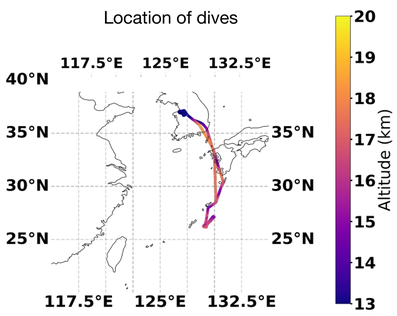
Water vapor isotopic variations of the upper troposphere/ lower stratosphere in the Asian Summer Monsoon:

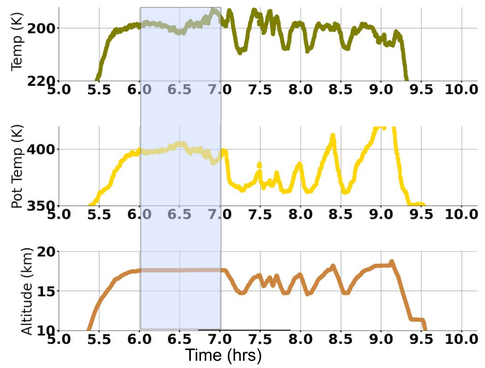
Stratospheric temperature and tracer variations above supertyphoon Hinnamnor

AS1.30 - X5.24

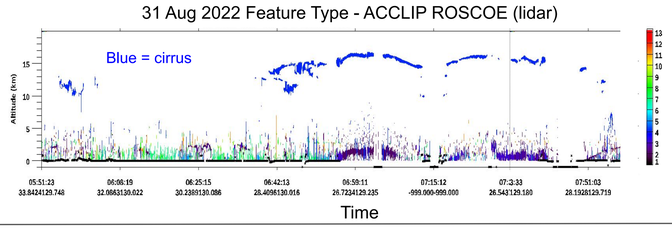
Carly KleinStern (cckleinstern@uchicago.edu), *Benjamin Clouser, Elisabeth Moyer | University of Chicago;* Thaopaul Bui | NASA Ames; Giovanni Bianchini, Francesco D'Amato, Silvia Viciani | CNR-INO; Troy Thornberry | NOAA CSL

Introduction: On 31 August 2022, one flight of the Asian Summer Monsoon Chemical and Climate Impact Project (ACCLIP), out of South Korea, included an overflight of supertyphoon Hinnamnor. The aircraft (NASA WB-57) flew within ~140 km of the core of the typhoon. We aim to explore the isotopic characteristics of the typhoon and its effect on the stratosphere. Previous aircraft campaigns (for example [1], [2]) have produced mixed results regarding the troposphere - stratosphere interactions in and around typhoons.

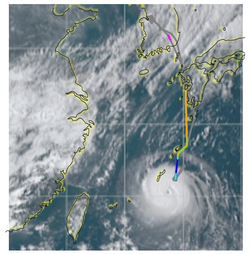


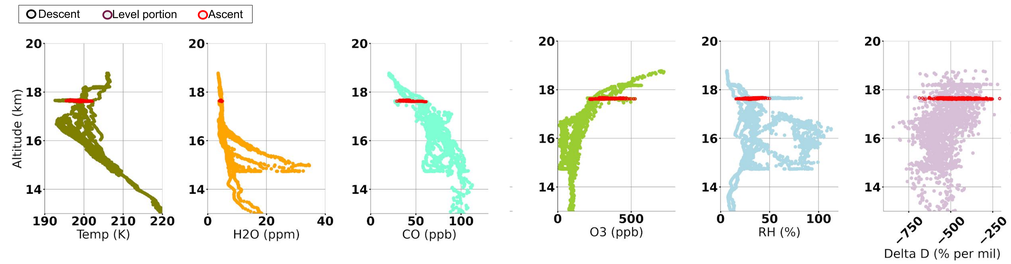


warmer

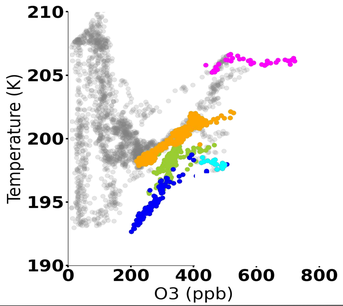


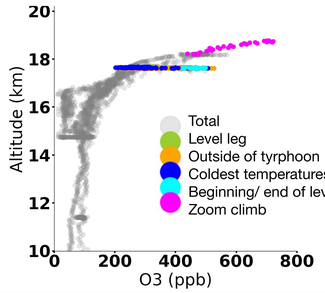
Typhoon induces internal gravity waves:





Large isotopic variation likely partially due to instrument noise

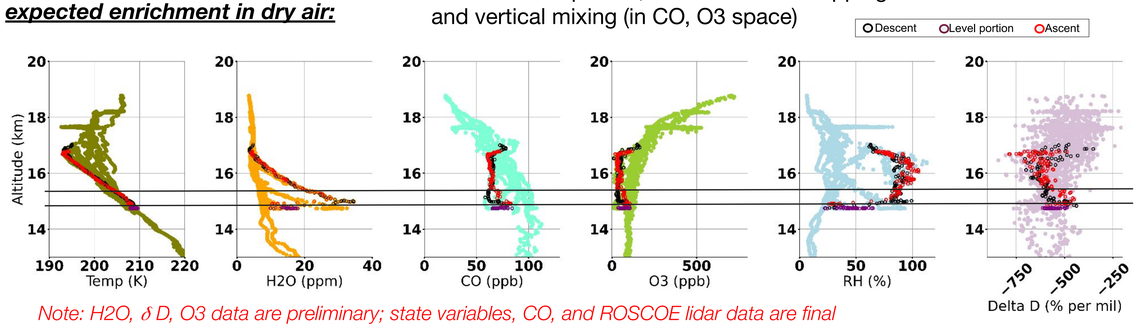




On the level leg approaching the typhoon (but not yet in it), we see internal gravity waves, confirmed by looking at ERA5 temperature and ozone fields. We have validated that similar temperature patterns are seen by ERA5 and aircraft measurements.

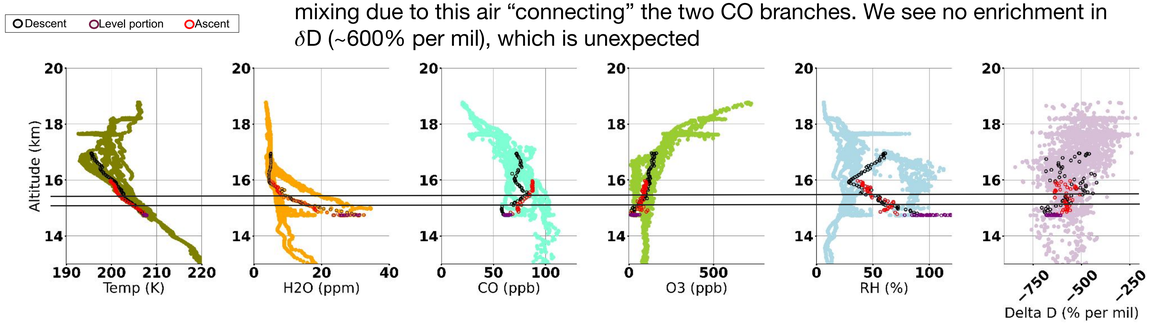
This mixing is distinct from the sucking in of stratospheric air discussed in [2] but not seen by [1]. This is seen by looking at the tracer profiles: they are consistent with air "bobbing" up and down; "sucking in" would manifest as a larger, skewed perturbation from the expected stratospheric O3 branch.

Typhoon brings up boundary layer air; expected enrichment in dry air: δD is ~500 % per mil; coincides with dropping RH and vertical mixing (in CO, O3 space)



Note: H2O, δD, O3 data are preliminary; state variables, CO, and ROSCOE lidar data are final

Unexpected depletion in dry air: From 15-15.5 km; dry air is being mixed with typhoon air. RH decreases, and we infer vertical mixing due to this air "connecting" the two CO branches. We see no enrichment in δD (~600% per mil), which is unexpected



Conclusions:

- **Typhoon induces internal gravity waves (seen by others, including [4]))**
- **Typhoon brings up air from the surface (seen by others, including [1])**
- **We see expected enrichment in dry air due to sublimating ice**
- **We see an example of unexpected depletion of vapor in dry air**

Questions raised by these results:

- Are ice particles big and sedimenting out before they can sublimate, or tiny and then when they sublimate leave behind no isotope signature?
- Is the typhoon incorporating shed air from the ASM anticyclone?
- Why isn't mixing consistently stronger over typhoon arm vs clear air (green, dark blue vs orange region of flight track)?

References:
[1] Cairo et al. Atmos. Chem. Phys., 8, 3411–3426, 2008.
[2] Penn. J Appl Meteorol., 4, 212-216, 1965.
[3] Roux et al. Atmos. Chem. Phys., 20, 3945–3963, 2020.
[4] Kim, Chun, and Wu. J of Geophys Research, 114, 2009.

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