

Can machine learning help improving environmental performance and its indicators?

Gabriel JARRY



ACROPOLE

Expert Workshop
Vertical Flight Efficiency

Outline

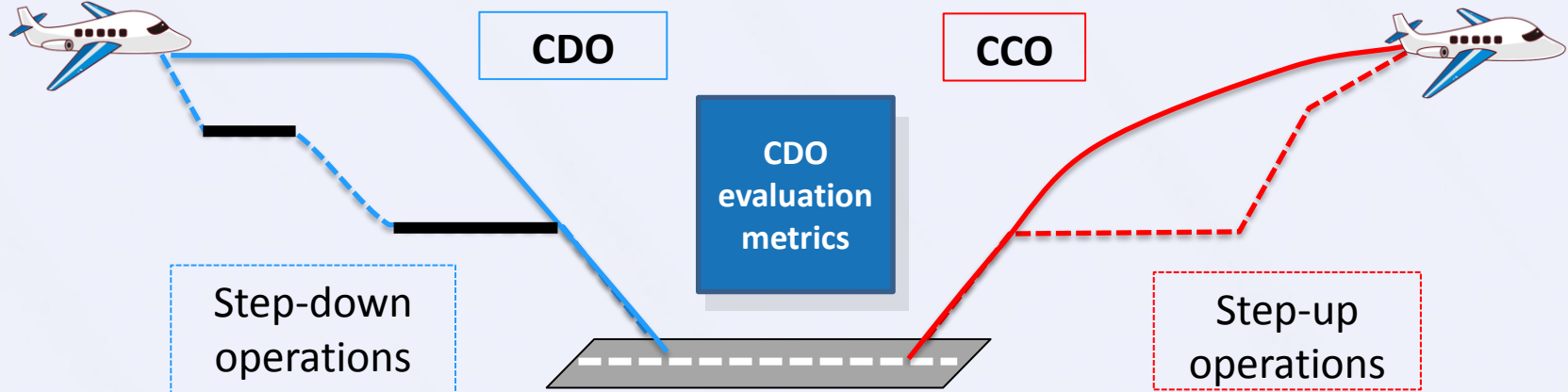
1. Operational Context
2. ML models
3. Metrics illustration
4. Next steps and conclusions

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Operational context

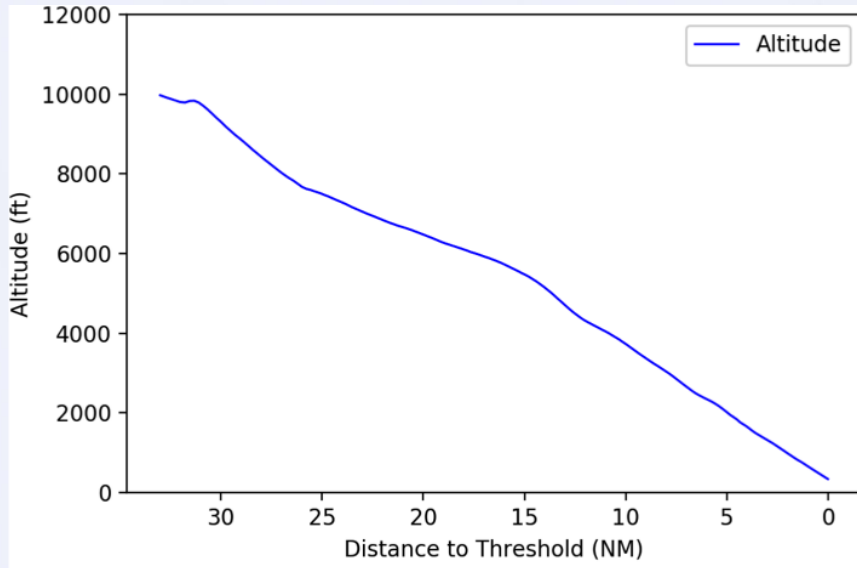
Current trend to control pollutant emissions and noise



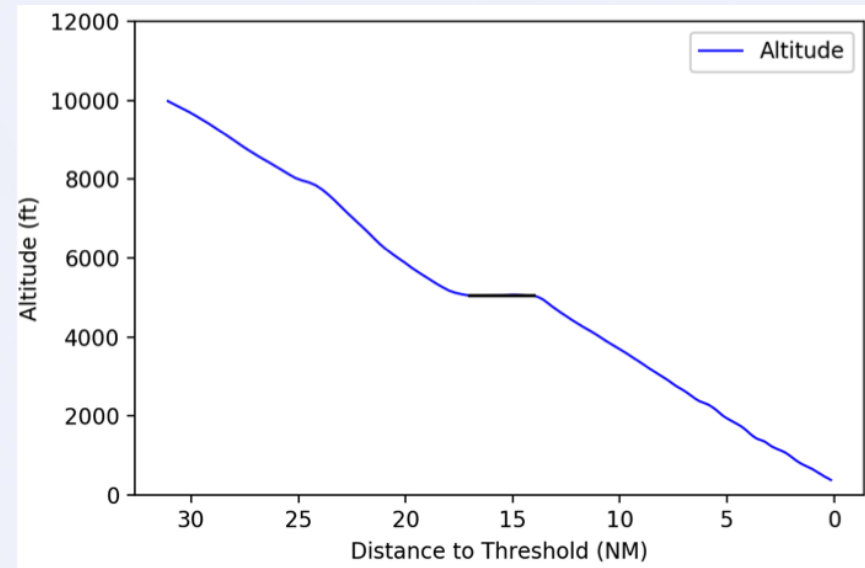
Limitation examples

DSNA

Geometric CDO



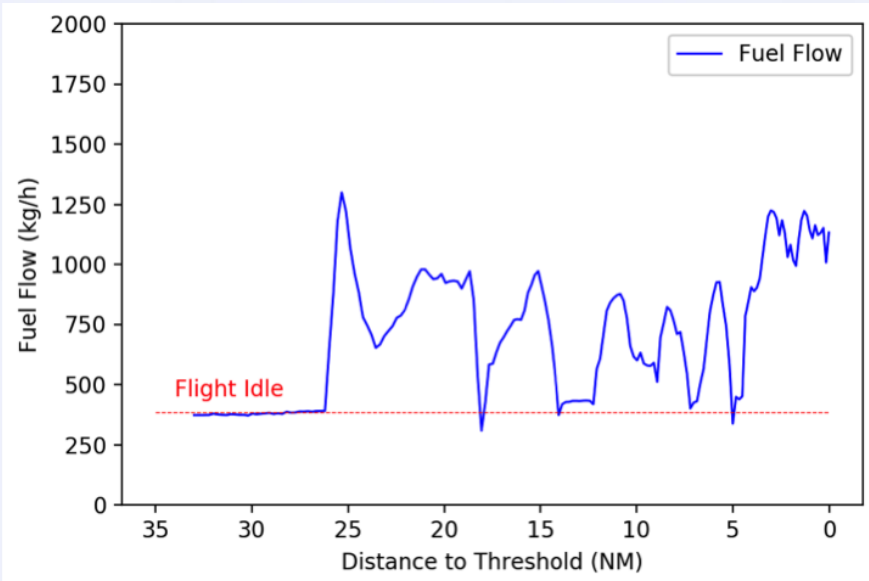
Level flight



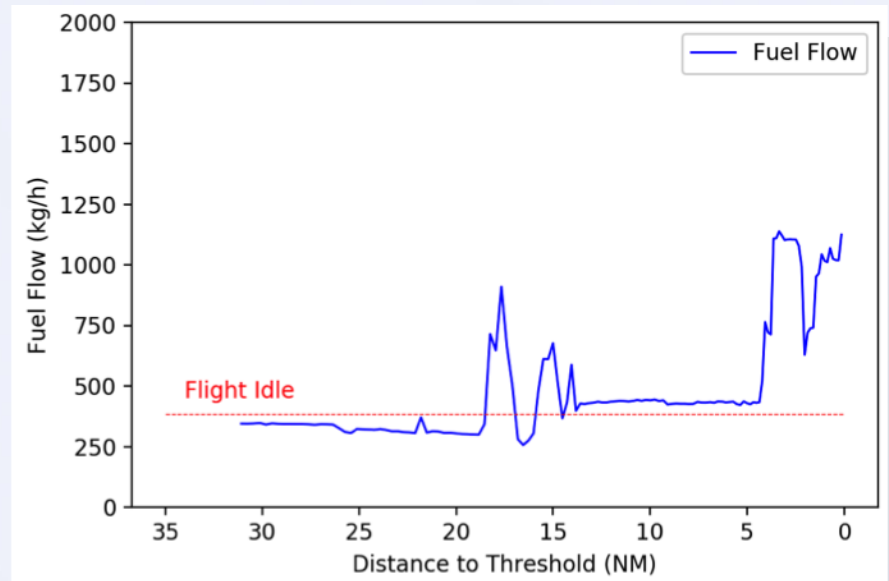
Limitation examples

DSNA

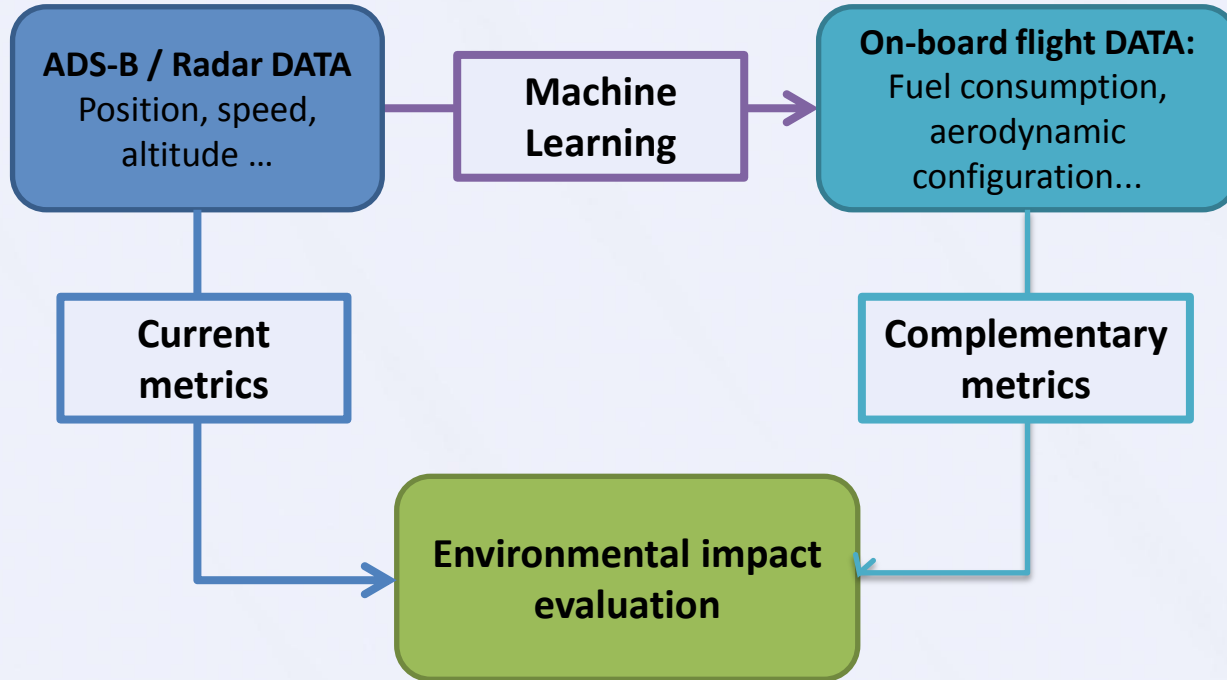
Geometric CDO



Level flight



Philosophy



Outline

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Proof of concept

Data Set

A320
15 000 Trajectories

Model

LSTM Neural Network

Input parameters

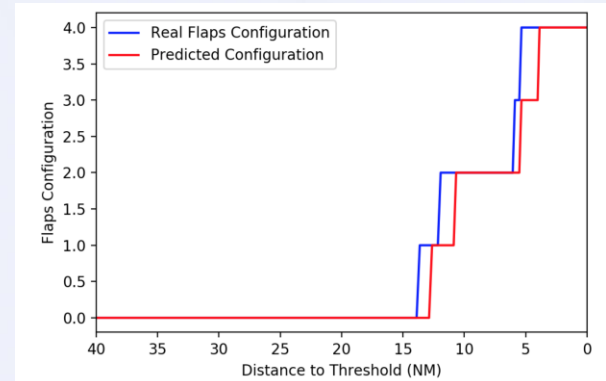
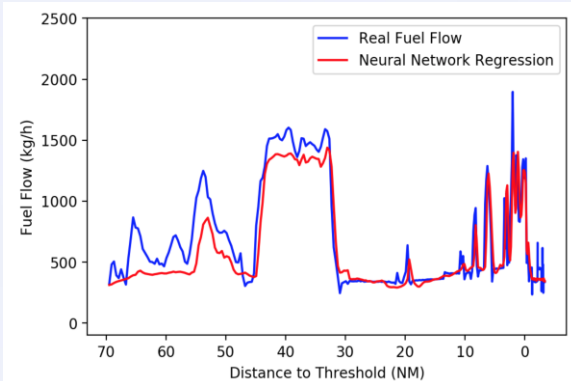
15pts every 4s (1min)

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

Outline

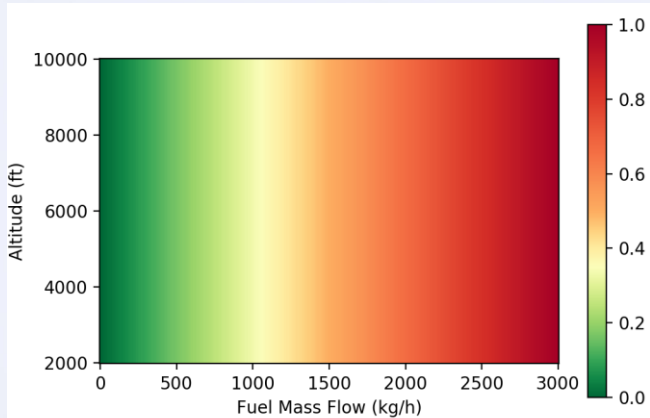
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Performance metrics (POC)

DSNA

Fuel
penalization

$f(\text{fuel flow})$



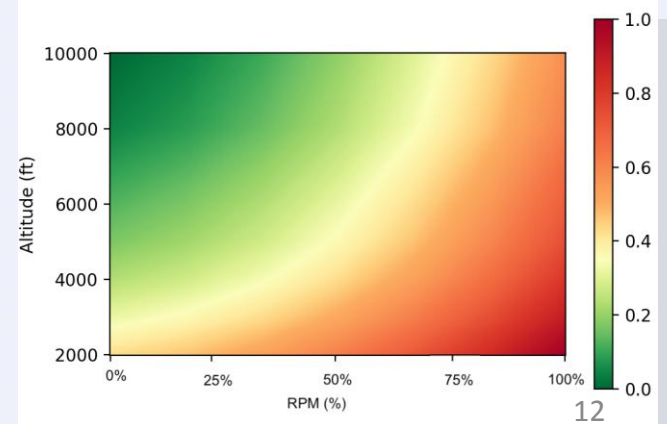
Aggregated
penalization
score

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

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Noise
penalization

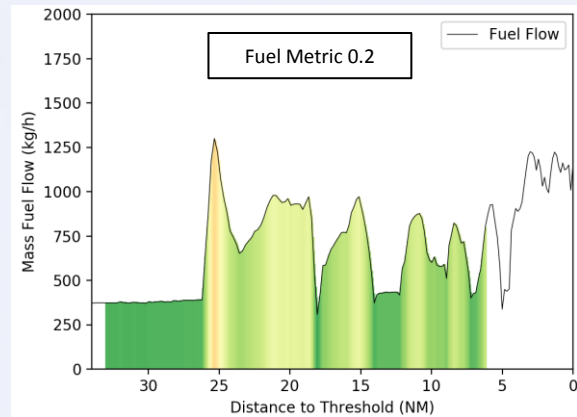
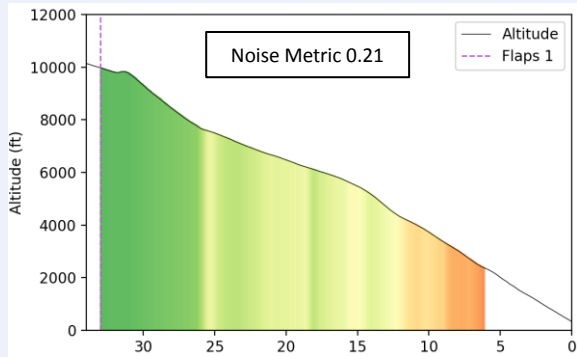
$f(N1, \text{altitude}) +$
 $f(\text{flaps, gear, altitude})$
or
 $f(\text{noise})$



Limitation examples

DSNA

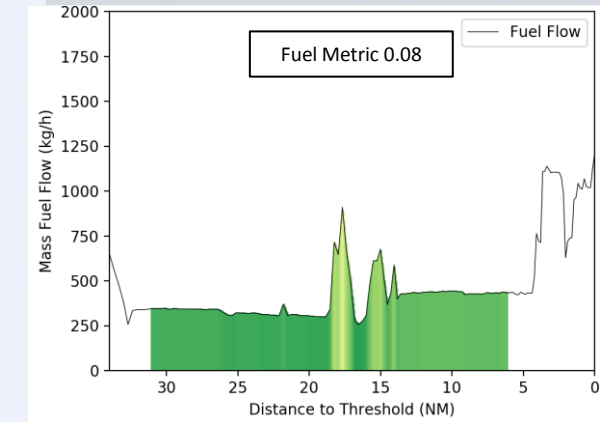
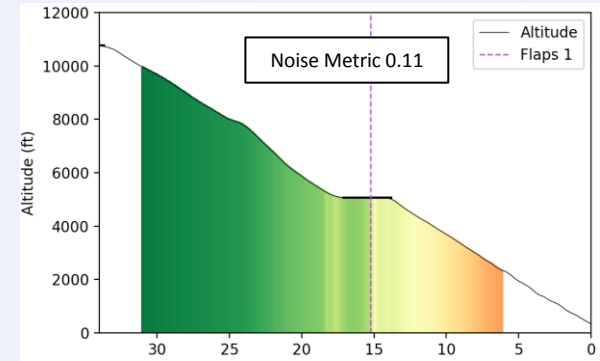
Geometric CDO



Complementary metrics enable a more precise impact estimate

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Level flight



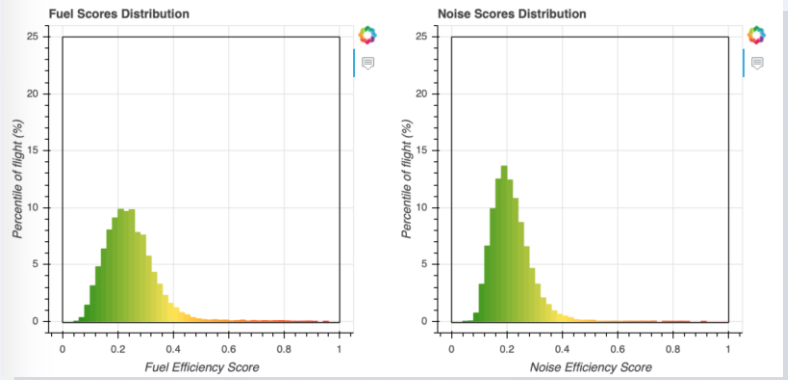
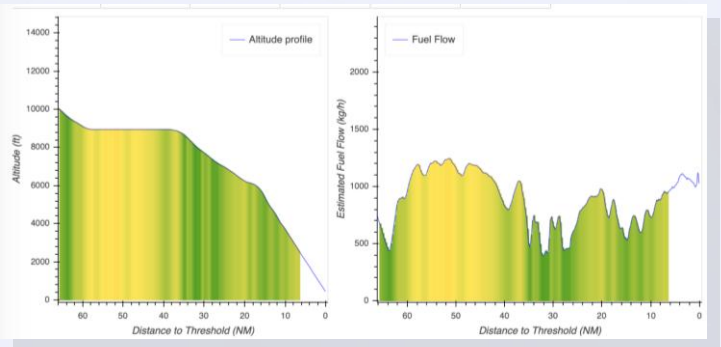
Granularity of metrics

DSNA

Micro
Trajectory analysis

Meso
Comparison between two trajectories/conting

Macro
Airport, Airline, ANSP monitoring



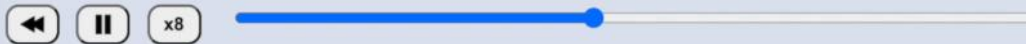
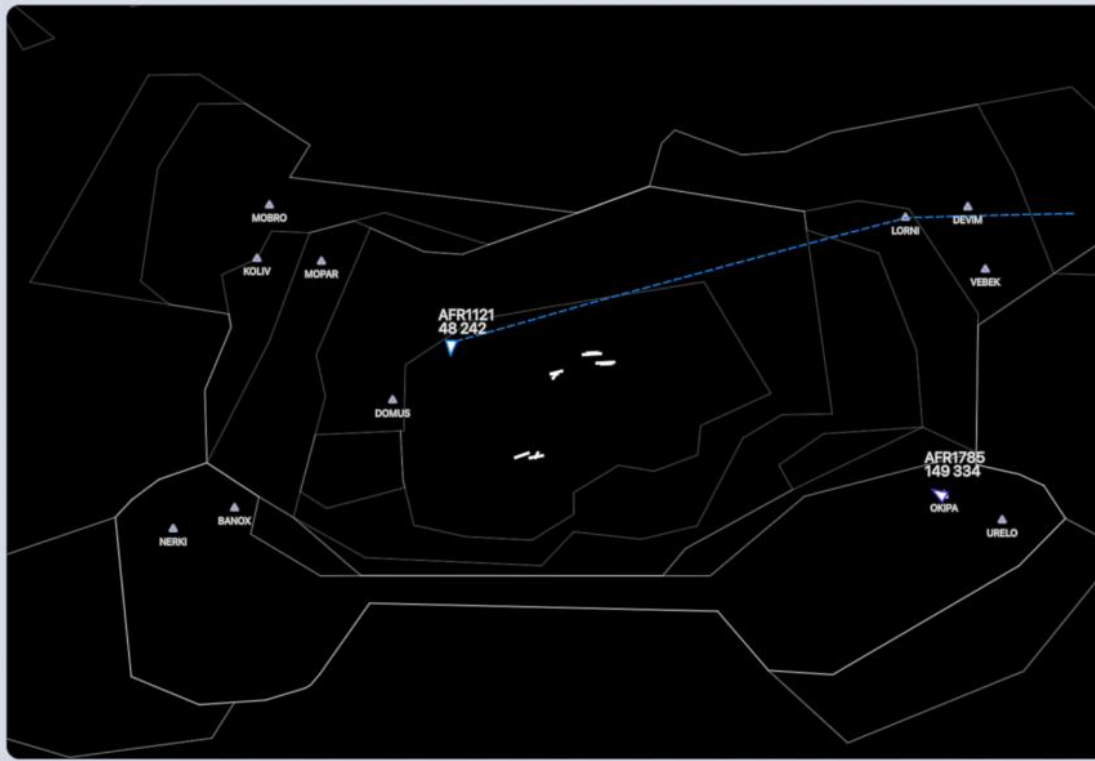
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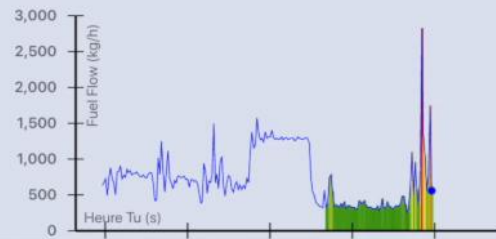
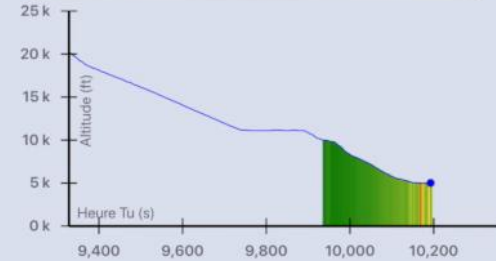
Real time extension for ATC (POC)

DSNA

Atypical
approach
detection



AFR1121	LLBG		
A320	LFPG		



Next step and improvements

ML Models

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



Metrics

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



Extensions

- Real time demonstrator
- Integration into optimization process



Conclusions

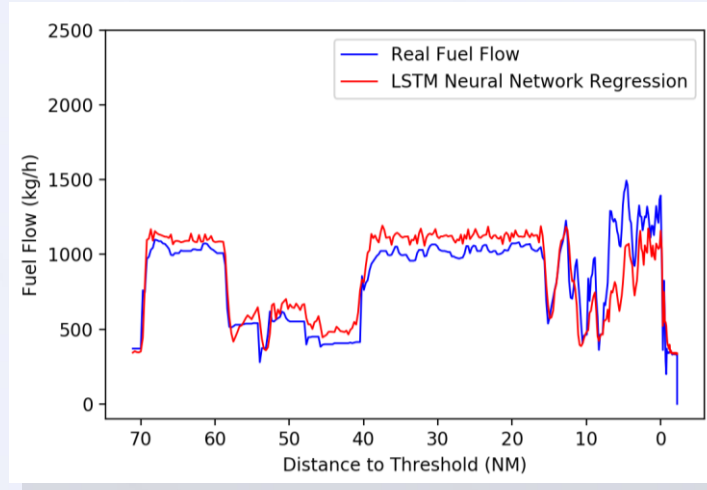
- Machine Learning could enables the improvement of system evaluation metrics such as environmental metrics
- Machine Learning could contribute to a collaborative ground/on-board improvement of the overall efficiency of the ATM system

Thank you for your attention !



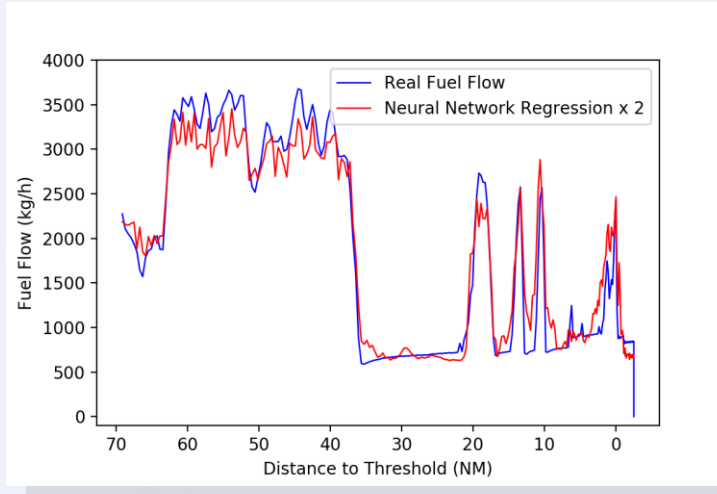
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Appendix : Generalization B737



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