Review of the paper:

Leading the Lorenz-63 system toward the prescribed regime by model predictive control coupled with data assimilation

by Fumitoshi Kawasaki and Shunji Kotsuki

1. General comments

The paper discusses a Control Simulation Experiment (CSE) framework for evaluating and exploring control approaches in weather forecasting. It involves manipulating Nature Run (NR) of numerical models together with model predictive control (MPC) in order to lead the dynamical system to prescribed regimes of the states. Previous studies, well described as a review provided in the introduction by the authors, already showcased the potential of this experimental framework. In the idea, the CSE framework enables control of the NR with feasible manipulations assuming a realistic atmosphere, thus aiming to develop effective control approaches for extreme weather events for instance.

The paper is overall well written and comes with a set of Figures that helps the reader to understand how MPC is used in the context of CSE studies. The procedures and equations are correctly presented. The concepts are tested on the Lorenz 63 system with successful results. The experiment is particularly well detailed with many evaluations of different setups and according analysis.

I recommend publication after minor review taking into account some additional questions (2) and correction of typing errors (3).

2. Specific comments:

Q.1: l.197. The authors mentioned that "*OTK23 noted that starting points around the large x are generally difficult for leading the system to the positive regime for the Lorenz-63 model*".

- Though intuitive, is there any additional reason to explain this result in the corresponding study?
- Also, would it be possible to improve this by the method proposed in the paper? It seems important because this means that the approach would improve the capability to drive the system back to prescribed regimes from "extreme states", which is one of the main objectives of such approaches as described by the authors in the abstract.

Q.2: l.275. Would it be possible to add a Figure presenting on the Y-axis the three metrics w.r.t the length of state prediction on the X-axis. That would help to read the comments made by the authors from l.274 to 277.

Q.3: l.303. This random pattern is also not consistent with the butterfly wing of the positive L63 regime. Can you explain a bit more why, according to your opinion?

Q.4: Conclusion, l.372. The authors said: “it is computationally difficult to apply the present approach to large-dimensional NWP models as it is. Therefore, further studies are needed to explore faster approaches to solve OCPs for high-dimensional models”. This relates to potential applications of the research findings in realistic weather control and designing cost-effective strategies for mitigating extreme events**.**

- Can the authors provide some lines of research with appropriate citations to look for solutions in high-dimensional dynamical systems? For instance, looking at a smaller representation of the system with projection on latent space? Maybe also looking at fast solvers for the optimization of the OCP?
- regarding the ethical considerations, I would also mention that mitigating extreme events may also lead to shift the entire dynamical regime of the system in high-dimensional space, with no extreme events but with other unseen/unknown characteristics that may not be beneficial on other aspects (for the biodiversity, the wind/sun-related power production for instance).

Q.5: Data availability. Would it be possible to make the code open source, as a Git repository with code and Notebooks for instance? Indeed the EnKF L63 experiments used in third work is often used by the community and it would be nice to make available both:

- the DA-L63 setup,
- together with the MPC code presented in the paper, to ensure reproducibility of the results and provide a quickstart initial setup for future works and people interested in collaborating on this topic.

3. Technical corrections

Please find below a list of grammatical or typing errors to consider before publication:

l.20-22: The authors used exactly the same 2 first sentences for the abstract and Introduction. This has to be modified.

l.26: In the sentence "Under the program, researchers are exploring various engineering manipulations such as cloud-seeding and atmospheric heating," the word "manipulations" may be replaced with "techniques" for a more precise and formal tone. Or at least, well define what you intend by “manipulations”.

l.127: The word "solve" in the sentence "Thus, this study solve them using a numerical approach" should be changed to "solves."

l.128: In the sentence "Given the first guess of control inputs $\mathbf{u}*(\tau;t)$, temporally forward computations (Eqs. 7 and 8) are performed to obtain $\mathbf{x}*(\tau;t)$ from $\tau = 0$ to $\tau = T$," the term "temporally" should be changed to "temporal" for accuracy.

l.366: The phrase "the constraint impose more difficulty" should be corrected to "the constraint imposes more difficulty."

l.326: In the sentence "In addition, the MTC decrease for smaller U," the verb should be in singular form as "decreases" to match the subject "MTC." In the same sentence, "but the SR and MTF worsen accordingly" could be improved by adding "do" before "worsen" for better clarity.