South West Asia Project

Center for Earth Observation

Landscape Changes in the Middle East

Organizations:

1) Yale Center for Earth Observation (NASA/IDS support)
2) International Center for Agricultural Research in Dry Areas (Aleppo)
3) Universities of Chicago and Damascus

SWAP Team

- Ronald B. Smith* (Yale:meteorology/RS)
- Roland Geerken* (Yale:geology/RS)
- Frank Hole* (Yale:archeology/anthropology)
- Nick Kouchoukos (Chicago: archeology)
- Eddy De Pauw (ICARDA: soils)
- Nabile Battika (ICARDA, soils)
- David Celis (ICARDA, soils/RS)
- Youssef Barkoudah (Damascus, botany)
- Jason Evans (Yale, climate modeling, hydrology)
- Eva Geerken (Yale, geology/RS)
- Robert Oglesby (MSFC, climate modeling)
- Kirk Maasch (Maine, climate modeling)

SWAP

The climate and landscape of South-West Asia are important for several reasons

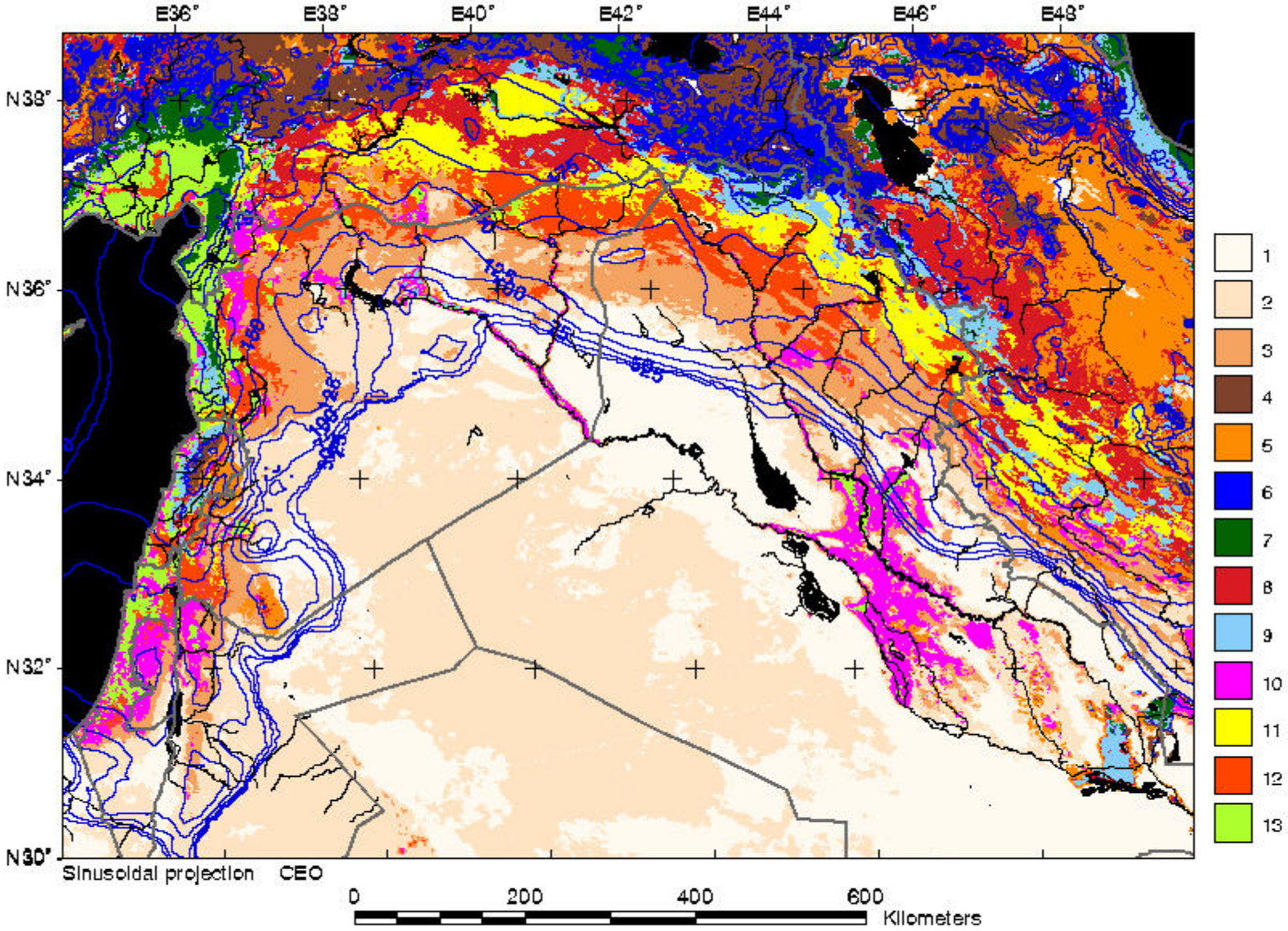
- It is a predominantly semi-arid to arid region surrounded by large water bodies (Mediterranean, Black, Caspian and Red Seas and the Persian Gulf) and framed by the sizeable Tauros and Zagros mountains.
- Historically, it played an important role in the development of agriculture, irrigation and civilization.
- Today and in the future it faces problems of rapid population growth, land degradation, water scarcity, global warming and political conflict.

SWAP Subprojects

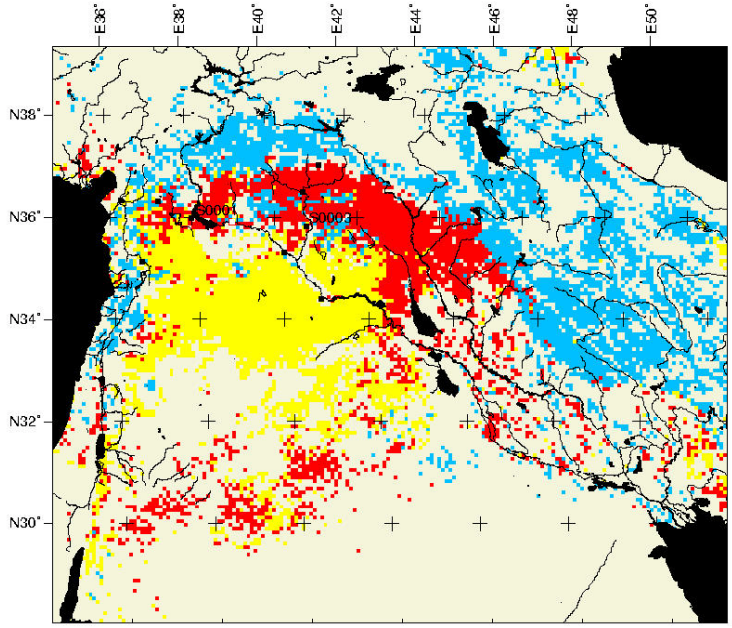
- Large scale land classification and hydrology
- Climate modeling
- Rangeland studies
- Agricultural Systems

Objectives: Land cover classification and hydrology

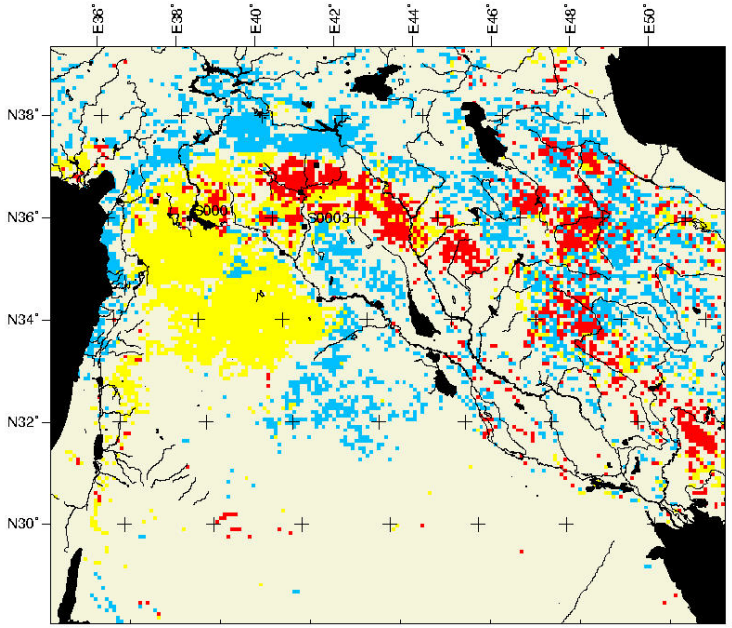
- Develop satellite-based methods for land cover classification suitable for change analysis in semi-arid landscapes
- Link land classification with a regional hydrology model



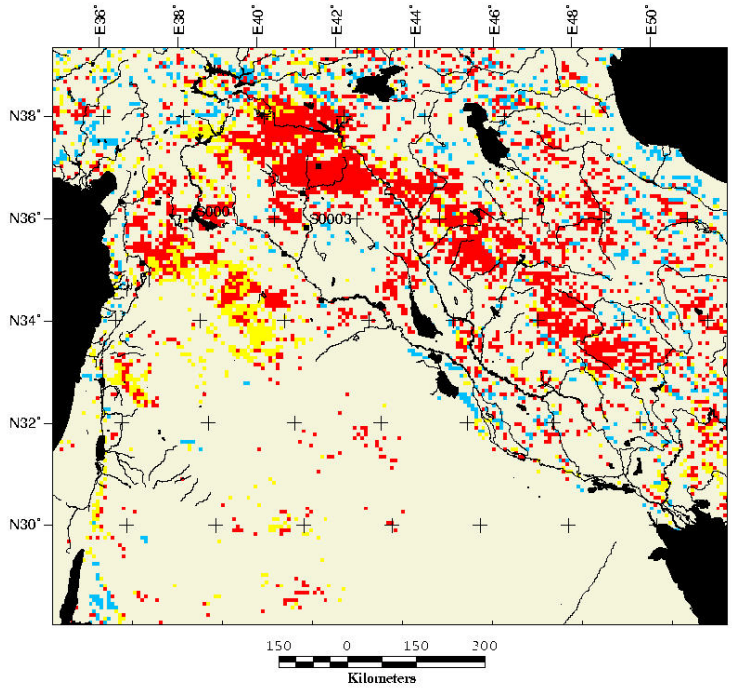
SWAP13 Multitemporal Unsupervised Classification of 1km Composite NDVI (10/1992-09/1993)



a



b



c

a: Climate Sensitivity of April Vegetation

b: Climate Sensitivity of May Vegetation

c: Climate Sensitivity of June Vegetation

Dec./Jan./Feb. - Minimum Temperature

Dec./Jan./Feb. - Precipitation

Feb./Mar./Apr. - Precipitation

Sinusoidal projection CEO

Climate modeling objectives

PRESENT

To adequately reproduce the current regional climate and investigate the role of water sources and transport, coastal effects, summer convection etc.

PAST

Model the change in climate over the past ~9000 years and investigate the role played by climate in the rise of agriculture and civilization.

FUTURE

Model the change in climate due to increasing greenhouse gases and the implications for water resources etc.

Models Used

- Global climate models
  - European Center for Medium Range Weather Forecasting
    - ECMWF
- Regional climate model
  - RegCM2

RegCM2 model run

Both runs

- Centered at 45N 35E
- ~8,000,000km^2 total domain
- Topography and landuse are interpolated from a global 10 min dataset
- Initial and boundary conditions are extracted from the ECMWF TOGA analysis
- Begins december 1989
- Covers 3 years
- Grid spacing = 25 km
- Time step = 90 s

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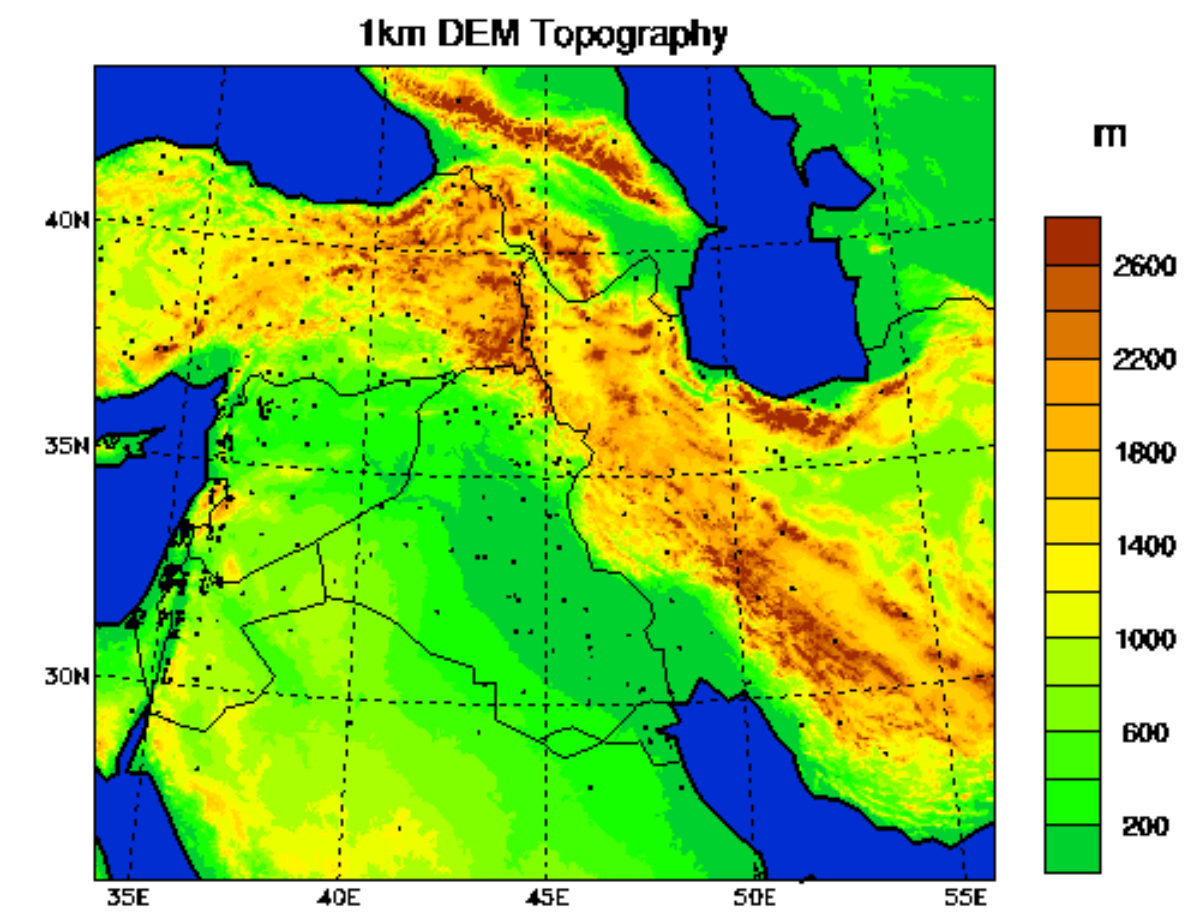
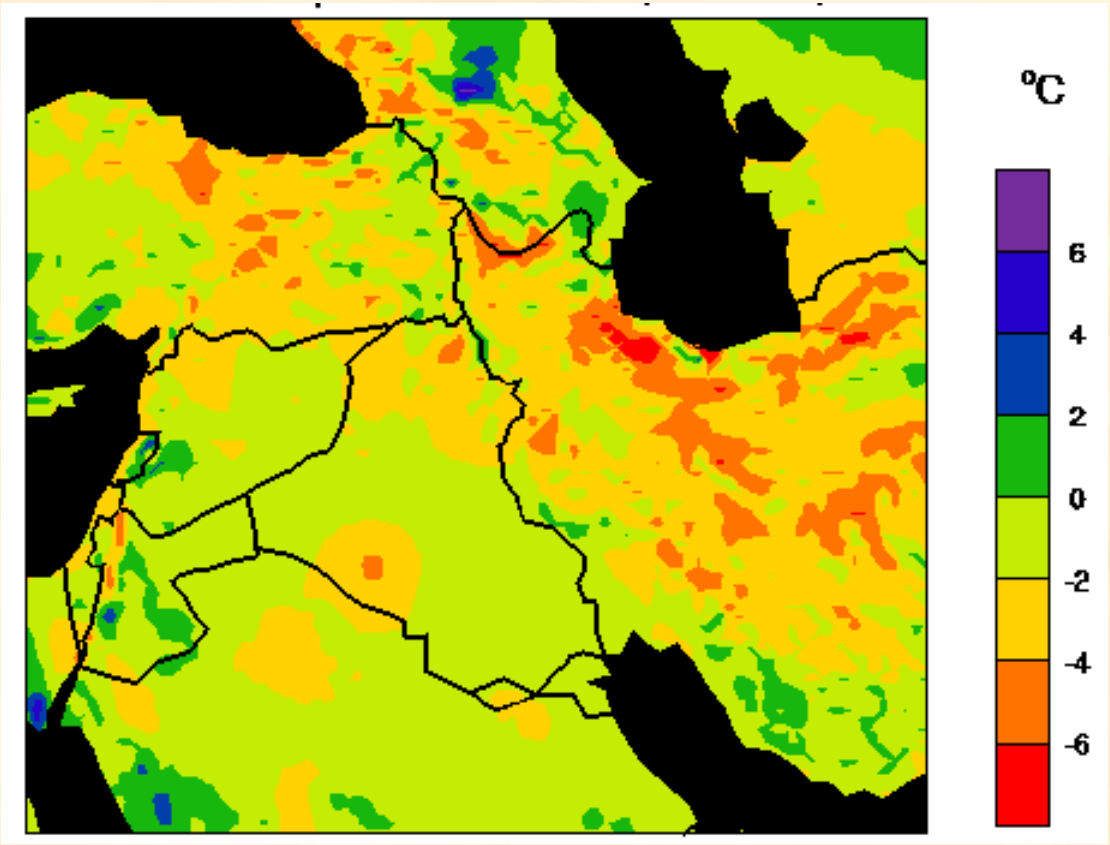
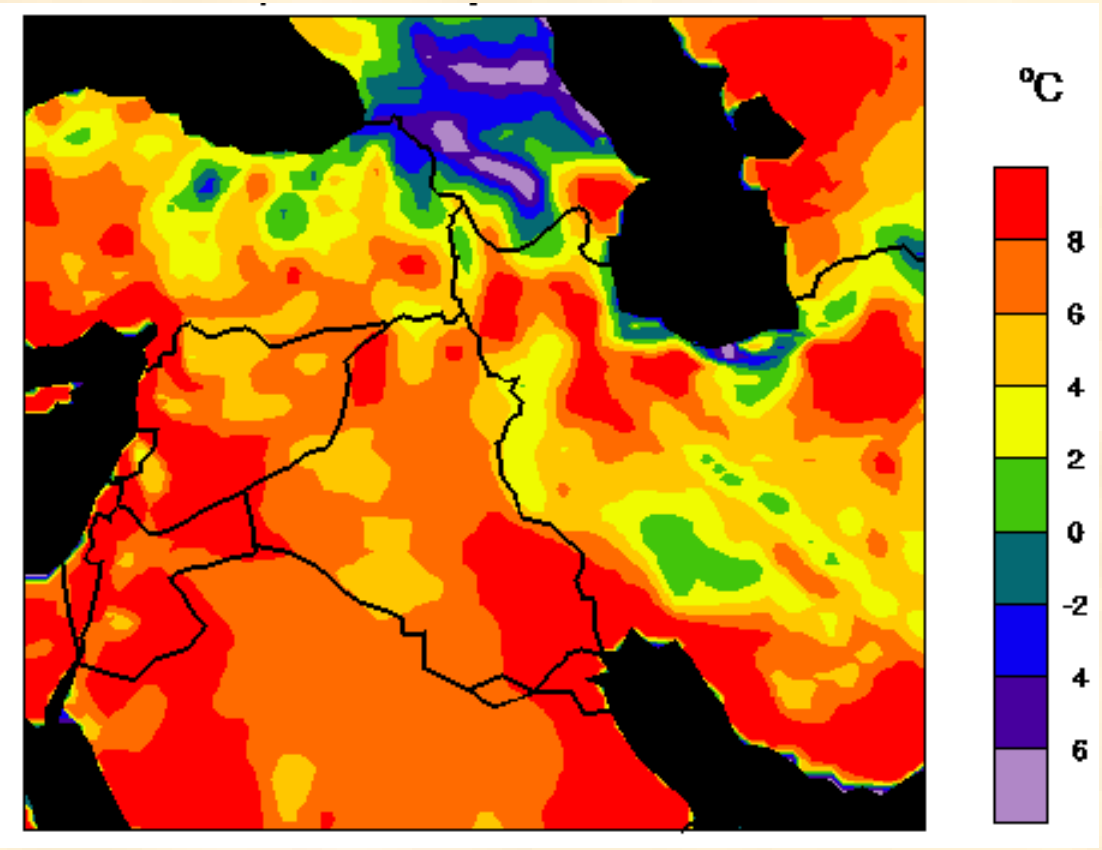
Topography and climate observation stations



Mean Annual Temperature Difference (model – obs)



Annual Temperature Range Difference (model – obs)



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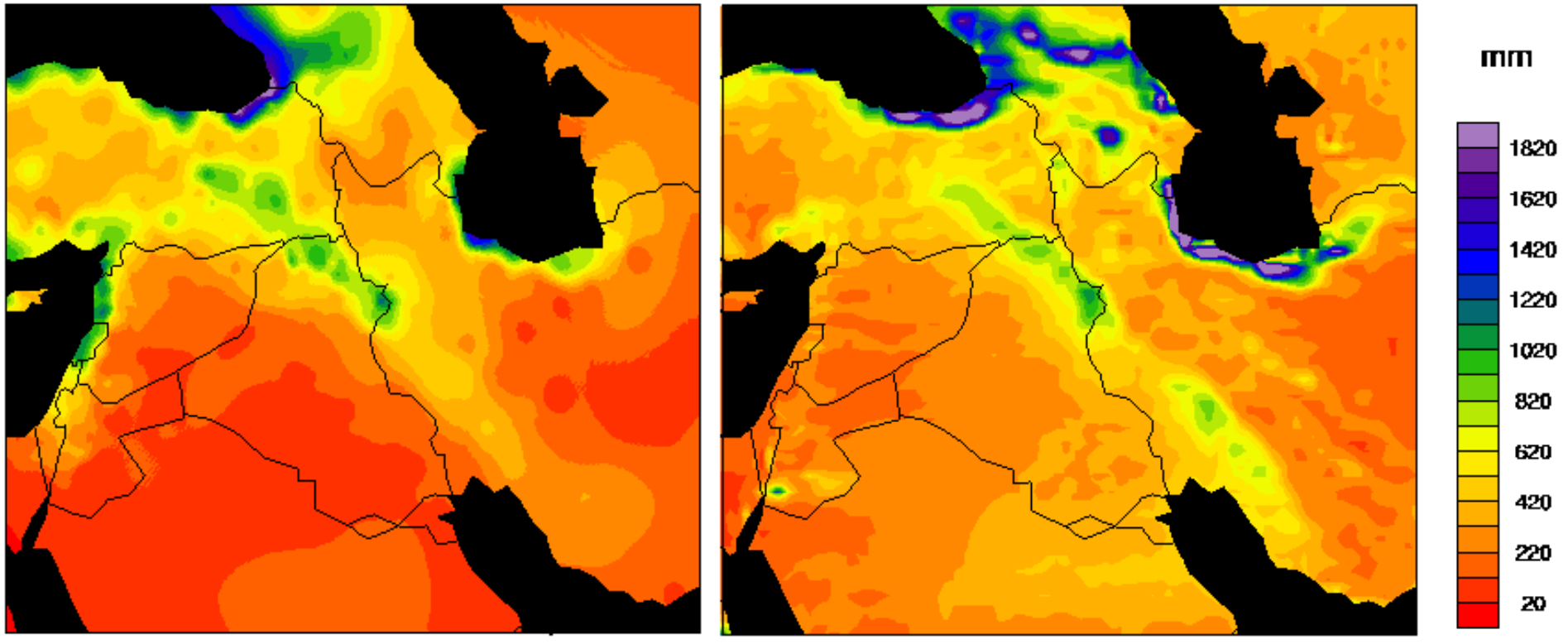
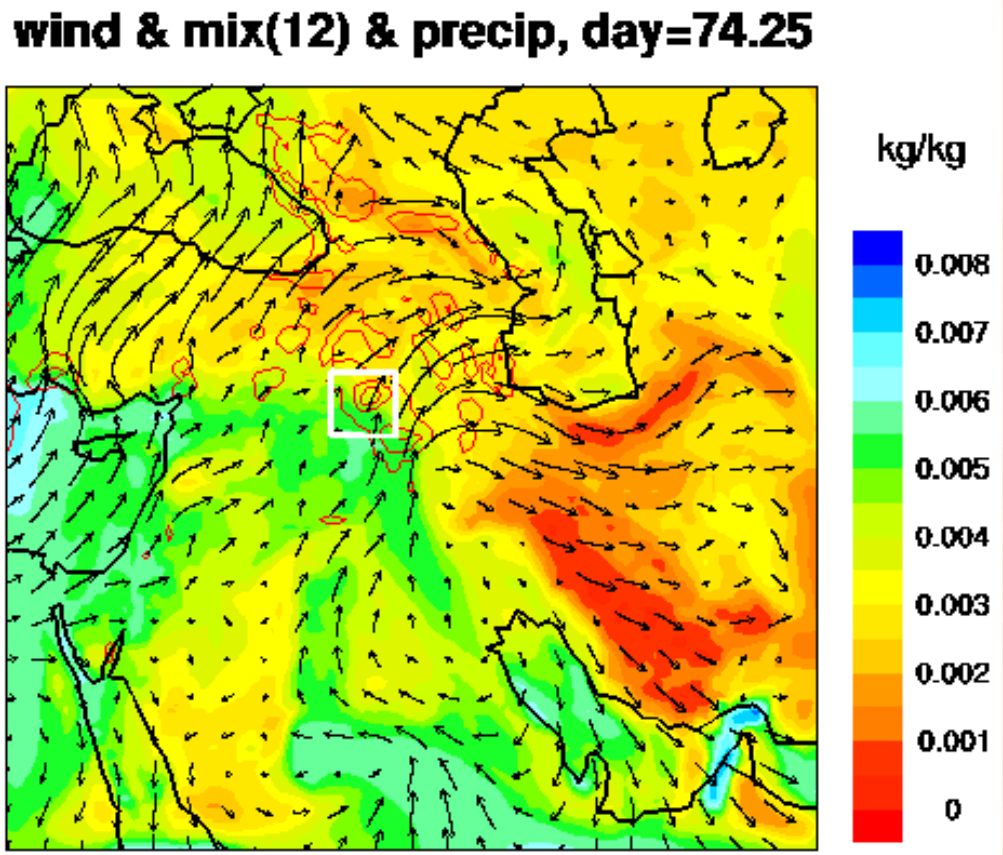
Mean Annual Precipitation



Event Analysis – precipitation, ~850mb wind & H_2O mixing ratio on 15th Feb 1990



Climate Modeling Summary

- While capturing the annual cycle and spatial trend of temperature the model has a cold bias and over-estimates the annual temperature range.
- The model simulates the precipitation distribution reasonably well with a few exceptions, in particular
  - The Mediterranean coastal maximum is not modeled
  - Too much precipitation is modeled in the Iraq-Saudi deserts
- The model demonstrates potential to investigate various dynamical questions such as the transport of water vapor.

Future work includes implementing regional climate model MM5, including a more comprehensive microphysics parameterization and a two-way nest in order to have better definition of the mountains along the Mediterranean coast.

Rangeland objectives

- Monitor environmental development of range lands and identify trends that may be indicative for degradation processes.
- Identify and analyze processes/activities that may play a role in initiating and propelling harmful trends in range land development especially human activities but also considering climate, soils, topography.
- Analyze status quo of vegetation cover according to its ecological value considering criteria such as a vegetation covers' contribution to soil stabilization or its palatability.
- Use the above results to give advice to responsible authorities for an improved range management. This could involve definition of suitable rehabilitation measures (location and type) or organizing grazing activities.

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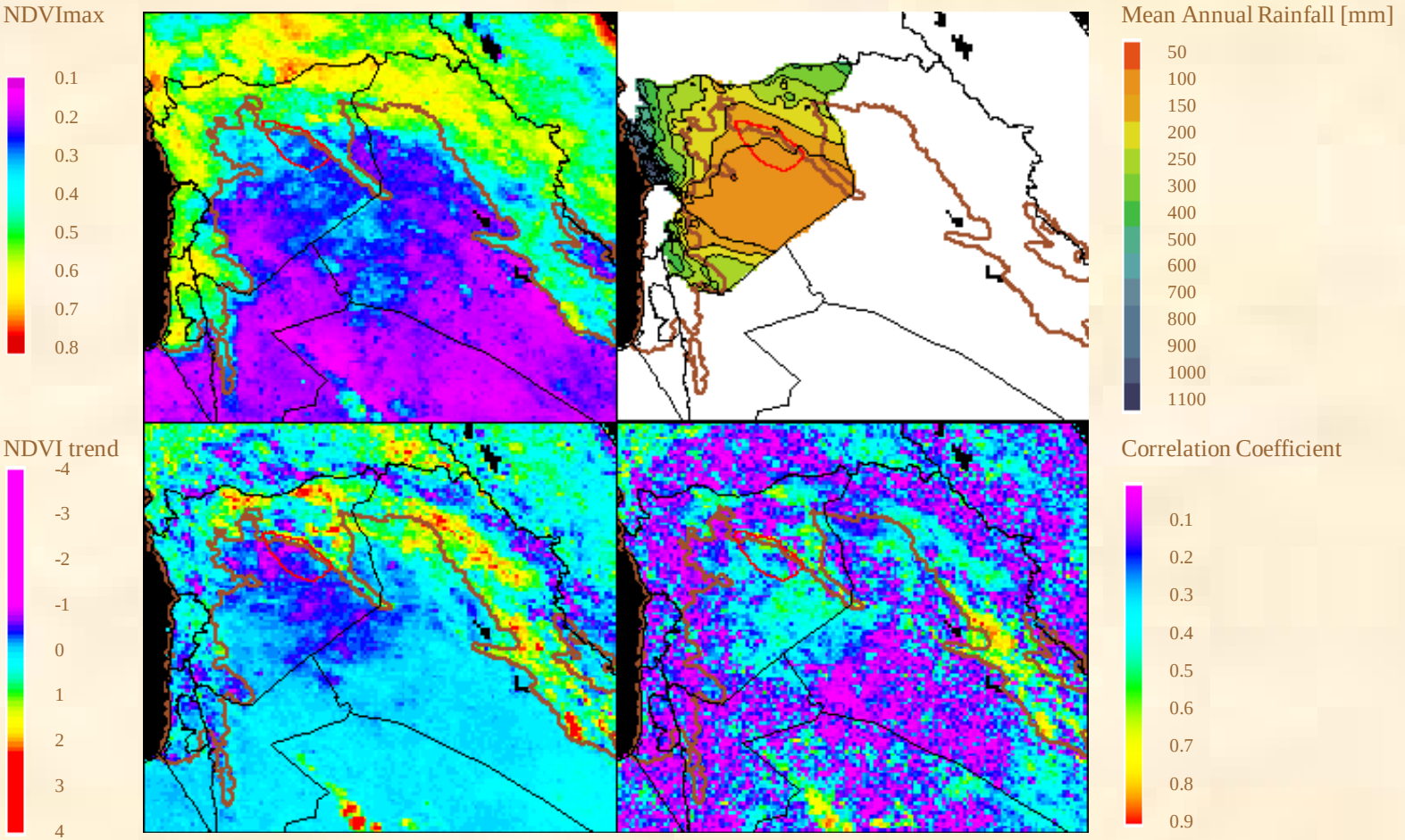
Trend Analysis with AVHRR NDVI 8-km Time Series, 81/82 – 95/96



~ 150 days greenperiod; length of green period defined from AVHRR using a threshold value of NDVI = 0.1

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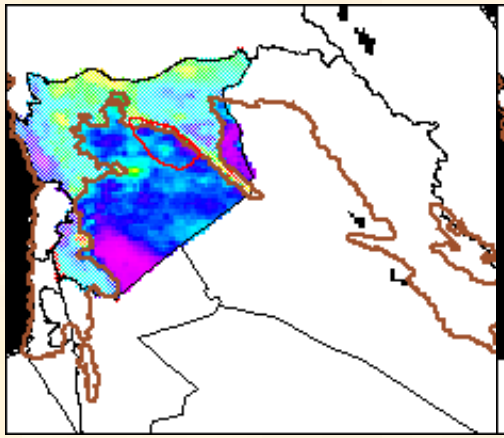
Trend Analysis of NDVImax – Spring Rainfall 81/82 – 95/96

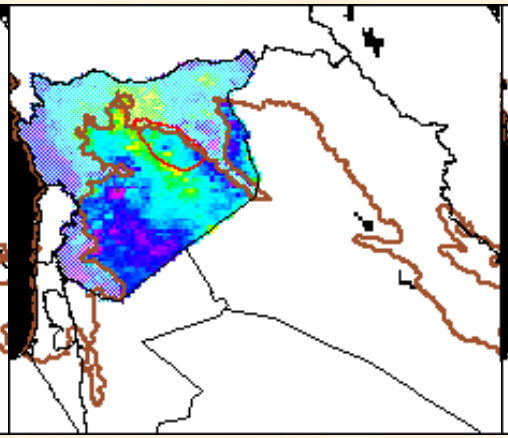
Mean RUE*



0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45

[NDVI-increase / 100mm rainfall]

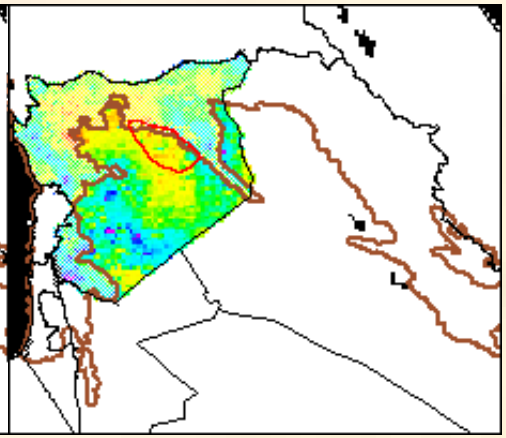
Regression NDVI – Spring Rainfall



0 0.1 0.2 0.3 0.4

Slope

Correlation of NDVI- Spring Rainfall



-0.20 0 0.20 0.40 0.60 0.80

*Rain Use Efficiency (RUE) tends to decrease with aridity but is especially tied to range degradation (Houerou, 1998)

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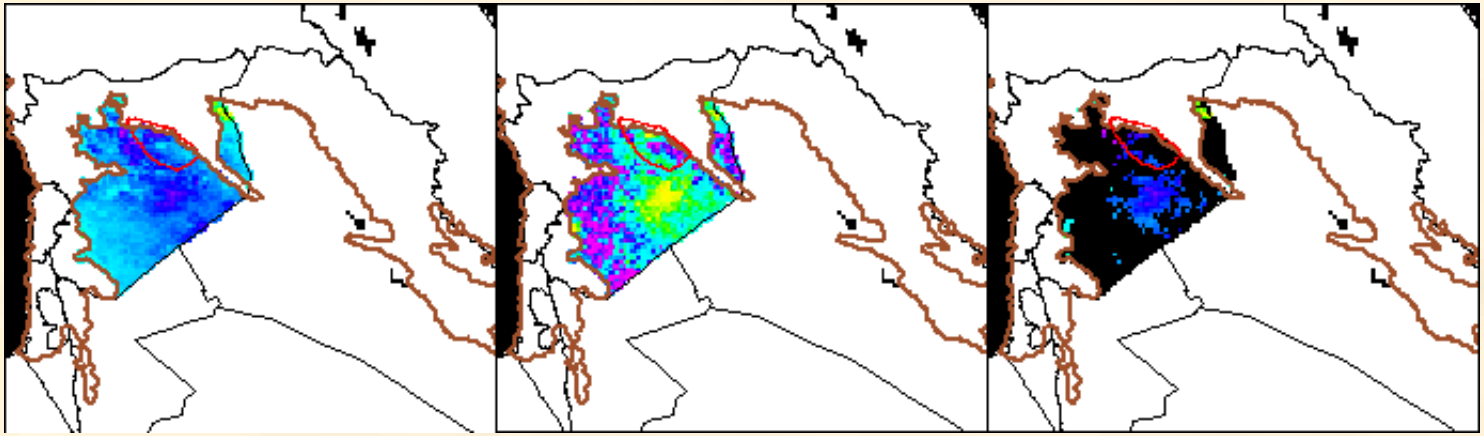
Trend Analysis of Residuals
NDVImax – Spring Rainfall 81/82 – 95/96

Trends of Residuals | Correlation Coefficients | Trends with Correlation Coefficents > 0.5



-1.5 -1.0 0 1.0 1.5 2.0 2.5 3.0 3.5 4.0

0 0.2 0.4 0.6 0.8

-1.5 -1.0 0 1.0 1.5 2.0 2.5 3.0 3.5 4.0

Slope

Slope

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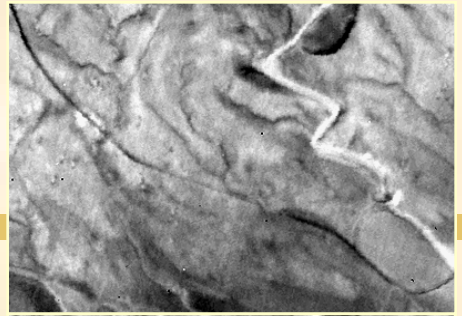
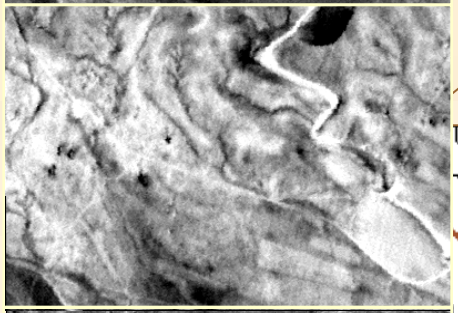
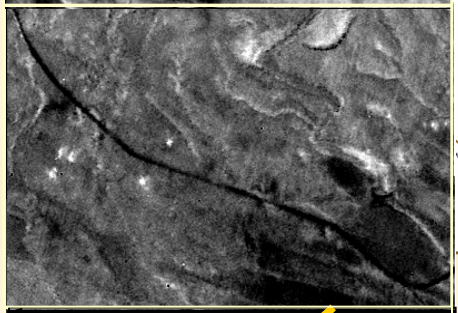


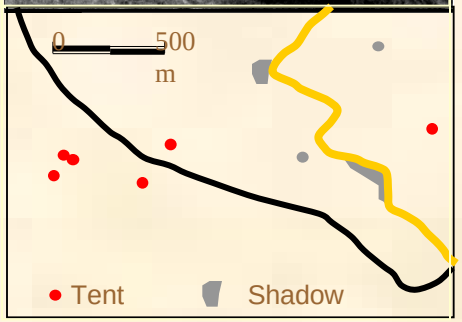
dry season (no tents)

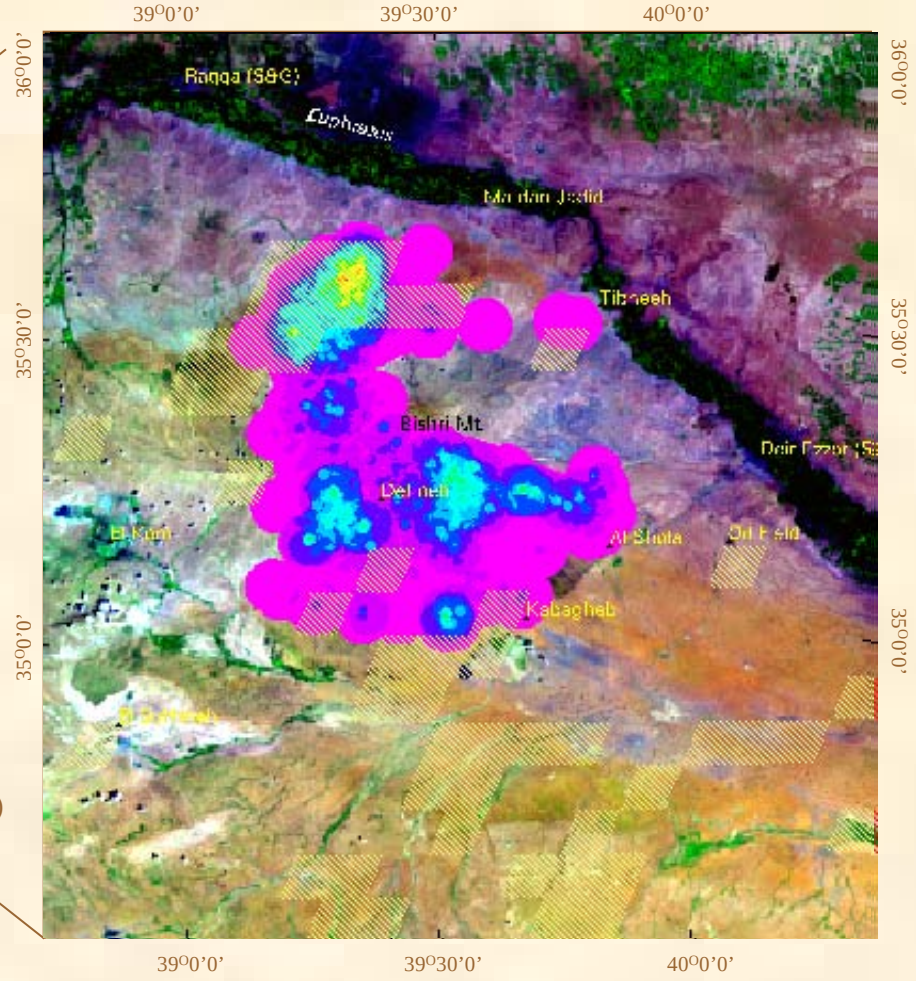


wet season (tents)



IRS-1C Ratio (96 over 97)





Recommendations

- Water collection sites

Based on assessments of water requirements and water availability

- Service centers

Optimum location with regards to minimum distances and accessability

- Location of potential rehabilitation areas

First attempts to be carried out in areas of lower population densities

- Preferable regreening techniques

- So far unused resources

is it desirable to open up additional areas and if so what is needed

Uncertainties in Degradation Assessment

- Replacement of palatable species by unpalatable ones
  Changes in green biomass may be minor and therefore undetectable using spectral indices for monitoring

- Agricultural activities
  Where cultivation has expanded into new areas this may suggest a positive trend in biomass development what is actually a harmful one. On the contrary where cultivation has been abandoned negative trends will prevail where something positive has been achieved.

- Situation of vegetation cover
  Composition (annuals, perennials), density, palatability and carrying capacity

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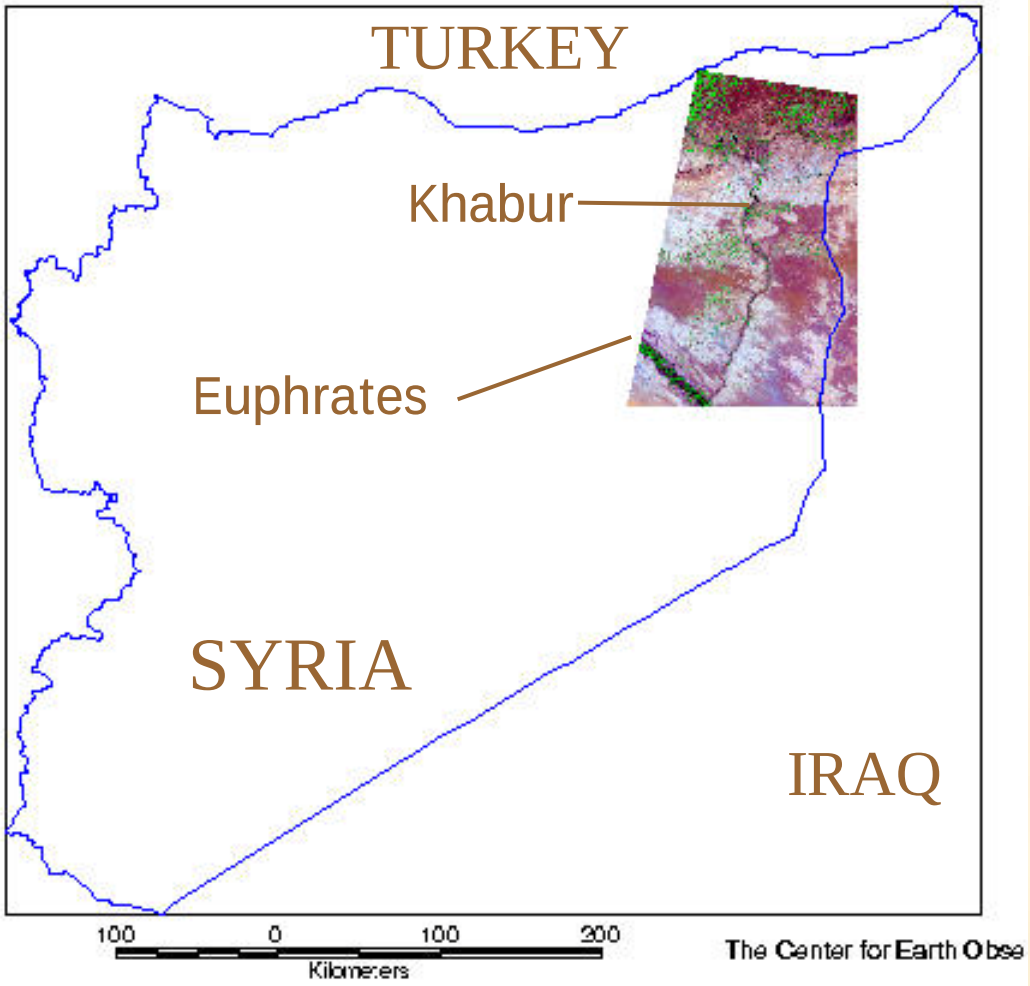
Land Use Changes in the Khabur Drainage – Northeast Syria



The lower Khabur receives less then 250mm of rain per year, and normally requires supplementary irrigation of wheat and barley in winter and full irrigation of cotton, vegetables and fruit in summer.

Land Use Changes 1900-2000

Years	Changes in lower Khabur region	Impacts on land
1900-1930	Herding with some cultivation along the river	Sustainable
1930-1990	Sedenterization and resettlement	Expansion of agriculture along the river
1950-1990	Extensive dry farming of steppe	Degradation of native vegetation, depletion of forage, wind erosion
1950-2000	Expansion of pump irrigation	Settlement of steppe, summer crops, depletion of ground water, erosion
1990-2000	Completion of reservoirs and canals	Further settlement of steppe, villages on river abandoned, river dry in summer, wind erosion

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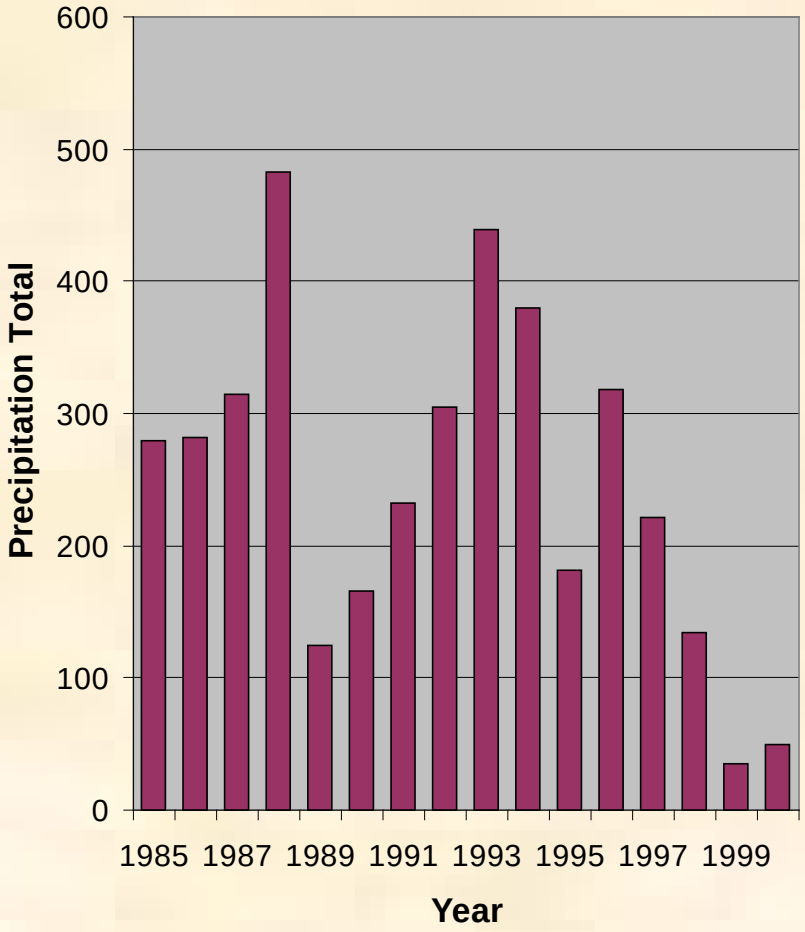
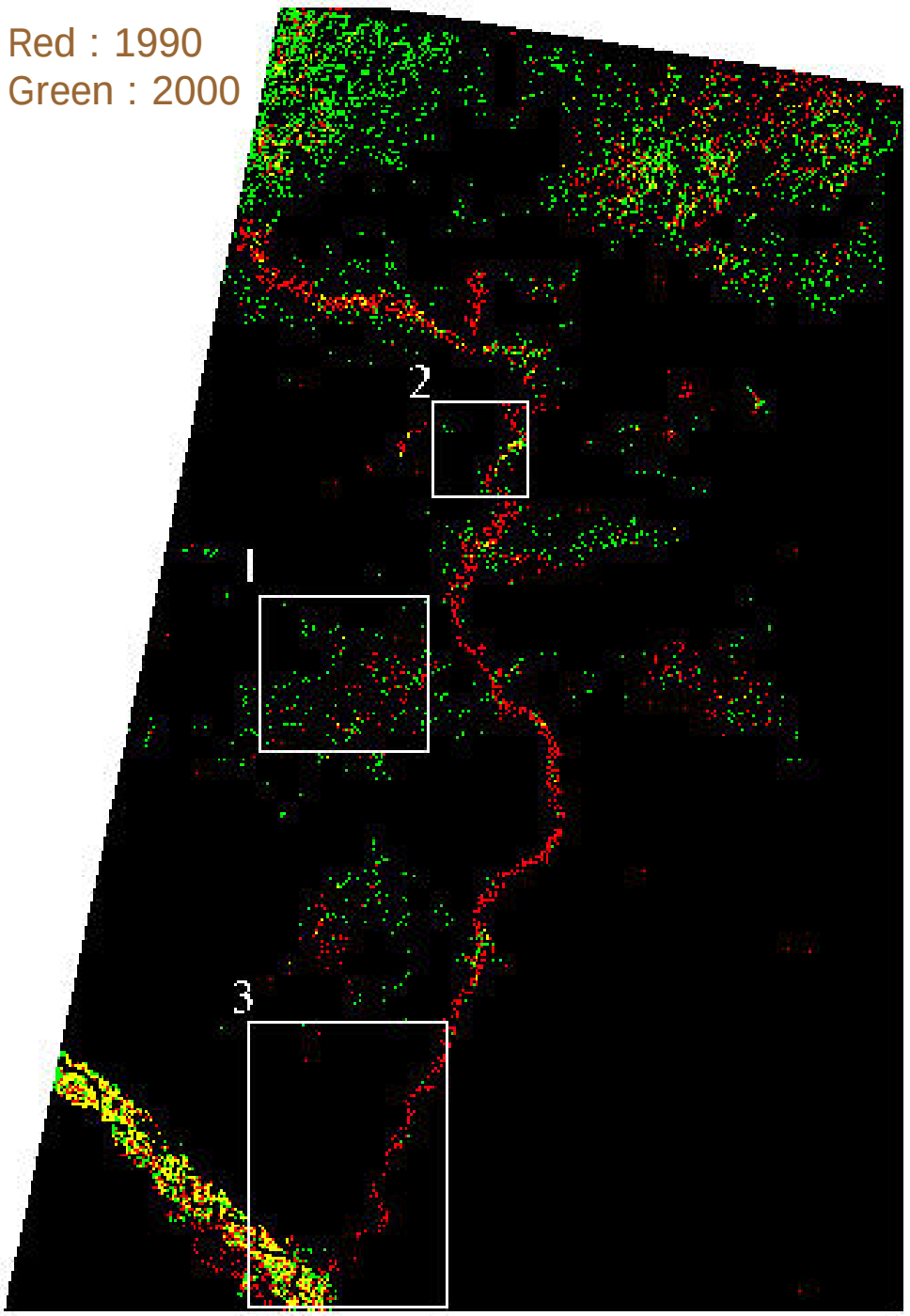
Difference in summer irrigation 1990-2000





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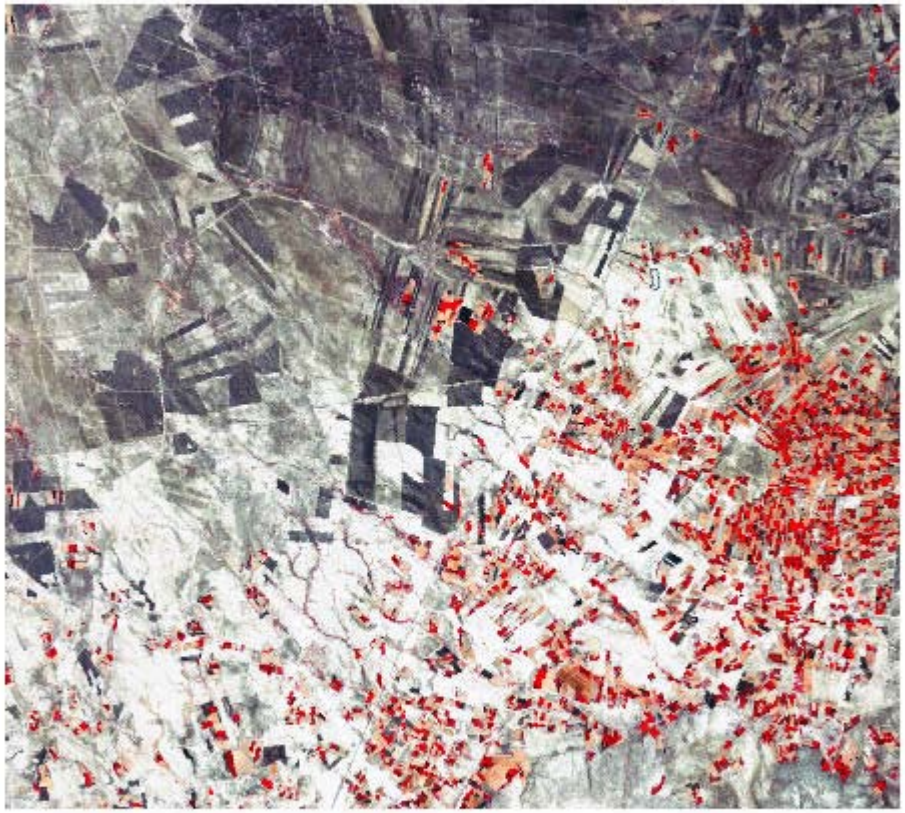
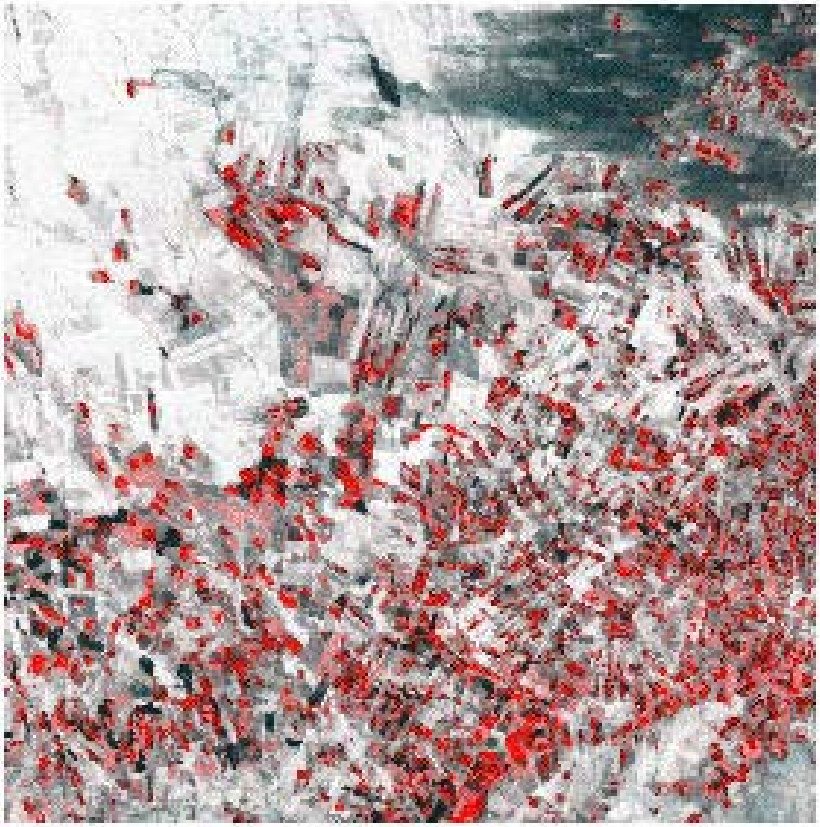


0 5 10
Kilometers

9/2/1990
TM 432-RGB



0 5 10
Kilometers

9/5/2000
TM 432-RGB

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Drivers of change in the Khabur region

- Settlement of Bedouin and refugees
- French mandate
- Syrian state formed
- Changing land use policies
- Introduction of pumps and tractors
- National and international markets for grain and cotton
- Population increase
- Building of dams, reservoirs and canals

RegCM2 description

- Dynamical component based on MM4
  - hydrostatic
  - compressible
  - primitive equation
  - terrain following σ vertical coordinate
- modifications include
  - detailed representation of radiative transfer
  - surface physics-soil hydrology (BATS)
  - planetary boundary layer
  - convective precipitation scheme

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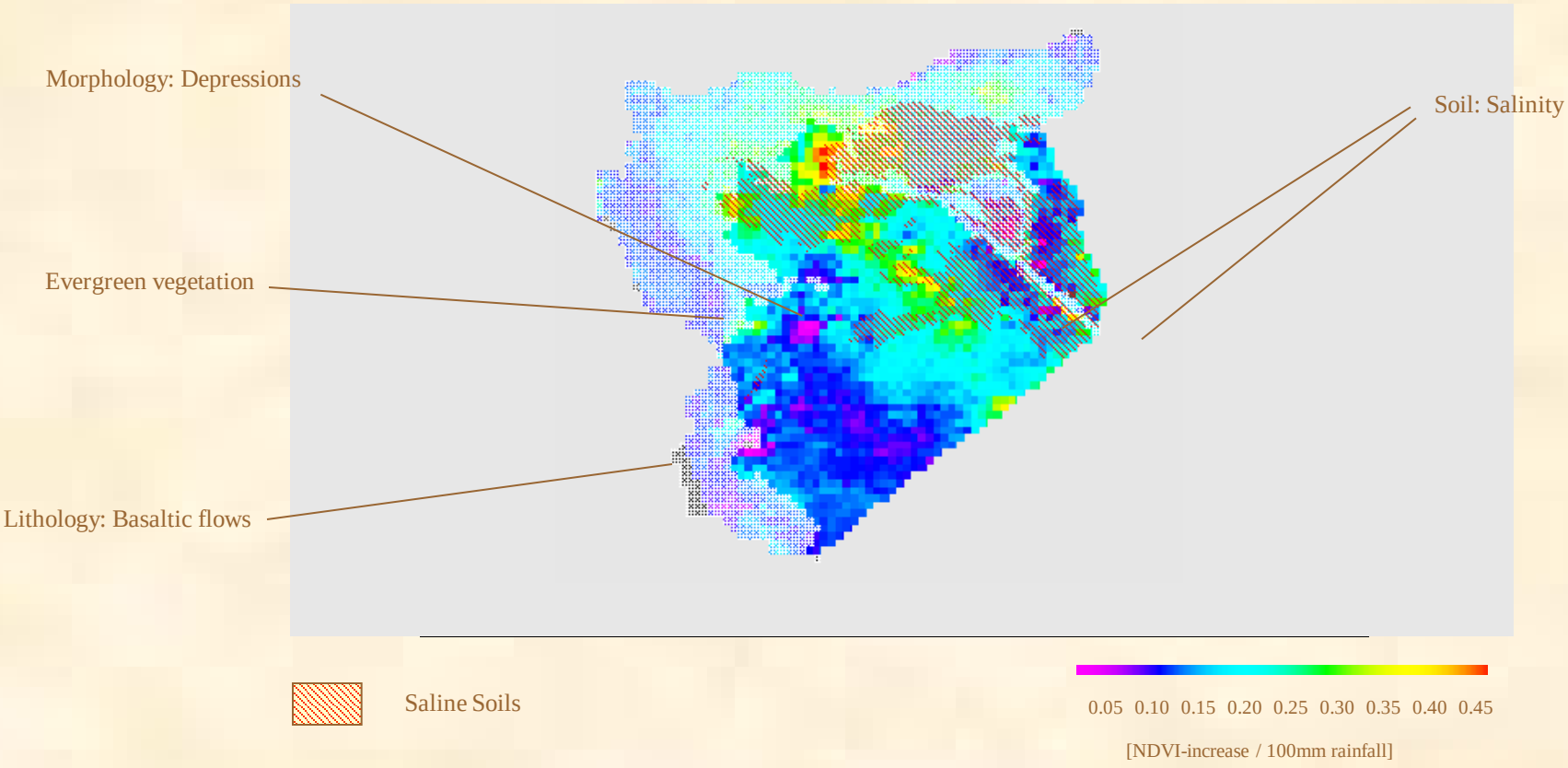
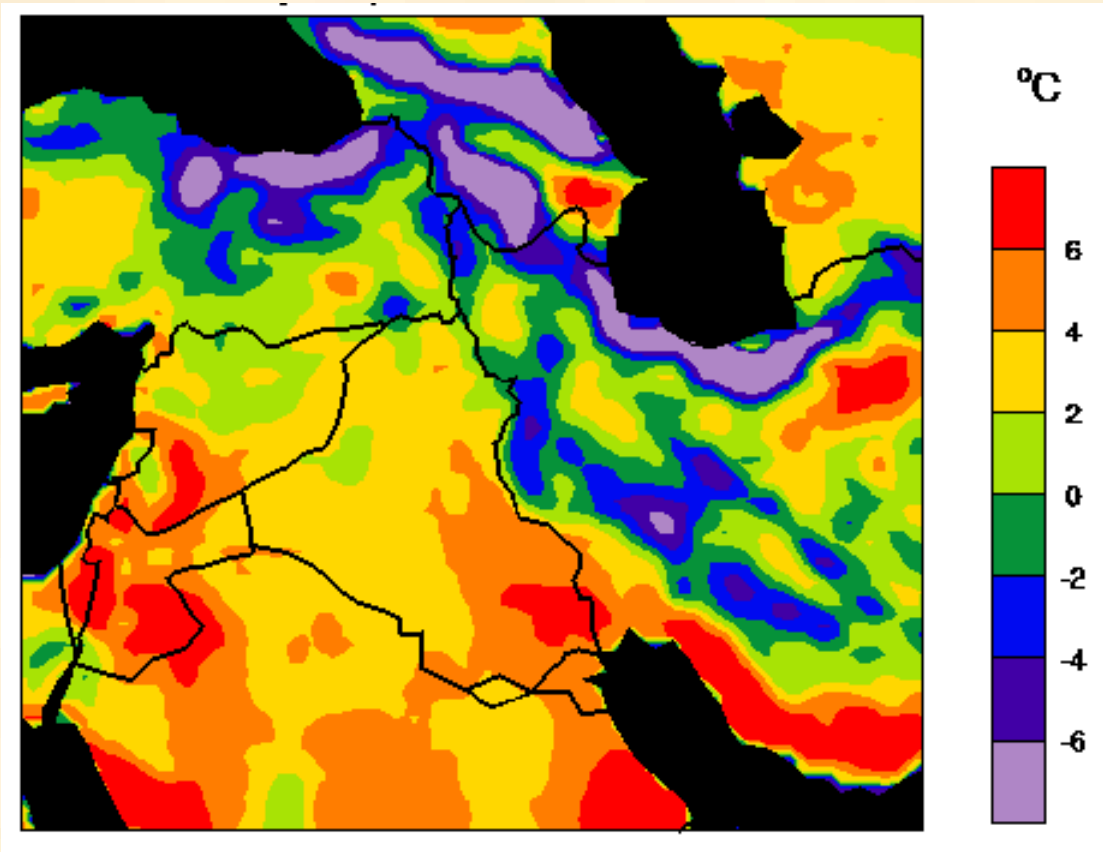
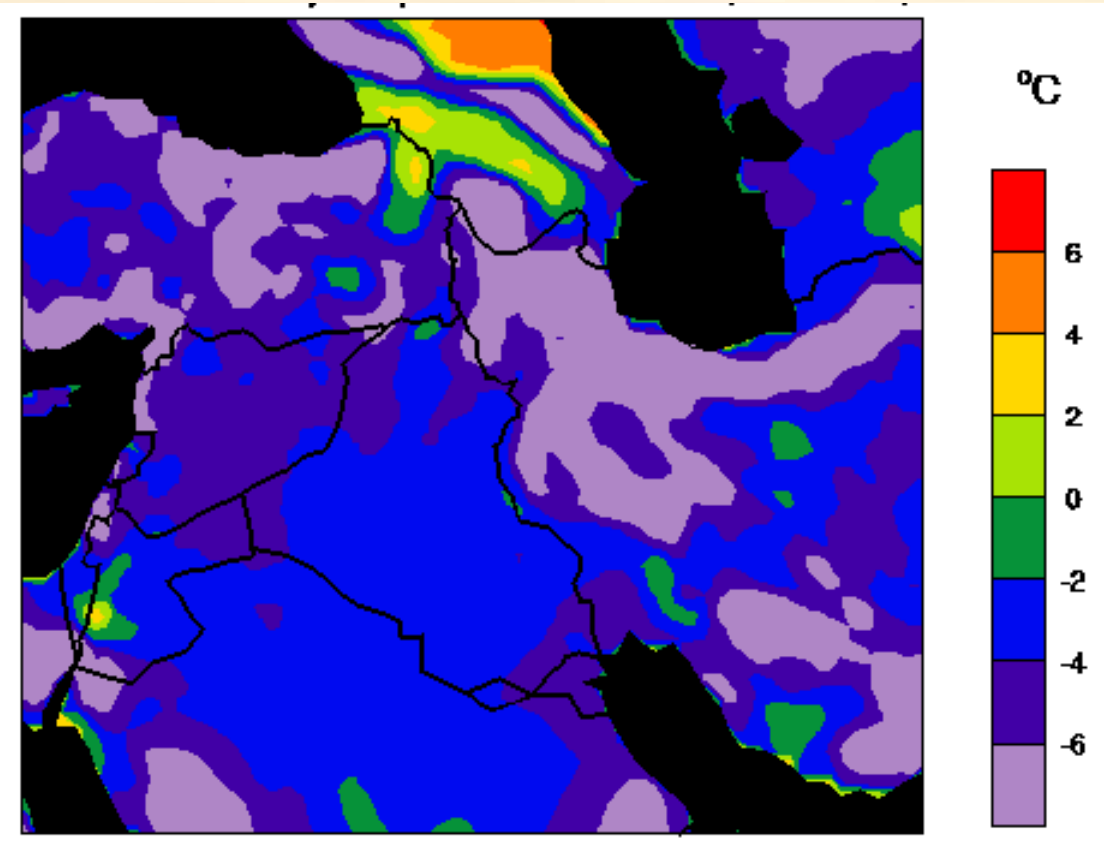
Relationship of water use efficiency and growth dynamics to Topography

Trends computed for regression "NDVImax – Spring Rainfall" (8-km) draped over MISR topography (1.1-km)



Maximum July Temperature Difference (model – obs)



Minimum January Temperature Difference (model – obs)