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SODA - Dynamics of Deep Earthquakes

Deep earthquakes that occur at depths greater than 70 km remain one of the most intriguing and least understood phenomena inside our planet. Even though they can reach magnitudes up to 9 and represent a serious hazard, the physical mechanisms that allow them to happen are still not fully resolved. Classical theory suggests that under the extreme temperatures and pressures found at such depths, rocks should deform smoothly rather than break abruptly. Yet for more than a century seismologists have observed deep earthquakes around the world. This contradiction raises a fundamental question: how can earthquakes occur so deep inside the Earth? To shed light on this problem, a clear change in our approach is needed. Progress requires new types of observations capable of revealing the processes and dynamics operating inside subducting plates. These observations must then be incorporated into physical models that more accurately represent the thermal structure, mineralogical transformations and geometry of slabs. The SODA project aims to address this challenge. We introduce advanced deep learning methods designed to analyse the vast amount of seismological data now available. This will greatly improve our ability to detect, characterize and classify deep events. The resulting observations will provide an unprecedented view of how deep seismicity evolves in space and time, including subtle patterns such as the migration of small clusters of events. These findings will directly inform us about the physical processes at work in subduction zones, such as the movement of fluids or the presence of aseismic deformation. In the next step we will combine machine learning with state of the art geophysical models to connect these new observations with the physical properties of slabs, including their temperature structure, mineralogy and overall geometry. This integrated strategy will allow us to identify the key conditions that control where deep earthquakes occur and how they evolve. The SODA project will ultimately deliver a new quantitative picture of the dynamics of the deep Earth. By providing fresh insights into the processes active at mantle depths, it will enhance our understanding of deep earthquakes and contribute to a broader comprehension of Earth dynamics and plate tectonics.

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