1. Observatory, Meteorology, and Data Management Operations

1.1. Mauna Loa Observatory

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1.1.1. Operations

The most noticeable changes to the observatory over the past 2 years involved moving instruments into the new Network for Detection of Stratospheric Change (NDSC) building that was, for the most part, completed in late 1997. The first to move, mainly from the Keeling building, were several solar radiation instruments from CMDL and the cooperative programs. The largest instrument, the new National Institute for Water and Atmospheric Research (NIWA) ultraviolet/visible (UV/VIS) spectrophotometer, was mounted at the top of a chimney above the solar radiation room. The older spectrophotometer that had been in service for 5 years at MLO was moved to Boulder. The CMDL lidars were the next instruments to be moved. The separate frames for the ruby and Nd:YAG lidar systems were redesigned and combined to form a single structure situated in two rooms of the NDSC building. A third room functions as a control room. The CMDL Carbon Cycle Greenhouse Gases (CCGG) group instruments (carbon dioxide, methane, and carbon monoxide) are now in their own room that includes a new flask sampling system. The CMDL Halocarbons and other Atmospheric Trace Species (HATS) group instruments were likewise moved into their own room that was modified with extra thermostat-controlled ventilation to main a constant temperature. Sample lines into the NDSC building from the 40-m tower were routed into both the CCGG and HATS rooms. The computer network hardware and an electrical shop area take up two additional rooms. Significant modifications were made to the electrical system by adding ceiling outlets in several of the rooms. A portion of the building is reserved for the Jet Propulsion Laboratory/National Aeronautics and Space Administration (JPL/NASA) ozone lidar currently housed in two trailers. Some work was done on the JPL rooms, and the lidar will be moved in the summer of 2000.

The U.S. Army installed an antenna for a new radio repeater system. The system introduced an intermittent noise in the NIWA UV/VIS spectrometer that was difficult to trace. The antenna will be moved down and away from the observatory and will use a directional antenna to eliminate the interference. University groups initiated two new weekly sampling programs; the Division of Geological and Planetary Sciences at Caltech installed an interplanetary dust collector, and the State University of New York installed a CO isotope sampler. The weekly samples are collected in 1000-psi cylinders that must be shipped as hazardous material. The Department of Energy (DOE) radon program was terminated and the instrument removed from the tower base and shipped back to New York. Two new NIWA spectrometers for NO_2 and BrO were installed in a chimney in the solar radiation room in the NDSC building.

Calibrations of 2-4 weeks duration by visiting instruments to the observatory continued to increase. There were many repeat visits, as well as several new groups. For the most part, the instruments are various solar radiation measurements of varying complexity. Computer network connections were added to the visitor building to accommodate these programs. Three Japanese astronomers visited the MLO site to see if it would be a suitable location for radio astronomy experiments. The U.S. Air Force conducted radio frequency (RF) and sun viewing tests at MLO to assess the suitability of the site for a solar observatory. MLO is attractive to new astronomy groups since the Mauna Kea facilities are full under the current usage plan. NOAA Environmental Technology Laboratory (ETL) and CMDL took advantage of the low water vapor above MLO during the El Niño to conduct unique infrared (IR) measurements by installing an ETL Fourier transform infrared (FTIR) spectrometer in the Microwave building that was operated during March and April 1998.

Movie and magazine groups used the observatory road to film a shoe commercial and four car commercials. Since the film crew vehicles can cause damage to the fragile road, sizable fees were charged for road access that directly funded road repair. There was a long drought on the Big Island in 1998 due to El Niño reducing the northeastern trade winds dramatically, thus reducing orographic rain on the Big Island. There were brush fires in 1998 and 1999 that impacted the observatory observations, and for the first time in many years, snow prevented access to the observatory in December 1999. A meteorologist was hired by the University of Hawaii to forecast the summit and upper air weather for Mauna Kea. These forecasts have been useful for lidar observing conditions and visiting solar radiation groups.

The only change in staffing at MLO was the retirement of Judy Pereira. She was with the observatory for over 30 years and will be greatly missed.

Outreach

There was an increase in visitors to the observatory in the past 2 years, many of whom used the Internet to make arrangements and get information. A group from the U.S. Department of Energy and the Japan Ministry of International Trade and Industry visited twice; these visitors were attending meetings on a carbon dioxide sequestration experiment that will be conducted on the western side of the Big Island. Tours were also given to the Department of Commerce (DOC) Deputy Secretary, the NOAA Administration Deputy Assistant Secretary, and the NOAA Ocean and Atmospheres Deputy Under Secretary. Several classes from the University of Hawaii at Hilo toured MLO.

The MLO station chief lectured on climate change and pollution to a group of 50 senior citizens at the Kilauea Volcano Visitors Center and to a group at the Volcano National Park. He also judged the Hawaii County Science Fair. Two high school summer students were mentored each summer on short data analysis projects. A local high school teacher and a high school science student also worked summers on the lidar program.

The VOGNET program continued in 1998-1999. For this program, students make regular observations of volcanic aerosols from a network of schools spaced around the island in order to study the distribution and relative levels of volcanic haze or "vog" in Hawaii. Each school uses a Gardner condensation nuclei (CN) counter and a 2-wavelength sunphotometer to make several measurements per day. By the end of 1999 the students had made over 6000 observations in 3.5 years. In the summer of 1998 an inexpensive automated CN counter was developed at MLO that uses common plumbing hardware, solenoid valves, a laser pointer, and a PC. This machine has been deployed at sites around the island to characterize the 24-hr cycle of vog concentration. An improved version was built by students at Hawaii Preparatory Academy as a science fair project that advanced through district and state fairs to eventually win third prize in the environmental division of the International Science Fair in Philadelphia in the spring of 1999.

Computers/Network

There were many changes to the MLO computer network during 1998-1999. In September 1998 the VAX was shut down and sent to Boulder and replaced by two NT servers. One is dedicated to function as an e-mail server, and the other is a main file, print, and primary administrative server for the Hilo office. The old NT server is now a dedicated web server. In January of 1998 we received about 60,000 MLO Web page hits per month, and by the end of December 1999 we were receiving about 190,000 per month.

In February 1998 the Hilo office switched to a 128-k frame relay circuit. In March of the same year the mountain site switched over to a 56-k frame relay circuit. Because of limitations of the telephone company's circuitry, 128 k at the mountain site is not available.

The network hubs and routers were moved from the Keeling building to the computer room in the NDSC building. The site's fiber optic cables were reconfigured with new topology. The NDSC building was also wired with fiber optic cabling to each room, and 10 base–T hubs are now being used with the existing coax-fiber network in various locations at the site.

At the end of 1999 MLO installed a five-camera security and sky-observation network operation at the observatory. The original camera is still located at the High Altitude Observatory facing the northern sky. The second camera is mounted about halfway up the high tower facing the eastern sky. The third camera, sponsored by JPL/NASA, is facing the southwestern sky. The fourth camera, sponsored by the Atmospheric Environment Service (AES) (Canada), is an all-sky camera vertical with the radiation deck. The fifth camera, located on the NDSC sundeck, is used to monitor the Brewer's tracking of the sun. All of the camera images can be seen on MLO's web site. About 80% of the hits to the MLO web site are looking at these live images (www.cmdl.noaa.gov/obop/mlo).

Remote control of much of the observatory's equipment was a major focus in 1999. A system to remotely turn "on" or "off" the lidar cooler was implemented as well as remote control of power to computers and other devices. Software control or monitoring through the network is available to the following systems: SO_2, new Scripps CO_2 computer, solar dome controller, AES Brewers, surface ozone, the camera computers, the power controller computer, the mountain server, and the main observer's computer. Links to monitor the CCGG and Chromatographs for Atmospheric Trace Species (CATS) gas chromatographs (GC) are available from MLO's website.

Network usage of administrative programs has increased. Payroll time and attendance is now done through the Hilo network instead of the phone line. Travel, training, and purchase orders are also completed through the network connection with the Boulder support group. In 1999 the Smithsonian Institution left MLO's Hilo network after receiving their own internet line. The U.S. Fish and Wildlife Service (FWS) has since been connected to the network and has taken the IP addresses of the Smithsonian Institution. A wireless bridge connects the FWS office to MLO's network across the street.

1.1.2. PROGRAMS

Table 1.1 summarizes the programs in operation or terminated at MLO during 1998-1999. Relevant details on some of the respective programs are as follows:

Gases

Carbon dioxide. The CMDL Siemens Ultramat-3 IR CO_2 analyzer, along with the associated equipment and the other CCGG measurement instruments (CH_4 and CO), were moved on November 13, 1998, from the original concrete block building built in 1957 to the newly constructed NDSC facility. The new location is well lighted, temperature regulated, and is approximately 15 m southeast of the old concrete block building. On November 13, 1998, a new target reference gas was added into the CO_2 system for its once daily calibration between W1, the low span reference gas, and W2, the high span reference gas. The target reference gas has a CO_2 concentration value in between W1 and W2 reference gases. The Scripps Institution of Oceanography (SIO) Applied Physics IR CO_2 analyzer (see listing under Cooperative Programs, Table 1.1) and its associated equipment remained in the same location. Both the CMDL and SIO CO_2 programs were operated without major problems throughout 1998-1999. Routine maintenance and calibrations were undertaken on both instruments as scheduled. SIO was required to purchase a freezing unit for its CO_2 program because of the CCGG equipment relocation.

The weekly CO_2, CH_4, and other gas sampling programs, using flasks at MLO and at Cape Kumukahi, were carried out according to schedule throughout the year without major problems. The Martin and Kitzis Sampler (MAKS) sampling unit for Cape Kumukahi was discontinued in early 1998 and was replaced with a new Air Kitzis sampler (AIRKIT) sampling unit. Since November 20, 1998, the 0.5-L flasks were replaced with the 2.5-L flasks for the weekly samplings through the CO_2 analyzer at MLO.

CO_2 emissions from the Mauna Loa volcano measured at MLO resumed their steady decline in 1998-1999 after a brief factor-of-2 rise in 1994-1995 that was probably due to new emissions from the upper southwest rift. Because emissions from the volcanic vents at the Mauna Loa caldera and along the northeast rift zone at Mauna Loa have fallen by over 2 orders of magnitude since 1984, the tables for MLO outgassing that appeared in prior reports have been discontinued. They will be reinstated should MLO outgassing become active again, as is the case following major eruptions.

Carbon monoxide. The Trace Analytical RBA3 reduction gas analyzer for the continuous measurement of CO mixing ratios returned from CMDL (Boulder) on November 12, 1998, and was back in operation at MLO on November 13, 1998. The stream selection valve malfunctioned in early 1999 and caused a brief downtime; otherwise, the system has been operating continuously.

Methane. The HP6890 methane GC system operated without problems during 1998-1999. Occasionally the flame died out during the normal runs and relighting was difficult. An increase in the hydrogen gas flow in the GC from 45 mL min^{-1} to 47 mL min^{-1} corrected the problem. Since April 1996, CMDL has purchased the nitrogen carrier gas (99.999% pure, size 200 cylinder, 6.5 m^3 volume) and the oxidizer from Gaspro in Hilo for the CH_4 program at discounted prices. The oxidizer is 40% oxygen in balanced nitrogen with an analytical accuracy of ±2% and an analysis precision of ±1%, (size 200 cylinder 5.7 m^3 volume). The usages of these gases are one cylinder of nitrogen per 5 weeks and one cylinder of oxidizer per 2.5 weeks.

TABLE 1.1. Summary of Measurement Programs at MLO in 1998-1999

Program	Instrument	Sampling Frequency
Gases		
CO_2	Siemens Ultramat-3 IR analyzer†	Continuous
	2.5-L glass flasks, through analyzer	1 pair wk^{-1}
CO	Trace Analytical RGA3 reduction gas analyzer no. R5†	Continuous
CO_2, CH_4, CO, and ^{13}C, ^{18}O of CO_2	2.5-L glass flasks, MAKS pump unit	1 pair wk^{-1}
	AIRKIT pump unit, 2.5-L glass flasks‡	1 pair wk^{-1}
CH_4	3-L evacuated glass flasks‡	1 pair wk^{-1}
	HP6890GC†	Continuous
SO_2	TECO model 43S pulsed-fluorescence analyzer; 4, 10, 23, 40 m†	Continuous
Surface O_3	Dasibi 1003-AH UV absorption ozone monitor†	Continuous
Total O_3	Dobson spectrophotometer no. 76†	3 day^{-1}, weekdays
O_3 profiles	Dobson spectrophotometer no. 76† (automated Umkehr method)	2 day^{-1}
	Balloonborne ECC sonde	1 wk^{-1}
N_2O, CFC-11, CFC-12, CFC-113, CH_3CCl_3, CCl_4, SF_6, HCFC-22, HCFC-141b, HCFC-142b, CH_3Br, CH_3Cl, CH_2Cl_2, $CHCl_3$, C_2HCl_3, C_2Cl_4, H-1301, H-1211, H-2402, HFC-134a	850-mL, 2.5-L, and 3-L stainless steel flasks	1 sample wk^{-1}
CFC-11, CFC-12, CFC-113, N_2O, CCl_4, CH_3CCl_3	HP5890 automated GC†	1 sample h^{-1}
N_2O	Shimadzu automated GC†	1 sample h^{-1}
CFC-11, CFC-12, CFC-113, N_2O, CH_3CCl_3, CCl_4, CH_3Br, CH_3Cl, H-1211, SF_6, HCFC-22	Automated CATS GC	1 sample h^{-1}
Aerosols		
Condensation nuclei	Pollak CNC	1 day^{-1}
	TSI CNC†	Continuous
Optical properties	Three-wavelength nephelometer: 450, 550, 700 nm	Continuous
Aerosol light absorption (black carbon)	Aethalometer†	Continuous
Stratospheric and upper tropospheric aerosols	Nd:YAG lidar: 532-, 1064-nm wavelengths	1 profile wk^{-1}
Solar Radiation		
Global irradiance	Eppley pyranometers with Q, OG1, and RG8 filters†	Continuous
Direct irradiance	Eppley pyrheliometer with Q filter†	Continuous
	Eppley pyrheliometer with Q, OG1, RG2, and RG8 filters†	3 day^{-1}
	Eppley/Kendall active cavity radiometer†	1 mo^{-1}
Diffuse irradiance	Eppley pyrgeometer with shading disk and Q filter†	Continuous
UV solar radiation	Yankee Environmental UVB pyranometer (280-320 nm)†	Continuous
Turbidity	J-202 and J-314 sunphotometers with 380-, 500-, 778-, 862-nm narrowband filters	3 day^{-1}, weekdays
	PMOD three-wavelength sunphotometer†: 380, 500, 778 nm; narrowband	Continuous
Column water vapor	Two-wavelength tracking sunphotometer: 860, 940 nm† (2 instruments)	Continuous
Meteorology		
Air temperature	Aspirated thermistor, 2-, 9-, 37-m heights†	Continuous
	max.-min. thermometers, 2.5-m height	1 day^{-1}, weekdays
Air temperature (30-70 km)	Lidar	1 profile wk^{-1}
Temperature gradient	Aspirated thermistors, 2-, 9-, 37-m heights†	Continuous
Dewpoint temperature	Dewpoint hygrometer, 2-m height†	Continuous
Relative humidity	TSL 2-m height†	Continuous
Pressure	Capacitance transducer†	Continuous
Wind (speed and direction)	8.5-, 10-, and 38-m heights†	Continuous
Precipitation	Rain gauge, 20 cm	5 wk^{-1}
	Rain gauge, 20 cm§	1 wk^{-1}
	Rain gauge, tipping bucket†	Continuous
Total precipitable water	Foskett IR hygrometer†	Continuous

TABLE 1.1. Summary of Measurement Programs at MLO in 1998-1999—continued

Program	Instrument	Sampling Frequency
Precipitation Chemistry		
pH	pH meter	1 wk^{-1}
Conductivity	Conductivity bridge	1 wk^{-1}
Cooperative Programs		
CO_2 (SIO)	Applied Physics IR analyzer†	Continuous
CO_2, ^{13}C, N_2O (SIO)	5-L evacuated glass flasks*	1 pair wk^{-1}
CO_2, CO, CH_4, $^{13}C/^{12}C$ (CSIRO)	Pressurized glass flask sample	3 pair mo^{-1}
CH_4, CH_3CCl_3, CH_3Cl, HCFC-22, CFC-12, CFC-11, CFC-113, CO, CO_2, N_2O, $CHCl_3$, CCl_4 (OGIST)	Pressurized stainless steel flasks* (Ended 6/99)	3 wk^{-1}
O_2 analyses (SIO)	5-L glass flasks through tower line and pump unit*	3 $(2\ mo)^{-1}$
O_2 analyses (URI)	3-L glass flasks through tower line and pump unit ‡ (Ended 12/98)	2 $(2\ mo)^{-1}$
CH_4 ($^{13}C/^{12}C$) (Univ. of Washington)	35-L evacuated flask (Ended 12/98)	2 mo^{-1}
Total suspended particulates (DOE)	High-volume sampler	Continuous (1 filter wk^{-1})
Ultraviolet radiation (CSU-USDA)	Multi-wavelength radiometer (direct, diffuse, shadow band)	Continuous
Radionuclide deposition (DOE)	Ion-exchange column (Started 1/98)	Quarterly sample
Aerosol chemistry (Univ. of Calif.-Davis)	Programmed filter sampler	Integrated 3-day sample, 1 continuous and 1 downslope sample $(4\ days)^{-1}$
Sulfate, nitrate, aerosols (Univ. of Hawaii)	Filter system	Daily, 2000-0600 LST
Radon (ANSTO)	Aerosol scavenging of Rn daughters†; 2-filter system	Continuous; integrated 30-min samples
AERONET sunphotometers (NASA Goddard)	Automated solar-powered sunphotometers	Continuous
Global Positioning System (GPS) Test Bed (FAA and Stanford University)	GPS-derived column water vapor profiles	Continuous
Earthquakes HVO/USGS Menlo Park	Seismometer	Continuous
Earthquakes Northwestern University	Seismometer	Continuous
CO isotopes (SUNY)	1000 psi cylinder	1 wk^{-1}
Cosmic dust (CALTECH)	Magnetic collector	1 wk^{-1}
Network for Detection of Stratospheric Change (NDSC)		
Ultraviolet radiation (NOAA and NIWA)	UV spectrometer (280-450 nm), 1-nm resolution†	Continuous
Stratospheric O_3 profile, 20-64 km (Univ. of Mass., Amherst)	Millitech Corp., 110.8-GHz microwave ozone spectroscopy	3 profiles h^{-1}
Stratospheric O_3 profiles (15-55 km), temperature (20-75 km), aerosol profiles (15-40 km) (JPL)	UV lidar†	3-4 profiles wk^{-1}
Stratospheric water vapor profiles, 40-80 km, 10-15 km resolution (NRL)	Millimeterwave spectrometer	Continuous
UV/visible radiation (NIWA and NOAA)	Slant column NO_2 spectrometer	Continuous, day
UV/visible radiation (NIWA and NOAA)	Column BrO spectrometer (Began 10/99)	Continuous, day
Column O_3, UV (AES, Canada)	Brewer spectrophotometers (Two instruments)	Daily
Solar spectra (Univ. of Denver)	FTIR spectrometer, automated†	5 days wk^{-1}

All instruments are at MLO unless indicated.
* MLO and Kumukahi
†Data from this instrument recorded and processed by microcomputers
‡Kumukahi only
§Kulani Mauka

The CH_4 data continued to show clearly defined cycles of varying frequencies. The typical diurnal cycle was well correlated with up- and downslope winds, with the marine boundary layer air having higher CH_4 concentrations. Multi-day or synoptic-scale CH_4 cycles were also observed, which apparently relate to different air mass source regions.

Sulfur dioxide. A new system, using a TECO 43S pulsed-fluorescence analyzer, was developed in Hilo in early 1998 and installed at MLO in April. By the end of June the system was fully operational. Every hour SO_2 is measured sequentially from inlets at 4,10, 23, and 40 meters on the tower, followed by a zero measurement. A single-point calibration is made once per day by injecting calibration gas into the airstream at the 40-m intake. All of the inlet lines are thermostatically maintained at 20ºC. In August 1999 a break in the 40-m intake occurred, and sampling was restricted to the lower three levels for the remainder of the year while the damaged line section was removed and repaired.

This is the first time multi-point continuous vertical profiles of an atmospheric constituent have been measured at MLO. The SO_2 profiles show several features that change along with the diurnal cycle of upslope/downslope winds. During the daytime, pollution from the Kilauea volcano is commonly brought to MLO in the upslope wind by late morning. Turbulent mixing causes the concentrations at all four tower levels to be similar. After sunset the surface temperature inversion develops, and the downslope wind commences. Residual pollution from Kilauea at that time has a SO_2 profile with concentrations increasing with height. After midnight, pollution episodes from Mauna Loa volcano are seen 10% of the time, as indicated by increases in CO_2 by up to several ppm. These are accompanied by increases in SO_2 of up to several hundred ppt above a baseline of tens of ppt with concentrations decreasing with height, indicating the gas is trapped beneath the surface temperature inversion. Throughout 1998-1999, the molecular ratio of SO_2 to CO_2 in the Mauna Loa volcanic plume remained at about 5×10^{-5}. This ratio is being monitored closely as an eruption precursor. An increase in the ratio is expected if magma migrates closer to the surface.

Ozone monitoring. The 1998-1999 MLO ozone monitoring program consisted of three measurement foci: continuous MLO surface ozone monitoring using a Dasibi model 1003-AH UV absorption ozone monitor; daily total and Umkehr ozone profile measurements using a computer-based automated Dobson instrument (Dobson no. 76); and ozone profile measurements based on weekly ascents of balloonborne electrochemical concentration cell (ECC) ozonesondes released from the NWS station at the Hilo airport.

Dobson no. 76 was operated daily during weekdays throughout the period with daily morning and afternoon Umkehr checks. Summer intercomparisons with standard Dobson no. 83 occurred in 1998 and 1999. The instrument was maintained as needed with repairs to the pedestal unit, stainless steel wedge band replacement, dome (hatch and shutter) work, and miscellaneous motor, belt, and tension spring adjustments.

The Dasibi program operated normally throughout the period, and the data transmission software and hardware were upgraded in June 1999. The Dasibi was calibrated, and yearly maintenance was carried out by MLO-based staff in 1998 and 1999. Absorption tubes were cleaned by other MLO-based staff in August 1999 at which time A/D checks were also completed. The Dasibi unit also was connected to its own uninterruptible power supply (UPS) at this time.

Ozonesondes were launched weekly whenever supplies were available from Boulder. In 1998 there were 44 ozonesonde flights, and in 1999 there were 47. The new “2Z” sondes were used beginning April 1998. These sondes send telemetry in a 1-s packet versus 6 seconds for the old “6A” type that results in much less susceptibility to radio interference. As a result, data acquisition is consistently over 90% instead of the <20% that occurred on some flights of the old sondes.

Halocarbons and other atmospheric trace species. In 1998 the Radiatively Important Trace Species (RITS) unit had airline pump board changes, a Keithley replacement, UPS battery replacements, and computer hardware repairs. In September 1998, the RITS GC and a new four-channel CATS GC were installed in the new NDSC building. The new CATS GC went through hardware changes throughout the year until June 1999 when it stabilized. CAL2 was shut down in July.

Radon. Radon has been measured continuously since 1989 by the Australian Nuclear Science and Technology Organization (ANSTO). Since March 1998, monthly manual calibrations have been made with a commercial radon source.

Aerosols

Condensation nuclei. The Thermo Systems Incorporated (TSI) unit is a continuous expansion CN counter (CNC) in which condensation occurs in butyl alcohol vapor in a chamber, and single-particle counting statistics are used as a basis for calculating CN concentrations. The TSI was in Boulder from November 1998 to October 1999 for repairs and maintenance. The Pollock CNC continues to be used as a primary daily calibration.

Aerosol light scattering. The four-wavelength nephelometer in operation at MLO for decades was retired in July 1998 and was replaced by a fast-response three-wave nephelometer measuring at 450, 550, and 700 nm. The old and new nephelometers operated together for more than 1 year.

Aerosol absorption. The aethalometer performed satisfactorily during most of 1998-1999. Since August 1998, transfer of the aethalometer data to Boulder has been done every week. The internal hoses that were cracked because of ozone attacking the rubber were replaced in July 1999.

Stratospheric and upper tropospheric aerosols. Weekly observations continued with the Nd:YAG lidar throughout 1998 and 1999. The optical framework was redesigned for the move into the NDSC building in February 1998. The lidar for the telescopes, lasers, and controls each have their own room in the new building. Only 2 weeks were needed to move and get the Nd:YAG system operating in the new building. On the other hand, the ruby system (694-nm wavelength) showed a severe loss of signal after the move. Since the Nd:YAG system measures aerosol profiles at 532 and 1064 nm, which give an interpolated 694 nm value, it was decided to discontinue the ruby observations as there was already over a year of overlap between the two systems, and the interpolated 694 nm profile is more accurate than the measured 694 nm signal.

The Nd:YAG laser power supply failed in February 1998. Fixing the problem required a service call from Spectra-Physics in California. In February 1999 a potentiometer failed on the laser and was repaired by MLO staff. Other maintenance consisted of flashlamp and cooling water changes.

Solar Radiation

The solar radiation program continued with the same instrumentation described in the previous summary report [*Hofmann et al.*, 1998]. Normal Incident Pyroheliometer data (which goes back to 1958) is calibrated periodically against an active cavity radiometer. Eight of these comparisons were done in 1998 and six in 1999. Mauna Loa Observatory is also used to calibrate handheld sunphotometers using the Langley technique; 23 instruments were calibrated in 1998, and 28 were calibrated in 1999. The observatory is also used to calibrate CMDL’s Yankee UVB instruments; four were calibrated in 1998, and three were calibrated in 1999.

Meteorology

A computer-based "New Met System" measures station pressure, temperatures at the 2-, 9-, and 37-m levels, dewpoint temperature at the 2-m level, and wind speeds and directions at the 8.5-, 10-, and 38-m levels of the MLO Observation Tower. Precipitation is measured with a tipping bucket rain gauge. This new system has remained in operation unaltered and operating with high reliability to date.

Precipitation Chemistry

The MLO modified program of precipitation chemistry collection and analyses continued throughout 1998-1999 within the basic MLO operational routine. This program consists of collections of a weekly integrated precipitation sample from the Hilo National Weather Service (NWS) station and the collection of precipitation event samples at MLO. Analyses of these samples are undertaken in the Hilo laboratory for pH and conductivity.

Cooperative Programs

MLO cooperative programs are listed in Table 1.1. New programs and changes not discussed in the NDSC section are presented here.

In March 1996 MLO began calibrating automated sunphotometers for the NASA Aerosol Robotics Network (AERONET). Thirteen instruments were calibrated in 1998, and fifteen were calibrated in 1999. In September 1997 the Federal Aviation Administration (FAA) installed high quality Global Positioning Satellite (GPS) and meteorology sensors on the MLO Observation Tower in a study of atmospheric effects on GPS positioning. From this program MLO will receive nearly continuous column water vapor measurements. In November 1997 the Colorado State University (CSU) and U.S. Department of Agriculture (USDA) UV-B monitoring instruments were installed and continue to operate.

Network for the Detection of Stratospheric Change (NDSC)

All NDSC instruments operated in previous years continued observations. Two additional spectrometers operated by the National Institute for Water and Atmospheric Research (NIWA) (New Zealand) were added in December 1999 for column measurements of NO_2 and BrO. The NOAA lidar, ozonesonde, and Dobson operations, which are also part of the MLO NDSC facility, are described in other sections of this report.

UV/VIS spectroradiometer. This new instrument was put into operation in the NDSC building in November 1997. Weekly quality control calibrations were performed with a mercury lamp and a 45-W quartz lamp. An absolute-standard 1000-W FEL lamp calibration was performed twice each year. In fall 1999 an intermittent noise source in the background level was traced to the new U.S. Army radio repeater. Tracing the problem required a visit from a NIWA engineer. The problem was fixed temporarily by reducing the radio transmitter power and using a directional antenna. The permanent solution is to move the antenna down and away from the observatory; this will be completed in summer 2000.

Microwave ozone spectroscopy system. The University of Massachusetts microwave instrument measures the vertical profile of ozone from 20 to 70 km with a vertical resolution of 10 km or less up to 40 km, degrading to 15 km at 64 km. The ozone altitude distribution is retrieved from the details of the pressure-broadened line shape.

UV lidar. During the last 2 years the JPL UV lidar conducted several extensive studies of the dynamics of the middle atmosphere above MLO. Using the lidar, one can observe gravity waves, planetary waves, atmospheric tides, and mesospheric inversions. Temperature climatologies were developed using these results. Work was also done on the new space in the NDSC building. It is assumed that the more stable concrete floor in the NDSC building will allow JPL to slightly improve data quality. JPL will also use the opportunity offered by the move and the rebuilding of the lidar to extend the range of its measurements to lower altitudes. The additional space will certainly make the lidar easier to operate and maintain.

NO_2, BrO spectrometers. Since July 9, 1996, stratospheric nitrogen dioxide (NO_2) has been measured at MLO using the twilight zenith technique with a NIWA UV/VIS spectrometer. Data have been analyzed, quality confirmed, and then submitted to the NDSC archive. The new NO_2 and BrO spectrometers began operation in December 1999.

Brewer spectrophotometer. A single monochromator Brewer instrument was installed by the Canadian AES at MLO and began routine measurements of O_3 and UV-B radiation on March 24, 1997. A second instrument was added in November 1997. The measurements are supplemented by all-sky images that are recorded every 10 minutes in order to assist in the analysis of the UV-B data. Overviews of the automatic operation of the instrument and data retrievals have since been carried out remotely from AES in Downsview, Ontario, over the Internet.

The data are archived at the World Ozone and Ultraviolet Data Centre (WOUDC) in Toronto. Up-to-date preliminary data are available over the Internet from AES. Publication of some new results is planned after thorough analysis of a longer data record is completed.

Solar FTIR spectrometer. The University of Denver FTIR spectrometer routinely monitors HCl, HNO_3, O_3, N_2O, HCFC-22, HF, CH_4, NO, HCN, CO, C_2H_2, and C_2H_6. Because of the automatic nature of the instrument, the program is able to look at diurnal variations in the species. Data are not collected on Sundays or Monday mornings unless special operators are on site to add liquid nitrogen to the instrument.