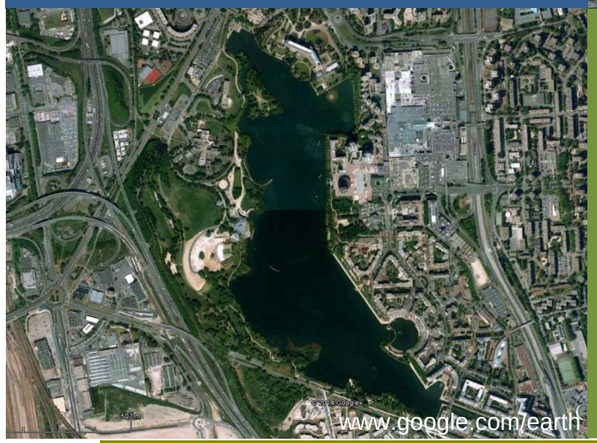
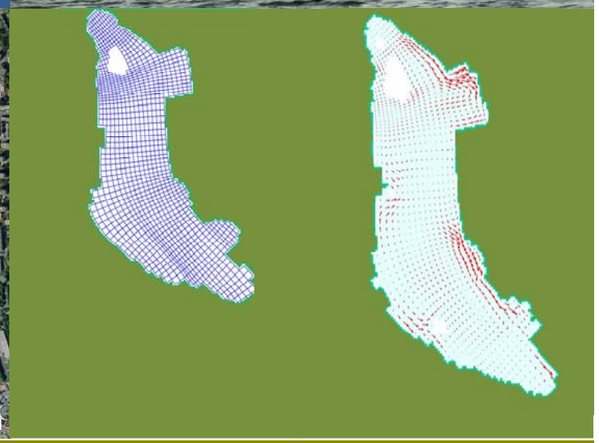
Urban Lake Monitoring: preserving lake ecosystems for sustainable cities

Case Lake Créteil





Urban lakes are vulnerable ecosystems that require constant monitoring:

- Urban lakes can provide several eco-services besides water supply, as flood risk reduction, humidity control, temperature cooling, birds and wild life support and preservation, leisure, recreation and landscape integration.
- Pollutants generated in urban areas affect lake behavior causing low oxygen rates, loss of water visibility, toxic algal blooms, sedimentation, unbalanced growth of aquatic plants, disease vectors habitats and fish death.
- Urban lake management is a challenge that involves public and private actions for waste water and solid waste control, public areas washing and cleaning, construction regulation permits and restrictions.
- Lake monitoring and modelling are efficient decision support tools for achieving a sustainable urban environ.

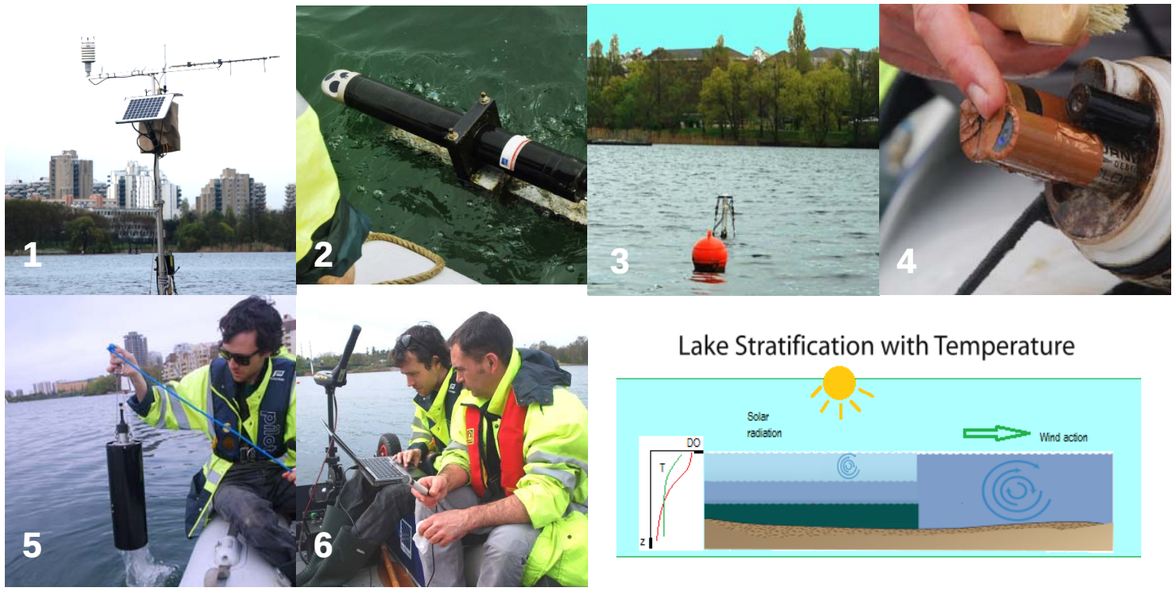


Figure 1. Meteorological Station collects air temperature, relative humidity, solar radiation and atmospheric pressure each 30s and transmit data using GSM network.

Figures 2 - 4. Submerged sensors tied to buoys collect automatically water temperature, water velocity and Chlorophyll concentration, storing data in flash memory cards.

Figure 5. Periodic water samples are taken to the Lab for nutrients and other chemicals evaluations.

Figure 6. Each 2 weeks, researchers recover data from data-loggers and send them to the LEESU for analysis and modelling.

Figure 7: Bloom of algae with toxic cyanobacteria darkens the water, dumping light and heath transfers, powering temperature stratification. Bottom water tends to stay cooler than surface waters, stopping vertical circulation that spread oxygen through water column. Pollutants at bottom tend to concentrate and the oxygen rate decreases. Wind action can turn over the stratification and redistribute oxygen but pollutants at bottom can be re-suspended.

Stratification, Pollutants and Water Use

Stratification occurs when the surface temperature of the lake is higher than the bottom. It has important implications for fishery management, phytoplankton (algae) populations, and water use in general.

As the sun radiation warms the lake surface through late spring and early summer, the temperature differences increase between the surface and deeper waters causing the reduction of the water density in the surface. In lake portions deeper than 3 to 5 m the temperature differences eventually create a physical barrier where the lighter waters float over the dense ones, interrupting the vertical circulation and the oxygen supply to bottom layer.

Blooming of algae, caused by the excess of nutrients like nitrogen and phosphorus can color the water, avoiding light penetration and majoring the problems. Those nutrients are generated by urban and rural human activities.

Absence or loose sewer systems, lack of non-source pollution control, loos of pervious areas, erosion, wind blocking by buildings and accidents are among the main causes of lake degradation.

Continuous non planned city growing and climate changes are also important components to be taken into account in sustainable lake management.

The Ecosystem of Lake Créteil

Lake Créteil was originally an extraction quarry of gravel and gypsum between 1940 and 1976. The quarry was dug in the former alluvium of Seine and Marne rivers, near their confluence.

Excavations reached the groundwater surface that flows from the Marne River leading the pond formation. In the middle of 70's the pond was transformed into an urban lake, now in an urbanized area in the south-east Paris.

Covering 40 ha and storing 1.9 Mm^3 of water, the lake is 1.5 km lengthwise and 250 to 400 m wide. The northern portion is shallower than the southern and along its 4 km perimeter it is surrounded by buildings in the North, East and South-East banks. An artificial hill was built in the east to reduce the noise from the nearby motorway.

Direct precipitation and runoff from storm waters supply the lake as well as the groundwater. The water is used to watering the park at the west side and also in road cleaning. A leisure center is present and aquatic sports are regularly practiced on its waters.

The lake is temperature stratified every spring-summer period and shows the presence of plants (phitoplanctum) and nutrients, that highlights the importance of its monitoring.

STUDY SITE
Lake Créteil

INSTRUMENTATION

Meteorological Station
Sensors Chains
Velocity Profilers

SCENARIOS

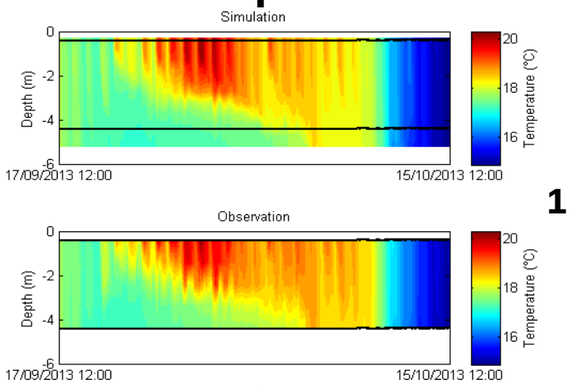
Floating Buildings
Air-Conditioning (DWSC)*
Heat Inter-seasonal Storage
Climate Change
…

DATA BASE

Meteorological Variables
Currents
Water Temperature
Chlorophyll *a* Concentration

MODELS

Hydrodynamic 3D Model: Delft3D-FLOW
Water Quality Model : DELWAQ



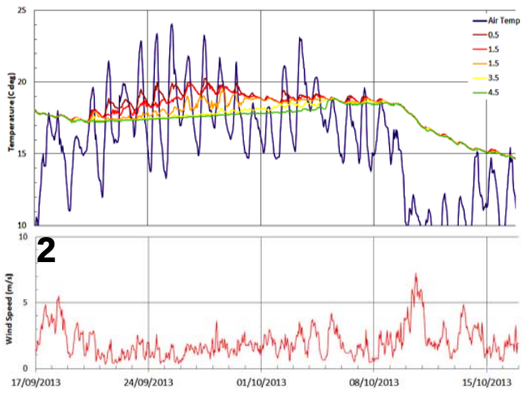


Figure 1. Temperature stratification observed and measured in central point of Lake Créteil. Stratification turn-over can be seen when warm colors turn to blue.

Figure 2: Air Temperature and Wind are most important parameters governing stratification in Lake Créteil.

FORECAST

Scenario impacts on lake behavior
Emergency action plans

DECISION

*** DWSC: Deep Water Source Cooling**

Learn more:
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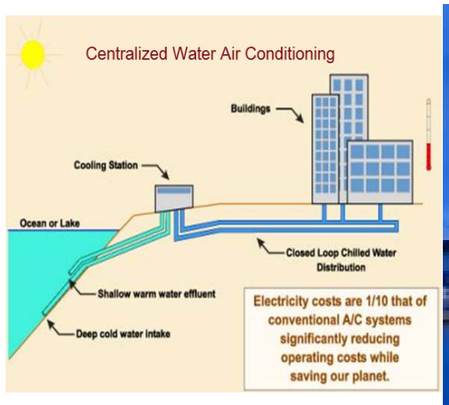
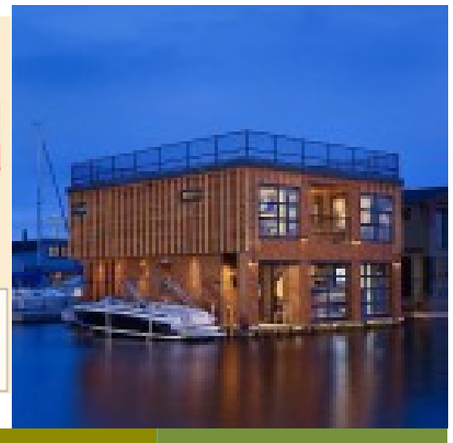
Applications

Urban lake waters can be used for several sustainable purposes that help save energy and preserve natural resources. Building air-conditioning can be done employing heat circulation pumps that conduct hot water from inside of the buildings through submerged cooling systems on the lake.

Electric energy production using water column temperature gradient or submerged turbines are alternatives to conventional oil and coal small thermic plants with less greenhouse gases emissions in the overall process.

Constant lake monitoring and modelling allow an optimized design of those facilities and limit its impacts over the lake ecosystem, contributing to a sustainable urban environ.





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