

Overview of the preprint

This manuscript proposes a control scheme to reduce precipitation over a target domain Ω within a target time window $[0, T]$. The deterministic framework aims to minimize the following cost function:

$$\arg \min_U \frac{\Delta t}{|\Omega|} \sum_{t=1}^T \sum_{q \in \Omega} y_t(q), \quad (1)$$

where $y_t(q)$ represents the mean precipitation rate during $[t-1, t]$ at point q in the domain, and U denotes the set of all control variables—specifically, the locations of the sails. The orientation of the sails is not treated as a control variable because it is determined by the wind field. The authors assume that small-scale atmospheric dynamics cannot be resolved by current NWP models. This leads to the following stochastic optimization problem:

$$\arg \min_U \mathbb{E}_{\Xi} \frac{\Delta t}{|\Omega|} \sum_{t=1}^T \sum_{q \in \Omega} y_t(q), \quad (2)$$

where Ξ is the set of random signals, which in this manuscript refers to perturbations in the water vapor mixing ratio. Owing to computational constraints, this manuscript does not attempt to find the local minimum of either cost function. Instead, the authors propose changing the positions of the sails in an organized way: moving all sails toward either e^+ , $-e^+$, $e^\perp$, or $-e^\perp$ by $d_s = 15$ km, or keeping them at their original positions. Here e^+ is the upwind direction, and $e^\perp$ is perpendicular to e^+ . Both e^+ and $e^\perp$ vary from point to point. However, the optimization procedure proposed in this manuscript requires that the choice among e^+ , $-e^+$, $e^\perp$, and $-e^\perp$ be identical—that is, the same category—for all sails. The initial value of U is determined by the Voronoi tessellation weighted by the moisture field. Numerical experiments show that the precipitation in the target area is reduced by 8% to 25%.

Major Comments

The research topic is interesting and meaningful. However, the actual optimization procedure proposed in this manuscript is too much simplified and the numerical results are not analyzed sufficiently. See below for more details.

1. The cost function in Eq. (6) is reasonable. However, the optimization problem actually solved in this manuscript, Eq. (8), is oversimplified. The authors explain that this simplification is motivated by the absence of a tangent-linear model in the current versions of SCALE-RM or SCALE-LETKF, which would be needed for a gradient-based solution of Eq. (6). I appreciate this difficulty. Nevertheless, Eq. (8) restricts the search at each control step to only $K = 5$ candidate sequences. I suggest that the authors replace Eq. (8) with a less restrictive optimization problem that can still be solved with the tools currently available.

2. The authors compared the 72-hour accumulated area-averaged precipitation over the target region across three experiments: a no-control experiment, a random-placement control experiment with randomly generated actuator positions and orientations, and a humidity-informed control experiment using CVT-based warm starts followed by sampling-based optimization. The authors claim that the proposed optimization strategy can reduce precipitation by up to 25%. However, it remains unclear whether this reduction stems from the CVT-based warm start or from the optimization procedure itself. I suggest adding a CVT-only experiment, i.e., one that applies the CVT-based initialization without subsequent optimization.

3. The proposed control scheme uses sails to reduce the near-surface wind speed at selected positions. It acts as a near-surface dissipation, which prevents water vapor from being transported along its original path. Does the proposed control scheme merely redistribute the precipitation? Would the control scheme trigger nonlinear effects such that total water vapor increases or decreases? These questions should be discussed in the current draft rather than left for future work.

Minor Comments

1, [L146] "optimization problem" $\rightarrow$ "optimization problems" or "a ... optimization problem".

2, [L339] "random-placement ensemble" $\rightarrow$ "the random-placement ensemble".