Impact of Model Resolution in ACOS-xCO_2 Observation Assimilation

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Acknowledgement

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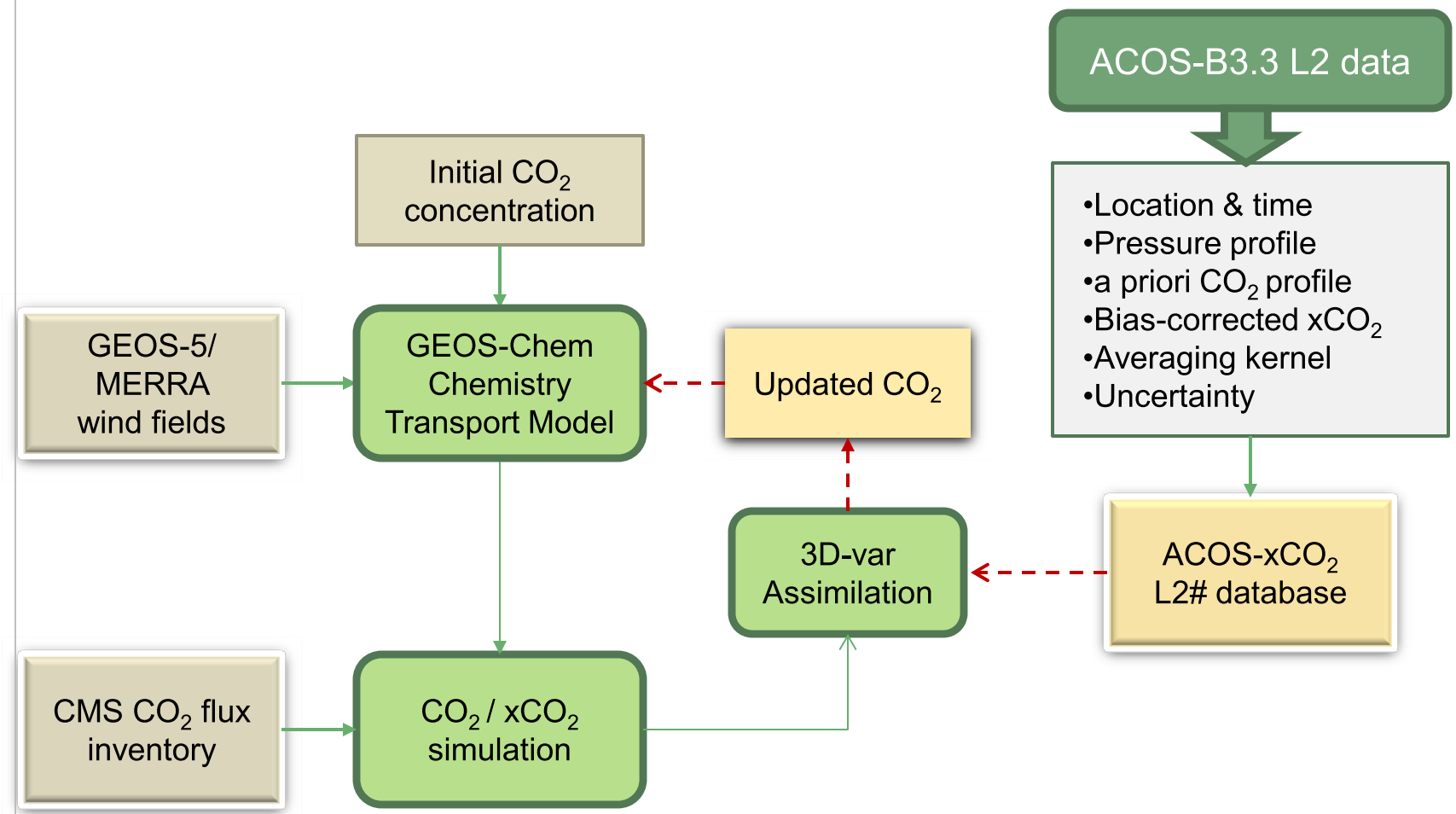
This research utilized meteorology fields generated by NASA Global Modeling and Assimilation Office (GMAO) and CO2 flux datasets developed by NASA Carbon Monitoring System (CMS) program.

Multi-resolution ACOS-xCO_2 Assimilation Process



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ACOS B3.3 Observation Analysis

- Quality screening
- Bias correction
- Sampling frequency
- Comparison with TCCON xCO_2

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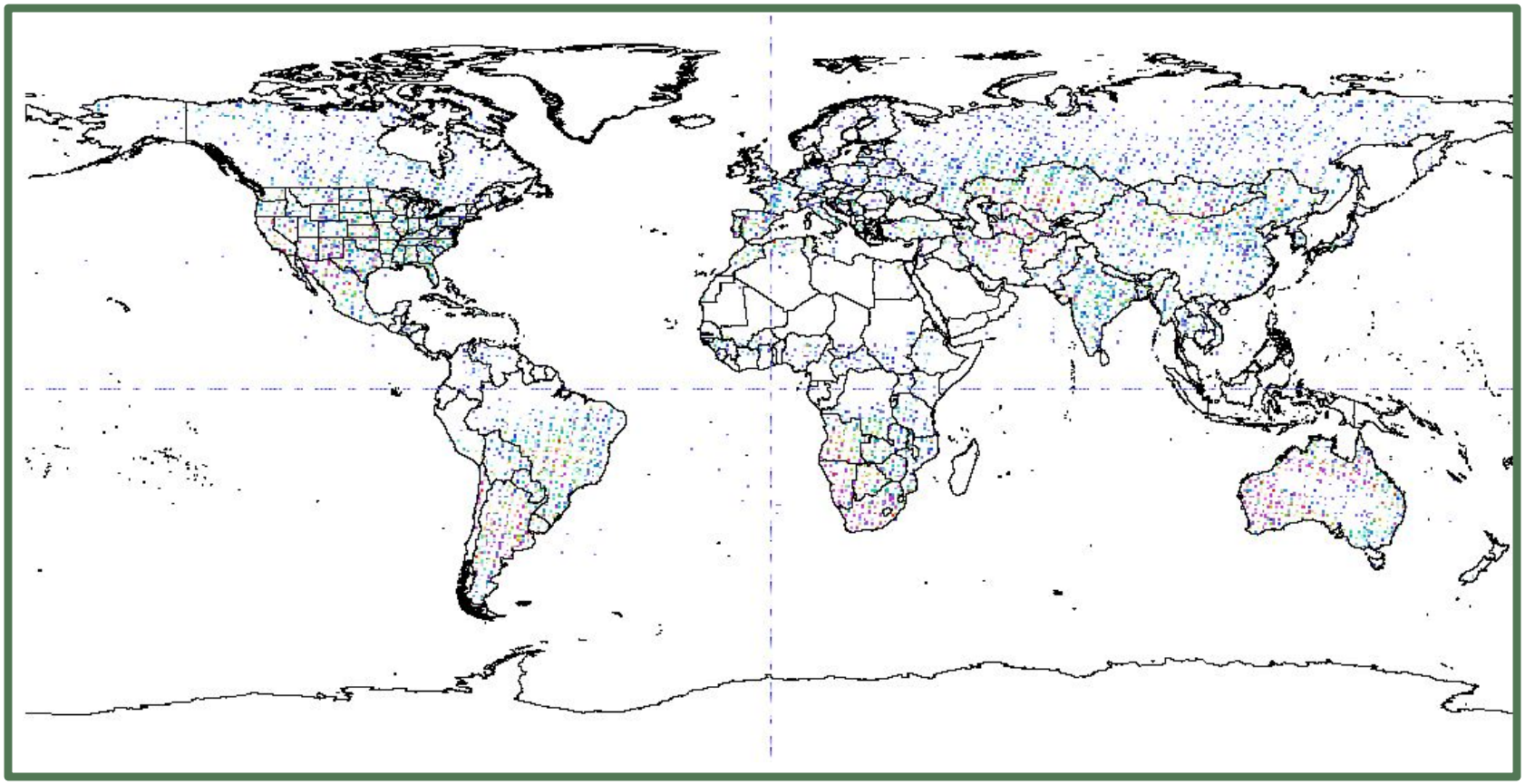
Cumulative Sample Density – 0.5°x0.625°



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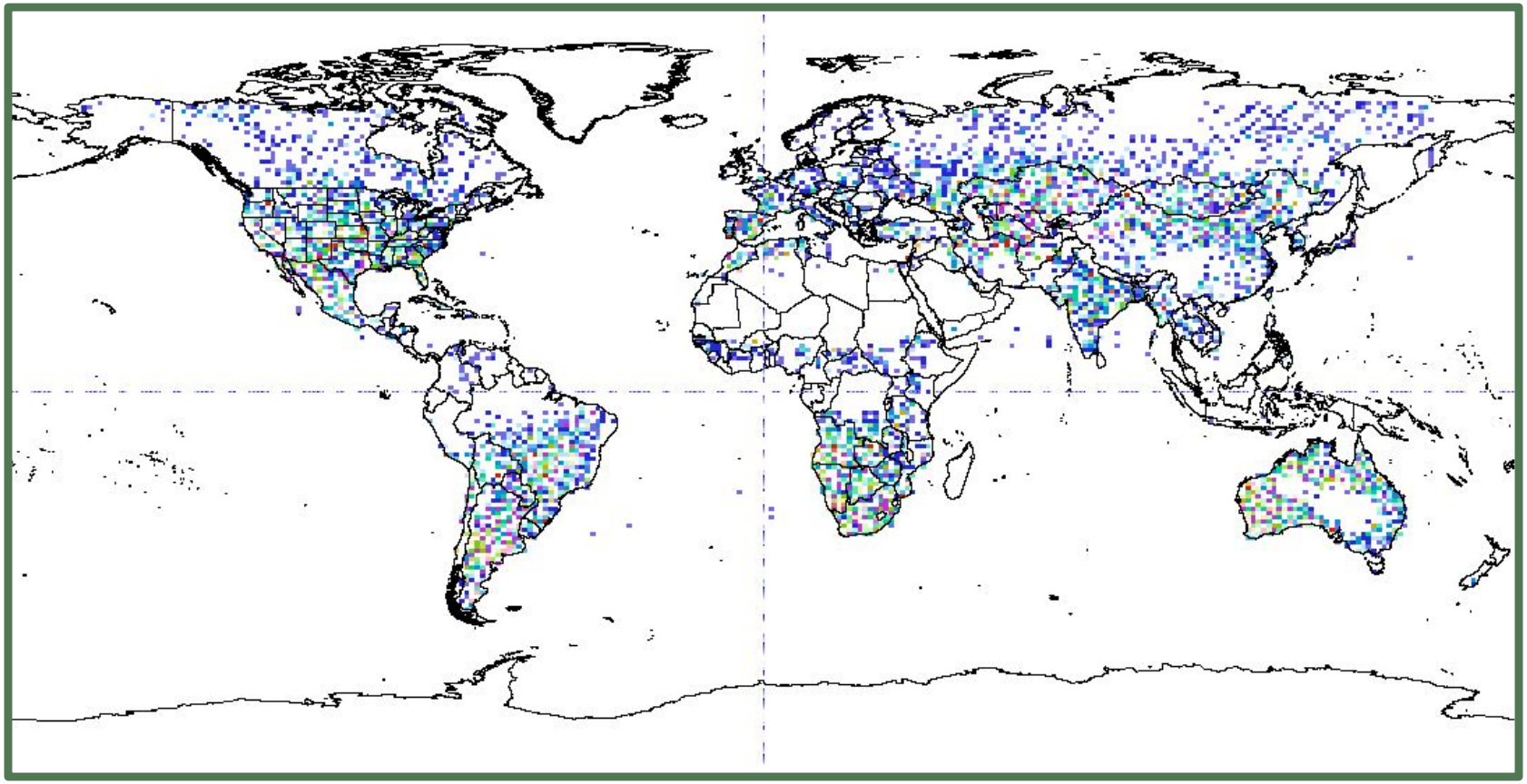
Sample Frequency – 1.0°x1.25°



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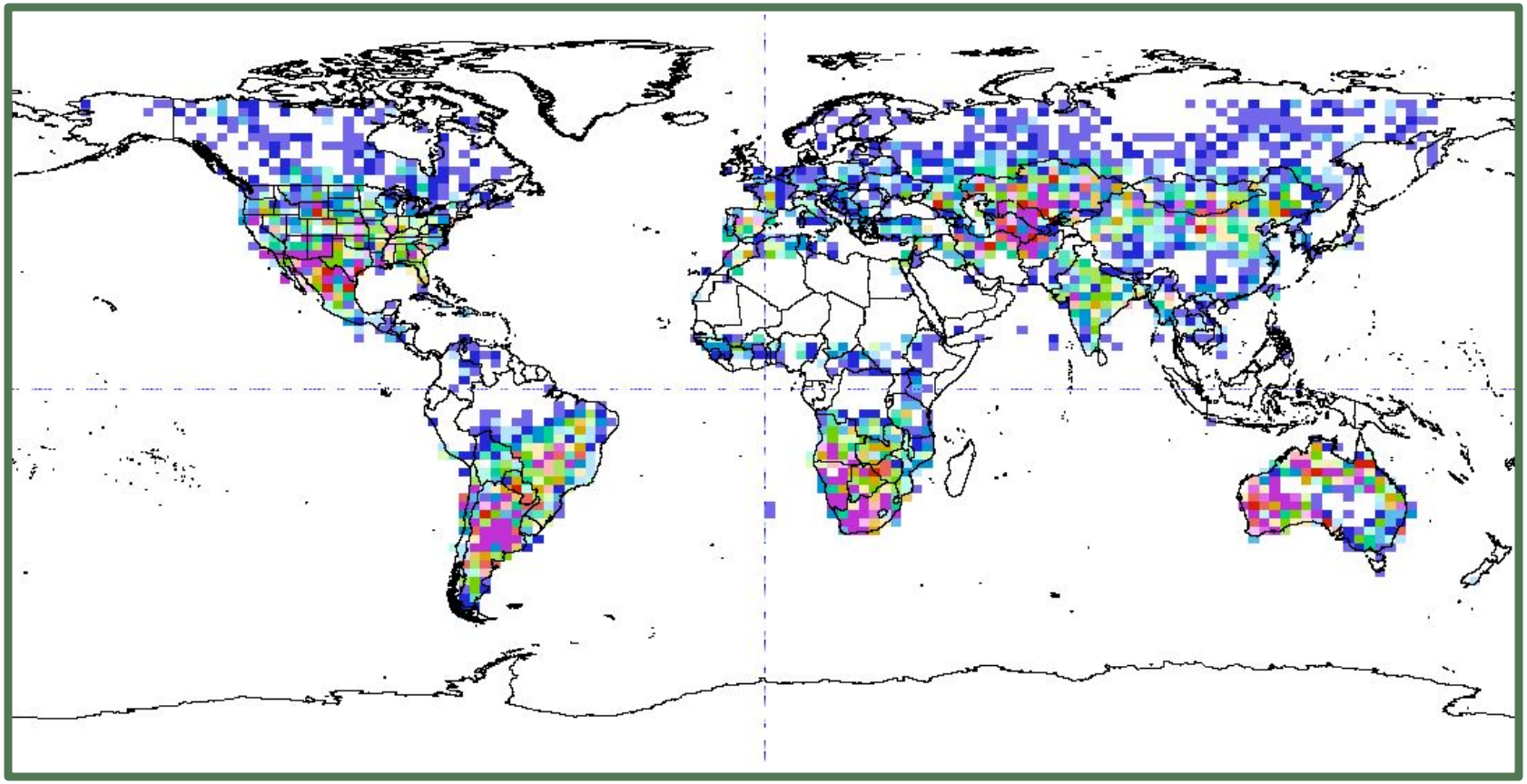
Sample Frequency – 2.0°x2.5°



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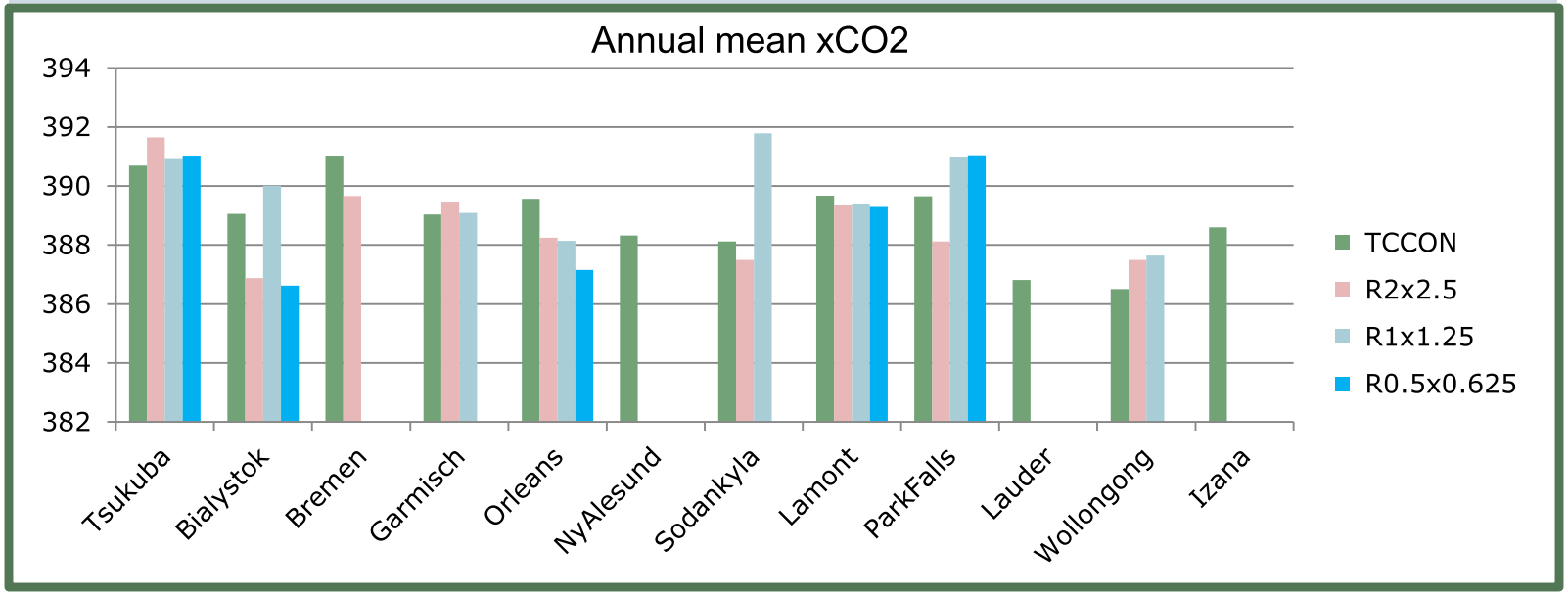
ACOS observations at TCCON Sites

city	TCCON		R2x2.5		R1x1.25		R0.5x0.625	
Tsukuba	41	390.6884	34	391.6422	11	390.9407	9	391.028
Bialystok	120	389.0569	8	386.8777	3	390.0056	1	386.6185
Bremen	53	391.0307	10	389.6589				
Garmisch	114	389.0386	13	389.4728	2	389.0824		
Orleans	89	389.563	31	388.2453	10	388.1425	5	387.154
NyAlesun	34	388.3244						
Sodankyla	122	388.1229	6	387.4985	1	391.7808		
Lamont	300	389.6729	47	389.3735	37	389.4086	27	389.2834
ParkFalls	155	389.6512	30	388.1156	3	391.002	1	391.0364
Lauder	76	386.8178						
Wollongo	149	386.5067	43	387.4939	15	387.6479		
Izana	51	388.6007						



Multi-resolution xCO_2 simulation

Spatial resolution	MERRA Wind fields	CMS Emission inventory	Simulation step size	ACOS sampling	Global maps
2.0°x2.5°	3 hourly	Varying	15 min	15 min	3 hourly
1.0°x1.25°	3 hourly	Varying	5 min	5 min	3 hourly
0.5°x0.625°	3 hourly	Varying	2.5 min	2.5 min	3 hourly

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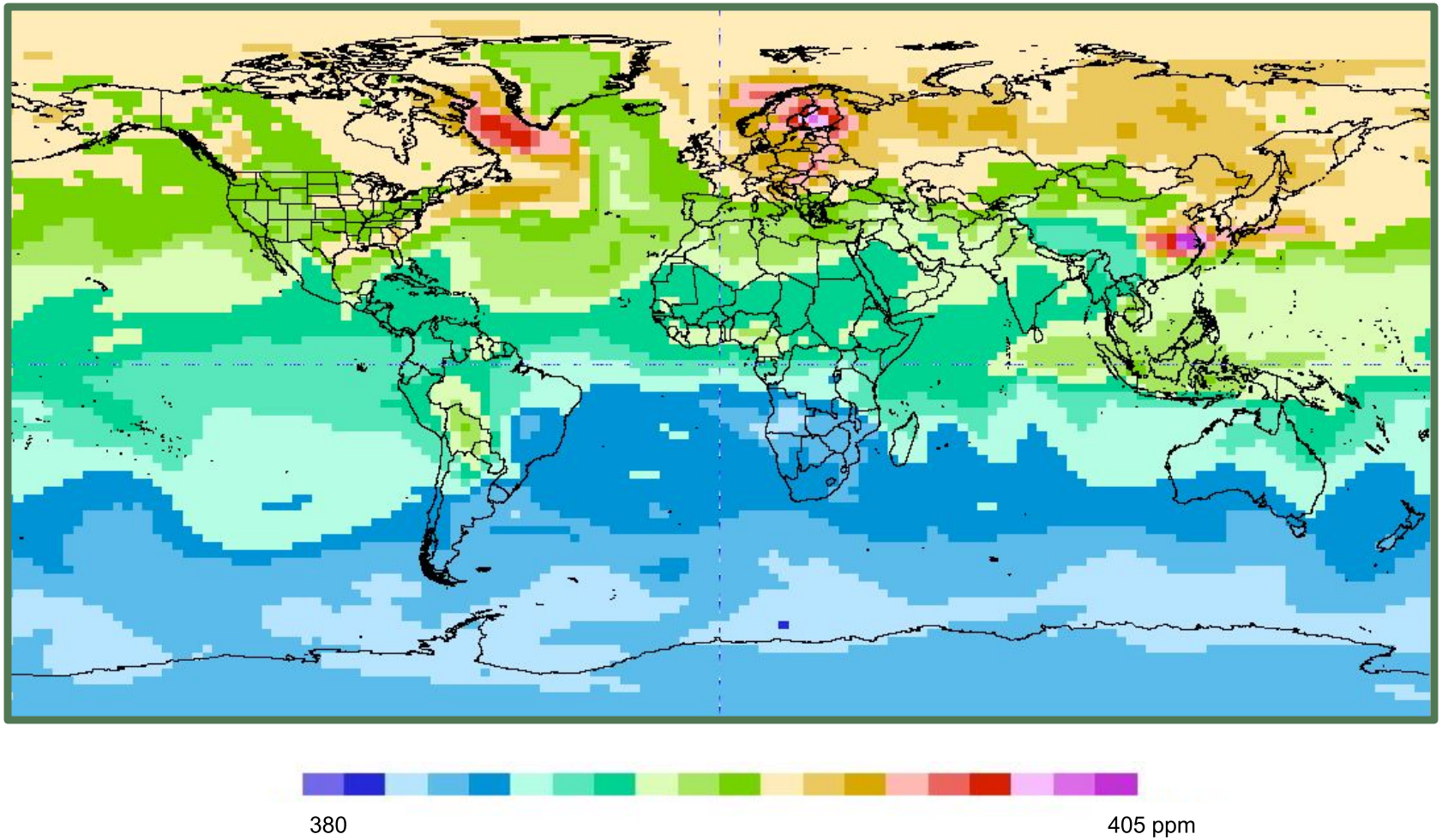
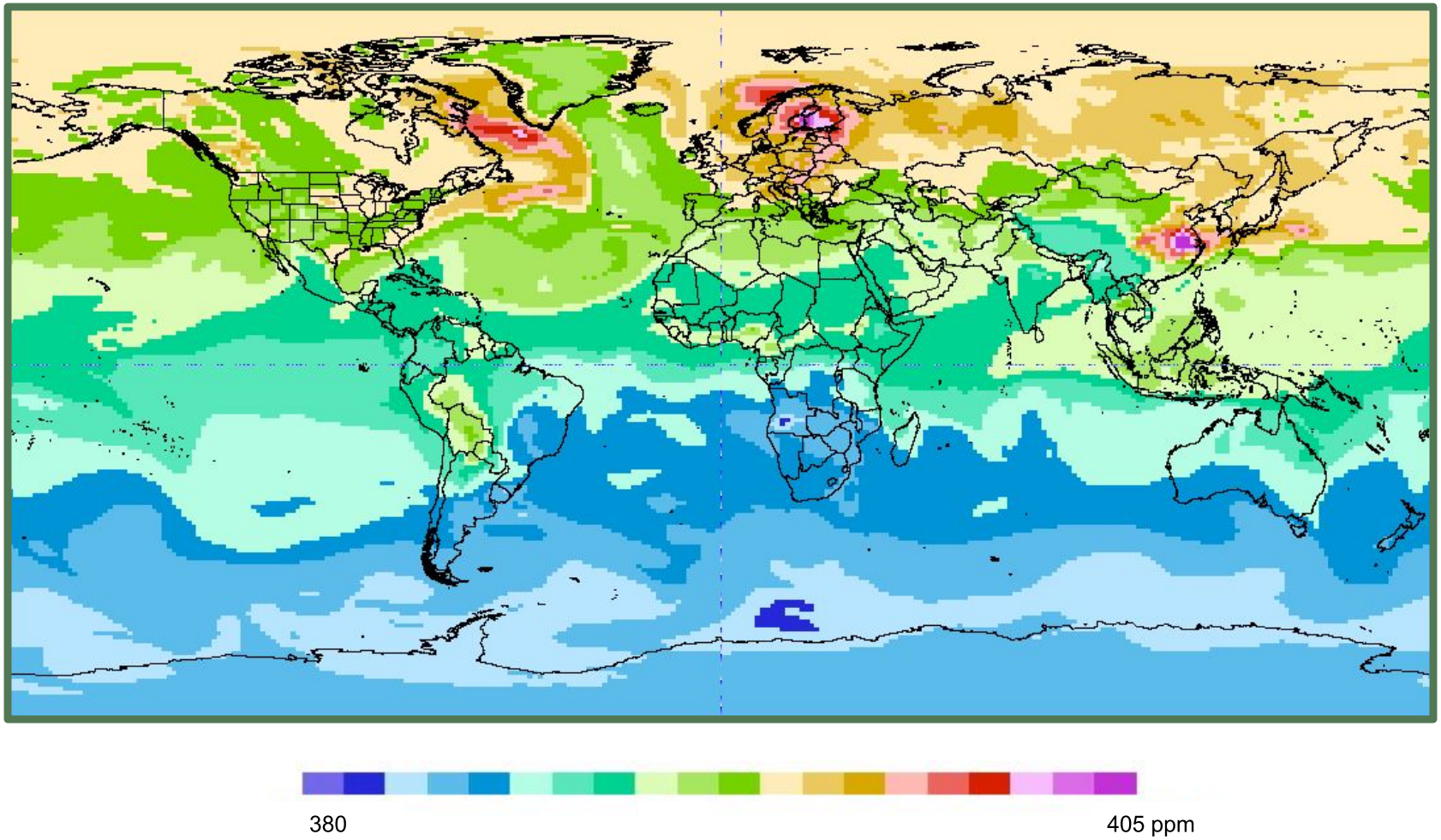
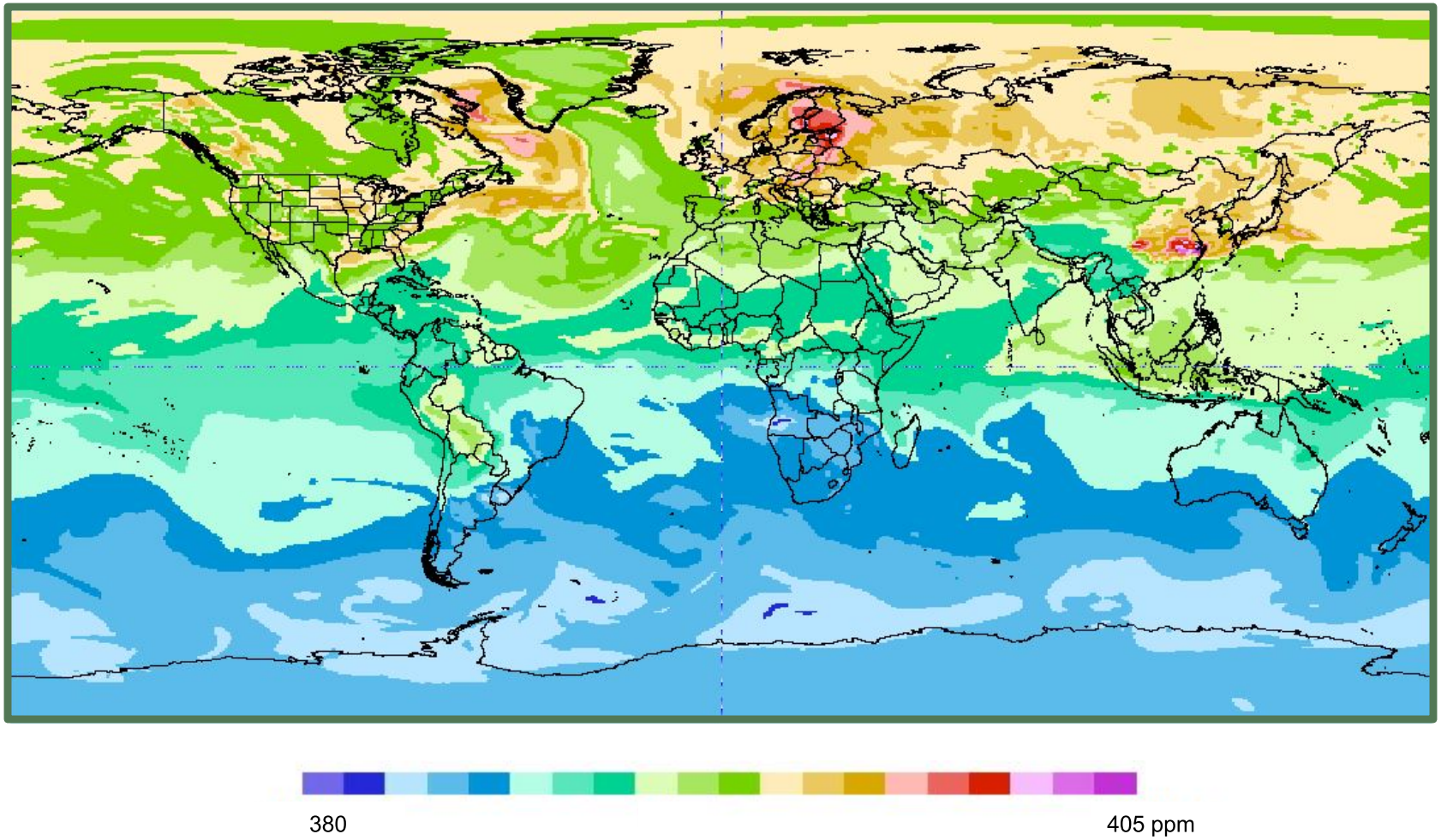
xCO_2 – 2.0°x2.5° (2010/01/31/12:00:00)



xCO2 – 1.0°x1.25° (2010/01/31/12:00:00)



xCO2 – 0.5°x0.625° (2010/01/31/12:00:00)



Simulated xCO_2 at Large cities

(2010/May)

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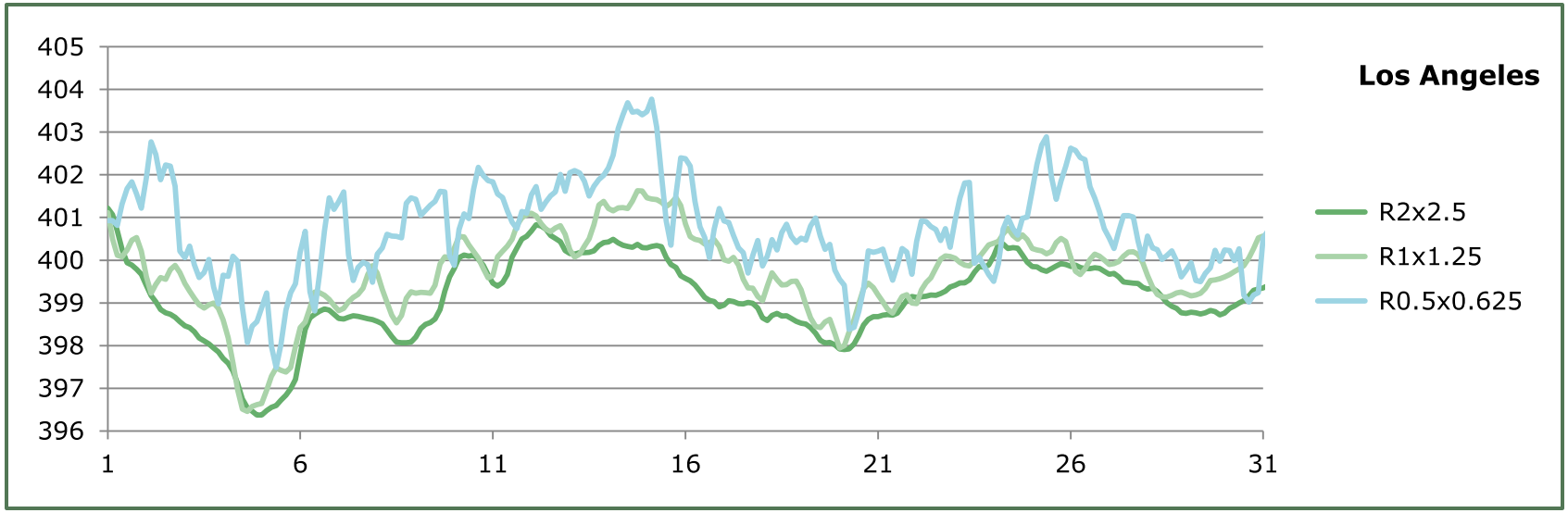
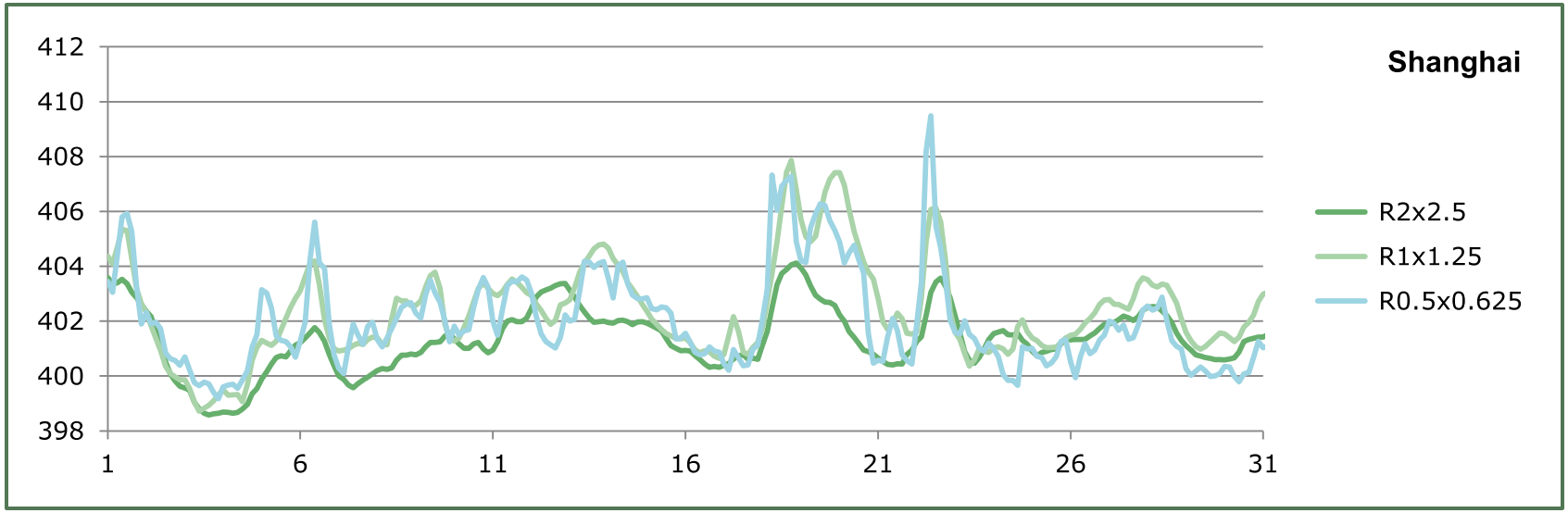
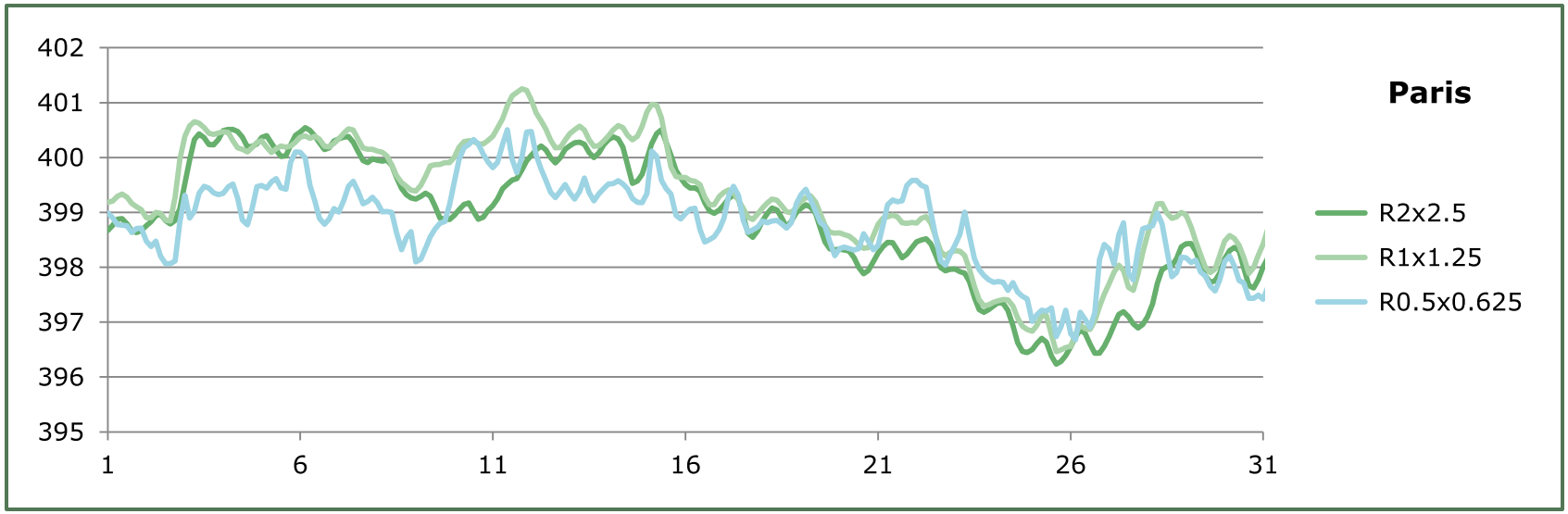

Los Angeles
405
404
403
402
401
400
399
398
397
396
1
6
11
16
21
26
31
R2x2.5
R1x1.25
R0.5x0.625


Shanghai
412
410
408
406
404
402
400
398
1
6
11
16
21
26
31
R2x2.5
R1x1.25
R0.5x0.625


Paris
402
401
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395
1
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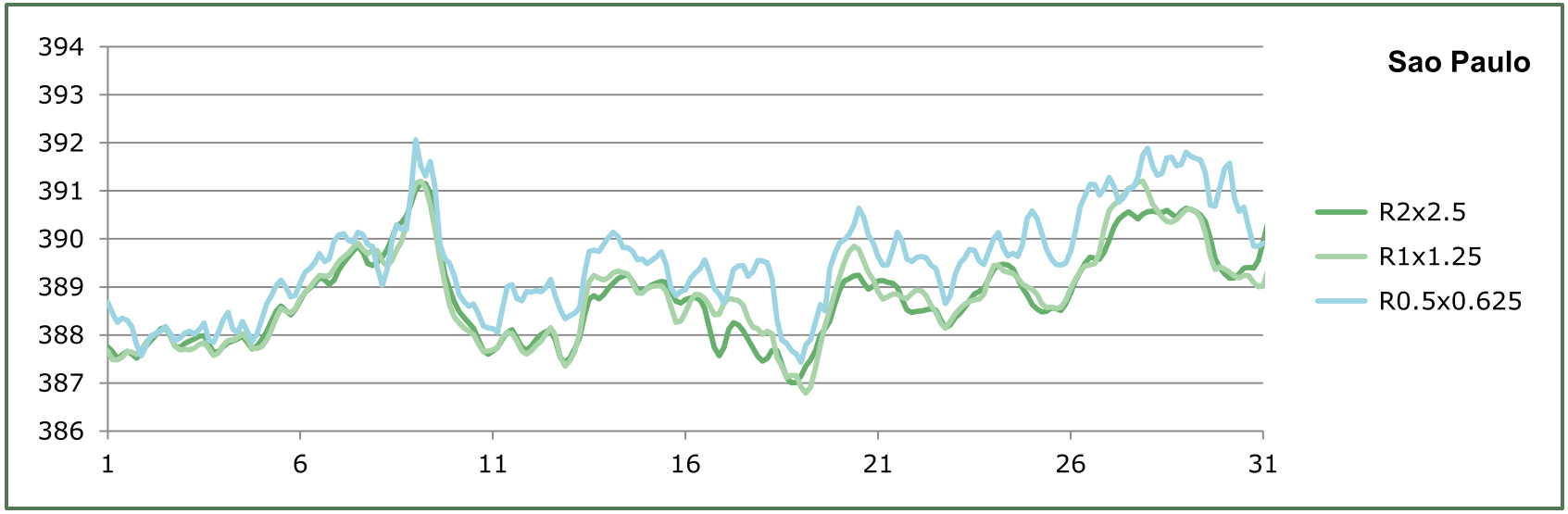
16
21
26
31
R2x2.5
R1x1.25
R0.5x0.625


Sao Paulo
394
393
392
391
390
389
388
387
386
1
6
11
16
21
26
31
R2x2.5
R1x1.25
R0.5x0.625

Simulated xCO_2 at TCCON sites

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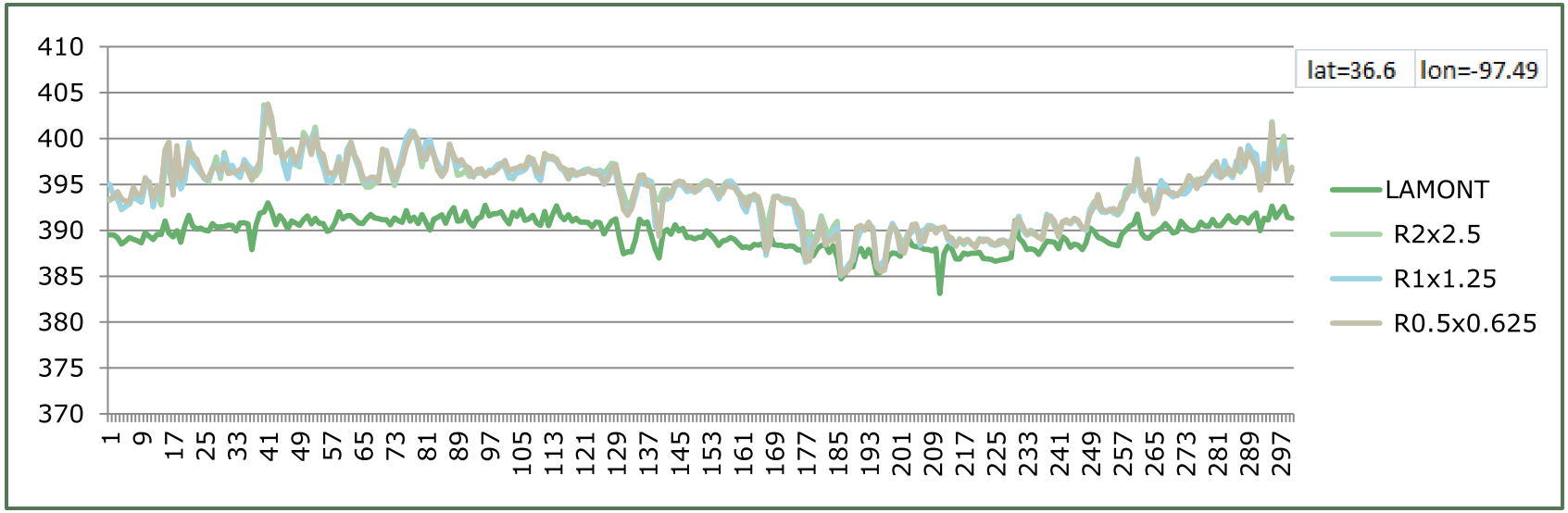
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LAMONT
R2x2.5
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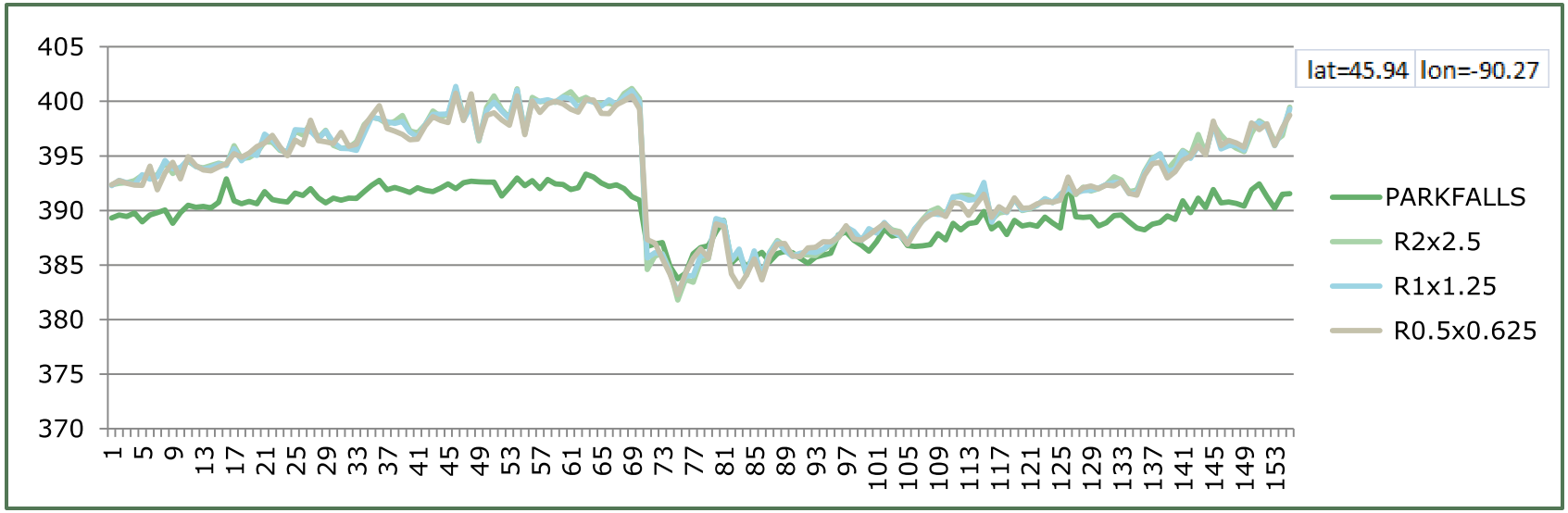
R0.5x0.625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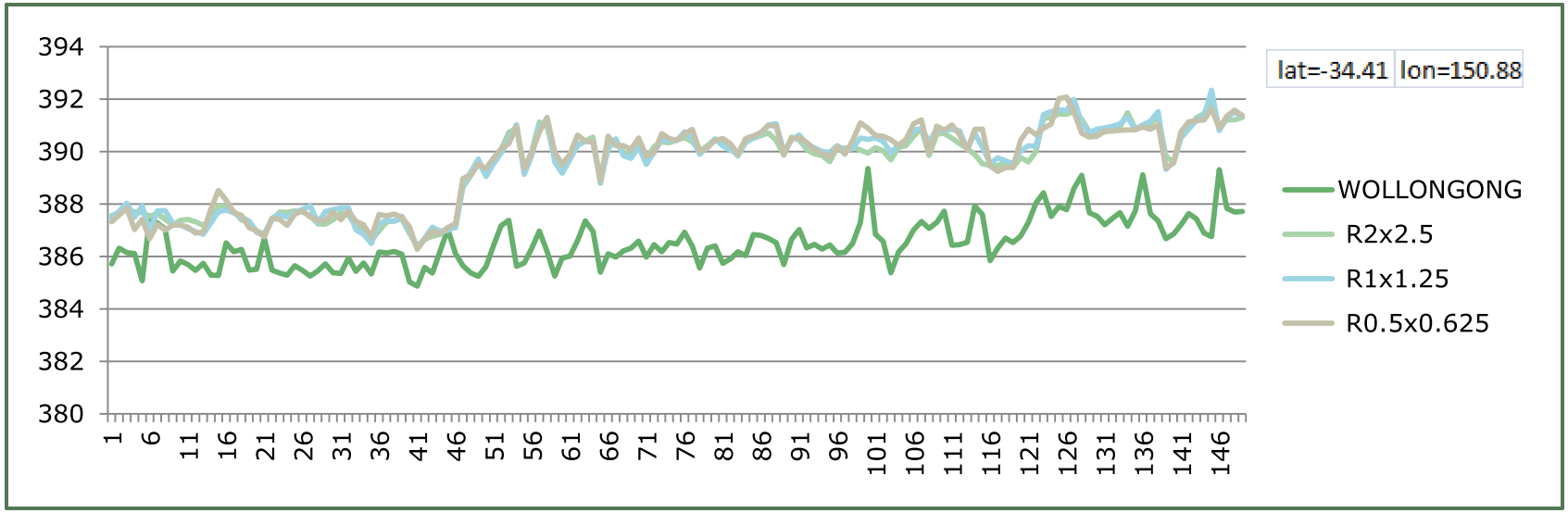
R1x1.25
R0.5x0.625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392
390
388
386
384
382
380
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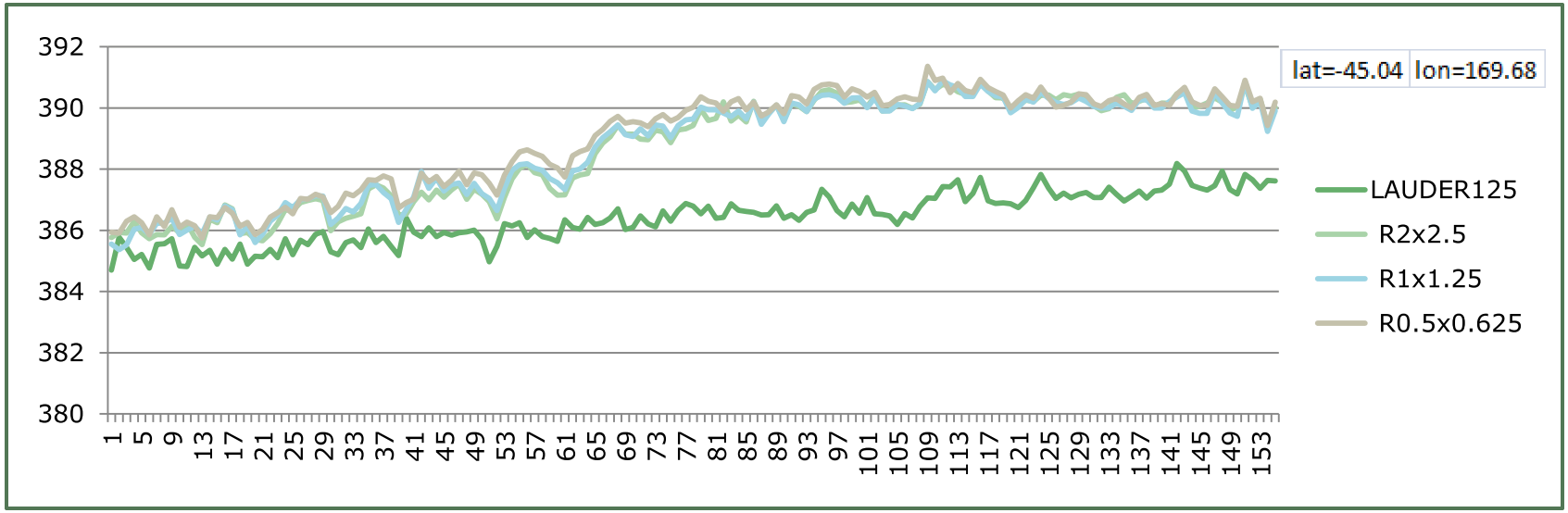
WOLLONGONG
R2x2.5
R1x1.25
R0.5x0.625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384
382
380
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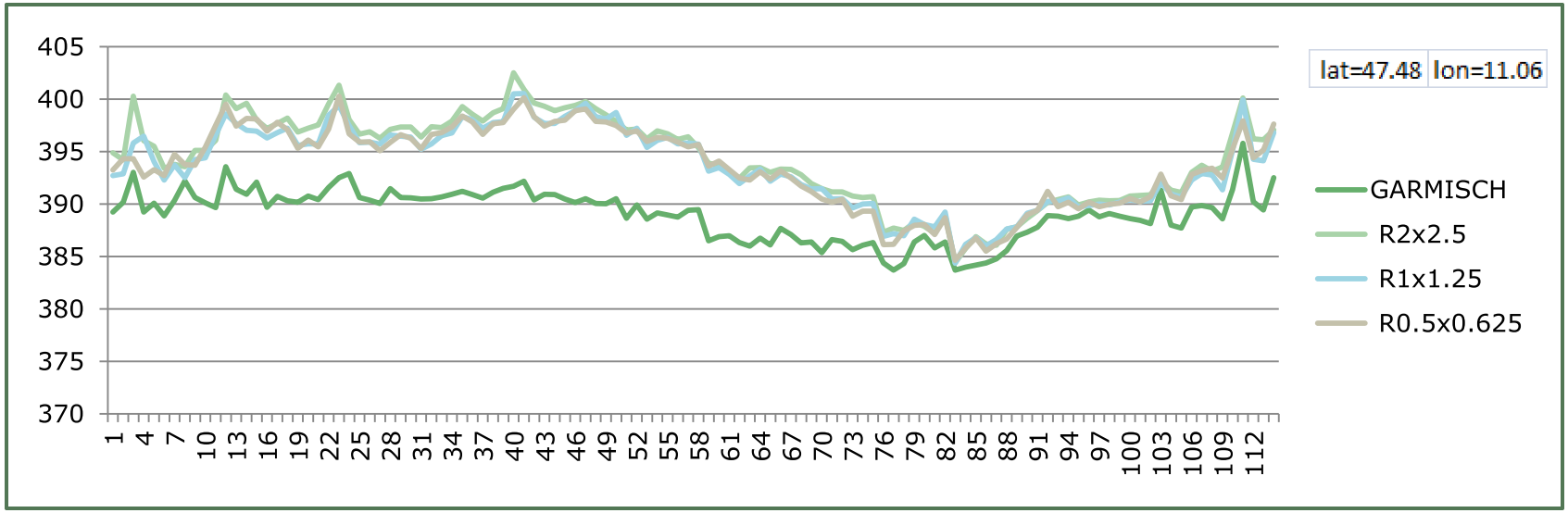
LAUDER125
R2x2.5
R1x1.25
R0.5x0.625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400
395
390
385
380
375
370
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85 88 91 94 97 100 103 106 109 112
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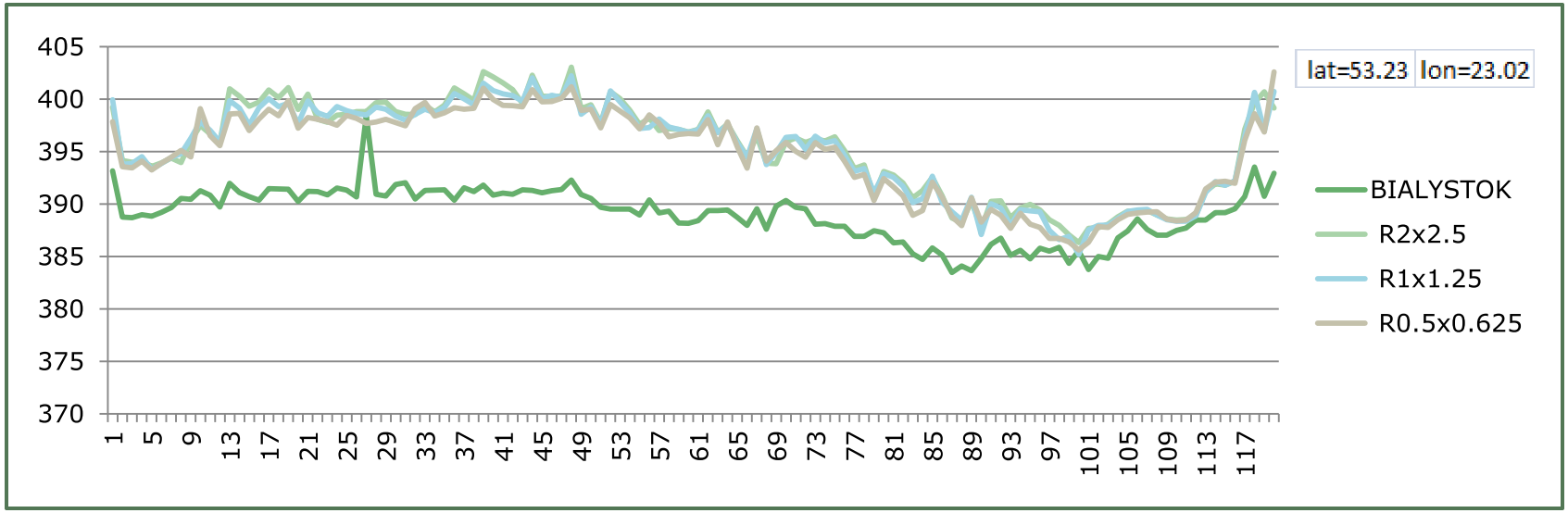
GARMISCH
R2x2.5
R1x1.25
R0.5x0.625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375
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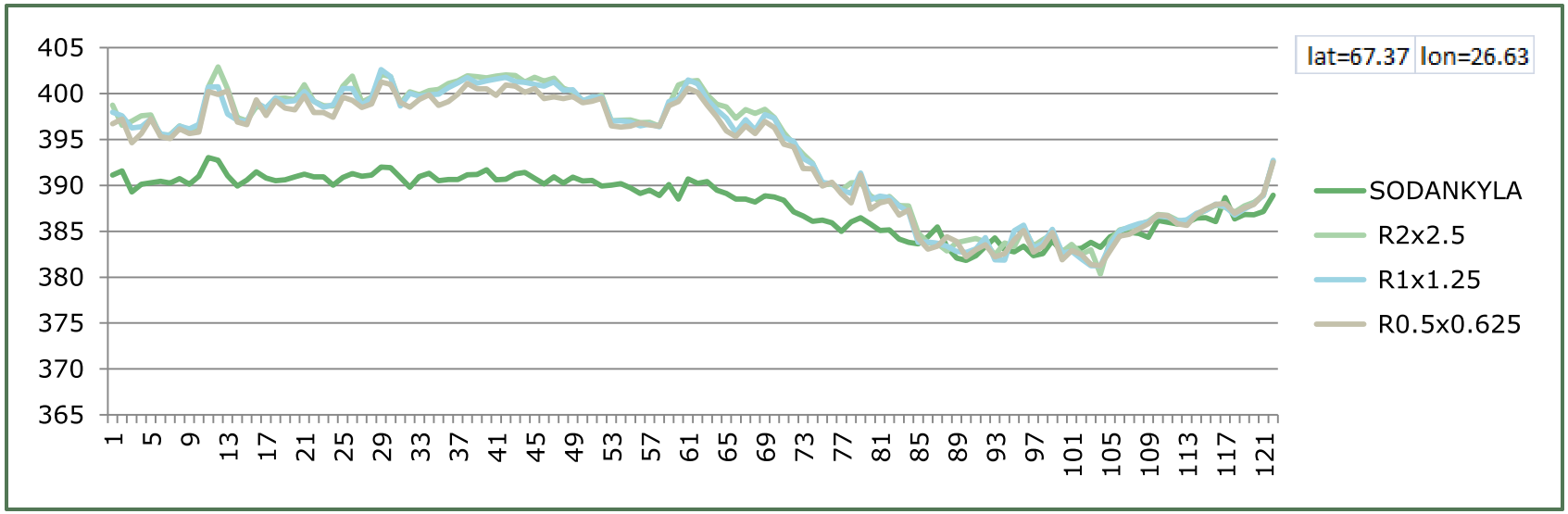
BIALYSTOK
R2x2.5
R1x1.25
R0.5x0.625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375
370
365
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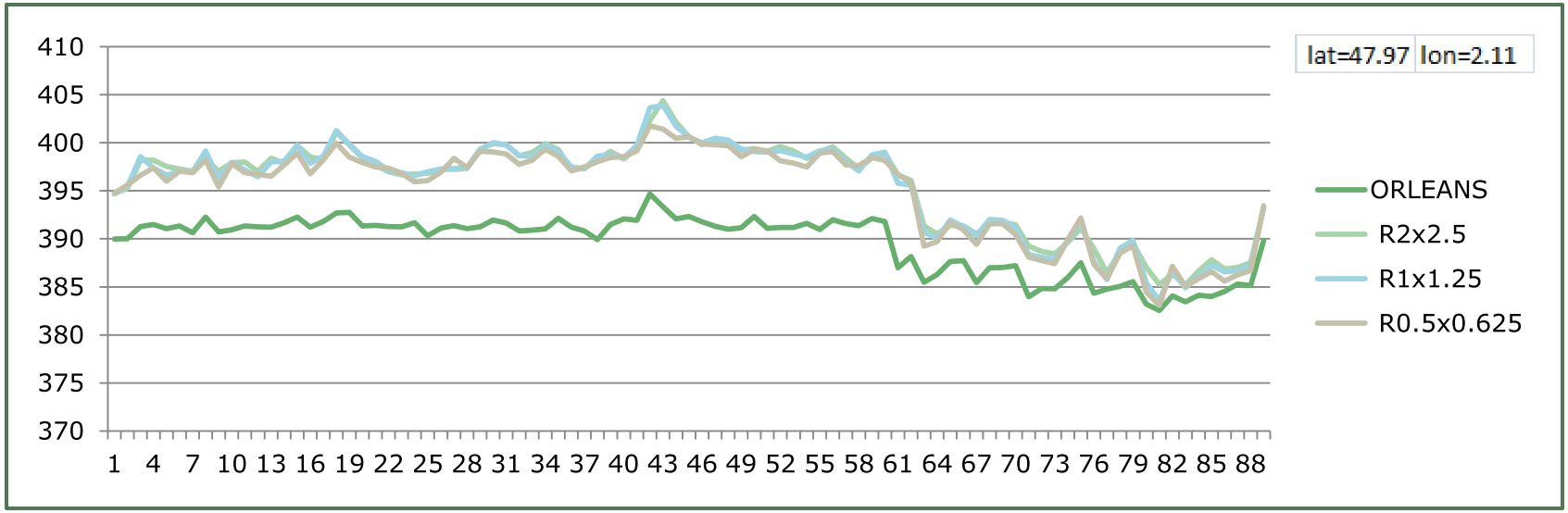
SODANKYLA
R2x2.5
R1x1.25
R0.5x0.625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405
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375
370
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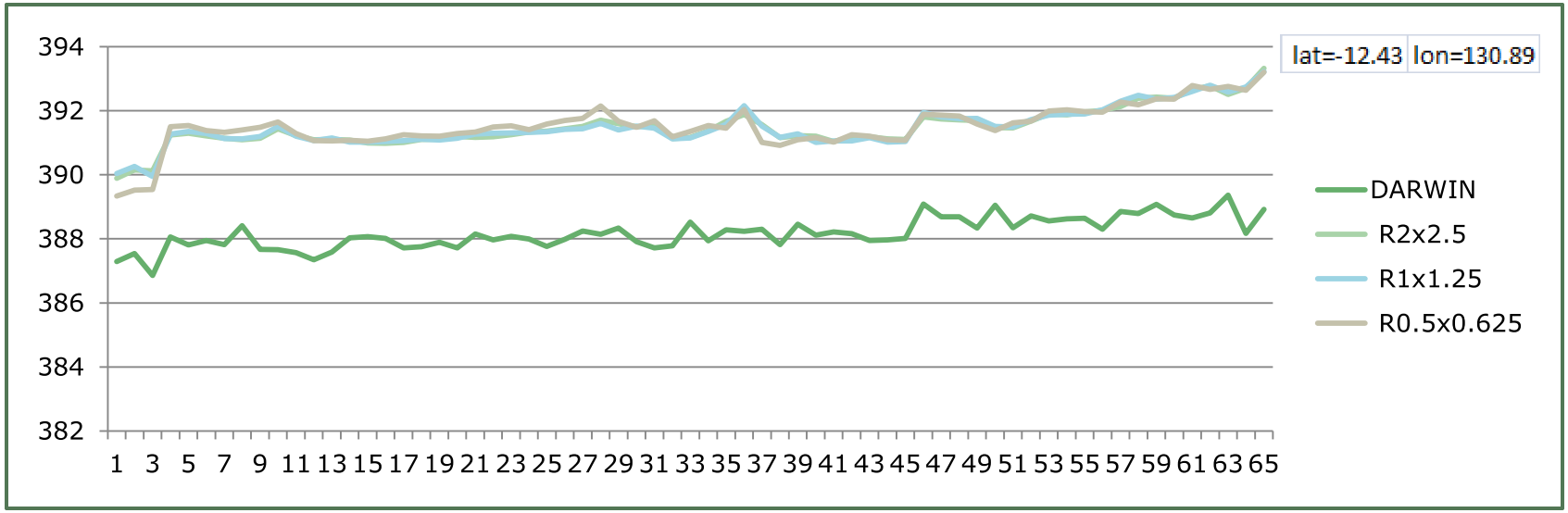
ORLEANS
R2x2.5
R1x1.25
R0.5x0.625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392
390
388
386
384
382
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DARWIN
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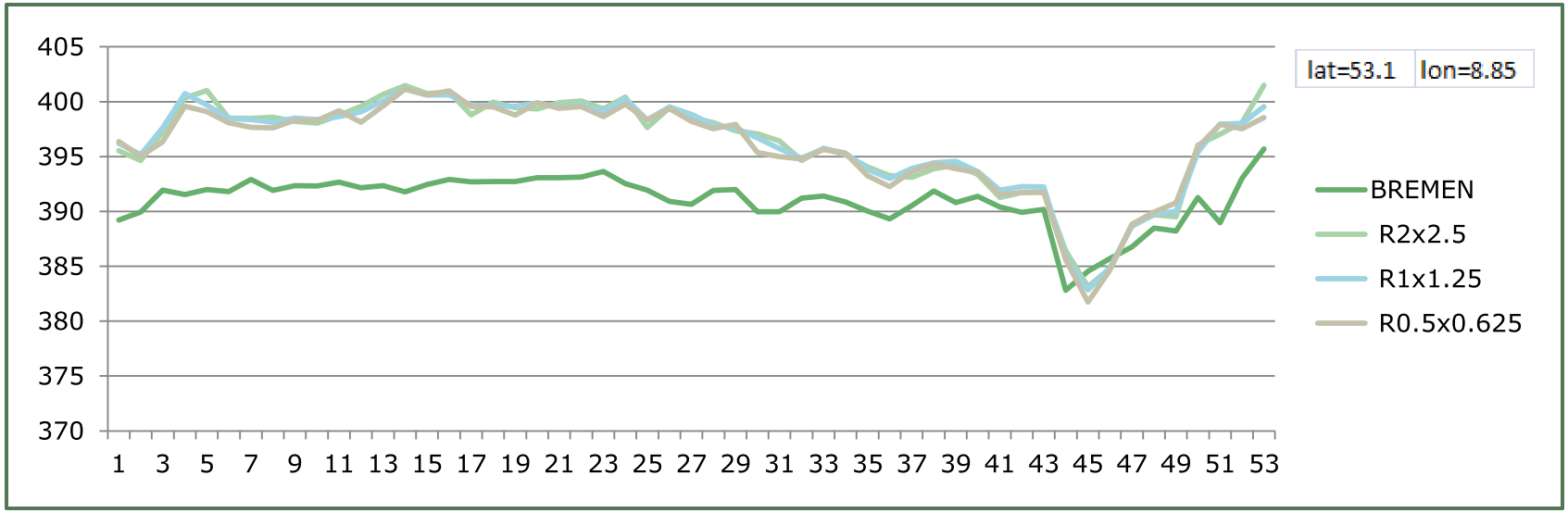
R1x1.25
R0.5x0.625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395
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380
375
370
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BREMEN
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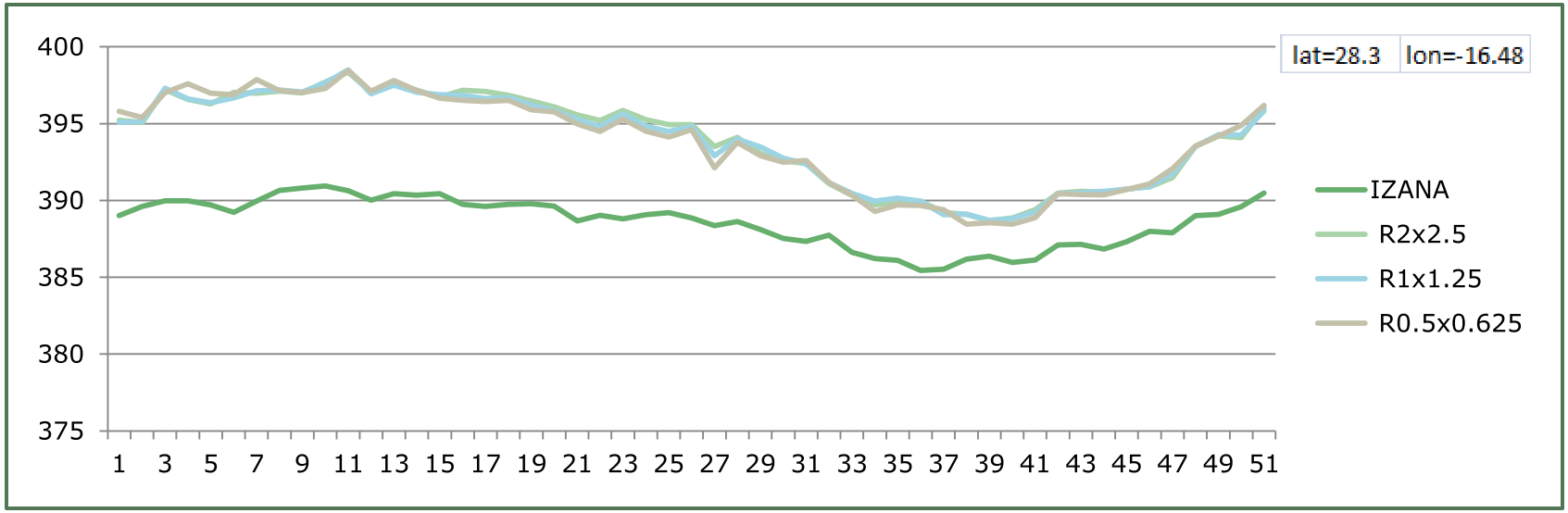
R1x1.25
R0.5x0.625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375
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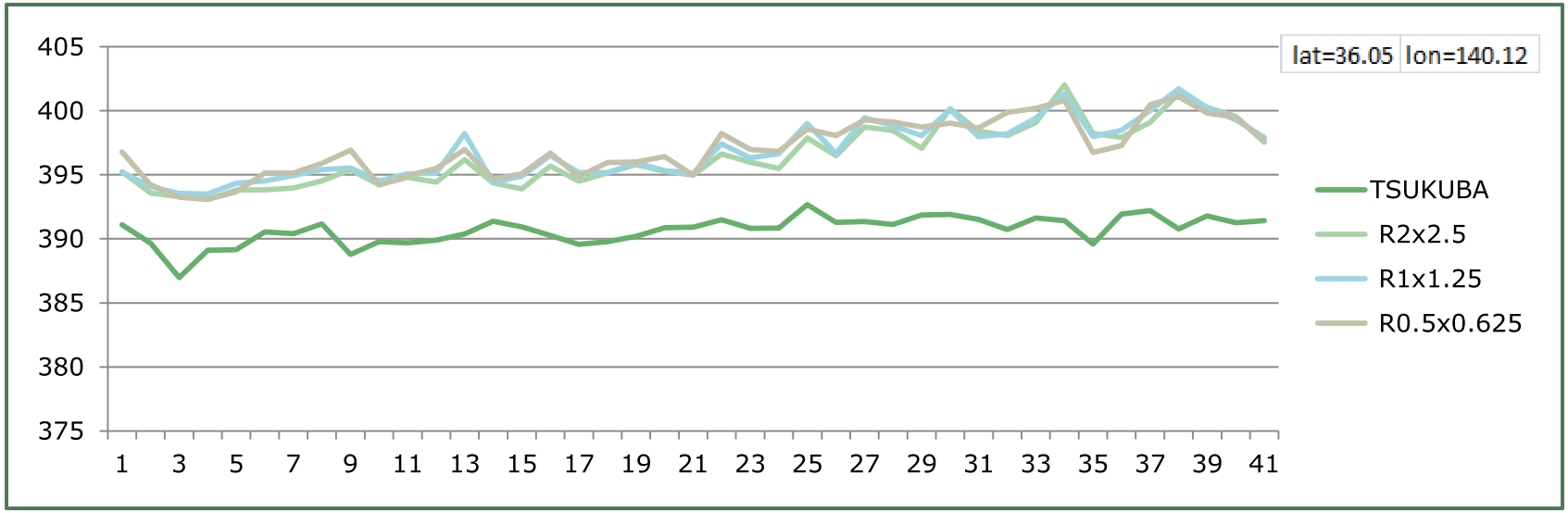
R1x1.25
R0.5x0.625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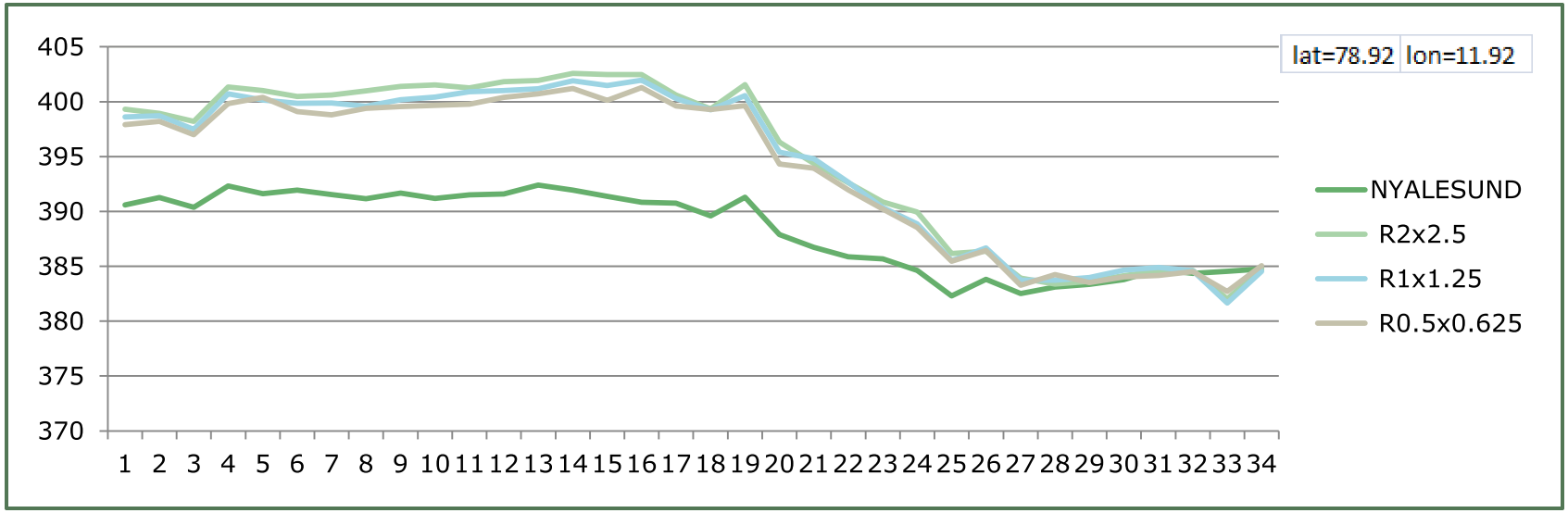
R0.5x0.625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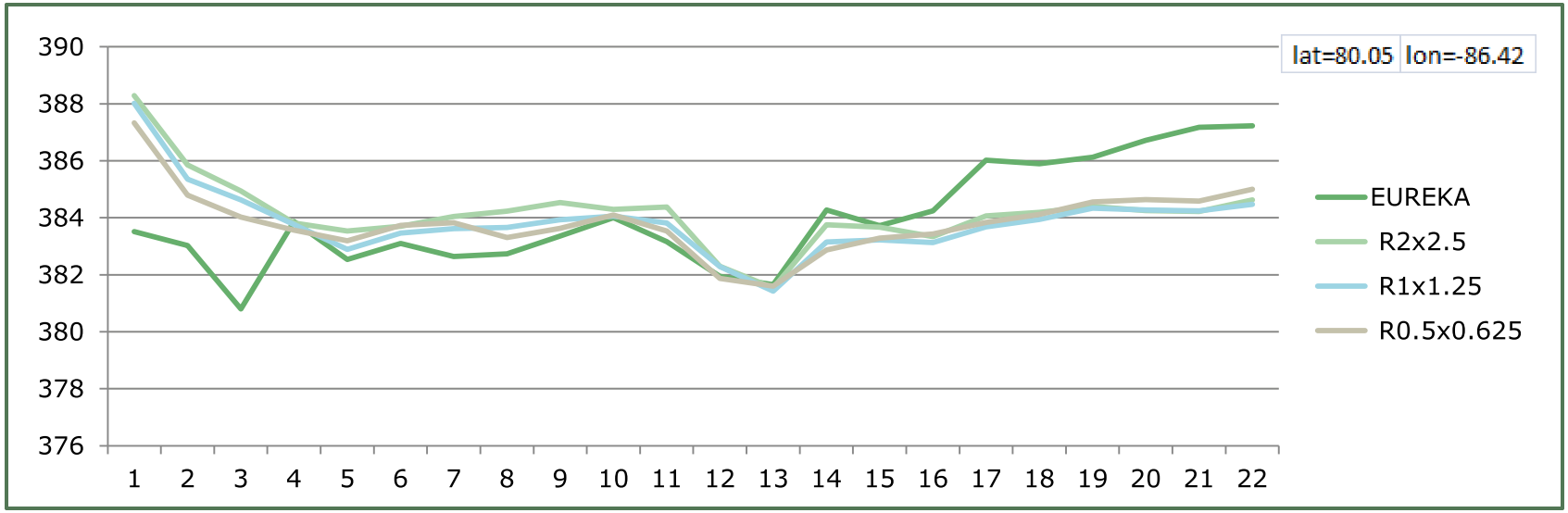
NYALESUND
R2x2.5
R1x1.25
R0.5x0.625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390
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386
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382
380
378
376
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EUREKA
R2x2.5
R1x1.25
R0.5x0.625

Observation force function analysis

$$J^{Model} = (xCO_2^{\ ACOS} - xCO_2^{Model})^2 / U^{\ ACOS}$$

$xCO_2^{\ ACOS}$: bias corrected ACOS-xCO_2
$xCO_2^{\ Model}$: simulated xCO_2 at model resolution
U^{ACOS} : observation uncertainty

The sample location (longitude, latitude) is mapped to the nearest model grid (x, y) and the sample time is mapped to the nearest simulation time.

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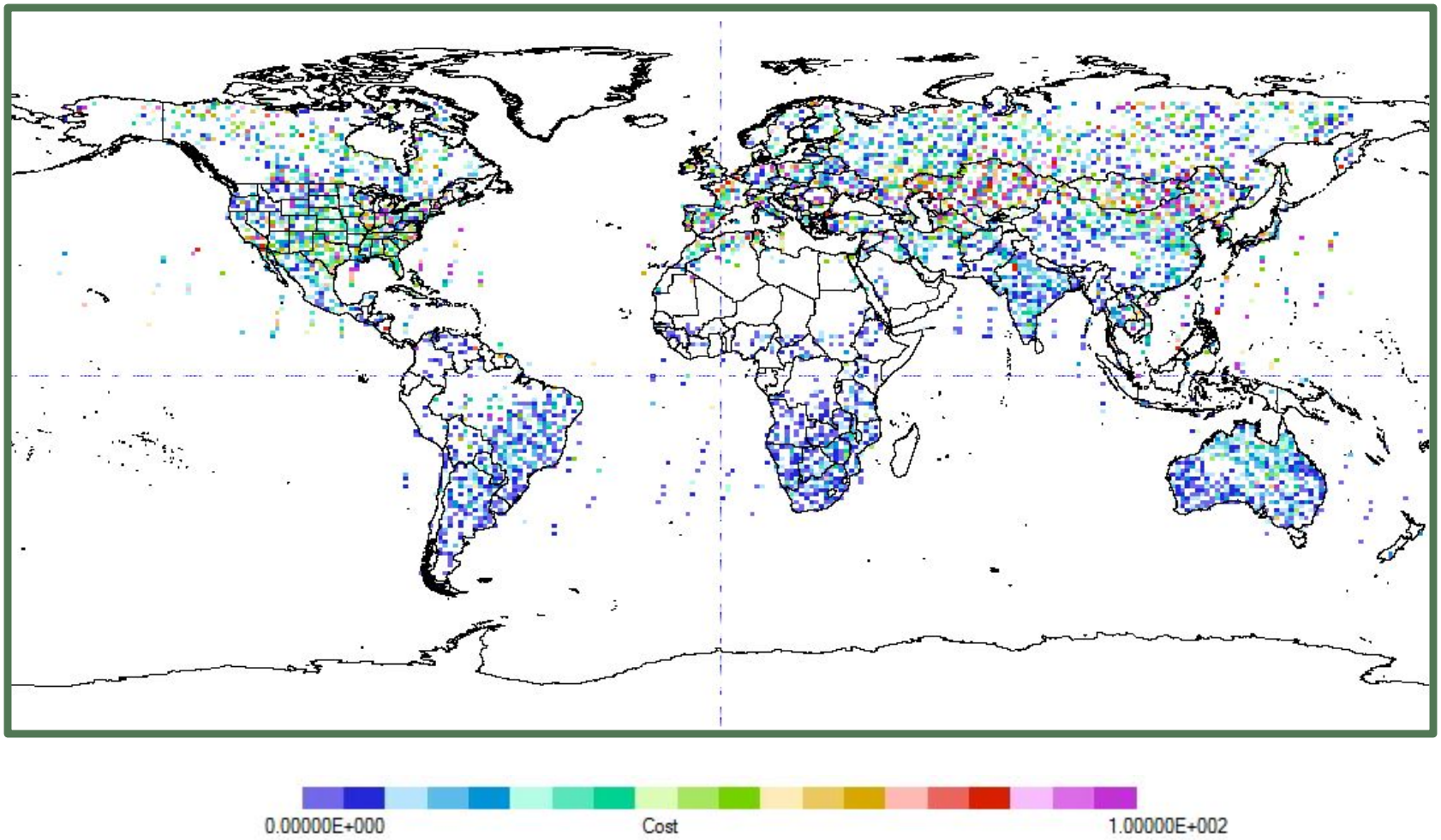
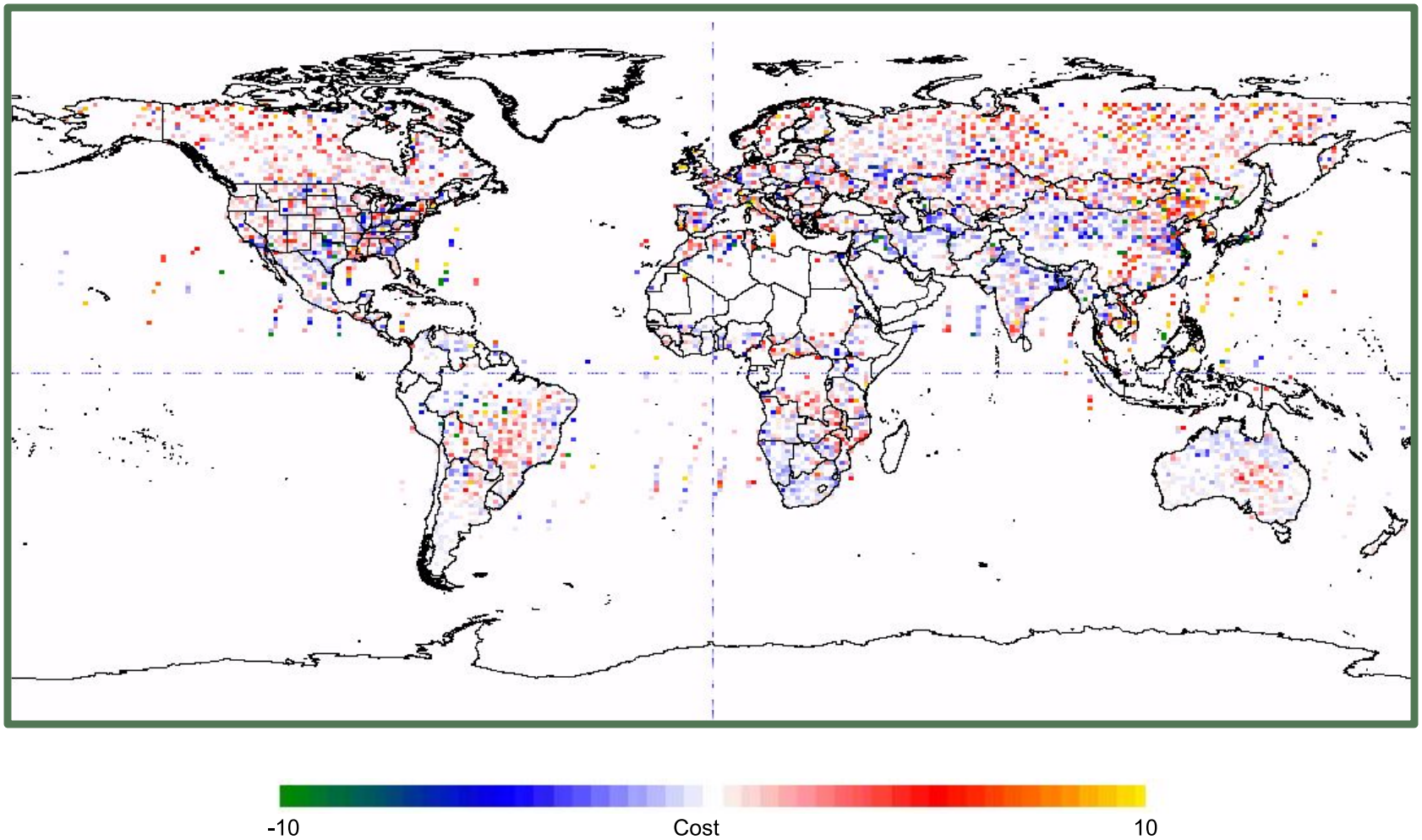
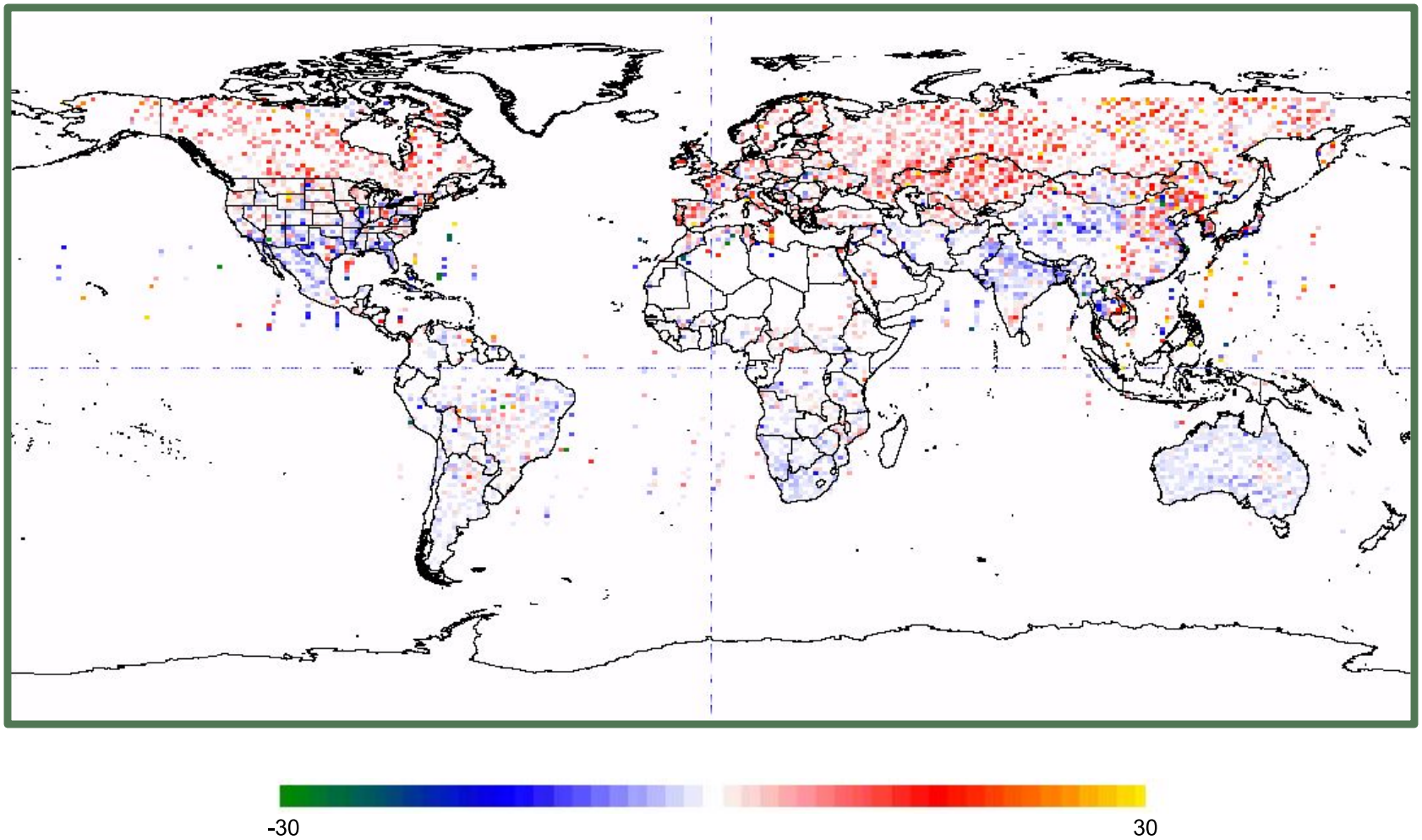
$J^{FR}(2.0°x2.5°)$

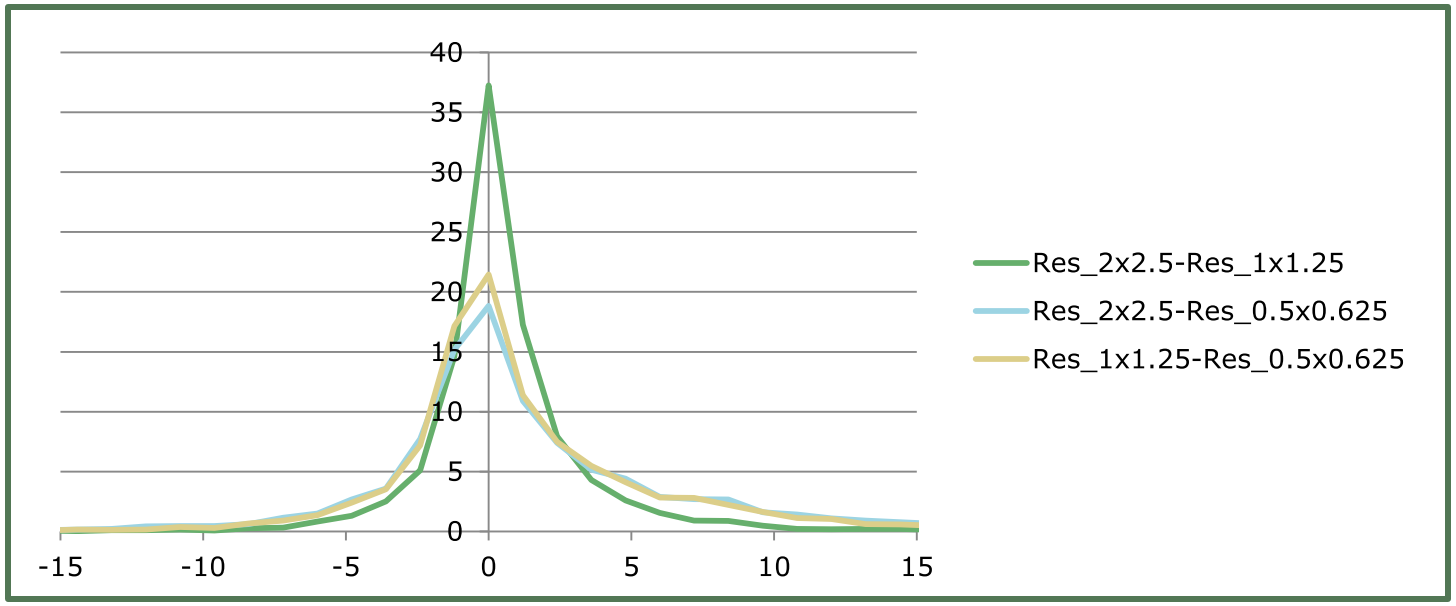


$J^{FR}(2.0°x2.5°) – J^{FR}(1.0°x1.25°)$



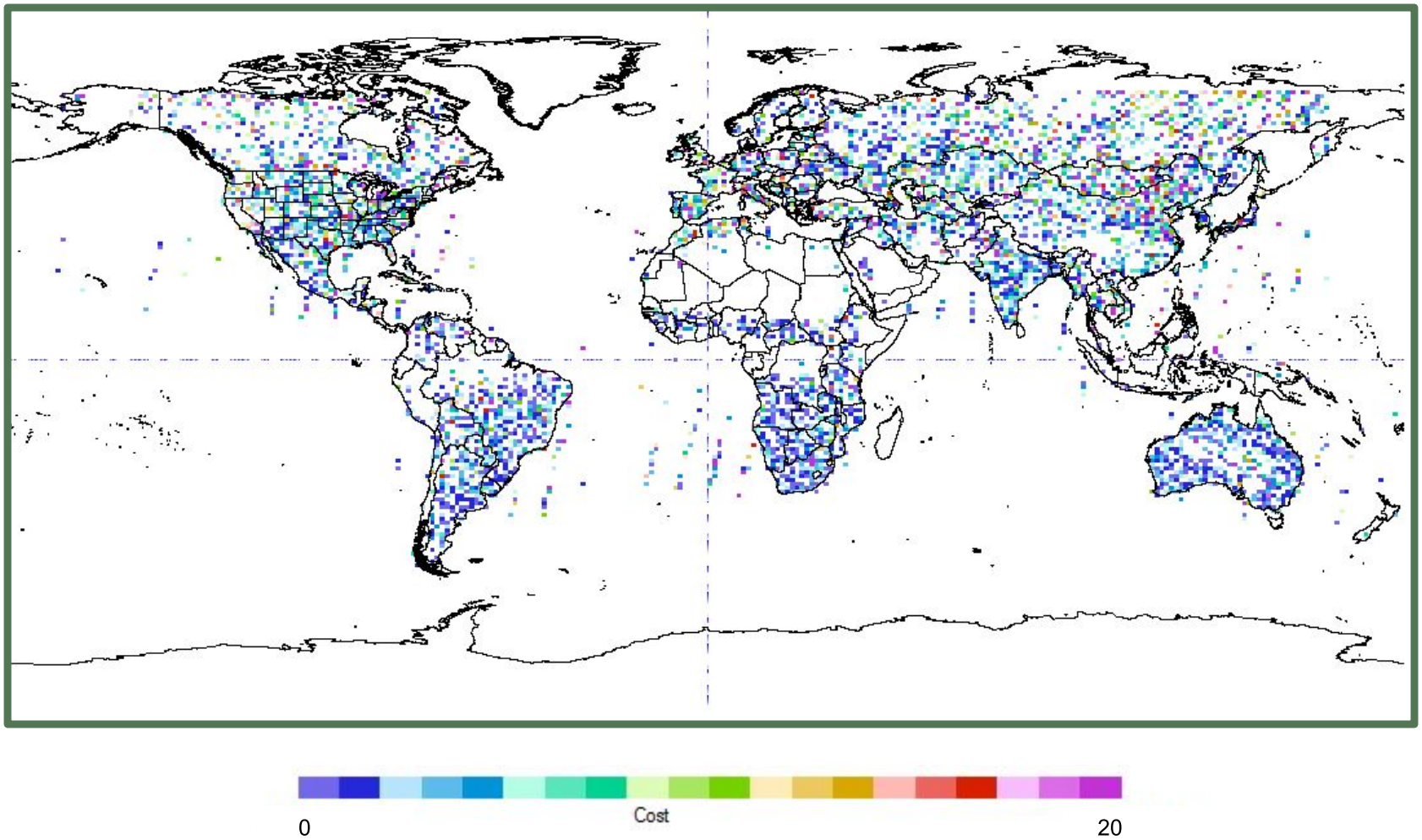
$J^{FR}(2.0°x2.5°) – J^{FR}(0.5°x0.625°)$



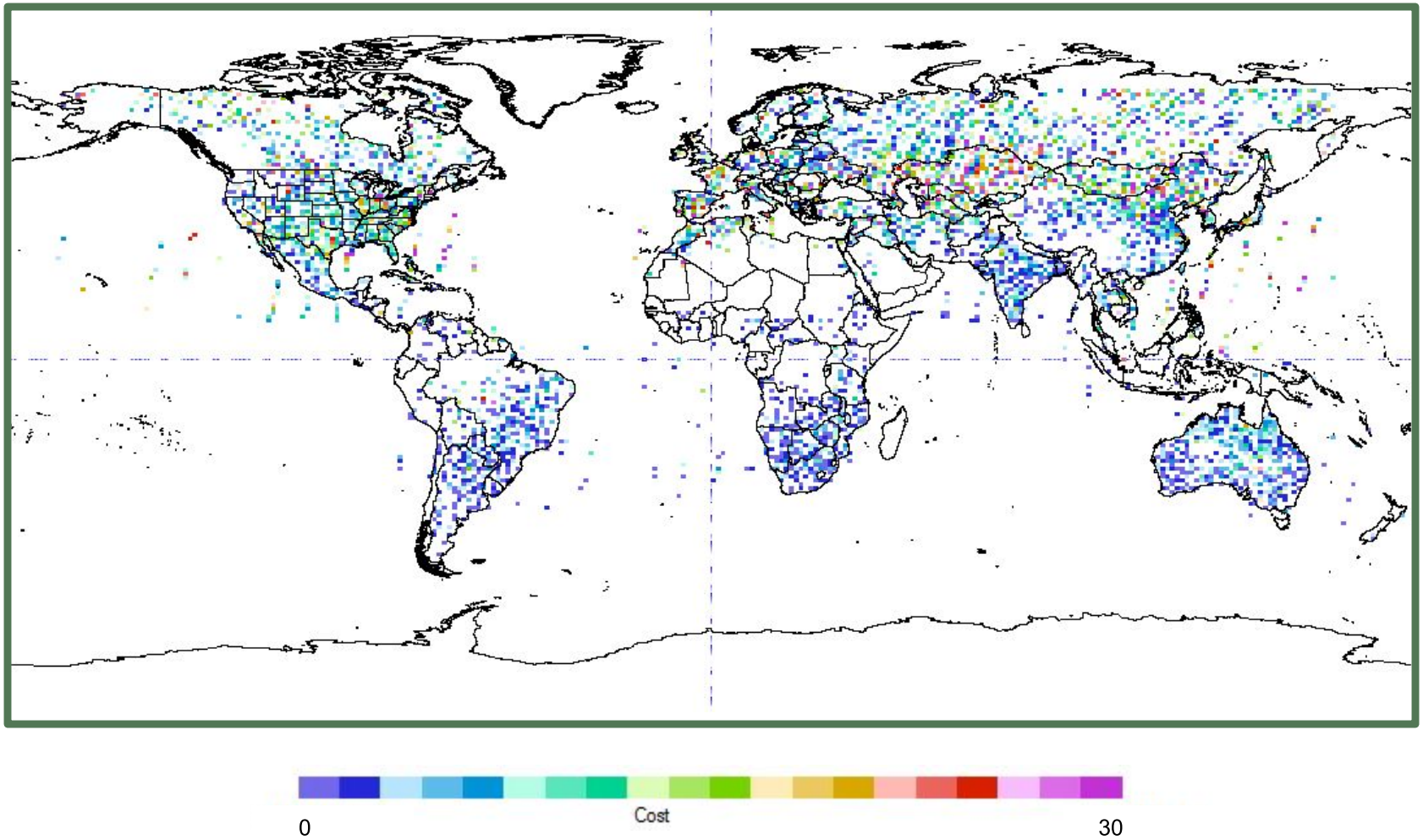


	2x2.5-1x1.25	2x2.5-0.5x0.625	1x1.25-0.5x0.625
Mean	0.47	1.7	1.23
RMS	3.22	7.0	5.63
Positive difference	3138 (56%)	3073 (55%)	2984 (53%)
Negative difference	2444 (44%)	2509 (45%)	2598 (47%)

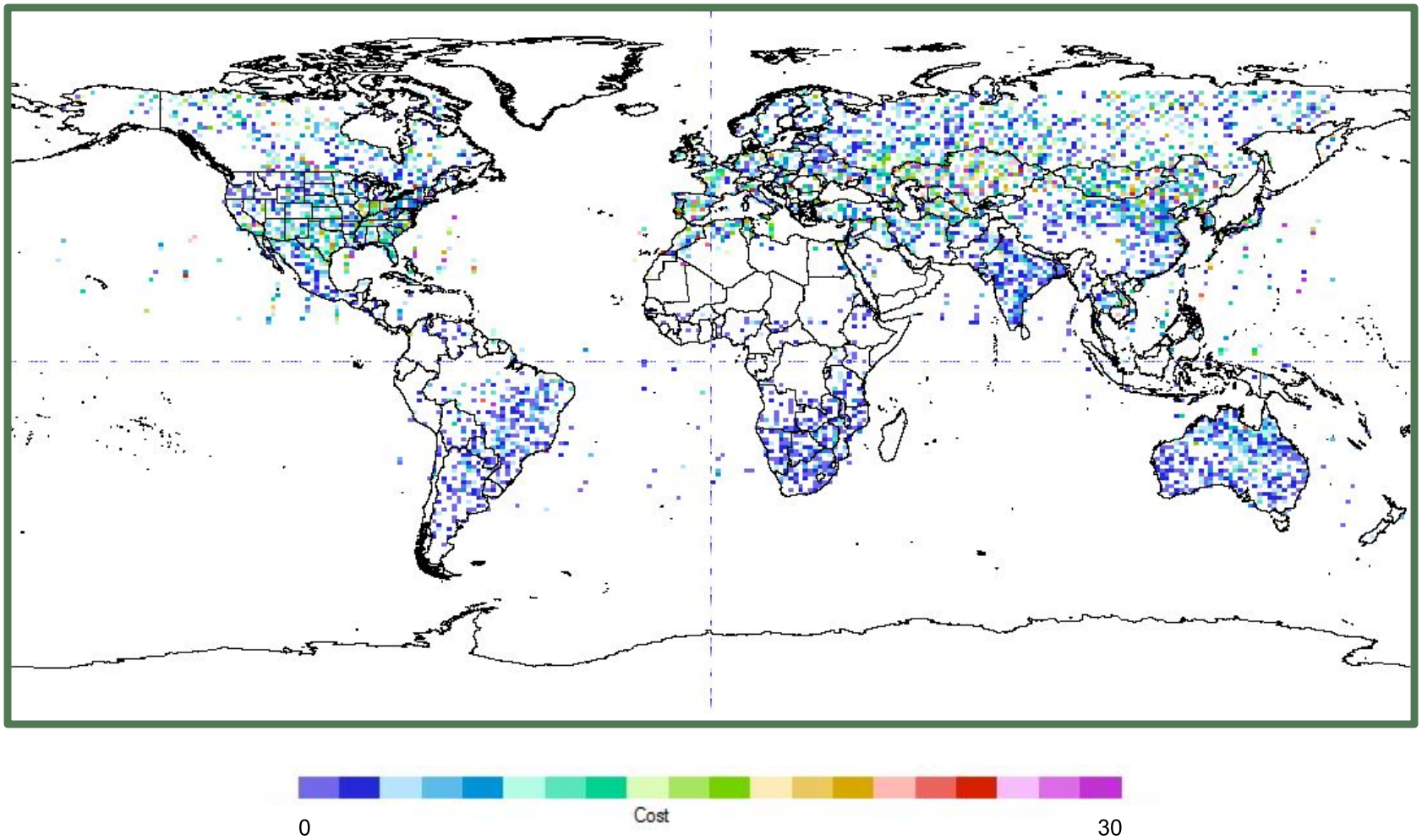
J^{ASM} (2.0°x2.5°)

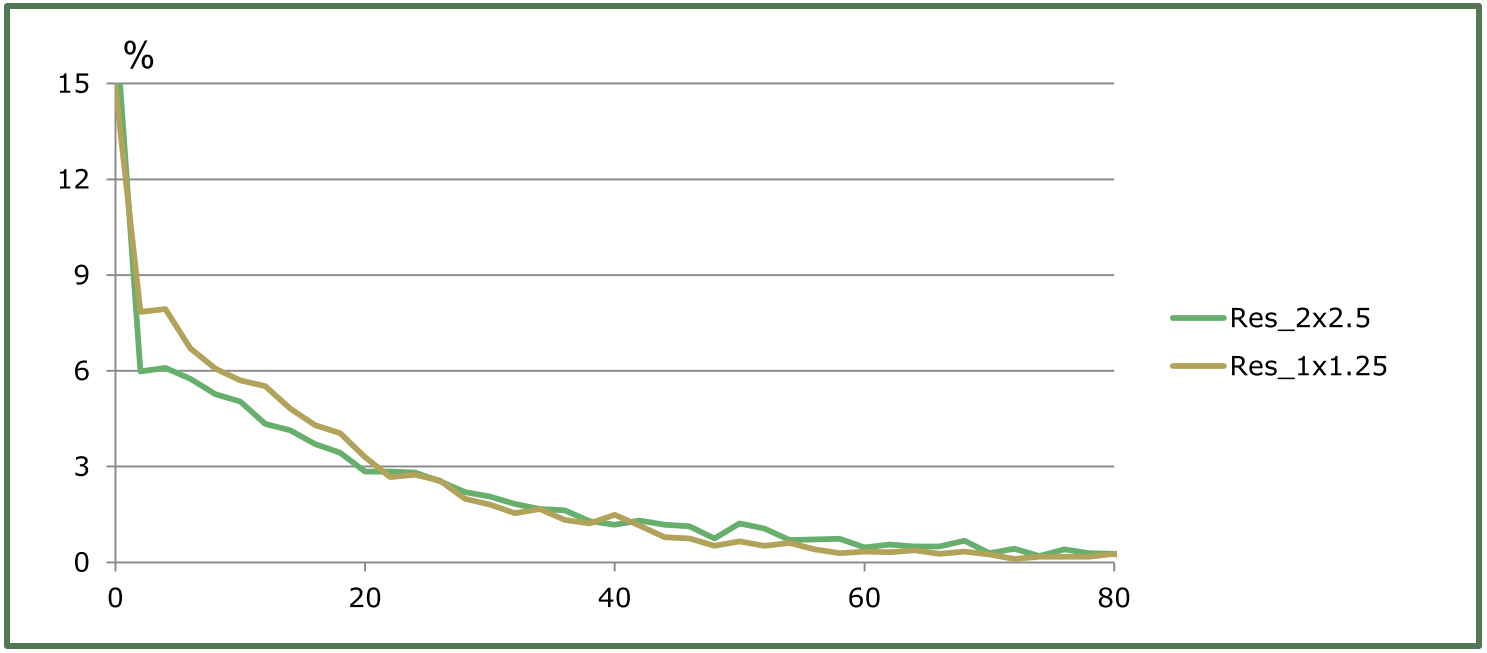


$J^{FR}(2.0°x2.5°)$ - $J^{ASM}(2.0°x2.5°)$



$J^{FR}(1.0°x1.25°)$ - $J^{ASM}(1.0°x1.25°)$





Average observation force reduction from assimilation is ~20 in 2x2.5 resolution and ~17 in 1x1.25 resolution with similar probability distribution.

Summary

•For large cities, higher model resolution shows greater dynamic range of xCO_2.

•TCCON sites show little variation between model resolutions.

•In Free run, higher model resolution shows spatially varying deviation from ACOS observation with greater dynamic range.

•On average, higher model resolution exhibits slightly reduced deviation from ACOS observation.

• ACOS observation density is adequate only for 2x2.5 model resolution.

•Assimilation reduces the model bias > 80%.

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