Letters to the Editor

Note on Radioactive Compounds in the Atmosphere

Dear Sir,

I have read with much interest the contribution of Messrs Rossby and Egnér "On the Chemical Climate and Its Variation with the Atmospheric Circulation Pattern" in the preceding issue of Tellus Vol. 7, No 1. It seems as if a new and promising field of meteorological activities has been opened up by the "synoptic" studies made on the basis of the Scandinavian network of sampling stations. I was also interested in the Note of Messrs Egnér and Eriksson on "Current Data on the Chemical Composition of Air and Precipitation" and I highly appreciate your plans of publishing quarterly chemical data, in order to make the material of the enlarged Western European network available to all persons interested in atmospheric chemistry.

The aim of this letter is to call your attention to a field in atmospheric chemistry, which is extremely new, namely that of the artificial radio-activity in air and precipitation. Some work in this field has been done by various authors,[1] mainly in relation to thermonuclear explosions. It is however clear — and here I like to refer to Putnam's fascinating book "Energy in the Future"[2] — that contamination of the atmosphere by artificially created radio-active matter, might in due course also result from such more normal human activities as the operation of nuclear reactors for the generation of energy.

One could of course leave the study of the radio-active pollution of the precipitation and the air to medical and biological workers as they are mainly concerned with the dangers of radio-active contamination to human and animal life. I feel, however, that Meteorological Services also have a responsibility in this field. Their task is twofold, namely 1) to give assistance in collecting the samples to be investigated in special laboratories, and 2) to interpret the results of the obtained measurements.

You may be interested to know that the Royal Netherlands Meteorological Institute, in collaboration with the Medical-Biological Laboratory of the National Defense Research Council, hopes to embark on a programme of continuous supervision of the radioactivity in the atmosphere. Preliminary experiments have shown how strongly such radio-activity of the air can vary. The following table gives the activities, determined 3 – 5 days and 2 – 4 weeks after air samples were taken on days during the last decade of April (μC per liter $\times 10^{-10}$).

	After 3—5 days	After 2—4 weeks
	$\times 10^{-10}$ μC per liter	
April 19—20	10.7	6.9
April 20—21	8.8	8.1
April 21—22	11.3	8.9
April 22—23	11.8	7.0
April 23—24	6.4	3.9
April 24—25	6.4	3.9
April 25—26	3.5	2.6
April 26—27	7.8	7.8
April 27—28	18.7	10.1
April 28—29	27.4	13.5
April 29—30	14.2	10.9
April 30—May 1	4.5	4.3

It is interesting to note that periods of higher activity usually consist of groups of 3 – 5 days; the period of 28 – 30 April, with tropical air transported from the South on the 29th, gave the highest values ever experienced since January 1, 1955, when observations started.

The radio-activity of artificial origin i rainn water or snow also varies considerably from ay tod

[1] H. GARRIGUE, 1951: L'invasion d'air radio actif d'origine atomique et son influence sur les précipitations atmosfériques; *C.R.* **232**, 1003—1004.
M. ABRIHAT, R. PINOIR, J. POURADIER and A. M. VENET, 1952: Sur l'existence de produits radio actifs artificiels dans les eaux de pluie de la région parisienne; *C.R.* **234**, 1161—1163.
D. C. ROSE and J. KALZMANN, 1952: Radio-active deposits found at Ottawa after the atomic explosions of Jan. and Febr. 1951. *Canadian J. of Physics* **30**, 111—128.
N. V. RYDER and C. N. WATSON-MUNRO, 1954: The direction of radio active dust from the British nuclear bombs of October 1953; *N. Zealand J. Sc. and Technol.* **36**, 155—159.
J. F. GABITES, The drift of radio active dust from the British nuclear bomb tests in October 1953; *N. Zealand J. Sc. and Technol.* B **36**, 160—165.
R. J. LIST, On the transport of atomic debris in the atmosphere; *B.A.M.S.* **35**, 315—325.

[2] P. S. PUTNAM, 1953: *Energy in the future;* Van Nostrand Co, New York, Toronto, London, 1953.

day; activities of 8×10^{-7} μC per ml have been observed.

It is the intention to place the results of the observations at the disposal of the Royal Netherlands' Academy of Sciences. I would, however, appreciate if you could consider the possibility of publishing these data also in Tellus and in case your reaction to this suggestion is favorable, to invite other countries to follow our example.

I hope you will agree with me that it is of importance to make information on this subject available to scientists, the more so as the study of artificial radio-activity may in the long run lead to interesting meteorological results.

Sincerely yours,

Ir. C. J. WARNERS
Director in Chief of the Royal Netherl. Meteor. Institute

Note on Fjørtoft's Graphical Method of Integrating the Barotropic Vorticity Equation

Dear Sir:

In the graphical method of integration of the barotropic vorticity equation due to FJØRTOFT (1952) the grid length of the finite difference net is chosen to be one quarter of the wavelength of the most rapidly changing Fourier components of the contour field. This ensures the complete damping of those components when the finite difference equivalent is substituted for the Laplacian operator and a fictitious velocity field changing more slowly than the real velocity field can be derived.

If a more accurate determination of vorticity is required than is possible with a 600 km grid, then as Fjørtoft pointed out, a new slowly changing advection field would have to be found to make the graphical method practicable. It can be shown however that where the most rapidly changing component is taken to have a wavelength of about 2,500 km, such a velocity is possible only for a grid length of about 600 km.

For with Fjørtoft's notation, in the conservation formula

$$\frac{d\xi}{dt} = 0 \text{ put } z = +z^{\star\star} + z^{\star} \text{ where } z^{\star\star} = c\xi.$$

The constant c has then to be found for some grid length d.

$$\text{Now } \frac{\partial \xi}{\partial t} = \frac{g}{f}\nabla z^{\star} \times \mathbf{k} \cdot \nabla \xi = \frac{g}{f}\nabla (z - c\xi) \times \mathbf{k} \cdot \nabla \xi$$

$$= \frac{g}{f}\nabla z \times \mathbf{k} \cdot \nabla \xi$$

$$= \frac{g}{f}\nabla [\bar{z} + J(\phi)] \times \mathbf{k} \cdot \nabla z \qquad (1)$$

The same result can be derived directly from the conservation formula without any substitution for,

$$\frac{\partial \xi}{\partial t} = \frac{g}{f}\nabla z \times \mathbf{k} \cdot \nabla \xi$$

$$= -\frac{g}{f}\nabla z \times \mathbf{k} \cdot \nabla [\bar{z} + J(\phi)]$$

$$= \frac{g}{f}\nabla [\bar{z} + J(\phi)] \times \mathbf{k} \cdot \nabla z \qquad (2)$$

From (1) and (2)

(a) It does not matter what value is given to c for $\frac{g}{f}\nabla c\, \xi \times \mathbf{k}$ has no advective effect on the field of ξ
The substitution $z = z^{\star} + z^{\star\star}$ is not necessary for the same result is found more directly as in (2).

(b) Advection of the ξ field is equivalent to advection of the z field by the geostrophic wind due to the $\bar{z} + J(\phi)$ field.

(c) $\bar{z} + J(\phi)$ is slowly changing only when the most rapidly changing components are suppressed, *i.e.* when $d =$ about 600 km. For any other grid length more slowly changing components are damped out and therefore the time steps would have to be shorter. The graphical method is practicable then for one grid length only.

REFERENCE

FJØRTOFT, R. (1952): On a numerical method of integrating the barotropic vorticity equation. *Tellus* **4**, 179—194.

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Professor R. Fjørtoft wants to refer to a forthcoming article in Tellus Vol. 7, No. 4 where his results are generalized and where the questions raised by Drs J. F. de Lisle and I. S. Kerr will be discussed in some detail.

The Editor