Nat. Hazards Earth Syst. Sci. Discuss., 2, C799–C806, 2014
www.nat-hazards-earth-syst-sci-discuss.net/2/C799/2014/

Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Numerical modeling and analysis of the effect of Greek complex topography on tornado genesis" *by* I. T. Matsangouras et al.

I. T. Matsangouras et al.

john_matsa@geol.uoa.gr

Received and published: 21 May 2014

The authors would like to thank the Reviewer for providing insightful comments on the manuscript, allowing us to improve its scientific and presentation quality Our reply to the reviewer's comments follows:

Comment: The numerical setup of the experiments should be better justified. In particular, at Page 6 Line 6, it is not clear why you remove the orography only in the inner domain. In this way, you initialize the inner grid with fields that are calculated using the normal orography (and model levels whose height is modulated by the orography). A

more appropriate and standard procedure removes the orography of the area of interest (domain 3) also in the other domains. I suggest to include, if possible, a reference to justify the way you followed. Reply:The methodology used for the removal of the topography has also been followed at various numerical studies in the international peer-reviewed literature: Miao et al. (2003) in order to examine the influence of topography on the sea breeze over eastern Spain, performed an experiment (using RAMS model) identical to the control run but with a homogeneous flat terrain in grid 2 only i.e. their inner fine grid (please see page 164, right column of their paper). Koletsis et al. (2009) performed a numerical study of a downslope windstorm in northwestern Greece using MM5 model. In page 181 they state that "in addition to the control run, two sensitivity simulations were performed with modified topography height of Grid 3 (i.e. their inner fine grid), while all the rest of the setup characteristics were identical to the control simulation". Koletsis et al. (2010) performed a numerical study using MM5 model in order to investigate the interaction of northern wind flow with the complex topography of Crete Island. In page 1117 they state that "in addition to the control run, a sensitivity simulation was performed with modified topography of Grid 3 (i.e. their inner fine grid), while all the rest of the setup characteristics were exactly the same to the control simulation". Chiao et al. (2004) employed MM5 model with three nested domains of 45-, 15-, and 5-km horizontal resolution, in order to study the orographic forcing of heavy precipitation. "To test the effect of upstream mountains, they performed a simulation without the Ligurian Apennines as well as without the mountains of Corsica and Sardinia (NAPN) on 15- and 5-km domains, while keeping everything else identical to the CTRL" (page 2186, right column). It is mentioned that Corsica and Sardinia were included in their 45- and 15-km domains (i.e. D01 and D02), but not in the 5-km domain (D03). Chen et al. (2010) in their numerical study (with WRF model) used 4 nested domains of 36km, 12km, 4km and 1.33km and followed a procedure similar to the one of Chiao et al. (2004) in their experiment without Taiwan's topography. "In order to examine the Taiwan orographic effects on the occurrence of the heavy rainfall over southwestern Taiwan, they performed a sensitivity test without

Taiwan's topography (NT) on 12-, 4-, and 1.33-km grid spacing simulations, while keeping everything else identical to the control run." (page 241, right column). Chen et al. (2011, 2013) in their numerical study (with WRF model) followed a procedure similar to the one of Chiao et al. (2004) in their experiments without topography (please see page 600 of Chen et al. 2011 and pages 316-322 of Chen et al. 2013). In all these experiments the topography was not removed in the coarse grid.

These references (appearing below) have been added in the revised version of the paper in order to justify the methodology we followed. Finally, the inner grid would be initialized with fields that are calculated using the normal orography in all methodologies that appear in the literature, i.e. no matter if the topography was removed in the inner or in all grids. This happens in experiments with modified topography even if only one grid is utilized (i.e. even without any nested grids). For example Moscatello et al. (2008) investigated the effect of Atlas mountains on the development of a Mediterranean "Hurricane" using only one grid in the area of these mountains. In page 4381, they state that "To test the importance of the Atlas Mountains in producing a lee-side cyclone (phase 1), EXP-1 is performed with the same grid configuration and numerical set up employed in the control run, but without the Atlas Mountains. Initial and boundary conditions are those provided by ECMWF fields at all pressure levels (including those below mountains) interpolated onto the WRF model vertical levels, which have been modified after setting the height of the orography to zero over Africa.". In all the abovementioned studies (with one or multiple grids) the normal orography was present in the initial conditions of all grids.

Chen C.-S., Y.-L. Lin, W.-C. Peng, C.-L. Liu (2010) Investigation of a heavy rainfall event over southwestern Taiwan associated with a subsynoptic cyclone during the 2003 Mei-Yu season. Atmos. Research, 95, 235-254. Chen C.-S., Y.-L. Lin, N.-N. Hsu, C.-L. Liu, C.-Y. Chen (2011) Orographic effects on localized heavy rainfall events over southwestern Taiwan on 27 and 28 June 2008 during the post-Mei-Yu period. Atmos. Research, 101, 595-610. Chen C.-S., Y.-L. Lin, H.-T. Zeng, C.-Y. Chen, C.-L. Liu

(2013) Orographic effects on heavy rainfall events over northeastern Taiwan during the northeasterly monsoon season. Atmos. Research, 122, 310-335. Chiao S., Y.-L. Lin, M.L. Kaplan (2004) Numerical study of the orographic forcing of heavy precipitation during MAP IOP-2B. Monthly Weather Review, 132, 2184-2203. Koletsis I., K. Lagouvardos, V. Kotroni, A. Bartzokas (2009) Numerical study of a downslope windstorm in Northwestern Greece. Atmos. Research, 94, 178-193. Koletsis I., K. Lagouvardos, V. Kotroni, A. Bartzokas (2010). The interaction of northern wind flow with the complex topography of Crete Island – Part 2: Numerical study. Nat. Hazards Earth Syst. Sci., 10, 1115-1127. doi:10.5194/nhess-10-1115-2010. Miao J.-F., L.J.M. Kroon, J. Vila-Guerau de Arellano, A.A.M. Holtslag (2003) Impacts of topography and land degradation on the sea breeze over eastern Spain. Meteorol. Atmos. Phys., 84, 157-170. DOI 10.1007/s00703-002-0579-1. Moscatello A., M.M. Miglietta, R. Rotunno (2008) Numerical analysis of a Mediterranean "Hurricane" over Southeastern Italy. Monthly Weather Review, 136, 4373-4397.

Comment: You used ERA-Interim reanalysis with horizontal resolution 0.75° x 0.75° to initialize the model on the external grid with a resolution of 12 km. The jump in resolution is quite large (about 6 or 7:1), larger than what is normally used for limited area model simulations (3:1 or 5:1). Also this choice should be possibly supported with appropriate references. Reply: Beck et al. (2004) studied the impact of different one–way nesting strategies on precipitation simulations over the European Alps with the LAM ALADIN model. The LAM was forced by initial and lateral boundary data derived from ERA40 reanalyses with 120 km horizontal grid-spacing. They examined the dynamical downscaling of ERA40 data to 12 km grid-spacing with a large resolution jump of 10:1 over complex terrain. Their results indicated that "the considered nesting strategies are comparably successful in terms of precipitation simulation, despite the large resolution jump (120 to 12 km) involved". Liu et al. (2012) investigated the sensitivity of WRF rainfall using different domain settings and various storm types. They concluded that "moderate downscaling ratios of 7:1, 5:1 and 3:1 were found to perform better with the WRF model in giving more reasonable results than smaller ratios". Papadopoulos et al. (2011) applied a downscaling procedure to reproduce high resolution historical atmospheric records across the Mediterranean region. They employed the POSEIDON weather forecasting system with a horizontal grid increment of 0.1ïĆřx0.1ïĆř (about 10km). The forcing was provided by ERA40 reanalyses at a horizontal grid spacing of 1.125ïĆřx1.125ïĆř latitude/longitude. Finally, it is mentioned that model output that resulted from resolution jumps higher than 5:1 (and up to 10:1) have been successfully used at various peer-reviewed articles of the international literature such as Galanis et al. (2006), Louka et al. (2009), Zoras et al. (2010), Katsafados et al. (2011), Stathopoulos et al. (2013). The abovementioned articles have been included in the revised version of the paper as: Beck A., B. Ahrens, K. Stadlbacher (2004) Impact of nesting strategies in dynamical downscaling of reanalysis data. GEOPHYSICAL RESEARCH LETTERS, 31, L19101, doi:10.1029/2004GL020115. Galanis G., P. Louka, P. Katsafados, I. Pytharoulis and G. Kallos 2006: Applications of Kalman filters based on non-linear functions to numerical weather predictions. Annales Geophysicae, 24, 2451-2460 Katsafados P., E. Mavromatidis, A. Papadopoulos and I. Pytharoulis, 2011: Numerical simulation of a deep Mediterranean storm and its sensitivity on sea surface temperature. Natural Hazards and Earth System Sciences, 11, 1233-1246. DOI: 10.5194/nhess-11-1233-2011 Liu J., M. Bray, D. Han (2012) Sensitivity of the Weather Research and Forecasting (WRF) model to downscaling ratios and storm types in rainfall simulation. Hydrological Processes, 26, 3012-3031. DOI: 10.1002/hyp.8247 Louka P., G. Galanis, N. Siebert, G. Kariniotakis, P. Katsafados, I. Pytharoulis and G. Kallos 2008: Improvements in wind speed forecasts for wind power prediction purposes using Kalman filtering. Journal of Wind Engineering and Industrial Aerodynamics, 96, 2348-2362. DOI: 10.1016/j.jweia.2008.03.13 Papadopoulos A., G. Korres, P. Katsafados, D. Ballas, L. Perivoliotis, K. Nittis (2011) Dynamic downscaling of the ERA-40 data using a mesoscale meteorological model. Mediterranean Marine Science, 12/1, 183-198. Stathopoulos C., A. Kaperoni, G. Galanis, G. Kallos (2013). Wind power prediction based on numerical and statistical models. J. Wind Eng. Ind. Aerodyn., 112, 25-38. Zoras S., V. Evagelopoulos, I. Pytharoulis and G. Kallos, 2010: Development and

validation of a novel-based combination operational air quality forecasting system in Greece. Meteorology and Atmospheric Physics, 106, 127-133. DOI: 10.1007/s00703-010-0058-z.

Comment: Section 6 “Results and Discussion” should be improved. It is not clear if the values of the four variables are larger, comparable or smaller than the values normally observed for tornado events: this point should be clarified. In this effort I suggest to show in Figure 8 the values for the two sets of simulations and not their differences. Also, I suggest you add a new Figure showing the spatial distribution of the four variables at the time of tornadogenesis for each case (12 panels in total). The discussion should be based on this new Figure; in the present version, the discussion from Page 12, Line 15 to Page 13, Line 11 is difficult to follow and interpret without a figure that represents the patterns of the instability variables. Reply: Following reviewer recommendations we revised Section 6 “Results and Discussion” in order to clarify our results. Figure 8 was replaced with a new Figure presented the values for the two sets of simulations. Moreover, a new Figure was adopted in order to illustrate the spatial distribution of the four instability variables at the time of tornadogenesis for each case (a 12 panel figure).

Comment: English is very poor and needs substantial revision, possibly by a native English speaker. It is not a task of the reviewer to identify each mistake, anyway some indications are provided below Reply: We have performed a substantial revision in language and the paper is under review by a native English speaker.

Comment: Minor points Reply: All minor points and suggestions were taken into account.

Comment: Minor points Page 10 Lines 16-20: it is not clear why the error considering METAR should be larger than using SYNOP. Also, the last sentence (Line 20) is obscure. Reply: The SYNOP reports include the actual mean sea-level pressure, 2m temperature and 2m dew-point temperature with one decimal place (e.g. 1010.9 hPa, 15.5*C). On the other hand, in METAR reports, the mean sea-level pressure appears as an integer because its decimal part is truncated. For example, an actual mean sea-level pressure of 1010.9 hPa is transmitted as 1010 hPa (Q1010) in METARs. Also, in METARs the 2m temperature and the 2m dew-point temperature appear as integers because the actual observations are rounded to the nearest integer. For example, an actual temperature measurement of 15.5 *C is transmitted as 16*C in METARs. Therefore, a maximum error up to 0.9 hPa in mean sea-level pressure and +/- 0.5*C is possible to be introduced by the use of METAR instead of SYNOP reports. In the revised form of the paper, the typing error of +0.33 hPa was corrected to +0.9 hPa. The last sentence of section 4 (Model Verification) was improved in order to make its meaning clearer. This sentence became:"Moreover, the fact that the METARs are available in hourly or half-hourly intervals (contrary to the 6-hourly intervals of SYNOP which are employed in other studies) allows the identification of temporary model errors which could have been missed if the model validation was based on SYNOP."

Comment: MINOR POINTS –Tables: - in Tab. 1, the formula for SRH is incomplete (it is not clear the meaning of k, x) - in Tab. 2, is the comparison performed during the whole day? why not focusing on the period close to the occurrence of the event? Also, why not removing the spin up time (first 6-8 hours) from the comparison? Finally, it is not clear whether you interpolate the model output fields in the station location, or you use the grid point closest to the station. Reply: In Table 1 a correct formula of SRH was provided accompanied with the necessary meaning of all components. In Table 2, the comparison was originally performed during the whole day of the event (indicated at the first row of the Table). Following the comments of the reviewer the spin-up time (first 6 hours) is not taken into account in the updated Table of the revised paper. The model verification did not focus only on the period close to the event because in this case the sample size (available observations) would be extremely limited. It is reminded that the verification was based on hourly or half-hourly observations. The model output fields of the grid point closest to each station were used in the verification. This information is included in the revised version of the paper.

Comment: MINOR POINTS –Figures: - the names in Fig. 1 are difficult to read, thus they should be written more clearly; also, all geographic names you mention in the text should added in the Figure. - in Figure 4, it is not clear whether the fulminations represent the total number cumulated in a previous period. The meaning of the colors is not explained. METAR (tactical??? reports) data are difficult to read. - Figure 8: in which area are the variables evaluated? this piece of information is relevant and should be added. Reply: A new Figure 1 was inserted in the revised paper that clearly illustrates all geographical names that were mentioned in the text. Figure 4 was replaced by a new Figure illustrated more clearly the spatial distribution of lightning activity, the meaning of the colors and the data of the aeronautical meteorological report METAR. In new Figure 8 all values for the two sets of simulations illustrated the values of instability indices in radius of less than 20km from tornadogenesis formation location. This piece of information was also added in the revised paper.

Finally we would like to thanks the Reviewer for his/her time and his/her valuable comments that improved the quality of our paper and illustrated more clearly our results.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 2, 1433, 2014.