How Climate Change will affect the need for MET Support to Civil Aviation

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Issues addressed:

- Overview of state of knowledge on impacts of climate on aviation from a science perspective
- Time lines: Long-term, decadal, interannual, resulting “weather” types
- Summarize state of knowledge regarding climate change risk and resilience – the stakeholder perspective
- A look at extreme phenomena
Scientific issues

• Complex interaction between variability (on an inter-annual to decadal time scale) and long-term trends (if these can be clearly separated from the former?)

• Extreme events: Are they just a result of shifting the Gaussian to the right? What is the role of feedback mechanisms? (Lehmann and Coumou)

• Small to Local Scale hugely complex (e.g. nature of convective storms)
...and more issues:

- Risk management in light of extremes and slowly evolving disasters
- Potential conflicts of interests between different environmental and safety issues
- Linkage between alternative fuels and climate
- Predictability and manageability of high-impact weather and new air traffic systems: Areas for multi-disciplinary research and development
Comparison Observations-Models (Frei et.al.)

Winter precipitation (DJF) obs-models
Confidence in Trends?

• Regional trends may differ significantly from each other (Francis and Vavrus, Screen and Simmonds)
• Observed trends in local scale-phenomena rendered unreliable by automation of observations (hail, tornadoes rarely detected by AWOS)
• Inter-annual variability (ENSO, NAO) very strong, not sure how they are linked to climate trends or obscuring them?
Potential/Expected Changes (Wuebbles et al 2014)
Emerging consensus on some issues:

1. Temperature: Warming at the surface and upper levels [high confidence], cooling of stratosphere regionally
   - More temp extremes at surface, two contributing factors:
     - Gaussian shifted to right (trivial)
     - Complex feedback mechanisms, regional increase in blocking highs (mid-lat)

2. Small changes to jet stream
   - Acceleration (obscured by large variance?), Poleward shift
   - High-Amplitude low wave-number regimes (Francis and Vavrous, Coumou et al.)
   - High uncertainty about CAT (probably shift of affected regions)
   - Massive gaps in data over large areas (Africa, S. America, Pacific)
Role of quasi-stationary system (Coumou et al.)

• “Furthermore, we demonstrate that the anomalous circulation regimes lead to persistent surface weather conditions and therefore to mid-latitude synchronization of extreme heat and rainfall events on monthly timescales. The recent cluster of resonance events has resulted in a statistically significant increase in the frequency of high-amplitude quasi-stationary waves of wave numbers 7 and 8 in July and August.”
Effects on predictability?

• While no detailed studies exist yet, there are some indications that:
  • The increased Available Potential Energy may lead to different characteristics of mid-latitude convection
  • Storms develop in anticyclonic regimes irrespective of the presence of wind shear and gradients
  • Location, intensity and characteristics of storms may defy current NWP prediction methods
Expected Changes...details for aviation

3. Storms and Ice

- More extreme thunderstorms (height of Cb tops, ice content) [High confidence]
  - High Altitude Ice Content expected to increase
  - Tornadic storms and hail: Models seem to indicate a positive trend post-2040, observational trend affected by increasing automation of observations

- Extreme surface precipitation: more large events See Coumou and Lehmann [High confidence]

- Hail and windstorms, ice storm changes:

- Dramatic change of observing system from human to automated systems affecting statistics [Low confidence]
Expected Changes...details for aviation

4. Local conditions (low and ground level)

- Strongly varying by region and also with inter-annual variations (e.g. ENSO, NAO)
  - Coastal regions need better protection: sea level rise [high confidence], extreme events [uncertain]. Cyclones: uncertain.
- Flooding (+extreme precipitation) = more potential for flooding, difficult to detect trend of rare events (Frei et al.)
- Fog and Low Ceiling: again, no uniform trend to be expected, dependency not only on temp. and humidity, but also aerosols
- Consensus on need for regional and local in-depth analyses
Risk Management by stakeholder category

- **Longest time horizon:** Airport planners, Manufacturers, Tourism and town planners
  - Planning horizons around 30 years
  - Not only stationary “end state”, but variations and extremes along the time line to be accounted for
  - Multi-disciplinary approach, including civil engineers, designers, sociologists, life-sciences

- **Medium Horizon:** ANSP, Regulators/legislators

- **Short –time:** Airlines operators
Airports

- Pioneering work done for London Heathrow study, to be adapted to other regions, climate types and infrastructure.
- Agreement on the need for a multi-disciplinary approach, ranging from Bio-Scientists (Pest control, bird migration), Epidemiologists to hydrologists (Water table, flood risk, landslides etc.), all with an understanding of climate change.
- Demand analyses and predictions in mostly tourism-oriented regions (incoming, outgoing).
- Rainfall characteristics (length of drought, wet periods, maximum intensity, water tables).
- Snow fall (clearing capability) and max load for building infrastructure.
Airports

• Frequency, duration, intensity of electric storms causing a shut-down - no clear trend identified as yet, but increase likely
• Duration of low wind, high stability periods with consequences for air quality, wake vortex dissipation, visibility - strong regional variations
• Maximum heat, wind and precipitation stress on buildings and infrastructure
• Regularity, maximum intensity and prevailing temperature at snow fall events, freezing precipitation
• Off-airport impacts on transport and supply infrastructure (access for goods, passengers, staff, electrical power, water)
Manufacturers

- Strong dependency on regulatory (certification) envelope developed by regulators in response to changing conditions, in particular for:
- Take-off performance in hot&moist conditions
  - High altitude and “classical” icing
  - Frequency of lightning strikes in all climate zones (structural impact, life cycle impact)
  - Heavy hail (e.g. recent Delta incident!) – max impact may have to be reconsidered
  - Area and period affected by sand storms, tropical cyclones, other extreme conditions
  - Changes in the location, variability and characteristics of typical flow pattern (jet streams)
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