

# USING ENSEMBLE SPREAD AS A MEASURE OF GNSS-RO IMPACT: REAL AND SIMULATED DATA

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**K. Lonitz (1)** and S. Healy (1)

(1) ECMWF

At ECMWF we have performed ensemble data assimilation (EDA) experiments and Observing System Experiments (OSEs) using an extensive set of GNSS-RO observations, using real and simulated data. This is done to study the spread-skill relationship and compare to previously performed theoretical studies. Results show that adding real data from Spire or COSMIC-2 reduces the spread for temperature by about 9% at 10hPa in the southern hemisphere, whereas adding Spire and COSMIC-2 reduces the spread by 14%. In the tropics the addition of COSMIC-2 has the largest effect on reducing the spread by about 13% at 10hPa, whereas Spire reduces the spread by 5%. In general, the spread in temperature reduces with more real GNSS-RO data being added, with the larger reductions happening in the stratosphere. When we compare this reduction in ensemble spread by adding new GNSS-RO data with fits to radiosonde observations, it can be seen that both measures are qualitatively consistent. Comparing the change in ensemble spread using real data with simulated one, shows many similarities. We also have run sensitivity experiments changing the observation errors of the simulated data to understand their impact on the ensemble spread.

The challenges when studying ensemble spread values and comparing them with forecast error statistics or observations are numerous. For example, one must be fully aware that for the EDA experiments the variability of the perturbations does not grow sufficiently through the forecast (under-dispersive) in some regions and height levels. This means the EDA can underestimate the impact of the addition of GNSS-RO data in these areas. Furthermore, the evaluation of forecast error statistics depends on the choice of analysis as a reference, which has limitations. Also, the model resolution of the experiments does matter for which scales can be captured at the various height levels. Nevertheless, in the tropics where most of the GNSS-RO data is located, a linear relationship between ensemble spread and variance in first guess (FG) departures can be seen at higher altitudes. Here, ensemble spread and variance in FG departures can be used to see the effect from adding GNSS-RO data which shows a reduction in their values.