Powerline Contamination In Time-Domain Electromagnetic Data: Experiment, Theory, and Basic Building Blocks

by

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Master of Science Thesis Defense

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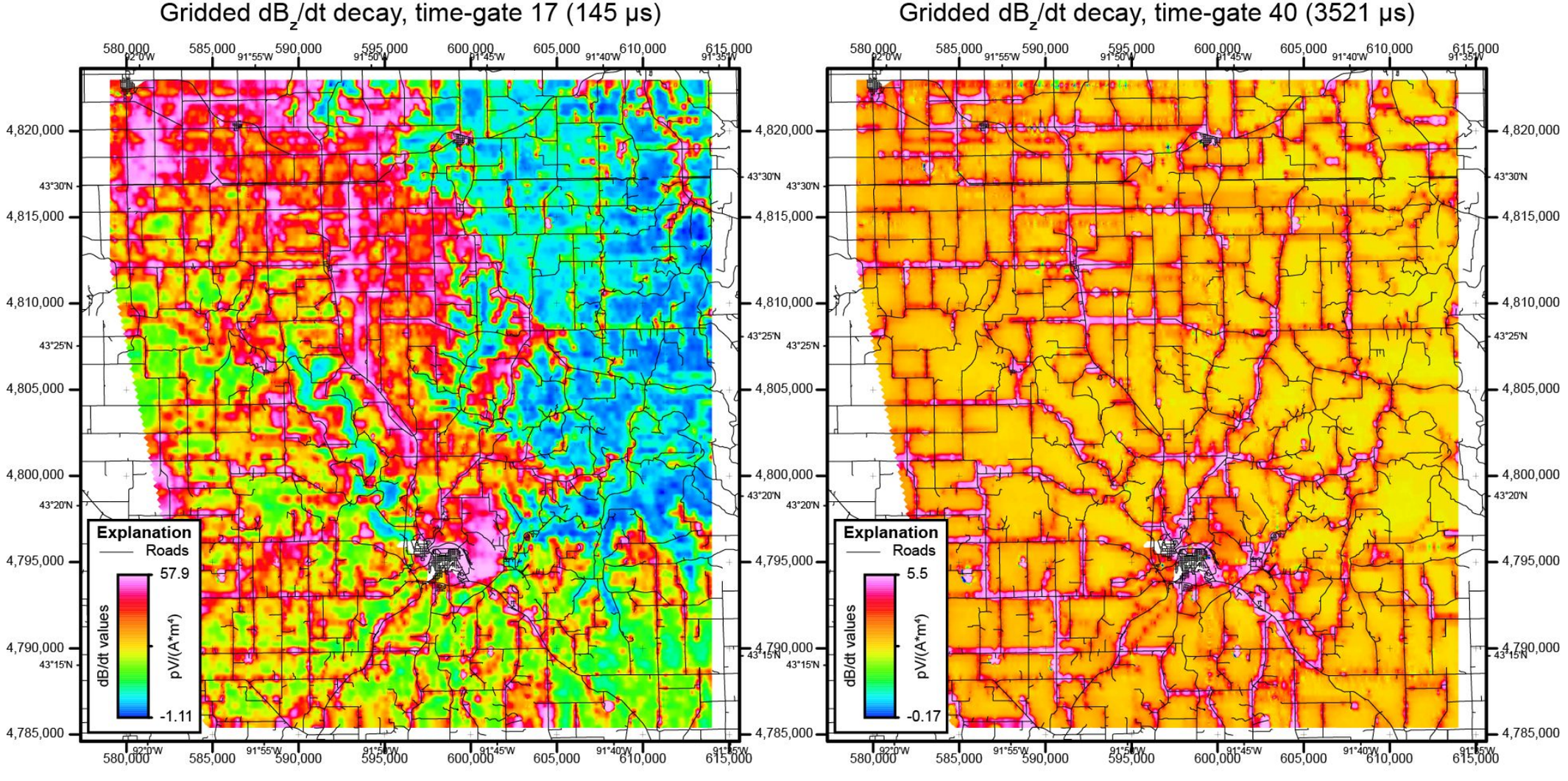
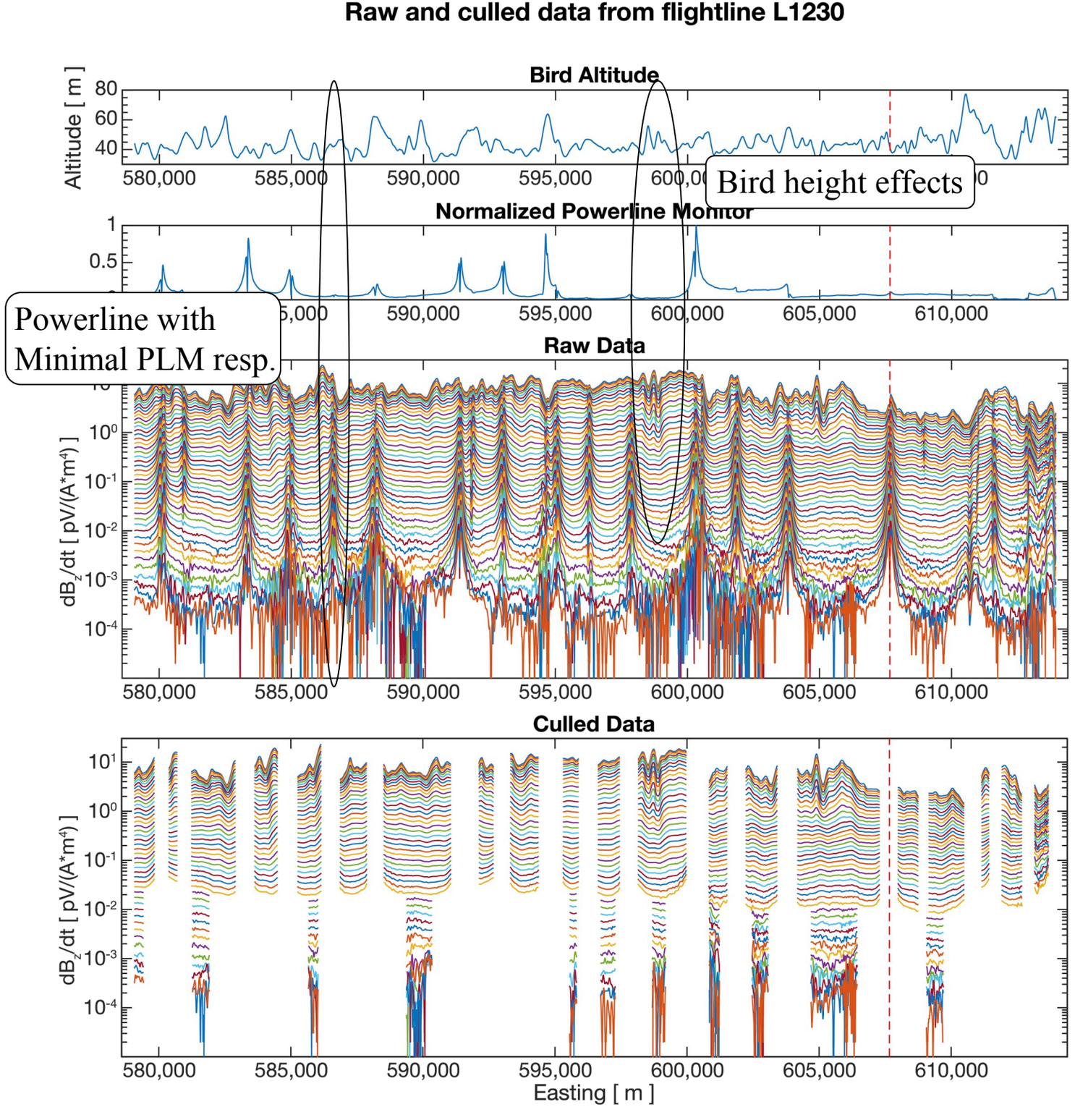
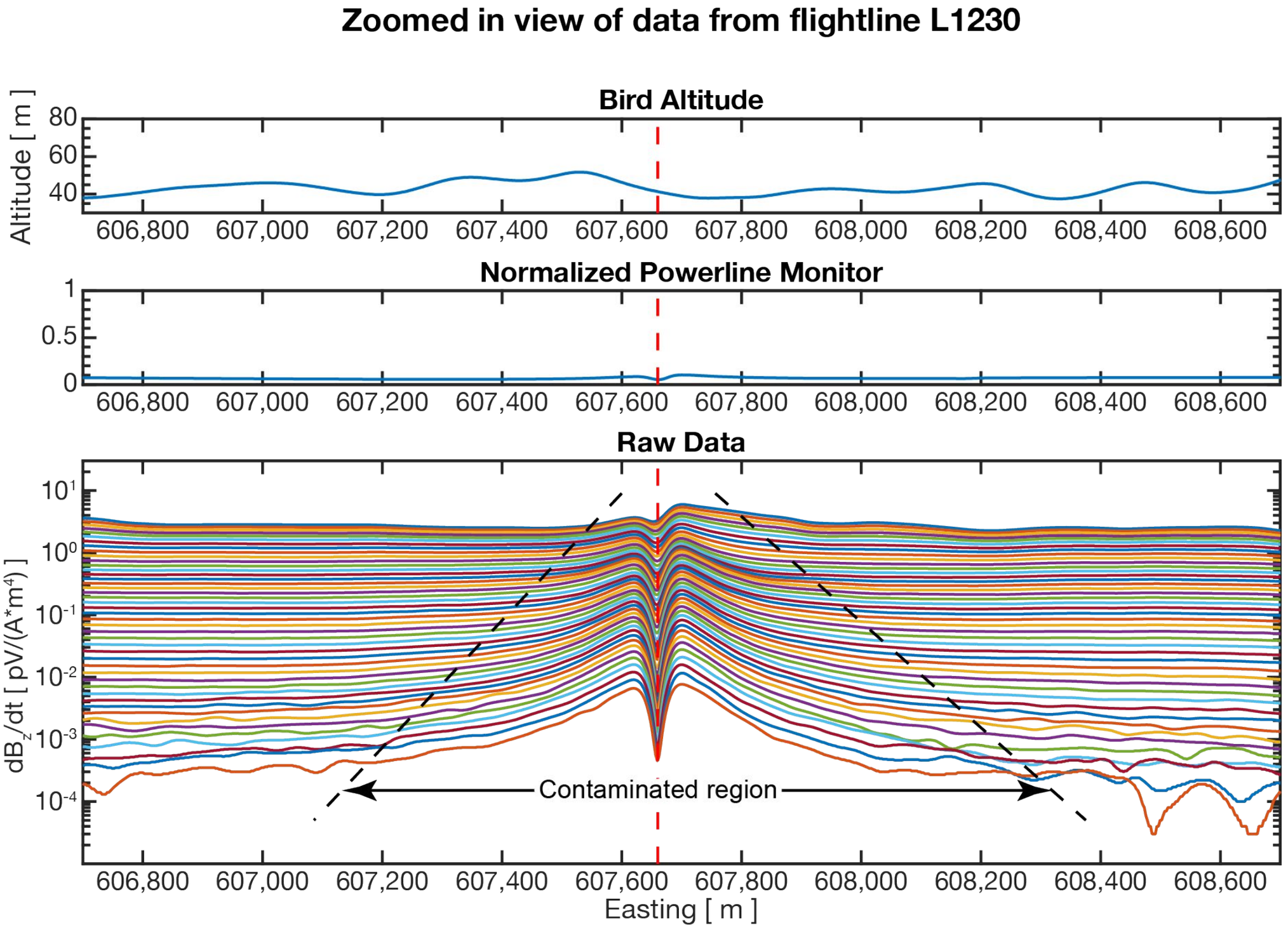
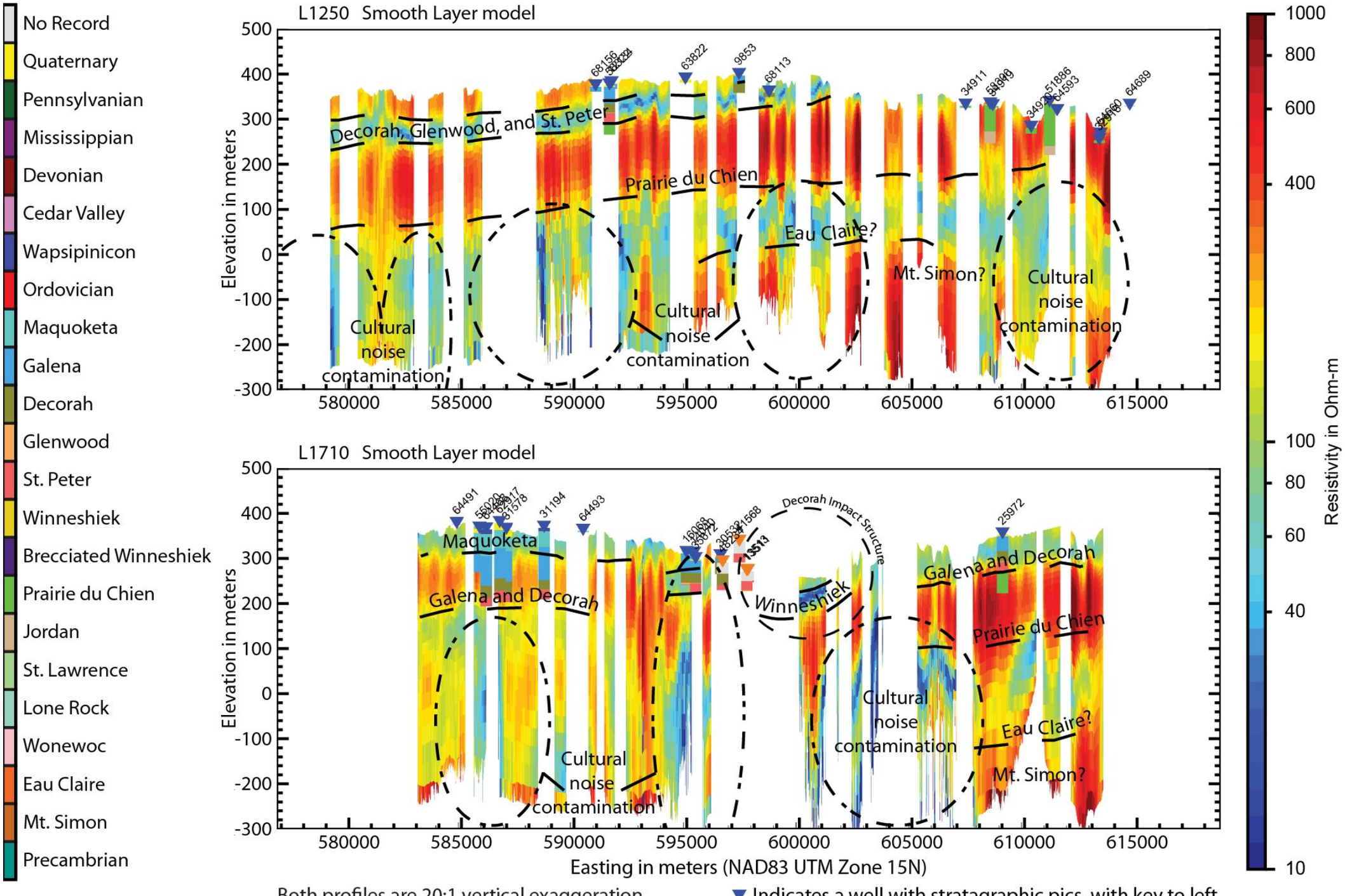
What motivated this powerline study?

- A USGS survey from North-Eastern Iowa, USA

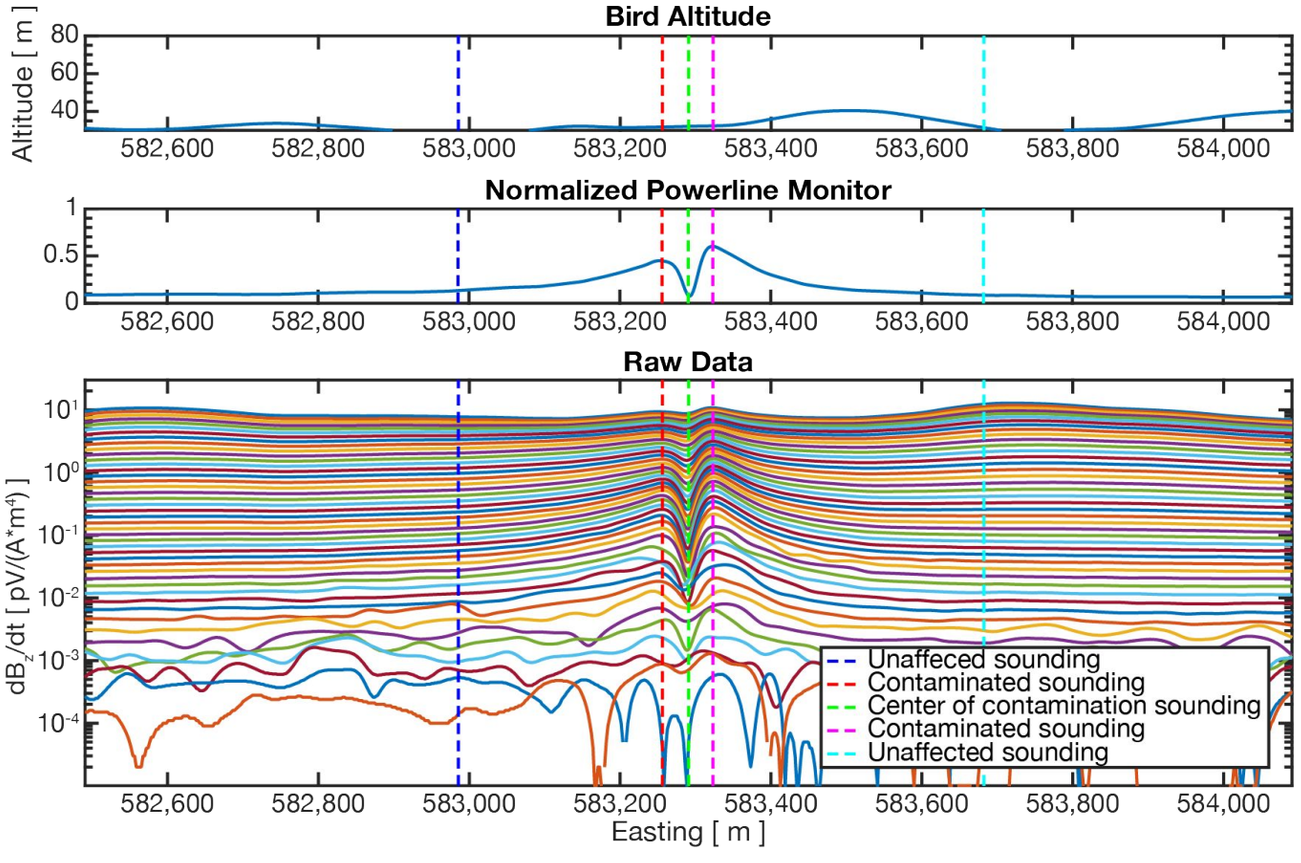


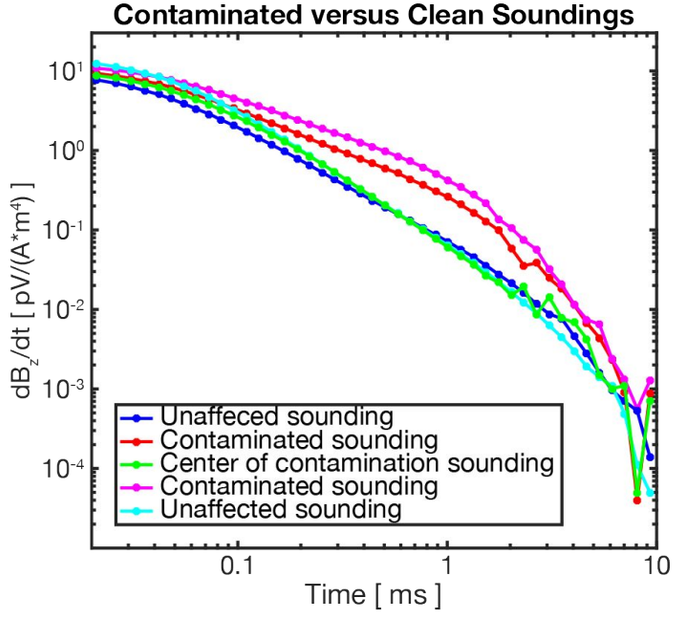

Raw and culled data from flightline L1230
Bird Altitude
Altitude [m]
80
60
40
580,000
585,000
590,000
595,000
600,000
Bird height effects
Normalized Powerline Monitor
1
0.5
590,000
595,000
600,000
605,000
610,000
Powerline with
Minimal PLM resp.
Raw Data
dB_z/dt [pV/(A*m^4)]
10^0
10^-1
10^-2
10^-3
10^-4
580,000
585,000
590,000
595,000
600,000
605,000
610,000
Culled Data
dB_z/dt [pV/(A*m^4)]
10^1
10^0
10^-1
10^-2
10^-3
10^-4
580,000
585,000
590,000
595,000
600,000
605,000
610,000
Easting [m]

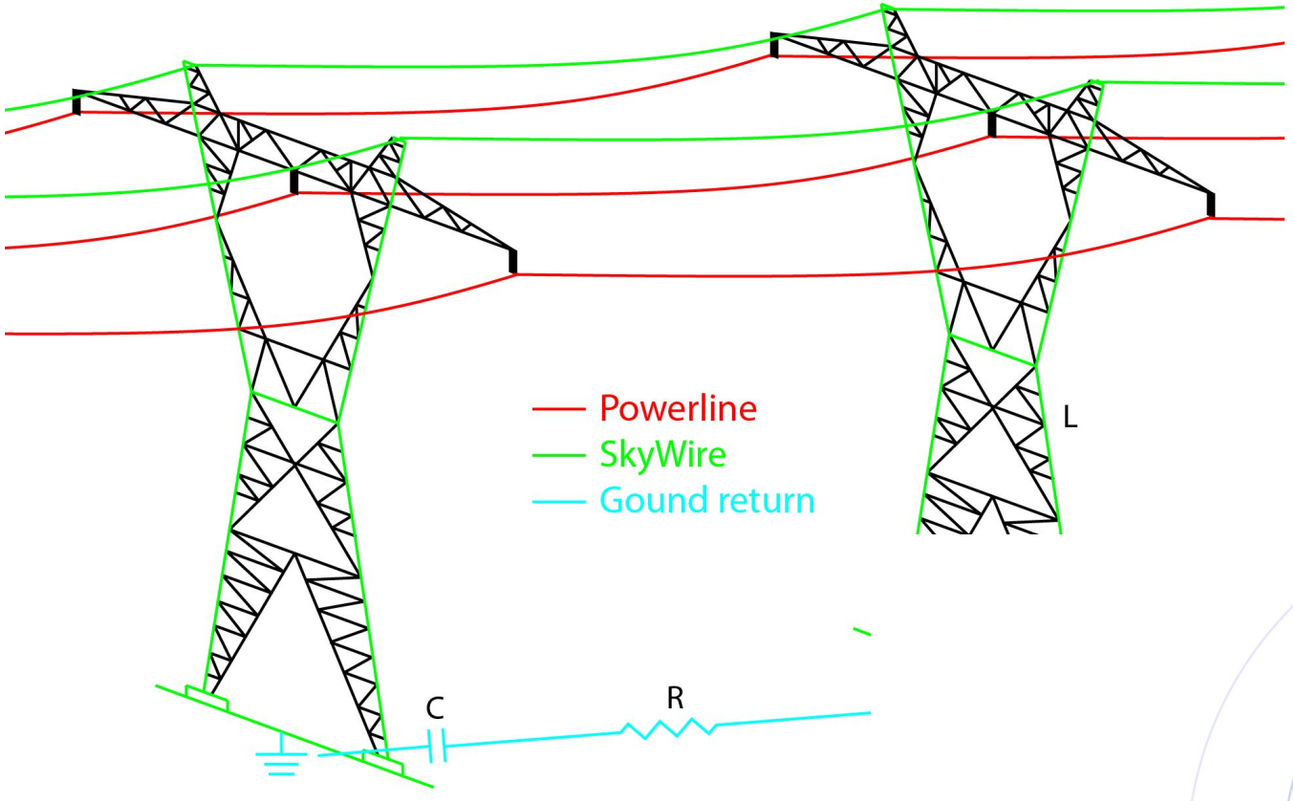

Zoomed in view of data from flightline L1230
Bird Altitude
Altitude [m]
80
60
40
606,800
607,000
607,200
607,400
607,600
607,800
608,000
608,200
608,400
608,600
Normalized Powerline Monitor
1
0.5
0
Raw Data
dB_z/dt [pV/(A*m^4)]
10^1
10^0
10^-1
10^-2
10^-3
10^-4
Contaminated region
Easting [m]

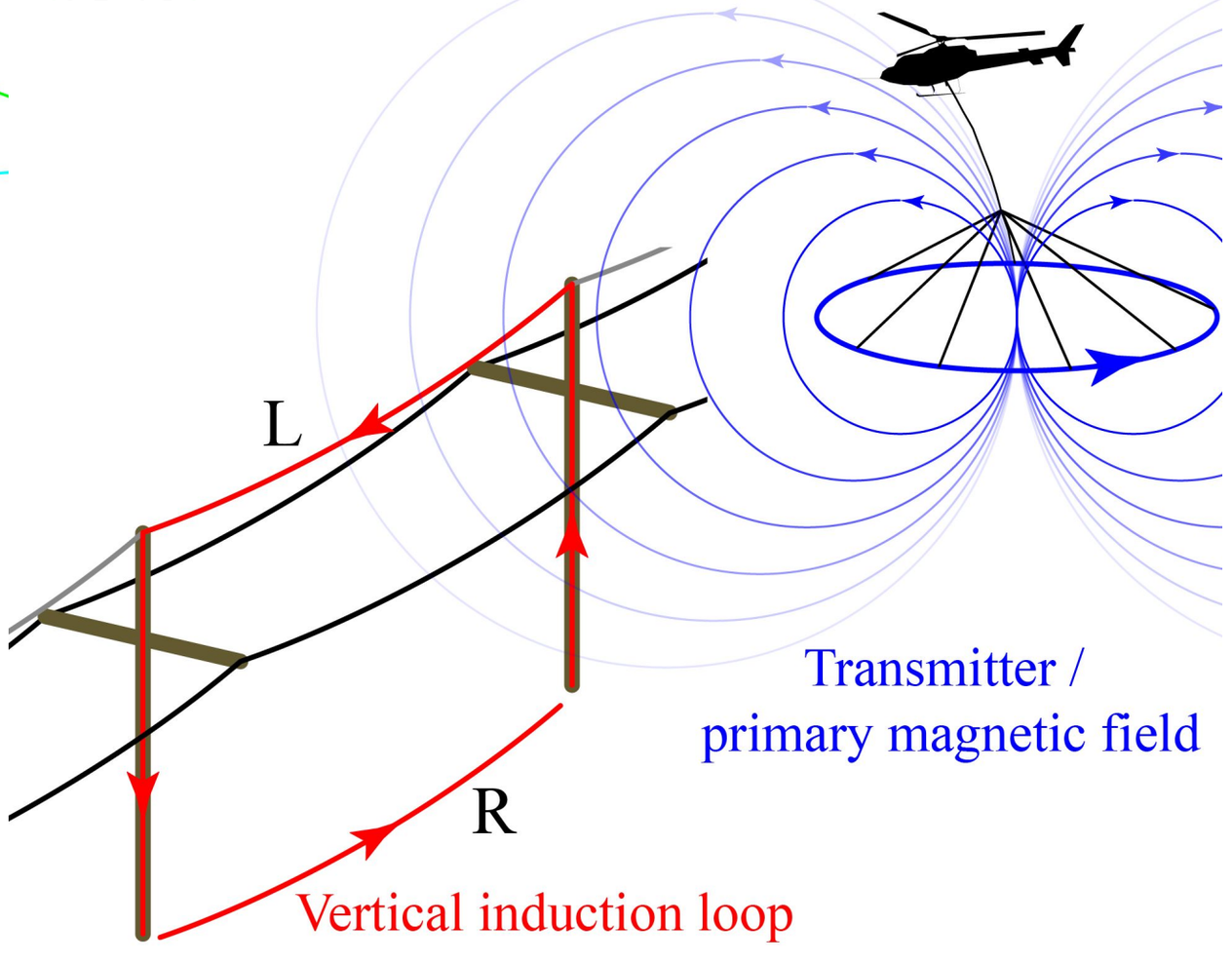

No Record
Quaternary
Pennsylvanian
Mississippian
Devonian
Cedar Valley
Wapsipinicon
Ordovician
Maquoketa
Galena
Decorah
Glenwood
St. Peter
Winneshiek
Brecciated Winneshiek
Prairie du Chien
Jordan
St. Lawrence
Lone Rock
Wonewoc
Eau Claire
Mt. Simon
Precambrian
L1250 Smooth Layer model
Elevation in meters
Decorah, Glenwood, and St. Peter
Prairie du Chien
Eau Claire?
Mt. Simon?
Cultural noise contamination
L1710 Smooth Layer model
Maquoketa
Galena and Decorah
Winneshiek
Decorah Impact Structure
Prairie du Chien
Eau Claire?
Mt. Simon?
Cultural noise contamination
Easting in meters (NAD83 UTM Zone 15N)
Resistivity in Ohm-m
Both profiles are 20:1 vertical exaggeration
Indicates a well with stratagraphic pics, with key to left

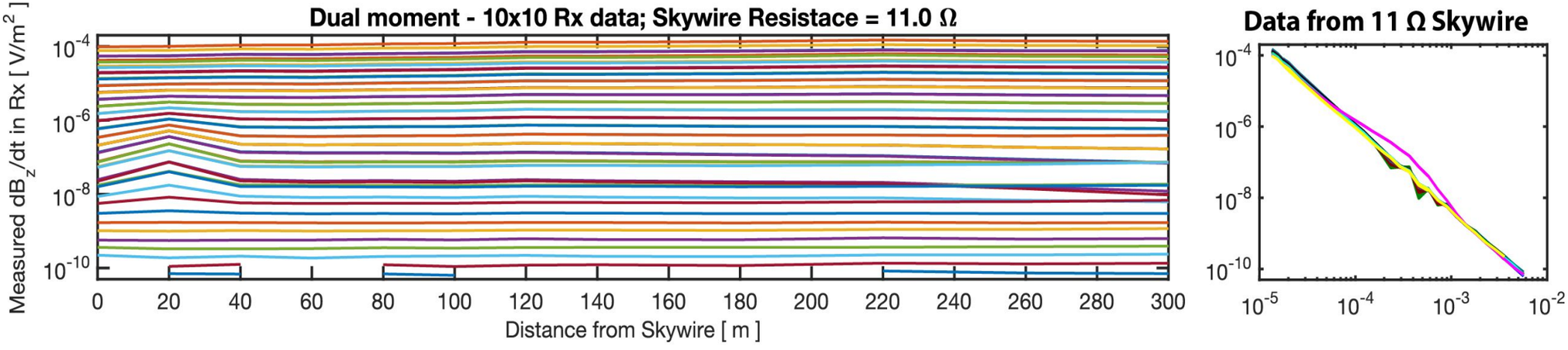
Zoomed in view of data from flightline L1190

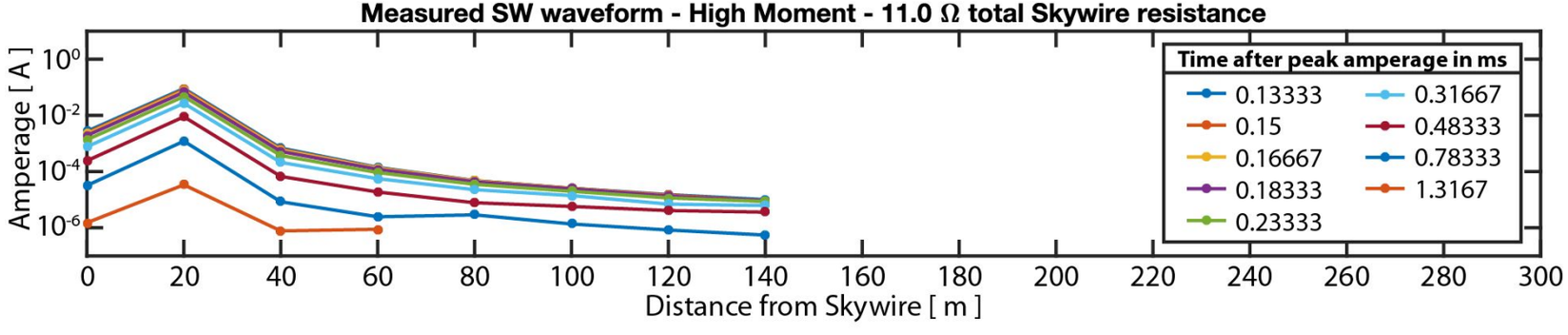


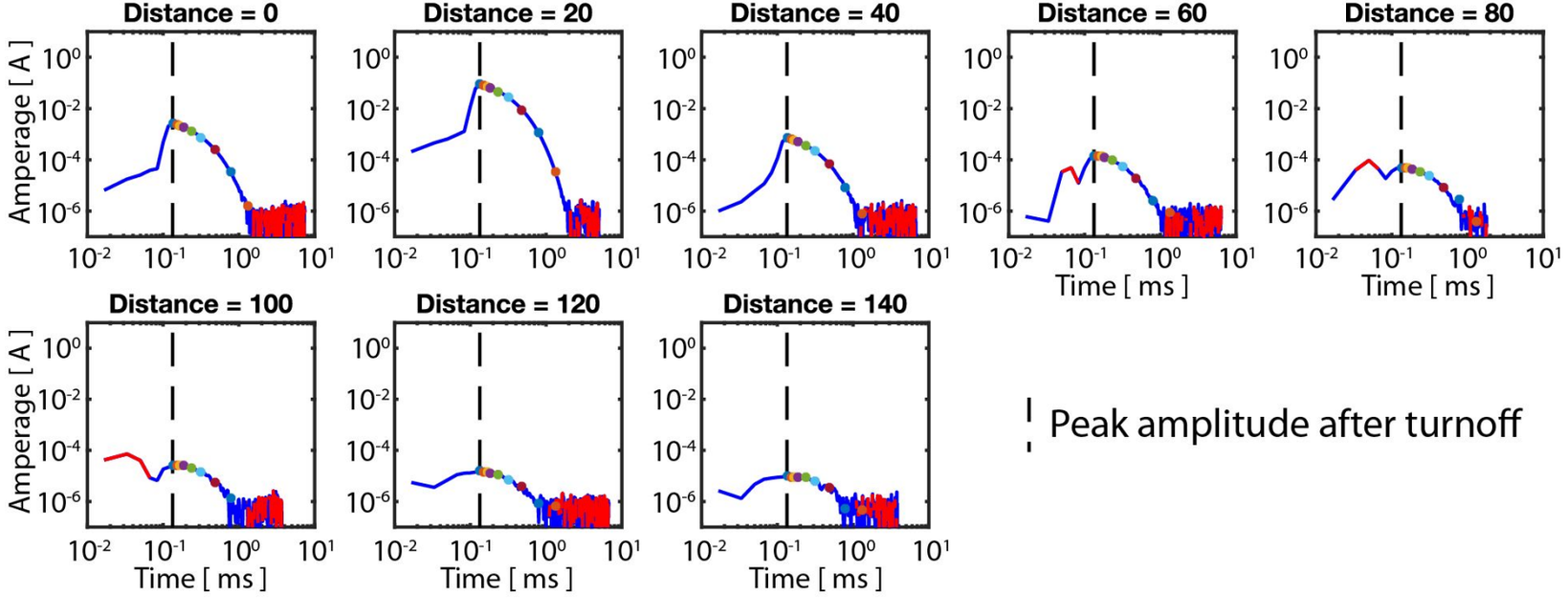



Powerline
SkyWire
Gound return
L
C
R


L
R
Transmitter /
primary magnetic field
Vertical induction loop







Peak amplitude after turnoff

Program input

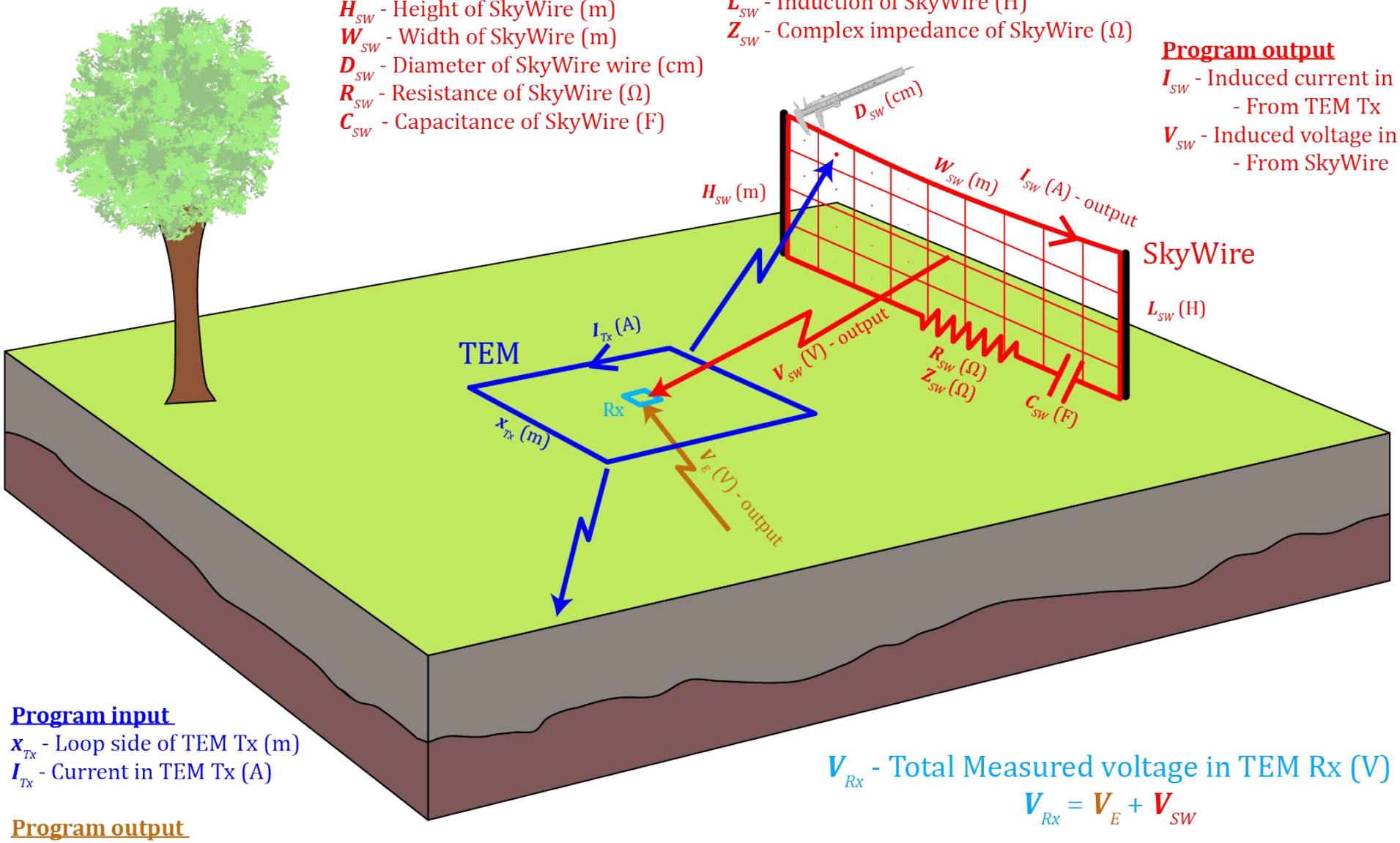
H_{SW} - Height of SkyWire (m)
W_{SW} - Width of SkyWire (m)
D_{SW} - Diameter of SkyWire wire (cm)
R_{SW} - Resistance of SkyWire (Ω)
C_{SW} - Capacitance of SkyWire (F)

Calculated variables

L_{SW} - Induction of SkyWire (H)
Z_{SW} - Complex impedance of SkyWire (Ω)

Program output

I_{SW} - Induced current in SkyWire (A)
- From TEM Tx
V_{SW} - Induced voltage in TEM Rx (V)
- From SkyWire



Program input

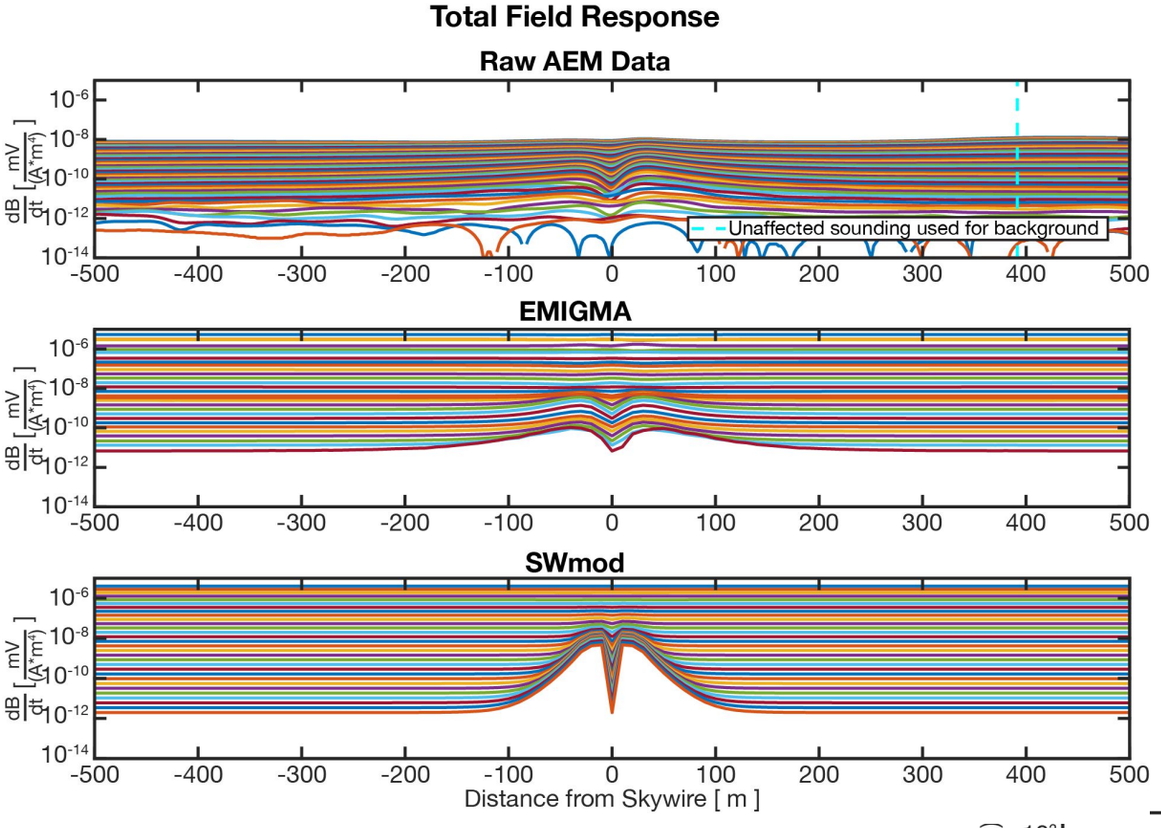
x_{Tx} - Loop side of TEM Tx (m)
I_{Tx} - Current in TEM Tx (A)

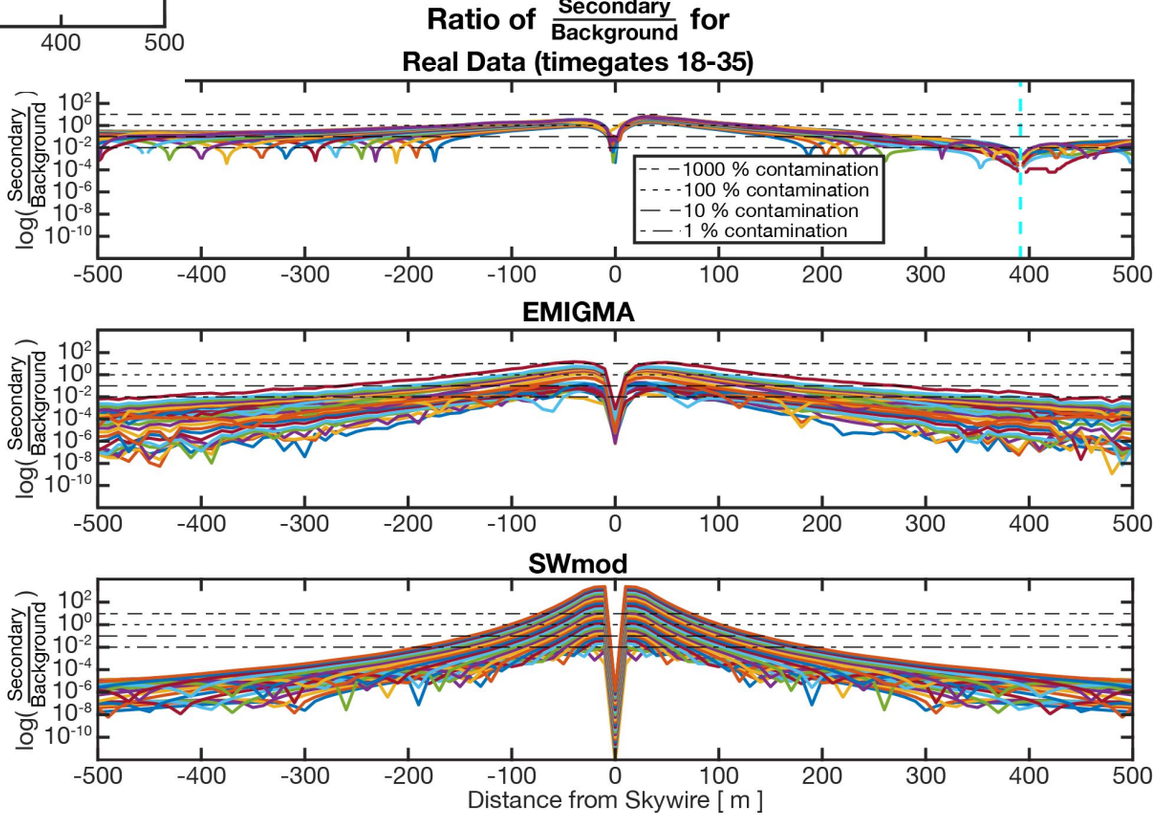
Program output

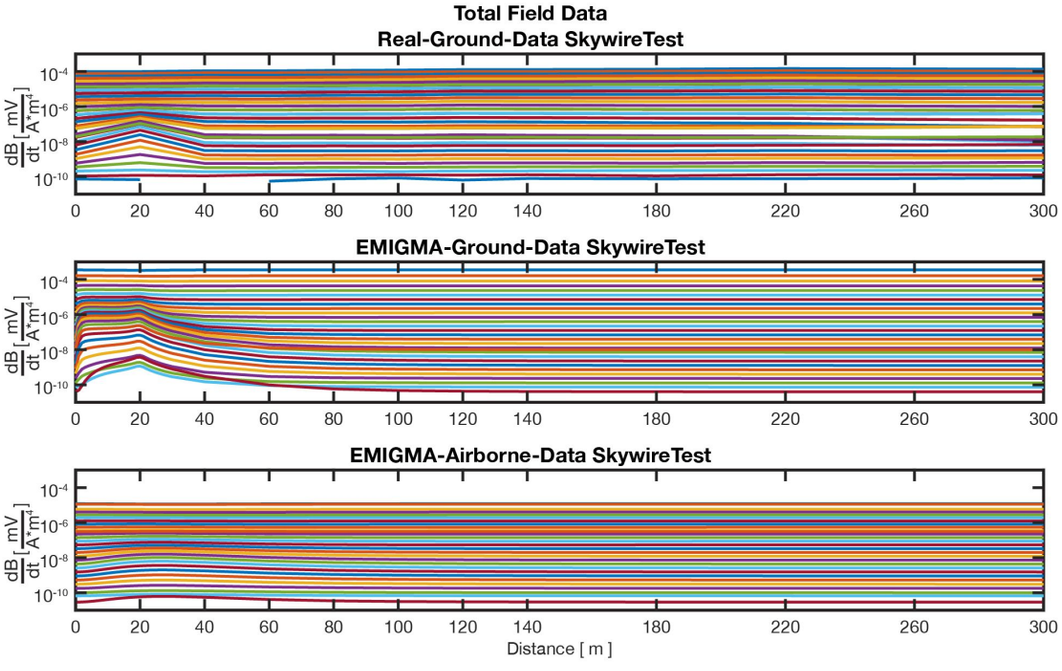
V_E - Induced voltage in TEM Rx (V)
- From Earth Response

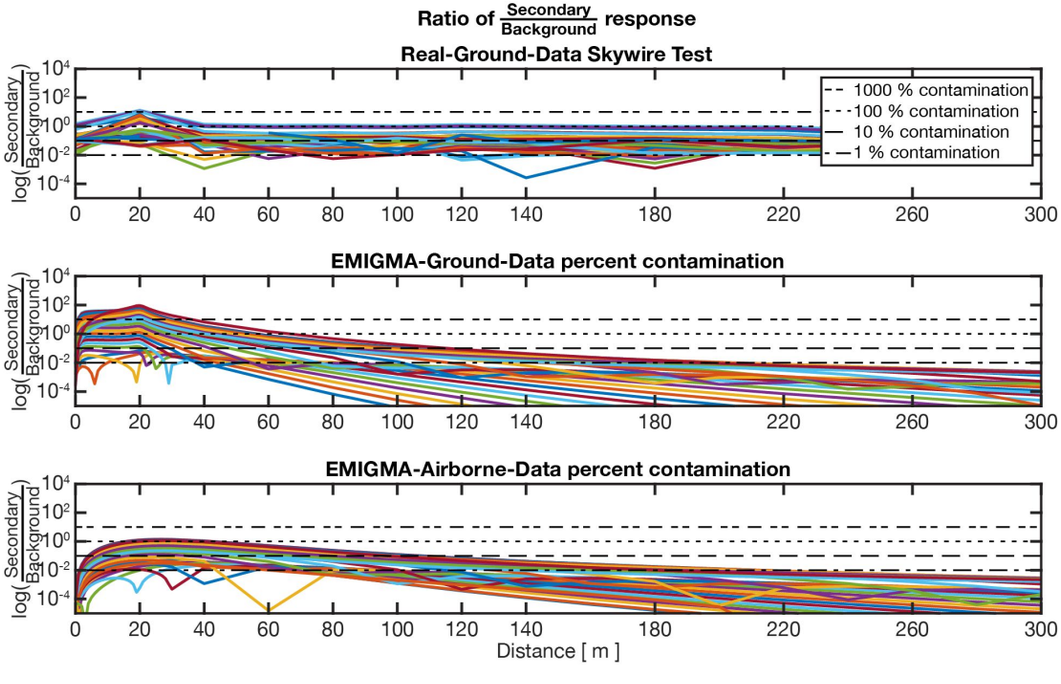
V_{Rx} - Total Measured voltage in TEM Rx (V)

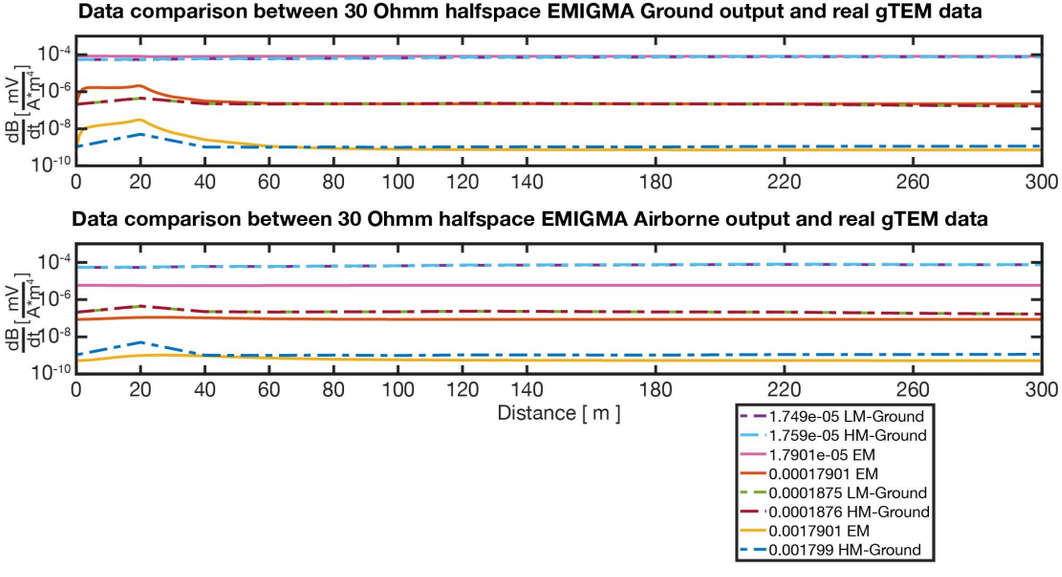
$$V_{Rx} = V_E + V_{SW}$$

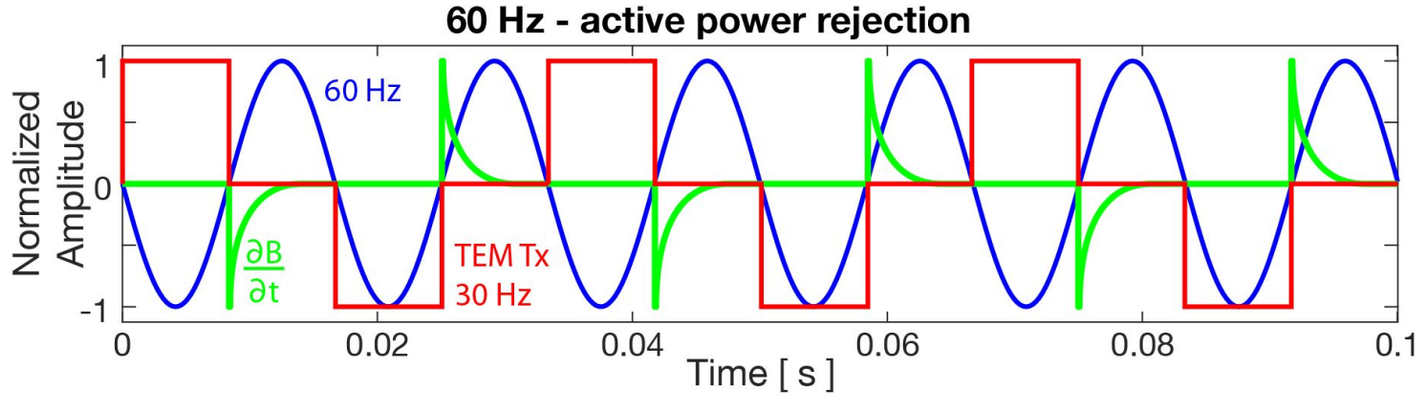

Total Field Response
Raw AEM Data
EMIGMA
SWmod
Unaffected sounding used for background
Distance from Skywire [m]


Ratio of Secondary / Background for
Real Data (timegates 18-35)
1000 % contamination
100 % contamination
10 % contamination
1 % contamination
EMIGMA
SWmod
Distance from Skywire [m]

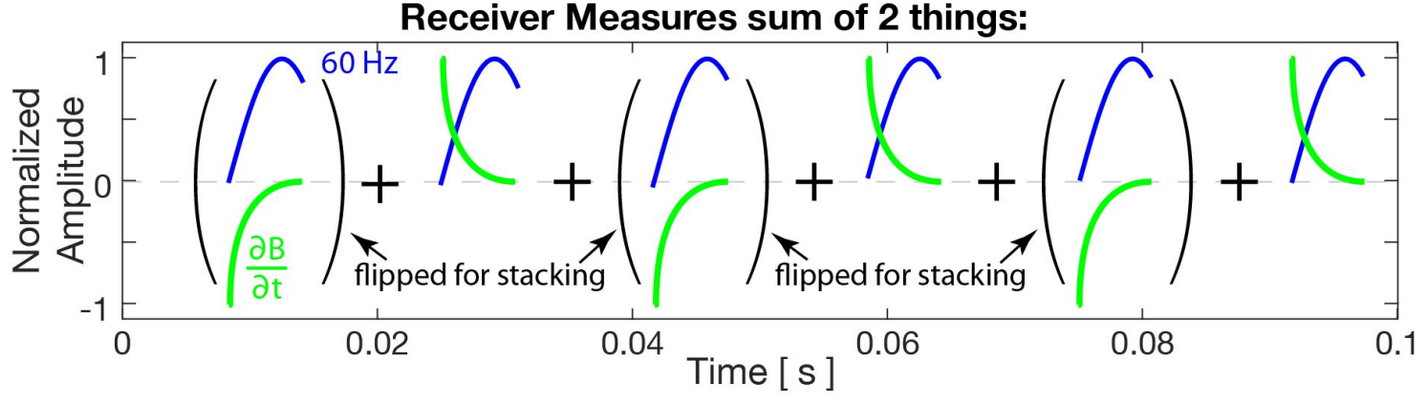

Total Field Data
Real-Ground-Data SkywireTest
EMIGMA-Ground-Data SkywireTest
EMIGMA-Airborne-Data SkywireTest
dB/dt [mV/(A*m^4)]
Distance [m]

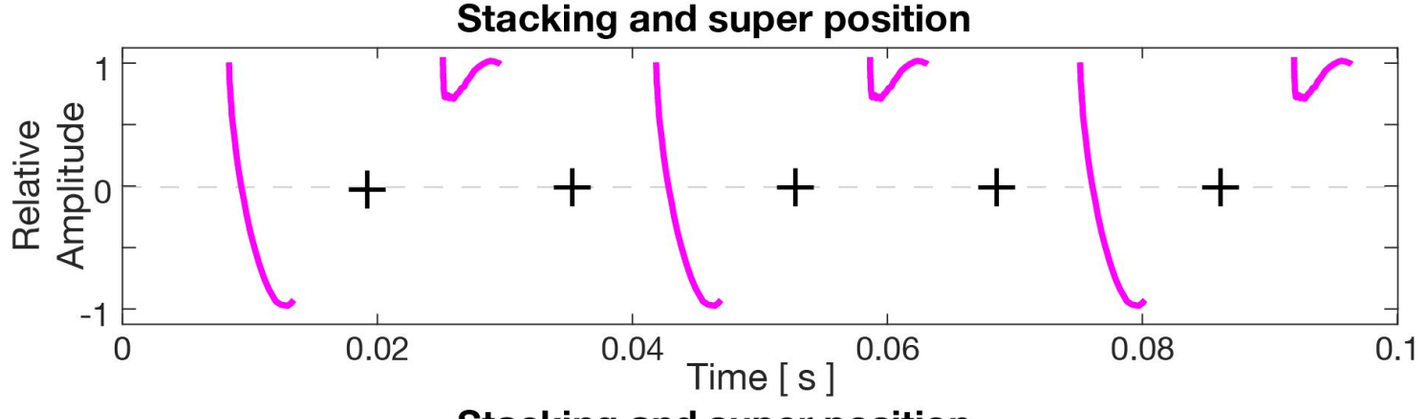

Ratio of Secondary/Background response
Real-Ground-Data Skywire Test
1000 % contamination
100 % contamination
10 % contamination
1 % contamination
EMIGMA-Ground-Data percent contamination
EMIGMA-Airborne-Data percent contamination
log(Secondary/Background)
Distance [m]

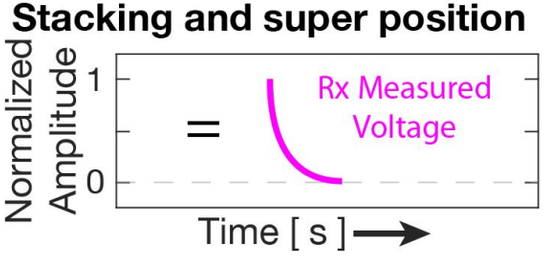

Data comparison between 30 Ohmm halfspace EMIGMA Ground output and real gTEM data
Data comparison between 30 Ohmm halfspace EMIGMA Airborne output and real gTEM data
dB/dt [mV/(A*m^4)]
Distance [m]
1.749e-05 LM-Ground
1.759e-05 HM-Ground
1.7901e-05 EM
0.00017901 EM
0.0001875 LM-Ground
0.0001876 HM-Ground
0.0017901 EM
0.001799 HM-Ground

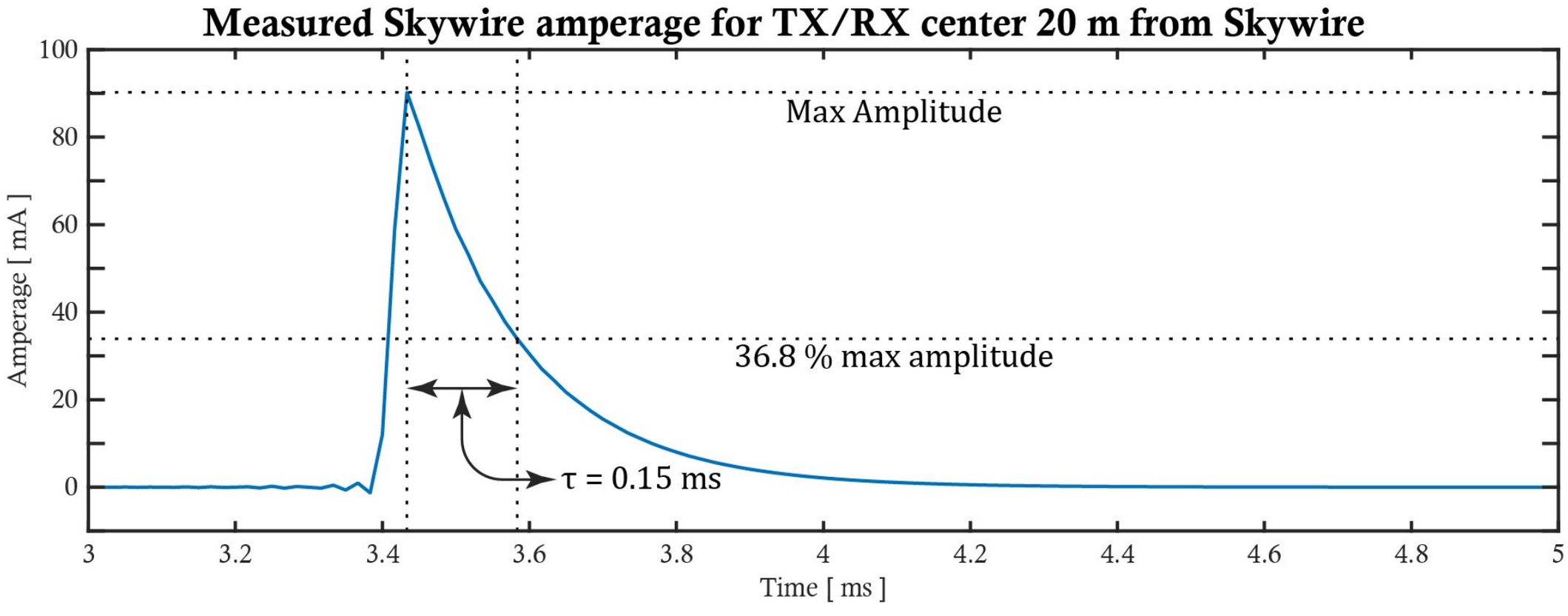


Measured TEM Rx response = ∂B/∂t + 60 Hz








Measured Skywire amperage for TX/RX center 20 m from Skywire
Max Amplitude
36.8 % max amplitude
τ = 0.15 ms
Amperage [mA]
Time [ms]
100
80
60
40
20
0
3
3.2
3.4
3.6
3.8
4
4.2
4.4
4.6
4.8
5