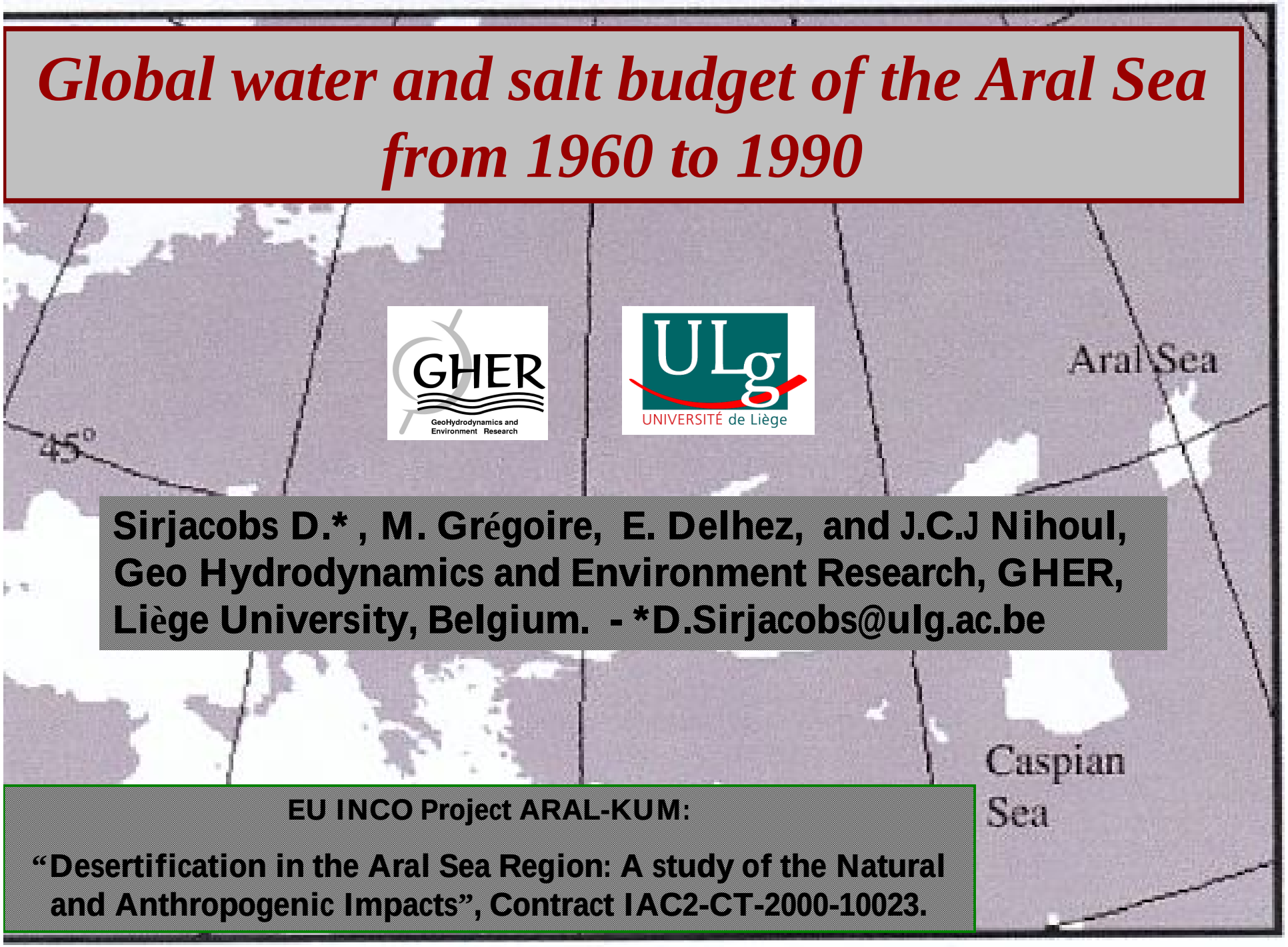
Global water and salt budget of the Aral Sea from 1960 to 1990



Sirjacobs D.* , M. Grégoire, E. Delhez, and J.C.J Nihoul,
Geo Hydrodynamics and Environment Research, GHER,
Liège University, Belgium. - *D.Sirjacobs@ulg.ac.be

EU INCO Project ARAL-KUM:

"Desertification in the Aral Sea Region: A study of the Natural and Anthropogenic Impacts", Contract IAC2-CT-2000-10023.

1. Introduction

- **Task of the GHER within the ARAL-KUM Project:**
  implementation of a 3D coupled physical-biological model of the Aral Sea

First results of hydrodynamic model presented tomorrow, at the INCO special session

First steps of work:

1) Gather large water balance data set for the Aral region

2) Implement a simplified water and salt balance model

3) Assess the quality of the digitized bathymetry used

4) Assess the quality of the whole water component dataset in order to provide a correct simulation of basic Aral Sea characteristics (level, volume, area, salinity)

List of litterature data used

A: Aladin, N.V., I.S. Plotnikov and W.T.W. Potts, The Aral Sea dessication and possible ways of rehabilitating and conserving its northern part, Environmetrics, 6(1), 1995, pp 17-29.

D: Dement 'ev, N.F. Analysis of the causes of the Aral Sea Drying up, 1993, Russian Meteorology and Hydrology, 6, pp 59-65.

G: Glazovsky, N.F., Aral Sea, in Mandych (see Mnd), pp 19-154.

K: Kostianoy, A., personnal communication within Aral-Kum INCO project, 2001.

L: Lyatkher, M., Solar cycle length stochastic association with caspian sea, Geophysical Research Letters, 2000, 27(22), pp 3727-3730.

Mick: Micklin, P.P. and Williams W. D., The Aral Sea Bassin, 1996, Springer eds, Berlin.

Mill: Miller, J.R., R.F. Ferrari and G.L. Russell, Modeling the effect of wetlands, flooding, and irrigation on river flow : Application to the Aral Sea, Water Ressources Research, 35(6), 1999, pp 1869-1876.

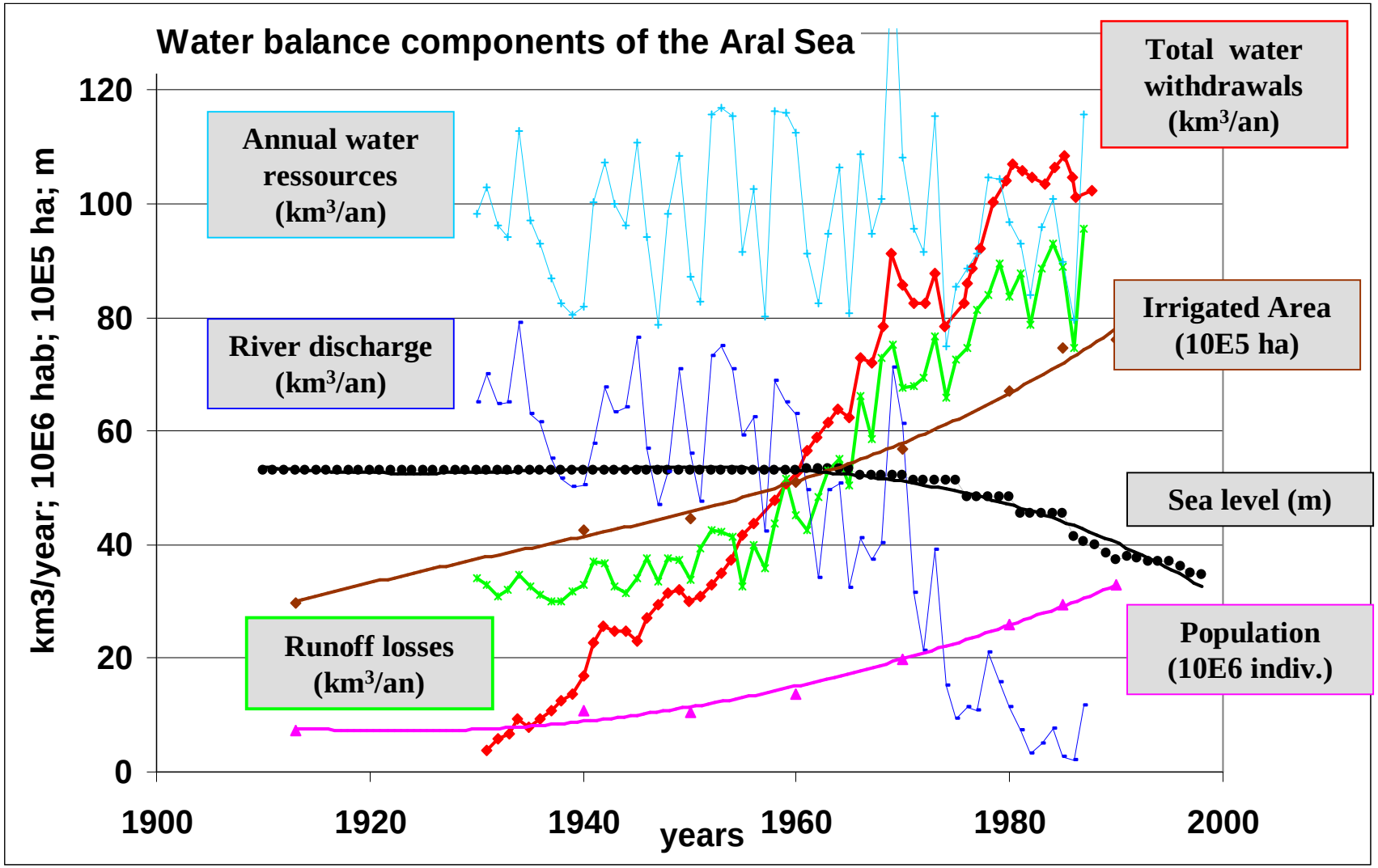
Mnd: Mandych, A.F., Enclosed seas and large lakes of eastern Europe and middle Asia, ed. by A.F. Mandych. –Amsterdam : SPB Academic publishing.-III.

P: Perminov, V.M., Yu.A. Reva, and A.G. Tsytsarin, Seasonal variations of the Aral Sea level under contemporary conditions, Russian Meteorology & Hydrology, 11, 1993 (1994), pp 67-73.

R: Russian Hydrology and Meteorology Institute, Synthesis of hydro-meteorological data of the Aral Sea, 1990, 200 p.

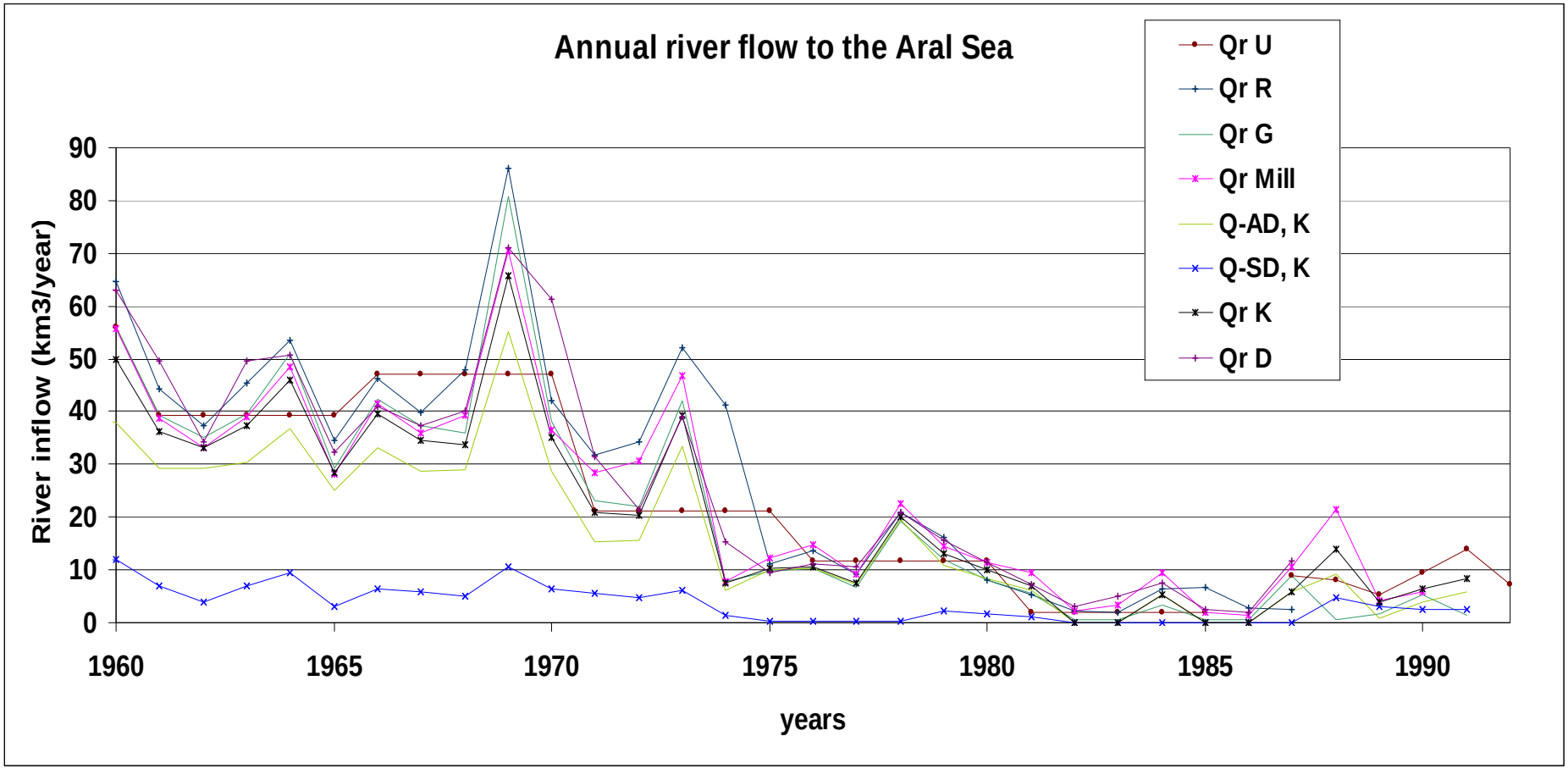
U: UNEP, 1992 in Barth, A., Modélisation mathématique et numérique de la mer d'Aral, Travail de fin d'études de Licence en Sciences Physiques, Université de Liège, 2000.

The anthropic factor in the Aral Sea Watershed

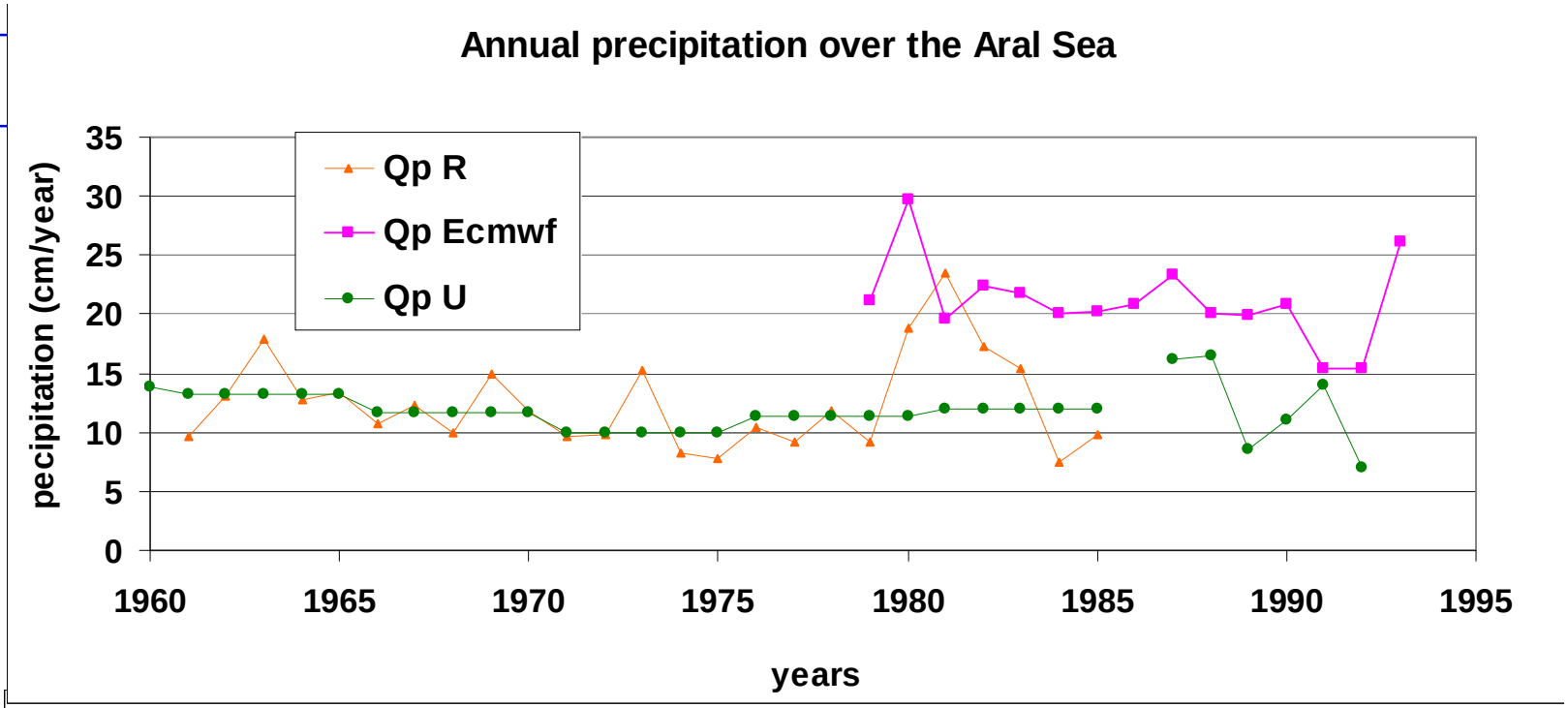


2. Annual water balance components: synthesis of available data

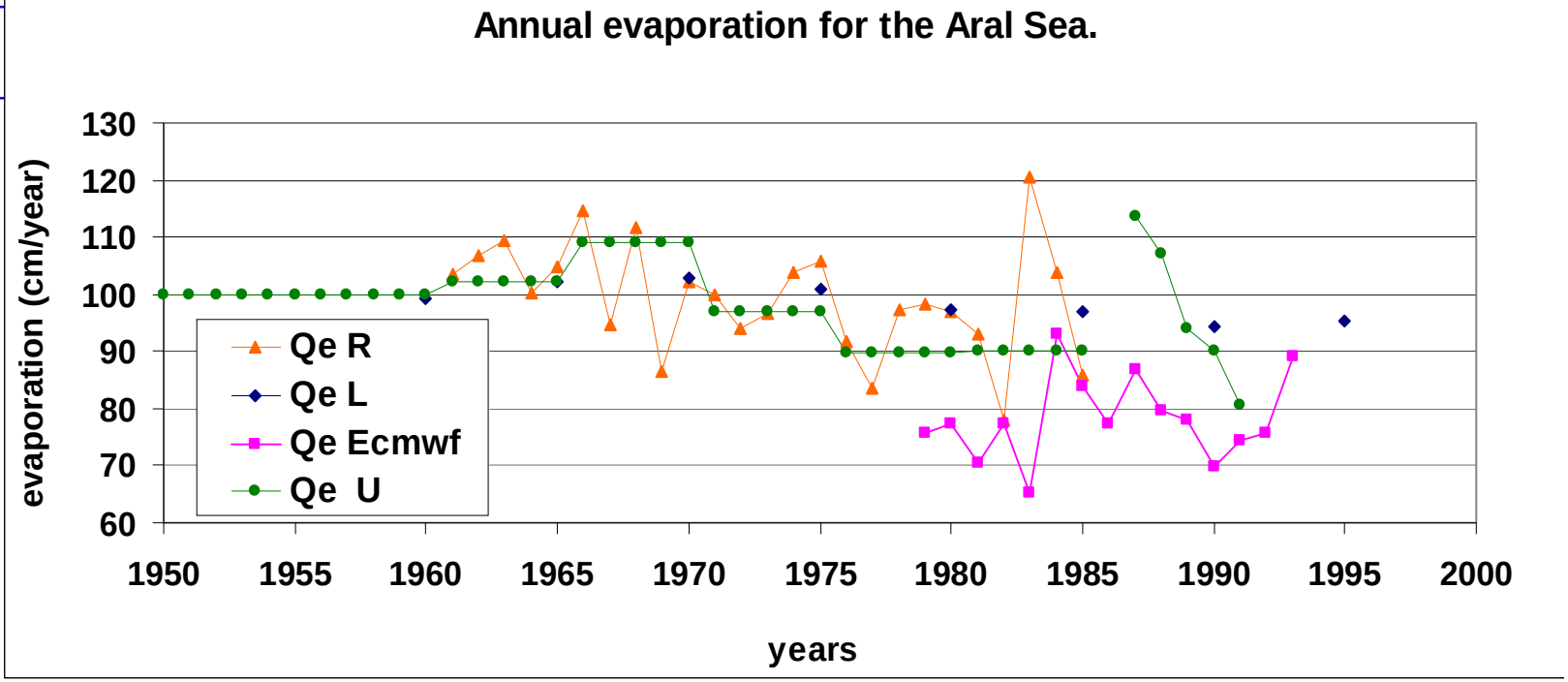
River discharge



Precipitation

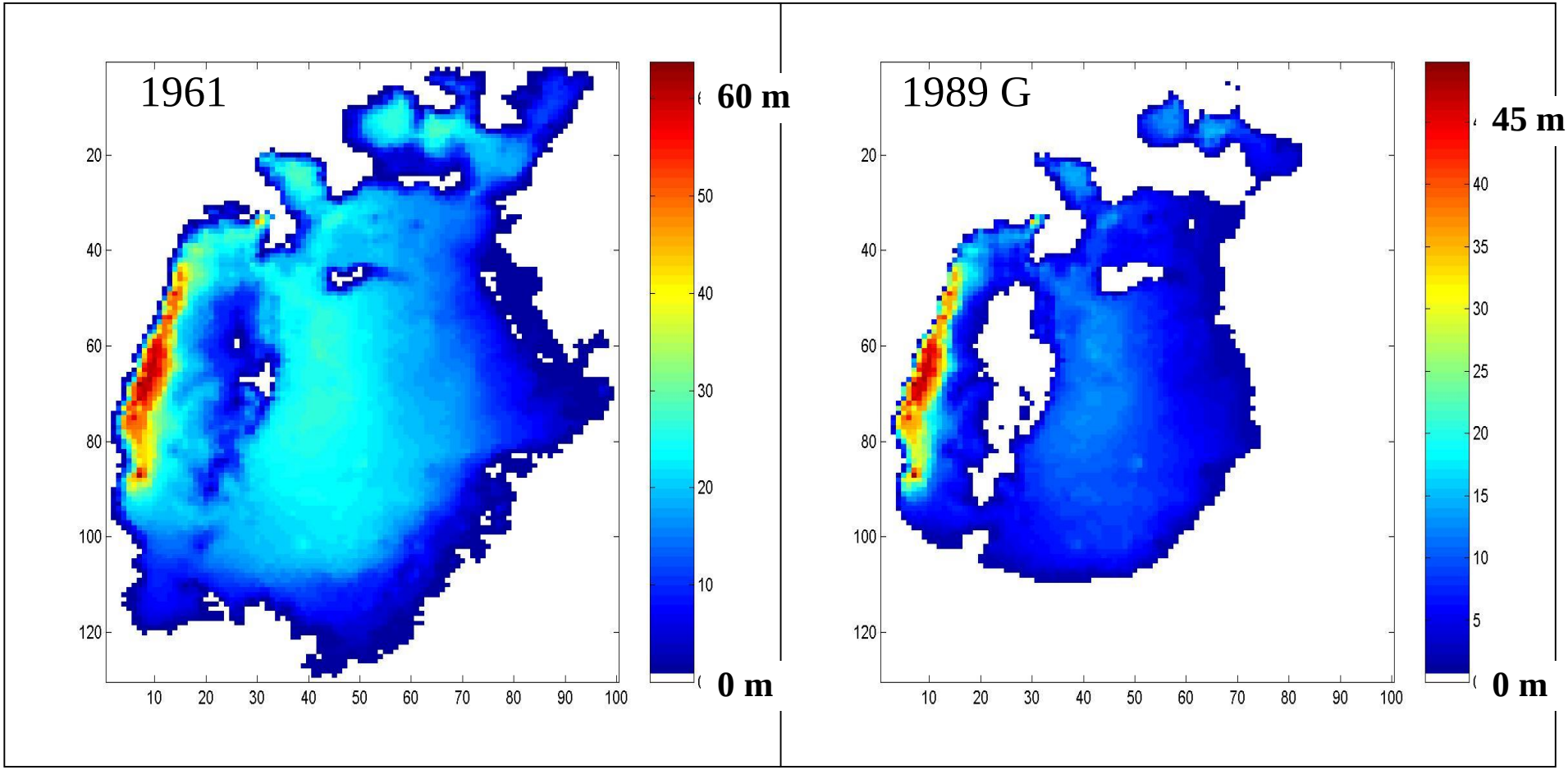


Evaporation

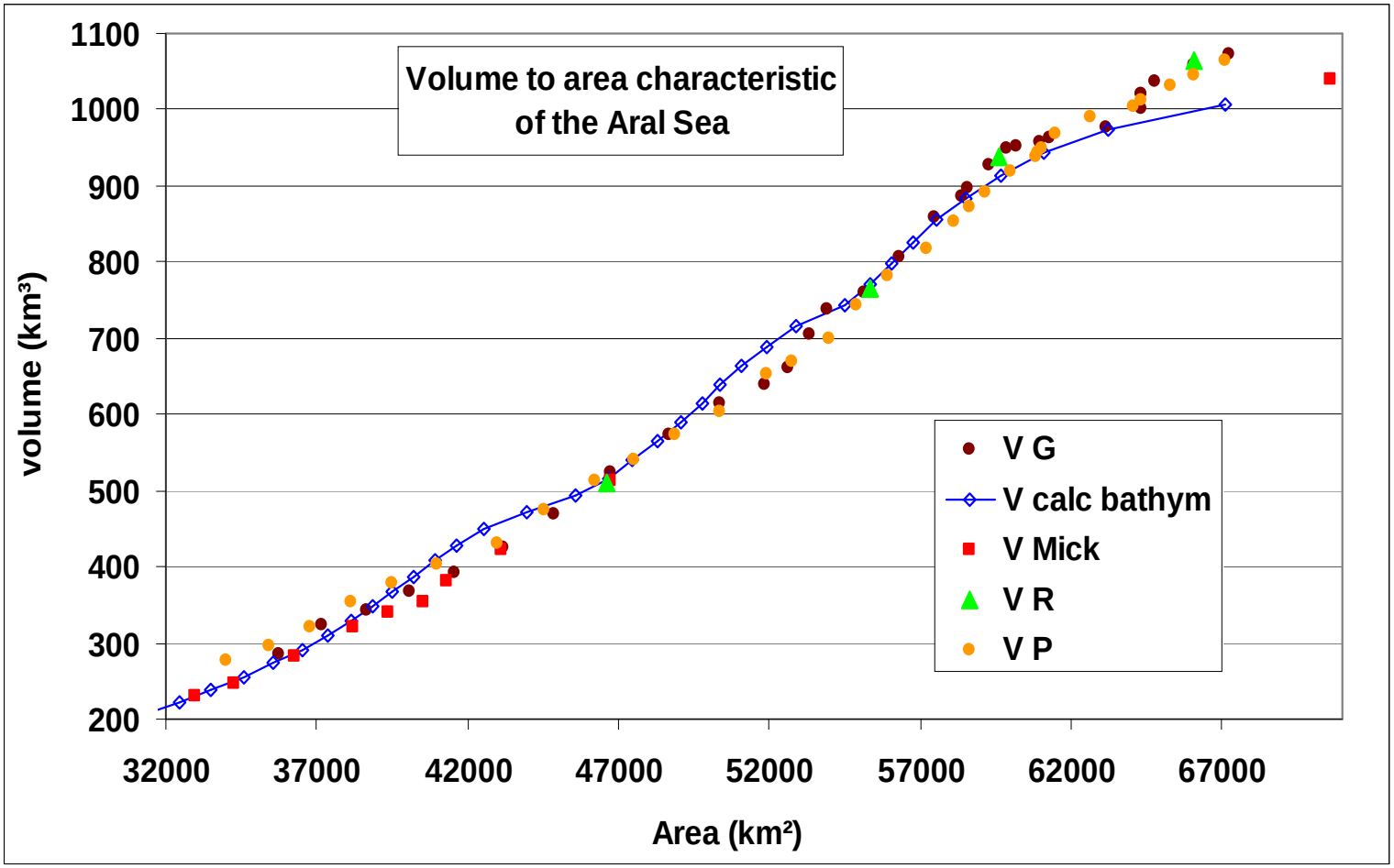


3. *Simulation of the shrinking process of the Aral Sea*

water and salt balance model

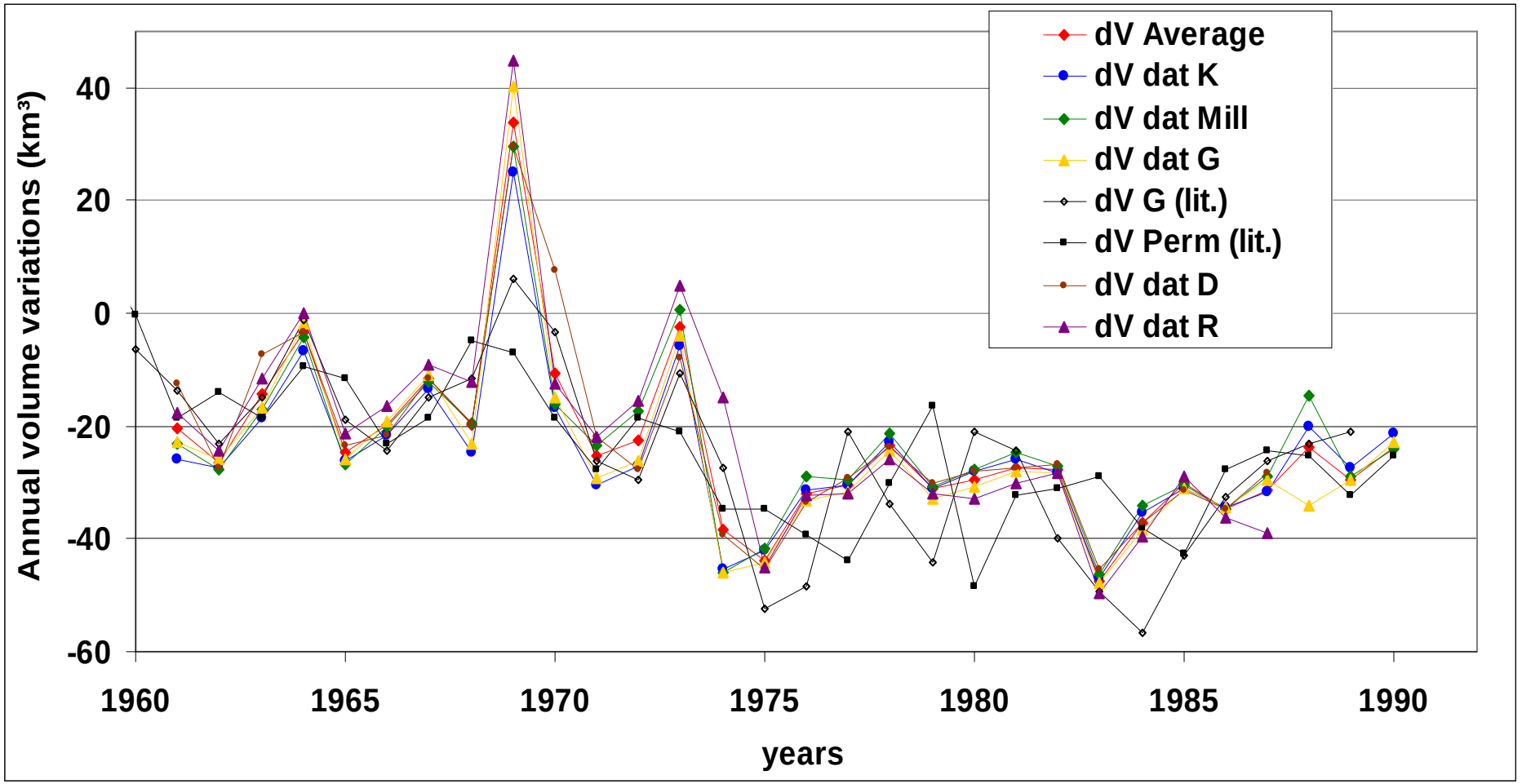


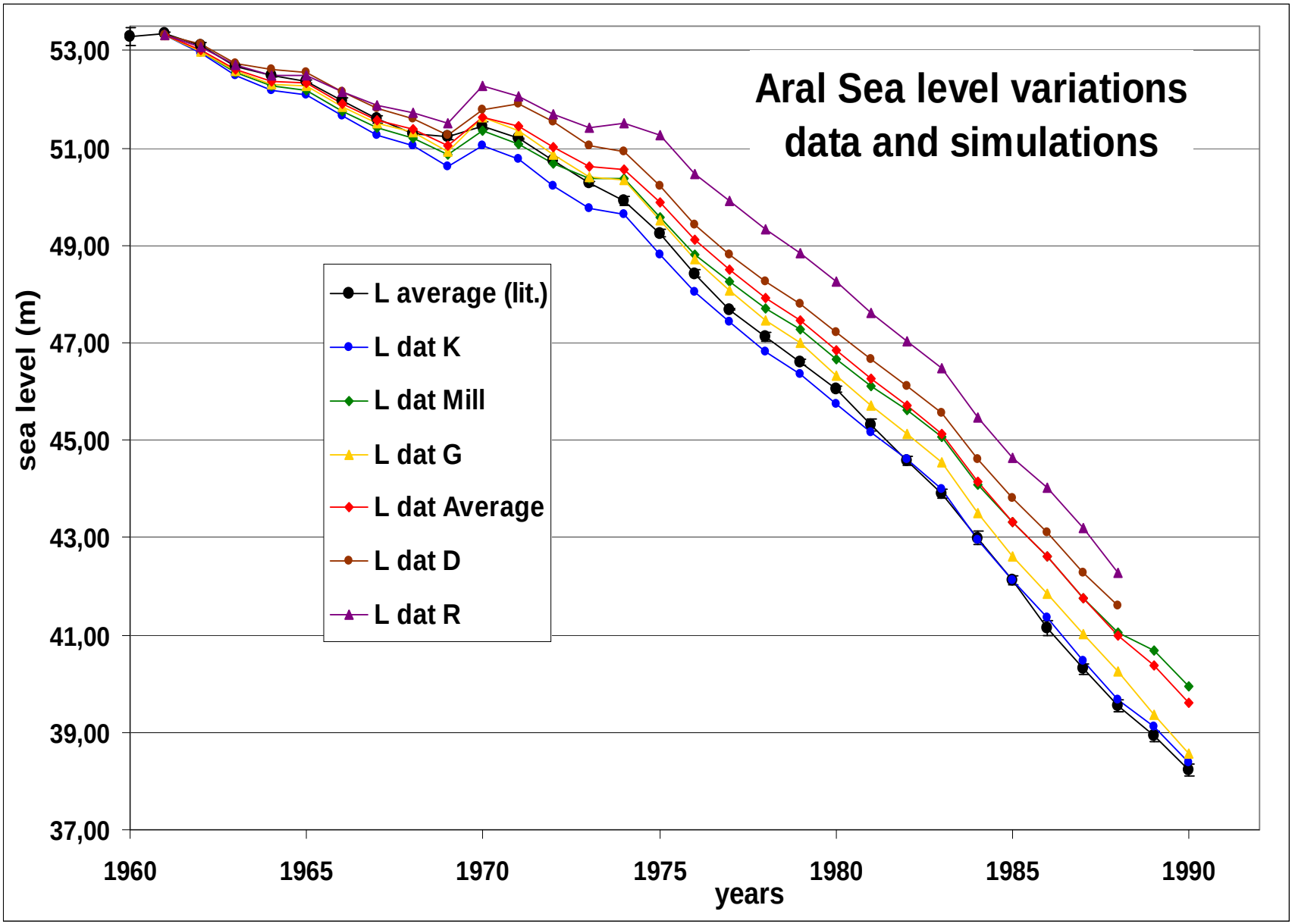
morphometric curves

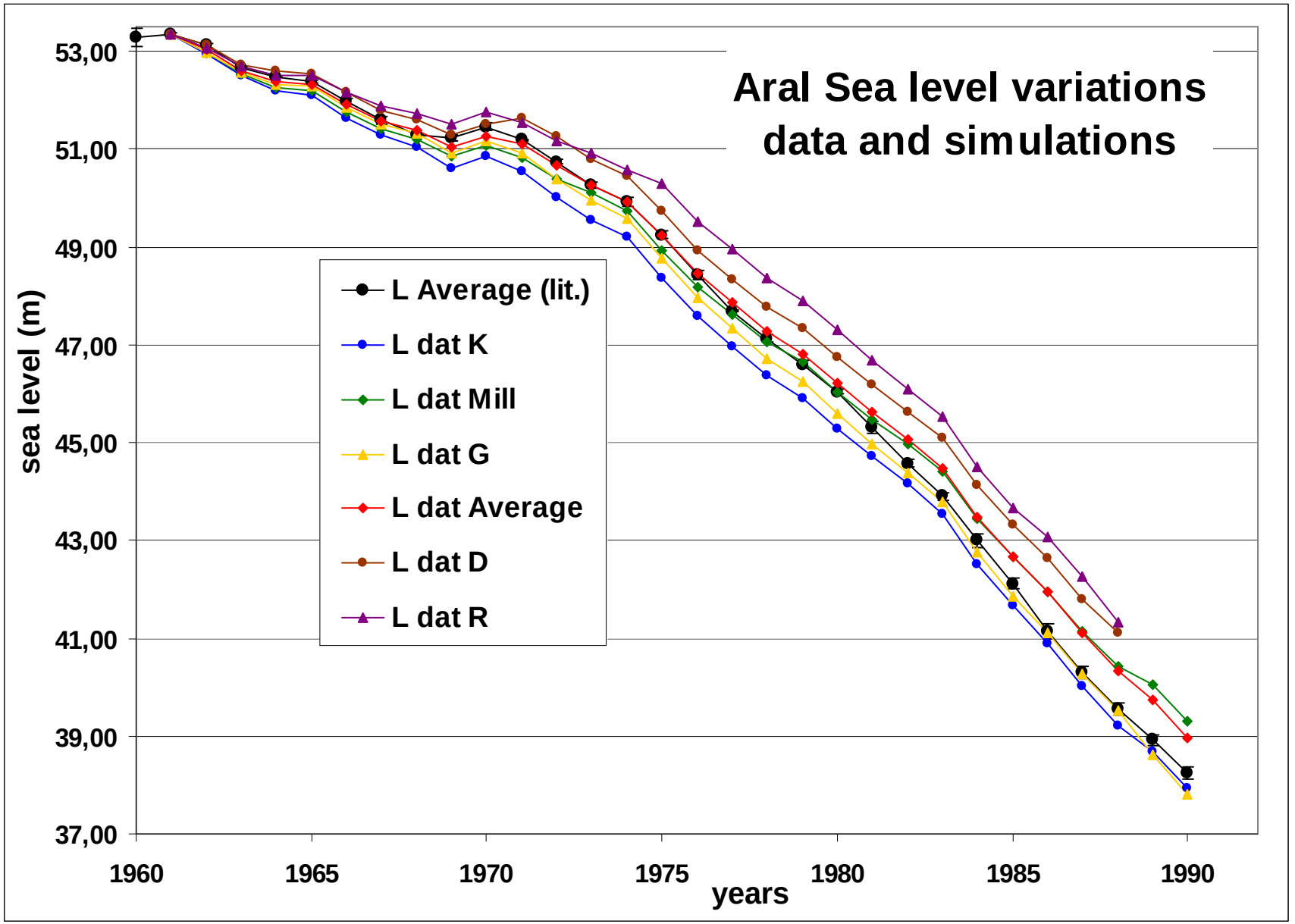


Quality assesment of the dataset

Annual fluctuations of Aral Sea volume




Aral Sea level variations
data and simulations
sea level (m)
53,00
51,00
49,00
47,00
45,00
43,00
41,00
39,00
37,00
1960
1965
1970
1975
1980
1985
1990
years
L average (lit.)
L dat K
L dat Mill
L dat G
L dat Average
L dat D
L dat R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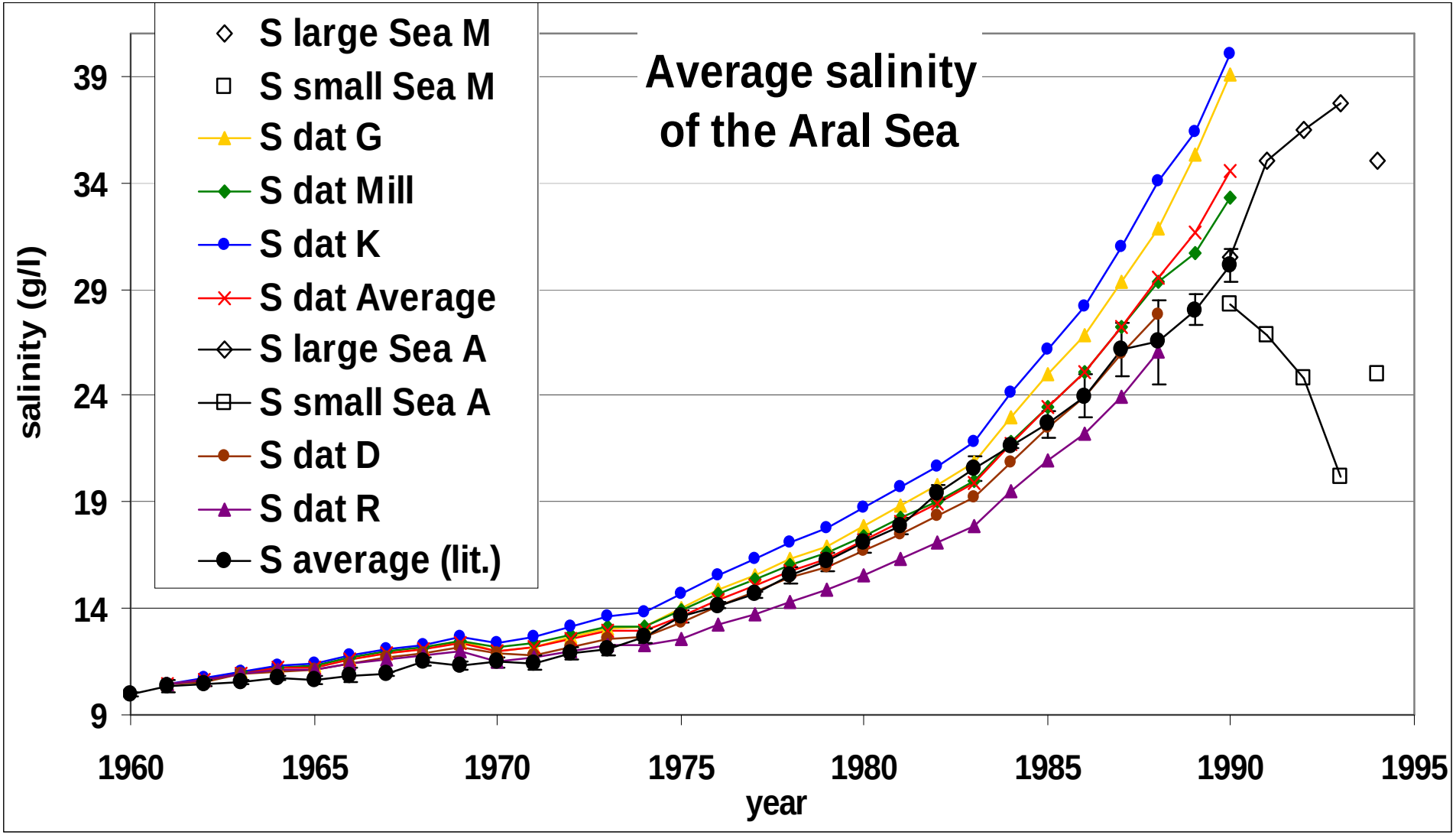
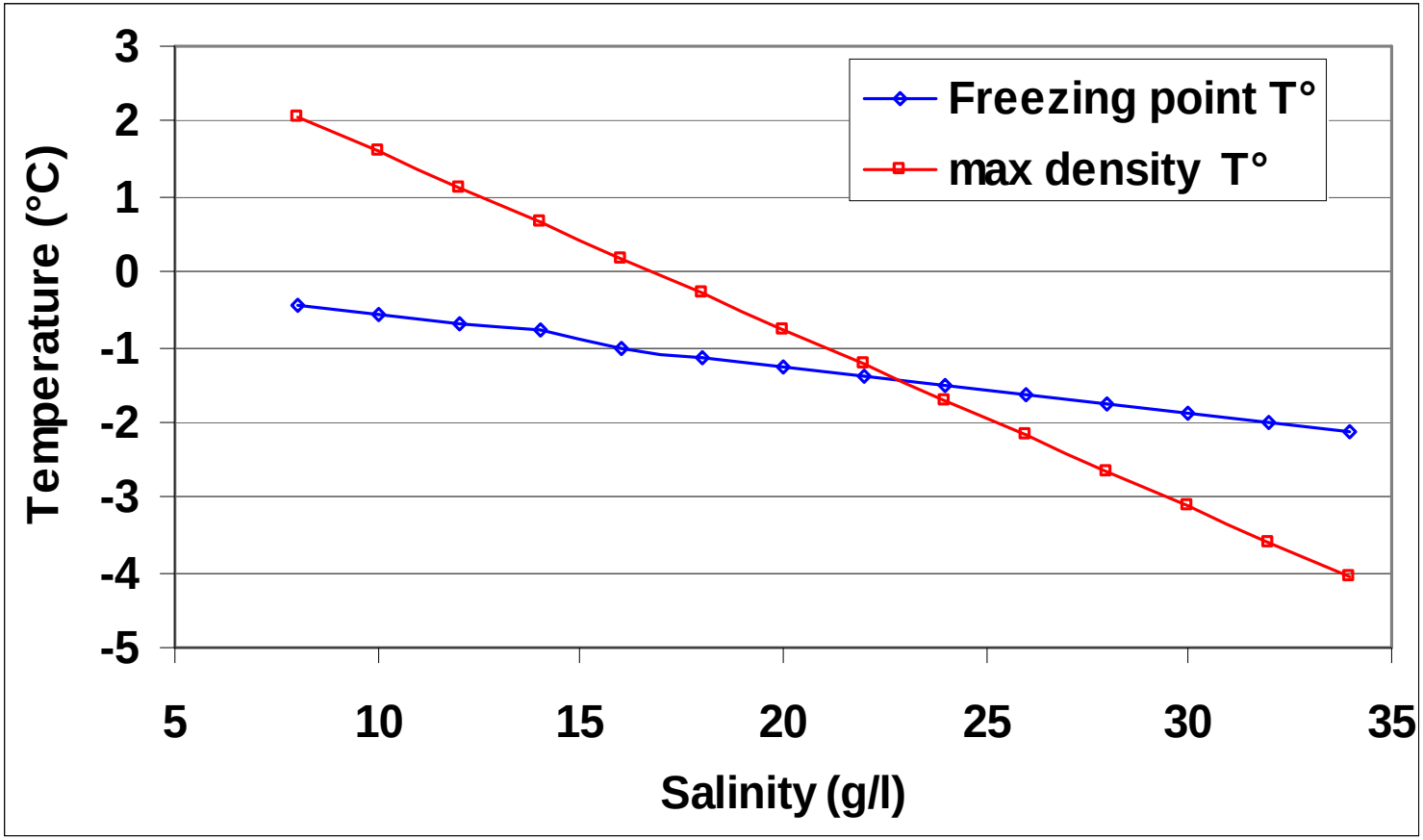
L dat R


Average salinity of the Aral Sea
S large Sea M
S small Sea M
S dat G
S dat Mill
S dat K
S dat Average
S large Sea A
S small Sea A
S dat D
S dat R
S average (lit.)
salinity (g/l)
39
34
29
24
19
14
9
1960
1965
1970
1975
1980
1985
1990
1995
year

Evolution of freezing point temperature and maximum density temperature for the Aral Sea water composition (R).



Further simulations: goals and required informations

! Required data for further investigation

- **From 60 until today:**

  Ground flows, informations about biological and geochemical evolution (from in situ or satellite derived), estimation of (separated) river discharge, precipitation, evaporation, flow through Berg 's strait, area and shape of water table, seasonnal level changes,…

- **Future scenario: what if?..**

  Estimated water saving from possible agricultural reforms (irrigation efficiency improval, evolution of irrigated area and type of crops,..)

  Prevision of total water withdrawalls

6. Conclusions

The quality assessment of water balance data set shows:

important RD « events » are generaly over-estimated (1969, 1973)

average RD allowed very good sea level drop simulation for the first 20 years (1960 to 1980, confirming the hypothesis of relatively low ground flow contribution to water balance).

an increasing loss of RD trough expanding and desertifying deltas may explain part of the observed level drop unsupported by our simulations

RD data from Glazovsky and Kostianoy are most accurate for level simulations, if one trusts given hypothesis and selected forcings datasets

general trend of simulated salinity raise is in good agreement with observed data

Around 1984, the appearing differences between salinity simulations and observations are in correspondance to change in winter mixing regime

An efficient tool was developped for

long term evaluation of basic water body parameters of the Aral Sea according to various future scenarios

testing hypothesis concerning unmeasured contributions to the Aral Sea water and salt budget (ie: ground water fluxes, salt precipitation)