Study of the Impacts of Dry Deposition Schemes in MCIPv2.3 on Deposition Velocity and Concentration of Gaseous Pollutants Using CMAQ

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Dry Deposition

- The transport of gaseous and particulate species from the atmosphere onto surfaces in the absence of precipitation.

- Factors:

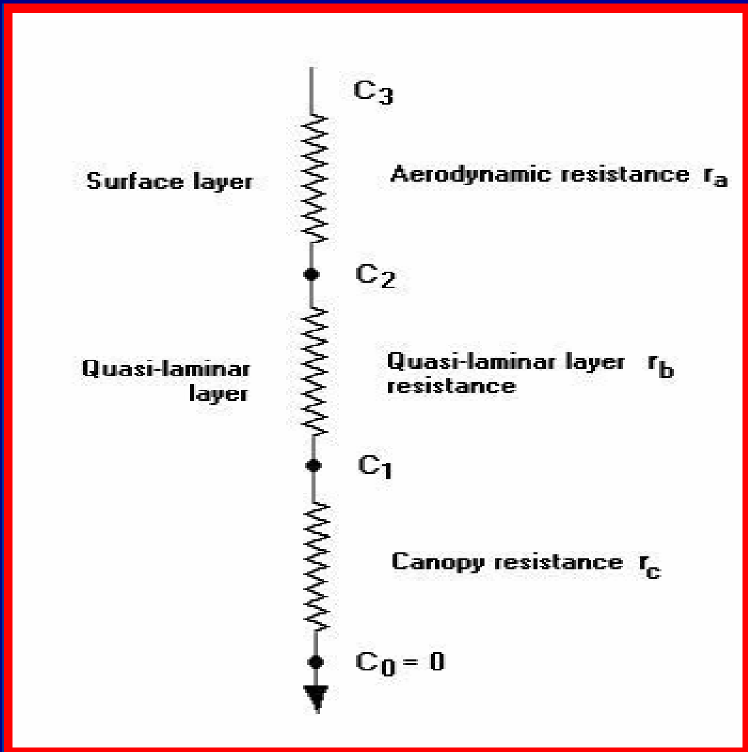
  a) Level of atmospheric turbulence
  b) Chemical properties of depositing species
  c) Surface characteristics

- $F = -V_d \times C$

- Resistance model

  $V_d = (R_a + R_b + R_c)^{-1}$

R_a - aerodynamic resistance
R_b - quasi laminar layer resistance
R_c - canopy resistance



Motivations

- Change in V_d can cause O_3 concentration variations upto 20%. (*Olerud et al., 1997*)

- Dry deposition study important for the Southeast Texas region.

- Two dry deposition schemes in CMAQ v4.4

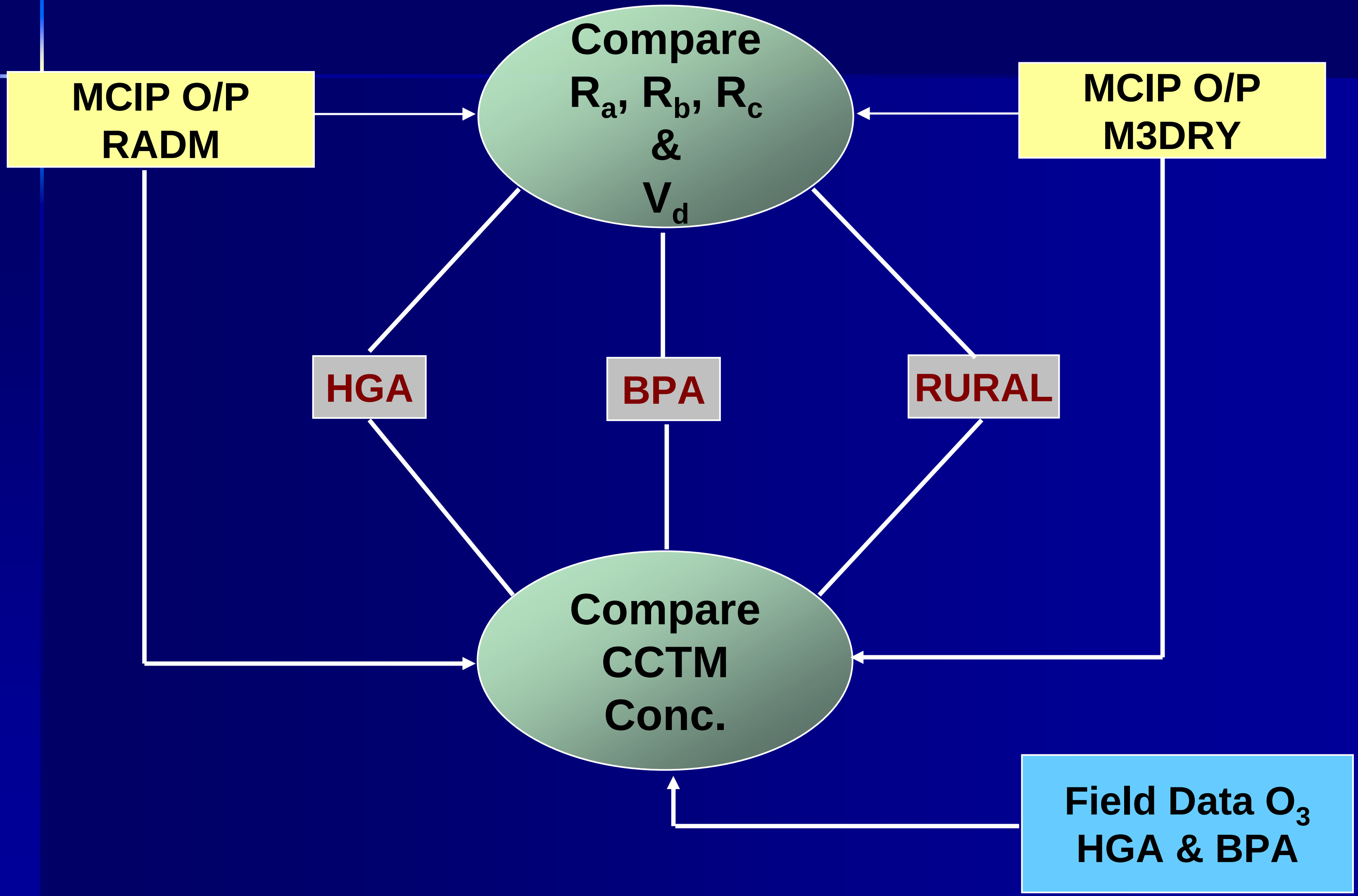
a) RADM (*Chang, 1987; Wesely, 1989*)

b) M3DRY (*Pleim and Xiu, 2001*)

Objectives

- Compare the significance of R_a, R_b, and R_c in the urban and rural regions of Southeast Texas.
- Analyze the differences between dry deposition velocities (V_d) computed by RADM and M3DRY schemes, and its impacts on the gaseous pollutant concentrations.
- Determine a suitable dry deposition scheme for the Southeast Texas region.

Methodology



Canopy Resistances

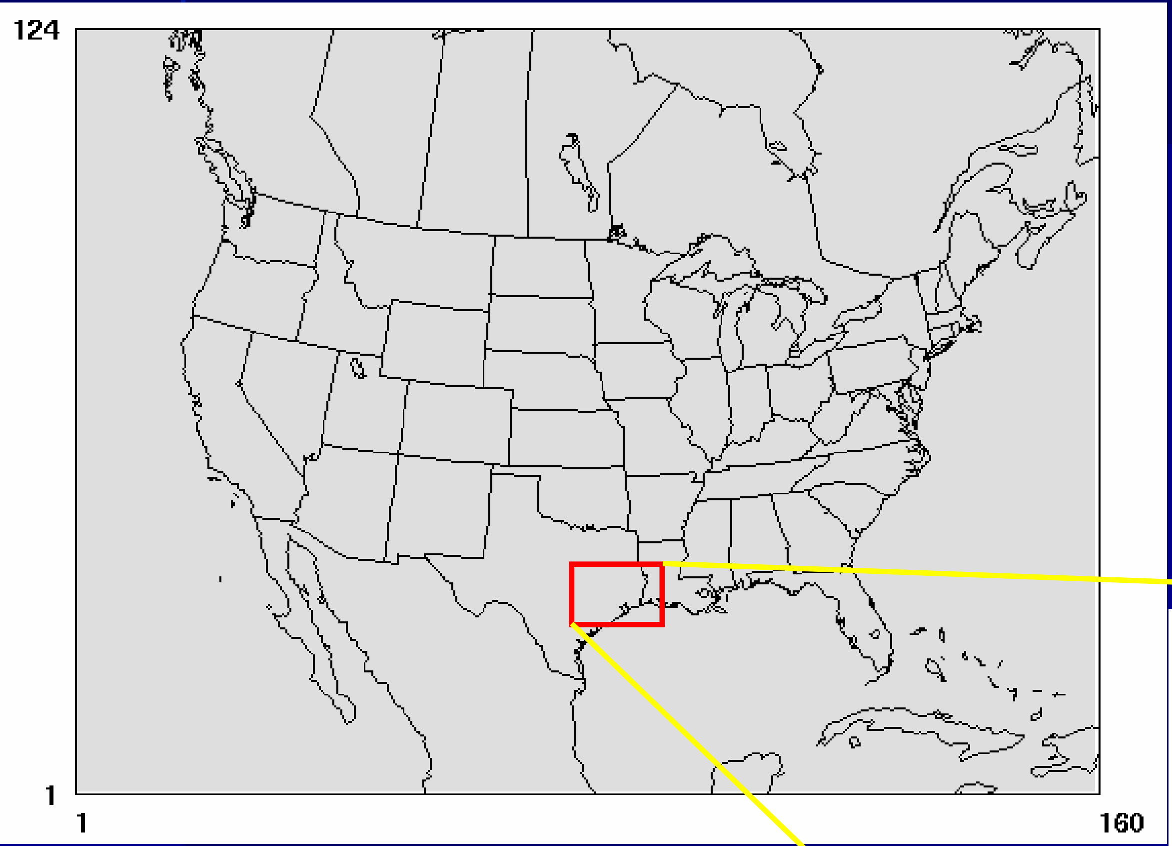
RADM

- 11 landuse categories.
- Soil moisture kept constant for a given season.
- Reactivity compared to that of O_3 (f_{ox}= 0, 0.1, 1.0).
- Resistance calculated based on physical properties or from look-up tables.

M3DRY

- Dynamic solar radiation values and soil moisture from MM5PX.
- a) 1-cm surface layer b) 1-m root layer.
- r_{st} parameterized by a) Root zone soil moisture b) T_{air} and RH c) PAR d) LAI and r_{stmin}.

Domain

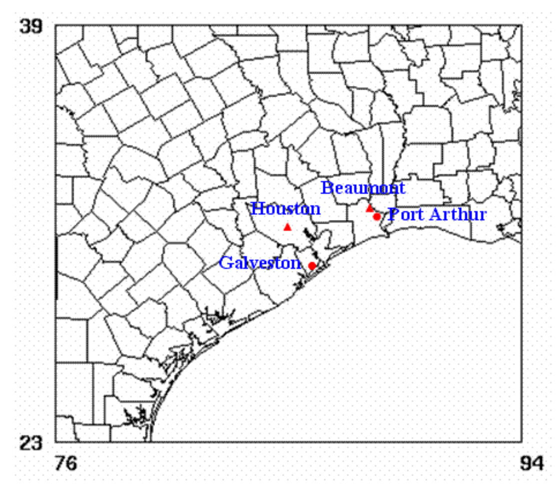


36km CONUS Domain

- Lambert Conformal Conics
- Domain center: 97 ^{0}W, 40 ^{0}N
- Vertical Layers: 21

Analysis domain

- BPA- 4 grids
- HGA- 6 grids
- Rural- 91 grids



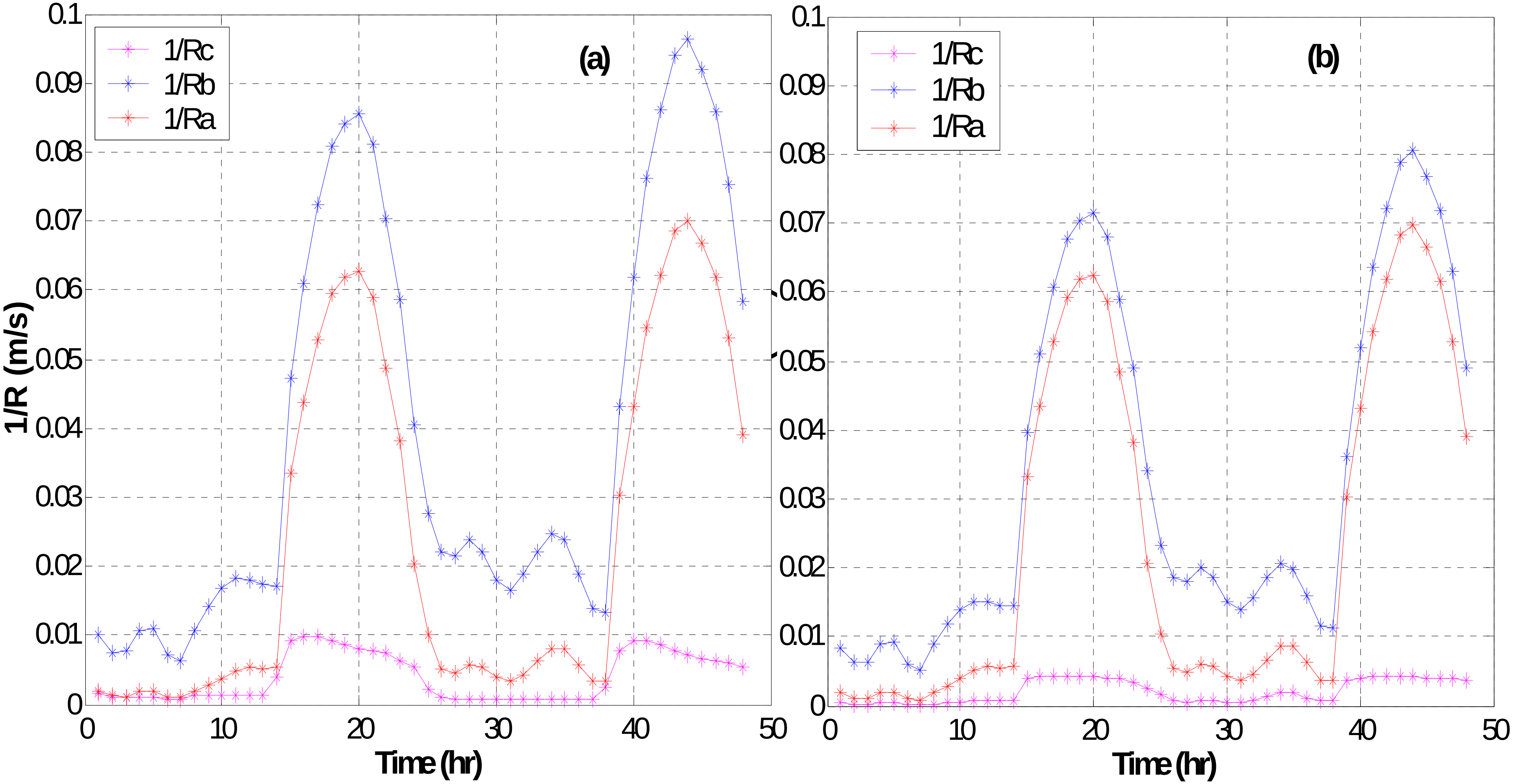
Models and Data

- September 13, 2002 & September 14, 2002
- Emissions inventory: NEI99 Final version 3
- Meteorological model: MM5PX
- Spatial allocator: MIMS*β*
- Emissions modeling: SMOKE v2.1
- Meteorology Chemistry Interface Processor: MCIPv2.3
- Chemical transport model: CMAQv4.4
- Chemistry mechanism: saprc99_ae3_aq

Results and Discussion

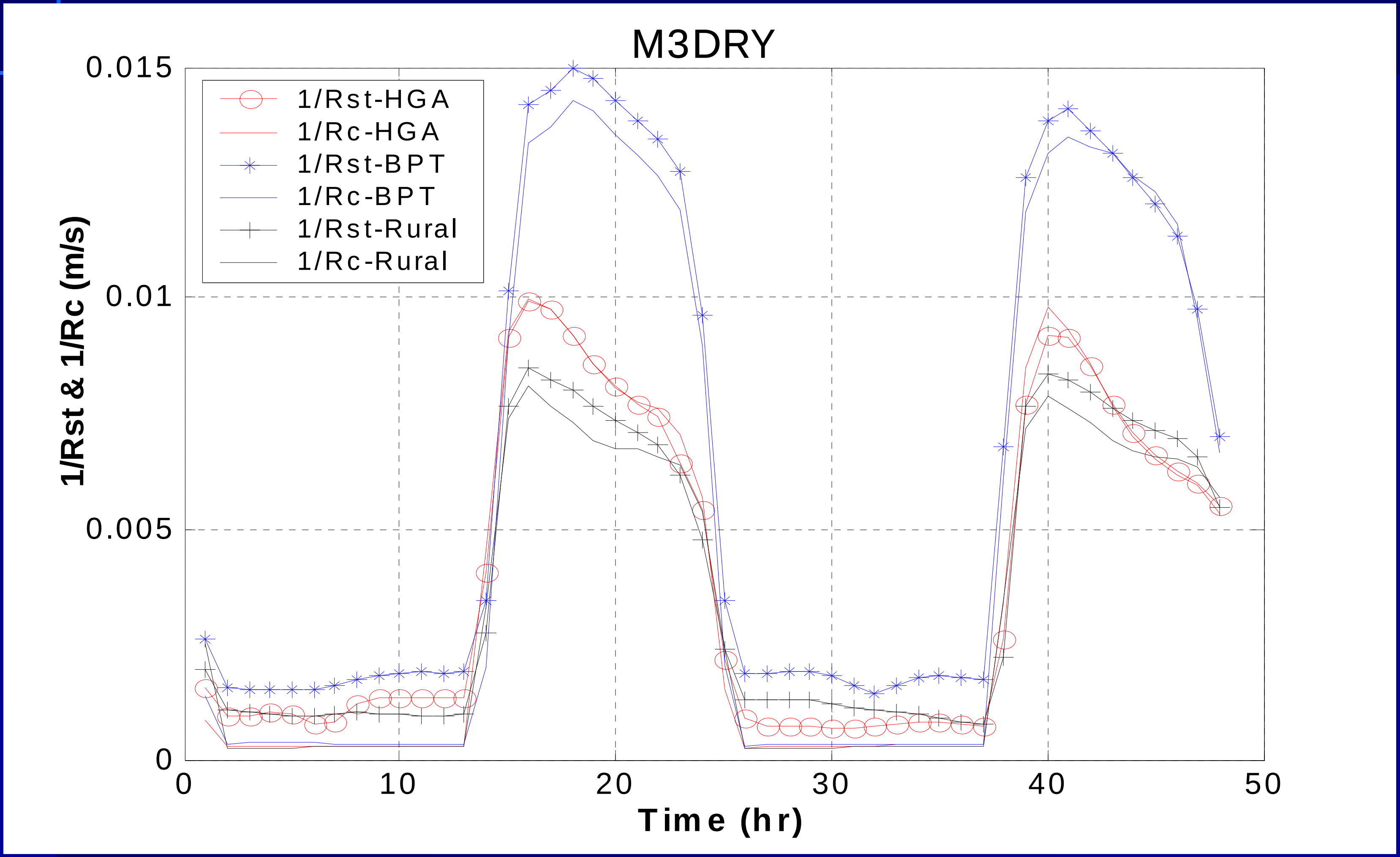
- Comparison among resistance terms in HGA, BPA, and Rural regions.
- Effect of deposition velocities on pollutant concentrations.
- Flux values of the pollutants.
- Statistical analysis for O_3.

HGA



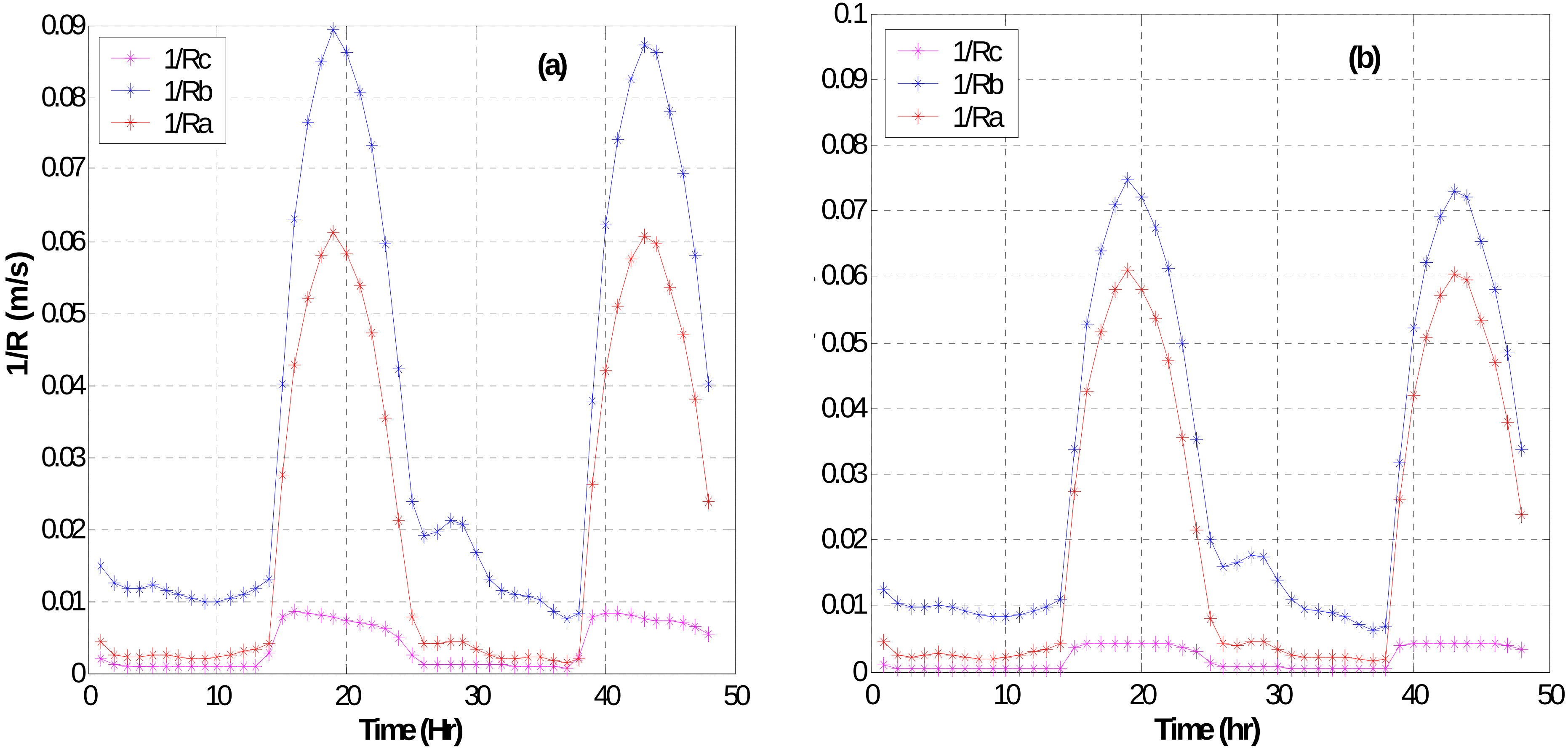
Conductances from a) M3DRY, and b) RADM for O_3

Canopy Conductance



Canopy Conductance for M3DRY in HGA for O_3

Rural Region



Conductances from a) M3DRY, and b) RADM for O_3

Gaseous Species

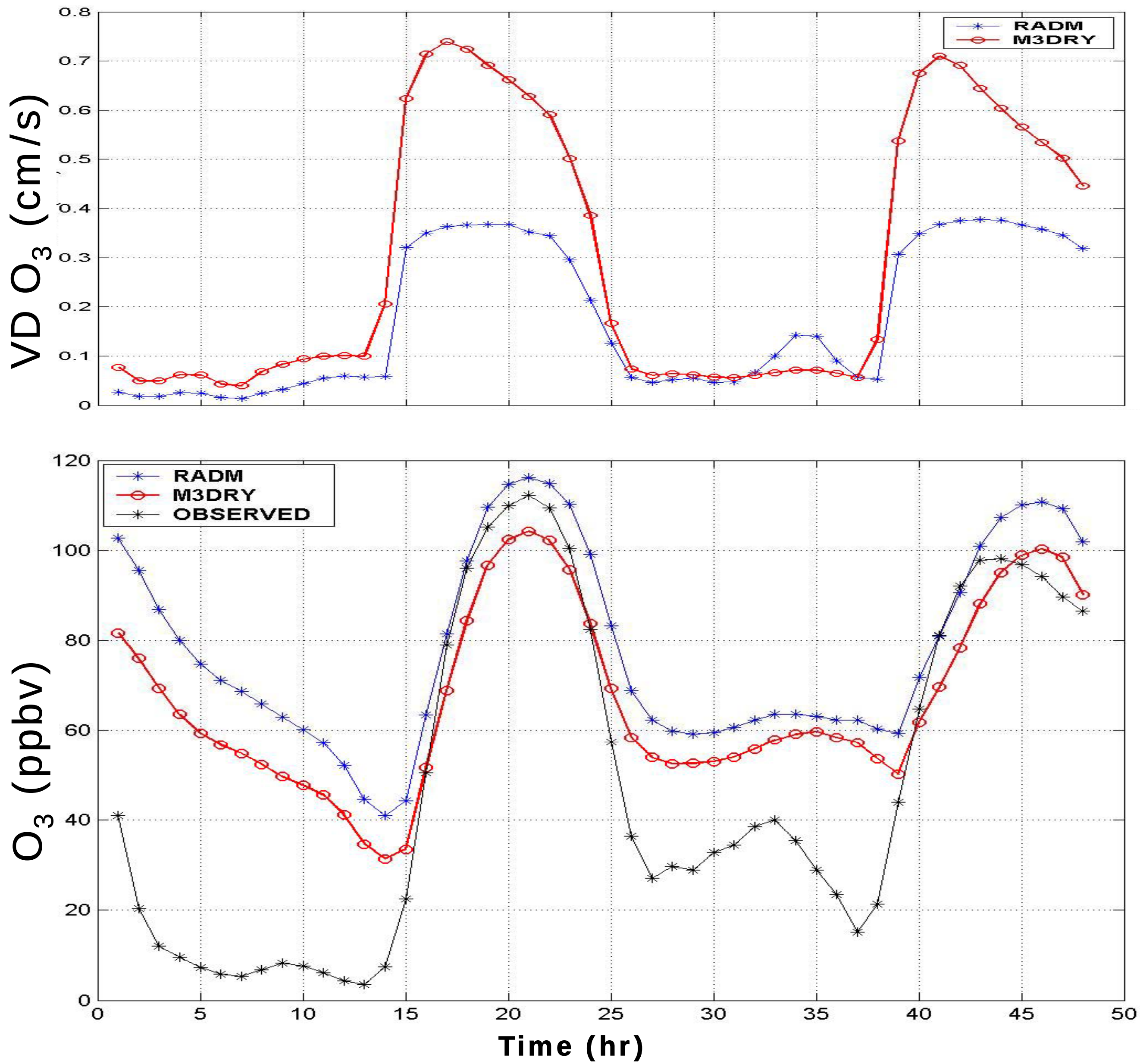
Primary importance:

- Ozone
- Nitric oxide
- Nitrogen dioxide
- Nitric acid vapor
- Peroxyacetyl nitrate
- Hydrogen peroxide
- Ammonia

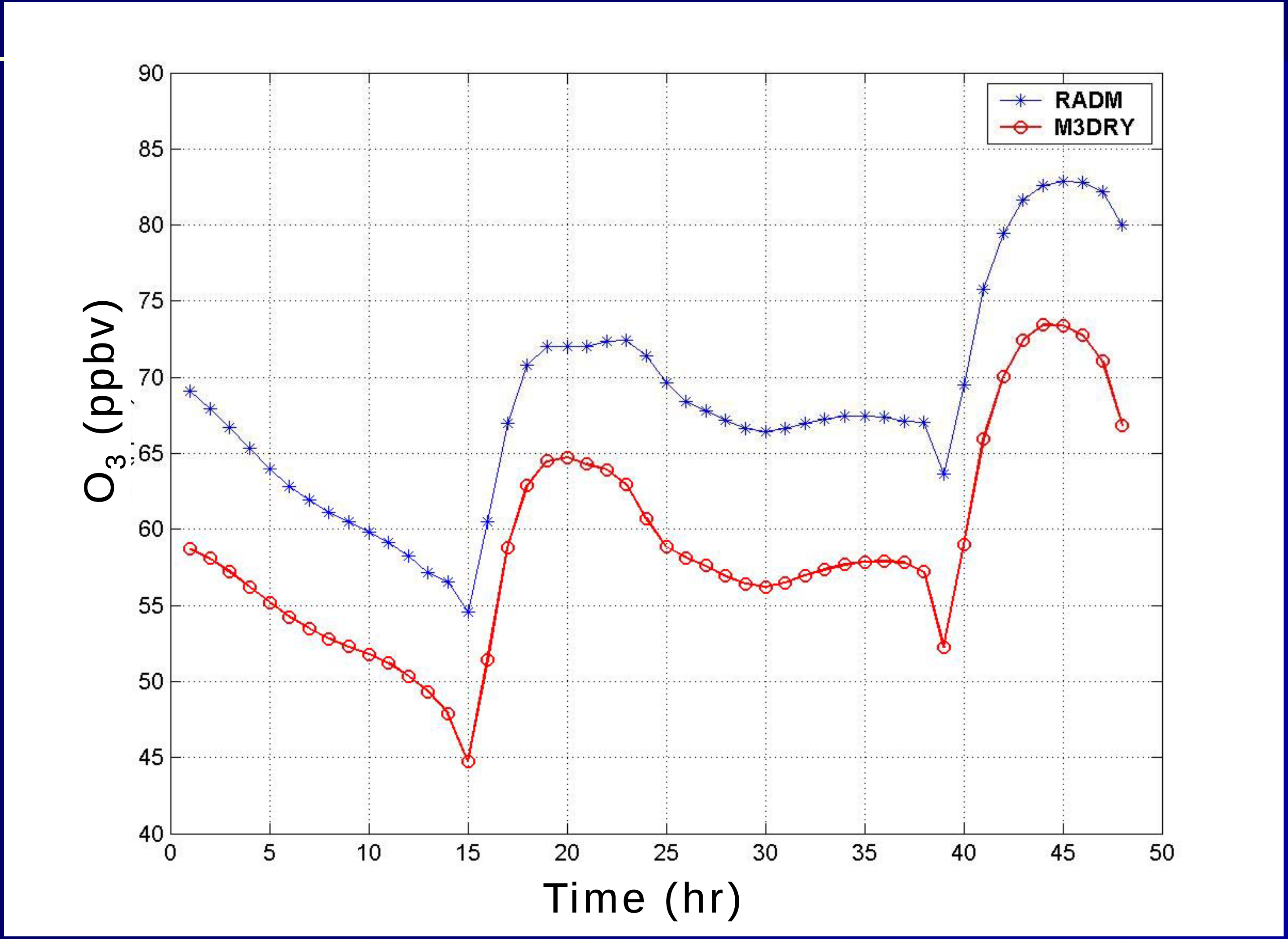
Secondary importance:

- Formaldehyde
- Acetaldehyde
- Dinitrogen pentoxide
- Sulfur dioxide
- Nitrates
- Carbon monoxide
- Nitrous acid
- Sulfate
- Formic acid
- Methyl hydroperoxide
- Peroxyacetic acid
- Methanol
- Generic aldehydes

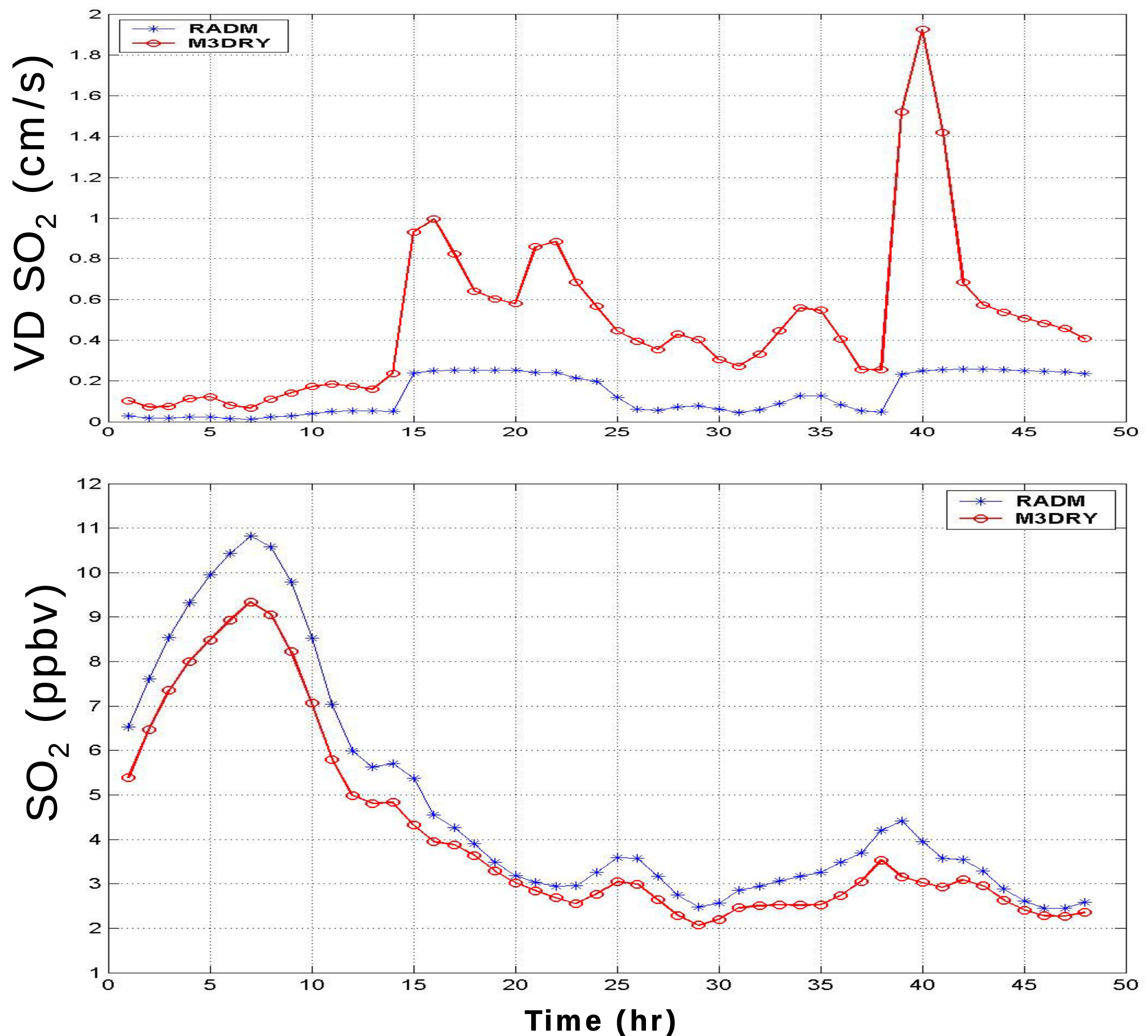
Ozone Profile in HGA



Ozone in Rural Region



SO_2 Profile in HGA



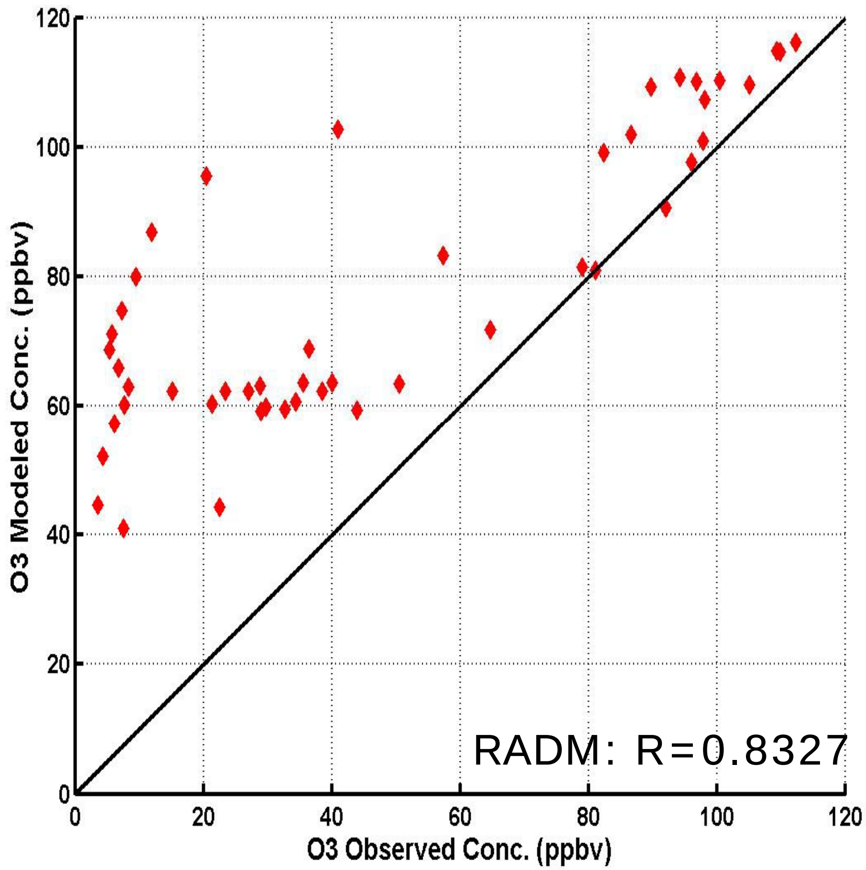
Daily Average Fluxes

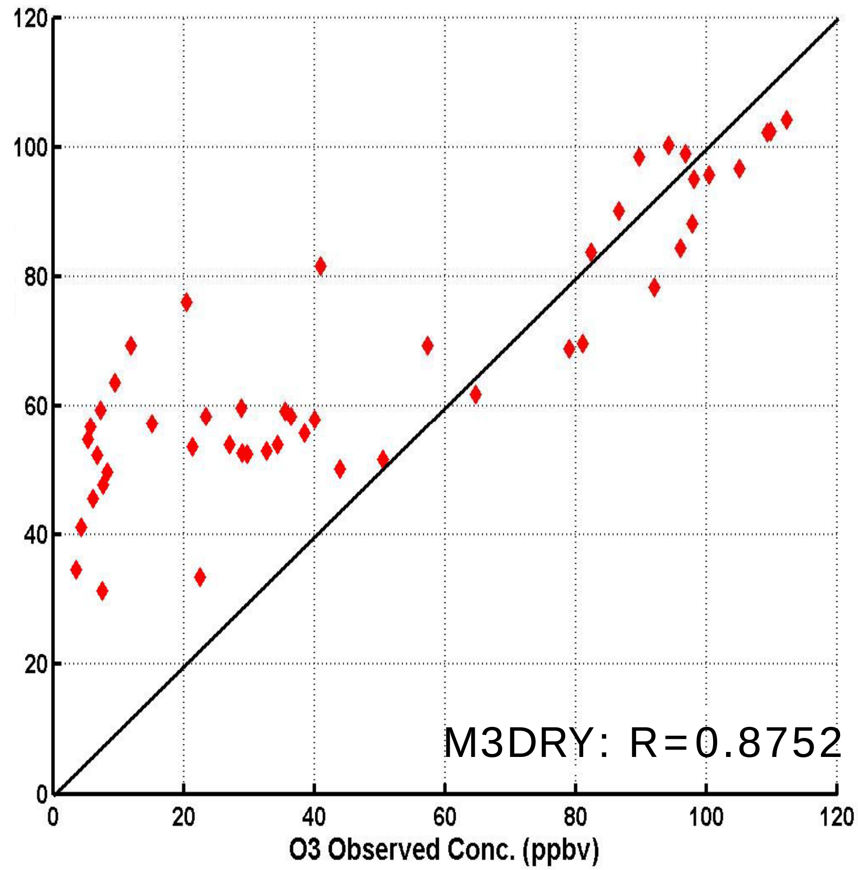
Species	HGA		BPA		RURAL	
	RADM	M3DRY	RADM	M3DRY	RADM	M3DRY
O_3	**1.012**	**1.565**	**0.993**	**1.786**	**0.773**	**1.111**
NO_2	0.025	0.142	0.019	0.106	0.005	0.021
SO_2	0.050	0.141	0.056	0.136	0.022	0.052
H_2O_2	0.027	0.054	0.030	0.053	0.027	0.045
HNO_3	0.4823	0.4620	0.185	0.180	0.105	0.099

September 13, 2002

Units are in kg km^{-2} hr^{-1}

Analysis of O_3 in HGA





Conclusions

- During day-time dry deposition is governed by R_c, and during night-times it is governed by both R_a and R_c for the regions selected.
- V_d differences of 0.4 cm/s (O_3) forces an average concentration difference of 12 ppbv and 10 ppbv for urban and rural areas.
- Daily average dry deposition flux for O_3 from M3DRY is 1.5 times that of RADM for HGA and Rural.
- M3DRY compares more closely to the observed ozone levels.