SATAVIA
MAKING AVIATION SMARTER

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SATAVIA

We simplify decision-making for smarter, greener aviation.

Smarter.
Greener.

Atmospheric contaminants degrade engine performance
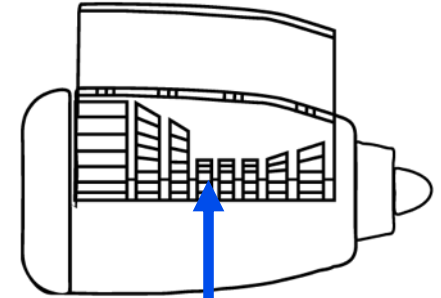
Volcanic ash

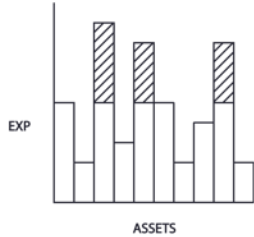**Ice crystals**

Dust

Air pollution

Smarter maintenance and flight operations

DECISIONX
SATAVIA

Maintenance risk

Performance and health

Network planning

Flight planning

SMARTER MAINTENANCE

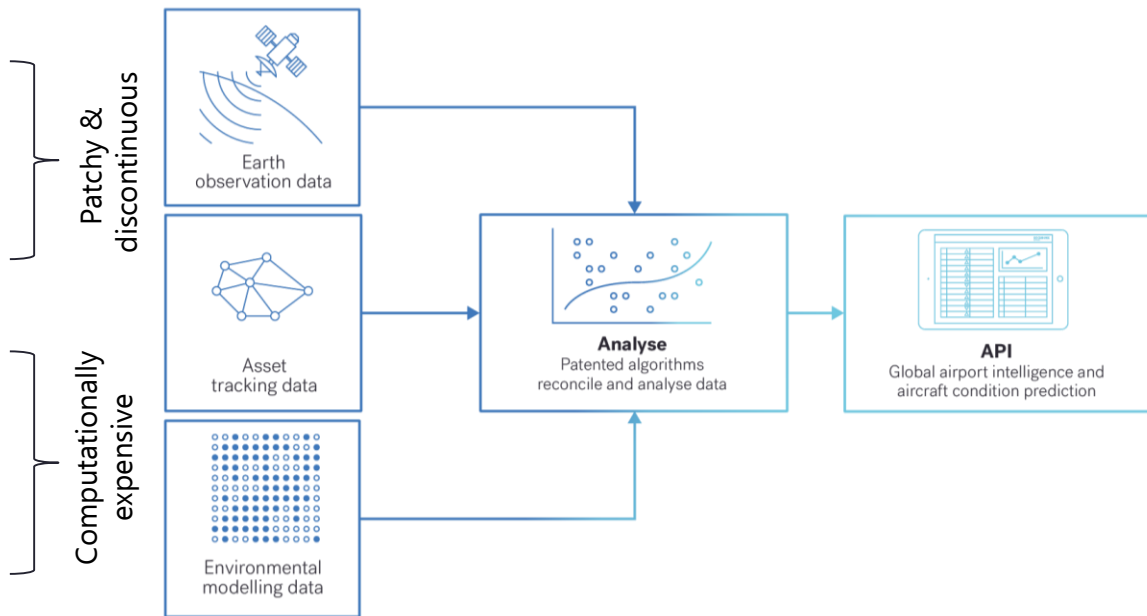**SMARTER FLIGHT OPS**

Reduce cost

Increase time-on-wing

Artificial intelligence and enviro-tech

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- Dust is a local (health, pollution) and global (advection) problem

- **Observations:**
  - Remote sensing (e.g. satellites)
  - Ground-based measurements (e.g. LIDAR)
  - Flight campaigns (e.g. Fennec project)
  - Proxy observations (e.g. visibility)

- **Weather Precition models:**
  - High vertical, spatial, and temporal resolution
  - Require accurate cloud microphysics, optical properties, vertical distribution, cloud cover, albedo etc.
 - Out-of-date emission inventories
  - Complex dependent chemistry

Patchy & discontinuous

Computationally expensive

Earth observation data

Asset tracking data

Environmental modelling data

Analyse
Patented algorithms reconcile and analyse data

API
Global airport intelligence and aircraft condition prediction

Case Study: Canary Islands Dust Storm (Feb 2020)

- *La Calima* – prevalent in winter

- Hot, dry, strong southeasterly winds

- All airports across the Canary Islands closed on 22nd February, and most stayed closed until 24th February

- 800 flights cancelled or re-routed

- Roads shut due to poor visibility, and wildfires led to school and university closures

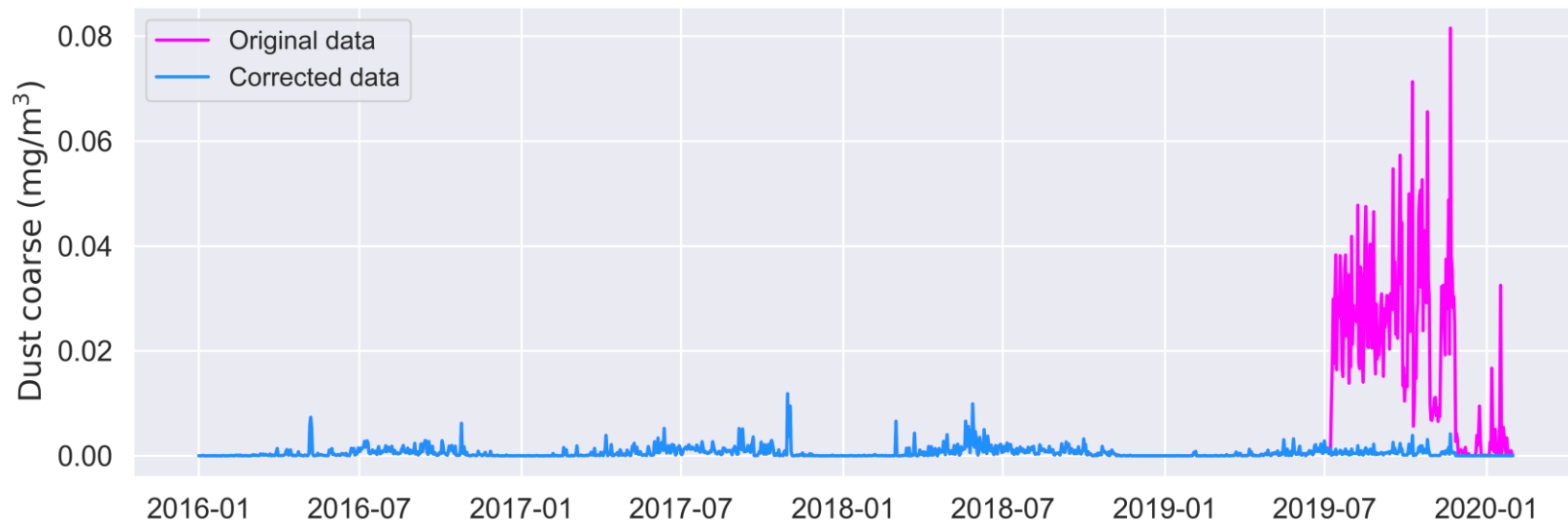10-year climatology (2010 – 2020) of suspected dust storms at Izaña (Tenerife)
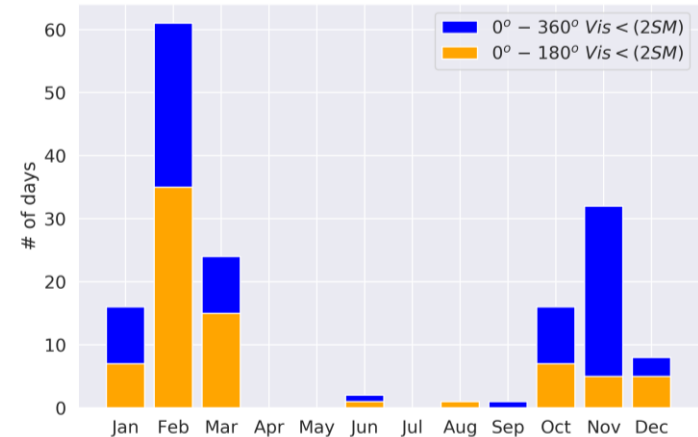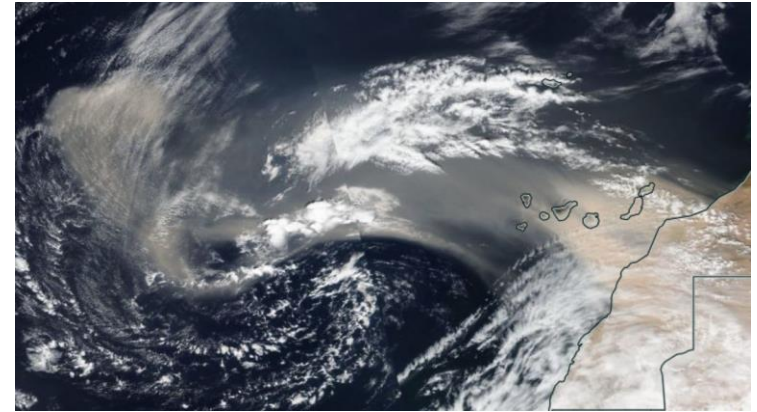
Canary Islands: AOD Observations
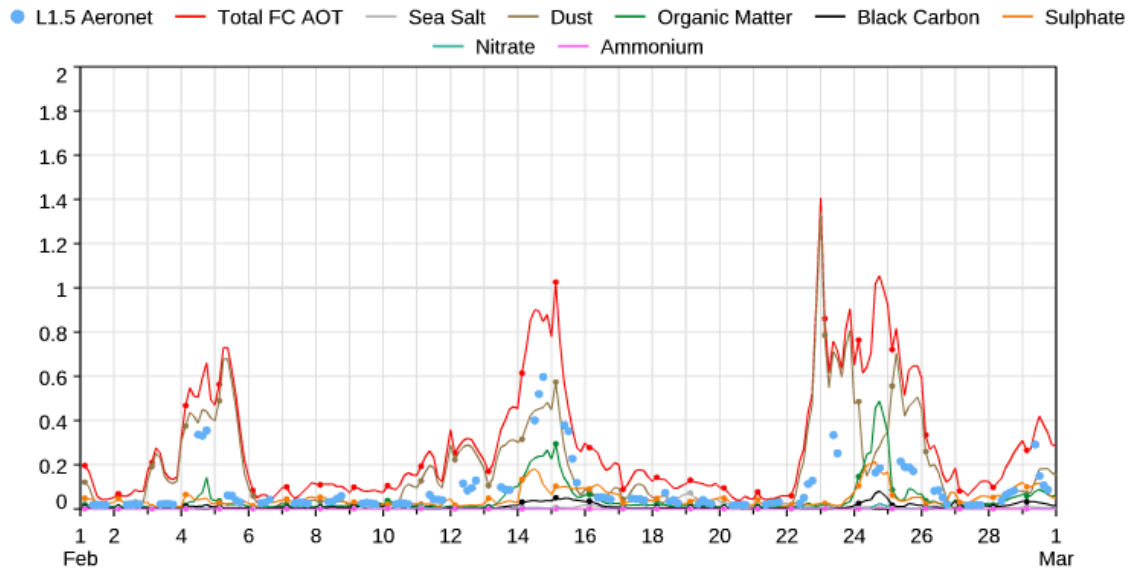
Comparison of model (red) and AERONET AOD (blue dots) over Izaña (Tenerife)

- Measurements likely underestimate the severity of dust storm
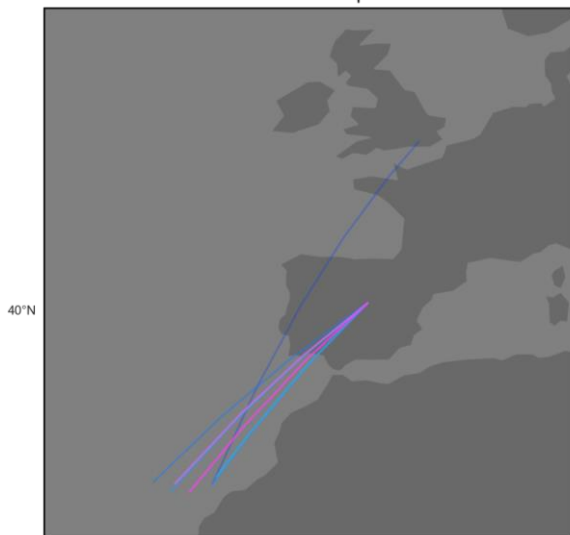
Canary Islands: Data from Models

Timeseries of dust concentration (2016 – 2020) demonstrating jump in values (9th July 2019) caused by a new online dust model
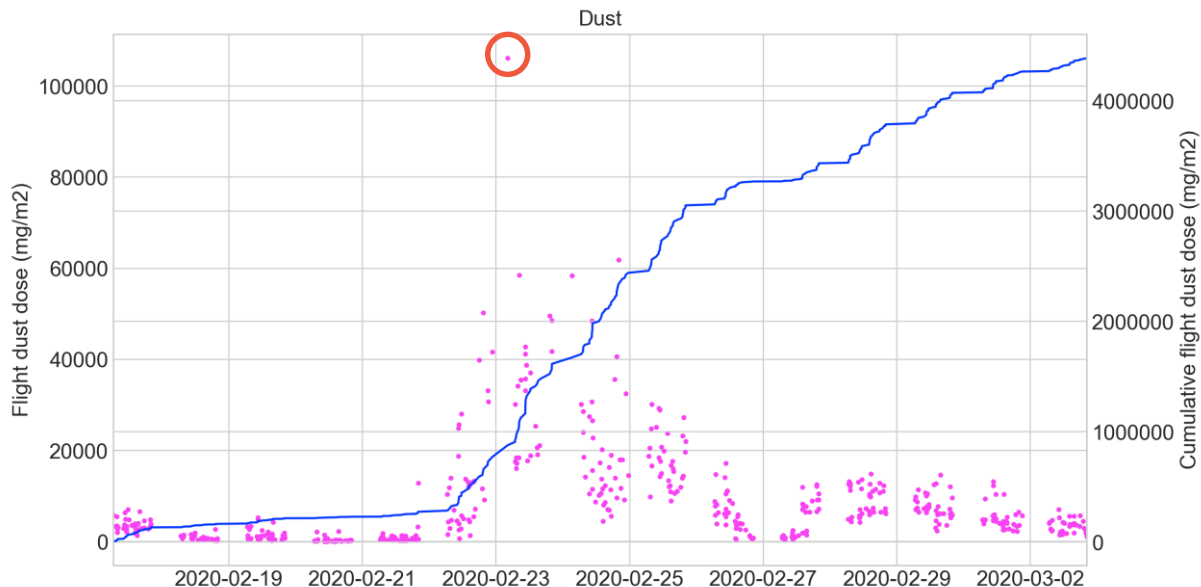
Canary Islands: Dust Exposure

- Analysis of flight to/from the Canary Islands over a two-week period for one aircraft carrier

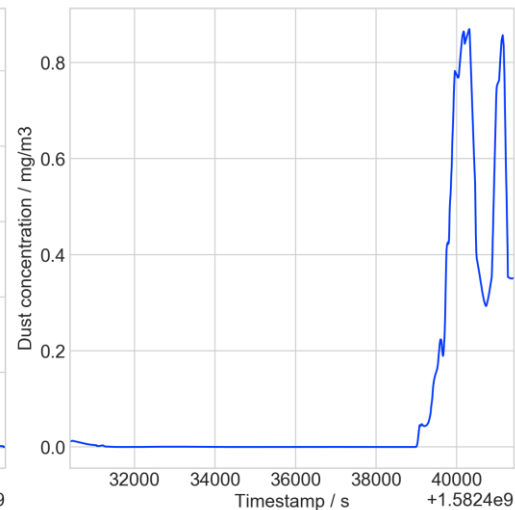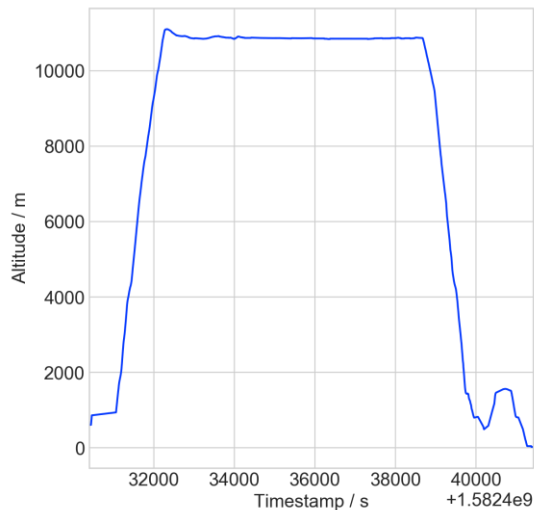- Flights show significantly higher dust doses during dust storm

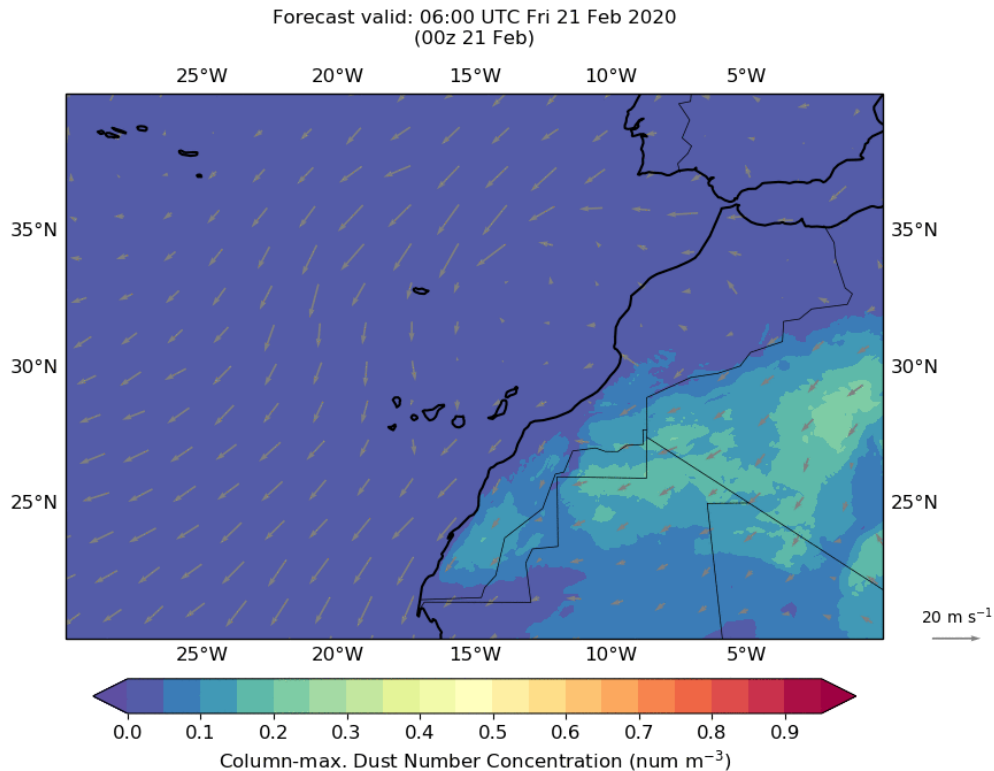- Picking out the single extremely high dose flight...

Route map

Dust

Canary Islands: Dust Exposure

- Flight details:
  - Madrid to Gran Canaria
  - Departure time: 0400 UTC 23rd March 2020
  - Arrival time: 0703 URC 23rd March 2020

- Looks like holding/go-around on arrival
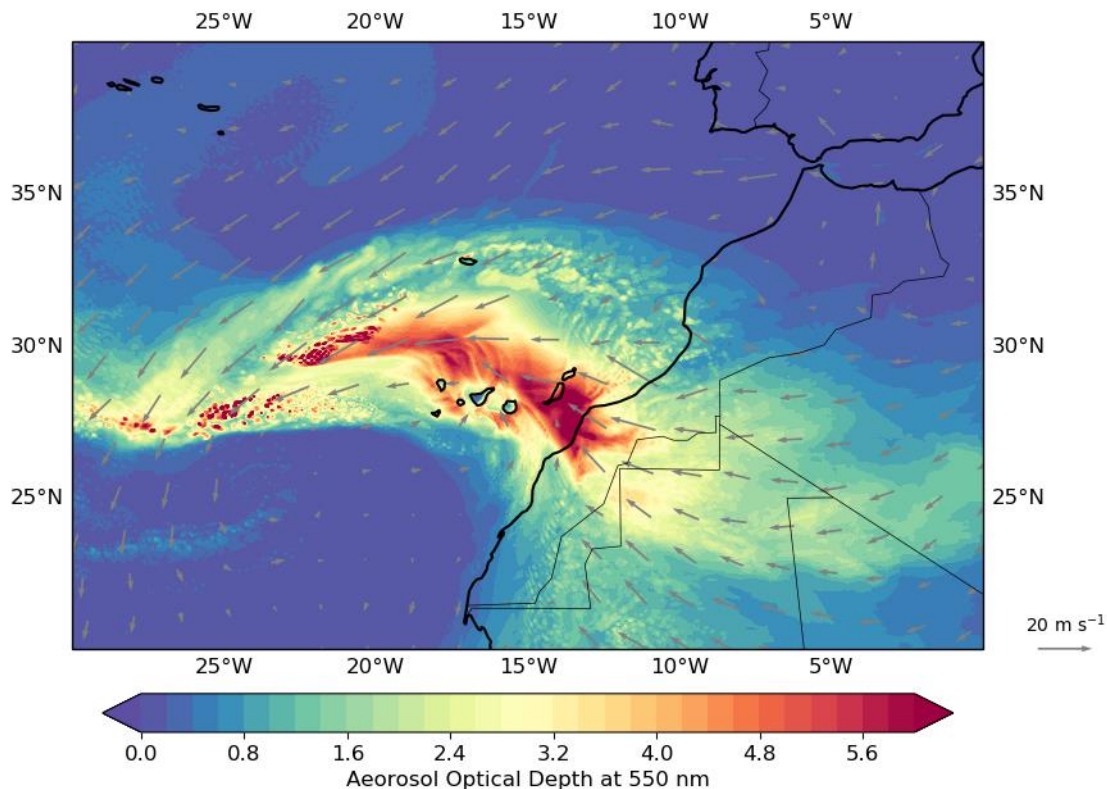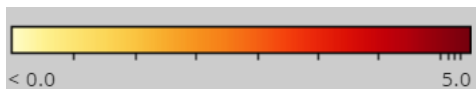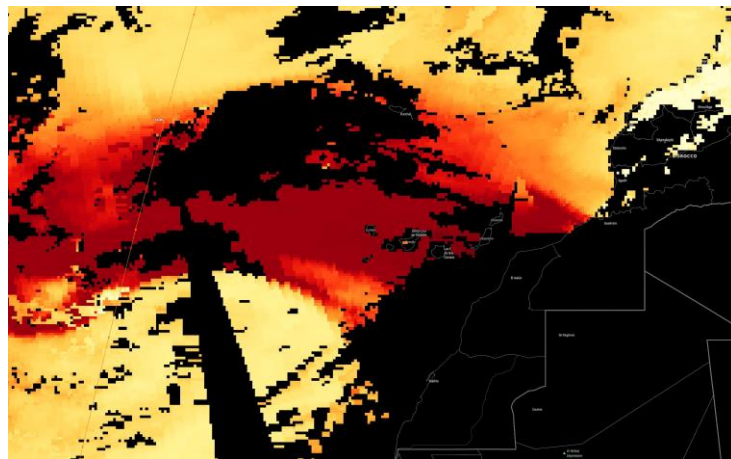- Very high dust concentrations at arrival
- Why?

Canary Islands: Regional High-Resolution Modelling

4-km spatial resolution simulation (using the WRF model) of the Canaries dust storm

Canary Islands: Regional High-Resolution Modelling

Comparison between observed (MODIS, left) and modelled (WRF, right) AOD on 23rd February 2020 at 1300 UTC

Dust Interaction with Cloud Formation

- Dust plays a significant role in the evolution of deep convective systems

- Dust acts as an ice nuclei
  - Irregular, insoluble, most abundant aerosol, smaller particles can easily reach upper troposphere
  - Leads to larger ice crystal concentrations and enhances the Bergeron process

- However, large uncertainties exist due to the varied activation properties and different ice nuclei measurements

- Understanding the interaction of dust (and other aerosols) with cloud formation is imperative in order to improve flight performance and safety at high altitude
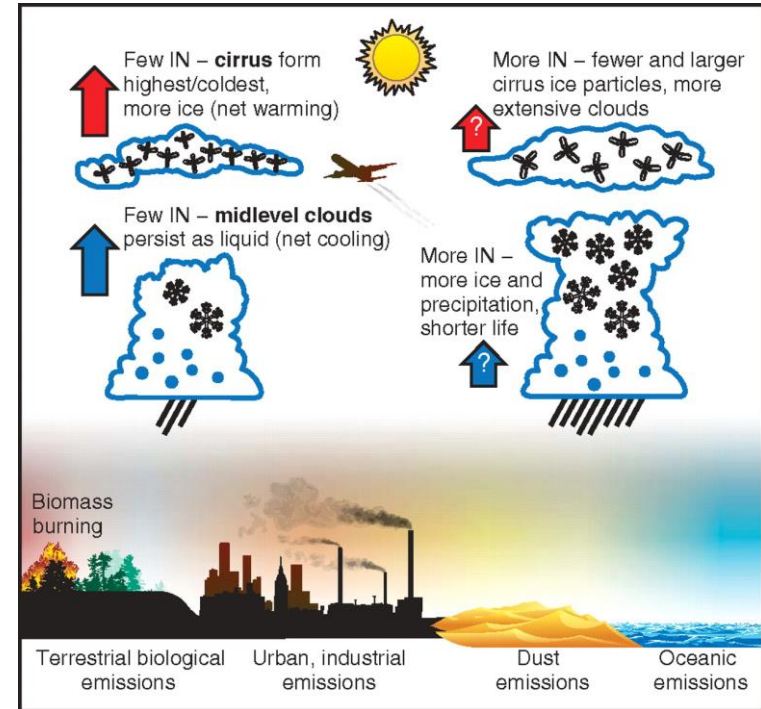
DeMott *et al.* (2010)

Design Excellence–Ice Crystal Engine Research (DE-ICER)

- The DE-ICER project aims to develop a means of designing and certifying new engine architectures for operations in ice crystal icing conditions to TRL6

- Involves developing and testing ice crystal detection technologies and targeted heat based anti-icing systems that will allow targeted application and therefore provide additional SFC benefit

- SATAVIA is characterizing the in-service ice crystal environment to improve operability and maintainability

- Funded by the UK Aerospace Technology Institute; £7m between 2018-2022

High Altitude Ice Crystal (HAIC) Operational Forecasting

SATAVIA-optimized version of the Weather Research and Forecasting (WRF) model

- Optimized to better reproduce high altitude clouds

- 3 forecast domains (30-hour forecast, once per day)

- 5 km spatial resolution, 60 vertical levels

- 20% of Earth's surface

- Hourly output for entire grid, 30 second output at airport locations
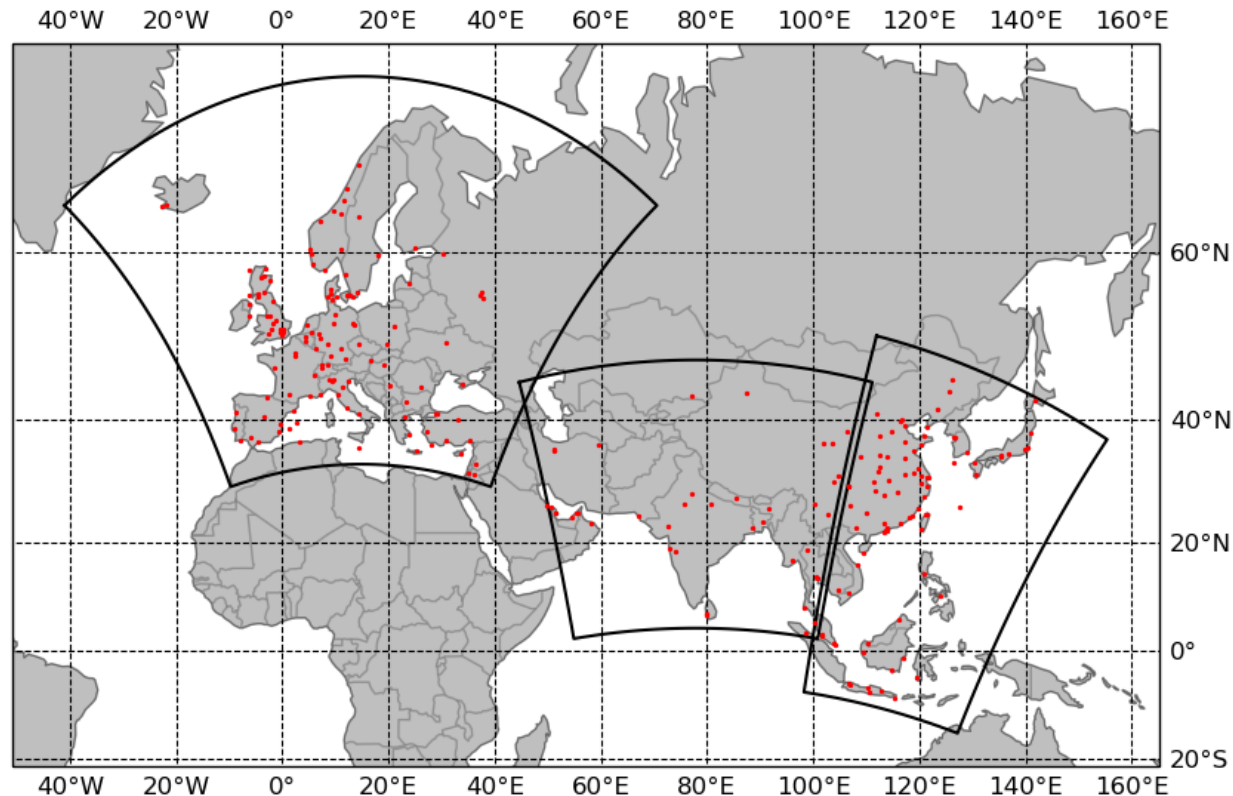
Model domains (black boxes) used to obtain HI-ICE climatology. 252 airports with 30-second meteorological data are also shown.

High Altitude Ice Crystal (HAIC) Operational Forecasting

Near-real-time HAIC Ice Crystal Icing (ICI) forecasting for flight planning and situational awareness on the flight deck

- Discriminates low risk (blue) and high risk (red) ICI regions

- Products available as geoJSON layer files which are compatible with flight planning and electronic flight bag software

- Forecast timesteps of 1 h

- Individual file size ~1 00-200 kb; ideal for transmission via satellite data communications

Forecast valid: 06:00 UTC Fri 23 Aug 2019
(00z 23 Aug)

Ice Water Path (kg m^{-2})
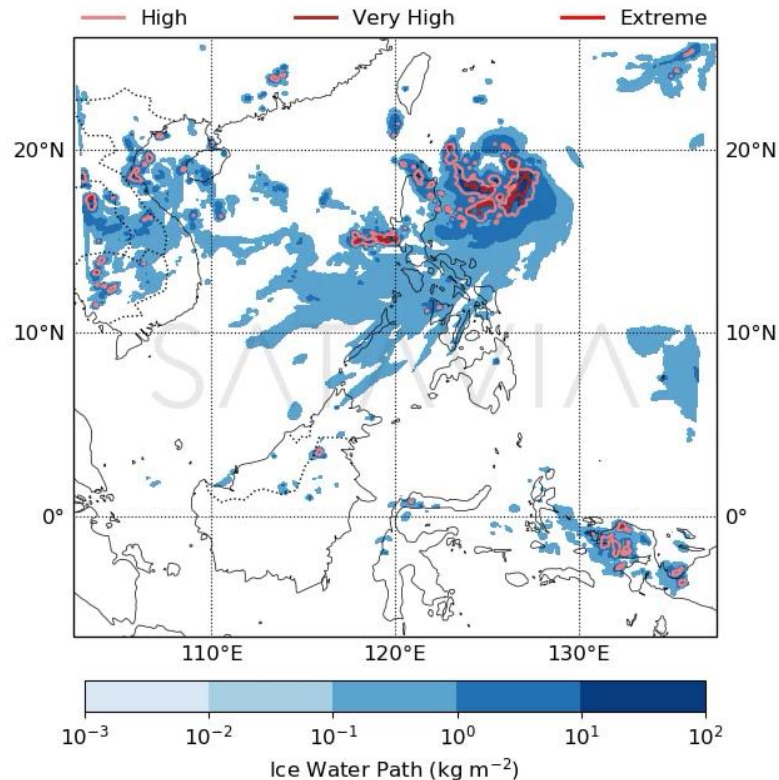
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