The SACADA system for new operational 4Dvar chemistry data assimilation

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Brief Abstract:

A four dimensional-variational stratospheric chemistry data assimilation system SACADA (Synoptic Analyses of chemical Constituents by Advanced Data Assimilation) is presented, which produces chemical analyses based on a newly developed General Chemistry Circulation Model (GCCM).

The system consists of:
1. the German weather service's global forecast model GME, with an icosahedral grid structure, which is
2. online coupled with a semi-Lagrangian chemistry transport module (CTM) with state-of-the art stratospheric chemistry mechanism,
3. the adjoint of the CTM, and 4. a limited memory BFGS quasi-Newton minimisation algorithm.

The icosahedral grid structure with its nearly isotropic gridpoint distrubution over the globe has been selected for efficiency reasons and is presently implemented with for 250 km horizontal resolution, 1 and 2 km resolution in the stratosphere.The chemistry mechanism and its adjoint comprises 41 species with heterogeneous chemistry including NAT, ice, sulfur particles. 4D var needs the square root of the background error covariance matrix. Its formulation follows the diffusion paradigm, with the basic idea to formulate covariances by Gaussians and approximate these Gaussians by integration of the diffusion operator over some prespecified time. The presentation demonstrates assimilation results from ESA MIPAS Standard data, comprising O_3, N_2O, CH_4, HNO_3, NO_2, H_2O FZK-IMK MIPAS, which additionally includes HNO_4, N_2O_5 , $ClONO_2$, NO, CFC11, CFC12, ClO SCIAMACHY limb data, and solar occultation data, which includes O_3 and NO_2.The system is designed to run operationally at the German space ageny DLR-DFD in near real time. With a daily operation and an assimilation intervall of 24 hours, it can be demonstrated that the analysis takes about 6 hours on a 6 processor PC cluster, using 15 iterations. The cost function evolution shows clearly fullfilment of the chi^2 condition. Further validation statistics like analysis-minus-observation and forecast-minus-observation demonstrates outstanding success of the 4D-var assimilation system.