Toward Evaluating Surface Heat Flux Parameterizations From A Large-Scale Perspective: Arctic Ocean Example

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Abstract

We develop a method of evaluating surface heat flux parameterizations using the assumption that the parameterizations represent ensemble-averages of the sub-grid physics. This method is applied to Arctic Ocean surface energy budget parameterizations.

Current Method of Evaluating Surface Flux Parameterizations

Fig. 1 shows an example of how parameterizations are commonly evaluated, i.e. by a “fit by eye.”

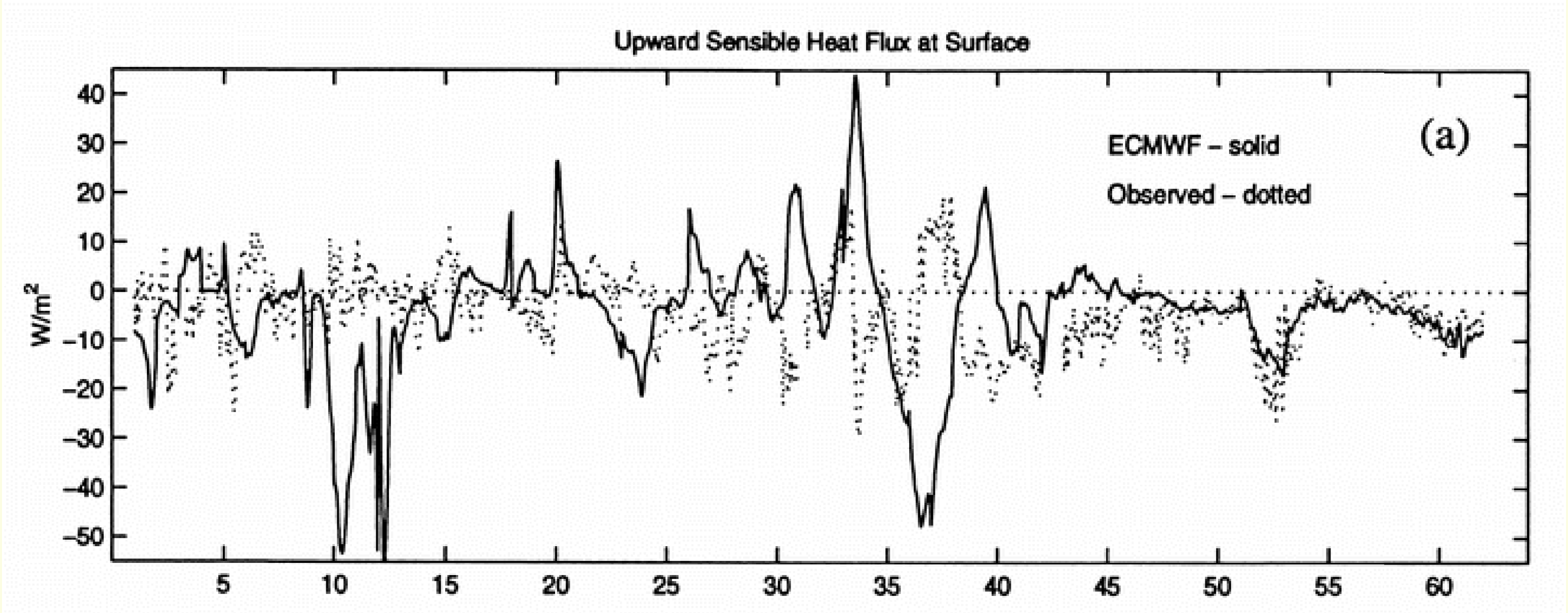

Fig. 1: November-December 1997 SHEBA ECMWF and measured sensible heat flux from Beesley et al. (2000). Abscissa is day number (1 = 0 UTC 1 Nov 1997).

Is there another way of evaluating surface flux parameterizations? In the present work we try to formulate another method, one that takes a “large-scale” perspective, in which we analyze whether the parameterized values properly represent an ensemble-average of the sub-grid physics.

Data

Parameterizations (hourly averages) come from the ECMWF forecast model (“model”). Local hourly average point-observations taken at the ASFG Tower (“Tower”) during SHEBA are assumed to approximate the small-scale contribution. Two periods are examined: “Dec/Jan” [1 Dec 1997 (0Z) to 30 Jan 1998 (3Z)]; and “Jul“, [28 Jun (1Z) to 6 Aug 1998 (2Z)].

Using the Ensemble-Average Assumption To Evaluate Surface Flux Parameterizations

If the parameterized value represents an ensemble-average of the sub-grid physics, it can be shown that the variance structure of the parameterization should be similar to the structure of a point observation representing small-scale physics. We can then use an eigenvector method on the parameterization/point observation covariance matrix to visualize in what ways the variance structures are similar/different.

Figs. 2-3 shows rotated EOFs (REOFs) from rotated principal component analysis (RPCA) of the covariance matrix of hourly fluxes of the terms in the surface energy budget for Dec/Jan and Jul. Here are some things REOF loading structures can tell us about the variance structures:

REOF Structure	Shows Variance Structures Are
Each REOF dominated by single model or Tower term	For those terms, unlinked and unique
Multiple terms contribute to the same REOF	For those terms, closely tied together

Some Results

In Jul, parameterized net radiation, residual, and ice conduction have variance structures strongly linked to point observations. This suggests the parameterizations are behaving consistently with the ensemble-average premise.

In Jul, parameterized sensible and latent heat flux does not have variance structures tied to point observations, suggesting these parameterizations are not strongly following the ensemble-average premise. In fact, sensible and latent heat variance structures (both model and observed) are separated from each other, even though both presumably are the result of the same turbulent eddies.

The Dec/Jan patterns are more complex, but as none of the surface flux terms shown have loadings where the parameterization and point observation contributions are both on the same REOF, it suggests that none of the parameterizations in this time period are behaving very strongly with the behavior expected if the parameterizations are ensemble-averages of sub-grid phenomena.

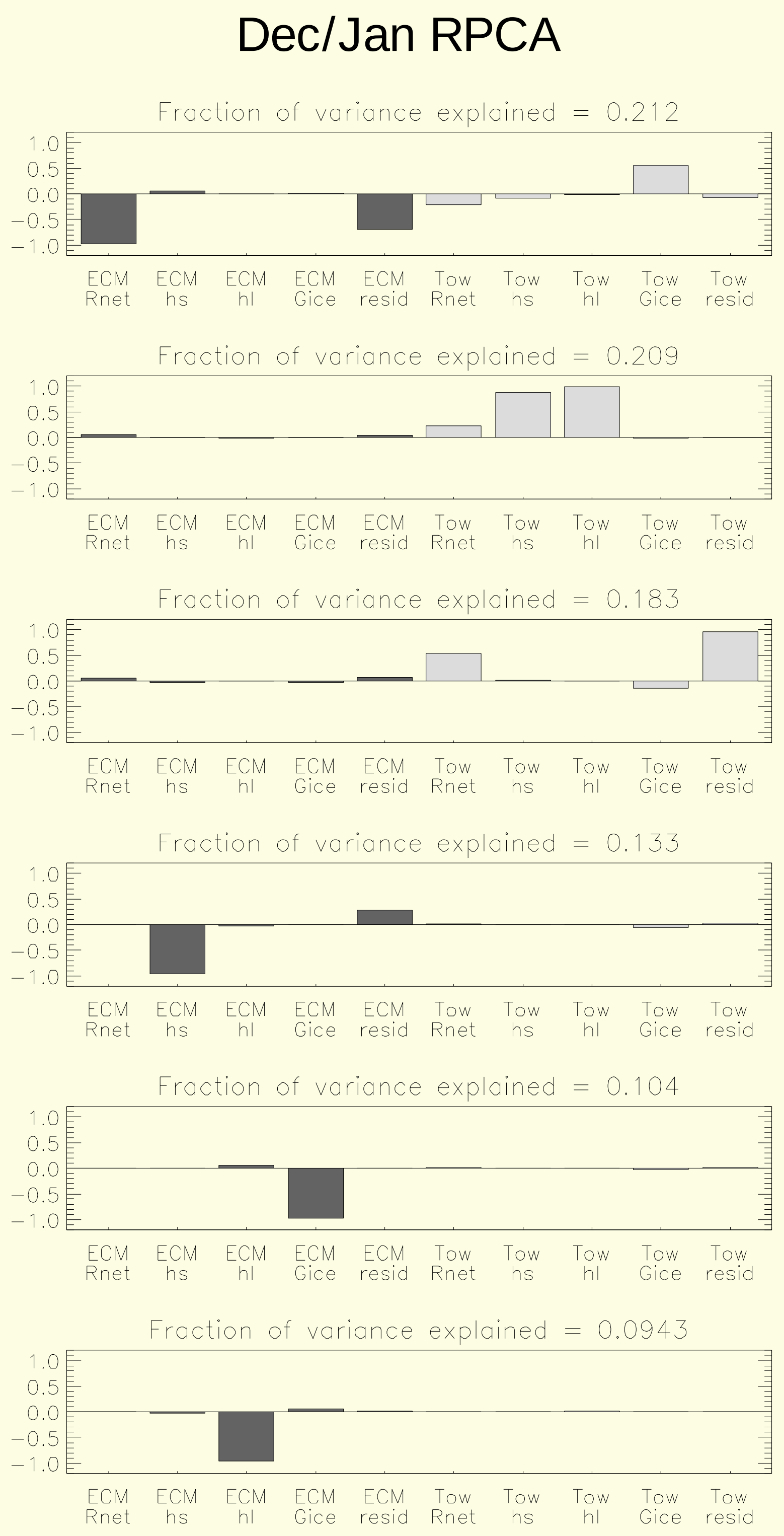

Fig. 2: Dec/Jan model and Tower fluxes selected REOFs. Arbitrary units.

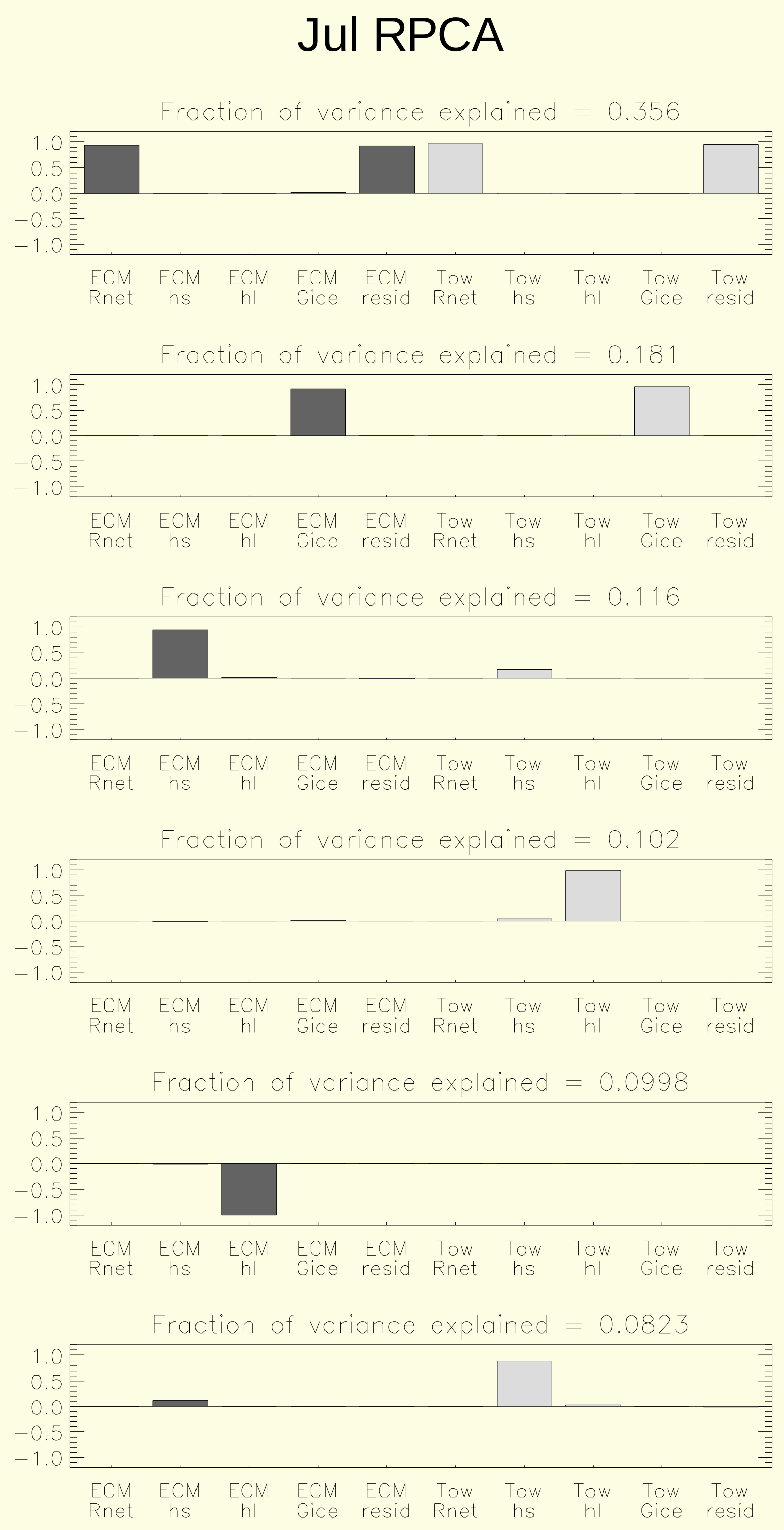

Fig. 3: Jul model and Tower fluxes selected REOFs. Arbitrary units.

Reference, Acknowledgments, Contact Information

Beesley, J. A., C. S. Bretherton, C. Jakob, E. L Andreas, J. M. Intrieri, T. A. Uttal (2000), A comparison of cloud and boundary layer variables in the ECMWF forecast model with observations at Surface Heat Budget of the Arctic Ocean (SHEBA) ice camp, *J. Geophys. Res.,* **105,** 12,337-12,349.

This research was partially supported by National Science Foundation grants ATM-0121028 and OPP-0129800 and a CIRES visiting fellowship.

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