3.8 Observations and Simulations of Intense Spring Sea Breezes Along the New York – New Jersey Coast

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1. Introduction

The sea breeze along the New York-New Jersey coast is most common in summer, but the strongest sea breezes occur on warm days in early spring when the sea surface temperature (SST) is still very cold. In recent years, considerable progress has been made in pinpointing and forecasting the onset and boundary of these intense sea breezes as a result of the increased density of surface observations and high resolution mesoscale models such as the fifth generation Pennsylvania State University-NCAR Mesoscale Model version 3 (MM5).

During 1998, hourly weather data was recorded at a dense network of about 50 private stations, mostly in New Jersey, in addition to the network of NWS stations. The added coverage provided a more detailed mesoscale view of weather for that year that included several cases of intense early spring sea breezes (Gedzelman, et. al., 2003). In a few cases the network revealed that a sea breeze front developed just west of the New Jersey coastline and New York City. In this preprint the intense sea breeze of 28 March 1998 is analyzed and simulated using MM5.

2. The 28 March 1998 Sea Breeze

Beginning on 26 March 1998, strong SW flow through the troposphere produced several days of record breaking warmth with temperatures as high as 30°C at inland points of the Greater New York Metropolitan region. At the time, SST's were much colder. Buoy temperatures ranged from 4°C near Boston to 6°C in the New York Bight, and IR satellite temperatures indicated almost uniformly cold waters right up to the New Jersey coastline. As a result, strong sea breezes kept temperatures from rising much above 10°C on the coast.

After about noon local time (1700 UTC) on 28 March, surface winds backed about 30º to the SSW and a strong southerly sea breeze crossed Long Island and the coastal barrier islands of New Jersey. By 1700 UTC a sharp sea breeze front had formed and extended from just west of Manhattan south to Toms River. The front remained almost stationary and persisted until it dissolved when inland temperatures fell late in the afternoon, and shortly after 2100 UTC (Fig. 1.). It appeared to be sharpened further just north of Staten Island by winds with a larger westerly component at the stations just south of the Watchung Mountains of New Jersey. The mountains appeared to deflect the winds westward on 26 and 30 March as well - other days with strong sea breeze fronts. On these days the lowest 150 hPa was stably stratified.

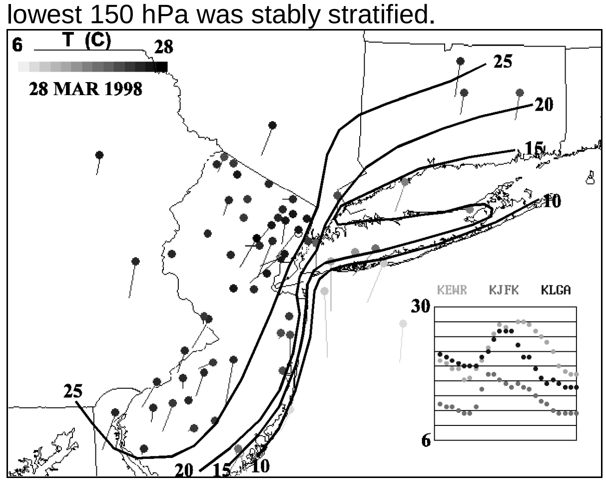

Fig. 1. Wind and temperature at 2100 UTC 28 March 1998. Heavy lines are isotherms. Inset at lower right shows hourly temperatures at KEWR, KLGA and KJFK.

3. MM5 Simulations

MM5 was run in an attempt to simulate the intense sea breeze and sea breeze front on 28 March. The model used two nests. The outer nest had 82 x 82 grid points with horizontal resolution of 7.5, while the inner nest had 37 x 37 grid points with 2.5 km resolution. The model was initialized at 0000 UTC on 28 March and run for 24 hours.

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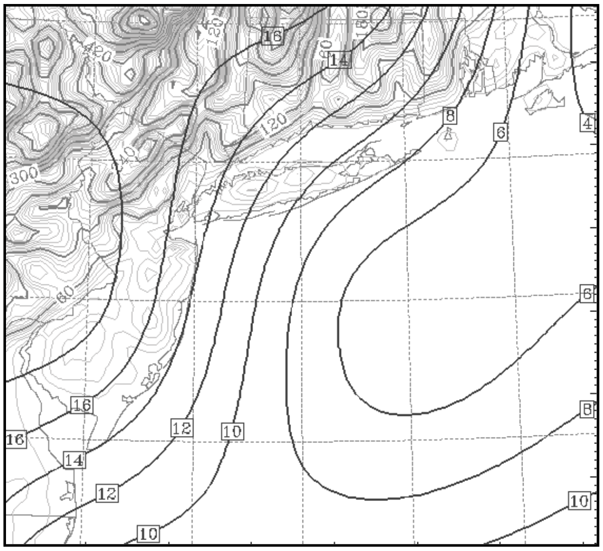

Fig. 2. MM5 produced objective analysis of the sea surface and reservoir temperatures used in Run #1.

Run #1 (not shown) failed to produce anything that resembled a sea breeze front. SW winds covered the entire outer region throughout the run, with only slight backing about 50 km east of the NJ coast. This was due an enormous warm bias of the objective SST (and reservoir) analysis near the New Jersey coastline (Fig. 2). The IR satellite images showed that water along the New Jersey coast were no warmer than 7°C whereas the objective analysis had 14°C.

In Run #2 the warm bias of the objective analysis was replaced with a zonal profile of SST and reservoir temperatures that matched observations closely over waters west of the Gulf Stream. Run #2 contained a ribbon of large temperature gradient that resembled but was weaker and developed several hours later than observed (Fig. 3). Simulated winds backed less while temperature remained higher than observed along the New Jersey coast, in good part because the surface winds over the entire domain in all runs had too large a westerly component. Surface temperatures over land were simulated accurately.

In Run #3 (Fig. 4) vertical resolution was doubled by adding 4 sigma layers in the boundary layer while cold coastal waters were retained. This led to a significant sharpening and slight westward displacement of the temperature gradient, coupled with sharper backing of the winds just off the New Jersey coast. Surface temperatures over the New York Bight were about 2°C colder than in Run #2. This resulted in a greater area of fog formation south of Long Island (the shaded region in Fig. 3).

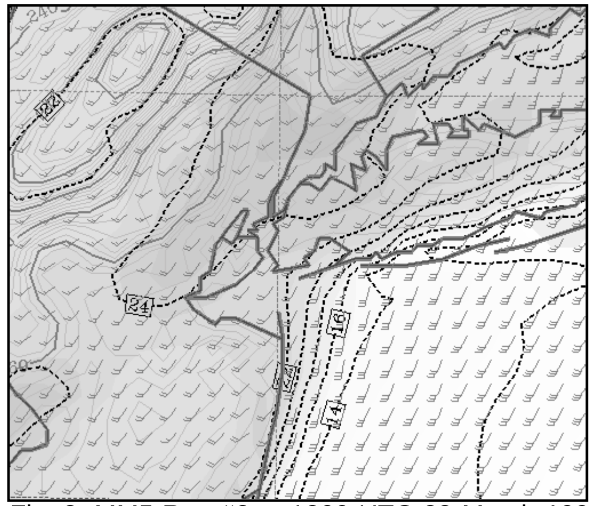

Fig. 3. MM5 Run #2 at 1200 UTC 28 March 1998 with corrected SST and reservoir temperature and 23 sigma levels. Shading indicates low humidity over land and fog over water.

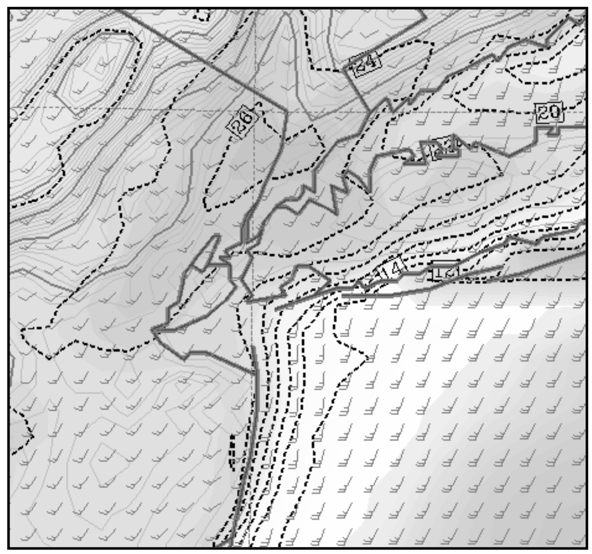

Fig. 4. Same as Fig. 3 but with 27 sigma levels (Run #3). Notice the sharper sea breeze.

In summary, MM5 captured the main features of the strong sea breeze once the objective SST analysis was corrected and vertical resolution was increased in the atmospheric boundary layer. But none of the runs captured the small region of stronger westerly winds south of the Watchung Mountains. Further experiments using MM5 with increased horizontal resolution and topography will be conducted to see if this feature emerges.

4. Reference

Gedzelman, S. D., et. al., 2003: Mesoscale aspects of the urban heat island around New York City, *Theor. Appl. Climatol.*, **75**, 29-42.