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From ERA-Interim to ERA5: considerable impact of ECMWF's next-generation reanalysis on Lagrangian transport simulations

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The European Centre for Medium-Range Weather Forecasts' (ECMWF's) next-generation reanalysis ERA5 provides many improvements, but it also confronts the community with a "big data" challenge. Data storage requirements for ERA5 increase by a factor of □80 compared with the ERA-Interim reanalysis, introduced a decade ago. Considering the significant increase in resources required for working with the new ERA5 data set, it is important to assess its impact on Lagrangian transport simulations. To quantify the differences between transport simulations using ERA5 and ERA-Interim data, we analyzed comprehensive global sets of 10-day forward trajectories for the free troposphere and the stratosphere for the year 2017. The new ERA5 data have a considerable impact on the simulations. Spatial transport deviations between ERA5 and ERA-Interim trajectories are up to an order of magnitude larger than those caused by parameterized diffusion and subgrid-scale wind fluctuations after 1 day and still up to a factor of 2–3 larger after 10 days. Depending on the height range, the spatial differences between the trajectories map into deviations as large as 3 K in temperature, 30 % in specific humidity, 1.8 % in potential temperature, and 50 % in potential vorticity after 1 day. Part of the differences between ERA5 and ERA-Interim is attributed to the better spatial and temporal resolution of the ERA5 reanalysis, which allows for a better representation of convective updrafts, gravity waves, tropical cyclones, and other meso- to synoptic-scale features of the atmosphere. Another important finding is that ERA5 trajectories exhibit significantly improved conservation of potential temperature in the stratosphere, pointing to an improved consistency of ECMWF's forecast model and observations that leads to smaller data assimilation increments. We conducted a number of downsampling experiments with the ERA5 data, in which we reduced the numbers of meteorological time steps, vertical levels, and horizontal grid points. Significant differences remain present in the transport simulations, if we downsample the ERA5 data to a resolution similar to ERA-Interim. This points to substantial changes of the forecast model, observations, and assimilation system of ERA5 in addition to improved resolution. A comparison of two Lagrangian trajectory models allowed us to assess the readiness of the codes and workflows to handle the comprehensive ERA5 data and to

demonstrate the consistency of the simulation results. Our results will help to guide future Lagrangian transport studies attempting to navigate the increased computational complexity and leverage the considerable benefits and improvements of ECMWF's new ERA5 data set.

Reference: Hoffmann, L., Günther, G., Li, D., Stein, O., Wu, X., Griessbach, S., Heng, Y., Konopka, P., Müller, R., Vogel, B., and Wright, J. S.: From ERA-Interim to ERA5: the considerable impact of ECMWF's next-generation reanalysis on Lagrangian transport simulations, Atmos. Chem. Phys., 19, 3097–3124, https://doi.org/10.5194/acp-19-3097-2019, 2019.