High-resolution weather and air quality forecasts for Zeeland, the Netherlands

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1 Introduction

ARGOSS provides daily high-resolution weather and air quality forecasts for the province of Zeeland, the Netherlands. Zeeland covers an area of approximately 50x50 km$^2$ with several water bodies, bordering the North Sea. To properly represent the land-water boundaries and to simulate the associated weather effects, a spatial resolution of 1 km is required.

The abstract presents the operational ARGOSS model setup where WRF is used to drive the Chimère chemistry-transport model. Two experiments designed to address the problem of a cold model start are described. A few related validation results are also presented comparing the performance of 48-hour WRF forecasts to local ground observations (SYNOP) and KNMI HIRLAM forecasts.

2 Model setup

The purpose of the current operational model setup at ARGOSS is to provide high-resolution (1x1 km$^2$) 48-hour weather and air quality forecasts for the province of Zeeland, located in the south-west of the Netherlands. In order to achieve this resolution, a nested setup is used (see figure 1). A coarse domain covering part of Western Europe was set up with a 16x16 km$^2$ resolution. The boundary conditions for this domain are provided by global NCEP (GFS) model fields. A smaller domain, covering the Netherlands is nested into the Europe grid. This has a resolution of 4x4 km$^2$ and provides the boundary conditions for the innermost, Zeeland, domain which has a grid spacing of 1 km. The results from the fine domains are fed back into their parent domains via the two-way nesting option.

Figure 2 illustrates the effect of the domain resolution on wind speed fields. It can be clearly seen that at higher resolutions the water bodies become better
Figure 1: WRF model domains used in the operational setup at ARGOSS. Left: Western-Europe domain (16 km resolution) with the embedded Netherlands domain (4 km resolution). Right: The Noordoostpolder (not used operationally) and Zeeland high-resolution (1 km) domains nested into the Netherlands grid. The outermost domain is driven with GFS data.

represented and effects such as the velocity increase of the flow over water can be captured.

WRF model outputs are used to provide meteorological input data for the chemistry-transport model Chimère. Chimère is used in a nested setup identical to that of WRF (see figure 1) in order to achieve a 1x1 km² resolution over the province of Zeeland. Example ozone forecasts for the three domains are shown in figure 3.

3 Experiments

The first operational setup used a cold start, that is, each 48-hour forecast started from initial conditions which were interpolated from NCEP global model data onto the 16, 4, and 1 km² WRF grids. The forecasts were verified against SYNOP measurements and HIRLAM data. The verification showed that the first few hours of model forecasts display a spin-up effect. This effect is illustrated in figure 4 which shows verification results (mean error) of 48-hour 10 m wind forecasts for all three domains. The forecasts are compared to SYNOP observations and HIRLAM forecasts. It can be clearly seen that the WRF model errors are relatively large at the start of the integration and they decrease to a more-or-less steady level after the first 3 hours. In order to overcome this cold start/spin-up problem, two solutions were proposed, implemented, and verified.

The first was essentially a free model run. The 48-hour forecasts were always started from the 6-hour forecast of the previous run. The forecasts were performed with a start time of 00 and 12 UTC. In between these 48-hour forecasts, at 06 and 18 UTC, shorter, 6-hour forecasts were also performed to provide the initial conditions (6-hour forecasted fields) for the 00 and 12 UTC runs. Verification
Figure 2: The effect of grid resolution on the wind speed. Top left: 16 km, top right: 4 km and bottom: 1 km resolution.

Figure 3: Example Chimère model results for the three domains (top left: Western Europe, top right: the Netherlands and bottom: Zeeland). The grid resolutions are the same as for the WRF model (see figure 1).
showed no improvement in forecast results. Even though the spin-up problem itself disappeared, the overall quality of the forecasts has deteriorated.

The second proposed solution relies on the introduction of a spin-up time. First, a 3-hour forecast is performed and this provides the initial conditions for the 48-hour forecast which start at 00 and 12 UTC. This setup is currently used operationally at ARGOSS. Initial validation results show that the spin-up problem has been eliminated and forecast results did not deteriorate considerably.

4 Issues and future plans

There are a number of remaining issues for which solutions are currently being sought. One of these are nest boundary effects. Sometimes the transition from the parent to the nested domain is not smooth which can result in sharp edges near the boundaries of the nested domain. This problem is the most obvious in the precipitation fields, especially in the events of light rainfall (below 0.5–1 mm/3 hrs).

Planned improvements to the model setup include the implementation of high-resolution land-use and orography maps and the installation and use of the 3D-Var package.