# Impact of deforestation events on atmospheric dynamics using Lagrangian reanalysis data

Lucie Bakels[1], Silvia Bucci[1], and Andreas Stohl[1]

1) Department of Meteorology and Geophysics, University of Vienna, Vienna, Austria

lucie.bakels@univie.ac.at

## Motivation and research questions

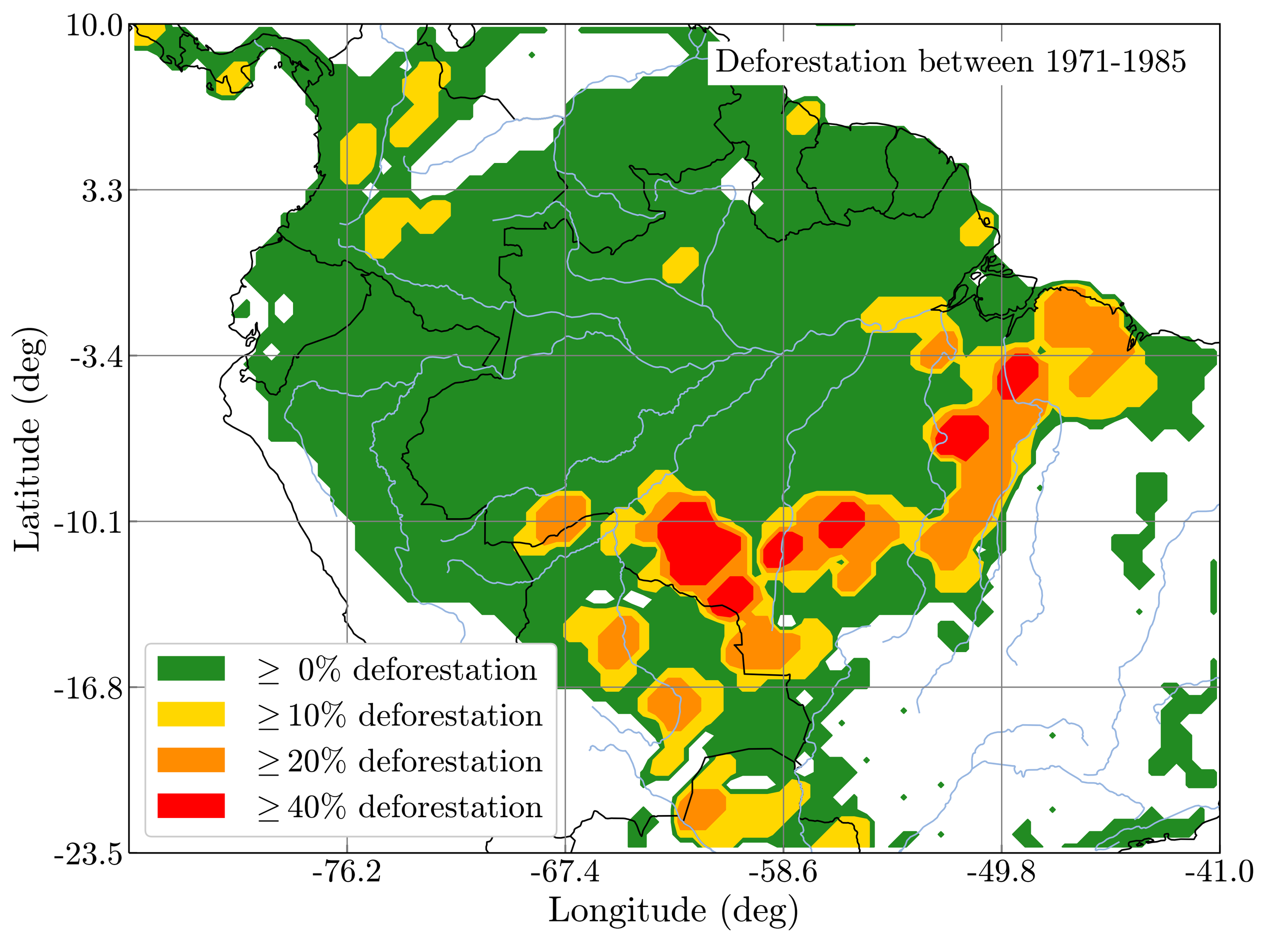
Deforestation in the Amazon Basin has the potential to affect regional atmospheric circulation, possibly causing changes in the moisture transport by altering the regional Hadley and Walker cells (*Zhang et al. 1996*).

Previous studies modelling the atmosphere under different extreme deforestation scenarios have shown that deforestation in the Amazon basin could increase the length and frequency of dry seasons in the Southern Amazon, while an increase in rainfall is expected in the Northern Amazon (e.g. *Ruiz-Vasquez et al., 2020*).

**How has deforestation affected air and moisture transport after past large deforestation events?**

## Data

- Focussing on **transport of air and moisture:** We use a Lagrangian transport model applied to atmospheric reanalysis data:
  ➞ **The LARA dataset:** A global FLEXPART-11 (*Bakels et al. in prep.*) simulation applied to the ERA-5 ECMWF reanalysis dataset (*Hersbach et al. 2020*)
- **Figure 1:** Deforestation identified using the **HILDA+ dataset** (*Winkler et al. 2020*)




## Methods

**Air parcels** are followed through the atmosphere and selected when they are:

- Within (**pre-**)**deforested** area: ≥10%/20%/40% deforestation on a 0.5°x0.5° grid between 1971 and 1985
- Below 1 km altitude
- For the **forested period**: 1960-1971* and **deforested period**: 1985-1996*
  **El Niño and La Niña years are excluded*
- In the months Dec-Jan-Feb, every day between 11:00-13:00 o'clock

Selected air parcels are tracked for 48 hours forward in time and **precipitation** is computed using the method described in *Dütsch et al. 2018* .

## Deforestation reduces vertical air transport in the Amazon Basin

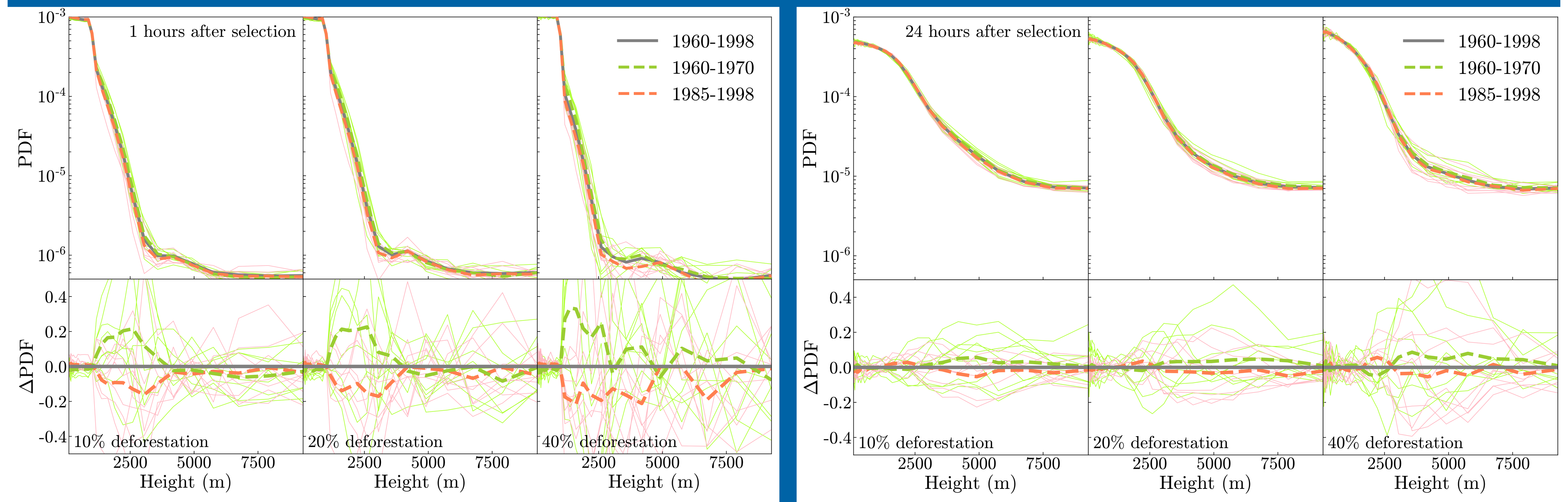



**Figure 2:** Average vertical movement of air that passed through deforested regions. **Green lines** show the PDF of air before (1960-1971) and **orange** after (1985-1996) deforestation (1971-1985). **Grey lines** show the averages for the whole period (1960-1996). Thin lines show the results for individual years.

## Moisture from deforested areas is precipitated elsewhere

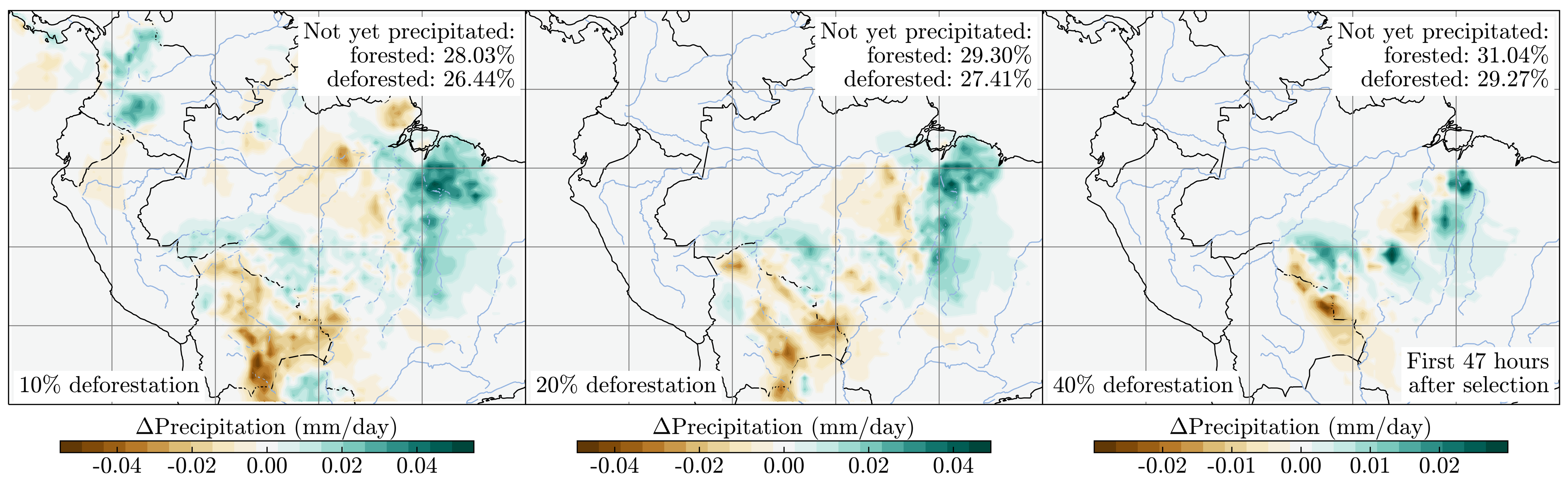



**Figure 3:** The mean difference in precipitation before (1960-1971) and after (1985-1996) deforestation (1971-1985). Positive values indicate more precipitation in the period before deforestation.
*Preliminary result: longer tracing is necessary to see where **all** moisture is precipitated.*

## Results

- Vertical transport of air changes after deforestation. On average, air is transported to lower altitudes.
- Moisture transport deviates on short time scales.

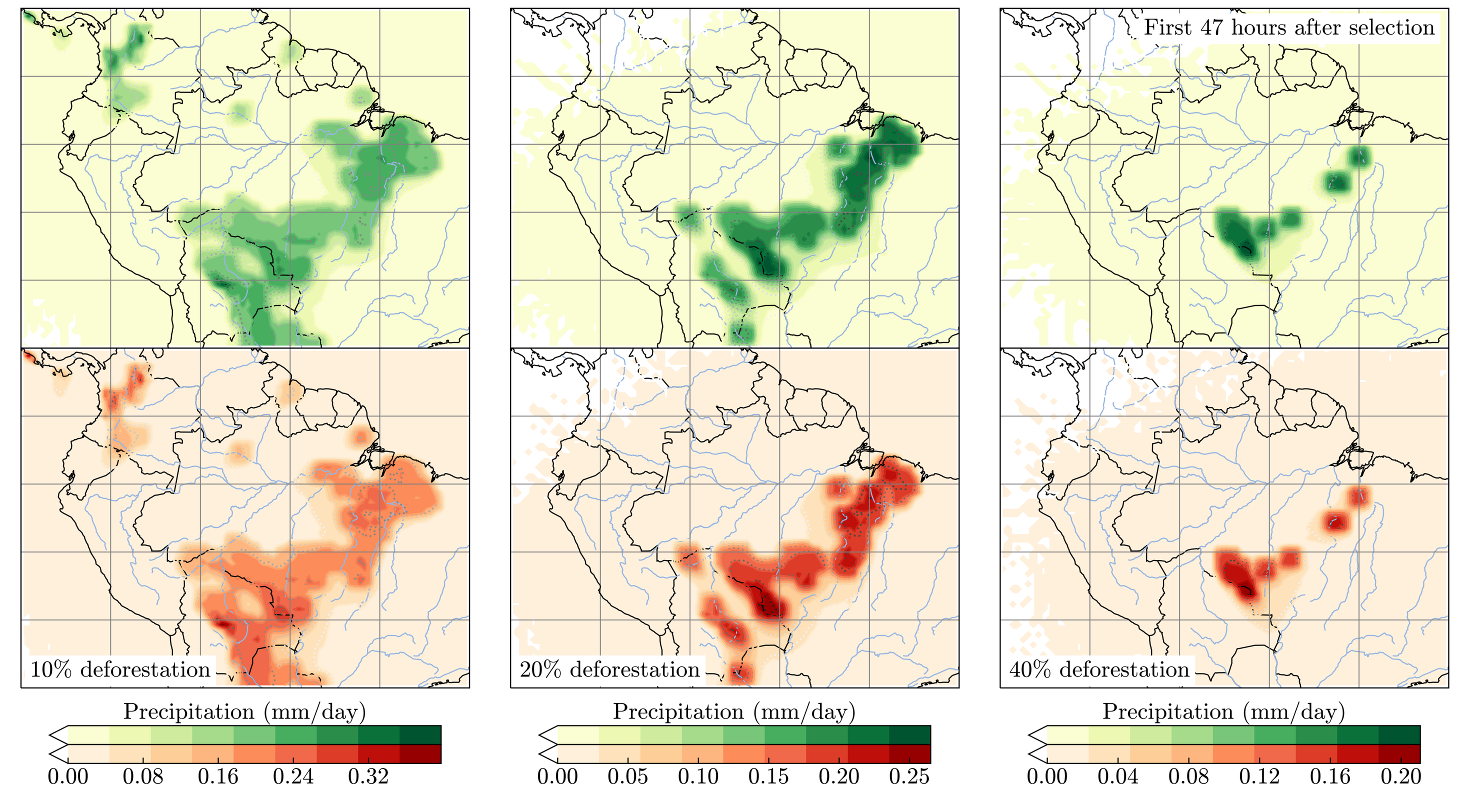



**Figure 4:** Absolute precipitation of moisture taken up over the (**pre-**)**deforested** areas

## Conclusion and Outlook

**Proof of concept:** Deforestation has affected atmospheric transport in the past and can be studied using reanalysis data.

However, many factors still need to be taken into account:

1. Making our results robust to changes beyond deforestation (e.g. global warming).
2. Expanding our dataset to include all months of each year.
3. Tracing particles for longer periods to see the effect on larger scale circulation.

In addition to perfecting our analysis, our aim is to extend this work to deforestation around the globe to study both long and short term changes in the atmosphere:

a) Is there a link between deforestation and climate extremes from an atmospheric transport perspective?

b) Does deforestation affect atmospheric circulation patterns?

## References

- Zhang, H., Henderson-Sellers, A. and McGuffie, K., 1996. Impacts of tropical deforestation. Part II: The role of large-scale dynamics. Journal of climate, 9(10), pp.2498-2521.
- Ruiz-Vásquez, M., Arias, P.A., Martínez, J.A. and Espinoza, J.C., 2020. Effects of Amazon basin deforestation on regional atmospheric circulation and water vapor transport towards tropical South America. Climate Dynamics, 54, pp.4169-4189.
- Hersbach, H., Bell, B., Berrisford, P., Hirahara, S., Horányi, A., Muñoz-Sabater, J., Nicolas, J., Peubey, C., Radu, R., Schepers, D. and Simmons, A., 2020. The ERA5 global reanalysis. Quarterly Journal of the Royal Meteorological Society, 146(730), pp.1999-2049.
- Winkler, K., Fuchs, R., Rounsevell, M. and Herold, M., 2020. HILDA+ Global Land Use Change between 1960 and 2019. Pangaea https://doi.org/10.1594/PANGAEA, 921846.
- Dütsch, M., Pfahl, S., Meyer, M. and Wernli, H., 2018. Lagrangian process attribution of isotopic variations in near-surface water vapour in a 30-year regional climate simulation over Europe. Atmospheric Chemistry and Physics, 18(3), pp.1653-1669.

universität wien
Department of Meteorology and Geophysics