Environmental Monitoring in Semi-Arid Central- and West-Asia: Drivers and Trajectories

NASA Energy- and Water-Cycle Sponsored Research (NEWS)
Discovery-driven NEWS investigation:LCLUCC

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http://www.yale.edu/emcwa/

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Objectives

1. Watershed Characterization

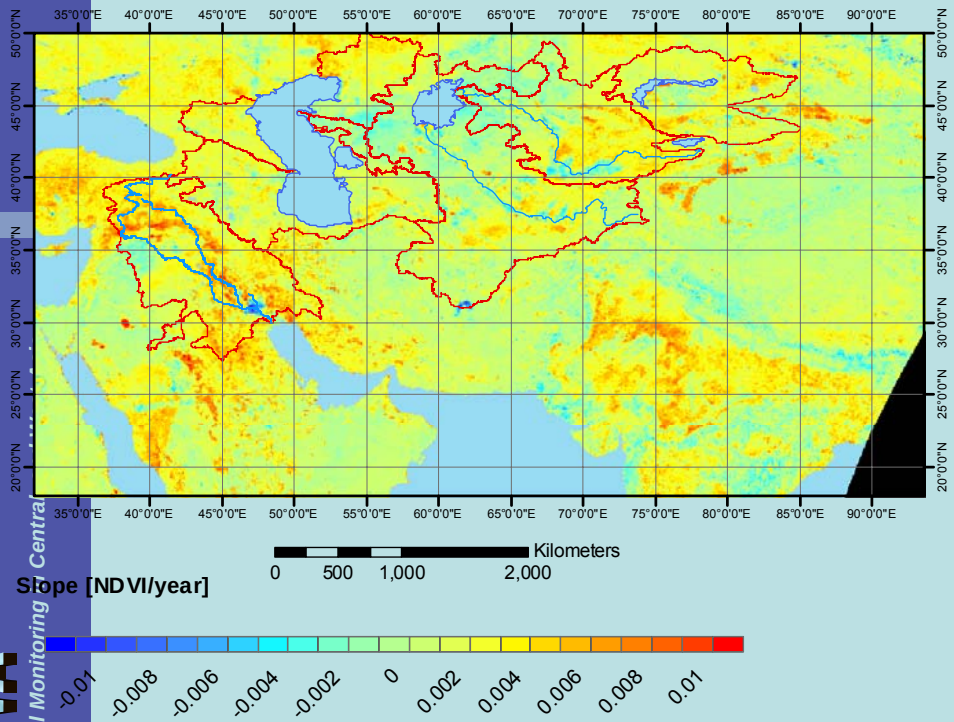
- Climate sensitivities
- Natural resource variability (seasonal, inter-annual)
- Long term trends (climate, vegetation)
- Feed backs between hydrological cycle and vegetation (short-/long-term response)
- Sustainability of agricultural systems and rangelands

2. System Development

- Functional characteristics of vegetation
- Parametrization of functional characteristics (hydro-meteorologically, ecologically)

Spatial and Temporal Issues

NDVImax Trends between 1982 and 2001



Requirements

- Thematic and spatial details that are useful for local decision making.
- Spatially and temporally comparable analyses, with regard to LCLU, hydrology, and derived variables used as model inputs.
- Suitable models and parameter definition.

Therefore

- Use of multi-sensor data
- Use of processing techniques that provide comparable results for different sensor data (AVHRR, SPOT, MODIS)
- Use of processing techniques that allow analogies between high spectral and high temporal resolution data

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Classification Requirements

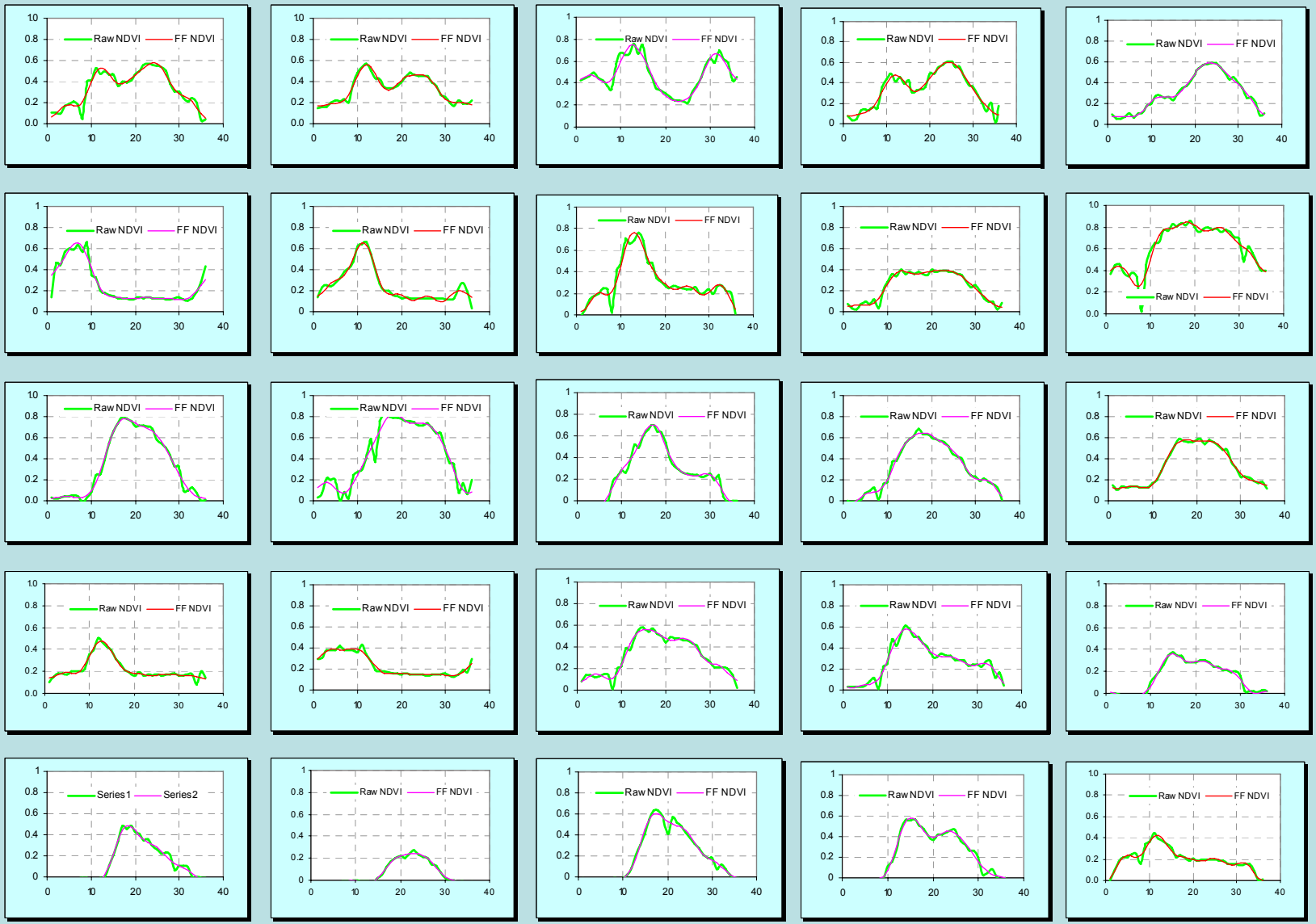
- Consistent classification of vegetation types

- Ensure spatial and temporal comparability/compatibility
- Invariant to distinct natural vegetation variations
- Full compatibility between data from different sensor systems characterized by different spatial and/or temporal resolutions.

- Aggregation into functional groups

- Parametrization of functional characteristics

Annual NDVI-cycles



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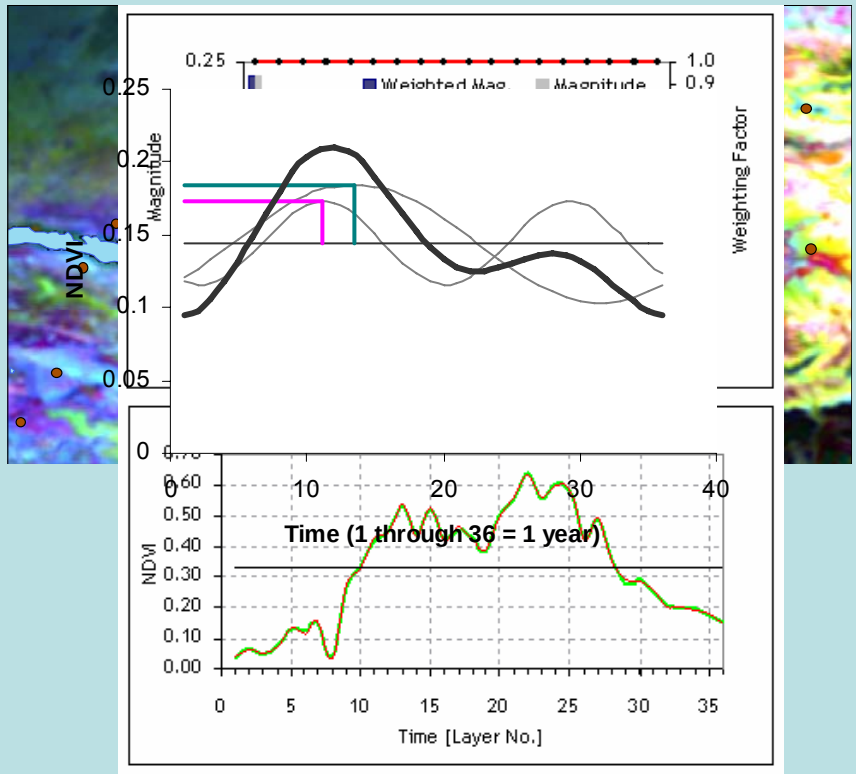
Classification Approach

- Discrete Fourier Transform to reduce noise and enhance phenological characteristics
- Identification of reference cycles
  Color composite using magnitudes 1,2,3.
  Magnitudes 1 to 3 contain about 85 to 97% of original cycle variation.
- Fourier components magnitude and phase as inputs
- Setting of user thresholds, e.g.
  accuracy thresholds
  coverage variations
  bare soil threshold



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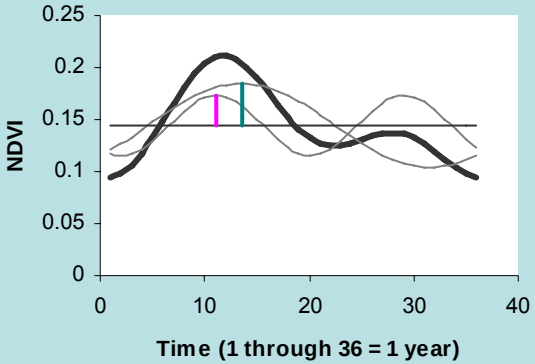
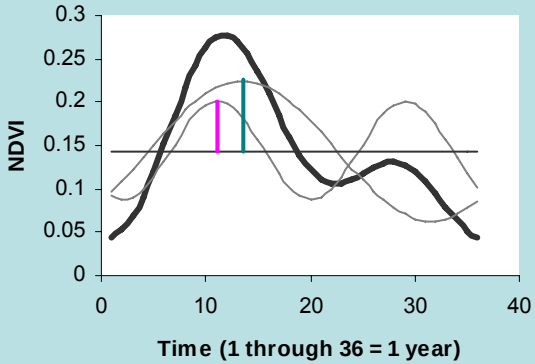
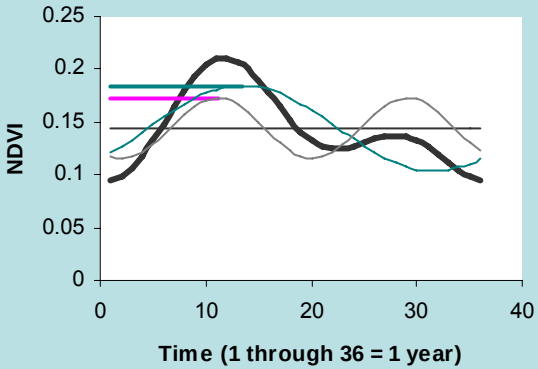
Main Classifiers: Amplitude Ratio and Phase Difference

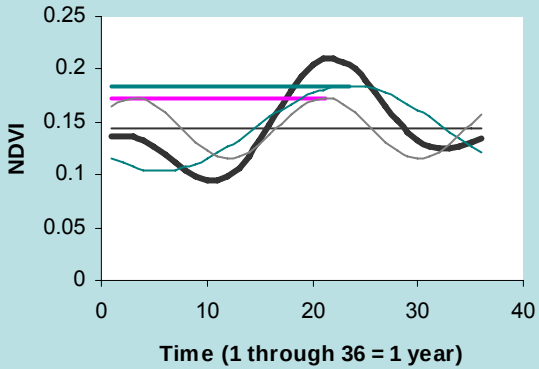
Requirements for identical shapes:

1. Identical amplitude ratio
2. Identical phase difference









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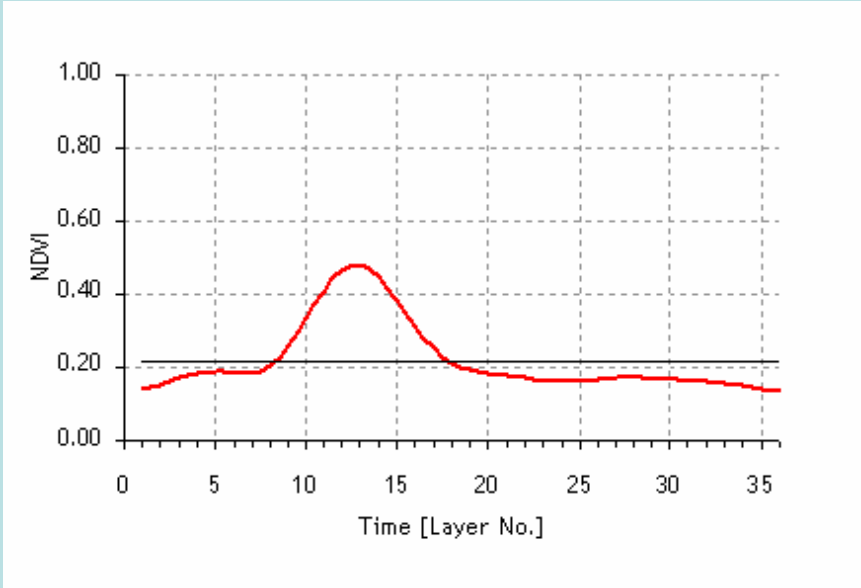
Invariant to distinct natural vegetation variations

- Invariant to temporal shifts, as may be caused by climate gradients
- Invariant coverage variations
- Invariant to background reflectance



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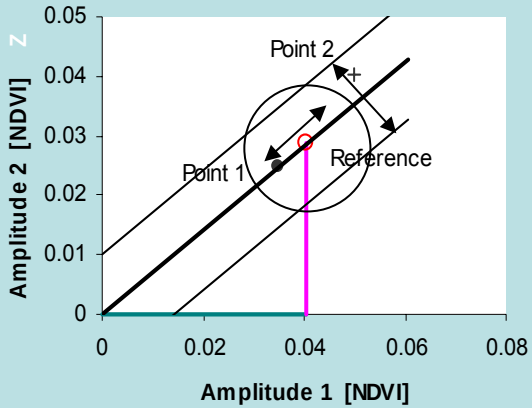
User Set Accuracy Variables

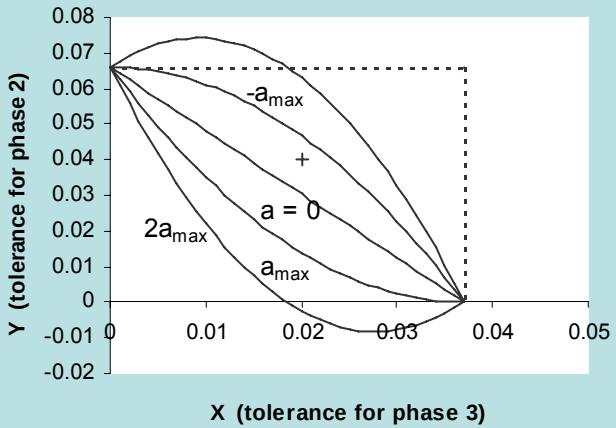


Tolerable amplitude variation

$$\left| y - y_P \right| = \left| a * x_P - y_P \right| \leq \delta_{Mag}$$

Tolerable coverage variation

$$\mathrm{cov}\,erage_p = \sqrt{x_P^2 - x_{ref}^2} + \sqrt{y_P^2 - y_{ref}^2}$$



Tolerable phase variations

$$\theta_k = \left(1 - \frac{A_k}{\sum_k^n A}\right)^X * \frac{2 * \pi}{k^{th} Harmonic}$$

Phase filter

$$y = ax^2 + bx + c$$

$$b = a * \left(-x - \frac{c}{a * x}\right) \qquad \pm a_{\max} = \left|\frac{c}{x^2}\right|$$

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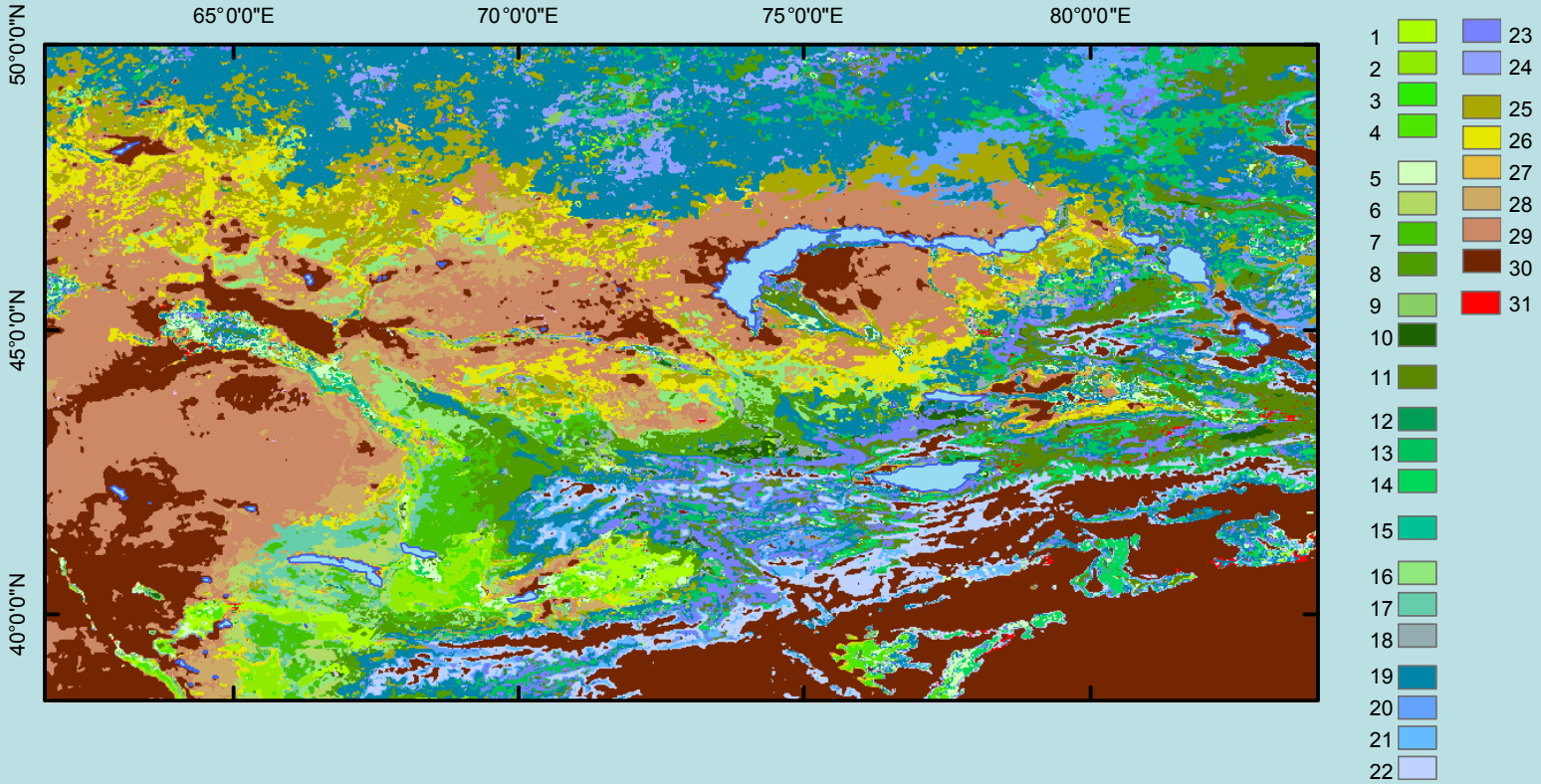
User Defined Variables

- Tolerable deviation from the ideal amplitude ratio.
- Tolerable deviation from the ideal phase difference (also depends on amplitude).
- Tolerable coverage variability.
- Setting threshold for ‘Bare Soil’ cycle.
- Tolerable standard deviation from cycle-mean

Additional possible criteria for differentiation/identification:

- Climate
- Elevation
- Cropping calendar
- Others

Fourier Component Classification (FCC)

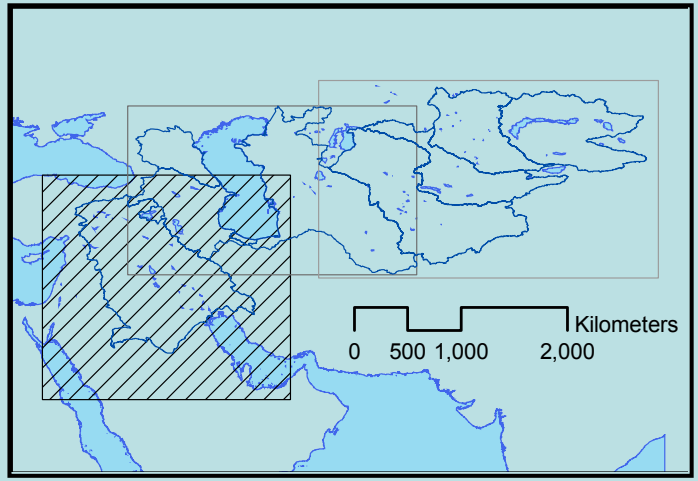


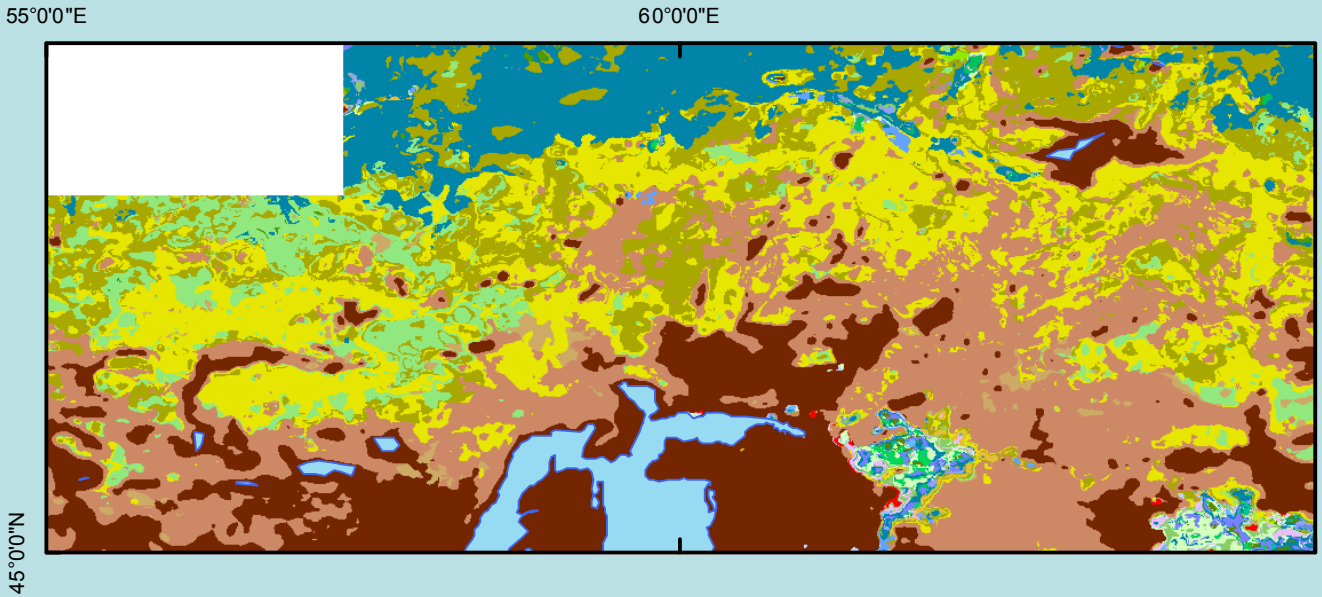
Due to scale issues, the original 117 classes have been merged to 30 classes.
Class 30 is Bare Soil/Permanent Snow/Ice, Class 31 represents unclassified pixels.

Matching Mosaics

Precondition

- More or less identical set of reference cycles
- Identical thresholds





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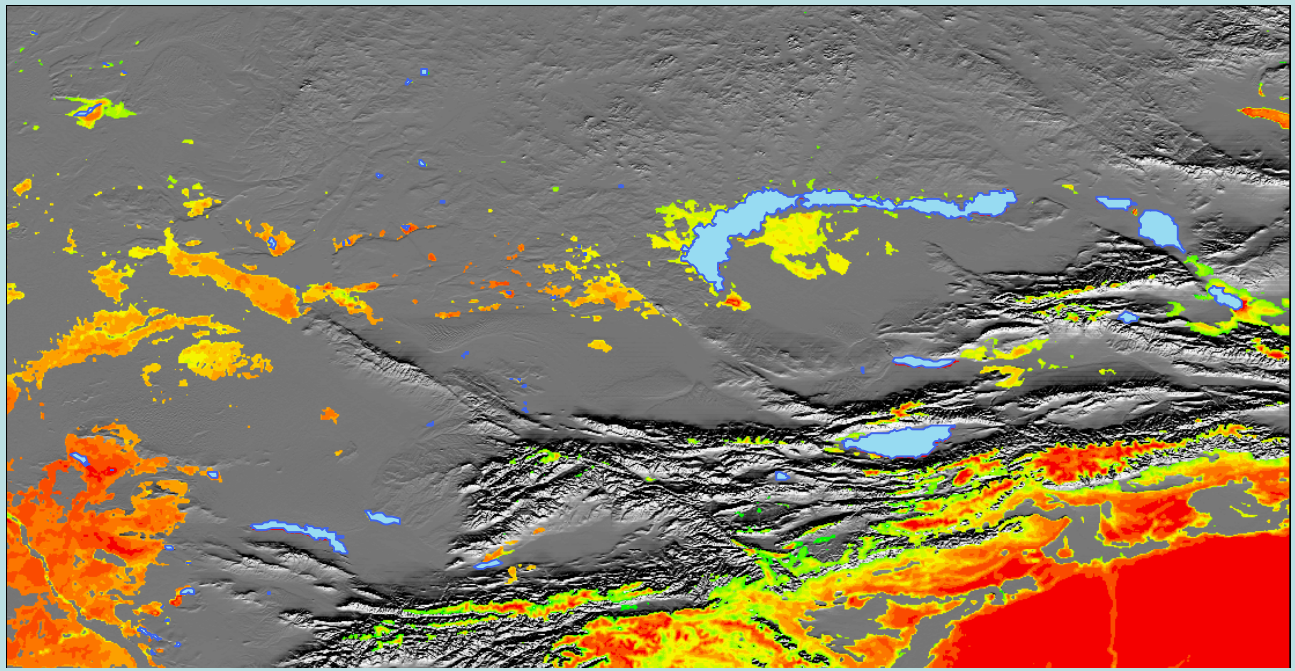
Intra-Class Coverage Variations

Class ‘Bare Soil’



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Advantages

- Consistent classification of vegetation growing cycles/phenologies.
- Spatially and temporally comparable.
- Compatible between sensor systems of different temporal (spatial) resolutions.
- Represents a superordinate product that facilitates to link between results from geographically disconnected higher spatial resolution data.
- Allows the monitoring of change with regard to changes in phenology and in vegetation cover/vigor.

Immediate Project Goals

- Land cover land use change analyses
- Aggregation of shape classes into functional vegetation classes with regard to their hydro-meteorological characteristics.
- Parametrization of functional vegetation classes.
- Integration of parameters into hydrologic models.

Objectives: Project – *Long-Term*

- Improve our understanding of NDVI-cycles and their natural variations.
- Investigate possibilities for data fusion and/or integrated analyses of spectral information together with temporal information.
- Further improve our algorithm and investigate possibilities for handling problems including clouds, snow cover and others.
- *Investigate possibilities for building a global (by region, continent) data set of reference cycles?*
- *Global Land Cover / Land Use Classification with regular updates?*

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Potential Applications

- All disciplines where vegetation has an impact on is affected by, or can be related to some process, action or situation, including:

- LCLUC, hydrology, climate change, carbon storage, invasive species, pollution (air, soil, water), epidemiology, etc.