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Diurnal variability of middle atmospheric H_2O and comparison with WACCM

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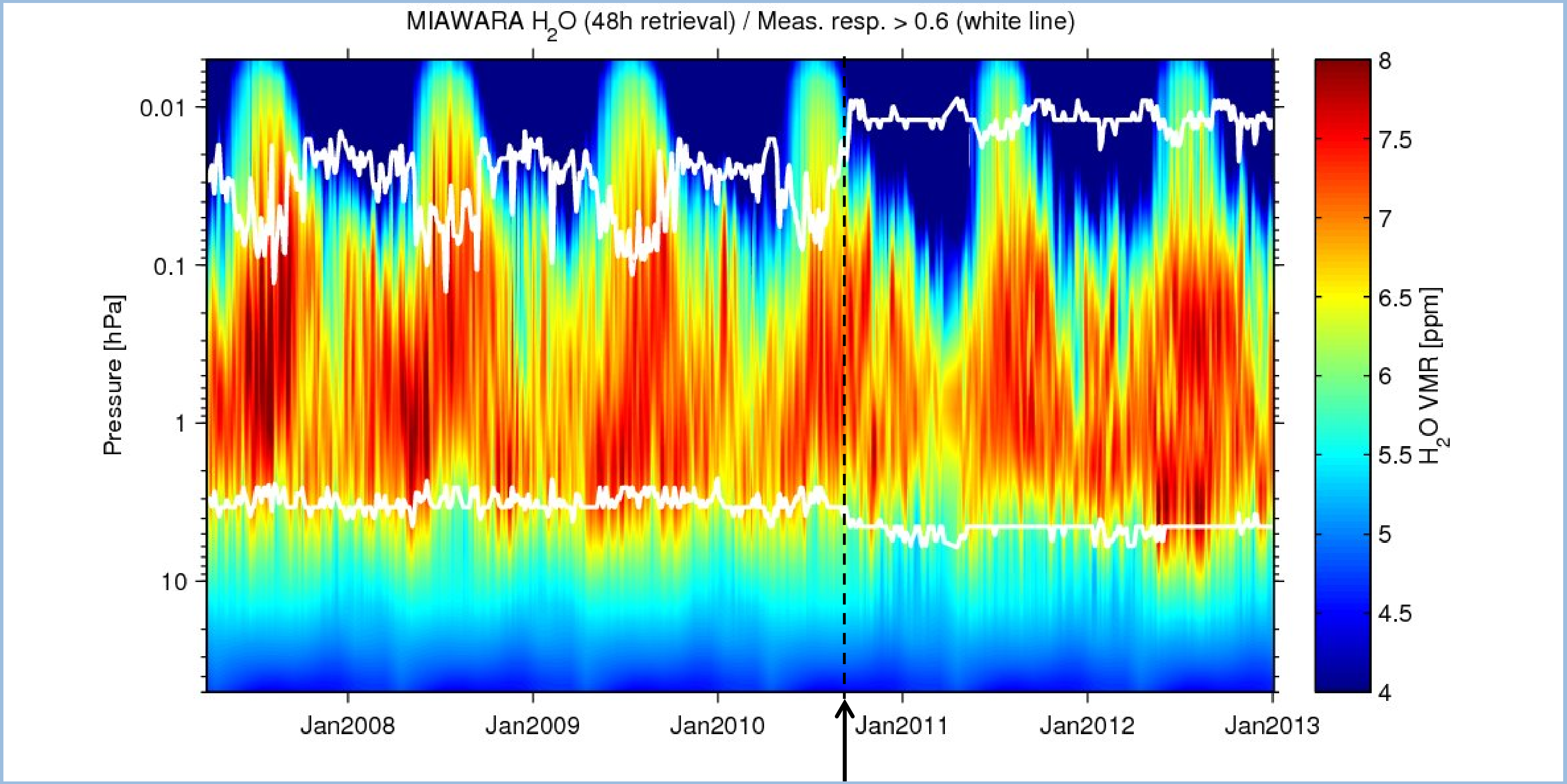
MIAWARA: Middle Atmospheric Water Vapor Radiometer

- Located near Bern, Switzerland (47°N / 7°E)
- Operational since 2002
- Operating during day and night at all weather conditions except precipitation (rain, snow)
- Measures the pressure broadened rotational transition line of H_2O at 22.235 GHz
- Vertical H_2O profile retrieval by the Optimal Estimation Method (OEM)

MIAWARA H_2O data set



Upgrade Sept. 2010

Origin of diurnal variations in the middle atmosphere

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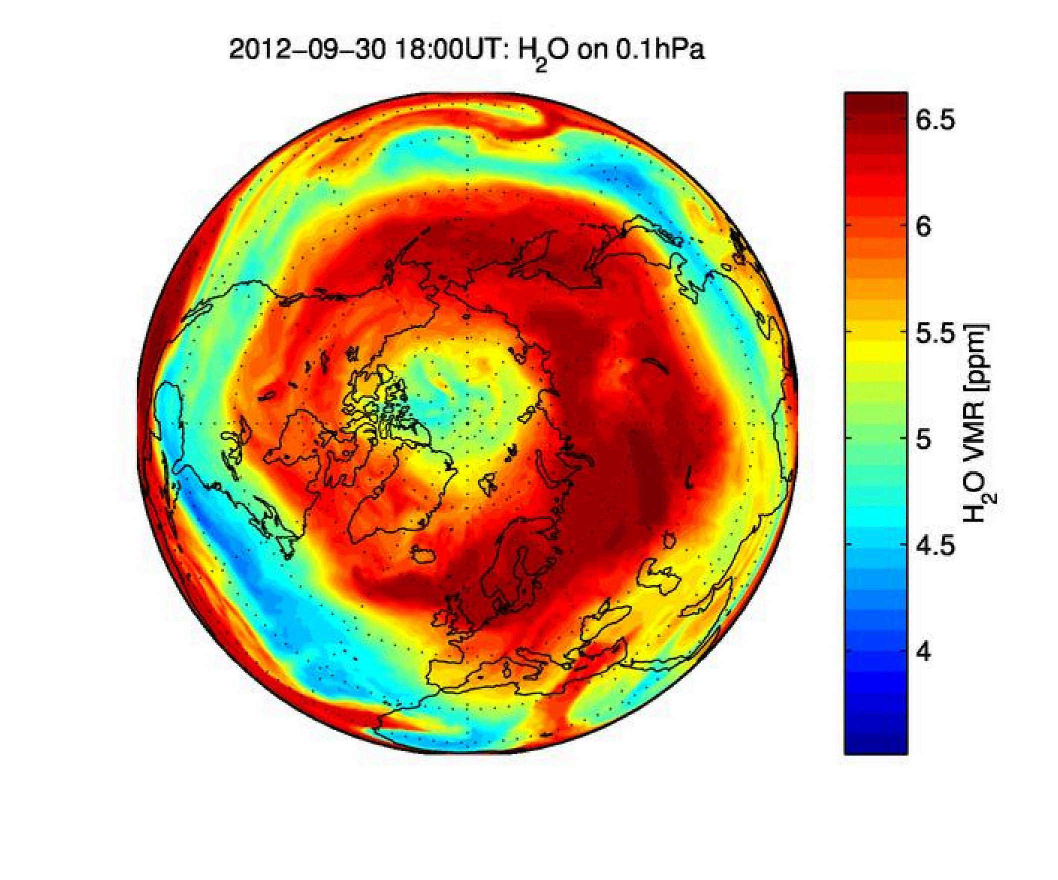
- Solar radiation directly affects the chemical composition through (photo-)chemical reactions.
- Periodic heating of the stratospheric ozone layer and latent heat release in the troposphere
- Waves propagate through the whole atmosphere and their amplitudes increase with altitude
- Changes in pressure, wind and temperature also lead to changes in chemical composition.

Diurnal variations in mesospheric H_2O according to ECMWF:



Fourier-Transformation of our H_2O dataset

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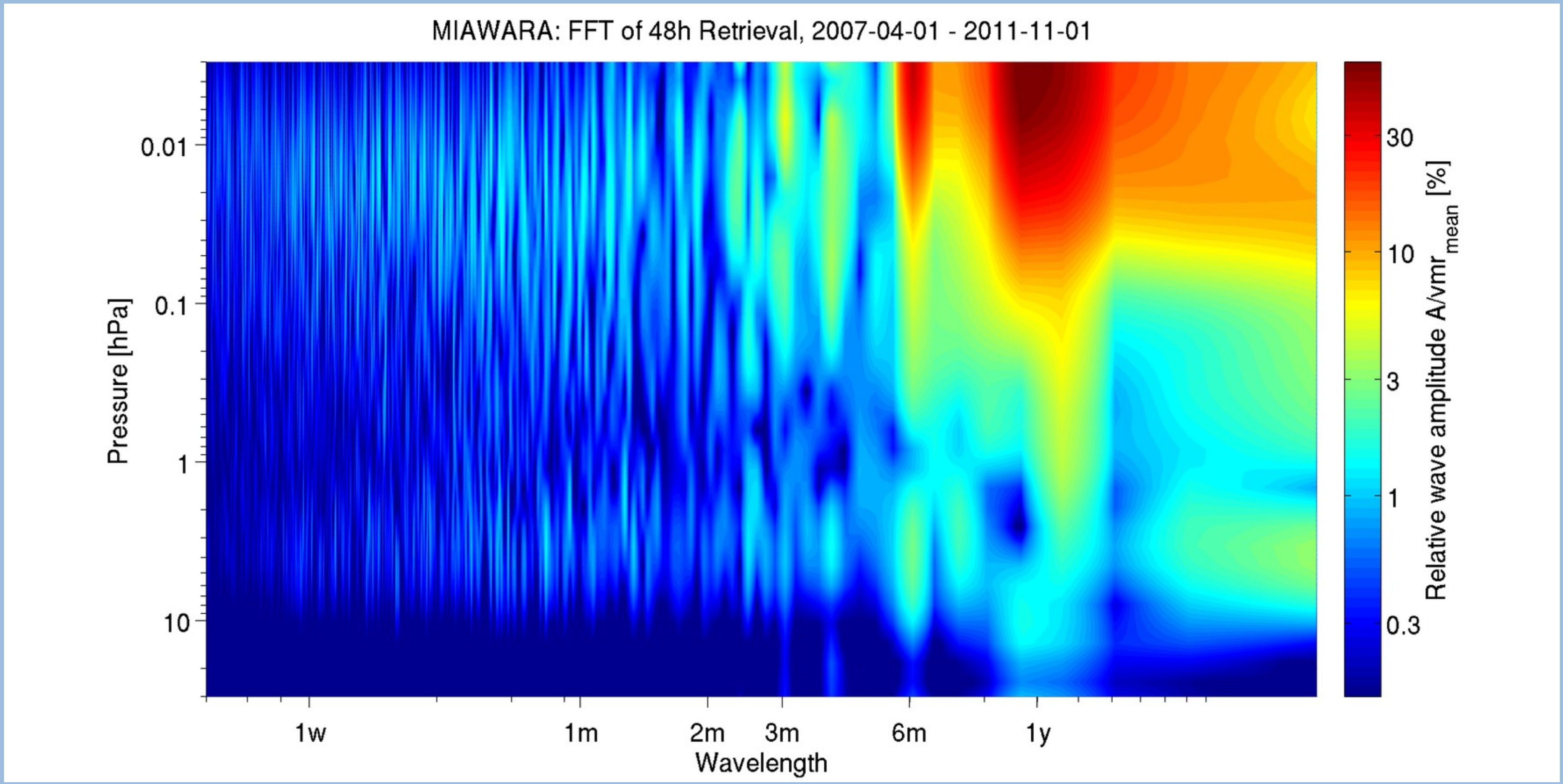

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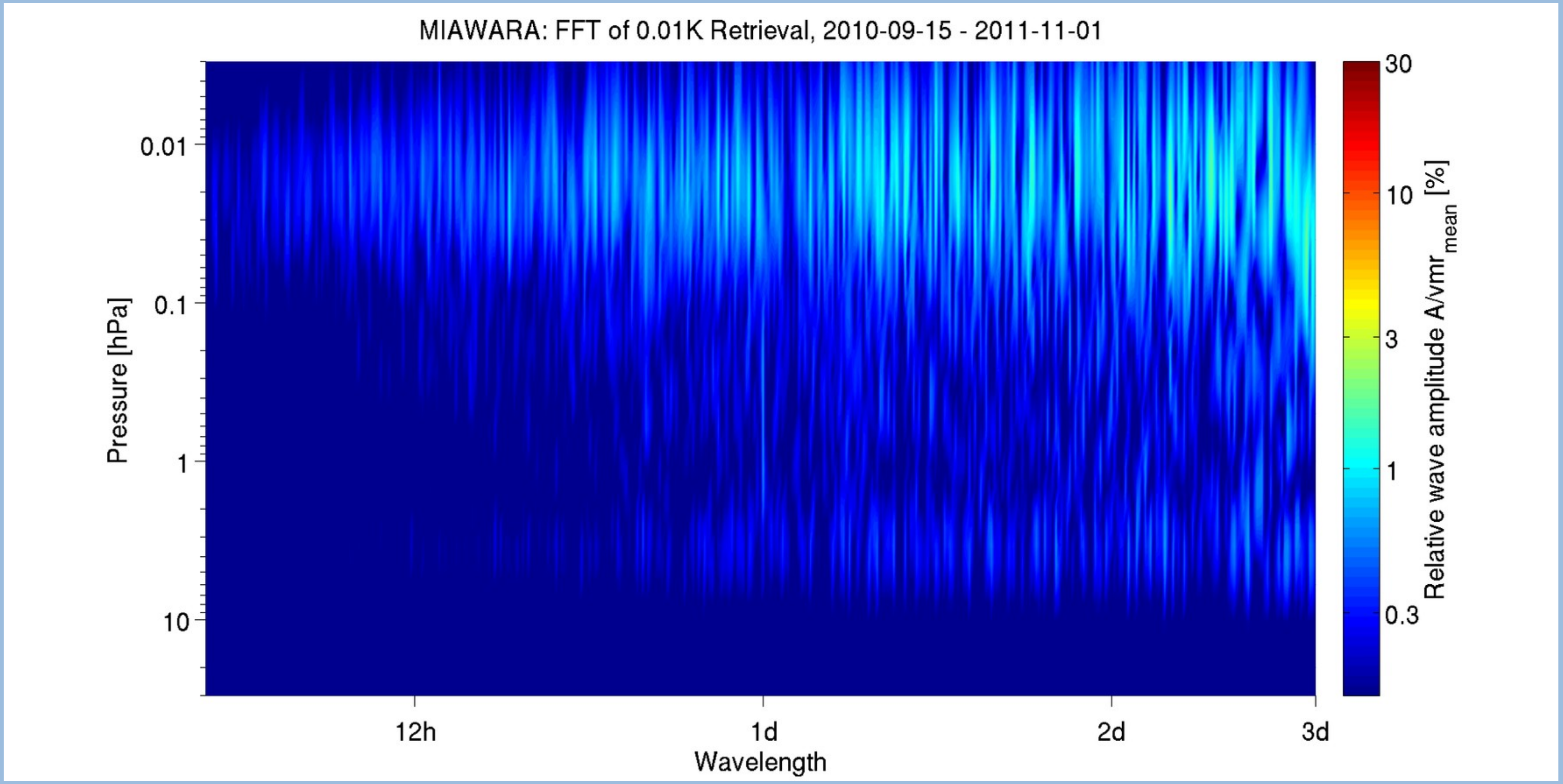

Fourier-Transformation of our H_2O dataset

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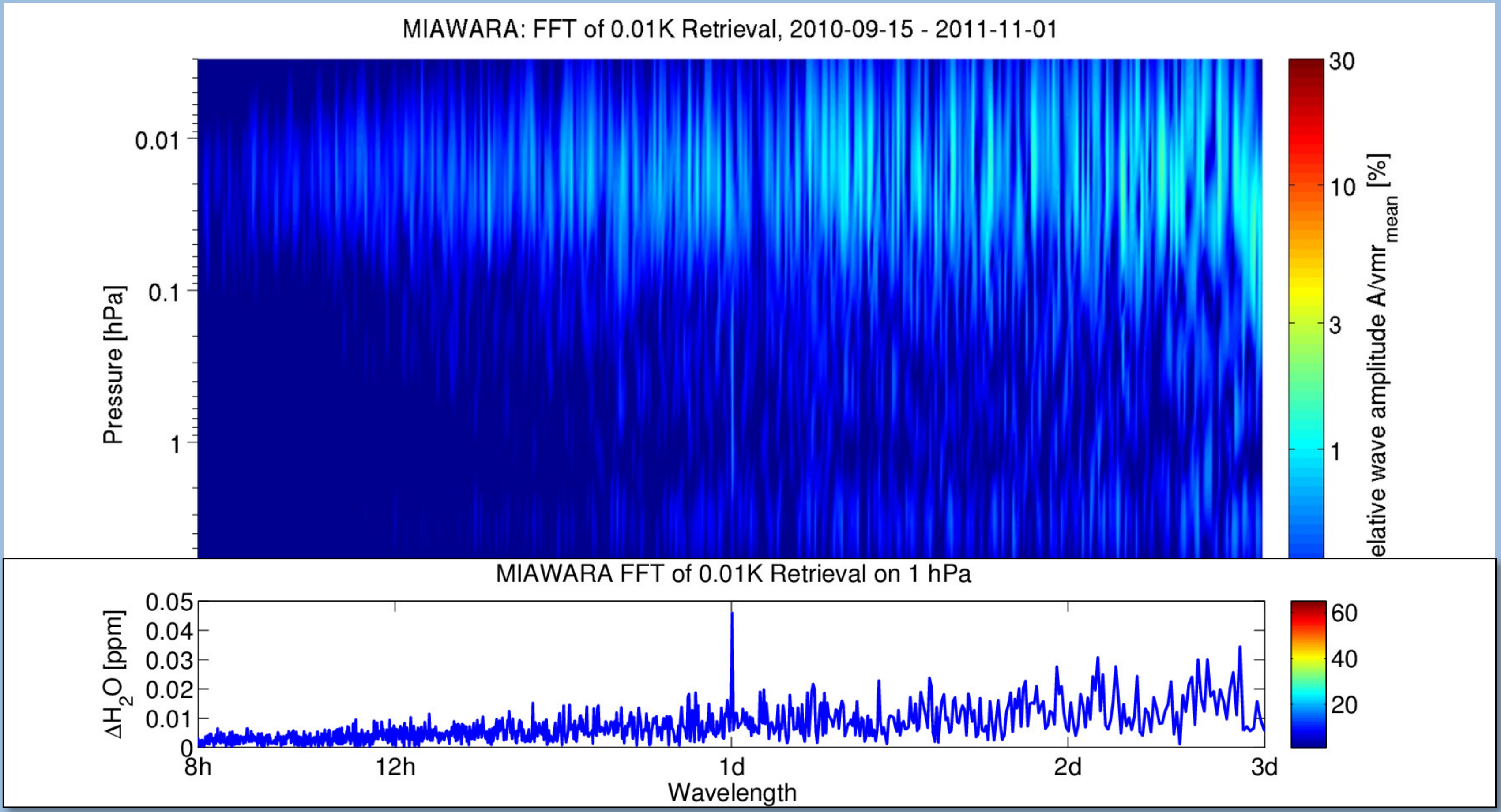

Extracting the diurnal variations

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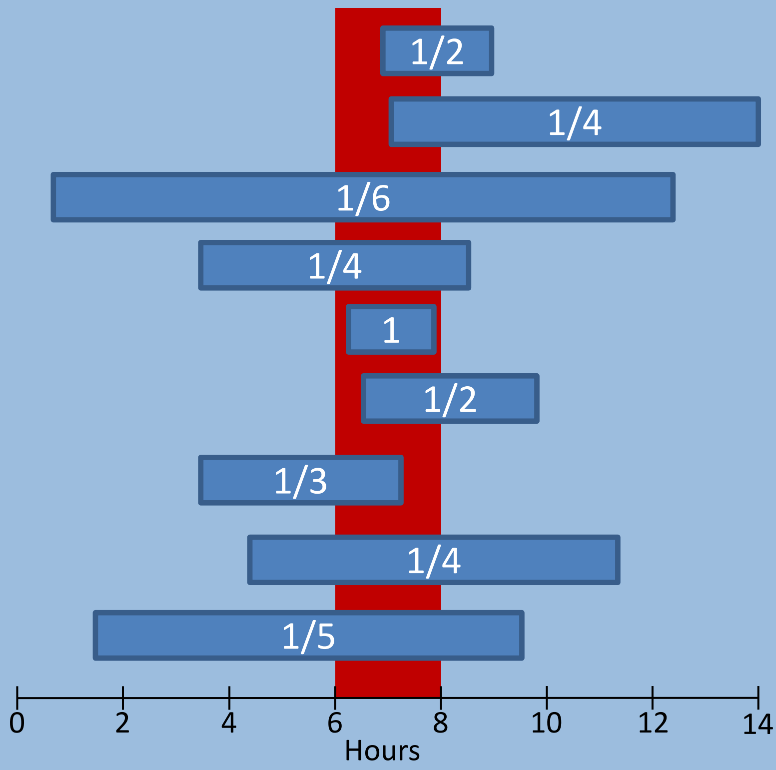
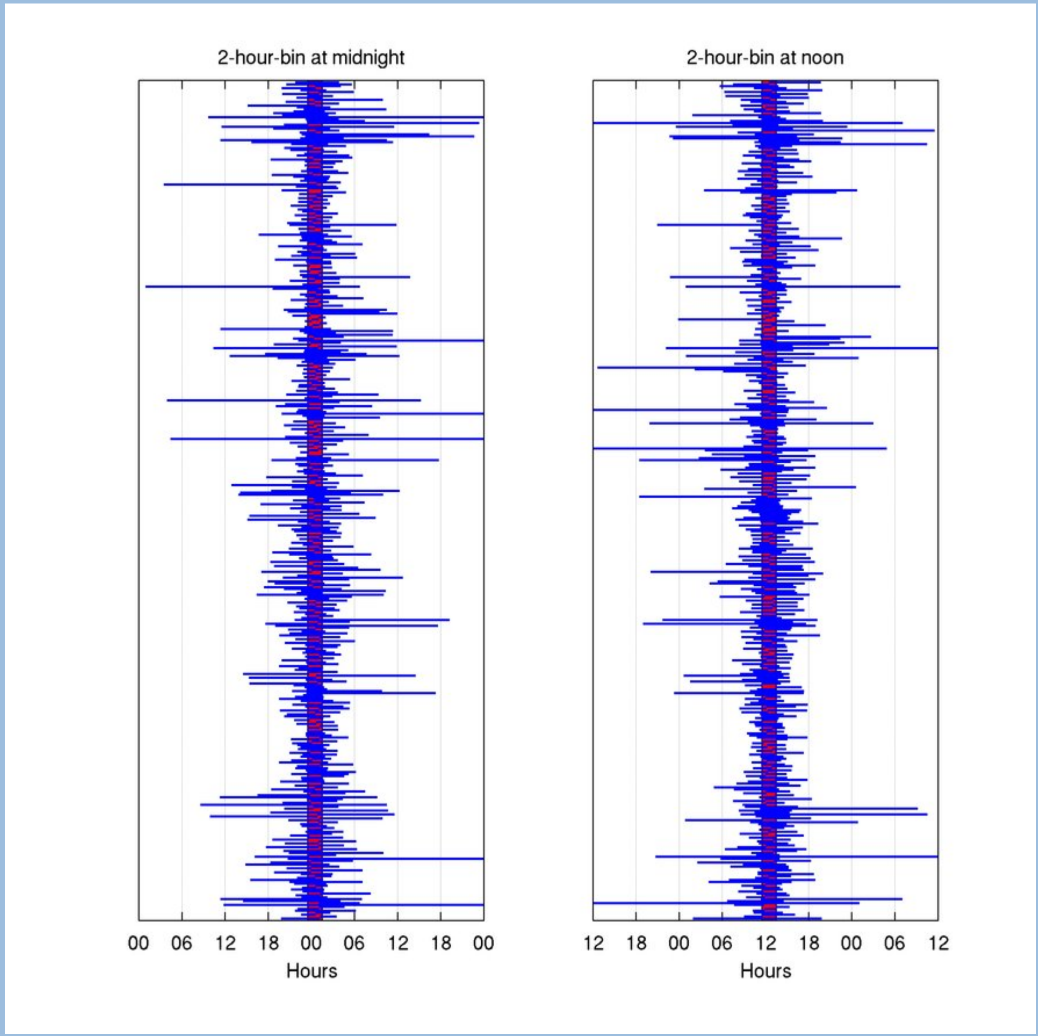
- Diurnal variations in the order of 1%
- Statistical noise level of one retrieval between 5% and 20%
- To detect diurnal variations without FFT, averaging over a large data set is required
- To average individual retrievals, the averaging kernels should be similar.
- Therefore, we use Sigma-Retrievals instead of fixed-time-period-retrievals.
- The Sigma-Retrievals are binned into 2-hour-bins including a weighting factor.

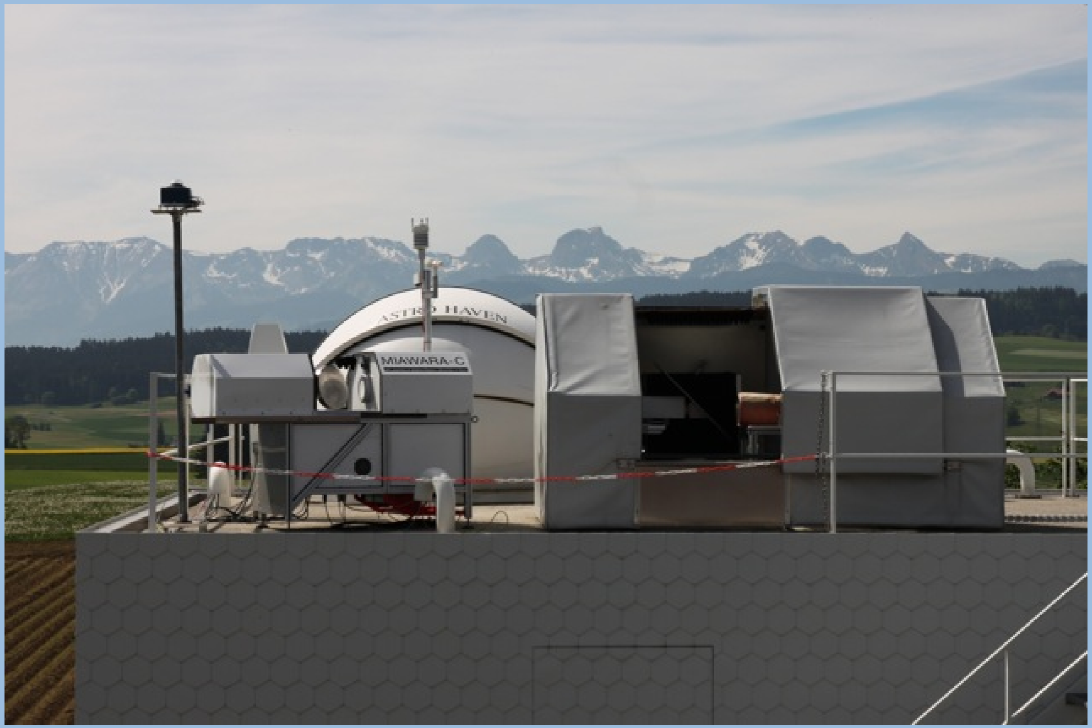
Weighting the retrievals





Used datasets

- We use the opportunity to compare MIAWARA and MIAWARA-C during MIAWARA-C's stay in Zimmerwald.



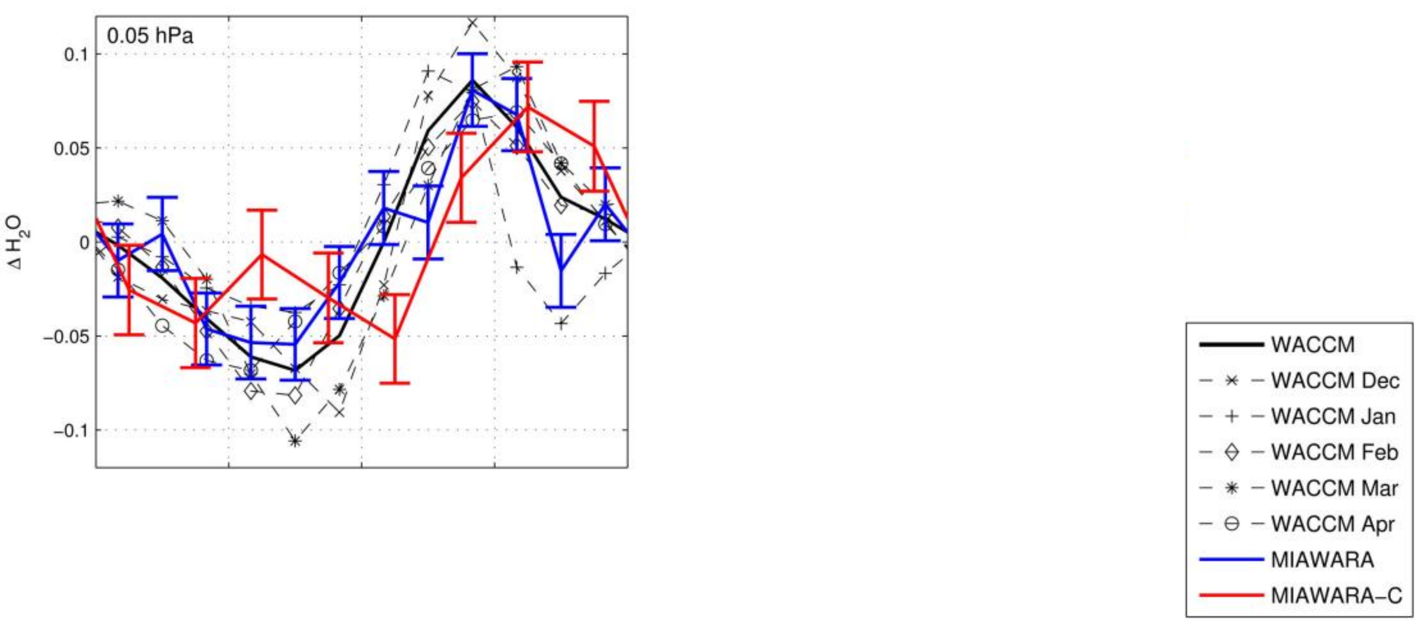
Courtesy of M. Canavero

+ WACCM

And we compare it to WACCM

Diurnal variability of middle atmospheric H_2O

Winter (Dec – Apr)



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Diurnal variability of middle atmospheric H_2O

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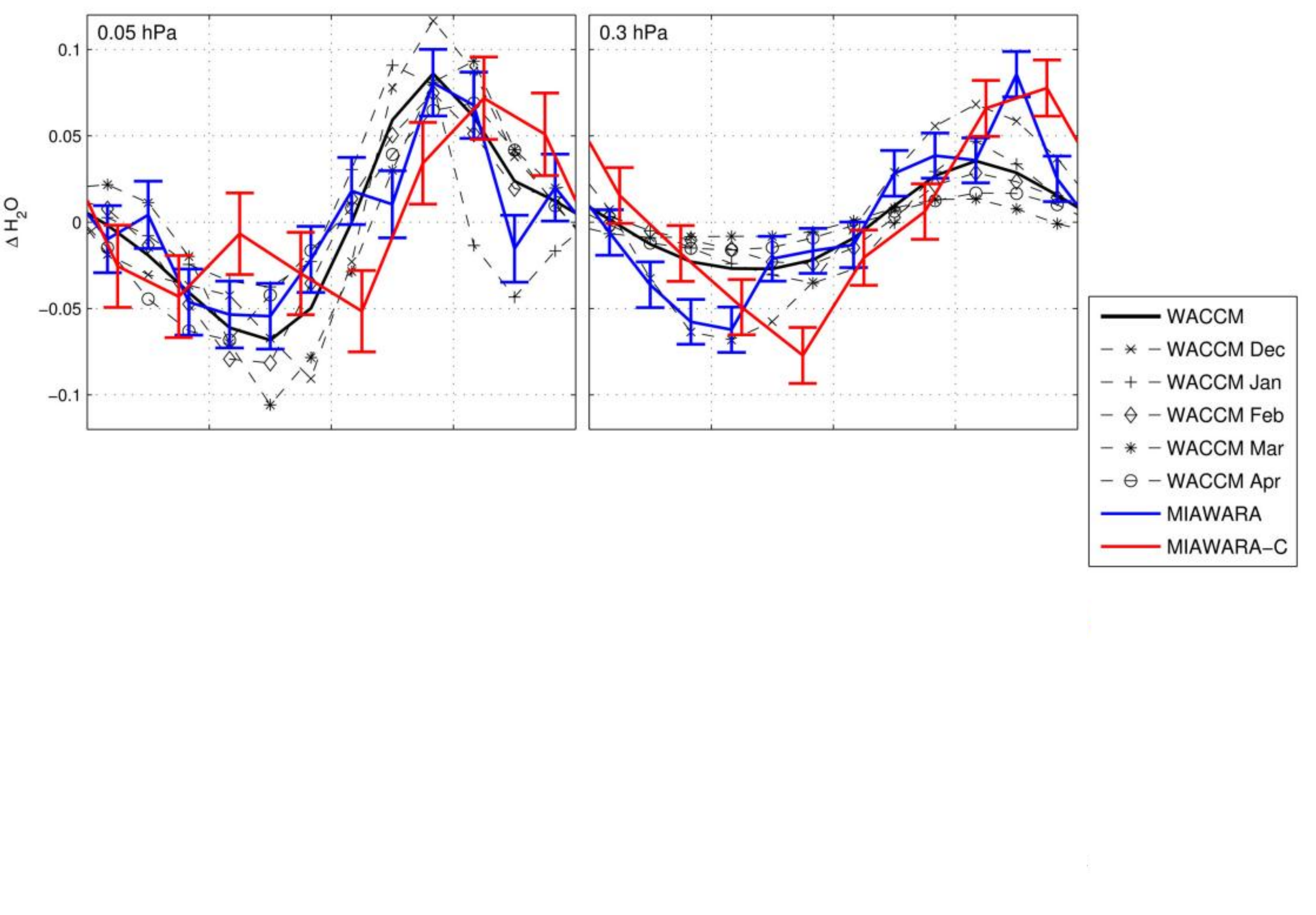

Diurnal variability of middle atmospheric H_2O

Winter (Dec – Apr)

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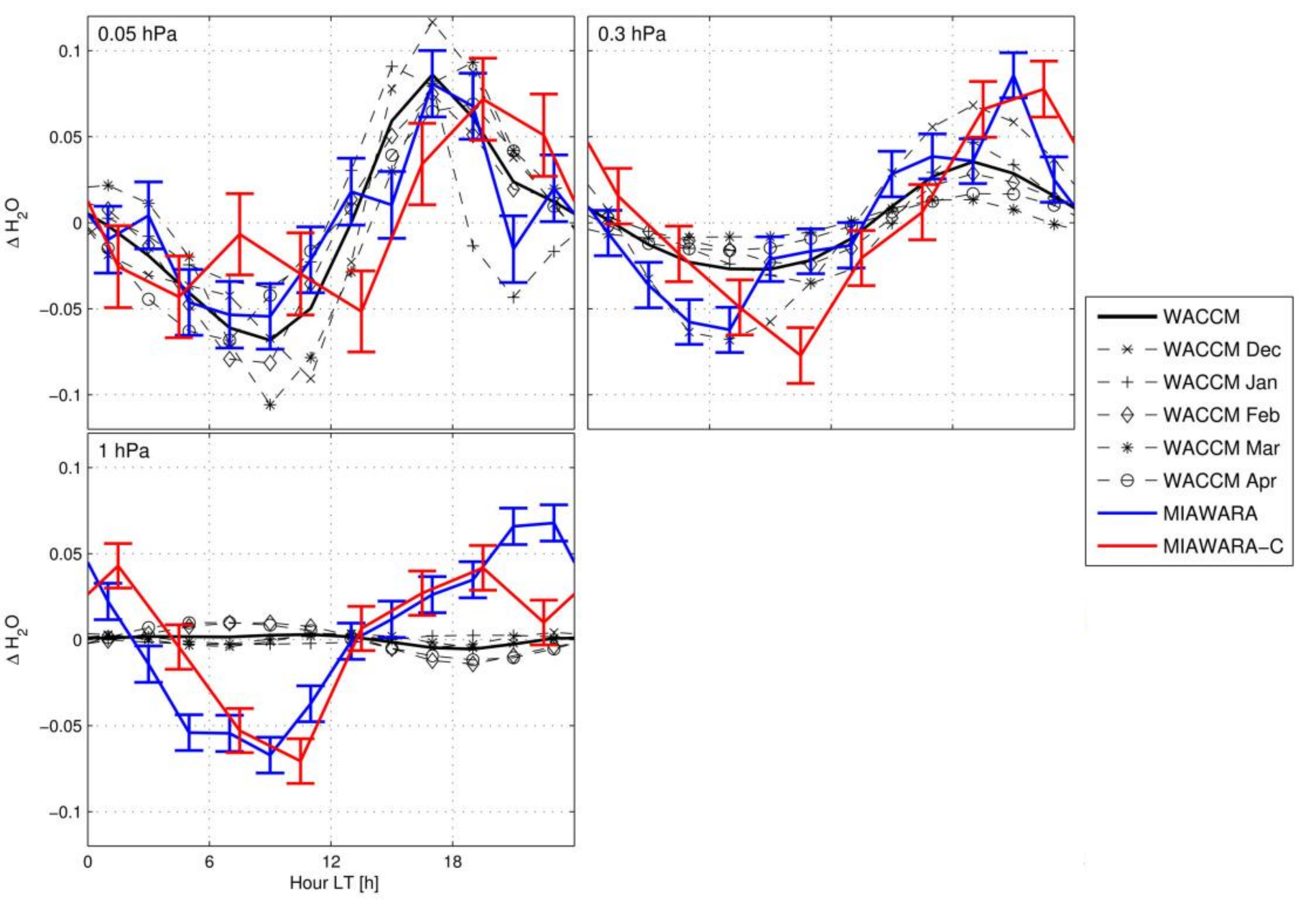

Diurnal variability of middle atmospheric H_2O

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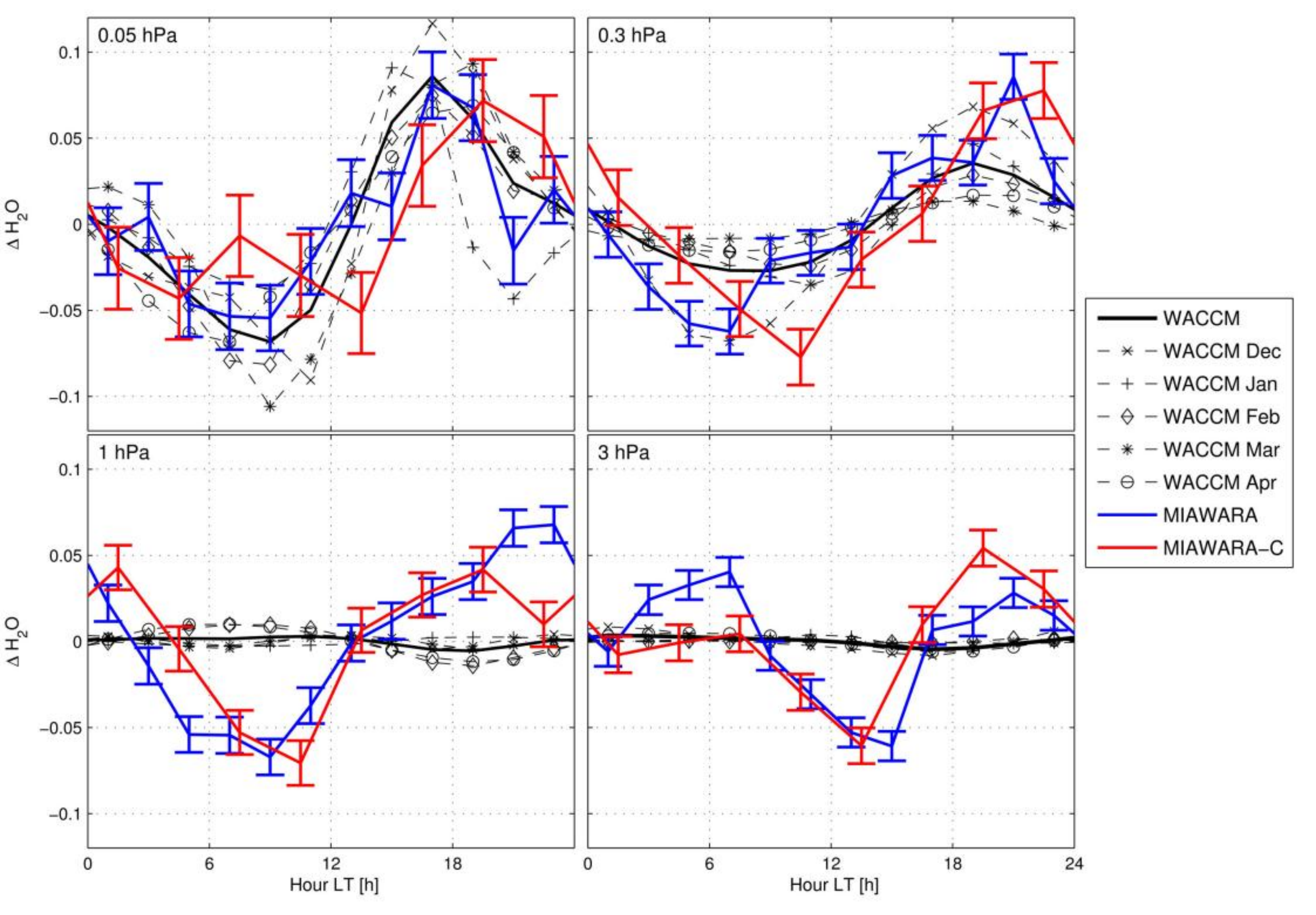

Diurnal variability of middle atmospheric H_2O

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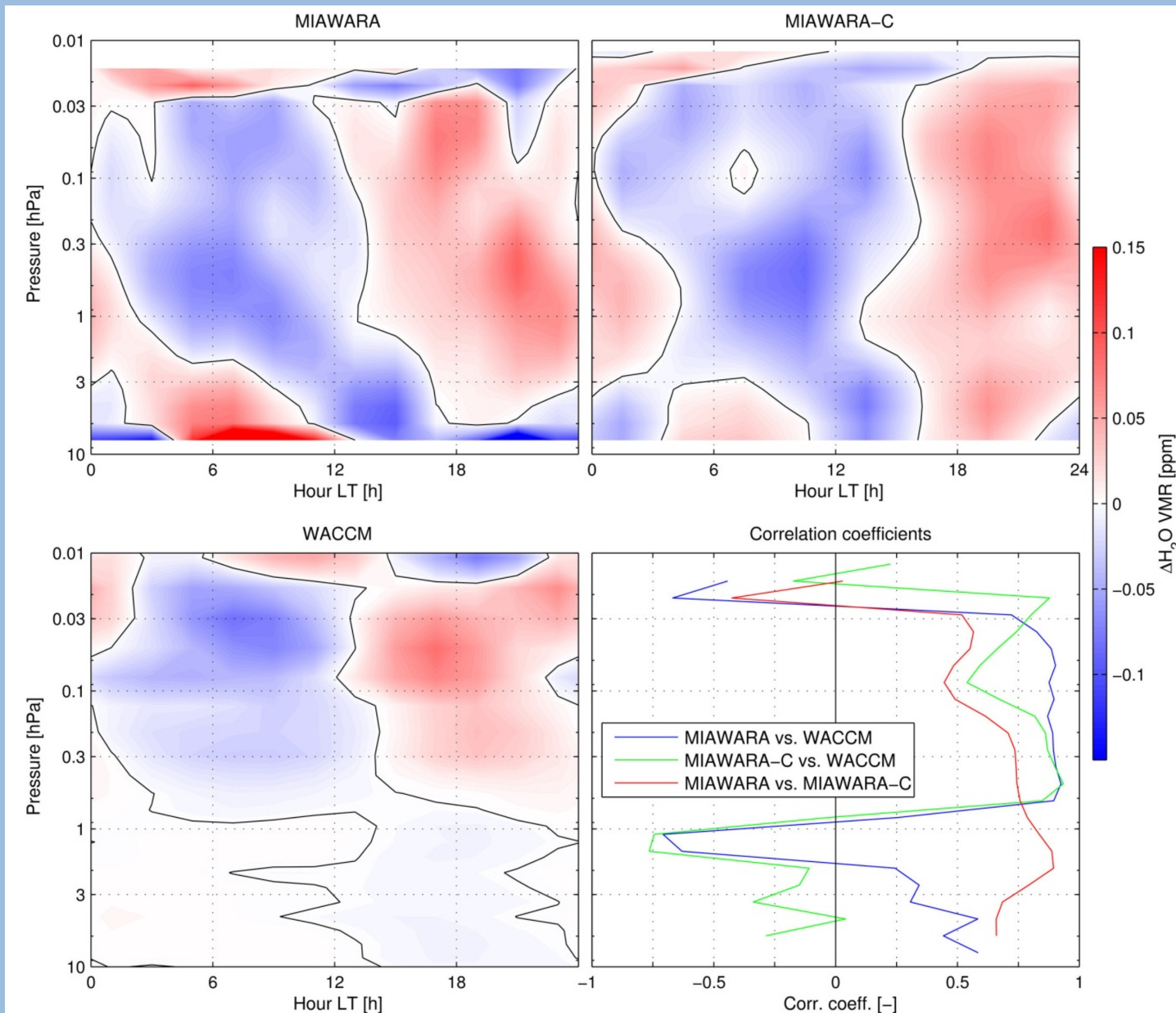
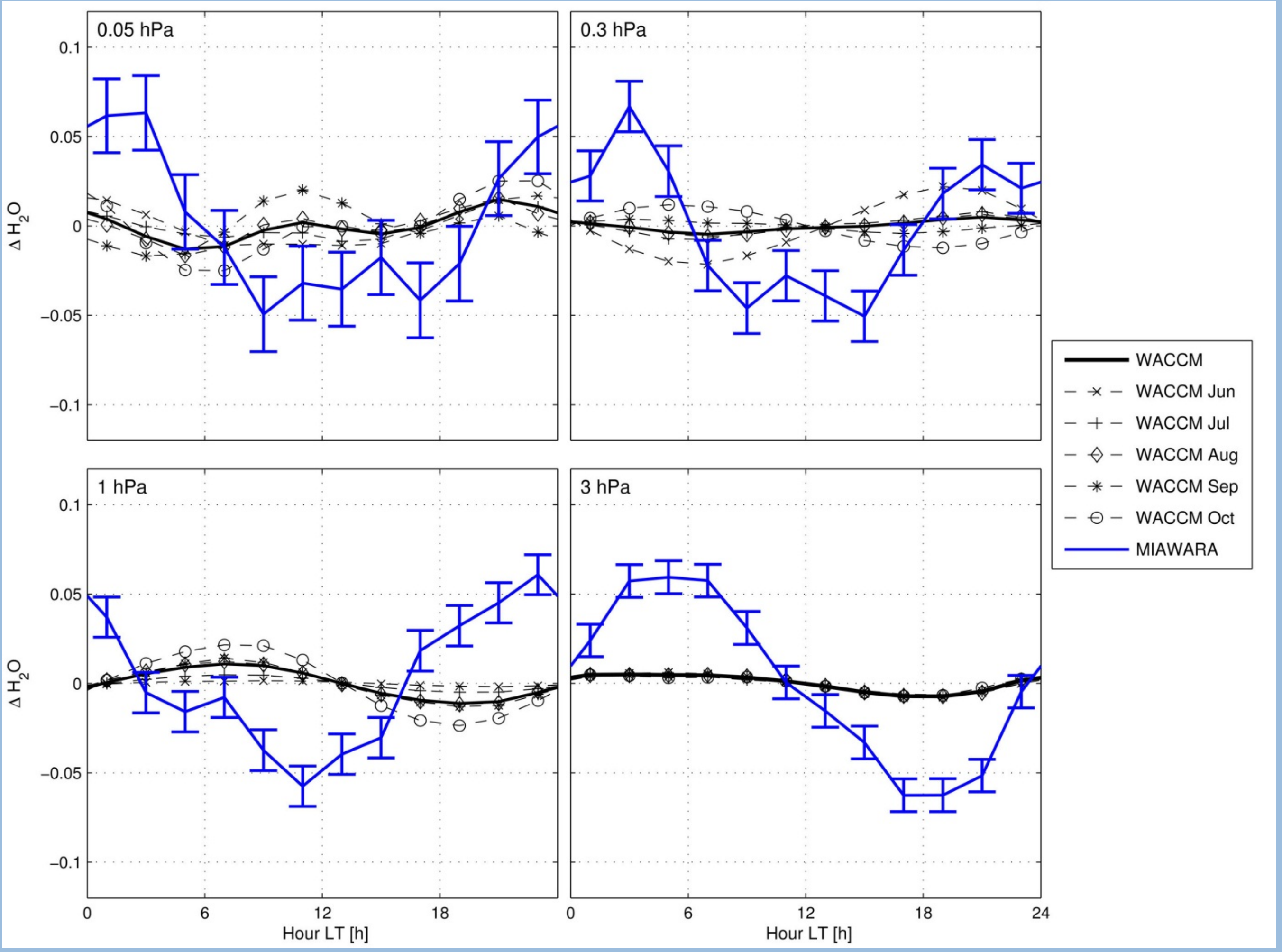


- Good agreement between MIAWARA and MIAWARA-C
- Good agreement between observations and model in the mesosphere
- Agreement in amplitude decreases with decreasinig height
- Altitude offset in the phase shift at the stratopause region

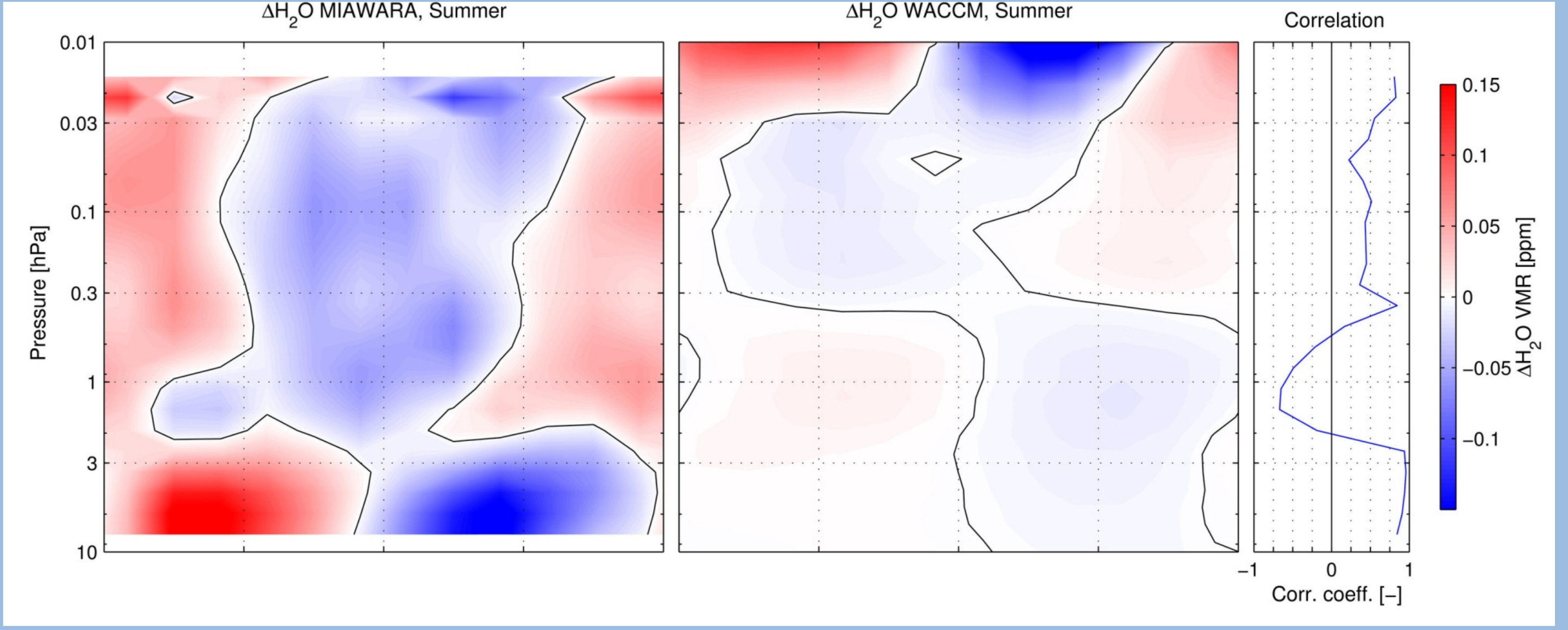
Diurnal variability of middle atmospheric H_2O

Summer (Jun - Oct)



Diurnal variability of middle atmospheric H_2O

Summer (Jun - Oct)



- For summer, only MIAWARA is available
- Agreement between observations and model is worse than during winter
- Altitude offset in the phase shift at the stratopause also in summer

Origin of the diurnal cycle according to WACCM

The material derivative:

$$\frac{d\Psi}{dt} = \frac{\partial \Psi}{\partial t} + u\frac{\partial \Psi}{\partial x} + v\frac{\partial \Psi}{\partial y} + w\frac{\partial \Psi}{\partial z}$$

Total derivative from a Lagragian perspective

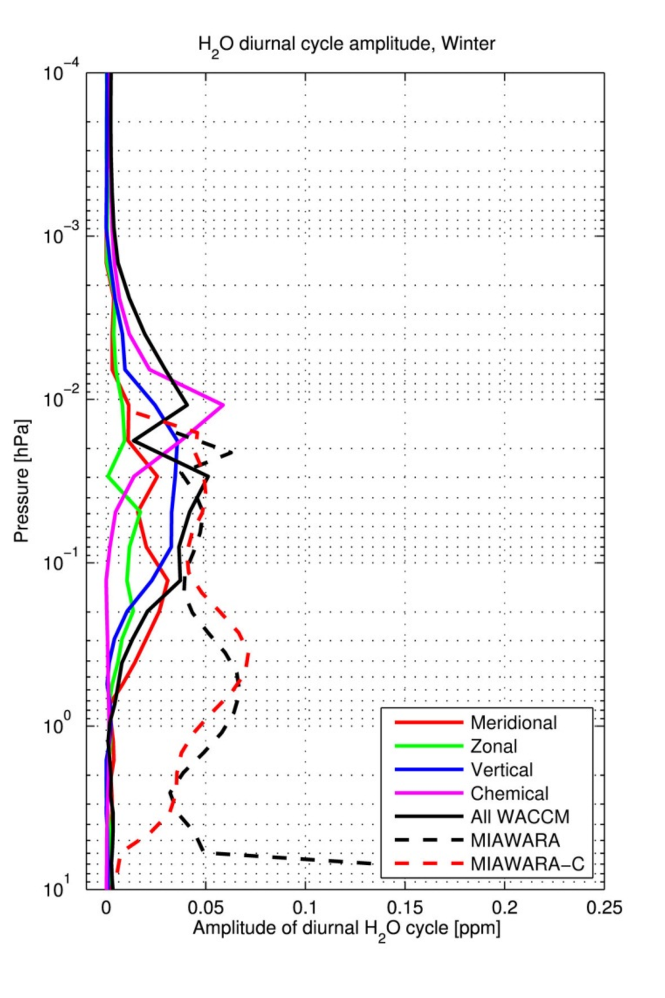
Local derivative from a Eulerian perspective

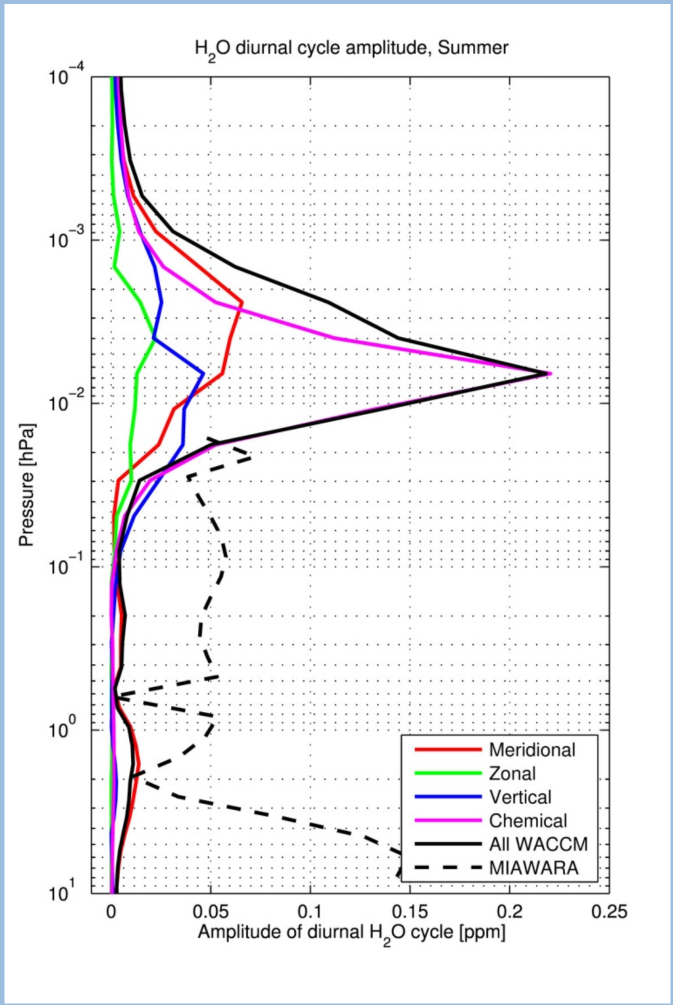
Advection terms

To derive each term’s diurnal amplitude, we

- integrate each term individually and
- determine the diurnal amplitudes for each integrated term.

Origin of the diurnal cycle according to WACCM





- Above 0.02 hPa: Photochemistry
- Between 0.1 and 0.02 hPa: Vertical advection
- Below 0.1 hPa: Meridional advection

Conclusions

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Diurnal variations in H_2O are observed by our radiometers

- Qualitative agreement with WACCM
- Altitude offset between WACCM and MIAWARA(s)
- Differences in diurnal amplitudes (reason for that remains unclear)
- Origin of the diurnal cycle in mesospheric H_2O:
    - Meridional advection below 0.1 hPa (approx. 64 km)
    - Vertical advection above 0.1 hPa
    - Photochemistry above 0.02 hPa (approx. 76 km)

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Thank you for your attention!

Questions?