HTAP Work Package 2.6: Comparison of Source Receptor (SR) and Source Attainment (SA) Methods

HTAP Meeting
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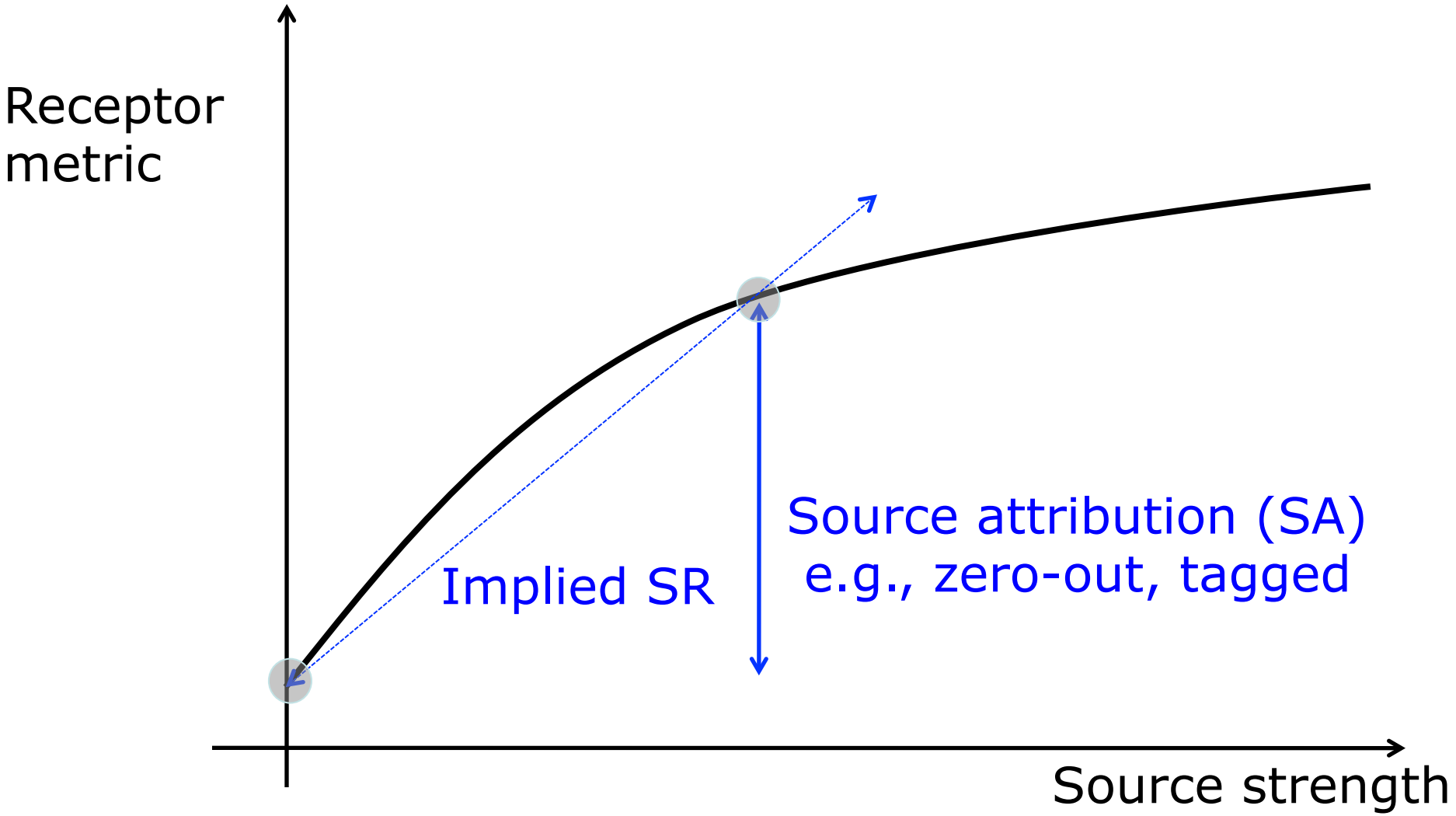
NASA AQAST

Concerns for nonlinear systems



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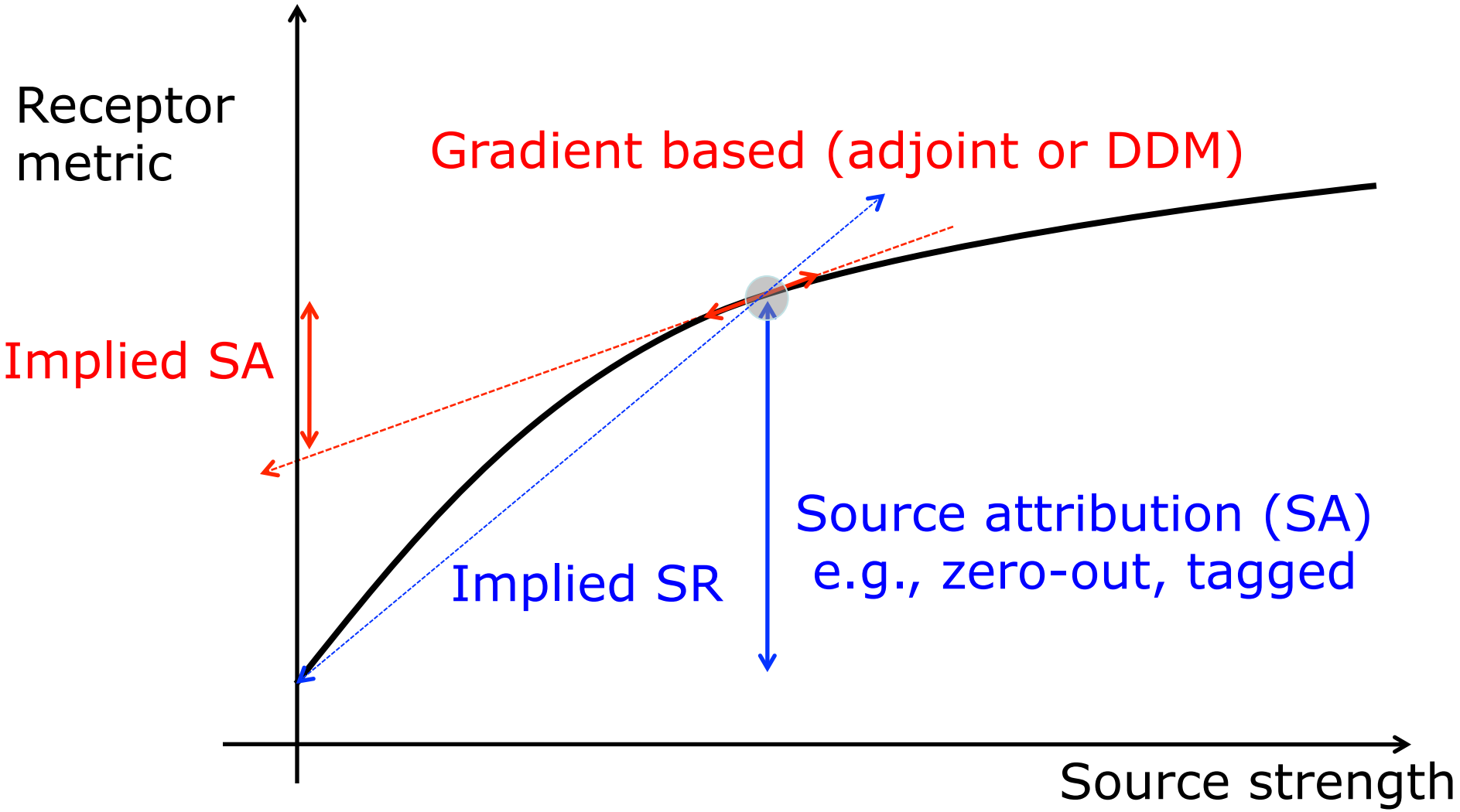

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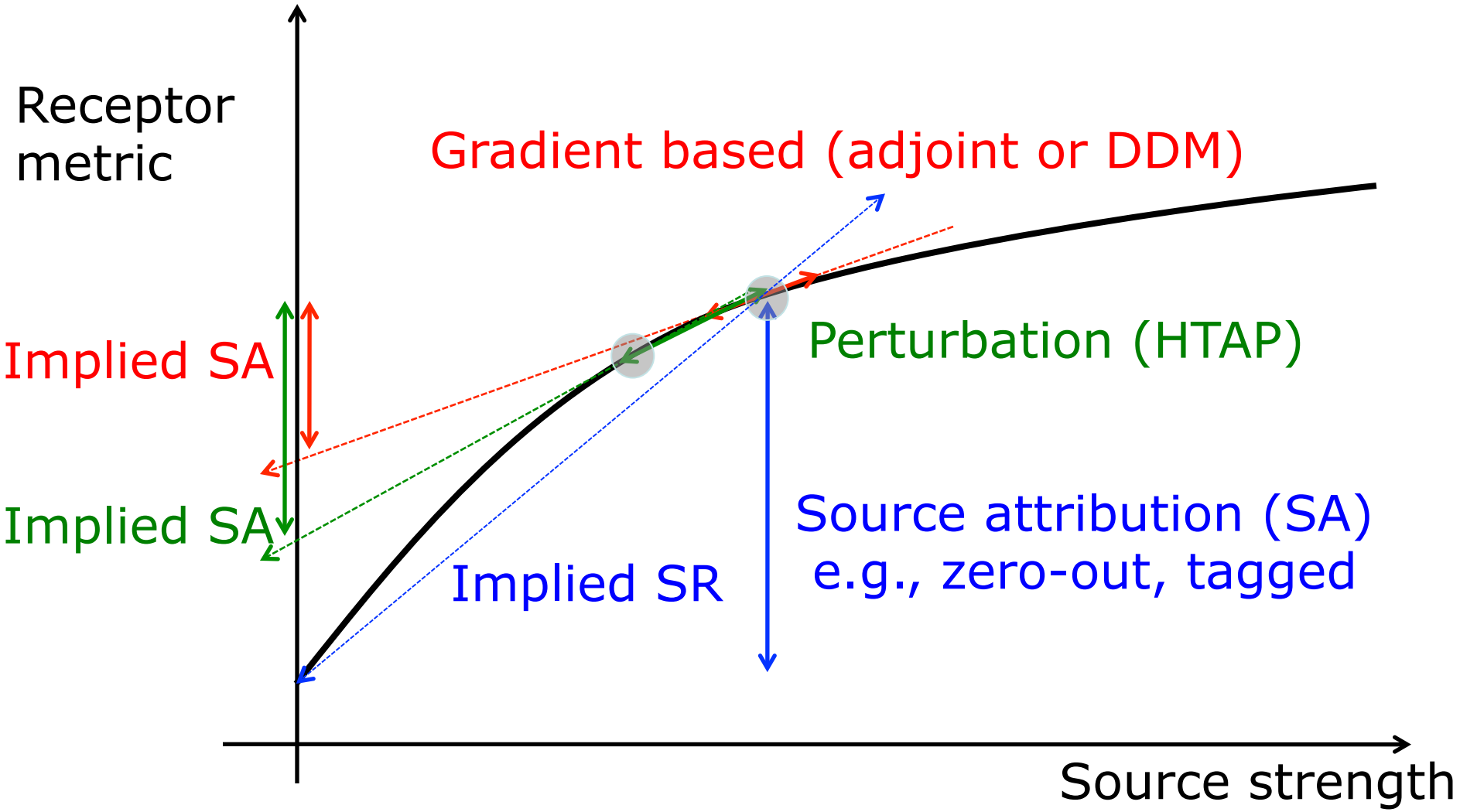
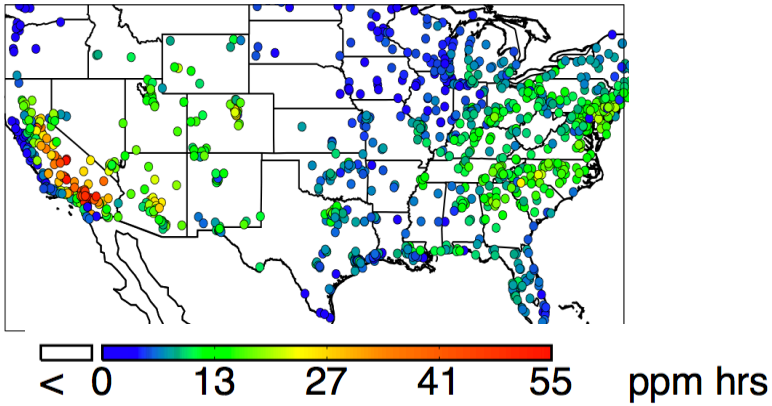
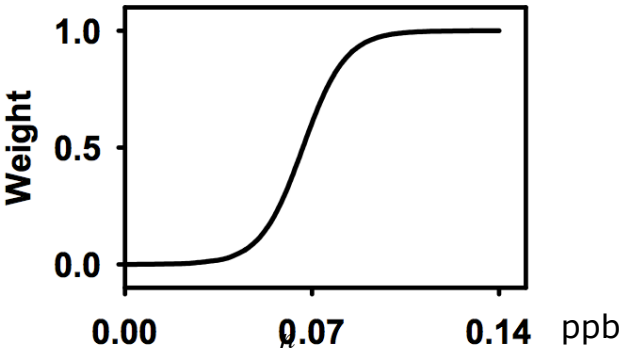


HTAP: we have multiple models capable of each

Case study: US vegetative ozone exposure

W126 in 2008 (AQS & CASTNET)





$$W126 = \sum_{i=1} w_i \times [C_{O3}]_i$$

Many of the US counties are projected to violate secondary standard, even if they are not violating primary O_3 standard

Case study: US vegetative ozone exposure

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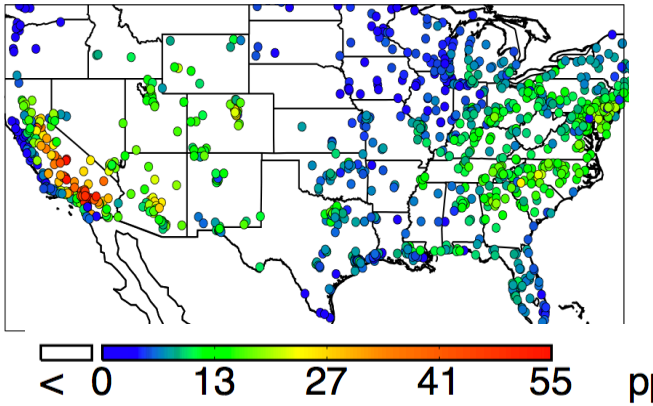

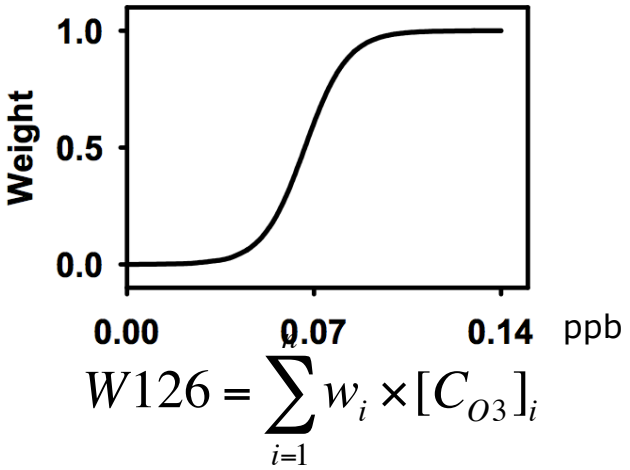

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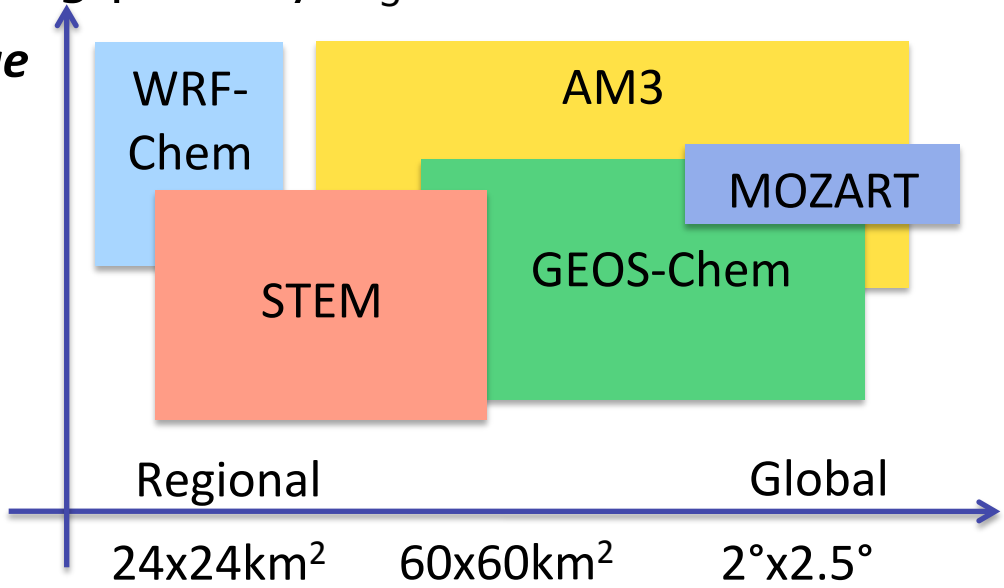
Many of the US counties are projected to violate secondary standard, even if they are not violating primary O_3 standard

Source Attribution Technique

Tagged tracers

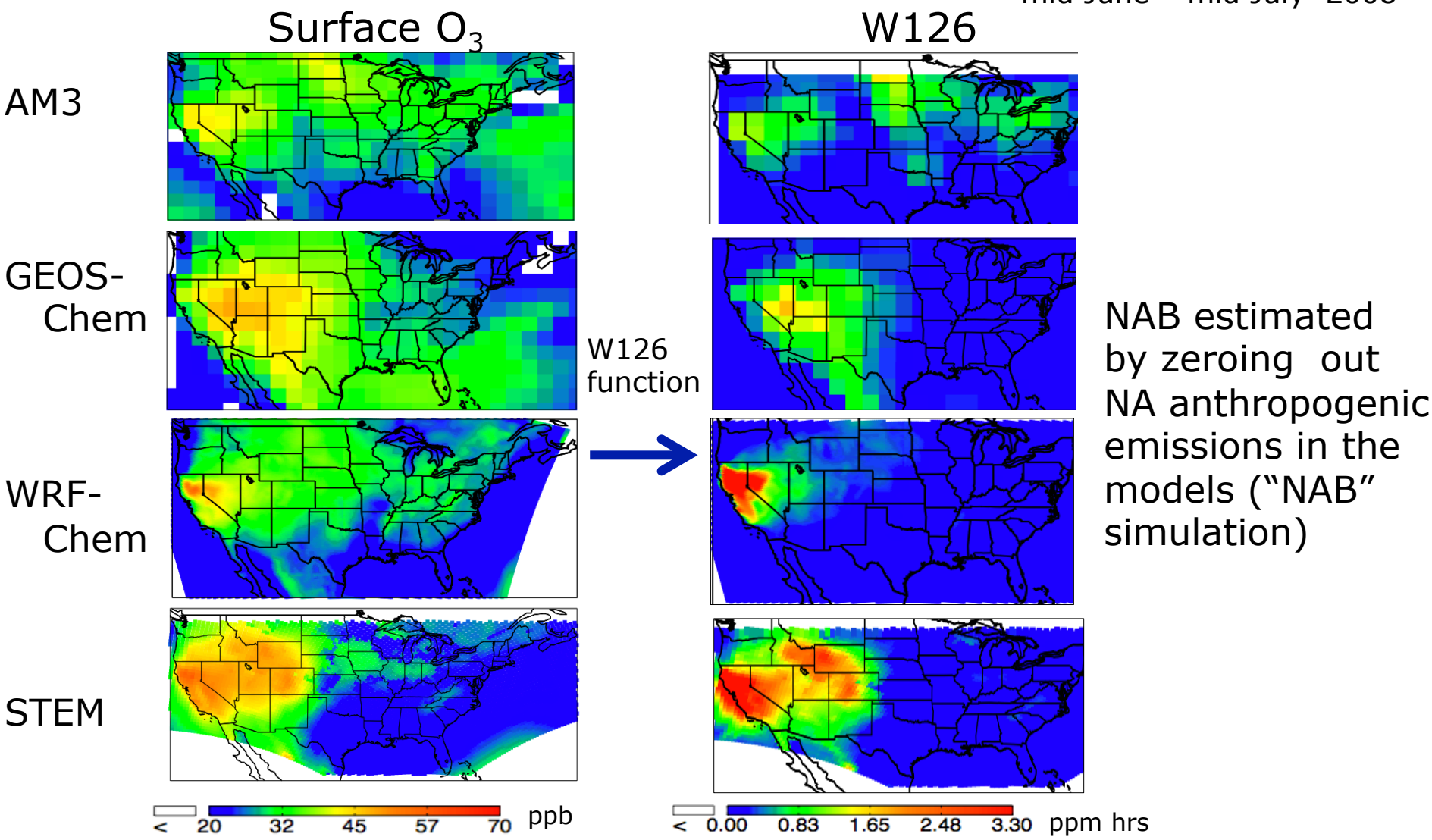
Emission perturbations

Adjoint sensitivities



North American Background (NAB)

mid June – mid July 2008



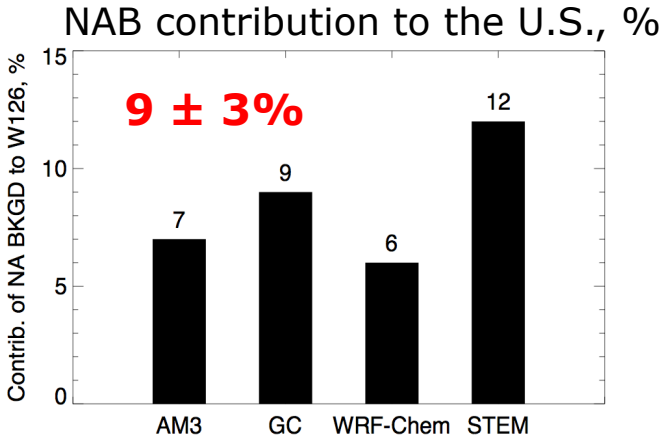
NAB estimated by zeroing out NA anthropogenic emissions in the models ("NAB" simulation)

Normalization in needed given the variability across models

Variability in one SA approach: NAB Contribution to W126

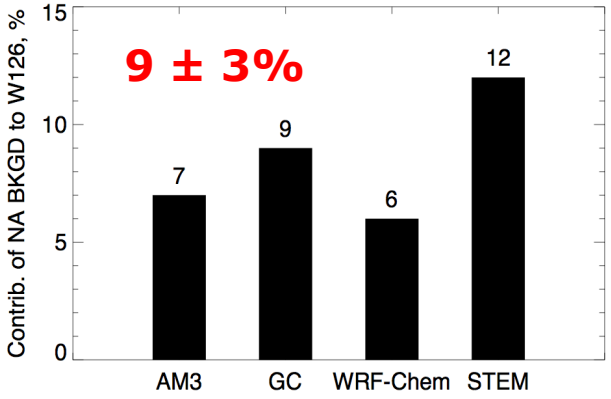
Model-only: NAB contribution based on the base and "NAB" model runs, %:

$$\frac{\sum_{i,j} W126\_\mathrm{NAB}_{i,j}}{\sum_{i,j} W126\_\mathrm{total}_{i,j}} \times 100\%$$



Variability in one SA approach: NAB Contribution to W126

NAB contribution to the U.S., %



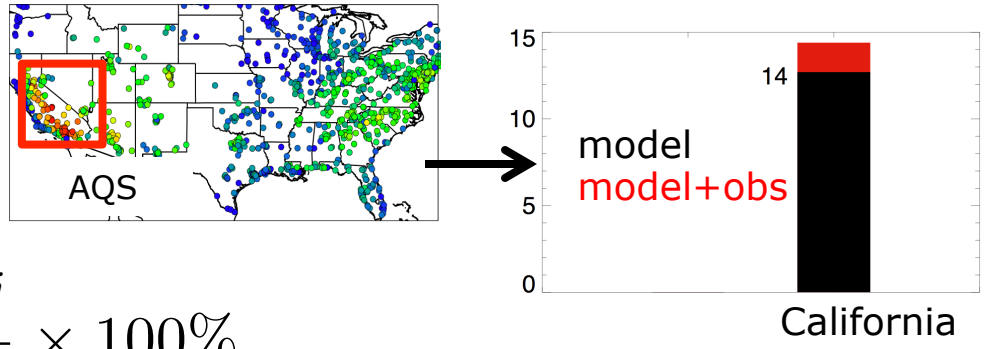
Model-only: NAB contribution based on the base and "NAB" model runs, %:

$$\frac{\sum_{i,j} W126\_\mathrm{NAB}_{i,j}}{\sum_{i,j} W126\_\mathrm{total}_{i,j}} \times 100\%$$

Model & Observations: contribution relative to the observed W126, model is used in a relative sense:

$$\frac{\sum_{i,j} \frac{W126\_\mathrm{NAB}_{i,j}}{W126\_\mathrm{total}_{i,j}} \times W126\_\mathrm{obs}_{i,j}}{\sum_{i,j} W126\_\mathrm{obs}_{i,j}} \times 100\%$$

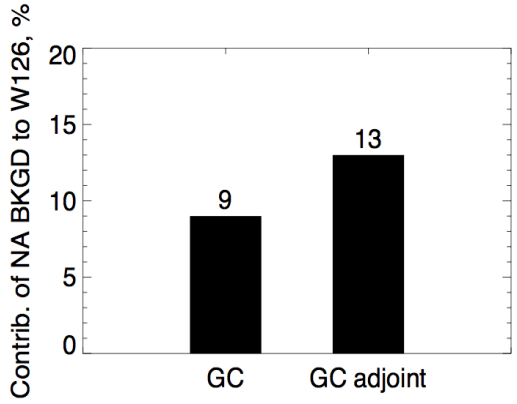
NAB contribution to selected regions, %



- RERER metric when source ≠ receptor?
- Use observations to adjust SA/SR relationships to account for bias?

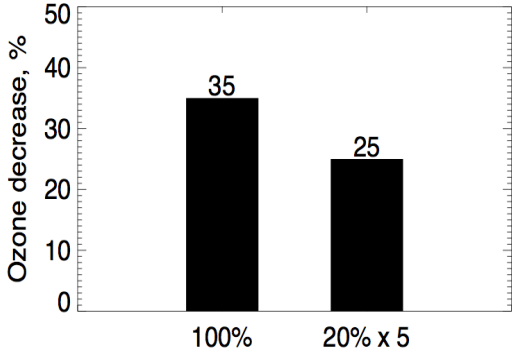
Variability across SA approaches

W126 NAB:
100% ΔNO_x vs adjoint

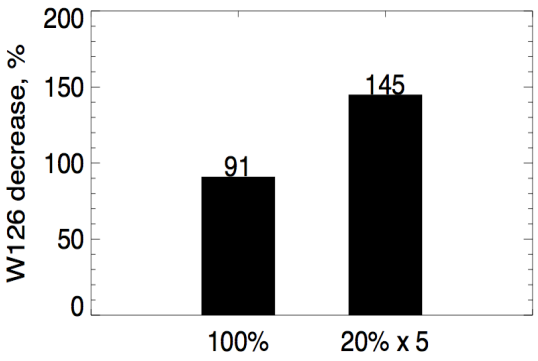


(20% ΔNO_x) x 5
vs
100% ΔNO_x

Daytime surface O_3



W126

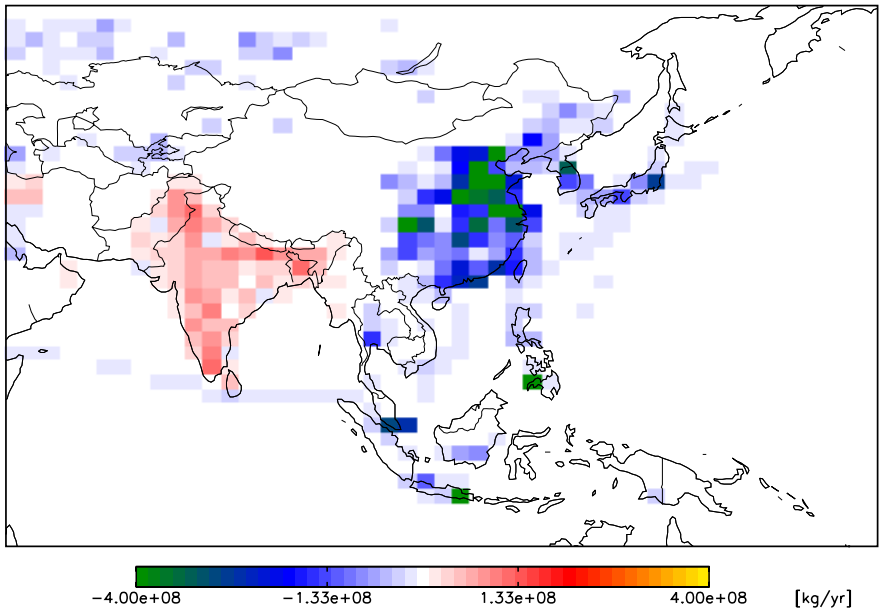


Variability across approaches depends upon response metric

Importance of highly resolved source regions

Spatial heterogeneity in SO_2 emissions changes following
- a single Representative Concentration Pathway for AR5

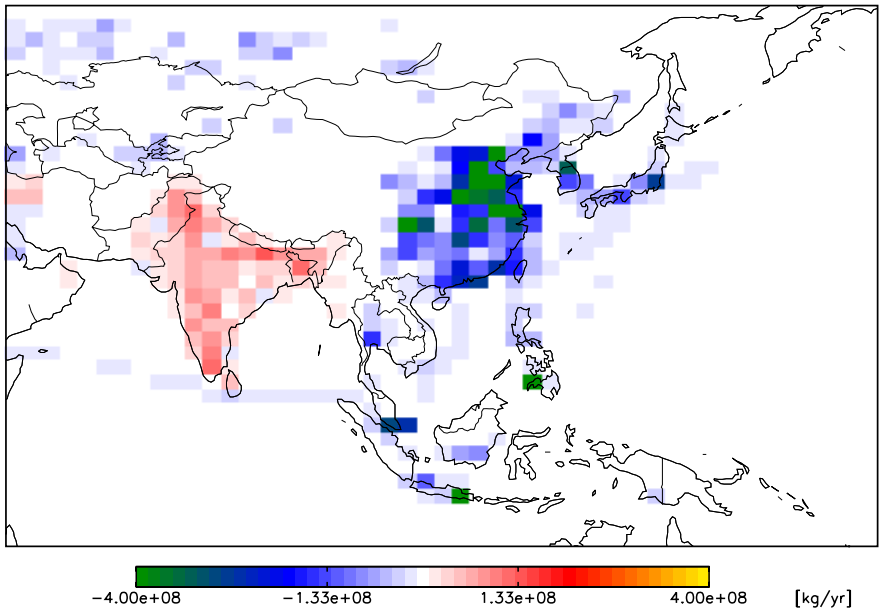
RCP 8.5: 2050 - 2000



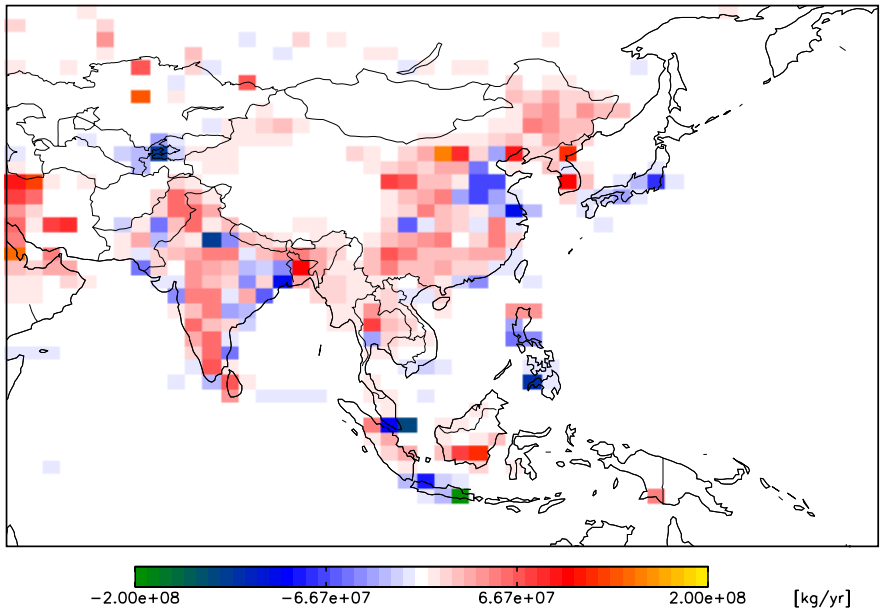
Importance of high-resolution emissions-based RF

Spatial heterogeneity in SO_2 emissions changes following
- a single Representative Concentration Pathway for AR5
- the difference between two Pathways for AR5

RCP 8.5: 2050 - 2000



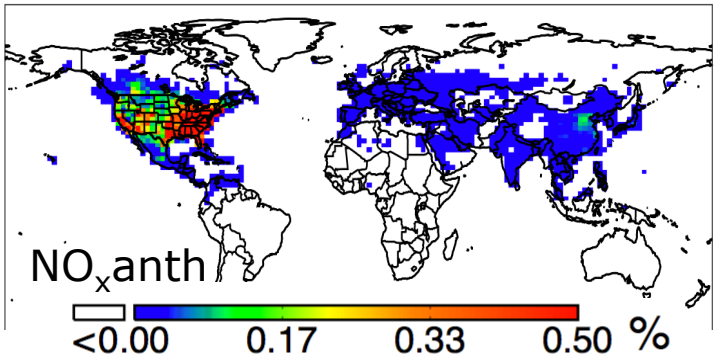
RCP 8.5 2050 – RCP 4.5 2050



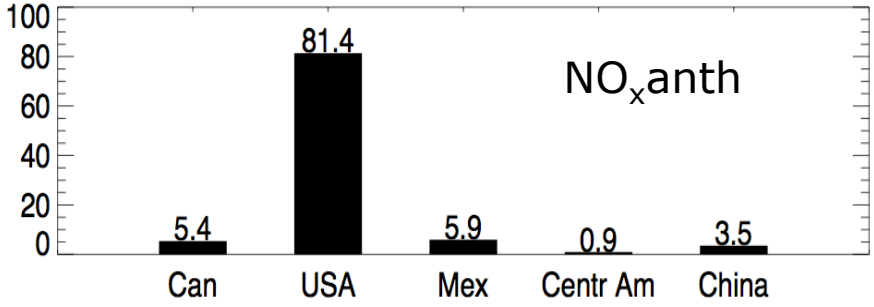
Significant intra-regional variability

GEOS-Chem Adjoint, Cost Function = W126 in the US

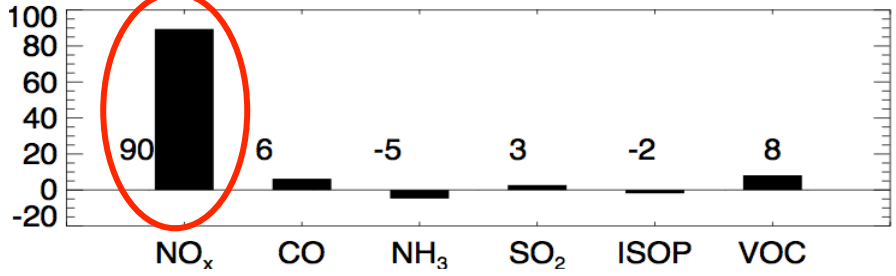
Adjoint provides spatially-resolved sensitivities to emissions, which can be aggregated into % of W126 sensitivities by species, regions or sectors



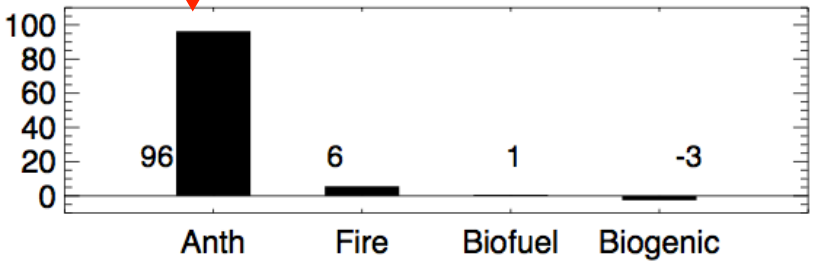
by Region [%]



by species [%]



by sector [%]

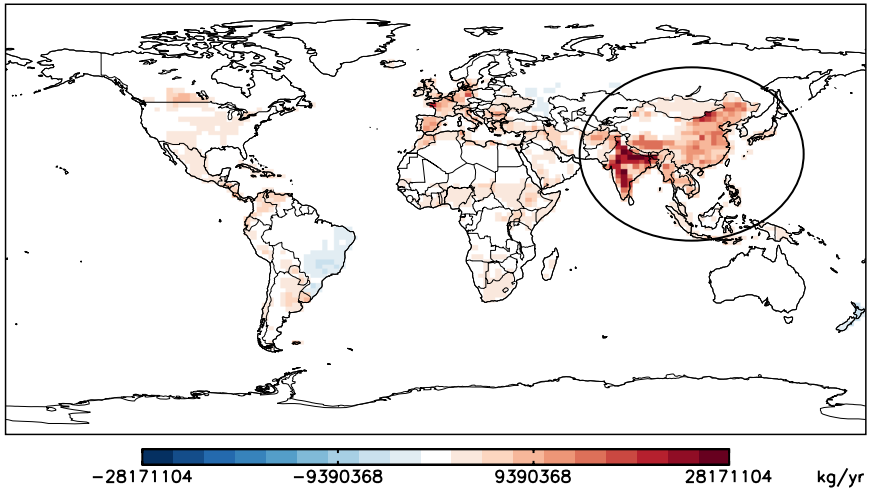


- No need to pre-specify source regions or sectors
- Must begin with specification of receptor
- Repeat calculations per receptor

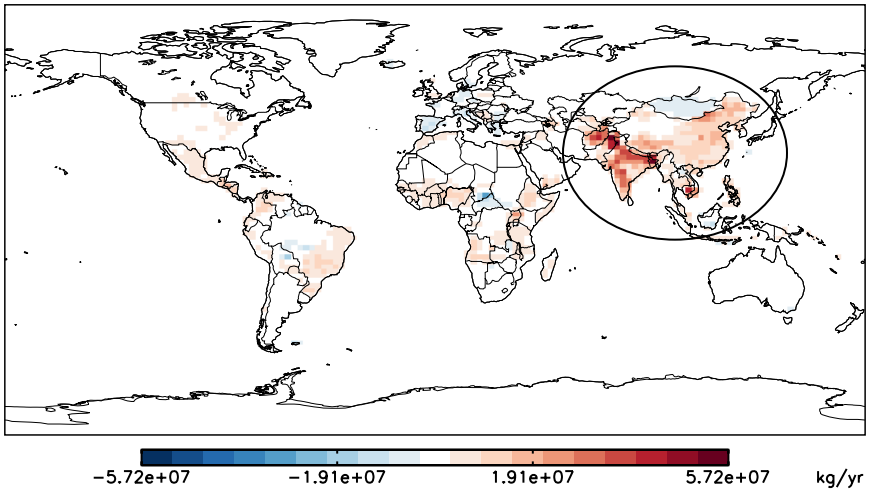
Cross-species impacts on aerosol DRF

NH_3 emissions: 2050 - 2000

RCP 6.0



RCP 2.6



Cross-species impacts on aerosol DRF

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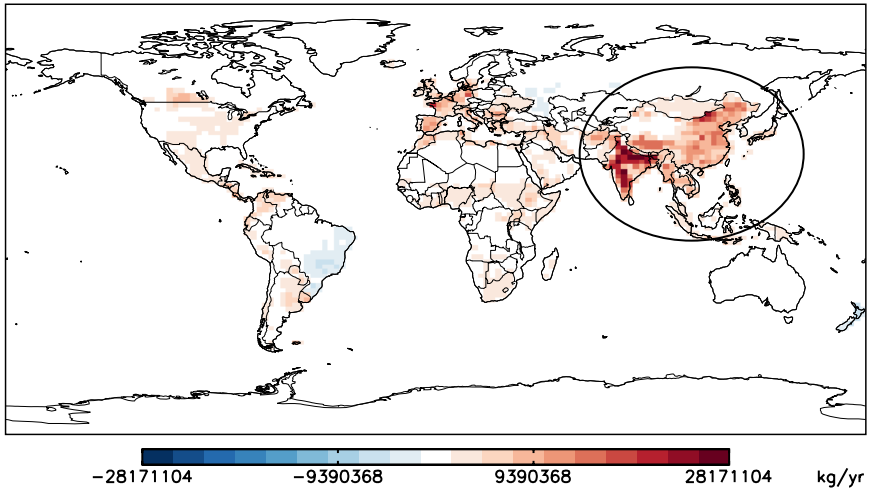

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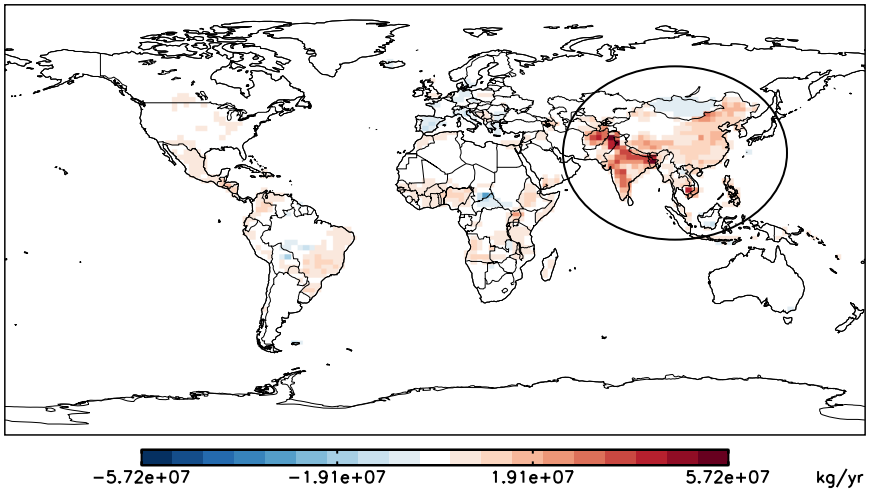
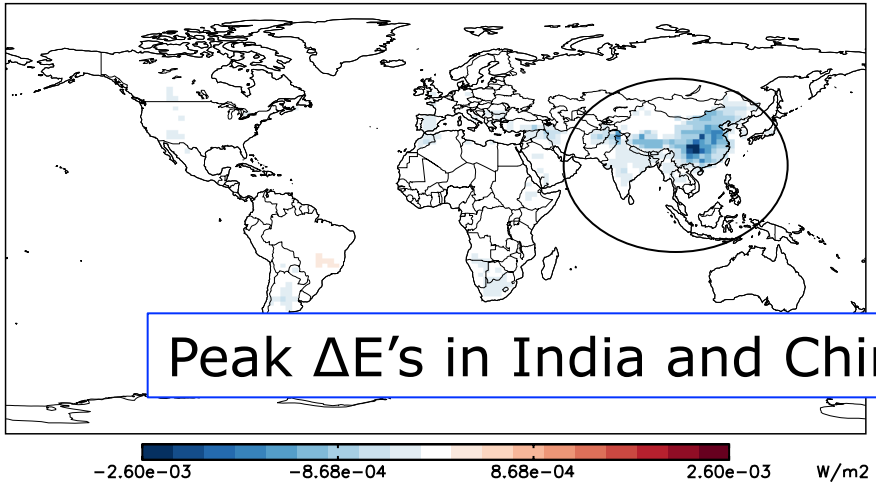


NH_3 DRF: $(dRF/dE)_{6.0} * \Delta E$



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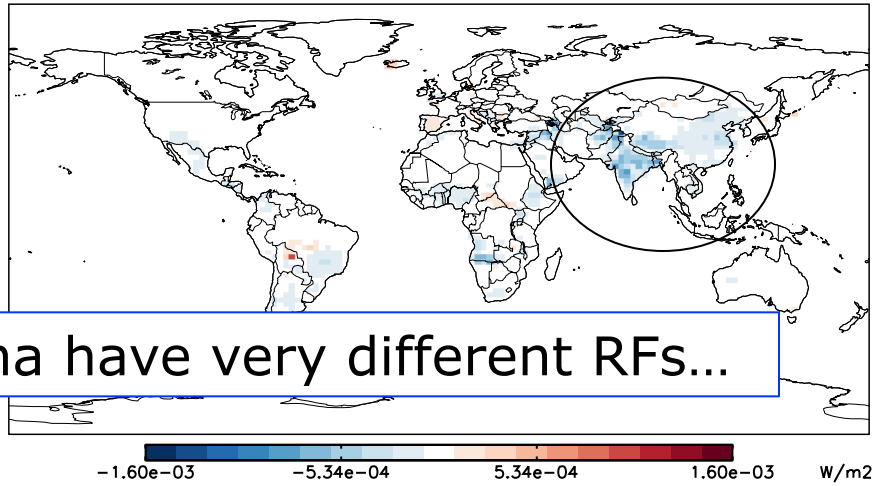
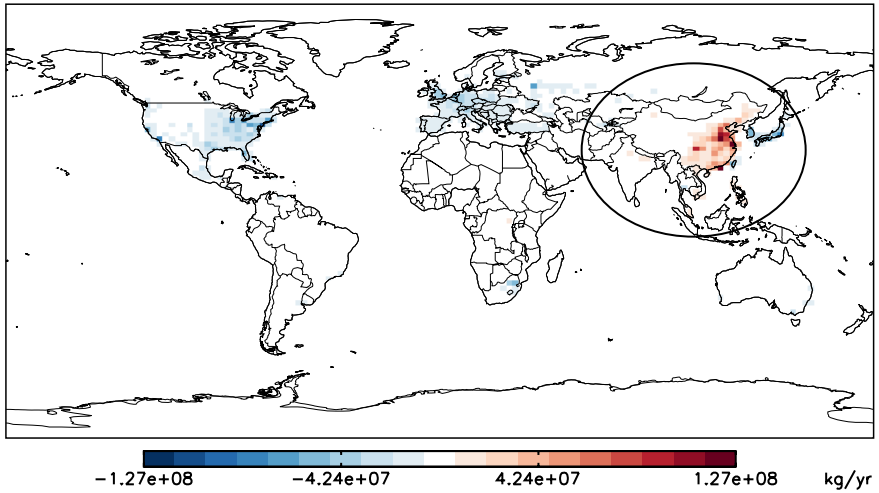


Peak ΔE's in India and China have very different RFs…

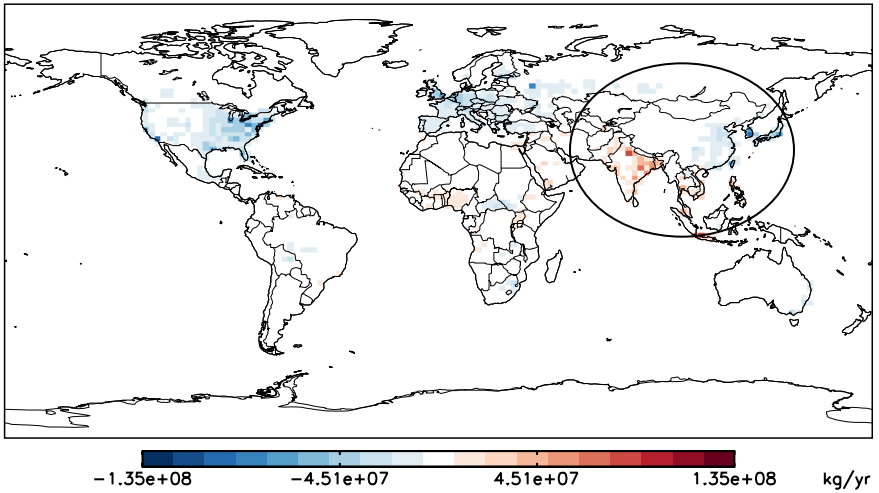
Cross-species impacts on aerosol DRF

NO_x emissions: 2050 - 2000

RCP 6.0



RCP 2.6



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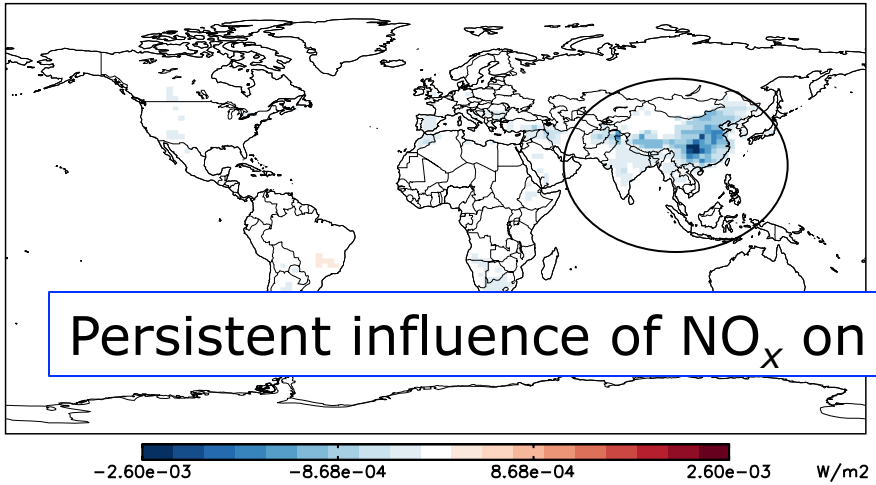

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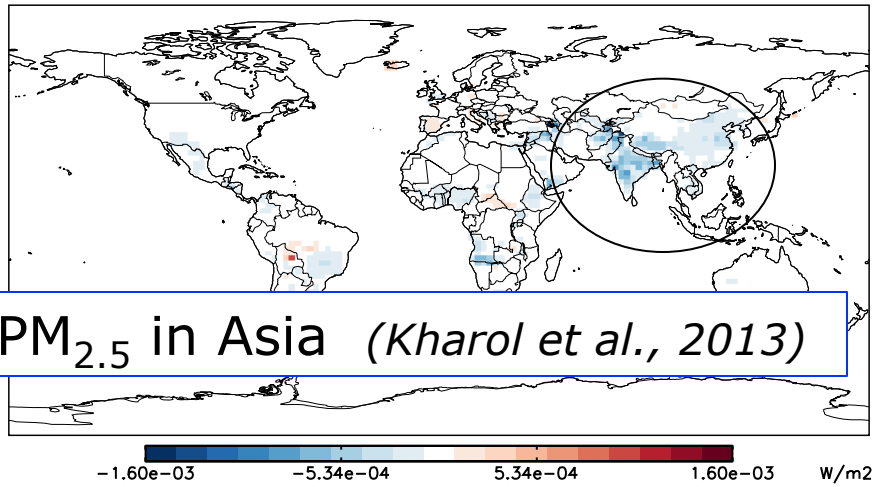
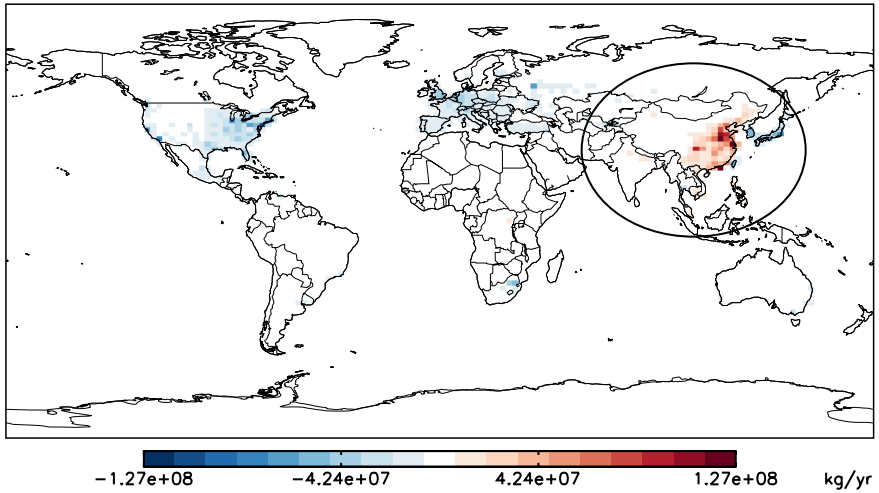


Persistent influence of NO_x on $PM_{2.5}$ in Asia *(Kharol et al., 2013)*

Cross-species impacts on aerosol DRF

NO_x emissions: 2050 - 2000

RCP 6.0



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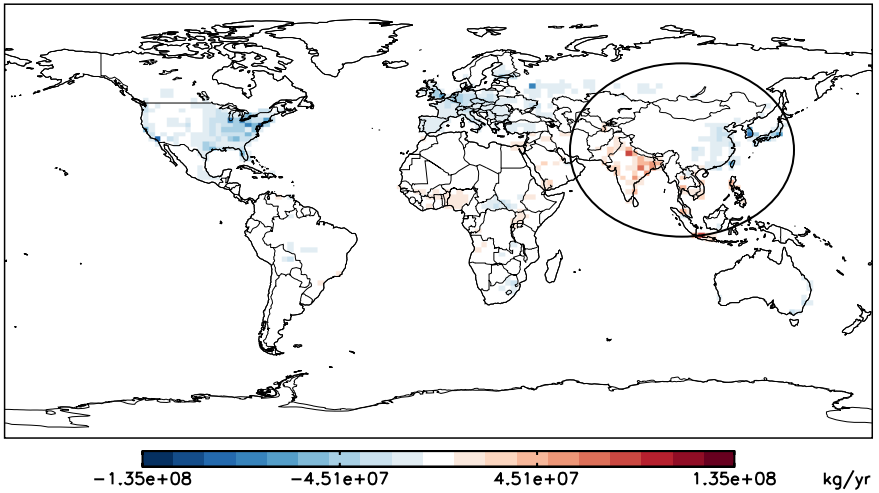

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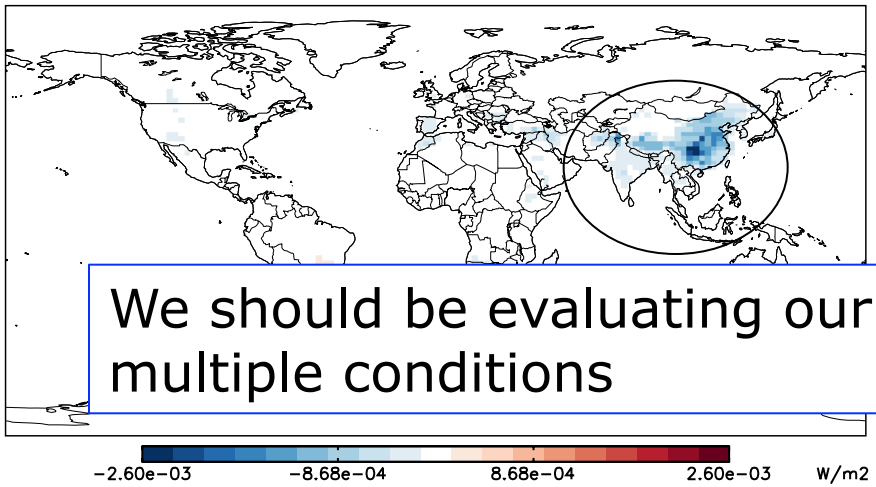
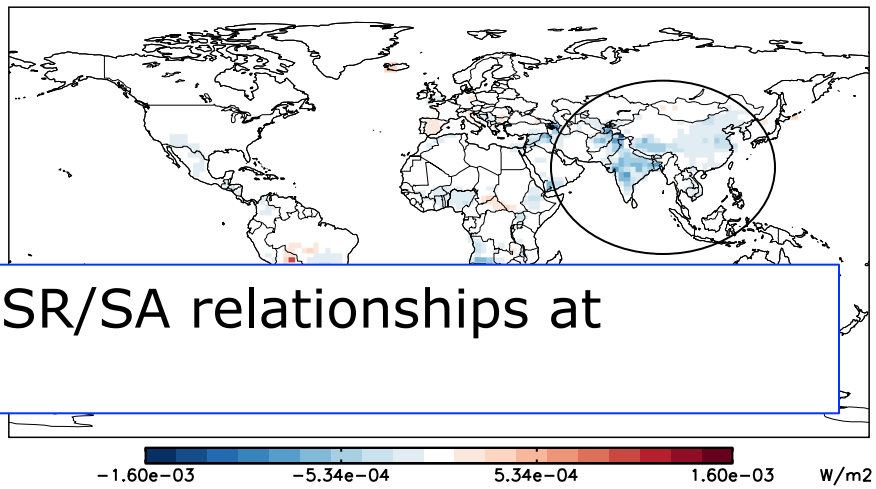


$(dRF/dE)_{2.6} * \Delta E$



We should be evaluating our SR/SA relationships at multiple conditions

HTAP 2.6: Comparison of SR and SA methods

Explore differences across models for a single SR approach
- need (new?) unifying normalized metrics
- incorporate observations to correct for bias?

Explore differences across SR approaches
- interpretation
- implementation (e.g., global <-> regional)

Additional considerations
- response-per emissions basis; need emissions harmonization?
- cross-sensitivities (space, species)
- validation experiments

Strategy
- target a few response metrics, response regions, future scenarios
- work from overlap with CCAC / NASA AQAST activities
- address issues listed above in detail for limited/targeted cases