





Universidad de Granada. (SPAIN)



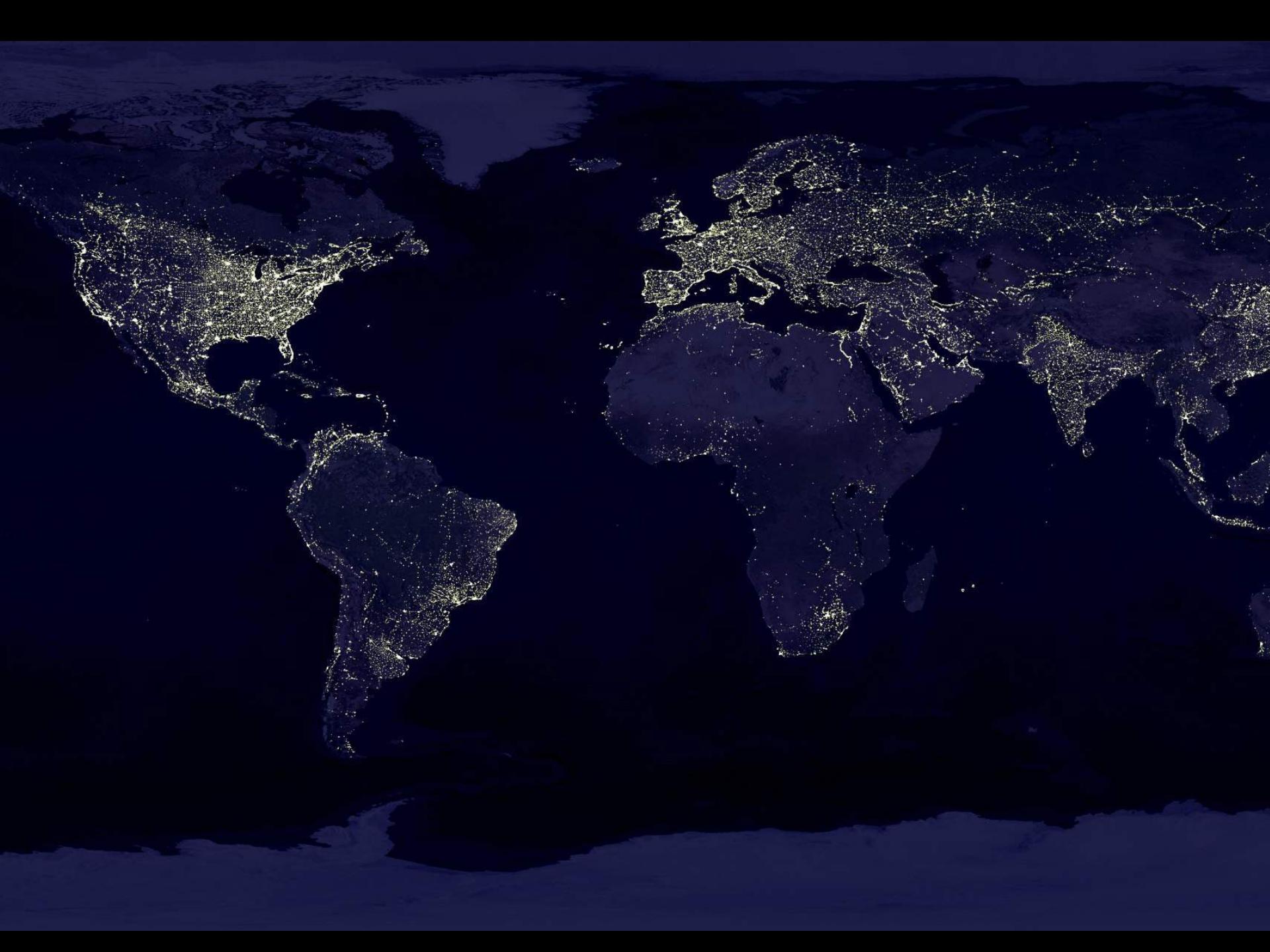
Water Problems and Solutions in Spain

by

Professor J. Gonzalez-Lopez
and
Professor M.V. Martinez-Toledo



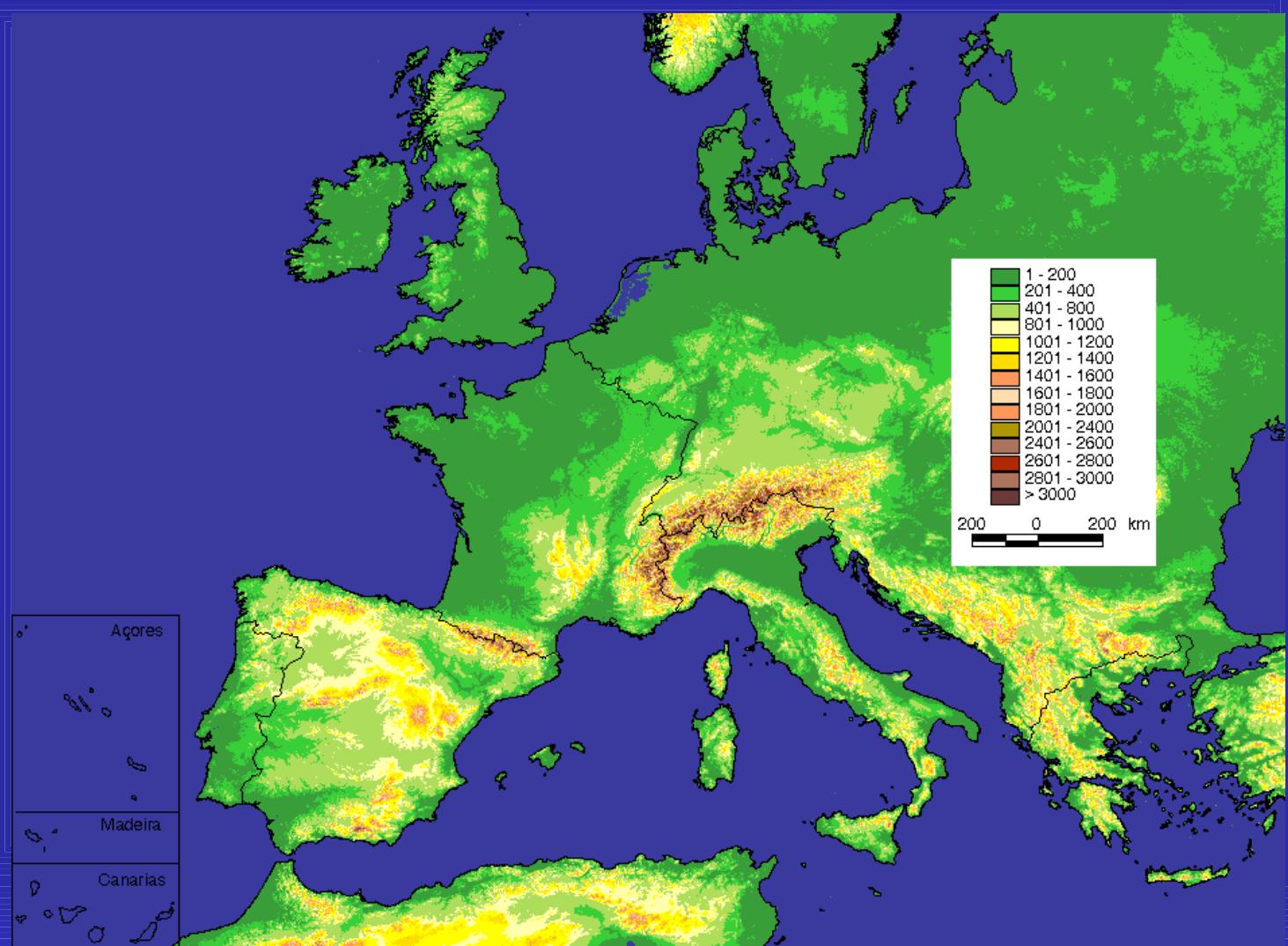
THE WORLD





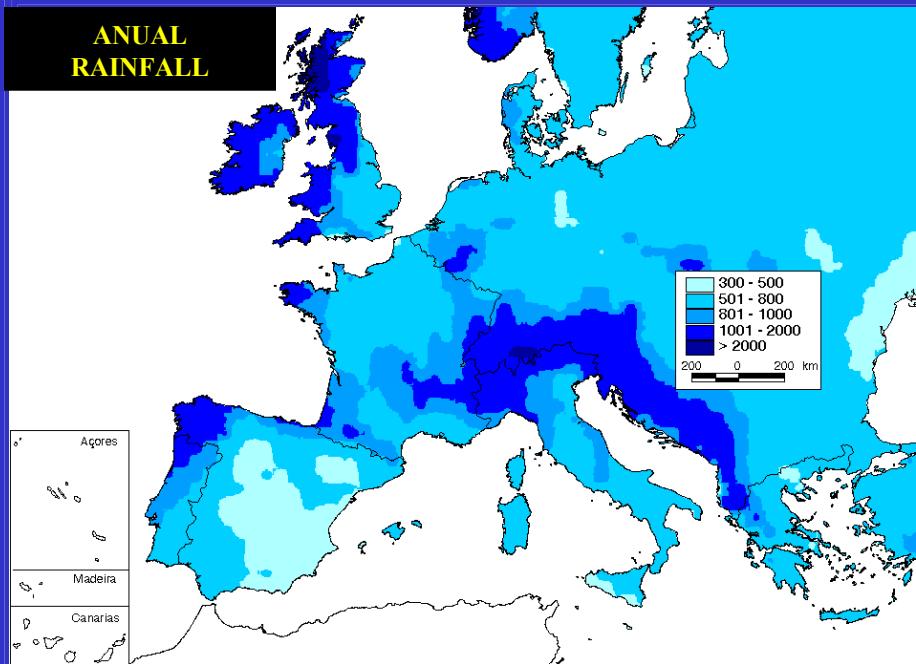


EUROPE

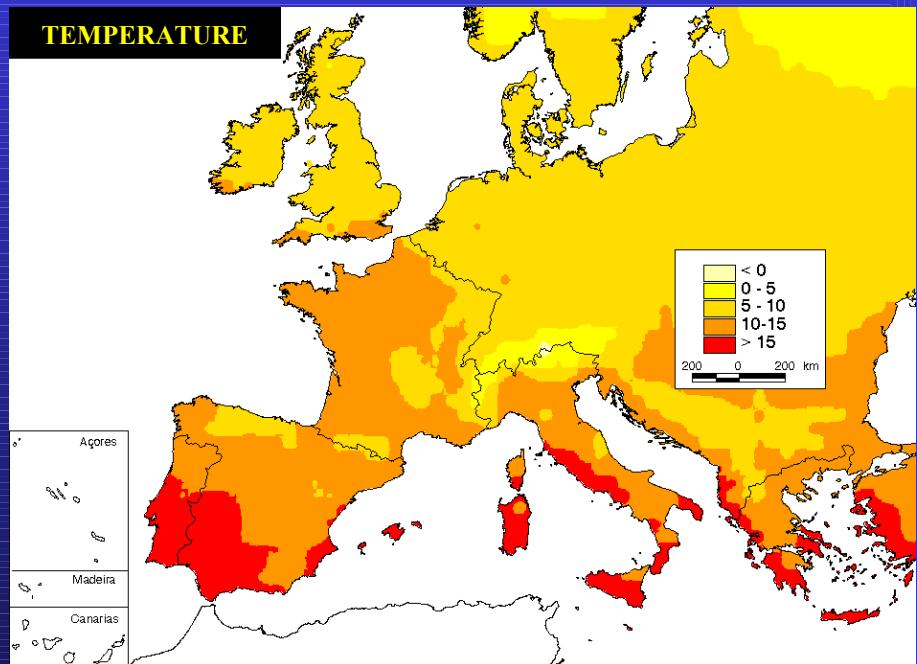


Modelo digital del terreno de Europa. Fuente: U.S. Geological Survey's EROS Data Center

**ANUAL
RAINFALL**



TEMPERATURE



EEA – EUROPEAN TOPIC CENTRE ON INLAND WATERS
CEDEX-ITGE

- 1) 500 - 700
- 2) 701 - 1000
- 3) 1001 - 1250
- 4) > 1250

**ANUAL POTENTIAL
EVAPOTRANSPIRATION**

ANNUAL POTENTIAL EVAPOTRANSPIRATION
DATA FROM EUROSTAT

EEA – EUROPEAN TOPIC CENTRE ON INLAND WATERS
CEDEX-ITGE

- 1) < -2
- 2) > -2 - -5
- 3) > -5 - 1
- 4) > 1

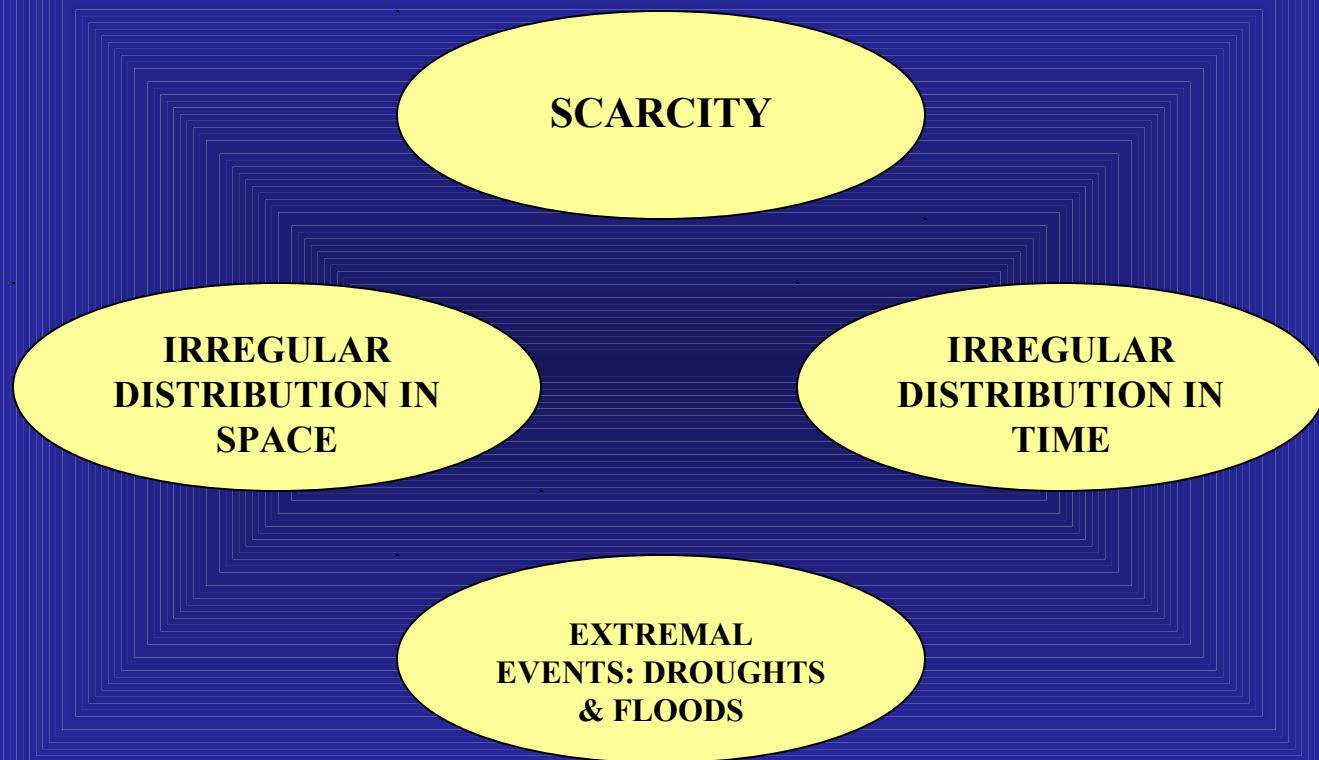
MOISTURE INDEX

HUMIDITY INDEX



SPAIN

Spanish Main Problems



SCARCITY

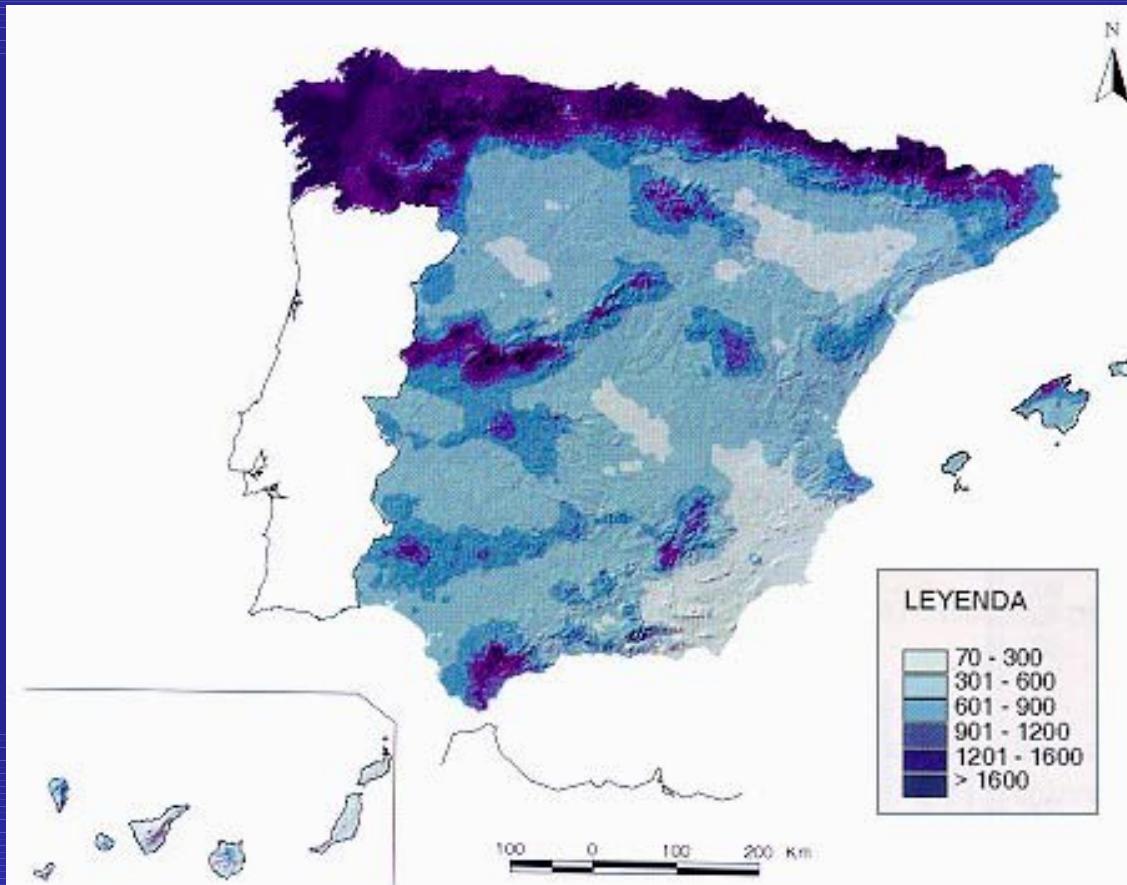
DIFFICULT DEVELOPMENT

AQUIFERS OVEREXPLOITATION

DESERTITATION

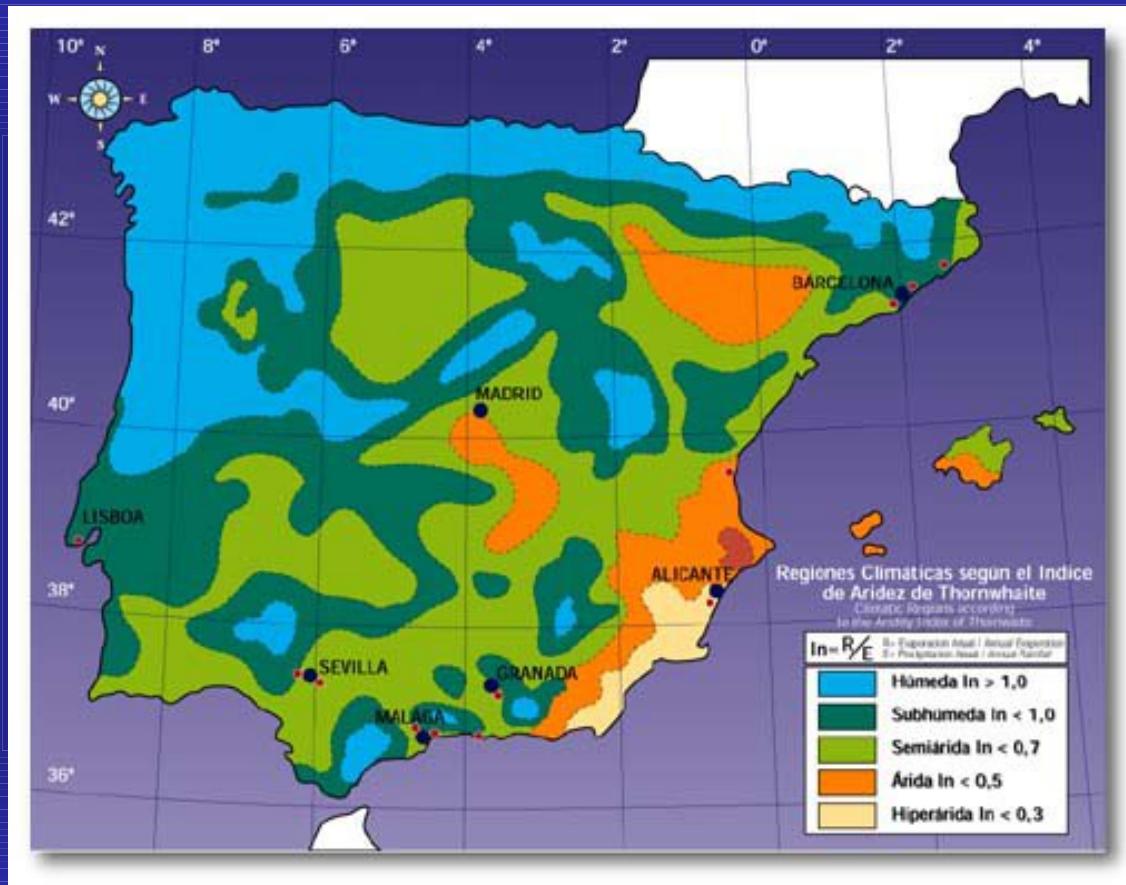
MANY OTHERS...

IRREGULAR
DISTRIBUTION IN
SPACE



ANUAL AVERAGE RAINFALL (mm)

IRREGULAR DISTRIBUTION IN SPACE

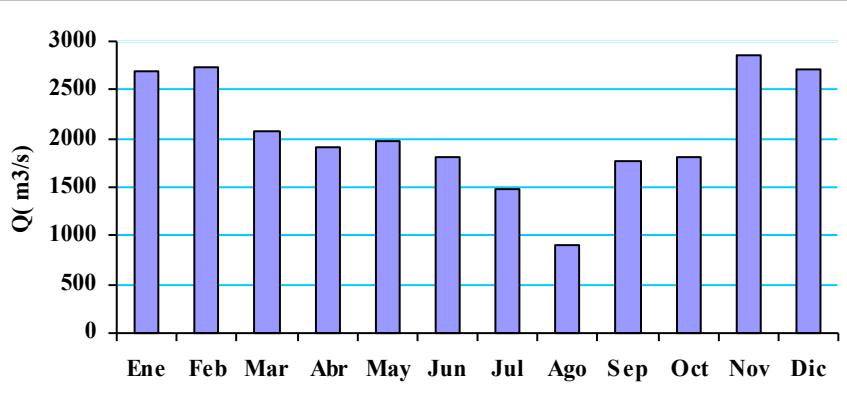


AVERAGE ARIDITY INDEX

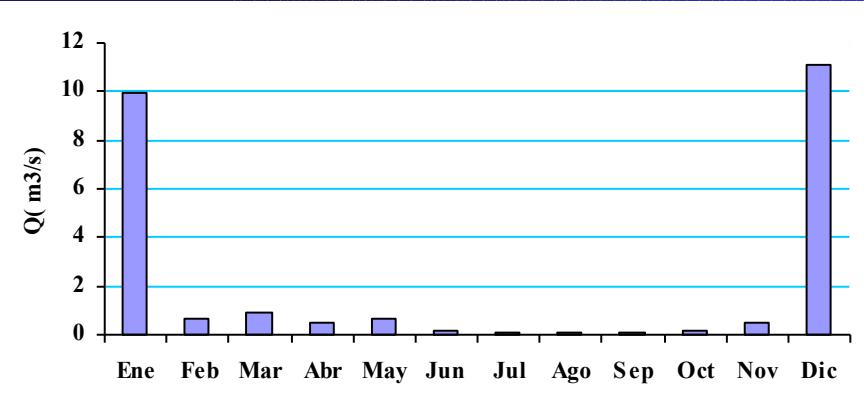
**IRREGULAR
DISTRIBUTION
IN TIME**



ANUAL RAINFALL DISTRIBUTION IN SPAIN



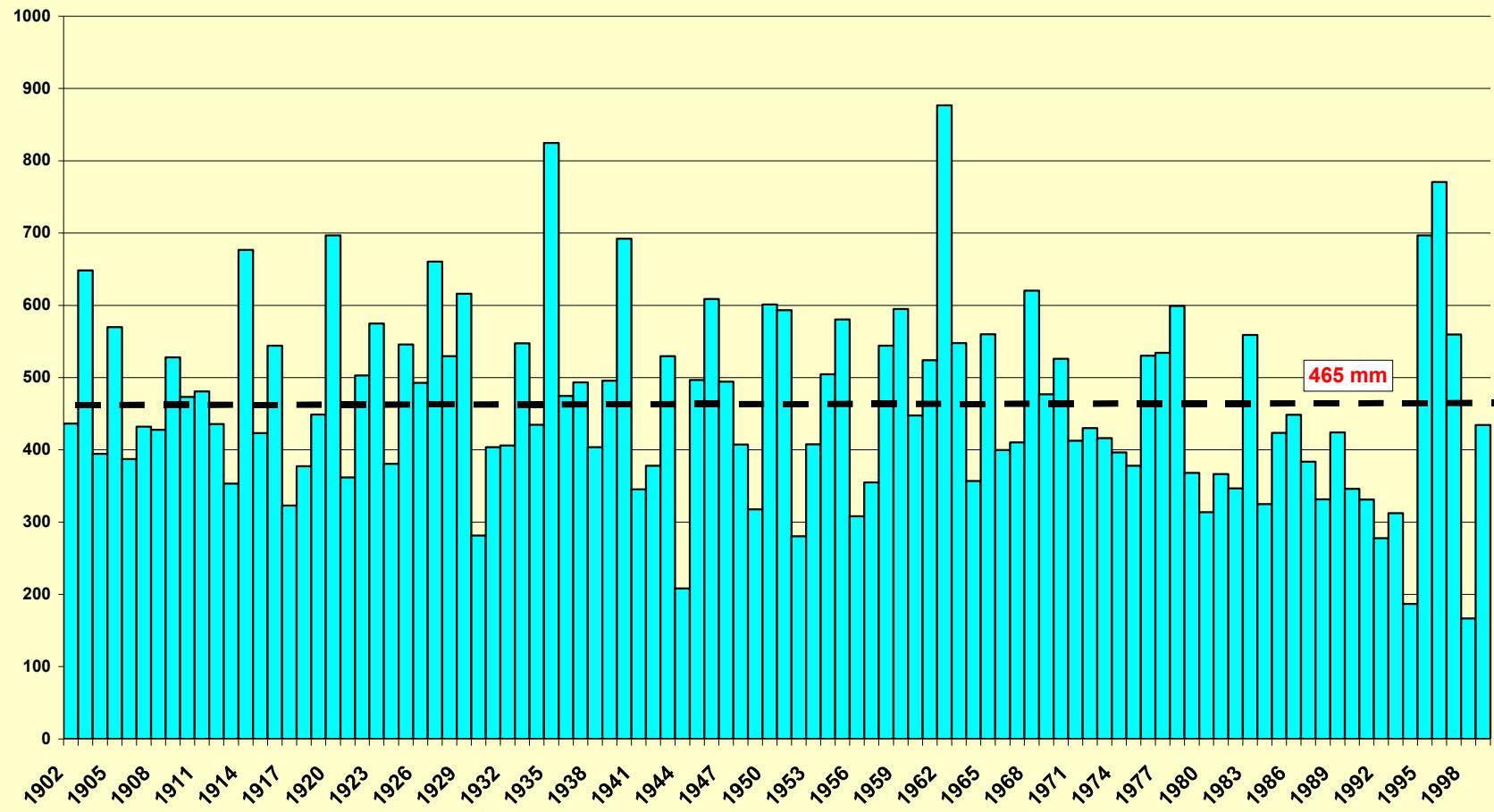
River Ródano, Beaucaire (Francia) 1990-97 except year 91



River Guadiaro, San Pablo de Buceite (España).1990-96

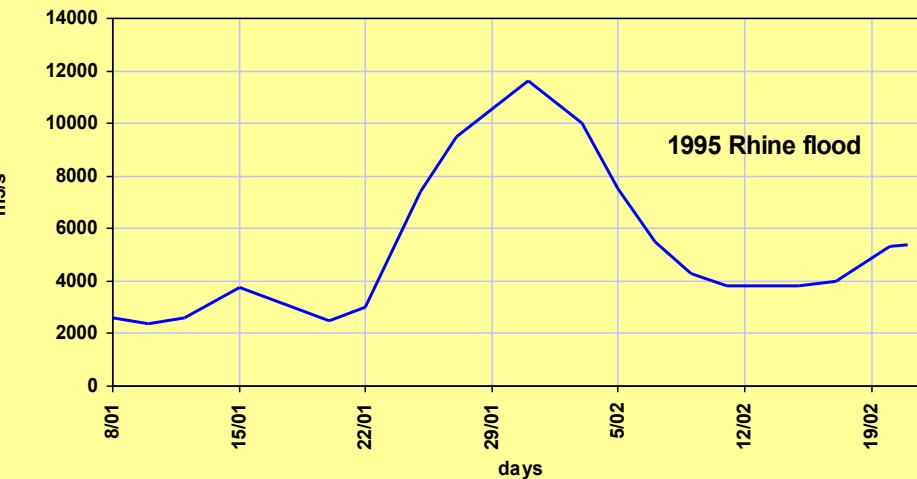
IRREGULAR
DISTRIBUTION
IN TIME

PRECIPITACION ANUAL EN GRANADA

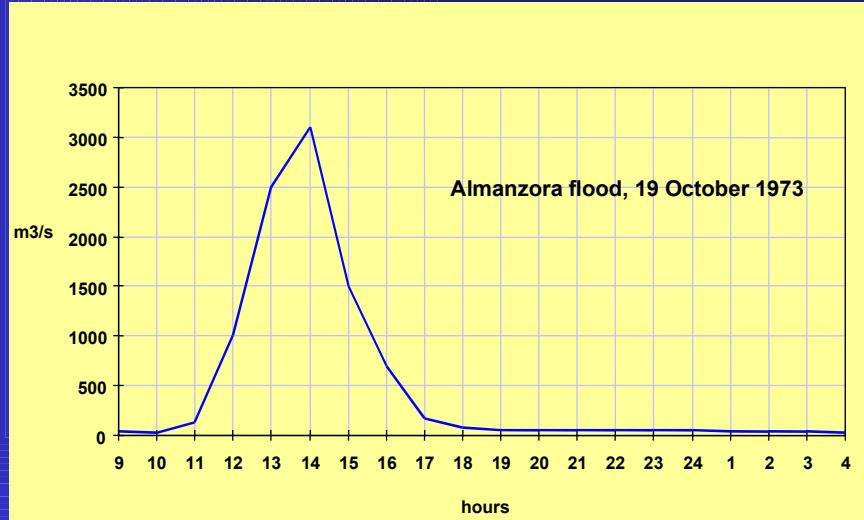


INTERANUAL VARIATION

EXTREMAL EVENTS: DROUGHTS & FLOODS

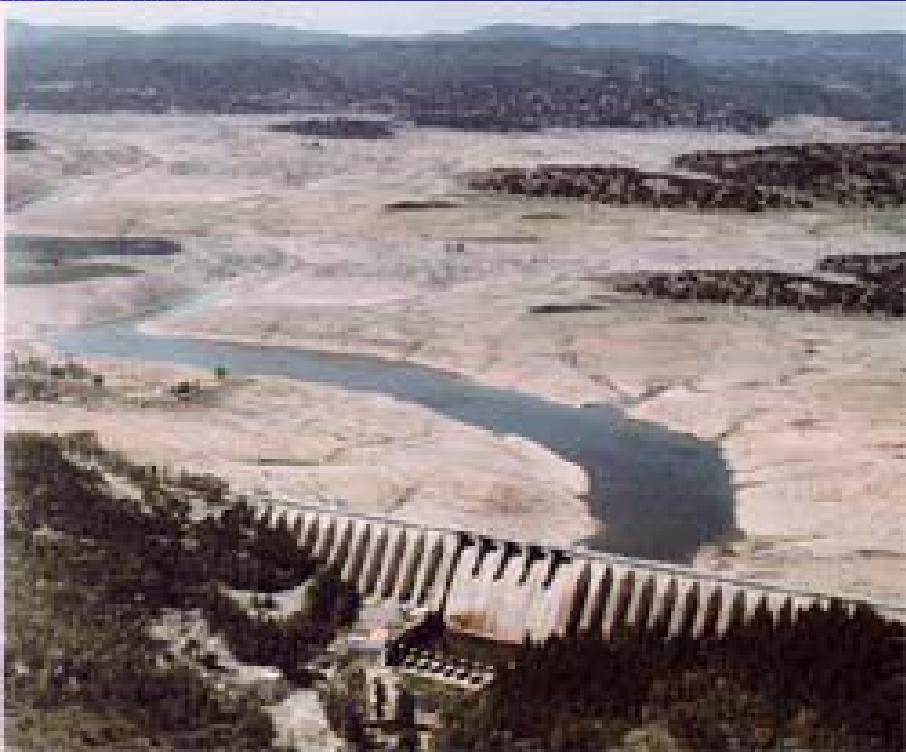


Hidrograma de la avenida de 1995 en el Rhin. Fuente: German Ministry for the Environment, 1996.



Hidrograma del río Almanzora en Almería, España durante la avenida del 19 de Octubre de 1973. Fuente: MIMAM, 1998

EXTREMAL
EVENTS: DROUGHTS
& FLOODS



DROUGHTS

Aracena Dam, (Huelva), 1995



FLOODS

Tous Dam Break, (1982). 550mm/24h,
Qin max=10,000m³/s Qout
max=15,000m³/s, 8 deaths.

What can we do with this problem?

A.- Leave such a “horrible” country and move to a more comfortable land

B.- Stay and enjoy our “paradise” but “fighting against the Gods”

C.- Just drink some WINE, have a “Siesta” and wait for a better weather

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Spanish Hydraulic Works through the HISTORY

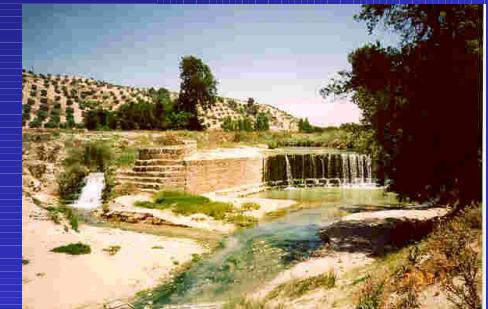
Roman Empire

XXII
XX
XVIII
XVI
XIV
XII
X
VIII
VI
IV
II
+

- Water supply, industry, irrigation and navigation
- Small dams but with regulation capacity
- Examples:

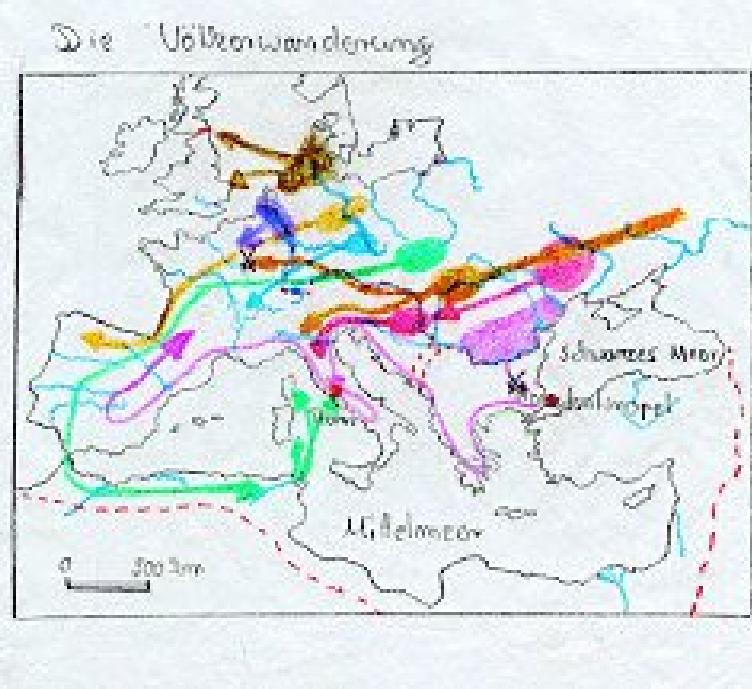


- *Toledo: Alcantarilla (17) + 40 km*
- *Mérida: Proserpina (19) & Cornalvo (24) + 10km*
- *Cádiz: 75 km*
- *Granada: Barcinas + 10km*
- *Itálica: 37 km*
- *Córdoba: 15 km*
- *Segovia: 12 km*
- *Tarragona.*
- *Ponferrada: 100 km*



Germanic Tribes

- more pasture than agriculture
- not new hydraulics works
- hydraulic development stopped



XXII

XX

XVIII

XVI

XIV

XII

X

VIII

VI

IV

II

+

Arabs & Christians

XXII

XX

XVIII

XVI

XIV

XII

X

VIII

VI

IV

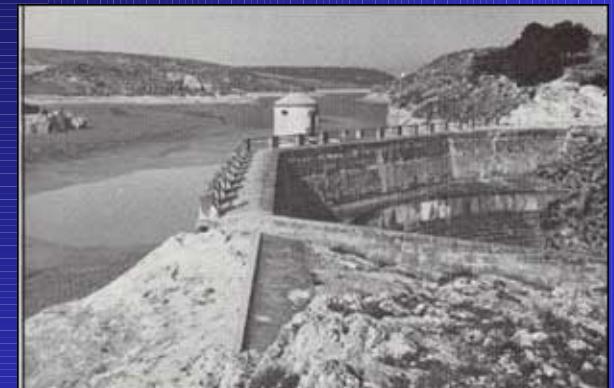
II

+

- water as a valuable natural resource
- agriculture (great development) and gardens
- water distribution more than water regulation
- use of Roman structures
- origin of the traditional Spanish irrigation systems



- *Granada: Alhambra and Generalife*
- *Zaragoza: Almonacid Dam (30)*
- *Albacete: Almansa Dam (15-21)*



Habsburg's Dynasty

XXII

XX

XVIII

XVI

XIV

XII

X

VIII

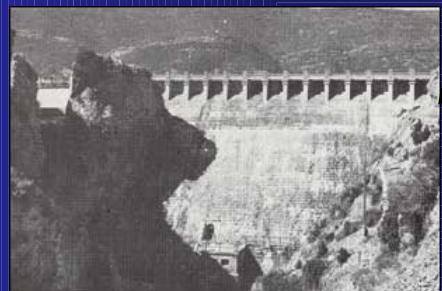
VI

IV

II

+

- new Hydraulic Works in Levante and Ebro's Area
- use of rivers for navigation purposes
- hundreds of new projects



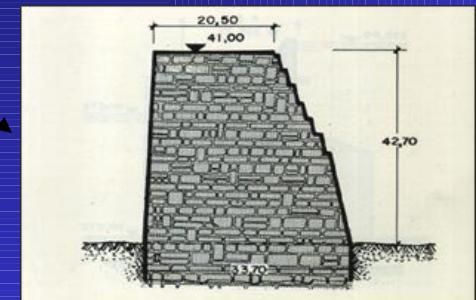
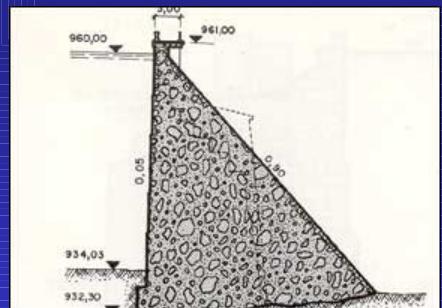
• „*Canal Imperial de Aragón*“

• *Huesca: Arguis Dam (1687, 23m)*

• *Castilla Channel (beginning)*

• *Alicante: Tibi Dam (1580, 46m)*

• *Transfers to Murcia (project)*



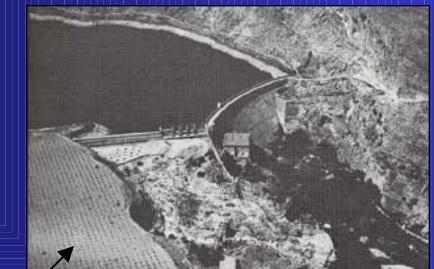
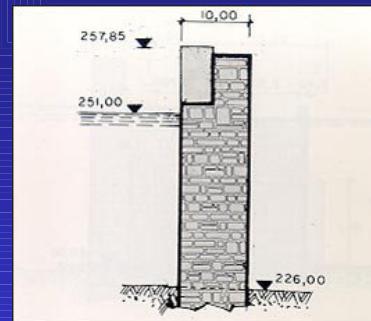
BORBONES' DINASTY

XXII
XX
XVIII
XVI
XIV
XII
X
VIII
VI
IV
II
+

- navigation channels as first objective all across the country
- still using Roman structures (repaired) and new ones
- lots of large dams



- *Madrid: Gasco Dam (1787, 91m but destroyed with only 50m)*
 - *Alicante: Relleu Dam (1653,32m)*
 - *Murcia: Puentes Dam (1785,50m)*
- *Zaragoza: Mezalocha Dam (1719, 45m)*
- *Castilla Channel (cont.)*



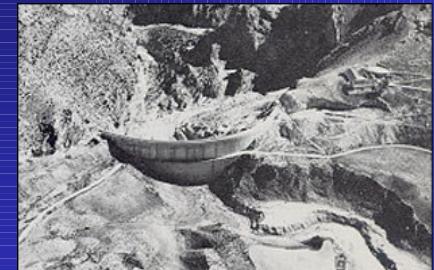
S. XIX

XXII
XX
XVIII
XVI
XIV
XII
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VIII
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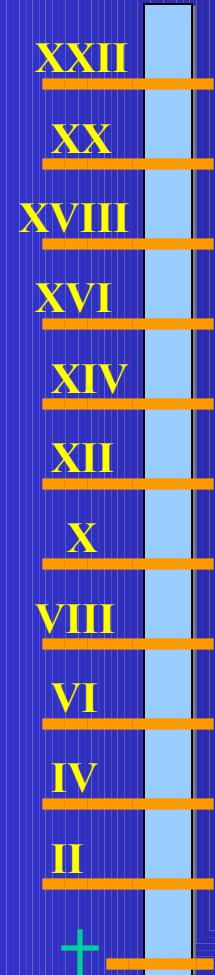
- great development after Independence War
- trains substitute navigation channels
- 1799: Cuerpo de Ingenieros de Caminos, Canales y Puertos and ist “Technical Highest School”
- 1864 first “global” planification
- 1866: first Law of Water
- 1870. Law of channels and reservoirs



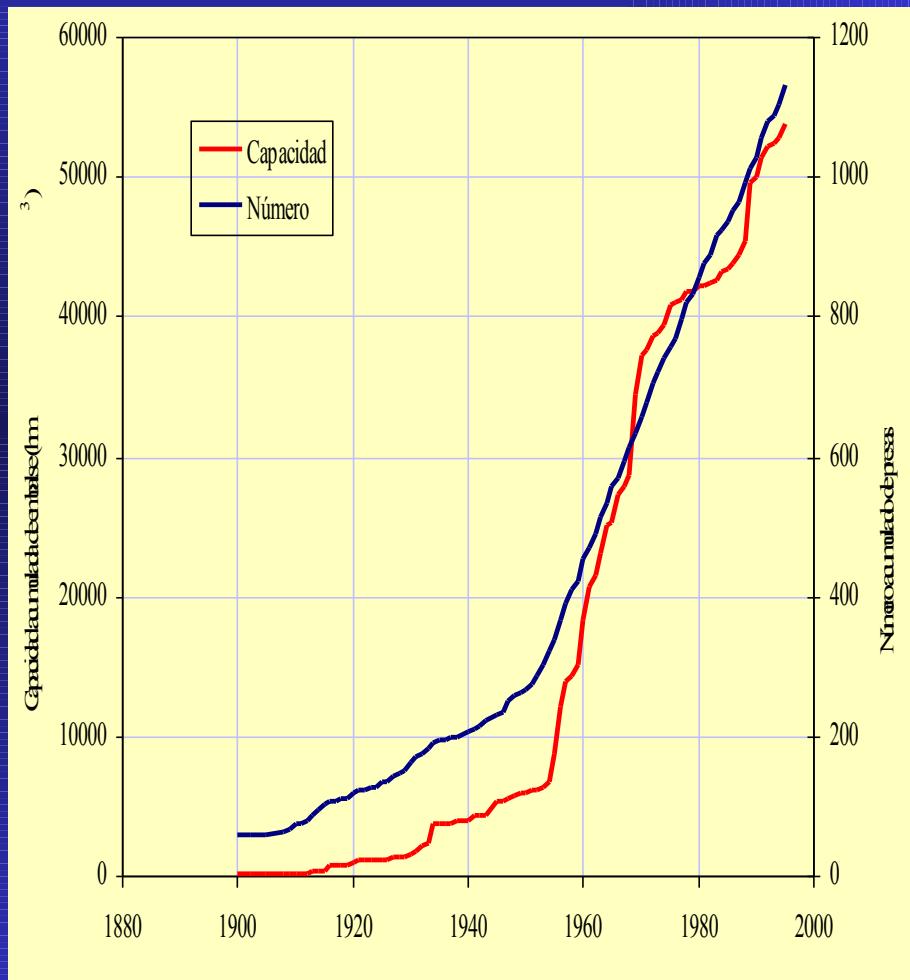
• Madrid: *El Villar Dam (1873, 50m)*
• Murcia: *Valdeinfierno Dam (1785-1806, 49m)*



S. XX



- 1902 General Plan of Irrigation Channels and Reservoirs (205 new hydraulics works but without a general organisation)
- 1926 creation of the “Hydrographic Confederations”
- 1936-1939 Civil War
- 1933 and 1940 National Plans of Hydraulic Works
- 1967-1978 Transfer Tajo-Segura
- 1985 Present Law of Water
- Enormous development



... And, what do
we have TODAY?

WATER RESOURCES

DAMS

GROUNDWATER
EXPLOITATION

WATER RE-USE

DESALINIZATION

TRANSFERS

WATER RESOURCES

DAMS

**GROUNDWATER
EXPLOITATION**

WATER RE-USE

DESALINIZATION

TRANSFERS



MORE THAN 1,200 LARGE
DAMS IN SPAIN

WATER RESOURCES

DAMS

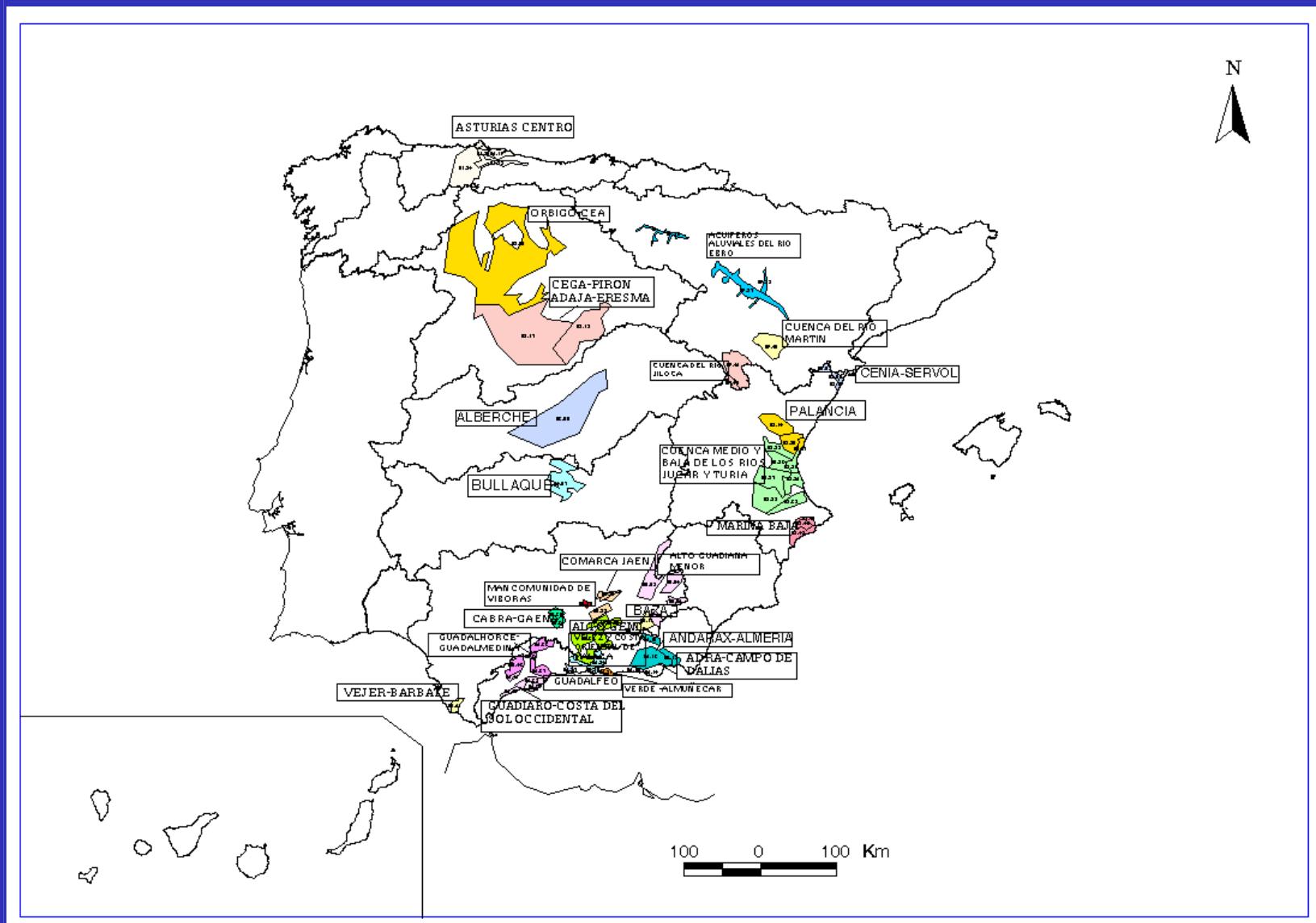
**GROUNDWATER
EXPLOITATION**

WATER RE-USE

DESALINIZATION

TRANSFERS

AQUIFERS-RESERVOIRS SYSTEMS



WATER RESOURCES

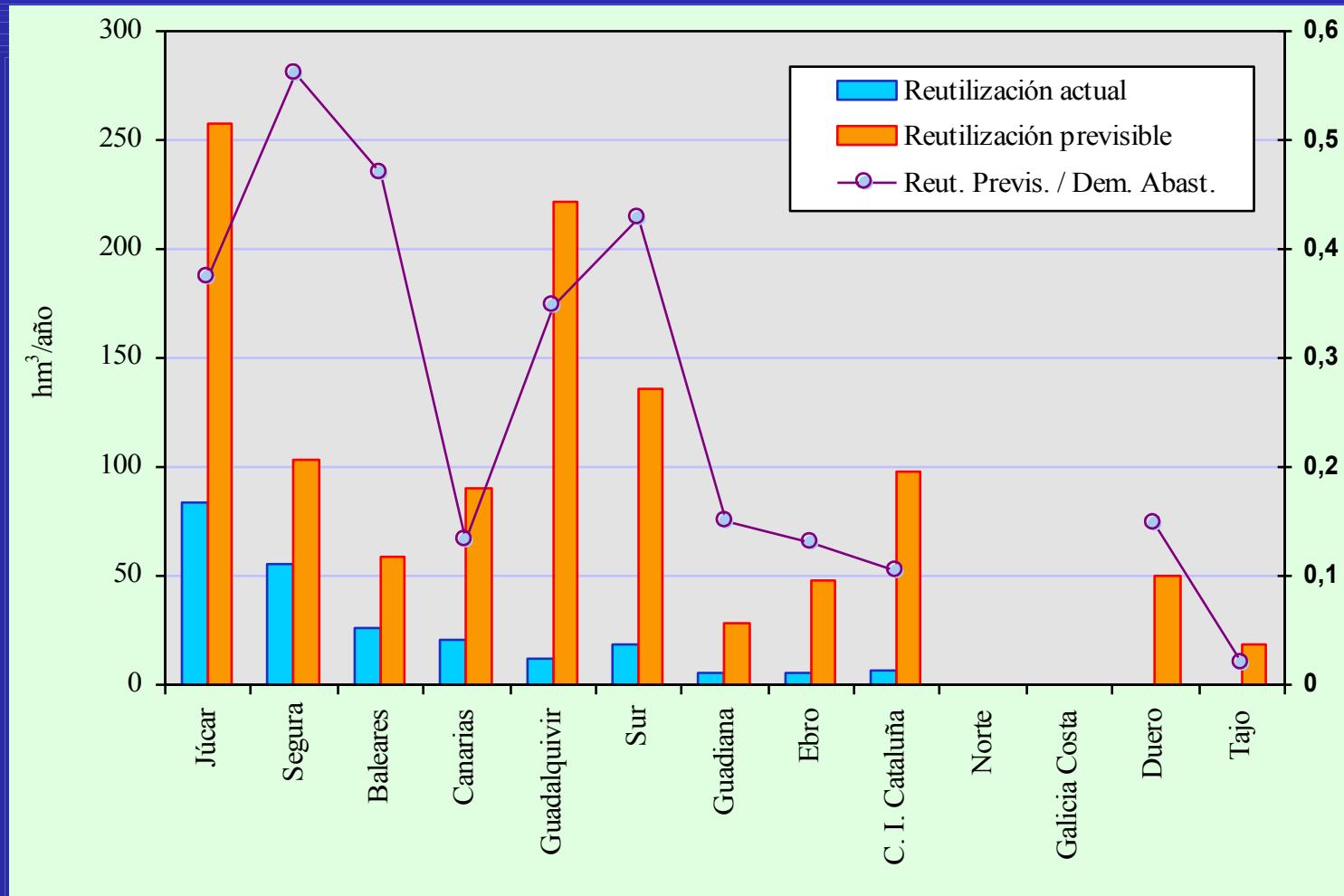
DAMS

GROUNDWATER
EXPLOITATION

WATER RE-USE

DESALINIZATION

TRANSFERS



Volúmen total de reutilización previsible en España (2º horizonte de los Planes Hidrológicos de cuenca): 1.100 $\text{Hm}^3/\text{año}$: (CEDEX)

Fuente: CEDEX

WATER RESOURCES

DAMS

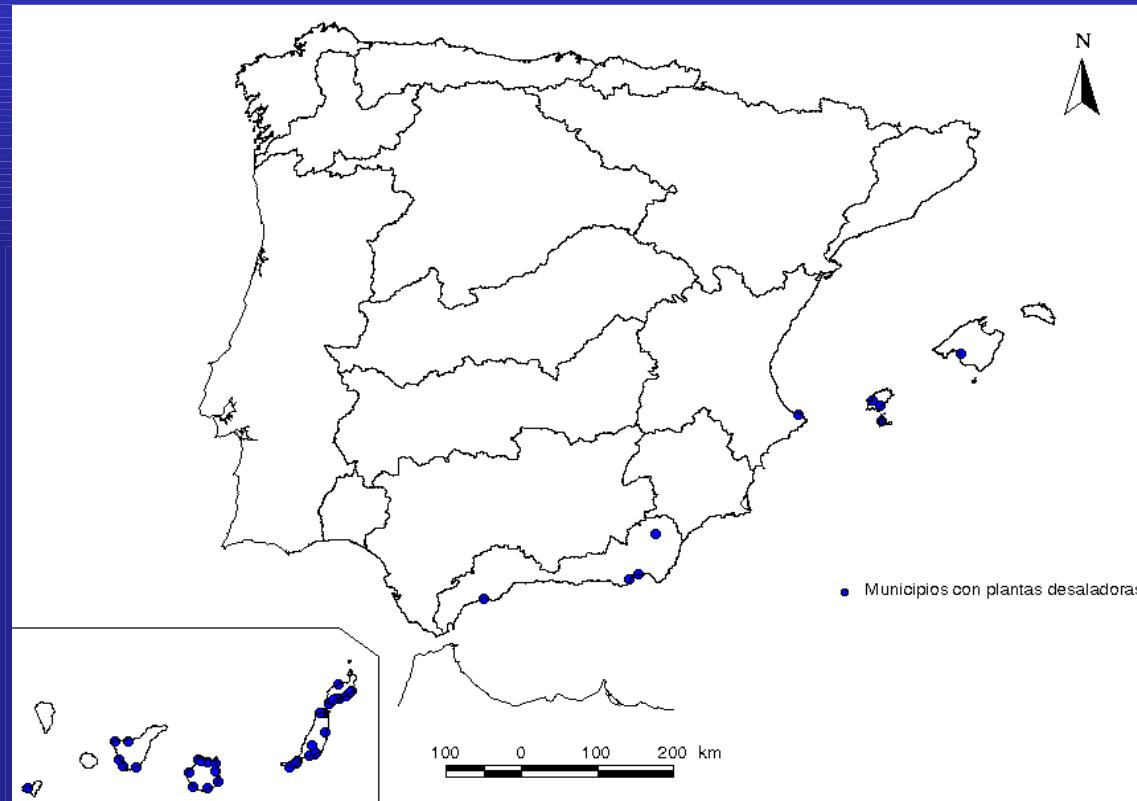
**GROUNDWATER
EXPLOITATION**

WATER RE-USE

DESALINIZATION

TRANSFERS

DESALINIZATION INSTALLATIONS



Mapa de municipios con instalaciones de desalación para abastecimiento urbano

Agua de mar	Uso urbano	89 hm ³ /año
	Uso agrícola	5 hm ³ /año
Agua salobre	Uso urbano y turístico	29 hm ³ /año
	Uso industrial	40 hm ³ /año
	Uso agrícola	58 hm ³ /año

Distribución por usos de las aguas desaladas marinas y salobres. Total: unos 220 Hm³/año

WATER RESOURCES

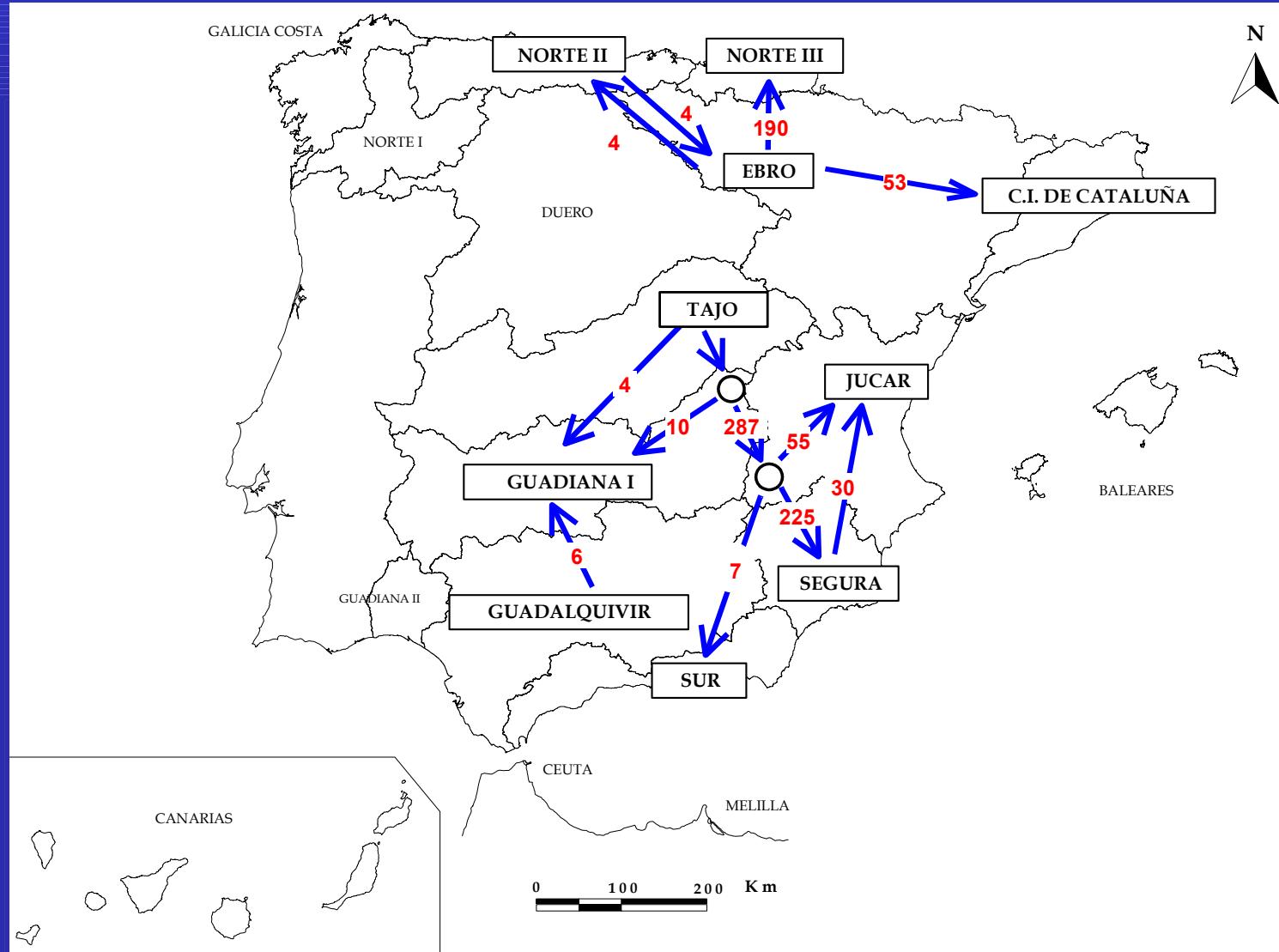
DAMS

GROUNDWATER
EXPLOITATION

WATER RE-USE

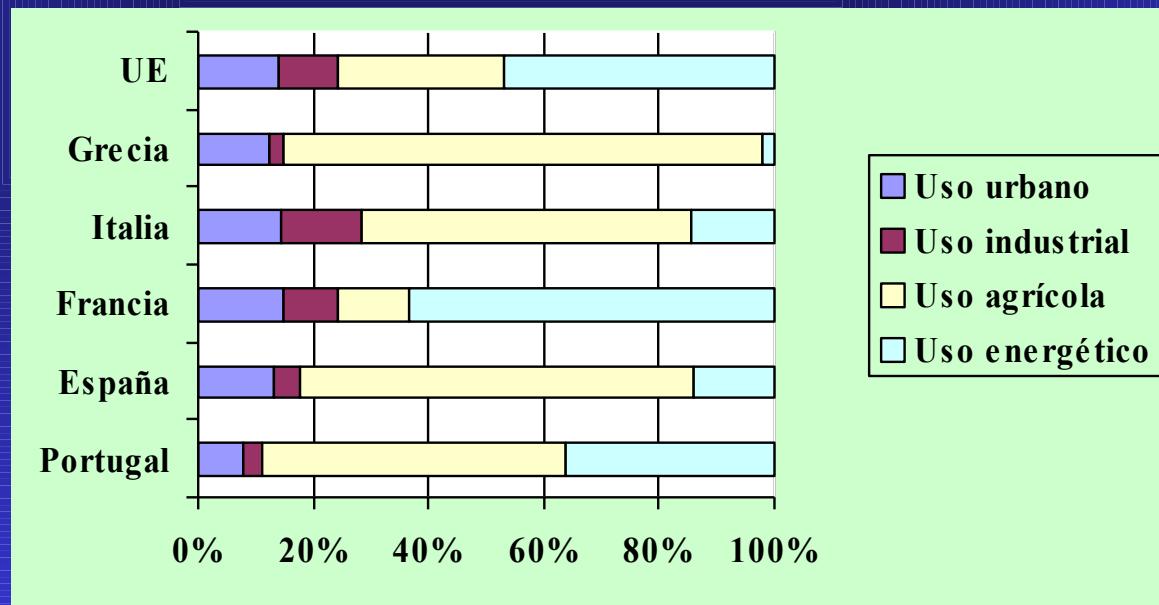
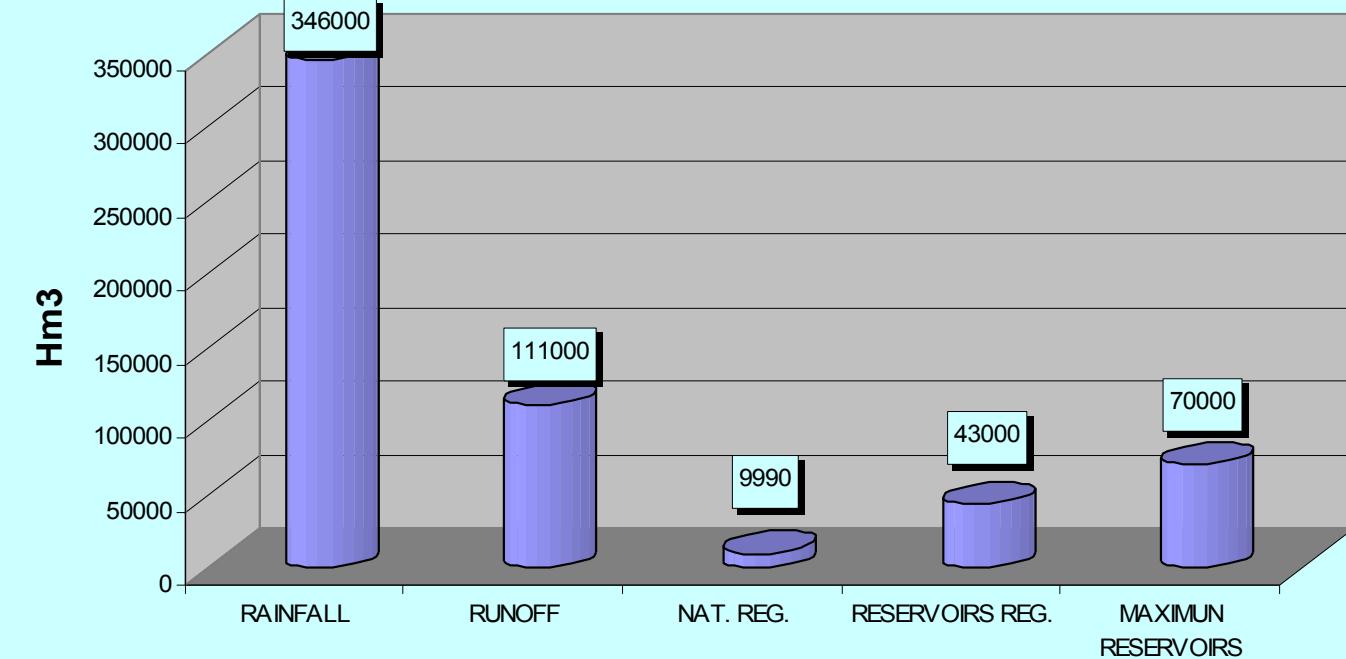
DESALINIZATION

TRANSFERS



Main Current Tranfers in Spain (average anual values hm³)

SPANISH FRESH WATER RESOURCES



Fuente: CEDEX

... Is the problem
solved, or we have
to keep on
working
TOMORROW?

**IN THE NEXT DECADE WE HAVE TO
DO...**

PLAN HIDROLÓGICO NACIONAL

PLAN NACIONAL DE REGADÍOS

NEW LAW ABOUT FLOOD RISK PROTECTION

NEW REGULATIONS ABOUT DAM SAFETY

EUROPEAN ENVIRONMENTAL POLICY

AUTONOMIC COMMUNITIES' HYDRAULIC WORKS

CONCLUSIONS





Thank you for your
attention