ABSTRAK

Turbulensi penerbangan merupakan fenomena cuaca yang dapat mempengaruhi keselamatan, efisiensi, dan keteraturan penerbangan. Fenomena ini dapat menyebabkan cedera pada penumpang dan awak pesawat, kerusakan badan pesawat, hingga penundaan penerbangan. Saat ini, informasi turbulensi bersumber dari laporan pilot yang sulit diperoleh dan memiliki beberapa keterbatasan. Penelitian ini bertujuan untuk mengidentifikasi distribusi turbulensi penerbangan, mengidentifikasi asosiasi turbulensi penerbangan dengan awan menggunakan satelit Himawari 8 dan menguji pengaruh topografi pada kejadian turbulensi. Metode yang digunakan meliputi analisis konten laporan *National Transport Safety Committee* (NTSC), perubahan ketinggian pesawat menggunakan data *Automatic Dependent Surveillance Broadcast* (ADS-B), analisis citra satelit Himawari 8, dan simulasi menggunakan model cuaca *Weather Research and Forecast* (WRF). Hasil penelitian menunjukkan perbedaan penyebab turbulensi antara wilayah lintang tengah dan wilayah tropis. Di wilayah lintang tengah (Hong Kong, Jepang, Korea Selatan), turbulensi sering dikaitkan dengan *jet stream*, *front*, dan *wake turbulence*, sementara di wilayah tropis seperti Indonesia, dominan disebabkan oleh aktivitas konvektif. Terdapat perbedaan signifikan penyebab turbulensi di Indonesia yaitu berdasarkan musim, dimana pada bulan Juli (musim kemarau) turbulensi didominasi jenis non-konvektif (89%), sedangkan pada bulan Desember (musim hujan) seluruh kejadian turbulensi bersifat konvektif (100%). Perbedaan ini memperlihatkan adanya variasi kondisi atmosfer musiman di Pulau Jawa, dimana musim kemarau memiliki kondisi atmosfer yang lebih stabil dimana gelombang atmosfer yang teridentifikasi pada 20% kejadian. Hal ini berperan dalam pembentukan *Clear Air Turbulence*. Sementara pada musim hujan, tingginya aktivitas konvektif menghasilkan awan Cumulonimbus dengan puncak mencapai 10-14 km. Hal

ini konsisten dengan ketinggian jelajah pesawat yang mengalami turbulensi. Analisis menunjukkan bahwa topografi Pulau Jawa berperan signifikan dalam memodulasi stabilitas atmosfer pada ketinggian rendah (1500-5000 kaki), namun pengaruhnya kecil pada ketinggian jelajah (31000-36000 kaki). Kombinasi data ADS-B dan citra satelit Himawari-8 efektif untuk mengamati awan dan posisi turbulensi pesawat secara *near real-time* sehingga berpotensi digunakan untuk pengembangan sistem prediksi dan peringatan dini turbulensi penerbangan di wilayah tropis.

Kata kunci: *Turbulensi Penerbangan, ADS-B, Satelit Cuaca Himawari 8, Filter Highpass, Gelombang Atmosfer dan Simulasi Cuaca.*

ABSTRACT

Aviation turbulence is a weather phenomenon that can affect the safety, efficiency, and regularity of flights. This phenomenon can cause injuries to passengers and crew, damage to the aircraft body, and flight delays. Currently, turbulence information is sourced from pilot reports which are difficult to obtain and have several limitations. This study aims to identify the distribution of aviation turbulence, identify the association of aviation turbulence with clouds using the Himawari 8 satellite and examine the effect of topography on turbulence events. The methods used include content analysis of the National Transport Safety Committee (NTSC) report, changes in aircraft altitude using Automatic Dependent Surveillance Broadcast (ADS-B) data, analysis of Himawari 8 satellite imagery, and simulations using the Weather Research and Forecast (WRF) weather model. The results of the study show differences in the causes of turbulence between mid-latitude and tropical regions. In mid-latitude regions (Hong Kong, Japan, South Korea), turbulence is often associated with jet streams, fronts, and wake turbulence, while in tropical regions such as Indonesia, it is predominantly caused by convective activity. There are significant differences in the causes of turbulence in Indonesia, namely based on the season, where in July (dry season) turbulence is dominated by non-convective types (89%), while in December (rainy season) all turbulence events are convective (100%). This difference shows the variation in seasonal atmospheric conditions in Java, where the dry season has more stable atmospheric conditions where atmospheric waves are identified in 20% of events. This plays a role in the formation of Clear Air Turbulence. While in the rainy season, high convective activity produces Cumulonimbus clouds with peaks reaching 10-14 km. This is consistent with the cruising altitude of aircraft experiencing turbulence. The analysis shows that the topography of Java Island plays a significant

role in modulating atmospheric stability at low altitudes (1500-5000 feet), but its effect is small at cruising altitudes (31000-36000 feet). The combination of ADS-B data and Himawari-8 satellite imagery is effective for observing clouds and aircraft turbulence positions in near real-time so that it potential used to develop a prediction system and early warning of aviation turbulence in tropical regions.

Keyword: *Aviation Turbulence, ADS-B, Himawari 8 Weather Satellite, Highpass Filter, Atmospheric Waves and Weather Simulation*