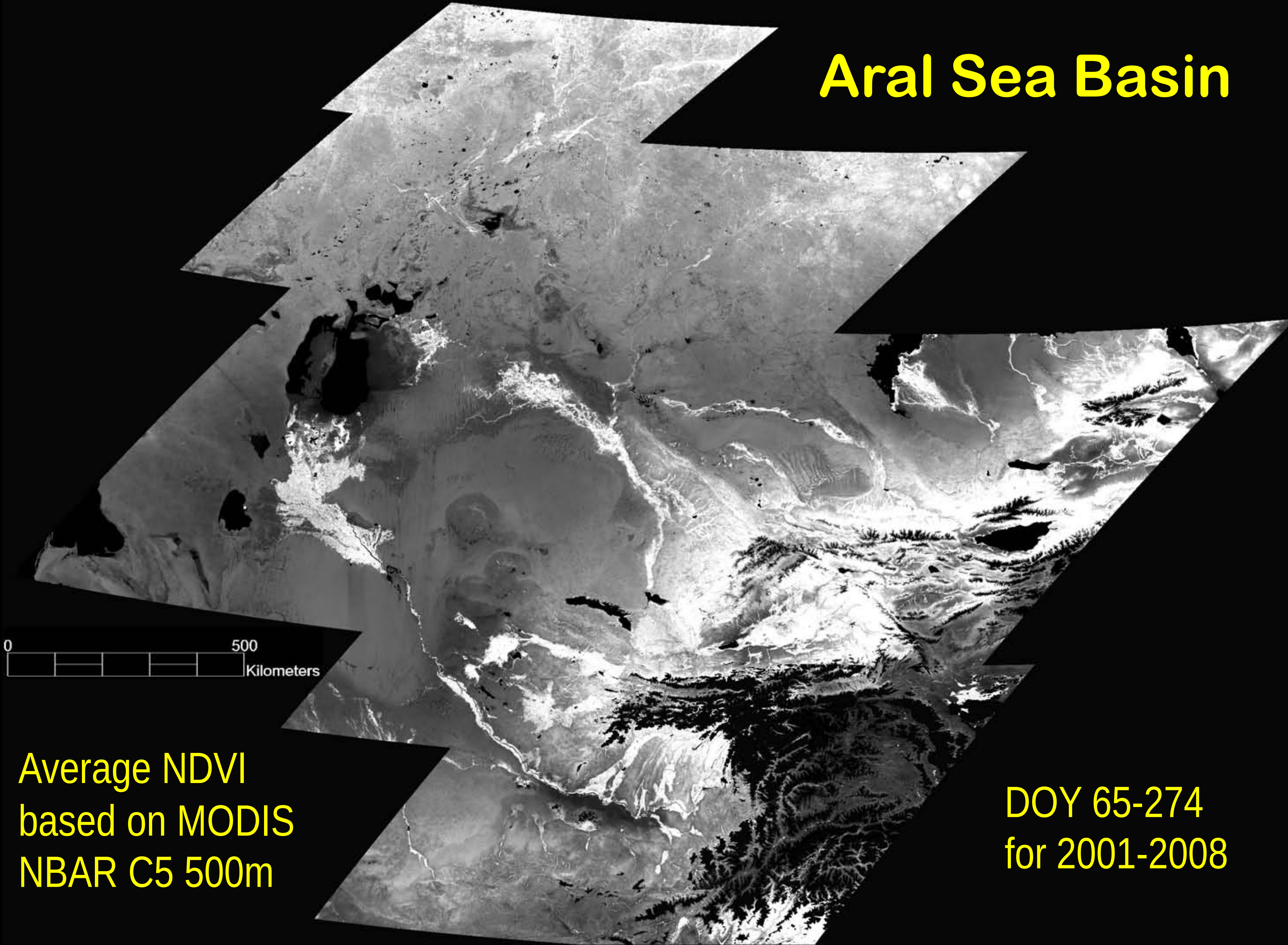

Average length of season based on the average SOS and average EOS computed from NDII composites from 2001 to 2007. White areas have a retrieved length of season less than 50 days.




Vegetation trends from 2000 to 2008 revealed by NASA MODIS at 0.05° spatial resolution. Areas outlined in orange and green indicate highly significant ($p \leq 0.01$) negative and positive trends, respectively. Areas in tan were excluded from analysis. Areas in shades of gray did not exhibit highly significant trends.

Source: de Beurs, Wright & Henebry. 2009. *Environmental Research Letters.*

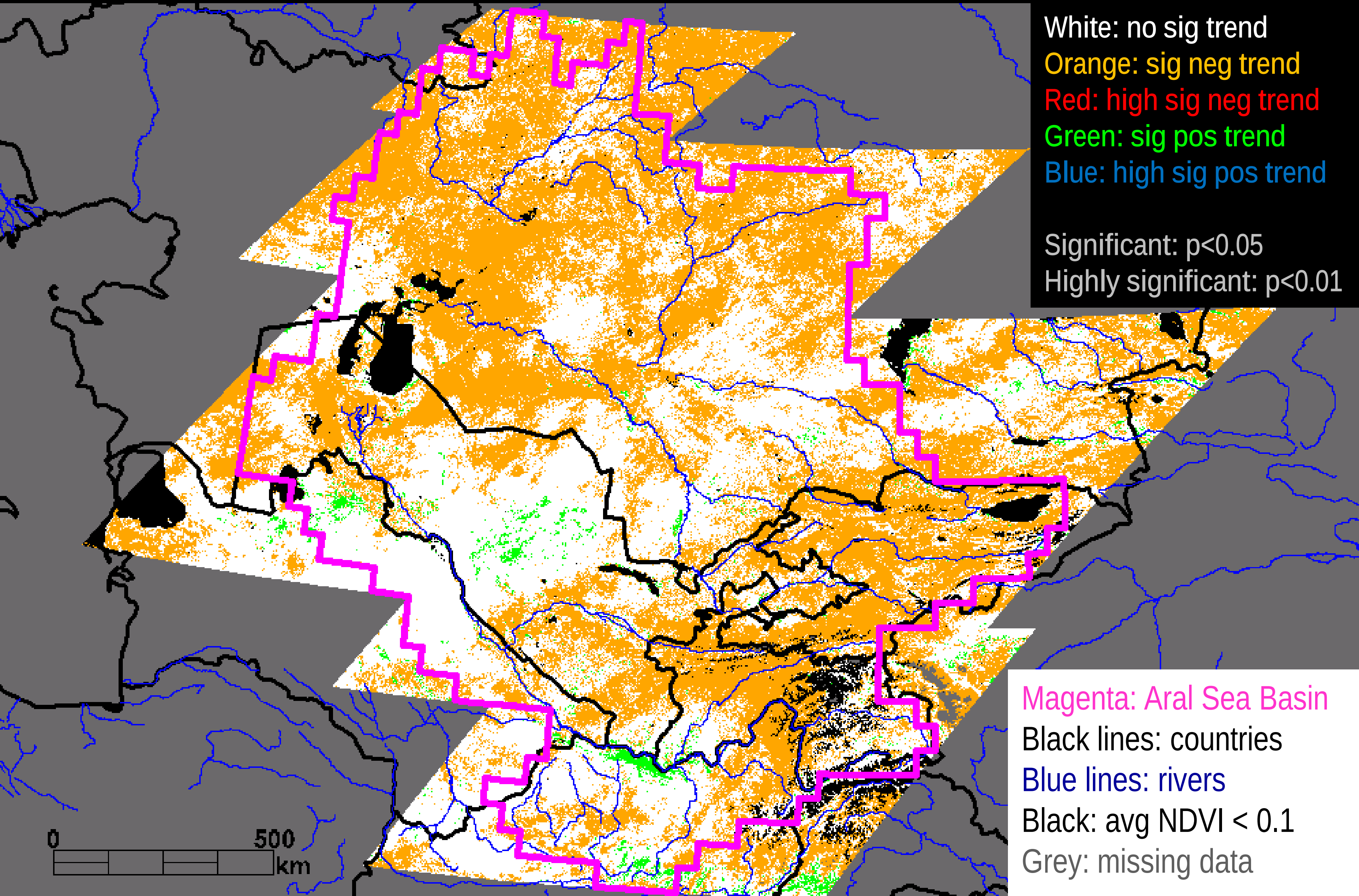
# Aral Sea Basin



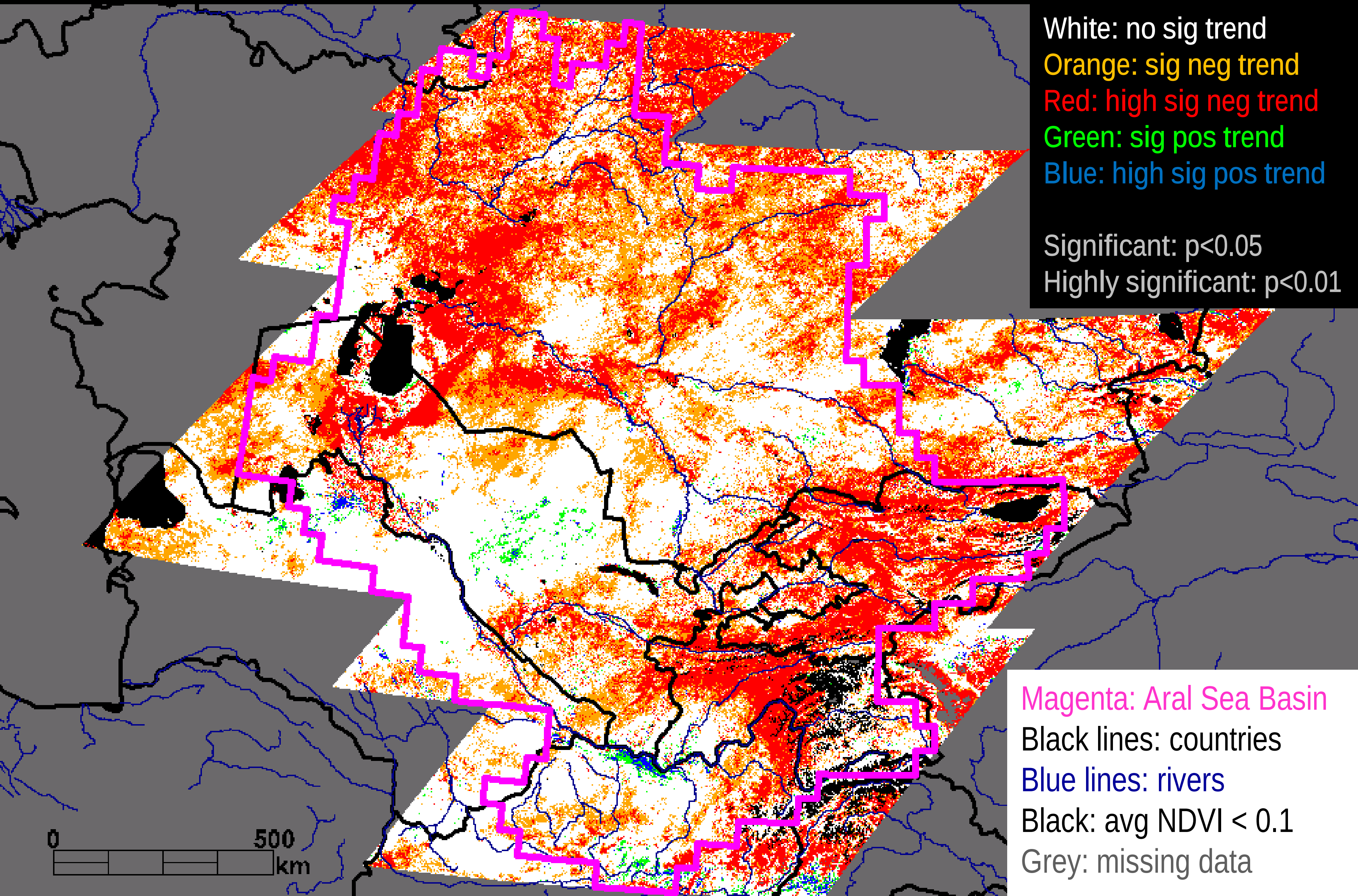

Average NDVI
based on MODIS
NBAR C5 500m

DOY 65-274
for 2001-2008

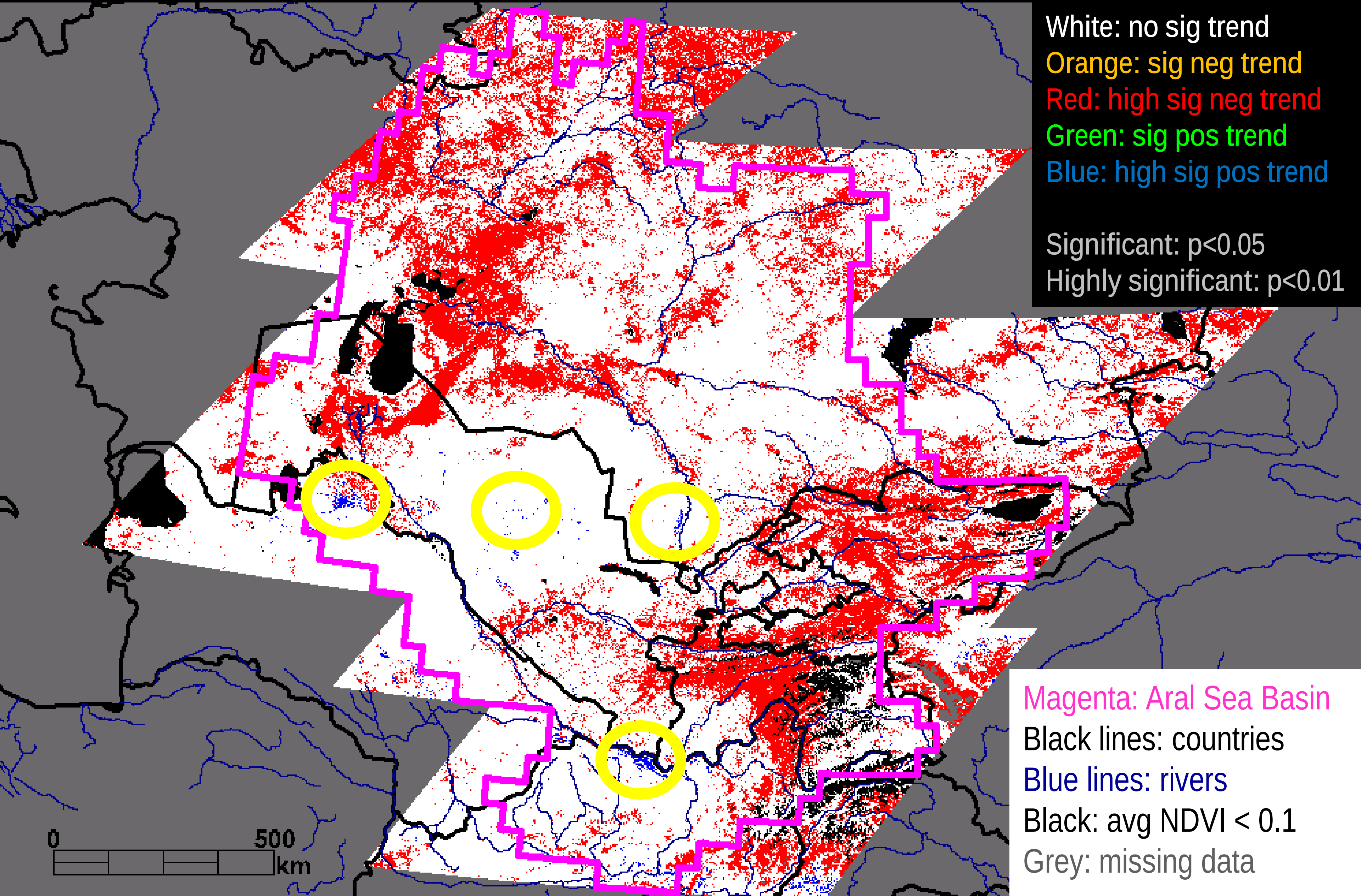
# MODIS NDVI Trends in Aral Sea Basin: Seasonal Kendall Test



# MODIS NDVI Trends in Aral Sea Basin: Seasonal Kendall Test



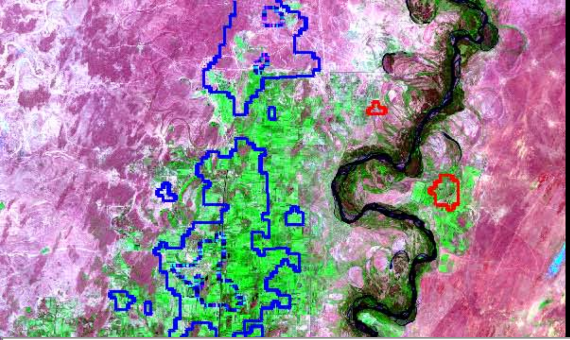
# MODIS NDVI Trends in Aral Sea Basin: Seasonal Kendall Test



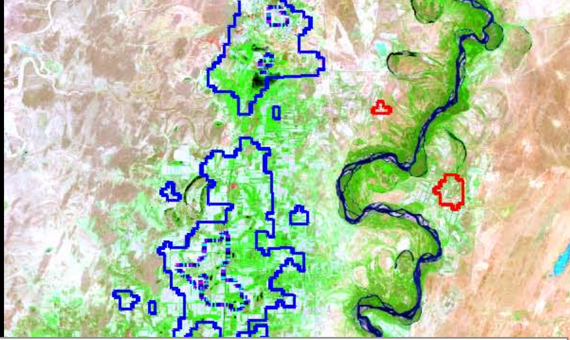

White: no sig trend
Orange: sig neg trend
Red: high sig neg trend
Green: sig pos trend
Blue: high sig pos trend

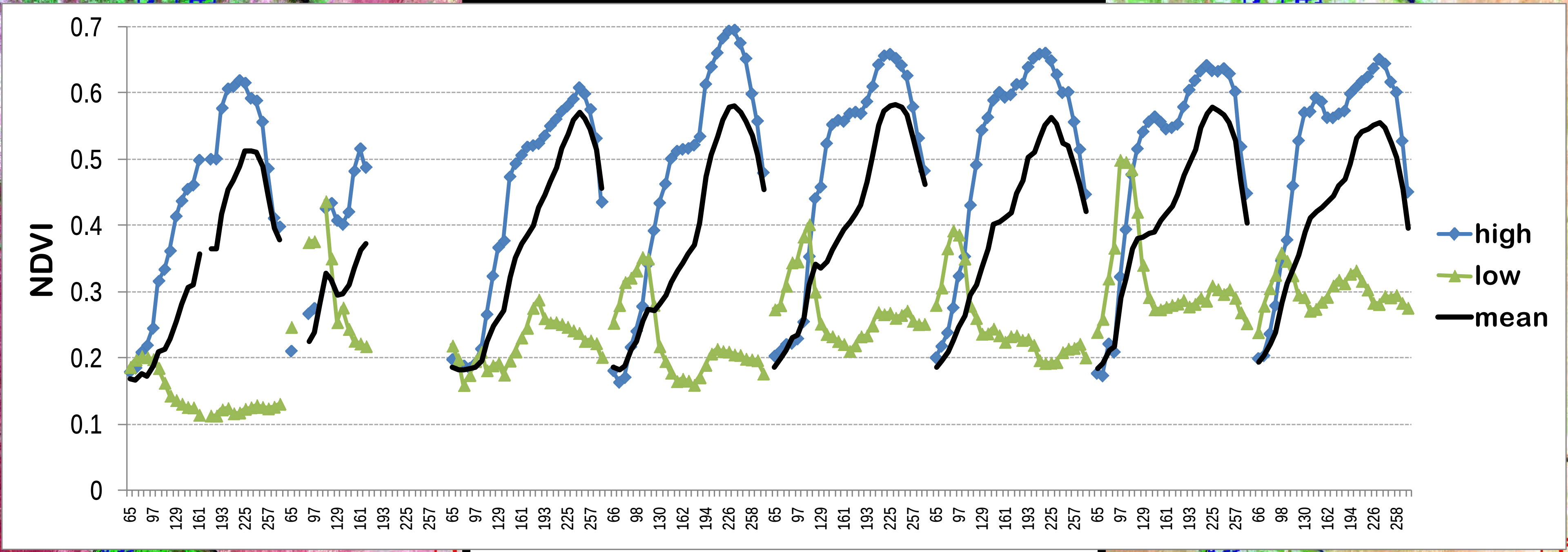
Significant: $p<0.05$
Highly significant: $p<0.01$

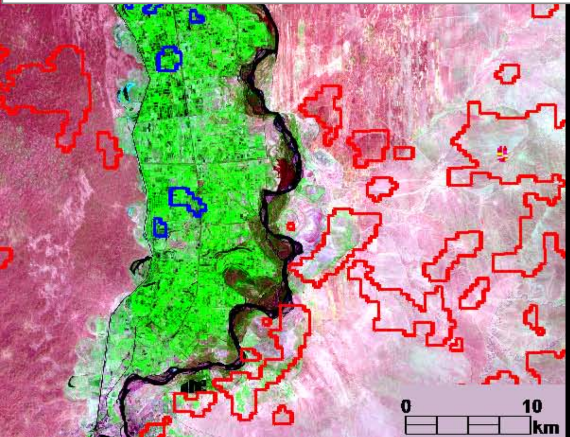
Magenta: Aral Sea Basin
Black lines: countries
Blue lines: rivers
Black: avg NDVI < 0.1
Grey: missing data



# Along the Syr Darya, downstream of the Chardara Reservoir, KZ

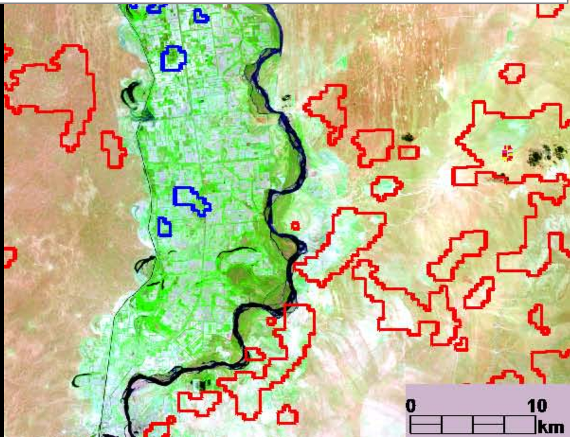


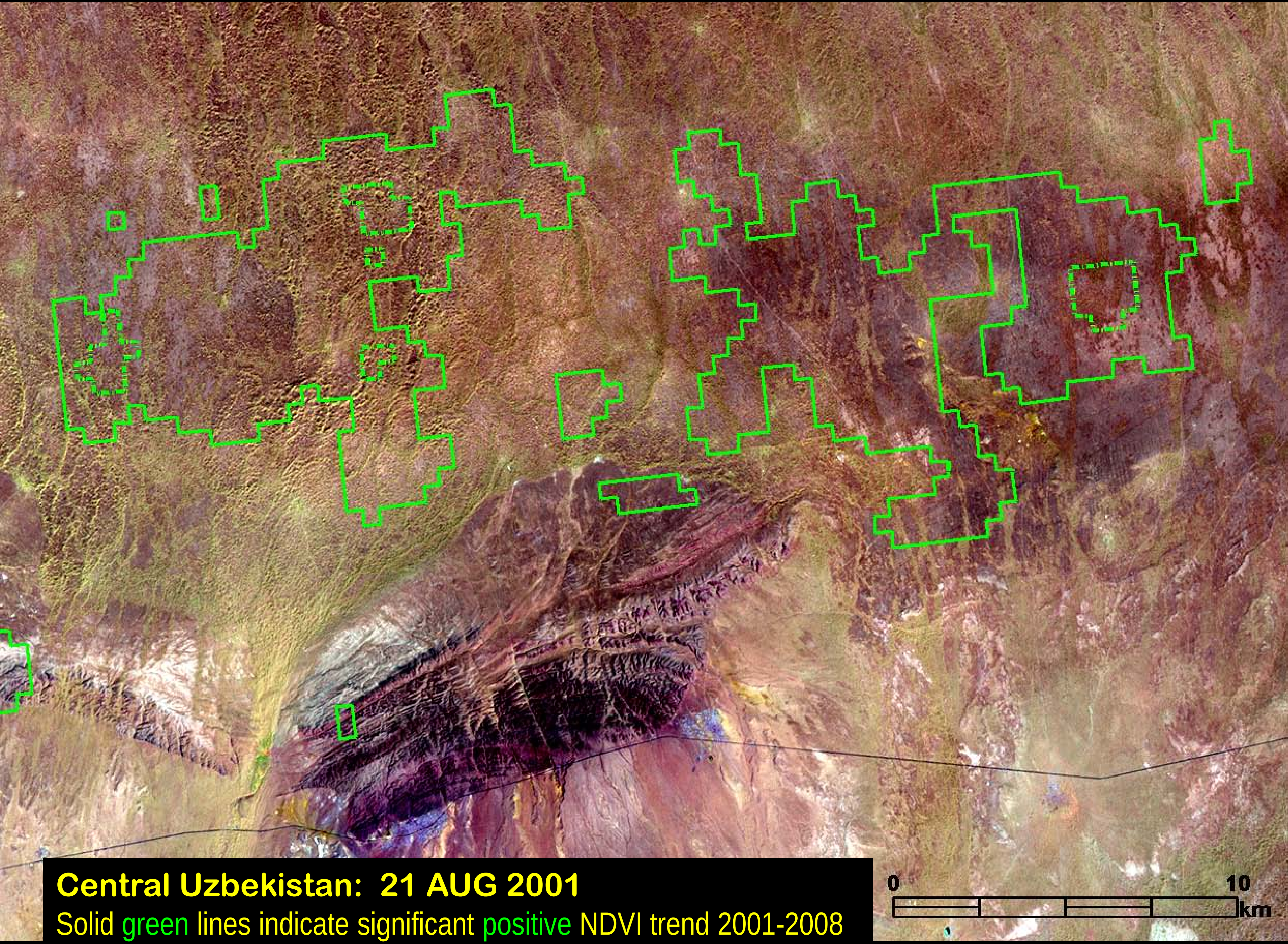



**Examples of highly significant (p<0.01) positive trends**

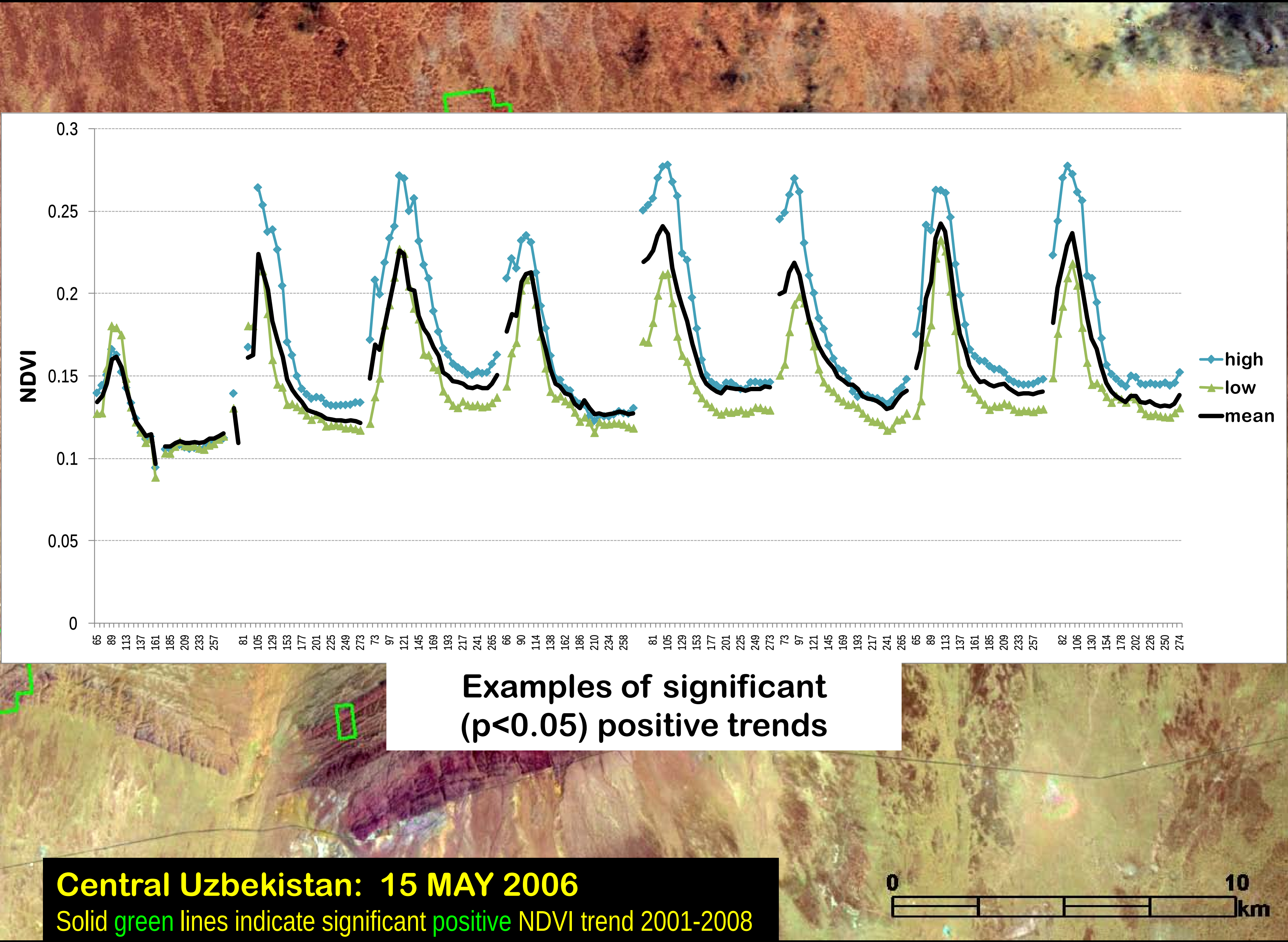
Solid blue (red) lines includes areas with highly significant positive (negative) NDVI trends from 2001-2008

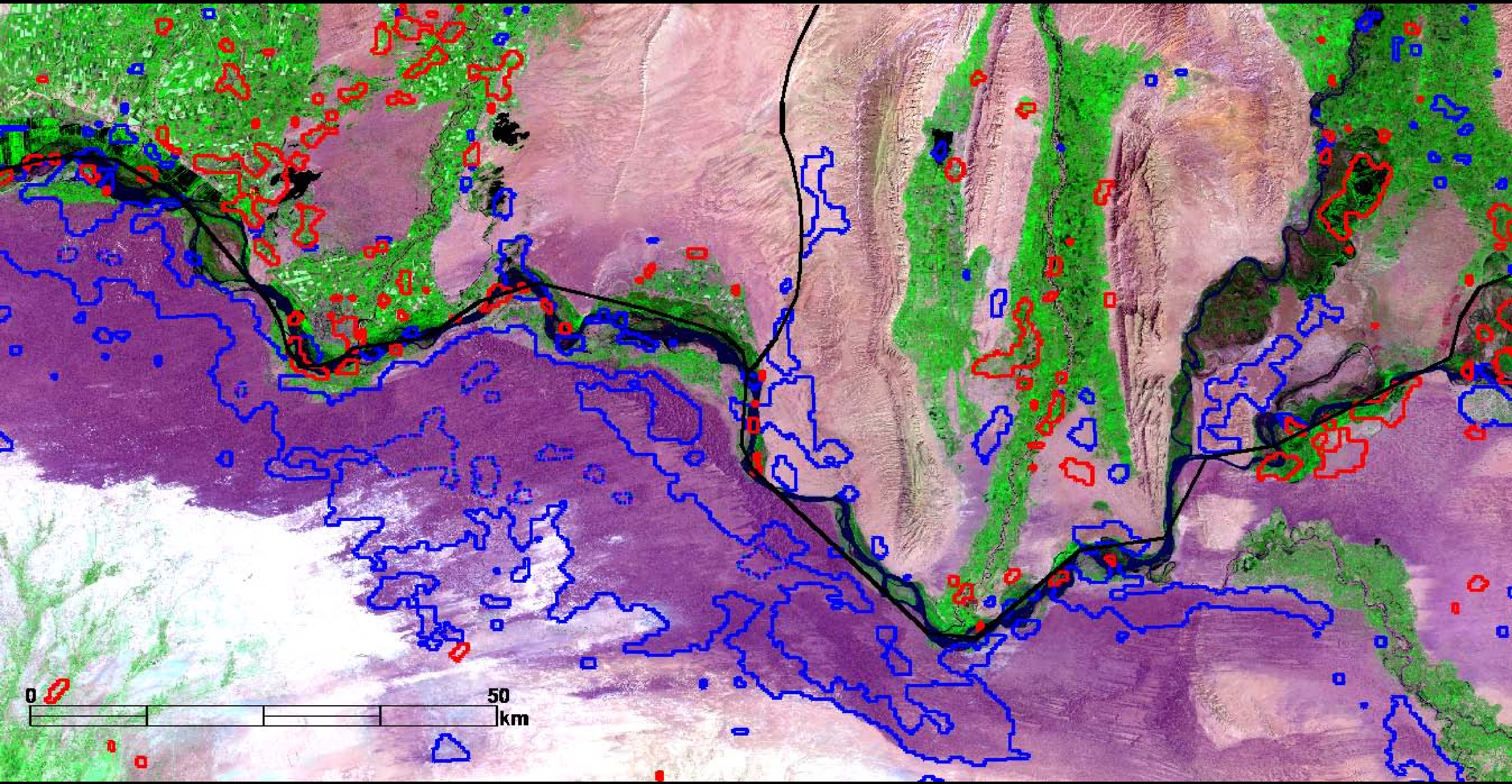





**Central Uzbekistan: 21 AUG 2001**

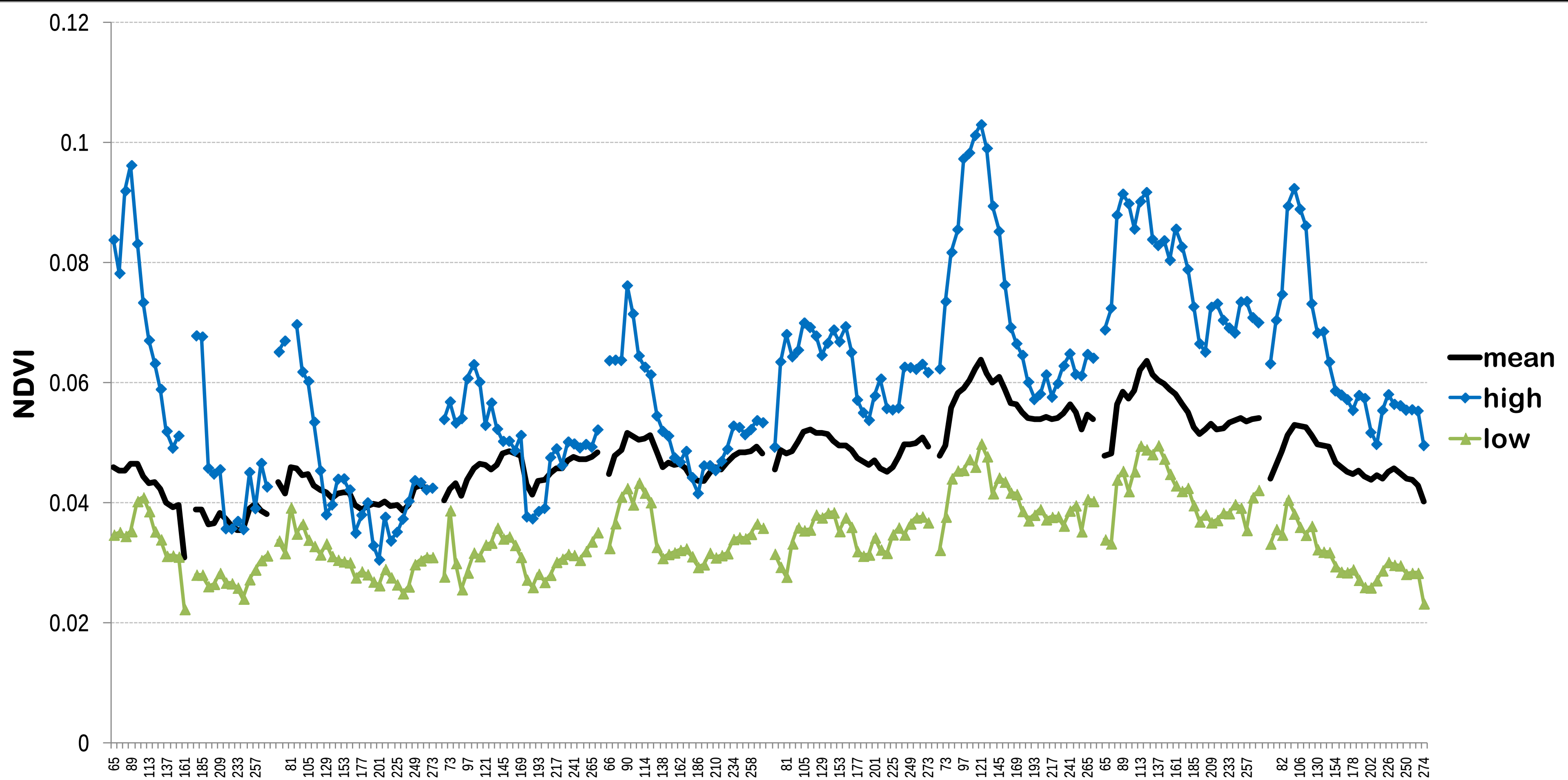
Solid green lines indicate significant positive NDVI trend 2001-2008


0.3
0.25
0.2
0.15
0.1
0.05
0
NDVI
high
low
mean
Examples of significant (p<0.05) positive trends
Central Uzbekistan: 15 MAY 2006
Solid green lines indicate significant positive NDVI trend 2001-2008
0
10
km

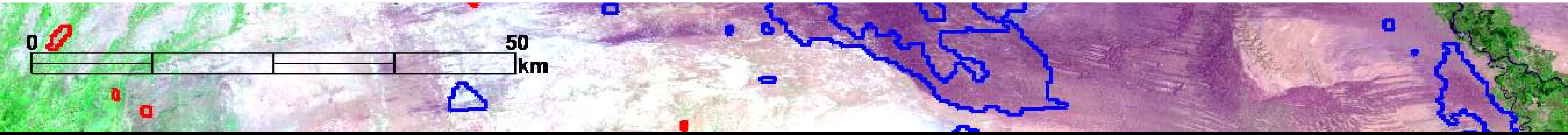



**Border of Uzbekistan, Tajikistan, and Afghanistan (east of Termez): 31 JUL 2001**

Solid blue (red) lines includes areas with highly significant positive (negative) NDVI trends from 2001-2008

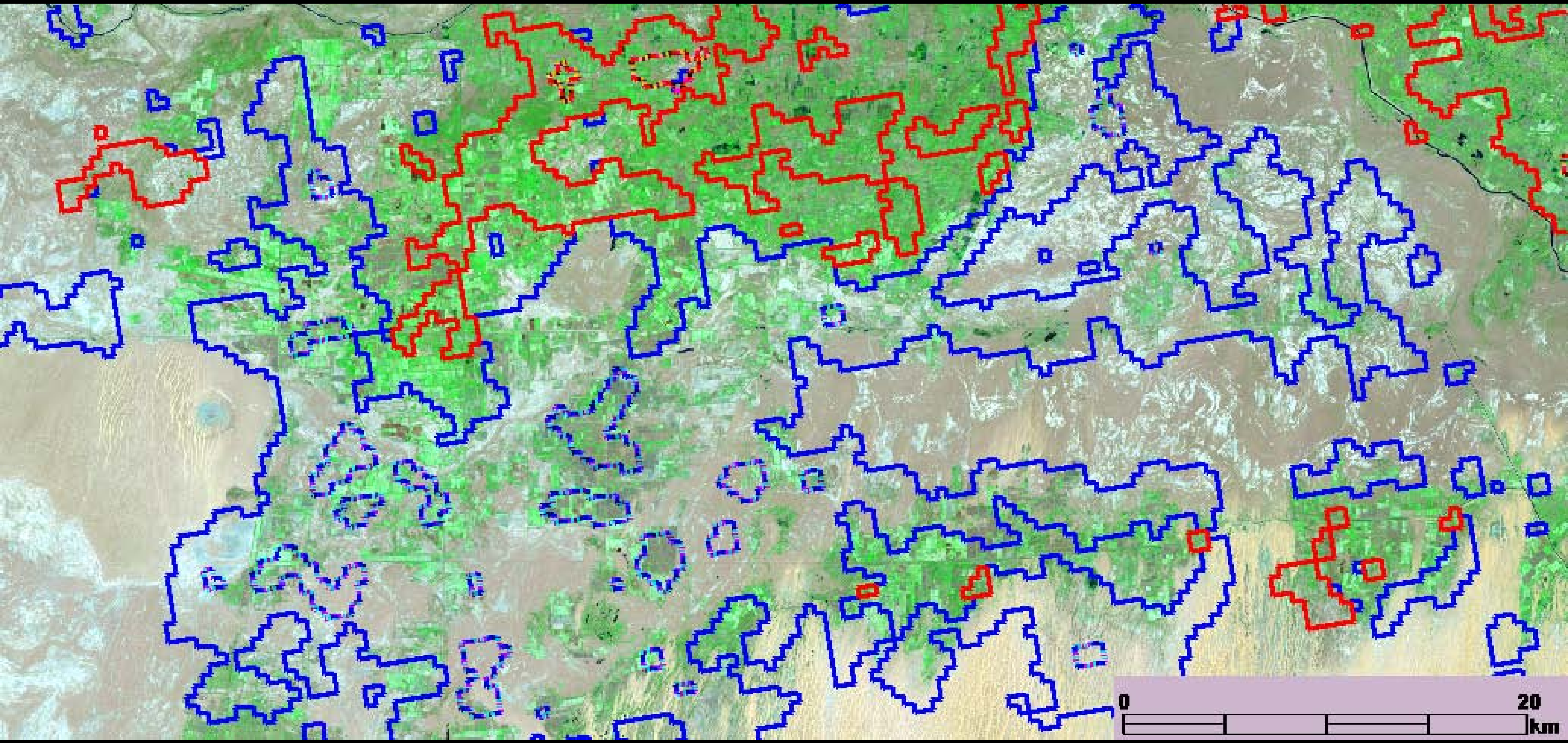



## Examples of highly significant negative trends



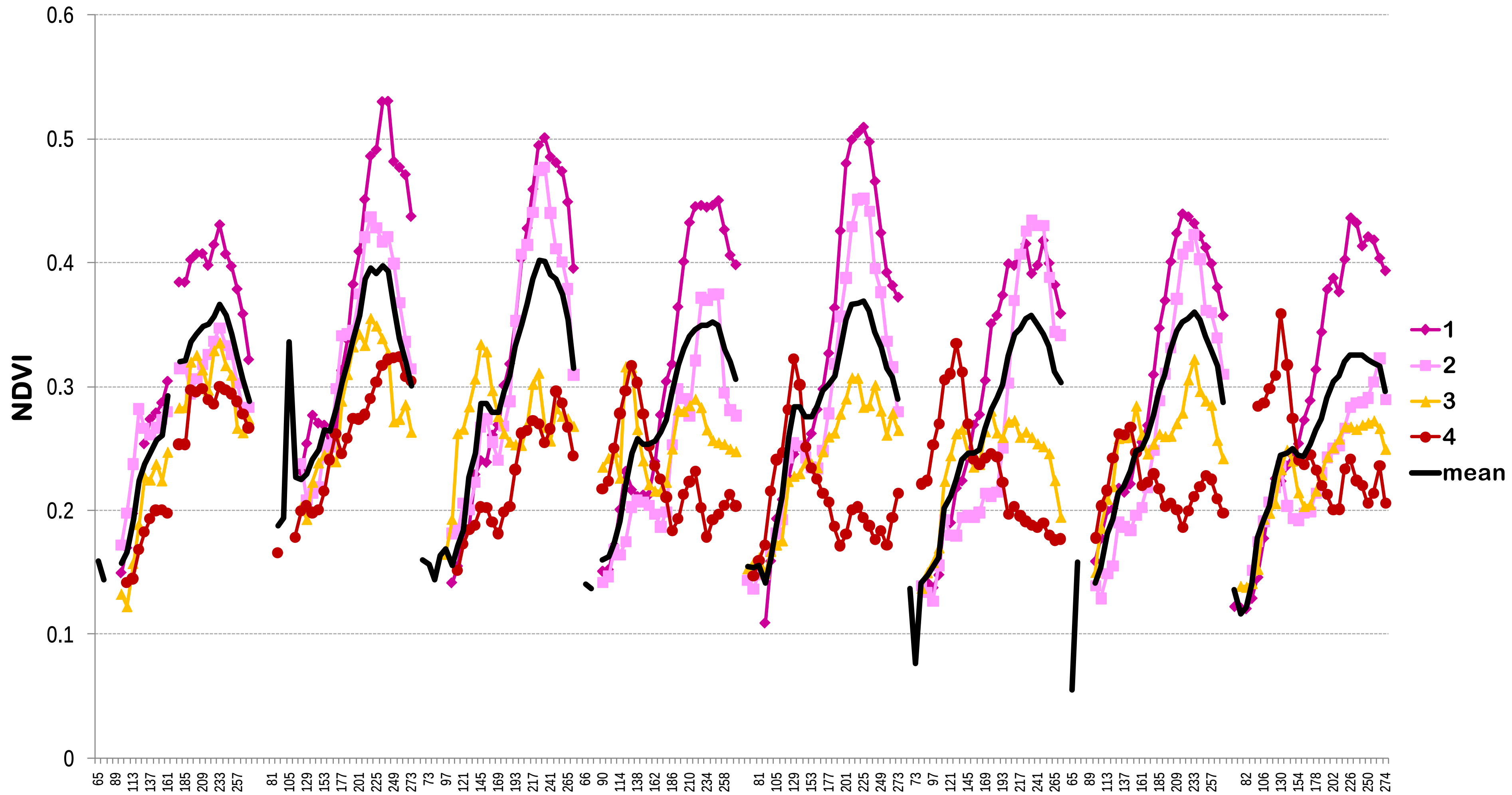

**Border of Uzbekistan, Tajikistan, and Afghanistan (east of Termez): 29 JUL 2006**

Solid blue (red) lines includes areas with highly significant positive (negative) NDVI trends from 2001-2008

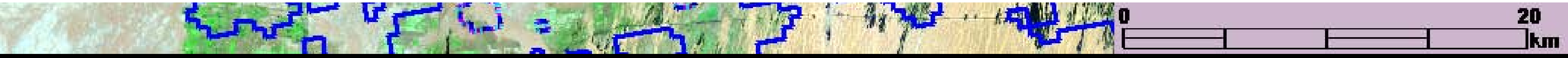



**Delta of Amu Darya west of Akdepe, TK: 29 JUL 2000**

Solid blue (red) lines includes areas with highly significant positive (negative) NDVI trends from 2001-2008




## Examples of highly significant negative trends




**Delta of Amu Darya west of Akdepe, TK: 27 JUL 2005**

Solid blue (red) lines includes areas with highly significant positive (negative) NDVI trends from 2001-2008

# What are potential effects of LCLUC on regional weather & climate?

Seven climate models were used to explore the biogeophysical impacts of human-induced land cover change (LCC) at regional and global scales. The imposed LCC led to statistically significant decreases in the northern hemisphere summer latent heat flux in three models, and increases in three models. Five models simulated statistically significant cooling in summer in near-surface temperature over regions of LCC and one simulated warming. There were few significant changes in precipitation. Our results show no common remote impacts of LCC. **The lack of consistency among the seven models was due to: 1) the implementation of LCC despite agreed maps of agricultural land, 2) the representation of crop phenology, 3) the parameterisation of albedo, and 4) the representation of evapotranspiration for different land cover types.** This study highlights a dilemma: LCC is regionally significant, but it is not feasible to impose a common LCC across multiple models for the next IPCC assessment.

Pitman, A. J., et al. (2009), Uncertainties in climate responses to past land cover change: First results from the LUCID intercomparison study, *Geophysical Research Letters*, 36, L14814, doi:10.1029/2009GL039076.

## Pitman *et al.* (2009) used GCMs, but found fundamental differences in the representation of land surface processes between models.

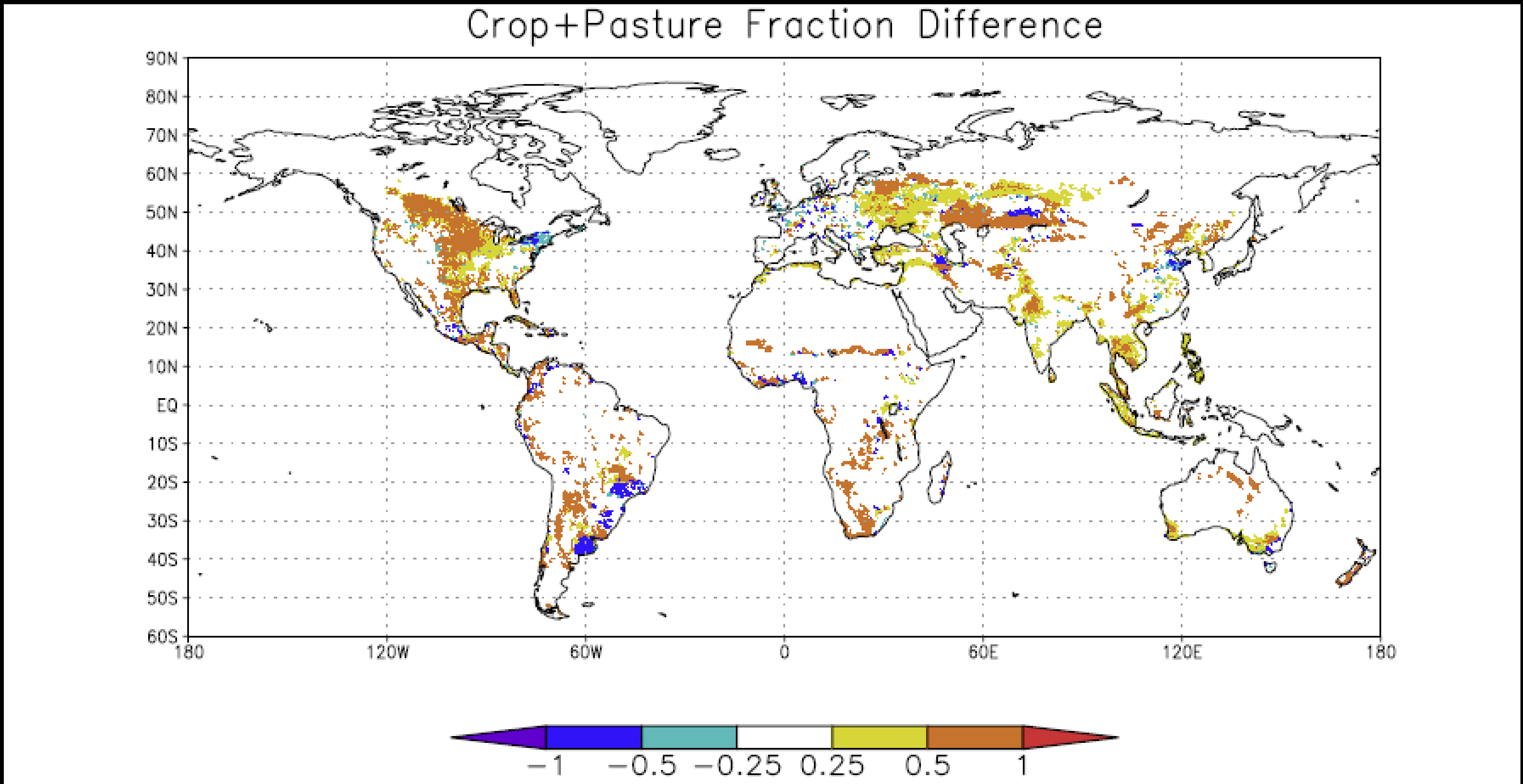



**Figure 1.** Extent of land cover change between experiments PD and PDv (PD − PDv) expressed as the difference in crop and pasture cover between the two experiments. Blue colours represent changes that decrease pasture and crop cover while yellows and browns are increases (25%–50% and 50–100% respectively).

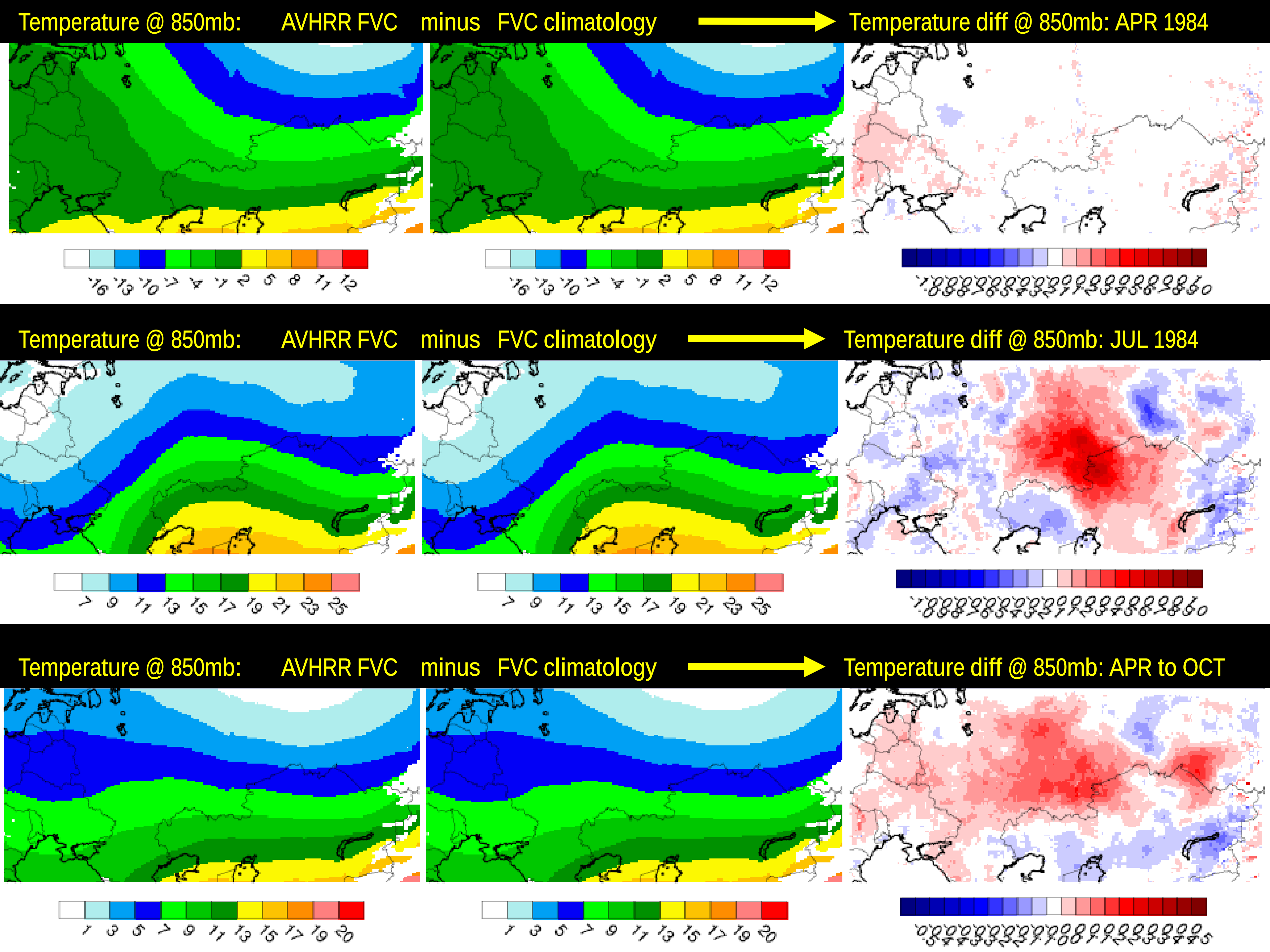
To explore the impacts of LCLUC in the grain belt of northern Eurasia, we used a mesoscale meteorological model (WRF) in climate mode.

20km grid spacing with daily output fields

Modify WRF to increase update frequency of FVC to 3X/month to improve representation of LSP

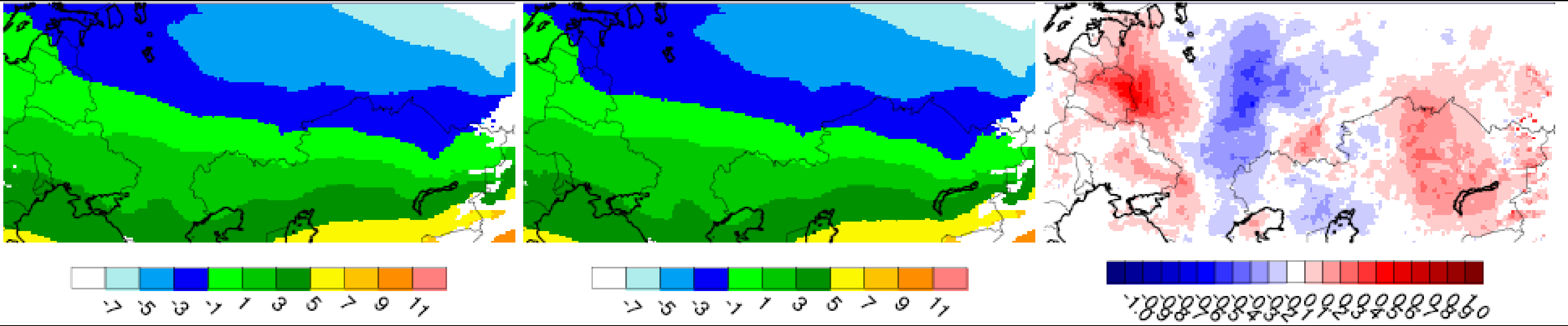
Compare results from default LSP with LSP derived from AVHRR NDVI for two years: 1984 (dry) and 1990 (normal)

Temperature fields at the top of the boundary layer (~850mb) and precipitation fields at the surface.

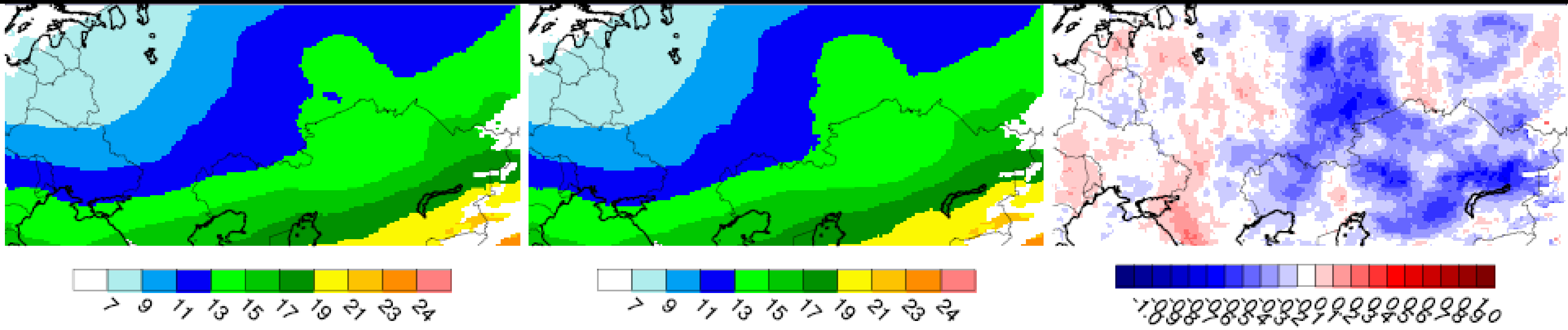


Temperature @ 850mb: AVHRR FVC minus FVC climatology
Temperature diff @ 850mb: APR 1984
-16 -13 -10 -7 -4 -1 2 5 8 11 12
-16 -13 -10 -7 -4 -1 2 5 8 11 12
Temperature @ 850mb: AVHRR FVC minus FVC climatology
Temperature diff @ 850mb: JUL 1984
7 9 11 13 15 17 19 21 23 25
7 9 11 13 15 17 19 21 23 25
Temperature @ 850mb: AVHRR FVC minus FVC climatology
Temperature diff @ 850mb: APR to OCT
1 3 5 7 9 11 13 15 17 19 20
1 3 5 7 9 11 13 15 17 19 20

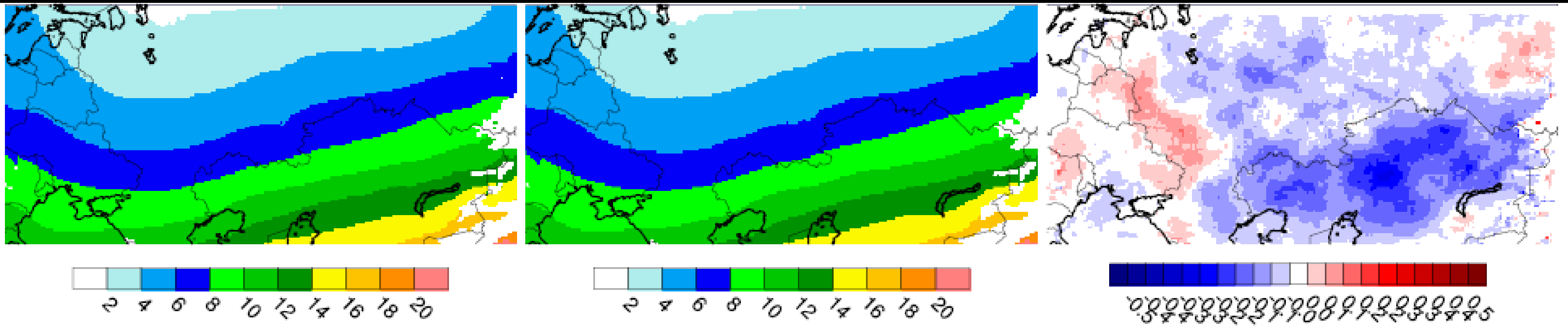
Temperature @ 850mb: AVHRR FVC minus FVC climatology → Temperature diff @ 850mb: APR 1990




Temperature @ 850mb: AVHRR FVC minus FVC climatology → Temperature diff @ 850mb: JUL 1990

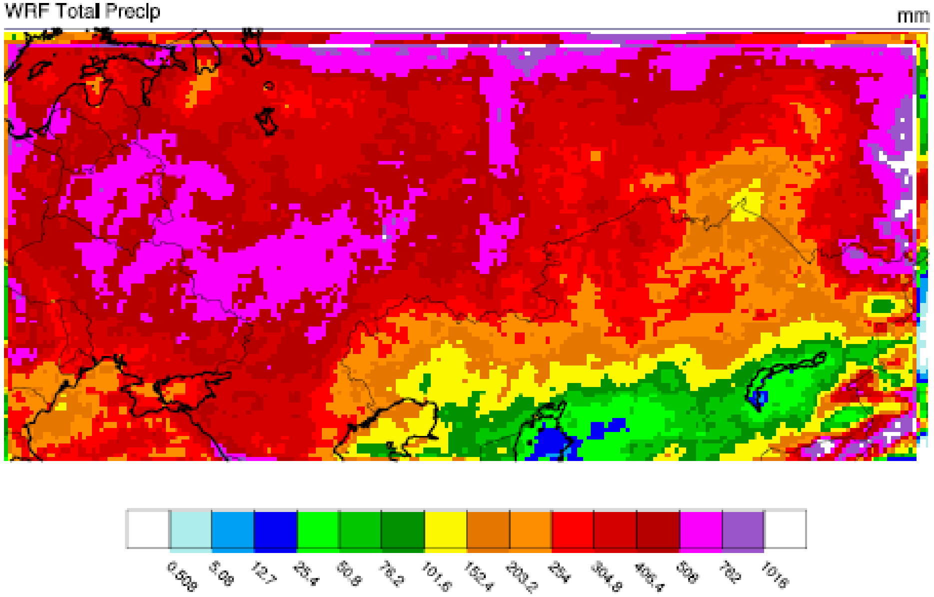



Temperature @ 850mb: AVHRR FVC minus FVC climatology → Temperature diff @ 850mb: APR to OCT

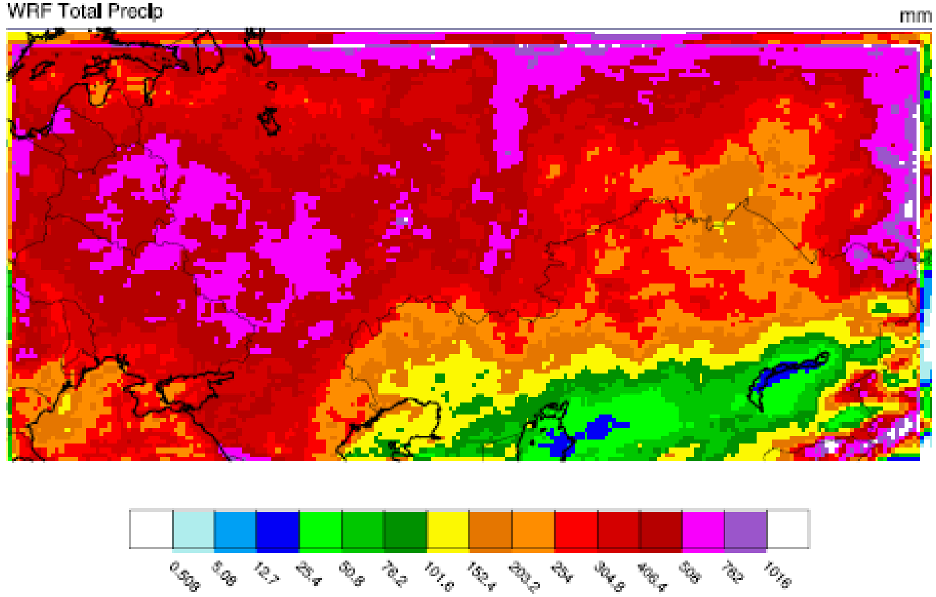


# 1990-04-01_00z to 1990-10-01_00z

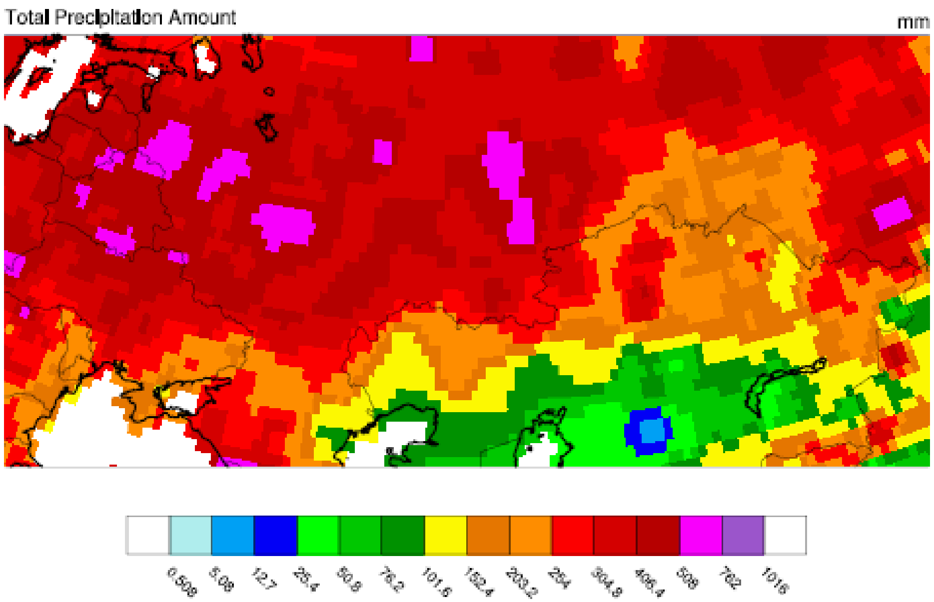
Total WSM6 NOAH YSU G3 CAM R2 AVHRR Precip



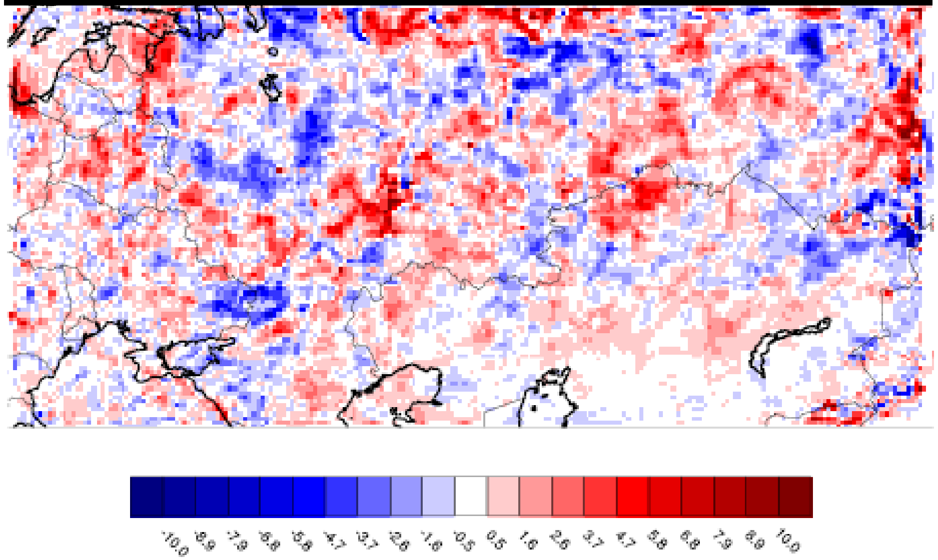

Total WSM6 NOAH YSU G3 CAM R2 DEFAULT Precip




Total GPCC half degree Precip

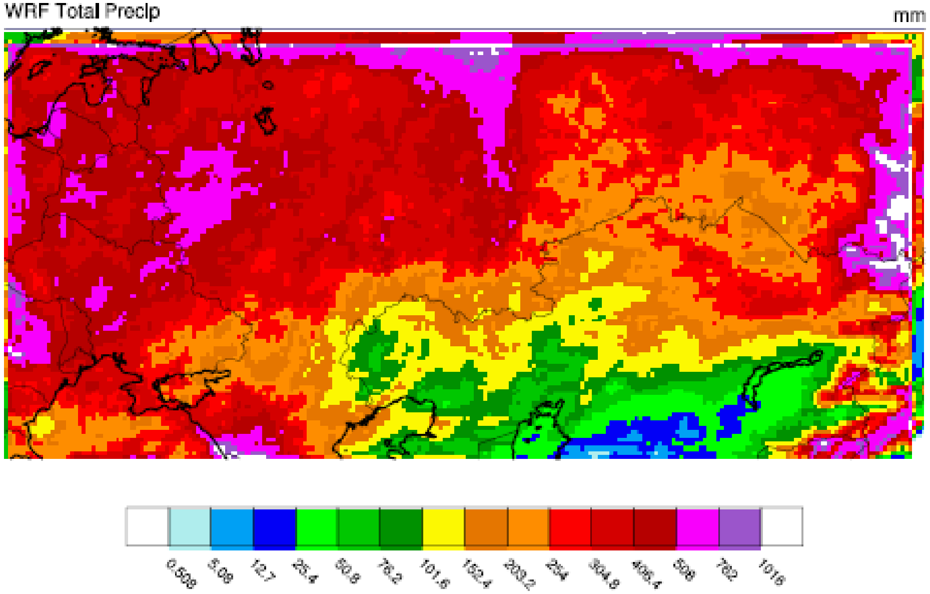



Seasonal Difference in Precipitation in 1990 (normal):
AVHRR FVC minus default climatology (in mm)

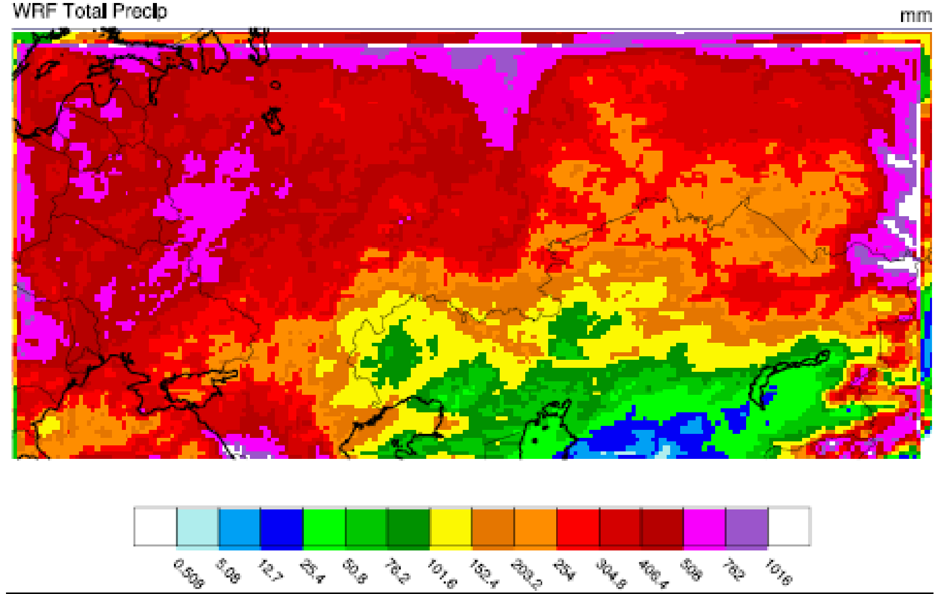


# 1984-04-01_00z to 1984-10-01_00z

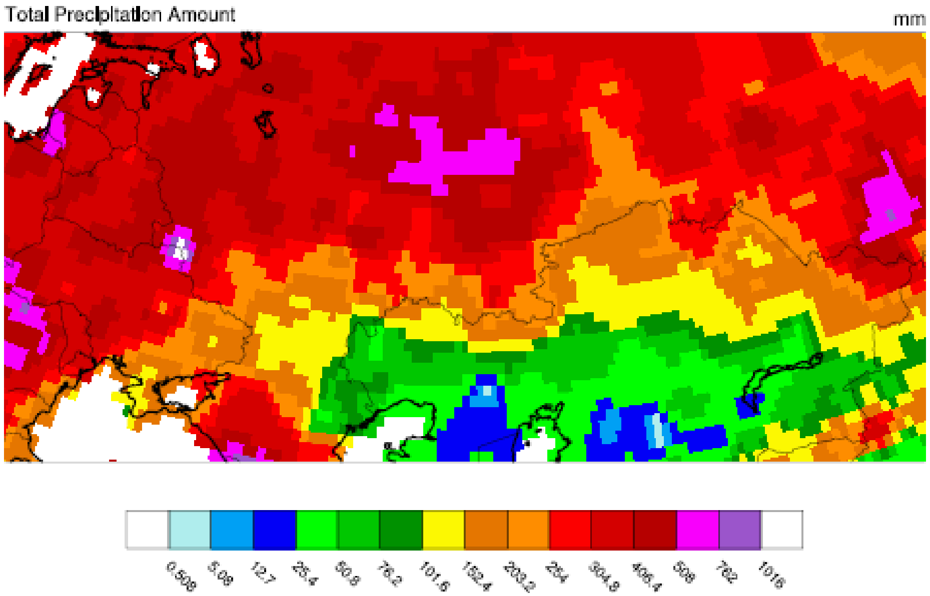
Total WSM6 NOAH YSU G3 CAM R2 AVHRR Precip



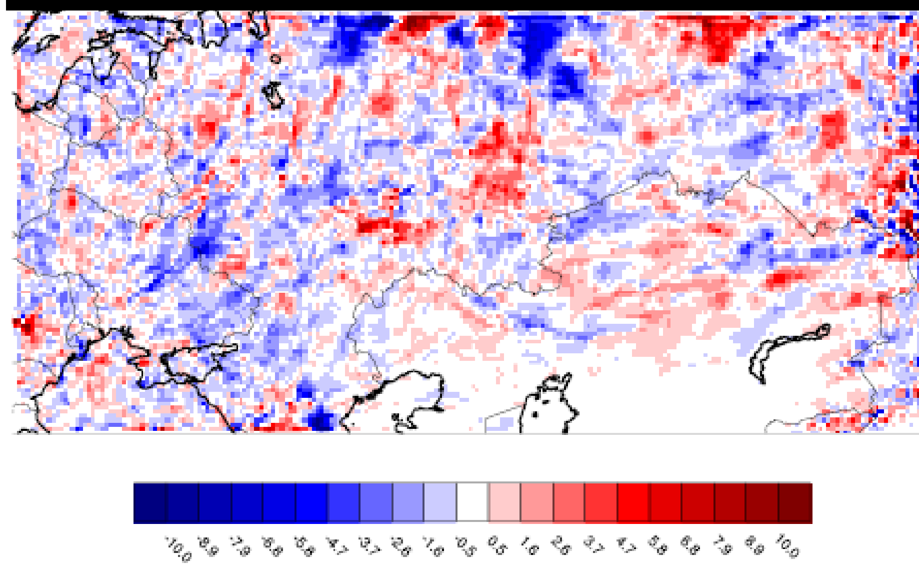

Total WSM6 NOAH YSU G3 CAM R2 DEFAULT Precip




Total GPCC half degree Precip




Seasonal Difference in Precipitation in 1984 (drier):
AVHRR FVC minus default climatology (in mm)



# Concluding Thoughts…

- **Monitoring vegetation condition must address land surface phenologies to be able to link monitoring with process modeling (weather, water, carbon).**

- **However, we must move beyond look-up tables keyed to thematic classes and embrace the variabilities (and uncertainties) of land surface dynamics.**

- **The GCM & RCM communities (desperately) need improved representations of land surface dynamics, including land cover / land use change and land surface phenologies.**

- **Focused community effort is needed *now*, if our current understanding of LCLUC & LSPs are to be incorporated in IPCC AR6.**

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