

## **Response to Topical Editor Report for Assimilating Compact Phase Space Retrievals of Atmospheric Composition with WRF-Chem/DART: A Regional Chemical Transport/Ensemble Kalman Filter Data Assimilation System**

### **1. *Definitions of $E_m$ and $C_m$***

We recognize the confusion identified by the reviewer and propose to address it as follows:

On page 4, line 1: we have revised "... with error covariance  $E_m$ " to read "... with error covariance  $E_m$  - the measurement error covariance in retrieval space."

On page 11, lines 23 – 28: we have replaced the text with the following: "The retrieval error covariance  $E_r$  associated with each MOPITT CO retrieval profile is provided as part of the data product. That error covariance is derived by the retrieval process based on a specified *a priori* error covariance  $E_a$ . Under the optimal estimation theory of Rodgers (2000)  $E_r$  is related to  $E_a$  through the averaging kernel  $A$  by  $E_r = (I - A)E_a$ . The measurement error in retrieval space  $E_m$  is also related to  $E_a$  and  $A$  by  $E_m = (I - A)E_a A^T$ . Generally for retrieval data sets,  $E_a$ ,  $E_r$ , and  $E_m$  are non-diagonal."

For those revisions, we used symbols consistent with those used by Migliorini et al. (2008) to avoid further confusion.

### **2. *Use of the term "observation error covariance"***

We use that term throughout the paper. Its meaning depends on its use. For example, in Sections 1 and 2 we used it 14 times. There it generally refers to the "measurement error covariance in retrieval space" because that is the basis for the error term in the retrieval equation. However, for data assimilation purposes the measurement error covariance underestimates the observation error because it does not account for other error sources such as representativeness error. In Section 6 (page 12, line 18) we explain that for our experiments we use the "reported MOPITT retrieval error covariance as the observation error covariance." For the rest of the paper, that term generally refers to the retrieval error covariance.

In the data assimilation context, that definition flexibility is necessary because "observation error covariance" refers to the uncertainty in the observations to be assimilated. That uncertainty is initially based on an uncertainty estimate such as the measurement error covariance in retrieval space or the retrieval error. But then it is often adjusted to account for other error sources and/or to tune the assimilation system. In our experiments, we used the retrieval error covariance and made no further adjustments.

To address the reviewers concern, we modified page 12, line 18 as follows: "(vi) the reported MOPITT retrieval error covariance as the observation error covariance to account for unrepresented error sources such as representativeness error."