



**MINISTÈRE
CHARGÉ
DES TRANSPORTS**

*Liberté
Égalité
Fraternité*



AIRPORT VULNERABILITY TO CLIMATE CHANGE

INFORMATION NOTE



**MINISTÈRE
CHARGÉ
DES TRANSPORTS**

*Liberté
Égalité
Fraternité*



AIRPORT VULNERABILITY TO CLIMATE CHANGE

INFORMATION NOTE

Civil Aviation Technical Service

Environnement, Systems and operations safety, Planning Department

AUTHORS

David SMAGGHE

Deputy Head of the Environment Division

David **SMAGGHE**, public works engineer, joined the STAC (technical center of civil aviation) in 2010 and began his career in civil aviation in the field of airport safety and planning. He then moved to the Environment Division, where he was in charge of issues relating to aircraft noise emissions around airports, and airport adaptation to climate change. Involved in the French National Climate Change Adaptation Plan, David contributed to the development of the VULCLIM methodology to assess the vulnerability of French airfields to the impacts of climate change. Today, he is deputy head of the Environment Division, in charge of issues relating to noise, air quality, biodiversity, wildlife hazard and de-icing products.

Constance ANELLI

Engineering studies

Constance **ANELLI**, engineer in civil aviation studies and operations, began her career at the DSAC (French civil aviation authority) as a flight operations surveillance inspector. At the end of 2021, she joined the STAC to be in charge of wildlife hazard management and biodiversity issues. As part of her role in the Environment Division, she is also working on the continuation of the work begun in 2013 on the vulnerability of airports to climate change.



TABLE OF CONTENTS

1. A PART OF THE NATIONAL ADAPTATION PLAN TO CLIMATE CHANGE (PNACC)	6
1.1. INTRODUCTION	6
1.2. A THREE-STAGE STUDY	6
2. CLIMATE HAZARD IMPACTS ON AIRPORTS	7
2.1. CLIMATE HAZARDS	7
2.2. IMPACTS OF THESE CLIMATE HAZARDS	7
3. VULCLIM : A METHOD TO ASSESS AIRPORT VULNERABILITY TO CLIMATE CHANGE	9
3.1. METHOD	9
3.2. IMPLEMENTING THE METHOD : NICE CÔTE D'AZUR AIRPORT	10
3.3. A PROACTIVE ASSESSMENT	11
3.4. THE VULCLIM IT TOOL	12
4. BIBLIOGRAPHY	13
5. GLOSSARY	14



SUMMARY - KEYWORDS

EXECUTIVE SUMMARY

The STAC, in collaboration with the actors of the scientific and technical network of the Ministry of Ecological Transition and Territorial Cohesion, responded to the mandate of the National Plan for Adaptation to Climate Change (PNACC), launched in 2011, with the VULCLIM study. A methodology for assessing the vulnerability of aerodromes has been developed. In order to make the methodology available to as many aerodromes as possible, the STAC has developed a simple online survey type assessment tool. The VULCLIM tool, available on the STAC website, is aimed at aerodrome operators in mainland France who wish to assess the vulnerability of their platform to the expected effects of climate change.

KEYWORDS

Climate, Climate change, PNACC, Vulnerability, Climate impacts, Climate hazards, VULCLIM, Adaptation, Resilience, Airports, Airport operators.

1. A PART OF THE NATIONAL ADAPTATION PLAN TO CLIMATE CHANGE (PNACC)

This document is intended for all airport operators, and does not require any special expertise to understand it.

1.1. INTRODUCTION

This study is part of the National Adaptation Plan to Climate Change (PNACC in French), which aims to prepare the country for climate change hazards and impacts. The PNACC includes a section on transport for which the French Civil Aviation Administration is responsible for the air transport. STAC was asked to develop a methodology to assess the vulnerability of civil airports to climate change.

1.2. A THREE-STAGE STUDY

Step 1: identify relevant potential climate impacts on airport infrastructure and relevant technical standards.

Step 2: develop a methodology to assess the vulnerability of French airports to climate change and test the methodology on representative French airports.

Step 3: develop a vulnerability assessment tool for French airports.



2. CLIMATE HAZARD IMPACTS ON AIRPORTS

2.1. CLIMATE HAZARDS

Airport-specific climate hazards have been identified from several sources (e.g. Intergovernmental Panel for Climate Change [IPCC], PNACC January 2011 report on climatic scenarios by J. JOUZEL, Météo France data...).



Temperature change



Precipitation change



Wind pattern changes



Extreme weather events



Changes in Sea level



Changes in biodiversity

2.2. IMPACTS OF THESE CLIMATE HAZARDS

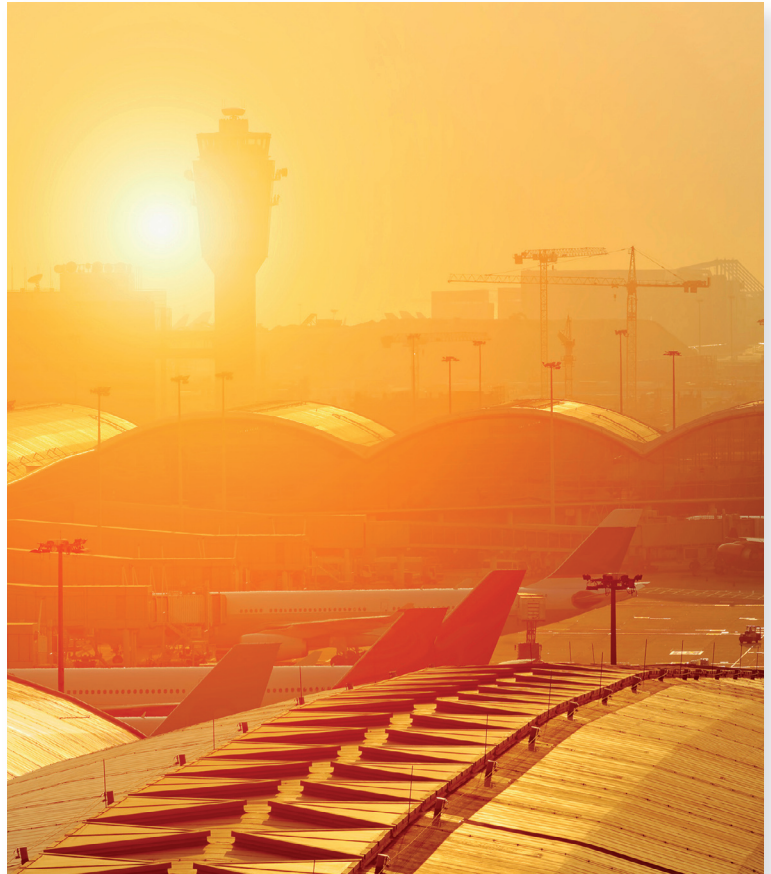
For each hazard, potential impacts have been identified based on feedback from airport operators and literature review. Three key “areas” were identified to characterise the elements of an airport likely to be affected: infrastructure (e.g. movement, road access, parking...), buildings (e.g. terminal, control tower...) and operations (e.g. take-off/landing, catering, fuel storage area...).

IMPACT ON INFRASTRUCTURE

- * Changes in take-off distances in certain cases, requiring runway extension or MTOW reduction;
- * Accelerated runway/taxiway pavement deterioration, reduced pavement load movement area damage, clay swelling or shrinkage causing pavement damage;
- * Reduced need for de-icing materials, reducing soil/water pollution;
- * Flooding of carriageway, requiring construction of protection (dykes, reinforced embankments);
- * Flooding of movement areas, need to build protection;
- * Collapse of coastal infrastructure;
- * Non-optimal runway orientation due to changes in prevailing wind direction.

IMPACT ON BUILDINGS

- * Temperature increase in buildings (terminal and control tower): changes in energy demand for heating, increased need for air conditioning;
- * For airports adjacent to forest areas, increased risk of closure due to forest fires;
- * Flooding/submergence of coastal areas;
- * Clay swelling or shrinking causing damage to buildings;
- * High winds destroying mobile or fragile equipment (footbridges...);
- * Partial or total destruction of buildings (tornado, flood...).



IMPACT ON OPERATIONS

- * Increased risk of reduced visibility due to smoke from forest fires during droughts or heat waves;
- * Increased frequency of crosswinds/tailwinds reducing runway capacity;
- * Storms/high winds increasing frequency of FOD, increase in temporary runway closures;
- * Airport closure due to storm/tornado warning or aftermath, isolating remote areas (overseas);
- * Less traffic disruptions/delays due to snow events;
- * Harsher apron working conditions, especially during heat waves, leading to absenteeism;
- * Temporary apron or runway closure due to heavy rain/flooding;
- * Changes in bird populations and natural habitats, potentially increasing bird hazards.

3. VULCLIM: A METHOD TO ASSESS AIRPORT VULNERABILITY TO CLIMATE CHANGE

3.1. METHOD

VULCLIM uses risk mapping to assess airport vulnerability. It provides a thorough vulnerability analysis while delivering an easy-to-understand result. The process starts with a thorough analysis of the airport, a comprehensive knowledge of its traffic characteristics (e.g. composition, known vulnerabilities to malfunctions, critical components). It is followed by the definition of climate change scenarios, with identified climate hazards and clearly defined scenarios. The need to understand a hypothetical future situation of the airport under study, using both average and extreme climate projections, makes the vulnerability analysis more complex. Analysis of past climate events and feedbacks is critical to inform the forecast and is an integral part of the vulnerability analysis.



The combination of these two analyses (airport concerns and climate hazards) allows the creation of a double entry matrix, where the analysis of the climate hazard is crossed with the level of impact on the airport so as to assess the actual risk.

Climate hazard occurrence likelihood			Vulnerability matrix				Vulnerability level
1	Low	Hazard is highly unlikely to occur at the studied airport. It should not occur during infrastructure lifetime					
2	Medium	The hazard already occurred at least once (see forecast) at studied airport. According to climate forecasts, the hazard could occur with a small return period during the infrastructure's lifetime	3	Low (3)	Medium (6)	High (9)	High (12)
3	High	The hazard already occurred several times at the studied airport. Climate forecasts predict an increase in the hazard frequency and/or intensity. Ex: frequent floods or storms (several times a year)	2	None (2)	Low (4)	Medium (6)	High (8)
			1	None (1)	None (2)	Low (3)	Low (4)
				1	2	3	4



Hazard impact level on airport stake			
Impact level		System's malfunction	
1	Trivial	Normal	No disturbances
2	Minor	Acceptable degraded conditions	System's functionality is affected
3	Serious	Restrictive degraded conditions	System malfunction, functionality is threatened
4	Catastrophic	Unacceptable degraded conditions	Systemdemise, or long term malfunction

None (green) Airport stake concern ? Is not vulnerable to climate change.
Low (yellow) Climate change will not affected normal operations. However it could sometimes operate under acceptable degraded conditions owing to meteorological conditions.
Medium (orange) Climate change will have an impact which will not prevent operations. However operations will often suffer acceptable and restrictive degraded conditions owing to poor weather conditions. Vulnerability assessment will have to be repeated regularly. Preventive or protective means should be used to reduce airport vulnerability
High (red) Climate change will strongly affect airport operations and could result in its demise without protective/preventive measures.

3.2. IMPLEMENTING THE METHOD: NICE CÔTE D'AZUR AIRPORT

Features:

- * Third busiest French airport with over 14.5 million passengers in 2019 and 177 718 movements;
- * 370 ha footprint, with more than 200 ha built on sea;
- * Two parallel runways;
- * Two terminals;

Nom	Nice Côte-d'Azur
Code OACI/IATA	LFMN/NCE
Plan de situation	Vue aérienne
	

The Nice airport vulnerability matrix, developed in collaboration with the airport operator, allows the identification of the airport's strengths (green and yellow areas) and weaknesses (orange and red) in relation to the impacts of climate change.

Example; heavy rain and road access

High hazard probability

Common event, with increased intensity forecast

3 / 2

6

Medium vulnerability

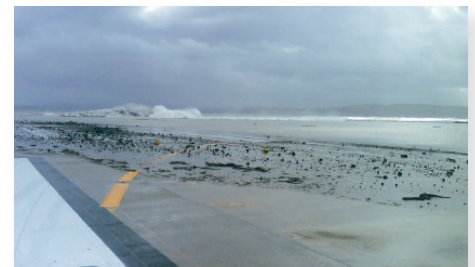
Low impact severity

The airport has several road accesses; past floods increased access time without isolating the airport (road access although degraded was acceptable)



Climate changes		Wind	Biodiversity	Sea level	Temperatures			Extreme events Hurricanes/Tempests Snow falls		
		Change in the direction of winds	Evolution of local bird distribution	Sea level rise	Heat waves	Draughts	Sea swell	Floods	Extreme winds	Snow falls
Infrastructures	Accesses			3	3	1	3	6	2	1
	Parking			3	2	1	3	6	1	1
	Runways	3	4	6	3	1	9	3	2	1
	Taxiways		4	3	3	1	6	3	2	1
	Apron			3	3	1	3	3	2	1
Bâtiment	Terminals			3	3	1	3	3	2	
	Liaison between terminals			3	3	1	3	3	2	1
	Offices and other buildings			3	3	1	3	3	2	
	Airy bridges			3	3		3	3	2	1
	Tower			3	3	1	3	3	2	1
Exploitation	Fuel deposit			3	3		3	3	2	1
	Deicing			3			3	3	2	3
	ARRF			3	3		3	3	2	2
	Trucks			3	3		3	3	2	1
	Navigation and equipment			6			6	6	2	1
	Human resources				3			6	2	2

Some storms disrupt airport operations by bringing stones onto the runways, flooding parts of the maneuvering area or disrupting surface drainage. Projected sea level rise could increase vulnerability of airport to these hazards.



3.3. A PROACTIVE ASSESSMENT

At Nice airport, the parallel runway system, which is partly built over the sea and at a low elevation, will be vulnerable to maritime hazards such as sea level rise and rough seas during storms. Climate change will increase the frequency and intensity of these hazards. « Aéroports de la Côte d'Azur », the airport operator, has carried out a maintenance campaign of the existing embankments. The aim of this work, with a cost of 10,40 M€ from 2011 to 2013, was to reinforce rip-rap areas that protect the runways from storms on the seaward side of the airport.



3.4. THE VULCLIM IT TOOL

The VULCLIM IT tool has been developed and made available to all aerodromes that request it at: <https://www.stac.aviation-civile.gouv.fr/fr/outil-devaluation-vulnerability-to-climate-change>


It consists of an on-line questionnaire containing a series of simple questions, systematically accompanied by a help section to enable the operator to choose the most appropriate answer.

Example of a question:

*** 24 Quelle est la situation de l'aérodrome face à l'aléa de sécheresse ?**
Veillez sélectionner une réponse ci-dessous

L'aérodrome est situé en zone blanche (2)
 L'aérodrome est situé en zone rose (3)

? Pour répondre repérez la position de l'aérodrome sur le carte suivante (nombre maximum de jours secs consécutifs – écart par rapport à la valeur de référence / Horizon 2071-2100 ; RCP 8.6 ; Moyenne annuelle ; issue des données DRIAS 2020), puis en déduire la réponse la plus adaptée. Si l'aérodrome se situe à la frontière entre deux zones, il est recommandé de retenir la couleur la plus foncée.



Example of matrix:

186

Matrice de vulnérabilité des infrastructures

	Changeement de régime des vents	Péril animalier	Montée des eaux	Vague de chaleur	Sécheresse	Fortes houles	Pluies extrêmes	Vents extrêmes	Froid extrême et chutes de neige
Accès			4	6	3	6	4	1	
Parkings Automobiles			2	6	1	4	4	2	
Système de piste	2		2	6	4	2	2	3	
Voies de circulation		6	2	6	1	2	2	3	
Aire de trafic			2	6	2	4	2	1	
Aérogares			2	6	2	4	4	2	
Liaisons entre les terminaux									
Bureaux et autres bâtiments			4	6	1	6	4	2	
Passerelles			4				4	1	
Tour de contrôle			2	6	1	2	2	3	
Dépôt carburant et avitaillement			2	6	2	4	4	1	
Dégivrage				6	3	4	6	2	
SSLIA				6	1	8	2	1	
Engins et tracteurs			2	6	1	2	4	1	
Équipements d'aide visuelle				6	1	2	2	2	
Équipements d'aide radioélectrique				6	3	4	6	2	
Facteur humain			4					1	

All the questions are used to determine the probability of occurrence of each climate hazard and its impact on each area of the airport, resulting in the airport's vulnerability matrix at the end of the survey.

In this way, the airport can identify its strengths and vulnerabilities to climate change and use this as a basis for determining appropriate measures to adapt its platform and thus reduce its vulnerability.

4. BIBLIOGRAPHY

4. BIBLIOGRAPHY

<https://www.eea.europa.eu//publications/climate-change-impacts-and-vulnerability-2016> Site de l'agence européenne de l'environnement, page dédiée au changement climatique.

www.drias-climat.fr a pour vocation de mettre à disposition des projections climatiques régionalisées (France).

<http://www.cnrm-game.fr/spip.php?article531> Centre National de Recherches Météorologiques, Groupe d'études de l'Atmosphère Météorologique.

<http://pluiesextremes.meteo.fr/> site dédié aux "pluies extrêmes" dont l'objectif est d'informer sur la fréquence des évènements pluviométriques extrêmes et de présenter les épisodes les plus marquants qui se sont produits en métropole, depuis 1958 et jusqu'en 2009.

<http://flood.firetree.net/> simulateur de montée des eaux développé par Google.

<https://www.ecologie.gouv.fr/observatoire-national-sur-effets-du-rechauffement-climatique-onerc> Observatoire Nationale sur les Effets du Réchauffement Climatique.

<https://www.ecologie.gouv.fr/adaptation-france-au-changement-climatique> Adaptation de la France au changement climatique, PNACC.

<https://www.icao.int/environmental-protection/Pages/Climate-Change-Climate-Risk-Assessment,-Adaptation-and-Resilience.aspx> Documentation OACI sur le changement climatique (Évaluation des risques climatiques, adaptation et résilience).

<https://store.aci.aero/product/policy-brief-airports-resilience-and-adaptation-to-changing-climate/> Documentation ACI sur l'adaptation des aéroports face au changement climatique.

<https://www.eurocontrol.int/publication/eurocontrol-study-climate-change-risks-european-aviation> Étude d'EUROCONTROL sur les risques liés au changement climatique pour l'aviation européenne.

<https://meteofrance.com/changement-climatique> Articles Météo France sur le changement climatique.

https://www.ecologie.gouv.fr/sites/default/files/ONERC_Climat_France_XXI_Volume_1_VF.pdf Scenarios climatiques de janvier 2011 - J.Jouzel

5. GLOSSARY

5. GLOSSARY

STAC: Service Technique de l'Aviation Civile (technical center of DGAC)

DGAC: Direction Générale de l'Aviation Civile (French Civil Aviation Authority)

PNACC: Plan National d'Adaptation au Changement Climatique (French Civil Aviation Administration)

FOD: Foreign Object or Debris

DRIAS: This website provides regionalized climate projections produced by French climate modeling laboratories. Climatic information is provided in various graphical and numerical formats

Design : STAC/Administration, Information Systemse Dissemination Department

Cover: © Adobe stock

Inside pictures: © Adobe stock 6, 8
© DGAC/STAC 10, 11

Illustrations: © DGAC/STAC
© Freepik
© Google earth

November 2023



Direction générale de l'Aviation civile
service technique de l'Aviation civile
CS 30012 - 31 avenue du Maréchal Leclerc
94 385 Bonneuil-sur-Marne CEDEX FRANCE
Téléphone : 01 49 56 80 00

www.stac.aviation-civile.gouv.fr

www.ecologie.gouv.fr