Abstract

Primitive equation model, used for numerical weather prediction, generates two types of solutions, one being the meteorologically significant Rossby wave and the other, the high frequency gravity wave, called as noise. Initialization is a process of removing the noise and hence producing a balanced initial state.

In this thesis, various initialization schemes are applied for a shallow water limited area model over a tropical region and their results are studied. A potential enstrophy conserving finite difference scheme is utilized to solve the shallow water model equations. Dependent variables are presented on a Arakawa C grid. Along the boundaries, time invariant boundary conditions are applied. The time integration used is the leapfrog scheme which follows forward marching for the first step.

Among various initialization schemes, nonlinear normal mode initialization technique is the most widely used technique. This is based on the principle of identification and suppression of gravity waves. In the conventional normal mode initialization, the normal modes of the linearized model equations are to be calculated explicitly. This scheme is known as explicit normal mode initialization (ENMI). However for certain limited area model, these normal modes are inseparable. In implicit normal mode initialization (INMI), the explicit knowledge of the normal modes is not required and the same can be applied in physical space itself. The above two initialization schemes (ENMI and INMI) are first applied to a shallow water model over a tropical region by considering the Coriolis parameter as a constant while linearizing the model equations and the results of the above are studied. As the domain of the experiment includes tropical region, the latitudinal variation of the Coriolis parameter (beta-terms) becomes important. ENMI scheme is generalized by considering three cases of linearizations: including all the beta terms (ALLNMI), some beta terms (SBNMI) and no beta terms (NOBNMI). NOBNMI is same as the above mentioned ENMI. ALLNMI and SBNMI also take into account nonstationary Rossby modes.

As the properties used for INMI includes stationarity of Rossby modes, the above (INMI) cannot be applied for the case where all/specific beta terms are included, while linearization of the model equations. Though ALLNMI and SBNMI have been applied over the midlatitude region, the effects of inclusion of all/specific beta terms while linearization have not been studied for a domain over the tropical region, where the beta terms may play an important role. Towards this end, the effect of inclusion of all/specific beta terms while linearization of the model equations is studied by applying ALLNMI, SBNMI and NOBNMI to a shallow water model over a tropical region and the above results are discussed.

Another alternate approach for initialization uses a digital filter for initialization. Digital filtering initialization (DFI) is inherently simple and relatively easy to implement. Both the nonrecursive and recursive filters can be used for initialization. The output of nonrecursive filter depends on the past and future input values. The DFI with nonrecursive filter requires forward and backward integrations and the variables at each time step are multiplied with a weighting factor which is the Fourier transform of an ideal frequency response modified by different windows. Though in recent times, some studies have been done using nonrecursive filters, most of the studies involving nonrecursive filters have utilized Lanczos window. A nonrecursive digital filter utilizing three different windows (Lanczos, Hamming and Dolph) has been used for DFI and the above results are studied. The output of a recursive filter depends on the past and present values of the input as well as the previous values of the output and hence avoids the backward integration. The construction of a recursive filter is more difficult than a nonrecursive one. Although some studies using Quick-Start (QS) filter has been done in recent times, the detailed study of the various recursive filters as applied to initialization over a tropical region has not been undertaken. Both the Quick-Start (QS) and Butterworth (BW) recursive filters are studied in this thesis over a tropical region and their results are studied.