Network and Environmental Impacts of Passenger and Airline Response to Cost and Delay

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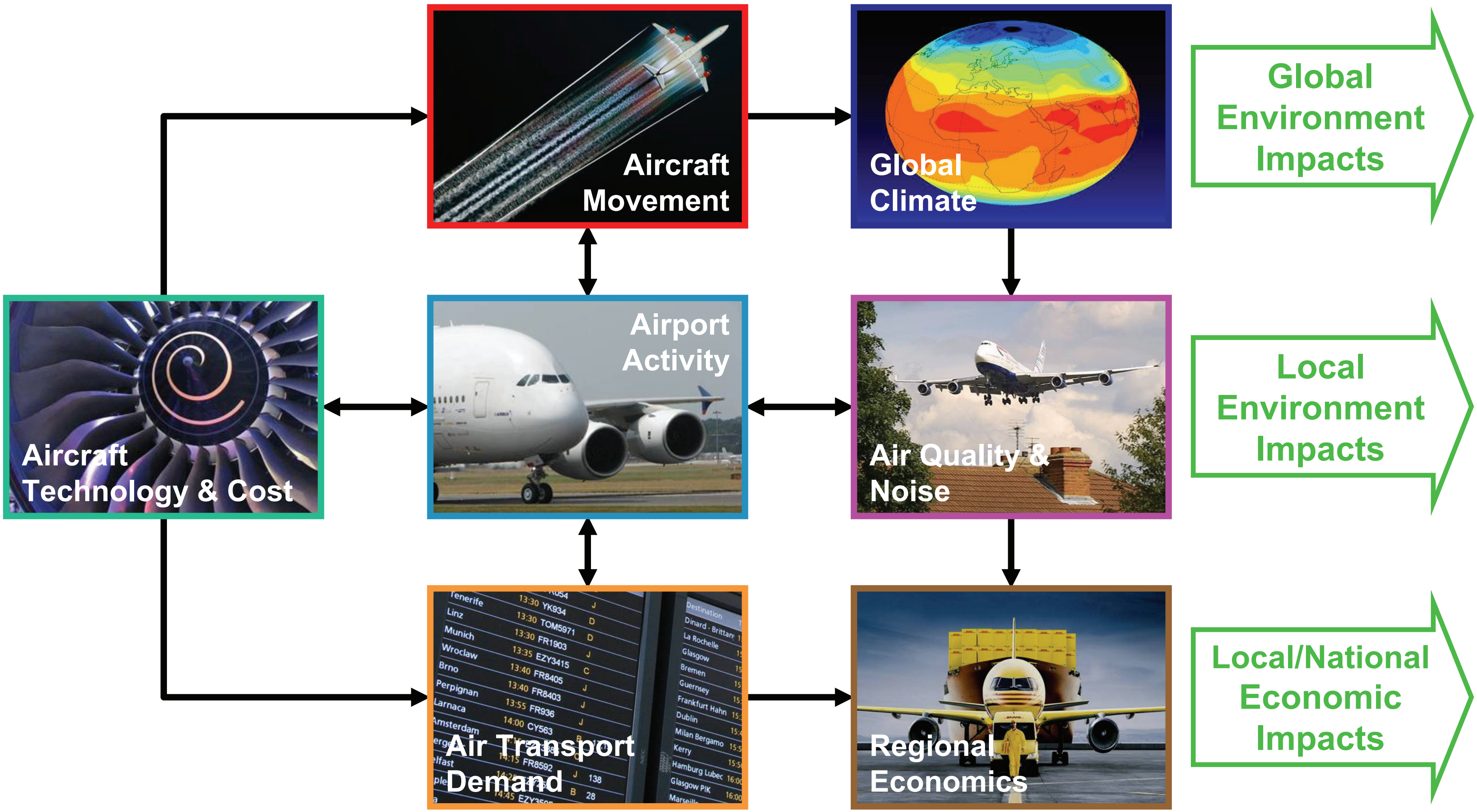
Introduction

- Long-term continued growth in aviation RPKM
  - Domestic US forecasts 2006-2026 are ~ 2-4% per year
  - Domestic India forecasts 2006-2026 are ~ 6-12% per year
- Highly integrated system – fares, delays, demand, schedule all interdependent
  - Equilibrium state also depends on runway capacity provision
- Environmental challenges
  - A number of proposed environmental policies involve changing system equilibrium via impact on fares
  - Response may not be straightforward
  - Tradeoff between different environmental effects

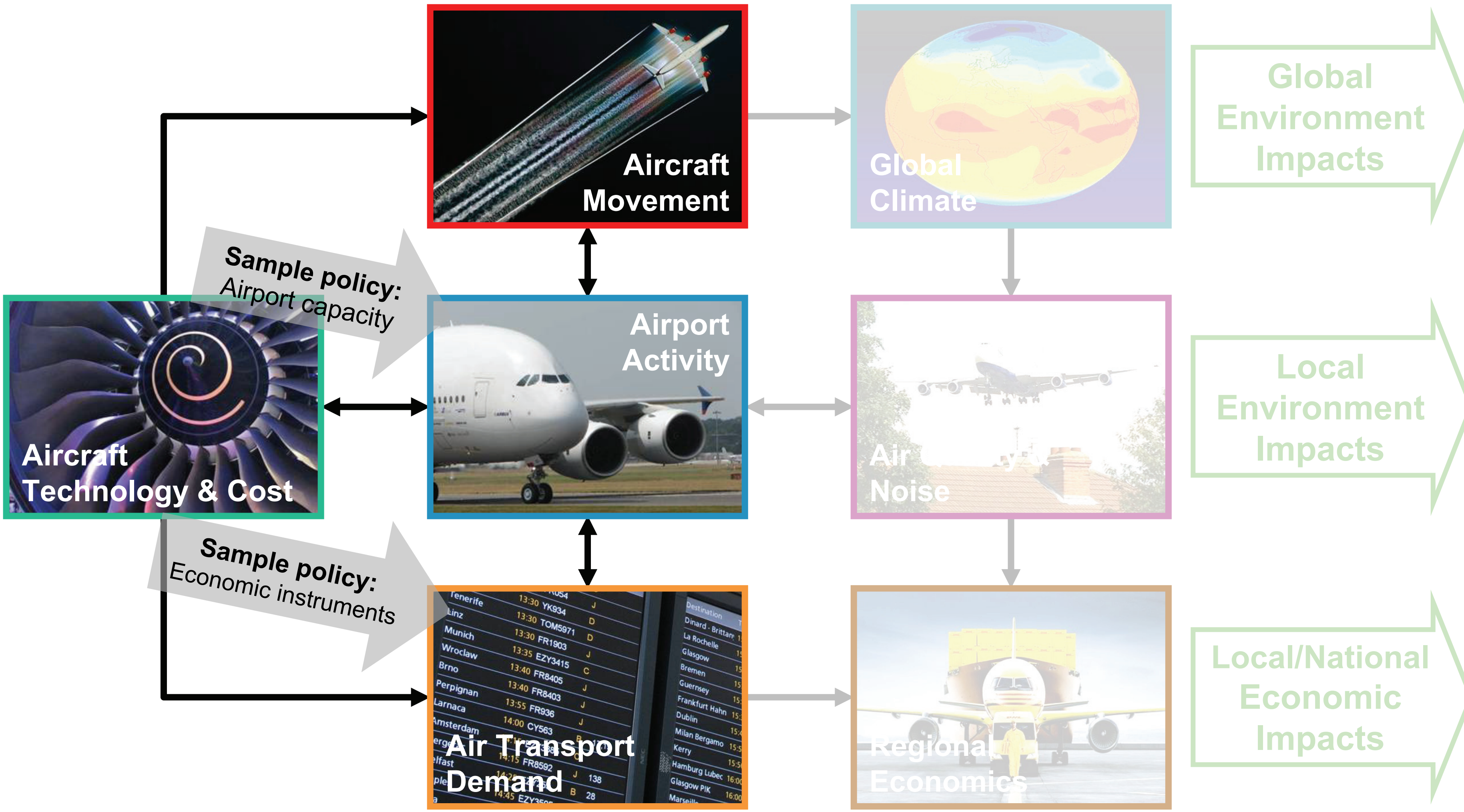
Aviation Integrated Modelling (AIM)

- **Goal:** Develop policy assessment tool for aviation, environment & economic interactions at local & global levels, now and into the future
  - Assess policies to strike appropriate balances between economic benefits and environmental impact mitigation
  - Independent & transparent tool for mediating between stakeholders

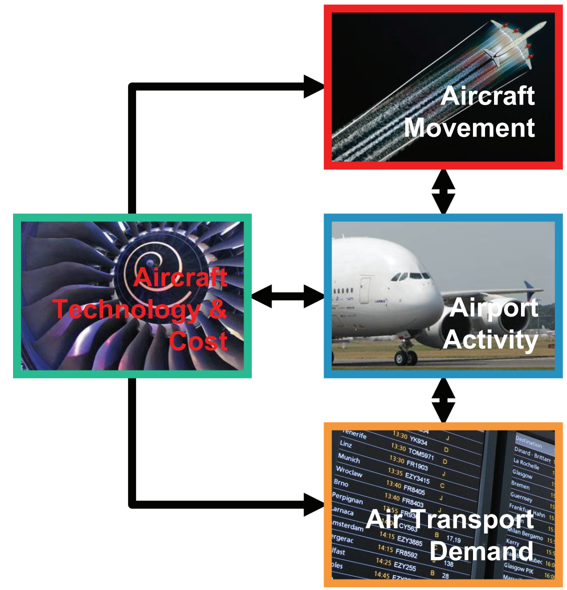
AIM Architecture



AIM Policy Assessment



Aircraft Technology & Cost



Goals

- Simulate emission rates by aircraft type, and the associated direct operating costs

Methodology

- Below 3000 feet: ICAO Exhaust Emission Data, Reference LTO Cycle
- Above 3000 feet: Eurocontrol Base of Aircraft Data (BADA)
- Three size and two technology age categories
- Simple fleet turnover model for introduction of new technology

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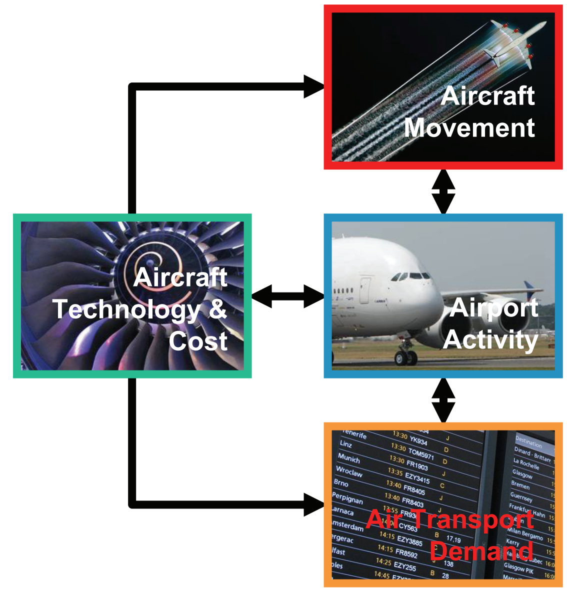
Air Transport Demand



Goals

- Forecast true origin-ultimate destination passenger and freight demand for air travel
- Global set of 700 cities, 95% of scheduled RPKM

Methodology

- Simple gravity-type model
- Demand is a function of population, income, fare, travel time etc.
- Estimate separately for short-, medium-, long-haul and different world regions
- Does not include mode choice
- Modular – can plug in other projections if required

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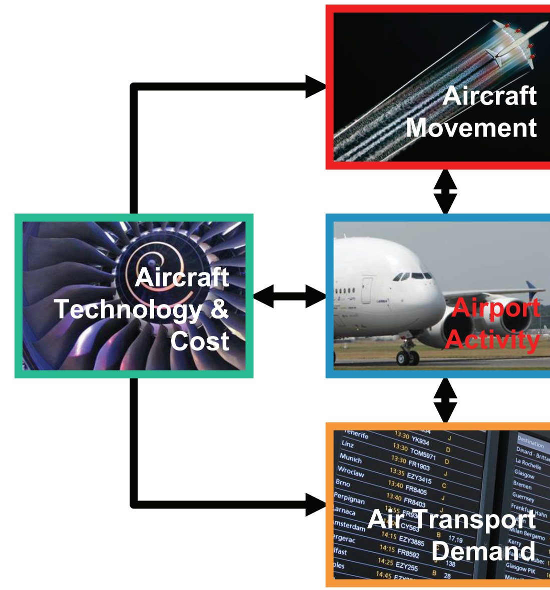
Airport Activity

Goals

- Generate flight schedules
- Predict delay and LTO emissions



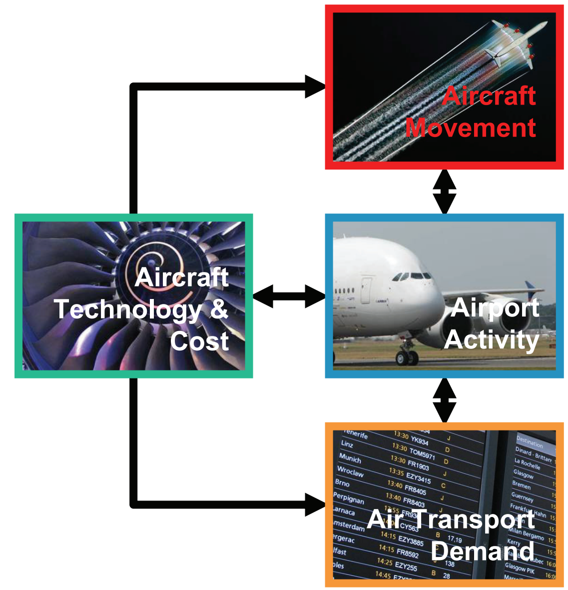
Methodology

- Flight routing and scheduling modelled according to forecast passenger demand
  - Routing network scaled from base year
  - Proportion of flights of each aircraft type estimated using a multinomial logit regression
  - Flight frequencies applying estimated base year load factors
- Flight delay modelled using queuing theory
- LTO emissions estimated according to schedule, delays, and engine emission rates
- More detailed study: Evans et al., this conference

Aircraft Movement

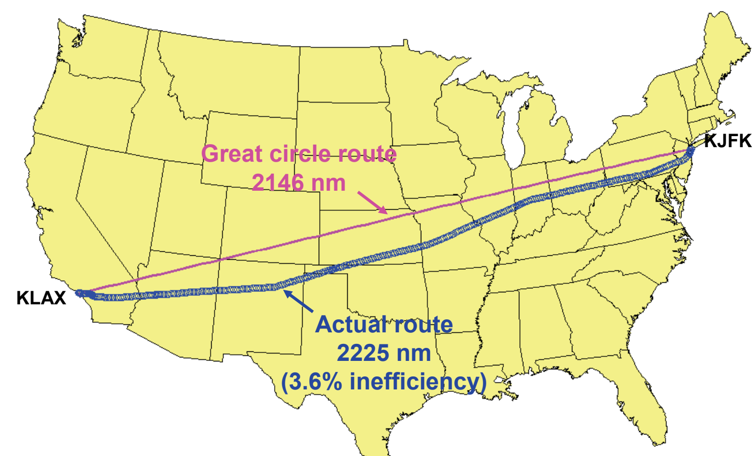
Goals

- Simulate the location of emissions release from aircraft in flight, accounting for ATM inefficiencies



Methodology

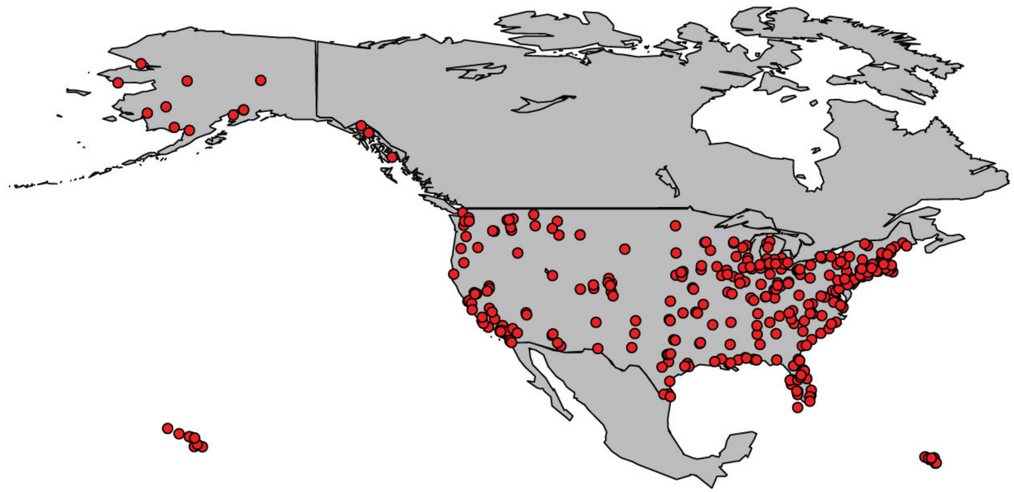
- Calculate optimal routes between given city pairs, e.g. great circle
- Add "inefficiency factors" to account for air traffic control



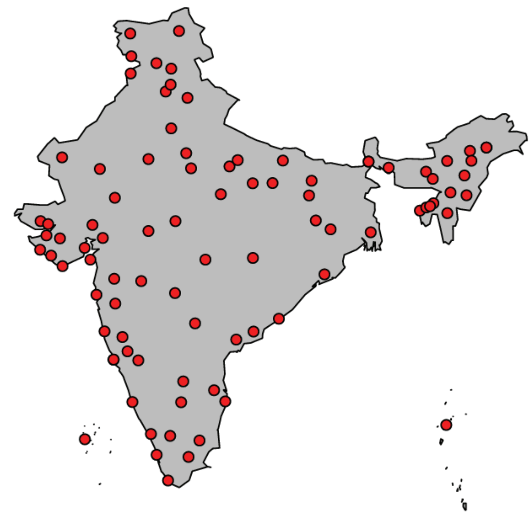
- See Reynolds, this conference

Scenarios & Assumptions

US: 178 city / 337 airport set



India: 88 city / 94 airport set



- **Reference Scenario**
  - No policy measures impacting costs
  - Sensitivity studies to look at effect of fare changes
- **Policy Scenario – Emissions Trading**
  - Exogenous carbon price from global trading scheme
  - Higher carbon price affects airline operating costs, fares, and thus passenger demand, air traffic and emissions growth

Scenarios & Assumptions

- Aircraft Technology and Cost Module
  - Operating costs (excl. fuel) remain constant
- Air Transport Demand Module
  - Annual population, GDP/cap, oil price and carbon price derived from US Climate Change Science Program (CCSP, 2007) study – IGSM model
    - For India, present-day GDP growth is much higher than IGSM scenario – use SRES B2 instead (IPCC, 2000)

	US	India
Population Growth	1.4% per year	1.0% per year
GDP/capita Growth	4.4% per year	5.7% per year
Oil Price Growth	2.4% per year	2.1% per year
Carbon Price **(year 2005 dollars)**	Up to $960 per tonne C Depends on stringency and year	

  - Short, medium and long haul modelled in US

Scenarios & Assumptions

- Airport Activity Module
  - Base year capacities from ASPM (US) and theoretical single runway model (India)
  - Load factors remain constant
  - Fare modelled according to airline competition model as function of flight frequency and costs per passenger
- Aircraft Movement Module
  - ATM inefficiencies based on ETMS flight track analysis

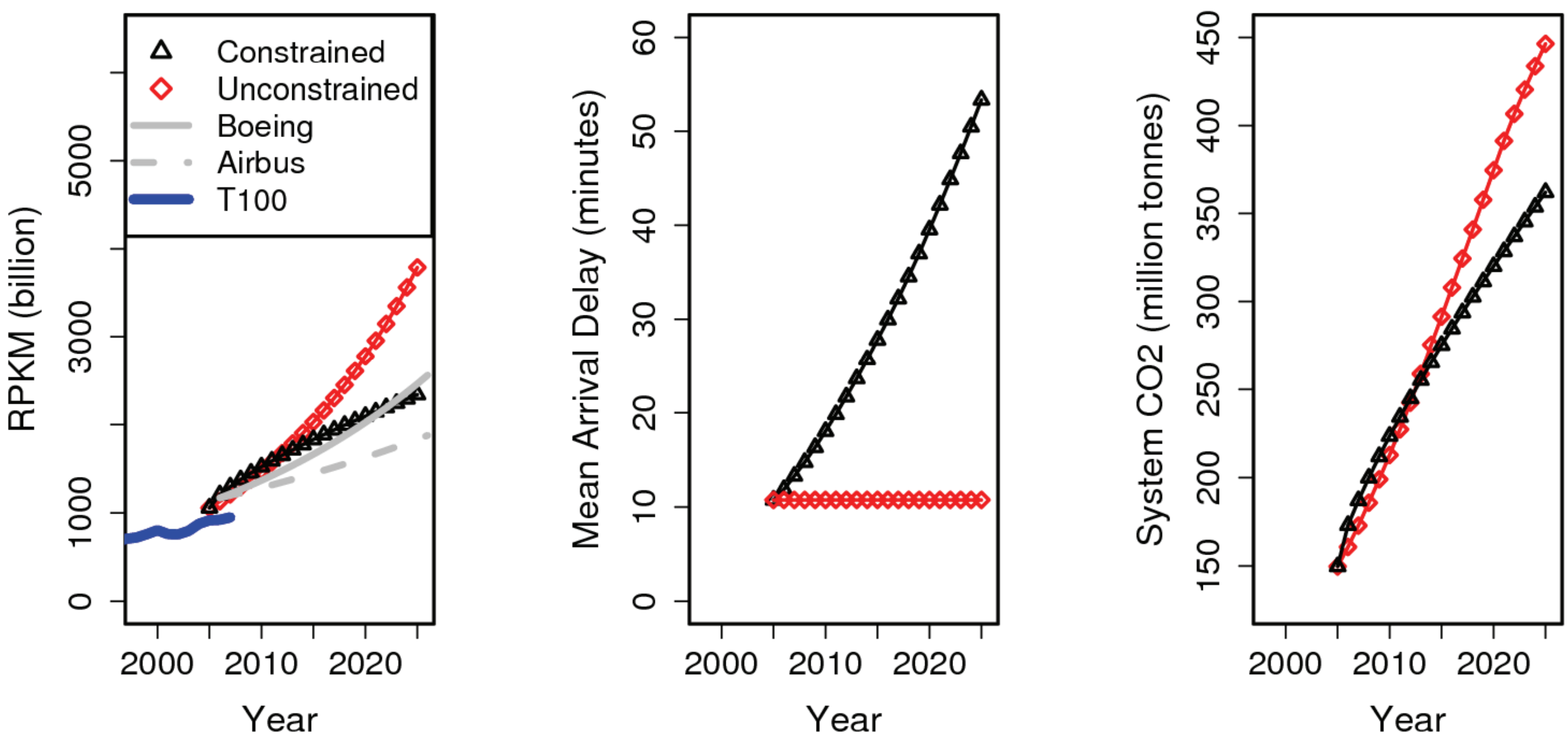
Future Capacity

- Information about capacity growth at individual airports is limited and uncertain
- Concentrate on two extreme scenarios:

CONSTRAINED No extra capacity is added, either at the airport or the regional level Fares modelled using competition model
UNCONSTRAINED Extra capacity is added as required to ensure that delay remains at 2005 levels Fares follow past trends

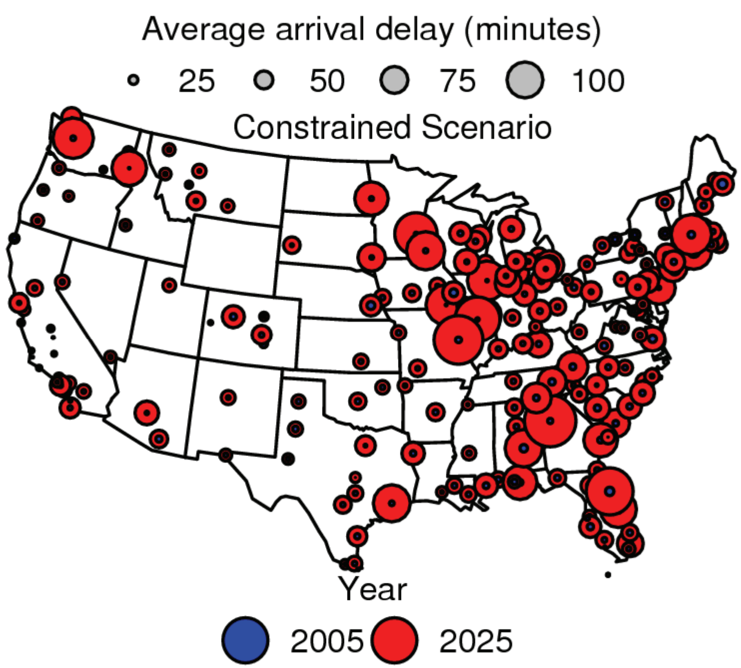
Domestic US Reference Scenario

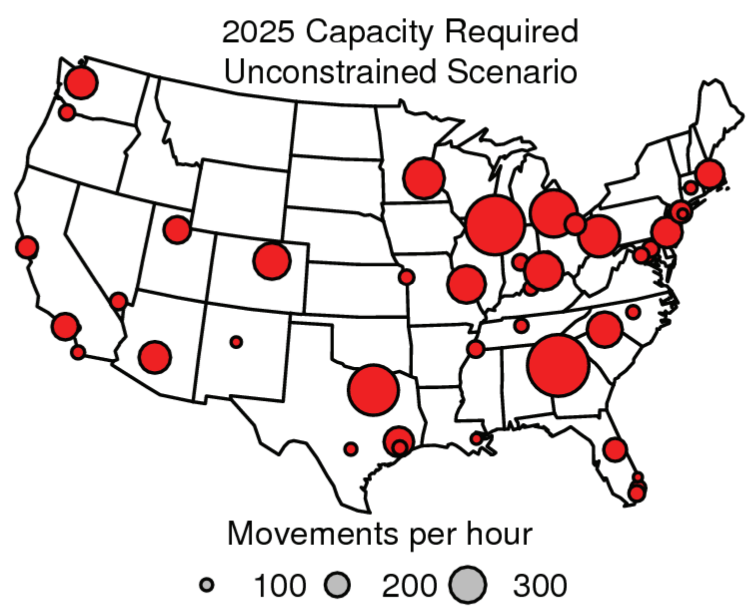
- Capacity constraints have strong effect
- Current growth closer to constrained model



Domestic US Reference Scenario

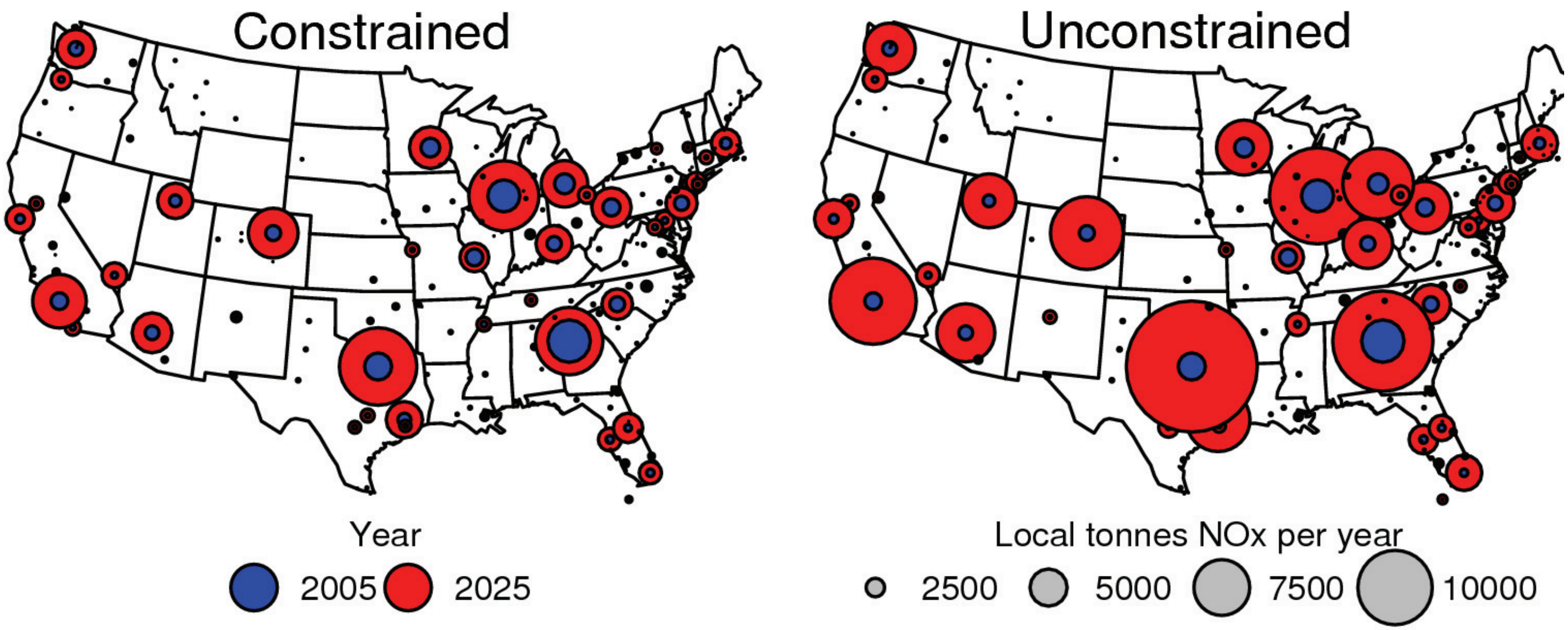
- Largest capacity increases required at hub airports
  - Dependent on growth scenario
  - Some airports require 3x or more capacity increase by 2025
  - May require growth of secondary airports





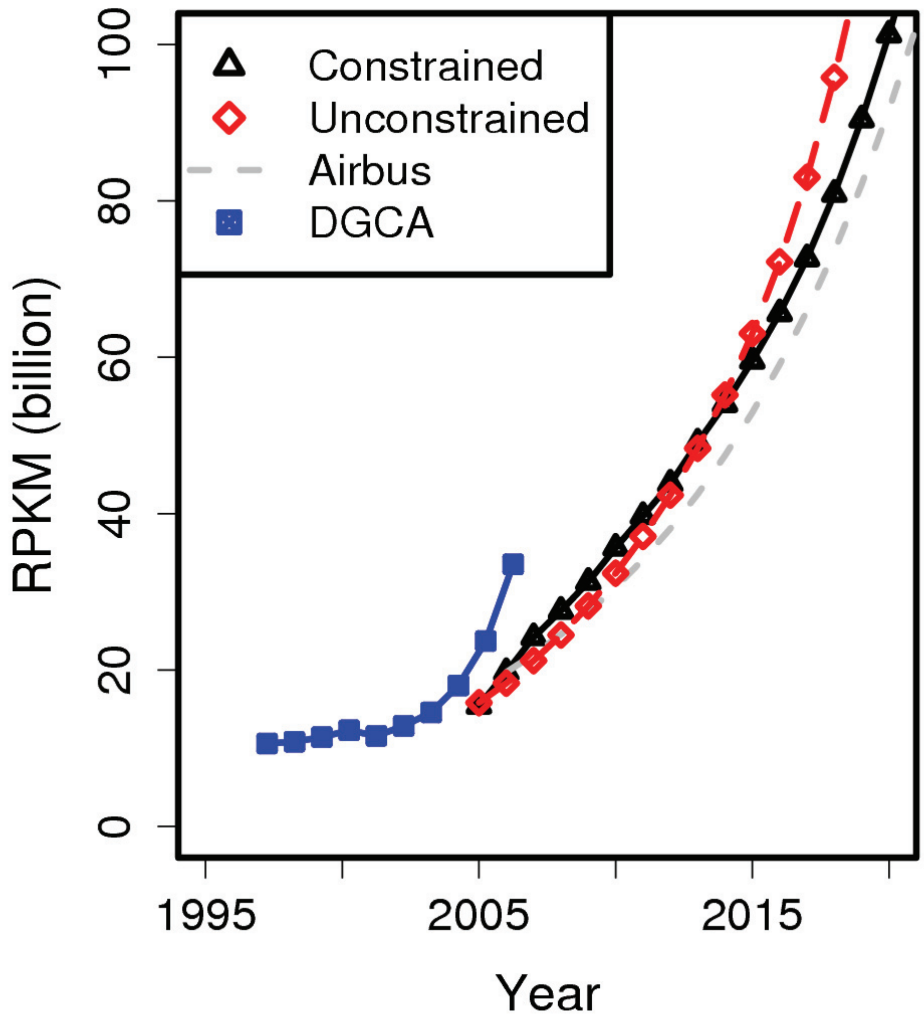
Domestic US Reference Scenario

- Constrained scenario shows smaller and more evenly distributed growth in LTO emissions
  - Delays discourage use of congested hubs



Domestic India Reference Scenario

- Contrasting world region to US
  - Rapid growth from a low base
  - New airports being built
- Current growth trend is more rapid than all model predictions
- Current behaviour is similar to unconstrained model
  - Constrained model growth also similar – spare capacity available at airports other than Mumbai and Delhi



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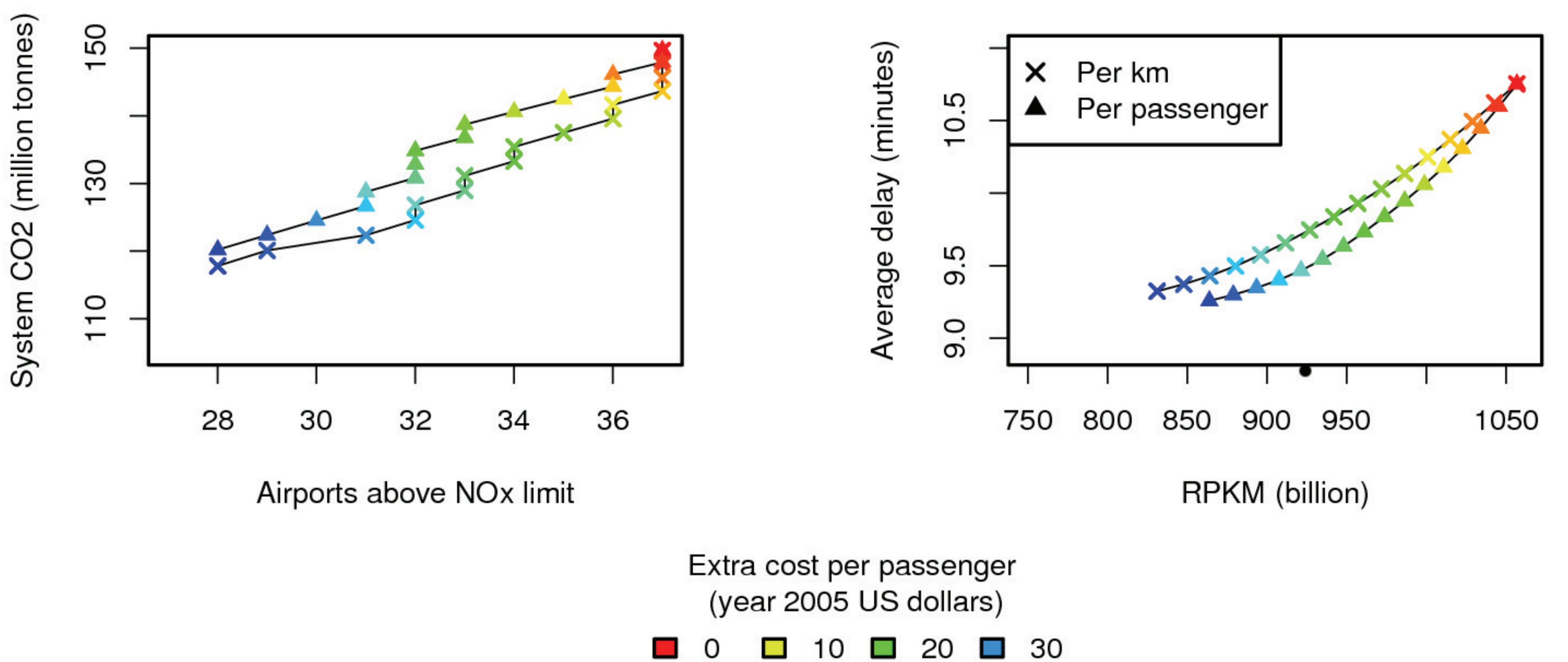
Sensitivity

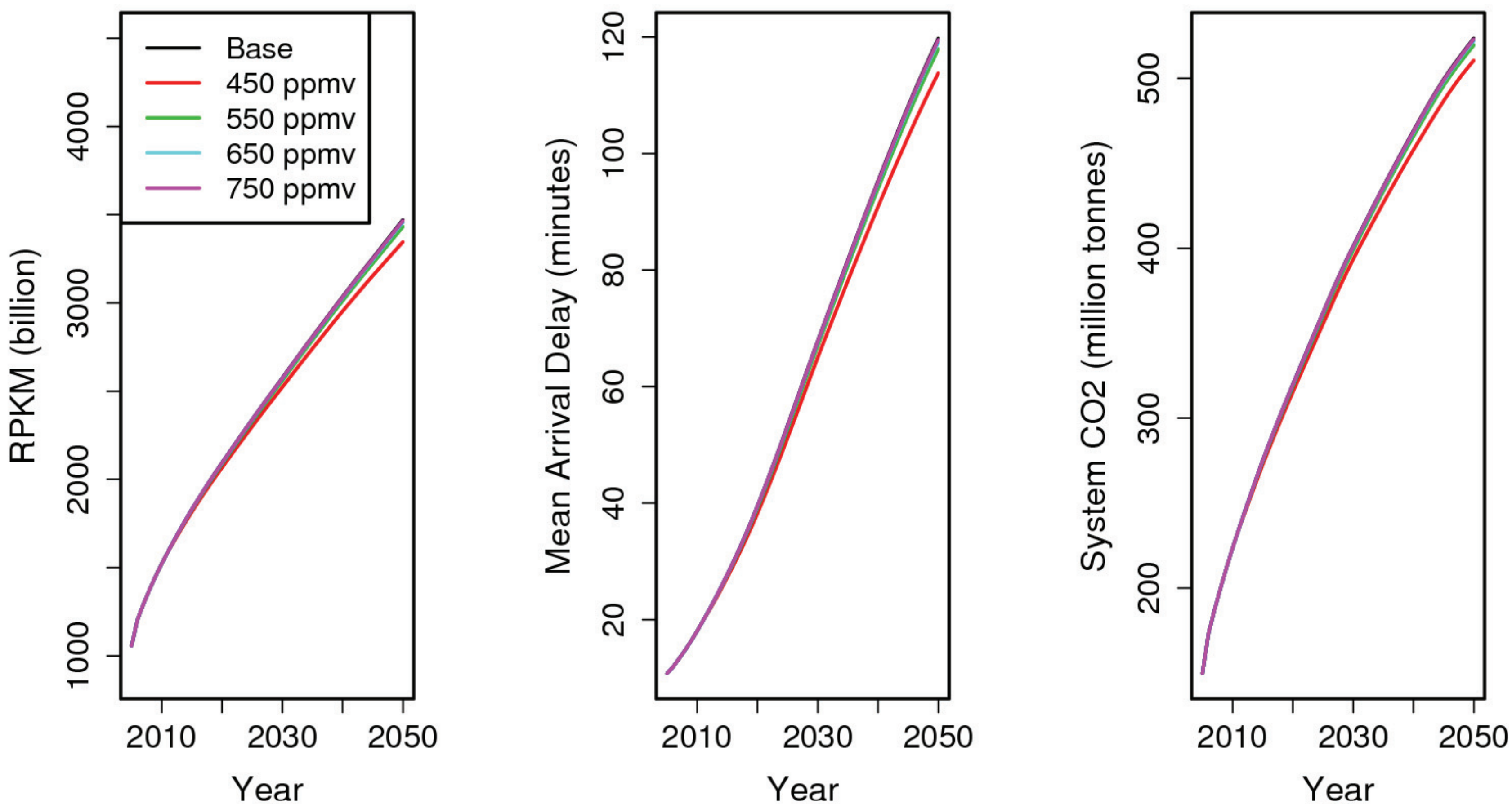


Sensitivity

- Extra taxes/charges on ticket prices are a feature of many proposed environmental policies
- Different formulations possible
  - Proportional to distance flown, e.g. fuel taxation
  - Proportional to landings/takeoffs, e.g. airport charges
- Distance-based charges better at reducing CO_2, RPKM
- Takeoff-based charges better at reducing delay, airport-region emissions
- General effects of cost increases only – not a detailed economic analysis

Emissions Trading Scenario

- Domestic US, constrained model



US Emissions Trading Scenario

- Use CCSP IGSM scenario carbon price, constrained models
  - Assumes open, global trading scheme, introduced in 2012, of which aviation is a relatively small component
  - Four carbon trading scenarios – atmospheric CO_2 stabilisation targets between 450ppm and 750ppm
- Effect on demand is much smaller than that of capacity limits
  - Mainly affects long-haul traffic
- Decrease in 2050 emissions from reference scenario is not linear with CO_2 atmospheric stabilization target
  - Stabilisation at 750 or 650 ppm has negligible effect on demand

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Conclusions

- Importance of capacity constraints
  - May require expansion of secondary airports
  - Largest capacity increases required at hubs, but this depends on capacity and economic growth scenarios
- Open, global emissions trading has relatively small effect on aviation emissions
  - Suggests emission reductions will be made elsewhere
  - Effect on aviation may be bigger after 2050
  - Only has a noticeable impact in high stringency cases
  - Minimal effect on short-haul traffic

AIM Team

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