

distribution is much more strongly influenced by complex atmospheric chemistry and nonanthropogenic sources, such that more sophisticated, area-specific modeling may be needed to estimate changes in this part of the distribution likely to occur as a result of programs designed to attain a more stringent O₃ NAAQS.

In addition, although not relevant to assessing direct respiratory effects, the vertical distribution of O₃ concentrations up through the mixing layer becomes important in assessing the effect of O₃ in shielding UV-B radiation. The current lack of routine vertical profile measurements means that little is known about the relative effect of ground-level control strategies on O₃ in the mixing layer.

With regard to characterizing changes in O₃ concentrations within microenvironments relevant to UV-B radiation exposure, it is clear that this set of microenvironments would differ in some respects from the set of microenvironments that were relevant for respiratory effects. For example, while indoor microenvironments can reduce exposure to both ambient O₃ and UV-B radiation, outdoor microenvironments that are relevant for inhalation exposure do not reflect the characteristics that are important for UV-B radiation exposure. Further, while not relevant to inhalation exposure, microenvironments shaded by the presence of trees, buildings, and other structures in many heavily occupied areas would be important to characterize for UV-B radiation analyses because these microenvironments would tend to have greatly reduced UV-B radiation exposures even when at the same ground-level O₃ concentration as a sunny microenvironment.

A few commenters expressed the view that estimating area-specific changes and microenvironment changes in ground-level O₃ is just as important in conducting exposure and risk assessments for direct respiratory-related effects of ground-level O₃ as it would be in conducting such assessments for UV-B radiation-related effects mediated by changes in ground-level O₃. These commenters further asserted that since EPA was able to estimate area-specific changes and microenvironment changes in ground-level O₃ to conduct the respiratory-related exposure and risk assessments discussed above (section II.A.2), then EPA should also be able to estimate such changes as part of an assessment of UV-B radiation-related exposure and risk. While EPA agrees that these factors are relevant for both types of

assessments, EPA does not agree that the same information on area-specific and microenvironment changes is relevant for both types of assessments. The EPA believes that these commenters are ignoring both the important differences, discussed above, in the information needed on area-specific and microenvironment factors to conduct the two types of exposure and risk assessments, and the limitations in the available information.

In particular, EPA's 9-city exposure and risk assessment of acute respiratory health effects of O₃ appropriately focused on the higher portion of the distribution of ground-level O₃ concentrations during the O₃ season, in contrast to an area-specific assessment of chronic UV-B radiation-related effects that would need to focus on the entire distribution of O₃ concentrations, not only at ground-level but extending up throughout the vertical mixing layer, across the entire year. While EPA has available air quality monitoring data sufficient for simulating changes in ground-level O₃ concentrations within the O₃ season associated with attaining a more stringent O₃ NAAQS, data are not generally available for simulating changes throughout the vertical mixing layer (necessary for calculating changes in UV-B radiation penetration to the earth's surface as a function of changes in ground-level O₃ concentration patterns) or for simulating changes beyond the O₃ season (which is only 4 to 5 months in many parts of the country). Further, while data are available on microenvironments relevant to direct inhalation-related exposures, data are not yet available on the different microenvironments relevant to dermal UV-B radiation exposures. Thus, while methodologically analogous, sufficient information is simply not yet available to address these factors as part of an area-specific assessment of UV-B radiation-related exposure and risk mediated by changes in ground-level O₃ associated with programs designed to attain a more stringent O₃ NAAQS.

(ii) Estimation of temporal and spatial patterns of UV-B radiation flux.

Relative to the assessment of direct respiratory effects, the assessment of the indirect effect of O₃ shielding on UV-B radiation-related health effects requires the additional step of estimating how changes in the temporal and spatial patterns of O₃ concentrations result in changes in the patterns of UV-B radiation. Given a three-dimensional pattern of O₃ levels, a first-order approximation of UV-B penetration to the earth's surface can be readily made. The factors that influence radiation flux

through the stratosphere are fairly well characterized, and most are directly related to the modest changes in stratospheric O₃ and large variations in sun angle that depend on latitude, time of year, and time of day (U.S. EPA, 1987). Nevertheless, beyond these factors, and in addition to changes in ground-level O₃, a number of other (second-order) factors in the boundary layer and the rest of the troposphere can affect the amount of UV-B radiation reaching potentially affected populations. One such factor is cloud cover, which can reduce UV-B radiation reaching the earth's surface by 50 percent or more (Cupitt, 1994). Another such factor is the presence of UV-B radiation scattering and absorbing aerosols. Depending on local circumstances and the NAAQS implementation strategy chosen, aerosol-related UV-B radiation exposure might increase or decrease as a result of ground-level O₃ reductions (U.S. EPA, 1996a, Chapter 3). Both O₃ and aerosols can affect local climate as well as UV-B radiation, and this could affect cloud cover as a further indirect consequence of a reduction strategy. While any such indirect effects might be expected to be small for modest O₃ changes, it is not currently possible to predict the magnitude or the sign of their net effect on UV-B radiation penetration.

A few commenters expressed the view that these types of uncertainties do not preclude a quantitative assessment of exposure and risk related to UV-B radiation, because assessments of environmental risks always include simplifying assumptions. While EPA agrees that simplifying assumptions could be made about these types of second order uncertainties, EPA notes that there is little information available for judging whether any such assumptions were realistic or even plausible. Thus, EPA continues to maintain that having relevant information on these factors would be important in judging the credibility of any area-specific assessment of UV-B radiation-related exposure and risk mediated by changes in ground-level O₃.

(iii) Estimation of temporal and spatial patterns of movement of people throughout microenvironments. While population densities are high in areas with the highest ground-level O₃ concentrations, people may not receive their highest exposure to UV-B radiation in such locations. Reductions in O₃ shielding would presumably be most significant in outdoor recreational areas such as the beach or rural open areas where many people likely receive a disproportionate share of their cumulative sun exposure. Local or