Spatial-temporal analysis of the Colombo flight information region

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The Colombo Flight Information Region (FIR), as an important airspace sector in the South Indian Ocean, has experienced a notable growth of air traffic movement in the past few years. The objective of this research is to examine the spatial and temporal distribution of aircraft movement in the Colombo FIR to determine trends in traffic, clustering patterns, and possible hotspots that could impact airspace capacity and safety. The main emphasis is on exploring the frequency and distribution of flight paths over time, and revealing patterns in directional flows and traffic concentrations. A vast dataset of aircraft positional and temporal observations for the years 2021-2023 was used, where each record corresponds to the movement of one aircraft through the region. The main variables were waypoint coordinates, entry/exit timings, aircraft direction, and flight routes. Kernel Density Estimation (KDE), Density-Based Spatial Clustering of Applications with Noise (DBSCAN) algorithm and Ordering Points to Identify the Clustering Structure (OPTICS), which is a spatial-temporal clustering technique, were applied to map traffic intensity and detect high-density clusters. The analysis also involved temporal aggregation to examine variations across months, seasons, and years. The results showed clear seasonal peaks in flight movements, with the busiest periods having the highest traffic counts. Flight paths were mainly concentrated around entry and exit points, as well as at certain crossing points inside the Colombo FIR. Cluster analysis highlighted these high-density waypoints, which may need attention for future sector restructuring or capacity improvements. This study yields useful information on the dynamics of air traffic in the Colombo FIR. These results can be used for decision making in air traffic management, for example capacity assessment, and in the introduction of performance-based navigation procedures. Continuous monitoring and analysis are proposed to develop airspace infrastructure at a rate commensurate with traffic demands to ensure safety and efficiency in the region.

Keywords: *Spatial-temporal analysis, Hotspot detection, Airspace capacity, Air traffic flow management*