

Air Mass Transport to the Tropical West Pacific Troposphere inferred from O₃ and RH Balloon Observations above Palau

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ACCLIP STM 10.-13.2022



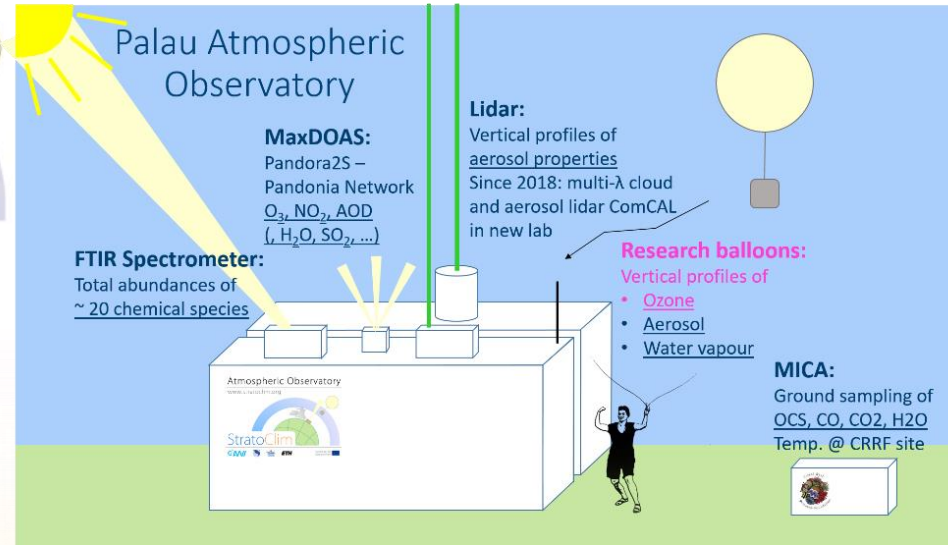
Quick intro: Palau Atmospheric Observatory



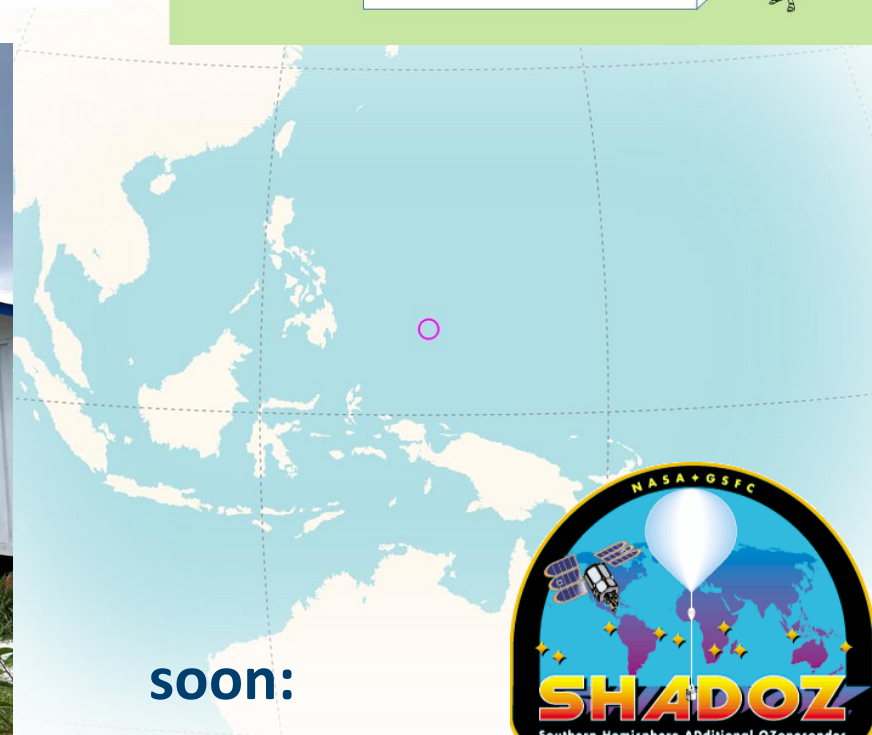
StratoClim (2015-2019)

→ Müller 2020 (thesis),
2x Müller et al. in prep,
Cairo et al. 2021

POSIDON (2016)



PARTNERS:

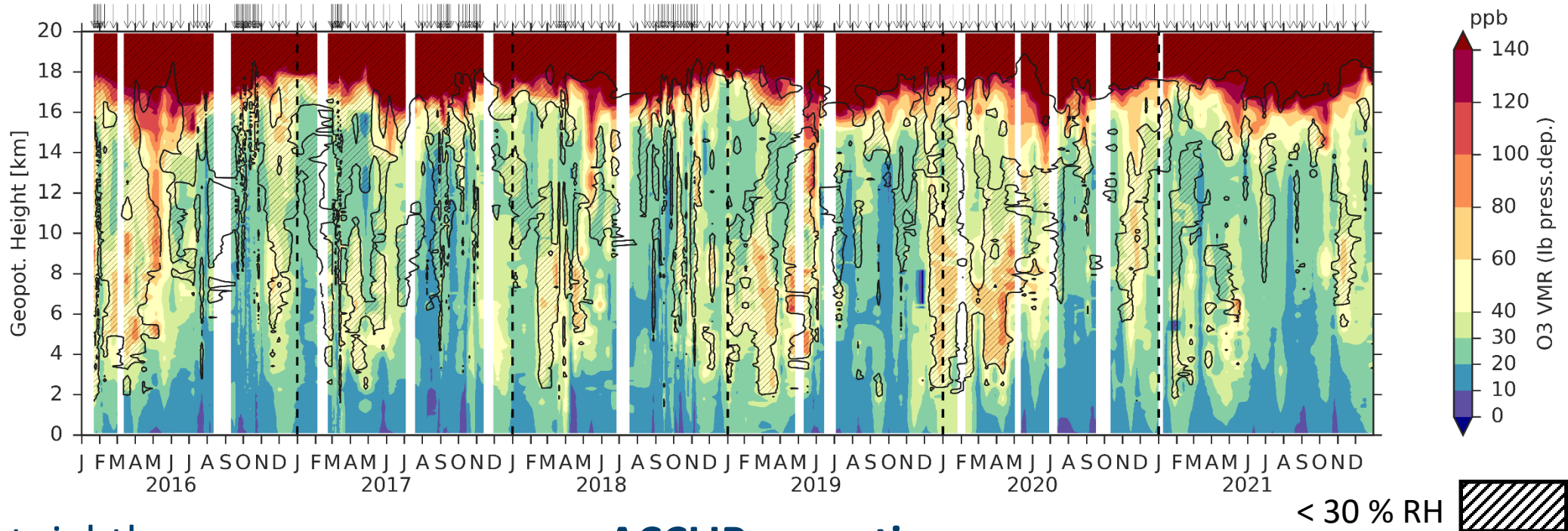


soon:



By Ingo Beninga

Ballooning Program



- Continuous fortnightly ECC soundings (SPC) since 2016 + several intensive campaigns
- Irregularly: CFH-COBALD-ECC payload (12 x)

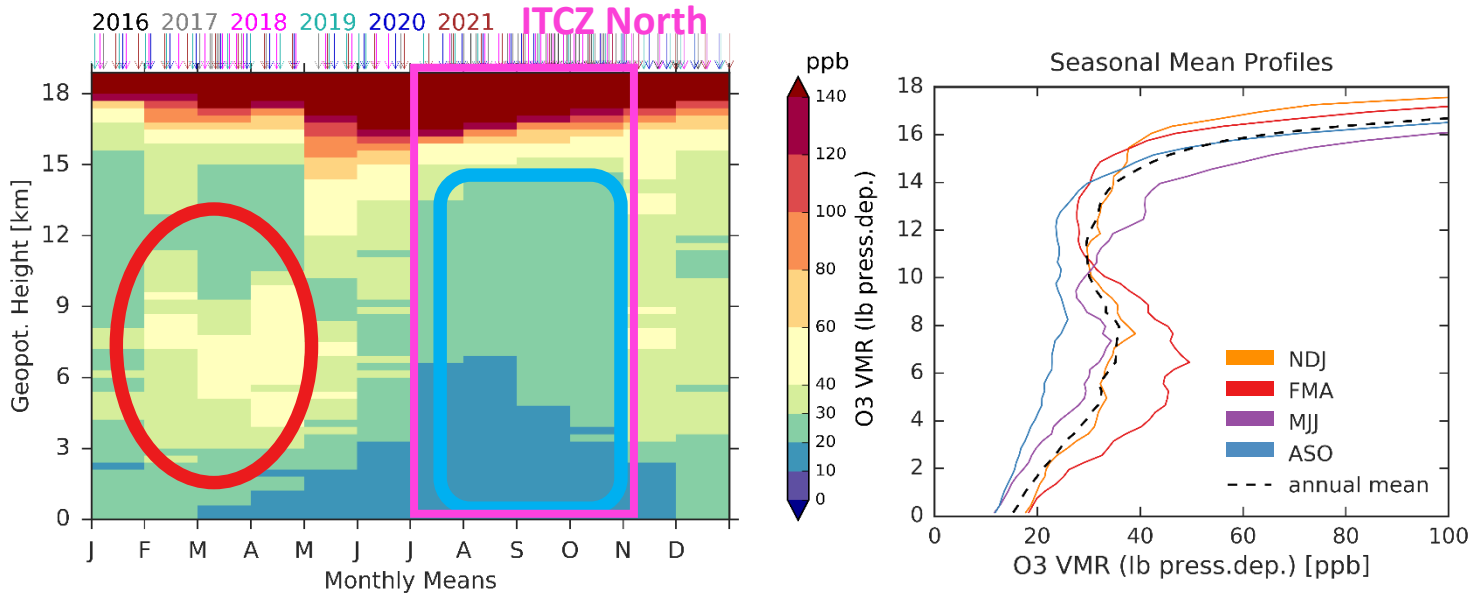


ACCLIP operations:

- Intensive (pre-)campaign in Feb-Apr (1st time since the pandemic)
- Jul-Sept: ECC sondes on demand and every 2-3 days, additionally 3-4 ECC-CFH-COBALD
- All other instrumentation (FTIR, Cloud&Aerosol Lidar, Pandora2S) operational (fingers crossed)

Main Scientific Objectives

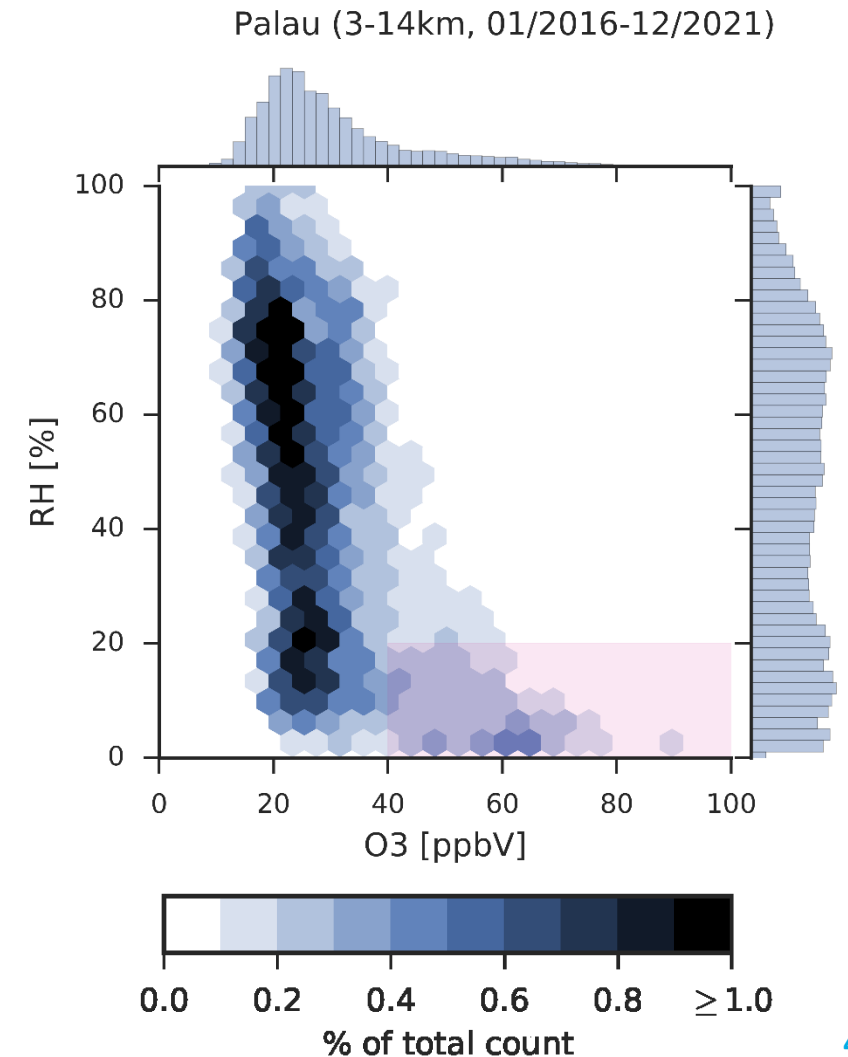
- Assess tropospheric O₃ (and OH) variability in the TWP



<https://epic.awi.de/id/eprint/54569/>

- Identify tropospheric air mass origin and its seasonality using observed unique tracer-tracer relation O₃/RH
- Next up: more focus on TTL O₃ and H₂O variability and related STE processes
- Open for collaborations within the ACCLIP community

Free-tropospheric O₃/RH distribution of all observations



Backward Trajectories

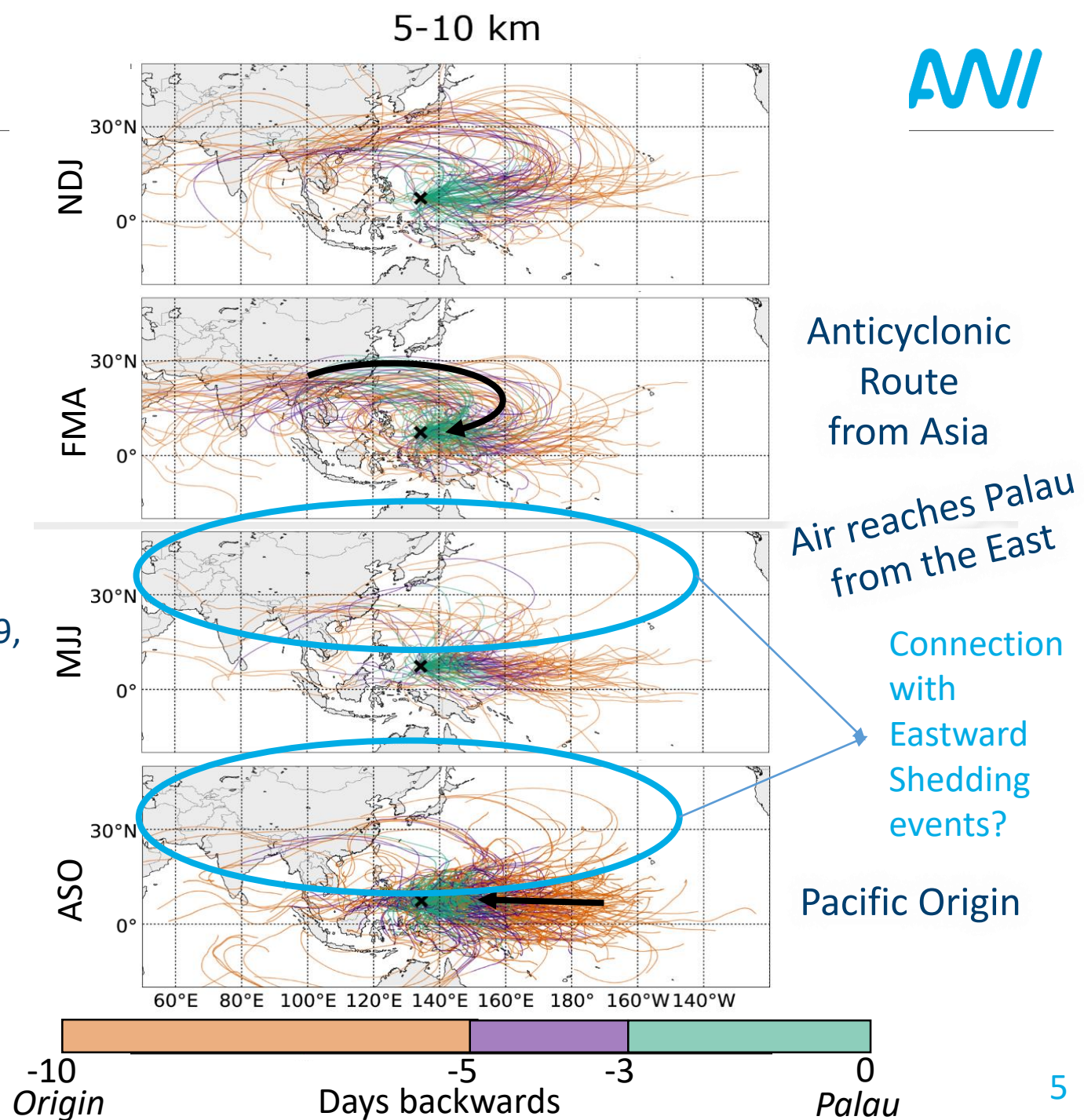
Transport module of Langrangian Chemistry and Transport Model ATLAS (Wohltmann et al. 2010)

Setup:

- driven by **ERA5** reanalysis data, no diffusion, no convective model parameterization, 10-min time steps
- initialized from ozone sounding data, 01/2016-10/2019, 2-14 km, every 10th measurement
→ **focus on 5-10 km altitude range**

Assumptions:

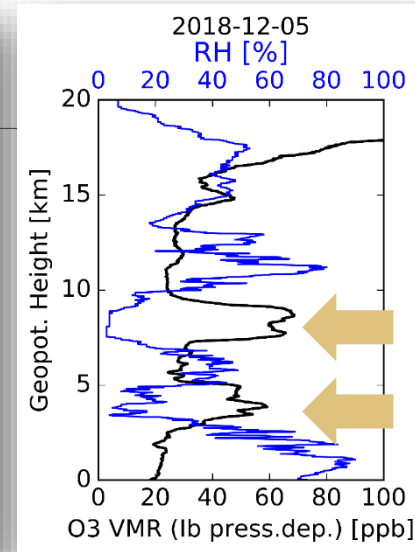
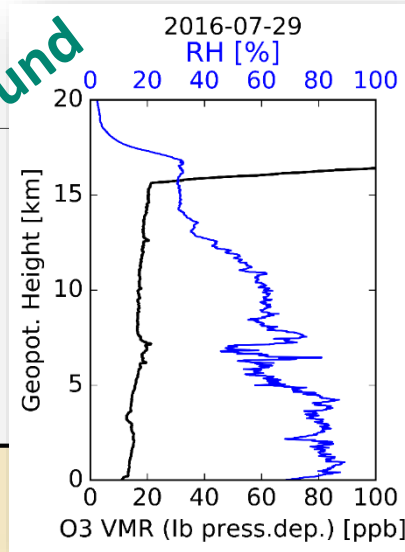
- 10-day-backtrajectories for **dynamical footprint**
- Due to typical lifetime of marine boundary layer O_3 : **5-day-backtrajectory** ending points = origin of air mass composition



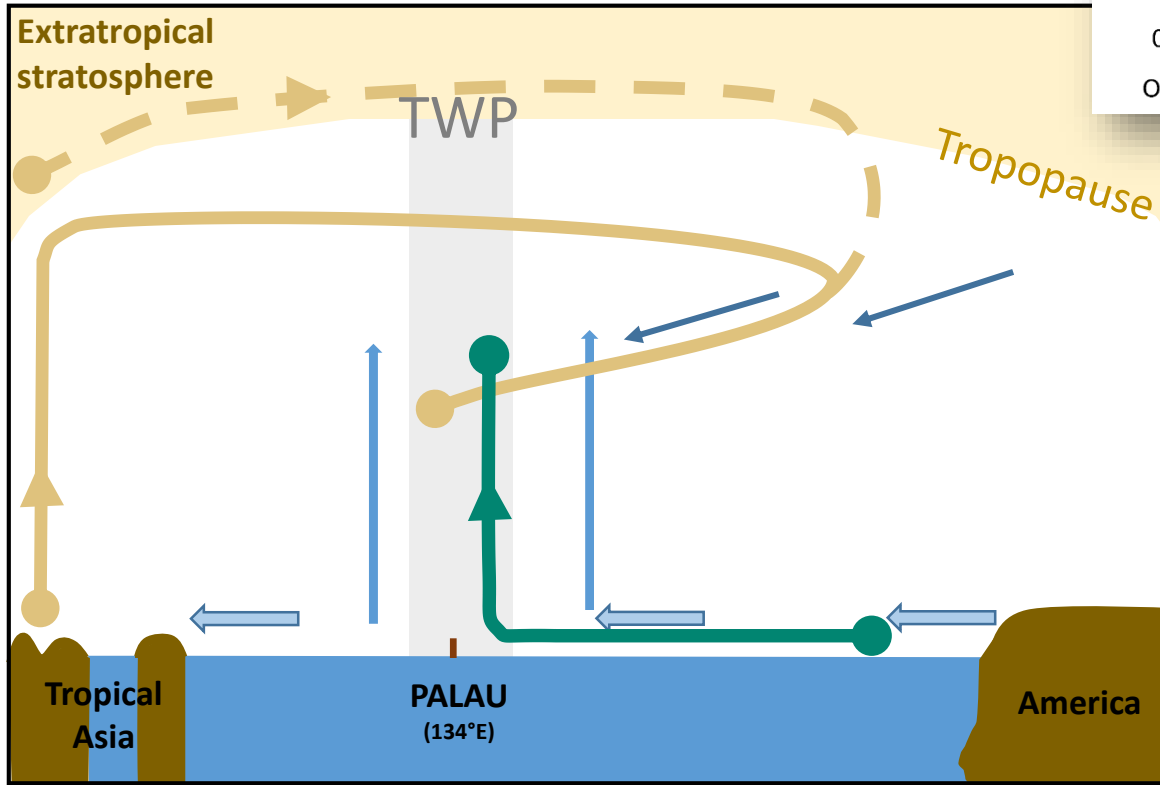
Transport Hypothesis

Background

For air masses with anti-correlated O_3 /RH:



Anomalous Layers



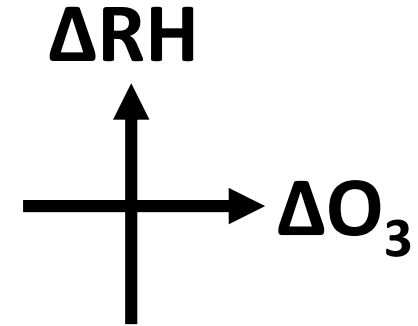
O_3 -RH+ RH

Typical clean boundary layer air

O_3

Controversial debate on origin and genesis

O_3 +RH-



Statistical approach anomalies from tracer backgrounds: the monthly 20th (O_3) and 83rd (RH) quantile (altitude dependent)

← Trade winds ↑ Convective uplift ↘ Clear sky cooling

Origin of Air Masses

5-days-back trajectory ending points \equiv origin,
trajectory start @ 5-10 km in Palau **x**

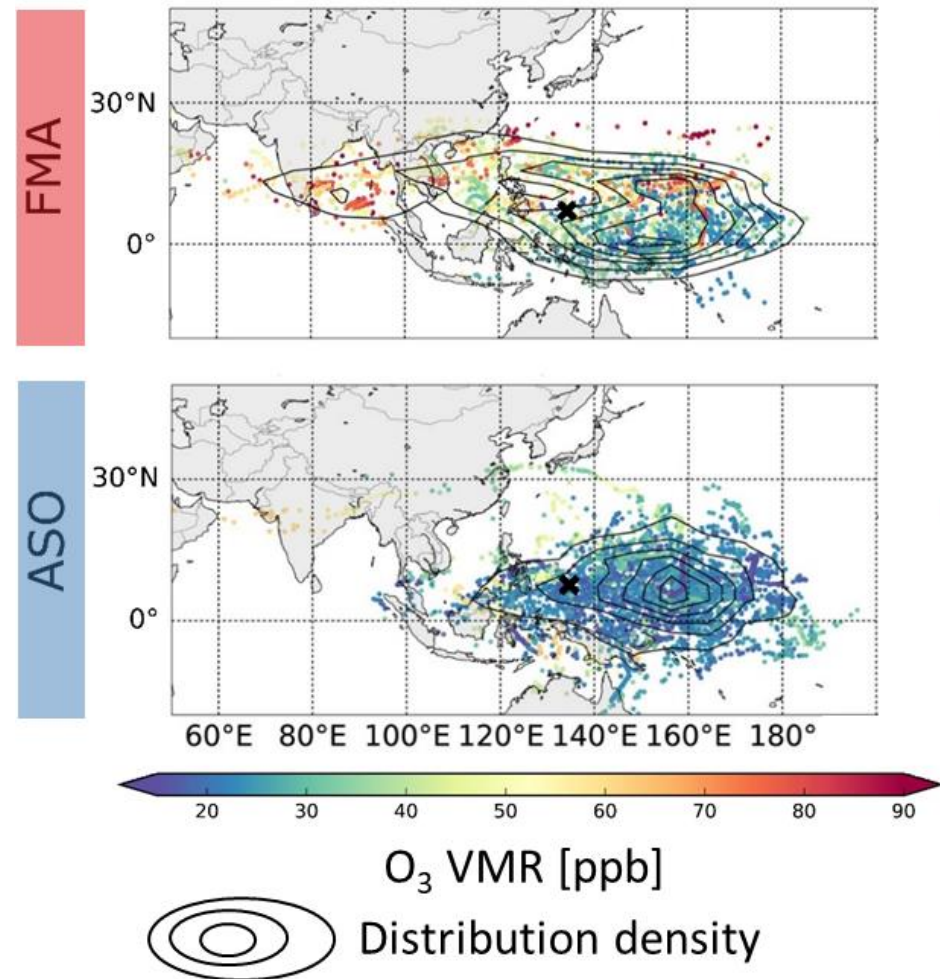
All Observations by season:

O₃ VMR distributions:

- Center of **low O₃** in both seasons, FMA and ASO, East of Palau
- Secondary center of **enhanced O₃** in FMA, North of Palau from India to East China

Vertical displacement:

- Mainly in FMA, North of Palau air masses **descend** towards Palau (**anti-cyclonic route**), consistent with large-scale descent within the Hadley circulation and subsequent dehydration
- **Ascent** dominates ASO air masses (**Pacific origin**), corresponding well with the dominance of convective uplift



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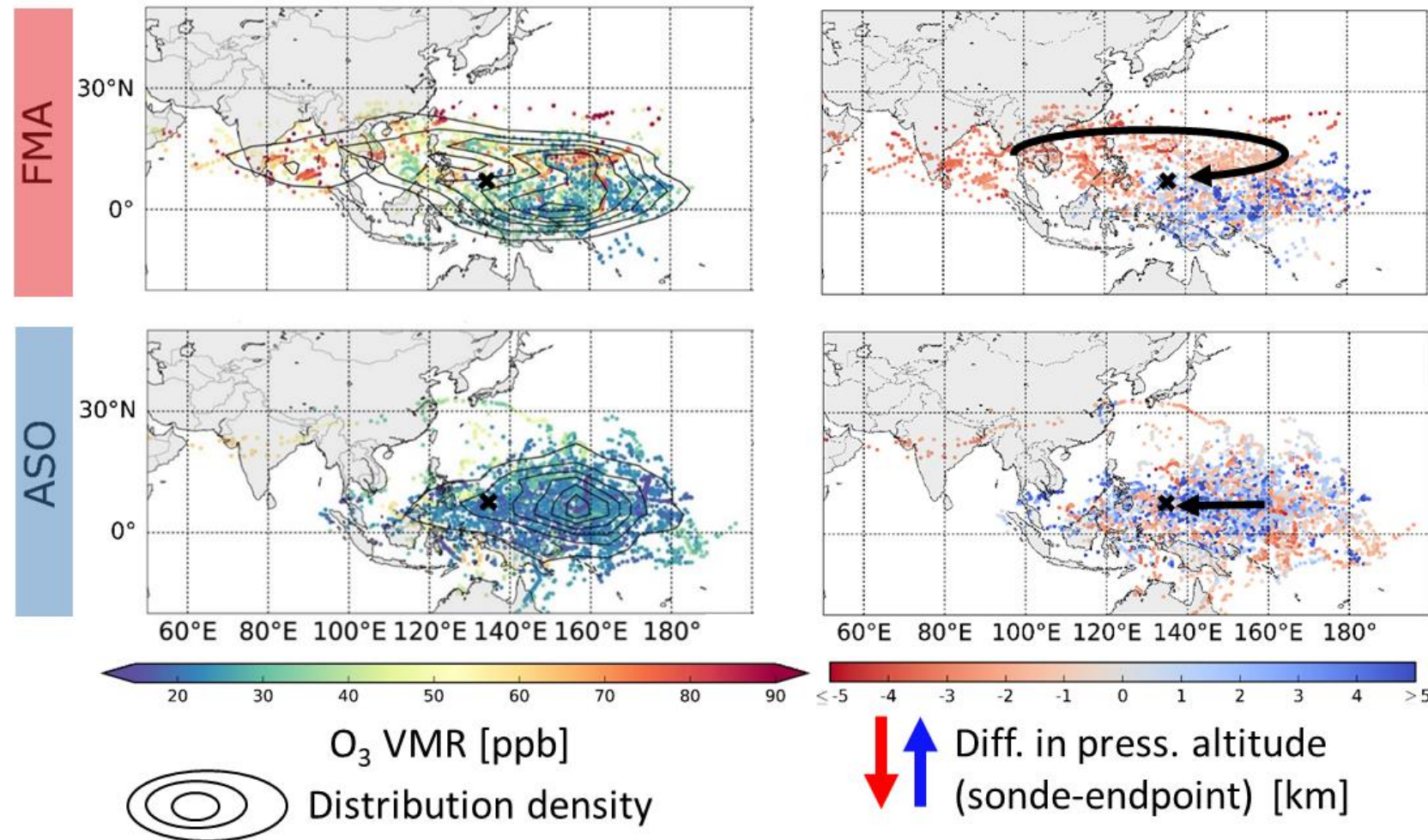
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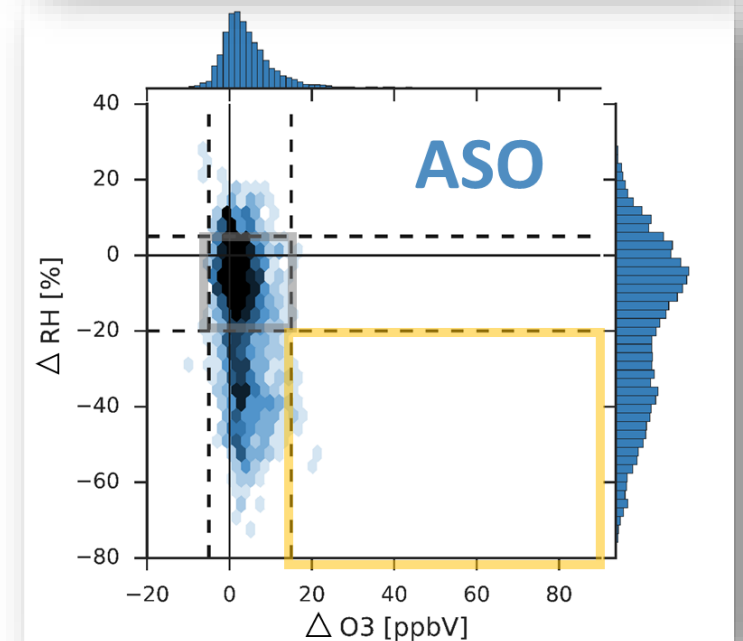
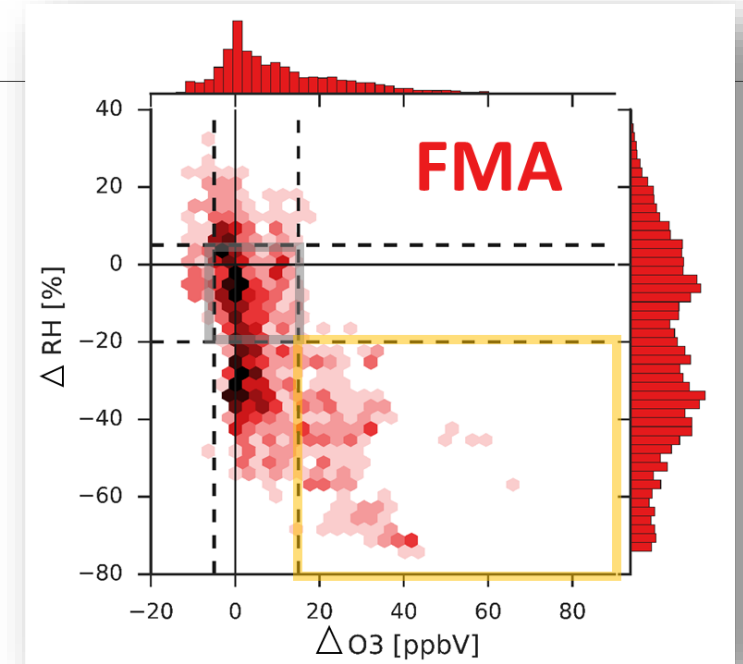
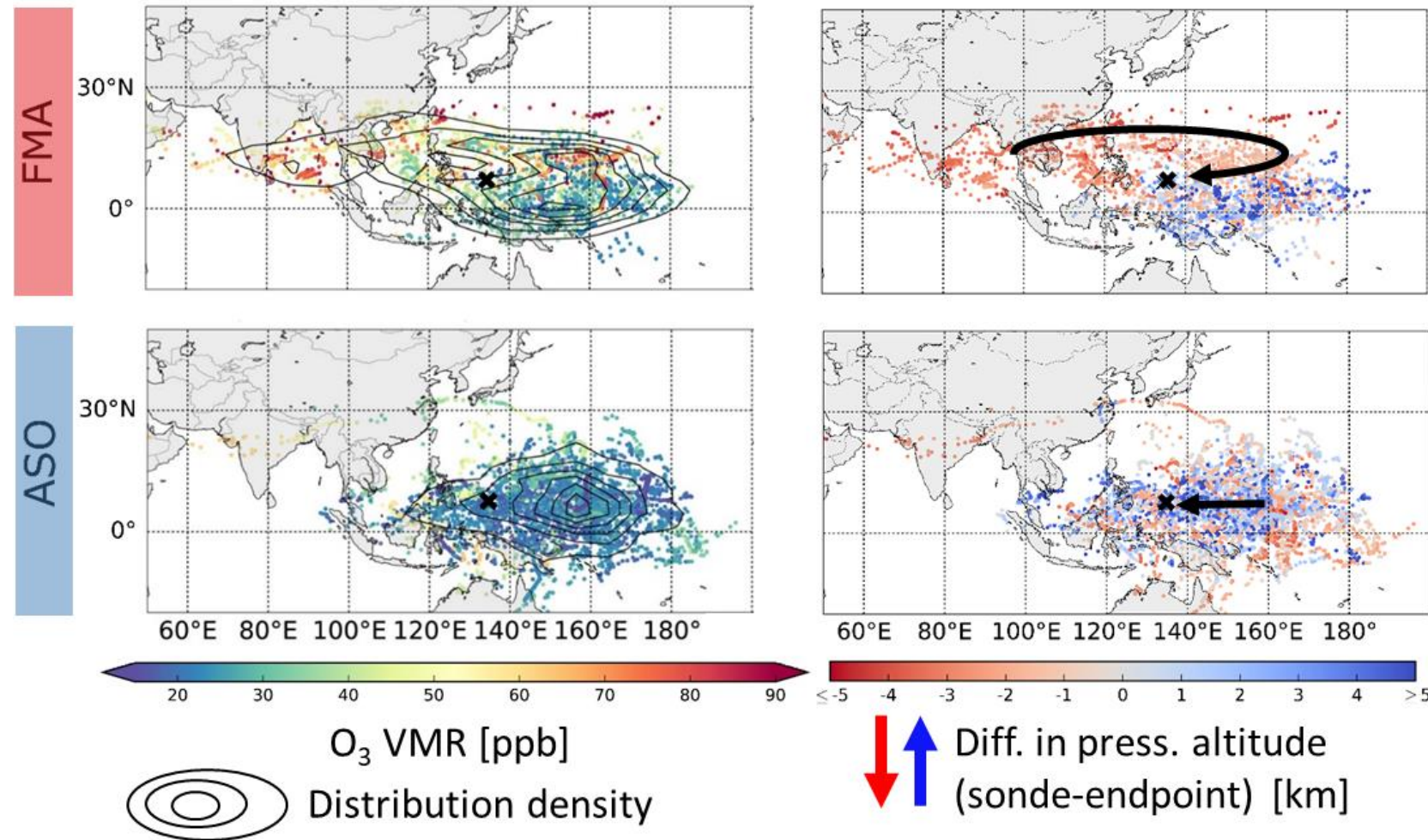
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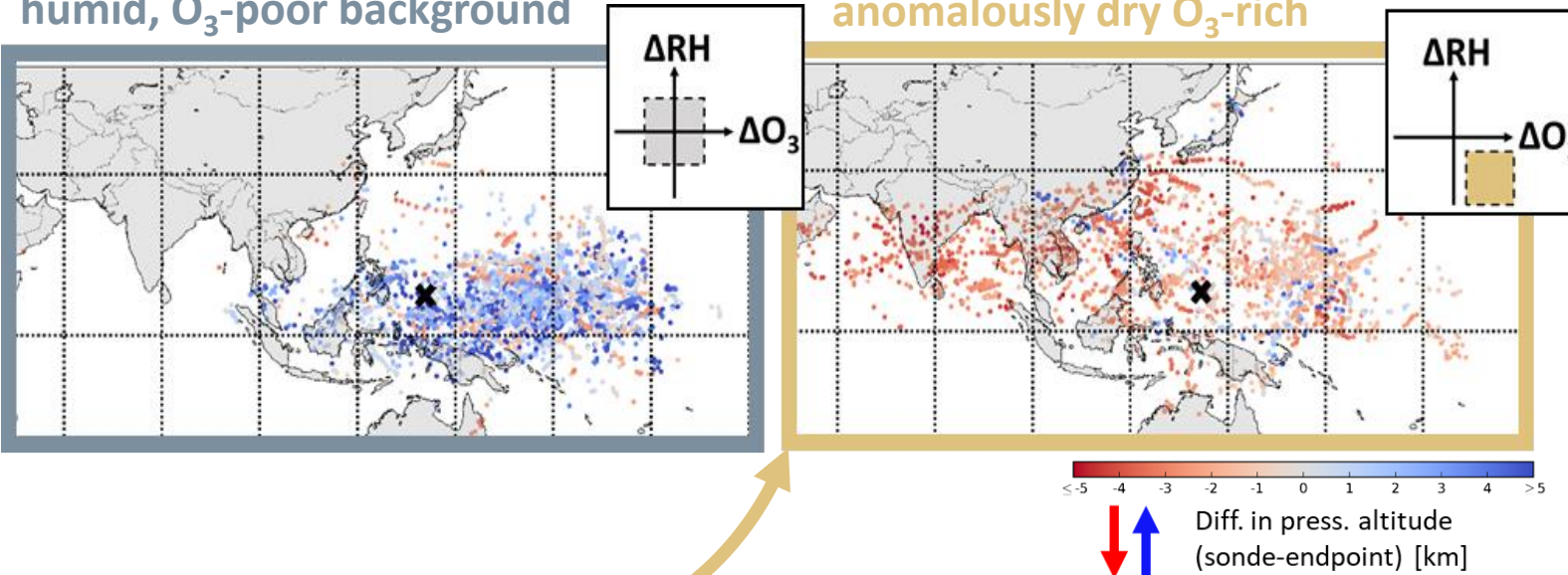


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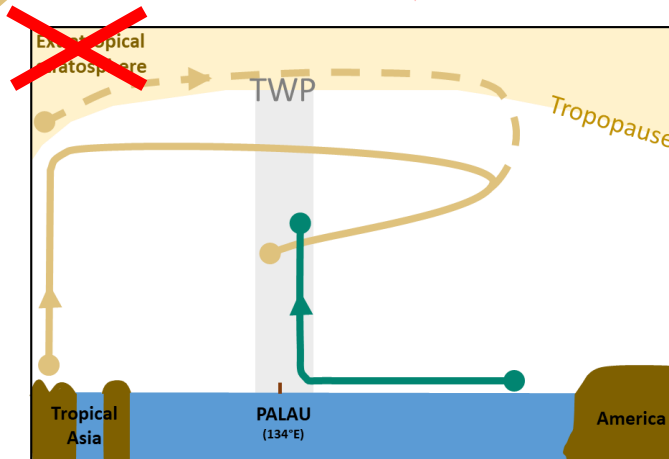
5-days-back trajectory ending points \equiv origin,
trajectory start @ 5-10 km in Palau \times

humid, O_3 -poor background

anomalously dry O_3 -rich



Various areas of increased air pollution on the ground from industry or bio mass burning, speaking in favor for a **pollution based origin**



All Observations by $\Delta O_3/\Delta RH$ group :

Separation of air masses according to processes controlling RH (Convective **uplift**, ASO; dehydration during **descent**, FMA) and spatially separate source regions

No indication for significant contribution of **stratospheric air:**

Potential Vorticity analysis for all trajectories (from 4 years, 138 profiles, 5-10 km) revealed essentially **no air mass crossing the 1.5 PVU threshold** for more than a day during 10 days backwards.

Take home messages

- ✓ We are **prepared for** and looking forward to the **2022 campaigns**.
- ✓ Using the Palau ECC O₃ sounding data set (01/2016-10/1019), seasonal analysis, trajectory modelling and a statistical approach to distinguish air masses by O₃/RH relation, we **identified transport processes and pathways to the TWP troposphere**:

Humid, O₃-poor

| | |
|------------------|-------------------------------|
| Processes | Convective background |
| Origin | Pacific or local |
| Frequency | Year-round, dominates Aug-Oct |

Dry, O₃-rich

| |
|------------------------------------|
| Large scale descent, pollution |
| Tropical Asia (anticyclonic route) |
| Most frequent in Feb-Apr |

- ✓ **Watch out** for the upcoming publications!
- ✓ I am happy to **collaborate** and provide data any time!

