Grabowski, W. W., 2016: Towards global large eddy simulation: super-parameterization revisited. *J. Meteor. Soc. Japan*, **94**, 327-344.
https://doi.org/10.2151/jmsj.2016-017

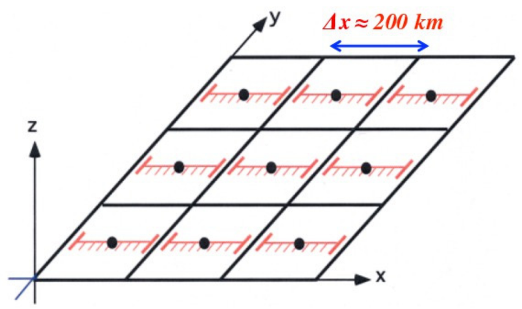

Figure 1. Super-parameterization as proposed by Grabowski and Smolarkiewicz (*Physica D*, 1999, **133**, 171-178). Red color depicts 2D (x-z) cloud-resolving models (CRMs, horizontal grid length ~1km) embedded in a large-scale model with the horizontal grid length ~200 km and aligned along the x-axis. Modified figure from Randall et al. (*BAMS*, 2003).

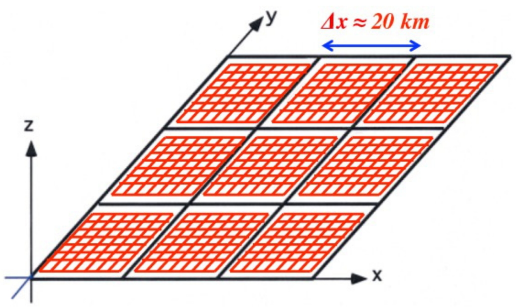

Figure 2. Super-parameterization with 3D large-eddy simulation (LES) models (horizontal grid length ~100 m) embedded in a large-scale model with horizontal grid length ~20 km as proposed in this paper.

- The super-parameterization (SP) approach, illustrated in Fig. 1, originally called the cloud-resolving convection parameterization (CRCP; Grabowski and Smolarkiewicz 1999) revolutionized representation of clouds in climate system modeling, especially for the tropical climate (e.g., representation of convectively-coupled equatorial waves and the Madden-Julian Oscillation). This paper provides a review of various studies conducted applying the SP methodology during the last two decades.

- Continuously increasing computational power makes it possible to foresee application of the LES methodology over the entire Earth to better represent small-scale processes, such and boundary-later dynamics, shallow convection, or entrainment in deep convection, as well as the coupling between cloud microphysics cloud dynamics. However, applying traditional parallel processing methodologies (such as the horizontal domain decomposition) leads to a communication bottleneck because of the large amount of data that needs to be transferred every model time step between neighboring domains. Moreover, compressible equations, needed for the representation of the entire range of spatial scales, from small-scale turbulence to synoptic- and planetary-scale circulations, are cumbersome because of the presence of sound waves that are marginally (if at all) relevant for weather and climate.

- If the SP methodology is applied in a LES global model as shown in Fig. 2, then the communication bottleneck no longer exists as the neighboring LES models communicate only through the large-scale model. Moreover, the outer model can apply hydrostatic equations and LES models can be analestic. This eliminates the need to apply compressible equations. Finally, there are also other benefits as illustrated in the paper by a computational expample.