FORM TO SPECIFY INPUT DATA FOR ATMOSPHERIC LOSS MODEL SBLOSS

This attenuation model for atmospheric acoustic waves is based on the paper by Sutherland and Bass (2004) with errata given by Sutherland and Bass (2006) and a summery given by Bass and Hetzer (2006).

The attenuation coefficient in Nepers per kilometer is given by

$\alpha = \frac{\omega}{C_s}\left[\Re(-ik_1k_2) + \sum_{i=1}^{2} \frac{(A_{max,i}/\pi)(\omega/\omega_{\mathrm{vib},i})}{1+(\omega/\omega_{\mathrm{vib},i})^2}\right]$, where ω is angular frequency, C_s is sound speed, the first term combines classical absorption and rotational loss, we neglect diffusion loss, and the sum includes vibrational relaxation loss from O_2 and N_2.

We have $k_1^2 = -\frac{1}{1+i\nu}$, where $\nu = \frac{4\omega\mu}{3p}$, $\mu = \mu_0\left(\frac{T}{T_0}\right)^{3/2}\frac{T_0+S}{T+S}$ is viscosity, p is pressure, and $T_0 = 293.15$ K.

The other variables are defined on the following pages.

Specify–

the model check for SBLOSS = ____3.0____ (w500)

the input data-format code = ________ (w501)

an input data-set identification number = ________ (w502)

an 80-character description of the model with parameters:

____

and the model values:

Reference viscosity at T_0, μ_0 = ________ kg $s^{-1}m^{-1}$ (w503) (18.192 $\times 10^{-6}$ suggested)

Sutherland's constant, S = ________ Kelvins (w504) (117 suggested)

$Z_{N_2,\infty}$ = ________ (w505) (63.3 suggested)

$T_{N_2}^{1/3}$ = ________ $K^{1/3}$ (w506) (16.7 suggested)

$Z_{O_2,\infty}$ = ________ (w507) (54.1 suggested)

$T_{O_2}^{1/3}$ = ________ $K^{1/3}$ (w508) (17.3 suggested)

Characteristic temperature for O_2, θ_{O_2} = ________ (w509) (2239.1 K suggested)

Characteristic temperature for N_2, θ_{N_2} = ________ (w510) (3352 K suggested)

a_1^* = ________ Hz (w511) (24 suggested)

a_2^* = ________ Hz (w512) (2400 suggested)

b^* = ________ Hz/% (w513) (40400 suggested)

c^* = ________ % (w514) (0.02 suggested)

d^* = ________ % (w515) (0.391 suggested)

e^* = ________ Hz (w516) (9 suggested)

g^* = ________ Hz (w517) (28000 suggested)

Ratio of x' to x, c_1 = ________ (w518) (2.36 suggested)

c_2 = ________ (w519) (9.16 suggested)

c_3 = ________ (w520) (10 suggested)

c_4 = ________ (w521) (11.2 suggested)

c_5 = ________ (w522) (8.41 suggested)

c_6 = ________ (w523) (19.9 suggested)

c_7 = ________ (w524) (4.17 suggested)

OTHER MODELS REQUIRED: Any sound speed, pressure, temperature, and molecular weight model.

References

[Sutherland and Bass (2004)] Sutherland, Louis C. and Henry E. Bass, "Atmospheric absorption in the atmosphere up to 160 km," J. Acoust. Soc. Am 115, 1012-1032, 2004.

[Sutherland and Bass (2006)] Sutherland, Louis C. and Henry E. Bass, "Erratum: 'Atmospheric absorption in the atmosphere up to 160 km," [J. Acoust. Soc. Am 115, 1012-1032, 2004], J. Acoust. Soc. Am 120, 2985, 2006.

[Bass and Hetzer (2006)] Bass, Henry E. and Claus H. Hetzer, "An overview of absorption and dispersion of infrasound in the upper atmosphere," Inframatics, The newsletter of subaudible sound, Number 15 September 2006, pp. 1-5.

Definitions:

FORTRAN variable	Variable name	Definition
OW	ω_v	angular wave frequency
OWI	$\omega = \omega_v - \mathbf{k} \cdot \mathbf{v}$	intrinsic wave frequency
V	$\mathbf{v}$	wind velicity
K	$\mathbf{k}$	wave number
Cs	C_s	sound speed
CsSQ	C_s^2	square of sound speed
APH	α	attenuation coefficient
PI	π	
PIT2	2π	
PID2	$\pi/2$	
k1	k_1	
k1SQ	$k_1^2 = -1/(1+i\nu)$	
i	$i = \sqrt{-1}$	
nu	$\nu = 4\omega\mu/(3p)$	
mu	$\mu = \mu_0 \left(\frac{T}{T_0}\right)^{3/2} \frac{T_0+S}{T+S}$	viscosity
mu0	μ_0	reference viscosity
p	p	pressure
p0	p_0	reference pressure
T	T	temperature
T0	T_0	reference temperature
S	S	Sutherland's constant
Rgas	R	universal gas constant
XN2	X_{N_2}	mole fraction of N_2
XO2	X_{O_2}	mole fraction of O_2
XN	X_N	mole fraction of N
XO	X_O	mole fraction of O
XH2O	X_{H_2O}	mole fraction of H_2O
XO3	X_{O_3}	mole fraction of O_3
k2	$k_2 = \frac{(\sigma^2-1)x+2i\sigma(1+x'^2)}{2\sigma[(1+x'^2)(1+\sigma^2x'^2)]^{1/2}}$	
AmaxN2	$A\mathrm{max}_{,N_2}$	
AmaxO2	$A\mathrm{max}_{,O_2}$	
AmaxN2dp	$A\mathrm{max}_{,N_2}/\pi$	
AmaxO2dp	$A\mathrm{max}_{,O_2}/\pi$	

	$\frac{A_{max,i}}{\pi} = \frac{(X_i/2)(C_i'/R)}{(7/2)(5/2+C_i'/R)}$	
omvibN2	$\omega_{\text{vib},N_2} = 2\pi \frac{p}{p_0}\frac{\mu_0}{\mu}[E + FX_{O_3} + GX_{H_2O}]$	
omvibO2	$\omega_{\text{vib},O_2} = 2\pi \frac{p}{p_0}\frac{\mu_0}{\mu}[A_1 + A_2 + Bh'(C+h')(D+h')]$	
N2rat	$\omega/\omega_{\text{vib},N_2}$	
N2ratSQ	$(\omega/\omega_{\text{vib},N_2})^2$	
O2rat	$\omega/\omega_{\text{vib},O_2}$	
O2ratSQ	$(\omega/\omega_{\text{vib},O_2})^2$	
vibN2	$\frac{(A_{max,N2}/\pi)(\omega/\omega_{\text{vib},N2})}{1+(\omega/\omega_{\text{vib},N2})^2}$	
vibO2	$\frac{(A_{max,O2}/\pi)(\omega/\omega_{\text{vib},O2})}{1+(\omega/\omega_{\text{vib},O2})^2}$	
sigma	$\sigma = 5/(21)^{1/2}$	
x	$x = 3n\nu/4$	
xprine	$x' = c_1 x$	
xpXQ	x'^2	
n	$n = \frac{4}{5}\left(\frac{3}{7}\right)^{1/2} Z_{\text{rot}}$	
Zrot	$Z_{\text{rot}} = \frac{1}{X_{N_2}/Z_{\text{rot},N_2} + X_{O_2}/Z_{\text{rot},O_2}}$	
ZrotN2	$Z_{\text{rot},N_2} = Z_{N_2,\infty}\exp(-T_{N_2}^{1/3} T^{-1/3})$	
ZrotO2	$Z_{\text{rot},O_2} = Z_{O_2,\infty}\exp(-T_{O_2}^{1/3} T^{-1/3})$	
ZN2inf	$Z_{N_2,\infty}$	
T3N2	$T_{N_2}^{1/3}$	
ZO2inf	$Z_{O_2,\infty}$	
T3O2	$T_{O_2}^{1/3}$	
	$C_i'/R = (\theta_i/T)^2 \exp(-\theta_i/T)/[1-\exp(-\theta_i/T)]^2$	
exN2	$\exp(-\theta_{N_2}/T)$	
exO2	$\exp(-\theta_{O_2}/T)$	
CpN2dR	C_{N_2}'/R	
CpO2dR	C_{O_2}'/R	
thN2	θ_{N_2}	characteristic temperature for N_2
thO2	θ_{O_2}	characteristic temperature for O_2
thN2dT	θ_{N_2}/T	
thO2dT	θ_{O_2}/T	
Tr	$T_r = \left(\frac{T}{T_0}\right)^{-1/3} - 1$	
A1	$A_1 = (X_{O_2} + X_{N_2})a_1^* \exp(-c_2 T_r)$	
A2	$A_2 = (X_O + X_N)a_2^*$	
B	$B = b^* \exp(c_3 T_r)$	
C	$C = c^* \exp(-c_4 T_r)$	
D	$D = d^* \exp(c_5 T_r)$	
E	$E = e^* \exp(-c_6 T_r)$	
F	$F = 60000$ Hz	
G	$G = g^* \exp(-c_7 T_r)$	
hprime	$h' = 100(X_{H_2O} + X_{O_3})$	
a1st	a_1^*	
a2st	a_2^*	
bst	b^*	

cst	c^*	
dst	d^*	
est	e^*	
gst	g^*	
c1	c_1	ratio of x' to x
c2	c_2	
c3	c_3	
c4	c_4	
c5	c_5	
c6	c_6	
c7	c_7	