R010-21
A 会場 ：9/25　AM2 （10:45-12:30）
11:25〜11:40

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Nighttime geomagnetic response to jumps of solar wind dynamic pressure: A possible cause of Quebec blackout in March 1989

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By performing a global magnetohydrodynamic (MHD) simulation, we investigated magnetic disturbances on the ground at high-latitudes in response to jumps in the solar wind dynamic pressure, namely a sudden commencement (SC). After the arrival of the jump, a pair of field-aligned currents (FACs), related to the preliminary impulse (PI), develop and travel in the anti-sunward direction. Soon after, another pair related to the main impulse (MI), travel in the anti-sunward direction. The MI current remains strong when propagating to the nightside, and it flows clockwise on the dawnside. Consequently, northward (southward) magnetic disturbance appears at higher (lower) latitudes in the post-midnight sector. These features are similar to those observed in the high-latitude post-midnight sector during which the Quebec blackout took place on 13 March 1989. The MI current appears regardless of the amplitude of the jumps of the solar wind dynamic pressure and the polarity of north-south component of IMF. The amplitude of the geoelectric field, which is closely related to the geomagnetically induced currents (GICs) reaches the maximum value just before and around the maximum of the southward magnetic disturbance. This is consistent with the moment at which the blackout occurred during the southward magnetic perturbation. We suggest that the blackout in Quebec was caused by the MI-associated Hall current passing over the Hydro-Quebec power system on the nightside. The nighttime polar region is shown to be sensitive to hazardous GICs when a large-amplitude jump of the solar wind dynamic pressure comes.