The authors have addressed most comments, and the quality of the manuscript improves a lot. I suggest publishing it after a minor revision.

Minor revision:
Line 66: "assimilating w observations as a control variable" is not accurate, replace it with "assimilating w observations with control variable w".

Lines 70-71: "This operator ensures … the 3DVar cost function". This sentence is a little bit confusing to me. The observation operator links the model state variables (not control variable) to the observed variables. How about "This operator ensures adherence to physical constraints and links the w observations to other model state variables for the minimizing the 3D-Var cost function".

Lines 86-92: The Cv, d, R, x, xb and B are either vectors or matrixs, so they should be bold and non-italic. Please check it throughout the manuscript.

Figure 2: As I mentioned in previous review, adding a constraint to the vertical propagation of w assimilation would have an impact. It would be better if some discussions are given here even though it is not implemented.

Lines 184-185: It should be "a series of continuous 10-day runs … were".

Line 215: it is a little bit confusing "lower BIAS" here, better to be "closer BIAS to 1".

Lines 221-222: delete "compared to the CTRL experiment".

Line 228: better to modify "has a better adjustment effect" to "has a positive impact" to be clearer.

Lines 260-264: Could you discuss more on it. A deeper discussion could benefit more to this paper.