Geophysical Research Abstracts
Vol. 14, EGU2012-11910-1, 2012
EGU General Assembly 2012

The Figure of Merit in Space (FMS) and Probability Analyses of the Concentrations for Forecasted Transport of Particles using the WRF and HYSPLIT Models over Istanbul for January and July, 2009.

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The main focus of this study is to compare the 24 hourly WRF model and HYSPLIT performances to the observations in terms of concentrations using FMS technique and to determine the probabilities of the spread of the modeled concentrations. In this study, 0.25-degree grid size ECMWF operational model data set is used to generate 24-hour forecasts of atmospheric fields by the WRF model. Each daily forecast is started for both 00 UTC and 12 UTC for the months of January and July of 2009. The interested model area is downscaled by the ratio of 3, starting from 9km resolution to the 1km resolution. 45 vertical levels were structured for the 3 nested domains of which Istanbul is centered. After the WRF model was used for these four sets of simulations, the dispersions of particles are analyzed by using HYSPLIT model. 30,000 particulates with the initial delivery of 5,000 particles to the atmosphere are released at 10m over Istanbul. The concentration analyses are performed for the nested domains in the order of one mother domain only, domain 1 and 2, and three nested-domains, which are named as WRFD1, WRFD12, and WRFD123, respectively.
The Figure of Merit in Space (FMS) method is applied to the HYSPLIT results, which are obtained from the WRF model in order to perform the space analysis to be able to compare them to the concentrations calculated by ECMWF Interim data. FMS can be counted as the statistical coefficient of this space analysis, so one can expect that high FMS values can show high agreement between observations and model results. Since FMS is a ratio between the intersections of the areas to their union, it is not possible to deduce whether the model over predicts or under predicts, but it is a good indicator for the spread of the concentration in space. In this study, we have used percentage values of FMS for the fixed time as January and July 2009 and for a fixed concentration level. FMS analysis is applied to the three domain structures as defined above, WRFD1, WRFD12, and WRFD123. FMS values are calculated for the threshold value of 1 pgm-3. The FMS results verify that WRF model wind velocity results are in good agreement with ECMWF ERA Interim data for the level of 10m. FMS values show us that probabilities of 13 days are higher than 50% for July average. Whereas, in January, only 4 days pass over 50%. Consequently, this indicate that July model forecasts may give better results than January forecasts.
Moreover, we have calculated the probabilities of the concentration spread for both July and January and detected different spreads between 12 UTC and 00 UTC initialization. Therefore, 12 UTC results show higher probabilities than 00 UTC. According to January 00 UTC and 12 UTC model results, dominant direction of particles' spread is southwesterly. Consistently, the higher probability concentrations can be seen in the Black Sea region extending to the Northern neighbors of Turkey with the probability of approximately 20%. We also observed secondary dominant particles dispersion in the northeast direction with the probability of 25% extending to the Northern Aegean Sea and to the coast of Greece. Since Istanbul is the hypothetical origin location of particle release, the highest probability of concentrations is seen in this location. In July, for 00 UTC, the highest probability spread is toward to the south. Because the predominant wind direction in summer is northeasterly in the northwestern part of Turkey, north Aegean and Marmara Seas are affected by particles with 40% chance. Although, for further south, this probability is decreased to 25 to 30%, Central and Western Anatolia and the border of Greece are still at higher risk. As a result, our analyses indicate that if there is an explosion in Istanbul area, high-risk regions depend on the season. If it occurs in winter, the transported hazardous particles might affect the northern part of Turkey and its neighbors, while in summer the southern and western part of Turkey is under the threat.

Key words: Turkey, FMS and probability analyses, concentration analysis, WRF, HYSPLIT models.