

**METEOROLOGICAL AND DEPOSITION CHEMISTRY MONITORING**  
**- 1994 -**

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**COOPERATORS:**

UVM Proctor Maple Research Center (PMRC), VT Dept. of Environmental Conservation (DEC), WCAX-TV staff at Mt. Mansfield transmitter station, National Atmospheric Deposition Program (NADP), US Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), Lake Champlain Research Consortium (LCRC), National Weather Service (NWS), the Electric Power Research Institute (EPRI).

**ABSTRACT:**

Continuous monitoring of meteorology and wet and dry deposition chemistry has been conducted at the VMC Mt. Mansfield site. Several projects are underway, including collection of basic meteorological data, precipitation chemistry monitoring, and dry deposition monitoring programs. Continuous hourly meteorology data from PMRC (400 m elevation) are available from 1988 to present, and daily temperature and precipitation data from the summit of Mt. Mansfield (1205 m) are available from 1954 to present. In addition, meteorology is monitored within the forest at the canopy research tower and the Nettle Brook gauging station; these are discussed elsewhere in the Annual Report. The National Atmospheric Deposition Program, operating at PMRC since 1984, provides weekly analysis of major ions in precipitation, while the Atmospheric Integrated Research Monitoring Network (AIRMoN), also at the PMRC, established in January 1993, provides similar data on a daily basis. In addition, atmospheric mercury monitoring in precipitation, gaseous and aerosol phases was established in at the PMRC in 1993, and the Vermont Acid Precipitation Monitoring Program provides daily precipitation pH since 1980 (Mount Mansfield summit) and 1983 (PMRC); these projects are also discussed elsewhere in the Annual Report. The Dry Deposition Inferential Measurement system, started mid year in 1992, provides weekly data on dry deposition of nitrogen ( $\text{HNO}_3$  vapor) and sulfur ( $\text{SO}_2$ ) compounds.

**OBJECTIVES:**

Continuous monitoring of meteorological variables and the chemistry of precipitation and dry deposition at several locations at the VMC Mansfield site.

**METHODS:**

Several monitoring stations and programs were operated at sites in Underhill in 1994:

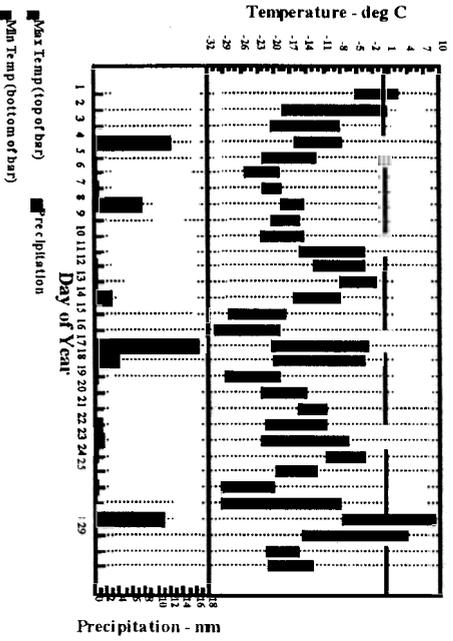
**1. Basic Meteorology** - Temperature, dew point, wind speed and direction, standard deviation of wind direction, and precipitation amount is monitored at the VMC Mansfield air quality monitoring station at the Proctor Maple Research Center (400 m). This station has remote (modem) access and has been in continuous operation since June 1988. Data are updated continuously and are stored electronically and as hard copy. Data are available from the VMC as spreadsheets (Lotus, Excel), and in Voyager format. Station supervision is by Tim Scherbatskoy and operated by Joanne Cummings and Carl Waite.

Consolidation of the historic and current basic meteorology data from the VMC Mansfield site has been completed, and consists of annual daily and hourly data for all variables. Monthly data summaries are produced routinely. These data are available in ASCII text files, and Excel spreadsheets from the VMC Data Manager. Figure 1 on the following pages graphically displays monthly maximum and minimum temperatures and precipitation amounts for the Air Quality site at the PMRC during 1994.

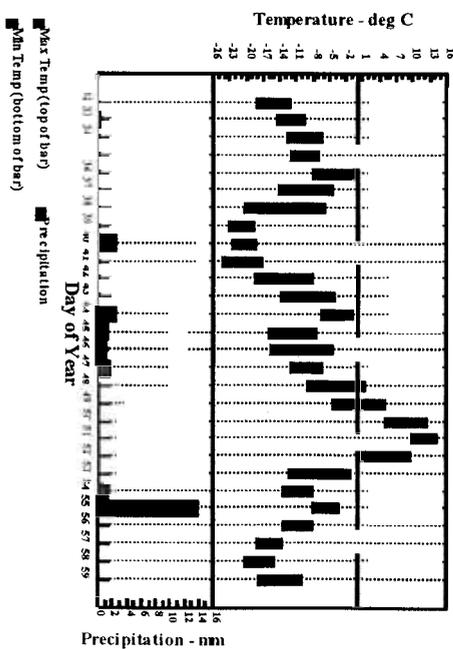
The National Weather Service (NWS) under NOAA supervises a second weather station at the WCAX-TV transmitter station near the nose of Mt. Mansfield (1205 m), one of 45 NWS cooperative weather stations currently operating in Vermont. This station has monitored temperature (daily minimum, maximum and temperature at time of observation) and precipitation amount (daily rainfall, snowfall and snow depth on the ground) since 1954. Data are collected and stored by the National Climatic Data Center. The National Weather Service data is now being used to develop statewide meteorological and deposition maps. The VMC does not directly support this station, but has access to the data for this station and all others in Vermont through the NWS. Data are now available from the VMC in Voyager format for the period 1954-1994, as part of the Vermont Coop Network meteorological database. Data for this project may be obtained from the VMC Data Manager.

**Figure 1. Monthly Temperatures and Precipitation Amounts for PMRC in 1994**

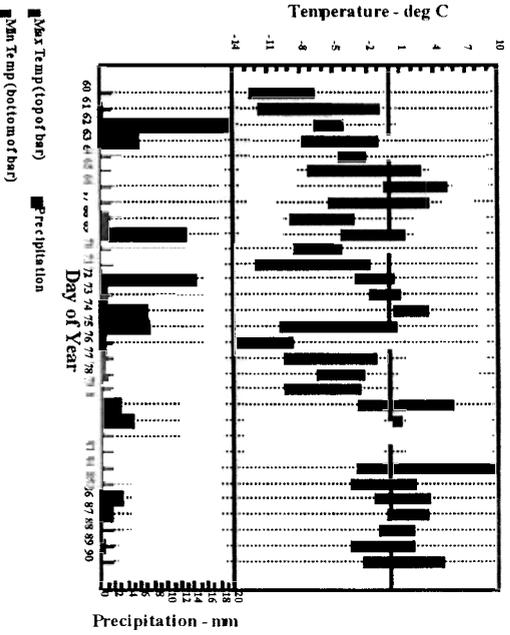
**Mean Daily Maximum/Minimum Temperatures  
& Precipitation at PMRC - January 1994**



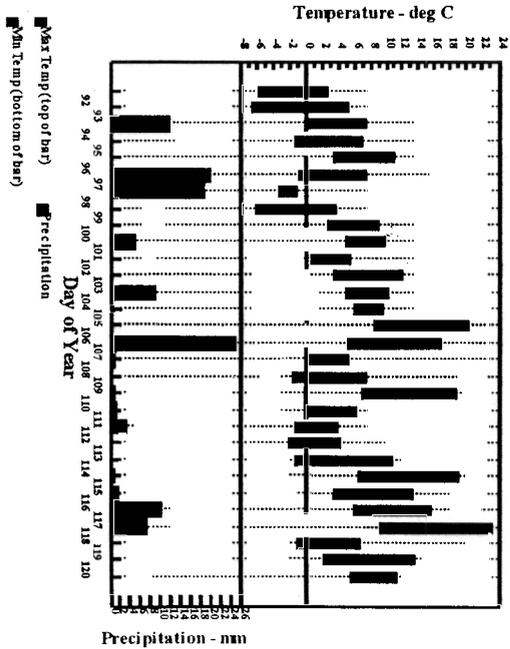
**Mean Daily Maximum/Minimum Temperatures  
& Precipitation at PMRC - February 1994**



**Mean Daily Maximum/Minimum Temperatures  
& Precipitation at PMRC - March 1994**

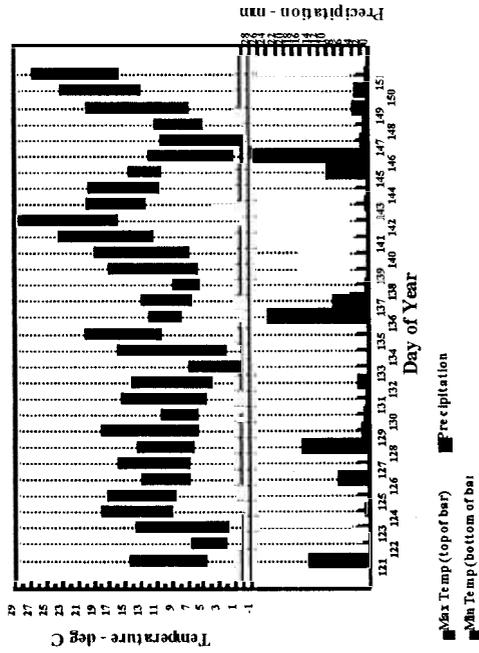


**Mean Daily Maximum/Minimum Temperatures  
& Precipitation at PMRC - April 1994**

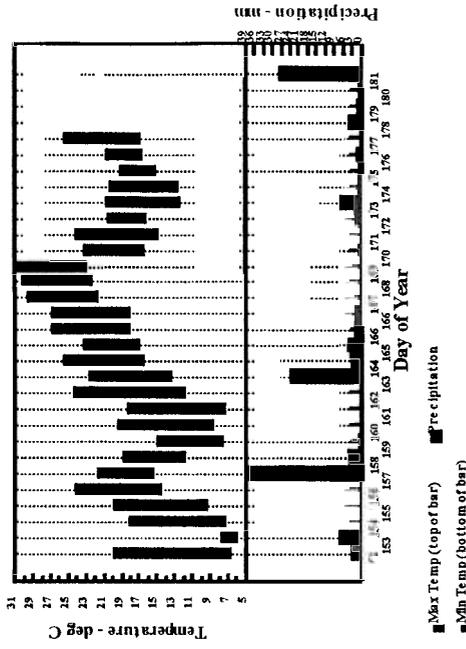


**Figure 1 (cont'd) Monthly Temperatures and Precipitation at the PMRC 1994**

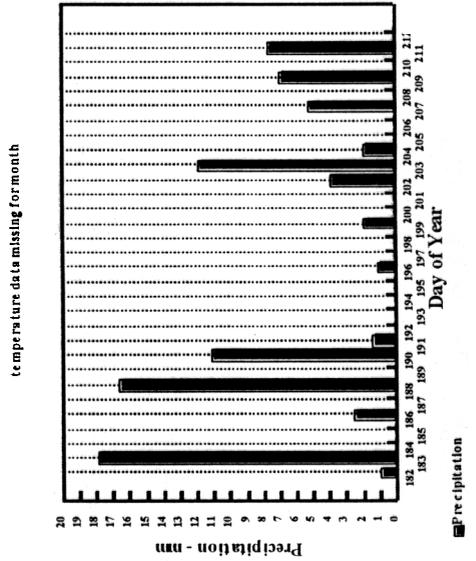
**Mean Daily Maximum/Minimum Temperatures  
& Precipitation at PMRC - May 1994**



**Mean Daily Maximum/Minimum Temperatures  
& Precipitation at PMRC - June 1994**



**Precipitation at PMRC - July 1994**



**Mean Daily Maximum/Minimum Temperatures  
& Precipitation at PMRC - August 1994**

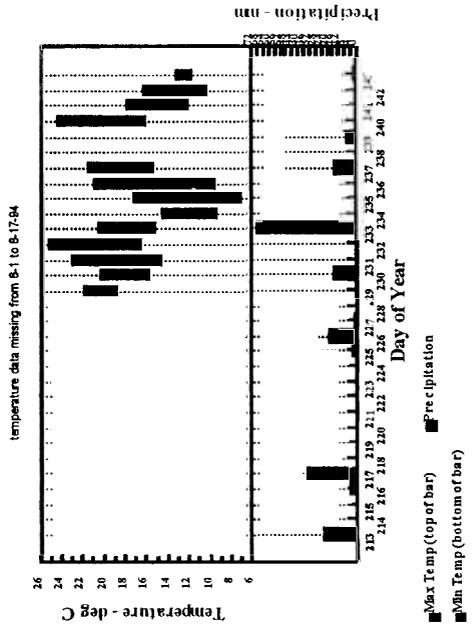
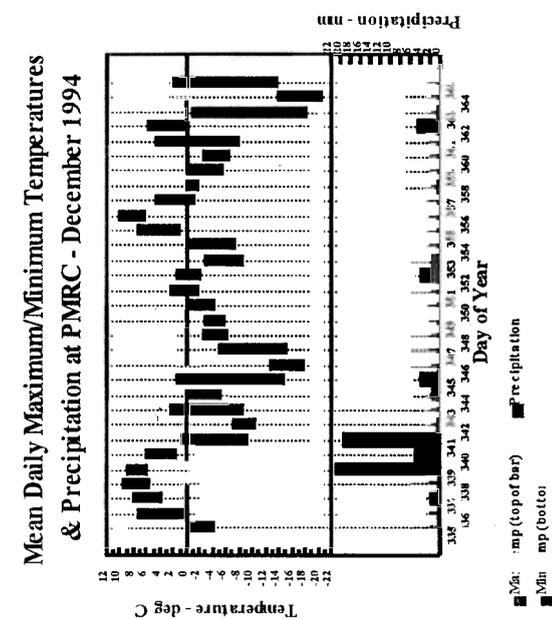
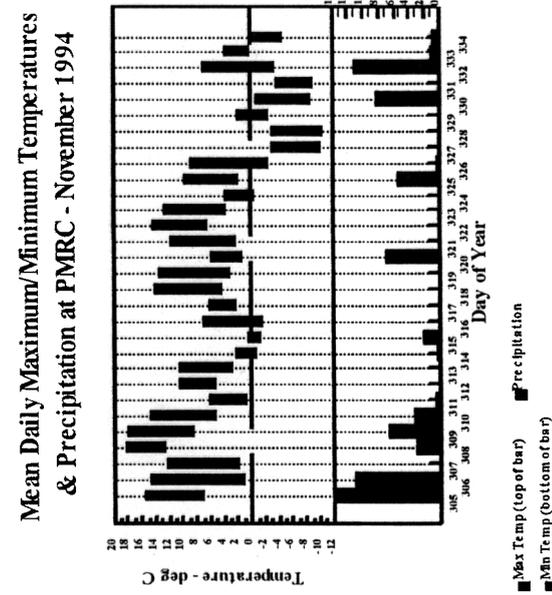
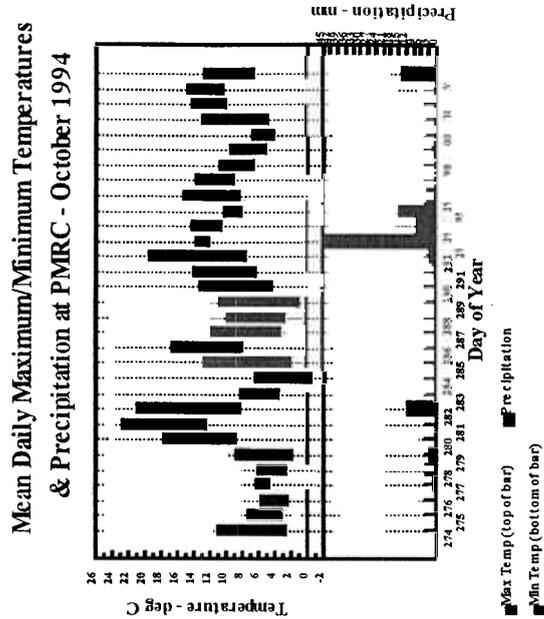
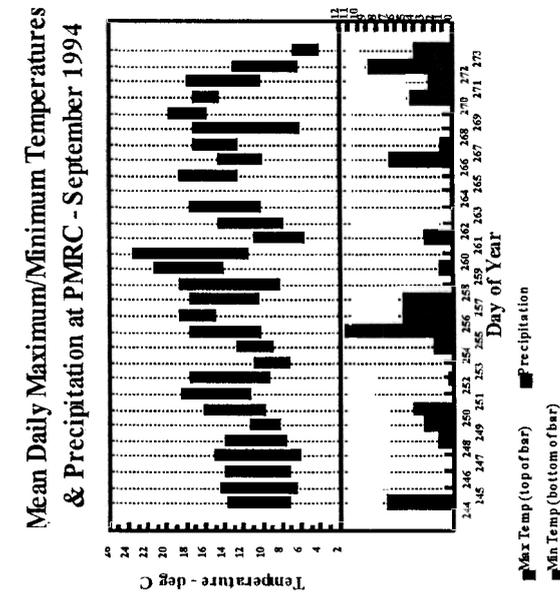


Figure 1. (cont'd) Monthly Temperatures and Precipitation at the PMRC in 1994



**2. Precipitation Chemistry** - The NADP/NTN (National Atmospheric Deposition Program/National Trends Network) maintains a site at the air quality monitoring station at PMRC (400m) for the weekly collection of precipitation for chemical analysis. Precipitation amount, pH and conductivity are measured locally, and the sample is then shipped to the NADP Central Analytical Laboratory in Illinois for analysis of pH, conductivity, Ca, K, Mg, Na, NH<sub>4</sub>, NO<sub>3</sub>, Cl, SO<sub>4</sub> and PO<sub>4</sub>. The sample collection, field lab processing and shipment protocols were modified in 1994 after discovery and verification of contamination to samples from an "O" ring which sealed the lid to the sample bucket for shipping. The contamination was not sufficient to negate the data from previous years, but significant enough to require initiation of new procedures.

This station has been operational since 1984, and is part of a national network of over 200 stations including one other in Bennington, Vermont. Data are available from the VMC in Voyager format or in other forms from the NADP Central Analytical Laboratory. The site supervisor is Tim Scherbatskoy, and the site operator is Joanne Cummings with cooperation from Sumner Williams at PMRC. Table 1 on the following pages shows the 1994 annual summary for NADP precipitation chemistry.

AIRMoN (Atmospheric Integrated Research Monitoring Network) is an event based precipitation monitoring program established at the end of 1992 to provide high-resolution data on precipitation chemistry to support regional modeling efforts. There are 7 sites in the network, located in the northeastern US. Except for being an event based sampling program, it follows the protocol and measures the variables of the NADP/NTN program; the sampler is located at the Air Quality site at PMRC (400 m). Station operation is by Joanne Cummings with supervision by Tim Scherbatskoy. The AIRMoN station was installed in December, 1992. Data for the 1994 sample period are not shown here, but can be accessed from NADP.

**Table 1. National Atmospheric Deposition/National Trends Network**

Data from the NADP station are available for each 2-month period, and as a semi-annual summary from the site supervisor; data is also available for the entire network as an annual and seasonal data summary from NADP; the last annual data summary is for 1994, and is presented in Table 1.

National Atmospheric Deposition Program/National Trends

1994 ANNUAL & SEASONAL DATA SUMMARY  
(Printed 10/26/95)

<b>SITE IDENTIFICATION</b>		<b>SAMPLE VALIDITY FOR ANNUAL PER</b>				
Site	Underhill	Sampling Intervals				
State	VT	Valid Samples 47				
County	Chittenden	with precipitation 46				
Operation	SAES-University of Vermont/USGS	with full chemistry# (45)				
Funding	USGS	without chemistry (1)				
Site No.	470180	without precipitation				
CAL Code	VT99	Invalid Samples				
Latitude	44:31:42	with precipitation				
Longitude	72:52:08	missing precipitation data				
Elevation	399 m					
<b>SUMMARY PERIOD INFORMATION</b>		<b>Annual</b>	<b>Winter*</b>	<b>Spring</b>	<b>Summer</b>	<b>Fall</b>
First summary day (yrmoda)		940104	931130	940301	940531	940830
Last summary day (yrmoda)		950103	940301	940531	940830	941129
Summary period (days)		364	91	91	91	91
Sampling intervals		52	12	13	--	--
Measured precipitation (cm)		113.6	17.6	31.7	41.9	23.4
Valid samples with full chemistry#		45	10	10	12	--
Valid samples with full chemistry & valid field pH		40	10	10	10	--
<b>NADP/NTN COMPLETENESS CRITERIA</b>		<b>Annual</b>	<b>Winter*</b>	<b>Spring</b>	<b>Summer</b>	<b>Fall</b>
1. Summary period with valid samples (%)		92.3	76.9	76.9	92.3	100.0
2. Summary period with precipitation coverage (%)		100.0	100.0	100.0	100.0	100.0
3. Measured precipitation with valid samples (%)		91.8	83.5	85.7	88.7	100.0
4. Collector efficiency (%)		90.6	66.0	89.8	96.8	97.2
Measured precip. with full chem. & valid field pH (%)		85.9	83.5	85.7	80.6	96.6

STATISTICAL SUMMARY OF PRECIPITATION CHEMISTRY FOR VALID SAMPLES

<b>PRECIPITATION-WEIGHTED MEAN CONCENTRATIONS</b>	Ca	Mg	Na	NH4	NO3	SO4	H(lab)	H(fld)	pH (lab)	pH (fld)		
Annual	0.09	0.013	0.015	0.031	0.30	1.52	0.07	2.04	4.44e-2	4.89e-2	4.35	4.31
Winter*	0.04	0.007	0.006	0.044	0.09	1.98	0.09	0.64	3.88e-2	4.15e-2	4.41	4.38
Spring	0.15	0.020	0.022	0.027	0.32	1.59	0.06	1.58	3.19e-2	3.79e-2	4.50	4.42
Summer	0.08	0.013	0.016	0.035	0.41	1.47	0.07	3.24	6.28e-2	6.73e-2	4.20	4.17
Fall	0.08	0.011	0.011	0.030	0.27	1.35	0.07	1.64	3.63e-2	4.02e-2	4.44	4.40
<b>DEPOSITION</b>	----- kg/ha -----											
Annual	1.02	0.148	0.170	0.352	3.44	17.22	0.76	23.12	5.04e-1	5.55e-1		
Winter*	0.07	0.012	0.011	0.077	0.15	3.47	0.16	1.13	6.82e-2	7.29e-2		
Spring	0.48	0.063	0.070	0.086	1.02	5.04	0.20	5.02	1.01e-1	1.20e-1		
Summer	0.32	0.054	0.067	0.147	1.70	6.17	0.29	13.55	2.63e-1	2.82e-1		
Fall	0.19	0.026	0.026	0.070	0.64	3.15	0.16	3.85	8.51e-2	9.41e-2		
<b>WEEKLY SAMPLE CONCENTRATIONS</b>	----- mg/L -----											
Minimum value	0.01	0.003	0.003	0.011	0.02	0.20	0.03	0.18	6.76e-3	7.76e-3	3.81	3.78
Percentile 10	0.02	0.003	0.003	0.014	0.05	0.45	0.04	0.36	1.45e-2	1.60e-2	3.99	3.93
Percentile 25	0.04	0.004	0.004	0.019	0.07	0.78	0.05	0.63	2.11e-2	2.79e-2	4.19	4.13
Percentile 50	0.06	0.009	0.011	0.030	0.28	1.49	0.07	1.43	3.55e-2	4.17e-2	4.45	4.38
Percentile 75	0.11	0.025	0.019	0.046	0.38	2.22	0.09	2.76	6.47e-2	7.42e-2	4.68	4.55
Percentile 90	0.38	0.045	0.045	0.101	0.69	3.54	0.20	3.91	1.03e-1	1.18e-1	4.84	4.80
Maximum value	0.48	0.069	0.064	0.272	1.02	9.16	0.55	5.30	1.55e-1	1.66e-1	5.17	5.11
Arithmetic mean	0.11	0.016	0.016	0.045	0.28	1.89	0.09	1.88	4.67e-2	5.31e-2	4.33	4.27
Arith. std. dev.	0.13	0.017	0.016	0.046	0.23	1.72	0.09	1.43	3.40e-2	3.66e-2		
Below detection	3	6				2	0	0				
<b>OTHER PARAMETERS</b>	Measured Precipitation** cm	Conductivity uS/cm	Equivalence Ratios			<b>OTHER ANNUAL &amp; SEASONAL DEPOSITION VALUES</b>						
			SO4	SO4+NO3	Cation	Total N from NO3 & NH4 (kg/ha)		Equivalence Ratios				
			NO3	H(lab)	Anion	SO4	SO4+NO3	Cation				
						NO3	H(lab)	Anion				
Minimum value	0.03	3.7	0.09	0.88	0.72	Annual	6.56	1.73	1.51	1.00		
Percentile 10	0.46	6.6	0.36	1.05	0.94	Winter*	0.90	0.42	1.17	1.01		
Percentile 25	1.10	13.7	0.75	1.25	0.97	Spring	1.93	1.29	1.84	1.00		
Percentile 50	2.13	19.2	1.49	1.40	1.00	Summer	2.71	2.84	1.45	0.99		
Percentile 75	3.06	33.8	2.23	1.61	1.03	Fall	1.21	1.58	1.54	1.00		
Percentile 90	4.41	53.8	3.00	2.66	1.19							
Maximum value	8.48	75.6	4.20	4.34	1.36							

\* Valid samples for which all laboratory chemical measurements were made (the only samples described by the percentile distributions in the STATISTICAL SUMMARY OF PRECIPITATION CHEMISTRY FOR VALID SAMPLES)

\*\* Data do not meet NADP/NTN Completeness Criteria for this period.

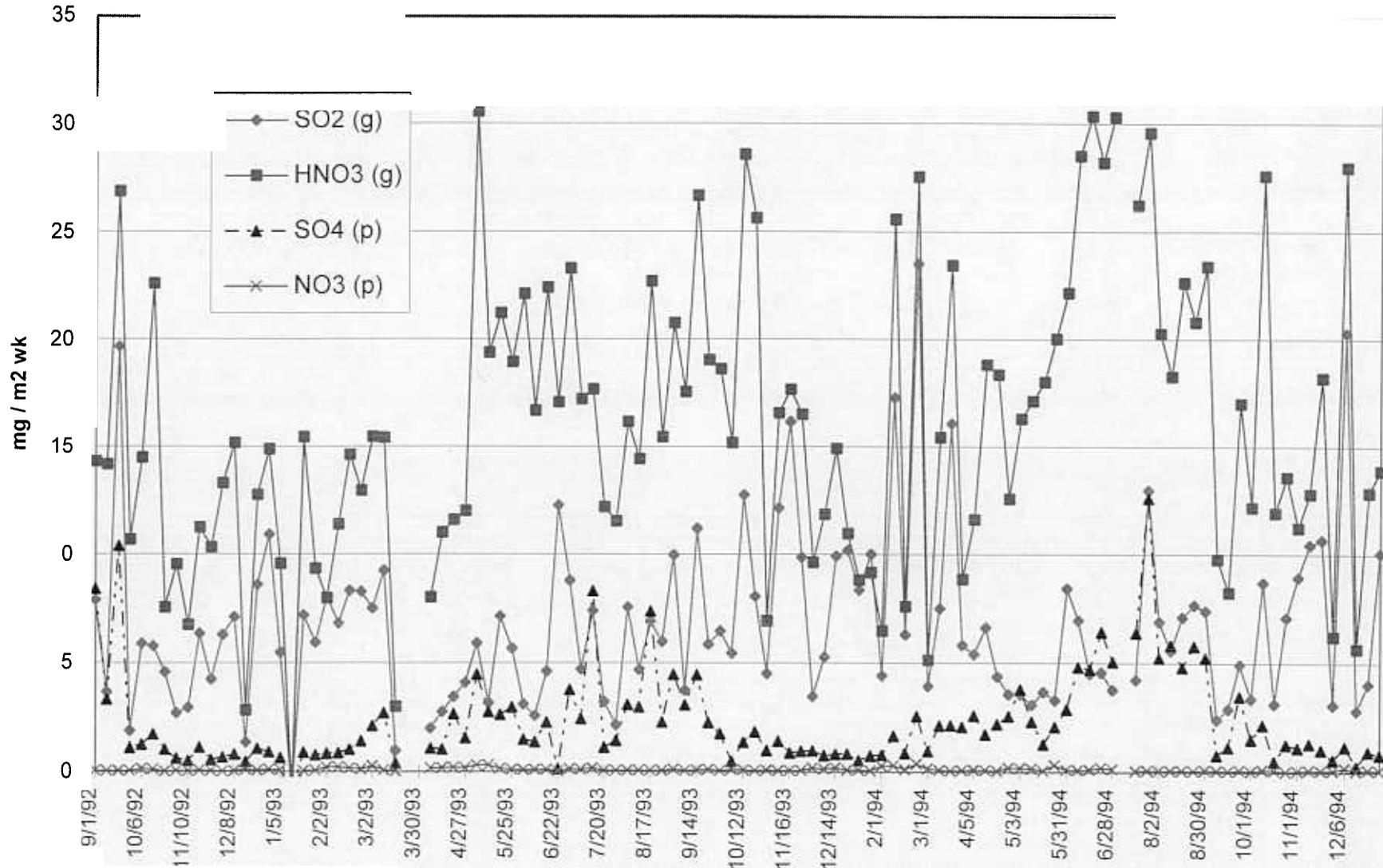
\*\*\* Measured precipitation for sample periods during which precipitation occurred and for which complete valid laboratory chemistry data are available.

**3. Dry Deposition** - The Dry Deposition Inferential Measurement program was started in August 1992 at the forest canopy research tower at the PMRC. This monitoring program uses filterpack technology to collect continuous weekly samples of dry deposition of sulfur (SO<sub>2</sub>) and nitrogen (HNO<sub>3</sub> vapor), and also continuous meteorology including temperature, relative humidity, wind speed and direction, surface wetness and precipitation amount. The goal of this program is to measure atmospheric concentrations of these species and model their deposition rates. This station is one of 10 stations in the NOAA network in the eastern US; the data collected are comparable to other dry deposition monitoring programs in the US operated by the EPA. This equipment is located above the forest canopy at 22 m on the forest research tower. Station operation is by Joanne Cummings with supervision by Tim Scherbatskoy. Filterpack and data analysis are conducted by NOAA, with data returned to the VMC quarterly. Figure 2 shows dry deposition data for 1993-94 at the PMRC forest tower research site.

**SIGNIFICANT FINDINGS:**

No major analyses of trends and relationships in these projects have been completed at this time. The principle goal of these projects is to provide a high-quality, long-term database on meteorological and chemical deposition for use by VMC cooperators and others. Data are maintained as up-to-date as possible, and are generally available from the VMC in various forms. Periodic reports are made available by the major sponsor of each program (e.g., NADP annual statistical summaries).

Figure 2. Dry Deposition at PMRC Forest Tower  
1993-1994



## **FUNDING:**

**1. Basic meteorology** - The PMRC weather station is maintained with funds from the VMC base budget, the University of Vermont, and the VT Dept. of Environmental Conservation (DEC). During its first two years this station was funded and operated by EPRI as part of the Operational Evaluation Network.

National Weather Service data collection and station operations are supported by the NOAA National Weather Service and WCAX-TV. VMC activity and funding was used for initial acquisition of the data and data processing. Access to future updates of the data is anticipated to be provided at no charge by the Vermont State Climatologist.

**2. Precipitation Chemistry** - The NADP/NTN program is funded by several federal agencies; operation of the VMC station is supported by the US Geological Survey. Chemical analysis and data management are supported by the USGS. The AIRMoN program is supported by NOAA.

**3. Dry Deposition** - The overall program as well as the VMC station at the forest research tower is supported by the National Oceanic and Atmospheric Administration (NOAA).

## **FUTURE PLANS:**

All of these stations will continue to operate in 1995. Updates for the Mt. Mansfield weather station (as well as all other National Weather Service Vermont stations) will be obtained in May. The VMC will be installing a remote weather station at 2800 ft in the Underhill State Park area on Mount Mansfield.