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Cluster Analysis of the Trajectories for Forecasted Transport of Air Pollutants using WRF and HYSPLIT Models over Istanbul for January and July, 2009

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The objective of this study is to determine the risk areas which would be under the influence of particulates and gases released from a hypothetical source in Istanbul and transported by dominant atmospheric flows for months of January and July. Both January and July wind simulations are performed for the year of 2009 using the WRF model to distinguish the seasonal variations. For the initial and boundary conditions, ECMWF forecast data set is used and the results are compared to the ECMWF ERA-Interim data. Three nested domains are used over the Northwestern part of Turkey, Istanbul has been chosen as the centre point of the nested domains, which have 420x270, 385x352, and 400x310 grid points for the 9km, 3km, and 1km resolutions, respectively, and all domains have 45 vertical levels. WSM6 microphysics and YSU planetary boundary layer schemes are used for all domains. Grell-Devenyi cumulus parameterization scheme is used for the mother domain. 30s horizontal grid spaced MODIS land use data is preferred instead of USGS land use data. 24 hours forecasts are calculated starting from both the 00 UTC and 12 UTC for all days of January and July.
In this study, HYSPLIT 24 hourly forward trajectory analyses are performed by using WRF results for thirteen height levels: 10m, 50m, 100m, 200m, 300m, 400m, 500m, 600m, 800m, 1000m, 1500m, 2000m, and 3000m. 5 clusters are determined using Total Spatial Variance (TSV) method for each January and July trajectory analyses. Only the trajectories for 10m, 50m, 500m, and 2000m levels are clustered in order to decide the predominant flow regime for each month. Moreover, the same cluster analyses are achieved for the WRF simulations for the mother domain, ECMWF operational data, and ERA-Interim to discuss the model performance versus observational data based on 5 cluster members.
Comparisons of wind speeds for Istanbul between observations (surface/upper air), and simulations (ECMWF Interim/ECMWF forecast/WRF) revealed that both forecast and WRF simulations are closer to the observations below 850hPa level. These comparisons increase our confidence on WRF simulations and associated forward trajectories below 850hPa level. Our analysis shows that the WRF model results and ECMWF forecast data have in good agreement for both January and July clusters especially for the levels of 10m, 500m, and 2000m for January and 10m and 500m for July. The cluster analyses of forward trajectories indicate that the predominant flow regime is northeasterly in both January and July. On the other hand, the longest trajectory is southwesterly in January but it is northeasterly in July indicating that the stronger flows dominate these directions. It is also estimated that the trajectories extend longer in January than July to the Northern part of Turkey for each cluster because of the stronger winds prevailing during winter months in association with synoptic scale systems. The distance between the trajectories end points and the source location is shorter in July due to relatively weak winds and it is estimated that only the Southern part of Turkey might be under the influence of particulates and gases released from Istanbul.

Key words: Turkey, cluster analysis, trajectory analysis, WRF, HYSPLIT models.