Probabilistic Characterization of Operational Uncertainties in Transport Aircraft using OpenSky

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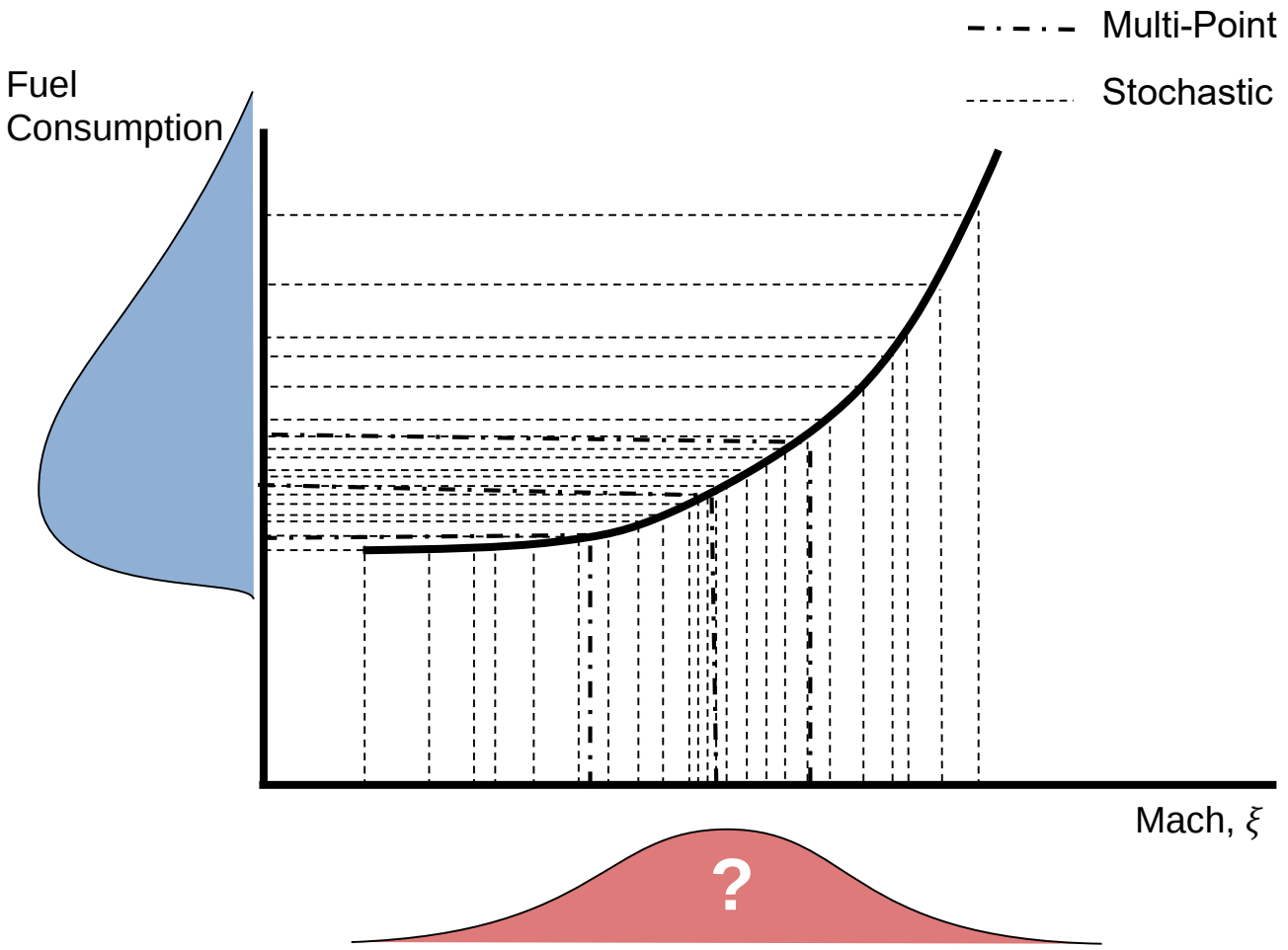
Introduction

Motivation

- Aerodynamic design takes place at a representative but limited range of flight conditions
- In practice airliners do not fly at the conditions they were designed to operate
- Lack of real operational data necessary to characterize uncertainty sources in flight

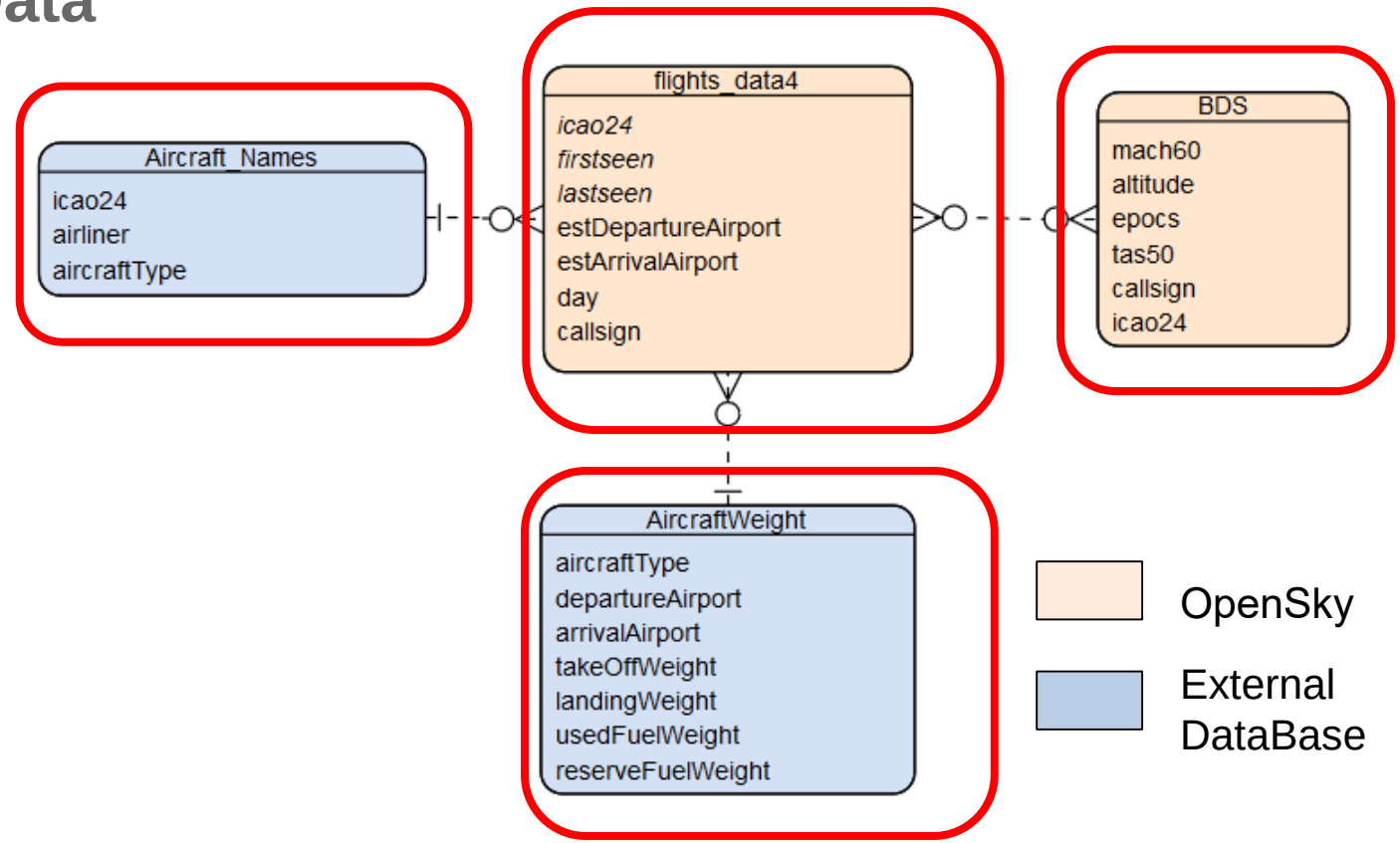
Objective

- The characterization and quantification of operational uncertainty sources for taylored aerodynamic design based on aircraft surveillance data



Gathering OpenSky Surveillance Data

1. Select ICAO24 codename for given aircraft type operated by a given airliner Aircraft_Names
2. Select records for previous ICAO24 codenames for a given day flights_data4
3. Access flight data (Mode-S) from given icao24 airplane from firstSeen to lastSeen: BDS [1, 2]
4. For given departure and arrival airports, obtain Initial and Final Fuel Weight : AircraftWeight



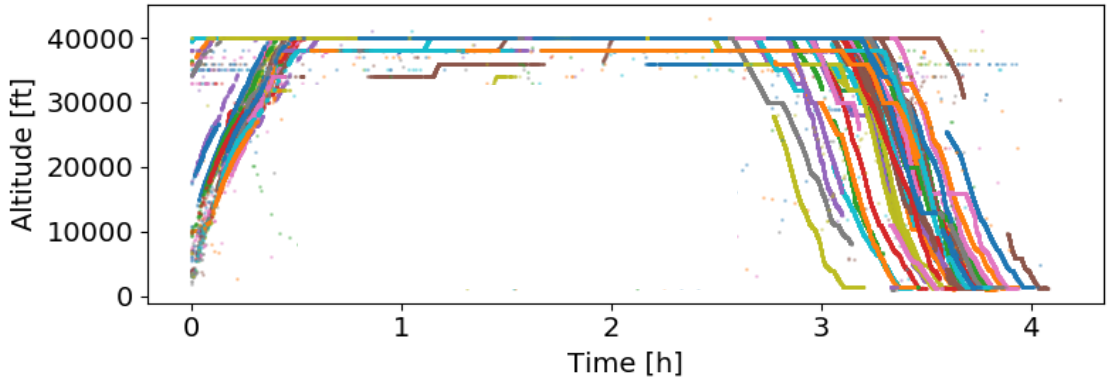
[1] Integrating pyModeS and OpenSky Historical Database, Junzi Sun, Jacco Hoekstra
[2] pyModeS: Decoding Mode-S Surveillance Data for Open Air Transportation Research.

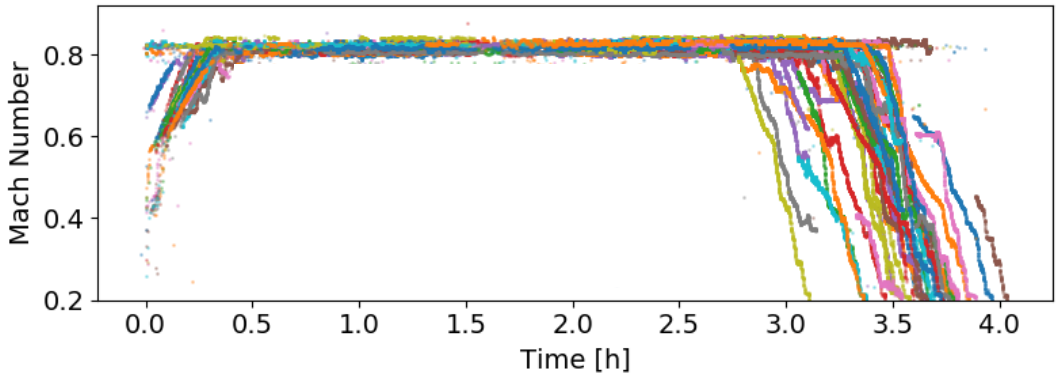
Gathering OpenSky Surveillance Data

Altitude:
- Pressure altitude directly obtained from ADS-B Data
- Influences Reynolds number

Mach Number
- Directly obtained from BDS-60 code
- Freestream Boundary Condition, affects shock wave location

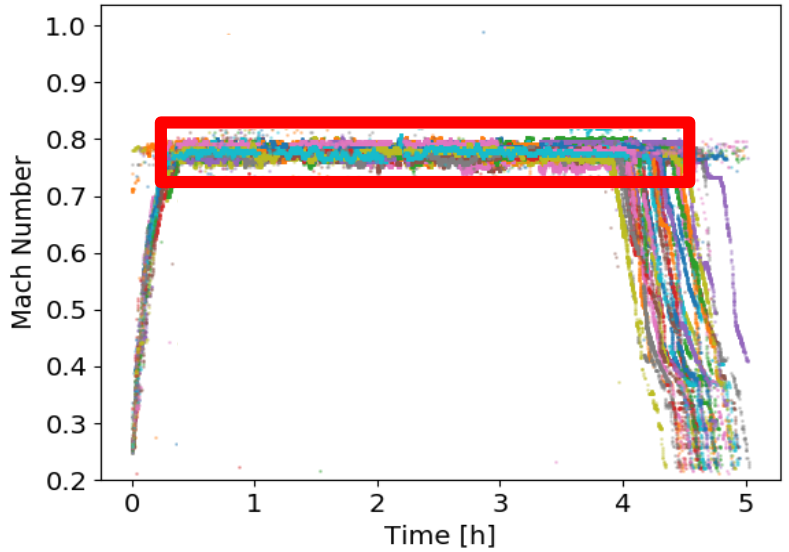
Lift Coefficient
- Weight exponentially decreases from take-off to landing
- Influences aircraft angle of attack



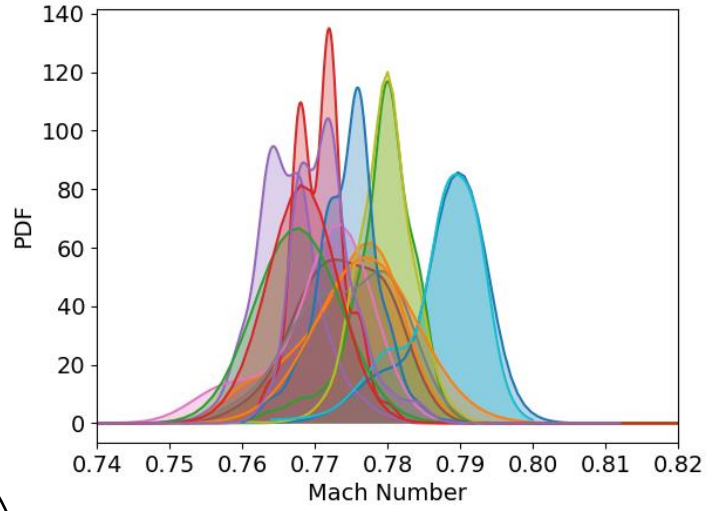


Filtering Data and Obtaining PDF for callsign

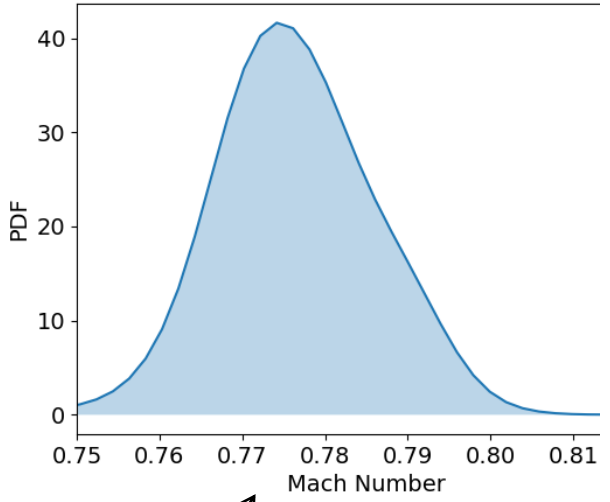
Mach vs Time for different flights



PDF of Mach for different flights

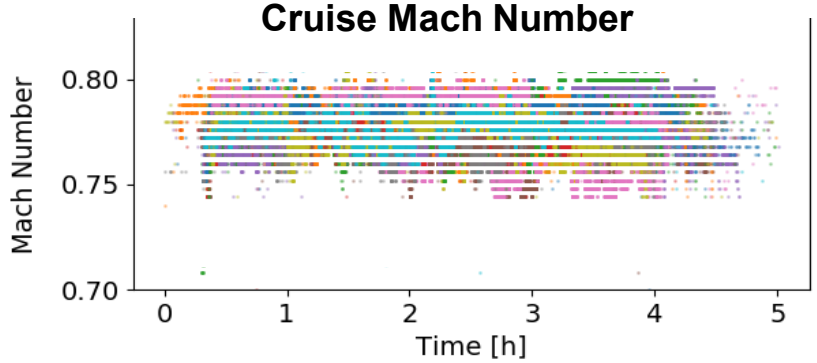


PDF of Mach for all flights



1.- Filter Cruise conditions

Cruise Mach Number

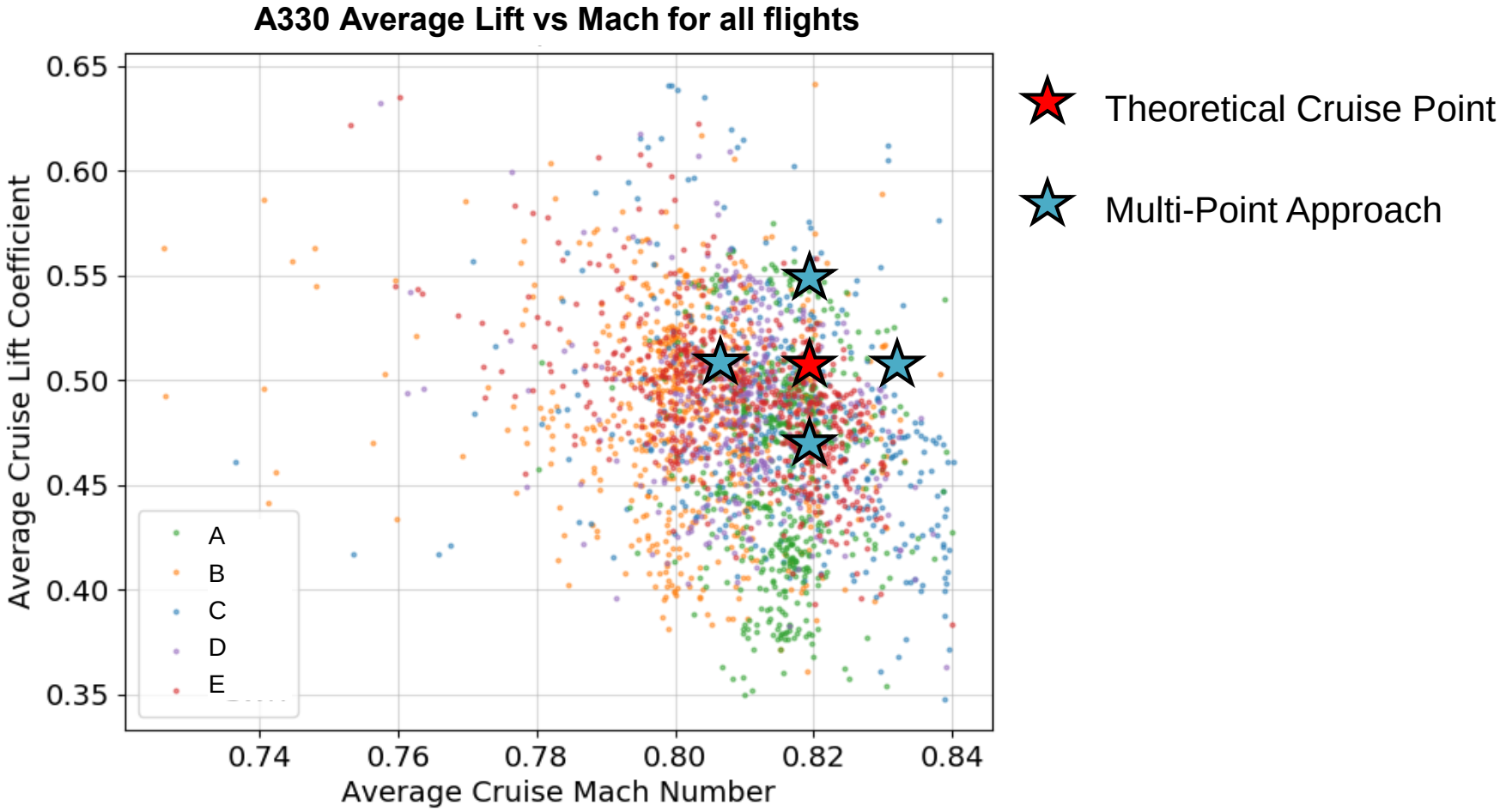


2.- Compute KDE for each flight

3.- Combine KDEs for all Flights

Analysis of A330 Operational Data

- Surveillance data of A330 flights extracted for 5 major European airliners (A, B, C, D, E) for July-August 2019.
- Flights covering most of the time continental Europe, Middle East and USA
- Total of 2692 complete flights are extracted from 165 different callsigns (Average of 16 flights per callsign)



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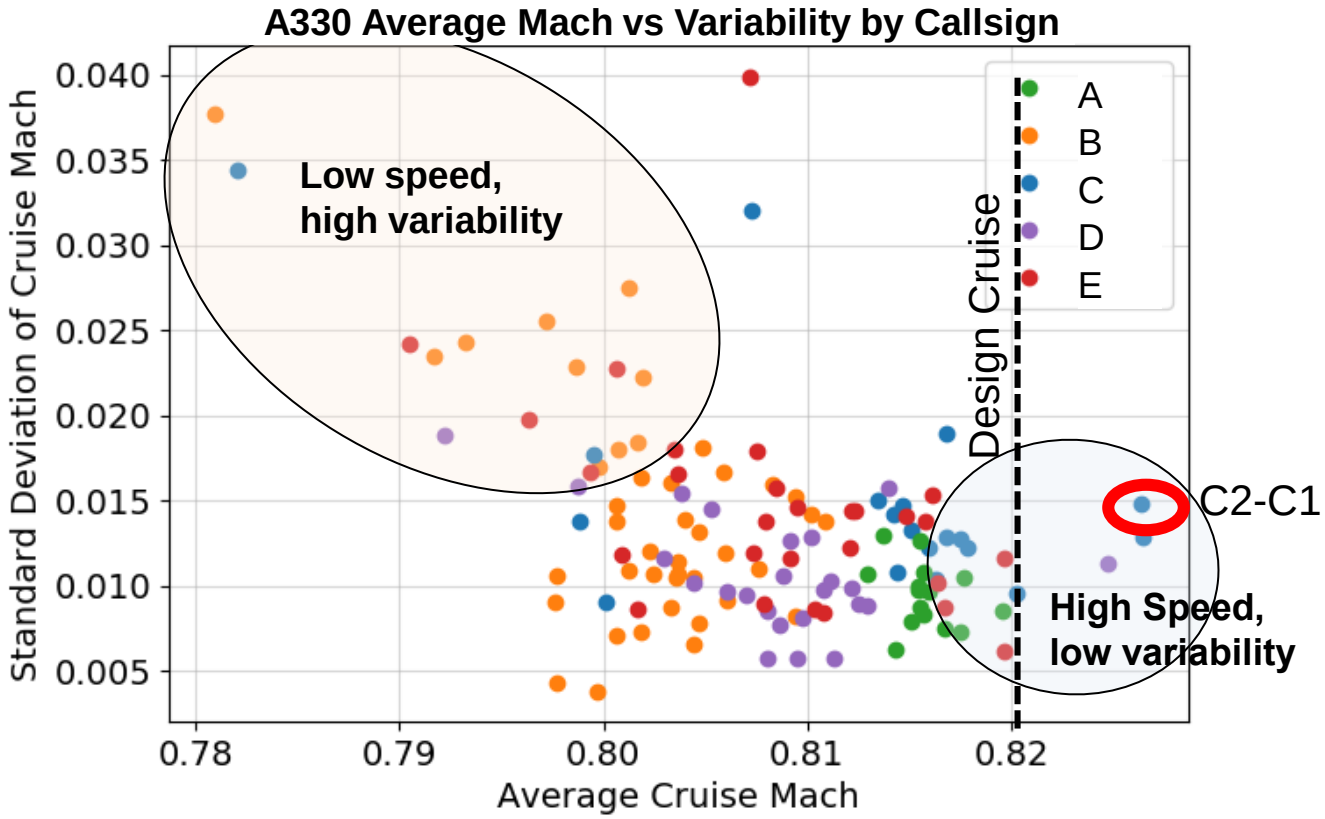
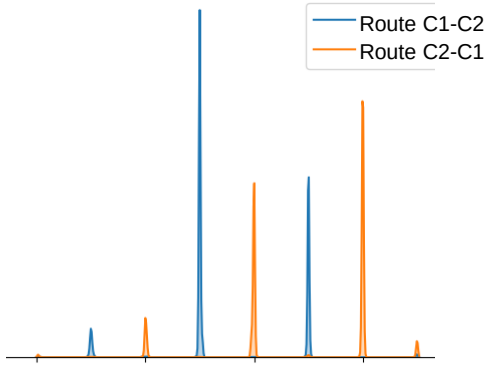


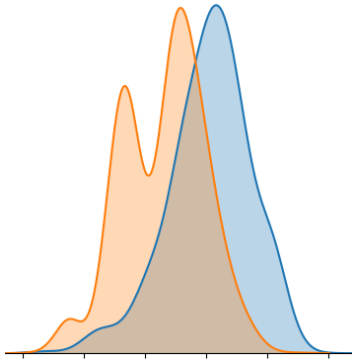
Uncertainties of given flight route

Altitude



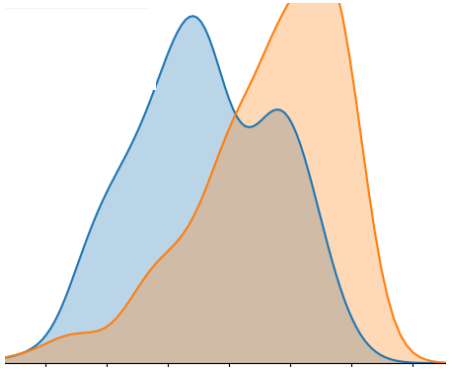
Altitude [FL]

Lift



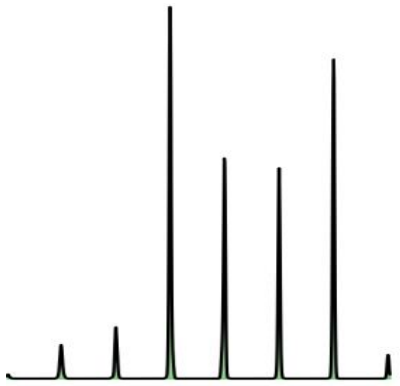
Lift Coefficient

Mach

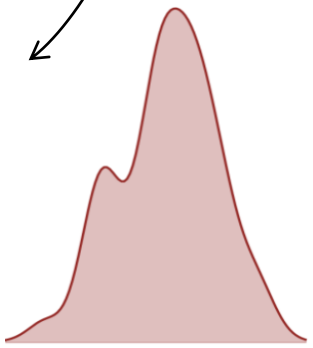


Mach Number

Combined



Altitude [FL]

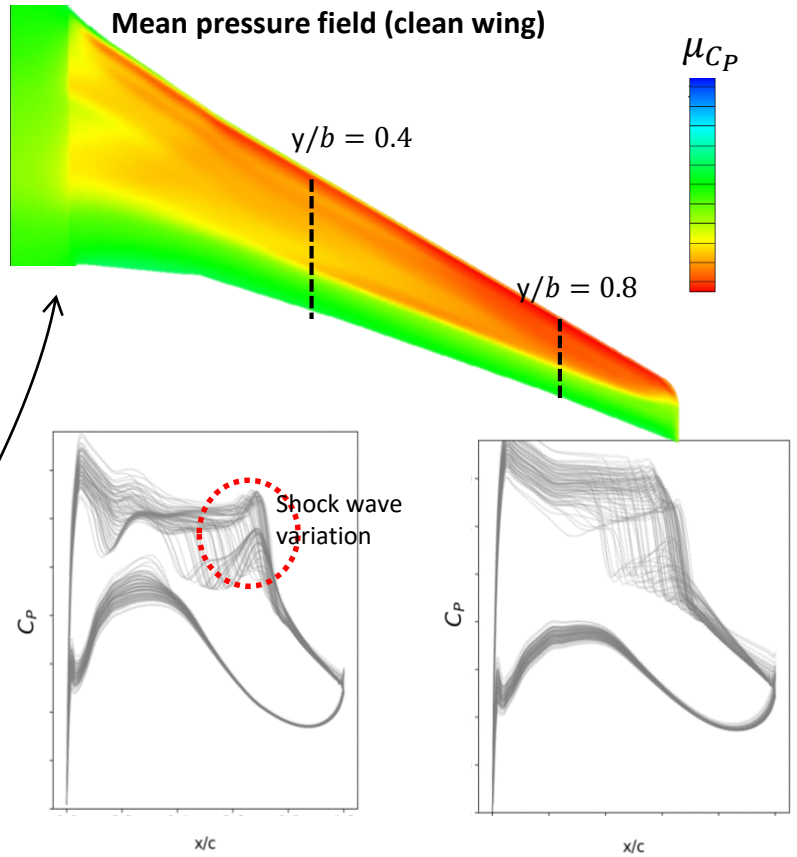


Lift Coefficient

Mach Number

CFD Solver + Surrogate Based UQ

XRF1 Configuration



Conclusions

Probabilistic Characterization of Operational Uncertainties

- Mach Number, lift coefficient, altitude (Reynolds number)
- Gather operational data of specific callsigns / return routes / airliners / aircraft type

Methodology useful:

- To understand how aircraft are operated in reality by researchers / airliners/ OEMs
- To robustly design the next generation of aircraft
- To design special retrofits tailored to aircraft operations

Thank you for your attention!

Any Questions?

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