Investigating the Changing Sediment Loads of the World's Rivers: Problems and Findings

DES WALLING

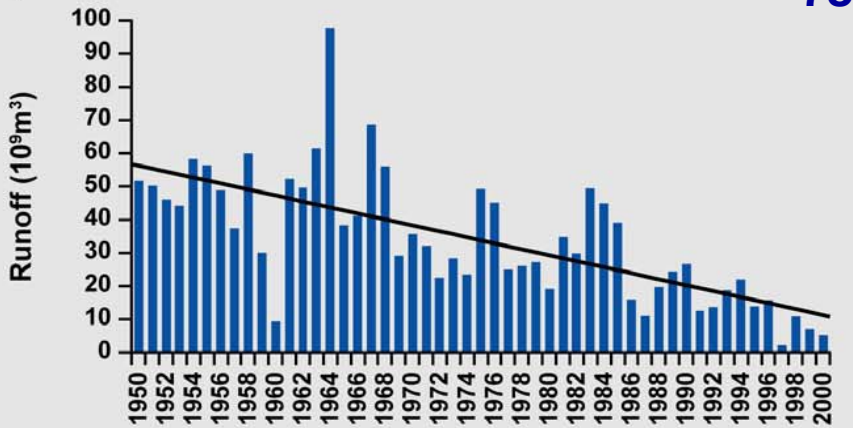
Department of Geography

International Sediment Initiative

Yellow River at Lijin, China, 1950 - 2000

750000 km²

i)



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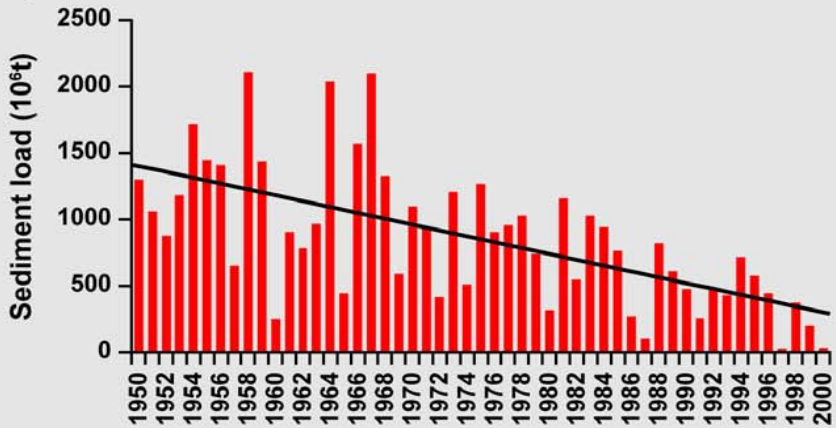
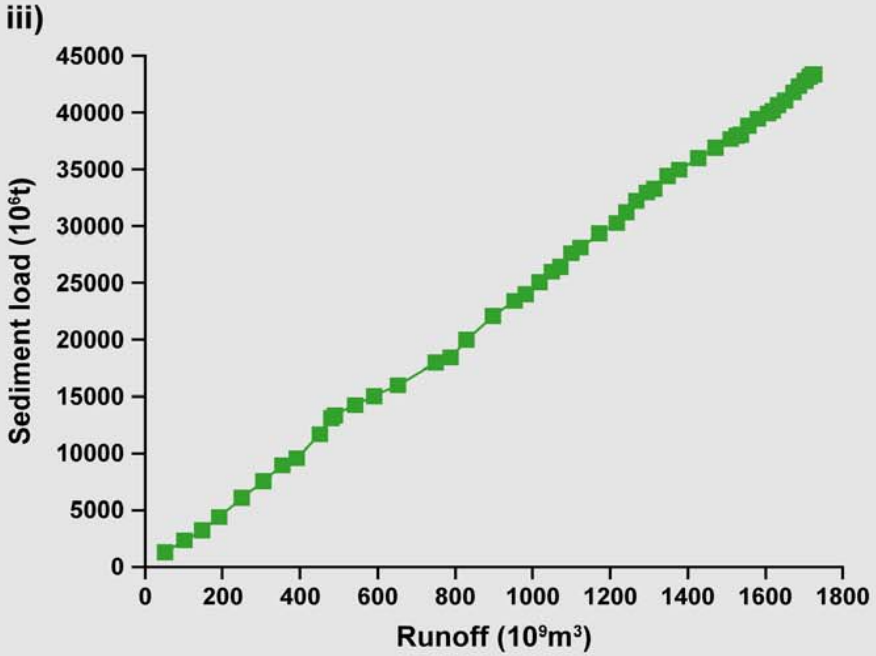


iii)



CAUSES OF REDUCED SEDIMENT LOAD

Wang et al. (2006)

Soil Conservation 40%

Climate Change 30%

Reservoir Trapping 30%

RECENT CHANGES IN THE SEDIMENT LOAD OF THE YELLOW RIVER

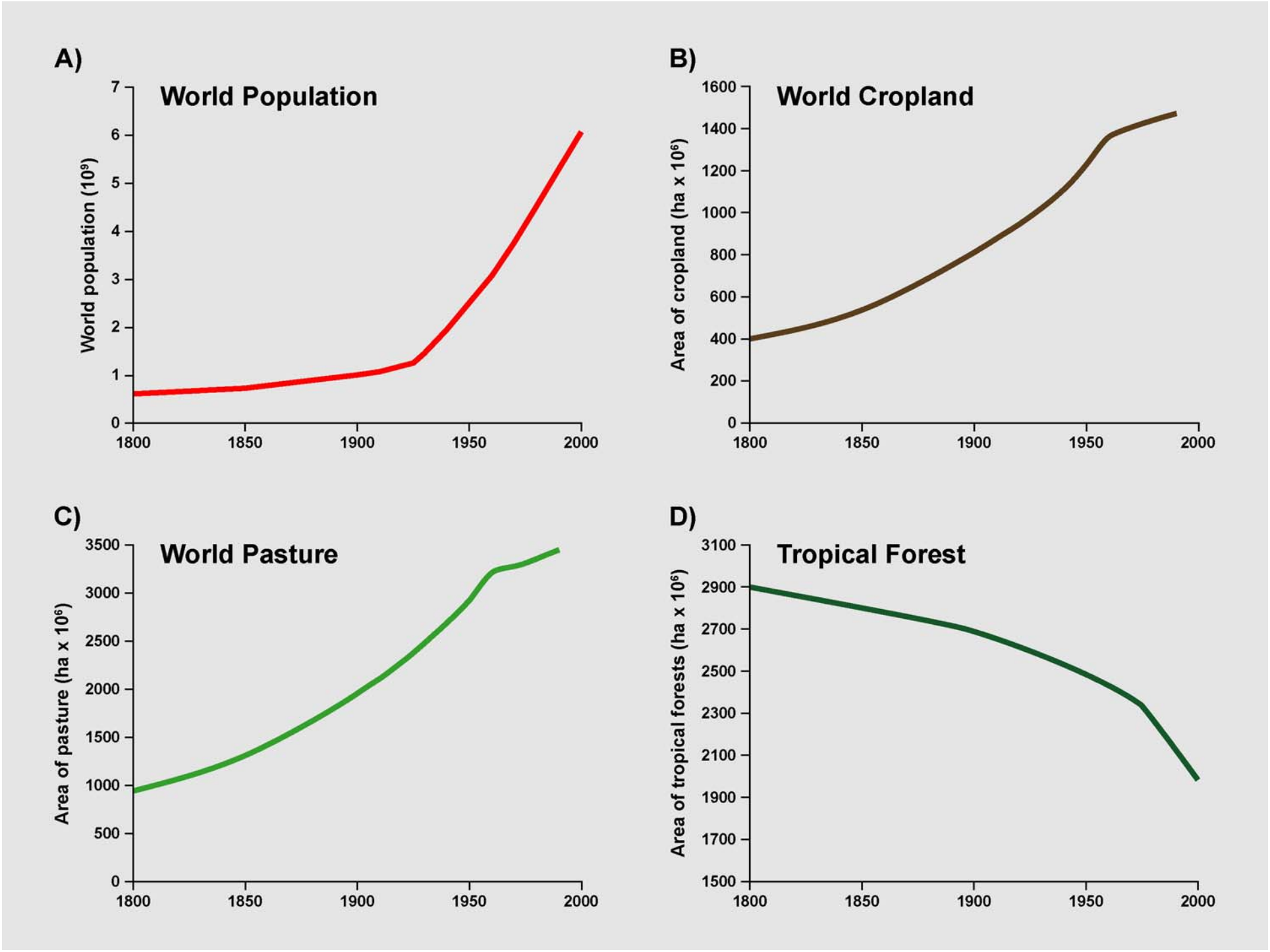
Longer-term mean annual suspended sediment load (1950s – 1970s)
1.1×10^9 t year^{-1}

Mean annual suspended sediment load in the 1980s
0.8×10^9 t year^{-1}

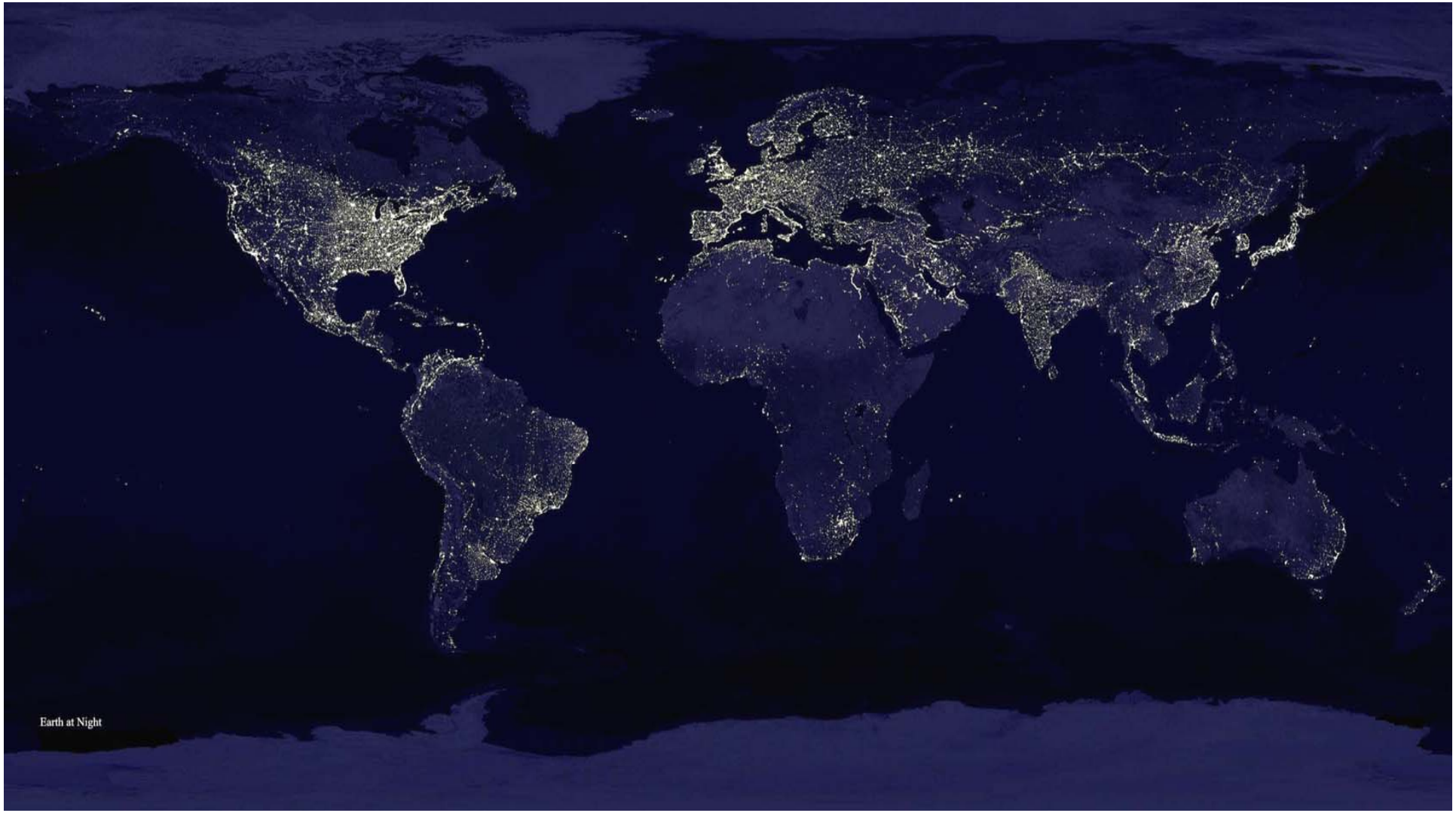
Mean annual suspended sediment load in the 1990s
***ca.* 0.4×10^9 t year^{-1}**

Mean annual suspended sediment load 2000-2004
***ca.* 0.15×10^9 t year^{-1}**

What about the sediment loads of the world’s rivers more generally?


A)
World Population
World population (10^9)
0
1
2
3
4
5
6
7
1800
1850
1900
1950
2000
B)
World Cropland
Area of cropland (ha x 10^6)
0
200
400
600
800
1000
1200
1400
1600
1800
1850
1900
1950
2000
C)
World Pasture
Area of pasture (ha x 10^6)
0
500
1000
1500
2000
2500
3000
3500
1800
1850
1900
1950
2000
D)
Tropical Forest
Area of tropical forests (ha x 10^6)
1500
1700
1900
2100
2300
2500
2700
2900
3100
1800
1850
1900
1950
2000

URBANISATION



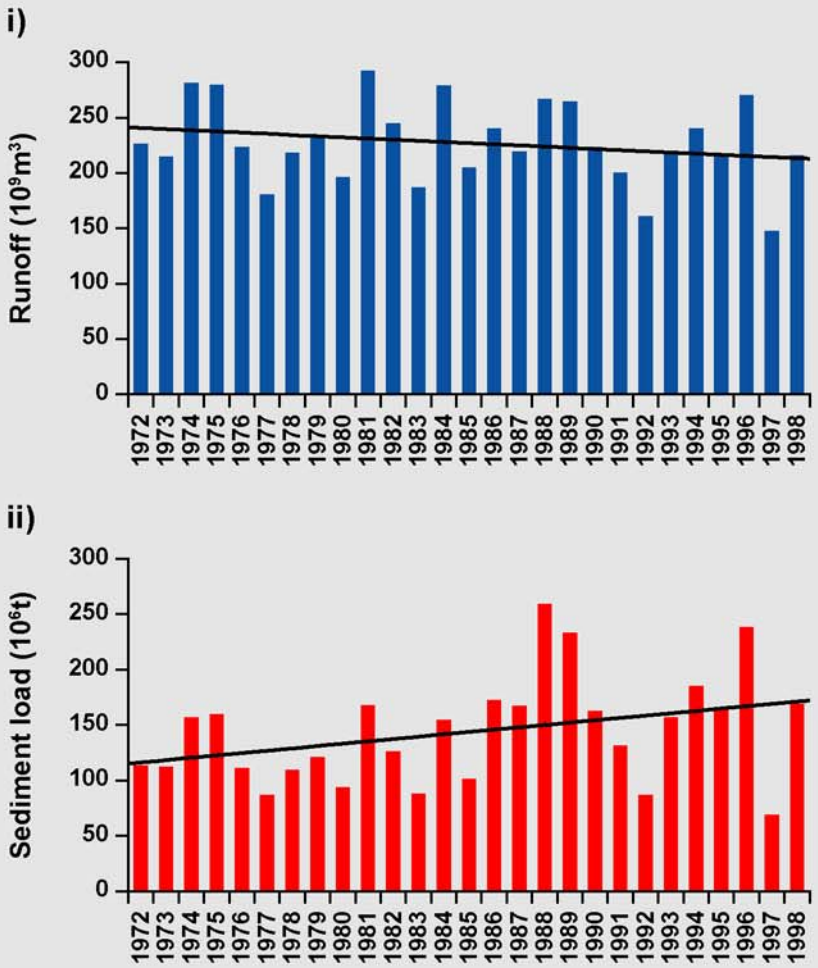

FOREST CLEARANCE

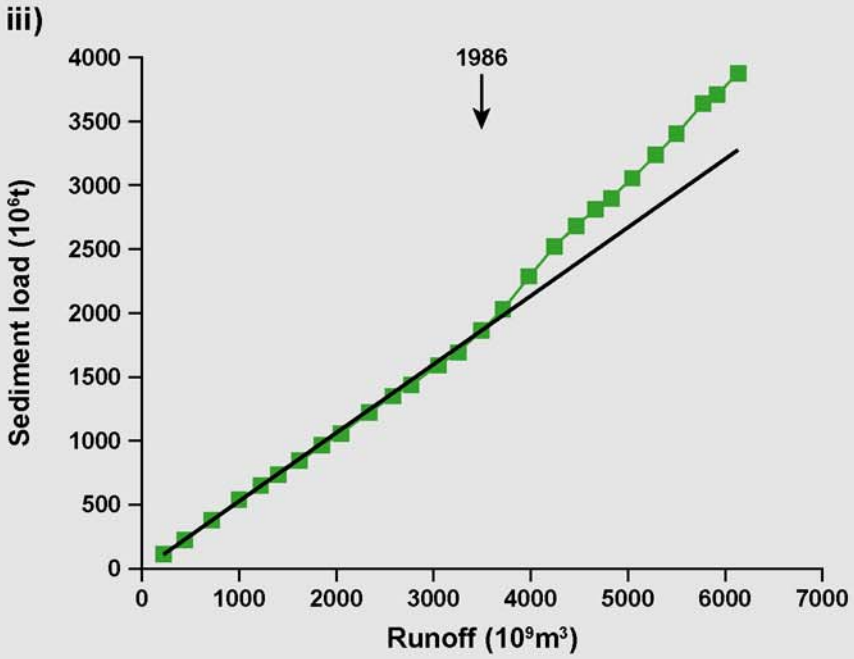

LAND USE CHANGE


WATER RESOURCE DEVELOPMENT
World Commission on Dams
47,655 Large Dams in 1998


SAND MINING
DYNA
GX - 3804

Rio Magdalena at Calamar, Colombia, 1972 - 1998

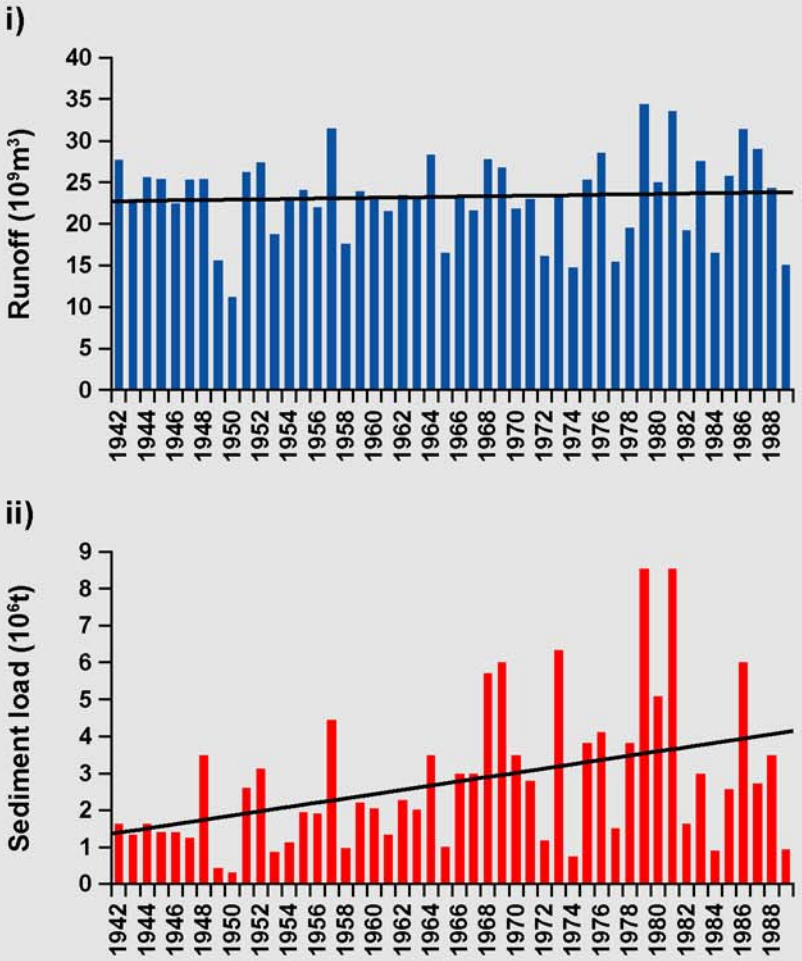


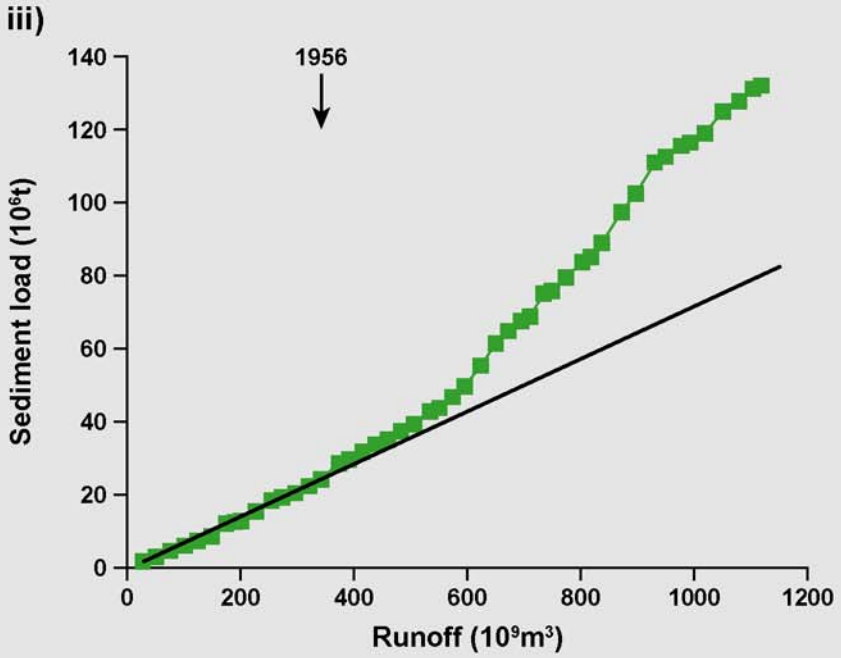


250000 km^2


ALASKA
Chukchi Sea
ST.LAWRENCE ISLAND
Provideniya
Wrangel Island
Bering Sea
Pevek
Anadyr'
East Siberian Sea
180
Cherskiy
KOLYMA RIVER
U.S.
NORTH PACIFIC OCEAN
Petropavlovsk-Kamchatskiy
Magadan
Sea of Okhotsk
Okhotsk
Yakutsk
KURIL ISLANDS

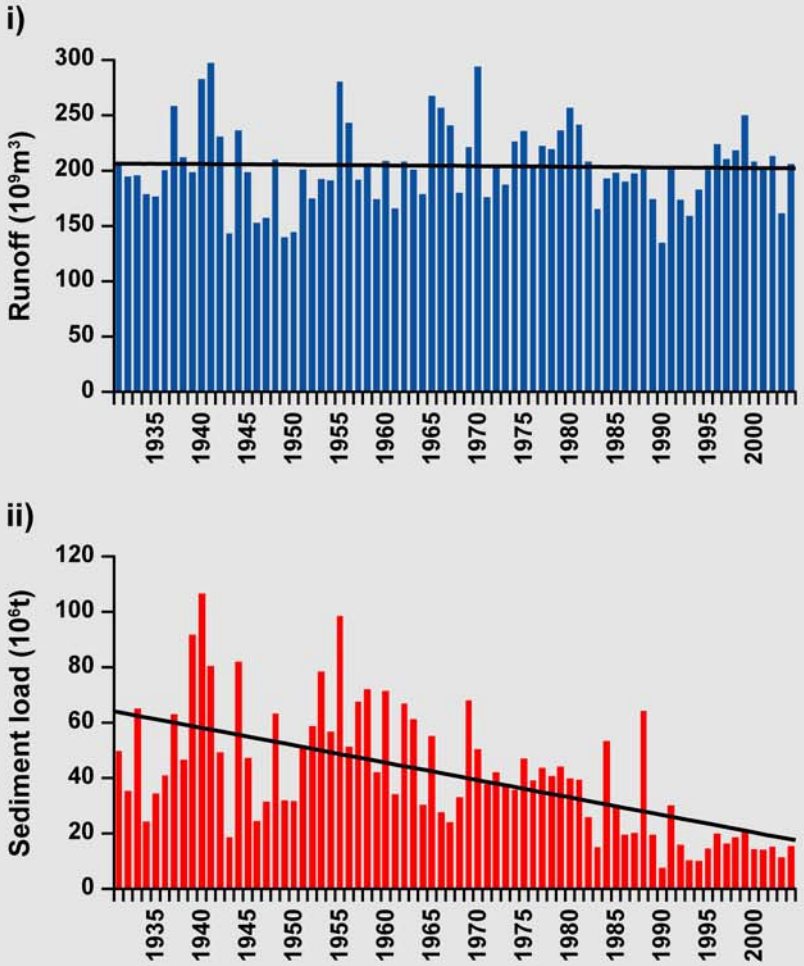
Kolyma River at Srednekansk, Siberia, 1942-1989

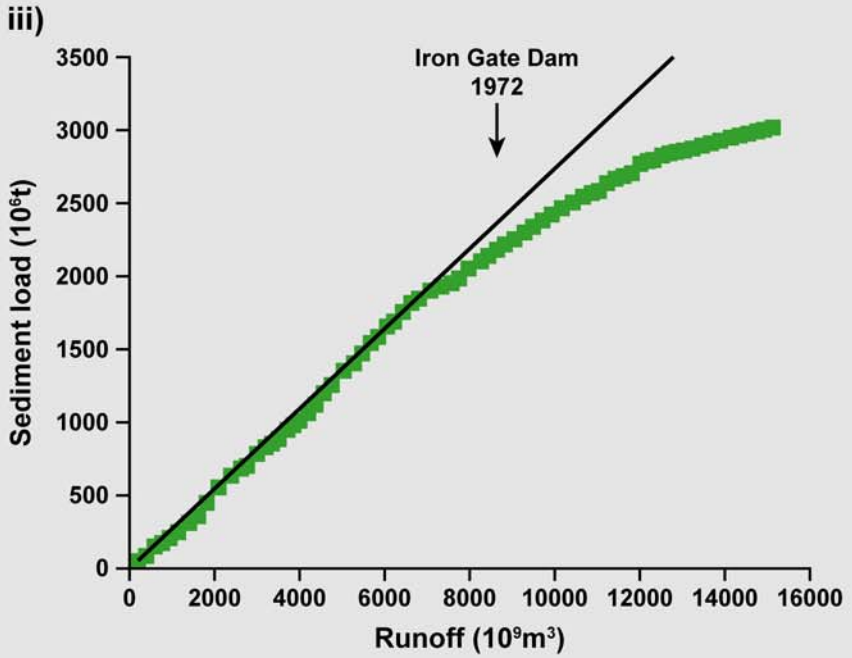




100,000 km^2

Danube River at Ceatal-Izmail, Romania, 1931 - 2004





800000 km^2

Investigating the Changing Sediment Loads of the World's Rivers

DATA ISSUES

- **Data Availability/Accessibility**
- **Length of Record**
- **Data Reliability**
  - Sampling Procedures
  - Sampling Frequency
  - Precision versus Accuracy
- **Temporal Resolution**
  - Sampling Frequency
  - Use of Rating Curves

Reduction in Sediment Monitoring Activity

- USA and Canada: ceased monitoring at many stations
- USSR: monitoring ceased at many stations after the breakup of the USSR
- Africa: monitoring initiated by colonial authorities ceased or reduced e.g. Kenya, Ghana etc

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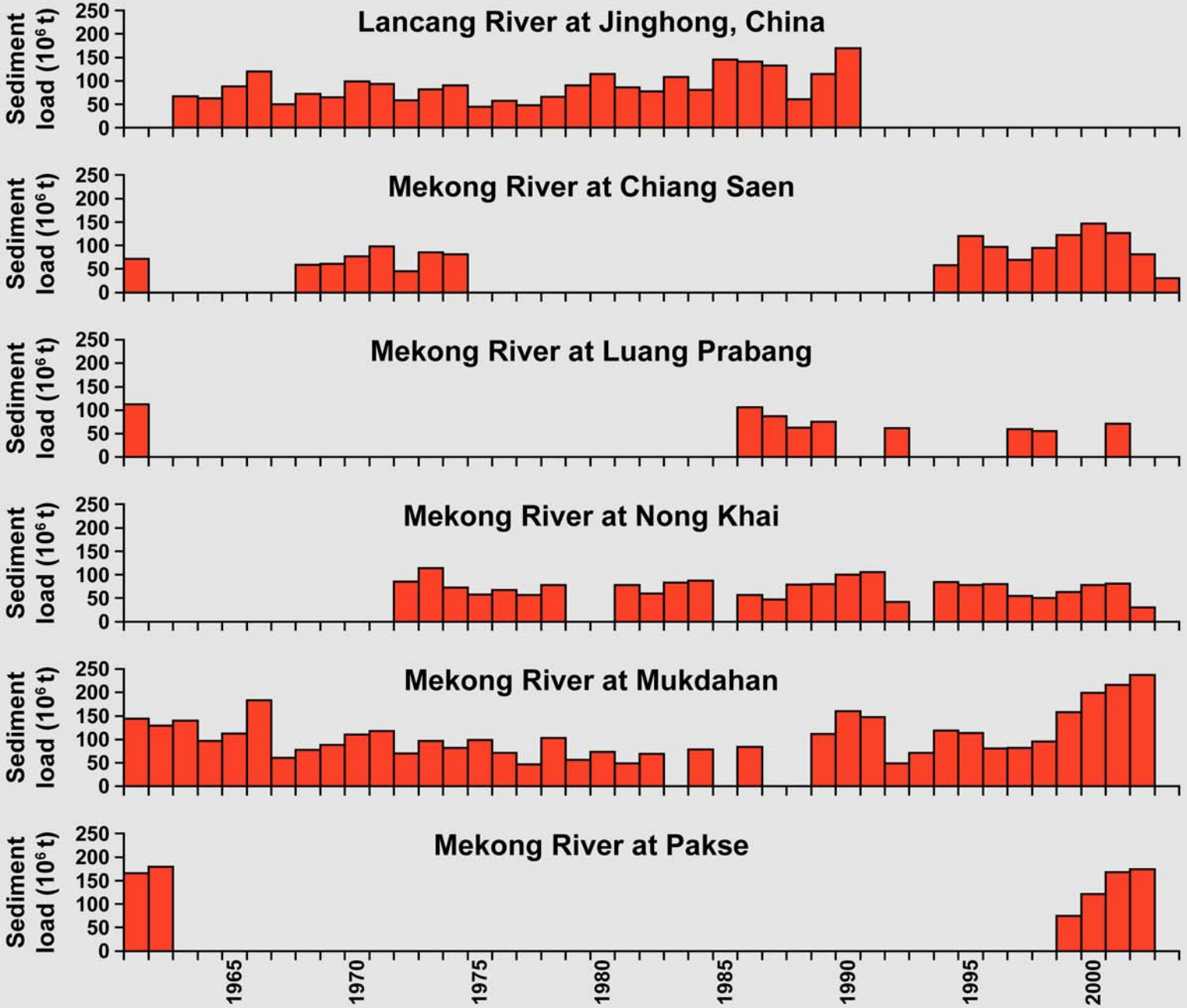
The Mekong Example:


Measurement station
Mekong basin
National boundary
N
Mekong River
CHINA
MYANMAR
Jinghong
VIETNAM
HANOI
Chiang Saen
Luang Prabang
LAO PDR
South China Sea
Mekong River
VIENTIANE
Nong Khai
Mukdahan
THAILAND
Pakse
Andaman Sea
BANGKOK
Tonle Sap Lake
CAMBODIA
PHNOM PENH
HO CHI MINH CITY
0 100 200 300 400 500km

NUMBER OF DATA DAYS FOR INDIVIDUAL YEARS FOR THE SEDIMENT MEASURING STATIONS ON THE MEKONG RIVER

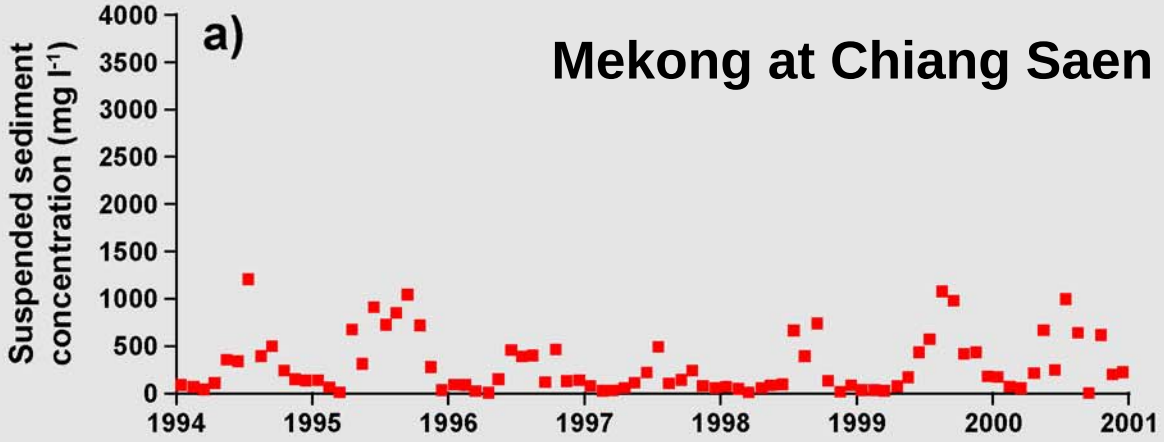
Year	Location				
	Chiang Saen	Luang Prabang	Nong Khai	Mukdahan	Pakse
1960	22	8		9	9
1961	20	105		60	109
1962	5			71	44
1963				32	
1964				42	
1965				38	
1966				35	
1967				42	
1968	38			45	
1969	73			66	
1970	83			73	
1971	71			58	
1972	65		58	72	
1973	33		89	74	
1974	33		87	71	
1975	9		33	36	
1976			27	16	
1977			46	26	
1978			47	26	
1979				27	
1980				25	
1981			21	22	
1982			16	19	
1983			18		
1984			16	20	
1985		2	4	1	
1986		22	18	18	
1987		43	15	4	
1988		41	14	6	
1989		44	20	11	
1990		37	22	14	
1991		18	14	19	
1992		37	23	21	
1993				19	
1994	48		24	22	
1995	45		15	18	
1996	32		20	19	
1997	39	12	25	11	11
1998	38	12	26	35	10
1999	40	7	29	43	12
2000	40	9	27	41	14
2001	38	11	30	42	13
2002	38	9	42	38	11
2003	36				

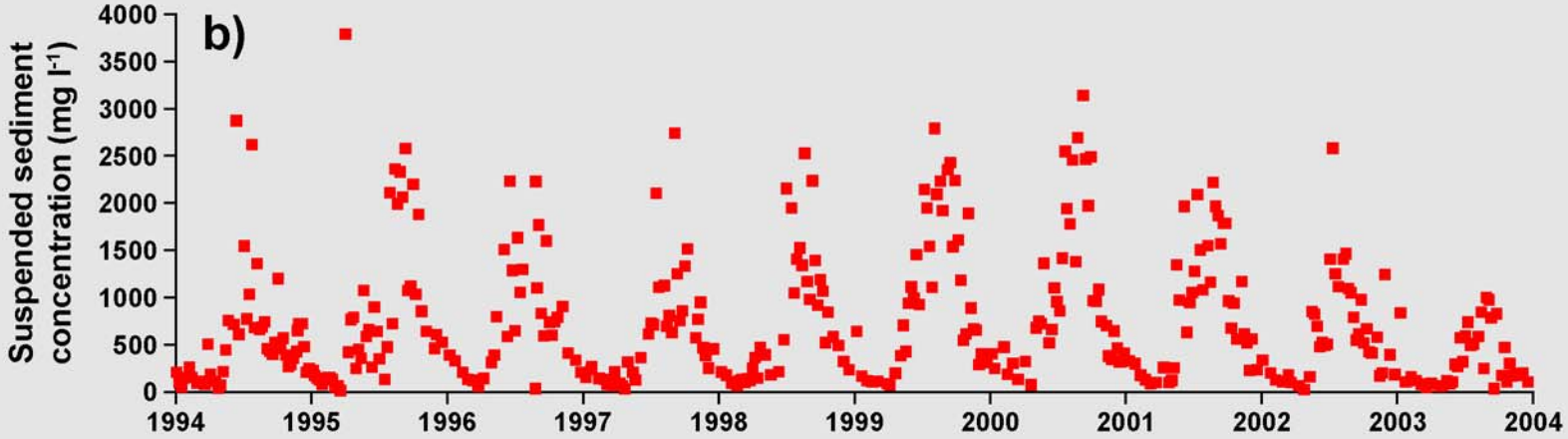

Lancang River at Jinghong, China
Mekong River at Chiang Saen
Mekong River at Luang Prabang
Mekong River at Nong Khai
Mekong River at Mukdahan
Mekong River at Pakse
Sediment load (10^6 t)
250
200
150
100
50
0
1965
1970
1975
1980
1985
1990
1995
2000

The use of data from Water Quality Monitoring Programmes?

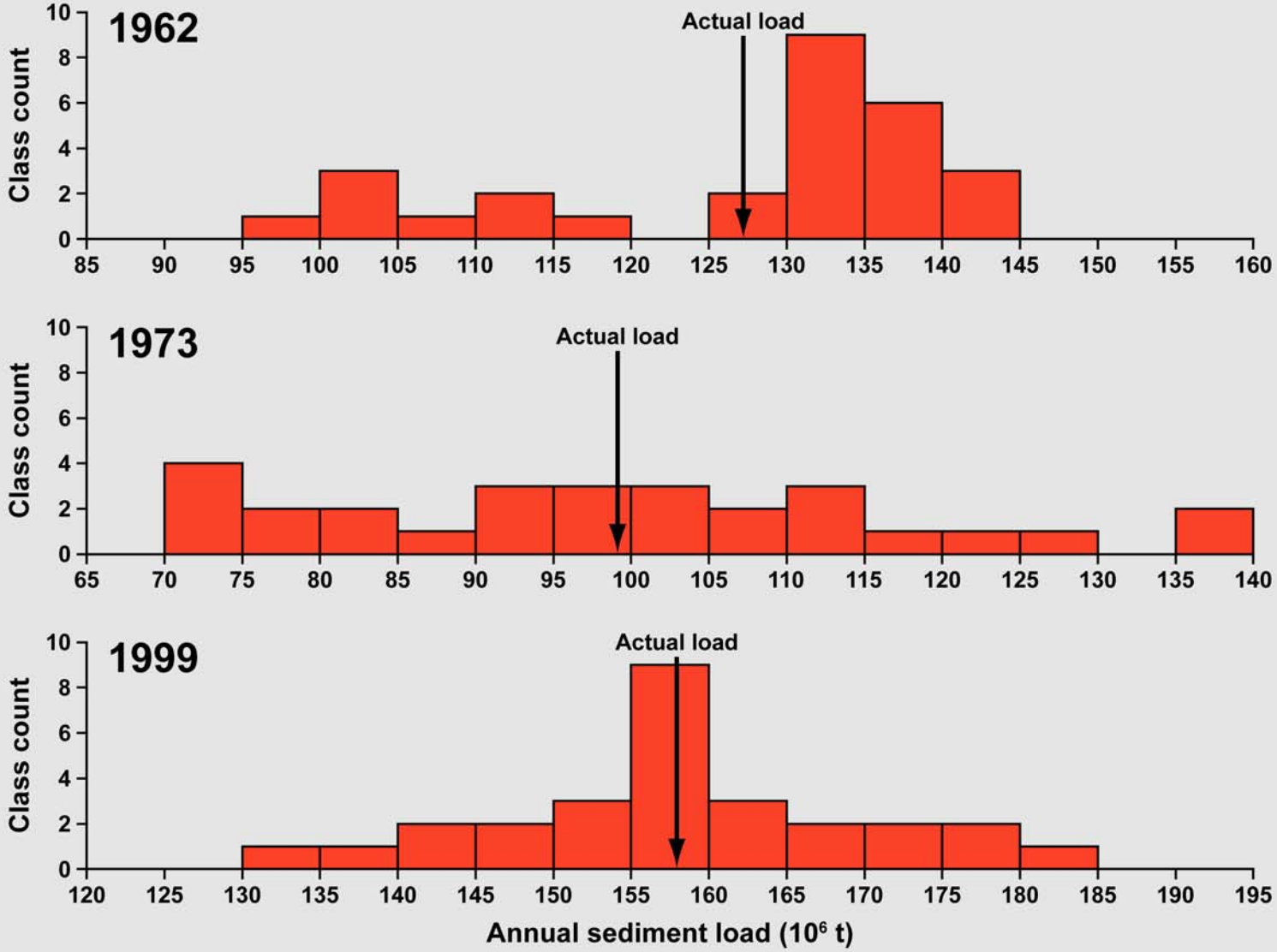
- Sampling procedures
- Sampling frequency

The Reliability of the TSS data provided by the Mekong River Commission Water Quality Monitoring Programme





Mekong River at Mukdahan



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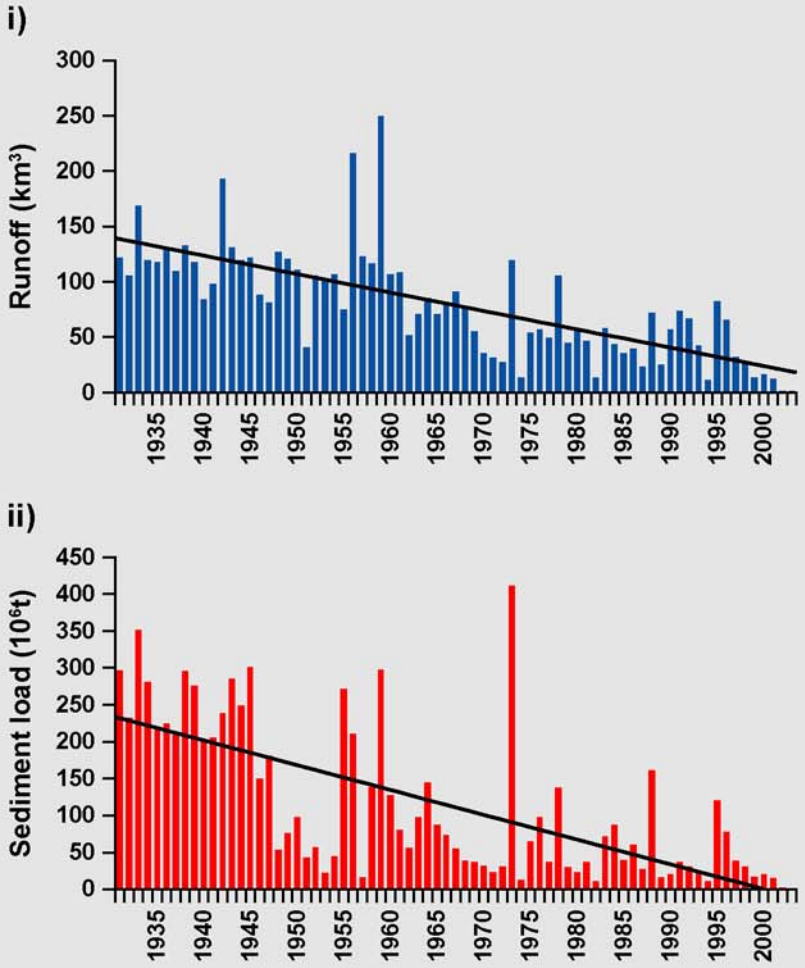
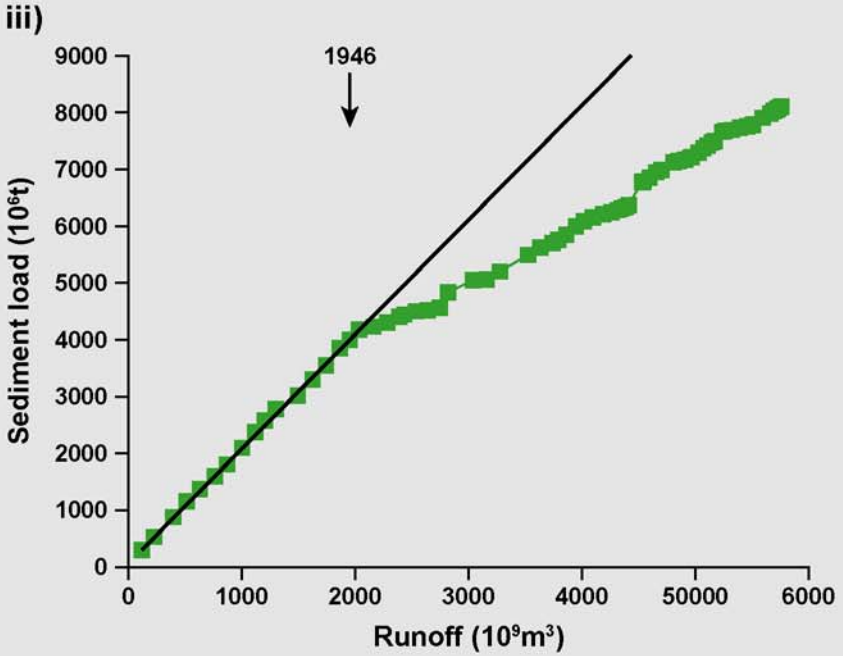
  - Use of Rating Curves

River Indus at Kotri, Pakistan, 1931 - 2003

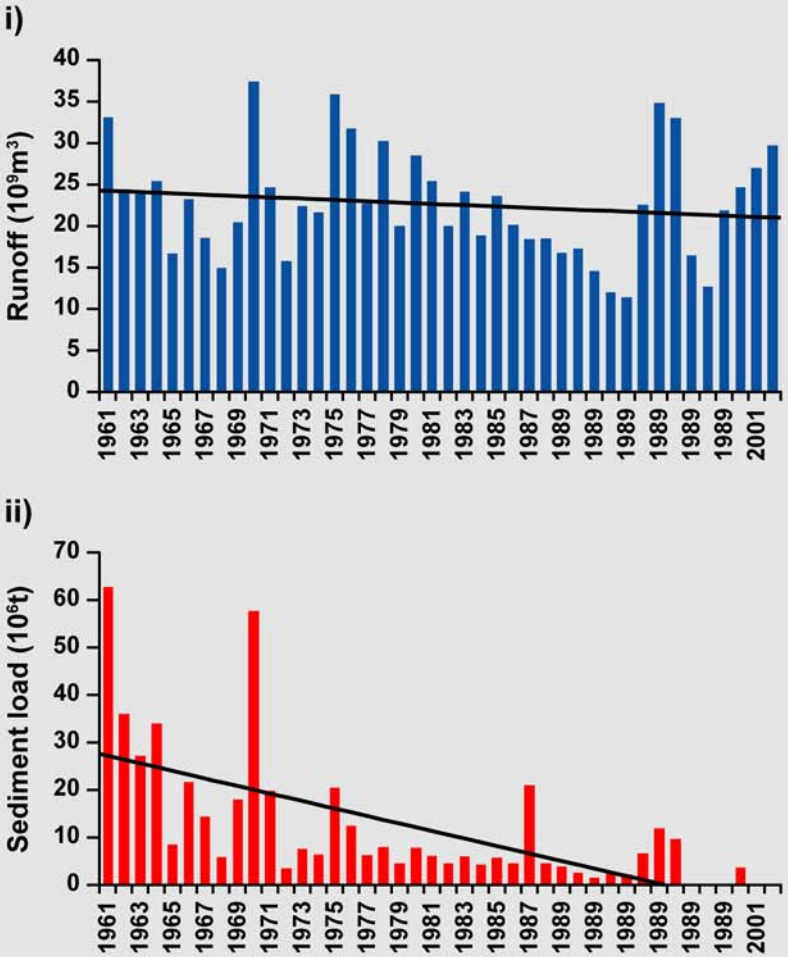


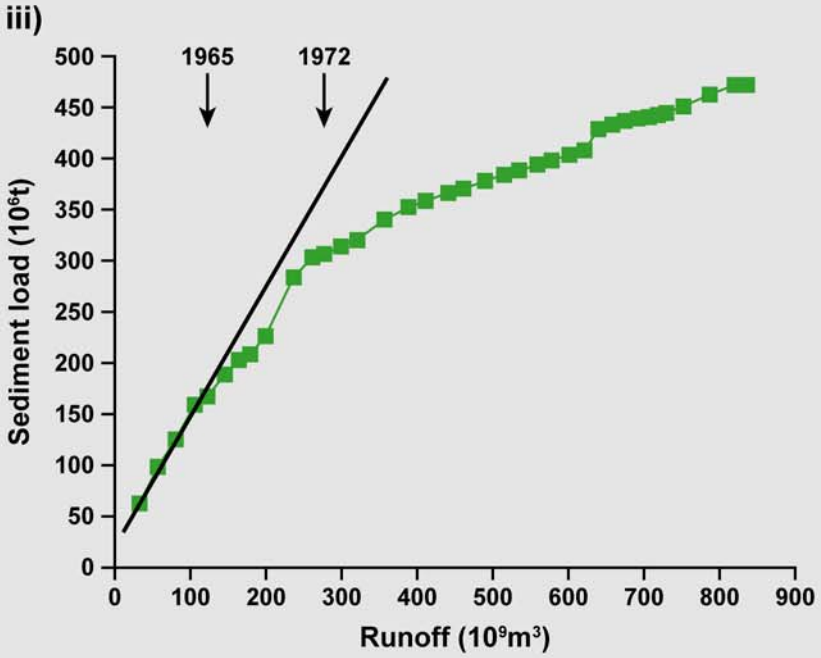
Walling Diagram



970,000 km^2

Chao Phraya River at Ban Phai Lom, Thailand, 1961 - 2002

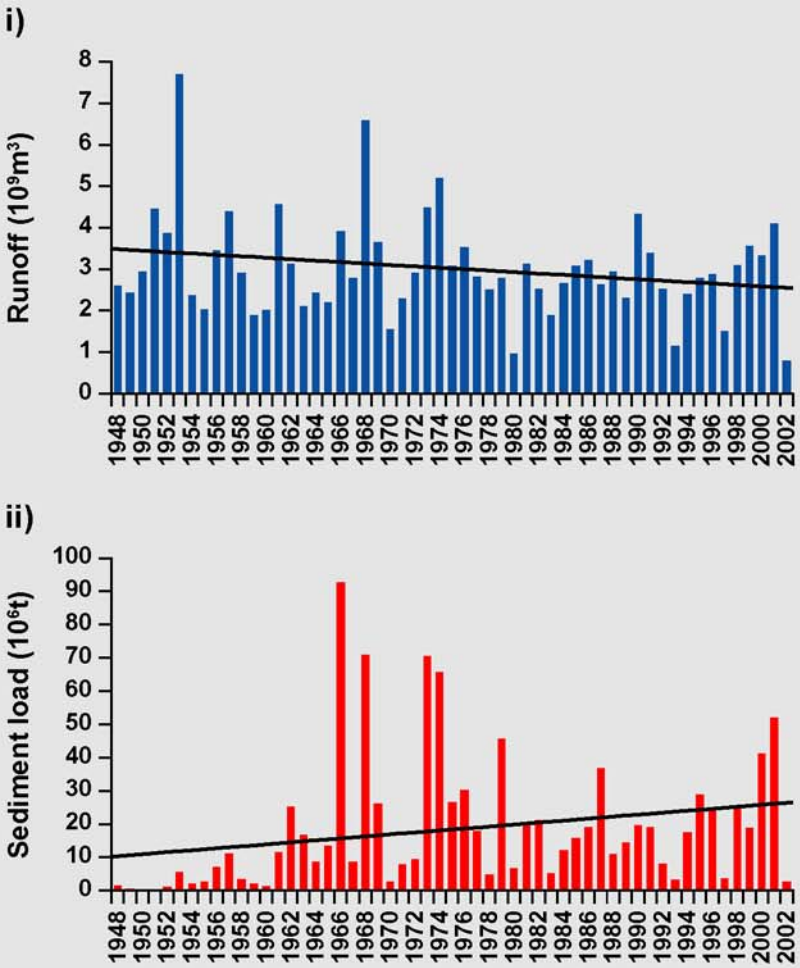


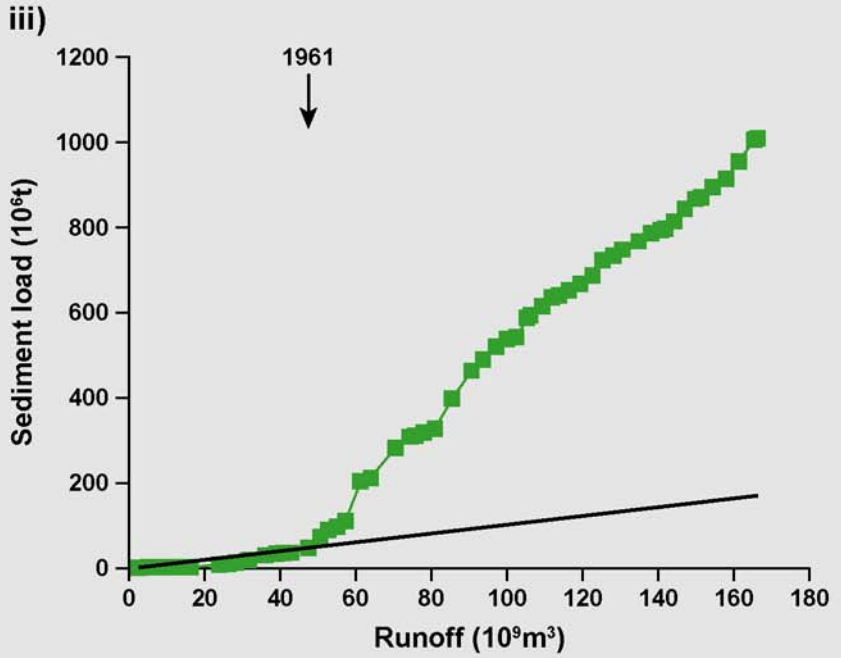


110000 km^2

1965 Bhumibol Dam
1972 Sirikit Dam

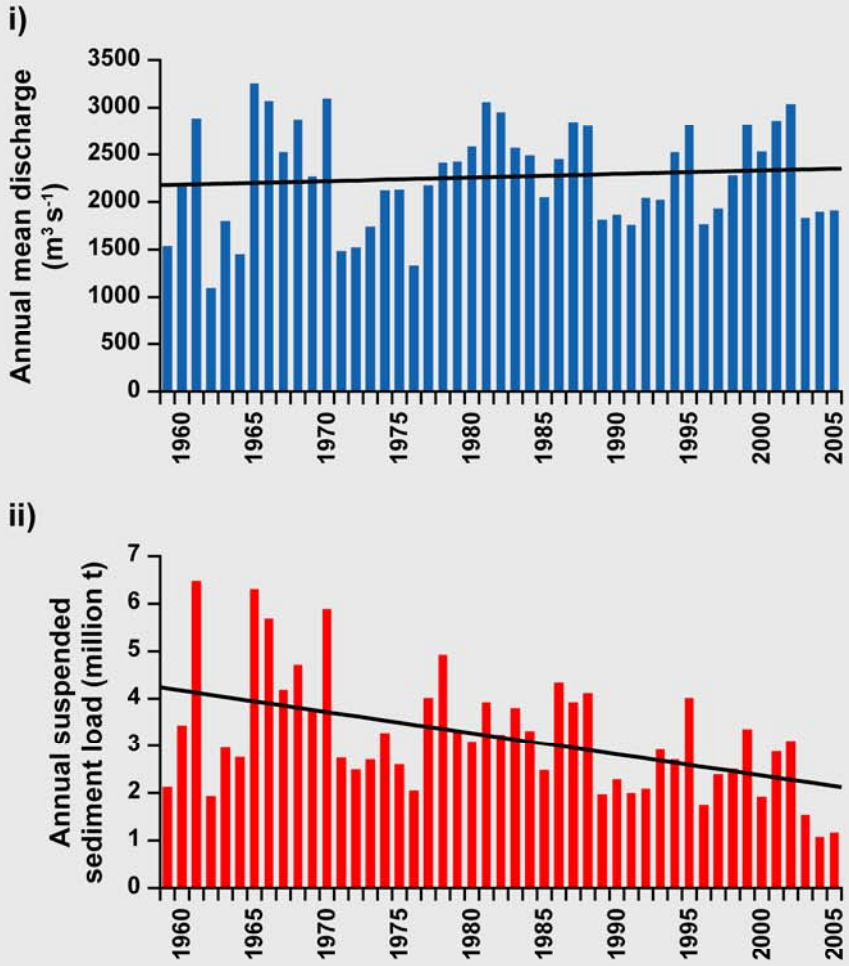
Bei-Nan River, Taiwan, 1948 - 2002

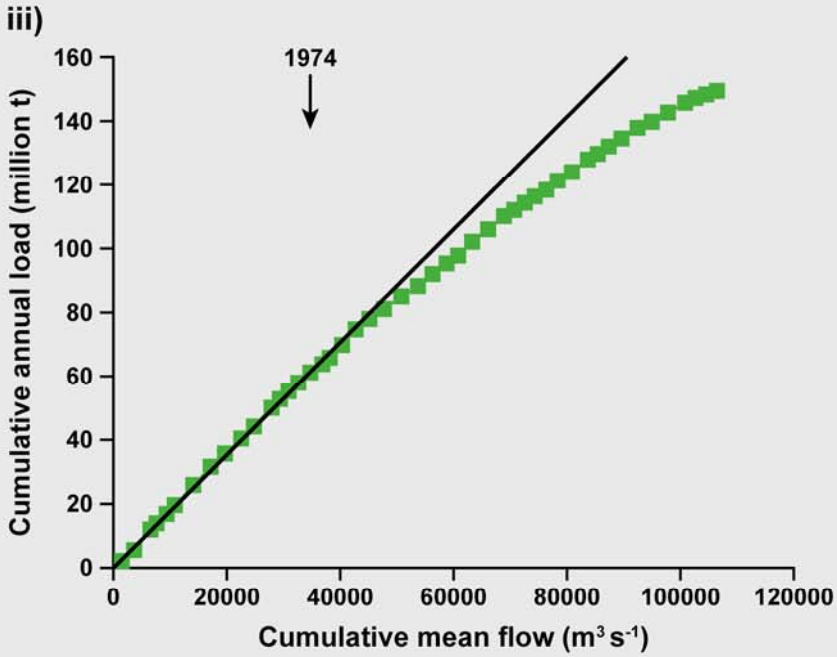




1600 km^2

River Rhine at Lobith, The Netherlands, 1959 - 2005



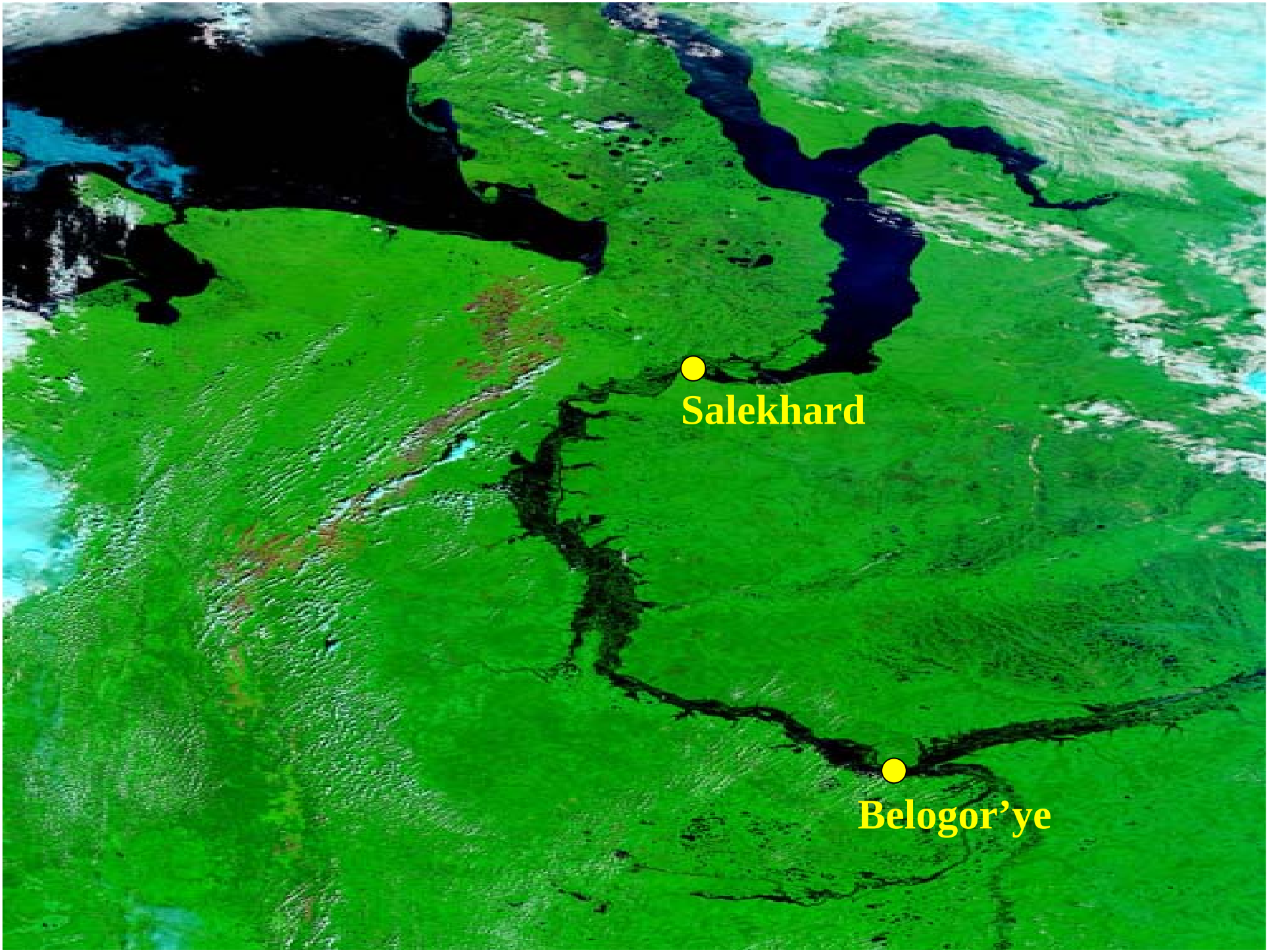


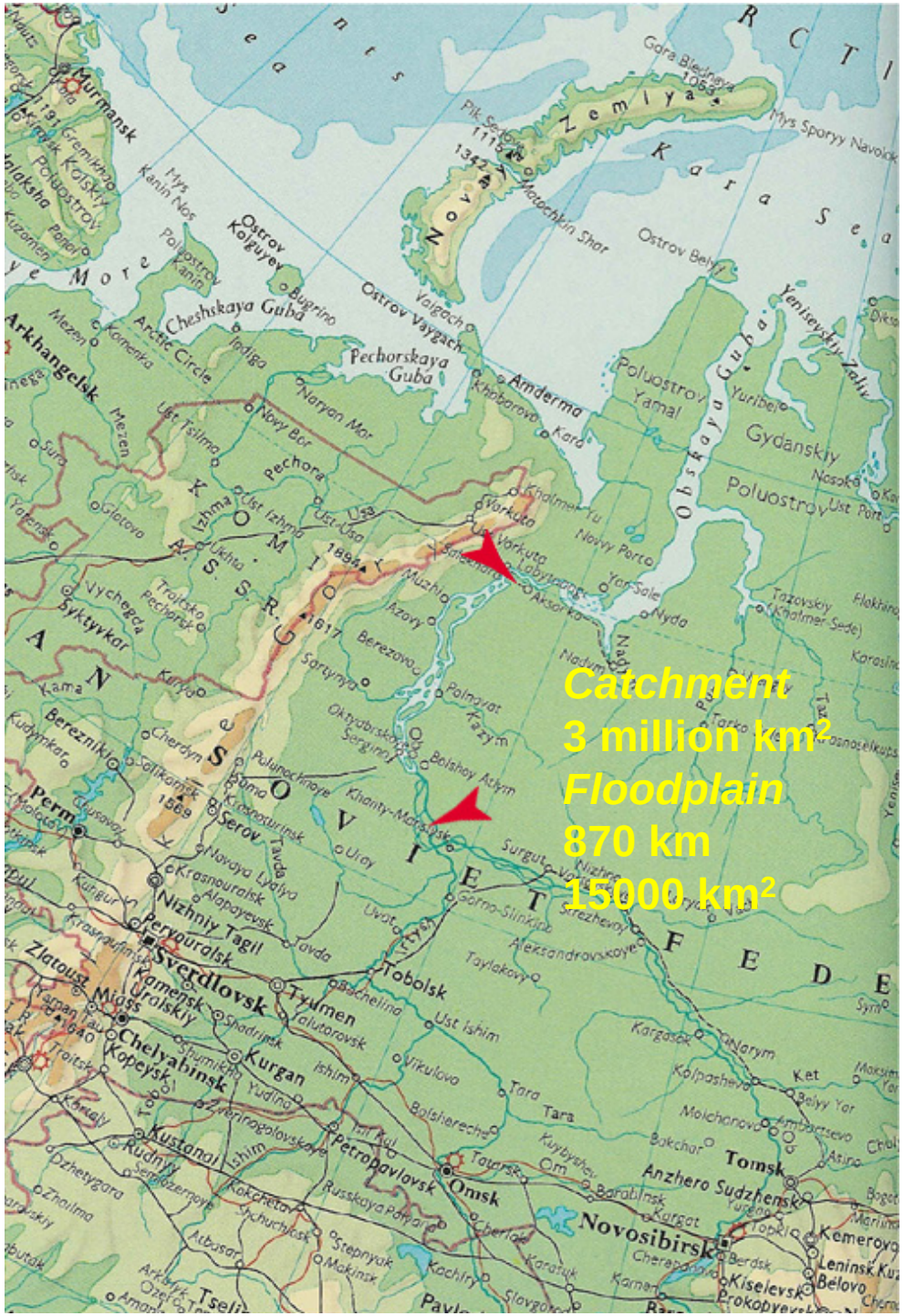
Adding the Complexity

- Aggregation effects
- Buffering and attenuation
- The temporal dimension: short-term versus long-term changes

Buffering Effects

The example of the Ob River

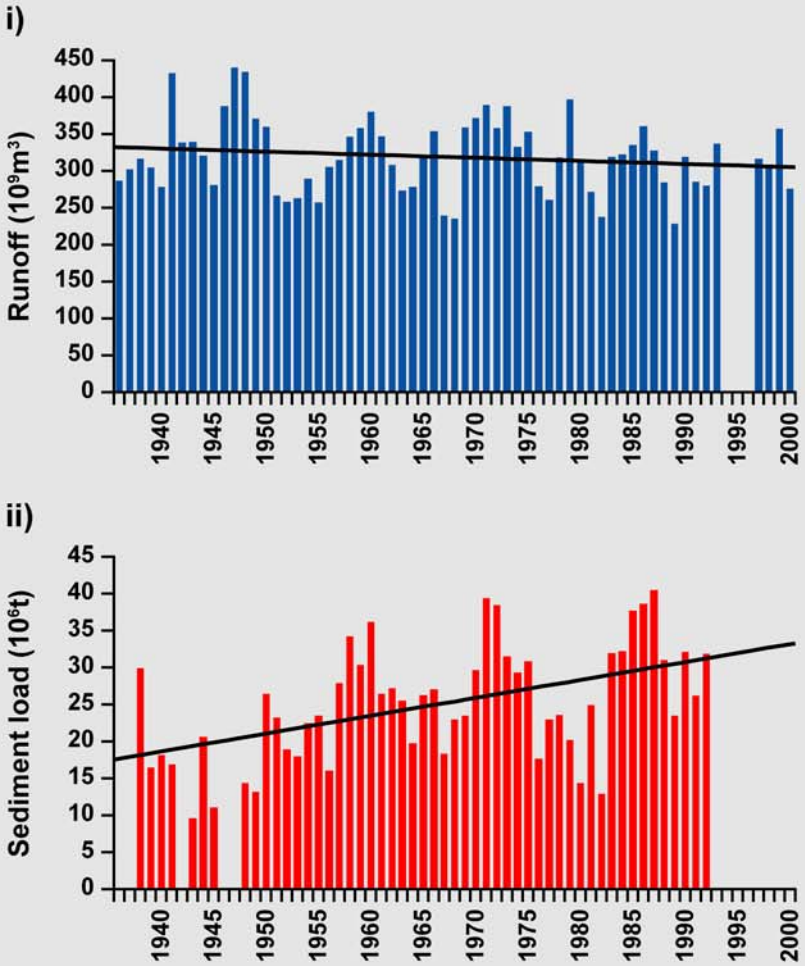

Salekhard
Belogor’ye

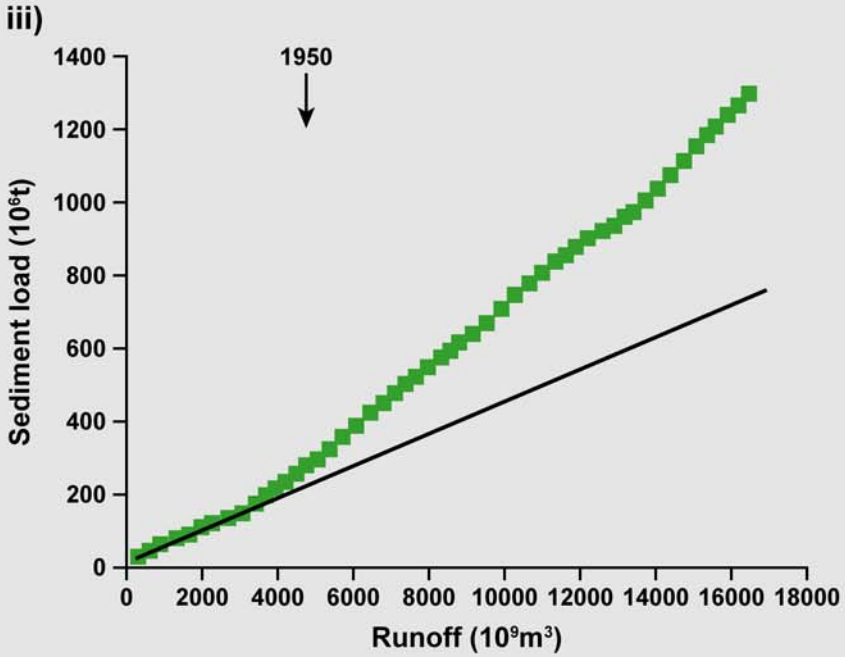


	Q ($km^3\ a^{-1}$)	Load ($10^6\ t\ a^{-1}$)
Belogor'ye	322	28.4
Salekhard	396	16.2
% Change	+25%	- 40%

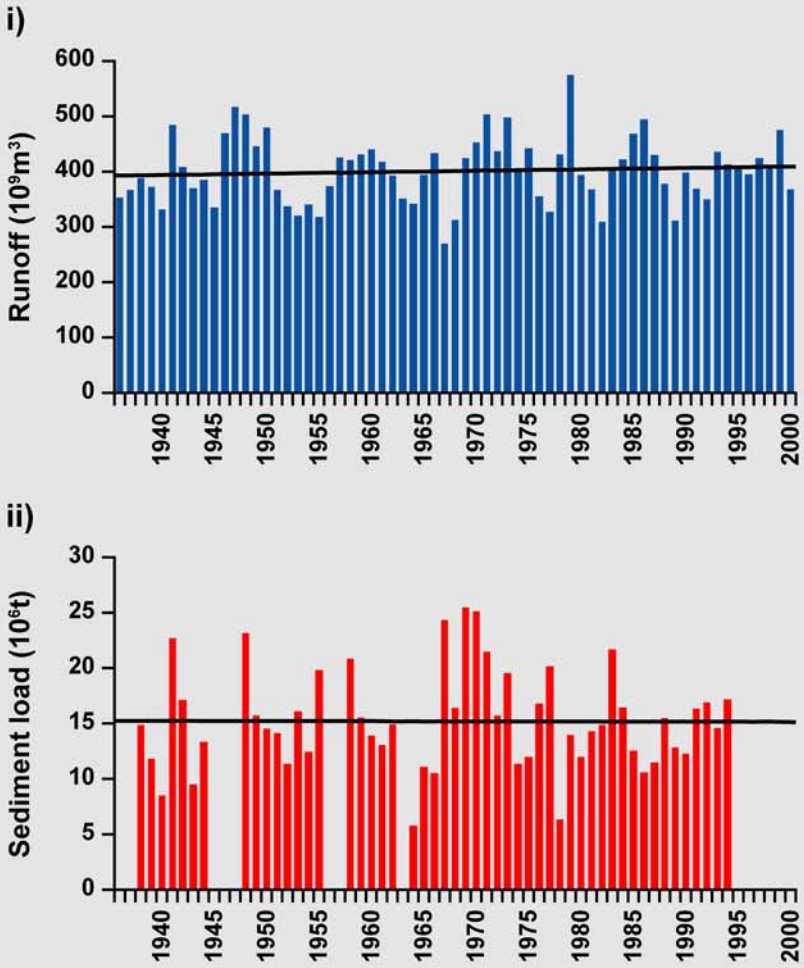
Based on Bobrovitskaya *et al.* (1996)

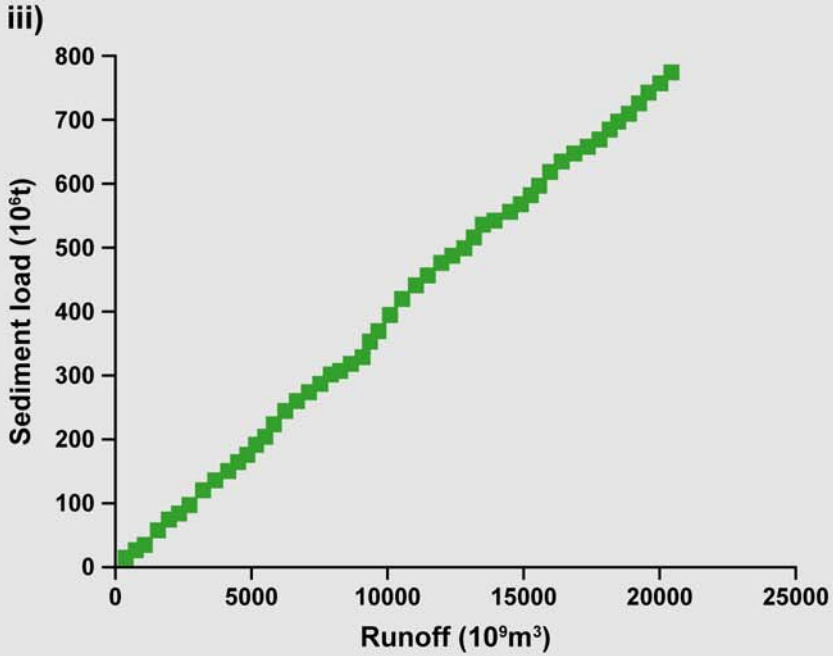
Ob River at Belegor'ye, Russia, 1936 - 2000





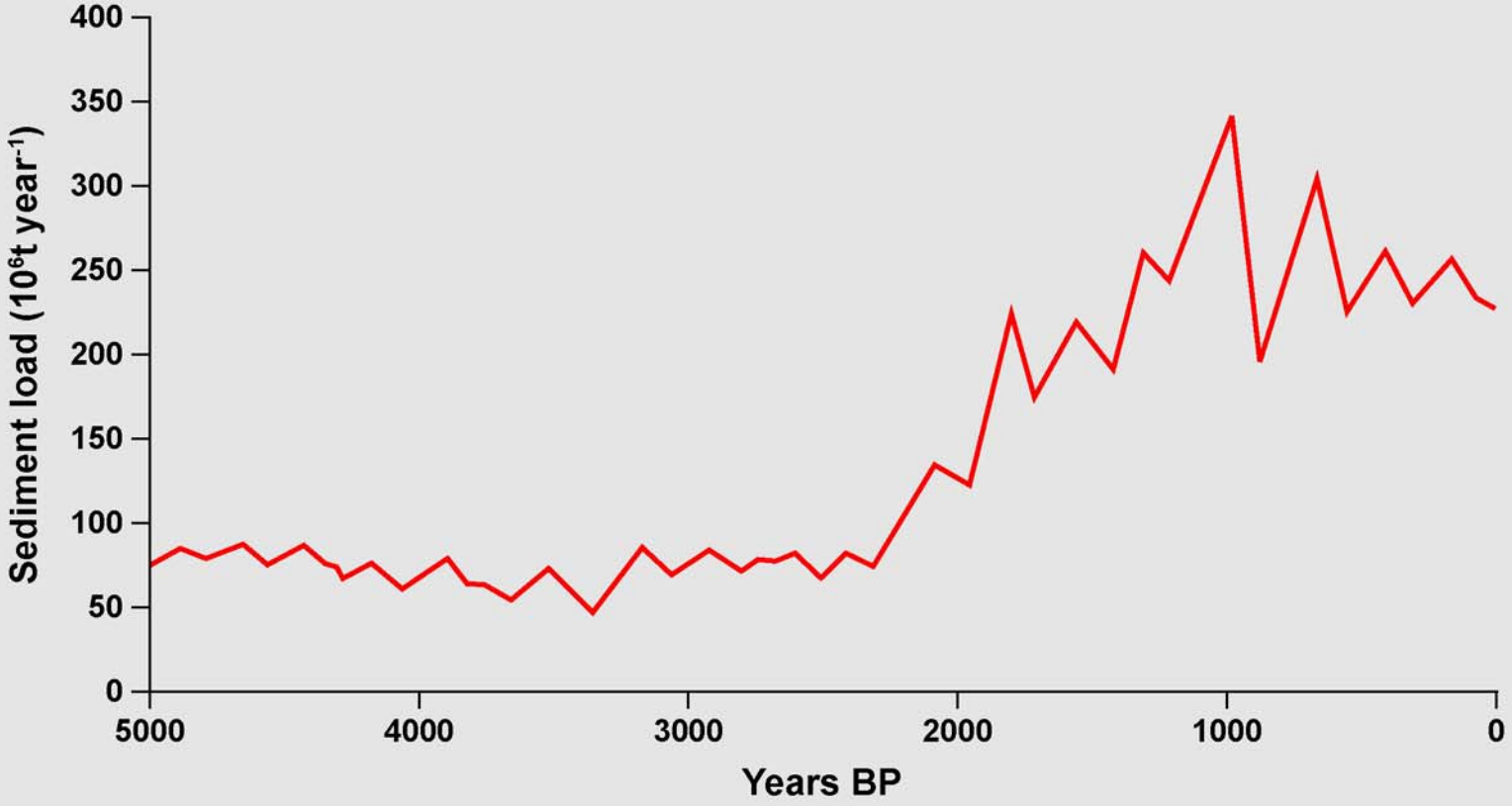
Ob River at Salekhard, Russia, 1936 - 2000





The Temporal Dimension

Sediment Input to the Black Sea from its Main Tributary Rivers



Based on Degens et al. (1991)

Yellow River at Lijin, China