MONITORING HYDROLOGICAL REGIME OF THE EUPHRATES-TIGRIS RIVER BASIN USING SATELLITE OBSERVATIONS

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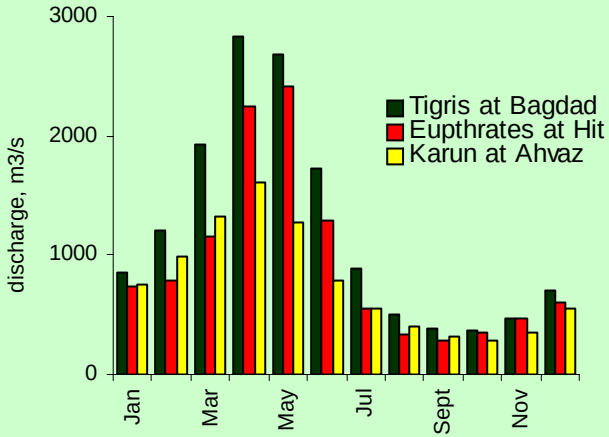
E-T WATERSHED

A = 765 000 km²
W=105 km³

$L_{Euphrates}$ = 2800 km **L_{Tigris} = 1750 km**
$W_{Euphrates}$ = 30 km³/y **W_{Tigris} = 55 km³/y**



E-T WATERSHED

4 riparian states:

Turkey, Syria, Iran, Iraq

Before 70s

Turkey by Euphrates

↓ 31 km³/y

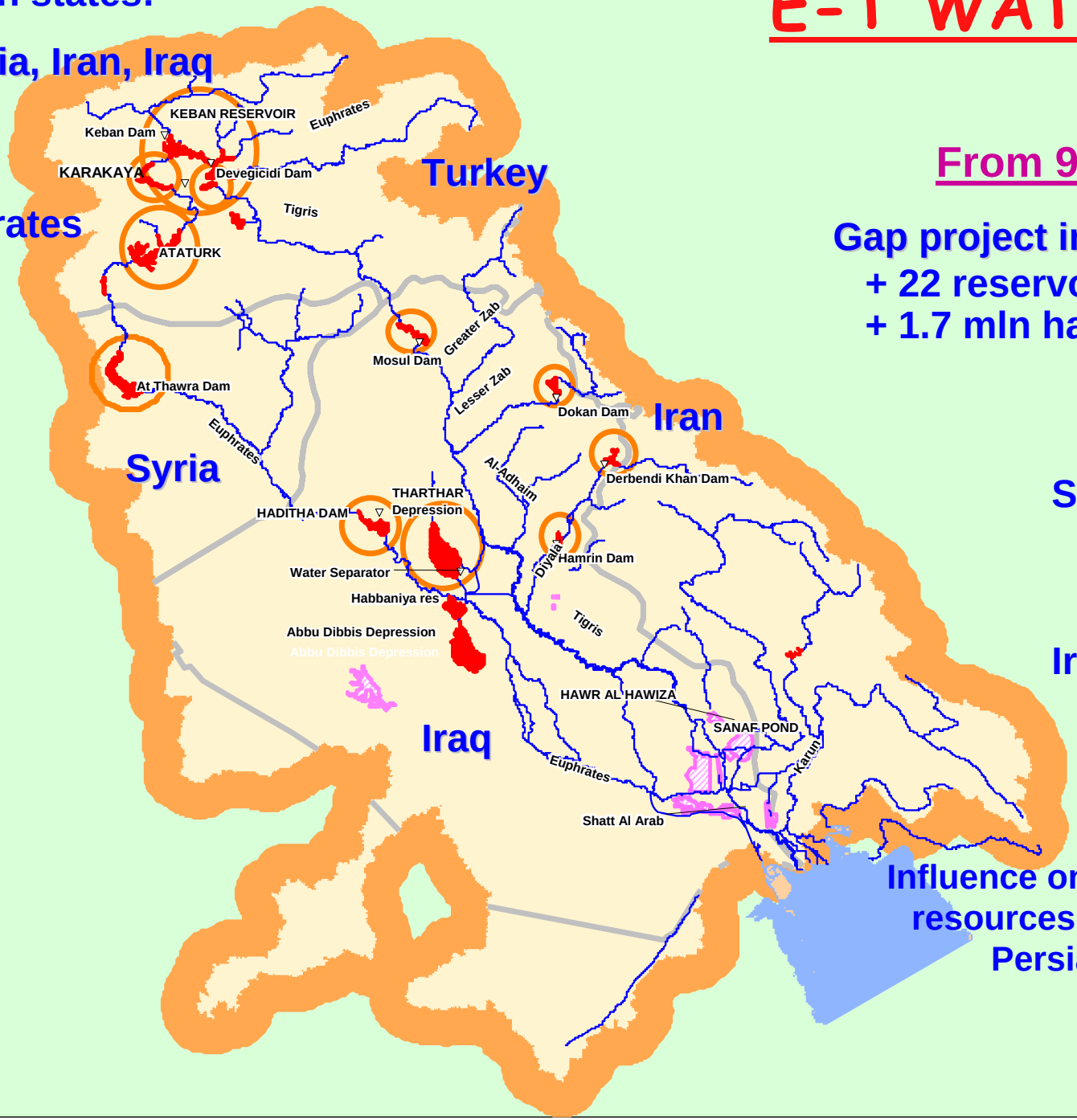
Syria

↓ 27 km³/y

Iraq

↓ ? km³/y

Persian Gulf



From 90s

Gap project in Turkey
+ 22 reservoirs
+ 1.7 mln ha in irrigation

↓ 16 km³/y

Syria

↓ 9 km³/y

Iraq

↓ ? km³/y

Influence on fishery resources in the Persian Gulf

E-T WATERSHED

Main reservoirs

Euphrates R.

Keban W = 31 km³

Karakaya W = 10 km³

Ataturk W = 49 km³

Tharthar Lake
W = 73 km³

Tigris R.

Mosul W = 13.5 km³

40 reservoirs

Water storage = 5 times of annual ET discharge

In situ data - scarce and difficult to access

DATA AQUISITION

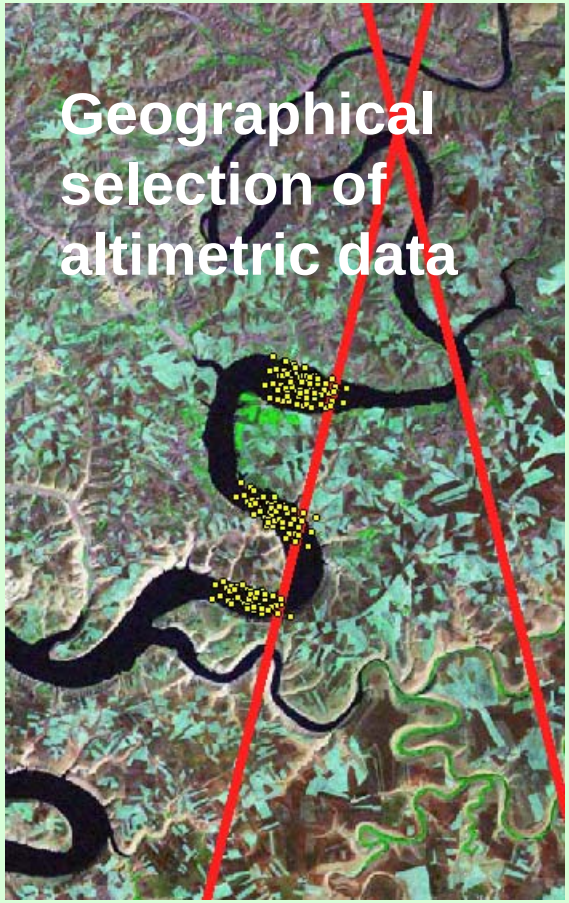
T/P (Oct 1992- Aug 2002, new orbit - Aug 2002-2005)
Jason-1 (since Feb 2002)
GFO (since Jan 2000)
ENVISAT (since Nov 2002)
GRACE (data since 2003)

FOOTPRINT: RADAR - 12 km (ocean), RADIOMETER - 22 TO 42 km, GRACE ~ 625 km^2

REPEAT PERIOD: 10 days (T/P, Jason), 17 days (GFO) and 35 (ENVISAT),

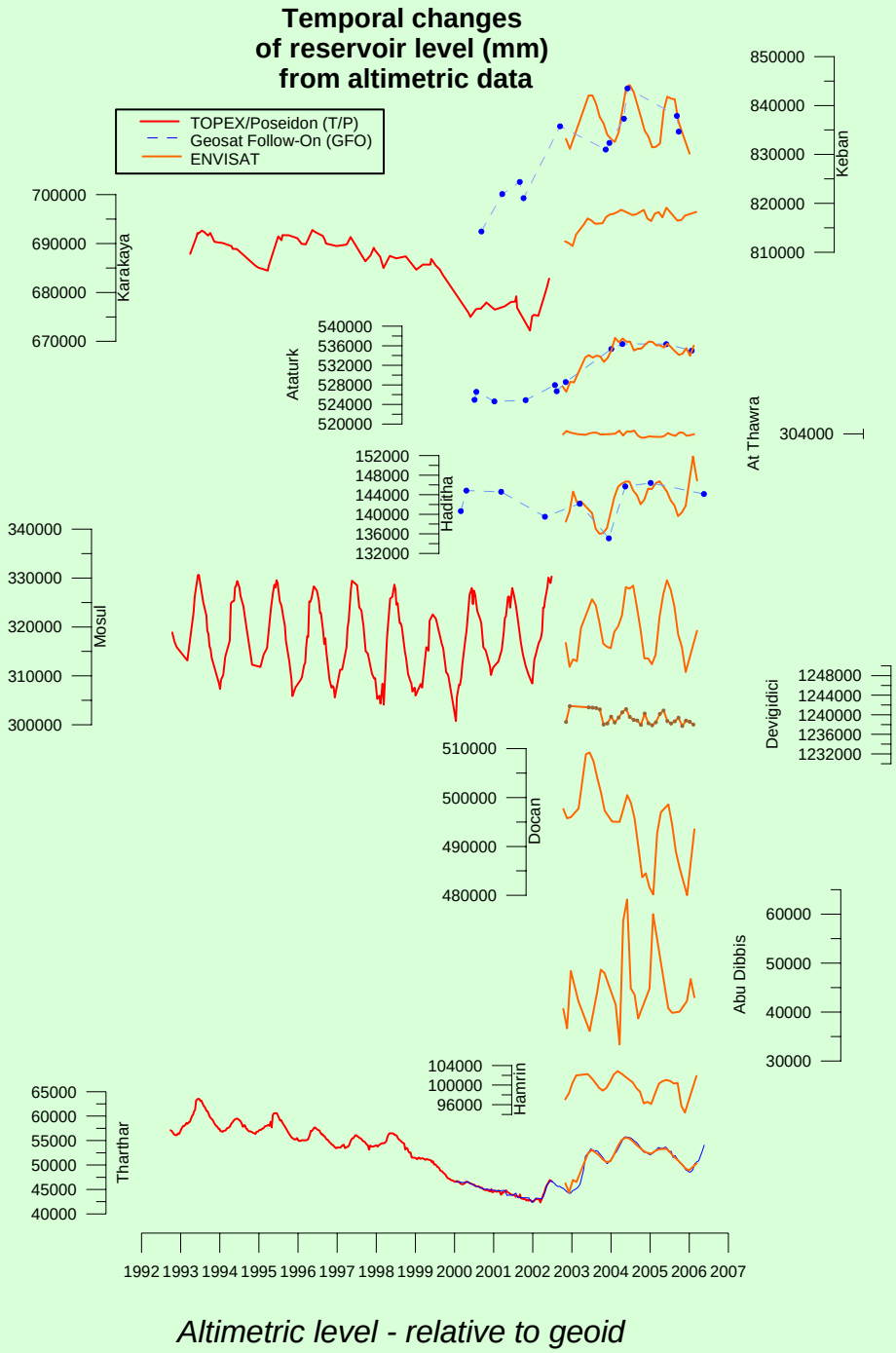
GRACE product: maps of 1-degree-square mean geoid height differences between 30-day solutions and EIGEN_GL04S static solution (10 days resolution).

From International Gravimetric Bureau (http://bgi.cnes.fr:8110/)



ENVISAT ground tracks and selected altimetric measures for all cycles (yellow circles) over the upper part of the Ataturk water reservoir. Background - Landsat TM image from ca 1990.

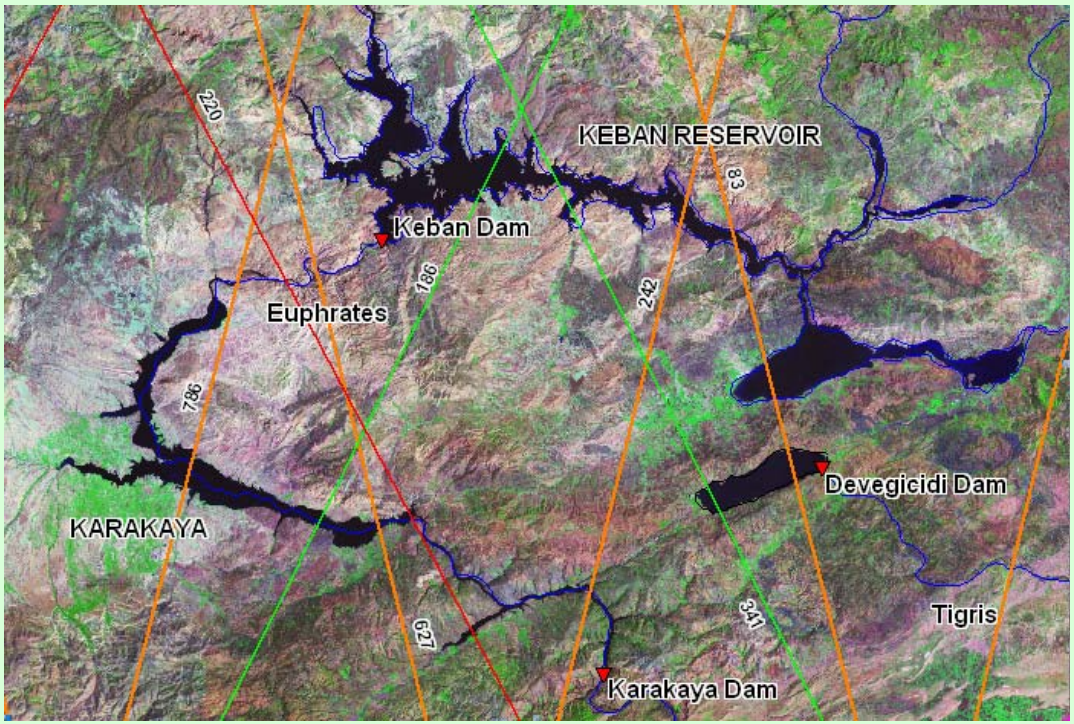
RESERVOIRS:
WATER LEVEL



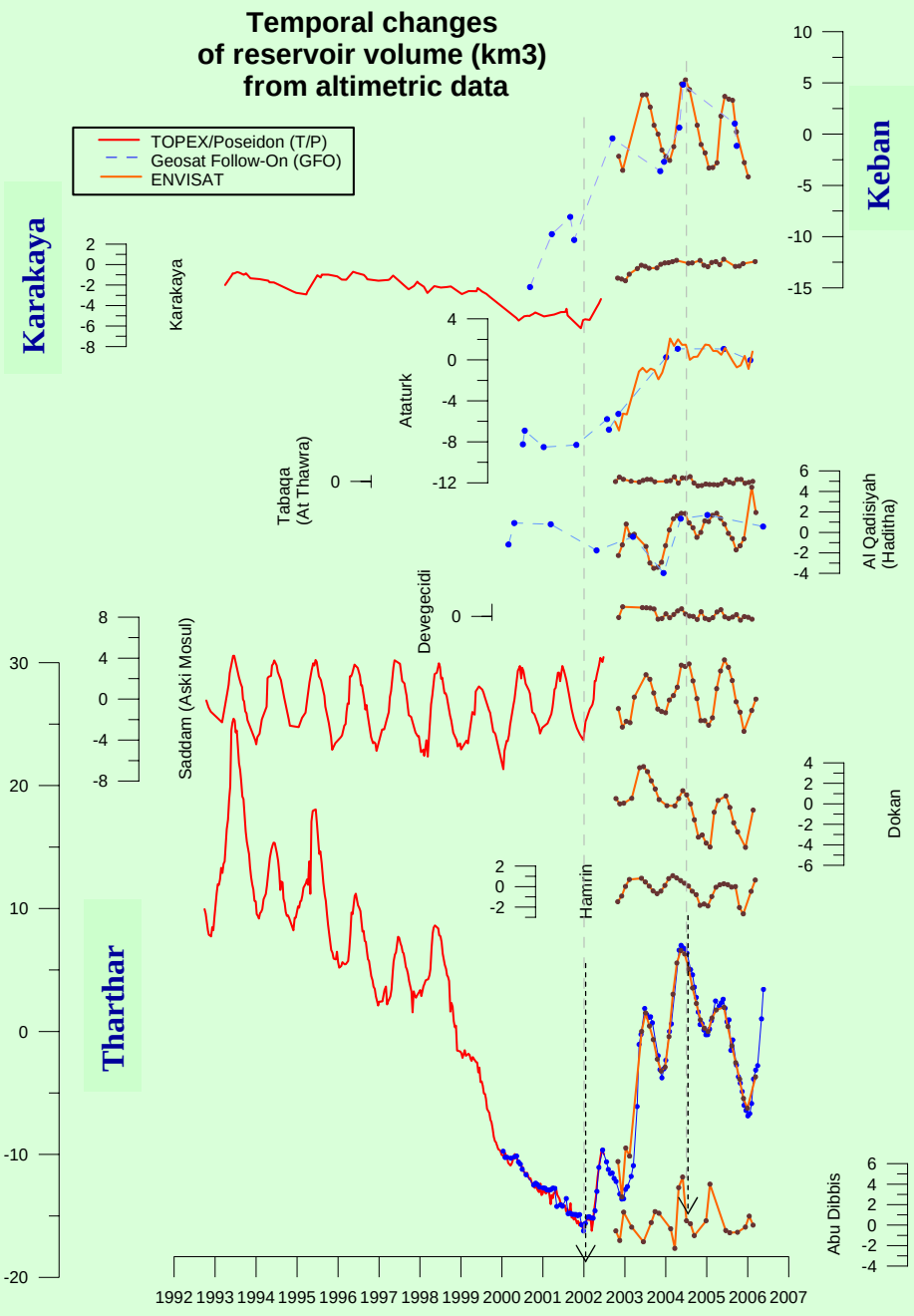
Altimetric level - relative to geoid

T/P + GFO + ENVISAT: Karakaya, Mosul and Tharthar

Cross-comparison of satellites Times series for 11 reservoirs



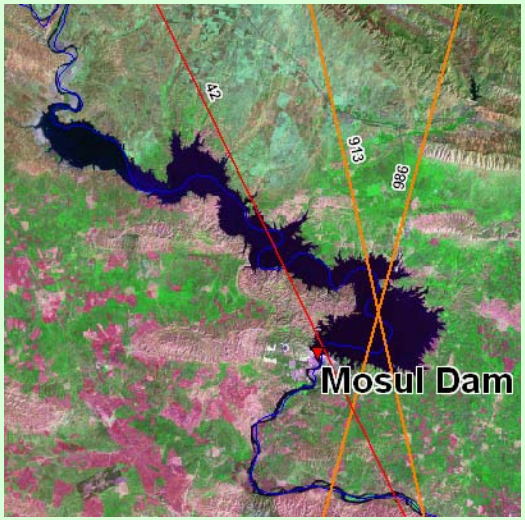
RESERVOIRS:
WATER VOLUME

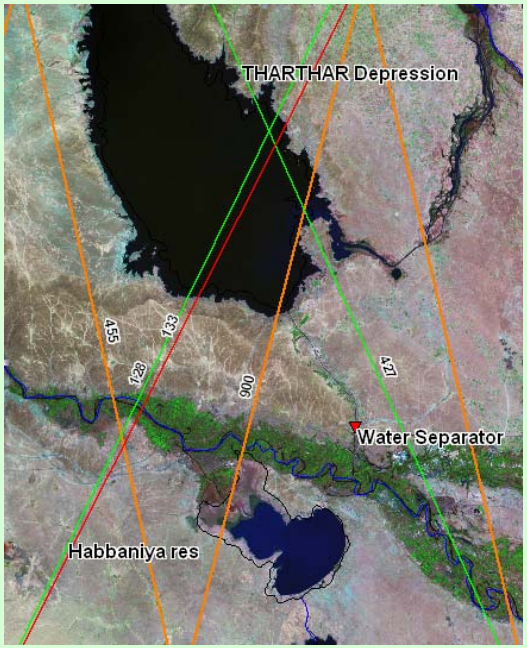


Volume changes - relative to mean value for 2002-2006

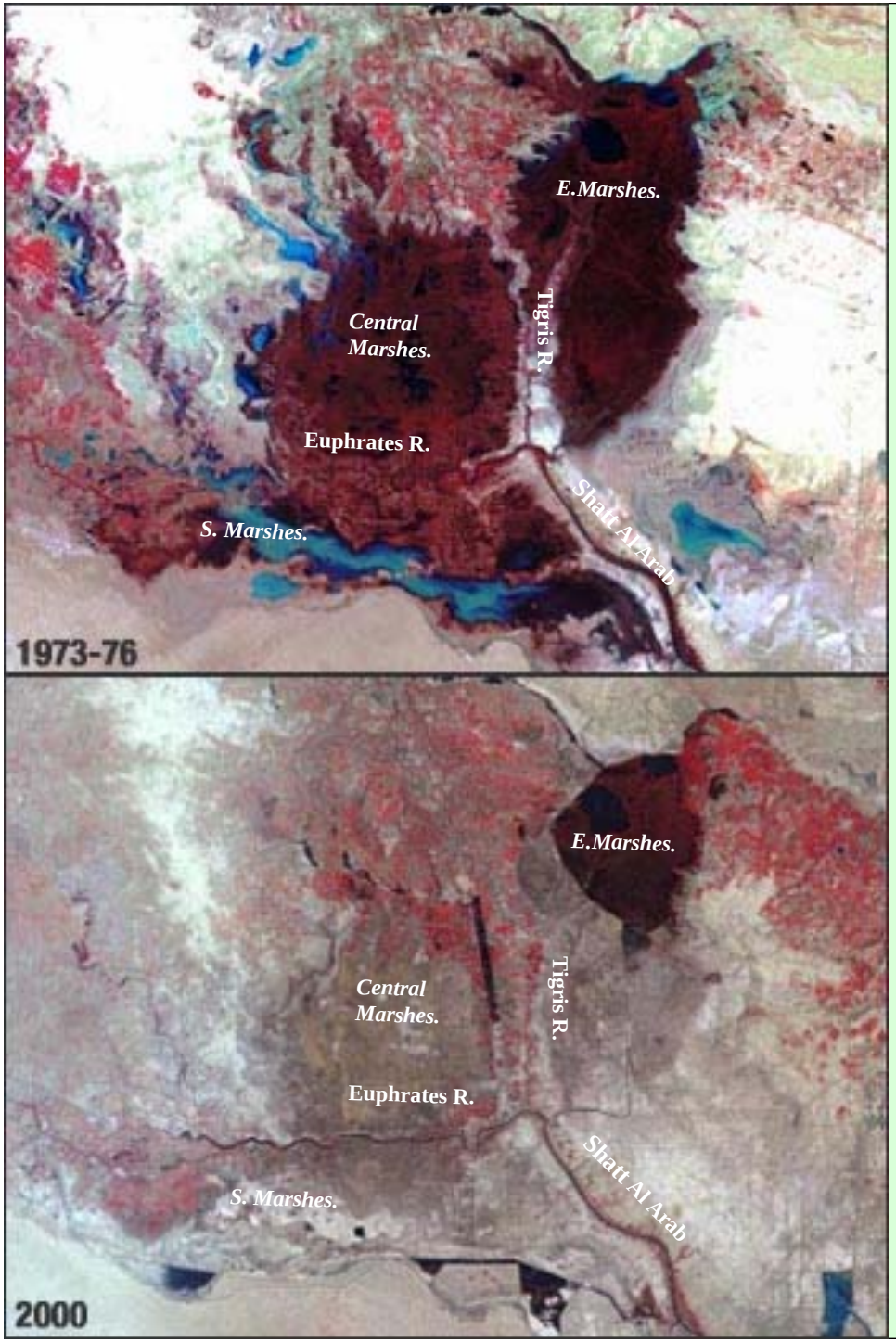
Preliminary assessment
(surface=const)

1999 - 2002
30 - 40 % of volume loss in reservoirs on Euphrates R.





MESOPOTAMIAN MARSHES



Multi-Spectral Scanner (MSS) aboard Landsat mom http://landsat.gsfc.nasa.gov/

Changes in the marshes from Landsat MSS imagery

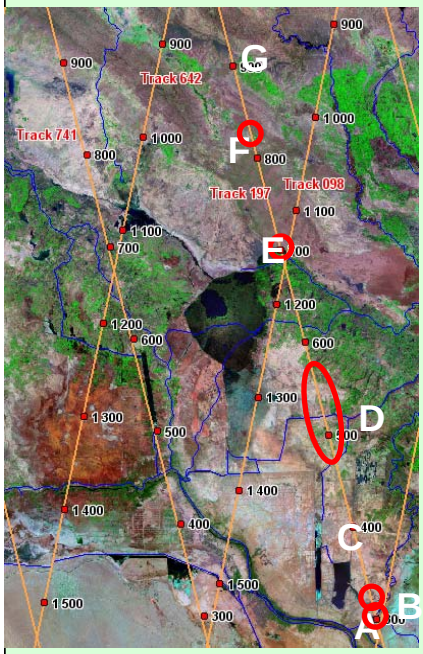
20,000 km² in 70s

3,000 km² in 90s

Hassan Janali, U.S. Army Corps of Engineers, 2003

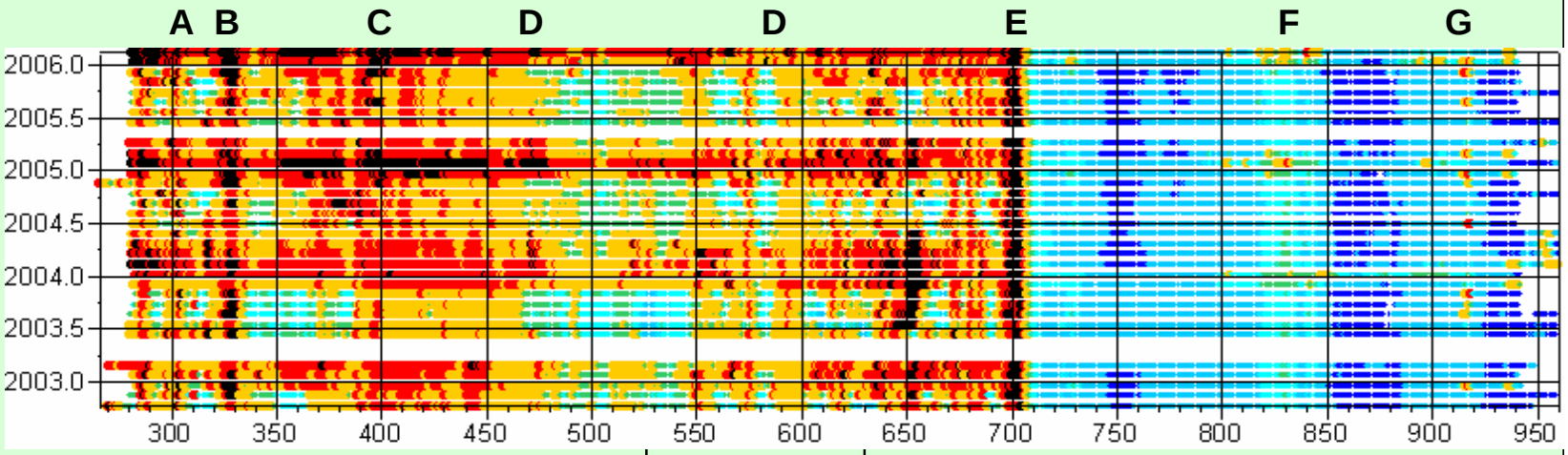
MARSHES

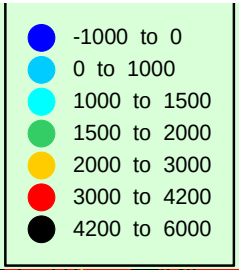
SPATIAL AND TEMPORAL VARIABILITY



Landsat image ca 2000

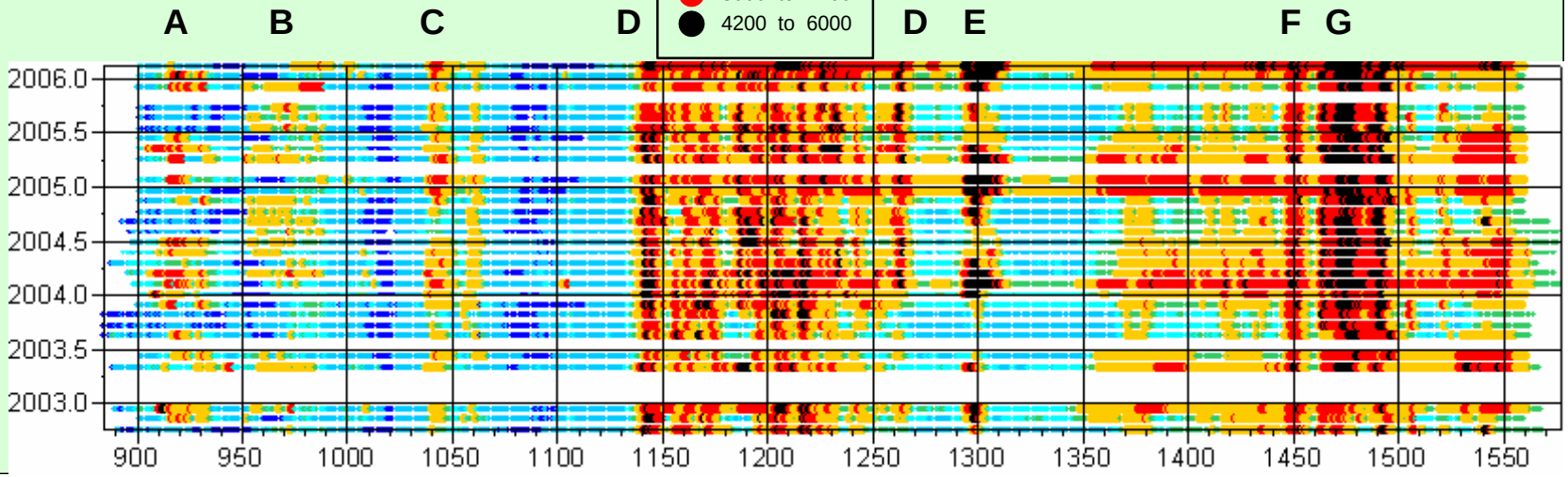
ENVISAT Tr.197





Backscatter in Ku band,
ice1 algorithlm,
100*dB

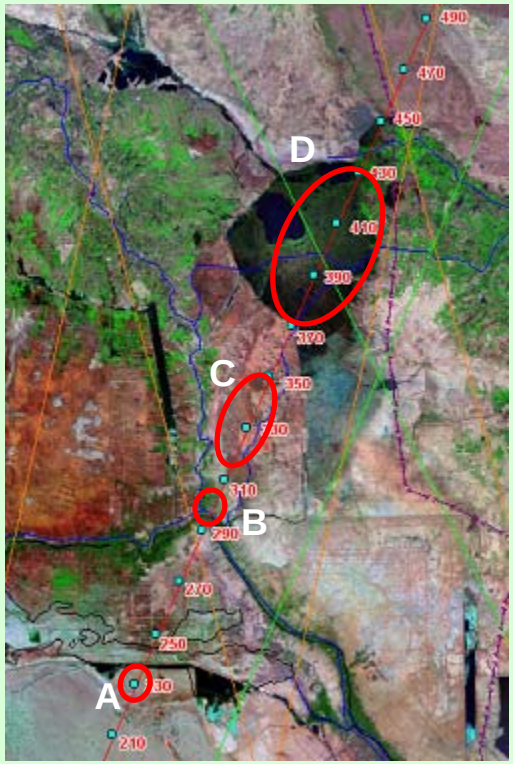
ENVISAT Tr.098



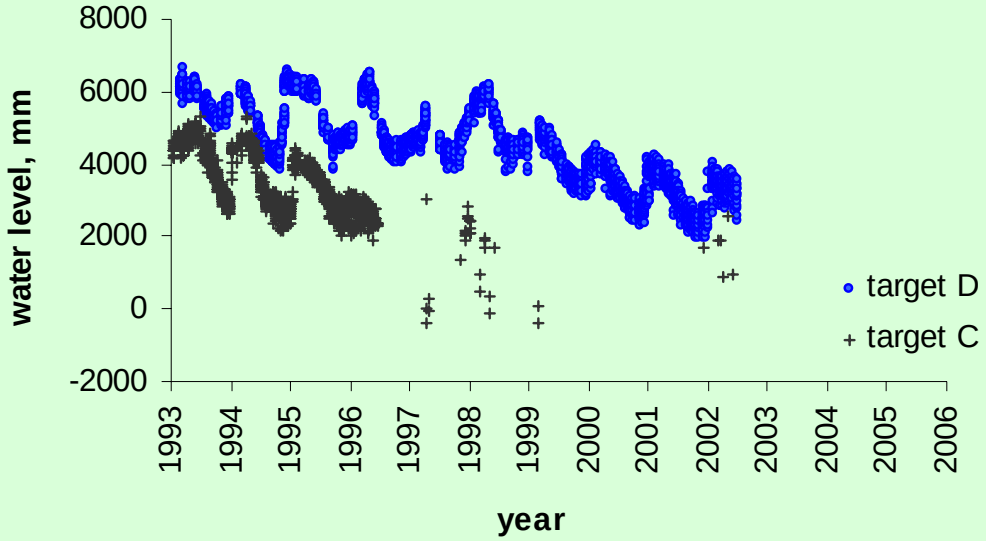
EASTERN MARSHES

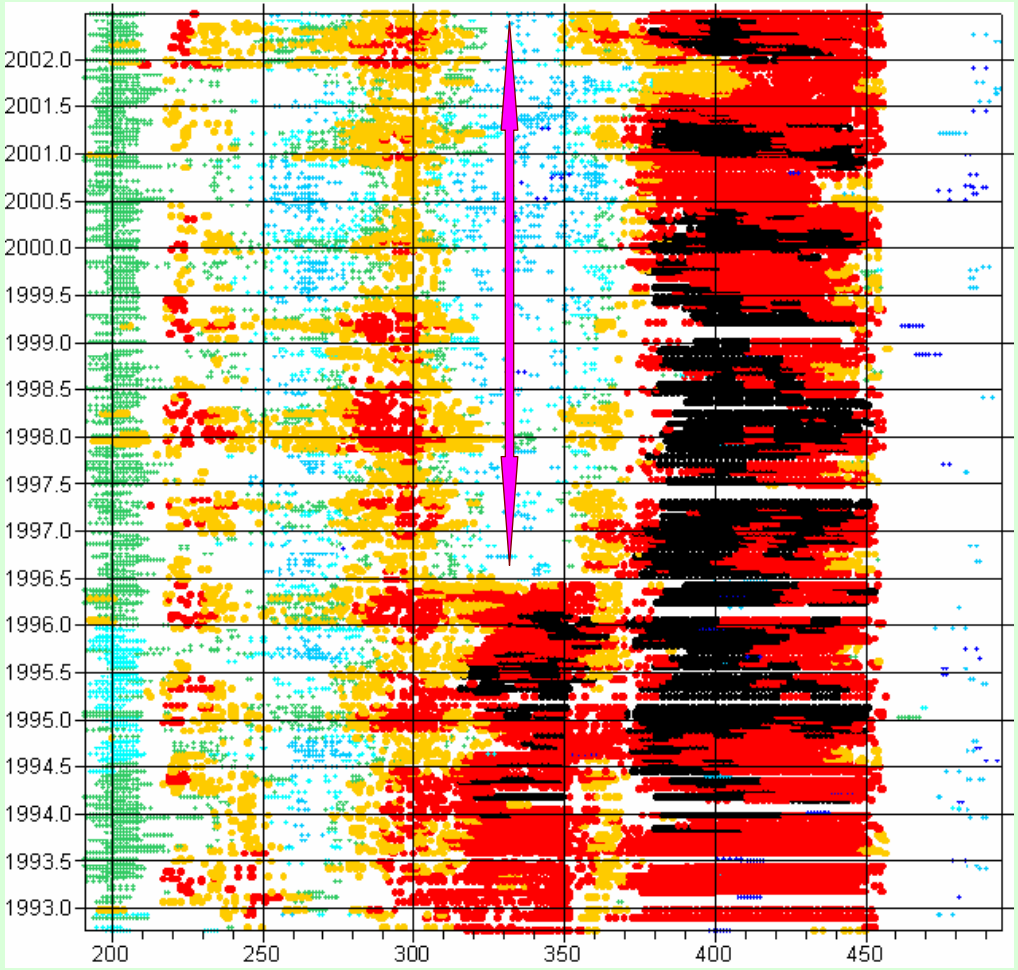
- T/P 31

Landsat image ca 1990



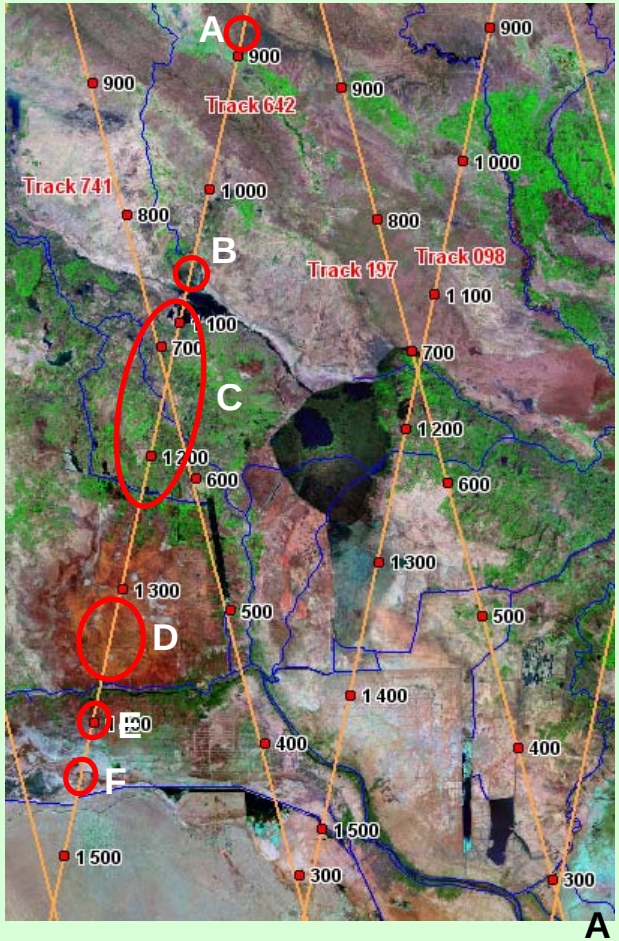
Landsat image ca 2000





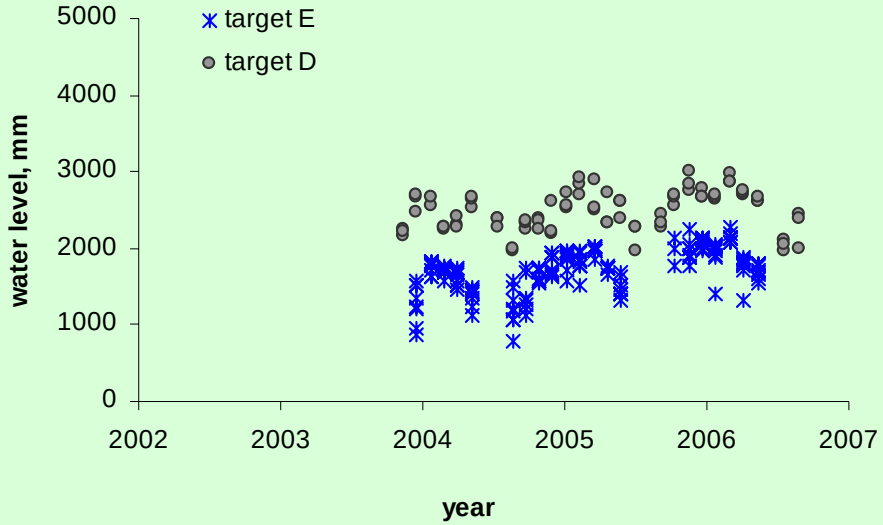
A - southern marshes
B - confluence of Tigris and Euphrates
C - part of eastern marshes,
drained out between 3 and 23 June 1996
D - eastern marshes

MARSHES - INONDATION

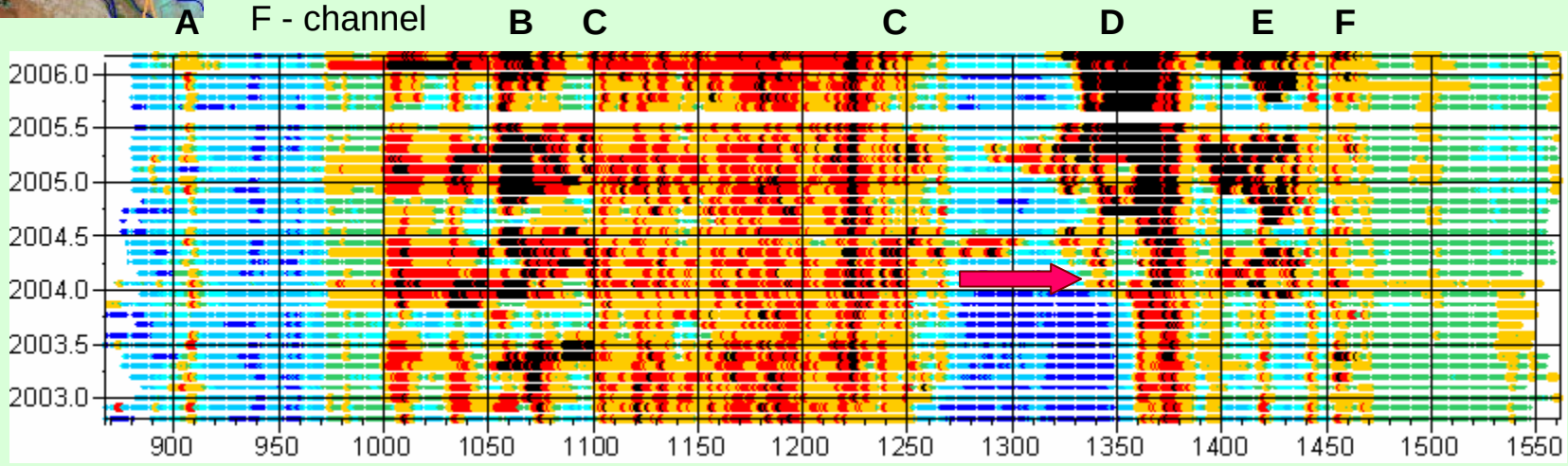


Landsat image ca 2000

ENVISAT Tr.642



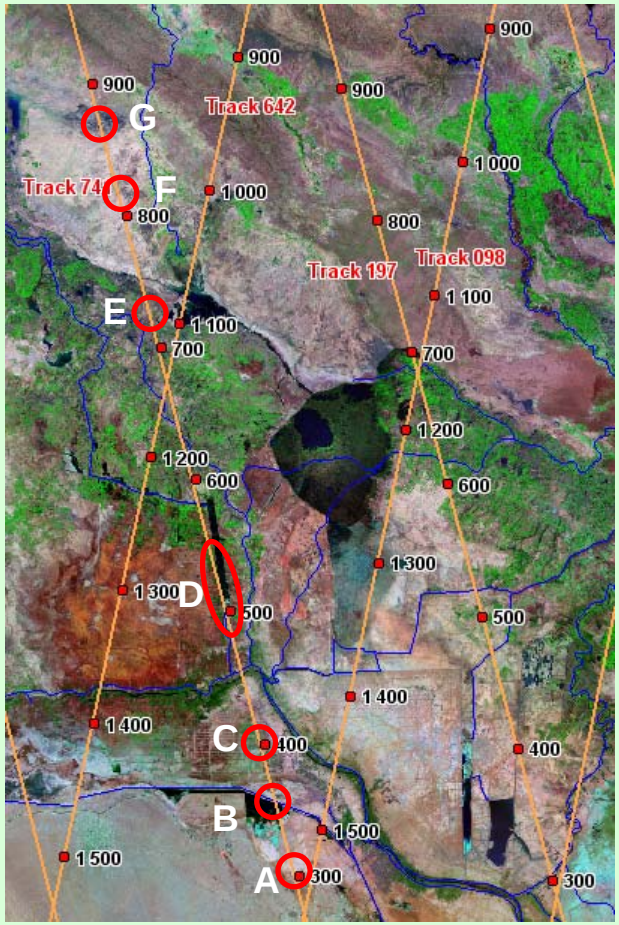
A - river channel
B - flooded reservoir
C - large flooded area
D - partly flooded central marshes
E - southern marshes have been drained out in 1996 and were flooded in 2004
F - channel



Backscatter in Ku band, ice1 algorithlm, 100*dB

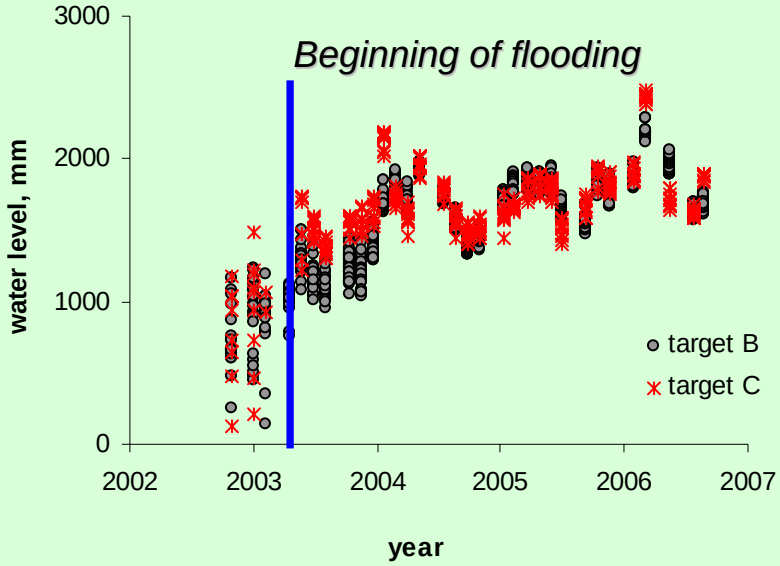
- -1000 to 0
- 0 to 1000
- 1000 to 1500
- 1500 to 2000
- 2000 to 3000
- 3000 to 4200
- 4200 to 6000

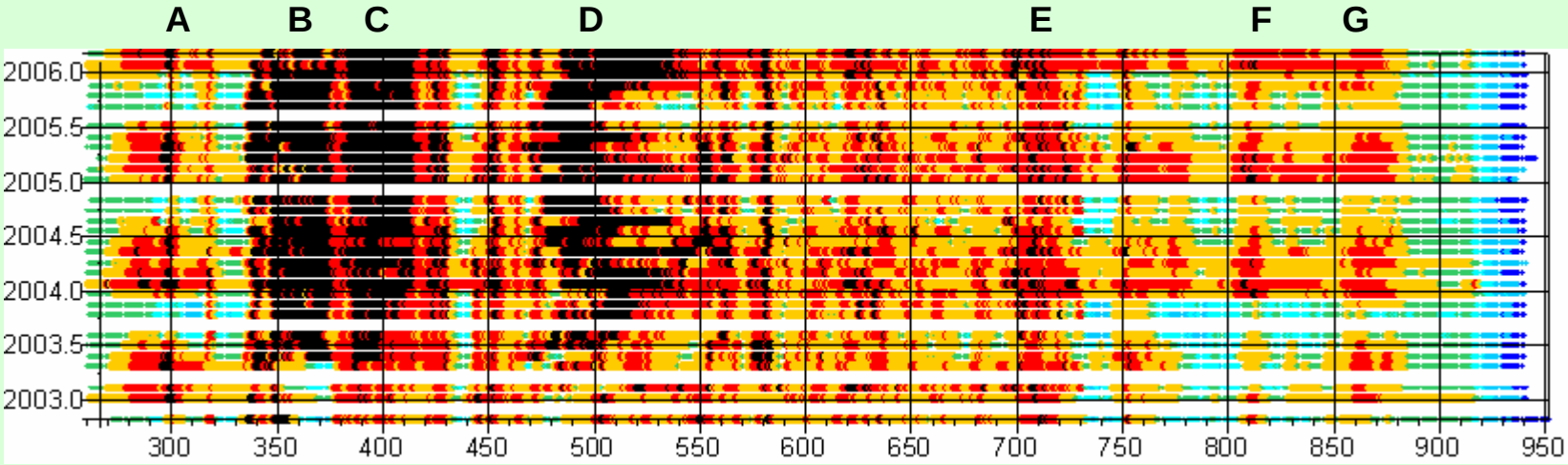
MARSHES -INONDATION



Landsat image ca 2000

ENVISAT 741



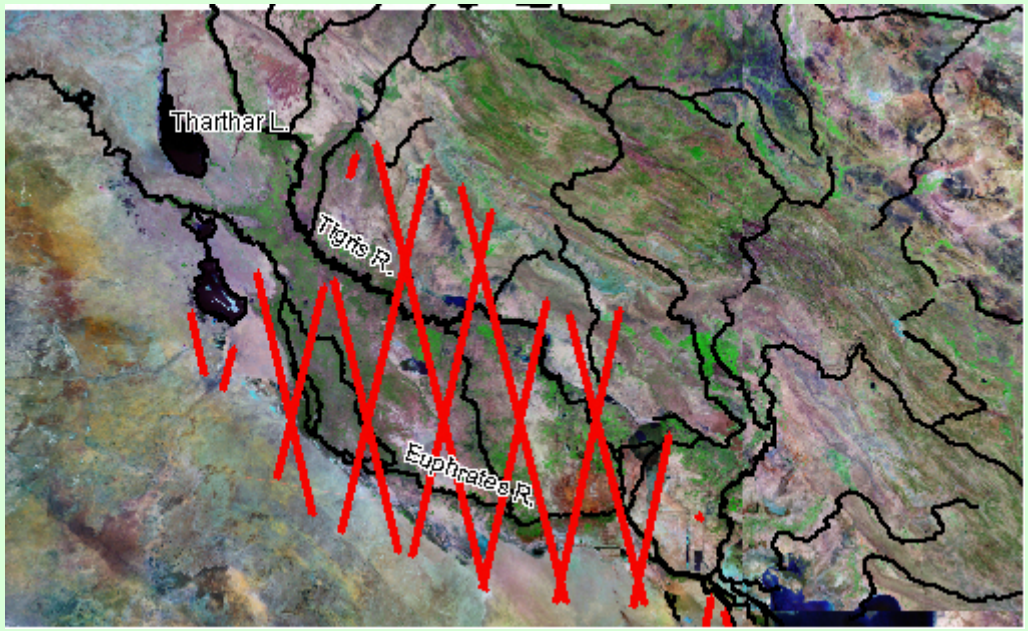


Backscatter in Ku band, ice1 algorithlm, 100*dB

- -1000 to 0
- 0 to 1000
- 1000 to 1500
- 1500 to 2000
- 2000 to 3000
- 3000 to 4200
- 4200 to 6000

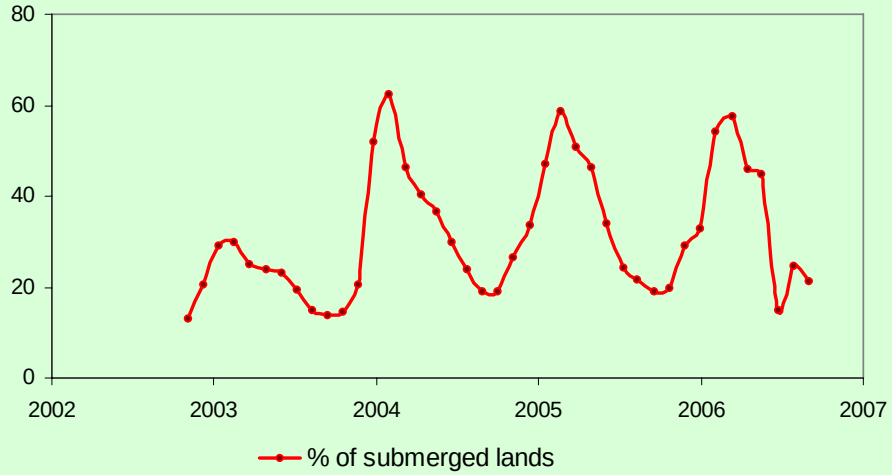
MARSHES -INONDATION

along track seasonal variability



Landsat image ca 2000 and Envisat tracks

% of submerged lands =
number of points with σ0_Ku≥20 db
total number of points



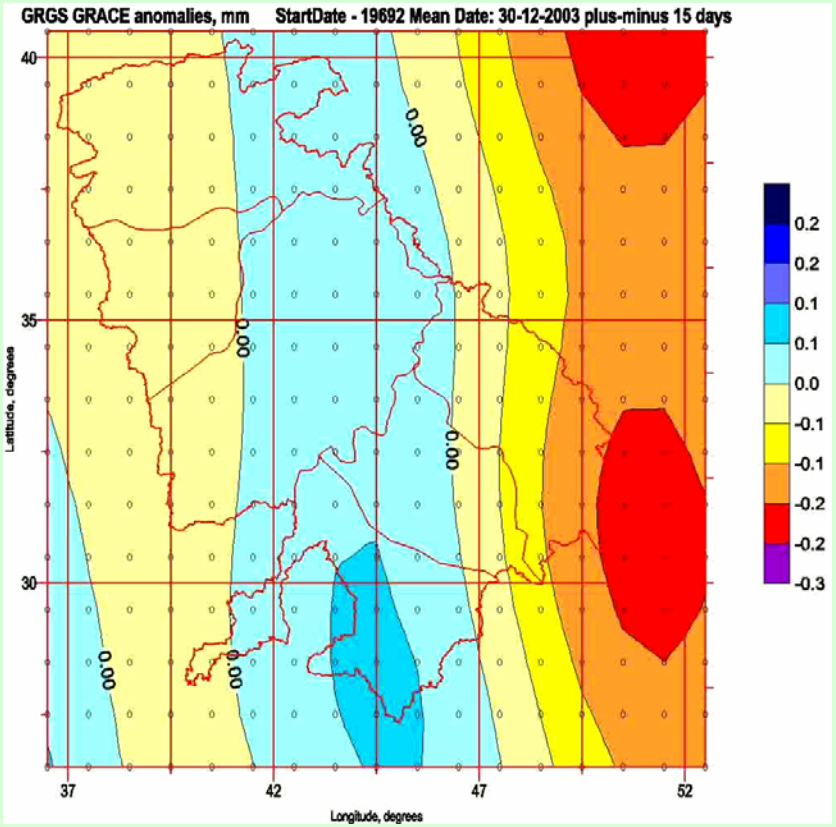
Perspectives:

- calibration of flooding areas with Modis
- estimation of water storage using altimetry

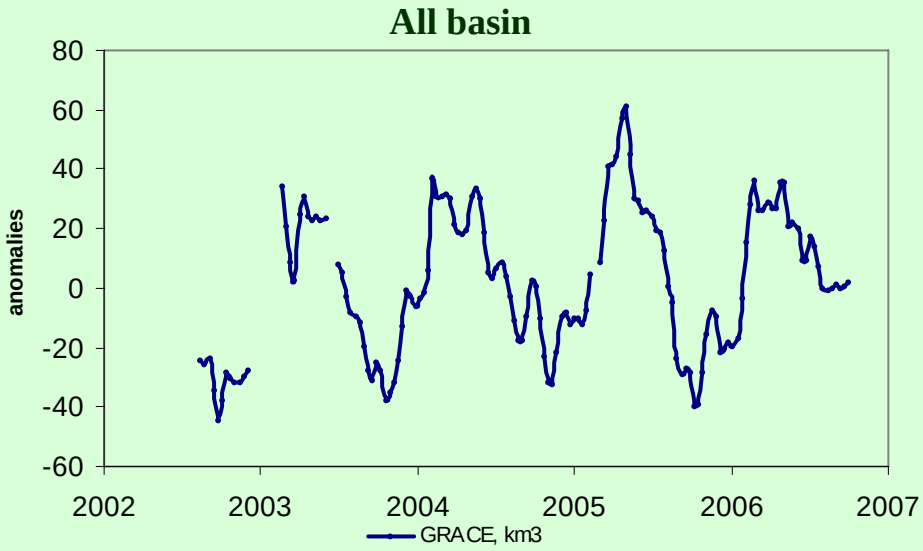
GRACE MISSION:

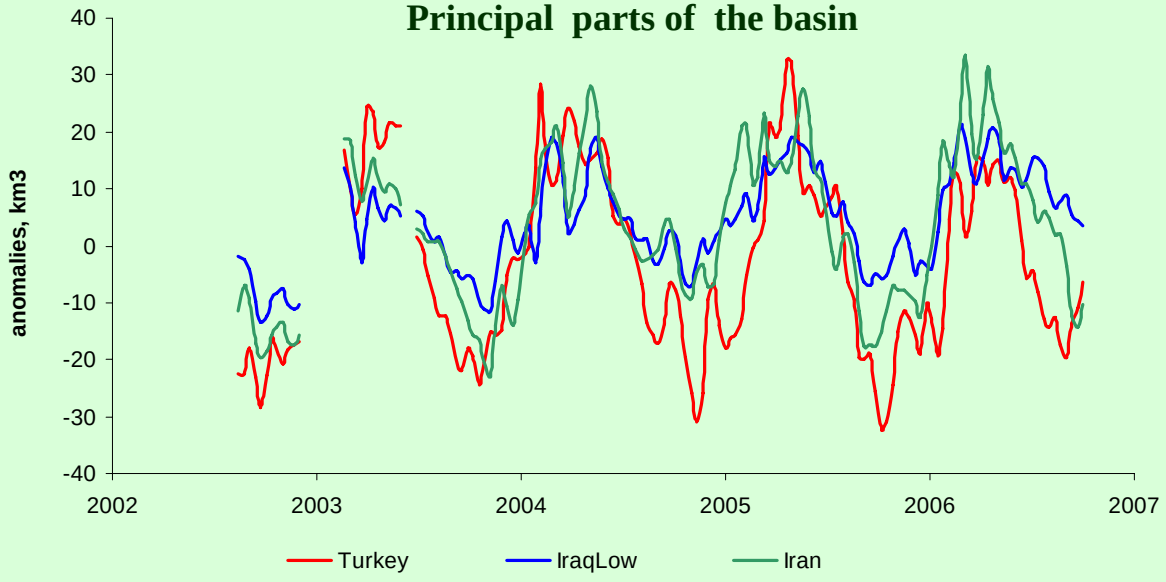
VARIABILITY IN WATER RESOURCES

Watershed surface
765 000 km²

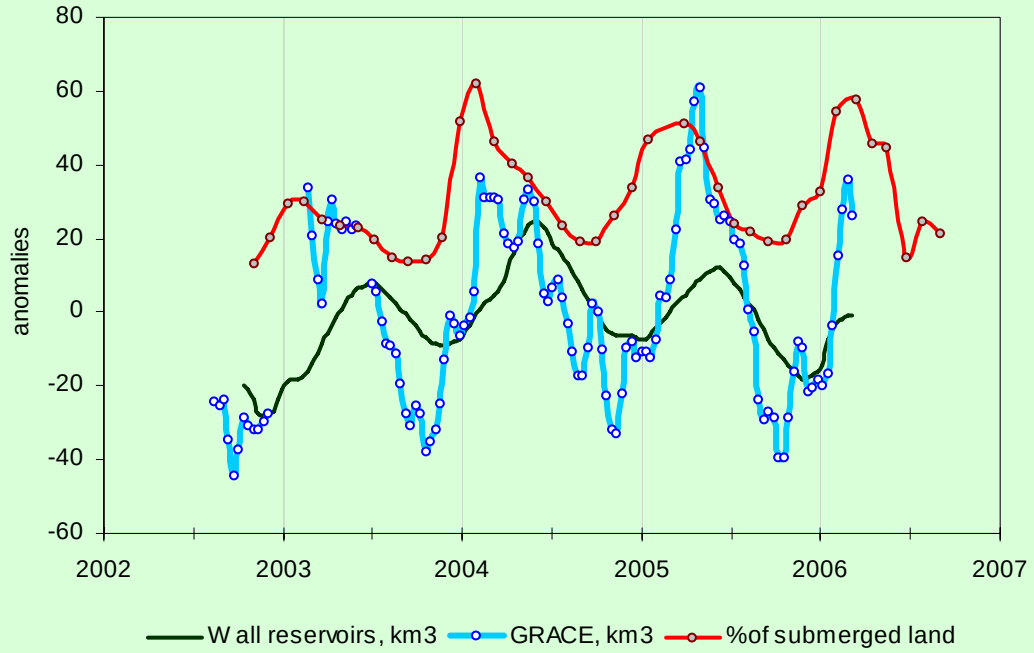


Gravity anomalies (mm) over the TE basin for 2004





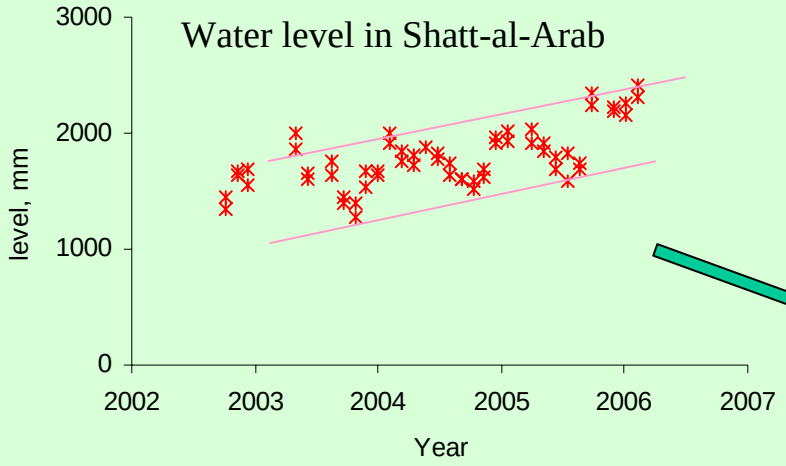
RELATION BETWEEN OBSERVED PARAMETERS

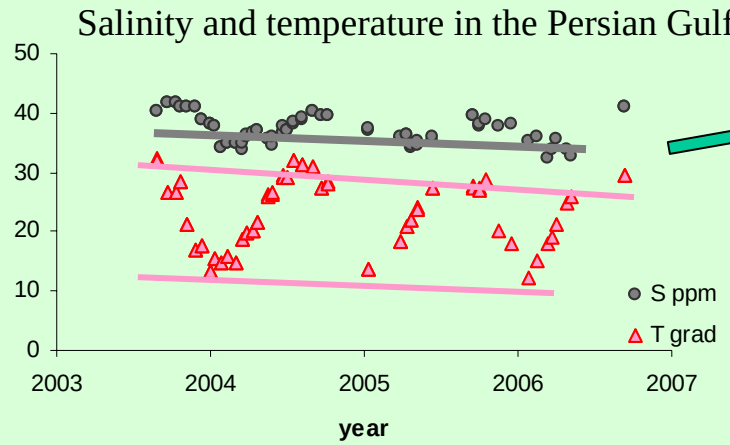


Cross-correlation coefficients between the part of submerged lands and other parameters , n≈40

Time lag, days	0	10	20	30	40	50	60	70	80	90	100	110	120
GRACE, ET	0.58	0.63	0.72	0.78	0.78	0.80	0.79	0.64	0.65	0.60	0.49	0.29	0.24
GRACE, Iran	0.68	0.75	0.78	0.83	0.80	0.73	0.69	0.67	0.61	0.52	0.42	0.25	0.12
GRACE, Turkey	0.56	0.57	0.65	0.73	0.73	0.73	0.71	0.58	0.59	0.54	0.38	0.18	0.12
GRACE, Low Iraq	0.56	0.66	0.69	0.75	0.78	0.73	0.77	0.69	0.63	0.57	0.54	0.40	0.32
Altimetry, dV in all reservoirs	0.20	0.29	0.38	0.47	0.55	0.63	0.69	0.74	0.77	0.79	0.79	0.77	0.72

IMPACT ON PERSIAN GULF





FUTURE WORK

* Assessment of reservoirs surface-level relationship using optical imagery

* More precise estimation of reservoirs volumetric changes

* Altimetry + optical imagery - flooded regions

* Surface and level of flooded zones

* Estimation of annual and seasonal changes in water storage

* Freshwater input to the Persian gulf