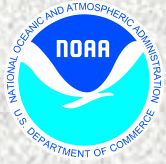
Use of Prognostic Meteorological Model Output in Dispersion Models

Eighth Modeling Conference
Research Triangle Park, NC



Current Approach for Meteorological Data Input

- NWS observation data
- NWS upper air soundings
- On-site data
- Parameters calculated from profiles

Proposed Approach for Meteorological Data Input

- Utilize met model data currently available
  - Regional applications and National rules
  - Data must be processed for dispersion modeling
- Model-ready input pre-processed
  - Default settings

Long-Term Goal for Meteorological Data Input

- Sub-regional dispersion model applications using inputs from regional grid model applications
- Real-time or forecasted dispersion modeling – may be in conjunction with similar regional grid modeling

Advantages to Modeled Meteorology Data

- Better geographical representation in many cases
  - More consistent upper-air representation
- More scientifically sound
- Accepted for other modeling (MM5) or by NWS
  - NWS updates and improvements

Advantages to Modeled Meteorology Data

- Consistent with regional modeling applications
- Less costly to develop for modeling
- Easier transition to real-time and forecasting applications
- Should be easier to use

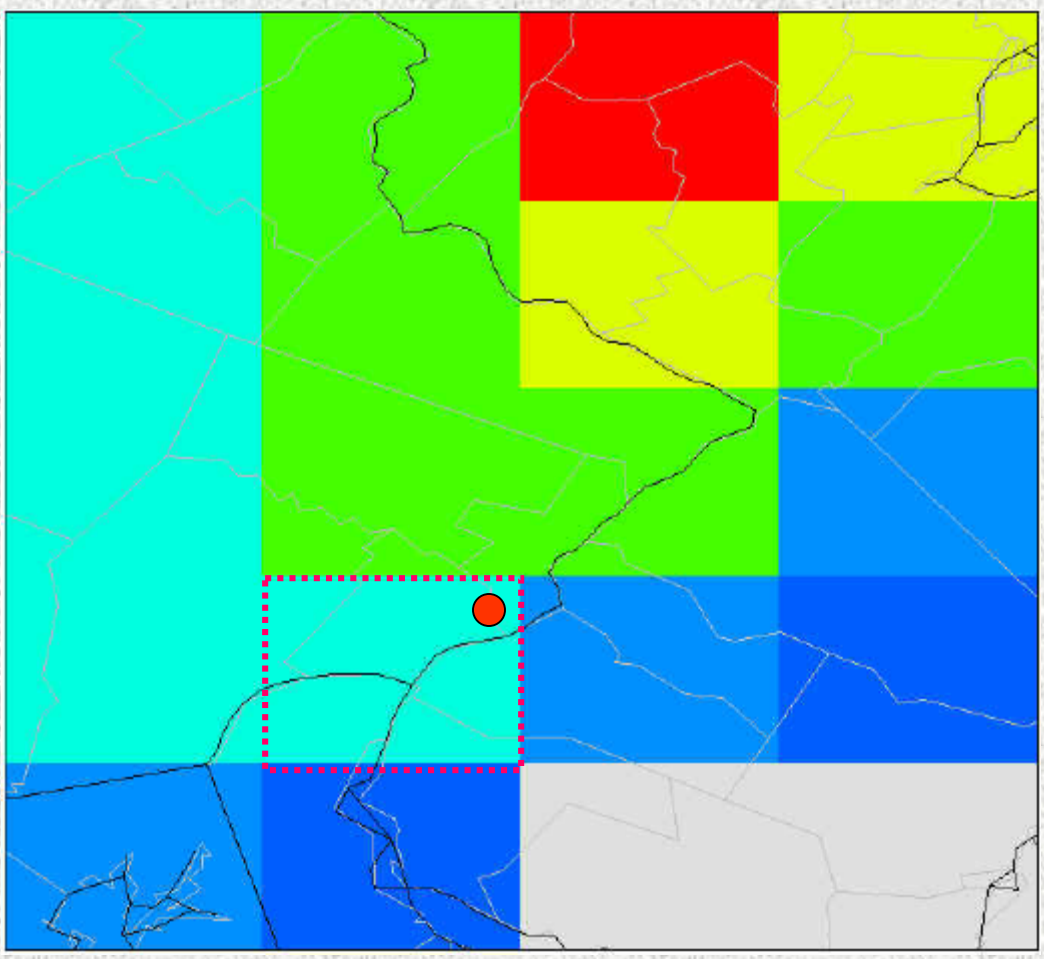
General Steps

- MM5 data into dispersion model
- NCEP product data into dispersion model
  - Build upon NCEP's Eta input into CMAQ for forecasting
  - Start with initialized fields, then move to forecast fields
- Evaluate every step of the way

Test Project – Philadelphia Benzene 2001

- Goal: To conduct an air quality model simulation using meteorological input exclusively from a prognostic grid model (MM5) as a simple replacement for NWS observation data at the same location.
  - Well-characterized emissions
  - Reasonable results from ISC and AERMOD
  - Corresponding MM5 output available

Philadelphia Domain from 36 km MM5



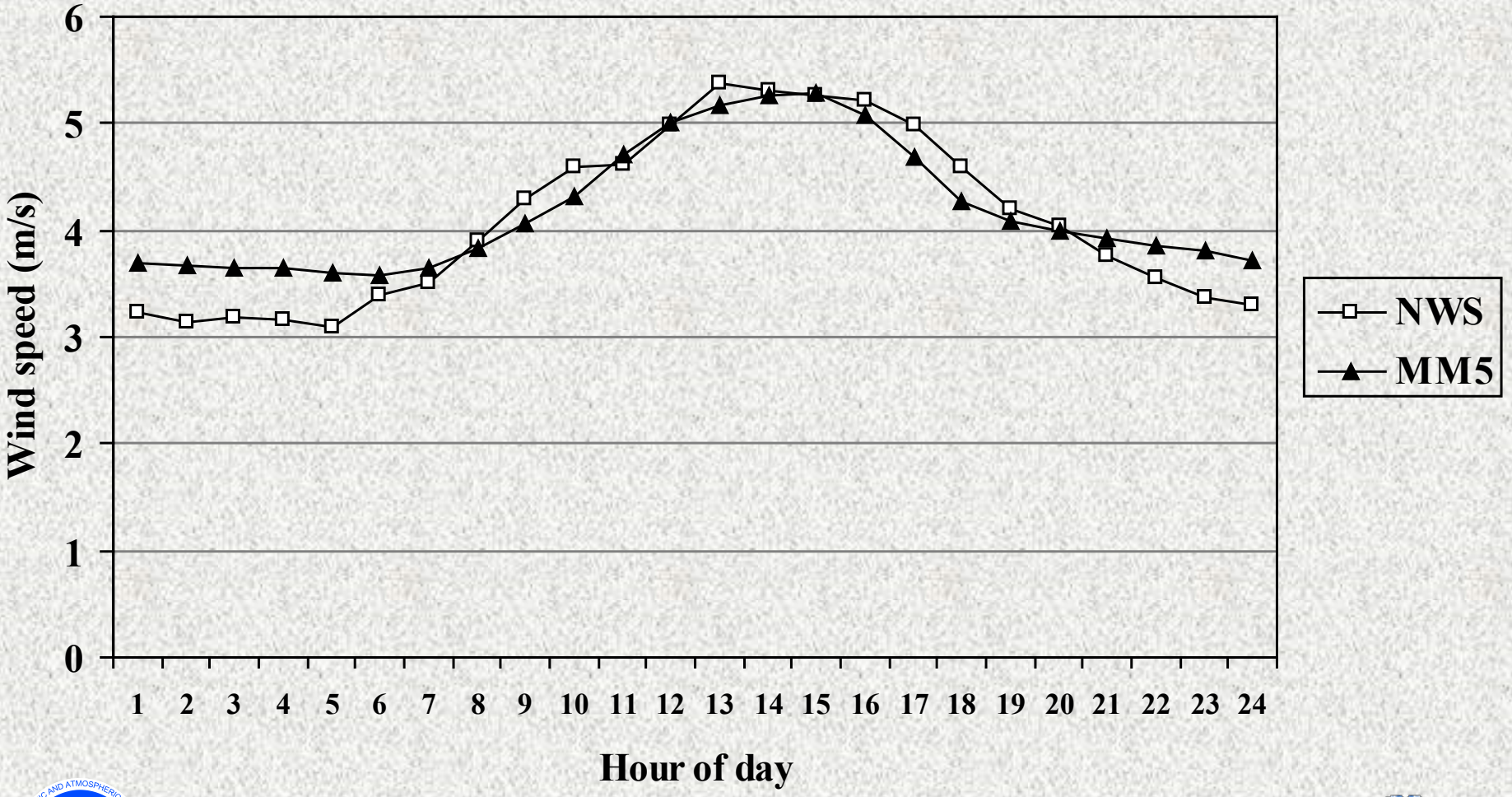
Tasks

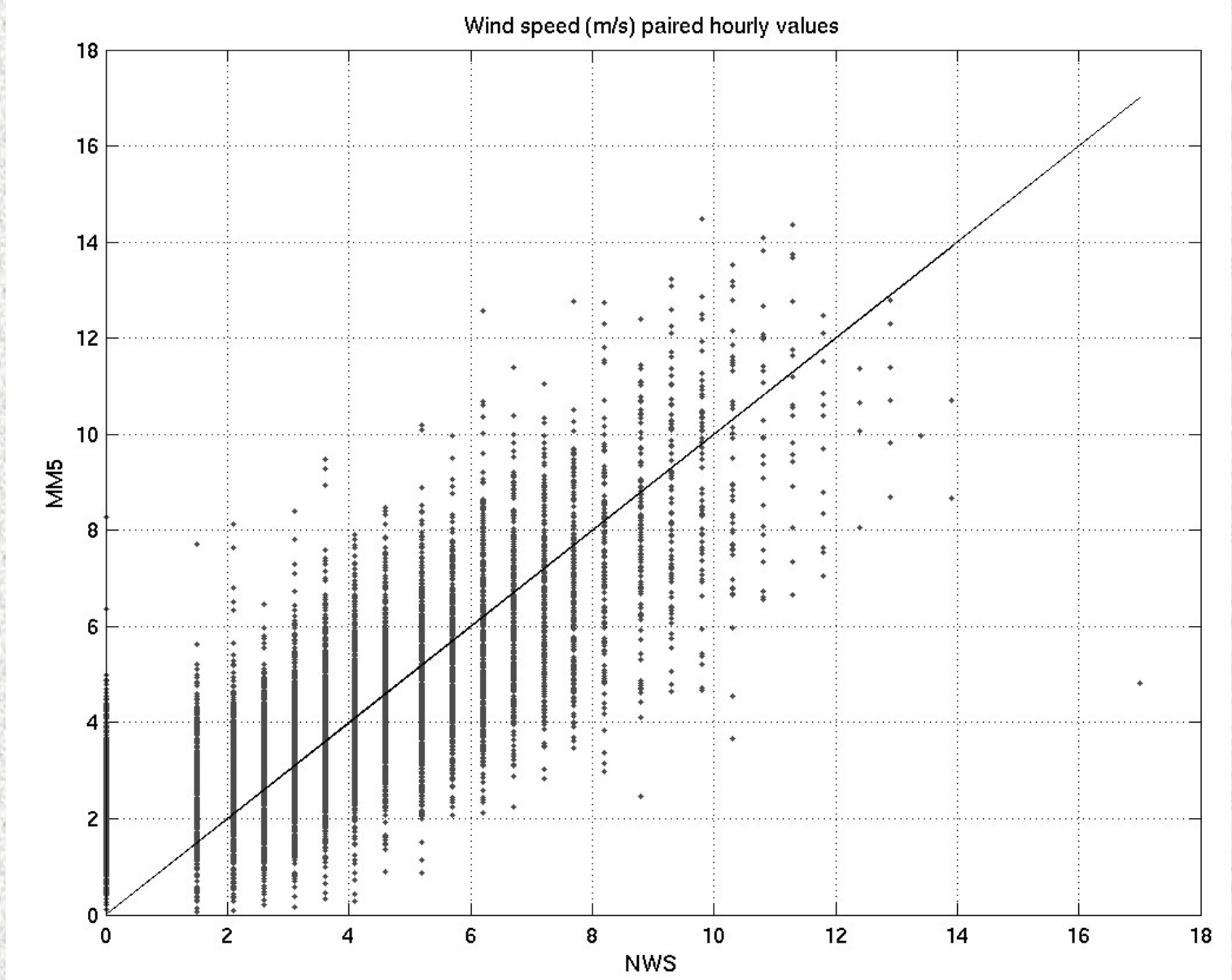
1. Run MPRM/ISC using NWS observations and compare to original
2. Run AERMET/AERMOD using NWS observations and compare to 1
3. Extract met data from MM5 for corresponding grid
4. Translate parameters from MM5 to AERMET output
5. Calculate any values not explicitly output my MM5 but output by AERMET

Tasks

6. Replace AERMOD calculated meteorological data with MM5 output only if available from MM5
7. Run AERMOD using reformatted MM5 data hybrid as meteorological input
8. Examine met processor and dispersion model output

Hourly average wind speed




Wind speed (m/s) paired hourly values
MM5
NWS
0
2
4
6
8
10
12
14
16
18

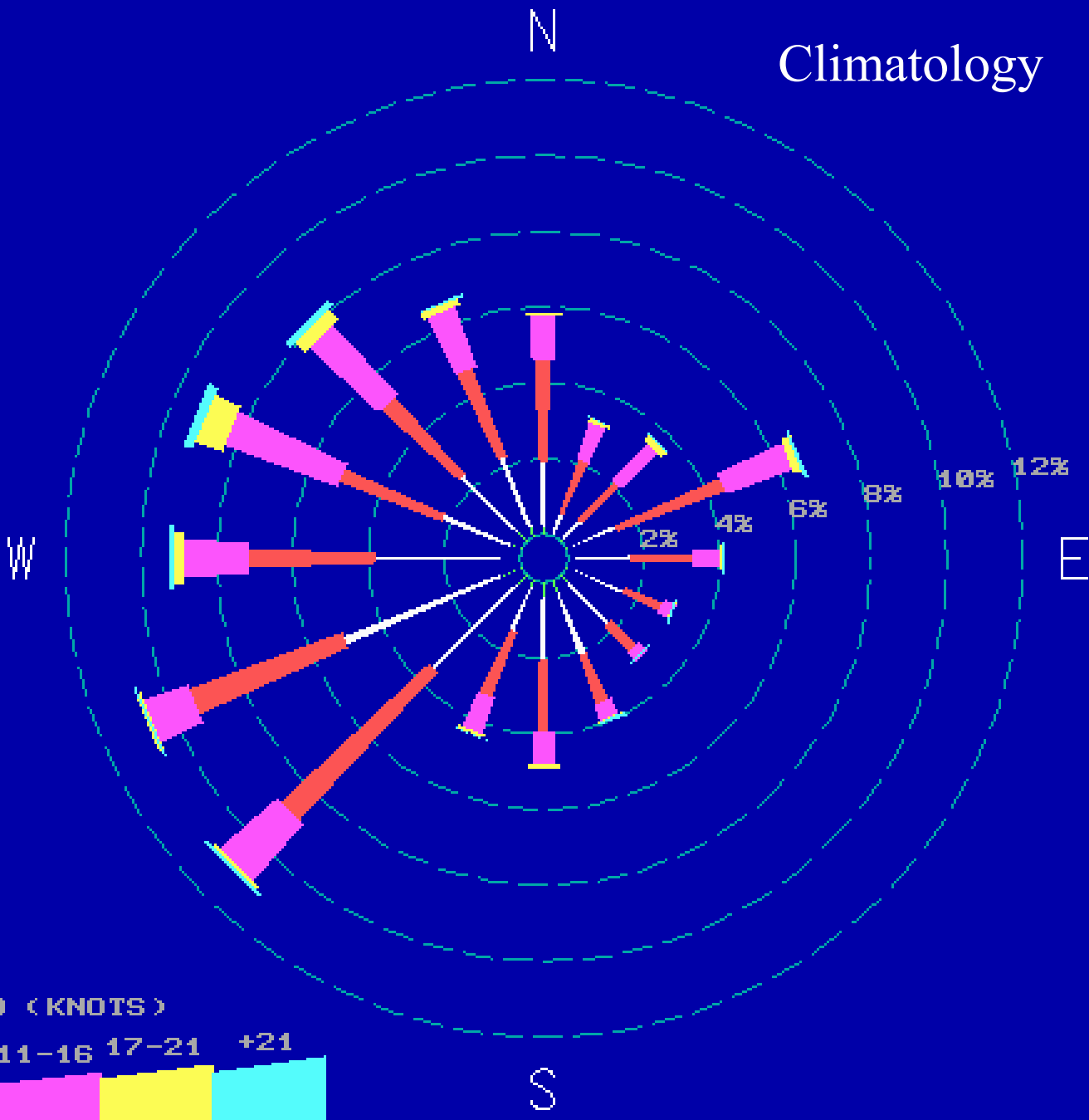
1984-1992 PHL

January 1

December 31

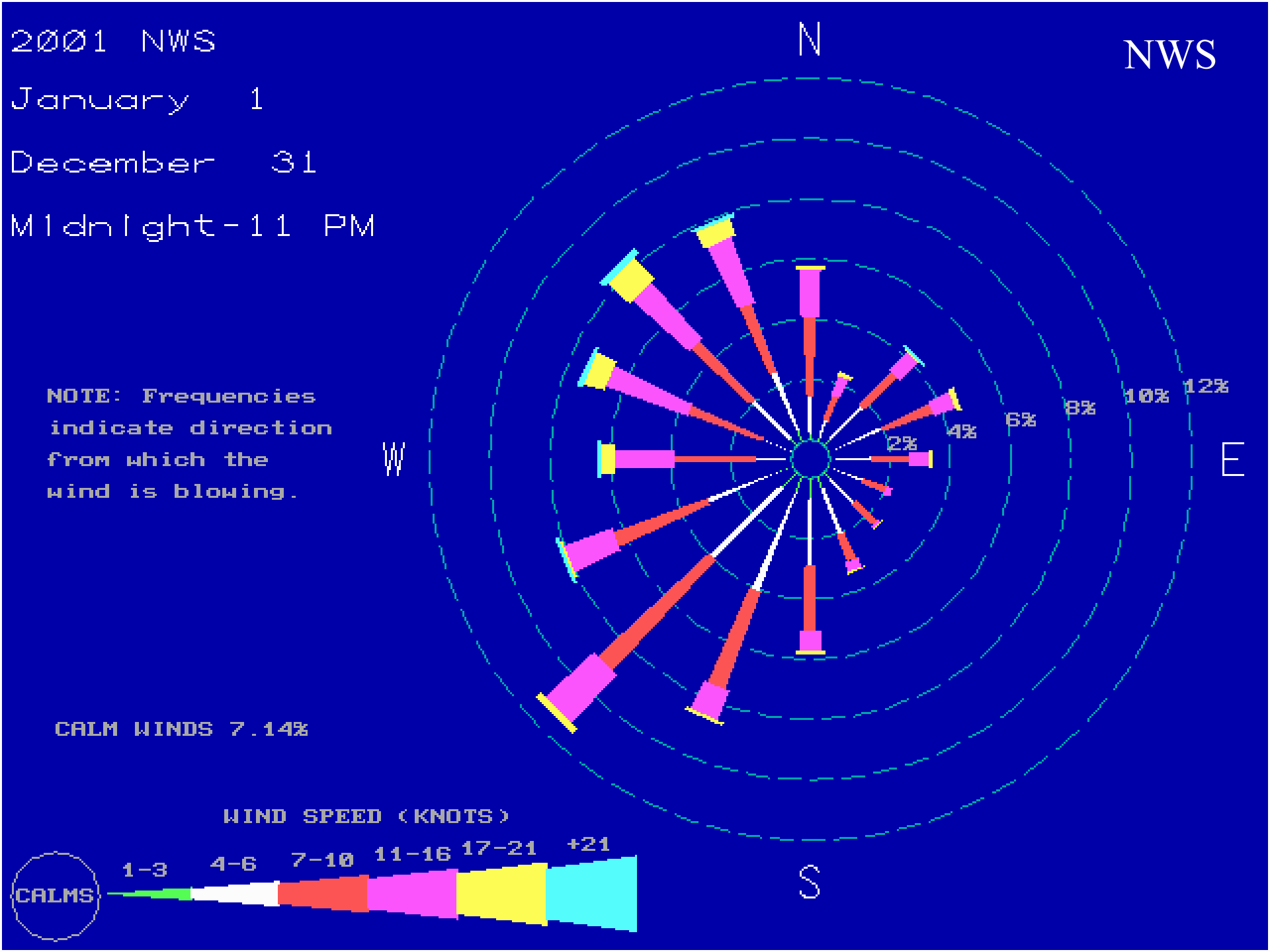
Midnight-11 PM

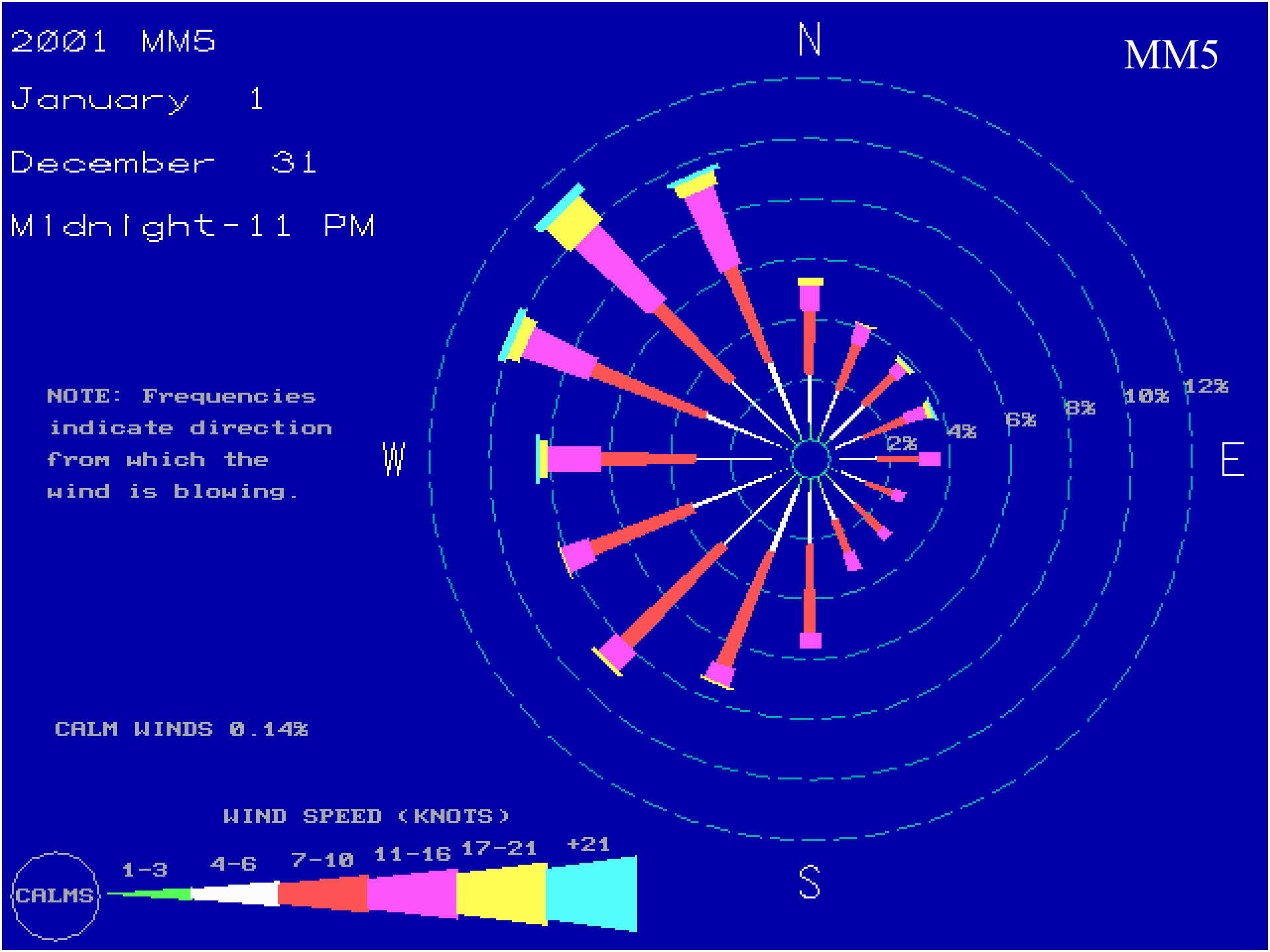
Climatology



NOTE: Frequencies indicate direction from which the wind is blowing.

CALM WINDS 1.85%


2001 NWS
January 1
December 31
Midnight-11 PM
NOTE: Frequencies indicate direction from which the wind is blowing.
N
W
E
S
NWS
2%
4%
6%
8%
10%
12%
CALM WINDS 7.14%
WIND SPEED (KNOTS)
CALMS
1-3
4-6
7-10
11-16
17-21
+21


2001 MM5
January 1
December 31
Midnight-11 PM
MM5
N
W
E
S
2%
4%
6%
8%
10%
12%
NOTE: Frequencies indicate direction from which the wind is blowing.
CALM WINDS 0.14%
WIND SPEED (KNOTS)
CALMS
1-3
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+21

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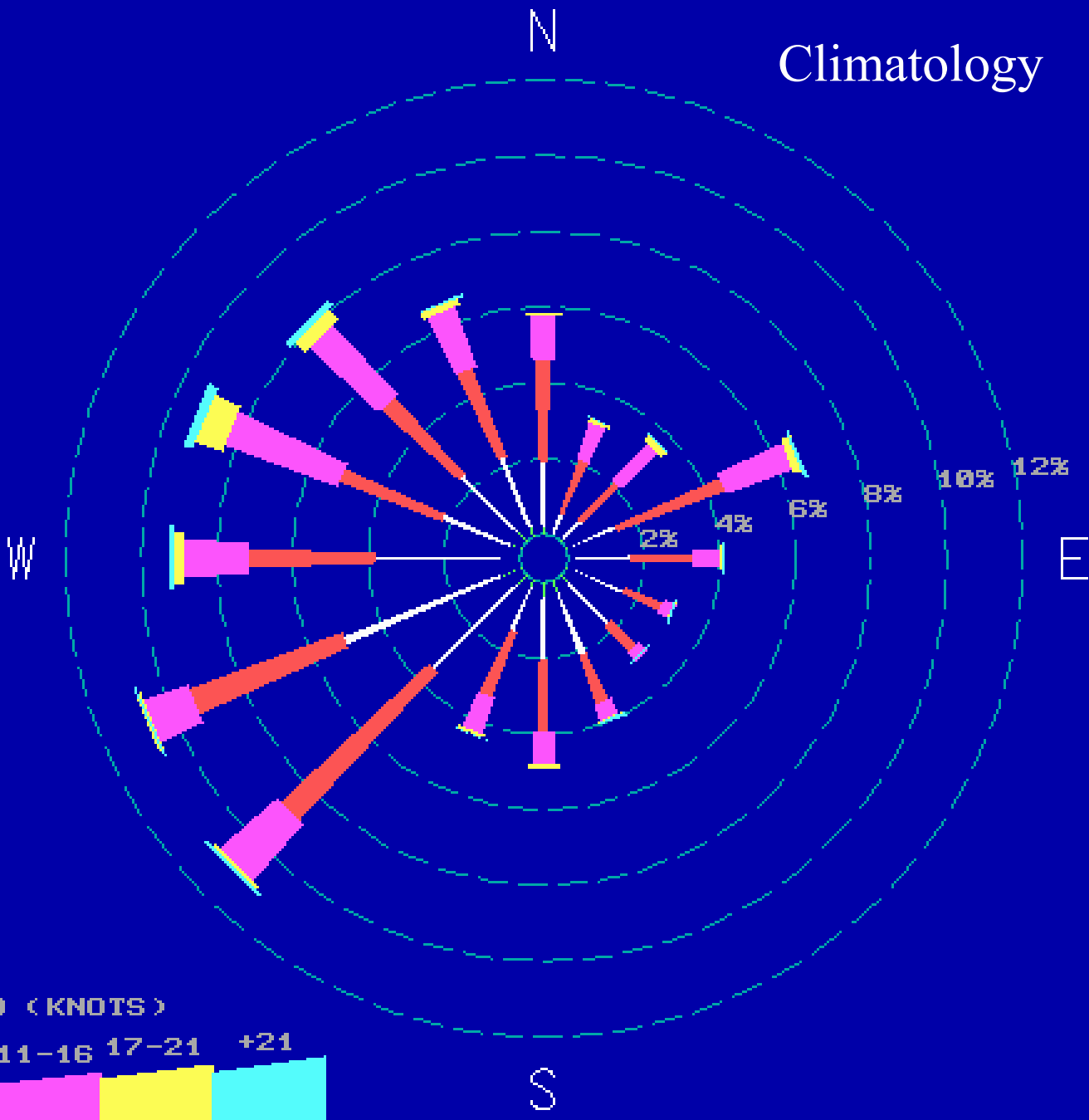
Climatology



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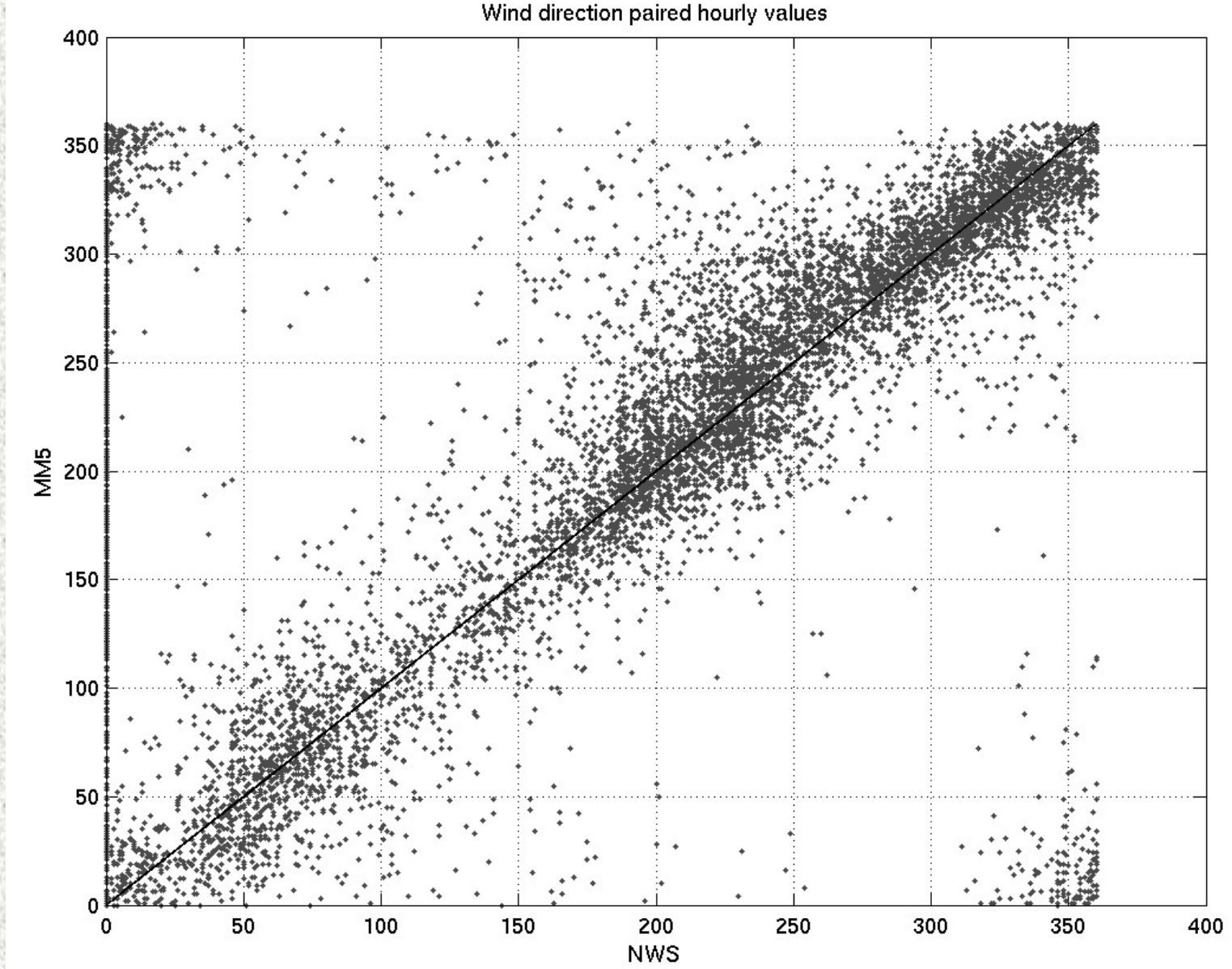
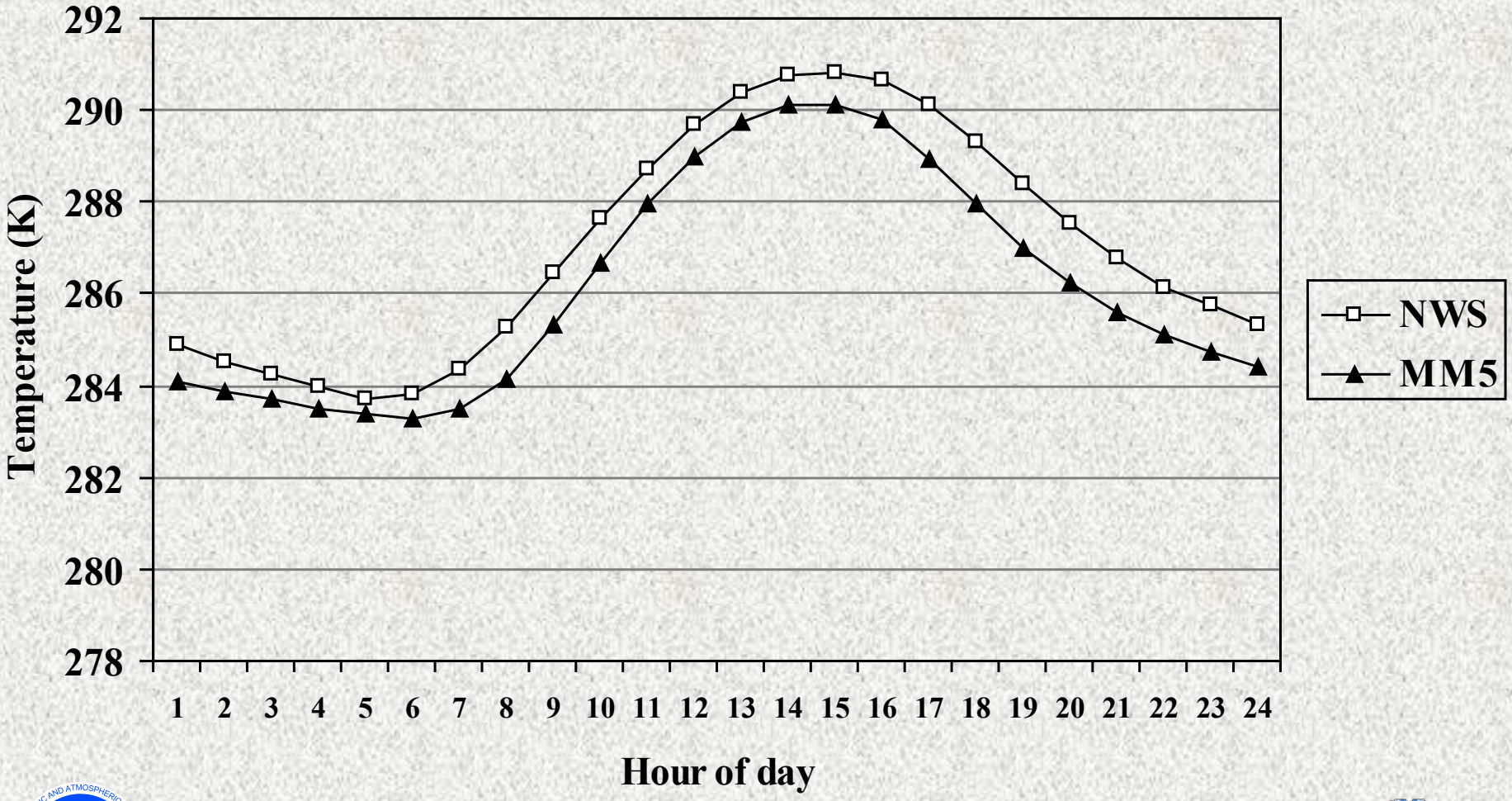
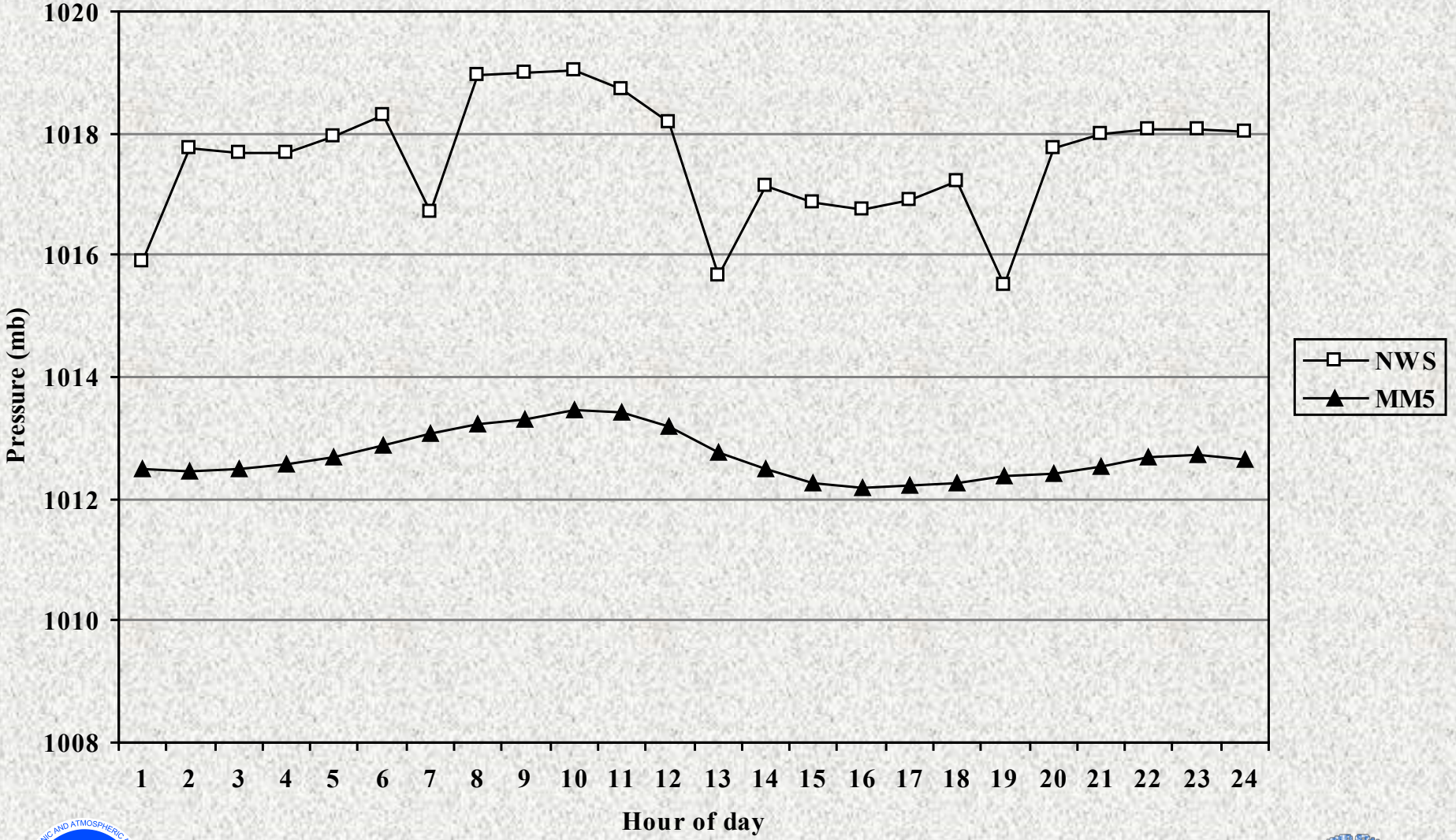

Wind direction paired hourly values
MM5
NWS
0
50
100
150
200
250
300
350
400

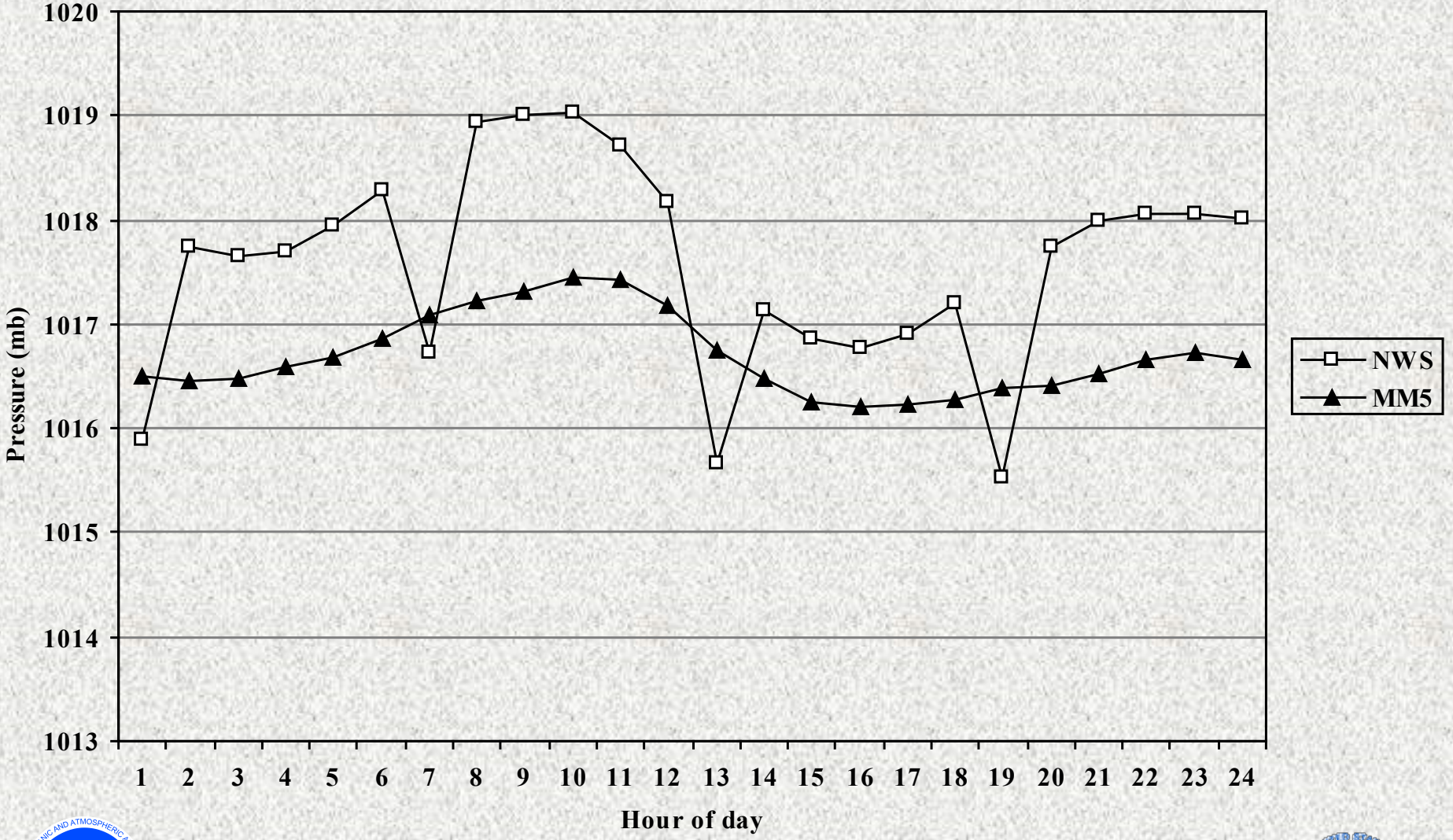
Hourly average 2 meter temperature



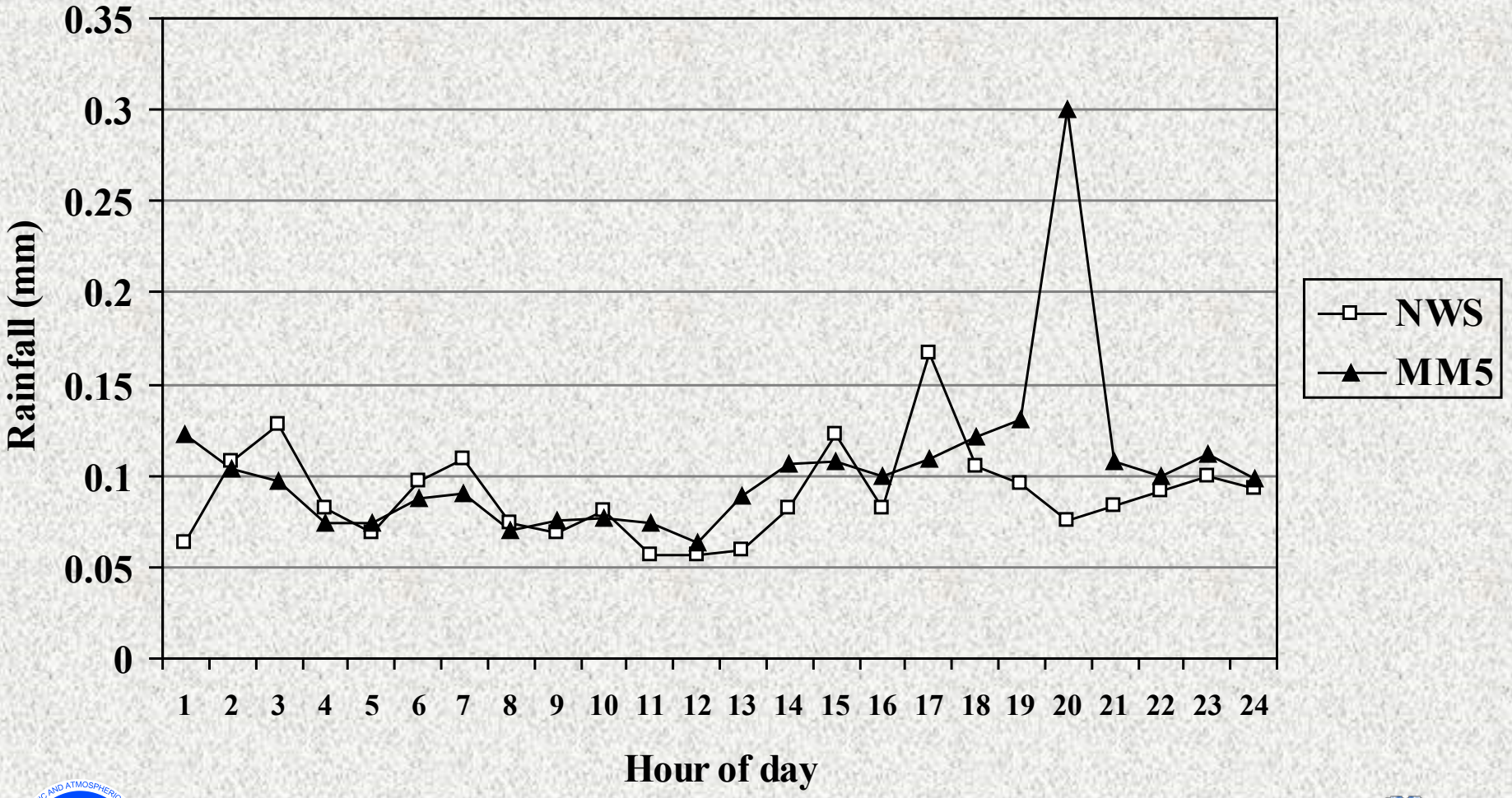
Hourly average surface pressure



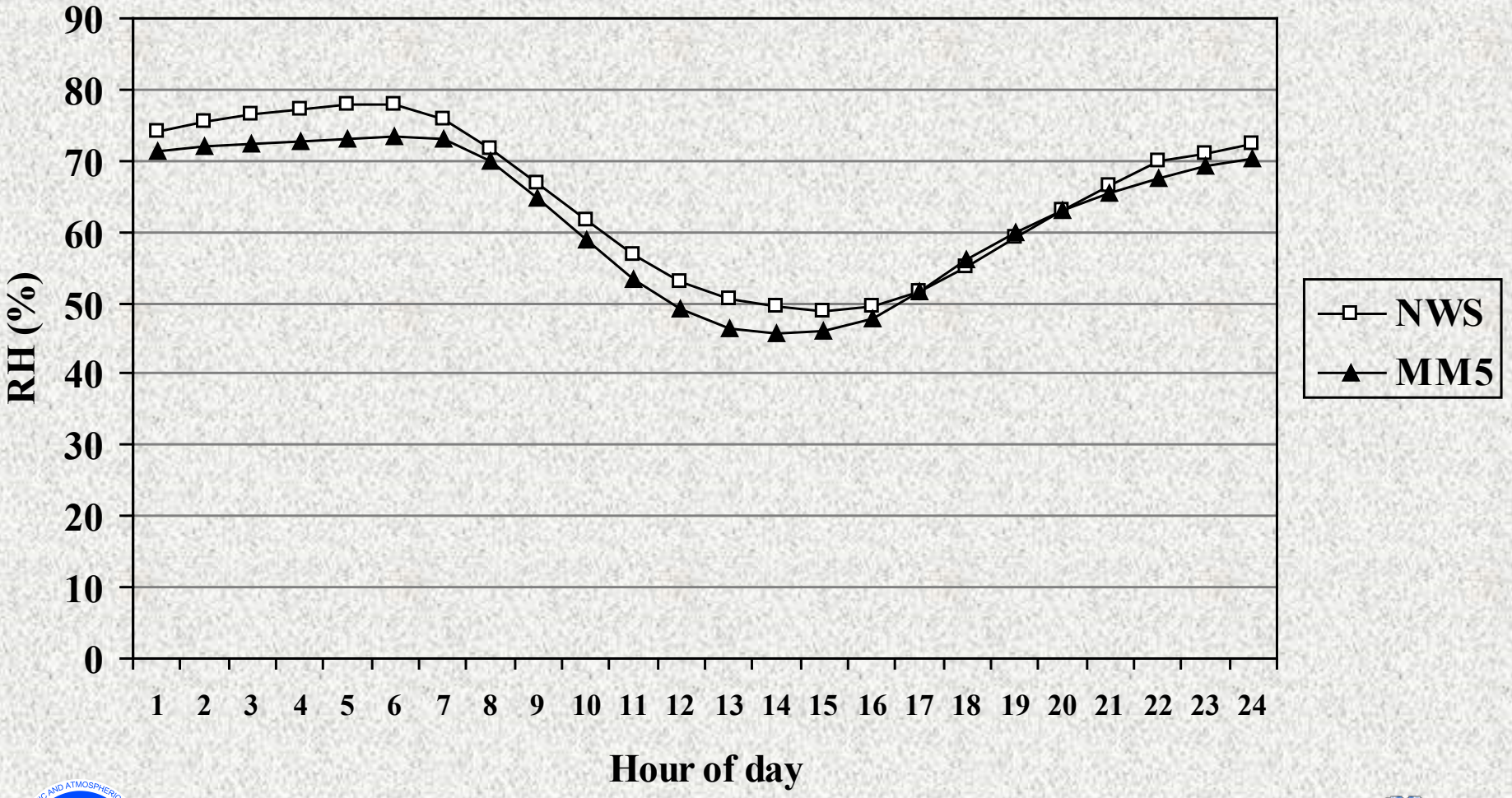
Hourly average surface pressure with 4 mb correction to MM5



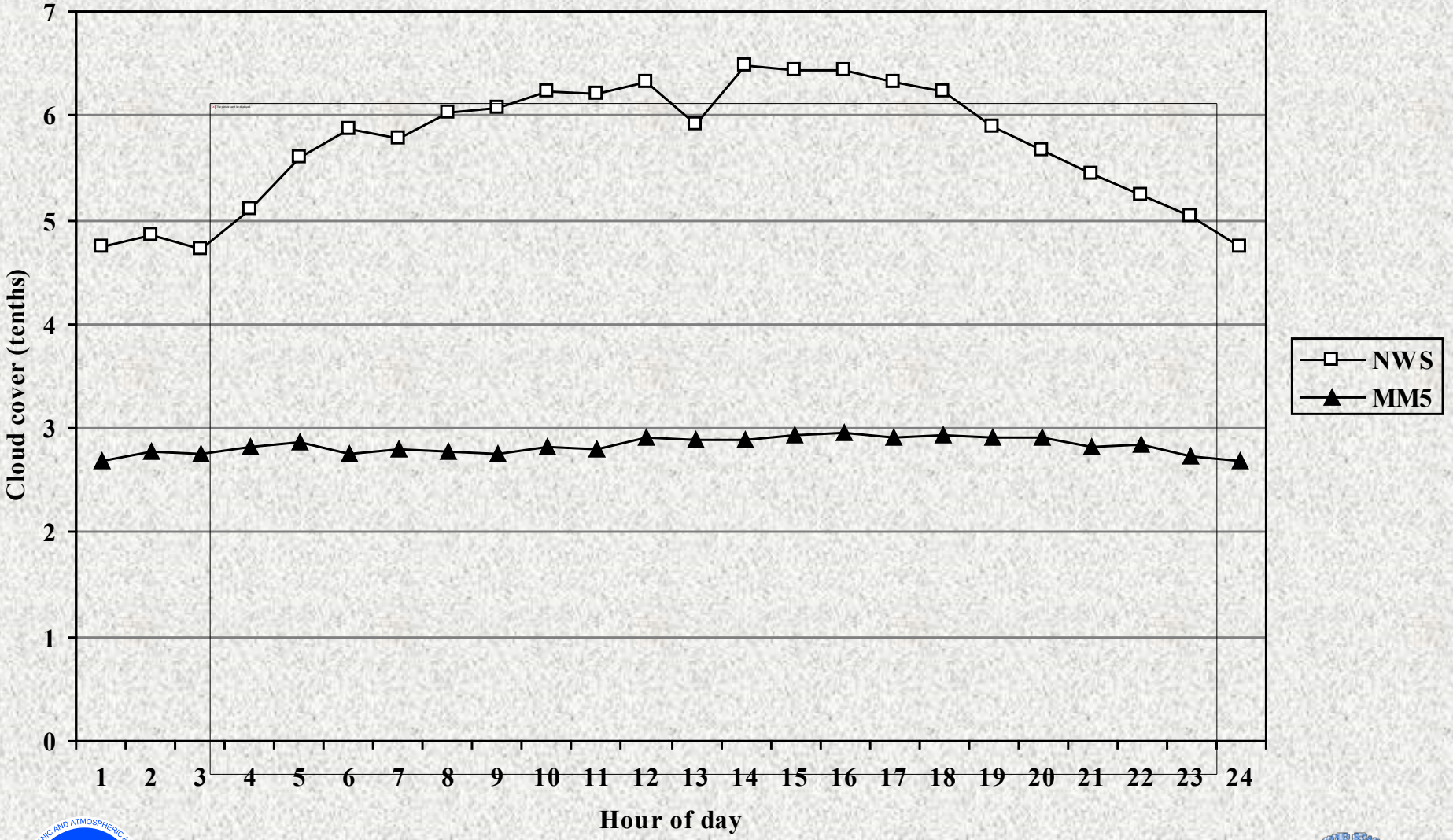
Hourly average hourly rainfall



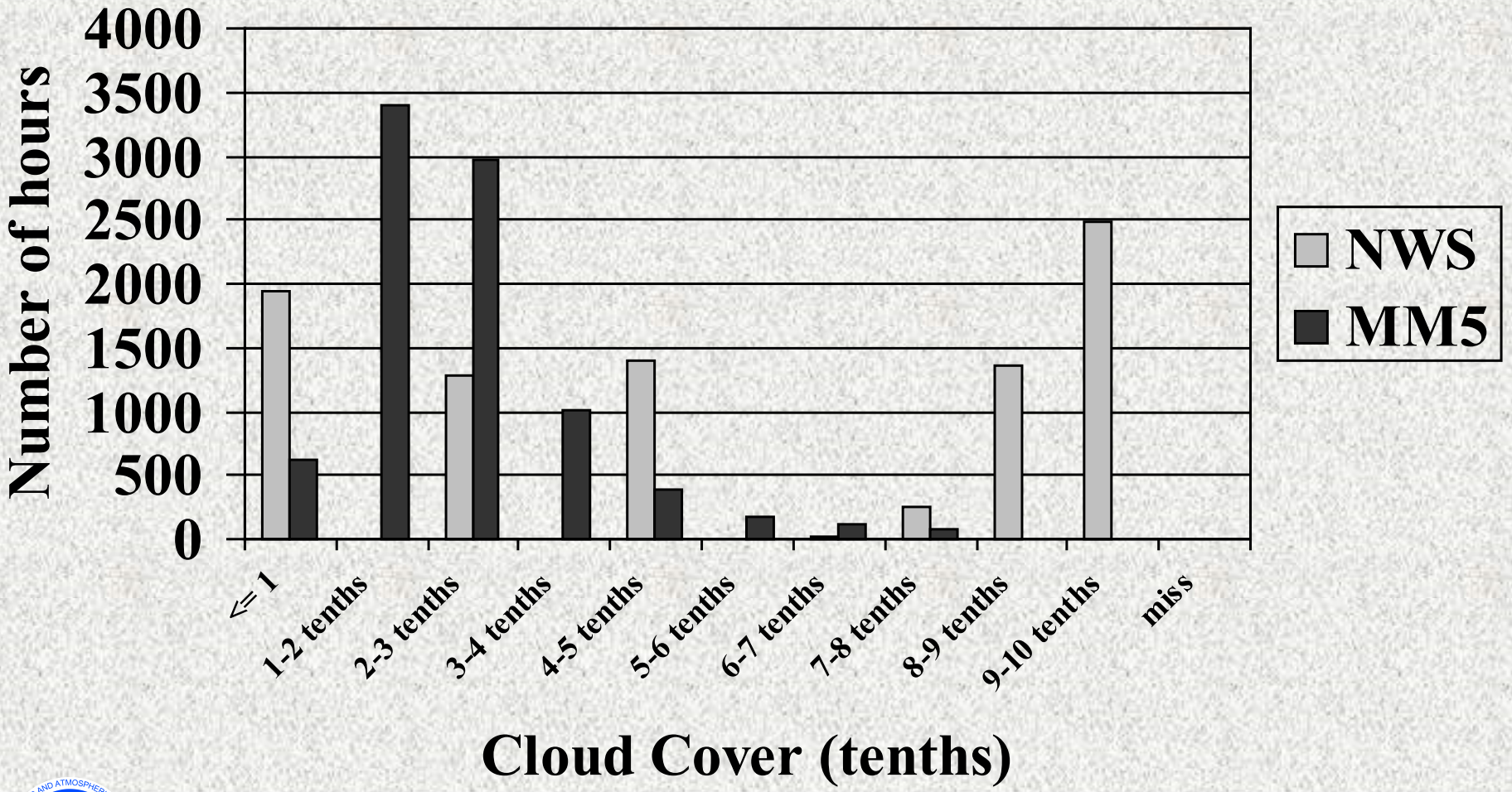
Hourly average relative humidity

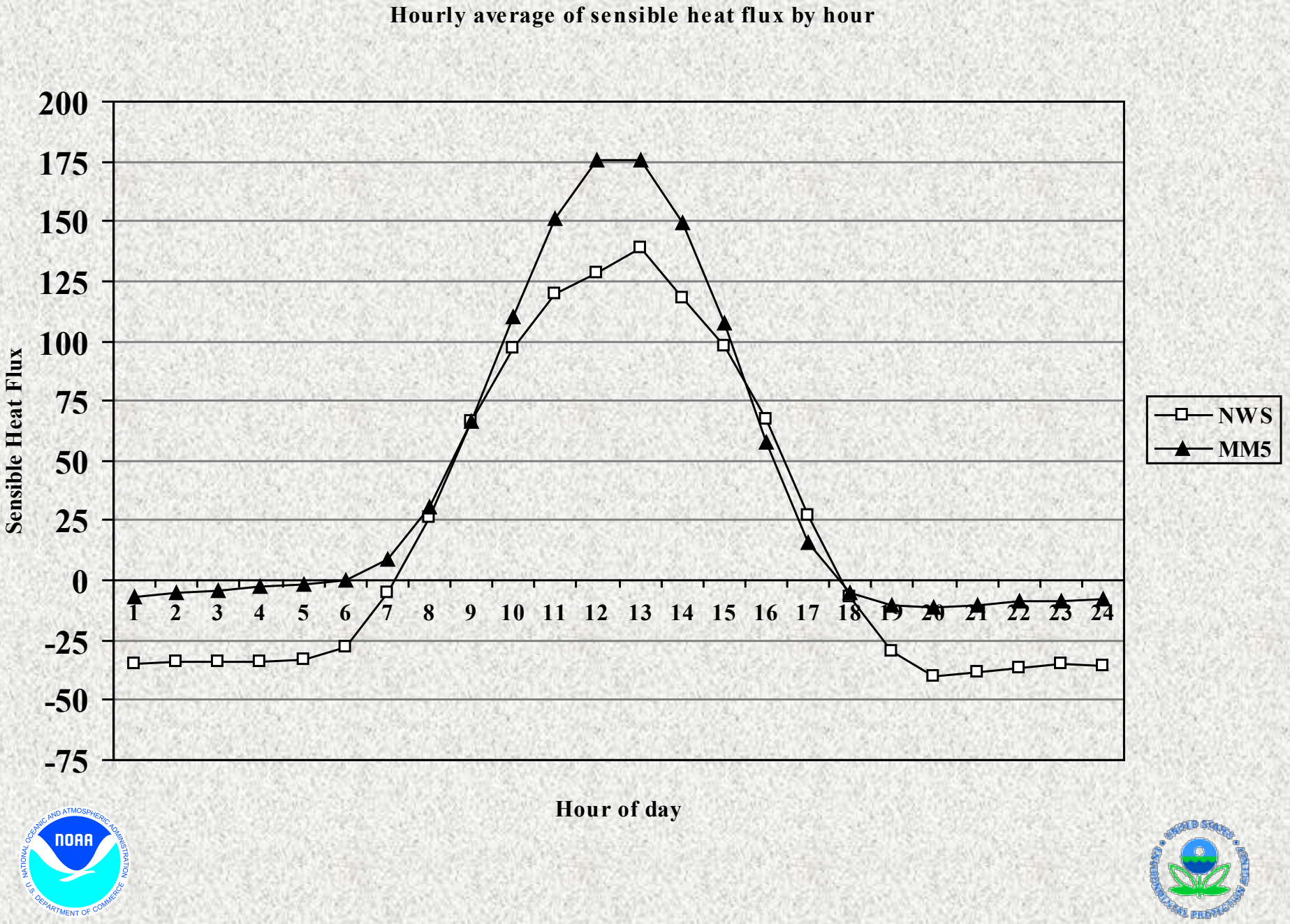


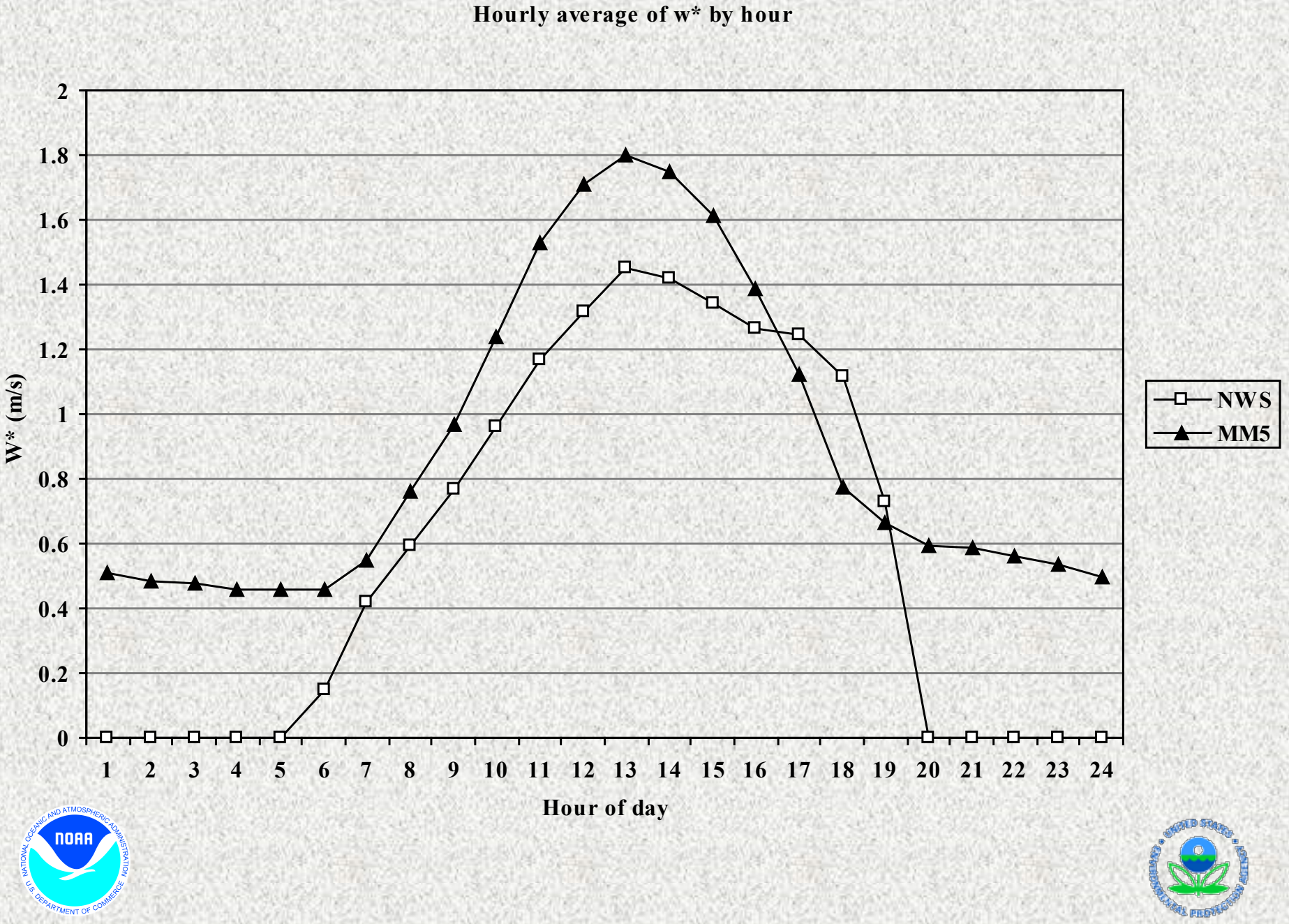
Hourly average cloud cover



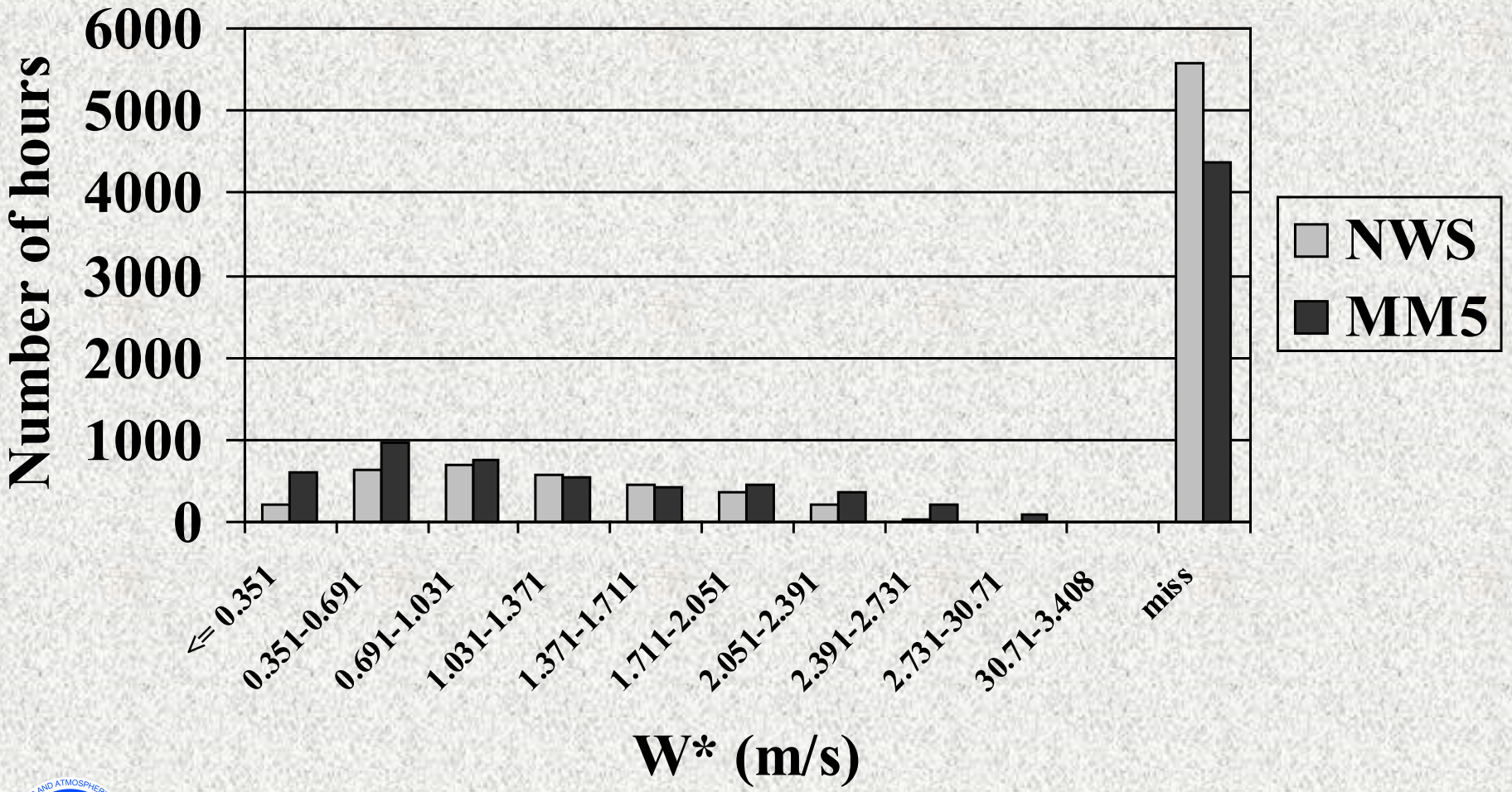
Cloud cover classes



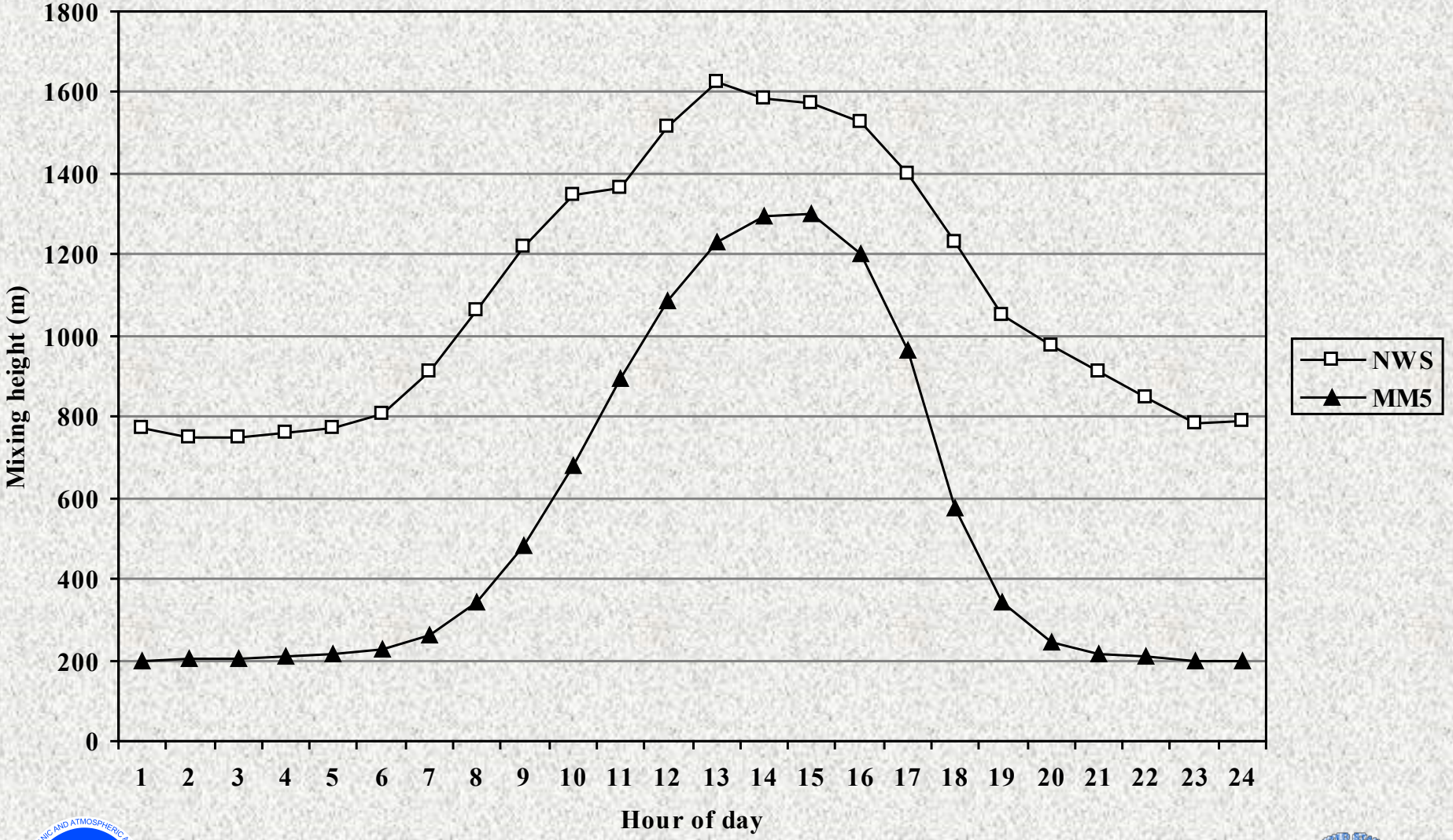

Hourly average of sensible heat flux by hour
Sensible Heat Flux
200
175
150
125
100
75
50
25
0
-25
-50
-75
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour of day
NWS
MM5


Hourly average of w* by hour
W* (m/s)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour of day
NWS
MM5

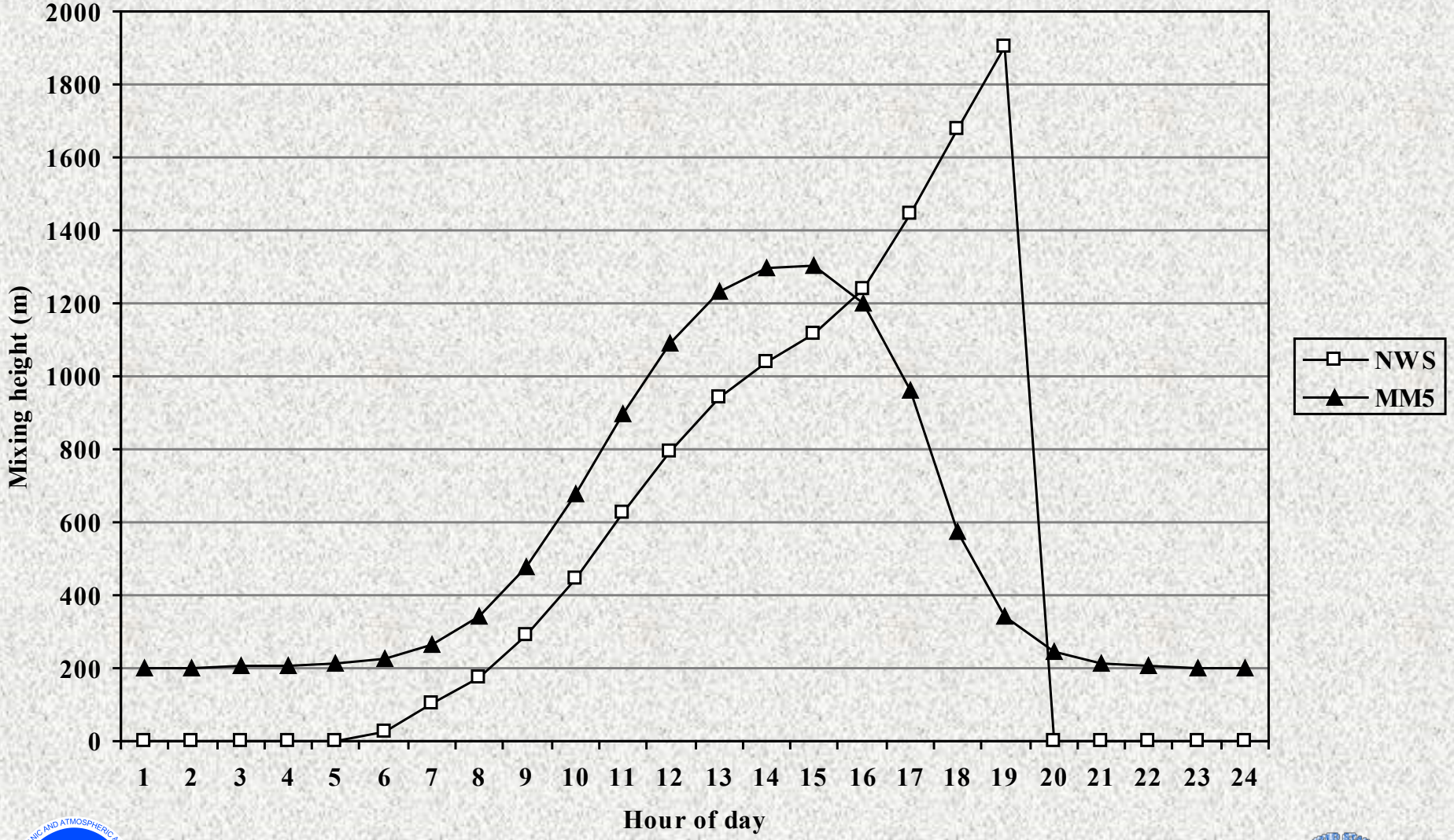
W* classes


Number of hours
6000
5000
4000
3000
2000
1000
0
<= 0.351
0.351-0.691
0.691-1.031
1.031-1.371
1.371-1.711
1.711-2.051
2.051-2.391
2.391-2.731
2.731-30.71
30.71-3.408
miss
W* (m/s)
NWS
MM5

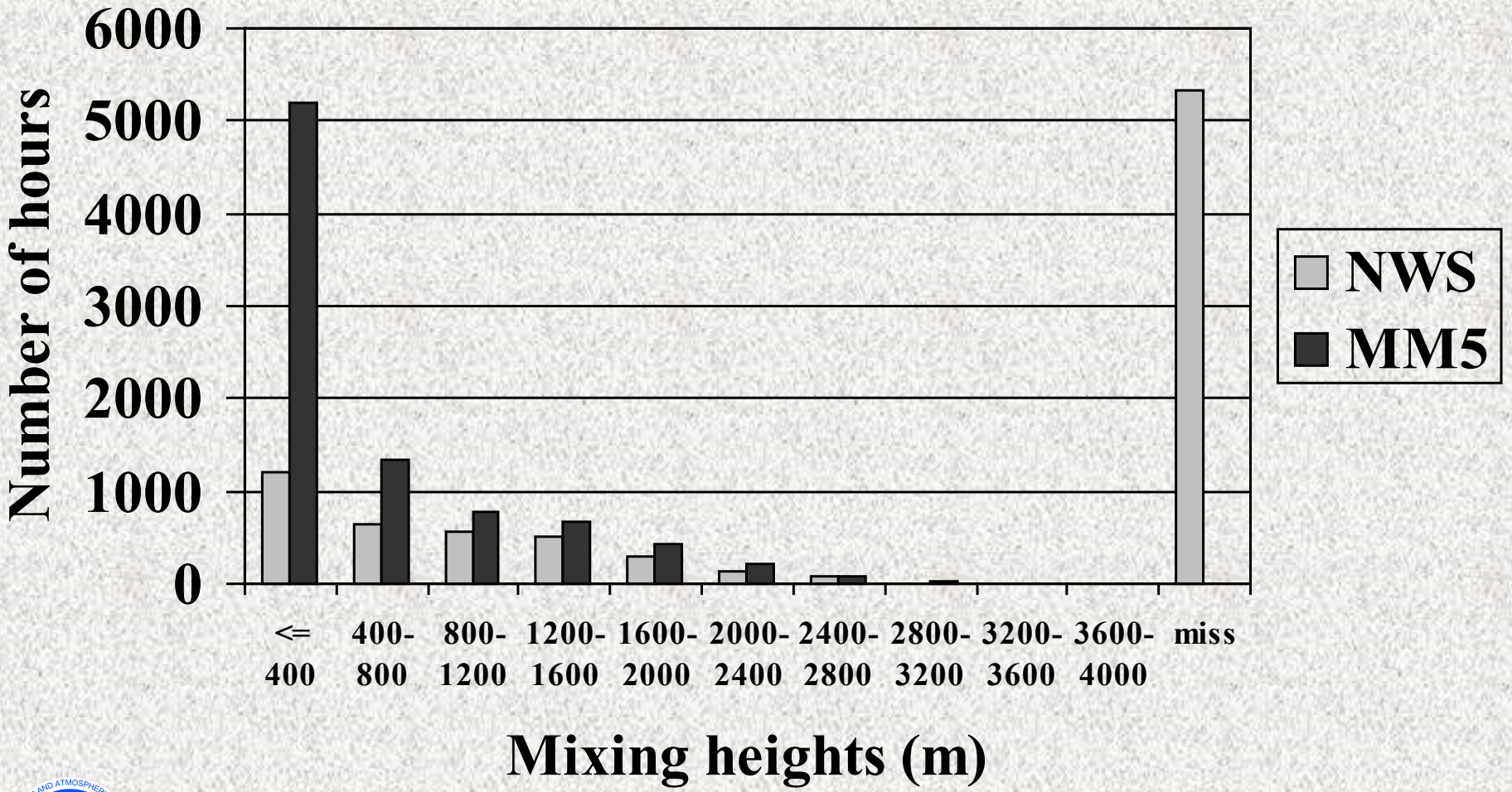
Hourly average mechanical mixing heights



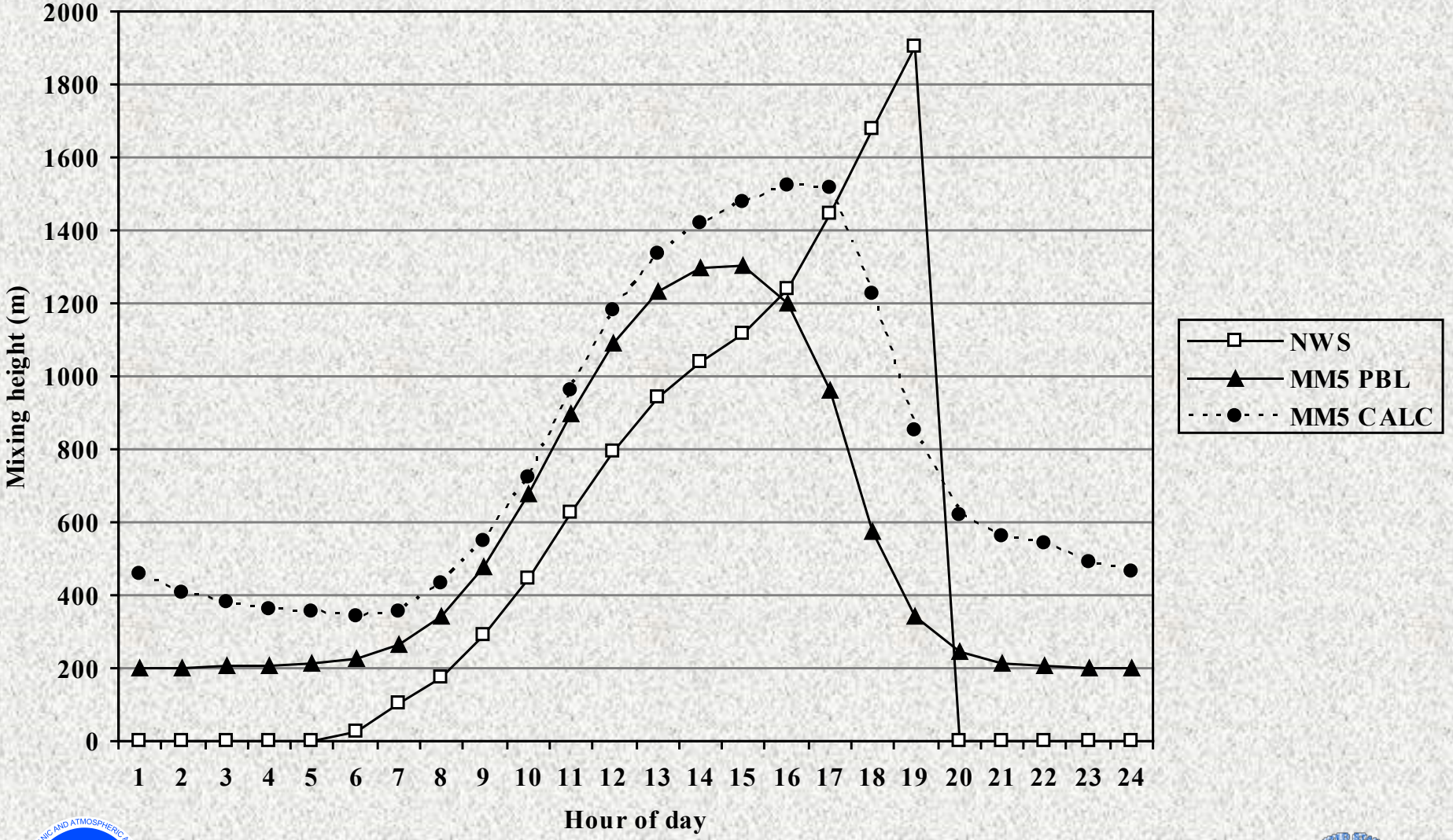
Hourly average convective mixing heights



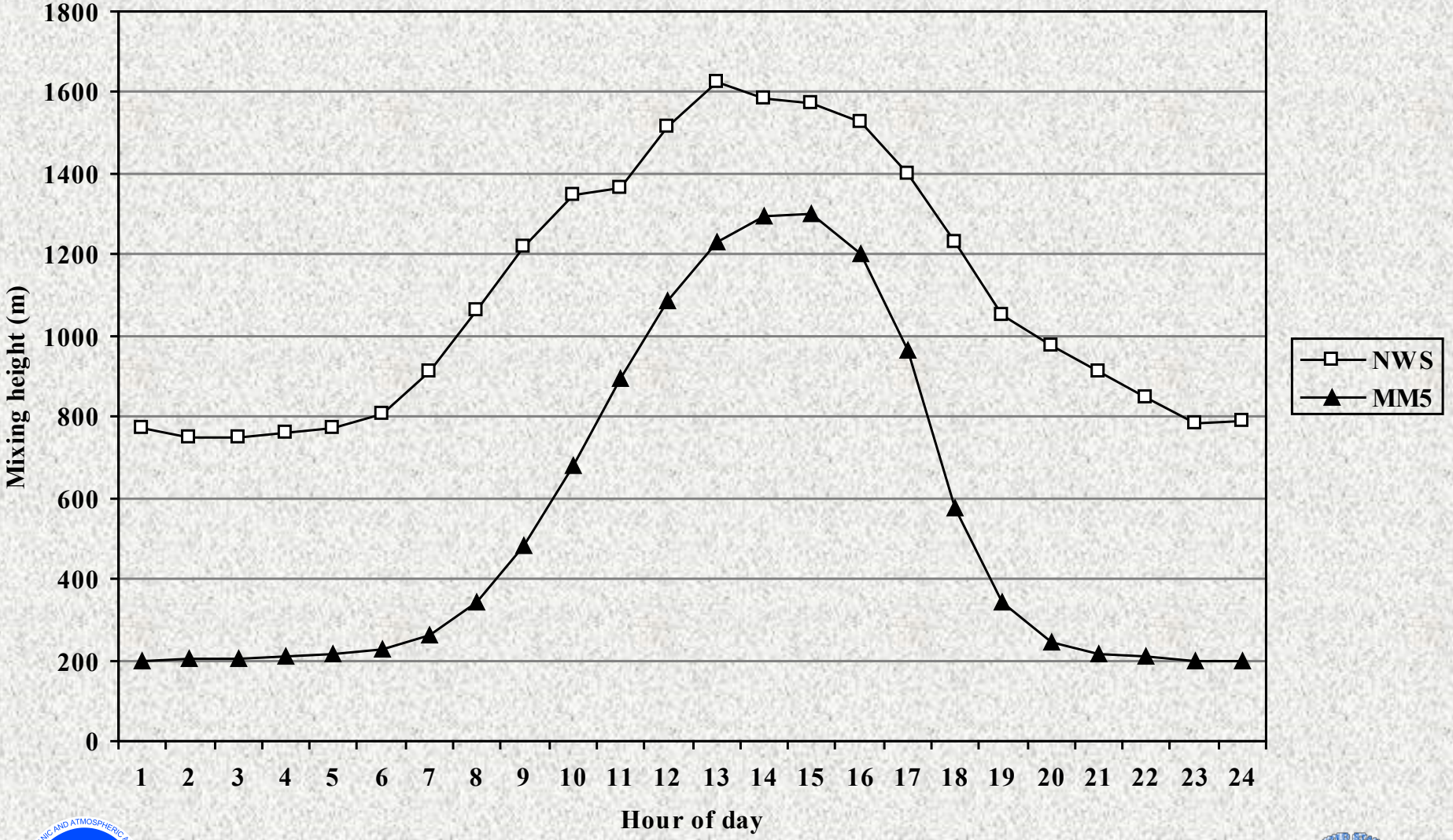
Convective mixing height classes



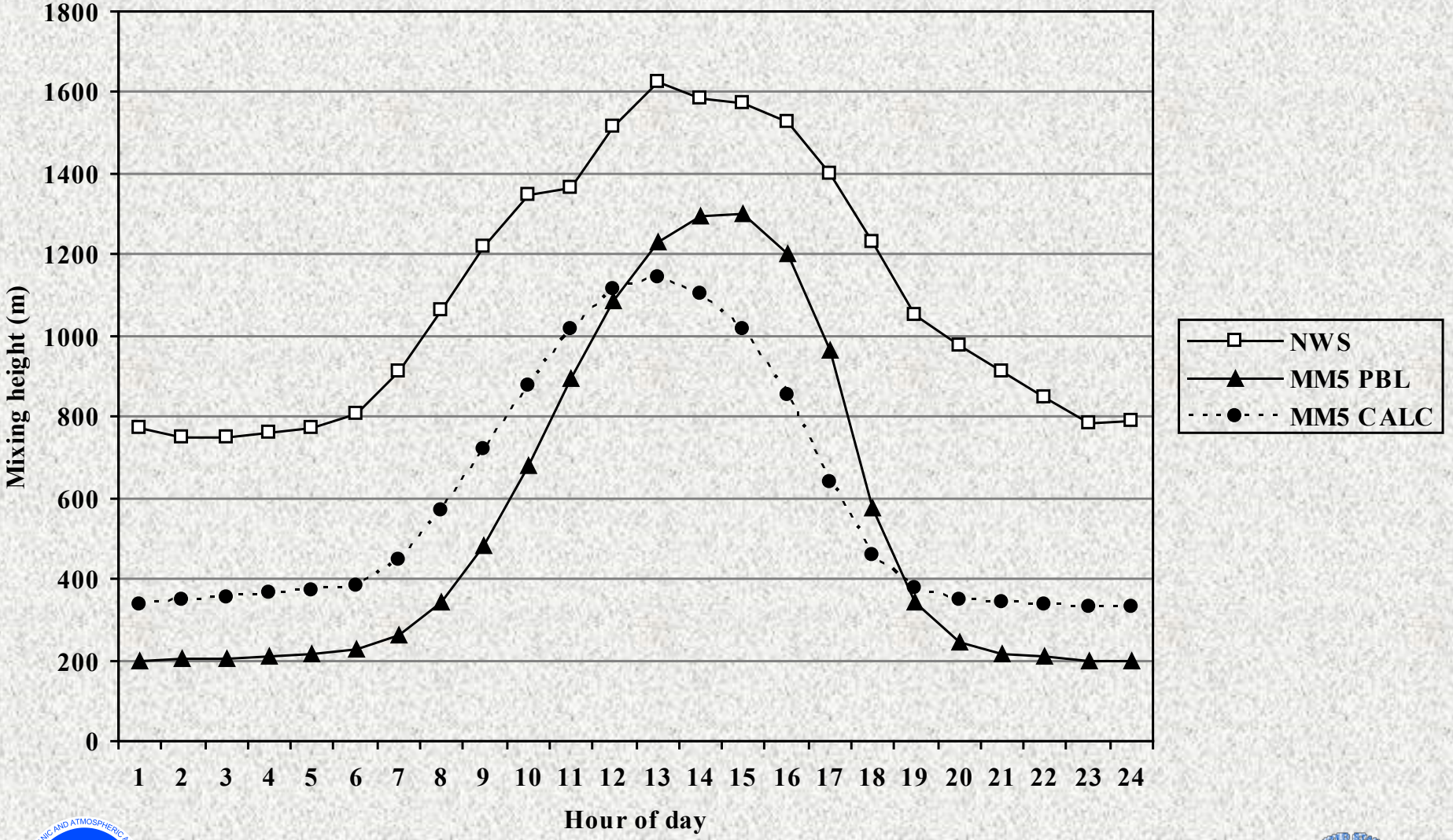
Hourly average convective mixing heights



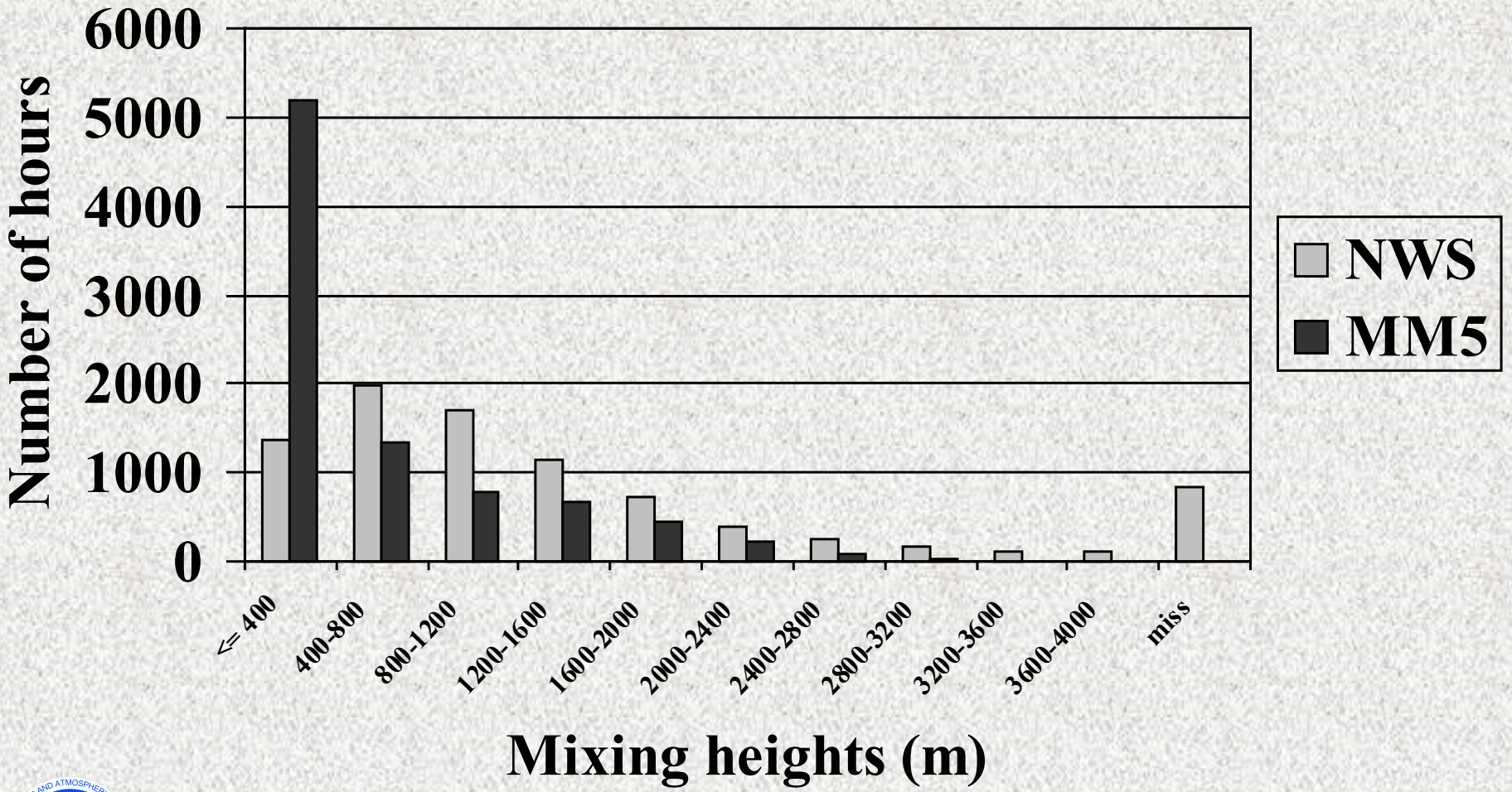
Hourly average mechanical mixing heights



Hourly average mechanical mixing heights



Mechanical mixing height classes



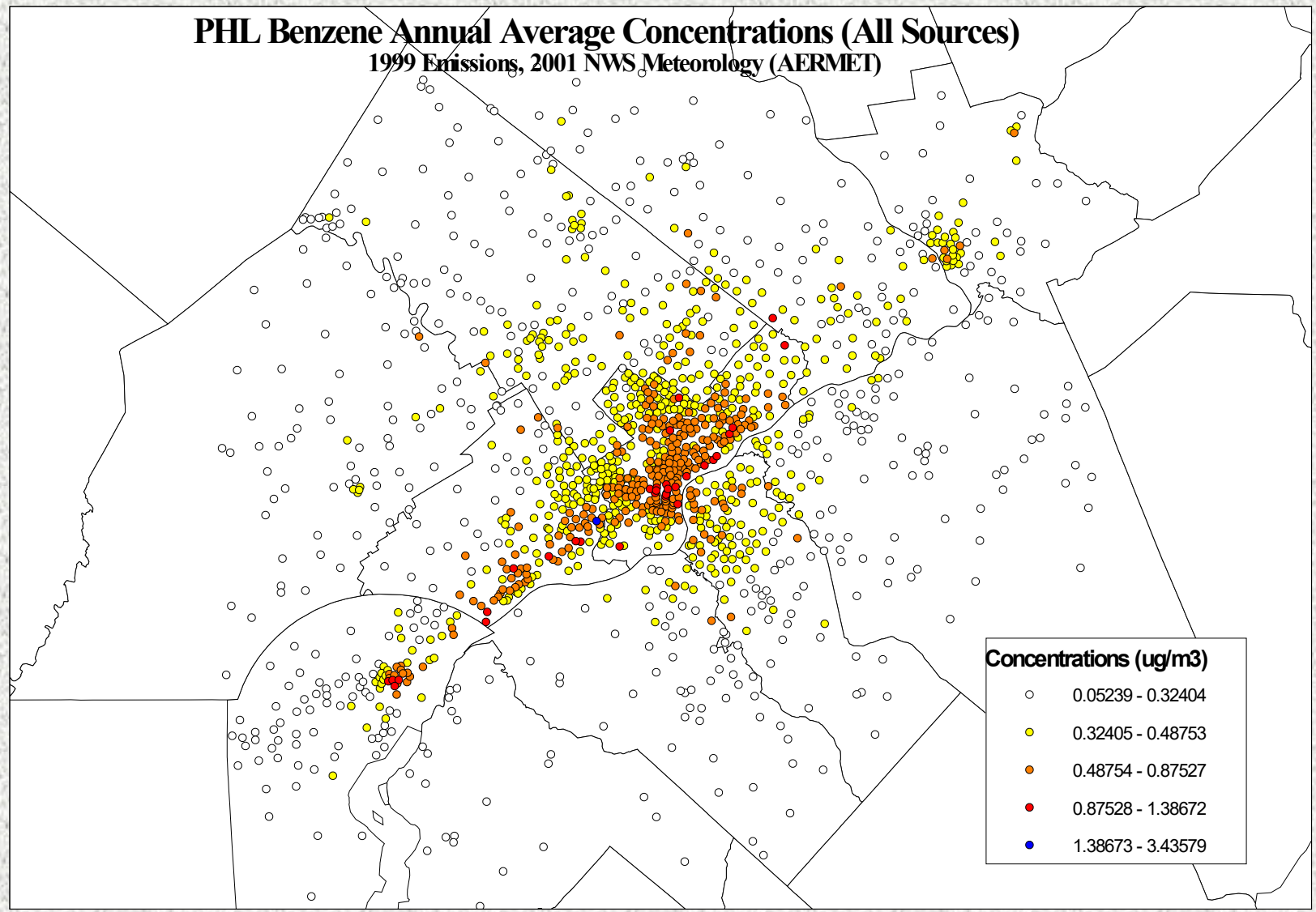
Summary Statistics for AERMOD Annual Average Benzene Concentrations ($\mu g/m^3$)

for Philadelphia using 1999 Emissions and 2001 Meteorological Input Data

	Min Value	20th Pct.	40th Pct.	60th Pct.	80th Pct.	Max Value
AERMET Benzene	0.05239	0.23427	0.32708	0.40961	0.50605	1.55951
MM5 Benzene	0.25023	0.8288	1.13717	1.38664	1.6522	3.43579

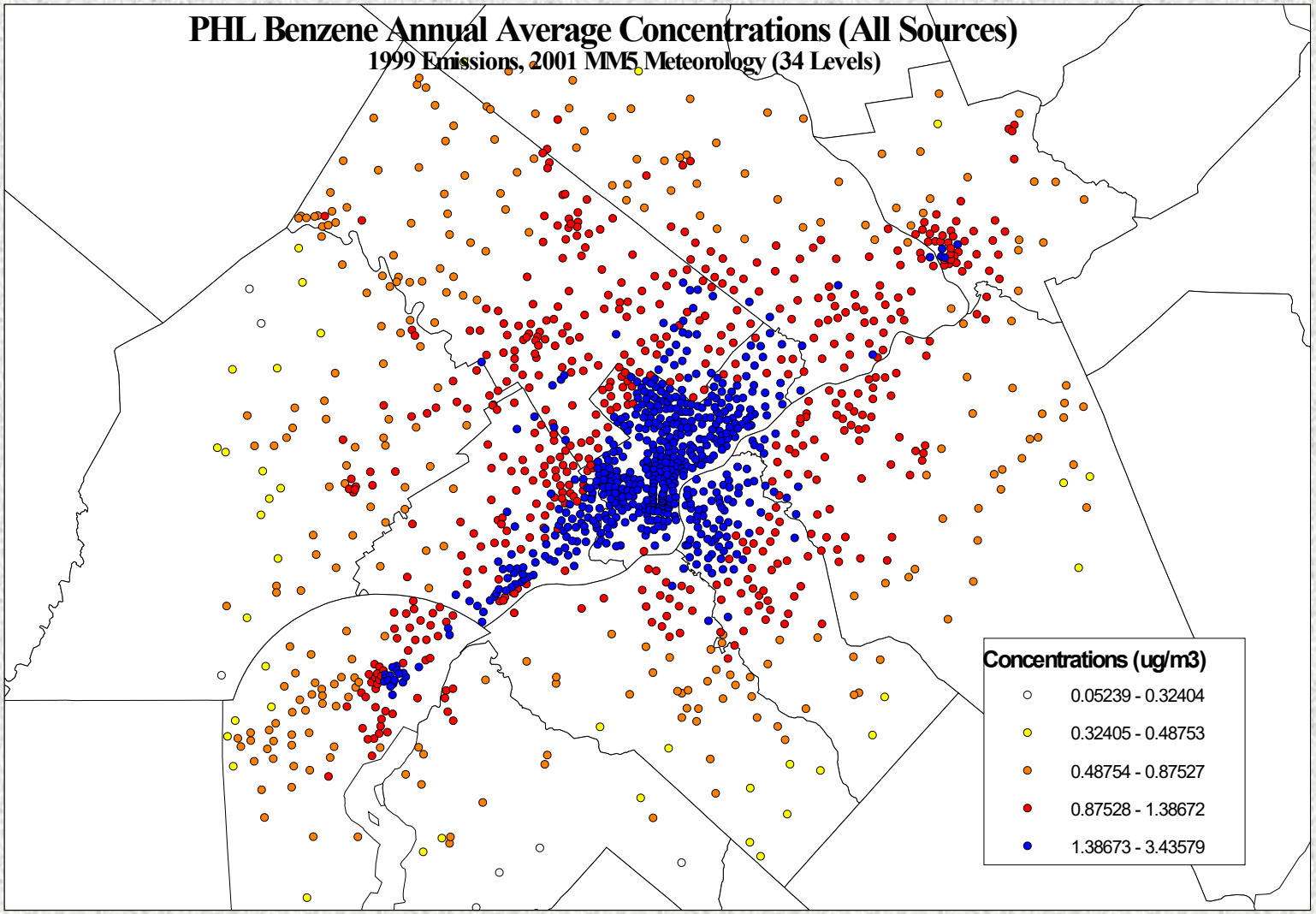
PHL Benzene Annual Average Concentrations (All Sources)

1999 Emissions, 2001 NWS Meteorology (AERMET)



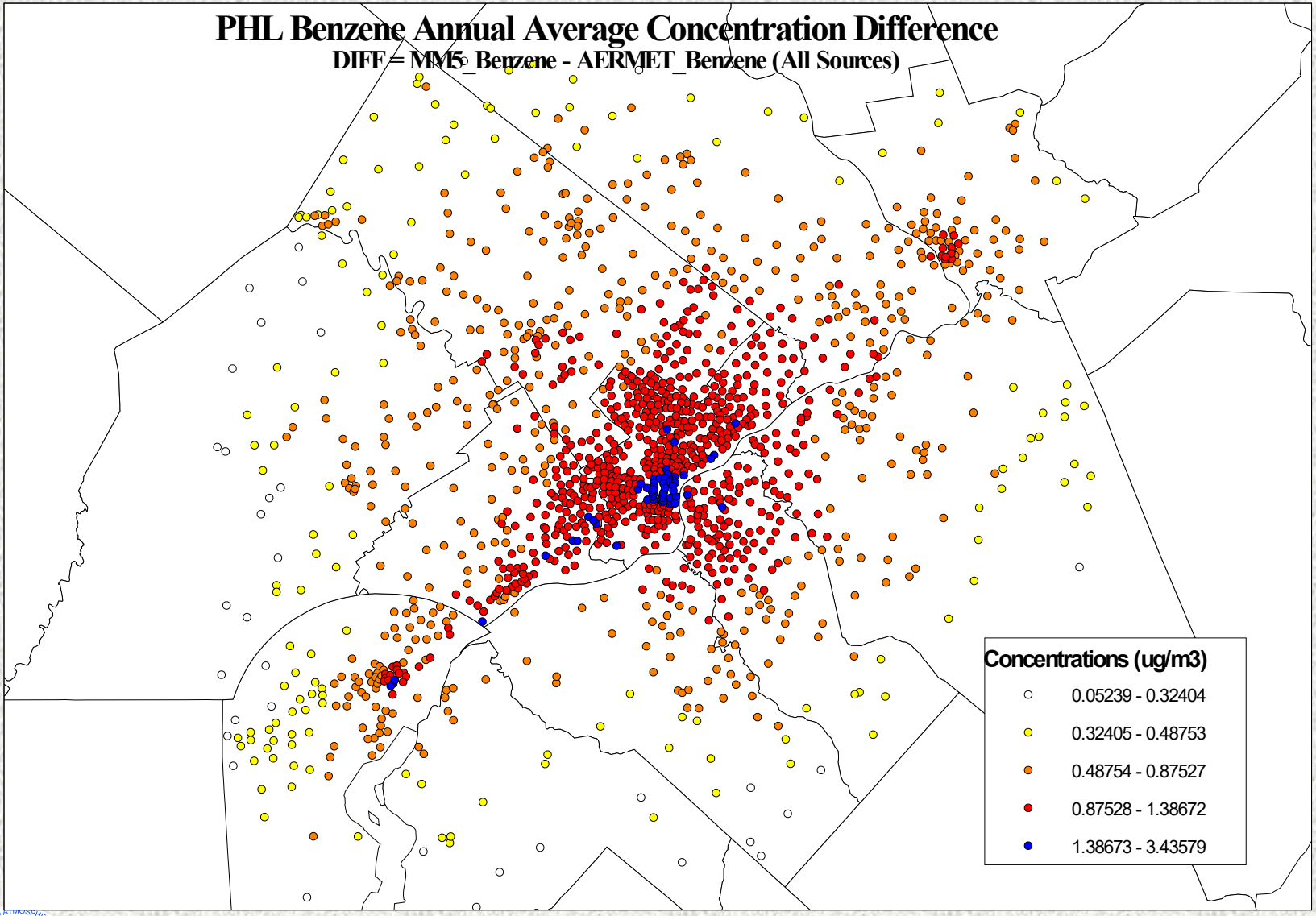
PHL Benzene Annual Average Concentrations (All Sources)

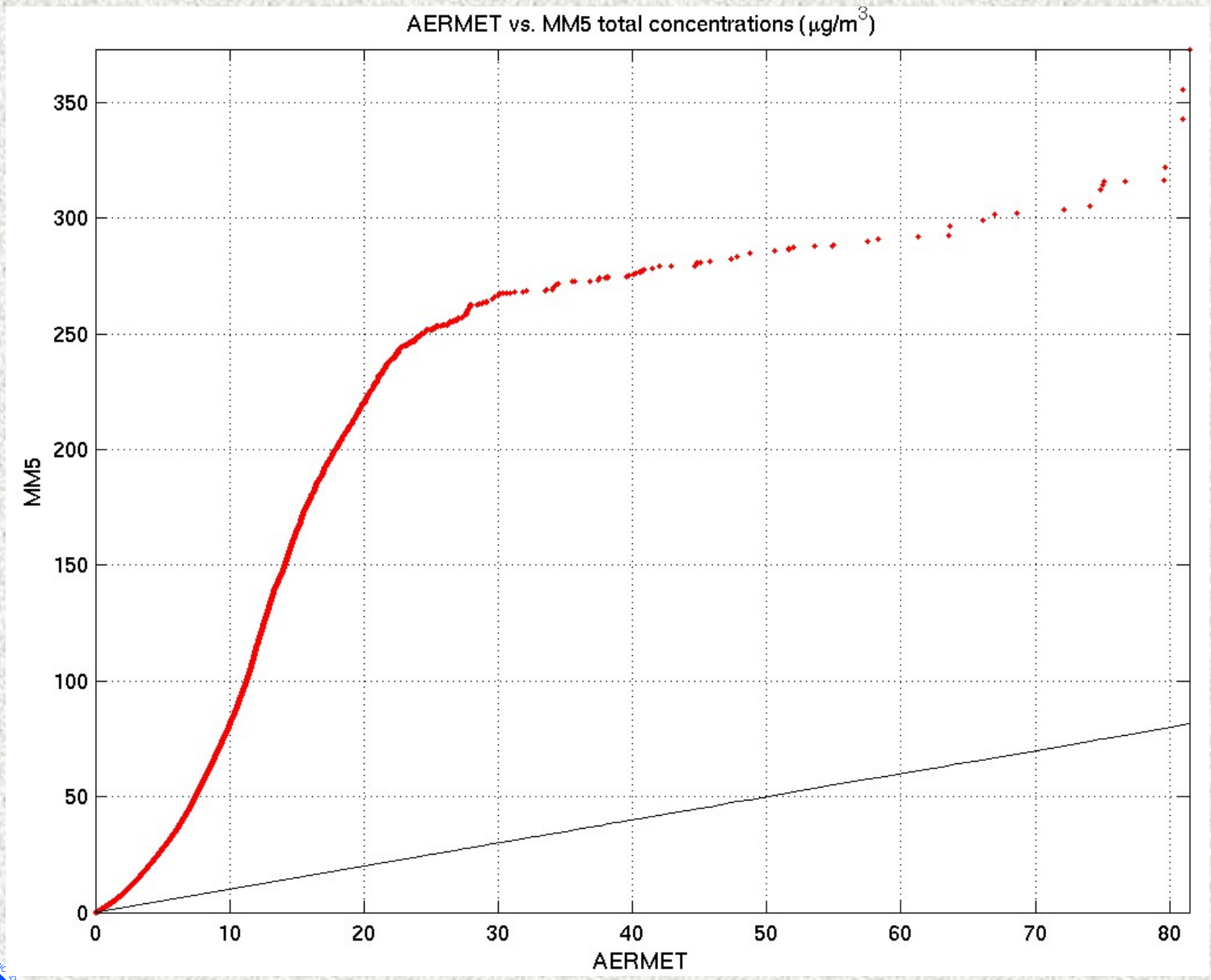
1999 Emissions, 2001 MM5 Meteorology (34 Levels)

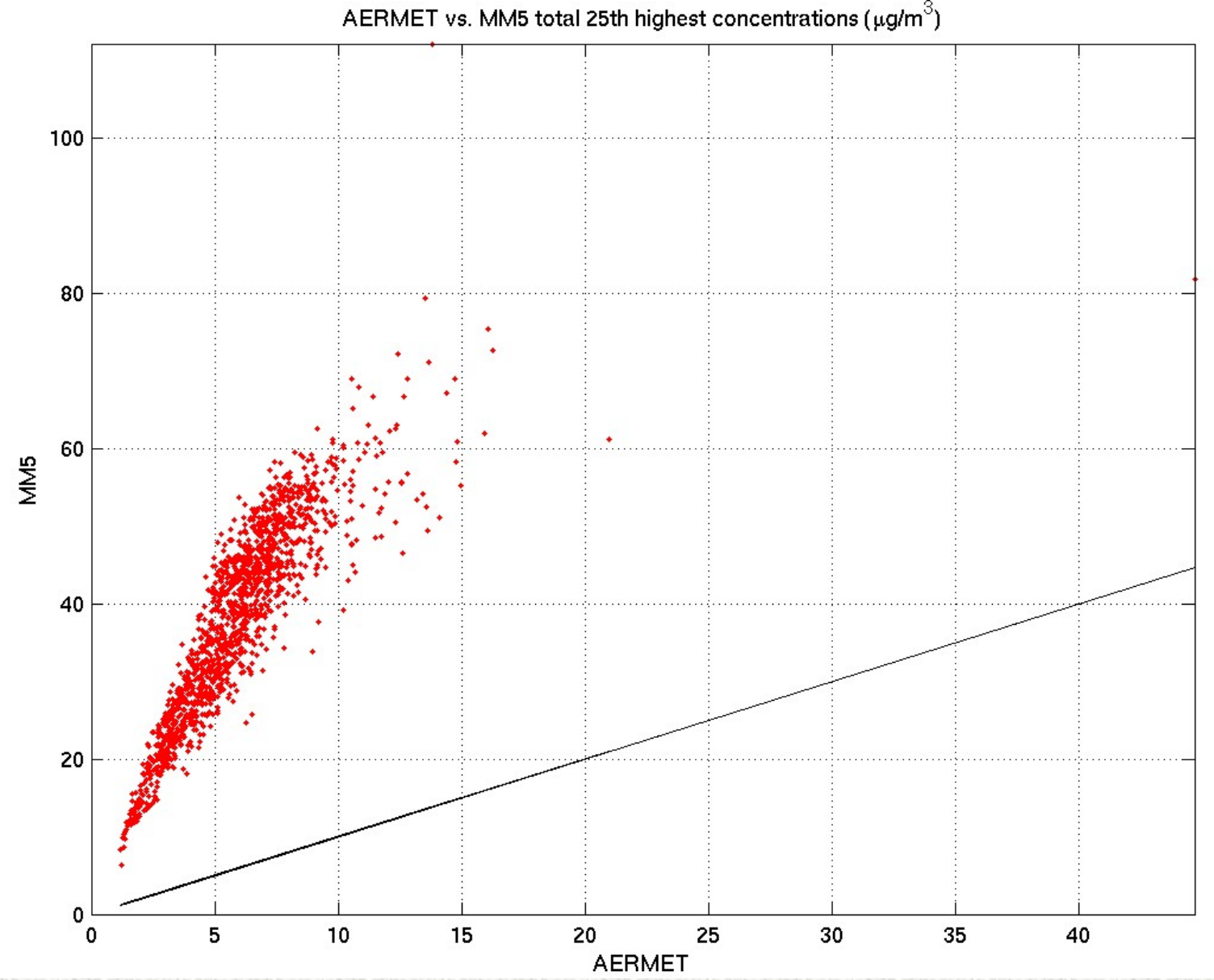


PHL Benzene Annual Average Concentration Difference

DIFF = MM5_Benzene - AERMET_Benzene (All Sources)




AERMET vs. MM5 total concentrations (μg/m3)
MM5
AERMET
0
50
100
150
200
250
300
350
0
10
20
30
40
50
60
70
80


AERMET vs. MM5 total 25th highest concentrations (μg/m3)
MM5
AERMET
0
20
40
60
80
100
0
5
10
15
20
25
30
35
40

Next steps – MM5 and AERMOD

- Different meteorological station locations (surface and upper-air)
- Emissions datasets similar to permit applications (not toxics)
- Expand beyond single MM5 grid cell
- Expand evaluations

Next Steps
(Beyond MM5 & AERMOD)

- Continue to evaluate
- CALPUFF adaptations of AERMOD activities (CALMM5)
- NCEP model output replaces MM5, preferably in both regional grid and local dispersion modeling
- Transition to real-time and forecast model output.
- Collaborate with Workgroup