

## **Observations of the Roots of Plasma Bubbles: Are They Sometimes Foamy?**

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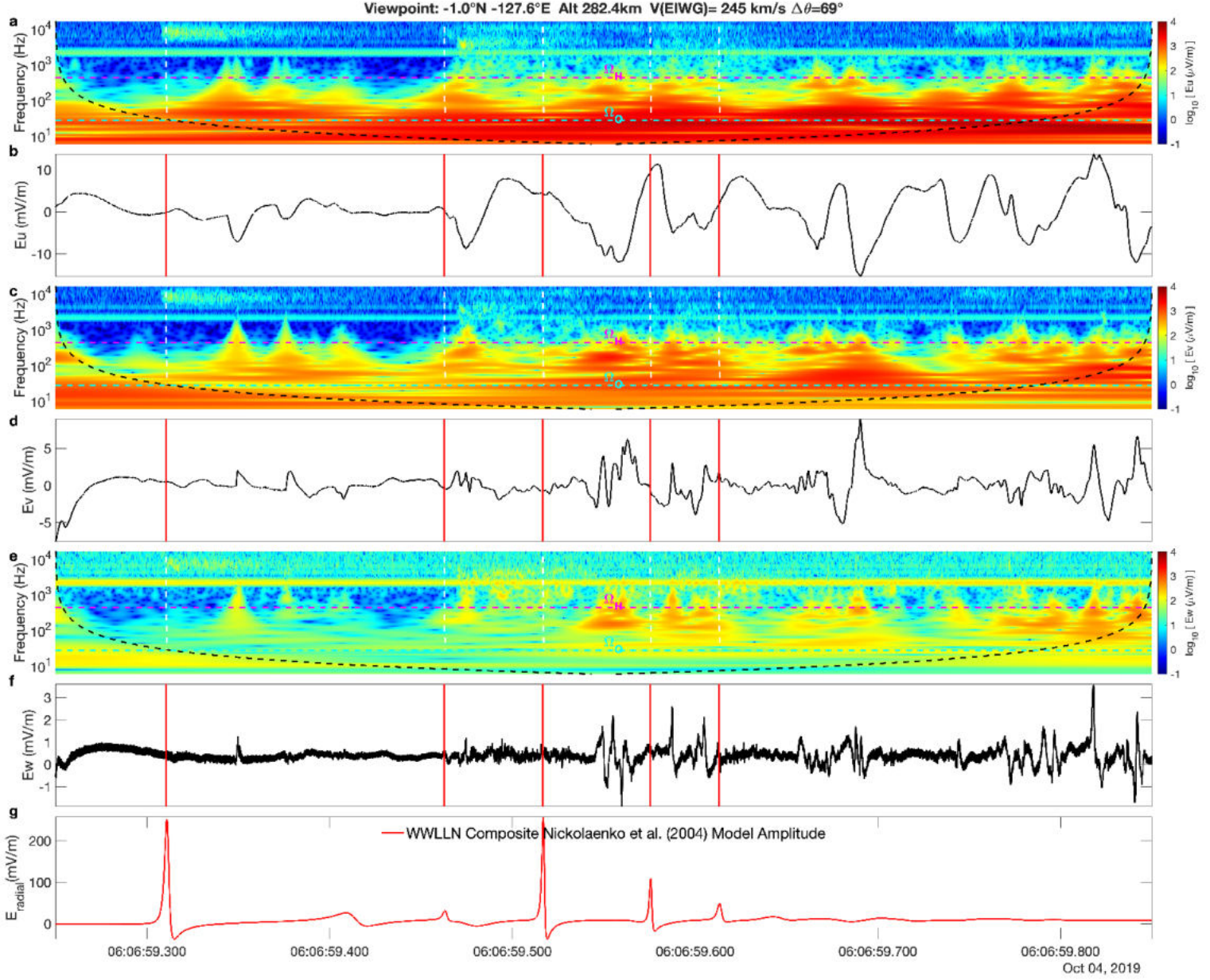
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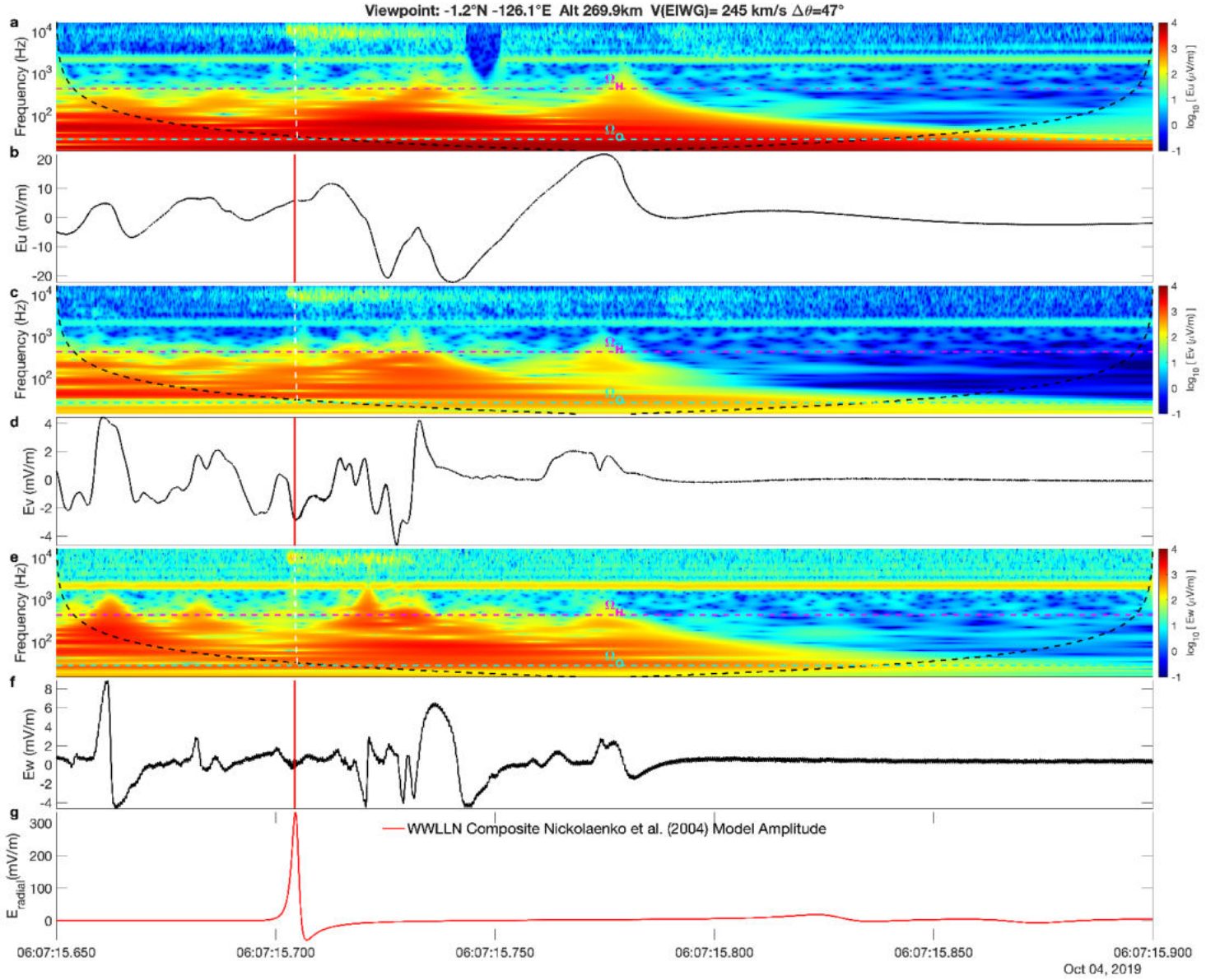
### **Introduction**

The first nine of these figures provide supporting evidence for the existence of occasional “precursors” to the unusual nearly dispersionless spikes observed in scalograms while the Van Allen probe is located within the root of a plasma bubble. The layout of each of these nine figures follows that of Figure 1 and 2 in the main article.

The last three of these figures provide the supporting evidence for the group velocity of 245 km/s for the propagation of lightning generated EMPs through the Earth-Ionosphere waveguide (EIWG) at the time of the data shown in Figure 2 of the main article. In each of these three figures, the scalograms and time resolved plots of the two horizontal magnetic field fluctuations observed at one of the WERA ground stations are shown. The appearance times for lightning generated (LG) pulses from the three lightning strikes are indicated on the plots by red vertical lines.

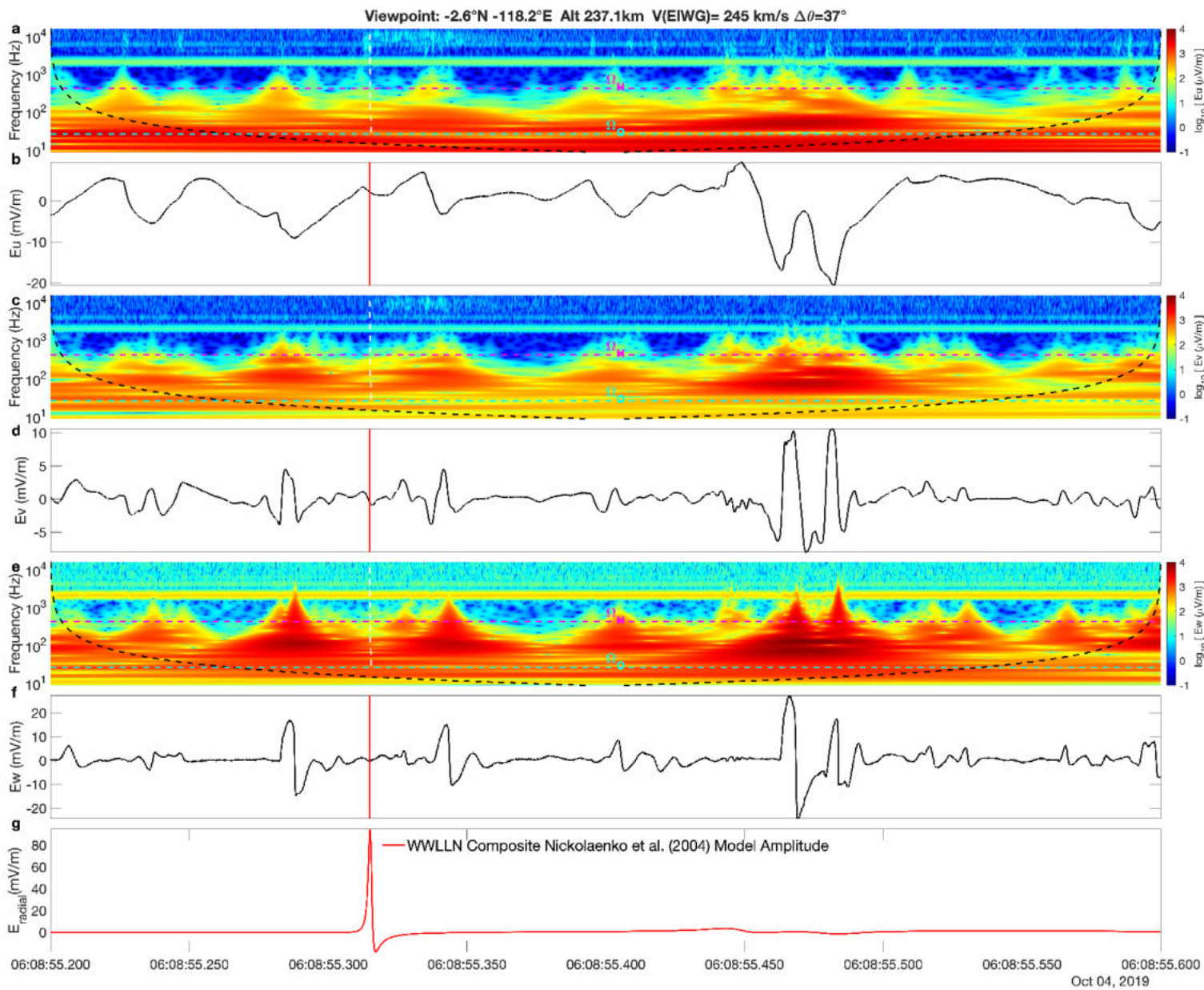


**Figure S1.** The layout of this figure is the same as Figures 1 & 2 in the main article. Scalograms (in a, c, and e) and time resolved plots (b, d, and f) of the electric field components are shown for a period while VAP-A passes through the root of a plasma bubble. In g the radial electric field from all WWLLN detected lightning strokes within this time interval using the (Nickolaenko et al., 2004) model is plotted. This case includes five distinct lightning strokes. The first of these has significant “precursor” activity in Eu and Ev between 3 kHz and 10 kHz, but the presence of corresponding Ew activity is obscured by the high noise level. Only the first two strokes are sufficiently well isolated that their precursors can be seen clearly aligned with the LG pulse arrival times. Because so many spikes appear in the scalograms, it is difficult to properly correlate specific spikes with their precursors.

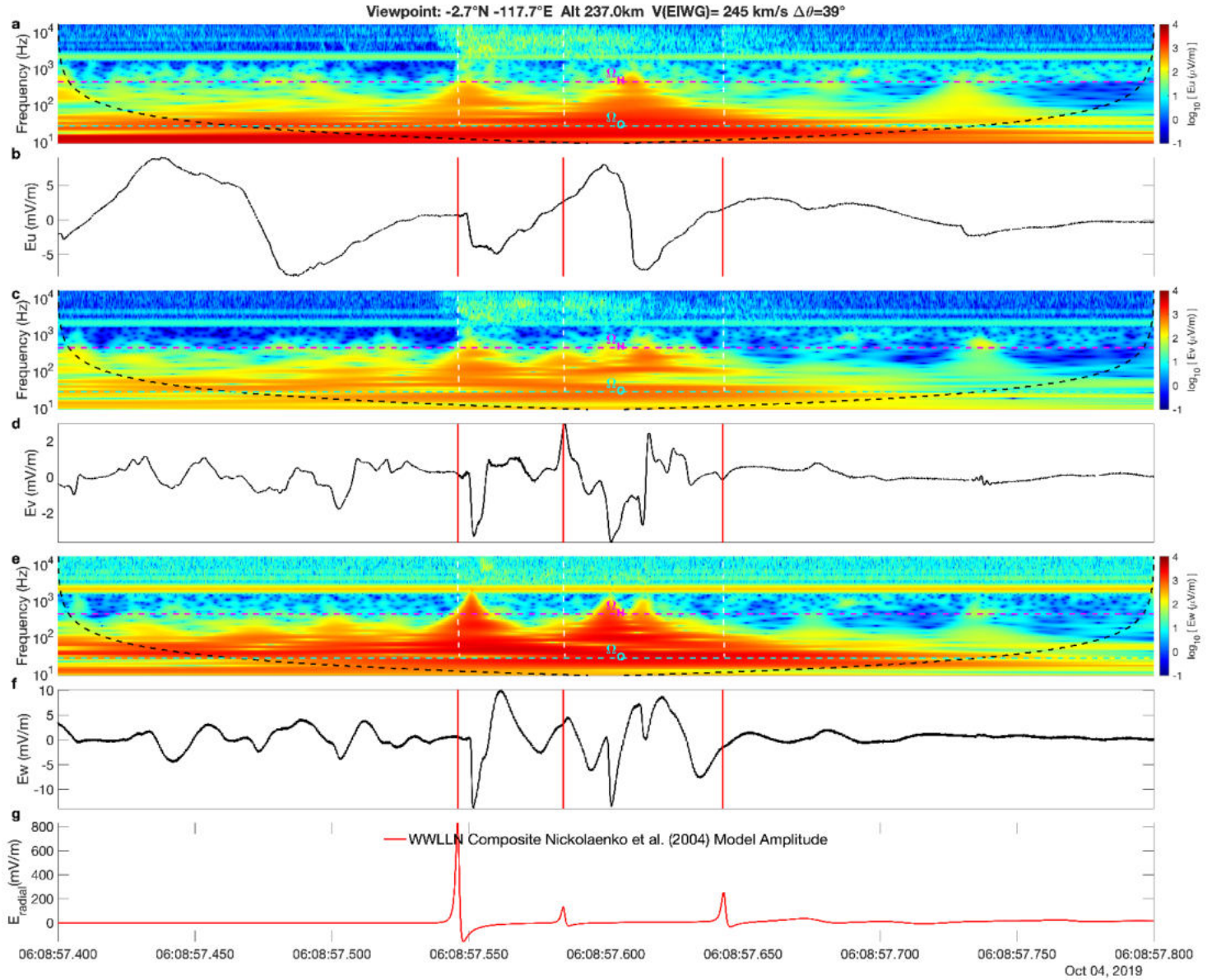


**Figure S2.** The layout of this figure is the same as the previous figure. In this case, although the precursor timing is clear, it is very unclear which, if any, of the spikes in the scalograms are associated with it.



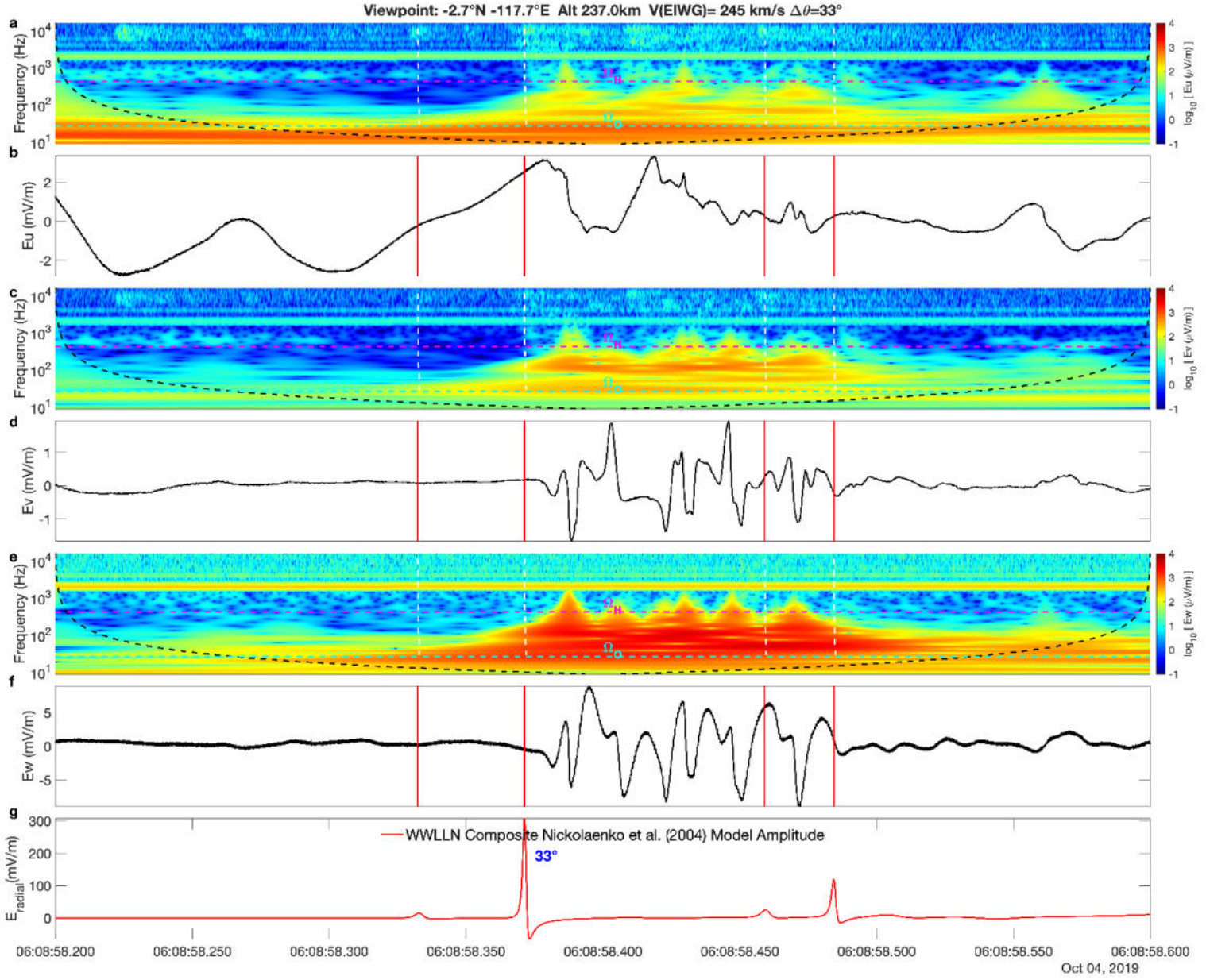


**Figure S3.** The layout of this figure is the same as the previous figure. In this case, although the precursor timing is clear, it is very unclear which, if any, of the spikes in the scalograms are associated with it.

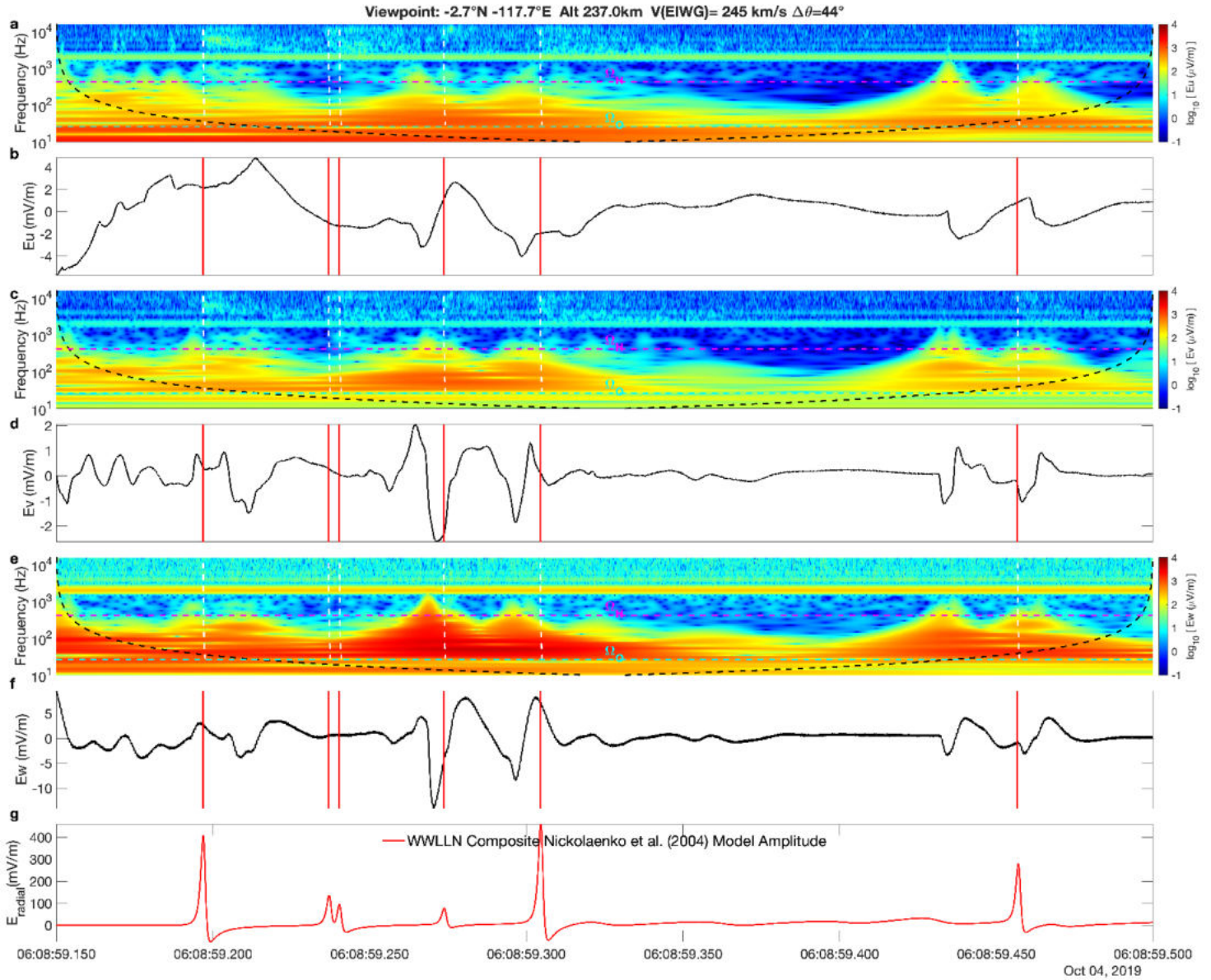


**Figure S4.** The layout of this figure is the same as the previous figure. In this case, although the precursor timing is clear for the first and third strokes, it is very unclear which, if any, of the spikes in the scalograms are associated with them.



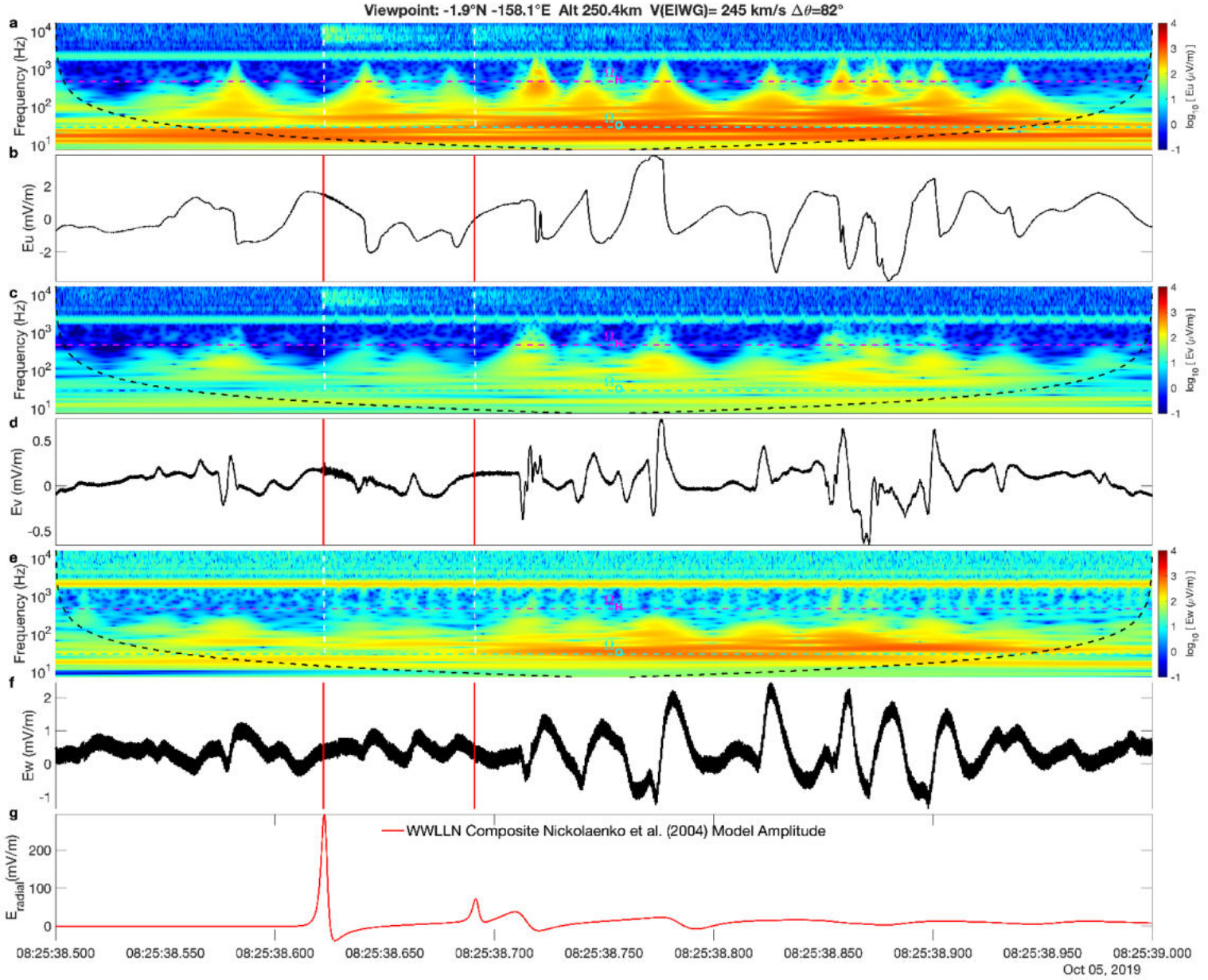


**Figure S5.** The layout of this figure is the same as the previous figure. In this case, although the precursor timing is clear for the first and second strokes, it is very unclear which, if any, of the spikes in the scalograms are associated with them.



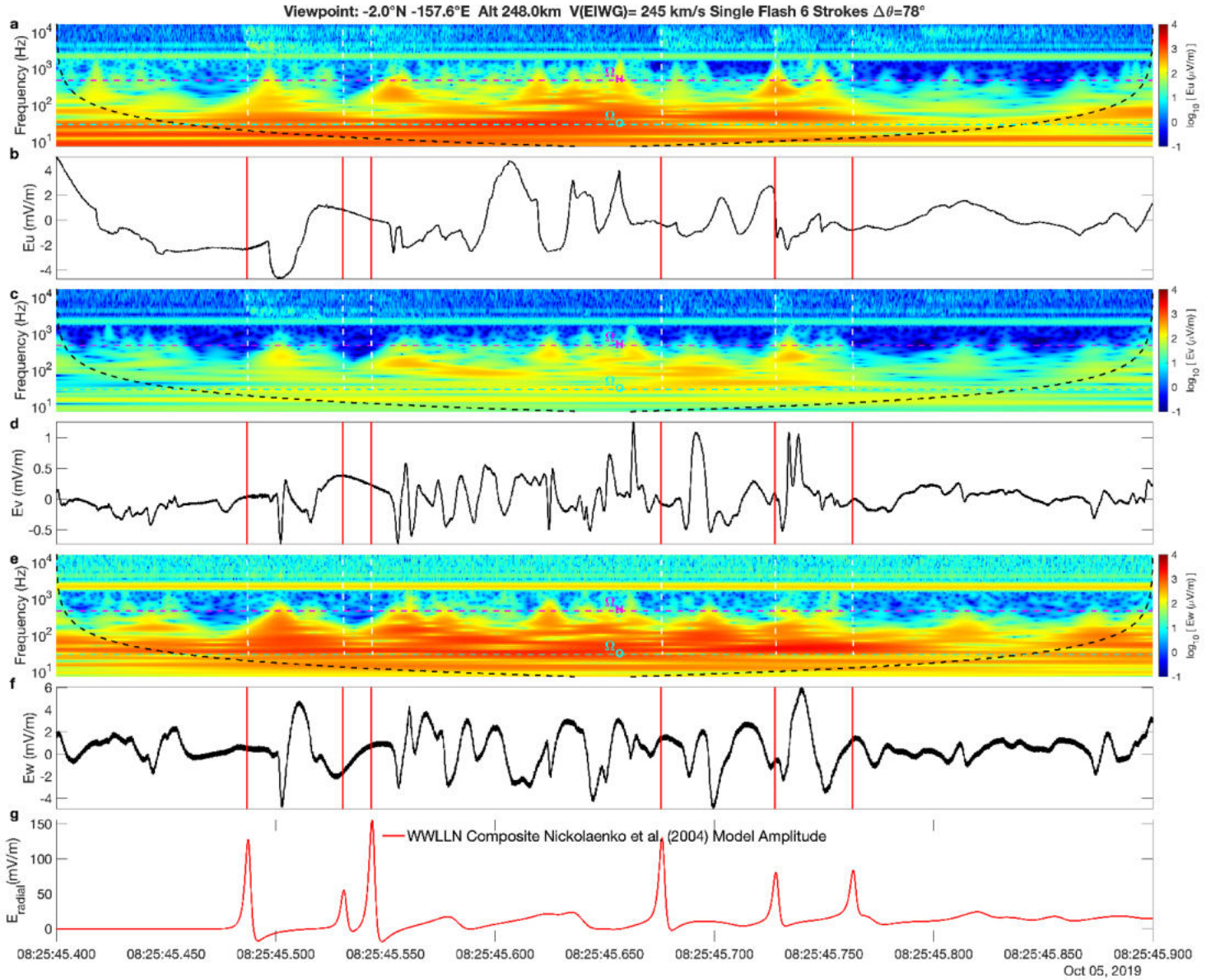
**Figure S6.** The layout of this figure is the same as the previous figure. In this case, although the precursor timing is clear for five of the six strokes, it is very unclear which, if any, of the spikes in the scalograms are associated with them.



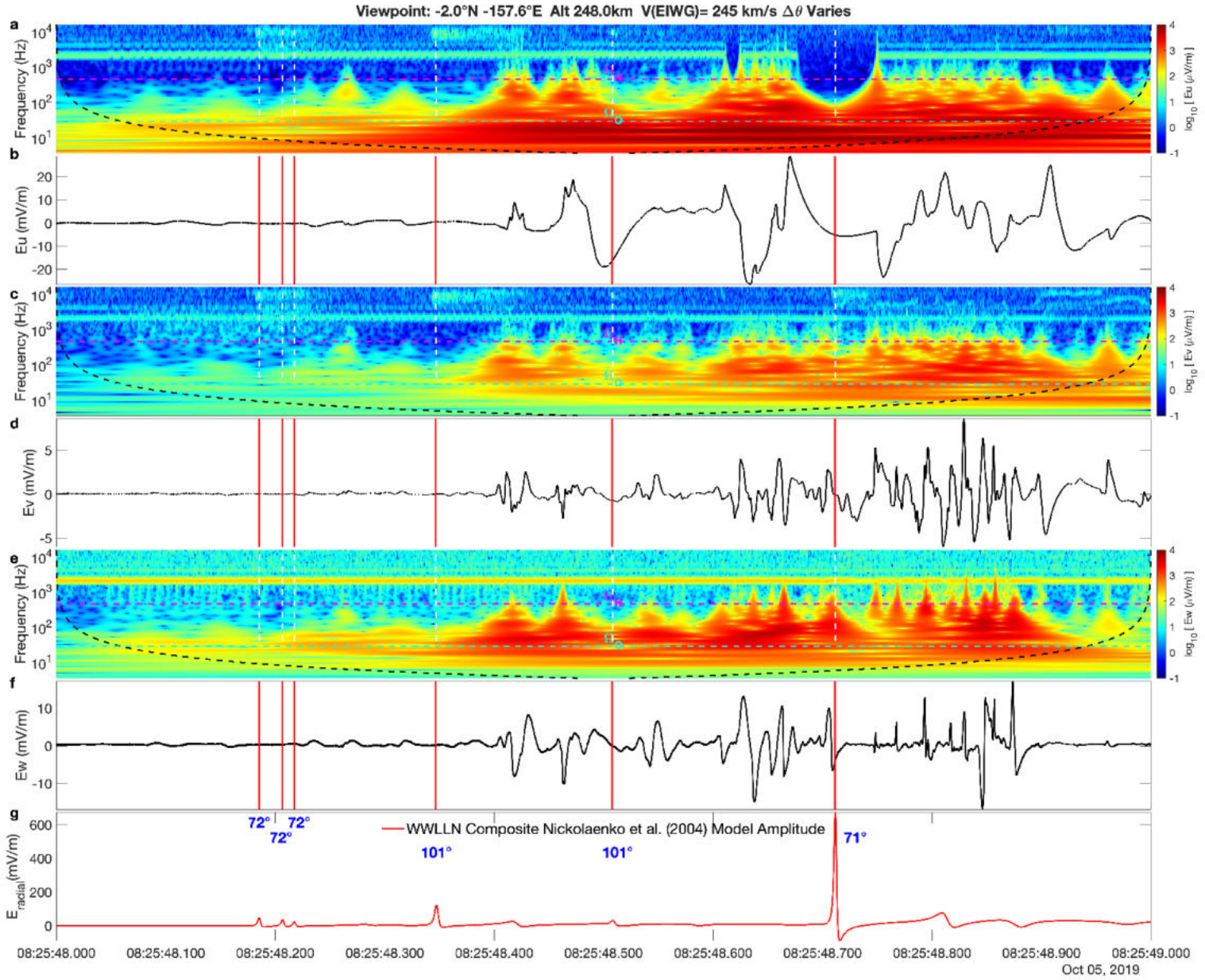


**Figure S7.** The layout of this figure is the same as the previous figure. In this case, although the precursor timing is clear for both strokes, it is very unclear which, if any, of the spikes in the scalograms are associated with them.

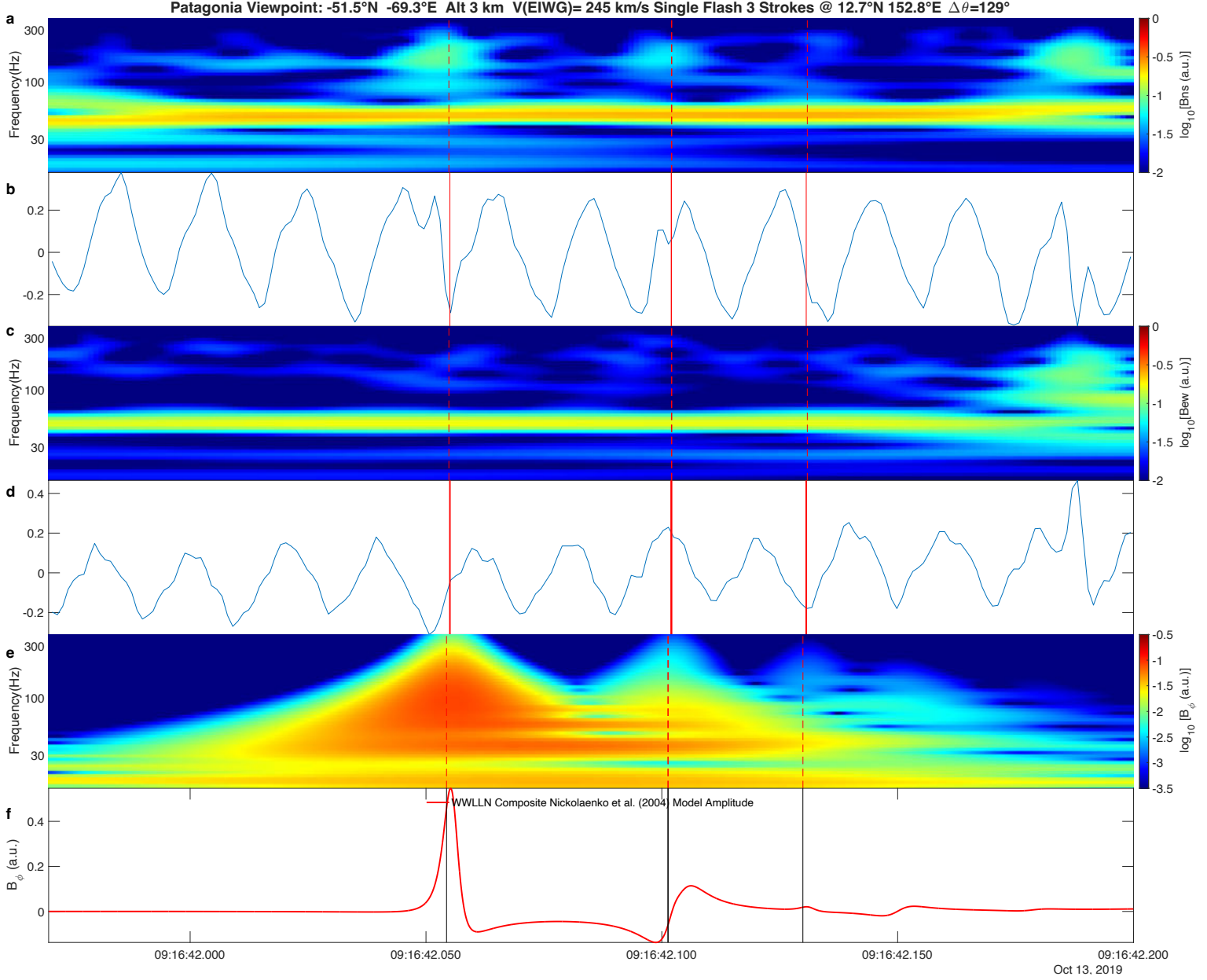




**Figure S8.** The layout of this figure is the same as the previous figure. In this case, although the precursor timing is clear for strokes #1, #4, #5 and #6, it is very unclear which, if any, of the spikes in the scalograms are associated with them.

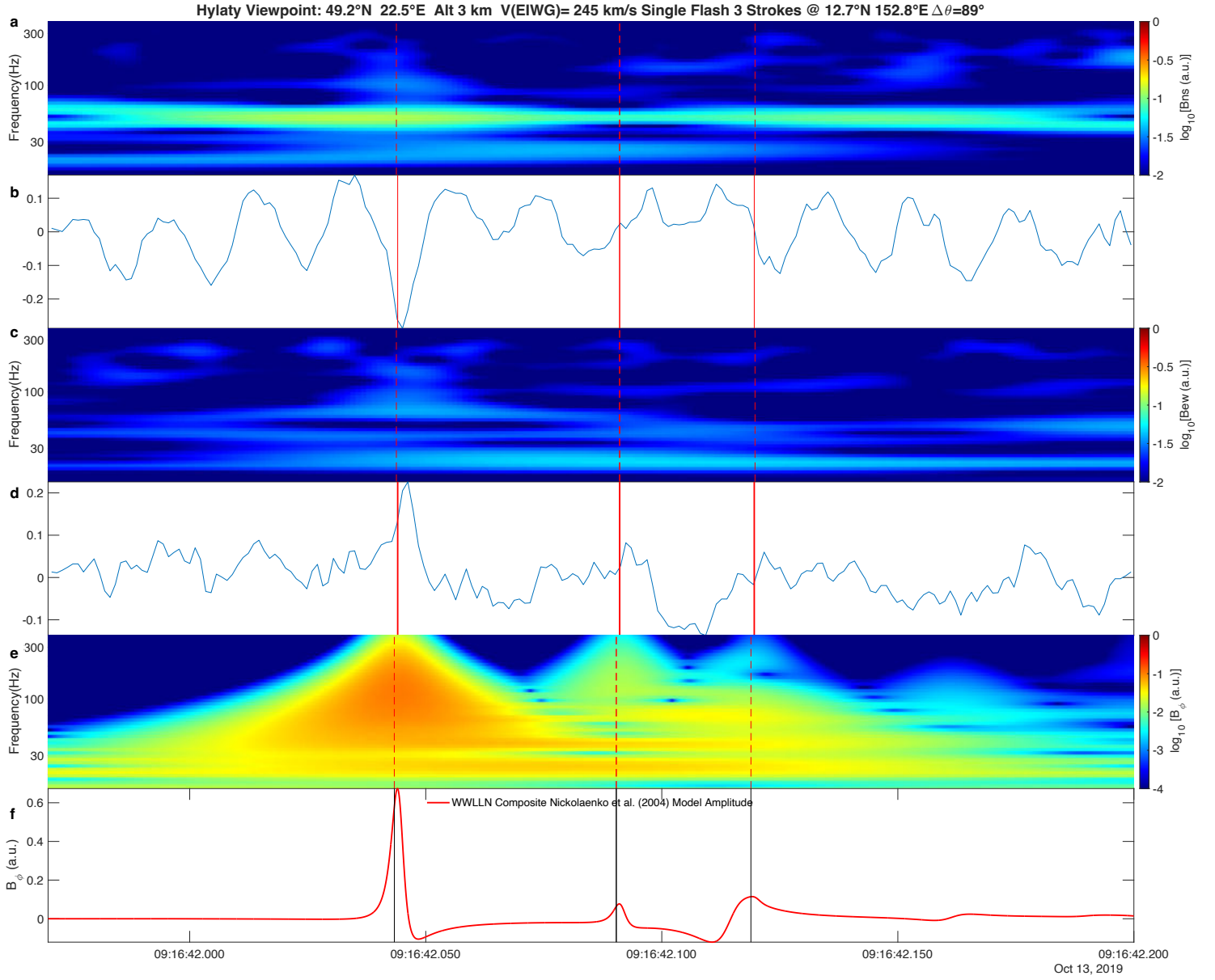


**Figure S9.** The layout of this figure is the same as the previous figure. In this case, although the precursor timing is clear for strokes #1, #4, #5 and #6, it is very unclear which, if any, of the spikes in the scalograms are associated with them.

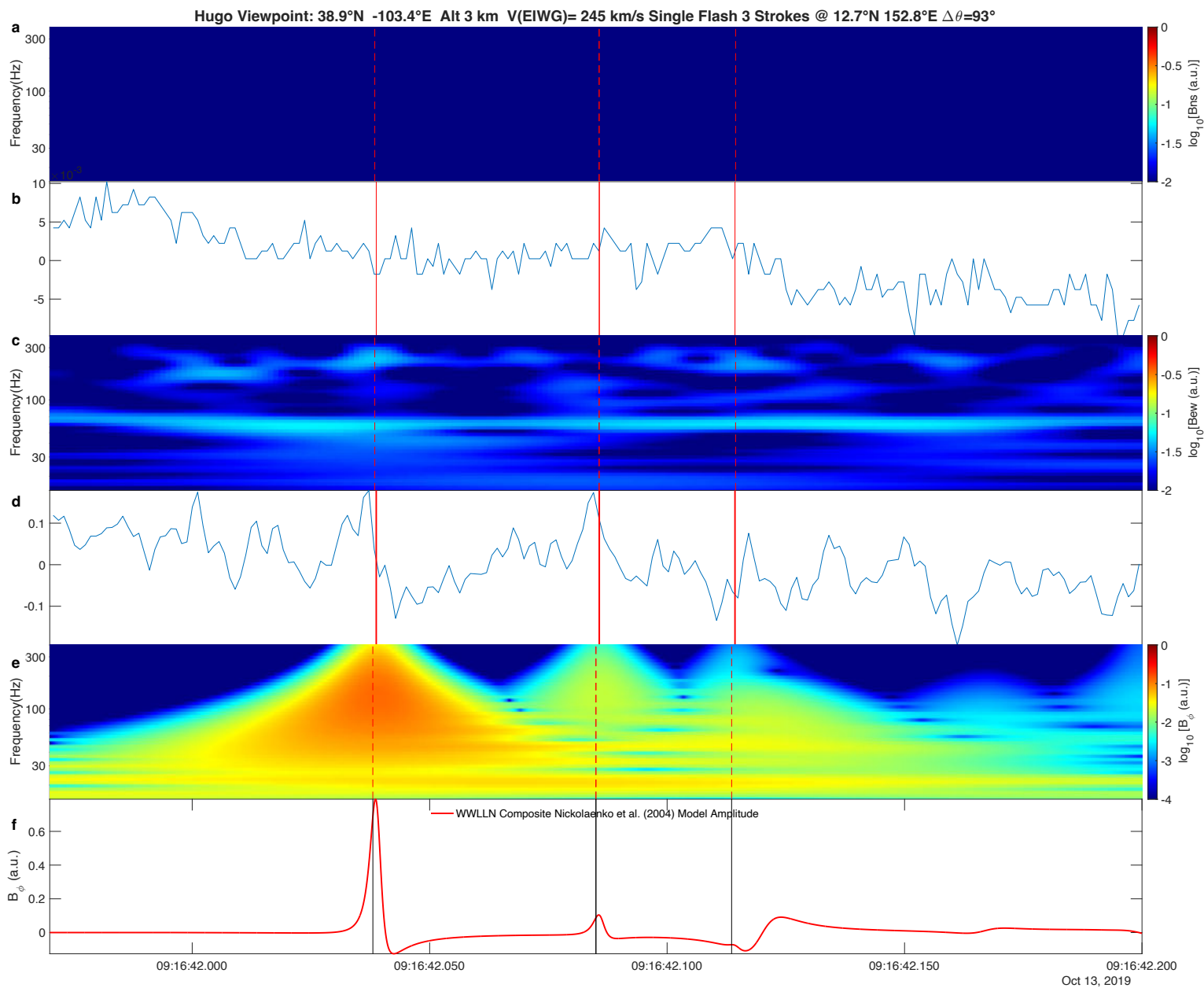


**Figure S10.** Scalograms for the two WERA magnetic field components observed at the Patagonia site, along with their time resolved values are shown for the 0.23 s interval centered around the time of the three lightning strokes discussed in Figure 2 of the main article. In (a and c) scalograms for the North/South (NS) and East/West (EW) components of magnetic field are shown. In (b and d) the NS and EW magnetic fields are plotted as a function of time. In (f) the summation of the azimuthal magnetic field contributions from the three WWLLN detected strokes during this time using the (Nickolaenko et al., 2004) model is plotted. In (e) the scalogram of the temporal function plotted in (f) is shown. Red dashed or solid lines show the arrival time assuming the propagation speed of 245 km/s at the subsatellite location for each of the three lightning stroke pulses.





**Figure S11.** Scalograms and time resolved values for the two WERA magnetic field components observed at the Hylaty site are shown with the same layout as the previous figure.



**Figure S12.** Scalograms and time resolved values for the two WERA magnetic field components observed at the Hugo site are shown with the same layout as the previous figure. In this case, the NS magnetic field components were noisy and not meaningful.