Advancing weather and climate science to serve aviation’s evolving needs

African Conference on Meteorology for Aviation (ACMA-2018)
28 to 30 November 2018, Dakar, Senegal
Gate-to-gate needs

<table>
<thead>
<tr>
<th>AERODROME</th>
<th>TERMINAL AREA</th>
<th>EN-ROUTE</th>
<th>TERMINAL AREA</th>
<th>AERODROME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-flight planning</td>
<td>Take-off</td>
<td>Climb</td>
<td>Cruise</td>
<td>Descent</td>
</tr>
<tr>
<td>Parked</td>
<td>Initial climb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate push-back</td>
<td></td>
<td>Climb</td>
<td>Cruise</td>
<td>Descent</td>
</tr>
<tr>
<td>Taxi</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Consideration of the weather impact at **every stage** in the decision-making process

- **Strategic planning**
- **Pre-tactical**
- **Tactical**
- **Post-flight analysis**
Aviation’s vision for the 2030s

• Globally interoperable, harmonized ATM system
  • TBO
  • CCO/CDO
  • PBN

• **Meteorology as a key enabler**
  • Through SWIM
  • MET data and information services
WMO Aeronautical Meteorology Scientific Conference 2017

• Held 6 to 10 November 2017 in Toulouse

• Aviation, weather and climate: *Scientific research and development for future aeronautical meteorological services in a changing atmospheric environment*
Science R&D
- Ice crystal icing and airframe icing research
- Turbulence research
- Significant convection research
- Wake vortex detection and prediction
- Fog/low visibility research
- Space weather research
- Atmospheric aerosols and volcanic ash research
- Advances in observing methods and use of observations
- Seamless nowcast and numerical weather prediction, probabilistic forecast and statistical methods

Service Delivery
- In-cockpit and on-board MET capabilities
- Terminal area and impact-based forecast
- Enroute hazards information systems
- Collaborative decision-making (CDM), air traffic flow management (ATFM) and network management
- Trajectory-based operations (TBO), flight planning and user-preferred routing
- Use of MET information for climate-optimized trajectories

Climate change & variability
- Jet stream position and intensity and related phenomena
- Extreme weather events and airports, changes to established scenarios
- Re-evaluation of airframe/avionics resilience standards and certification
High-altitude ice crystal icing research

- Infrequent but high impact events
- Meteorologically complex to parameterize
- Observation/detection
- Nowcast and forecast
- Experimental trials ongoing
- **More encounter reports needed to validate observations and calibrate forecasts**

Graphic: NASA
Atmospheric turbulence research

• Multiple types/sources
• Often localized, often transient but often high impact
• Observation/detection
• Nowcast and forecast
• More encounter reports needed to validate observations and calibrate forecasts
Significant convection research

- Towering Cumulus (TCU) and Cumulonimbus (CB)
- Pose multiple aviation hazards
- Observation/detection
- Nowcast and forecast
Wake vortex detection and prediction

- Ground/near-ground and enroute hazard
- Prevailing meteorological conditions important
- Aircraft parameters important
- Wake vortex or low-level wind shear?
- Experimental trials ongoing
- More encounter reports needed to validate observations and calibrate forecasts

Graphic: Thales
Advances in observing methods and use of observations

• Complementing or even replacing ‘traditional’ methods of observation
• Direct support to NWP and in-cockpit user applications
Importance of aircraft-based observations

- **Aircraft Meteorological Data Relay** (AMDAR)
- Low cost, high benefit
- **Wind and temperature** via AMDAR are amongst the most important data sources
  - Other key parameters include **pressure**, **turbulence** and **moisture**
- In-situ moisture measurements/water vapour datasets **important for climate studies**

Source: Airbus Working arrangement signed July 2017
Seamless nowcast and forecast

- **Observation**: ‘Now’ with reduced latency
  - Ground-based
  - In-situ/aircraft-based
  - Satellite-based

- **Nowcast**: Next few minutes up to next few hours
  - Advection/extrapolation + NWP
  - Rapid refresh

- **Forecast**: Several hours up to several days or weeks
  - Blending, ensembles, probabilistic
  - NWP + climatology
  - Regular update
Impact-based forecasting

• Many solutions emerging tailored to the various ATM users’ needs
  • ‘Playbook’ scenarios

• Pro-active management of weather impacts on ATM system
  • **MET-ATM COLLABORATION KEY**
Collaborative decision-making support

• Numerous trials, evaluations and best practices already exist
  • Ground-based and in-cockpit applications
• Qualitative and quantitative impact assessments of the weather on ground and air operations
  • Common, shared situational awareness
  • Met information in combination with air traffic loads
    • Actual and forecast
  • Proactive airspace management
  • Quality, reliability, predictability
### Extreme weather and climate events

<table>
<thead>
<tr>
<th>Phenomenon</th>
<th>Early 21st century (2016-2035)</th>
<th>Late 21st Century (2081-2100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warmer and/or fewer cold days and nights over land areas</td>
<td>Likely</td>
<td>Virtually certain</td>
</tr>
<tr>
<td>Warmer and/or more frequent hot days and nights over most land areas</td>
<td>Likely</td>
<td>Virtually certain</td>
</tr>
<tr>
<td>Warm spells/heat waves. Frequency and/or duration increases over most land areas</td>
<td>Not formally assessed</td>
<td>Very likely</td>
</tr>
<tr>
<td>Heavy precipitation events. Increase in the frequency, intensity and/or amount of heavy precipitation</td>
<td>Likely over many land areas</td>
<td>Very likely over most of the mid-latitude land masses and over wet tropical regions</td>
</tr>
<tr>
<td>Increase in intense tropical cyclone activity</td>
<td>Low confidence</td>
<td>More likely than not in the Western North Pacific and North Atlantic</td>
</tr>
<tr>
<td>Increased incidence and/or magnitude of extreme high sea level</td>
<td>Likely</td>
<td>Very likely</td>
</tr>
</tbody>
</table>
Changes to established scenarios

- Shifting wind patterns modify optimal flight routes and fuel consumption
- Stronger jet-stream wind shears increase clear-air turbulence
- Warmer air imposes take-off weight restrictions
- More extreme weather causes disruptions and delays
- Rising sea levels and storm surges threaten coastal airports

Puempel & Williams (2016)
ICAO Environmental Report
Changes to established scenarios

- Increased convective weather
  - Amplification of climate change impacts
  - Loss of en route capacity
  - Airport/en route delay

- Change in wind speed/direction
  - Change to runway configuration and airspace design
  - Change to environmental impact (e.g., noise)

- Increased precipitation
  - Loss of airport capacity
  - Increased delay

- Increased storm surges
  - Temporary loss of airport capacity

- Increased temperatures
  - Change in demand
  - Change in climb performance

- Sea level rise
  - Permanent loss of airport capacity

Flooding and sea-level rise:
- Inundation of runways and taxiways
- Loss of ground transport access
- Inundation of electrical infrastructure

Higher summer temperatures:
- Changes in summer demand patterns
- Heat damage to infrastructure
- Increased cooling requirements

Increased convective weather:
- Increased delay / loss of capacity
- Lack of capacity at diversionary airports

Increased precipitation:
- Impacts on capacity/delay
- Inundation of runways and taxiways
- Inundation of electrical infrastructure

Changes in wind direction:
- Increased crosswinds
- Capacity implications
- Potential procedure changes
- Potential changes to noise distribution

Source: Eurocontrol
Aeronautical Meteorology Programme

WMO Aeronautical Meteorology Scientific Conference (AMSC-2017)

Introduction

Toulouse, France
Monday, November 6, 2017 to Friday, November 10, 2017

The theme of the Conference is:

“Aeronautical, weather and climate: Scientific research and development for future aeronautical meteorological services in a changing atmospheric environment.”

The objective of this event is to provide an overview of the current state-of-the-art and foreseen advances in meteorological science and technology needed to underpin the changing global aviation environment.

www.wmo.int/aemp/AMSC-2017
Final thoughts

• Weather and climate scientific research activities demand improved access to data, especially aircraft-derived MET observations.

• The transition from scientific research to operations needs to be accelerated and well-communicated in concert with users’ needs.

• Conveying forecast uncertainty is a priority but remains a challenge that needs further research and guidance.

• The mitigation of extreme weather events and the adaptation to a changing climate by aviation demands a multidisciplinary effort.

• The time to act is now!
Thank you

GREG BROCK  GBrock@wmo.int  @WMO