SHUTTLE DERIVED ATMOSPHERE

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The shuttle descends along a rather shallow path, thus providing some information on the horizontal structure of the atmosphere. Small scale structures have been suggested (shears, "potholes"). The best estimates of the shuttle drag coefficient and projected areas are used to go from accelerometer data to density through the use of BET's (Best Estimated Trajectories). Data are from the IMU's (Inertial Measurement Unit) and the HiRAP (High Resolution Accelerometer Package).

SHUTTLE ATMOSPHERE PRESENTATION

AT THE USRA/MSFC JOINTLY SPONSORED WORKSHOP ON

UPPER AND MIDDLE ATMOSPHERIC DENSITY MODELING

REQUIREMENTS FOR SPACECRAFT DESIGN AND OPERATIONS

November 19-21, 1985

Huntsville, Alabama

J. T. Findlay
Flight Mechanics & Control, Inc.

- Ambient parameters determined as:
  - $\rho C_N = \frac{2m\ A_N}{C_{N_P}\ V_A^2\ S_{ref}}$ (sensed density)
  - $dp = -\rho C_N\ gdh$ (hydrostatic eqn)
  - $T = \frac{P}{\rho C_N R}$ (perfect gas law)
- Shuttle descent shallow when compared to usual sounding devices thus, implications in the vertical necessarily includes some horizontal structure.
  - profile applicable to vehicles such as AOTV's, ERV's, etc.
  - small scale structure (shears, "potholes") suggested as vertical implications

DATA SOURCES

- BETs - reconstructed trajectory fit to entry tracking data defining inertial position, velocity and attitude history
- IMUs - mg instruments (tri-redundant set)
- HiRAP - µg instrument
- PRE-OP - ORBITER AERODYNAMIC DATA BASE (vintage 1978, upgrading to '82 pre-Op ADDB)
  - Predicted normal force coefficient good to ±5 percent
- DFI - pressure data for STS-3, STS-5

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COMPARISON SOURCES

- Atmospheric data
  - ROBIN spheres, thermistors - launched in support of entry aerothermodynamic research (time and spatially optimum)
    - Two separate treatments are utilized (by others) to translate these NWS data to the Shuttle ground track and vertical profile
      - Langley Atmospheric Information Retrieval System (LAIRS) files by Price of LaRC
      - NOAA "totem-pole" atmospheres by Gelman of the NWS (for JSC)
- Models (latitudinal and seasonal dependent)
  - GRAM (ρ, T, winds)
  - AF'78 (ρ, T), see Cole, Kantor - USGRL

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Shuttle Flight Data Base

STS	Date
1	April 14, 1981
2	November 14, 1981
3	March 30, 1982
4	July 4, 1982
5	November 16, 1982
6	April 9, 1983
7	June 24, 1983
8	September 5, 1983
9	December 8, 1983
11	February 11, 1984
13	April 13, 1984
14	September 5, 1984
17	October 13, 1984
19	November 16, 1984
23	April 19, 1985
24	May 6, 1985

6 spring
4 summer
5 fall
1 winter

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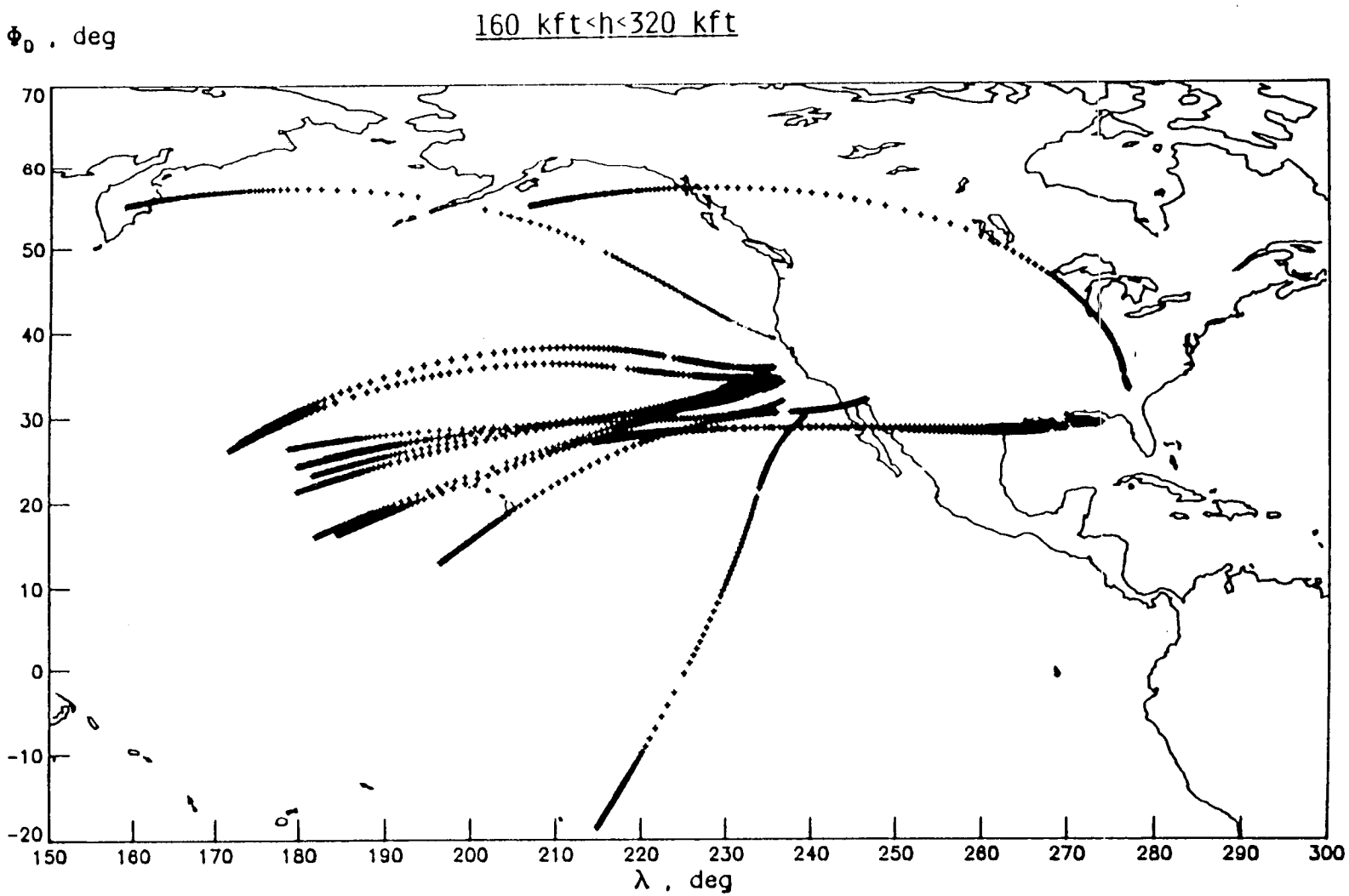

SHUTTLE GROUND-TRACKS IN MIDDLE ATMOSPHERE, 16 FLIGHTS THRU STS-24

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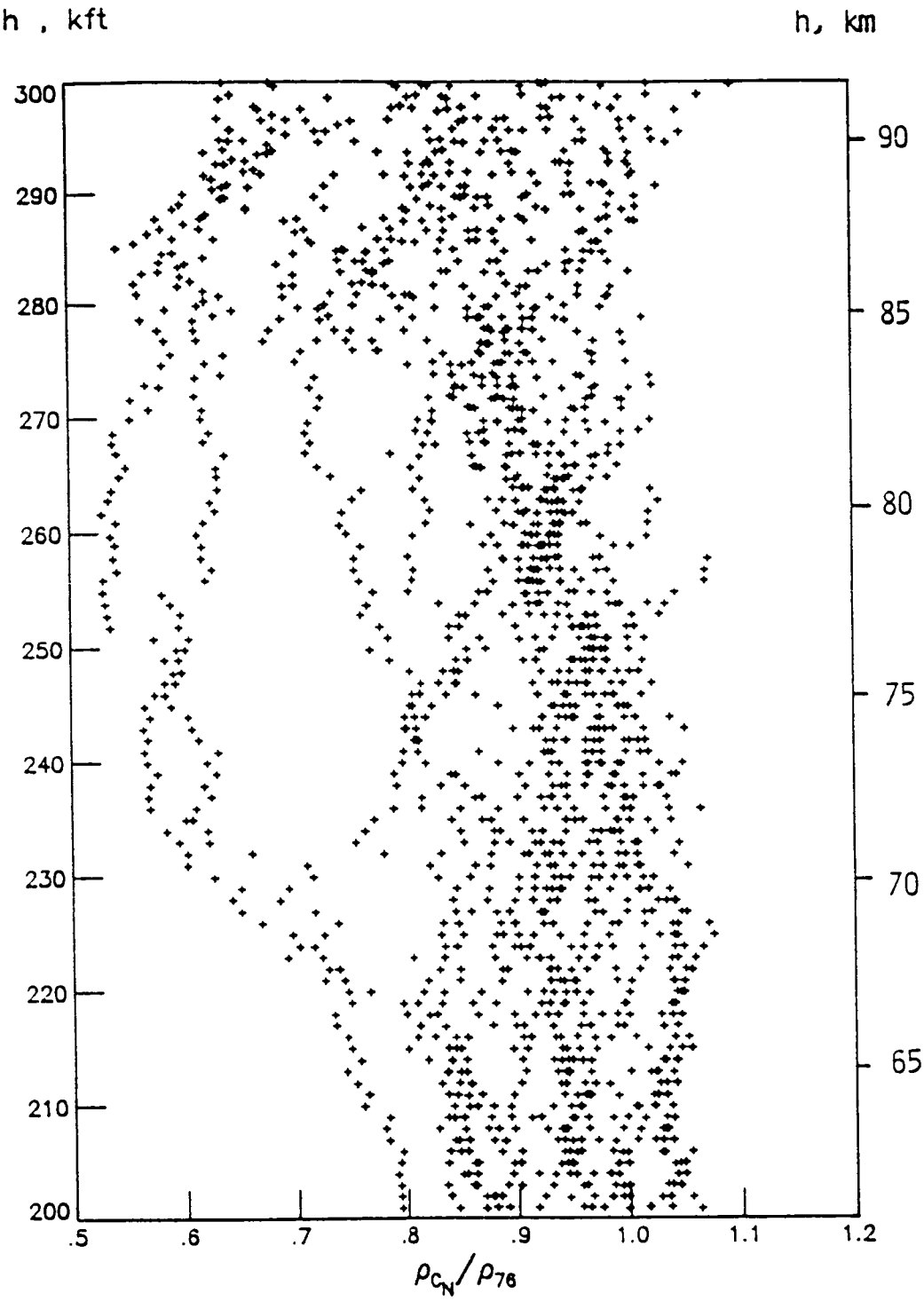

SHUTTLE DERIVED DENSITIES IN MIDDLE ATMOSPHERE

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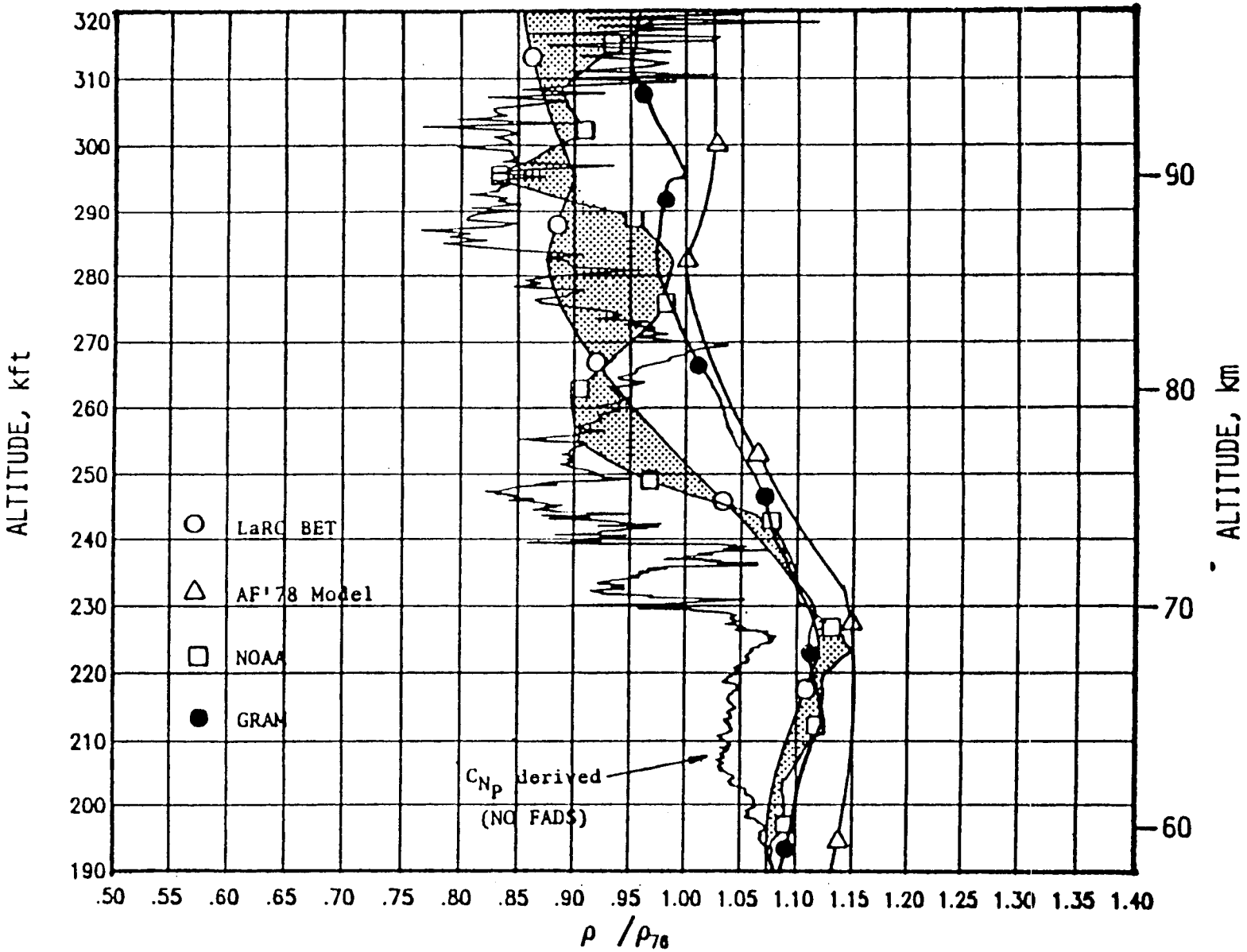

Typical Summer density comparisons [STS-4, July] showing shear structure in the mesophere.

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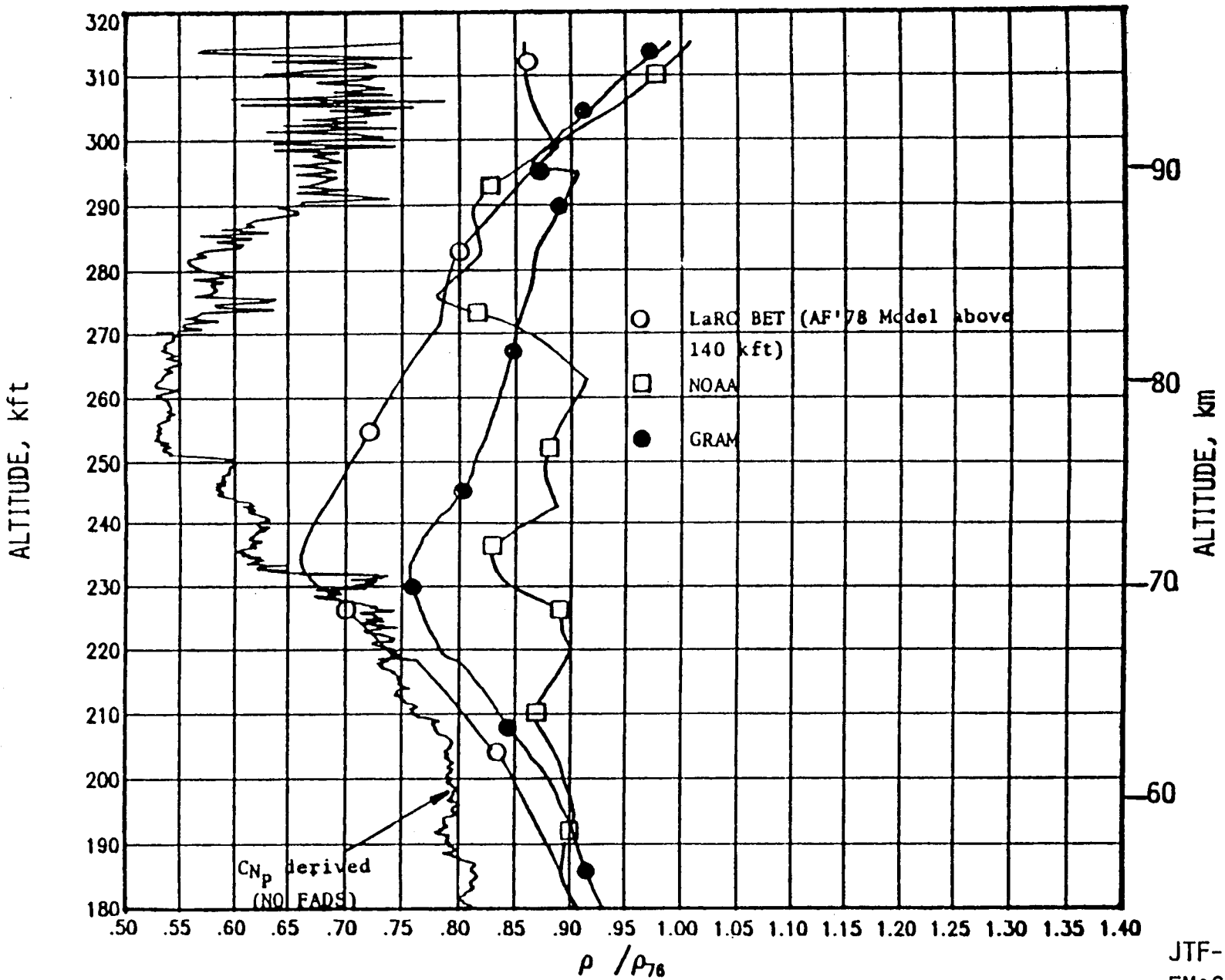

Density comparisons for more Northerly latitudes [STS-9, December]

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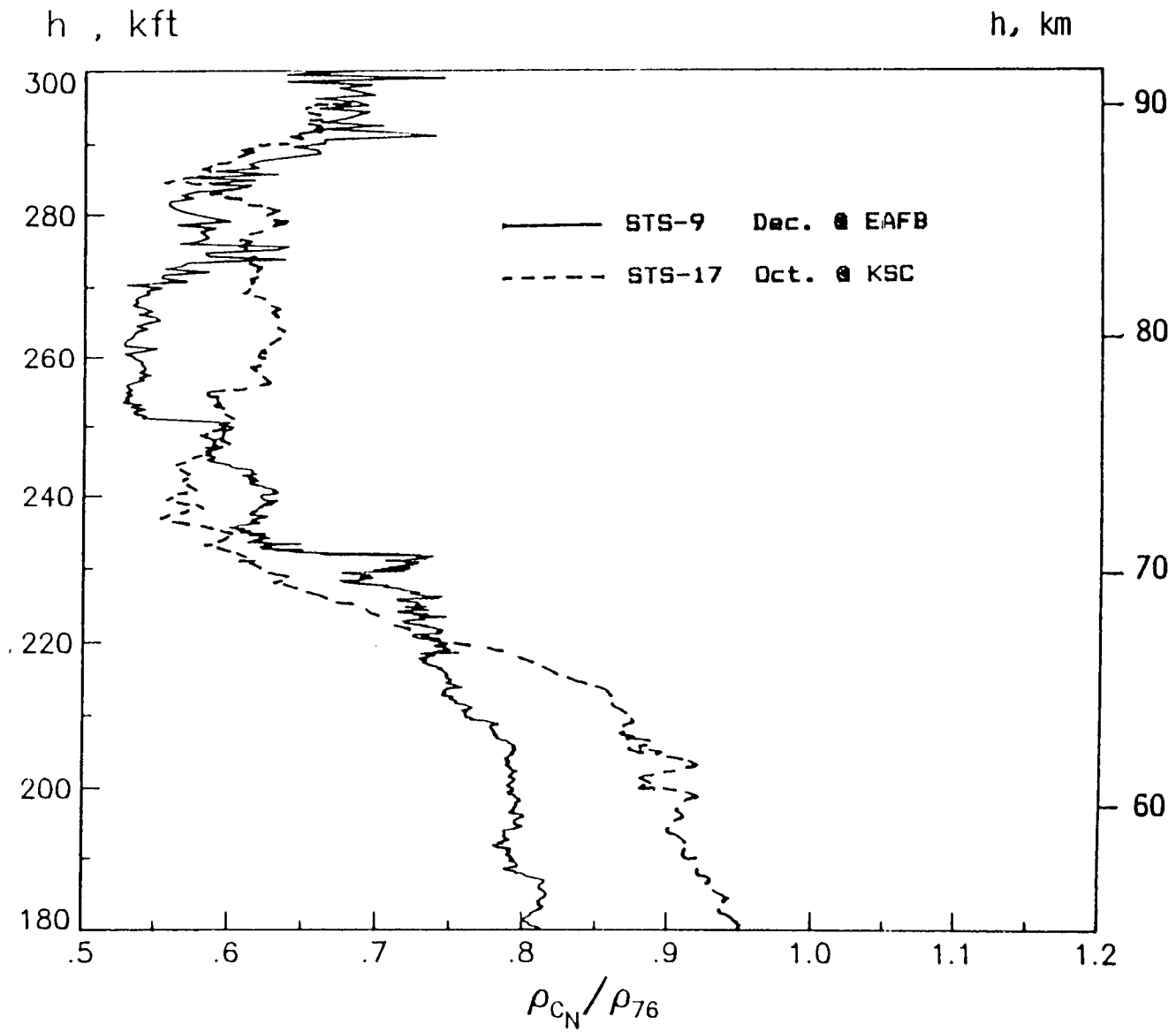

DENSITY COMPARISONS - SHUTTLE HIGH LATITUDE ENTRIES

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CONCLUSIONS

- SHUTTLE PROVIDES ACCURATE SOURCE OF ATMOSPHERIC DATA
  - INTERESTING STRUCTURE INDICATED
  - APPLICABLE FOR FUTURE NASA VEHICLE/DESIGN STUDIES
- IMPROVEMENTS SUGGESTED IN MEAN LATITUDINAL/SEASONAL DEPENDENCE OF EXISTING MODELS

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