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Atmospheric Inversions: Temperature Inversions

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Abstract

China's air has become extremely polluted as a result of temperature inversions, which prevent momentum, heat, and moisture from moving through the atmosphere. Using sounding data from the past four decades, this study examined the spatiotemporal variation in temperature inversions in China. In a single sounding dataset, surface-based, elevated, and both types of inversion were examined. The inversion parameters were subjected to frequency, strength, and depth statistical analyses. At six stations representing various climate zones Beijing, Harbin, Haikou, Shaowu, Ruoqiang, and Xining the annual frequency of total inversions did not show any significant trend of increasing or decreasing, with mean values of 0.78, 0.33, 0.24, 0.28, 0.5, and 0.36, respectively. There were downward trends in the annual inversion strength and depth. The frequency and strength of the monthly variation in inversion varied between stations. Summertime in Beijing and Harbin saw the weakest surface-based inversion, with mean values of 1 and 1.3°C; winter had the strongest surface-based inversion, with mean values of 3.5 and 3.6°C. The monthly variation in inversion depth, with a minimum at the six respective stations of 165, 334, 135, 267, 363 and 420 meters and a maximum at the six stations of 250, 646, 140, 591, 806 and 664 meters, may be explained by higher surface temperature in the summer and subsidence above the ground in the winter. Absolute reversal was least successive in southwestern China, surface-based reversal was generally continuous in the north, and raised reversal was generally regular in the southeast. In the north, the strongest and deepest surface-based inversion predominated. There were no significant regional differences in elevated inversion strength. The southeast was dominated by the deepest elevated inversion. Accurate model simulations of temperature inversions and the interactions between aerosols and inversions should be the primary focus of future endeavors.

Keywords: Temperature inversion; Inversion frequency; Inversion strength; Inversion depth

Introduction

Temperature inversion is a meteorological term for a layer of air in which the temperature rises with altitude. It is important for maintaining atmospheric stability and has a significant impact on environmental and meteorological issues [1]. High humidity and weak winds are common outcomes of the temperature inversion layer acting as a "lid" that restricts vertical airflow through the layer and significantly slows momentum, heat, and moisture transfer [2]. Because strong stratification prevents local circulations from expanding vertically, temperature inversions make it difficult for deep local circulations to form. Poisons that are radiated into a reversal layer are challenging to weaken by vertical blending [3]. Chemical reactions in liquid and heterogeneous phases benefit from the stagnant conditions created by temperature inversion, which also favor the formation of new secondary aerosols. Temperature inversion layers that persist for an extended period of time have been linked to serious incidents of atmospheric pollution [4]. Due to their strong connection to physical processes and air pollution, studying the behaviour of temperature inversions and the variation in their general characteristics is crucial [5]. In addition, temperature inversions are a prominent feature of the climate, and changes in temperature inversions over time may even be a sign of climate change. Due to the influence of different terrain, surface land, and atmospheric circulation, temperature inversions may differ in various regions [6]. Different mechanisms, such as surface cooling as a result of a negative radiation budget, warm air advection over a colder surface layer, subsidence, and topography, generate the inversion layers at various heights above the ground with varying strengths and depths [7]. Temperature inversion spatial variation and long-term trends must therefore be investigated. There has been a lot of exploration on temperature reversals throughout the course of recent many years researched long haul changes in the low-level tropospheric reversal layer and found that the temperature distinction across the reversal layer expanded fundamentally during winter and harvest time [8]. Oman's surface temperatures and strength of surface-based inversions both increased in tandem with a decrease in surface-based inversion depths, according to a study that focused on monthly variations in inversion frequency, depth, and strength [9]. Analysed a two-year record of ground-based and elevated inversions in the Bergen Valley, Norway, and discovered that ground-based inversions were prevalent during the nighttime hours of the winter, whereas elevated inversions were mostly observed in the spring and summer. The relationship between Alaskan surface-based temperature inversions and the Pacific Decadal Oscillation changes over time, and it was stronger before 1989 than in recent years, according to the analysis of surface-based temperature inversions in Alaska [10].

Conclusion

Sounding data from 82 stations in China were used to examine the temporal and spatial characteristics of atmospheric temperature inversions from 1976 to 2015. In sounding data, we looked into the frequency, strength, and depth of surface-based inversion, elevated inversion, and both surface-based and elevated inversion. Over the 40 years that were included in the dataset, the annual FTI had mean values of 0.78, 0.33, 0.24, 0.28, 0.5, and 0.36 in Beijing, Harbin, Haikou, Shaowu, Ruoqiang, and Xining, respectively. There was no significant increase or decrease in either of these values. Yearly FSI, FEI and FSEI

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showed various patterns at various stations. Despite a slight decrease in inversion depth across all four seasons, there was no discernible increase or decrease in the inversion frequency. Despite a general decrease in annual inversion strength, seasonal variations in inversion strength were observed, with significant winter inversion strength increases from 2012 to 2015. The stations showed similar patterns in the monthly frequency of all inversions, with the peak occurring in the winter and the lowest during the summer. At the six stations, the monthly FSI, FEI, and FSEI were all inconsistent. The maximum and minimum of the monthly inversion depth coincided with the same seasons. At each of the six stations, the monthly inversion strengths were different. Strong and deep inversions were to blame for winter's severe air pollution. At the Beijing station, wintertime PM2.5 concentrations were high due to strong inversions. Spatially, a lower FTI was tracked down in southwestern China. The longer winter than in the south may have contributed to the north's higher FSI. SEI showed no significant difference across the nation (mean 0.06), while EI was more common in the southeast. Due to lower surface temperatures in the north, stronger SI and SEIs predominated. In that there were no significant differences between regions, the inversion strengths of EI and SEIe showed similar spatial variation. As a result of lower surface temperatures in the north, deeper SI and SEIs (mean 398 and 337 m, respectively) dominated in north China. In the southeast, deeper EI and SEIe dominated, possibly as a result of the region's stronger influence from ocean circulation. This is the principal spatiotemporal investigation of air temperature reversal qualities over all of China. To comprehend the causes of the variation in inversion characteristics, additional research should incorporate additional datasets, such as long-term air pollution, sunshine duration and intensity, and larger-scale climate change. Additionally, more in-depth model simulation studies are required. Our outcomes could be utilized in numerous different examinations, for example, investigations of air contamination connected with temperature reversals, the collaborations among vapor sprayers and temperature reversal according to a spatiotemporal viewpoint and the impact of temperature reversal on spatiotemporal wet-cooling tower execution in light of the ends in regards to the spatiotemporal variety in temperature reversals in this review. In addition, our research can be used as a model for future research on the formation of an atmospheric stable boundary layer in India, another country with high levels of air pollution. Based on the spatiotemporal variation in temperature inversions, we intend to investigate the long-term interactions between TI and aerosols.

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