Upper-tropospheric clouds and pollution over Asia: New insights from MLS on Aura

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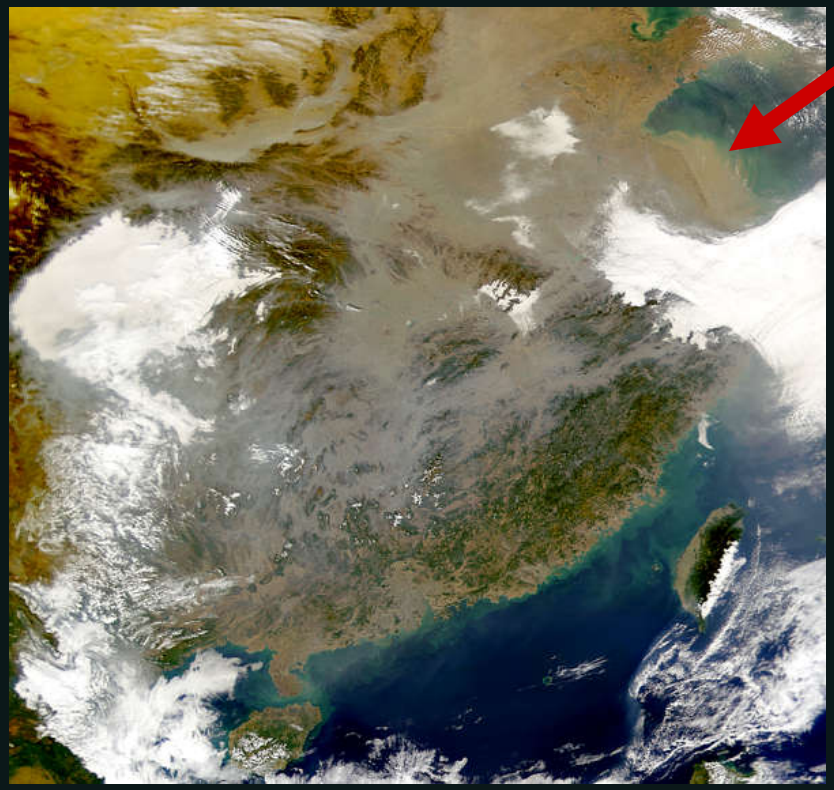
Outline:

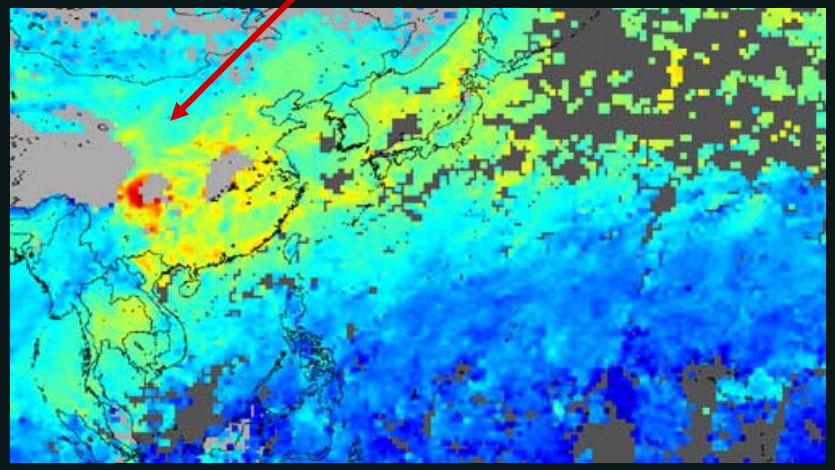
1. Pollution problems over Asia
2. Observations from Microwave Limb Sounder (MLS) on Aura
3. Enhancements during Asian summer monsoon
4. Implications to climate change

Acknowledgments
We thank our colleagues in MLS Science and Engineering teams for instrument development, operation, and data processing.

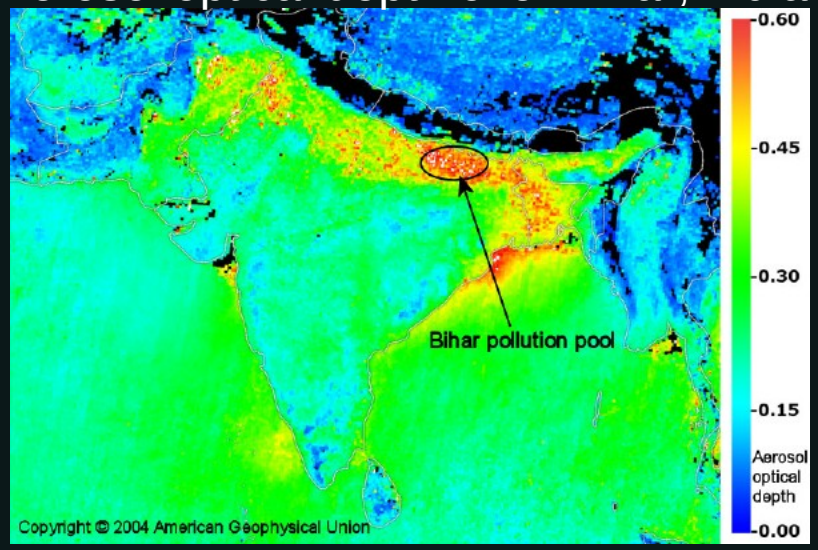


China Haze
on 2 Jan. 2002
(credit: NASA SeaWiFS)

China CO Emission
1-20 Jan. 2003
(credit: NCAR MOPITT)



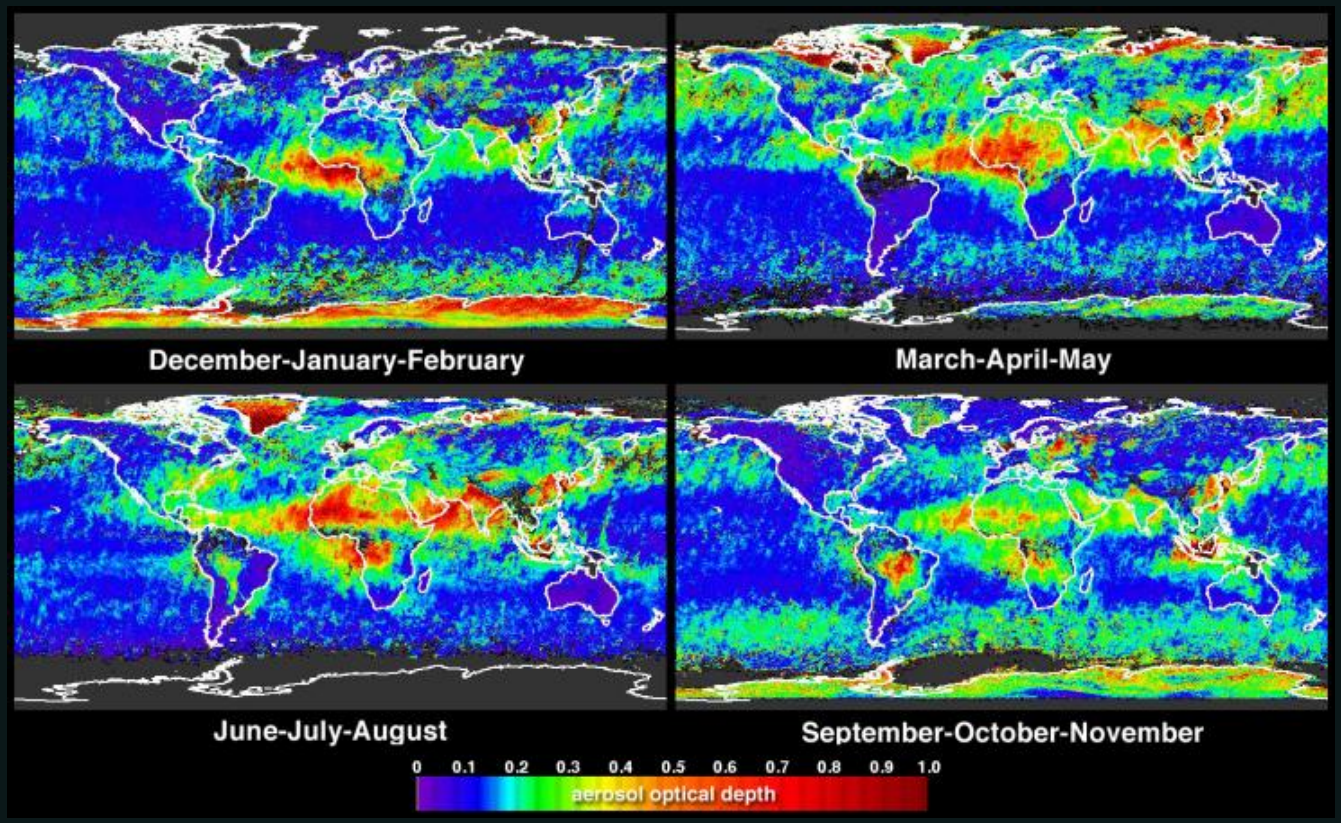
Aerosol optical depth over Bihar, India



Clouds
over India
on 2004.12.17

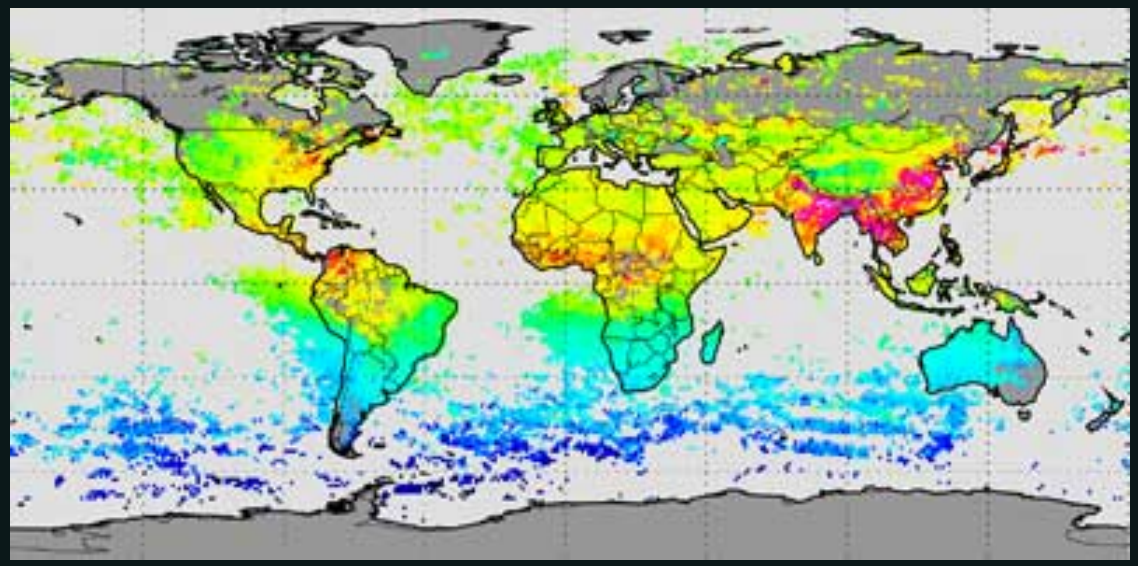
Photo credit: NASA MODIS team

Image credit: NASA MODIS team



Global Aerosol Optical Depth from MISR

Credits: NASA MISR team

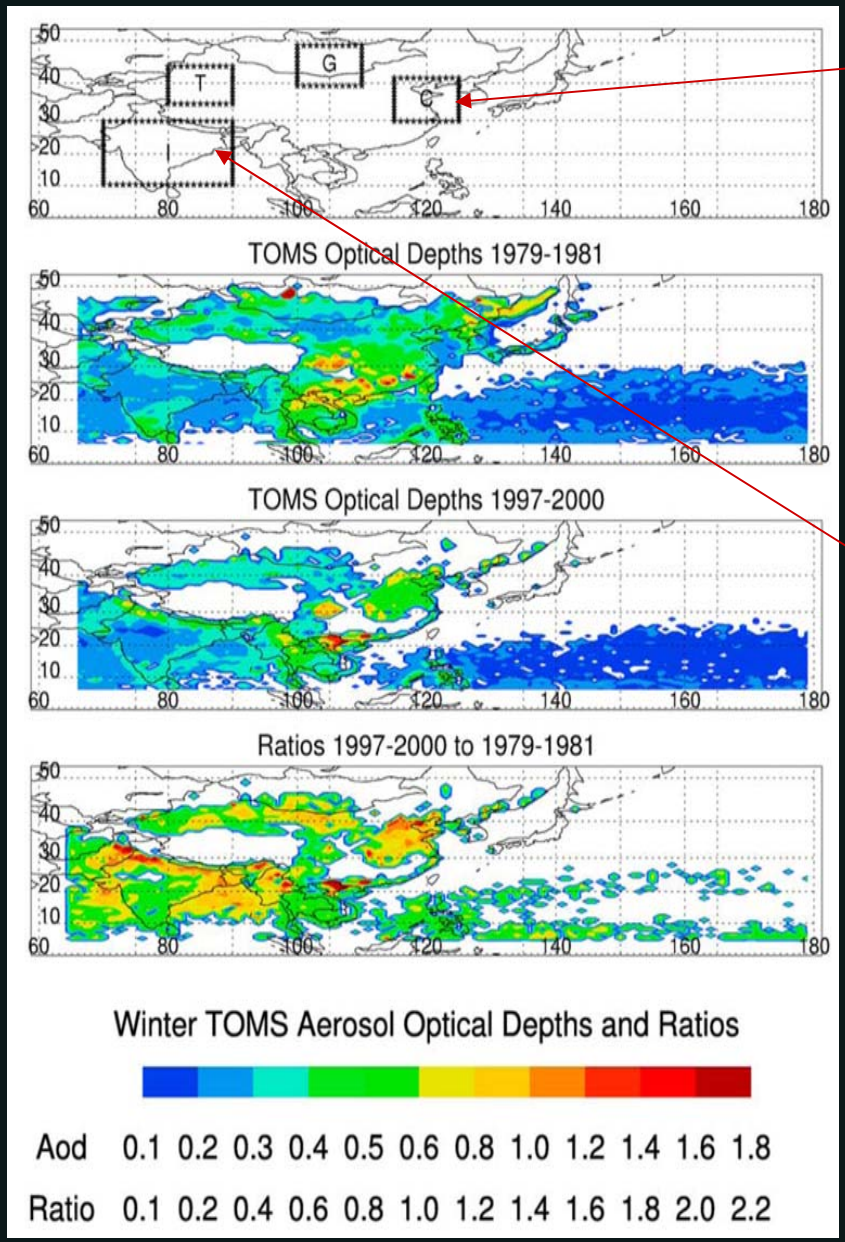


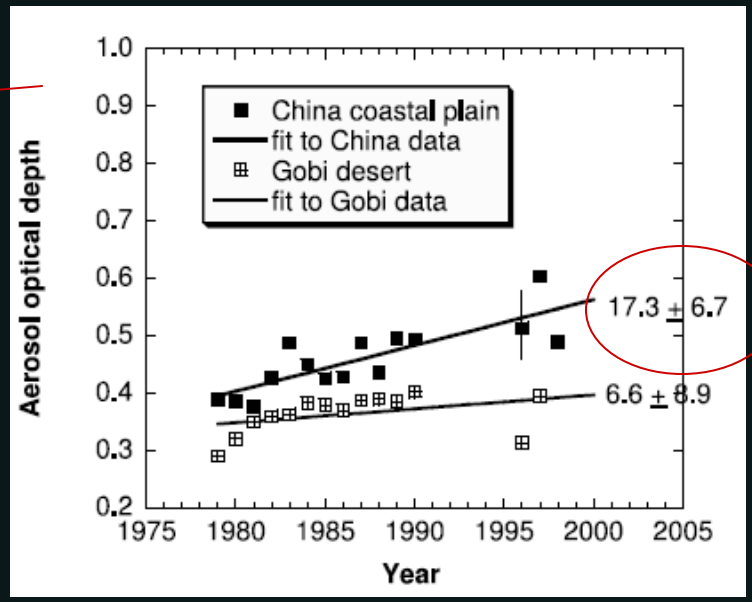
Global CH_4 Distribution from SCIAMACHY

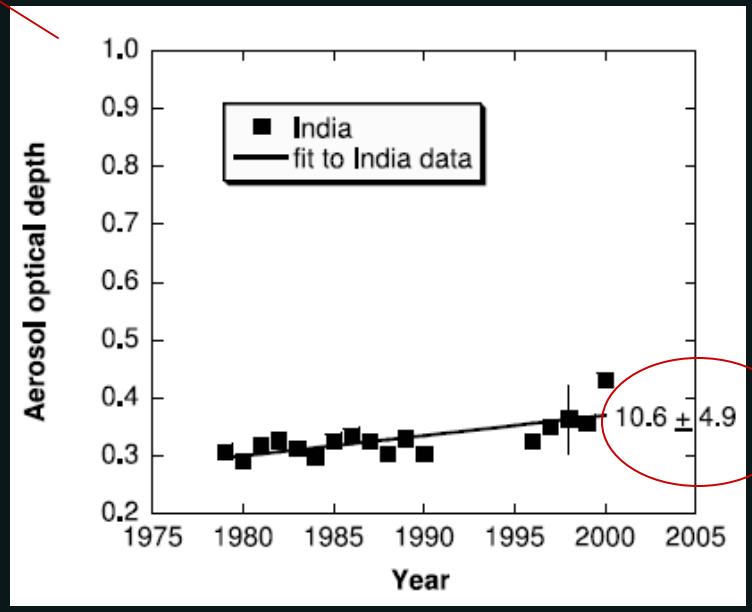
(August-November 2003)

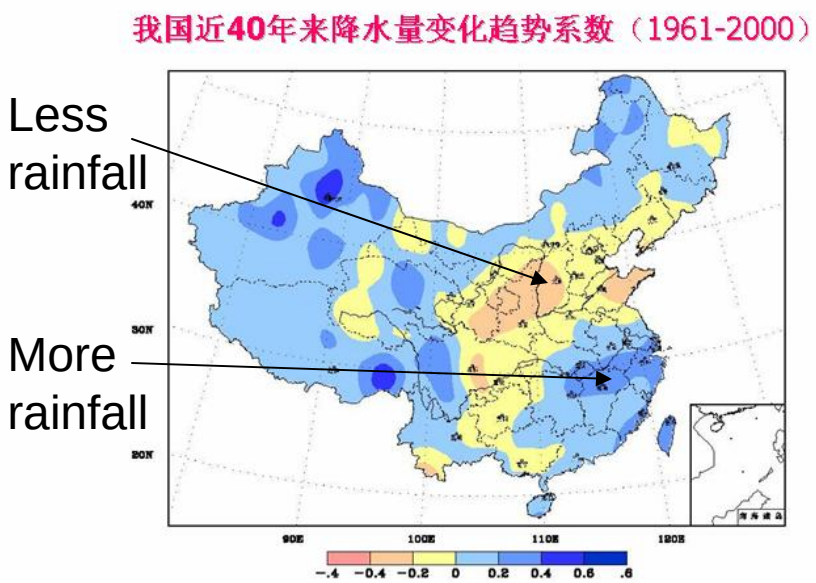
Credits: University of Heidelberg/KNMI

Massie et al. (2003)

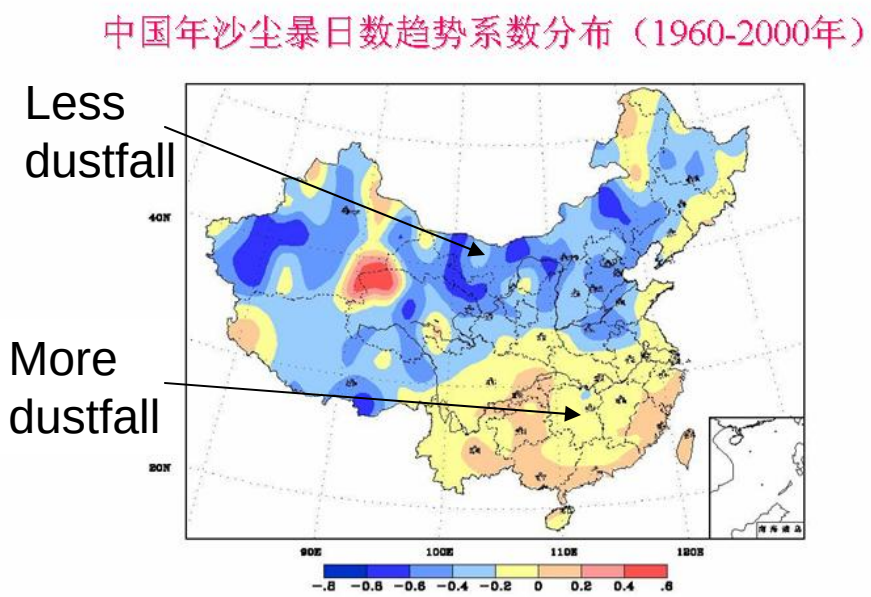






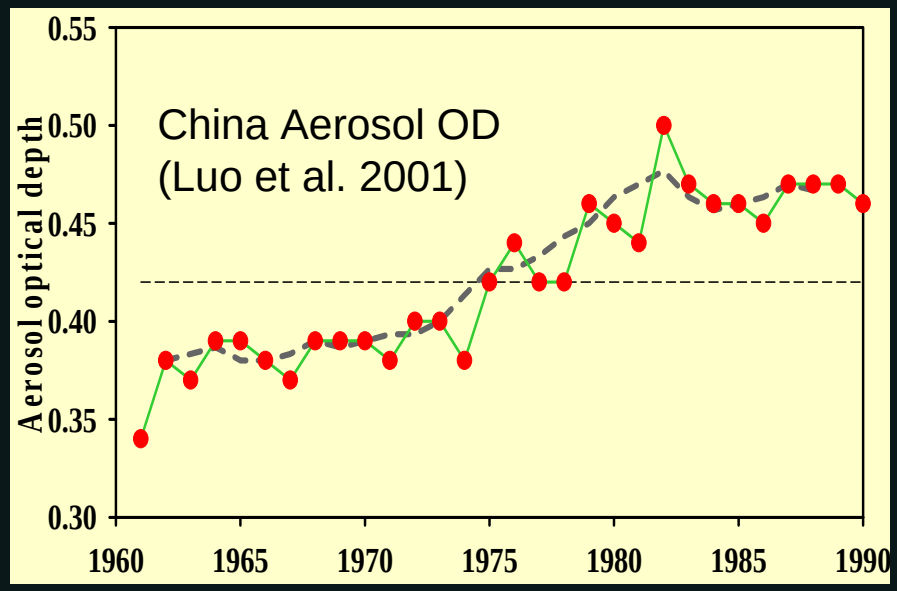


China Precipitation Trend (1961-2000)



China Dustfall Trend (1960-2000)

- Are these changes due to anthropogenic aerosol emissions?
- Does climate respond linearly to the forcing?
- Where will these trends lead us to ?



The EOS MLS on NASA Aura satellite

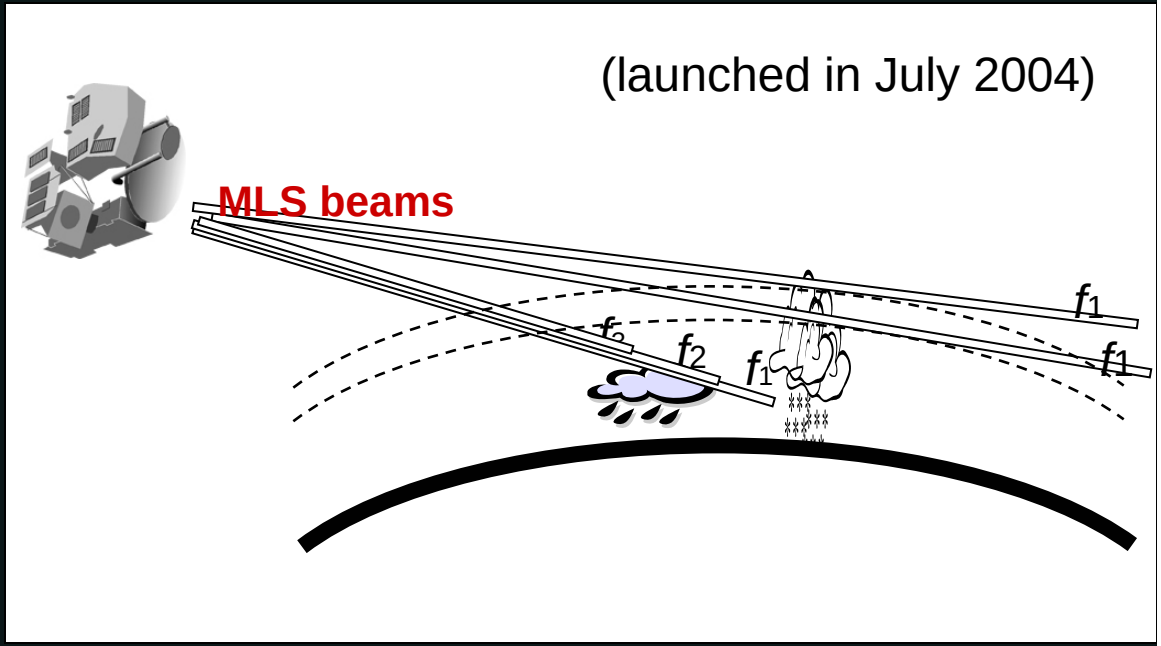
Frequency (GHz)	Pol	Vertical (km)	Horizontal (km)
R1A (115-122)	V	6.5	13
R1B (115-122)	H	6.5	13
R2 (178-184, 200-207)	V	4.5	9
R3 (230-237, 243-250)	H	3.5	7
R4 (625-637, 649-661)	H	1.5	3
R5H (2501-2515, 2531-2544)	~H	2.5	2.5
R5V (2501-2515, 2531-2544)	~V	2.5	2.5

Advantages with MLS:

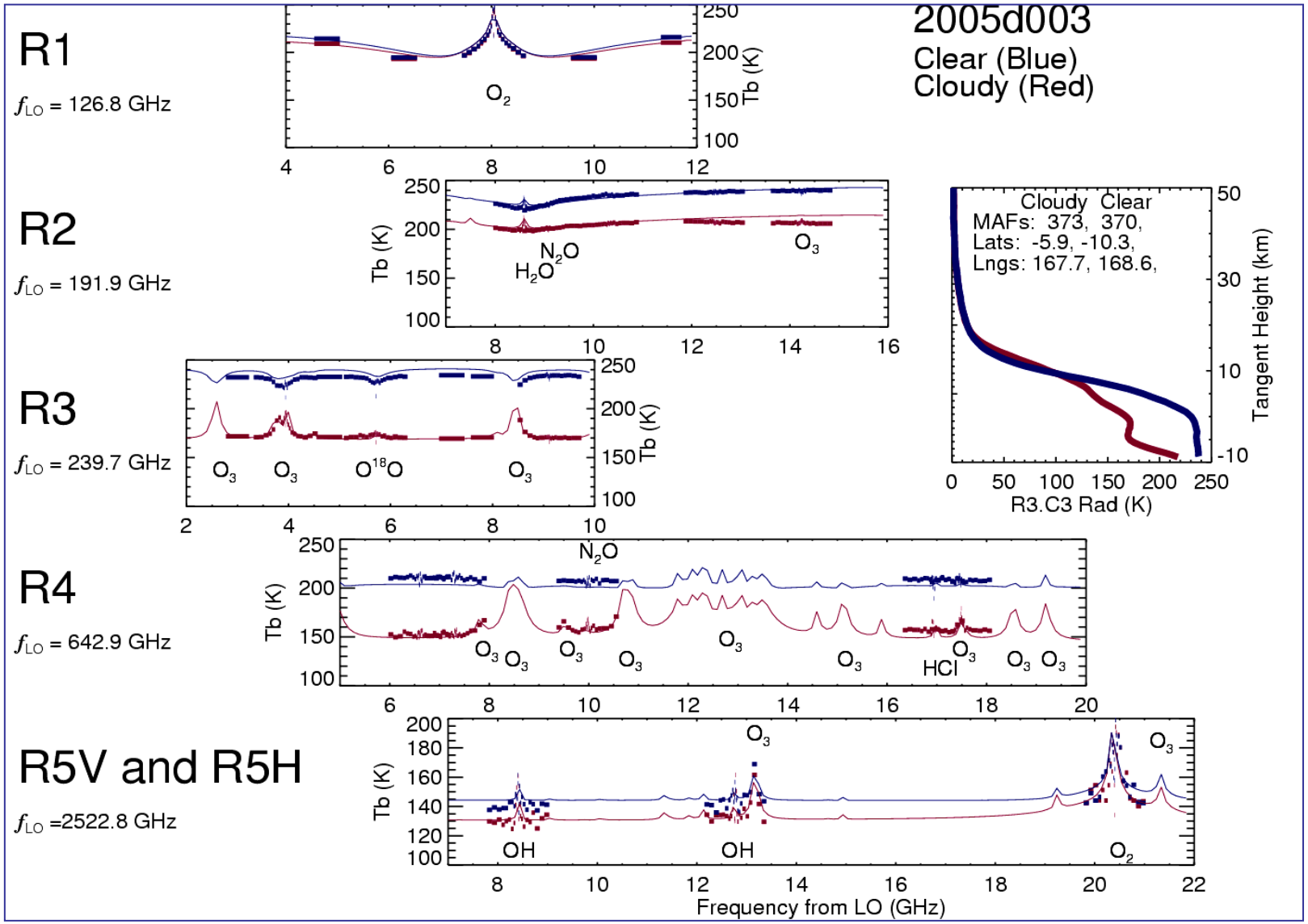
- **Better vertical resolution**
- **Less contamination from surface and low clouds**
- **Better sensitivity to low density clouds**
- **Simultaneous measurements of CO, H_2O, O_3, and T.**

Trade-offs:

Poor horizontal resolution



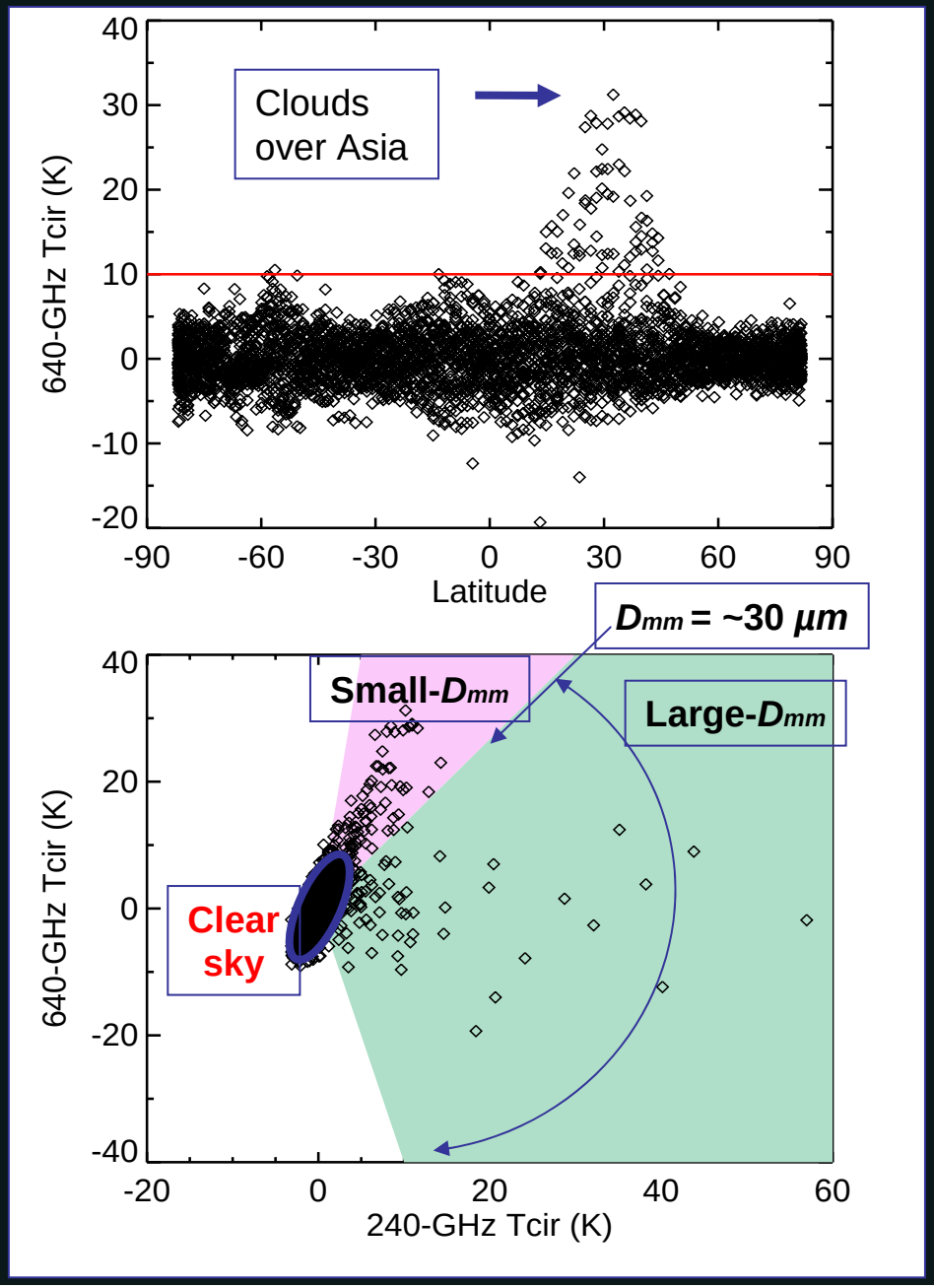
MLS Limb Radiance Spectra



MLS Cloud-Induced Radiance (Tcir) Measurements

- Tcir is the excessive radiance beyond clear-sky variability
- Tcir is proportional to cloud ice mass (e.g., IWC, IWP)
- The ratio of Tcir at 240 and 640 GHz provides particle size information.

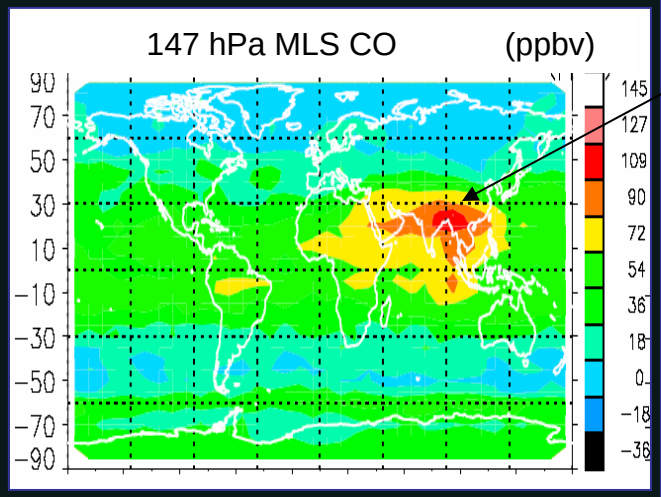
30 August 2004; Ht =~15 km

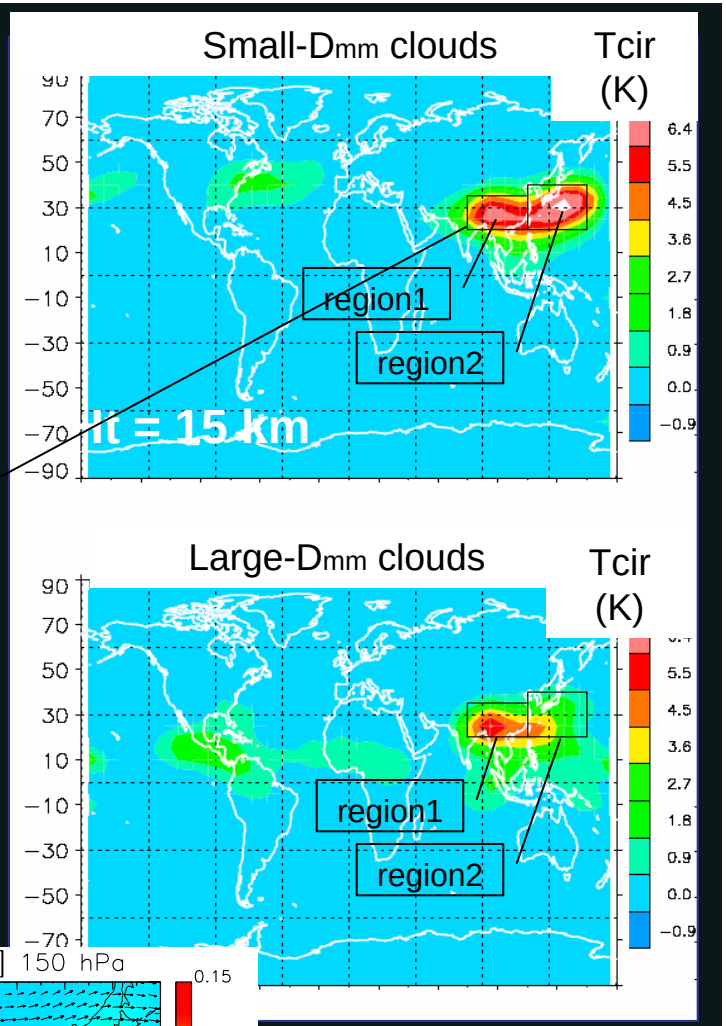


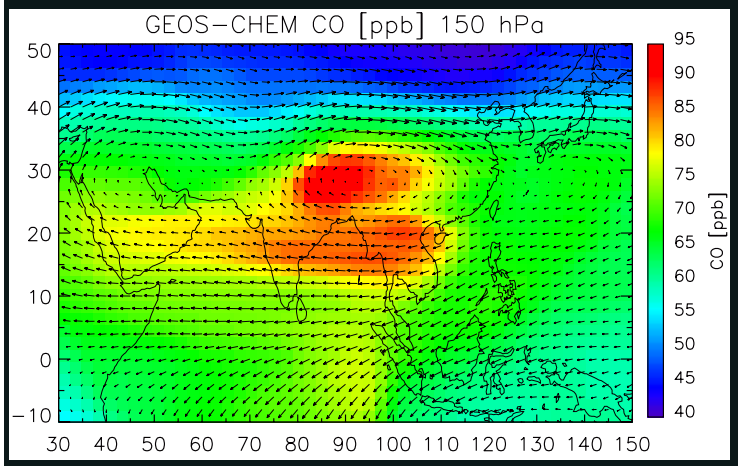
Clouds and pollution over India and southern China

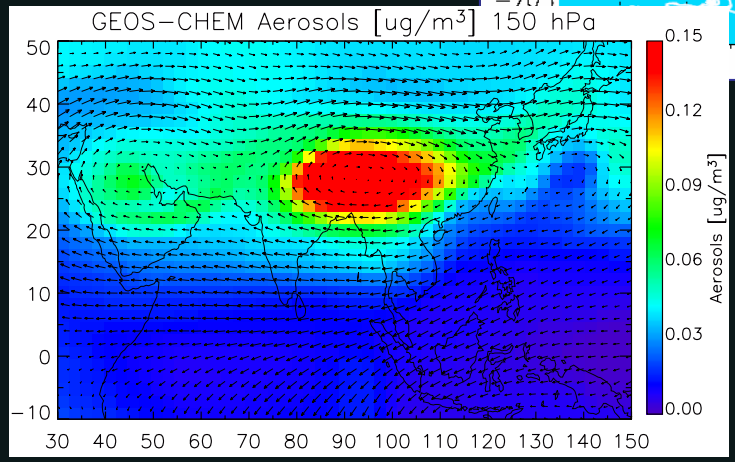
(15 Aug - 14 Sep 2004)

- Collocated cloud and CO enhancements
- Strong Influences by monsoon and typhoon dynamics
- Aerosol and high cloud interactions?









(Li et al., 2005)

GEOS-CHEM:
Aerosol and CO both enhanced and trapped in the region

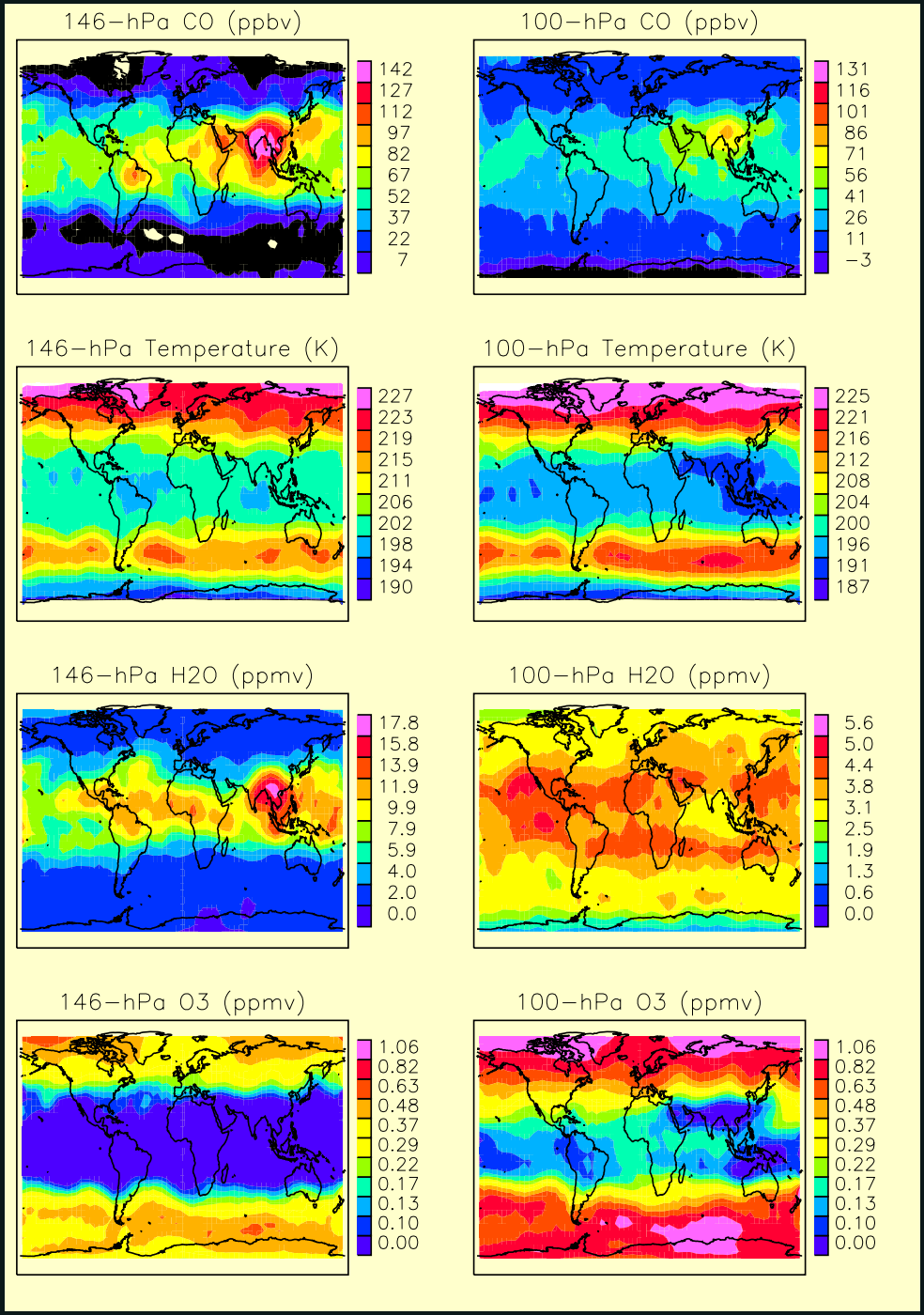
MLS Obs on 29 Aug – 3 Sep 2004

CO
Large enhancements at 147 and 100 hPa over India and southern China

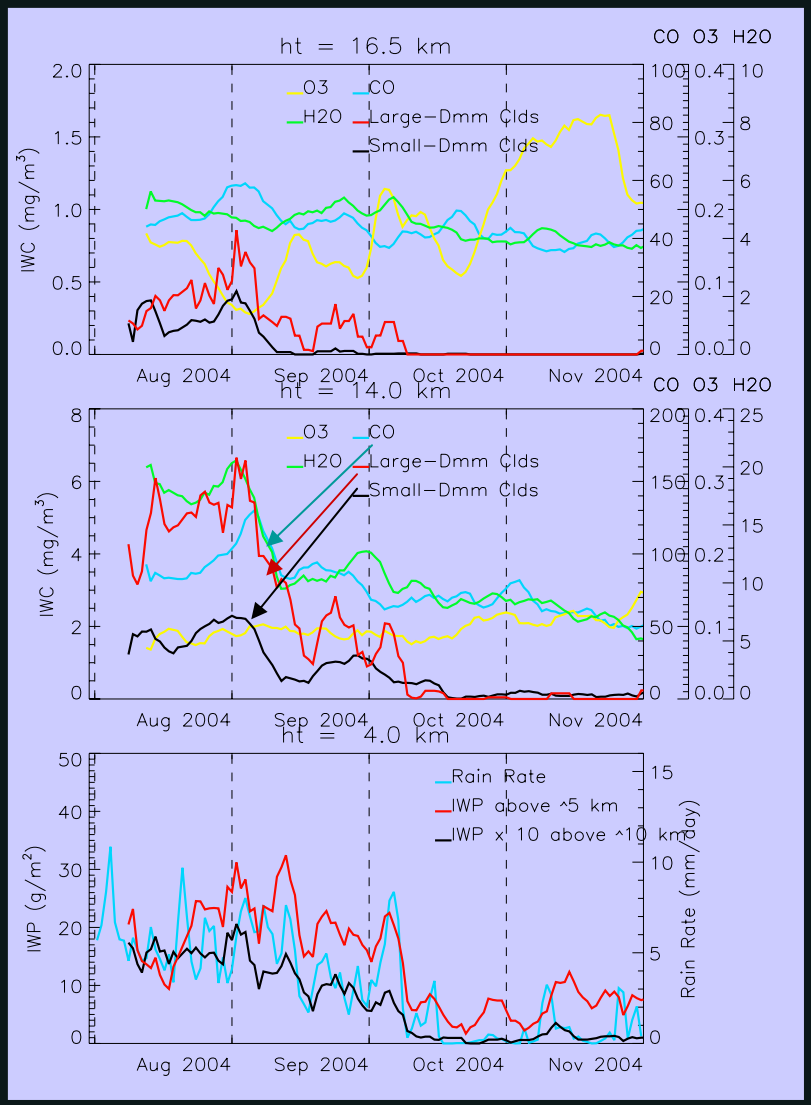
Temperature
Cold regions at 100 hPa over South Asia and Indonesia

H_2O
Enhancements at 147 hPa in the regions similar to CO but not at 100 hPa

O_3
Low values at 100 hPa in the regions similar to Temeprature

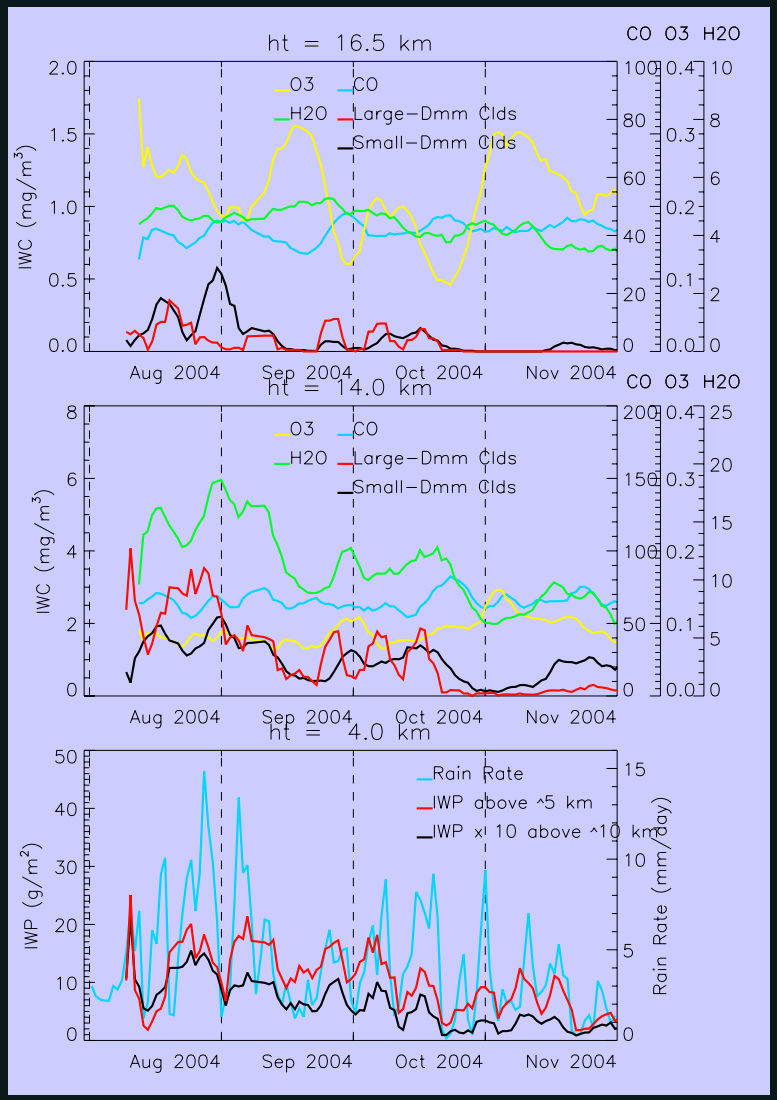


Southern China



- Slow buildup but sharp dropoff in clouds
- CO and O3 anti-correlation at 100mb
- CO lag H2O/Cloud peaks
- Rainfall/Low cloud lag high cloud peaks

East China Sea and Japan

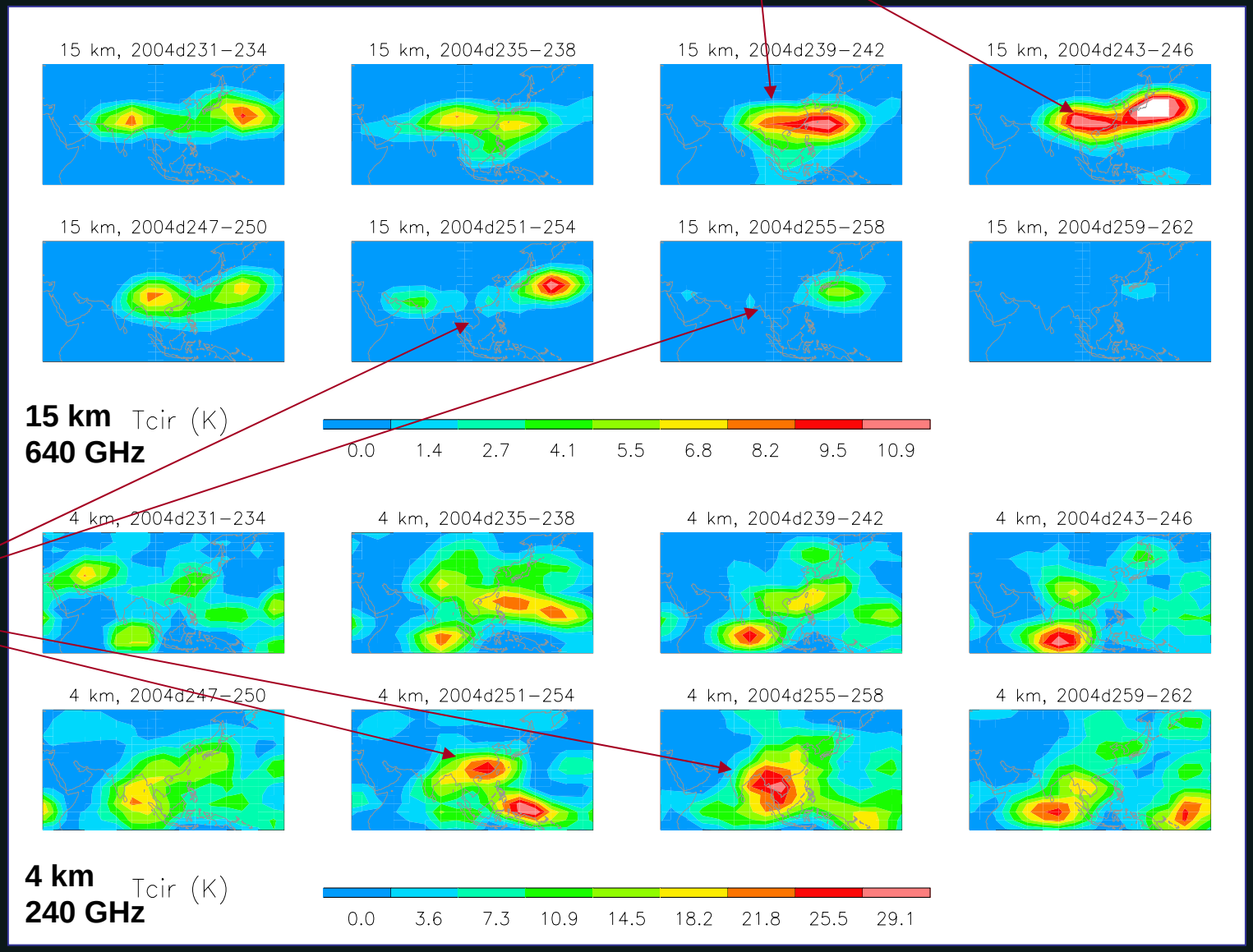


- Same rates in cloud buildup and dropoff
- CO and O3 anti-correlation at 100mb
- Weak CO and H2O/Cloud correlation
- Rainfall/Low cloud correlated with high clouds

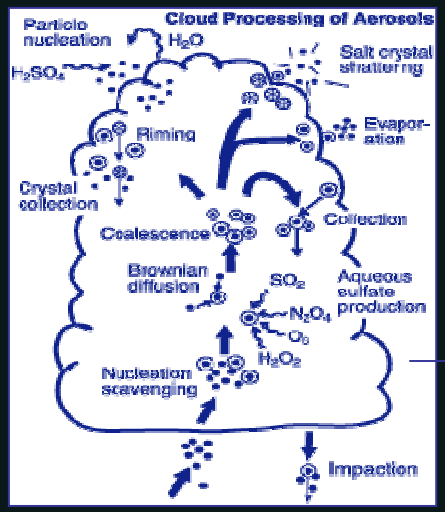
Cloud variations over Asia
(18 Aug-18 Sep 2004)

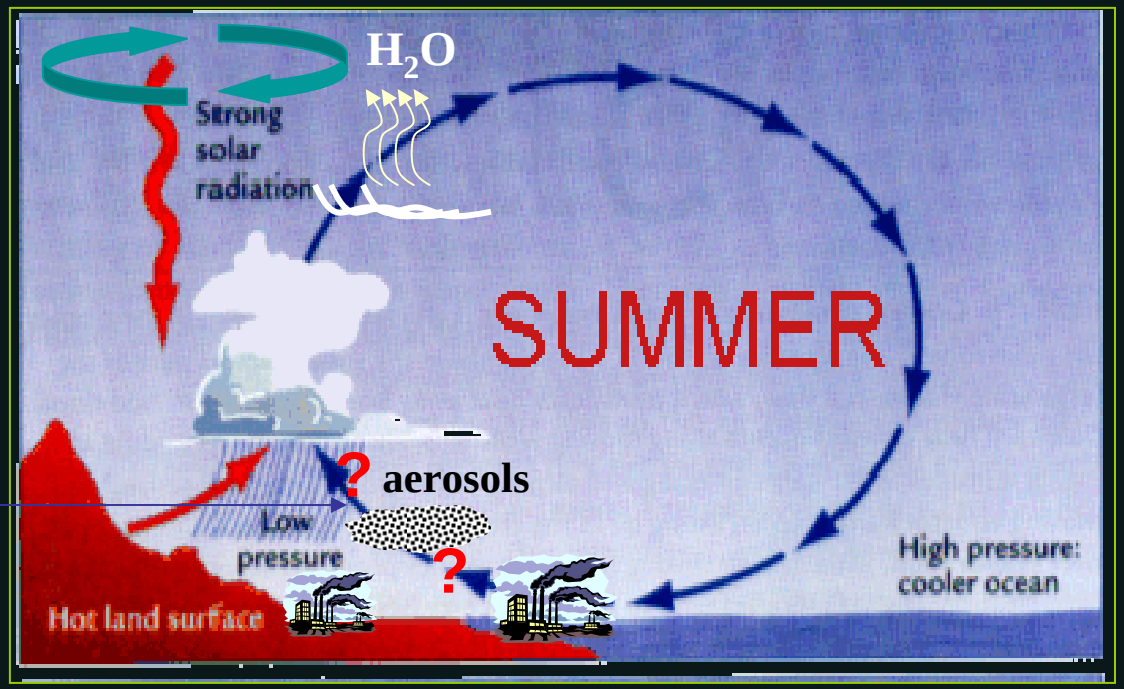
Accumulating dense cirrus

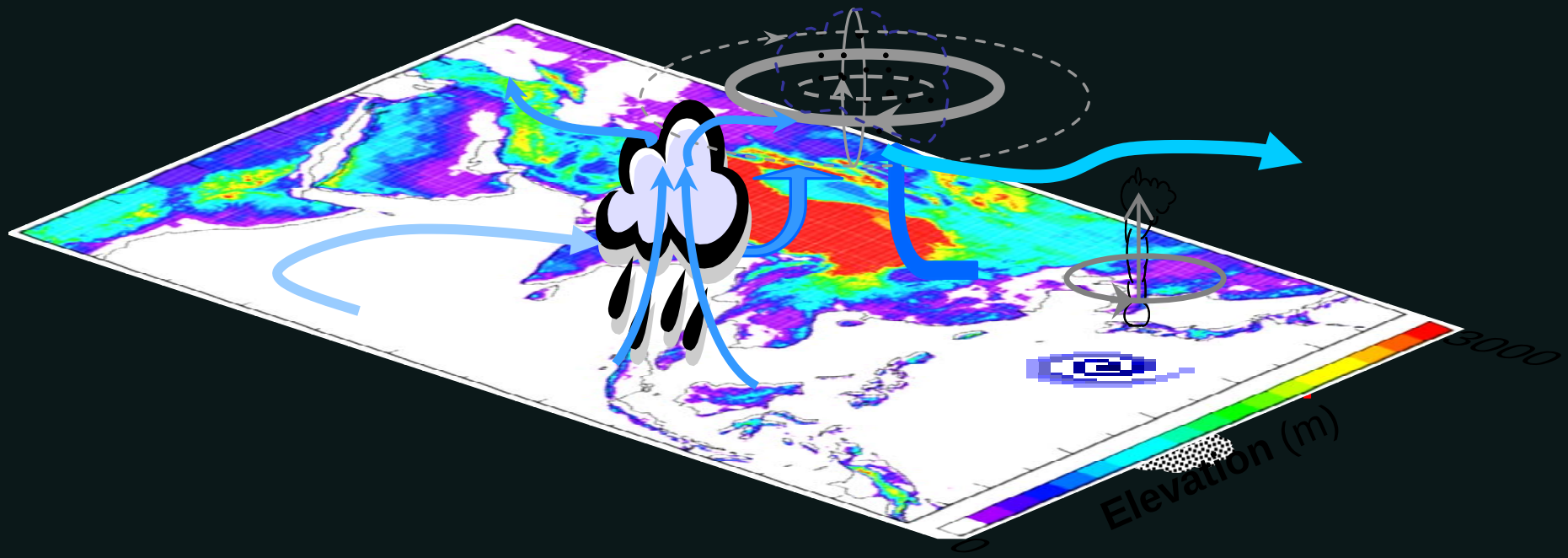
Rainout & Fall

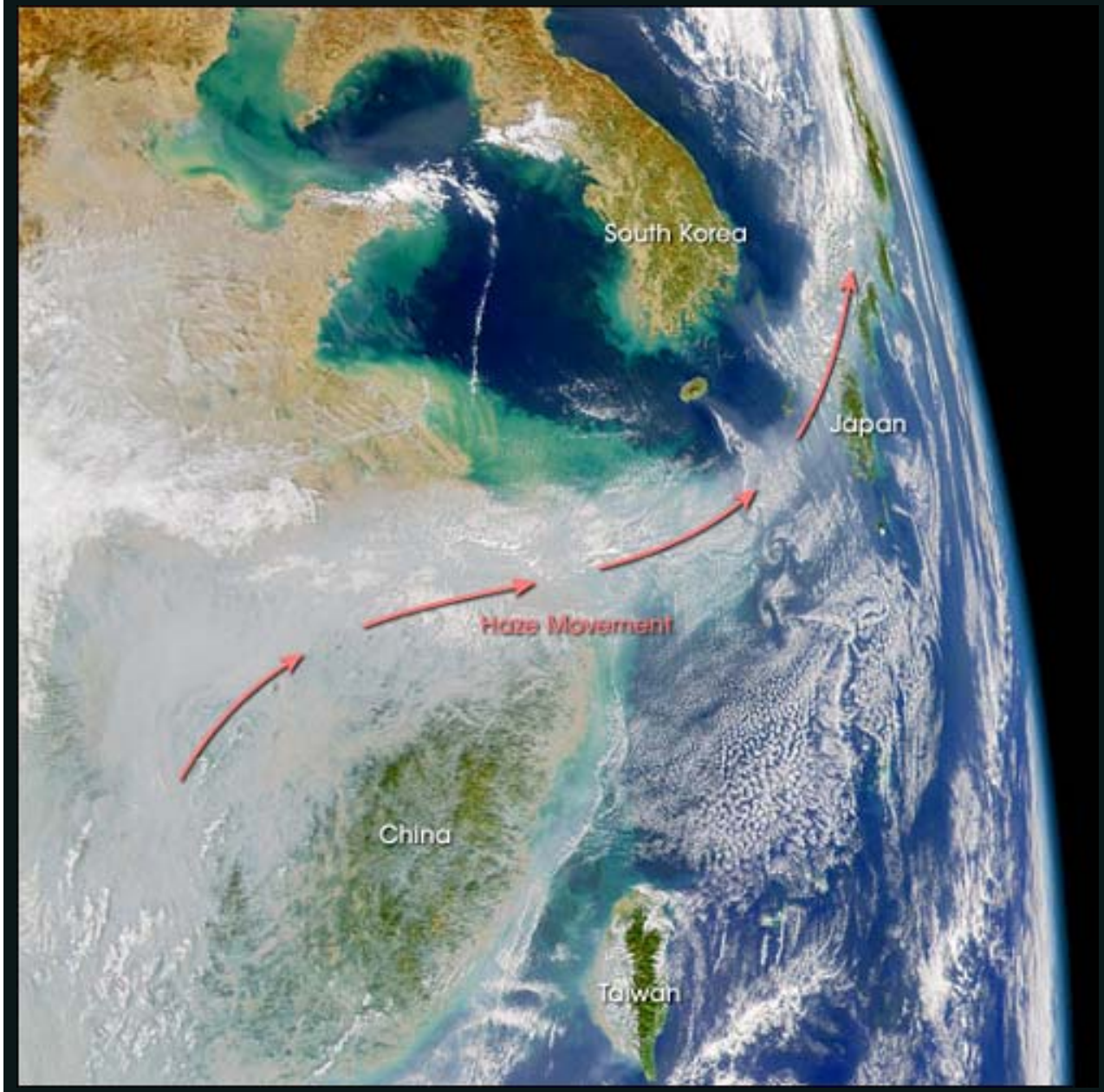


Aerosol-Cloud Interactions: Chemistry and Dynamics









Credit: NASA Earth Observatory

- Aerosol-cloud interactions?
  sources, sinks
  transport, properties
- Radiative effects?
  heating vs. cooling
- Hydrological effect?
  drought vs. flooding
- Regional climate change?
  health, warming

Summary

- MLS on Aura provides detailed observations on interactions between high clouds and pollution over Asia.

- Polluted air is likely to hold more water and delay rainfall over southern China by modifying cloud properties in both the lower and upper troposphere.

- Aerosol-cloud interactions are complex and influenced strongly by monsoon and typhoon dynamics.

- Interplays among aerosols, clouds and rainfalls are key elements to the regional climate, but remain unclear at present.