Climate Change and Human Response in the Semi Arid Near East

Funding: NASA ESE/IDS (12/96 to 12/99)

Group: Yale Center for Earth Observation

Subprojects:

- Large scale climate, landscape** and hydrology (Smith et al.)
- Hyperspectral crop yield analysis (Thenkabail et al.)
- Farming systems (Hole et al.)
- Epidemiology and landscape change (Wilson et al.; U. Mich.)

(** This presentation)

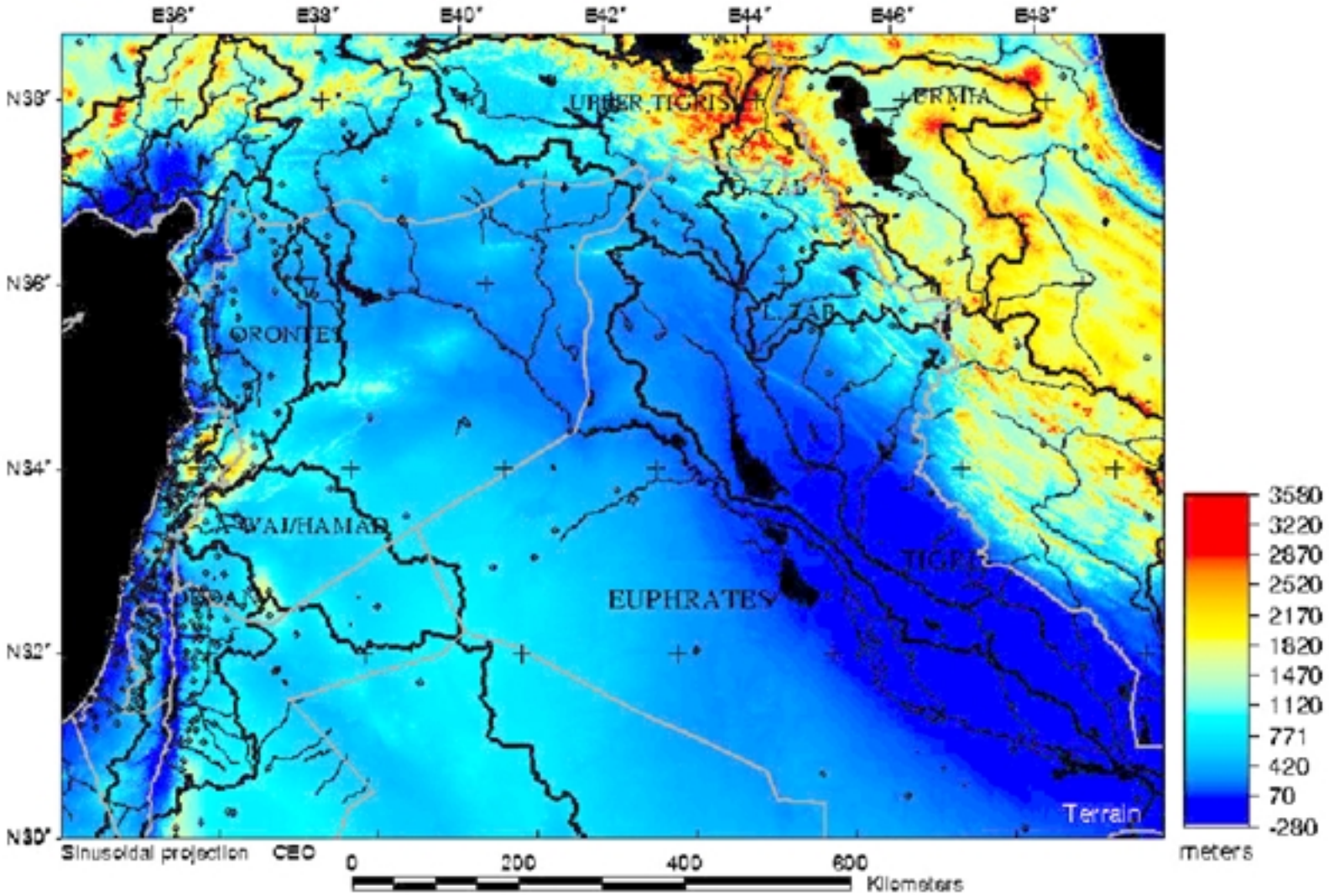
Characteristics of the Middle East Region

- Semi-arid climate; strong climate gradients
- Degraded landscape
- Rapid population growth
- Shifting economic/agricultural strategies

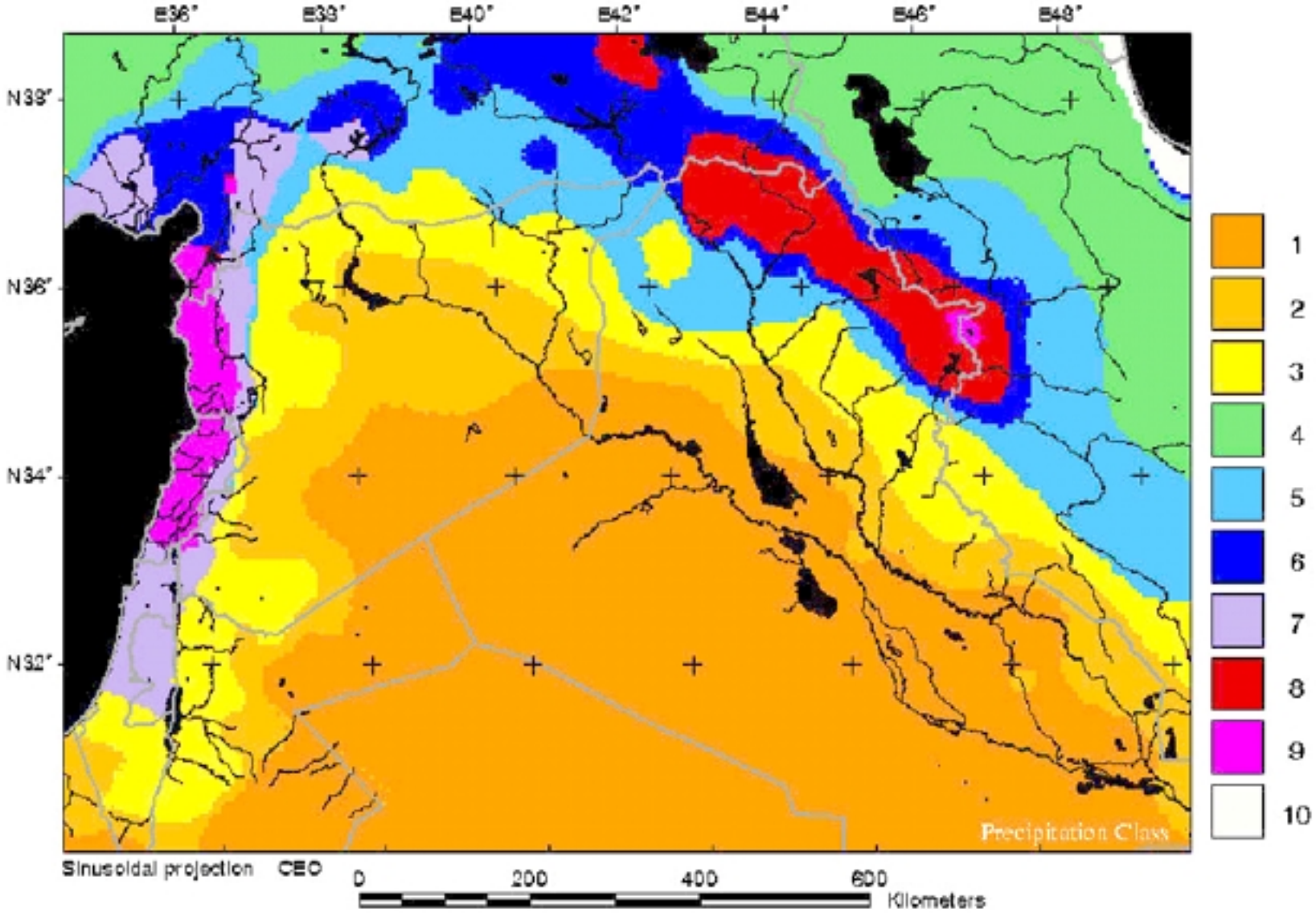
LC/LU in a dynamic arid landscape

Outline:

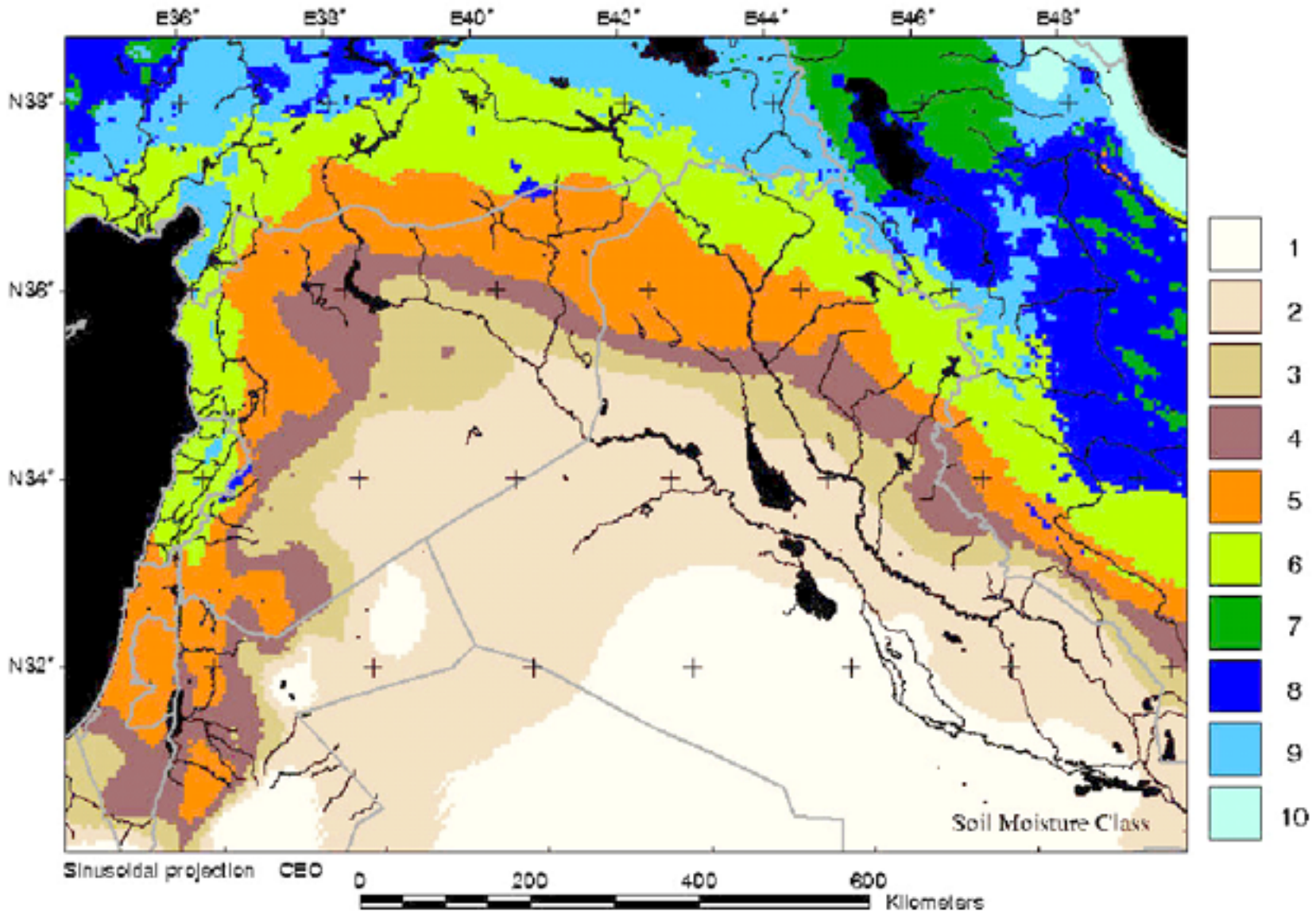
- Climate and Terrain
- Land cover classification
- Snow variability
- Irrigation variability
- Rainfed agriculture variability
- Discussion



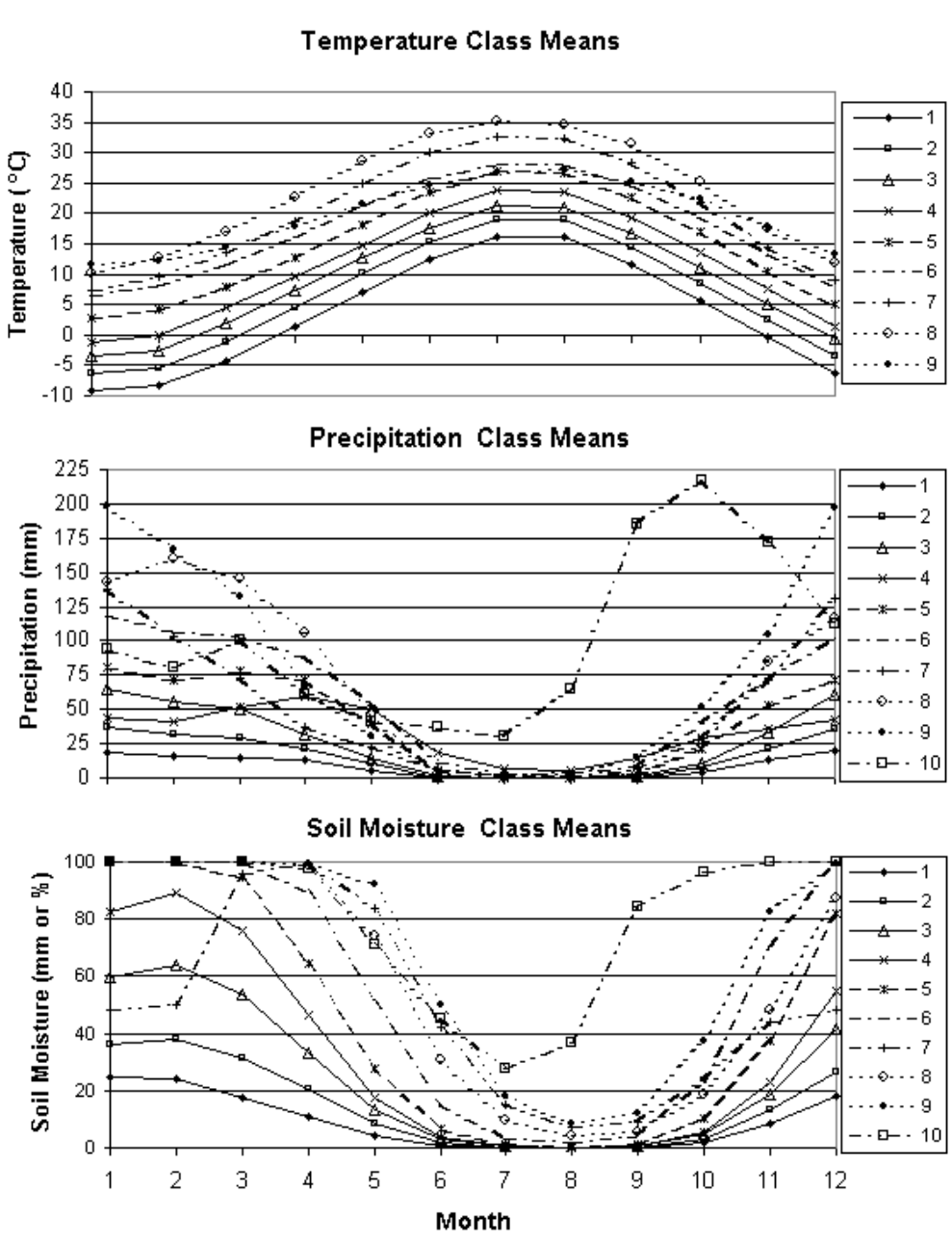
Digital Elevation Model with 30 Arc Second Resolution (black circles represent meteorological stations)

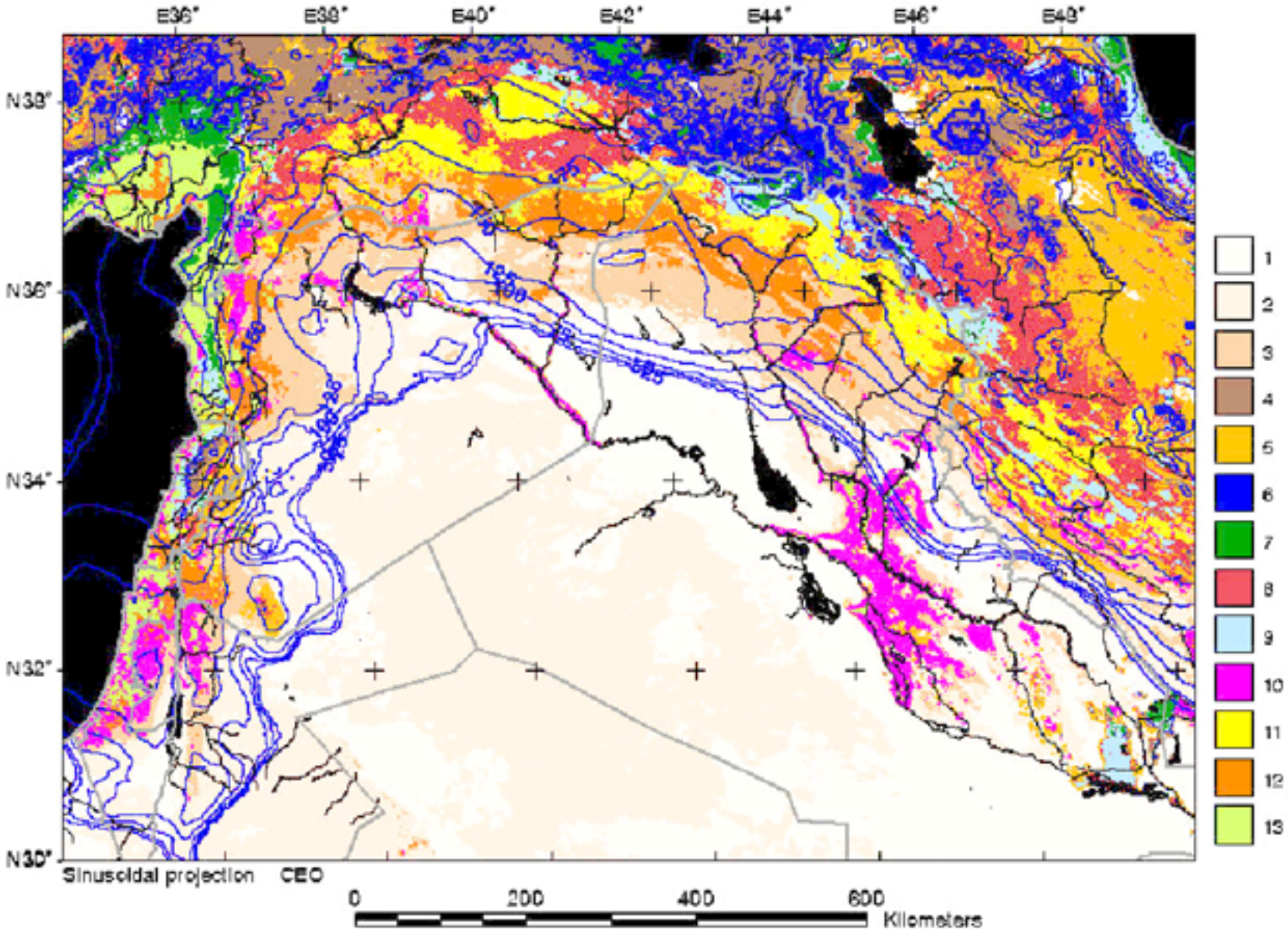


Multitemporal Unsupervised Classification of Monthly Precipitation Data



Multitemporal Unsupervised Classification of Monthly Soil Moisture Data


Temperature Class Means
Temperature (°C)
40
35
30
25
20
15
10
5
0
-5
-10
1
2
3
4
5
6
7
8
9
Precipitation Class Means
Precipitation (mm)
225
200
175
150
125
100
75
50
25
0
1
2
3
4
5
6
7
8
9
10
Soil Moisture Class Means
Soil Moisture (mm or %)
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
11
12
Month



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

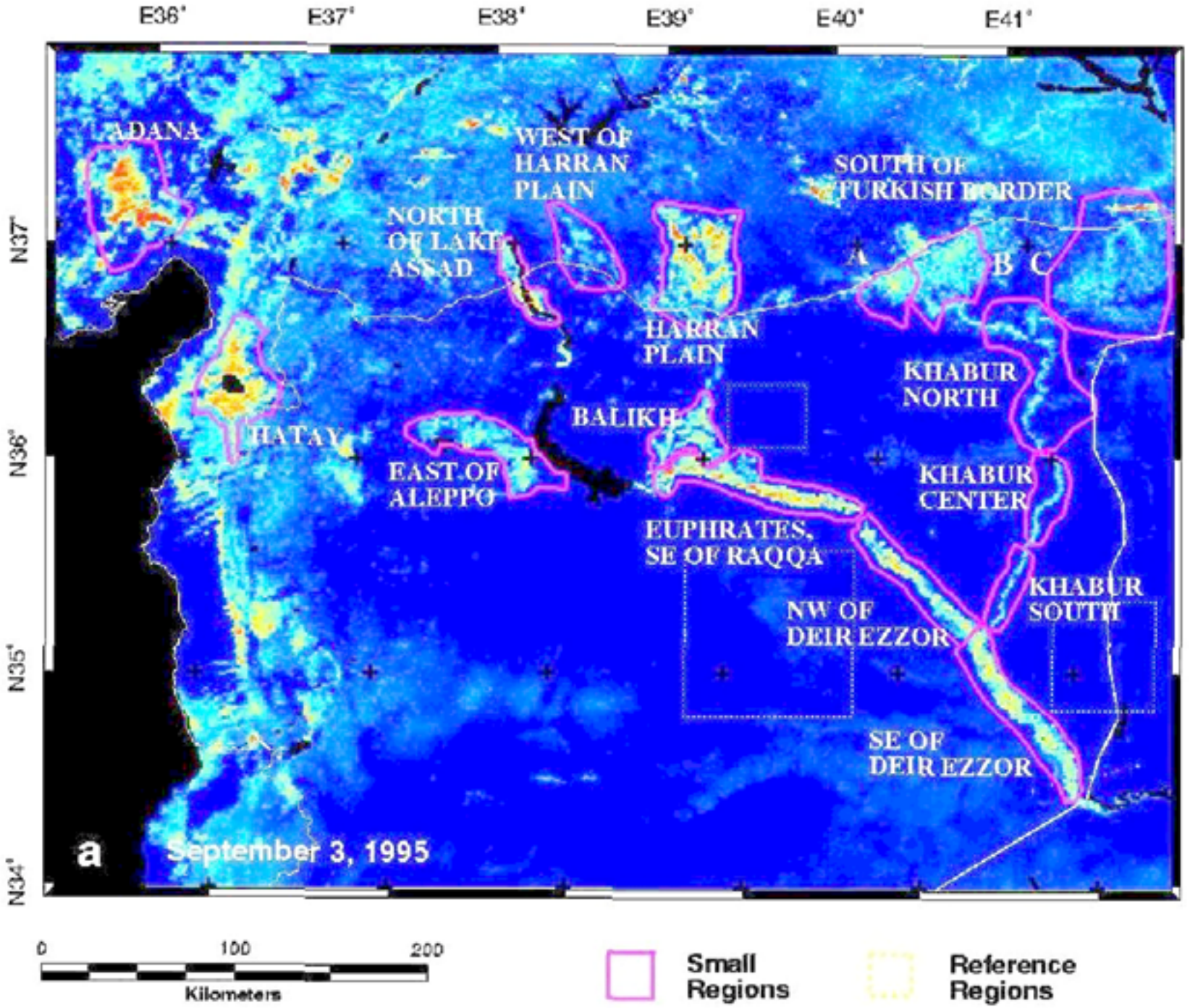
Problems in the satellite estimation of irrigated area

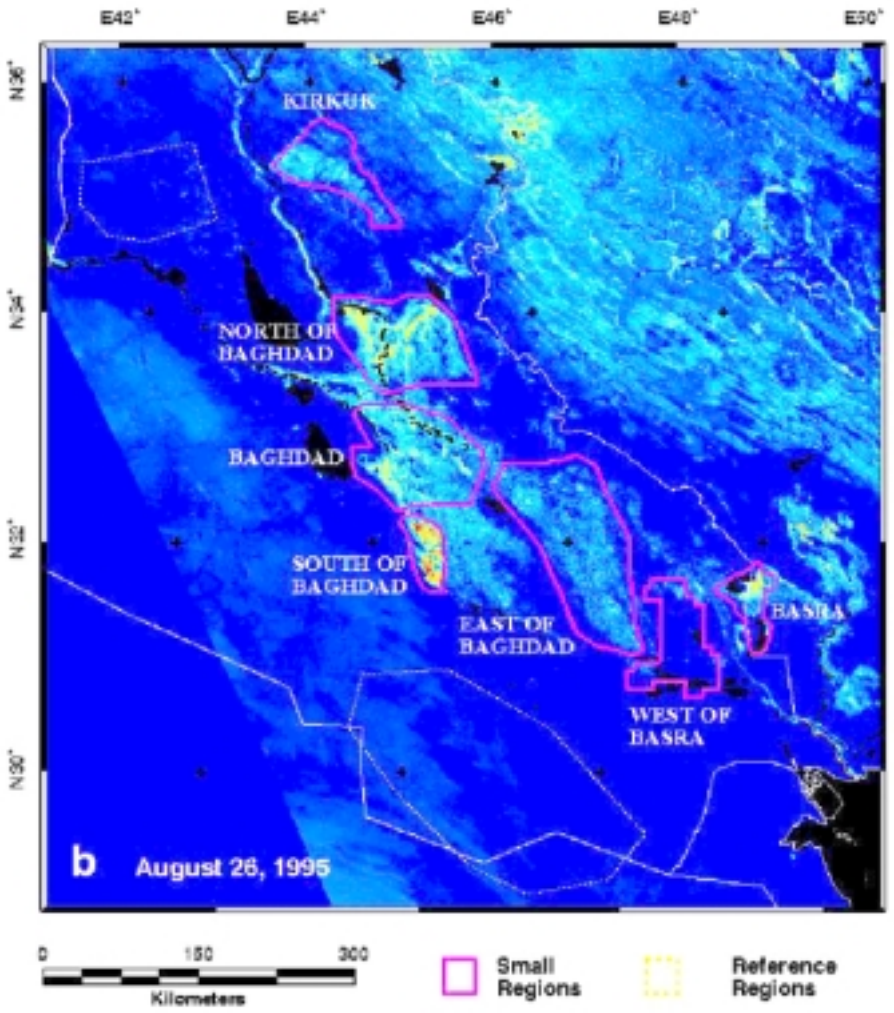
Detection of spring supplemental irrigation is difficult. We focus on summer crops.

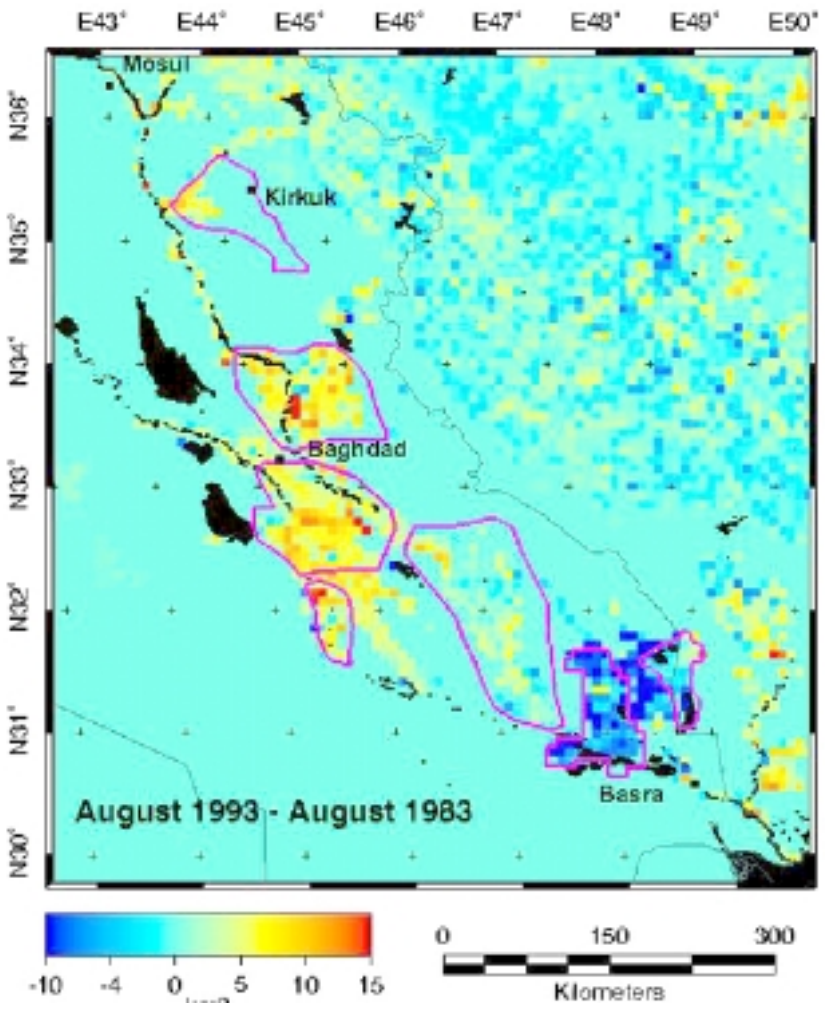
Phenology of irrigated crops mimics other landcovers. We use other factors such as terrain to reduce misidentification.

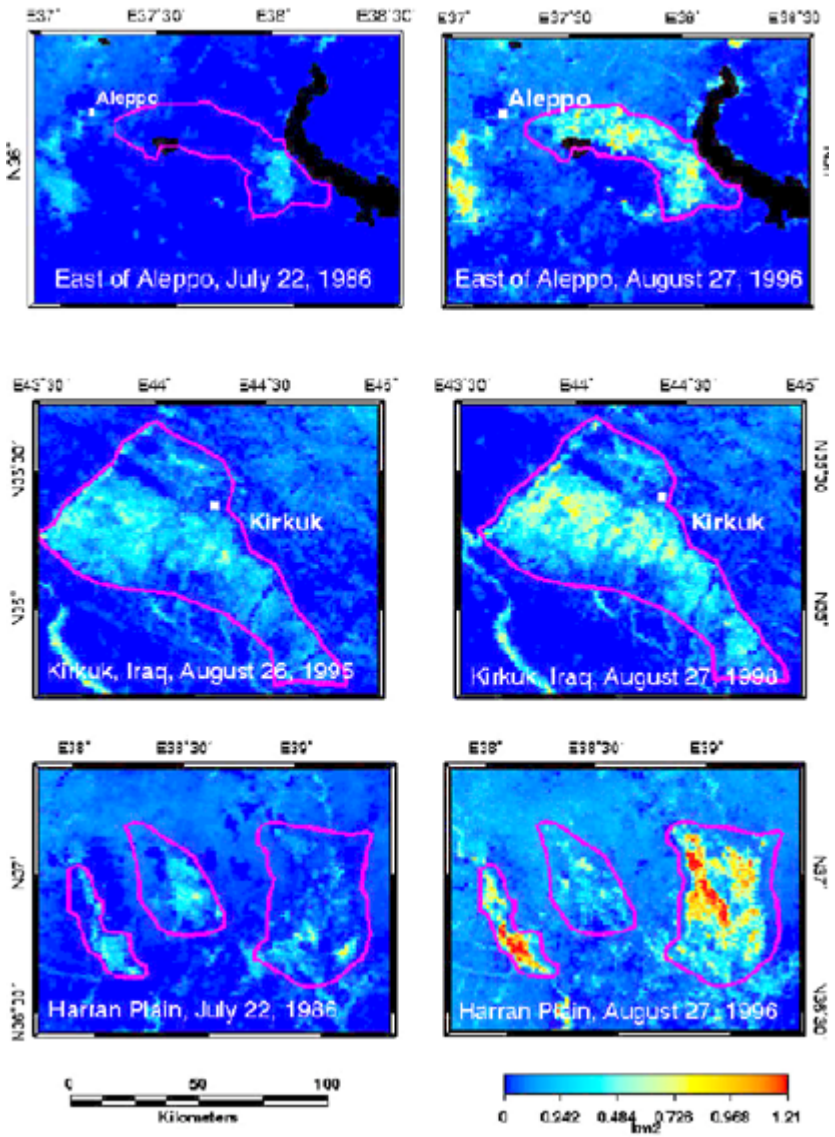
Broad size distribution of irrigated fields ($F(A)=C\ A^{m}$; m = -1.9). Small fields dominate. We combine Landsat and AVHRR data.

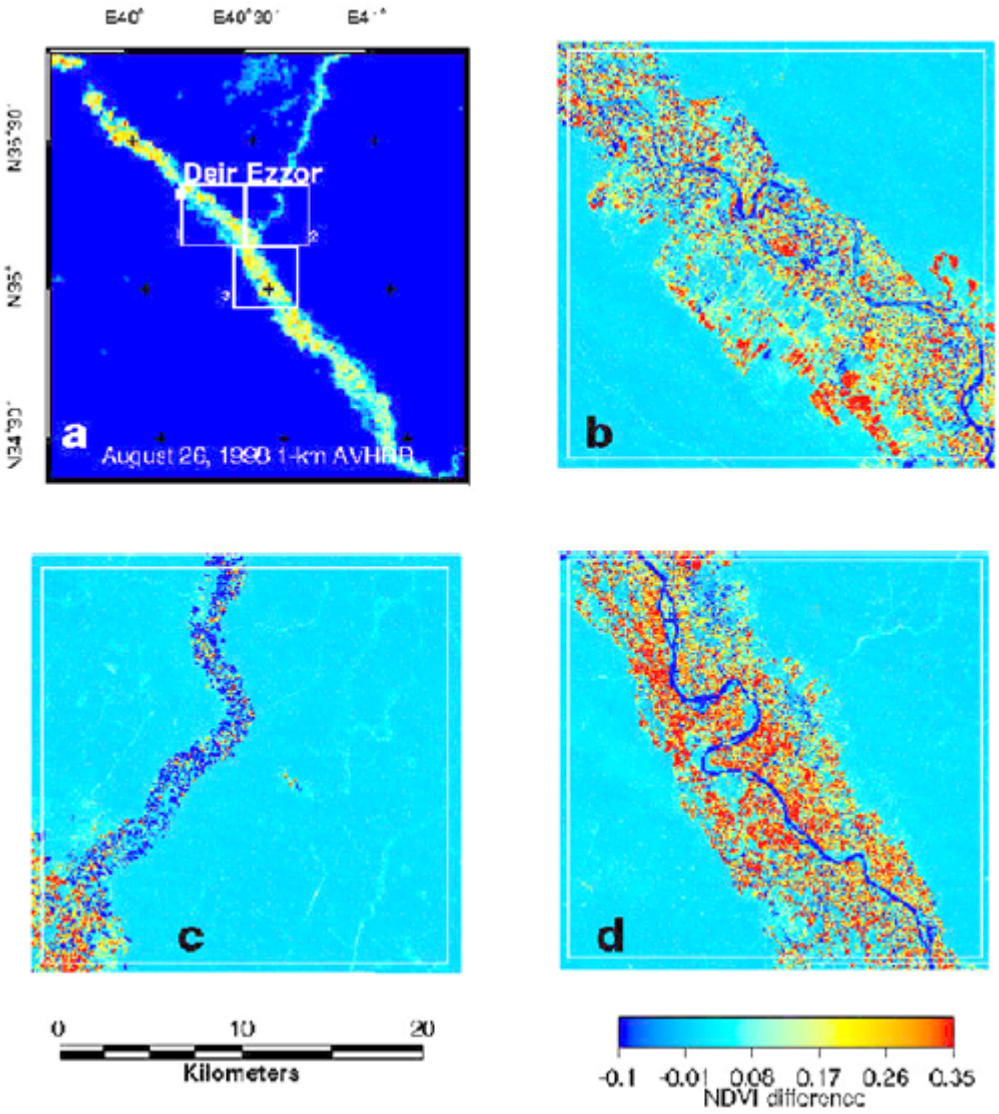
Sensor and orbit drift. We use a desert reference area.

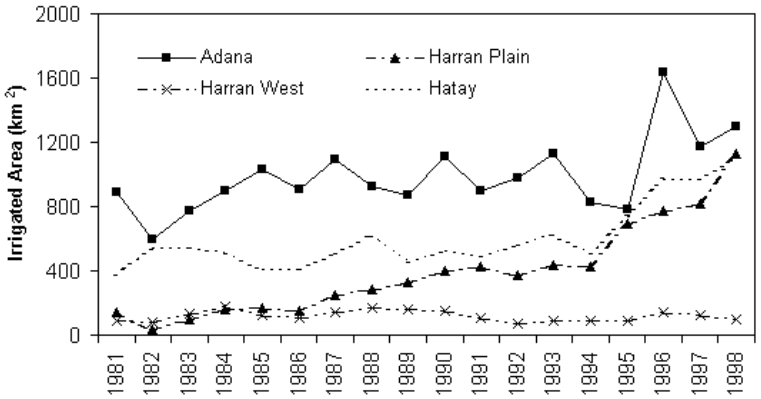

E36°
E37°
E38°
E39°
E40°
E41°
N37°
N36°
N35°
N34°
ADANA
WEST OF HARRAN PLAIN
SOUTH OF TURKISH BORDER
NORTH OF LAKE ASSAD
A
B
C
HARRAN PLAIN
KHABUR NORTH
BALIKH
HATAY
EAST OF ALEPPO
KHABUR CENTER
EUPHRATES, SE OF RAQQA
KHABUR SOUTH
NW OF DEIR EZZOR
SE OF DEIR EZZOR
a
September 3, 1995
0
100
200
Kilometers
Small Regions
Reference Regions

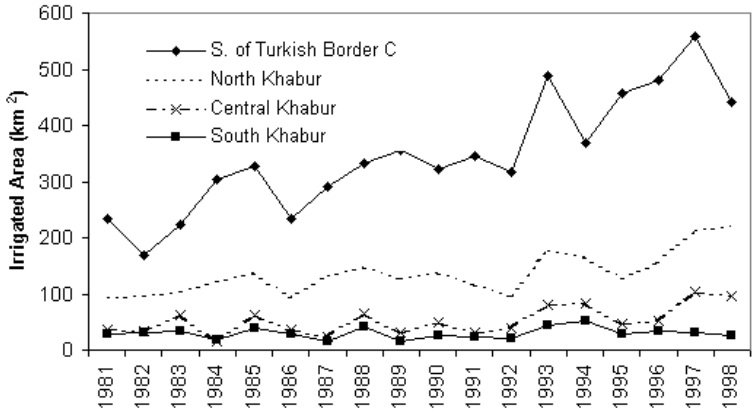

E42°
E44°
E46°
E48°
E50°
N36°
N34°
N32°
N30°
KIRKUK
NORTH OF BAGHDAD
BAGHDAD
SOUTH OF BAGHDAD
EAST OF BAGHDAD
BASRA
WEST OF BASRA
b
August 26, 1995
0
150
300
Kilometers
Small Regions
Reference Regions

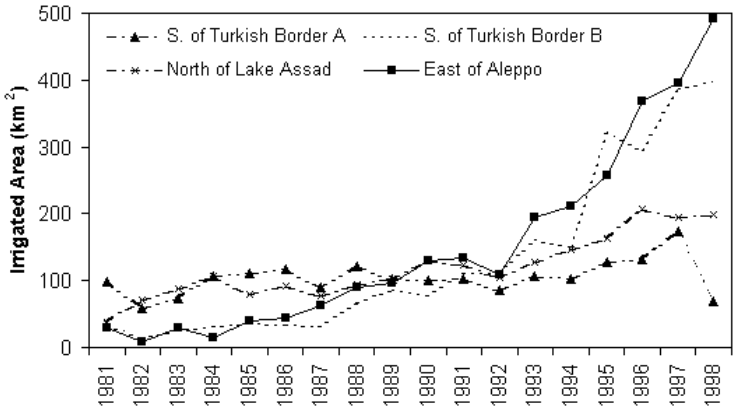

E43°
E44°
E45°
E46°
E47°
E48°
E49°
E50°
N36°
N35°
N34°
N33°
N32°
N31°
N30°
Mosul
Kirkuk
Baghdad
Basra
August 1993 - August 1983
-10
-4
0
5
10
15
0
150
300
Kilometers

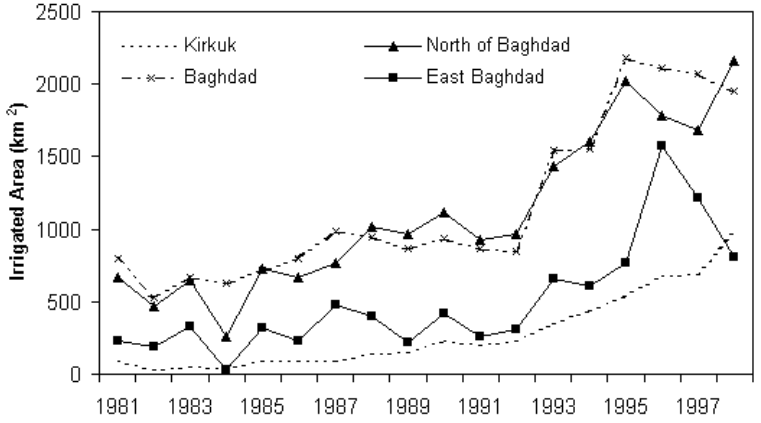

Aleppo
East of Aleppo, July 22, 1986
Aleppo
East of Aleppo, August 27, 1996
Kirkuk
Kirkuk, Iraq, August 26, 1995
Kirkuk
Kirkuk, Iraq, August 27, 1996
Harran Plain, July 22, 1986
Harran Plain, August 27, 1996
0
50
100
Kilometers
0
0.242
0.484
0.726
0.968
1.21
km2

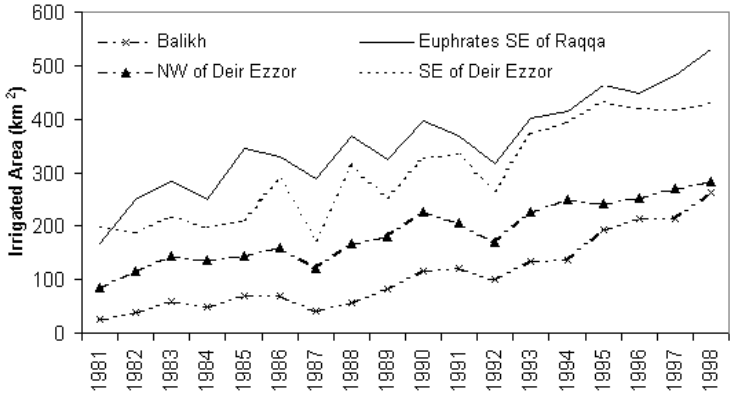

E40°
E40°30'
N35°30'
N35°
Deir Ezzor
a
August 26, 1993 1-km AVHRR
b
c
d
0
10
20
Kilometers
-0.1
-0.01
0.08
0.17
0.26
0.35
NDVI difference

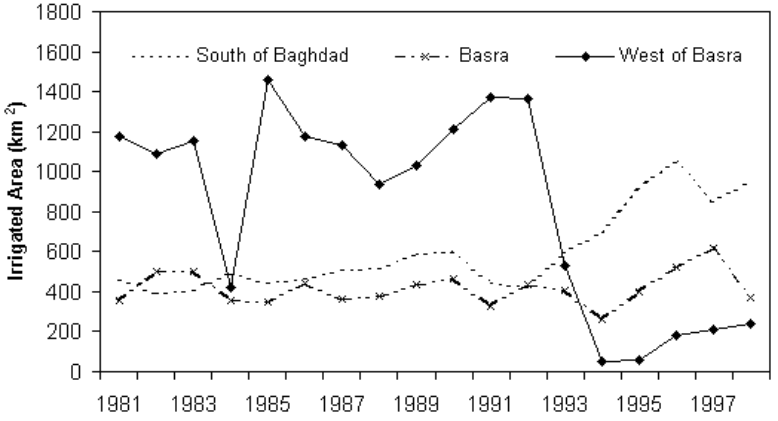

Adana
Harran Plain
Harran West
Hatay
Irrigated Area (km 2)
2000
1600
1200
800
400
0
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998


S. of Turkish Border C
North Khabur
Central Khabur
South Khabur
Irrigated Area (km 2)
600
500
400
300
200
100
0
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998


S. of Turkish Border A
S. of Turkish Border B
North of Lake Assad
East of Aleppo
Irrigated Area (km 2)
500
400
300
200
100
0
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998


Kirkuk
North of Baghdad
Baghdad
East Baghdad
Irrigated Area (km 2)
2500
2000
1500
1000
500
0
1981 1983 1985 1987 1989 1991 1993 1995 1997


Balikh
Euphrates SE of Raqqa
NW of Deir Ezzor
SE of Deir Ezzor
Irrigated Area (km 2)
600
500
400
300
200
100
0
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998


South of Baghdad
Basra
West of Basra
Irrigated Area (km 2)
1800
1600
1400
1200
1000
800
600
400
200
0
1981 1983 1985 1987 1989 1991 1993 1995 1997

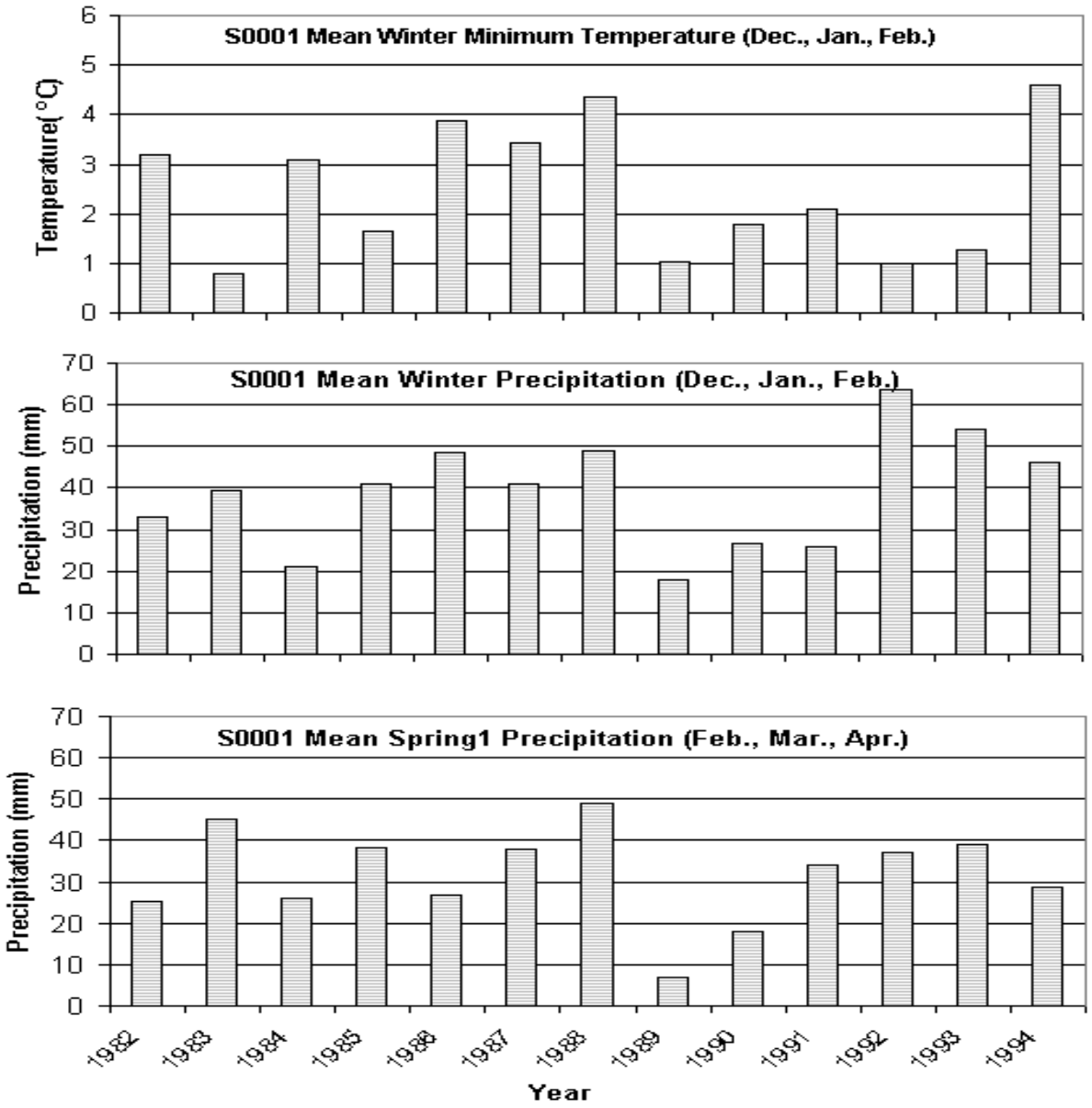
Correlation of Climate and Spring Vegetation

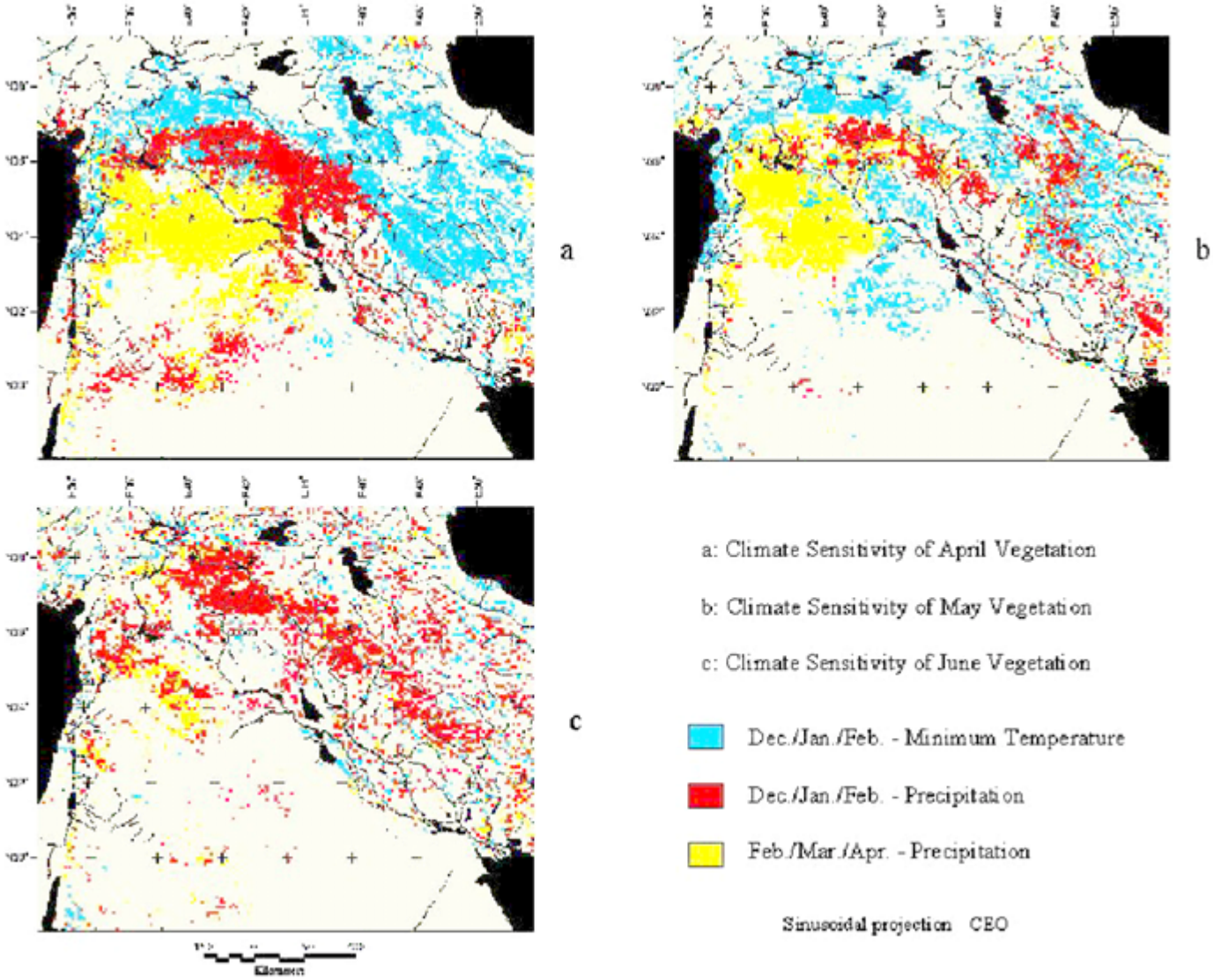
Datasets: 12 years (1983-1994) AVHRR NDVI and climate indices from a cluster of six WMO stations in NW Syria.

Methods: Compute the correlation coefficients (R) between April, May and June NDVI and 16 climate indices. Select the three most important climate indices.

Results: Winter (DJF) precipitation and minimum temperature and Spring (FMA) precipitation influence specific vegetation zones in different months

$$R = \sum_{i=1}^{12}(N_i - \overline{N})(C_i - \overline{C}) \times (\sum_{i=1}^{12}(N_i - N)^2 \times \sum_{i=1}^{12}(C_i - \overline{C})^2)^{-1/2}$$


S0001 Mean Winter Minimum Temperature (Dec., Jan., Feb.)
Temperature(°C)
0
1
2
3
4
5
6
S0001 Mean Winter Precipitation (Dec., Jan., Feb.)
Precipitation (mm)
0
10
20
30
40
50
60
70
S0001 Mean Spring1 Precipitation (Feb., Mar., Apr.)
Precipitation (mm)
0
10
20
30
40
50
60
70
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
Year


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

Landscape Issues in the Middle East

- Degraded land + restoration
- Water Resources
- Sensitivity to Climate Change
- Changing Agricultural Strategies
- Landscape "drivers"

--Government decisions

--Globalization / Population

--Oil money / end of oil

--Gulf war / embargo

--Peace process

--Upstream water consumption

--Bedouin family structure

Overcoming Technical Limits

- Improved ET (L-7)
- Crop Yield (L-7, EO-1)
- LC/LU (L-7, Modis)
- Saline Soils (Aster)
- Soil Moisture (Light SAR)
- Climate Sensitivity (MODIS)
- Rangeland (L-7, MODIS)