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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Upscaling surface energy fluxes over the North Slope of Alaska using airborne eddy-covariance measurements and environmental response functions" *by* Andrei Serafimovich et al.

Anonymous Referee #1

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This is a very promising synergy of airborne turbulence measurement, machine-learned environmental response functions, and mesoscale modeling (WRF) to project air-surface exchanges of water and heat out over large areas of the North Slope of Alaska. It looks to be a significant advance in addressing this important issue.

Assets

1. Airborne campaign was generally well designed including straight tracks with multiple passes over some tracks and frequent profile ascents to find the mixed-layer struc-

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ture and depth. Instrumentation and sample rate (100/s at about 70 m/s true airspeed) are appropriate to the mission. One apparent deficiency was in radiation. Although the investigators measured shortwave insolation, they did not mention measuring reflected shortwave (they did determine the albedo), or upwelling and downwelling long-wave (infrared) radiation.

2. Pg 5 line 17: “Wavelet cross-scalograms were integrated in frequency over transport scales up to 20 km” This raises the question of the length of the fight tracks. From the map (Figure 1) they appear to be mostly about 100 km, which still provides an adequate 80 km of flux uncontaminated by edge effects at the largest width (20km?) of the cone of influence.

3. Section 2.3: It’s good to see a mesoscale model used in the study. In principle it can describe the mesoscale environment of the airborne campaign. It is difficult to relate model results quantitatively to what the aircraft and any fixed surface sites are reporting, especially in Alaska where the input data are relatively sparse. But for a “projection” (see item 6) it appears to work well.

4. Page 6, line 6: The verb “project” is a great word to describe the inference of air-surface exchange over large areas from measurements over small areas because it implies some sort of model which represents knowledge and draws on data both of which grow more sparse as the scale increases. “Upscaling” is commonly used but is troublesome because it implies that the system is (largely) scale-independent, like going from a model to a full-scale prototype.

5. Page 8: MODIS has something like 500 m to 1000 m pixels, which appears a good match to the km-scale spatial averages of the fluxes derived from this campaign’s measurements.

6. Figures 5 and 6, pages 9 and 10: The “rug” plots showing the distribution of the variables in deciles are appreciated.

Questions and Issues

1. Page 5 and thereabouts: Recognizing flight safety as the ultimate first priority, did they next prioritize near-constant height above ground or did they try to minimize pilot adjustments? These are often a trade-off because terrain is rarely really flat. Minimizing control pressures improves fidelity of the flux measurements by minimizing the flow distortion, but usually requires higher-altitude flight to clear the terrain safely. Higher altitude gives up the advantage of cleaner sampling of heterogeneous surface fluxes.

2. Page 5, line 25 into Page 6: I presume that a sample of sensible or latent heat flux is one of the 1000 m mean fluxes computed every 100 m, perhaps further segregated by land-surface type. Because of the deep overlap, these are strongly autocorrelated implying fewer degrees of freedom (DF) than there are fluxes in the sample. There are ways to estimate this reduction in DF by determining the decorrelation length. A coarse guess would be to divide the sample size by 10 since the reporting interval (100 m) is one tenth of the averaging length (1 km). The loss is probably not that much. At the least the loss of DF by autocorrelation should be mentioned qualitatively.

3. Page 8, Fig 4: in the second-row left node the dashed arrow intrudes into the ellipse partially obscuring the criterion for insolation making it hard to read (S > 380 W/mˆ2?).

4. Pg 11 Figure 8 Caption: Is it proper to call the quality parameter a standard error, or is it more an uncertainty? If an error, what constitutes "truth"?

5. Figure 7 is interesting. There are two slopes of BRT predicted vs aircraft measured. The majority of the aircraft data match the BRT predicted quite well, but the majority of the spread of BRT vs measured has a shallower slope. Away from the training data, the BRT underpredicts the strong fluxes and overpredicts the weak fluxes. Were measures taken to avoid overfitting?

6. Page 17, line 7ff: It is indeed likely that under free-convection conditions (light winds and strong insolation) that fixed sites do not experience the larger patterns that air-

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craft can readily penetrate. If these structures are in fact turbulence (hence “random”) they can be treated by integral techniques such as time/frequency-domain methods or time/space-domain averages. If they are not random it is not clear that an individual aircraft track in space and time will capture the relevant (nonrandom) structure unless it can be designed to do so.

7. Page 19, lines 2 and 3: The data set is no longer unique. Sayres et al. (2017), cited in this manuscript, also used an aircraft to measure fluxes (primarily latent heat and methane) over heterogeneous Arctic landscapes. Exclusive use of airborne data can be considered a liability because of the inherently greater uncertainty in airborne measurements. Having a surface reference, as in this manuscript with Atqasuk and Happy Valley, is important both for temporal continuity and for sanity check. Data are, of course, the more readily acquired from aircraft than from fixed sites over remote areas difficult of access as on Alaska’s North Slope.

Copy-editing items (a few were found and noted, not guaranteed to be exhaustive list)

1. Page 4 line 16: “reference period” 2. Page 14 line 15: Likely: “periods that were” 3. Page 14 line 20: Sentence starts with Greek letter (beta for Bowen Ratio). Recasting of the sentence is recommended. 4. Page 15 line 19 Remove “An”; insert “an”: “measure water vapor <an> LI-7200 gas analyzer...”; remove “for water vapor measurements. 5. Page 17 line 25: Turbulent fluxes over water surfaces are more likely to be suppressed (due to lack of both mechanical and buoyant generation) than to be directed to the surface. 6. Page 17 line 30: “Project” (verb) would be a really great word here instead of “upscale.”

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