



WORLD  
METEOROLOGICAL  
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## Integrated weather, climate, hydrology and related environment services for sustainable cities

**The accelerating growth of urban populations, especially in developing countries, has become a driving force of human development. Crowded cities are centers of creativity and economic progress but, from polluted air to flooding and other climate impacts, they also face major weather, climate, water and environment-related challenges. Increasingly dense, complex and interdependent urban systems leave cities vulnerable: through a domino effect, a single extreme event can lead to a broad breakdown of a city's infrastructure.**



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Meteorological and related services provide essential information and forecasts that can assist urban decision-makers to face these challenges. These services can be used by emergency managers to map out risks and provide early warnings. They can be used by transport departments to minimize emissions, health providers to prepare heat-action plans and responses to severe pollution events, and agriculture and clean-energy managers to optimize production. Water departments can rely on such services to implement integrated flood-management plans, and urban planners can use them for siting buildings and infrastructure where they will be less vulnerable to sea-level rise and other climate change and environmental impacts.

The World Meteorological Organization (WMO) is promoting safe, healthy and resilient cities through the development of Urban Integrated Weather, Environment and Climate Services. The aim is to build urban services that meet the special needs of cities through a combination of dense observation networks, high-resolution forecasts, multi-hazard early warning systems, disaster-management plans and climate services. This approach gives cities the tools they need to reduce emissions, build thriving and resilient communities and implement the UN Sustainable Development Goals.

## City-scale observations and forecasts

Urban areas have many unique meteorological, hydrological and climatological characteristics. Their tightly packed mix of green spaces, tall buildings and concrete surfaces produces intricate rain, wind, heat and air-quality patterns. Hard surfaces can shape water flow and aggravate flood risks. Lines of buildings can create local wind tunnels. Tiny particles emitted by traffic and industry can reduce air quality, while the urban heat-island effect can raise urban temperatures by up to 5-10°C and exacerbate heatwaves. To adapt to and, where possible, benefit from these micro-patterns, cities need to invest in high-density observation networks and high-resolution forecast models tailored to the urban environment.

New and emerging technologies can be used to harmonize, integrate and densify meteorological, hydrological and environmental observations in urban areas. Crowdsourced data collection and networks of mobile sensors embedded, for example, in cell phones or cars, can provide low-cost

and flexible solutions that complement more traditional sources of observations.



*Dense observations make it possible to provide high-resolution, city-scale forecasts for a wide range of urban decision-makers.*

## Hazards and warnings

The number of reported hydro-meteorological disasters has steadily increased over the past few decades. Improvements in weather forecasting, disaster management and emergency planning have drastically lowered the resulting loss of life. At the same time, the risk of greater disasters has risen as urbanization and other human pressures have increased public exposure and vulnerability to natural hazards.

WMO recommends that urban governments consider adopting Multi-Hazard Early Warning Systems (MHEWS) to minimize losses from hazards. This approach allows a single cost-effective system to deliver warnings on a wide range of hazards, including storms, temperature extremes and air pollution. By employing impacts-based warnings, which describe the physical impacts of a hazard, rather than difficult-to-interpret measurements such as “100 km/h wind” or a “3m sea-surge,” these systems provide essential information to assist people in taking action.



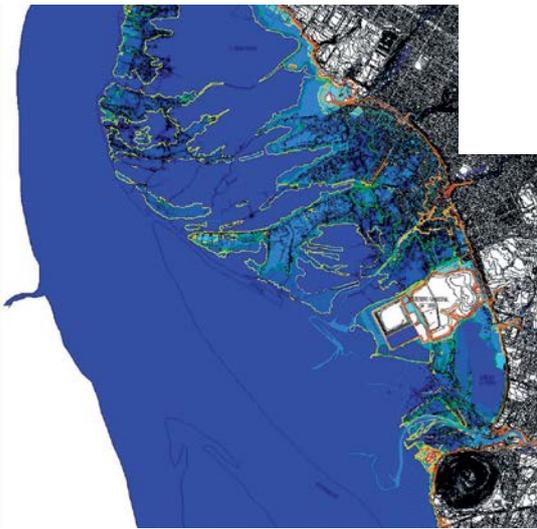
One of the first cities to successfully implement a MHEWS is Shanghai, which collaborated with WMO's Global Atmosphere Watch (GAW) Urban Research Meteorology and Environment (GURME) project when it prepared for the safety of the Shanghai World Expo 2010. In early 2016, WMO also launched the HIWeather project which aims to dramatically increase urban resilience to high-impact weather over the next 10 years.

Developing a MHEWS requires analyzing and mapping city-specific information on population patterns, hospitals and other infrastructure, evacuation routes, and other relevant factors. It also requires political commitment, clear authority and roles, and standardized procedures.

# Climate services

Because of climate change, it is no longer possible to rely on past experience when planning for future natural hazards. Sea-level rise and changing patterns of floods and other natural hazards are already affecting the risks faced by infrastructure and public health. To build truly resilient cities, urban planners must therefore look beyond the next storm and plan for long-term changes in the weather and climate. Fortunately, recent advances in our understanding of urban climate processes, together with higher resolution predictions, allow climate services to provide the information and projections cities need to take long-term decisions for reducing vulnerability and promoting sustainable development.

## Integrated Flood Management – Focus on Asunción, Paraguay



Climate services can also help cities to minimize their greenhouse gas emissions. These services can monitor emission sources and air composition so that cities can develop targeted emission reduction strategies. In addition, because burning fossil fuels and biomass for power generation, cooking, heating, manufacturing and transport also releases health-damaging aerosols, mitigating greenhouse gases provides the co-benefit of improved air quality.

Although cities face unique conditions, urban weather, climate, hydrological and environmental services cannot be developed in isolation. Cities must also consider regional interactions and the cross-border nature of water, weather and pollution, as well as the influence of large-scale weather and climate patterns. Collaborating with rural governments and with nearby town and regions is therefore essential.

*Urban areas can adapt to floods through the adoption and implementation of Integrated Flood Management practices, which maximize the efficient use of floodplains and minimize the loss of life.*

*A risk and infrastructure map (left). Populations living in informal settlements are most at risk from hydrometeorological disasters (right).*

3.7

million premature deaths due to outdoor air pollution

12%

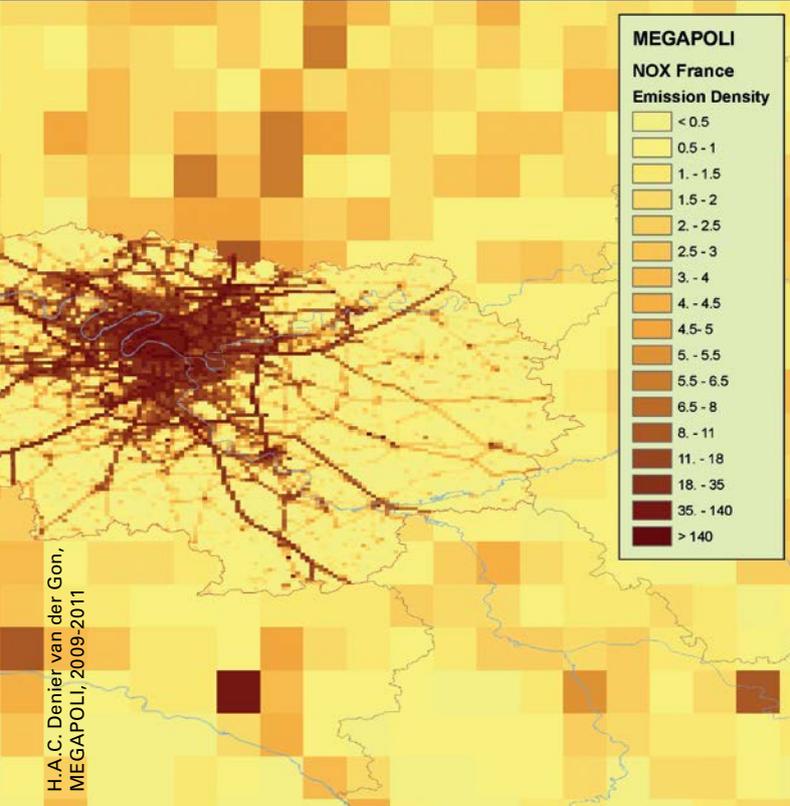
of cities meet the WHO air quality guidelines

0.6°C

of warming could be avoided by 2050 by regulating short-lived climate pollutants



An increase in the frequency and magnitude of floods is already evident as a direct consequence of climate change.



*Monitoring emission sources and air composition helps cities develop targeted emission reduction strategies.*

The WMO community is committed to ensuring high-quality, consistent and relevant information for urban communities on weather, climate, hydrology and related environmental issues. Impact-based forecasts, multi-hazard early-warning systems, and city-specific response guidelines will enable

urban decision-makers to prepare more effectively for extreme weather, floods, air pollution, heatwaves and extreme cold. In this way, science-based and integrated urban services will become an essential part of life in the safe, healthy and resilient cities of the future.

## About WMO

**The World Meteorological Organization (WMO) is the United Nations system's authoritative voice on weather, climate and water. Its 191 Member States and Territories collaborate to strengthen the scientific and operational foundations of their weather, climate, hydrological, environmental and marine services. They do this by sharing observations and data, collaborating on research, setting technical standards and designing effective services. In this way, WMO contributes significantly to human safety and well-being and to sustainable development.**

WMO is committed to working with its partners to develop multi-disciplinary solutions for sustainable urban development. The entire WMO community, from National Meteorological and Hydrological Services to research institutes, meteorological societies, and private-sector service providers, is ready to contribute. Together, these organizations provide the data, research findings and operational services that urban decision-makers need to address the diverse array of urban challenges.

For more information, please contact:

### World Meteorological Organization

7 bis, avenue de la Paix – P.O. Box 2300 – CH 1211 Geneva 2 – Switzerland

**Communication and Public Affairs Office**

Tel.: +41 (0) 22 730 83 14/15 – Fax: +41 (0) 22 730 80 27

E-mail: [cpa@wmo.int](mailto:cpa@wmo.int)

[www.wmo.int](http://www.wmo.int)

