

SuperDARN : 現状と将来展望

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Super Dual Auroral Radar Network (SuperDARN) : present and future perspective

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Super Dual Auroral Radar Network (SuperDARN) started in 1995 as an international co-operative organisation/project of HF radars network observation. About 20 radars operated by more than 10 countries and institutions cover the considerably large portion of polar ionosphere at both hemispheres, measure Doppler spectra of mainly F-region ionosphere, and hence derive plasma convection and electric field potential map over the whole polar ionosphere at high temporal resolution as snapshots which could not be achieved by either ground based or satellite observation before. As the derived physical parameters are extremely fundamental and important, a number of researches collaborating with other ground based and satellite measurements have been successfully made, which not only include dynamics of global-, meso- or small-scale convection including transient phenomena, but also include remote sensing of magnetic reconnection, field aligned currents, substorms, MHD waves, ionospheric irregularities (FAIs) and so on, some of which were not expected at the beginning of SuperDARN project. Other than many researches on ionosphere - magnetosphere - solar wind interaction including validation of theoretical and simulation works on M-I coupling, SuperDARN can also contribute to neutral atmosphere researches including gravity waves, TIDs, tides, meteor winds, PMSEs etc., which have been more stimulated by recent increasing researches. The reason why SuperDARN could have achieved a number of outstanding outcomes and even is still extensively growing, has been thought partly because of good balance between international co-operation and competition (as well as very informal good atmosphere in the community), and also partly because the community shares all the radars' data as well as radar control and analysis software, and also its open data policy.

More than 10 years have passed since the advent of SuperDARN. The number of the radars is still growing, including 'PolarDARN' whose FOVs are centered around magnetic pole and 'StormDARN' installed at mid-latitude like Hokkaido radar with which we expect a variety of researches on substorms/storms, inner magnetosphere and mid-latitude ionosphere and MLT region. Though there exist many researches using SuperDARN data only, considerable collaborative researches with ground based radars like EISCAT and SPEAR, optical instruments, and satellites like IMAGE, CLUSTER, THEMIS, REIMEI etc. could have addressed a wide range of scientific questions. SuperDARN will be thought to be important to monitor ionospheric potential map including for space weather nowcast and forecast continuously, but we believe that improvement of the observation methods, which has often been recently discussed in the community, as well as more active collaboration with other science communities like polar and domestic dense ground based observation network, international satellites communities, and theoretical works, with concrete objectives, will be important keys for SuperDARN future perspective.

SuperDARN (Super Dual Auroral Radar Network) は、1995 年、国際地上短波レーダー網観測計画・組織として誕生した。国内 3 研究機関を含む 10 以上の国・研究機関によって運用される約 20 基のほぼ同規格の短波レーダーによる、南北両極域電離圏の相当部分を覆う広大な視野における電離大気のドップラースペクトル測定により、従来の地上・衛星観測では得られなかった極域電離圏全体の電離大気対流及び電位分布を、常時 2 次元且つ高時間分解能で時々刻々得ることを可能とした。観測データの有用性から、地上・衛星観測との共同研究が当初から活発に行われてきた。様々な空間規模の電離圏対流力学の研究が盛んに行われると同時に、磁気再結合の遠隔監視、沿磁力線電流、サブストーム、波動現象、電離圏不規則構造等、研究範囲は当初の予想以上に多岐に亘っている。更に、電離圏・磁気圏・太陽風間相互作用に関わる、理論・計算機模擬実験との比較検証も含んだ研究に留まらず、中性大気（大気重力波、TID、大気潮汐波、流星風、PMSE 等）や領域間結合の研究も活況を呈しつつある。国際協調と競争の調和、他分野との活発な共同研究、レーダー運用・解析ソフトのみならず全 ACF データの参加研究機関内での共有、観測データの Web 即時公開等が、拡大的發展に大きく寄与したと考えられる。

SuperDARN 開始から早 10 年が経つが、現在もレーダー数・観測視野は増大し、近年では、磁気嵐時の電磁圏力学や、内部磁気圏、及び中緯度電離圏や MLT 領域まで研究領域を拡大する、北海道・陸別 HF レーダーの様な中緯度の StormDARN や、磁気極を視野に含み、極冠電離圏のより精密観測を目指す PolarDARN も生まれ、その観測視野と研究領域を益々拡大しつつある。SuperDARN 観測のみで閉じる研究も多々あるが、地上光学観測や EISCAT 等のレーダー観測、IMAGE・CLUSTER・れいめい等の衛星との同時観測による共同研究で、大きな成果が挙げられてきた。SuperDARN は、電離圏対流・電場の宇宙天気監視装置としても、今後も重要な役割を担うと期待される一方、昨今議論が活発化しつつあるレーダー観測手法の精密化が、SuperDARN の今後の存在意義の重要性をより増大させる鍵であるとも考えられる。特に日本国内では、独自或いは国際共同の衛星観測や極域或いは国内の密な地上観測網体制のように、多種の観測研究の連携による総合的解析研究の道具立てはより充実しつつあり、全国大学共同利用研究所として共同研究も行われているものの、効率よく有機的に連携している状況は、部分的にはあっても、必ずしも十分活発な状態には至っていない感否めないとも思われる。高度化する観測研究の相互理解、積極的な共同研究の環境作り、後継者育成等が、国際競争と研究レベ

ル向上の中で実質的な成果を挙げる為にも、熟慮すべき重要な課題であろう。

参考文献：G. Chisham et al., A decade of the Super Dual Auroral Radar Network (SuperDARN): scientific achievements, new techniques and future directions, *Surv. Geophys.*, 28, 33-109, 2007.