

## Intercomparison of Middle Atmospheric Water Vapor Measurements from EOS-MLS, HALOE, and WVMS

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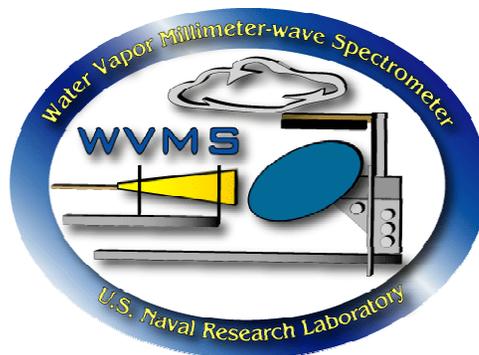
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Richard Bevilacqua (NRL)

Jim Russell III (Hampton Univ.)

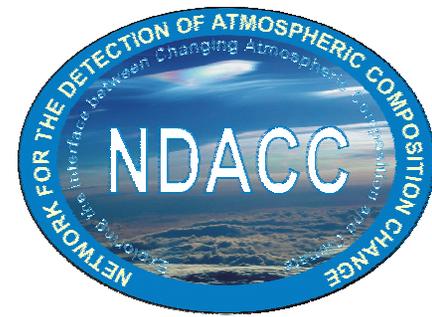
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Alyn Lambert (JPL/Cal Tech)





## Water Vapor Millimeter-wave Spectrometer (WVMS)



WVMS measurements are currently being made at 3 sites of the Network for the Detection of Atmospheric Composition Change (NDACC):

Lauder, New Zealand ( $45^{\circ}\text{S}$ ,  $169.7^{\circ}\text{E}$ ):

Nov. 1992-Apr. 1993, Jan. 1994-present

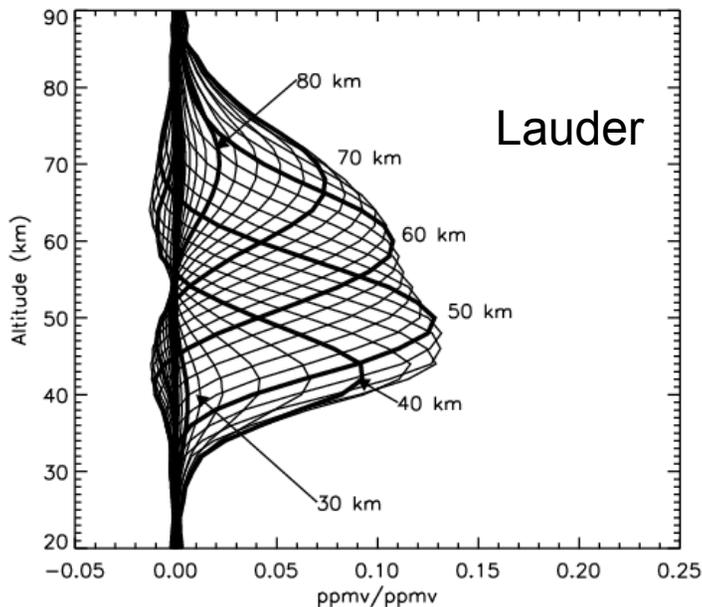
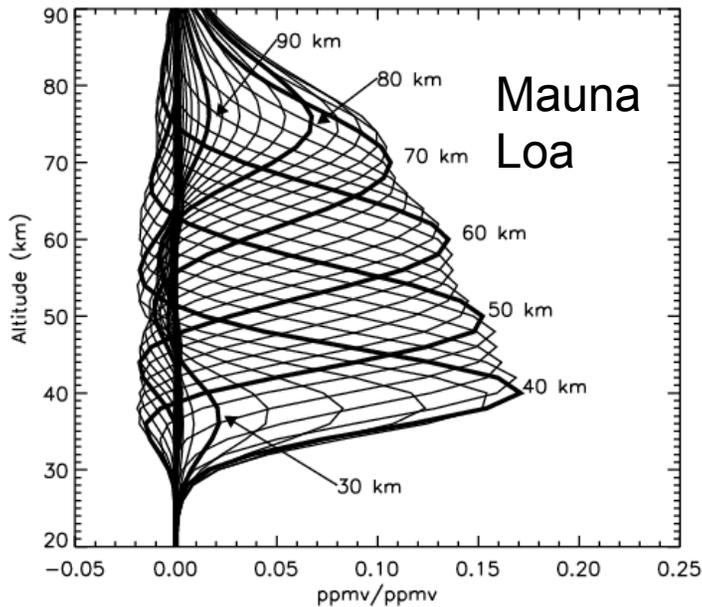
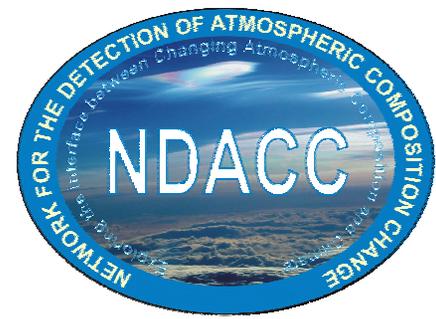
Table Mountain, CA ( $34.4^{\circ}\text{N}$ ,  $242.3^{\circ}\text{E}$ ):

May 1993-Nov. 1997, Nov. 2003-present

Mauna Loa, HI ( $19.5^{\circ}\text{N}$ ,  $204.4^{\circ}\text{E}$ ):

Mar. 1996-present





Whenever we compare WVMS measurements with satellite measurements we always need to convolve with the WVMS averaging kernels.

In convolving satellite data we assume that the satellite measurements have perfect vertical resolution.

Averaging Kernels are somewhat site specific. Mauna Loa measurements (taken from a higher and dryer site) have a slightly better vertical resolution and are sensitive to a larger range of altitudes.



### 3 Instrument Coincidence periods at Mauna Loa

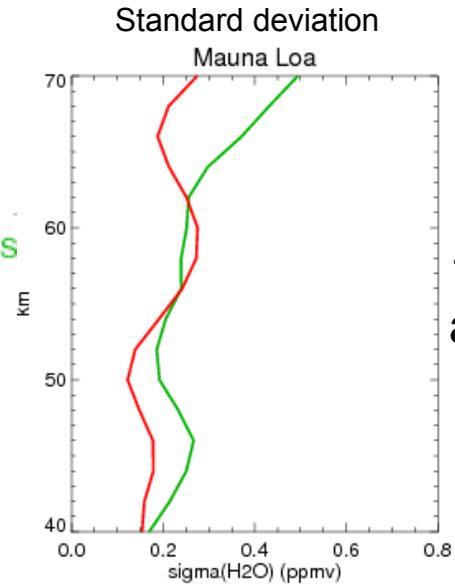
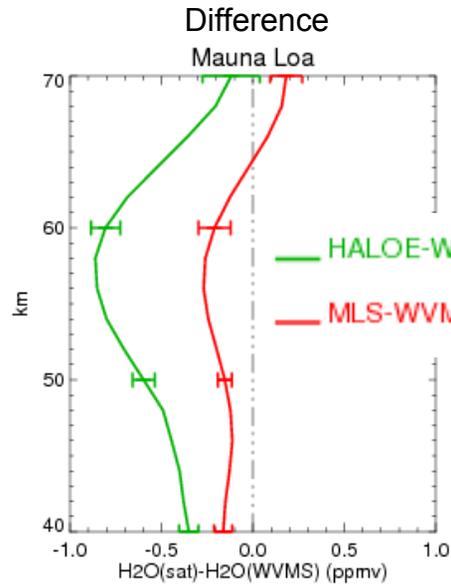
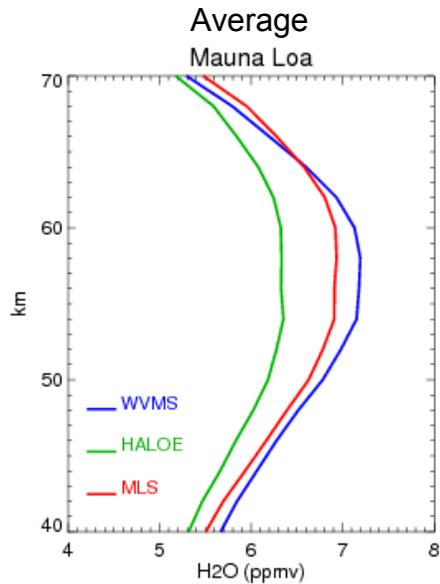
Dates	Number of HALOE measurements	Number of MLS measurements
Nov. 17-24, 2004	58	1362
Jan. 24-31, 2005	53	1403
Feb. 24-Mar. 3, 2005	11	1365
Mar. 10-18, 2005	23	1395
May 4-11, 2005	30	1171
May 17-24, 2005	14	718
May 24-31, 2005	17	945
July 13-20, 2005	15	1044
July 20-27, 2005	15	1239
Nov. 7-15, 2005	28	1332

~1-week periods where we can integrate the WVMS measurements and find coincident => within +/-5° latitude measurements from both **MLS** and **HALOE**

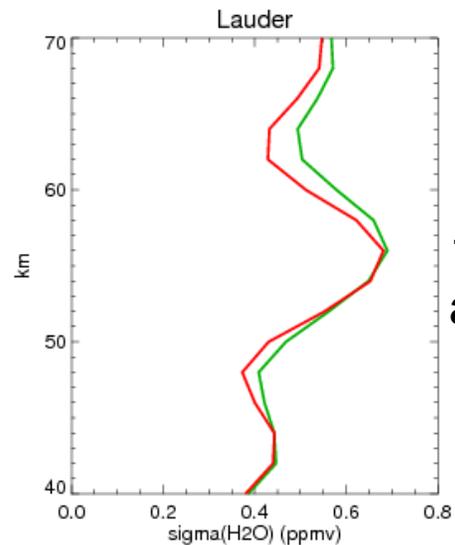
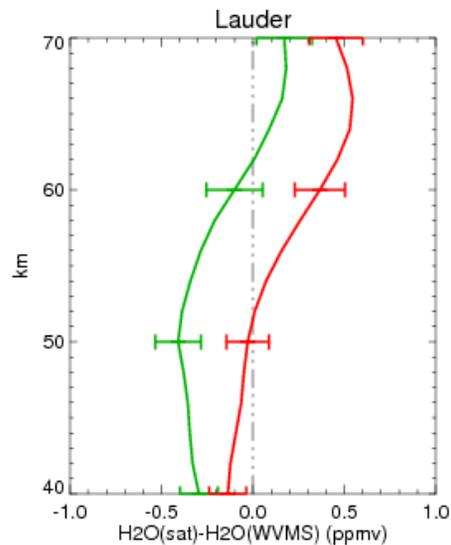
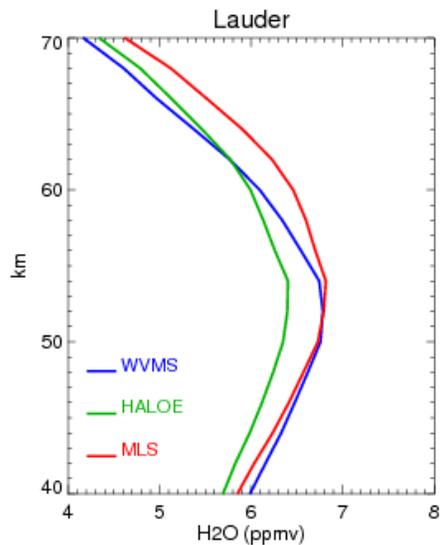
### 3 Instrument Coincidence periods at Lauder

Dates	Number of HALOE measurements	Number of MLS measurements
Aug. 22-28, 2004	37	1093
Aug. 28-Sept. 5, 2004	8	1076
Sept. 21-28, 2004	40	1124
Apr. 19-25, 2005	37	931
Apr. 15-May 1, 2005	35	915
May 7-13, 2005	49	1151
May 19-24, 2005	13	701
May 24-31, 2005	64	941
June 6-12, 2005	65	1326
June 29-July 6, 2005	31	1291
July 6-11, 2005	47	1299
July 17-23, 2005	33	1269
Aug. 17-23, 2005	62	1307
Nov. 11-18, 2005	14	1149

# 3-instrument (WVMS, HALOE, MLS) coincidence periods



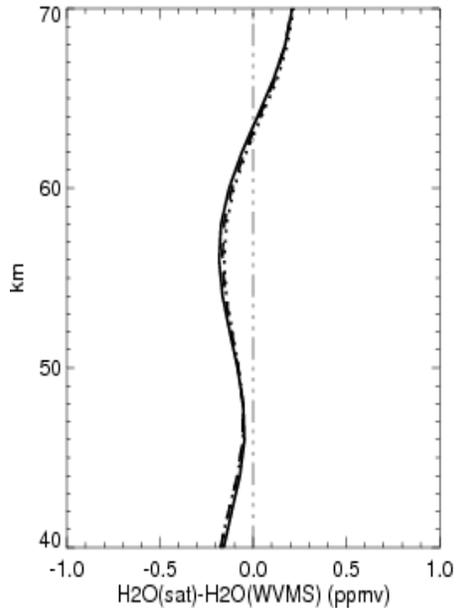
10 WVMS weeks  
at Mauna Loa



14 WVMS weeks  
at Lauder

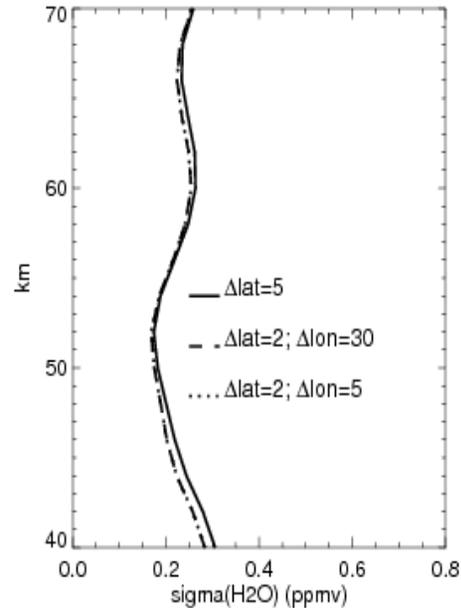
# MLS-WVMS

Mauna Loa



Standard deviation

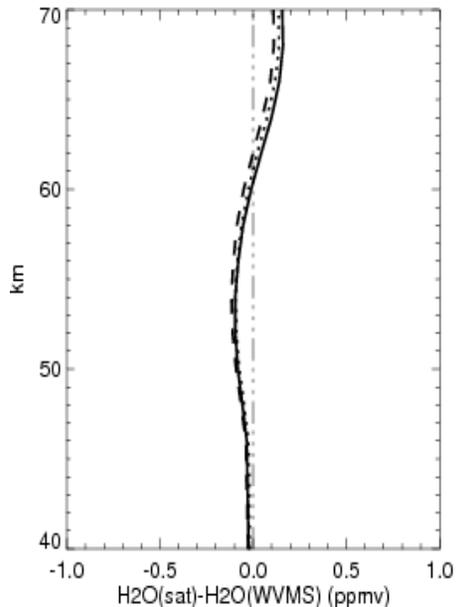
Mauna Loa



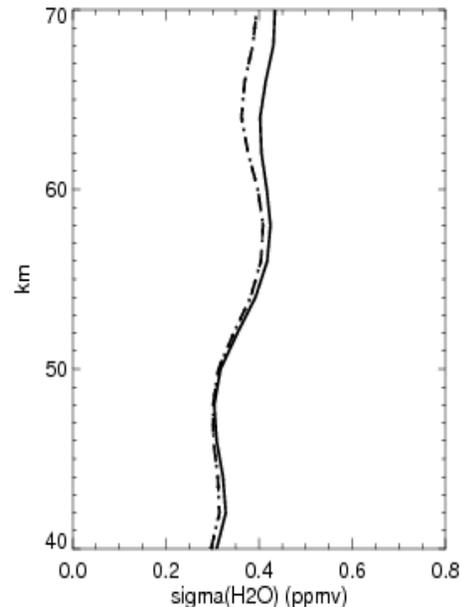
Comparisons between all **MLS v1.5** and **WVMS** coincident measurements (HALOE coincidence not required).

Comparisons between 1-week **WVMS** retrievals and **MLS** are not particularly sensitive to choice of coincidence criteria

Lauder



Lauder



—  $\Delta\text{lat}=5$   
- -  $\Delta\text{lat}=2; \Delta\text{lon}=30$   
...  $\Delta\text{lat}=2; \Delta\text{lon}=5$

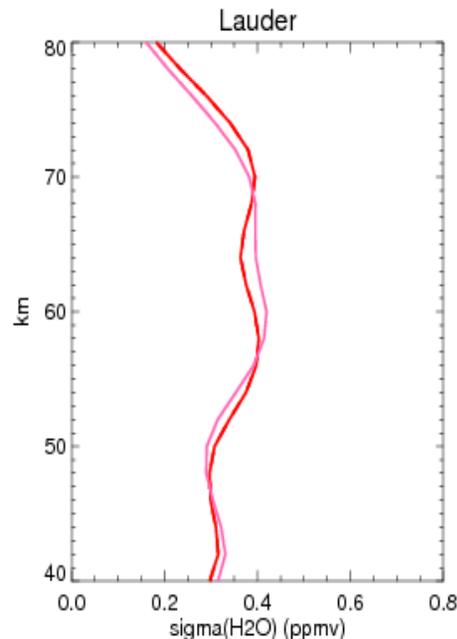
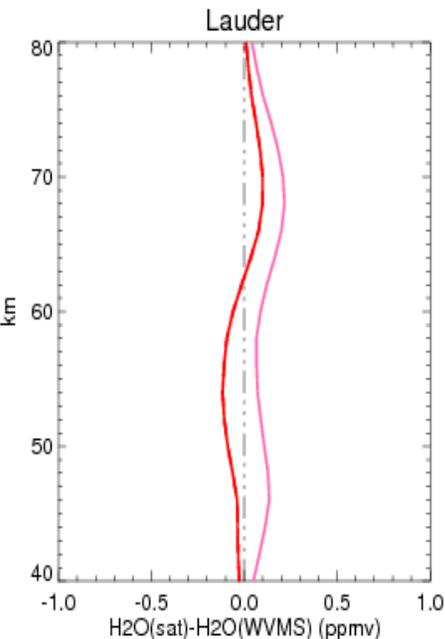
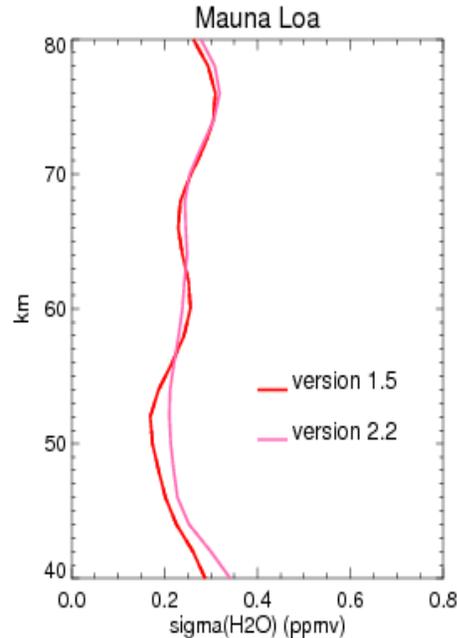
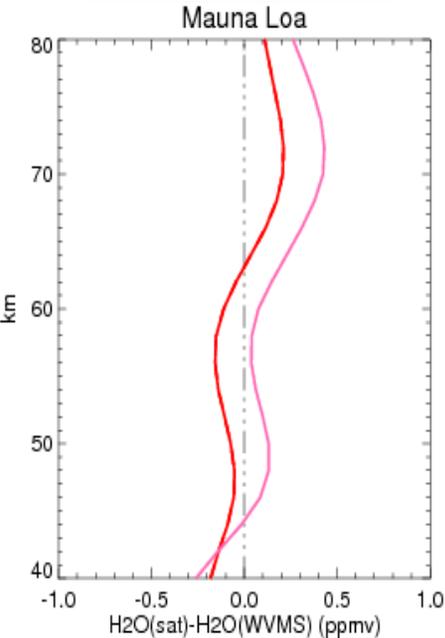
# MLS-WVMS

## Standard deviation

Differences between WVMS and available MLS v1.5 and v2.2 measurements.

The v1.5 and v2.2 comparisons are not over exactly the same time periods – which makes the agreement in shift between the two sites all the more encouraging.

The feature below ~45km at Mauna Loa is caused by slightly unusually high water vapor mixing ratios in the WVMS measurements near these altitudes in 2007.



# Daily average MLS data and weekly WVMS retrievals at Mauna Loa

80 km comparisons look okay – this is the top edge of the WVMS retrieval range.

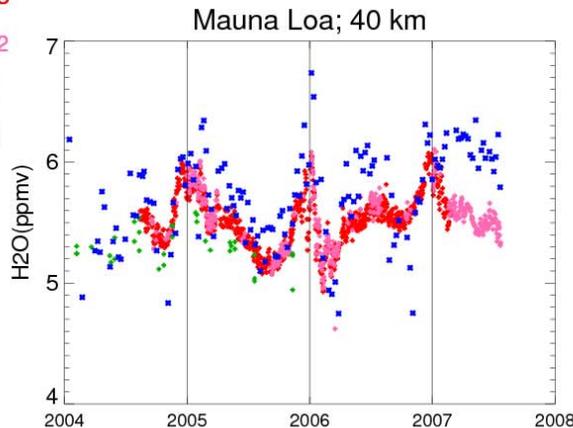
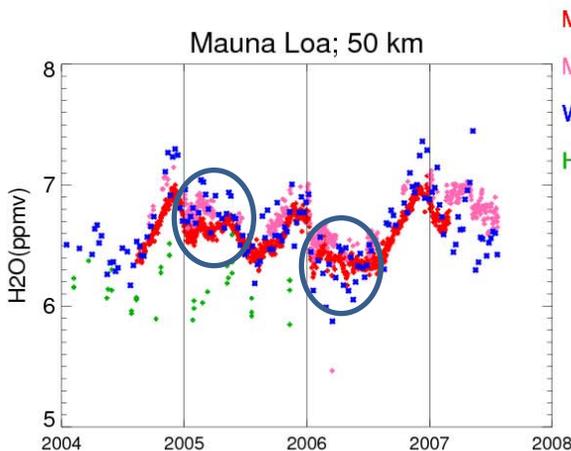
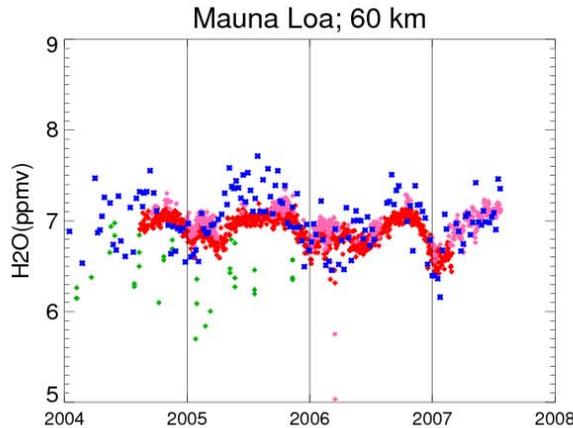
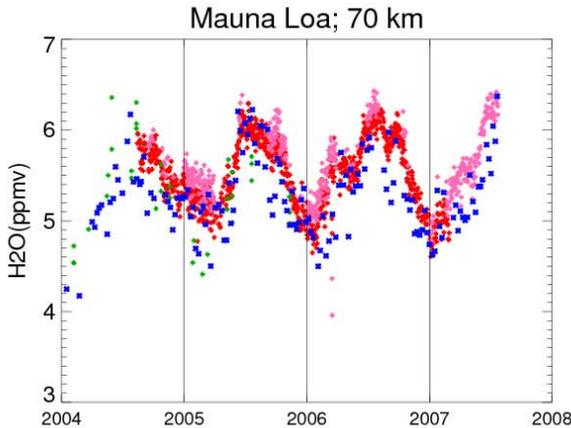
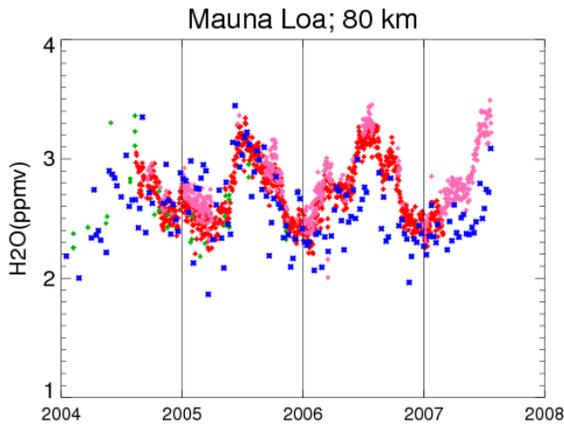
70 km comparisons look excellent

60 km comparisons look good – may look better when v2.2 summertime data is filled in for 2005 and 2006

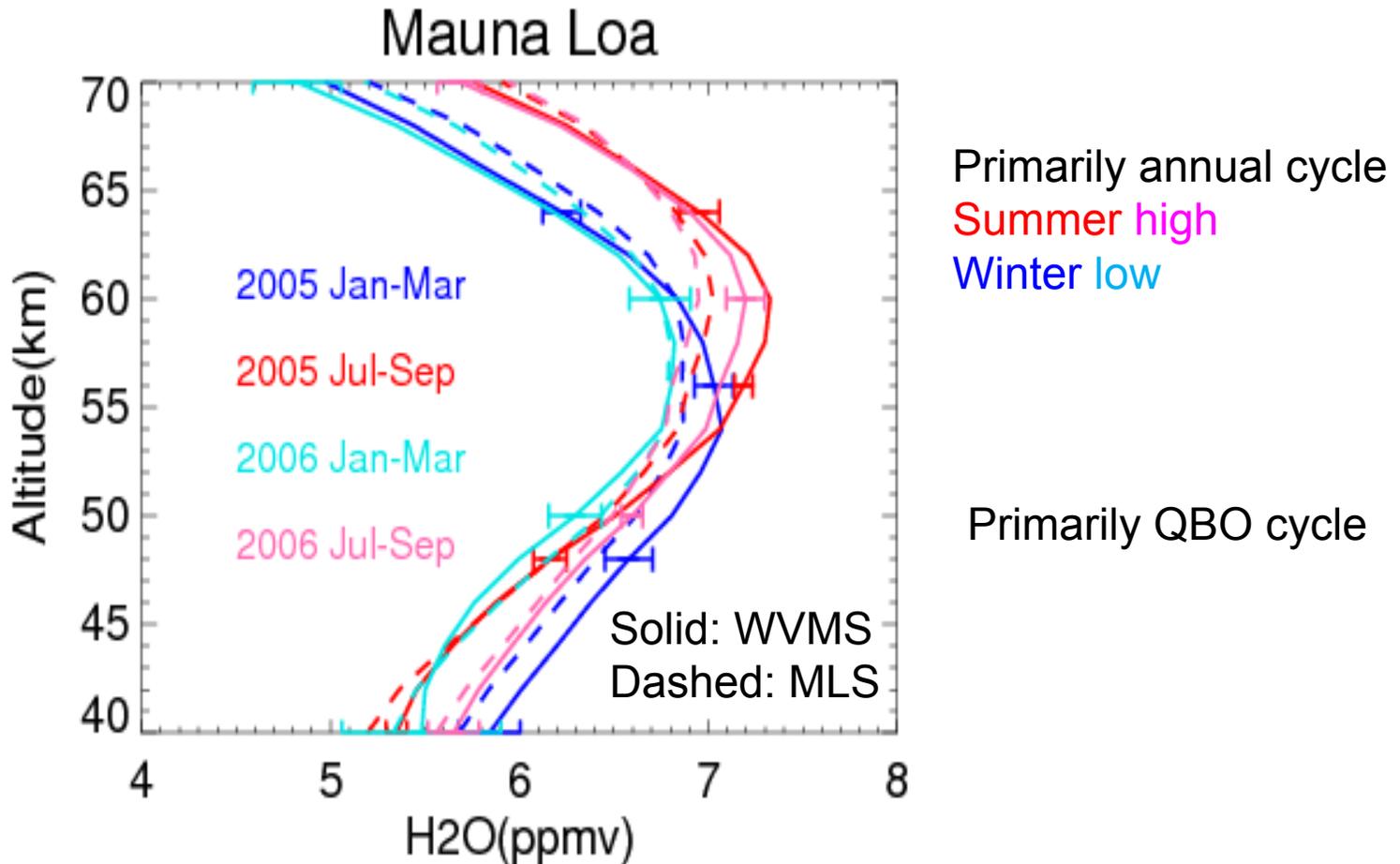
50 km comparisons show QBO – higher water vapor in 2005 than 2006

MLSv1.5  
MLSv2.2  
WVMS  
HALOE

40 km comparisons generally okay – this is the bottom edge of the WVMS retrieval range.



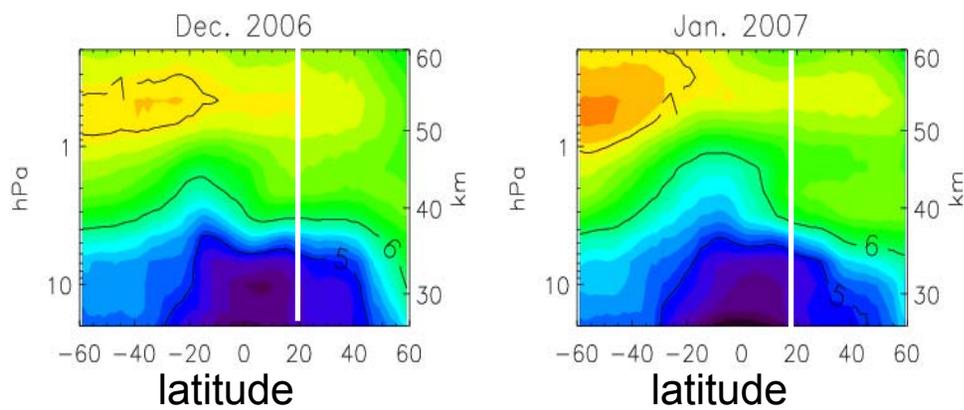
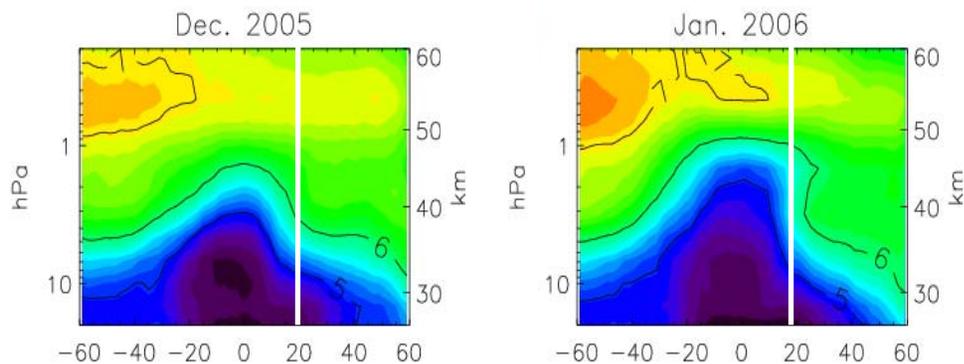
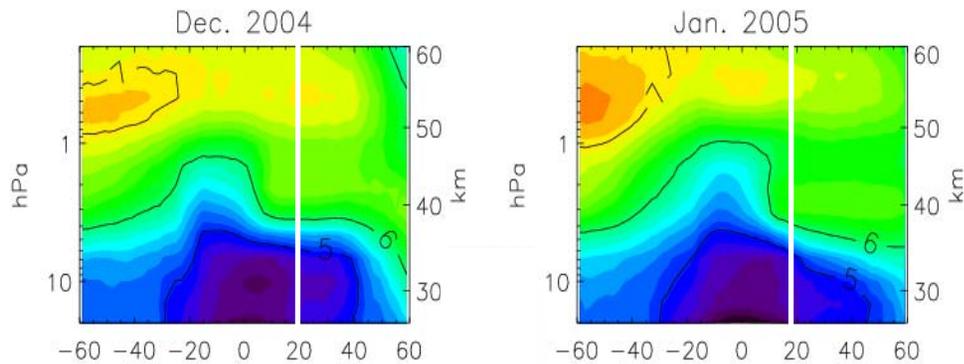
# 3-month average profiles (MLS v1.5)



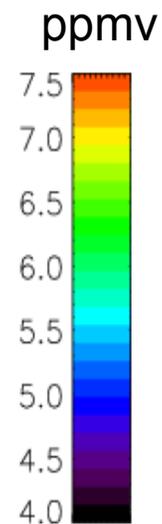
Both instruments show that:

Jul-Sep 2005 < Jul-Sep 2006 in stratosphere

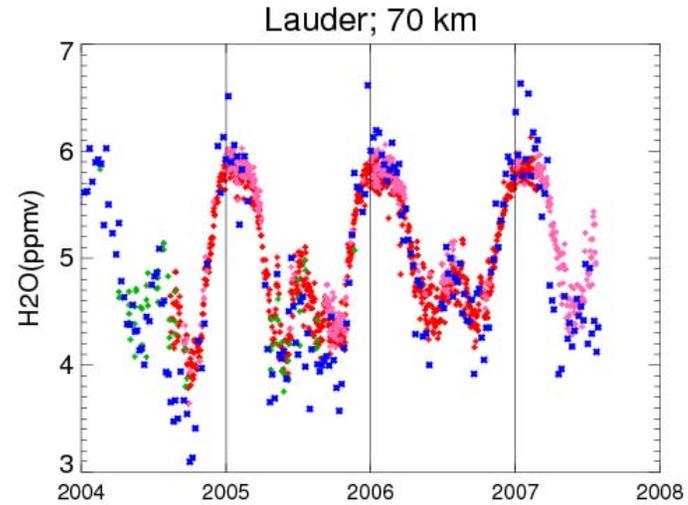
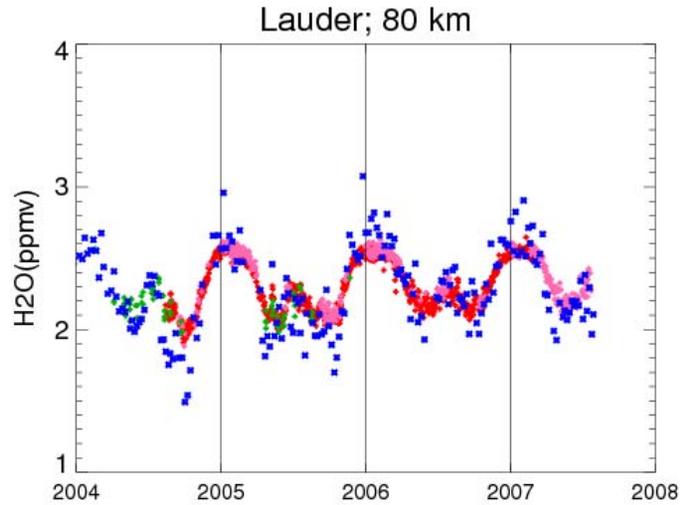
Jan-Mar 2006 < Jan-Mar 2005 in stratosphere



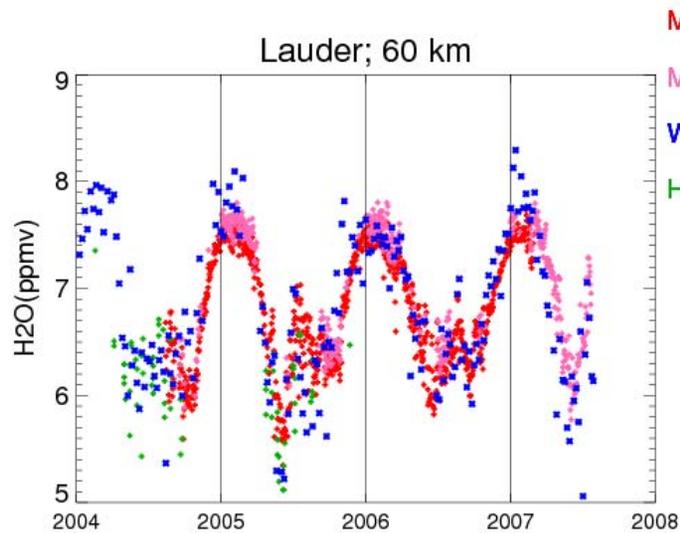
QBO effects reach the 19.5°N latitude of the WVMS instrument at Mauna Loa



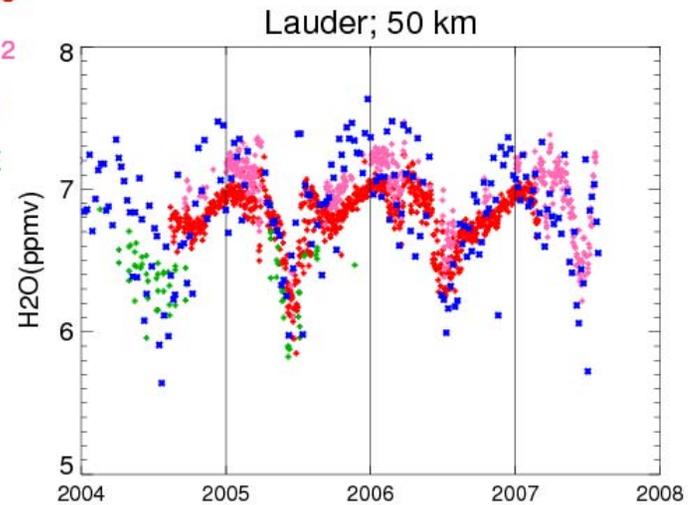
# Daily average MLS data and weekly WVMS retrievals at Lauder (45°S, 169.7°E)



MLSv1.5  
MLSv2.2  
WVMS  
HALOE

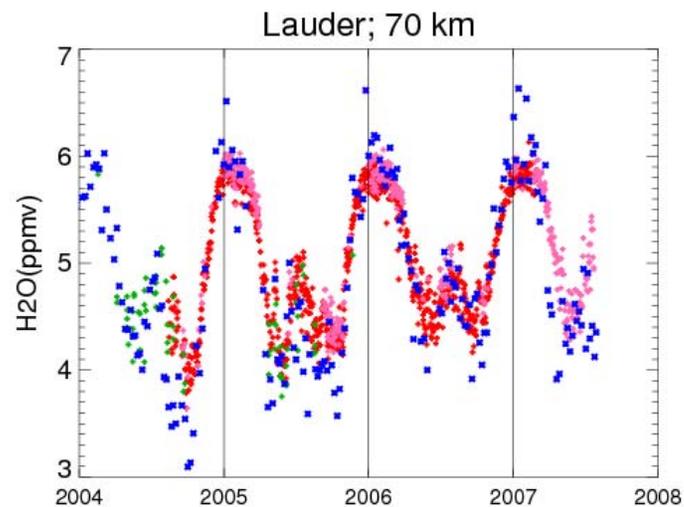
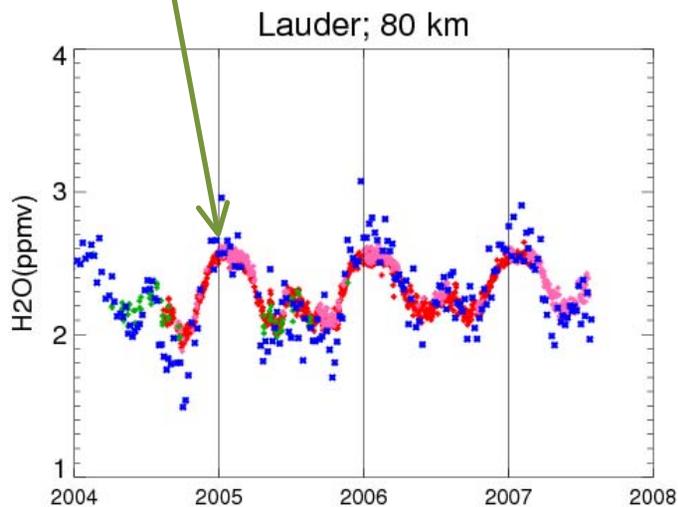


MLSv1.5  
MLSv2.2  
WVMS  
HALOE

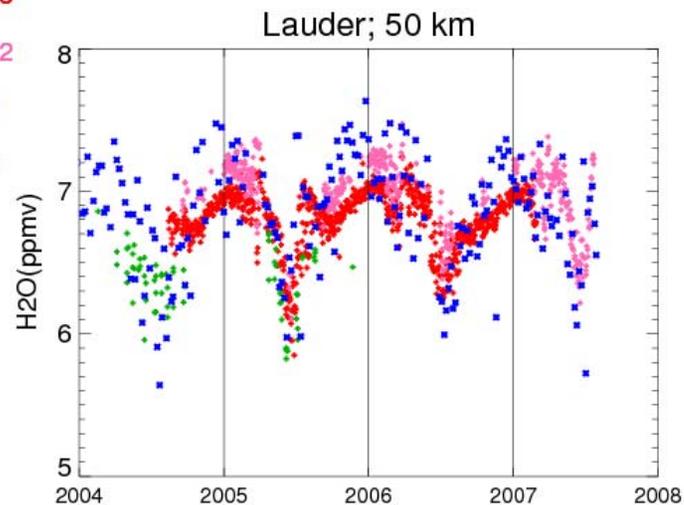
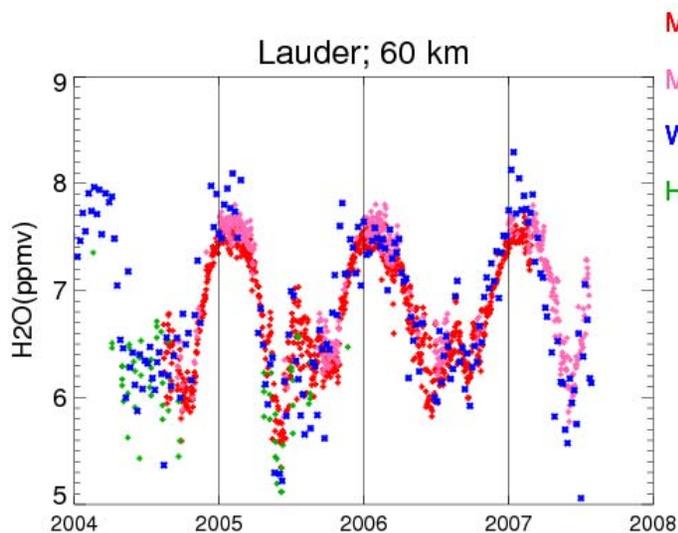


# Daily average MLS data and weekly WVMS retrievals at Lauder

80 km variations are significantly reduced by WVMS sensitivity; but agreement is good.



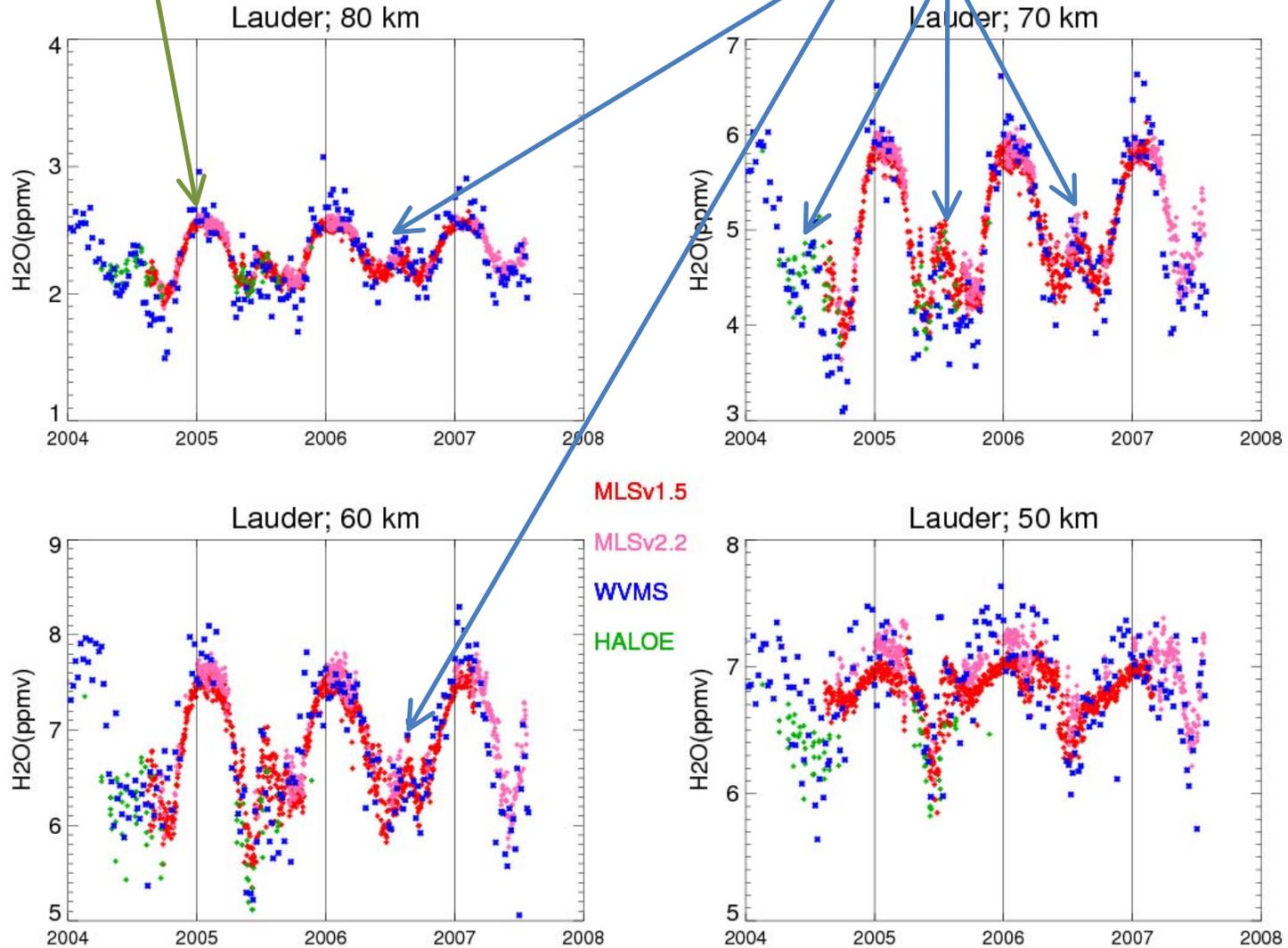
MLSv1.5  
MLSv2.2  
WVMS  
HALOE



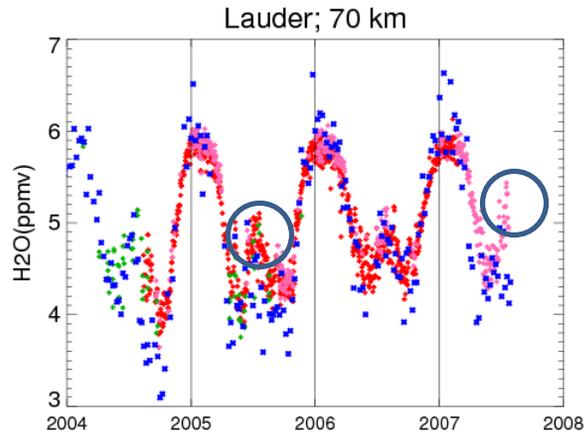
# Daily average MLS data and weekly WVMS retrievals at Lauder

80 km variations are significantly reduced by WVMS sensitivity; but agreement is good.

Good agreement in semi-annual variation

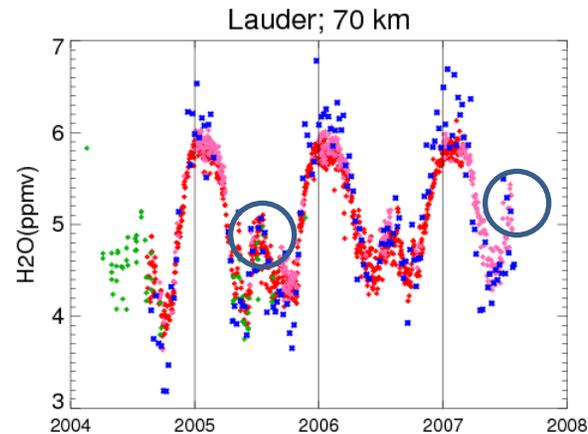


Standard WVMS retrievals using a combination of NMC temperatures and MSISE90 climatology

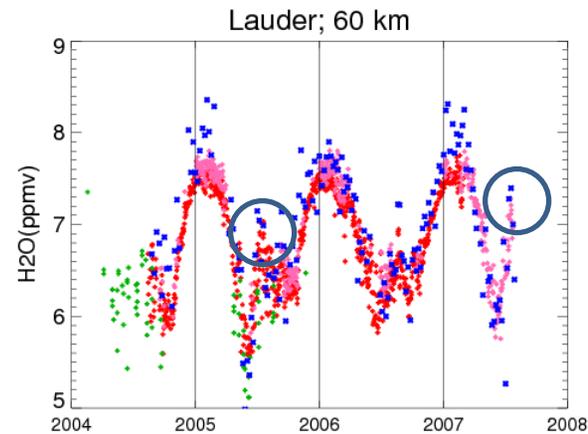
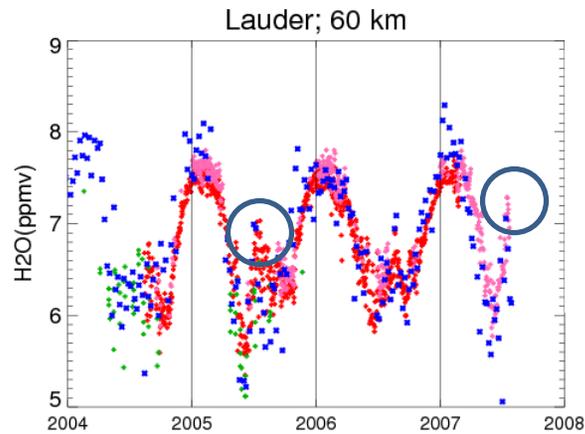


MLSv1.5  
MLSv2.2  
WVMS  
HALOE

WVMS retrievals using MLS temperatures



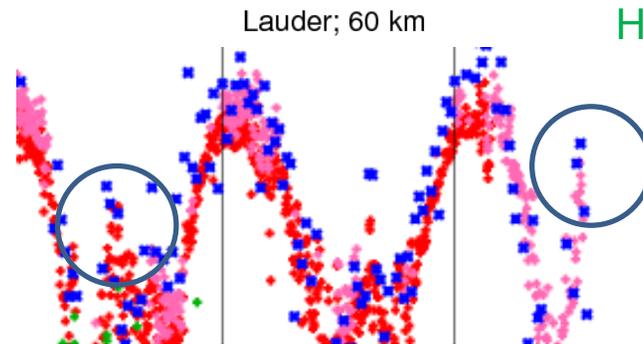
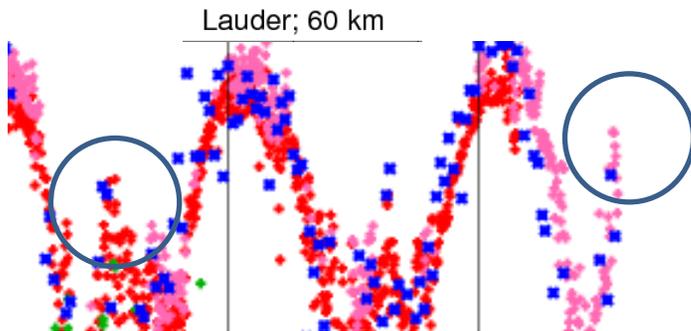
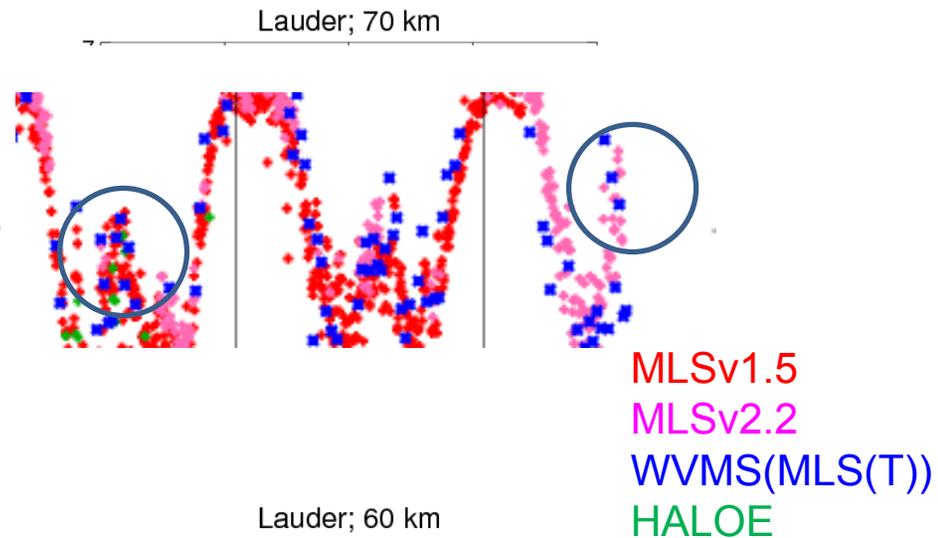
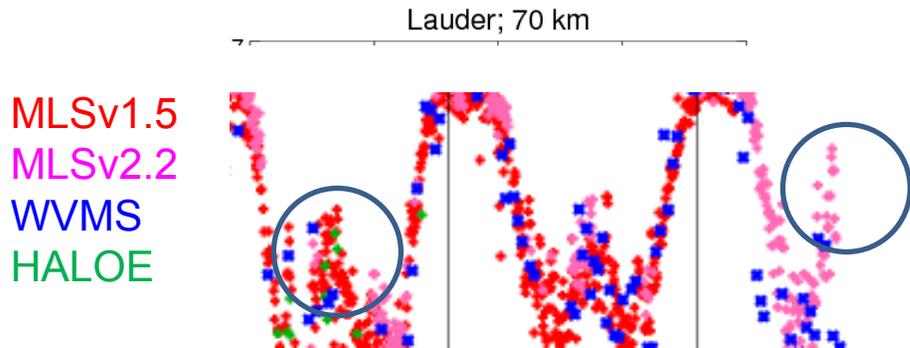
MLSv1.5  
MLSv2.2  
WVMS(MLS(T))  
HALOE



Differences are generally small, and seasonal cycles are similar, but interannual temperature variations can be important in mesospheric WVMS retrievals.

Standard WVMS retrievals using a combination of NMC temperatures and MSISE90 climatology

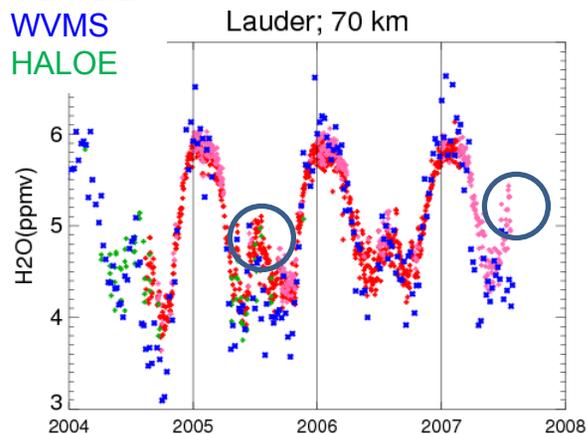
WVMS retrievals using MLS temperatures



Differences are generally small, and seasonal cycles are similar, but interannual temperature variations can be important in mesospheric WVMS retrievals.

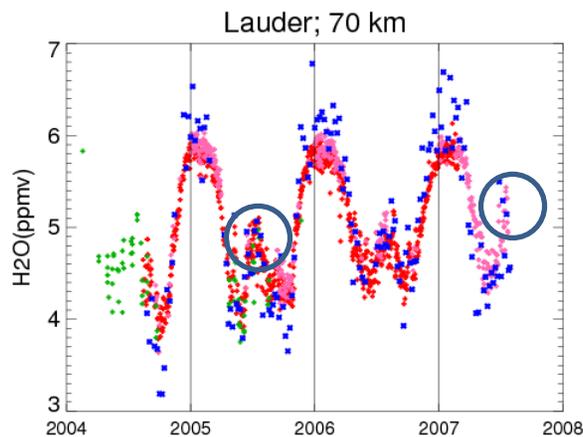
Standard WVMS retrievals  
using a combination of NMC  
temperatures and MSISE90  
climatology

MLSv1.5  
MLSv2.2  
WVMS  
HALOE

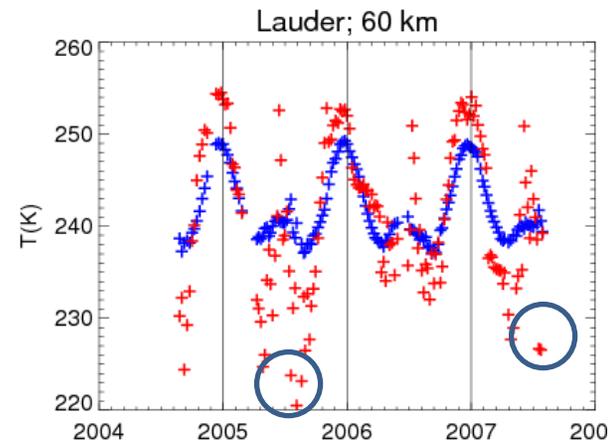
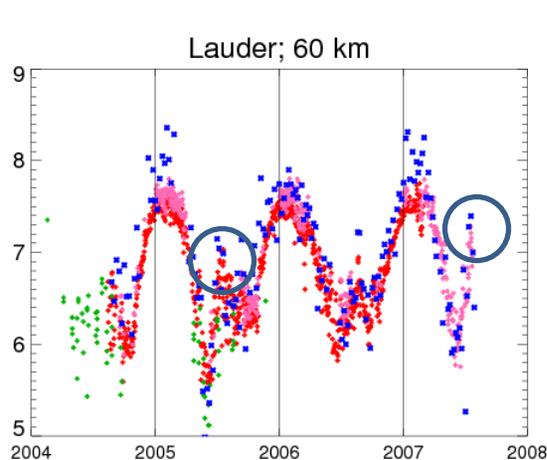
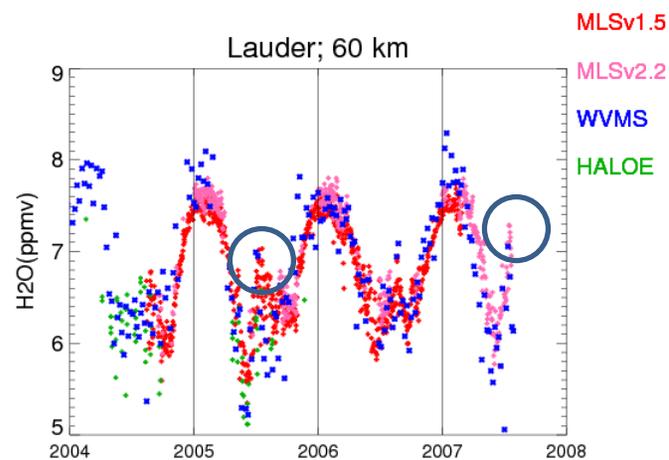
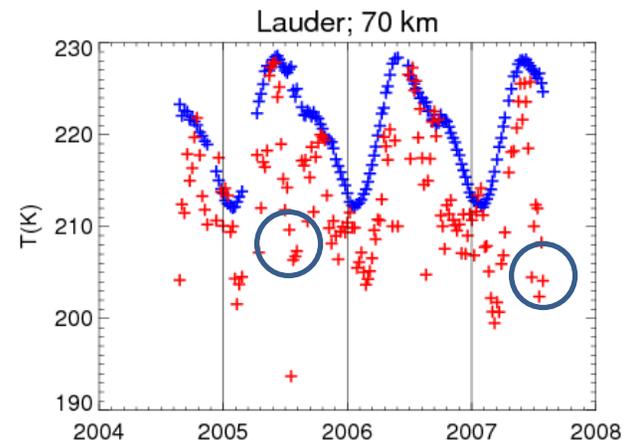


WVMS retrievals  
using MLS  
temperatures

MLSv1.5  
MLSv2.2  
WVMS(MLS(T))  
HALOE



MLS Temperature  
MSISE90+NMC



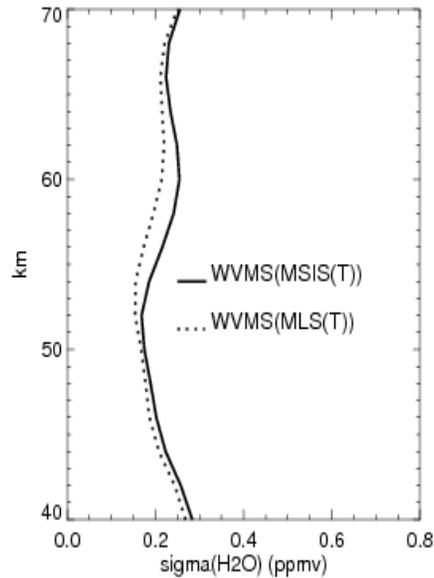
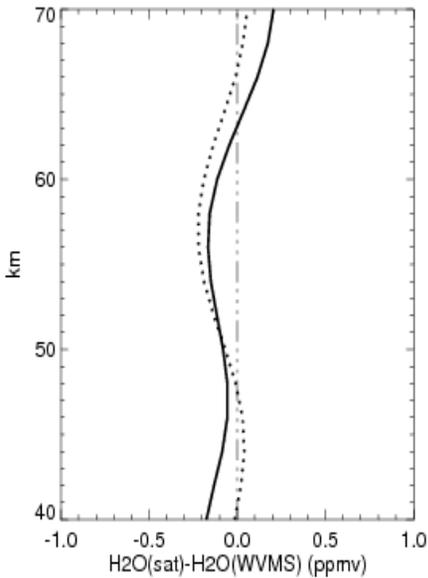
MLS v1.5 temperatures up to Jan 2007, v2.2 afterwards

# MLS v1.5-WVMS

Standard deviation

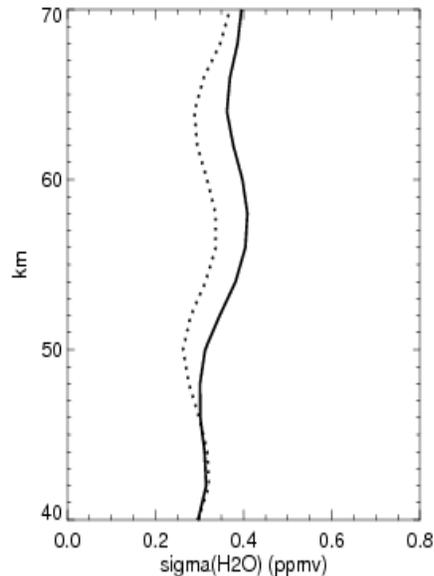
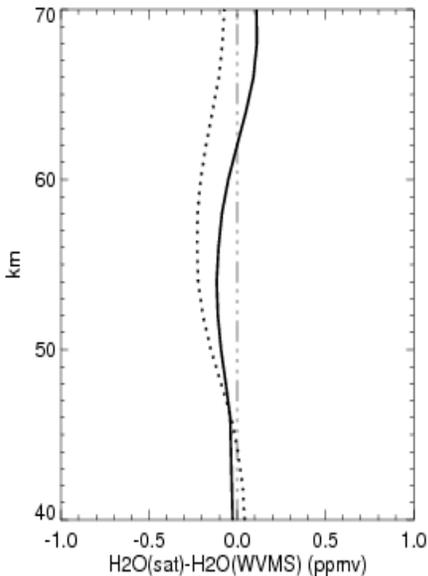
Mauna Loa

Mauna Loa



Lauder

Lauder



WVMS (MSIS(T)) =>  
Standard WVMS retrievals using a combination of NMC temperatures and a climatology (MSISE90)

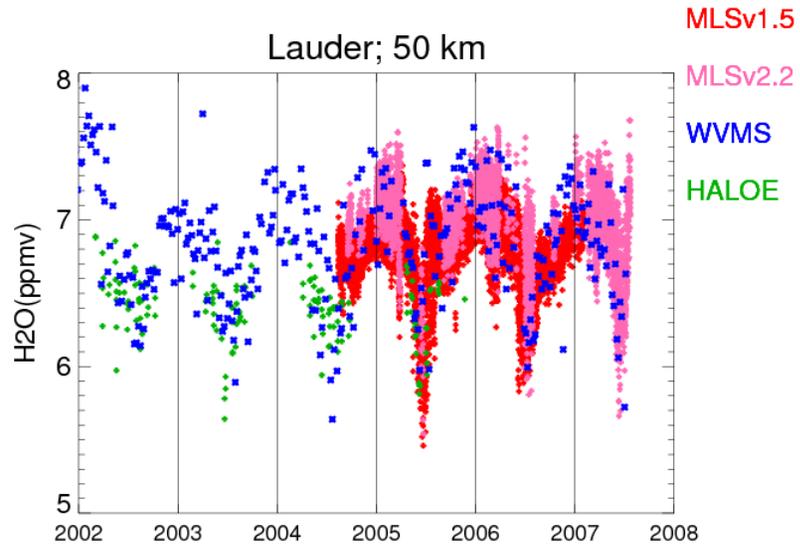
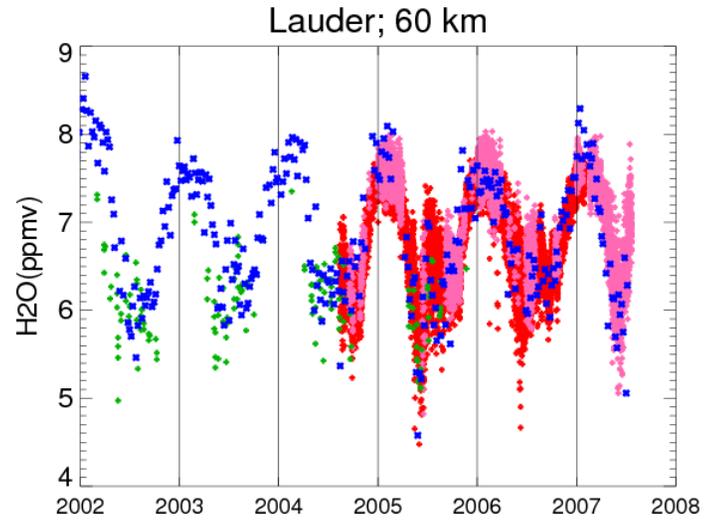
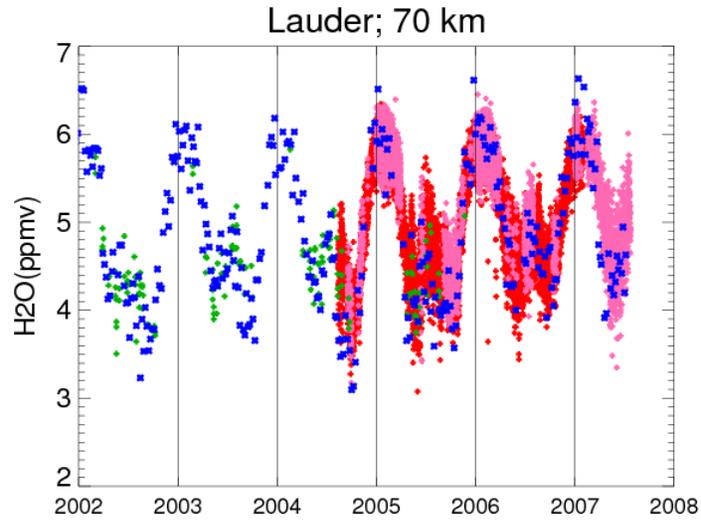
WVMS(MLS(T)) =>  
WVMS retrievals with MLS temperatures

• **MLS v1.5 - WVMS** average difference is not clearly better or worse (any better than it is now is just luck).

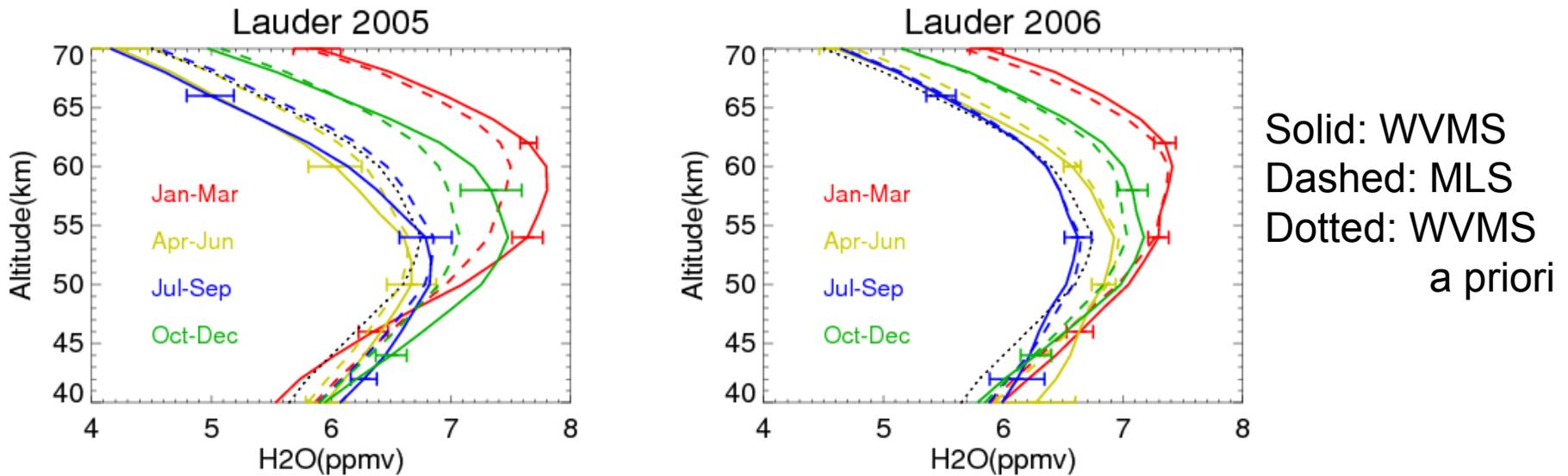
• Standard deviation of the difference does decrease when MLS temperatures are used in the WVMS retrievals.

# Summary

- Overall agreement between WVMS and MLS is very good, within  $\sim 0.2$  ppmv at almost all altitudes regardless of retrieval version. Both are slightly higher than HALOE at most altitudes.
- Seasonal and interannual variations observed by WVMS and MLS are in good agreement.
- Agreement between variations observed by WVMS and MLS can be improved by using MLS temperatures in the WVMS retrievals.
  - MLS temperatures are fine for MLS validation
  - For the historical WVMS database we should use an improved climatology.



## Water vapor variations at Lauder as a function of season



Differences near the peak of the profiles are largest in Jan-Mar and Oct-Dec 2005

Above ~50km the largest discrepancy occurs in Apr-Jun and Jul-Sep 2005

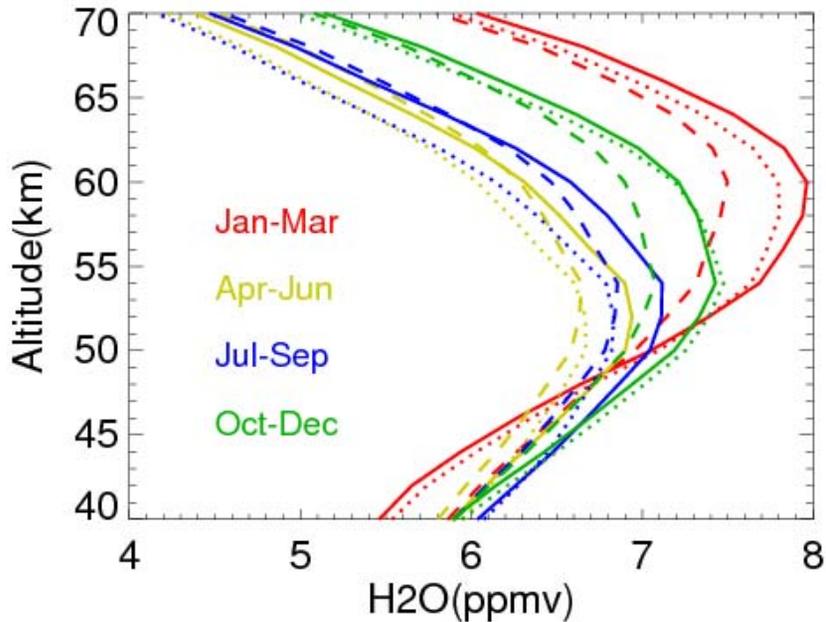
What happens if, instead of using a combination of NMC temperatures and a climatology (MSISE90), we use the MLS temperatures to run the WVMS retrievals?

Solid: WVMS retrievals with MLS temperatures

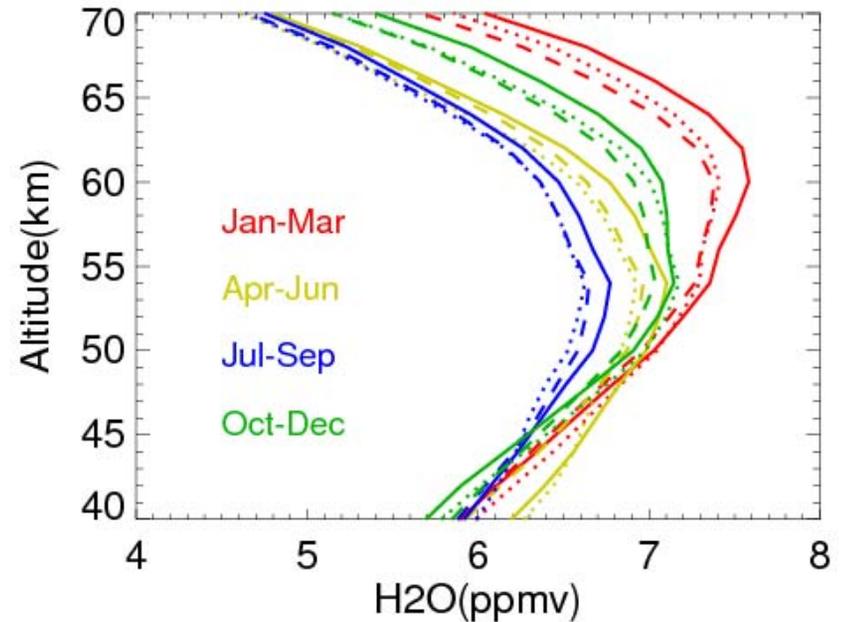
Dotted: Standard WVMS retrievals

Dashed: MLS

Lauder 2005

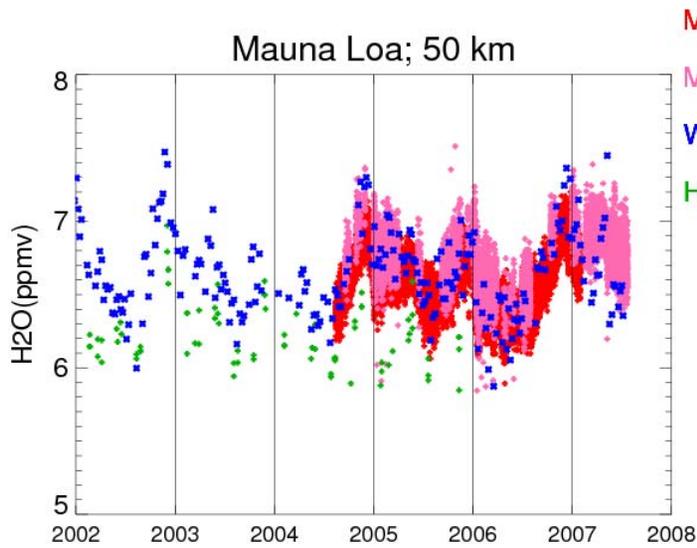
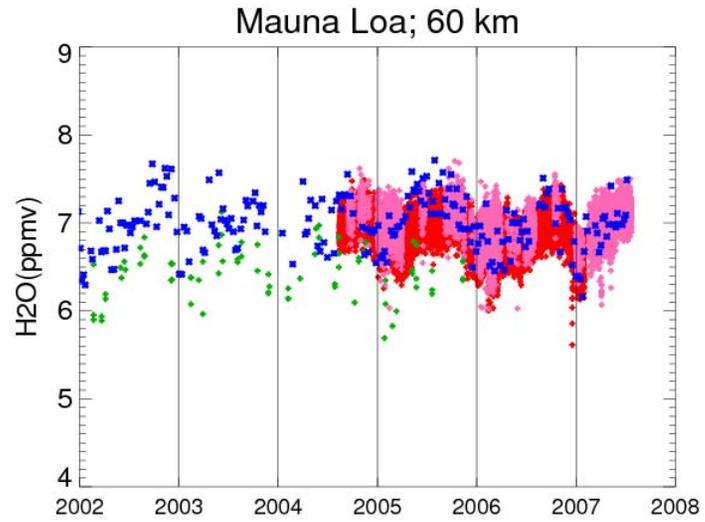
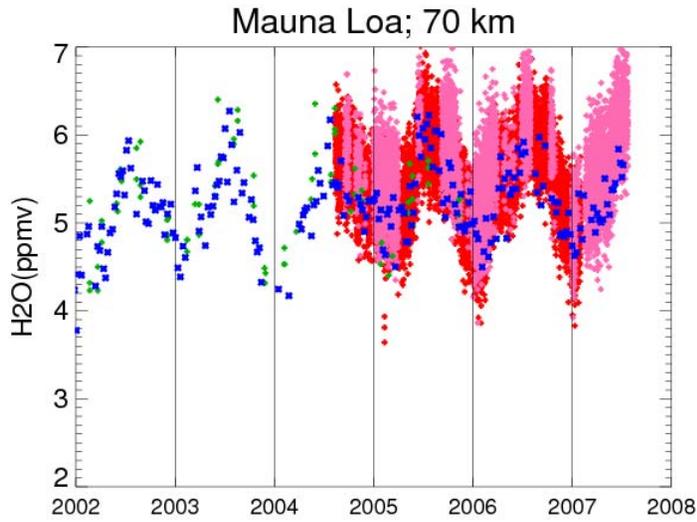


Lauder 2006



Marginal improvement in interannual consistency in Jan-Mar and Oct-Dec, but level at peak remains different

Biggest improvement is in Apr-Jun and Jul-Sep mesospheric differences.

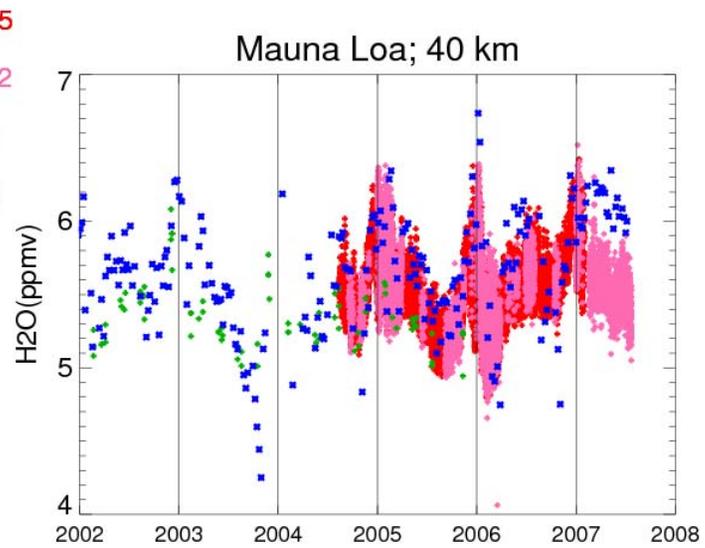


MLSv1.5

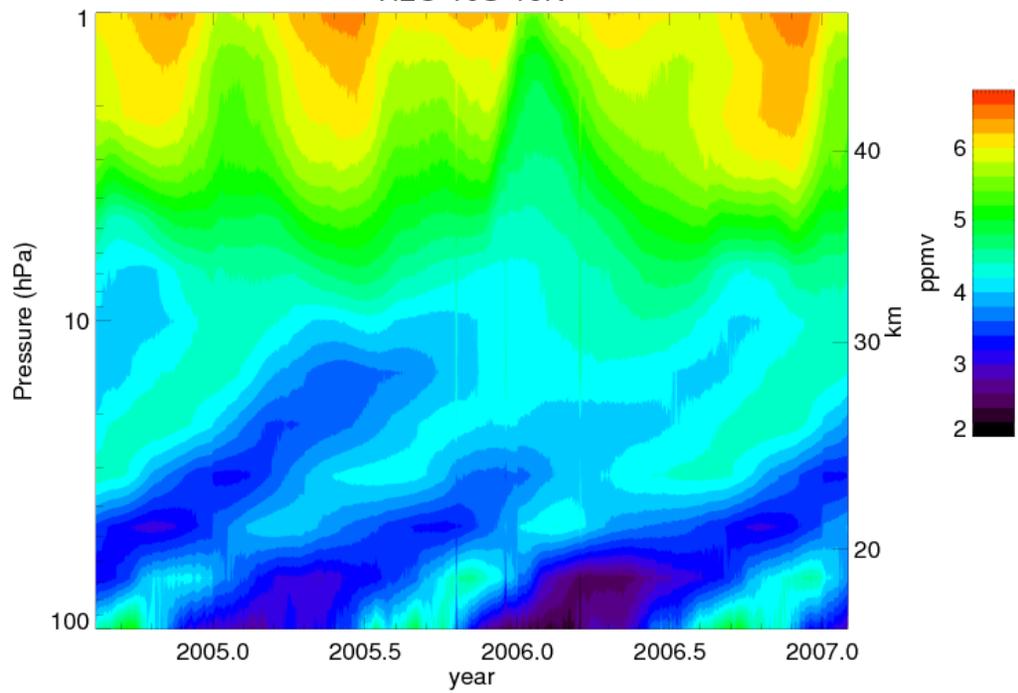
MLSv2.2

WVMS

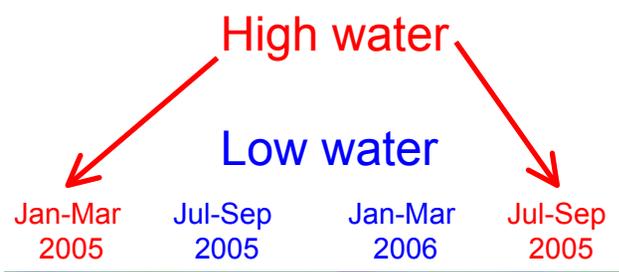
HALOE



H2O 10S-10N



MLS water vapor 10S-10N



MLS water vapor difference from average 10S-10N

