2004 Annual Report

Validation of humidity, temperature and ozone measurements of the AIRS instrument over Mauna Loa Observatory, Hawaii.

NRA00-OES-03, Validation studies for data products from the earth observing system Aqua (PM) platform.

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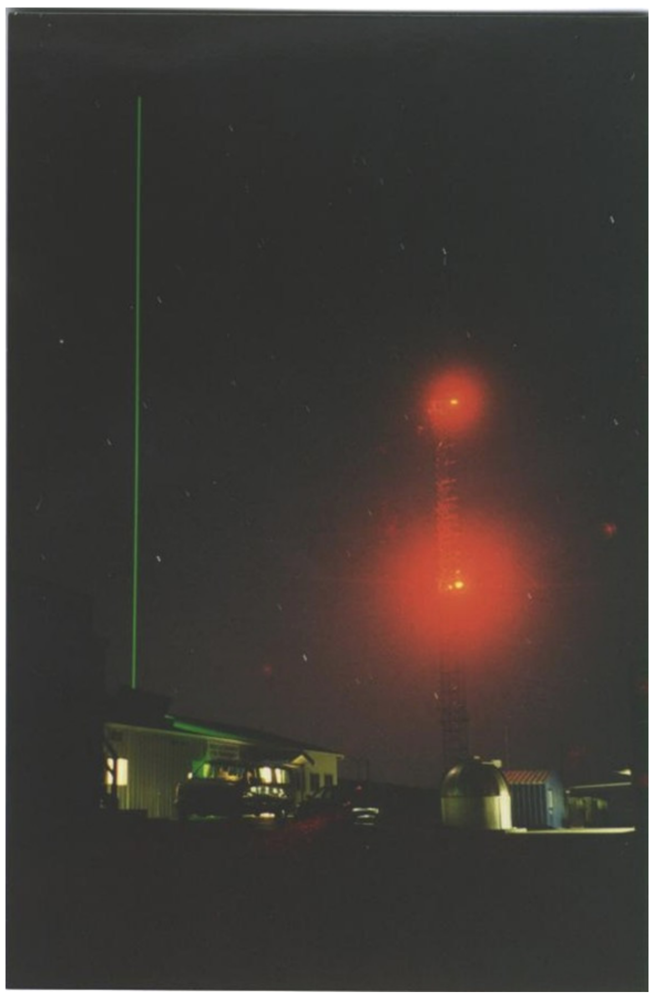


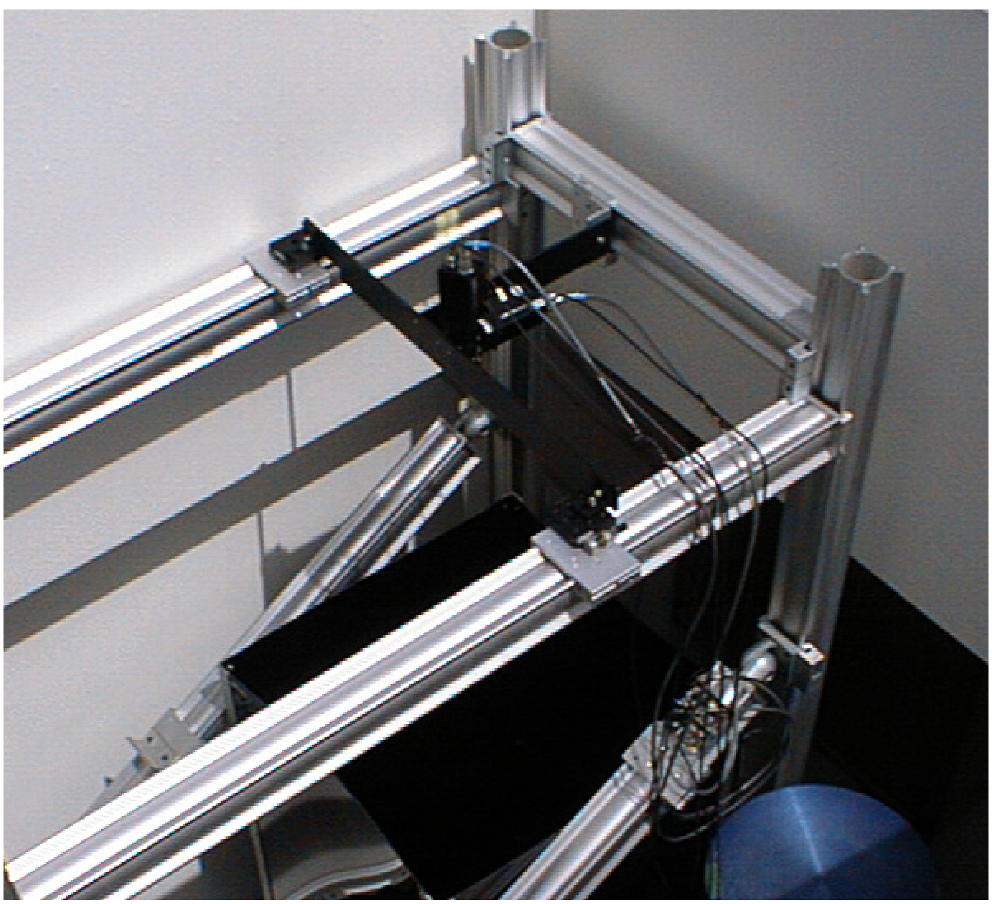
Introduction:

This proposal funded water vapor, temperature and ozone NASA/AQUA/AIRS validation measurements for a two year period. The measurements were made with water vapor lidar and with balloon sondes measuring water vapor, temperature and ozone. The funding also included an upgrade of the Mauna Loa Observatory (MLO) lidar and it's calibration.

All activities went generally as planned. The number of measurements actually made surpassed the number proposed in all categories.

Instrument Upgrade

The main improvement made to the MLO lidar under this proposal was the addition of new detectors which have high sensitivity in the red part of the spectrum. The upgrade was accomplished with two Hamamatsu photomultiplier tubes (Model H7421-40). The tubes came with their own coolers to reduce the dark counts. The actual added sensitivity was as estimated and the improved errors in the water vapor measurement were as expected. The detectors are shown below, connected to power and signal cables, mounted at the prime focus of the 74 cm mirror.

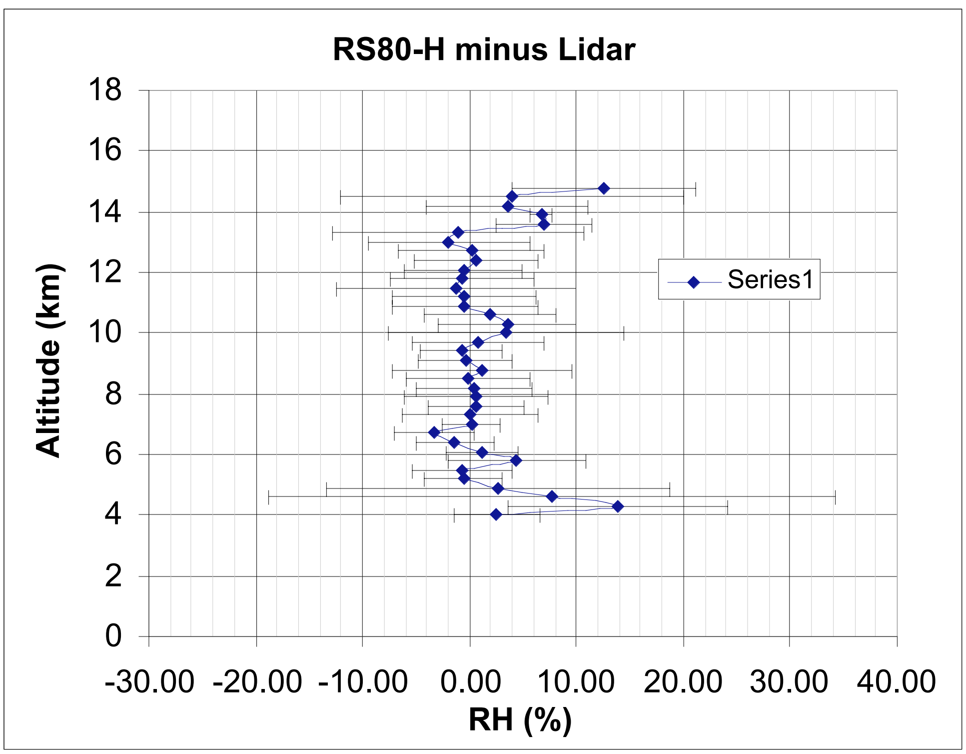


Instrument Calibration

Before the launch of the AQUA spacecraft, balloonsondes were flown for calibration of the MLO raman water vapor lidar channels. The balloons were launched directly from the observatory at the time the lidar was operating to get the best comparison. Commercial Snow White Frost-point hygrometers as well as one of the Climate Monitoring and Diagnostics Laboratory (CMDL) frost-points were flown. All flights and included a Vaisala RS80-H sonde. Some of these data were used to characterize the differences under various operating conditions:

Ref: Vömel, H., M. Fujiwara, M. Shiotani, F. Hasebe, S. J. Oltmans, and J. E. Barnes, The behavior of the Snow White chilled-mirror hygrometer in extremely dry conditions, J. of Atmos. and Oceanic Tech., 20, 1560-1567, 2003.

In the plot below the calibration flights are summarized. The difference between the sonde and the lidar was calculated and one standard deviation of the differences has been plotted. The lidar most directly measures the mixing ratio of water to air. Here the relative humidity (RH) has been calculated from the lidar measurements using sonde temperatures. The observatory is located at an altitude of 3.4 km and the lidar acquires water vapor data starting at 4.0 km. Below 6.0 km there is a significant overlap correction in the lidar data and the error is larger than between 6 and 13 km.



The deviation above 13 km is due to the inaccuracy of the RS80-H sensors on the radiosondes, not the lidar. At these altitudes the temperature is below -50 C and the humidity sensor has a systematic bias. Between 6 and 13 km the average difference (one standard deviation) is 6.3%. It should be noted that at the low humidities typically above MLO during the measurements, a difference of 6.3% can mean a larger difference in mixing ratios. For example, at 20% relative humidity and error of 6.3% would mean an error in the mixing ratio of 32%.

On 2004/4/21 the laser was serviced which significantly changed the calibration. The last three lidar validation measurements (2004/4/21, 23 and 25) use a frost-point flight on 2004/4/25 for calibration.

Data

The observations have been processed and formatted using the IDL (Interactive Data Language) routines to the standard netCDF (Network Common Data Format). The lidar data is in the principle investigator's account (Barnes) and the sonde data is in Holger Voemel's account.

Regular Dobson spectrophotometer measurements of column ozone are made at MLO on most weekdays during overpasses. These could be made available if there is interest. Also available are lidar measurements of stratospheric and upper tropospheric aerosol that coincide with the lidar water vapor profiles.

Observation Summary Tables

The following two tables summarize the validation data taken during AQUA overpasses. The first table list the total number of overpass measurements for each of the methods.

	Water	Water	Water		Temperature		Ozone
	Vapor	Vapor	Vapor		NWS or		
		CMDL	CMDL		CMDL		CMDL
	Lidar	Sonde	Frost Pnt.		Sonde		Sonde
Observations	30	22	8		52		22
Completed							
Observations							
Proposed	28	14	5		42		14

The times of the overpass are all near 2:00 AM or 2:00 PM local time (00Z or 12Z UT). These times happen to coincide with the launch of the National Weather Service sondes. So the temperature profile is available for nearly all overpasses. Unfortunately the humidity senor used by the NWS in Hilo is unreliable for water vapor validation. The table below lists the individual observations . Included with the lidar observations are general cloud conditions based on visual observation and the lidar aerosol channels.

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				Peak	Water	Water	Water		Temperature		Ozone	Comments
UT Time				Orbit	Vapor	Vapor	Vapor		NWS or			
Year	Mn	Day	Pass	Elev		CMDL	CMDL		CMDL		CMDL	
				(Deg)	Lidar	Sonde	Frost Pnt.		Sonde		Sonde	
2002	7	23	Night	86.5	1				2			Clear
2002	9	5	Day	59.4		1			2		3	
2002	9	9	Night	81.6	1				2			Thin uniform cirrus
2002	9	10	Day	80.6		1	1		2		3	
2002	9	16	Night	68.4	1				2			Clear
2002	9	20	Day	27.6		1			2		3	
2002	9	23	Night	60.1	1				2			Clear
2002	9	26	Day	81.6		1			2		3	
2002	10	2	Night	75.4	1				2			Cirrus 13-16 km, dry
2002	10	4	Night	80.9	1				2			Thick changing cirrus
2002	10	11	Night	84.2	1				2			Clear
2002	10	13	Night	67.9	1				2			Clear
2002	10	20	Night	80.4	1				2			Thin uniform cirrus, AIRS off
2002	10	25	Night	58.7	1				2			Thick, 11-15 km
2002	10	28	Day	78.3		1			2		3	
2002	10	29	Night	69.1	1				2			Thick, 8-15 km
2002	11	3	Night	68.0	1				2			Thin uniform cirrus, 13-15 km
2002	11	5	Night	84.9	1				2			Very thin cirrus, 17 km
2002	11	7	Night	60.4	1				2			Very thin cirrus, 13 km
2002	11	14	Night	66.5	1				2			Clear
2002	11	15	Day	71.2		1	1		2		3	Cirrus
2002	11	19	Night	72.6	1				2			Clear
2002	11	21	Night	78.6	1				2			Very thin cirrus, 17 km
2002	11	22	Day	83.2		1			2		3	

2002	12	17	Day	72.4		1	1		2		3	
2003	2	24	Day	65.8		1	1		2		3	Clear
2003	3	21	Day	80.2		1	1		2		3	
2003	6	2	Day	85.2		1	1		2		3	
2004	1	27	Night	80.5	1				2			Thin Cirrus, 5 & 10 km
2004	2	3	Night	84.6	1				2			Clear
2004	2	10	Night	70.9	1				2			Clear
2004	2	19	Night	84.2	1				2			Clear
2004	3	9	Day	72.6		1			2		3	
2004	3	16	Day	85.6		1			2		3	
2004	3	20	Night	59.3	1				2			Thin Cirrus, 7 km
2004	3	23	Day	79.9		1			2		3	
2004	3	29	Night	71.8	1				2			Clear
2004	3	30	Day	67.0		1			2		3	
2004	3	31	Night	80.1	1				2			Cloud at MLO level, 3.4 km
2004	4	5	Night	59.8	1				2			Cloud, Asian dust below 10 km
2004	4	6	Day	55.5		1			2		3	
2004	4	8	Day	80.2		1			2		3	
2004	4	9	Night	67.0	1				2			Clear
2004	4	15	Day	66.6		1			2		3	
2004	4	16	Night	80.5	1				2			Cloud at MLO level, 3.4 km
2004	4	19	Day	60.2		1			2		3	
2004	4	21	Night	59.0	1				2			Thin cirrus, 5 to 10 km
2004	4	22	Day	54.7		1	1		2		3	
2004	4	23	Night	84.5	1				2			Clear
2004	4	25	Night	68.1	1		1		2			Clear
2004	4	26	Day	73.2		1			2		3	
2004	5	3	Day	84.3		1			2		3	