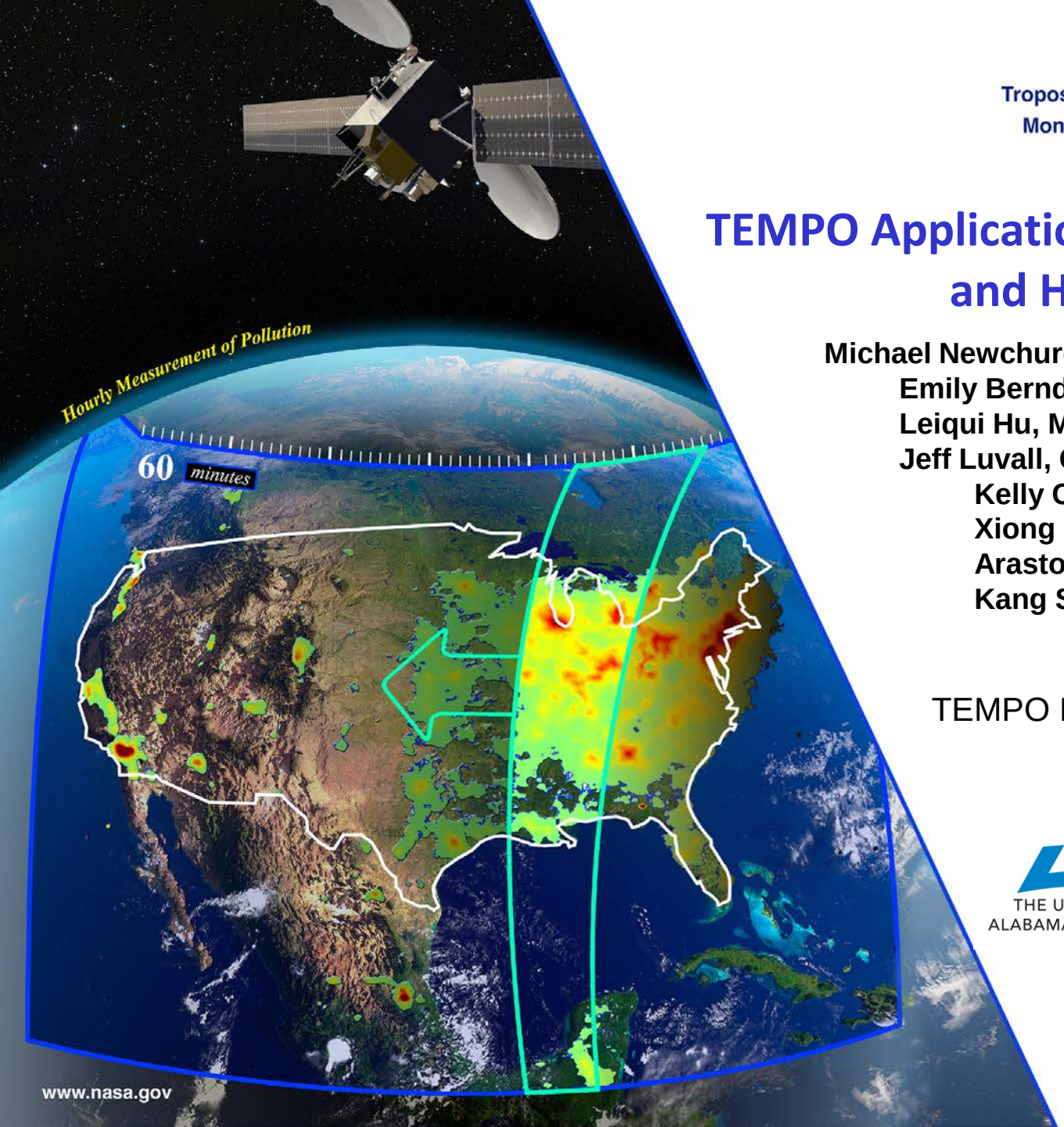

Tropospheric Emissions:
Monitoring of Pollution

TEMPO

TEMPO Applications to Air-Quality and Health

Michael Newchurch, Aaron Naeger, Emily Berndt, Susan Alexander, Leiqui Hu, Matthew Johnson, Jeff Luvall, Christopher Miller, Kelly Chance, Arlindo da Silva, Xiong Liu, Tom Moore, Arastoo Pour-Biazar, Kang Sun, Bradley Zavodsky

April 10, 2018

TEMPO Early Adopters Workshop

Fort Collins, CO

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

SPORT

Smithsonian

NASA

Presentation Outline

1. TEMPO instrument capabilities
2. Develop Simulated GEO AQ Products
    a. GEOS-Chem source of synthetic data
    b. Incorporate instrument uncertainties into synthetic observations
3. Utility of TEMPO data for public health community
4. Efficacy of TEMPO data for substantiating exceptional events
5. Prepare user community for TEMPO data

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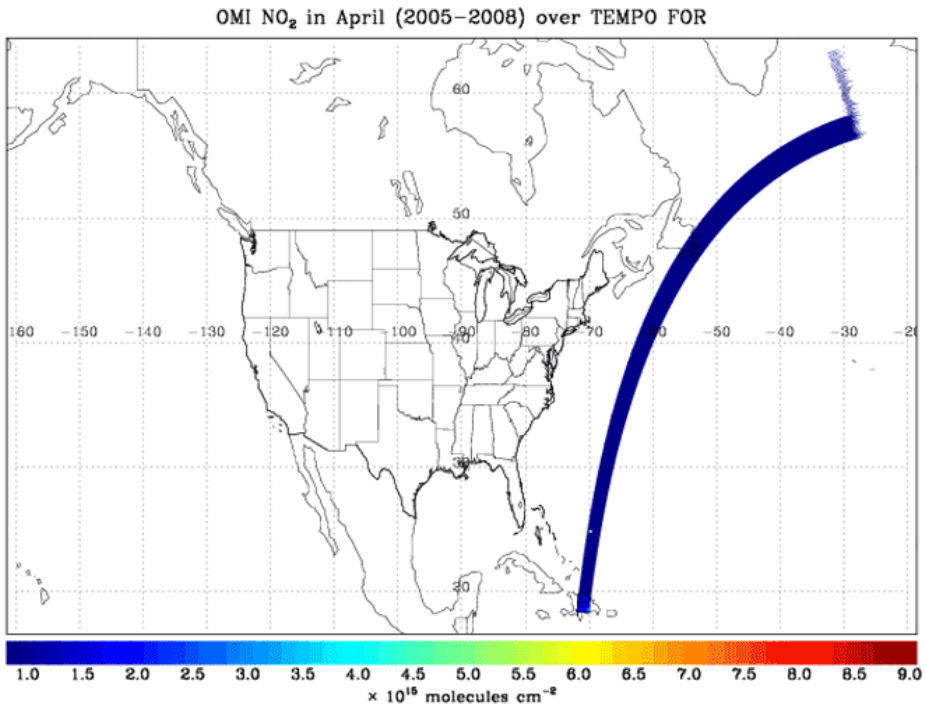
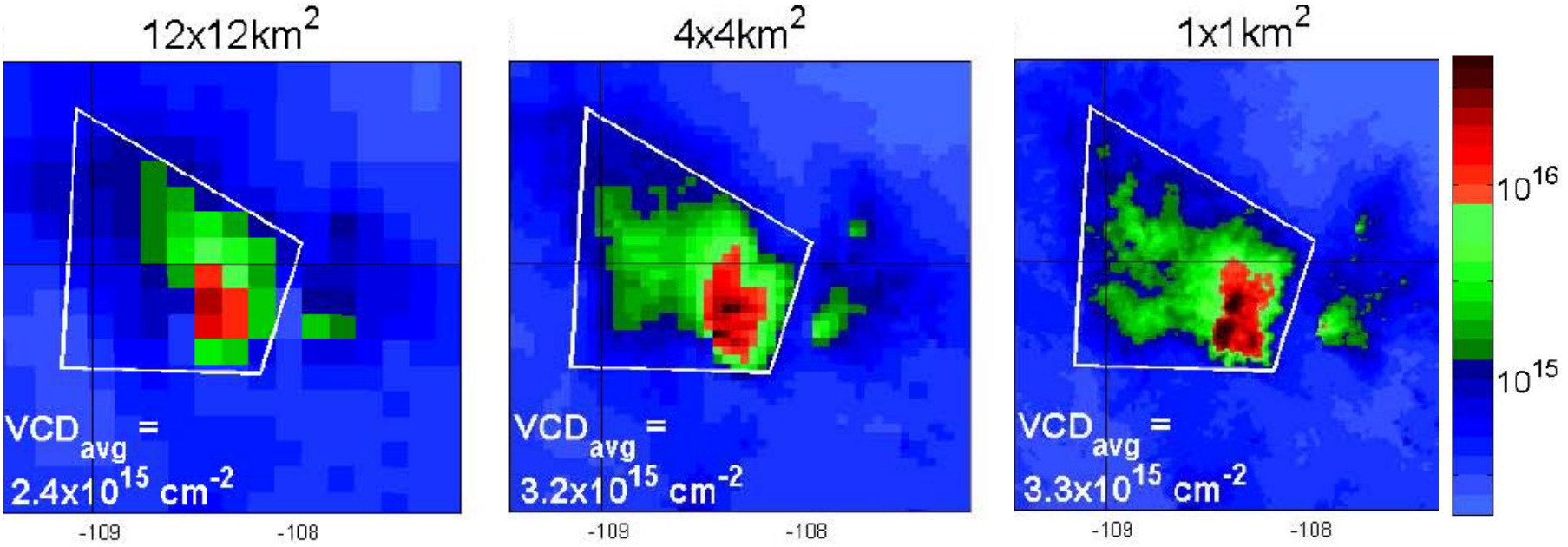
TEMPO measurements

- Hourly daylight measurements from TEMPO will effectively monitor the air quality conditions over North America
- Monitoring will be accomplished at sub-urban scales due to spatial resolution of 2.1 x 4.7 km
- Multi-spectral capabilities (ultraviolet & visible channels) will help distinguish between BL, free tropospheric, and stratospheric O_3



OMI vs TEMPO resolution

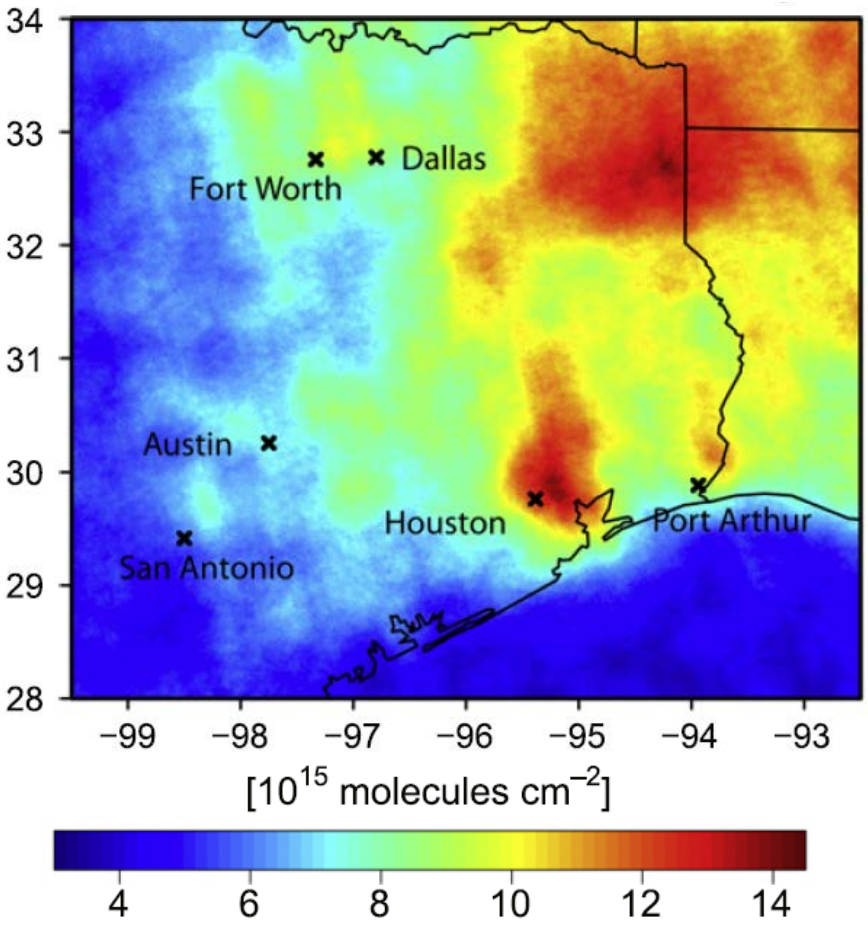


- Current spatial resolution of satellite sensors are too coarse for resolving emission source regions
- TEMPO's high spatial resolution will lead to a drastic improvement in monitoring emission source regions

Valin et al. (*ACP*, 2011)

OMI vs TEMPO resolution

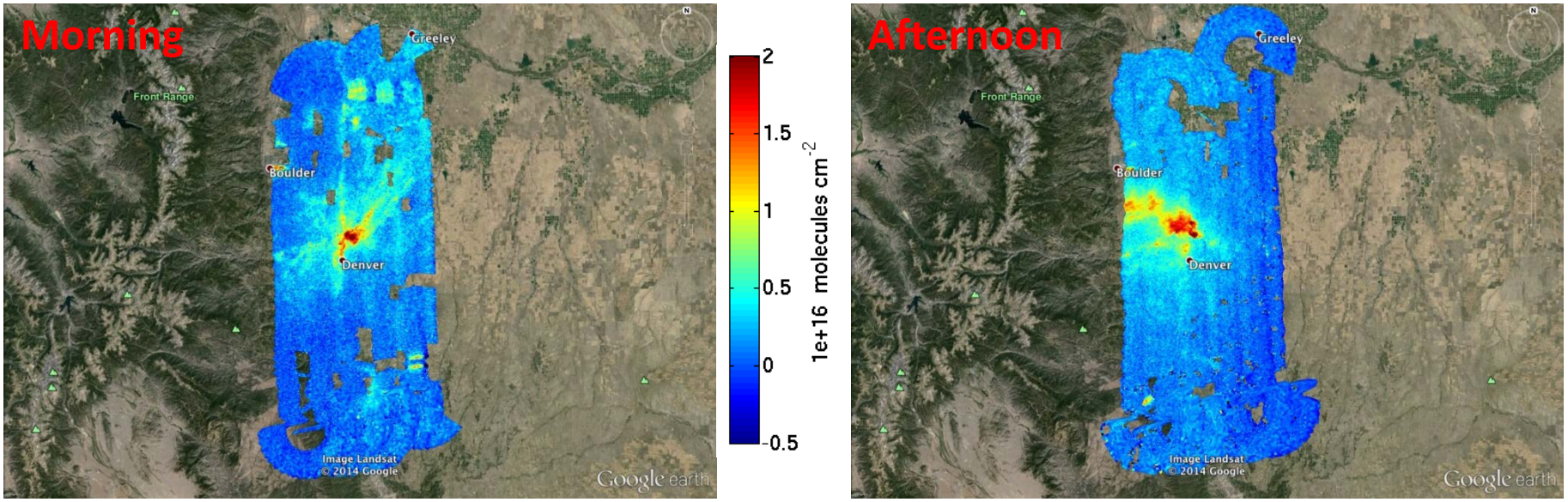
OMI H_2CO columns oversampled to 0.02° resolution



- TEMPO's high spatial resolution will allow it to resolve emission sources, including urban areas
- TEMPO will provide constraints on inventory emission magnitudes, spatial allocation, and possibly even sector partitioning

Zhu et al. (*Environ. Res. Lett.*, 2014)

TEMPO Aircraft-simulator data



GeoTASO data (Credit: Caroline Nowlan, SAO)

- Quality of TEMPO data will be similar to GeoTASO, albeit with lower spatial resolution than the 250 x 250 m^2 pixel size of GeoTASO
- NO_2 slant columns from TEMPO data will be able to monitor the rapidly varying emissions from source regions across North America

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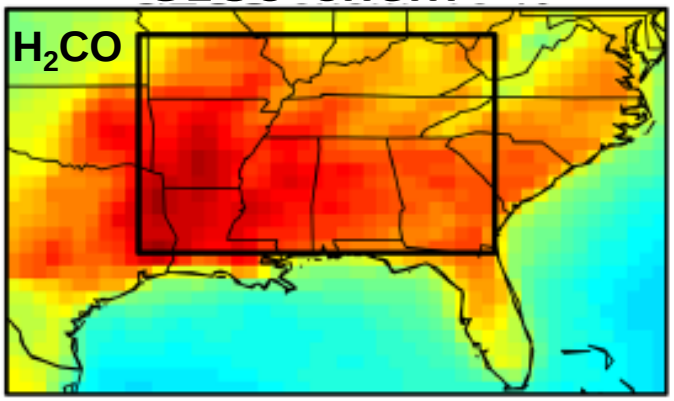
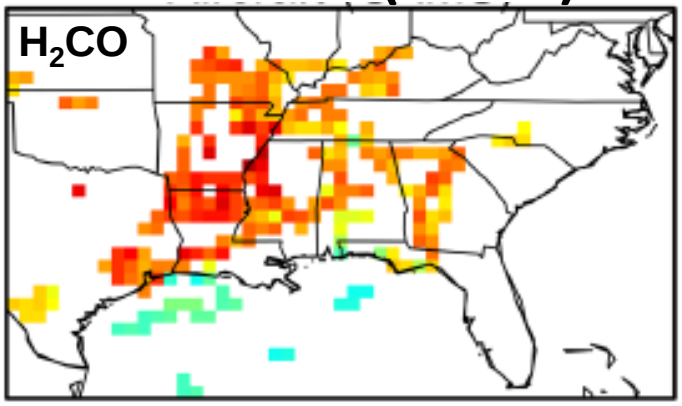
GEOS-Chem source data

- Synthetic TEMPO observations generated using simulated gaseous and aerosol composition from GEOS-NR
- GEOS-NR spatial resolution of ~12 x 12 km^2 spatiotemporally interpolated to finer TEMPO grid
- Profiles and vertical column amounts of species obtained from interpolation

GEOS-Chem



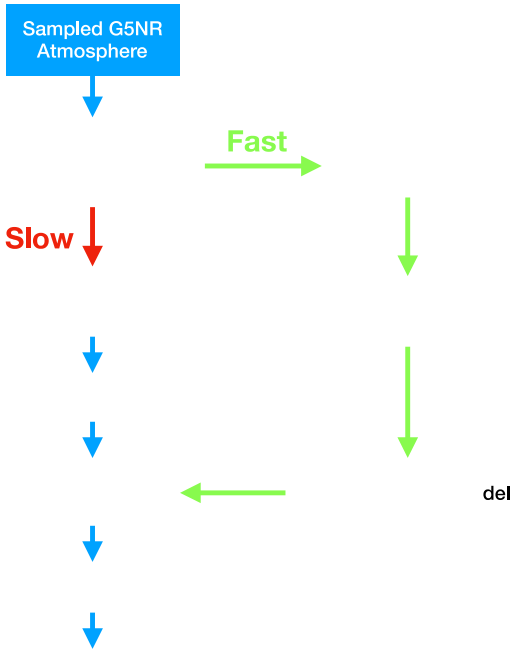
Aircraft (CAMS)



Zhu et al. (*ACP*, 2016)

Generating synthetic observations

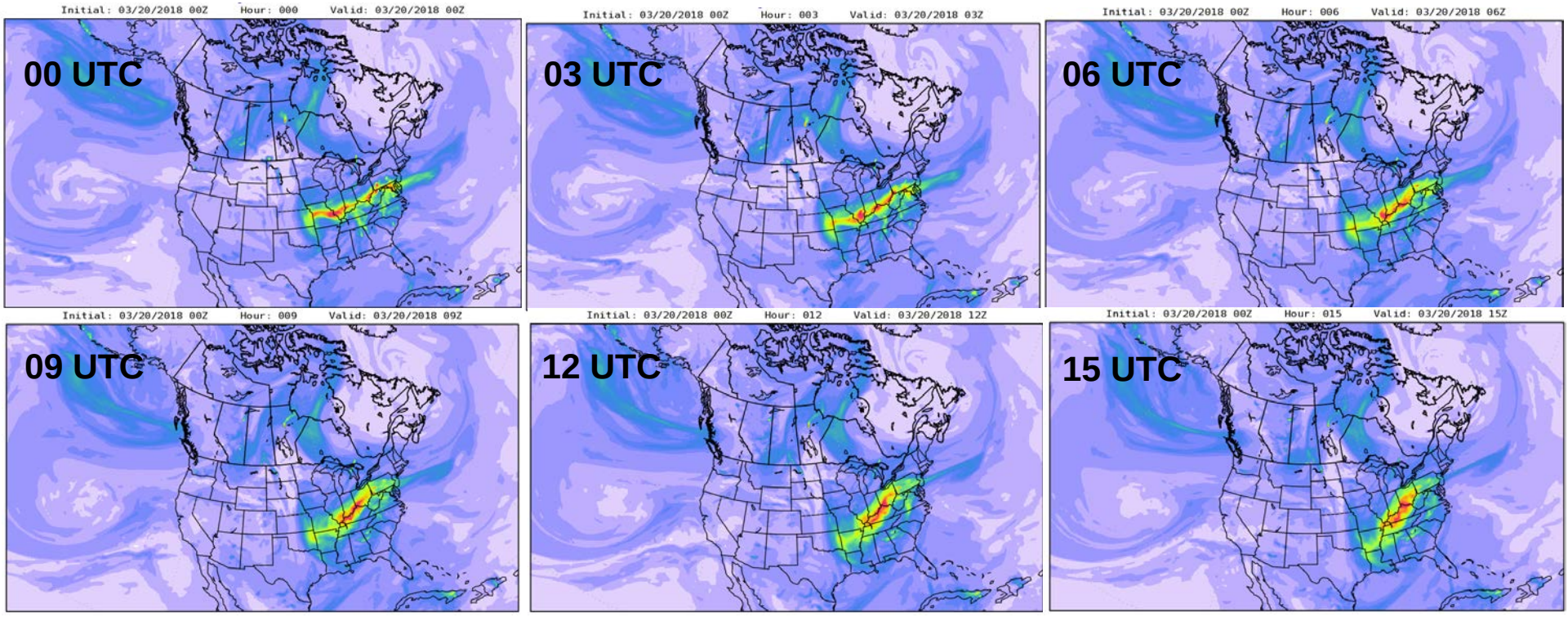
- TEMPO will produce ~2.6 million spectra per hour
- OSSE approach for generating synthetic obs (blue path) much too time consuming
- Spectral fitting algorithm for column retrievals (green path) yields a slant column (SCD)
- SCD can be accurately calculated from GEOS-NR profiles via Air Mass Factors (AMFs), which avoids slow radiative transfer calculations
- Final product is complete synthetic TEMPO trace gas products, which is appropriate for technical applications, such as DA



Flowchart for generating synthetic TEMPO observations

See C. Miller/SAO talk

TEMPO synthetic observations



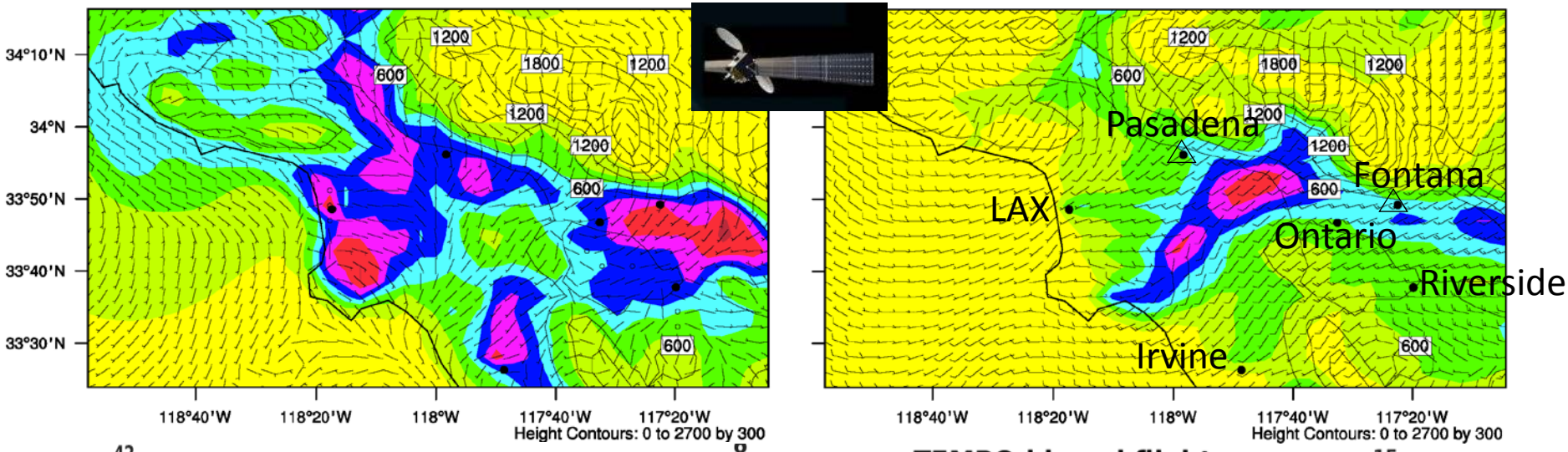
column SO_2 from GEOS-Chem model

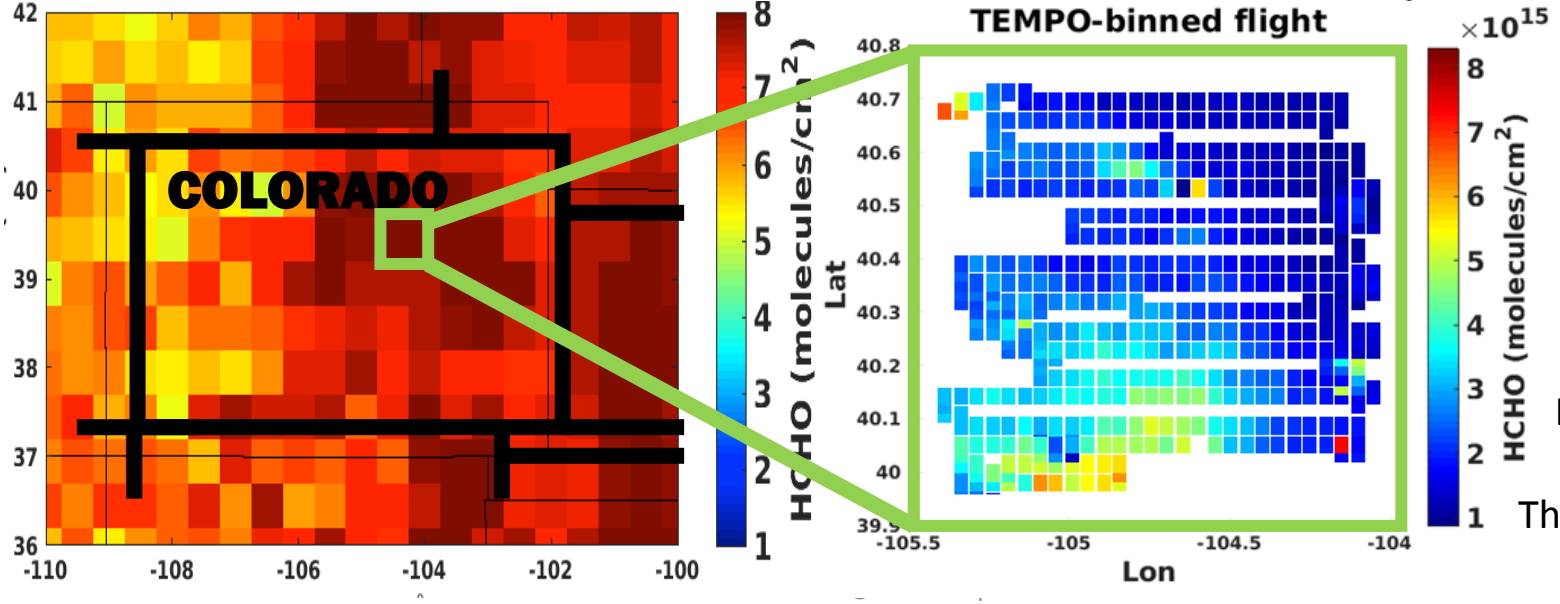
- TEMPO hourly observations will allow effective monitoring of following elements: tropospheric O_3, formaldehyde, NO_2, SO_2, glyoxal, H_2O, halogen oxides, aerosols, clouds, and ultraviolet-B radiation.

TEMPO synthetic observations

Si-Wan Kim et al.

NO_2 columns modeled at approximate TEMPO resolution





Frank Keutsch, Mitchell Thayer, et al.

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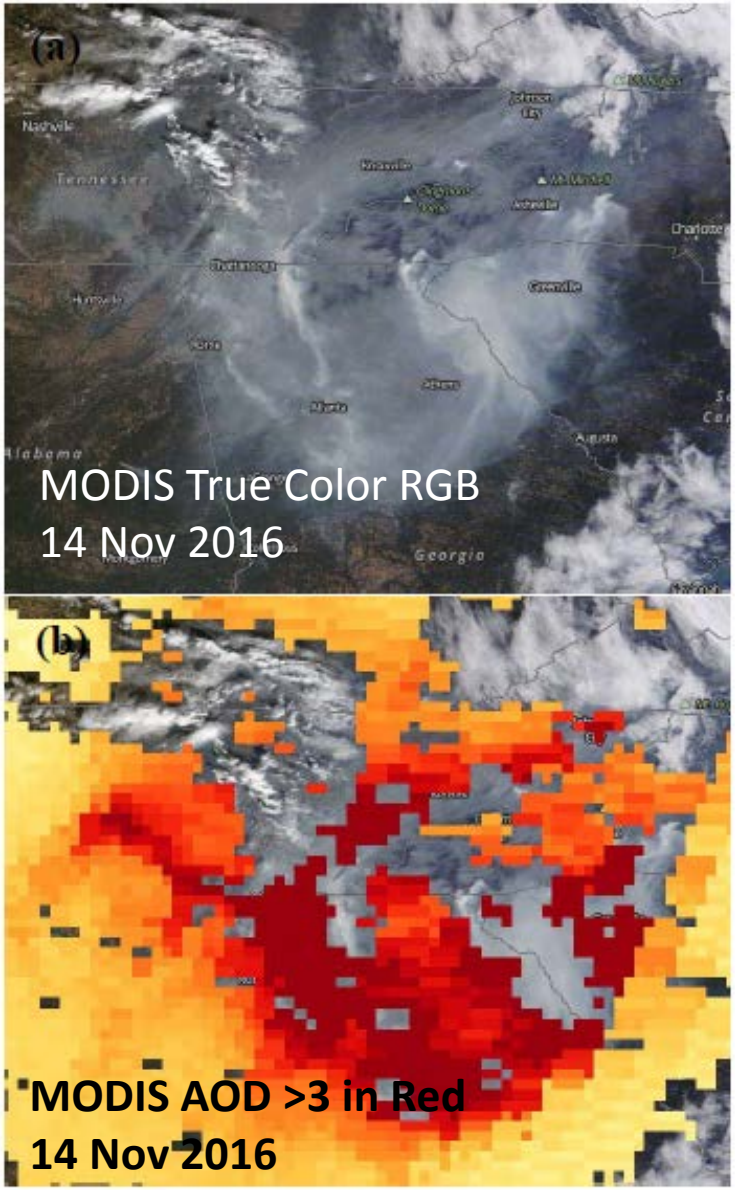
Rilot Project: Exceptional Event (Wildfires)

- How can TEMPO enhance monitoring the impact of exceptional events on air quality and human health?
- Focus on use of proxy data in partnership with the Chattanooga-Hamilton County Air Pollution Control Bureau
- TEMPO Advantage:
  - Accurate retrievals of AOD
  - Boundary layer trace gas concentrations
  - Better temporal/spatial resolution to document exceptional events
- End users provide feedback to researchers and prepare to integrate TEMPO data in daily operations quickly after launch



Pilot Project: Exceptional Event (Intermountain West)

- How can TEMPO be used to identify exceptional events caused by wildfires or stratospheric intrusions in complex terrain?
  - Distinguish between transport and source events
  - Identify frequency of exceptional events
- Focus on complex terrain in collaboration with WESTAR and WARP
- Can incorporation of proxy data improve PM2.5 and O3 precursor emission estimates used in regional modeling analysis to support planning and decision making to protect both human health and visibility?
- Early testing of data processing infrastructure and assimilation of proxy data in regional models will prepare state/federal agencies for use of TEMPO data quickly after launch

Map of western region showing whether PM2.5 and O3 standards were met from 2013-2015 in each county. Orange where PM2.5 standards not met, Yellow where O3 standards not met, and red where both standards not met

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Pilot Project: Public Health

- How can TEMPO be used to assess the impact of air pollutant exposure on hospital readmission rates for cardiopulmonary disorders?
- Collaboration with Alabama Department of Public Health and Alacare Home Health & Hospice
- TEMPO proxy products will be used to build the readmission rate prediction model
- The spatial/temporal resolution of air pollutants from TEMPO offer the capacity to assess environmental risk factors on health and provide critical time and space information to healthcare end users for mitigation actions

See S. Alexander/UAH talk

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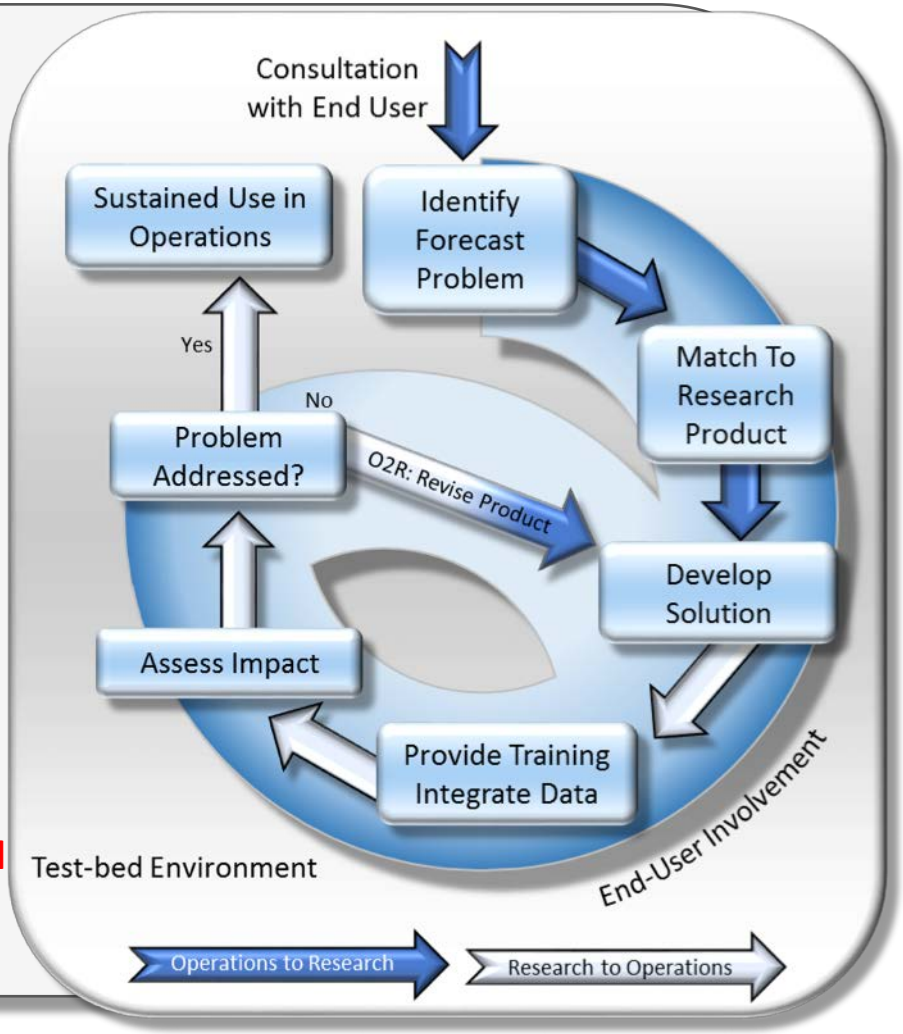
Short-term Prediction Research and Transition (SPoRT)

- **Over the past 15 years, SPoRT has successfully transitioned unique observations from more than 40 satellite datasets to operational end users**
- **Established research-to-operations/operations-to-research paradigm that engages in solving specific forecast problems**
- **SPoRT plans to use this successful approach to prepare the user community for TEMPO data**

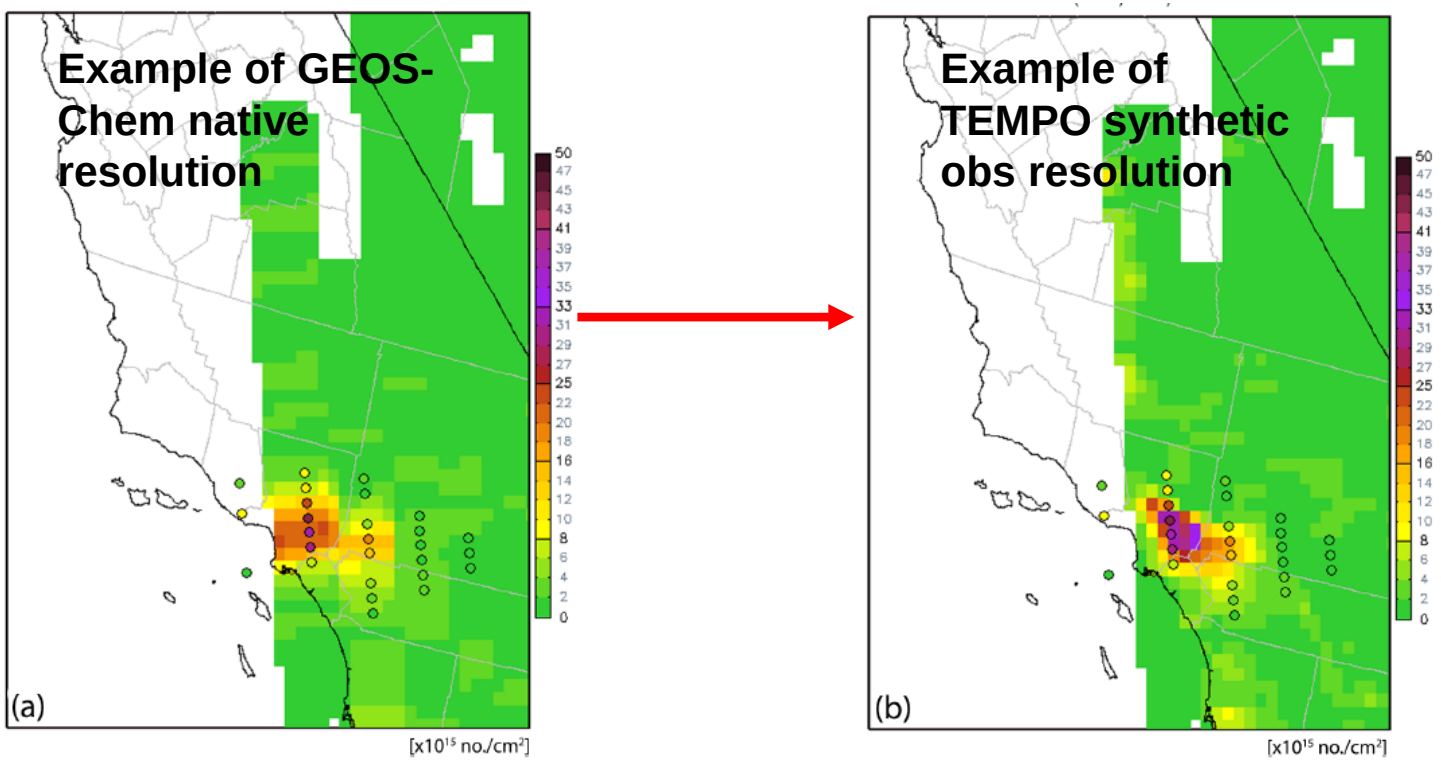
See NASA SPoRT talk (Emily Berndt and Aaron Naeger) – SPoRT R2O Paradigm: preparing end users for next-generation satellite missions before day 1 operations



https://weather.msfc.nasa.gov/sport/

Extra Slides

TEMPO synthetic observations



- The finer resolution (spatial and temporal) of the TEMPO synthetic observations will greatly enhance our ability to monitor air quality conditions

Kim et al. (GMD, 2016)