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The effects of water and intrusive magmatism on the evolution and dynamics of Venus

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Observations of Venus reveal tectonic expressions and recent volcanism, showing that the planet is still active. Tectonically deformed areas such as ridges or tesserae indicate surface mobility, however, no signs of active plate tectonics like on Earth have been found. The tectonics and volcanism of Venus and other terrestrial planets are defined by the active mantle convection mode. A key component of tectonics is rheology, which is affected by water as shown by numerous studies[1]. However, the effects of water have been mostly ignored when studying Venus because its interior has been assumed to be dry. This notion is being challenged by indications of strong hydrodynamic escape to space that requires volcanic replenishment[2]. Therefore, water should be present in Venus' interior, even if its content is not known. Importantly, the potential effects of water in the dynamics and evolution of Venus are poorly understood. This calls for the consideration of complex dynamic thermo-magmatic models that track water and take into account intrusive and extrusive magmatism.

In this study, we use the code StagYY to perform state-of-the-art 2D numerical models in a spherical annulus geometry to assess the effects of water on the tectono-magmatic evolution of Venus[3]. Particular attention will be given to changes in mantle viscosity, melt generation and crustal properties such as thickness and surface age. We explore model settings related to melting, intrusive magmatism, and water presence. Results show that intrusion depth influences the thermal evolution and related magmatism. Moreover, preliminary results show that the rate of water outgassing is directly related to changes in the thermo-magmatic evolution of Venus. Water outgassing rates have further implications on surface conditions and atmospheric compositions over time. In the future, coupling these improved mantle convection models to atmospheric evolution models may unveil new insights into the thermal and tectonic history that has shaped Venus into the planet we observe today.