Impact of the 2022 Hunga Volcano on Global Middle Atmosphere Water Vapour and Introduction of the Swiss H_2O Hub

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Hunga Tonga Water Vapour

- The Hunga Tonga Hunga Ha'apai volcanic eruption released an estimated 150 Tg of water vapour into the atmosphere, with the plume height reaching up to 55km[1,2].
- Over the following two years, water vapour was transported across the globe.

Scan to see what comes next

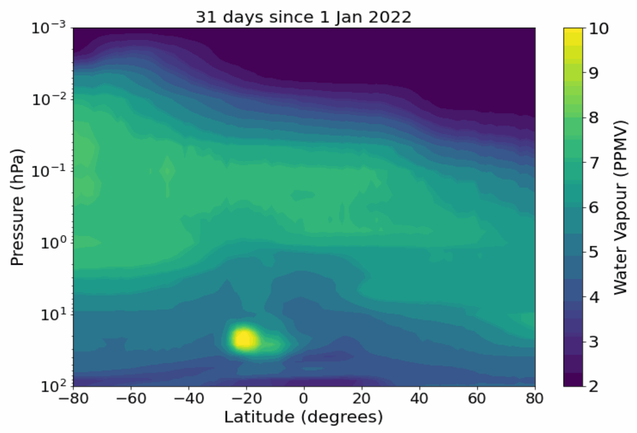

Figure 1: Zonal mean water vapour mixing ratio from the Microwave Limb Sounder onboard the Aura satellite, from 1st January 2022 until the 20th September 2023.

Observations above Bern, CH [49° North]

- Instrumental dataset: **MI**ddle **A**tmosphere **WA**ter vapour **RA**diometer (MIAWARA); Aura MLS; ACE-FTS
- Good agreement between all instruments
- Higher than average H2O in summer 2022, very large anomaly in summer 2023
- As of March 2024, above average mixing ratios persist

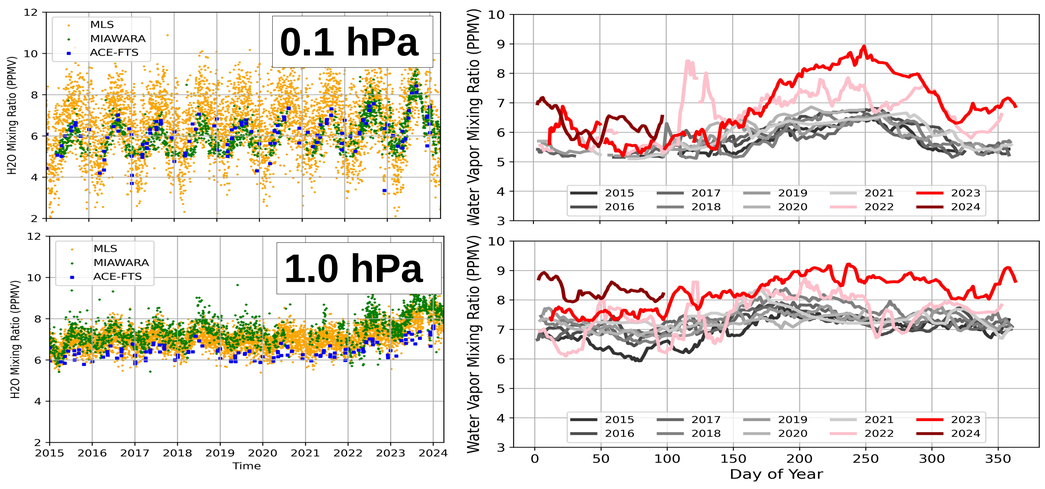

Figure 2: Water vapour mixing ratio above Bern, CH observed by three instruments between 2015 and 2024 (left); mixing ratio from MIAWARA showing the year-by-year differences.

Simulating Long-wave Downwelling Radiation

- Line by line radiative transfer simulations performed with the Atmospheric Radiative Transfer (ARTS)
- CO_2, H_2O and O_3 most radiatively important gases for long-wave downwelling at bottom of stratosphere (14km asl).
- "Simulated annealing" method[3] was used to select a reduced number of frequencies Total long-wave downwelling radiation simulated from 5 elevation angles

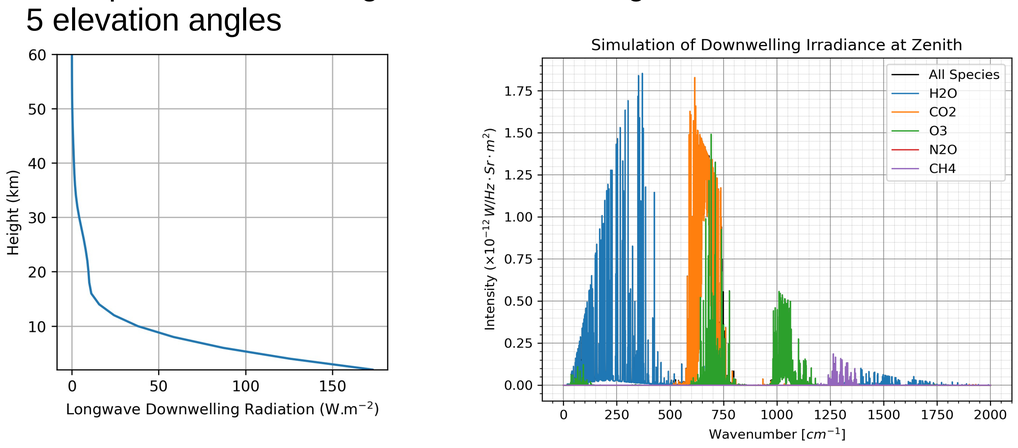

Figure 3: Simulated downwelling radiative power at different heights above the surface for a typical atmospheric profile above Bern, CH (left); spectral radiant intensity at a zenith viewing angle originating with the main emitting gases highlighted.

Radiative Impact at 14km asl

- Using same methodology, but with data retrieved from MIAWARA over Bern, CH
- Positive anomaly, increases through summer 2023
- Difference less pronounced than at latitude of eruption – magnitude and height of water vapour anomaly important
- Mean increase in long-wave downwelling: 0.06W/m²

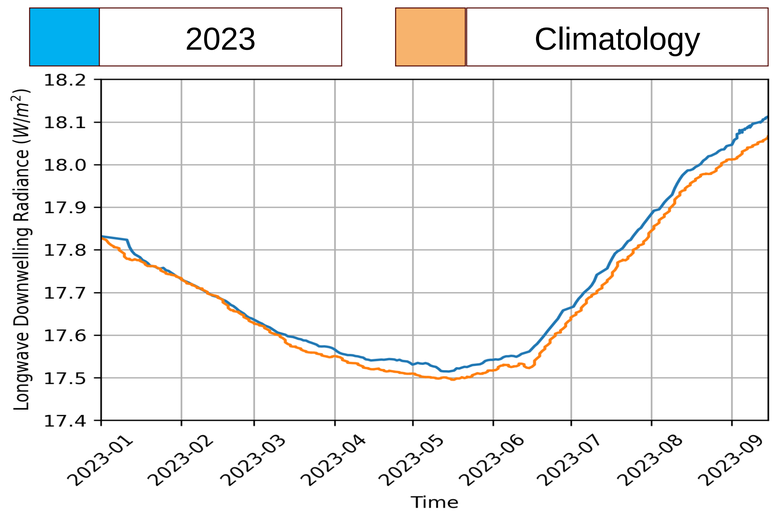

Figure 4: Simulated long-wave downwelling radiation at 14km asl above Bern one year after the eruption of the Hunga volcano.

Swiss H_2O Hub

Objective: Close critical observational gaps in the atmospheric water vapour profile from the surface to the mesosphere by combining in-situ and remote sensing observations in a development/testing phase and a monitoring phase.

Continuously re-visiting calibration, traceability, and homogeneity of this Essential Climate Variable (ECV) to guarantee usability for climate monitoring

Instruments:

- ALBATROSS (balloon-borne laser spectrometer)
- PCFH (Peltier-cooled frostpoint hygrometer)
- MIAWARA (middle atmosphere microwave radiometer)
- RALMO (Raman lidar for meteorological observations)
- Auxiliary measurements (RS41, CFH, MLS)

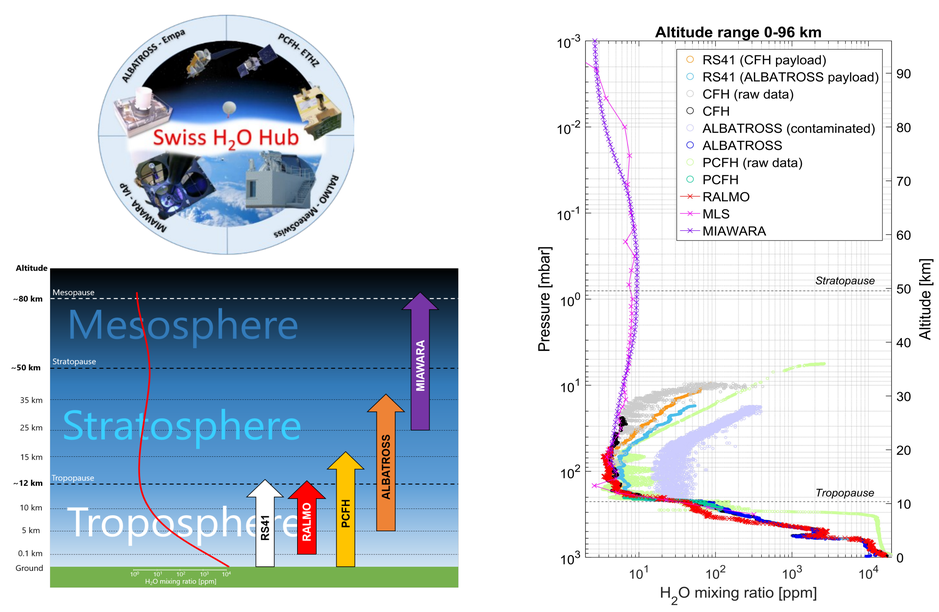

Figure 5: Swiss H2O Hub instruments and their operating range (left); results from the first field campaign showing measurements from all instruments on the 17th August 2023.

References

1. Millan, Luis, et al. "The Hunga Tonga-Hunga Ha'apai hydration of the stratosphere." Geophysical Research Letters 49.13 (2022): e2022GL099381.

2.Carr, James L., et al. "Stereo plume height and motion retrievals for the record-setting Hunga Tonga-Hunga Ha'apai eruption of 15 January 2022." Geophysical Research Letters 49.9 (2022): e2022GL098131.

3. Buehler, Stefan A., et al. "Efficient radiative transfer simulations for a broadband infrared radiometer—Combining a weighted mean of representative frequencies approach with frequency selection by simulated annealing." Journal of Quantitative Spectroscopy and Radiative Transfer 111.4 (2010): 602-615.