Atmospheric Measurement Techniques Discussions

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Comment on amt-2021-86

Anonymous Referee #2

Referee comment on "Novel approach to observing system simulation experiments improves information gain of surface–atmosphere field measurements" by Stefan Metzger et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-86-RC2, 2021

General comments

Metzger et al present an article where they describe the importance of using observing system designs (OSD) to maximize scientific insights from surface air exchange measurements. The authors propose that one particular observation system design that is useful for the study of biosphere-atmosphere interactions is the Observation System Simulation Experiment (OSSE), which is obtained through the use of Large Eddy Simulations (LES) in combination with Environmental Response Functions as previously described by Metzger (2013). Thus, the OSSE used in this study is referred as LES_ERF.

The authors argue that most researchers in the field set up the instrumentation first to gain "knowledge from data", however, an alternative is to use OSDs such as this OSSE to gain "data from knowledge" and thus optimize the scientific insight gained from the observations. For example, this type of optimization can be used to determine an optimal location for an eddy-covariance sensor both vertically, and horizontally, thus guaranteeing the adequate fetch but also guaranteeing the correct spatial heterogeneity that may account for mesoscale circulations.

The goal of the paper is to show that making informed Observing System Designs (OSDs) for surface-atmosphere field measurements can improve the amount of useful information, or as the authors say, "double the scientific return". And that creating OSSE can be one of the best ways to attain an optimal OSD. The novel approach is to provide design information prior to testing OSDs in the field.

The authors make use of the CHEESSEHEAD19 dataset, which was originally designed to test the hypothesis that mesoscale features, driven by surface heterogeneity can explain the lack of closure in energy balance. The campaign was also used to evaluate the use of Environmental Response Functions (ERFs) for estimating "fluxes in a box" an approach previously created by the authors. In this paper, the authors use LES_ERF to find the optimal flight strategy to maximize the amount of useful information to evaluate the energy balance closure at the CHESSEHEAD19 site. The OSDs are built around 2 hypotheses, one is that it is critical for airborne EC to measure perpendicular to the prevailing wind, and 2, that it is more informative to fly a finely spaced pattern. 13 different OSD were created: the first based on tower-only data, and the other 12 based on the combination of four track angles (0,45,60,90 °), and 3 flight patterns (Alternating, Outbound, Return). The results show that flight patterns with a track angle of 45-90 double the percent improvement based on three optimality criteria when compared to parallel flight patterns.

I think the paper addresses relevant scientific questions within the scope of Atmospheric Measurements Techniques, and that it presents novel concepts, ideas, and tools. However, I think there are some issues with the clarity of the methodology and with the application of this technique to other studies.

The methodology can be very confusing. This is what I understood from section 2.2. The methodology consists of first combining information from different sources into ERFs. This would be, for example, combining information from existing towers and aircraft data to create a space-and-time aligned dataset. The second step is to then create multiple OSDs by using LES, and finally benchmark the candidate OSDs by evaluating if the candidate OSD can recreate the environment from the original ERF. One of the 3 ways to evaluate this approach, is the Energy Balance Ratio, defined as the sum of the sensible and latent heat fluxes produced by the ERF, to the sum of latent and sensible heat fluxes produced by the LES. It is my understanding that the numerator in equation 1 does not vary and that the denominator should vary according to different OSDs. But I may be wrong. This section could use some synthesis to make it clearer to the reader. I think there are some conflicts between what is said in the caption and what is said in section 2.2.

After reading the results (L. 440) I now see that there is a baseline OSD for the tower-only dataset and 12 other OSDs for the combined tower-aircraft. The tower-only dataset has a given spatial coverage that can be improved by aircraft sampling, and the goal is to maximize this coverage by deciding on certain flight tracks. By applying different OSDs with different flight angles, it was found that the spatial coverage is maximized in a perpendicular flight track (25% improvement). In table 1, similar analyses are given for energy balance ratio, and spatial patterning, the other two optimality criteria.

Reading section 2.4, I see that the LES are created with surface fields of H and LE created from the ERF. So, isn't this some circular reasoning? You are creating OSDs from ERFs that are benchmarked against LES created using ERF… Please explain

I think the results are clear and easy to follow but as mentioned previously the methodology can be a little confusing and I think needs more synthesis and needs to be clearer.

It is my understanding that the LES_ERF approach is designed specifically for the combination of airborne EC measurements with tower EC measurements. If this is the case this needs to be stated clearly in the abstract and perhaps even in the title.

To me, it is not clear what the “scientific return” means. How can you double the scientific return? Isn’t this all subjective? Whatever information you gained by using one flight path instead of the other depends on how you interpret it. Doesn’t it? What the results show is that flight patterns with a track angle of 45-90 double the percent improvement based on three optimality criteria, when compared to parallel flight patterns. I’m also not sure how you can “order-of-magnitude improve flight operation and crew safety”. The last two statements are part of the main conclusion but the way they are quantified seems subjective.

Lastly, a question of applicability. How many other researchers are in the capacity to apply airborne EC measurements with such large-scale deployment of towers and the capacity to run computationally expensive LES at this scale? The authors present a good analysis of other large-scale field campaigns in section 4.2 but still, I’m not sure about the use of this approach to support the last conclusion of the abstract that “the approach lends itself to optimize observing system designs also for natural climate solutions, emission inventory validation, urban air quality, industry leak detection, and multi-species applications” What would be the cost-benefit analysis of implementing a large-scale field campaign like this for every natural climate solution project?

Specific comments

- 31 This approach doubled the ability to explore energy balance closure? This is a very subjective statement. How do you double the ability to explore?
- 371. Please specify the subsection in Section 4 where we can learn why the PBL was so low
- 409 Should this be “near-surface moisture”? “Land surface moisture” sounds like soil moisture and is redundant.

L.465 Indicate in the table that these are percent values

I find that in the introduction and methods there are multiple statements that are hard to follow, such as:

192 "*Here, we propose the extensible LES-ERF approach that explicitly simulates the joint scientific return in response to different candidate OSDs for addressing user-defined design hypotheses*"

I think part of the problem is the use of the term "scientific return", which should be reevaluated.

I also think that an effort to synthesize the introduction and the methods would help the readability of the paper.

L.286 What is the LES time step?

Technical comments

- should the verb be "creating" rather than "observing". Aren't you creating these OSSE?