Use of AIRS Data in Understanding Land-Ocean-Atmosphere Coupling

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Contributions from

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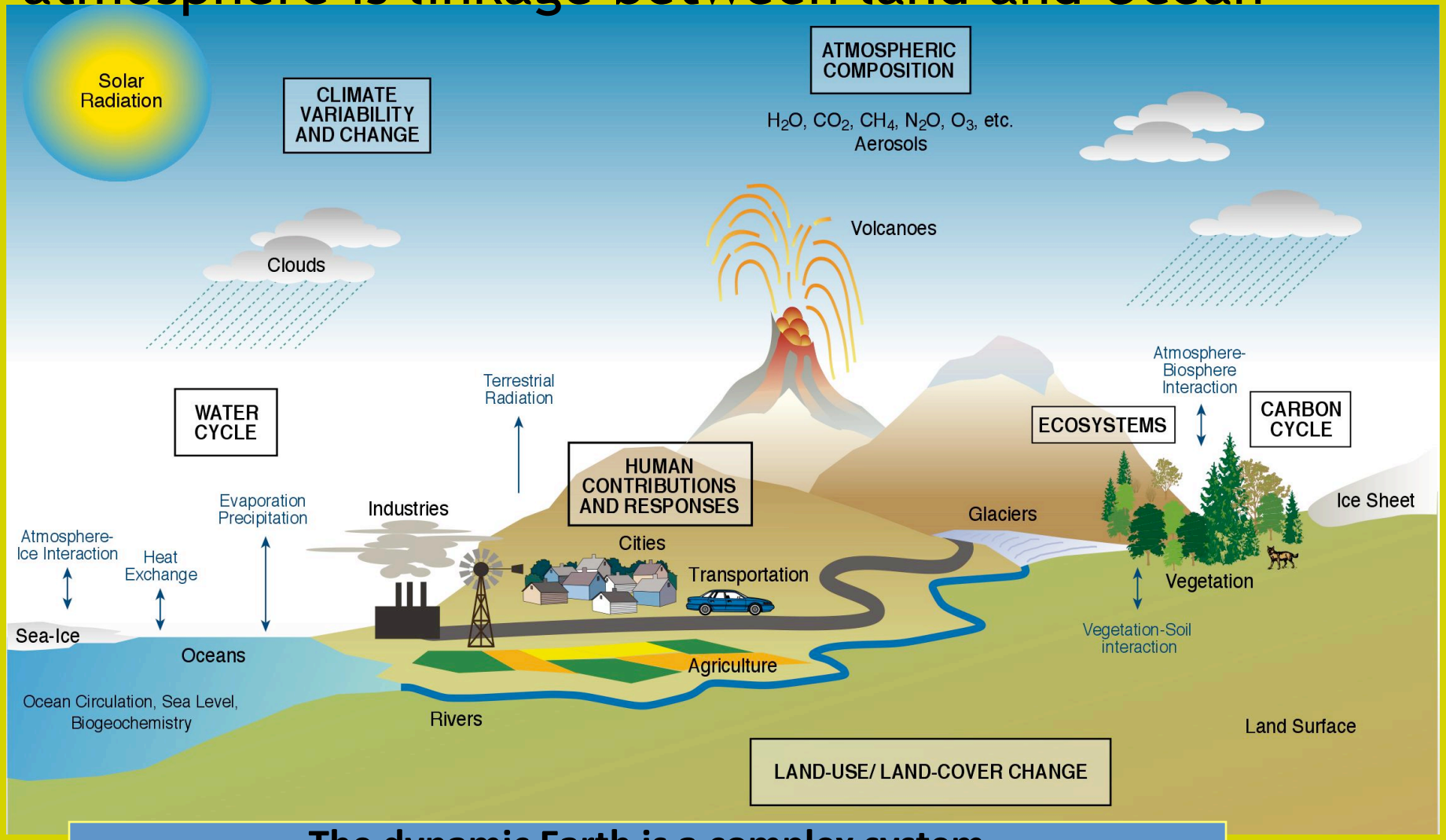
- **Ritesh Gautam**
- **Partha S. Bhattacharjee**
- **Rachita Singh**
- **Menas Kafatos**

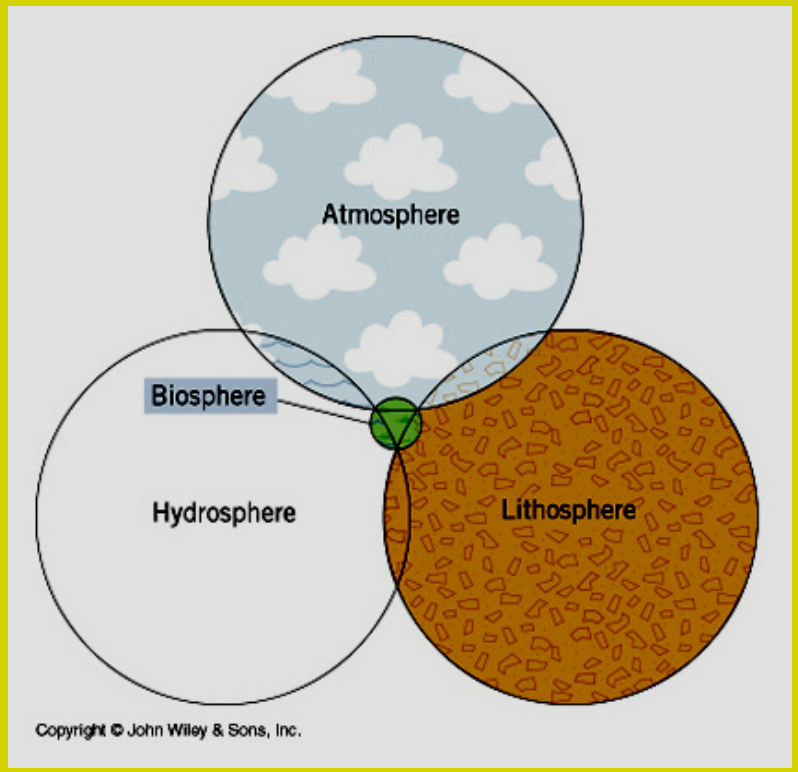
- Why Coupling is important!
- Important of AIRS data – few examples
- Activities Related to Validation of AIRS Data

Earth covers 30% Land and 70% Ocean

atmosphere is linkage between land and Ocean



The dynamic Earth is a complex system of systems.


Atmosphere
Biosphere
Hydrosphere
Lithosphere
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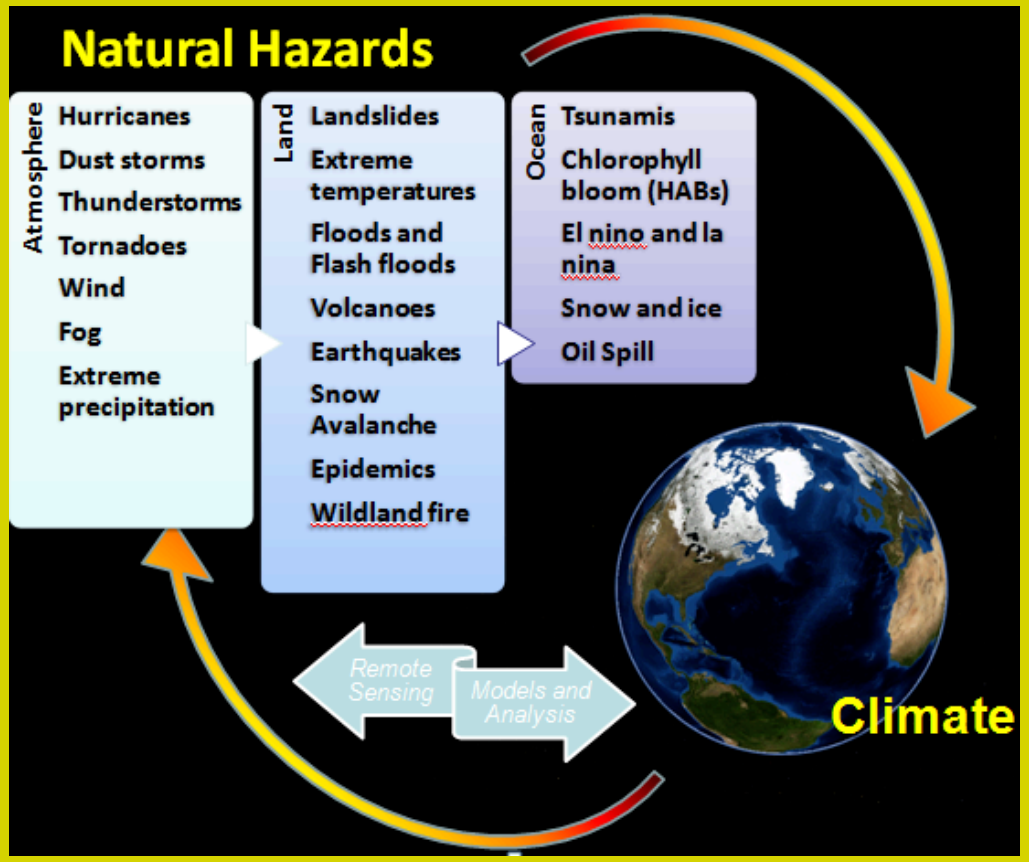
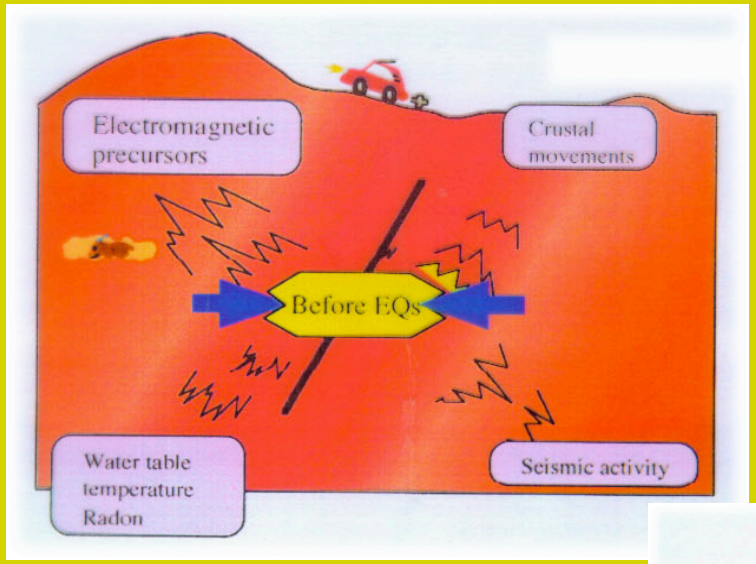

Natural Hazards
Atmosphere
Hurricanes
Dust storms
Thunderstorms
Tornadoes
Wind
Fog
Extreme precipitation
Land
Landslides
Extreme temperatures
Floods and Flash floods
Volcanoes
Earthquakes
Snow Avalanche
Epidemics
Wildland fire
Ocean
Tsunamis
Chlorophyll bloom (HABs)
El nino and la nina
Snow and ice
Oil Spill
Remote Sensing
Models and Analysis
Climate

Mount Etna

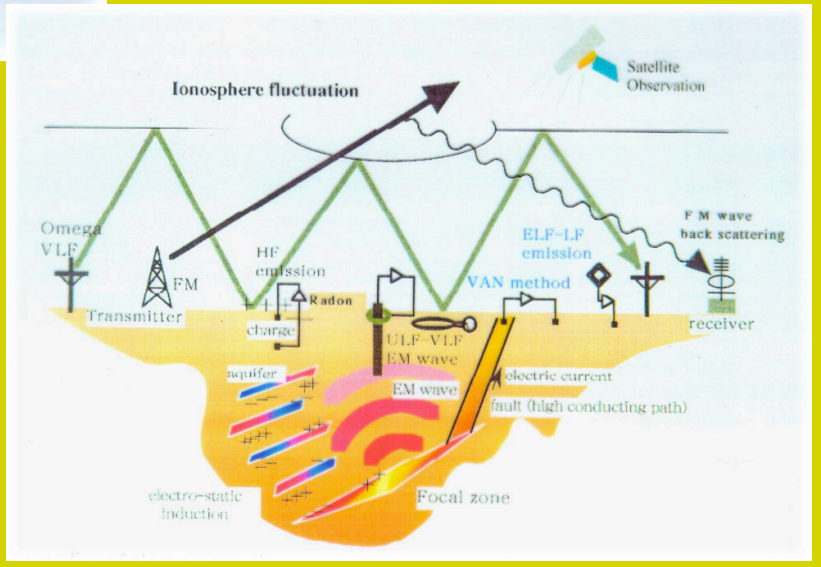
Stromboli

Arenal Volcano, Costa Rica

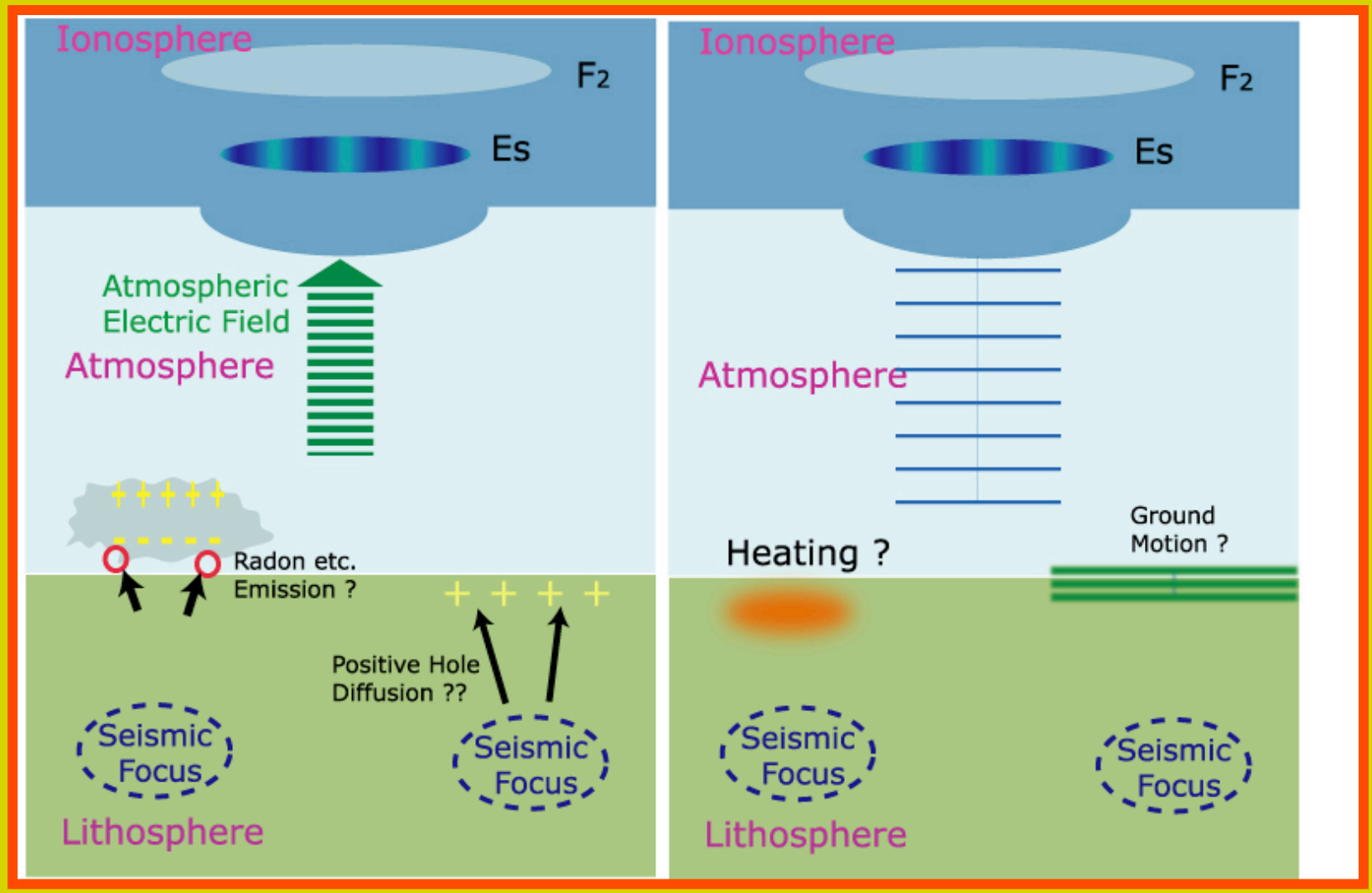


Possible earthquake precursors

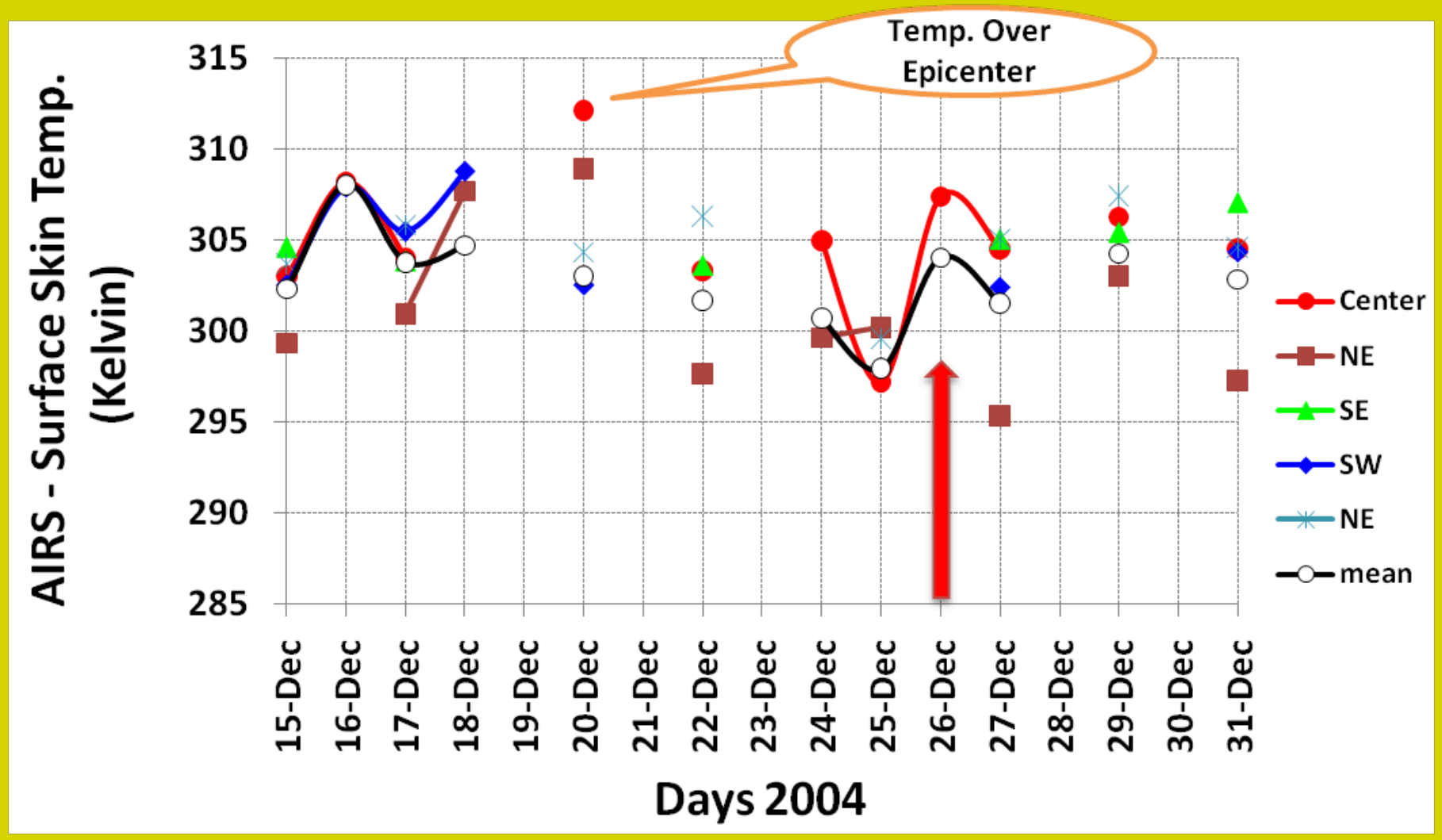
Current studies of electromagnetic methods for short-term EQ prediction.

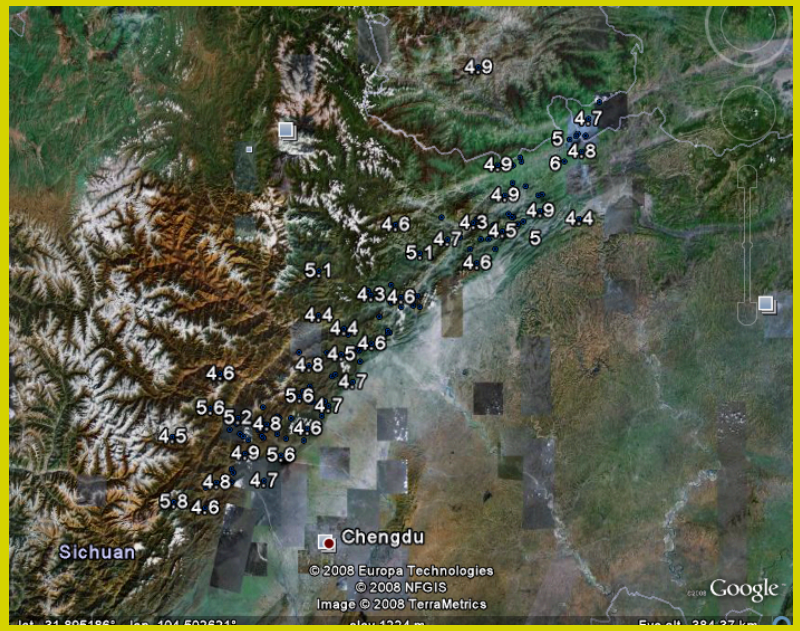


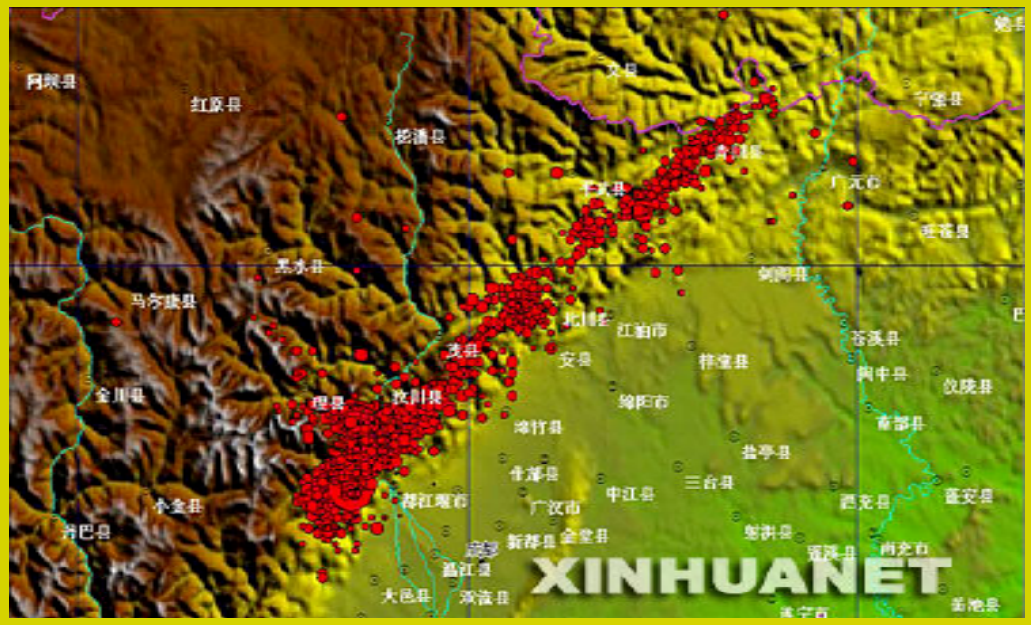
Lithosphere-Atmosphere-Ionosphere (LAI) Coupling



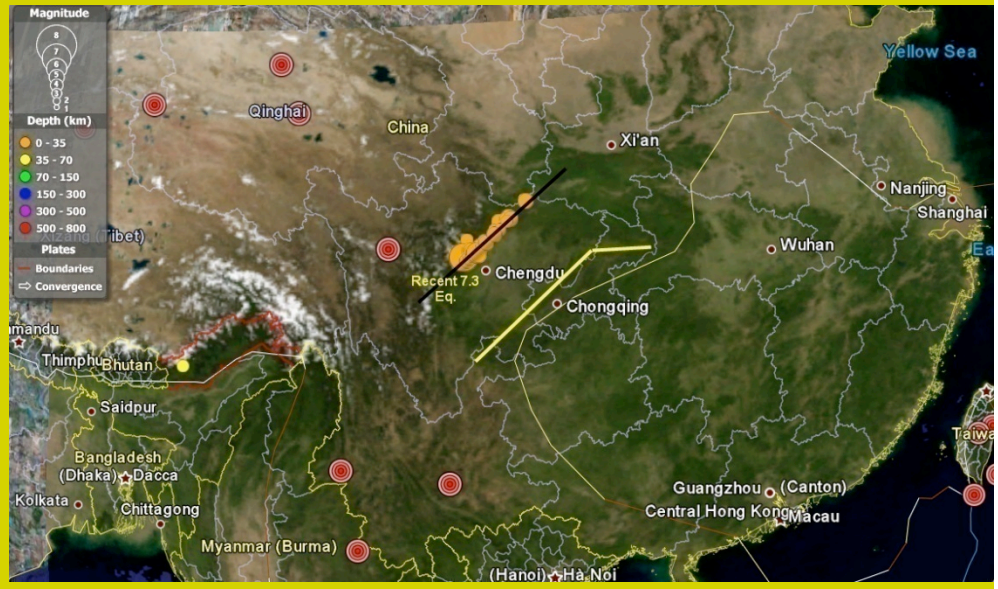
Kamogawa[2006, GRL]

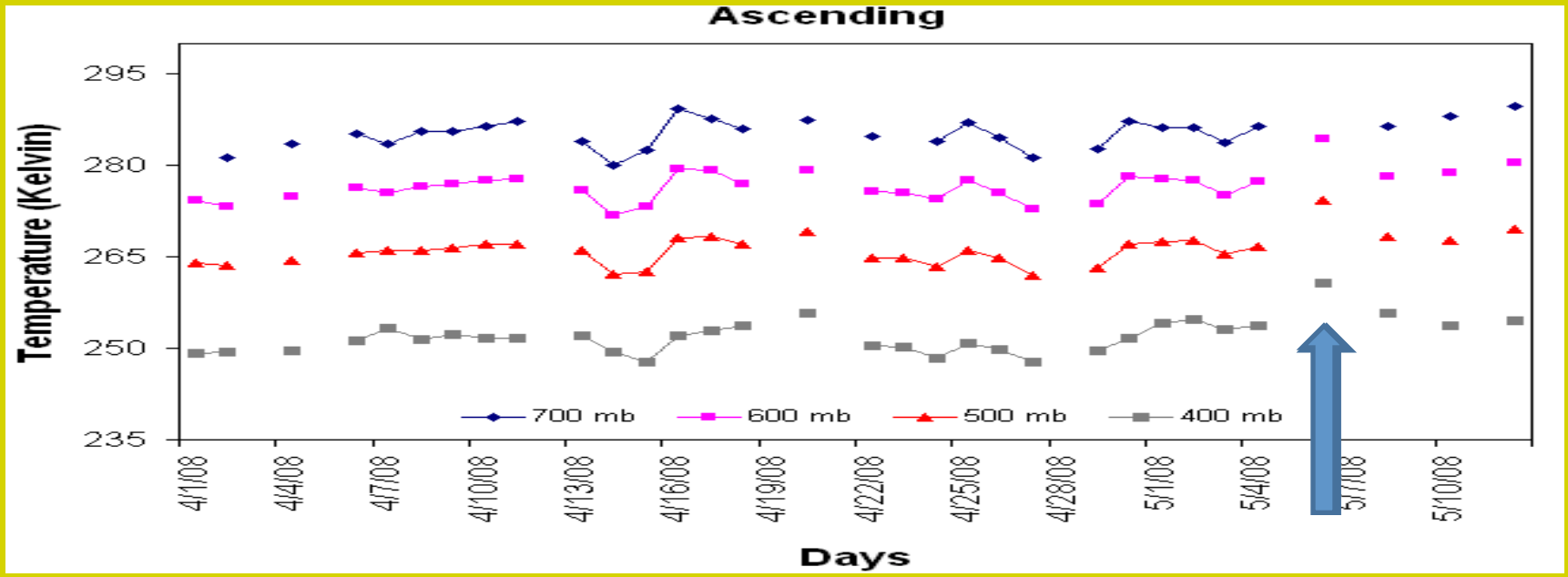

AIRS - Surface Skin Temp. (Kelvin)
315
310
305
300
295
290
285
Temp. Over Epicenter
15-Dec
16-Dec
17-Dec
18-Dec
19-Dec
20-Dec
21-Dec
22-Dec
23-Dec
24-Dec
25-Dec
26-Dec
27-Dec
28-Dec
29-Dec
30-Dec
31-Dec
Days 2004
Center
NE
SE
SW
NE
mean


Chengdu
Sichuan
© 2008 Europa Technologies
© 2008 NFGIS
Image © 2008 TerraMetrics
Google


XINHUANET

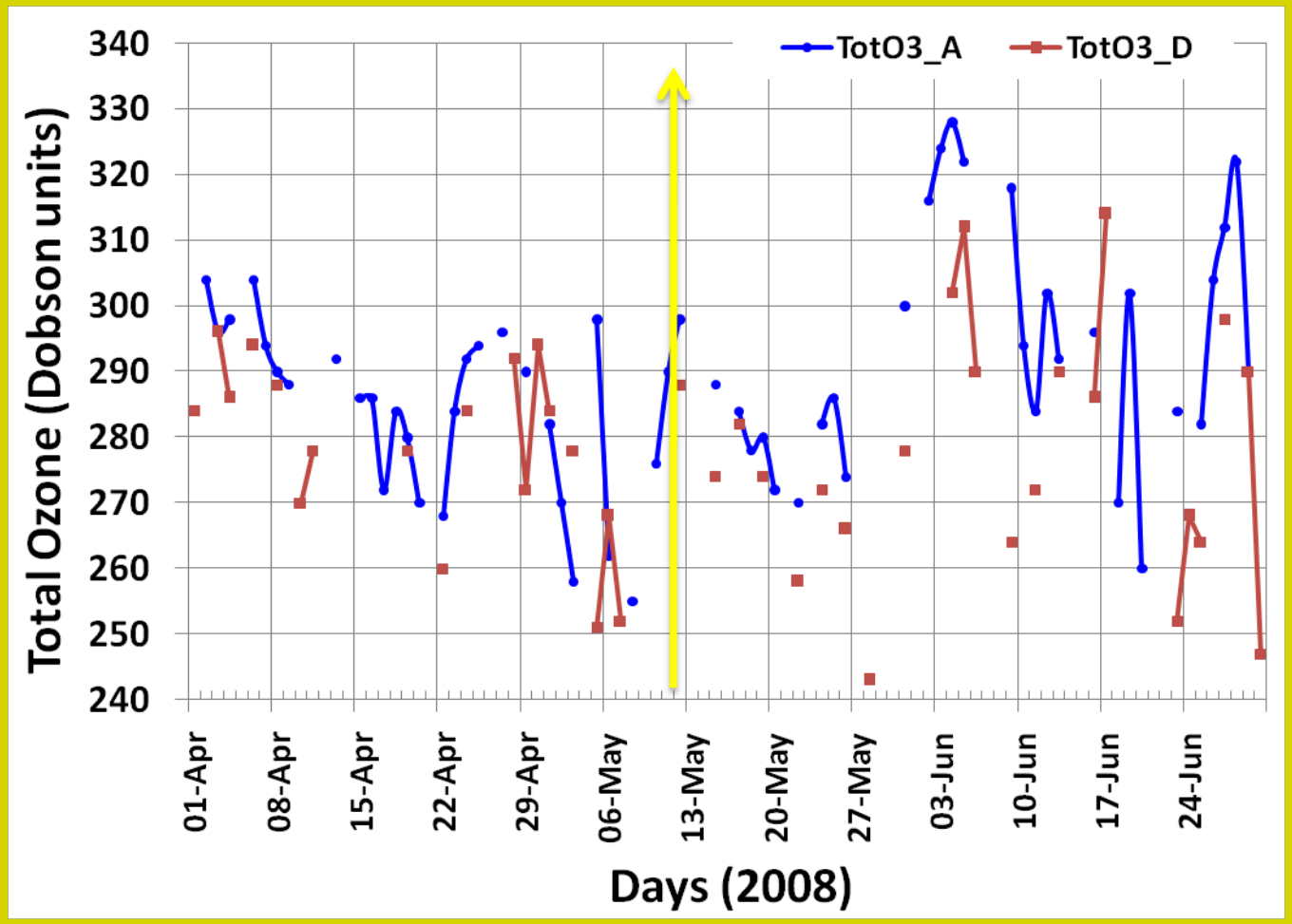

Legend
Epicenter
Most severely damaged counties
County capital
County boundary


Magnitude
Depth (km)
0 - 35
35 - 70
70 - 150
150 - 300
300 - 500
500 - 800
Plates
Boundaries
Convergence
Yellow Sea
Qinghai
China
Xi'an
Nanjing
Shanghai
Wuhan
Chengdu
Recent 7.3 Eq.
Chongqing
Thimphu
Bhutan
Saidpur
Bangladesh
(Dhaka)
Dacca
Kolkata
Chittagong
Myanmar (Burma)
Guangzhou
(Canton)
Central Hong Kong
Macau
(Hanoi)
Ha Noi

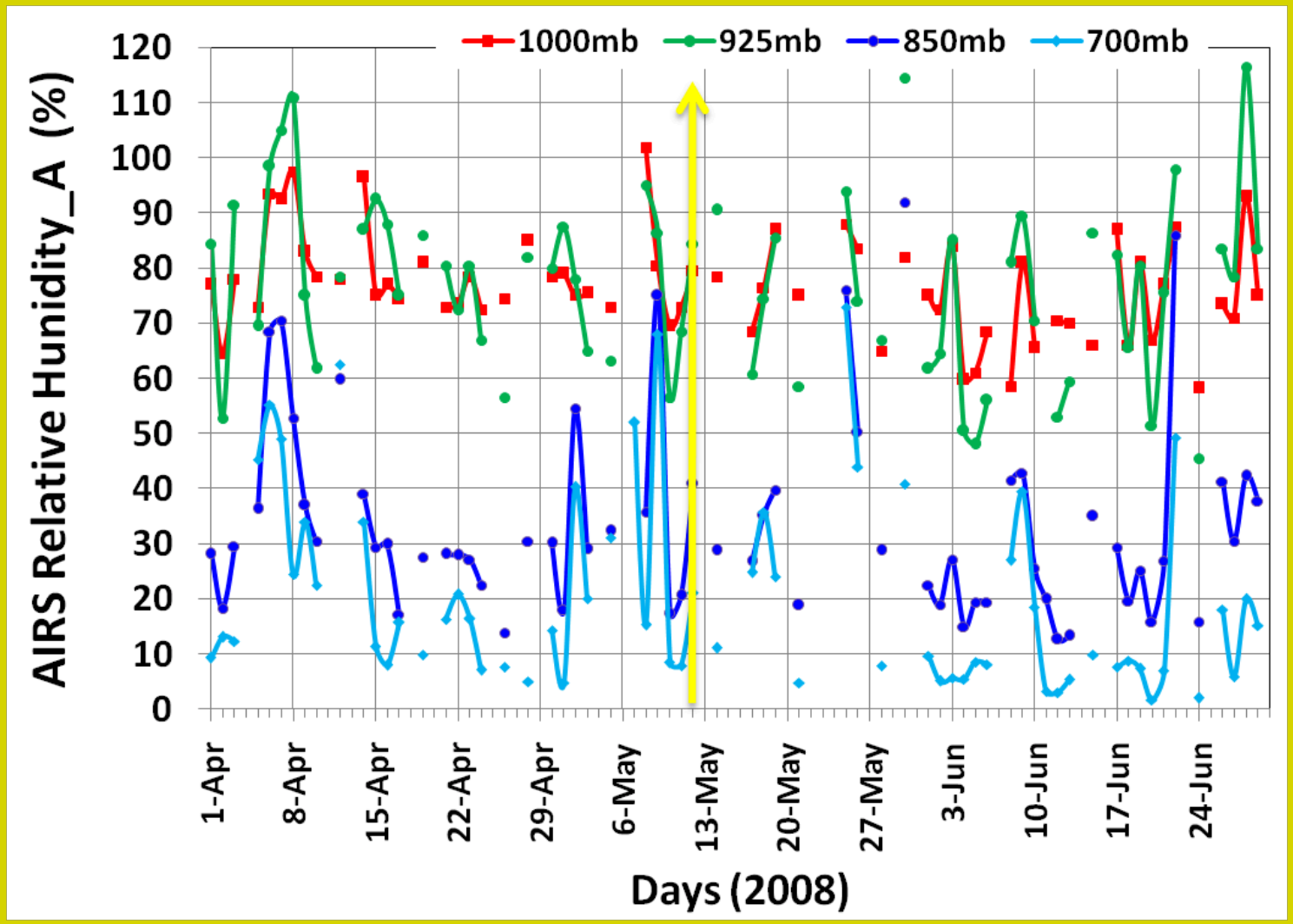

Ascending
Temperature (Kelvin)
295
280
265
250
235
700 mb
600 mb
500 mb
400 mb
4/1/08
4/4/08
4/7/08
4/10/08
4/13/08
4/16/08
4/19/08
4/22/08
4/25/08
4/28/08
5/1/08
5/4/08
5/7/08
5/10/08
Days

AIRS
A-Ascending mode (day time)
D-Descending mode (night time)

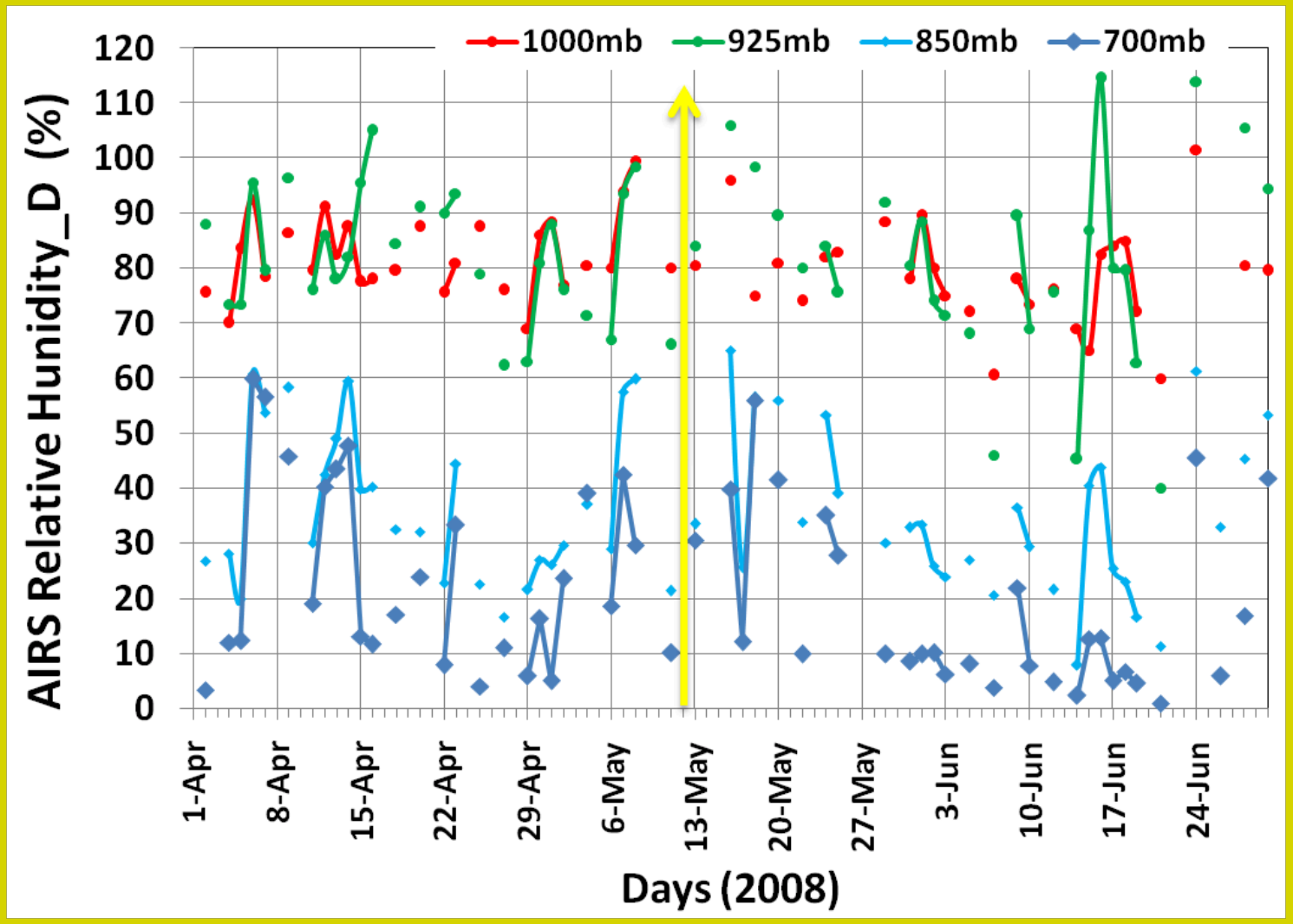
1BY1 degree



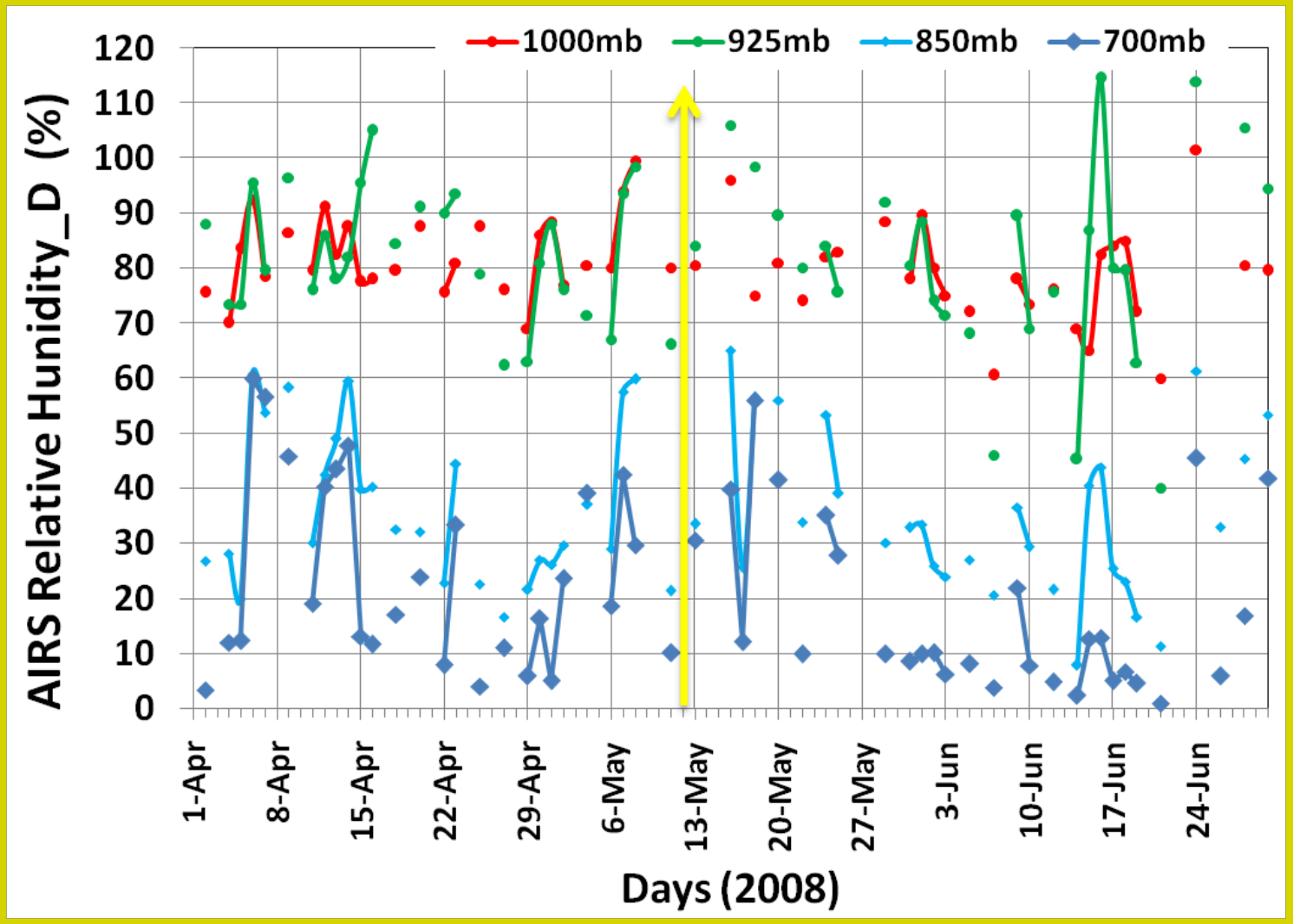
AIRS RH (ascending mode)

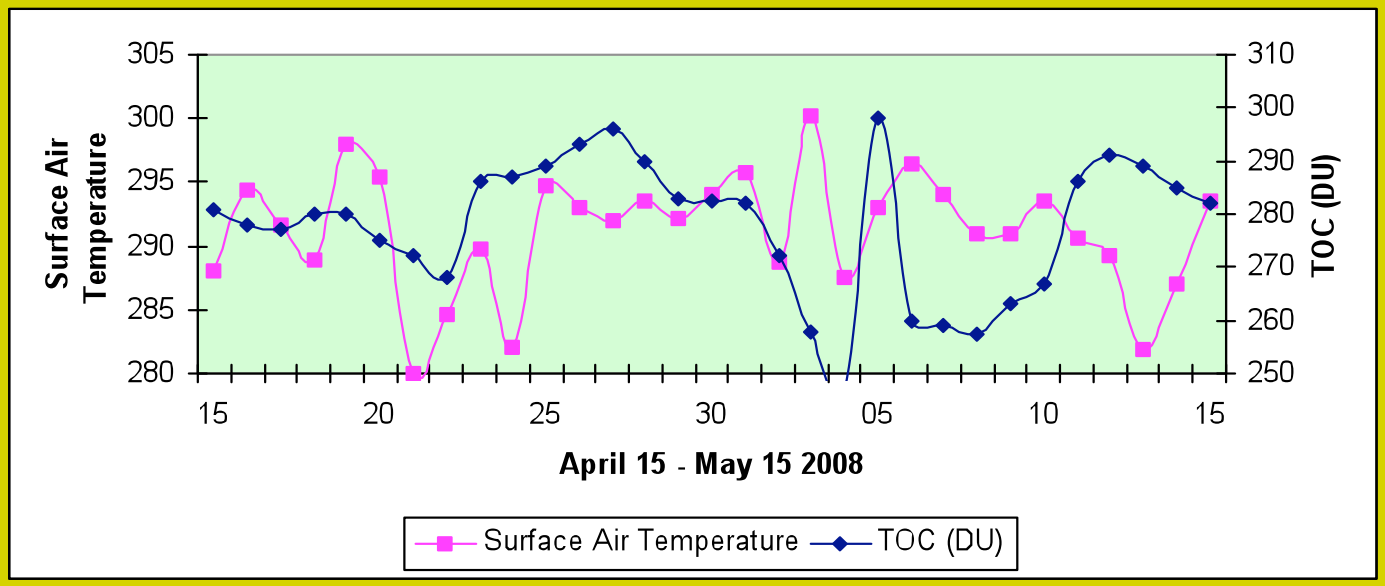


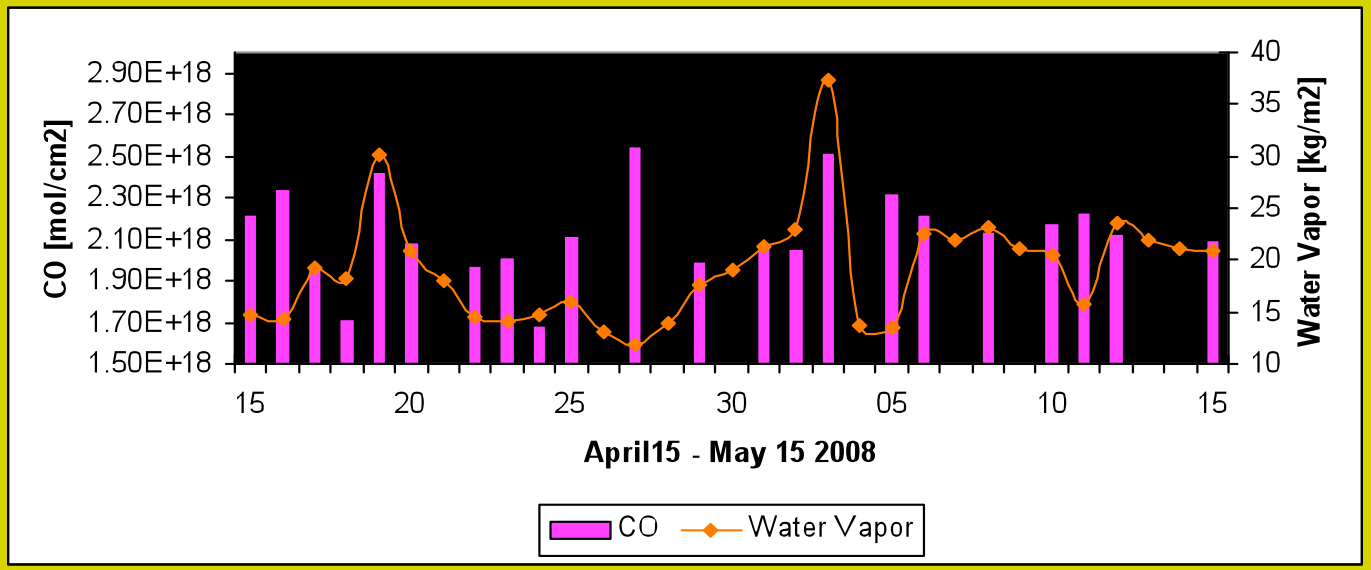
AIRS RH (Descending mode)



AIRS RH (Descending mode)




Surface Air Temperature
TOC (DU)
305
300
295
290
285
280
310
300
290
280
270
260
250
15
20
25
30
05
10
15
April 15 - May 15 2008
Surface Air Temperature
TOC (DU)


CO [mol/cm2]
Water Vapor [kg/m2]
2.90E+18
2.70E+18
2.50E+18
2.30E+18
2.10E+18
1.90E+18
1.70E+18
1.50E+18
40
35
30
25
20
15
10
15
20
25
30
05
10
15
April15 - May 15 2008
CO
Water Vapor

Ist stage - Sometime, due to EQ, hydrological regime changes, not always though. Such change give rise to oozing of greenhouse gases (CO2, CO), Helium and radon emission, this enhances skin temperature of the earth (Thermal temperature).

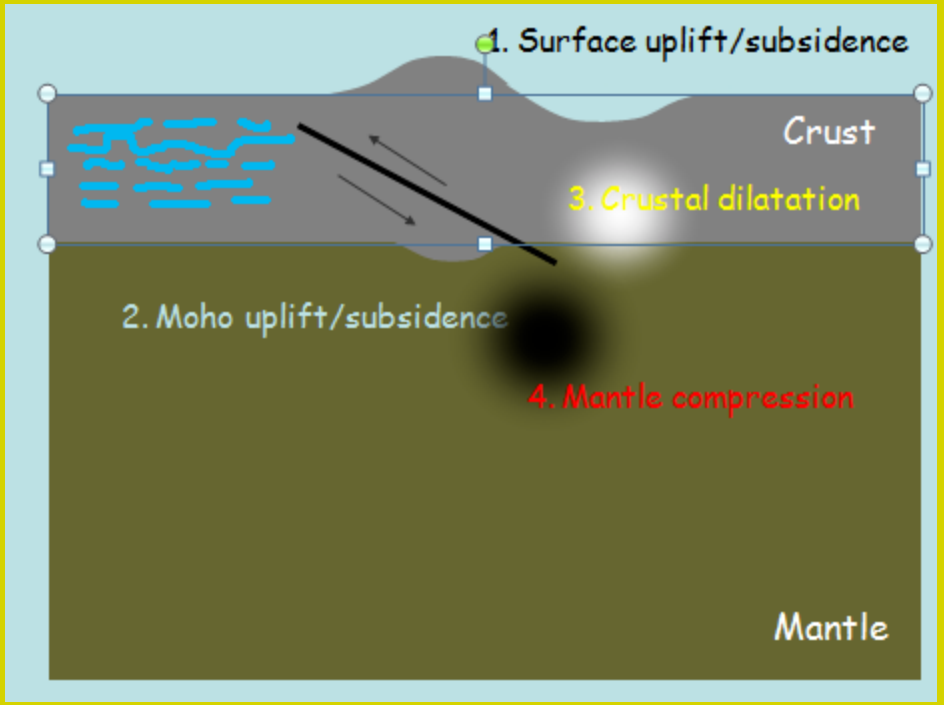
IInd Stage – Latent Heat Flux changes, One can find change in Gravity wave and also change in Relative Humidity, Air Temperature and other meteorological parameters.

IIIrd Stage – One can find changes in TEC and Ionospheric perturbations

As a result one can find EQ precursors.

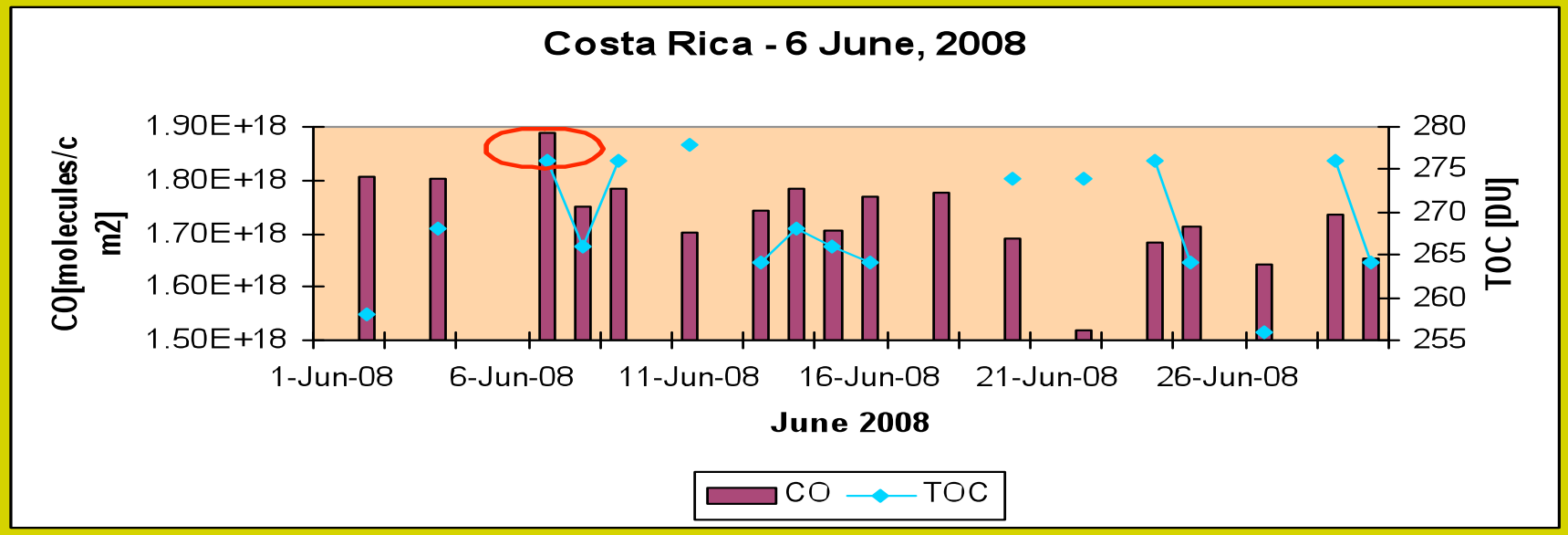
Or One can not find any changes as a Result EQ Precursory signals one may not find.

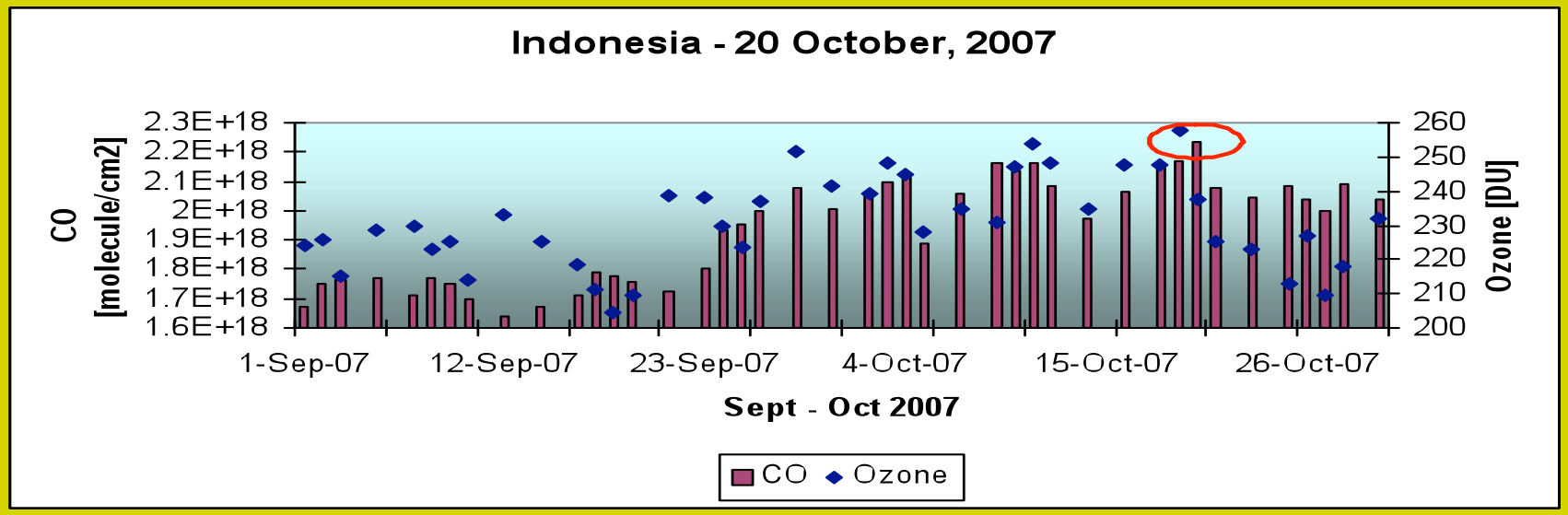
Good example - California

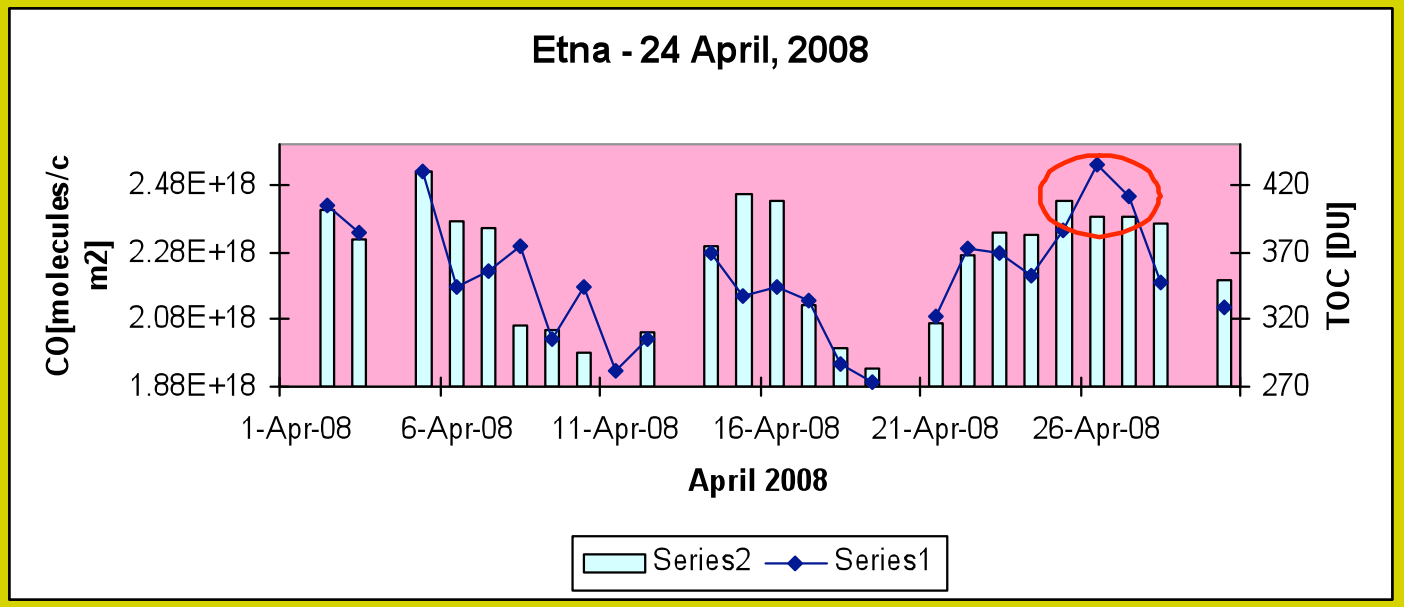


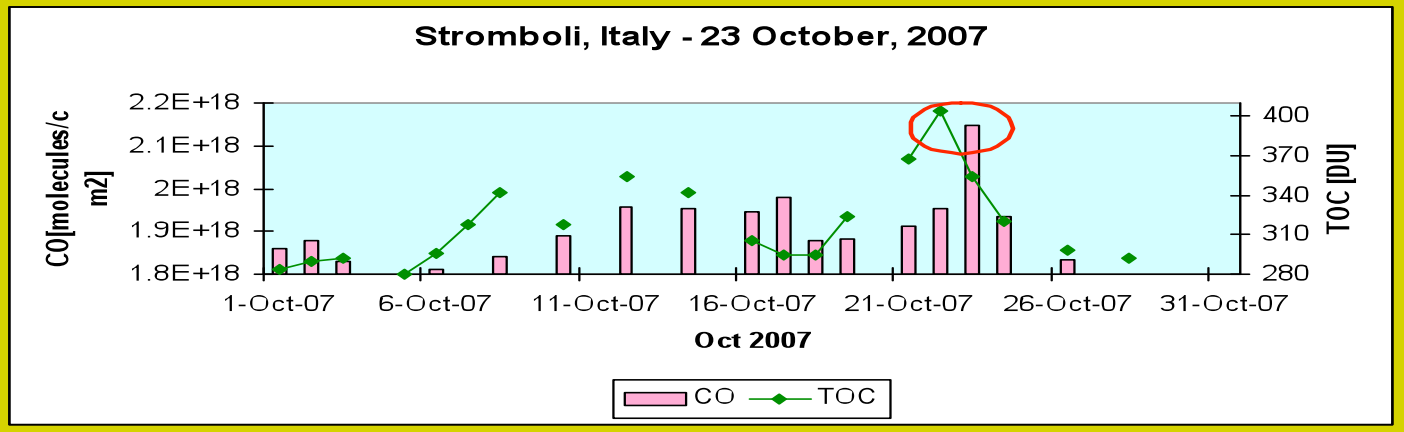
VOCANOES - emission of gases SOx, COx, NOx --

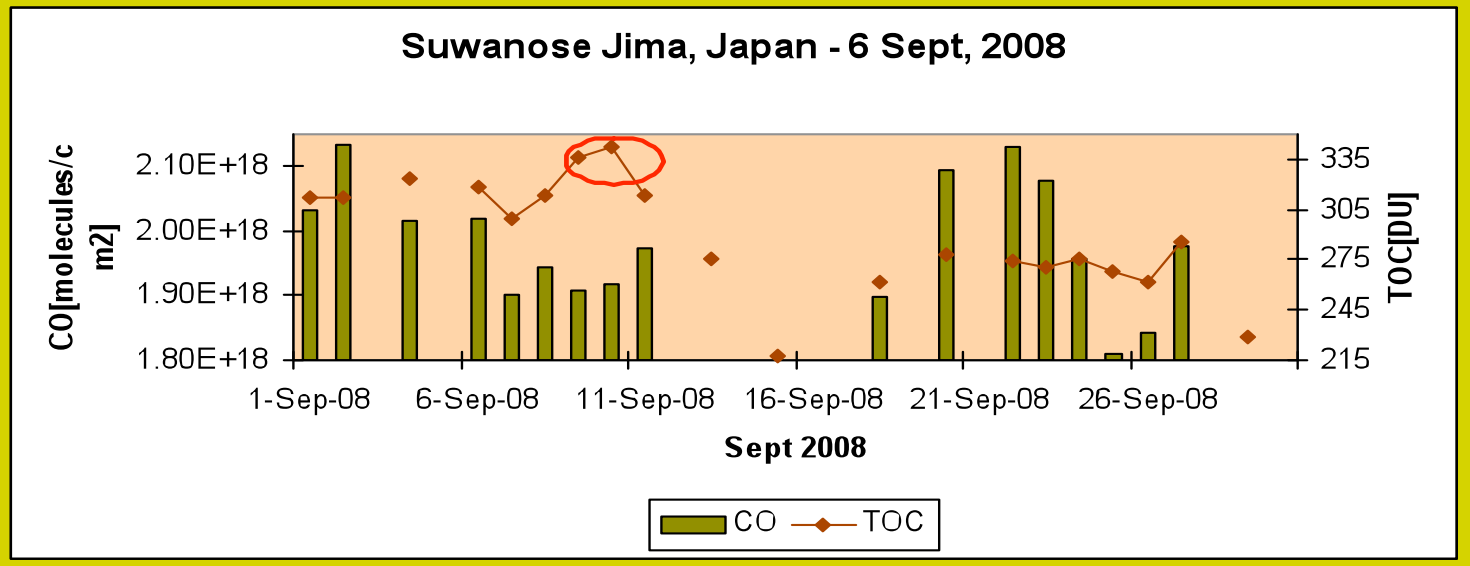
AIRS
OMI
MOPITT

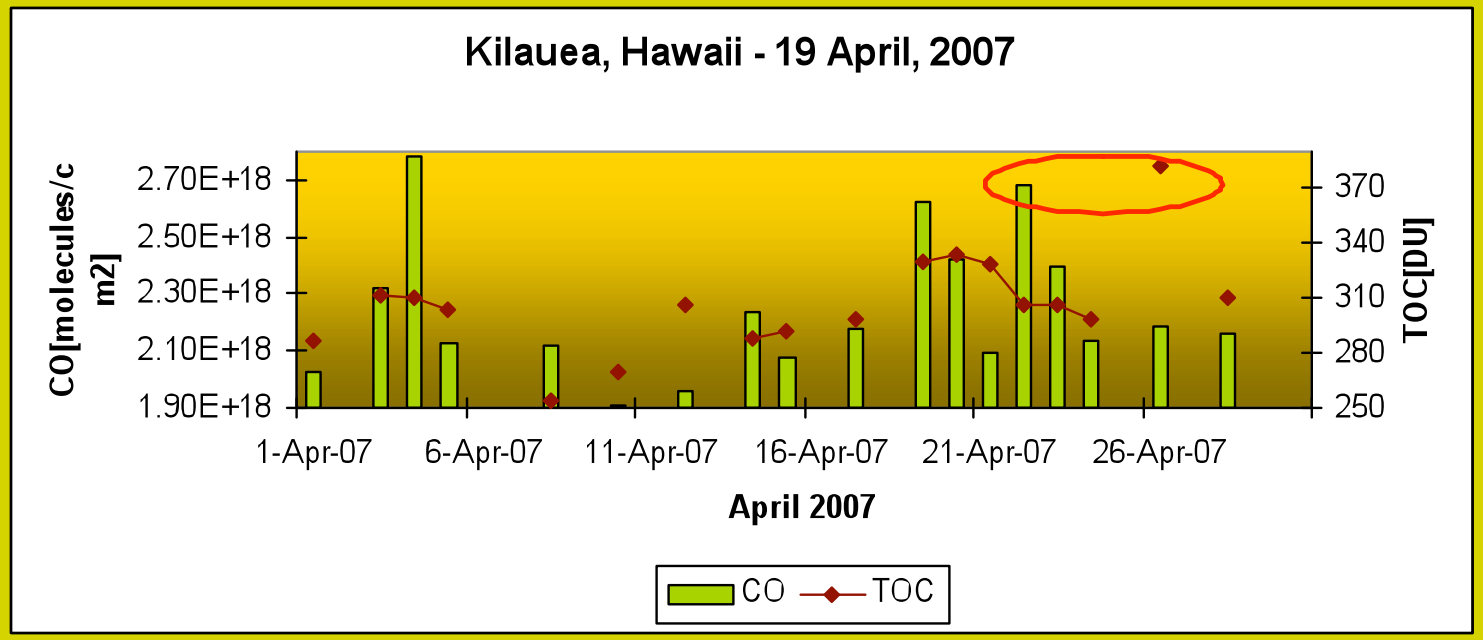

Costa Rica - 6 June, 2008
CO[molecules/cm2]
1.90E+18
1.80E+18
1.70E+18
1.60E+18
1.50E+18
280
275
270
265
260
255
TOC [DU]
1-Jun-08
6-Jun-08
11-Jun-08
16-Jun-08
21-Jun-08
26-Jun-08
June 2008
CO
TOC


Indonesia - 20 October, 2007
CO [molecule/cm2]
2.3E+18
2.2E+18
2.1E+18
2E+18
1.9E+18
1.8E+18
1.7E+18
1.6E+18
260
250
240
230
220
210
200
Ozone [DU]
1-Sep-07
12-Sep-07
23-Sep-07
4-Oct-07
15-Oct-07
26-Oct-07
Sept - Oct 2007
CO
Ozone


Etna - 24 April, 2008
CO[molecules/cm2]
2.48E+18
2.28E+18
2.08E+18
1.88E+18
420
370
320
270
TOC [DU]
1-Apr-08
6-Apr-08
11-Apr-08
16-Apr-08
21-Apr-08
26-Apr-08
April 2008
Series2
Series1


Stromboli, Italy - 23 October, 2007
CO[molecules/cm2]
2.2E+18
2.1E+18
2E+18
1.9E+18
1.8E+18
400
370
340
310
280
TOC [DU]
1-Oct-07
6-Oct-07
11-Oct-07
16-Oct-07
21-Oct-07
26-Oct-07
31-Oct-07
Oct 2007
CO
TOC

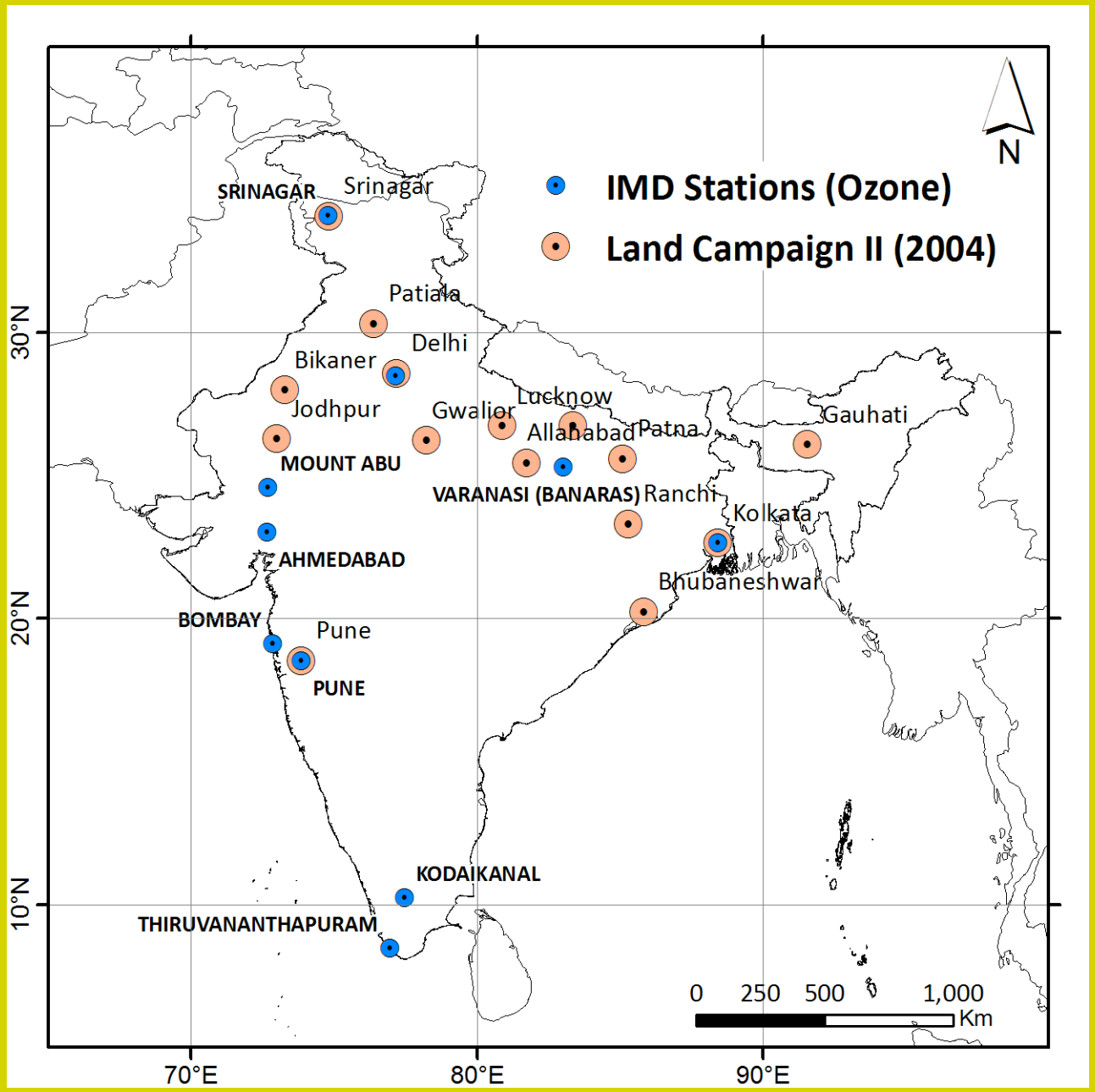

Suwanose Jima, Japan - 6 Sept, 2008
CO[molecules/cm2]
2.10E+18
2.00E+18
1.90E+18
1.80E+18
335
305
275
245
215
TOC[DU]
1-Sep-08
6-Sep-08
11-Sep-08
16-Sep-08
21-Sep-08
26-Sep-08
Sept 2008
CO
TOC

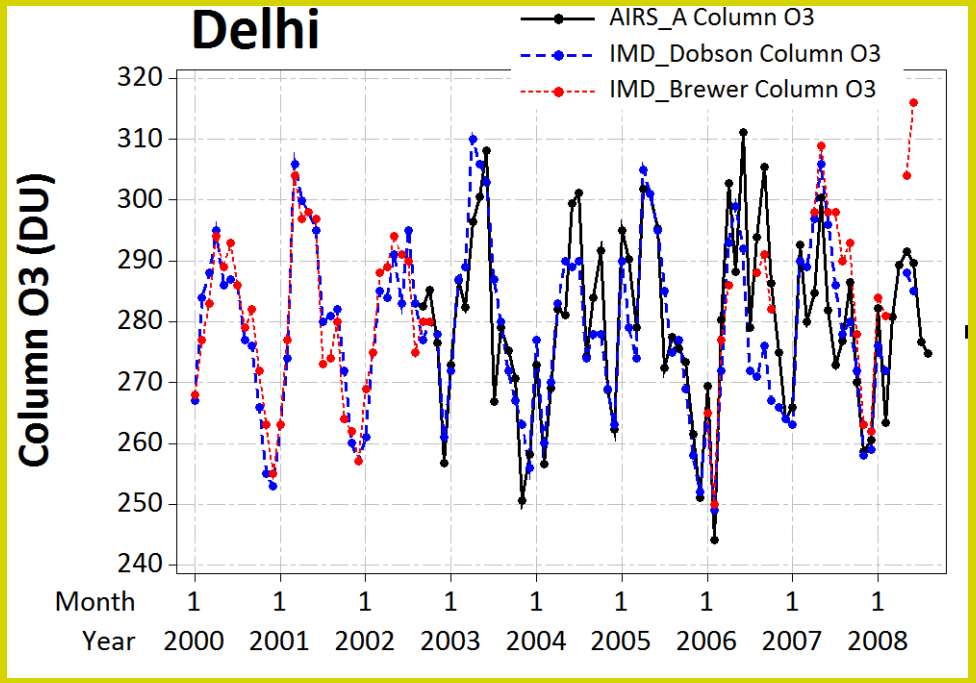

Kilauea, Hawaii - 19 April, 2007
CO[molecules/cm2]
2.70E+18
2.50E+18
2.30E+18
2.10E+18
1.90E+18
370
340
310
280
250
TOC[DU]
1-Apr-07
6-Apr-07
11-Apr-07
16-Apr-07
21-Apr-07
26-Apr-07
April 2007
CO
TOC

- Validation of AIRS Data
- Water vapor with AERONET and GPS
- Relative humidity and Ground observation
- Total Ozone Column with Ground data

Column Ozone

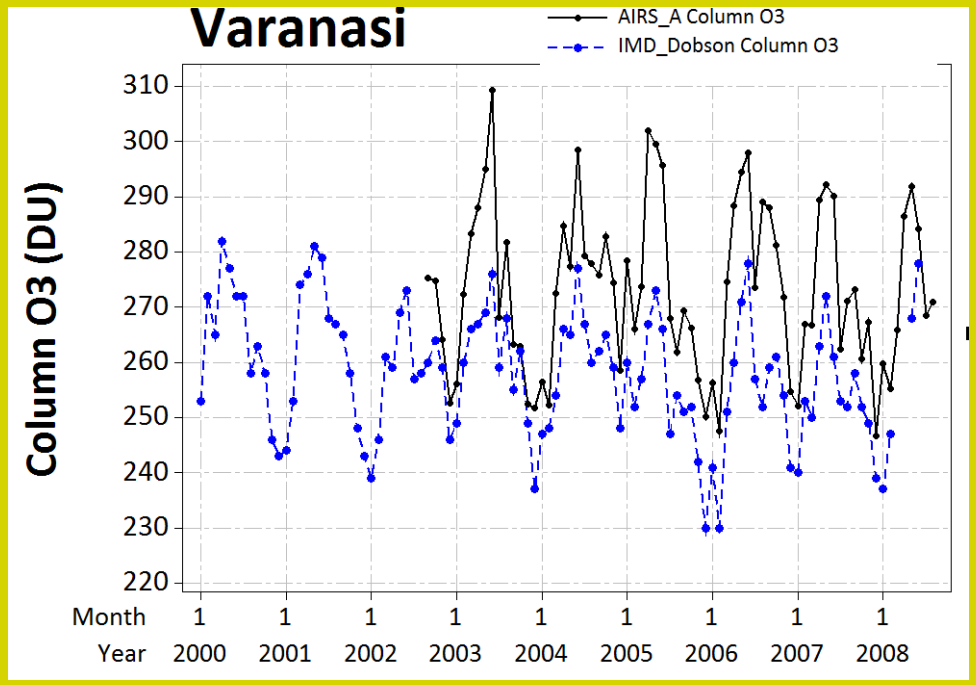
- AIRS Ascending (day time)
- IMD DOBSON or BREWER Ground Stations

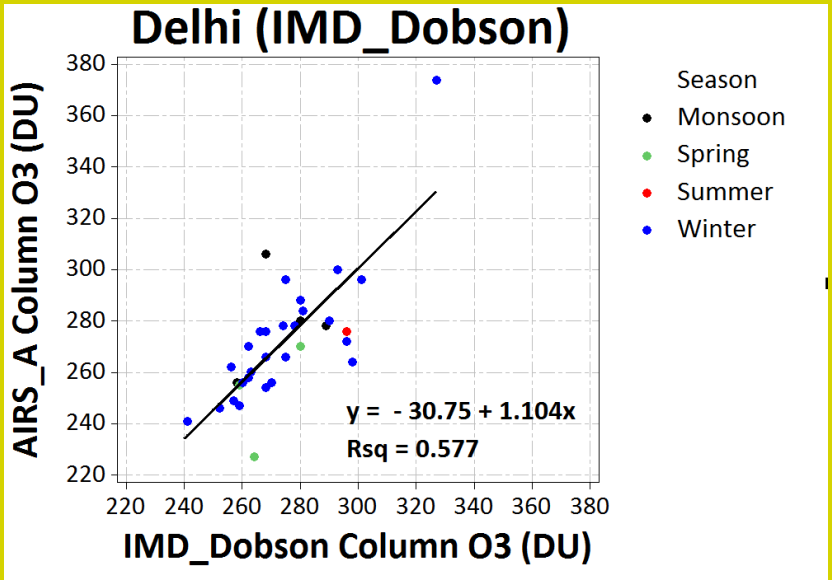

IMD Stations (Ozone)
Land Campaign II (2004)
N
SRINAGAR
Srinagar
Patiala
Delhi
Bikaner
Jodhpur
Gwalior
Lucknow
Allahabad
Patna
Gauhati
MOUNT ABU
VARANASI (BANARAS)
Ranchi
Kolkata
AHMEDABAD
Bhubaneshwar
BOMBAY
Pune
PUNE
KODAIKANAL
THIRUVANANTHAPURAM
30°N
20°N
10°N
70°E
80°E
90°E
0 250 500 1,000
Km

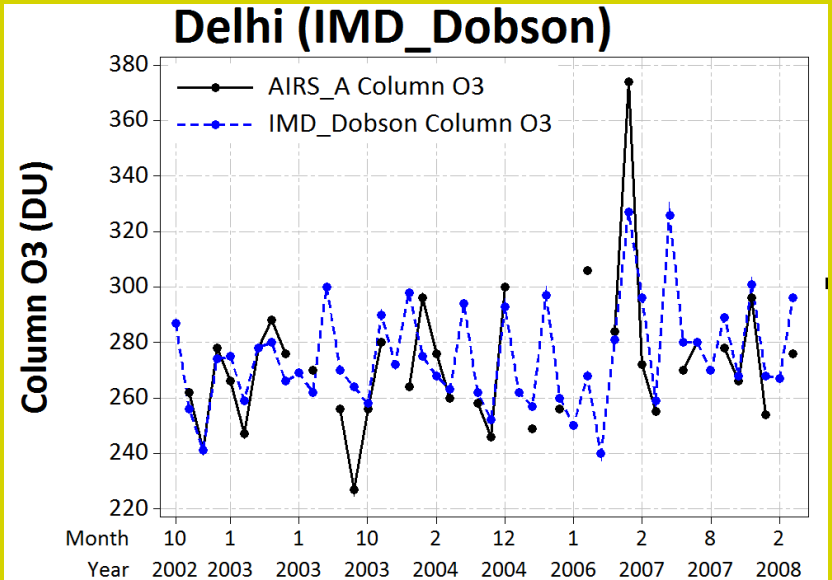


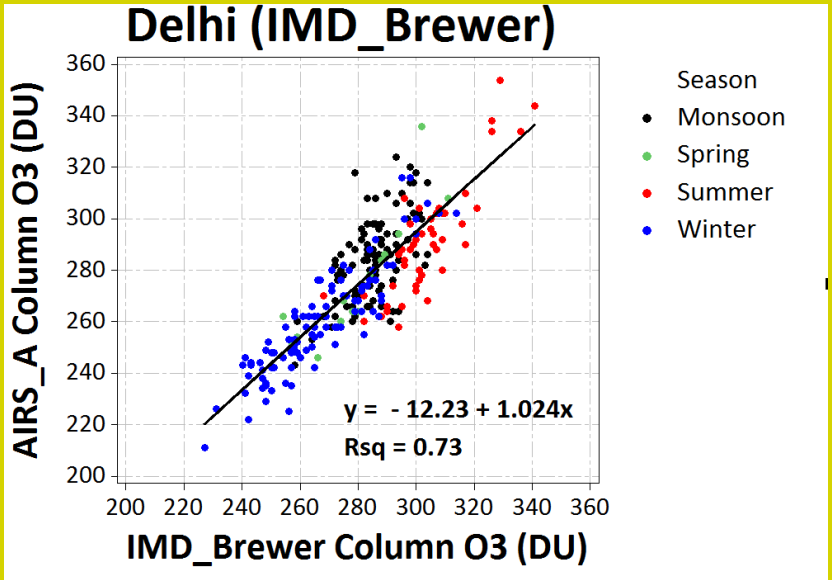
Short term Ozone trend

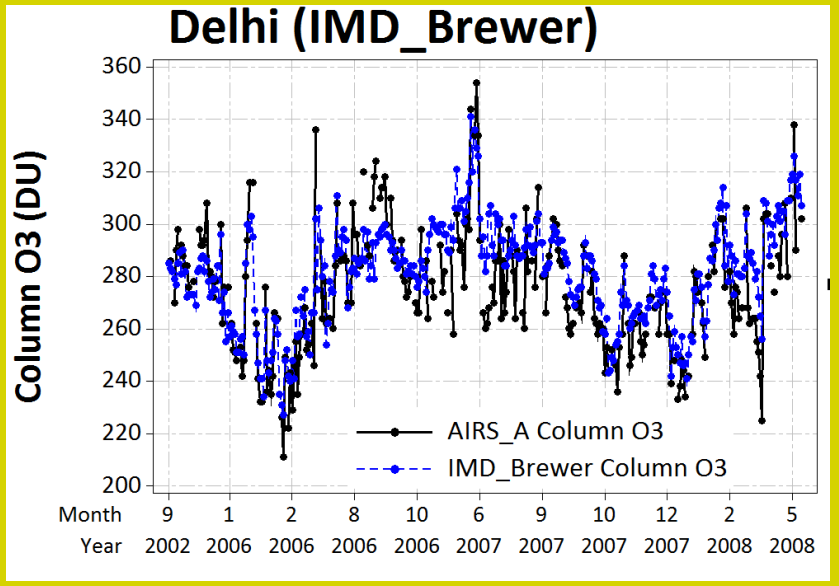
(AIRS_A, Ground)
2000-2008





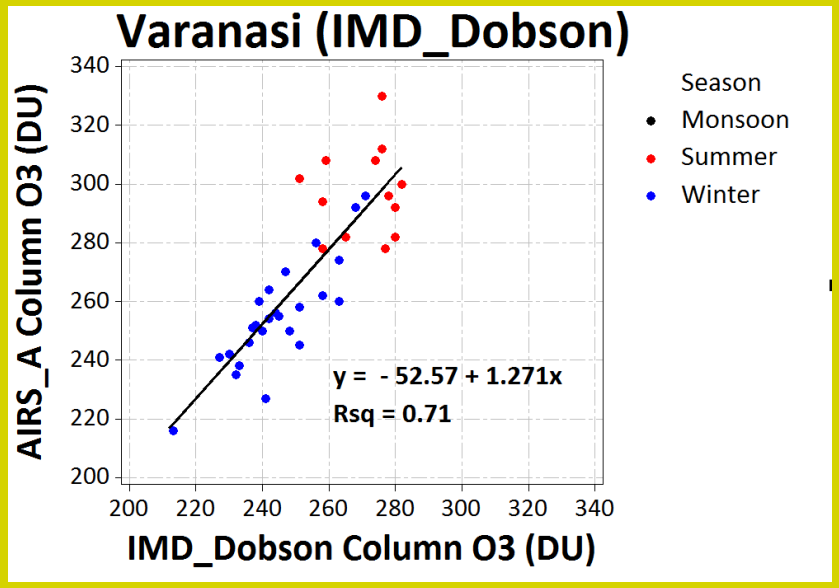


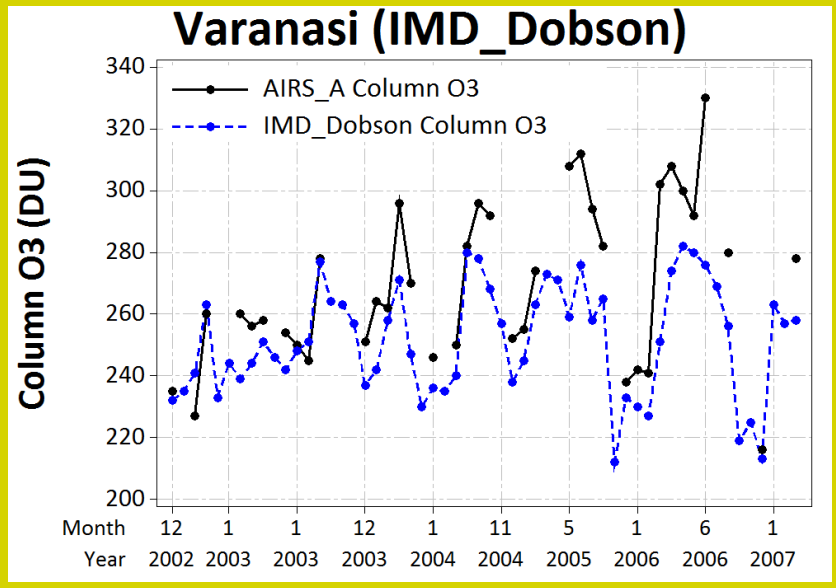




2002-2008

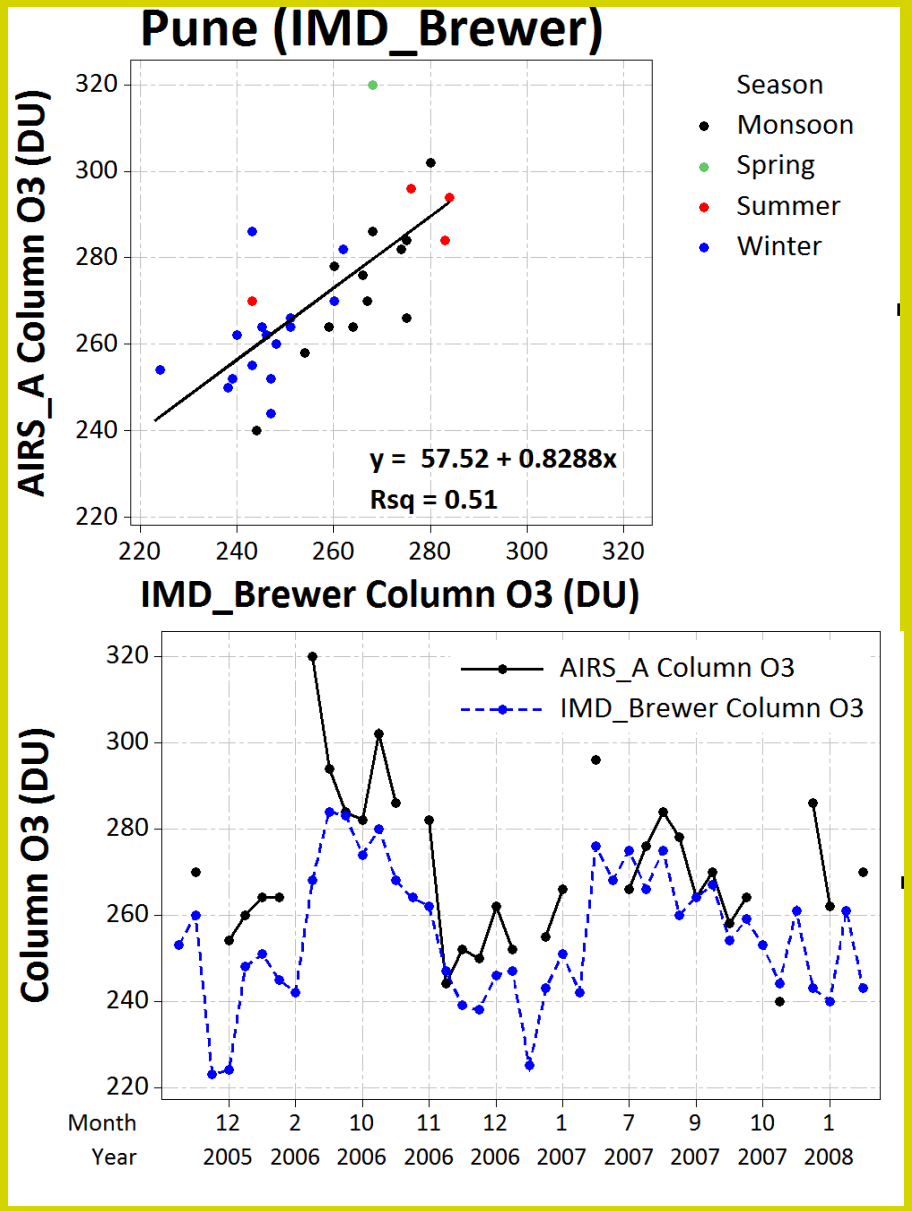
7UTC, daily





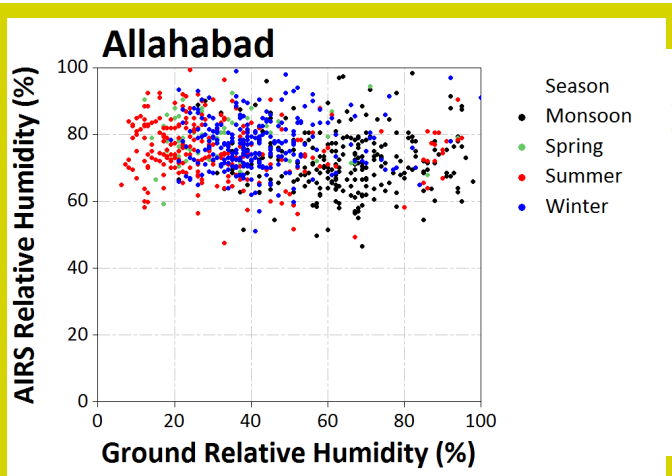
Drift ?

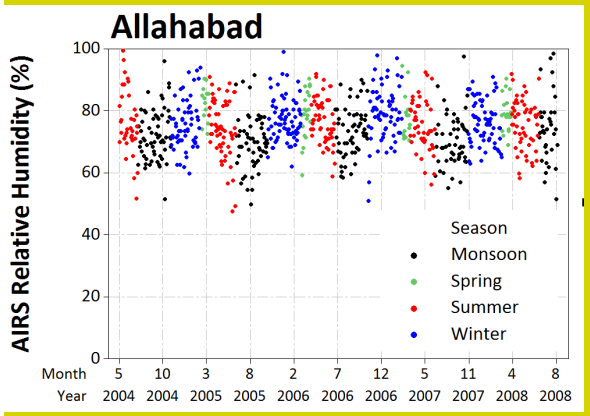
2002-2008
7UTC, daily
Thin clouds = measurement through thin clouds (IMD)

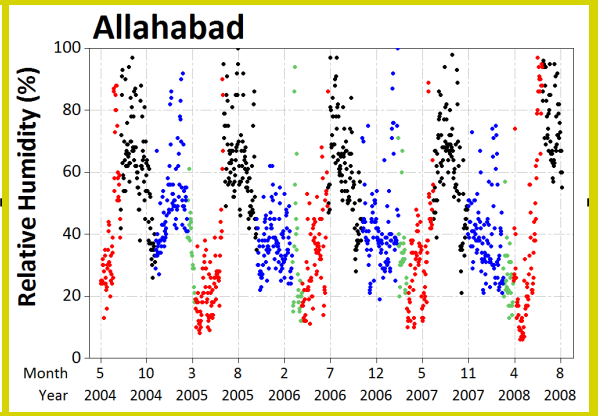

Pune (IMD_Brewer)
AIRS_A Column O3 (DU)
IMD_Brewer Column O3 (DU)
Season
Monsoon
Spring
Summer
Winter
y = 57.52 + 0.8288x
Rsq = 0.51
220
240
260
280
300
320
AIRS_A Column O3
IMD_Brewer Column O3
Column O3 (DU)
Month
Year
12 2 10 11 12 1 7 9 10 1
2005 2006 2006 2006 2006 2007 2007 2007 2007 2008

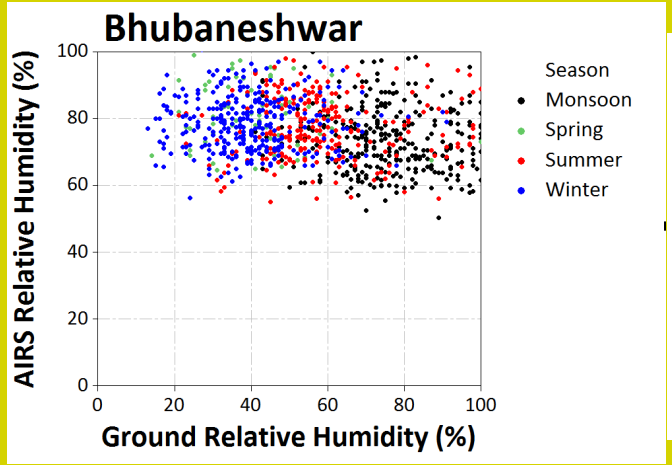
Relative Humidity

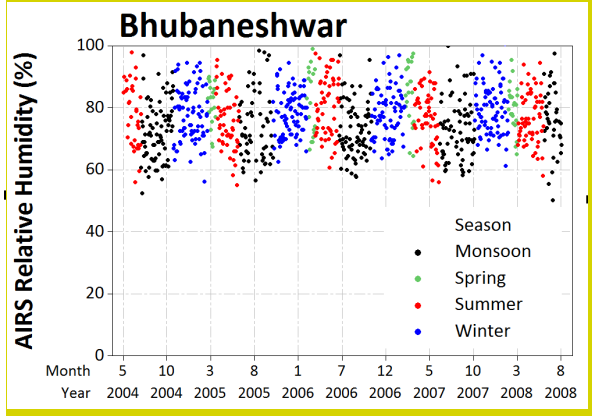
- AIRS Ascending (day time) (All station: 1000mb, except 850mb Srinagar)
- IMD Stations

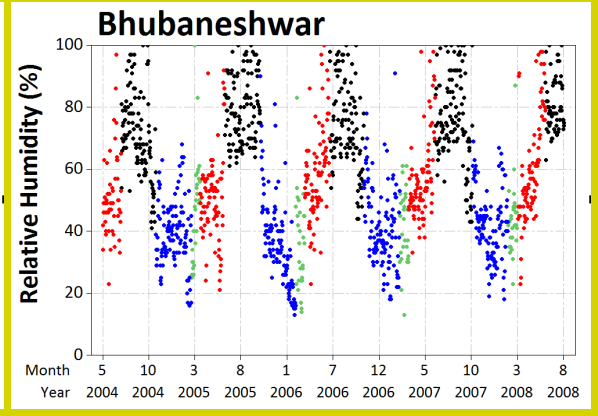

Allahabad
AIRS Relative Humidity (%)
Ground Relative Humidity (%)
Season
Monsoon
Spring
Summer
Winter

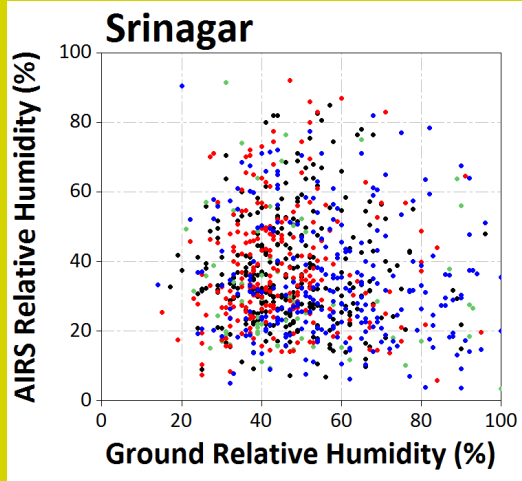

Allahabad
AIRS Relative Humidity (%)
Season
Monsoon
Spring
Summer
Winter
Month
Year

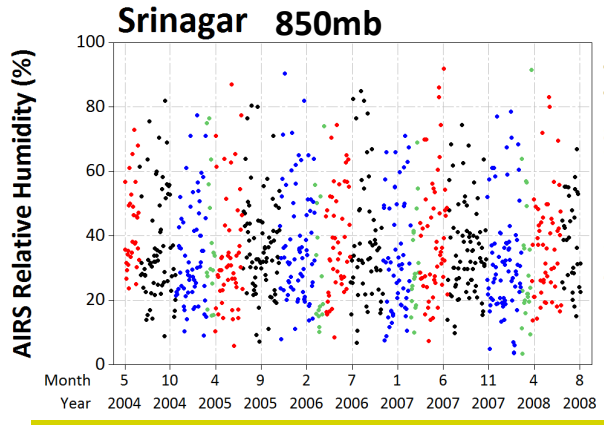

Allahabad
Relative Humidity (%)
Month
Year

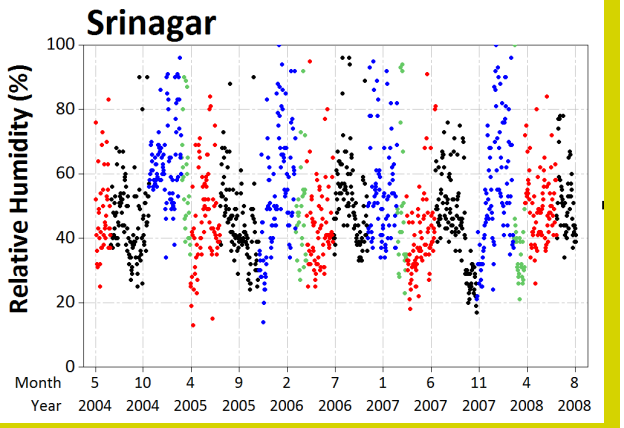

Bhubaneshwar
AIRS Relative Humidity (%)
Ground Relative Humidity (%)
Season
Monsoon
Spring
Summer
Winter

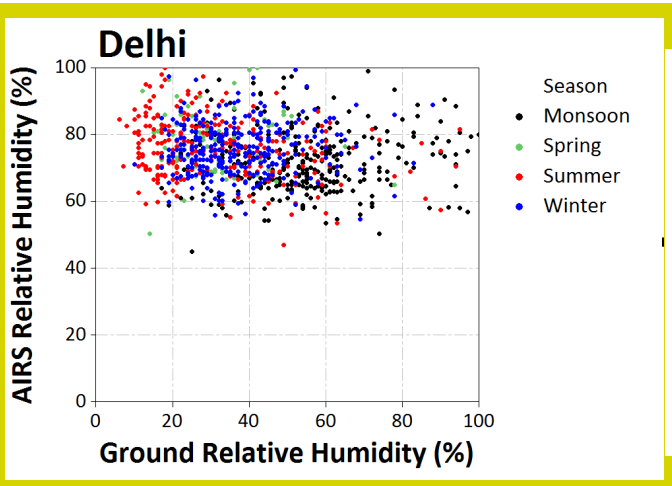

Bhubaneshwar
AIRS Relative Humidity (%)
Season
Monsoon
Spring
Summer
Winter
Month
Year

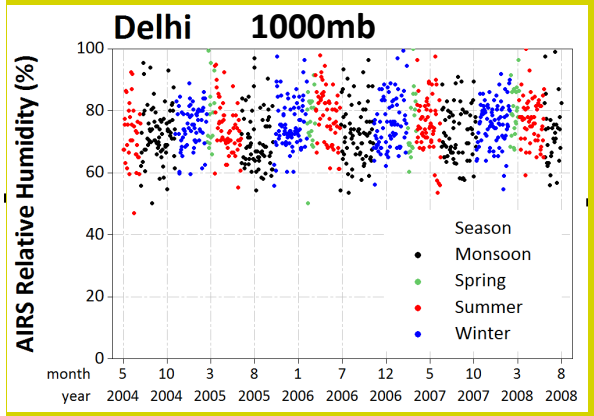

Bhubaneshwar
Relative Humidity (%)
Month
Year

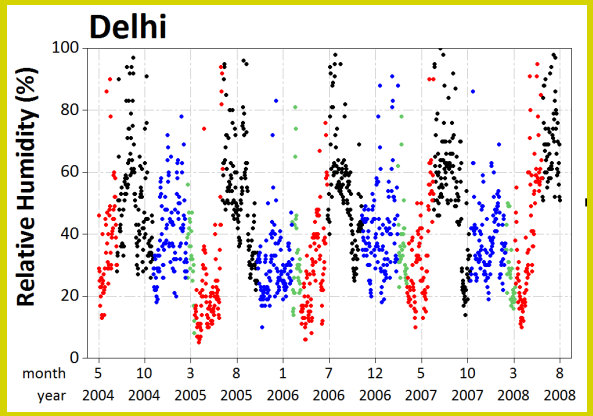

Srinagar
AIRS Relative Humidity (%)
Ground Relative Humidity (%)
Season
Monsoon
Spring
Summer
Winter

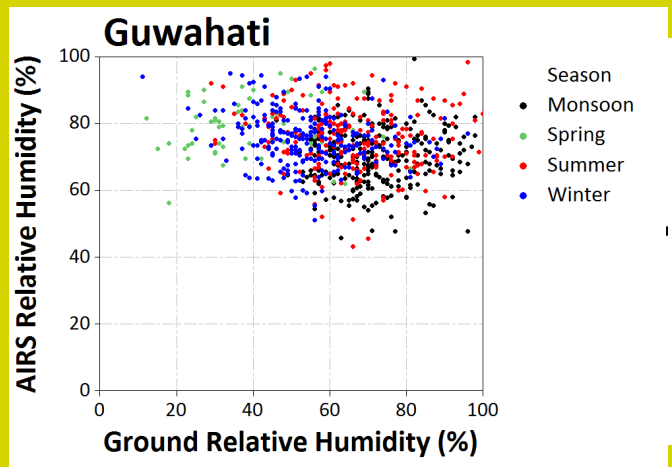

Srinagar 850mb
AIRS Relative Humidity (%)
Month
Year

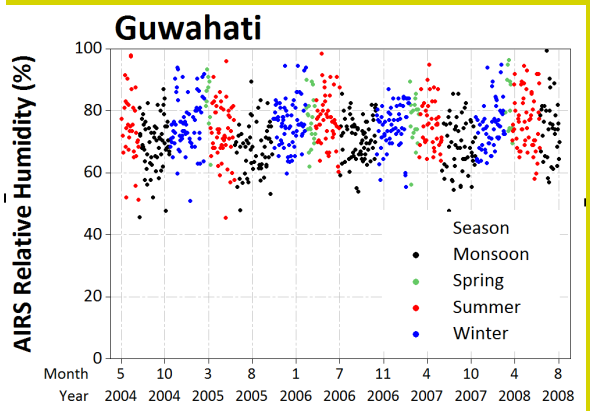

Srinagar
Relative Humidity (%)
Month
Year

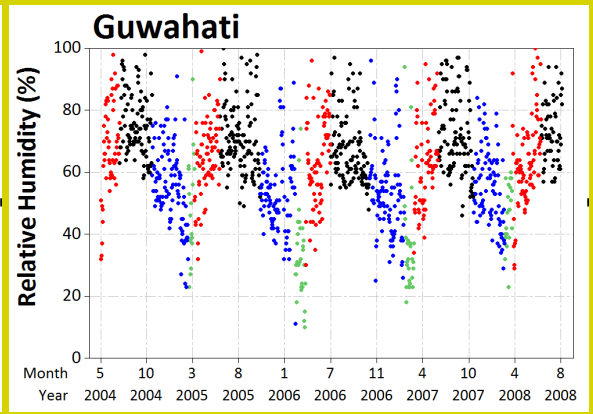

Delhi
AIRS Relative Humidity (%)
Ground Relative Humidity (%)
Season
Monsoon
Spring
Summer
Winter

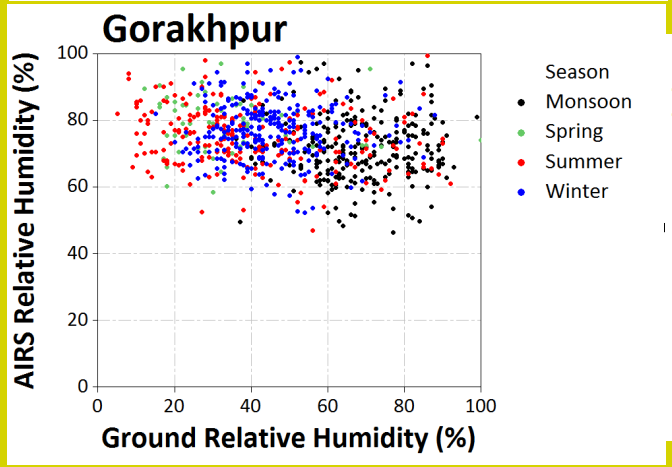

Delhi 1000mb
AIRS Relative Humidity (%)
Season
Monsoon
Spring
Summer
Winter
month
year

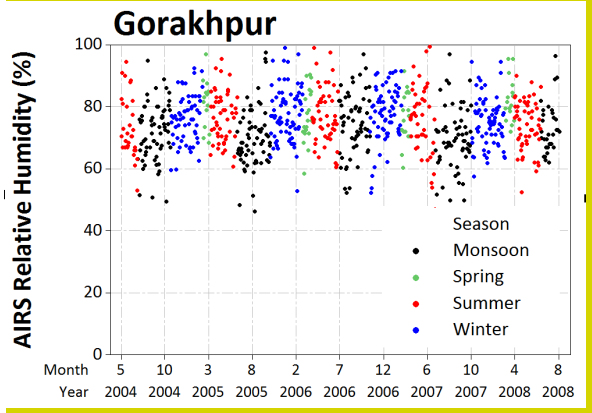

Delhi
Relative Humidity (%)
month
year

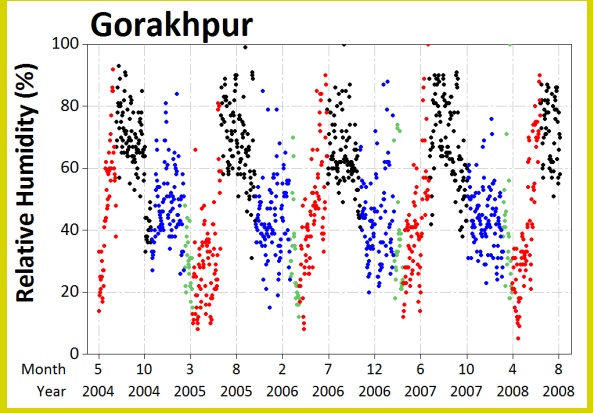

Guwahati
AIRS Relative Humidity (%)
Ground Relative Humidity (%)
Season
Monsoon
Spring
Summer
Winter

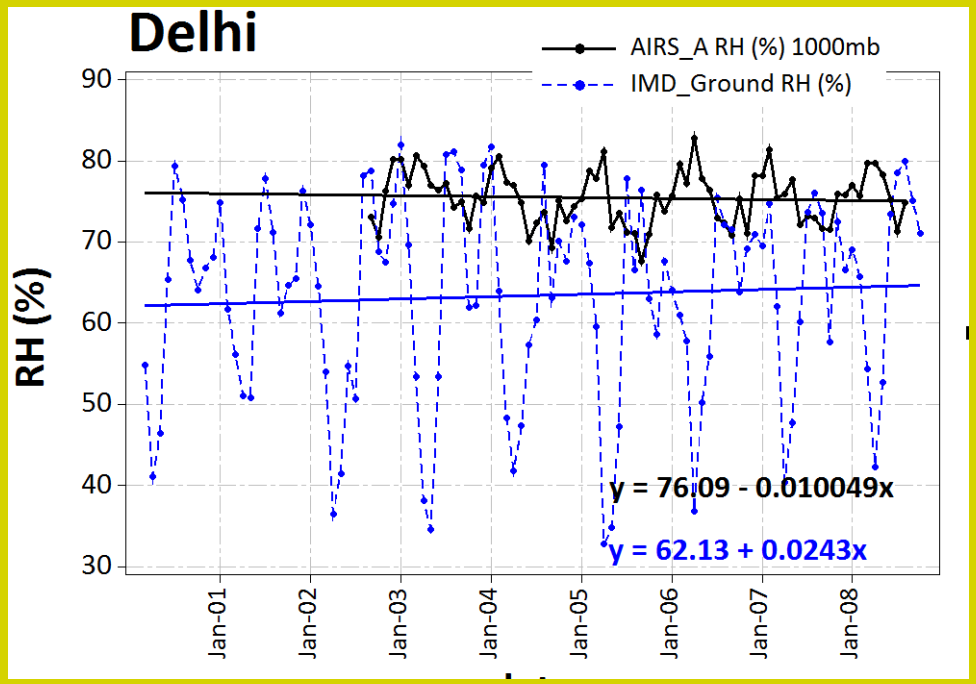

Guwahati
AIRS Relative Humidity (%)
Season
Monsoon
Spring
Summer
Winter
Month
Year

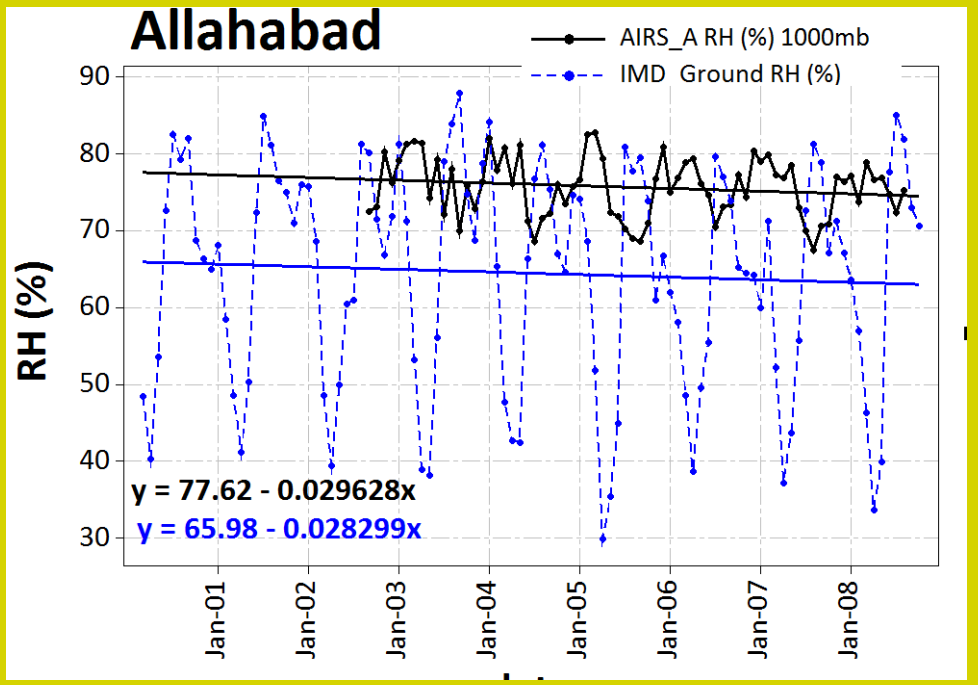

Guwahati
Relative Humidity (%)
Month
Year

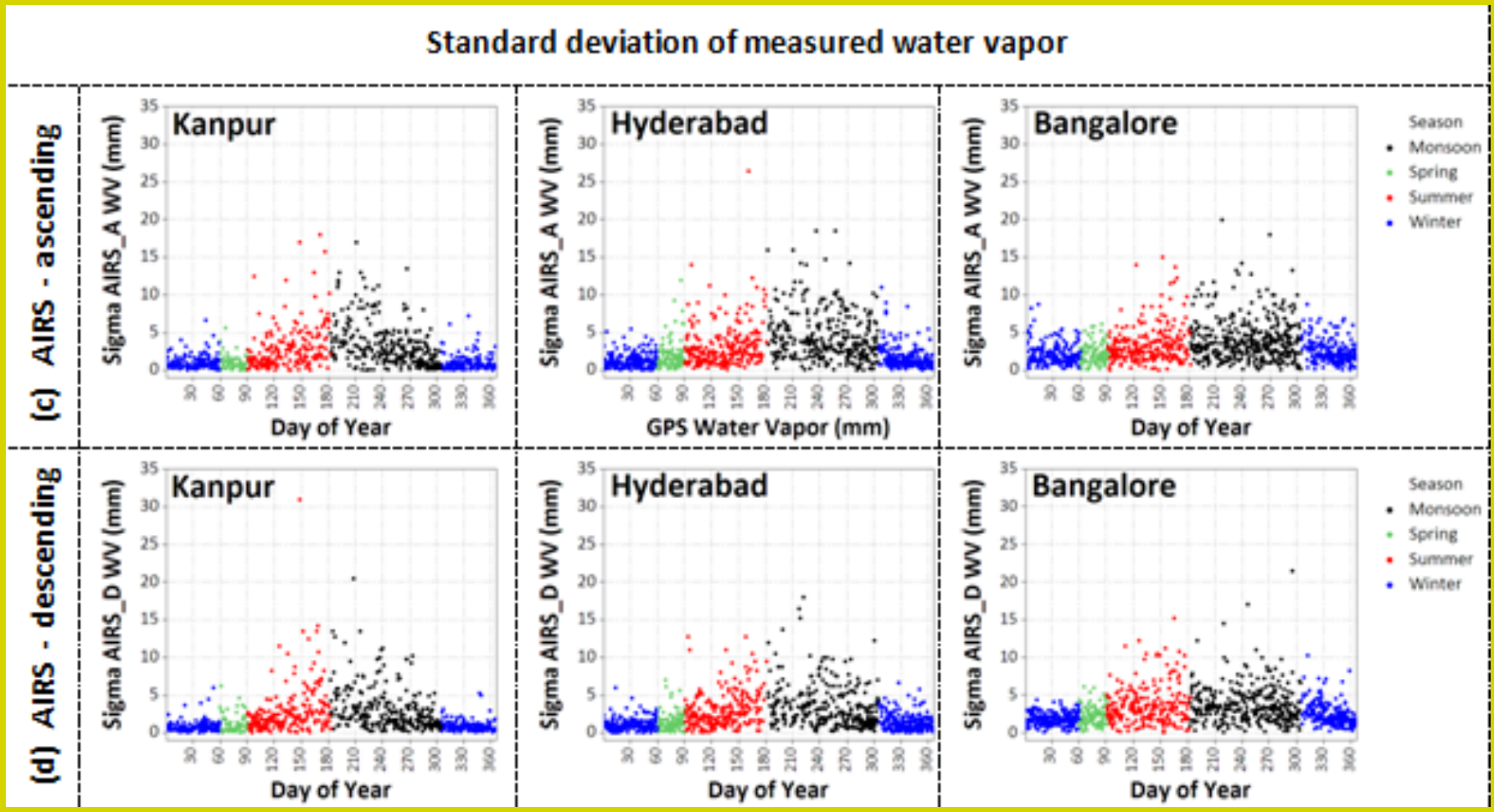

Gorakhpur
AIRS Relative Humidity (%)
Ground Relative Humidity (%)
Season
Monsoon
Spring
Summer
Winter


Gorakhpur
AIRS Relative Humidity (%)
Season
Monsoon
Spring
Summer
Winter
Month
Year


Gorakhpur
Relative Humidity (%)
Month
Year


Delhi
AIRS_A RH (%) 1000mb
IMD_Ground RH (%)
RH (%)
90
80
70
60
50
40
30
y = 76.09 - 0.010049x
y = 62.13 + 0.0243x
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08


Allahabad
AIRS_A RH (%) 1000mb
IMD Ground RH (%)
RH (%)
90
80
70
60
50
40
30
y = 77.62 - 0.029628x
y = 65.98 - 0.028299x
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08


Standard deviation of measured water vapor
(c) AIRS - ascending
(d) AIRS - descending
Kanpur
Hyderabad
Bangalore
Sigma AIRS_A WV (mm)
Sigma AIRS_D WV (mm)
Day of Year
GPS Water Vapor (mm)
Season
Monsoon
Spring
Summer
Winter

•Thanks to Dr. Menas Kafatos, Director, CEOSR, GMU for financial support

•Giovanni Team

Thank you for your attention