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LETTER TO THE EDITOR

Comments on "Comparative estimates of climatic consequences of Martian dust storms and of possible nuclear war" by G. S. Golitsyn and A. S. Ginsburg

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Golitsyn and Ginsburg (1985) have attempted to draw some similarities between the effects of dust storms and those of a nuclear war. The authors use a rather simplified model to reach their conclusions. It seems to me, however, that some assumptions on which the model is based are incorrect, so that rather contradictory results are reached.

First of all, the assumption of using a single atmospheric temperature (T_a) both for the upward and downward IR flux has some unphysical consequences. Using their formula (2.7) to calculate T_s, with $D = 0.14$, $A = 0.3$ and $\alpha_s = 0.45$, we get $T_s = 282.6$. In order to get $T_s = 288$, consistent with α_s and A observed, a value of $D = 1.28 \times 10^{-2}$ should be used.

To prove their formula, the authors show that it works satisfactorily for a CO_2 doubling. To obtain $T_s = 288$ with $D = 0.14$, α_s should be 0.594, which implies $\alpha = 0.10$, a rather low value for atmospheric absorption. The climatic sensitivity parameter (Lacis et al., 1982) turns out to be 0.35, while for CO_2 only, the same parameter is 0.5. This kind of test is rather inconclusive and does not represent any improvement over the assumption of a surface flux given by σT_s^4. As is well-known, when $\Delta T_e \sim \Delta T_s$ (with T_e, effective temperature), this approximation also gives $\Delta T \sim 1.2°K$ for a $4\ Wm^{-2}$ perturbation in the outgoing flux. However both approximations only work for very small perturbations and it is rather surprising that the method is applied to calculate the effect of such large deviation introduced by a dust storm or a nuclear winter.

Turning now to the specific application of this model to the smoke or dust perturbation, again some assumptions seem incorrect. The authors, for example, assume that optical thickness of dust at visible wavelength (τ_s) is about four times the same quantity at infrared wavelengths (τ). For smoke particles, the assumption is $\tau_s = 10\tau$. Calculations available in the literature (Coakley and Grams, 1976) and more recently by Ramaswamy and Kiehl (1985), give a completely opposite result with $\tau_s \sim 30\tau$ for smoke and $\tau_s \sim 60\tau$ for dust. We have carried out independent calculations for a lognormal distribution with $\sigma = 1.9$ and $r_m = 0.15\mu$. For $n = 1.5–0.001i$ (dust), we get $\tau_s \sim 50\tau$ and for $n = 1.75–0.3i$ we get $\tau_s \sim 10\tau$. This, of course, has some consequences for the authors' conclusion, in the sense that D is much less affected, especially in the case of dust. In this way, T_s could be even lower than the value reported by Golitsyn and Ginsburg.

However, a major objection can be raised to the way the authors deal with the albedo of the earth-atmosphere system A. They report cases with $A = 0.3$ and 0.1, the latter value being approached when $\tau \to \infty$. We regard A as a dependent parameter which cannot be fixed independently of α_s. To illustrate this point, we have calculated A for a simple atmospheric layer over the ground to which a reflectivity Rg is assigned. Transmission T, reflection R for the layer can be calculated with the well-known Sagan and Pollack (1967) formula. This layer can be combined with the ground, and thus to calculate the albedo A, the downward and upward flux at the ground and consequently, α_s. This can be done following, for example, Lacis and Hansen (1974). Taking into account the smoke particles with $\omega = 0.5$ and $g = 0.5$, we found for $\tau_s = 5$, $R = 0.1$ and consequently it does not make any sense to report these cases with $A = 0.3$. If we calculate the same reflectivity for a dust layer ($\omega = 0.9$, $g = 0.7$) for $\tau_s = 2$, we get $R = 0.2388$, $T = 0.4748$. If we impose $A = 0.3$, we have $Rg = 0.254$, and $\alpha_s = 0.376$. Going back to the Golitsyn and Ginsburg formulae, we calculate $T_s = 279.9$ and $T_a = 253.3$, while for the same case they have $T_s = 257.3$ and $T_a = 255.0$ with $\alpha_s = 0.5$ (unperturbed) and $D = 0.14$ (unperturbed). We see that imposing consistency between A, α_s and Rg we do not get any cooling.

This example also illustrates that the approximation of reducing α_s by $e^{-r_s \tau_s}$ can be rather crude. In case of $\omega < 1$, the effect is not important because T is always low at least for large optical depth. However, in the case of $\omega \sim 1$, the approximation used by the authors can drastically underestimate α_s. For the example discussed above, the transmission would be $e^{-r_s \tau_s} \sim 0.295$, while we found 0.4748. It is to be noted that we have found the former value by diurnal averaging the $e^{-r_s \tau_s}$ transmission given by the author. From their work, it is not clear whether this averaging is carried out.

Finally, it is rather surprising to note that some general arguments on the effects of dust or smoke on the atmospheric circulation have been developed by Golitsyn himself (Golitsyn, 1970), but are neglected here. However more recent works (Held and Hou, 1980; Schneider, 1983) deal with the effect of an isolated heat source in a rapidly rotating atmosphere. The main results seem to be an enlargement of the Hadley circulation.

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