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Final Report

for Project

"A Unified Satellite-observation Polar Stratospheric Cloud Database for Long-term Climate-change Studies"

February 12, 2000

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Computational Physics, Inc.

Co-investigators: Michael Pitts
NASA

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Executive Summary

This report summarizes the project team's activity and accomplishments during the period 12 February, 1999 - 12 February, 2000. The primary objective of this project was to create and test a generic algorithm for detecting polar stratopsheric clouds (PSC), an algorithm that would permit creation of a unified, long term PSC database from a variety of solar occultation instruments that measure aerosol extinction near 1000 nm. The second objective was to make a database of PSC observations and certain relevant related datasets. In this report we describe the algorithm, the data we are making available, and user access options.

The remainder of this document provides the details of the algorithm and the database offering.

A Long-Term, Unified Polar Stratospheric Cloud Database: Algorithm Description, Database Definition, and Results Overview

1 Introduction

Satellite-based observations of stratospheric aerosol extinction by the Polar Ozone and Aerosol Measurement (POAM) II and III, Stratospheric Aerosol Measurement (SAM) II, and Stratospheric Aerosol and Gas Experiment (SAGE) II instruments have been combined into a single, unified database of polar stratospheric cloud (PSC) and other aerosol-enhancement observations, along with a database of collocated meteorological variables. The database is designed to be readily extended when additional POAM III and SAGE III observations are available and validated. Access to the database is possible via the world wide web, by linking to http://www.cpi.com/unify.

SAM II, POAM II and III, and SAGE II have produced an impressive polar data record covering a span of 22 years (1978-present) enabling the production of a long-term, near-continuous record of polar stratospheric aerosol and cloud data on a time scale that permits assessment of long-term, climate change issues. There is, at this writing, no other data source of similar extent, temporally or spatially, for studying the link between PSCs, polar dynamics, and climate change.

In section 2 we describe the input data sets in more detail. Section 3 covers the cloud detection algorithm. We compare results derived by this method with those of prior methods in section 4. In section 5 we describe the contents of and interfaces to the Unify long-term stratospheric aerosol and cloud database.

2.0 Data

Figure 1 shows a schematic timeline of the various data sets used in our project.

2.1 Aerosol Data Sets

The POAM II archive [Bevilacqua et al., 1997] extends from 16 October 1993 to November 14, 1996. The POAM II aerosol extinction database includes the Antarctic "PSC seasons" of 1994 through 1996, and three in the Arctic: 1993/94 through 1995/96. POAM III [Lucke et al., 1999] began taking measurements in April 1998 and continues as of this writing. POAM III sampling is identical to POAM II. There are approximately 16,600 POAM II and III northern hemisphere profiles and 16,700 southern hemisphere profiles through 1999, which is the point at which our database terminates.

SAM II [McCormick et al., 1982] operated between November 1978 and January 1994. A degradation of the Nimbus 7 orbit after 1986 caused a year-to-year drift in the SAM II measurement latitudes, especially in the southern hemisphere. In addition, this degradation resulted in a progressive loss of measurement events. The northern hemisphere measurement record becomes discontinuous in mid-June 1988 and ends in January 1991. In the Antarctic, a data gap exists from mid-January through October 1993, with the final two months of SAM II Antarctic data collected during November and December 1993. There are approximately 48,900 SAM II northern hemisphere profiles and 66,400 southern hemisphere profiles.

The SAGE II [Mauldin et al., 1985] archive begins in October 1984. The instrument is still in full operation as of this writing. For our project we have used only the SAGE II measurements poleward of 45° latitude in each hemisphere. Our database contains approximately 37,000 northern hemisphere SAGE II profiles and 67,300 southern hemisphere profiles.

2.2 Auxiliary Data Sets

Previous attempts to identify PSCs from SAM, POAM, and SAGE data have relied on meteorological (MET) data from different sources. SAM and SAGE data are accompanied by MET data from NCEP. POAM data are accompanied by MET data from UKMO. Prior studies of PSC observations have utilized not only a variety of sources for air mass definition, but a variety of criteria as well. For instance, Poole and Pitts, [1994] used NCEP 50-mb geopotential analyses for vortex edge definition; Fromm et al., [1999] used potential vorticity on isentropic surfaces. This project uses the NCEP reanalysis data set [Kalnay et al., 1996], which spans the entire satellite data set. We use this data set to calculate temperature and potential vorticity (PV) collocated to the satellite measurement location. The NCEP data temperature, wind, and PV data are also the inputs to an objective polar vortex edge determination algorithm. The vortex edge algorithm is discussed in more detail in section 3.2.

One meteorological field that is essential to the Unified PSC detection algorithm is tropopause height (Ztrop). We use a dynamical definition of tropopause height; it is the altitude at which the potential vorticity (PV) = 3 PV units.

3.0 PSC Detection

3.1 Algorithm Concept

The primary objective of this project was to create a unified, long-term PSC database using a logically and physically generic algorithm, which is applied to measurements from similar but unique satellite instruments. Our view is that the POAM, SAM, and SAGE data products, near-1000 nm aerosol extinction with a vertical resolution of 1 km, are similar enough that one algorithm could be effectively used for all of the data processing necessary to produce a PSC database. Not only are the instruments similar in concept, the 1 micron aerosol extinction products have also been favorably compared. Randall et al., [1999] performed a comparison of SAGE II and POAM II aerosols. Although a rigorous comparison of POAM and SAM is not possible, we found a good qualitative agreement for November, 1993, during which both instruments were in simultaneous operation. Although the unified cloud detection algorithm does not require rigorous agreement (in fact, the primary advantage of such an algorithm is that it will work well in spite of differences between data sets.), it is reassuring to see that the two instruments that make up the bulk of the long-term database agree in both central tendency and variability when measuring the same air mass.

Historical efforts to perform automated PSC detection on SAM II [Poole and Pitts, 1994] and POAM II [Fromm et al., 1997 and 1999] were based on the same principal: to characterize PSC extinctions as distinct from ambient aerosol loading by virtue of aerosol enhancement thresholds. Even without a unified PSC detection method, Godin and Poole, [1999] performed a direct but qualitative comparison of SAM II and POAM II Antarctic PSC statistics, which indicates the potential value of and demand for combining these data sets with a unified approach.

The desired outcome of this approach to PSC detection is an instrument-independent method for characterizing ambient, reference aerosol loading (i.e. aerosol extinction characteristic of noncloudy conditions), aerosol enhancement thresholds for cloud detection, and the PSC database. We achieve this outcome by developing algorithm elements that are based on generic statistical principles and independent auxiliary data that are consistent throughout the temporal and spatial extent of the satellite data sets. Now we discuss each of these in more detail.

3.2 Vortex Air Mass Considerations

It is well known that polar and midlatitude air masses can have very different aerosol loading conditions. Fromm et al. [1999] showed that POAM II Arctic aerosol extinction was low inside the polar vortex, high outside. In that study the vortex edge region was determined objectively by the method of Nash et al. [1996]. We have computed vortex-edge potential vorticity (PV) values in this manner at 7 potential temperature surfaces (400, 450, 500, 550, 600, 650, 700 K) for both hemispheres for every day between November 1, 1978 and November 29, 1999. As suggested in Nash et al. [1996] we smooth the data with a five-day filter. In meteorological conditions with an indistinguishable polar front, the Nash algorithm returns a null value for the vortex edge. We use this information to determine the beginning and end of the "vortex season." When the vortex breaks down, the frequency of occurrence of null values increases in time. The opposite occurs in the transition from summer to winter. We determine a vortex season start and end date by computing the date at which the likelihood of a null value is 50%. This is accomplished by computing a running average of null value percent frequency. Once a vortex season start (or end) date is identified at a particular potential temperature level, the season is considered to be nearly continuous throughout, until the next (or prior) start/end date. In the same way, the no-vortex season is considered to be nearly continuous. In the course of the period we're analyzing, there are occasions when the vortex season is interrupted or otherwise discontinuous. For example, during major stratospheric warmings the polar vortex may completely break down. Our vortex edge algorithm will recognize "breaks" in the vortex season that extend for more than 5 days. During a vortex season, edge PV values are interpolated to shorter intervals for which a null value was computed by the Nash algorithm.

The vortex edge region was determined by Fromm et al. [1999], in terms of the transition of aerosol loading, to be between the Nash equatorward vortex edge boundary (which is roughly the location of equatorward extent of the high-PV gradient that defines the polar jet region) and the primary edge boundary (which is roughly the location of the maximum PV gradient). Therefore, Fromm et al. [1999] concluded that the "belt" defined by the Nash equatorward and primary vortex edge PV values defined the aerosol transition zone. In this project we adopt that convention and consider data points and profiles outside the Nash equatorward boundary as outside the vortex. Data points and profiles poleward of the Nash primary vortex edge boundary as inside the vortex.

3.3 Reference Aerosol and Zmin Calculation

3.3.1 Statistical Approach

As mentioned above, the basic concept is to identify PSCs (and other anomalous aerosol structures) by virtue of "enhancement" features in the SAM, SAGE, or POAM 1 um aerosol profiles. Two enhancement signals are considered, an increase of aerosol extinction above a reference threshold, and a profile termination altitude (hereafter referred to as Z_{min}) higher than normal. Fromm et al., [1997 and 1999] and Wang et al., [1995] documented the value of monitoring these "high Z_{min}s" for evidence of stratospheric and tropospheric clouds, respectively. Both of these enhancement features are defined in terms of departures from ambient norms, which are calculated using simple and generic statistical principles, described in greater detail below.

3.3.1.1 Reference Ambient Extinction Data Set

To calculate the reference ambient extinction we consider a population of data points and assume that it is comprised of clear-sky and cloudy measurements. A typical population of extinctions is shown in Figure 2, which is a histogram of Antarctic POAM III 1020 nm extinction at 20 km altitude in July, 1998. During this month, which is midsummer in the northern hemisphere and midwinter in the southern, the sky at 20 km is devoid of clouds in the summer hemisphere. PSCs and clear skies are both present in the southern. The PSC signature is the high extinction that makes up the right-side tail of the histogram. The preponderance of the data in this population though are grouped in a quasi-Gaussian distribution centered around a low extinction value. We make the assumption that extinctions on the low side of the modal value are clear-sky observations. This assumption is shown to be reasonable by comparing the modal value in the southern hemisphere July population with that of the northern hemisphere. Based on this assumption, we consider the subset of extinctions "to the left of" (i.e. less than) the modal value in a given sampling period to be the basis for characterizing the central tendency and variability of the ambient reference extinction.

The reference ambient aerosol calculation is performed as follows. Each profile is assigned to a polar air mass by invoking the objective polar vortex edge identification algorithm of Nash et al., [1996]. If the profile (between 13 and 30 km) is more than 90% inside the vortex, it is placed in the inside-the-vortex subset. If more than 60% is outside the vortex, the profile is placed in the outside-the-vortex subset. Profiles that don't meet one of the above conditions are considered to be representative of the vortex edge region. The reference ambient aerosol data set consists only of an outside-the-vortex and inside-the-vortex component—profiles at the vortex edge are ignored. For periods during which there is no discernible polar vortex, the outside-the-vortex dimension becomes the only air mass identified.

For each altitude bin between 13 and 30 km, the data in each subset are binned in 10-day intervals. Nominally, this time interval contains a maximum of approximately 140 data points (14 profiles per day for 10 days). When a 10-day sampling period consists of inside-the-vortex and outside-the-vortex profiles, the sample size is proportionally reduced. Statistics are computed in a 10-day interval only when the sample size is greater than 10 data points. Each subset is input to an algorithm that automatically, and through an iterative process, computes a modal value. Data points with an extinction less than the modal value are assumed to be representative of clear-sky measurements and consequently are selected for the computation of the reference aerosol central tendency and variability. The population of the chosen sample is then doubled by taking each observation and computing a "reflected" value. The reflected value is calculated per the equation below.

$$Er = Emodal + |Emodal - Eo|$$

Where Er is the new, reflected extinction, Eo is the original observation, Emodal is the modal extinction value, and the vertical bar bracketing signifies absolute value. The new population consists of the set of Eo and Er values. Emodal becomes the median of the new distribution and a new standard deviation is calculated about Emodal. These two statistics become the basis for the reference ambient aerosol data set and the cloud extinction threshold.

Over the span of the long-term SAM, POAM, and SAGE data sets, there are several occurrences when one of the two air mass subsets of the reference ambient extinction data set has insufficient data for a statistical calculation. One type of occurrence was mentioned above—during some non-winter months, when there is no distinction between polar air masses, there is no such thing as an inside-the-vortex reference statistic. For other reasons, such as normal sampling patterns or intermittent instrument performance, there are other periods when one or the other air mass subset is devoid of statistics. One recurring example in the SAM and POAM data sets is the months of August and September in the southern hemisphere. During these months both instruments typically sampled only inside the vortex. At these times there are no outside-the-vortex statistics. Another limitation on statistics gathering comes at times when cloud occurrence is so high that the sample has an indistinguishable clear-air modal value. When such conditions are encountered, the resulting clear-air statistics are suspect. Our algorithm has a second-pass element that flags outlier statistics in each air mass's 10-day intervals and removes them. The second pass through the clear-air statistics includes an interpolation scheme and a 5-point smoothing filter to produce the final reference ambient extinction data set.

3.3.1.2 Reference Ambient Zmin Data Set

The reference ambient Zmin dataset is computed using an analogous concept. Here the Zmin relative to the tropopause height (Ztrop) is used. Zmin-Ztrop is used because it factors out tropospheric influences on Zmin, whether due to tropospheric clouds or otherwise elevated tropospheric aerosol burden. This quantity is also useful in that it shows directly whether or not the extinction profile penetrated into the troposphere. Zmin-Ztrop is distributed in a roughly Gaussian manner in the summer, but with a distinctive skew in the winter. We have performed exhaustive analyses on POAM, SAM, and SAGE data that leads us to conclude that the skew is an artifact of PSCs. Furthermore, we have found (and continue to study) that these "High Zmins" are a signal of particularly opaque clouds, which suggests distinctive cloud compositions for such observations.

To compute the reference ambient Zmin data set, we perform operations logically identical to those for the reference ambient aerosol data set. However, we do not segregate Zmin data points into inside- and outside-the-vortex subsets as we do for extinction. Also, we use monthly bins instead of 10-day bins.

3.4 Changing Ambient Conditions

It is well known that ambient stratospheric aerosol conditions are significantly impacted by some volcanic eruptions. In the time frame of these satellite data sets, no fewer than 3 volcanic eruptions made an imprint on the SAGE, SAM, and POAM stratospheric aerosol time series. The manifestation of volcanic perturbations on these aerosol profiles is analogous to any cloud: an increase in aerosol extinction and an increase in Zmin. Both phenomena are widely reported in the literature. For example, Randall et al., [2000] discuss the impact relative to POAM and SAGE; McCormick and Trepte, [1987] do so in an analysis of the SAM II optical depth record.

As a consequence of the volcanic effect on these satellite data sets, it is challenging to derive a simple ambient reference atmosphere. Since aerosol burden has ranged between nearly background and volcanic conditions during this time frame, we recognize that any analysis of aerosol "enhancements" can and will have temporally changing thresholds and interpretations. For example, Poole and Pitts, [1994] chose to disregard the immediate post-El Chichon period (1982-1983) from their 12-year PSC climatology because the volcanic loading "obscured the identification of PSCs."

It is also quite possible for aerosol perturbations traceable to volcanoes or other non-PSC activity to be mistaken for PSCs. Since these solar occultation instruments have no direct way of measuring aerosol composition, final determination of the nature and source of the aerosol feature is usually made by inference. For instance Fromm et al. [1999] and Poole and Pitts, [1994] use a temperature threshold to qualify the observed aerosol enhancement as a PSC. Theoretically a volcanic aerosol feature could be present at a time, temperature, and location that is consistent with PSC activity. Therefore, it will always be a necessity, when using a database of such measurements, to be cognizant of the possibility of misinterpreting the nature of an aerosol enhancement feature.

An important element of the database we are producing is the reference aerosol data set. While noting the complications mentioned above, we believe that our algorithm for determining the characteristic central tendency and variability of these conditions represents a sound approach for capturing locally ambient aerosol loading conditions. Later in this document we discuss our approach for qualifying PSC observations in the presence of such limiting factors.

3.5 Unified Cloud-Detection Algorithm

The altitude range within which the cloud detection is performed is from 13 km to 30 km. An exception to this fixed range occurs when the tropopause is high enough to penetrate or be in the vicinity of this range. To ensure that the features being detected are stratospheric in origin, we require that the minimum altitude be 2 km above the tropopause.

PSCs and other stratospheric clouds are recognized as either an enhancement of aerosol extinction over local ambient conditions or a higher than normal profile Zmin. This determination is made by comparing each profile with the reference ambient extinction and Zmin data set, as described below.

3.5.1 Extinction Cloud Threshold

Through experimentation and sensitivity testing, we concluded that two extinction thresholds were appropriate. The lower cloud threshold is 3 standard deviations above the reference ambient extinction value. The high cloud threshold is 6 standard deviations. Each data point from every profile is compared with these cloud thresholds, so a cloud yes/no is produced for every SAM, POAM, or SAGE measurement in the altitude range mentioned above.

As mentioned in section 3.2, the location of a profile with respect to the vortex edge is crucial for determining the proper reference profile with which to compare. We compare an individual profile's measurements with the inside-the-vortex reference profile if the individual profile is inside the vortex at 75% of its measurement points. Otherwise, the reference profile is the outside-the-vortex profile.

3.5.2 High Zmin Threshold

Each profile's Zmin is compared with the reference ambient Zmin. To be precise, we compare the individual profile's Zmin-Ztrop with the reference value. The cloud criteria is a Zmin-Ztrop greater than three standard deviations from the reference norm. We also apply more tests to distinguish stratospheric clouds from all clouds (Tropospheric clouds can be inferred from High Zmins that are at altitudes lower than the tropopause.). The High Zmin must be 2 km above the tropopause to be flagged as a stratospheric cloud.

3.5.3 Temperature Screen

A temperature screen is an important element of a PSC-detection scheme. There are circumstances for which the above-mentioned PSC signals provide false positive information. We give three examples. First, an aerosol extinction profile that extends through a tilted vortex edge can produce a feature that looks like an enhancement layer that is, in fact, not a PSC. Secondly, in conditions of high volcanic aerosol loading, profile Zmin is typically elevated. Thirdly, observations of aerosol layers (that have a PSC-like signature) in the winter polar hemisphere outside the vortex in very warm (i.e. above 210 K) conditions have been observed by POAM II, SAM II, and SAGE II [Fromm et al., 1998b; and Poole, personal communication, 1997] as well as by other instruments [e.g. Rosen et al., 1992]. Therefore, it is essential to incorporate a "sanity" check on the detected PSC signal. We use a temperature scale based on a 5 K offset from NAT saturation temperature assuming a constant 6 ppmv of water vapor and 9 ppbv of HNO_3.

We also use what we call a "warm layer" temperature screen. Since there are known to be stratospheric aerosol layers in temperatures much warmer than well known PSC formation values, we flag aerosol layers at temperatures above T_{NAT}+15 K

4.0 Comparison of Unified Results with Prior Methods

Here we present and discuss a comparison of selected PSC data generated by the Unified method with results from the method of PP94. We have chosen one month of SAM II profiles, July 1986, in the southern hemisphere. The purpose of these comparisons is to quantify agreement and to identify where the Unified results are in disagreement, with an investigation into the sources of the disagreement.

Table 1 shows the breakdown of results between PP94 and the Unified method for July 1986. Here the numbers are in terms of what we call "PSC profiles." A PSC profile is one in which a PSC is detected at any altitude. In other words, the PSC profile is counted once, regardless of how many individual levels in the profile have a PSC signature.

Table 1

		Unified			
		Yes	No	Total	
PP94	Yes	177	17	194	(49.6%)
	No	55	142	197	(50.4%)
Total		232	159	391	
		(59.3%)	(40.7%)		

Table 1 shows that overall the Unified method produced a PSC sighting proportion of 59% in July 1986 compared with 50% for PP94. Of the 194 PSCs detected by PP94, 177 (91%) were also detected by the Unified method. However, the Unified method detected 55 PSC profiles that PP94 rejected; PP94 detected 17 PSC profiles that the Unify algorithm rejected. In general, the results in Table 1 indicate that the two methods produce a large core of agreement but the Unified method generates, in the net, a larger PSC sighting likelihood.

We now explore in more detail the two categories of disagreement. Figure 3 shows the July 1986 SAM II profiles in two categories related to Table 1, Unified "yes"/PP94 "no" and Unified "no"/PP94 "yes". The figure shows all the profiles and the mid-month, reference ambient aerosol norm and Unified cloud threshold. The figure also shows the collocated temperature profiles..

In the case of Unified "yes"/PP94 "no" (Figure 3a) we see that the extinction profiles generally exhibit a definite enhancement layer signature (with respect to the inside-vortex reference ambient extinction background), and the collocated temperature profiles consistently have Tmin below 200K. We conclude that the Unified PSC detection is reasonable and that the PP94 method misidentified these profiles as containing no PSC observation. Although it is not feasible to determine the exact reason in the case of every profile, our investigation indicates that the PP94 reference aerosol profile allowed a high number of false negatives due to contamination by clouds and outside-vortex air. As a result, the PP94 extinction threshold sufficiently large that a considerable number of modest-enhancement profiles were rejected.

In the case of PP94 "yes"/Unified "no" (Figure 3b) we see that in this small number of cases the profiles appear to have little or no enhancement feature, when compared with the outside-vortex reference ambient extinction threshold. We have determined that these profiles were in fact outside the vortex, so that the Unify method evaluated the enhancements as insufficiently large to exceed the PSC threshold.

5.0 Results and Database Products

5.1 Summary Statistics

Here we present a brief summary of PSC statistics from the Unified PSC database. It is beyond the scope and intent of this document to provide an exhaustive analysis of the results. However, this brief treatment is presented to give a general indication of the size of the database, the overall frequency with which PSCs are detected by the Unified algorithm, and the contribution of each of the three satellite instruments to this long-term record.

Table 2

		Total	In Vortex	PSCs
SAM II	N	48,853	12,927	1,959
	S	66,427	32,547	12,757
SAGE II	N	36,955	1,511	139
	S	67,322	3,748	1,391
POAM	N	12,345	11,234	1,234
	S	16,706	10,296	6,287

Table 2 shows that the superset of polar-region profiles contained in this database is over 230,000. Of that number there are in excess of 70,000 profiles inside the polar vortex. Thus it is apparent that there is significant potential for analyzing the changing properties of polar aerosol conditions, both cloud-free and cloudy. PSC profiles in the three data sets exceed 20, 000; even SAGE II contributes over 1,000 PSC profiles. Even though SAGE's sampling in the polar realm is episodic, these results suggest enormous potential for studying PSCs observed contemporaneously by SAM and SAGE or POAM and SAGE.

5.2 Database Description

The unified PSC database can be viewed is a set of data vectors that augment existing SAM II, SAGE II, and POAM II and III data structures. For example, the database contains vortex-proximity information for every extinction measurement making up a profile. Data vectors such as these are connected to each profile and are defined on each instrument's native altitude grid (POAM and SAM are on a 1-km altitude grid centered on the whole km; SAGE data re reported at 1-km intervals centered at 0.5 km.). In addition to the detailed vectors, we produce a database catalog, which is a 1-line summary extracted from each profile--each catalog entry represents a single altitude from a given profile. The catalog will be described in more detail later in this section. Two additional data sets that go into the Unified PSC database are also considered deliverables. One is the reference ambient aerosol/Zmin data set, the second is the Nash vortex edge data set. These also are described in detail later in this section.

5.2.1 Nash Vortex Edge Data set

The Nash vortex dataset describes for both hemispheres for the entire term of the satellite data set (starting on 1 November 1978 and ending on 29 November 1999) the Nash vortex edge values on 7 potential temperature levels, 400, 450, 500, 550, 600, 650, and 700 K. In general, potential temperature surfaces in this range are between 14 and 26 km.

This dataset is in the form of array variables in an IDL
save file.
The fundamental array dimensions are:

* time span = 7731 elements (1 November 1978 - 29 November 1999)
* theta levels = 7 (in array order from low to high value)
* edge values = 3 (in array order from equatorward to poleward)
* hemispheres = 2 (SH = 0; NH = 1)

The vectors in this data set describe:

1. Date (yyyymmdd format)
2. Vortex edge PV, directly from Nash algorithm
3. Binary vortex season indicator (1=yes, 0=no)

4. Smoothed, interpolated Vortex edge PV
5. Potential temperature

5.2.2 Reference Ambient Extinction/Zmin Data Set

These data are available for both hemispheres. The completeness along the long-term timeline for each instrument depends on its frequency of measurement. Null values are used when the instrument recorded insufficient measurements for valid statistics.

1. Median Extinction
    a. Inside vortex
    b. Outside vortex
2. Median deviation extinction
    a. Inside vortex
    b. Outside vortex

5.2.3 Unified PSC Database Elements

The Unified PSC database consists of the following data elements that uniquely identify each profile:

Instrument mnemonic
orbit number
date (yymmdd)
time(UT sec)
latitude
longitude (0 - 360 degrees)
profile Zmin (km)
tropopause height (km)

On each profile's altitude grid detail are the following elements (in addition to the 1 micron extinction)
temperature (K)
potential vorticity
potential vorticity of the Nash vortex edge (3 values)
vortex collocation initial (i=inside, e=edge, o=outside, n=no vortex)
psc yes/no,
layer psc yes/no
"warm layer" yes/no
HiZmin yes/no
extinction enhancement (multiple of standard deviation)

NAT saturation temperature
Frost point temperature

Note: the potential vorticity of the Nash edge is expressed as PV when a vortex exists. In cases when there is no discernible vortex, this data item is set to -999. In cases of a discernible vortex but when the potential temperature range (400-700 K) is insufficient to cover the altitude range of analysis (13 - 30 km) this data item is set to -800.

5.2.4 Database Catalog

A summary of the database detail is contained in ASCII catalog files. Here each profile is represented in one catalog line. The line in the catalog is from that altitude at which one of the following occurs, in the order listed:

1. If a PSC is detected in the profile, the altitude of the peak PSC extinction enhancement
2. If a PSC is not detected, the altitude of the peak extinction.

The catalog entries are:
event number
date (yymmdd)
time (UT seconds)
latitude
longitude
vortex colocation index (i,e,o, n)
PSC yes/no indicator (overall)
PSC yes/no indicator (Layer)
PSC yes/no indicator (High Zmin)
extinction enhancement
altitude of enhancement
temperature at the altitude of the enhancement
PSC temperature threshold at the altitude of the enhancement
Zmin-Ztrop departure(sigma)
temperature of Zmin
temperature threshold at Zmin
Tmin of profile
altitude of Tmin
PSC temperature threshold at altitude of Tmin
tropopause height

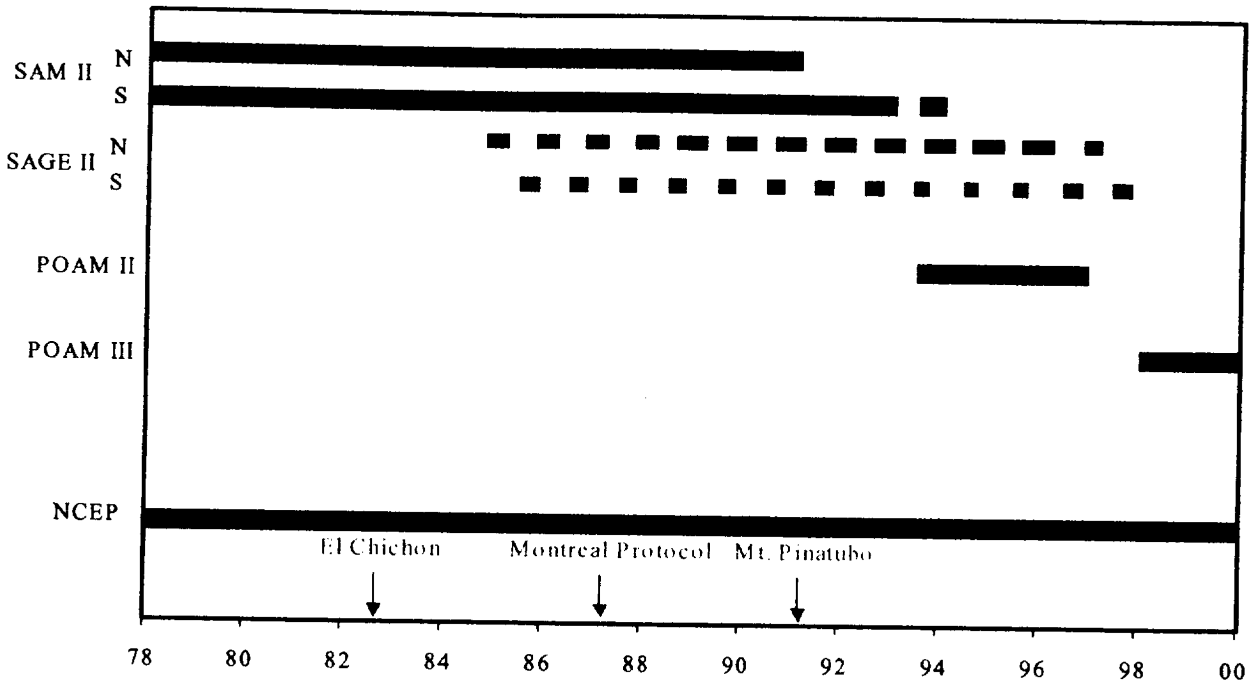

SAM II
N
S
SAGE II
N
S
POAM II
POAM III
NCEP
El Chichon
Montreal Protocol
Mt. Pinatubo
78
80
82
84
86
88
90
92
94
96
98
00

Figure 1

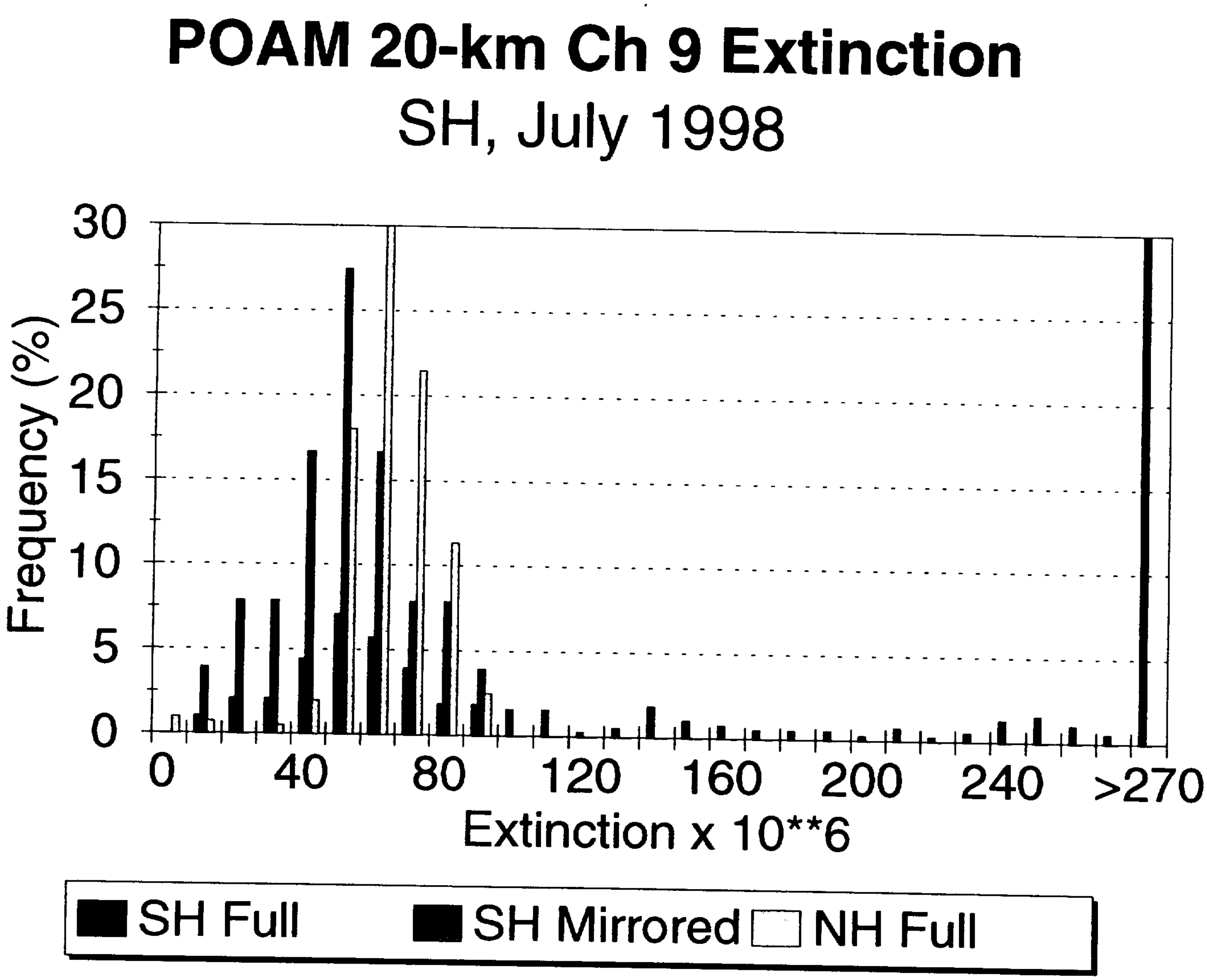
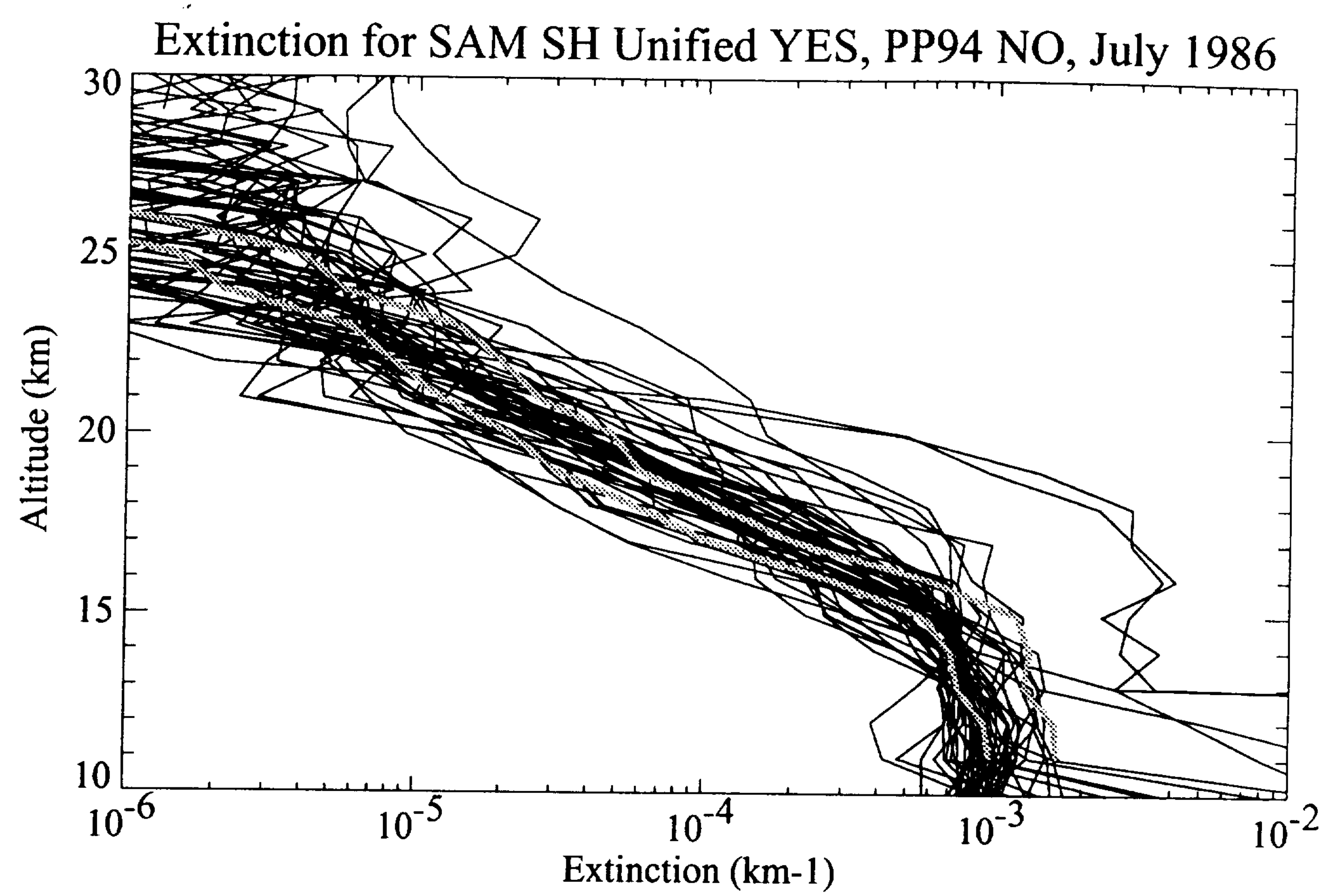

POAM 20-km Ch 9 Extinction
SH, July 1998
Frequency (%)
30
25
20
15
10
5
0
0
40
80
120
160
200
240
>270
Extinction x 10**6
SH Full
SH Mirrored
NH Full

Figure 2


Extinction for SAM SH Unified YES, PP94 NO, July 1986
Altitude (km)
Extinction (km-1)
30
25
20
15
10
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}

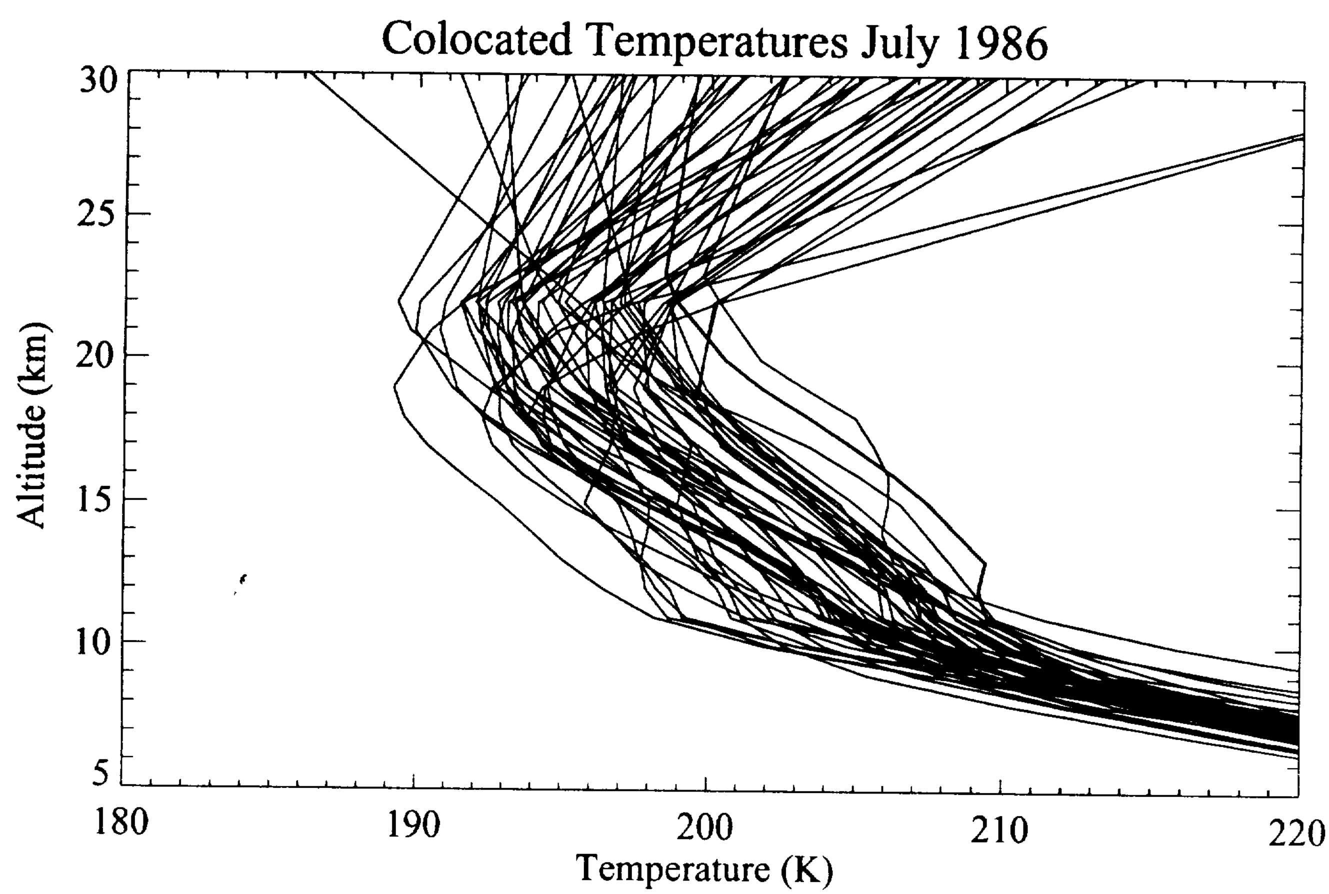
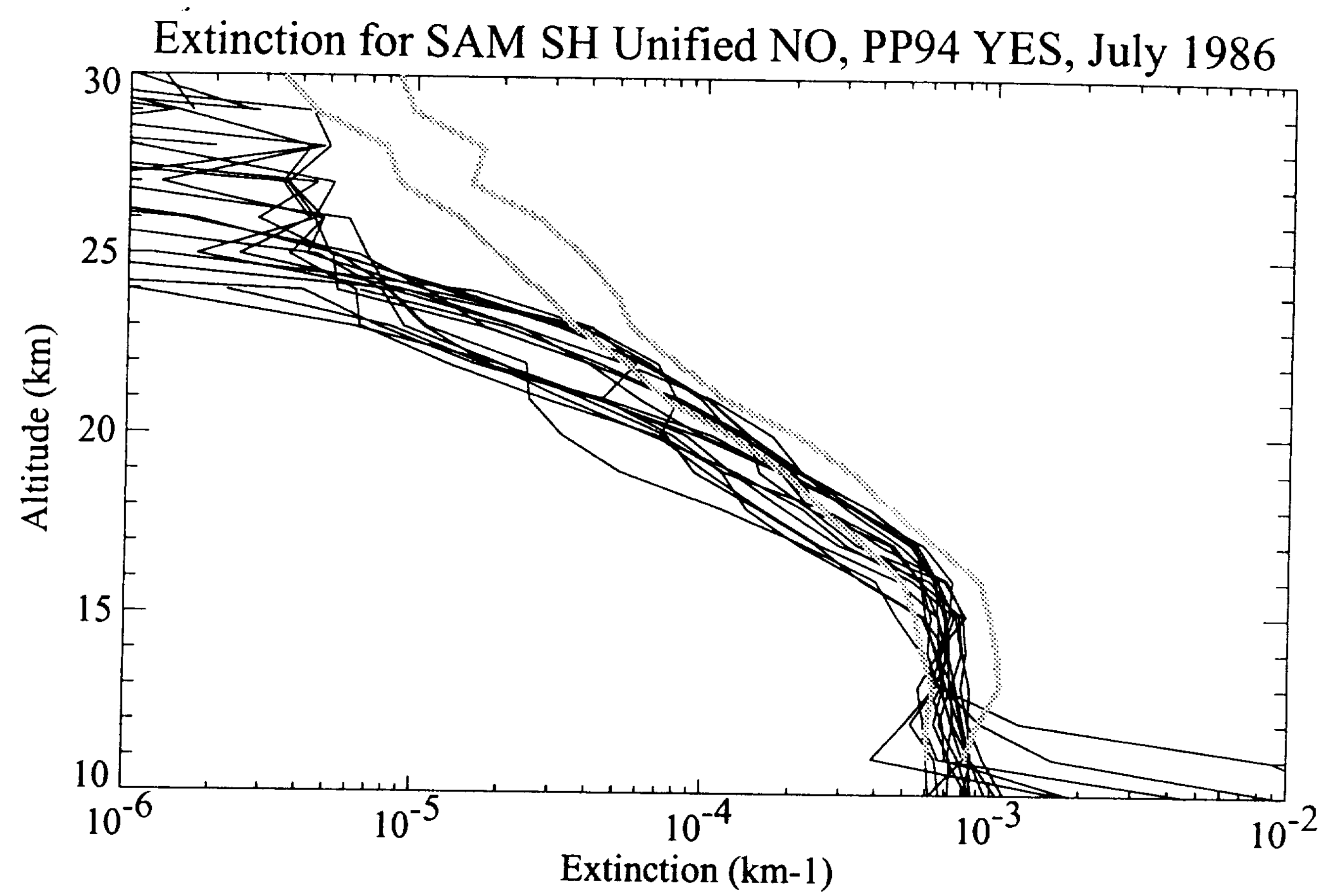
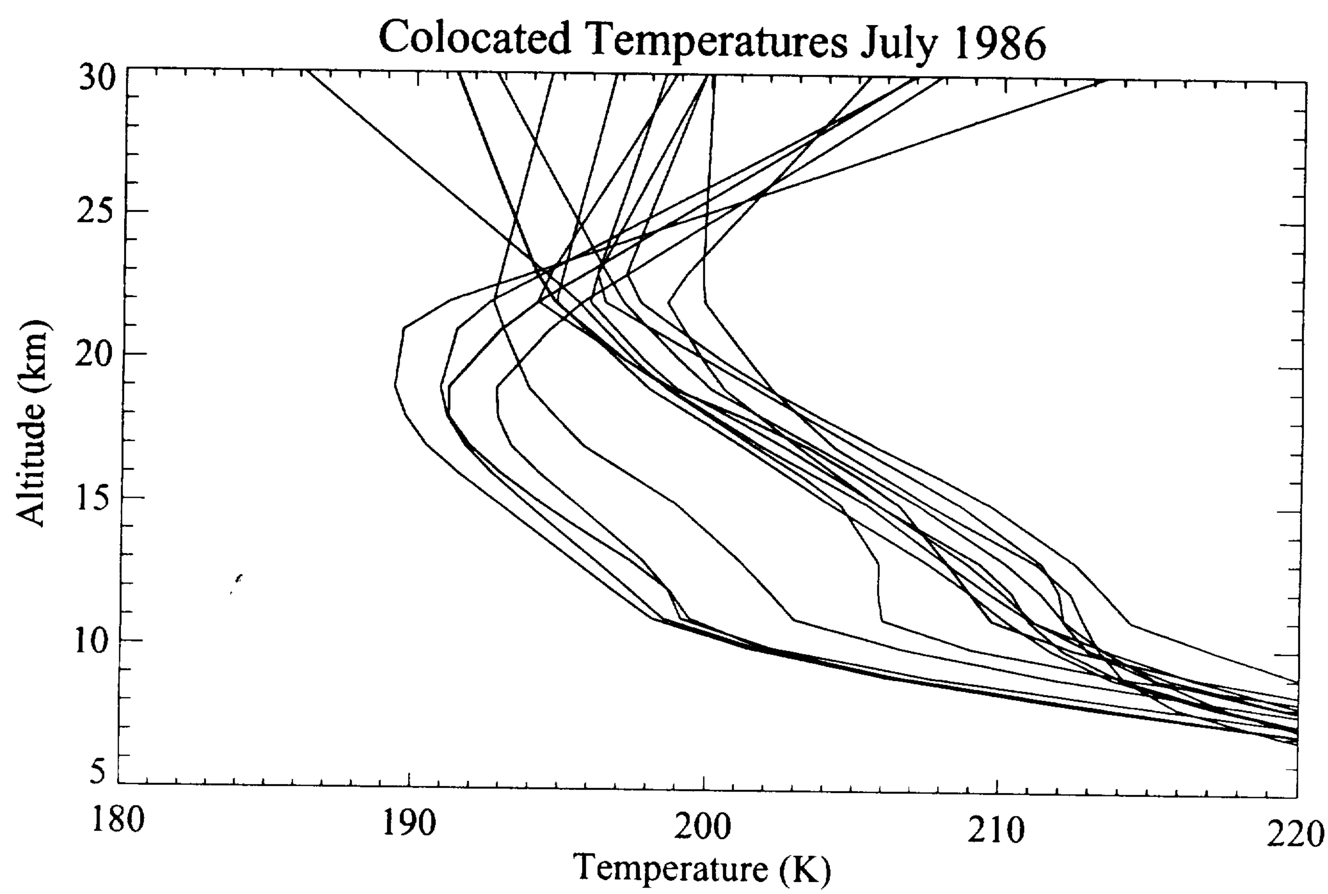

Colocated Temperatures July 1986
Altitude (km)
Temperature (K)
30
25
20
15
10
5
180
190
200
210
220

Figure 3?



Extinction for SAM SH Unified NO, PP94 YES, July 1986
Altitude (km)
30
25
20
15
10
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
Extinction (km-1)



Colocated Temperatures July 1986
Altitude (km)
30
25
20
15
10
5
180
190
200
210
220
Temperature (K)

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