WWF

FRANCE

CLIMATE CHANGE: THE WORLD OF SPORTS AT +2°C AND +4°C

With the financial support of the Ministry of Sport

MINISTÈRE DES SPORTS
Liberté
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ABOUT WWF

WWF is one of the world's leading independent conservation organizations. With a network active in more than 100 countries and nearly 6 million members, WWF works to stop the degradation of the planet's natural environment and build a future in which humans live in harmony with nature, conserving the world's biological diversity, ensuring the sustainable use of renewable natural resources, and promoting the reduction of pollution and waste.

Since 1973, WWF France has been acting daily to offer future generations a living planet. With its volunteers and the support of its 220,000 donors, WWF France carries out concrete actions to safeguard natural environments and their species, to promote sustainable lifestyles, to train decision-makers, to support companies in reducing their ecological footprint, and to educate young people. But for change to be acceptable, it can only happen through respect for each and every one of us. This is why WWF's philosophy is based on dialogue and action.

The navigator Isabelle Autissier is the honorary president of WWF France, Monique Barbut is the president of WWF France and Véronique Andrieux is the general manager.

To discover our projects, visit: wwf.fr

Together we are the solution.

A COLLABORATION BETWEEN WWF FRANCE AND THE MINISTRY OF SPORT

Sharing a common vision on the importance of mobilizing and supporting sports stakeholders in preserving the environment, WWF France and the French Ministry of Sport have worked together on several projects, including the charter of 15 eco-responsible commitments for event organizers and sports facility managers. In this context, WWF France wanted to carry out this study for which the French Ministry of Sport has provided financial support.

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Since 2008, I Care has been assisting companies, financial players, and the public sector in their transition to a low environmental impact society. From strategic thinking to operational solutions, I Care offers innovative solutions on a wide range of environmental issues: climate, biodiversity, circular economy, and resources... with the aim of helping society move from a "large footprint" to a "high environmental productivity". Based in Paris, Lyon and Belo Horizonte (Brazil), the team is currently composed of about 50 people.

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environnement et stratégie

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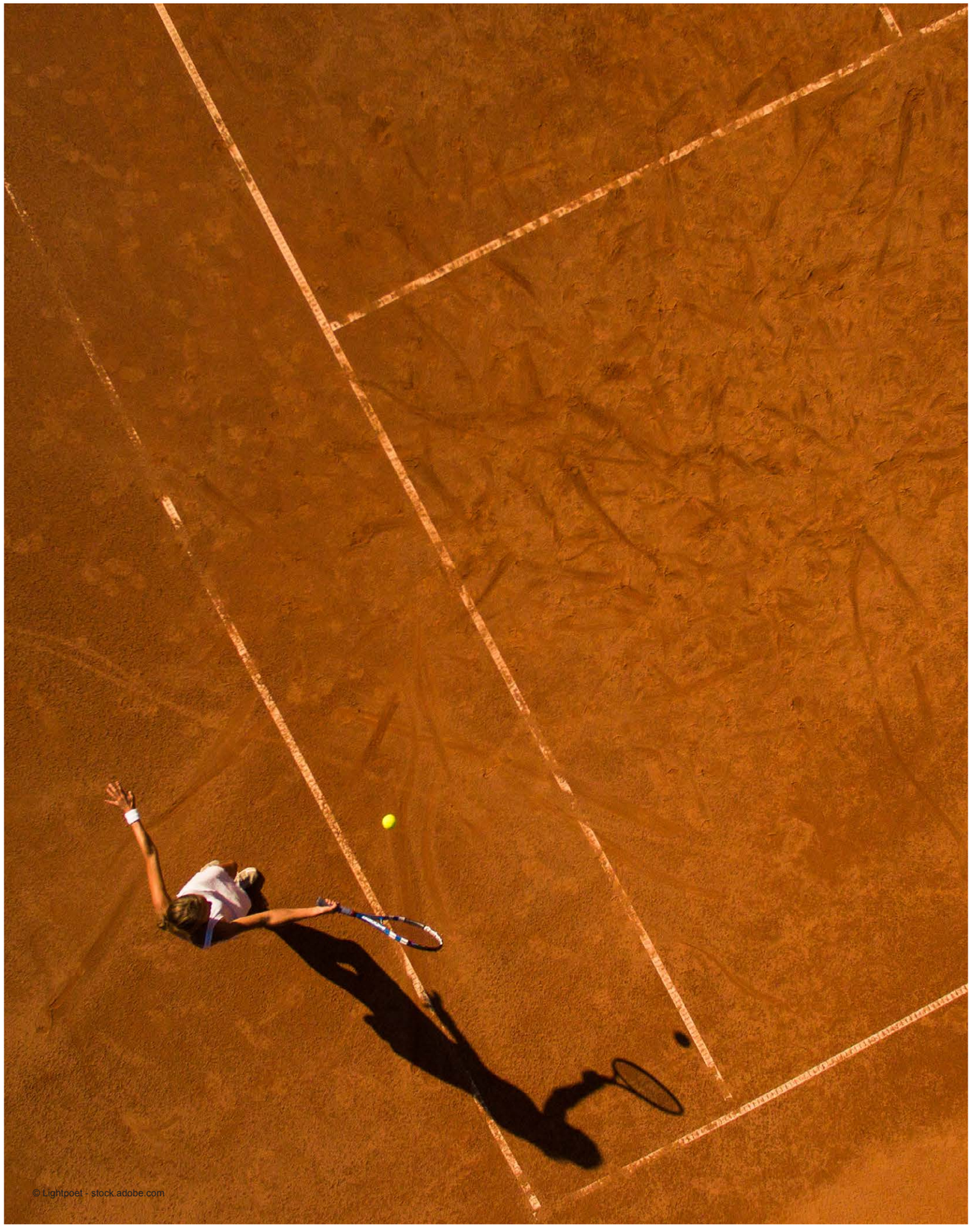

SUMMARY

Technical design and writing of the publication:
Mael Besson (WWF France), Aurélie Bourgoin (WWF France), Alessia Vittorangeli (I Care & Consult), Boris Bailly (I Care & Consult)

Graphic design: Laura François

WWF France 35-37 rue Baudin, 93310 Le Pré-Saint-Gervais.

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EDITORIAL

Climate change is increasingly worsening as the Earth warms up and humanity continues an unsustainable path with a model based on fossil fuels. Its effects are observed everywhere: accelerated melting of snow and glaciers, increased and more intense heat waves, more droughts, heightened extreme weather events...

According to scientists and IPCC[1] reports, several climate futures are still possible, depending on the ambition shown and decisions taken to change our model: a future in which the world can be lived in, if global warming is kept well below 2°C - given we adapt to its effects now - or a future in which the world is at 3, 4, 5°C, or even more, which is unbearable for the future of humanity.

As sportsmen and women, we also depend on the natural elements that are bound to change to a greater or lesser extent depending on the level of climate change, and therefore on the decisions taken to contain and adapt to it. What is a skier without snow? Which rugby player or marathon runner can perform in 40 or 45 degrees? What is a sailor in seas covered with toxic algae? What is a kayaker in dry rivers? To what extent can outdoor sports take place in arid landscapes? Climate affects not only performance, but also simply doing sports. This report explores some of the effects and consequences of climate change on sports under different scenarios and makes recommendations on how best to deal with them.

In this worrying context, we sportsmen and women must set an example and make the hopes for change credible and attainable. Because we represent a sphere of influence. Because we want to be responsible. Because we depend on nature, from our first breath, because it is urgent to act and because it is still possible, sport must commit itself to climate action and environmental preservation.

Sport, like all human activities, will suffer from the consequences of climate change. But the more we act together and effectively, the more we will be able to mitigate climate change and adapt to its effects.

The future is not written, it depends on the ability of each person to act at her or his own level of responsibility and decision. We all have a role to play!

SPORT, LIKE ALL HUMAN ACTIVITIES, WILL SUFFER FROM THE CONSEQUENCES OF CLIMATE CHANGE.

ISABELLE AUTISSIER,
HONORARY PRESIDENT OF WWF FRANCE

1. IPCC: Intergovernmental Panel on Climate Change. This panel was created in 1988 to provide policymakers with regular scientific assessments on climate change, its implications and potential future risks, as well as to put forward adaptation and mitigation options.

EDITORIAL

I have always had a strong relationship with nature. I like to walk in it, to train in it, to share a moment with my surroundings or simply to observe it. I believe that it is part of my life balance. I need it. In addition to allowing us to recharge our batteries, nature provides us with the essential elements we need to live: the air we breathe, the water we drink, the food we grow are all elements that are indispensable to us. Like many, I see that this nature is suffering from human activities. The images of the impacts of global warming touch me: seeing fires, deforestation, marine pollution... I do not want to remain a simple spectator.

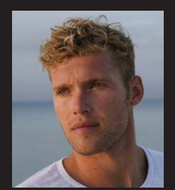
I also believe deeply in the importance of sport, its educational role, and the values it conveys. Sport allows many of us to build ourselves, to accomplish ourselves, to learn to live together, to cooperate and to surpass ourselves. Unfortunately, climate change will also have consequences on our ability to do our sport in good conditions and to perform. Too high temperatures, increased pollution peaks, impracticability of sports facilities... are all consequences that we must try to avoid and anticipate.

I, for one, want to achieve victories with the least impact possible on the environment. I want to be able to continue to exceed my own limits without seeing global warming records broken. Because, from now on, the value of each victory must be measured in terms of respect for the rules of the sport, for the opponent... and for the environment.

Scientists have shown that if we are threatened by climate change, we are also responsible for it: lifestyles, consumption choices, human activities... We alone can reverse the trend!

We, as sports enthusiasts, must act. Thanks to you, professionals and amateurs, the environmental footprint of sport can be reduced, and we can save our passions from the worst-case scenario. It is time for us to take on a challenge greater than that of sports records. I know I can count on you.

IT IS TIME FOR US TO TAKE ON A CHALLENGE GREATER THAN THAT OF SPORTS RECORDS



KEVIN MAYER,
FRENCH ATHLETE

INTRODUCTION

The climate disruption we are facing today is unprecedented in its magnitude, its pace and global dimension. Greenhouse gas emissions generated by human activities since the industrial revolution, in particular by the combustion of fossil fuels (oil, fossil gas and coal) for production and consumption, have increased sharply in recent decades, leading to a record concentration of CO2 in the atmosphere. France has its share of responsibility, on the one hand through the emissions generated on its territory (notably by transport or residential areas), and on the other hand through its «carbon footprint» linked to imports.

Today, we are already living in a world where the average temperature is 1°C higher than pre-industrial levels [2]and some of the effects and consequences associated with this warming are already observable.

Over the last thirty years, we have experienced twice as many heat waves in France as in the previous period[3]**.** Their frequency and intensity are increasing, as well as their impacts, notably on air quality with the increase in pollution peaks due to ozone or fine particles. Similarly, drought episodes are becoming more and more recurrent and intense, affecting a growing area of the metropolitan territory.

Climate change affects all areas. At high altitudes, under the effect of this disruption, snow cover is gradually decreasing. The thickness of the snow cover, the extent of snow-covered areas and the duration of snow cover will decrease over the decades, while avalanches and landslides are becoming more and more frequent with the melting of the permafrost, the cement of our mountains. The French coasts are also threatened. The rise in sea level, storms and other factors related to human activities modify the coastline and increase the risk of submersion. In addition to these different changes, there is also a growing number of extreme climatic phenomena that may disrupt our practices.

The environment is a decisive parameter for doing sport. Unfortunately, the impacts of climate change on this environment are already being felt, making it difficult to do sport, or to manage certain facilities, to ensure the sustainability of natural sites, to organize events properly, etc. Heat waves, burnt-out lawns, cancelled matches, skiing resorts in difficulty due to the decrease in snow cover, overheated sports halls, sailing and water sports clubs threatened by the rise in sea level... the consequences of climate disruption are unfortunately numerous and depend on our ability to reduce greenhouse gas emissions and to adapt.

The ambition of this report is to give an overview of the future climate context to which sports stakeholders will have to adapt, to different degrees. It highlights some of the consequences of climate change on sports, facilities, and sites.

For this report, the chosen methodology is based on the consideration of two global disruption scenarios[4].

- **The first, of +2°C compared to** pre-industrial levels[5], corresponds to the maximum temperature increase recommended by the Paris Agreement of 2015. This Agreement aims to limit the rise in global average temperature "well below 2°C" and to "pursue efforts to further limit the temperature increase to 1.5°C".
- **The second warming scenario, corresponding to +4°C** on average relative to pre-industrial levels, is one of the likely scenarios if we continue on our current greenhouse gas emission trajectory.

In both scenarios, the rise in temperature has important consequences for our planet, for our way of life, and for sport as we know it today.

Fortunately, it is still possible to limit global warming if we manage to drastically and rapidly reduce our greenhouse gas emissions by aligning ourselves with the trajectory objective of the Paris Agreement. To achieve this, we must move forward collectively and accelerate the ecological transition of our societies and sport can and must, through its exemplary role, help us to do so. The need to change the world has never been so urgent. The time has come for the world of sports to take up the challenge and become the first defender of the climate.

2. Pre-industrial reference period 1850-1900
3. ONERC, Extreme weather events in a changing climate, 2018
4. The methodology used to translate the RCP scenarios used by the IPCC into global warming scenarios is detailed in the methodological note in the Appendix
5. Pre-industrial reference period 1850-1900

POINTS ON METHODOLOGY

This report aims to provide an overview of the future climate context to which sports stakeholders will have to adapt. Knowing these present and future impacts is the first step in a collective reflection on the solutions to be implemented.

UNDERSTANDING THE WORLD OF SPORTS AT +2°C OR +4°C REQUIRES CLIMATE AND SPORTS DATA: study of past climate impacts and projections of future climate changes on the one hand, location of sports facilities and sensitivity thresholds of practices on the other. The two families of data present methodological and access difficulties that have imposed several methodological choices:

ALL OF FRANCE OR METROPOLITAN FRANCE? Mainly for reasons of availability of uniform climate projection models, the scope of the analysis covers metropolitan France only; subsequent studies may extend the analysis to overseas France.

TIME HORIZONS OR GLOBAL TEMPERATURE AVERAGES? This report does not take into account time scales and has been built around global warming scenarios of +2°C and +4°C[6] which are the most documented scenarios. As global warming curves are constantly evolving in line with our greenhouse gas emissions, these temporal benchmarks could quickly become obsolete. The translation of an approach by greenhouse gas emission trajectories (GGEs)[7] and by timeframes used by the IPCC[8] into global warming levels is necessarily approximate; it is detailed in the methodological note in the appendix.

ALL IMPACTS OR A SELECTION OF IMPACTS? This report focuses on five of the major impacts of climate change on some sports. In reality, these impacts represent only a partial picture of the likely consequences of climate change on sports. Other aspects, such as the consequences of climate change on the flow of freshwater rivers and their impact on water sports, or the consequences on glaciers and therefore on mountaineering, could not be addressed here. The themes and sports studied in this report were chosen according to their ability to best illustrate the impact of climate change on sport and according to the availability of data.

HIGH OR LOW GRANULARITY? The choice to study impacts that cut across several disciplines required the development of general hypotheses on the vulnerability of practices, which do not always correspond precisely to the reality of individual sporting practices. For example, for the increase in temperature, a threshold had to be chosen (32°C) beyond which the practice can have significant consequences on health. Of course, the level of danger varies according to the physiology of each person and the level of intensity of the practice.

IN THE END, THIS REPORT SHOULD BE CONSIDERED AS A FIRST STEP IN AN ANALYSIS THAT SHOULD BE DEEPENED IN THE FUTURE: ONE OF THE RECOMMENDATIONS AT THE BEGINNING OF THE DOCUMENT DEALS WITH THIS POINT. A MORE DETAILED PRESENTATION OF THE METHODOLOGY USED IN THIS REPORT IS AVAILABLE IN THE APPENDIX.

6. Compared to the pre-industrial reference period 1850-1900
7. The scenarios used by the IPCC to analyze the future of climate change are called Representative Concentration Pathways (RCP). These scenarios describe four trajectories of emissions and concentrations of greenhouse gases, ozone and aerosols, and land use.
8. IPCC stands for Intergovernmental Panel on Climate Change. It was established in 1988 to provide comprehensive assessments of the state of scientific, technical and socio-economic knowledge about climate change, its causes, potential impacts and coping strategies.

GLOBAL AVERAGE TEMPERATURE RISE

CONSEQUENCES ON THE FRENCH SPORTS WORLD

36 MILLION PEOPLE PRACTICING SPORTS IN FRANCE

SPORT ACTIVITIES IMPACTED BY RISING TEMPERATURES

OBSERVATIONS

THE FREQUENCY OF HEAT WAVES IS EXPECTED TO DOUBLE BY 2050

FORECAST

SPORT IS NOT RECOMMENDED ABOVE 32°C

AT + 2°C
UP TO +24 DAYS >32°C

AT + 4°C
UP TO +66 DAYS >32°C

CONSEQUENCES ON

HEALTH | EVENTS | AIR QUALITY | PERFORMANCE

COASTAL PRACTICE SITES TO BE RELOCATED

OBSERVATIONS

THE EQUIVALENT OF THE LAND SURFACE OF 4200 SOCCER FIELDS HAS DISAPPEARED IN 50 YEARS

ACCORDING TO THE IPCC, SEA LEVELS COULD STILL RISE BY 1 METER OR MORE IN A +4°C WORLD

CONSEQUENCES

AT + 2°C
80/576 SAILING CLUBS ARE THREATENED

AT + 4°C
131/576 SAILING CLUBS ARE THREATENED

MORE AND MORE COMPLEX GYMNASIUMS TO MANAGE

OBSERVATIONS

- INCREASE IN AVERAGE TEMPERATURES
- INCREASINGLY FREQUENT HEAT WAVES
- SUNSHINE RATE ON THE RISE

60 000
French collective sport halls

50% OF WHICH WERE BUILT BEFORE 1987 AND ARE NOT ADAPTED TO HIGH TEMPERATURES

CONSEQUENCES

- RESTRICTED ACCESS TO GYMNASIUMS
- REDUCED THERMAL COMFORT AND USERS' HEALTH IS THREATENED
- EXPENSIVE MANAGEMENT THE FACILITIES
- NEED TO UNDERTAKE THERMAL RENOVATION SPORT FACILITIES

GRASS FIELDS BECOME LESS AND LESS PLAYABLE

OBSERVATIONS

- INCREASE IN FREQUENCY AND INTENSITY OF DROUGHT EPISODES
- INCREASE IN EXTREME WEATHER EVENTS

nearly 43 500 PLAYING FIELDS IN FRANCE

more than 1 MILLION MATCHES EACH YEAR (AMATEUR AND PROFESSIONAL)

CONSEQUENCES

INCREASE IN THE NUMBER OF ADDITIONAL DAYS OF HEAT WAVES

AT + 2°C: 5 TO 20 DAYS

AT + 4°C: 20 TO 62 DAYS

MORE DAYS OF HEAT WAVES THAT WILL AFFECT LAWNS

TURF IS AT RISK IF TEMPERATURES EXCEED 32°C FOR SEVERAL DAYS AND DOES NOT DROP BELOW 24°C AT NIGHT

WATER AND HEAT STRESS FOR TURFGRASSS

WINTER SPORTS UNEVENLY THREATENED

OBSERVATIONS

-1 MONTH OF EXPECTED SNOWFALL PER DEGREE OF FUTURE WARMING

FORECAST

AVERAGE THICKNESS OF SNOW COVER IN WINTER IN THE ALPS AT +1500 M

AT + 2°C: -30%

AT + 4°C: -80%

NUMBER OF RESORTS WITH SUFFICIENT NATURAL SNOW COVER IN THE PYRENEES

AT +2°C: 3

AT +4°C: ZERO

CONSEQUENCES ON

THE QUANTITY AND QUALITY OF SNOW COVER | THE SNOW PERIOD | AVALANCHES AND LANDSLIDES

250 WINTER SPORTS RESORTS, MOST OF THEM THREATENED

SPORTS ARE THREATENED BY CLIMATE CHANGE

OUR RECOMMENDATIONS

1. DEVELOP SPORT AND CLIMATE OBSERVATION TOOLS
2. AFFIRM THE PRESERVATION OF THE ENVIRONMENT AS A FUNDAMENTAL VALUE OF SPORT
3. IMPLEMENT AN AMBITIOUS POLICY FOR THE ECOLOGICAL TRANSITION OF SPORT IN ORDER TO REDUCE ITS ENVIRONMENTAL IMPACT
4. ECO-CONDITIONING OF SPORTS FUNDING
5. PROMOTE "LOCAL AND SEASONAL PRACTICES"
6. ENGAGE ALL SPORTS STAKEHOLDERS IN CLIMATE PROTECTION
7. RELY ON THE EDUCATIONAL ROLE AND EXEMPLARY NATURE OF SPORT TO RAISE AWARENESS
8. SUPPORT ADAPTATION TO CLIMATE CHANGE

TO PRESERVE THE PRACTICE OF SPORTS, WE MUST PRESERVE THE CLIMATE

WWF RECOMMENDATIONS

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THE FIGHT AGAINST CLIMATE CHANGE IS BECOMING AN ISSUE OF PRESERVATION OF SPORTS PRACTICES. MORE THAN RESPONSIBLE, SPORT MUST BE COMMITTED.

Climate change is impacting and will inevitably impact our societies as a whole, modifying our lifestyles, our leisure activities... and sport will unfortunately not be spared. This report provides an initial assessment of the vulnerability of sport to the consequences of climate change. Sportsmen and women, event organizers, facilities managers, sports champions, sponsors, federations... the world of sport as a whole will have to adapt to and anticipate these climate changes. However, adapting may not be enough if we do not significantly reduce our impact on the environment. Indeed, the longer we delay the reduction in our CO_2 emissions, the greater and more irreversible the consequences will be, and the more difficult and costly the adaptations will be.

All the more so since, in addition to these direct climatic consequences, there are indirect consequences on the stability and security of our societies as outlined in our 2017 report «Sustainability, Security, Stability». It is obviously essential that each actor in sport limits his own environmental impact, in particular by reducing his own greenhouse gas emissions, but it also appears vital for sport that global greenhouse gas emissions also decrease. Considering the importance of climate issues for sport and the influence of sport, it is in the interest of sports stakeholders to become the first climate advocates.

The recommendations below aim to act in order to maintain a climate context favorable to the practice of sport. They set out the first steps towards structuring actions to reduce the impact of sport and to set an example, to anticipate the necessary adaptations and to use the power of influence of sport to support the preservation of the environment. Each actor in sport can take on these aims, bring people's attention to them and work towards the ecological transition of our society.

ANTICIPATE

1. DEVELOP TOOLS FOR OBSERVING SPORT AND CLIMATE

In order to be able to anticipate the consequences of climate change and to support the necessary adaptations for sport, it is essential to build management tools to complement the observations made on the economy of sport, allowing us to evaluate the impact of sports activities on the environment, to measure and anticipate the consequences of climate change on sport, and to build scenarios for the organization of sport aligned with the objectives of the Paris Agreement. In the form of regular analyses, dedicated observatories, or integrated into existing observatories, these observations should provide visibility of the future context to which sport will have to adapt and, consequently, develop recommendations.

IMPROVE

2. TO DECLARE THE PRESERVATION OF THE ENVIRONMENT AS A FUNDAMENTAL VALUE OF SPORT

A sporting victory is only valuable if it is built with respect for the rules of the game, the opponent, the officials, etc. but also for the environment. Indeed, it is becoming more and more unacceptable that the practice, the performance and the spectacle of sport, can be done at the expense of the planet. It is therefore important to put the fight against pollution on the same level as the fight against doping, fair play, respect of refereeing decisions... by including it in the sports rules and by providing for sports sanctions in case of failure.

3. TO IMPLEMENT AN AMBITIOUS POLICY FOR THE ECOLOGICAL TRANSITION OF SPORT IN ORDER TO REDUCE ITS ENVIRONMENTAL IMPACT

Sport, like any human activity, can have a negative impact on the climate. It is therefore essential to pursue and strengthen policies for the ecological transition of sport and to take into account the greenhouse gas emissions generated in each of the sports decisions and policies. Whether it concerns the energy performance of sports facilities, the environmental excellence of major international sports events, the reduction and optimization of travel generated by the practice of sport or the transformation of food practices in sports events, all sports activities must be aligned with the objectives of the Paris Agreement.

4. ECO-CONDITIONING OF SPORTS FUNDING

All public and private funding for sport should be conditional on the environmental preservation commitments of the project sponsors. This would accelerate the ecological transition of sport. In addition, it is important to include in the selection criteria, an analysis of the environmental and economic cost of the entire life cycle of the project or facility in question, and not just its construction or commissioning.

5. PROMOTE «LOCAL AND SEASONAL PRACTICES »

Adopting a local and seasonal sports practice can significantly reduce its impact on the environment. Indeed, local practice means less travelling, which often strong produces a large quantity of greenhouse gases. Adopting a seasonal sports practice implies accepting a certain seasonality in the frequency of tournaments and games, and the use of sites. This would notably reduce the need for infrastructures that can be energy consuming and consume a lot of water or phytosanitary products.

CONTRIBUTE

6. ENGAGE ALL SPORTS STAKEHOLDERS IN CLIMATE PROTECTION

Sport, even if exemplary, will suffer the consequences of climate change caused by other human activities. France, notably in the framework of its commitments in the Paris Agreement and the 2030 Agenda relating to the 17 Sustainable Development Goals (SDGs), is conducting a certain number of public policies (national plans, strategies, laws, etc.) aimed at environmental protection. Sports actors must get involved in the various bodies and support the stated ambitions as much as possible. Through its power of influence, its exemplary role and its capacity to federate and create synergies, sport must become an actor of change and climate preservation, in the interest of all and of its own preservation. It is therefore necessary to include the fight against climate change as a strategic objective in all regulatory texts, public policies and strategies of all sports actors.

7. RELY ON THE EDUCATIONAL ROLE AND EXEMPLARY NATURE OF SPORT TO RAISE AWARENESS

Sport has a special place in people's lives and development. Through its educational role model , sport and athletes can and should instill social norms of environmentally friendly behavior. Thus, sport and sportsmen and sportswomen must emphasize and promote low environmental impact behaviors, whether this is materialized through educational content, in sports regulations, on television or by banning the advertising of the most polluting product brands through sports sponsorship.

ADAPT

8. SUPPORTING ADAPTATION TO CLIMATE CHANGE

Even if we manage to keep the average global temperature rise below +2°C, sport will still have to adapt. It is therefore crucial to anticipate and accompany the necessary changes that sport and its various bodies will have to face. However, the solutions must be in line with the commitments of the Paris Agreement. It is therefore essential to avoid any errors in adaptation that would contribute to climate change. A national plan for the adaptation of sport to climate change must be developed.

WHAT ARE THE CONSEQUENCES FOR THE FRENCH SPORTING WORLD?

SPORTING ACTIVITIES IMPACTED BY RISING TEMPERATURES

One of the first consequences of climate change is the rise in temperature and the increase in heat waves.

OUTDOOR SPORTS:

SOME KEY FIGURES

36 MILLION

occasional sports participants

ABOVE 32°C

sporting activities are not recommended

OBSERVATION

THE FREQUENCY OF HEAT WAVES IS EXPECTED TO DOUBLE BY 2050

CONSEQUENCES FOR SPORT ON

The Tour de France, the soccer and rugby championships, the Roland Garros tournament, amateur soccer matches, cycling, jogging after work... In total, there are a little over 36 million[9] people doing sport in France. All these activities rely on the same prerequisite: weather conditions and temperatures suitable for sport. Mainly because of human activities and climate change, this common base is becoming more and more challenged.

9. Croutte P., Y., Müller J., 2018, Baromètre national des pratiques sportives 2018, Barometer conducted by CREDOC under the direction of Hoibian S. for INJEP and the Ministry of Sports, INJEP Notes & Reports/Study Report.

A. INCREASINGLY FREQUENT AND INTENSE HEAT WAVES

The last three decades have been successively the warmest at the Earth's surface compared to the past decades since 1850[10] .

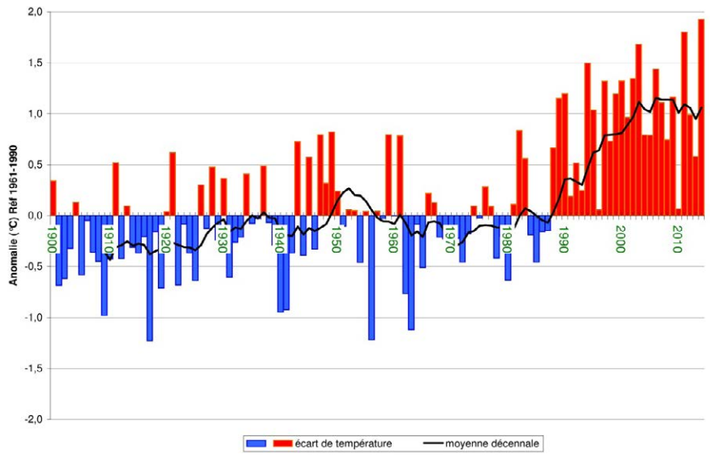


Figure 1. The evolution of average annual temperatures in metropolitan France shows a warming since 1900
Source: Météo France

Heat waves[11] are becoming more and more frequent and intense. In France, they have doubled in number over the last thirty years, compared to the previous period. [12]

These extreme phenomena have a major human and economic cost; the impacts of the 2003 heat wave are still fresh in everyone's mind. Its duration and unprecedented intensity - 16 days with an average temperature of over 29°C - caused 15,000 deaths and economic losses estimated at over 15 billion euros[13] . More recently, in June 2019, the Gard (French department) observed the highest temperature ever recorded in France: 45.9 ° C. [14]

If this observation is already striking, all climate scenarios agree on a continuation of the current warming[15]. According to the IPCC, in a scenario where no climate policies are implemented, global warming could exceed **4°C** by 2100 compared to the pre-industrial period. In the case of rapid economic growth fueled by fossil fuels, temperatures could even reach +6°C or +7°C by the end of the century according to the work of a hundred scientists published in 2019, which will serve as a basis for the drafting of the 6th IPCC report (scheduled for 2021-2022)[16] .

The scenarios agree that in France, the frequency of heat waves should double by 2050.

DEFINITIONS

HEAT WAVES:
According to Météo-France, a heat wave episode corresponds to abnormally high temperatures observed for several consecutive days. There is no universal definition of the phenomenon, however Météo-France refers to a heat wave when a daily value of the national thermal indicator reaches or exceeds 25.3°C and remains high for at least 3 days. In this report, considering that the health of the players and the quality of the playing fields are impacted from a temperature of 32°C, this temperature threshold has been chosen to define heat waves.

"CANICULE" (EXTREME HEAT WAVE):
According to Météo-France, an episode of high temperatures, day and night, over a prolonged period. To identify them, temperature and duration thresholds are defined and vary according to region.

10. IPCC, Synthesis Report: Climate Change, 2014
11. Meteo France : http://www.meteofrance.fr/prevoir-le-temps/meteo-et-sante/canicules
12. ONERC, Extreme weather events in a changing climate, 2018
13. Létard, Flandre, and Lepeltier, La France et les Français face à la canicule : les leçons d'une crise, 2004
14. http://www.meteofrance.fr/actualites/73726667-record-absolu-45-9-c-c-est-la-temperature-la-plus-chaude-jamais-mesuree-en-france
15. http://www.meteofrance.fr/climat-passe-et-futur/climathd
16. http://www.cnrs.fr/sites/default/files/press_info/2019-09/DP_confpresse_CMIP6_OK.pdf

> *"The ability to adapt to the heat can be limited depending on the cyclists, even if some adapt more easily than others, there are inevitably physiological consequences: reduced performance with lower-than-average speeds, a more stretched 'peloton', extreme and marked fatigue on a greater number of riders, which can lead to discomfort."*
>
> **CÉDRIC CHAUMOND,**
> **DEPUTY NATIONAL TECHNICAL DIRECTOR OF THE FRENCH CYCLING FEDERATION**

In the next 30 years, the planet will heat up - regardless of the global warming trajectories we follow. However, our efforts to reduce emissions are critical, especially in the second half of the century. If we align ourselves today with the commitments made in the Paris Agreements, and achieve carbon neutrality[17] by 2050, it is still possible to slow the rise in temperature and stabilize it at 2°C.

B. THREATS TO THE PERFORMANCE AND HEALTH OF COMPETITORS

High-level athletes as well as amateurs are and will be impacted by rising temperatures and increasingly intense and frequent heat waves. More and more examples of sports competitions, affected by temperatures, demonstrate the urgency to consider these impacts and to act.

The Australian Open in 2014 is a good example. Started in the middle of a heat wave, the succession of four consecutive days with temperatures exceeding 41°C and sometimes bordering on 44°C greatly endangered the health of athletes and spectators. Several players fell ill and a record number of nine players dropped out of the tournament in the first round. The spectators were not spared either, as 1,000 fans suffered heatstroke (see box "Heatstroke, is it serious?" on page 22).

In France, during the heat wave episode of June 2019, the organizers of the Ironman of Nice had to shorten the distances of the mythical event when the thermometer showed 34°C at the finish. The region was placed on alert 2 heat wave "enhanced vigilance for all people".

The French Cycling Federation has also experienced difficulties with these heat waves. In particular, professional and amateur cyclists suffered during the French Cycling Championships held in June 2019 on the circuit of La Haye-Fouassière (Loire-Atlantique). The event was the scene of several ailments with temperatures approaching 40 ° C.

These few examples give us a glimpse of the future challenges for sport in France.

It is difficult to estimate the precise number of days on which it will be impossible to do sport in the future because of rising temperatures. According to Jean-François Toussaint, director of the Institute of Bio-Medical Research and Epidemiology of Sport (IRMES), "There is no physiological threshold for doing sport per se: there is a continuity of risk as we move away from comfortable temperatures. The physiological threshold depends on the effort required by the sport itself, as well as the training and physiology of each runner.

17. Carbon neutrality is to stop sending more CO_2 into the atmosphere than we can remove.

HEATSTROKE, IS IT SERIOUS?

As temperatures rise, the health of athletes, but also of spectators, volunteers, officials and organizers, is very quickly put at risk by the increased risk of heat stroke, which can occur in very hot weather, or following prolonged exposure to more moderate temperatures[18].

If the average temperature of the human body at rest is around 37°C, with effort and high outside temperatures, this body temperature tends to rise, allowing the body to maintain a difference in temperature with the surrounding air and therefore to promote the regulation mechanism that is sweating.

"Body temperature must remain below 40°C-41°C in order to avoid discomfort and heat stroke, which can be fatal. Obviously, the higher the outside temperature and the more intense and prolonged the activity, the lower the heat dissipation capacity."

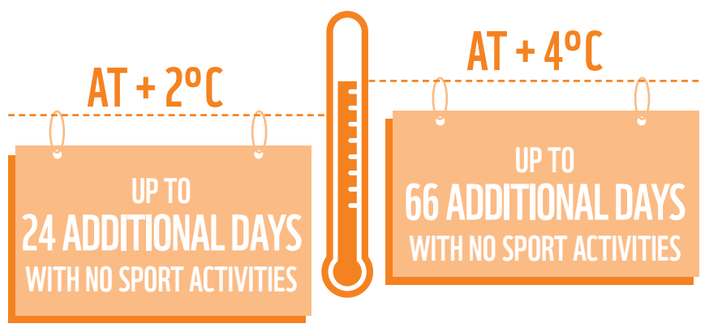
JEAN-FRANÇOIS TOUSSAINT,
DIRECTOR OF THE INSTITUTE OF BIOMEDICAL RESEARCH AND EPIDEMIOLOGY OF SPORTS (IRMES)

Symptoms of heatstroke can alert the athlete. They may start with cramps, heavy sweating, great thirst and/or abnormal fatigue. Then, there may be a cessation of sweating due to the lack of fluid in the body, shivering, and the nervous system may be affected, resulting in a loss of coordination and difficulty in thinking and concentrating.

18. Kosaka et al, Human body temperature regulation in extremely stressful environment: epidemiology and pathophysiology of heat stroke, 2004

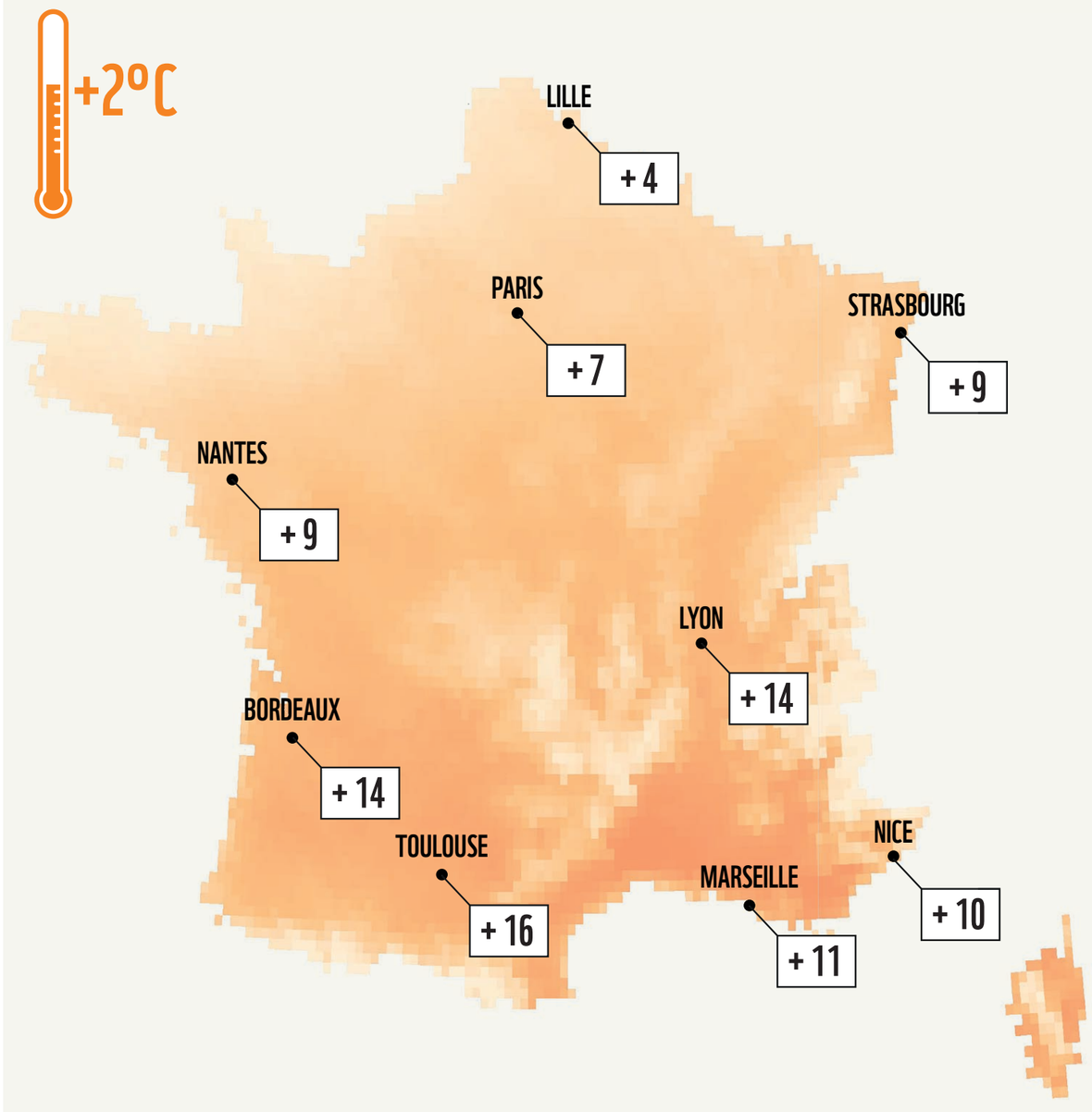
It is considered that above an outdoor temperature of 32°C, the health of professional and amateur athletes is potentially at risk.

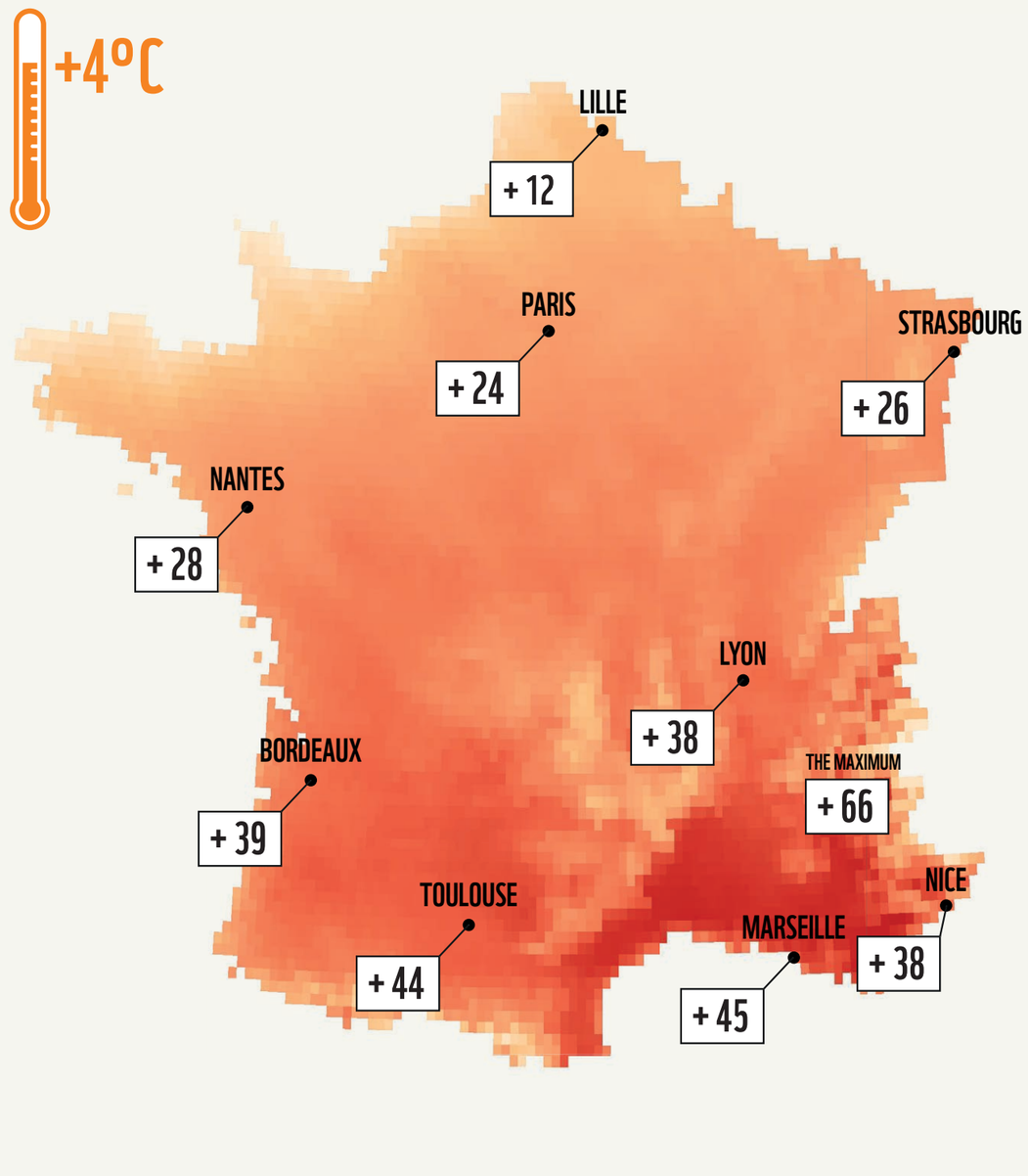
- In a global warming scenario of +2°C (i.e., 1 degree higher than today), we can expect an average of 9 additional days per year with temperatures above 32°C in France, and therefore, sporting activities will not be recommended. In the South of France, this figure could rise to 24 additional days.
- In a +4°C scenario, the number of days on which it is too dangerous to do sport will average 22 across France, with significant regional disparities: this figure will triple in the South of France, which could have up to 66 additional days on which it is not advisable to do sport.



MAPS OF THE NUMBER OF ADDITIONAL DAYS PER YEAR WHEN THE MAXIMUM TEMPERATURE WILL EXCEED 32°C

+2°C AND +4°C SCENARIOS





NUMBER OF ADDITIONAL DAYS PER YEAR WHEN THE MAXIMUM TEMPERATURE WILL EXCEED 32°C

0 15 30 45 67

Source: I Care & Consult

New behaviors to observe in the face of heat waves

If professional competitions are maintained, they will be increasingly broken up by drinking breaks, which are essential to protect the health of athletes. In rugby, for example, the National League has already introduced a refreshment break for summer matches.

Performance reduced by rising temperatures

Beyond health, rising temperatures also affect the performance of athletes. According to Jean-François Toussaint, the ideal temperature for high-intensity sport over a short period of time (e.g., sprinting) is around 23°C; for prolonged efforts, such as running a marathon, a temperature of around 10°C is preferable. As soon as you move away from these temperatures, performance generally drops. .

> *In all our games in August, we take drinking breaks every 20 minutes to hydrate the athlete and lower his body temperature. We've determined a 30-degree feel threshold, which is calculated based on humidity, temperature and sunlight.*

CHRISTOPHE GESTAIN,
TURF EXPERT FOR THE NATIONAL RUGBY LEAGUE AND THE FRENCH RUGBY FEDERATION

HOW DO FRENCH SPORTS REGULATIONS TAKE INTO ACCOUNT TEMPERATURE THRESHOLDS?

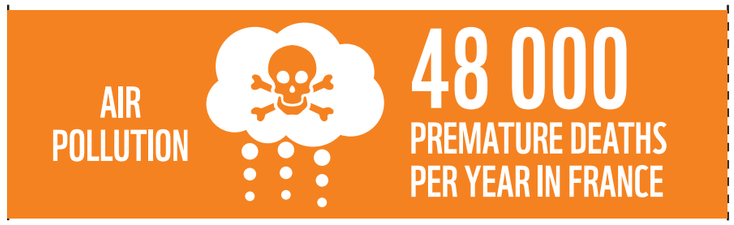
The consideration of weather conditions, and particularly temperatures, in federal sports regulations is very heterogeneous. For example, the French Swimming Federation takes into account, for open water swimming, minimum and maximum air and water temperature thresholds, beyond which competitions are modified (shortened distances, modified schedules...), postponed or cancelled depending on the severity of the conditions. The French Athletics Federation, in its running regulations, also takes into account the ratio of outside temperature to relative humidity using a WBGT (Wet-Bulb Globe Temperature) thermometer. On the other hand, many federations let the officials judge if temperatures are moderate or feel too extreme and decide what consequences these temperatures will have on the course of the sporting event. In addition, local authorities and 'prefectures' are often involved in the decision-making process to modify or postpone events in case of hot weather.

Federal regulations for indoor sports do not, for the most part, take into account temperature thresholds. Faced with a notable increase in summer heat waves in recent years, federations such as the French Cycling Federation are beginning to change their sports regulations to include measures to adapt to high temperatures in their amateur events. As temperatures are expected to rise in the future, it will become necessary to protect participants (both amateur and professional), the public, officials and organizers at sporting events by formally including in sporting regulations, temperature thresholds (and other indicators) beyond which competitions will have to be postponed or modified and specifying the type of heat adaptation to be deployed.

AIR QUALITY, A CRUCIAL ISSUE FOR SPORTS

In France, air pollution is responsible for 48 000 premature deaths per year[19]. This air pollution is a direct consequence of human activities and is exacerbated by climate change. Thus, as early as 2050, the negative influence of climate change on air pollution could counterbalance, in some areas, the effects of policies aimed at improving air quality. Indeed, heat waves increase the concentration of pollutants such as ozone or fine particles in the atmosphere.[20] The increase in periods of drought and heat waves will allow pollution to accumulate and stagnate and will also promote the formation of elements harmful to human health such as ozone and fine particles. These pollutants have a direct effect on the respiratory and cardiovascular systems: by clogging the capillaries and affecting the vascularization of tissues (brain, heart...)[21], they can lead to numerous hospitalizations and deaths.

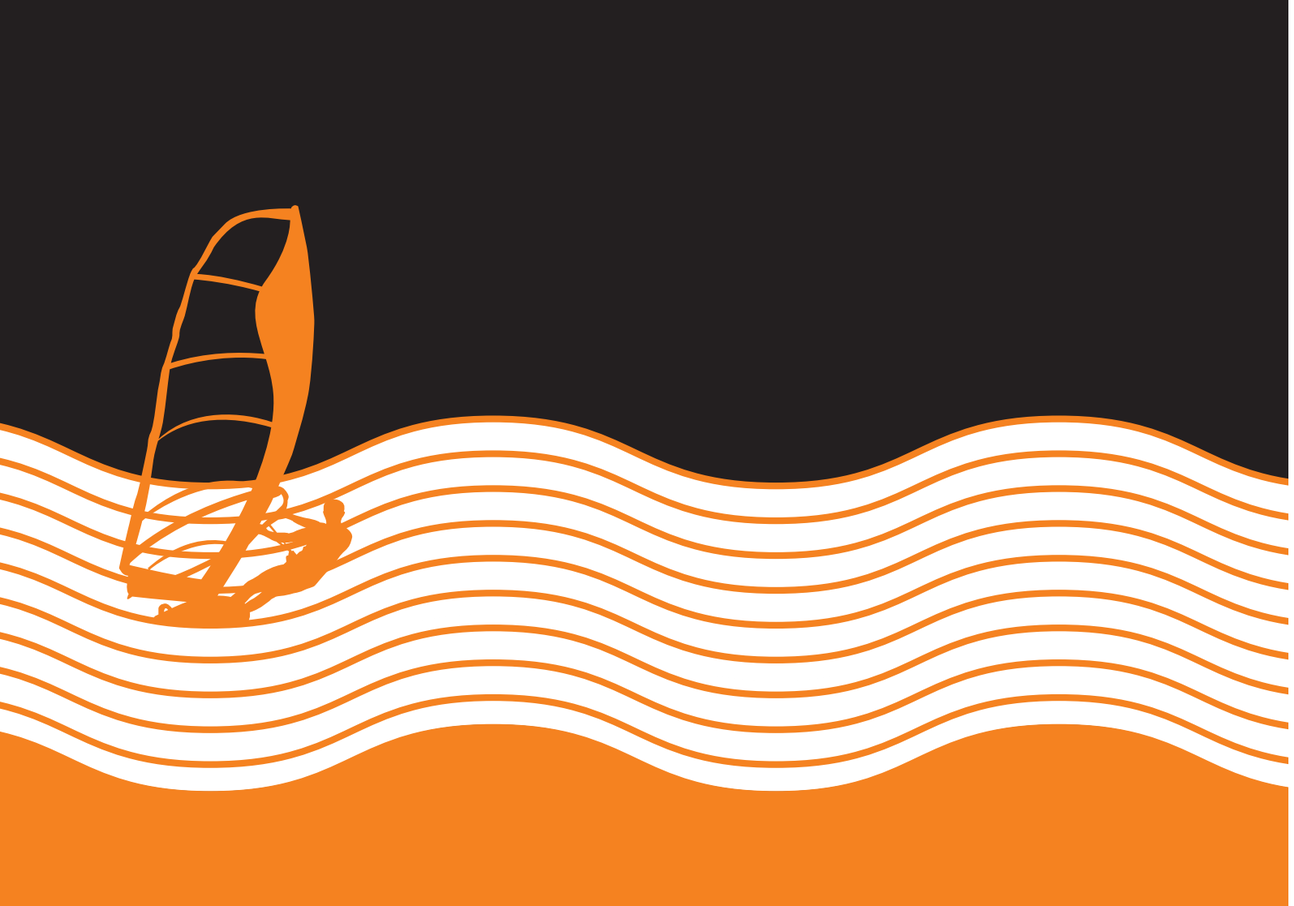
Athletes are particularly exposed to air pollution because physical effort leads to hyperventilation.[22] According to Greenpeace, the doses of air pollutants inhaled during physical activity are 4 to 10 times higher than at rest.[23] In a world where the conditions for pollution peaks will be more and more frequent and marked, the health of the participants and consequently the place of sport will be threatened. This is all the more true as high temperatures add to, or even exacerbate, the harmful effects of atmospheric pollutants, as is the case for ozone. Because of the strong interactions between temperature and air pollution, these issues must be addressed in a coordinated manner.



19. Health impacts of air pollution in France: new data and perspectives
20. https://www.teqoya.fr/rechauffement-climatique-pollution/
21. https://www.apc-paris.com/actualite/bande-dessinee-notre-sante-face-changement-climatique
22. Carlisle et Sharp, Exercise and outdoor ambient air pollution, 2001
23. Greenpeace, Air pollution takes over the soccer field, 2018

2

COASTAL SITES TO BE RELOCATED



With several coasts, 5500 kilometers of coastline - not counting its overseas territories, not taken into account in this study, France offers ideal conditions for coastal sports.

WATER SPORTS IN FRANCE

SOME KEY FIGURES[24]

11 MILLION
occasional users

MORE THAN HALF
of them do water sports on vacation

288 000 MEMBERS
of the French Sailing Federation and the French Surfing Federation

OBSERVATIONS

ACCORDING TO THE IPCC, SEA LEVELS COULD RISE BY 1 METER OR MORE IN A +4°C WORLD

CONSEQUENCES

COASTAL EROSION AND FLOODING

LEADING TO THE RELOCATION OF CLUB INFRASTRUCTURES

The success of these activities depends on several environmental conditions: accessible and unpolluted beaches, uncontaminated waters, safe sports clubs and facilities, stable paths around cliffs, safe climbing routes, forests preserved from the risk of fire, acceptable temperatures to limit the risk of heat stroke and drowning, etc. Unfortunately, climate change is already affecting these different conditions. Even greater impacts are expected in the future. Knowing them means being able to anticipate them and adapt - when possible.

24. MTES, Barometer of sports and leisure activities in France, 2016

SPORT THREATENED BY RISING SEA LEVELS AND MORE FREQUENT AND INTENSE STORMS

The coastline is far from being a fixed environment; its profile, shaped by sediments and waves, changes slowly but gradually. Human activities disturb this natural rhythm. They accelerate and exacerbate these transformations.

Sea level rise caused by melting ice and warming oceans is accelerating two natural phenomena:

- Coastal erosion, driven by sea movements;
- Floods, whether recurrent events due to tides or extreme episodes such as marine submersions (temporary invasion of the coastal zone by the sea).

These developments are clearly visible today: the sea level has already risen by about 15 centimeters on a global scale during the 20th century. These few centimeters, which may seem insignificant, have already led to the relocation of several coastal buildings. The fate of the Signal residence in Soulac-sur-Mer (Gironde) is a witness to this. Built in the 60s, 300 meters from the sea, it was only 20 meters from the shore in 2014 and had to be evacuated[25]. Since then, the rise in sea level has continued to accelerate and is now more than twice as fast as at the beginning of the century with an advance of 3.6 mm per year[26].

Between the periods 1924-1958 and 2005-2014, **20% of the French coastline has already suffered a retreat ranging from 0.1 to more than 3 meters,** this percentage rises to more than 50% in the departments of Seine-Maritime, Charente-Maritime, Gironde, Hérault and Bouches-du-Rhône[27]. In 50 years, we have already **lost 30 square kilometers of land surface, the equivalent of 4,200 soccer fields.**[28]

4 200

SOCCER PITCHES, THAT'S THE EQUIVALENT OF LAND AREA LOST IN 50 YEARS

THE EXAMPLE OF LACANAU

"The seaside resort of Lacanau (Gironde) has been experiencing the acceleration of coastal erosion since 2014, the level of recession of the coastline observed was the one initially expected for 2040. In total, there are 1200 apartments and 150 businesses threatened that we plan to relocate for a sum of about 330 million euros[29]."

LAURENT PEYRONDET,
MAYOR OF LACANAU

25. Lorin and El-Shafey, Impact of human activities on coastal erosion, 2018
26. Pörtner et al., IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, 2019
27. CEREMA, National coastal erosion indicator, 2018. Available online: http://www.geolittoral.developpement-durable.gouv.fr/premiers-enseignements-r476.html
28. Ibid.
29. Pörtner et al., IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, 2019

We are only at the beginning. According to the IPCC, without climate action and in a world of +4°C, the **sea level could rise by 1 meter or more**. Today, the frequency of episodes of marine submersion is only 100 years, but these phenomena **could become 500 to 800 times more frequent in the regions of Perpignan, the Basque coast and Finistère**[30].

The coastal territories are thus **caught "between two waves"**[31]; threatened both by human pressure caused by the tourist attraction of the coastline and by the rise in sea and ocean levels.

SITES AND FACILITIES IMPACTED BY THESE PHENOMENA

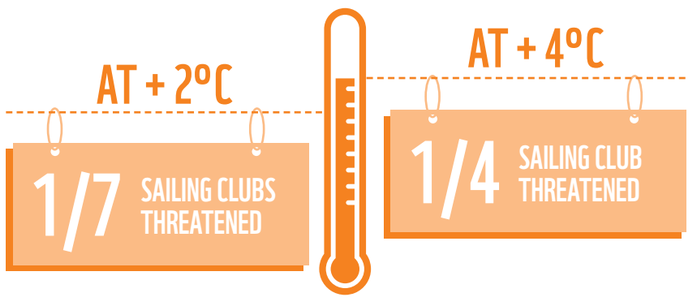
The rise in sea level, coastal erosion and the increase in the frequency of marine submersion episodes threaten sports areas (disappearance of beaches, destruction of hiking trails ...) and facilities.

The map below shows the future consequences under the two scenarios.

- In a world of +2°C, one sailing club out of seven located on the coast, is threatened by the rise in sea level. In France, this represents about 80 clubs[32]**.** More than half of these clubs are located on the Mediterranean. The consequences on clubs can range from damage to infrastructure (partitions, wall coverings, floors, ceilings, doors and windows...) to the erosion of foundations or retaining walls, or even the permanent loss of the building[33].

- In a +4°C scenario, the relocation of almost a quarter of the clubs located on the French coast (131 clubs out of 57634) would become potentially unavoidable. This figure rises to one in three clubs if only the Mediterranean coast is considered.

The consequences of climate change on sport do not stop there. The variation of the tides, but especially the rise in temperatures which, combined with the reverberation of the water, lead to an increased risk of heatstroke[35] and drowning (see chapter 1), will have a significant impact on the schedules and conditions of water sports.



30. European Environment Agency, Climate change impacts in Europe, 2020
31. Grosvalet, Les Départements face au défi littoral : Agir, animer, accompagner, 2017
32. Total number of clubs listed by the FFVoile on the French coasts
33. CEPRI, Les collectivités territoriales face aux risques littoraux, 2016
34. Total number of clubs listed by the FFVoile on the French coasts
35. Coles, Impacts of Climate Change on Tourism and Marine Recreation, 2020

MAPS OF SAILING CLUBS THREATENED BY SEA LEVEL RISE

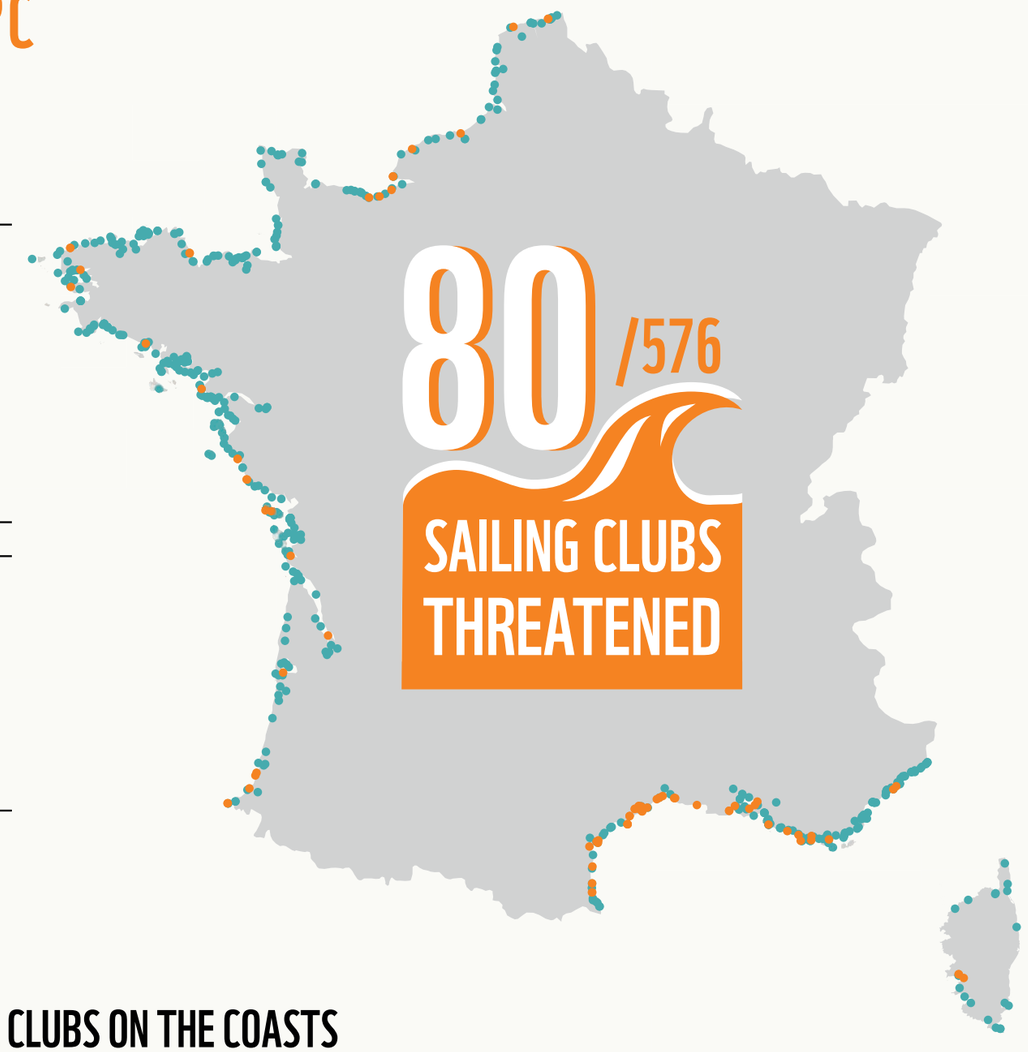
+2°C AND +4°C SCENARIOS

+2°C

11%

6%

12%



23%

+4°C

15%

12%

19%

38%

FFVOILE CLUBS ON THE COASTS

- AT RISK
- NOT IMPACTED

PERCENTAGE OF CLUBS AT RISK BY SEA FRONT

Source: I Care & Consult

3

MORE AND MORE COMPLEX GYMNASIUMS TO MANAGE

COLLECTIVE SPORT HALLS

SOME KEY FIGURES

collective sport halls in France

(source: Atlas MS 2011)

built before 1987

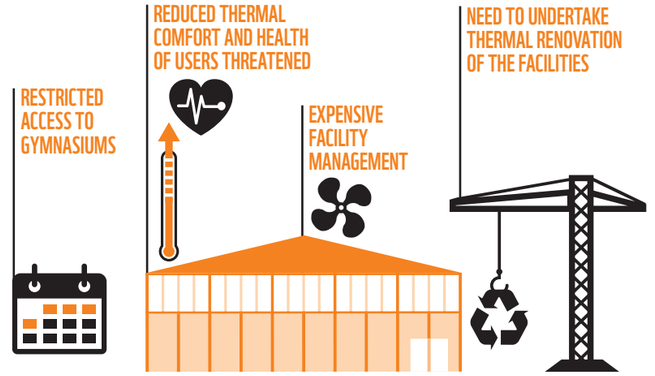
OBSERVATIONS

INCREASE IN AVERAGE TEMPERATURES

HEAT WAVES MORE AND MORE FREQUENT

SUNSHINE RATE ON THE RISE

CONSEQUENCES



Climate change is impacting sports facilities, which are often managed by local authorities. Whether it is for school sports classes, club training or weekend competitions, the 60,000 or so French sports halls frequently welcome the public[36]. With emblematic sports such as basketball or handball, whose respective federations have more than 500,000 members each[37], gyms are the scene of many matches. Faced with rising temperatures, the thermal comfort[38] and consequent health of the players are impacted and indoor practices are threatened. Therefore, local authorities must face these impacts by committing to the thermal renovation of their facilities.

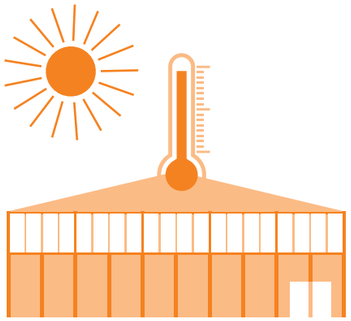
36. Ministry of Sports, Atlas of French sports facilities, 2011
37. INJEP, Les chiffres clés du Sport, 2017
38. Thermal comfort is defined as a feeling of well-being in a thermal environment specific to each individual. The greater the thermal discomfort, the more the individual's metabolism will be affected. Behind the issue of comfort, there is above all an issue of health and safety.

COLLECTIVE SPORTS ROOMS PROGRESSIVELY OVERHEATED

The observation is not new: during episodes of high temperatures, it becomes more often than not impossible to do sport indoors, and sporting sessions must be cancelled to preserve the health of the participants.[39] The increase in average temperatures, combined with increasingly frequent heat waves and rising sunshine levels, will increasingly reduce the accessibility of sports facilities.

It is a fact that the age of the French collective sports rooms is an additional difficulty. Most sports facilities date back to before the year 2000 and were not always built with materials that guarantee good insulation and are not adapted to high temperatures, as the issues of thermal comfort and health were rarely taken into account at the time of their construction.

In the event of extreme events such as heat waves[40], many sporting activities will be difficult to carry out in sports halls. The impact of rising temperatures will be different depending on the characteristics of the building: the construction materials used, the color of the exterior envelope and the roof, the orientation of the building and its ventilation are all parameters that can reduce or reinforce the consequences of rising outdoor temperatures and sunshine on the thermal comfort of sports halls. The outdoor temperature is therefore not sufficient to accurately predict the thermal comfort in a given gym. In a world of +2°C or +4°C, the specificities of each gym (material, insulation, exposure...) will influence the thermal discomfort threshold downwards or upwards, with more or less serious consequences on the health of the users.

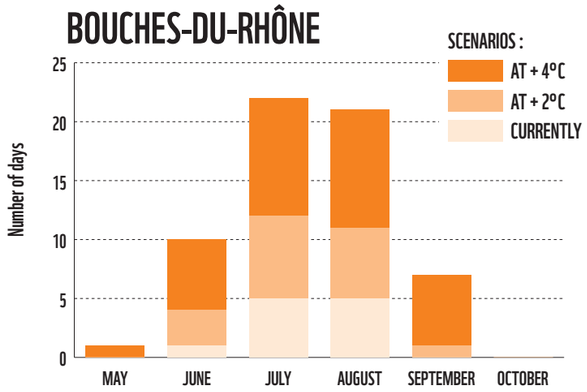


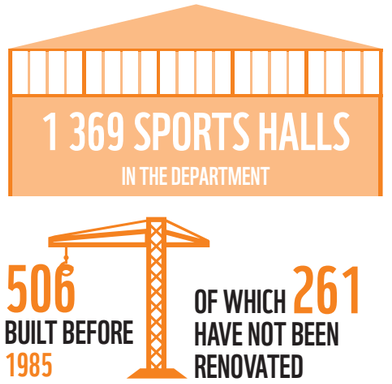
CASE STUDY:

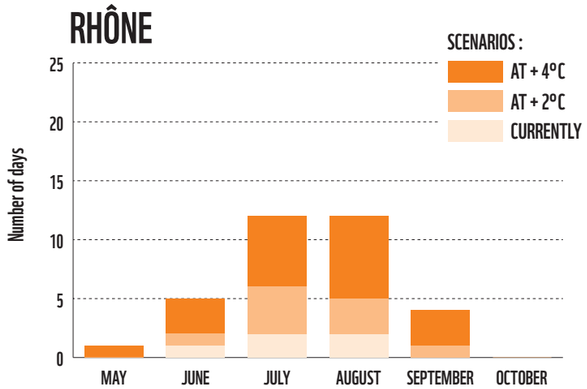
REGIONS FACED WITH HEAT WAVES

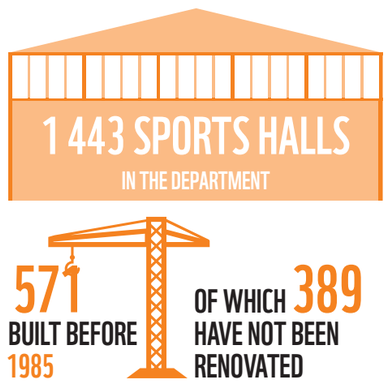
The study of the number of days of additional heat waves at +2°C and +4°C over the months of May to October for three regions with different climates (Bouches-Du-Rhône, Île-De-France and Rhône) reveals worrying situations for sports halls.

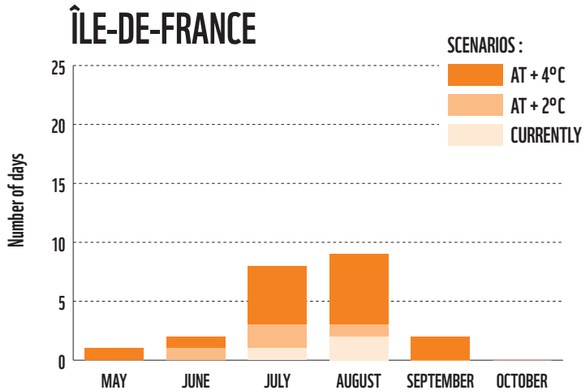
NUMBER OF DAYS OF HEAT WAVE ACCORDING TO THE SCENARIO

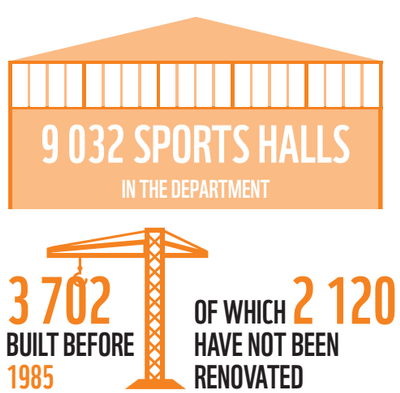












Number of additional heat wave days in +2°C and +4°C scenarios compared to today for the months of May to October, for the Bouches-du-Rhône, Rhône and Ile-de-France regions.
Source: I Care & Consult

39. https://www.jeunessecroissy-basket.fr/2019/06/canicule-fermeture-gymnase/
40. Understood here as episodes where the temperature exceeds 32°C for three consecutive days

If today in the Bouches-du-Rhône, there are 5 days of heat waves on average in July and August, tomorrow we could expect to observe:

• Up to 12 days of heat waves in a +2°C scenario,

• Nearly 22 days of heat waves with a +4°C scenario.

Heat waves will also affect the use of sports halls on the school calendar. In a +4°C scenario, in June, there could be 5 days of heat waves, instead of about one day today in the Lyon region, and up to 9 days in the Bouches-du-Rhône.

It should be noted that this data is conservative. The 'urban heat island' effect has not been adequately taken into account[41]. This phenomenon, which is characterized by higher temperatures in the urban area than in its immediate surroundings (due to heat-emitting human activities and urban materials), can result in up to 4°C higher temperatures in the city.

B. TOWARDS INCREASINGLY COSTLY MANAGEMENT OF SPORTS HALLS

About half of the French collective sports halls were put into service before 1987[42], that is to say almost 35 years ago. In Beauvais, for example, nearly half of the gymnasiums have not been renovated in 40 years, which means that the municipality now must pay a heavy renovation bill of nearly 6 million euros[43].

Faced with rising temperatures and increasing heat waves, it is in the best interest of local authorities in charge of facilities to undertake thermal renovations of buildings to make them energy efficient. New projects, on the other hand, offer the opportunity to integrate thermal comfort expectations, taking into account future climate changes from the design stage, while limiting the building's operating costs (on which energy expenses weigh heavily).

> *Over the entire life of the sport facility, we have three types of costs: operating costs (70%), investment costs (25%), and engineering costs (5%). Operating costs represent the vast majority of overall costs and there is a real challenge to optimize these costs. For example, we will make this a significant chapter in the next guide on public pools to help locally elected officials in their approach.*
>
> **CYRIL CLOUP,**
> **DIRECTOR GENERAL OF THE NATIONAL ASSOCIATION OF ELECTED OFFICIALS IN CHARGE OF SPORTS (ANDES)**

41. The models used have a spatial resolution of about 12 km, which is not sufficient to accurately account for temperature differences between urban areas and their surroundings.
42. Atlas of French sports facilities - Ministry of Sports - 2011 http://www.sports.gouv.fr/Atlas_des_equipements_sportifs_francais/index.htm#/32
43. From a testimony by Philippe Vibert, then deputy sports director of Beauvais, for Le Parisien - 2018 https://www.leparisien.fr/oise-60/a-beauvais-6-gymnases-sur-14-declares-vetustes-08-01-2018-7489779.php

Climate change can have a significant economic impact for the managers - and also the beneficiaries - of poorly adapted infrastructures. Conversely, the adaptation of these infrastructures presents an opportunity to control and sustainably reduce the economic and energy expenses for managers. Indeed, the building sector represents nearly 45% of national energy consumption and more than 25% of greenhouse gas emissions in France. To do this, a comprehensive and ambitious renovation would improve the insulation of buildings and considerably reduce heat loss while increasing the inertia of the building (constant heat in winter, distribution of coolness in summer).

BEWARE OF ERRORS OF ADAPTATION

Unfortunately, adaptation is not always well thought out. A widespread, but less than optimal solution is the installation of an air-conditioning system: although it may seem interesting from time to time and in the short term, air-conditioning will not meet the economic challenge because it is not very profitable, nor the environmental challenge. Indeed, air conditioning, through its energy consumption but also through the potential leakage of refrigerants with a high greenhouse effect (when they do not contribute to the destruction of the ozone layer), participates in the amplification of climate change and the phenomenon of urban heat islands, by heating the outdoor space: it is therefore not an effective solution in the medium and long term.

CASE STUDY:
THE RENOVATION OF THE GYMNASIUM IN HAUTE-SAÔNE HIGHLIGHTS THE BENEFITS OF THERMAL RENOVATION

Built in 1972, the gymnasium in the commune of Gy in Haute-Saône is used by schools, educational centers and sports associations. In 2013, the gymnasium underwent a complete renovation, improving the building's insulation and waterproofing, connecting the heating system to a heat network and equipping the roof with solar panels to heat domestic water. The result: a 68% reduction in the building's energy needs, a reduction in consumption of 200 kWhep (from 290 before renovation to 90 afterwards) and €24,400 saved per year for the municipality. Although the overall cost of the work was €1.65 million, including €990,000 for energy renovation, the municipality was able to count on €848,000 in aid from ADEME, the Franche Comté Regional Council, the Haute-Saône General Council, and the State[44].

THE RENOVATION RESULTED IN A 68% REDUCTION IN ENERGY NEEDS AND 24,400€ SAVED PER YEAR

44. ADEME, Energy savings thanks to a high-performance renovation at the gymnasium in Gy (70), 2014

GRASS FIELDS BECOME LESS AND LESS PLAYABLE

Doing sport on grass fields is more and more threatened every day. This concerns a large number of French people for whom daily life is sometimes punctuated by the weekly match on the communal field or by a professional match on television. Nearly 43,500 playing fields throughout France are the scene of more than one million matches each year, played by amateurs and professionals alike[45]. However, the increase in drought episodes, combined with other extreme weather events - floods, heavy rainfall, frost... - are jeopardizing the practicability of grass fields.

FIELD SPORTS

SOME KEY FIGURES

OVER 1 MILLION

soccer matches per season [46]

43 523

playgrounds in France[47]

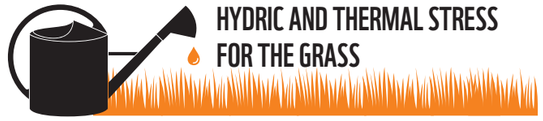
90 %

of the large French soccer fields are natural grass [48]

OBSERVATIONS

INCREASE IN FREQUENCY AND INTENSITY OF DROUGHT AND EXTREME WEATHER EVENTS

CONSEQUENCES



HYDRIC AND THERMAL STRESS FOR THE GRASS

THE GRASS IS IN DANGER IF TEMPERATURES EXCEED 32°C FOR SEVERAL DAYS AND DO NOT DROP BELOW 24°C AT NIGHT

45. INJEP, Les chiffres clés du Sport, 2017
46. Professional Football League and French Football Federation
47. Census of Sports Facilities (RES), Ministry of the City, Youth and Sports, situation as of July 1, 2016
48. ANSES, 2018 https://www.anses.fr/fr/system/files/CONSO2018SA0033.pdf

A. PLAYING FIELDS WEAKENED BY CLIMATE CHANGE

In a world where the climate is changing, the grass that makes up our playing fields is being damaged and their exposure to water[49] and heat[50] stress is becoming more frequent and intense.

As a result of a lack of water in the surface soils, **soil drought** has a significant impact on the proper development of vegetation - including grass. A natural phenomenon, soil drought is exacerbated by rising temperatures and lower rainfall because of climate change.

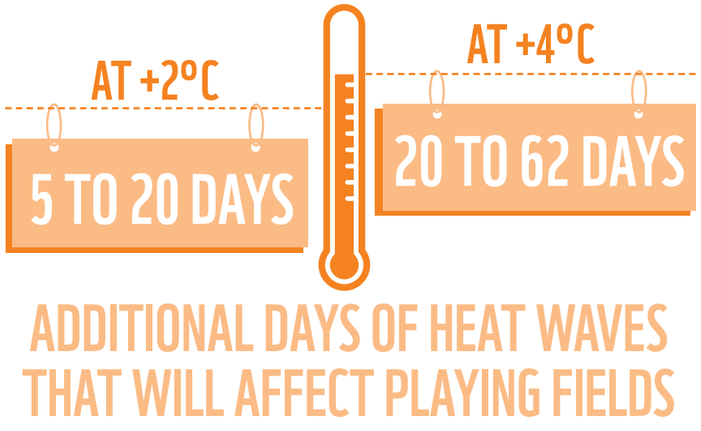
Today, **this intensification of soil drought is quite evident in France**. Since the 1960s, the surface area affected annually by this phenomenon has already increased from 5 to 10% of the national territory[51] and we are only at the beginning of this evolution. According to climate projections for metropolitan France, a situation that would have been described as extreme drought between 1960 and 1990 is likely to become normal in a world at +4°C[52].

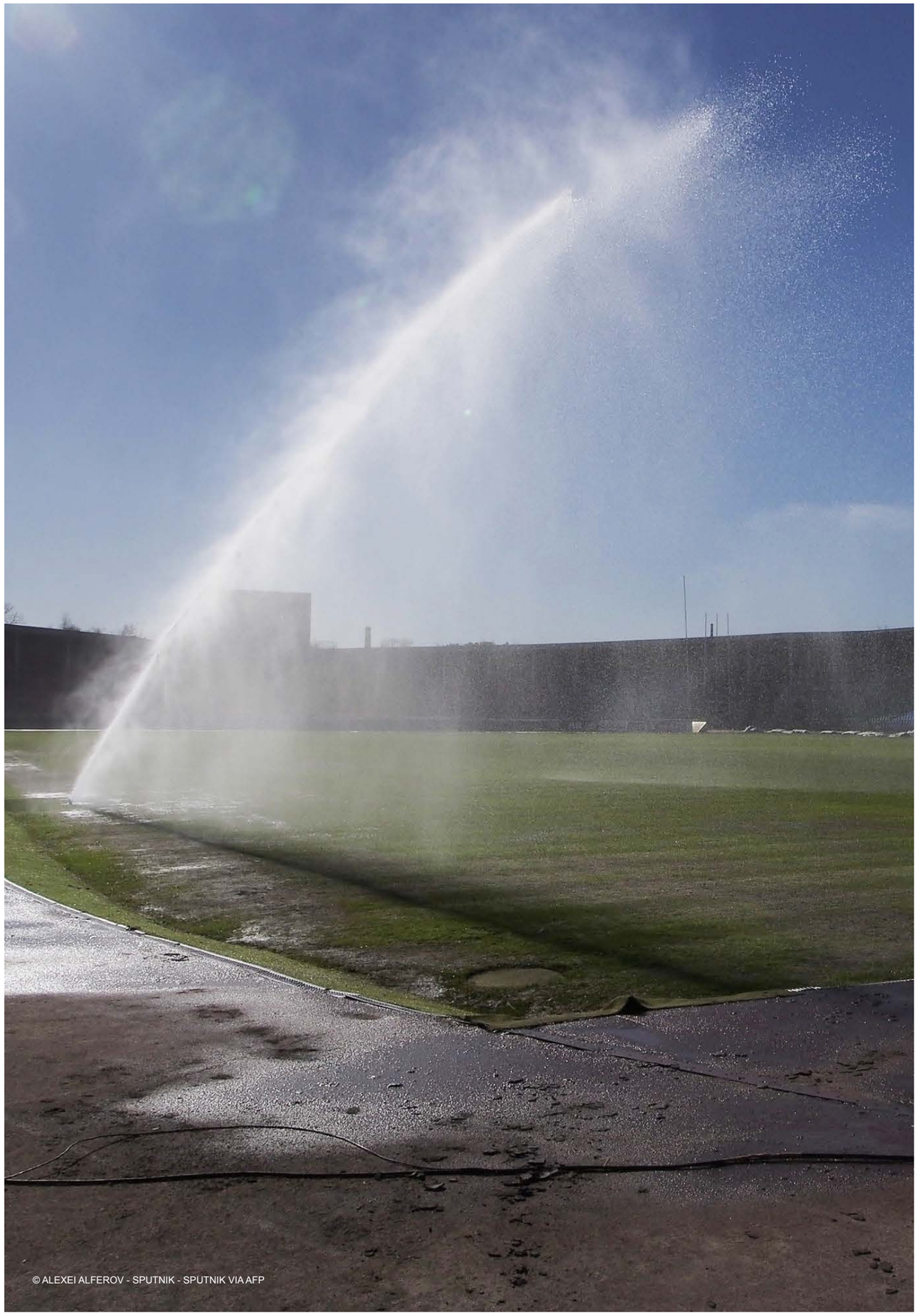
In addition to the risk caused by the decrease in the quantity of water available, thermal stress is also a major problem for the health of turf. Heat stress is caused by a prolonged rise in temperature that has a direct impact on the metabolism of plants and their roots. The sandy composition of the stadiums is sought after for its permeability during the very wet and cold months: it helps to fight against frost, favors soil heating and accentuates the turf's sensitivity to temperatures.

Thus, when temperatures exceed 26°C, the plant goes into semi-dormancy, a "self-defense" mechanism. After 32°C, the danger of death of the grass is imminent. **Finally, when temperatures exceed 32°C for several consecutive days and do not go below 24°C at night, the grass cover is seriously compromised** if no cooling solution is put in place. In a world that is **already more than 1°C warmer than** pre-industrial times[53], and with heat waves becoming more intense and frequent, **the threat of heat stress is a growing reality**.

• A rise in global temperatures of +2°C (1 degree higher than today) could result in 5 to 20 days of additional heat waves[54] for almost half of French stadiums, i.e., 16,309 amateur and professional stadiums. 648 stadiums, mostly located in the south of France, could experience 20 to 30 days of additional heat waves.

•In a world of +4°C, 30% of the stadiums in France would have to expect 20 to 30 additional days in heat waves. For a quarter of the stadiums (25%), the number of days of heat wave could be between 30 to 62 days.



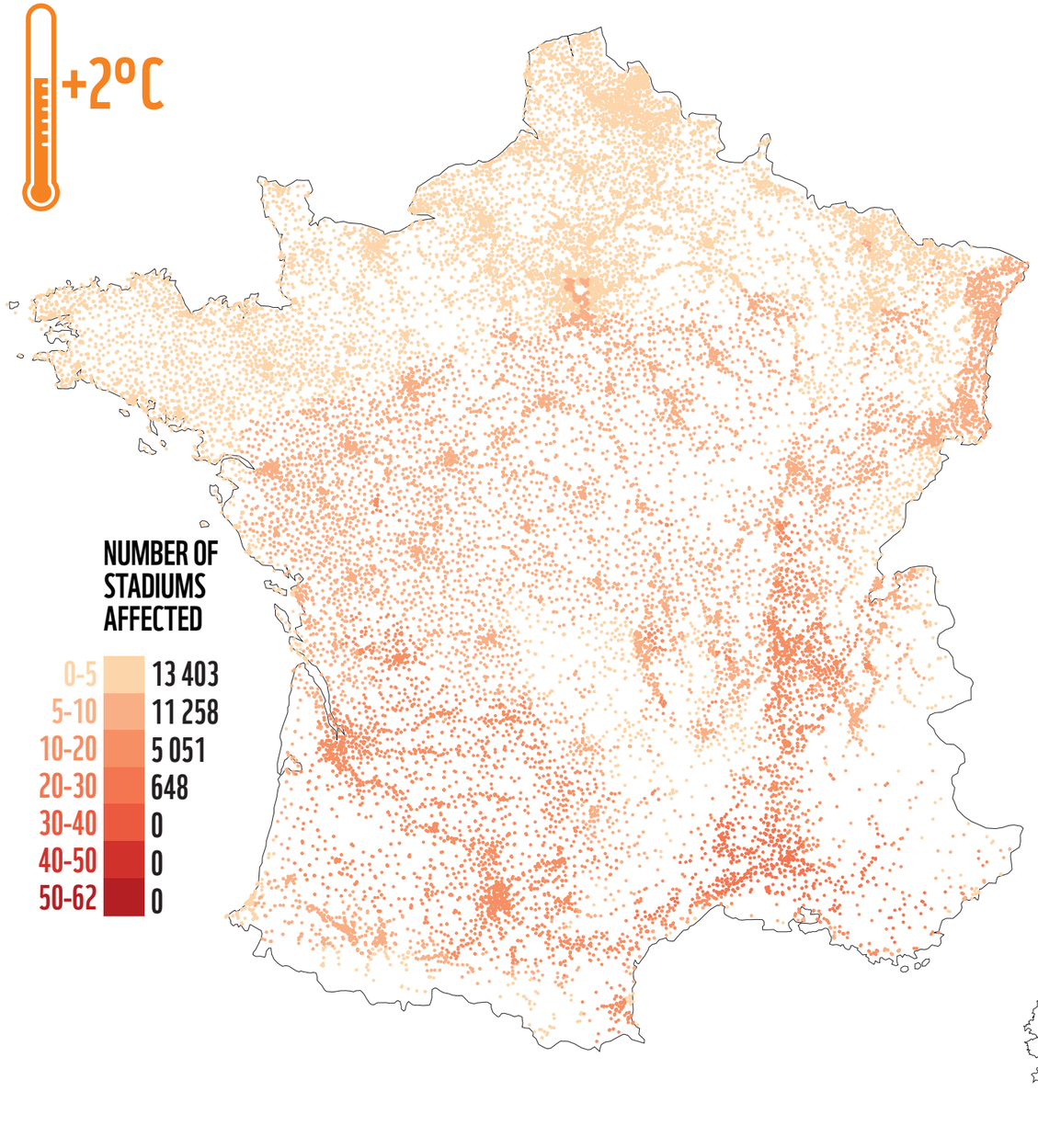


49. Water stress: stress suffered by a plant placed in environmental conditions such that the amount of water transpired by the plant is greater than the amount it absorbs
50. Thermal stress: changes in plant physiology when temperature increases or decreases beyond normal conditions
51. averages observed over 10 years
52. http://www.meteofrance.fr/climat-passe-et-futur/climathd
53. IPCC, 1.5° C Report, 2018
54. Compared to the IPCC reference period (2014): 1980 - 2004

EXPOSURE OF THE STADIUMS TO THE NUMBER OF ADDITIONAL DAYS OF HEAT WAVE

SCENARIOS AT +2°C AND +4°C

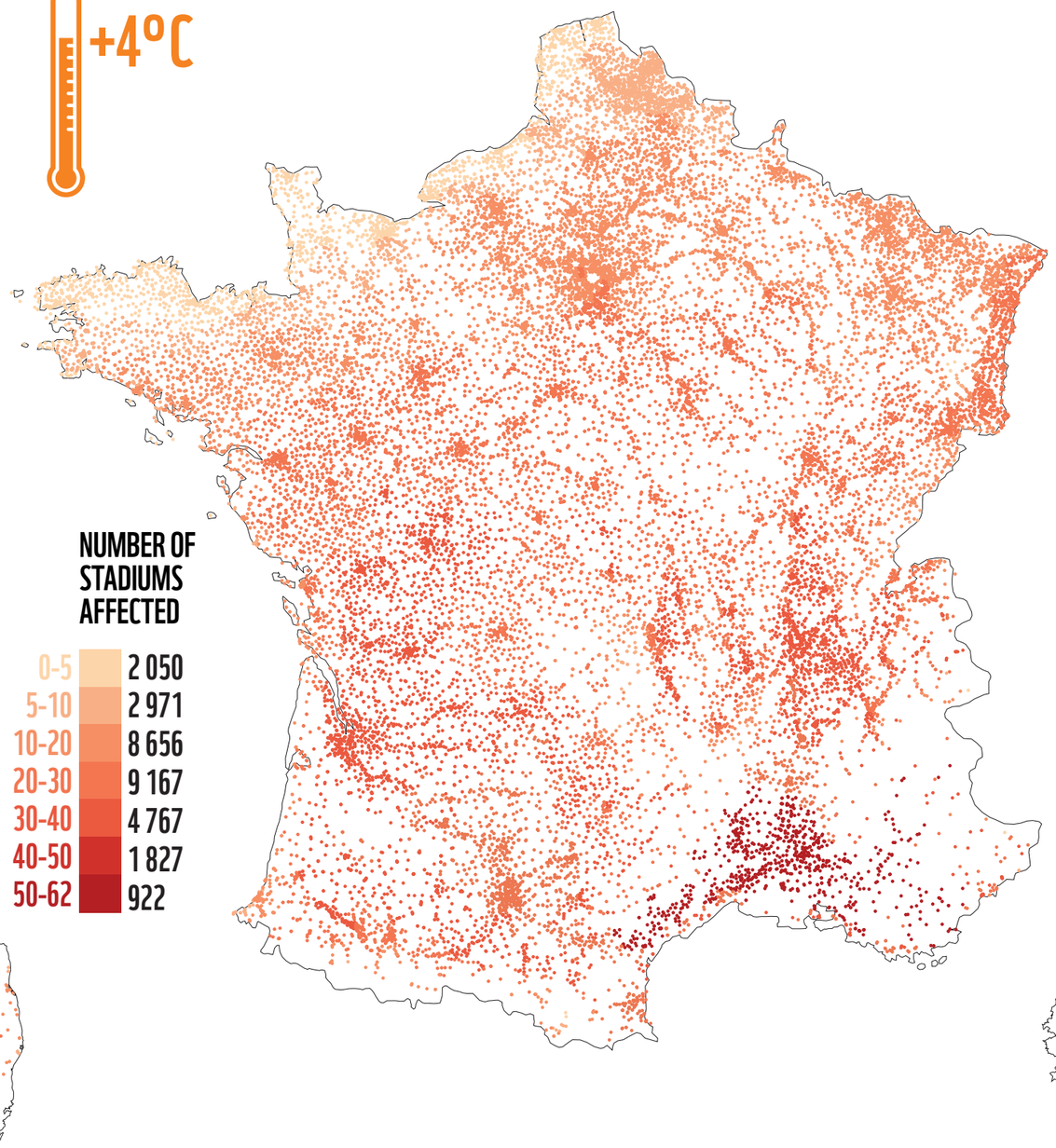
+2°C



NUMBER OF STADIUMS AFFECTED

0-5	13 403
5-10	11 258
10-20	5 051
20-30	648
30-40	0
40-50	0
50-62	0

+4°C



NUMBER OF STADIUMS AFFECTED

0-5	2 050
5-10	2 971
10-20	8 656
20-30	9 167
30-40	4 767
40-50	1 827
50-62	922

NUMBER OF ADDITIONAL DAYS OF HEAT WAVE PER STAGE

0-5 · 5-10 · 10-20 · 20-30 · 30-40 · 40-50 · 50-62 DAYS

Source: I Care & Consult

Ambivalent solutions to the phenomenon of «burnt-out playing fields»?

While the increase in the number of days of heat waves exacerbates the risk of burnt turf, several measures to cool the field are usually adopted during heat waves. Watering the field is the most common solution, but there are other techniques that can be very energy-intensive, such as ventilation with misting, or circulating cold water through underground anti-freeze pipes.

However, in case of high temperatures and drought, watering, when it is not forbidden by the prefectural decrees (see box below), is not always the solution. Indeed, hot and humid conditions favor the development of fungi. A classic example, Phythium made a name for itself in 2016 when it ravaged several fields in a few months (Saint-Étienne, Bordeaux, Bastia, Montpellier...). This fungus, which proliferates when temperatures exceed 30°C during the day and do not drop below 20°C at night, is treated with fungicides that make it impossible to use the pitch for 48 hours. Moreover, the use of fungicides does not appear to be a solution for the future in relation to environmental issues.

In conclusion, although adaptive solutions exist to combat overheating, they are not always viable or desirable. Faced with a rapidly increasing risk of heat stress, the management methods used to date are revealing their weaknesses and need to be rethought.

> *Today's field construction models are not eco-responsible, we have to admit. We need to rethink the agronomic approach; sand stadiums and the turf grass usually used, lead to excessive energy consumption for cooling and a greater thermal impact on the pitch than on a traditional pitch.*
>
> CHRISTOPHE GESTAIN,
> AGRONOMIST AND TURF EXPERT FOR THE NATIONAL RUGBY LEAGUE AND THE FRENCH RUGBY FEDERATION

FOCUS

DIFFICULT DECISIONS IN THE FACE OF WATER RESTRICTIONS AND EXTREME WEATHER EVENTS

With the intensification of heat waves and periods of drought**, stadium managers are more and more regularly confronted with water restrictions**. Indeed, in order to face a shortage of water resources during low water periods, the prefects are sometimes led to take exceptional measures of limitation or suspension of water uses. These restrictions, which can be triggered at different thresholds defined at the local level by the prefects, can concern the watering of pitches in case of reinforced drought alert.

In some cases, professional stadiums and other main grounds can be spared from prefectoral orders. However, the **problem of the acceptability** of these decisions is well and truly present. For example, **professional stadiums do not necessarily have a much greater capacity to adapt to** water and heat stress.

Concerning the question of professional championships, past events have shown us that **the rise in temperatures is not the only impact of climate disruption with serious consequences**. Indeed, with the **increase in frequency and intensity of extreme events,** professional players are not immune to seeing competitions postponed or even cancelled. This is shown by **the cancellation of the France-England and New Zealand-Italy matches during the first round of the 2019 Rugby World Cup in Japan due to the passage of a typhoon.** Consequence: a big disappointment for the fans who could not attend the France-England match and, if France and England were already both qualified for the 2nd round, Italy saw all its hopes of qualification reduced to nothing[55]. Beyond the sporting disappointments, the economic losses were high.

B. COSTLY SOLUTIONS FOR RESTORING A BURNT-OUT PITCH

A **good pitch is an essential ingredient** for a good game. On this subject, the rules are very clear**: the grass must be dense and uniform in all circumstances**. As an ally of the players, it allows them to absorb shocks and to protect their joints. Thus, a pitch that is too worn can quickly become a source of injury and potentially a hindrance to the game.

Faced with fields that burn out in the summer, managers have two options:

In the first case, for lack of anything better, the grass will be burnt and other types of less noble grass will take over. The manager will still decide to water at the end of the summer and to spread fertilizer, spending about 5,000 to 6,000€[56] and providing conditions to continue with certain competitions. However, this is not a permanent solution: in winter, the immature turf will be quickly destroyed by the trampling of the players.

The second option, which is more permanent, consists in redesigning the field according to the current standard. This option is rarely chosen by communities and involves closing the field for three months and paying up to 30,000 €[57].

ARTIFICIAL TURF, A CONTROVERSIAL SOLUTION

The impacts of synthetic fields on the health of players and on the environment are controversial. While concerns about the toxicity of rubber granules in synthetic stadiums have not yet been unanimously confirmed by the scientific community, the French National Health Security Agency (Anses) does not rule out a potential health risk[58]. Thus, **more and more cities, such as Paris and New York, prefer to prohibit its use while waiting for in-depth toxicological analyses.**[59]

From an environmental point of view, artificial turf also raises questions. **While natural grass captures and holds CO_2 and refreshes the air at the same time, synthetic grass only accumulates heat, until it becomes too hot and prevents the game from going ahead.** Managers then find themselves having to water the synthetic turf before games to lower its temperature.

55. https://www.lemonde.fr/sport/article/2019/10/09/coupe-du-monde-de-rugby-2019-un-typhon-menace-serieusement-france-angleterre_6014840_3242.html
56. This amount, indicated before tax, was communicated to us by Christophe Gestain, turf expert for the Professional Football League and French Football Federation and is based on his expertise in the field.
57. Ibid.
58. https://www.anses.fr/fr/system/files/CONSO2018SA0033.pdf
59. https://www.leparisien.fr/societe/les-terrains-de-foot-synthetiques-sont-ils-dangereux-pour-la-sante-21-02-2018-7572414.php

5

WINTER SPORTS UNEVENLY THREATENED

With the rise in temperatures, snow cover in the six French mountain ranges is threatened, and with it the sustainability of the current economic model of winter sports resorts based primarily on winter exploitation of mountain territories. The 250 French winter sports resorts rank third in the world in terms of skiing-days sold, after the United States and Austria[60]. With 10 million tourists per year, 7 million of whom do snow sports[61], winter tourism represents 10 billion euros spent in the resort each year and more than 120,000 jobs that depend on the opening of the skiing area[62].

WINTER SPORTS

SOME KEY FIGURES

250

winter sports resorts in France

120 000 JOBS

depend on the opening of skiing areas

10 BILLION €

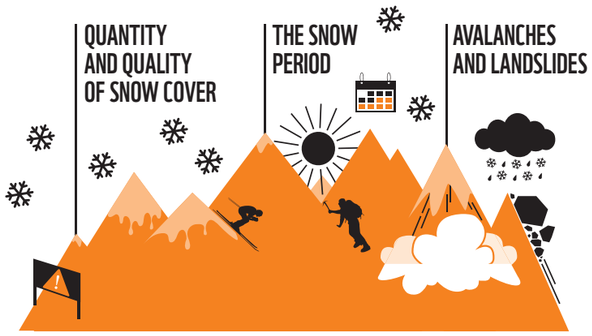
spent in resorts each winter

OBSERVATIONS

-1 MONTH

OF SNOWFALL EXPECTED PER DEGREE OF FUTURE WARMING

CONSEQUENCES ON



60. Domaine Skiables de France, Indicators and analysis, 2020, available online: http://www.domaines-skiables.fr/fr/publications/observatoire/
61. Ibid.
62. ibid.

A. DECLINE IN SNOW LEVELS

The downward trend in natural snow cover in low and medium mountain resorts is already evident today - even if conditions vary greatly from year to year. At the Col de Porte (Northern Alps), a reference station for Météo France located at an altitude of 1,325m, the observation is clear. **Over the last twenty years, the snow depth has been on average 40% less than in the previous period,** with an average depth of 110 cm over the period 1990-2017, i.e., a decrease of 39cm compared to the period 1960-1990[63].

Rising temperatures due to climate change pose a double threat to snowfall. On the one hand, higher temperatures lead to a rise in the altitude of the rain-snow line, which reduces snowfall. On the other hand, the rise in temperature has a direct impact on melting, and therefore on the thickness of the snowpack. As a consequence, the snow accumulation decreases, and the melting mechanisms increase in time and intensity[64]. The first effect is mainly active at low and medium altitudes, while the intensification of melting is observed at all altitudes.

Projections are not optimistic: they assume a significant reduction in average snow cover, especially in mid-altitude areas. Today, we know that in the Alps at an average altitude of 1500m:

• A global temperature increase of 2°C compared to pre-industrial levels corresponds to a 30% reduction in the average thickness of the snow cover in winter.

• In a +4°C world, this reduction could amount to 80%[65].

In addition to the decline in snow amounts, the snowfall season is being shortened. While the season and snow cover should be long enough to coincide with school vacations and public holidays (ideally from the beginning of December to the end of March[66]), climate change is tending to lengthen the summer period. Thus, mountain regions could lose almost one month of snow season duration per degree of future warming. This will[67] result in a lower quality and quantity of snow (with different consequences depending on the altitude), which will impact skiing and the associated economic benefits.

The reduction in snow cover is the most striking threat to winter tourism, but there are others. Climate change will also continue to affect the intensity and frequency of certain natural risks already present in the mountains. These include flooding, which will become greater with changes in precipitation patterns, wet snow avalanches, landslides, and the destabilization of rock faces.

Under the effect of global warming, infrastructure is endangered by the thawing of the permafrost[68], commonly called the cement of our mountains. The durability of mountain facilities that rely on permafrost is in question and it will become necessary for skiing resorts to invest in securing these infrastructures on which the future of the mountain destination depends.

1 MONTH LESS OF SNOW IN WINTER PER DEGREE OF FUTURE WARMING

63. http://www.meteofrance.fr/espace-presse/61477103-alpes-du-nord-nouvelles-projections-climatiques-de-l-enneigement-a-moyenne-altitude%22
64. Durand and al., Reanalysis of 47 years of climate in the French Alps (1958-2005): climatology and trends for snow cover, 2009
65. Morin and al., Linking variations of meteorological and snow conditions in the French mountain regions to global temperature levels, 2018
66. Clim'Ability, Climate Change: Winter Tourism in the Upper Rhine, 2019
67. http://www.meteofrance.fr/espace-presse/61477103-alpes-du-nord-nouvelles-projections-climatiques-de-l-enneigement-a-moyenne-altitude
68. The area of the ground where the temperature remains below 0°C and is covered by a layer of earth that thaws in summer, allowing vegetation to develop. Under the effect of global warming, its thawing can cause landslides and avalanches.

B. SHORTER WINTER TOURIST SEASONS FOR SKIING RESORTS

In the front line, winter sports resorts will particularly feel the consequences of the decline in snow cover and the gradual reduction of the snow season. In 2019, the Deux Alpes glacier, culminating at 3600 meters above sea level, had to close its lifts earlier than expected in early August due to a lack of snow. In Tignes, the Grande Motte glacier suffered the same fate. If these isolated episodes cannot be directly attributed to climate change, whose effects are observed over long periods (generally 30 years), we can expect an increase in the frequency of these situations in the future.

In concrete terms, what impact will these developments have on the reliability of snow conditions for skiing resorts? A study published in 2019[69] has attempted to provide an answer to this question. The evolution of the snowpack was studied for 175 resorts in the Alps and Pyrenees, based on several climate scenarios.

Snowpack reliability is assessed at two levels: natural reliability, which analyzes whether the snowpack is sufficient, taking into account only snowfall, and managed snow reliability, which takes into account the production of artificial snow and grooming of the slopes.

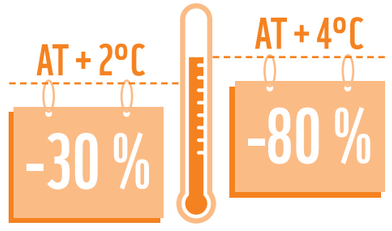
With all these assumptions, the result is clear.

• In a world of +2°C[70], in the Pyrenees, only 3 resorts will still be able to count on sufficient natural snow cover. Under these conditions, projections indicate that more than half of the resorts in the Pyrenees will face insufficient snow conditions in relation to current operating criteria, despite the use of artificial snow, which also amplifies other environmental impacts (see box on page 52).

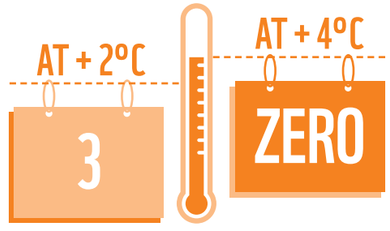
• For a +4°C scenario, the projections indicate that no skiing resort in the Alps and Pyrenees has a reliable natural snow cover. In most cases, artificial snow will not be sufficient to guarantee satisfactory snow cover under current operating conditions. With about 20 resorts whose snowmaking would be considered satisfactory, taking into account artificial snow, the Alps would become the last bastion of French skiing[71].

In the face of climate change, it is clear that resorts are already facing a high risk of revenue loss. Whether it is because of unfavorable weather conditions for the opening of the slopes, the decrease in the number of reservations from year to year, or the increase in expenses for the installation of snow guns and their operation, expenses will increase, and revenues will decrease. Mountain resorts will have to adapt their model and diversify their activities to survive the disappearance of winter sports.

AVERAGE THICKNESS OF SNOW COVER IN WINTER IN THE ALPS (AT AN AVERAGE ALTITUDE OF 1500M)



NUMBER OF RESORTS WITH SUFFICIENT NATURAL SNOW COVER IN THE PYRENEES



69. Spandre and al, Winter tourism under climate change in the Pyrenees and the French Alps: relevance of snowmaking as a technical adaptation, 2019
70. In this publication, and unlike the rest of our study, +2°C corresponds to the RCP 2.6 scenario at the end of the century (2080-2100)
71. ibid.

ARTIFICIAL SNOW, A LIMITED AND EXPENSIVE SOLUTION

Although artificial snow was originally used to make up for occasional shortfalls, this technique has now become widespread. In France, 32% of the surface area of French skiing resorts is equipped to produce artificial snow and this figure is constantly increasing.

From an environmental point of view, the process of producing artificial snow is extremely energy intensive. It depletes water reserves and increases greenhouse gases. There are additional repercussions on biodiversity: alteration of the chemical structure and make up of the soil and impacts on the development of vegetation and wildlife. In addition, because of climate change, artificial snow will not be a sustainable solution for many skiing stations, notably because of their altitude. Both the production and storage of artificial snow require low temperatures and days when it freezes. These conditions are becoming less and less likely as temperatures rise.

In addition, not everyone can afford this option. The production of snow requires substantial water and energy resources that can quickly weigh heavily on the bills of resorts. The resort of Tignes, which, with its 355 snow cannons, was able to increase the volume of artificial snow produced by 20% between 2007 and 2015, has seen its bill increase by 30% over the same period due to the rise in the price of electricity[72].

72. Source: Annual public report to the Court of Auditors, 2018

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FOCUS ON RUNNING AND SOCCER

RUNNING

13.5 MILLION RUNNERS

INCLUDING

- **5 MILLION** regular runners (at least once a week)
- **3.9 MILLION** occasional runners (less than once a week)
- **4.6 MILLION** who go running in addition to another sport

(Source: Union Sport & Cycle)

60% OF RUNNERS ORGANIZE THEIR DAILY LIVES AROUND THEIR RUNNING

(source: observatoire du running)

THE CONSEQUENCES OF RISING TEMPERATURES

ON RUNNING

AT +2°C: **-9 DAYS ON AVERAGE**

AT +4°C: **-22 DAYS ON AVERAGE**

and more and more days with temperatures exceeding 32°C

AT +2°C: UP TO +24 DAYS

AT +4°C: UP TO +66 DAYS

INCREASED RISK OF HEAT STROKE DEHYDRATION AND CRAMPS

CANCELLATION OF SPORTING EVENTS:

Poitiers Urban Trail cancelled in June 2019 due to heat wave; Montreal Marathon, cancelled in 2017 due to heat wave

ON HEALTH AND PERFORMANCE

INCREASING HEAT WAVES → **AMPLIFY AIR POLLUTION**

PARTICULES FINES, OZONE

DIRECT IMPACT ON THE CARDIOVASCULAR SYSTEM

by clogging the capillaries and affecting the vascularity of tissues (brain, heart ...).

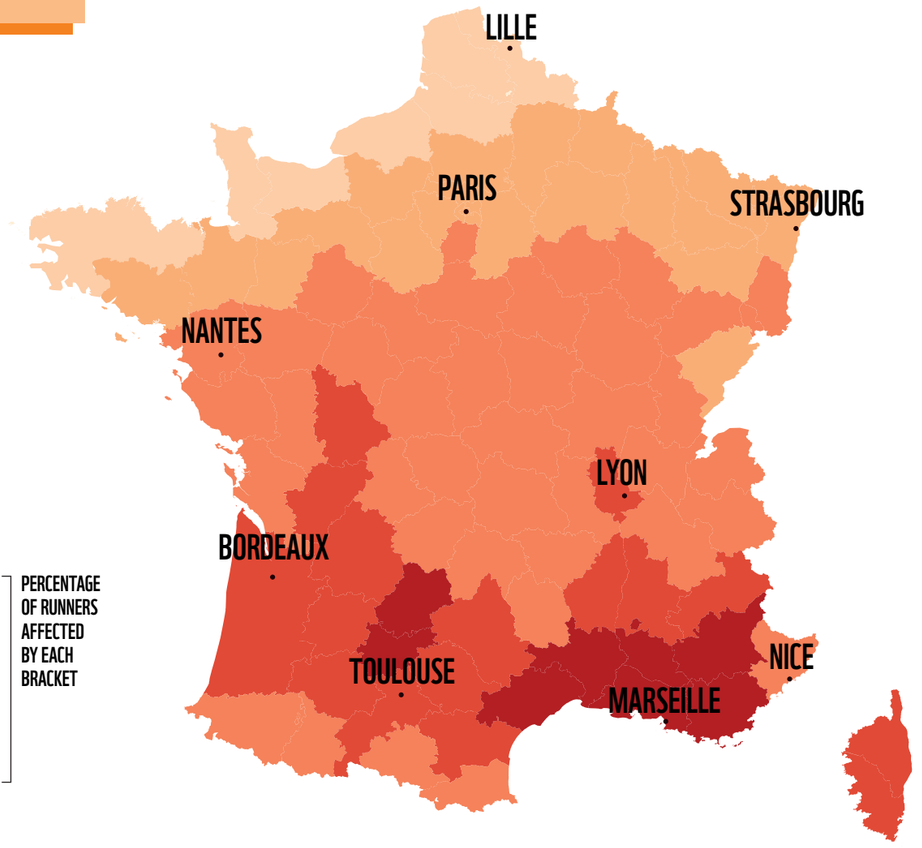
BETWEEN 10 AND 24°C, A PROFESSIONAL RUNNER WOULD LOSE 3'55" ON A MARATHON AND AN AMATEUR 16'44

(Source: Greenstone et al, The Marathon, The Climate and Your Race Against Time, 2017)

THE RUNNER IS PARTICULARLY AFFECTED BY THIS PROBLEM:

hyperventilation, due to the effort, increases the quantity of inhaled pollutants.

NUMBER OF REGULAR RUNNERS IN FRANCE IMPACTED BY THE INCREASE IN DAYS PER YEAR WHERE THE MAXIMUM TEMPERATURE EXCEEDS 32°C



IN A +4°C SCENARIO

NUMBER OF ADDITIONAL DAYS PER YEAR WHERE MAXIMUM TEMPERATURES WILL EXCEED 32°C

PERCENTAGE OF RUNNERS AFFECTED BY EACH BRACKET

5 to 15 days	10 %
15 to 25 days	50 %
25 to 35 days	21 %
35 to 45 days	13 %
45 to 55 days	6 %

AT +4°C, UP TO **-50 DAYS** FOR THE CITIES OF MARSEILLE AND NICE

AT + 4°C, UP TO **-27 DAYS** FOR PARIS = ABOUT 1 MILLION RUNNERS

SOCCER

2.1 MILLION REGISTRED MEMBERS

+1 MILLION GAMES PER SEASON

16,800 CLUBS

INCLUDING 40 PROFESSIONALS

35,000 JOBS CREATED BY FRENCH PROFESSIONAL SOCCER*

7,000 EMPLOYEES IN THE FFF

*2017 Barometer of the economic and social impacts of professional soccer, Ernst & Young

THE CONSEQUENCES OF CLIMATE DISRUPTION

ON HEALTH AND PERFORMANCE

AT + 2°C	AT + 4°C	AT + 2°C	AT + 4°C
-9 DAYS OF PLAY ON AVERAGE	-22 DAYS OF PLAY ON AVERAGE	UP TO -24 DAYS OF PLAY	UP TO -66 DAYS OF PLAY

INCREASED RISK OF HEAT STROKE, CRAMPS AND DEHYDRATION

23 °C
IDEAL TEMPERATURE

the ideal temperature for high-intensity sports over a short period of time (e.g., sprinting) is around 23°C; for prolonged efforts, for example to run a marathon, a temperature of around 10°C is preferable.

AS SOON AS YOU MOVE AWAY FROM THESE TEMPERATURES, PERFORMANCE GENERALLY DROPS

ABOUT THE EVENTS

MORE AND MORE FREQUENT CANCELLATIONS

DUE TO HEAT WAVE / RAIN / STORMS...

Depending on the location of the land, other extreme events such as flooding will threaten the season.

ON STADIUMS

CLIMATE CHANGE AND RISING TEMPERATURES INCREASINGLY

DEGRADED PITCHES
PROLIFERATION OF FUNGI SUCH AS PYTHIUM, BURNT LAWNS, IMPACTED UNIFORMITY

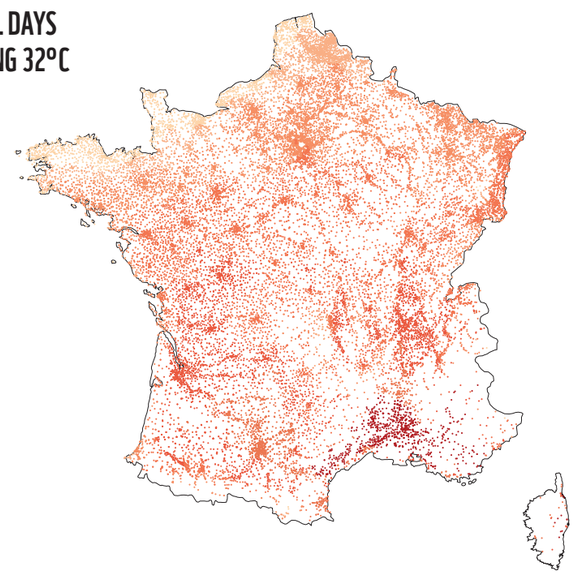
AT + 2°C	À + 4°C
5 TO 20 DAYS	20 TO 62 DAYS

DAYS IN ADDITIONAL HEAT WAVES THAT WILL AFFECT LAWNS

EXPOSURE OF STADIUMS TO THE NUMBER OF ADDITIONAL DAYS WITH TEMPERATURES EXCEEDING 32°C

IN A +4°C SCENARIO

NUMBER OF ADDITIONAL DAYS OF HEAT WAVE BY STAGE	NUMBER OF STADIUMS INVOLVED
0-5 days	2 050
5-10 days	2 971
10-20 days	8 656
20-30 days	9 167
30-40 days	4 767
40-50 days	1 827
50-62 days	922



IN THE WORDS OF

THE FRENCH SOCCER FEDERATION HAS MADE THE FOLLOWING STATEMENT

"For several seasons, we have seen an increase in the consequences of climate disruption on the playing of amateur soccer, and in particular those related to the multiplication of heat waves. In 2019, 85 French departments were affected by at least 1 prefectural order limiting the use of water due to drought, which has as a direct consequence a very rapid deterioration of grass fields. Beyond the quality of the game, which is obviously impacted, heat waves can have direct and indirect consequences on the health of players (dehydration and increased risk of injury), as well as on the pitches on which we note an increase in the presence of fungi in the summer period. Our regional leagues and districts are trying to adapt to these conditions by cancelling matches or training sessions when the health of the players may be in danger and by generalizing the implementation of "refreshment breaks" during the matches, which did not exist a few years ago.

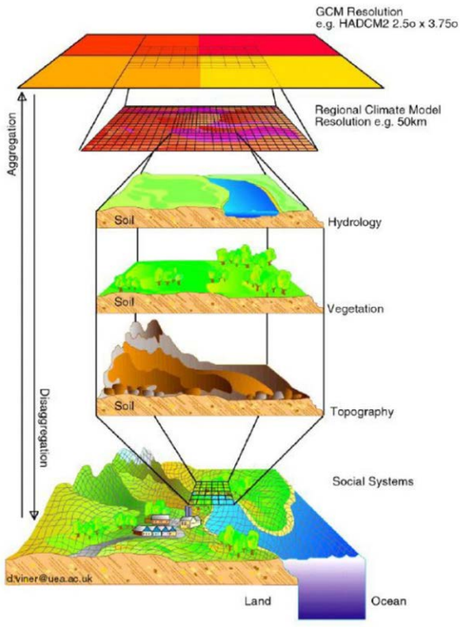
Beyond heat-related events, rising temperatures are also leading to an increase in weather events such as storms, heavy rainfall, flooding... in several French regions, with some territories facing long periods of competition cancellations in this context. »

THOMAS SEILLE
PROJECT MANAGER,
OSR COORDINATOR, INSTITUTIONAL AND INTERNATIONAL RELATIONS DEPARTMENT, FFF.

APPENDIX: METHODOLOGICAL NOTE

CLIMATIC DATA

The climate data used for this analysis are the Euro-CORDEX climate projections. This set of climate simulations is based on regional models that dynamically downscale to a resolution of 11 km, taking into account the topography, forced by the global models used in the last IPCC report (Coupled Model Intercomparison Project Phase 5 - CMIP5). The Euro-CORDEX simulations are then corrected for their bias by analyzing observation data.



Conceptual representation of spatial disaggregation. Source: CRU

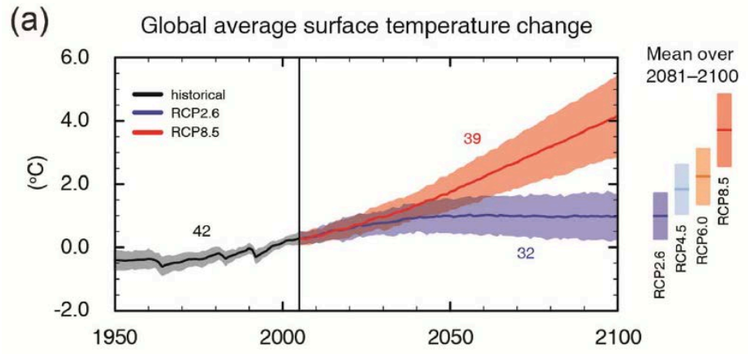
Euro-CORDEX gathers about twenty regional climate simulations, carried out with a set of regional climate models driven by a set of global climate models. The multi-model approach is used more and more systematically by researchers in climate modeling. It allows us to apprehend all possible evolutions for the future climate and to represent this dispersion by simple statistical products such as the mean and the inter-model dispersion.

In Euro-CORDEX, the regional climate simulations were carried out according to the RA protocol5[73]. They cover the period 1980-2100 and are forced by observed greenhouse gas emissions from 1980 to 2005 (called historical period) and by potential future emission scenarios for the period 2006-2100 (called RCPs scenarios). Among the RCPs scenarios of the AR5, representative of the evolution of greenhouse gas concentrations, the following two scenarios have been retained to force the Euro-CORDEX simulations:

• RCP 4.5: scenario with climate policy aimed at stabilizing CO2 concentrations in 2100.

• RCP 8.5, no climate policy scenario.

The AR5 report provides an assessment of global temperature change for the two RCPs.



Global temperature increase for RCPs scenarios (IPCC, 2013)

In this study, we have chosen to analyze frequency changes for targeted climate indicators in +2°C and +4°C global temperature scenarios relative to the pre-industrial period, in order to have a discourse that is more understandable by the general public. **The +2°C scenario relative to the pre-industrial period is reached in the RCP4.5 scenario by 2050, and the +4°C scenario (more precisely +4.3°C on average) in the RCP8.5 scenario by 2100.**

However, this correspondence is approximate; in fact, the fifth IPCC report 74states that:

- The temperature increase between 2046 - 2065 for the RCP 4.5 scenario is likely to be between 0.9 and 2°C relative to the baseline period (i.e. between 1.5 and 2.6°C relative to the pre-industrial period);

- The temperature increase between 2081-2100 for the RCP 8.5 scenario is likely to be between 2.6 and 4.8°C relative to the reference period (i.e. between 3.2 and 5.4°C relative to the pre-industrial period).

DATA USED FOR THE REALIZATION OF THE MAPS

Chapter 1: Sporting activities impacted by rising temperatures

• **Climatic data:** the indicator chosen for the sport of running is the number of very hot days per year. A very hot day is defined as a day for which the maximum temperature reached during the day exceeds 32°C. Following the methodology described above, a multi-model estimation of the evolution of this indicator was performed for the +2°C and +4°C scenarios with 5 Euro-Cordex models, with a spatial resolution of ~12 km.

• **Sports data:** Given the impossibility of defining a physiological threshold that is binding for the activity of sport per se and common to all individuals and all sports, an arbitrary and conservative threshold of 32°C has been chosen as the threshold of vulnerability to rising temperatures. The High Council of Public[75] Health considers that if the WBGT index[76] rises above 32°C, the risk of acute heat-related pathology becomes very high.

73. AR5 refers to the 5th assessment report of the IPCC (Intergovernmental Panel on Climate Change) released in 2014

74. IPCC, Synthesis Report: Climate Change, 2014
75. High Council for Public Health, Health recommendations of the National Heat Wave Plan 2014, 2014
76. Wet bulb globe temperature indicator: index that takes into account dry, wet and radiant temperatures.

Chapter 2: Coastal sites to be relocated

• **Climate data:** In this study, sea level rise projection data are taken from the SROCC (Special Report on the Ocean and Cryosphere in a Changing Climate, IPCC 2019) for the +2°C and +4°C scenarios. They are estimated with a spatial resolution of 1° (~100 km). Later, it will be appropriate to deepen this analysis by studying the vulnerability of nautical bases to marine submersion and coastal erosion.

• **Sports data:** The data on the location of French sailing clubs were provided by the French Sailing Federation. It lists a total of 576 structures located on the coasts of metropolitan France.

Chapter 3: More and more complex gymnasiums to manage

• **Climatic data:** The indicator chosen for the thermal comfort of gymnasiums is the number of heat wave days per month, for the months of May to October. A heat wave is defined here by at least three consecutive days for which the maximum temperature reached during the day exceeds 32°C. Following the methodology described above, a multi-model estimation of the evolution of this indicator was performed for the +2°C and +4°C scenarios with 5 Euro-Cordex models, with a spatial resolution of ~12 km.

Chapter 4: Grass fields become less and less playable

• **Climatic data:** The indicator chosen for stadium fields is the number of heat wave days per year. A heat wave is defined as at least three consecutive days where the maximum temperature reached during the day exceeds 32°C. Following the methodology described above, a multi-model estimation of the evolution of this indicator was performed for the +2°C and +4°C scenarios with 5 Euro-Cordex models, with a spatial resolution of ~12 km.

• **Sports Data:** The stadiums included in this chapter are from the RES census of sports facilities as of January 10, 2018[77]. This database lists a total of 30,060 stadiums.

For each interval representing the number of additional days in a heat wave, the data concerned is strictly above the low value and below or equal to the high value

Focus on running

• **Climate data:** see data in Chapter 1 “Sporting activities impacted by rising temperatures”.

• **Sports data:** Data provided by Sports Heroes France on the distribution (in %) of cyclists in the French departments. The distribution provided by Sports Heroes was applied to the total number of usual riders in France (5 millions according to Union Sports & Cycle) to get an approximation of the distribution of the usual riders impacted by the rise of temperatures on France.

For each interval representing the number of additional days in a heat wave, the data concerned is strictly above the low value and below or equal to the high value

Focus on soccer

For each interval representing the number of additional days in a heat wave, the data concerned is strictly above the low value and below or equal to the high value

77. https://www.data.gouv.fr/fr/datasets/recensement-des-equipements-sportifs-espaces-et-sites-de-pratiques/

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