1P10.5 Ceiling Forecasts for Naval Operations in Southern California

Rodney P. Jacques*
Naval Meteorology and Oceanography Center, San Diego

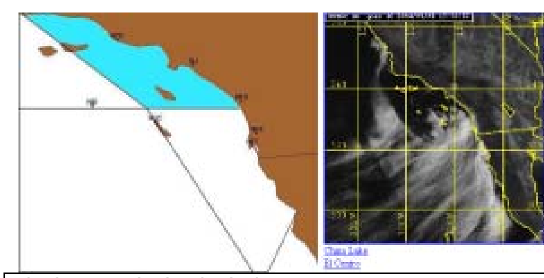
Daniel A. Geiszler
Science Applications International Corporation, Monterey, California

Rich Bankert
Marine Meteorology Division, Naval Research Laboratory, Monterey, California

1. INTRODUCTION

The coastal waters and adjacent land areas of Southern California are the primary west coast training grounds for the Navy and Marine Corp. The areas are used extensively for aviation, amphibious, and undersea military exercises. A major weather impact for Navy and Marine Units is due to low cloud ceilings produced by the coastal marine layer primarily during the summer months (May – September).

Traditionally, text based forecasts produced by Navy or Marine Corp weather personnel are used to describe the temporal and spatial variability of the marine layer. The text based forecast (Fig. 1) classified cloud ceiling as partly cloudy, cloudy, clear, or mostly cloudy. Customer feedback indicates this needs improvement due to the lack of clarity and detail. The Naval Pacific Meteorology and Oceanography Center (NAVPACMETOCCEN) San Diego is experimenting with Government Off-The-Shelf (GOTS) software and Navy Mesoscale models to produce a new class of weather products that add significant improvement over text based products.



CLOUD BASES TOPS (ft): 007-015
LOW CLOUD TOPS (ft): 012-016
WINDS ALOFT (ft deg/kts):
- *1000* - 230/08 (coastal oparea), 330/20 (outer oparea)
- *3000* - 300/10 (coastal oparea), 340/20 (outer oparea)
- *5000* - 310/20 (coastal oparea), 330/25 (outer oparea)

TURBULENCE (ft): LGT 3000-8000 FT
FREEZING LEVEL (ft): 15,000
LOWEST ALTIMETER (ins): 29.67 INS

FIG 1. Text Based Coastal Waters Forecast for Southern California.

Naval operations are focused in the littoral zone, the ocean-land interface, where mesoscale and microscale processes impact weather forecasting to a greater extent than the open ocean. The Navy envisions using real-time meteorological and oceanographic data to “Characterize the Battlespace”. The goal is to gain an asymmetric warfare advantage by collecting, processing, and exploiting environmental data on-scene in synchronization with the battle forces. (Admiral Vern Clark, Proceedings 2002)

Southern California coastal waters provide the US Navy a unique area from which to practice littoral warfare and test operational warfare systems. In support of these naval operations, NAVPACMETOCCEN San Diego has developed a methodology to “characterize the marine layer cloud heights over the Southern California battlespace”, by combining the National Weather Service’s (NWS) Graphical Forecast Editor (GFE) and the Navy’s Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS™).

2. FORECAST METHODOLOGY

Weather personnel at NAVPACMETOCCEN San Diego are trained to use a forecast funnel in their approach to synoptic analysis. This process takes the forecaster from hemispheric to mesoscale analysis with a final focus on microscale cloud dynamics of the Southern California marine layer.

In support of this process, a radical shift from text to grid based forecasting is taking place. The point of departure from past forecasting techniques is the use of the NWS GFE application (Hansen T, et al, 2001) The GFE tool is processing COAMPS model fields of ceiling height, relative humidity, wind and temperature. Additionally, satellite imagery is pushed to GFE to assist in remote area forecasting. These model grids and satellite imagery become starting points in the mesoscale grid based forecasting scheme.

A new technique used at NAVPACMETOCCEN San Diego is the use of satellite derived ceiling heights (SATCIG – See Section 3 for details on SATCIG) in the Southern California marine environment. This product is ingested into GFE to produce a persistence model of cloud coverage and cloud base height over Southern California coastal waters. SATCIG was found to be useful during the summer months when persistence and continuity were good forecasting methods.

3. SATELLITE DERIVED CEILING HEIGHTS (SATCIG)

The Naval Research Lab (NRL) has been investigating the feasibility of using data mining methods to produce cloud ceiling height estimation algorithms. Data mining methods were applied to numerical weather prediction (NWP) and satellite data in order to develop automated algorithms for the diagnosis of cloud ceiling height in regions where no local observations are available (Bankert, et al, 2004). The algorithm development resulted in a 3-step approach applied at grid point (or pixel) location: (1) determine if a cloud ceiling exists, (2) if a cloud ceiling is determined to exist, determine if the ceiling is high or low (below 1000m), and (3) if the cloud ceiling is determined to be low, compute a ceiling height. Using 18 California METAR stations as ground truth, a database of hourly GOES-10 parameters, COAMPS parameters, and observed cloud ceiling height (METAR) was created over a 2.5 year period. Three cloud ceiling algorithms were produced through the data mining process: 1) using GOES-10 data only, 2) using COAMPS data only, and 3) using a combination of GOES-10 and COAMPS data. The SATCIG product is derived from the algorithm using only GOES-10 data. Within the database, performance testing resulted in low cloud ceiling height RMSE of 189.3 m with a correlation coefficient of .64 for the GOES-10 only algorithm. The SATCIG product is received from NRL on an hourly basis. The hourly SATCIG files are post-processed in GFE by a Navy weather forecaster to account for known errors and biases. The hourly files are repackaged into a Display 2 Dimension (D2D) persistence model for ingest into GFE (Fig. 2)

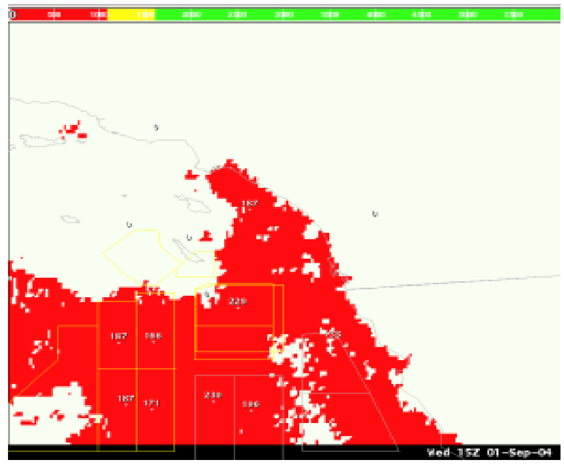


FIG 2. Satellite derived ceiling heights displayed as a D2D model in GFE.

4. COAMPS ™ CEILING HEIGHT FORECASTS

The Navy's Mesoscale model, COAMPS™ , forecasts ceiling height, surface relative humidity, 2m temperature, and 10m wind field that are ingested into GFE for use by Navy weather forecasters. (Fig. 3) The COAMPS™ model grids are used as reference tools to help a forecaster formulate his gridded forecast.

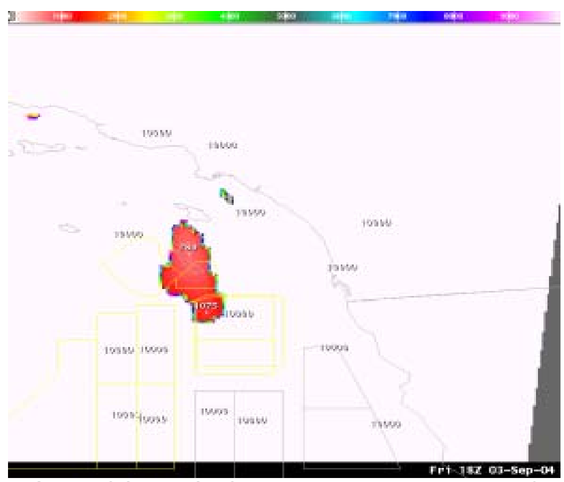


FIG 3. COAMPS Ceiling Height Forecast for Southern California Coastal Waters.

The ceiling height model output from COAMPS™ uses the Stoelinga-Warner algorithm that is based upon the concept of light extinction in the vertical due to the presence of water in the atmosphere. This COAMPS™ grid is 7-km and GFE subsamples the COAMPS™ grid to achieve a 1.25km resolution. The COAMPS™ ceiling fields are compared with SATCIG and GFE ceiling grids during the forecast process.

5. GRAPHICAL FORECAST EDITOR (GFE)

GFE has been deployed successfully to over 120 NWS Weather Forecast Offices (WFO) in the United States. The software was developed by the Forecast Systems Laboratory (FSL) in Boulder, Colorado and has undergone operational testing by NWS meteorologists.

NAVPACMETOCCEN San Diego sought to beta test GFE to help improve the mesoscale forecast methodology and tools for Southern California coastal waters. NAVPACMETOCCEN has configured GFE to ingest COAMPS model data, satellite imagery, and NRL derived satellite products.

Weather forecasting for naval operations in data sparse areas presents unique challenges to the weather forecaster. Remotely sensed satellite data attempts to address the problem by providing a data set that can be used by Navy weather forecasters who use GFE. Near real-time imagery is ingested into the grid editing software and become a persistence satellite model. Fig. 4 shows an example of GFE software at NAVPACMETOCCEN San Diego. Military operating areas (OPAREAS) are displayed in GFE, which allows for point forecasts to be obtained from gridded data.

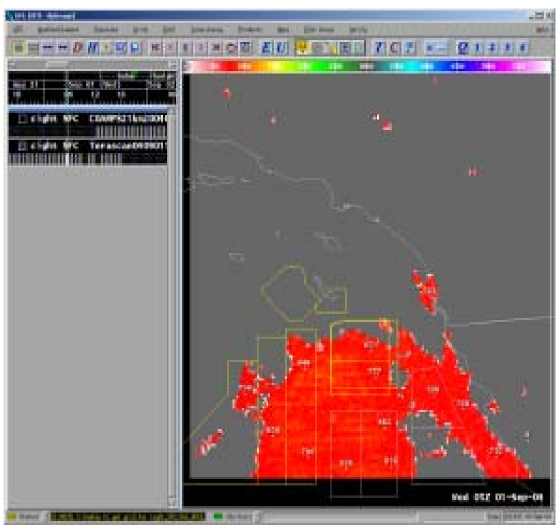


FIG 4. GFE – Graphical Forecast Editor (GFE) at NAVPACMETOCCEN San Diego.

Persistence and continuity are forecast methods used to predict the marine layer that covers Southern California and adjacent coastal waters. Fig. 5 shows a typical ceiling height forecast using persistence as a methodology.

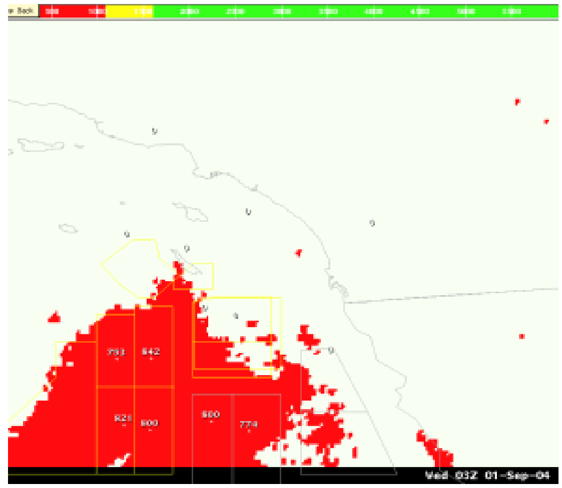


FIG 5. GFE Ceiling Height Forecast for Southern California Coastal Waters.

The persistence satellite model can be used by a weather forecaster to gauge daily changes in the marine layer. If persistence and continuity are applicable, then forecasters can extrapolate the satellite persistence model forward in time to serve as a starting point for a marine layer ceiling forecast.

6. VERIFICATION AND METRICS

GFE ceiling forecasts will be verified using METAR observations at four locations, (San Nicolas Island (KNSI), San Clemente Island (KNUC), Lindbergh Field (KSAN), and Miramar Marine Corp Air Station (MCAS).

. NAVPACMETOCCEN San Diego will test the NWS Western Region Gridded Verification method. (Cook, K., Jordan, Thomas, 2003) This process compares GFE forecast grids versus a gridded analysis, which should provide feedback to the forecaster.

Situational awareness of the cloud ceiling impacts upon naval operations can be obtained by deploying a 4 panel display as seen in Fig.5. The 4 panels will contain COAMPS ceiling forecasts, GOES-10 visible satellite pictures, GFE ceiling forecasts, and SATCIG. The real-time display of these products will help the forecaster maintain situational awareness of the rapid changes that can occur with the marine boundary layer.

The best measure of success with a ceiling height forecast is economic impact upon naval operations. A goal of the NAVPACMETOCCEN San Diego ceiling project is to record how missions were altered or cancelled due to low ceilings over Southern California coastal waters.

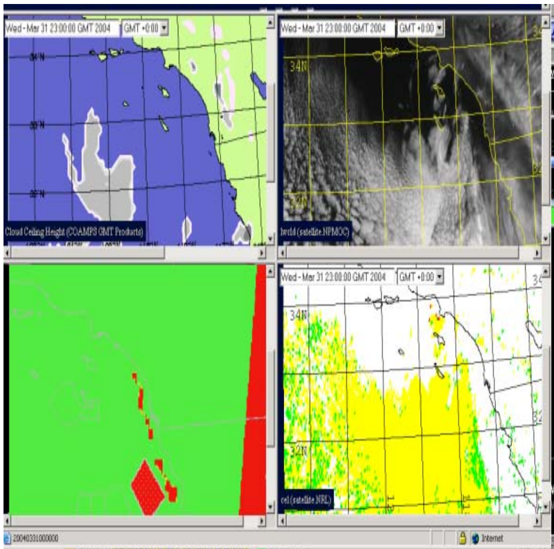


FIG 5. 4 - Panel Display

5. FUTURE

GFE and COAMPS™ are two components of a Globally Relocateable Mesoscale Forecast System (GRMFS) that is being developed at NAVPACMETOCCEN San Diego. The system will be tested over Southern California operational ranges. This is purely an experimental coupling of systems that need to be vigorously verified in a real-time environment to determine its accuracy and effectiveness for military operations.

6. REFERENCES

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