PRELIMINARY TESTING OF DIGITAL FILTERING INITIALIZATION IN AMPS

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1. INTRODUCTION

The Antarctic Mesoscale Prediction System (AMPS) produces two forecast runs initialized at 0000 UTC and 1200 UTC each day using a modified version of the Weather Research and Forecasting (WRF) model. These runs are launched in a so-called "cold start" mode, where initial conditions for each cycle are interpolated from the 0.5-degree Global Forecast System (GFS) forecast at each cycle before observations are assimilated using a 3-dimensional variational data assimilation system (WRF-Var). Invariably, there exists some level of imbalance between the AMPS interpolated mass and wind fields, and this leads to noise, taking the form of inertia-gravity waves, in the model forecast.

With the recent introduction of a digital filtering initialization (DFI) in the latest release of the WRF model, there arises the question of whether this DFI might be applied to WRF AMPS forecasts to eliminate noise in initial conditions, thereby improving the forecast. With the likely transition to WRF as the primary mesoscale model in AMPS in the near future, there exists the possibility that DFI could be applied to AMPS in real time if it were found to provide a systematic forecast improvement. However, the current WRF DFI implementation supports only a single nest, while the AMPS domain configuration has a number of nests, from a coarse-domain resolution of 60 km to a 2.2-km nest over Ross Island. In this abstract, the DFI technique is briefly reviewed, and initial attempts to use DFI with a two-domain model configuration are described.

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2. DIGITAL FILTERING INITIALIZATION

Digital filtering initialization is a technique that seeks to eliminate noise from the model initial state by filtering in the time domain. For any model field to be filtered, a time series of this field may be produced by integrating the model either backwards or forwards in time. Providing this time series as input to a low-pass digital filter yields, at each output time of the filter, a model state from a time series where high-frequency components are absent. If the cutoff frequency for the filter is chosen to be lower than the frequency of the noise in question, but higher than the frequency of other, meteorologically significant modes, then the output of the filter at a given time provides a model state where perturbations leading to noise have been removed.

In WRF, the DFI implementation supports three schemes for applying a low-pass digital filter. In the tests described herein, the twice DFI (TDFI) scheme has been used. The TDFI scheme begins by adiabatically integrating backward in time to produce a time series of model states, which are filtered to give a model state valid before the analysis time. Then, from this filtered state, the scheme launches a diabatic, forward integration to produce a second time series. This second time series is passed through the same filter to give a final filtered model state valid at the analysis time.

3. RESULTS

In light of the fact that the current WRF DFI implementation supports filtering of only a single model domain, the present attempt to initialize nested model domains using DFI relies on running nests as stand-alone, one-way nests. The idea is to first produce a short model forecast from the coarse domain for the purpose of generating lateral boundary conditions for a nest; also during this short forecast, the DFI procedure is used to produced a filtered initial state for the coarse domain. Using the resulting lateral boundary conditions, the nest may be run by itself, but only long enough to

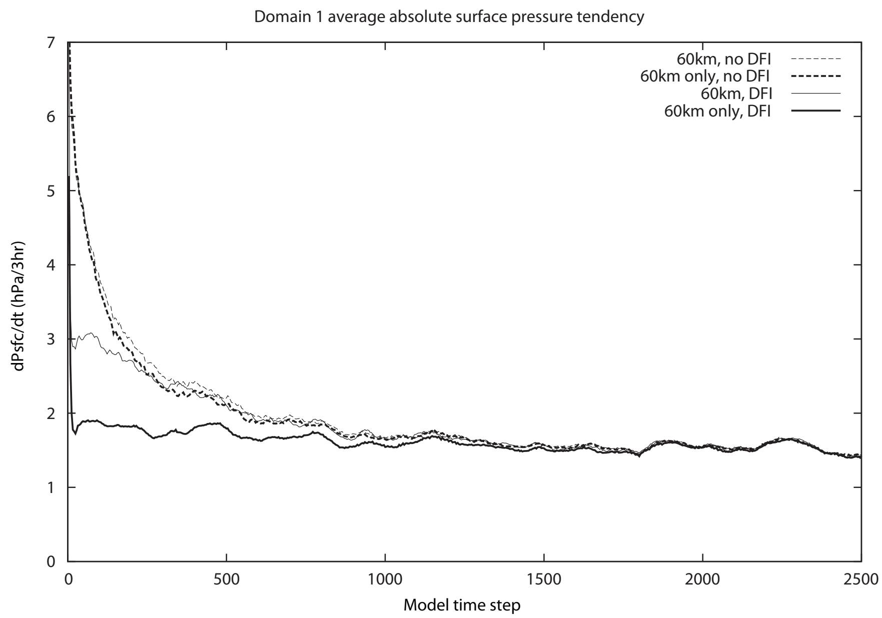


Figure 1. Noise level, measured as domain-averaged absolute surface pressure tendency, for the 60-km domain in four experiments: a single 60-km domain, a 60-km domain using DFI, a 60/20-km domain configuration, and a 60/20-km configuration using DFI. Forecasts begin 05 November 2007 at 1200 UTC, and the model time step for the 60-km grid is 240 s.

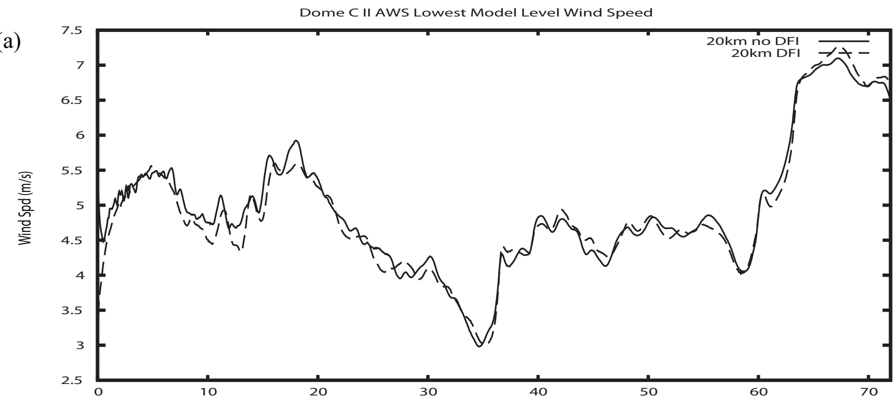
produce a filtered initial state for the nest. When there are multiple levels of nesting, this procedure may be applied recursively: obtain boundary conditions from a filtered integration of the parent domain, then run the DFI procedure on the nest itself. Given filtered initial states for all domains, the original initial conditions are replaced with the filtered model state, and a nested simulation is run as usual.

For the purpose of simplicity, only the two coarsest AMPS domains, which have horizontal resolutions of 60 km and 20 km, are considered. The noise level in a 60-km single-domain simulation and a 60/20-km nested-domain simulation, as measured by the domain-averaged absolute surface pressure tendency, is shown for the 60-km domain in Figure 1. It may be observed that the noise level when DFI is not used is similar for the nested and single-domain cases. However, the noise level in the first few forecast hours is markedly lower in the single-domain case when DFI is used. It seems likely that the increase in noise when a 20-km nest is present can be accounted for, at least partially, by the smoothing that occurs at the boundary of the 20-km domain, which feeds back its state to the 60-km domain.

To gain insight into the impact of DFI at specific locations, rather than in a domain-wide sense, time series of surface pressure, and temperature and winds at the lowest model level (LML), have been extracted for six locations, each coincident with an automatic weather station (AWS); these locations are Gill, Pegasus North, Siple Dome, Dome C II, Henry, and Mizuho. In Figure 2a, model time series of LML wind speed at the Dome C II AWS site are plotted from the 20-km AMPS domain for two forecasts initialized 05 November 2007 at 1200 UTC, one with DFI and the other without. In the figure, high-frequency changes in the wind speed are clearly visible during the first six hours of the forecast run without DFI, in contrast to the run with DFI, but these oscillations, when viewed in context of the full 72-hour time series, are minor. Such patterns are visible in many of the time series: DFI eliminates initial, high-frequency oscillations from the LML wind and surface pressure fields, although the time series with and without DFI follow each other closely throughout the forecast. Generally, it appears that DFI has a small impact on the forecast at point locations; however, it does eliminate noise from the initial state, as can be seen in plots of surface pressure tendency.

In contrast to the Dome C II time series, where the changes to the LML winds were minor, Figure 2b shows the LML wind speed time series at the Henry site. It should be noted that the time series diverge near forecast hour 18, but later re-converge around forecast hour 33. Between hours 18 and 33, the wind speeds between the two runs differ by nearly 8 ms^{-1}.

(a)



(b)

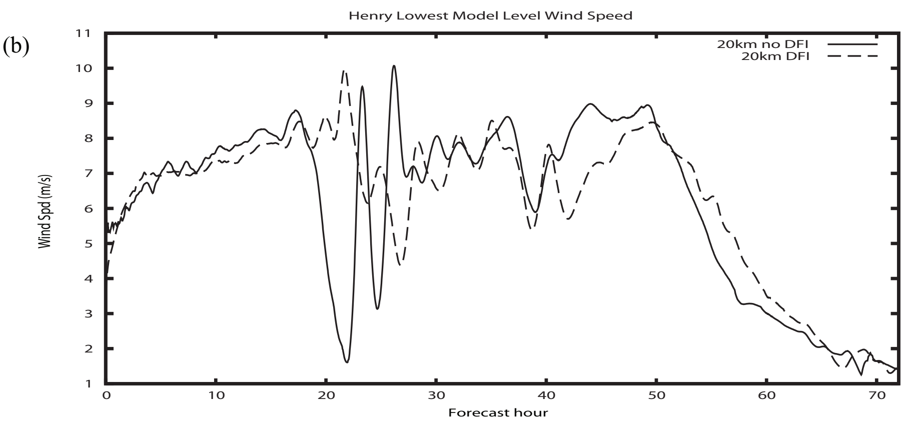


Figure 2. Time series of wind speed at the lowest model level taken from the 20-km nest of model runs with and without DFI. (a) shows time series for the Dome C II AWS site. (b) shows time series for the Henry AWS site.

4. CONCLUSIONS

Using the DFI capability in the latest release of the WRF model, basic testing with respect to the feasibility of using DFI in AMPS has been performed. In order to apply DFI to nested domains, which will be necessary if DFI is to be used at all in AMPS, a method whereby each domain is initialized separately has been employed. After each nest has been initialized, the fully-nested forecast run is launched using the filtered model states. Although noise levels are higher when a nested domain is added to the model grid configuration, there is still an improvement, with respect to noise, when using DFI. Comparison of time series from the 20-km nested domain of DFI-initialized and uninitialized runs shows few meteorologically-significant differences for the majority of the six locations considered; however, notable differences can be found, for example, in the time series at the Henry AWS site. This leaves open the possibility that DFI could have a significant impact on forecasts beyond the removal of any initial noise.

Overall, preliminary testing has not indicated any systematic change to model forecasts at point locations when using DFI. This is not necessarily surprising, since DFI modifies the initial conditions only slightly, and leaves all forcing terms untouched for the model forecast. Due to the high degree of nesting in AMPS, though, the high-resolution domains — like the 6.7-km Antarctic Peninsula domain or the 2.2-km Ross Island domain — may yet be found to benefit from a reduction in noise, especially when considering the difference in topography representation between such nests and the 0.5-degree GFS data.

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