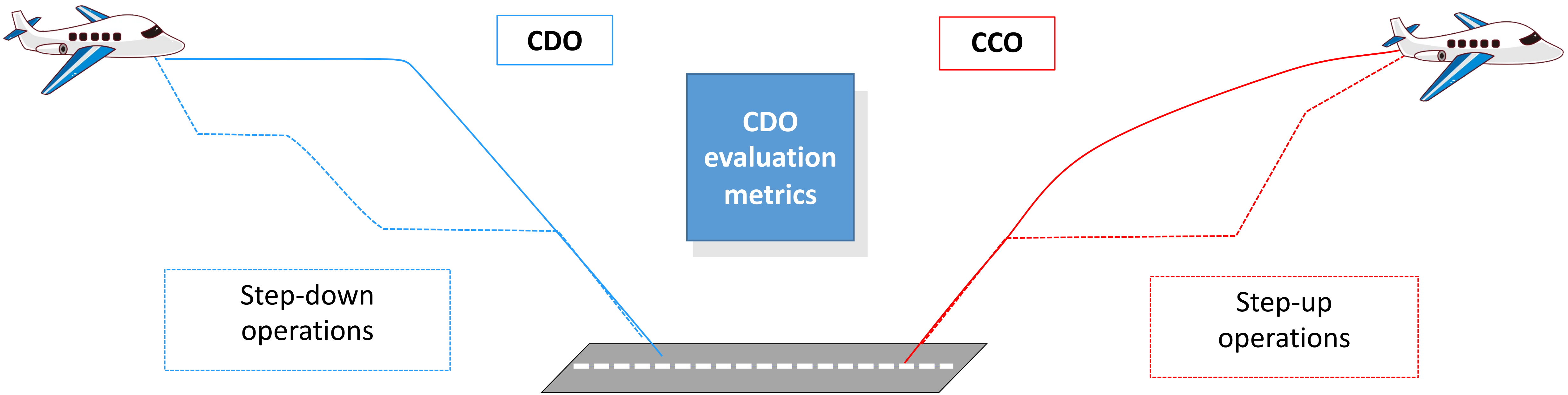
Can machine learning help improving environmental impact assessment ?

Gabriel JARRY

Hosted by SESAR JOINT UNDERTAKING

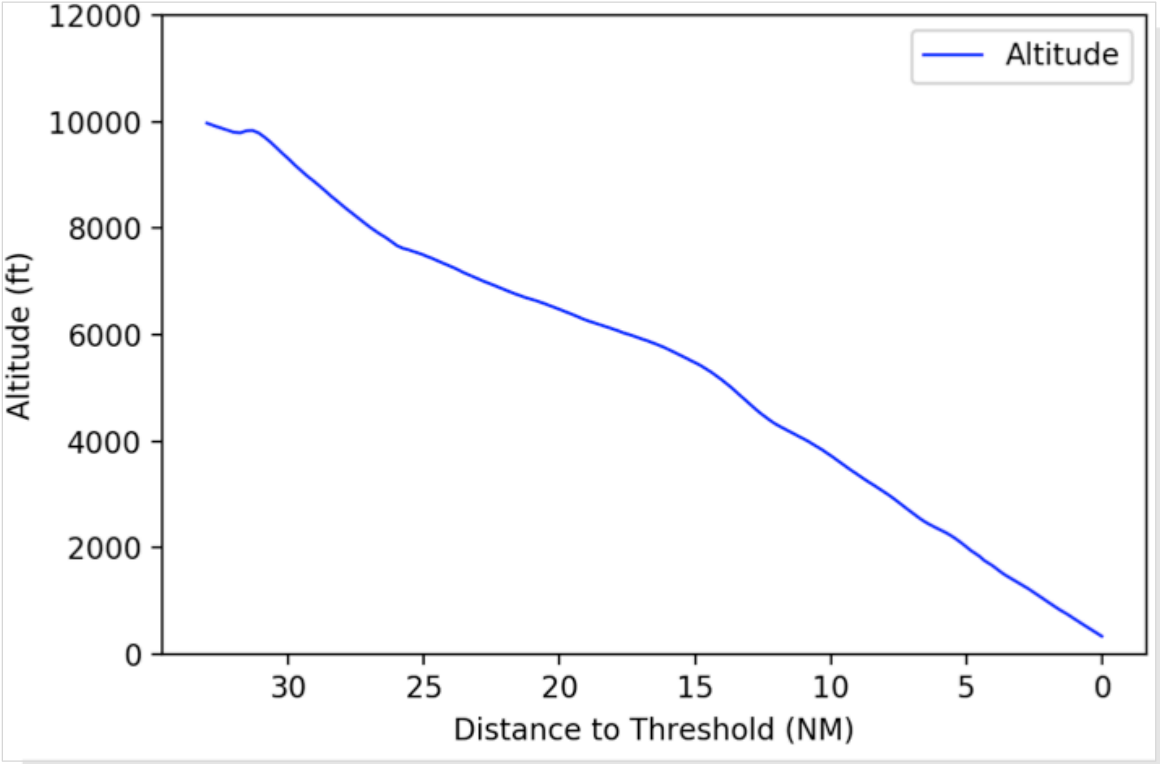
Operational context

Current trend to control pollutant emissions and noise

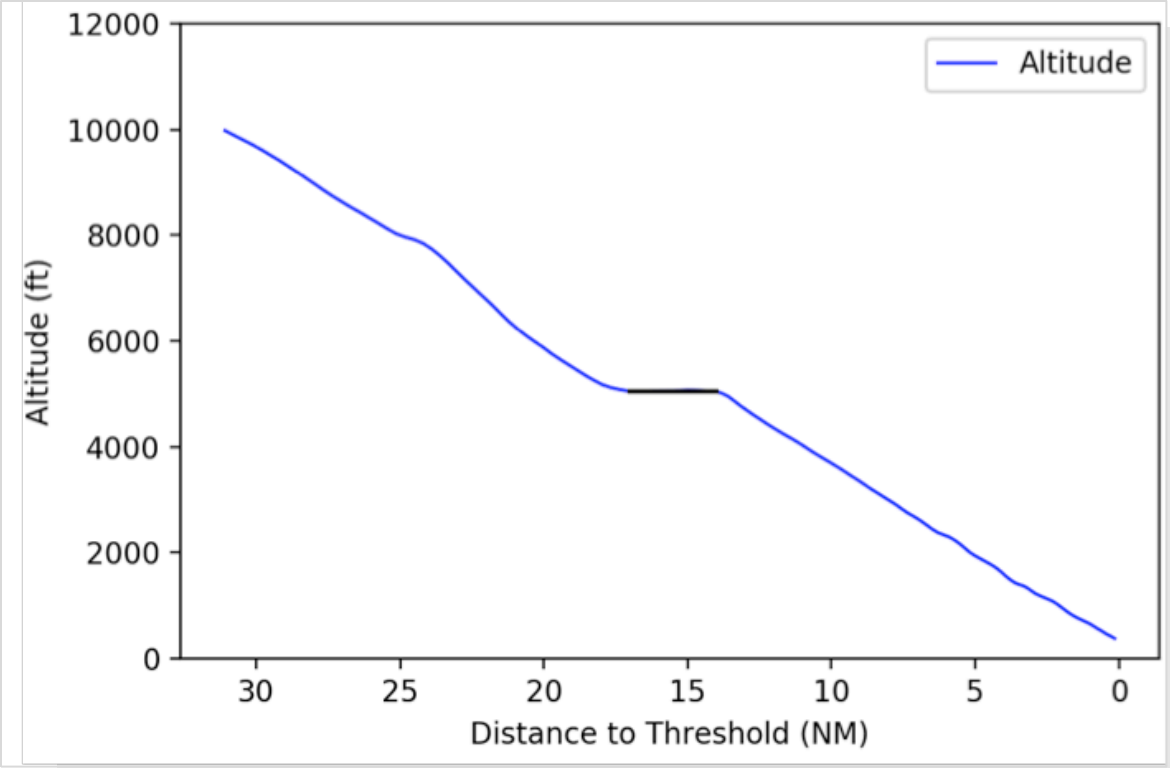


Limitation examples

Geometric CDO

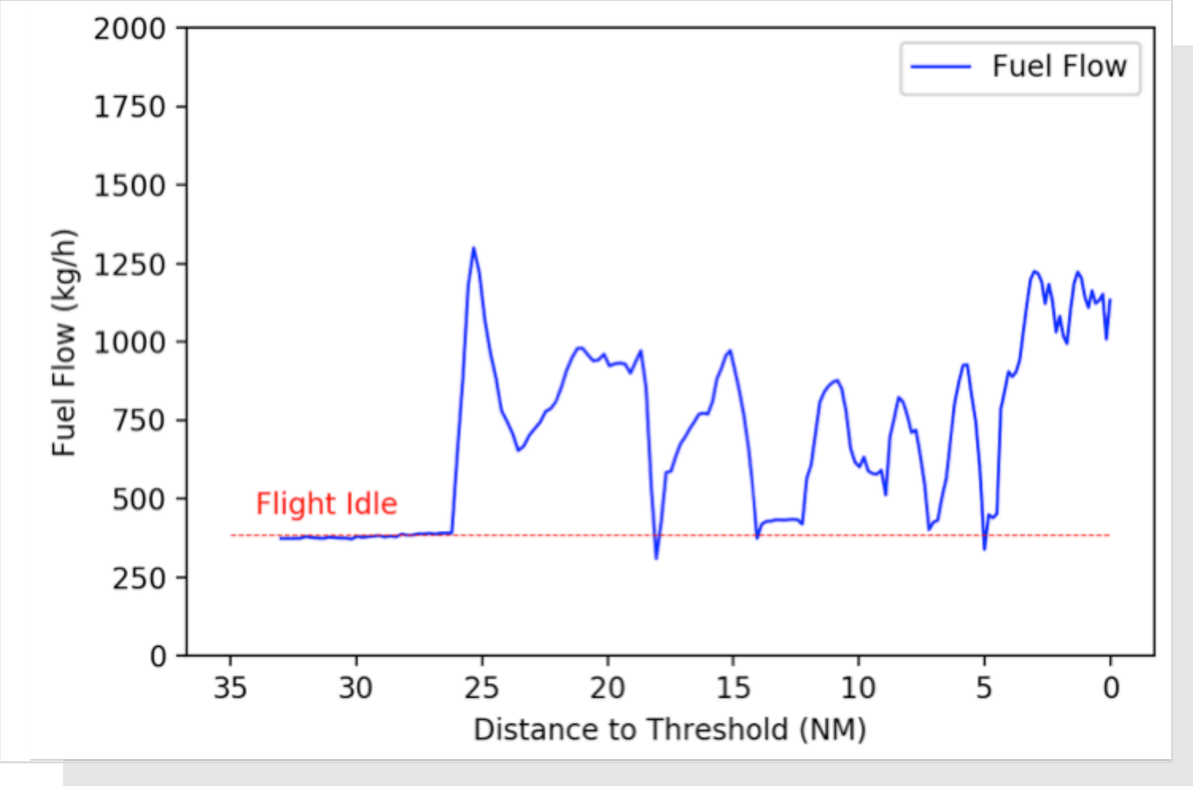


Level flight

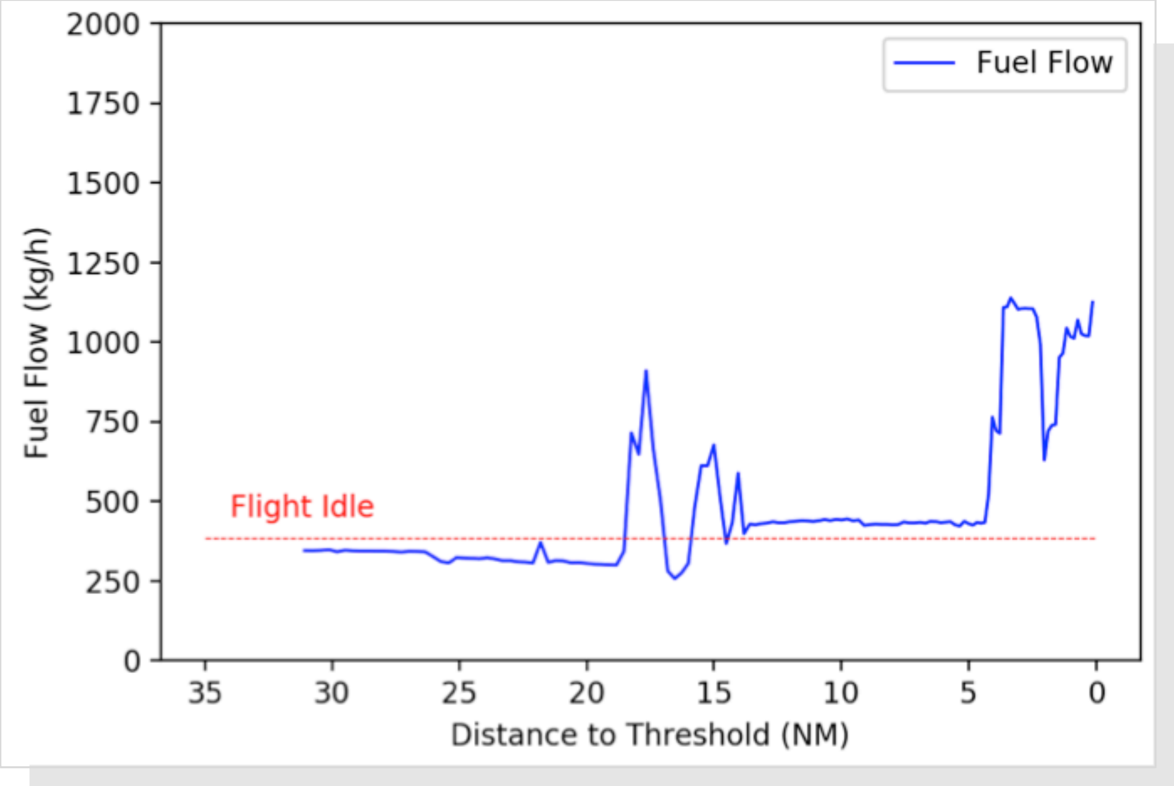


Limitation examples

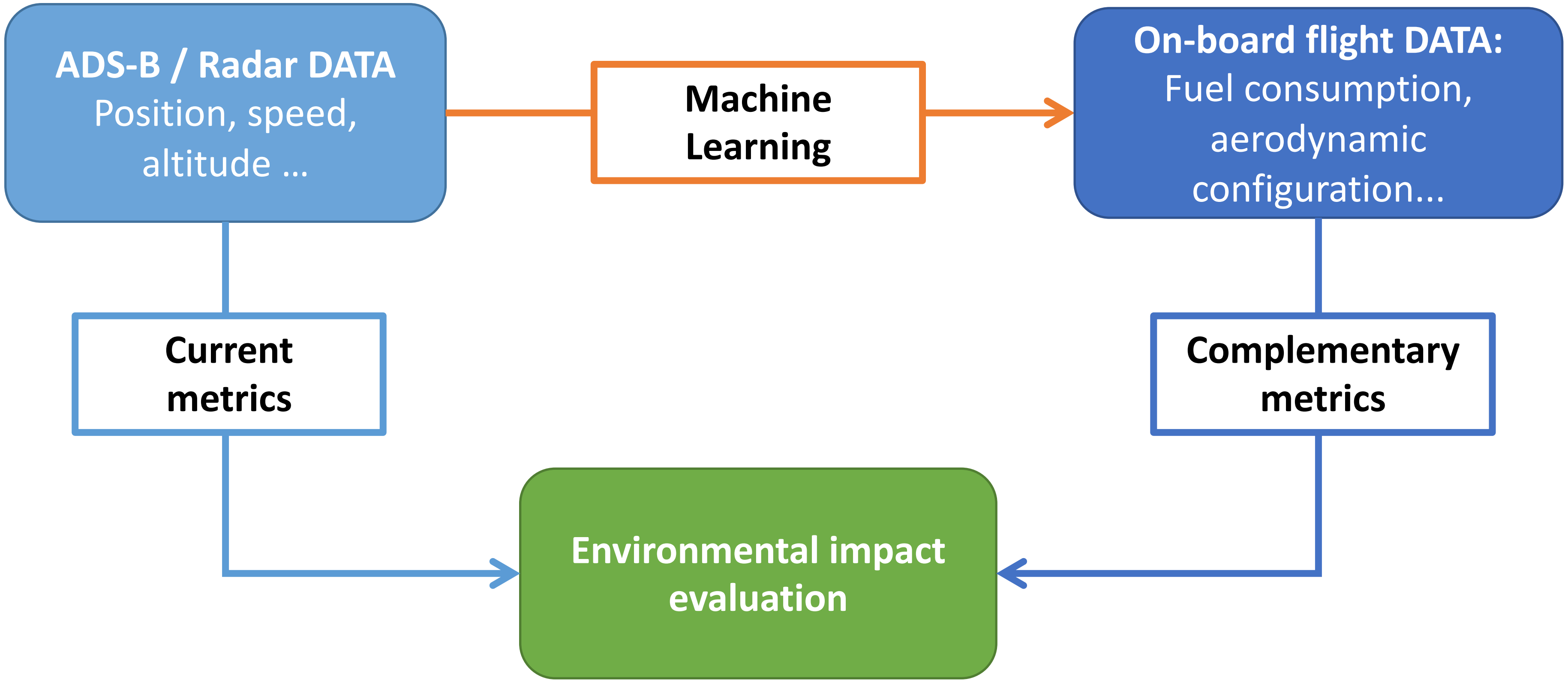
Geometric CDO



Level flight



Philosophy



ADS-B / Radar DATA
Position, speed, altitude …
Machine Learning
On-board flight DATA:
Fuel consumption, aerodynamic configuration...
Current metrics
Complementary metrics
Environmental impact evaluation

Proof of concept

Data Set

A320
15 000 FDR trajectories

Model

LSTM Neural Network

Input parameters

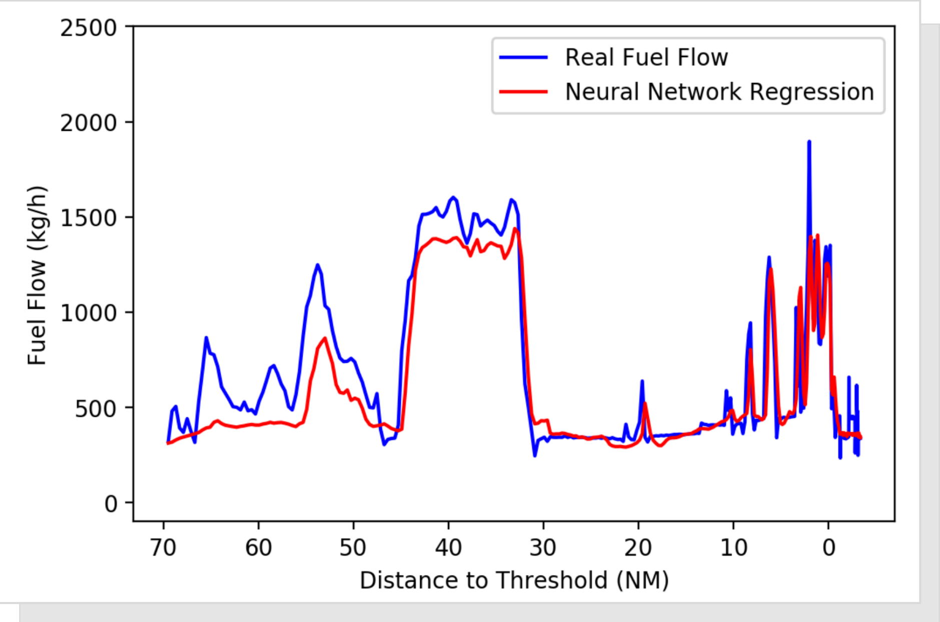
15pts every 4s (1min)

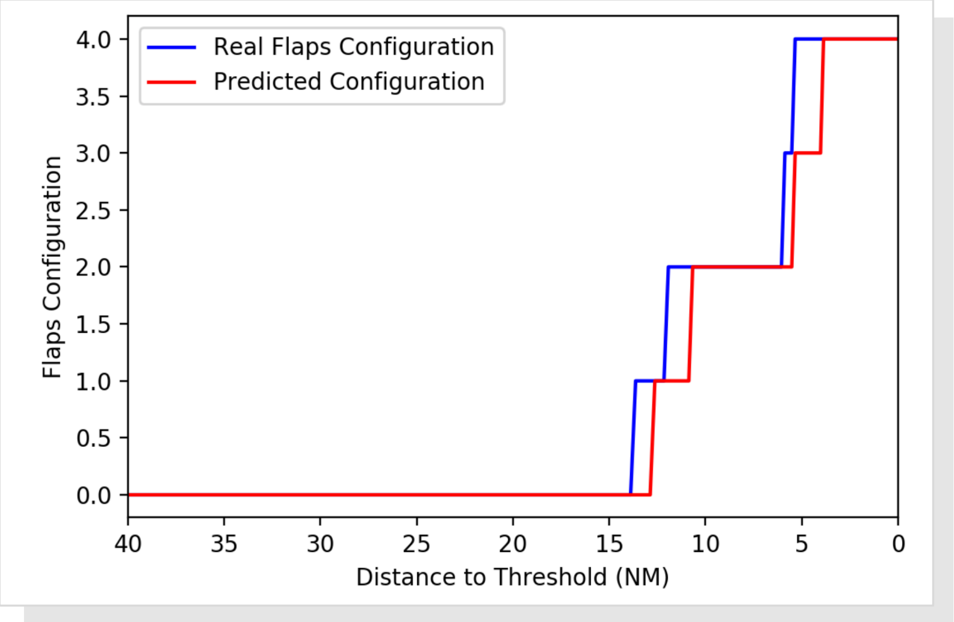
altitude (ft),
ground speed (kts),
vertical speed (ft/min)

Output parameters

Fuel flow (kg/h)
Engine N1 (RPM)
Flaps and gear position
Speed brakes use
(Noise ?)

Models error quantification



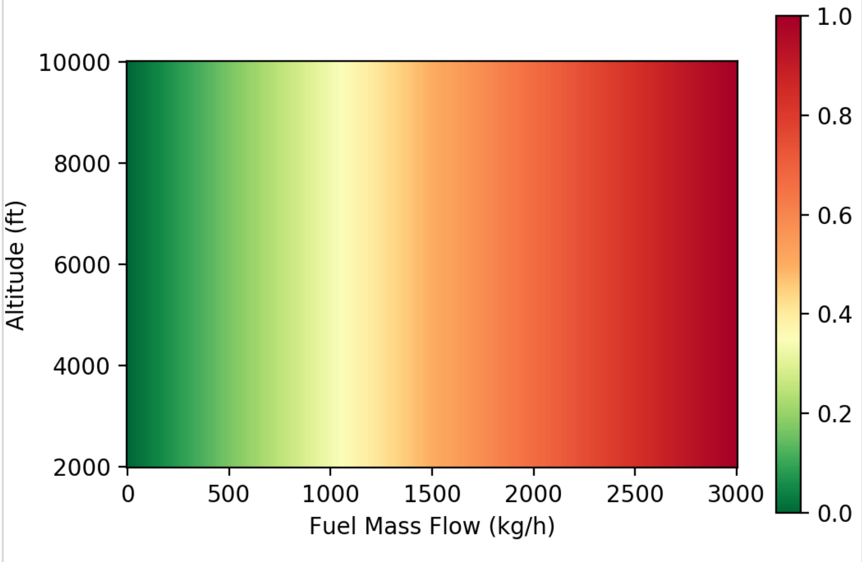


Parameter	Metric	Mean Score
Fuel Flow	Pearson Correlation	0.938
Fuel consumption	ME	3.8%
Landing Gear	Distance MAE	0.99NM
Flap Setting	Distance MAE	1.28NM

Performance metrics (POC)

Fuel penalization

f(fuel flow)

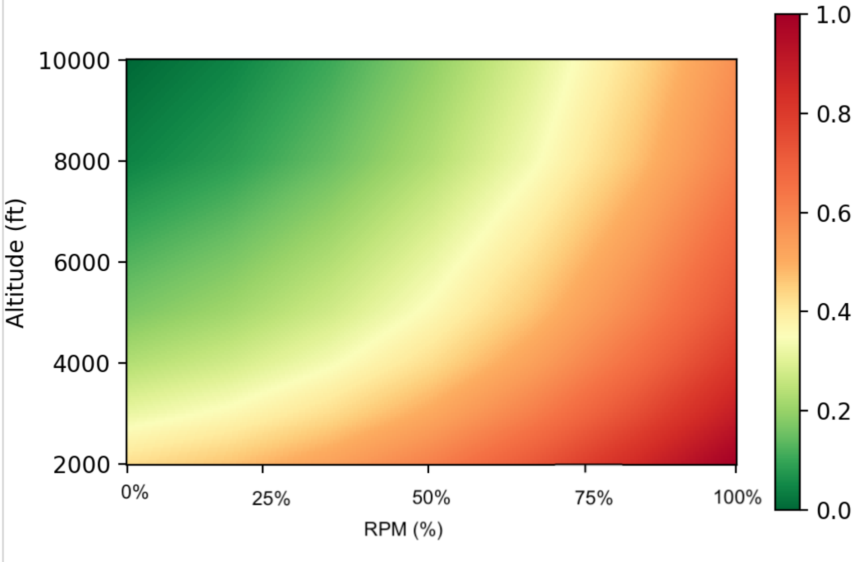


Aggregated penalization score

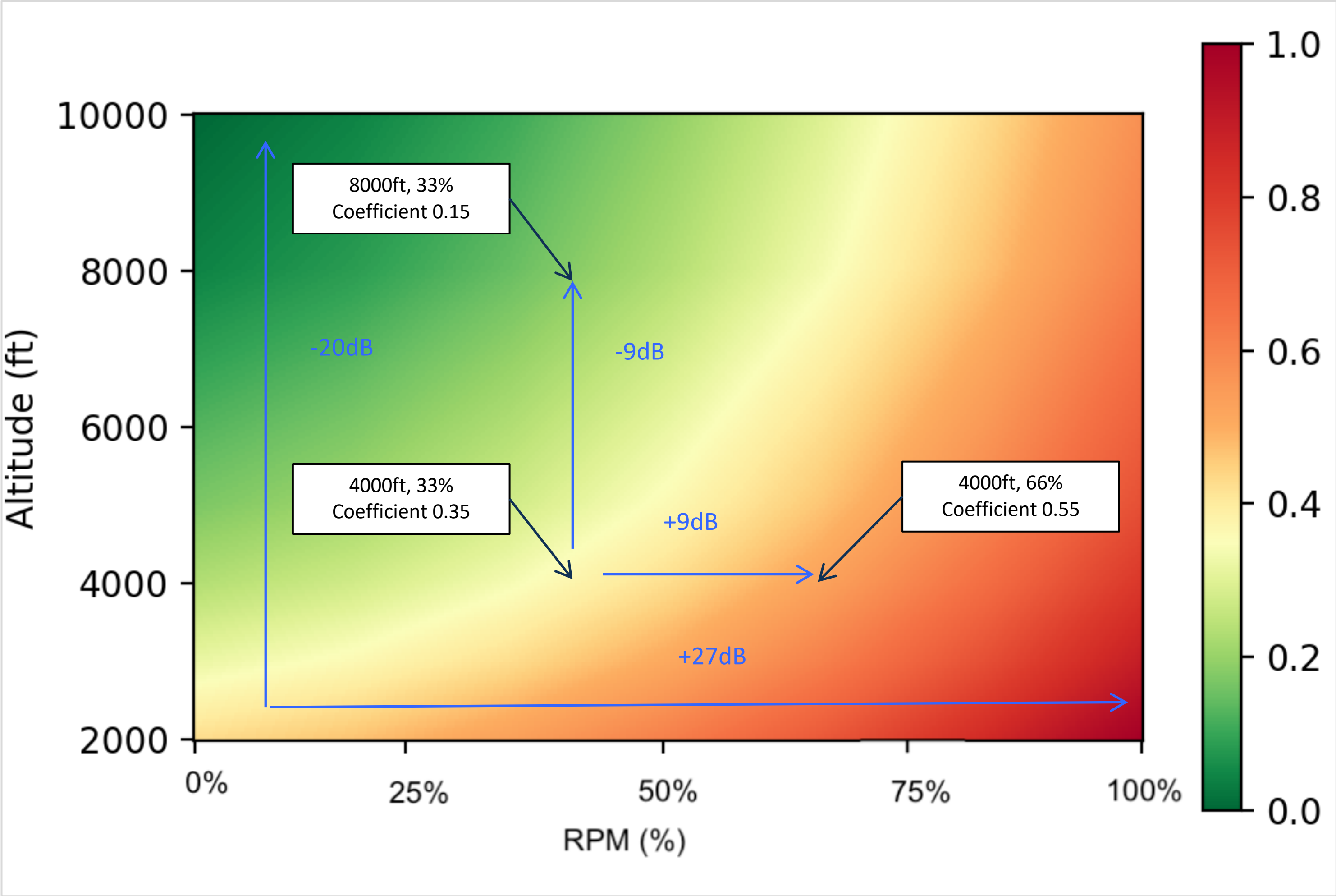
over a time interval
(POC : FL100-2000ft)

Noise penalization

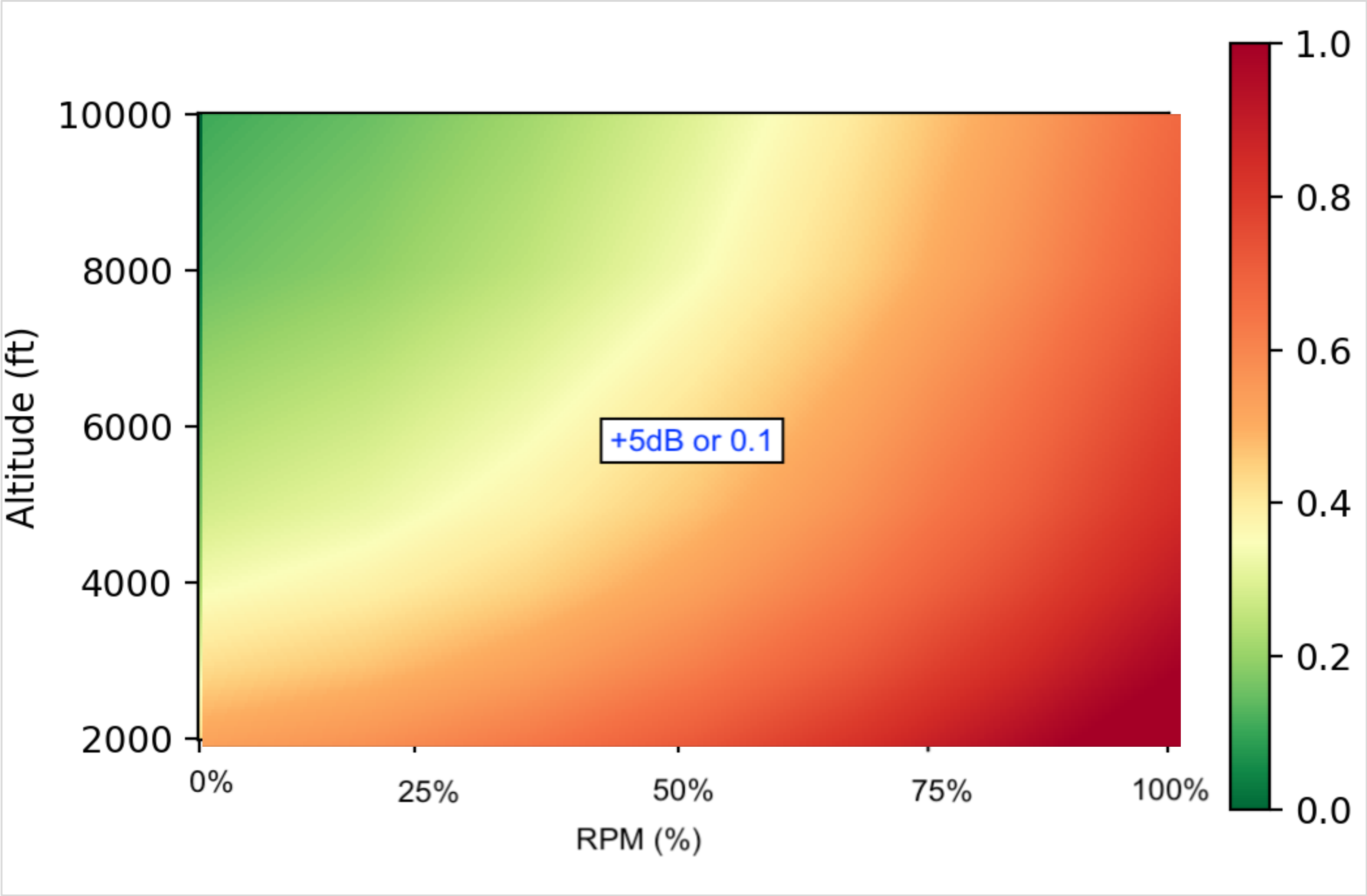
f(N1, altitude) +
f(flaps, gear, altitude)
or
f(noise)



Noise abacus engine (POC)

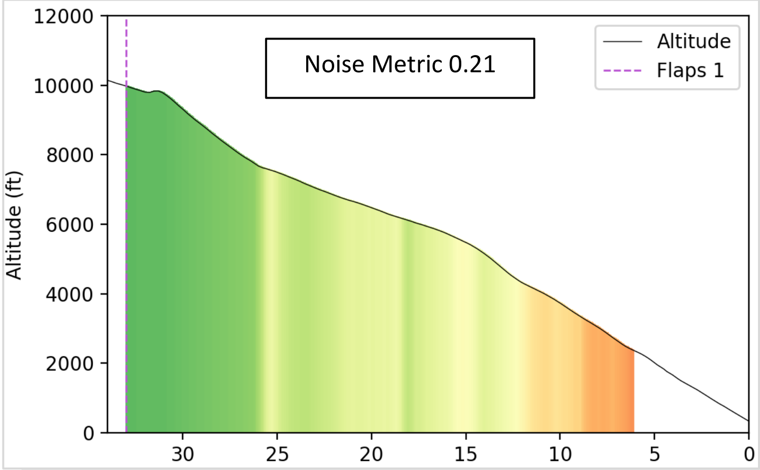


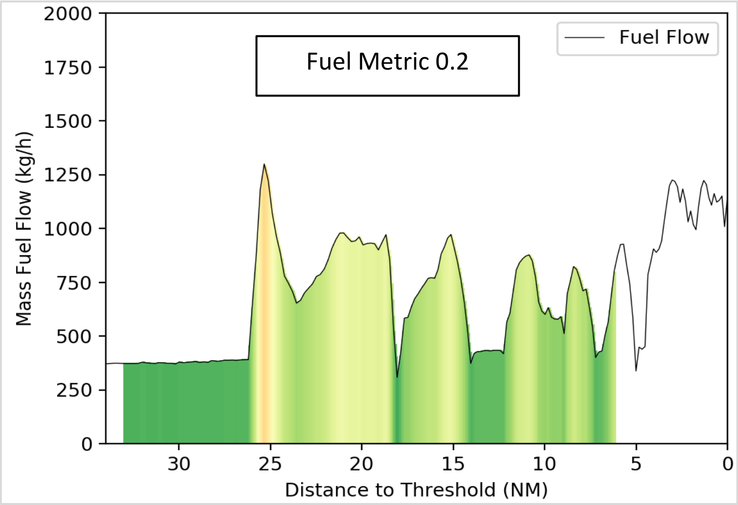
Noise Abacus flaps extended (POC)



Limitation examples

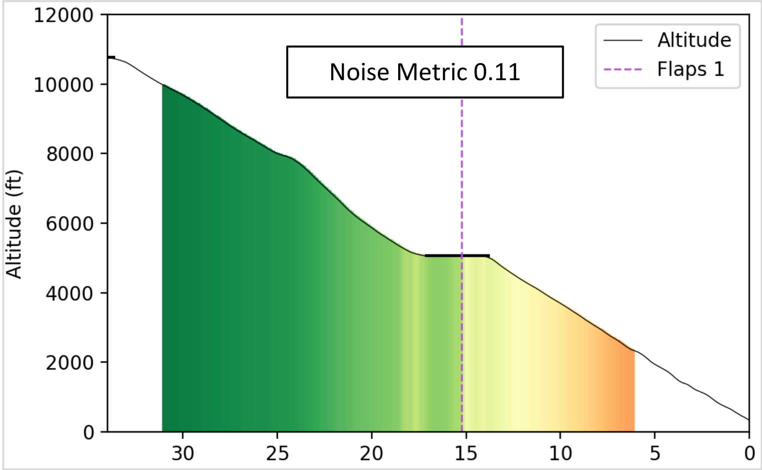
Geometric CDO

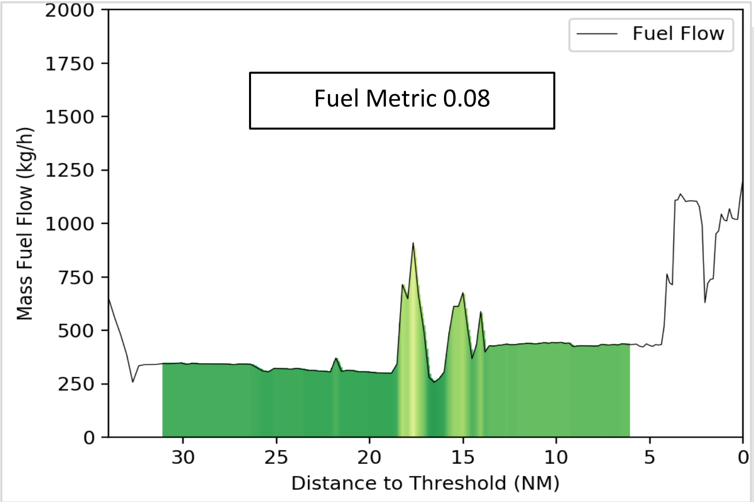




Complementary metrics enable a more precise impact estimate

Level flight





Granularity of metrics

Micro

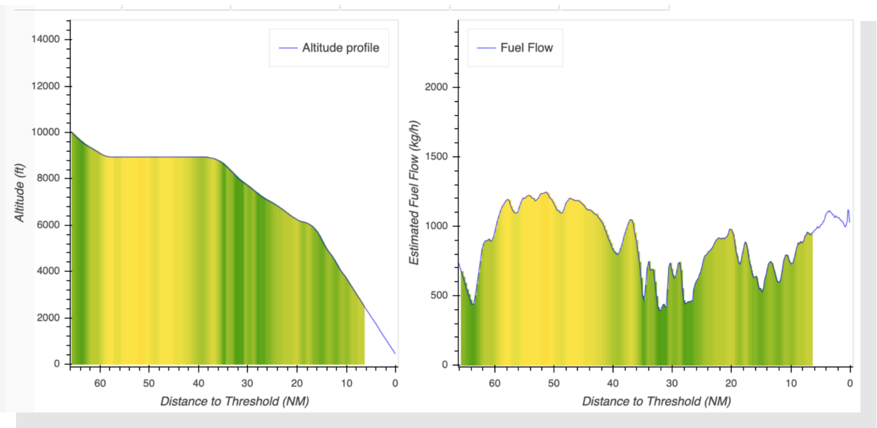
Trajectory analysis

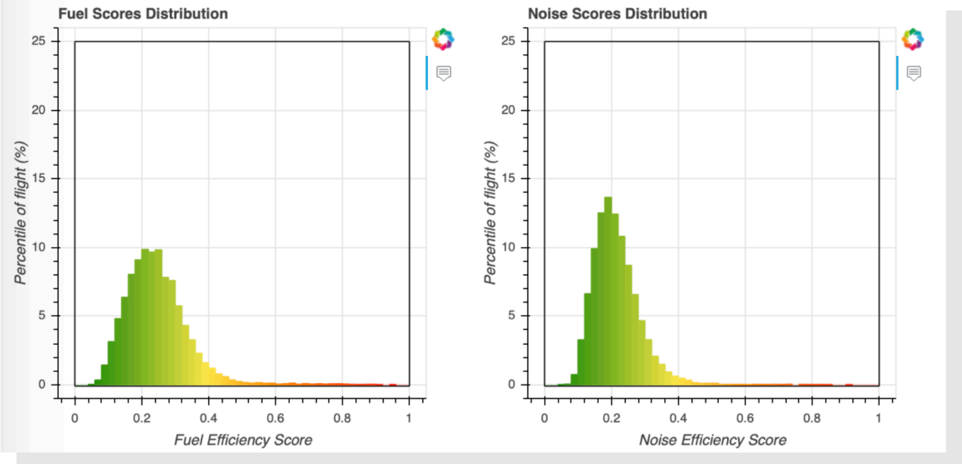
Meso

Comparison between two trajectories/conting

Macro

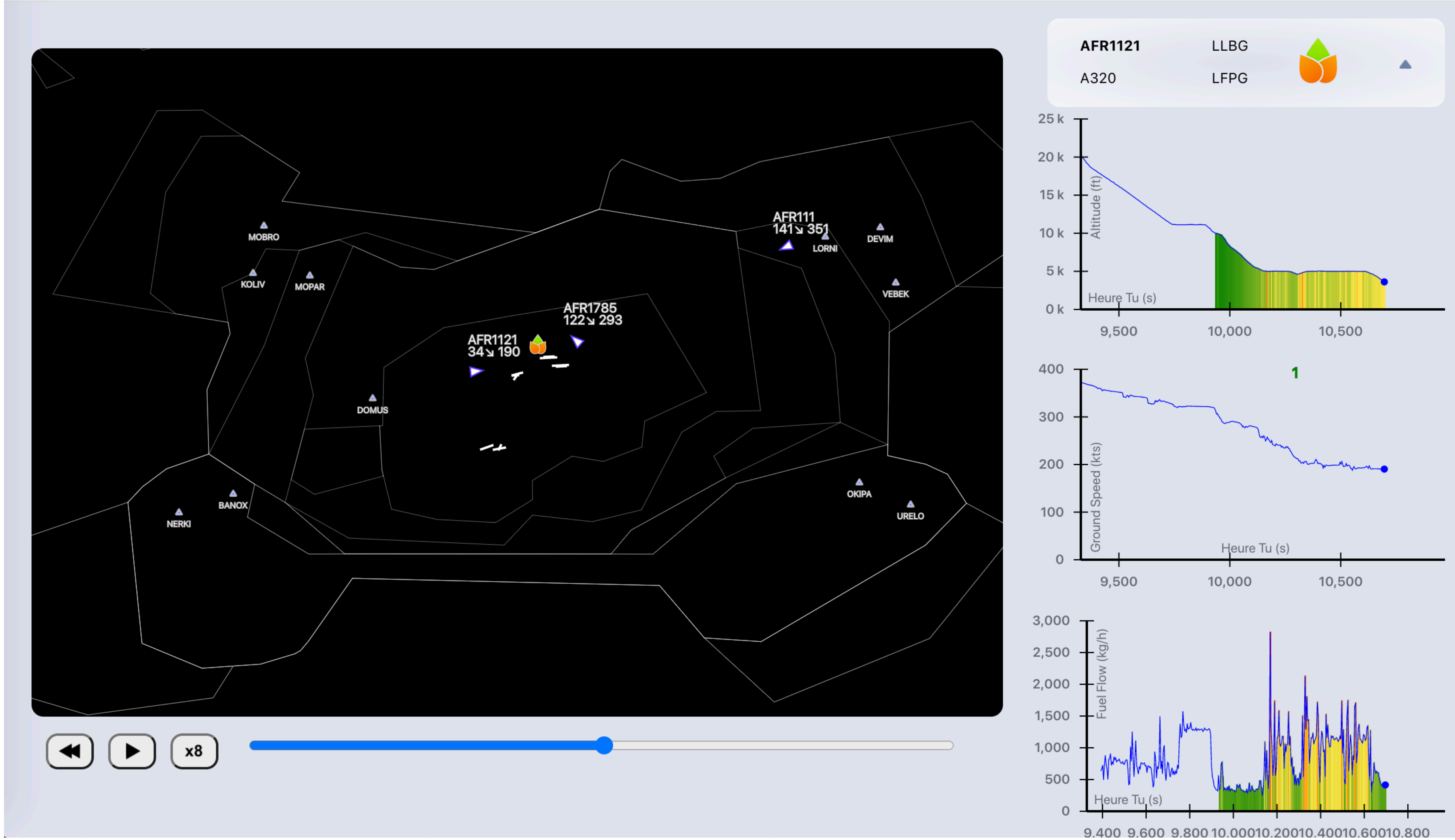
Airport, Airline, ANSP monitoring





Real time extension for ATC (POC)

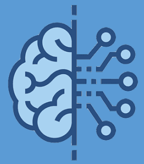
Atypical approach detection



Next step and improvments

ML Models

- Radar data Mode S
- Noise measurements
- Comparison with BADA IV



Metrics

- Abacus improvements
- Time interval (TOD)
- Large data set experimetations

Extensions

- Real time demonstrator
- Integration into optimization process

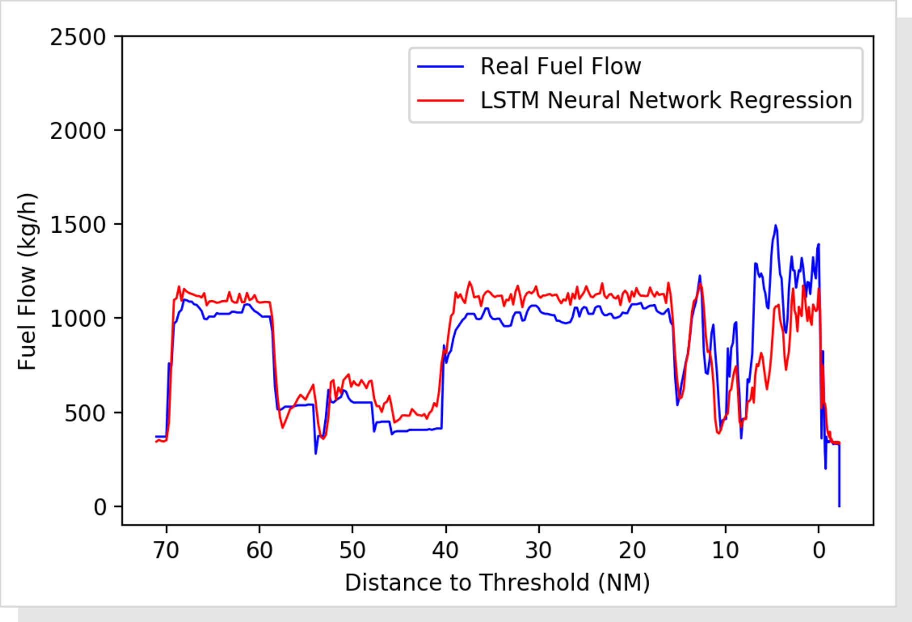
Conclusions

- Machine Learning could enables the improvement of system evaluation metrics such as environmental metrics
- Machine Learning could contribute to a collaborative ground/onboard improvement of the overall efficiency of the ATM system

Thank you
for your attention !

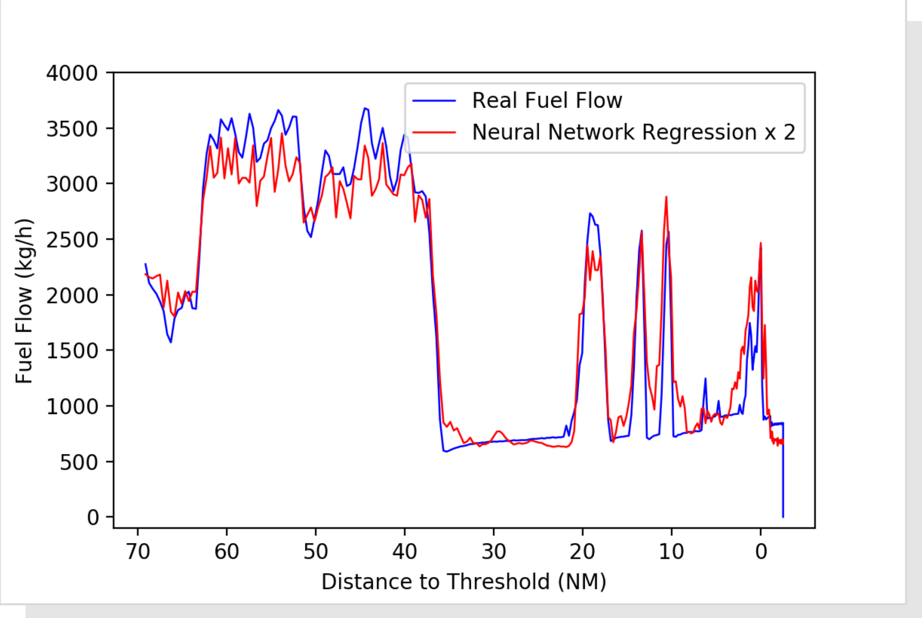
ACROPOLE

Appendix : Generalization B737



Parameter	Metric	Mean Score LFPO	Mean Score GMAD
Fuel Flow	Pearson Correlation	0.917	0.921
Fuel consumption	ME	4.35%	4.86%
Landing Gear	Distance MAE	1.23 NM	1.86NM

Appendix : Generalization A330



Parameter	Metric	Mean Score LFPO
Fuel Flow	Pearson Correlation	0.930
Fuel consumption	ME	4.84%
Landing Gear	Distance MAE	1.63 NM