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Mapping Future Air Travel Demand from Open Data

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INTRODUCTION

Air transport is currently responsible for 2-3% of global carbon emissions [1]. While modern passenger aircraft have a 95% lower fuel consumption per passenger-kilometer than the first jet aircraft of the 1950s [2], air transport remains a carbon-intensive form of transportation - now on par with cars at average occupancy [3].

As shown in Figure 1, air transport demand and economic growth are connected. A significant increase in air transport is therefore expected until 2050, especially driven by developing countries. However, most forecasts are available at a global level only. This makes it impossible to infer future carbon emissions on specific routes, which is relevant to the national emissions reduction strategies of different countries. We close this research gap by providing more specific, country/route-level forecasts from open data.

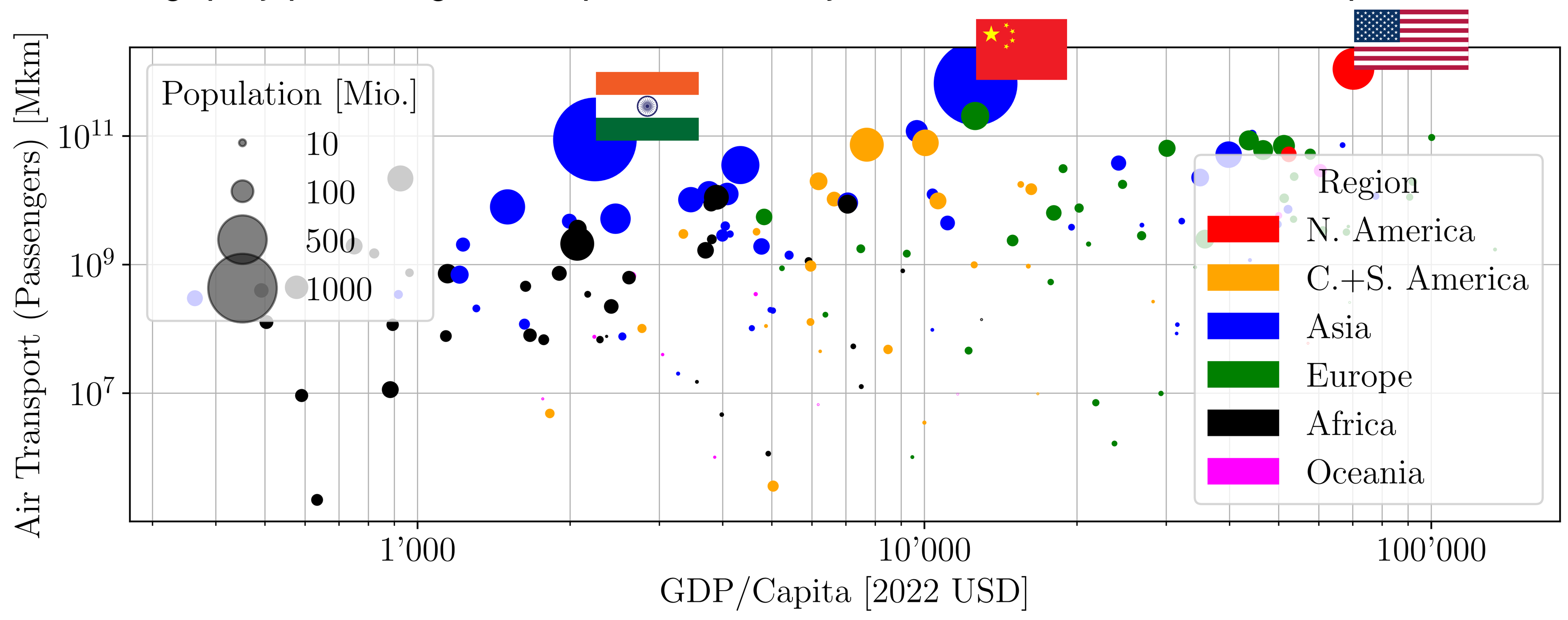


Figure 1: The relation between GDP/capita and air travel in passenger-kilometers in 2022. Note the double-logarithmic axes. As personal income grows, so does the total amount of air travel. Since geography is a major factor in the propensity for air travel at a country level, a direct regression of income and air travel is difficult. Data sourced from the UN SDG Indicator 9.1.2 and the World Bank.

CONTEXT: AIR TRANSPORT DEMAND AND ECONOMIC GROWTH

The demand for air transport is linked to economic growth [4]. The causal relationship is often bi-directional, especially for developing countries [5]. While some studies published during the COVID-19 pandemic suggested the possibility of changes to the historical trend of air transport demand growth [6], the most recent data shows a complete recovery of traffic, with new passenger records reported at airports in 2023/2024. This is clearly visible in Figure 2.

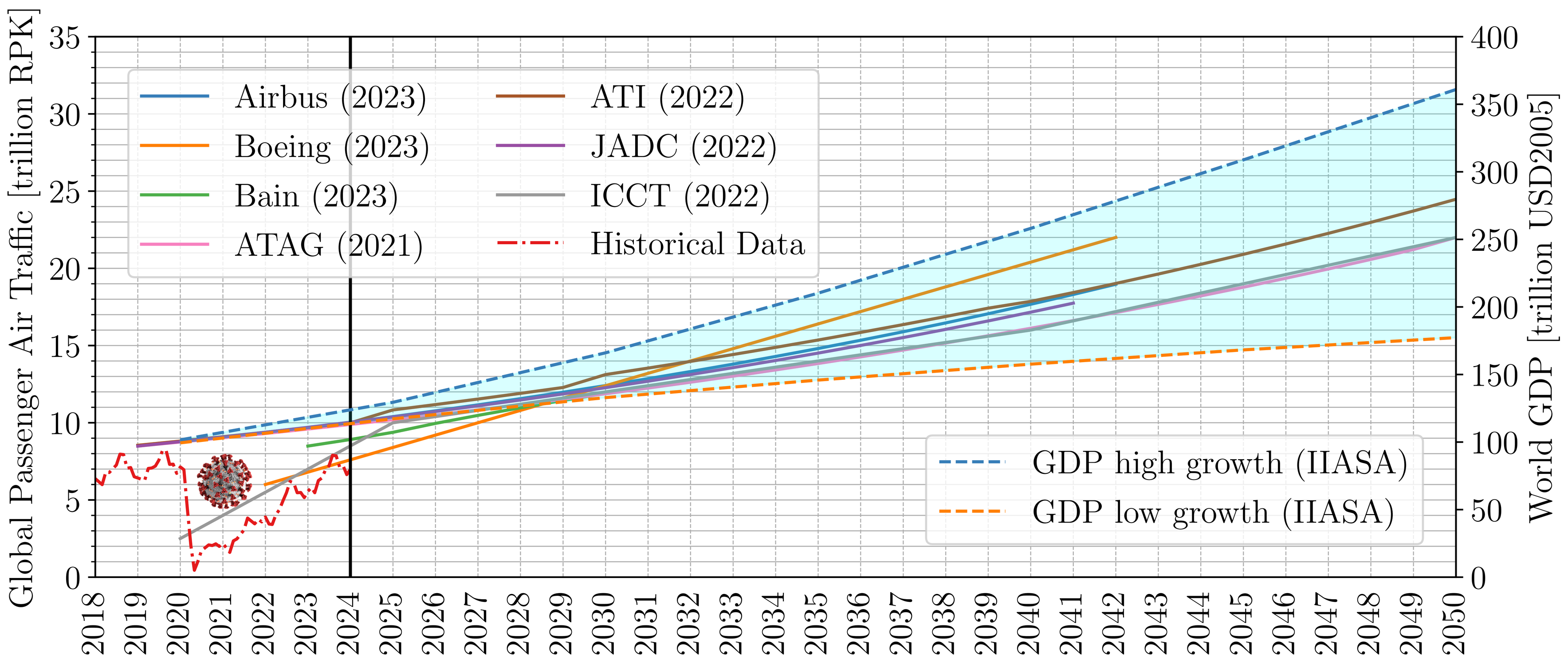


Figure 2: Comparison of different forecasts for global air transport demand up to 2050. Historical data, including the dip in traffic due to the COVID-19 pandemic, is shown for context. A low/high economic growth forecast from IIASA is shown for context. Data sourced from multiple independent forecasts and historical IATA reports.

METHOD: ALGORITHM FOR DATA COLLECTION

Unfortunately, the largest commercial providers of air travel data are prohibitively expensive for researchers. We therefore opted for a combination of two independent data sources, which provide limited data access for researchers free of charge: AeroDataBox and FlightRadar24. A combination of both allows us to estimate coverage. Figure 3 shows a qualitative comparison of different data sources and our algorithm.

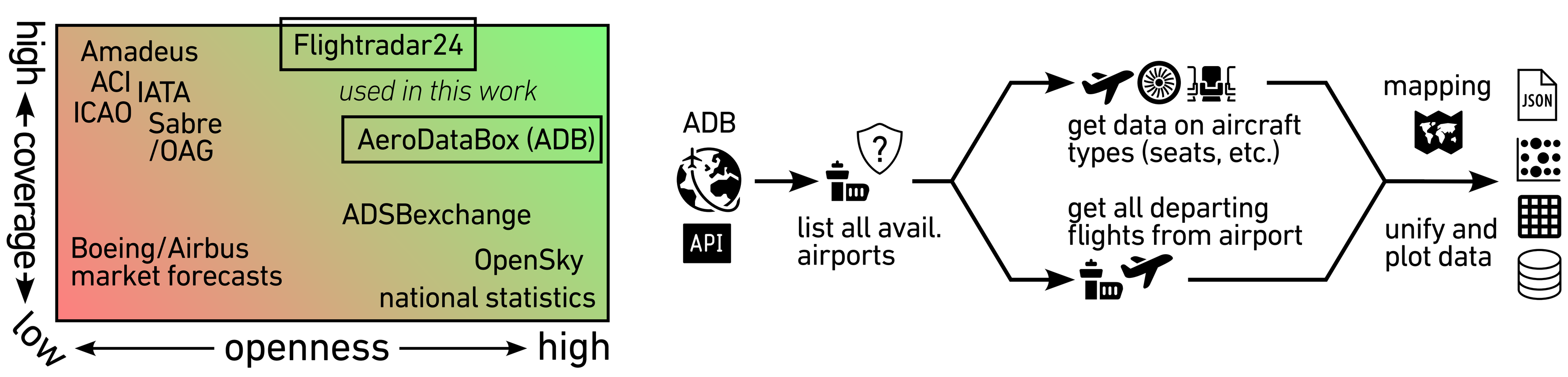


Figure 3: Qualitative ranking of possible data sources for global flight data and simplified visual representation of the data collection pipeline developed for this project.

RESULTS: WORLD AIR TRAFFIC (2023/2024)

Using the algorithm in Figure 3, we extracted data for flights from May 2023 to May 2024. In total, we obtained data on ~67.7mio. individual commercial passenger flights between 3'132 different airports, amounting to 106'873 unique connections.

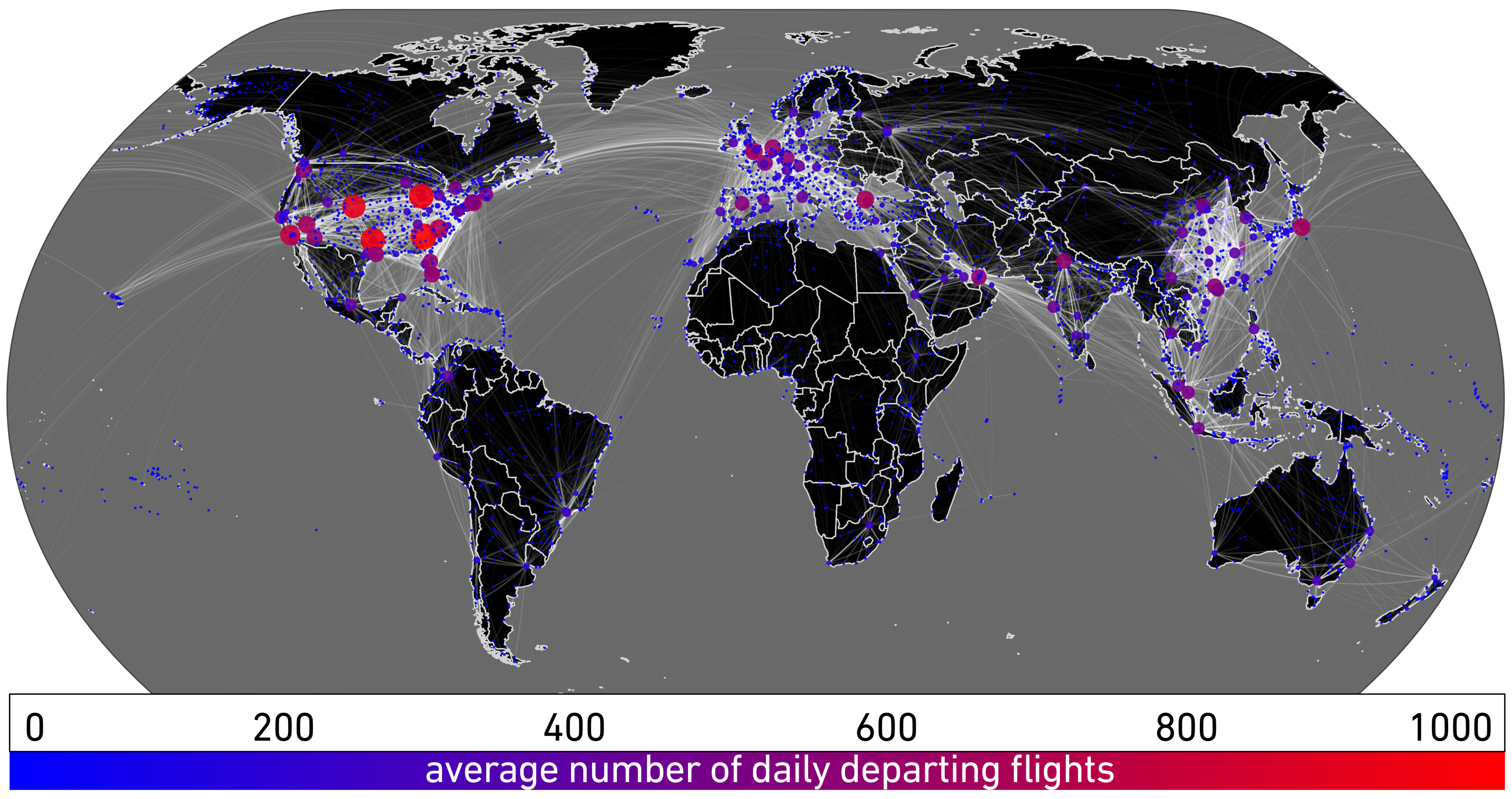


Figure 4: Map of global passenger air traffic during the period 05.2023-05.2024. Note that the shown connections are based on the shortest distance, not actual flight paths.

To check the coverage of our primary data source, we compared the total number of flights to the annual global traffic statistics of both FlightRadar24 (number of flights) and individual route data published by Sabre/OAG (number of seats available). In both cases, we assume that these validation data sources have near-complete coverage. As shown in Figure 5, our data covers between 87-99% of all commercial passenger flights:

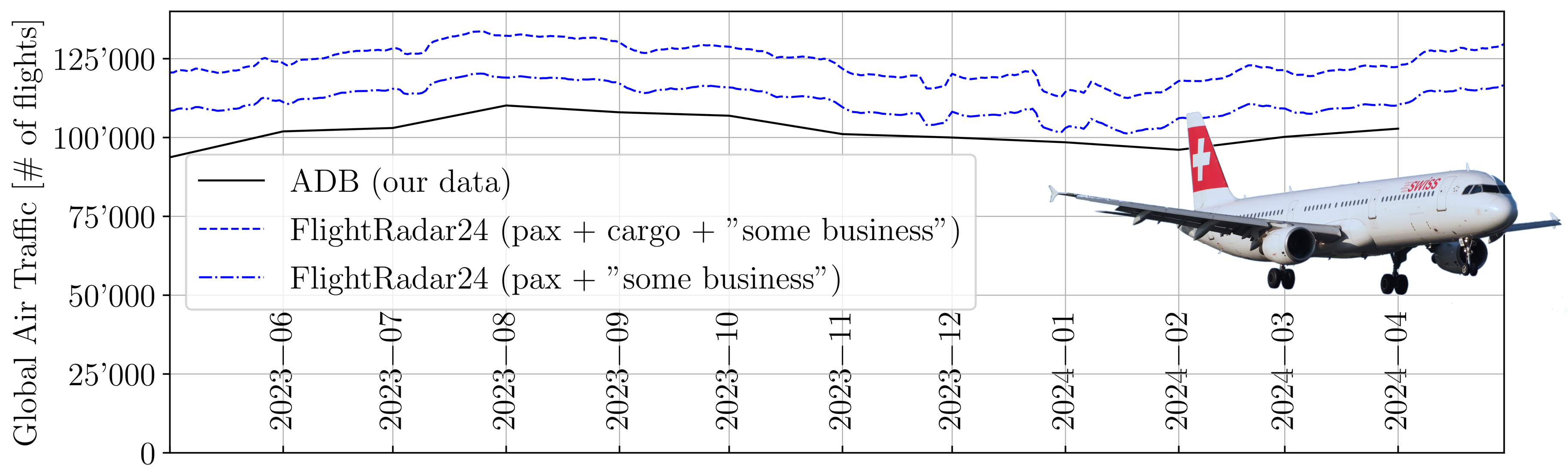


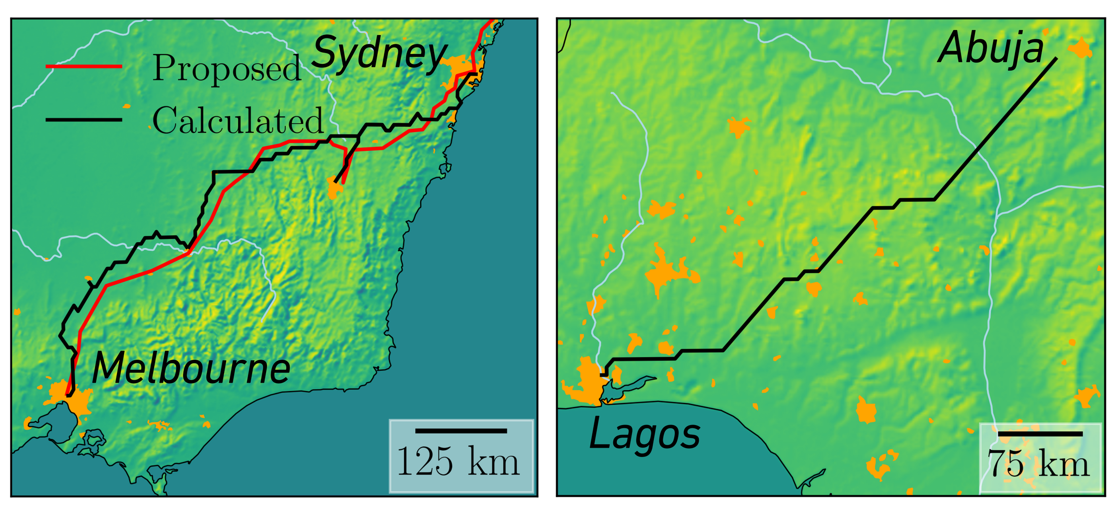
Figure 5: Comparison of the data coverage provided by AeroDataBox (ADB) and FlightRadar24. Cargo flights were subtracted based on latest Eurocontrol data [7].

RESULTS: FUTURE AIR TRAFFIC DEMAND

We estimate future air travel demand based on the most recent IATA 20-year-average "air travel GDP multiplier" [8], which can be used to scale up present-day demand based on national GDP forecasts. This is currently the most frequently used method in global reports, some of which we show in Figure 1. The primary distinction of our work is the ability to make forecasts for arbitrary city pairs, based on the present-day air traffic data we extracted.

POTENTIAL APPLICATIONS: INTERMODAL COMPARISON

One potential application of our data is the prediction of future carbon emissions on specific routes - and further the estimation of the carbon price necessary to affect modal shift. While a complete economic treatment of this problem is beyond the current scope of our work, we provide an illustrative back-of-the-envelope calculation in Figure 6.



Based on the calculated length of the railway track, we can calculate the (aviation) carbon price required to at least fund the annual track maintenance:

$$CO_2(2030) \sim 138'992t$$
$$\Delta cost(rail/air) \sim 60 \times 10^6 \$/a$$
$$min(\$/CO_2) \sim 431\$/t$$

Figure 6: City pairs with potential for future high-speed rail connections. For an accurate estimate of the track length, we adapted an algorithm by Weißenburger, which is based on Dijkstra's algorithm. As the left panel shows, it provides accurate train path forecasts.

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