



# Novel mechanism for troposphere-to-stratosphere transport due to the interaction between typhoons and orography

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## 1 INTRODUCTION

↕ The **Stratosphere-Troposphere Exchange (STE)** affects the global budget of chemical constituents.

The **role of typhoons** in STE has been highlighted in the tropics.



⚡ The **influence of orography** on STE in connection with typhoons **has not received much attention yet.**

## 2 RESEARCH QUESTION

How can orography promote the **Troposphere-to-Stratosphere Transport (TST)** of air masses in the vicinity of a typhoon during landfall?

## 3 METHODS

We combine a Lagrangian modelling tool, **FLEXPART**, with a high-resolution **WRF** simulation of **Typhoon Molave**, which took place over the Philippines from 22nd to 30th October 2020.

💡 **Development of the AirIntrusions Fortran package** for detecting the TST transport.

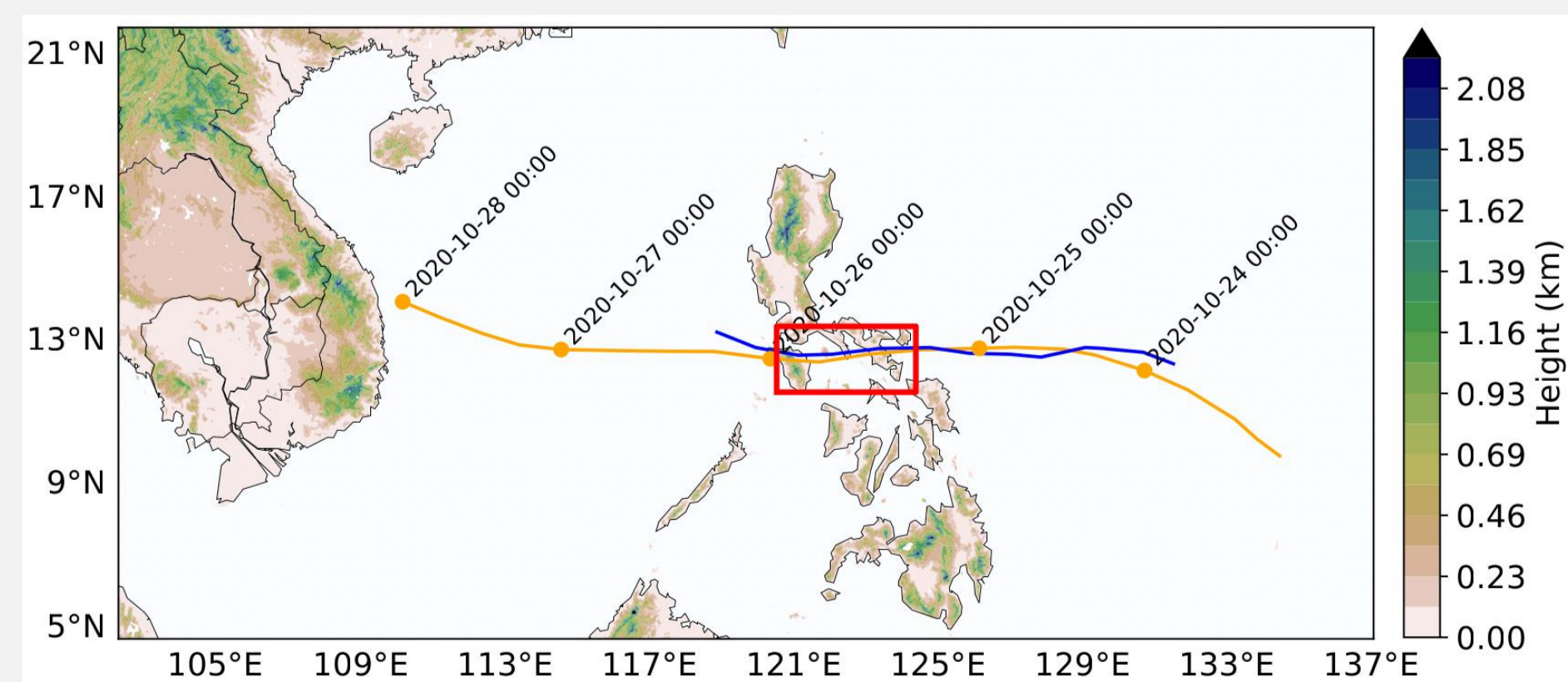
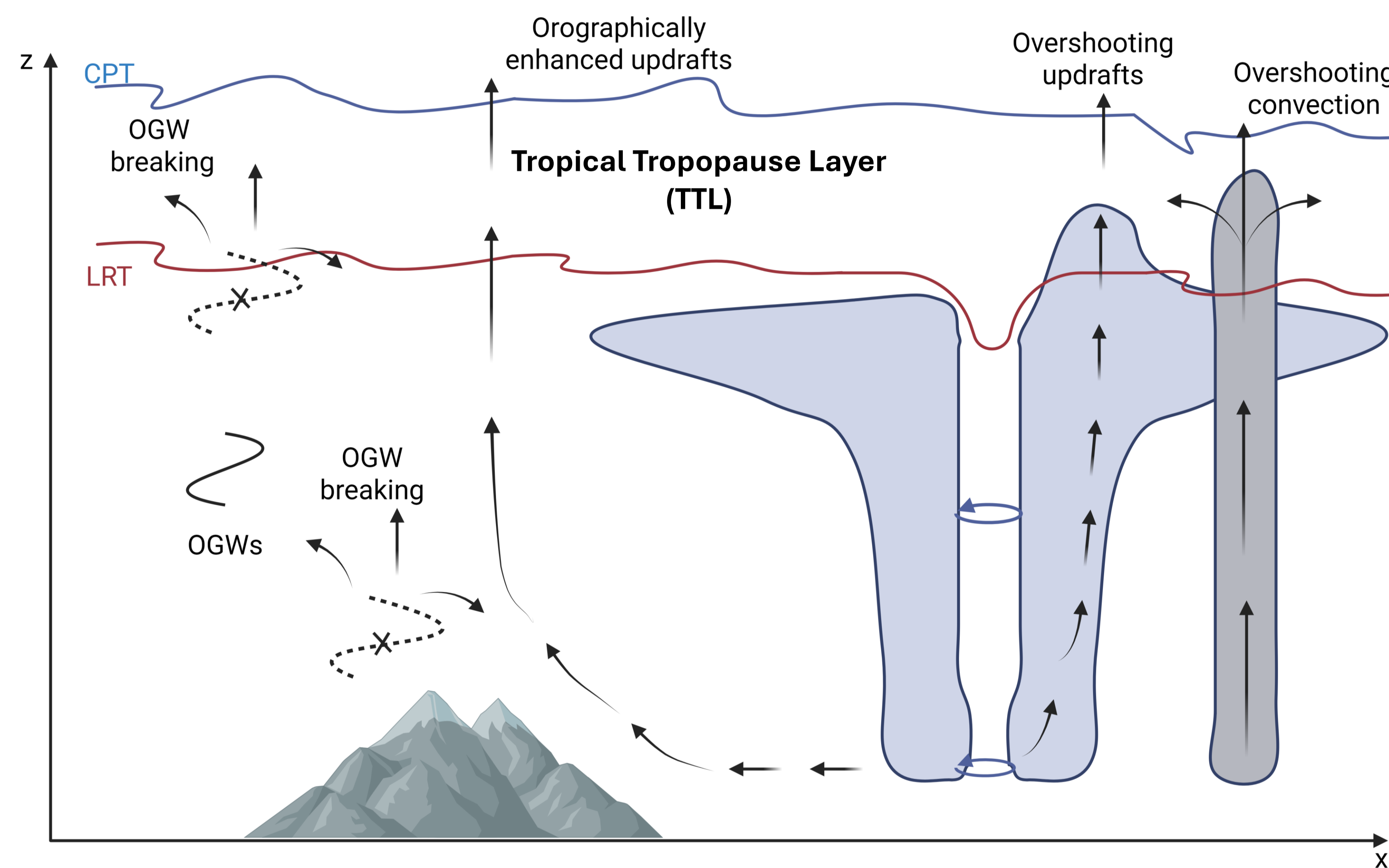


Figure 1. WRF domain and track of the typhoon Molave center according to the data from Kitamoto (2021-01-18) (orange line) and to the WRF simulation (blue line). The red rectangle shows the source area considered in the FLEXPART-WRF simulation



## KEY TAKEAWAYS

- **Orographic lifting** and **orographic gravity wave (OGW) breaking** enhance the **troposphere-to-stratosphere transport** ;
- **Implications** for the **development of climate models** (subgrid-scale orography (SSO) effects).



## 4 RESULTS - INTRUSIONS CHARACTERIZATION

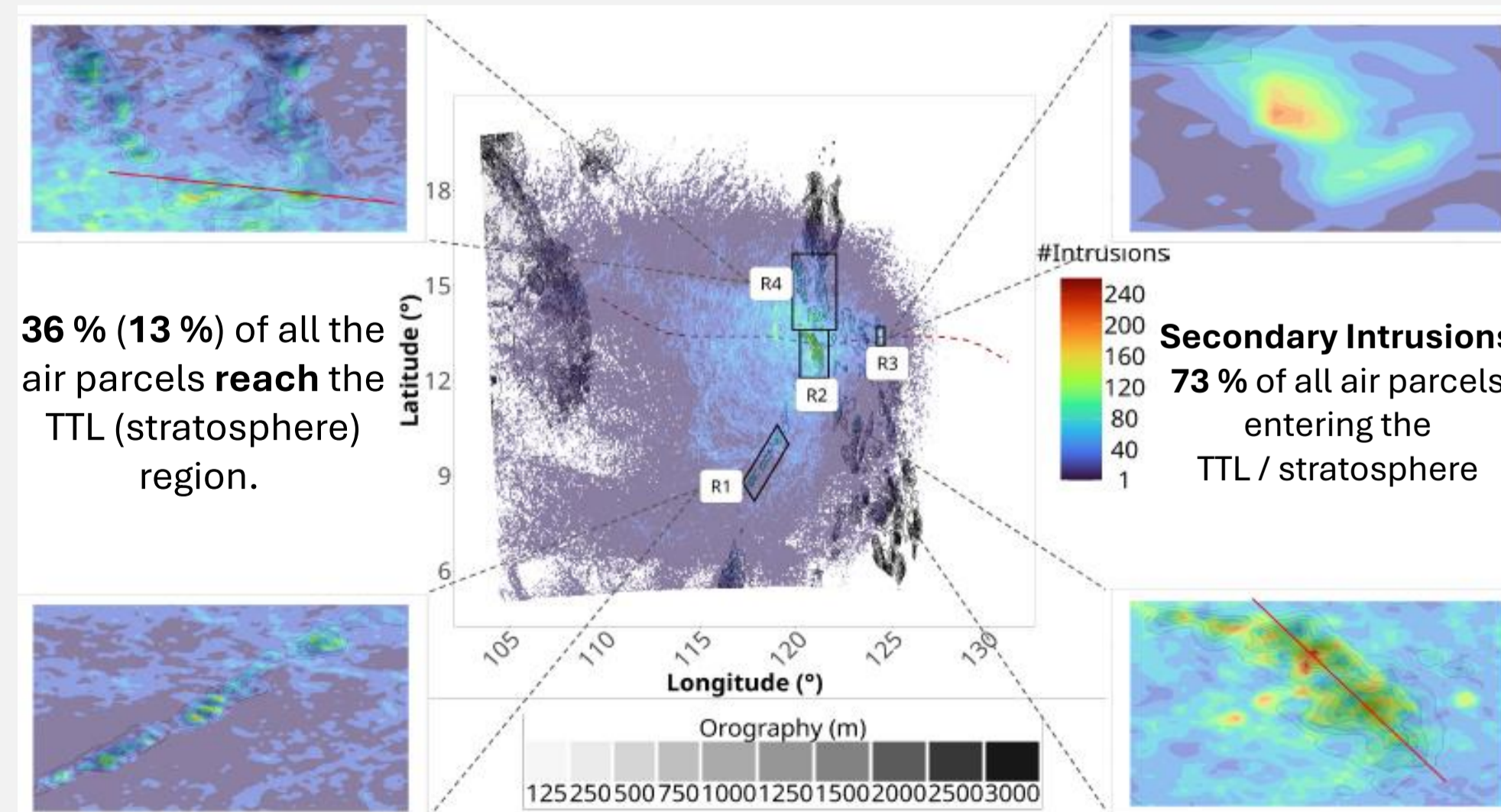


Figure 2. Mean number of intrusions computed for each grid point and taking into account penetration into both the TTL and the stratosphere (colours ranging from purple to red). The dashed red line shows the typhoon track; the red solid lines in the zoom panels in the upper left and bottom right corner show the location of the two transects used for the cross-sections.

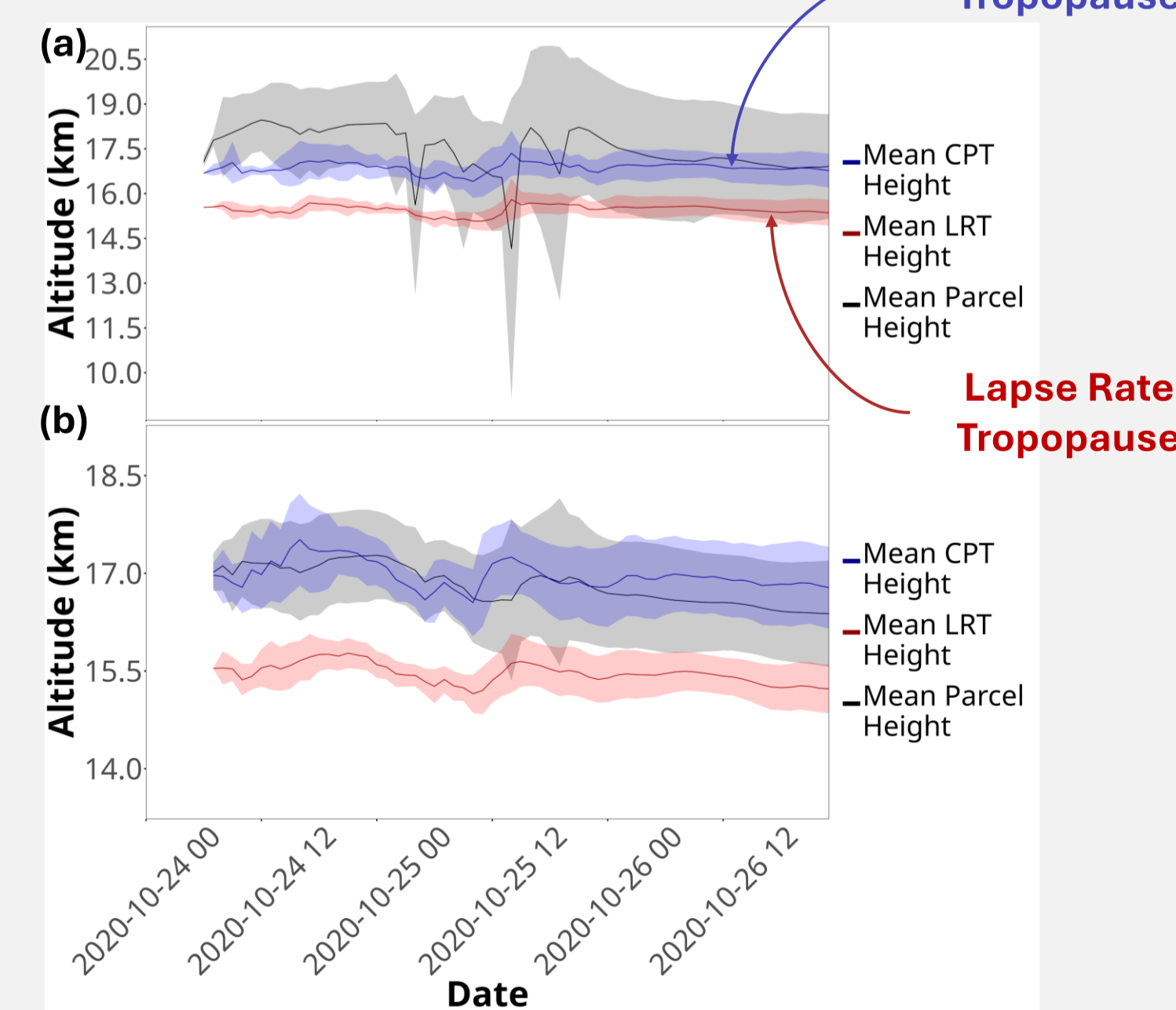
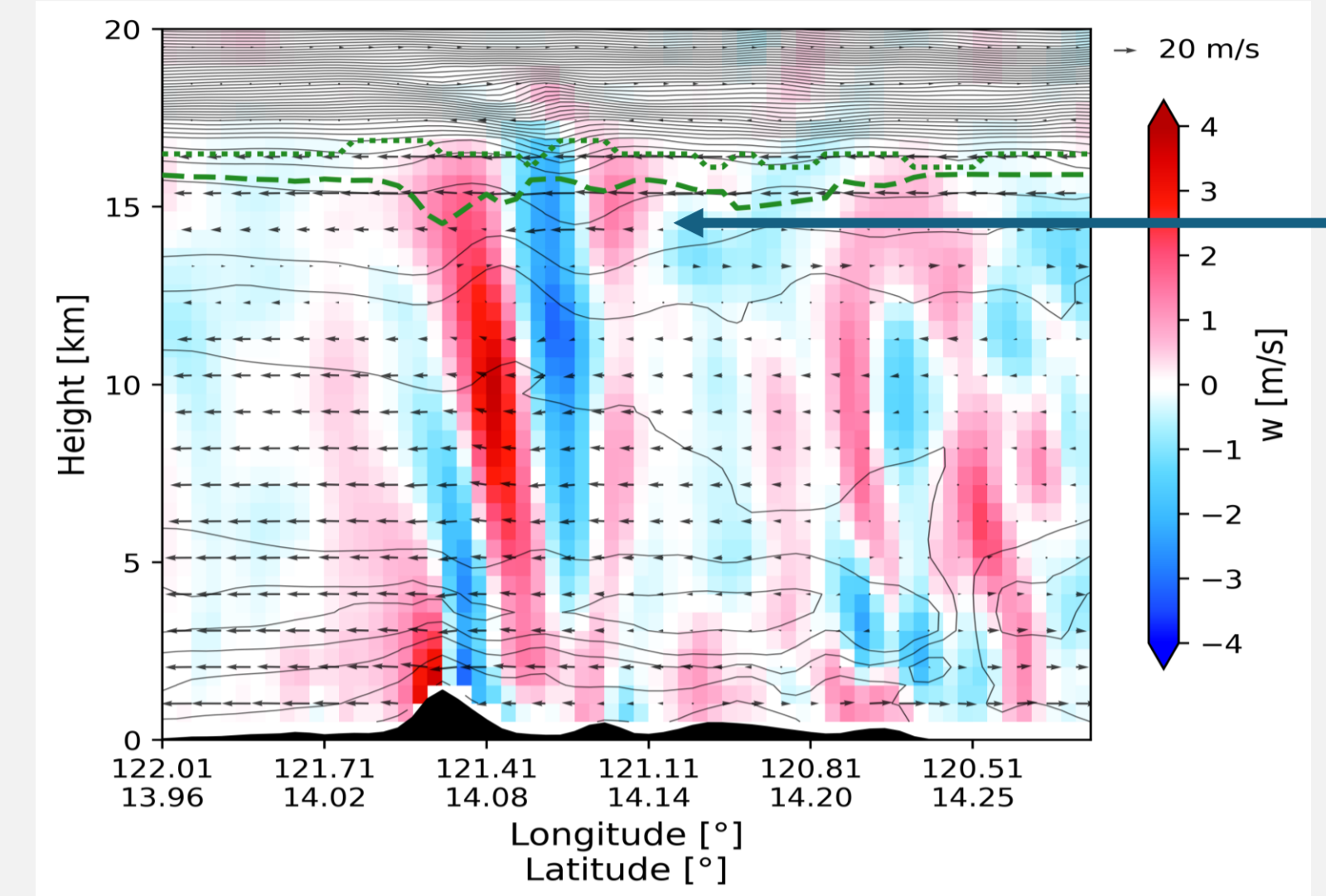


Figure 3. Mean altitude of air parcel trajectories (black line) after entering the stratosphere associated with a **single intrusion** (namely, not affected by secondary intrusions) (a) and with **secondary intrusions** (b). The mean heights of LRT and CPT are represented by the red and blue lines, respectively. Shaded regions indicate  $\pm\sigma$  (one standard deviation) values.

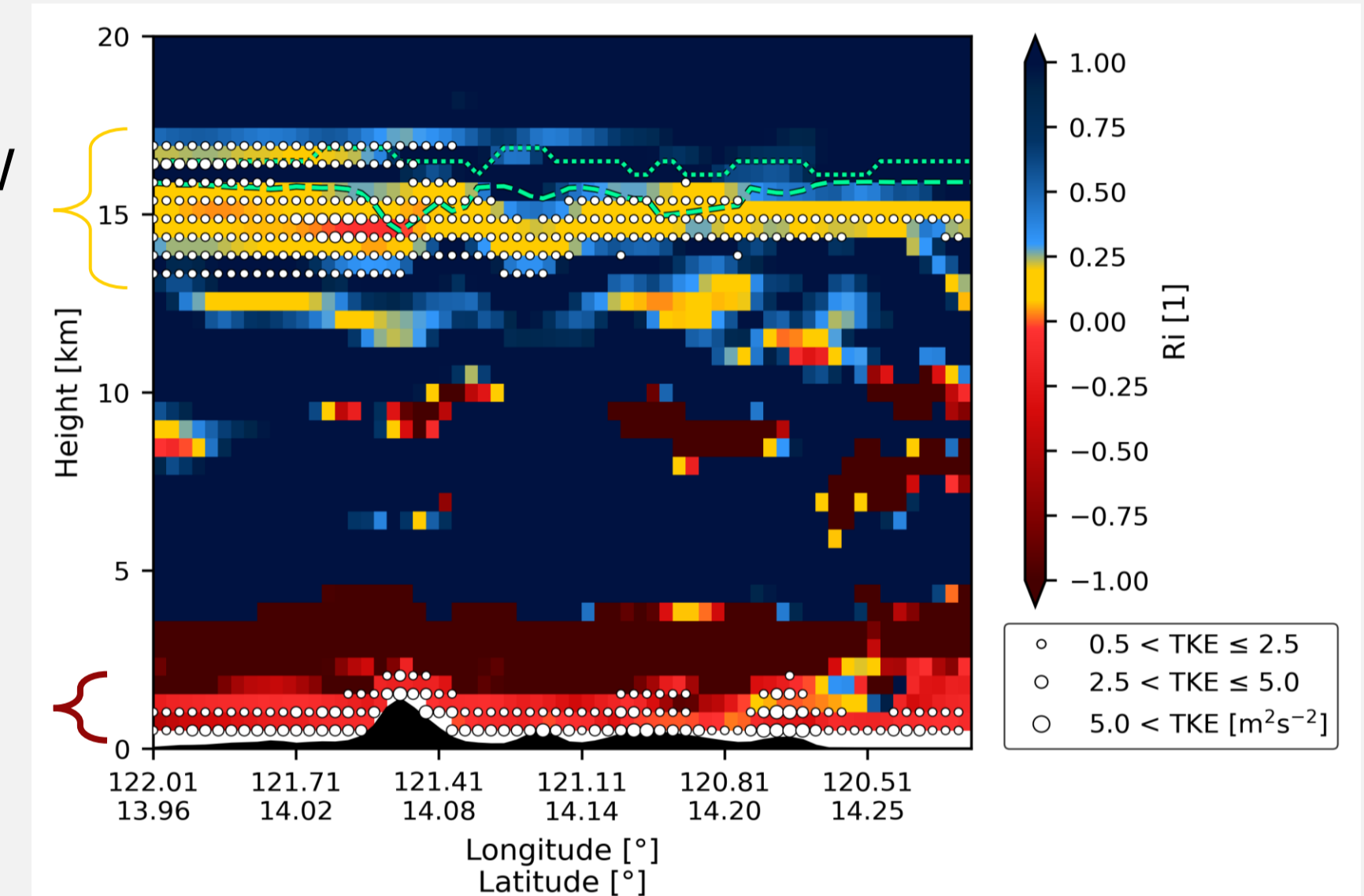
## 5 RESULTS – TRANSPORT MECHANISMS



Upward propagating OGW with an amplitude of about 3 m/s

Figure 4 presents vertical wind speed cross-sections; the arrows depict the wind direction along the cross-section, the contour lines represent equivalent potential temperature, the green dashed line lapse rate tropopause, and the green dotted line cold point tropopause.

## Secondary OGW breaking region



## Primary OGW breaking region

Figure 5. Richardson number in vertical cross-sections along the same transect as in Figure 4; the white dots represent TKE and are sized based on the TKE magnitude, the green dashed line denotes LRT, and the green dotted line CPT.

## 6 CONCLUSIONS

Our study proposes a novel mechanism for TST, connected with the interaction of typhoons with orography, highlighting the key role of orographic gravity wave breaking.

Do you want to know more?



PREPRINT

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ABSTRACT

