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High resolution WRF model simulation of gravity waves induced by topographical features

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Gravity currents are usually horizontal flows created due to differences in the density of two adjacent fluids. They are an important mesoscale phenomena that influences local weather. On relatively flat plains adjacent to mountain slopes, gravity currents may be initiated by a katabatic flow, "local down-slope gravity flows caused by nocturnal radiative cooling near the surface under calm, clear-sky conditions", coming off the mountains at night. Katabatic flows at the bottom of a given slope can be generated gradually by local cooling or can arrive as a sharp advected microfront which causes a sudden increase in wind speed and wind direction change as well as a sharp temperature decrease. The occurrence of these two contrasting regimes depends on the distribution of cooling along the slope, stratification at the bottom of the slope and the ambient wind speed and direction. In any case, the irruption of this flow with sudden variations in the above mentioned magnitudes may result in vertical displacement of air parcels from their equilibrium position, proving to be a common source of internal gravity waves acting as a modulator of the gravity current. In this study, observations from a 100 m meteorological tower located in the northern part of the Iberian Peninsula, in the upper Duero basin, are used to analyze the evolution of a gravity current and the features of the gravity waves which passed over this area throughout a specific night of SABLES 2006 field campaign. In addition, a model simulation is performed with the Weather Research and Forecasting (WRF-ARW) Version 3.1.1 model using five nested domains with 0.5 km horizontal resolution in the finest grid, in order to have high horizontal resolution over the studied area. Model outputs are used to complement the experimental information and mainly to demonstrate the capability of the WRF model to simulate the irruption of the gravity current and the corresponding generation of gravity waves. Observations and modelling results show that: (i) the gravity current is probably created by a complex set of drainage flows typically originated on the mountainous slopes located at the north-eastern part of the Duero basin site leading to a northeast flow over the plateau where the tower is located; (ii) the irruption of the current is marked by a pronounced pressure disturbance observation and is accompanied by vertical oscillations seen both in the tower data and in the model outputs, which confirm the capability of the model to simulate this type of phenomena. Furthermore, it is also seen that gravity waves formation is quite sensitive to PBL parameterizations in model simulations.