1 of 2

AT-938501

UCRL-ID-115607

**The WCRP '93 Workshop on the Parameterization of
Sub-Grid Scale Tracer Transport:
Results from the LLNL GRANTOUR Model**

J. Dignon

October 1993

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The WCRP '93 Workshop on the Parameterization of Sub-Grid Scale Tracer Transport: Results from the LLNL GRANTOUR Model

Jane Dignon

Global Climate Research Division
Lawrence Livermore National Laboratory

The primary goal of the WCRP Workshop is to improve the development of global chemical transport models by intercomparison of model parameterizations from the major modeling groups around the world. The Global Climate Research Division of LLNL has been invited to participate in this study.

A secondary goal of the workshop is to understand how the current models transport short-lived chemical species. Chemical change in the troposphere of the important trace species such as OH and ozone are dependent on the distribution of $\text{NO}_x (= \text{NO} + \text{NO}_2)$ which is short-lived (hours to days) and has a wide variety of sources. Three case scenarios representing an A: surface source (natural radon source), B: aircraft source, and C: lightning source run for both the winter and summer seasons have been prescribed for the model intercomparison. The figures and tables presented in this report represent the results of running these 3 case scenarios with the Lagrangian version of the LLNL GRANTOUR model. Complete descriptions of the three case scenarios along with the specification for all figures and tables are given in Appendix A (page 102). Appendix B (page 110) gives an example using the Case A: Dec-Jan-Feb, Natural Radon Source to describe the GRANTOUR run specifications. The other case runs for this report change only season and/or source of emissions.

Case A: Surface (natural radon)

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

• GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL		Case A: Time series Statistics (E-21 v/v)					Dec-Jan-Feb	
		mean	var*E-42	min	1/4	median	3/4	max
Kirov	300 mb	1.58	2.82	.32	.66	.97	1.84	12.2
	600 mb	8.09	19.0	2.30	5.18	7.17	10.6	30.2
	mixed	110	544	46.1	92.6	116	129	146
	surface	112	548	46.7	93.8	117	131	147
Cincinnati	300 mb	1.42	.871	.40	.82	1.08	1.73	6.61
	600 mb	6.45	14.0	1.53	3.75	5.20	8.33	19.8
	mixed	113	235	75.8	101	113	127	139
	surface	114	235	76.5	102	114	127	139
Socorro	300 mb	1.32	.495	.47	.87	1.10	1.59	4.26
	600 mb	6.33	17.6	1.83	3.53	4.87	7.83	23.5
	mixed	84.2	466	45.8	67.5	80.0	101	134
	surface	84.2	466	45.8	67.5	80.0	101	134
Hawaii	300 mb	1.21	.217	.47	.88	1.10	1.39	3.05
	600 mb	2.14	1.16	.60	1.27	1.90	2.84	5.57
	mixed	2.68	1.50	.93	1.73	2.47	3.44	5.83
	surface	2.75	1.62	.97	1.78	2.52	3.51	6.25
Samoa	300 mb	1.76	.967	.66	1.17	1.41	2.04	7.61
	600 mb	1.51	.505	.46	1.02	1.30	1.85	3.96
	mixed	1.28	.446	.65	.90	1.02	1.39	4.11
	surface	1.30	.455	.69	.91	1.04	1.39	4.42
Crozet	300 mb	.70	.282	.12	.33	.54	.89	3.14
	600 mb	1.32	.847	.19	.65	.96	1.89	4.66
	mixed	1.67	1.07	.56	.88	1.27	2.21	5.10
	surface	1.68	1.06	.59	.90	1.28	2.19	4.87
Ferraz	300 mb	.57	.502	.06	.14	.26	.70	3.64
	600 mb	1.14	1.39	.16	.34	.67	1.58	5.88
	mixed	2.43	3.72	.65	1.06	1.60	3.48	8.61
	surface	2.43	3.71	.65	1.05	1.61	3.48	8.71

GRANTOUR-LLNL

A: Mixed Layer

DJF

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

A: 600 mb

DJF

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

A: 300 mb

DJF

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

A: Zonal Avg

DJF

GRANTOUR-LLNL

A: OEW

DJF

GRANTOUR-LLNL

A: 180EW

DJF

GRANTOUR-LLNL

A: Zonal Avg

DJF

GRANTOUR-LLNL

A: OEW

DJF

GRANTOUR-LLNL

A: 180EW

DJF

LEAD-210 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

A: Mixed Layer

DJF

LEAD-210 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

A: 600 mb

DJF

LEAD-210 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

A: 300 mb

DJF

LEAD-210 Mixing Ratio [$\times 10^2$ v/v]

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL		Case A: Time series Statistics (E-21 v/v)					Jun-Jul-Aug	
		mean	var*E-42	min	1/4	median	3/4	max
Kirov	300 mb	3.93	10.1	.48	1.61	2.75	5.07	16.1
	600 mb	9.91	27.4	2.24	5.65	9.33	13.3	25.7
	mixed	68.1	362	27.6	52.7	69.7	81.6	112
	surface	68.3	366	27.7	52.8	70.0	81.7	112
Cincinnati	300 mb	5.37	14.1	.76	2.34	3.95	8.11	16.1
	600 mb	13.2	35.6	3.26	8.66	12.3	17.2	34.9
	mixed	89.7	272	37.9	79.4	92.3	99.9	130
	surface	89.8	272	38.1	79.4	92.3	100	130
Socorro	300 mb	3.14	5.97	.57	1.60	2.47	3.63	14.5
	600 mb	8.94	14.7	3.37	6.07	7.84	10.8	22.5
	mixed	98.8	299	54.3	84.9	102	112	127
	surface	98.8	299	54.3	84.9	102	112	127
Hawaii	300 mb	1.07	.359	.26	.61	.94	1.45	3.02
	600 mb	.54	.101	.18	.30	.39	.85	1.40
	mixed	1.71	.633	.73	1.18	1.56	1.98	4.54
	surface	1.83	.761	.78	1.24	1.64	2.08	5.18
Samoa	300 mb	.75	.145	.31	.50	.67	.89	2.76
	600 mb	.67	.054	.30	.49	.61	.84	1.48
	mixed	1.29	.512	.58	.83	1.02	1.50	4.36
	surface	1.37	.592	.61	.88	1.07	1.59	4.56
Crozet	300 mb	1.17	1.93	.17	.48	.80	1.23	12.1
	600 mb	2.31	2.90	.57	1.24	1.84	2.69	11.5
	mixed	2.52	4.60	.84	1.43	1.89	2.65	14.9
	surface	2.51	4.44	.86	1.42	1.89	2.70	14.4
Ferraz	300 mb	.30	.018	.09	.21	.28	.35	.94
	600 mb	1.03	.487	.21	.55	.88	1.25	4.86
	mixed	2.94	8.54	.57	1.26	1.82	3.45	14.9
	surface	2.94	8.51	.58	1.22	1.81	3.50	15.9

GRANTOUR-LLNL

A: Mixed Layer

JJA

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

A: 600 mb

JJA

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

A: 300 mb

JJA

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

A: Zonal Avg

JJA

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

A: OEW

JJA

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

A: 180EW

JJA

GRANTOUR-LLNL

A: Zonal Avg

JJA

GRANTOUR-LLNL

A: 0EW

JJA

GRANTOUR-LLNL

A: 180EW

JJA

GRANTOUR-LLNL

A: Mixed Layer

JJA

LEAD-210 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

A: 600mb

JJA

LEAD-210 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

A: 300 mb

JJA

LEAD-210 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL	Scenario A: Lead Loading in kg	
	Dec-Jan-Feb	Jun-Jul-Aug
<300 mb	.079	.099
<600 mb	.192	.235
Total	.343	.403

Case B: Aircraft

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL		Case B: Time series Statistics (E-21 v/v)					Dec-Jan-Feb	
		mean	var*E-42	min	1/4	median	3/4	max
Kirov	300 mb	70.5	2067	9.48	31.0	64.3	109	181
	600 mb	8.69	29.0	1.84	4.81	6.90	12.0	26.3
	mixed	1.29	.449	.44	.67	1.15	1.80	3.44
Cincinnati	300 mb	135	1467	64.4	106	130	160	245
	600 mb	12.2	29.1	4.14	8.31	10.9	14.5	38.3
	mixed	1.36	.324	.48	.97	1.22	1.66	3.21
Socorro	300 mb	96.6	952	25.6	74.1	98.2	117	192
	600 mb	9.83	12.1	4.04	7.32	9.26	11.6	24.6
	mixed	2.91	1.31	1.12	2.15	2.78	3.58	8.37
Hawaii	300 mb	22.2	176	1.50	9.81	21.9	32.5	56.9
	600 mb	9.87	48.2	1.74	5.42	7.50	12.2	36.6
	mixed	2.75	1.42	1.10	1.90	2.49	3.32	8.31
Samoa	300 mb	.24	.056	.06	.12	.20	.26	2.03
	600 mb	.19	.013	.05	.10	.15	.24	.59
	mixed	.15	.011	.03	.08	.11	.18	.54
Crozet	300 mb	5E-3	9E-6	9E-4	2E-3	4E-3	6E-3	.02
	600 mb	3E-3	3E-6	5E-4	1E-3	3E-3	4E-3	.01
	mixed	1E-3	2E-6	2E-4	4E-4	1E-3	2E-3	8E-3
Farras	300 mb	2E-3	3E-6	9E-5	7E-4	1E-3	2E-3	.01
	600 mb	1E-3	2E-6	5E-5	5E-4	7E-4	1E-3	7E-3
	mixed	6E-4	5E-7	3E-5	2E-4	4E-4	8E-4	4E-3

GRANTOUR-LLNL

B: Mixed Layer

DJF

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

B: 600 mb

DJF

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

B: 300 mb

DJF

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

B: Zonal Avg

DJF

GRANTOUR-LLNL

B: OEW

DJF

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

B: 180EW

DJF

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL		Case B: Time series Statistics (E-21 v/v)					Jun-Jul-Aug	
		mean	var*E-42	min	1/4	median	3/4	max
Kirov	300 mb	80.4	1736	14.6	47.2	75.5	108	217
	600 mb	16.1	62.5	3.95	10.0	14.7	21.7	51.1
	mixed	3.05	5.53	.53	1.68	2.36	3.72	16.3
Cincinnati	300 mb	184	3001	75.1	144	177	221	342
	600 mb	21.4	155	6.76	13.0	17.8	25.1	64.0
	mixed	4.92	20.4	1.04	2.39	3.21	5.34	30.7
Socorro	300 mb	93.8	1584	26.2	63.5	87.7	123	206
	600 mb	19.8	70.6	6.30	13.9	17.3	26.1	45.6
	mixed	4.14	3.76	1.79	2.86	3.45	5.12	10.4
Hawaii	300 mb	22.2	170	5.86	12.7	17.5	30.5	63.2
	600 mb	7.25	15.6	2.05	4.69	6.10	8.46	28.6
	mixed	1.13	.147	.44	.86	1.07	1.30	2.72
Samoa	300 mb	.45	.123	.09	.24	.33	.51	2.26
	600 mb	.15	.005	.05	.10	.14	.18	.45
	mixed	.04	4E-4	8E-3	.02	.03	.04	.12
Crozet	300 mb	.01	1E-4	1E-3	5E-3	.01	.02	.09
	600 mb	4E-3	1E-5	9E-4	2E-3	3E-3	5E-3	.03
	mixed	1E-3	9E-7	2E-4	8E-4	1E-3	2E-3	6E-3
Ferraz	300 mb	5E-3	3E-5	5E-4	1E-3	2E-3	6E-3	.03
	600 mb	2E-3	3E-6	4E-4	7E-4	1E-3	2E-3	9E-3
	mixed	7E-4	5E-7	1E-4	2E-4	4E-4	8E-4	4E-3

GRANTOUR-LLNL

B: Mixed Layer

JJA

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

B: 600 mb

JJA

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

B: 300 mb

JJA

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

B: Zonal Avg

JJA

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

B: OEW

JJA

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

B: 180EW

JJA

Case C: Lightning

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec--Jan--Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Dec-Jan-Feb

RADON-222 Mixing Ratio

GRANTOUR-LLNL		Case C: Time series Statistics (E-21 v/v)					Dec-Jan-Feb	
		mean	var*E-42	min	1/4	median	3/4	max
Kirov	300 mb	.10	.002	.03	.06	.09	.12	.25
	600 mb	.05	6E-4	.01	.03	.04	.06	.19
	mixed	.02	1E-4	6E-3	.01	.02	.03	.05
Cincinnati	300 mb	1.21	.457	.31	.76	1.08	1.46	5.02
	600 mb	.43	.039	.17	.27	.40	.54	1.09
	mixed	.10	.004	.02	.06	.08	.13	.35
Socorro	300 mb	2.07	.880	.39	1.34	1.96	2.70	5.36
	600 mb	.69	.088	.14	.50	.66	.85	1.68
	mixed	.23	.014	.04	.15	.21	.30	.59
Hawaii	300 mb	10.3	23.3	3.49	7.21	9.25	11.9	36.8
	600 mb	3.81	1.97	1.54	2.75	3.61	4.53	8.60
	mixed	.67	.144	.27	.46	.57	.77	3.54
Samoa	300 mb	7.00	9.18	2.18	4.91	6.57	8.51	17.3
	600 mb	2.69	1.16	1.04	1.94	2.51	3.09	6.89
	mixed	.61	.063	.21	.45	.59	.77	1.31
Crozet	300 mb	.19	.029	.03	.08	.14	.25	1.24
	600 mb	.09	.004	.02	.04	.07	.12	.28
	mixed	.04	.002	6E-3	.01	.03	.05	.26
Ferraz	300 mb	.06	.003	.01	.03	.04	.07	.45
	600 mb	.02	2E-4	5E-3	.01	.02	.02	.10
	mixed	7E-3	3E-5	1E-3	4E-3	6E-3	9E-3	.03

GRANTOUR-LLNL

C: Mixed Layer

DJF

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

C: 600 mb

DJF

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

C: 300 mb

DJF

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

C: Zonal Avg

DJF

GRANTOUR-LLNL

C: 0EW

DJF

GRANTOUR-LLNL

C: 180EW

DJF

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

2 of 2

GRANTOUR-LLNL

Jun-Jul-Aug

RADON-222 Mixing Ratio

GRANTOUR-LLNL		Case C: Time series Statistics (E-21 v/v)					Jun-Jul-Aug	
		mean	var*E-42	min	1/4	median	3/4	max
Kirov	300 mb	.12	.007	.02	.05	.09	.16	.43
	600 mb	.06	.001	.01	.03	.05	.08	.18
	mixed	.02	1E-4	4E-3	.01	.01	.02	.06
Cincinnati	300 mb	.24	.009	.08	.17	.22	.30	.62
	600 mb	.22	.028	.04	.09	.16	.32	.72
	mixed	.23	.083	9E-3	.04	.11	.30	1.61
Socorro	300 mb	.45	.052	.16	.28	.41	.55	1.27
	600 mb	.30	.097	.06	.14	.21	.30	1.89
	mixed	.19	.061	.02	.04	.06	.26	1.22
Hawaii	300 mb	.74	.254	.16	.37	.53	1.02	2.35
	600 mb	.36	.107	.06	.14	.26	.48	1.86
	mixed	.12	.056	.01	.03	.04	.06	1.61
Samoa	300 mb	13.8	79.3	2.04	6.78	12.2	18.4	49.1
	600 mb	7.79	21.3	2.25	4.72	6.58	9.67	31.6
	mixed	1.18	.175	.47	.86	1.15	1.43	2.67
Crozet	300 mb	.41	.157	.06	.20	.32	.49	3.17
	600 mb	.17	.018	.04	.08	.13	.19	.94
	mixed	.06	.003	.01	.03	.05	.07	.40
Ferraz	300 mb	.19	.054	.02	.06	.10	.23	2.00
	600 mb	.09	.007	.02	.04	.06	.12	.61
	mixed	.03	8E-4	5E-3	.01	.02	.04	.17

GRANTOUR-LLNL

C: Mixed Layer

JJA

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

C: 600 mb

JJA

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

C: 300 mb

JJA

RADON-222 Mixing Ratio [$\times 10^{21}$ v/v]

GRANTOUR-LLNL

C: Zonal Avg

JJA

GRANTOUR-LLNL

C: OEW

JJA

GRANTOUR-LLNL

C: 180EW

JJA

RADON-222 Mixing Ratio [$\times 10^{-21}$ v/v]

APPENDIX A

Sep 24 08:52 1993 standard input Page 1

From prather@halo.ps.uci.edu Thu Sep 23 17:03:42 1993
 Date: Fri, 24 Sep 93 00:11:03 GMT
 From: Michael Prather <prather@halo.ps.uci.edu>
 To: jane@scuba.llnl.gov (Jane Dignon)
 Subject: Re: WCRP '93 Workshop
 Content-Length: 14665

observations still being prepared
 comparison not done model-by-model, but across all models by topic,
 michael

=====#5
 WCRP '93 WORKSHOP ON THE
 PARAMETERIZATION OF SUB-GRID SCALE TRACER TRANSPORT
 30 Nov - 3 Dec 1993, Virginia Beach, VA

A Radon/Lead Simulation to Test Boundary-Layer & Cumulus Transport
 in Global Chemical Models --- REVISED 7 Sep 93
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=====NEW: TABLE & PLOT SPEC'S=====
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=====Rn/Pb Experiment===== (13 Jul 93)===
 This WCRP workshop includes tutorials and discussion about how to represent
 subgrid-scale transport of trace species in global models (i.e., boundary
 exchange between surface & free troposphere and cloud convection; transport of
 water vapor, heat, reactive and unreactive chemicals). This writeup defines
 the numerical simulation of 222Rn (and the extension to 210Pb).

The PRIMARY GOAL of this workshop is to develop global chemical transport
 models (CTMs) in conjunction with numerical weather prediction models and
 general circulation models of the atmosphere. Attendance at the workshop will
 be limited, and preference will be given to those groups developing high
 resolution 4-D (i.e., spatial and temporal) CTMs. This goal is met by the
 tutorials, discussions with the NWP modelers, and the Case A simulation of
 radon and lead deposition compared with observations.

A SECONDARY GOAL of this workshop is to understand how current CTMs transport
 short-lived trace species. The key element in model predictions of chemical
 change in the troposphere (i.e., ozone, OH) is the distribution of tropospheric
 NOx (=NO+NO2). NOx is short-lived (hours to days), has highly non linear
 chemistry, and has a wide variety of sources whose roles are not yet quantified.
 Cases B-C of the radon simulations are intended to give a standardized "first-
 look" at atmospheric distributions predicted for different source terms known
 to be important in the global NOx budget:

A=surface (natural radon), B=aircraft, C=lightning

This 2nd goal of the workshop is important to IPCC Climate Assessments, and will
 provide a necessary yardstick for interpreting the different model predictions
 of tropospheric chemistry that hinge on NOx distributions from different sources.
 Current CTMs include 2-D and coarse 3-D (e.g., monthly averaged) models, and
 we anticipate representation of some of these models at the Workshop.

 SOURCE: TOTAL = 16 kg/yr of 222Rn
 Case A - radon is emitted ubiquitously by decay of radium in soils:
 70 - 90 degrees latitude (N & S): no emissions (all surfaces)

60 - 70 degrees latitude (N & S): 1.6E-18 kg/m2/day (all surfaces)
60S- 60N degrees latitude ocean: 1.6E-18 kg/m2/day
60S- 60N degrees latitude land: whatever to get 16 kg/yr*
*this land source depends on model geography, about 3.3E-16 kg/m2/day
Case B - aircraft source of "radon":
Put emissions along 4 flight routes: (constant latitude OR longitude)
Japan-Calif (34N, 120E-120W), Calif-NY (40N, 120W-75W)
Boston-Rome (42N, 75W-10E), Rome-Oslo (42N-60N, 10E)
Emit EQUAL amounts on each leg (4 kg/yr/route = 16 kg/yr total)
Emit uniformly with air mass (pressure) between 200-400 mb.
Case C - tropical lightning source of "radon":
Put total source (16 kg/yr) EQUALLY into three tropical hot spots -
(10S - 10N) x 3 longitude belts: (45W-75W), (10E-40E), and (100E-130E).
Emit uniformly with air mass (pressure) between 200-400 mb (assumes
lightning source has been deposited aloft by cumulus transport).

CHEMISTRY:

Remove Rn with a constant loss frequency of $2.10E-6$ /sec (about 5.5 days)

****Case A only**** assume each ^{222}Rn loss = instantaneous production of ^{210}Pb . Apply a wet deposition sink to ^{210}Pb using any scheme by which a highly water-soluble, submicron aerosol is removed in your model. Include a dry deposition velocity of 0.1 cm/sec (referenced to 10 m altitude) for ^{210}Pb over all surfaces.

N.B. The focus of this workshop is on transport of radon, the lead experiment is included as an example of possible directions for future workshops. Therefore it is not so constrained as the radon experiment, and we leave the Pb results for an open discussion at the end of the workshop, comparing approaches on heterogeneous removal processes.

INITIALIZE with near-zero levels of Rn and Pb on NOV 1 and on MAY 1, RUN for 4 months, REPORT statistics for final 3: DEC-JAN-FEB & JUN-JUL-AUG.

UNITS: at 16 kg/yr, the global mean mixing ratio is thus $6.5E-21$ v/v, thus report all concentrations as mixing ratios in units of $1E-21$ v/v.

PERIOD: all statistics (means, rms, medians, q-tiles, fluxes) based on the full three month period June 1 - August 31 and December 1 - Feb 28.

MODEL DIAGNOSTICS & COMPARISON with MEASUREMENTS:

^{222}Rn DIAGNOSTICS (Cases A-D, except surface times series for Case A only):

3-Month (!) averages or times series requested for both DJF and JJA

(1) At the following geographic sites, record modeled time series of radon:

8 SITES:

3 ALTITUDES:

a Kirov, Russia	58N 49E	"mixed" layer = 300m above surface
b Cincinnati, Ohio	40N 84W	600 mb (true pressure, not sigma)
c Socorro, N. Mexico	34N 107W	300 mb (true pressure)
d Hawaii	**** 20N 155W	1 PLOT per site & season, 3 altitude on page):
e Samoa	**** 14S 171W	time series, sub-select surface @ 1400H
f Crozet Isl.	**** 46S 51E	TABULATED values (site x season x alt)
g Ferraz, Antarct	62S 58W	means, rms, min, 1/4, median, 3/4, max

(2) latitude x pressure (linear) of v/v 3-month means at DATELINE (180EW) and GREENWICH (0EW), and v/v 3-month zonal mean - [THREE PLOTS per season].

(3) latitude x longitude of v/v 3-month means at "mixed" layer (300 m), at 600 mb and at 300 mb - [THREE PLOTS per season].

^{210}Pb DIAGNOSTICS (Case A only):

(4) latitude x pressure (linear) of v/v 3-month means at DATELINE (180EW) and GREENWICH (0EW), and v/v 3-month zonal mean - [THREE PLOTS per season].

(5) table of amount of Pb (kg): (a) total in atmosphere, (b) $p < 600$ mb (altitudes above), and (c) $p < 300$ mb integrated over all latitudes & longitudes at the end of each of 3-month simulation (Feb 28 & Aug 31).

THE MEASUREMENTS (Rn/Pb) TO BE COMPARED WITH WILL BE DEVELOPED OVER THE SUMMER, AND THESE "DATA" PLOTS WILL BE SENT OUT TO ALL WHO CONTRIBUTE TO THE WORKSHOP BY GETTING THEIR RESULTS (PLOTS & TABLES) IN TO THE ORGANIZERS.

RESULTS DUE in by 1 NOV 93

WE PLAN TO HAVE 'TOPICAL' DISCUSSION LEADERS WHO WILL TAKE A SPECIFIC DIAGNOSTIC FROM ALL PARTICIPATING MODELS AND CROSS-COMPARE.

THIS IS THE TYPE MODEL COMPARISONS DONE FOR STRATOSPHERE OVER THE
PAST SEVERAL YEARS. THEREFORE, PLEASE SUBMIT COPIES OF YOUR FIGURES
AND TABLES IN THE FORMAT (INCLUDING SCALE) DESCRIBED BELOW.
ALSO, PLEASE BRING TRANSPARENCIES (ONE SET) TO THE MEETING, WE WILL NOT BE
ABLE TO MAKE THAT MANY TRANSPARENCIES AT THE MEETING.
MANY OF YOU WILL BE ASKED TO LEAD THE COMPARISON ON A SPECIFIC TOPIC:
e.g. REMOTE SITES, FREE TROP, LAT/LONG GRADIENTS, TIME SERIES,...

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DIAGNOSTICS SPECS: PLEASE PREPARE THESE SO THAT YOU CAN BRING TRANSPARENCIES
TO THE MEETING SO THAT THE TOPICAL DISCUSSION LEADERS CAN DO THEIR JOB

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	X-Model	A: Time Series Stats		(E-21 v/v)		Jun-Jul-Aug	
		mean	var	min	1/4 median	3/4	max
Kirov	300 mb	---	---	---	---	---	---
	600 mb	---	---	---	---	---	---
	mixed	---	---	---	---	---	---
Cincinnati	300 mb	---	---	---	---	---	---
	600 mb	---	---	---	---	---	---
	mixed	---	---	---	---	---	---
Socorro	300 mb	---	---	---	---	---	---
	600 mb	---	---	---	---	---	---
	mixed	---	---	---	---	---	---

Hawaii same for remaining 4 stations, all on one page,
Samoa use whatever decimal accuracy you deem appropriate
Crozet
Ferraz NEW PAGE for the Dec-Jan-Feb run

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and the same for Dec-Jan-Feb (NEW PAGE)

WE NEED TO BE ABLE TO PLAN A BALANCE BETWEEN THE DIFFERENT
 SCIENTIFIC GROUPS NEEDED FOR A SUCCESSFUL WORKSHOP.
 SO PLEASE SEND IN A NOTICE OF INTENTION TO PARTICIPATE IN
 THE MODEL COMPARISON AS SOON AS POSSIBLE TO
 Byron Boville and myself with copy to
 WCRP: V.Savtchenko, WCRP c/o WMO, Cass Postale 2300,
 CH-1211 Geneva 2, Switzerland, fax=41 22 734 0357
 IF YOU DID NOT RECEIVE THE WCRP ANNOUNCEMENT, PLEASE FAX V.SAVTCHENKO
 INCLUDE: name / address / tele & fax # / e-mail and the
 reason for attendance (abstract or description).

APPENDIX B

information from vgran code

```
cdg0728 2100000 generatedmp00000og0728 0.  
attfile open      card      cdg0728  
*uxascfil ioc,nam,op = 14 cdg0728 open  
* xrn cdg0728 2100000 generate dmp00000 og0728 0.
```

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```
c      *-----  
c      7/21/93  
c      code version:      rn.930726  
c      source library:    none  
c      sources:           srn9307  
c      meterology:        seasonal  
c      no. of parcels:    50,000  
c      time step:         6 hr.  
c      started from:      clean atmosphere  
c      run stored:        /30430/ipcc/radon/runs/930728  
c      purpose of run:    Jane's first IPCC run  
c      *-----  
c      * Pb dep. vel. is 0.1 cm s-1  
c      * trop. Kz = 1.e4 cm2 s-1  
c      * Rn to Pb decay with a 4.6719e5 sec. time constant.  
c      This is approximately 132 hours, or 5.5 days.  
c      *-----
```

npmtot 50000

c Time step, DT. This must equal the CCM coupling interval when

c running a COUPLED problem.

dt 6.

c Start time for the run, TMIN, need not be set at generation time, since

c it will be reset the first time the model is restarted from DMP00000.

tmin 0.

c The stop time, TMAX, and edit interval, EDIT, can be set here, but they

c may be re-set at the time of a restart. These are not used when a COUPLED

c run is being performed since stop time and edit interval are then controlled

c by the CCM.

tmax 24.
edit 12.

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c The name of the met. file, GTR____, to be used to initialize the run.

c INTCCM must be set to 0 so that CCMDATA1 will use the specified file.

intccm 0

nameccm gtr00000

c The number of records of grid point data permitted per dump file.

nperdump 5

c Initialize the arrays to be used by the code.

arrayset

attfile open ccm gtr00000

*uxbinfil ioc,nam,op = 13 gtr00000 open

*uxbinrd ioc,nam,mpt,len,adr = 13 gtr00000 1083446 238656 0

*infol uxbinrd nrecrd,impt,len,iaddrd = 1 1083446 20480 0

*infol uxbinrd nrecrd,impt,len,iaddrd = 2 1103926 20480 20480

*infol uxbinrd nrecrd,impt,len,iaddrd = 3 1124406 20480 40960

*infol uxbinrd nrecrd,impt,len,iaddrd = 4 1144886 20480 61440

*infol uxbinrd nrecrd,impt,len,iaddrd = 5 1165366 20480 81920

*infol uxbinrd nrecrd,impt,len,iaddrd = 6 1185846 20480 102400

*infol uxbinrd nrecrd,impt,len,iaddrd = 7 1206326 20480 122880

*infol uxbinrd nrecrd,impt,len,iaddrd = 8 1226806 20480 143360

*infol uxbinrd nrecrd,impt,len,iaddrd = 9 1247286 20480 163840

*infol uxbinrd nrecrd,impt,len,iaddrd = 10 1267766 20480 184320

*infol uxbinrd nrecrd,impt,len,iaddrd = 11 1288246 20480 204800

*infol uxbinrd nrecrd,impt,len,iaddrd = 12 1308726 13376 225280

attfile close ccm gtr00000

*uxbinfil ioc,nam,op = 13 gtr00000 close

c The species carried are (1) Rn & (2) Pb

c INITIAL INJECTIONS

c There are two major options, each with sub-options.

c An INITTYP card is the sentinel for initial injections, it will contain

c two words in addition to "inittyp". The options are:

c	1.	inittyp	grid	mixing
c	2.	"	grid	density
c	3.	"	plin	filename
c	4.	"	cpin	filename

c In practice I use "cpin" or "plin".

c Start from a clean atmosphere.

```

end
attfile close      card      cdg0728
*uxascfil ioc,nam,op =      14  cdg0728  close
1

```

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MODEL PARAMETERS

.... horizontal diffusion coefficients (cm² s⁻¹)

sigma	Kx	Ky
0.000000	1.00E+05	1.00E+05
0.009000	1.00E+05	1.00E+05
0.025000	1.00E+05	1.00E+05
0.060000	1.00E+05	1.00E+05
0.110000	1.00E+05	1.00E+05
0.165000	1.00E+05	1.00E+05
0.245000	1.00E+08	1.00E+08
0.355000	1.00E+08	1.00E+08
0.500000	1.00E+08	1.00E+08
0.664000	1.00E+08	1.00E+08
0.811000	1.00E+08	1.00E+08
0.926000	1.00E+08	1.00E+08
0.991000	1.00E+08	1.00E+08
1.000000	1.00E+08	1.00E+08

.... vertical diffusion coefficients (cm² s⁻¹)

sigma	Ks
0.004500	1.00E+02
0.017000	1.00E+02
0.042500	1.00E+02
0.085000	1.00E+02
0.137500	1.00E+02
0.205000	1.00E+02
0.300000	1.00E+04
0.427500	1.00E+04
0.582000	1.00E+04
0.737500	1.00E+04
0.868500	1.00E+04
0.958500	1.00E+04
0.995500	1.00E+04

.... species deposition velocities (cm s⁻¹)

species	Vd
Rn	none
Pb	1.00E-01

.... species precipitation scavenging coefficients (cm⁻¹)

sigma	Sls	Scv
Rn	none	none
Pb	2.00E+00	6.00E-01

1

species totals, in kg, at hour 0.

name	dry dep.	wet dep.	tot. dep.	elevated	total
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Rn	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Pb	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

```

attfile create      dump      dmp00000
*uxbinfil ioc,nam,op =      14 dmp00000 create
*uxbinwrt ioc,nam,mpt,len,adr = 14 dmp00000 579187 512 512
*info5 uxbinwrt nrecrd,len,l,iadd,iaddrd =
      1      1024      512      512      0
*uxbinwrt warning un-able to read record before write
*info6 uxbinwrt k1,k2,k3 =      579186      512      512
*info7 uxbinwrt nrecrd,len,l,iadd,iaddrd =
      1      1024      512      512      0
*uxbinwrt ioc,nam,mpt,len,adr = 14 dmp00000 50 16384 1024
*info5 uxbinwrt nrecrd,len,l,iadd,iaddrd =
      1      17408      1024      1024      0
*info6 uxbinwrt k1,k2,k3 =      49      1024      16384
*info7 uxbinwrt nrecrd,len,l,iadd,iaddrd =
      1      17408      1024      1024      0
*uxbinwrt ioc,nam,mpt,len,adr = 14 dmp00000 29877 512 0
*info5 uxbinwrt nrecrd,len,l,iadd,iaddrd =
      1      512      0      0      0
*info6 uxbinwrt k1,k2,k3 =      29876      0      512
*info7 uxbinwrt nrecrd,len,l,iadd,iaddrd =
      1      512      0      0      0
*uxbinwrt ioc,nam,mpt,len,adr = 14 dmp00000 30389 250368 17408
*info5 uxbinwrt nrecrd,len,l,iadd,iaddrd =
      1      20480      17408      17408      0
*info6 uxbinwrt k1,k2,k3 =      30388      17408      3072
*info7 uxbinwrt nrecrd,len,l,iadd,iaddrd =
      1      20480      17408      17408      0
*info4 uxbinwrt nrecrd,impt,len,iaddrd =      2      33461      20480      20480
*info4 uxbinwrt nrecrd,impt,len,iaddrd =      3      53941      20480      40960
*info4 uxbinwrt nrecrd,impt,len,iaddrd =      4      74421      20480      61440
*info4 uxbinwrt nrecrd,impt,len,iaddrd =      5      94901      20480      81920
*info4 uxbinwrt nrecrd,impt,len,iaddrd =      6      115381      20480      102400
*info4 uxbinwrt nrecrd,impt,len,iaddrd =      7      135861      20480      122880
*info4 uxbinwrt nrecrd,impt,len,iaddrd =      8      156341      20480      143360
*info4 uxbinwrt nrecrd,impt,len,iaddrd =      9      176821      20480      163840
*info4 uxbinwrt nrecrd,impt,len,iaddrd =     10      197301      20480      184320
*info4 uxbinwrt nrecrd,impt,len,iaddrd =     11      217781      20480      204800
*info4 uxbinwrt nrecrd,impt,len,iaddrd =     12      238261      20480      225280
*info4 uxbinwrt nrecrd,impt,len,iaddrd =     13      258741      20480      245760
*info5 uxbinwrt nrecrd,len,l,iadd,iaddrd =
      14      1536      0      266240      266240
*uxbinwrt warning un-able to read record before write
*info6 uxbinwrt k1,k2,k3 =      279220      0      1536
*info7 uxbinwrt nrecrd,len,l,iadd,iaddrd =
      14      1536      0      266240      266240
*uxbinwrt ioc,nam,mpt,len,adr = 14 dmp00000 280389 66048 531968
*info5 uxbinwrt nrecrd,len,l,iadd,iaddrd =
      26      20480      19968      531968      512000
*uxbinwrt warning un-able to read record before write
*info6 uxbinwrt k1,k2,k3 =      280388      19968      512
*info7 uxbinwrt nrecrd,len,l,iadd,iaddrd =
      26      20480      19968      531968      512000
*info4 uxbinwrt nrecrd,impt,len,iaddrd =     27      280901      20480      532480
*info4 uxbinwrt nrecrd,impt,len,iaddrd =     28      301381      20480      552960
*info4 uxbinwrt nrecrd,impt,len,iaddrd =     29      321861      20480      573440
*info5 uxbinwrt nrecrd,len,l,iadd,iaddrd =
      30      4096      0      593920      593920
*uxbinwrt warning un-able to read record before write
*info6 uxbinwrt k1,k2,k3 =      342340      0      4096
*info7 uxbinwrt nrecrd,len,l,iadd,iaddrd =
      30      4096      0      593920      593920

```



```
attfile close      dump      dmp00000
*uxbinfil ioc,nam,op = 14 dmp00000 close
```

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END