



# ICAO Symposium on Non-CO<sub>2</sub> Aviation Emissions

16 — 18 September 2024  
Montréal, Canada



## Zane Dedekind

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Forecasting Contrail Forming Regions –  
Development of the Contrail Avoidance Tool (CoAT)

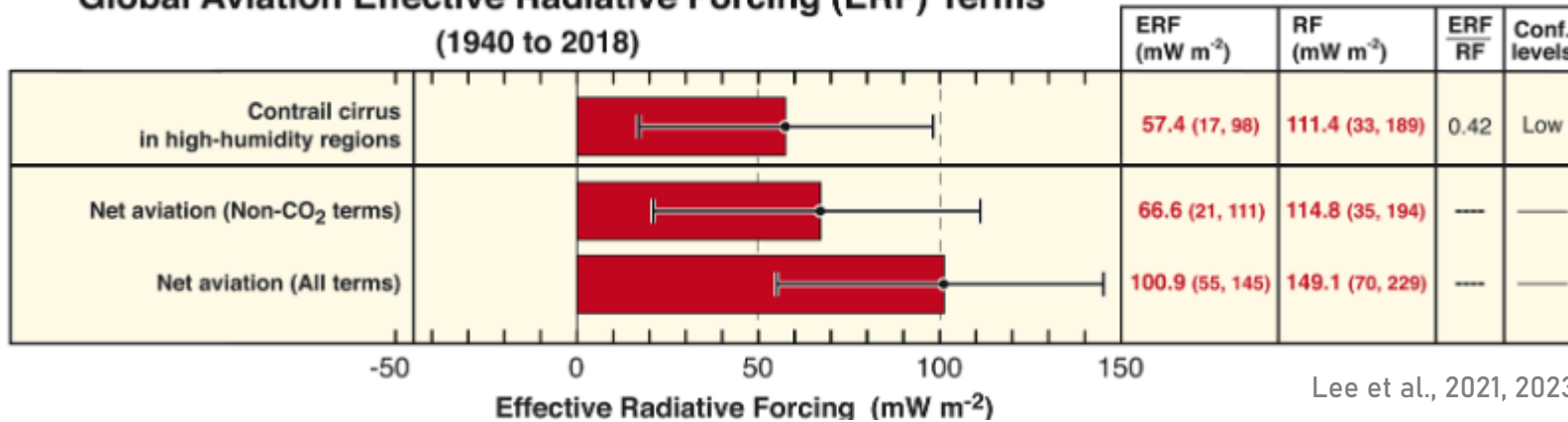
Environment and Climate Change Canada

# What are Contrails?

- Line shaped ice clouds generated by aircraft cruising
- Typically form in the **upper troposphere at 8 – 12 km** where temperatures are below **-40 °C**
- Short lived < 10 min
- **Long lived > 10 min**
- Persistent Contrails (Retain their shape)
- Contrail Cirrus (Spread over wide regions)

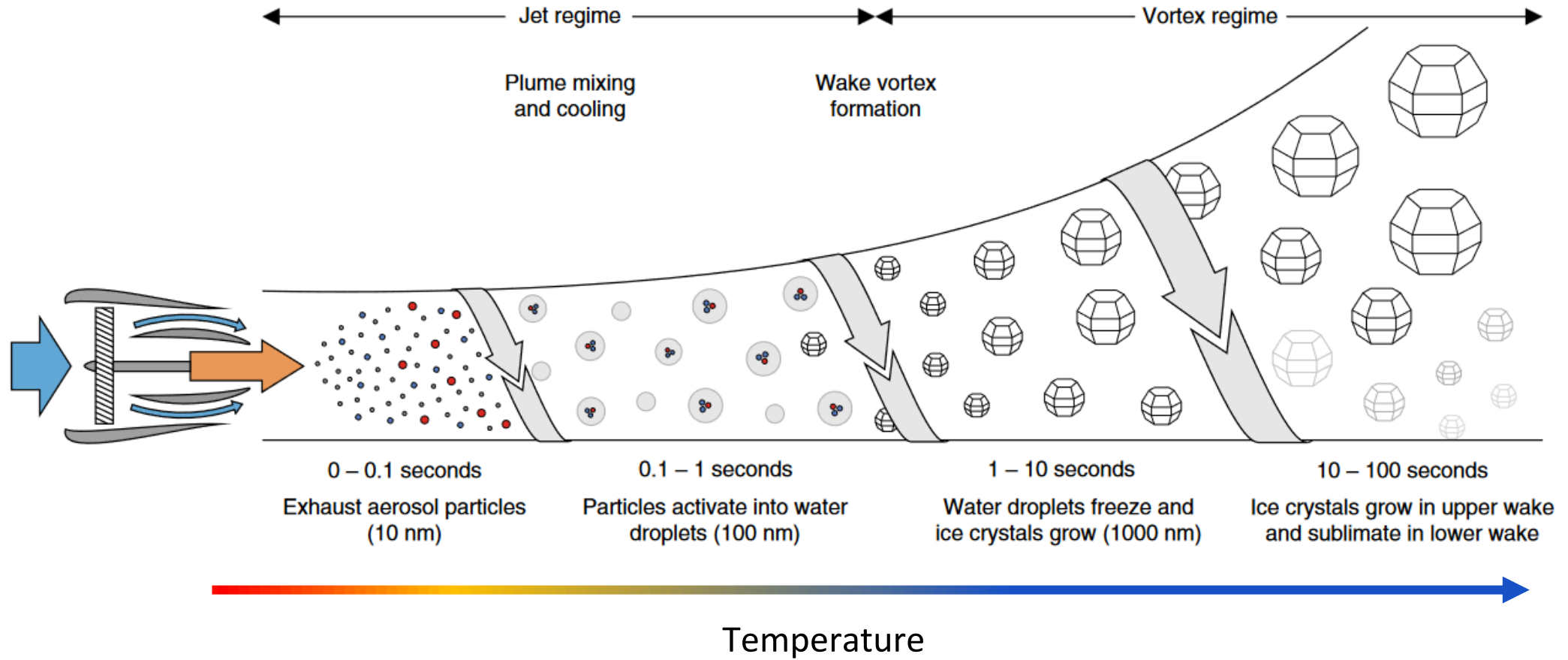


**Global Aviation Effective Radiative Forcing (ERF) Terms (1940 to 2018)**

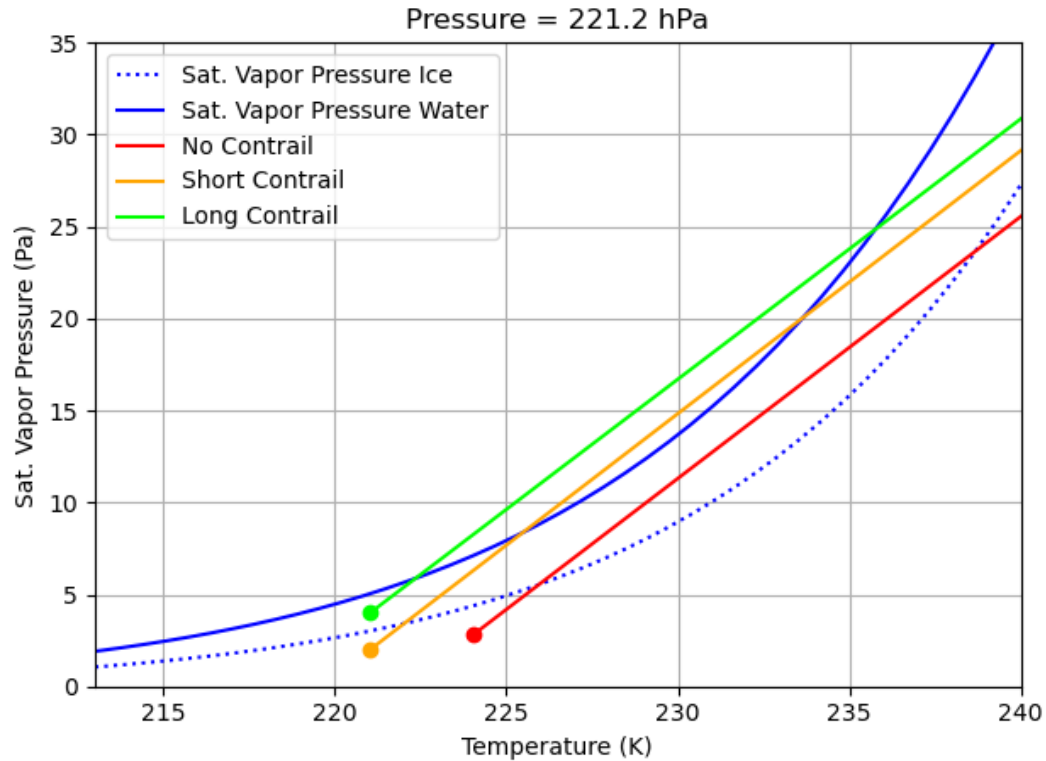


# How do Contrails form?

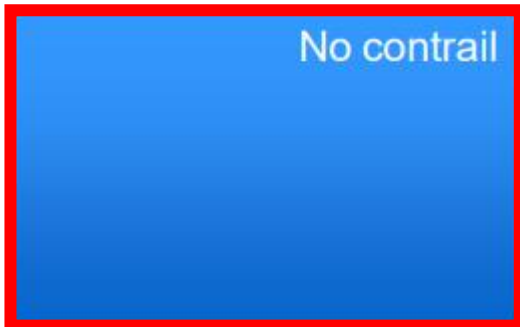
Kärcher, 2018



# Contrail forming regions → Schmidt-Appleman Criteria



Contrail formation → Aircraft, fuel properties and atmosphere  
Persistence → Atmosphere ( $RH_i > 100\%$ )



# Predicting contrails and contrail forming regions

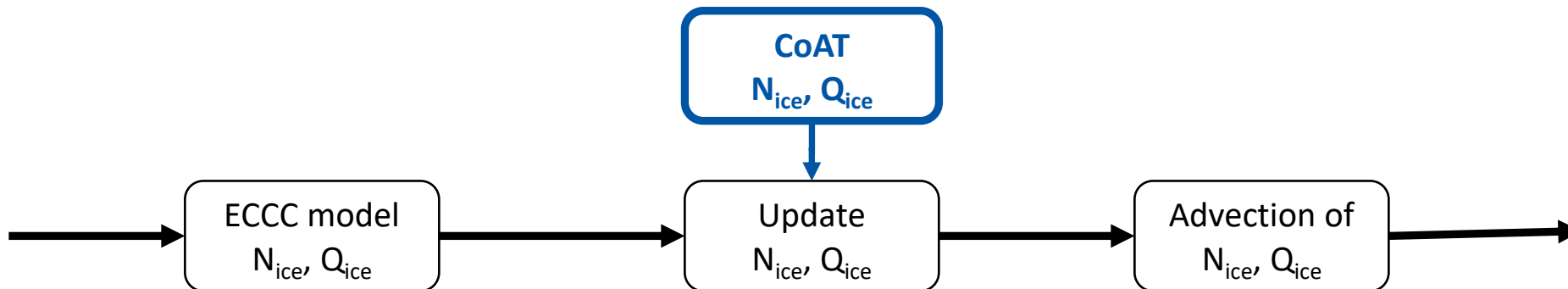
## Developing a Contrail Avoidance Tool (CoAT) at ECCC

### 1) Determine contrail formation regions in the atmosphere

- Use the Schmidt-Appleman Criteria Schumann 1996
  - Atmospheric condition, aircraft propulsion efficiency, aircraft fuel properties

### 2) **IF TRUE** then calculate the persistence of the contrail

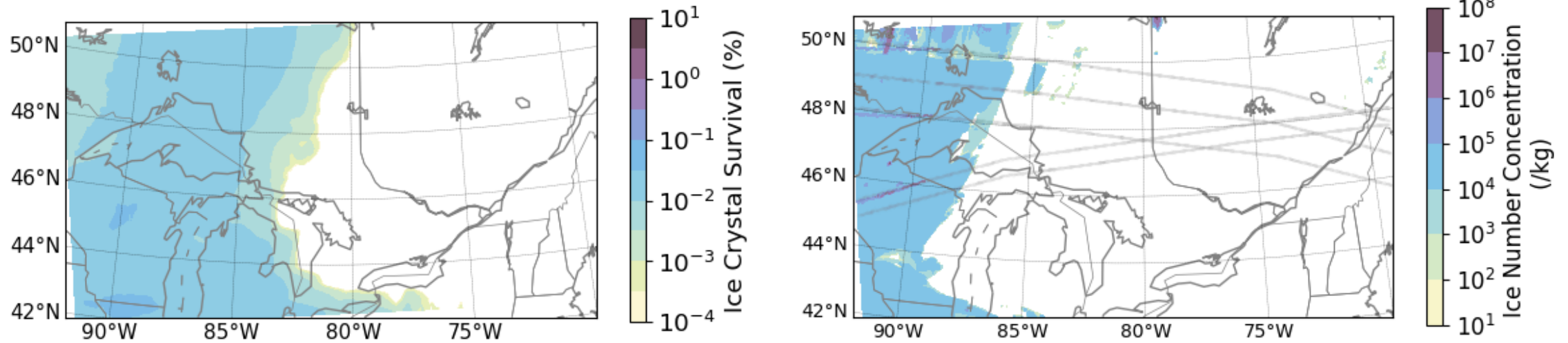
- Wake vortex model Unterstrasser 2016
  - Atmospheric condition, aircraft properties (wingspan, mass, ...), aircraft fuel properties
- Contrail volume, ice number concentration ( $N_{ice}$ ), ice mass concentration ( $Q_{ice}$ )



# Predicting contrails and contrail forming regions

## Developing a Contrail Avoidance Tool (CoAT) at ECCC

5 Jun 2023 12Z – 15Z (10min interval)  
210 hPa (cruising altitude)

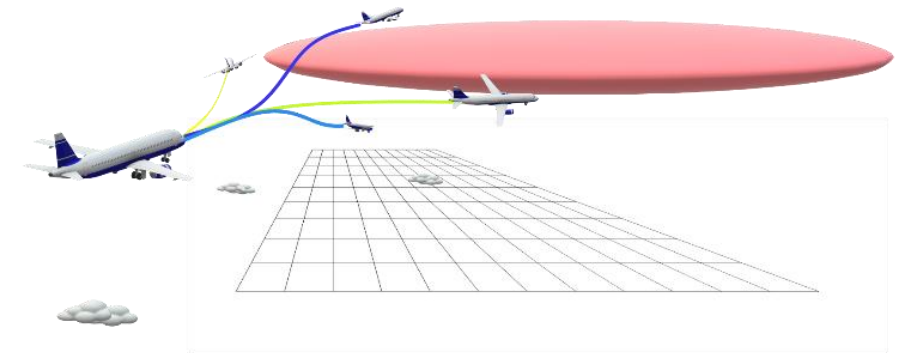


### Research areas:

- Usage of current, sustainable and hydrogen fuels impacting contrail formation
- Contrail lifetime and persistence
- Contrail vs cirrus vs vertical contrail cirrus overlap
- Impact of ice microphysics on contrail lifetime
- Contrail mitigation strategies

- Based on ECCC numerical weather prediction modelling system
  - Based on Global Environmental Multiscale atmospheric model (Côté et al., 1998; Girard et al., 2014)

- Test bed and verification:
  - High Resolution Deterministic Prediction System (Milbrandt et al., 2016)
  - Covering a pan-Canadian domain
  - Horizontal resolution: **1.0 km and 2.5 km**
  - Run four times daily with 48-h forecasts



- Adapted for Global Deterministic Prediction System (Buehler et al., 2015)
  - Covering for Canadian airspace, the Atlantic and Arctic Oceans
  - Horizontal Resolution: **10 km**
  - Run twice daily with 10-day forecast

- Information sharing with **stakeholders** for discission making

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# Thank You

