THE RADIATIVE-ADIABATIC MODEL AS THE BASIS OF THE GENERAL CLIMATE THEORY FOR A WIDE RANGE OF ENVIRONMENTAL CONDITION

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ABSRACT

Historically it was developed so, that the traditional models of greenhouse effect are used as the basic approximation a planet, devoid of atmosphere. Today, when we know that the contribution of an atmosphere into the general thermal radiation of a planet (Earth, Venus) may considerably exceeds the contribution of a surface, time has started for creation the new class of greenhouse effect models which take into account this fact. In this paper are analysed the basic approximation of radiative–adiabatic model from this class.

While analysing difficulties of traditional radiative-convective models of atmosphere, the basic attention is given to examination of the paleoclimatic data obtained as a result of ice-boring at Russian station "Vostok" in Antarctica. This examination evidently demonstrates that radiative-convective models are not applicable for description of climate of planets with the high optical density of atmosphere.

Taking into account the significant contribution of greenhouse effect in formation of climate of planets, the development of adequate model of greenhouse effect is important for creation General climate theory, suitable for the description of a wide class of planets with various planetary environment. In turn, the creation General climate theory is obviously necessary to study the problem of coevolution of life and planetary environment.

1. RADIATIVE-ADIABATIC MODEL. BASIC APPROXIMATIONS

The basic approximation of radiative-adiabatic model of greenhouse effect is the assumption that the power of long-wave radiation from the planet remain constant by the change of internal climatic parameters of a planet (CO_2 concentration and surface temperature of a planet). Such the approximation in turn based on assumption of constancy of the power radiating by central star and reflectance of a planet:

$$W^{rad}(\ _0^{CO_2}, T_0)$$
$$W_{atm}^{rad}(\ _0^{CO_2}, T_0) \quad W_{land}^{rad}(\ _0^{CO_2}, T_0) \text{ - } Const.$$

Taking into consideration two main greenhouse gases (CO_2, H_2O) we can write down analytical expressions for power of emitted long–wave radiation, emitted by atmosphere of planet:

$$W_{atm}^{rad}(\ _0^{CO_2}, T_0) \qquad dzdvW_{atm}^{rad}(\ _0^{CO_2}, T_0, v, z)$$

$$dzd \quad \frac{2 \ h \ ^3}{c \exp(h \ \ / kT(z))}$$

$$a^{CO_2}(v) \ _0^{CO_2} \exp \quad \frac{_{air}m_H g}{kT_{eff}} z \quad a^{H_2O}(v) \ ^{H_2O}(T \quad _A z)$$

$$\exp \quad a^{CO_2}(v) \ _0^{CO_2} \frac{kT_{eff}}{_{air}m_H g} \exp \quad \frac{_{air}m_H g}{kT_{eff}} z$$

$$a^{H_2O}(v) \ d \quad ^{H_2O}(T_0 \quad _A \ )$$
$$z$$

and emitted by planet surface:

$$W_{land}^{rad}(\ _0^{CO_2}, T_0) \qquad dvW_{land}^{rad}(\ _0^{CO_2}, T_0, v)$$

$$d \quad \frac{2 \ h \ ^3}{c \exp(h \ \ / kT_0)} a^{land}(v)$$

$$\exp \quad a^{CO_2}(v) \ _0^{CO_2} \frac{kT_{eff}}{_{air}m_H g} \quad a^{H_2O}(v) \ d \quad ^{H_2O}(T_0 \quad _A \ )$$
$$0$$

We introduced parameter of optical density of atmosphere:

$$\frac{W_{atm}^{rad}(\ _0^{CO_2}, T_0)}{W^{rad}(\ _0^{CO_2}, T_0)} \quad \frac{W_{atm}^{rad}(\ _0^{CO_2}, T_0)}{W_{atm}^{rad}(\ _0^{CO_2}, T_0) \quad W_{land}^{rad}(\ _0^{CO_2}, T_0)}.$$

The availability of special translation–dilatation symmetry in expression (1) allows at once to write down the expression for thermal change in case of high optical density of atmosphere 1:

$$T \qquad \ln \frac{_0^{CO_2} \qquad _0^{CO_2}}{_0^{CO_2}} \ .$$

The value of climate sensitivity for the Earth can be easily calculated directly proceeding from available estimations for adiabatic gradient and well-known parameters of atmosphere:

$$37 \quad 59 \ K \ .$$

3. PALEOENVIRONMENTAL TEST FOR VARIOUS MODELS OF GREENHOUSE EFFECT

Using paleoenvironmental data from station "Vostok" (Fig. 1) it is possible to directly obtain dependence of global temperature as functions of CO_2 concentration.

Having applied methods of nonlinear regression (quadratic n=2 and cubic n=3) we have obtained dependence of climate sensitivity as functions of CO_2 concentration too (Fig. 2)

One can see that in spite of the fact that in the past optical density of the Earth atmosphere was much lower than today, the observing values of climate sensitivity now is much closer to that were obtained in radiative-adiabatic model $37 \quad 59\, K$ [1], rather than in commonly used radiative-convective $2.2 \quad 6.5\, K$ [2].

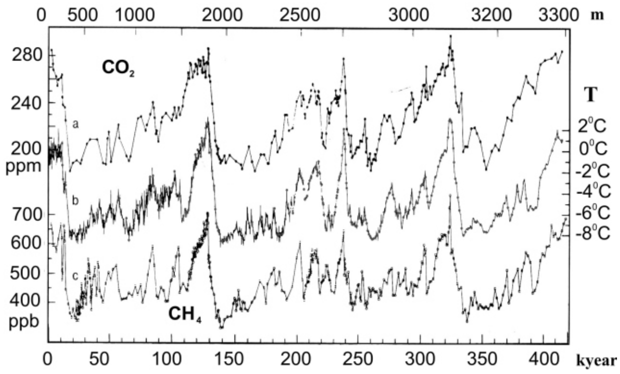

Fig.1 Paleoenvironmental data of CO_2(a) and CH_4(c) concentration and temperature T(b) during last 400 000 year.

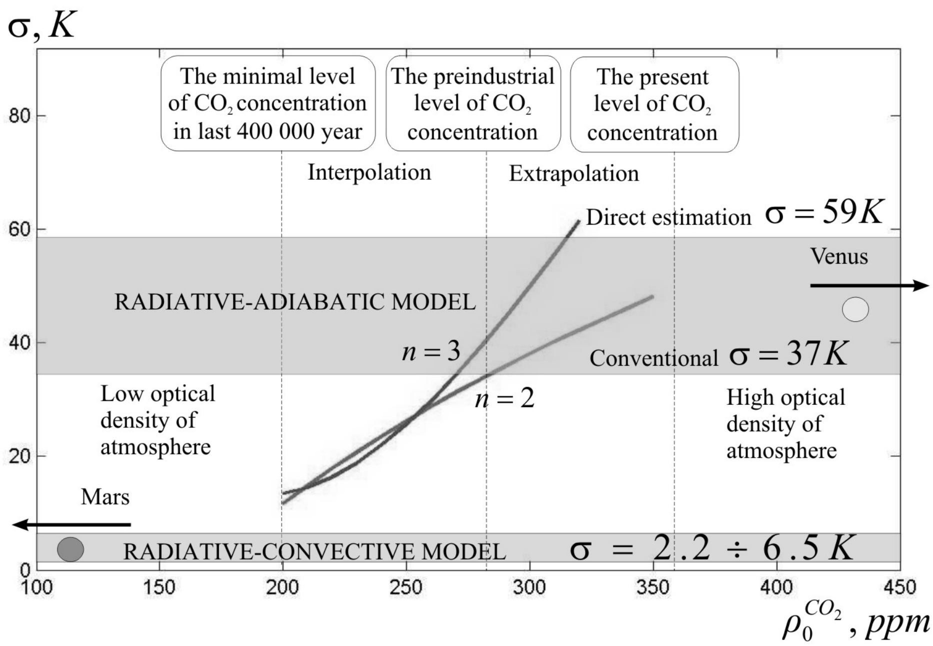

Fig. 2. Comparison of observation value of climate sensitivity and estimation that value from radiative-convective and radiative-adiabatic models.

CONCLUSION

We can see that the radiative-adiabatic model give us the better estimation of greenhouse effect than the common-used radiative-convective one in the case of high optical density of atmosphere. But it is important, that further development of radiative-adiabatic model can lead us to creation of General climate theory which would be able to describe successfully atmospheres of various optical density.

REFERENCES

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