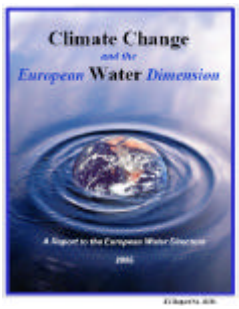
EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

DG JRC

Climate Change
and the
European Water Dimension



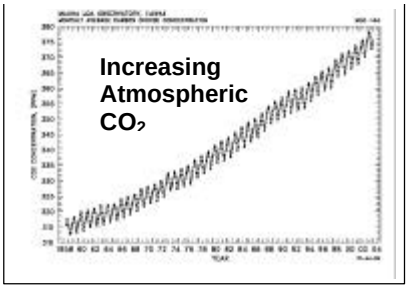
Climate change impacts on European waters

The compilation of this report follows a request from the European Water Directors (representatives from EU Member States and the European Commission). The study has been co-authored by more than 40 leading scientists from around Europe and Directorate General, Joint Research Centre's Institute for Environment and Sustainability (IES). The report, (as a synthesis of scientific information especially updated since the 2001 findings of the International Panel on Climate Change) will be used to assess existing water policy and whether it can accommodate real or anticipated impacts of climate change.

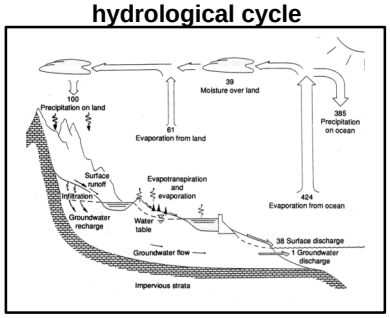
The European Water Directors asked the authors to determine: "to what extent have the Commission, Member States, marine and river basin commissions, and others, developed detailed predictions concerning the possible consequences of climate change? Do we know enough about the possible impacts of climate change at the European scale to act?"

The report offers additional convincing evidence of the warming of the atmosphere and European lakes and seas, alterations of biological, chemical and physical characteristics of European water bodies, and the dramatic impact the ecology of the region will undergo in response to sea level rises, extreme events and warming.

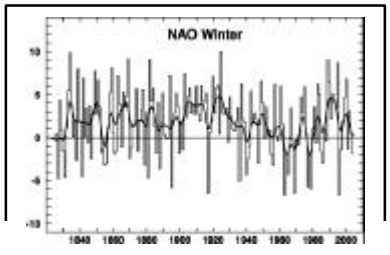
- **Average global temperature over land surfaces has risen by 0.6 ± 0.2°C in the period from 1861 to 2000. This temperature increase is unprecedented within the past millennium.**
- **The projected temperature increases over the 21st century for the full set of scenarios developed by the IPCC were in the range 1.4 to 5.8^{0}C.**
- **Projected sea level rises are in the range 0.1 to 0.9 m over the period from 1990 to 2100; however feedbacks and non-linear effects may lead to an accelerated collapse of ice sheets and thus larger sea level rises.**
- **The average increase in the observed annual mean temperature across the European continent is 0.8^{0}C.**
- **The summer of 2003 was the hottest summer on record and the last 30 years appear to have had the warmest climate over the last five centuries.**
- **Annual precipitation over Northern Europe has increased by between 10 and 40% in the last century while the Mediterranean basin has experienced up to 20% reduction in precipitation.**
- **Global average precipitation is predicted to rise, but this increase is likely to be regional. Winter**



Intensification of the hydrological cycle



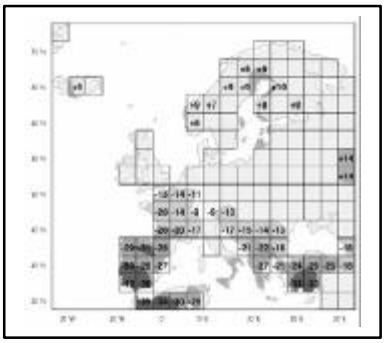
Historical Trends in Winter NAO



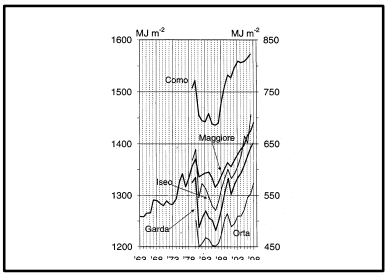
and spring precipitation may increase in Northern Europe and summer precipitation will decrease, although Southern, Central and Eastern Europe may experience reduced precipitation.

- The incidence of extreme precipitation events is predicted to increase.
- A positive North Atlantic Oscillation (NAO) index is associated with strong westerly winds and wet winters in Northern Europe, whereas drier conditions occur over much of Central and Southern Europe. The NAO has had a strong influence on winter temperatures across Western, Northern and Central Europe during recent decades.
- Response of lakes to climate forcing is most coherent for physical parameters: there is a high probability for earlier ice-out, increase of lake temperatures, and stronger thermal stratification in a warmer future.
- Biological changes induced by climate change are inherently unpredictable. Small variations in climate can have dramatic effects on biota.
- Lago Maggiore (large alpine lake) has fully mixed on average 1 every 7 years prior to 1971; the lake has fully mixed only once since 1971.
- Global warming is responsible for a rise in sea level of 1-2 mm/yr with a subsequent increase in coastal erosion, flooding, salinization of estuaries and land aquifers.
- Global sea surface temperature has warmed by a mean of 0.6°C resulting in a re-distribution and loss of marine organisms, higher frequency of anomalous and toxic bloom events, and enhancement of hypoxia at depth.
- Coastal lagoons will be the first to react to consequences of changes in climatic trends, especially in rainfall. Changes in precipitation patterns will have important consequences for the water balance of coastal ecosystems, increased nutrient transport from the watershed to the coastal lagoon and sediment transport both from land-side and sea-side.
- The main driver of floods and droughts is extreme precipitation linked to regional soil moisture and atmospheric temperature. Changes in extreme climate are likely to have a greater impact on society than changes in mean climate. Flood magnitude and frequency are likely (a 66-90% probability) to increase in most regions of Europe.
- Europe's vulnerability to drought is increasing due to increased demand for water in some sectors and regions and the impact of climate change.
- Climate change effects on aquatic ecosystems cannot be mitigated at the level of the river basins, but only at global scale. At the time scale of the programmes of measures foreseen under the Water Framework Directive, considerable change in climate can be expected with changed ecological status.

Trends in Precipitation (%) to 2080



Trends of the heat content in five deep Italian lakes



Conceptual diagram of climate impacts on catchment and lake processes

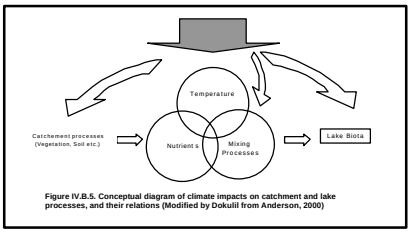
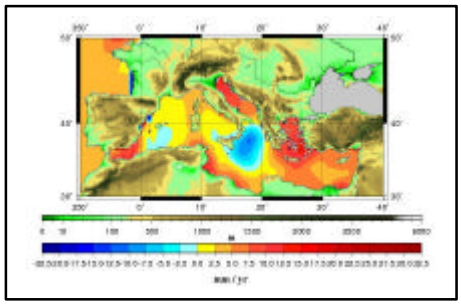
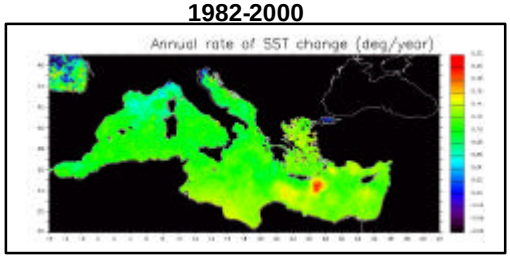


Figure IV.B.5. Conceptual diagram of climate impacts on catchment and lake processes, and their relations (Modified by Dokulil from Anderson, 2000)

Sea Level Rise in the Med. Sea 1993-2004



Annual rate of T change for the Mediterranean Sea for the period 1982-2000



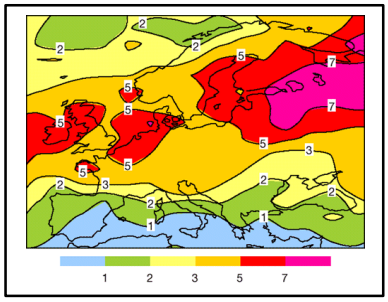
- **Agriculture is the most vulnerable human activity under unfavourable climatic conditions. In Europe, this applies for the northern (temperature-limited) and southern (moisture-limited) regions. Agriculture uses ~ 38% of the abstracted water with large regional differences - 50 to 80 % in southern Europe, < 5% in northern Europe**
- **Models suggest that air temperature may increase (2-3°C) and precipitation reduce (5-20%) for most of Spain, and for the Ebro watershed. Increased temperature will increase evaporative losses, crop water demands, and an increase in water resource demand from all sectors.**
- **The mobilisation, distribution and fate of chemical pollutants and pathogens through floodwaters are likely.**
- **Temperature is an important driver to the global cycling of organic contaminants through its influence on emissions from primary and secondary sources, gas-particle distributions, reactions, air-surface exchange (vegetation, soils, snow/ice) and global transport.**
- **Extreme variability in climatology in weather conditions increase the frequency of heavy rainfall events, with associated flooding and increased temperature, with a concomitant increase in waterborne and vector-borne infections.**

Adaptation and Some Actions

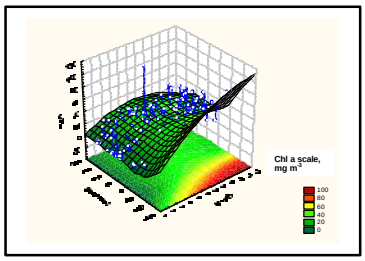
- **Develop and apply regional climate change models at the sub-regional and river basin scale to assess potential response of land and water systems, and mitigation strategies with associated costs.**
- **Quantify at the European and river basin scale the impacts of climate change on *water quality* of surface water and ground water, and water classification for river basin management by coupling river basin – coastal zone models in a climate changed world.**
- **Quantify at the European and river basin scale the impacts of climate change on *water quantity*, its spatial-temporal distribution including extreme events such as floods and droughts, and availability of surface and ground water under different scenarios and uses, and the associated costs of adaptation.**
- **Evaluate the effectiveness of different protection measures in trans-national river basins with hydrological models as a response to possible increase in extreme events.**
- **Evaluate the impacts of climate change on the re-mobilization, redistribution and emission of contaminants (as a result of warming and extreme events.**
- **Establish long term monitoring at the pan-European scale of marine/coastal systems using earth observing satellites and other tools of those parameters sensitive or indicative of climate change.**

Thau lagoon during a dystrophic episode (malaïgue) 1997

The number of times more likely it is that a European winter will be extremely wet in 50 to 100 years, compared with today.



Long-term distribution of chlorophyll *a* in L. Võrtsjärv as a function of water level and season, correlated with NAO



The Report is available at
http://ies.jrc.cec.eu.int/