Laboratory exercise no. 3: Radiation balance of the Earth

Aim: The aim of the laboratory is simulation of the global radiation budget of the Earth.

Laboratory programme:

1. Get acquainted with the simple Earth long-wave and short-wave radiation balance model.
2. Making a simple calculations of mean Earth temperature without atmosphere.
3. Writing of the programme code simulating the mean Earth temperature including the atmosphere effect.
4. Calculation of the relationship between mean temperature and solar constant optionally considering the glacial-interglacial transitions.

Set of energy balance equations (no atmosphere):

$$P_{Sł} = S \cdot \frac{Pow_Z}{4} \cdot (1 - A)$$

$$P_Z = \sigma \cdot T^4 \cdot Pow_Z$$

$$P_Z = P_{Sł}$$

where:

$P_{Sł}$ – Power of solar radiation arriving to the Earth (short wave radiation)
P_z – Power of radiation emitted from Earth (long wave radiation)
A – mean albedo of the Earth surface
S – solar constant
Pow_Z – area of the Earth
σ -Stefan-Boltzmann constant

Set of energy balance equations (with atmosphere):

$$(-t_a)(1-a_s)\frac{S}{4} + c(T_s - T_a) + \sigma T_s^4 (1 - a_a^{'}) - \sigma T_a^4 = 0$$

$$-(1 - a_a - t_a + a_s t_a)\frac{S}{4} - c(T_s - T_a) - \sigma T_s^4 (1 - t_a^{'} - a_a^{'}) + 2\sigma T_a^4 = 0$$

where:

t_a – transmission of the atmosphere for short wave radiation
a_a – albedo of the atmosphere for short wave radiation
a_s- surface albedo for short wave radiation
t_a'- transmission of the atmosphere for long wave radiation
a_a'- albedo of the atmosphere for long wave radiation

T_a- mean temperature of the atmosphere
T_s- mean Surface temperature

Input data:

for version 1:

$$A=0.3 \quad S=1366\ W/m^2 \quad \sigma=5.67x10^{-8}\ W/m^2K^4$$

for version 2:

Short wave radiation	Long wave radiation
$a_s=0.19$ $t_a=0.53$ $a_a=0.30$	$t_a'=0.06$ $a_a'=0.31$
$c=2.7\ Wm^{-2}K^{-1}$ Solar constant range 0.8 to 1.2 S	

Laboratory outline:

1. Performing of simple calculation of mean Earth temperature assuming no atmosphere
2. Writing the programme code solving set of nonlinear equations.
3. Calculation of relationship between mean temperature and solar constant
4. Comparison of the results
5. Implementation of glaciations mechanism in the model (Surface albedo depend on the temperature).
6. Calculation of solar constant values associated with glacial-interglacial transition of the Earth system.
7. Computer programme can be written in any programming language or software environment. Recommended environment is MATLAB.
8. Programme code supplemented with appropriate comments should be included as a part of a report prepared in pdf format.
9. The report must include the conclusion.