NCAR IASI studies in support of local air quality characterization

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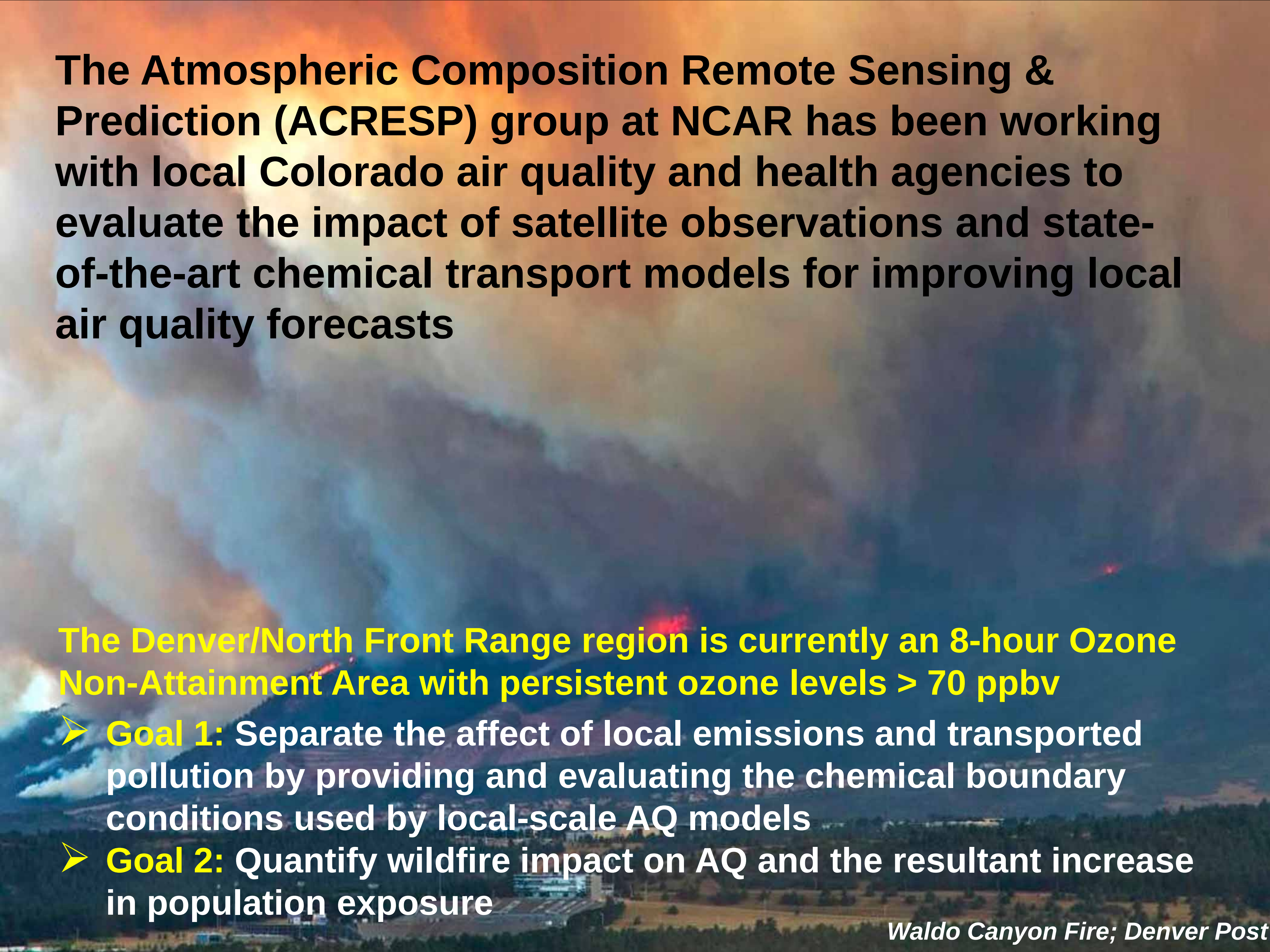
The Atmospheric Composition Remote Sensing & Prediction (ACRESP) group at NCAR has been working with local Colorado air quality and health agencies to evaluate the impact of satellite observations and state-of-the-art chemical transport models for improving local air quality forecasts

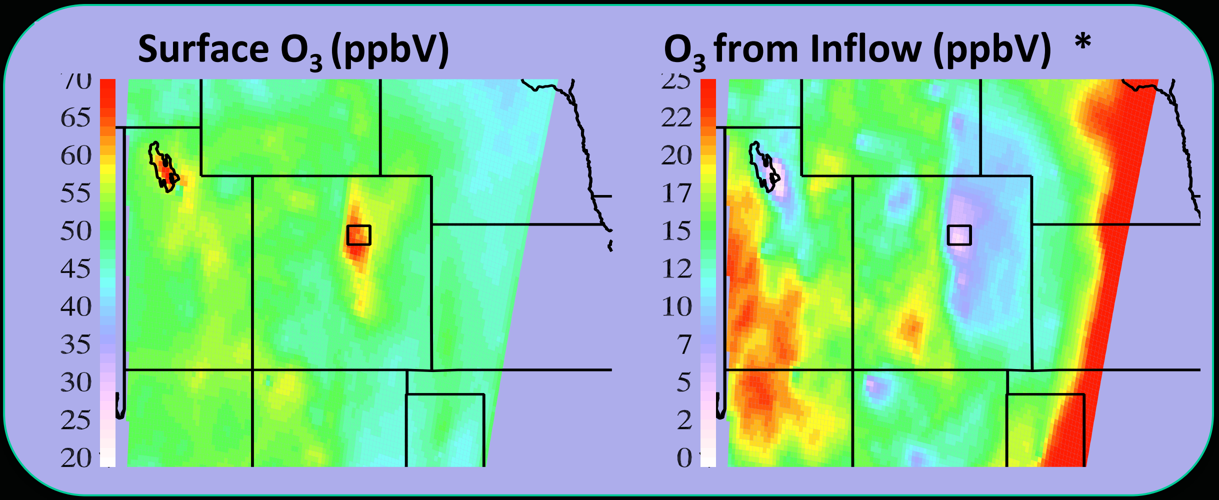
The Denver/North Front Range region is currently an 8-hour Ozone Non-Attainment Area with persistent ozone levels > 70 ppbv

- **Goal 1:** Separate the affect of local emissions and transported pollution by providing and evaluating the chemical boundary conditions used by local-scale AQ models
- **Goal 2:** Quantify wildfire impact on AQ and the resultant increase in population exposure

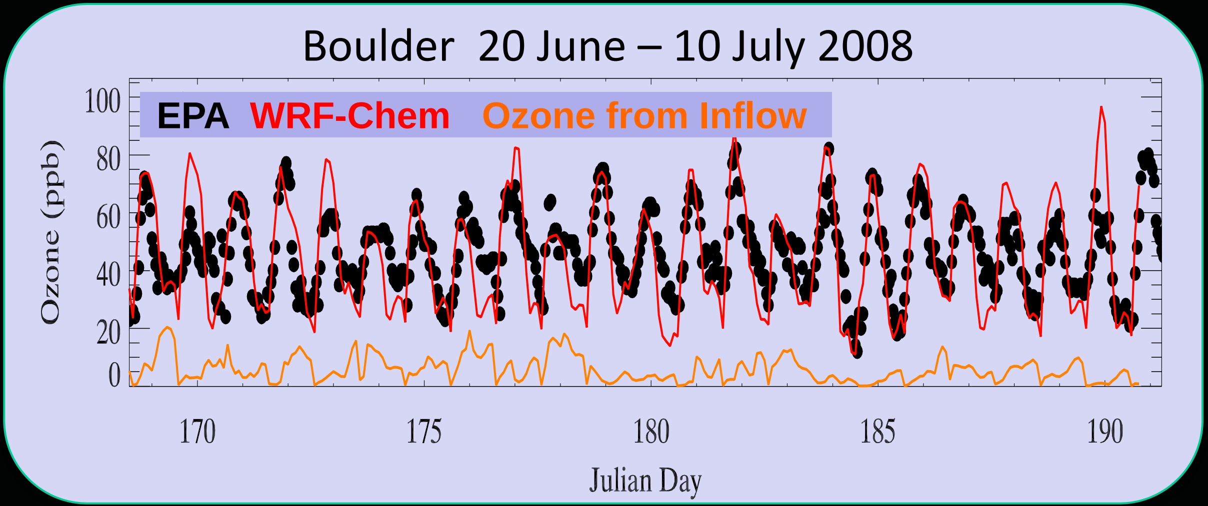


Waldo Canyon Fire; Denver Post

LRT contribution to CO Surface Ozone



- Use tagging of ozone and pre-cursors at lateral boundaries in WRF-Chem
- Ozone from inflow can account for ~20% of surface values
- Important to accurately predict boundary conditions



Tagging Scheme: NO tag from specified source is traced through HC and CO oxidation and through all odd N- species (HNO_3, PAN, N_2O_5, etc.) [Lamarque et al., 2005; Pfister et al., 2006, 2008; Emmons et al., 2010)

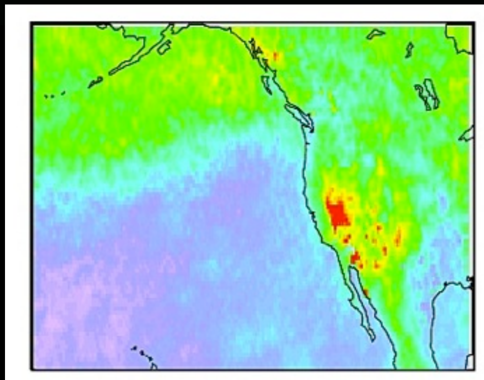
*Mean for 06/20-07/10, Local Afternoon

Model Evaluation with IASI ozone

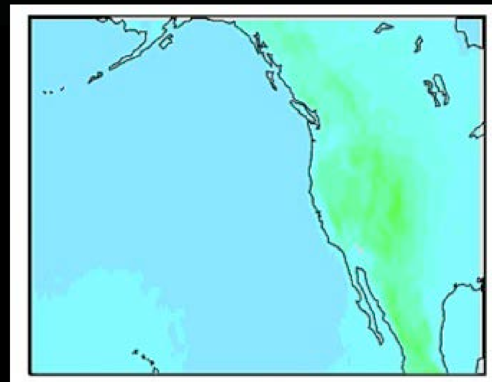
Ozone average mixing ratio:

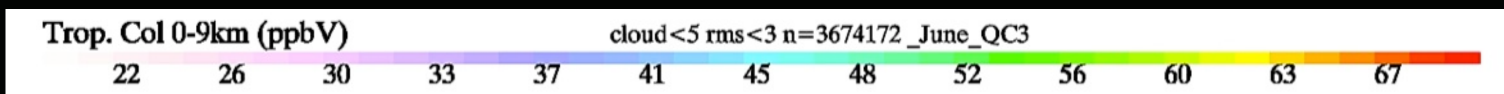
Surface – 9 km, June 2008

IASI

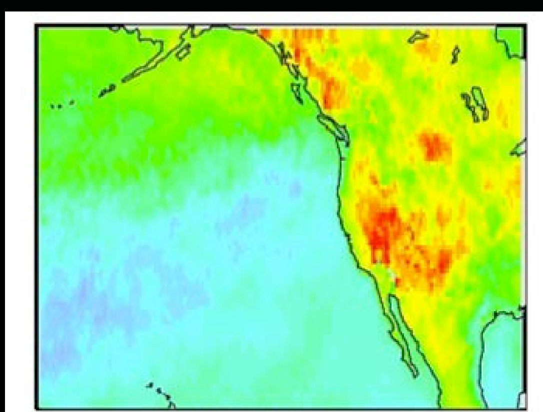


A priori

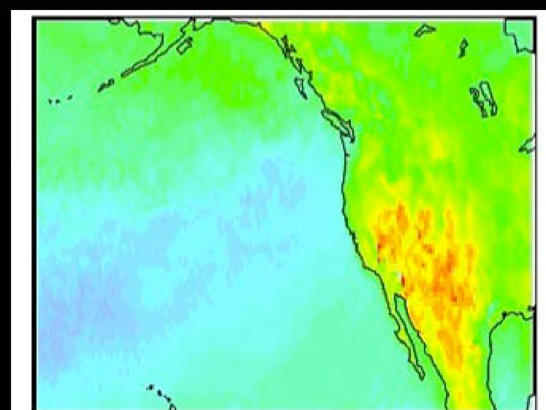




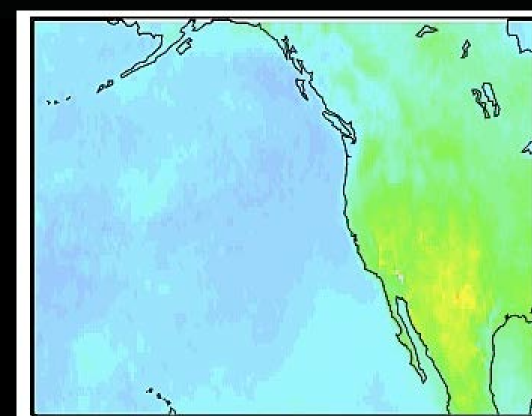
CAM-Chem AK



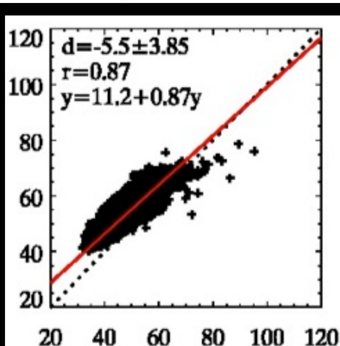
MOZART_GEOS AK



MOZART NCEP AK

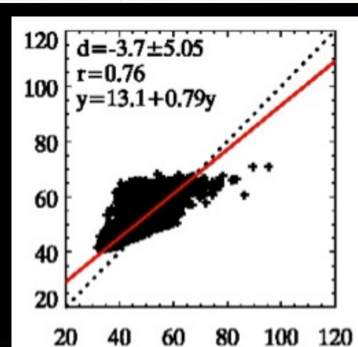


Model



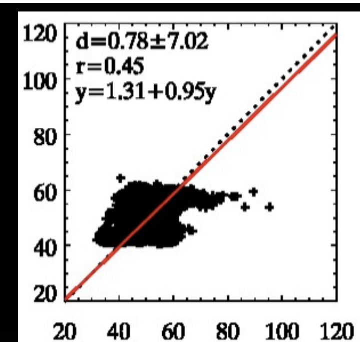
IASI

Model



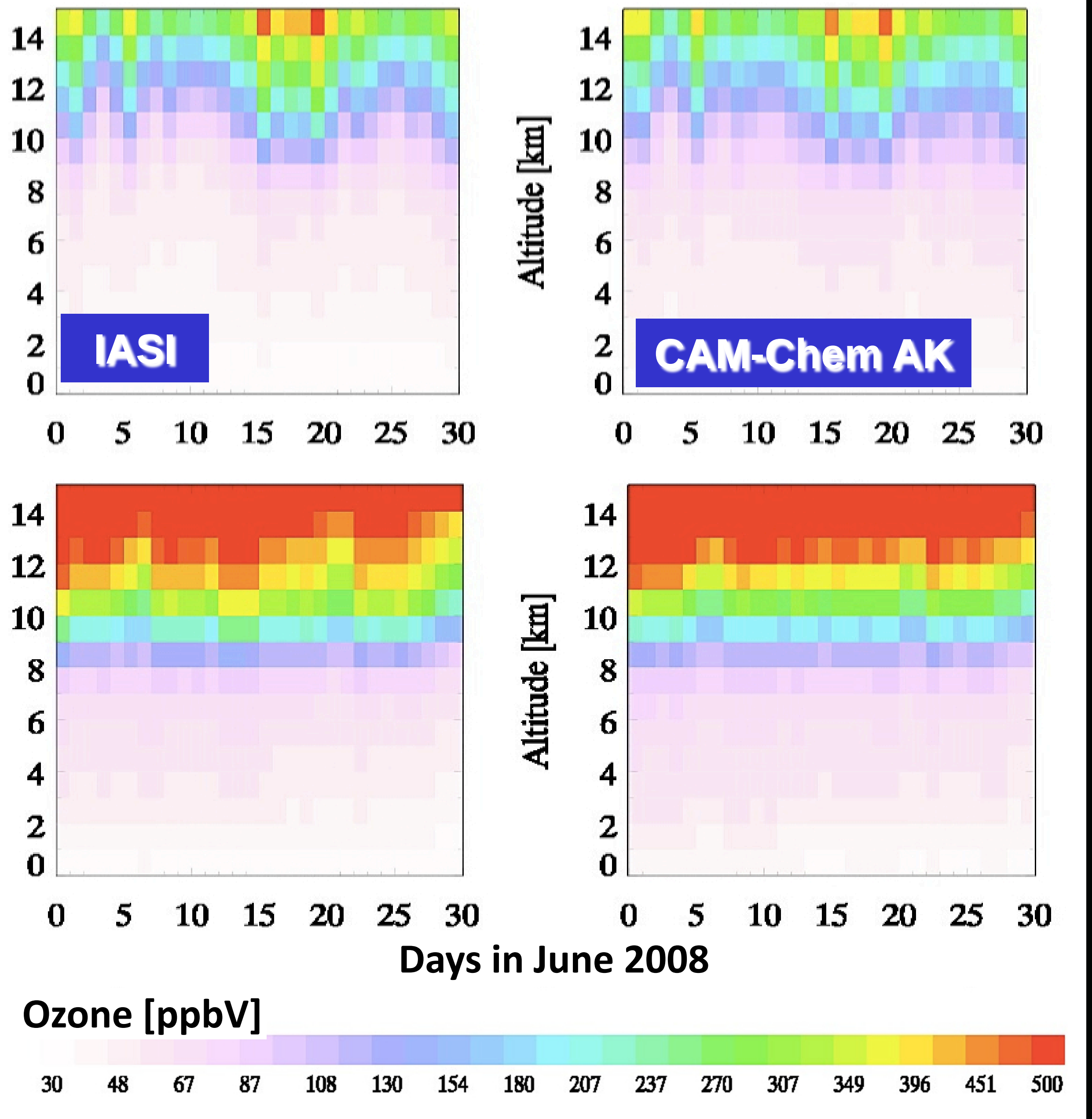
IASI

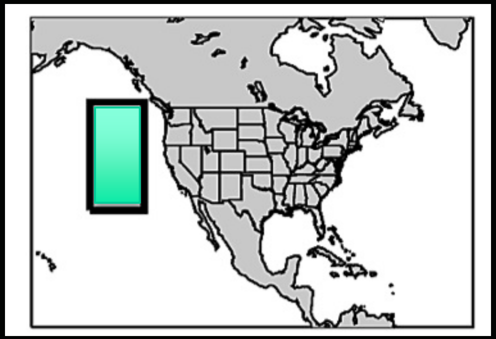
Model

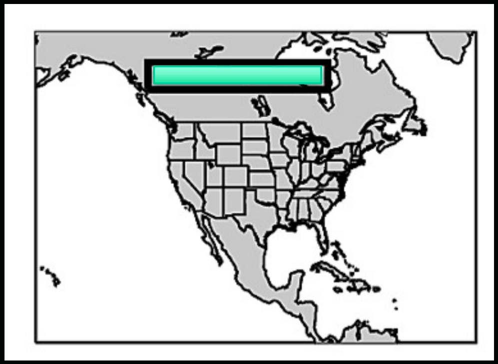


IASI

Vertical and Temporal Variation





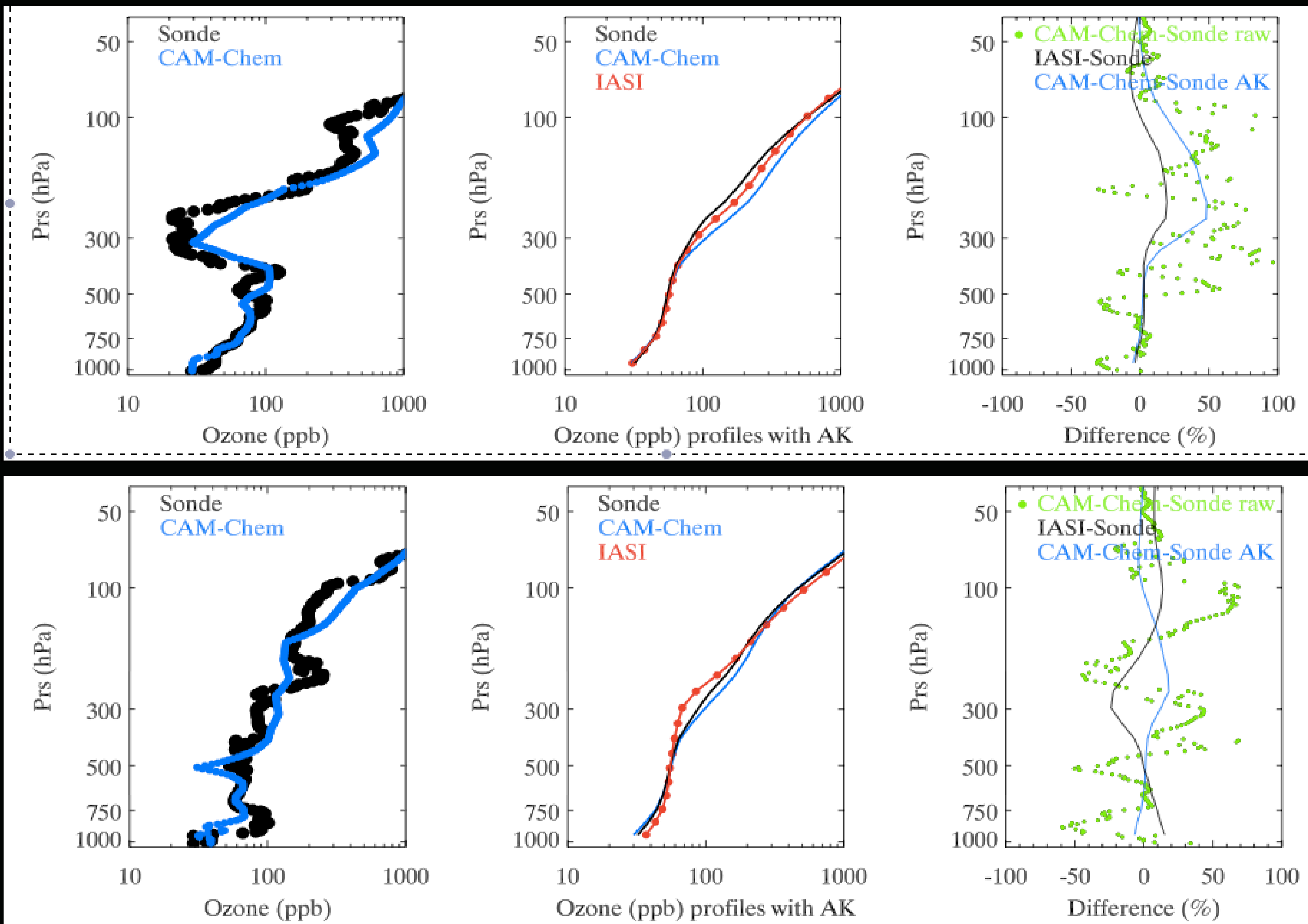


Evaluation of IASI & Model

Ozone Sondes @ Trinidad Head, CA *vs* IASI *vs* CAM-Chem

The nearest (in time & space) IASI retrieval compared to ozone sonde and model profiles

Sonde vertical resolution **Profiles with AK** **Difference**

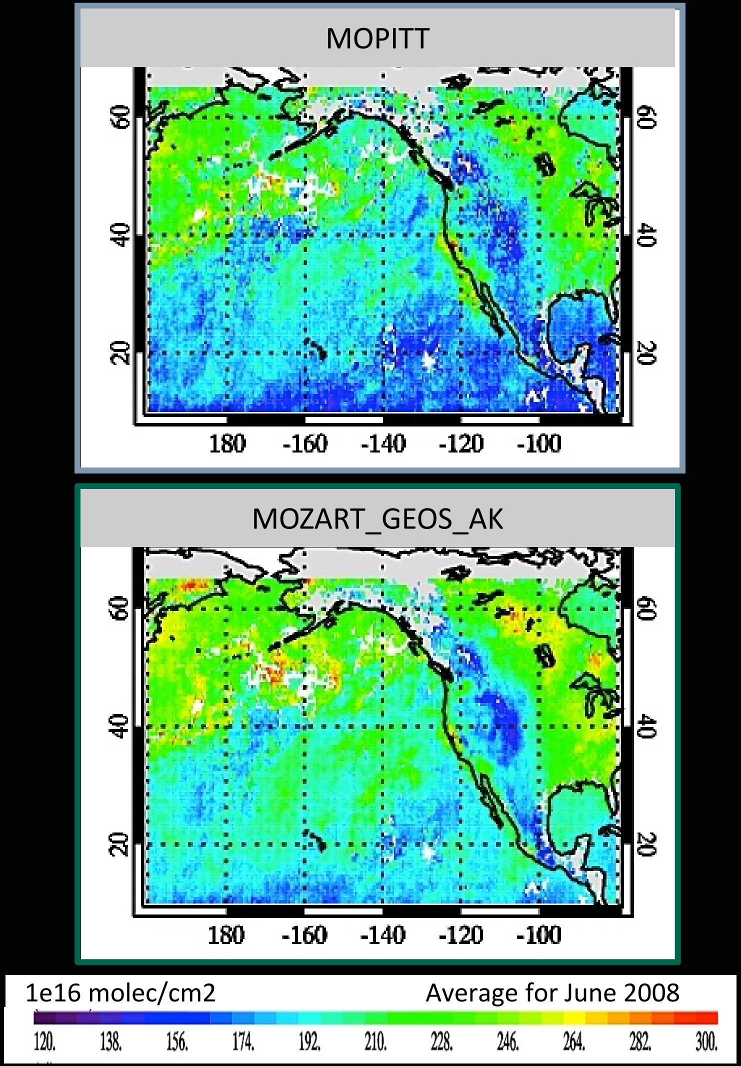


4 June 2008

29 June 2008

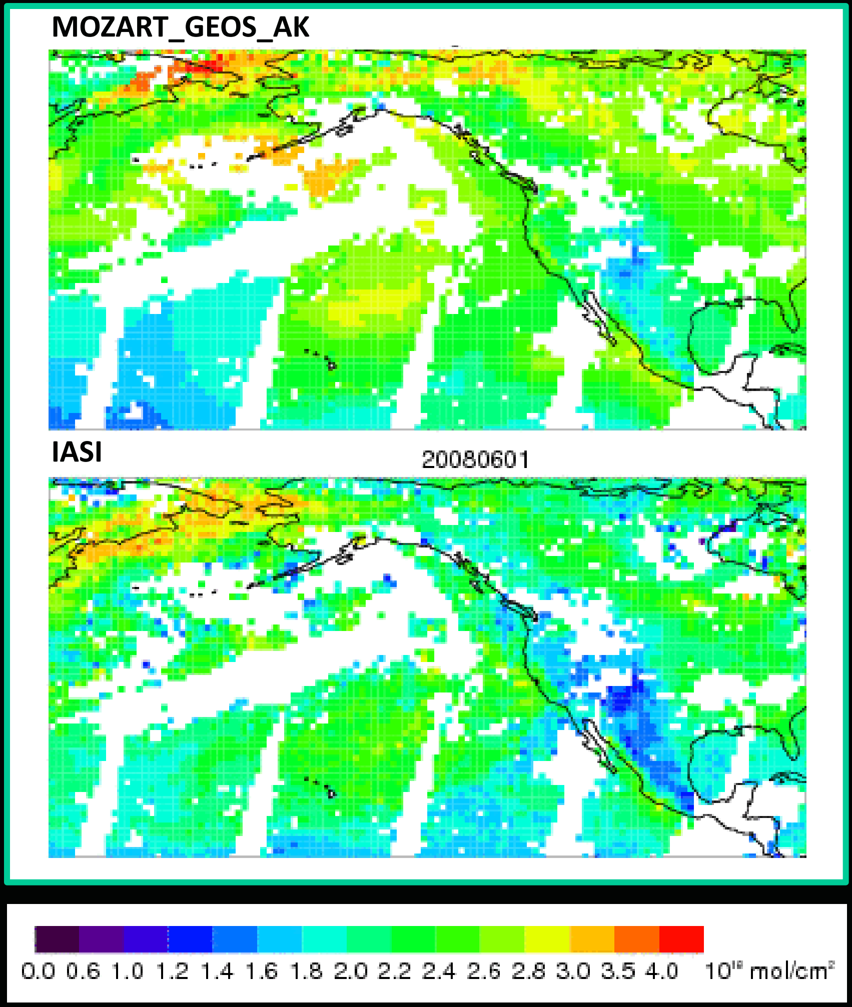
Model Evaluation: CO Column

MOPITT V5 Multispectral Retrieval
Monthly Mean CO Column
June 2008

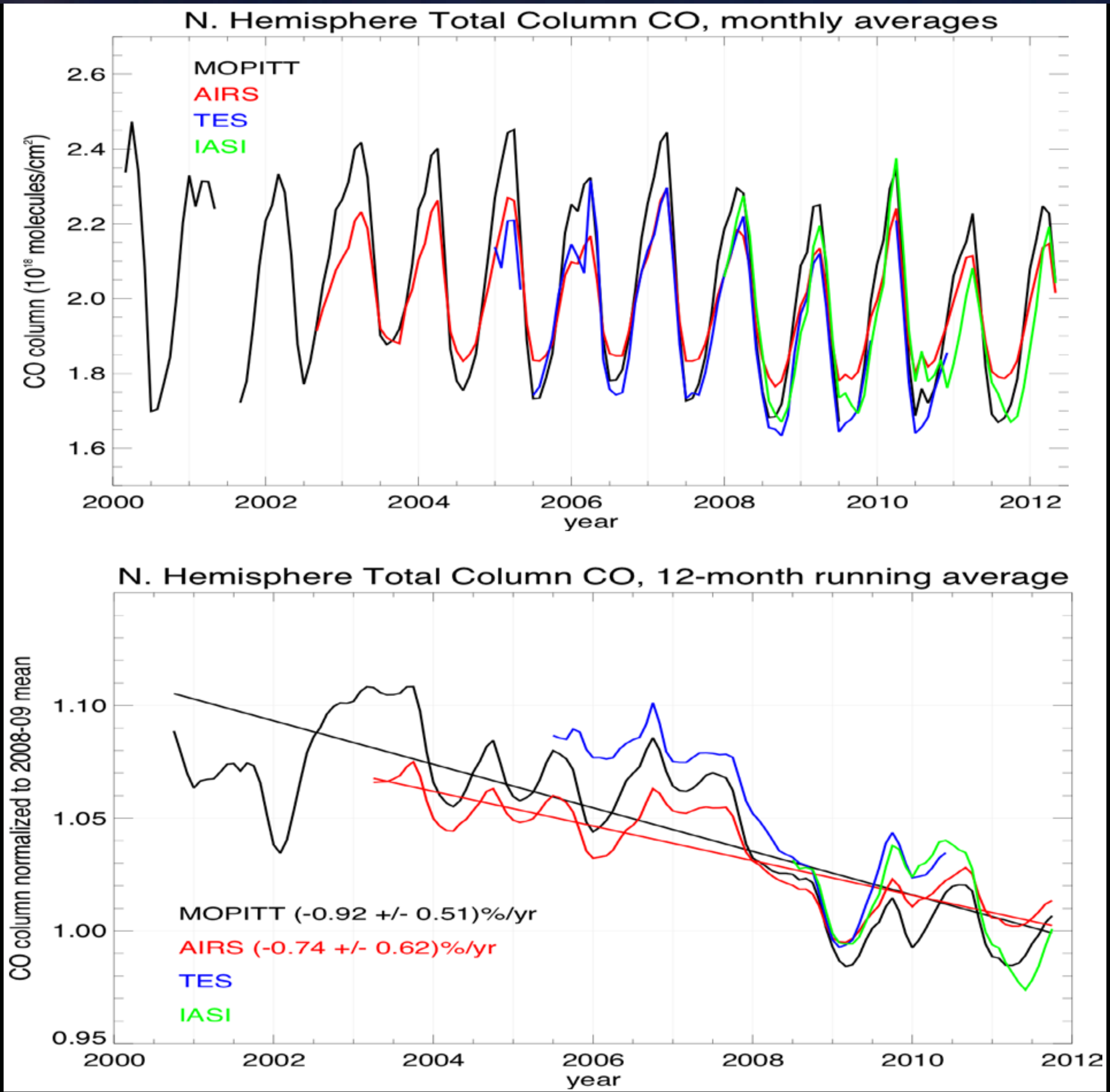


IASI FORLI retrieval
Cathy Clerbeaux (LATMOS)

Daily CO Column, 1-30 June 2008



Variability & Trend in CO Loading

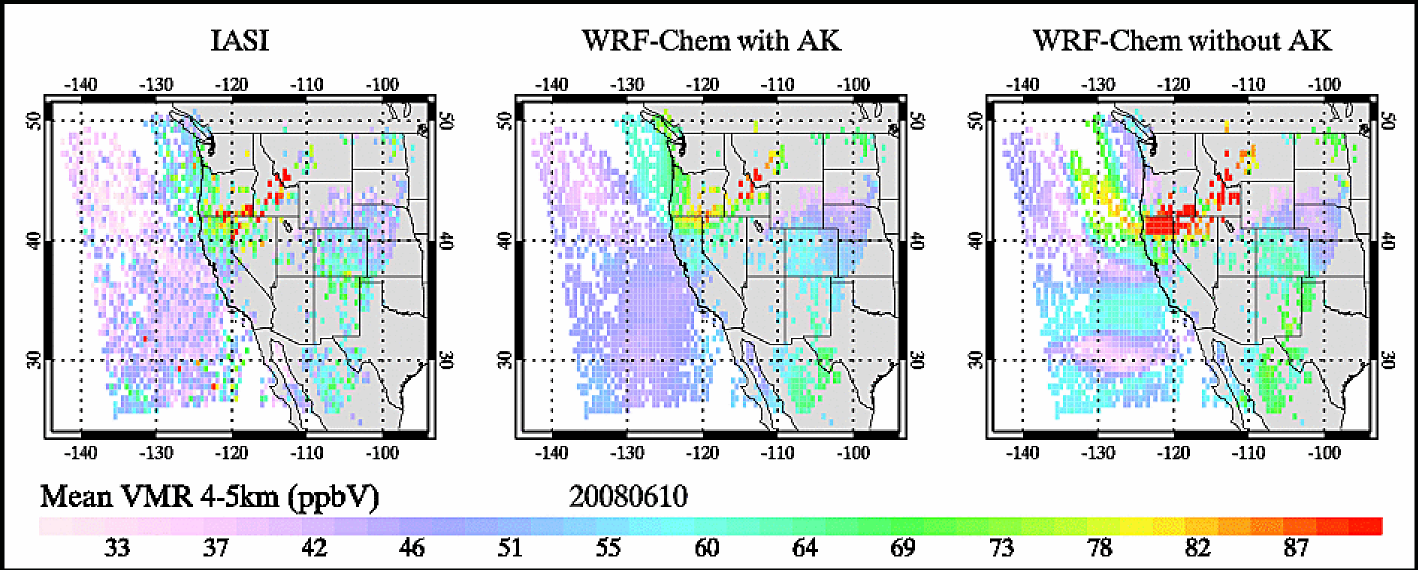


- **Instrument differences due to different retrieval *a priori* and sampling**
- **TES and IASI records too short to show trends alone, but give confidence to trend analysis of longer MOPITT and AIRS data records**
- **Trend (about -1%/yr) consistent with a continuation of 1991-2001 trend for NH surface CO: -0.8%/year [*Novelli et al., JGR, 2003*]**

Worden et al., ACP, 2013

Next Steps

- Continued research on boundary influence on surface AQ for target regions and time periods required by State agencies
- In addition to intercontinental transport, evaluate other regional issues such as transport of emissions from gas exploration in neighboring States such as Wyoming
- Provide improved boundary conditions for regional modeling through data assimilation

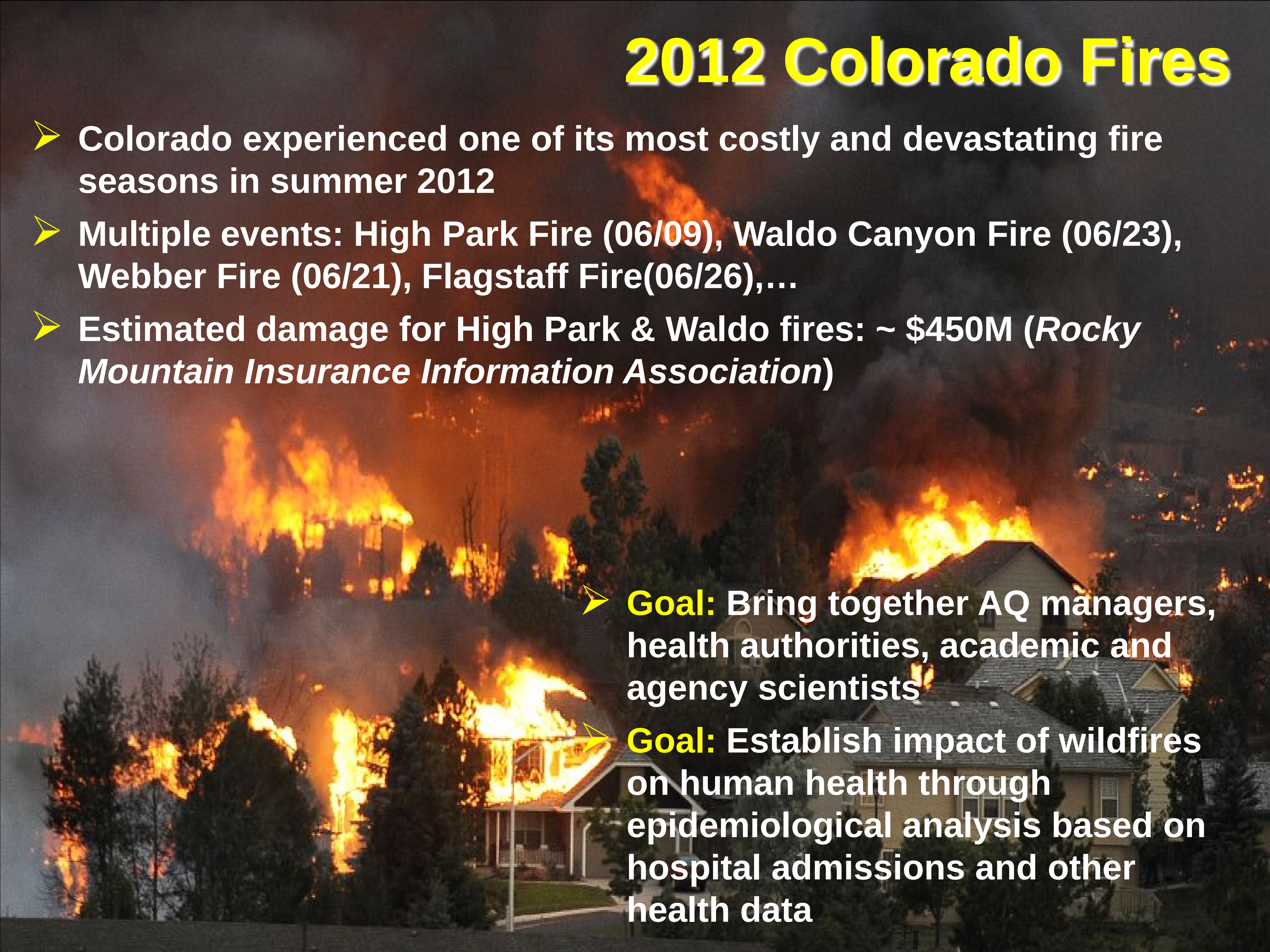


IASI retrieved ozone compared to WRF-Chem (12 km x 12 km) with and without consideration of IASI averaging kernel (WRF-Chem simulation, IASI and model

2012 Colorado Fires

- **Colorado experienced one of its most costly and devastating fire seasons in summer 2012**
- **Multiple events: High Park Fire (06/09), Waldo Canyon Fire (06/23), Webber Fire (06/21), Flagstaff Fire(06/26),…**
- **Estimated damage for High Park & Waldo fires: ~ $450M (*Rocky Mountain Insurance Information Association*)**

- **Goal: Bring together AQ managers, health authorities, academic and agency scientists**
- **Goal: Establish impact of wildfires on human health through epidemiological analysis based on hospital admissions and other health data**



Fort Collins, CO
High Park Fire

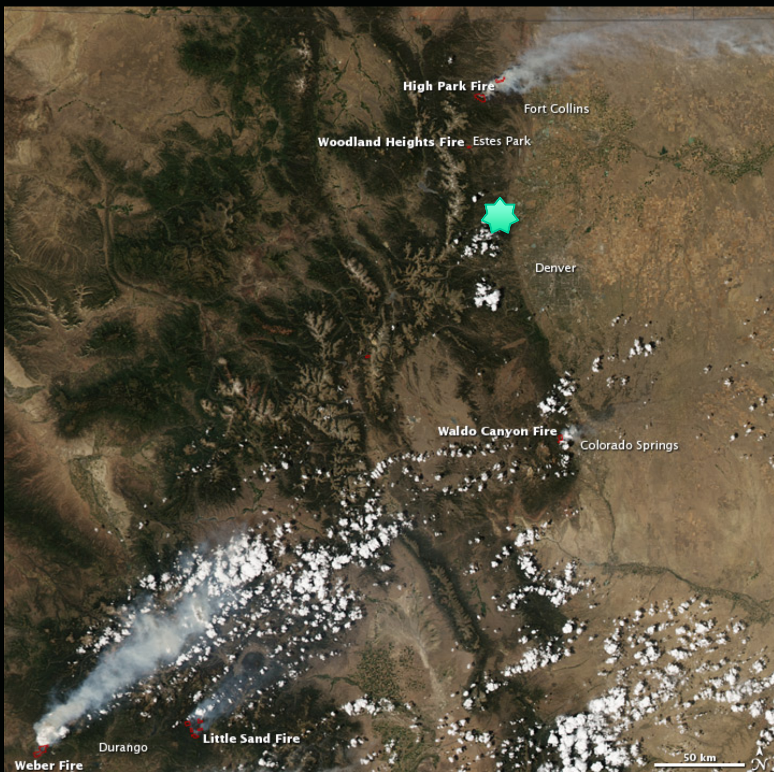
Prerequisite to quantifying fire impact on local AQ is accurate information on pollutant distributions and population exposure levels

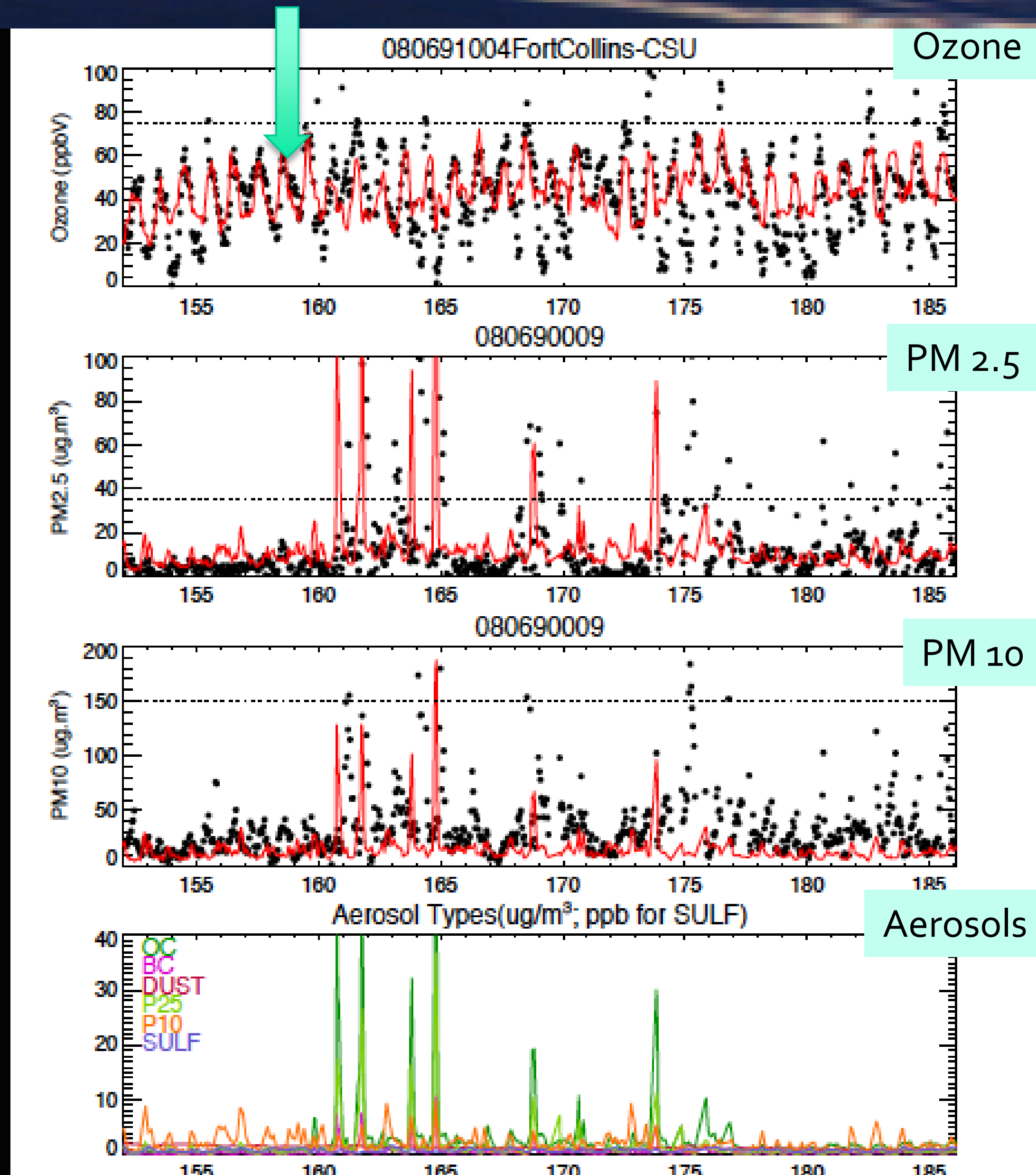
- **Surface AQ in CO Northern Front Range impacted by:**
  - **Complex topography and meteorological flow patterns**
  - **Diverse emissions: urban, agriculture, oil/gas, fires….**
  - **Long-range transport**

- **Model runs using the regional WRF-Chem model over the Western U.S. for a 5-week period 6/1-7/6, 2012 at 12×12 km^2 down to 4×4 km^2**
  - **Driven by assimilation of meteorological observations using the Data Assimilation Research Testbed (DART) to provide the best local meteorology**
  - **Evaluation of model pollutant fields using satellite and ground-based observations**

Surface AQ: Modeling and Observation

CDPE Site @ Fort Collins



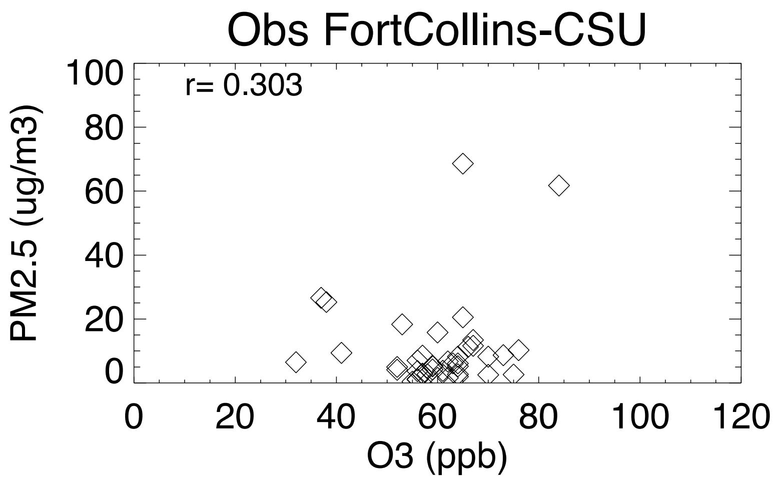


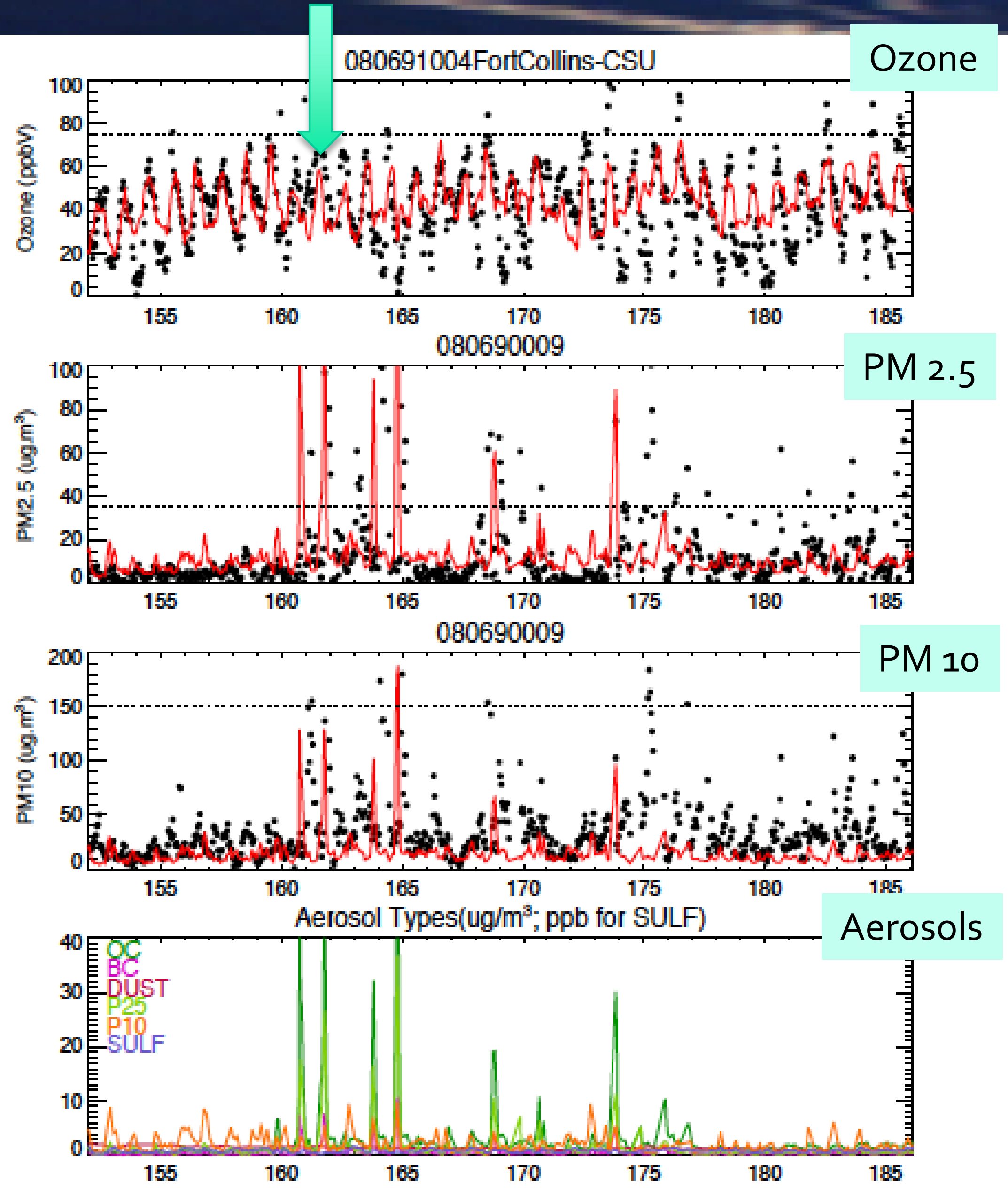
- O_3 & PM generally well represented before fires

Surface AQ: During Fires

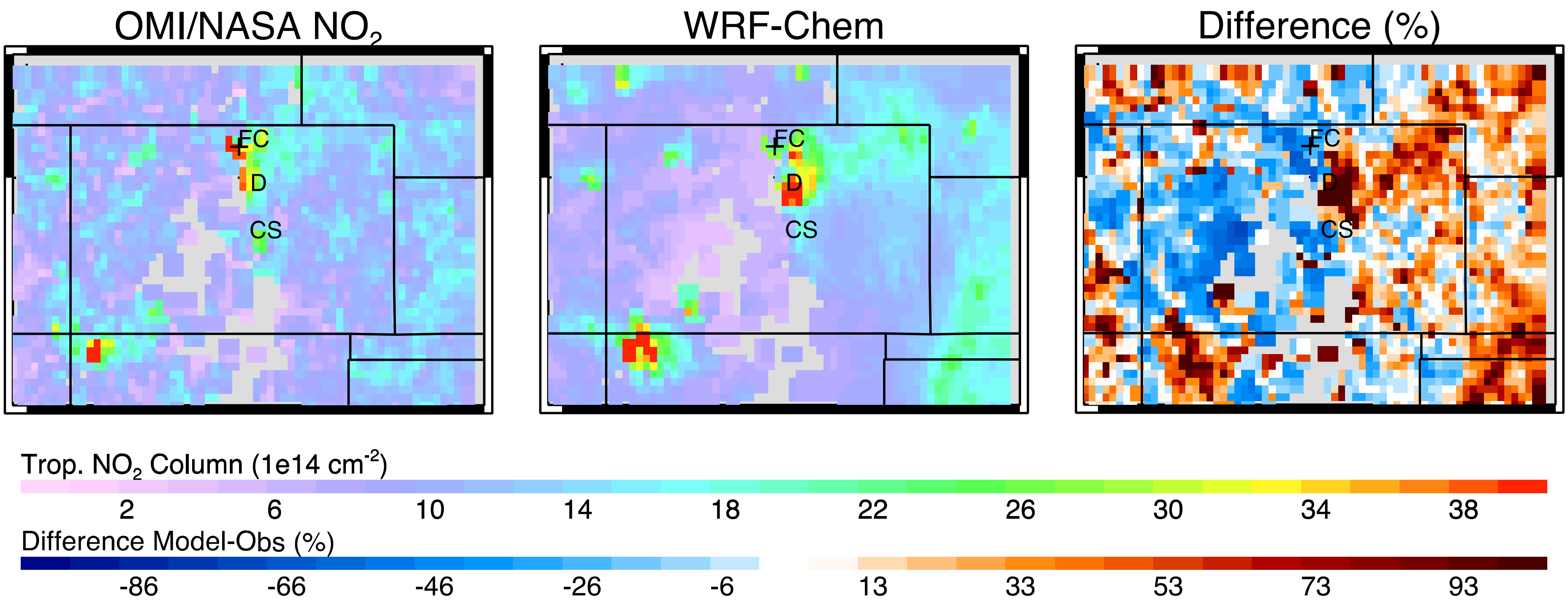
CDPE Site @ Fort Collins

- O_3 underestimated during fires
- PM peaks captured well in general
- O_3 and PM not necessarily correlated





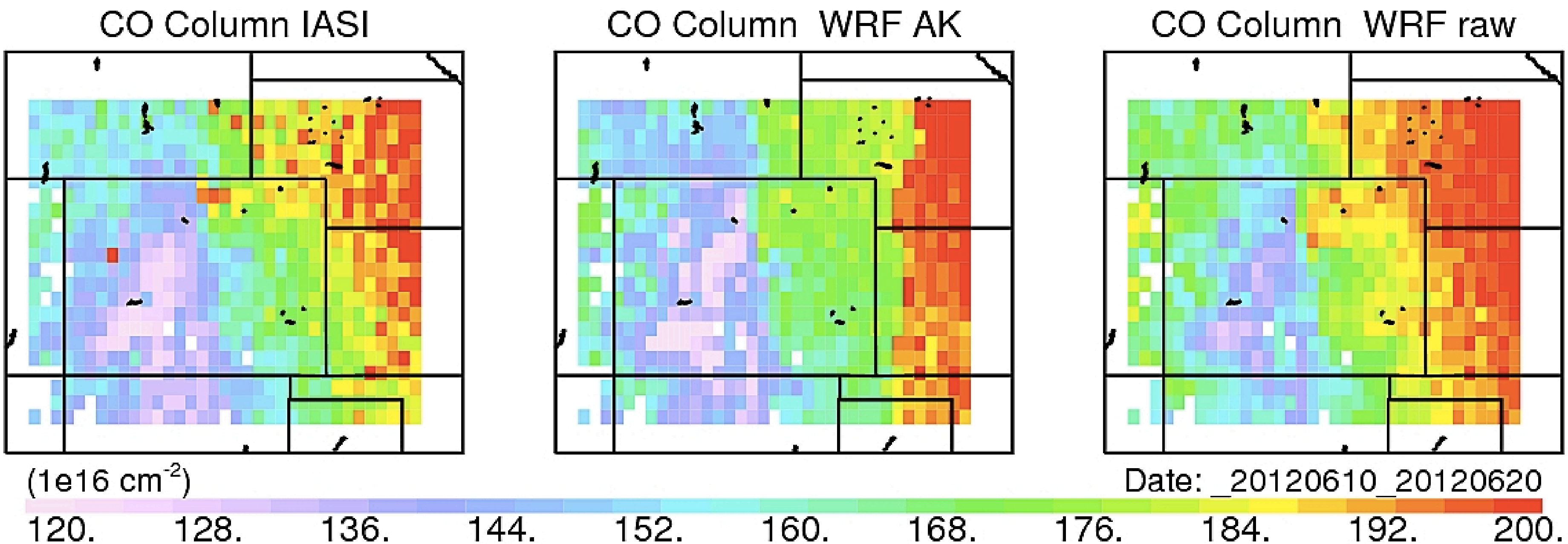
OMI NO_2 Column, 10-30 June

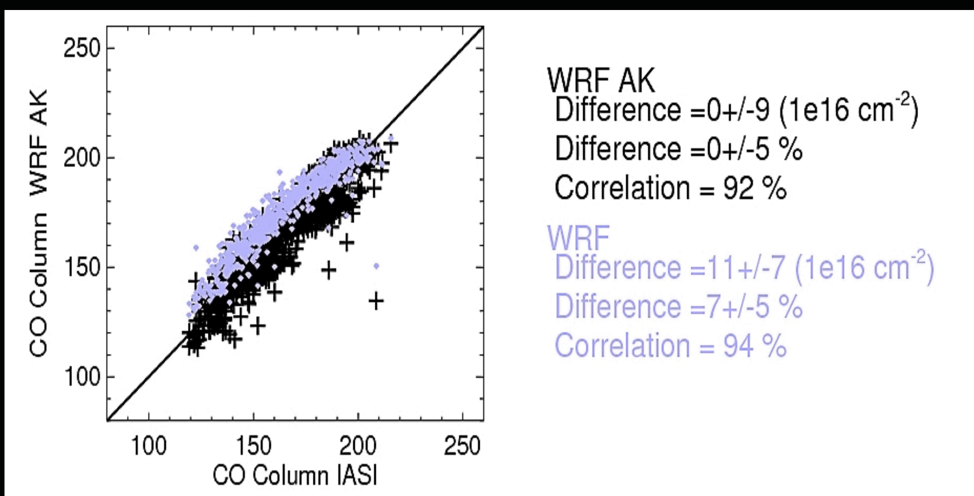


- **Indicates possible:**
  - **Overestimate in anthropogenic emissions**
  - **Underestimate in fire emissions**

Note: OMI data impacted by row anomaly; Filtering applied based on XTrackQualityFlag

IASI CO Column, 10-20 June





- Primary IASI sensitivity to free troposphere means that urban sources may not be evident
- Indication that fire emissions are too low

Summary & Next Steps

- Surface AQ in the Colorado Front Range is significantly impacted by meteorology, pollutant emissions and chemistry
- First simulations show promise, but leave room for improvements:
  - Improve fire emissions above currently obtained from the standard NCAR FINN model
  - CDPHE emission inventory instead of EPA for anthropogenic
  - Improve Meteorology – adjustments to DART; higher resolution

Next steps:

- Conduct simulations without wildfires to quantify fire impact and demonstrate AQ exceedance
- Assimilate satellite O_3, CO, NO_2 and AOD observations in addition to meteorology
- Correlate increased exposure due to fires with health data for hospital admissions


Thank You!