PPR - 86

MODELING TRANSPORT AND DIFFUSION IN COMPLEX SEA BREEZE WIND FIELDS

by

Walter A. Lyons, Dennis A. Moon, Roger A. Pielke

R•SCAN Corporation
1200 Washington Avenue South, Minneapolis, MN 55415-1258

There is increased concern about the suitability of operational emergency response dose assessment codes during certain mesoscale weather regimes at the Kennedy Space Center (KSC). The increased use of highly toxic chemical agents, plus the radioisotope thermoelectric generators (RTGs) on the Galileo and Ulysses space missions, culminated in the Kennedy Boundary Layer Experiment (KABLE), which acquired some of the most detailed wind measurements to date in the region. Detailed analysis of the KABLE data set for 7 November 1988 revealed that, even with the comparatively low solar angles late in the season, distinct sea and "river" breezes were present. The main Atlantic sea breeze (ASB) front began at 1500 UTC along the west bank of the Indian River and subsequently propagated inland. Embedded within the ASB was distinct convergence onto the heated land masses of Merritt Island and Cape Canaveral, plus their associated diffluent "river breezes" off the Indiana and Banana Rivers (Figure 1). These mesoscale circulations persisted until late afternoon.

ARAMS (Advanced Regional Atmospheric Modeling System), a new non-hydrostatic, two-way multiply-nested primitive equation prognostic mesoscale model, was configured to simulate the 7 November 1988 conditions. The nested grid scheme resolved general wind flow over peninsular Florida at 9 km resolution, but showed great detail in the KSC region with 1000 m local resolution. The complex wind surface wind patterns were accurately reconstructed using ARAMS (Figure 2). Importantly, sensitivity studies showed that, as the interior model grid length decreased towards 1000 m, the resolved vertical motions in the convergence zones reached the 150-175 cm/sec range, significantly higher than previous coarse-grid

simulations. Three distinct circulation cells (Figure 3) were found associated with the surface flow discontinuities.

A Lagrangian Particle Dispersion Model (LPDM) visualized the dispersion of tens of thousands of particles released from various sites around KSC, including Space Shuttle launch accidents which would release particulate radionuclides into the wind field. The results of using a completely resolved three-dimensional, time dependent wind field for dispersion calculations revealed dramatic plume behavior. Standard two-dimensional diagnostic wind field models using only the 49 surface layer wind measurements available at KSC would fail to properly account for plume transport due to regions of intense vertical motions. Complex three-dimensional, quasi-helical trajectories and streaklines were observed. Plumes from near-surface continuous point source releases often bifurcated, causing significant impacts at receptors separated by several tens of kilometers after several hours. Similar results have been obtained for simulations on the western shore of Lake Michigan. These findings have significant implications for users of Gaussian straight-line ERDACs at coastal installations where such surface wind discontinuities are commonplace. A prototype operational ERDAC using ARAMS, LPDM and Doppler sodar, implemented on a graphics supercomputer, will be discussed.

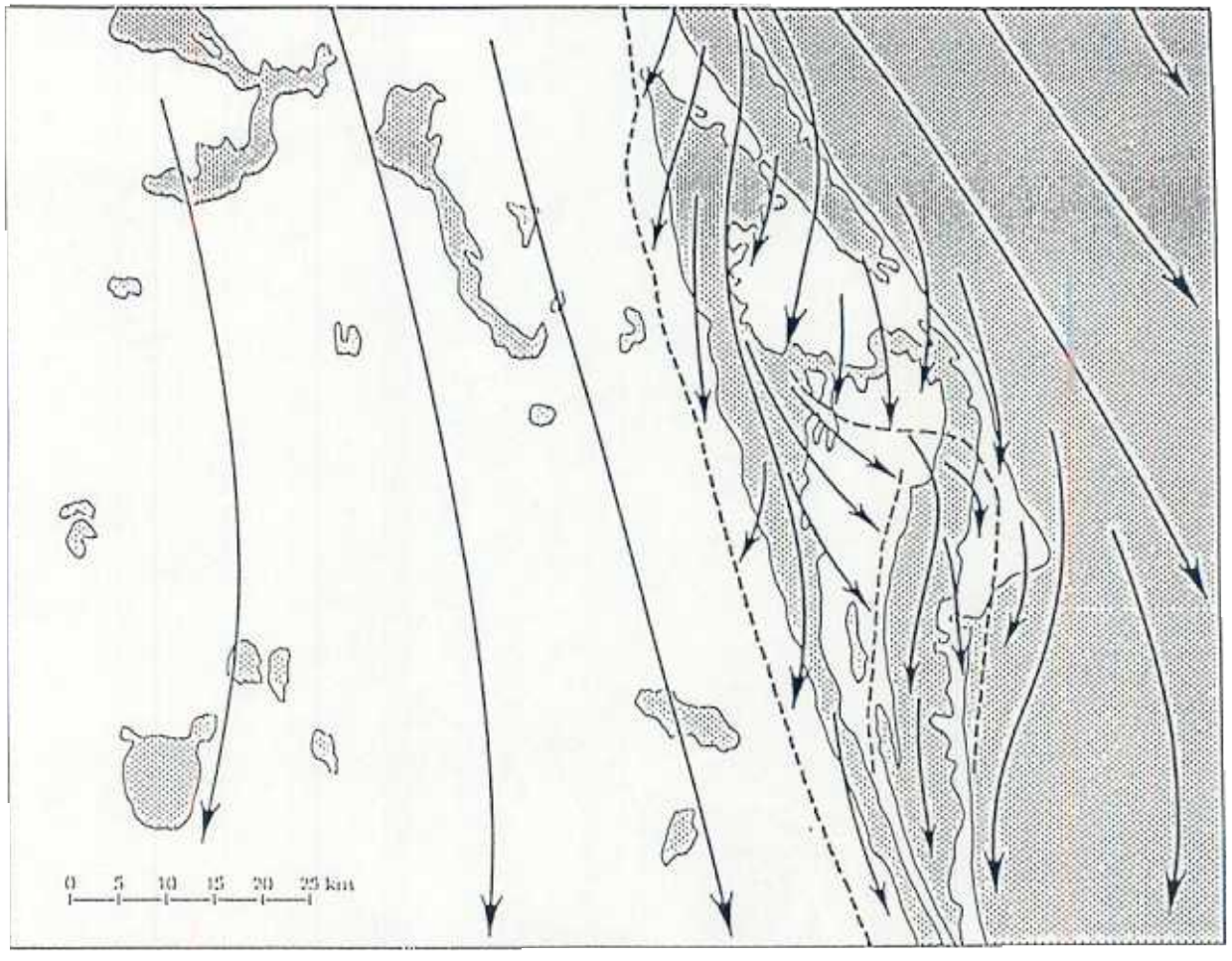

Figure 1. Observed streamlines of surface winds from the KABLE data experiment, for 1700 UTC, 7 November 1988. Convergence zones are shown as dashed lines. The main Atlantic sea breeze front had pushed about 7 km inland from the western shore of the Indian River.

Figure 2. ARAMS simulation of the 7 November 1988 surface layer winds at 1700 UTC, using a 1000 m interior grid size. Convergence zones are shown as heavy lines. All wind vectors have a component from the north.

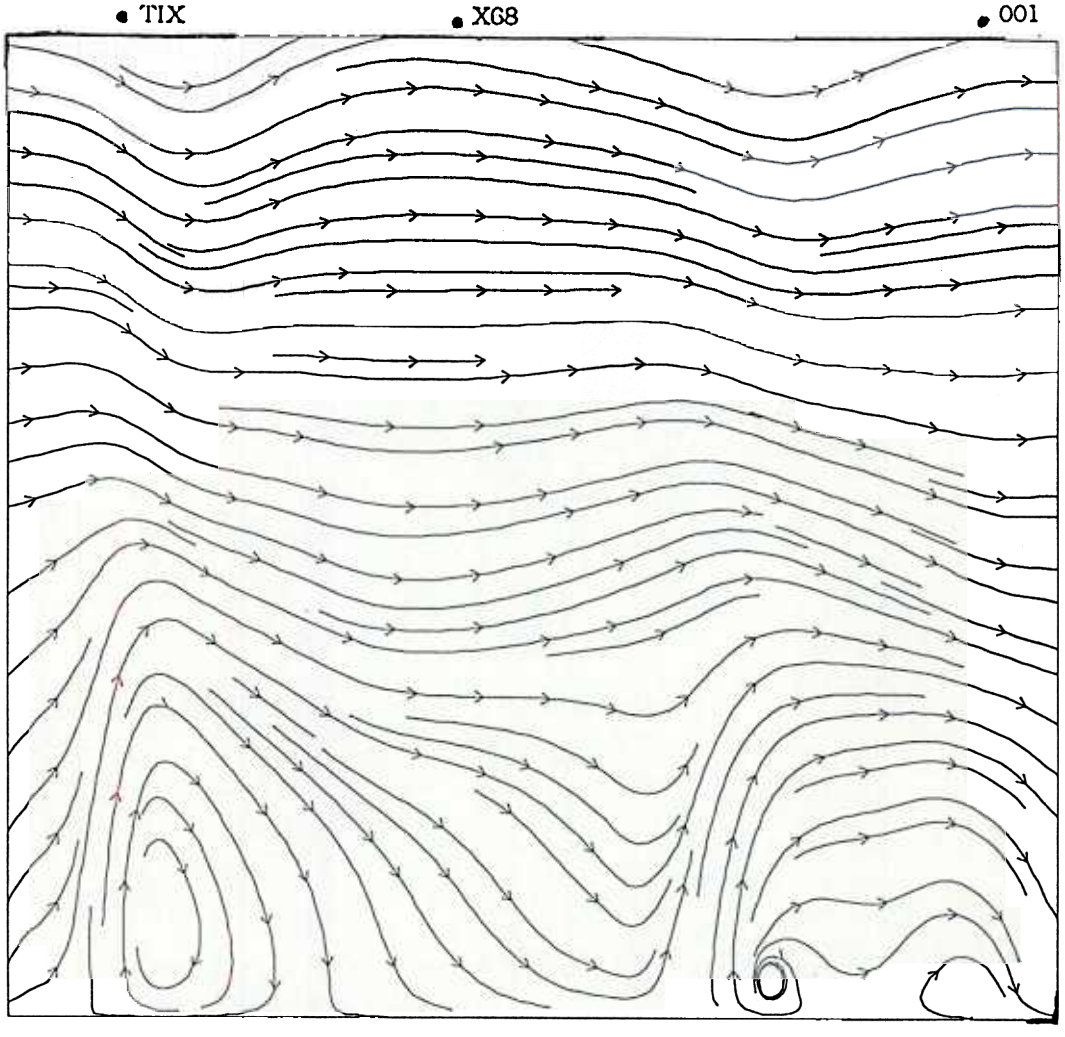

Figure 3. ARAMS simulation of the wind field, 1700 UTC, 7 November 1988, in an east-west plane, surface to 2000 m, from about 15 km inland from the west shore of the Indian River to about 3 km east of Cape Canaveral.