A Review of the Sporadic-E Phenomenom

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During the summer months when HF propagation quiets downs significantly, Sporadic-E activity becomes a major propagation mode on both Ten and Six Meters. This mode seems to come and go at random, making it a challenge for Hams to catch openings on these bands and sometimes on Two Meters!

It has been many years that the Sporadic-E phenomenon has been of intense interest to Hams operating on the VHF bands, ever since its discovery by Hams on the old Five Meter band, back in 1935. As the many Hams who operate on the VHF bands of Six Meters and even Two Meters know, a significant amount of stations can be worked during the summer months and occasionally during the winter months via Sporadic-E, even with station using modest setups of simple antennas and low power.

As the result of various rocket probes conducted over the years, it has been determined that a Sporadic-E layer consists primarily of metallic ions, typically iron and magnesium, that are capable of reflecting radio waves as shown in Figure 1. As the layer gets denser, the formation is capable of reflecting higher frequency radio waves. The phenomenon can be observed as low as Ten Meters as the layer gets denser, it is often observed on Six Meters and on rare occasion, the formation is dense enough to be able to reflect radio waves on Two Meters.

The phenomenon has a very unique yearly pattern of occurrence as shown in Figure 2. The pattern is characterized as a major summer season, a minor winter season and deep voids of activity during the equinoxes.

As a result of its unusual pattern of occurrence, the cause of the phenomenon has been the subject of much speculation and unfortunately many myths. Hams who have not consulted with the scientific literature before forming conclusions

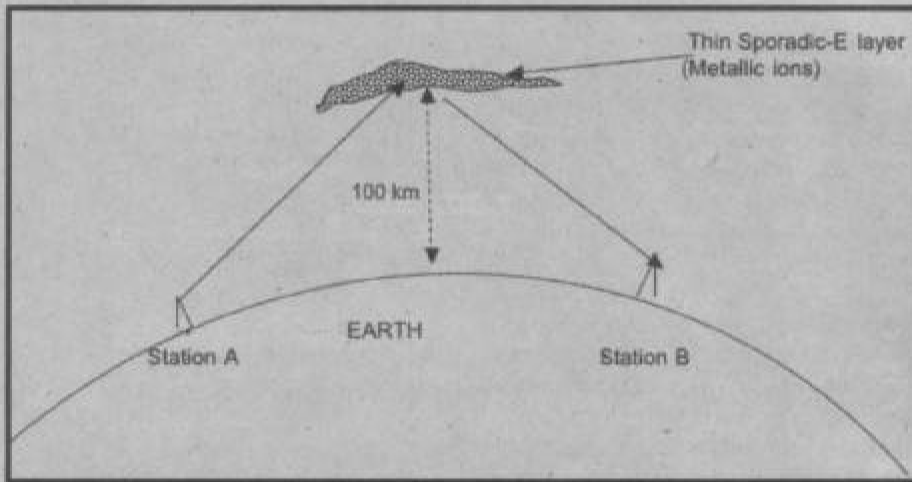

Figure 1 — Pictorial description of Sporadic-E.

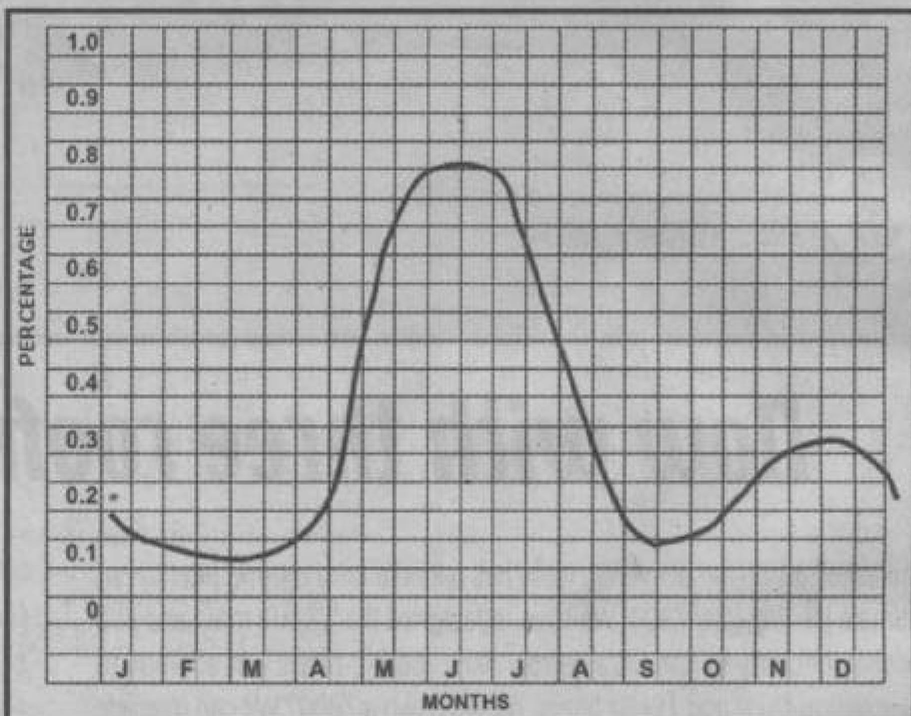

Figure 2 — Yearly 50 MHz Sporadic-E Pattern for North Temperate Zone (Percentage of days per month).
The figure above is a very general curve of Sporadic-E occurrences based on observations made by Ken Neubeck, WB2AMU, and others in the northeast U.S.

based solely on Amateur Radio observations have actually spread many of these myths. Early amateur articles from the 1960s and 1970s fell into the trap of trying to tie Sporadic-E directly to the formation of thunderstorms, particularly since both occur in force during the summer months. While an indirect connection may exist, the identification of thunderstorms and similar weather phenomenon as the prime cause of Sporadic-E by Hams has actually discredited radio amateurs in the eyes of the scientific community. For example, how does one explain the occurrence of Sporadic-E during winter months when thunderstorm activity is significantly reduced?

Fortunately, actual scientific data on Sporadic-E has been collected as early as 1960, beginning with the launching of a rocket equipped with a mass spectrometer an active formation by Russian scientists, leading to the discovery that the individual ions in the formation to be metallic (in this case, magnesium). Since then additional data has been collected through ionosondes, additional rocket launches and satellite data. However, many scientists have not made use of Amateur Radio data when examining the scientific data and getting a feel for the phenomenon. Thus when one discusses Sporadic-E with a scientist who does not have radio experience, there are apparent gaps in the knowledge of the phenomenon. Thus, the combination of using the combined resources of both Amateur Radio data and scientific data has proven to be a major tool in analyzing Sporadic-E. The effectiveness of this combination was documented in a paper by the author in 1996 (Reference 1).

In recent years, additional methods for measuring Sporadic-E have been developed in the form of Satellite data and EISCAT radar plots. Figure 3 shows a typical EISCAT radar plot made of a thin Sporadic-E layer in Europe.

As more data becomes available, the phenomenon becomes better defined and the direction of scientific thinking is that there is some sort of reservoir in the E-region where there is an active transport mechanism for the metallic ions. A major paper that was written recently was by Carter and Forbes in 1999 for Annales Geophysicae (Reference 2) that discusses the ion transport theory of metallic ions. In addition to summarizing earlier studies, the paper

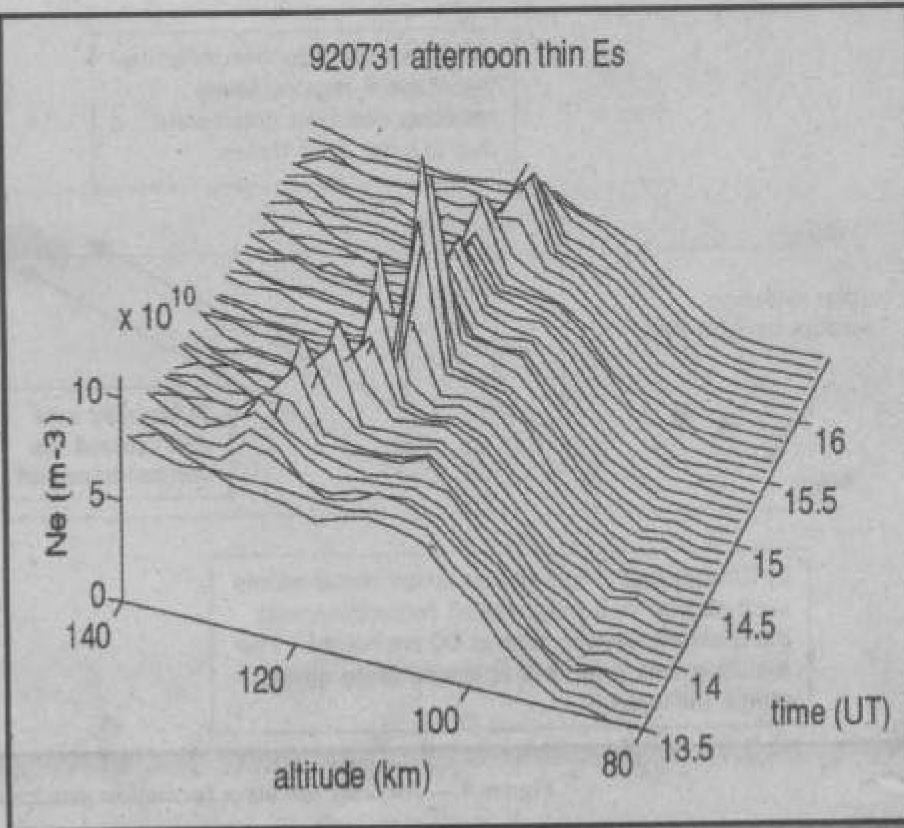

Figure 3 — Figure courtesy of S. Kirkwood.

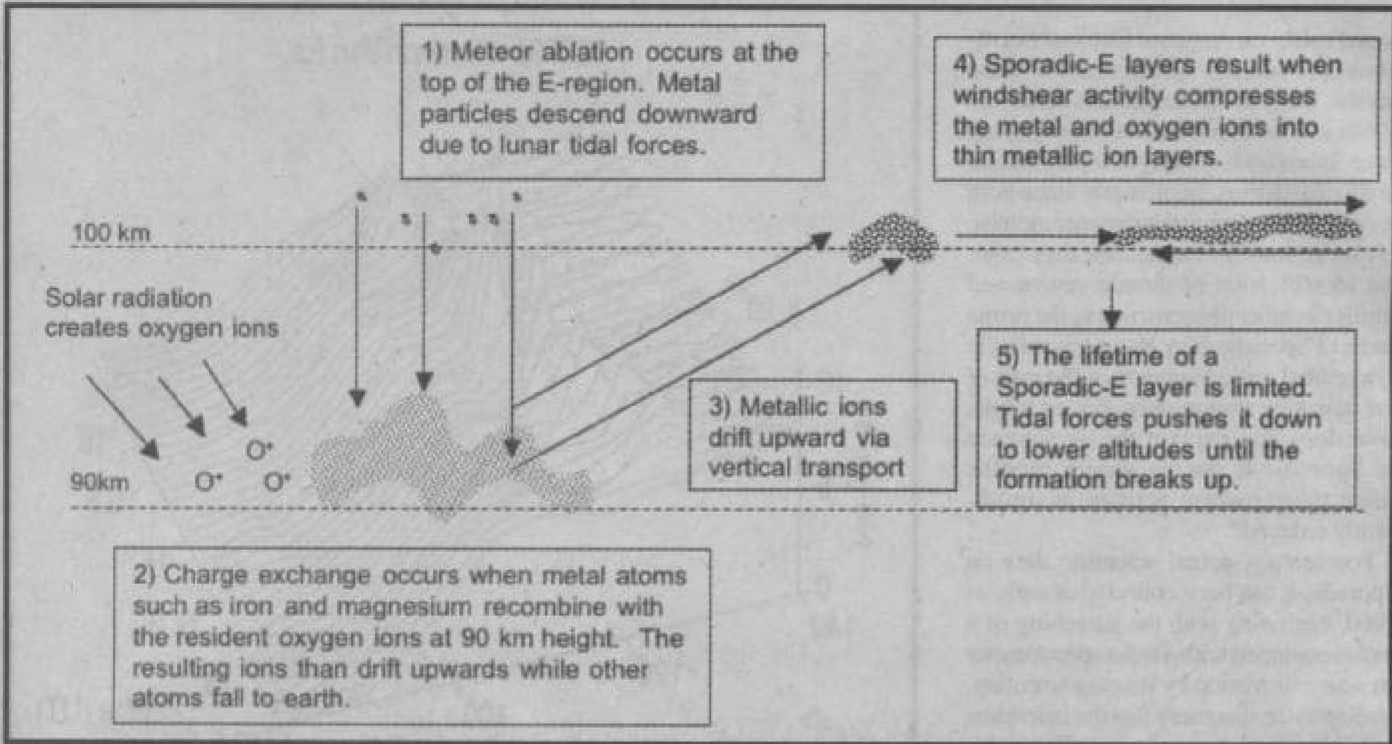

Figure 4 — Metallic ion layer formation process on Earth.

provides a schematic of the vertical transport mechanism for metallic ions. A simplified version of this transport mechanism is shown in Figure 4.

The authors also state, "Because of the separate ways in which zonal winds and meridional winds affect ion motion, the zonal component is more effective at lower latitudes and lower altitudes, and conversely the meridional component becomes increasing effect at high altitudes and high latitudes (horizontal transport becomes a fact at higher latitudes."

Also as Carter and Forbes note, the effects of Earth's geomagnetic field is an important factor to Sporadic-E events and how this and other factors in each of the major zones (temperate, equatorial and aurora zones) of Earth have different effects on Sporadic-E formation. Indeed, the authors note, "The daytime global electric field plays a vital role through the upward transport of metallic ions in the equatorial region, to a sufficient high altitude where gravity-induced downward drift along geomagnetic field lines caries them into mid and high latitude regions. One effect of this transport is that the highest metallic ion densities in the upper F region are found at the equatorial latitudes."

Recent satellite data on the atmospheres of other planets have shown the

Amateur Radio Call Signs

The following shows the last call sign in each group to be assigned for each VE Region under the sequential call system as of 12 August 2006. For more information about the sequential call sign system, see Fact Sheet PR5000 #206-S dated August 1996 or contact the Federal Communications Commission, Consumer Assistance Branch, 1270 Fairfield Rd., Gettysburg, PA 17325-7245, toll free 888/225-5322, or see the website: *www.wireless.fcc.gov/services.*

District	Group C/ Technician	Group B/ General	Group A/ Extra
0	KCØYHD	++	ACØET
1	KB1NWG	++	AB1GF
2	KC2QBL	++	AB2VQ
3	KB3NXB	++	AB3DV
4	KI4QNB	++	AI4QT
5	KE5JZA	++	AD5XW
6	KI6FCD	++	AE6YF
7	KE7ISP	++	AD7JH
8	KD8ECR	++	AB8WR
9	KC9JYM	++	AB9MR
N. Marianas	KHØSG	++	++
Guam	NH2DH	++	++
Hawaii	WH7BG	++	AH6SM
American Samoa	KH8DS	++	AH8Y
Alaska	KL2AC	++	AL2T
Virgin Island	NP2NF	++	++
Puerto Rico	WP4NSV	++	++

++ All calls in this group have been assigned

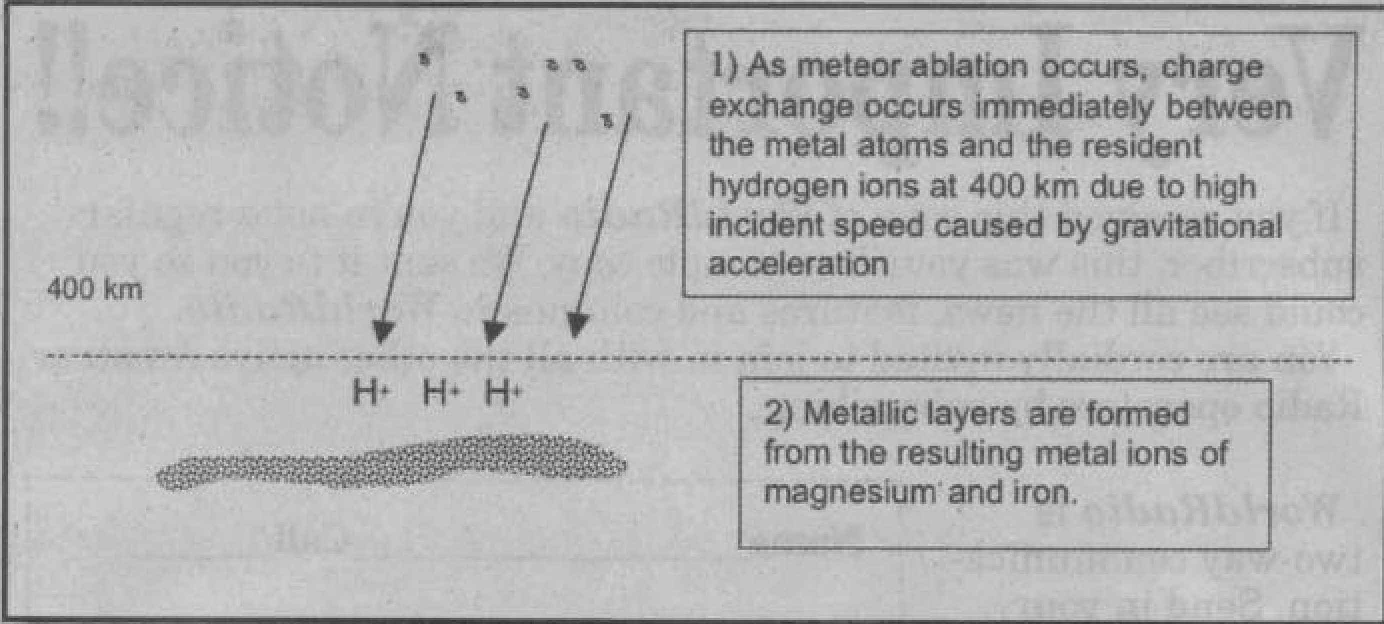

Figure 5 — Metallic ion layer formation process on and Juptier.

existence of metallic layers similar to that of earth. To date, planets such as Jupiter, Neptune, Mars and a few moons have the presence of metallic ion layers (References 3 through 8).

What distinguishes the metallic-ion layers of other planets from Earth is the fact that the layers are formed directly, shortly after impact of meteor debris. This is because of the effects of the stronger gravitational fields of these planets compared to Earth. See Figure 5 for this situation for the planet Jupiter.

In the case of Earth, there are additional steps from the point of meteor ablation, to where recombination takes places with oxygen ions at the 90 km mark and then with the right conditions of wind, before the formation of Sporadic-E layers result. Data collected over the years suggest that metallic ions are consistently present in the ionosphere of Earth.

It becomes apparent that the Sporadic-E phenomenon on Earth, while similar to metallic layers that appear on other planets in the solar system, has some distinguishing characteristics that make it unique. Certainly, the seasonal pattern is one feature that appears to be unique to Earth and one that continues to amaze and baffle VHF Amateur Radio operators! As more data from the ionosphere is collected in the future, a better understanding of the Sporadic-E phenomenon will result.

Also, the fact that these metallic ion layers exists on other planets besides Earth as a direct result of meteor ablation points away from the fact that secondary events like thunderstorms as a primary factor for Sporadic-E formation on Earth. The layers can form almost immediately on other planets due to the stronger gravitational fields while the process takes longer on Earth, because of the different atmospheric ion makeup. It would seem that local effects such as thunderstorms are not a major part of the process for Sporadic-E, except as a possible indirect effect in enhancing existing formations.

References

1) "Using the combined resources of Amateur Radio observations and ionosonde data in the study of temperate zone sporadic-E." Neubeck, Journal of Atmospheric and Terrestrial Physics, Volume, 58, number 12, August 1996

2) "Global transport and localized layering of metallic ions in the upper atmosphere," Carter L.N., Forbes J. M., Annales Geophysicae, Volume 17, (1999), pp190-209

3) "Meteoric ion production near Jupiter." Grebowsky J.M., Journal of Geophysical research, Vol 86, (1981), pp 1537-1543

4) "Meteoric Ions in the Ionosphere of Jupiter," Kim Y.H., Pesnell W.D., Grebowsky J.M., Fox J.L., Icarus 150 (2001), pp 261-278

5) "Metal ions in the atmosphere of Neptune," Lyons J. R., Science, February 1995, pp 648-651

6) "Ionospheric layer induced by meteoric ionization in Titan's atmosphere," Molina-Cueros et al, Planetary and Space Science, Volume 49, Feb 2001, pp 143-153

7) "Meteoric ions in planetary ionospheres," Pesnell W.D., Grebowsky J.M., Advances in Space Research, Vol 27, June 2001, pp 1807-1814

8) "Meteoric magnesium ions in the Martian atmosphere." Pesnell W.D., Grebowsky J.M., Journal of Geophysical Research, Volume 104, (2000), pp 1695-1708

*— Ken Neubeck, WB2AMU, has written several articles on VHF propagation, including the book, Six Meters, A Guide To The Magic Band (**WorldRadio** Books) and is a co-writer with Gordon West, WB6NOA, on the book on VHF Propagation, A Practical Guide For Radio Amateurs (CQ).*