Sub-chapter 2.5.1

Climate change and infectious diseases in the Mediterranean region

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Concerning communicable diseases, it should be noted that, to date, the area surrounding the Mediterranean Sea has received little attention, and available datasets and results on the impacts of climate change on infectious diseases are few and far between (Navarra and Tubiana 2013). The effects of climate change on the spread and on the intensity of infectious diseases have been studied only in the countries along the north-western and western coasts of the Mediterranean Sea, whereas evidence is drastically lacking in the countries on the eastern and southern shores. These regions already face numerous humanitarian crises, from conflicts to natural hazards, and recent geopolitical changes, and climate change is likely to exacerbate the impacts on health. The Mediterranean climate and the proximity to the sea makes it attractive to people, which is resulting in a high rate of conversion of ecosystems for agricultural and other human uses with a parallel reduction in coastal wetlands and forests. As a result, the main constraint faced by the Mediterranean is linked to high population density and population growth, and the expansion of urban areas into peri-urban and rural landscapes. In addition, the risks for public health represented by emerging infections in the region due to the possible expansion of the range of some tropical vectors are an important source of concern widely reported in the media.

The Mediterranean region is known to be vulnerable to climate change, and a significant increase in mean temperature has been measured in the basin in recent decades. Extreme weather events have become more common with an increase in the frequency and severity of heavy storms like the "Cévennes episodes" in southern France or of heat waves on the western and southern ridges, parallel with a reduction in rainfall amounts. The projected decrease in precipitation in North Africa is also a major health concern because 22% of the world's water-poor population are concentrated in the Mediterranean region (Giorgi and Lionello, 2008). As a consequence of these ongoing changes, infectious diseases, being contagious or indirectly transmitted via a vector or a reservoir host or both, are expected to be affected. For some infections such as Chikungunya and West Nile viruses, climate change is still debated as the main driver of the increased risk of local transmission in the area, and for others, like many water- and food-borne diseases, the risk of spreading in the near future is real. Overall, adaptation to and preparation for changing patterns of infectious disease distribution in the Mediterranean basin is essential in the context of climate change.

Here, our aim is to identify the possible impacts of climate change on the emergence and spread of human infectious diseases in the Mediterranean basin, based on a review of the scientific literature. We limited our selection to evidence-based studies because, in most of the scientific literature, notably on vector-borne diseases, there still is remarkable confusion between climate-sensitive infections and diseases that are impacted by climate change (Guégan and Simard, 2015). We have different recommendations for individual Mediterranean countries and regional institutions, depending on their national or regional needs and vulnerability.

Extreme events do matter in the emergence of infectious diseases in the Mediterranean region

Vibrio parahaemolyticus, *V. vulnifucus* and environmentally-persistent *V. cholera*e are halophilic bacteria that live in marine, lagoon and estuarine environments. These bacteria are recognized throughout the world as agents of gastroenteritis in human resulting from consumption of raw or undercooked seafood and serious infections caused by exposure of skin wounds to seawater (Esteves et al. 2015). Even if the pathogenic form of *V. cholerae* causing cholera appears to be absent from the Mediterranean Sea, there is a risk that pathogenic strains might be introduced. There is some scientific evidence showing that sea surface temperature is a major factor explaining the population dynamics of vibrios in coastal marine ecosystems, and that long-term effects of ocean warming should increase the dominance of these vibrios within the plankton-associated bacterial community (Vezzulli et al. 2012). However, a study conducted in French Mediterranean coastal lagoons in 2011 and 2012 showed that the highest concentrations in vibrios were in the Palavasian coastal lagoons, with an abrupt decrease in salinity caused by heavy rainfall and major flooding in the fall. These results clearly showed that flood events can have a major effect on the abundance of these environmentally-persistent bacteria in the lagoons of southern France. It is thus clear that harvesting shellfish from lagoons where the environmental conditions have changed significantly after flooding may represent a significant risk to public health in other sub-regions of the Mediterranean basin.

In September-November 2014, the French Health authorities reported a cluster of 11 autochthonous cases of Chikungunya disease in the city of Montpellier in the vicinity of a recently imported case. It has been demonstrated that the density of the female disease vector *Aedes albopictus* increased rapidly after the extreme "Cévennes episode", soon followed by an increase in the number of eggs collected in ovitraps (Figure 1). Observations suggest that the heavy rains after a period with little rainfall filled all the peridomestic containers where dessicated eggs of this mosquito were to be found, and that it was this situation that led to the increase in the number of mosquitos several weeks later (Roiz et al. 2015) (Figure 1). Before floods, accumulated temperatures are a good predictor of *Ae. albopictus* seasonal dynamics, but after accumulated rainfall over the four weeks prior to capture predicts the seasonal dynamics of this vector and extension of the transmission period of Chikungunya in Montpellier. This work presents the first evidence in support of a relationship between heavy rainfall and Chikungunya emergence in the Mediterranean region, and it goes against the common belief that heavy rainfall has a flushing effect on breeding sites, which in turn, negatively affects vector populations.

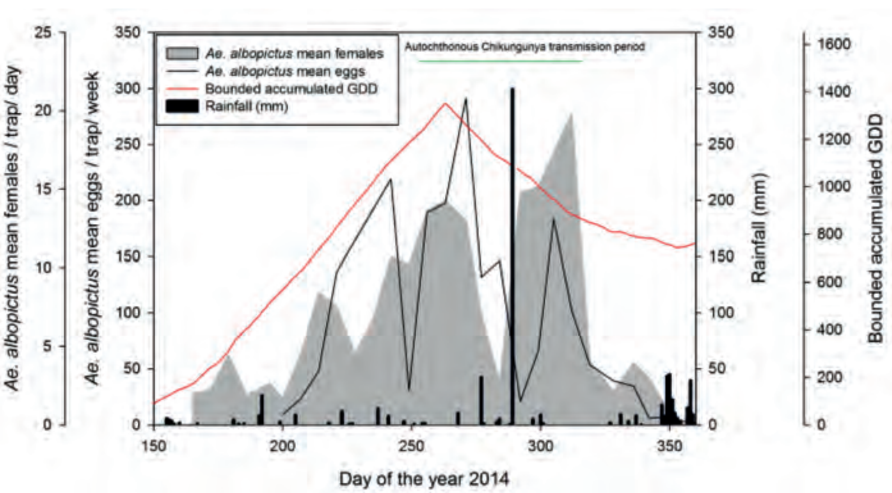

Figure 1
Number of female Aedes albopictus *tiger mosquitoes per trap per day (grey area) in different locations in Montpellier in 2014. Potential autochthonous Chikungunya transmission period (green line at the top of the figure). A massive rainfall event before day 300 was followed by a sharp increase in the number of female mosquitoes.*
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Taken together, these two illustrations clearly show that for water-borne and vector-borne infectious diseases, it is crucial to take extreme events into account in research on climate change and health. This is obviously the case for environmentally-persistent aquatic bacteria, but the same could be true for aquatic viruses that cause enteritis in human (and mass mortality in seafood mollusks; heavy rainfall can modify environmental conditions by decreasing water salinity, thus supporting the population dynamics of vibrios. Concerning vector-borne diseases, these extreme events may extend the period of infection transmission to human. These changes may increase the impact of many water-borne diseases like enteric fever, and vector-borne diseases like the West Nile virus, which are already problematic in the Mediterranean region (Vittecoq et al. 2013). Although very few cases of cholera have been reported in the Mediterranean basin in recent years (WHO 2016), *V. cholerae* was recently isolated from freshwater, water in coastal areas, and from seafood in European and North African countries (Eddabra et al. 2011; Senderovitch et al. 2010; Vezzulli et al. 2010). Recent geopolitical changes together with an increasing number of refugees fleeing ongoing conflicts in North Africa and the Middle East might generate favorable conditions for new cholera outbreaks, which often occur in overcrowded settlements. In this section, we do not review the impact of flushing caused by heavy rains, which may transport waste to the nearest stream, which, in turn, flows into larger rivers or into coastal lagoons and ends up in human populations. Human and animal waste contain bacteria, viruses and fungi that can be harmful to human, and their concentration may increase in the near future due to extreme flooding events interacting with failing sewage infrastructure.

Long term warming and infectious diseases in the Mediterranean region

Climate-sensitive diseases does not mean climate-change sensitive

As mentioned above, abiotic and biotic conditions in the environment determine the distribution of vector- and reservoir-borne diseases in that they influence the vector (or reservoir)-host-pathogen transmission cycle, including vector or reservoir distribution, abundance and diversity. Vector or reservoir host spatial distribution is constrained by the distribution of appropriate habitats, for instance, aquatic environments that support the development of larvae, and by the factors that determine adult mosquito habitats. However, not only the distribution of water for mosquito or rodent habitats needs to be taken into consideration but many other environmental parameters, for instance the vegetation type and cover. It is also important to take meteorological conditions into account in vector- and reservoir borne infections, and many studies have shown that the distributions of mosquito or rodent species are determined by winter and summer temperatures, precipitation patterns and most important, photoperiod (Guernier et al. 2004). Apart from mean temperature or precipitation values, minimum threshold values are also important as limiting factors for the development of the disease life cycle. Of course, other ecological and human factors may also influence the distribution of vector and reservoir populations, such as land use/land cover, urbanization or human population density. Climate influences different aspects of the vector (or reservoir)-host-pathogen system, and the potential impact of global warming on these diseases is still the subject of controversy (Guégan and Simard, 2015). In general, researchers consider that the effects of climate change, say an increase in mean temperature, will linearly affect mosquito distribution, abundance and longevity, pathogen incubation period and replication, and their interactions. Previous studies indeed concluded that high temperature and rainfall are positively associated with mosquito abundance, and hence with disease outbreak and spread, which is a simplistic view of disease transmission.

A recent survey conducted in the Doñana National and Odiel Natural Parks in south-west Spain by Roiz et al. (2014), based on data collected over a period of 10 years (2003-2012) consisting in bi-weekly surveys of seven mosquito species known to transmit West Nile virus, Usutu virus, dirofilariasis and *Plasmodium* protozoans, showed that the effects of climate and climate variability are species-specific, site-specific, time-dependent and are by essence non-linear in their reaction. Weekly temperatures are related to seasonal abundance patterns in the two mosquitoes *Culex pipiens* (a vector for West Nile and Rift Valley viruses) and *Ochlerotatus caspius* (a vector for West Nile and Tahyna viruses, and tularemia) while accumulated (1-4 weeks before) temperatures were shown to be positively correlated with *Cx. modestus* (a vector for West Nile and Tahyna viruses, and tularemia) and *Cx. perexiguus* (a vector for West Nile virus) abundances. On the contrary, accumulated temperatures were negatively correlated with *Cx. pipiens* and *O. detritus* abundances. These results clearly show that climate change will not necessarily lead to an increase in mosquito populations, and that over-simplified statements assuming that higher temperatures (or rainfall) lead to more mosquitoes, and hence increase the risk of epidemics, are not appropriate and overestimate the effect of climate change on real disease risks in the Mediterranean region (Guégan and Simard, 2015). Interestingly, this study showed that it is essential to carry out a careful analysis of temporal patterns of vector species in field data in order to analyze short, medium and long temporal trends and then distinguish the role played by climate variability and change from other important parameters in disease transmission. In any case, it is not possible to extrapolate from conclusions regarding climate change and mosquito abundances to the risk of disease outbreaks in the Mediterranean basin and elsewhere (Guégan and Simard, 2015). Recent modeling advances used to analyze the spread of mosquito species have shown for the tiger mosquito *Ae. albopictus* in southern France that human activities, notably transportation, are especially important for mosquito dispersion while land use appears to be a major factor influencing mosquito establishment, not climate change *per se* (Roche et al. 2015a). Monitoring and modeling both extreme events and long-term climate drivers of infectious disease outbreak and spread can help to anticipate, or even forecast, an upsurge of infections in the Mediterranean.

Some infectious disease study-cases in the region

The Mediterranean region has undergone several social, economic, political and environmental changes in recent decades. Wars have occurred in the Middle East and several countries in North Africa have experienced social and political instability and coups d'état. Many surrounding countries in both regions have also experienced wars, social instability, human migration, refugees, poor sanitation, and a low level of hygiene, with a high risk of consuming contaminated food or drinking water (Habib et al. 2010). Overall, all around the basin, increasing urbanization and human population density in coastal areas are critical in exacerbating air pollution and in creating ideal foci for the transmission of many contagious illnesses including diarrheal diseases and indirectly-transmitted diseases like dengue or Chikungunya virus infections. Natural environmental changes (warm temperature, less or heavy rainfall, longer periods of drought and extreme events) and human activities (transcontinental transportation of goods, animals and people within the basin, the disappearance of natural wetlands, coastal planning, dam construction on large Mediterranean rivers), all these changes may have enhanced natural cycle transmission of infectious agents. In this section, based on Rodríguez-Arias and collaborators' technical report (2008), we briefly review the emerging infectious diseases that pose serious health problems in the Mediterranean region. For eastern Mediterranean countries, Habib et al. (2010) and Khader et al. (2015) reviewed studies reporting the impacts of climate change on health or studied associations between meteorological parameters and human health outcomes, and the reader is invited to consult these references. Table 1 gives an overview of other potential infectious disease threats that could emerge in the near future in this area.

Visceral leishmaniasis is endemic around the Mediterranean basin and represents the main form of the disease. Countries on the northern rim of the basin like Spain, France, Italy, the Balkan sub-region, and Greece are where the disease transmission occurs. Generally, leishmaniasis occurs in rural areas, villages in mountainous regions and also in some peri-urban areas where dogs act as hosts for the disease life-cycle. This disease system is climate-sensitive, and strongly affected by changes in rainfall, temperature and humidity patterns. Global warming and land degradation together affect the epidemiology of leishmaniasis in a number of ways. According to WHO, changes in temperature, rainfall and humidity can have strong effects on sandfly vectors and reservoirs of rodent hosts by altering their distribution and influencing their survival and population size. Likewise, small modifications in temperature can have a profound effect on developmental cycle of *Leishmania* promastigotes in sandflies, thus supporting the development of the disease life-cycle in new as yet uncolonized areas. Finally,

Table 1

Climate-sensitive infectious diseases in the Mediterranean area and potential risk of emergence and spread. An asterisk means that since the information was originally published, cases have been detected in the area. Nota from the authors: "climate-sensitive diseases" does not mean that a formal demonstration of an effect of climate change has been demonstrated on the different listed diseases so far. These evidence-based studies of an effect of climate variability and change on the corresponding diseases were carried out at global scale. Modified from Rodriguez-Arias et al. (2008).

Infectious disease	Already present in the Mediterranean	Number of papers published (2007-2010)	Evidence for an effect of climate variability and change
Food- and water-borne			
Amoebiasis	Yes	4	No
Campylobacter enteritis	Yes	12	No
Cholera	No (potential risk)	9	Yes (South Asia, north-west South America, West Africa)
Cryptosporidiosis	Yes	22	No
Diphyllobothriasis	Yes	2	No
Escherichia coli infection	Yes	10	No
Food-borne *Vibrio* enteritis	Yes*	25	Yes (North Sea, Baltic, Atlantic Ocean, Mediterranean Sea)
Giardiasis	Yes	17	No
Legionella infection	Yes	17	No
Leptospirosis	Yes	21	No
Rotavirus enteritis	Yes	7	No
Salmonella infection	Yes	24	No
Schistosomiasis	Yes	3	No
Shigellosis	Yes	6	No
Strongyloidiasis	Yes	1	No
Typhoid and paratyphoid fevers	Yes	7	No
Air/human to human transmission			
Meningococcal infection	Yes	24	Yes (West Africa)
Vector-borne			
Typhus fever	Yes	12	No
Chikungunya virus disease	Yes	25	No
Dengue and dengue hemorrhagic fever	Yes*Some doubts	14	Yes (South-East Asia, northern South America)
Malaria	Yes	13	Yes (South-East Asia, East Africa, northern South America)
Rift Valley fever	Yes	6	Yes (South Africa)
West Nile virus infection	Yes	40	No (controversies)
Plague	Yes*	4	Yes (Central Asia)
Leishmaniasis	Yes	31	Yes (Southern Europe, South America)
Sandfly virus fever	Yes	15	No
Crimean-Congo hemorrhagic fever	Yes	24	No
Lyme disease	Yes	34	Yes (Northern Europe)
Spotted fever	Yes	21	No
Tick-borne relapsing fever	Yes	2	No
Tick-borne viral encephalitis	Yes	13	No
Tularemia	Yes	4	No
Filariasis	Yes	4	No

extreme climatic events and famine resulting from climate change can lead to massive displacement and migration of people to infected areas. Nowadays, we have a very limited understanding of the impact of climate change on leishmaniasis (re-)emergence and spread within the Mediterranean basin even if observations in southern France and northern Italy are congruent in showing the existence of a northwards colonization front. Local modifications in the environment like in Israel have favored the spread of rock hyrax colonies (*Procavia capensis*) close to human habitations, thereby establishing zoonotic transmission of *Leishmania (Leishmania) tropica*. Other concerns include the potential establishment of *Le. tropica* in Sicily, where the vector *Phlebotomus (Paraphlebotomus) sergenti* is locally abundant (Bates et al. 2015). In addition to the environmental risk factors for leishmaniasis transmission, urbanization, social instability, low hygiene education, inadequate housing and sanitation, domestic zoonosis involving dogs and HIV co-infection are important factors in leishmaniasis epidemiology.

The West Nile virus outbreaks that occurred in Romania (1996) and Israel (2000) followed a drought season, and the role of meteorological conditions is clearly important in the development and spread of this virus in the Mediterranean region. After high rainfall followed by a period of drought, pools become richer in organic materials and sediments from which *Culex* vector mosquitoes (see above) may benefit, thus extending their breeding season. These conditions are then optimal for bird species to congregate around rich pools with myriads of mosquitoes. The conditions are met for the virus to circulate easily (but see comments above about extreme events). In addition, warm temperature accelerates the extrinsic incubation period of viruses within mosquito carriers, and thus enhances the potential for transmission and dissemination (Conte et al. 2015). However, West Nile virus disease is a complex disease system where many parameters may act independently or synergistically (Chevalier et al. 2014, Roche et al. 2015b), and further studies are clearly needed in the Mediterranean to determine the exact role played by climate change in the observed emergence and spread of this disease (see Di Sabatino et al. 2014 for a recent review and Conte et al. 2015 for a time and space analysis of suitable habitats in the Mediterranean region and central Europe). Notably, habitat alteration and the disappearance of wetlands with increasing urbanization all around the basin might have profoundly modified bird species behavior and ecology.

In recent years, malaria has re-emerged in residual foci in Eastern Europe and the present climate change could actually increase mosquito vectorial capacity, especially in southern countries of Europe and the Mediterranean region. Malaria was endemic in Europe and the Mediterranean until the mid-20th century, but was considered eradicated on the northern rim of the Mediterranean Sea in the 1960s and 1970s. Southern Europe is among the most risky regions for malaria resurgence, especially for *P. vivax* malaria resurgence due to its climate characteristics, the proximity to Africa and Caucasus, and the presence of a range of more or less potential Anopheline vectors (Odolini et al. 2012). *Anopheles atroparvus* is known to be an efficient malaria vector and it is widely distributed in Europe, except in some Mediterranean regions including southern Italy, Greece and Turkey where *An. labranchiae* and *An. superpictus* are the dominant species. Studies on the receptivity of the European vector *An. atroparvus* revealed that it is not susceptible to the afro-tropical *P. falciparum* strains, which represents the dreadful killer of malaria forms, but is probably fully susceptible to infection by *P. vivax* strains imported from Africa. Since 2004, Morocco is considered to be malaria-free, but imported malaria cases in the northern central region highlights the potential risk of introduction of the parasite in this region. In summer 1997, one autochthonous *P. vivax* case occurred in Italy, in a rural zone where *An. labranchiae* occurs, and the same happened in Corsica in August 2006, where a case of indigenous *P. vivax* malaria - the first case of autochthonous transmission in France since 1972 - was diagnosed. Four years later, in 2010, Spain reported the first indigenous cases of *P. vivax* malaria in the province of Aragon, where the vector *An. atroparvus* is present. Then, in August 2011, a *P. vivax* infection was diagnosed in a Romanian traveler returning from Greece. Greece was officially considered malaria-free in 1974, but sporadic autochthonous cases were reported in 1991, 1999 and 2000 (Odolini et al. 2012). Recent studies in the Ebro delta in Spain, an historically endemic malaria area, showed that this ecosystem currently presents ecologically favorable characteristics, notably with the presence of *An. atroparvus* and its rice field landscape, for the re-appearance of malaria if an appropriate malaria strain were to be introduced and the extension of the potential transmission period due to ongoing global warming (Sainz-Elipe et al. 2010).

At present, there is concern about the possible emergence and spread of *Aedes*-borne viral diseases in the Mediterranean region. Dengue fever is the most important one, and dengue outbreaks were rather common in the Mediterranean at the beginning of the 20th century (Rezza 2016). Several epidemics also occurred in the 18th and 19th centuries in ports in the eastern Mediterranean and occasionally in the northern and western parts (Schaffner and Mathis 2014) (Table 2). The vector *Ae. aegypti* was re-introduced locally by vessels at that time and was widely present in southern Europe. Notably, the last major outbreak occurred in 1927/1928 in Athens and neighboring districts in Greece with a peak in August 1928 that affected more than 1 million people, and then left Mediterranean Europe. In September 2010, two cases of dengue were identified in Nice, southern France, and in the summer of the same year, another transmission event was detected in Croatia between August and October, 2010. Again, in 2013 and 2014, five autochthonous cases were identified in southern France in Bouches-du-Rhône and Var Departments. More recently, autochthonous cases of dengue were reported in Nimes, southern France (Succo et al. 2016). Since 2010, at least 23 cases of dengue have been reported by public health authorities in Mediterranean Europe. Chikungunya is another *Aedes*-borne viral disease threatening the health of Mediterranean citizens. In the summer of 2007, more than 250 cases of Chikungunya virus disease occurred in the north-east of Italy, and in September 2010 autochthonous transmission of the virus was identified in south-east France, in both situations, with primary cases returning from a visit in India (Rezza et al. 2007). In the Mediterranean area, *Ae. albopictus* (the main established vector) appears to be the vector implicated in all transmission events for dengue and Chikungunya. Nowadays, with the large epidemic of Zika virus, there is a possibility of an increased risk of Zika virus transmission within the Mediterranean basin during the summer season. However the risk of large scale outbreaks and endemicity for these *Aedes*-borne infections in the Mediterranean appears to be rather low. Climate change, which may favour overwintering of virus and mosquitoes in the region, is not the only driving factor that influences disease spread, and outbreaks caused by *Ae. albopictus* are less important than those due to its congener, *Ae. eegypti*, due to its feeding habits. In general, other important drivers of dengue transmission are socio-economic factors, including globalization, urbanization, and anthropological or social human behaviors. Nevertheless, the presence of *Ae. aegypti* now established on the Caucasian cost of the Black Sea, is less reassuring today (Schaffner and Mathis 2014).

Table 2
Historical and contemporary outbreaks of dengue fever in the WHO European region. Note that most of infected localities are in the Mediterranean region except the Canary Islands and Madeira in the Atlantic Ocean and Vienna, Austria in mainland Europe. From Schaffner and Mathis (2014).
The Lancet Infectious Diseases.

	Location	Notes
1784, 1788, 1793	Cadiz, Seville (Spain)	End of first pandemic, 1779–84
1861	Cyprus	–
1863, 1867	Cadiz (Spain), then Jerez, Seville, and other places in Andalusia	Imported from the West Indies by troops
1865	Canary Islands (Spain)	–
1881	Crete (Greece)	Half of the inhabitants affected
1887	Gibraltar	Fifth pandemic, 1887–89
1888–1889	Cyprus	–
1889	Athens, Piraeus, Salonica (Greece), Greek Islands (Rhodes, Chios, and others), southern Turkey, Izmir, Manisa to Istanbul, Trabizon (Turkey), Varna*(Bulgaria), Lisbon (Portugal), Israel	Around 80 000 cases in Izmir (80% of the inhabitants)
1889–1890	Istanbul, Izmir (Turkey), Napoli (Italy)	–
1895–1897	Athens (Greece)	–
1899	Antalya (Turkey)	–
1910	Athens, Piraeus (Greece)	–
1912	Israel	–
1913	Cyprus	–
1916	Dardanelles, Trabizon (Turkey)	–
1921	Vienna*(Austria)	–
1927	Malta	–
1927–1928	Piraeus, Athens, Euboea, Gulf of Aegina (Greece), Izmir to south of Rhodes (Turkey), Israel, Greece: DEN-1 and DEN-2 confirmed by retrospective serological study	More than 1 million of people affected (90% of the population in Athens); 1000–1500 deaths
1928	Cyprus, Andalusia	–
1929	Izmir	–
1929–1933	Greece	Confirmed by retrospective serological study
1945	Turkey, Israel (and other Middle East countries)	–
2010	Croatia; three DEN-1 clinical cases (including one reported in Germany) plus 15 recent infections	Virus probably introduced from Indian subcontinent
2010, 2013	France; DEN-1 cases (2010), one DEN-2 case (2013)	Viruses probably introduced from West Indies
2012–13	Madeira; more than 2200 DEN-1 cases from October, 2012, to January, 2013, plus 74 cases reported from Portugal mainland and 12 other European countries	Virus probably introduced from Venezuela

DEN-1=dengue virus serotype 1. DEN-2=dengue virus serotype 2. *Not clear whether data refer to a dengue outbreak or imported cases only, as there is no indication for the presence of *A aegypti* in Varna and Vienna.

***Table*: Historical and contemporary outbreaks of dengue in the WHO European region**

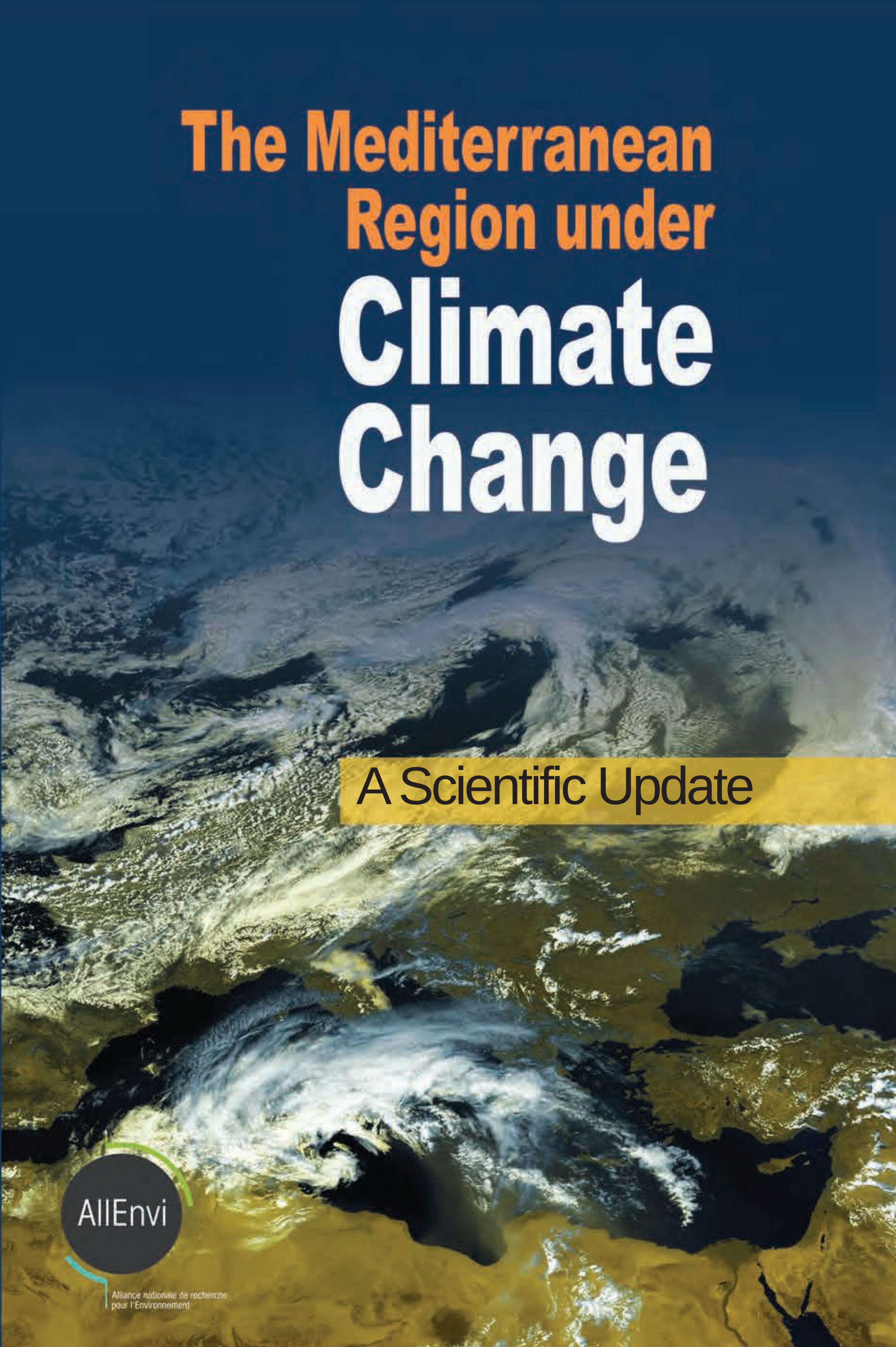
Research initiatives needed on communicable diseases for the future

To conclude this section, one personal observation that can be made compared to other regions of the world where climate-sensitive diseases have been studied is that studies on climate change and infectious diseases in the Mediterranean are sporadic, unfocused and often anecdotic from a data-orientated perspective, and too uncoordinated to make it possible to answer the question concerning the impacts of climate change on health. Habib (2011) made the same comment concerning chronic illnesses and socially situated health outcomes particularly impacted by climate change in the Eastern Mediterranean region. In general, studies do not formulate their findings within a conceptual framework that links them to climate change, but discuss how weather variations (which are not necessarily climate change indicators; see comments above) such as temperature, humidity and rainfall impact infectious diseases and their hosts. Concerning vector-borne diseases more specifically, most studies discuss the presence and development of a given potential vector species and the extension of its survival period, and very rarely or never analyze the association between the vector, the pathogen and the environment, and the possible changes in these interactions due to climate change (Guégan and Simard 2015). Longitudinal studies over extended periods of time and at different sites that investigate the link between climate change and infectious diseases are absolutely indispensable in the Mediterranean region since these studies represent the gold standard in climate change impact research today (Rodó et al. 2002, Morris et al. 2014). There is an absolute need for longitudinal studies to be extended to include more countries in the region and to include other environmental, ecological, social and economic factors that might affect the spread of the disease. Research on health outcomes of climate change requires multidisciplinary knowledge of complex and multi-layered environmental, social, economic, political and health processes, and it definitely requires the establishment of a strong trans-Mediterranean medical research and health coordinating body.

According to Navarra and Tubiana's (2013) book, the European Community funded FP6 Emerging Diseases in a changing European eNvironment (EDEN) integrated research program was an excellent opportunity to bring together researchers from different disciplines in Europe, Northern Africa and Turkey to develop systematic assessments of localized environmental, economic, demographic and health impacts of climate change on emerging infectious diseases. Even if this EC research initiative was not only focused on the Mediterranean region, a substantial part of the research activities were conducted in the Mediterranean basin, notable on leishmaniasis, malaria, tick-borne diseases, and West Nile virus and Rift Valley virus diseases.

The Mediterranean Region under Climate Change

A Scientific Update



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The Mediterranean Region under Climate Change

A Scientific Update

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