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FBE-J[1]: A REAL-TIME APPLICATION OF NAVAL NOWCAST AND FORECAST TECHNOLOGY

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1. INTRODUCTION

The battlegroup of today has limited capabilities in sampling the battlespace environment, fusing the available information, and sharing among its components a common picture of the relevant environment. This lack of comprehensive weather intelligence results in increased risk to the warfighter, failed missions, missed targets, and significant financial loss. Thus, the state-of-the-art for the assessment of battlespace environmental conditions is advancing from an infrequent, single-station perspective to a 4-D awareness by continuous fusion of multi-source observations and on-scene short-term mesoscale model predictions. Meteorological information in the 0-2h ("nowcast") timeframe is critical to tactical decision-making within the battlegroup, and until now, observations and real-time mesoscale forecasts have not been effectively bridged for Naval interests. NOWCAST for the Next Generation Navy, together with the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS™) – On Scene (COAMPS-OS™) at theater centers and shipboard, compose the on-scene, tactical-scale tier of the Naval Research Laboratory's (NRL) telescoping strategy for mission success. These projects have been developed to deliver necessary environmental information directly to the battlegroup to mitigate the risk associated with the absence of such integrated high-resolution data.

COAMPS-OS and NOWCAST were synthesized as components of Fleet Battle Experiment Juliet (FBE-J), July-August 2002. FBE-J was the Naval component of the US Joint Forces Command Millennium Challenge 02 (MC02) experiment, in which live and simulated exercises engaged recent technological innovations to support various experiment initiatives. One specific interest of the exercise was the determination of the joint force's ability to attain knowledge superiority. A corresponding major warfighter concern in MC02 was the establishment of an information network through concepts such as the Common Relevant Operational Picture (CROP). The CROP comprises a near real-time situational awareness of all forces on the battlefield, a network of data-sharing among all relevant agencies, decision-makers, warfighters, and applications, interoperability among forces, and an advancement in the speed at which information is gathered and distributed on the battlefield. In response to this need for complete environmental awareness, NOWCAST and COAMPS-OS were deployed during FBE-J. The system is designed to gather and fuse all available data (observed and modeled), rapidly update the user to continuously provide a very-high resolution depiction of the current weather situation, and provide the end-user with appropriate and useful products. The Joint Task Force Commander's West Coast forecasting center was stationed at Naval Pacific Meteorology and Oceanography Center – San Diego (NPMOC-SD), where the NOWCAST and COAMPS-OS systems were physically situated. Remote NOWCAST clients included the USS Coronado, Naval Air Warfare Centers at Pt. Mugu and China Lake, CA, and the Naval Amphibious Base at Coronado, CA.

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2. NOWCAST FOR THE NEXT GENERATION NAVY

The groundwork for NOWCAST began in 1998 while forward-deployed mesoscale data assimilation was established at Navy regional Meteorology and Oceanography (METOC) centers. A year later, the NOWCAST architecture, design elements, and communication requirements were documented, and a prototype system was begun. In 2002, an operational prototype was implemented concurrently with COAMPS-OS in San Diego for use in Millennium Challenge 02.

COAMPS-OS provides background model fields and hourly analyses for NOWCAST artificial intelligence algorithms currently under development; the algorithms blend these first-guess fields with observations gathered from the battlegroup and beyond, and perform real-time verification. The resulting database is rapidly updated, on the order of 5-60 min, and products are delivered to end users throughout the battlegroup via web-based client/server technology. Products are derived from the fused data, and they can be easily tailored to the needs of either warfighters or METOC personnel using the NOWCAST Java web interface.

2.1 Four-Tier Architecture

The client-server framework of NOWCAST enables all remote users on the network equal and adaptable access to all available environmental information residing in a central database. Fig. 1 is a schematic diagram of NOWCAST components. The system architecture follows a four-tier Internet design. The user directly interfaces with Tier 1, the client web browser and Nowcast applet. Tier 2 is the secure HTTP server, Java servlet engine, IRC server, and LDAP database. Tier 3 comprises the real-time, on-demand product generation, data fusion, and automated quality control. Raw data production and a database compose Tier 4.

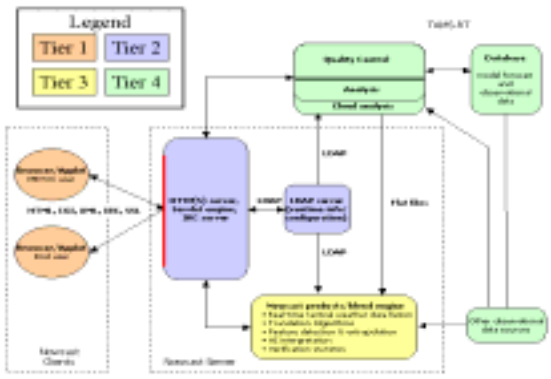

Fig. 1. Nowcast architecture showing four-tier design (from Cook et al., 2000).

2.1.1 Tier 1

Fig. 2 shows a screen shot of the NOWCAST Java applet. The applet is launched through a login web page from any web browser on the network. Users can customize folders of product "tabs" based on their specific operational tasks. To create an individual product tab, the region of interest is selected from a global map, and then products are chosen for display as shown in Figure 2. Up to two products may be displayed on a given tab, and these product images are displayed in geo-registered layers on top of a background map. Each element of the plot may be toggled on or off, including the background topography, reference lines, political or other significant boundaries, and the meteorological products themselves. Interactivity is permitted, including zooming, data interrogation, looping, creation of time series, overlay toggling, units switching, and tab manipulation. Displayed products are automatically updated in real time.

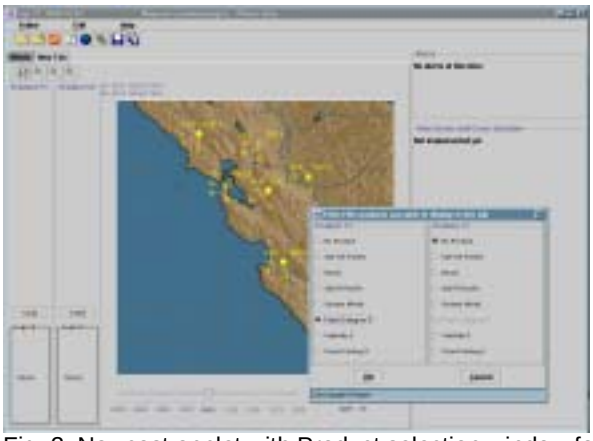

Fig. 2. Nowcast applet with Product selection window for a new tab.

2.1.2 Tier 2

The servers of Tier 2 communicate with the Tier 1 interface to provide the user with requested information as well as to push information to the user. Products in the open folder are continually refreshed as more recent data and products are made available by Tier 3 processes. Alerts based on configurable thresholds can be broadcast to the users of a particular folder. The components of this tier manage the users' configuration, runtime information, and login/authentication. Chat capabilities will allow warfighters to consult local METOC experts and conduct discussions with other users in the future.

2.1.3 Tier 3

Products are generated through data fusion processes in Tier 3. Data from Tier 4 are fused through various algorithms; products are derived from these data and pushed to the user through Tier 2. All products are created with available observations or analyses, and certain parameters are extrapolated into short-term forecasts (nowcasts) verifying over the subsequent 2h. Feature detection algorithms will be incorporated along with model first-guess information to improve these extrapolated fields. A unique feature of NOWCAST products is an end-user confidence level that is computed with each product update. When a new product is created, the old product is verified using available data at the valid time. This information is stored for 24h and the trends are used to give the end-user some indication of the confidence of the current product.

2.1.4 Data Processing Elements

1. ADAS – Advanced Regional Prediction System (ARPS) Data Assimilation System has been adapted into NOWCAST. ADAS fuses satellite and radar data with observations onto model background fields for improved hourly three-dimensional cloud and moisture fields, with future feedback into mesoscale models for initialization.
2. National Center for Atmospheric Research (NCAR) Ceiling and Visibility Algorithm – Fuzzy logic blending model fields, satellite data, surface observations, and upper-air reports and forecasts has yielded improved ceiling and visibility products.
3. Radar – A 10 min nationwide composite of Level III NEXRAD reflectivity data has been developed and implemented. Progress is being made using 3.5DVAR data assimilation to incorporate Doppler wind information into NOWCAST. Joint efforts with NCAR and the University of Oklahoma have produced more quality control processing, with intentions to include shipboard tactical radar data for meteorological use.
4. Satellite – Satellite data are processed through Terascan on a separate server. Raw fields are stored in Tier 4 and are enhanced and rendered as imagery in Tier 3.
5. Observations – Varied observations, including METARs, rawinsondes, shipboard reports, aircraft (manned/unmanned) reports, and buoy data, are integrated into NOWCAST. Observing station reports are also treated as an overlay within the applet.
6. Quality Assurance – Users can obtain product-specific verification of analyses against observations, with drill-down capability from a given region to a station history. Development of the automated verification system continues and will also allow for a human element – the METOC expert will eventually be able to perform quality control as products are generated.

2.1.5 Graphical Products

Two-dimensional products are rendered using Generic Mapping Tools (GMT) from the University of Hawaii, and transparent PNG overlays are created for display within the applet. Carrier air operations, strike warfare, and electromagnetic propagation have been established as significant priorities for NOWCAST. Carrier operations and strike warfare depend upon ceiling and visibility conditions and the accurate and continual assessment of these environmental variables. Thus, physical weather elements such as ceiling and visibility were among the initial products produced by NOWCAST; derived products with value to aviation interests, such as flight category, have also been incorporated. These are presented as color-shaded regions highlighting areas of interest (e.g. low visibility, low ceilings), and the remainder of the plot is left transparent to allow the user to see through to the background for geographical reference. Figure 3 shows a cloud ceiling product along with a station interrogation pop-up window. Satellite cloud imagery is rendered in conventional greyscale, with transparency in cloud-free regions. Radar reflectivity follows an accepted convention with transparency in echo-free regions. Multiple products may be displayed in a given tab, as Figure 4 illustrates. Radar, satellite, and observation locations are all overlaid on a topographical background.

Fig. 3. Screen shot of Nowcast applet with ceiling product with METAR interrogation.

Fig. 4. Screen shot of Nowcast applet with satellite, radar, and station locations.

Graphical NOWCAST products available throughout FBE-J included METAR observations, high-resolution surface winds, ceiling height, visibility, flight conditions, infrared and visible satellite imagery, and NEXRAD radar reflectivity. Planned products include Level II NEXRAD radar data, lightning data, icing and turbulence risk analyses, wind shear and microburst risk, electromagnetic duct height, modified refractivity profiles, and illumination. Products that necessitate a meteorological background for interpretation will be designed directly for the METOC community; derived products of value in operations and decision-making will be provided to the warfighter community.

2.1.6 Tier 4

Raw data enter the NOWCAST system at Tier 4, the database repository for all available environmental data. Fused NOWCAST fields are written back to Tier 4 and are subsequently made available for use in external applications, including chemical/biological agent dispersion models and electromagnetic/ electrooptical (EM/EO) propagation path predictions.

3. LESSONS LEARNED FROM FBE-J

Conclusions regarding the performance and utilization of NOWCAST during FBE-J are still being drawn, and will be presented at the conference. Initial reports from users indicate that NOWCAST provided remote users with unprecedented access to radar reflectivity, cloud cover, and high-resolution surface winds, at a 5-minute refresh rate. High-resolution NOWCAST and COAMPS-OS forecasts and analyses filled the voids left by sparse, irregular, and previously unassimilated observations throughout the battlespace.

For more information on NOWCAST for the Next Generation Navy, please refer to the project web site:

http://www.nrlmry.navy.mil/Apps/nowcast

NOWCAST is sponsored by the Office of Naval Research (Code 322MM), award N000142WX20459.

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