are trying to investigate how we can improve the coupling scheme while using the existing available coupling data.

The solution proposed to solve the problems described above is the introducing of the spectral coupling method, solution offered by the fact that ALADIN is a spectral model using Fourier expansions in both horizontal directions. A spectral method of nesting a high-resolution limited area model (LAM) in a low-resolution global model was elaborated and implemented inside the LAM. Generally the used method of coupling the LAM with the global model is to couple the inner model with the outer one in the terms of lateral boundary conditions in real space. In the proposed method, the boundaries expressed in wavenumbers, in spectral space are the key of joining the LAM with the global model [4]. A spectral coupling scheme was built on the same analogy with the Davies relaxation scheme but as an additional coupling step.

The spectral coupling method consists in blending of the large scale spectral state vector with the state vector of the coupled model, so that the blended state vector is equal to the large scale one for small wavenumbers and equal to the coupled one for large wavenumbers with a smooth transition in between. The equation for coupling is very similar with the gridpoint one, see Janiskova [5]. Between the advantages of the spectral coupling scheme it is mentioned the scale selection where large scales are dominated by the spectra of the coupling model and only small scales resolved by the forcing model are dominated by the LAM. But the main potential advantage of spectral coupling is that that scales resolved by the coupled model are forced to LAM, even if the location of the system of the given scale is inside the domain. The spectral coupling cannot eliminate spurious inward propagation through the lateral boundaries. Without the damping by the standard Davies scheme all waves that exit on one side of the domain would freely enter on the opposite side. By using simultaneous Davies scheme and spectral coupling the advantages of both coupling methods are combined.

4 TUNING AND VALIDATION

The implementation of the spectral coupling method in a realistic model would be too tedious and the computation tests too high so that firstly we performed the tests on a 1D shallow-water model. It looked very reasonable to apply the conclusions to the 3D model ALADIN/LACE afterwards.

4.1 1D Shallow-Water tests

The sensitivity of the spectral coupling method was studied using the 1D spectral shallow-water model developed by I. Gospodinov and P.Termonia [6]. The model uses shallow-water velocity and shallow-water height as fields and it is running on two types of domains, a global model domain and a limited area domain. The domain of the model is periodic and thus can be interpreted as a global model. The model is integrated with a two time level semi-implicit semi-lagrangian scheme and a trajectory scheme proposed by Gospodinov with second order accurate treatment of the non-linear residual. In this model the calculation of the large scale fields is generally done by using linear or quadratic grid-point interpolation, but many tests were done before in order to find the optimum interpolation scheme. The relaxation takes place at the end of the grid-point calculation like in ALADIN.

Our tests were initially performed using the linear interpolation in time between the spectral coefficients of the large scale fields. The spectral coupling is done that for large scales only long waves from Arpege are taken into account and for small scales short waves from the LAM are considered with a smooth linear transition in between. The 1D shallow-water tests, by coupling the global model with the LAM using the same initial conditions consist of a depression in a Gaussian shape which propagates from west to east with constant speed through the whole domain. This can be considered as the 1D version of the Christmas storm, from 25 December 1999, even if the propagation speed in the 1D model is higher. The experiment was set up to test the coupling. We were interested in the case with a most likely deficient coupling [7]. Several unidimensional experiments were performed using the parameters to characterize the domains as follows:

Global model: 200 grid points, dX=50km (grid points distance), dt=300s (time step length) LAM : 200 grid points, 8 points extension zone, dx=10km (grid points distance), dt=300s (time step lenght), 36 h max. time integration.

(a) LAM forecast failure case (Figure 2a) - 3h Davies relaxation (we will note this as gridpoint coupling GPCPL): The cyclone is missing in the forecast.

(b) Reference case (Figure 2b) - 1h Davies relaxation (GPCPL): By increasing the coupling frequency, the LAM is able to receive and to keep the information from the large scale model. The given LAM forecast is considered as the ideal one, but too expensive for operational use.

(c) Forcing, jumps, dipole case (Figure 2c) - 3h Davies relaxation (GPCPL) combined with spectral coupling (SPCPL) every time step: It gives too strong large scale forcing. The cyclone oscillates inside the LAM domain due to the external large scale forcing. The LAM develops a dipole structure.

(d) Small jumps case (Figure 2d) - 3h Davies relaxation (GPCPL) with 3h spectral coupling (SPCPL): By decreasing the spectral frequency of coupling, the dipole structure is not present anymore because of less forcing from large scale which is a good sign.

(e) Once spectral coupling case (Figure 2e) - 3h Davies relaxation (GPCPL) with spectral coupling (SPCPL) applied at one time step after 6h of integration: Any dipole present in the LAM solution, but the cyclone appears later because of the chosen spectral coupling time with an uncertain lifetime inside the LAM. It cannot be sure that the LAM keeps and resolves the problem correctly. If the spectral coupling is applied only once, this time has to be close to the real time entering of the cyclone into the LAM domain.

(f) Wavenumbers time dependence case (Figure 2f) - 3h Davies relaxation (GPCPL), spectral coupling (SPCPL) every time step with a time relaxation : We can observe the dipole structure again and a strange evolution of the LAM solution as well. Introduction of the wavenumbers time dependence proves that the idea to get large scale information varying in time during the integration is far to be considered as a positive result.

In the Figure 2 the x-axis indicates the global model domain (200 gridpoints). The LAM is nested inside the vertical lines representing the borders of the LAM's different zones (e.g. the extension zone is between the last two vertical lines). On the left on y-axis we have the shallow-water height. On the right y-axis we have the shallow-water velocity. The curves inside the LAM represent the LAM forecast while the other ones show the global model forecast, which serves as reference.

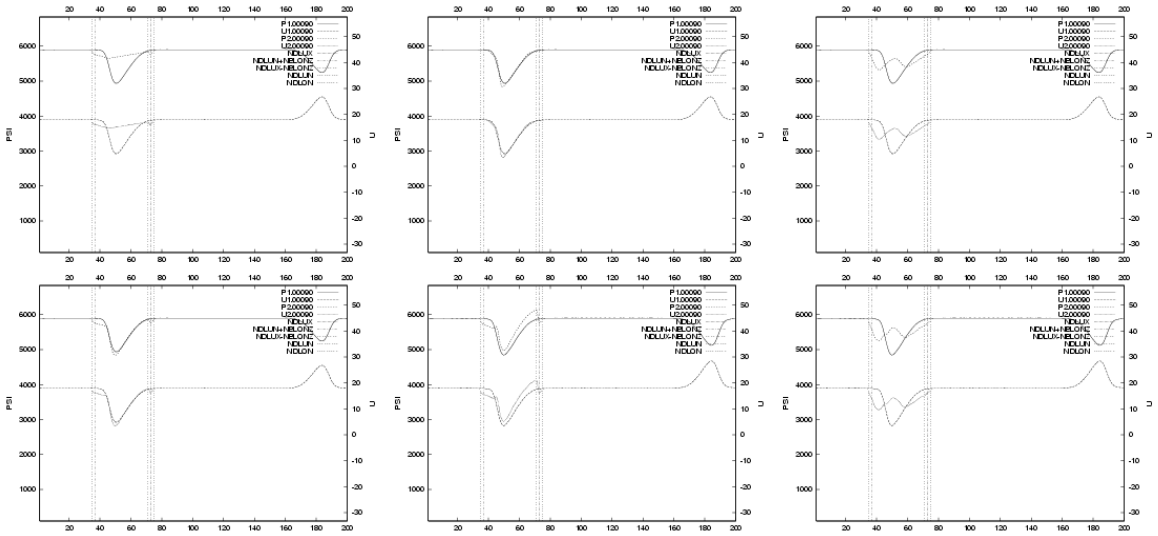

Figure 2: forecasted global and LAM shallow-water velocity and height fields (a) 3h GPCPL the cyclone is missing in the forecast; (b) 1h GPCPL the cyclone is present by increasing the coupling frequency; (c) 3h GPCPL and SPCPL every time step : dipole structure; (d) 3h GPCPL and 3h SPCPL: less forcing; (e) 3h GPCPL and SPCPL once after 6h integration: altered LAM solution; (f) 3h GPCPL and SPCPL every step with time relaxation: dipole structure and altered LAM solution

4.2 Discussion

When spectral coupling method was applied, the signal coming from the large scale is kept and solved by the limited area model which is very promising thing, but one should take care that only a suitable tuning of the proposed method will allow a correct evolution of the large scales inside the LAM. The preliminary unidimensional tests with the shallow-water model showed a positive expected impact of this method, but revealed at the first look certain difficulties:

- suddenly appearence of the cylone into the LAM when the spectral coupling method is applied at the fixed operational time interval 3h of updating the boundary information at the same moment of the operational coupling,

- corruption represented by a dipole structure of locally growing and shrinking lows, a direct linear time intepolation effect, produced by increasing the frequency of the spectral coupling. This structure comes from the fact that at the first coupling step the LAM gets the information from the linearly time interpolated spectral coefficients between two coupling files which disturbs the dynamical evolution of the large scale information inside the LAM during the integration time.

The forcing case raises the idea to introduce frequency of spectral coupling, providing spectral features from large scale not every time step, but at a lower frequency.

Different experiments were made with the 1D shallow-water model in order to minimize the strength of the forcing while keeping the large-scale information coherent inside the LAM. As a solution to this problem the spectral coefficients from the second coupling file were used to combine with the ones of the coupling model. The result is the absence of the dipole in the LAM solution, [8].