




FUTURE EMISSIONS OF CRITERIA POLLUTANTS -


Analysis of some existing model runs for climate
change scenarios



Bill Battye and Janet Hou, EC/R Incorporated
Terry Keating, U.S. EPA



Purpose

- Analyze the variations in estimates of criteria pollutant emissions in order to inform upcoming modeling efforts
 - Pollutants NO_x, SO₂, VOC
 - Focus on projections for 2050
 - Draw on existing climate change projection scenarios, to provide an indication of the range of possible outcomes from ongoing efforts
- 

Ongoing IPCC projection efforts

Representative concentration pathways (RCPs)

- 3 W/m² around 2060
- 4.5 W/m² by 2100-2200
- 6 W/m² by 2100-2200
- 8.5 W/m² in 2100

Models


- MESSAGE
- IMAGE
- MINICAM
- NIES

Previous projections analyzed in this study

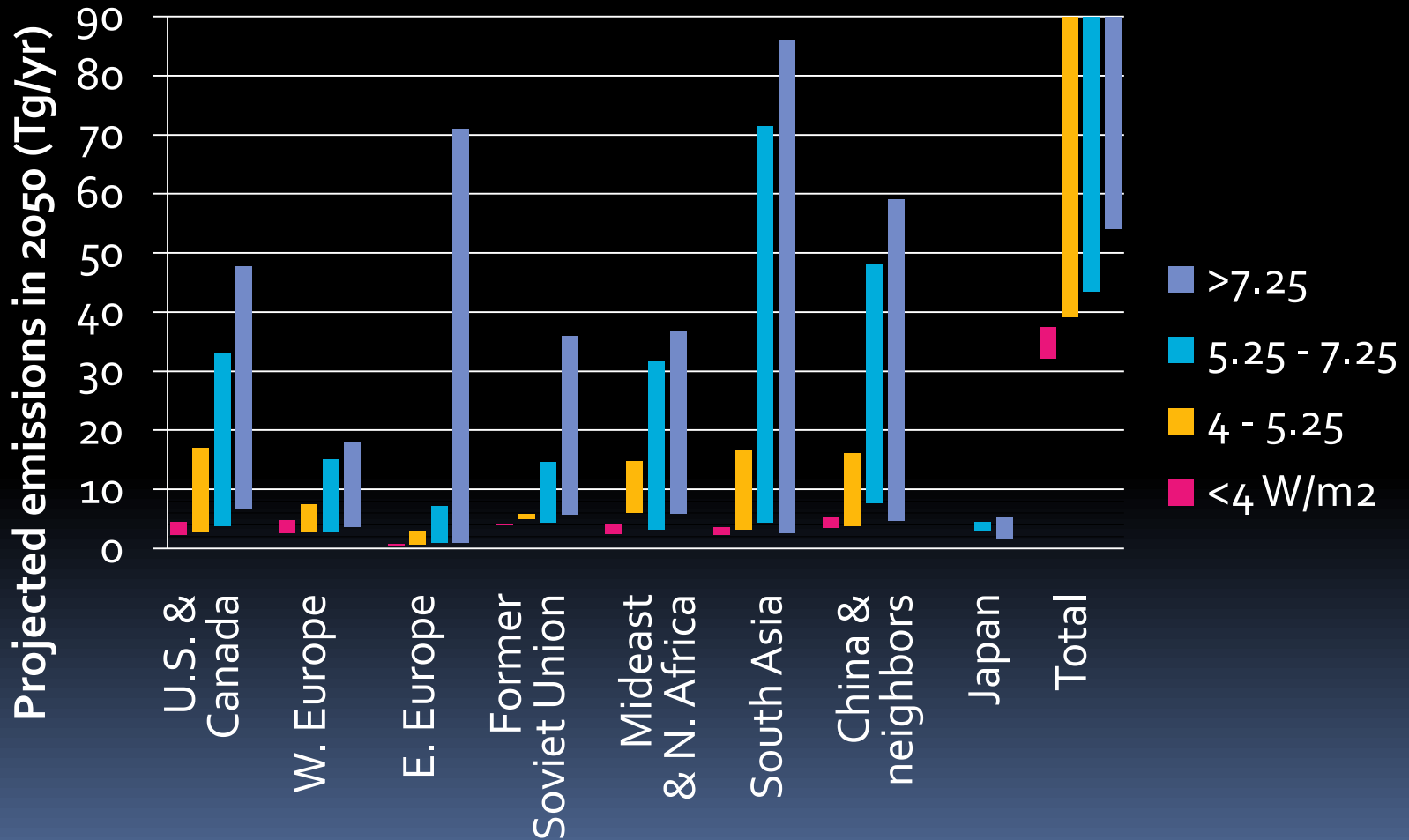
- MESSAGE
 - 10 runs ranging from 3.8 to >8.5 W/m²
- IMAGE
 - 6 runs ranging from 4.4 to >8.5 W/m²
- EPPA (MIT)
 - 3 runs representing high, low, and average conditions



Factors analyzed

- Overall projected emissions in 2050
 - Projected change from 2000 to 2050
 - Distribution of projected emissions among different regions
- 

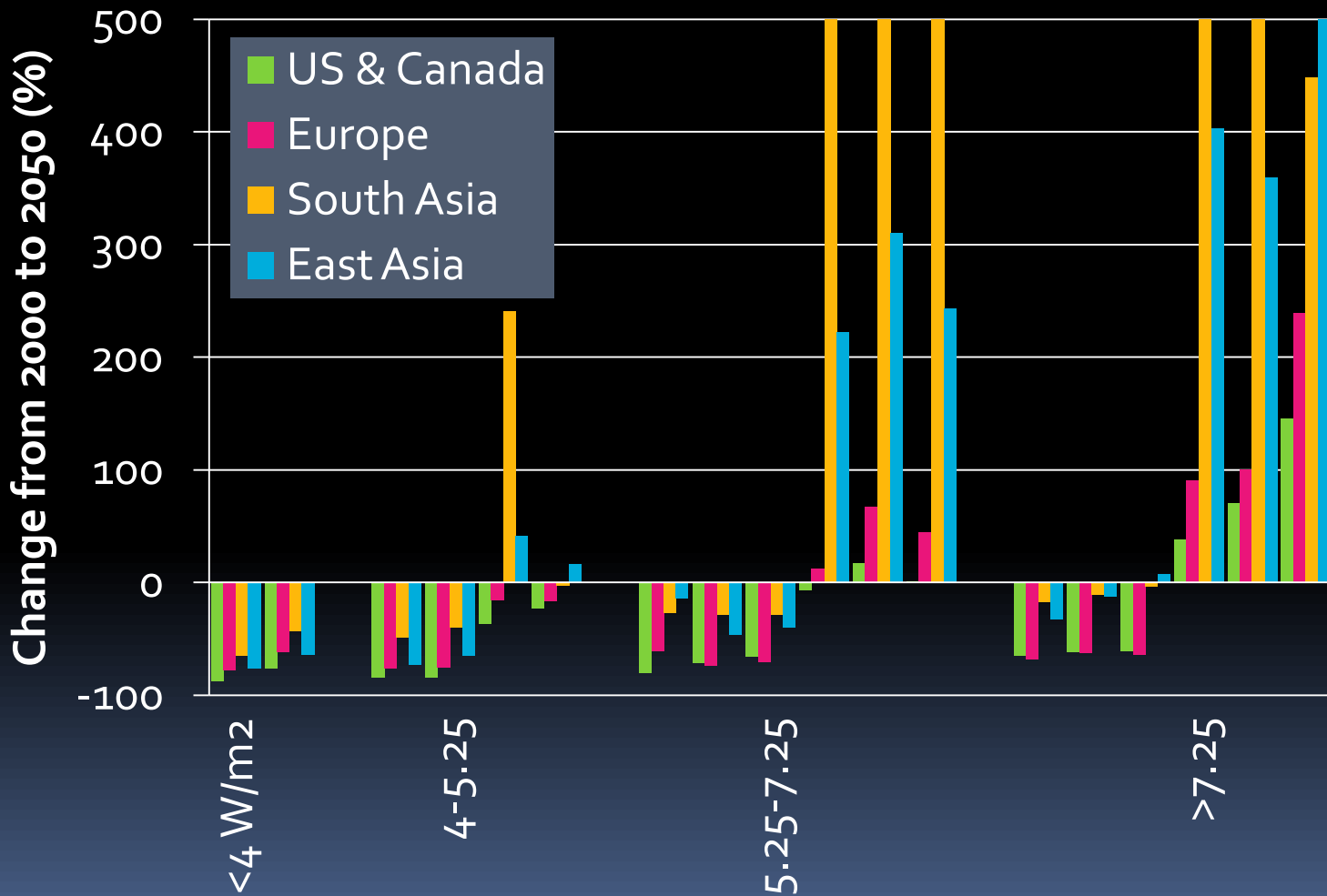
NO_x emissions for different scenarios



Future NO_x estimates with different models and RCPs

<u>Region</u>	NO _x emissions projected for 2050 (Tg/yr)			
	<u><4 W/m²</u>	<u>4-5.25 W/m²</u>	<u>5.25-7.25 W/m²</u>	<u>>7.25 W/m²</u>
U.S.& Canada	2.3 - 4.5	2.9 - 17.1	3.8 - 33	6.7 - 48
Western Europe	2.6 - 4.8	2.7 - 7.5	2.8 - 15.1	3.5 - 18
Eastern Europe	0.5 - 0.7	0.7 - 2.9	0.9 - 7.1	1.0 - 71
Former Soviet. Union	3.9 - 4.2	5.0 - 5.9	4.4 - 14.6	5.8 - 36
Mideast & N. Afr.	2.5 - 4.3	6.1 - 14.9	3.2 - 31.7	5.8 - 37
South Asia	2.2 - 3.6	3.2 - 16.5	4.5 - 71	2.6 - 86
China & neighbors	3.5 - 5.2	3.8 - 16.2	7.7 - 48	4.7 - 59
Japan	0.4 - 0.5	1.9	3.0 - 4.5	1.6 - 5.3
Worldwide total	32 - 37	39 - 112	43 - 294	54 - 345

Projected change in NO_x emissions

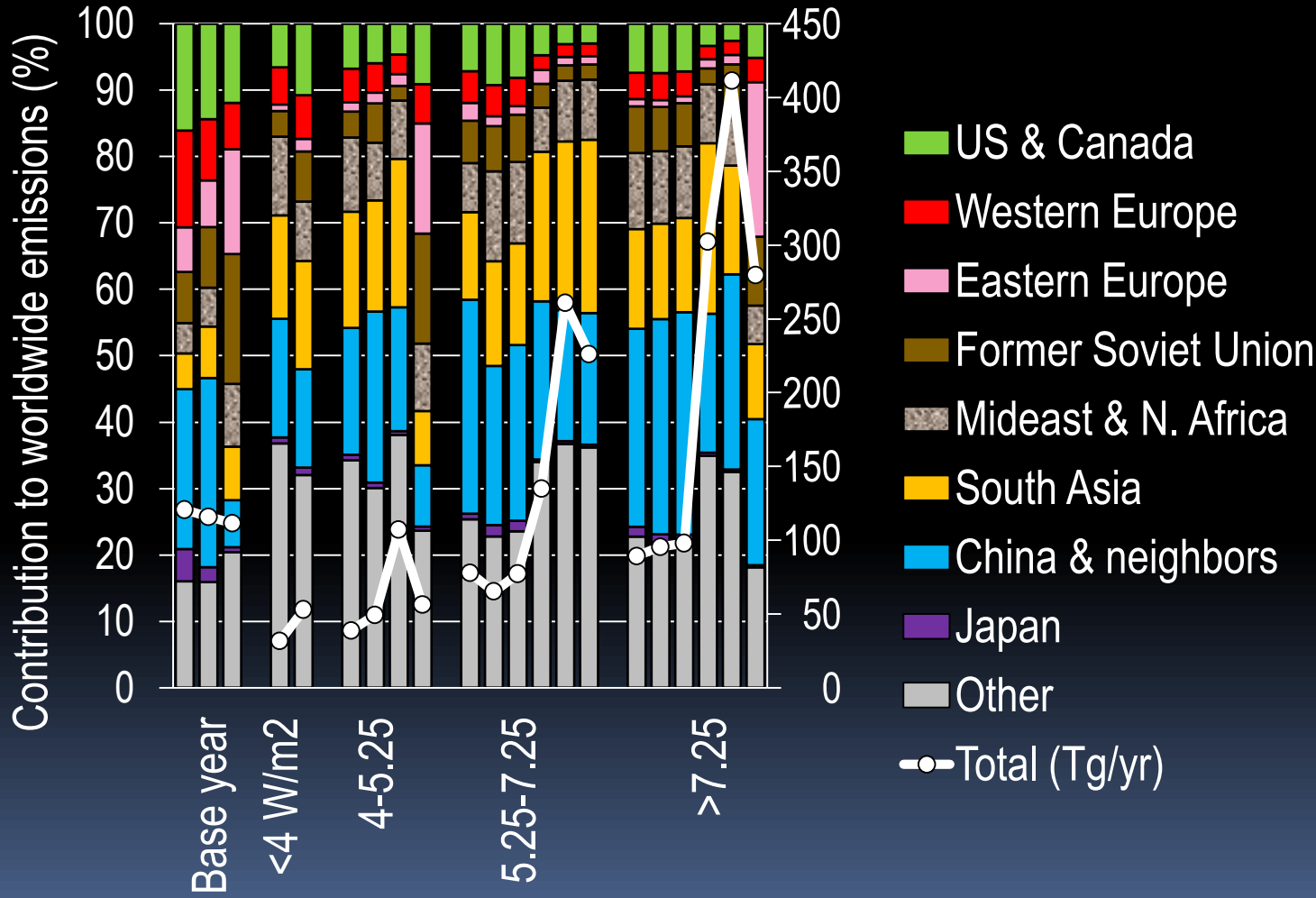


Change in NO_x estimated with different models and RCPs

NO_x change between 2000 and 2050 (%)

<u>Region</u>	NO _x change between 2000 and 2050 (%)			
	<u><4 W/m²</u>	<u>4-5.25 W/m²</u>	<u>5.25-7.25 W/m²</u>	<u>>7.25 W/m²</u>
U.S.& Canada	-88 to -77	-85 to -37	-80 to 17	-65 to 146
Western Europe	-79 to -61	-78 to -27	-77 to 35	-71 to 107
Eastern Europe	-77 to -67	-68 to 41	-57 to 241	-53 to 302
Former Soviet Union	-33 to -28	-13 to 16	-23 to 179	1 to 238
Mideast & N. Afr.	-66 to -41	-16 to 214	-56 to 564	-12 to 693
South Asia	-65 to -44	-49 to 241	-29 to 1321	-17 to 1612
China & neighbors	-76 to -64	-74 to 42	-47 to 310	-33 to 508
Japan	-91 to -89	-38	-8 to 34	-12 to 70
Worldwide total	-67 to -61	-59 to 41	-55 to 256	-44 to 318

Regional distribution of SO₂ emissions

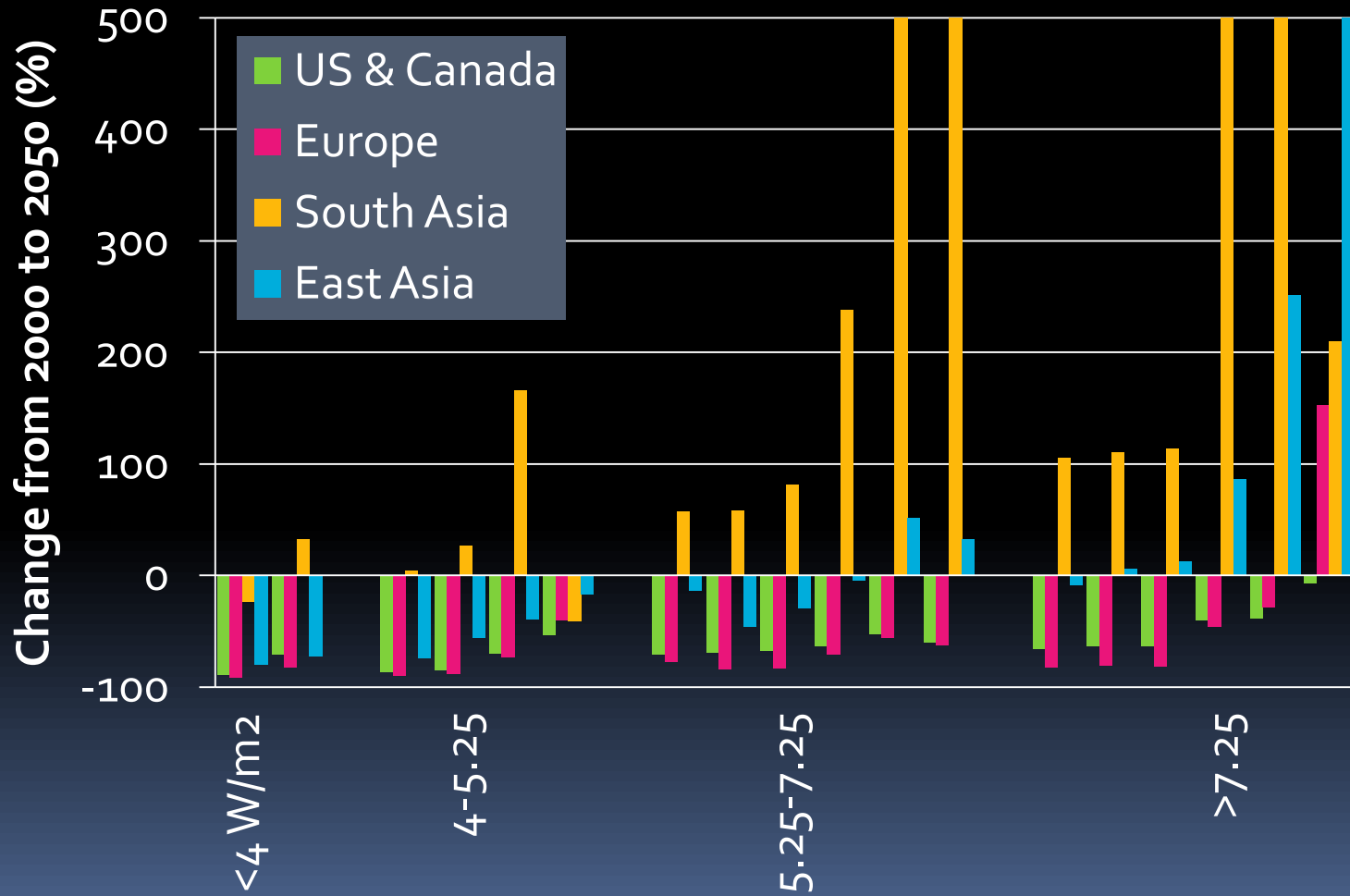


Future SO₂ estimates with different models and RCPs

SO₂ emissions projected for 2050 (Tg/yr)

<u>Region</u>	SO ₂ emissions projected for 2050 (Tg/yr)			
	<u><4 W/m²</u>	<u>4-5.25 W/m²</u>	<u>5.25-7.25 W/m²</u>	<u>>7.25 W/m²</u>
U.S.& Canada	2.1 - 5.7	2.6 - 4.9	5.5 - 8	6.6 - 14
Western Europe	1.8 - 3.5	1.9 - 3.2	3.0 - 5.0	3.5 - 10
Eastern Europe	0.3 - 1.0	0.5 - 1.9	1.0 - 3.3	1.0 - 65
Former Soviet. Union	1.2 - 4.0	1.5 - 2.9	4.4 - 6.0	6.3 - 29
Mideast & N. Afr.	3.8 - 4.7	4.3 - 9.4	5.7 - 23.9	10.2 - 35
South Asia	4.9 - 8.6	6.8 - 23.9	10.3 - 66	13.4 - 78
China & neighbors	5.7 - 7.8	7.4 - 20.0	15.6 - 51	26.6 - 121
Japan	0.3 - 0.6	0.6	0.5 - 1.1	0.9 - 1.5
Worldwide total	32 - 53	39 - 107	65 - 261	89 - 411

Projected change in SO₂ emissions

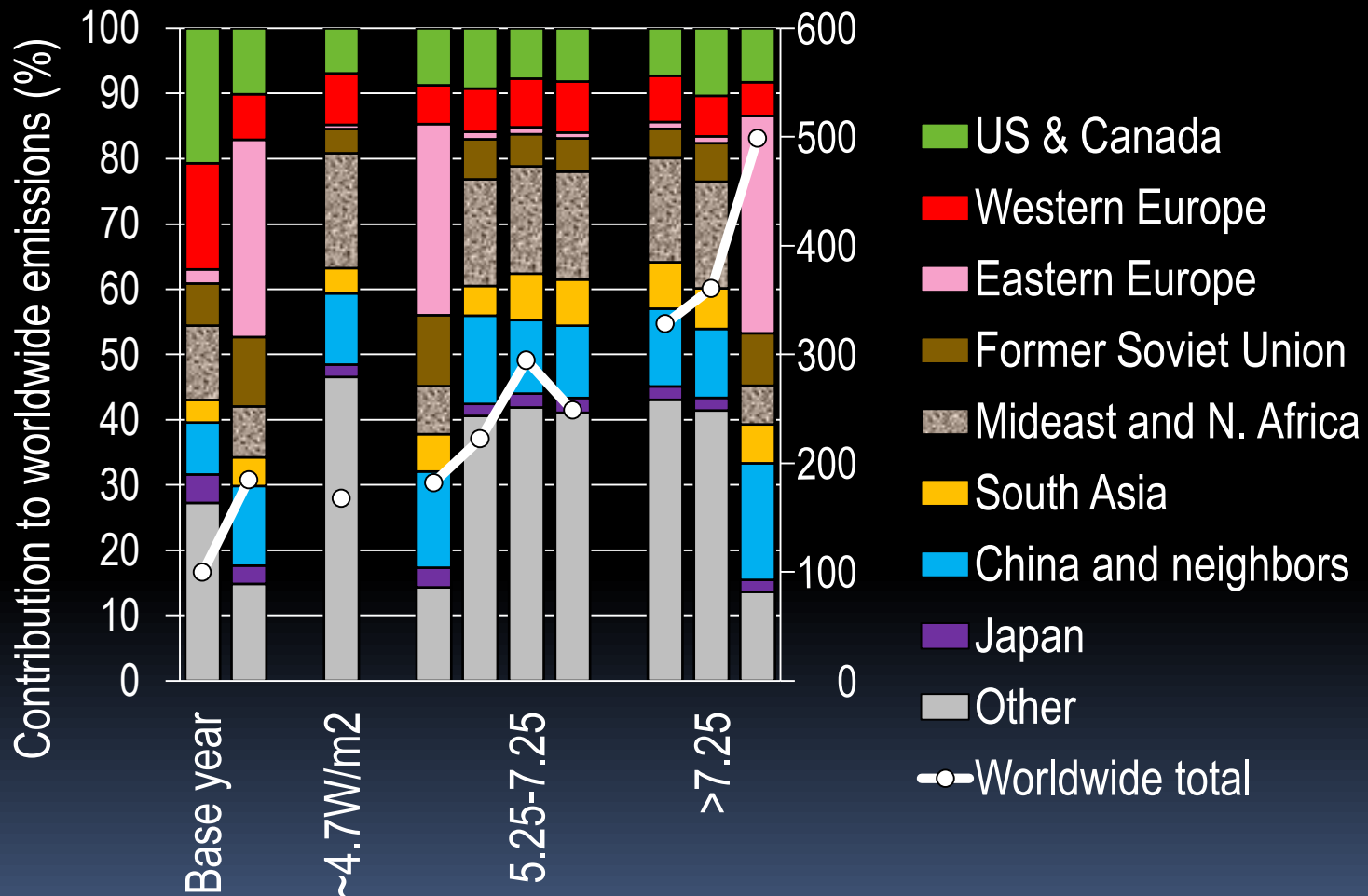


Change in SO₂ estimated with different models and RCPs

SO₂ change between 2000 and 2050 (%)

<u>Region</u>	SO ₂ change between 2000 and 2050 (%)			
	<u><4 W/m²</u>	<u>4-5.25 W/m²</u>	<u>5.25-7.25 W/m²</u>	<u>>7.25 W/m²</u>
U.S.& Canada	-89 to -71	-87 to -70	-71 to -52	-66 to -8
Western Europe	-90 to -80	-89 to -70	-83 to -53	-80 to 15
Eastern Europe	-96 to -88	-93 to -77	-88 to -60	-88 to 212
Former Soviet Union	-87 to -57	-84 to -68	-56 to -41	-50 to 150
Mideast & N. Afr.	-32 to -14	-22 to 39	4 to 252	-38 to 423
South Asia	-24 to 33	4 to 167	58 to 636	-41 to 762
China & neighbors	-80 to -73	-75 to -39	-46 to 52	-17 to 543
Japan	-95 to -90	-76	-82 to -57	-50 to -5
Worldwide total	-74 to -56	-68 to -8	-46 to 122	-41 to 243

Regional distribution of VOC emissions

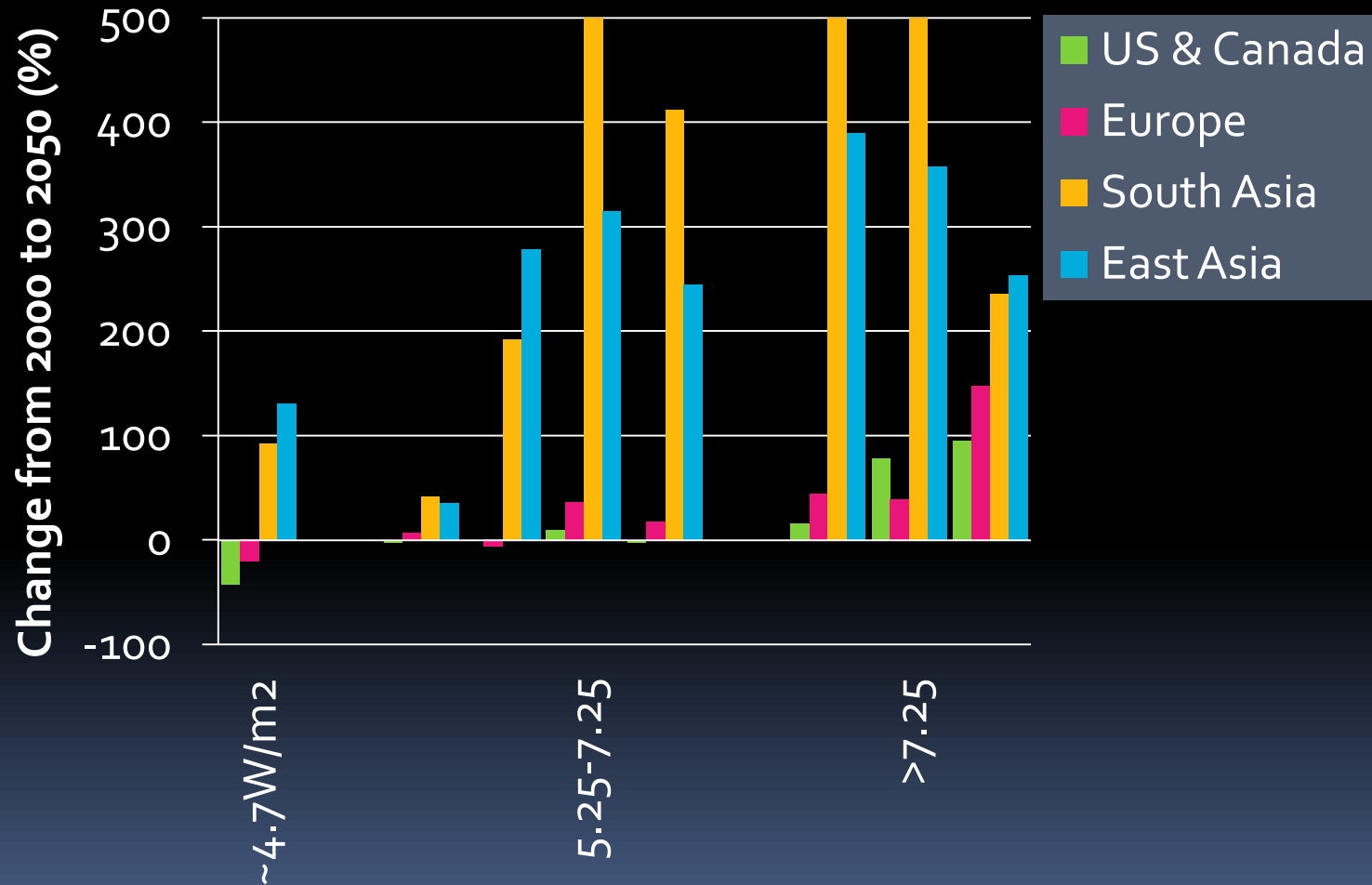


Future VOC estimates with different models and RCPs

VOC emissions projected for 2050
(Tg/yr)

<u>Region</u>	<u>4.7 W/m²</u>	<u>5.25-7.25</u>	<u>>7.25</u>
U.S.& Canada	12	20 - 23	24 - 41
Western Europe	13	15 - 22	22 - 26
Eastern Europe	1	2 - 3	3 - 166
Former Soviet Union	6	13 - 15	15 - 40
Mideast & N.Afr.	30	36 - 48	30 - 59
South Asia	6	10 - 21	22 - 30
China & neighbors	18	28 - 33	38 - 89
Japan	3	4 - 6	7 - 9
Worldwide total	168	222 - 295	328 - 499

Projected change in VOC emissions



Change in VOC estimated with different models and RCPs

<u>Region</u>	VOC change between 2000 and 2050 (%)		
	<u>4.7 W/m²</u>	<u>5.25-7.25</u>	<u>>7.25</u>
U.S.& Canada	-42	-2 to 10	15 to 95
Western Europe	-16	-9 to 35	35 to 78
Eastern Europe	-51	-1 to 41	54 to 164
Former Soviet Union	-4	95 to 123	89 to 230
Mideast & N.Afr.	150	219 to 309	85 to 416
South Asia	92	192 to 510	235 to 580
China & neighbors	131	245 to 315	253 to 389
Japan	-27	-6 to 43	53 to 66
Worldwide total	70	123 to 194	142 to 254

Findings

- Projections of overall NO_x , SO_2 and VOC for 2050 vary widely
- Ranges of projections can be large, even among scenarios with similar climate change impacts
- Projected emissions of NO_x , SO_2 and VOC depend on the choice of models in addition to the future scenario
- Projection models also give different regional distributions of emissions

Caveats

- These analyses are based on previous projections and readily-available summaries of results
- Geographic regions are not entirely consistent among models
- All projections are currently being updated and refined
- NO_x , SO_2 , and VOC were not a primary focus for the previous rounds of projections
- Control assumptions for these pollutants are being improved