ATLAS OF
HEALTH AND CLIMATE

World Health Organization

World Meteorological Organization
Weather · Climate · Water
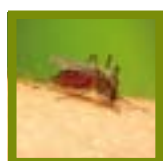
ATLAS OF
HEALTH AND CLIMATE

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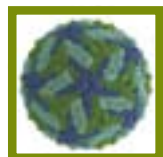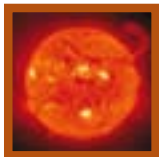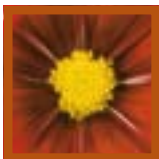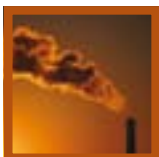
PREFACE

ATLAS OF HEALTH AND CLIMATE: REALIZING THE POTENTIAL TO IMPROVE HEALTH OUTCOMES THROUGH THE USE OF CLIMATE SERVICES

Human health is profoundly affected by weather and climate. Extreme weather events kill tens of thousands of people every year and undermine the physical and psychological health of millions. Droughts directly affect nutrition and the incidence of diseases associated with malnutrition. Floods and cyclones can trigger outbreaks of infectious diseases and damage hospitals and other health infrastructure, overwhelming health services just when they are needed most.

Climate variability also has important consequences for health. It influences diseases such as diarrhoea and malaria, which kill millions annually and cause illness and suffering for hundreds of millions more. Long-term climate change threatens to exacerbate today's problems while undermining tomorrow's health systems, infrastructure, social protection systems, and supplies of food, water, and other ecosystem products and services that are vital for human health.

While the impact of climate change on health is felt globally, different countries experience these impacts to different degrees. Evidence shows that the most severe adverse effects tend to strike the poorest and most vulnerable populations. In addition, the adverse health impacts of climate are worsened by rapid and unplanned urbanization, the contamination of air and water, and other consequences of environmentally unsustainable development.

Concern about how a changing climate will affect health is reflected in the UN Framework Convention on Climate Change and the Global Framework for Climate Services. Countries have also recognized the need to protect health from climate-related risks through collaborative action on managing disaster risk, ensuring access to safe and adequate water and food, and strengthening preparedness, surveillance and response capacities needed for managing climate-sensitive diseases.

In order to achieve these goals, decision-makers at all levels need access to the most relevant and reliable information available on the diverse connections between climate and health. The World Health Organization and the World Meteorological Organization are working together to meet this need through a practical and innovative approach that uses climate services to strengthen the climate resilience of health systems and support proactive decision-making. These climate services will contribute to protecting public health and achieving better health outcomes.

The Atlas of Health and Climate is a product of this unique collaboration between the meteorological and public health communities. It provides sound scientific information on the connections between weather and climate and major health challenges. These range from diseases of poverty to emergencies arising from extreme weather events and disease outbreaks. They also include

environmental degradation, the increasing prevalence of noncommunicable diseases and the universal trend of demographic ageing.

The Atlas conveys three key messages. First, climate affects the geographical and temporal distribution of large burdens of disease and poses important threats to health security, on time scales from hours to centuries. Second, the relationship between health and climate is influenced by many other types of vulnerability, including the physiology and behaviour of individuals, the environmental and socio-economic conditions of populations, and the coverage and effectiveness of health programmes. Third,

climate information is now being used to protect health through risk reduction, preparedness and response over various spatial and temporal scales and in both affluent and developing countries.

It is our hope that the Atlas of Health and Climate will serve as a visual "call to action" by illustrating not only the scale of challenges already confronting us – and certain to grow more acute – but also by demonstrating how we can work together to apply science and evidence to lessen the adverse impacts of weather and climate and to build more climate-resilient health systems and communities.

Margaret CHAN
Director General
World Health Organization
Geneva,
October 2012

Michel JARRAUD
Secretary-General
World Meteorological Organization
Geneva,
October 2012

A patient suffering from dengue fever lies
on a bed covered by a mosquito net at San Felipe
hospital in Tegucigalpa, Honduras

SECTION 1
INFECTIONS

Infectious diseases take a heavy toll on populations around the world. Some of the most virulent infections are also highly sensitive to climate conditions. For example, temperature, precipitation and humidity have a strong influence on the reproduction, survival and biting rates of the mosquitoes that transmit malaria and dengue fever, and temperature affects the life-cycles of the infectious agents themselves. The same meteorological factors also influence the transmission of water and food-borne diseases such as cholera, and other forms of diarrhoeal disease. Hot, dry conditions favour meningococcal meningitis – a major cause of disease across much of Africa. All of these diseases are major health problems. Diarrhoea kills over two million people annually, and malaria almost one million. Meningitis kills thousands, blights lives and hampers economic development in the poorest countries. Some 50 million people around the world suffer from dengue fever each year. The public health community has made important progress against all of these diseases in recent decades, but they will continue to cause death and suffering for the foreseeable future.

One of the important challenges for control of all of these diseases is to understand and, where possible, predict their distribution in time and space, to allow control programmes to target interventions and to anticipate and prevent epidemics. All of these diseases are strongly influenced by climate and weather – but these effects are mediated by other determinants. For diarrhoea, meningitis and malaria, these are closely associated with poverty and weaknesses in health programmes, which leaves populations without the protection of reliable water and sanitation services, protective vaccines and life-saving drugs. In the case of dengue, unplanned urbanization, the proliferation of mosquito breeding sites in household waste, and population movement, are contributing to a re-emergence of the disease. The climate sensitivity of these diseases means that there is an important role for meteorological information. The interaction with other determinants means that climate services will only reach their full potential through a true collaboration between the meteorological and health communities.

By working with disease control programmes, meteorological services can help to identify where their information can be applied most effectively. Early experience shows that providing the relatively simple meteorological monitoring data that are collected by National Meteorological Services can often bring the greatest value to health programmes. These include short-term observations of local precipitation to provide an alert for epidemics of cholera or malaria, or gridded maps of routinely collected temperature and humidity data, to generate maps of suitability for meningitis or malaria transmission, in order to improve targeting and efficiency of disease surveillance and control. Disease control programmes, meteorological services and researchers, are also beginning to work together to explore the potential of more sophisticated climate products, such as seasonal forecasts, to provide more advance warning of risks of infectious disease.

While the evidence base in favour of collaboration between health and climate services continues to expand, these techniques are not currently used to their full potential. This requires building the capacity of the meteorological services to collect information and to process it into useful products, and the capacity of health services to interpret and apply these products to health challenges – and thereby increase their own demand for climate services.
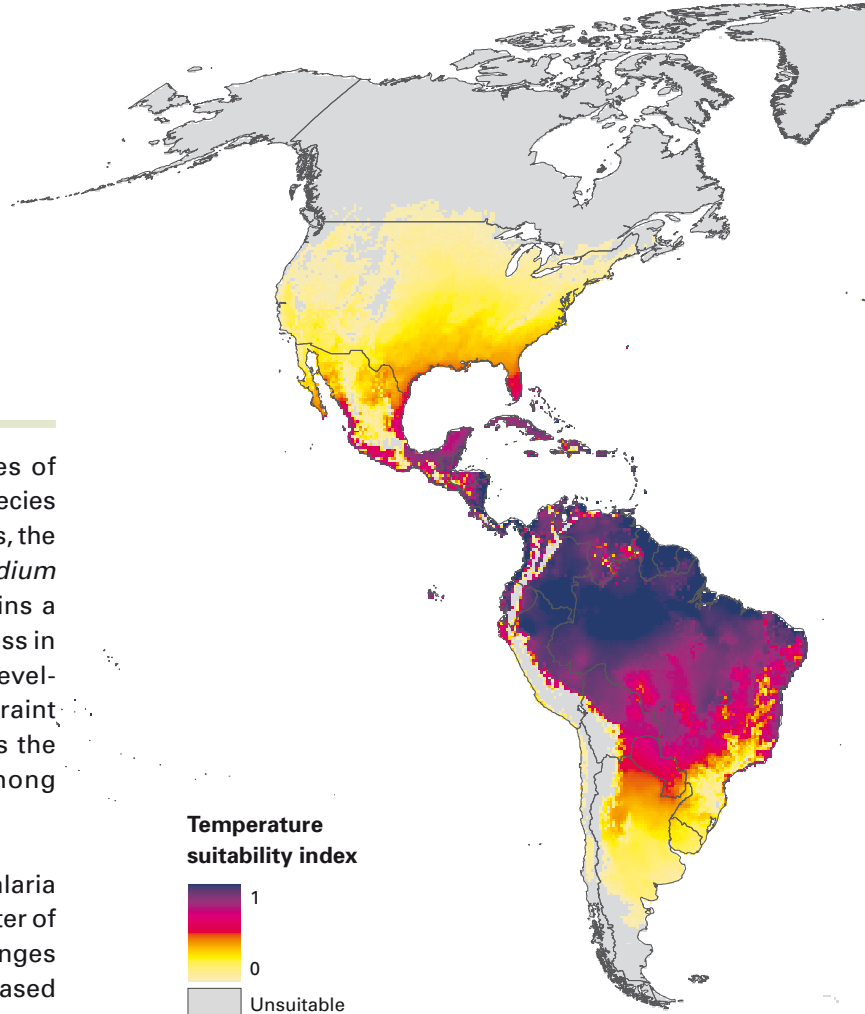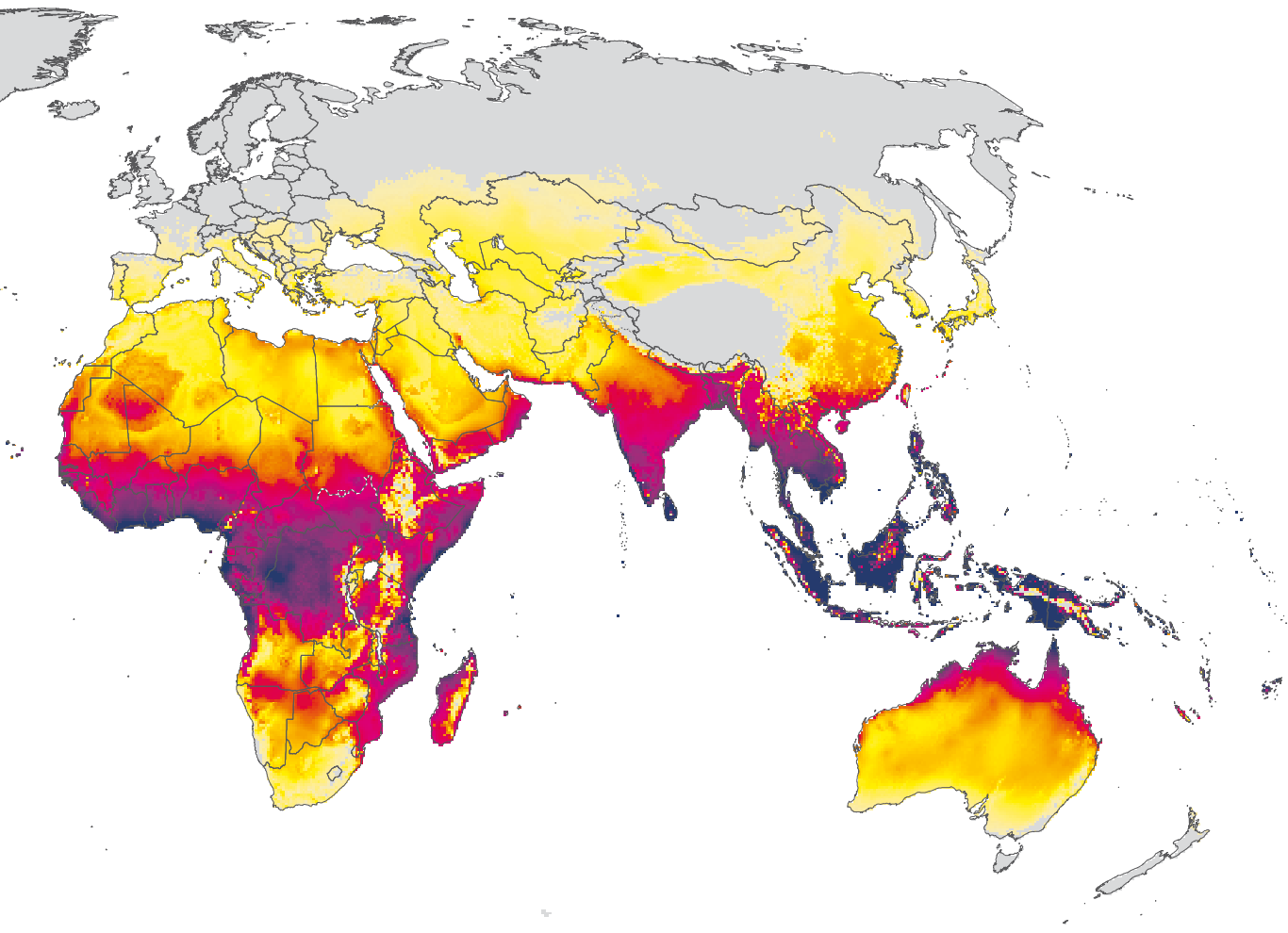
MALARIA

THE BURDEN OF MALARIA

Malaria is a parasitic disease spread by the bites of infected *Anopheles* mosquitoes. There are many species of malaria parasites but, of the five affecting humans, the greatest threat to health comes from the *Plasmodium vivax* and *Plasmodium falciparum*. Malaria remains a disease of global importance despite much progress in recent years. It is a persistent threat to health in developing nations where it represents a major constraint to economic development measures and reduces the likelihood of living a healthy life, especially among women, children and the rural poor.
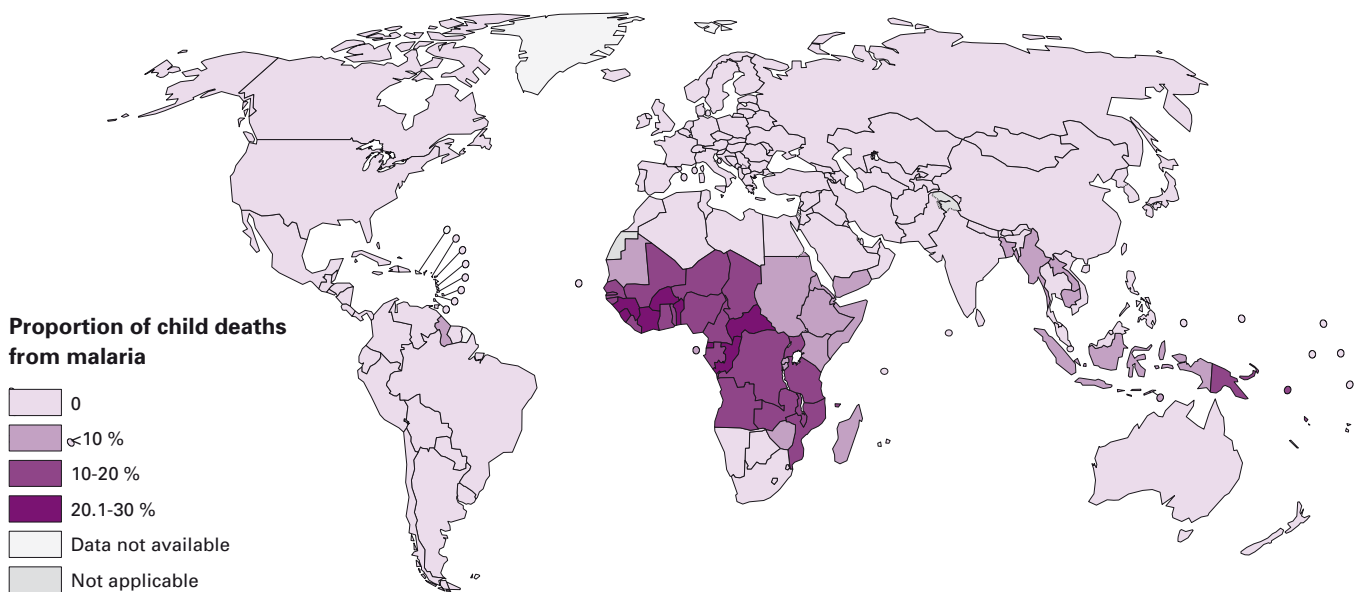
Over the last century, the surface area on which malaria remains a risk has been reduced from half to a quarter of the Earth's landmass, but due to demographic changes the number of people exposed to malaria has increased substantially over the same period. Estimates of cases and deaths differ greatly: the number of cases stands between 200 million and 500 million while the death estimate is around 1 million per year. According to the World Malaria Report in 2011, malaria remains prevalent in 106 countries of the tropical and semi-tropical world. Thirty-five countries in central Africa bear the highest burden of cases, more than 80 per cent, and deaths, more than 90 per cent. This is due to a number of factors: most deadly parasite species, most efficient mosquito vectors and poor rural infrastructure.[1]

Temperature suitability index

1

0

Unsuitable

WHO / STEPHENIE HOLLYMAN

Temperature suitability for transmission of Plasmodium falciparum[2]

Proportion of child deaths from malaria

- 0
- ∝10 %
- 10-20 %
- 20.1-30 %
- Data not available
- Not applicable

Estimates of the percentage of mortality in children aged under 5 years that was related to malaria cases in 2010[3]

REDUCING THE INCIDENCE OF MALARIA

Where malarial control is inadequate, the climate can provide valuable information about the potential distribution of the disease in both time and space. Climate variables – rainfall, humidity and temperature – are fundamental to the propagation of the mosquito vector and to parasite dynamics. Rainfall produces mosquito-breeding sites, humidity increases mosquito survival and temperature affects parasite development rates. Mapping, forecasting and monitoring these variables, and unusual conditions that may trigger epidemics such as cyclones or the breaking of a drought in a region, enable health services to better understand the onset, intensity and length of the transmission season.

WHO, WMO and the Famine Early Warning Systems[4] have routinely produced such information products for continental Africa for a number of years. More recent collaboration with National Meteorological Services have built capacity in seasonal forecasting[5] and enabled a much denser network of ground station data to be combined with the extensive coverage of satellite data.[6] The resulting mapping, forecasting and monitoring products are made available to health services through National Meteorological and Hydrological Services websites and joint training workshops encourage mutual learning and negotiation around information needs. Regional Outlook Fora[7] and National Climate and Health Working Groups[8] have been established in a number of countries to elicit priorities for research, policy, practice and training.

WHO / STEPHENIE HOLLYMAN
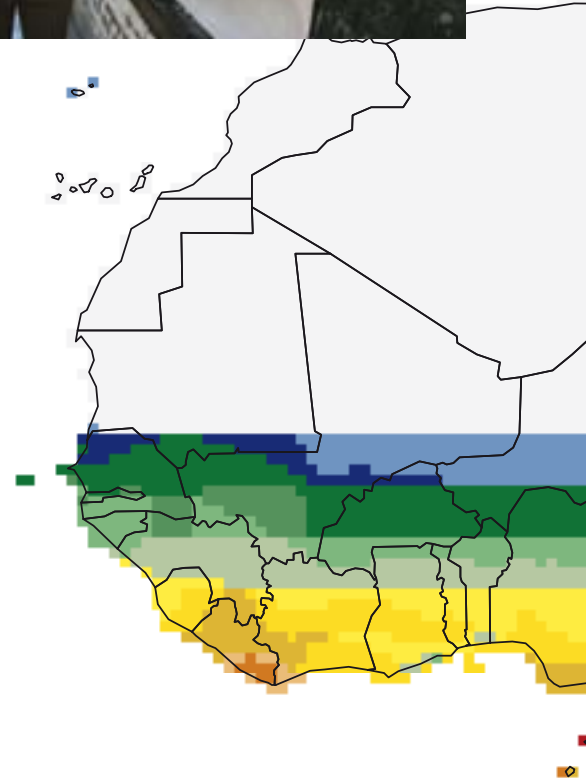
## CASE STUDY: MALARIA EARLY WARNING IN SOUTHERN AFRICA

The WHO's Global Malaria Programme in the southern African countries of Angola, Botswana, Namibia, Madagascar, Mozambique, South Africa, Swaziland, Zambia and Zimbabwe offers a good example of the practical use of weather and climate information in combating disease. The programme uses the seasonal climate forecasts issued by the Southern African Regional Climate Outlook Forum to predict malaria epidemics several months ahead of time, allowing effective control, and other preventive measures, to be put in place. The climate forecasts have been central to the development of the Malaria Early Warning System. Through programmes co-sponsored by WMO, several projects based on the "Learning through Doing" concept have been launched to help National Meteorological and Hydrological Services (NMHSs) collaborate and build partnerships with their health communities. Thus, in Botswana and Madagascar, the health ministries now have longer lead times on the likely occurrence of malaria, plague and Rift Valley Fever epidemics, based on climate predictions provided by the NMHSs. Similar projects have been launched in Ethiopia, Burkina Faso, Chile, Panama and Peru.

Climatology for
~11 km x 11 km grid box
centred on 36.15E, 6.35N
(located within Ethiopia).

for parasite: falciparum

11km   36.15E   6.35N

View Climatology

Precipitation
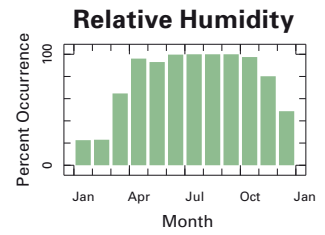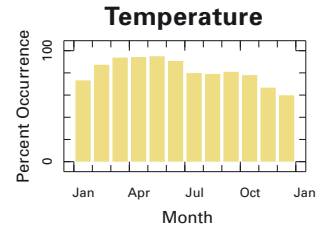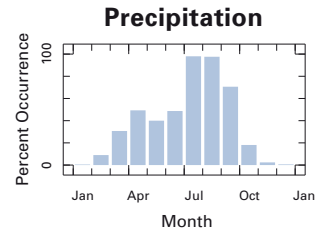
**Percent Occurence of Climate Conditions
Suitable for Malaria Transmission**

Temperature

Relative Humidity
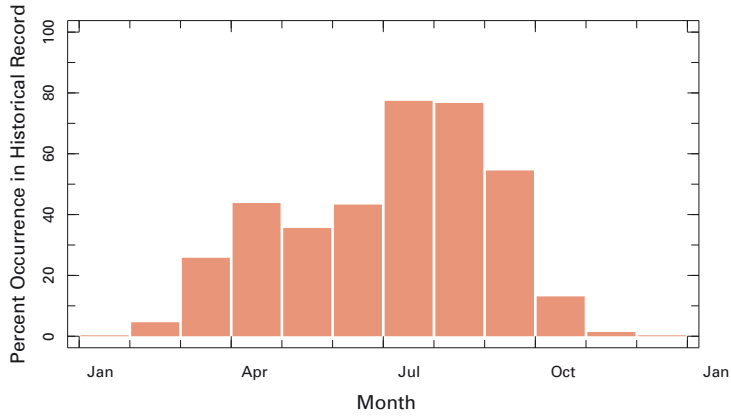
National Meteorological Services can supply more accurate local assessments[9]

0 1 2 3 4 5 6 7 8 9 10 11 12

Number of months suitable for malaria transmission[10]
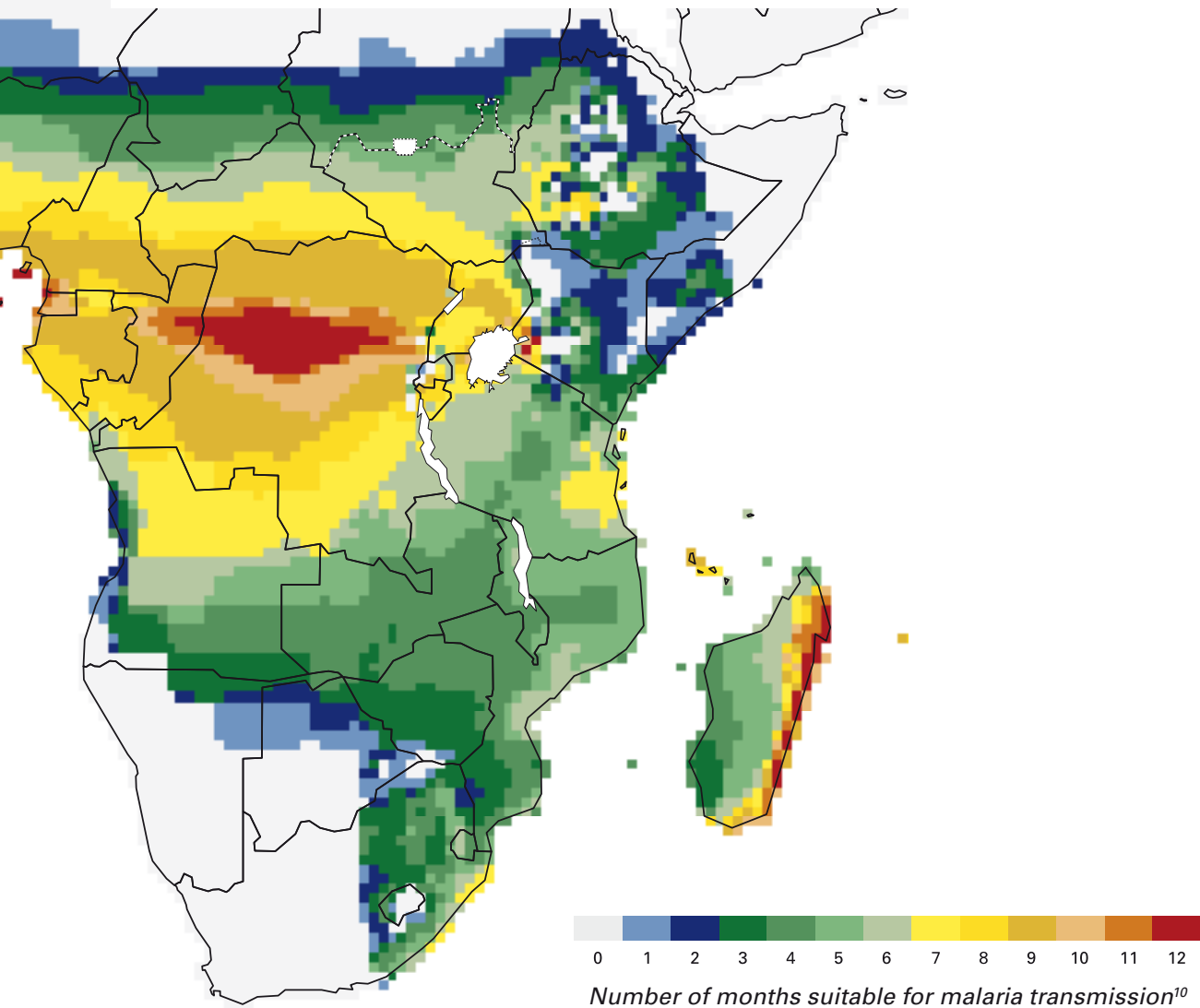
DIARRHOEA

Around two million people die every year due to diarrhoeal disease – 80 per cent are children under 5. Cholera is one of the most severe forms of waterborne diarrhoeal disease. There are sporadic incidences of the disease in the developed world, but it is a major public health concern for developing countries, where outbreaks occur seasonally and are associated with poverty and use of poor sanitation and unsafe water. Extreme weather events, such as hurricanes, typhoons, or earthquakes, cause a disruption in water systems resulting in the mixing of drinking and waste waters, which increase the risk of contracting cholera.

In 1995 a combined average of 65 per cent of the world's population had access to improved drinking water sources and sanitation facilities.[1] That left two billion people relying on drinking water that could potentially contain pathogens, including *Vibrio cholerae*, the causative organism of cholera. There is a definite correlation between disease outbreaks and inadequate access to safe water and lack of proper sanitation. Therefore people in the least developed regions of the world who only have access to unsafe water and poor sanitation also have the greatest burden of related diseases, like cholera or other diarrhoeal diseases.

Extreme weather-related events such as increased precipitation and flooding further contaminate water sources, contributing to an oral-faecal contamination pathway that is difficult to manage and which increases the cases of disease and fatalities. When such events take place, *Vibrio cholerae* persists in aquatic ecosystems, causing the rapid spread of seasonal epidemics in many countries.
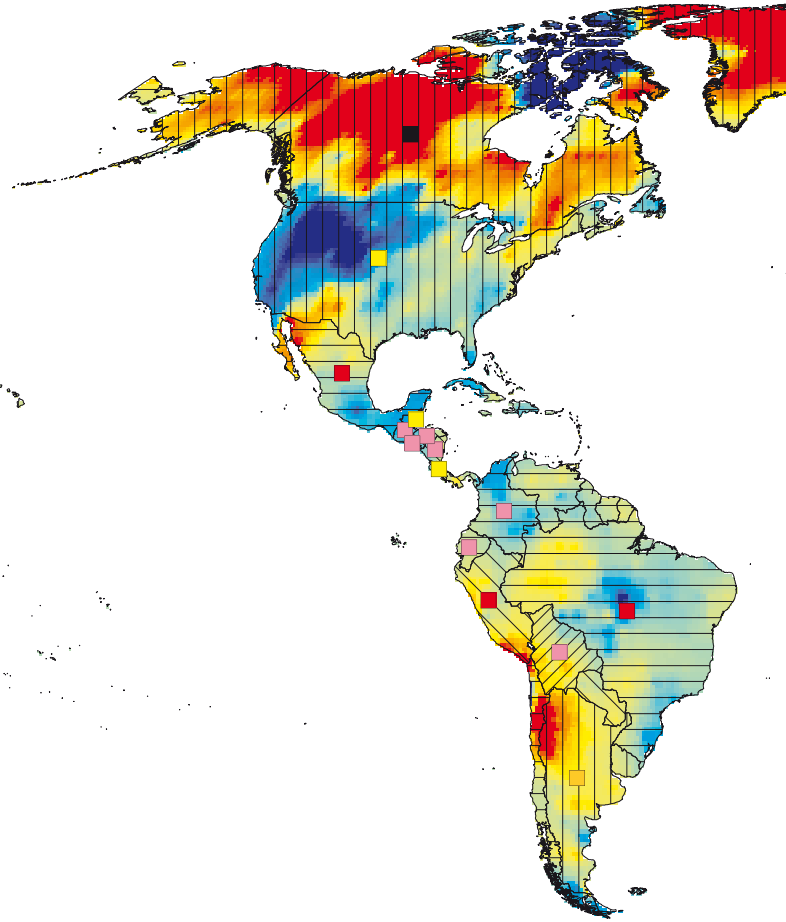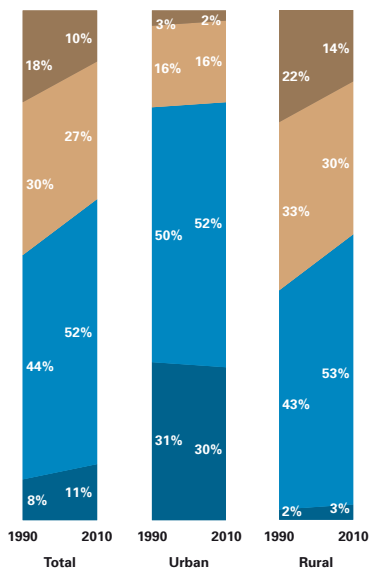

WHO / DERMOT TATLOW
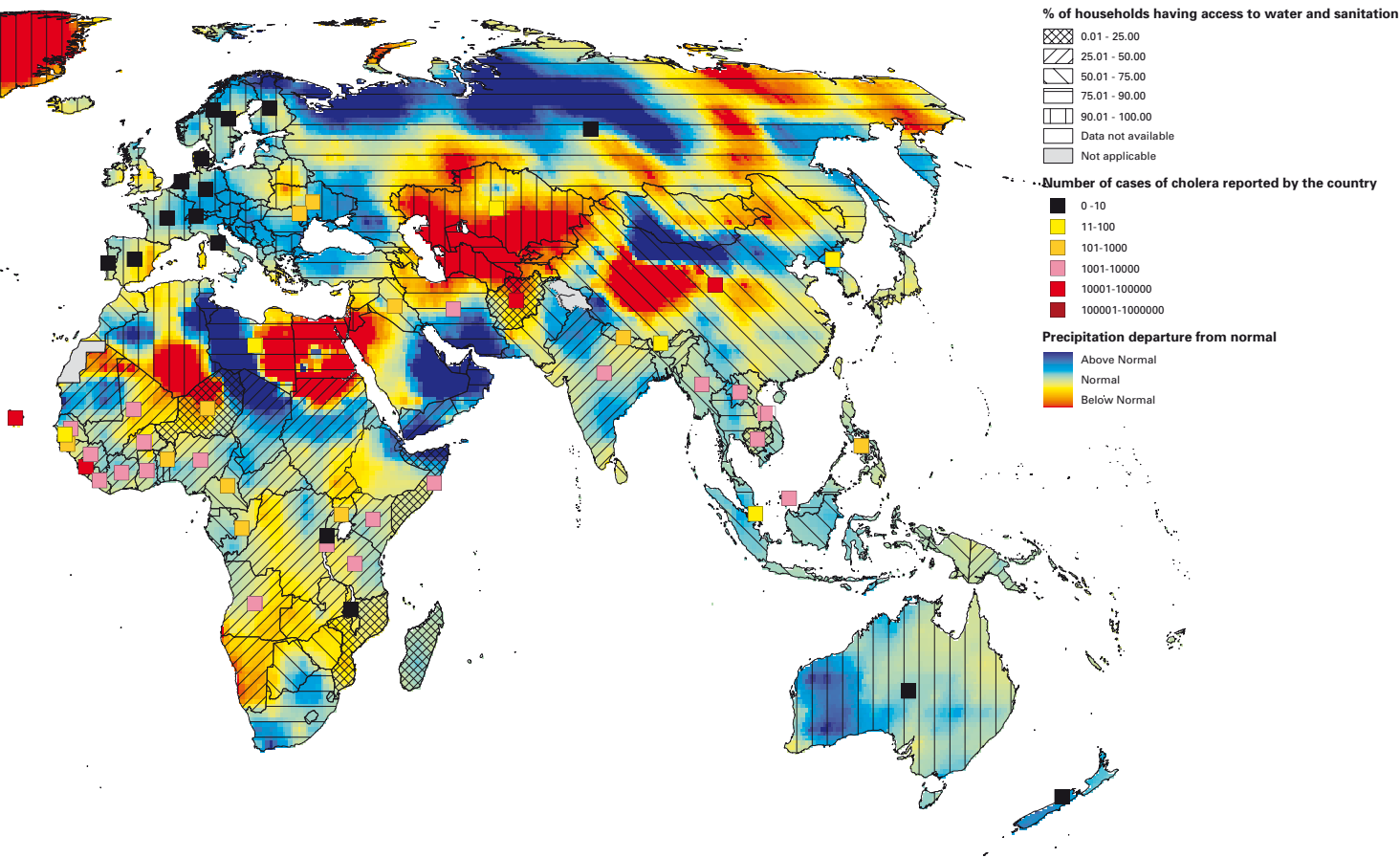
This map demonstrates that in 1995 there was a widespread correlation between cholera prevalence and poor access to water and sanitation as well as precipitation anomalies[2]

Ten percent of the population in least developed countries rely on surface water

Open defecation is practised by nearly a quarter of the population in least developed countries
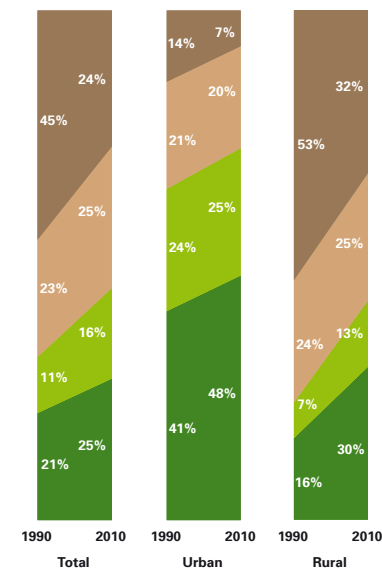
Left: Trends in the use of piped water on premises, improved drinking water sources, unimproved sources and surface water in least developed countries by urban and rural areas[1]

Right: Trends in the use of improved, unimproved and shared sanitation facilities and open defecation in least developed countries by urban and rural areas[1]

THE CLIMATE DATA LAYER

In 2010, the world met the Millennium Develop Goals' target on water, as measured by its proxy indicator: "(by 2015) halving the proportion of (1990) population without sustainable access to an improved source of drinking water" (see the figure below). Despite such progress nearly eight hundred million people still lacked access to water from such sources, and public health research[3] has shown that billions are still using unsafe water. At the same time we are still badly off track to meet the Millennium Develop Goal on sanitation. Access to water and sanitation improved from 1995 to 2010, but not substantially in the parts of the world where cholera is recurring. Cases of cholera continue to rise in parts of poverty-stricken Africa and Asia where access to water and sanitation are already poor and progress towards improving such services is slow or stagnant.

Extreme weather-related events have made disease transmission pathways worse. Thus, climate services have an important role to play if effective prevention is to be put in place. By adding a climate layer such as precipitation anomalies, including flooding, to maps containing other datasets such as disease burden, one can pinpoint hotspots where further analyses would be needed and data gathering should be improved and enhanced. Such maps can help decision-makers to visualize the water, sanitation and the environmental problems in their region and to put measures in place to avoid outbreaks and thus diminish the spread of such diseases.

This complex topic is part of an ongoing research. Nevertheless, these high level maps can contribute to informing policymakers on measures to reduce the disease burden of cholera.
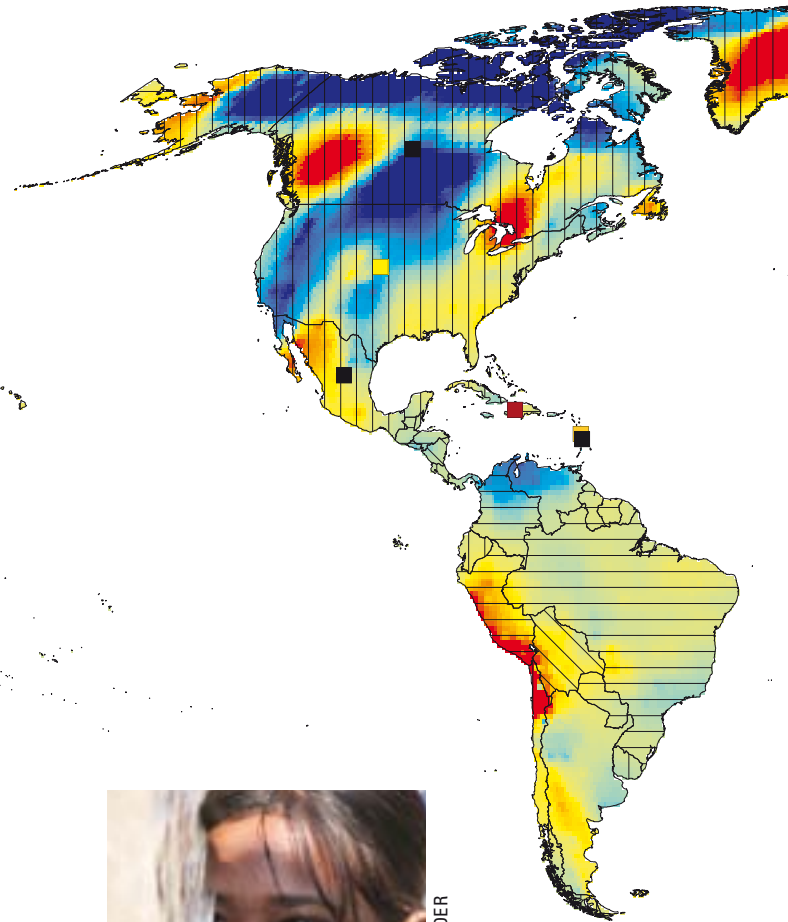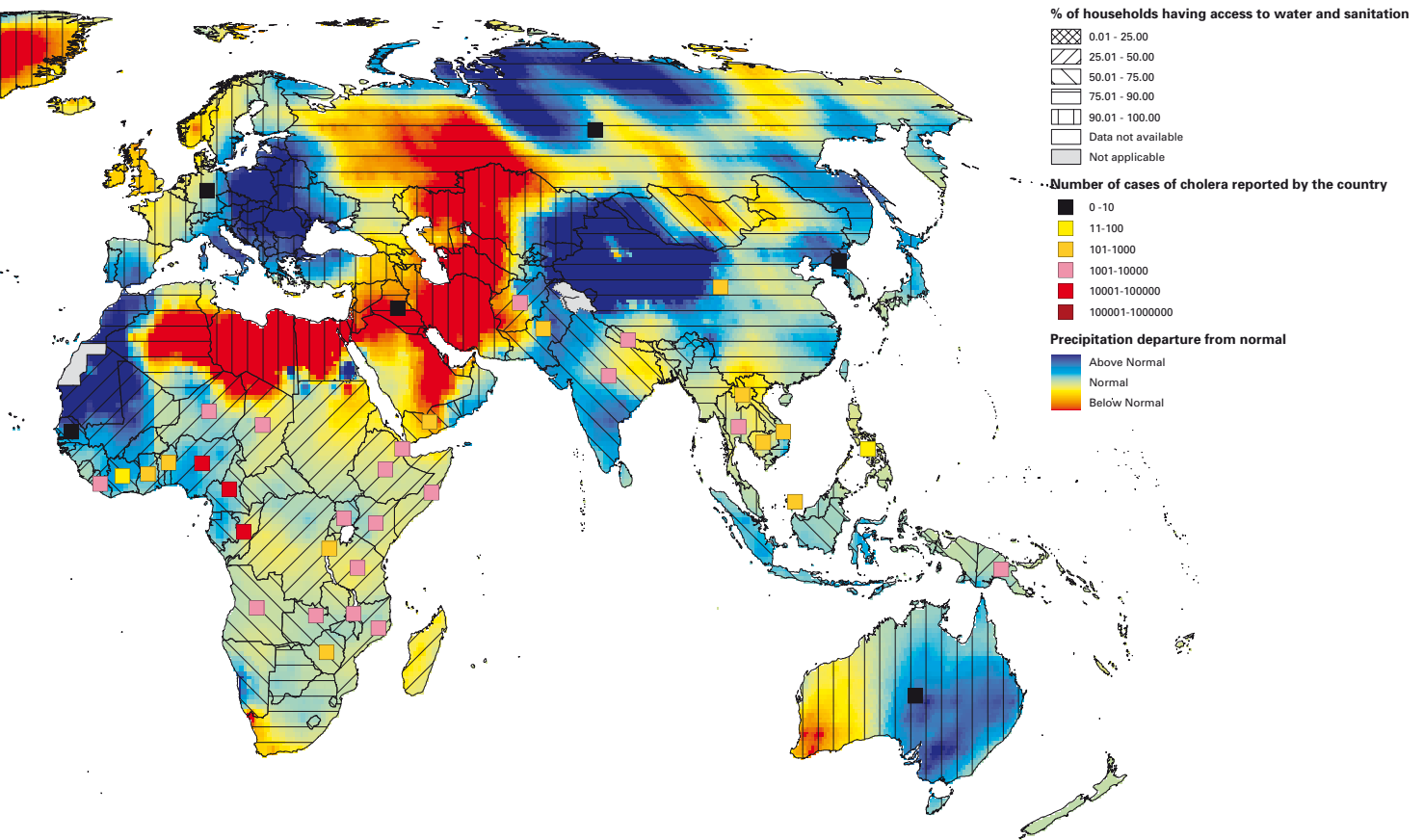
WATERAID / JUTHIKA HOWLADER

CASE STUDY: GLOBAL INFORMATION MANAGEMENT SYSTEM ON HEALTH AND ENVIRONMENT

The goal of the WHO project Global Information Management System on Health and Environment (GIMS)[4] is to save lives by preventing communicable water borne diseases through providing an evidence base for ensuring good environmental health modalities like access to safe water and basic sanitation in a sustainable manner under changing global environmental conditions. Prevention of environment-related disease requires a comprehensive information system for adequate planning and targeted resource use for assisting the most vulnerable populations in hotspot analyses. GIMS plans to produce these maps on a real time basis and with its in-built predictive tool also aims to contribute to an early warning system for diarrhoeal diseases. In its initial phase, which will last until 2015, the project will focus on cholera and be tested in selected pilot countries where cholera is present.

% of households having access to water and sanitation
- 0.01 - 25.00
- 25.01 - 50.00
- 50.01 - 75.00
- 75.01 - 90.00
- 90.01 - 100.00
- Data not available
- Not applicable

Number of cases of cholera reported by the country
- 0 - 10
- 11-100
- 101-1000
- 1001-10000
- 10001-100000
- 100001-1000000

Precipitation departure from normal
- Above Normal
- Normal
- Below Normal

Information on precipitation anomalies, overlaid with 2010 reported cholera cases from the countries where access to water and sanitation remains poor, indicate priority areas for further research and health intervention[2]

Trends in global drinking water coverage, 1990–2010, projected to 2015

■ Improved sources ■ Unimproved sources − − − Open defecation
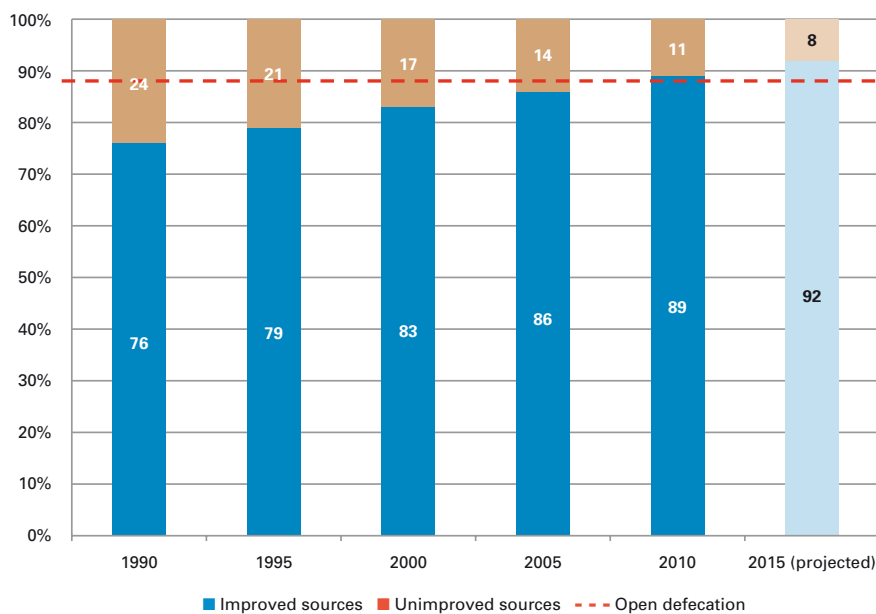
The MDG proxy indicator for the drinking water target, which is showing steady improvement, has been met[1]

15

MENINGITIS

## MENINGITIS – THE HEALTH CHALLENGE

Meningococcal meningitis is a severe infectious disease of the meninges, a thin layer around the brain and spinal cord. Several micro-organisms can cause meningitis. The bacterium with the greatest epidemic potential is *Neisseria meningitidis*.

Although meningitis is a ubiquitous problem, most of the burden of disease lies in sub-Saharan Africa in an area called the "Meningitis Belt". The Meningitis Belt is regularly hit by epidemics that occur only during the dry season, from December to May. Over the past 10 years, more than 250 000 cases and an estimated 25 000 deaths have been reported. The disease is an obstacle to socio-economic development: outbreak management is extremely costly and paralyses the health system – about 10 per cent of the survivors suffer life-long sequels such as deafness and blindness. A study in Burkina Faso[1] – one of the world's poorest countries with an annual income of US$ 300 – indicated that the financial burden for the family of a patient suffering from meningitis is on average US$ 90 and up to US$ 154 more when meningitis sequels occur.

There is a clear seasonal pattern of meningitis cases that corresponds to the period of the year when there are increases in dust concentrations as well as reductions in humidity levels linked to the movement of the Inter Tropical Convergence Zone. While the temporal association between climate and meningitis is evident, what triggers or ends an epidemic is as yet unknown. One hypothesis is that dry, hot and dusty air irritates the respiratory mucosa thus facilitating invasion of the bacteria.
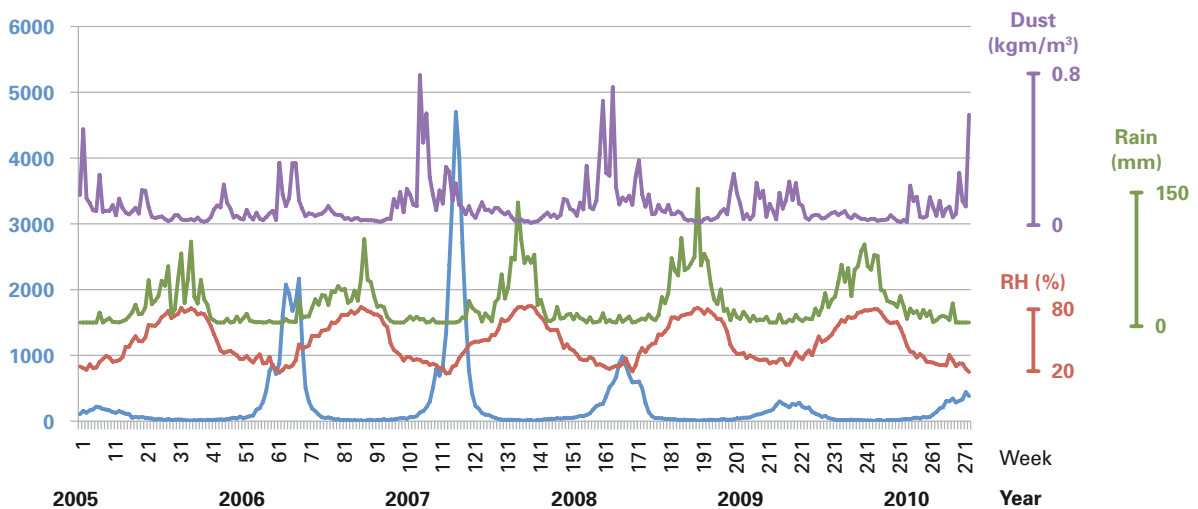
Meningitis cases increase in the dry, hot and dusty season. Data from Burkina Faso (2005-2011)[2]
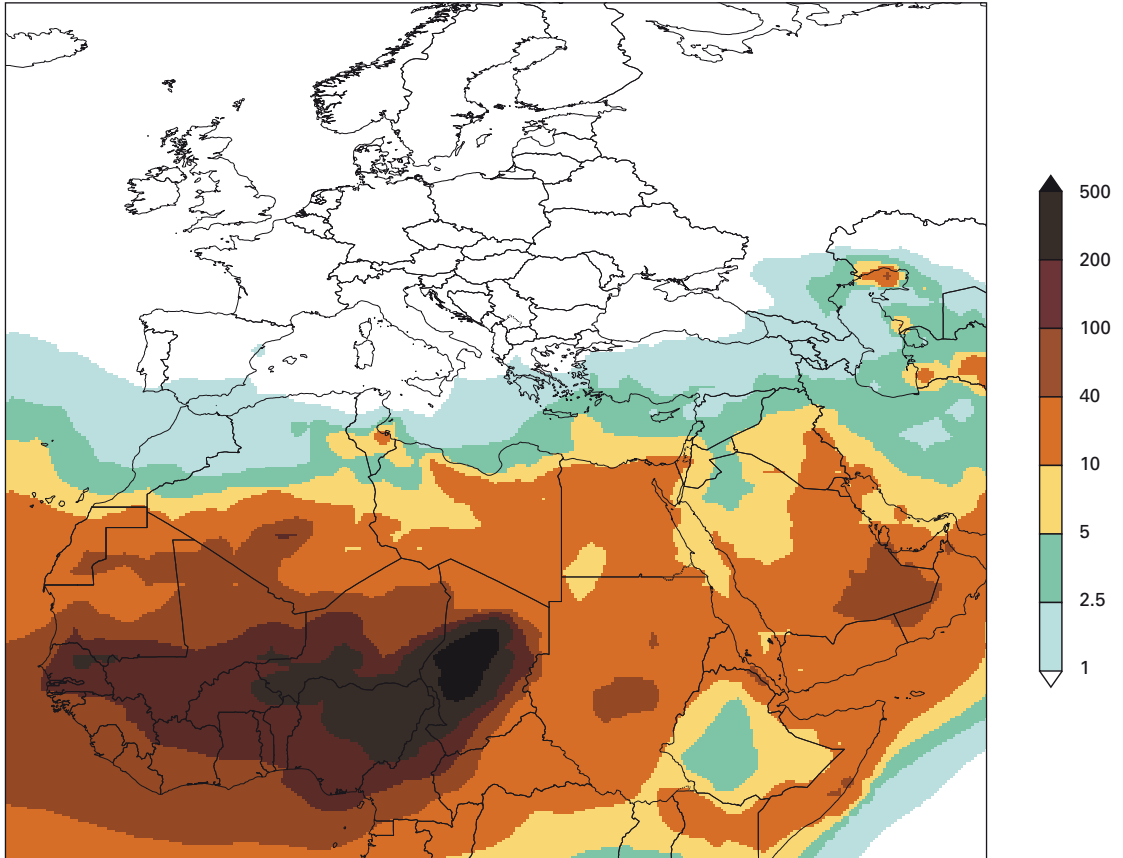
Dust surface concentration (μg/m³) across the Meningitis Belt in December to February, averaged over 1979-2010[3]

African Meningitis Belt: Loosely defined as areas that experience frequent epidemics during the dry season[4]
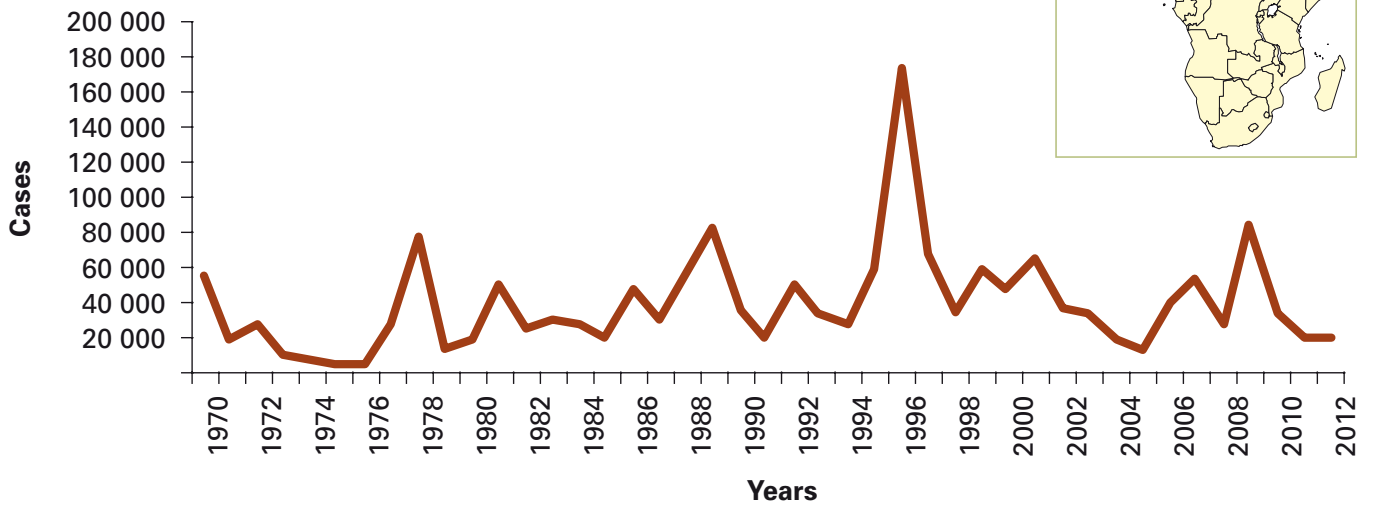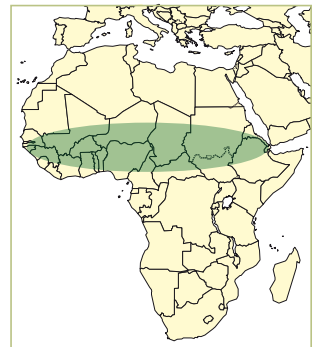
Number of suspect cases of meningitis per year in the Meningitis Belt between 1970 and 2012[5]

ADDRESSING THE MENINGITIS CHALLENGE

The public health strategy to control meningitis epidemics relies on the implementation of large-scale vaccination campaigns in a timely manner to prevent further cases.

Knowing if, where and when an outbreak is likely to occur would help public health decision makers prepare for vaccination campaigns and procure sufficient vaccine quantities to immunize the population at risk and ultimately reduce the impact of the disease. By increasing the understanding of meningitis risk factors and how they influence the occurrence of an epidemic, public health officials will have greater capacity to predict and prepare for potential outbreaks through reactive vaccination campaigns.

A preventive vaccination strategy, involving a conjugate vaccine against Neisseria meningitidis serogroup-A, is being implemented in the highest risk countries in sub-Saharan Africa. This offers great potential to eliminate large meningitis outbreaks as a public health problem. While the introduction of the meningitis A conjugate vaccine promises to significantly reduce the problem of meningitis epidemics in Africa, the reactive vaccination approach remains an important part of the control strategy.[6]

Improving the prevention and control of meningitis epidemics is the focus of numerous research projects in Africa and internationally. Under a collaborative partnership initiative known as Meningitis Environmental Risk Information Technologies 'MERIT' constituted by WHO, WMO, the International Research Institute for Climate and Society and other leaders within the environmental and public health communities, research projects have been designed and developed to respond directly to public health questions and priorities.

The combined output of operational research activities is being assessed to determine the effectiveness of predictive models in strengthening the public health strategy. For example, the expected probability of an epidemic occurring based on climatic and environmental factors combined with epidemiological spatio-temporal models at the district level, may in the future help public health officials respond to potential outbreaks. The climate service in support of the public health officials in meningitis-affected countries, should supply forecasts of the likely duration and end of the dry season and update these with any pertinent meteorological forecasts.
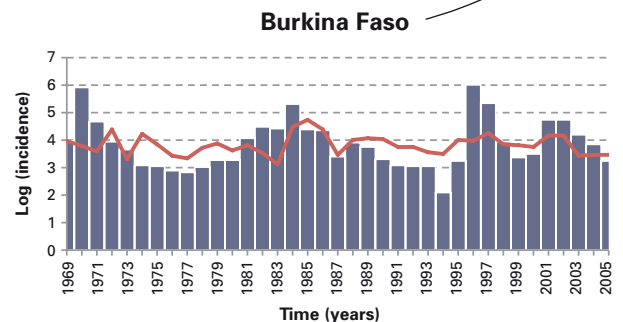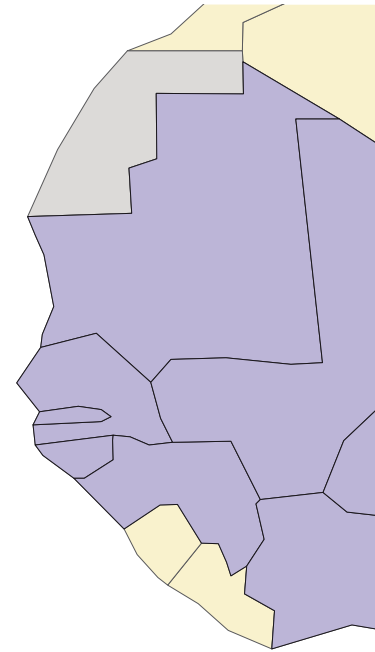
Observed annual meningitis incidence (purple bars) and predictions based on meridional winds (red lines); offering potential to inform outbreak response[7]

Niger
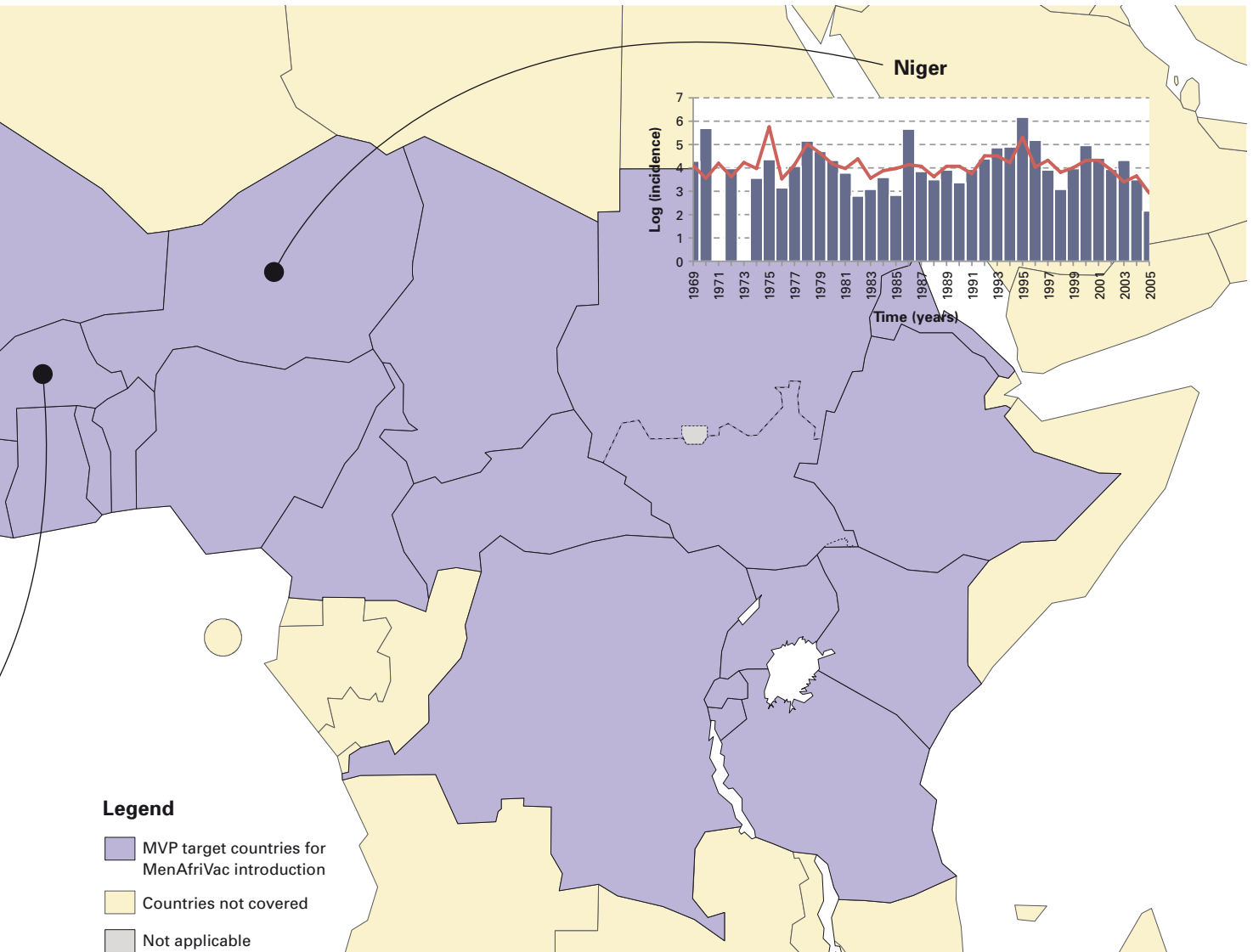
Target countries for the meningitis A conjugate vaccine, containing approximately 450 million people at risk of meningitis[8]

Legend

- MVP target countries for MenAfriVac introduction
- Countries not covered
- Not applicable

WHO / CHRISTOPHER BLACK
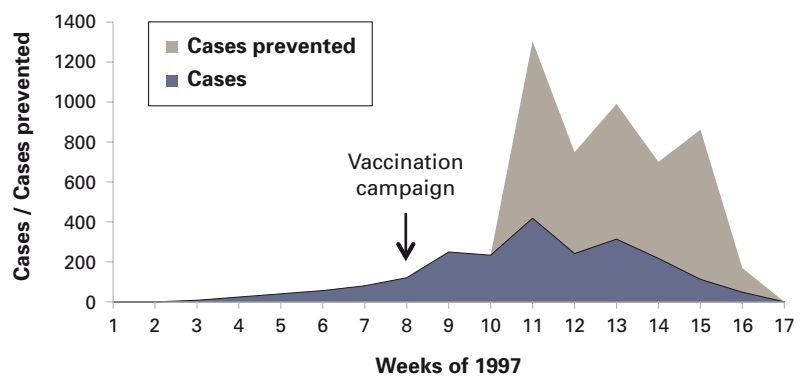
Early vaccination prevents many cases. Data and modelling for Reo district, Burkina Faso, 1997[9]
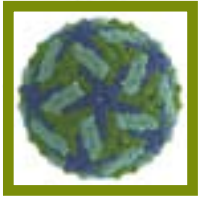
DENGUE FEVER

DENGUE FEVER – THE GROWING CHALLENGE

Transmitted by *Aedes* mosquitoes, dengue is the most rapidly spreading mosquito-borne viral disease in the world. It is estimated to cause over 50 million infections, and around 15,000 deaths every year across approximately 100 countries.[1, 2]

Infection could range from a mild flu-like fever to the potentially fatal severe dengue, which particularly affects individuals who are exposed to one of the four different strains of the virus as a secondary infection. The impact of dengue, and other mosquito-borne viruses, goes beyond the immediate medical effects. Often occurring as epidemics, includi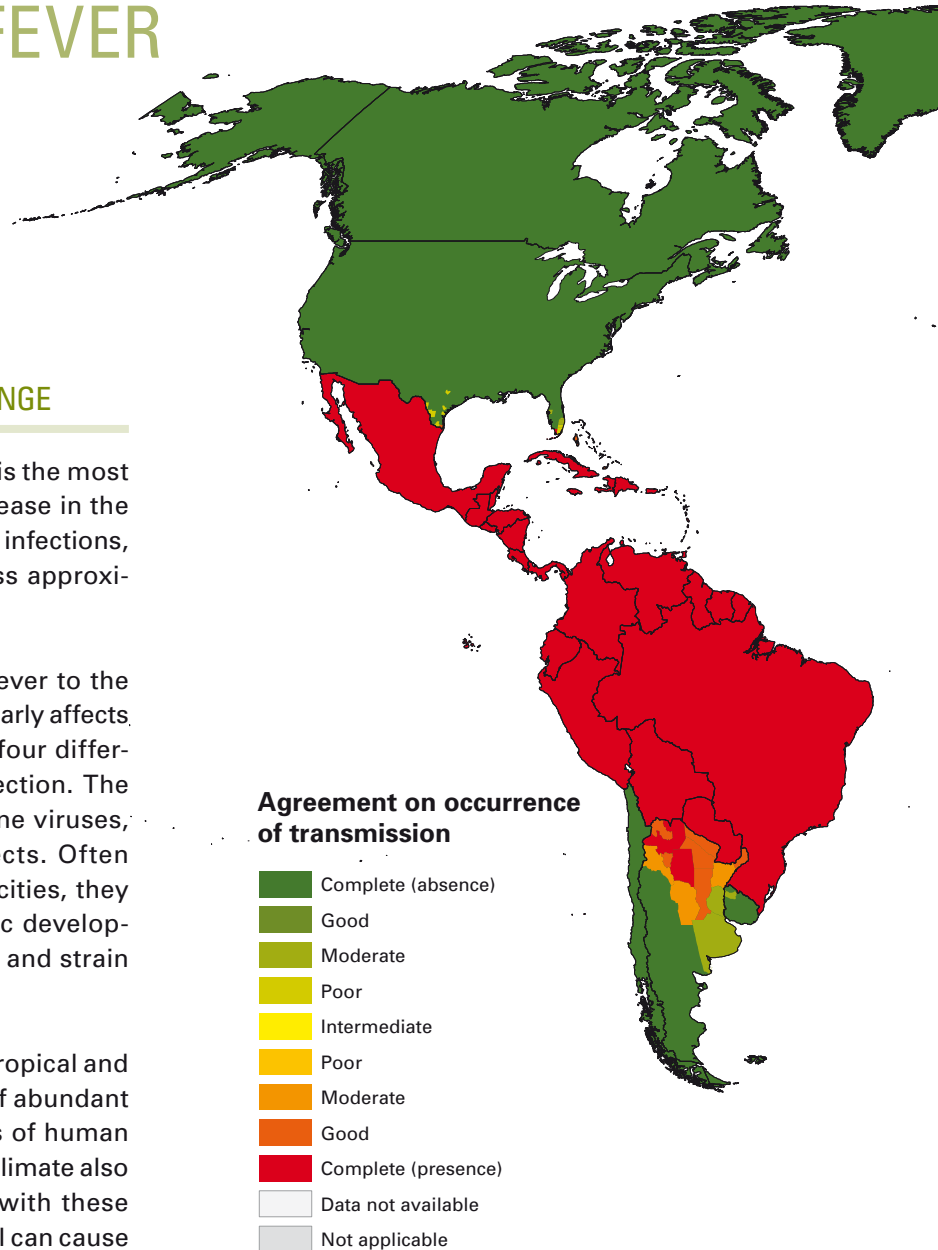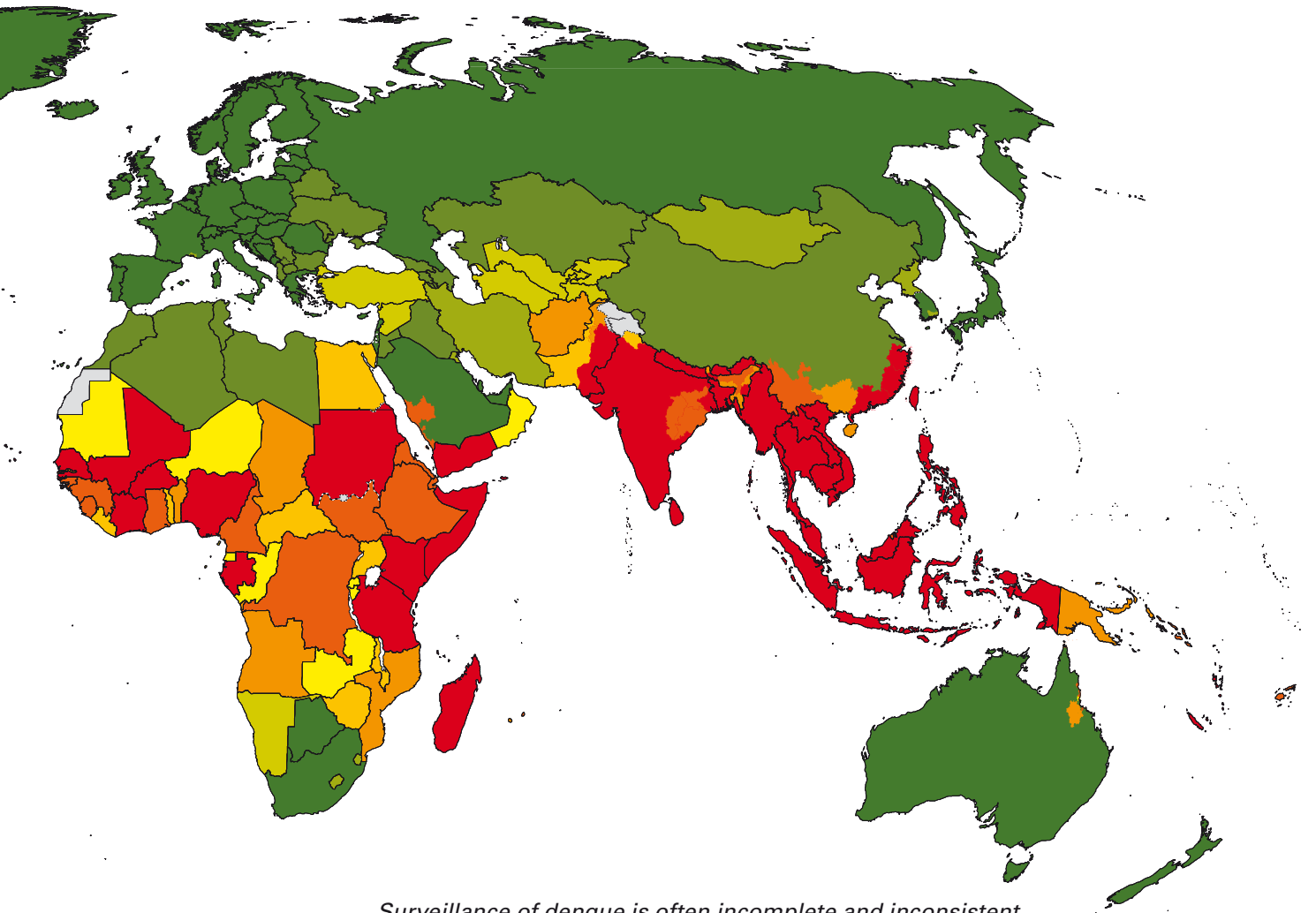ng in large cities, they can have an important impact on economic development – for example, it may affect tourism – and strain health systems, crowding hospitals.

Dengue is particularly prevalent in cities in tropical and subtropical areas, where the combination of abundant mosquito breeding sites and high densities of human populations support high rates of infection. Climate also exerts a strong influence, in combination with these socio-economic determinants. Heavy rainfall can cause standing water, while drought can encourage people to store more water around the home, both providing breeding sites for *Aedes* mosquitoes. Warm temperatures increase the development rates of both the mosquito vector and the virus, fuelling more intense transmission.

Dengue is now increasing in many parts of the world, driven by development and globalization – the combination of rapid and unplanned urbanization, movement of goods and infected people, dispersal of mosquitoes to newer territories, spread and mixing of strains of the virus, and more favourable climatic conditions.[3]

Agreement on occurrence of transmission

- Complete (absence)
- Good
- Moderate
- Poor
- Intermediate
- Poor
- Moderate
- Good
- Complete (presence)
- Data not available
- Not applicable

ASIANET-PAKISTAN / SHUTTERSTOCK.COM

*Surveillance of dengue is often incomplete and inconsistent.
The map combines information from different sources to show the degree of consensus as to
whether dengue transmission occurs in each country[4]*
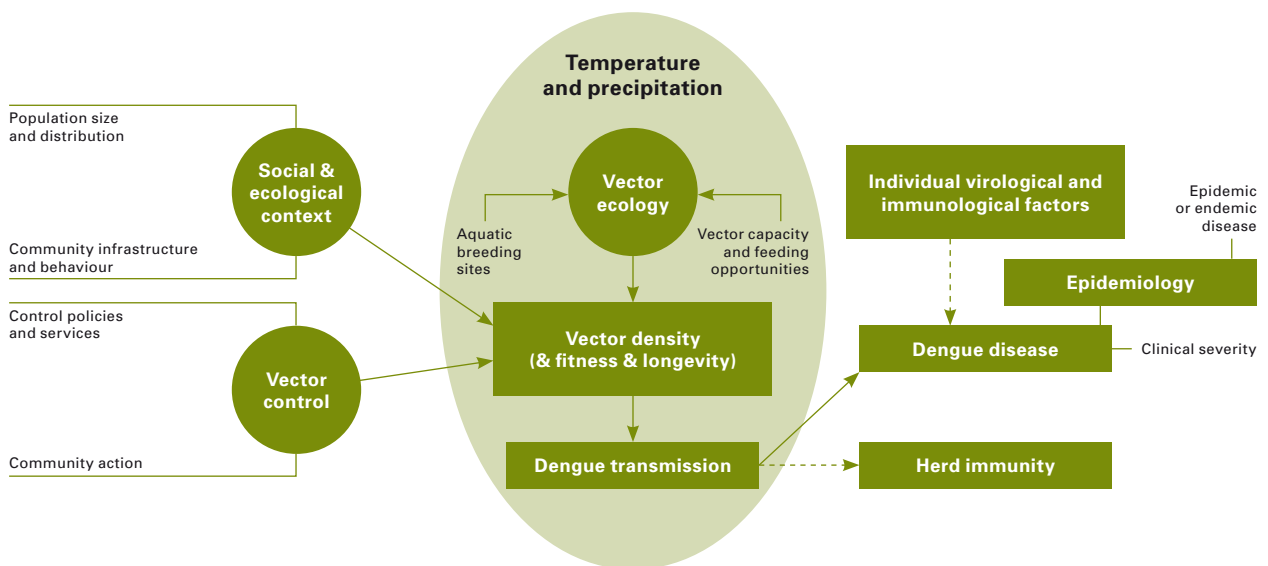
*Climate exerts a strong influence on dengue transmission - in interaction with
many other non-climate factors[5]*

USING CLIMATE SERVICES TO SUPPORT DENGUE CONTROL

There is currently no effective vaccine or drugs for dengue. Control programmes rely on environmental or chemical control of the vectors, rapid case detection and case management in hospitals for severe dengue. But these interventions are challenging, and there has been only very limited success in disease outbreak control within the most suitable transmission zones. Future initiatives are likely to depend not just on development of better interventions, but also on more effective targeting of control in time and space. In such scenarios, meteorological information can make an important contribution to understanding where and when dengue cases are likely to occur.
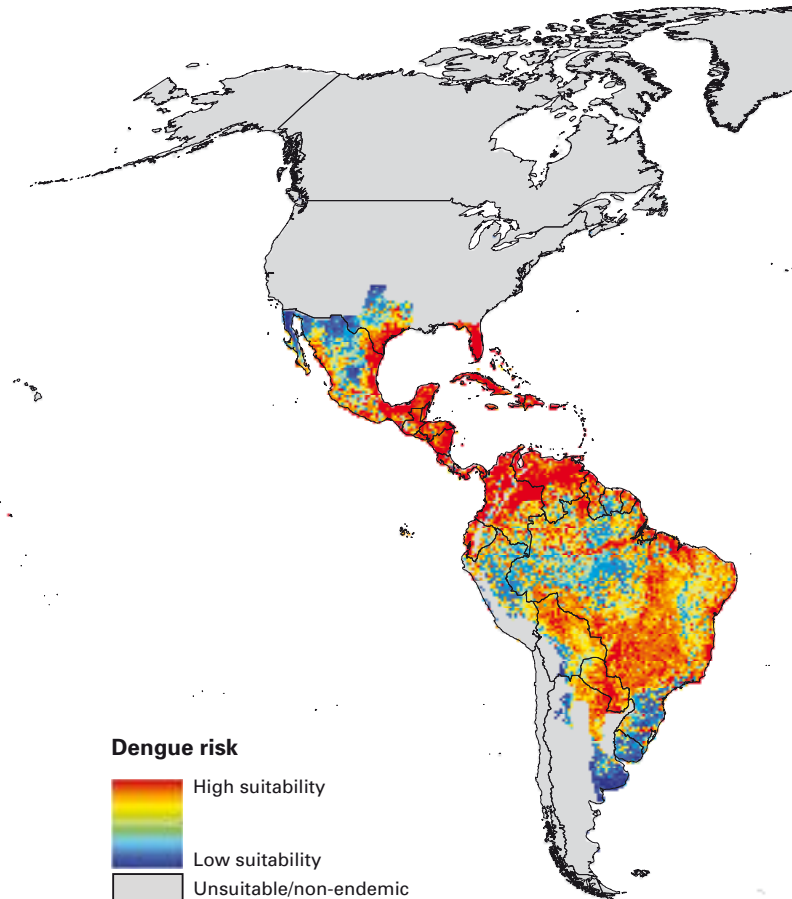
For example, statistical models, based on correlations between climate and other environmental variables and incidence of dengue in areas with good epidemiological and entomological surveillance, can be used to make predictions of the likelihood of transmission in locations where disease surveillance is weak or absent. Such information can also be used to alert authorities to the potential spread of dengue by mapping where the climate and other conditions either are, or may become, more suitable for transmission. Such information can be shared with neighbouring countries for sound planning and effective control of transmission.

Dengue risk

High suitability

Low suitability

Unsuitable/non-endemic

Meteorological information – knowledge of seasonal patterns and weather forecasts – can also play a role in targeting resources in time. Combining information on precipitation and temperature, with an understanding of non-climate factors such as availability of breeding sites and the previous exposure of populations to infection, can help to predict when and where epidemics may occur, or be particularly severe.

WHO / JIM HOLMES
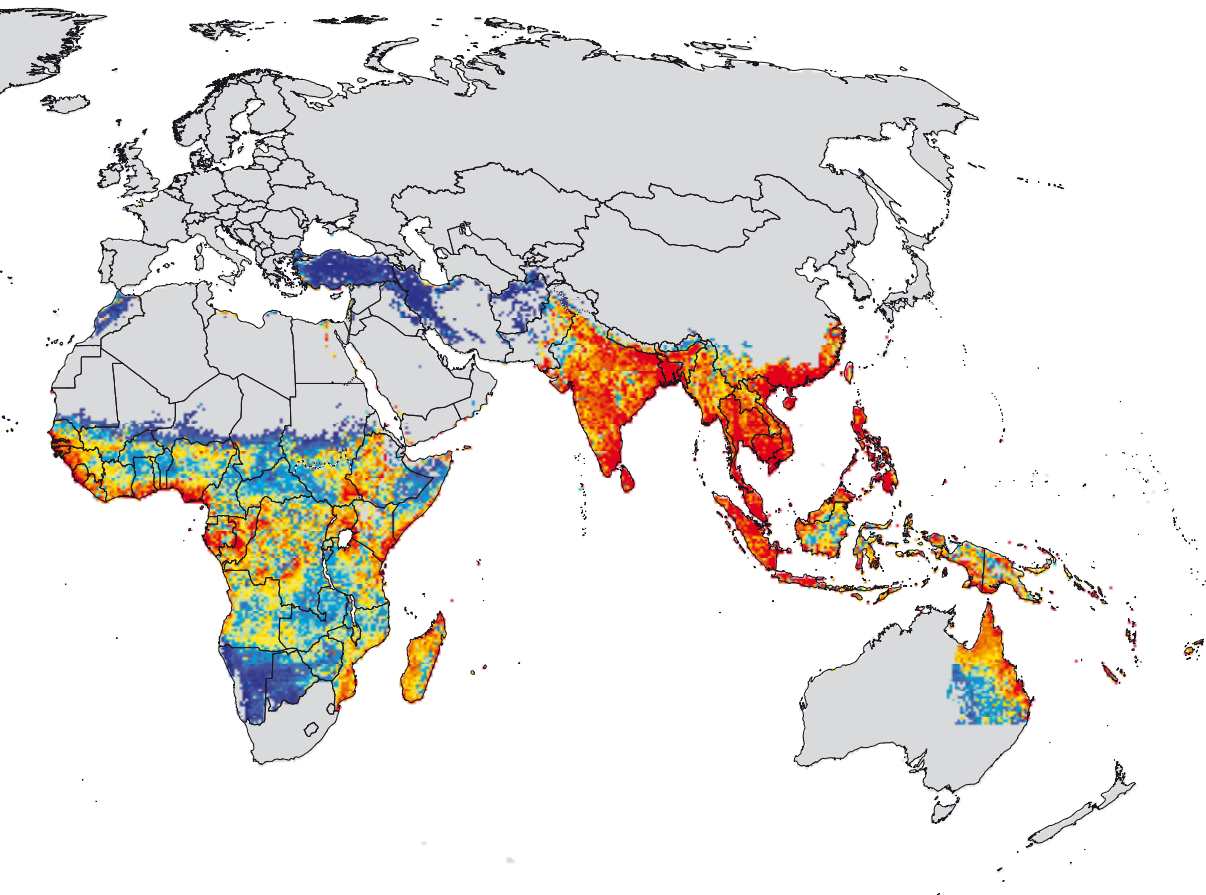
Climate information can be used to improve dengue surveillance. The map shows the estimated suitability for dengue in specific locations, based on a combination of disease surveillance data, and predictions based on climate and other environmental factors[6]
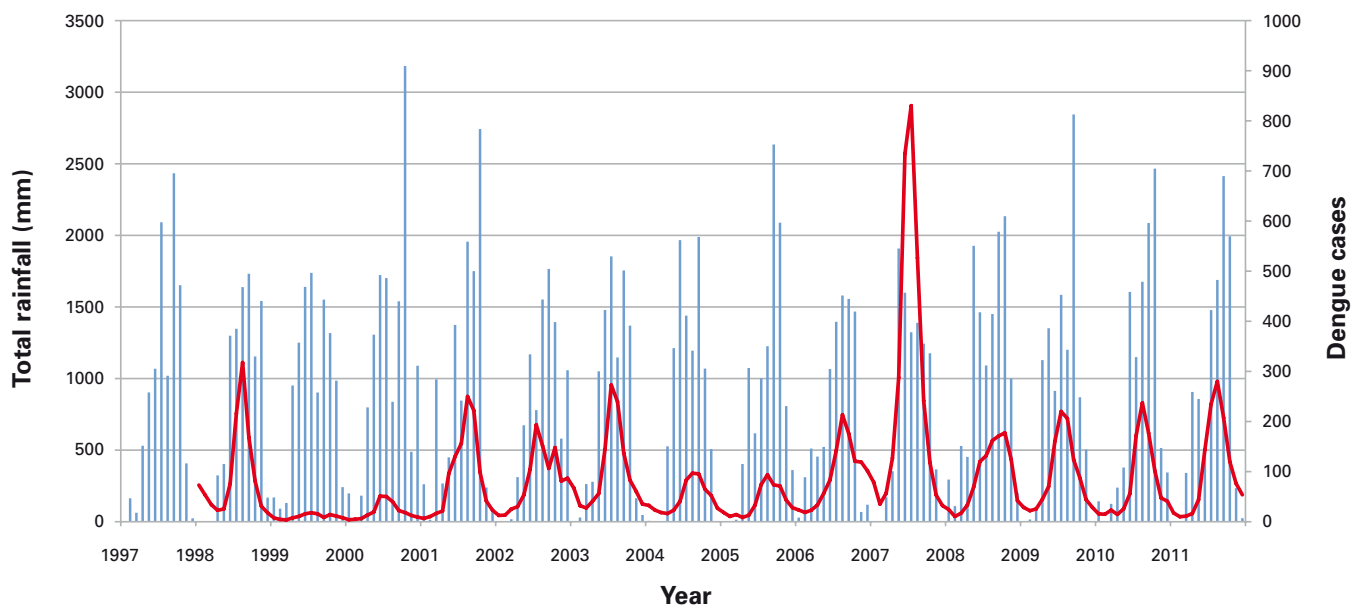
In many locations, dengue shows a strong seasonal pattern, and understanding of meteorological effects may help preparedness and targeting of control efforts. The figure shows pooled monthly dengue cases (red line) and monthly rainfall (blue bars) in Siem Reap and Phnom Penh, Cambodia[7]

A girl is helped off a truck after being evacuated from the flooded area of Thailand's Ayutthaya province

SECTION 2
EMERGENCIES

Every year, emergencies caused by weather-, climate- and water-related hazards impact communities around the world, leading to loss of life, destruction of social and economic infrastructure and degradation of already fragile ecosystems. Between 80 and 90 per cent of all documented disasters from natural hazards during the last ten years have resulted from floods, droughts, tropical cyclones, heat waves and severe storms.

STATISTICS AND THE HIDDEN IMPACT

In 2011, 332 disasters from natural hazards were recorded in 101 countries, causing more than 30 770 deaths, and affecting over 244 million people. Recorded damages amounted to more than US$ 366.1 billion.[1]

But statistics cannot reflect the full health impact or the depths of human suffering felt during such emergencies. Millions of people have suffered injuries, disease and long-term disabilities as well as emotional anguish from the loss of loved ones and the memories of traumatic events.[2]

Over the past 30 years the proportion of the world's population living in flood-prone river basins has increased by 114 per cent and those living on cyclone-exposed coastlines by 192 per cent.[3]

Reports of extreme weather events and disasters have more than tripled since the 1960s and scientists expect such events to become more frequent and severe in the future due to climate change in many parts of the world. There is also growing evidence that links escalations in violence and conflict over access to food and water resources to climate.[4]

CLIMATE SERVICES AND HEALTH EMERGENCIES

Adopted by 168 Member States at the World Disaster Reduction Conference in Kobe, Japan in 2005, the Hyogo Framework For Action describes the work that is required from all different sectors and actors, including health and climate communities, to reduce disaster losses. The Global Framework for Climate Services will contribute to the implementation of the Hyogo Framework by making tailored science-based climate-related information available to support informed investment and planning at all levels as a critical step in disaster risk management.[5]

Climate services support health and other sectors to save lives and reduce illness and injury in emergencies by:

- assisting health emergency response operations, for example, by providing early warnings of extreme hot and cold temperatures;

- providing seasonal forecasting and early warning systems to enable planning and action;

- determining which populations and health care facilities are at risk of hydrometeorological hazards using risk assessment tools;

- applying climate change models to forecast the long-term effects of climate change, information which could be used, for example, to decide where to locate new health facilities away from high risk areas; and,

- providing real-time meteorological and hydrological data, properly integrated with related health services data and information, to support local and national decision-making.

FLOODS AND CYCLONES

WIDESPREAD EFFECTS

Floods can cause widespread devastation, resulting in loss of life and damages to personal property and critical public health infrastructure that amount to billions of dollars in economic losses.

Floods and cyclones may directly and indirectly affect health in many ways, for example by:

- increasing cases of drowning and other physical trauma;

- increasing risks of water- and vector-borne infectious diseases;

- increasing mental health effects associated with emergency situations;[1]

- disrupting health systems, facilities and services, leaving communities without access to health care[2] when they are needed most; and

- damaging basic infrastructure such as food and water supplies and safe shelter.[3]

United States
Widespread flooding in Missouri and Southern Indiana during 2008.

Mexico
Massive floods in November 2007 were the worst experienced in 5 decades and caused the worst disaster in Mexico's history.

Colombia and Venezuela
November 2010 saw the worst flooding in over 30 years.

Peru and Bolivia
Heavy seasonal rainfall in 2004 caused crop damage and at least 50 deaths.

Chile
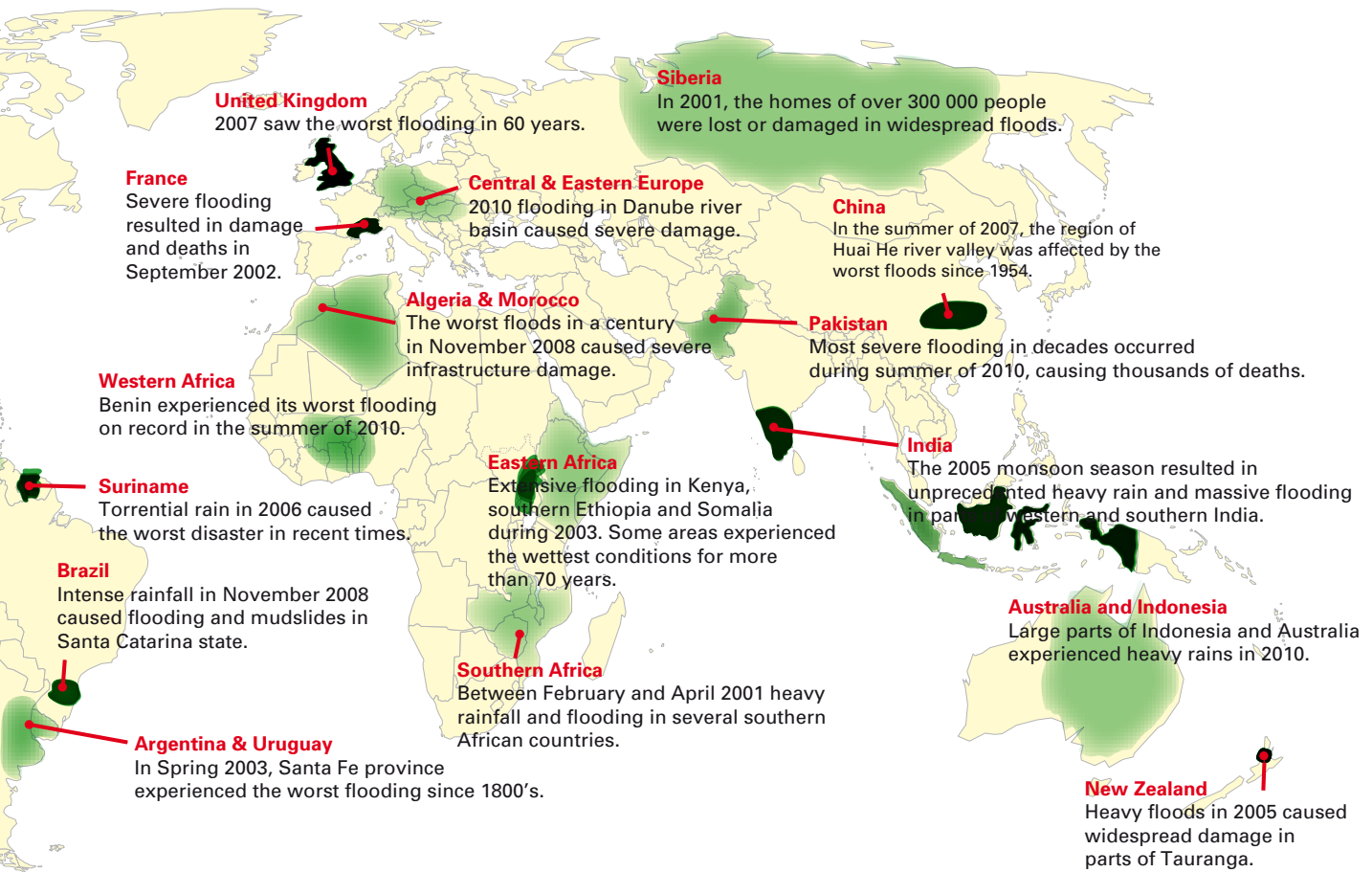There was severe flooding in the southern-central region in 2002.

WHO

CASE STUDY: BANGLADESH

In 1970, the world's most devastating cyclone to date claimed approximately 500 000 lives in Bangladesh, and another in 1991 claimed around 140 000 lives. Since 1991, the government with the support of the UN, including WHO and WMO, has established early warning systems, shelters along coastal areas, search and rescue teams and first-aid training and equipment.

Bangladesh now has the capacity to evacuate hundreds of thousands of people from the path of floods and cyclones. When Sidr, a very strong, Category-4 cyclone struck Bangladesh in November 2007, the devastation it wreaked was widespread. Sidr was of similar strength as the cyclone of 1991, but its death toll, 3000 lives, was much lower.[4]

United Kingdom
2007 saw the worst flooding in 60 years.

Siberia
In 2001, the homes of over 300 000 people were lost or damaged in widespread floods.

France
Severe flooding resulted in damage and deaths in September 2002.

Central & Eastern Europe
2010 flooding in Danube river basin caused severe damage.

China
In the summer of 2007, the region of Huai He river valley was affected by the worst floods since 1954.

Algeria & Morocco
The worst floods in a century in November 2008 caused severe infrastructure damage.

Pakistan
Most severe flooding in decades occurred during summer of 2010, causing thousands of deaths.

Western Africa
Benin experienced its worst flooding on record in the summer of 2010.

Suriname
Torrential rain in 2006 caused the worst disaster in recent times.

Eastern Africa
Extensive flooding in Kenya, southern Ethiopia and Somalia during 2003. Some areas experienced the wettest conditions for more than 70 years.

India
The 2005 monsoon season resulted in unprecedented heavy rain and massive flooding in parts of western and southern India.

Brazil
Intense rainfall in November 2008 caused flooding and mudslides in Santa Catarina state.

Australia and Indonesia
Large parts of Indonesia and Australia experienced heavy rains in 2010.

Southern Africa
Between February and April 2001 heavy rainfall and flooding in several southern African countries.

Argentina & Uruguay
In Spring 2003, Santa Fe province experienced the worst flooding since 1800's.

New Zealand
Heavy floods in 2005 caused widespread damage in parts of Tauranga.

A number of major flood events from 2000 – 2010[5]

NORTH AMERICA
1,190
640

EUROPE
1,870
1,650

ASIA
77,640
29,780

CARIBBEAN*
180
70

Average Physical Exposure to Floods Assuming Constant Hazard in thousands of people per year

in 2030
in 1970

Circles are proportional to the number of persons affected

CENTRAL AND SOUTH AMERICA
1,320
550

AFRICA
3,640

AUSTRALIA NEW ZEALAND
60
30
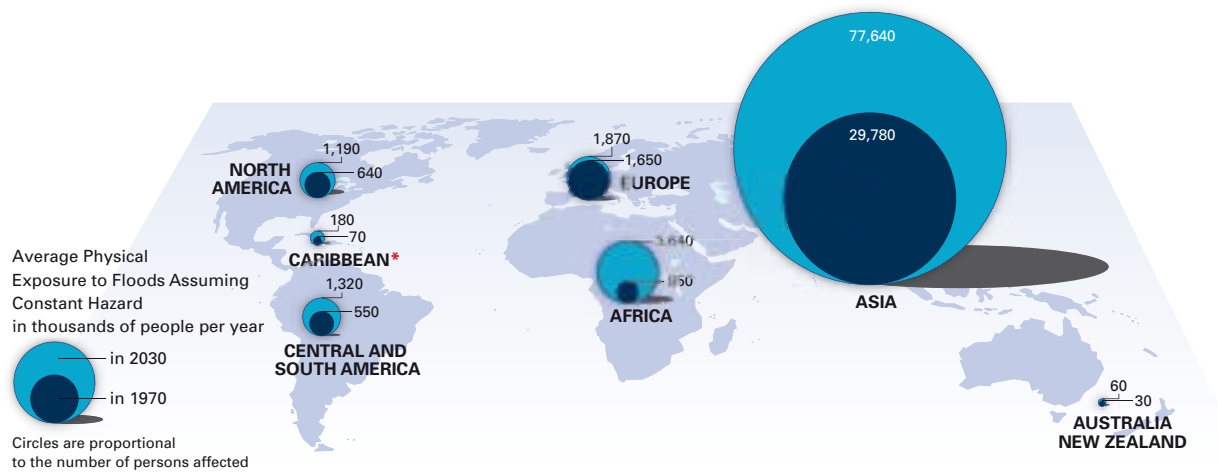
* Only catchments bigger than 1,000 km² were included in this analysis. Therefore, only the largest islands in the Caribbean are covered.

The projected increase in the number of people (in thousands) exposed to floods in 2030 compared to those in 1970[6]

FORECASTING FLOODS AND CYCLONES: PREPARE AND PREDICT TO SAVE LIVES

Climate information about flood and cyclone risks, routinely prepared by national meteorological services, inform billions of people around the world of the hazards they face, of ways of reducing their vulnerability and of emergency preparedness measures. These same services provide advice to government and other organizations concerning disaster response.

The El Niño/La Niña "cycle" is an episodic change between large scale warming and cooling either side of the equator in the Pacific Ocean. When El Niño and La Niña are at their most intense extreme weather events may result in disaster when communities are ill-prepared to face them.

Making hospitals safe from disasters, either by reinforcing existing hospitals or ensuring that all new hospitals are built to withstand local hazards, protects patients and staff, and enables them to provide health services in the aftermath of an emergency, when they are most needed. Using climate information about flood hazards, health facilities can be built in areas that are not prone to flooding, and early warnings can ensure that staff are ready to respond to emergencies.[7]
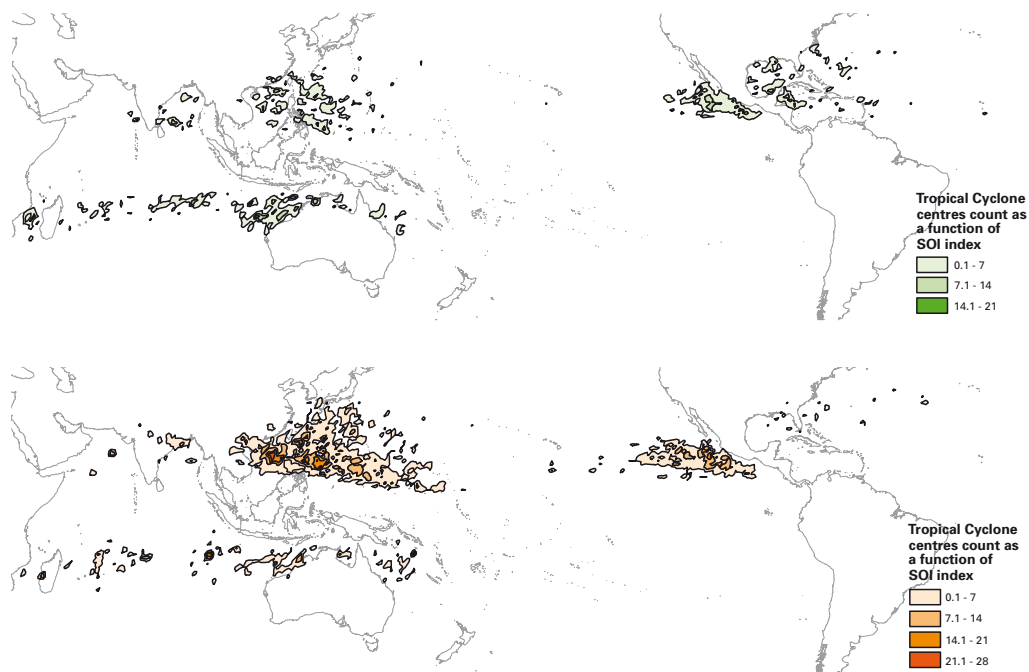
Tropical cyclone tracks vary substantially between times El Niño and times of La Niña. The locations of tropical cyclones is shown above for months of La Niña conditions (upper panel), and months of El Niño conditions (lower panel)[8]

CASE STUDY: PAKISTAN

During Pakistan's 2010 flood emergency, monsoonal rains and raging floodwaters damaged or destroyed more than 500 hospitals and clinics.[9] Information on the extent of the flooding enabled the Ministry of Health, supported by WHO and Health Cluster partners, to plan and position health services for the affected populations.

Facilities damaged during the 2010 floods had been identified as at risk of damage in a flood hazard modelling analysis conducted by the Ministry of Health and WHO in 2008.[10] WMO continues to work with the National Meteorological Service to improve their capability to forecast extreme events such as the 2010 flood.

Province	Established	In progress	Not Established	Total
Balochistan	11	4	0	15
Khyber Pakhtunkhwa	27	0	0	27
Punjab	12	4	2	18
Sindh	11	7	2	20
Grand Total	61	15	4	80

Status of
Diarrhoea Treatment Centers (DTCs)

(WHO, 04/10/2010)

- ■ Established
- ☐ In Progress
- ☐ Not Yet Established
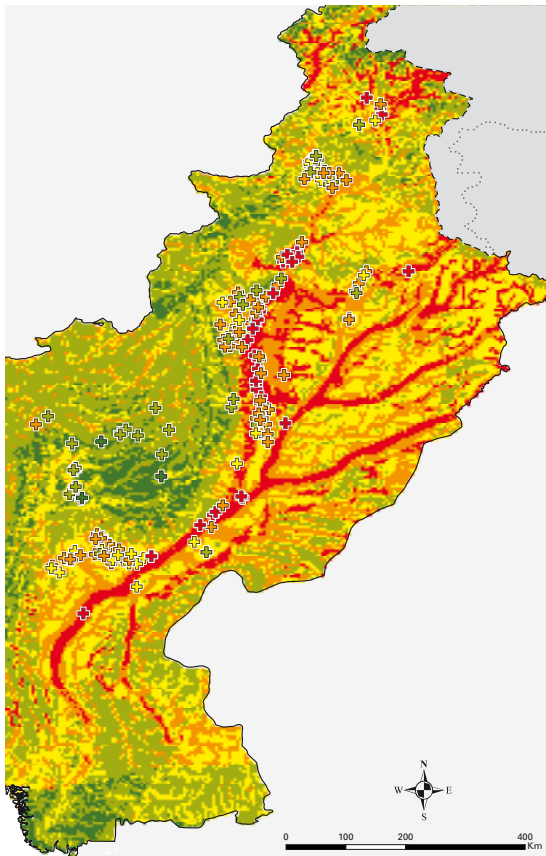- WHO Hubs and Health Clusters

Flood-Affected Areas

- ■ Flood Extent (UNOSAT Satellite Imagery Analysis, 08/08/2010 to 16/09/2010)

(Official, NDMA, 20/09/2010)

- Severe
- Medium
- Not applicable
- — International Boundaries
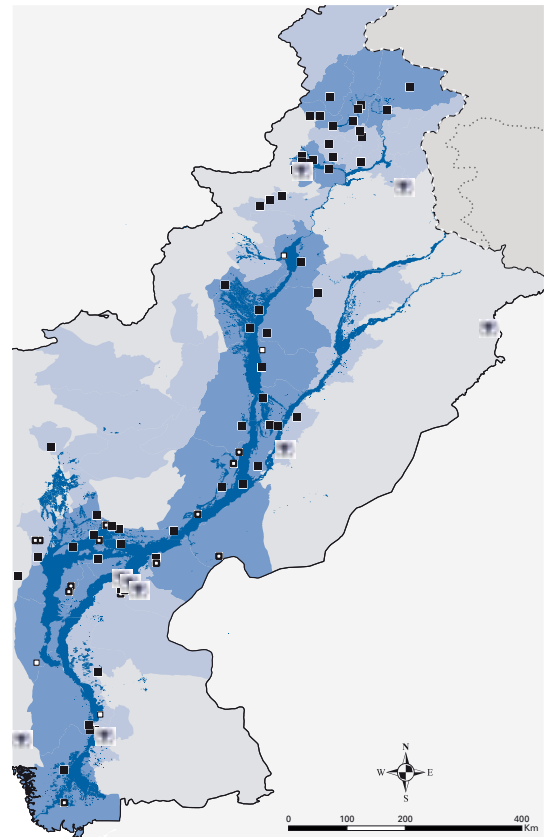
Flood-affected districts of Pakistan during 2010 and the location of diarrhoea treatment centres[11]

Flood Hazard (index)
(WHO, 2008)

- ✚ Very low
- ✚ Low
- ✚ Medium
- ✚ High
- ✚ Very high
- Not applicable
- — International boundaries
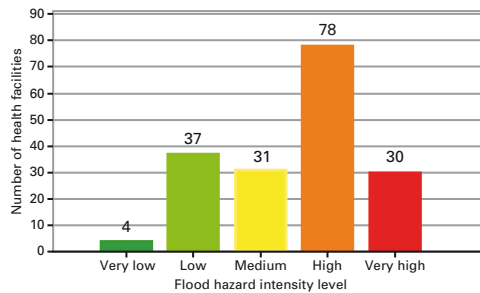
Map produced in 2008, indicating flood hazard prone areas and grading the level of exposure of health facilities[12]
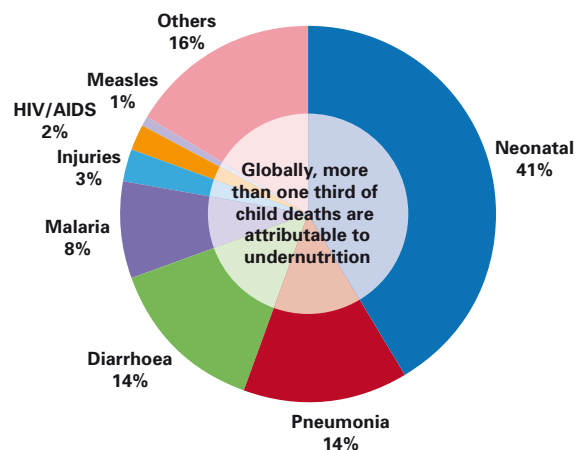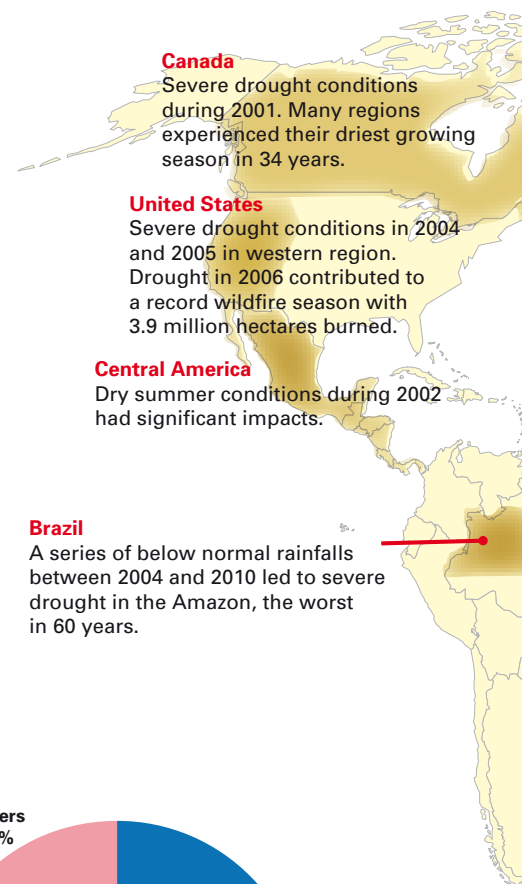
DROUGHT

DROUGHT: THE BIGGER PICTURE

Drought is a prolonged dry period in the natural climate cycle that can occur anywhere in the world. It is a slow-onset phenomenon caused by rainfall deficit. Compounding factors such as poverty and inappropriate land use increase vulnerability to drought.

When drought causes water and food shortages, there can be many impacts on the health of the affected population which may increase morbidity and result in deaths. In recent years, most drought-related mortality has occurred in countries also experiencing political and civil conflicts.

Drought may have acute and chronic health effects:

• malnutrition due to the decreased availability of food;

• increased risk of communicable diseases due to acute malnutrition, inadequate or unsafe water for consumption and sanitation, and increased crowding among displaced populations;

• psycho-social stress and mental health disorders;

• overall increase of population displacement; and

• disruption of local health services due to a lack of water supplies and/or health care workers being forced to leave local areas.[1,2]
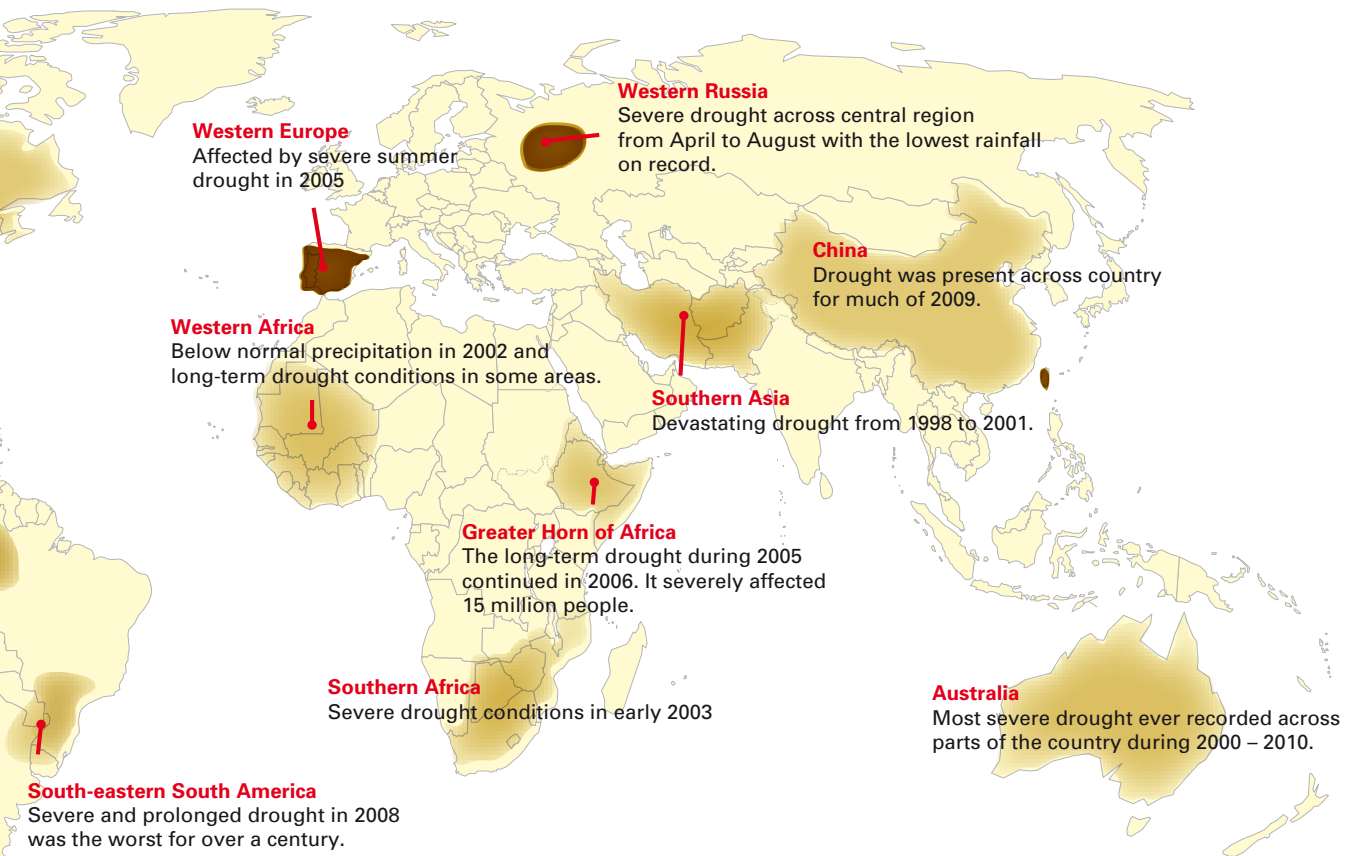
Canada
Severe drought conditions during 2001. Many regions experienced their driest growing season in 34 years.

United States
Severe drought conditions in 2004 and 2005 in western region. Drought in 2006 contributed to a record wildfire season with 3.9 million hectares burned.

Central America
Dry summer conditions during 2002 had significant impacts.

Brazil
A series of below normal rainfalls between 2004 and 2010 led to severe drought in the Amazon, the worst in 60 years.

Others 16%
Measles 1%
HIV/AIDS 2%
Injuries 3%
Malaria 8%
Diarrhoea 14%
Pneumonia 14%
Neonatal 41%

Globally, more than one third of child deaths are attributable to undernutrition

Undernutrition contributes to a range of diseases, and causes 35 per cent of all under-five deaths[3,5]

WHO

Western Europe
Affected by severe summer drought in 2005

Western Russia
Severe drought across central region from April to August with the lowest rainfall on record.

China
Drought was present across country for much of 2009.

Western Africa
Below normal precipitation in 2002 and long-term drought conditions in some areas.

Southern Asia
Devastating drought from 1998 to 2001.

Greater Horn of Africa
The long-term drought during 2005 continued in 2006. It severely affected 15 million people.

Southern Africa
Severe drought conditions in early 2003

Australia
Most severe drought ever recorded across parts of the country during 2000 – 2010.

South-eastern South America
Severe and prolonged drought in 2008 was the worst for over a century.

A number of major drought events from 2000 – 2010 [4]

Children aged < 5 years underweight (%)

- <10
- 10-19.9
- 20-29.9
- ≥ 30
- Data not available
- Not applicable
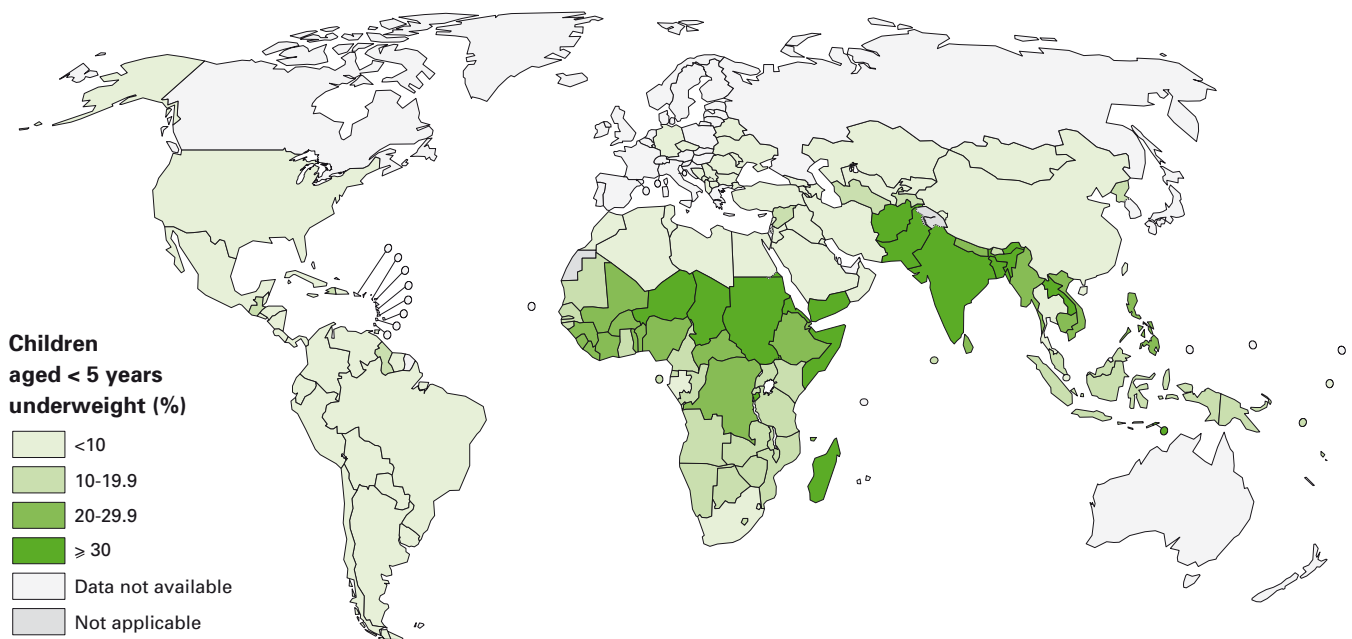
Percentage of underweight children under 5 years of age
(based on latest available data from 2000) [6]

31

CASE STUDY: HORN OF AFRICA CRISIS 2010-2011

Two consecutive seasons of significantly below average rainfall made 2011 one of the driest years in the Eastern Horn of Africa since 1995. The on-going conflict in Somalia aggravated the situation, leading to a significant outflow of refugees into neighbouring states. Famine was declared in six regions of Somalia, with large areas of Kenya, Ethiopia, and Djibouti facing severe food insecurity, which led to high levels of acute malnutrition.

As of September 2010, climate services gave clear early warnings of the reduced rainfall and of the emerging crisis situation, but coordinated and proactive action aimed at alleviating the predicted effects of the crisis did not take place. As a result, 13.3 million people were in need of humanitarian assistance in the region.

Preventive action is possible. The Tana River Drought Recovery Project in Kenya supported modern agricultural practices and health activities, including conducting monthly mobile clinics in hard to reach areas, a house-to-house campaign on immunization and malaria, distribution of mosquito nets and the construction of a maternity wing at Mulago hospital. The 33 farms created by the Project provided long-term food security for almost 10 000 people. The same money, spent on food aid, would have given only 1 250 people a partial food ration for six months.[7-10]

Legend

- No information
- Wetter than normal
- Drier than normal
- Water bodies

Figures represents probabilities of

- A Above normal
- N Near normal
- B Below normal
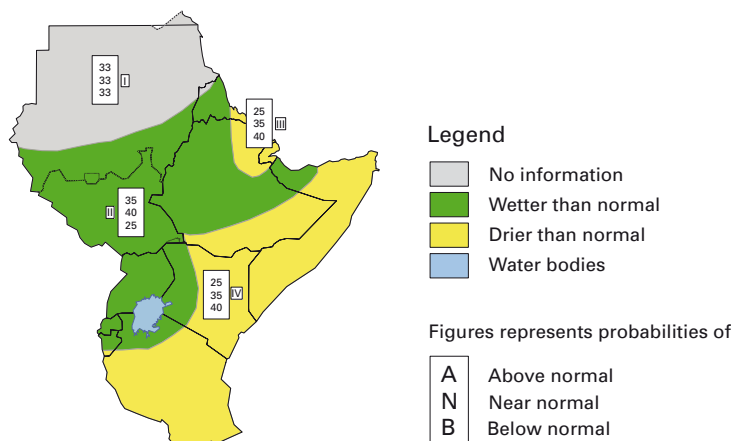
The probabilities of above, near or below normal rainfall in the Horn of Africa for September to December 2010[11]
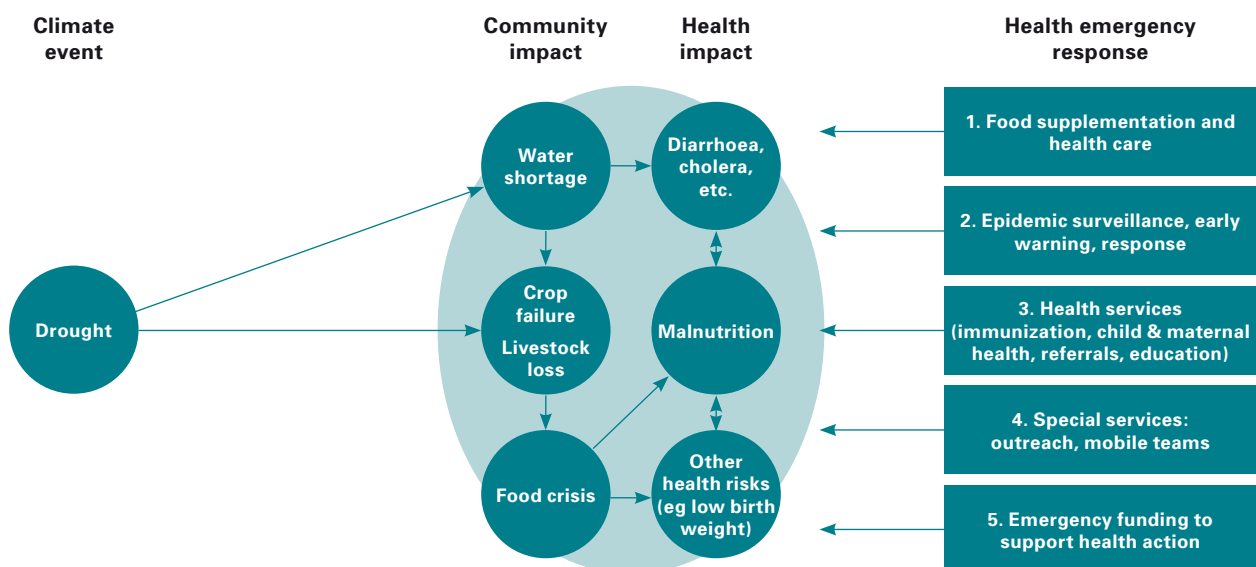
Drought as a risk factor for complex public health impacts and the possible areas for public health response[12]

CASE STUDY: THE SAHEL – EARLY WARNING, EARLY RESPONSE

As predicted by the regional Famine Early Warning System Network (FEWS NET) below-average rains in the Sahel in late 2011 resulted in drought conditions in 2012 and widespread food insecurity throughout the region. The UN estimated that over 18 million people were at risk in areas in nine countries where food insecurity and malnutrition were already chronic.

In the Sahel the humanitarian community's response to the early warning included:

- Providing food assistance, including special foods designed to combat malnutrition;

- Treating malnutrition, by training nurses, providing medical supplies and supporting free access to health care;

- Preventing communicable diseases through vaccination, disease surveillance, and prepared-ness for outbreaks; and

- Improving water and sanitation services thereby, promoting hygiene.[13]
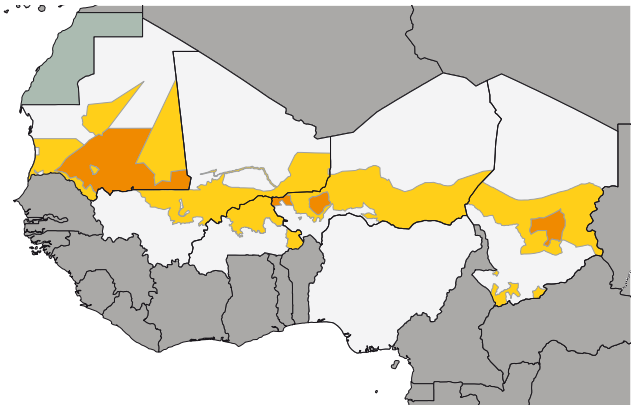
Food Security Conditions April-June 2012
(Integrated Food Security Phase Classification Scale)

Normal or minimal	Data not available
Stressed	Not applicable
Crisis	
Emergency	
Catastrophe/Famine	

Most likely food security conditions in the Sahel Region between April-June (at 2 April 2012). Senegal, Gambia, northern Nigeria and northern Cameroon was also affected[14]
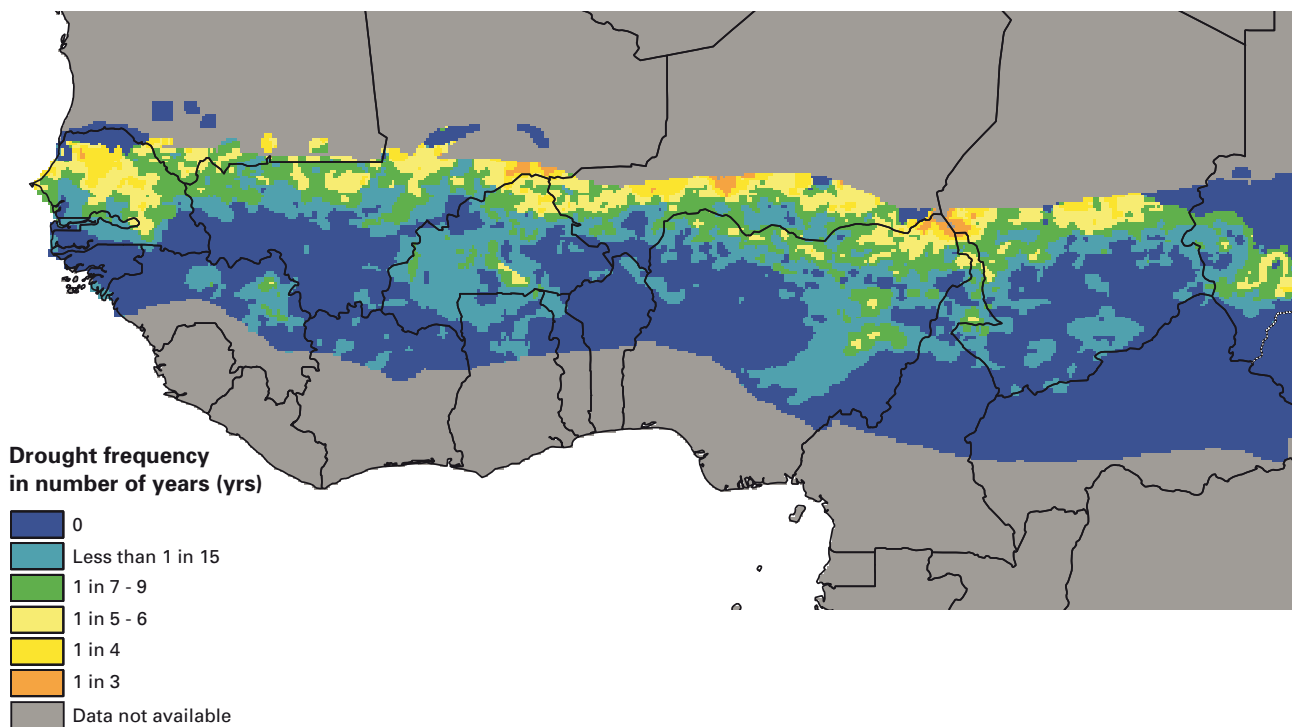
Drought frequency in number of years (yrs)

	0
	Less than 1 in 15
	1 in 7 - 9
	1 in 5 - 6
	1 in 4
	1 in 3
	Data not available
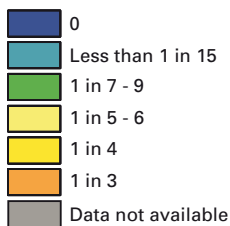
Frequency of drought (WRSI for Millet) from 1996-2011 across the Sahel region[15]

AIRBORNE DISPERSION OF HAZARDOUS MATERIALS

Large-scale dispersion of airborne hazardous materials such as smoke from large fires, chemicals released from hazardous facilities and radiological materials from nuclear incidents can adversely affect human and animal life and the environment.[1]

WILDFIRES AND FOREST FIRES

Wildfires and forest fires occur in all vegetation zones. Caused by natural phenomena or by human activity, emissions from fires contain gas and particle pollutants that can cause diverse health problems, as well as disrupt transportation, tourism and agriculture. Extreme radiant heat and smoke inhalation may cause injury and death to people directly exposed to the fires. The occurrence of wildfires is strongly determined by the incidence of drought and heat waves. Climatologists believe that climate change will increase in the incidence of wildfires as the associated droughts and heat waves are expected to increase in frequency and intensity.

CASE STUDY: SOUTH-EAST ASIA FOREST FIRES OF 1997

South-East Asia witnessed one of its worst smoke and haze episodes in autumn 1997 due to forest fires that were exacerbated by the El Niño-related drought. It is estimated that more than two million hectares of forests burned in the Indonesian islands of Kalimantan and Sumatra, emitting the equivalent level of carbon dioxide as a whole year of CO_2 emissions in Europe.[2]

Meteorological services tracked the resulting smoke and haze, which adversely affected the health of populations of Indonesia and neighbouring countries. In Indonesia, among the 12 360 000 people exposed to the haze, it was estimated that there were over 1 800 000 cases of bronchial asthma, bronchitis and acute respiratory infection. Health surveillance in Singapore from August to November 1997 showed a 30 per cent increase in hospital outpatient attendance for haze-related conditions, as well as an increase in "accident and emergency" attendances.[3]
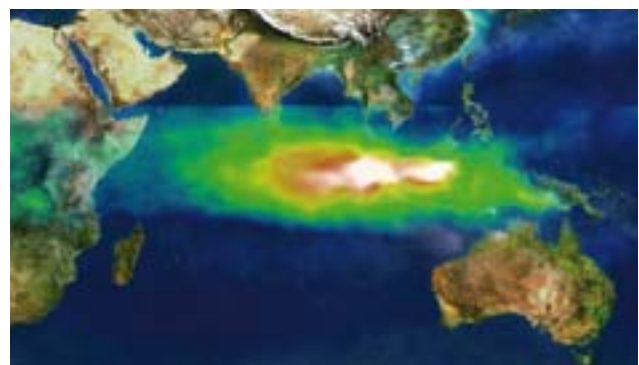
The image shows the pollution over Indonesia and the Indian Ocean on October 22, 1997. White represents the aerosols (smoke) that remained in the vicinity of the fires. Green, yellow, and red pixels represent increasing amounts of tropospheric ozone (smog) being carried to the west by high-altitude winds.[4]
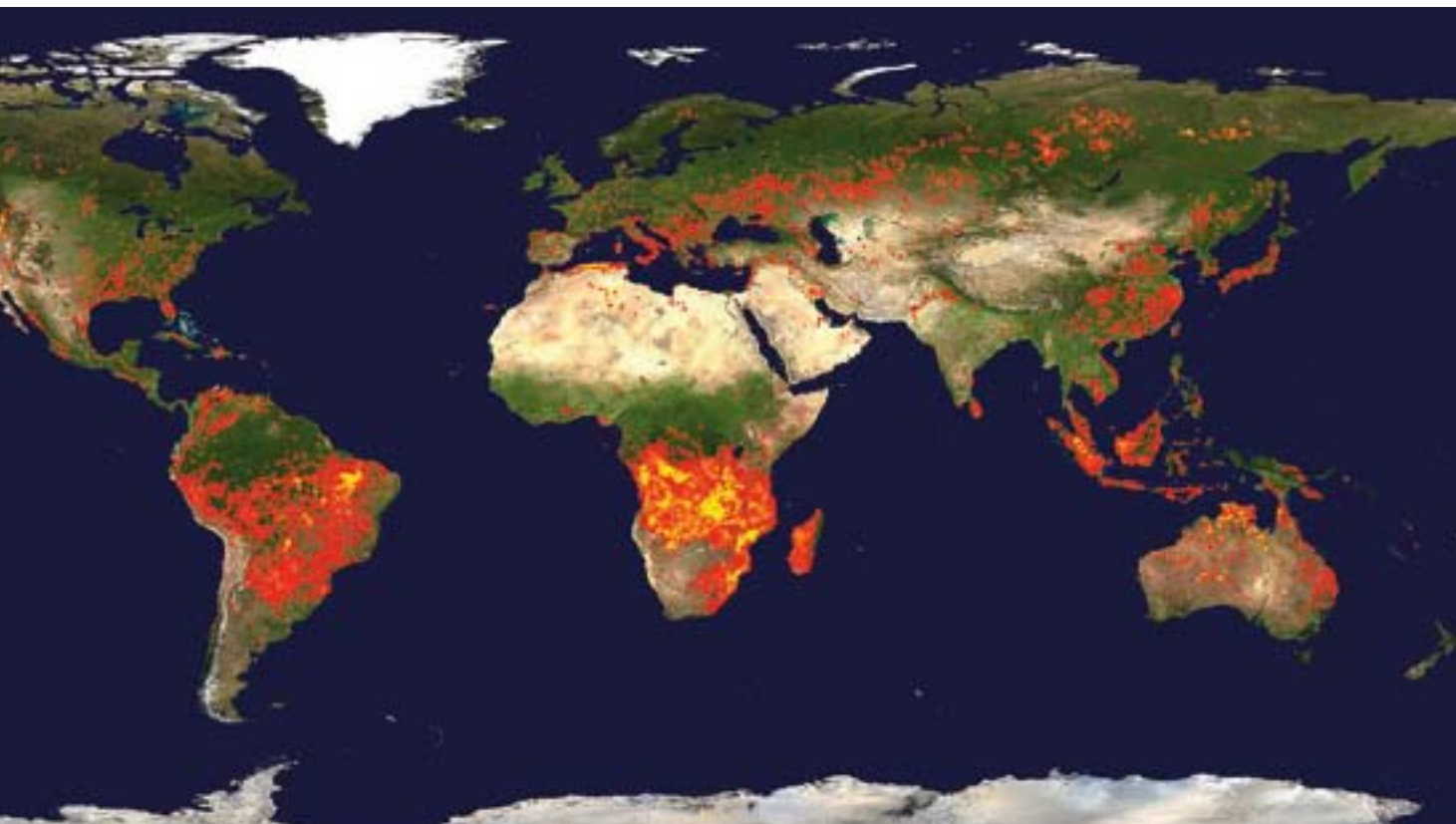
*Red areas show global distribution of fire occurrences over a
10-day period from 08/08/2012 - 17/08/2012.[5]*

CASE STUDY: CHERNOBYL NUCLEAR ACCIDENT

On 26 April 1986 a nuclear accident at the Chernobyl Nuclear Power Plant in the former Union of Soviet Socialist Republics (in what is now Ukraine) released large quantities of radioactive materials which were carried in the atmosphere over much of Eastern and Western Europe. These releases caused radiation exposure of the workers involved in the emergency and clean-up operations after the accident, those evacuated from nearby settlements, and people living in contaminated areas out-side the immediate vicinity of Chernobyl. A substantial increase in thyroid cancer was recorded among children due to radioactive iodine exposure during the first few months following the accident.[6]

The Chernobyl accident was the main reason for the development of modelling systems to forecast atmospheric transport of radioactivity and to start the Emergency Response Activities programme of WMO.
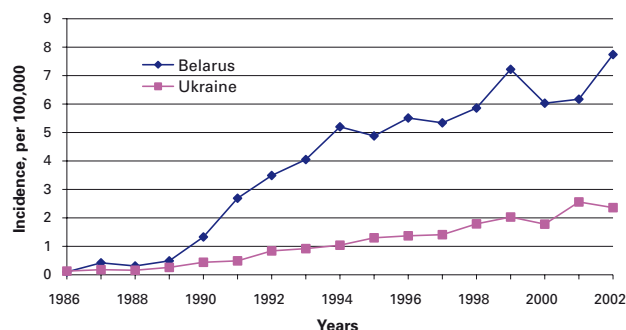
The graph illustrates the number of cases of thyroid cancer, per 100 000 population, for children and adolescents in Belarus and Ukraine who were exposed to radiation after the Chernobyl accident[7]

METEOROLOGICAL SERVICES

National Meteorological Services can provide information on the dispersion and spread of the fire and smoke plumes to support health and emergency management authorities in taking decisions on, for example, the evacuation of neighbourhoods, the closing of roads or advising the population of water and foods likely to be contaminated. The occurrence of wildfires is strongly determined by the incidence of drought and heat waves.

Meteorology can play an important role in reducing the health effects of hazardous material suddenly released into the environment. Meteorological information such as weather forecasts support local and regional emergency response operations and meteorological modelling and mapping systems can assess and predict the movement, spread and concentration of airborne hazardous substances from the location of sudden release. The meteorological services provide an analysis of how wind, rain and other meteorological phenomena will affect the dispersion of the hazardous substances.

CASE STUDY: MAJOR FIRE AT BUNCEFIELD, UNITED KINGDOM

On 11 December 2005, there was a major explosion at the Buncefield Oil Depot in Hemel Hempstead, United Kingdom, resulting in the largest peacetime fire in Europe to date. The fire burned for four days before it was extinguished.[1]

The Met Office Operations Centre in the United Kingdom provided immediate and hourly data as well as forward-looking modelling on the smoke plume to government departments across the United Kingdom, including the Health Protection Agency. Data on the composition of the smoke was compiled with information from the modelling of the plume spread and dispersal. The areas at risk from grounding of the smoke plume were thus identified and the high-level command decisions on evacuation and emergency response were facilitated.[9]

In summary 244 individuals attended hospital in the aftermath of the fire, 43 were directly injured by the blast but there were no fatalities. The incident demonstrates the value of an integrated health protection service, informed by the meteorology service, able to work across different sectors and provide comprehensive advice and support to emergency responders and the population at risk.[9]

Air concentration of particulates

- Lowest
- Medium
- High
- Highest
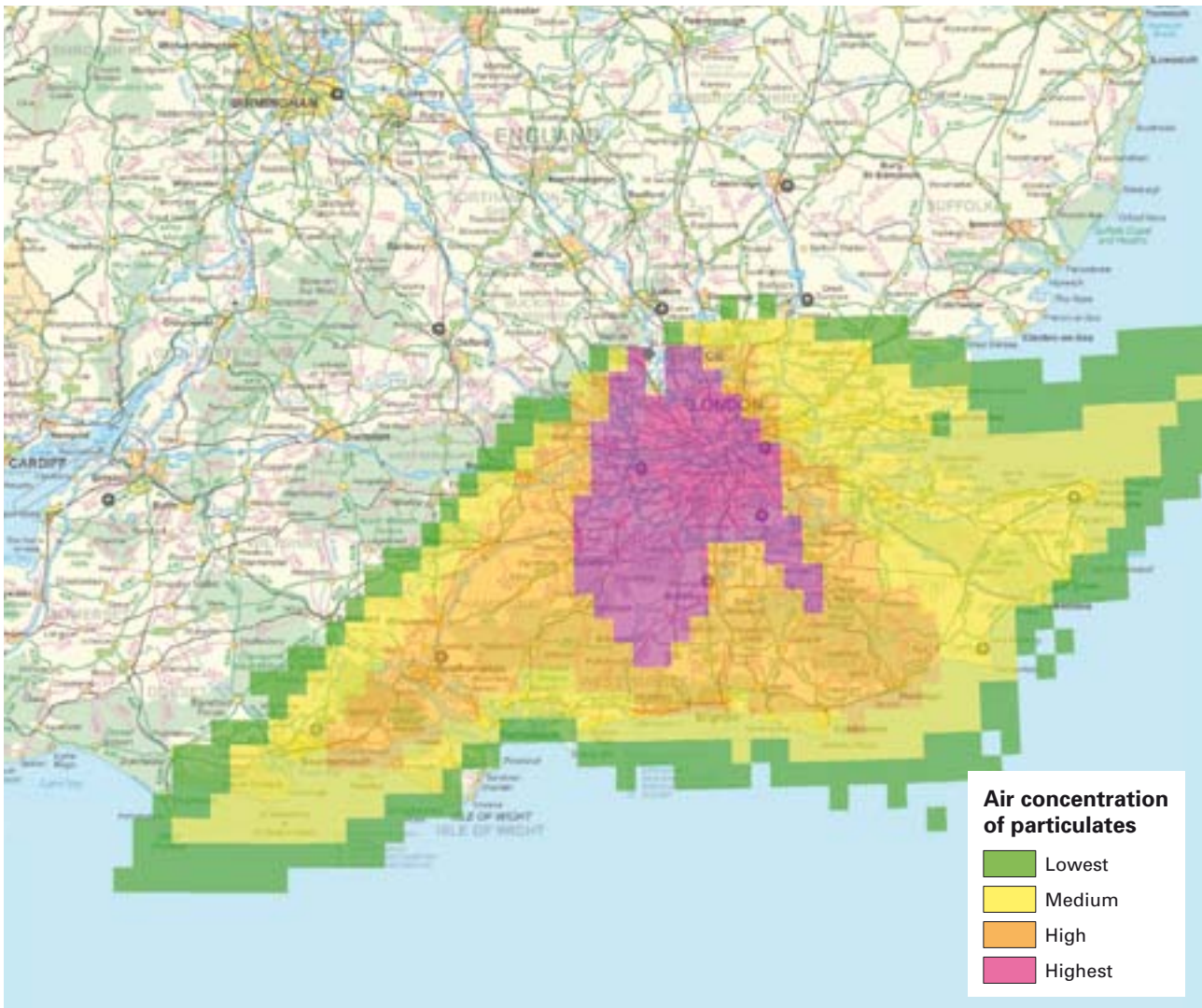
The dispersion model mapping the density of the plume across the south-east of the UK from the Buncefield fire, 2005[8]

Vehicles clog a major
thoroughfare as smog shrouds
the skyline in Beijing, China

SECTION 3
EMERGING ENVIRONMENTAL CHALLENGES

Current development patterns, and individual behavioural choices, are bringing a range of new challenges to public health. Many of the most important relate to environmental changes.

The clearest example is climate change. The accumulation of greenhouse gases in the atmosphere, driven mainly by the use of fossil fuels, is increasing temperatures and exposing populations to more frequent and intense weather extremes as well as undermining environmental determinants of health, such as clean water and adequate nutrition. Similarly, the accumulation of Chlorofluoro-carbons (CFCs) and other industrial chemicals in the atmosphere has degraded the stratospheric ozone layer, increasing levels of ultraviolet radiation – the major risk factor for developing skin cancers.

The health impacts of these environmental changes, however, are strongly mediated by local factors. Air pollution, both inside and outside the home, is caused by a combination of global development patterns, and weak control of polluting energy sources at the national and local level, making it one of the largest, and fastest growing, contributors to global ill health. The health issues related to the increasing frequency of heat waves is compounded by a rapid increase in the size of the most vulnerable populations: older people, particularly those living in large cities in the tropics and subtropics. The hazard of ultraviolet radiation has combined with a tendency over recent decades for fair-skinned populations to spend increasing amounts of time in the sun. In some cases, such as with the rapid rise in asthma and other respiratory conditions associated with pollen exposure the mechanisms are poorly understood – but the early evidence suggests that the rise in observed cases is also caused by a combination of more conducive climate and environmental conditions, more active surveillance by health services, and individual susceptibility.

A combined response to emerging environmental challenges is needed from the individual up to the local, national and international levels. A close collaboration between climate and health services can make an important contribution to all of these efforts. At the local level, weather forecasts in many parts of the world now routinely provide information on levels of ozone and particulate air pollutants, of pollen, of exposure to ultraviolet radiation, and warnings of when high temperatures may become hazardous to health. When this service is properly connected with guidance or plans for preventive action, it can enable individuals, and health services, to avoid or limit harm to health.

Meteorological and other environmental monitoring services also provide information on environmental hazards over wider spatial scales, and over longer time periods. This includes, for example, monitoring of the dispersal of particulate air pollution within and across national boundaries over weeks or months, and of the condition of the ozone layer over years. Perhaps most fundamentally, meteorological services provide the essential data allowing us to track, and to predict, the progress of global climate change over decades to centuries. Health services can use this information to ensure that health protection services adapt as much as possible to changing conditions. They can also use it to advocate for environmental protection, and sustainable development, as fundamental contributions to sustain healthy human lives.
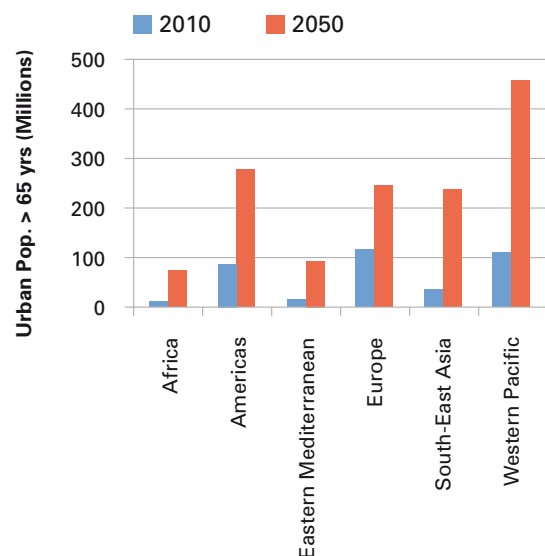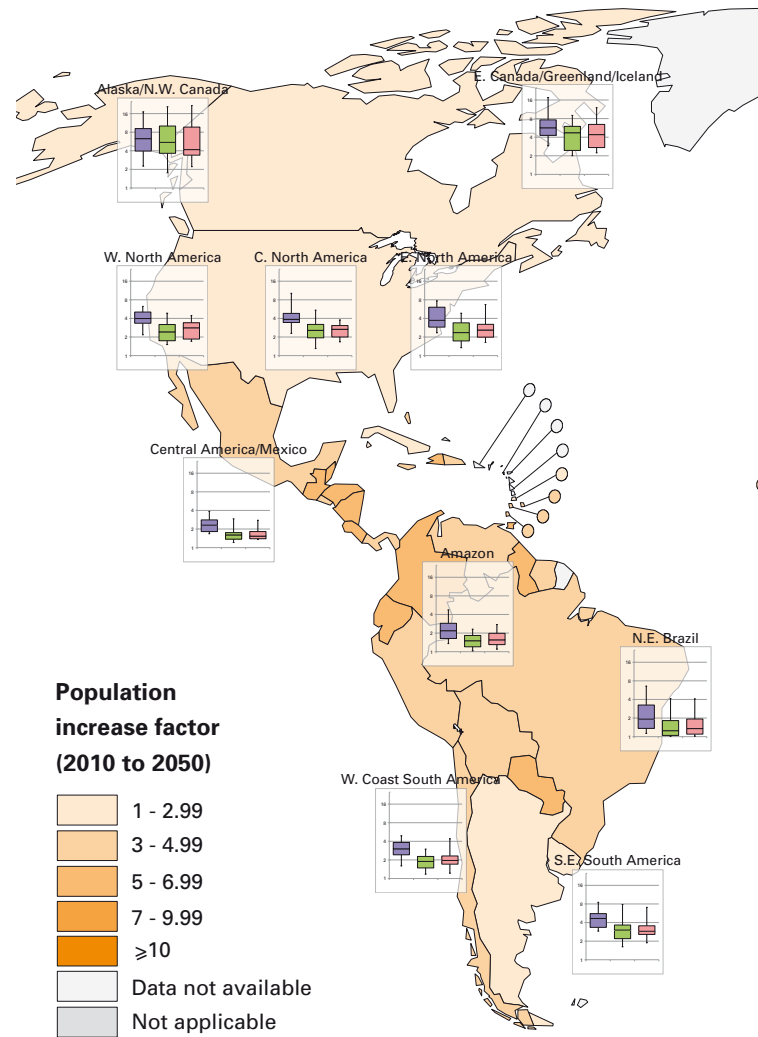
HEAT STRESS

THE DANGERS OF THE SUN

Excessive heat is a growing public health threat – for every degree Centigrade above a threshold level, deaths can increase by 2 – 5 per cent. Prolonged, intense heat waves heighten the risks. Elderly, chronically-ill and socially-isolated individuals, people working in exposed environments and children are particularly vulnerable.[1,2]

While extreme heat affects populations around the world in both developing and developed countries, some of the most dramatic heat waves have occurred in relatively wealthy regions of the world with cooler average temperatures and mid-latitude climates. The extended heat of the European summer of 2003 caused a rise in death rates that was 4 to 5 times expected levels at the peak of the event in some cities, eventually causing over 70 000 additional deaths across twelve countries.[3,4] Heat stress affects rural areas but is particularly severe in cities, where the urban heat-island effect can raise temperatures by more than 5°C,[5] and high temperatures exacerbate the harmful effects of ozone and particulate air pollution.

Climate change – which is expected to increase the intensity and frequency of such extremes – will worsen the hazards to human health. By the 2050s, heat events that would currently occur only once every 20 years will be experienced on average every 2 – 5 years.[6] Population growth, ageing and urbanization are also expected to increase the numbers of people at high risk. By 2050, it is estimated that there will be at least 3 times as many people aged over 65 living in cities around the world, with developing regions seeing the greatest increases.[7] The combined effects of escalating hazards and growing vulnerable populations will make heat stress a health priority for the coming decades.

Population increase factor (2010 to 2050)

- 1 - 2.99
- 3 - 4.99
- 5 - 6.99
- 7 - 9.99
- ≥10
- Data not available
- Not applicable

Older people living in cities are at particular risk; and their number is expected to increase dramatically by the middle of the Century[7]
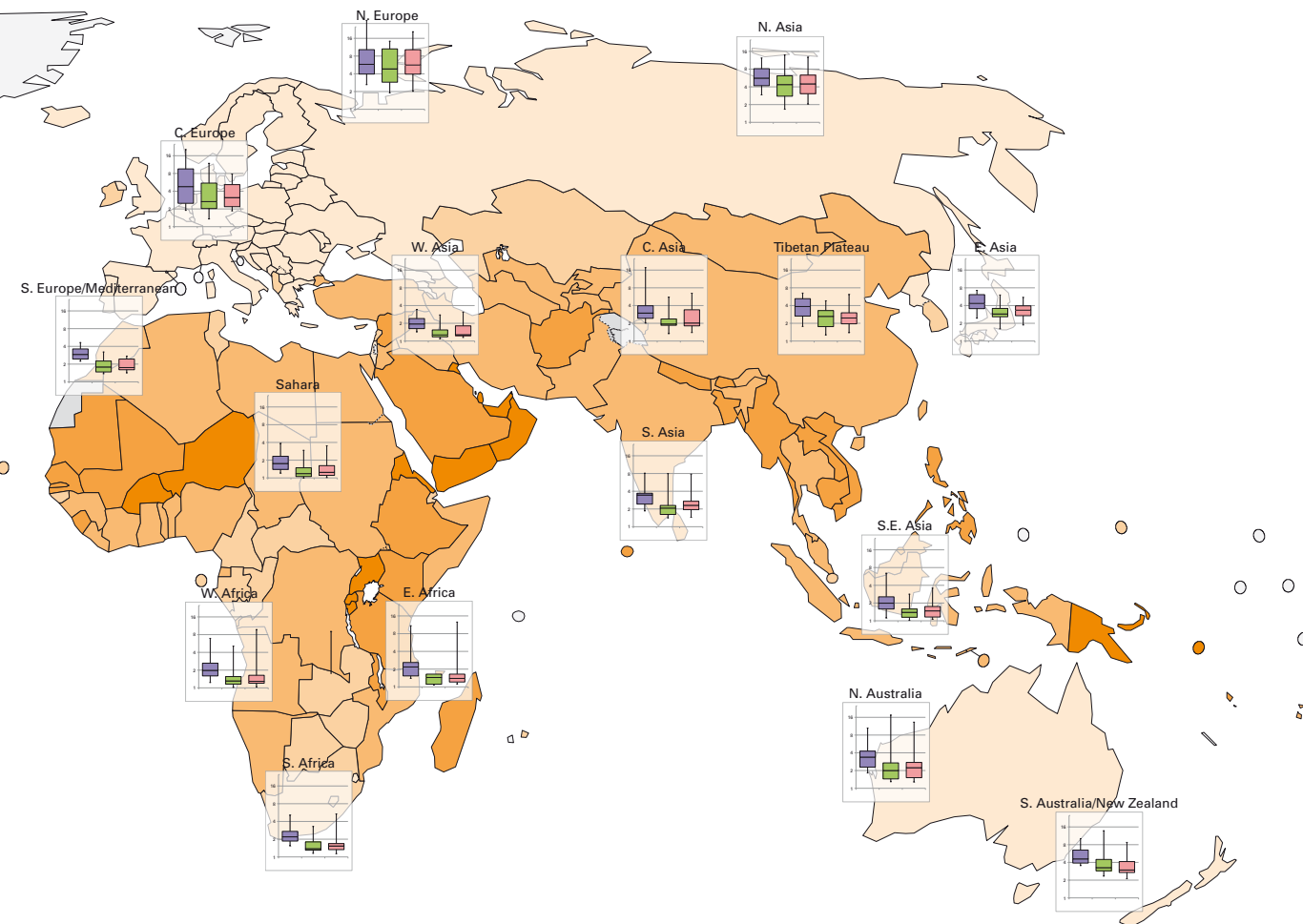
Increasingly frequent heatwaves will combine with growing vulnerable populations. Bar graphs show how frequently a heat event that would have occurred only once in 20 years in the late 20th Century, is expected to occur in the mid 21st Century, under different climate change scenarios.[6] Lower numbers indicate more frequent events. Countries are shaded according to the expected proportional increase in urban populations aged over 65[8]
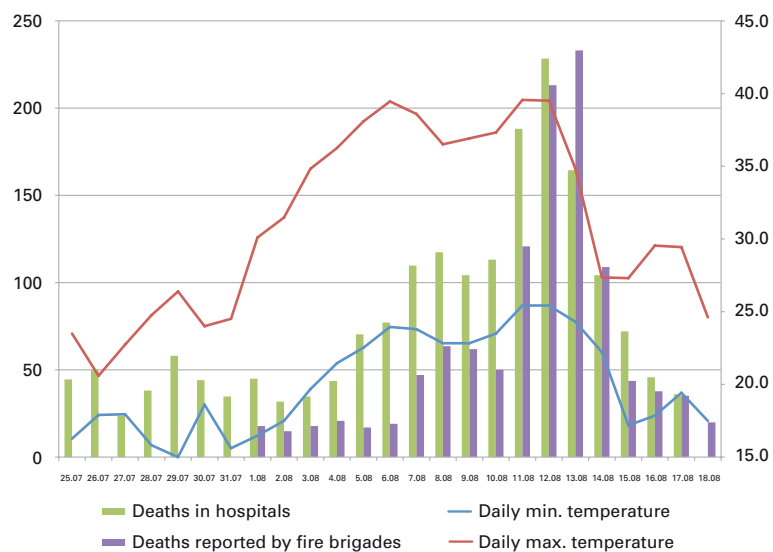

Extreme heat is lethal in developed and developing countries: Daily maximum and minimum temperatures, and number of deaths: Paris, Summer 2003[9]

PROTECTING POPULATIONS FROM HEAT STRESS

Protection from extreme heat requires a range of actions, from providing early warning, surveillance and treatment for vulnerable populations through to long-term urban planning to reduce the heat-island effect as well as initiatives to reduce greenhouse gas emissions to limit the severity of global climate change.

Collaboration between health and climate services is critical to implement all of these actions. For example, following the devastating 2003 heat wave, 17 countries across Europe established heat-health action plans. The essential components of such action plans are the identification of weather situations that adversely affect human health, the monitoring of meteorological forecasts, mechanisms to disseminate warnings, and public health activities to reduce or prevent heat related illness and death. Hence, a pre-defined meteorological forecast will trigger a series of pre-defined actions, such as the broadcasts of health warnings, targeted care for vulnerable population groups, real-time surveillance and evaluation, and the preparation of the health and social care services. Such systems provide accurate and timely alerts and are also cost-effective as European and North American experience shows. Broader use could be made of such actions in other regions of the world.[1,10]

Through observation and study of essential data recorded over years, meteorologists are also providing a clearer understanding of how the combination of energy use, changes in land use and global warming are modifying the pattern of extreme temperatures over the long-term. Meteorological data provide essential inputs to develop climate scenarios, and allow verification of how weather eventually changes over time. Such information is critical to planning local health adaptation, and monitoring the progress of global climate change.
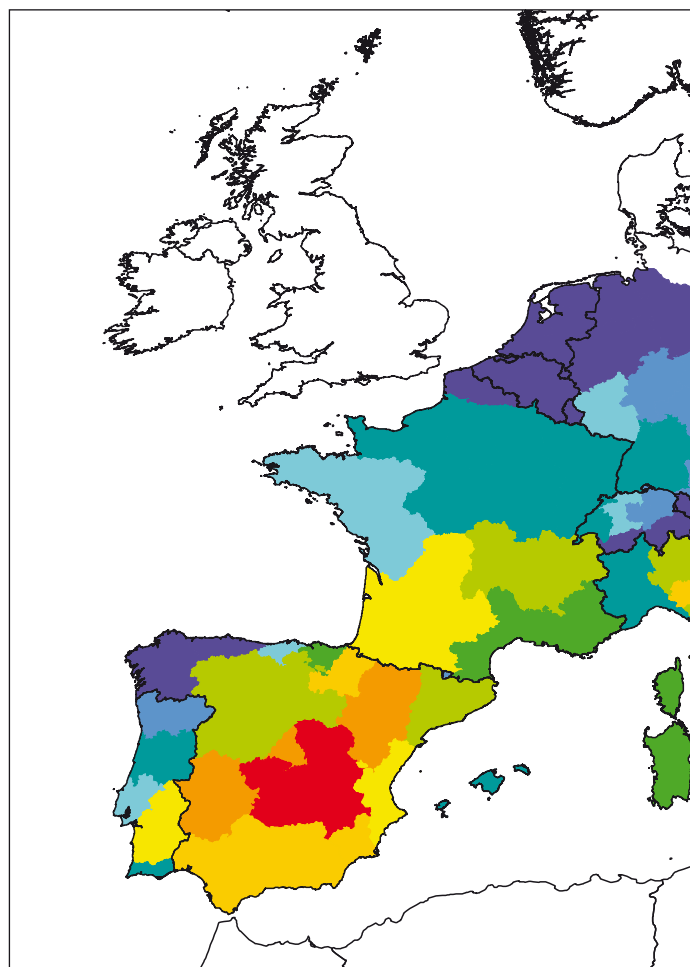
ANDREY SMIRNOV, AFP / GETTY IMAGES
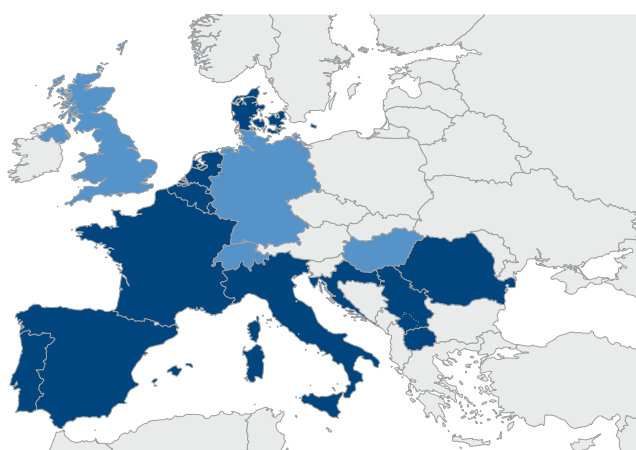
Countries with operational heat-health action plans

■ National plans
■ Sub national plans

A large number of European countries now have operational heat-heath action plans[11]

42

Heat-wave probability (%)

- 0%
- 0.01 - 9.99%
- 10.0 - 19.9%
- 20.0 - 29.9%
- 30.0 - 39.9%
- 40.0 - 49.9%
- 50.0 - 59.9%
- 60.0 - 69.9%
- 70.0 - 79.9%
- 80.0 - 89.9%
- 90.0 - 99.9%
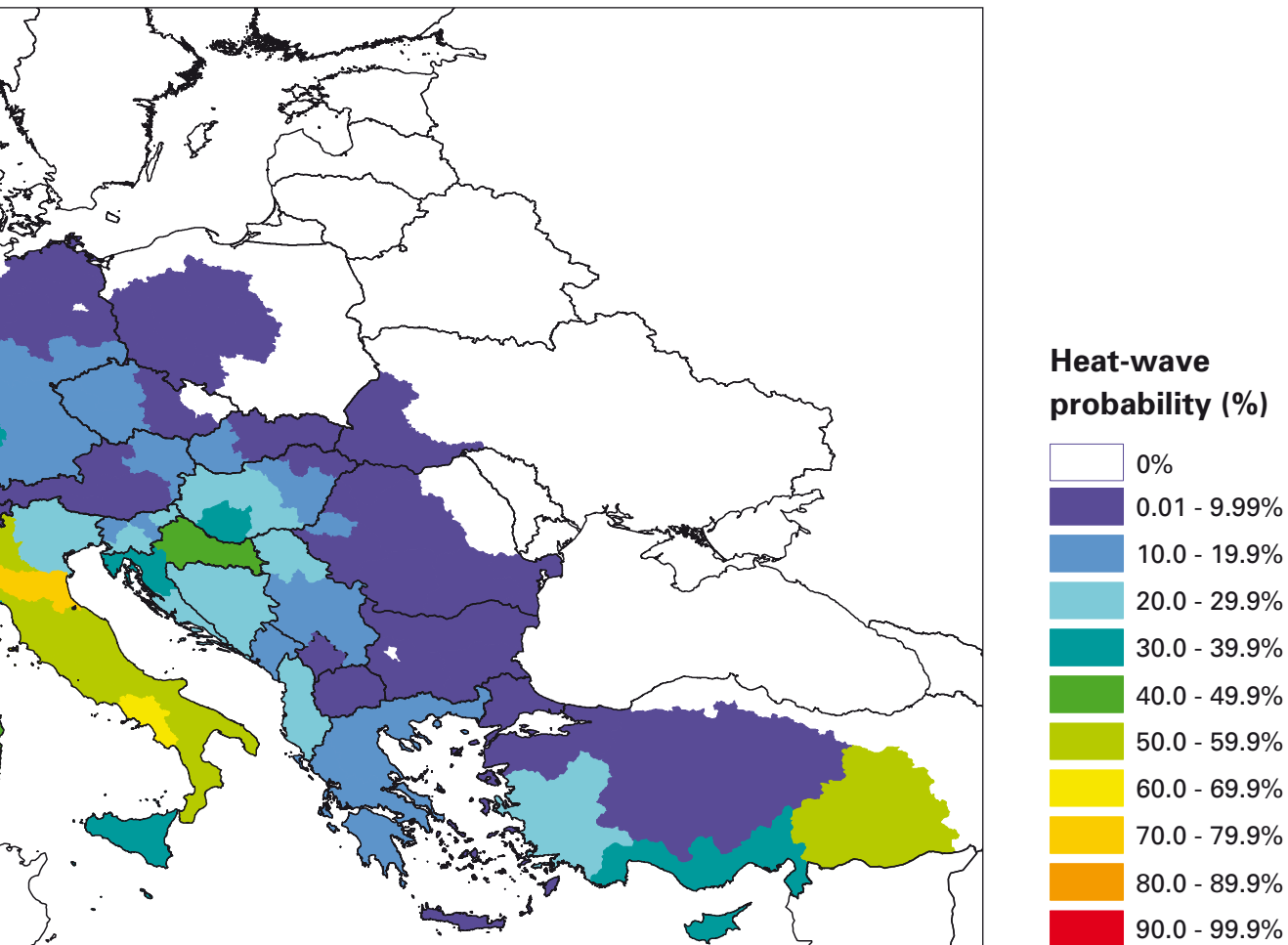
Temperature forecasts can be automatically converted into the probability of exceeding a pre-defined threshold for a heat wave[12]
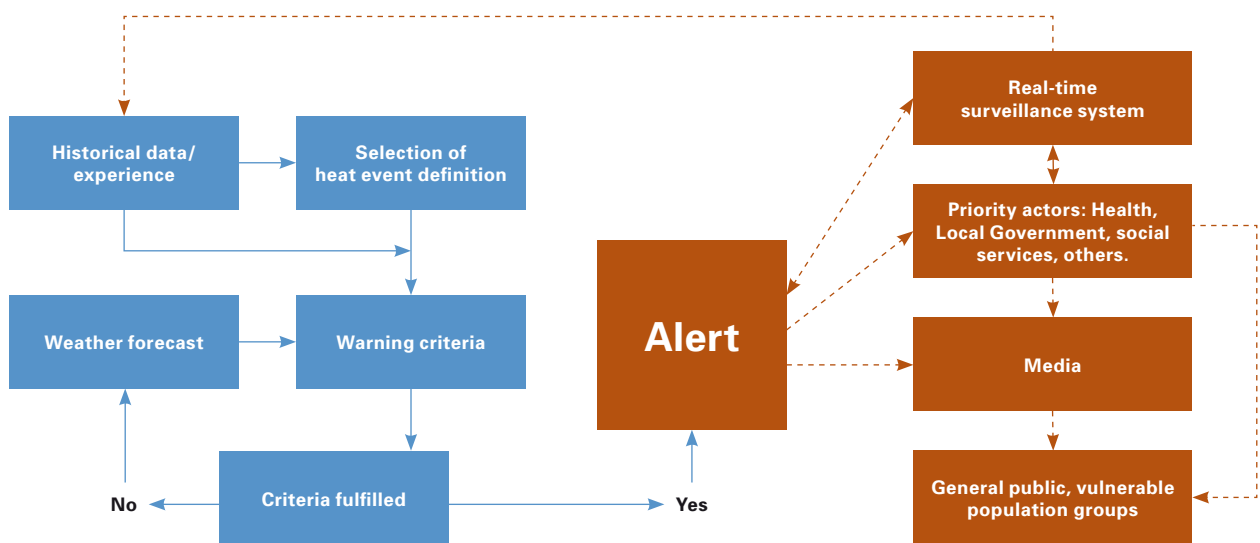
The information generated by meteorological agencies needs to be connected to preventive actions by health and other sectors to form a heat-health action plan[13]
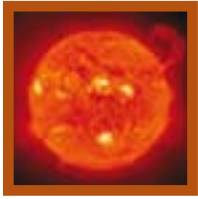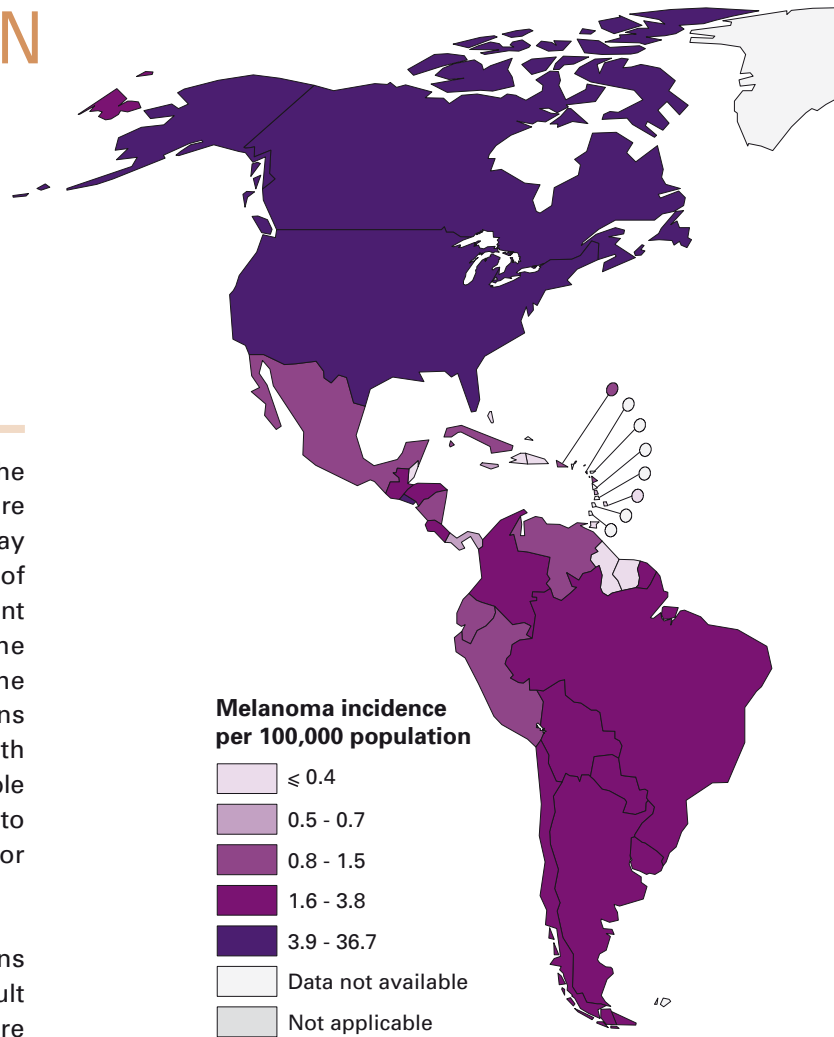
UV RADIATION

THE DANGERS OF THE SUN

While small doses of ultraviolet (UV) radiation from the sun help the body produce vitamin D, excessive exposure is damaging to human health. Excessive exposure may have consequences ranging from premature ageing of the skin to skin cancer. The number of cases of malignant melanoma has doubled every 7 to 8 years over the last 40 years – mostly due to a marked increase in the incidence of skin cancers in fair-skinned populations since the early 1970s. This is strongly associated with personal habits: the societal view is that a tan is desirable and healthy. Children are most at risk, as exposure to the sun during childhood appears to set the stage for the development of skin cancer later in life.

UV radiation can also severely damage the cornea, lens and retina of the human eye – long exposures can result in photo keratitis and a lifetime of cumulative exposure contributes to the risk of cataracts and other forms of ocular damage. In addition to the above risks, a growing body of evidence suggests that levels of UV radiation in the environment may enhance the risk of infectious diseases and limit the efficacy of vaccinations.

Aggravating the situation is the hole in the ozone layer over Antarctica, which was discovered in 1985. Chlorofluorocarbons (CFCs), and other industrial chemicals released into the atmosphere, are destroying the stratospheric ozone, which shields the Earth from harmful UV radiation. That hole has now expanded to about 25 million km^2.

Melanoma incidence per 100,000 population

- ≤ 0.4
- 0.5 - 0.7
- 0.8 - 1.5
- 1.6 - 3.8
- 3.9 - 36.7
- Data not available
- Not applicable

ANDREAS G. KARELIAS / SHUTTERSTOCK.COM
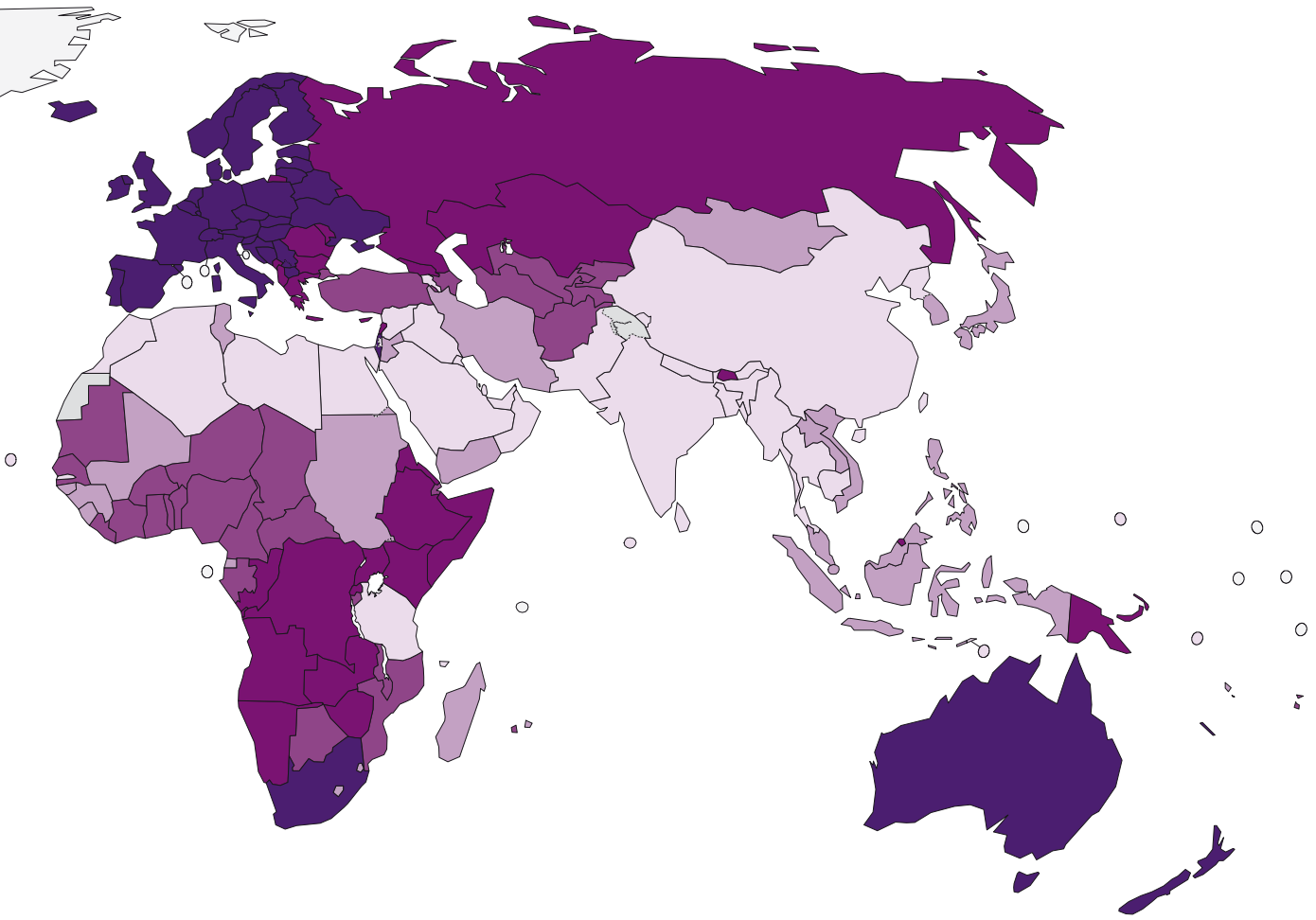
Estimated age-standardized incidence rate of melanoma, per 100,000 population[1]
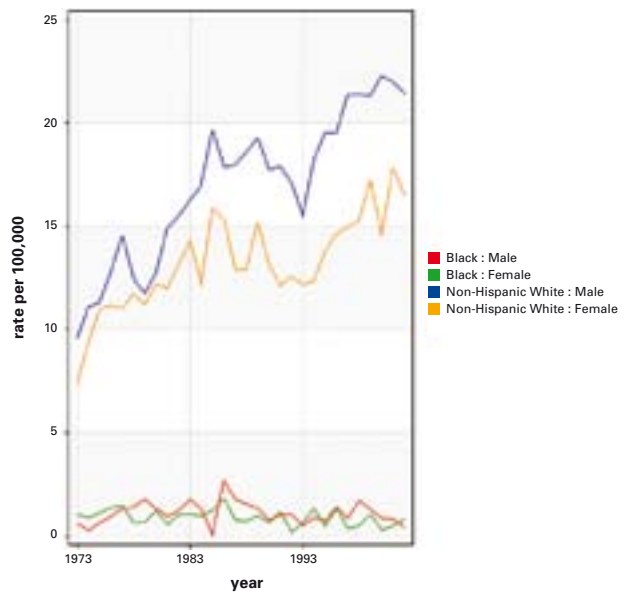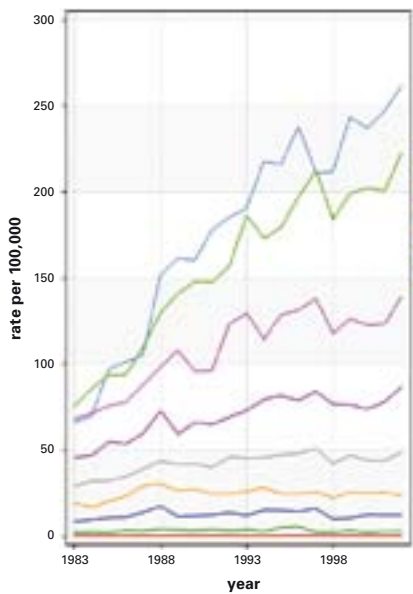
*Incidence rates of skin melanoma in Australia, for different age groups (left hand side)
and Los Angeles, USA for different skin types (right hand side)[2]*

ENJOYING THE SUN WISELY

Awareness on how to behave in the sun is important for curbing the rapid increase in skin cancer observed in many populations. The Global Solar UV Index is a daily reminder to stay alert in the sun. It is a simple measure of the solar UV radiation level received at a particular time on the Earth's surface and an indicator of the potential for skin damage. It was introduced in 1995 as a harmonized measure to monitor long-term changes in UV irradiation and UV spectrum on the Earth's surface caused, for example, by ozone depletion.

The UV Index also serves as a vehicle to raise public awareness and to alert people about the need to adopt protective measures when exposed to UV. It is reported along with the weather forecast during the summer months in many countries. Encouraging individuals to protect themselves – by seeking shade and wearing suitable clothes – remains the key to preventing the 66 000 deaths from skin cancer every year.

Environmental protection is also necessary. WMO and UNEP played a leading role in setting up the 1985 Vienna Convention for the Protection of the Ozone Layer. The Montreal Protocol, signed in 1987, controls the use of substances that could damage the ozone layer. WMO and the scientific community monitor the development of ozone worldwide by using meteorological data obtained from the ground, balloons, aircraft and satellites. With the prospect of global climate change compounding the skin cancer risk through systemic and unprecedented influences on stratospheric ozone, hopefully, the lessons learnt can help us meet even greater challenges to preserve our planet's and our health.
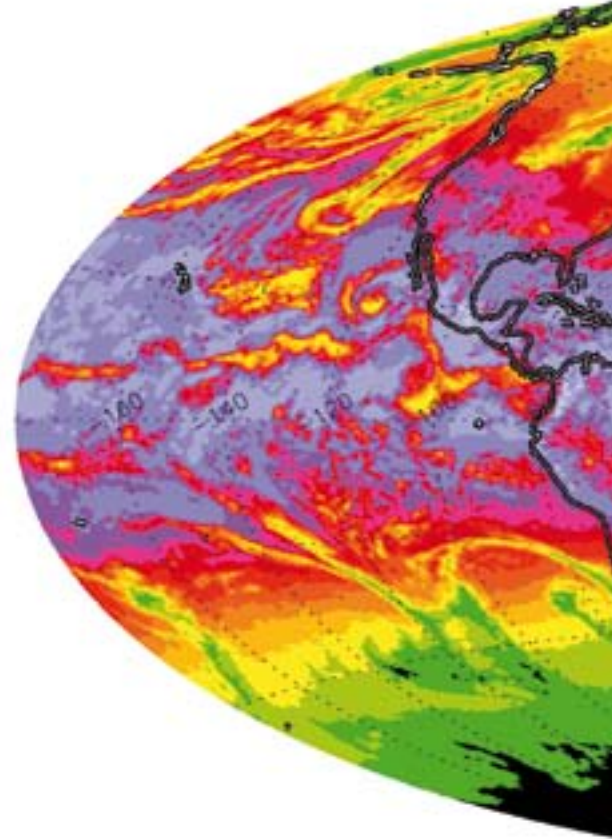
THE BASIC SUN PROTECTION MESSAGES[3]

- Limit exposure during midday hours.

- Seek shade.

- Wear protective clothing.

- Wear a broad-brimmed hat to protect the eyes, face and neck.

- Protect the eyes with wrap-around-design sunglasses or sunglasses with side panels.

- Use and reapply broad-spectrum sunscreen of sun protection factor (SPF) 15+ liberally.

- Avoid tanning beds.

- Protect babies and young children: this is particularly important.
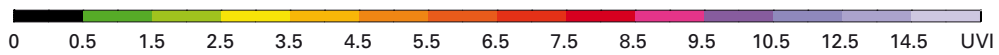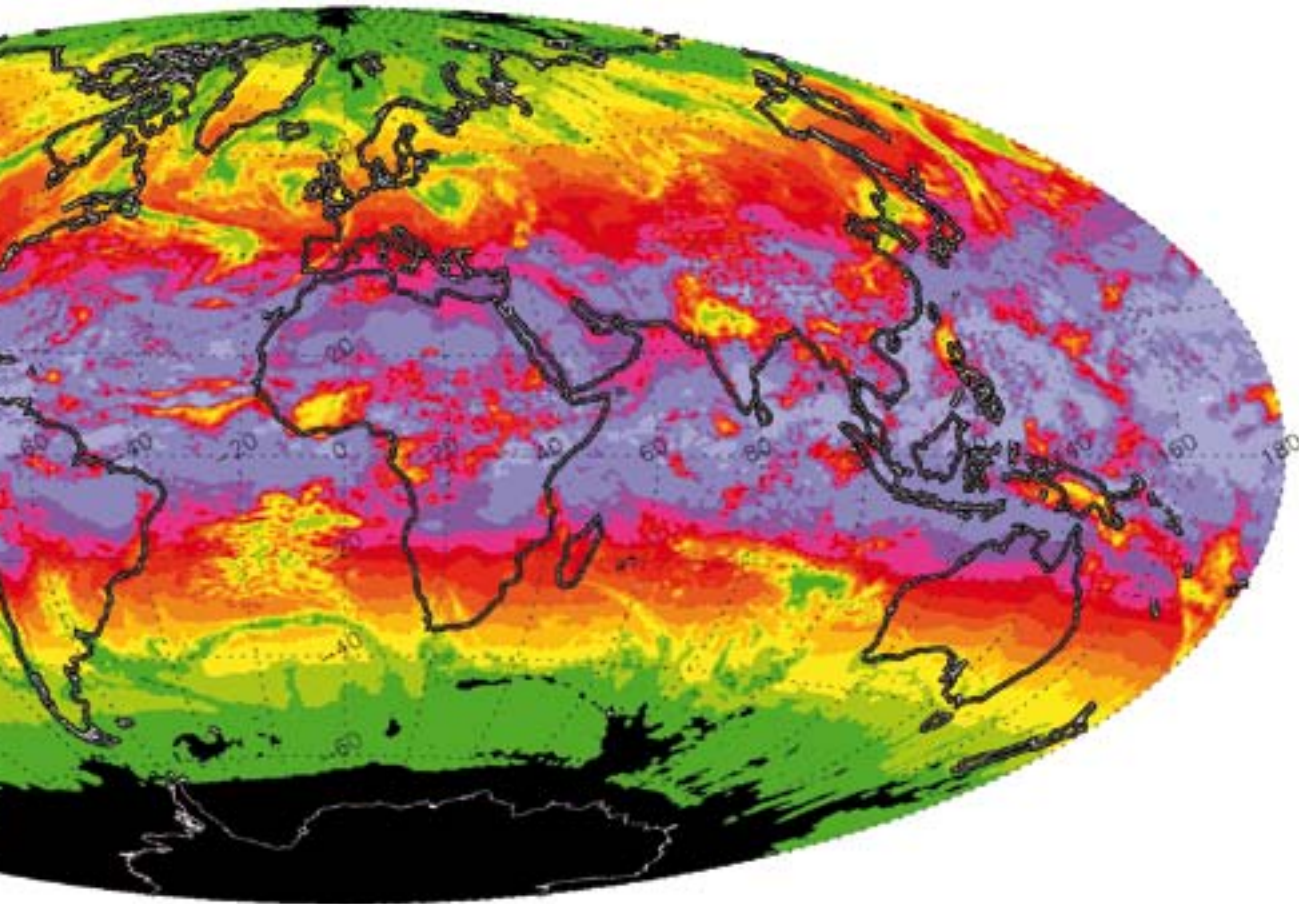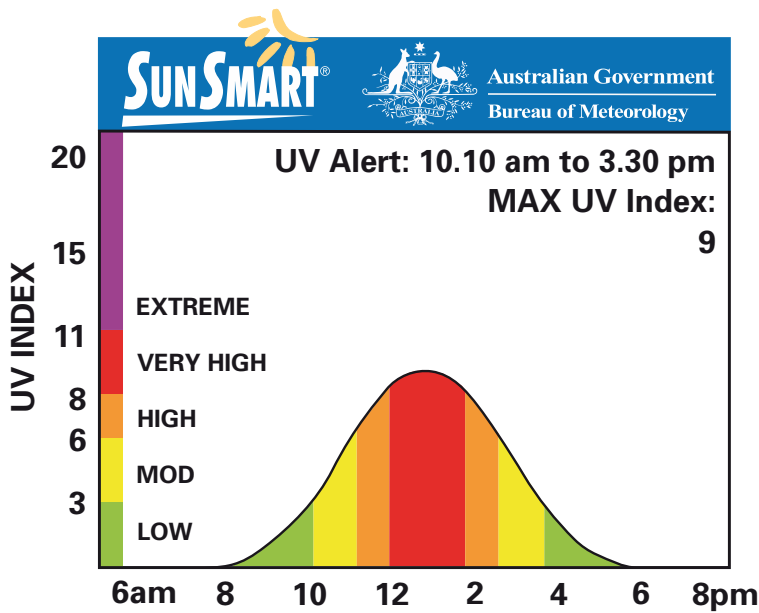
Daily maximum of UV Index cloudy, 15.08.12 00:00 UTC period= +12 h

Global UV index under cloudy conditions[4]

How to read the SUNSMART UV ALERT

Example of Global UV index incorporating information on time of day[5]

POLLENS

THE IMPACT OF NATURAL ALLERGENS

WHO estimates that around 235 million people currently suffer from asthma worldwide. It is the most prevalent chronic childhood disease. Asthma can be caused by many factors, including poor air quality and the presence of strong airborne allergens. Asthma costs Europe an estimated 17.7 billion per year, including the cost of lost productivity estimated at €10 billion per year.

The European Federation of Allergy and Airway Diseases Patients Associations estimates that 80 million (over 24 per cent) adults living in Europe suffer from various allergies, while the prevalence in children is 30 – 40 per cent and increasing. One of the most widespread types of allergies is related to the presence of allergenic pollen in air. Its seasonal outbreaks cause a quick rise of symptoms and an increase in the consumption of antihistamines.

The reasons for the increase in susceptibility to allergens, in particular to pollen allergens, remain elusive; however, environment and life-style factors appear to be the driving forces. Evidence shows that chemical air pollutants and anthropogenic aerosols can alter the impact of allergenic pollen by changing the amount and features of the allergens thereby simultaneously increasing human susceptibility to them.

Climate change is also affecting natural allergens in several ways. Over most of Europe, the growing season of many trees and grasses starts earlier and lasts longer than 10 – 20 years ago. The total amount of pollen observed in the air is also growing, probably due to the interaction between changing land use, temperature and CO_2 concentrations, although how they correlate is not yet fully understood. However, experiments in climate chambers with controlled CO_2 showed that pollen productivity of ragweed increases by 60 per cent when CO_2 concentration is doubled.

Ambrosia Pollen 2011

none
very low
low
medium
high
very high
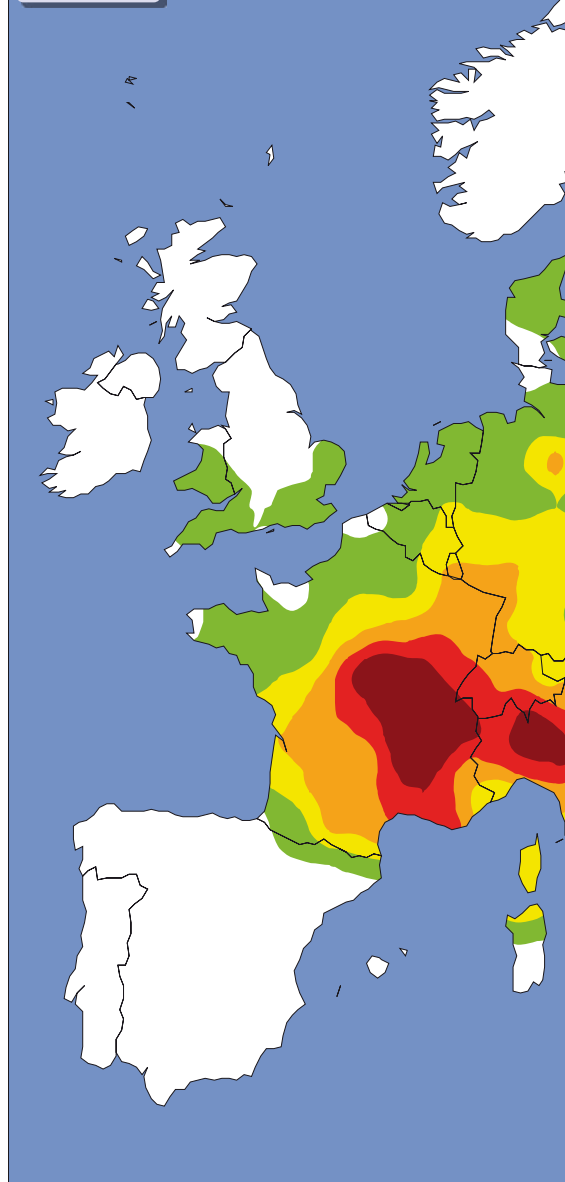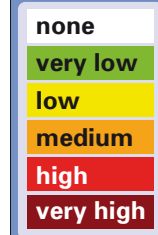
Annual observed ambrosia pollen count in 2011[1]
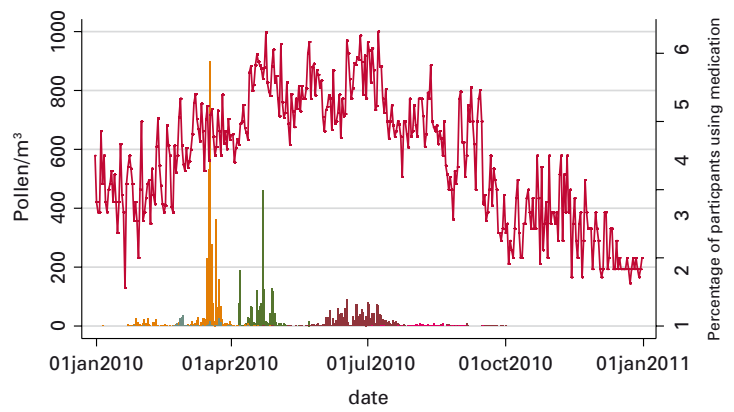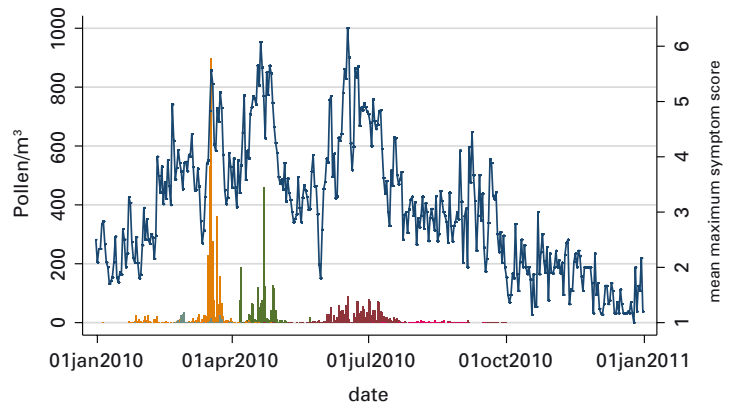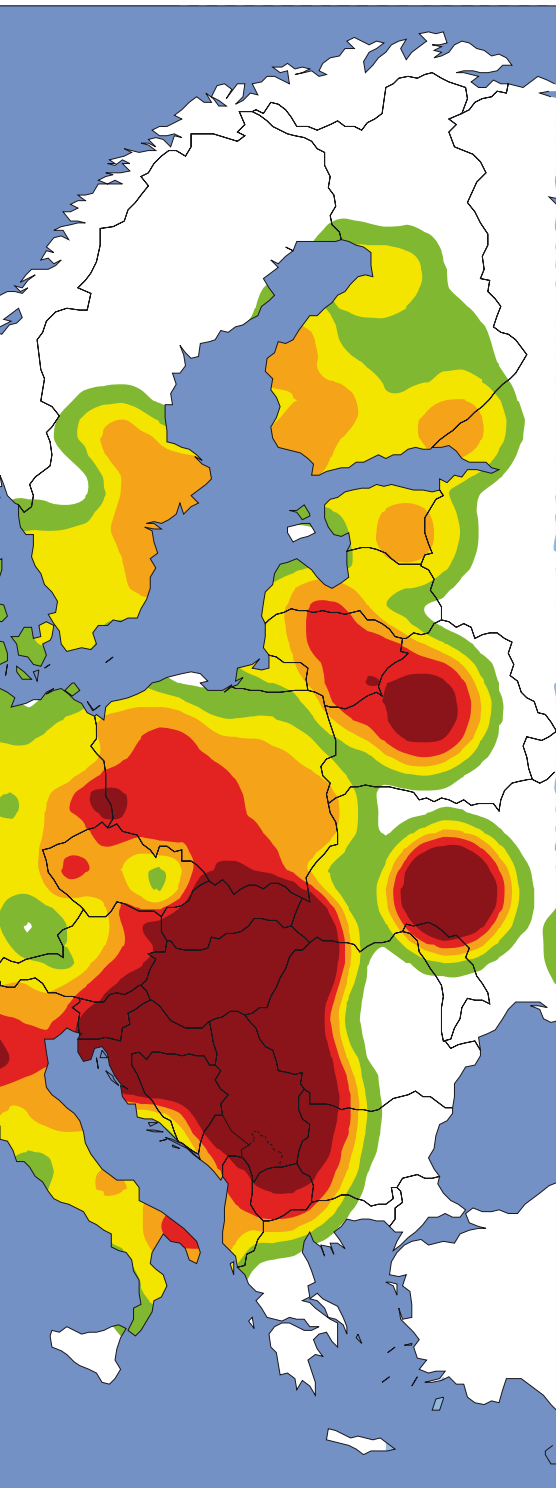
Birch   Hazel   Grass   Alder   Mugwort

Correlation between the presence of several types of pollen in the air with allergy symptom score (upper panel) and medication intensity (lower panel) in the Netherlands[2]

MITIGATING THE IMPACT OF
## NATURAL ALLERGENS

Pollen concentrations in air change strongly over time and space. A single plant usually pollinates only for a few hours or days, mainly releasing pollen during daytime, but pollen can remain suspended in air several tens of hours, causing allergy outbreaks far away from their source at any time of the day. However, pollen concentration decreases rapidly with distance from the source, so that a single tree in a garden can have stronger health impact than a large forest 10 km away.

Aerobiological networks undertake systematic observations of pollen concentrations in many parts of the world. Modern atmospheric composition models can also forecast pollen distribution. This information, if available to allergic people, would allow for short-term adjustments of their planned outdoor activities and, possibly, application of pre-emptive medication, thus reducing the health impact.

Cities where allergy prevalence has increased most, owing to chemical and aerosol air contamination and, possibly, to more aggressive pollen released by stressed plants, must pay particular attention to mitigation measures. The selection of low-allergenicity ornamental plants for streets and gardens can significantly reduce allergen exposure. The timely mowing of certain types of grass can prevent pollen release, thus almost completely eliminating the corresponding allergens from the air. These measures can significantly reduce allergy prevalence and improve the quality of life of a large fraction of the global population.
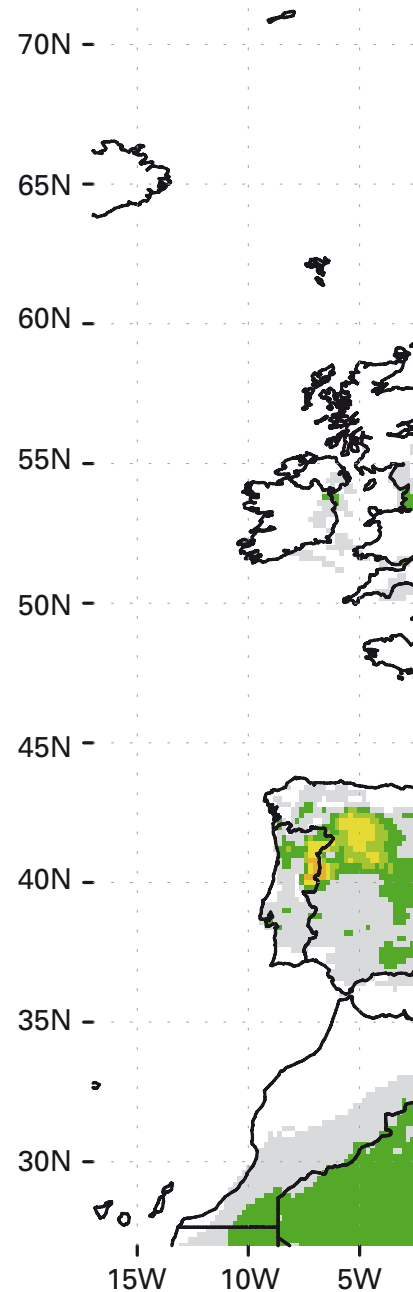
CASE STUDY: RAGWEED

More than 10 per cent of the German population suffers from pollinosis, and its prevalence is increasing. The main allergenic pollens are from hazelnut, birch, alder, grasses, rye and mugwort. The regionalized daily pollen forecast is based on the weather forecast of the Deutscher Wetterdienst (DWD, the German Weather Service), particularly on wind flow and precipitation, data from the 50 pollen-measuring stations of the Foundation Pollen Information Service and on up-to-date phenological data. Forecast texts are automatically generated.

Ragweed pollen concentration (grain / m³)
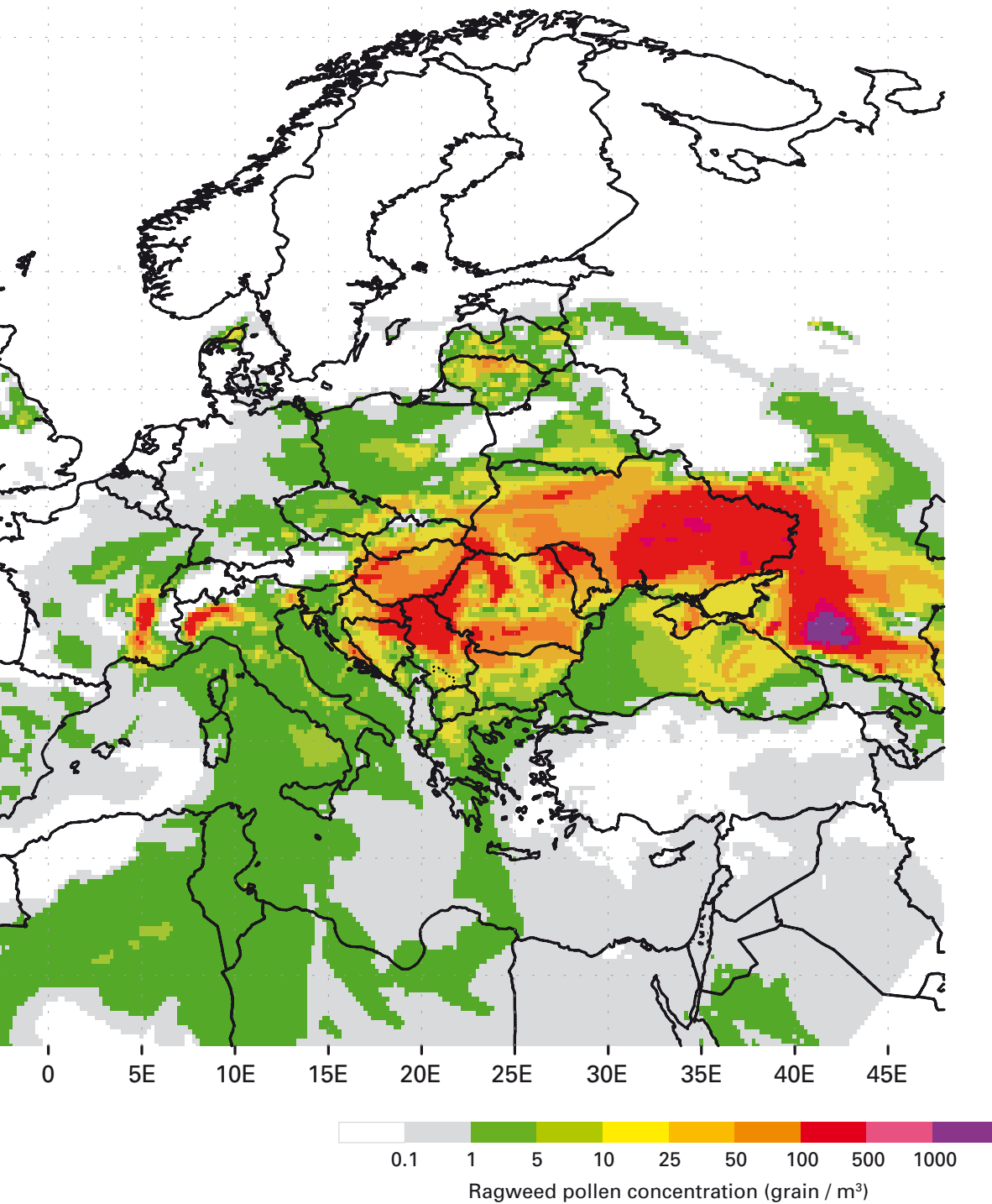
72-hours-long ragweed forecast[3]

AIR POLLUTION

AIR POLLUTION: A GROWING GLOBAL PROBLEM

Air pollution and climate change are closely linked.[1] The greenhouse gas CO_2 is the major cause of human-induced climate change, and is emitted from the use of carbon-based fuels for power generation, transport, building and industry, and from household cooking and heating. Additional climate change is caused by some of the air pollutants arising from inefficient use of these fuels. These include methane and carbon monoxide, which interact with other volatile organic pollutants in the environment to form ozone, as well as various forms of particulate matter such as black carbon. It is these non-CO_2 air pollutants that also have direct and sometimes severe consequences for health. For example, in 2008, exposure to unsafe levels of outdoor air pollution in the form of fine particulate matter (PM_{10}) accounted for 1.3 million premature deaths in urban areas.[2] This is a major concern as urban population is rising – from 50 per cent of the world's total population today, it is expected to reach 70 per cent by 2050.

Air pollution in and around the home carries an even heavier disease burden. Close to two million premature deaths annually, mostly in women and children in developing countries, are attributed to household air pollution due to the inefficient use of solid fuels for cooking.[3] Controlling air pollution through improvements in both the efficiency and renewability of energy supplies and use, as well as monitoring and modelling air quality, holds substantial benefits now and in the future for both health and climate.[4]

% of total childhood mortality

- ≤0.5
- 0.6 - 2
- 2.1 - 5
- 5.1 - 8
- 8.1 - 10
- >10
- Data not available
- Not applicable
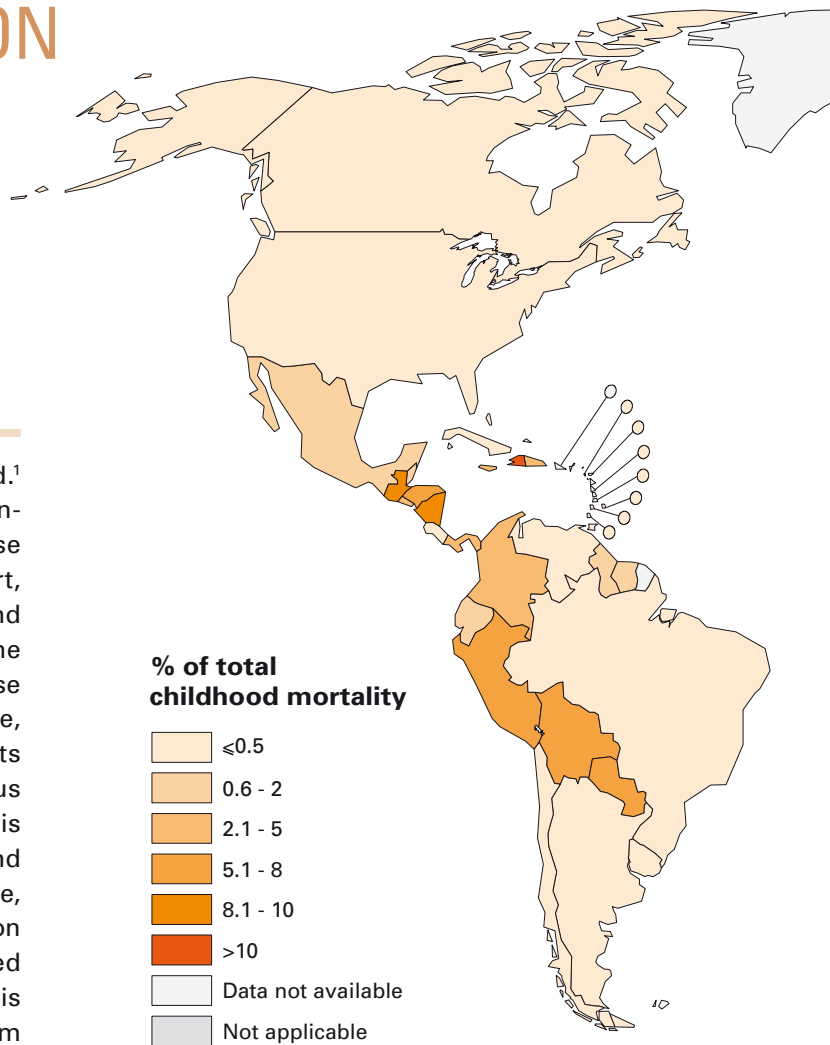
WHO
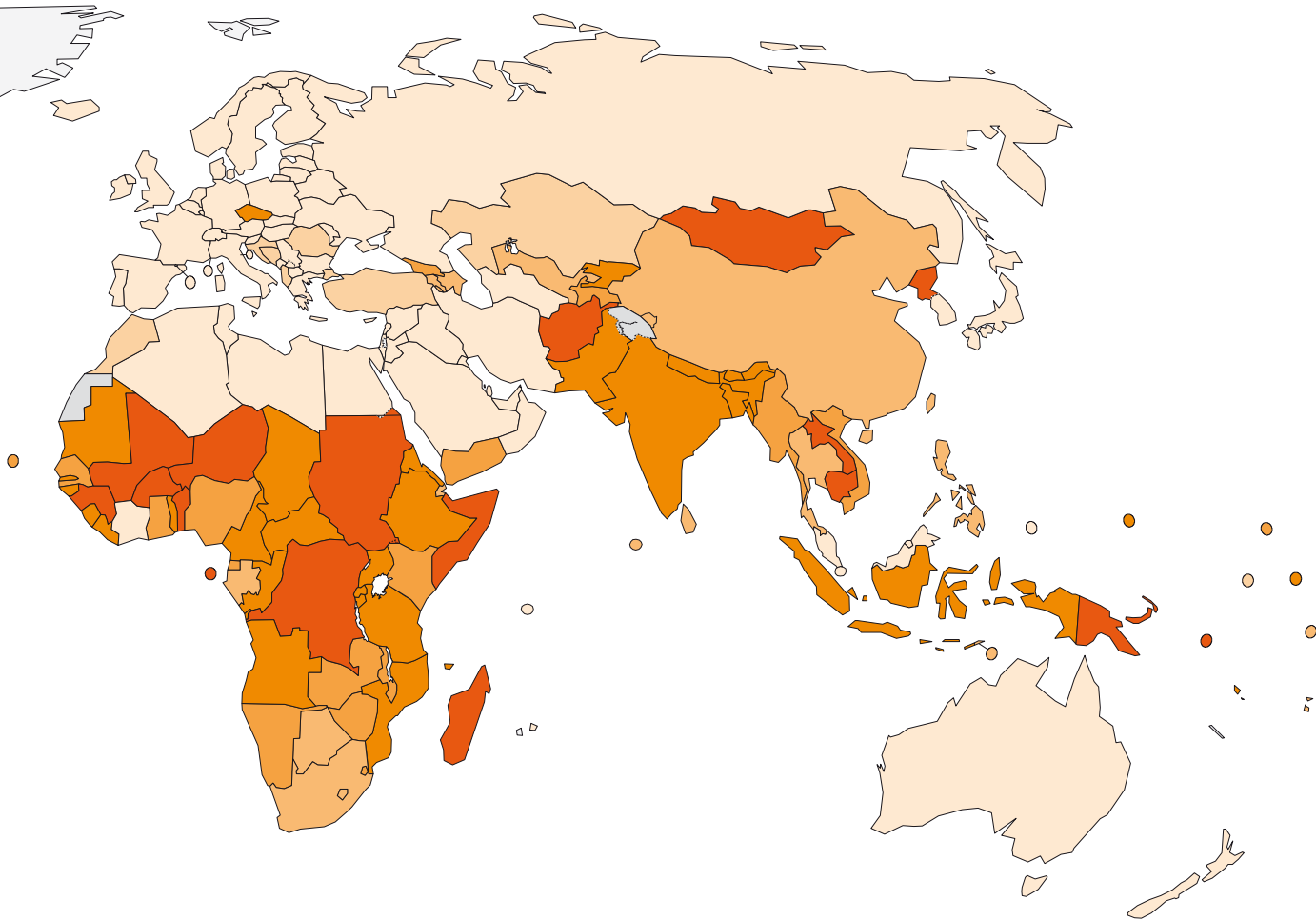
Approximately 677 000 deaths in children under five each year (over 8% of the global total) are due to pneumonia caused by household air pollution[5]


■ Africa ■ Americas ■ Eastern Mediterranean ■ Europe ■ South-East Asia ■ Western Pacific
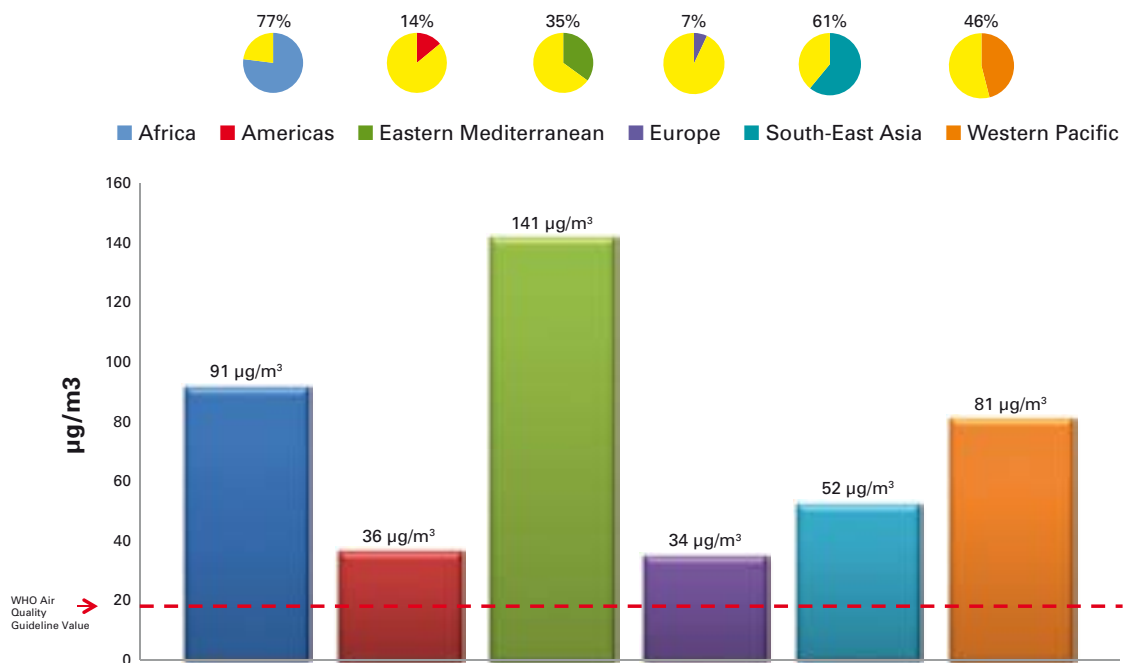
Regional means of percentage of population using solid fuels (pie charts), and annual mean urban air pollution levels (bar charts), by WHO region[6]

DEALING WITH AIR POLLUTION

Better use of available technologies, policies and measures to reduce short-lived air pollutants could generate immediate, significant benefits in human well-being, the climate system and the environment.[7] For example, switching to cleaner and more efficient energy sources can markedly reduce the level of climate-changing pollutants released from millions of households as well as improve health.[8]

Globally around 2.8 billion people[9] rely on solid fuels for cooking, often using rudimentary stoves or open fires that generate high levels of short-lived pollutants that are harmful to the environment and health.[10] The risks of respiratory and cardiovascular diseases, cataract formation and various cancers are in particular increased. Replacing rudimentary stoves globally with cleaner technologies such as advanced combustion stoves could avert over 8 per cent of all childhood mortality annually.[11]

WHO tracks the use of polluting fuels and technologies, and their health impacts, and monitors the health benefits from shifts to less polluting alternatives. Together with WHO's Air Quality Guidelines,[12] these resources support policies and interventions for improving air quality and health. The WMO – through its Members – gathers, disseminates and assesses information on the chemical composition of the atmosphere and its relation to climate change and to air pollution.[13] Capacity development for air quality modelling and forecasting services provides authorities with information to take appropriate actions to avert health risks.[14] The evidence-based knowledge provided by WHO and WMO is used for the design and implementation of effective policies and interventions.
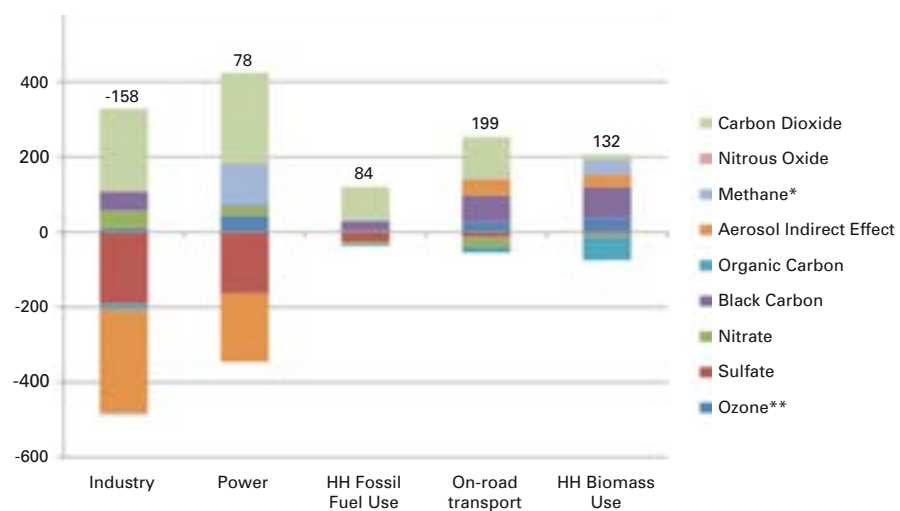

WHO

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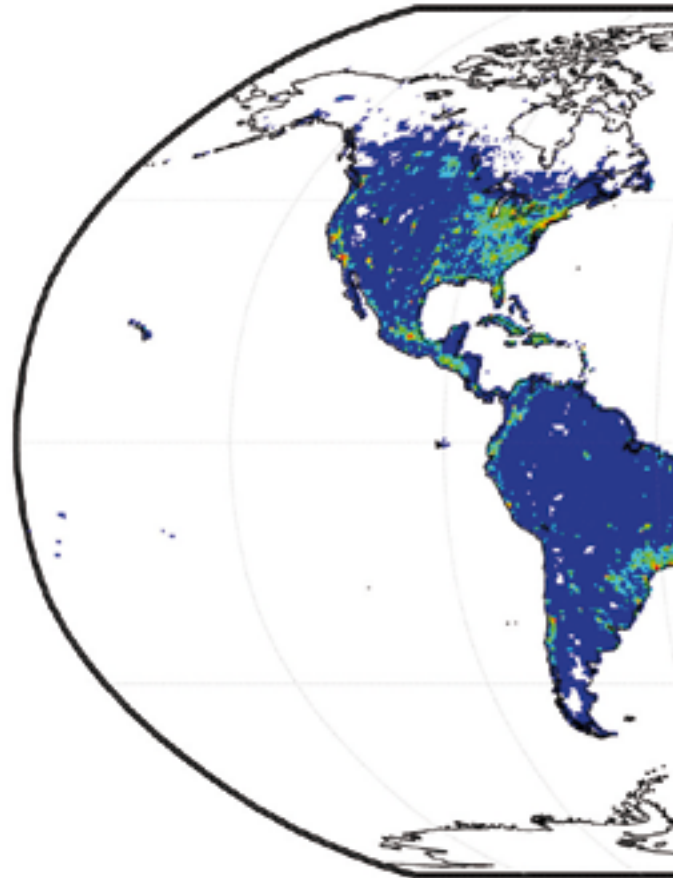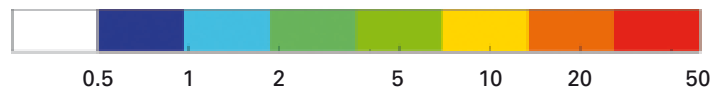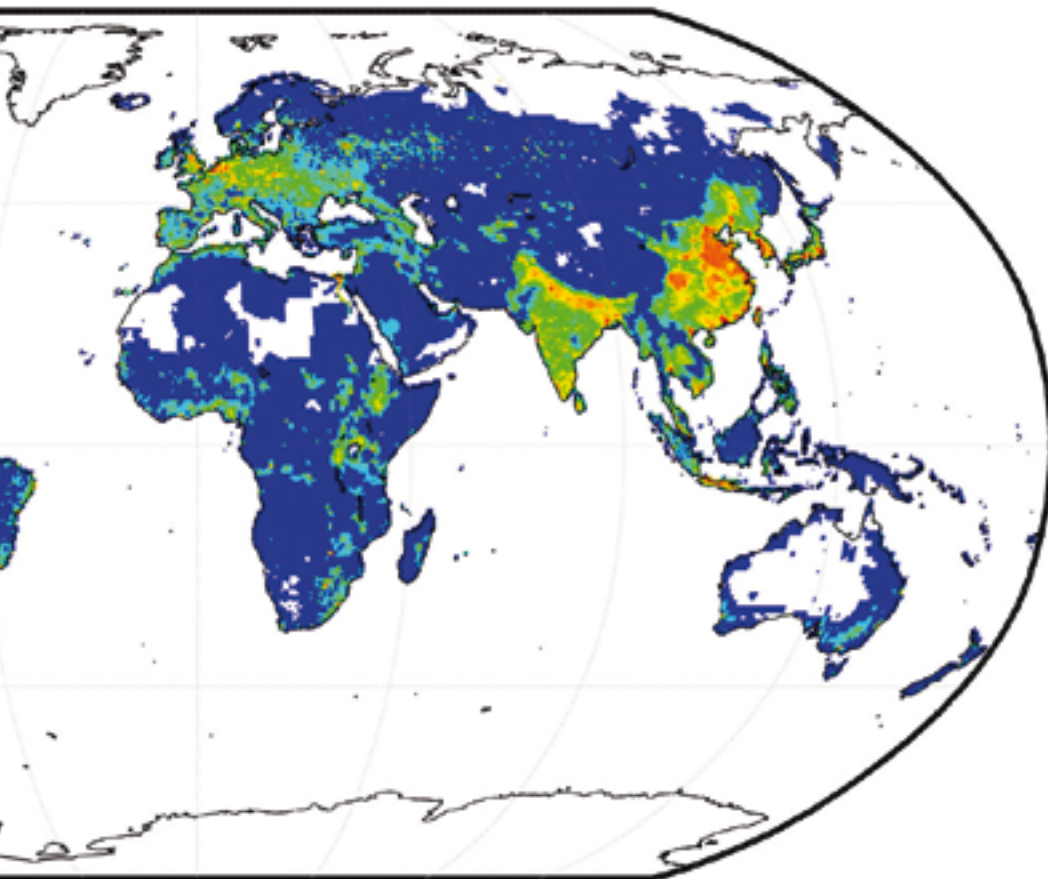
Global Black Carbon Emissions from combustion, in Gigagrams (Gg). This includes emissions from fossil fuels and biofuels such as household biomass (i.e. wood, charcoal, dung, crop waste) used for cooking[15]

Expected contributions of different sectors to Radiative Forcing (warming effect) by 2020. Interventions to reduce black carbon in transport and household (HH) energy sectors also have substantial potential for climate change mitigation[16]

ACKNOWLEDGEMENTS

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2. Methods described in Gething, P.W. and others 2011. *Modelling the global constraints of temperature on transmission of* Plasmodium falciparum *and* P. vivax. Parasites & vectors; 4: 92. Data source: Peter Gething, Oxford University. Map production: WHO-WMO. Copyright: WHO-WMO.

3. World Health Organization, 2012. *Global Health Observatory*. Available from: http://www.who.int/ gho/child_health/mortality/causes/en/index.html/. Comparison between the two maps provides insight into the extent of control success over the past century. Data source: WHO. Map production: WHO-WMO. Copyright: WHO-WMO.

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5. Thomson, M.C. and others, 2006. *Malaria early warnings based on seasonal climate forecasts from multi-model ensembles*. Nature; 439(7076): 576-9.

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7. DaSilva, J. and others, 2004. *Improving epidemic malaria planning, preparedness and response in Southern Africa*. Malaria Journal; 3(1): 37.

8. Ghebreyesus, T.A. and others, 2008. *Public health and weather services-Climate information for the health sector*. WMO Bulletin 57(4): 257.

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10. Continental Map of Climate Suitability for Malaria Transmission in Africa shows the number of months where the combination of temperature, rainfall and humidity are considered sufficient to support malaria transmission. http://iridl.ldeo.columbia.edu/map- room/.Health/.Regional/.Africa/.Malaria/.CSMT. Data source: Steven Connor, University of Columbia. Map production: WHO-WMO. Copyright: WHO-WMO.

Diarrhoea

1. JMP biennial report (www.wssinfo.org): *Progress on Drinking water and Sanitation, 2012 update,* UNICEF and WHO, New York and Geneva 2012.

2. Data sources: WHO and NOAA as follows:

    a. Access to water and sanitation: average of the percentages for improved water and improved sanita- tion as published by WHO/UNICEF Joint Monitoring Programme for Water supply and Sanitation. For definition of improved water and sanitation and data see: *Progress on Drinking water and Sanitation, 2012 update*, UNICEF and WHO, New York and Geneva 2012.

    b. Cholera cases (in logarithmic scale): as reported by WHO member states, extracted from WHO Global Health Observatory (June 2012): http://www.who. int/gho/en/, Countries showing no cholera case incidence are not necessarily not having cholera but not reported by the countries.

    c. Precipitation anomaly: these calculated by sub- tracting annual means and dividing by standard deviation. For example a value for Jan 2010 is cal- culated by subtracting 60-year mean and standard deviation of the month. Data source NOAA precl 2.5 x2.5, Time period 1950-2010.

    Map production and copyright: WHO-WMO

3. Onda et al, 2012 http://www.mdpi.com/1660-4601/9/3/880/pdf

4. This work is possible with generous support from US National Oceanic and Atmospheric Administration to WHO project GIMS.

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1. Colombini, A. and others, 2009. *Costs for households and community perception of meningitis epidemics in Burkina Faso*. Clinical Infectious Diseases; 49(10):1520-5.

2. Epidemiological data: WHO African Sub-Regional Office, Intercountry Support Team West Africa, Ouagadougou Burkina Faso. Climate data: Geoff Love, World Meteorological Organization.

3. Data source: Earth Sciences Department, Barcelona Supercomputing Center-Centro Nacional de Super-computación (BSC-CNS), Spain. Map production and copyright: WHO-WMO.

4. Source, map production and copyright: WHO-WMO.

5. Source: WHO African Sub-Regional Office, Inter-country Support Team West Africa, Ouagadougou Burkina Faso.

6. The development of the meningitis A conjugate vaccine was achieved through a successful partnership lead by the "Meningitis vaccine Project" (http://www.meningvax.org/).

7. Source: Adapted from Yaka, P. and others, 2008. For further information please see *Relationships between climate and year-to-year variability in meningitis outbreaks: a case study in Burkina Faso and Niger*. International Journal of Health Geography; 7:34.

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16. The combined global warming effect of long-lived and short-lived pollutants can be described in terms of "radiative forcing". A net positive RF indicates a net 'warming' effect and a net negative RF indicates a net 'cooling' effect. The RF values for methane include both direct and indirect chemical effects of short-lived species, and the RF values for ozone include both primary & secondary ozone. Data adapted from Unger, N. and others, 2010. *Attribution of climate forcing to economic sectors*. Proceedings of the National Academy of Sciences of the United States of America, 107(8):3382-7.

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