AIM2015: Validation and Initial Results from an Open-Source Aviation Systems Model

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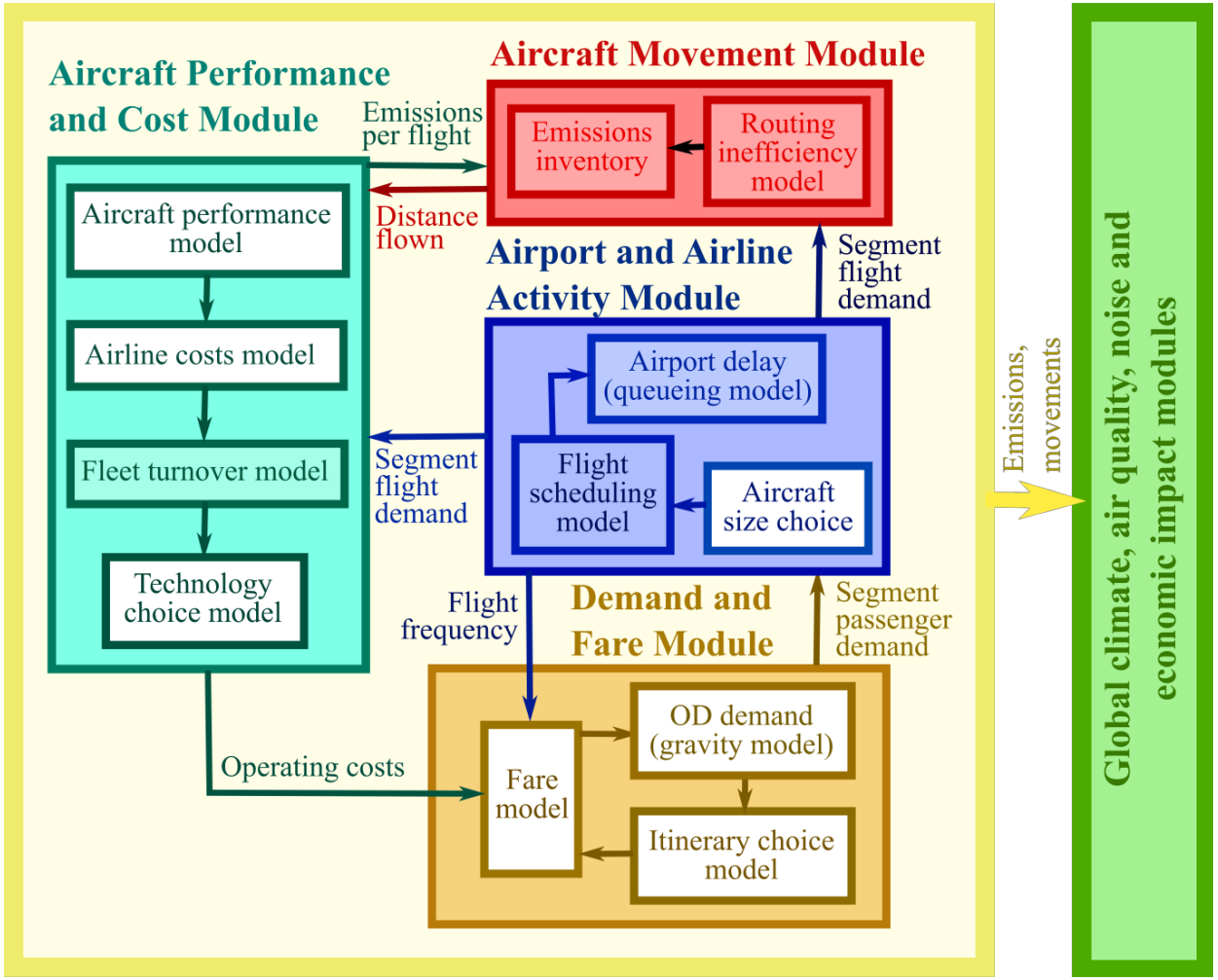
Background

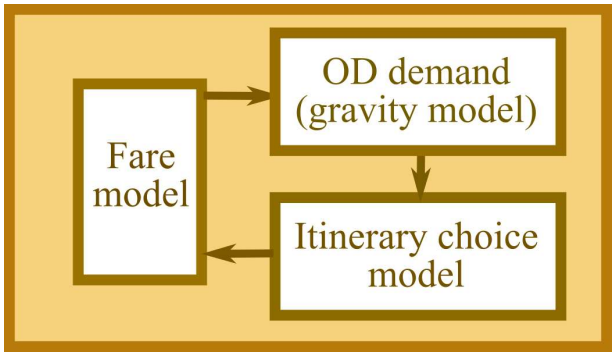
- UCL/Southampton/Imperial College ACCLAIM project on the consequences of airport capacity expansion
  - Eventual goal: assess network-wide economic and environmental implications of expanding/not expanding airport capacity
  - Global aviation systems model, will include network change and airline competition effects (e.g. Evans & Schäfer, 2011)
  - Current model is a first step towards this:
    - Based on AIM model (e.g. Dray et al. 2014)
    - Major updates, e.g. 2015 base year, passenger choice model, airline performance and cost models…
    - Airline competition model under development
    - Open source for transparency
- Funding from: EPSRC Engineering and Physical Sciences Research Council

Model Structure

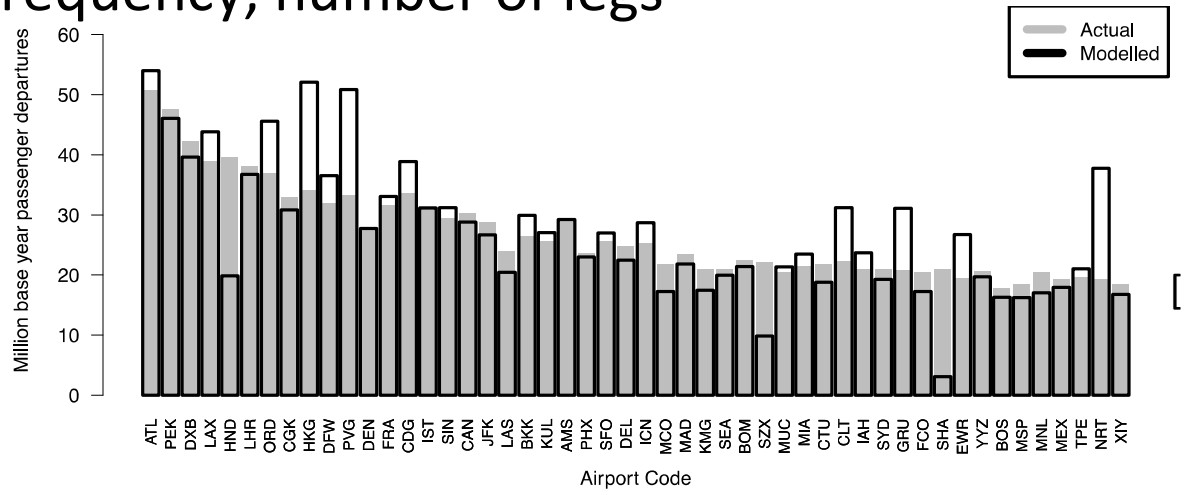
- Updated components shown in white boxes



Demand and Fare Module

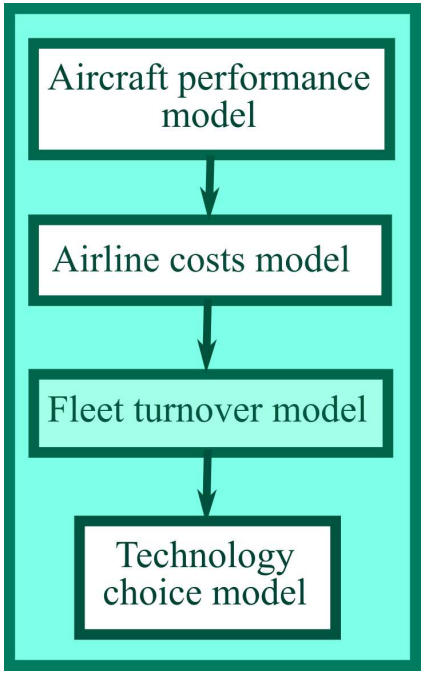


- See Wang et al. (2017, this conference) for fare model
  - Projects fares on an itinerary basis based on airline costs and route characteristics
  - Can be used to assess cost pass-through
- Interim OD demand model adapted from Dray et al. (2014)
- New passenger itinerary/airport choice model based on fare, time, frequency, number of legs



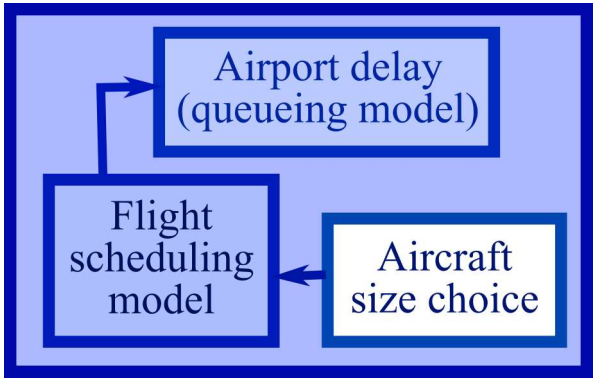
[Data: Sabre, 2016]

Aircraft Performance and Cost Module



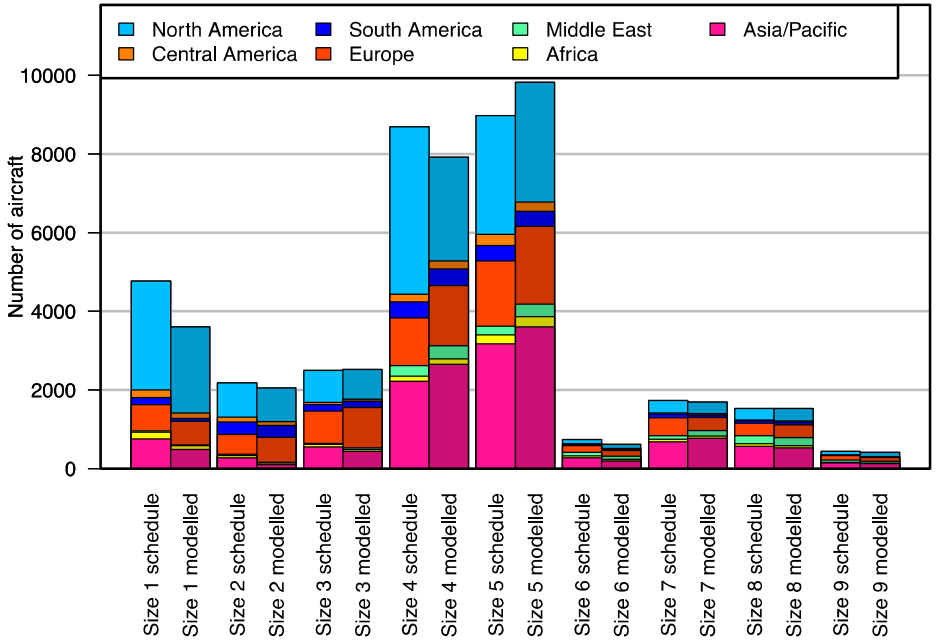
- See Al Zayat et al. (2017, this conference) for performance and cost model updates
  - Interpolated performance model based on output from Piano-x for nine aircraft size classes
  - Output is CO_2, NOx etc by flight stage
  - Cost model assesses operating cost by category
  - Used to assess electric aircraft viability
- Fleet turnover model discussed in Dray (2013), assesses fleet age distribution, retirement and impact on performance
- Technology choice based on Schäfer et al. (2016)
  - NPV used to assess uptake of new aircraft models, operational changes, retrofits

Airline and Airport Activity Module



- Rapid queueing model for airport delay
  - See Evans (2008)
- In-flight emissions based on perfomance model and routing inefficiency factors
  - See Reynolds (2009)

- Aircraft size choice model picks fleet to use based on demand, airport characteristics, etc.
  - Assuming typical segment load factors this gives flight frequency and fleet requirement



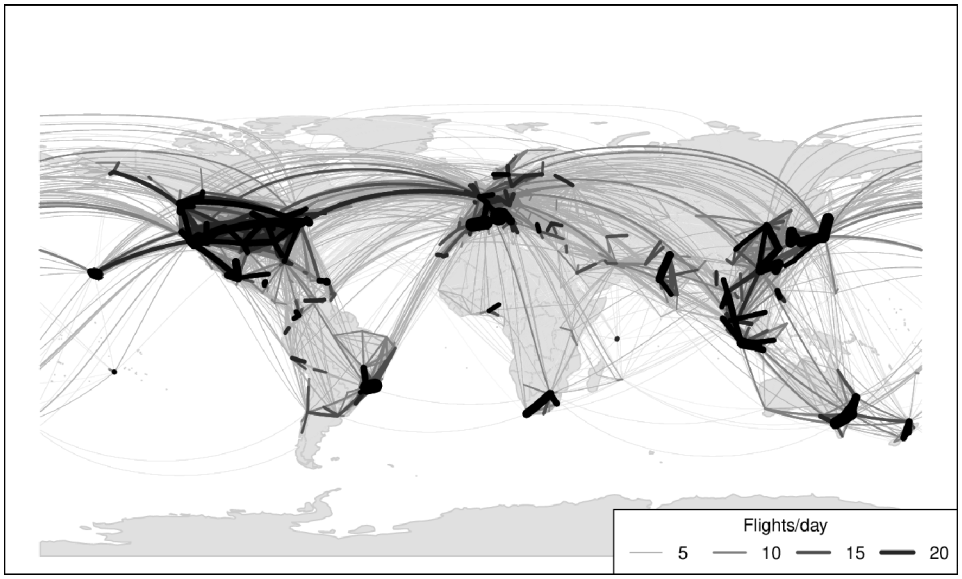
[Data: Sabre, 2016; FlightGlobal, 2016]

Validation

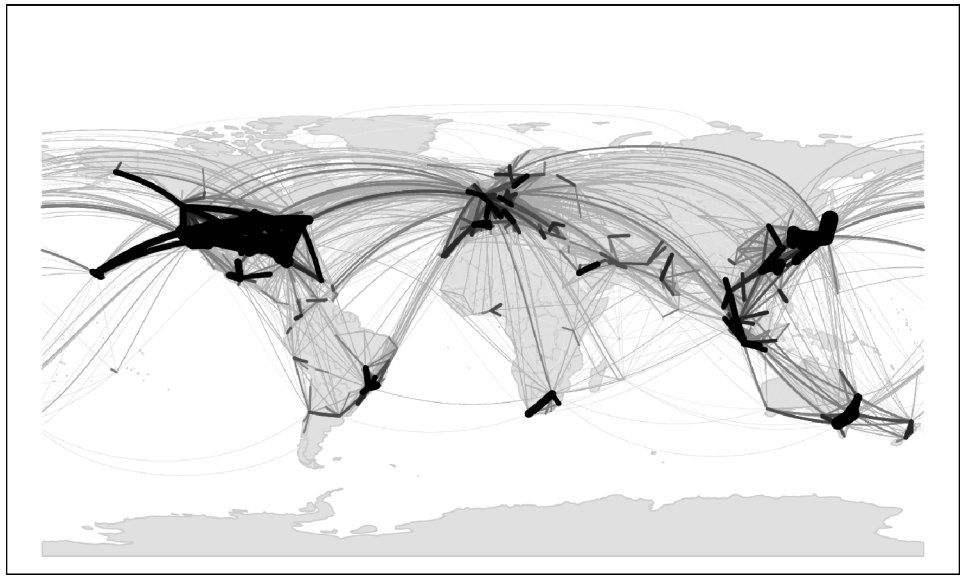
- Four components:
  - Validation of individual sub-models – see references for each model
  - Check 2005 and 2015 base year outcome against actual data
  - Run model with 2005 base year to 2015
  - Run 2015 base year into the future and check against other projections
  - See paper for full details

2005 base year model

Scheduled departures, 2005



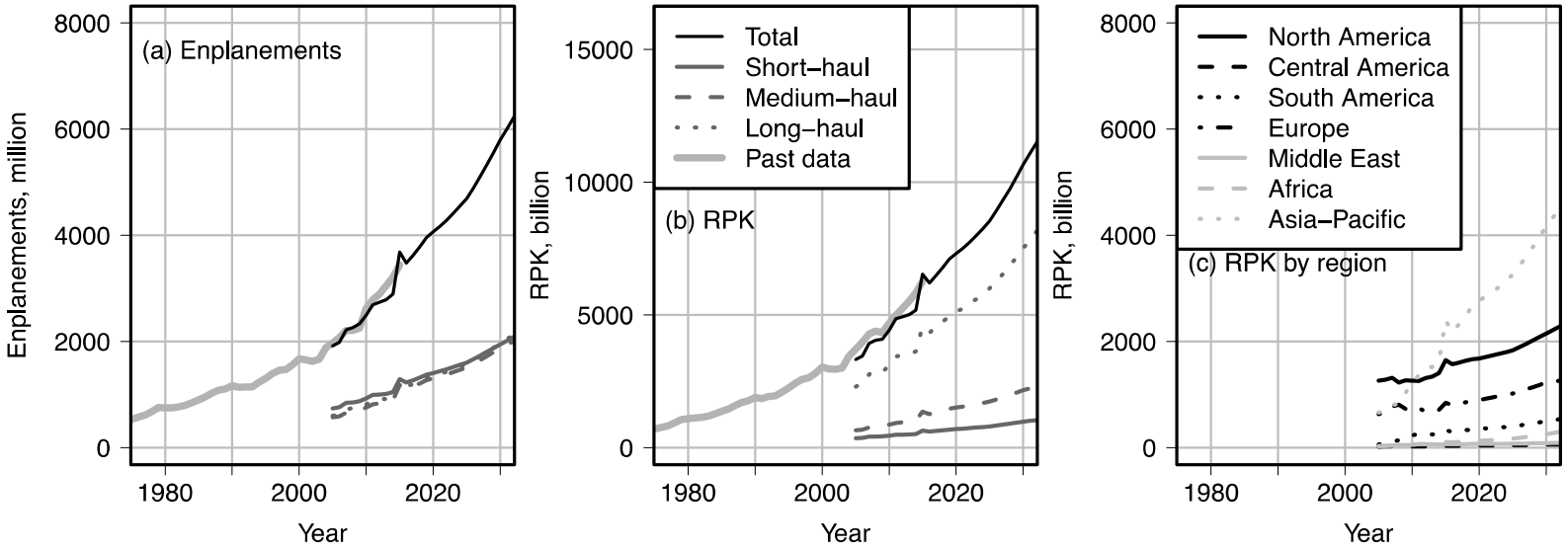
Modelled departures, 2005



[Data: Sabre, 2016]

2005 base year model

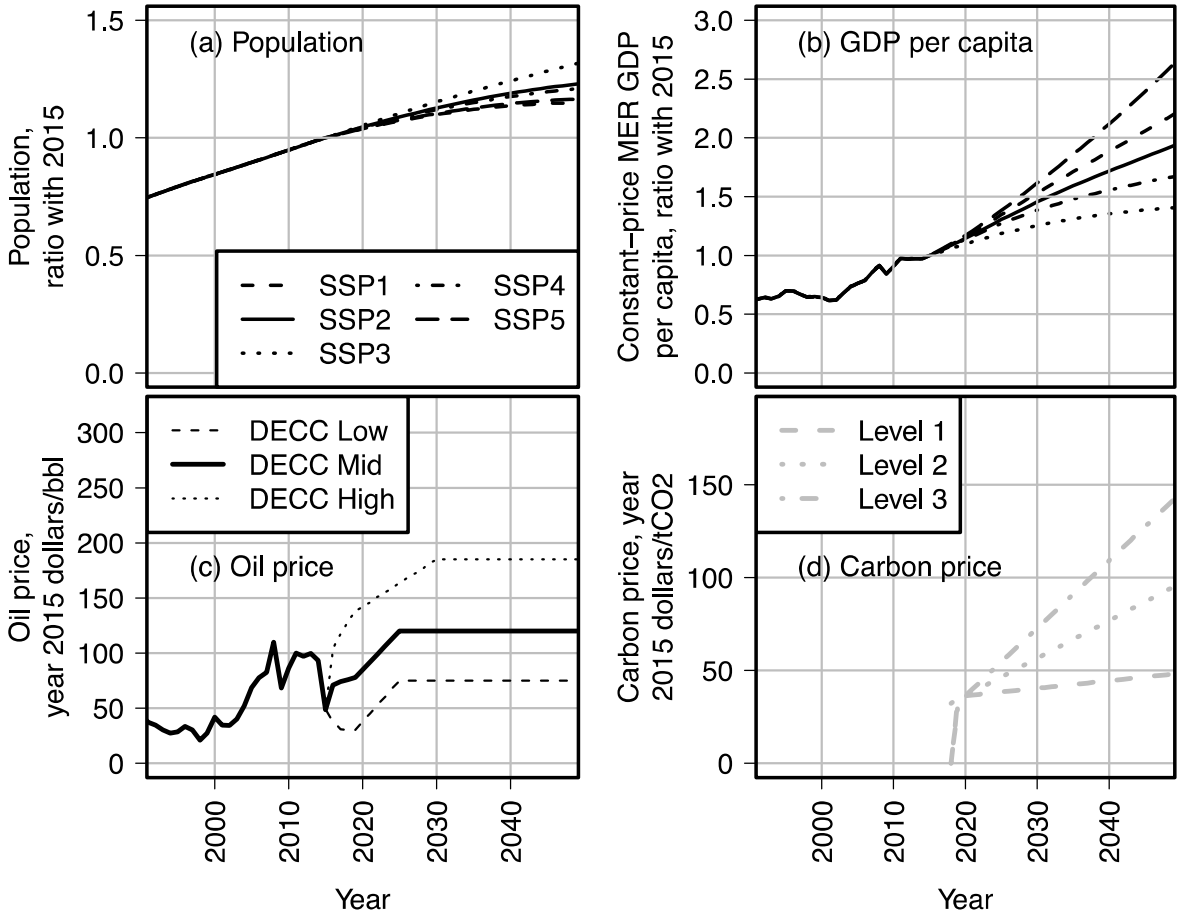
- Captures 2005-2015 total demand growth well
  - E.g. modelled year 2015 enplanements within 5% of actual
  - May need to model hedging and its impact on fuel prices to fully capture effect of large oil price fluctuations



[Data: ICAO, 2016]

Future scenarios

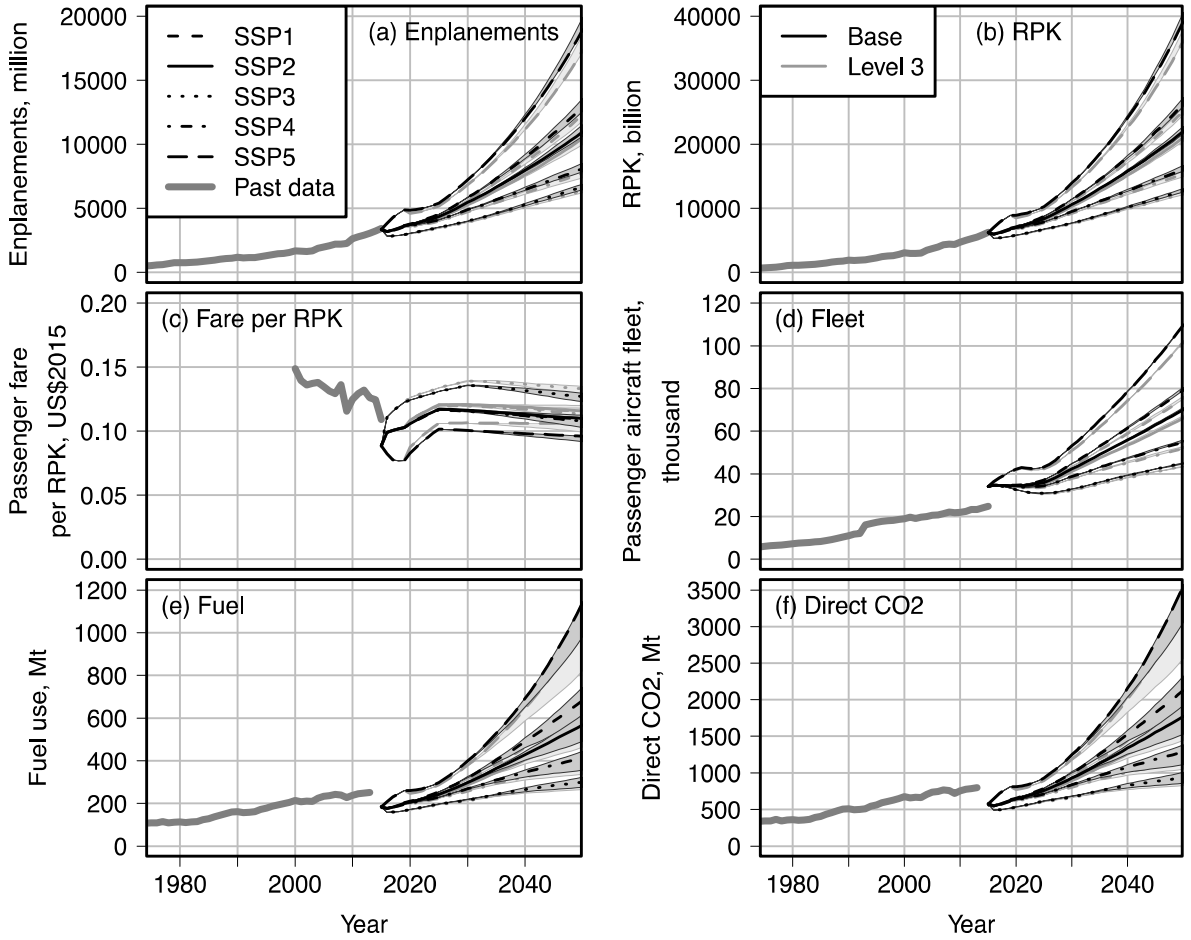
- Need projections of:
  - Population
  - GDP/capita
  - Oil price
  - Carbon price
- If running electric aircraft also:
  - Carbon intensity of electricity generation
  - Electricity price



[Data: O'Neill et al., 2013; DECC, 2015]

Future projections

- Population/ income scenario has greatest impact on future growth rates
- RPK growth rates 1.8 %/year – 5.6%/year, central case 3.8%/year
  - Compare Airbus (2016), Boeing (2016) 4.5 % and 4.8%, next twenty years



[Data: ICAO, 2016; IEA, 2017; FlightGlobal, 2016]

Conclusions

- Model reproduces past aviation system trends well
- Future projections based on IPCC scenarios indicate a wide range of plausible futures
  - Supports adaptive policymaking
- Open source model, please ask if interested
- Work ongoing on updates and case studies
  - Airline response model
  - Updated OD demand model
  - Electric aircraft study
  - … watch this space! (www.ATSlab.org)