Geophysical Research Abstracts
Vol. 20, EGU2018-17551, 2018
EGU General Assembly 2018

Improving the Representation of Flow by Local - Regional Scale Model Coupling

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Introduction
Low wind speed conditions and frequent inversions are frequently encountered in alpine valleys and basins causing poor dispersion conditions and may cause high air pollutions levels. Regional models such as WRF have resolution restrictions. In addition, a wind speed bias over basins and valleys was reported in several studies. Local scale flow models can resolve topographic effects on finer resolutions, however their initialisation and specification of boundary conditions is challenging.
This study attempts to improve the representation of flow in complex terrain by nesting the local scale flow field model GRAMM within the regional scale WRF model.

Methodology
For the WRF simulations a multiple nesting strategy was applied with three nested domains, covering mainland Europe and finally a 100 km x 100 km sized domain D03 (dx,dy $\sim$ 1 km) at the southern fringe of the Alps. The local scale flow field model GRAMM was nested within the WRF D03 domain at domain sizes of 12 km x 8 km and 53 km x 83 km using fine grid resolutions (dx,dy 150m/250 m). WRF computed flow and temperature were interpolated towards the finer grid and the flow computed by GRAMM (approach AP1). For the GRAMM in WRF nesting two further set-ups using observations from four stations within the domain were applied. In AP2 WRF simulated flow was adjusted using monitored winds to scale WRF interpolated horizontal wind components within GRAMM. In AP3 ground based wind and temperature measurements were used to initialize flow and near surface temperature inversions in case of significantly mismatching WRF simulation results. A period characterised by a strong air pollution burden in January 2010 was used for these three approaches.

Results
Comparing the WRF D03 results with the four monitoring stations Maribor (MB), Leibnitz (LB), Ahrnfels (AF) and Graz (G) reveals a significant overestimation of wind speed (WS) by up to a factor of two at the basin located stations (MB, LB and G) and a poor representation of wind direction (WDir) at all four sites. At the hill station AF wind speed is underestimated by 20%.
AP1: The GRAMM in WRF nesting resulted in significantly improved simulated WS and WDir compared with the WRF D03 results. Using the large simulation domain proved to be beneficial to reduce the overestimation of WS. WS is overestimated at the basin sites by 15 to 35%, the representation of WDir ranges from fair to good.
AP2: The scaling approach resulted in good results for WS and poor to fair results in WDir.
AP3: The hybrid model forcing (near the ground by observations and from the summit level onwards by WRF) resulted in a good representation of wind speed and further improved representation of wind direction compared with AP1.

Conclusions
The nesting of a local scale model within the WRF model resulted in a significantly improved representation of flow in complex terrain which is important for air quality modelling as well as wind resource evaluation.