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A reference water vapor profile above ALOMAR from ground-based microwave observations.

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Introduction

The vertical distribution of water vapor is of interest for a diverse set of atmospheric models, from spectral transmittance models to large-scale climate models.

Although the middle atmosphere at polar latitudes display interesting phenomena closely related to the available water vapor there is a lack of up to date reference profiles. We here present such a profile for a standard year based on 14 years of ground-based microwave observations.

Observations

We have been observing the middle atmospheric water vapor above ALOMAR since 1996. Over time the observing instrument has changed; different backend spectrometers has been used, the receiver has been refurbished and in 2008 a completely new instrument was installed.

In order to minimize differences between the instruments the WASPAM-data has been reanalyzed with the updated retrieval process developed for cWASPAM, which *e.g.* use a different approach for baseline removal.

Data version	v3.1	v3.2	v3.3	v3.4
Frontend	WASPAM	WASPAM	WASPAM	cWASPAM
Bandwidth [MHz]	40	180	40	40
Spectral resolution	20 kHz	44 kHz	10 kHz	10 kHz
In operation	1995 - 2002	2002 - 2005	2004 - 2006	2008 - . . .

Retrieval method

All data has been retrieved with a 168 hour (1 week) integration time. The long integration time increase the sensitivity at high altitude which is especially important for WASPAM, which was less sensitive than cWASPAM.

The background atmosphere needed for the inversion consist of true atmospheric data from NCEP nudged to CIRA86 model data. During summer the CIRA86 temperatures are modified with a falling sphere climatology.

In addition to the background atmosphere the inversion calculation needs an a priori profile. We employ the same, piecewise linear, profile over the whole year.

Figure: cWASPAM1 on location at ALOMAR.

Results

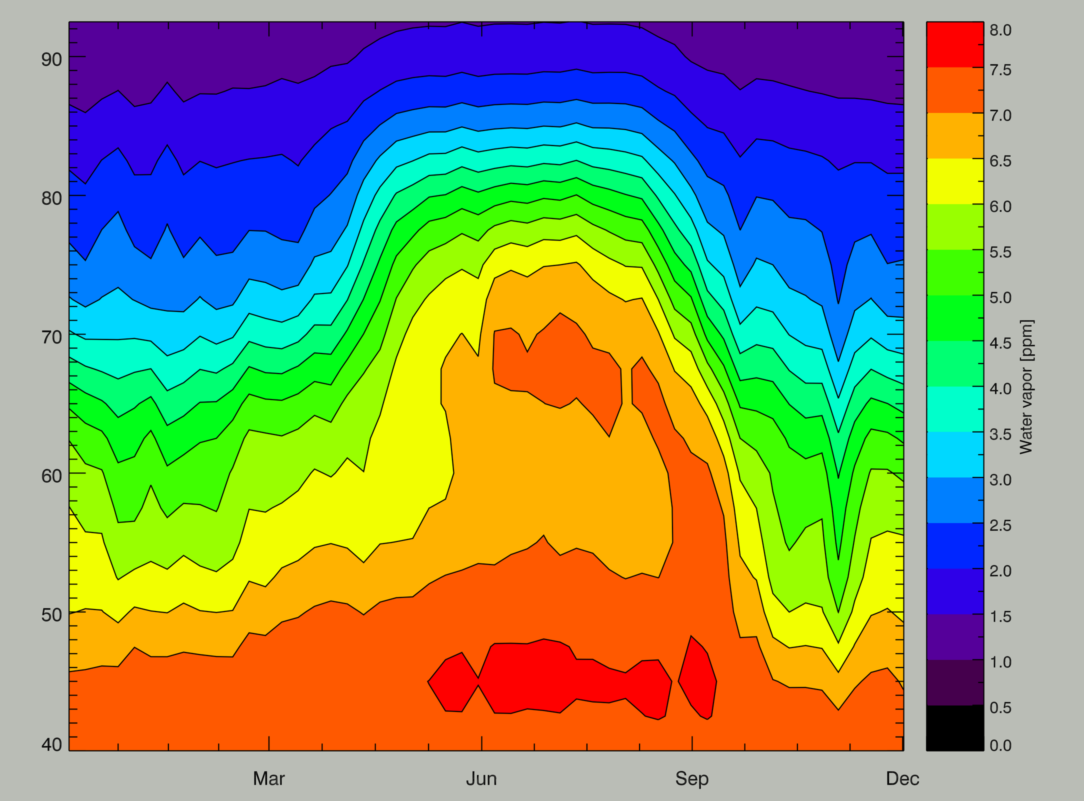


Figure. The mean yearly water vapor above ALOMAR.

The above figure show the water vapor variation for a mean year as observed by our instrument and the most obvious feature is the well known annual variation. The figure at the bottom show the same state of affairs for 4 separate layers; 50, 60, 70 and 80 km. In addition to the mean level of water vapor the variability over the years is plotted as dashed lines.

A secondary maximum due to autocatalytic production of water can be seen in the contour plot. Initially only visible at high altitude it slowly expands downwards.

The variability of water vapor in the two lower altitude layers has a maximum during winter whereas the opposite is true for the higher altitudes. This is to be expected as the state of the atmosphere during winter in the northern hemisphere is very unstable and characterized by a high degree of variability. In general the variability at high altitude is lower than at low altitude and more importantly maximizes during summer.

The variability during the transitional periods is small which indicates that this yearly behavior is stable. No drift in the onset of the transition has been found during the observed time.

A similar stable behavior can be seen for the 80 km layer. The very strong annual variation is much less evident in the 50 and 60 km layers from the point of view of available water vapor.

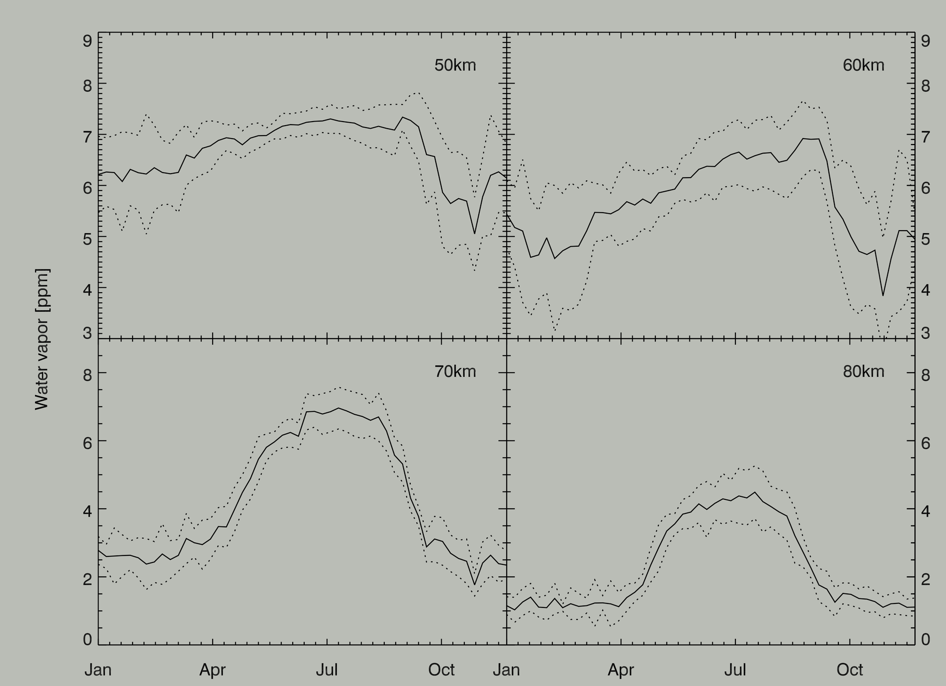


Figure. The yearly mean distribution at four different altitudes. The dotted line demarks the yearly standard deviation from the mean.

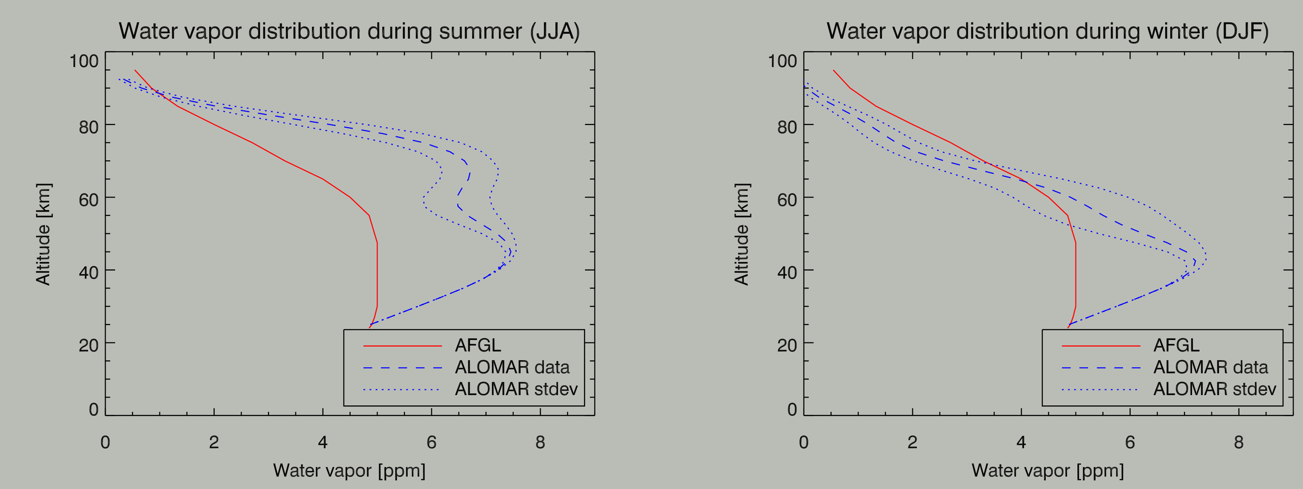
Comparison to AFGL model

In the figures below the vertical water vapor profile from the Air Force Geophysics Laboratory (AFGL) Atmospheric Constituent Profiles (1986) for a subarctic (60N) location can be seen in comparison with the observed profiles. In Figure (a) summer (JJA) conditions are compared and (b) shows winter (DJF) conditions.

The observed water vapor profile differ significantly between summer and winter season, especially at high altitude.

In the case of the AFGL profiles the difference between summer and winter is small and located in the lower region of the atmosphere (<30 km, which is below our sensitivity limit).

In general the AFGL profiles underestimate middle atmospheric water vapor with the largest difference at high altitude during the summer season at high altitude.



(a) (b)

Figure: Comparison of the observed water vapor above ALOMAR to the AFGL Atmospheric constituent profiles for a subarctic location. Figure (a) shows summer (JJA) conditions and (b) winter (DJF) conditions.

Summary

- 14 years of ground-based microwave observations of water vapor above a polar location (ALOMAR, 69N) has been averaged to compile a mean year with a weekly time-step.
- The annual variation is very stable and no drift in transition onset has been detected.
- The year-to-year variability is larger during winter for the lower altitudes whereas the opposite is true for higher altitudes.
- A secondary maximum due to autocatalytic production of water vapor is clearly visible.
- The observed vertical water vapor profile differ significantly from available constituent profile models (such as AFGL). The difference is larger during summer than during winter.

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