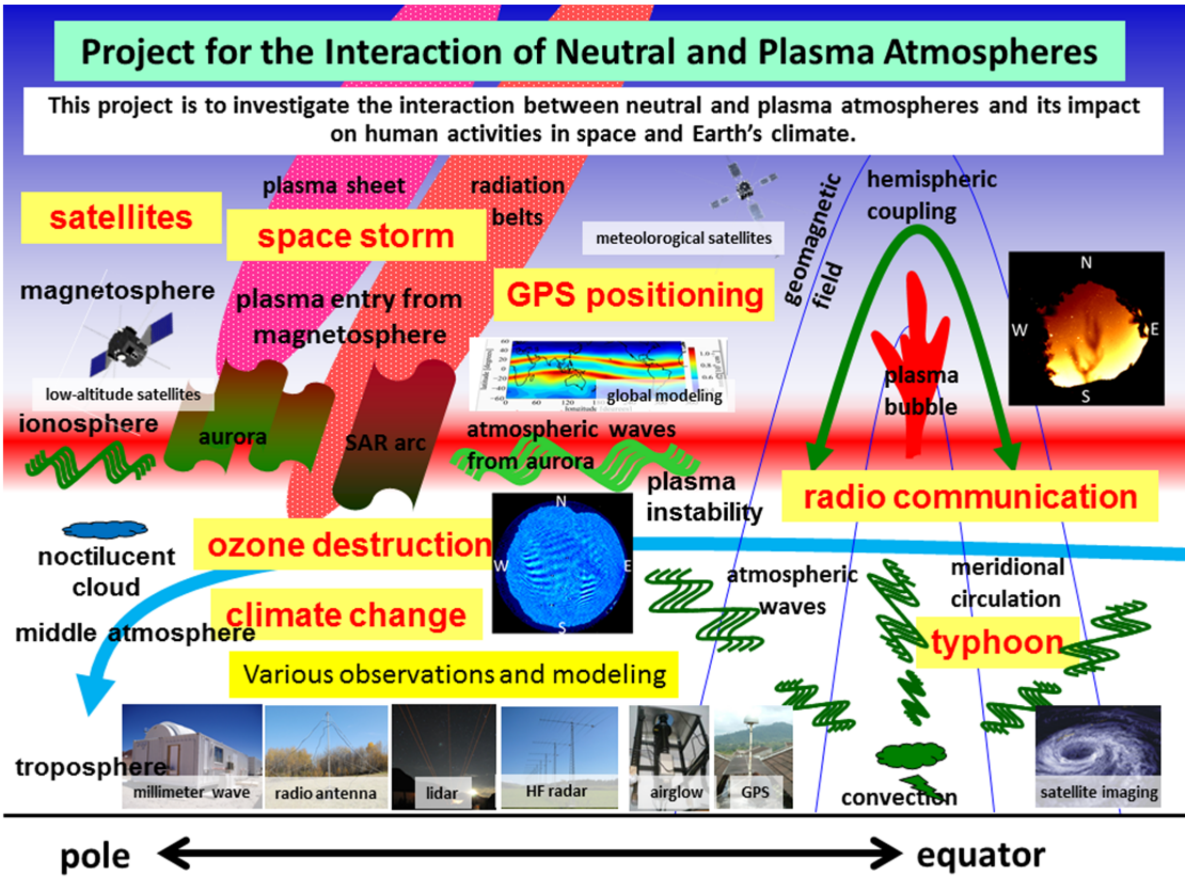
Project for the Interaction of Neutral and Plasma Atmospheres

The Earth's upper atmosphere is partly ionized because of solar ultraviolet emissions, forming the ionosphere. Ionospheric plasma affects human activities in space, such as radio communications and GPS positioning. The consequences of climate change appear significantly in the upper atmosphere and ionosphere. As shown in the figure below, neutral-plasma interaction processes in the upper atmosphere and ionosphere can be observed as various phenomena occurring from high to low latitudes. The aurora in the polar region is caused by the precipitation of high-energy plasma, which heats the upper atmosphere and generates atmospheric waves and disturbances that propagate toward low latitudes. However, ionospheric plasma instability, known as plasma bubbles, occurs in the equatorial upper atmosphere, causing interference with satellite-ground communications and GPS positioning. These phenomena can be measured by various ground-based remote-sensing instruments, such as airglow imagers, magnetometers, radars and lidars, and millimeter wave telescopes. This interdisciplinary project investigates the interaction of neutral and plasma components of the Earth's atmosphere using various ground remote sensing techniques and in situ satellite measurements, as well as global and regional high-resolution modeling of the neutral-plasma interaction, and contributes to the reliable use of space by humans.



Research topics of the project for the interaction of neutral and plasma atmospheres.

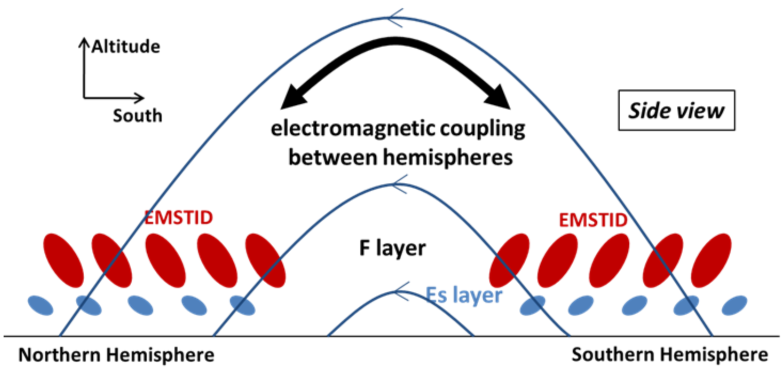
Main Activities in FY2018

Polar aurora as an indicator of the plasma-atmosphere interaction (photo taken at Nain, Canada on Sept.16, 2018, during a ERG-ground campaign observation).

In FY2018, we operated 11 international collaborative studies, 8 domestic collaborative projects, and 21 domestic meetings under ISEE. Various scientific results have been obtained through these collaborative projects.

As mentioned in the previous paragraph, interaction of neutral and plasma components is an essential and important issue for understanding the partially ionized atmosphere or the ionosphere and thermosphere. We are expecting a dramatic improvement in the ground-based ionospheric measurement accuracy with start in operation of EISCAT_3D in Scandinavia in 2022. In contrast, as the measurement of the neutral components in the thermosphere is impossible for EISCAT_3D in principle, preparation of diagnosing neutral components or the thermosphere has been perceived as an urgent issue. Then, we established an international project team (Japan, US, Finland, Sweden, and Norway) in 2018 with a view of deploying three SDIs, which are capable of measuring the thermospheric wind vector and temperature in 1000 km^2. Collaborations between the EISCAT_3D and 3 SDIs in Scandinavia will create an ideal environment of studying the polar ionosphere-thermosphere coupled system with the state-of-the-art ground-based instruments. We restarted the monitoring observation by the millimeter-wave spectrometer at Tromsø, Norway, after repair of the FFT processor in December 2018, to measure the NO that is produced by ion-chemistry due to the energetic particle precipitation. The new scientific satellite Arase (ERG) was launched by ISAS/JAXA in December 2016 to investigate wave–particle interactions between high-energy electrons and ions in the inner magnetosphere. We have conducted several ERG-ground campaign observations in FY2018. From the combined ground-satellite measurements, including EISCAT and newly installed high-speed EMCCD cameras, several science results, especially for wave–particle interactions, have been reported in scientific journals including Nature and Nature Communications. An ISEE researcher was hired by University of Oulu in Finland through a cross appointment and will conduct collaborative research related to this interdisciplinary project.

At middle and low latitudes, we studied MSTIDs using airglow imagers, Fabry-Perot interferometers, and ionosondes installed at geomagnetic conjugate points in Japan and Australia. We conclude that the sporadic E layer is the most effective in controlling the appearance/non-appearance of nighttime MSTIDs compared to neutral winds and ionospheric F-layer parameters. We have also studied long-term variation of gravity waves and MSTIDs using 16-year airglow images obtained at Shigaraki and Rikbetsu, Japan, and show latitudinal dependences of these phenomena in the mesosphere and ionosphere.



Schematic picture of hemispheric coupling of nighttime medium-scale traveling ionospheric.