# Atmospheric Electricity at the Ice Giants

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**Abstract**

Atmospheric electricity can take the form of electrical discharges such as lightning, but there are also weaker electrical processes continually active in all planetary atmospheres from ionisation, mainly from galactic cosmic rays (GCR). Lightning detection can provide insight into convection, whereas electrical processes away from storms may modulate cloud formation and chemistry, particularly if there is little insolation to drive other mechanisms. The ice giants appear to be unique in the Solar System in that they are far enough away from the Sun for GCR-related mechanisms to be significant in cloud formation, yet both also seem convective enough for lightning.
Electrical discharges at Uranus and Neptune were observed by Voyager 2 during its flybys of both planets in the 1980s (Zarka et al., 2008). Uranus Electrostatic Discharges (UEDs) were similar to, but an order of magnitude weaker than, Saturn Electrical Discharges (SEDs), which were first detected by Voyager 1. SEDs were verified with subsequent simultaneous optical and electromagnetic detection by Cassini, and by the ground-based radio telescope UTR-2 (Aplin and Fischer, 2017; Konovalenko et al., 2013). Unexpectedly, given Neptune's strong internal heat source, only four tentative sferics were detected by Voyager 2, and they were weaker than the UEDs (Kaiser et al., 1991). There was no optical detection at either planet by Voyager 2's cameras, which could have been because the discharges were taking place deep in the atmosphere. Modelling found that Neptune lightning was most likely to occur in the ammonium hydrosulphide clouds between 10 and 50 bar, with the pressures considered too great in the lower water cloud layer for breakdown (Gibbard et al., 1999). Uranus is assumed to be similar. Recently it has been suggested that terrestrial radio telescopes may be able to detect Uranian lightning, however Neptune lightning is expected to be too weak for terrestrial detection, requiring a space instrument for further investigation (Mousis et al., 2017). First attempts with inconclusive results for ground-based UED detection have been made with the UTR-2 radio telescope in 2014, when storms were seen in the atmosphere of Uranus.

Recent reanalyses of ground-based telescope observations of the albedo of Neptune, in combination with Voyager 2 GCR data, have explained the well-known 11-year solar cycle modulation of the brightness fluctuations in terms of a combination of UV and GCR-modulated

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cloud formation (Aplin and Harrison, 2016). The mechanism involved is condensation of a supersaturated vapour onto ions formed by GCR, much like in a cloud chamber (Moses et al, 1992). Spectral analyses of similar ground-based telescope observations of Uranus' brightness show a clear 11-year periodicity, which is also linked to GCR ionisation (Aplin and Harrison, 2017). This presentation will review atmospheric electrical processes at the ice giants and make suggestions for further studies, both in situ and Earth-based.

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