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An Environmental Experiment on Databases for War Games

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Abstract

Environmental effects are frequently modeled in many war game simulations. The data for these environmental effects can be either default values within the game databases or data accessible from external database sources, such as the Navy's Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS) or the Total Atmosphere Ocean Services (TAOS). However, differences can occur in the data, even within the same data source, and the question arises whether those differences can produce significant changes in the play of a war game. This report describes an experiment that demonstrates that the difference is strategically important. Results show that significant effects can occur when data are obtained from the same source in two otherwise identical situations. If environmental data are not consistent, questionable results can occur within a simulation. Results that are derived from such a simulation may lead to wrong conclusions.

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1. Introduction

Environmental effects are frequently modeled in many war game simulations. The data for these environmental effects can be either default values within the game databases or data accessible from external database sources, such as the Navy's Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS) or the Total Atmosphere Ocean Services (TAOS) [1]. However, differences can occur in the data, even within the same data source, and the question arises whether those differences can produce significant changes in the play of a war game. This report describes an experiment that demonstrates that the difference is strategically important.

It is well known that wind direction and wind speed can have militarily significant effects during smoke operations. In fact, when plans are made for the deployment of smoke during an engagement, one of the parameters always considered is the wind. However, it is not apparent whether, within the atmospheric databases that support military computer simulations, there exists sufficient variation in the wind speed and direction to cause any operational effects. As part of the Representational Resources Integration Experiment (RRIE) [2], the U.S. Army Research Laboratory (ARL) conducted an experiment to demonstrate the significance of the variations in different resolutions of the same atmospheric data sets generated by the COAMPS model. The Computer Generated Forces (CGF) software, ModSAF 4.0, was used to portray a military encounter involving the U.S. Army's Grizzly vehicle. The scenario selected, a notional representation of a Grizzly encounter during a mine-breaching operation, is intended to visualize the impact of smoke during the encounter. A militarily valid scenario was not the primary concern, and the elements of the scenario were kept as simple—and as few—as possible. The next section describes the models used, as well as the scenario and its implementation in ModSAF 4.0.

2. Models

Two models were used in this experiment: COAMPS and ModSAF 4.0.

The Marine Meteorology Division of the Naval Research Laboratory developed COAMPS, a complete three-dimensional atmospheric data assimilation system comprising data quality control, analysis, initialization, and forecast model components; an option for one of two ocean models; and a wave model. Features of COAMPS include a globally relocatable grid, user-defined grid resolutions and dimensions, nested grids, an option for idealized or real-time simulations, and code that allows for portability between mainframes and workstations.

Observations from aircraft, rawinsondes, ships, and satellites are blended with the first-guess fields to generate the current analysis. For the idealized experiments, the initial fields are specified by an analytic function and/or empirical data (such as a single sounding) to study the atmosphere in a more controlled and simplified setting. The atmospheric model uses nested grids to achieve high resolution for a given area and contains parameterizations for subgrid scale mixing, cumulus parameterization, radiation, and explicit moist physics. Typical mesoscale phenomena that COAMPS has been applied to includes mountain waves, land-sea breezes, terrain-induced circulations, tropical cyclones, mesoscale convective system, coastal rainbands, and frontal systems.

The COAMPS model domain typically covers a limited area on the earth. The model grid size, usually referred to as grid resolution, can range from a few hundred kilometers (synoptic scale) down to approximately one meter when the large-scale eddy mode is used. The actual dimensions used depend on the scale of the phenomena the user is interested in simulating. The model dimensions can be set to produce any rectilinear pattern and can also be rotated to align with any surface feature, such as the terrain or a coastline. COAMPS can be run with any number of nested grids, with the grid resolution in any mesh one-third that of the next coarser mesh.

The COAMPS data, available from the Naval Research Laboratory in Monterey, California, were used to obtain the wind speed and wind direction at two separate data resolutions. Because terrain is represented in two different ways when two different resolutions are specified, some environmental values can be different for the same spatial point. Differences are expected to occur in regions that have variable terrain. A flat terrain, such as in the plains of Kansas, will not show substantial changes, while hills and mountains, such as at the National Training Center, can generate large variations.

ModSAF, created by the U.S. Army Simulation, Training, and Instrumentation Command (STRICOM) [3], is designed for use on a network with participants located throughout the world. As such, it requires real-time performance for all the interactive participants. The latest reviewed version of this model is version 4, released in April 1998. A newer version, version 5, was released in March 1999. The model is written in the C programming language and will run on a number of Unix-based platforms, including Sun and Silicon Graphics.

A player in the simulation is located at a workstation that displays a map of the engagement terrain. The same screen also displays a set of tools for updating and controlling the entities under the control of this workstation. The player normally views only the forces he creates and any forces within his viewing capability. If the appropriate information is communicated over the network, other forces—controlled by other workstations or representing actual forces training on the battlefield—can be placed on the display. Each player generates the orders for the forces played from his workstation, determining where, when, and how far his forces move. If the forces have weapon systems, he can also generate the commands that determine their engagement rules.

The parameters used enable ModSAF to simulate such phenomena as illumination from solar, lunar, and man-made sources, and obscuration from smoke, boundary-layer aerosols, and precipitation. There are two options on how the weather and these parameters are to be played. The state of the weather can be defined by parameters set by the user or a source of "live" data, such as TAOS. The default values for ModSAF correspond to an exercise running on a clear, sunny day.

Illumination levels are determined from an ephemeris model, Solar/ Lunar Almanac Core (SLAC, part of the ModSAF suite of models), and the Natural Illumination Under Realistic Weather Conditions (ILUMA) model, part of the Electro-Optical Systems Atmospheric Effects Library (EOSAEL) suite of models. These models will support both cloud cover and precipitation. Within ModSAF, ILUMA is implemented as a set of three precomputed lookup tables. The first table is for solar illumination, the second for lunar illumination, and the third for background sky illumination.

Atmospheric transmission is determined from two EOSAEL models, LOWTRAN (Low-Resolution Transmittance) and XSCALE, and a third model, called BCIS, which is used to determine the transmissivity of a dust storm. The Air Force has replaced LOWTRAN with an improved model called MODTRAN (Moderate-Resolution Transmittance) [4], and ModSAF is expected to incorporate this change. Again, within ModSAF, precomputed lookup tables are used for the extinction coefficients.

Determination of obscuration, caused by battlefield smoke and dust, is provided by an EOSAEL model, the Combined Obscuration Model for Battlefield-Induced Contaminants (COMBIC), developed by ARL [5]. In ModSAF, this model is separated into two groups of code and implemented in two different ways. The first group of code represents the growth of the obscurant, taking into account diffusion, gravity, thermal effects, and wind speed (but not wind direction). Because of the time necessary to repetitively run this code, the results are precomputed as a set of lookup tables. The second group of code computes the transmission between an observer and a target, and the actual COMBIC code is included as a separate module. This second computation takes into account the location and size of the obscurants that fall within the line of sight between the target and observer. This part of COMBIC will run in real time.

The ModSAF 4.0 software was installed on our system in the default version as received from STRICOM. This model has a standard Grizzly breaching vehicle model that does not contain the modifications made to the "plow" representation that other parts of the RRIE program incorporated [2]. The modifications take into account the nature of the soil as influenced by the amount of precipitation.

3. Scenario

Since the other parts of the Grizzly experiment may take place in the "Valley of Death" at the National Training Center (NTC) in California, the coordinates of that site (116° 35′ W, 35° 15′ N) were chosen for the center of the terrain displayed. A 3- by 5-km representation of the area is shown in figure 1. The grid lines showing on the terrain in this image are separated by 1 km. A minefield was placed on one of the roads traversing the area at a location in the scenario where the roads divided; the location could be a place that would impede a force attempting to make use of the road structure in that area. ModSAF allows the placement of a templated minefield, with the required parameters, a location and orientation for the minefield.

An enemy tank (here, a T80 was selected) was placed in a position where it could view the minefield and the roads through the minefield. There is no terrain masking of either the road approach to the minefield nor of the minefield itself. The line of sight for the T80 can be seen in figure 2. The areas portrayed in black in the figure cannot be seen by the T80 due to masking by the terrain. The "Mission" for the T80 was an "Attack by Fire." The "Rules of Engagement" given to the tank were for free fire at any targets that traveled on the ground. All other restrictions were left at default levels.

Two Grizzly vehicles (the default version of the vehicle) were placed on the road east of the minefield and, initially, outside the 3.5-km range of the T80. The first Grizzly was given a three-phase mission: a "Road March," a "Mine Breaching Operation," and, finally, another "Road March." The second Grizzly was given only a "Follow-the-Leader"

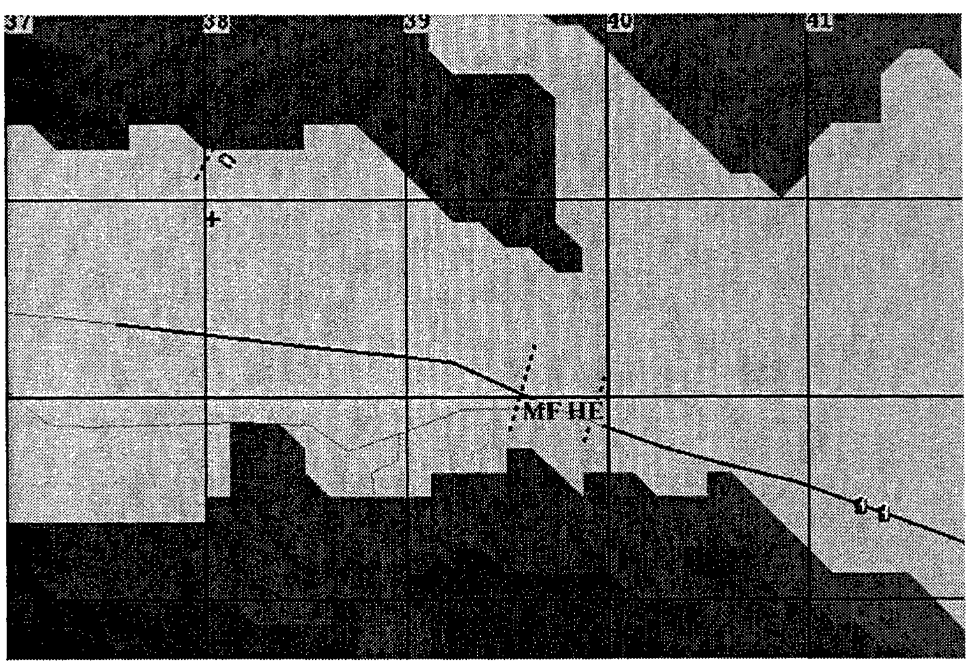
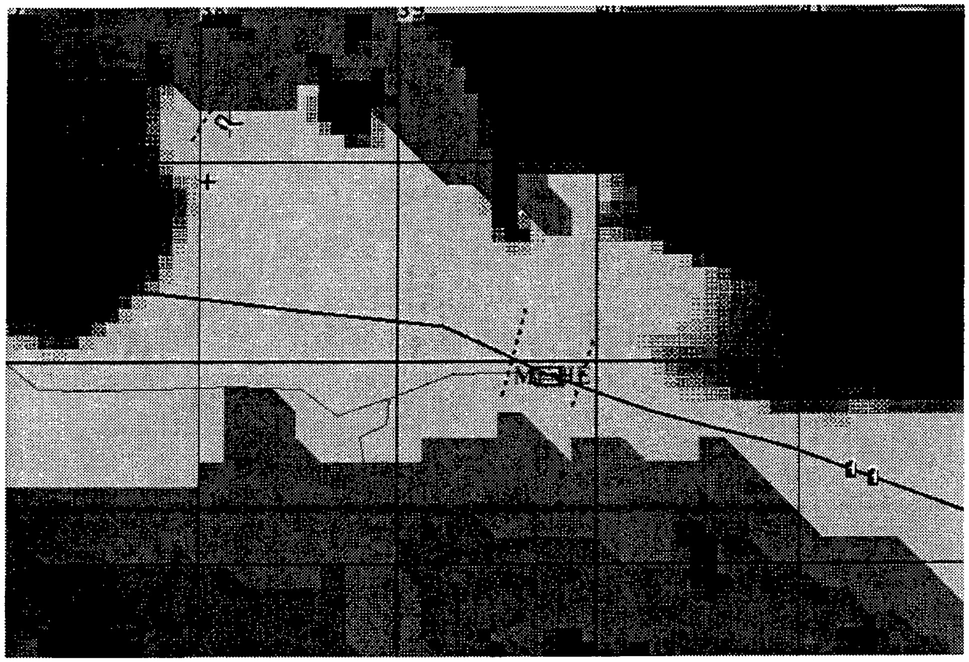


Figure 1. Baseline scenario for Grizzly atmospheric experiment.

Figure 2. Line of sight for baseline scenario.

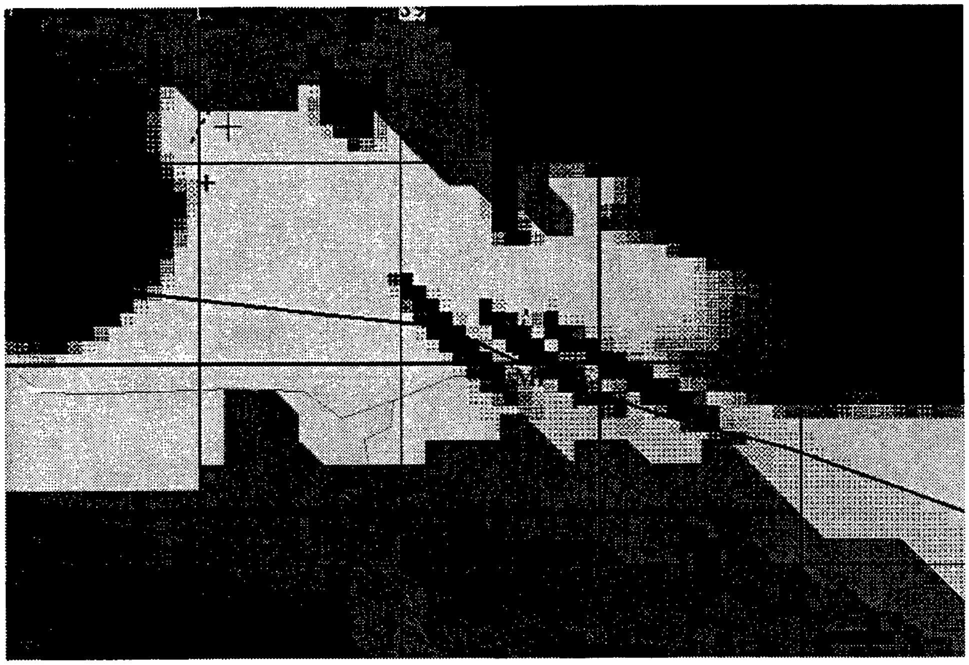


mission. Default values were used for all the parameters of the vehicles. Locations of the mission changes can be seen on figure 1, where the dotted lines cross the roads on either side of the minefield.

As the Grizzly vehicles moved into range of the T80, the T80 began to fire. Once the first round arrived, smoke was deployed for the protection of the Grizzly vehicles, using the white phosphorus M825 rounds as a smoke source; these rounds would normally be fired by a 155-mm howitzer. In ModSAF 4.0, smoke is played using the COMBIC model. This model computes the growth of a cloud under the influence of diffusion, gravity, and a static, uniform wind. Since neither the artillery units nor the communications necessary for giving the artillery a fire order were represented in this game, both the timing and placement were accomplished by direct intervention of the operator. It was decided that smoke rounds would be placed in the vicinity of the minefield, close to the road. The response time of the player was such that smoke rounds were started about the same time as the T80 fired a second round.

The mission was executed twice, with environmental data from two COAMPS runs. The wind velocity parameter was altered between the two runs. In the first run, obtained from the 27-km COAMPS data, the wind direction was from the west at 3.7 m/s. In the second run, obtained from the 9-km/s COAMPS data, wind values were changed to be from the northwest at 2.2 m/s (shown in fig. 3). This change in wind represents the scale of differences that can result from two different COAMPS runs (27-km and 9-km resolution), when the terrain features are "smoothed over" at the course resolution.

Figure 3. Line of sight when smoke is deployed with wind from northwest at 2.2 m/s.



4. Experiment Results

With the wind coming from the west (shown in fig. 4), the minefield remained clear and unobstructed for the mine-clearing operation by the Grizzly. In addition, the T80 was blocked from sighting both the clearing operation and the traverse of the Grizzly; the threat did not fire during this period of time. As the smoke evolved and covered the battlefield, the line of sight from the T80 to the minefield had to pass through several of the clouds generated by the smoke. Thus, target detection by the T80 was more difficult and the tank fired fewer rounds. In fact, neither of the Grizzly vehicles was killed or damaged during the run. In contrast, as the scenario was being developed, and before smoke was included as a response, the T80 would normally expend all its ammunition and kill or damage both Grizzly vehicles.

With the wind coming from the northwest, the minefield became obscured. This is shown in figure 3, in a snapshot of the game during the second run of the same models. While the model representing the performance of the Grizzly did not show any degradation of the mine-clearing operation, some probably occurred (however, the information to quantify the degradation is not known). Also, while the Grizzly was hidden from the T80 the majority of the time, there were a few gaps in the smoke that allowed target acquisition by the T80 to occur and a few additional rounds to be expended by the T80. However, the additional rounds did not generate any damage or kills of the Grizzly vehicle.

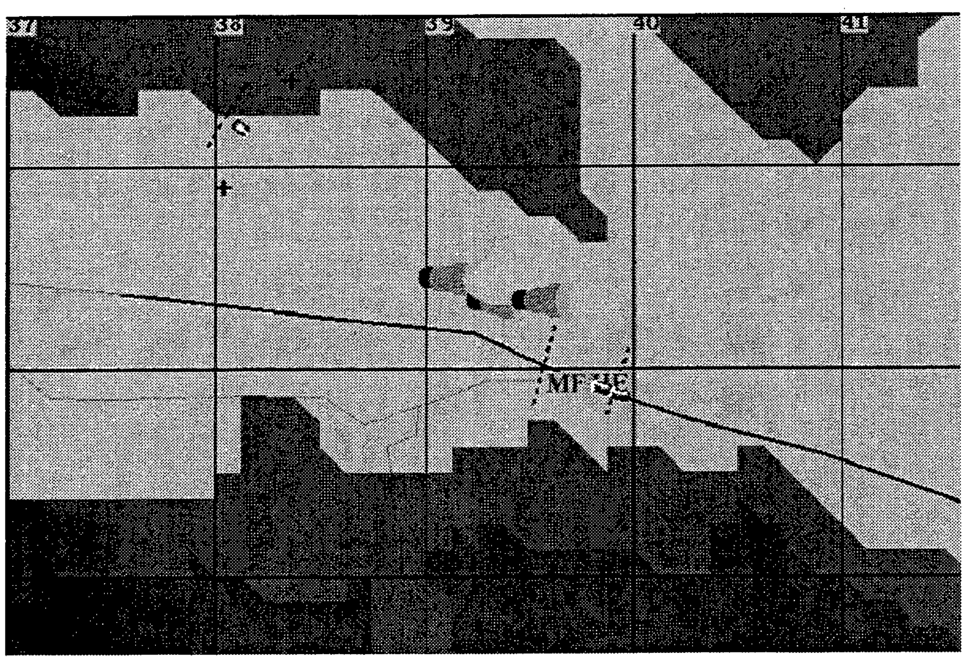


Figure 4. Smoke deployment with wind from west at 3.7 m/s.

5. Conclusions

The basic difference between the simulations performed in this experiment was the resolution of the data requested from the COAMPS databases. It is not surprising that a change in wind direction and speed can cause an obscurant to inadvertently affect the results of a simulation. Rather, the results demonstrate that significant effects can occur when data are obtained from the same source in two otherwise identical situations. If environmental data are not consistent, unexpected results occur within a simulation. Most simulations do not perform consistency checks on all the data entries into the model. If the models used in a simulation draw data from different databases (for example, from both COAMPS and TAOS), one has no assurance that the results will be consistent. Finally, if the simulation is interfaced to a live-play situation, the validity of the output of all noninteracting environmental models is subject to question.

Because the scenario was simplistic and does not include the other operational forces that would be present, the measures of effectiveness (MOEs) were not determined. Typical MOEs for this encounter would be the survivability of the Grizzly, the time to complete the breaching operation, and the number of munitions expended by the threat. It would be interesting to perform the simulations in a more realistic situation, to determine the sensitivity of the MOEs to a change in environmental parameters. This would require that the simulation have the modeling capability to tactically take advantage of the change in environmental parameters. For example, if the wind shifts direction, the location where smoke is deployed will have to be altered. For an interactive war game with a real-time player, the player can probably make this alteration. For a noninteractive war game, the appropriate rules must be written into the simulation—a more difficult task, since all possible contingencies must be modeled.

Many other factors involving the description of the environment can influence the results of an analysis. The wind does not blow at a constant speed and direction, even for the brief time (about 15 min) of a brigade-level simulation. Similarly, the rate of rain is not constant, and it varies by location on the battlefield. The importance of these phenomena in the MOE results of a simulation needs to be analyzed and a method found for incorporating them into the simulation (not an easy task). The constraint of real-time performance of a simulation is the size of the database necessary to support it; size limitations can prevent the use of detailed data in simulations. Also, if these data vary between the sources of information and the simulation does not verify the consistency of the phenomena between the two databases, this experiment has shown that significant differences in the play of a war game can occur.

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