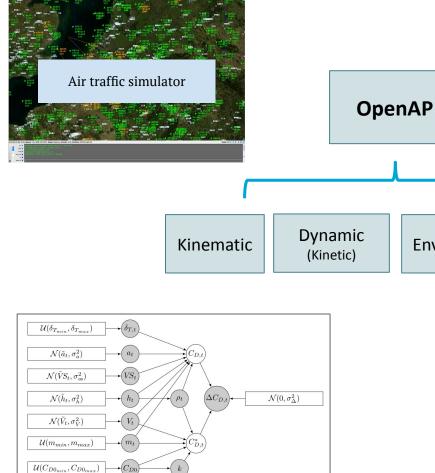
## OpenAP: From Open Data to Sustainable Aviation

Dr. Junzi Sun

Faculty of Aerospace Engineering Delft University of Technology







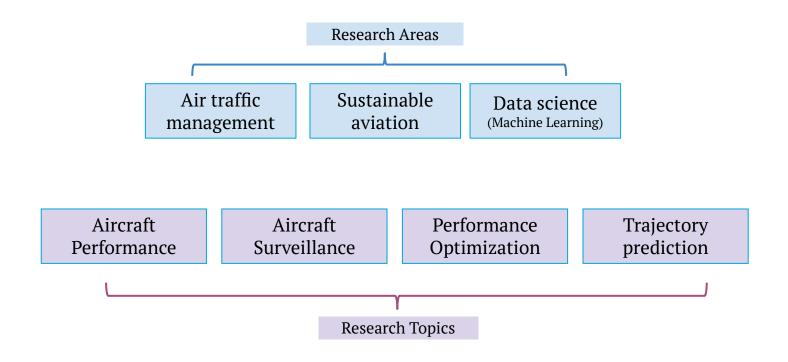
Environment

Weather



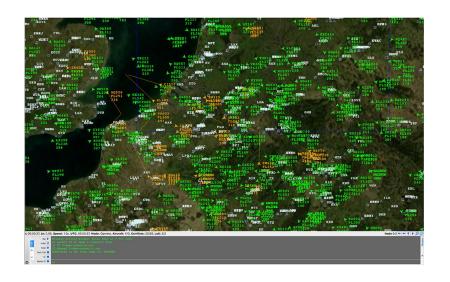


## My current work





## Motivation



What are we going to do with the performance model?

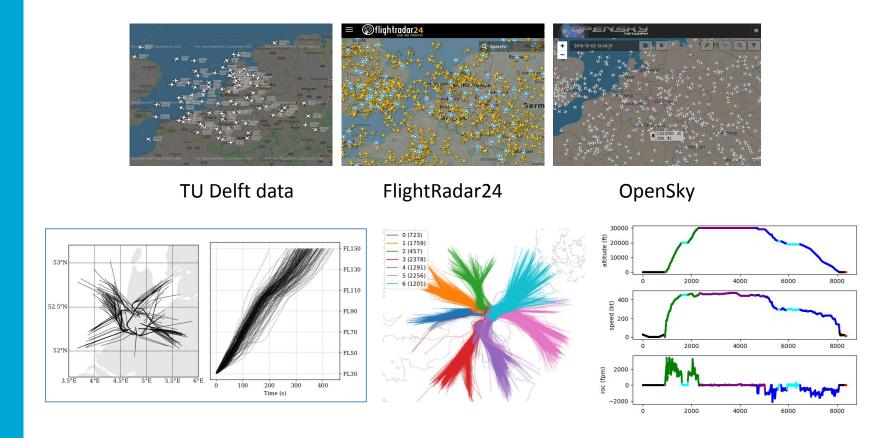
Open Data

Open Models



## Open Aircraft Surveillance Data

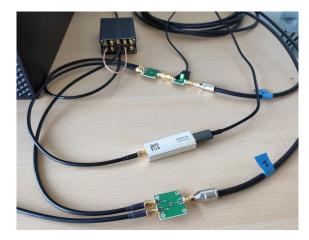
## Data mining (ADS-B / Mode S)





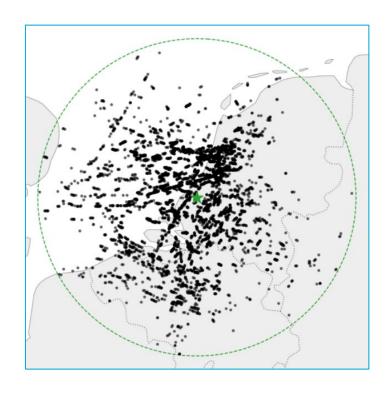
## Mode S signal quality analysis







## Mode S signal quality analysis



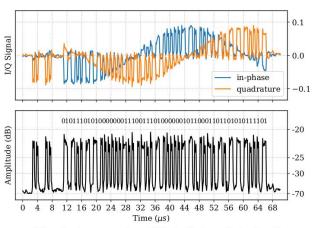


Fig. 5: An example of Mode S downlink signal



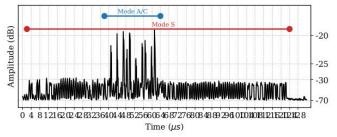


Fig. 7: An example of signal garbling between a Mode A/C message and a Mode S message

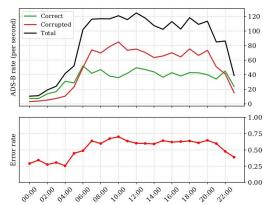


Fig. 15: Corruption detected in ADS-B messages during a 24 hour period on 29 January, 2020, including all signals 10dB above noise floor.

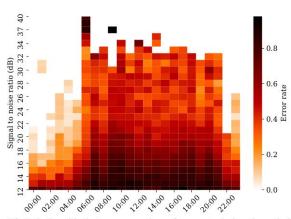
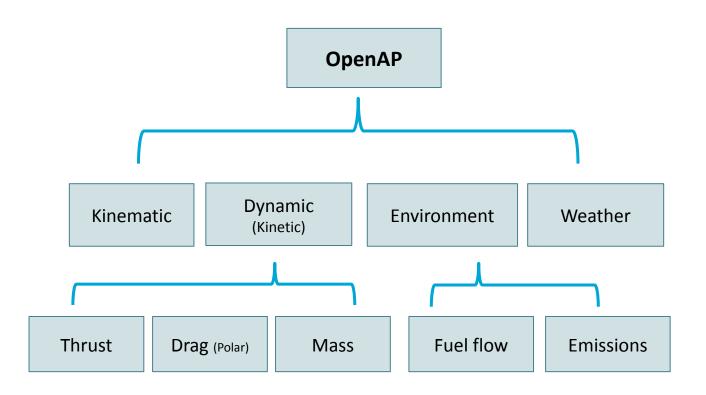


Fig. 16: Relationship between number of corrupted signals and signal power over a 24-hour period. The darker the shade of red, the higher the error rate under a specific signal power at a specific time. Showing only pairs with more than 20 messages.

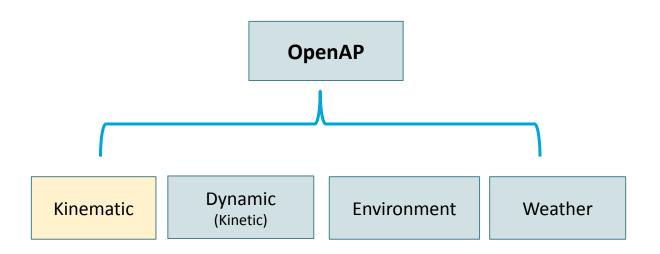


## Aircraft Performance Modeling

## Open Aircraft Performance Model (OpenAP)









## Constructing kinematics models

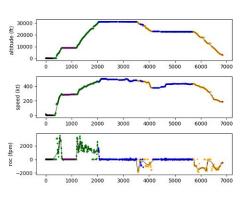
Local and global ADS-B Data Flight trajectory process, -Flight phase identificationPost-processing

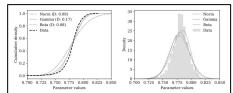
Construct parametric model for key performance parameters (CAS, Mach, vertical rate, etc)

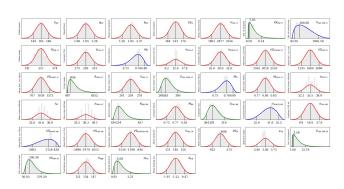








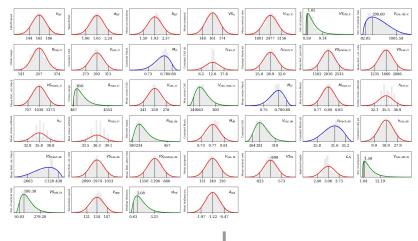




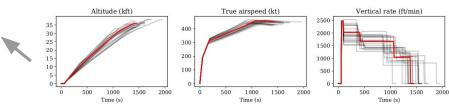


## Kinematics models in BlueSky

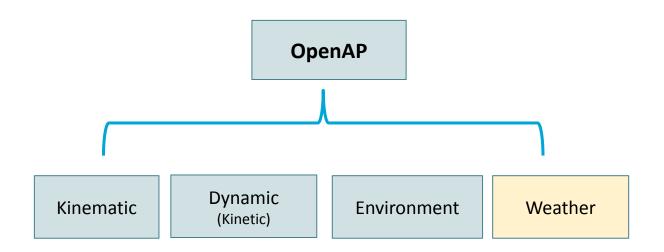






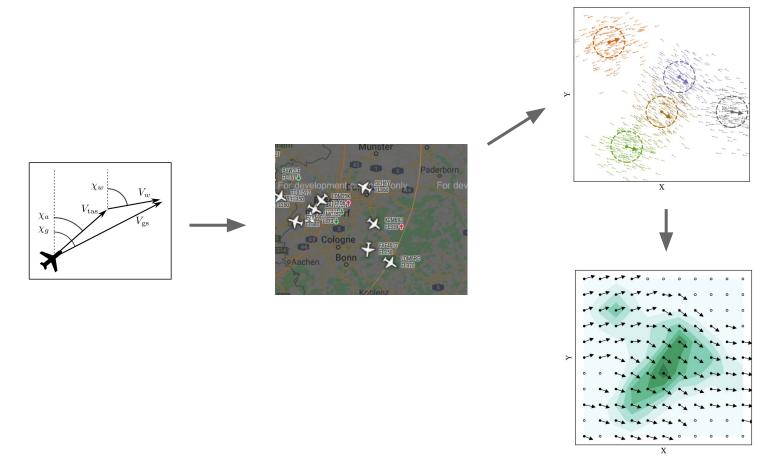








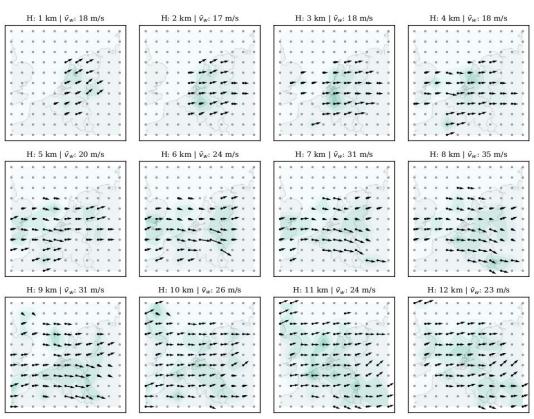
## Constructing weather field using aircraft data (meteo-particle model)





### Constructing weather field using aircraft data (meteo-particle model)

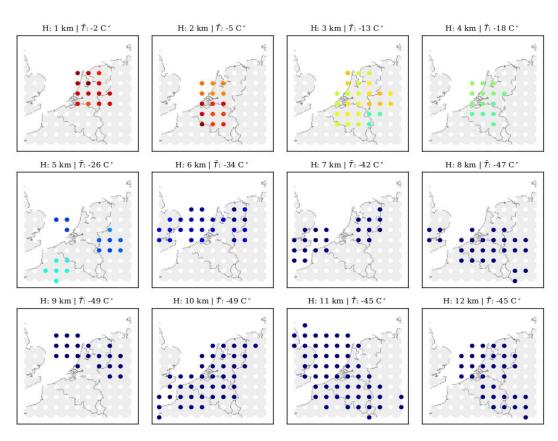


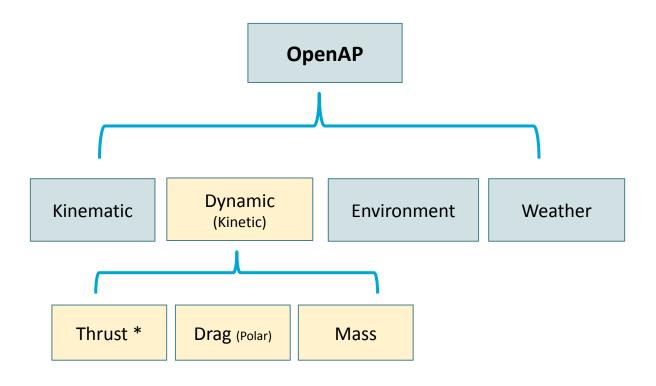




## Constructing weather field using aircraft data (meteo-particle model)





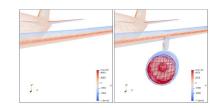


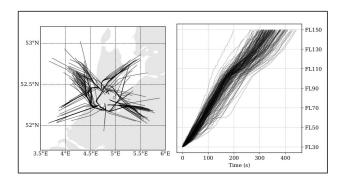


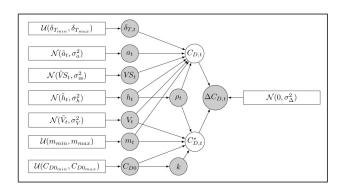
<sup>\*</sup> Bartel, M., Young, T.M., 2008. Simplified thrust and fuel consumption models for modern two-shaft turbofan engines. Journal of Aircraft 45, 1450–1456.

### Drag polar estimation

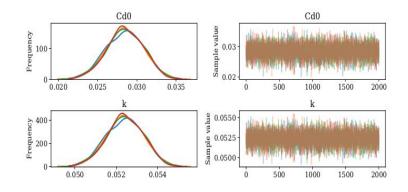
#### Bayesian estimation / Markov chain Monte Carlo (MCMC) simulation









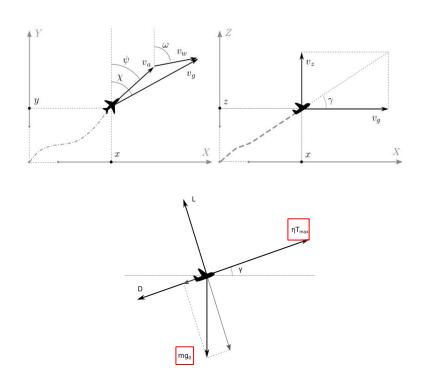


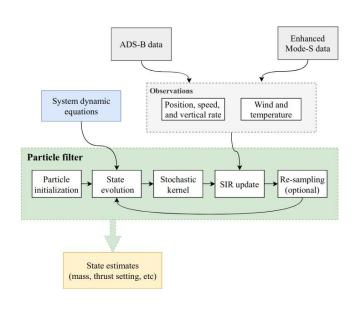
A milestone for the open model



### Aircraft mass

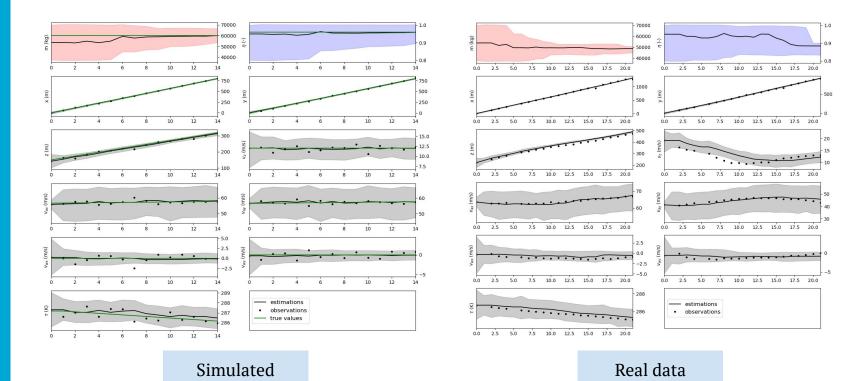
(Recursive Bayesian estimation / particle filter )







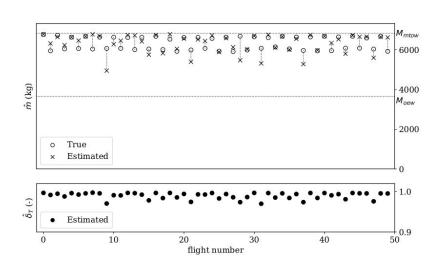
# Aircraft mass (using recursive Bayesian filter)





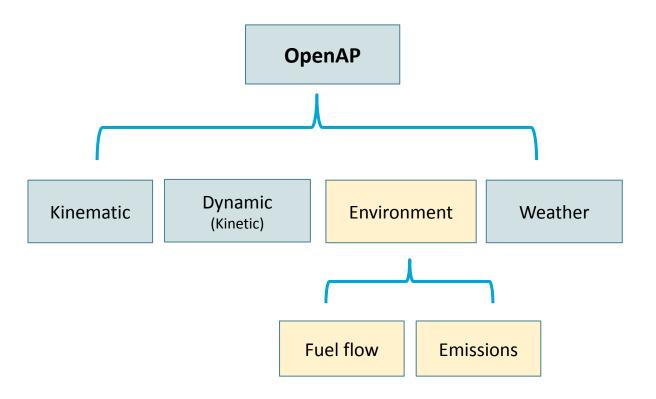
# Aircraft mass (using recursive Bayesian filter)







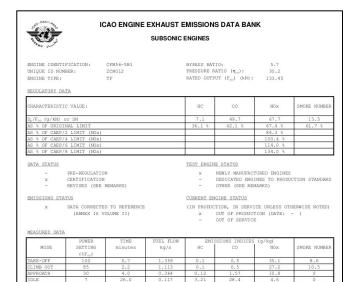
## Sustainable air transport





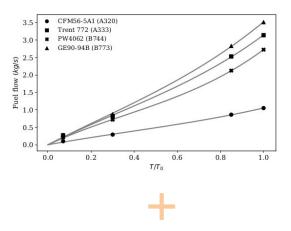
## OpenAP fuel module

TO TOTAL FUEL (kg) or EMISSIONS (g)

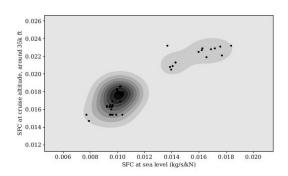


5423

7783



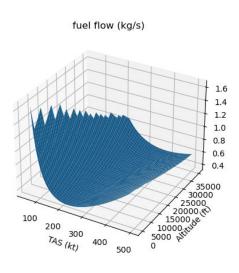
#### Fuel flow correction model





## OpenAP fuel module

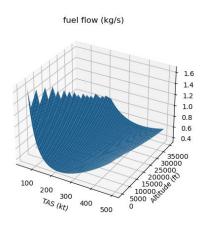
- Fuel flow model enables calculation of fuel consumption directly from trajectory data.
- Simplified APIs for calculating different pollutant emission (CO2, H2O, CO, NOx, HC) from trajectory data.



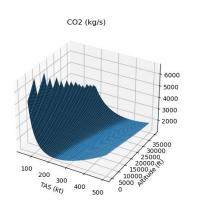


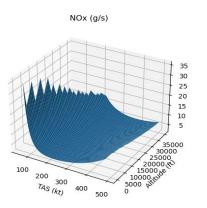
## OpenAP emission models

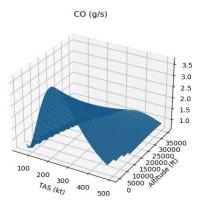
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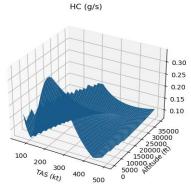














## OpenAP fuel and emission calculations

```
from openap import FuelFlow, Emission

fuelflow = FuelFlow(ac='A320', eng='CFM56-5B4')
emission = Emission(ac='A320', eng='CFM56-5B4')

TAS = 350
ALT = 30000

fuelflow = fuelflow.enroute(mass=60000, tas=TAS, alt=ALT) # kg/s

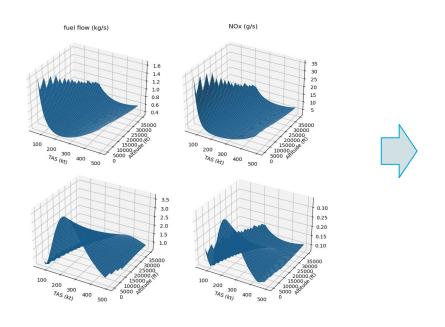
CO2 = emission.co2(fuelflow) # g/s
H2O = emission.h2o(fuelflow) # g/s
NOX = emission.nox(fuelflow, tas=TAS, alt=ALT) # g/s
CO = emission.co(fuelflow, tas=TAS, alt=ALT) # g/s
HC = emission.hc(fuelflow, tas=TAS, alt=ALT) # g/s
```

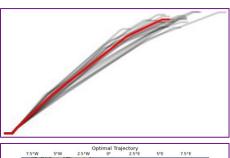
https://github.com/junzis/openap

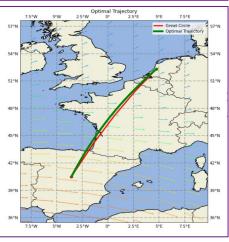


## Trajectory optimization

- Trajectory optimization to minimize environmental impacts.
- Trade off between different types of emissions.
- Multi-objective, 4D optimized trajectories.









One more thing...

## Sustainable Aviation Lab (SA Lab) @ TU Delft

#### **Global Scope**

- Better assess aviation's global environmental impact
- Utilize large amount of crowd-sourced flight data
- Design operational mitigation strategies to reduce air transport footprint



#### **Local Scope**

- Assess the impact of both noise and air quality
- Utilize flight data and other measurements near regions of airport
- Design optimal flight operations that reduce impact of noise and local air quality





# Thank you!

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GIthub: @junzis

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