7 Apéndices

7.1 Comunicación con el Profesor John Harte

A continuación se reproduce el mensaje que el director de este trabajo envió al Profesor John Harte de Berkeley para conocer su opinión sobre el concepto de tiempo de residencia de la energía. El doctor Harte es un reconocido investigador especializado en la aplicación de la física a problemas medioambientales, con varios libros publicados.

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-------- Mensaje Original --------
Asunto: Residence time of energy in the atmosphere
Fecha: 2020-04-23 11:06
De: amalio <amalio@unizar.es>
Destinatario: jharte@berkeley.edu

Dear Prof. Harte,
Please find enclosed in this email our paper "Residence time of Energy
in the
Atmosphere" which has just been accepted for publication in "Nonlinear
Processes in Geophysics".

In this work, following a similar approach as atmospheric chemists, when
they define a
residence time in the atmosphere for each type of molecular species, we
define a residence time for the energy in the atmosphere. We consider
the atmosphere as a big box where energy is in equilibrium: In e.g.
annual time averages, the energy influx is equal to the energy out flux,
so that the energy stored in the box keeps constant. Under this
hypothesis, and inserting accepted values for the energy stock and for
the
energy influxes, the result for the residence time of energy in the
atmosphere is about two months.
As far as we know, this time scale is not coincident with any known
periodic phenomenon in meteorology. However, a comparison with Solar
Physics has lead us to conclude that this time scale is what the
atmosphere  would need to reach a new steady state, after having
received
a global thermal perturbation.
Any comment or criticism from you about the content of this paper would
be very welcome.
I'd like to take this opportunity to express my admiration for your
books, which have always been a source of inspiration to me.
Sincerely yours,
Amalio Fernández-Pacheco
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Seguidamente se incluye su respuesta positiva:

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-------- Mensaje Original --------
Asunto: Re: Residence time of energy in the atmosphere
Fecha: 2020-04-23 19:28
De: John Harte <jharte@berkeley.edu>
Destinatario: amalio <amalio@unizar.es>

This looks good to me.  In my Spherical Cow book I had used the concept
of residence time of energy in the atmosphere to come up with an
estimate of the urban heat island effect.  And I had given students in a
class I taught the same problem as in your article: residence of
tropospheric energy.  My answer agreed with yours. I like the way you
interpreted it.

Keep well in these difficult times,

John

John Harte
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7.2 Datos atmosféricos utilizados

Los datos para la Tierra se han extraído de [3] y provienen de medidas directas. Los datos para el resto de planetas se recogen en [2] y son resultado de misiones espaciales.

Tabla 10: Datos en la Tierra

z (km)	p (Pa)	T (K)
0	101330	288.15
1	89880	281.65
2	79500	275.15
3	70120	268.66
4	61660	262.17
5	54050	255.68
6	47220	249.19
8	35650	236.22
10	26500	223.25
12	19400	216.15
15	12110	216.65
20	5529	216.65
25	2549	221.55
30	1197	226.51
35	574.6	236.51
40	287.1	250.35
45	149.1	264.16
50	79.78	270.65
55	42.53	260.77
60	21.96	247.02
65	10.93	233.29
70	5.221	219.59
75	2.388	208.4
80	1.052	198.64
85	0.496	188.89
90	0.184	186.87
95	0.076	188.42
100	0.032	195.08
105	0.014	208.84
110	0.007	240
115	0.004	300
120	0.003	360

Tabla 11: Datos en Marte

z (km)	p (Pa)	T (K)
0	636	214
2	529.9788	213.8
4	441.384	213.4
6	368.244	212.4
8	305.916	209.2
10	253.7864	205
12	209.88	201.4
14	172.674	197.8
16	141.4764	194.6
18	116.07	191.4
20	94.7004	188.2
22	77.0196	185.2
24	62.4552	182.5
26	50.562	180
28	40.7676	177.5
30	32.8176	175
32	26.3304	172.5
34	21.0516	170
36	16.77132	167.5
38	13.3242	164.8
40	10.5576	162.4
42	8.3316	160
44	6.56352	158
46	5.1516	156
48	4.03224	154.1
50	3.1482	152.2
52	2.45496	150.3
54	1.90164	148
56	1.474884	147.2
58	1.139712	145.7
60	0.878952	144.2
62	0.676068	143
64	0.519612	142
66	0.398136	141
68	0.304644	140
70	0.233412	139.5
72	0.17808	139
74	0.136168	139
76	0.104113	139
78	0.079627	139
80	0.060865	139

Tabla 12: Datos en Venus

z (km)	p (Pa)	T (K)
0	9119250	735
2	8024940	720
4	7052220	705
6	6170693	689
8	5390490	674
10	4681215	658
12	4063133	642
14	3515978	626
16	3029618	609
18	2593920	593
20	2219018	576
22	1884645	560
24	1590803	543
26	1347623	526
28	1124708	509
30	935229.8	492
32	773109.8	476
34	635307.8	460
36	518784	444
38	420898.8	428
40	338425.5	413
42	270537.8	400
44	213795.8	387
46	168199.5	374
48	131722.5	361
50	101325	347
52	77412.3	328
54	58059.23	308
56	42759.15	289
58	30904.13	274
60	21987.53	261

Tabla 13: Venus cont.

z (km)	p (Pa)	T (K)
62	15401.4	250
64	10639.13	245
66	7335.93	241
68	5015.588	236
70	3404.52	232
75	1215.9	220
80	412.3928	208
85	128.6828	192
90	37.3889	187
95	10.3352	182
100	2.75604	175
104	0.85	160
108	0.27	150
112	0.08	140
116	0.021	129
120	0.00517	117
124	0.0012	125
128	0.00033	135
132	0.000099	142
136	0.000033	146
140	1.26E-05	147
144	5.65E-06	140
148	2.83E-06	134
152	1.54E-06	131
156	8.68E-07	129
160	5.02E-07	127
164	3E-07	126
168	1.84E-07	125
172	1.13E-07	125
176	7.2E-08	125
180	4.73E-08	125

Tabla 14: Datos en Titán

z (km)	p (Pa)	T (K)
0	144000	93.9
0.5	140000	93.3
1	137000	92.7
1.5	134000	92.1
2	130000	91.5
3	124000	90.5
4	118000	89.5
5	112000	88.5
6	106000	87.3
8	95700	85.5
10	85900	83.6
12	77000	82.1
14	68800	80.6
16	61400	79.2
18	54700	78
20	48700	76.7
22	43200	75.7
24	38300	74.7
26	34000	73.9
28	30000	73.1
30	26500	72.3
32	23500	71.8
34	20700	71.5
36	18300	71.4
38	16100	71.2
40	14200	71.1
42	12600	71.1
44	11100	71.2
46	9810	71.4
48	8670	71.5
50	7670	71.7
52	6790	72.2
54	6010	72.8
56	5340	73.8
58	4750	75.4
60	4230	77.6
62	3790	80.9
64	3420	85.9
66	3100	92.6
68	2830	100.5
70	2600	106.1
72	2400	111.9
74	2230	116.6

Tabla 15: Titán cont.

z (km)	p (Pa)	T (K)
76	2070	119.7
78	1930	122.7
80	1800	125.8
82	1680	128.8
84	1570	131.5
86	1470	133.8
88	1380	135.8
90	1300	137.6
92	1220	139.1
94	1150	140.6
96	1080	142.1
98	1020	143.7
100	961	145.1
102	906	146.5
104	856	147.8
106	808	149
108	763	150.1
110	722	151
112	682	151
114	645	151.9
116	610	152.6
118	578	154.3
120	548	155.3
122	519	156.3
124	491	157.5
126	466	158.6
128	442	159.6
130	419	160.5
132	390	161.2
134	378	161.8
136	359	162.4
138	341	163
140	324	163.7
142	308	164.5
144	293	165.3
146	278	166
148	265	166.7
150	252	167.4
152	240	167.9
154	229	168.5
156	217	169
158	207	169.5
160	197	169.9