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Why is energetic particle precipitation important for climate research and seasonal forecasting?

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Over the past decades, numerous observations and model studies have provided substantial evidence that energetic particle precipitation (EPP) affects the chemistry and dynamics of the stratosphere. Concurrently, the significance of stratospheric dynamics, particularly in winter short-range and seasonal forecasts, has been highlighted. However, there has been little effort to integrate the knowledge from these two research fields. This review aims to bridge the gap between the Space Physics and Climate research communities. It will elucidate current knowledge on EPP and its impact on the chemistry and dynamics of the mesosphere and stratosphere, highlighting recent research. Additionally, it will present scientific findings demonstrating that EPP induced changes in the mesosphere and stratosphere can migrate downwards into the troposphere and reach the surface. Particularly during the eastward phase of the Quasi-Biennial Oscillation and/or close to a Sudden Stratospheric Warming (SSW), EPP can significantly impact stratospheric dynamics projected onto the North Atlantic Oscillation or Northern Annular Mode. The review highlights EPP as a potential moderator of SSWs in terms of their occurrence, timing, and strength, which are all crucial parameters for short-range and seasonal forecasts for the Northern Hemispheric winter. Moreover, it presents research demonstrating that the EPP chemical-dynamical coupling is becoming stronger in an atmosphere influenced by climate change. Bridging the gap between space physics and climate research is essential, as the natural variability of the atmosphere underpins the climate signal. Better prediction of SSWs and their effects on the northern winter weather is crucial in preparing for extreme weather events and supporting economic activities. This interdisciplinary approach can enhance our overall understanding of the Earth's atmosphere and its complex processes.

Author: NESSE, Hilde (University of Bergen, Norway)

Presenter: NESSE, Hilde (University of Bergen, Norway)

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