Aircraft Measurements of Atmospheric Electricity Including Ionospheric Potential

Fair-Weather Electrical Properties of the Atmosphere
Global Electrical Circuit

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Abstract

A modified dedicated atmospheric electrical research aircraft has been used to study fair-weather conditions over the ocean. Measurements include interactive parameters including: electric field, both polar conductivities, aerosols, temperature, relative humidity, turbulence, sea surface temperature and ionizing radiation.

The oceanic regime is advantageous compared to over land for studying fair-weather electricity and the global circuit because of clean air and no thermal activity from ground heating. Also there is no radon or ionizing radiation from uranium by-products in the ground which affect conductivity and electric field at ground locations.

However, oceanic conditions have a problem. There always is an electrode effect causing a positive space charge layer in the lower roughly 100 meters, mostly concentrated near the surface. This space charge causes increases of electric field near the ocean typically in the range of 20 to 80% of the unamplified fair-weather field intensity. This space charge blanket would have strongly affected the Carnegie electric field measurements which have generally been accepted as the gold standard for the absolute value of Earth's fair-weather electric field intensity. This sailing ship's masts and moveable rigging also would have affected the measurements. The classic "diurnal variation" of fair-weather electric field intensity obtained from the Carnegie data is of great importance in global circuit research, but in the presence of space charge it could have been influenced by diurnal variations in wind and eddy diffusion that sometimes exist over the ocean.

It is found that cosmic radiation, the source of most atmospheric ionization and thus conductivity, is responsible for only about 10% of the radiation at ground level, the remaining 90% is from radon and radiation emitters in the ground. Over the ocean cosmic radiation provides all the ionization so the ionization rate is 10% of the rate over ground containing uranium, which includes most of Earth's land surface.

Vertical profiles show the inverse relationship of conductivity and electric field intensity with variations caused by aerosols. A basic feature of the exchange layer often found over the ocean is a rapid decrease in conductivity and increase in electric field in the upper part of the mixed layer due to the growth of hygroscopic aerosol. When the relative humidity reaches about 80%, deliquescence occurs and water vapor causes the particles to grow rapidly, thus reducing their mobility. Thus electric field profiles can show large values in the upper half of the planetary boundary layer up to the inversion.

Recent electric field soundings have provided the first estimates of ionospheric potential in recent years. Absolute values will not be available until the aircraft electric field system is recalibrated, but initial estimates suggest Vi is about the same as the last measurements in 2004. Additional Vi measurements will be made and reported.