4DWX Support for US Army Future Combat System (FCS)

4DWX and Future Combat System (FCS)

FCS(http://www.army.mil/fcs/__and__http://www.globalsecurity.org/military/systems/ground/fcs.htm) is the U.S. Army's program to modernize American war-fighting capabilities, using a network of soldiers, military leaders, technology and hardware in a complex environment. FCS seeks the capability to rapidly deploy a dominant ground force anywhere in the world within days. The goal of the FCS project is to strike an optimum balance between critical performance factors, including ground platform strategy, operational and tactical mobility, lethality, survivability, and sustainability.

NCAR's contribution to the FCS/VPG (Virtual Proving Ground) program is the 4DWX system. The **4DWX** system is a real-time four-dimensional data assimilation and forecasting (RTFDDA) system, developed in collaboration with ATEC (Army Test and Evaluation Command) to support routine test operations at six Army test ranges. RTFDDA is built around non-hydrostatic MM5/WRF models. The RTFDDA model is capable of providing high-resolution 4-D synthetic, complete weather analyses and forecasts by continuously merging all available observations with full physics (such as radiative transfer, the surface energy budget, detailed terrain and land-surface forcing, and hydrological cycle) models. Because most weapon testing and military operations rely heavily on accurate weather information, the 4DWX RTFDDA system has become a critical tool providing weather model support for operational exercises using various elements of the emerging VPG simulation test beds.

History of Developments

In late 2002, the Department of Defense started to steer 4DWX system development toward supporting VPG applications. Since then, the 4DWX modeling system has been integrated into VPG and is continuously modified and operated according to the evolving requirements of FCS/VPG field and virtual experiments. The 4DWX model not only provides direct weather maps through the internet, but also feeds the FCS/VPG weapon test models with the weather data in appropriated formats. FCS and VPG R&D involve a broad spectrum of test missions, including bio- and chemical dispersions, missile launch and control, bomb testing, parachute drops, infrared scene generation, helicopter and UAV flight dynamics, and ground vehicle trafficability**,** airdrops and so on. These missions have different requirements on the weather environment aspects and data formatting. For example, for bio- and chemical simulant dispersion experiments, knowledge of accurate weather conditions in the boundary layer are essential; whereas, for the mobilization of corps in war fields, knowledge of land surface wetness becomes more important. In the last three years, the 4DWX model was adjusted and enhanced to accommodate mission needs of the diverse FCS/VPG tests.

There are two major areas of R&D work: 1) refine and customize the model system to generate the best possible weather environments for the various special FCS/VPG mission needs, and 2) develop effective tools to interface the 4DWX model outputs with the FCS/VPG specific tools. The former includes running model simulations for specified real-time field experiments and/or given retrospective weather scenarios in different

regions with different model configurations. Special field data are incorporated into the system. The latter involves customizing a model data display, and extracting and formating according to the requirements of subsequent test models. The 4DWX model-supported FCS/VPG test missions include: 1) testing a release of a chemical weapon simulant in a virtual battleground at the Yuma Proving Ground Army test range in Arizona, 2) the MSS-P system verification experiment at the White Sands Missile Range (WSMR), 3) Dugway Proving Ground (DPG) Stryker tests at DPG, 4) trafficability/mobility-related and obscuration to visibility-related elements, 5) battle field simulation, 6) VPG Distributed Test Event (DTE) 4 and 5 at WSMR, and others.

Significant Achievements

It is worthwhile to note four additional 4DWX R&D tasks accomplished for FCS/VPG during 2005, summarized below.

1. Solar and Lunar Illumination

With collaboration between NCAR, FCS and the Astronomical Applications Department (AAD), and the U.S. Naval Observatory, the 4DWX model meteorological products are enhanced with celestial object positions, moon phase, solar and lunar illumination and soil moisture saturation computations for given regions and times of interest. Twilight duration, sunset/rise and moonset/rise times are also provided. The 4DWX model simulated hydrometeors are used to estimate the attenuation of solar and lunar illumination. The AAD Solar-Lunar Almanac Core (SLAC) software, developed by John Bangert, is interfaced with the 4DWX model to generate the full set of meteorological data and celestial information, which are provided as a bundle in GRIB format to the FCS/VPG testbed. Figure 1 demonstrates an example of the time evolution of lunar illumination over the eastern States during an summer convective episode and its modulation by clouds.

2. Parachute Drift Model

A parachute drift model was developed for calculating the air release point for a dropped payload. This model used the wind speed and direction analyzed or forecasted by the 4DWX model to determine the parachute drift at a number of vertical levels. These level displacements were accumulated to obtain the total drift from the stabilization point. The parachute drift model also calculated the deceleration from the releasing aircraft to the stabilization point, where the parachute was fully deployed and descended at a constant speed. Although short, this deployment phase accounted for a large portion of the total drift. The model was used to calculate air release points over White Sands Missile Range in September 2005.

3. UAV Applications

In 2005, potentials of the 4DWX model in support of UAV and/or other special aviation controls were evaluated and demonstrated. Clearly, flight missions in either battlefields or military bases are most vulnerable to adverse weather processes. The 4DWX model system, with its flexible relocatability and its ability to provide high-

resolution and accurate current analyses and nowcasts, provide a critical role to the small-scale flight needs in regions where operational aviation weather supports are not available or are inaccurate. A preliminary set of weather variables, including icing, turbulence and convection, are diagnosed from the model output. A protocol graphics of interactive and 3-D displays of aviation–sensitive variables are demonstrated.

4. Doppler Radar BL Wind Analysis

The fourth task is to use the NCAR/RAL VDRAS (Variational Doppler Radar Analysis System) to retrieve the boundary layer wind fields using the WSR-88D radar at the WSMR.

Vision and Plans for Future Development

In the next few years, RAL will continue to support the FCS/VPG missions. Dedicated hardware will be purchased and configured to facilitate the model execution for FCS applications. A 4DWX FCS web server will be built to provide FCS/VPG personnel a more efficient way to use the model products. New variables more commonly used by military operations, such as turbulent optical transfer, ultraviolet extinction coefficient, refraction index, visibility, windchill, and **WBGT** (a damaging heat index), will be derived to promote the 4WDX model capabilities. In order to improve the model QPF, radar wind and reflectivity and satellite cloud observations will be assimilated into the 4DWX model. With the dedicated FCS/VPG model cluster, probability forecasts with an ensemble approach will be explored for the FCS/VPG applications and microclimatologies for areas of interest to FCS and will be generated and presented to FCS users.