Methodology for Verification of Mesoscale Model Predictions and Analyses with Atmospheric Boundary Layer Profilers

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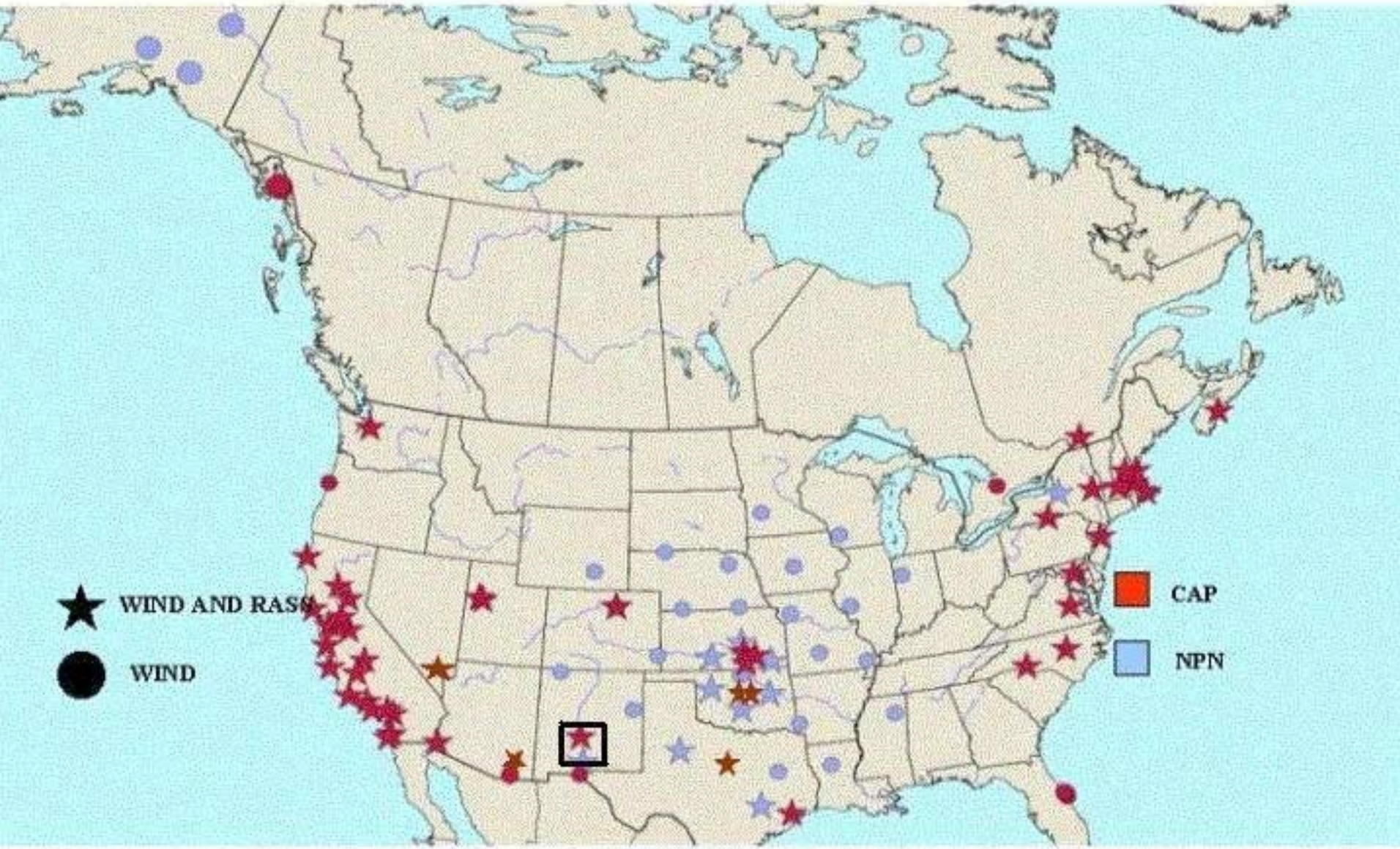
OUTLINE

- **Introduction**
- **Area of Study**
- **Modeling System**
- **Profiler Measurement System**
- **Analysis Procedure**
- **Results**
- **Summary and Conclusions**
- **Future Studies**

INTRODUCTION

- **Atmospheric circulations in complex terrain**
- **Help improve mesoscale modeling and forecasting of boundary layer structure**
- **Applications in air quality studies**

Cooperative Agency Profilers (CAP) with NPN Systems

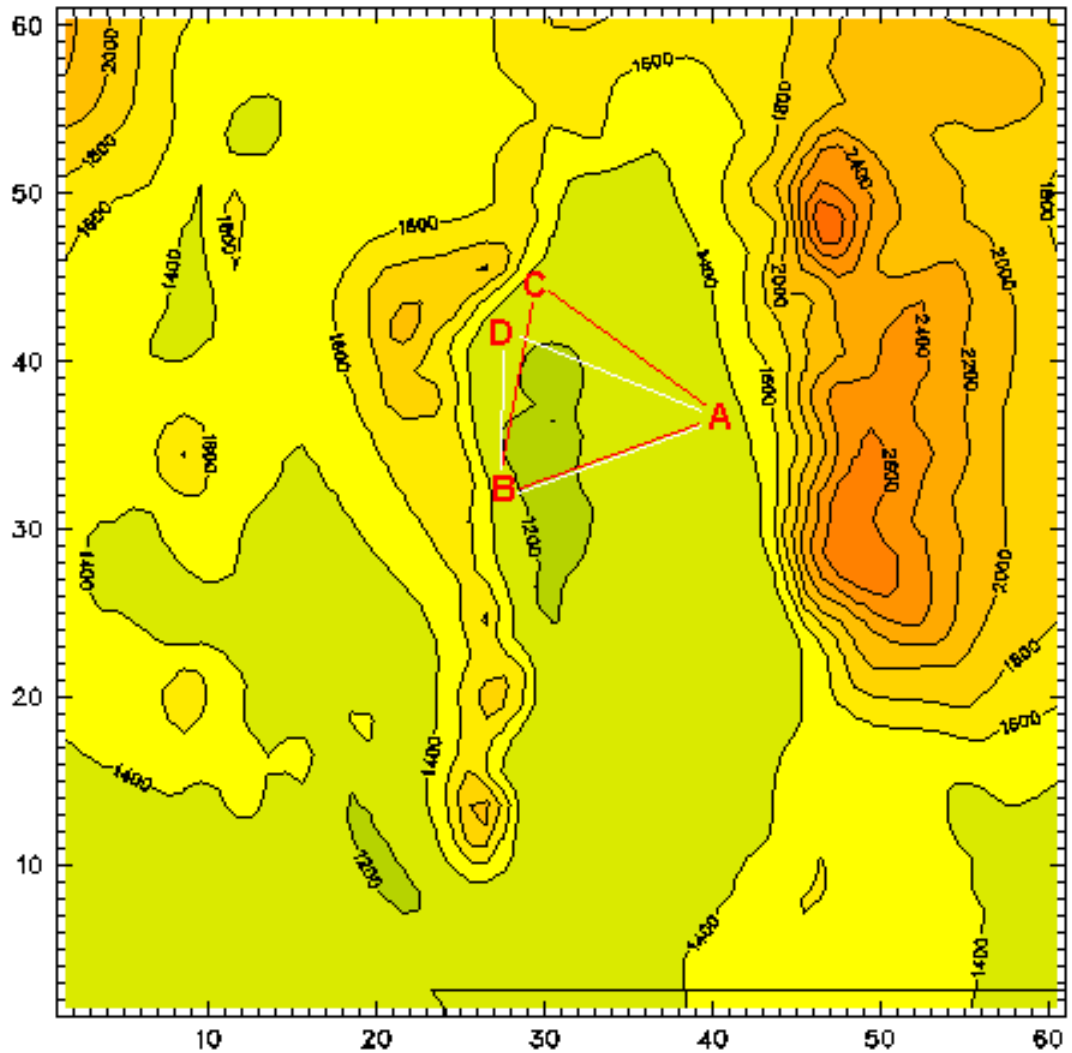


June 2004

MODELING SYSTEM

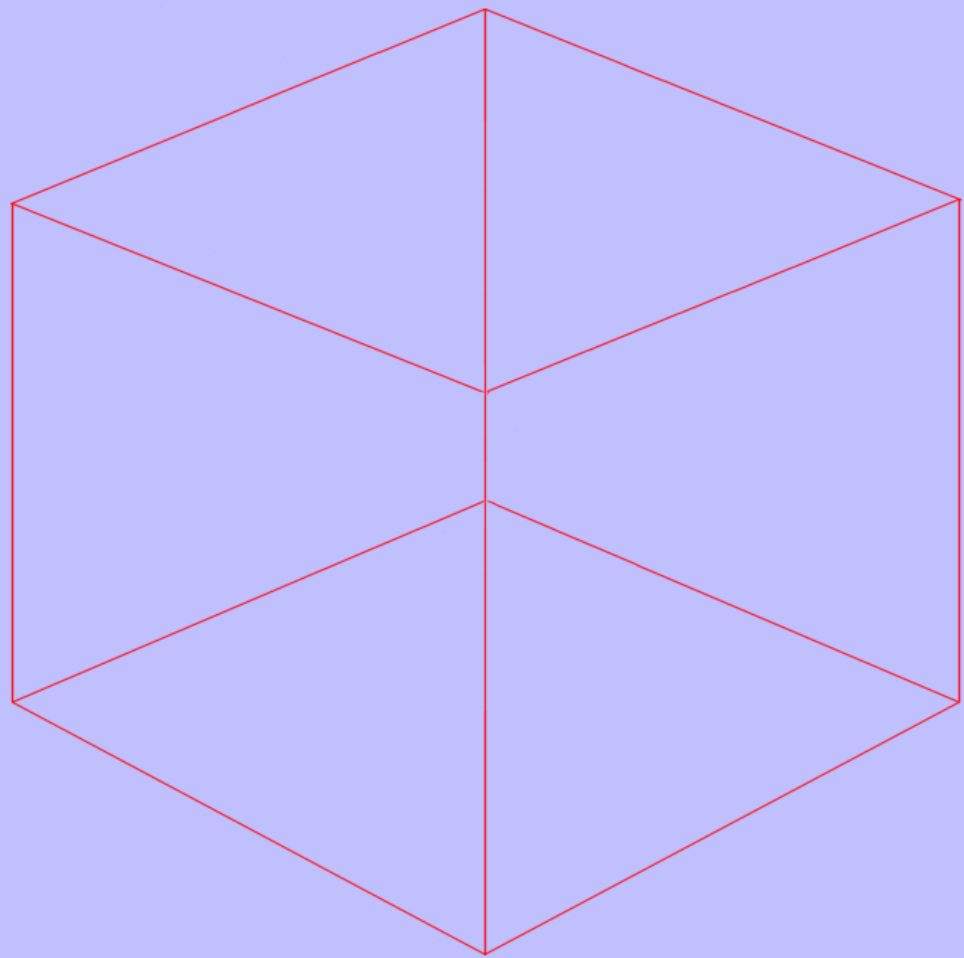
Penn State/NCAR Mesoscale Model Ver 5 (MM5) Four-Dimensional Data Assimilation (FDDA)

- Three Domains (30-, 10-, and 3.3 km grid spacing)
- Full physics with land surface model component
- Continuous Real-Time (RT)-FDDA with updated final analyses
- Data sources include automated mesonet surface stations & upper air measurements, satellite cloud motion vectors, 404-MHz profiler (924-MHz not included)

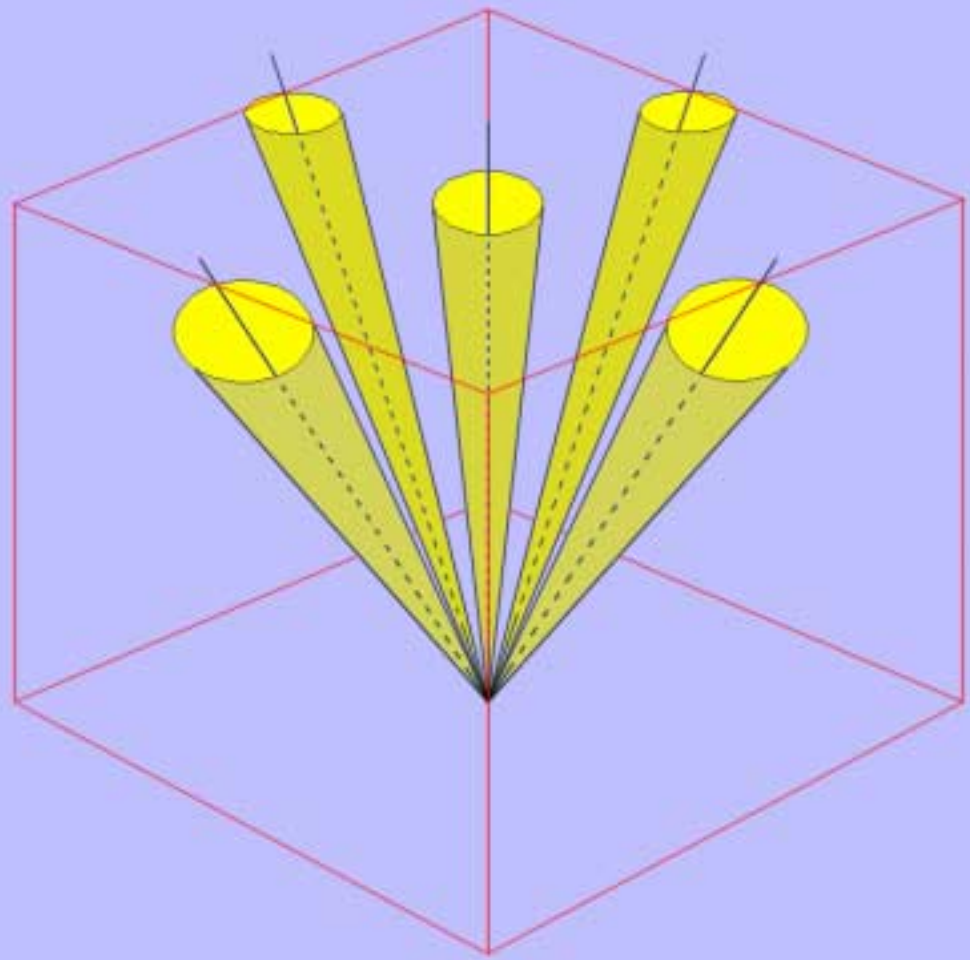

A
B
C
D
10
20
30
40
50
60

PROFILER MEASUREMENT SYSTEM

Quantity	Value
Frequency	924 MHz
Wavelength	0.331 m
Beam width	10^{o}
Configuration	3 beam
Beam directions	1 vertical & 2 orthogonal
Beam elevations	1 @ 90^{o} & 2 @ 66.4^{o}
Range resolution	55 m
Height of 1^{st} gate	124 m
Number of gates	54

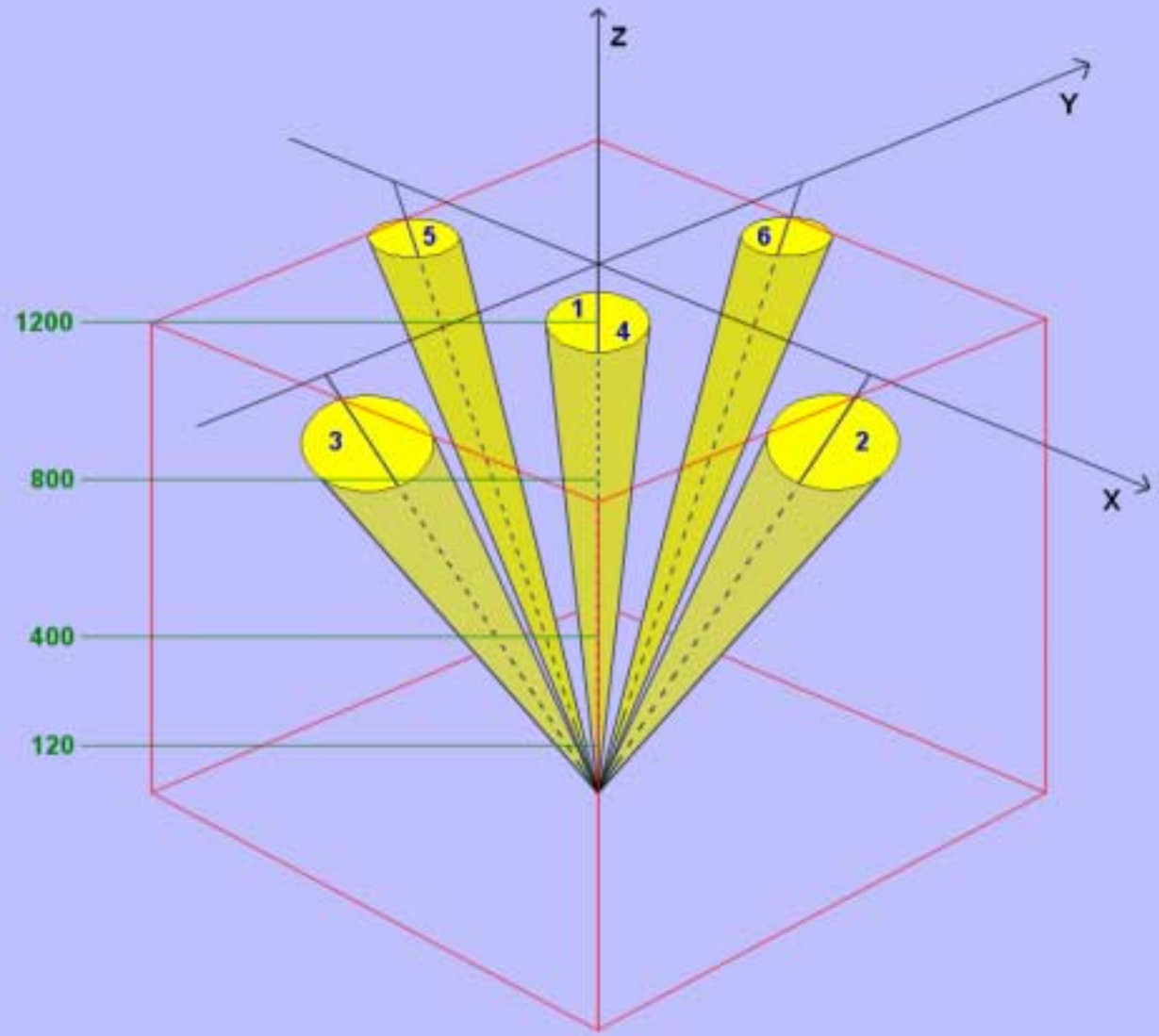


MM5/RT-FDDA
Grid Box



MM5/RT-FDDA
Grid Box

Profiler Beam
Configuration



MM5/RT-FDDA Grid Box

Profiler Beam Configuration

Model & Profiler

ANALYSIS PROCEDURE (model)

- **Domain 3 RT-FDDA output files (1-h)**
  - **U wind component***
  - **V wind component***
  - **W wind component**
- **Spatial Interpolation from Domain 3**
  - **Horizontal bi-linear to profiler locations**
  - **Vertical interpolated to 40 profiler measurement levels between 120 & 2000 m**

***coordinates may be rotated to align with airport runway or axis of mountain valley

ANALYSIS PROCEDURE
(profiler)

- **QC criteria for profiler measurements**
  - **Accepted when SN level > -20 dB**
  - **Deleted when magnitude W > 2 m s^{-1}**
  - **Deleted when consensus < 10 returns**

- **Averaged two 25-min periods in each hour**

ANALYSIS PROCEDURE
(40 subsets from model & profiler)

- **Computed Bias, Root-Mean-Square Differences (RMSD), & Corr. Coeff. for RT-FDDA output and profiler measurements**

- **Averaged Bias & RMSD into 3-h intervals & 5 vertical levels AGL**

120 – 400 m (*diurnal*)

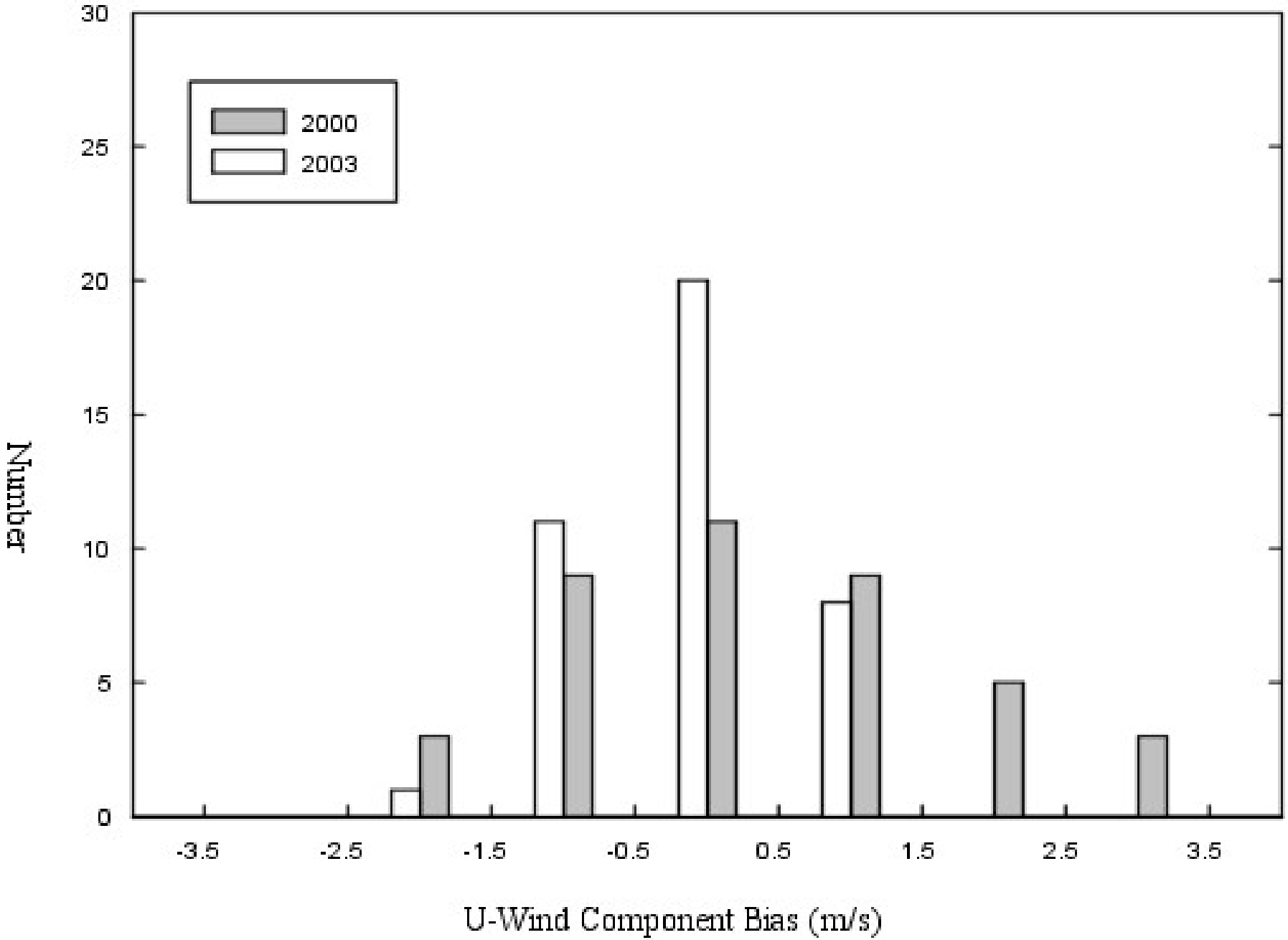
400 – 800 m (*diurnal*)

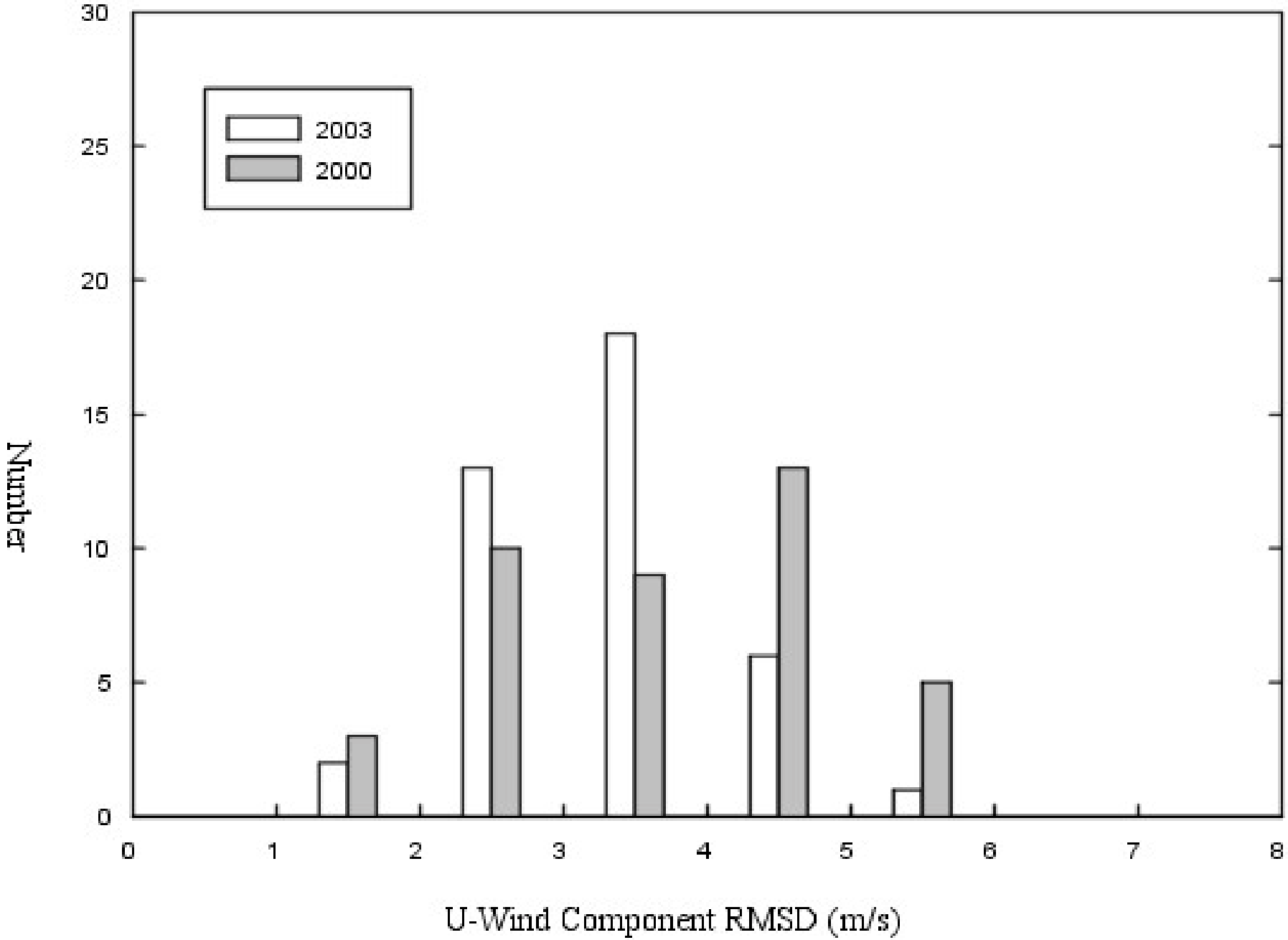
800 – 1200 m (*ridge top*)

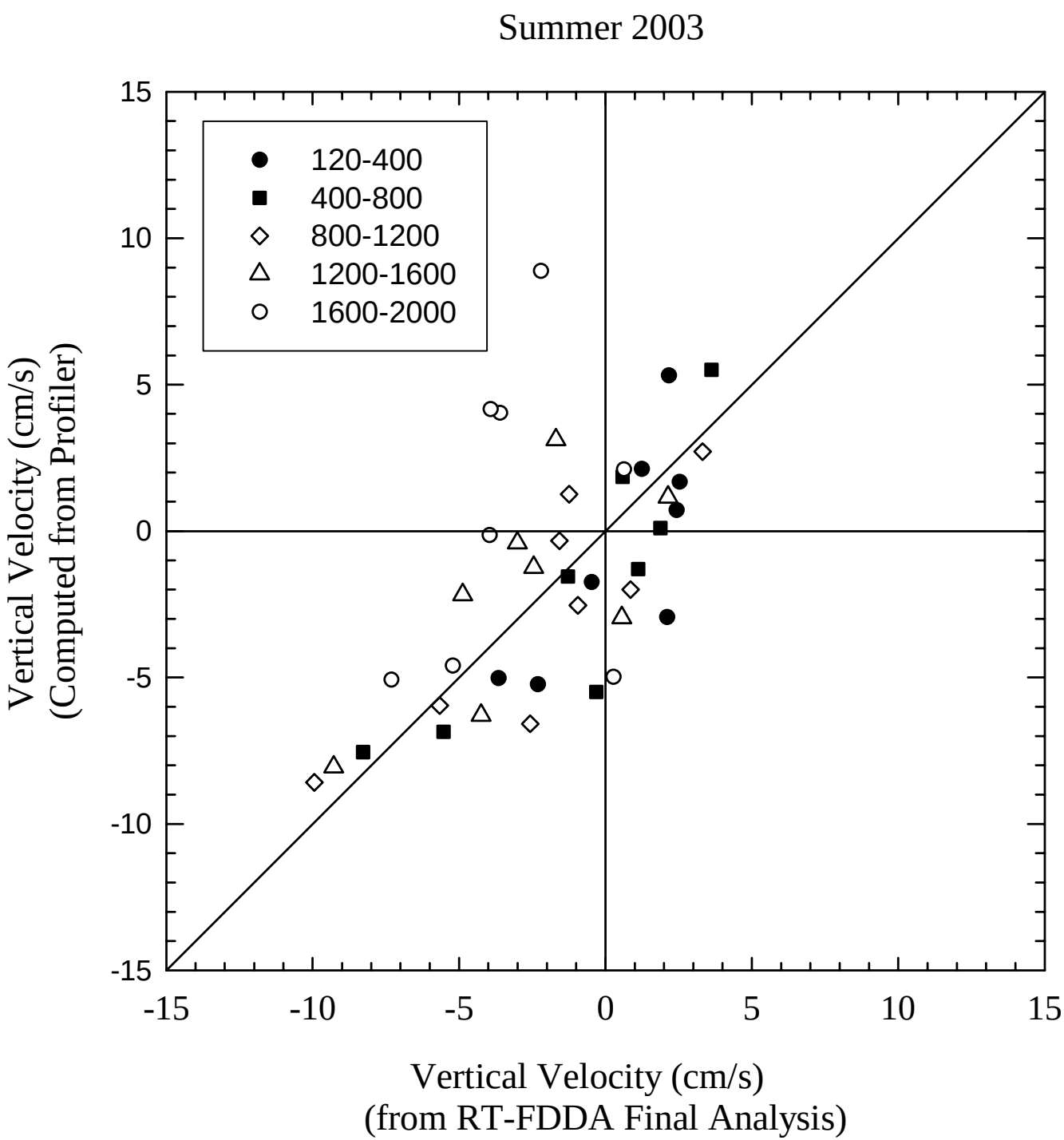
1200 – 1600 m (*transition*)

1600 – 2000 m (*ambient flow*)

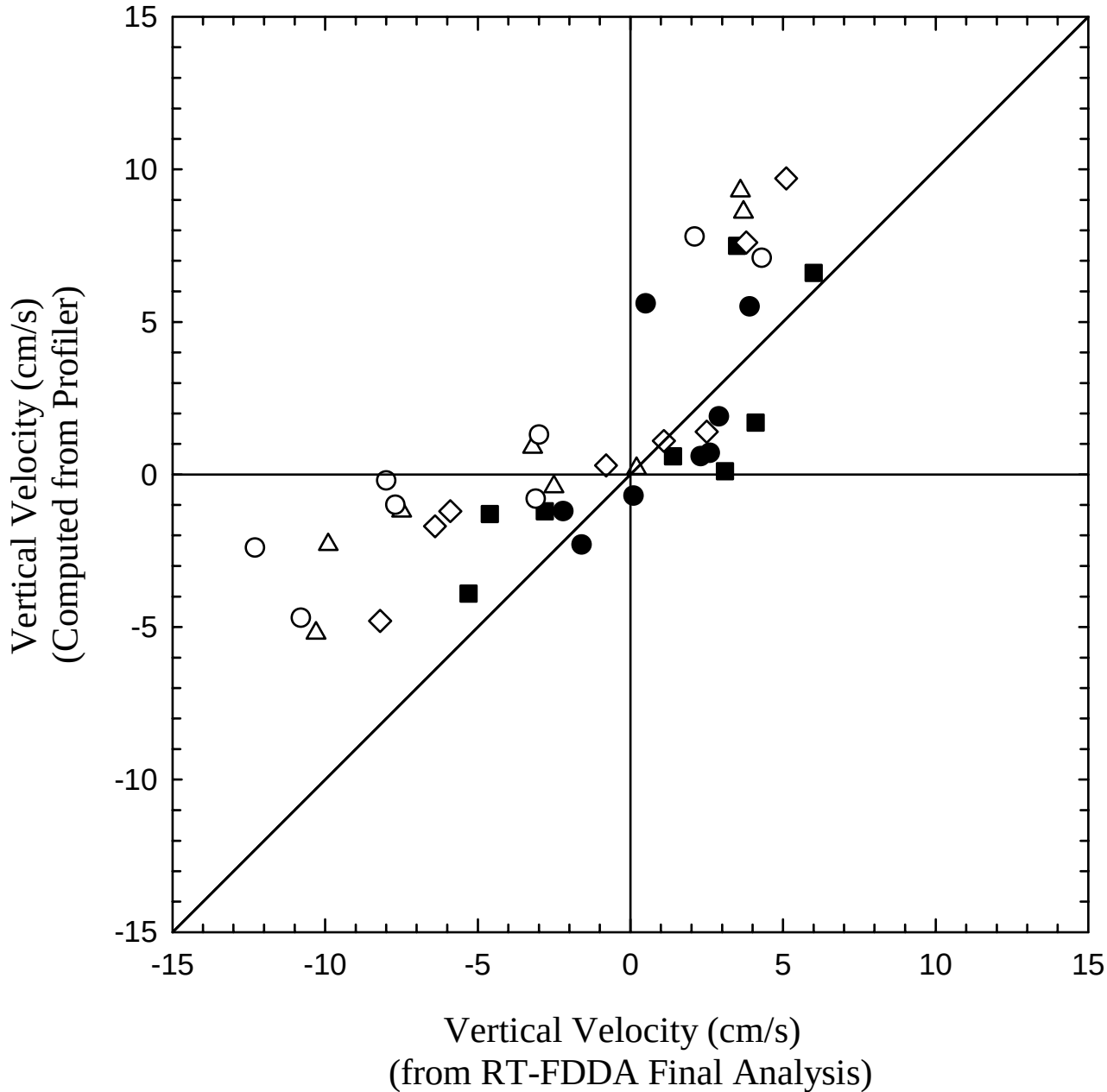
120 – 2000 m (*all layers*)


2000
2003
30
25
20
15
10
5
0
Number
-3.5
-2.5
-1.5
-0.5
0.5
1.5
2.5
3.5
U-Wind Component Bias (m/s)


2003
2000
Number
U-Wind Component RMSD (m/s)
0
5
10
15
20
25
30
0
1
2
3
4
5
6
7
8


Summer 2003
120-400
400-800
800-1200
1200-1600
1600-2000
Vertical Velocity (cm/s)
(Computed from Profiler)
Vertical Velocity (cm/s)
(from RT-FDDA Final Analysis)
15
10
5
0
-5
-10
-15
-15
-10
-5
0
5
10
15

Summer 2000


15
10
5
0
-5
-10
-15
-15
-10
-5
0
5
10
15
Vertical Velocity (cm/s)
(Computed from Profiler)
Vertical Velocity (cm/s)
(from RT-FDDA Final Analysis)

COMPARISONS WITH RESPECT TO HEIGHT
(linear correlation of vertical motions)

Level	Height (AGL)	Correlation
1	120 - 400 m	.57
2	400 - 800 m	.85
3	800 - 1200 m	.84
4	1200 - 1600 m	.79
5	1600 - 2000 m	.67

SEASONAL COMPARISONS
(linear correlation of vertical motions)

Season	All Hours	Without Transition Periods*
Summer 2000	.49	.53
Summer 2003	.70	.79
Fall 2003	.56	.70
Winter 2003-4	.68	.84

* Omitted 3-h times at sunset & sunrise

SUMMARY AND CONCLUSIONS

- **Atmospheric boundary-layer profiler provided an independent data source to carry out verification of the MM5/RT-FDDA final analyses**
- **The verification methodology used bias and RMSD statistics for subsets in eight different time periods and five different layers**
- **Results from subsets help identify times and levels for evaluating model performance**

FUTURE STUDIES

- **Develop strategy for locating boundary layer profilers in RT-FDDA model domain**
- **Investigate specific cases**
- **Include 3D wind fields from Doppler weather radar measurements**
- **Apply other statistical methods**