NOTES AND CORRESPONDENCE

Comments on "Dynamical Effects of the Variable Tropopause"

S. Kubota

Meteorological Research Institute, Tokyo

(8 March, 1966)

I have recently read Dr. Nitta's interesting paper, "Dynamical effects of the variable tropopause" on the *J. meteor. Soc. Japan*, 43, 124-137, and found some questions in the last four lines of section 2, namely, "Moreover it is also assumed that the atmosphere is isentropic in the stratosphere and accordingly $\dot{\sigma}$ vanishes on every coordinate plane".

- (1) What is the physical basis for the isentropic assumption of the atmosphere?
- (2) How can be derived " $\dot{\sigma}$ vanishes on

every—" from the above assumption?

- (3) I don't think there this assumption $\dot{\sigma}=0$ at $p=p_T$ is desirable "in treating the interaction between the tropospheric and stratospheric motions", which is imagined to be the main purpose of his paper.

Reference

Nitta, T., 1965: Dynamical effects of the variable tropopause. *J. meteor. Soc. Japan*, 43, 124-137.

Reply

Takashi Nitta

Development Division, National Meteorological Center

U. S. Weather Bureau, ESSA, Maryland, U. S. A.

(29 March 1966)

I appreciate the interest Mr. Kubota has taken in my recent publication (*J. meteor. Soc. Japan*, 43, 124-137.). Concerning the sentence to which he referred, I think that my expression for the assumption is insufficient. I should rather state as follows: "Moreover, it is also assumed that a σ -coordinate plane in the stratosphere coincides with an isentropic surface. Accordingly, $\dot{\sigma}$ is assumed to vanish so as to keep the potential temperature constant with respect to time on the σ -surface." I am afraid if my former description makes the impression that I assume a constant uniform potential temperature throughout whole the stratosphere.

Next, I would like to answer the questions Mr. Kubota presented.

1. The coincidence of a σ -surface (where

$p=\sigma p_T$) with an isentropic surface in the stratosphere is more or less a crude assumption. However, for short-term evolution of atmospheric motion, it seems to me allowable. For instance, please refer to Figure 13 of Defant and Taba (1957). Without breaks of the tropopause level, isentropic surfaces in the stratosphere are roughly parallel to the tropopause, then to the σ -surface. Physically the approximate coincidence may be interpreted as the representation of stability in the stratosphere.

2. Under assumption mentioned above and that of adiabatic motion, $\dot{\sigma}$ on an isentropic σ -surface turns out to be zero.

3. I understand that the dynamical interaction between the tropospheric and the stratospheric motions is best shown by the kinetic

energy generation term in the equation for the eddy kinetic energy. The kinetic energy generation term over a region, which derived from pressure force term in the original equation of motion, is separated to $\overline{(\partial/\partial\sigma)(\sigma\Phi')}$ $\overline{(\partial\pi'/\partial t)}$ and $\overline{\omega'\alpha'}$ in σ -coordinate system or to $\overline{(\partial/\partial p)(\omega'\Phi')}$ and $\overline{\omega'\alpha'}$ in p -coordinate and so on, where π' is a function of the perturbed pressure at the ground surface, tropopause, etc., ω' the vertical p -velocity of the eddy motion, α' and Φ' deviations of the specific volume and of the geopotential height from the zonal mean values and $\overline{(\quad)}$ shows space average over the region, respectively. Physical meaning of these two terms is evident. Since the assumption that $\dot{\sigma}=0$ at $p=p_T$ does not mean either $(\partial p'_T/\partial t)=0$ or $\omega'=0$ at $p=p_T$ and also $[\dot{\sigma}(\partial p/\partial\sigma)]$ -term at $p=p_T$ has less magni-

tude than other terms, I think we are still able to treat the dynamical interaction problem reasonably. However, as the tropopause level departs from a material and isentropic surface as time advances, we should use more realistic assumption for describing the long-term aspects of the physics of the tropopause and the dynamical coupling of the troposphere and the lower stratosphere through the tropopause. Needless to say for high resolute treatment in the vertical, we should replace this crude assumption by more accurate one, even for short-range development.

Reference

- Defant, Fr. and H. Taba, 1957: The threefold structure of the atmosphere and the characteristics of the tropopause. *Tellus*, **9**, 259-274.