Comments on "Density Variation and Isopycnic Layers"

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The recent article in this journal by J. W. Smith (1964), "Density variation and isopycnic layers," contains contradictory statements on the physical properties of the isopycnic level. Considerable research has been done in this area in recent years, as noted by Smith. The results of his study, however, which provide detailed information on the isopycnic levels, conflict with much of this work. It appears that Smith has misinterpreted the definition of the isopycnic level.

By definition the isopycnic level is a horizontal surface in the atmosphere where air density is approximately constant in *space* and *time*. In Fig. 2 of Smith's paper, relative deviations of January and July densities from mean annual values are shown for 21 locations. Levels of minimum variability around the annual mean densities at each location in Fig. 2 have been designated as the first isopycnic level. The densities on the various surfaces, which Smith calls the first isopycnic level, range from 0.33 at Guayaquil to 0.66 g m^{-3} at Hall Lake, and the height of the surfaces vary as much as 6 km. Since density is neither constant (100 per cent variation) nor the surface horizontal (6 to 12 km altitude range) these surfaces cannot be termed the "first isopycnic level." They are merely heights of minimum density variability at each location.

Conclusions reached by Humphreys (1950), Sissenwine, Ripley and Cole (1958), Cole, (1961), Cole and Court (1962) and Whitehead and Blick (1963) are all based on the generally accepted definition for an isopycnic level, as given in the *Glossary of Meteorology*.

The generally accepted isopycnic level is located between 7 and 8 km, has a density of approximately 0.55 kg m^{-3}, and is global in extent. Density anomalies above this level are generally of opposite sign from anomalies below this level. This isopycnic level can easily be detected on Figs. 4 through 7 (page 293 of Smith, 1964) and is quite obviously the only such level that qualifies if all four figures (time and space) are considered. It also shows up on all time and space plots of the relative variability of density contained in Mr. Smith's references.

Table 1 here presents densities at the 8-km level by latitude and month. These data taken from the report by Smith, McMurray and Crutcher (1963) indicate that the relative variability of mean monthly densities over the Northern Hemisphere is very small at this altitude. The density ranges from 510 to 530 g m^{-3} grams, within plus or minus two per cent of 520 g m^{-3}. There is no other region in the atmosphere where the relative variability of mean monthly values is less. This can be seen by examining the slopes of the density surfaces shown on the density cross sections in the report by Smith, McMurray and Crutcher (1963) and the density profiles in the report by Cole and Court (1962). Fig. 1 from Cole and Court (1962) presents the coefficients of variability of day-to-day density variability around January and July monthly means at five locations. Although the coefficients at 8 km are not always the absolute minimum they are within 0.5 per cent of the lowest at all five stations. This small day-to-day variability around monthly means, however, is only one of the characteristics of the isopycnic level. Seasonal and latitudinal variability must also be considered, otherwise the region between 2 and 12 km in the Tampa July profile, Fig. 1, would consist of either an infinite number of isopycnic levels or one big isopycnic layer as suggested by Mr. Smith in his analysis of Cape Kennedy data. Actually, it is merely a reflection of the relatively small variability in atmospheric structure in tropical regions.

TABLE 1. Densities g m^{-3} at 8 km by latitude and month.

	Latitude								
Month	0	10	20	30	40	50	60	70	80
January	530	530	530	530	520	520	520	515	515
February	525	520	530	525	520	520	510	510	510
March	520	520	530	530	530	520	520	510	510
April	520	520	525	530	530	520	520	510	510
May	520	520	520	530	530	520	520	520	520
June	520	520	520	520	520	520	520	520	520
July	525	520	530	525	525	520	520	520	525
August	520	520	520	520	520	520	520	520	520
September	520	520	520	520	520	520	520	520	520
October	520	520	520	525	530	530	524	520	510
November	520	520	520	530	530	520	520	510	510
December	520	520	530	530	530	520	520	510	510

The author states that seasonal changes north of 60 deg are as large at 7 or 8 km as at 15 km, and he presents a cross section (Fig. 12) of absolute density values to support his argument. If January and July values in this figure are converted to relative deviations around mean annual values at a specific height, the per cent deviations north of 60 deg at 8 km in this figure are roughly one-third of those at 15 km, the exact opposite of that indicated by the author. Because of the large vertical variations, relative rather than absolute values must be used in comparing the variability at various levels. With this in mind, Fig. 12 provides a good illustration of how much more stable density is between 7 and 8 km than at 15 km on a seasonal (time) and latitudinal (space) basis; it supports the findings of Humphreys and others.

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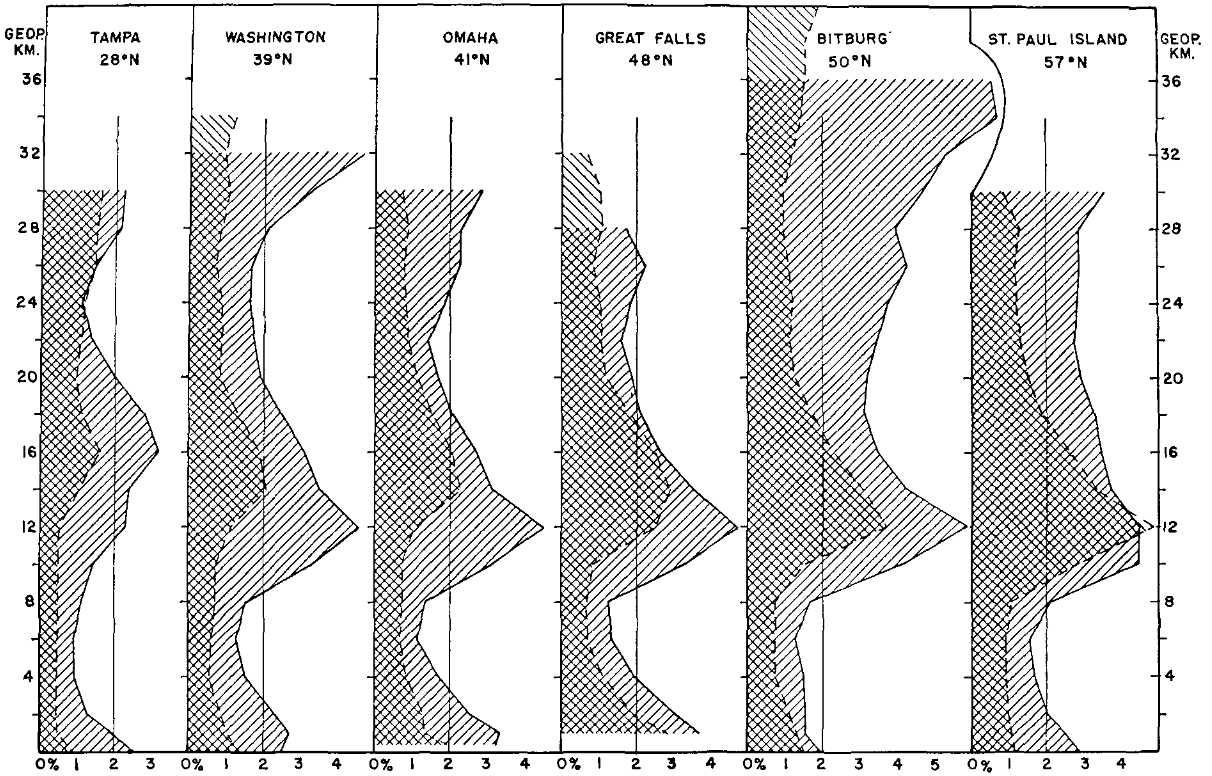

FIG. 1. Coefficients of day-to-day density variability (100 standard deviation/mean) around January and July monthly means at five locations. (Diagonal hatching represents January and cross hatching July.)

The level of minimum density variability near 26 km *is not* an isopycnic level since seasonal variability of density at this altitude is relatively large. However, for any given month or season, variations with latitude and longitude as well as with synoptic change, are small. Whitehead (1964) has found that on a seasonal basis density surfaces near 26 km are nearly horizontal, indicating little spatial variability at this level.

In summary, Smith's paper provides useful information on levels of minimum and maximum density variability, especially for Cape Kennedy, but confuses rather than improves our knowledge of isopycnic levels.

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