P1.10 IMPROVED TERRAIN ANALYSIS FOR THE COUPLED OCEAN/ATMOSPHERE MESOSCALE PREDICTION SYSTEM (COAMPS^{TM})[1] AND ITS IMPACT TO THE FORECAST PERFORMANCE

Sue Chen*, Jerome M. Schmidt, and Jason E. Nachamkin
Naval Research Laboratory, Monterey, California

1. Introduction

Better orographic representation in the numerical weather prediction model is important to properly simulate the local surface forced weather phenomena and crucial to the propagation and downstream development of the synoptic scale waves. The problem of deriving a representative terrain estimate from the up-scale aggregation of the fine resolution (on the order of 1km or less) topography data now routinely available on the global scale has given rise to various methods to treat this issue in the literature. These methods include the mean and envelope orographic (Jarraud et al, 1987), silhouette averaging (Mesinger et al, 1988), the Cressman objective analysis (Guo and Chen, 1993), and fractal interpolation (Bindlish and Barros, 1996). The scope of this paper is limited to the comparison of the envelope and silhouette analysis methods that are used in the Naval Research Laboratory's (NRL) Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS).

2. COAMPS terrain analysis

The COAMPS terrain analysis algorithm can access two different resolutions of global terrain database. The 10-minute resolution terrain data is from the National Aeronautics and Space Administration while the 1 km meter terrain data is from the National Imagery and Mapping Agency. The independent terrain analysis is performed on each model grid. Since COAMPS is a nested nonhydrostatic model, terrain matching is performed near the nest boundaries to ensure a smooth transition in the orgraphy from the child to parent mesh. This is accomplished by using a weighted average to gradually replace the fine mesh estimates with the parent values obtained at coincident points.

2.1 Envelope method

Currently in COAMPS, the envelope and silhouette methods are the only two terrain analysis options available for deriving an estimate of the terrain value at each grid point. In the envelope method, the terrain height is first linear interpolated from the surrounding terrain points closest to the model grid point. A weighted standard deviation value is then added to this estimate using linearly interpolation from a global standard deviation database derived from a 10-minute global terrain field.

$$Z_{i,j} = Z_{i,j} + \omega\sigma_{i,j} \qquad (1)$$

In this equation, $Z_{i,j}$ is the model terrain height, ω is the user defined weighting factor, and $\sigma_{i,j}$ is the standard deviation at the model grid point. The weighting factor ω is set to be 0.5 in the operational runs used at FNMOC since 1997. In general, the envelope method works reasonably well to preserved the overall topography peaks. However, it can introduce a phase shift in the terrain field, tends to broaden ridges and can raise the height of even relatively broad valleys (Fig. 2). Also, since the weighting used changes with grid resolution, artificial terrain gradients can be created along the nested boundaries due to the fact that the ridges/valleys are better resolved in the high-resolution nested domain.

2.2 Silhouette Method

In February 2002 the operational COAMPS runs at FNMOC switched to using the silhouette method for obtaining the terrain analysis. The up-scale aggregation of terrain using the silhouette method (Fig. 1) is based on the technique used in the Colorado State University's Regional Atmosphere Modeling System. The 1 km global terrain dataset is used for the analysis regardless of the model grid resolution. The silhouette method is derived by placing a sample box surround a given model grid point. These sample points can be constructed using the native grid resolution or by specifying a four delta-x grid spacing to eliminate small -scale aliasing issues. The model grid point is placed at the center of the box consisting of equally spaced topography points. The size of the box used to derive the terrain estimate is user-defined and for these experiments set equal to the horizontal resolution of the model gridbox.

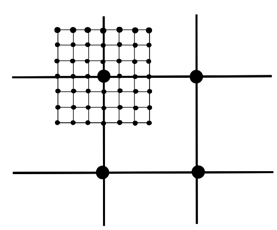

Fig. 1 Schematic illustration of the topography points (small dots) and the model grid points (large dots). The model grid point is placed at the center of the silhouette box. In this example, the horizontal grid resolution is 6 km.

The topography points within the sample box are obtained by linear interpolation from the 1km global dataset. The silhouette height of the sample box is derived from a weighted average of the maximum terrain

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Corresponding author address: Sue chen
Naval Research Laboratory, Monterey, CA 93943-5502; email: chen@nrlmry.navy.mil

[1]COAMPS^{TM} is a trademark of the Naval Research Laboratory.

height obtained in the box and the averaged silhouette terrain value obtained by averaging the peak height obtained in each row and column (Eq. 2). The final model grid terrain height is obtained by weighting this average value with the mean terrain value obtained within the box (Eq. 3)

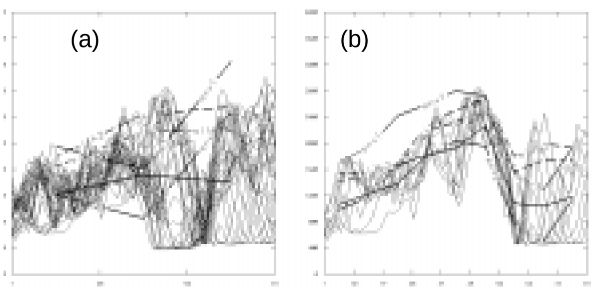

Fig. 2 An east-west section of the terrain plots across the northern ALPS in (a) 27 and (b) 9 km horizontal resolution. The thin solid curves represents the actual terrain in the y direction. The analyzed terrain is plotted at the center of the horizontal axis tick marks. The “silh1” curve uses ω_1=1 and ω_2=0.5; the “silh2” curve uses ω_1=0.25 and ω_2=1.0; the “env1” and “env2” curves represents coamps envelope method and uses ω=1.0 and ω=0.0 with respectively.

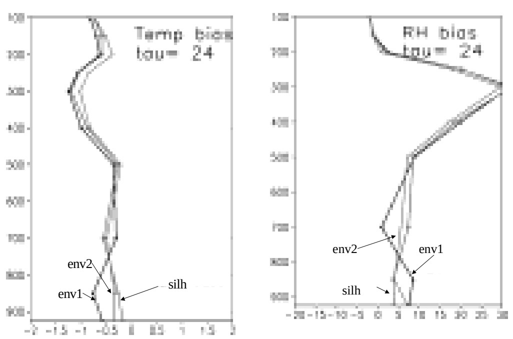

Fig. 3 A two-week model bias comparison between the envelope and silhouette terrain. The “env1” run uses the COAMPS envelope method with the full standard deviation. The “env2” run uses zero standard deviation. The “silh” run uses the silhouette method.

$$Z_s = \omega_1 Z_{max} + (1 - \omega_1)\left(\frac{Z_{sx} + Z_{sy}}{2}\right) \qquad (2)$$

$$Z_{i,j} = \omega_2 Z_s + (1 - \omega_2) Z_{mean} \qquad (3)$$

Where Z_s is the silhouette terrain height of the sample box, Z_{sx} and Z_{sy} is the silhouette terrain height obtained by averaging silhouette height obtained in each row and column, Z_{max} is the maximum terrain height in the sample box, $Z_{i,j}$ is the final grid terrain height, Z_{mean} is the average terrain height in the sample box, and ω_1 and ω_2 are the weighting factors. Different combinations of weighting factors ω_1 and ω_2 will draw the grided terrain analysis toward preserving the peaks (ω_2=1) or preserving the valleys (ω_2=0). Fig. 2 shows a comparison of the analyzed terrain heights using the silhouette and envelope terrain methods across an east-west section of northern ALPS in Europe with 27 and 9 km resolutions. One can see that the silhouette method allows the user a greater degree of freedom to determine the model terrain analysis. Various combinations of the silhouette weightings can be used to draw toward the maximum peak heights and, in general, does a much better job representing the overall terrain slope. The envelope method, meanwhile, is seen to overestimates the highest peaks and shows a pronounced phase shift in the peak locations, particularly on the coarser domains. With an increase in the model resolution, the various methods with the exception of fully weighted envelope (env1) tend to converge toward a similar estimate of the terrain.

3. Comparison of the model statistics using the silhouette and envelope terrain

Recent work has begun to evaluate the impact of the silhouette technique on the overall model performance. An example from a two-week period selected at random from model runs performed over the Mediterranean region with the 81x27 km grid configuration is shown in Fig. 3. The comparison of the average bias (model-observation) at the 24 hour forecast time suggests that use of the silhouette method helps reduces bias scores especially in the lower troposphere than the envelope method. Additional tests performed over a longer period of time and with additional parameters are planned for the near future.

4. References

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5. Acknowledgement

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