Quantification of the Physical Process Leading to Day-to-Day Temperature (DTDT) Extremes

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Introduction

Day-to-day temperature (DTDT) variation, representing the temperature differences between consecutive days, is a crucial indicator of short-term variations *(Gough, 2008)*. This temperature variation carries significant implications across various sectors, encompassing economic, ecology, agriculture and human health *(Kotz et al., 2021; Hovdahl, 2022; Wang et al., 2022)*. Nevertheless, the underlying physical processes and the relationship between extreme events and large-scale atmospheric circulation remain poorly understood.

Data and Methodology

- ❑ **Observation:** ***HadGHCND (1980-2014)***
- ❑ **Gridded datasets:** ***ERA5 (1980-2020)***

➢ **Definition of DTDT variability and extremes**

• *DTDT* (δ_t) = (D_t-D_{t-1})

• $\sigma_{DTDT} = \sqrt{2\sigma_t^2(1-ACORR(D_t, D_{t-1}))}$

• 5th and 95th percentile as cold and warm events

➢ **Lagrangian 3d backward trajectory:** initiated at 10, 30, 50 and 100 hPa

➢ **Lagrangian temperature decomposition change**

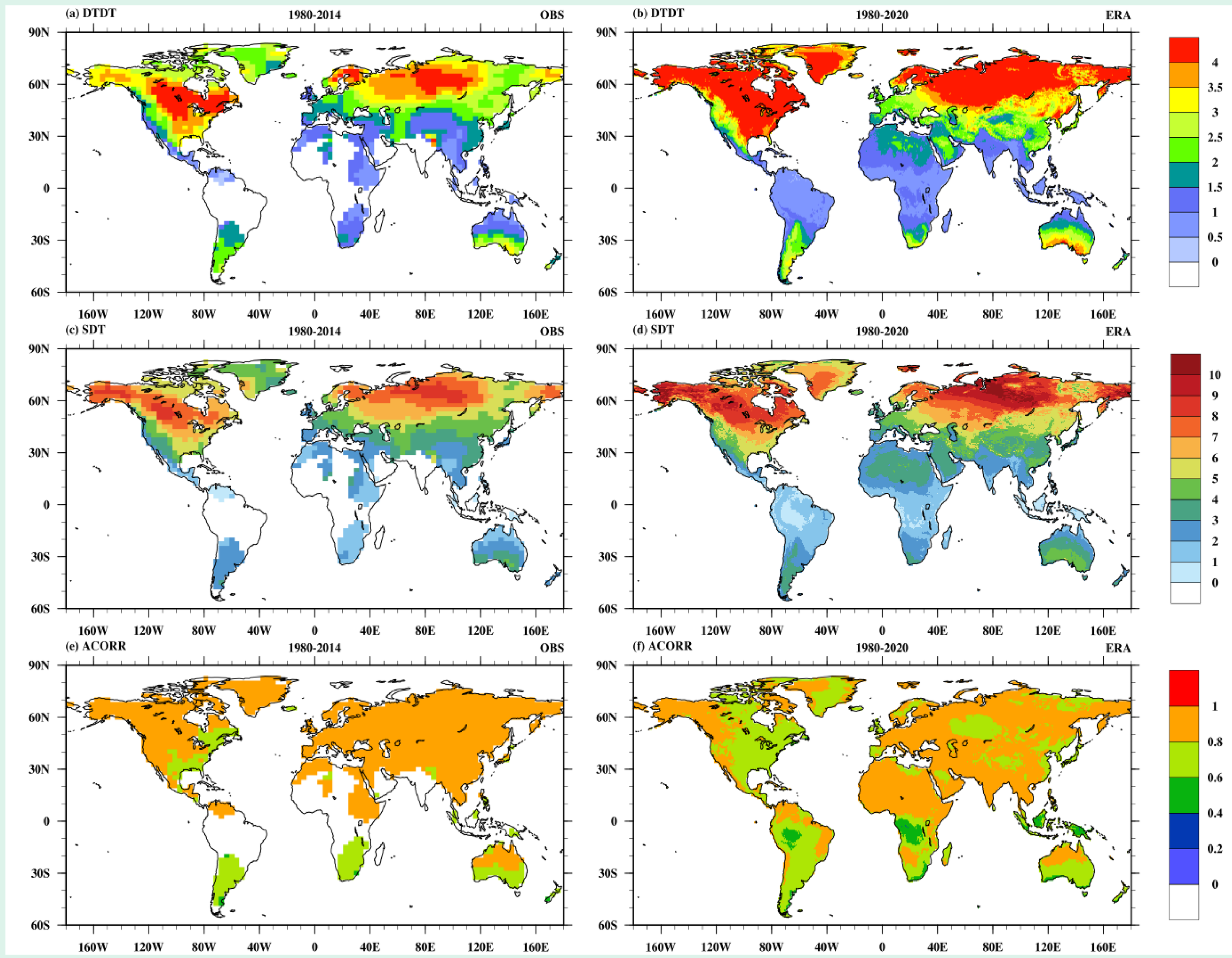
• $\delta_t^0 = \delta_{\bar{t}}^{-3d} + \delta_{\bar{t}}^{ad} + \delta_{\bar{t}}^{dia}$ +res

Where, advection ($\delta_{\bar{t}}^{-3d}$)= $\overline{D}_t^{-3d} - \overline{D}_{t-1}^{-3d}$

adiabatic warming ($\delta_{\bar{t}}^{ad}$)= $\langle \int_{p^{-3}}^{p^0} \frac{KT}{P}\, dp \rangle_i$

diabatic warming ($\delta_{\bar{t}}^{dia}$)= $\langle \int_{\theta^{-3}}^{\theta^0} \left(\frac{p}{p_0}\right)^k d\theta \rangle_i$

Background

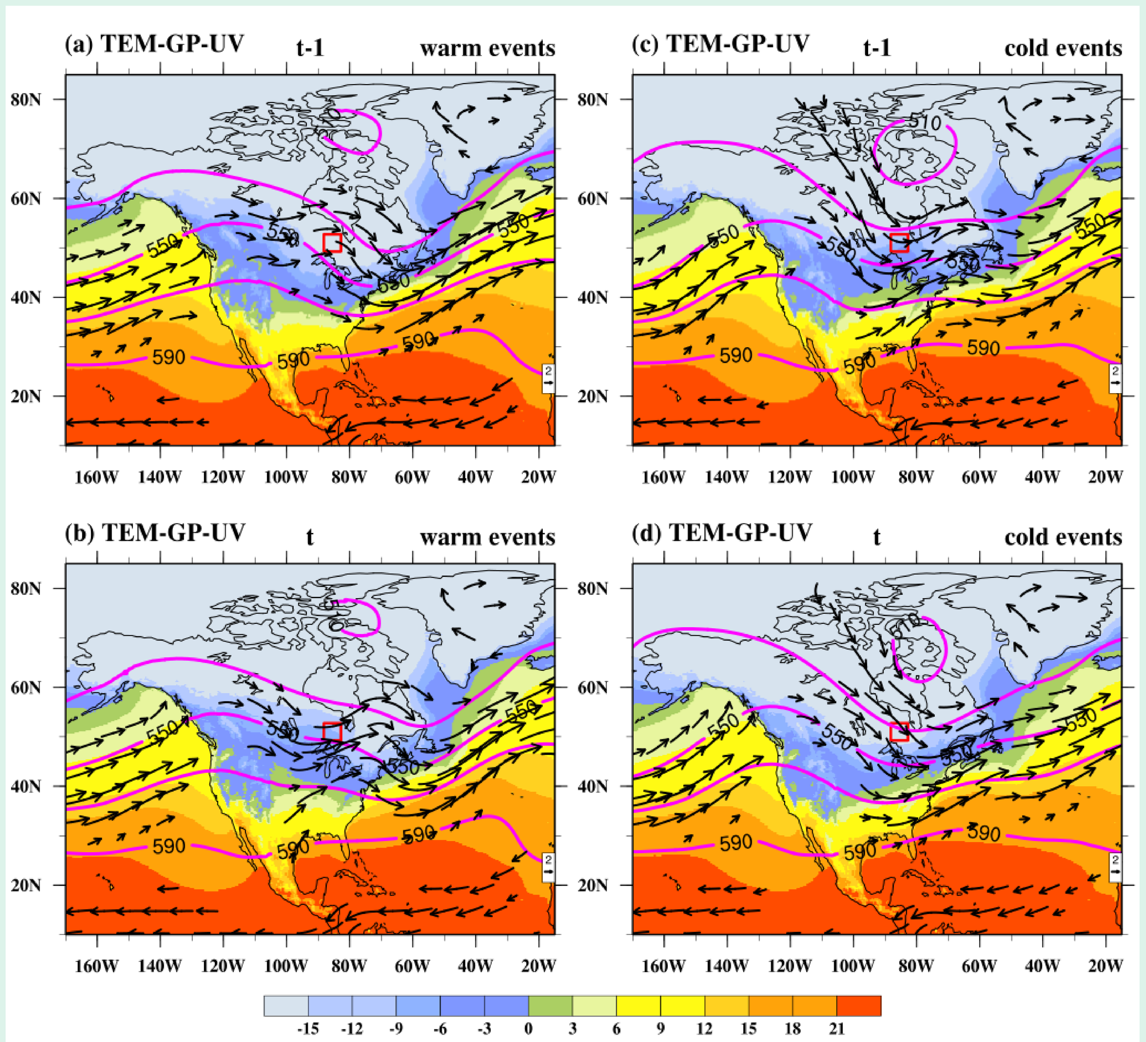


DTDT (°C/day), SDT(°C/day) and ACORR

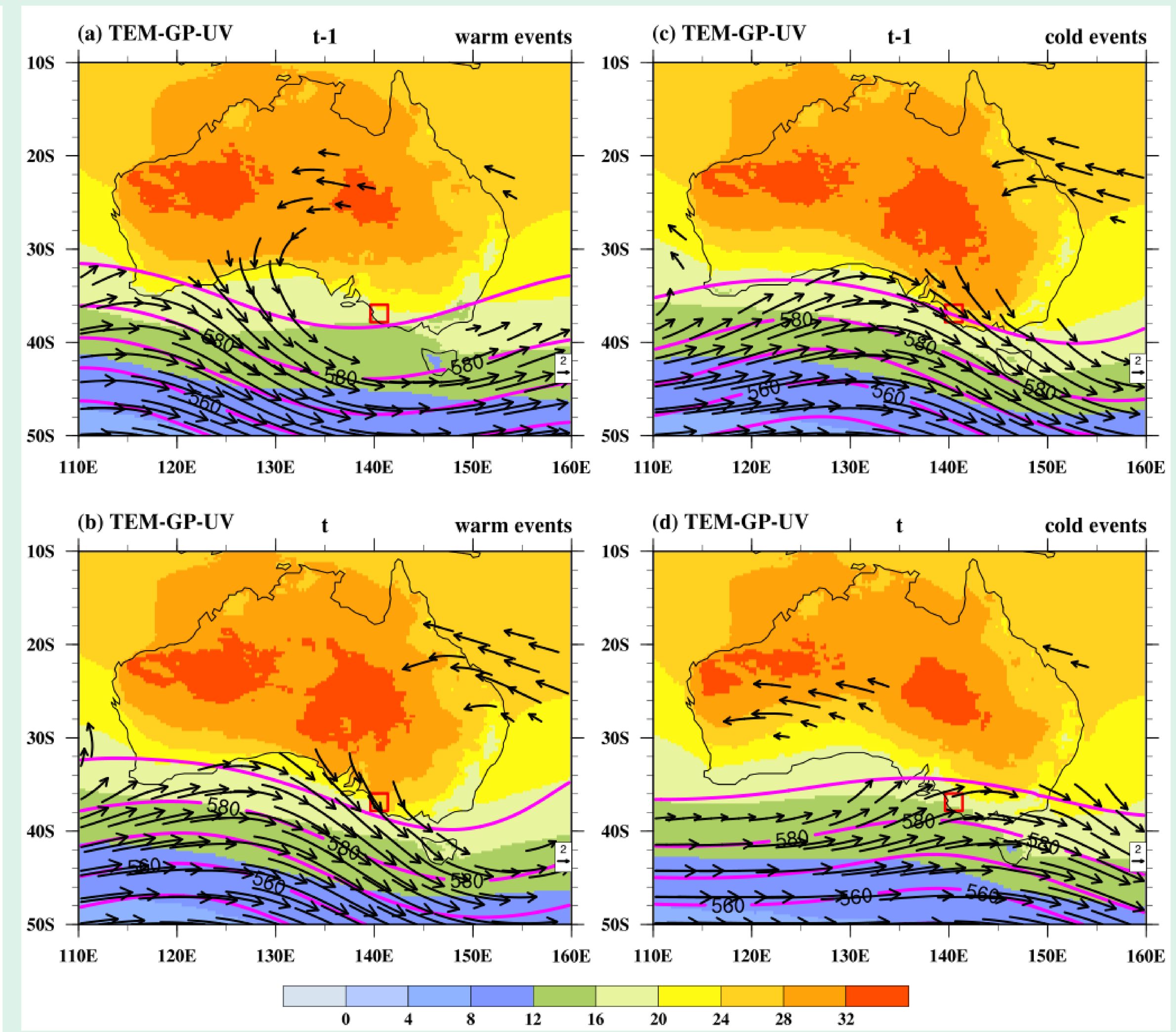
❑ During Dec-Feb, larger magnitude of variation in mid-high latitudes and southern coastal latitudes compared to tropical regions.

1. What will atmospheric circulation be on consecutive days?

Mid-latitude: North America



Southern Coastal: Australia

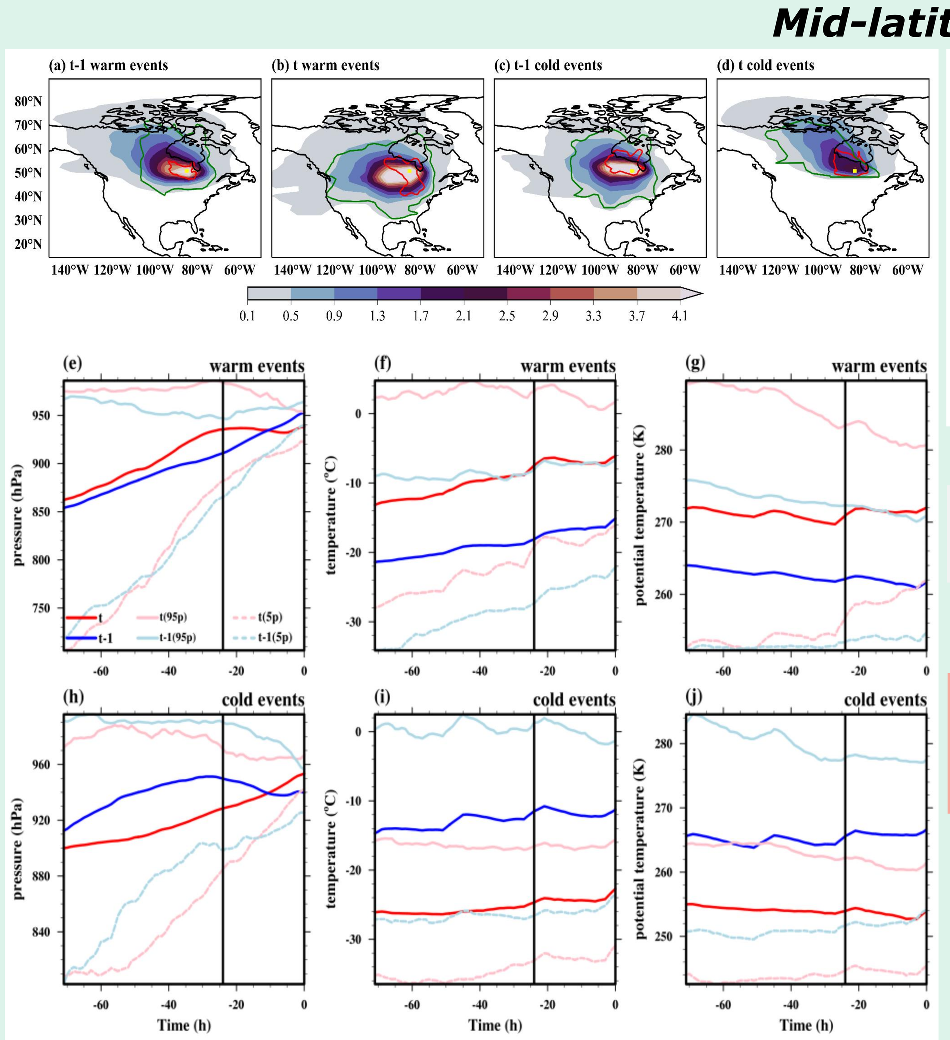


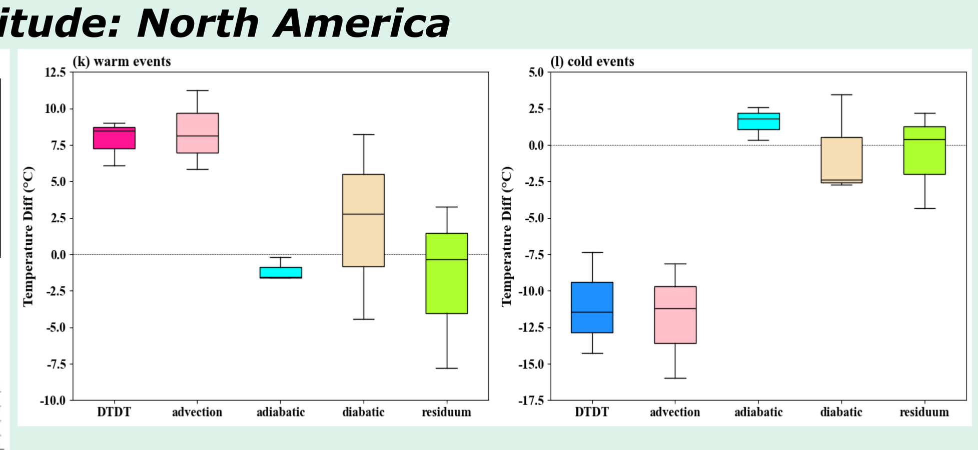
2m-surface air temperature (°C, colors), Geopotential height at 500hPa (gpm, contours) and wind at 850hPa (m/s, vectors)

❑ In the extratropics, extreme DTDT changes are typically linked to regionally specific synoptic-scale circulation, such as ridge or trough patterns, which are associated with shifts from warm to cold advection or vice versa.

2. Which physical process contributes to the occurrences of the DTDT extremes?

Mid-latitude: North America



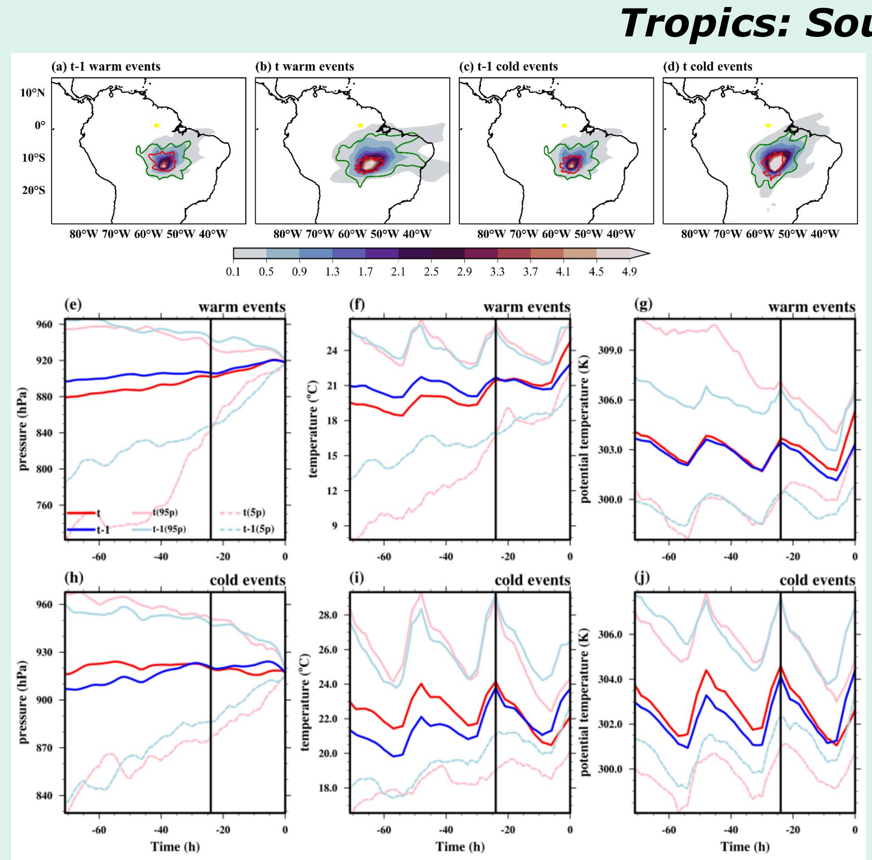


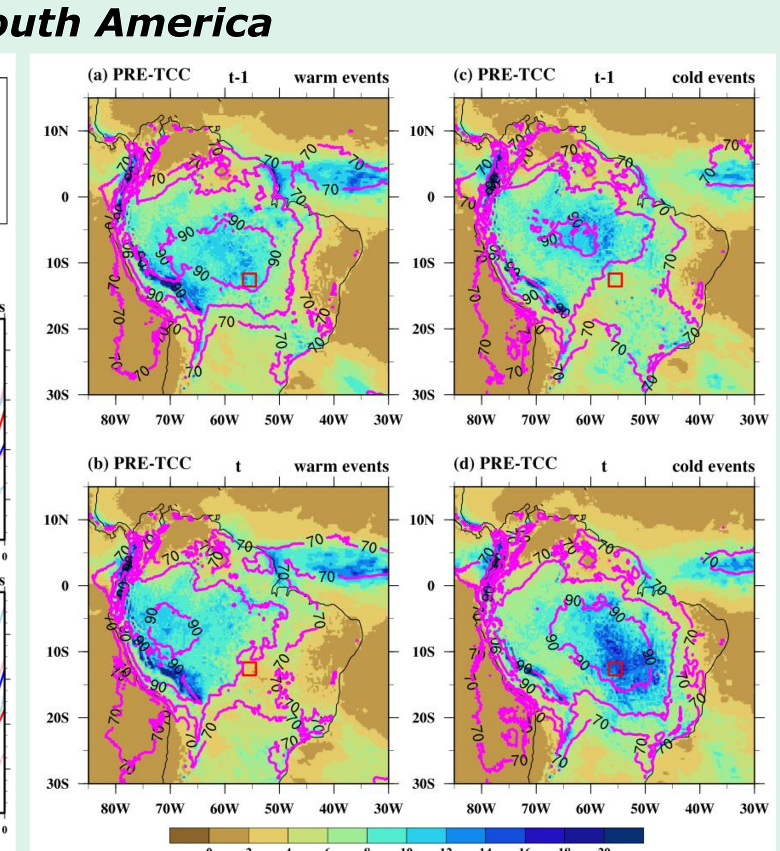
❑ In both extremes, advection is slightly dampened by the adiabatic warming

❑ **Warm events:** warm advection and slightly increased diabatic heating contributes to the extremeness.

❑ **Cold events:** cold advection and slightly increased diabatic cooling contributes to the extremeness .

Tropics: South America

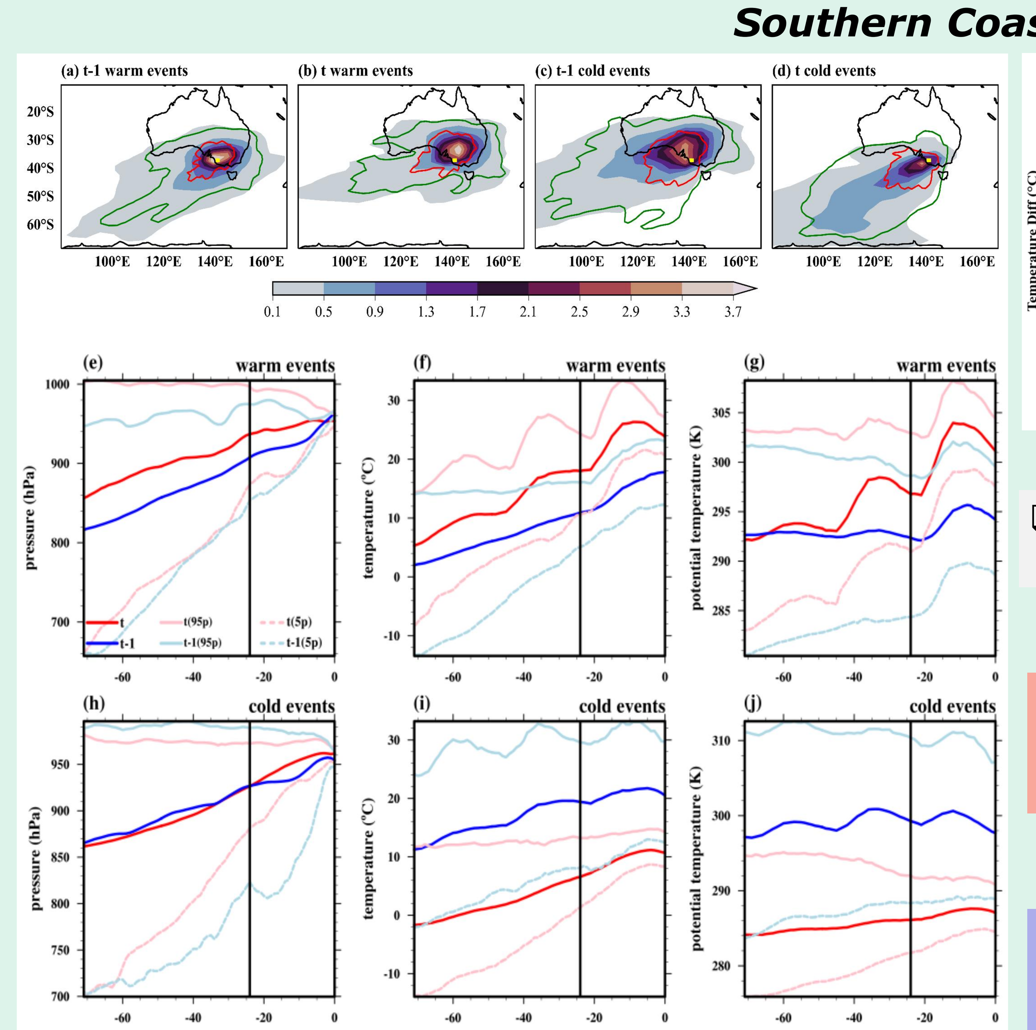


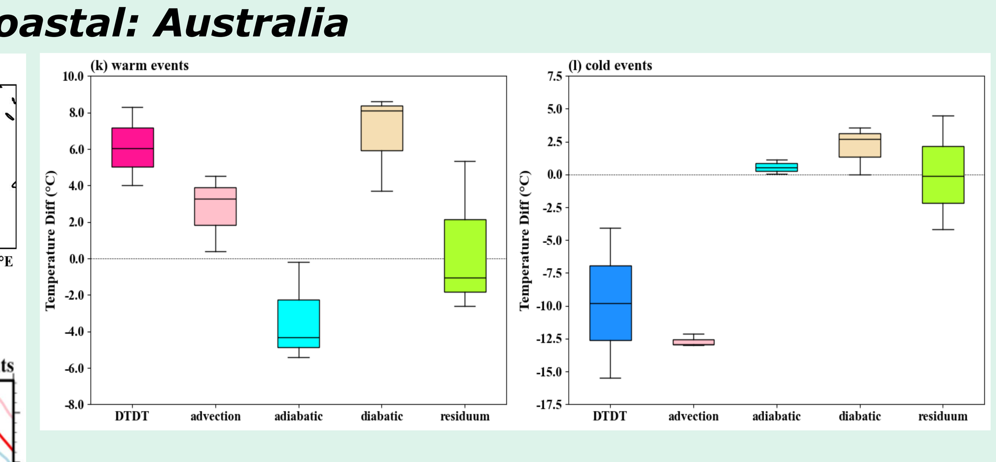


Precipitation (mm) and cloud cover (%)

❑ In the tropics, local conditions rather than remote factors are dominant, as exemplified by the most significant DTDT cooling associated with a shift from predominantly cloud-free and dry to cloudy and wet conditions.

Southern Coastal: Australia





❑ In both extremes, advection is slightly dampened by the adiabatic warming

❑ **Warm events:** warm advection and strong increased diabatic heating contributes to the extremeness.

❑ **Cold events:** cold advection is dominant, but some increased diabatic heating helps to mitigate extremeness .

Summary

- ✓ Role of advection from warmer or colder regions in DTDT extremes is apparent across all regions except the tropics during DJF.
- ✓ In the extratropics, the Lagrangian temperature changes indeed play a complementary role, enhancing or dampening the DTDT extremes.
- ✓ In the tropics, local processes take precedence over changes in advection, highlighting the crucial role of radiative heating.
- ✓ Mechanistic insights into extreme DTDT changes obtained in this study can help to improve the prediction of such events and anticipate future changes in their occurrence frequency and intensity.

Future works

- ✓ Current research lacks insight into projected changes in DTDT variability and extremes.
- ✓ Aim to address this gap by employing the Lagrangian temperature decomposition approach in warming climate
- ✓ To offer detailed insights into the thermodynamic and dynamic contributions driving future changes in DTDT extremes.

References

- ✓ Gough, W. (2008). Theoretical considerations of day-to-day temperature variability applied to Toronto and Calgary, Canada data. *Theoretical and Applied Climatology*, *94*, 97-10.
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- ✓ Hovdahl, I. (2022). The deadly effect of day-to-day temperature variation in the United States. *Environmental Research Letters*, *17*(10), 104031.
- ✓ Wang, J., Zhang, J., & Zhang, P. (2022). Rising temperature threatens China's cropland. *Environmental Research Letters, 17(8)*, 084042.