PERFORMANCE OF A LOCAL MESOSCALE MODEL WITH DATA DENIAL

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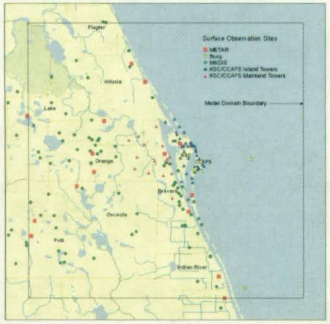
OBJECTIVE:

Determine the impact to high resolution model forecasts due to denial of local observations. Impending budget cuts may result in the elimination of some weather observation systems on KSC/CCAFS. Loss of these data may affect output from local weather prediction models. Forecasters at the 45 Weather Squadron (45 WS), National Weather Service, Melbourne (NWS MLB) and the Spaceflight Meteorology Group (SMG) use such model output for their operational forecasts.

DATA AND MODEL CONFIGURATION

- Twenty cases, split into warm and cool season candidate days
- The period of record (POR) for choosing warm season candidate days was Jun – Sep 2007. Potential warm season candidate days had to meet three criteria:
  - The 45 WS must have issued a wind advisory or warning for KSC/CCAFS
  - Days consisting of dominant synoptic-scale forcing patterns were not considered
  - The KSC/CCAFS wind towers must have recorded significant wind events, or winds greater than 18 kt
- The POR for choosing cool season candidate days was Nov 2007 - Jan 2008. The two criteria for selection included:
  - The issuance of a wind advisory or warning for KSC/CCAFS by the 45 WS
  - The existence of specific cold season phenomena, such as fronts and their associated precipitation
- Used Weather Research and Forecasting (WRF) Model Environmental Modeling System (EMS) software (STRC; http://strc.comet.ucar.edu/wrf/index.htm), Advanced Research WRF (ARW) core, Local Analysis and Prediction System (LAPS; McGinley 1995) for a "hot-start" initialization of the WRF model. Configuration included:
  - 1.3 km horizontal grid spacing centered over the KSC/CCAFS area,
  - 40 irregularly spaced, vertical sigma levels,
  - 0900 UTC initialization time, integrated 12 hours,
  - Four runs per candidate day for a total of 80 model runs, and
  - 12km North American Mesoscale (NAM) model used for boundary conditions



- Data ingested by the model through LAPS:
  - Level II Weather Surveillance Radar-1988 Doppler (WSR-88D) data,
  - Geostationary Operational Environmental Satellites (GOES) VIS and IR imagery,
  - Meteorological Assimilation Data Ingest System (MADIS) data, and
  - KSC/CCAFS wind tower and XMR RAOB data
- Compared four LAPS data ingest combinations:
  - included all available data described above,
  - all available data except mainland wind tower data,
  - all available data except RAOB data, and
  - and all available data except mainland wind tower and RAOB data

List of the physics options used for each LAPS-WRF model run

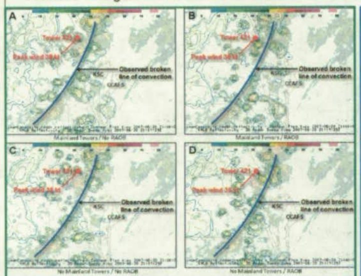
Physics Option	LAPS-WRF
Microphysical scheme	Lin et al. (1983)
Planetary boundary layer scheme	Mellor-Yamada-Janjic (Janjic 1990, 1996, 2002)
Land surface option	Noah Land Surface Model (Chen and Dudhia 2001)
Surface layer scheme	Janjic Eta (Janjic 1996, 2002)
Shortwave radiation scheme	Goddard (Chou and Suarez 1994)
Longwave radiation scheme	RRTM (Mlawer et al. 1997)

SUBJECTIVE WIND ANALYSIS

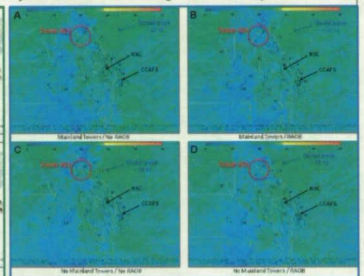
- Compared model output to observations to see if any of the four scenarios produced better results than the others and if any could provide an indicator to the forecaster that the winds may meet advisory/ warning criteria for the day

WARM SEASON CASE – 20 JUNE 2007

- The 45 WS issued a Weather Watch (winds ≥ 50 kt, hail ≥ 0.75 in and/or tornadoes) valid 1830 to 2000 UTC, then issued a Wind Warning (winds from surface to 300 ft ≥ 35 kt for KSC after a peak wind of 38 kt was observed at 2115 UTC on Tower 421 at the north end of KSC
- Observed wind gust from isolated thunderstorm was the only one that met the warning criteria that day



- 12-hr model forecast radar reflectivity (contours) valid at 2100UTC compared to 2117 UTC observed radar reflectivity (shaded) from the Melbourne, FL WSR-88D
- Model forecast radar reflectivity in all scenarios did a fairly good job depicting the observed broken line of convection extending NE to SW from offshore northern KSC and across the mainland

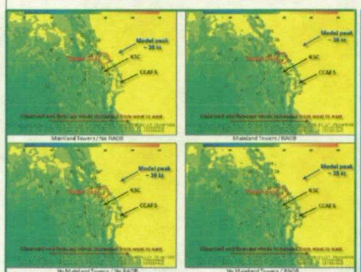


- 12-hr forecast peak wind speeds valid at 2100 UTC were compared to 2115 UTC observed peak winds
- In all four scenarios the maximum peak winds were highly correlated to the model forecast radar reflectivity

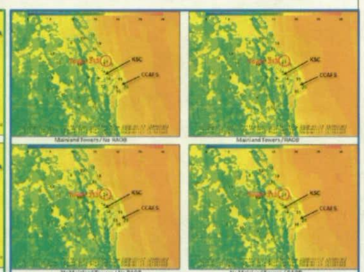
- Scenarios that included the mainland towers and RAOB (B) and excluded the mainland towers and included the RAOB (D) best matched the observed radar reflectivity in coverage, location and intensity and the observed peak winds in location and speed
- There was little difference among all four scenarios
- Although the model did not forecast peak winds at or above the warning threshold, the output provided valuable information that would allow the forecaster to be alert for convective winds requiring a warning

COOL SEASON CASE – 17 JANUARY 2008

- Synoptic scale gradient flow was the primary cause of high wind events that warranted advisories and warnings
- WRF peak wind speeds were better during the cool season in timing and location compared to the warm season which was expected as the model can better handle strong synoptic scale forcing vs. weak mesoscale forcing
- 45 WS issued a Wind Warning (winds from surface to 300 ft ≥ 50 kt) for KSC valid 1200 to 1700 UTC, then downgraded to a Wind Warning (winds from surface to 300 ft ≥ 35 kt) for KSC at 1612 UTC after observing a maximum peak of 33 kt at Tower 313 at 1500 UTC



- 1500 UTC model peak winds (shaded) at ~33 ft compared to observed winds at 54 ft (295ft Tower 313)
- Model peak winds were stronger over KSC/CCAFS and offshore than inland with peak speeds of ~20-25 kts inland, ~27-31 kts along the coast, and >35 kt offshore

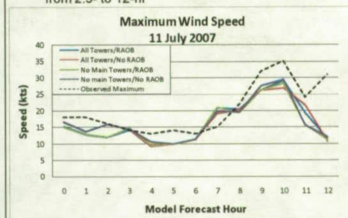


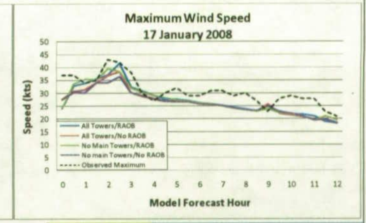
- 1500 UTC model average wind speed forecast (shaded) at ~33 ft were compared to observed average wind speeds at 54 ft (295 ft from Tower 313)
- Model average winds were stronger over KSC/CCAFS and offshore than inland with speeds of ~13-18 kts inland, ~18-24 kts along the coast, and >25 kt offshore

- Observed winds were lower than forecast, but the trend was the same with strongest winds at the coastal towers
- There was little difference among all four scenarios in this case as well as the other seven cool season cases

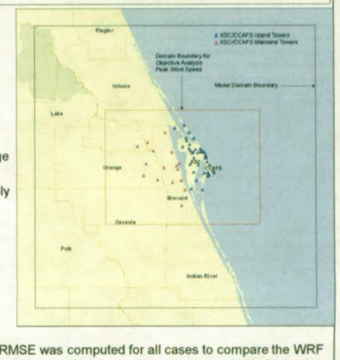
OBJECTIVE PEAK WIND ANALYSIS

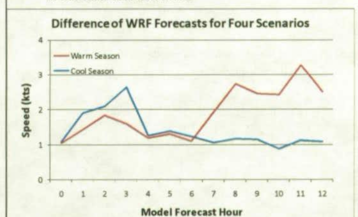
- Compared maximum model-domain peak wind speed to observed maximum peak wind speed
- 11 Jul 2007: Max observed vs. forecast wind speed for four scenarios plot for the 12-hr forecast at 60-min intervals
  - All forecasts matched the trend of the observed maximum peak wind speed: decrease from 0- to 5-hr, increase from 5- to 10-hr, decrease from 10- to 12-hr
- 11 Jan 2008: Max observed vs. forecast wind speed for four scenarios plot for the 12-hr forecast at 30-min intervals
  - All forecasts matched the trend of the observed maximum peak wind speed: increase from 0- to 2.5-hr, decrease from 2.5- to 12-hr





- Did any of the four scenarios perform better than the others with regard to the maximum peak wind forecasts?
  - Computed average difference between maximum and minimum peak wind forecasts for each hour and case
  - Warm season: four scenarios within 2 kt of each other through the 7-hr forecast, average difference for entire forecast was 1.91 kt
  - Cool season: four scenarios tracked better after the 4-hr forecast and remained within 1.4 kt of each other, average difference for entire forecast was 1.38 kt
  - Indicates the data denial scenarios performed comparably to the data rich scenarios

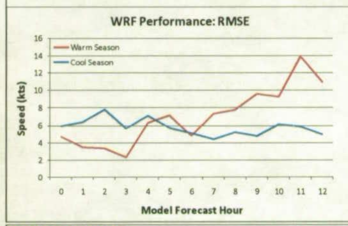




- RMSE was computed for all cases to compare the WRF forecasts to the observed maximum peak wind speeds

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(f_i - o_i)^2}$$

- Where:
  - n = 12 for warm season and 8 for cool season,
  - f = average of four forecast scenarios maximum peak wind speeds for each forecast interval, and
  - o = average of the observed maximum peak wind speeds for each WRF forecast interval
- Warm season: RMSE decreased from 0- to 3-hr by ~2 kt and then increased throughout the 12-hr forecast to a maximum of 13.87 kt at 11-hr
- Cool season: RMSE was consistent throughout forecast at ~5-7 kt with a maximum RMSE of 7.77 kt at 2-hr
- Indicates WRF performance is worse in the warm season over the sub-domain



CONCLUSIONS

- In both the subjective and objective analyses, there was little difference among the four WRF model scenarios
- The WRF model did perform better in the cool season during prevailing synoptic forcing regimes and it was also a good indicator of the threat of advisory or warning criteria wind speeds over each 12-hr forecast model run
- This would provide added value to the forecaster's daily planning forecast

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14. ABSTRACT

Forecasters at the 45th Weather Squadron (45 WS) use observations from the Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS) wind tower network and daily rawinsonde observations (RAOB) to issue and verify wind advisories, watches, and warnings for operations. They are also used by the Spaceflight Meteorology Group and Melbourne, Florida National Weather Service to initialize locally run mesoscale models. Due to impending budget cuts, some or all of the mainland wind towers and RAOBs may be eliminated. The loss of these data may significantly impact the forecast capability of the 45 WS and SMG. The Applied Meteorology Unit (AMU) was tasked to conduct an objective independent modeling study to determine how important these observations are to the accuracy of the model output used by the forecasters as input to their forecasts. To accomplish this, the AMU performed a sensitivity study using the Weather Research and Forecasting (WRF) model run with and without KSC/CCAFS wind tower and CCAFS RAOB observations and assessed the accuracy of model forecasts by comparing them to the observations.

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