Satellite observations and air quality

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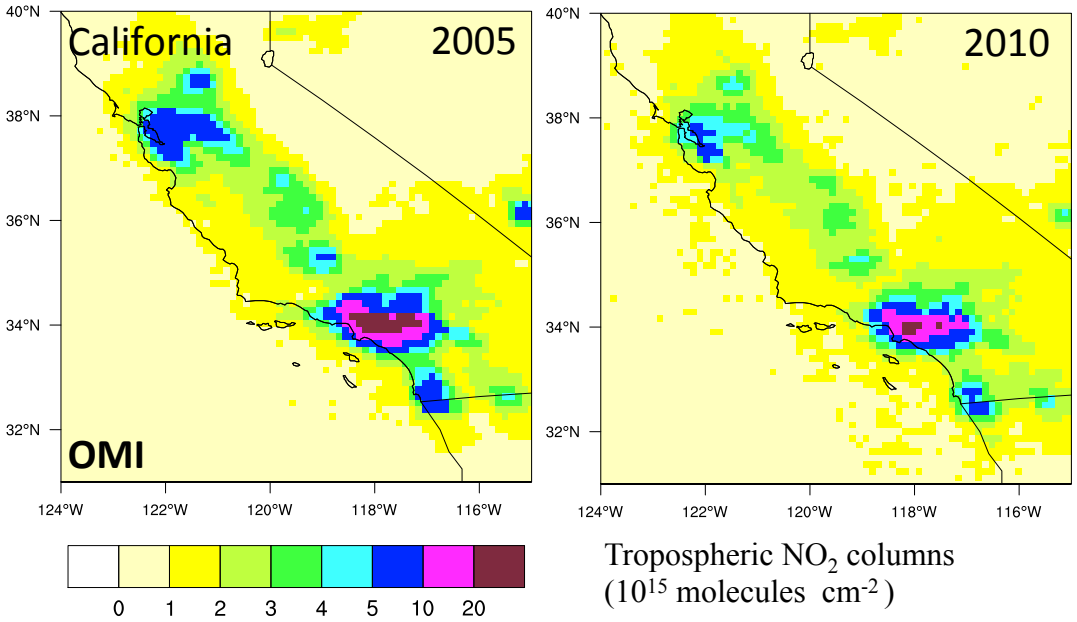
NOAA CSD's efforts to use satellite data and chemical transport model

- **Derive long-term NO_x change to understand its impact on air quality and climate**
- **Reduce uncertainties in emission inventory**

  Provide accurate input to weather and climate model
- **Validate satellite data sets** by integrating emission inventory, regional chemical model, aircraft observations, and multiple retrievals.

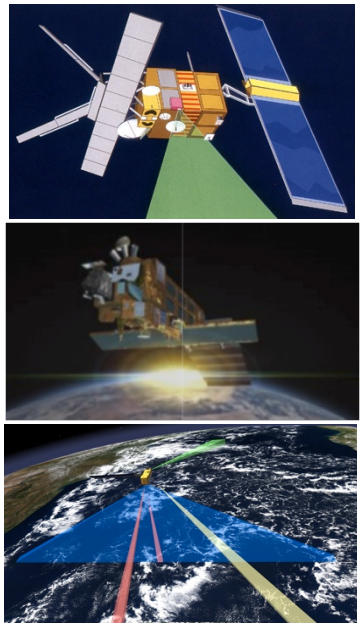
  CSD's field campaigns and model were critical in validating satellite data.



Satellites observed the impact of motor-vehicle pollution control.

NO_x → 8% per year reduction

Satellite observations of atmospheric composition



Satellite Instrument	Period	Overpass time	Global coverage	Pixel size
GOME (ERS-2)	1995/4-2003/6	10:30 LT	3 days	340 x 40 km^2
SCIAMACHY (ENVISAT)	2002/8-2012/4	10:00 LT	6 days	60 x 30 km^2
OMI (EOS Aura)	2004/7-present	13:30 LT	1 day	27 x 13 km^2 (nominal)
GOME-2 (MetOp)	2007/3-present	09:30 LT	1.5 days	80 x 40 km^2

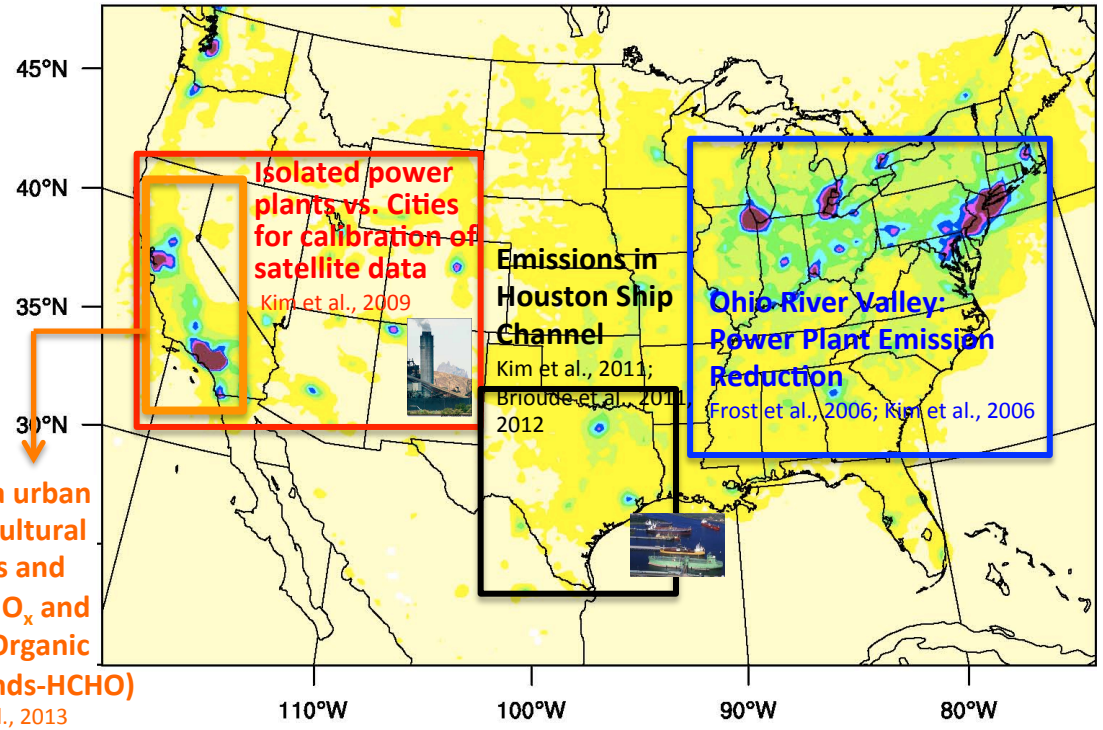
Vertical Column
= Slant Column /Air Mass Factor

Air mass factor is a main source of uncertainty. CSD's model provided trace gas profiles for accurate air mass factor calculation.

GOME = **G**lobal **O**zone **M**onitoring **E**xperiment
SCIAMACHY = **SC**anning **I**maging **A**bsorption spectro**M**eter for **A**tmospheric **CH**artograph**Y**
OMI = **O**zone **M**onitoring **I**nstrument
ERS = **E**uropean **R**emote **S**ensing satellites
ENVISAT = **ENV**ironmental **SAT**ellite
EOS = **E**arth **O**bserving **S**ystem
MetOp = **Met**eorological **Op**erational satellite

Summary of CSD Studies

OMI tropospheric NO_2 columns



California urban and agricultural emissions and trends (NO_x and Volatile Organic Compounds-HCHO)
Brioude et al., 2013
Kim et al., 2015, in preparation

European/NASA Satellite data

NOAA CSD field campaign data

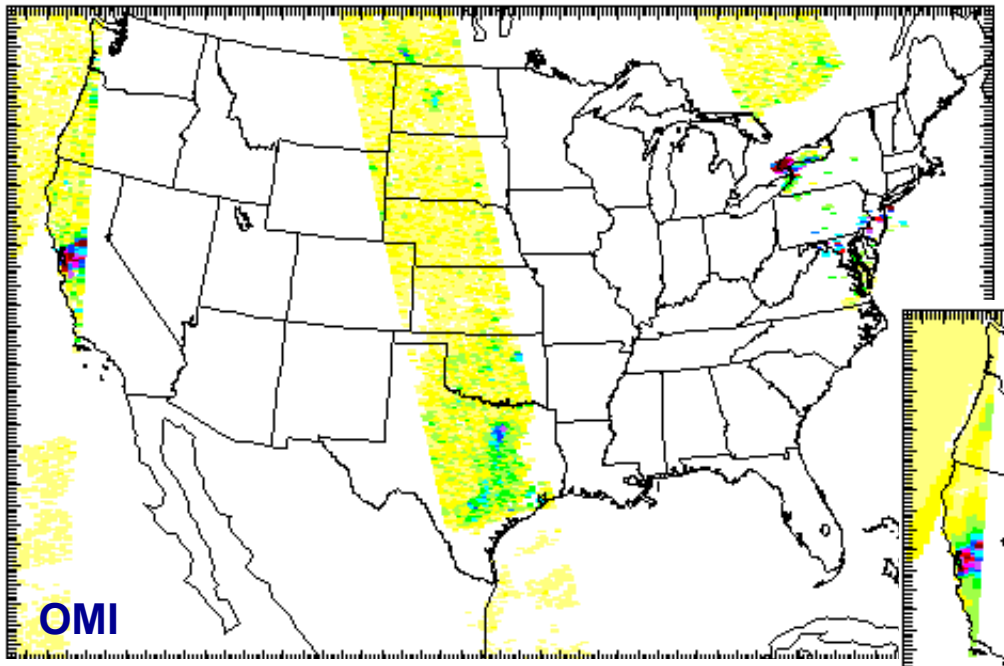
NOAA GSD/CSD lead WRF-Chem model

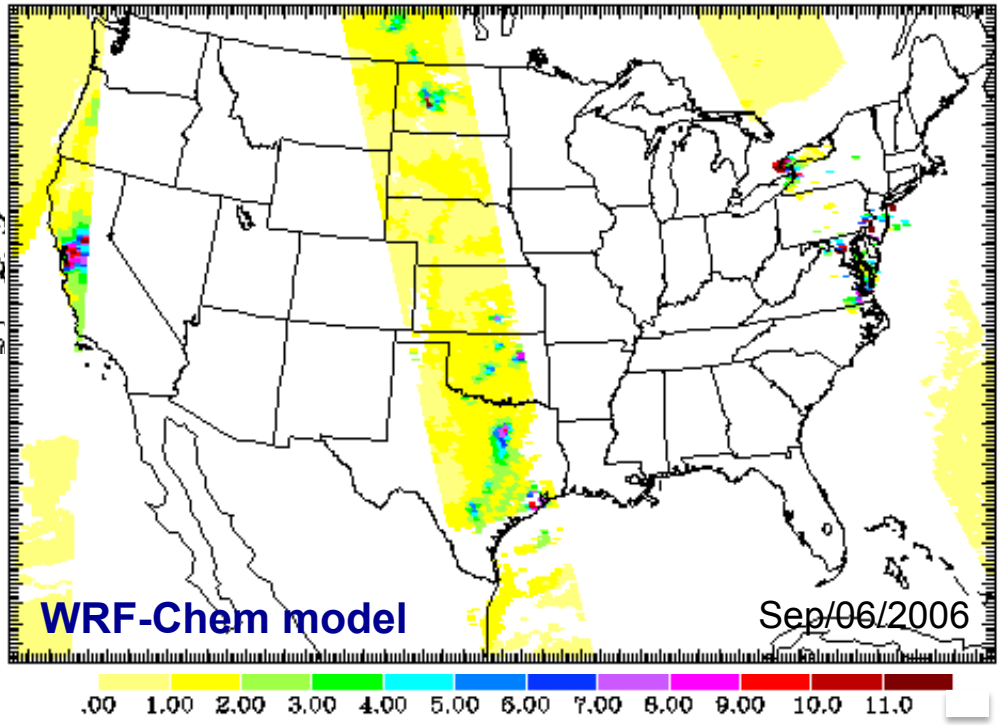
NOAA High Performance Computing System/ NOAA NCEP Global Forecast System data

WRF-Chem model = Weather Research and Forecasting-Chemistry model

Satellite vs. Model NO_2 columns

- Model results are sampled following satellite orbit and pixels
- Cloud fraction ≤ 15% scenes only
- 20 ≤ OMI Pixel Number ≤ 40





NO_2 columns (10^{15} molec. cm^{-2})

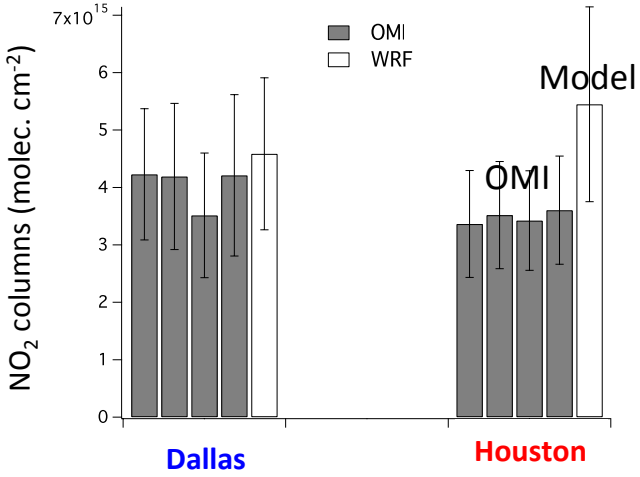
- For quantitative comparison, we made the number and spatial resolution of samples in satellite and model the same as much as possible.
- The satellite retrievals are re-calculated based on our model profiles.

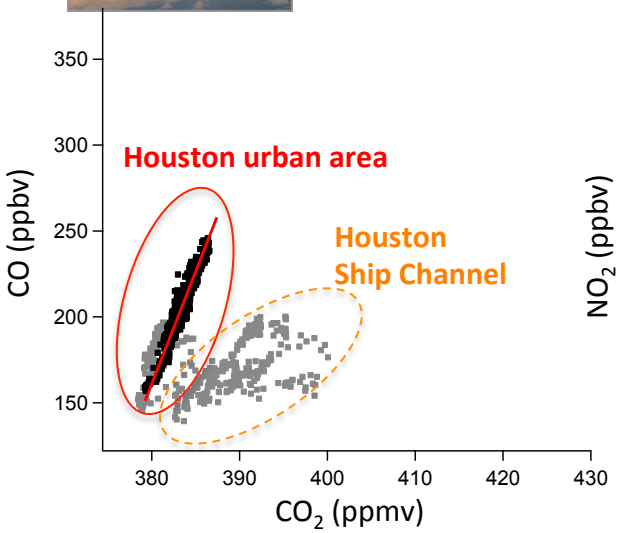
Highlights from Texas study

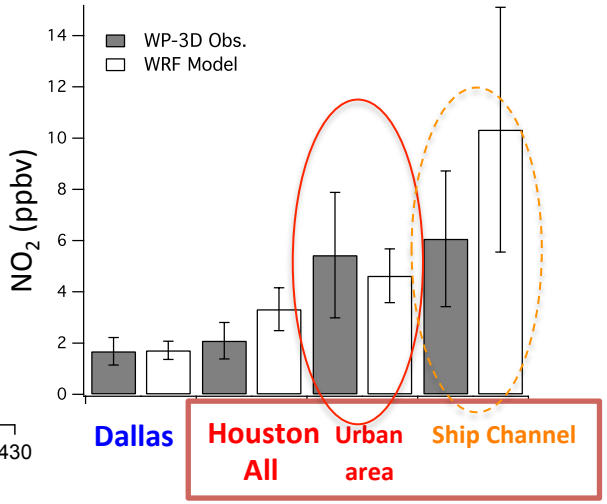
OMI vs. Model NO_2

Texas Air Quality Study 2006

Aircraft vs. Model NO_2







Satellite or aircraft obs. vs. model using NEI05

Dallas – Model and observations agree.

Houston - Model overestimates NO_x obs.

- ✓ Errors in NO_x emission estimates for industry and shipping in Houston Ship Channel.
- ✓ Underestimated VOC emissions from industries in Houston Ship Channel
- ✓ We improved model ozone prediction with updated emissions.

Publication

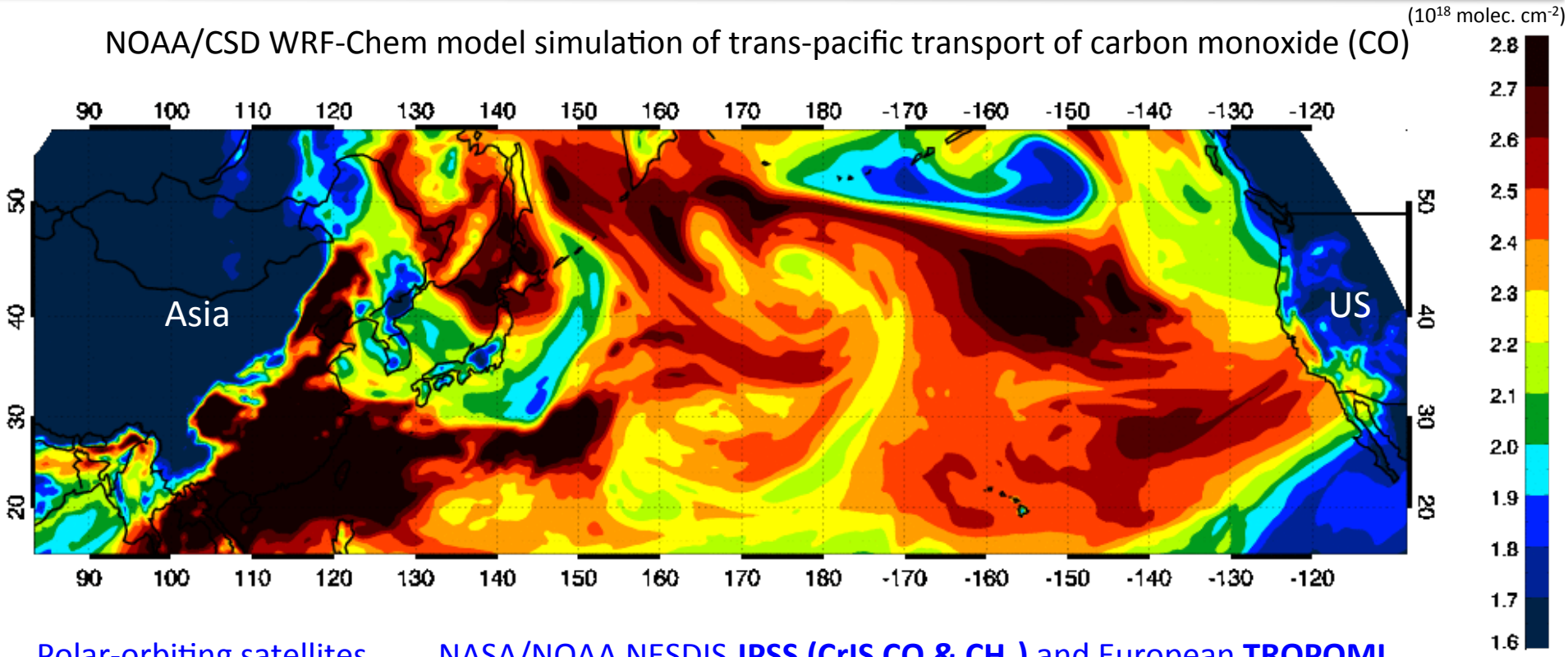
Kim et al., 2011, *Atmospheric Chemistry and Physics*

- Emission inventory and model: NOAA/CSD, CIRES
- Satellite data: KNMI (Royal Netherlands Meteorological Institute), NASA, U. of Bremen
- Aircraft data: NOAA/CSD, CIRES and National Center for Atmospheric Research (NCAR), U. of Miami
- Ground data: Chalmers U., Sensor Sense, NOAA/PSD, CIRES

Future research

- Local emissions and chemistry (NO_x, volatile organic compound, methane)
- Impacts of global emission changes on U.S. background ozone

NOAA/CSD WRF-Chem model simulation of trans-pacific transport of carbon monoxide (CO)



Polar-orbiting satellites NASA/NOAA NESDIS **JPSS (CrIS CO & CH_4)** and European **TROPOMI**

Geostationary satellites **Sentinel-4** (Europe), **GEMS** (Asia), **TEMPO** (U.S.)

Field campaigns NASA **Korea field campaign** NASA/NOAA **ATom** NOAA/CSD **US campaigns**

JPSS = **J**oint **P**olar **S**atellite **S**ystem
TROPOMI = **TROPO**spheric **M**onitoring **I**nstrument
ATom = **A**tmospheric **Tom**ography Mission
GEMS = **G**eostationary **E**nvironmental **M**onitoring **S**pectrometer
TEMPO = **T**ropospheric **E**missions: **M**onitoring of **PO**llution

CSD's field campaigns and modeling activities in coordination with satellite observations will be critical for advancing science and service.