Recent use of AIRS data in ozone, aerosol and weather modeling studies

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Acknowledgements to:

Aqua, Aura, SMAP and field campaign science teams

HTAP2 and NOAA chemical transport modeling groups

NASA Aura, NCA indicator and SUSMAP funding

Today's focus: "boundary" related questions

Three ongoing/recent projects relevant to AIRS and other satellites, addressing trans-boundary air pollution or/and surface boundary impacts on the atmosphere:

c. Assimilating SMAP to LIS/NUWRF in support of airborne campaigns

SMAP Soil Moisture Active Passive

NASA Land Information System LIS

NU-WRF
NASA-Unified Weather Research and Forecasting

a. Multi-scale multi-model study of hemispheric air pollution transport (started at JPL)

LRTAP Long-range Transboundary Air Pollution

Task Force on Hemispheric Transport of Air Pollution

Year 2012 *2015* *2016*

b. Dust indicators for future national climate assessment

Task Force on Hemispheric Transport of Air Pollution

LRTAP
Long-range Transboundary Air Pollution

- **An international scientific cooperative effort to improve the understanding of the intercontinental transport of air pollution across the northern hemisphere**
- **Quantify pollution changes in one region as anthropogenic emissions change (e.g., -20%) in other regions**

HTAP Phase 1 studies (prior to 2010):

- Studied year of 2001
- Rough source & receptor region definitions
- Reported multi-global model monthly mean results
- Models evaluated by surface observations

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Multimodel estimates of intercontinental source-receptor relationships for ozone pollution

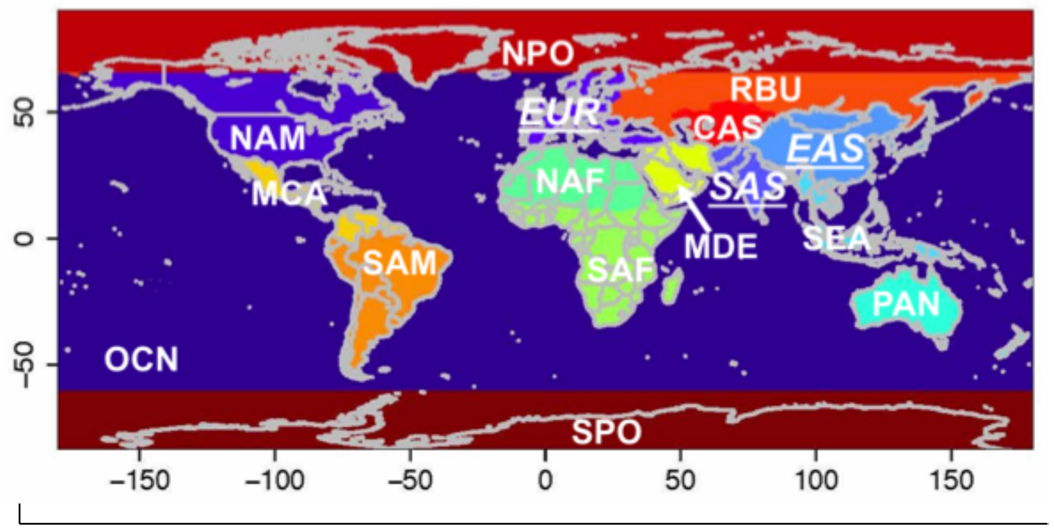
A. M. Fiore,[1] F. J. Dentener,[2] O. Wild,[3] C. Cuvelier,[2] M. G. Schultz,[4] P. Hess,[5] C. Textor,[6,7] M. Schulz,[7] R. M. Doherty,[8] L. W. Horowitz,[1] I. A. MacKenzie,[8] M. G. Sanderson,[9] D. T. Shindell,[10] D. S. Stevenson,[8] S. Szopa,[7] R. Van Dingenen,[2] G. Zeng,[11,12] C. Atherton,[13,14] D. Bergmann,[13] I. Bey,[15] G. Carmichael,[16] W. J. Collins,[9] B. N. Duncan,[17] G. Faluvegi,[10] G. Folberth,[15,18] M. Gauss,[19] S. Gong,[20] D. Hauglustaine,[7,21] T. Holloway,[22] I. S. A. Isaksen,[19] D. J. Jacob,[23] J. E. Jonson,[24] J. W. Kaminski,[25] T. J. Keating,[26] A. Lupu,[25] E. Marmer,[2] V. Montanaro,[27] R. J. Park,[23,28] G. Pitari,[27] K. J. Pringle,[9,29] J. A. Pyle,[11] S. Schroeder,[4] M. G. Vivanco,[30] P. Wind,[24] G. Wojcik,[31] S. Wu,[23,32] and A. Zuber[33]

LRTAP
Long-range Transboundary Air Pollution

Task Force on Hemispheric Transport of Air Pollution

HTAP Phase 2 studies (2012-now):

- Studying year of 2008-2010
- Source & receptor regions redefined by geographical boundaries
- Also involving regional model analysis on event-scale
- Using diverse, three dimensional observations (ground, satellite, sonde…) to evaluate and interpret model results



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Volume 17, issue 9

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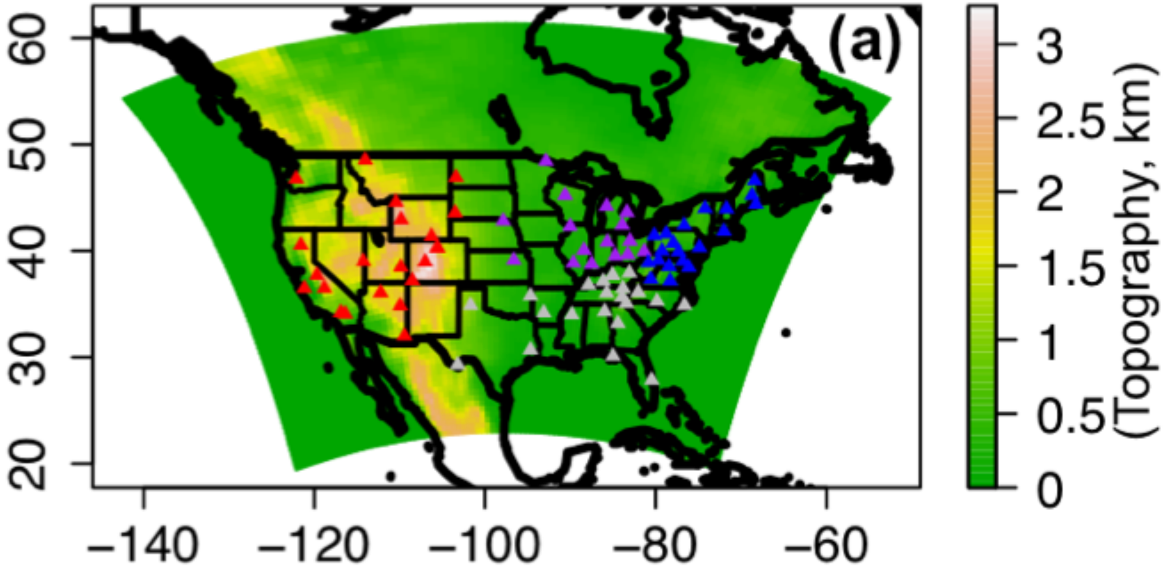
Research article 08 May 2017

Impact of intercontinental pollution transport on North American ozone air pollution: an HTAP phase 2 multi-model study

Min Huang[1,2], Gregory R. Carmichael[3], R. Bradley Pierce[4], Duseong S. Jo[5], Rokjin J. Park[5], Johannes Flemming[6], Louisa K. Emmons[7], Kevin W. Bowman[8], Daven K. Henze[9], Yanko Davila[9], Kengo Sudo[10], Jan Eiof Jonson[11], Marianne Tronstad Lund[12], Greet Janssens-Maenhout[13], Frank J. Dentener[13], Terry J. Keating[14], Hilke Oetjen[8,a], and Vivienne H. Payne[8]

Simulations for HTAP2

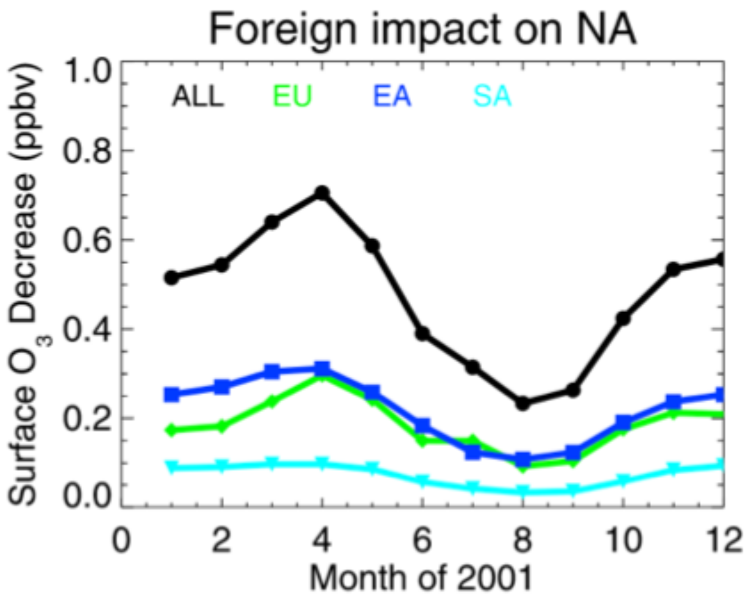
- Eight global models performed base and sensitivity runs in which anthropogenic emissions in selected source regions were reduced by 20%
- Regional STEM simulations performed over North America in May-June 2010, with chemical boundary conditions from three global models (SNU GEOS-Chem; ECMWF C-IFS; NOAA RAQMS) base and sensitivity runs



- All models evaluated with ground observations for the entire simulation period
- Satellite data (TES, OMI, MLS, AIRS, IASI) used for analyzing polluted events/improving one boundary condition model RAQMS

Foreign impacts on North America (NA) ozone

Fiore et al., 2009: HTAP1

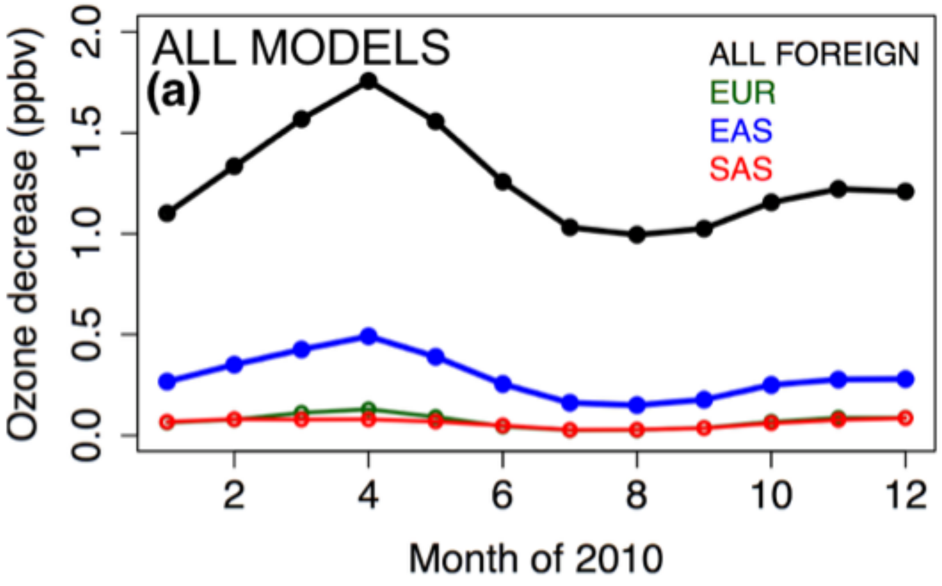


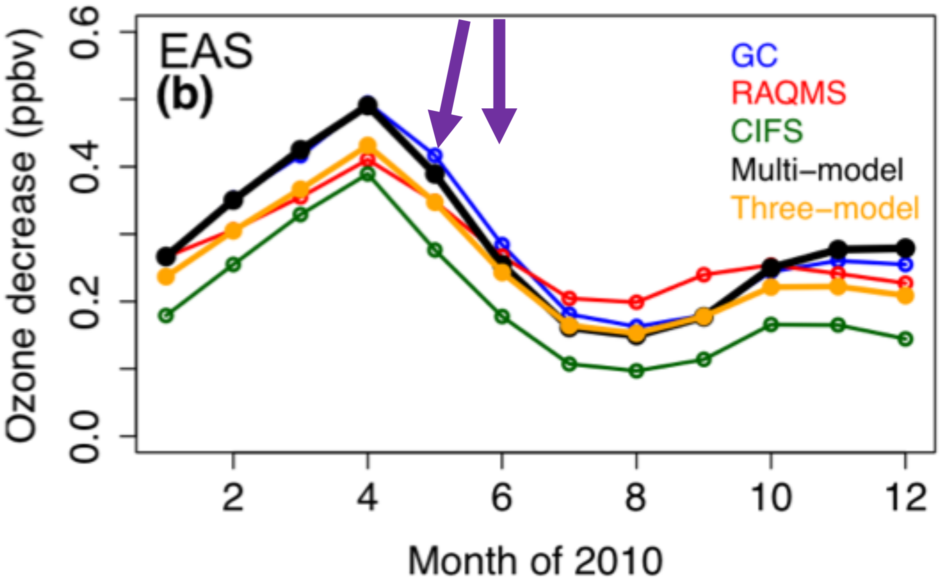
HTAP2 NA ozone sensitivities compared with HTAP1:

- Similar seasonality
- >50% larger sensitivities to total non-NA emissions
- 2-3 times smaller sensitivities to European (EUR) emissions

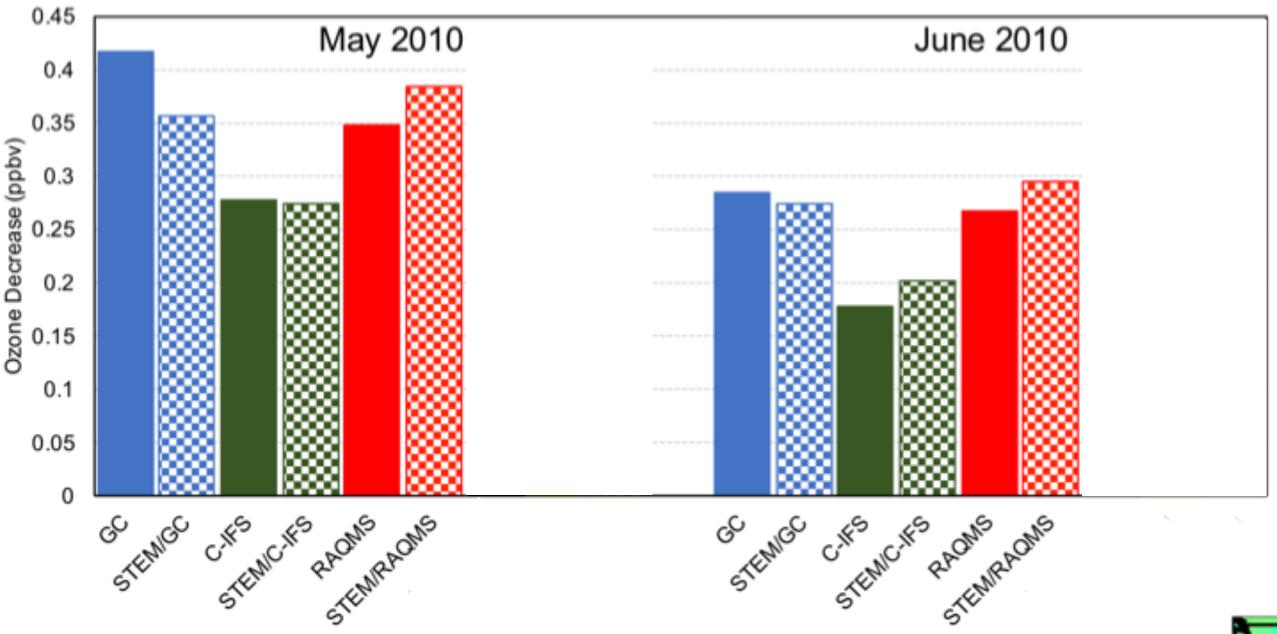
Notable intermodel differences

Huang et al., 2017: HTAP2



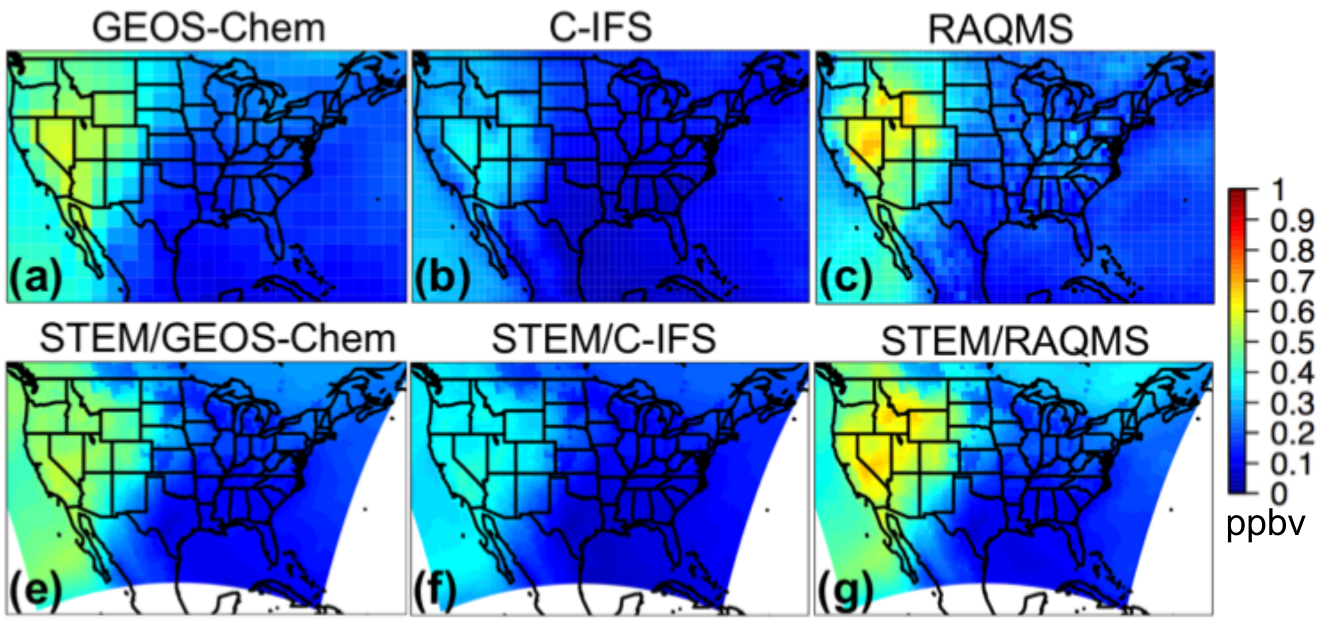


East Asian emission impact on NA monthly mean ozone

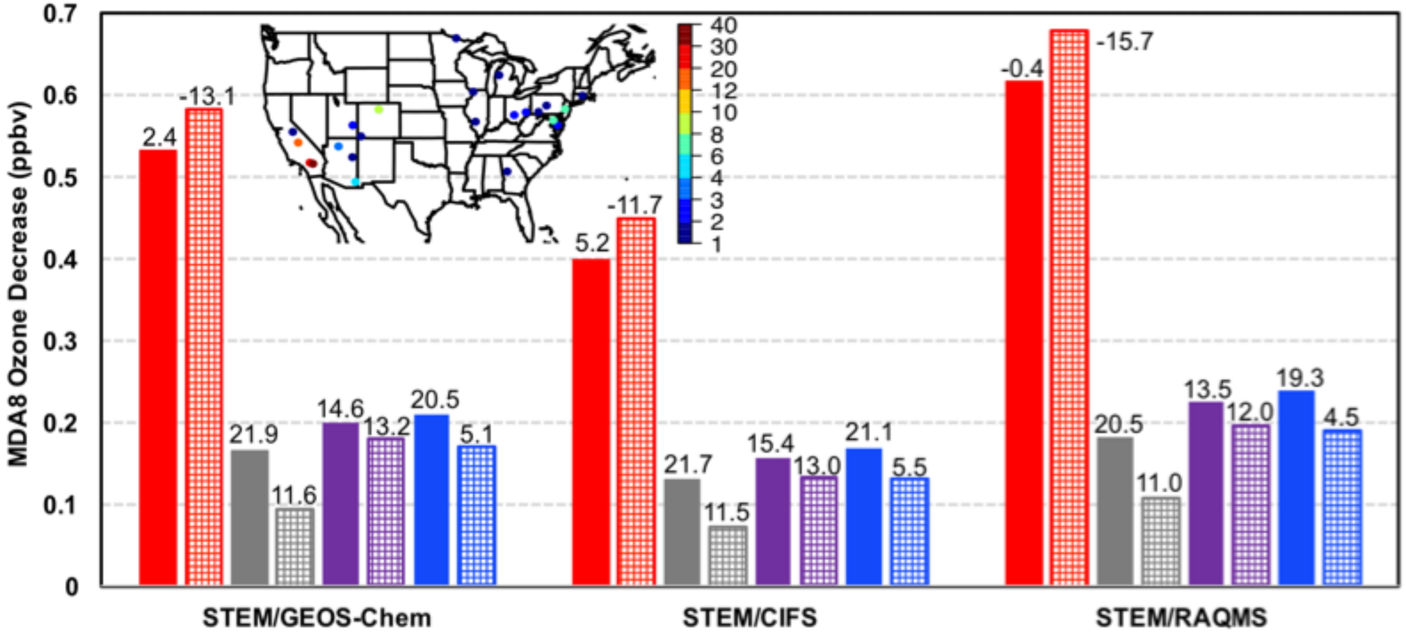


Similar spatial patterns and domain wide mean values between STEM sensitivities and its corresponding boundary condition model's (domain wide mean differences <10%)

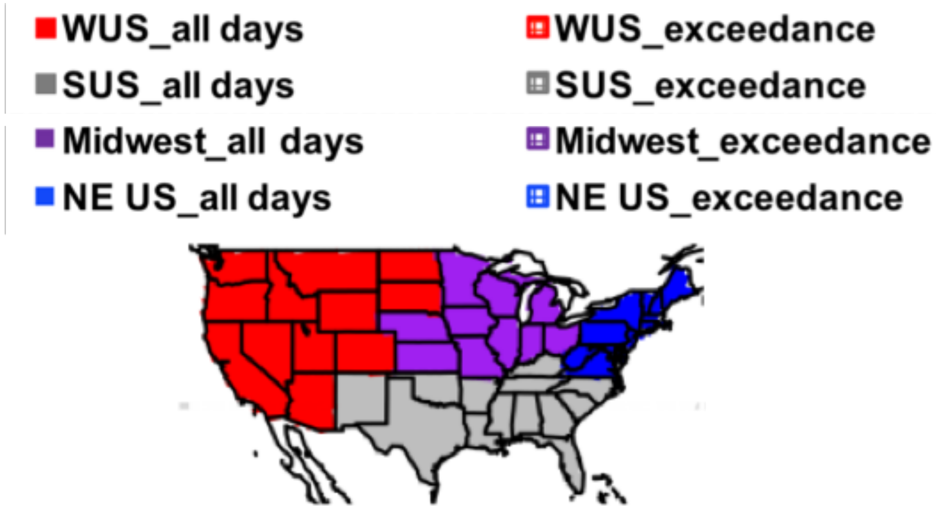
- GEOS-Chem and RAQMS gave close domain-mean values, but the latter shows sharper spatial gradients
- C-IFS related sensitivities are the lowest

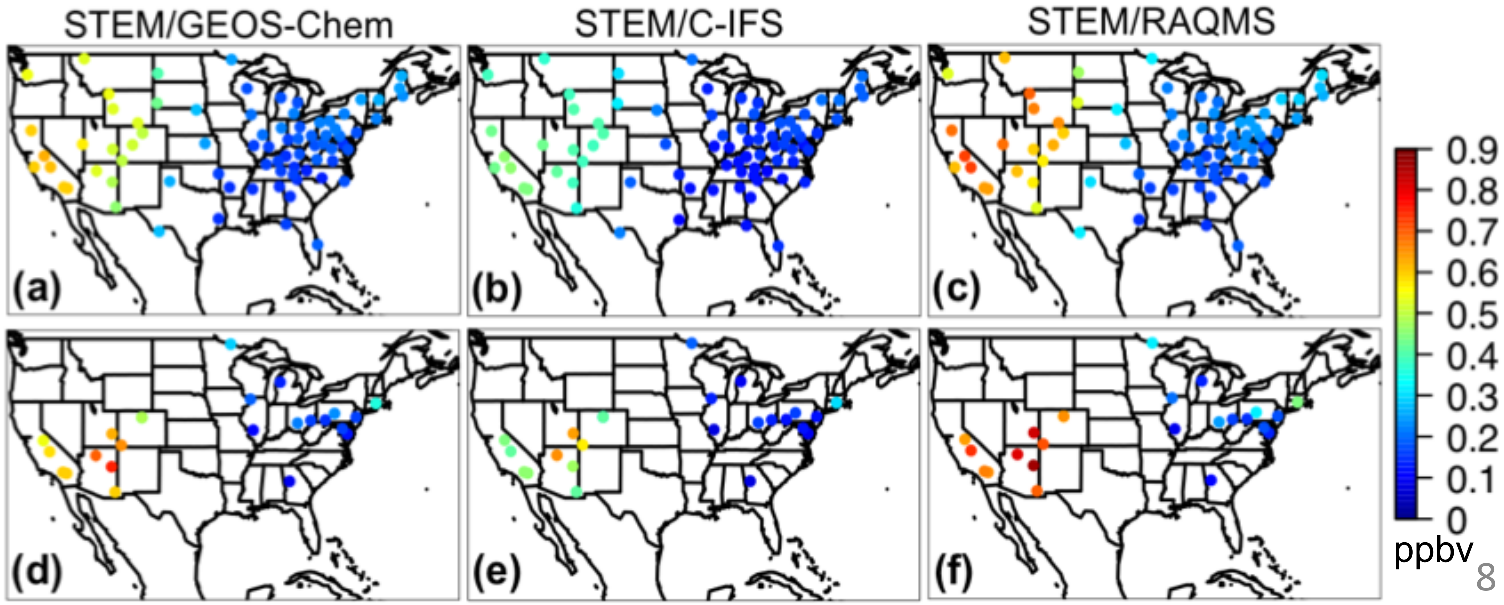


E Asian emission impact on NA MDA8 exceedances



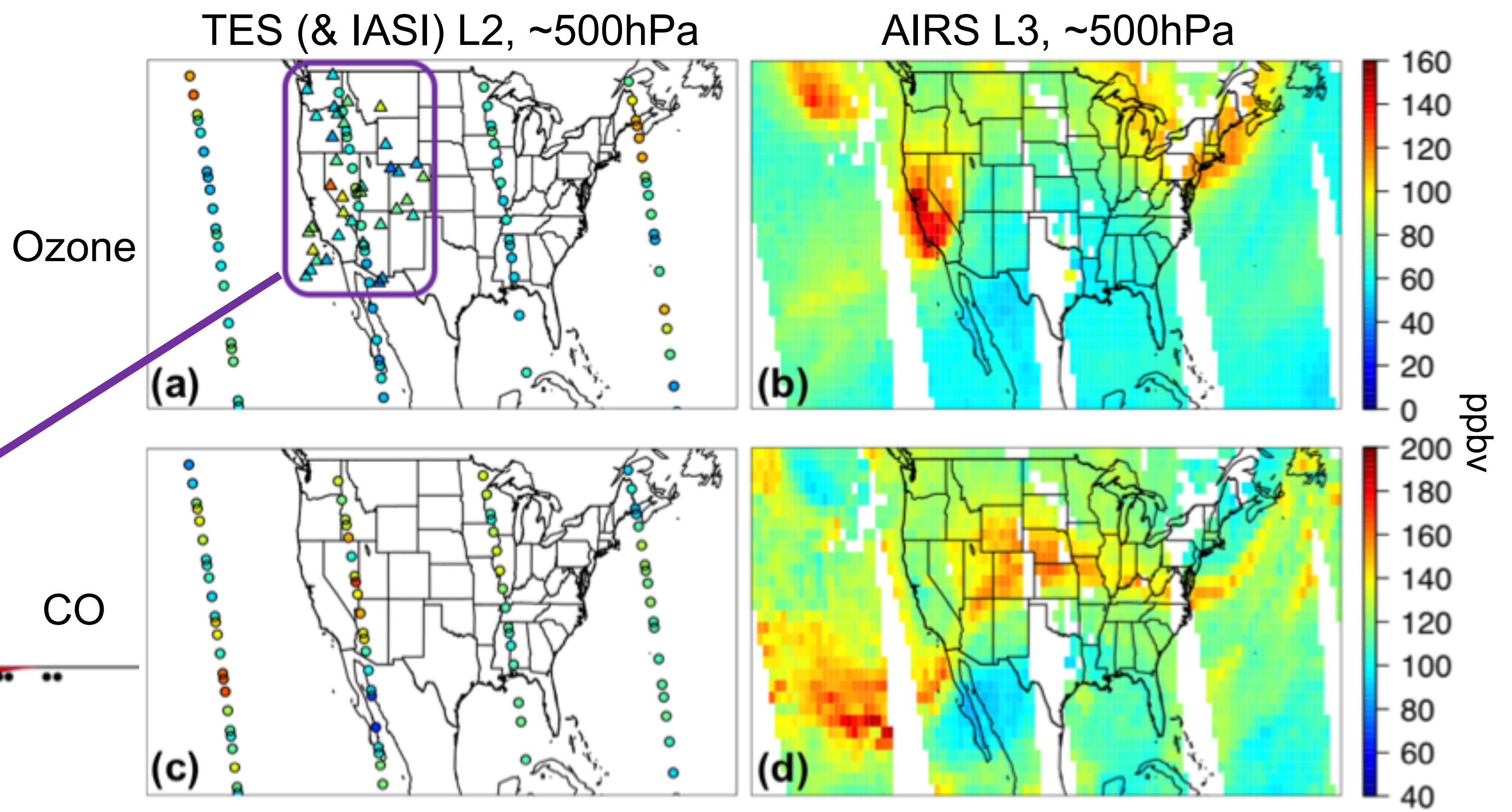
- Non-western US: sensitivity 0.02–0.07 ppbv smaller during high total ozone days than for all days
- Western US: sensitivity 0.05 ppbv higher on high total ozone days than for all days; these differences are larger in rural and remote areas where local influences are less dominant

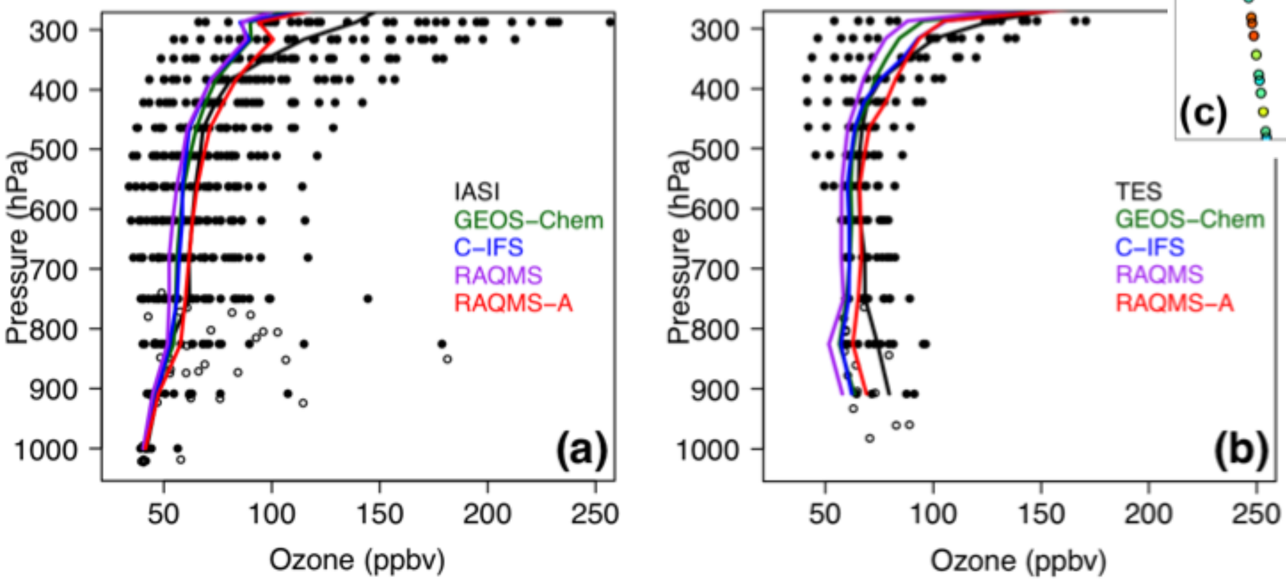




Spring ozone exceedance event study: May 9

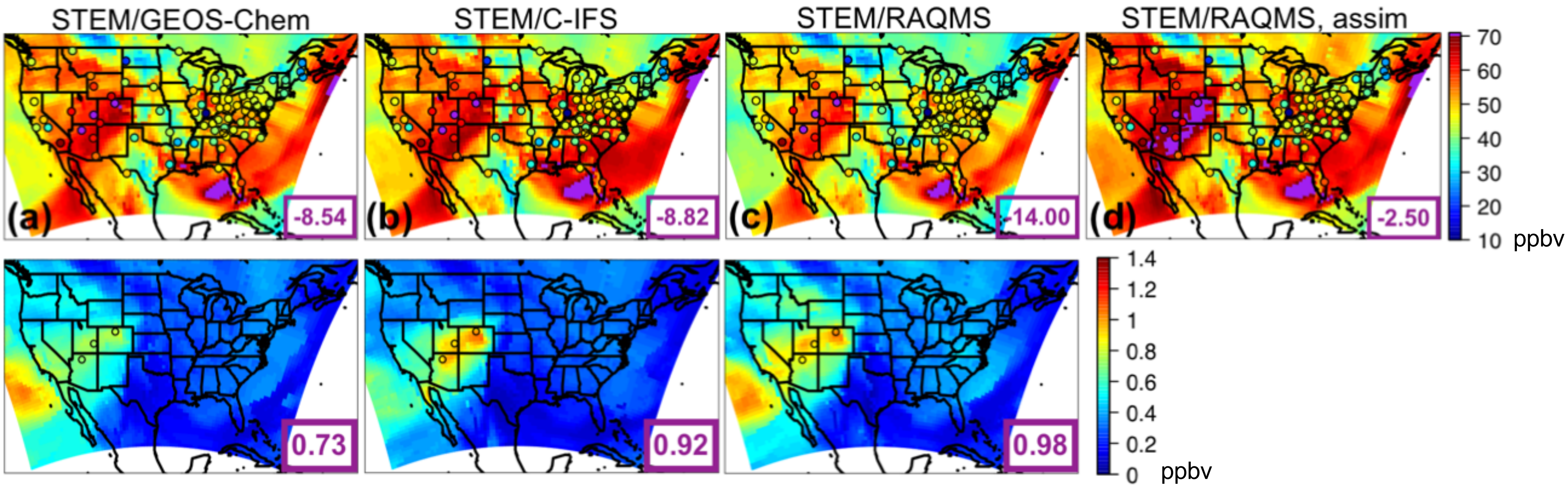
AIRS data helped locate stratospheric ozone intrusion in W and NE US and LRT pollution through SW US





TES and IASI data, retrieved using the same algorithm, indicated underpredicted free tropospheric ozone (by >10 ppbv) in all free running simulations, which can be improved by satellite (OMI+MLS ozone) assimilation

Spring ozone exceedance event study: May 9



- Underprediction in free tropospheric ozone led to 9-14 ppbv negative biases at sites experiencing ozone exceedances, which would be effectively reduced by using OMI+MLS constrained boundary conditions
- Stratospheric ozone intrusion impact on NE US did not enhance surface ozone
- At least 0.2 ppbv intermodel differences of E Asian impact at ozone exceedances sites

Atmospheric dust and its impacts

Ecosystems
- Neutralizes acid rain
- Interacts with terrestrial and ocean ecosystems

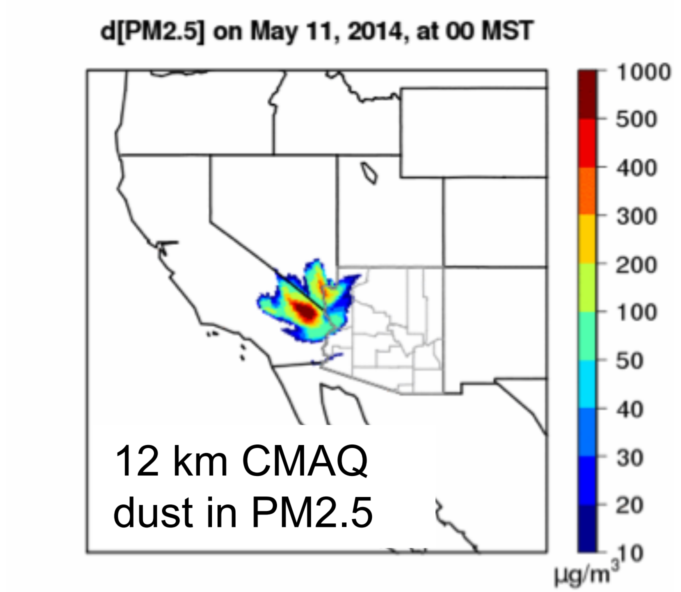
Chemistry
Alter the chemical balance of the atmosphere through surface adsorption and reaction

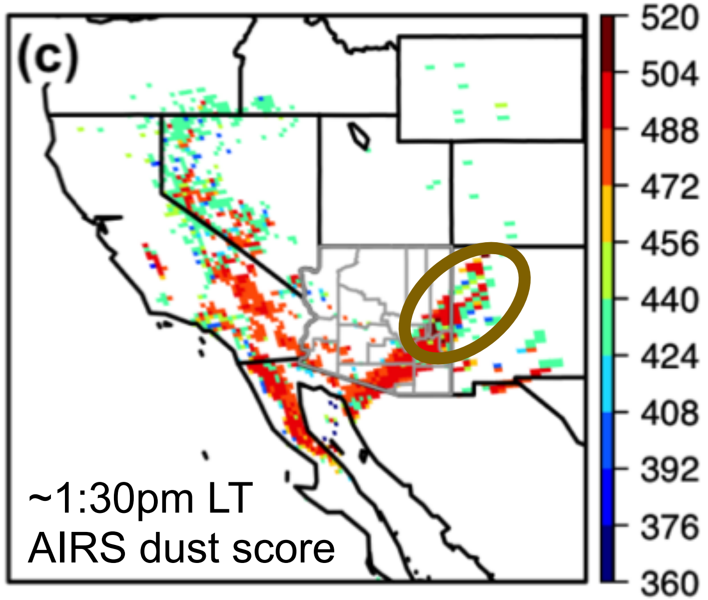
Human life
- May be associated with certain human diseases such as "valley fever"
- Degrades visibility and prevents normal outdoor activities and transportation

Climate
- Absorbs sunlight
- Reduces the planetary albedo over bright surfaces
- Deposition on snow/ice & accelerate their melting
- Modifies monsoon
- …

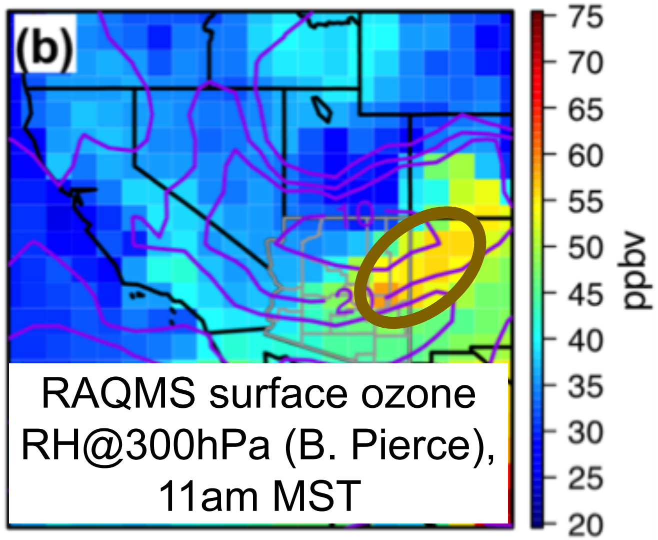
Goudie, 2013; Panikkath et al., 2013; Carslaw et al., 2010; Brahney et al., 2013; Zhao et al., 2012; Grassian, 2001; Usher et al., 2003

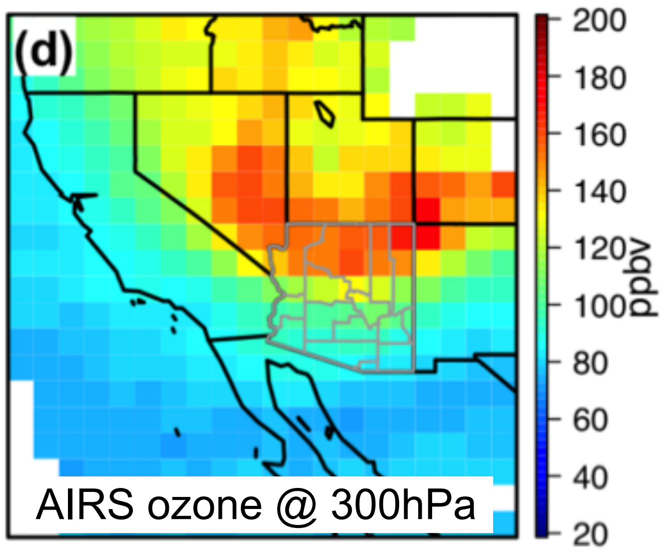
A dust & stratospheric ozone intrusion event (May 11, 2014)

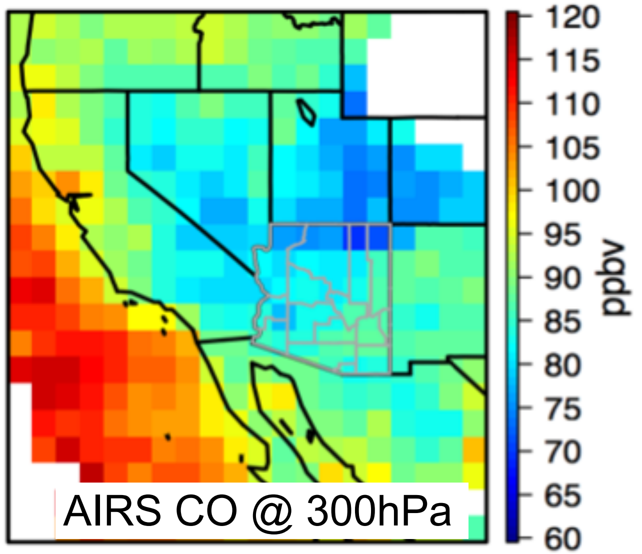




- AIRS dust score indicates the high dust/PM2.5 areas
- Descending dry air containing rich ozone enhanced surface ozone in E Arizona & New Mexico, which also enhanced horizontal winds and dust emissions at the same areas.







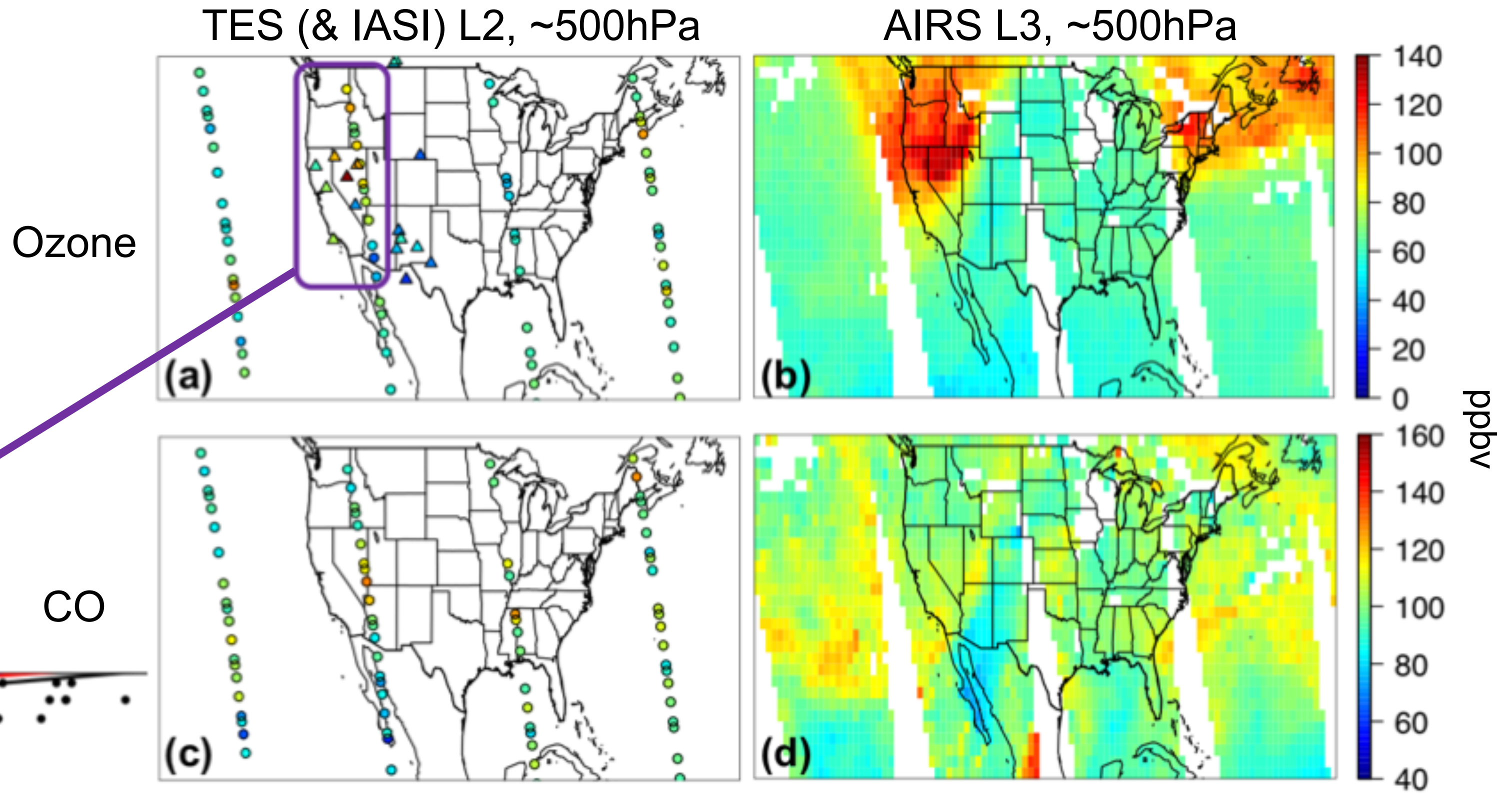
Ongoing analysis during the KORUS-AQ period

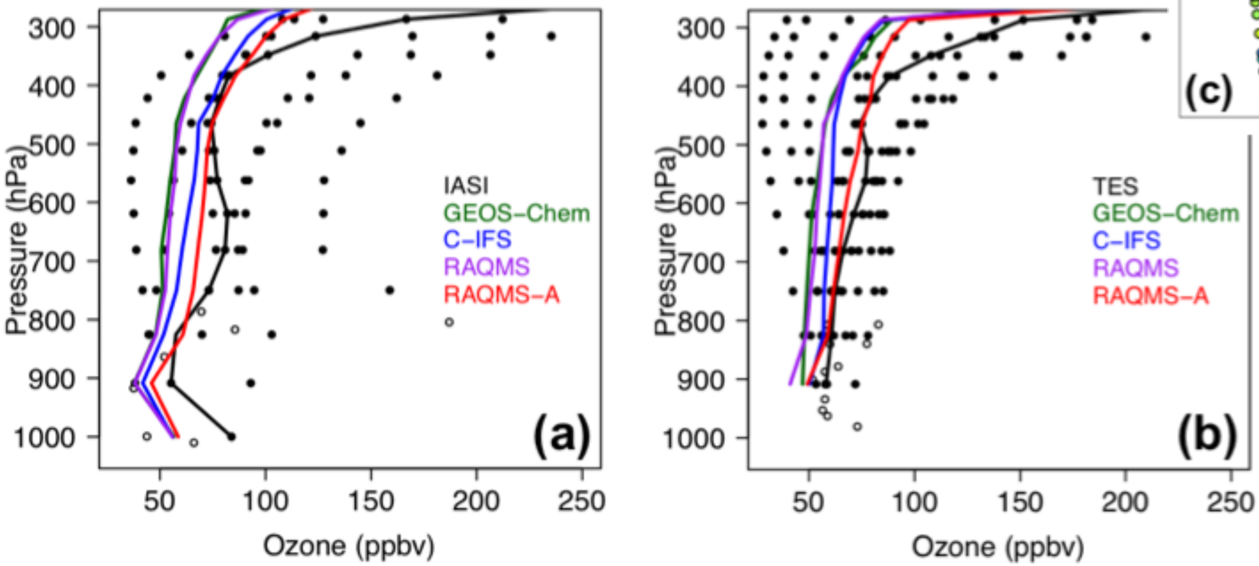
- Assimilating SMAP soil moisture to improve weather modeling
- Connecting weather and air quality over E Asia
- Potential future use of CrIS CO, OMI/AIRS ozone, and AIRS atmospheric physics products. Open to collaborations

Thank you and questions?

Summer ozone exceedance event study: June 10

AIRS data helped locate stratospheric intrusion in NW US and LRT pollution through SW US





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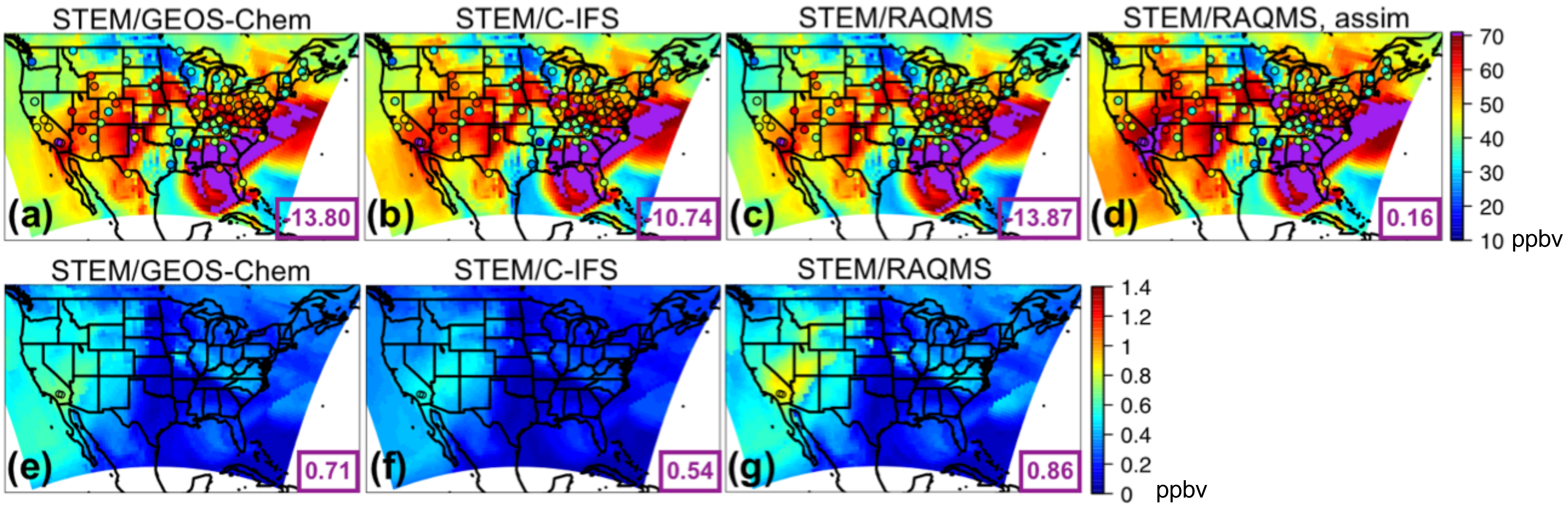
Summer ozone exceedance event study: June 10



- Underprediction in free tropospheric ozone led to >10 ppbv negative biases at sites experiencing ozone exceedances, which would be effectively reduced by using OMI+MLS constrained boundary conditions
- At least 0.15 ppbv intermodel differences of E Asian impact at ozone exceedances sites
- E Asian impacts were weaker than during the spring event