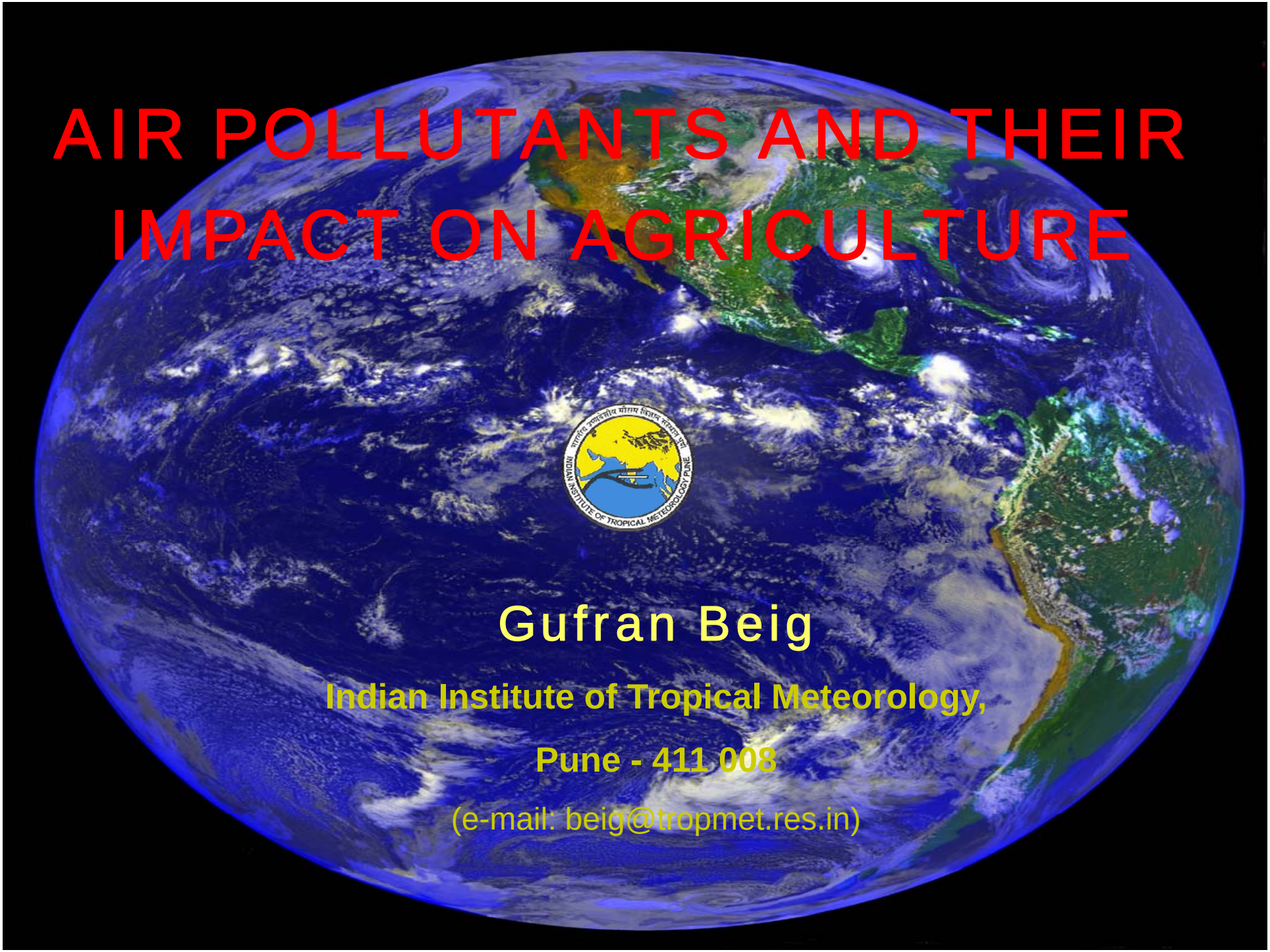
AIR POLLUTANTS AND THEIR IMPACT ON AGRICULTURE



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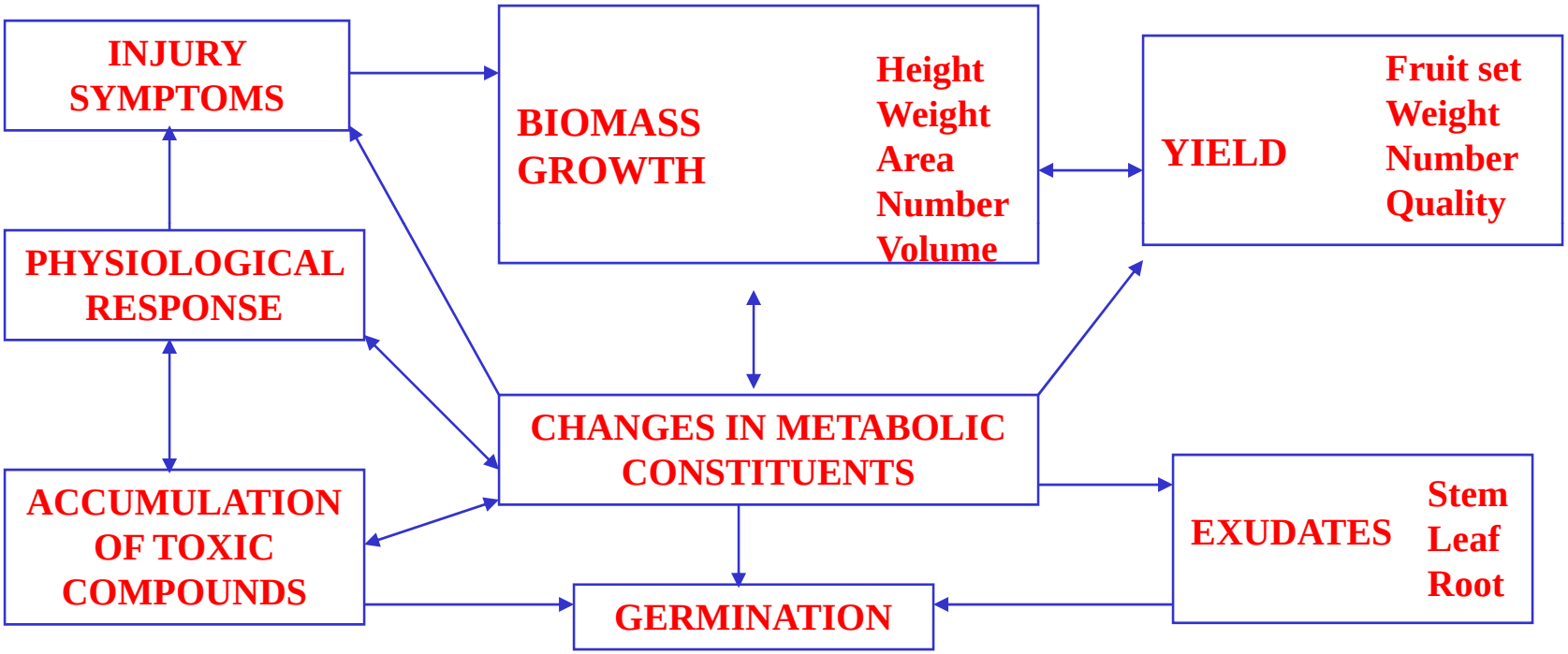
MEASURE OF EFFECTS
HOW THEY INTERRELATE?



AIR POLLUTION EFFECTS ON PLANTS
CONCEPTUAL INTERRELATIONSHIP

Ambient air pollution effects on crops in selected countries of Asia

Country	Pollutant	Crop	Yield loss	References
Japan (Kantoh)	O_3 (40-60 ppb)	Rice	0- 7%	Kobayashi (1999)
China (7 provinces) (south west)	SO_2 and acid rain	Vegetables	7.8 %	Feng *et al.*(1999)
		Wheat	5.41 %	
		Soybean	5.73 %	
		Cotton	4.99 %	
	O_3 (ppb) (night 15 mid day max 75)	Green pepper	Sensitive	Zheng *et al.* (1998)
		pepper	"	
		Rice	"	
		Cauliflower	"	
		Aubergine		
Taiwan (S) Taipei Basin	O_3	Spinach	"	Sun (1993)
		Sweat potato	"	
China, Japan and South Korea	O_3 50- 55 ppb (1990)	Corn		
		Rice	1- 9 %	Wang and Mauzerall, 2004)*
		Wheat		
		Soybean	23- 27 %	
	60- 65 ppb (2020)	Corn		
		Rice	2- 16 %	"
		Wheat		
		Soybean	28- 35 %	

*** MOZART- 3 O_3 exposure and yield relationship**

Photosynthesis rate (μ mol $CO_2m^{-1}s^{-1}$) in selected plants grown (Mean ± 1SE)

Site	Mustard	Wheat	Pea	Mung
Reference area	13.75 [a] ± 0.3	20.7 [a] ± 0.31	11.51 [a] ± 0.41	10.03 [a] ± 0.28
Industrial and urban area	7.24 [c] ± 0.35	13.9 [c] ± 0.67	4.56 [d] ± 0.64	5.26 [d] ± 0.26
Periurban area	11.65 [b] ± 0.34	15.2 [c] ± 0.42	5.68 [c] ± 0.38	8.11 [b] ± 0.14
Urban area	10.21 [b] ± 0.49	14.2 [c] ± 0.50	4.96 [d] ± 0.19	7.29 [c] ± 0.32
Rural area	13.55 [a] ± 0.26	18.0 [b] ± 0.52	7.62 [b] ± 0.09	8.34 [b] ± 0.11

Within each plants values not followed by the same letter are significantly different at $p < 0.05$

Yield (g plant$^{-1)}$ in selected plants grown at different sites
(Mean ± 1SE)

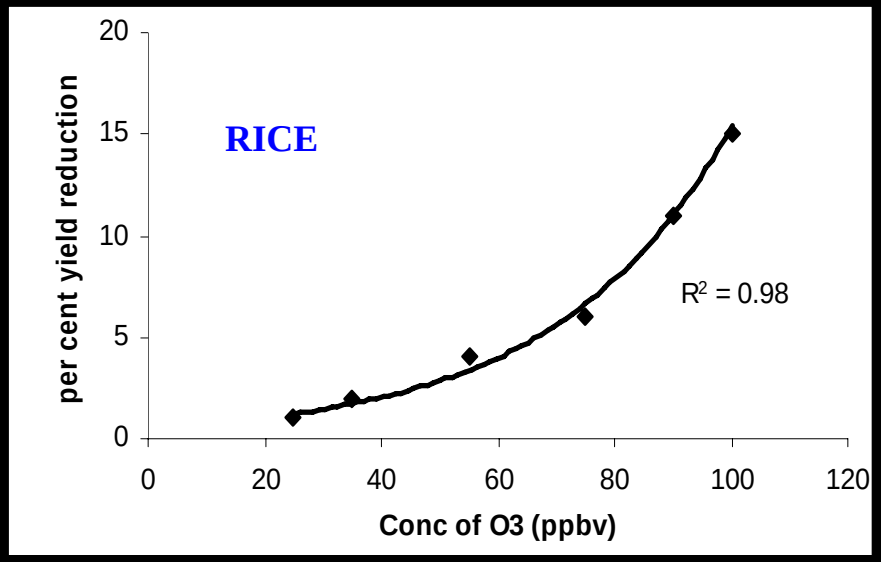
Site	Mustard	Wheat	Pea	Mung
Reference area	6.03 ^{a} ± 0.32	7.48 ^{a} ± 0.81	9.40 ^{a} ± 0.42	6.44 ^{a} ± 0.61
Industrial and urban area	4.51^{b} ± 0.21	5.57 ^{c} ± 0.39	5.85 ^{d} ± 0.35	1.71 ^{d} ± 0.22
Periurban area	4.97 ^{b} ± 0.32	6.24 ^{c} ± 0.55	6.63 ^{c} ± 0.49	3.78 ^{c} ± 0.41
Urban area	4.77 ^{b} ± 0.24	6.15 ^{c} ± 0.49	6.37 ^{c} ± 0.33	3.25 ^{c} ± 0.32
Rural area	5.67 ^{a} ± 0.41	6.44 ^{b} ± 0.62	7.10 ^{b} ± 0.49	4.23 ^{b} ± 0.45

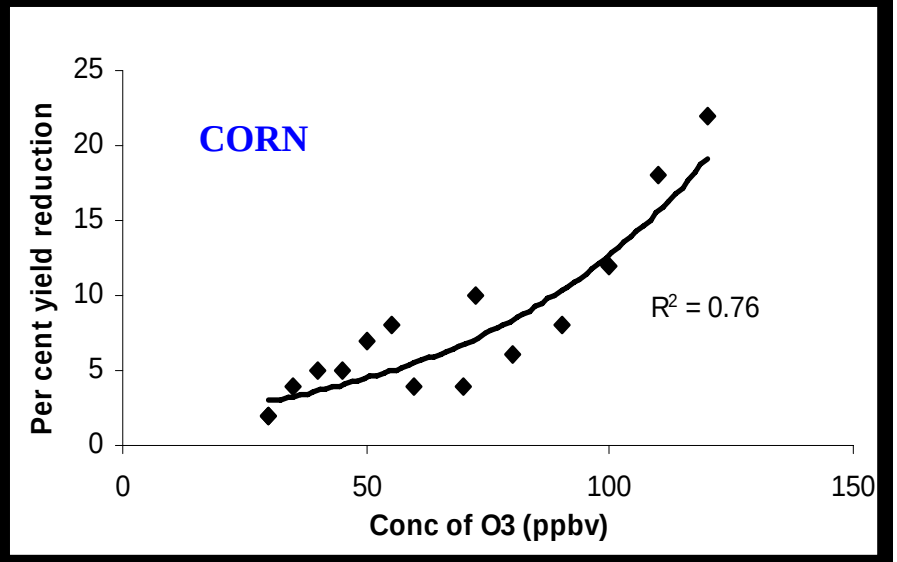
Within each plant values not followed by the same letter are significantly different at $p < 0.05$

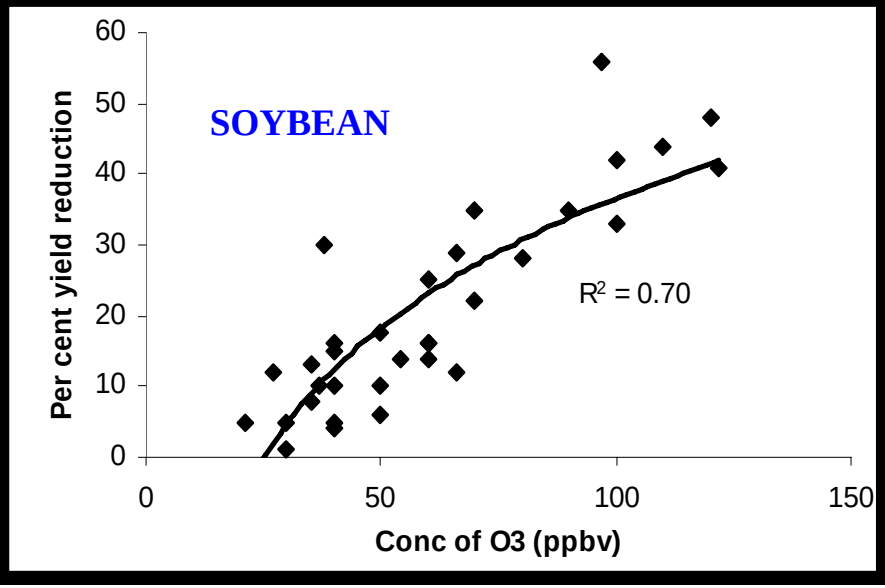
PRODUCTION, ECONOMIC VALUE AND % LOSS IN ECONOMIC VALUE OF YIELD AT DIFFERENT SITES

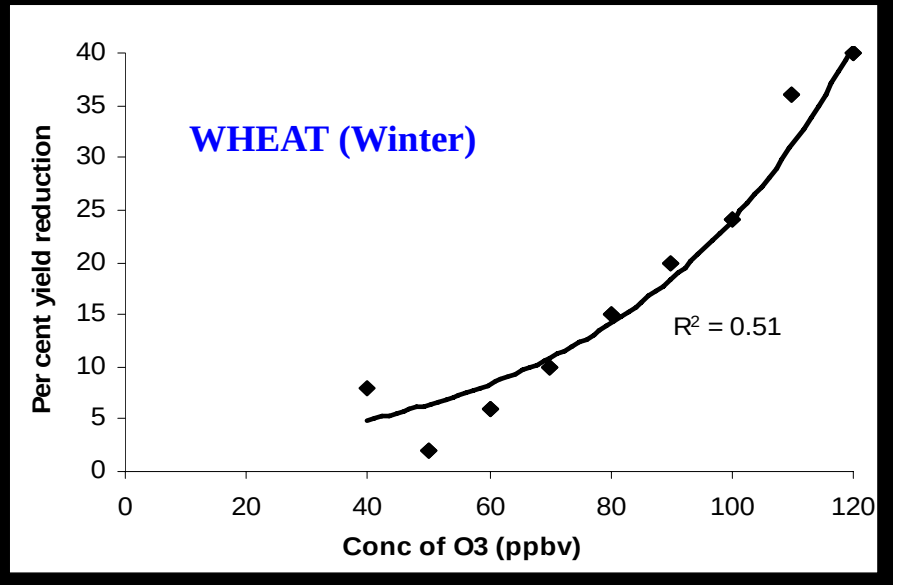
Sites/Plants	Production ($q\ ha^{-1}$)	Economic value (Rs.)	%loss
Wheat			
Reference area	29.50	17995.0	
Rural area	24.25	14792.5	17.80
Periurban area	22.15	13511.5	24.91
Urban area	20.60	12566.0	30.17
Industrial and Urban area	20.50	12505.0	30.50
Mung			
Reference area	10.11	13244.0	
Rural area	7.20	9432.0	28.78
Periurban area	6.66	8724.6	34.12
Urban area	5.85	7663.0	42.14
Industrial and Urban area	6.00	7860.0	40.65
Pea			
Reference area	23.50	30550.0	
Rural area	17.75	23075.0	24.47
Periurban area	16.57	21541.0	29.49
Urban area	15.92	20702.5	32.23
Industrial and Urban area	14.62	19012.5	37.76

Impact of Ozone Exposure to Crop Yield (Yield Reduction)









Agriculture Altering Atmosphere

	1990		2020
	CH_4	N_2O	CH_4
Rice	4 Tg		5Tg
Enteric Fermentation	7.5 Tg		9 Tg
Manure Management	0.9 Tg		1.1Tg
Agricultural Soil		240 Gg	
Agriculture residue burning	0.1Tg		
Total	12.6 Tg		16.2 Tg (+30%)

CO2 Equivalent:

Energy 570 Tg/yr
Agriculture 340 Tg/yr
Agriculture/Energy = 0.6

Threshold exceedances and cumulative ozone exposure indices at Pune

Objectives:

- Assessing and evaluating air quality at the tropical suburban site Pune.
- To determine where ozone concentrations in excess of current limit values are exceeded significantly and whether the objectives for the protection of vegetation can be met.

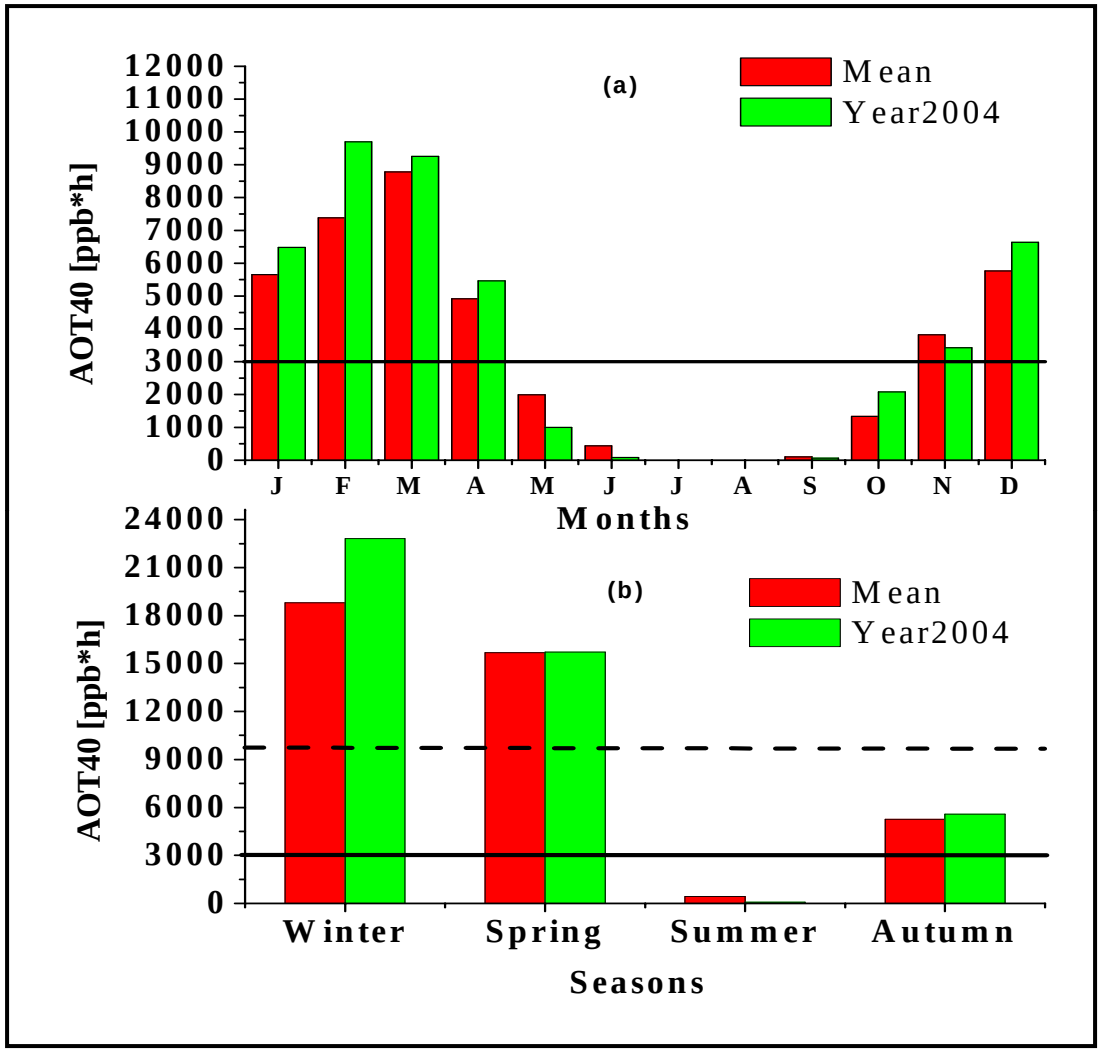
What is AOT40

AOT 40 (Accumulation exposure over threshold of 40 ppb) is an exposure-plant response

$$AOT\ 40 = \sum_{i=1}^{n} ([O3] - 40)i \qquad \text{for } [O3] > 40 \text{ ppb}$$

- An AOT 40 value of 10,000 ppb h for daylight hours (radiation > 50 W m-2) over a 6 month period has been established as a critical level for the protection of forests.

- While, for the protection of agricultural crops of 5% loss in yield, an AOT 40 valve of 3000 ppb h for daylight hours over 3 months growing season has been established as the critical level (WHO, 1996).



AOT40 values for the mean period (2003-2006) and for the year 2004 during various months (a) and seasons (b) at monitoring site, Pune. The target and threshold values relating to vegetation protection as established by EU (dashed) and WHO (solid).

Results

- The AOT40 (3000 ppb*h) target and WHO threshold for the protection of vegetation is a factor of 1.7 during pre-monsoon, 6.5 during winter, and 5.3 during pre-monsoon when compared to the AOT40 critical limit for the protection of vegetation.
- The human health protection threshold is exceeded for up to an average of 84 (28%) days per year.
- Threshold for information to the public is surpassed up to an average of 32 (11%) days per year.

Conclusion:

The current ozone concentrations at the tropical Indian suburban site Pune are high enough to exceed 'Critical Levels' for the protection of human health, vegetation and forest.

(Beig et al., **GRL**, 2008)

Model Experiment

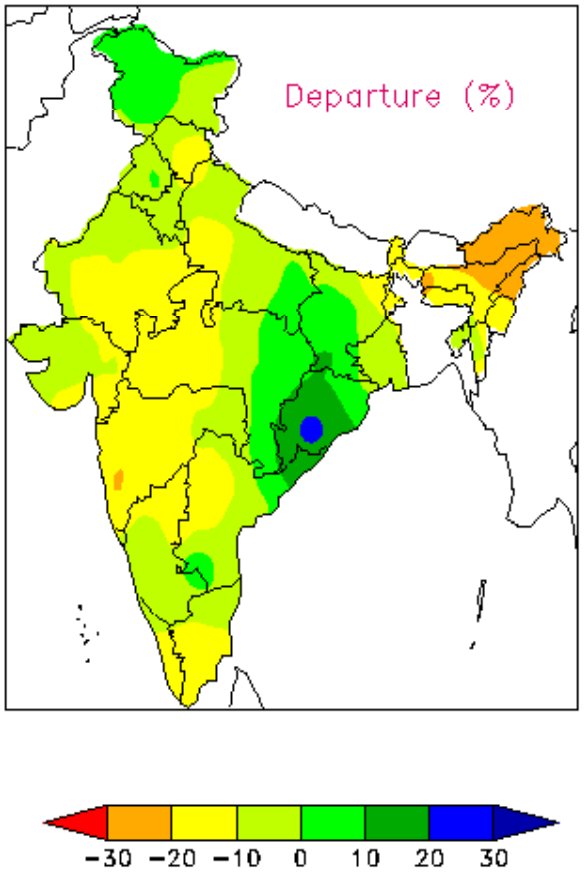
Ozone v/s Wheat Crop Yield

- **Ozone from Chemistry Transport model –Pune**
- **Crop yield: INFOCROP model**

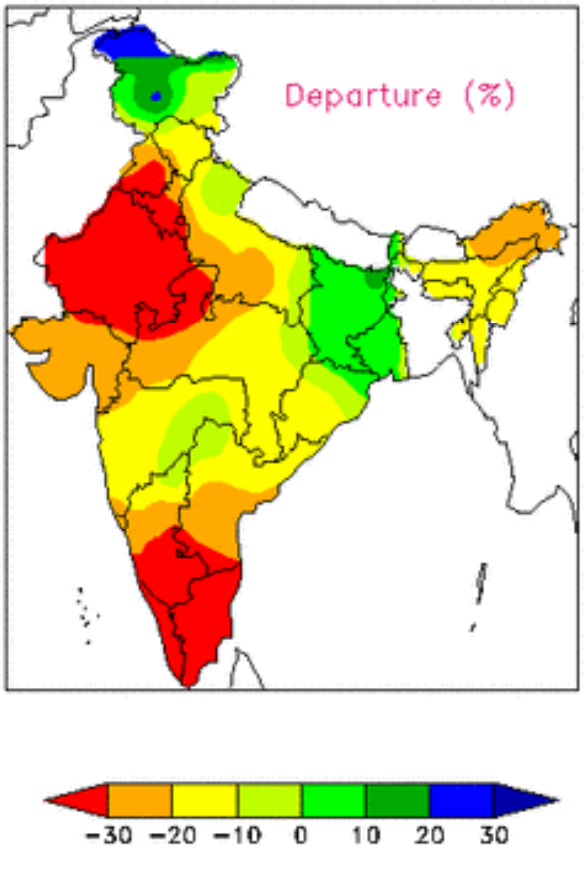
All India Monsoon Rainfall

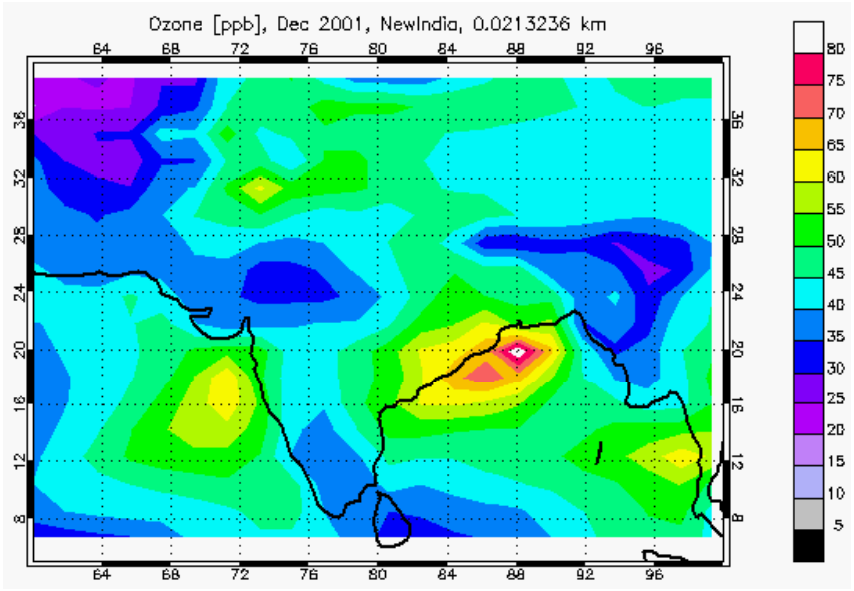
Departure from Normal
(Cumulative: June-September)

2001 (June-Sep)-Normal



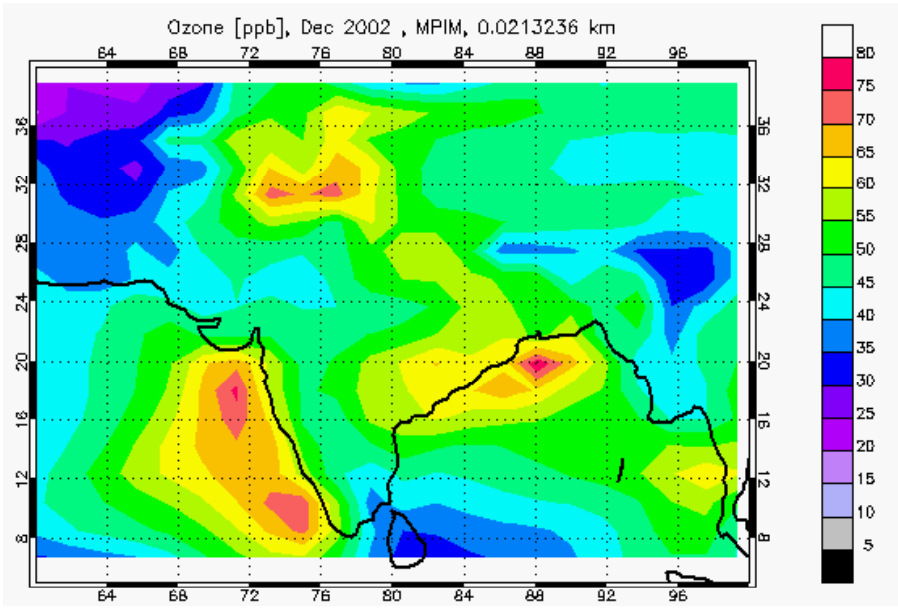
2002(June-Sep)-Deficit





2001:

Normal Monsoon

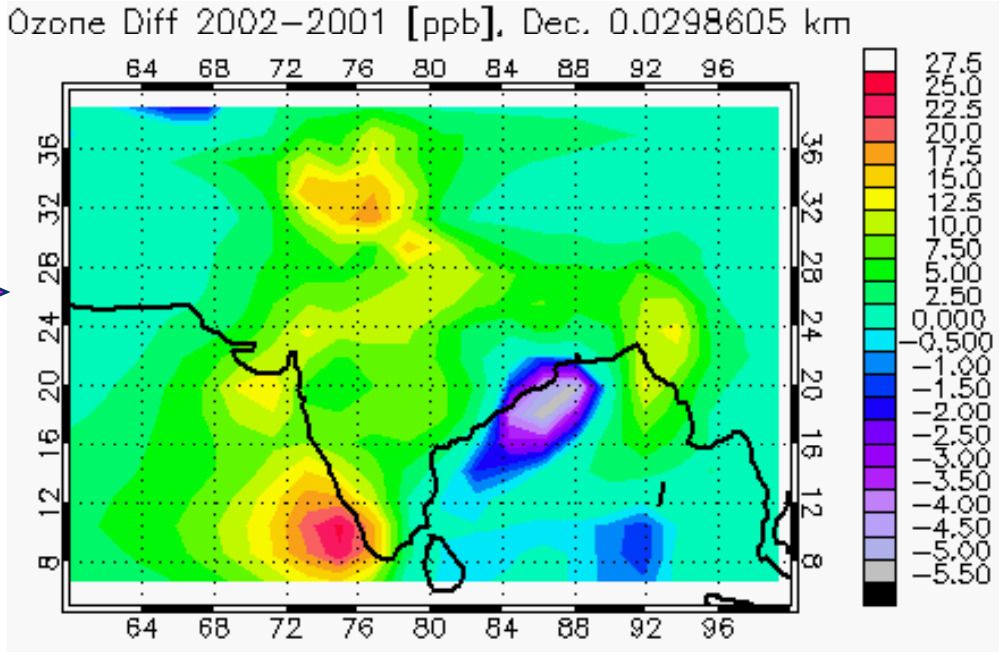


2002:

Deficit rainfall

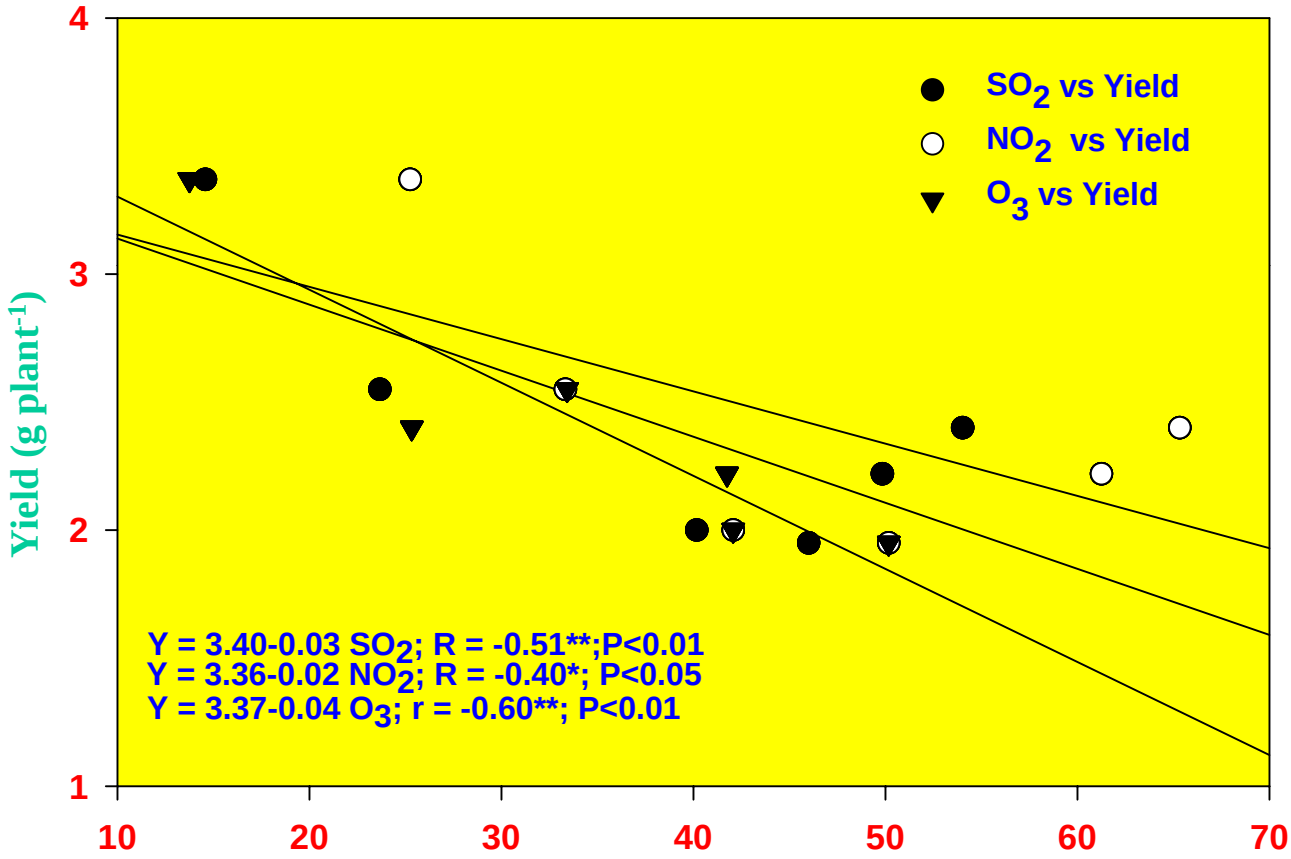
OZONE

Ozone Increase (ppb):
2002 – 2001
Effect of Deficit Rainfal
l



OPEN TOP CHAMBER (OTC)

CORRELATION COEFFICIENTS AND REGRESSION EQUATIONS BETWEEN INDIVIDUAL POLLUTANTS AND YIELD OF MUNG PLANTS



Mean pollutant concentration (ppb)

Concentration of pollutants (ppb) in filtered (F) and non filtered (NF) chambers at a rural site during winter

Months	SO_2*		NO_2*		O_3**	
	NF	F	NF	F	NF	F
December	40.3	4.5	47.5	5.5	33.9	3.8
January	39.3	4.6	49.5	6.9	29.2	3.2
February	36.5	4.7	43.2	6.9	38.9	3.7
March	33.6	3.8	35.7	5.0	43.7	5.1

* 12 h average (7.00- 19.00 h)
** 8 h average (9.00- 16.00 h)

Selected parameters of carrot plants grown in filtered and non- filtered chambers at a rural site

Parameters	Non- filtered	Filtered
Yield (g plant^{-1})	1.52	2.78 (+82.8)
Nitrogen (mg g^{-1})	1.09	0.95 (- 12.8)
Phosphorus (mg g^{-1})	0.09	0.21 (+133.3)
Sulphates (mg g^{-1})	0.73	0.17 (-76.7)
Energy (k cal g^{-1})	39	51 (+30.7)
Total carotene (µg g^{-1})	71.20	89.30 (+25.42)
Beta Carotene (µg g^{-1})	52.36	64.79 (+23.73)
Thiamine (µg g^{-1})	0.1	0.4 (+300)

Values within parentheses show percent change from non filtered plants

Pollutant concentrations (ppb) and associated leaf injury indices obtained using tobacco Bel W3 plants

Site	Pollutant concentration (ppb)		Leaf injury (%)
	NO_2*	O_3**	
Urban area	58	34	8
Periurban area	27	52	20
Rural area	10	66	31

* Weekly mean

** 6 h mean concentration (10.00- 16.00 h) once $week^{-1}$

Conclusion

- **Air pollution negatively affects the yield and quality of crops**
- **Sensitivity of crops differs among species and cultivars**
- **Meteorological conditions during crop growing season affect the degree of negative effects on growth and yield of crops**
- **Ozone poses the greatest threat to agriculture**
- **Plants also differ in their response to different air pollutant combinations**

Recommendations

- **Expand air pollutant monitoring networks into agricultural and forested areas**
- **Need to establish yield response relationships applicable to different environmental conditions**
- **Develop bioindicator protocols for impact evaluation**
- **Explore high and low risk zones of air pollution impact in different regions**
- **Establish realistic air quality guidelines for protecting vegetation including crops**

Source: W. Eugene Smith *The Family of Man Exhibition*

Thank You

There is no
time to lose.