Supplement of Atmos. Chem. Phys., 20, 15401–15426, 2020
https://doi.org/10.5194/acp-20-15401-2020-supplement

Atmospheric Chemistry and Physics
Open Access
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Supplement of

Constraining the relationships between aerosol height, aerosol optical depth and total column trace gas measurements using remote sensing and models

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Table S1: Statistical summary of MISR daily measurements over each of the 14 regions in this work, where mean is the average, STD is the standard deviation, and skewness is the skewness.

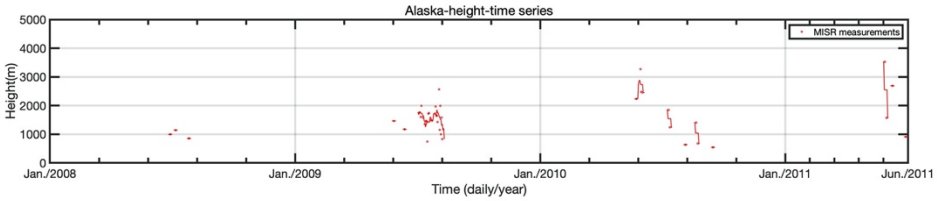
	Mean	STD	Skewness
Central Africa	1.38km	0.53km	1.76km
Midwest Africa	0.92km	0.30km	0.79km
Southern Africa	1.67km	0.40km	0.46km
Central Siberia	1.50km	0.56km	0.60km
Siberia and Northern China	1.09km	0.44km	0.75km
Eastern Siberia	1.11km	0.31km	-0.18km
Western Siberia	1.06km	0.58km	0.99km
Northern Southeast Asia	1.38km	0.81km	1.32km
Northern Australia	0.91km	0.45km	1.91km
Alaska	1.62km	0.71km	0.93km
Central Canada	1.80km	0.98km	1.23km
South America	0.87km	0.38km	1.36km
Argentina	0.63km	0.40km	2.48km
Eastern Europe	1.24km	0.78km	1.52km

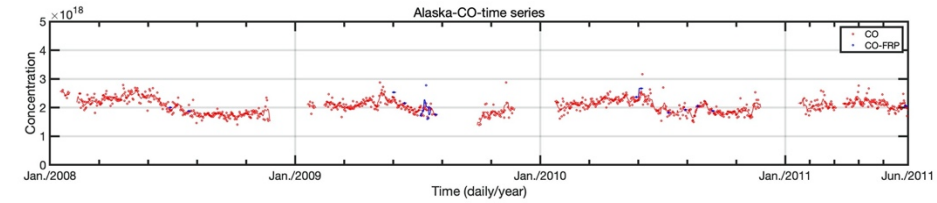
Table S2 High and low percentile cutoffs (5%, 10%, 90% and 95%) of the column NO_2 loading and the NO_2/CO column loading ratio over each region and globally.

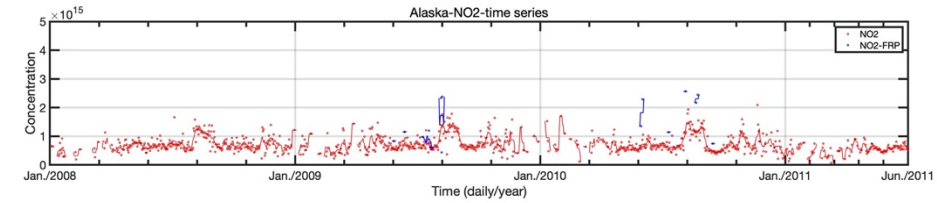
All data $*10^{15}$ [mol/cm^2]	5%	10%	90%	95%
Global NO_2	0.38	0.51	5.85	8.50
Siberia and North China NO_2	0.29	0.40	2.2	2.68
East Siberia NO_2	0.35	0.64	2.58	3.24
West Siberia NO_2	0.48	0.63	3.11	4.22
Northern Southeast Asia NO_2	0.61	1.12	5.52	6.3
Northern Australia NO_2	0.44	0.58	3.31	4.69
Alaska NO_2	0.5	0.69	2.68	3.22
Central Canada NO_2	0.22	0.28	1.86	2.66
South America NO_2	1.35	1.83	12.8	15.8

All data $*10^{-4}$	5%	10%	90%	95%
Global NO_2/CO	1.65	2.34	23.6	3.15e-3
Siberia and North China NO_2/CO	0.80	1.10	8.60	11.0e-4
East Siberia NO_2/CO	2.81	3.13	10.9	1.93e-3
West Siberia NO_2/CO	1.85	2.43	13.4	1.77e-3
Northern Southeast Asia NO_2/CO	2.30	3.04	16.6	2.14e-3
Northern Australia NO_2/CO	2.65	3.63	20.4	2.94e-3
Alaska NO_2/CO	2.59	2.91	12.6	1.33e-3
Central Canada NO_2/CO	1.24	1.55	8.10	12.9e-4
South America NO_2/CO	4.46	6.00	43.5	5.23e-3

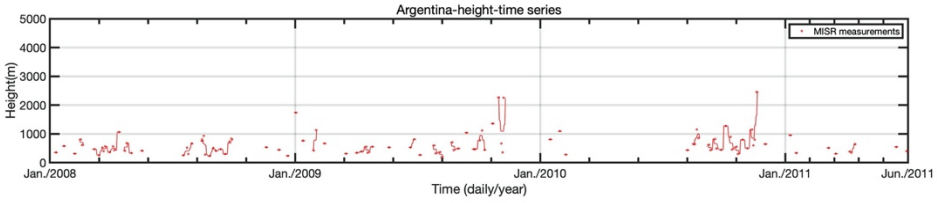
Figure S1: time series of different satellite products over all regions (top panel is MISR measurements, central panel is MOPITT CO measurements, and the bottom panel is the OMI NO_2 measurements). In all cases, the black line is move mean value using a seven-day window.

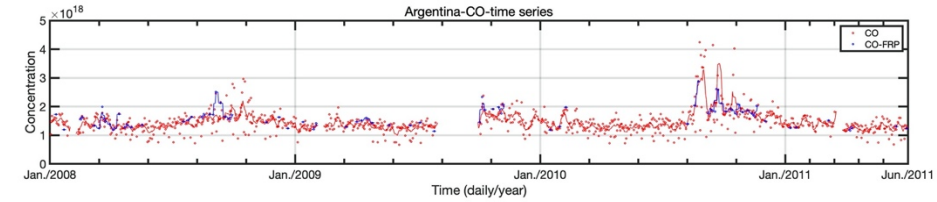


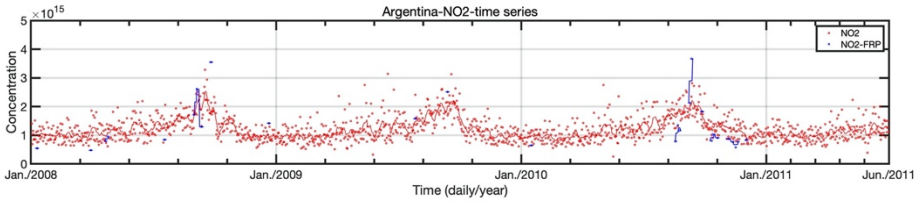




(1) Alaska







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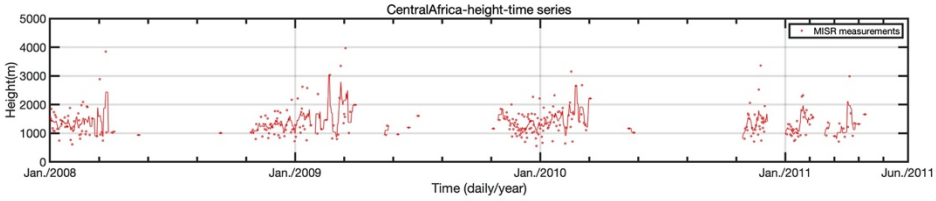

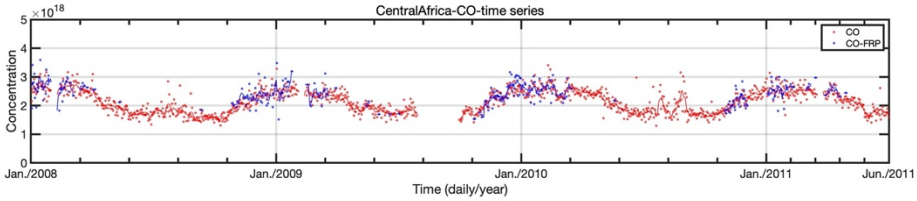

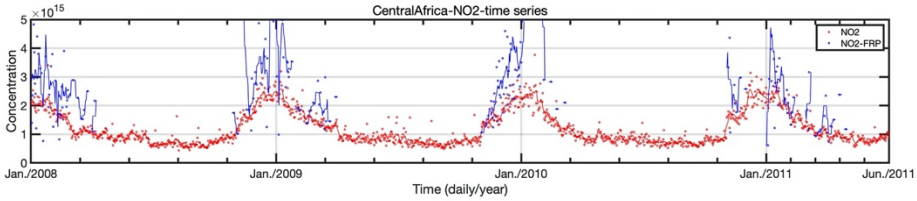

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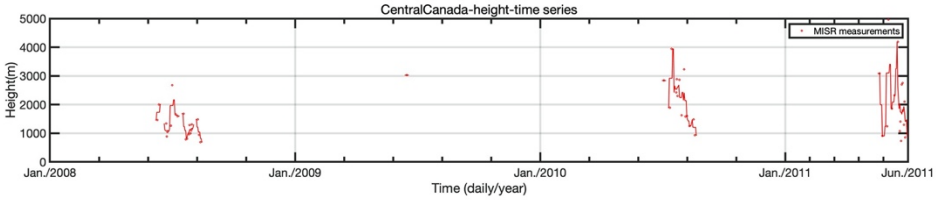

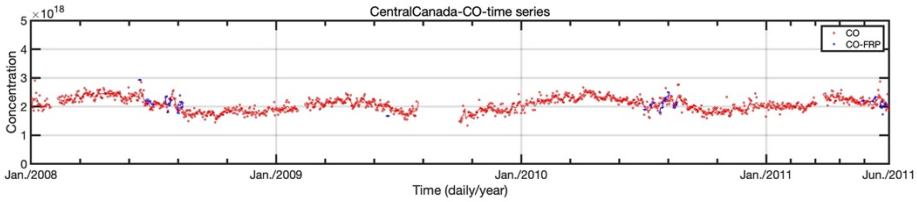

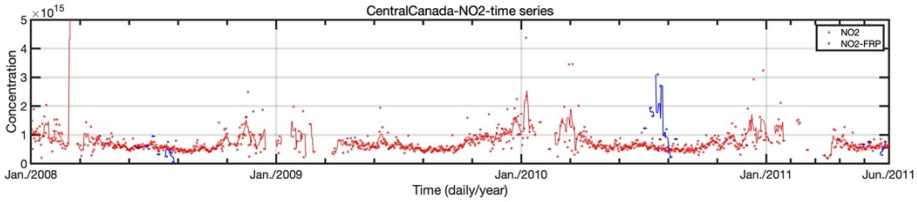

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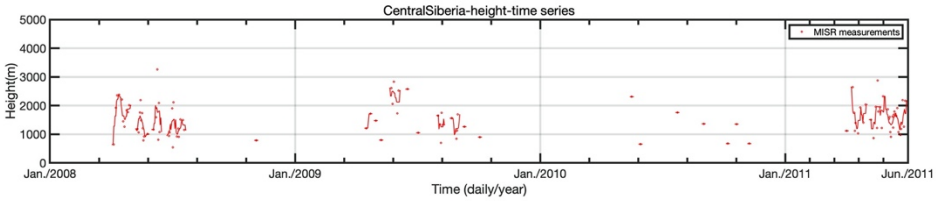

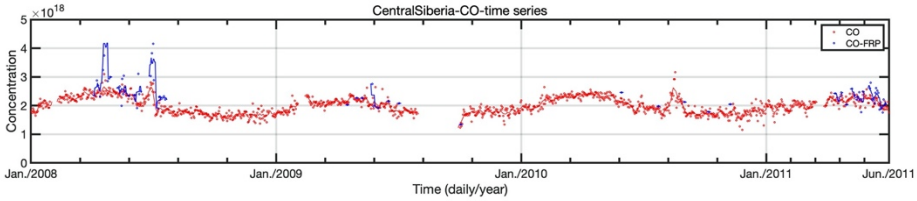

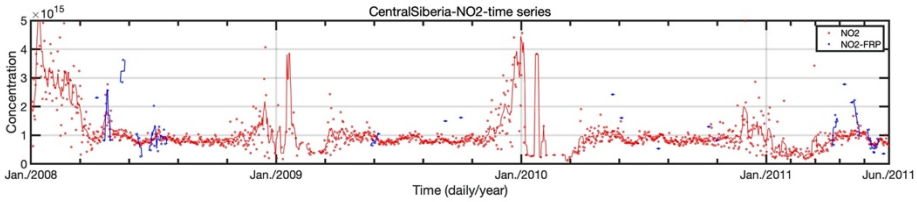

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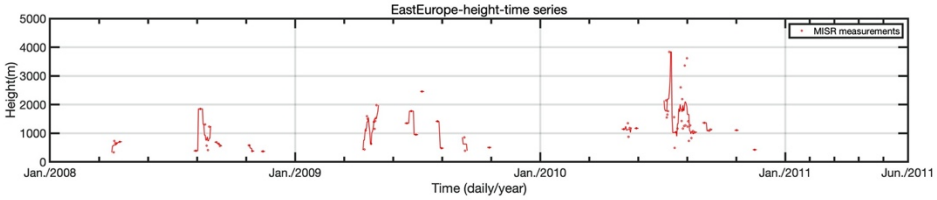

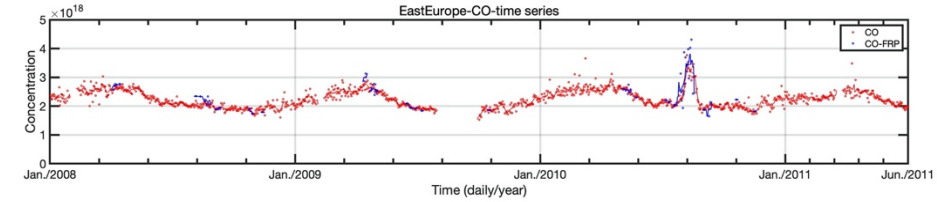

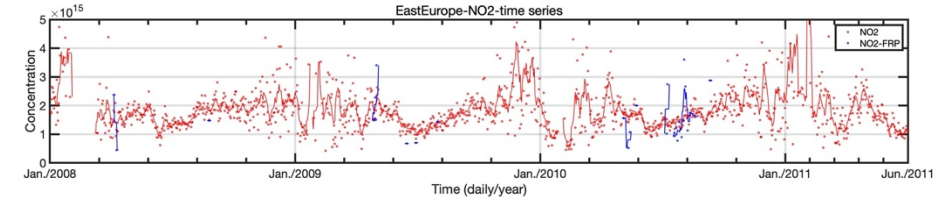

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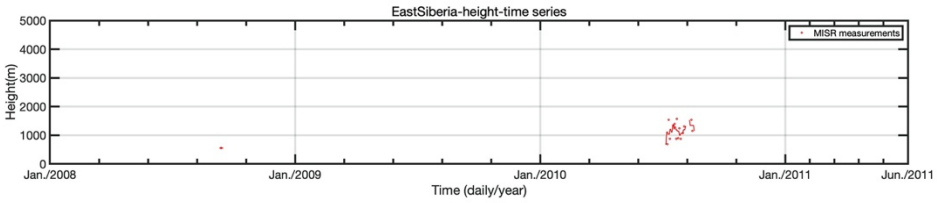

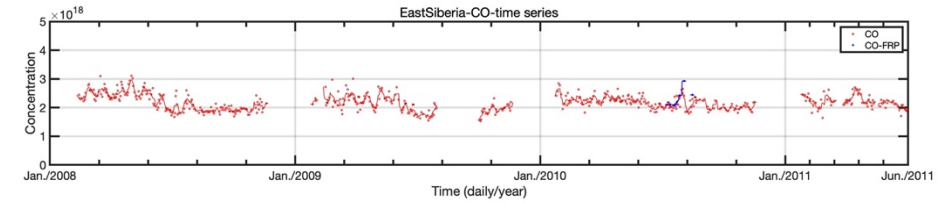

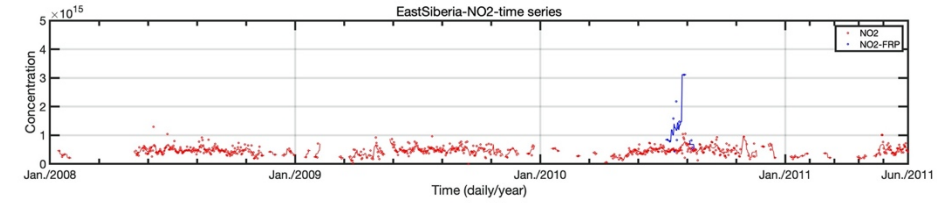

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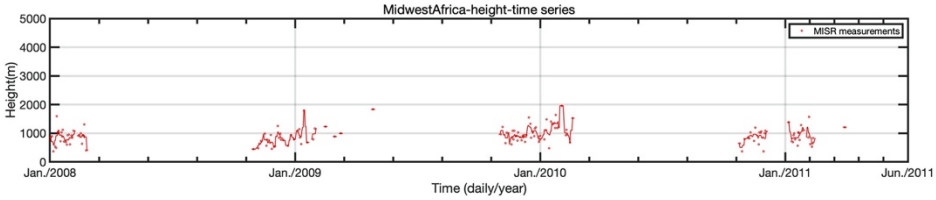

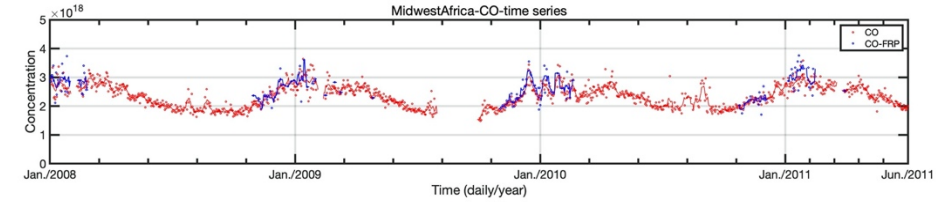

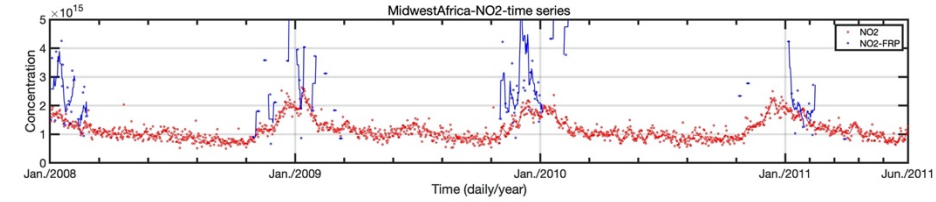

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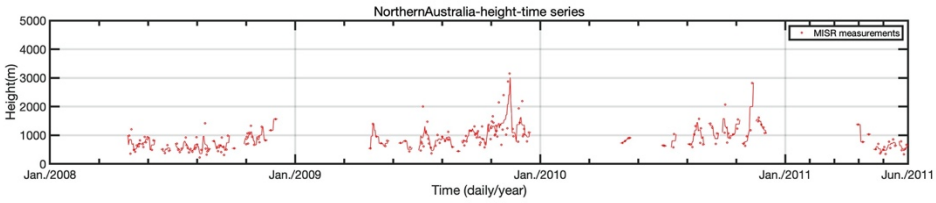
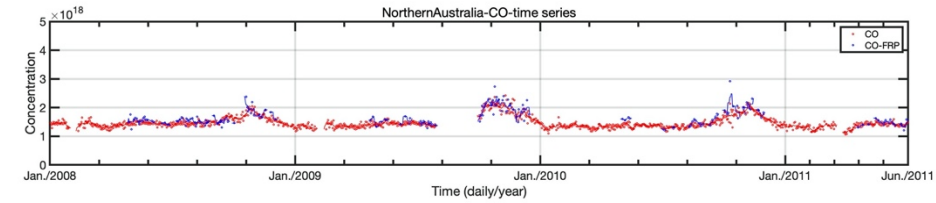
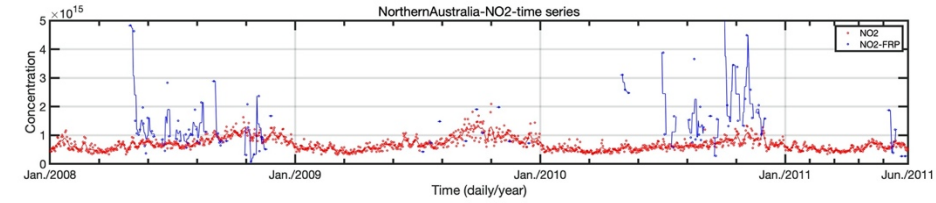
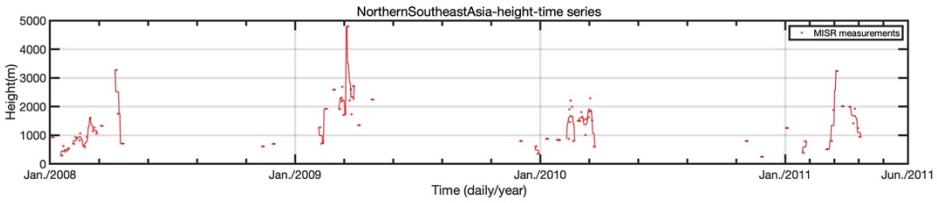
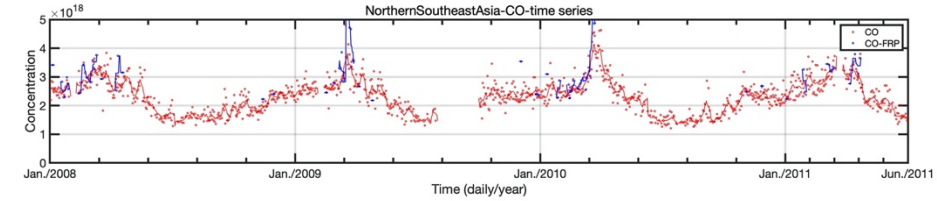


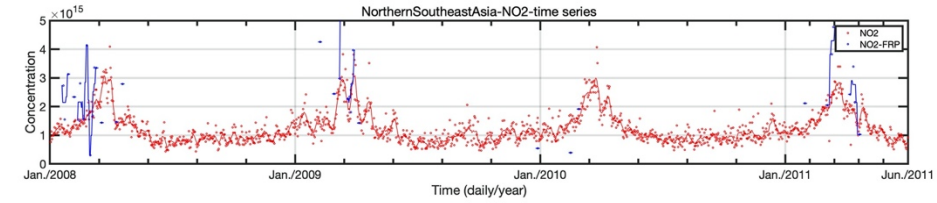




（9）Northern Australia







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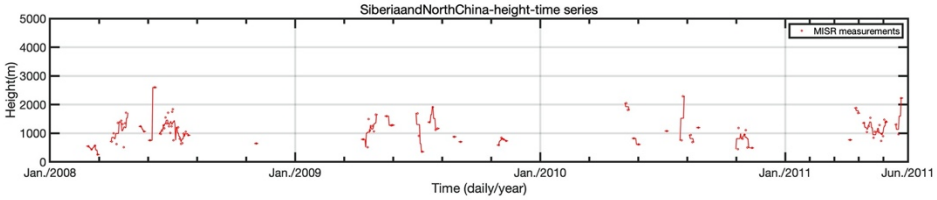

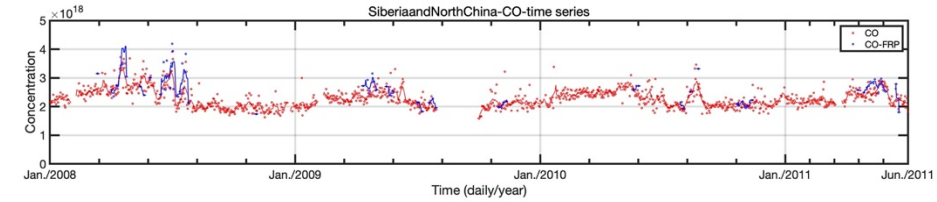

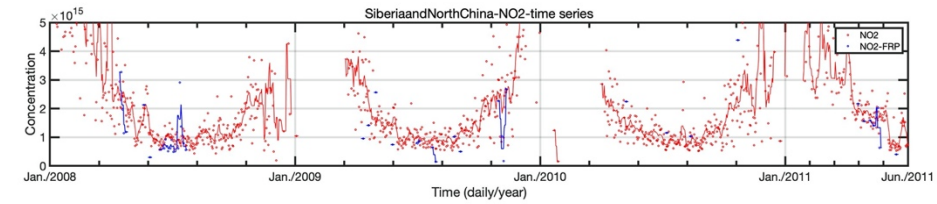

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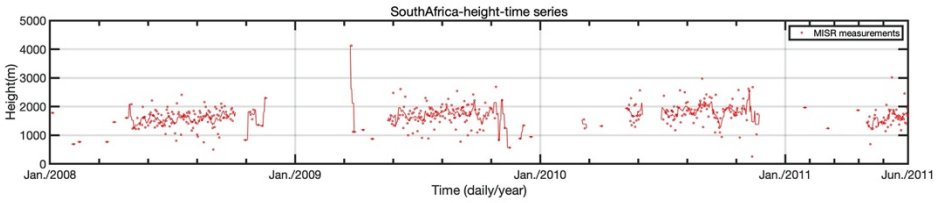

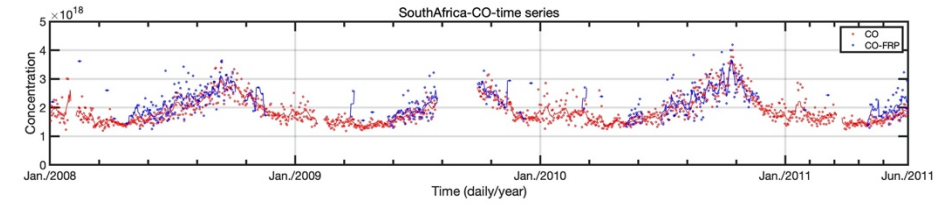

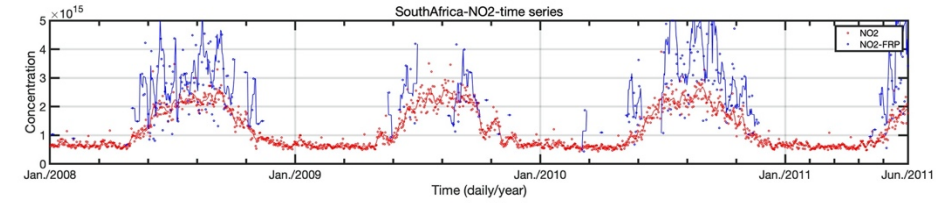

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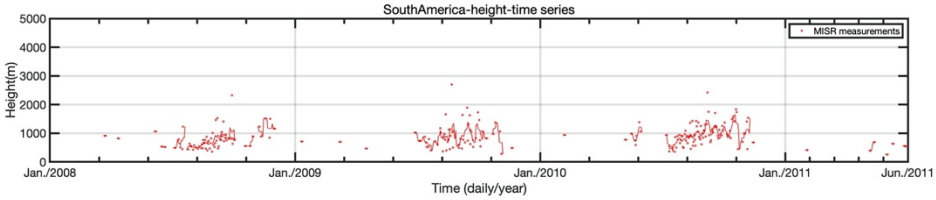
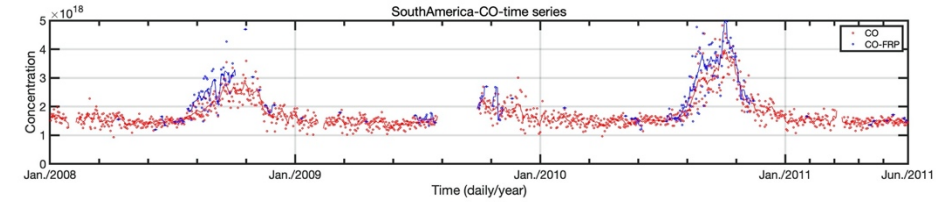
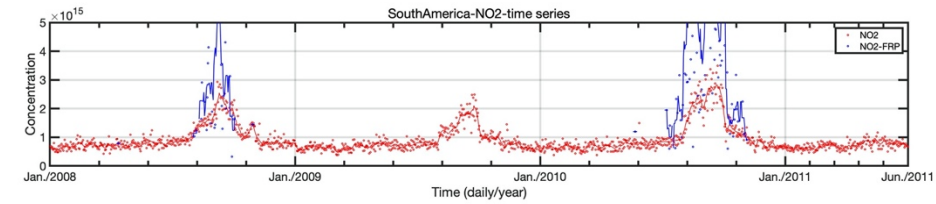
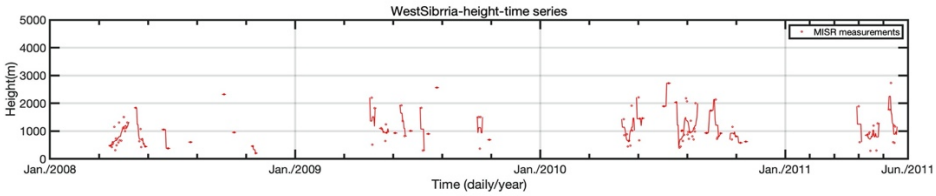
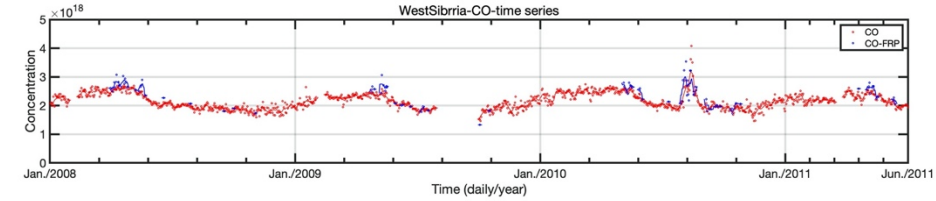


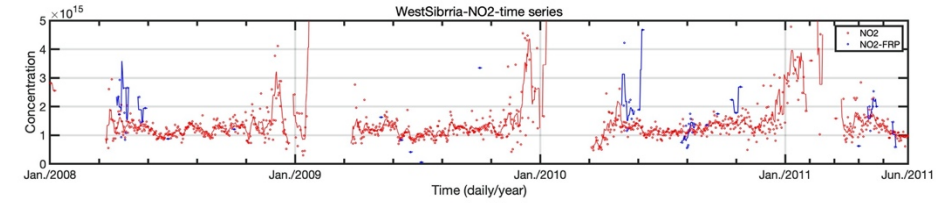




（13）South America

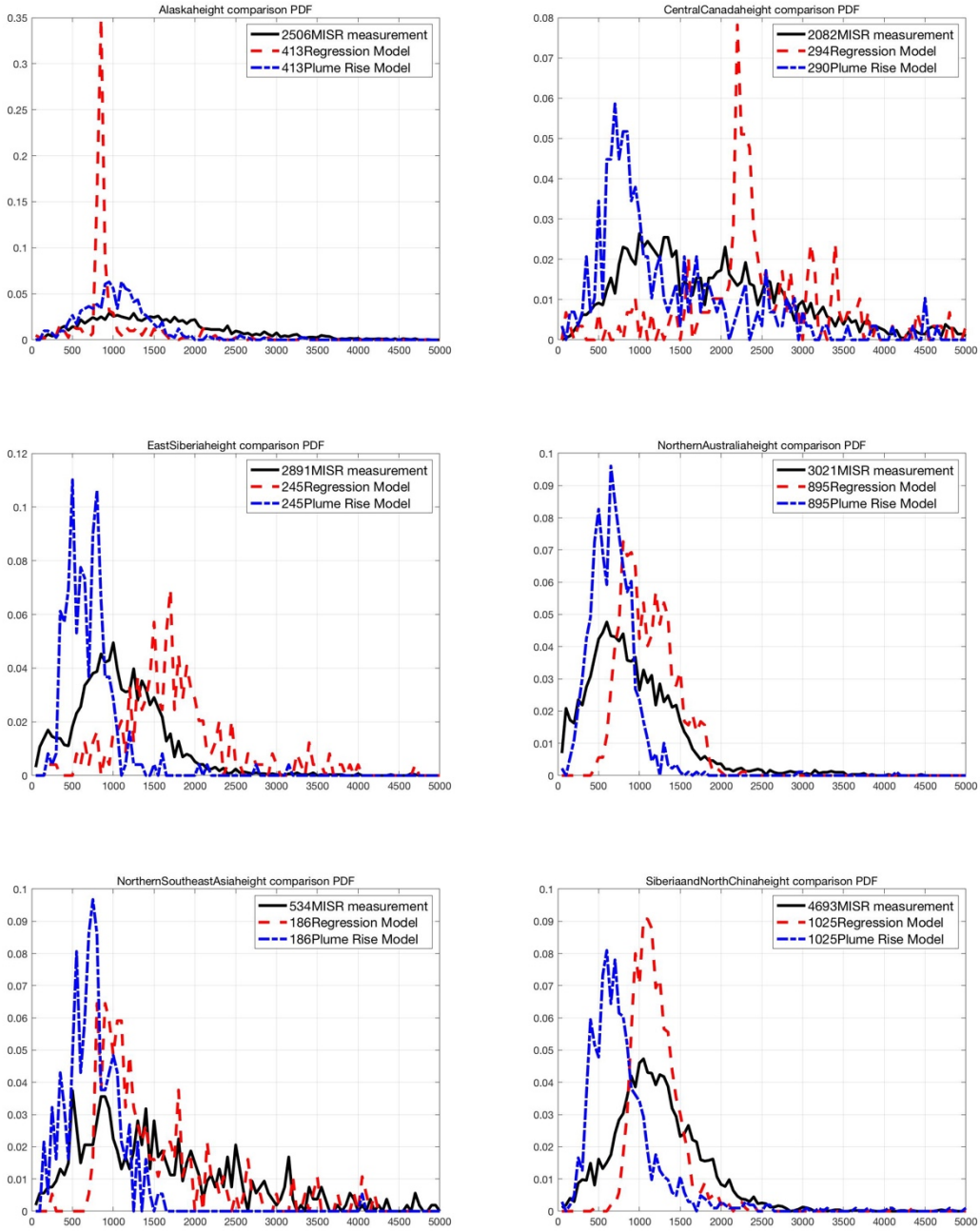


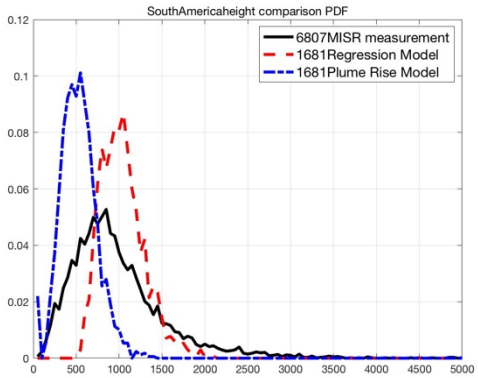




（14）West Siberia

Figure S2: PDFs of the overall MISR height data in each region, and the corresponding PDFs over the plume rise model and regression model heights, where they are available. The total number of height measurements available is given in each legend.




SouthAmericaheight comparison PDF
6807MISR measurement
1681Regression Model
1681Plume Rise Model
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0.08
0.06
0.04
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1500
2000
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4500
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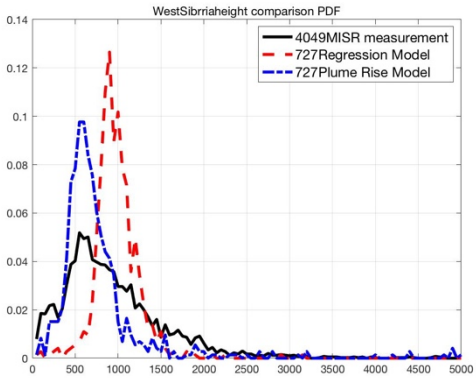
WestSibrriaheight comparison PDF
4049MISR measurement
727Regression Model
727Plume Rise Model
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0.12
0.1
0.08
0.06
0.04
0.02
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

Figure S3: Daily MISR measured heights in blue circles, with a 1 standard deviation range in blue lines. Plume rise model calculated heights in red boxes, regression model calculated heights in black boxes, and MERRA calculated heights in blue diamonds, where available.

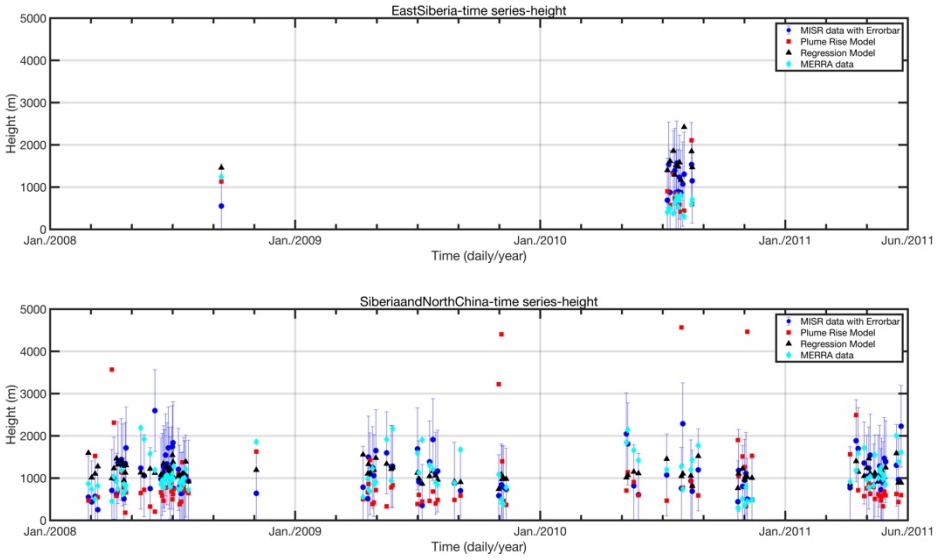
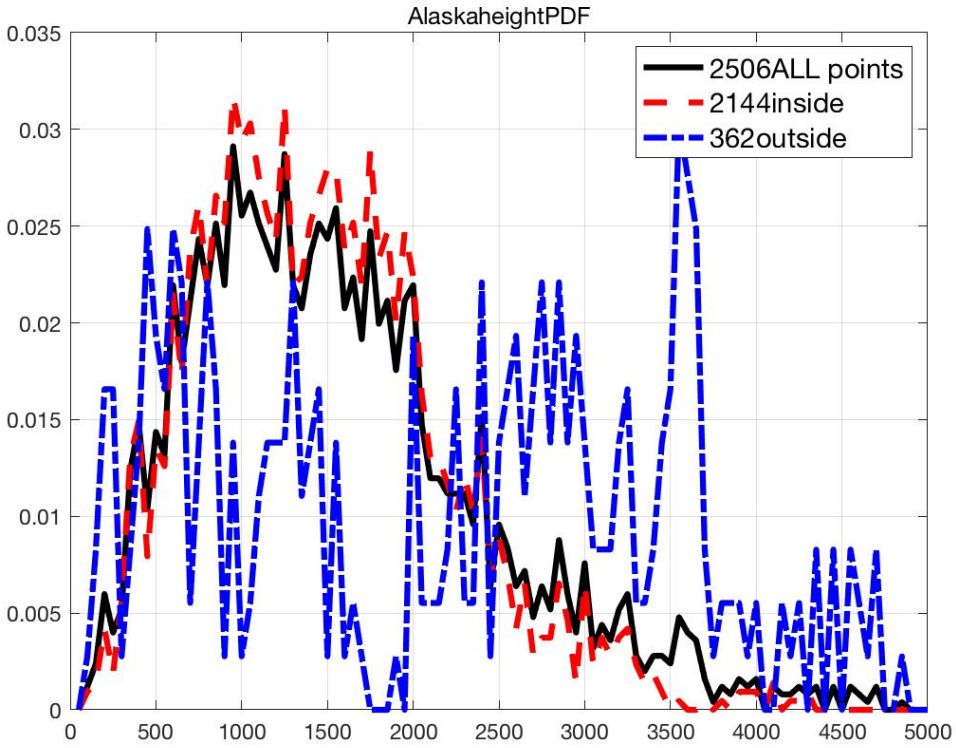
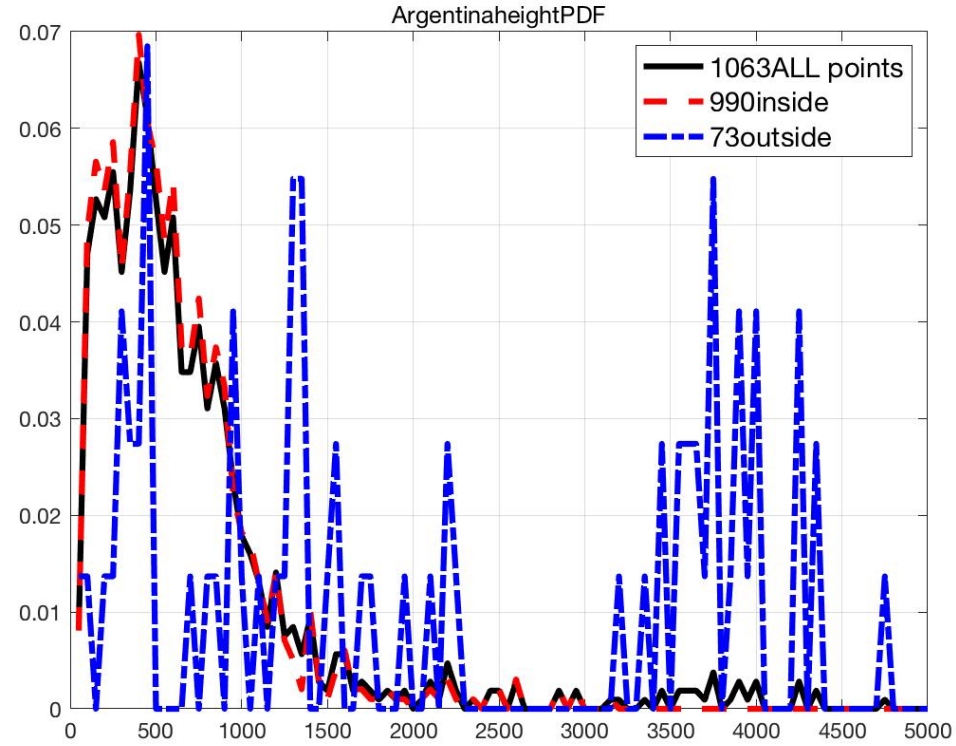
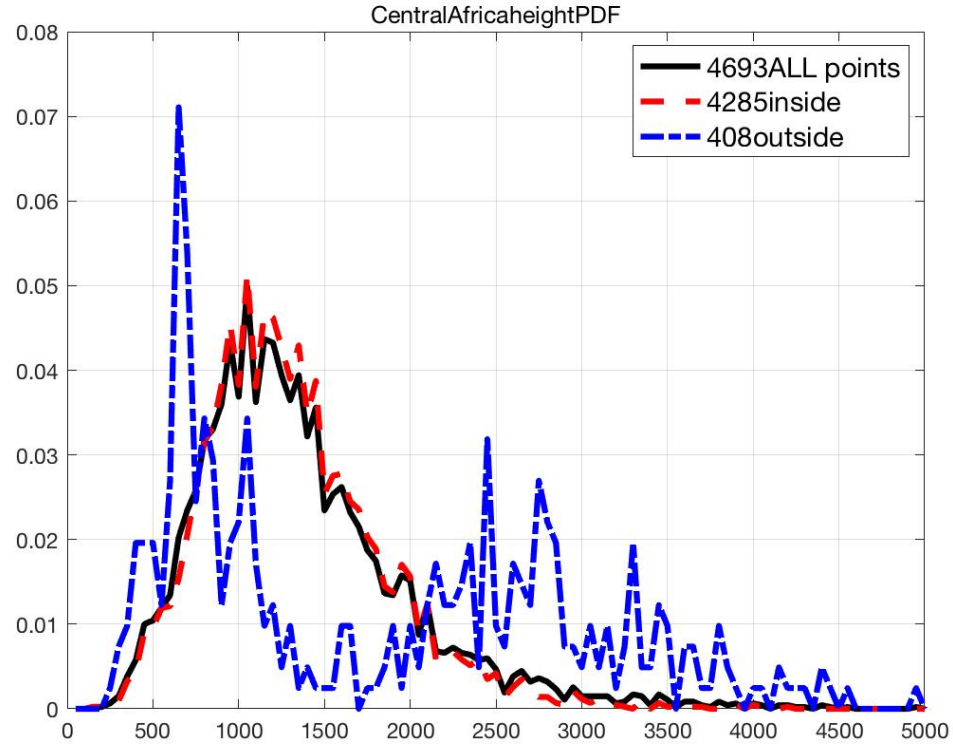
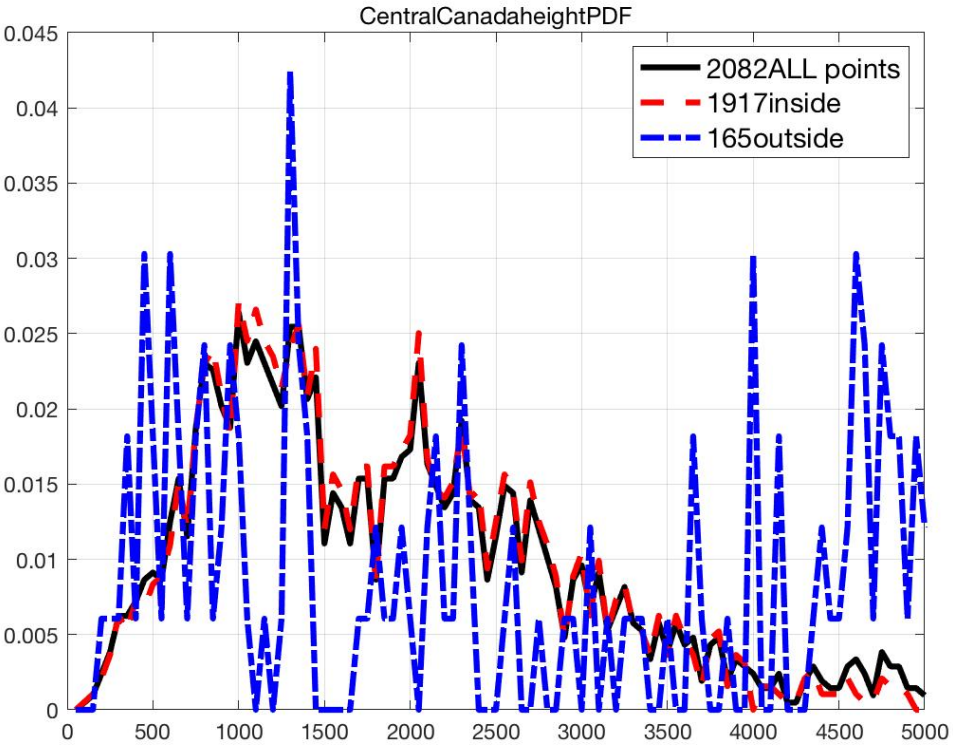


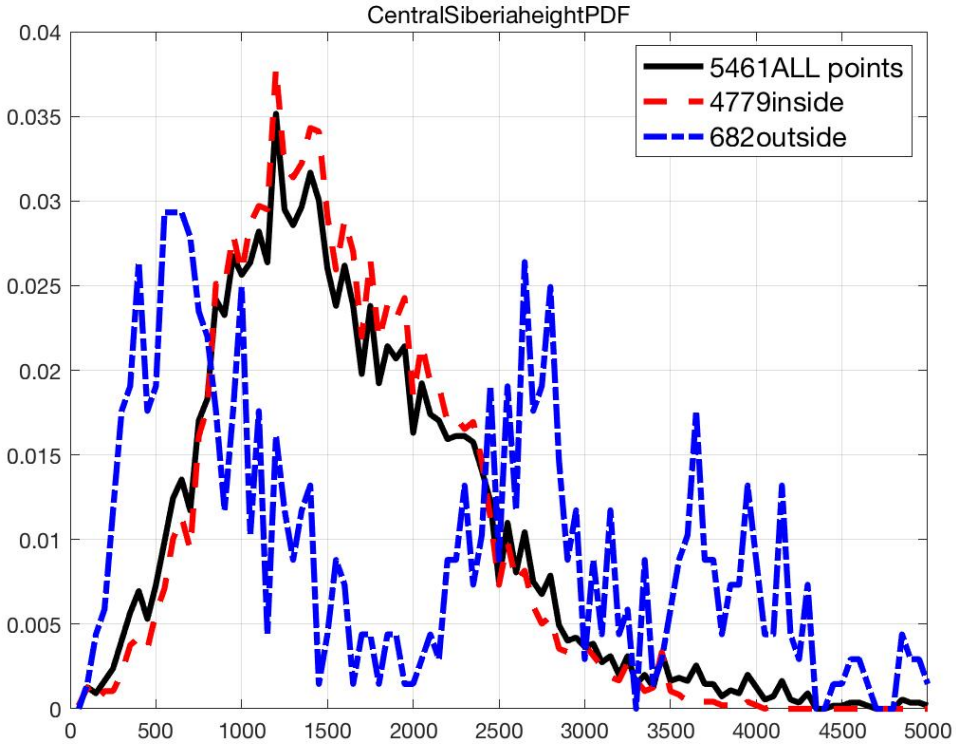
Figure S4: Probability density functions (PDFs) of all measured MISR heights. The boundary between inside and outside is defined as 1 standard deviation from the mean. The total number of measurements within each range is given in the legend.

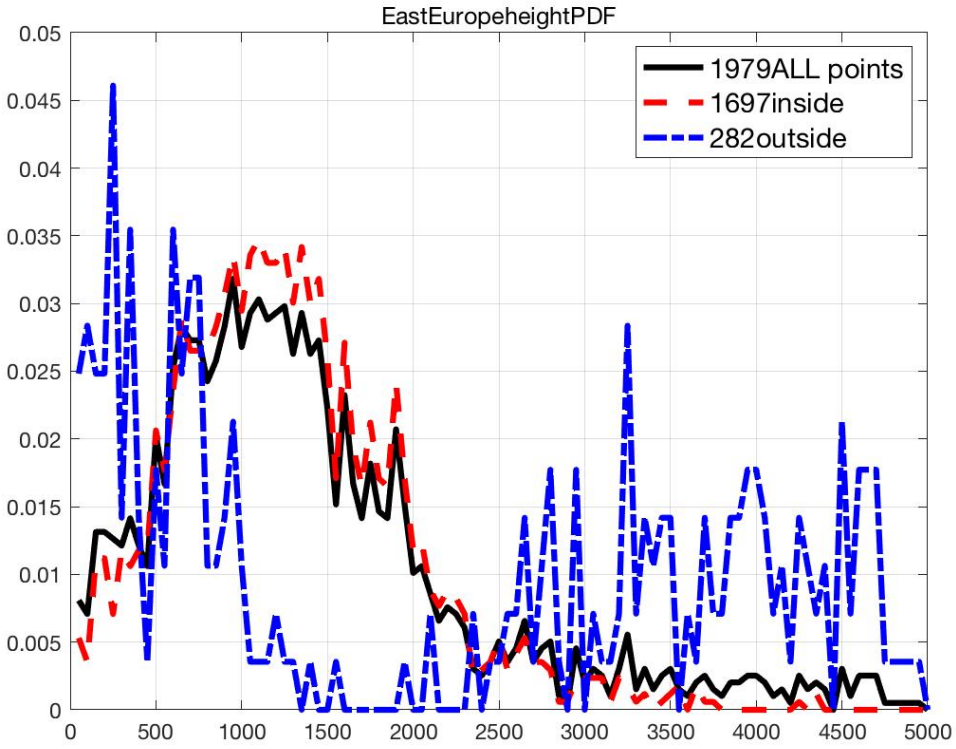


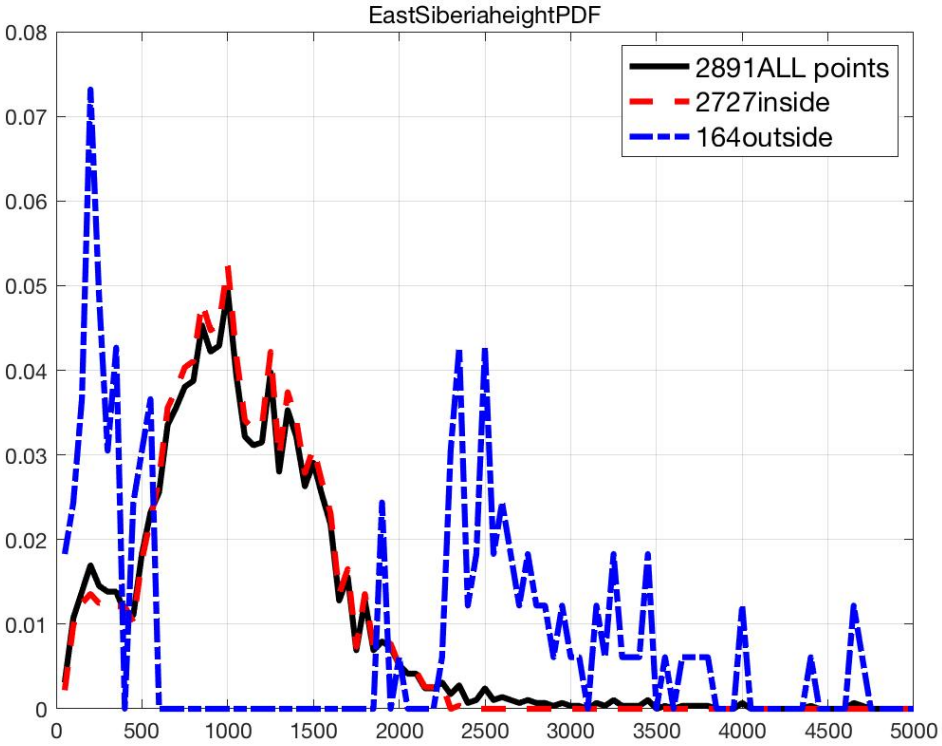


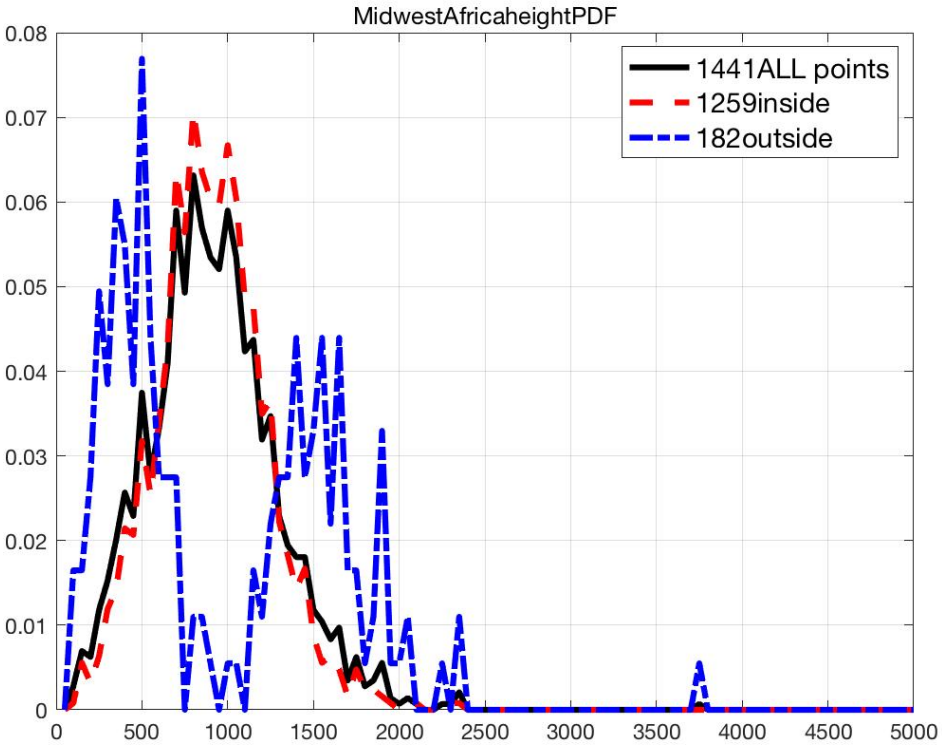

CentralAfricaheightPDF
4693ALL points
4285inside
408outside
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

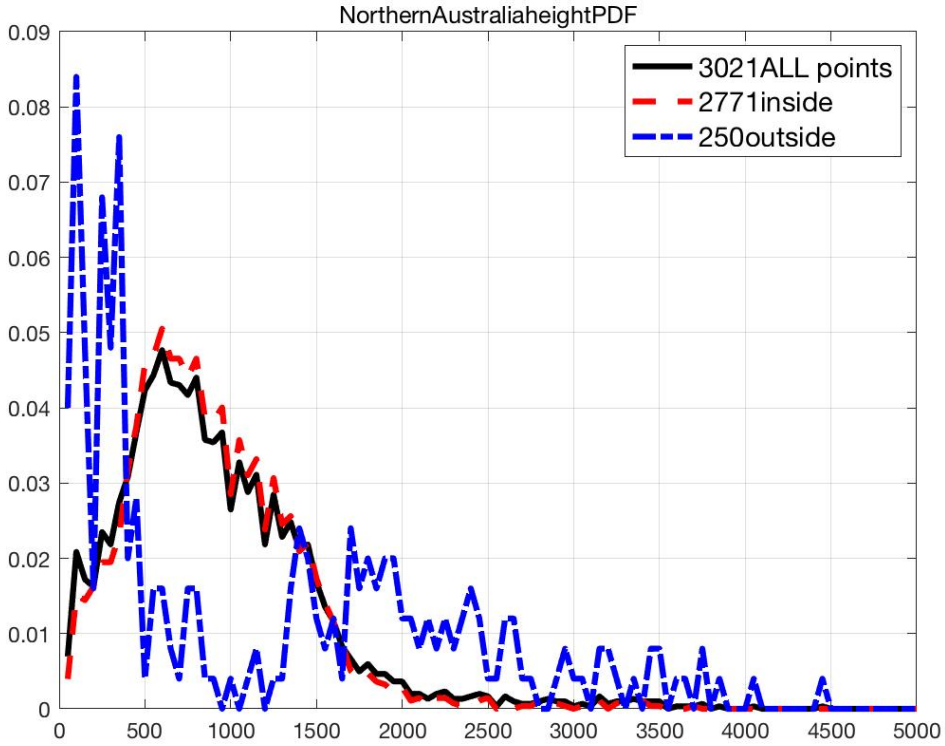

CentralCanadaheightPDF
2082ALL points
1917inside
165outside
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

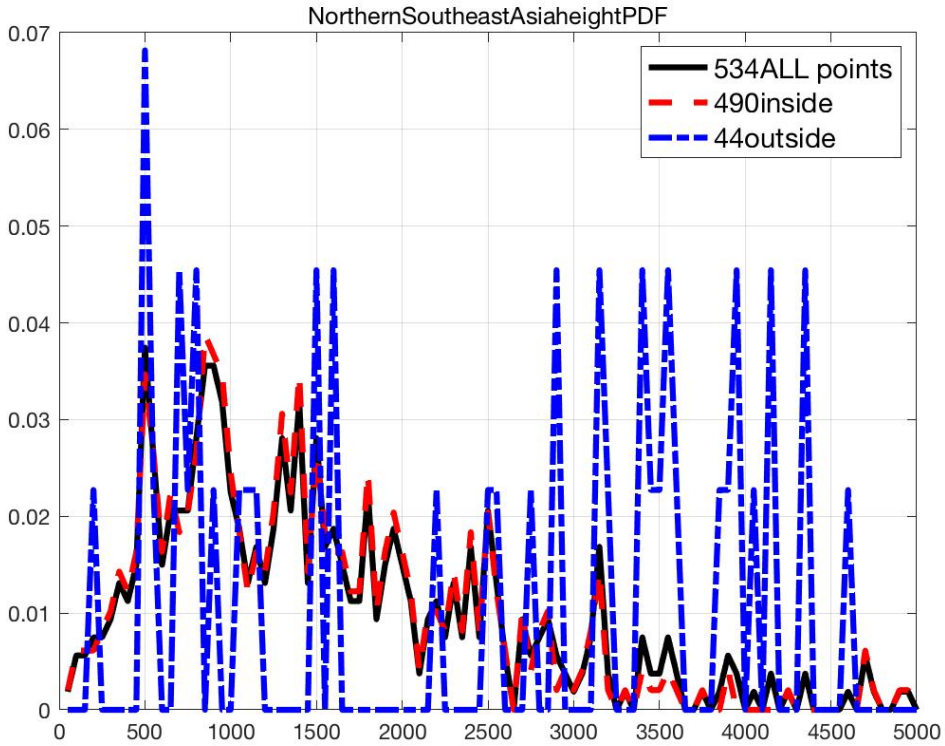

CentralSiberiaheightPDF
5461ALL points
4779inside
682outside
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

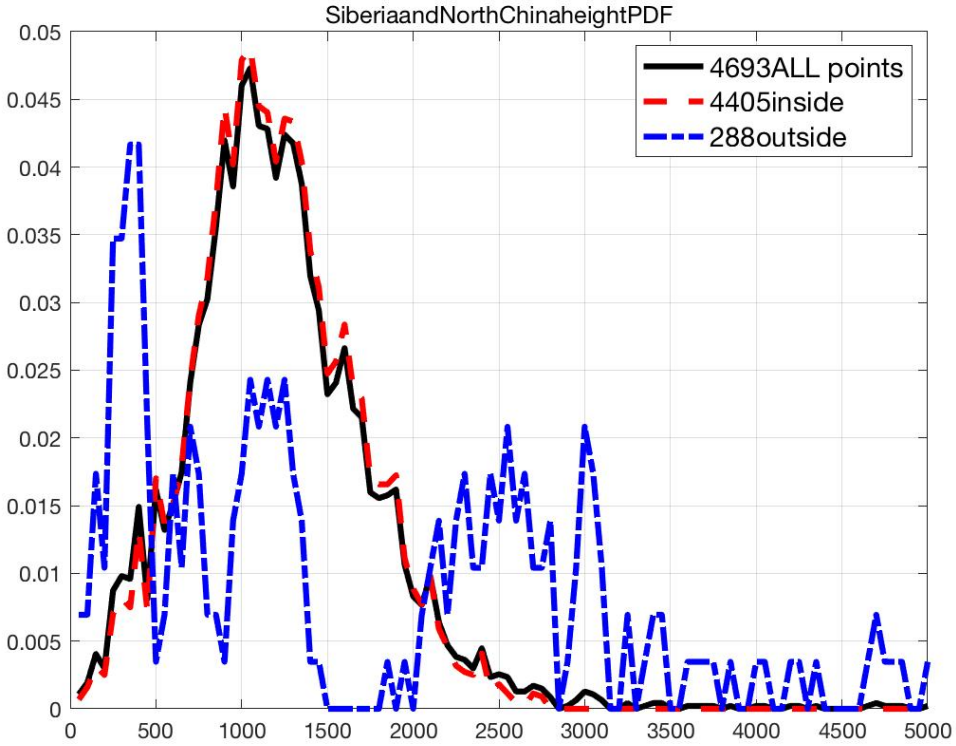

EastEuropeheightPDF
1979ALL points
1697inside
282outside
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

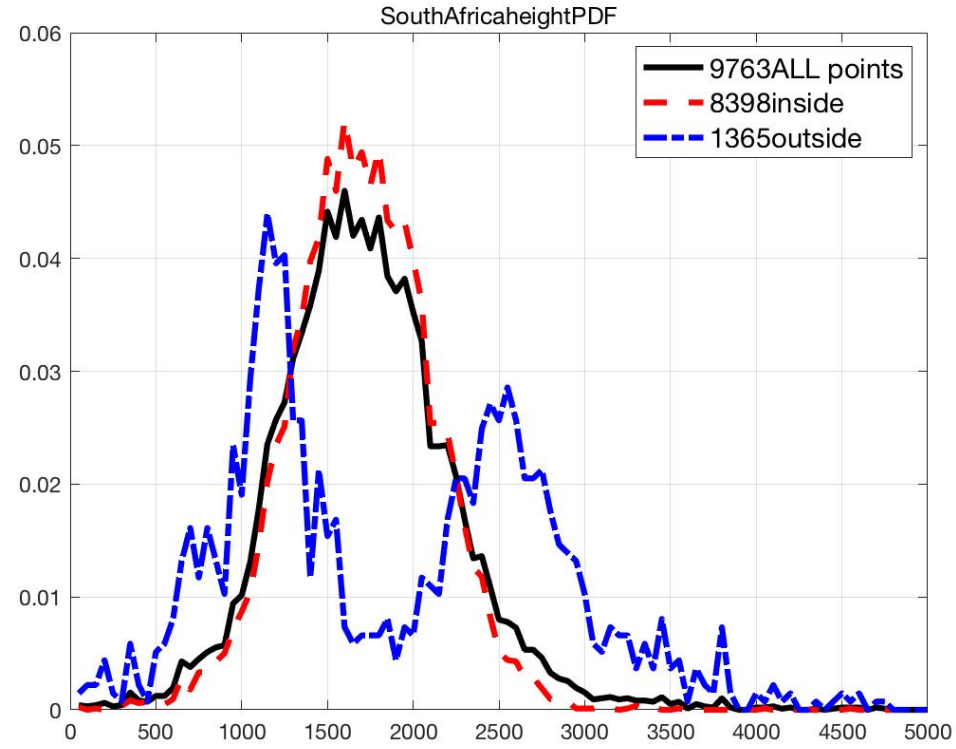

EastSiberiaheightPDF
2891ALL points
2727inside
164outside
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

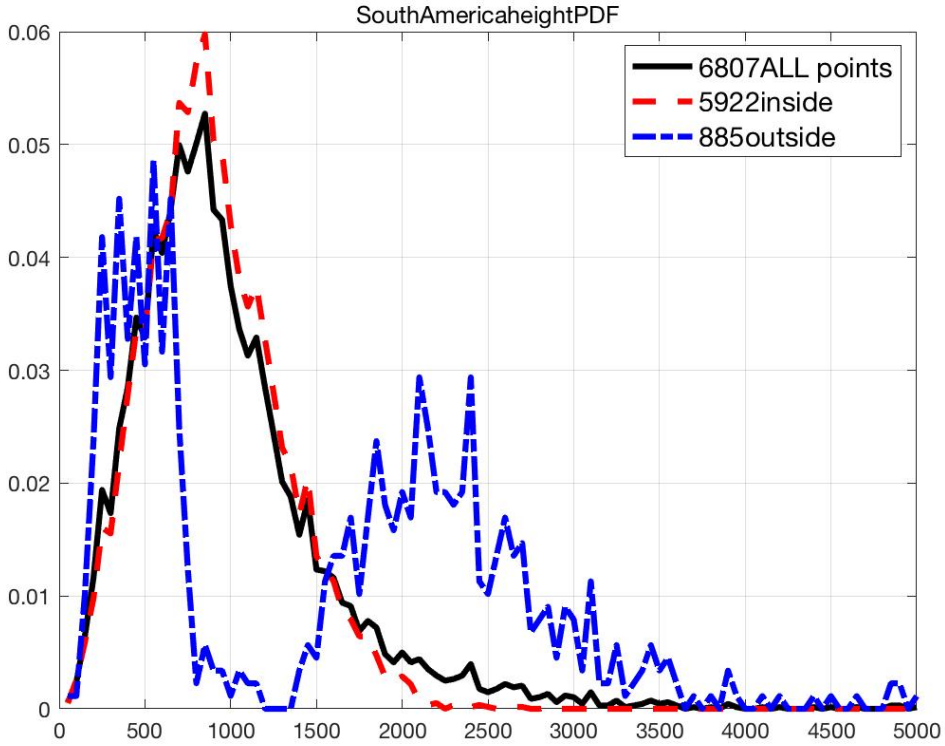

MidwestAfricaheightPDF
1441ALL points
1259inside
182outside
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


NorthernAustraliaheightPDF
3021ALL points
2771inside
250outside
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


NorthernSoutheastAsiaheightPDF
534ALL points
490inside
44outside
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


SiberiaandNorthChinaheightPDF
4693ALL points
4405inside
288outside
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


SouthAfricaheightPDF
9763ALL points
8398inside
1365outside
0.06
0.05
0.04
0.03
0.02
0.01
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


SouthAmericaheightPDF
6807ALL points
5922inside
885outside
0.06
0.05
0.04
0.03
0.02
0.01
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

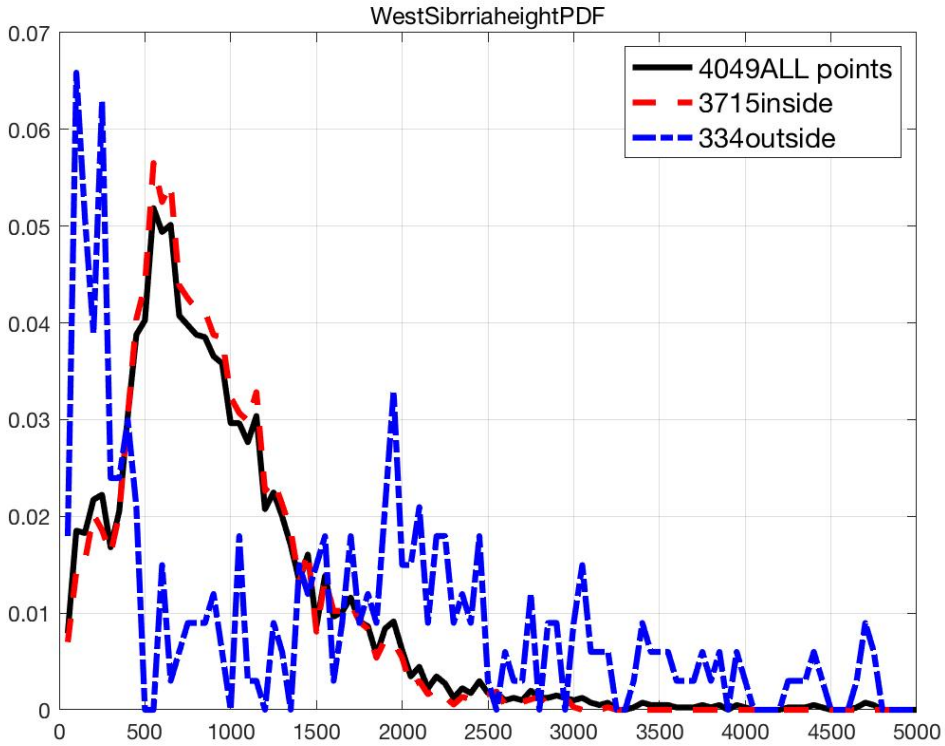

WestSibrriaheightPDF
4049ALL points
3715inside
334outside
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

Figure S5 PDF of the vertical distribution of MISR heights (red lines for 2008, red dashes for 2009, red dots for 2010, and red dash-dots for 2011) and MERRA hydrophobic black carbon heights (blue lines, color scheme the same as for MISR). These plots are only over regions in which the regression model does not apply.

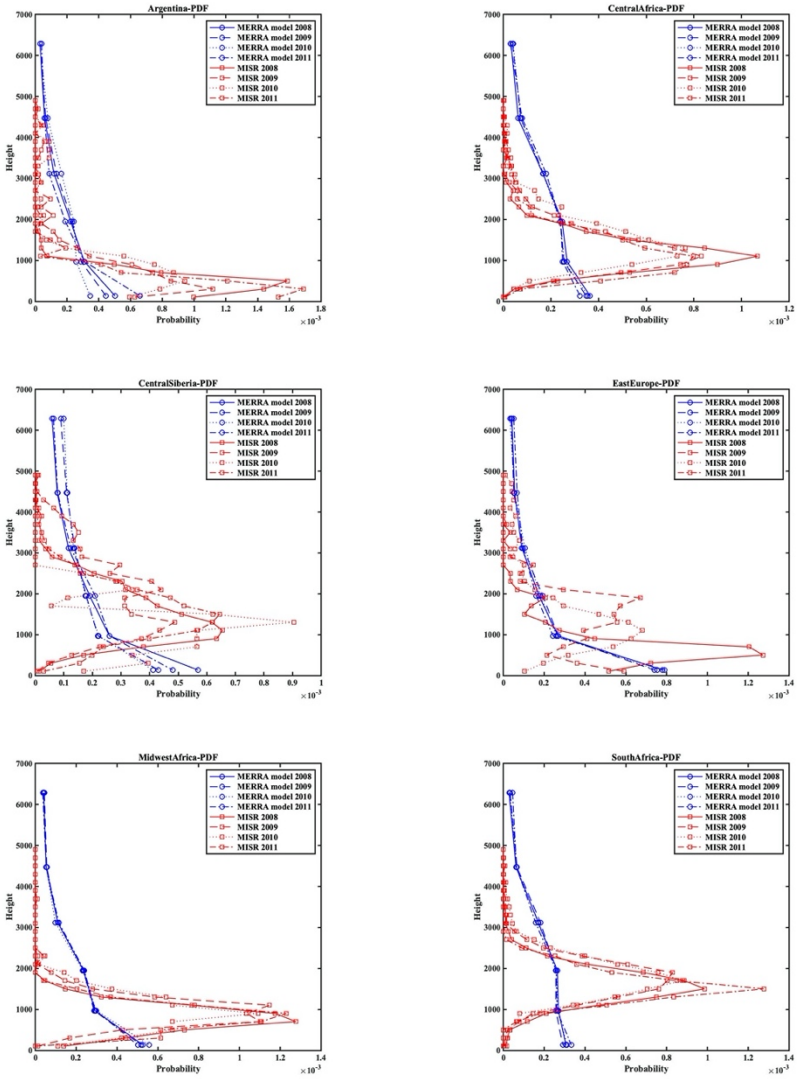
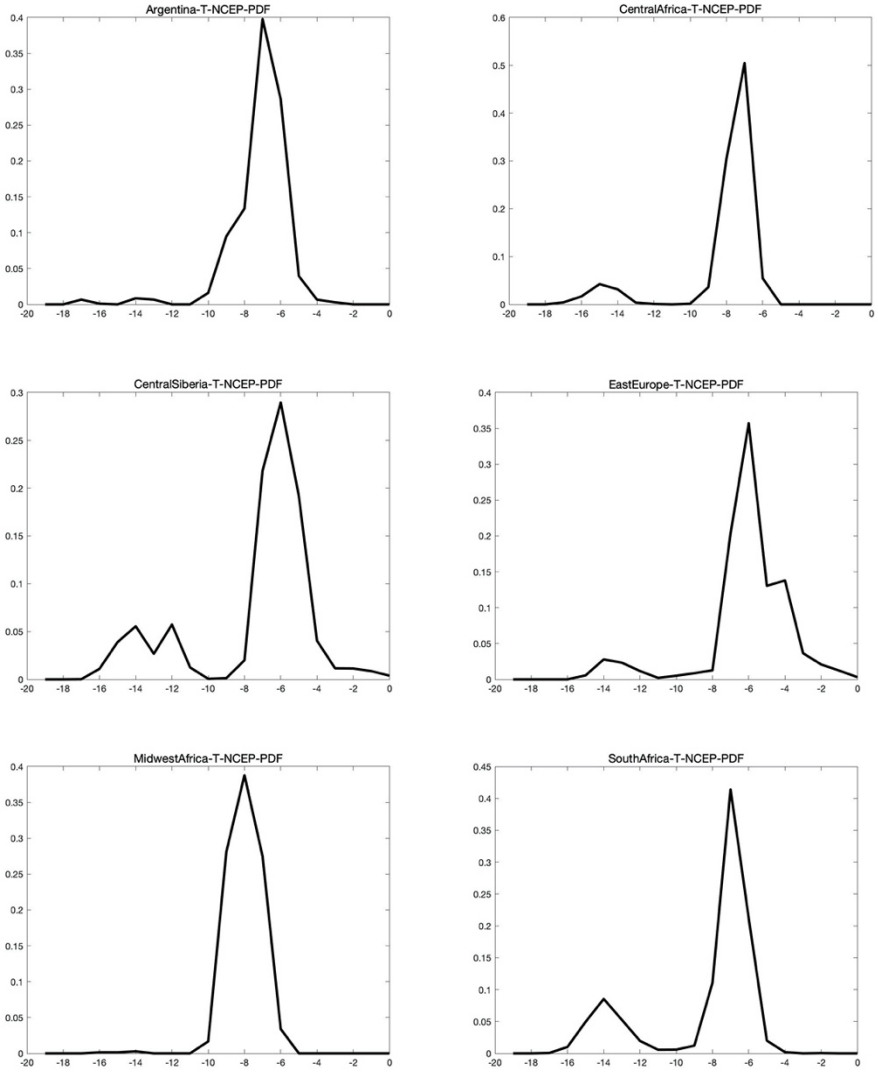
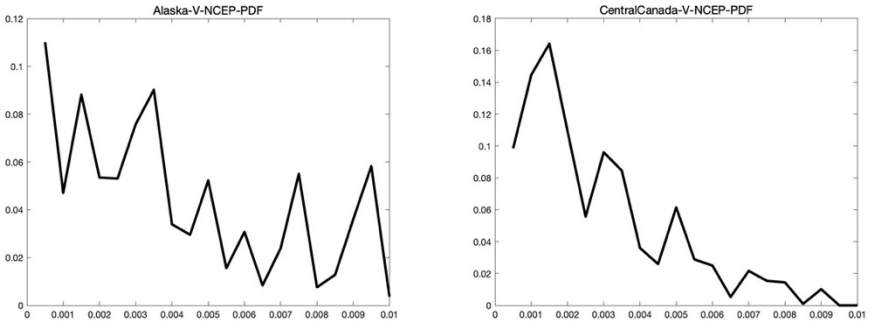
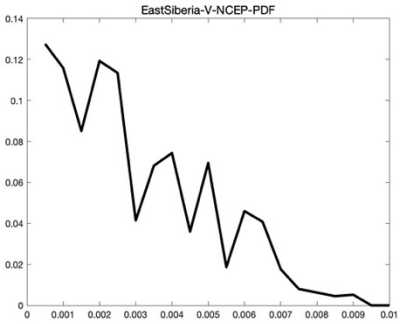


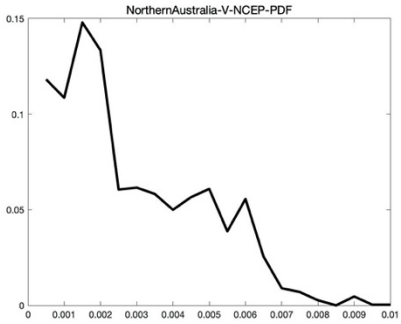
Figure S6 PDFs of various NCEP reanalysis products used in this work

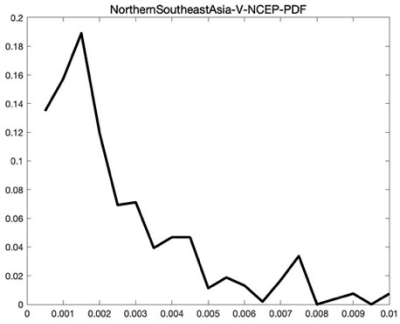


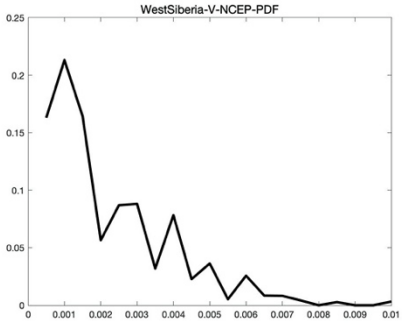
(a) vertical temperature gradient d[K]/d[km] over the locations and days that contain MISR plumes over the 6 regions over which the regression model is not valid.

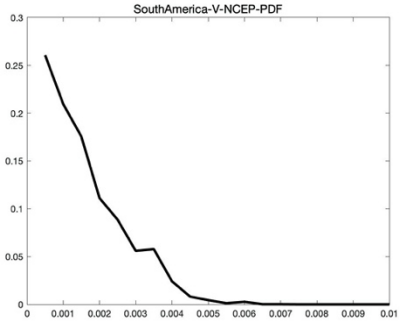


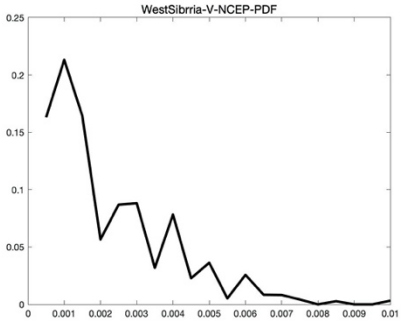




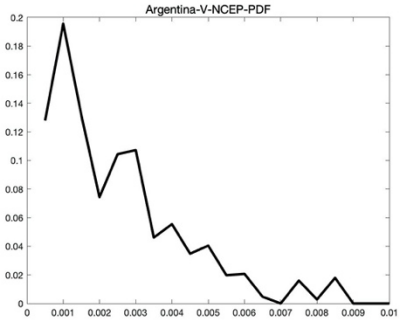


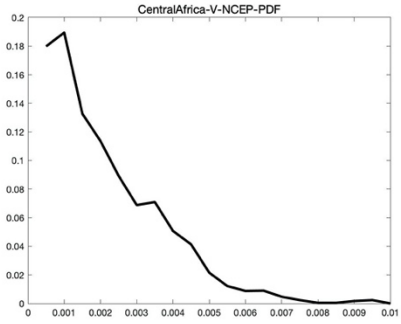


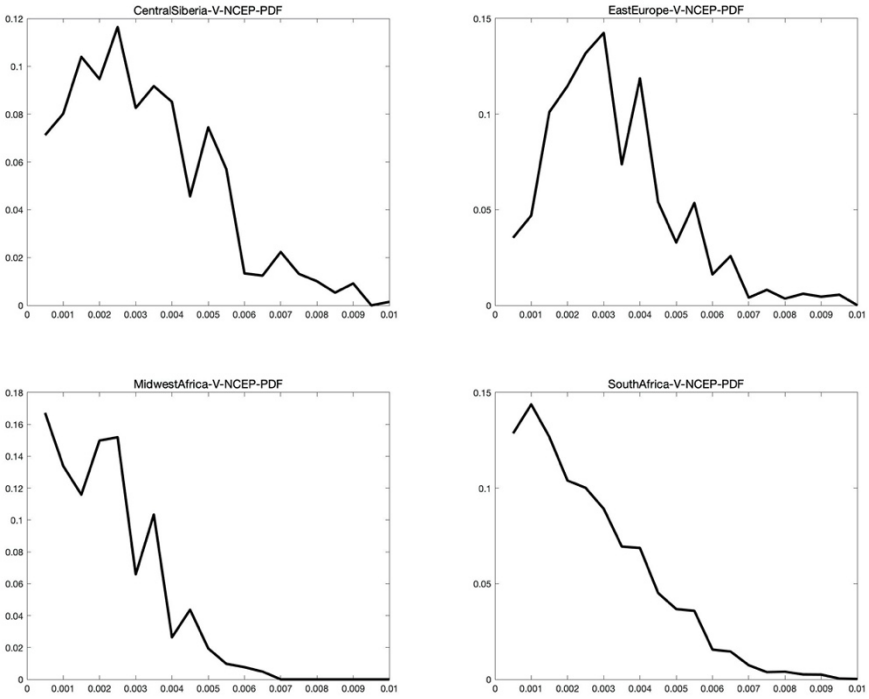




(b) surface vertical wind over the locations and days that contain MISR plumes over the 8 regions that have a valid regression model result.







(c) surface vertical wind over the locations and days that contain MISR plumes over the 6 regions that do not have a valid regression model result.

Figure S7 PDFs of heights from MISR measurements (red), plume rise model (yellow), and regression model (blue) over each region. High NO_2/CO ratio conditions are given as solid lines, while low NO_2/CO ratio conditions are given as dashed lines.