Impact of the 2022 Hunga Tonga Volcano on Global Middle Atmosphere Water Vapour

UNIVERSITÄT BERN

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Hunga Tonga-Hunga Ha'apai Eruption

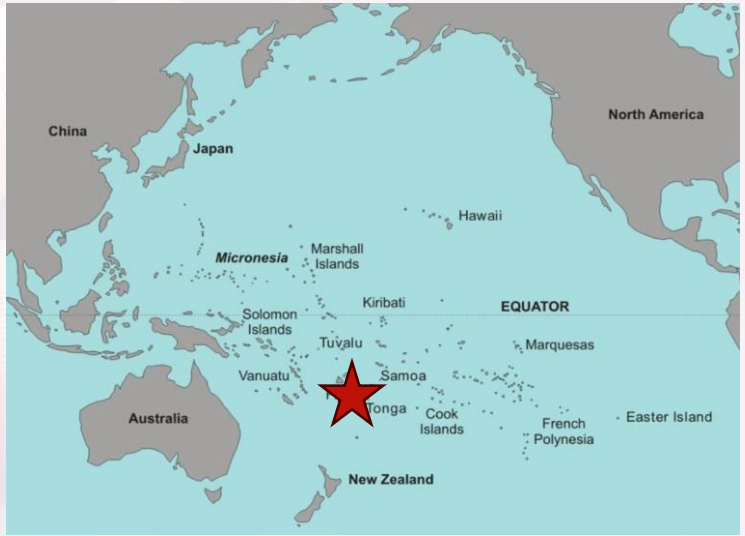
Submarine eruption which reached its climax on 15 January 2022

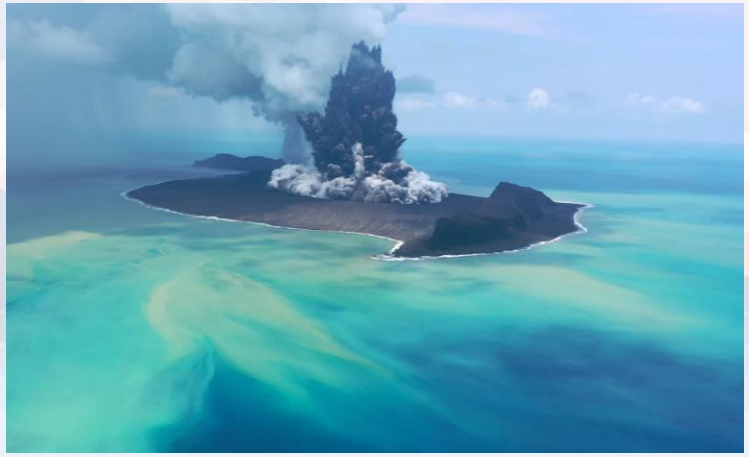
Volcanic explosivity index of 5 - classified as the largest eruption of the 21st century

Estimated 150 Tg of water vapour injected into stratosphere* (~10% of global stratospheric water vapour)

Initial plume height up to 55km

*Estimates by Khaykin et al. (2022) and Millán et al. (2022)





Instruments

MIAWARA

MIddle Atmosphere WAter vapour RAdiometer

Continuous measurements in Bern, Switzerland since 2006

MIAWARA-C

Compact version of the original with polarised receiver

Continuous measurements in Ny-Alesund, Svalbard since 2015

ACE-FTS

Atmospheric Chemistry Experiment Fourier Transform Spectrometer onboard SCISAT.

High-resolution Fourier Transform Spectrometer with a Michelson interferometer

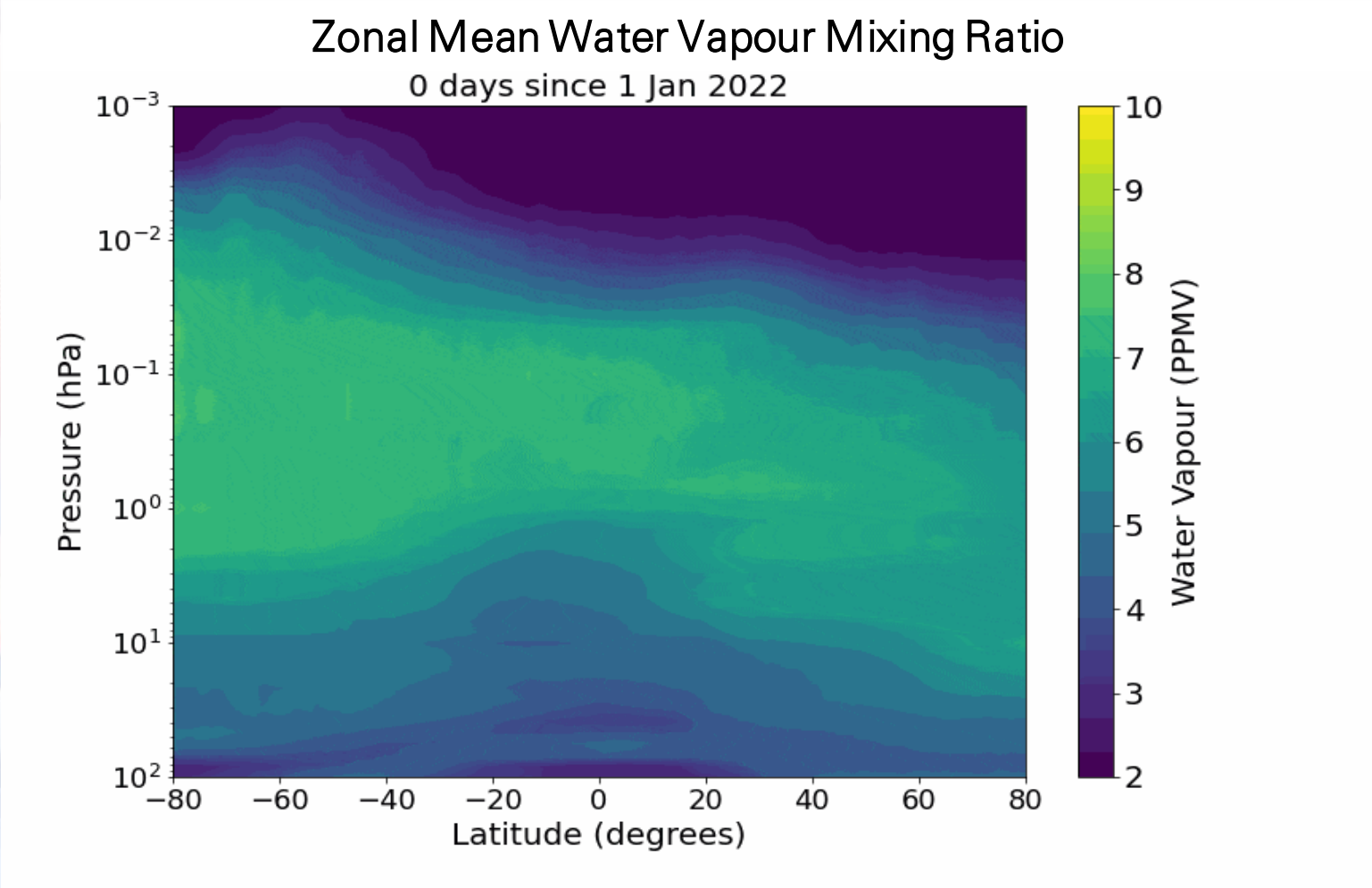
MLS

Microwave Limb Sounder onboard Aura Satellite

Version 5 retrievals used

Transport of Water Vapour

Scan to See More



Observations: Bern, Switzerland

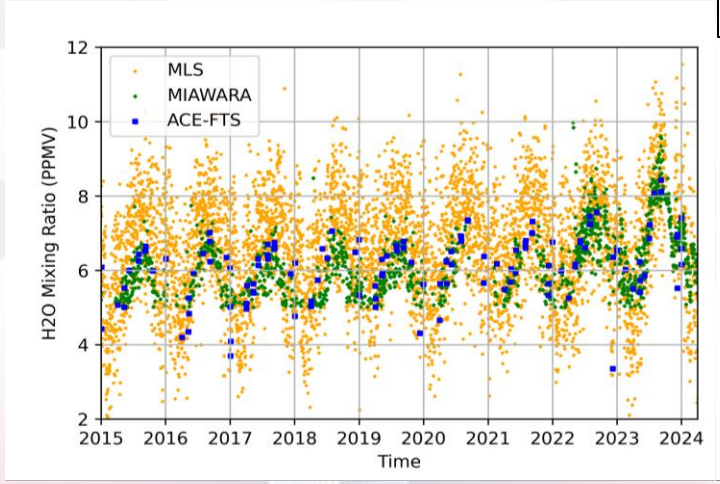
Bern- latitude of 46.9°N

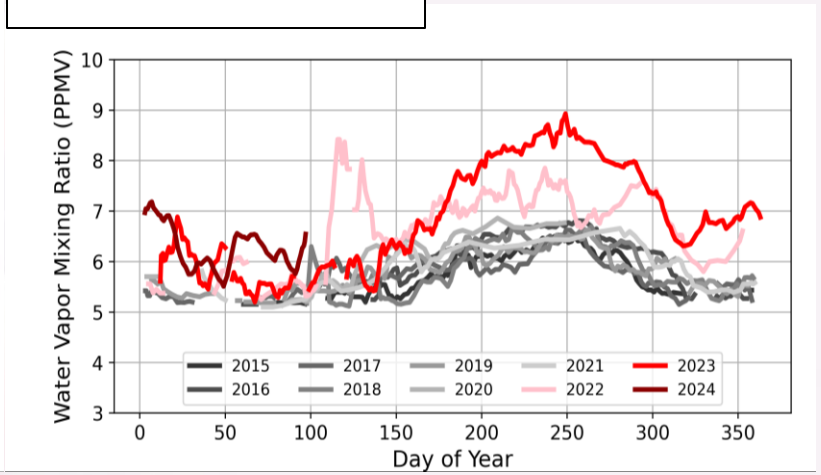
Good agreement between all instruments

Higher than average H2O in summer 2022, very large anomaly in summer 2023

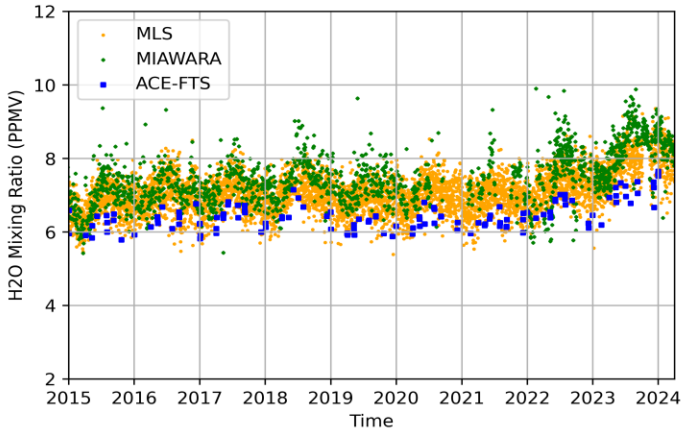
As of March 2024, above average mixing ratios persist

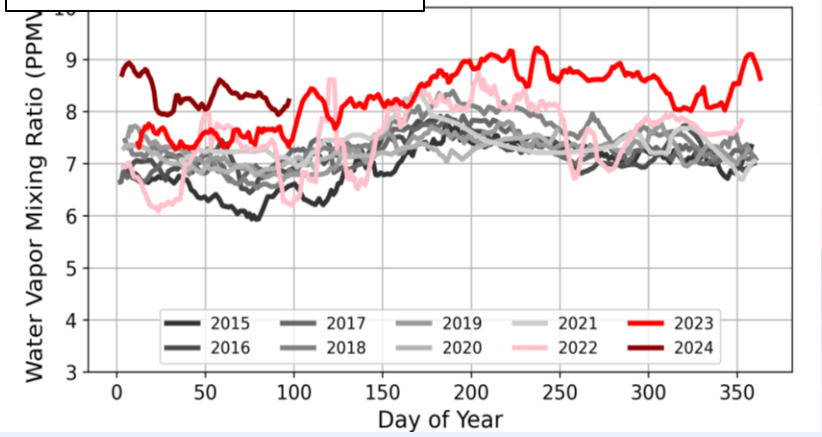
0.1hPa





1hPa





Observations in Ny-Alesund

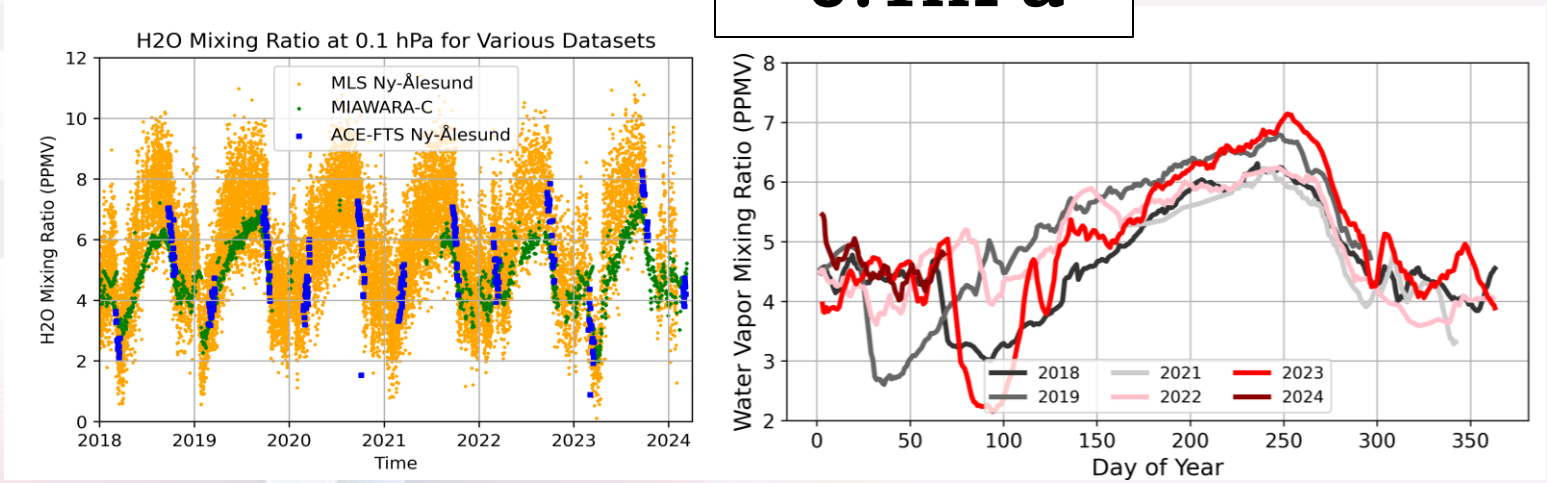
Ny-Alesund- latitude of 78.6°N

Good agreement between all instruments

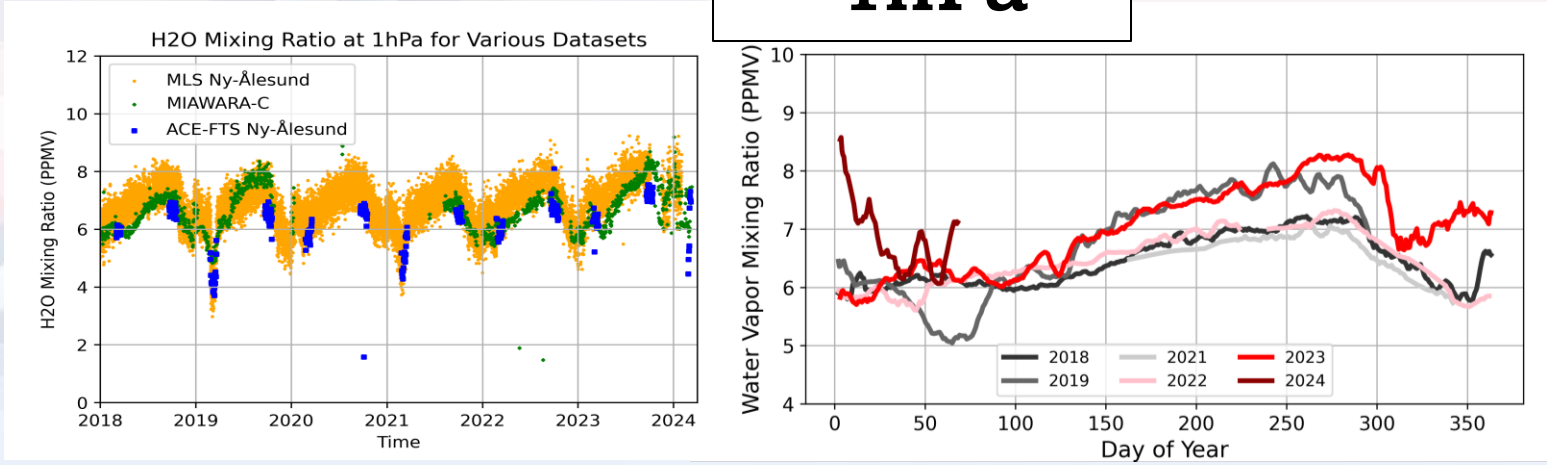
No significant impact before until 2023

Elevated mixing ratio in Summer 2023 before falling back to normal levels

0.1hPa



1hPa



Longwave Downwelling Radiation

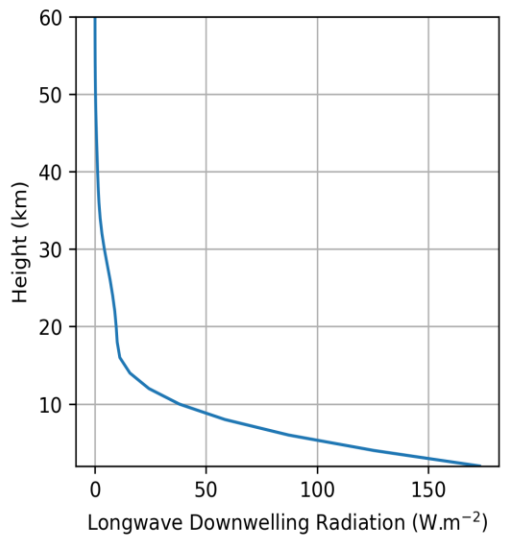
Line by line radiative transfer simulations performed with the Atmospheric Radiative Transfer (ARTS)

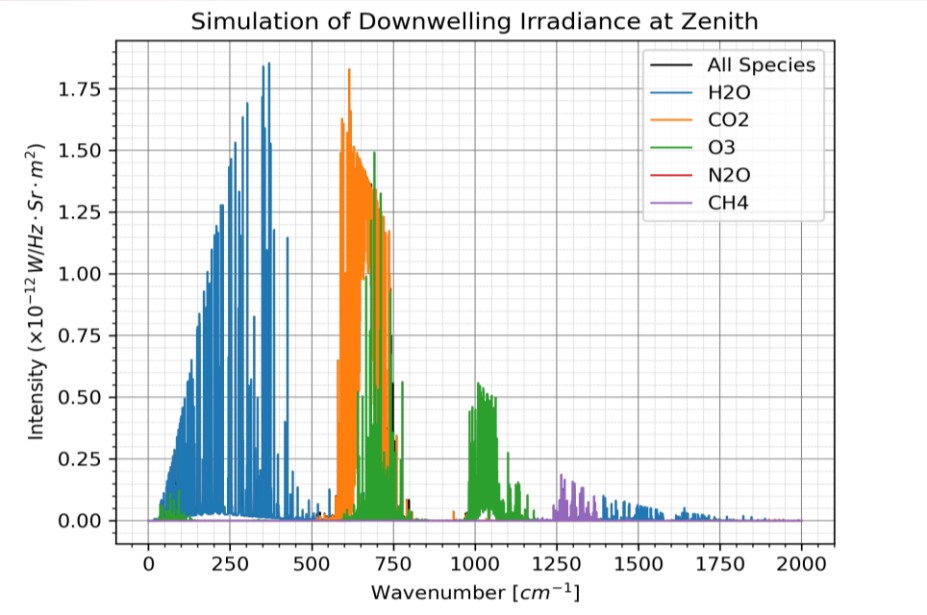
CO_2, H_2O and O_3 most radiatively important gases for downwelling at bottom of stratosphere

"Simulated annealing" method* was used to select a reduced number of frequencies

Total longwave downwelling radiation simulated from 5 elevation angles

*Buehler et al. (2009)





Longwave Radiation at –20°N

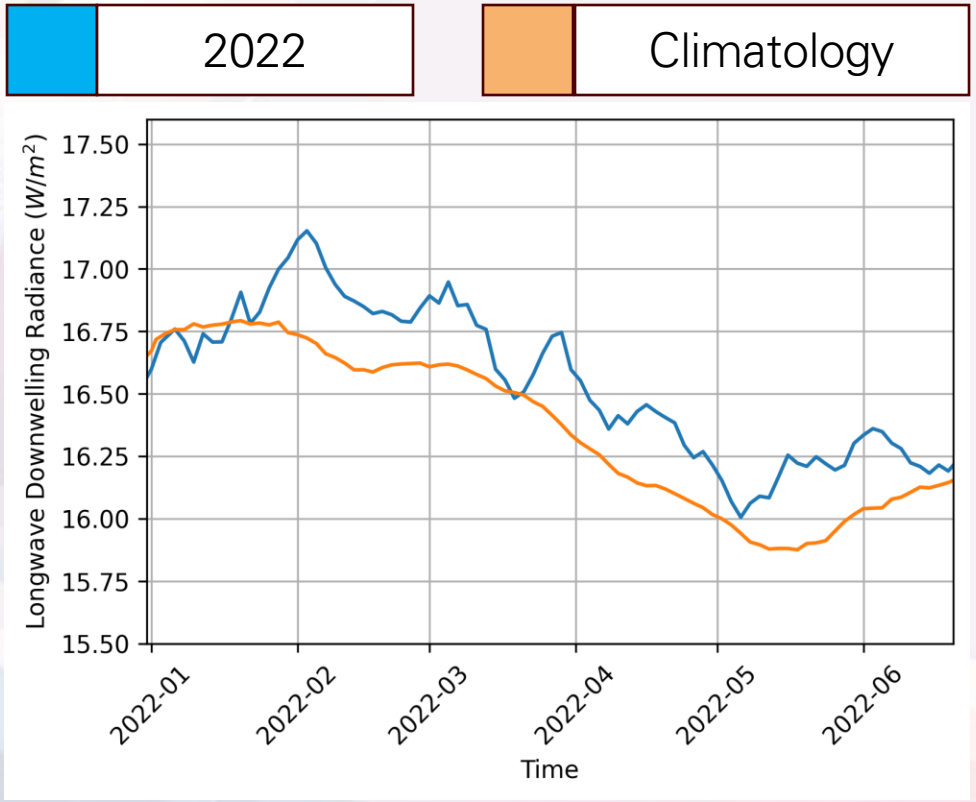
Longwave downwelling modelled for average water vapour at latitude of –20 (same as Hunga Tonga Volcano)

Measurements from MLS used

14km asl with standard atmospheric temperatures and other gas composition

Shortly after Eruption, increase in the downwelling radiance

01/01/2022 - 01/06/2022 : difference in mean downwelling radiance of +.25 W/m^2



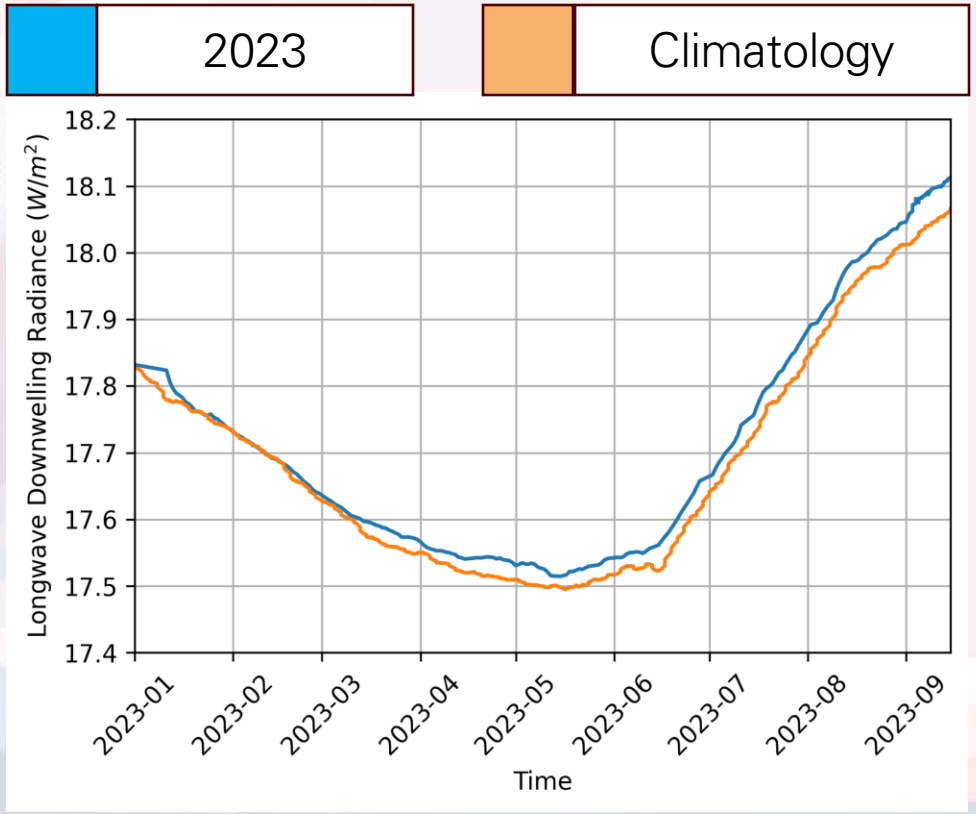
Longwave Downwelling Radiation above Bern

Using same methodology, but with data retrieved from MIAWARA over Bern

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 longwave downwelling: 0.06W/m^2



Conclusions and Further Work

Above average global middle atmospheric water vapour resulting from Hunga Tonga predicted to last up until 2032*

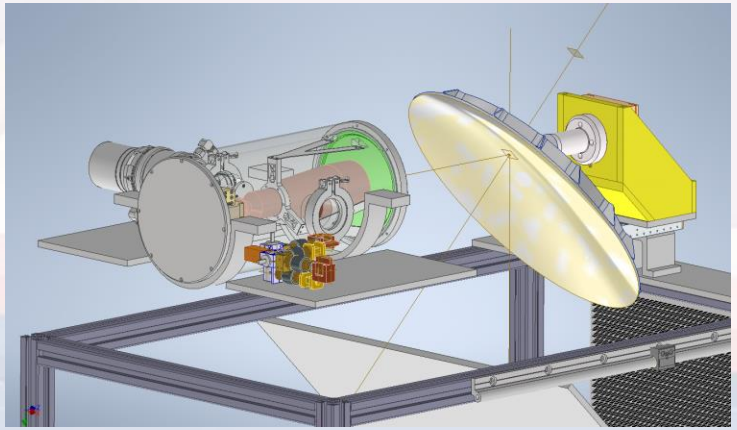
Long term measurement of water vapour needed for relevance to climate change

CryoWaRa-C – new generation H2O Radiometer

Increase in frequency of polar stratospheric and mesospheric clouds?

Continuation of Swiss H2O Hub –
Simone Brunamonti [X5.54 10:45-12:30 today]

Polar stratospheric cloud seen over Switzerland in 2023



Design of new cryogenic radiometer