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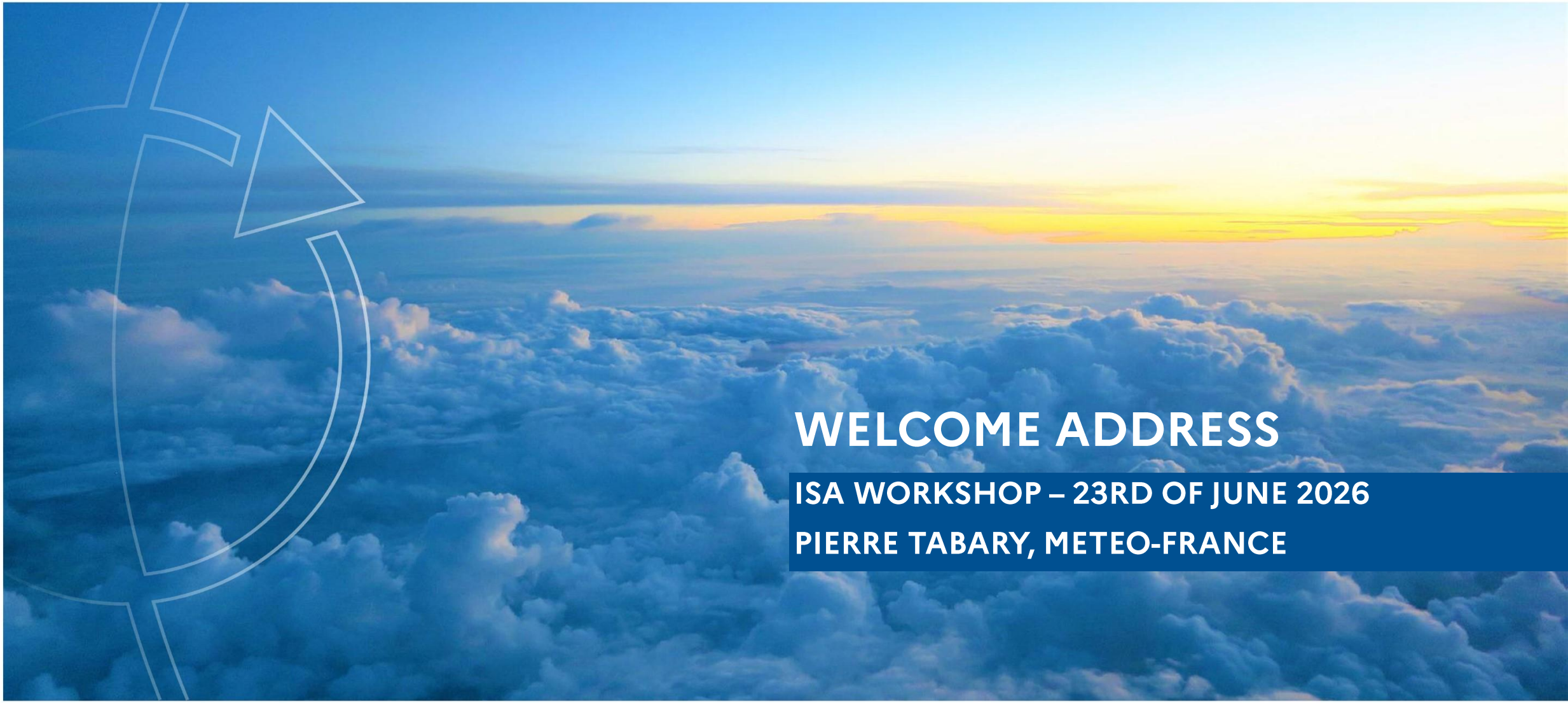
METEO FRANCE
À VOS CÔTÉS, DANS UN CLIMAT QUI CHANGE



WELCOME ADDRESS

ISA WORKSHOP – 23RD OF JUNE 2026

PIERRE TABARY, METEO-FRANCE

WELCOME TO « LA MÉTÉOPOLE »

La Météopole à Toulouse

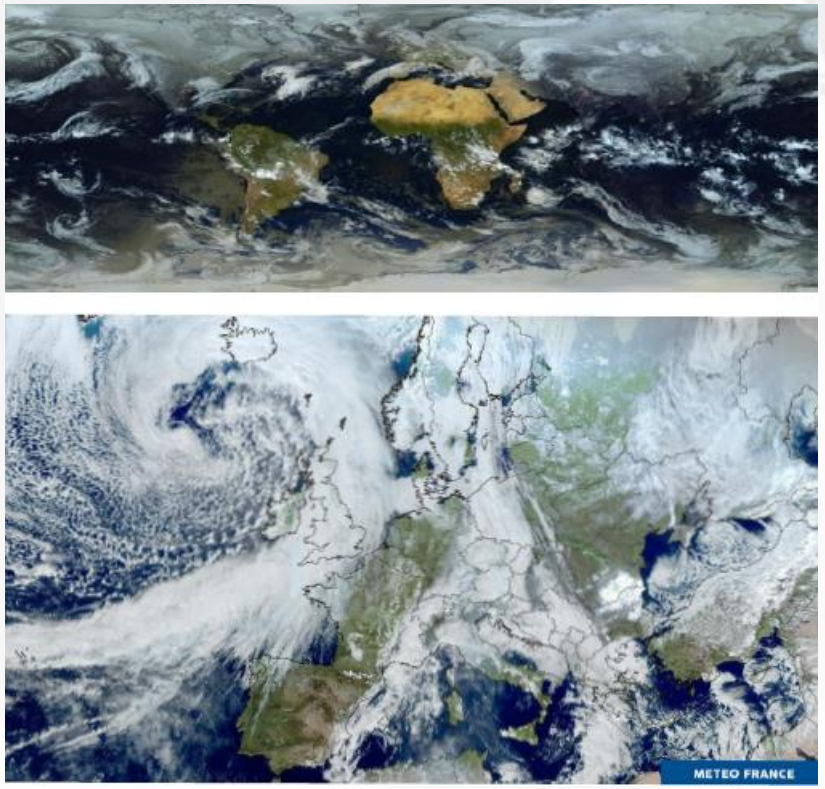
1100 agents de Météo-France et 4 partenaires :

Service Central Vigicrues, CERFACS, CISMF, SHOM

40+ YEARS OF « LA MÉTÉOPOLE » IN TOULOUSE

METEO-FRANCE - WHO ARE WE?

- Météo-France is a public administrative establishment (EPA) under the authority of the ministry of transportation.
- The 2022-2026 Objectives and Performance Contract (passed with our supervising authorities) sets the institution's objectives.
- Estimated socio-economic benefits: EUR 1.1 to 2.6 billion per year (France Stratégie, 2018).
- Budget : 415.5 M€ (2025).

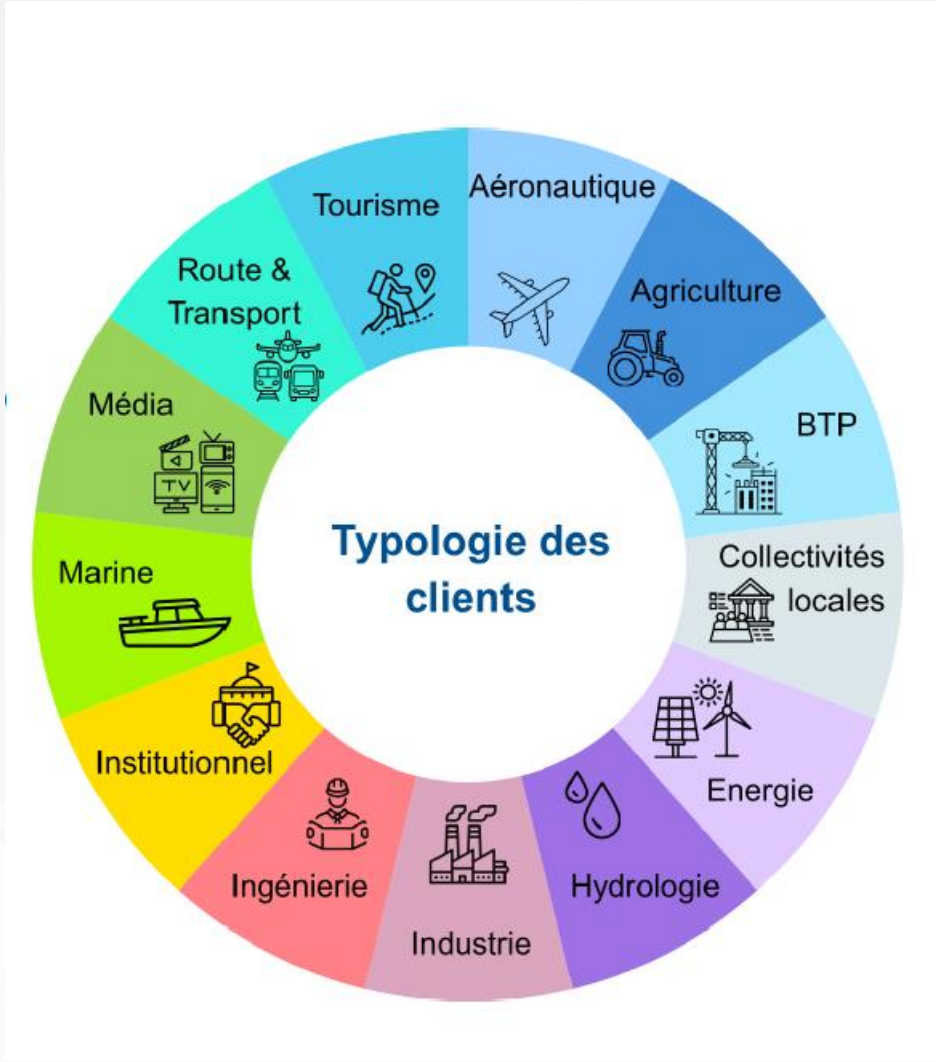


OUR CORE ACTIVITIES

- Weather "vigilance"
- Weather forecasting
- Climate change
- For whom?

→ A wide range of users: aviation, agriculture, construction, local authorities, energy, hydrology, industry, engineering, institutional users, marine, media, road & transport, tourism.

- 25-30% of France's GDP is directly influenced by weather.



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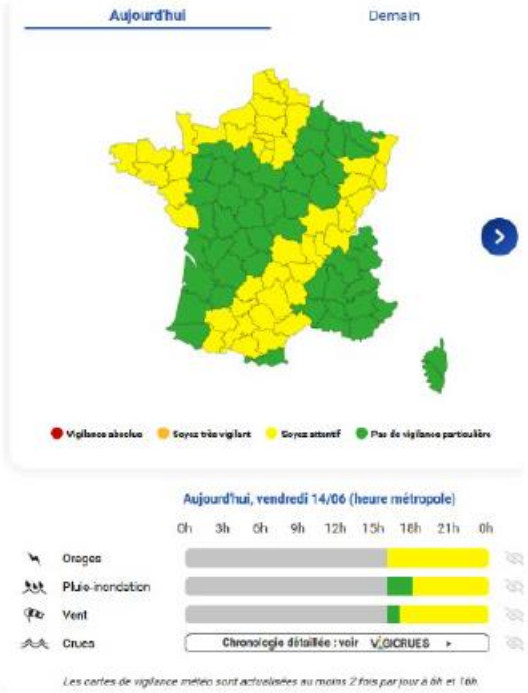
PROTECTING PEOPLE AND GOODS AGAINST WEATHER HAZARDS – SUPPORT TO PUBLIC AUTHORITIES

Production of weather vigilance, support to public authorities in a variety of domains : road management, air and maritime traffic, fires, armed forces.

Production de la vigilance Météo



Soutien aux services de l'Etat

Garantir **la sécurité des routes** avec les services techniques

Assurer la sécurité du **trafic aérien**

Assurer la **sécurité maritime**

Lutter contre **les feux de forêt** avec la sécurité civile

Soutenir nos **forces armées**

OFFERING PRODUCTS TAILORED TO CUSTOMERS' SPECIFIC NEEDS – SAFEGUARDING ECONOMIC ASSETS

- Specific products serving many sectors.
- Highest-priority sectors: energy, water resource management, transportation.


Énergie


Transports


Éolien

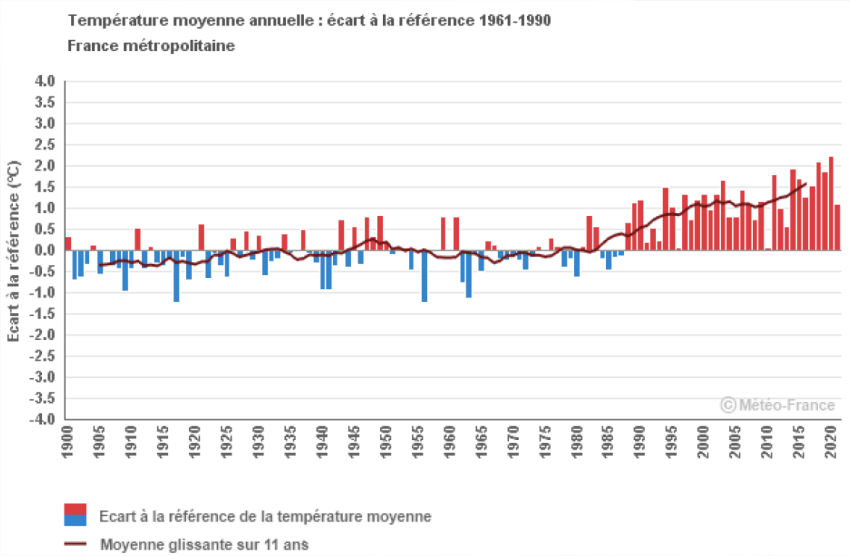

BTP


Ressource en eau


Évènements

CLIMATE "MEMORY", CLIMATE-CHANGE DIAGNOSIS AND FUTURE CLIMATE PROJECTIONS

- Enhance the national climate database to support climate studies.
- Diagnose climate change across France, and at global and regional scales.
- Contributions to IPCC work since 1995; regionalized climate projections.
- Develop decision-support tools in the context of climate change.



RESOURCES AVAILABLE TO MÉTÉO-FRANCE FOR FULFILLING ITS MISSIONS

- **Training**: the School of Meteorology (ENM) in Toulouse trains civil servants and civilian engineers and technicians in meteorology and climate.
- **Research**: 300 researchers and engineers develop world-class models
- **Observation**: a network of 39 radars, several thousand ground stations, radiosonde stations, buoys at sea, and access to data from around twenty satellites.
- **High-performance computing (HPC)** and information systems: some of the most powerful supercomputers in the world.
- **Forecasting services**: 600 forecasters in mainland France and overseas.
- **HR** : 2,640 FTEs (2025).
- **Budget** : 415.5 M€ (2025).

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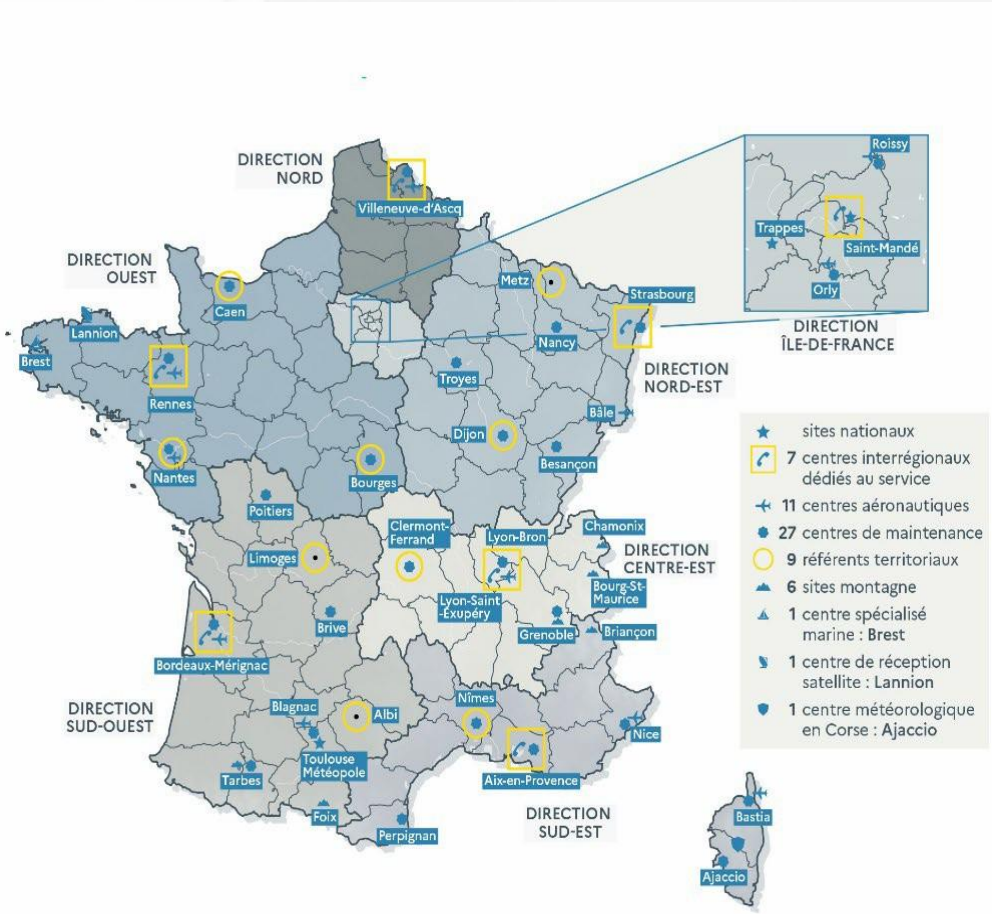
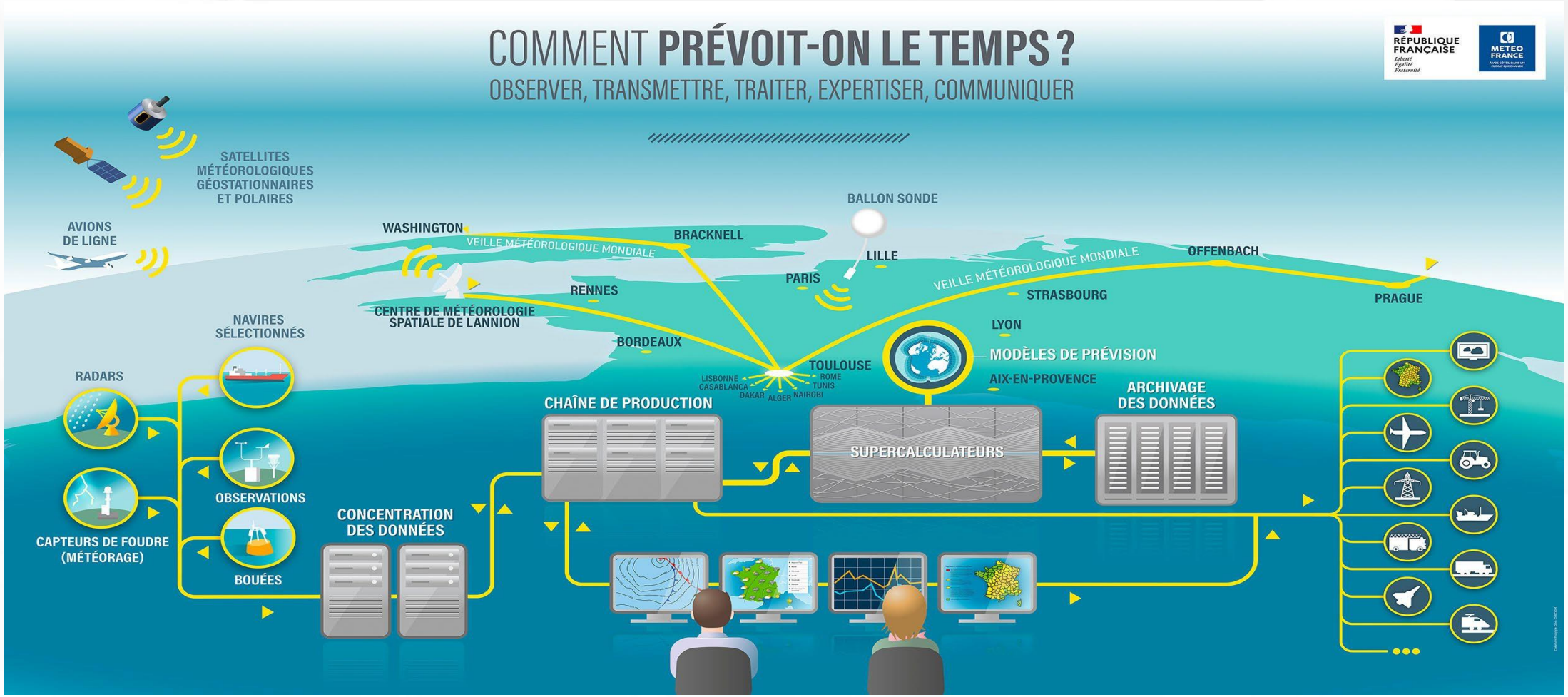
MÉTÉO-FRANCE IN MAINLAND FRANCE AND IN OVERSEAS TERRITORIES



WEATHER FORECAST HAS COME A LONG WAY SINCE THE FIRST ATTEMPT BY LEWIS FRY RICHARDSON (1922) …

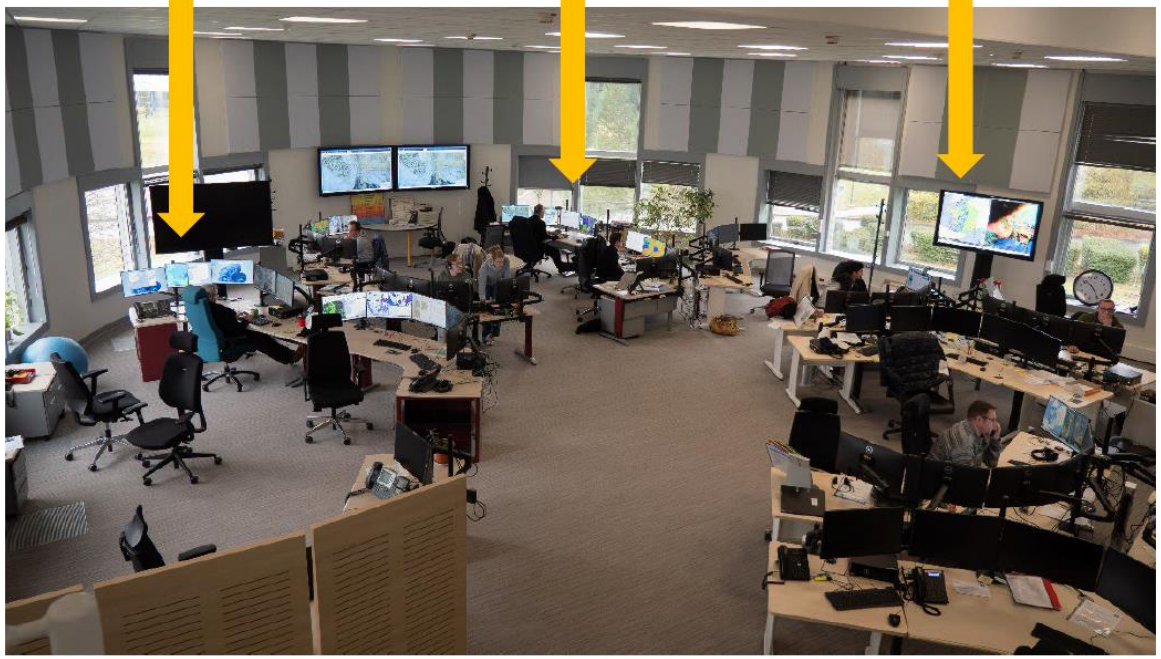


THE NATIONAL FORECASTING CENTRE IN TOULOUSE

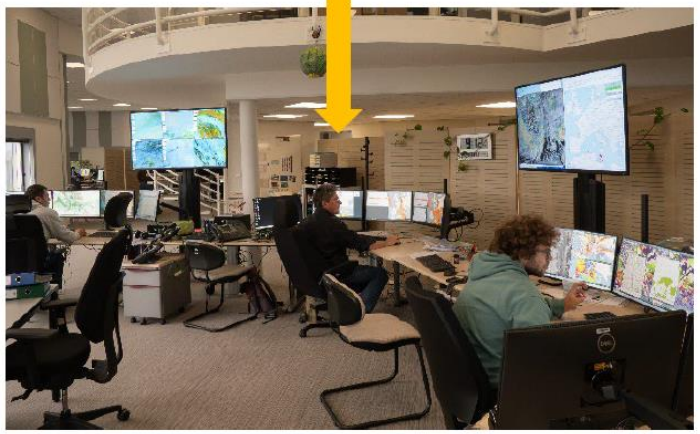
Prévisions spécialisées,
grands comptes, international

Prévision marine

Prévision générale

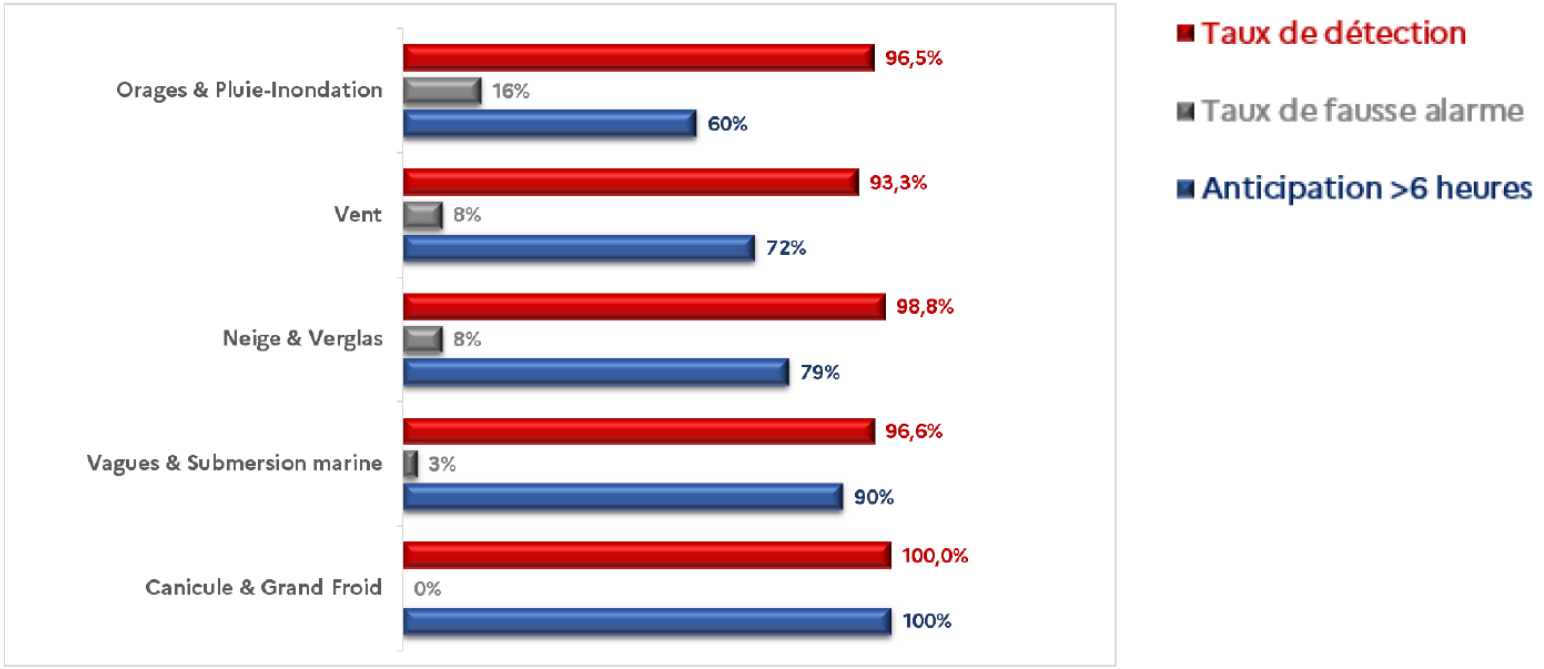


Prévision aéronautique



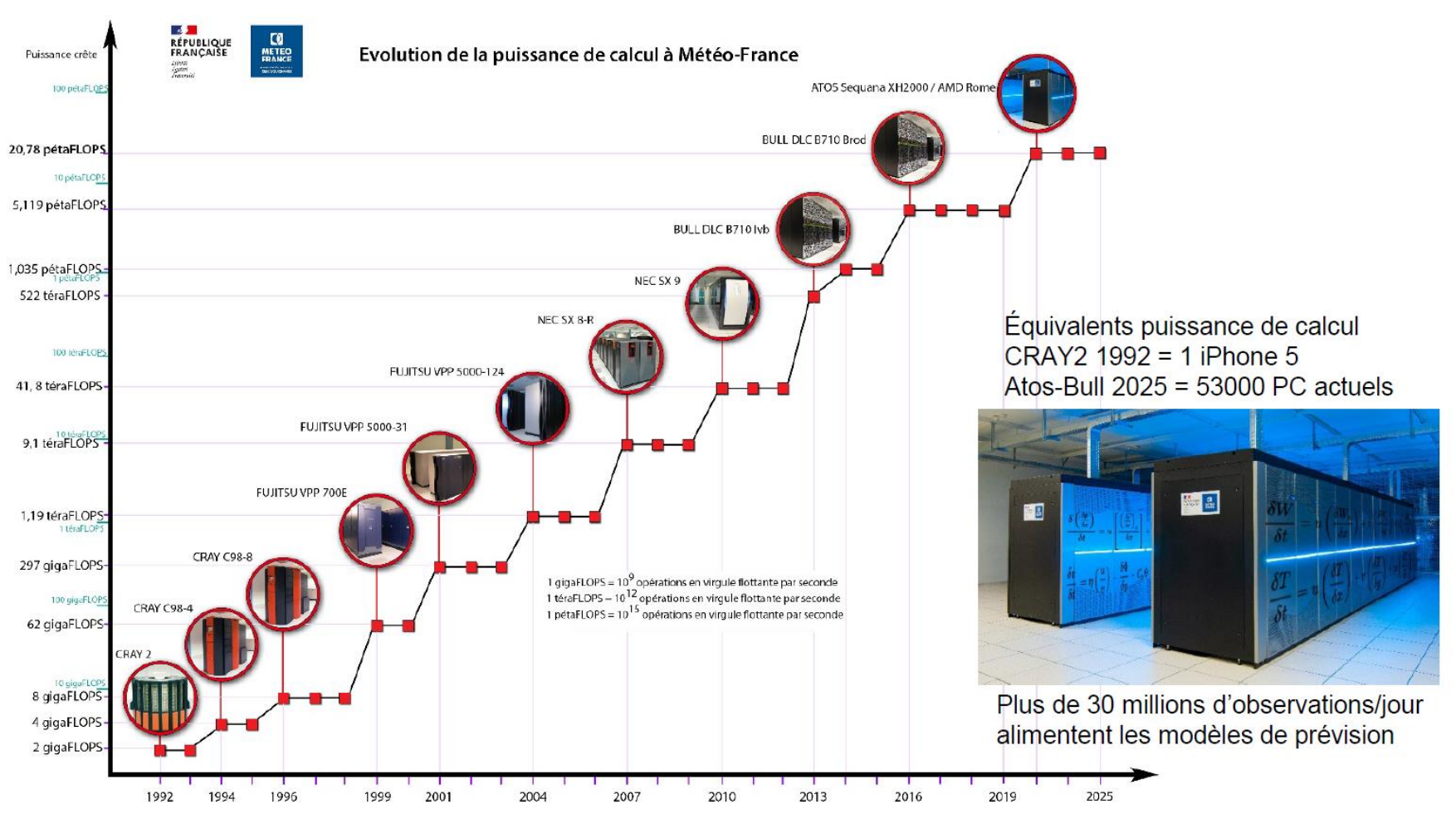
RELIABILITY OF VIGILANCE WARNINGS ISSUED BY MÉTÉO-FRANCE

- Evaluation over a 10-year period, classified by phenomenon (storms and floodings, winds, snow, waves & coastal floodings, heat and cold waves



SUPERCOMPUTERS (HPC)

- Logarithmic scale
- 1 petaflop = 1,000 000 000 000 000 operations per second (10^{15})



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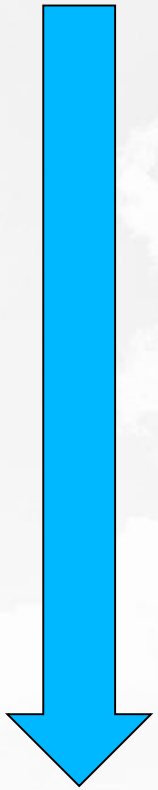
OVERVIEW OF METEO-FRANCE'S PRODUCTS, SERVICES AND PROJECTS FOR AVIATION

KEY CHALLENGES IN AVIATION METEOROLOGY

- **Safety**: enable aircraft to take off, fly and land safely, in a context of weather-related risks and increasing traffic.
- **Optimisation**: support more efficient airport and en-route operations, in terms of delays, costs and environmental impact.
- **Attenuation**: help reduce the climate impact of air transport, including CO_2 and non-CO_2 effects such as persistent contrails.
- **Adaptation**: help the aviation sector adapt to climate change, at airports and en route.



Météo-France supports all stakeholders in those challenges

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A HIGHLY REGULATED ACTIVITY

- **ICAO** (since 1944) – Chicago convention - Annex 3
- **Single European Sky** – EU regulations : 2017/373, CP1, …
- **National framework :**
  - DGAC/DTA = MET supervisory authority (“regulator”)
  - DGAC/DSAC = MET competent authority (“conformity monitoring”)
  - DGAC/DSNA = operational partnership
- Météo-France is the SES-certified, **designated MET service provider** for the French national airspace on an exclusive basis (“Arrêté du 20/12/2011”)
  - Includes France mainland and overseas territories

Normes et règlements internationaux :

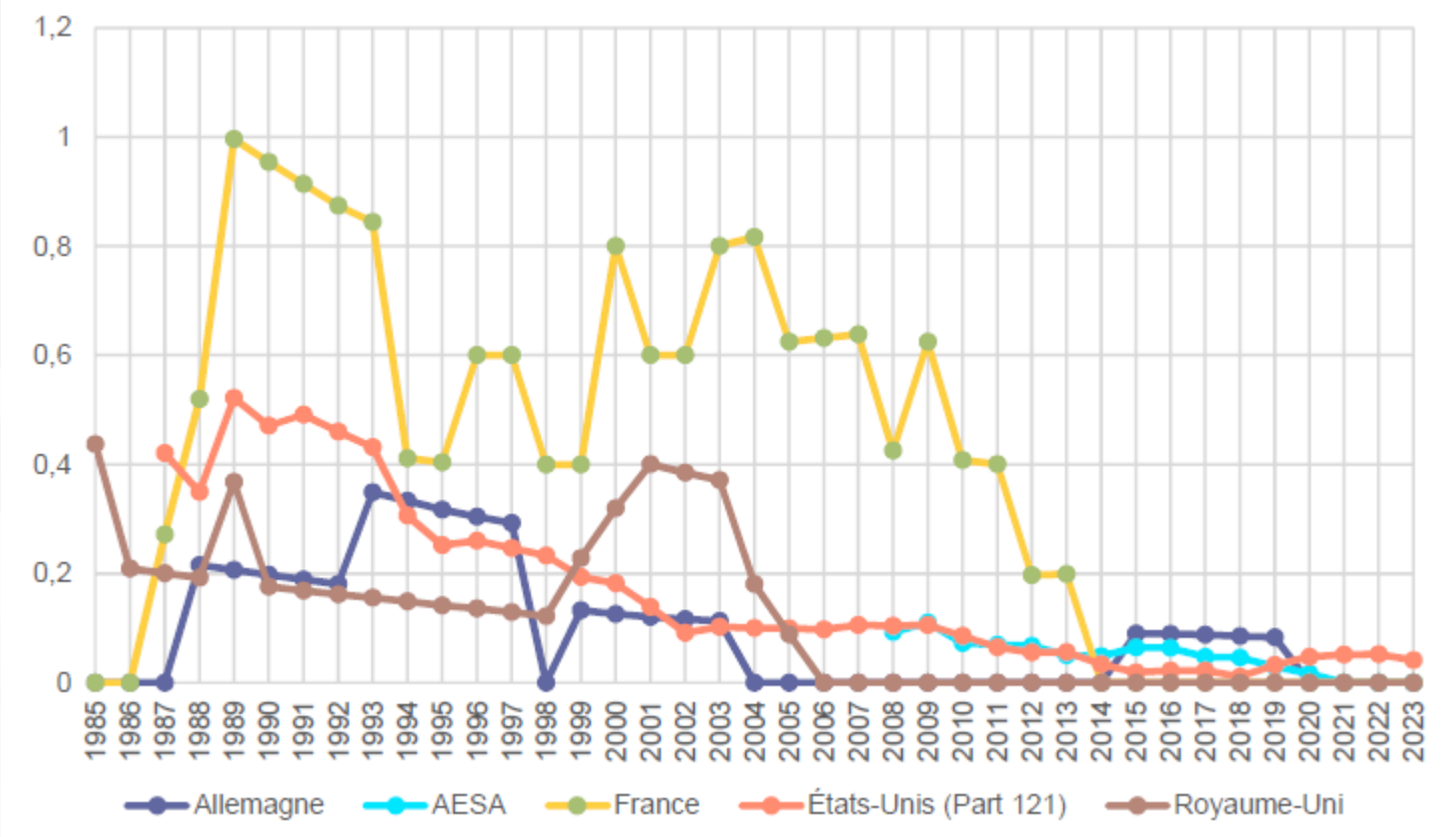
Annexe 3 de l'OACI
Règlement (UE) 2024/2803, dit « SES2+ »
Règlement (UE) 2018/1139, dit « règlement de base »
Règlement (UE) 2017/373, dit « IR ATM/ANS »

Règlements nationaux :

Arrêté du 20 décembre 2011 portant désignation de Météo-France en tant que prestataire de services météorologiques.
Arrêté du 13 février 2020 relatif à la fourniture de services météorologiques pour les besoins de la navigation aérienne, dit « arrêté MET »

THE BENEFITS OF REGULATION

- Number of deadly accidents of aircrafts with ≥ 20 seat passengers (or equivalent in all-cargo version) per million flight hours in commercial aviation
- 1985 - 2023



THE SIGNIFICANCE OF AVIATION AT METEO-FRANCE

- More than 160 civil and dual airports are served in mainland France and overseas, with service levels tailored to each airport.
- En-route services include :
  - Meteorological Watch Offices (MWO → SIGMET) for
    - 5 FIRs in mainland France
    - 2 FIRs in overseas territories (French Guiana and Tahiti).
  - Supranational ICAO missions :
    - VAAC (volcanic ash, Toulouse VAAC)
    - TCAC (tropical cyclones – La Réunion Center)
    - Regional OPMET Center (Toulouse)
    - Space Weather (MF member of the FR Spectra consortium, part of the ACFJ international consortium)
- Aviation services revenues represent about ¼ of the annual Météo-France budget
- About 300 FTE contribute directly to delivering the aviation services
- 200 aviation forecasters (mainland + overseas)
- Dedicated strategic guidance documents (publicly available on the web):
  - Stratégie Aéro 2024 – 2027
  - Stratégie Recherche à horizon 2030

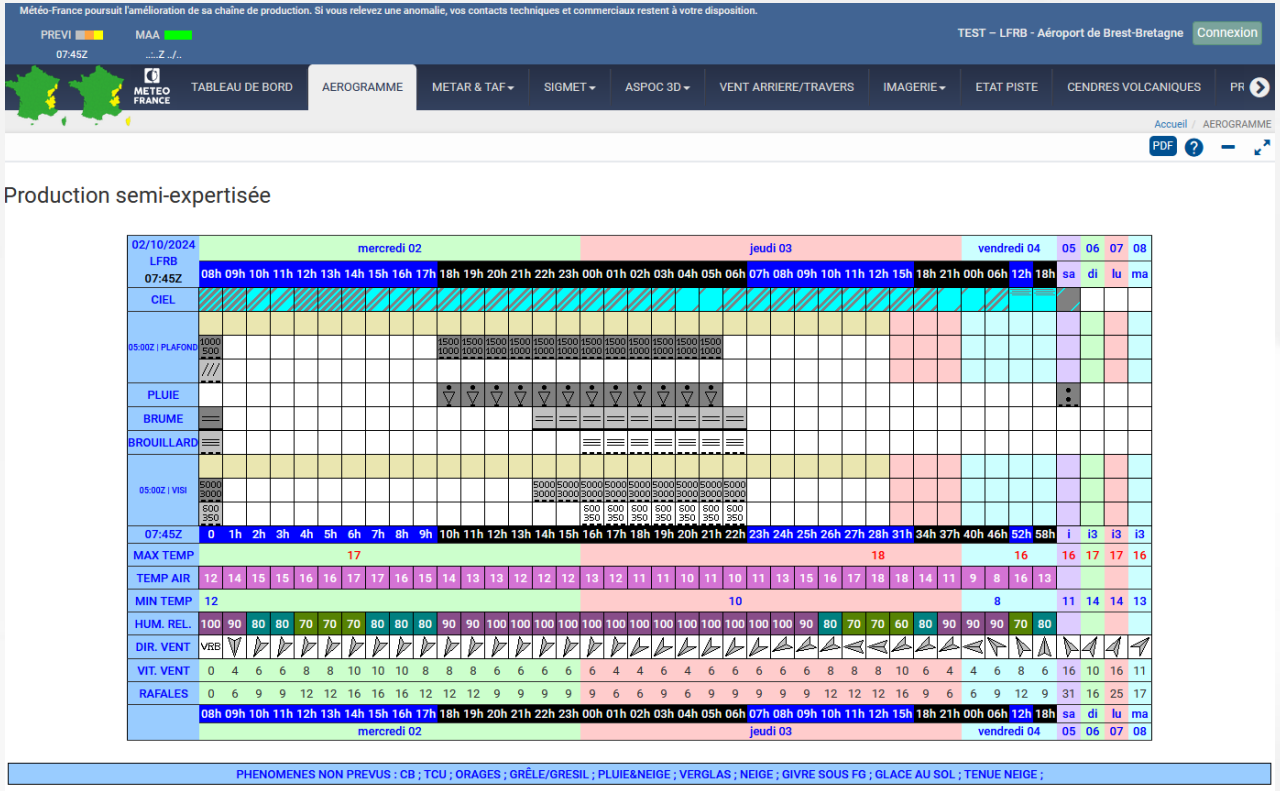
AIRPORT SERVICES (1)

- Dedicated operational instruments at airports providing pressure, temperature, wind, visibility and runway visual range, ceilometer, …
- Additional, redundant or advanced instruments at major airports : weather radar, Doppler lidar, …
- Provision of standard observation and forecast products : local routine report, METAR, TAF, Aerodrome warnings, wind shear warnings, …
- The service relies on a network of regional maintenance (about 30) and forecast (11) centers (figures for mainland France)
- Forecast centers are staffed 24/7 keeping a constant contact with all users

Diffusomètre DF320 de nuit

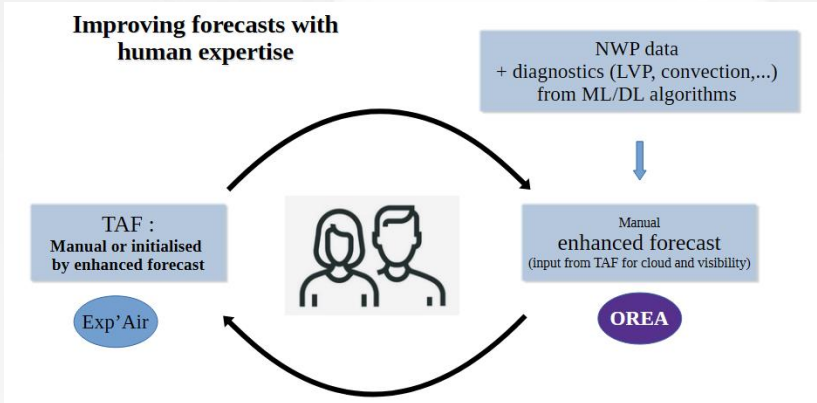
AIRPORT SERVICES (2)

- Forecasts are based on models but also take into account the expertise of aviation forecasters, introduced through interactive tools (CSYM/OREA)
- Examples of advanced products : LVP bulletins, 7-day outlook of the weather situation at the airport (“aerogramme expertise”), cross- and tail-wind conditions, …
- Aviation forecasters are involved in collaborative decision making process, supporting complex decision-making in high-stake situation (e.g. snow at CDG)



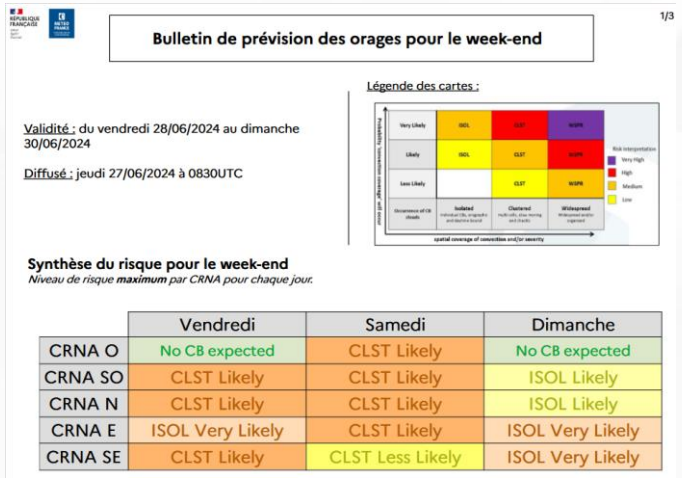
AIRPORT SERVICES (3) – MAIN CHALLENGES AHEAD

- Improving service resilience
  - More redundancy on sensors, equipments and communication links, improvement of cybersecurity of systems, contingency plans, …
- Improving the forecasts (with all means, including AI)
  - Starting project on AI-based, high refresh rate, 6h forecasts of wind and QNH at airports
- Blending automated forecasts with human expertise, especially in high-stake situations and at high-stake airports.
- Providing uncertainties in an intelligible and usable form for the users
  - A challenge that is not specific to aviation
- Promoting the discovery and the insertion of the products and services in the users operational tools and procedures
  - A long-lasting challenge in aviation
- Evolution of the weather conditions at airport in a changing climate
  - high temperatures, sea level rise and risk of coastal flooding, change in the dominant wind regimes,



EN-ROUTE SERVICES (1)

- Operational provision of standard ICAO-regulated products such as SIGMET, SIGWX over the 5 mainland France FIRs and the 2 Overseas FIRs (Cayenne / Tahiti)
- Extending the temporal (convective) forecast horizon in support to sector planning – Up to Day3 – "Bulletin week-end"



1/3

Bulletin de prévision des orages pour le week-end

Légende des cartes :

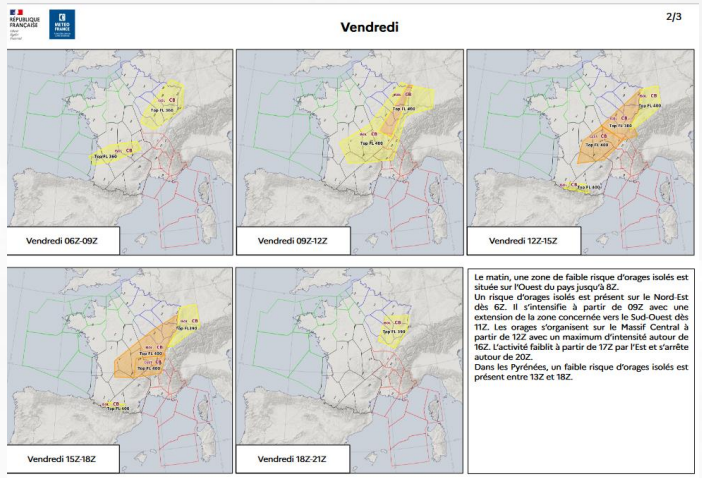
Validité : du vendredi 28/06/2024 au dimanche 30/06/2024

Diffusé : jeudi 27/06/2024 à 0830UTC

Synthèse du risque pour le week-end

*Niveau de risque **maximum** par CRNA pour chaque jour.*

	Vendredi	Samedi	Dimanche
CRNA O	No CB expected	CLST Likely	No CB expected
CRNA SO	CLST Likely	CLST Likely	ISOL Likely
CRNA N	CLST Likely	CLST Likely	ISOL Likely
CRNA E	ISOL Very Likely	CLST Likely	ISOL Very Likely
CRNA SE	CLST Likely	CLST Less Likely	ISOL Very Likely



2/3

Vendredi

Vendredi 06Z-09Z

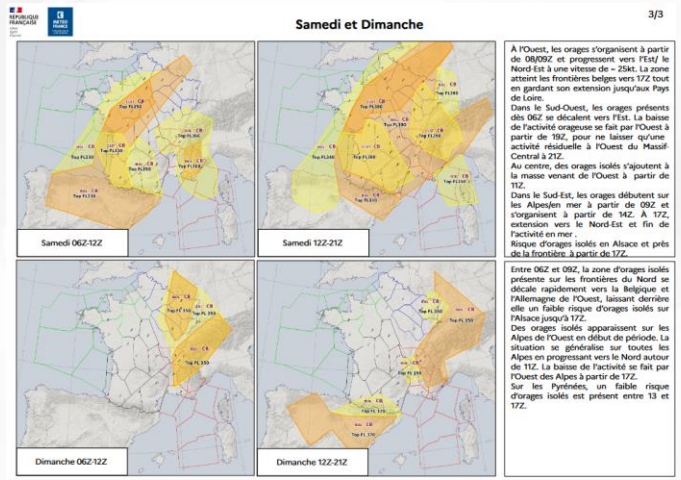
Vendredi 09Z-12Z

Vendredi 12Z-15Z

Vendredi 15Z-18Z

Vendredi 18Z-21Z

Le matin, une zone de faible risque d'orages isolés est située sur l'Ouest du pays jusqu'à 8Z.
Un risque d'orages isolés est présent sur le Nord-Est dès 6Z. Il s'intensifie à partir de 09Z avec une extension de la zone concernée vers le Sud-Ouest dès 11Z. Les orages s'organisent sur le Massif Central à partir de 12Z avec un maximum d'intensité autour de 16Z. L'activité faiblit à partir de 17Z par l'Est et s'arrête autour de 20Z.
Dans les Pyrénées, un faible risque d'orages isolés est présent entre 13Z et 18Z.



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Samedi et Dimanche

Samedi 06Z-12Z

Samedi 12Z-21Z

Dimanche 06Z-12Z

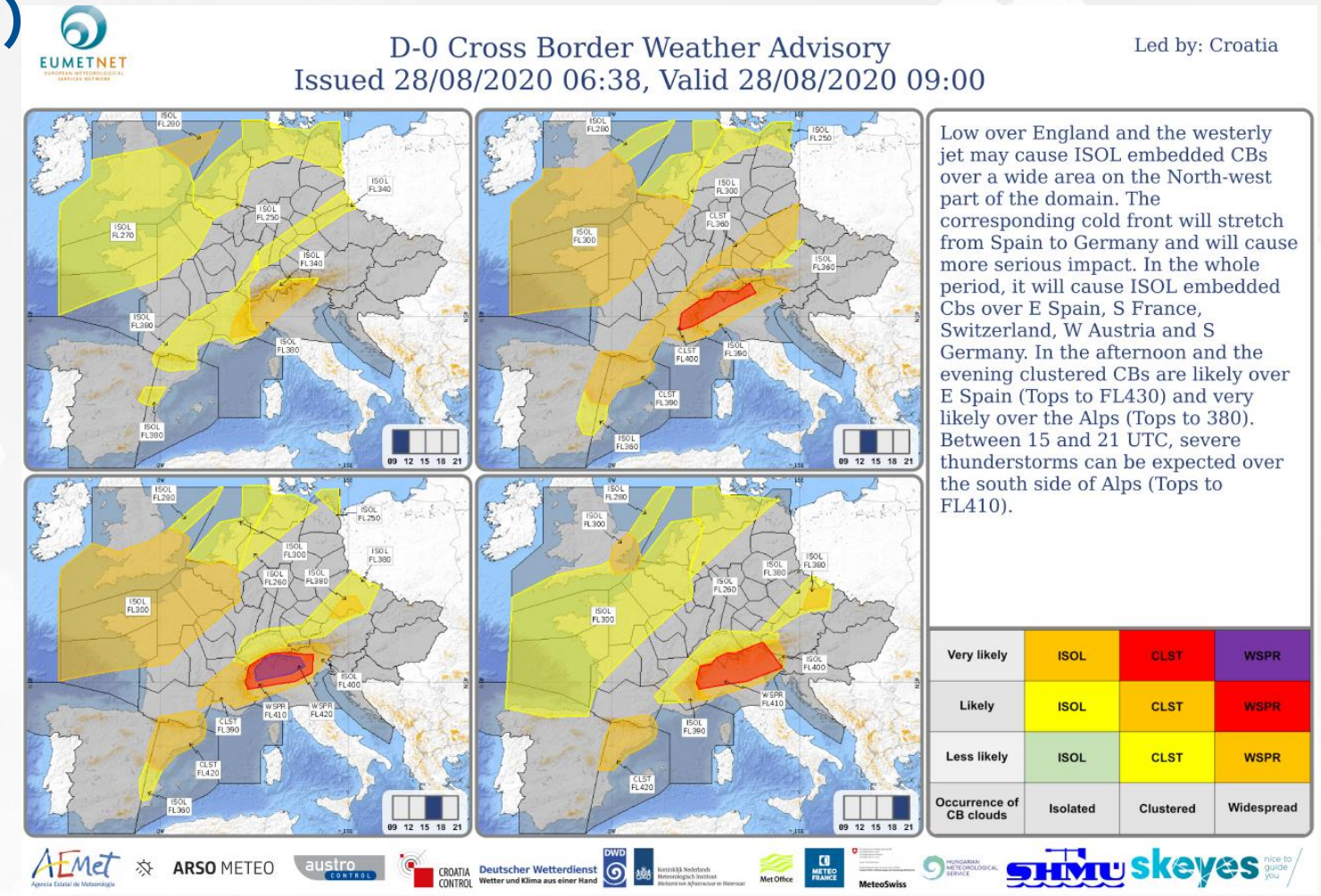
Dimanche 12Z-21Z

À l'Ouest, les orages s'organisent à partir de 08/09Z et progressent vers l'Est/ le Nord-Est à une vitesse de ~ 25kt. La zone atteint les frontières belges vers 17Z tout en gardant son extension jusqu'aux Pays de Loire.
Dans le Sud-Ouest, les orages présents dès 06Z se décalent vers l'Est. La baisse de l'activité orageuse se fait par l'Ouest à partir de 19Z, pour ne laisser qu'une activité résiduelle à l'Ouest du Massif-Central à 21Z.
Au centre, des orages isolés s'ajoutent à la masse venant de l'Ouest à partir de 11Z.
Dans le Sud-Est, les orages débutent sur les Alpes/en mer à partir de 09Z et s'organisent à partir de 14Z. À 17Z, extension vers le Nord-Est et fin de l'activité en mer ;
Risque d'orages isolés en Alsace et près de la frontière à partir de 17Z.

Entre 06Z et 09Z, la zone d'orages isolés présente sur les frontières du Nord se décale rapidement vers la Belgique et l'Allemagne de l'Ouest, laissant derrière elle un faible risque d'orages isolés sur l'Alsace jusqu'à 17Z.
Des orages isolés apparaissent sur les Alpes de l'Ouest en début de période. La situation se généralise sur toutes les Alpes en progressant vers le Nord autour de 11Z. La baisse de l'activité se fait par l'Ouest des Alpes à partir de 17Z.
Sur les Pyrénées, un faible risque d'orages isolés est présent entre 13 et 17Z.

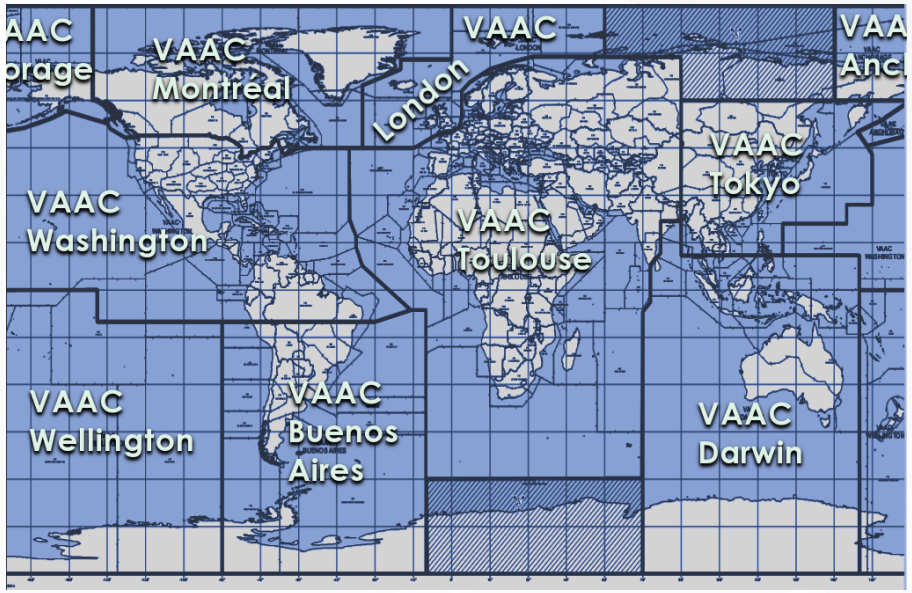
EN-ROUTE SERVICES (2)

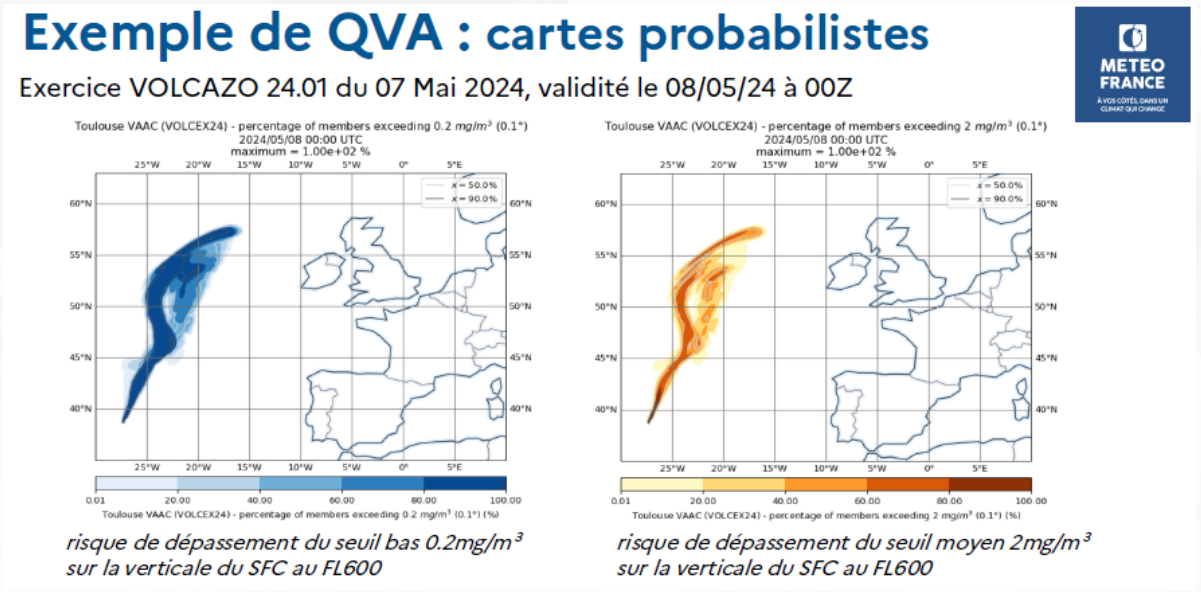
- Extending the spatial (convective) forecast coverage and providing a seamless and consistent service at the European scale
- The "cross-border convection forecast" – An activity carried out every summer under the EUMETNET umbrella for the sake of EUROCONTROL Network Manager



EN-ROUTE SERVICES (3)

- Volcanic Ash Advisory Center Mission – Toulouse VAAC
- Warnings based upon observations (dedicated ground-based lidars, satellites), dedicated numerical forecasting models (plume dispersion models) and human expertise
- New quantitative products (quantitative volcanic ash – QVA) now operational and disseminated to users → Towards a quantitative and probabilistic information





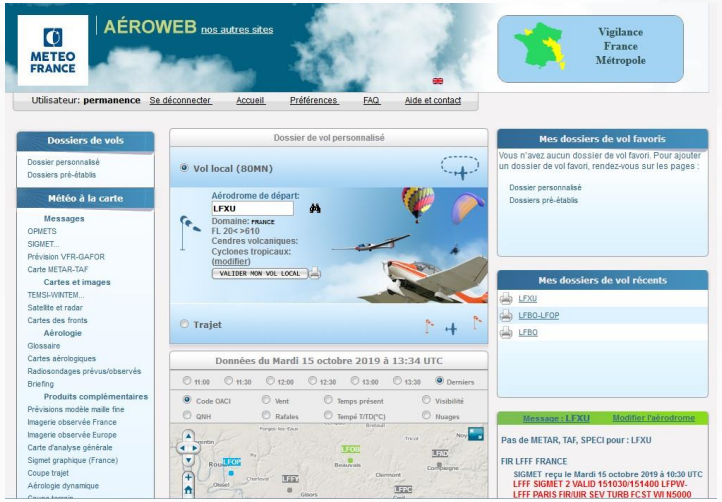
EN-ROUTE SERVICES (4) – CHALLENGES AHEAD

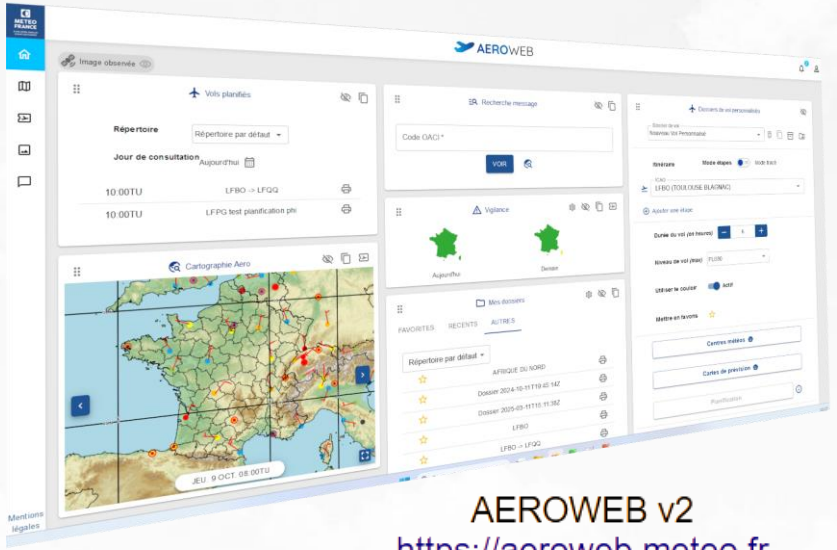
- Improving forecasts
  - New HPC, new satellite date (e.g. MTG IRS), more data from aircrafts (?)
- Towards seamless – in space and time – forecasts
  - Starting R&D project on blending observation-based nowcasting with NWP to provide rapid refresh 0 – 48h convection forecasts at global level
  - New ICAO Hazard Weather Information Service (HWIS) in discussion
- Keeping aviation forecasters in the expertise loop
  - Need for interactive tools
- Quality
  - More systematic introduction of product quality assessment (though not easy for some parameters – e.g. icing or turbulence)
- Climate
  - Forecasting areas prone to contrail formation, in support to optimized operations and / or new regulation
  - How will en-route weather conditions evolve in a changing climate ? PhD Project focused on the climatological evolution of en-route turbulence conditions (CAT)

A PRODUCT NOBODY KNOWS, NOBODY CAN ACCESS, AND NOBODY USES IS JUST A VERY EXPENSIVE SECRET

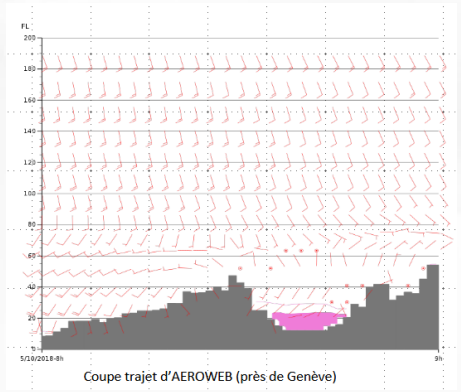
Aéroweb

- A website enabling aviation users to retrieve, in real time, the regulatory aeronautical charts and messages required to produce flight meteorological documentation, as well as non-regulatory products and satellite and radar imagery.
- New version of Aéroweb (2.0) deployed operationally by end of 2026.





AEROWEB v2
https://aeroweb.meteo.fr



A PRODUCT NOBODY KNOWS, NOBODY CAN ACCESS, AND NOBODY USES IS JUST A VERY EXPENSIVE SECRET

MetGate

What is it exactly ?

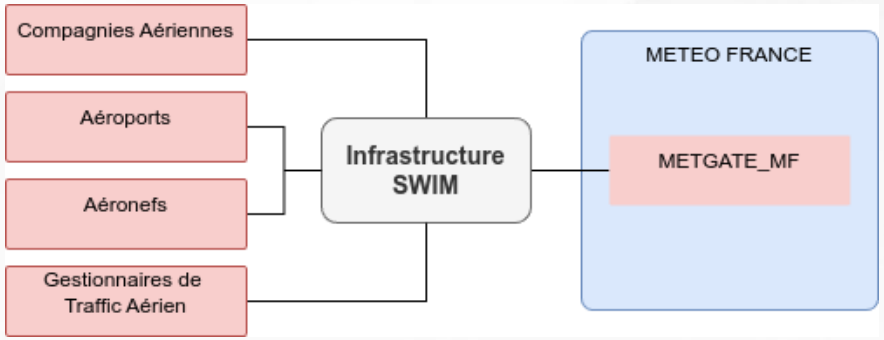
- A means of making MET data available to aviation users 24/7.
- A single platform connecting Météo-France to the SWIM network
- A machine-to-machine service, with no user interface, accessible via API
- Météo-France's response to the European CP1 regulation.
- A key pillar of the Météo-France new aviation production architecture, both in a regulated framework and, in the future, for commercial services.

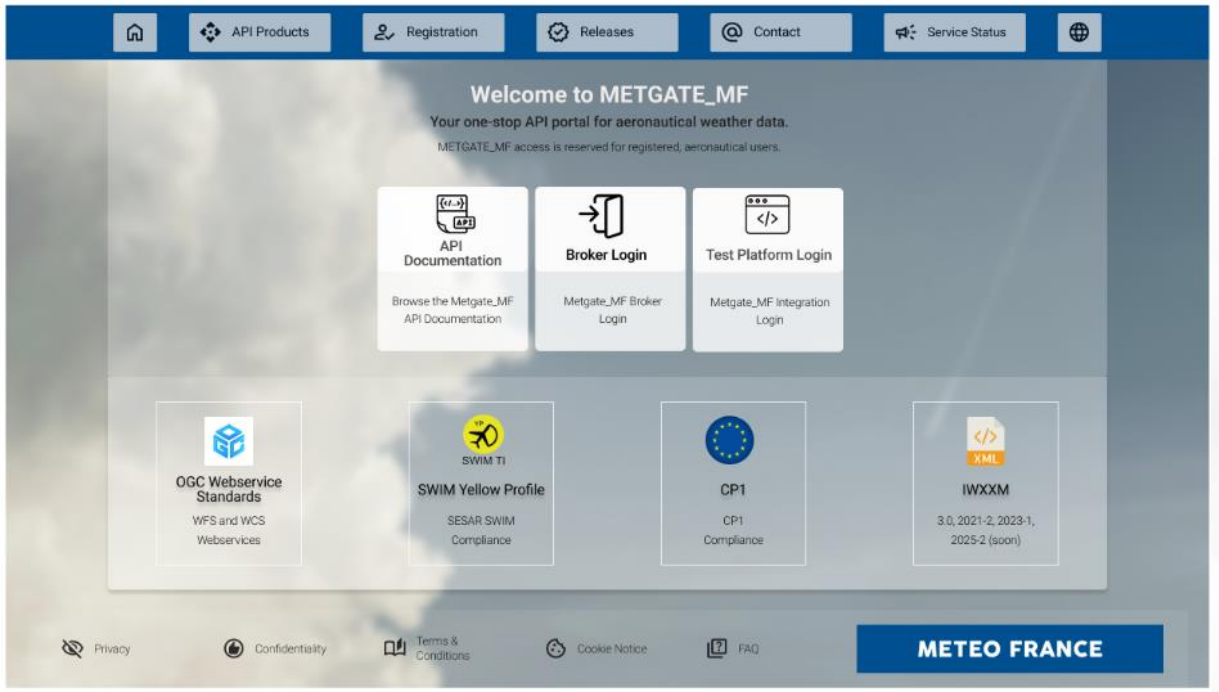
How does it work?

- I subscribe to a product, for example METAR.
- I build a standardized filter, for example for French aerodromes.
- I am notified when new METAR messages are available.
- I consume the data through a user interface, processing software, or other systems.

A PRODUCT NOBODY KNOWS, NOBODY CAN ACCESS, AND NOBODY USES IS JUST A VERY EXPENSIVE SECRET

METGATE





NON REGULATED SERVICES

- Provision of MET information for electronic flight bags
- Dedicated support to airlines

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Merci de votre attention