F. No. 42/3/2018/PMU-OC
Government of India
Ministry of Environment, Forest and Climate Change
Ozone Cell

Core IV B, 2nd Floor
India Habitat Centre
Lodhi Road
New Delhi – 110003
Ph.: 24642176
Fax: 24642175
Email: amit.love@nic.in
pmucfc-mef@nic.in

Dated: 28th May, 2018

Sub. : - XXXXII meeting of the Empowered Steering Committee (ESC)

The XXXXII meeting of the ESC for Implementation of the Montreal Protocol was held on 26th March, 2018 at 3.00 PM in Kaveri Conference Hall, Prithvi Block, Ministry of Environment, Forest and Climate Change, Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi – 110003 under the Chairmanship of Secretary (EF&CC).

The Minutes of the meeting are enclosed herewith for your kind perusal and comments, if any.

(DR. AMIT LOVE)
JOINT DIRECTOR (O)

To,

All Members of the Committee

Copy for information to:

(i) PPS to Secretary (EF&CC)
(ii) PPS to AS (AKJ)
(iii) PPS to JS (GB)

MINUTES OF THE XXXXII MEETING OF THE EMPOWERED STEERING COMMITTEE (ESC) FOR IMPLEMENTATION OF THE MONTREAL PROTOCOL HELD ON 26TH MARCH 2018 IN KAVERI CONFERENCE HALL, PRITHVI BLOCK, MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE, INDIRA PARYAVARAN BHAWAN, JORBAGH ROAD, NEW DELHI 110003

The XXXXII meeting of the Empowered Steering Committee (ESC) for Implementation of the Montreal Protocol was held on 26th March 2018 at 03.00 P.M in Kaveri Conference Hall, Prithvi Block, Ministry of Environment, Forest and Climate Change (MoEF&CC), Indira Paryavaran Bhavan, Jorbagh Road, New Delhi under the Chairmanship of Mr. C.K. Mishra Secretary (EF&CC). The list of participants is attached at ***Annexure-I.***

The Chairman welcomed the participants to the XXXXII meeting of the ESC and requested the Member Secretary, Mr. Gyanesh Bharti, Joint Secretary, MoEF&CC to present the agenda for consideration of the Committee. The Agenda was considered ad seriatim. The annotated agenda and agenda papers were earlier circulated to all the members.

The agenda items considered and the decisions/observations of the ESC there upon are as follows:

Agenda Item No. 1: Confirmation of Minutes XXXXI meeting of the ESC

The Minutes of the XXXXI meeting of the ESC were circulated to the members and as no comments were received, the minutes of the XXXXI meeting of the ESC held on 19th December 2016 were confirmed.

Agenda Item No. 2: Action taken on decisions of the XXXXI ESC

The brief item-wise Action Report was circulated along with agenda papers and was also presented to the Committee. It was mentioned that as separate items related to the actions taken were part of agenda detailed deliberations could be taken up separately for the following items:

a) Audit of HCFC-22 production facility (Agenda item No 13)
b) HCFC Phase out Management Plan (HPMP) Stage-II (Agenda Item No 6)
c) HPMP Stage-I (Agenda item No 7)
d) Collaborative Research Program on low Global Warming Potential (GWP) alternatives to Hydrofluorocarbons (HFCs) (Agenda item No 9)

The ESC noted the Action Taken Report presented with respect to decisions taken in the XXXXI meeting of the ESC.

Agenda Item No. 3: Overview of Stratospheric Ozone Layer Monitoring in India

Dr. Siddantha Singh, Scientist 'E', India Meteorological Department (IMD), made a presentation on Ozone Layer monitoring in the Country. A copy of the presentation is at ***Annexure-II***.

The ESC took note of the presentation and the fact that Ozone Layer is on a recovery path as evidenced from stratospheric ozone measurement. Also, that Implementation of the Montreal Protocol has led to recovery of ozone layer which is noteworthy.

Agenda Item No. 4: National Cooling Action Plan

The ESC was informed that MoEF&CC had constituted a committee for developing a National Cooling Action Plan (NCAP) in July, 2017. The proposed NCAP will provide an integrated long-term vision towards cooling across sectors inter alia encompassing reducing cooling demand, refrigerant transition, enhancing energy efficiency and better technology options. It was stated that pursuant to the Kigali Amendment to the Montreal Protocol for phase down of HFCs, adopted by the 28th Meeting of the Parties (MOP) to the Montreal Protocol held during October 2016 at Kigali, Rwanda, dovetailing maintaining and/or enhancing energy efficiency of Refrigeration and Air-conditioning (RAC) equipment with refrigerant transition will enhance the overall climate benefit, for which integrated action with respect to cooling across sectors will have a higher impact than actions taken in isolation.

The ESC was informed of the actions taken pursuant to constitution of the committee for the development of NCAP, including having stakeholder consultations on development of NCAP.

The ESC was informed that as an outcome of stakeholder consultations on NCAP, the following working groups on identified thematic areas were constituted with specific Terms of Reference:

1. Space Cooling and Cold Chain
2. Air-conditioning and Refrigeration technology
3. R&D and Production Sector-Alternative Refrigerants and technologies
4. Servicing Sector
5. Transport Air-conditioning (car, bus, train and Metro air-conditioning)
6. Cross cutting policy regulation w.r.t Montreal Protocol, Kigali Amendment, Sustainable Development Goals and other international Conventions

The ESC was also informed that the first meeting of the Committee for the development of NCAP was held under the Chairmanship of Secretary, EFCC on 1st

March, 2018. The following timeline was agreed for development of NCAP in the meeting:

Assessment and Compilation of documentation by the Working Groups of identified thematic areas	February to May 2018
Draft Plan	June 2018
Stakeholder Consultations	July 2018
Proposed Launch	World Ozone Day – 16th September, 2018

Dr. Ajay Mathur, Director General, The Energy and Resources Institute (TERI) proposed for a wider stakeholder consultation and awareness generation while finalizing the NCAP. Mr. Kamal Sharma, representing Confederation of Indian Industry (CII) proposed inclusion of CII in the thematic working group on cross cutting policy regulation w.r.t Montreal Protocol, Kigali Amendment, Sustainable Development Goals and other international conventions.

Dr. R. Gopichandran observed that the NCAP should be developed taking into account the evidences at hand, have capability to identify the unknowns, provide for generating new evidences and co-evolve accordingly. He suggested that the NCAP should be open-ended.

The ESC noted the constitution of Committee for the development of NCAP by MoEF&CC and also the progress made towards development of the NCAP. Ex-post facto approval for constitution of the six thematic working groups for development of sectoral reports/documentation for inclusion in the NCAP was accorded. The ESC also approved the proposed timeline for development of the NCAP and launch on the World Ozone Day scheduled to be held on 16 September 2018.

Agenda Item No. 5: Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer - Issues relating to financial and technical support for energy efficiency in Article- 5 countries. Conference Room Paper (CRP) submitted by India, Saudi Arabia, Kuwait, Lebanon, Bahrain and African Group.

The ESC was informed that during the 39th meeting of the Open-Ended Working Group (OEWG) of the Parties to the Montreal Protocol held at Bangkok, Thailand from 11-14 July 2017, India along with Saudi Arabia, Kuwait, Lebanon, Bahrain and African Group introduced a Conference Room Paper (CRP) on issues related to financial and technical support for energy efficiency in Article-5 countries.

The CRP was considered and deliberated in the 29th Meeting of Parties to the Montreal Protocol (MOP) held from 20th to 24th November, 2017. A contact group to further discuss the CRP submitted by India along with Bahrain, Kuwait, Lebanon and Saudi Arabia and African States was established during the MOP. India was able to pilot after sustained and intensive negotiations the adoption Decision XXIX/10 in the MOP emerging out of the CRP on the issues related to financial and technical support for energy efficiency in Article-5 Parties submitted by India and other proponents.

Vide Decision XXIX/10 of the MOP, the Technology and Economic Assessment Panel of the Montreal Protocol was to inter alia assess (i) Technology options and requirements, (ii) Related costs including capital and operating costs, (iii) Capacity – building and servicing sector requirements in relation to maintaining and/or enhancing energy efficiency in the refrigeration, air-conditioning and heat-pump sectors and submit a comprehensive report to the Parties for further consideration. The TEAP shall be presenting an interim report of the Task Force to the 40th meeting of the OEWG scheduled to be held at Vienna during July 2018 and final report to the 30th MOP scheduled to be held in November 2018 at Ecuador. In addition, the Ozone Secretariat shall hold an international workshop on the subject for the Parties in Vienna in July 2018.

The ESC was also informed that the MoEF&CC has nominated Shri J.M. Bhambure, Executive Vice-President, R&D and Technology, Bluestar Ltd in the Energy Efficiency Taskforce of the Technology and Economic Assessment Panel (TEAP) of the Montreal Protocol, constituted pursuant to the adoption of the CRP by the 29th MOP.

The ESC noted the submission of CRP by India in 39th OEWG and adoption of Decision XXIX/10 in the Meeting of Parties held in Montreal. The ESC accorded Ex-post facto approval to the nomination of Shri J.M. Bhambure, EVP, Bluestar to the Energy Efficiency Task Force of TEAP.

Agenda item No. 6: HCFC Phase out Management Plan (HPMP) Stage-II

The ESC was briefed on India: HCFC Phase out Management Plan (HPMP) Stage-II, approved by the Executive Committee (Ex-Com) of the Multilateral Fund (MLF) during its 77th meeting held during December 2016, including on the investment activities to be implemented in the foam and RAC manufacturing sectors by the United Nations Development Programme (UNDP), the lead implementing agency for HPMP Stage-II and for the investment component in the enabling activities and activities in the RAC servicing sector to be implemented by the UN Environment and GIZ in cooperating agencies for HPMP Stage-II.

The summary of the total funding approved for conversion of enterprises from ODS to non-ODS technology servicing sector and enabling activities by the 77th Ex-Com excluding agency support to meet the 2020 phase out target and beyond up to 2023 as per the Montreal Protocol phase-out schedule is as follows:

Component	**Agency**	**Actual phase out consumption**		**Net funding Request (US$) excluding agency support cost**
		MT	**ODP**	
Project Management Components	UNDP Lead Implementing agency	N/A	N/A	2,400,000
Polyurethane Foam sector		5800	638.02	24,000,000
Air-conditioning Manufacturing Sector Plan		1140	62.72	12,511,459
Service Sector Plan	Government of Germany	1250	68.75	5,100,000
Enabling Activities	UNEP			900,000
Total				44,911,459

The HPMP Stage-II was launched on 6th March, 2017 at New Delhi by the then Hon'ble Minister of Environment, Forest and Climate Change in a stakeholder meeting with the unveiling of the HPMP Stage-II document. The HPMP Stage-II document inter alia includes the enterprise-wise allocation of funds to large and medium foam manufacturing enterprises and 6 large RAC enterprise based upon the approved funds allocated by Ex-Com subject to third party physical verification.

A total of 419 enterprises with the following breakup had been considered for participation in HPMP Stage-II document:

Foam Manufacturing Enterprises	
Large	24
Medium	33
Small	356
Sub- Total	413
Refrigeration and Air-conditioning Manufacturing Enterprises	
Large	6
Sub-Total	6
Total	419

The names of participating enterprises mentioned in the HPMP Stage-II were provided by Refrigeration and Air-conditioners Manufacturers Association (RAMA) and Indian Polyurethane Association (IPUA).

In its XXXIst meeting, the ESC had sought for the reverification of enterprises, earlier surveyed by the IPUA for participation in foam manufacturing sector and the RAMA for participation in the RAC sector respectively. The UNDP had appointed M/s PriceWaterhouse Coopers Ltd (PWC) for carrying out the said reverification. The PWC submitted the report for the 6 RAC enterprises, out of which the UNDP has recommended for inclusion of 4 enterprises in the HPMP Stage-II. The Committee was informed that recommendation of UNDP for remaining 2 enterprise were still to be received. All the 6 enterprises included in HPMP-II. The committee was informed that reverification of 413 enterprises in foam manufacturing sector was still ongoing and technical comments of UNDP on third party reverification were awaited.

The ESC was also informed that since the approval of HPMP Stage-II, Ozone Cell, MoEF&CC had separately received around 62 additional applications for participation in HPMP Stage-II, with a total consumption of around 2500 MT of HCFC-141b. The Indian Polyurethane Association (IPUA) informed that out of the additional applications received, 22 enterprises were contacted by IPUA for participation in HPMP Stage II while the rest were not contacted.

The ESC noted the status of third party reverification of participating enterprises in HPMP Stage II in the foam manufacturing and RAC sectors earlier surveyed by IPUA and RAMA. The ESC accorded approval to process balance payment to RAMA as per procedure on completion of milestones as all the participating enterprises in RAC sector have been re-verified and to await the reverification of enterprises with respect to the foam sector and process for payments to IPUA subsequently as appropriate on consideration of reverification of enterprises. The ESC also noted that HPMP Stage-II was launched in March 2017, therefore the Implementation of HPMP Stage-II needs to be expedited.

Agenda Item No. 7: HPMP Stage-I

The ESC was briefed on the progress and actions taken pursuant to the decision taken in the XXXXI meeting of the ESC , wherein, the ESC has sought third party verification investment projects supported under HPMP Stage-I. The ESC was also apprised that the Ex-Com of the MLF in its 80th meeting held in November 2017 approved the extension of the duration of HPMP Stage-I to 31st December 2017.

The ESC was apprised about the findings of the third party verification report as also the status of completion of projects under HPMP Stage-I. The detailed status was mentioned in the Agenda papers. Briefly, under HPMP Stage-I, assistance was provided to 15 foam manufacturing enterprises for technology conversion to non-Ozone Depleting Substances (ODS) alternatives of which 5 enterprises were pending completion of work and of 15 System Houses which were provided technical assistance all were pending completion of work.

Since, the last meeting of the ESC, final payments have been released to 4 out of the 5 enterprises in the foam manufacturing sector and 5 out of the 15 System Houses after third party verification of all the milestones set out in the MOA by PWC and recommendation of UNDP, the lead implementing agency.

Regarding the remaining one enterprise in the foam manufacturing sector and 10 System Houses where activities need to be completed, the ESC was informed that response from PWC/UNDP was awaited. Based upon the response of UNDP, further appropriate action will be taken in the matter.

The ESC provided ex-post facto approval to the final payments released to the following enterprises after third party verification by PWC that all the milestones set out in the MoA have been met, and recommendation of UNDP to the effect, after further extension of time period of the MoA as per schedule given below:

Foam Manufacturing Enterprises			
S. No.	Name of Enterprise	Amount released (in USD)	MoA extended till
1	M/s Empire	153,713.80	31st March, 2018
2	M/s Isolloyd	266,187.20	31st March, 2018
3	M/s Sintex	253,036.60	31st March, 2018
4	M/s Synergy	572,324.00	31st March, 2018
	Sub total (A)	1,245,261.60	
System Houses			
1	M/s Industrial Foam	55,989.00	31st December, 2017
2	M/s Shivathane Linopack	31,873.00	31st December, 2017
3	M/s Manali Petrochemicals	55,988.50	28th February, 2018
4	M/s Organomettalic Industries	31,872.50	31st March, 2018
5	M/s Expanded Polymer Systems	55,988.50	31st March, 2018
	Sub total (B)	231,711.5	
	Total (A) + (B)	1,476,973.1	

The ESC noted that the Ex-Com of the MLF in its 80th meeting held in November, 2017 approved vide decision 80/20, the extension of the duration of HPMP Stage-I to 31st December, 2017, to obtain response from UNDP, the lead implementing agency with respect to the remaining enterprises, where HPMP Stage-I activities need to be completed, at the earliest. Based on the response of UNDP, further appropriate action will be taken in the matter. The ESC observed that it needs to be ensured that the enterprises have completed the works as per the MoAs.

Noting the progress on activities in the enabling component and the decision of the 80th Ex-Com of the MLF on HPMP Stage-I, the ESC accorded Ex-Post facto approval for the MOAs signed with National Academy of Customs, Indirect Taxes & Narcotics (NACIN), The Energy and Resources Institute (TERI) and Energy Efficiency Services Limited (EESL). The ESC observed that the works under enabling activities of UN Environment under HPMP I need to be expedited for completion of the remaining activities at the earliest. The ESC also noted the completion of the activities in the RAC servicing sector by GIZ under HPMP Stage-I.

Agenda Item No. 8 : Submission of Article 7 of the Montreal Protocol to the Ozone Secretariat and Country Programme Progress Report (CPPR) to the Multilateral Fund Secretariat for the year 2016.

The ESC was briefed that each year data on production, consumption, import and export is to be submitted to the Ozone Secretariat under Article 7 of the Montreal Protocol and Country Program Progress Report (CPPR) to the MLF Secretariat and accordingly data has been submitted for the year 2016.

Chairman, Central Pollution Control Board, who is also the Chairman, Standing Committee on Monitoring which reviews the Article-7 and CPPR data and recommends the same for submitting to Ozone Secretariat and MLF Secretariat, observed that presently the data reported is based upon information provided by producers the same could be further strengthened by considering the data reported by the enterprises under the Consent mechanism and Environment Statement.

The ESC accorded Ex-Post Facto approval for submission of Article 7 of the Montreal Protocol to the Ozone Secretariat and CPPR to the Multilateral Fund Secretariat for the 2016.

Agenda Item No. 9 : Collaborative Research Programme on low Global Warming Potential (GWP) alternatives to Hydrofluorocarbons (HFCs).

The ESC was briefed about the proposed collaborative research programme and the efforts made to move ahead in the direction. The ESC noted the relevance

and importance of the programme, which would also help in improving the negotiation position of the country in the Montreal Protocol meetings.

Prof. R.S. Agarwal proposed that RAC sector and alternative technologies should also be taken up as a thrust area along with development of new molecules and chemical production and proposed establishment of an interdisciplinary centre of excellence under one of the existing institutions.

Dr. R. Gopichandran welcomed the idea of an interdisciplinary centre of excellence and also the need for development of human capital and institutional capabilities in the area to handhold refrigerant transitions and develop alternative technologies for leapfrogging. He also mentioned that the programme should also cover the fate of chemicals within the system and in the external environment.

The ESC advised to expedite implementation of activities proposed under the collaborative research programme in collaboration with DST/CSIR.

Agenda Item No. 10 : Service Sector Plan by Electronics Sector Skill Council of India (ESSCI), National Skill Development Corporation, Ministry of Skill Development under Pradhan Mantri Kaushal Vikas Yojana (PMKVY)

The ESC was briefed on the development of the joint proposal of the Ozone Cell and Electronic Sector Skill Council of India (ESSCI) for upskilling and certification of 100,000 RAC service technicians under the Pradhan Mantri Kaushal Vikas Yojana (PMKVY) scheme of the Ministry of Skill Development. Implementation of the proposal would result in significant environmental and societal benefits, including in generation of livelihood for several RAC technicians. It was decided that a reference may be sent from Secretary, EFCC to Secretary, Ministry of Skill Development requesting to expedite the matter and advised to take action on the same at the earliest. The ESC noted the proposal and advised to expeditiously move towards implementation of the proposal keeping in view significant environmental and societal benefits in terms of livelihood generation.

Agenda Item No. 11 : Fiscal Incentive Scheme

The ESC accorded Ex-Post facto approval for the recommendations of the Technology and Finance Standing Committee (TFSC) in its meeting held on 21st September, 2017 for the 6 applications for grant of customs duty exemption, been approved by Secretary, EF&CC in his capacity as Chairman, ESC.

Agenda Item No. 12 : World Ozone Day 2017

The ESC noted the activities undertaken on the World Ozone Day for the year 2017 and the 30th anniversary of the Montreal Protocol.

Agenda Item No. 13 : Audit of HCFC-22 Production facilities regarding pricing of domestically produced HCFC-22.

The ESC noted the report of the audit of HCFC-22 production facilities regarding pricing of domestically produced HCFC-22.

Agenda Item No. 14 : Major Publications/Outreach and Awareness Activities

The ESC noted the outreach and awareness activities organized by the Ozone Cell in collaboration with UNDP, UN Environment, GIZ and the industry on Montreal Protocol and related issues.

Agenda Item No. 15 : International Recognition – Awards

The ESC noted with appreciation the recognition of Political Leadership provided by the then Hon'ble Minister of State (Independent Charge) Environment, Forest and Climate Change, Government of India, Late Shri Anil Madhav Dave during the Kigali Amendment negotiations through an Ozone Award presented at the 29th MOP held during November 2017 at Montreal.

The meeting ended with thanks to the Chair.

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Annexure-I

LIST OF PARTICIPANTS

1. Shri. C.K. Mishra
   Secretary
   Ministry of Environment, Forest and Climate Change
   Indira ParyavaranBhawan
   JorBagh Road
   New Delhi 110003

2. Shri S.P. Singh Parihar, IAS
   Chairman
   Central Pollution Control Board (CPCB),
   Parivesh Bhawan, CBD-cum Office Complex
   East Arjun Nagar, Shahadara
   New Delhi – 110032
   Email: ccb.cpcb@nic.in

3. Dr Ajay Mathur,
   Director-General
   The Energy and Resources Institute (TERI),
   6C Darbari Seth Block,
   India Habitat Centre Complex,
   Lodhi Road,
   New Delhi 110003
   Email: dg@teri.res.in

4. Shri Gyanesh Bharti
   Joint Secretary
   Ministry of Environment, Forest and Climate Change
   Indira ParyavaranBhawan
   JorBagh Road
   New Delhi 110003

5. Dr. Amit Love
   Joint Director
   Ozone Cell
   Ministry of Environment, Forest and Climate Change
   Core IV B, 2nd Floor
   India Habitat Centre
   Lodhi Road
   New Delhi - 110003

6. Dr. Siddhartha Singh
Scientist 'E'
India Metrological Department (IMD),
Ministry of Earth Science,
Lodhi Road, New Delhi – 110 003
Ph: 43824235
Cell: 9868085602
Mail: siddharth.singh74@gmail.com

7. Shri Gaurav Dhanda
Deputy Commissioner Customs,
Central Board of Excise and Customs (CBEC),
Department of Revenue,
Ministry of Finance
5th Floor, HUDCO Vishala Building,
Bhikaji Cama Place, R.K. Puram, New Delhi-110 066
Cell: 9910717103
Mail: gaurav.dhanda @icegate.gov.in

8. Dr. S.S. Gupta
Department of Industrial Policy & Promotion (DIPP),
Ministry of Commerce & Industry
Room No. 153A,
Udyog Bhawan,
New Delhi - 110011
Ph: 23061526
Mail: ss.gupta@nic.in

9. Dr. Rohit Mishra
Industrial Adviser
Ministry of Chemicals & Fertilizers,
Department of Chem. & Petro-Chemicals,
Room No. 217-A SB, A-Wing, Shastri Bhavan
New Delhi – 110001
Ph: 23384206
Mail: rohit.mishra@nic.in

10. Shri R.K. Bharati
Dy. Director
Ministry of Micro, Small and Medium Enterprises (MSME),
Room No. 701, A-Wing,
7th Floor, Nirman Bhavan,
New Delhi – 110011
Mail: rk.bharati69@gov.in

11. Shri Harpreet Singh
Ministry of Micro, Small and Medium Enterprises (MSME),
Nirman Bhavan,
New Delhi – 110011

12. Shri Mahinder Vikram Singh
Under Secretary
Ministry of Commerce & Industry,
Room No.423, Udyog Bhawan
New Delhi – 110011
Mail: us7tpd-doc@gov.in;
d2tpd-doc@nic.in

13. Shri Puneet Jain, CA
Ministry of Petroleum & Natural Gas,
MOPNGC Cell
Shastri Bhawan, New Delhi-110001
Mail: puneet.jain84@nic.in

14. Ms. Mallika Bose
Sr. Assistant Director,
Environment and Climate Change Division,
Federation of Indian Chambers of Commerce and Industry (FICCI),
Federation House, Tansen Marg,
New Delhi – 110 001
Mail: mallika.bose@ficci.com

15. Prof. R.S. Agarwal,
Ex-Dy. Director & Dean,
Industrial Research and Development I.I.T. Delhi,
C-9/95 11, Vasant Kunj,
New Delhi – 110 070

16. Dr. R. Gopichandran,
Ex-Director,
Vigyan Prasar,
Department of Science & Technology (DST),
Email: r.gopichandran61@gmail.com

17. Shri Raj Kumar Rakhra,
Energy Efficiency Services Limited (EESL),
4th & 5th Floor, IWAI Building,
A-13, Sector-1, Noida – 201301, U.P.
Cell: 9483533374
Email: rkrakhra@eesl.co.in

18. Shri Ashish Jinda
Energy Efficiency Services Limited (EESL),
4th & 5th Floor, IWAI Building,
A-13, Sector-1, Noida – 201301, U.P.
Cell: 9643776448

19. Mr. Kamal Sharma,
Counsellor,
Confederation of Indian Industry (CII)
2nd Floor Thapar House, 124, Janpath,
New Delhi – 110 001
Email : kamal.sharma@cii.in

20. Shri S V Subbarao
National Program Manager
SPPU, UNDP
New Delhi

21. Ms. Chanchal Sharma
Technical Officer
Project Management Unit, Ozone Cell
Ministry of Environment, Forest and Climate Change
New Delhi

22. Shri Sharad Kumar Chouriha
MIS Coordinator
Project Management Unit, Ozone Cell
Ministry of Environment, Forest and Climate Change
New Delhi

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Annexure - II

Ozone Monitoring Over India : An Overview of IMD's Activities

Dr. Siddhartha Singh

Scientist 'E'

National Ozone Centre, EMRC, IMD, New Delhi

siddhartha.singh74@gmail.com

भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

Ozone Measurement in IMD

- The first Total Columnar Ozone Observations were made in 1928-29 at Kodaikanal as part of Dobson's worldwide Total Ozone Measurements.
- IMD acquired first Dobson Spectrophotometer in 1940 and regular observations are available from 1957.
- Development of Indian Ozone sonde by Instrument division of IMD in 1964. Vertical Ozone profiles using indigenous balloon-borne ozone-sondes were observed fortnightly at 4 stations including Maitri.
- Total ozone is measured with Dobson/Brewer Ozone Spectrophotometer from five locations including Maitri (Antarctica).

Ozone Measurement in IMD

- Surface ozone measurements using electrochemical method had recorded continuously at 7 stations Srinagar, Pune, Nagpur, New Delhi, Kodaikanal, Trivandrum and Maitri.
- IMD had also installed Serinus 10 Surface UV Ozone Analyzers at nine locations e.g. New Delhi, Pune, Nagpur, Kodaikanal, Guwahati, Portblair, Ranichouri, Thiruvananthpuram, Antarctica and Varanasi.

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INDIA METEOROLOGICAL DEPARTMENT

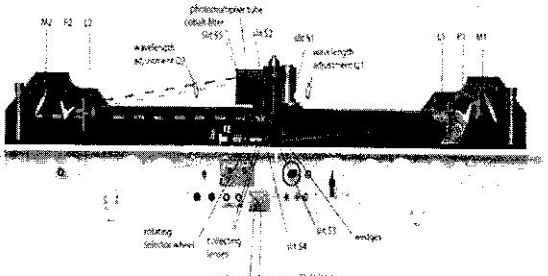
Total Columnar Ozone Measurements in IMD

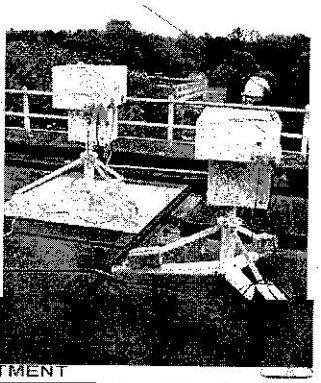
S. No.	Name of Station	Lat.	Long.	Instrument Type & S. No.	Frequency of Obsn.	Since when
1.	Srinagar	34° 05' N	74° 50' E	Dobson 10	6/day	Nov. 1955
2.	New Delhi	28° 35' N	77° 12' E	Dobson 36	6/day	Jan. 1955
3.	New Delhi	28° 35' N	77° 12' E	Brewer 089	Continuous	Aug. 1994
4.	Varanasi	25° 18' N	83° 01' E	Dobson 55	6/day	Dec. 1963
5.	Pune	18° 32' N	73° 51' E	Dobson 39	6/day	Mar. 1973
6.	Kodaikanal	10° 14' N	77° 28' E	Dobson 45	6/day	July 1957
7.	Kodaikanal	10° 14' N	77° 28' E	Brewer 094	Continuous	May 1994
8.	Maitri (Antarctica)	70° 48' S	11° 42' E	Brewer 153	Continuous	July 1999
9.	New Delhi	National Standard		Dobson 112	Since April 1969	

भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

Total Columnar Ozone Measurements in IMD

- IMD is collaborating at both the national and international levels through international inter-comparison of instruments.
- National Standard Donson is inter-compared with world standard in international inter-comparisons held at Belsk (1974), Boulder (1977), Melbourne (1984) and Japan (1996 & 2006).
- IMD's National Ozone Centre at New Delhi is designated as Secondary Regional Ozone Centre for Regional Association II (Asia) of the World Meteorological Organization.



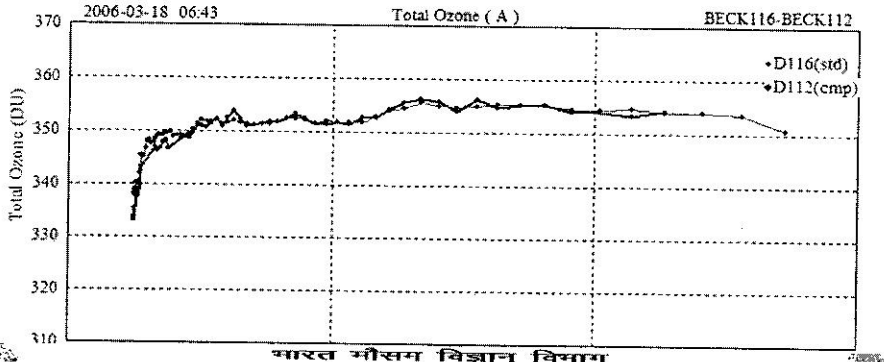


भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

Calibration of IMD's Dobson Spectrophotometer

The results of 2006 Inter-comparison of Dobson Spectrophotometer no.112 are as follows :

- Initial calibration results have showen that the d-Nad value shown an average + 0.2 % error in calculated ozone value, mu = 1 to 3, Total ozone=300 D.U.
- Final inter-comparison shows average difference against the standard for ADDSGQP observations in mu range 1.15 to 3.2 was 0.1% in total ozone.



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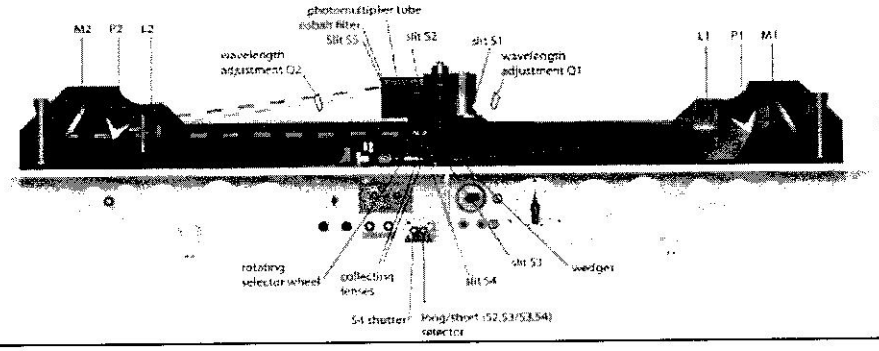
Measurement of Total Column Ozone by Dobson Spectrophotometer

- The Dobson Spectrometer measures the total ozone by measuring the relative intensity of the dangerous UVB radiation that reaches the Earth and comparing it to that of UVA radiation at ground level. If all of the ozone were removed from the atmosphere, the amount of UVB radiation would equal the amount of UVA radiation on the ground.
- As ozone does exist in the atmosphere, the Dobson Spectrometer can use the ratio between UVA and UVB radiation on the ground to determine how much ozone is present in the upper atmosphere to absorb the UVC radiation.

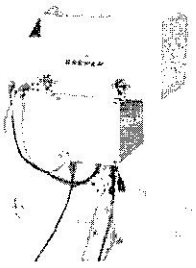


Measurement of Total Column Ozone by Brewer Spectrophotometer

The Brewer spectrophotometer measures ozone based on the same technique as the Dobson instrument.

Unlike the Dobson instrument, however, the Brewer spectrophotometer is completely automated and can be programmed by a laptop computer to make measurements at any given time during the day.

The absolute accuracy for a total ozone measurement made by a well calibrated Brewer instrument is estimated to be +/- 2.0%.



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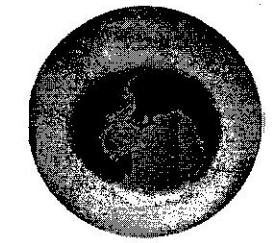
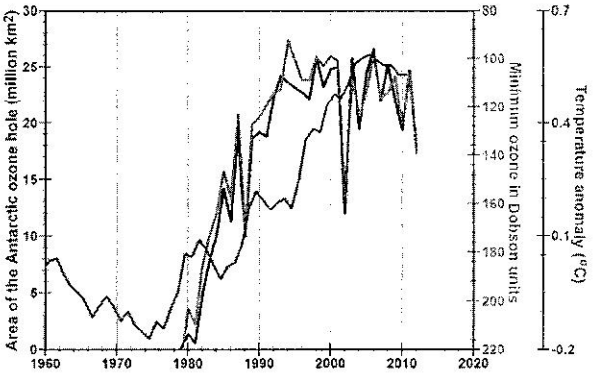
The "Ozone Hole"

What is the "ozone hole?"





The ozone hole is the region over Antarctica with total ozone 220 Dobson Units or lower.

(The avg. total column ozone in the atmosphere is about 300 DU.)

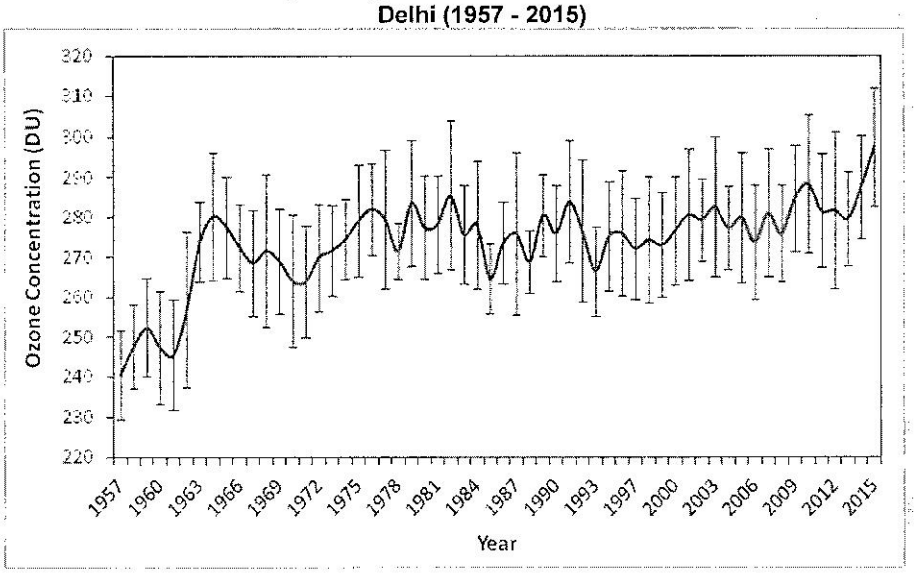
So what are we doing about it?

- After the discovery of ozone hole in the 1985, many countries agreed that something must be done worldwide to stop the production of man-made, ozone harmful products.
- The international community adopted the Vienna Convention in 1985 followed by the Montreal Protocol in 1987.
- The latest reports confirm that it has led to the phasing out of about 95% of the consumption of ozone-depleting substances (ODS) listed in the agreement. In turn, this has led to the prospect of the ozone layer recovering by 2050 to 2075.
- Furthermore, the phasing out of ozone-depleting substances has helped to fight climate change since many of these chemicals are also powerful greenhouse gases. According to a recent study, the phasing out of substances under the Protocol led to more reductions in greenhouse gases than what is foreseen under the Kyoto Protocol.

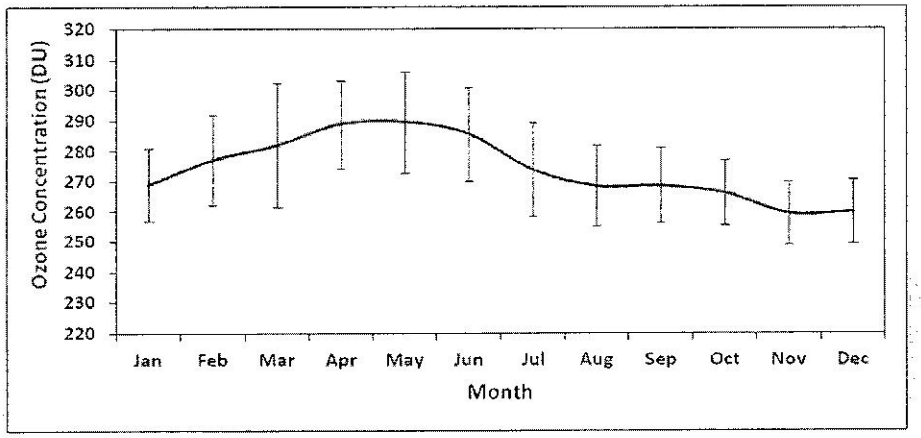
How does ozone depletion affect global warming and ultimately climate change?

- As ozone levels in the stratosphere are depleted, more solar radiation penetrates the Earth's atmosphere.
- This affect results in an increase in solar radiation reaching the Earth's surface adding to an increase in surface temperature.

Variation of Yearly Averaged Total Columnar Ozone Concentration at Delhi (1957 - 2015)



Variation of Monthly Averaged Concentration of Total Columnar Ozone at Delhi (1957 - 2015)



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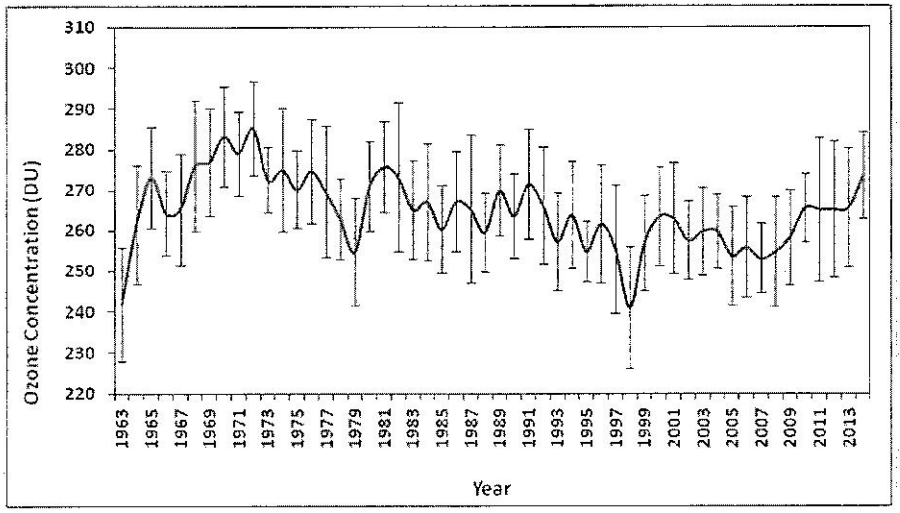
Variation of Yearly Averaged Concentration of Total Columnar Ozone at Varanasi (1963 - 2014)



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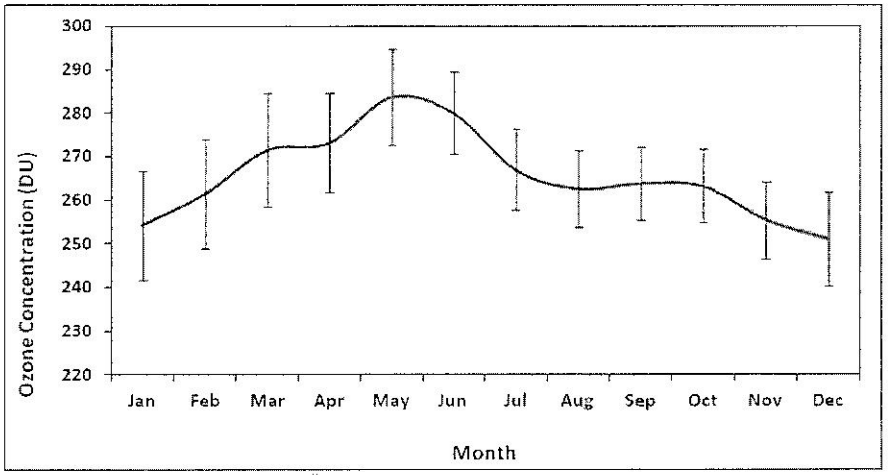
Variation of Monthly Averaged Concentration of Total Columnar Ozone at Varanasi (1963 - 2014)



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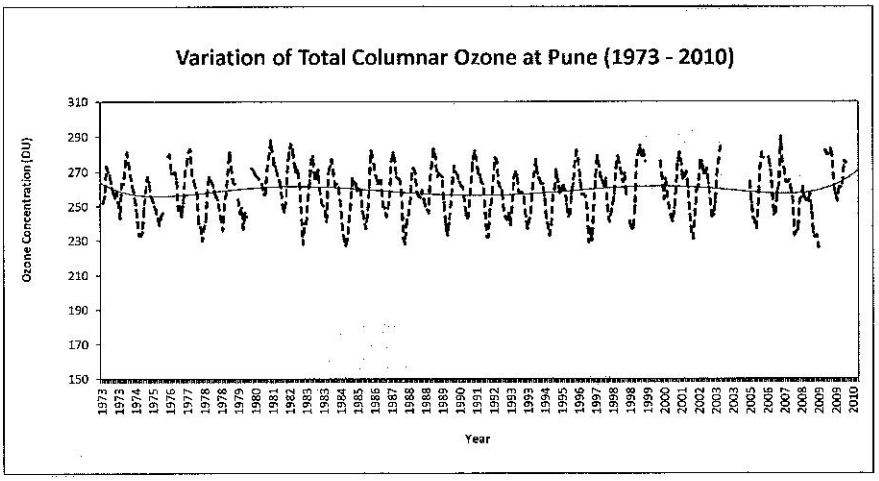
Variation of Total Columnar Ozone at Pune (1973 - 2010)



Time Series of Concentration of Total Ozone at Pune during the period 1973 – 2010

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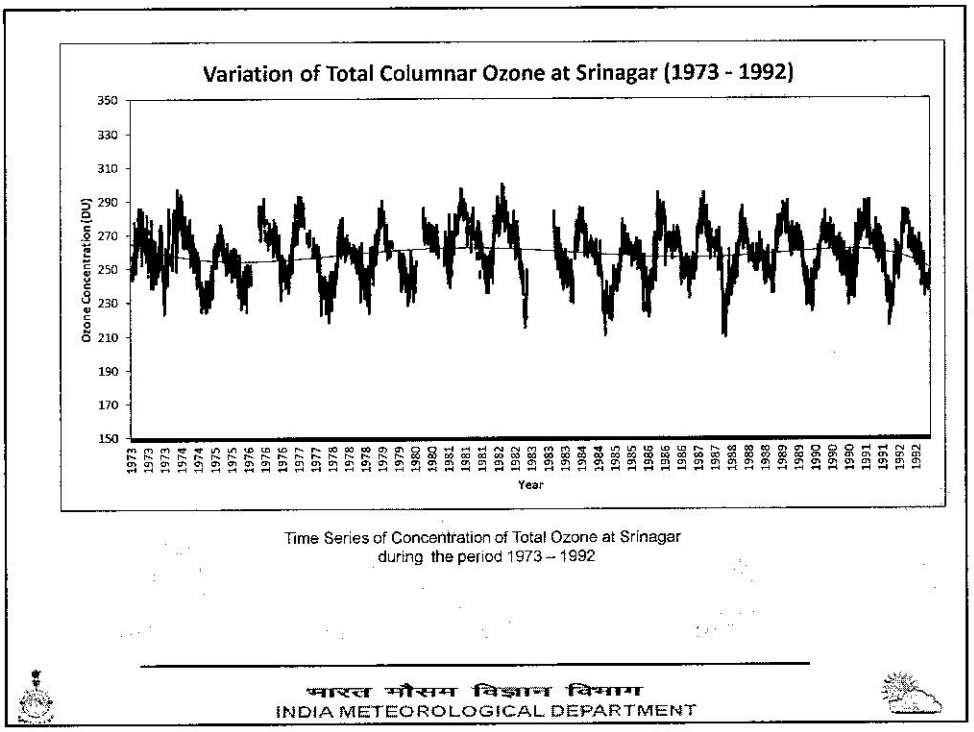
Variation of Total Columnar Ozone at Srinagar (1973 - 1992)
Ozone Concentration (DU)
Year
Time Series of Concentration of Total Ozone at Srinagar
during the period 1973 – 1992
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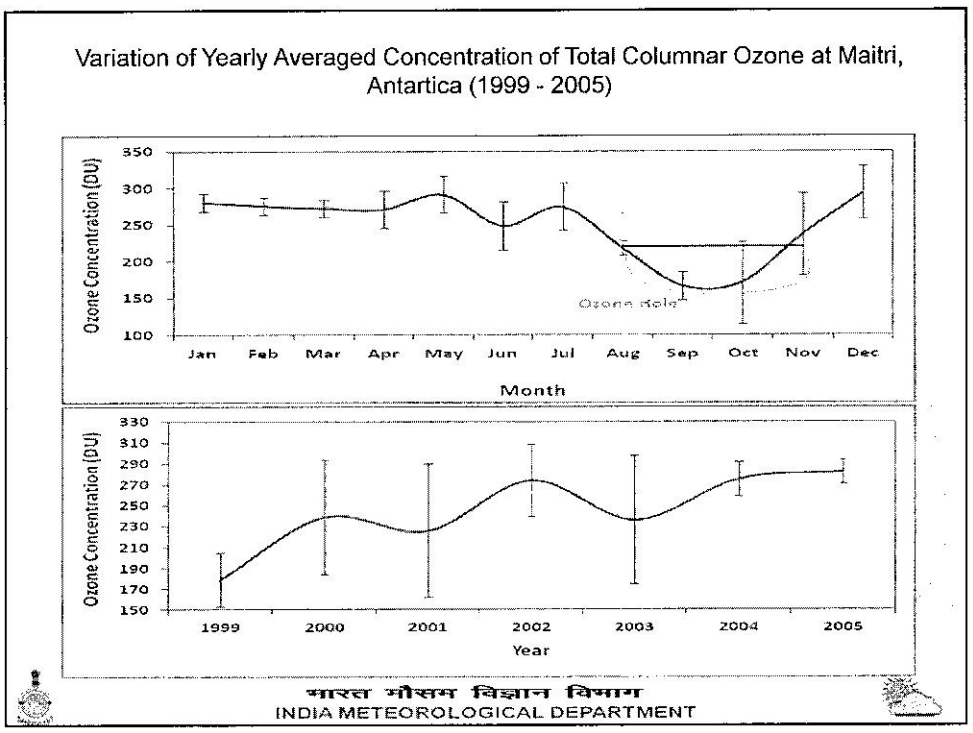
INDIA METEOROLOGICAL DEPARTMENT


Variation of Yearly Averaged Concentration of Total Columnar Ozone at Maitri, Antartica (1999 - 2005)
Ozone Concentration (DU)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month
Ozone Hole
Year
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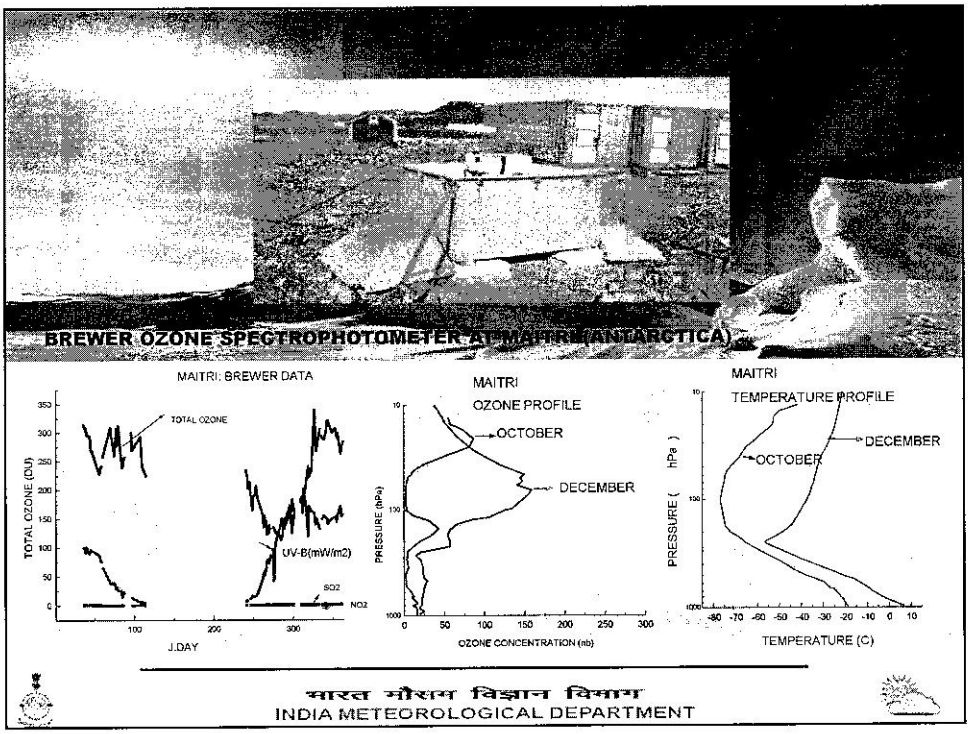

❖ **Satellite Measurements**

Satellites measure ozone over the entire globe every day, providing comprehensive data. In orbit, satellites are capable of observing the atmosphere in all types of weather, and over the most remote regions on Earth.

They are capable of measuring total ozone levels, ozone profiles, and elements of atmospheric chemistry. In the mid-1980s wide-ranging ozone depletion over the Antarctic was first recognized from satellite data.

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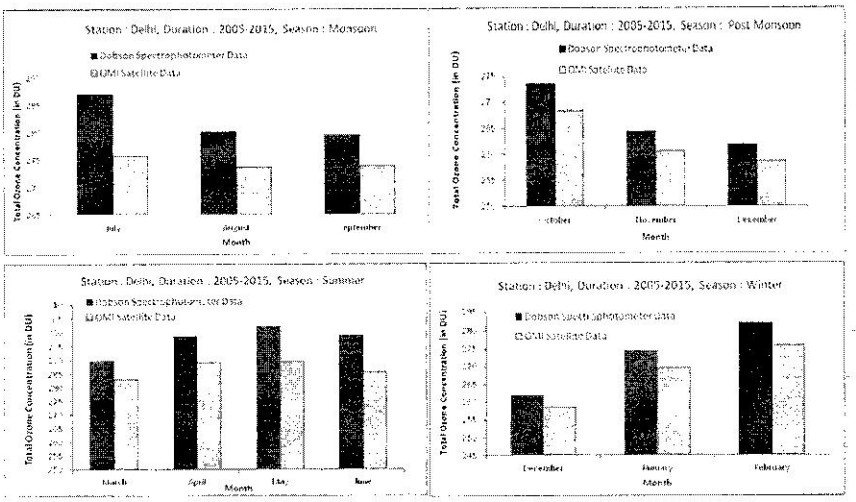
Ten Yearly Averaged Total Ozone Concentration at Delhi during 2005 – 2015 : A Comparative Representation



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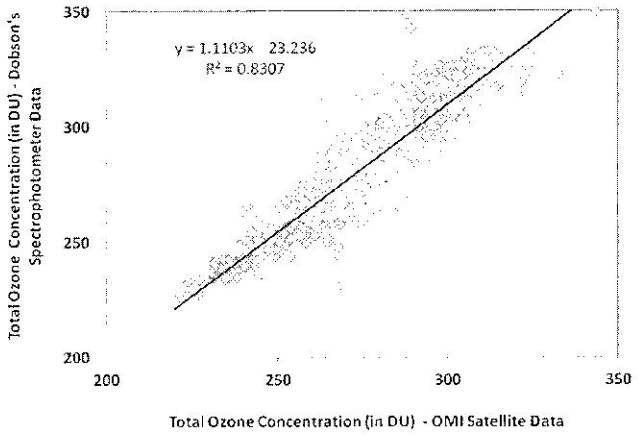
Correlation between Dobson Spectrophotometer's data and OMI Satellite Observations over Delhi (2005 – 2015)



Strong correlations of 0.92 is found between OMI-TOMS and Dobson total columnar ozone. Overall, there is good agreement between OMI-TOMS and Dobson observations over Delhi.

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INDIA METEOROLOGICAL DEPARTMENT

R. Bhattacharya et al. 2012, Vol. 4 No.05, International Journal of Engineering Science and Technology (IJEST)

- TCO level is 5.24% high over northern India from January to May. However ozone poor days have found to increase at all the stations. A systemativ variation of TCO is noted having maximum value at May and minimum at January.

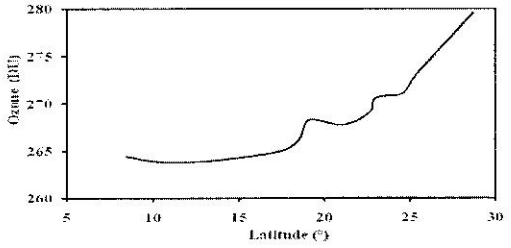

Fig. 3 Latitudinal variation of average ozone

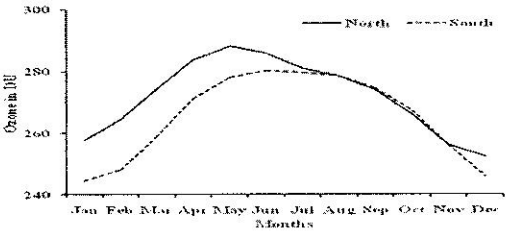

Fig. 4 Seasonal variation of ozone over India

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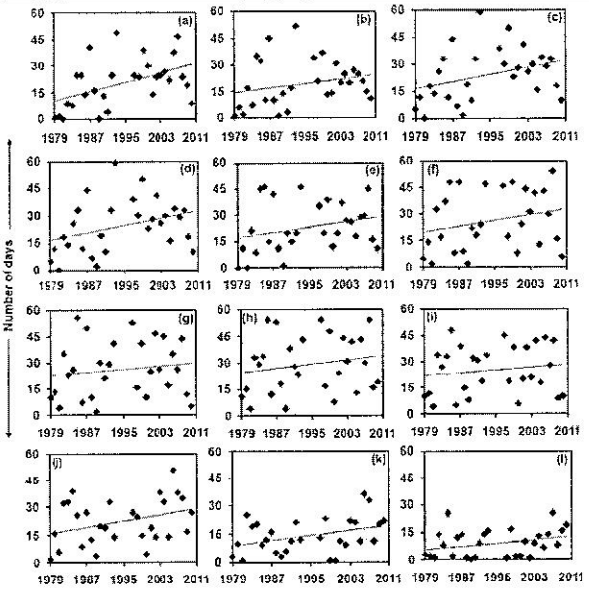


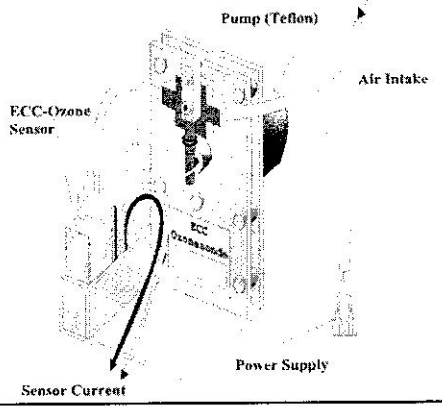
Fig. 5 Number of ozone poor days in Indian stations (a) New Delhi, (b) Varanasi, (c) Mount Abu, (d) Ahmadabad, (e) Kolkata, (f) Nagpur, (g) Bombay, (h) Pune, (i) Hyderabad, (j) Bangalore, (k) Kodaikanal and (l) Trivandrum

R. Bhattacharya et al. 2012, Vol. 4 No.05, International Journal of Engineering Science and Technology (IJEST)

Measurement of Vertical Distribution of Ozone (Ozone Sonde)

- Vertical ozone profiles using balloon-borne ozone-sondes are observed fortnightly at New Delhi.
- The ozone-radiosonde is a lightweight, balloon-borne instrument that is mated to a conventional meteorological radiosonde.
- The balloon will ascend to altitudes of about 115,000 feet (35 km) or about 3 hPa before it bursts.
- The heart of the ozone-radiosonde is an electrochemical concentration cell (ECC) that senses ozone as is reacts with a dilute solution of potassium iodide to produce a weak electrical current proportional to the ozone concentration of the sampled air.
- Ozonesondes are composed of an ozone sensor, a battery, a small gas pump, and some electronic circuit boards.

The ozone sensor is connected to a meteorological radiosonde. This radiosonde transmits values of air temperature, air pressure, relative humidity, detector current, detector temperature, and pump speed to a ground receiving station. The air containing the ozone sample is pumped through a solution which is oxidized by this ozone producing an electrical current. The electrical current is proportional to the flow of ozone. By knowing the flow (pump speed), the ozone concentration can be deduced. The result is an ozone partial pressure vertical profile.

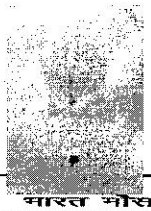


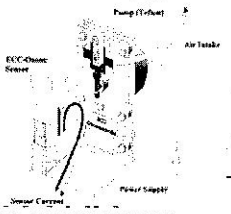
Schematic of an electrochemical concentration cell (ECC) Ozone sonde

Vertical Distribution of Ozone Measurements in IMD

- Development of Indian Ozone sonde was done by Instrument division of IMD in 1964 (Sreedharan, 1968).
- Indian Ozone-sonde was intercompared in West Germany in 1970 and 1980, Canada in May 1991 and in Germany February 1996.

S. No.	Name of Station	Lat.	Long.	Frequency of Observation	Since when
1.	New Delhi	28° 35′ N	77° 12′ E	Fortnightly	1971
2.	Pune	18° 32′ N	73° 51′ E	Fortnightly	1971
3.	Thiruvananthapuram	08° 29′ N	76° 57′ E	Fortnightly	1971
4.	Maitri (Antarctica)	70° 48′ S	11° 42′ E	Weekly	1986-89
5.	Dakshin Gangotri	70° 03′ S	12′ E	Weekly	1990





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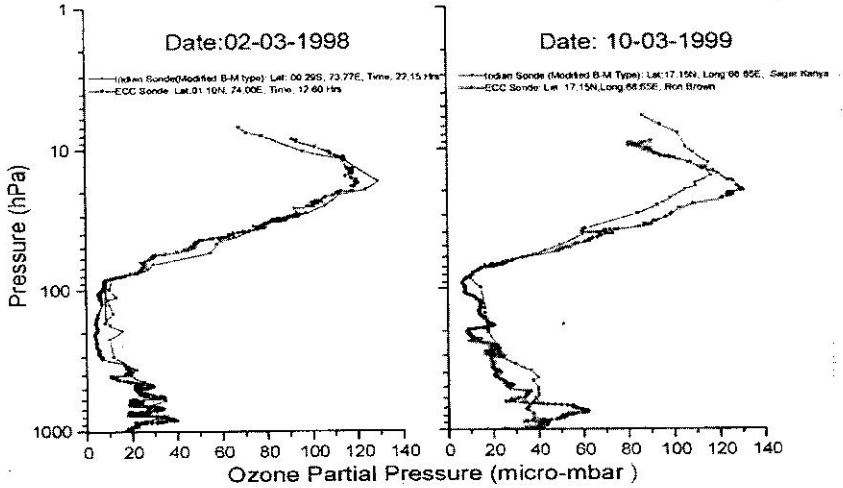
Comparison of IMD's Ozone sonde with ECC sonde during INDOX – 1999 experiment



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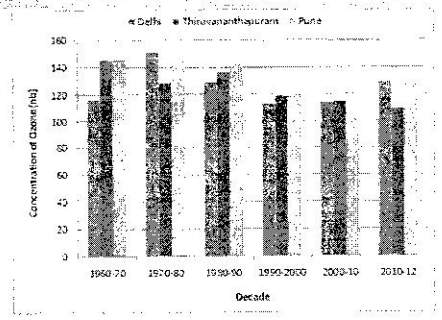
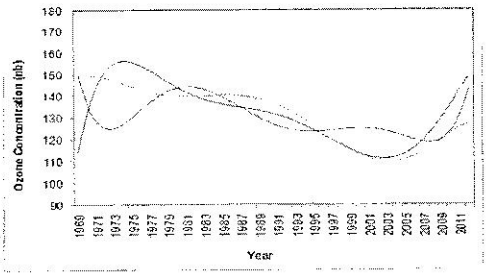
Variation of Decadal Averaged Max. Stratospheric Ozone Concentrations at New Delhi, Thiruvananthapuram, Pune





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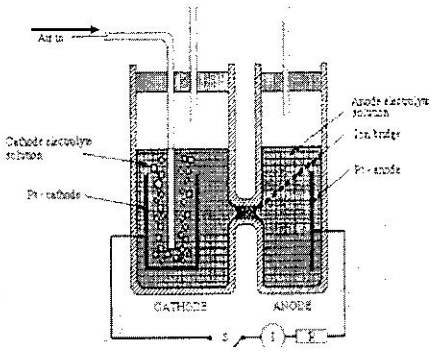
Electrochemical Conductivity Cell (ECC)



Idea:

Titration of ozone in a potassium iodide (KI) solution according the redox reaction:

$$2\ KI + O_3 + H_2O \rightarrow I_2 + O_2 + 2\ KOH$$

Measurement of "free" iodine (I_2) in electrochemical reaction cell(s). The iodine makes contact with a platinum cathode and is reduced back to iodide ions by the uptake of 2 electrons per molecule of iodine:

$$I_2 + 2\ e^- \text{ on Pt} \rightarrow 2\ I^- \quad \text{[cathode reaction]}$$

- The electrical current generated is proportional to the mass flow of ozone through the cell
- Continuous operation through pumping of air through the solution

Applications: Measurement of vertical O_3 distribution up to the stratosphere, Surface O_3

Problems: Interference by SO_2 (1:1 negative) and NO_2 (5-10% positive)

- Solution preparation has large impact on measurement accuracy
- Pump efficiency is reduced at high altitudes

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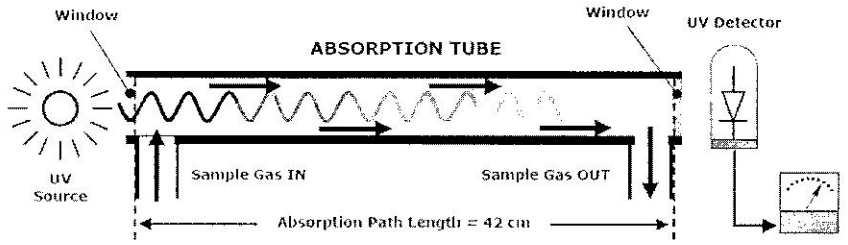
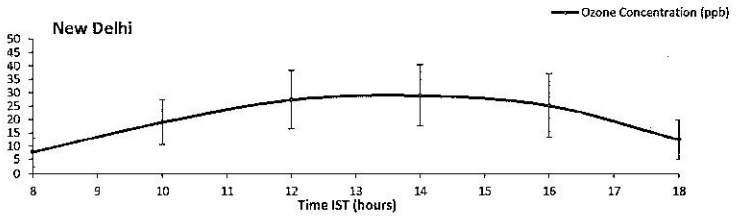
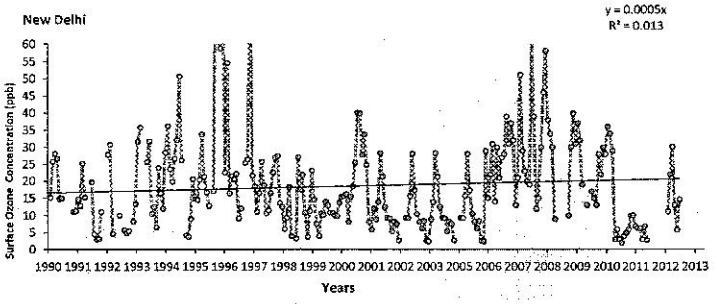
Surface Ozone analyzer
UV Absorption Ozone Analyzer



- UV photometer determines ozone concentration by measuring the attenuation of light due to ozone in the absorption cell.
- Absorption wavelength is 254 nm.
- The concentration of ozone is directly related to the absorbance.





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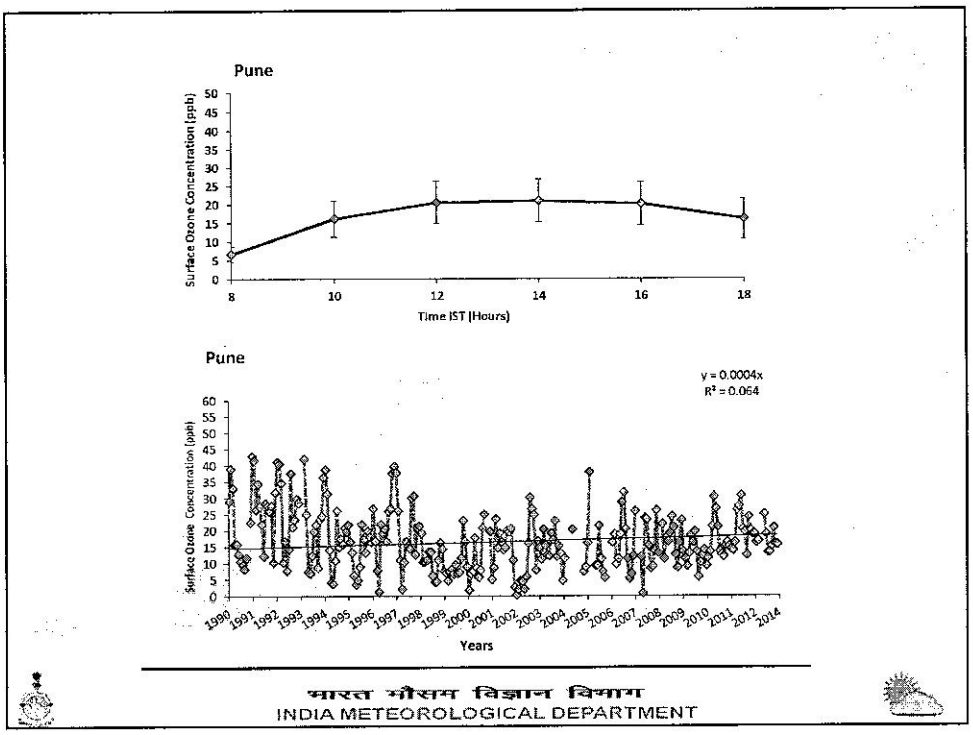
Pune
Surface Ozone Concentration (ppb)
Time IST (Hours)
Pune
y = 0.0004x
R² = 0.064
Surface Ozone Concentration (ppb)
Years
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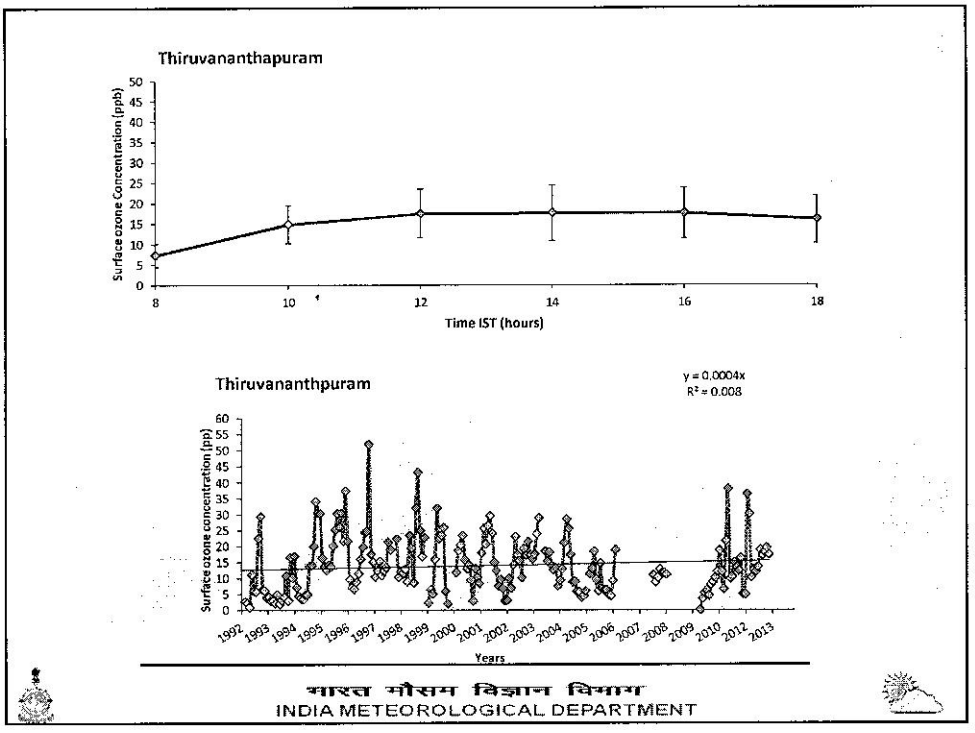
Thiruvananthapuram
Surface ozone Concentration (ppb)
Time IST (hours)
Thiruvananthpuram
y = 0.0004x
R² = 0.008
Surface ozone concentration (ppb)
Years
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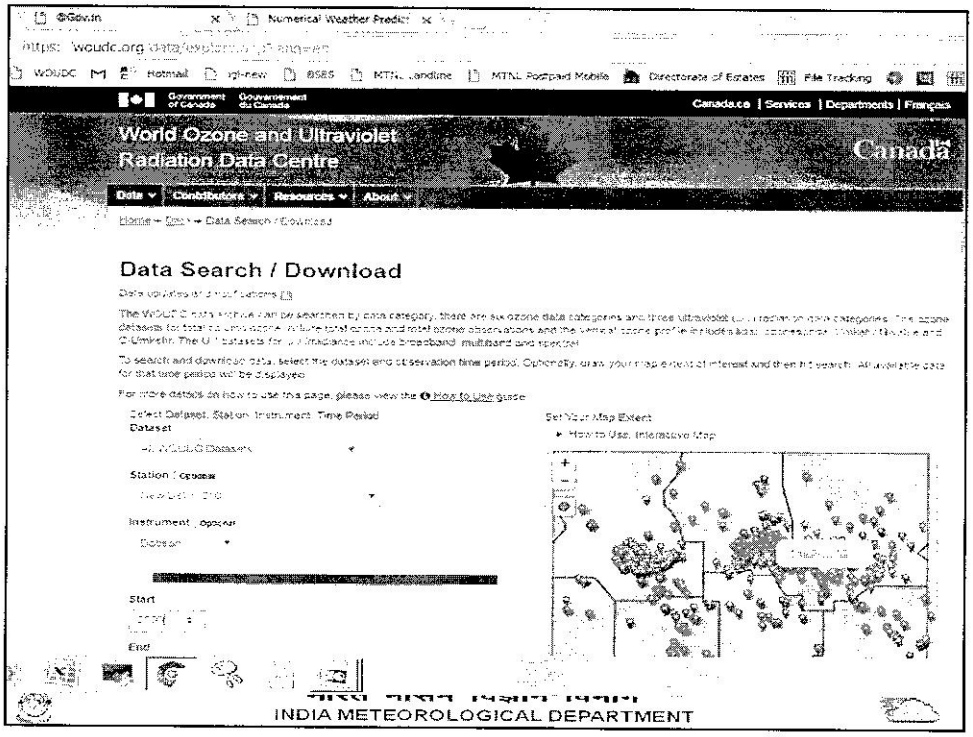

Conclusions

- Yearly averaged concentrations of Total Ozone show an increasing trend in Delhi. Monthly maxima in Total Column Ozone values has been observed in the month of May with monthly minima in the month of November during last 50 years.
- Monthly averaged max. total Ozone concentrations has been found in the month of May and min. monthly concentrations has been observed in the month of February at Srinagar. No trend in yearly concentrations of total ozone at Srinagar has been noticed.
- During the period 1963 – 2014, total ozone concentrations at Varanasi have been found min. in 1998 and showing increasing trend after the year 1998. Max. Ozone concentration have been found in May and minimum in December at Varanasi.
- No trend in yearly averaged concentrations of total ozone has been observed at Pune.
- The phenomena of 'Ozone Hole' is captured clearly by data monitored at IMD's station Maitri, Antarctica. Data clearly show that the Ozone Hole starts appearing in August every year and becomes strongest in September and finally disappears in December.
- The concentration of Ozone in stratosphere has start increasing at Delhi, Pune and Thiruvananthapuram in recent years particularly after 2006.
- Overall, an increasing trend in total ozone values at Delhi and Maitri has been found while no significant increasing or decreasing trend in total ozone values has been observed over Pune, Srinagar, Kodaikanal and Varanasi.

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Thank You

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