USE OF NOAA POLAR ORBITING SATELLITES TO PROVIDE REFRACTIVE INDEX PROFILES FOR TROPOSPHERIC DUCTING MODELLING

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ABSTRACT

In the absence of conventional data, we have been investigating the use of TOVS sounding products in providing atmospheric refractive index profiles over ocean regions. These data are used to study the likely occurrence of the ducting of radio frequency communications. While improved vertical resolution and temporal coverage is desirable, the TOVS instrument presently provides the only data available over remote regions of large geographical extent. Future developments planned for sounding instruments will improve the quality of data.

1. INTRODUCTION

One of the main difficulties impeding progress in the modelling of tropospheric ducting phenomena is the unavailability of atmospheric temperature and humidity data with sufficient vertical resolution over large spatial areas. The required vertical resolution is comparable to that normally obtained by radiosondes, i.e., of the order of 100 m. However, in the case of some propagation events, this may not be adequate as it has been shown theoretically that for very intense microwave ducting events to occur sharp refractive gradients over heights of the order of metres are required. In meteorological parameters, this translates into sharp lapses in water vapour (humidity) content and/or temperature inversions. However, the refractive index is more sensitive to water vapour decrements than temperature increments. Radiosonde data have been shown to be useful for modelling purposes (but usually only providing enough data for one-dimensional modelling). For satellite sounding, a vertical resolution requirement equivalent to that of the radiosonde is the desired goal.

One important potential benefit from satellite remote sensing of refractive index is the delineation of horizontal gradients or slopes in the duct boundaries. It has been suspected from the propagation measurements across the Great Australian Bight that horizontal gradients are a necessary ingredient to maximize transfer of energy between the elevated duct and the ground terminals.

2. TWO CASE STUDIES

Curtin University supplied temperature and dewpoint profiles for 18 NOAA-9 orbits over the Great australian Bight (Figure 1) for the period January to March 1986. These profiles were produced using the VAX/VMS version of the International TOVS Processing Package (ITPP Version 3) distributed by CIMSS, University of Wisconsin. The simultaneous physical retrieval scheme using regression first guess was utilised. Near the surface profile values were calculated at pressure levels of 1000, 960, 920 and 850 mbars in an attempt to extract the maximum resolution possible from the retrievals. The data were then interpolated by ERL across an experimental VHF/UHF transmission path between Albany (WA) and Salisburg (SA), (a distance of 1800 km). Two particular orbits showing significant structure in the derived refractive profiles are discussed further below.

Attached are profiles derived from two NOAA-9 orbits, numbers 5456 and 5752. These show regularly spaced profiles along a path between Albany and Adelaide across the Great Australian Bight (obtained by gridding the data supplied by Curtin). The full-scale range of each curve is between the tick marks above the horizontal axis (maximum) and the adjacent tick mark below the axis (minimum). The refractivity shown in the middle curve is given by

$$N = (77.6\ P/T + 3.73 \times 10^5\ e/T - 1) \times 10^6$$

where N is the refractivity in N units, P is the pressure (millibars), T the temperature (K) and e is the partial pressure of water vapour (millibars). The lower curve is the modified or "flat earth" refractive index given by

$$M = N + h/R \times 10^6$$

where h is the height and R is the radius of the earth.

Height intervals where dM/dh is negative indicate the presence of radio ducting and the horizontal extent of these gradients is a major interest in this study. Orbit No. 5456 (Figure 2) shows the presence of gradients approaching, and even exceeding, negative values right across the bight which suggests the presence of a radio duct. However, there were no amateur radio operator reports of propagation. Of course, it is quite possible that a propagation opening was missed by operators. The other interesting case occurred on 21/1/867 (orbit no. 5752). The satellite profiles (Figure 3) suggest a duct with sloping walls at both terminals. Such a structure has been postulated to be the likely candidate to support propagation across the Bight. Amateur radio reports confirmed strong propagation on this day, hence this initial result is encouraging.

3. FUTURE WORK

The retrieved profiles were processed without the inclusion of surface data. There was not one ship surface observation in the region on the 18 days investigated. The data will be reprocessed using sea surface temperatures from climatology. Sensitivity to the humidity guess will be examined.

A useful set of 20 ship sondes coincident with satellite overpasses are presently under analysis. The sondes were released during scientific cruises on HMAS Cook and HMAS Franklin off the Western Australian coast (Figure 1). While the sondes will provide only point verification of the satellite retrievals, they will be a useful guide to the confidence which should be attached to the boundary layer refractive index profiles for the larger region.

4. FUTURE PROSPECTS

The limitations of satellite sounders in this work have been mentioned above. In data sparse ocean regions, however, they remain the only source of information on refractive index behaviour.

Without doubt, the higher spectral resolution sounder (e.g., AIRS - Atmospheric Infra-red Sounder) proposed for the Earth Observing System offers the prospect of a substantial improvement in the vertical resolution of atmospheric soundings. It will be possible with these new generation instruments to obtain improved structural information on the marine boundary layer adequate for identifying mesoscale situations in which ducting is favoured. The temporal coverage of a given region provided by polar orbiters will continue to be a severe limitation to studying the development of gradients in the boundary layer. Geostationary sounders of high vertical resolution, when available over the Australian region, will address this concern.

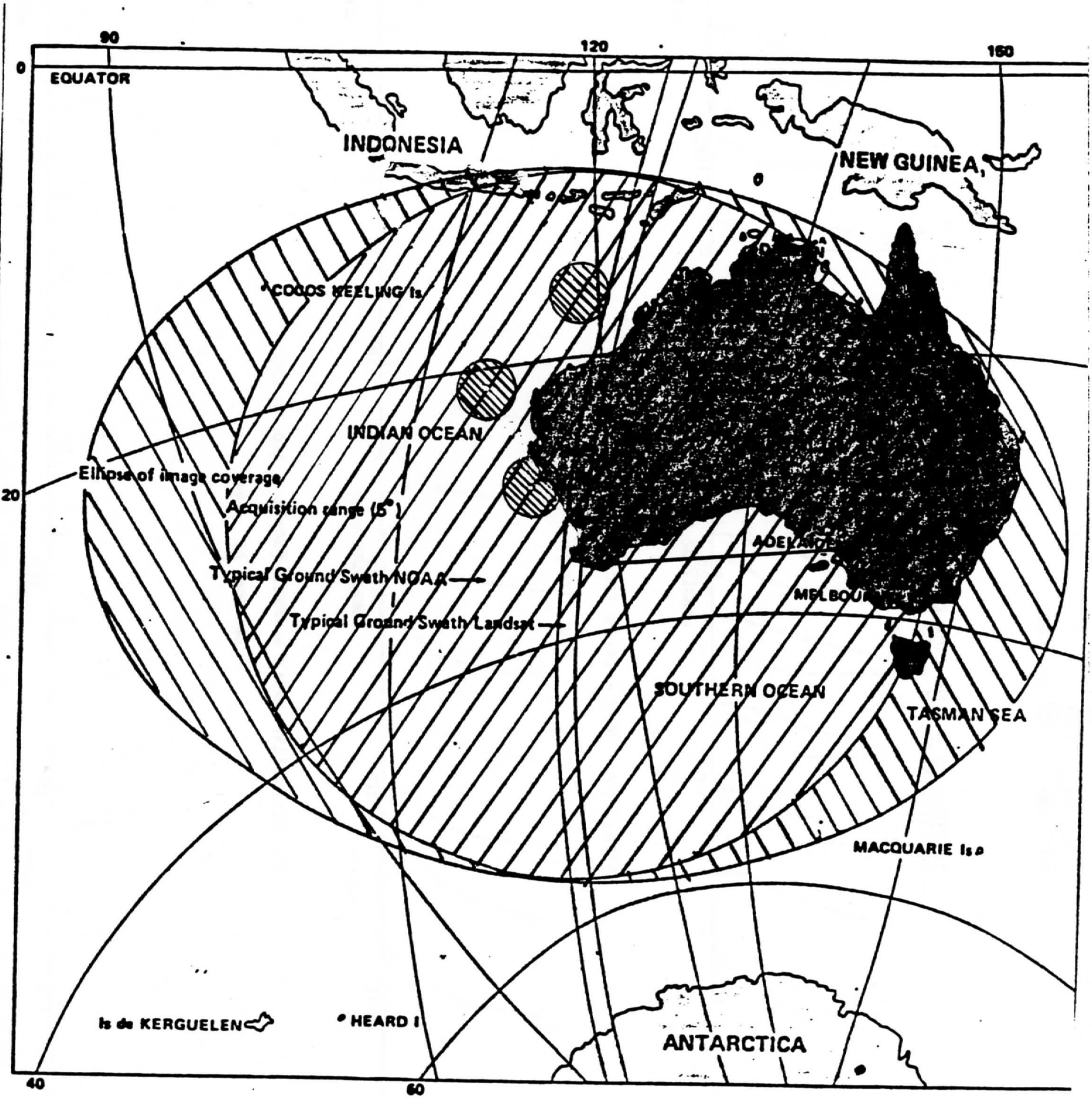

FIGURE 1: AREAS OF IN-SITU, SATELLITE AND RADIOSONDE DATA COLLECTION [].

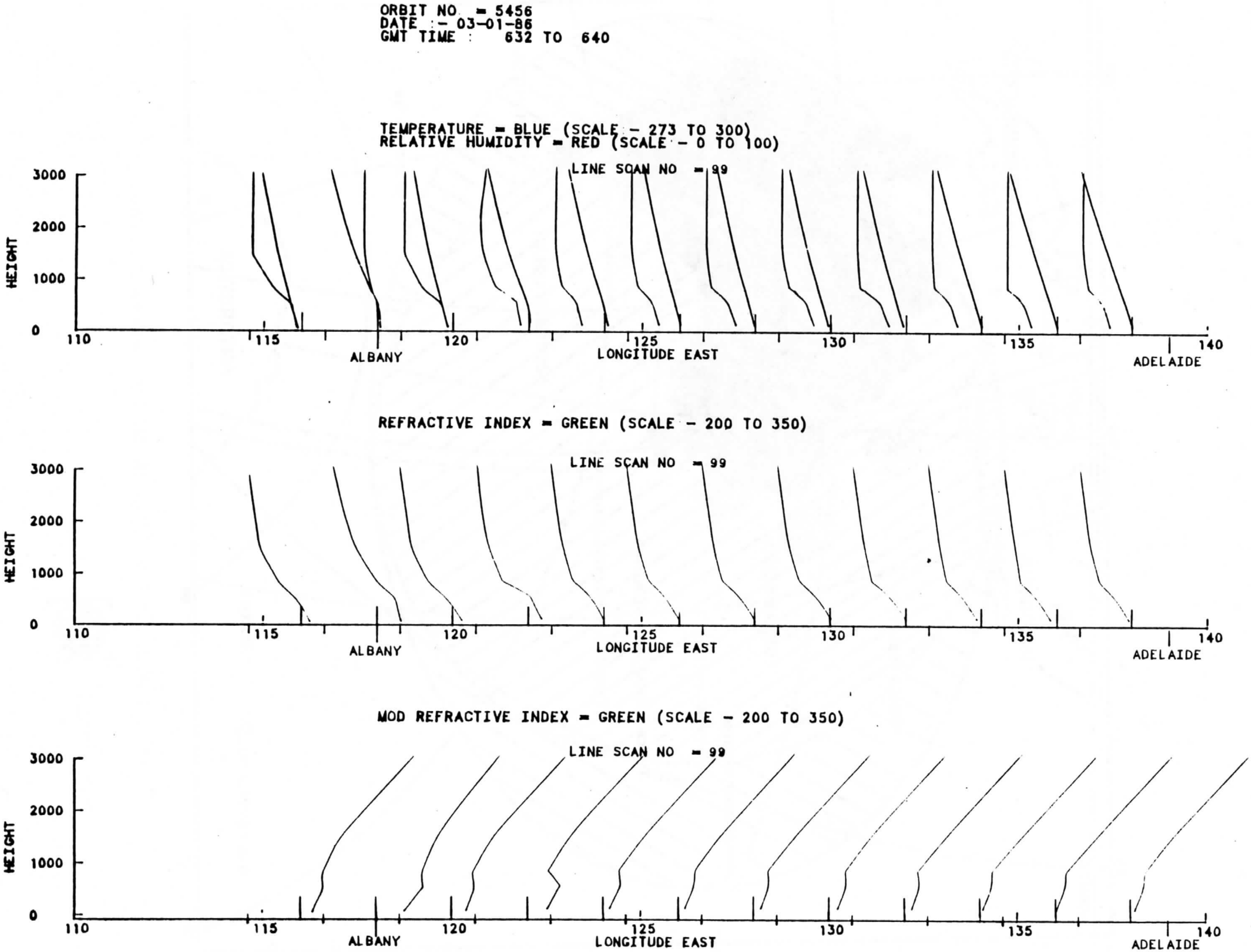

FIGURE 2: ATMOSPHERIC TEMPERATURE , MOISTURE AND REFRACTIVE INDEX PROFILES.

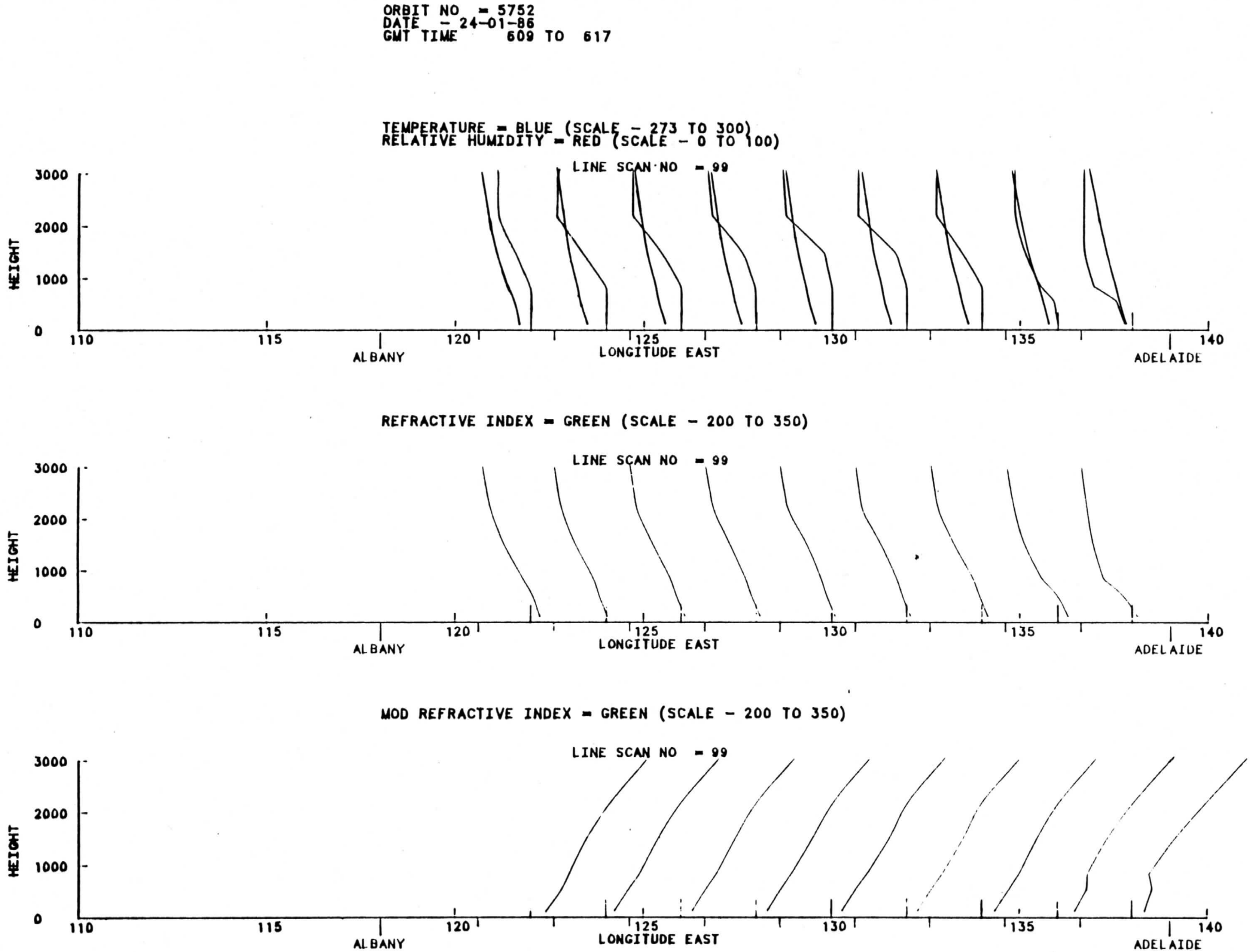

FIGURE 3: ATMOSPHERIC TEMPERATURE, MOISTURE AND REFRACTIVE INDEX PROFILES.

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