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A brief overview of climate change impacts on aviation, industry needs, and the resulting “home work” for scientists

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# Overview of expected climate change effects

- *Very likely* that **hot extremes, heat waves, and heavy precipitation events** will continue to become more frequent
- *Likely* that future **tropical cyclones** will become more intense, with larger peak wind speeds and more heavy precipitation
  - **less confidence in changes of total number of events**
- **Extra-tropical storm tracks** projected to move poleward with consequent changes in wind, precipitation, and temperature patterns, likely increase of storm intensity
- More cases of “High-amplitude / low wave number situation in NH mid-latitudes (“Blocking situations”)

# Regional and temporal variation

- Emerging evidence of strong temporal variation on several time-scales
- Need to better understand interaction with periodical changes (ENSO, NAO, QBO...)
  - Extremely complex Ocean-Atmosphere interactions lead to large spread in model projections
  - Latest studies may point to an increase in intensity and frequency of ENSO and La Nina

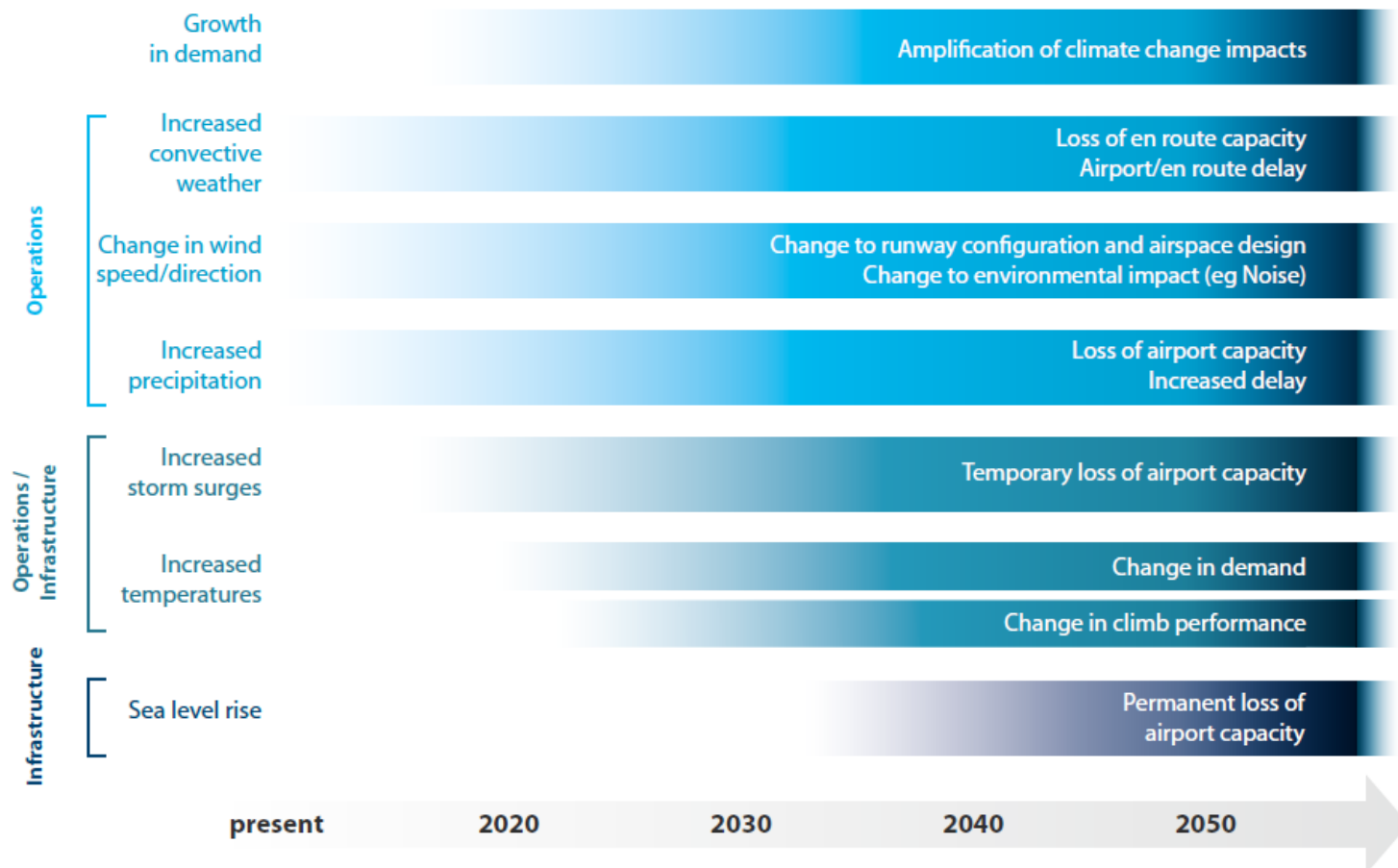
# Regional differences

- Strong evidence for high impact on cryosphere
  - Arctic sea ice reduction
  - Massive reduction of Alpine glacier mass
- Intensification of drought and rain fall in wet regions (strong seasonal dependence)
- Rainfall often linked to specific scenarios at regional scale

# Industry concerns & needs

## The perspective of an A/C manufacturer

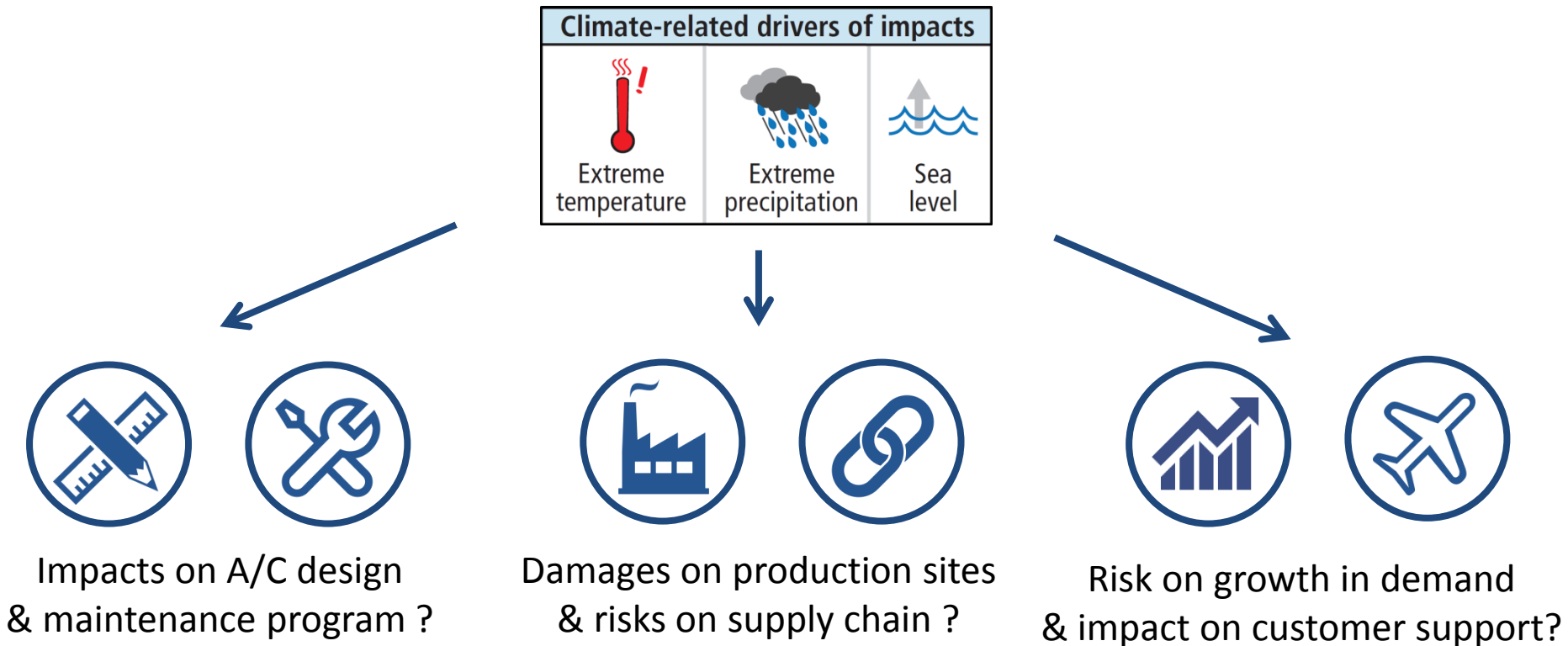
- Operational impacts (source: Eurocontrol)



# Industry concerns & needs

## The perspective of an A/C manufacturer

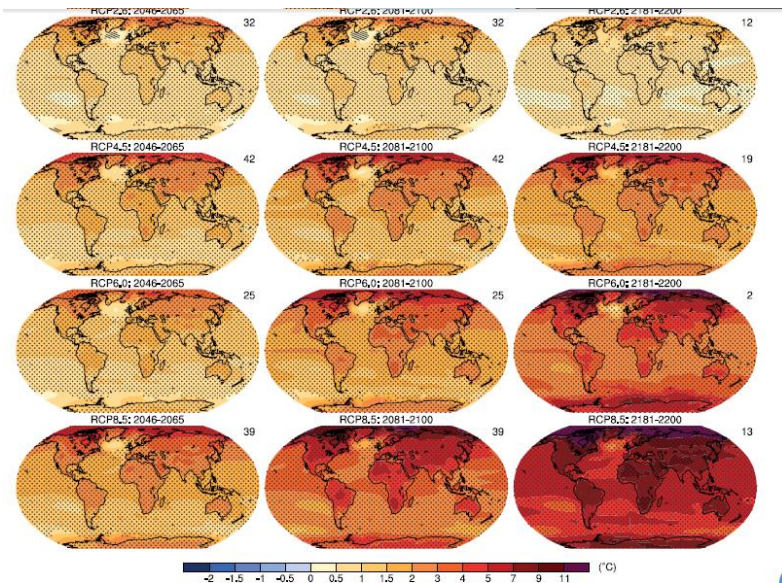
- Multifactorial impacts



# Industry concerns & needs

## The perspective of an A/C manufacturer

- Global science versus detailed regional/local/specific info



Scenarios for mean temp evolution



How will the max temperature evolve in Dubai, Doha, Mexico, Bogota, Abu Dhabi, Jeddah, Delhi ?

# Industry concerns & needs

## The perspective of an A/C manufacturer

- The priority questions:
  - Universal max/min temperatures
  - In-flight icing conditions
  - Turbulence and surface winds
  - Humidity conditions
  - Frequency and extreme intensity of lightning strikes
  
- Anticipate climate evolution without over-designing



# Job-cards for the scientific community

- Mitigation will rely on a multi-disciplinary effort involving Geology, Hydrology, Biology (vegetation studies) and Medical Research into pandemics and airborne diseases
- Consider not only long-term, model-based climate projections, but a continuous validation of these projections against emerging evidence of high impact scenarios occurring and documented already now,
- Specific impact-scenarios already becoming evident need to be linked to a down-scaling to the regional and local scale of projections of future climates to identify priorities in mitigation measures.

# Research priorities

- Issues of temperature and humidity limiting take-off and landing performance:
  - Extremes of temperature at and near the surface of the earth occurring during extended periods of heat waves or cold outbreaks in mid-latitudes
  - Role of regional and local wind systems (sea breeze effects, valley winds, low-level jets), how issues such as soil moisture, vegetation and land use will influence extremes
  - Increase of moisture on density altitude, diurnal cycle of temperatures, changes in vegetation pattern around major hub airports

# Issues of surface winds:

- Focus on severe storms , tropical and local wind systems as they are affected by flow pattern and regimes
- Questions of storm surge affecting coastal aerodromes
- Occurrence of extreme cross-winds with severe storms, prevalence of high amplitude- , prevalence of high amplitude-low wave-number regimes etc, and their impact on runway availability

# Safety Risk Mitigation

- High-Level Icing as a result of stronger convection producing high values of icicle mass per volume
- Changing propagation and movement of convective systems under low shear-high CAPE regimes, their predictability and their effects on airport throughput/shut-down
- Issues of moderate and severe/extreme turbulence:
  - Location and frequency of moderate turbulence as a result of changing flow patterns (jet positions, stronger anti-cyclonic curvature in extreme ridges, troughs)
  - Fundamental question of extreme turbulence in high shear with high stability situations (not detected by typical Richardson -number based algorithms), possibly enhanced by convective cells pushing into Tropopause)
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Thank you

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