The Top-Down Thermodynamic Control of Atmospheric Blockings on the Magnitude of Surface Heat Waves

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2021 Pacific Northwest heat wave

Neal et al. (2022)
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(a) $\theta$ at 49°N 119°W 00 UTC

(b) Surface Heat Fluxes at 49°N 119°W

- red: solar radiation
- blue: sensible heat flux
- green: longwave radiation
- orange: latent heat flux

Neal et al. (2022)
Question

• What mechanism set the maximum surface temperature?

Hypothesis

• A warm anomaly aloft, set up by atmospheric blocking, suppressed convection.
Encroachment

Prediction of boundary layer temperature and height based solely on the thermodynamics (e.g., Stull, 1988).
Encroachment | Example

- **Morning Sounding**: A linear relationship between temperature (K) and distance (km).
- **Sensible Heat Flux**: A graph showing the variation of heat flux (W/m²) with time (Hour).
- **Boundary Layer Height**: A linear increase in height (km) with temperature (K).
Encroachment | Example

\[ \Delta \theta(\Gamma, a) \]

\[ d(\Gamma, a) \]
Encroachment | Thought Experiment

**Morning Sounding**

- Plot shows variations in temperature (K) against altitude (km).

**Sensible Heat Flux**

- Graph illustrates the heat flux (W/m²) over a 12-hour period (Hour 0 to 12).

- Question mark indicates a point of uncertainty or query.
Encroachment | Thought Experiment
Encroachment | Thought Experiment
Encroachment | Column Model
Encroachment | Column Model

Diurnal cycle of boundary layer temperature

Surface Heat Fluxes
Encroachment | Column Model

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Diurnal cycle of boundary layer temperature

Surface Heat Fluxes
Summary

- Extreme heat waves in the midlatitudes are linked to anomalies in the upper level jet.
- We expect warming aloft to influence surface extremes by influencing the convective boundary layer.
- Future modeling work will investigate the role of top-down warming in the presence of processes such as cooling overnight and changes to the ground layer.