Inclusion of linearized moist physics in NASA's Goddard Earth Observing System Data Assimilation Tools

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Inclusion of moist physics in the linearized version of a weather forecast model is beneficial in terms of variational data assimilation. Further it improves the capability of important monitoring and research tools, such as adjoint based observation impacts and sensitivity studies. A linearized version of the Relaxed Arakawa-Schubert (RAS) convection scheme has been developed and tested in NASA's Goddard Earth Observing System (GEOS) data assimilation tools. A previous study of the nonlinear RAS scheme showed it to exhibit a reasonable degree of linearity and stability. This motivates the development of a linearization of a version of the RAS scheme that has only minor modifications to the algorithm. Linearized large scale condensation is included through a simple scheme that converts super saturation into precipitation. The linearization of moist physics is validated against the full nonlinear model for 6-hour and 24-hour intervals, which are relevant to variational data assimilation and observation impacts respectively. For a small number of profiles sudden large growth in the perturbation trajectory is encountered. Efficient filtering of these profiles is achieved though the diagnosis of steep gradients in a reduced version of the operator of the tangent linear model. With filtering turned on, the inclusion of linearized moist physics increases the correlation between the nonlinear perturbation trajectory and the linear approximation of the perturbation trajectory. A month long observation impact experiment is performed and the effect of including moist physics on the impacts is discussed. Impacts from moist sensitive instruments and channels are increased. Discussion is presented on the inclusion of moisture in the error metric. The effect of including moist physics is examined for adjoint sensitivity studies. A case study examining an intensifying northern hemisphere Atlantic storm over a 24-hour period is presented. The results suggest that in regions of active moist physics the magnitude of the sensitivity with respect to moisture is equivalent to the sensitivity with respect to other model variables. Results from updating the observation operator with the new linearized moist physics are shown.