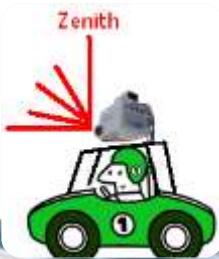


# **SMOG(OKE) Choked the life in the City of Lahore, Pakistan as air pollution hits the Hazardous levels**

- Dr. Muhammad Fahim Khokhar & C-CARGO Team Members
- Institute of Environmental Sciences and Engineering (IESE) NUST – Islamabad, PAKISTAN



# SMOG (Fog+ Smoke)

- Consist of PM (particulate matter), gases and smoke.
- Reduces the visibility and causes haze (Middleton, Kendrick Jr et al., 1950).
- Formation of smog is due to moisture content, cold winds and the phenomenon of temperatures' inversion (Sati & Mohan, 2014)
- Smog is cumulative effect of anthropogenic activities (fossil fuel burning, expedited industrial activities, vegetation residual burning and forest fires etc.) and local climatic conditions
- Smog problem is not new to the World as it has been causing severe problems since 1950s (e.g. London Smog). January 2013, Beijing- China experienced several smog episodes with PM<sub>2.5</sub> concentrations approximately 800 $\mu\text{g}/\text{m}^3$  (Zhou et al., 2015).

**Visuals from the City of Lahore 01- 07 November 2017**

Newspost

# Smog in Lahore

November 8, 2016

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## Pakistan's Lahore chokes on toxic smog

By AFP

Published Friday, November 04, 2016



Thousands of citizens of Pakistan's Lahore, one the world's most polluted cities, complained Thursday of breathing difficulties and irritable eyes as a blanket of thick smog was forecast to persist for several days.

INTERNATIONAL

# THE NEWS

Dubai Post



Healthy and Smart... Rice Pudding



Teddy Bear Treatment for Dubai



Videos



Woods looks bewildered in new police breathalyzer



Enormous Stratolaunch aircraft rolled out for first



Newborn tries to walk minutes after birth



Hilarious moment a farting goat scares a child



Female zookeeper dies in UK in 'freak accident' with



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Does the iftar stay true to N'ecos claims of all natural?



## Air Quality Monitoring in Lahore

- Most of the time pollutant levels were exceeding the PEQS
- PM<sub>2.5</sub> and NO<sub>2</sub> was higher than prescribed safety levels
- Temperature ranged 19 to 22 °C
- Calm winds prevailed

Date	NO	NO <sub>2</sub>	SO <sub>2</sub>	O <sub>3</sub>	CO	PM <sub>2.5</sub>	PM <sub>10</sub>	W.Sp	R.H	Air.T
UNITS	µg/m <sup>3</sup>	µg/m <sup>3</sup>	µg/m <sup>3</sup>	µg/m <sup>3</sup>	mg/m <sup>3</sup>	µg/m <sup>3</sup>	µg/m <sup>3</sup>	m/sec	%	°C
PEQS/ GUIDELINE	40	80	120	130	5	35	150	-	-	-
2-Nov-16	306.61	74.82	32.49	28.39	21.29	104.06	119.57	0.05	89.31	19
3-Nov-16	59.72	120.9	247.87	63.87	6.76	62.31	126.87	0.25	68.51	23.31
4-Nov-16	134.6	89.8	113.1	18.3	4.47	55.33	93.23	0.04	82.6	19.3
5-Nov-16	132	119.4	70.81	24.4	4.54	62.82	94.37	0.2	71.97	21.51
6-Nov-16	43.29	90.64	189.9	52.4	4.72	44.6	124.2	0.22	57.2	22.43
7-Nov-16	25.7	105.7	72.9	34.98	2.81	37.31	64.49	0.22	54.2	21.8

## Hazards Related to SMOG incident during November 2017

- "fine particulate matter" was reported four times the World Health Organization's recommended level, exceeding 104 ug/m<sup>3</sup> in the worst-hit parts of the city of around 10 million.
- Hundred thousands of citizens of Lahore, complained of breathing difficulties and eye irritation
- Visibility plunged to less than 20 meters and citizens wore face masks to help with breathing.
- Separately, at least 13 people were killed and nearly 100 wounded in two pile-ups involving 16 vehicles on the Lahore-Islamabad motorway due to dense smog on 4 Nov 2016
- Sections of M2 and M3 motorways were closed
- Warnings were issued to avoid the outdoor activities

## SMOG Choked life in Delhi during November 2017



# The Smog in India Is So Bad Right Now, You Can See It From Space, This is terrifying.

BEC CREW, 9 NOV 2016

- Earlier this week, the Indian government declared a national emergency, as air pollution in its capital, New Delhi, reached levels more than 16 times the safe limit.
- Schools closed, locals began to flee
- Delhi's chief minister compared the city to a "gas chamber".
- System of Air Quality and Weather Forecasting and Research (SAFAR), New Delhi experienced PM10 hit  $876 \mu\text{m}/\text{m}^3$ , and PM2.5 hit  $680 \mu\text{m}/\text{m}^3$  earlier this week.



# SMOG Choked life in Delhi during November 2017

03:30 PM



04:00 PM



[vir.sanghvi@virsanghvi](mailto:vir.sanghvi@virsanghvi)

The same view first at 3.30 and then at 4 pm. What ----- is happening to Delhi?

[#DelhiSmog #DelhiChokes #pollution](#)  
[#Breathe](#)

**Q : Is that SMOG  
or simply SMOKE ?**

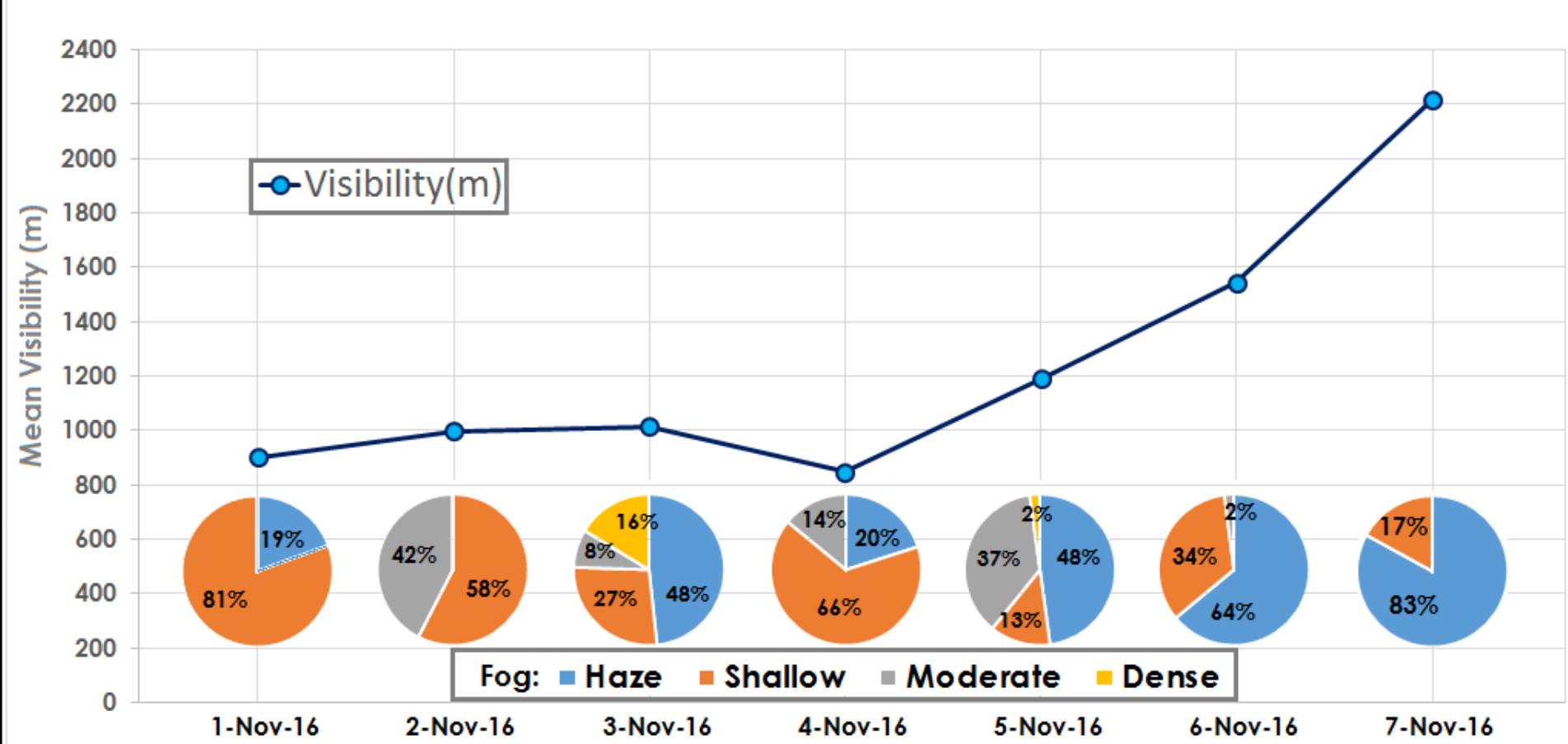


# Fog

- According to (Ahrens 2012, Ch.5, Page 114 ) fog is defined as" when the visibility lowers to less than 1 km (0.62 mi), and the air is wet with countless millions of tiny floating water droplets, the wet haze becomes a cloud resting near the ground."
- Condensation is a continuous process and starts when water vapor condenses on hygroscopic nuclei at relative humidity as low as 75 %
- As the relative humidity gradually approaches 100 percent, the haze particles grow larger, and condensation starts on even less-active nuclei.
- According to Pakistan Meteorological Department (PMD), see Yasmin et al., 2012
  - very Dense Fog: visibility < 50 meters
  - Dense Fog: visibility < 200 meters
  - Moderate Fog: visibility < 500 meters
  - Shallow Fog: visibility < 1000 meters
  - Haze and Mist: visibility > 1000 meters

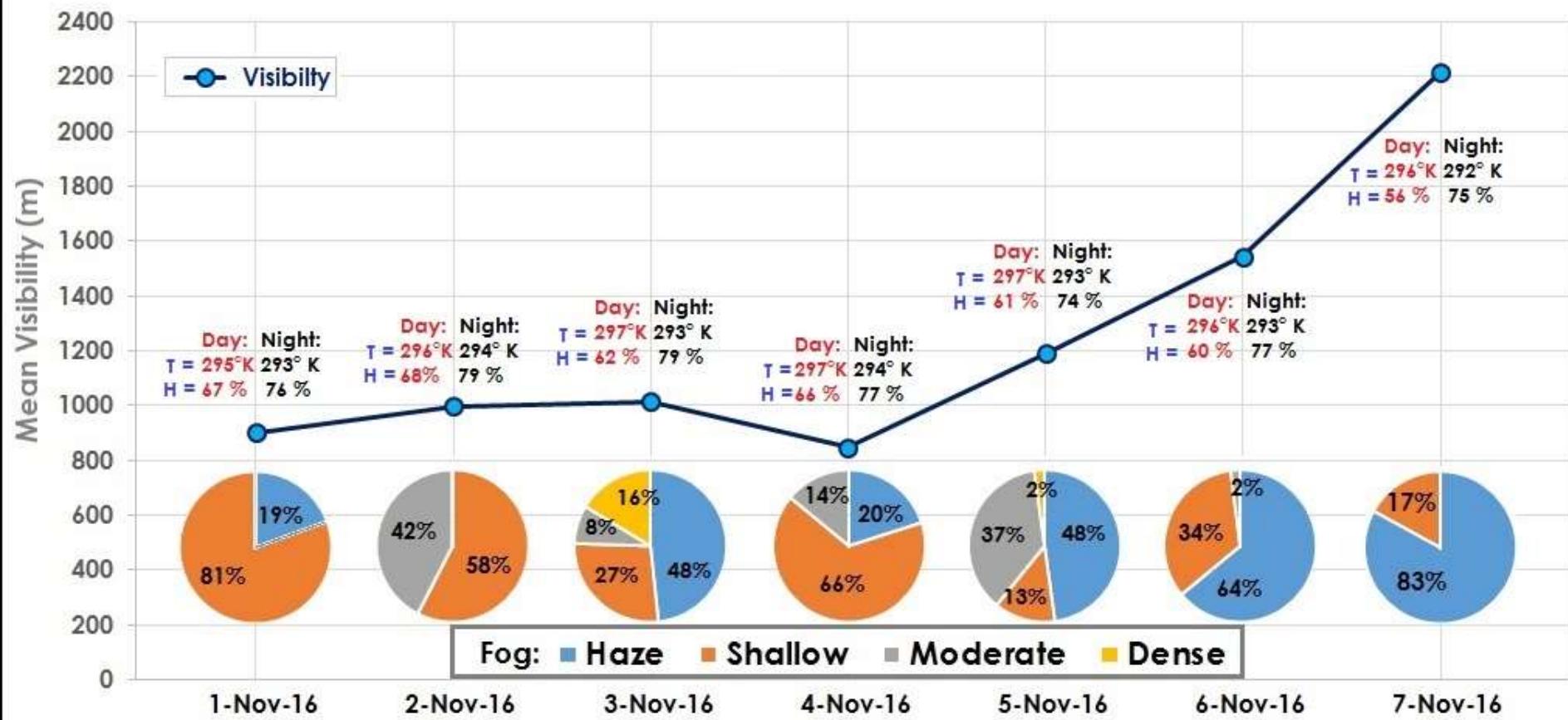
## Visibility Data from Lahore (1-7 Nov. 2017)

In order to determine the total number of fog days in the city of Lahore, visibility data from Pakistan meteorological department and online weather forecast (<http://www.weatherforyou.com/>)



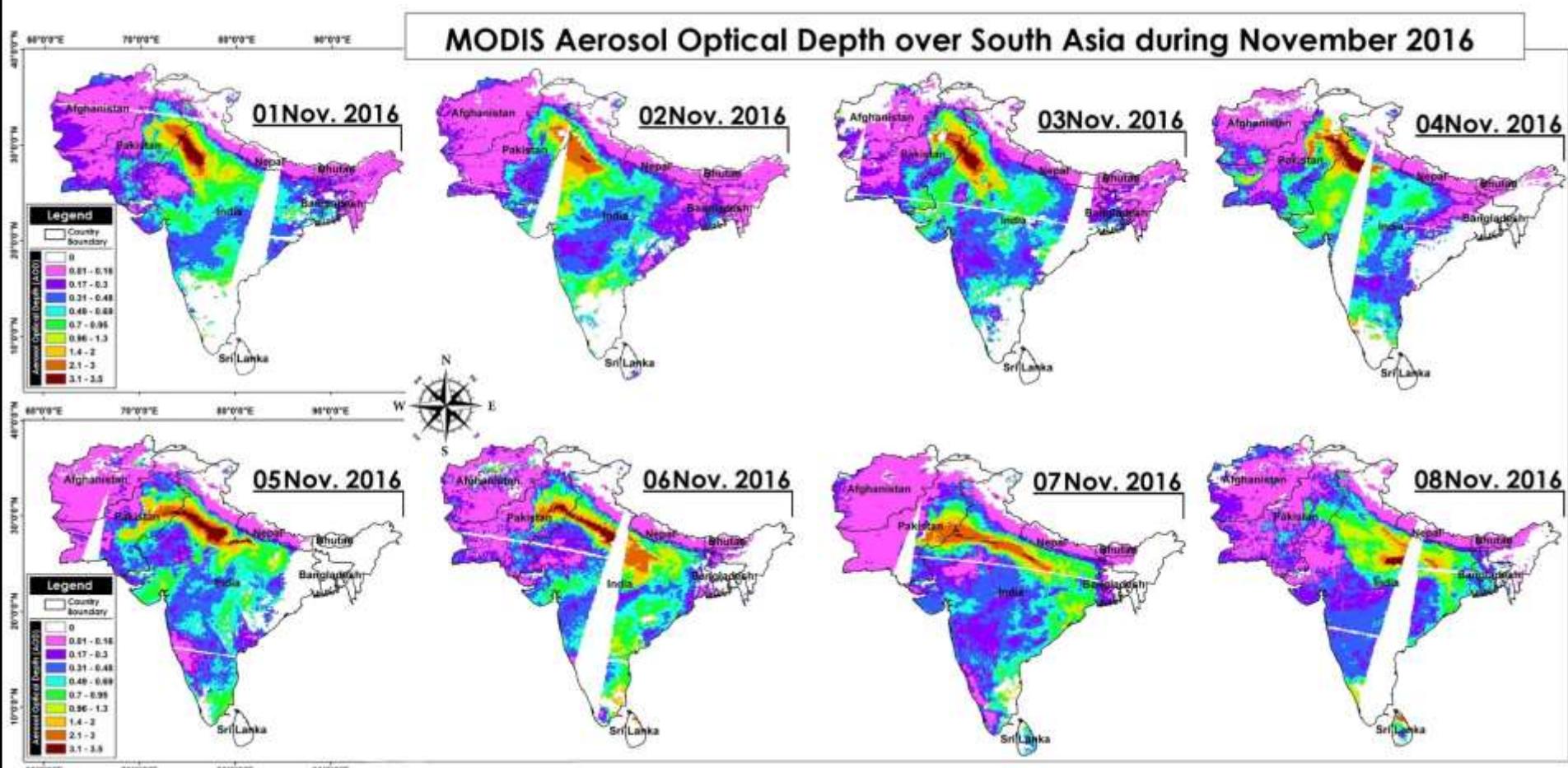
## Visibility Data from Lahore (1-7 Nov. 2017)

- Mean daily visibility
- Mean daytime rel. Humidity and Temperature in red
- Pie charts >> frequency of types Fog incidents
- All of these reported Fog events were during night time and before 0900 AM



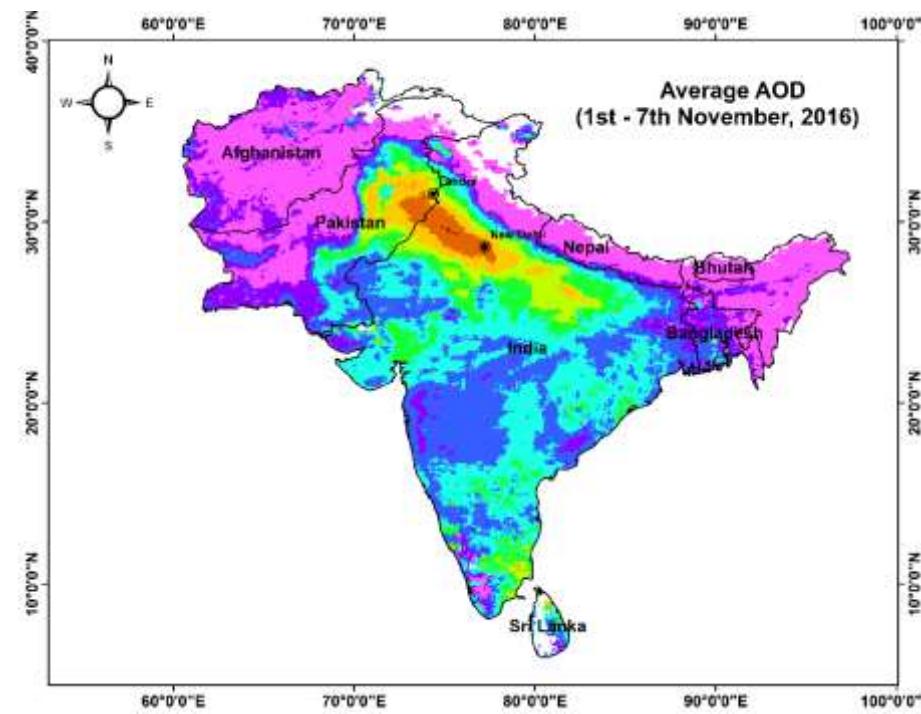
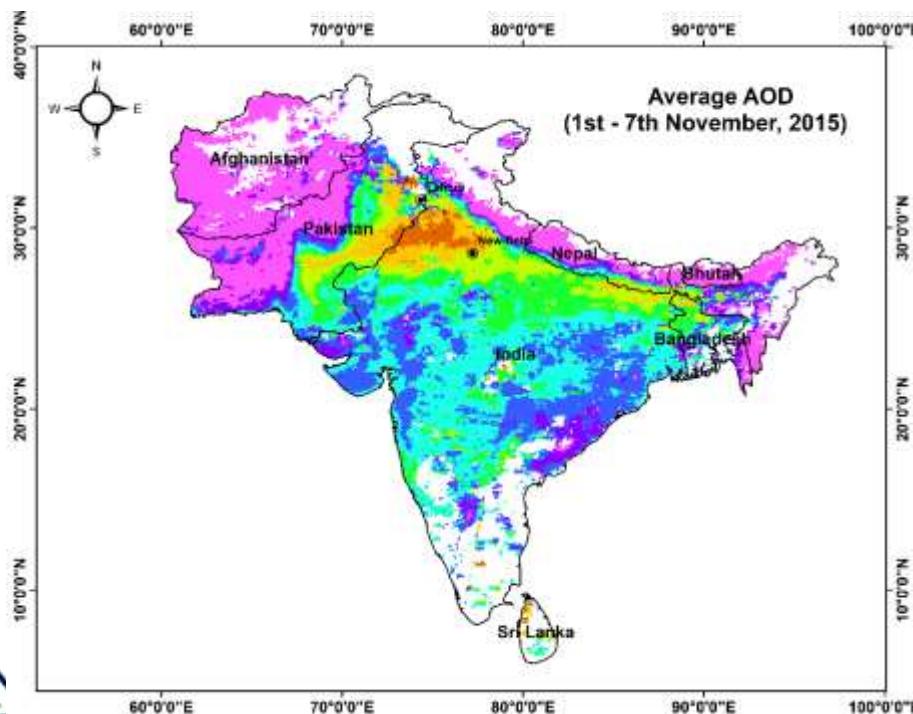
# Aerosol Optical Depth (AOD) over South Asia

- Max AOD was observed over Punjab regions from both sides of the border between India and Pakistan >> (MODIS Observations collection 6)
- Lahore >> maximum aerosol load is observed between 01 to 04 Nov. 2016
- Aerosol plume was dissipated and shifted southward



## Aerosol Optical Depth (AOD) over South Asia

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Bridging the Gaps from Local to Global

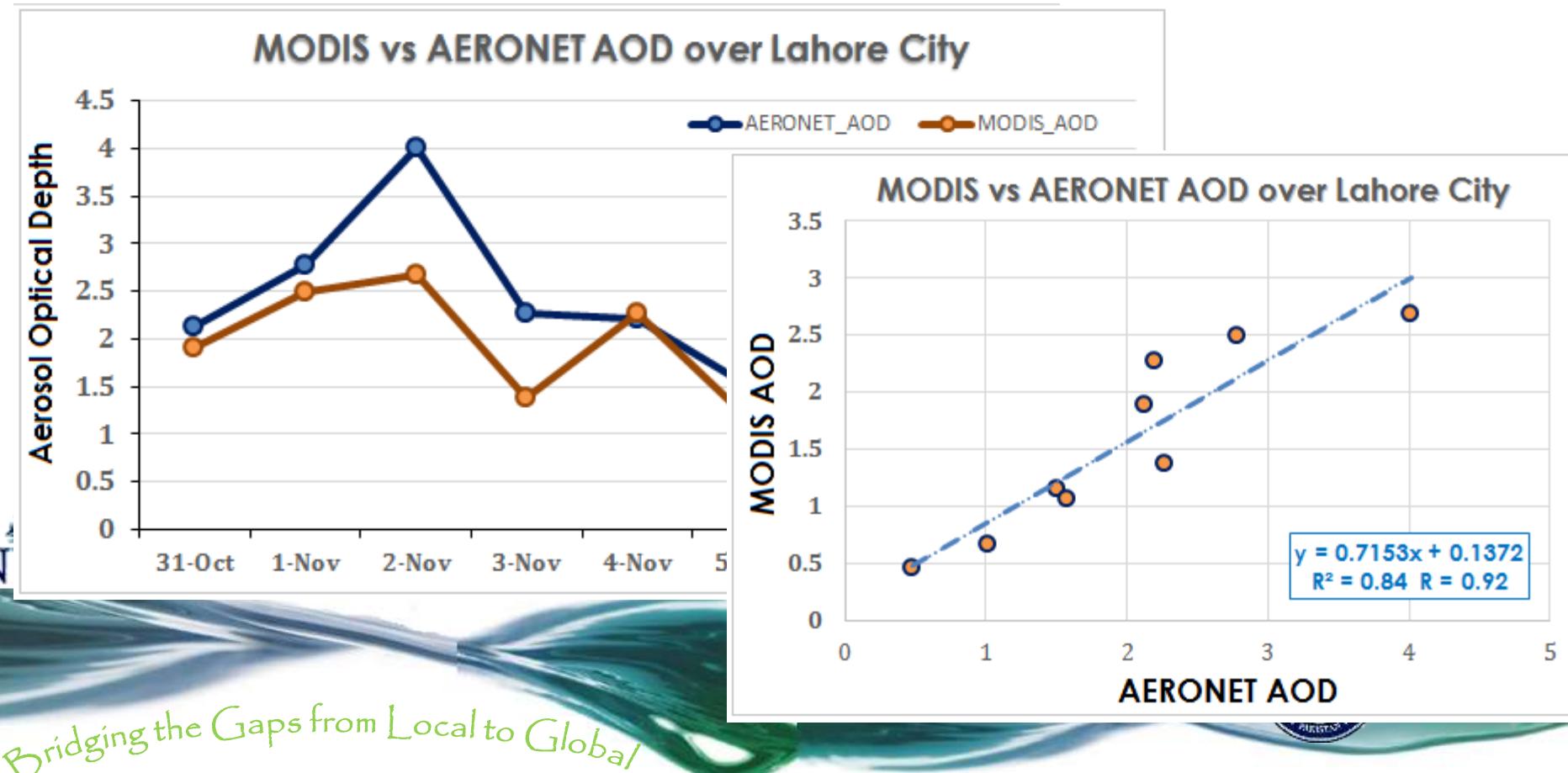


## MODIS vs AERONET observations

- Aerosol particles come from a variety of sources and can affect the human health in number of ways e.g. lung diseases, reduce visibility
- Increasing aerosol load is considered as a significant aspect in contributing towards frequent fog/smog incidents in urban regions.
- assessment of variability in aerosol load both in space and time is important to understand the dynamics, composition and associated impacts of aerosols on global climatic conditions
- For such purposes, satellite observation with broad spatial coverage have advantages over ground-based observation
- Validation of satellite observations with ground-based observations is a scientific requirement which allows applicability towards greater spatial scales.
- Validated MODIS AOD with AERONET station data from Lahore and Gual Pahari Delhi

## Aerosol Optical Depth - MODIS vs AERONET Observations

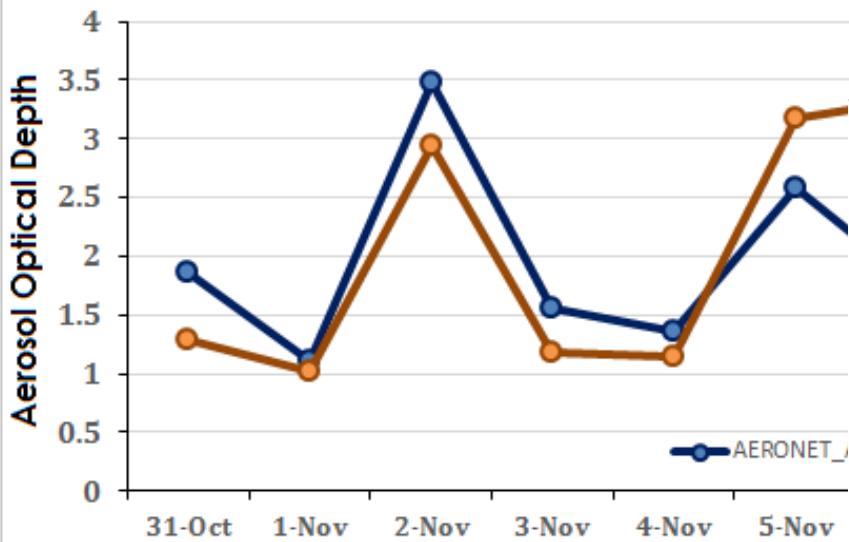
- AERONET AOD was extrapolated to 550 nm
- Lahore >> maximum aerosol load is observed on 2<sup>nd</sup> Nov. 2016
- Both observations are in good agreement , R = 0.92



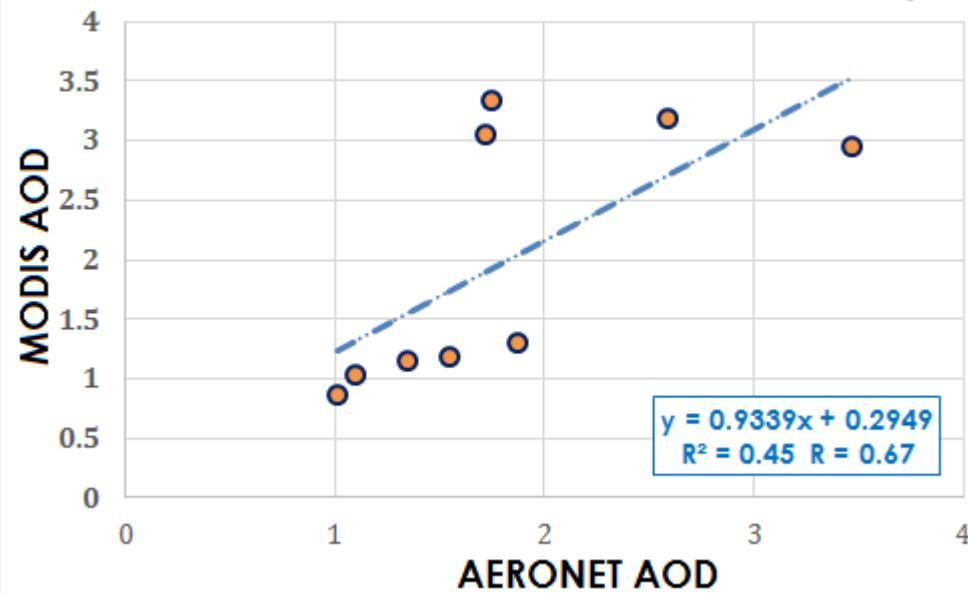
## Aerosol Optical Depth - MODIS vs AERONET Observations

- AERONET AOD was extrapolated to 550 nm
- Lahore >> maximum aerosol load is observed on 2<sup>nd</sup> Nov. 2016
- Both observations exhibited reasonable agreement , R = 0.67

MODIS vs AERONET AOD over Gual Pahari, Delhi



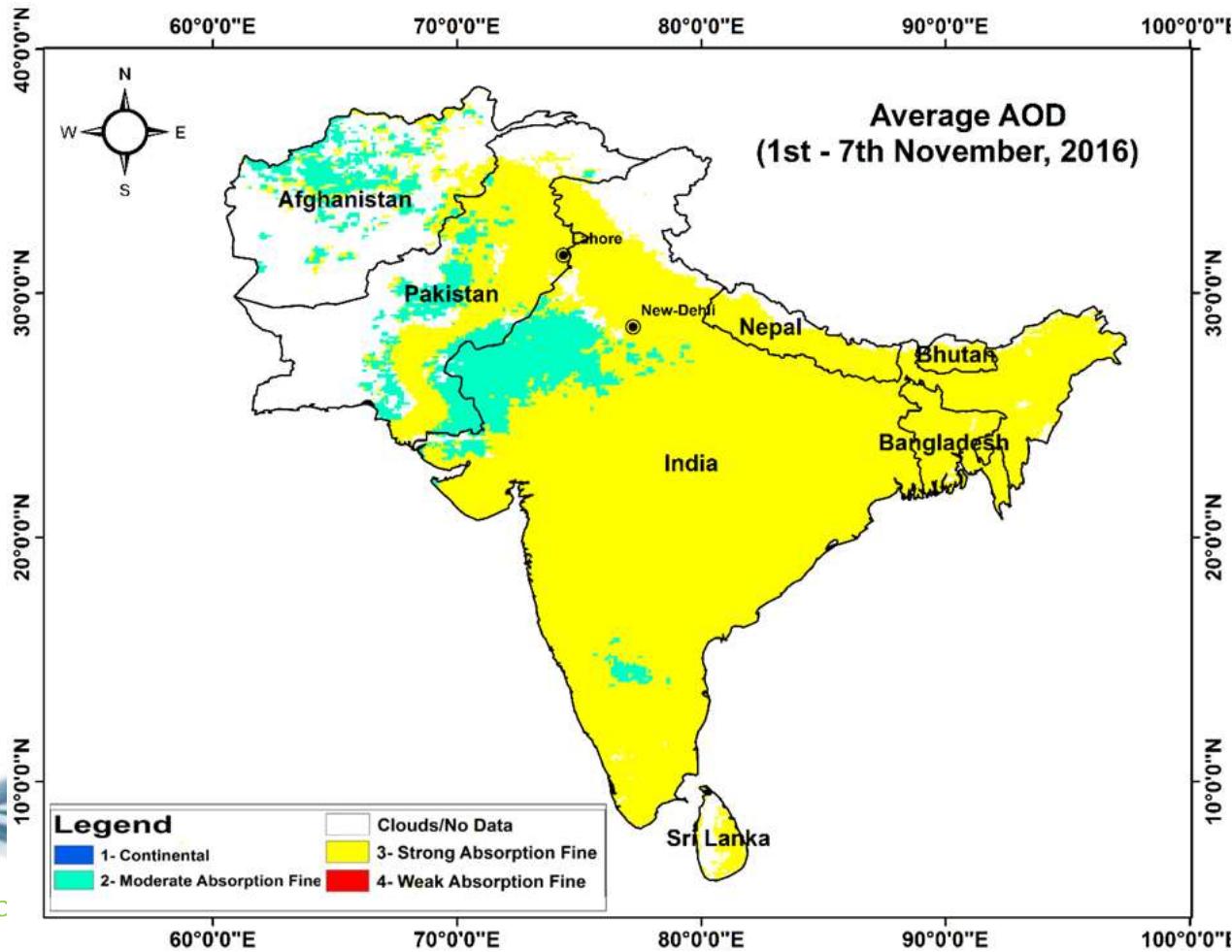
MODIS vs AERONET AOD over Gual Pahari, Delhi



## AEROSOL - Characterization

- MODIS product named aerosol type over land (ATL) was used.
- MODIS aerosol types were categorized into four types: continental, weak, moderate and strong absorption fine.

- **the most dominant aerosol type over IGP/South Asia was found: strong and moderate absorption fine**

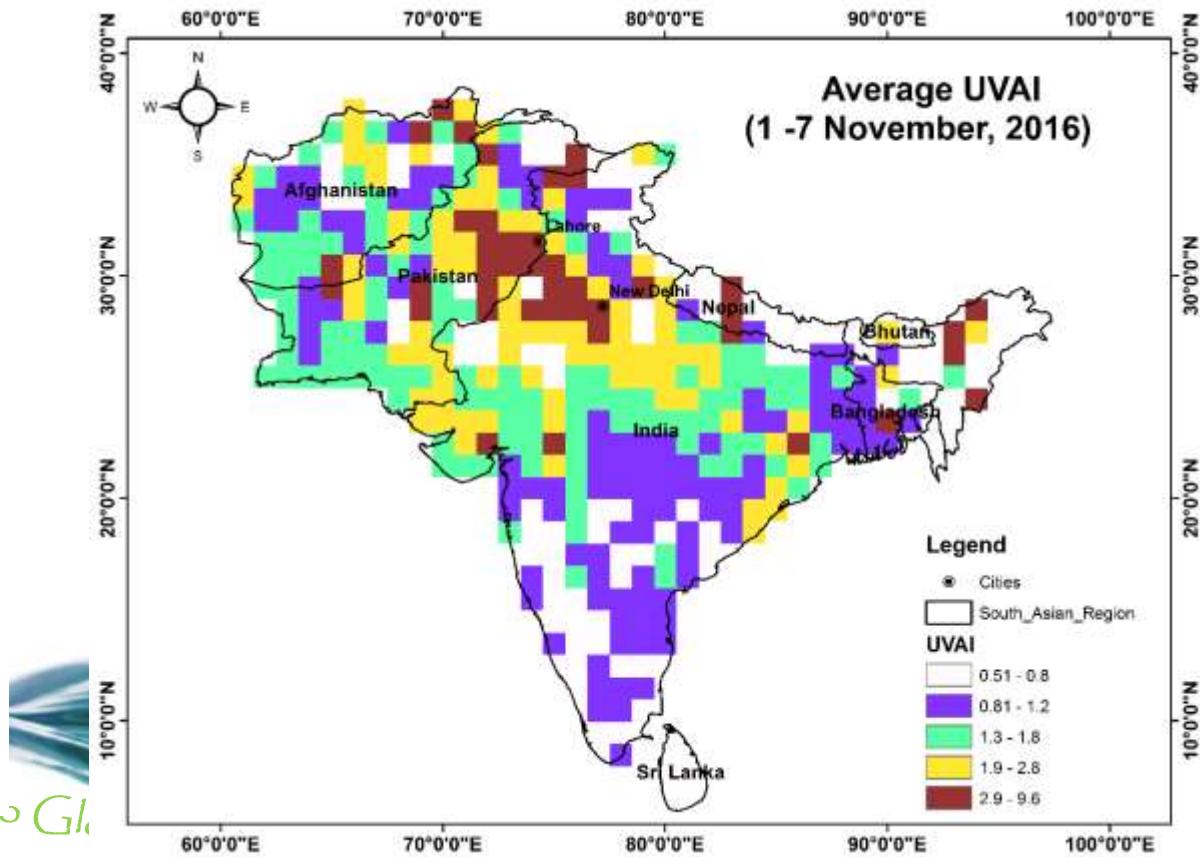


## AEROSOL - Characterization

- OMI UV absorbing aerosol index (OMI-UVAI) was also used.
- It is a residual quantity resulting from the comparison between measured and calculated radiances in the range 330-390 nm (Torres et al. 2002).
- sensitive to carbonaceous and mineral aerosols, represents the presence of absorbing aerosols (smoke and dust) and insensitive to surface types.

- For clear sky/Rayleigh scattering conditions UVAI values are near zero,
- **+ve values** for absorbing aerosols (smoke, dust)
- **-ve values** for non-absorbing aerosols (sea salt, sulfate/nitrates etc.).

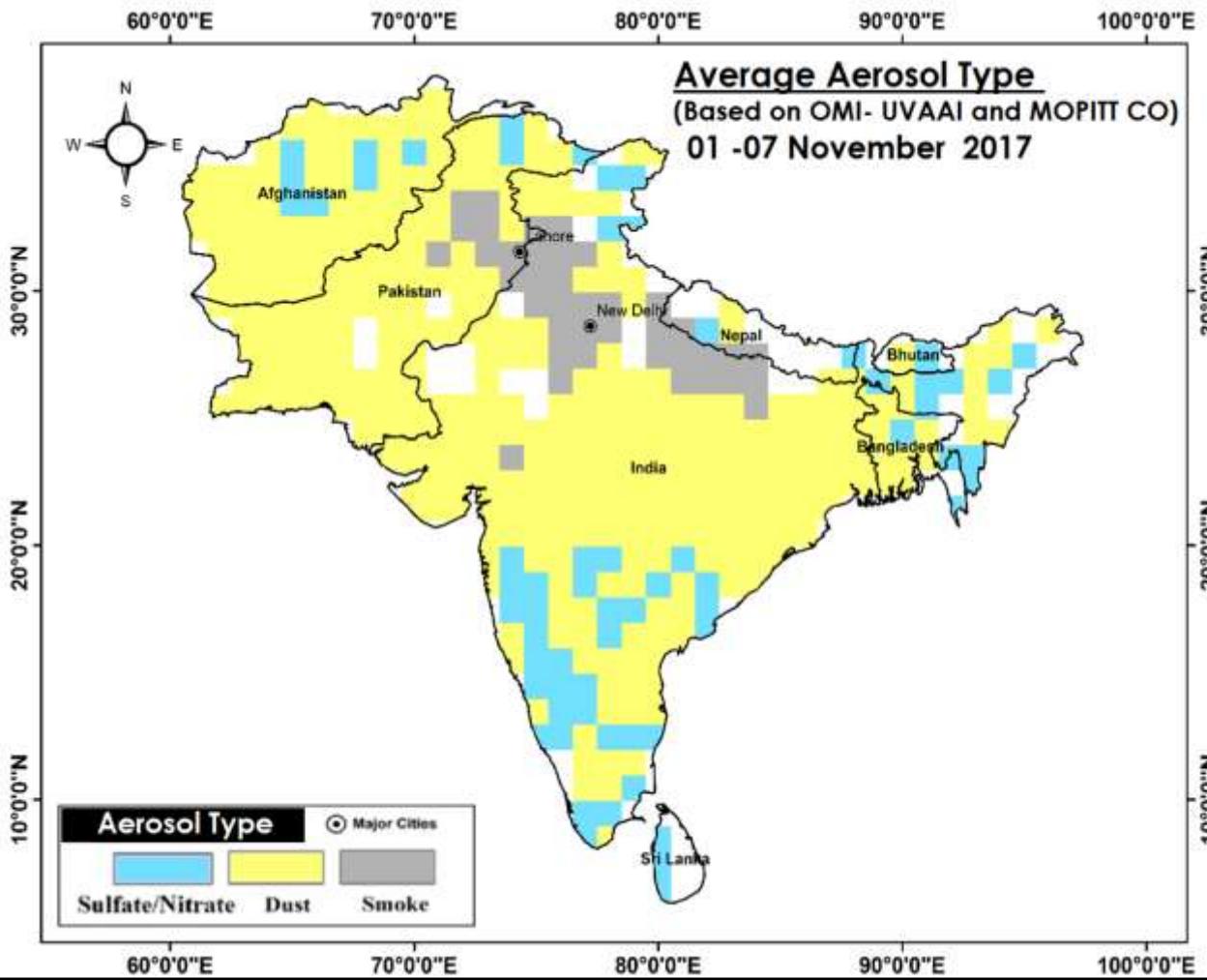


# AEROSOL - Characterization

- Aerosol types were further characterized by using OMI-UVAAI in combination with MOPITT/AIRS CO total columns, as CO is taken as a good precursor for biomass burning emissions

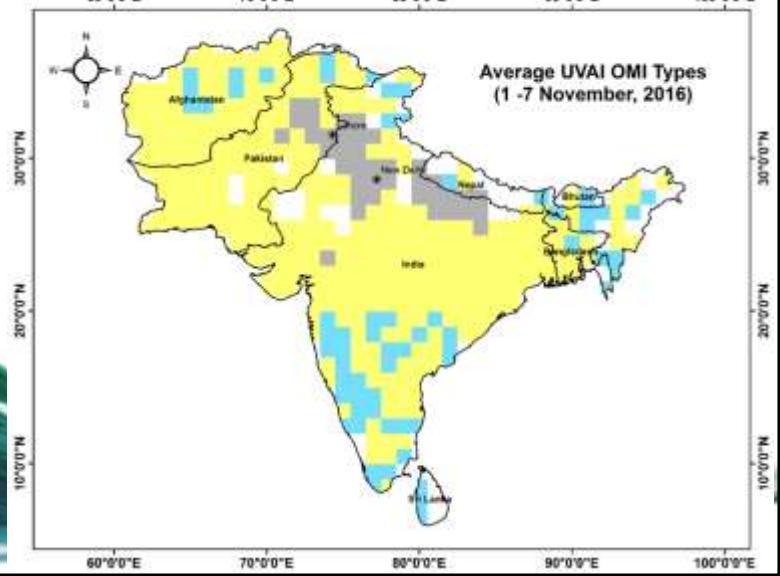
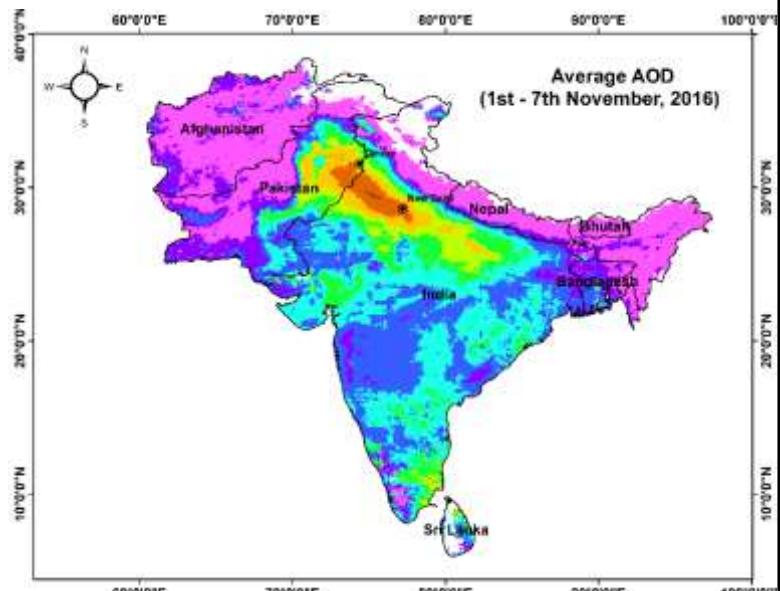
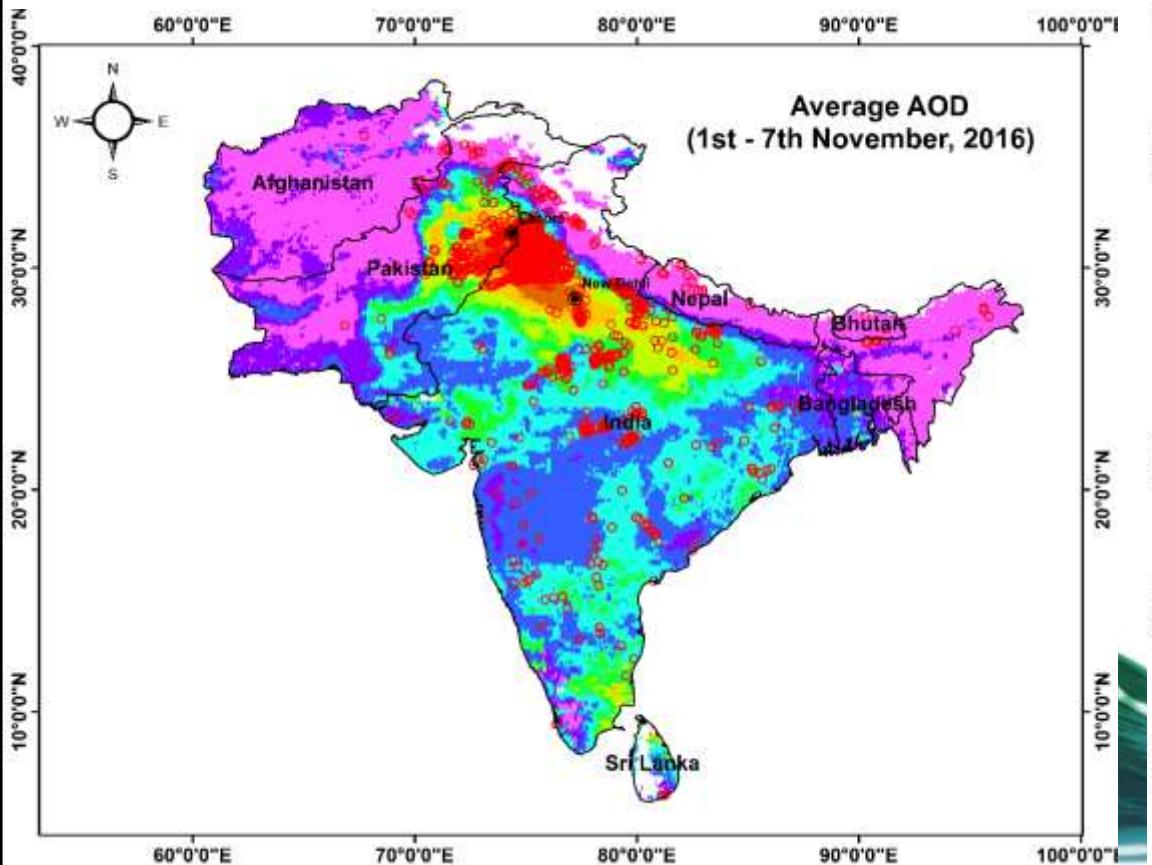
- The aerosol categories include:

- Smoke** (for UVAAI  $>0.8$  and CO columns= $2.2 \times 10^{18}$  molecules/cm $^2$ ),
- Dust** (UVAAI  $> 0.8$  and arid - semiarid surface types)
- Sulphate** (UVAAI  $< 0.8$ )
- Dominant section of smoke type Aerosols**



# AEROSOL - Characterization

- active fire counts were also plotted (red circles)
- indicate a strong coincidence with smoke type of aerosols.



## Source – Agricultural Fires SMOKE

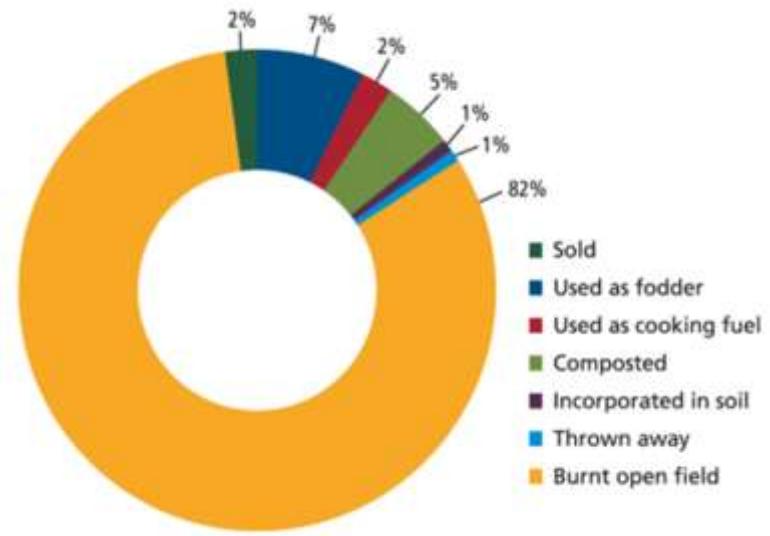
- Recent SMOG episode during November 2016 - India and Pakistan >> major cities
- Rice paddies clearing for the next crop
- Crop residue burning in Indian Punjab (75% more than usual)

*(Dr. Hiren Jethva, Research Scientist at USRA, India)*



## Source – Agricultural Fires SMOKE

- Air pollution/Air quality related issues are not different from other countries of South Asia
- Crop residue burning
  - 2- 3 cycles per year
  - Wheat crop (May – June)
  - Sugarcane (Jan – Feb)
  - Rice paddies/Cotton crop (October - Nov)
- Recent Report from Aisling Irwin  
IGBP's Global Change magazine 83,  
December 2014

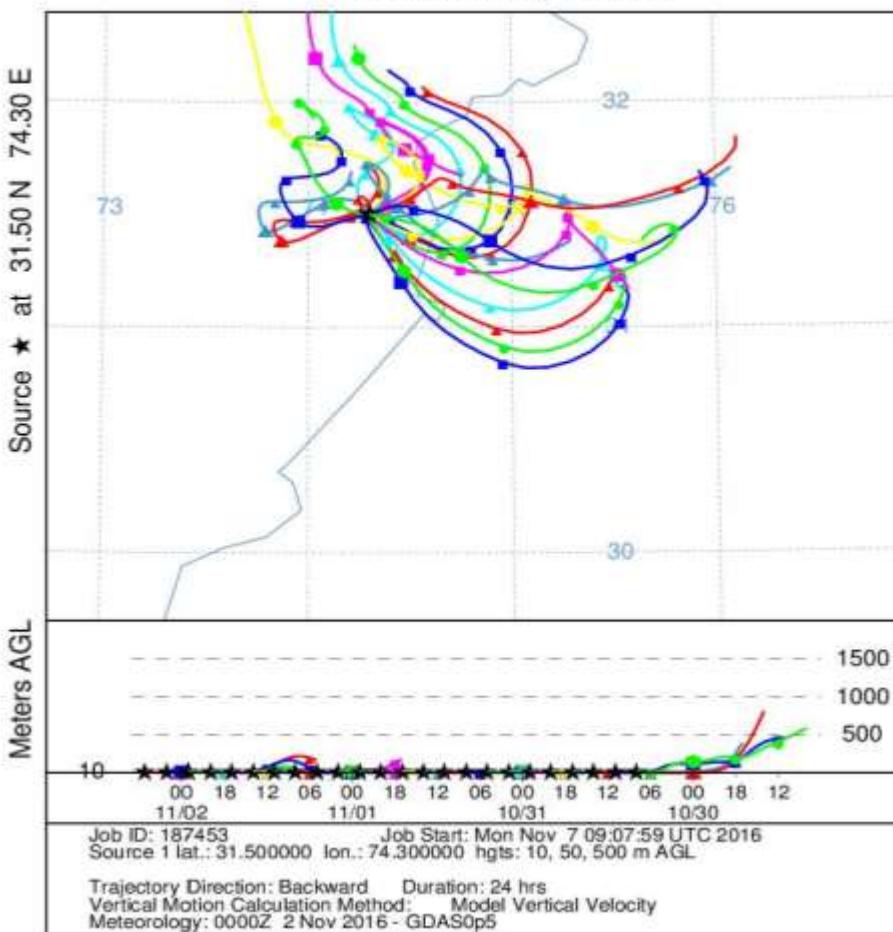


In South Asia, crop-residue burning (82 %) is a regionally significant source of black carbon or soot and other pollutants – that affect human health and climate.

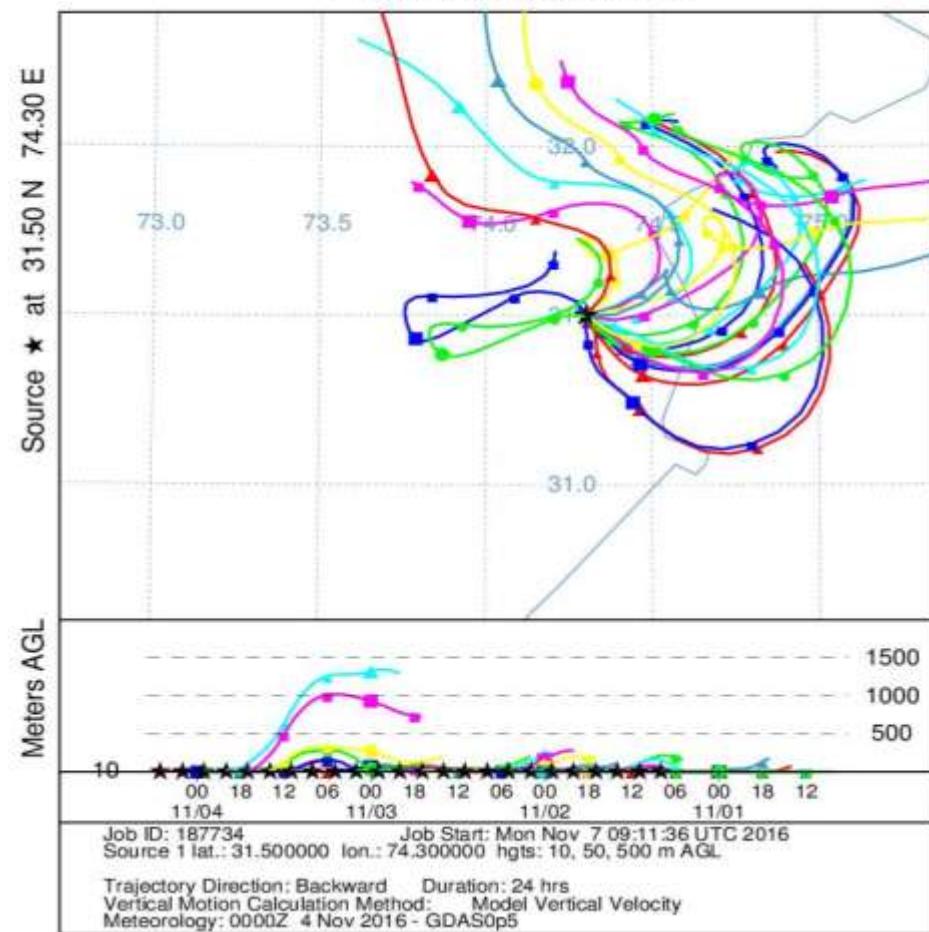
## HYSPLIT MODEL - Lahore City

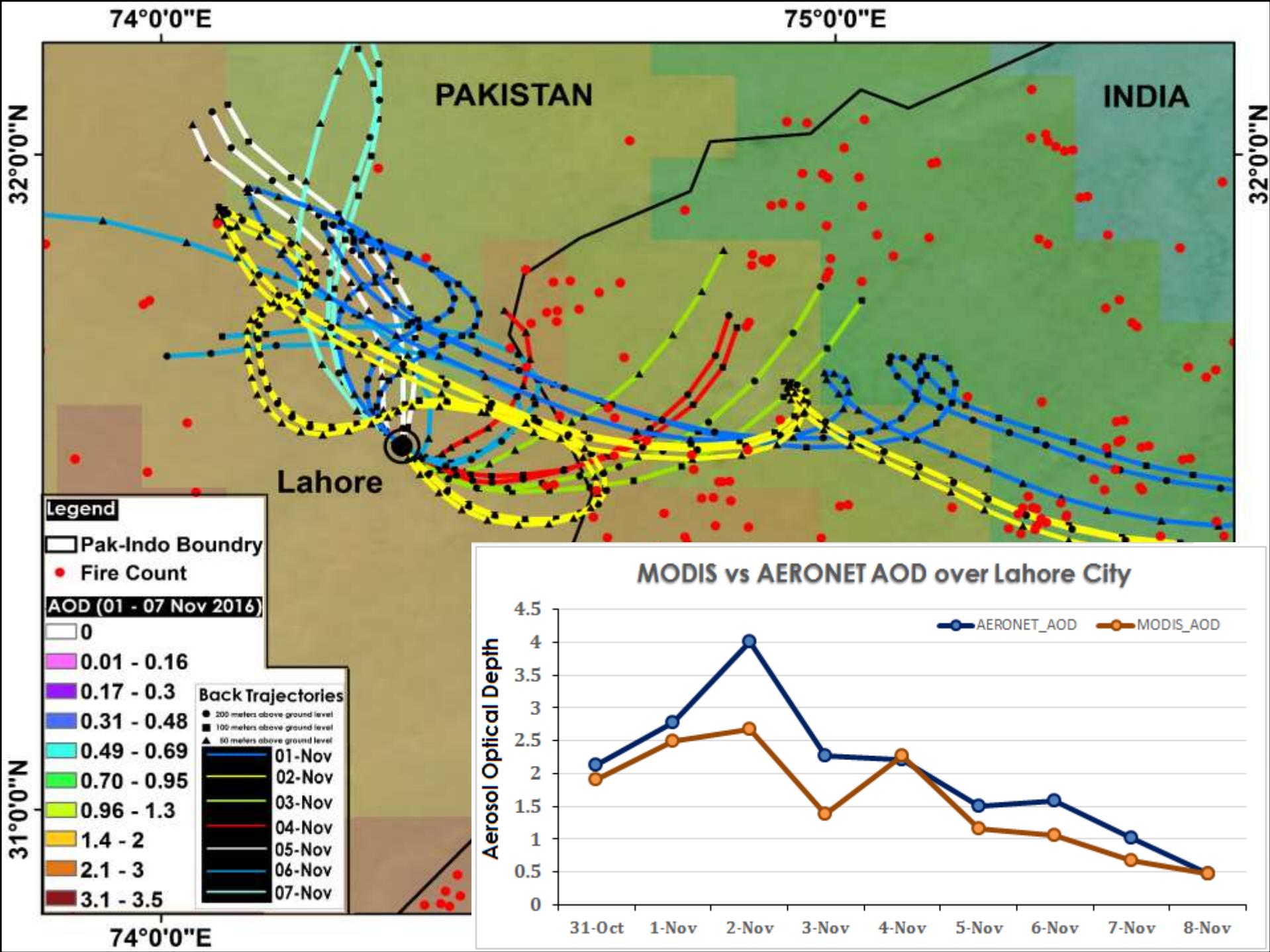
- Back Trajectory Analysis for 02 and 04 of November 2016
- Smog remained stationary in Lahore city generally.
- vertical mixing was absent

NOAA HYSPLIT MODEL  
Backward trajectories ending at 0500 UTC 02 Nov 16  
GFSG Meteorological Data



NOAA HYSPLIT MODEL  
Backward trajectories ending at 0500 UTC 04 Nov 16  
GFSG Meteorological Data





# ~~SMOG~~ (SMOKE) Choked the life in Provincial Capital of Lahore, Pakistan

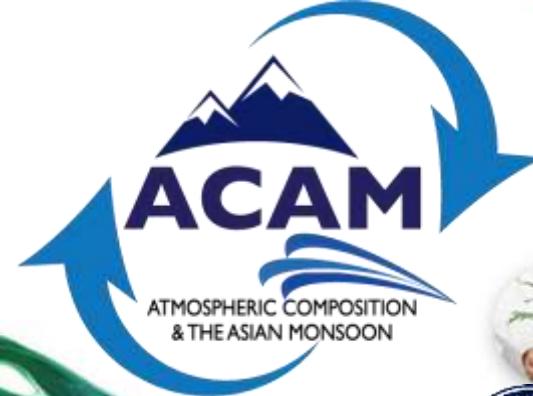
- as most of the fog event took place before 09:00 AM
- type of the aerosol observed over Lahore was predominantly “SMOKE”
- Aerosol plume was coincident with fire events

# Acknowledgment

- C-CARGO Team
- NUST - Pakistan
- ICIMOD
- ACAM
- Jinan University
- All the sponsors of ACAM workshop



ICIMOD



<http://www.flickr.com/photos/2449683/6798535972>



# Air Pollution related Issues in Pakistan

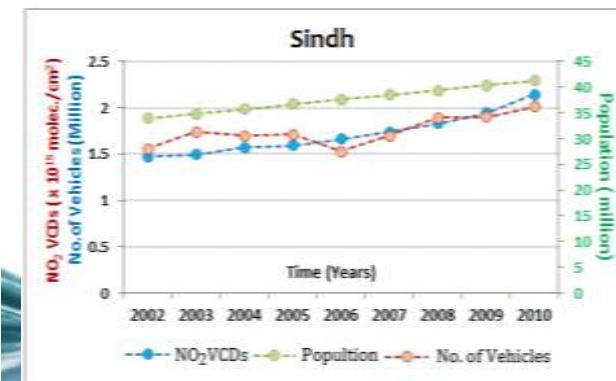
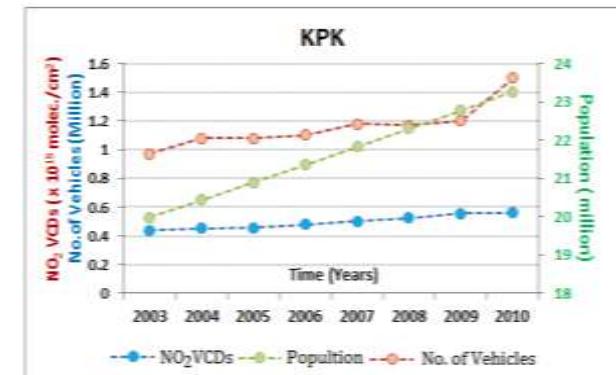
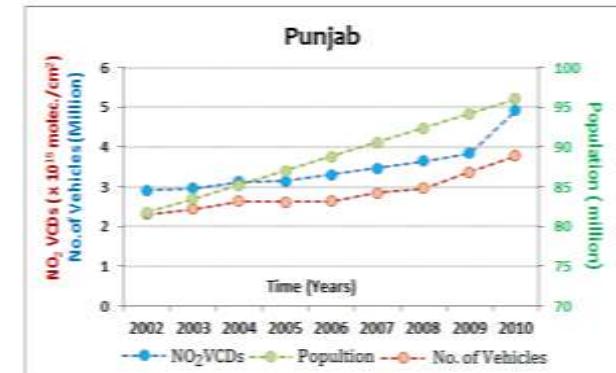
- Air pollution/Air quality related issues are not different from other countries of South Asia
- Degraded air quality - major cities
  - recent report from WHO listed Lahore, Rawalpindi and Peshawar as among worlds top 30 polluted cities
- Dense winter fog episodes (December – January)
  - Socio-economic implications
  - Health related issues
  - Causalities (road side accidents due to poor visibility)
- Frequent Photochemical SMOG (major cities)
  - Health related issues
  - causalities ( sensitive groups)
  - urban heat island
- increasing heat waves (summer 2015-2016) and drought period
  - causalities ( sensitive groups)
  - urban heat island

# Air Pollution related Challenges in Pakistan

- Biggest Challenge: Air pollution/Air quality related issues are not priority of Government (GOs) at all levels
  - Political will
  - Public awareness
- Lack of consistent monitoring facilities
  - Since year 2010 not a single air quality monitoring station from Pak-EPA is functional
  - Lack of funding
  - Lack of capacity >> majorly at government levels
  - We did not have any proper information
  - We did not have any continuous monitoring
  - We did not have a proper database of atmospheric composition over Pakistan
  - We do have PAK-NEQS but without ANY strict implementations
  - We did not have effective/strict monitoring plan
- Results in less effective policies to address air pollution

# Air Pollution related Challenges in Pakistan

- 2<sup>nd</sup> Biggest Challenge: Air pollution/Air quality related data sharing
  - quality of existing data
  - no access to general public
  - no/limited access to academic institutes
- Other changes include
  - Ever increasing urbanization
    - Cities are sprawling at faster rates without proper implementation of environmental friendly designs
  - Ever increasing traffic
    - 150% increase since 1990 -2014 (70% since 2002)
    - poor management as existing infra structure unable to cater the increasing vehicular fleet
    - frequent traffic jams
    - Worsen air quality



(Khokhar et al. 2015)

# South Asia

- Afghanistan
- Pakistan
- Nepal
- Sri Lanka
- Bhutan
- Bangladesh
- Maldives
- Myanmar



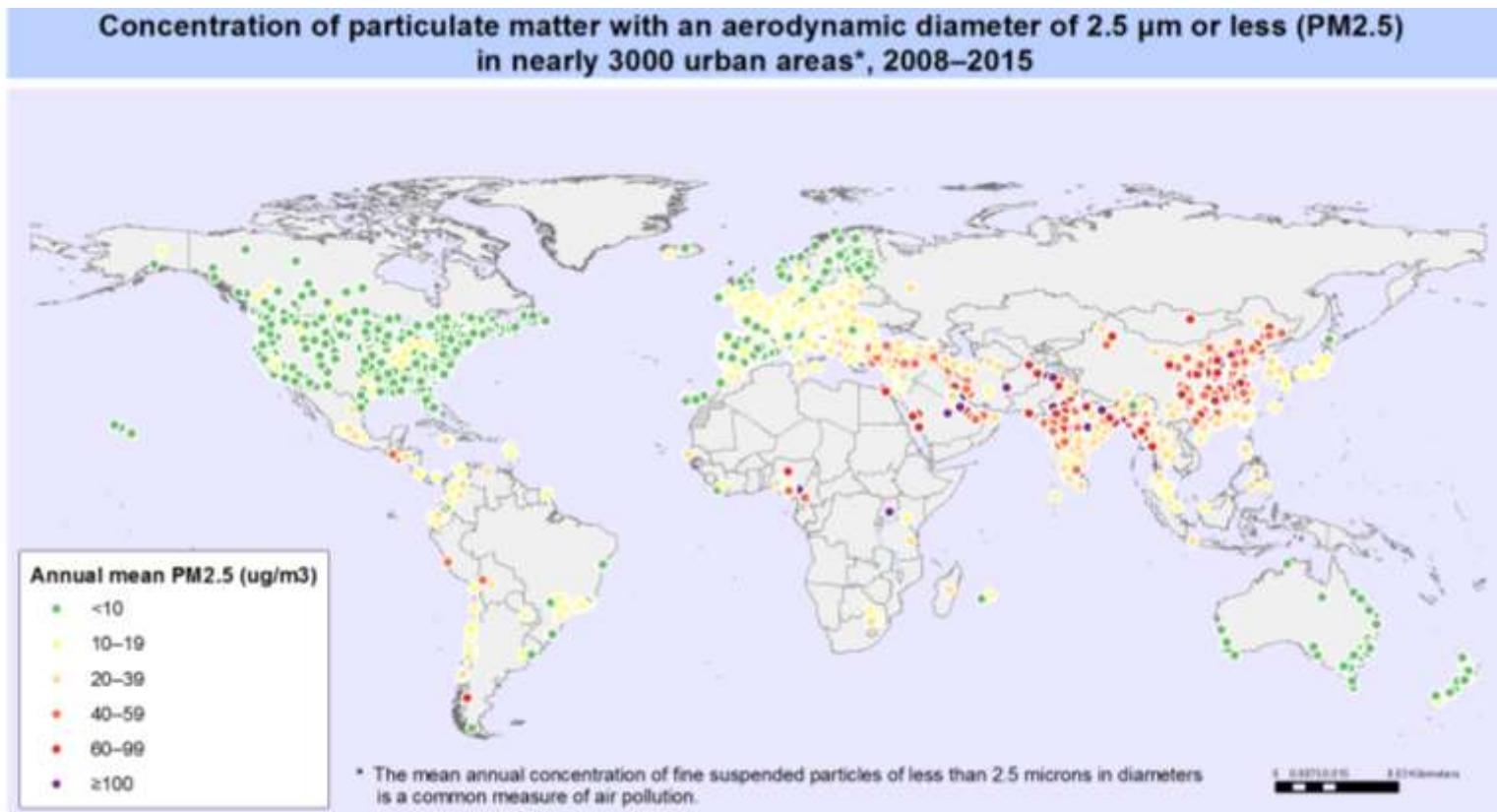
## Atmospheric Science Research Activities/Facilities

- **Pakistan**
  - Academic institutes and Govt. Organizations
- **Nepal**
  - Academic institutes and Govt. Organizations
- **Bangladesh**
  - Academic institutes and Govt. Organizations
- **India**
  - Academic institutes and Govt. Organizations



# Air Pollution related Issues in Pakistan

- Recent SMOG episode during November 2016 - India and Pakistan >> major cities
  - recent report from WHO listed Lahore, Rawalpindi, Karachi and Peshawar as among worlds top 30 polluted cities



The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

Data Source: World Health Organization  
Map Production: Information Evidence  
and Research (IER)  
World Health Organization

 World Health Organization

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# Global Model: Role of Academia

- **Academic Institutes >> Important stake holder**

Major role include:

- Basic science involved
  - Ozone hole / depletion
  - Air quality to Climate Change
  - Climate forcing
  - Ozone recovery
- Update about the recent development in respective areas





# Global Model: Role of Academia



- **Academic Institutes >> Important stake holder**

- Scientific basis for policy making
- updating about implication of policies through regular monitoring
- bridges the gap:
  - policymakers and NGOs
  - from local to global scales (international collaborations)
- Act as research wing for both NGOs and Govt. sectors
- Hub of young and enthusiastic professionals
- Fresh intake on yearly basis
- Capacity to work/address the issues
- Prepare/maintain database of atmospheric composition on longer time scales





# Pakistan's Scenario

## Problems:

- Lack of Atmospheric Science activities
- Lack of monitoring networks at all levels
- Stake holder are
  - Involved in individual efforts
  - Isolated from each other

## Effects:

- enormous societal issues relevant to air pollution
- To larger extents efforts are useless
- Targets are not achieved
- Policies are not up to date



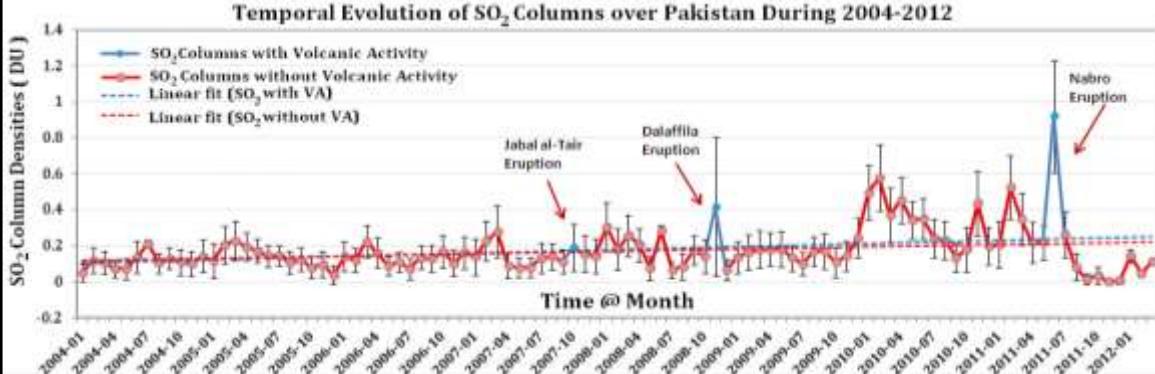
## Reasons:

- Missing link among all of them
- Lack of information sharing
- Findings remain by them mainly
  - Academia: research thesis, journal publication
  - NGOs: project reports
  - Govt. Agencies: policies remains without feedback



# Air Pollution related Issues in Pakistan

- Brick Kilns Emissions
- Industrial solid waste burning
- Transboundary air pollution
- Dust storms



# Pakistan's Scenario

- International Funding Agencies
- Funds >> hot issues
- Global issues
- GOs and NGOs

International  
Donors  
( UNEP,  
UNDP)

Government  
Organization  
(Ministries,  
EPA)

- No RnD facilities
- lack of will
- lack of capacity

- inadequate RnD
- lack of Funding
- isolation
- focused on MS/PhD research

Academia

NGOs

- No RnD facilities
- lack of will
- No agenda:  
subject to  
available funding



# Lahore Smog 2016







# What is current Scenario of global Ozone



Answer:

- Ozone layer is on recovery (1979-2013)
- Worldwide action to phase-out ODS



# What is current Scenario of Ozone over Pakistan



Answer:

- We did not have any information
- We did not have any continuous monitoring
- We did not have a proper database of atmospheric composition over Pakistan