



## **The impact of wave number selection and spin up time when using spectral nudging for dynamical downscaling applications**

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Nudging techniques are commonly used to constrain the evolution of numerical models to a reference dataset that is typically of a lower resolution. The nudged model retains some of the features of the reference field while incorporating its own dynamics to the solution. These characteristics have made nudging very popular in dynamic downscaling applications that cover from short range, single case studies, to multi-decadal regional climate simulations. Recently, a variation of this approach called Spectral Nudging, has gained popularity for its ability to maintain the higher temporal and spatial variability of the model results, while forcing the large scales in the solution with a coarser resolution field. In this work, we focus on a not much explored aspect of this technique: the impact of selecting different cut-off wave numbers and spin-up times. We perform four-day long simulations with the WRF model, daily for three different one-month periods that include a free run and several Spectral Nudging experiments with cut-off wave numbers ranging from the smallest to the largest possible (full Grid Nudging). Results show that Spectral Nudging is very effective at imposing the selected scales onto the solution, while allowing the limited area model to incorporate finer scale features. The model error diminishes rapidly as the nudging expands over broader parts of the spectrum, but this decreasing trend ceases sharply at cut-off wave numbers equivalent to a length scale of about 1000 km, and the error magnitude changes minimally thereafter. This scale corresponds to the Rossby Radius of deformation, separating synoptic from convective scales in the flow. When nudging above this value is applied, a shifting of the synoptic patterns can occur in the solution, yielding large model errors. However, when selecting smaller scales, the fine scale contribution of the model is damped, thus making 1000 km the appropriate scale threshold to nudge in order to balance both effects. Finally, we note that longer spin-up times are needed for model errors to stabilize when using Spectral Nudging than with Grid Nudging. Our results suggest that this time is between 36 and 48 hours.