NDP-013

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Volcanic Loading: The Dust Veil Index

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NDP-013

VOLCANIC LOADING: THE DUST VEIL INDEX

Contributed by
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September 1985

Prepared by the
Carbon Dioxide Information Center
Information Resources Organization
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-2008
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CDIC NUMERIC DATA PACKAGE NDP-013

ABSTRACT

1. NUMERIC DATA PACKAGE NAME

Volcanic Loading: The Dust Veil Index

2. CONTRIBUTOR(S)

H. H. Lamb
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Norwich, UNITED KINGDOM

3. HISTORICAL BACKGROUND INFORMATION

Dust ejected into the high atmosphere during explosive volcanic eruptions has been considered as a possible cause for climatic change. Dust veils created by volcanic eruptions can reduce the amount of light reaching the Earth's surface and can cause reductions in surface temperatures. These climatic effects can be seen for several years following some eruptions and the magnitude and duration of the effects depend largely on the density or amount of tephra (i.e. dust) ejected, the latitude of injection, and atmospheric circulation patterns.

Lamb (1970) formulated the Dust Veil Index (DVI) in an attempt to quantify the impact on the Earth's energy balance of changes in atmospheric composition due to explosive volcanic eruptions. The DVI is a numerical index that quantifies the impact of a particular volcanic eruptions release of dust and aerosols over the years following the event. The DVI for any volcanic eruption is based on a review of the observational, empirical, and theoretical studies of the possible impact on climate of volcanic dust veils. Various lists of volcanic eruptions are available (Royal Society 1888, Sapper 1917 & 1927, Shaw 1936, Humphreys 1940, Gutenberg and Richter 1954, Bulletin Volcanologique 1924-60, Bulletin of Volcanic Eruptions 1961, and the Smithsonian Institution's SEAN Bulletin 1976-) and have been used in estimating Lamb's dust veil indices.

4. SOURCE AND SCOPE OF THE DATA

This package provides DVI's for the period 1500 A.D. to 1983 A.D. along with DVI estimates for the eruptions of Santorin in 1470 B.C., Vesuvius in 79 A.D., and Oraefajokull in 1362 A.D. Descriptions of individual eruptions and details on the methods used in assessing the DVI of a

particular eruption are provided in the critical documents.

Five different methods have been used by Lamb to determine the DVI for any particular eruption. Final DVI values are averages, sometimes corrected subjectively, of the estimates produced by as many of the five methods as data availability permits. The first method used was to make subjective estimates based on previous compilations of secondary historical sources. Three methods that were developed incorporate formulas devised to systematize the estimation of the DVI after the initial subjective or "free" estimates had been made. These three formulas estimate the DVI based on the depletion of radiation following the eruption, temperature variations following the eruption, and the amount of solid material dispersed as dust after an eruption, respectively. The three formulas are:

$$DVI = 0.97\ R_{max}\ E_{max}\ t_{mo} \quad (1)$$

$$DVI = 52.5\ T_{dmax}\ E_{max}\ t_{mo} \quad (2)$$

$$DVI = 4.4\ q\ E_{max}\ t_{mo} \quad (3)$$

The quantity t_{mo} and E_{max} in each equation are estimates of the veil duration in months and the geographical extent of the veil, respectively. E_{max} for any eruption is dependent on the latitude of the particular volcano and is:

1.0 for an eruption between 20^{o}N and 20^{o}S
0.7 for an eruption between 20^{o} and 35^{o}
0.5 for an eruption between 35^{o} and 40^{o}-42^{o}
0.3 for an eruption in higher latitudes.

R_{max} (1) is the greatest percentage of depletion of direct radiation following the eruption, as registered by the monthly averages in middle latitudes of the hemisphere concerned. T_{dmax} (2) represents the estimated lowering of average temperature in degrees Celsius over the middle latitude zone of the affected hemisphere in the year most affected following an eruption. The value q (3) is an estimate in cubic kilometers of the solid matter dispersed as dust in the atmosphere. All five estimation methods have been intercalibrated to give a DVI of 1000 for the eruption of Krakatoa in 1883. The numerical constants (e.g., 0.97) given in the above formulas are scaling factors to aid in accomplishing this intercalibration. Greater detail about the formulas and assumptions used in estimating the DVI values are given in the critical documents provided in this package.

Many of the earlier eruptions had no data available other than Sapper's rating of the lava and tephra magnitude of the eruption. The fifth method developed by Lamb was to calculate an average DVI value for each of Sapper's tephra ratings for eruptions where independent data were available.

5. APPLICATIONS OF THE DATA

The DVI is an attempt to place a quantitative measure on the magnitude of volcanic eruptions and allows comparisons of volcanic eruptions by a single numerical index. Comparisons can also be made to the Volcanic Explosivity Index (VEI) recently developed by Simkin et al. (1981) (see also Newhall and Self 1982), although the VEI is based on geological considerations. The impact on the energy balance by the dust and aerosols ejected into the atmosphere results in climatic change on a short-term basis. The short-term effects can be used to calibrate models for simulating climate change under various regimes. Additionally, the DVI has been used extensively in assessing climatic change that may be attributed to an increase in the atmospheric concentration of carbon dioxide.

6. LIMITATIONS/RESTRICTIONS

The DVI values should be used only to indicate order of magnitude and should not be used without reference to the method(s) used in its estimation. The data available for many early eruptions are not sufficient to place a high degree of reliability on the DVI estimates for these eruptions. The fact that DVI estimates could not be made for many eruptions indicates the sparcity of data available for many known eruptions. The formulas used in estimating the DVI lend a false impression of precision to the DVI when in actuality estimates of DVI by any of these methods are subject to considerable error. However, consistency studies suggest that reasonable confidence can be achieved in dust veil index values derived from two or more formula.

7. DESCRIPTION OF VARIABLES AND FORMATS

The data are catalogued by the date of the eruption with one line of data per eruption. The variables and data given for each eruption are: YEAR (year of eruption), LAT (latitude of volcano), LONG (longitude), NAME (name of volcano), EMAX (maximum extent), DURAT (duration), DVIG (DVI for the entire globe), DVIN (DVI for the Northern Hemisphere), DVIS (DVI for the Southern Hemisphere), and RATIO (DVI for the entire globe/maximum extent). The data are formatted as:

```
FORMAT(I4,F6.2,F6.1,26A1,F3.1,2X,I2,4I5)
```

8. KEYWORDS

DUST VEIL INDEX; VOLCANIC ERUPTIONS; CLIMATE CHANGE; ENERGY BALANCE

9. CONTENTS OF THE PACKAGE

The package contains the referenced documents (a), and three files of information written in EBCDIC on magnetic tape as card images: a descriptive file, a FORTRAN data retrieval code (lacking job control language), and the dust veil index data file. Total records: 525.

a. Included in the package:

Lamb, H. H. 1970. "Volcanic Dust in the Atmosphere; With a Chronology and Assessment of its Meteorological Significance". Philosophical Transactions of the Royal Society of London, Series A **266**:425-533.

Lamb, H. H. 1977. "Supplementary Volcanic Dust Veil Assessments". Climate Monitor **6**:57-67.

Lamb, H. H. 1983. "Update of the Chronology of Assessment of the Volcanic Dust Veil Index". Climate Monitor **12**:79-90.

Kelly, P. M. and C. B. Sear. 1982. "The Formulation of Lamb's Dust Veil Index". pp. 293-298 In A. Deepak, Ed. Atmospheric Effects and Potential Climatic Impact of the 1980 Eruptions of Mount St. Helens. NASA Conference Publication 2240, National Aeronautics and Space Administration, Washington, DC.

b. Background information:

Bulletin of Volcanic Eruptions, 1961. I.U.G.G. (International Association of Volcanology and Volcanological Society of Japan), Tokyo.

Bulletin Volcanologique, 1924-1960. I.G.G.I. (Association Internationale de Volcanologie), Brussels.

Gutenberg, B. and C. F. Richter. 1954. Seismicity of the Earth. Princeton University Press

Humphreys, W. J. 1940. The Physics of the Air. McGraw-Hill (New York and London).

Newhall, C. G. and S. Self. 1982. "The Volcanic Explosivity Index (VEI): An Estimate of Explosive Magnitude of Volcanic Eruptions". Journal of Geophysical Research **87**: 1231-1238.

Royal Society. 1888. The Eruption of Krakatoa and Subsequent Phenomena. G. J. Symons, Ed. Harrison and Tribner (London).

Sapper, K. 1917. "Beitrage zur Geographic der tatigen Vulkane". Z. Vulk. (Berlin) 3:65-197.

Sapper, K. 1927. Vulkankunde. Engelhorn Verlag (Stuttgart).

Shaw, N. 1936. Manual of Meteorology, Vol. II: Comparative Meteorology. Cambridge University Press.

Simkin, T. L. et al. 1981. Volcanoes of the World. Hutchinson Ross, Stroudsberg, Pa.

Smithsonian Institution 1976- . SEAN Bulletin. Washington, DC.

10. HOW TO OBTAIN THE PACKAGE

The documentation of NDP-013 contains a sample listing of the dust veil index data file. The appendices in the critical documents also contain listings of the DVI's. Entire listings of the data file are available on magnetic tape upon request. Requests for computerized data should be accompanied by a reel of tape and special instructions for transmitting the data. Tape requests not accompanied by a tape or instructions will be filled with a standard-labeled, 6250 BPI, 9-track density tape with files formatted as listed in the Tape Contents Section (pg. 6).

Requests should be addressed to:

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Oak Ridge, Tennessee 37831-2008

11. NUMERIC DATA PACKAGE PREPARED BY:

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Technical Coordinators -
Thomas A. Boden

Computer Coordinator -
Julia A. Watts
Thomas A. Boden

12. DATE OF ABSTRACT

September 1985

TAPE CONTENTS

Tape Information ________
Density ________ 9 Track

Package NDP-013
Date Packaged: 09-85
Most Recent Update:

Description	Mode	Logical Records	DCB Parameters		
1. Descriptive Information	EBCDIC	54	FB	4240	80
2. FORTRAN Data Retrieval Code (lacking JCL)	EBCDIC	16	FB	4240	80
3. Dust Veil Index Data	EBCDIC	455	FB	8000	80
Total Records		525			

Files 1 and 2 are provided by the Carbon Dioxide Information Center. File 2 is a FORTRAN retrieval code (lacking job control language) to read and list the dust veil index data (File 3). The dust veil index data was contributed by H. H. Lamb of the Climatic Research Unit, University of East Anglia, Norwich, UNITED KINGDOM.

NDP-013 TAPE INFORMATION

Dataset Title: Volcanic Loading: The Dust Veil Index

Contributor(s):

H. H. Lamb
Climatic Research Unit
University of East Anglia
Norwich, UNITED KINGDOM

Scope of the Data: This package provides dust veil indices (DVI) for the period 1500 A.D. to 1983 A.D. along with estimates for the eruptions of Santorin in 1470 B.C., Vesuvius in 79 A.D., and Oraefajokull in 1362 A.D. Descriptions of individual eruptions and details on the methods used in assessing the DVI of a particular eruption are provided in the critical documents.

Data Format: The data are catalogued by the date of the eruption with one line of data per eruption. The variables and data given for each eruption are: YEAR (year of eruption), LAT (latitude of volcano), LONG (longitude), NAME (name of volcano), EMAX (maximum extent), DURAT (duration in months), DVIG (DVI for the entire globe), DVIN (DVI for the Northern Hemisphere), DVIS (DVI for the Southern Hemisphere), and RATIO (DVI for the entire globe/maximum extent). The data are formatted as:

```
FORMAT(I4,F6.2,F6.1,26A1,F3.1,2X,I2,4I5)
```

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REFERENCES
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Lamb, H. H. 1970. "Volcanic Dust in the Atmosphere; With a Chronology and Assessment of its Meteorological Significance". Philosophical Transactions of the Royal Society of London, Series A **266**: 425-533.

Lamb, H. H. 1977. "Supplementary Volcanic Dust Veil Assessments". Climate Monitor **6**:57-67.

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DATA RETRIEVAL LISTING

```
      INTEGER YEAR
      REAL*4 LAT,LONG
      DIMENSION DESC(80),NAME(26)
      INTEGER DURAT,DVIG,DVIN,DVIS,RATIO
      DO 10 I=1,100
 1    READ(5,100,END=99) YEAR,LAT,LONG,(NAME(K),K=1,26),
     1EMAX,DURAT,DVIG,DVIN,DVIS,RATIO
100     FORMAT(I4,F6.2,F6.1,26A1,F3.1,2X,I2,4I5)
      WRITE(6,200) YEAR,LAT,LONG,(NAME(K),K=1,26),EMAX,DURAT,
     1DVIG,DVIN,DVIS,RATIO
200  FORMAT(1H,I4,2X,F6.2,2X,F6.1,2X,26A1,2X,F3.1,2X,I2,2X,I5,1X,I5,1X,
     1I5,1X,I5)
 10   CONTINUE
      GO TO 1
 99   STOP
      END
```

TABLE 1. Sample listing of the dust veil index data file.

YEAR	LAT	LONG	NAME	EMAX	DURAT	DVIG	DVIN	DVIS	RATIO
1470	36.50	25.5	SANTORIN	0.5	50				
79	41.00	14.0	VESUVIUS	0.5					
1362	64.00	-17.0	ORAEFAJOKULL	0.3	40				
1500	-6.00	106.0	JAVA	1.0		1000	500	500	1000
1510	65.00	-17.0	TROLLADYNGJA						
1510	64.00	-19.5	HEKLA						
1520	-53.00	-65.0	TIERRA DEL FUEGO						
1535	38.00	-15.0	ETNA	0.5		150	150		300
1538	41.00	14.0	VESUVIUS						
1539	0.00	-78.5	PICHINCHA						
1539	19.00	-98.5	POPOCATEPETL	1.0	24	50	33	17	50
1550			TALA	1.0		70	35	35	70
1553	0.00	-78.5	PICHINCHA	1.0					
1554	64.00	-19.5	HEKLA						
1558	28.00	-17.0	TENERIFFE						
1565	14.00	-91.0	PACAYA						
1569	19.00	-97.0	CITALTEPTL	1.0		10	7	3	10
1577	0.00	-78.5	PICHINCHA						
1580	63.50	-19.0	KATLA						
1581	14.50	-91.0	FUEGO						
1583	64.00	-23.0	REYKJANES						
1586	-8.00	112.5	KELUD	1.0		1000	500	500	1000
1587	64.00	-21.0	THINGVALLA HRAUN						
1587	0.00	-78.5	PICHINCHA						
1590	19.50	-104.0	COLIMA	1.0	24	50	33	17	50
1593	-8.00	114.0	RINGGIT	1.0		1000	500	500	1000
1595	-9.50	166.0	TINAKULA						
1597	64.00	-19.5	HEKLA	0.3		100	100		300
1598	64.00	-17.0	ORAEFAJOKULL	0.3		20	20		70
1598	64.50	-17.5	GRIMSVOTN	0.3		20	20		70
1603	38.00	15.0	ETNA	0.5		300	300		500
1608	1.00	127.0	TERNATE						
1614	-8.00	118.0	LITTLE SUNDA ISLAND	1.0		1000	500	500	1000
1615	-4.50	130.0	GUNUNG API						
1619	64.00	-19.5	HEKLA						
1625	63.50	-19.0	KATLA	0.3		250	250		800
1627			CARABALLOS						
1631	41.00	14.0	VESUVIUS	0.5		300	300		600
1635	1.00	127.5	TERNATE						
1636	64.00	-19.5	HEKLA	0.3		100	100		300
1637	-9.00	124.0	TIMOR						
1638	-8.00	114.0	ROUNG	1.0		500	250	250	500
1640	39.00	141.0	KOMAGATAKE	0.5		250	250		500
1641	3.50	125.5	AWU	1.0		1000	500	500	1000
1641	14.00	121.0	TAAL						
1641	-8.00	112.0	GUNUNG ADIKSA	1.0		500	250	250	500
1646	0.50	127.5	MAKJAN	1.0		300	150	150	300
1646	28.00	-18.0	PALMA						
1650	36.50	25.5	SANTORIN	0.5		250	250		500

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