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A particle swarm optimizer based on directions and its application to the four dimensional variational data assimilation

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A variant particle swarm optimizer based on directions (PSOBD) is presented and applied to the four dimensional variational data assimilation (4DVar). In the PSOBD update process, not only both the historical optimal positions of the particle swarm and the current particle are utilized, but also for each direction (component) of particles, both the historical optimal directions of the particle swarm and the current particle are used. To verify the performance of the PSOBD in the 4DVar, an idealized simple model with "on-off" switches is firstly employed as the governing equation, and three assimilation schemes are performed. One is the 4DVar based on the traditional adjoint method (ADJ_4DVar), the second is based on the classic PSO (PSO_4DVar), and the last is based on the PSOBD (PSOBD_4DVar). Twin numerical experiment results show that both the classical PSO and the PSOBD can produce satisfied assimilation retrieval with high probability, while the traditional adjoint method fails to work. Compared with the PSO_4DVar, the PSOBD_4DVar only takes 1/30 of time on average to obtain good assimilation retrievals with 99.7% probability, which is larger than 88.5% with the classical PSO. Furthermore, the PSOBD is applied to the shallow-water equation (SWE) 4DVar to test its effectiveness for complex model. Twin experiment results show that the PSOBD_4DVar keeps its strong search ability and yield good assimilation retrievals with 99.5% probability. Besides, the parallel PSOBD is designed and applied to the SWE 4DVar. Numerical experiment results show that, on average, the assimilation time of the parallel PSOBD is 1/13 of the one of the serial PSOBD, which is encouraging and demonstrates the potential of the PSOBD to apply to the 4D-Var in real atmospheric or oceanic models.