2.4 LOCAL MESOSCALE MODELS FOR NOWCASTING SPACE SHUTTLE LANDING WEATHER

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1. Introduction

The NWS Spaceflight Meteorology Group (SMG) is responsible for issuing all landing weather forecasts for Space Shuttle missions. These landing forecasts include emergency landing forecasts during launch for the Kennedy Space Center (KSC) in Florida, abort landing sites in Spain and Africa, and for the planned end-of-mission landing at KSC, White Sands, New Mexico; and Edwards AFB, California. These landing nowcasts require accurate predictions of unique Shuttle Impact Variables (SIV) over time periods ranging from 25 to 90 minutes. The specific SIV are documented in the Space Shuttle weather-related flight rules. Some of the unique SIV include mixed phase clouds at specified temperatures, detached non-transparent thunderstorm anvil clouds, and small light rain showers within 10 nm of the Shuttle's landing approach paths.

SMG has been implementing a suite of mesoscale models to provide the forecasters with additional diagnostic and prognostic information for issuing these forecasts. A wealth of observed weather data exists surrounding KSC. The 45th Space Wing at Cape Canaveral Air Force Station operates a network of wind towers and 915 MHz Doppler wind profilers. KSC operates a 50 MHz Doppler wind profiler. Four WSR-88D radars provide coverage of portions of the SMG forecast area in east central Florida in addition to visible and IR satellite imagery. In order to provide the forecaster with gridded data sets of SIV, the Advanced Regional Prediction System (ARPS) Data Analysis System (ADAS) has been implemented to provide the forecaster with high-resolution analyses at 15-minute intervals that incorporate the locally available data. This analysis system planned to be used as an initialization for the ARPS prognostic model in the near future to provide forecasters with 2 km grid spacing data.

Historically, SMG forecasters have used the Aviation model for the primary input for forecasts over Spain and northwestern Africa. The Aviation model in use at SMG currently has a grid spacing of 80 km. SMG is now running the workstation Eta model at a grid spacing of about 22 km over the Transoceanic Abort Landing (TAL) landing sites in Spain and Morocco to improve forecast guidance for emergency landings at these sites.

Examples from the workstation Eta running over Spain and northwestern Africa will demonstrate the use of model data to display unique SIV and evaluate flight rules. The utility of the ADAS analysis to monitor the SIV in the area surrounding KSC will be shown. This will include some unique displays of diagnosed cloud water/ice versus altitude. The ability of the workstation Eta to successfully depict mesoscale circulations in Spain and Morocco will also be shown. The addition of these models to the SMG forecaster's tools is a significant improvement over centrally produced model output. Forecaster acceptance of both models became universal once the output was adapted to the Advanced Weather Interactive Processing System (AWIPS) displays. Forecasters have access to data from the models at the highest spatial and temporal resolutions. The addition of the ARPS prognostic model run over the KSC domain has potential to improve significantly the prediction of summertime convection, a difficult forecast challenge.

2. ADAS at SMG

ADAS was implemented at SMG with the assistance of the Applied Meteorology Unit. The NWS Melbourne, Florida office is also running ADAS, but with slightly different input data. Case et al (2002) describes the ADAS configurations being run at SMG and WFO Melbourne, Florida in more detail. Analyses are available to SMG forecasters in three different ways: hourly GIF images via the World Wide Web (WWW) (http://www.srh.noaa.gov/smg/adas_realtime.html), hourly gridded fields in AWIPS, and the

complete 15-minute interval data using GEMPAK/GARP on supplementary forecaster workstations. The most widely used displays are those in AWIPS despite being available on the hour. SMG forecasters are far more familiar with AWIPS since most daily operations are conducted using AWIPS. Work is underway to transfer and display the 15-minute data to AWIPS. Rather than mentally integrating and inferring the amounts and locations of cloud parameters from a multitude of disparate data sources (e.g., pilot reports, radar tops, satellite imagery, and METARS), the forecaster has an objective analysis quickly available at his fingertips every 15 minutes. Objective ADAS analysis of cloud coverage and ceiling height (Figure 1) are new displays that are being used in support of Space Shuttle landing operations. Factors important for analyzing cloud electrification, such as liquid water and ice content above specified isotherm thresholds, may be diagnosed for the first time integrating numerous data types quickly.

3. Workstation Eta at SMG

Global model data is available to SMG meteorologists when preparing forecasts for the TAL sites in Spain and Morocco. Forecasters had occasionally used imagery from the Catalan Weather Services MASS model and the USAF MM5 available via the WWW and were impressed with their performance. Topography plays an important role in wind regimes at the landing sites in Spain and Morocco. It was believed that a mesoscale model such as the workstation Eta could provide added value to the global model forecasts. SMG forecasters desired more control over the model products so the SMG Techniques Development Unit implemented the workstation Eta into Space Shuttle weather operations. The Aviation model is used for initialization and boundary conditions. Model grids are available in 3 hourly intervals out to 36 hours. Like the ADAS output, the workstation Eta is available for forecaster use from 3 different sources: the WWW (http://www.srh.noaa.gov/smg/wseta_realtime.html), AWIPS, and GEMPAK/GARP. Subjective verification by the forecast staff so far has revealed that:

- Under some northerly low-level wind regimes the workstation Eta correctly simulates an increase in wind speed at Ben Guerrir, Morocco not forecast by the global models.
- The workstation Eta more frequently correctly forecasts southeast winds at Zaragoza, Spain under many terrain-blocked wind patterns.
- Wind circulations in the Strait of Gibraltar and near Moron, Spain are much more realistic than forecast by the global models.
- Like the global models the workstation Eta may overforecast low-level clouds at Zaragoza in northwest wind flow.

4. Future Considerations and Summary

Research is planned to determine if winds obtained from ADAS that follow the Space Shuttle's descent trajectory rather than using the nearest rawinsonde winds add value to predictions of Space Shuttle energy management and touchdown location.

Incorporating locally run diagnostic and prognostic mesoscale models at SMG has provided added value compared to centrally prepared model guidance. Customized displays of weather variables of interest to Space Shuttle launch and landing (SIV) may be created and used to brief mission flight controllers in new and improved ways. Mesoscale models produced by national centers have also improved greatly and may become the tool of choice in the future especially since modeling expertise is not as common in local offices.

5. Acknowledgements

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6. Reference

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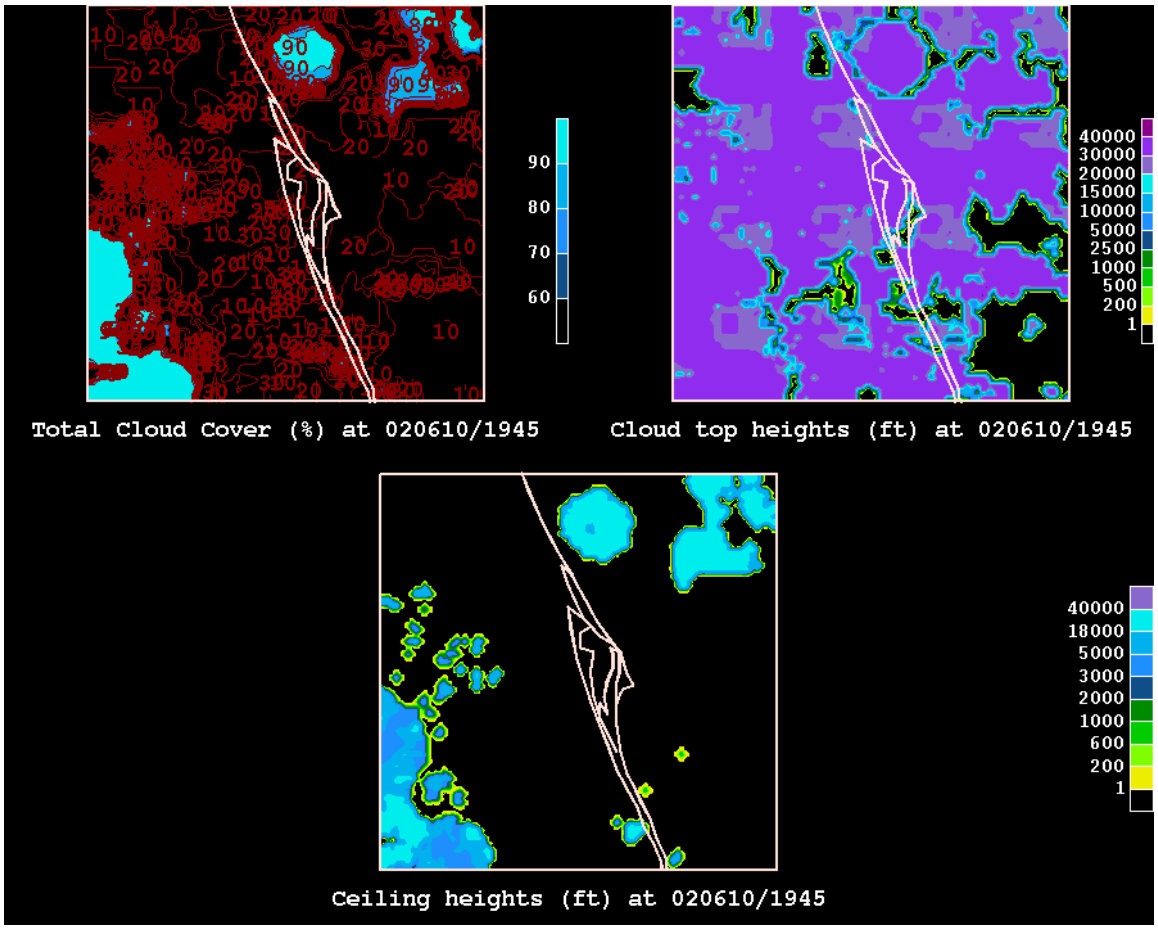

Figure 1. ADAS cloud cover, cloud top height, and ceiling analysis with 2 km grid spacing over the Kennedy Space Center vicinity.