THE ABOVE-INVERSION MOISTURE STRUCTURE OBSERVED DURING FIRE

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I Introduction

Analysis of thermodynamic parameters obtained over the FIRE region from the NCAR Electra aircraft during ascent and descent soundings through and above the subsidence inversion reveals the existence of alternating dry and moist layers in the free atmosphere just above above the inversion. This dry/moist wedge structure has been observed before over both the tropical and subtropical oceans (Lilly, 1968; Miller and Ahrens, 1970; Riehl, 1979; and Kloesel and Albrecht, 1989). In this presentation, the structure of these layers, as well as a preliminary investigation of their source are examined.

II. Observed Moisture Structure

Three distinct types of above-inversion moisture structure were encountered during the experiment. On some flights, a single moist layer was observed above a dry free atmosphere/inversion interface (Figure 1A). On other flights, the structure was much more complex with multiple dry/moist layers (Figure 1B). Furthermore, observations on several flights show a free atmosphere above the inversion with mixing ratios higher than those observed in the boundary layer (Figure 1C).

Presently, radiosonde soundings from coastal stations from Alaska to Mexico, as well as CLASS soundings from San Nicolas Island (Schubert, et al, 1988) are being used in conjunction with the aircraft soundings to determine the regional extent of this layered structure above the inversion.

III. Determining the source of the above-inversion moisture structure

The main process that would allow moisture to be injected into the free atmosphere is penetrating convection that would occur in areas where the inversion is either weakened or non-existent. Analysis of the soundings discussed above reveal that there is no significant breakdown of the subsidence inversion over the FIRE region until the very end of the experiment (July 18, 1987). Therefore, the source region for these layers is likely to be upstream of the region. Analysis of the u and v components of the wind, as well as comparisons of soundings taken several hours apart in the same location reveal that these layers may be advected in the horizontal and vertical by the sub-tropical high pressure system. Figure 2 illustrates two mixing ratio soundings taken two hours apart in approximately the same location on Electra Flight 4 (July 5, 1987). This comparison shows a subsiding moist layer.

This mechanism of advection and subsidence of layers in the free atmosphere is in agreement with a theory proposed by Riehl, 1979, when discussing motions in the trade wind regime. It appears that sinking motion in subsidence regions does not occur uniformly over a deep atmospheric layer, but is concentrated in thin isentropic sheets that slant downward along air trajectories.

To determine the source region of these layers, 5-day back isentropic trajectory analyses from NMC Global grids (provided by John Merrill, Univ. Rhode Island) were used.

While case studies of each Electra flight are still being compiled, and some problems exist with the trajectory analysis over a data sparse region such as the Pacific Ocean, some interesting patterns are emerging. For cases that have a layered moist/dry structure above the inversion such as Flight 5 (Fig.1A), the air appears to have two different points of origin, one moist and one dry. The trajectories for this case are shown in Figure 3A,B. For cases that do not have the layered structure, such as Flight 1, only one source region is suggested by the trajectory analysis (Figure 4A,B).

IV. Conclusions and further work

It appears that the alternating moist/dry layers above the subsidence inversion/free atmosphere interface originate upstream from the FIRE region and are advected along downward slanting isentropic surfaces around the semi-permanent sub-tropical high pressure system. It also appears that the layers are meso/synoptic scale in nature, and therefore their occurrence may be predictable by current modeling techniques. Ozone data is also being used to see if the dry wedges may have stratospheric origins.

The importance of these layers with respect to boundary layer modeling and the prospects of how these layers would effect the type of air (moist or dry) entrained into the boundary layer are still being developed. However, the existence of these layers may have implications in forecasting fractional cloudiness and stratocumulus break up.

V. References

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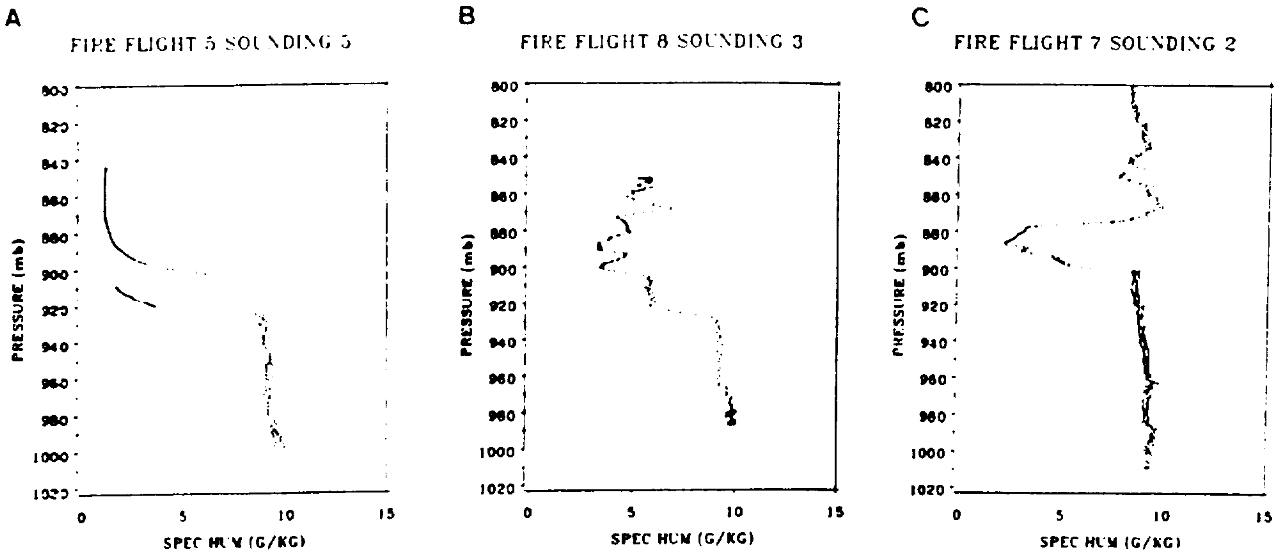

Figure 1. Vertical specific humidity (g/Kg) profiles from (A) Electra flight 5, July 7, 1987, (B) Electra flight 8, July 14, 1987 and (C) Flight 7, July 11, 1987.

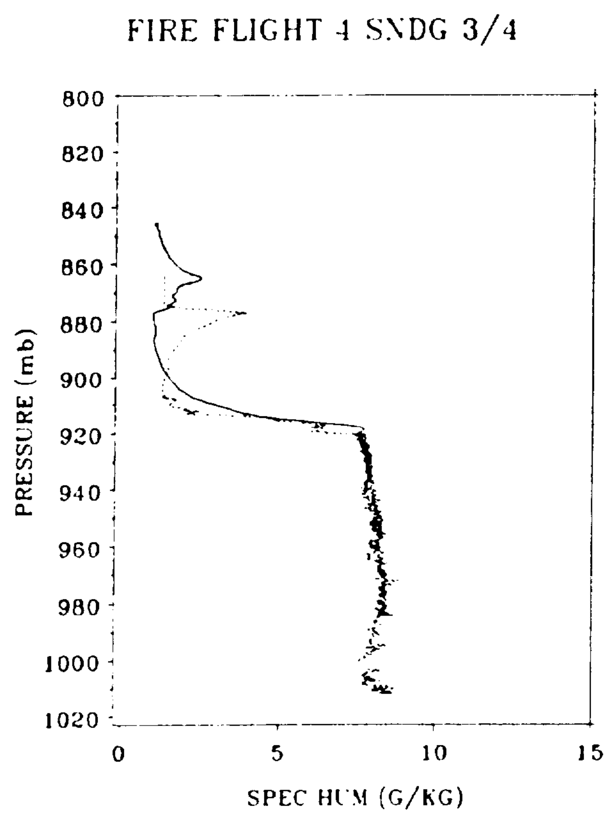

Figure 2. Vertical specific humidity (g/kg) profile from 32.5N 121.5W on Electra flight 4, July 5, 1987 at 1800UTC (solid) and 2000UTC (dashed).

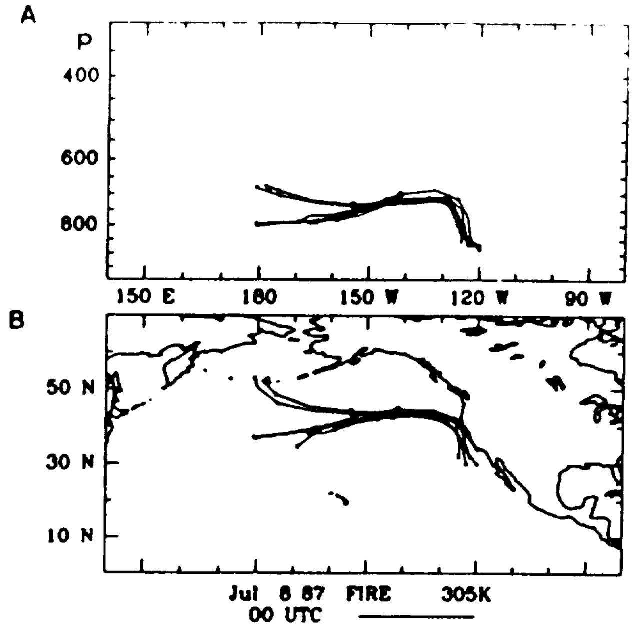

Figure 3. 305K Isentropic surface trajectories ending just above the inversion top at 0000UTC July 8, 1987 (Flight 5) in and around the FIRE region. Both the vertical (A) and horizontal (B) trajectories are provided. The distance between two dots on a specific trajectory represents the distance traveled in 24hours.

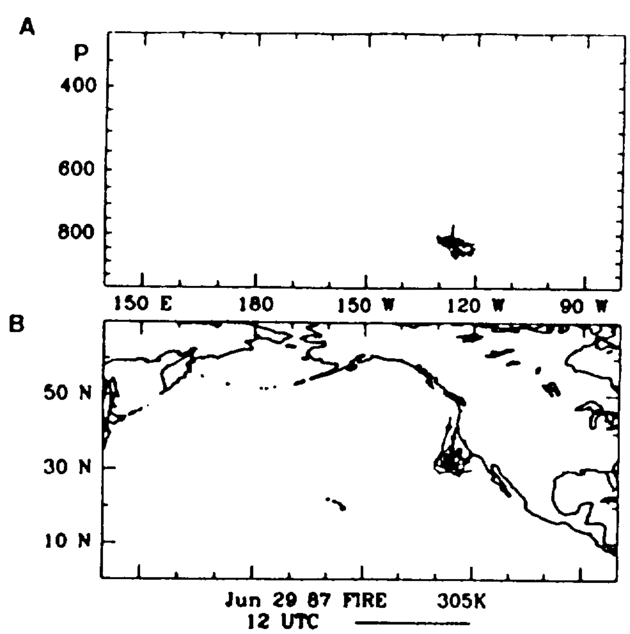

Figure 4. Same as Figure 3 but for 1200UTC June 29, 1987 (Flight 1).

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