Observed LW Changes Driven by Clouds at North Slope of Alaska

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Summary

Clouds are responsible for increasing wintertime surface net longwave radiation during the 20 years of ground-based observations at the North Slope of Alaska.

Methods

Using only ground-based observations, we quantify the drivers of the surface longwave flux response to temperature anomalies at monthly timescales.

We find the flux response attributable to changes in one driver (e.g., water vapor) alone.

$$\frac{dF}{dT} = \sum_{\text{driver}} \frac{\partial F}{\partial \text{driver}} \frac{\partial \text{driver}}{\partial T}$$

Attributable response is the product of the radiative effect of changing the driver (first term) and the observed change in the driver with temperature (second term).

Radiative effects are calculated by perturbing the observations in the radiative transfer model RRTM_LW (Mlawer et al. 1997).

Results

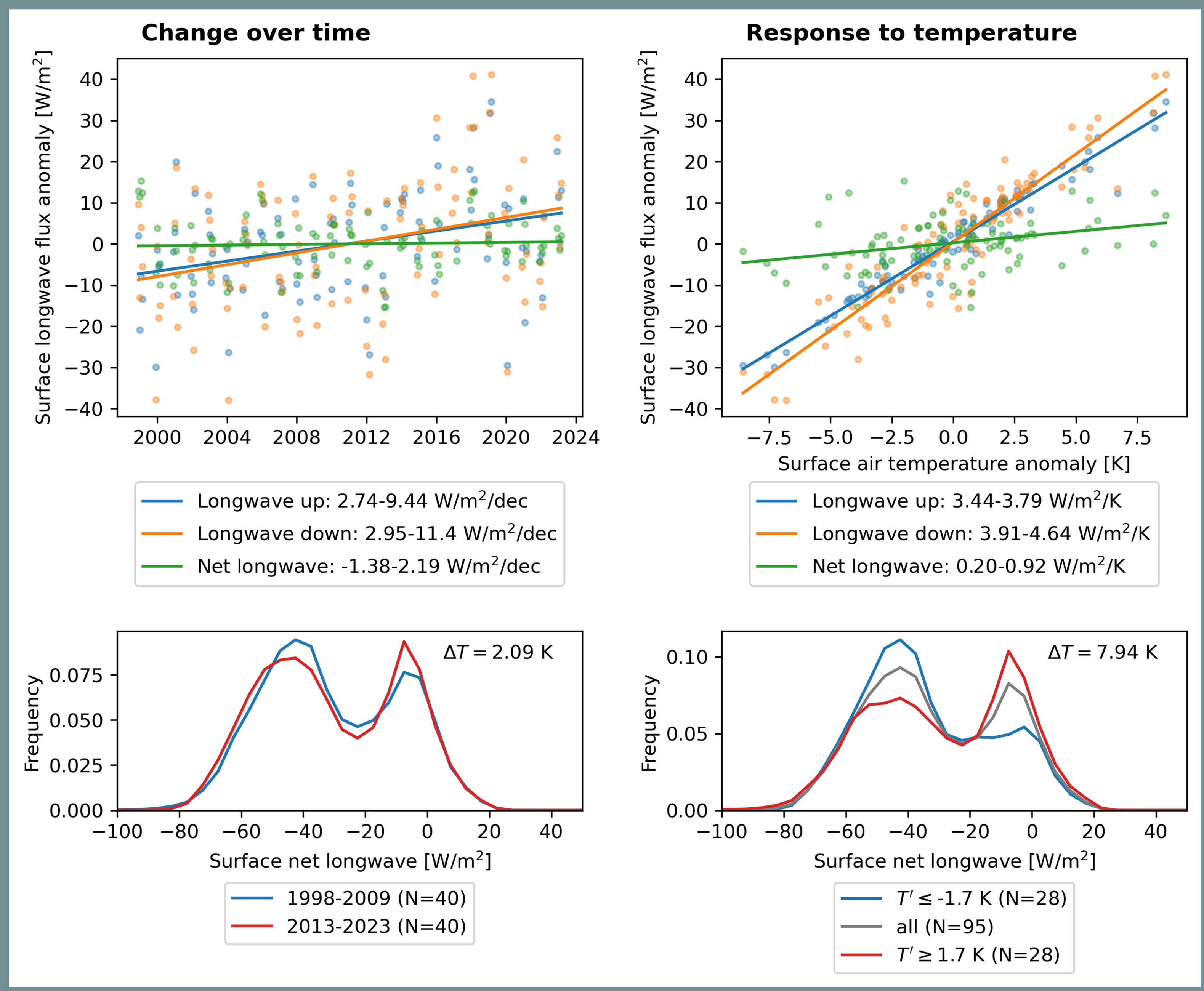

Fig 1. Observed changes in monthly surface longwave radiation due to local warming trend of 1±0.2 K/decade. Top row: monthly-mean surface longwave fluxes. Bottom row: surface net longwave distribution. All uncertainties reported at the 95% confidence interval.

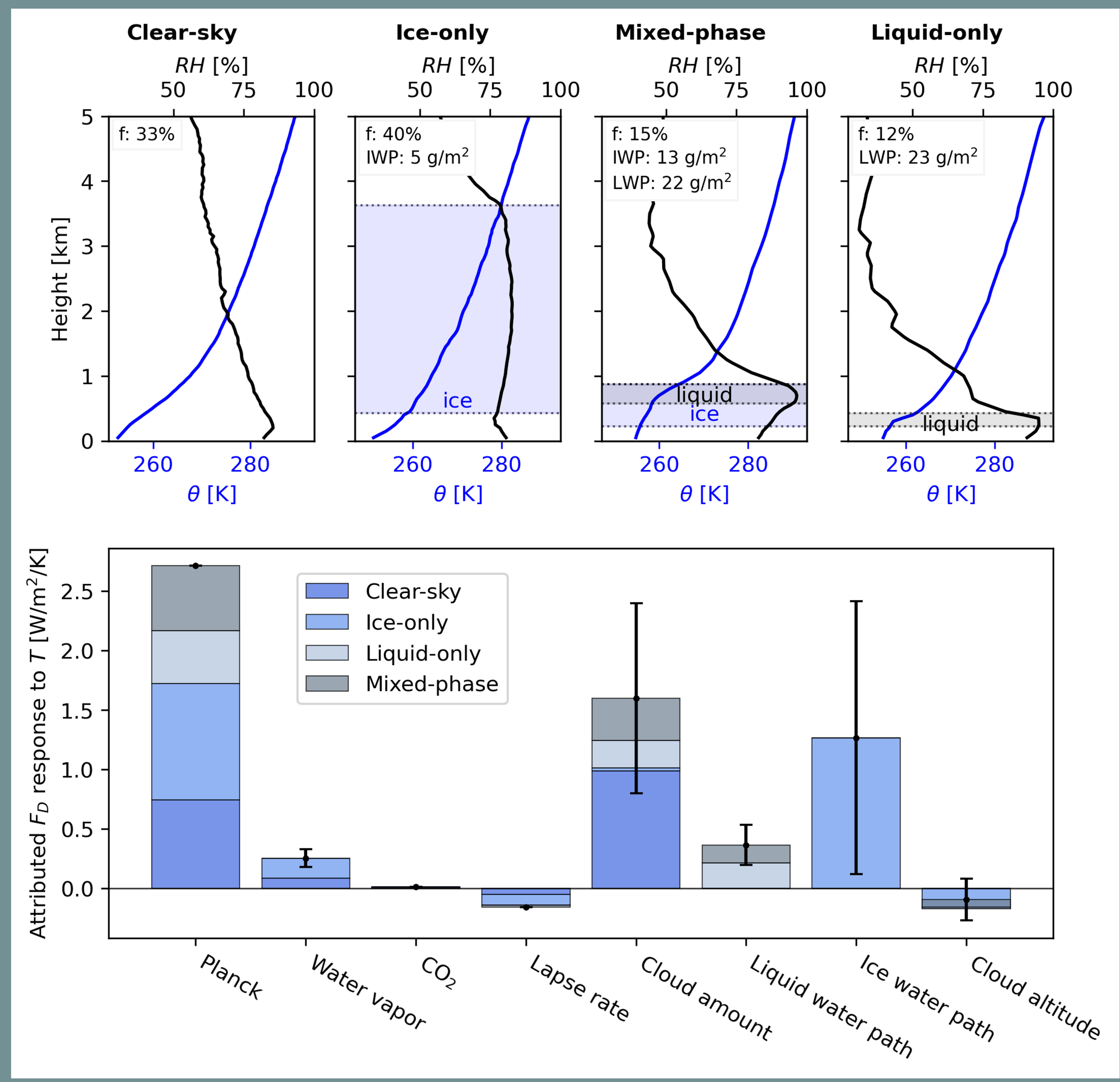

Fig 2. Observed wintertime average conditions by cloud phase (top row) and drivers of downwelling longwave flux response to temperature (bottom row). Totals indicated by dots and contributions by cloud phase indicated by colors.

Observations

Key datasets include 11 years of cloud phase and microphysics (Shupe et al. 2015) and 20 years of surface longwave fluxes from radiometers (Zhang 1998).

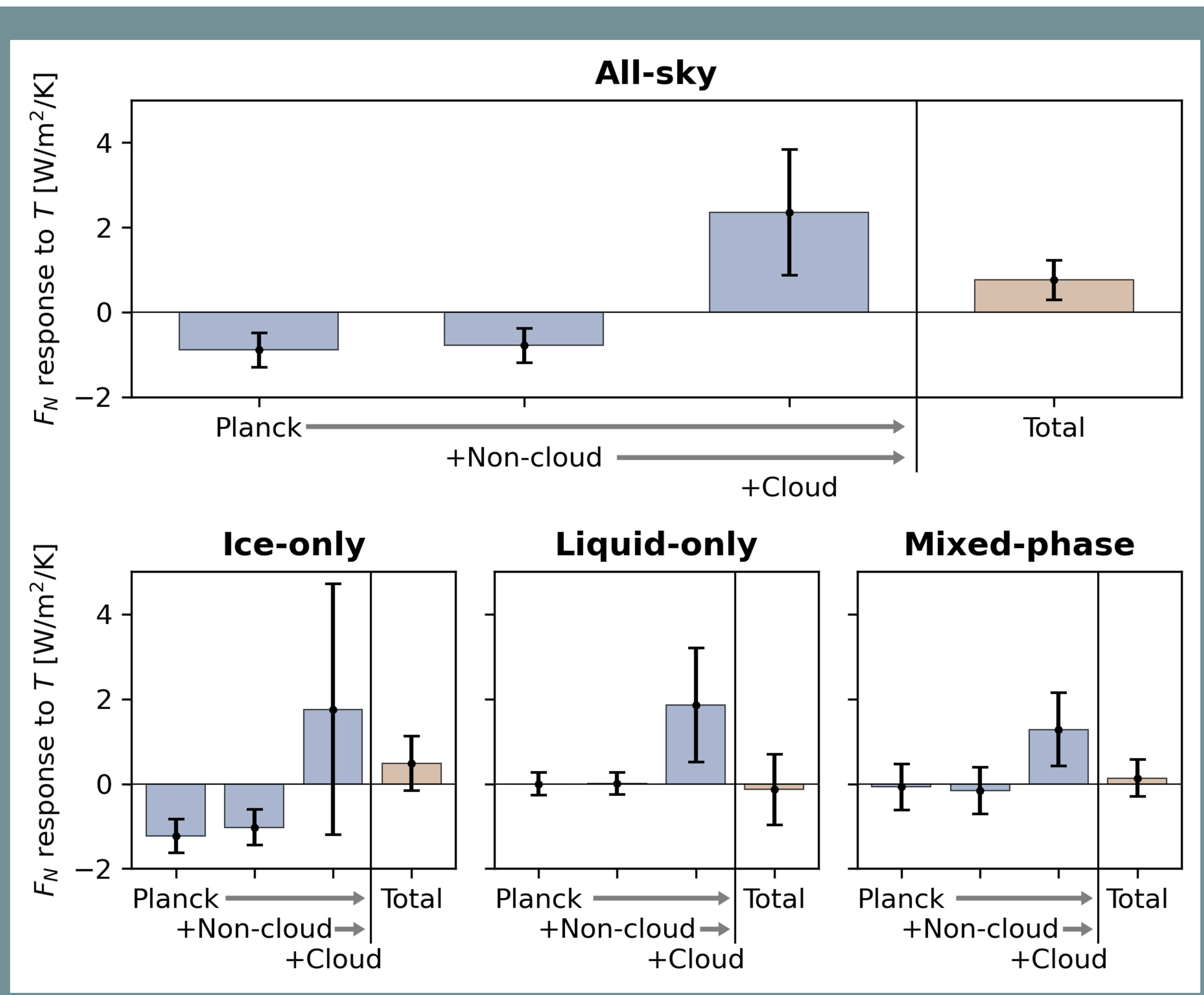

Fig 3. Attributed net longwave change due to warming alone (Planck); warming, lapse rate, and greenhouse gases (+Non-cloud); and warming, GHGs, and changing cloud properties (+Cloud). Independent radiometer totals in orange.

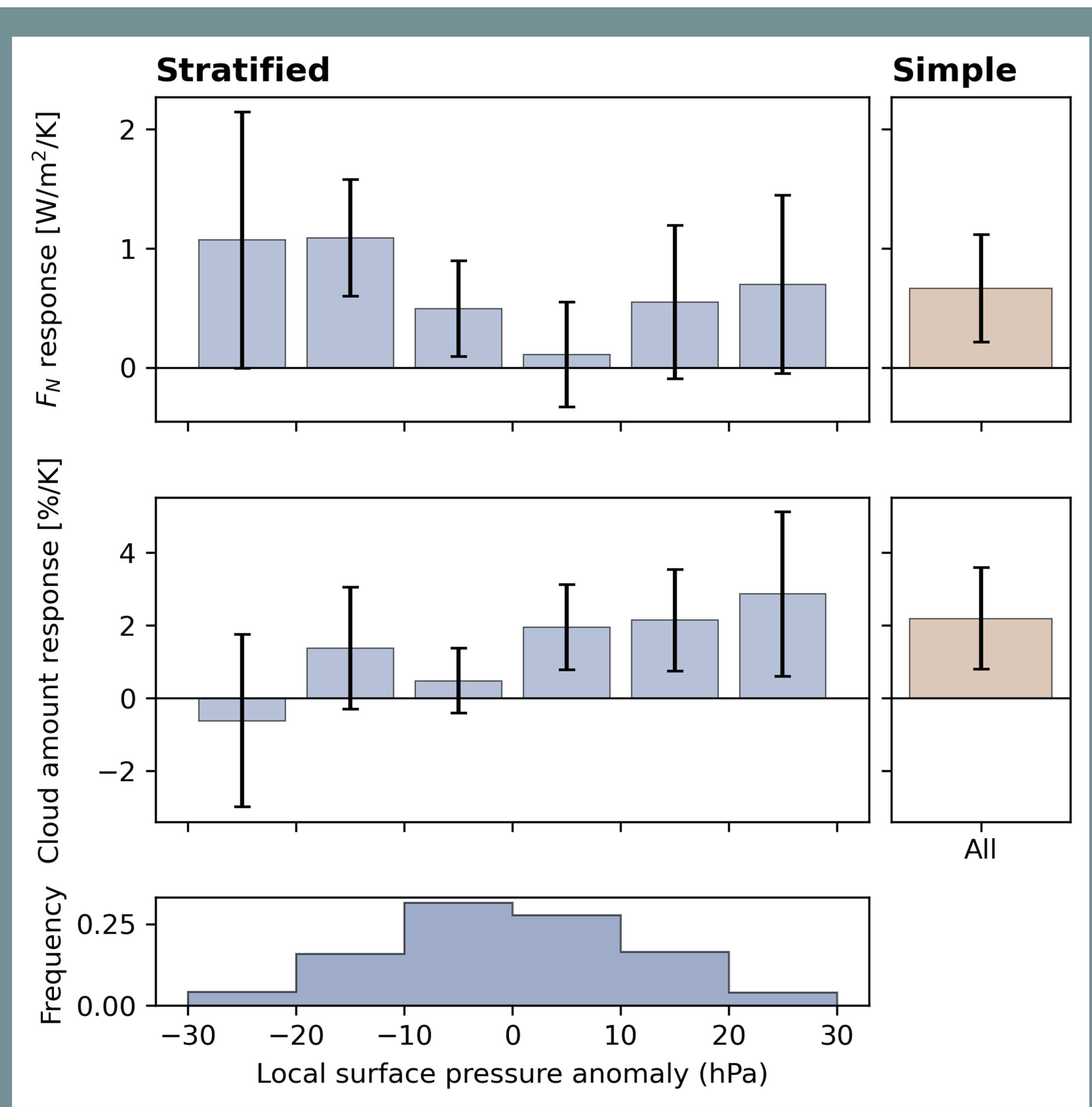

Fig 4. Responses to temperature controlling for synoptic variability (left) vs. simple unstratified estimate (right). Responses to temperature of surface net longwave (top row) and cloud amount (middle row). Frequency of daily local surface pressure anomaly bins (bottom row) indicate synoptic disturbances.

References

Mlawer, Eli J. et al., 1997. "Radiative Transfer for Inhomogeneous Atmospheres: RRTM, a Validated Correlated-k Model for the Longwave". DOI: 10.1029/ 97JD00237.

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