Assimilating IASI and MOPITT CO Retrievals using CESM/CAM-chem and DART

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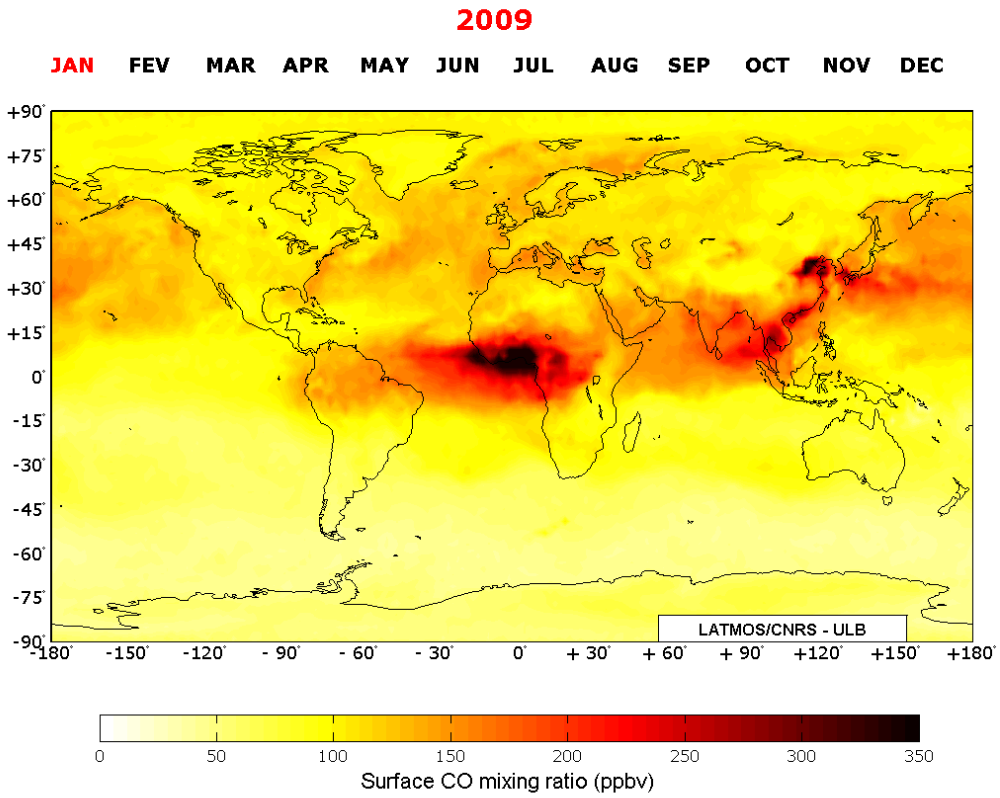
CO: Key Pollutant & Tracer

- CO has unique value for observing anthropogenic activity, evaluating pollutant emissions, and determining the transport and downwind impact of these emissions
- Sources are chemical oxidation and incomplete combustion including urban/industrial fuel burning, the transport sector and wildfires
- CO is the main sink for OH and impacts gases important for air quality and climate
- A lifetime of a week to two months makes CO an excellent tracer of long-range pollution transport with large contrasts between polluted air and the background atmosphere

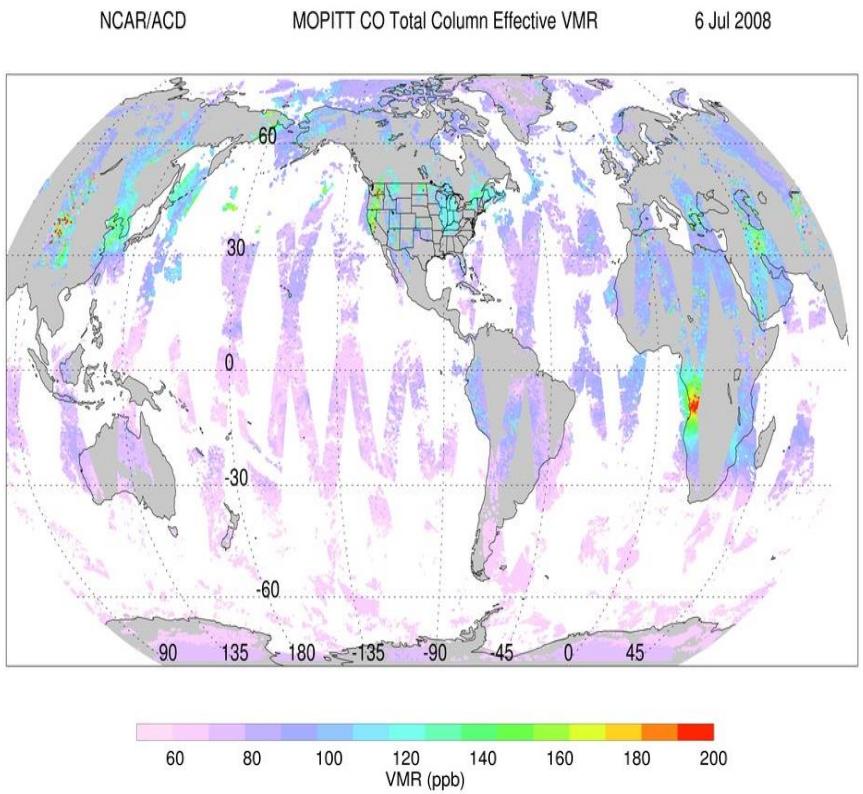


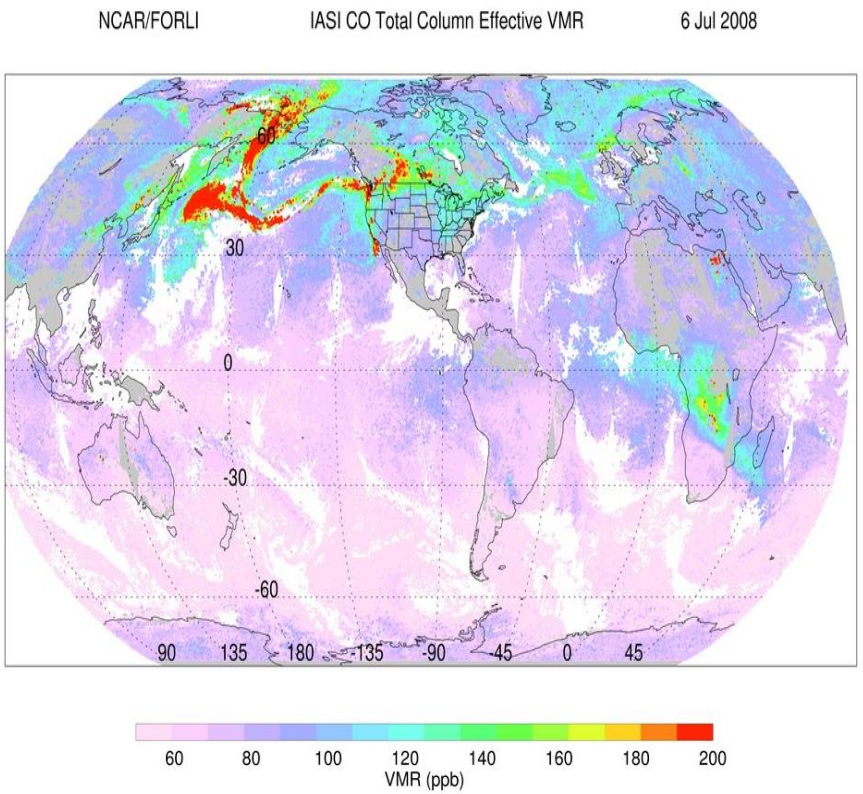
MOPITT and IASI

The sensors **MOPITT** and **IASI** are both measuring the tropospheric carbon monoxide using **nadir** geometries and **infrared** bands

Terra/MOPITT
Covers the globe in 3 days (narrow swath)

MetOp/IASI
Covers globe in one day (large swath)

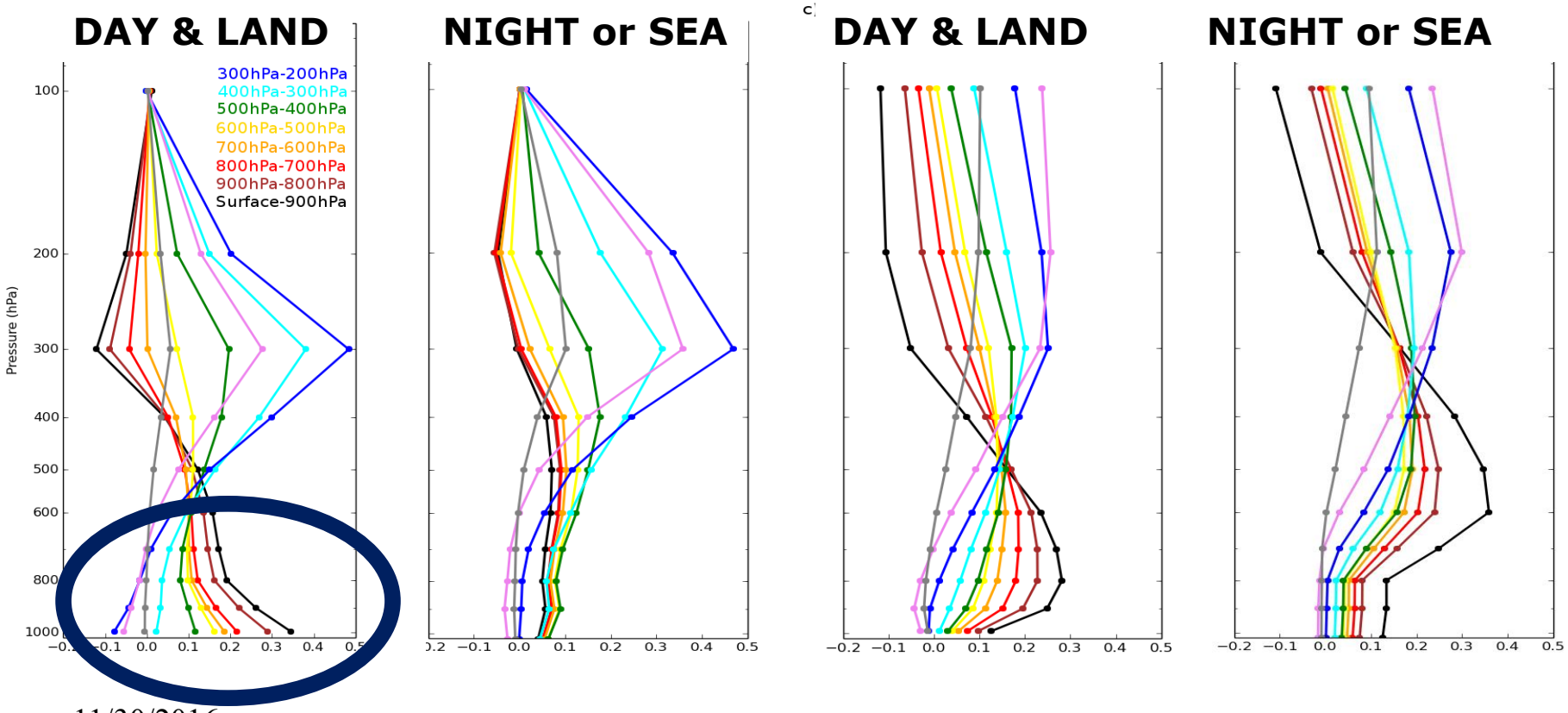




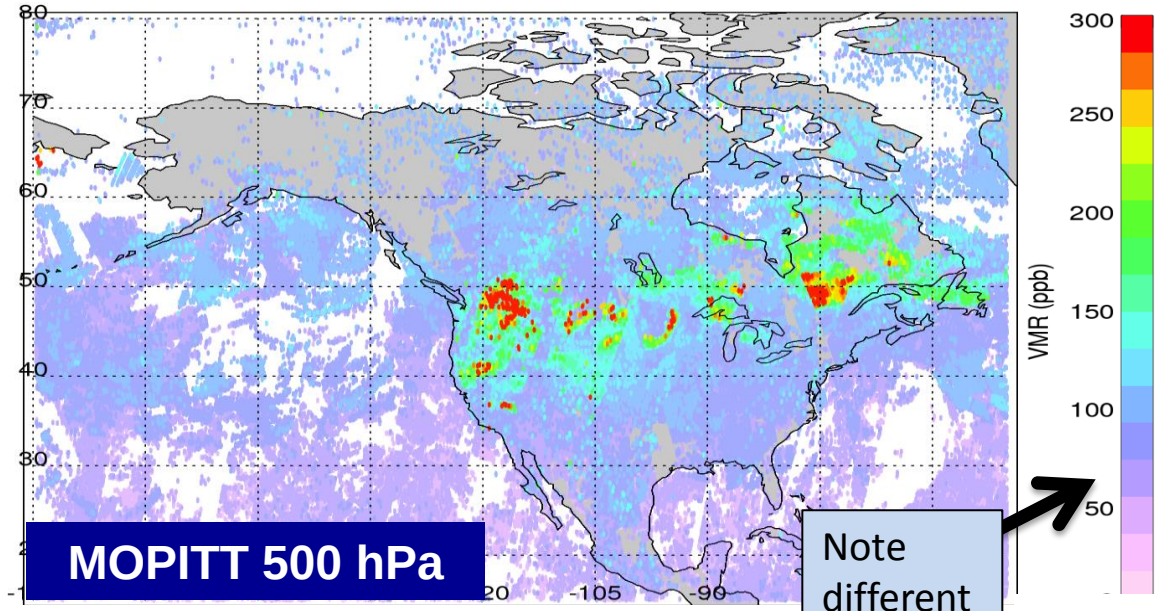
Measurement sensitivity

MOPITT:
Multi-spectral (NIR+TIR) allows enhanced surface sensitivity at CO source regions

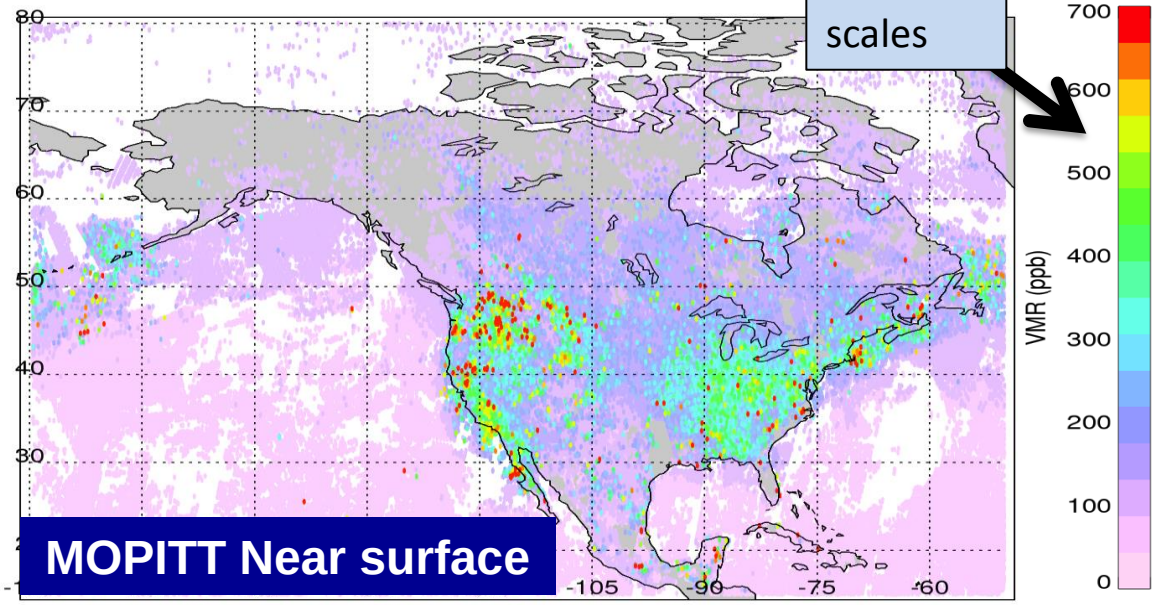
IASI:
TIR only; surface sensitivity reduced compared to MOPITT in day-land conditions

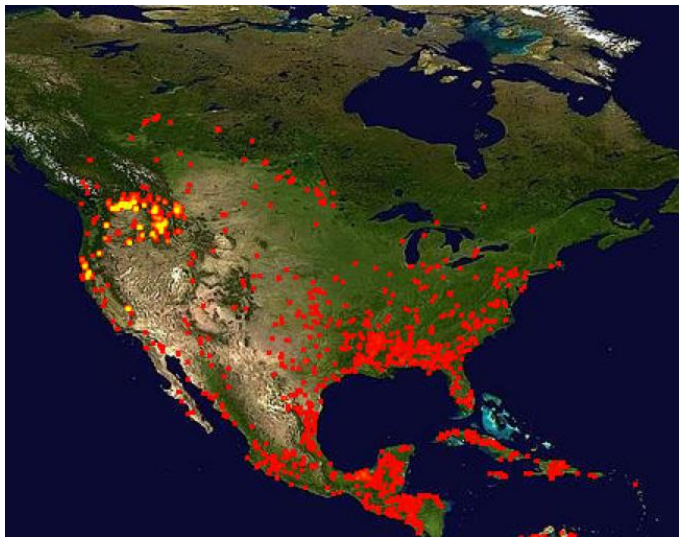


Multispectral retrievals distinguish signatures of pollution sources and transport



Note different scales

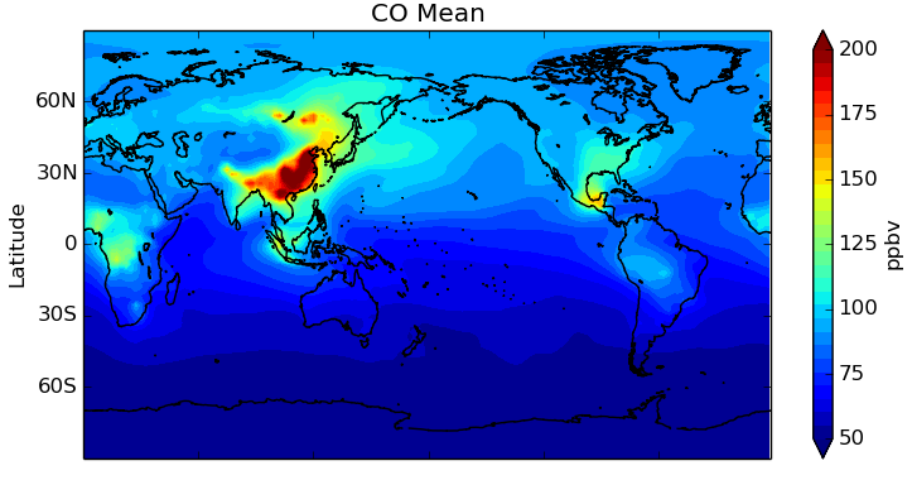


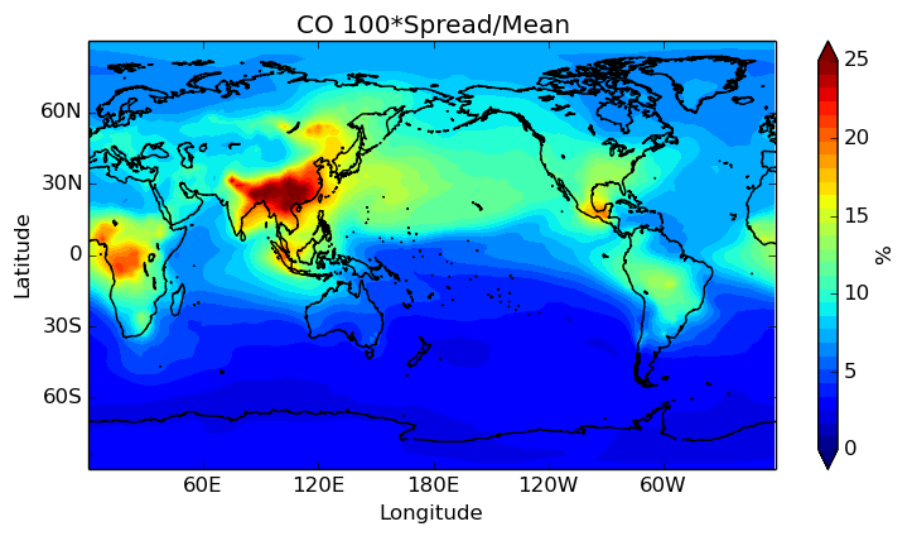


MODIS Fires 23 August, 2015: The Washington State fires in the north-central Okanogan Complex, is the largest in the state's history and has burned almost 400 square miles

MOPITT V5J multispectral retrievals of CO from MOPITT provide profile information that distinguishes fire source regions from free troposphere long range transport of pollution. 20-27 August 2015

Global model with assimilation





Surface-200hPa, June 2008 average

NCAR CAM5-Chem/DART EAKF

Emissions:
Anth: RCP8.5
Fires: FINN
Biog: MEGAN

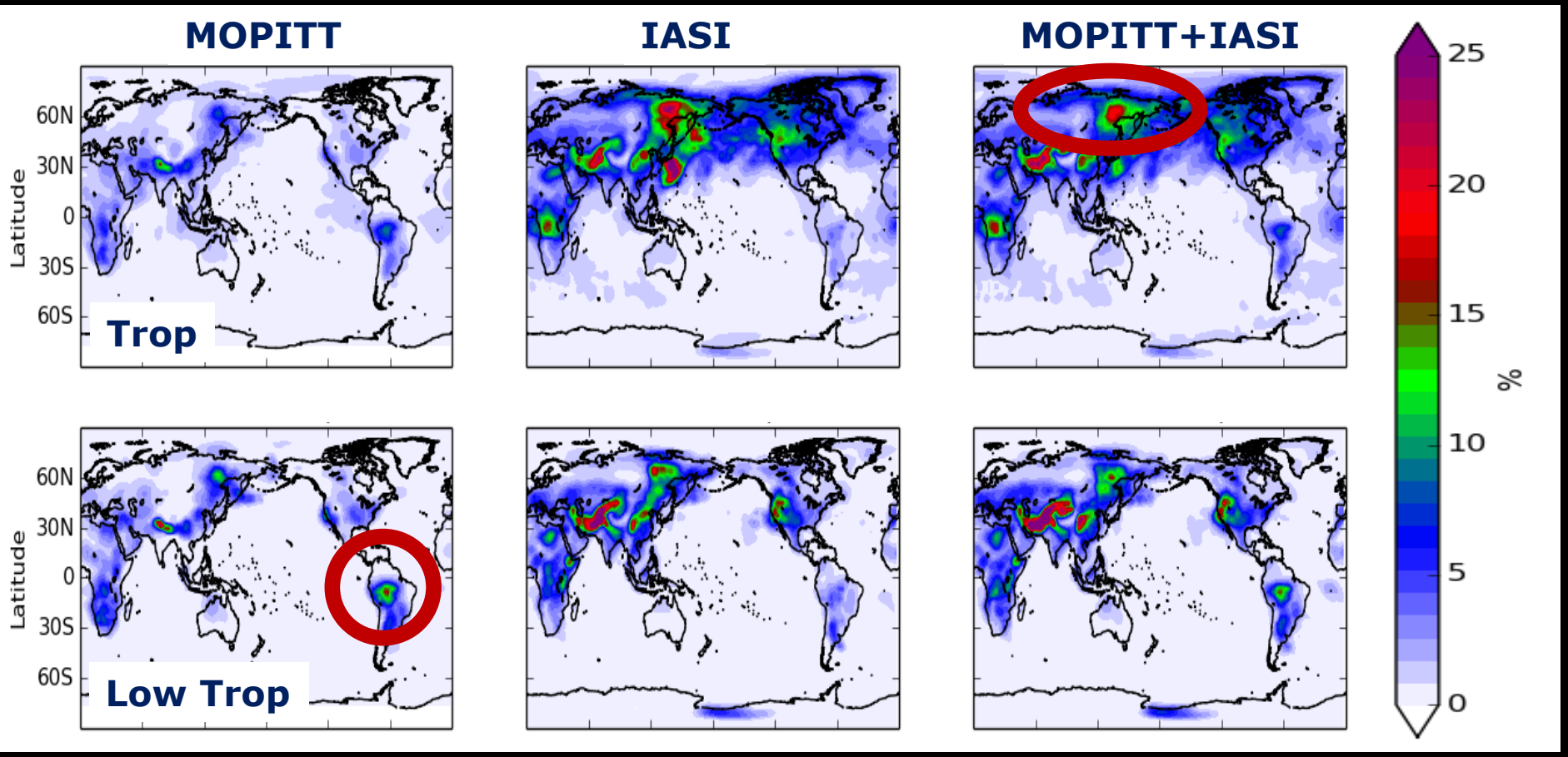
Chemistry:
MOZART "full" tropospheric chemistry
Aerosols (MAM) and chemistry
(87 species + 16 bulk aerosols)

Resolution:
Vertical: 30 levels (Surface - 3hPa)
Horizontal: 2°

DA Setup:
30 members, window 6h, perturbed emissions and meteo, Summer 2008: Spin-up April-May 2008, Assim. June-July 2008

Assimilation information impact as measured by higher RMS(Analysis-Forecast)

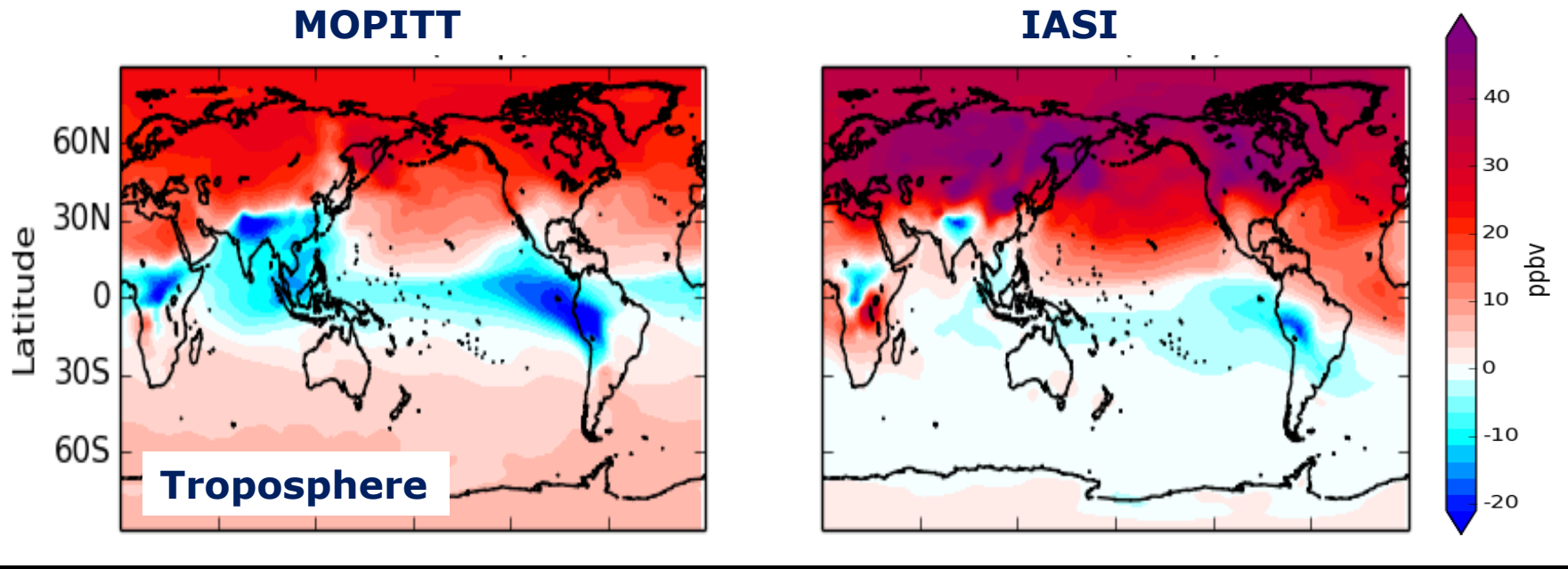
CO assimilation



- RMS generally stronger for IASI because of coverage and revisit
- Compared to IASI, MOPITT give a good constraint close to emissions because of near-surface sensitivity
- Combined assimilation shows both IASI and MOPITT increments

CO assimilation

Assimilation Runs – Control Run



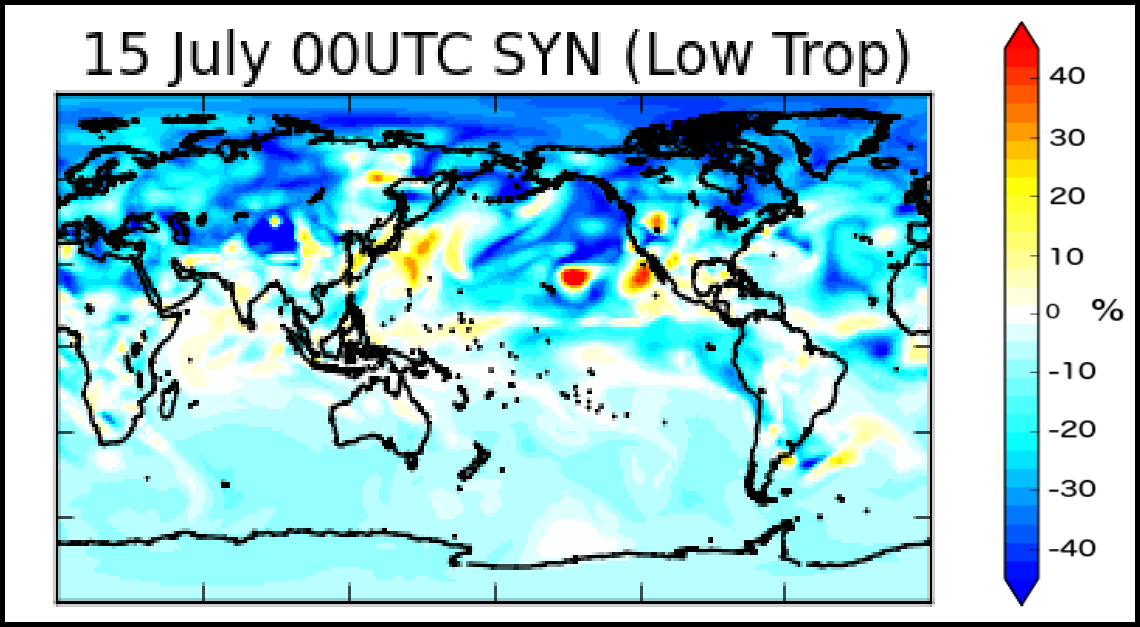
- Assimilation corrects model negative CO bias
- IASI provides stronger global constraint due much better coverage that MOPITT
- MOPITT decreases CO over BB source regions; but innovation persists out over the Pacific in the absence of new data to update assimilation

Synergies

SYNERGY: the creation of a whole that is greater than the simple sum of its parts (Barré et al., 2014)

$$SYN = [\,|DR - CR| - |IR - CR + MR - CR|\,] / CR$$

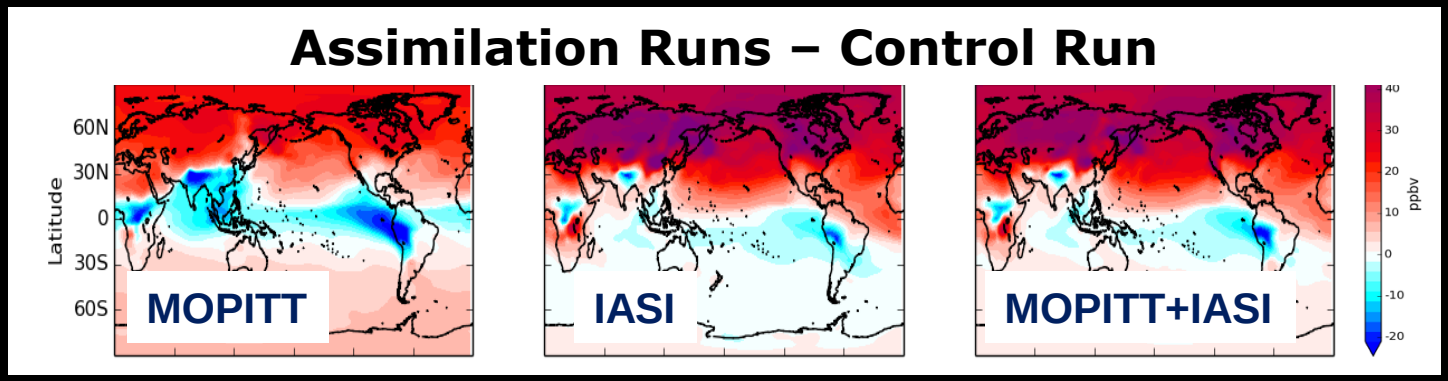
SYN<0 : redundant information
SYN>0 : synergistic information

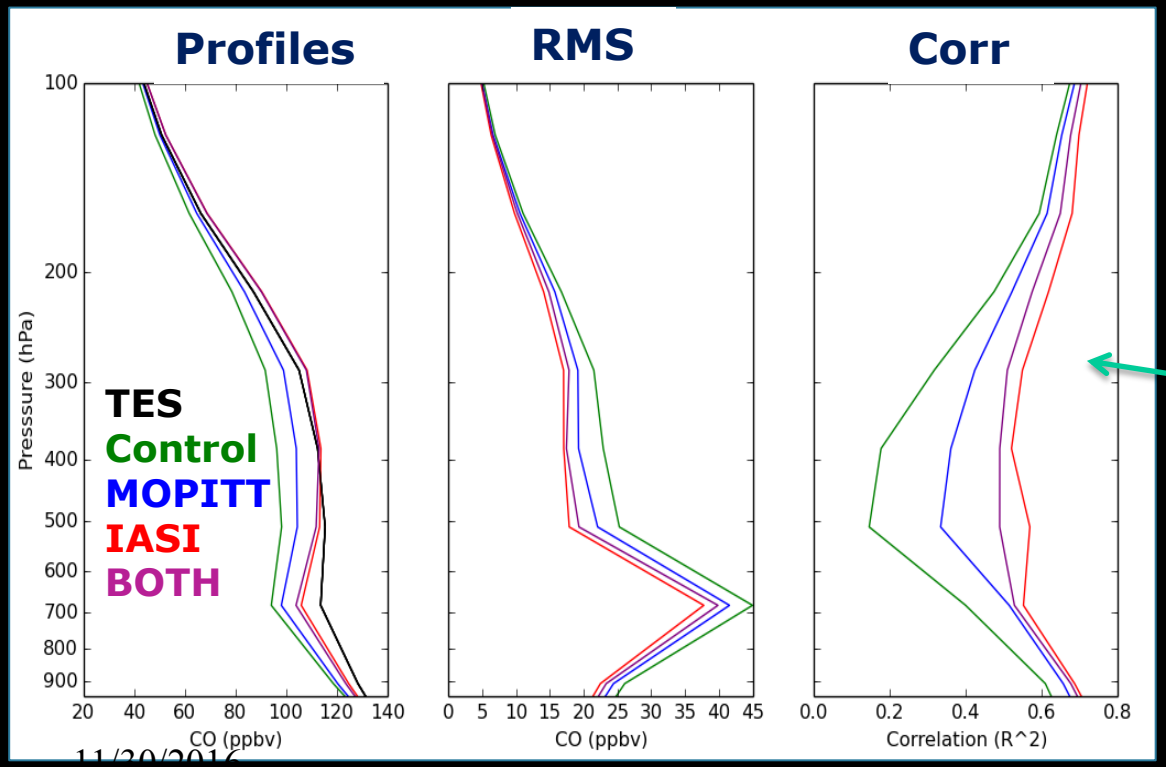


- Redundancy is more pronounced in arctic regions: CO lifetime longer; greater overlap of observations at pole; reduced MOPITT surface sensitivity
- Synergistic effects can be observed over, and downwind, of polluted regions when plume vertical information can be resolved
- "Blobiness" a result of patchy MOPITT coverage

Evaluation with TES CO

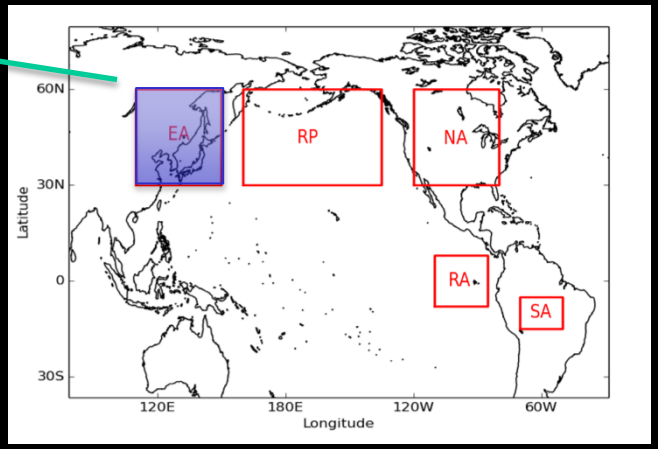
Eastern Asia July 2008





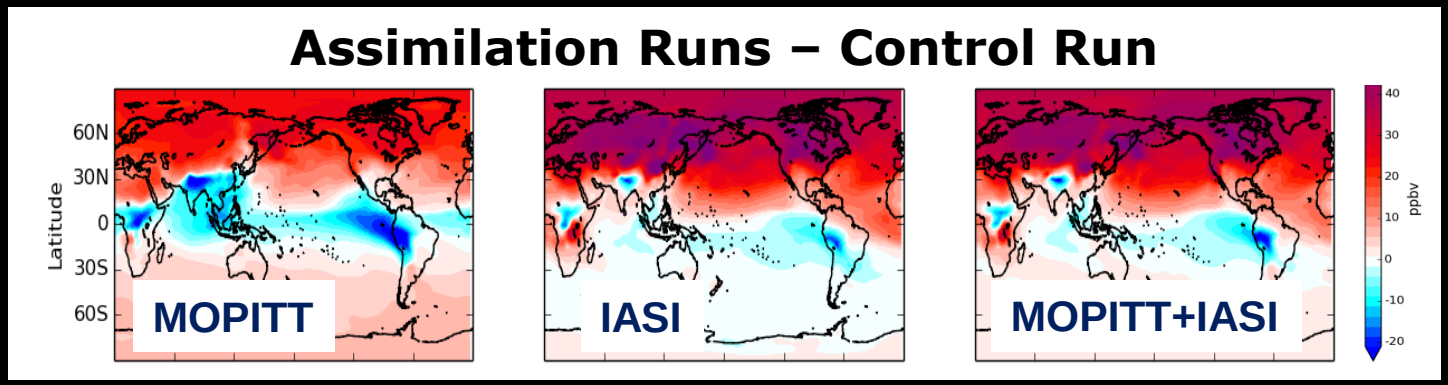
Revisit: IASI > MOPITT

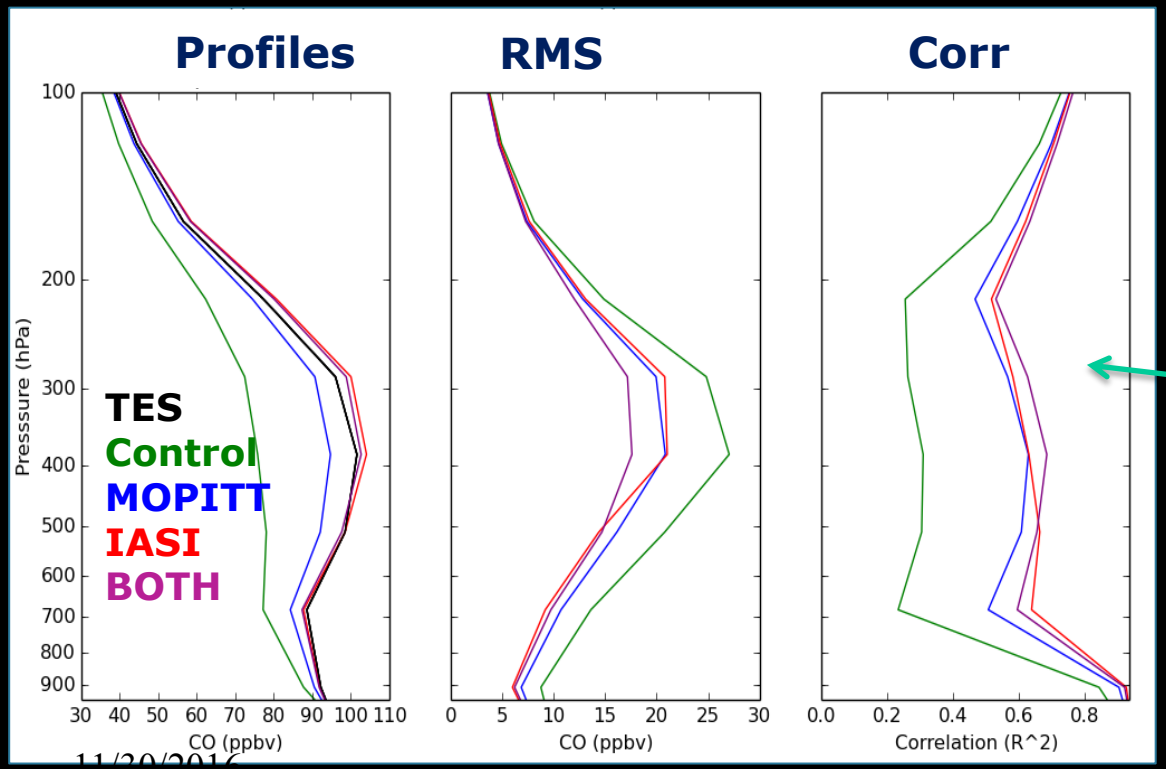
Crucial for reducing models errors due to active chemistry (VOC,Nox oxidations) and different emissions types



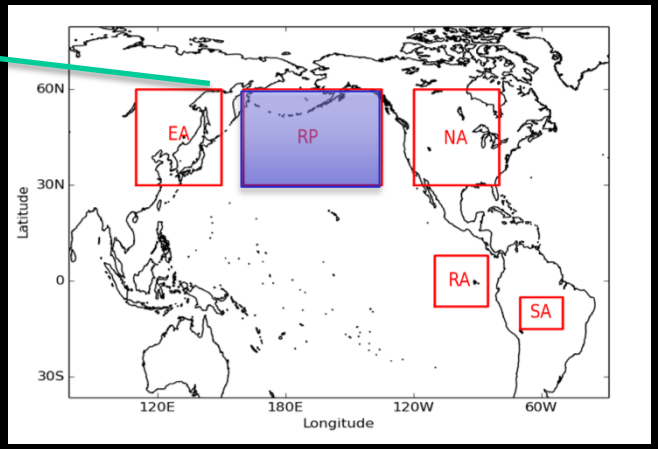
Pacific July 2008

Evaluation with TES CO



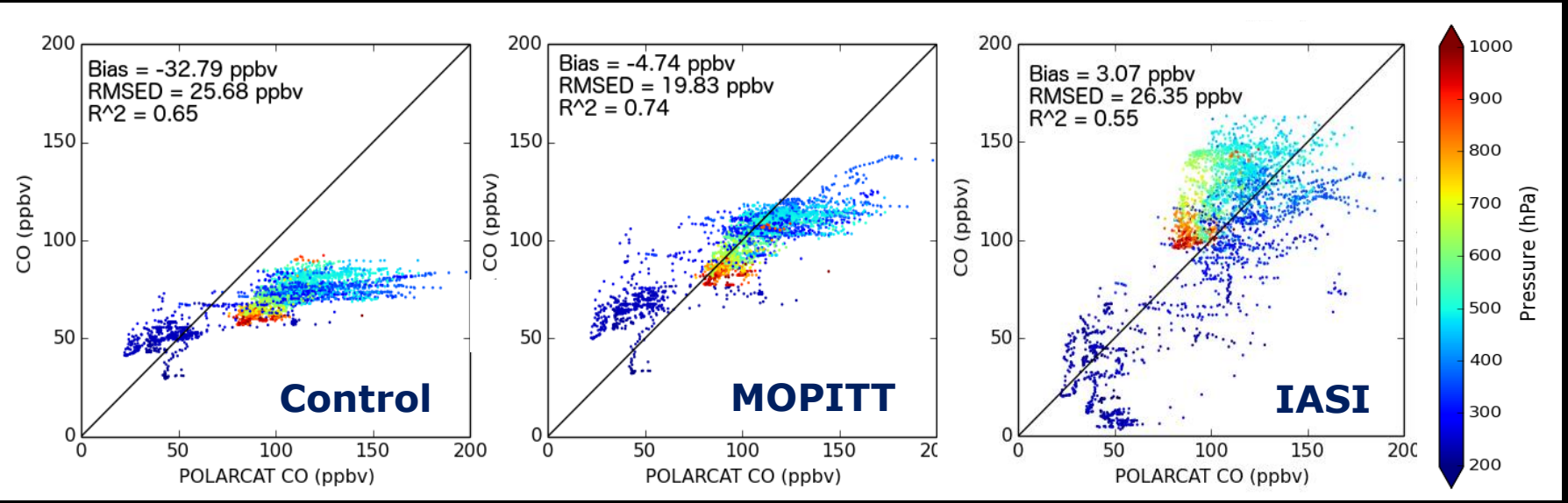


Similar performance for MOPITT and IASI in remote regions where revisit time is not so crucial to capture evolution of mid-trop plumes far from sources



Evaluation with POLARCAT

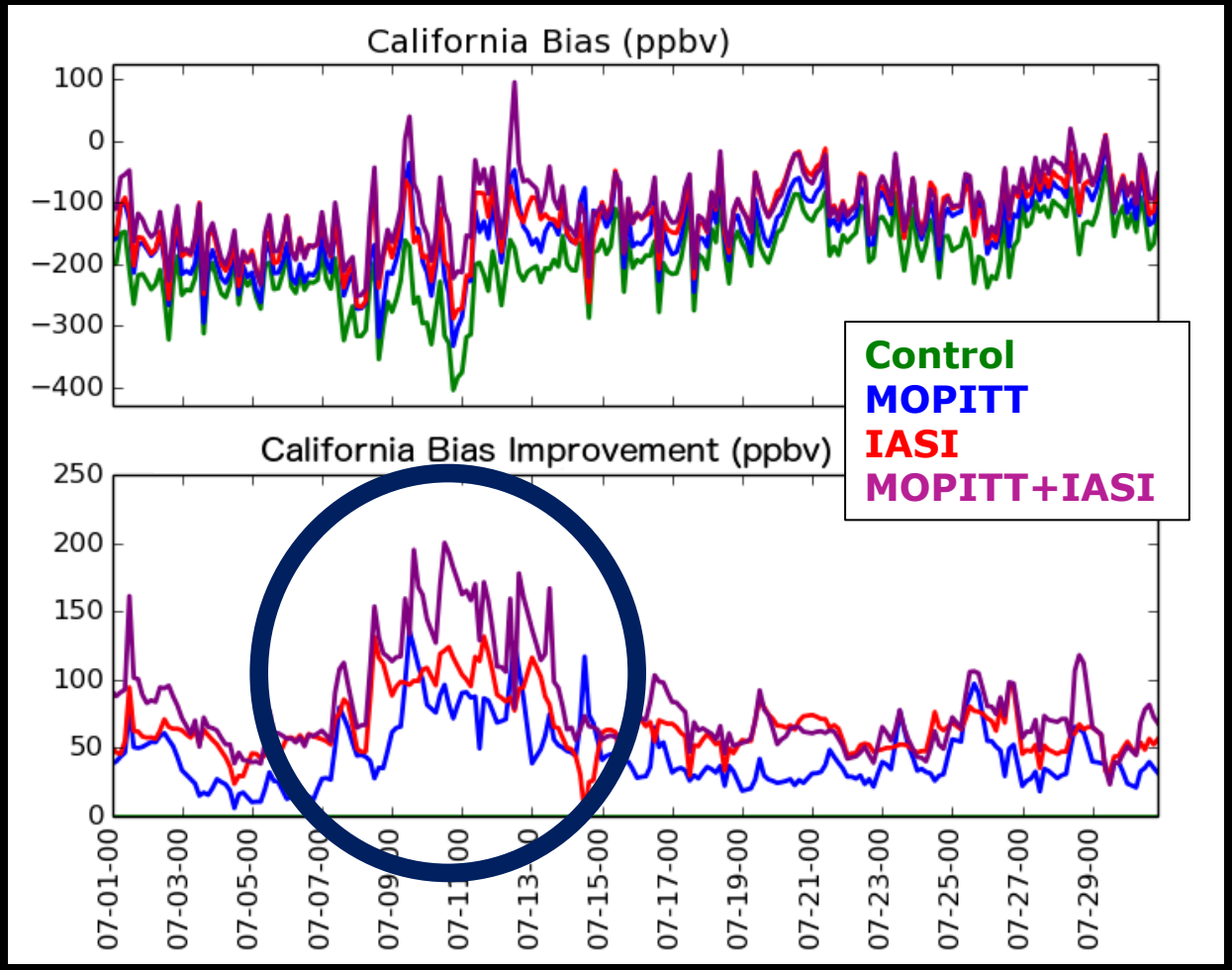
Arctic POLARCAT CO (altitude by color): June-July 2008



- Assimilation improved over control run
- Similar performance for MOPITT and IASI assimilation
- Slightly better statistics for MOPITT driven by vertical information from multispectral measurement

Surface evaluation with EPA data

Surface EPA CO: June-July 2008



- Overall negative bias: expected due to representation error; reduced by choosing only semi-urban and rural sites that miss high local urban concentrations
- IASI and MOPITT assimilation performance similar
- Value of extra profile info in combined assimilation for pollution event

Forecasts

ACOM | ACRESP | Forecasts | FINN | MOPITT-plots | IASI-plots | DC3 | SEAC4RS | KORUS-AQ

MOPITT / IASI MAPS

Valid Dates:

May 1, 2012 to present.

Region: Global

<< < September 2013 > >>

< Today >

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12

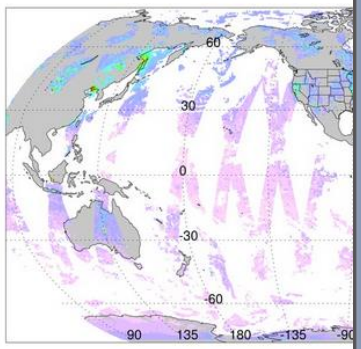
< Hr: 00 03 06 09 12 15 18 21 >

00:00 September 6, 2013

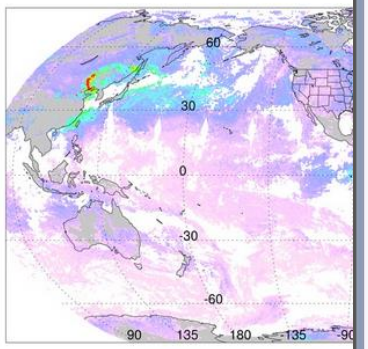
Play Stop

The MOPITT / IASI plots are a few days behind the current date.

NCAR/ACD MOPITT CO Total C



NCAR/FORLI IASI CO Total Col



ACOM | ACRESP | Forecasts | FINN | MOPITT-plots | IASI-plots | DC3 | SEAC4RS | KORUS-AQ

FORECAST MAPS

Valid Dates:

March 15-16 2016.

Region: Korea

<< < April 2016 > >>

< Today >

Sun	Mon	Tue	Wed	Thu	Fri	Sat
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
1	2	3	4	5	6	7

< Hr: 00 06 12 18 >

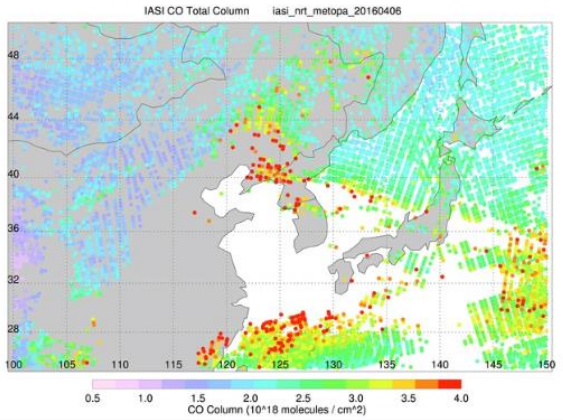
00:00 April 6, 2016

Play Stop

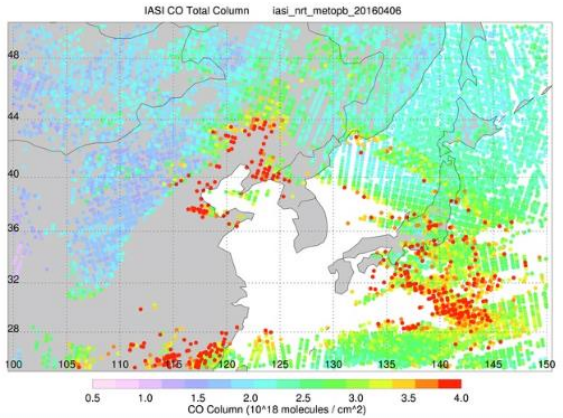
KORUS-AQ

IASI NEAR-REAL-TIME RETRIEVALS

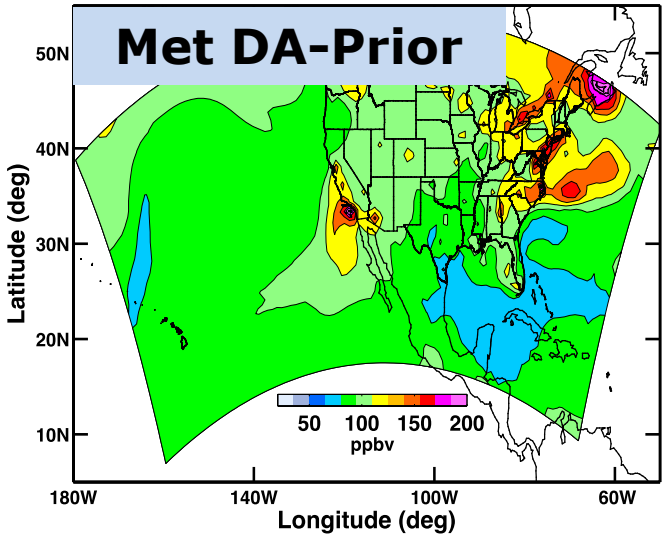
Satellite: **Metop-A**

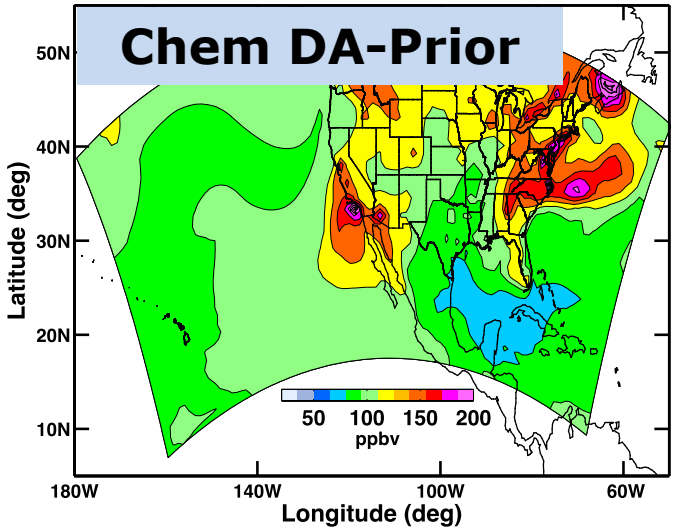


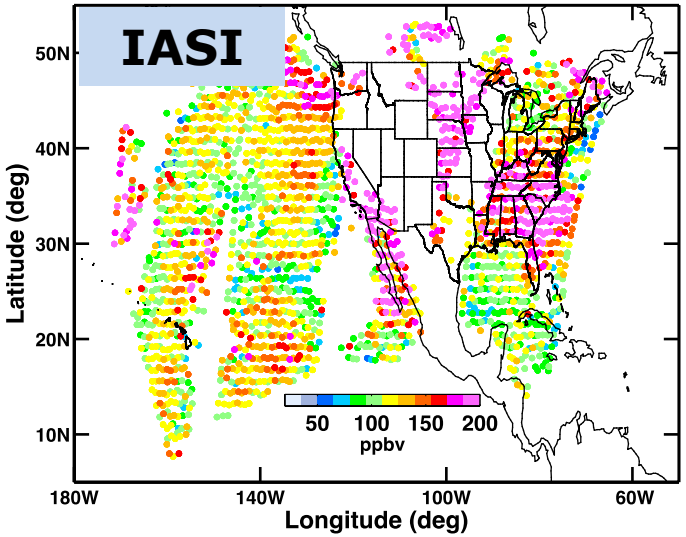
Satellite: **Metop-B**

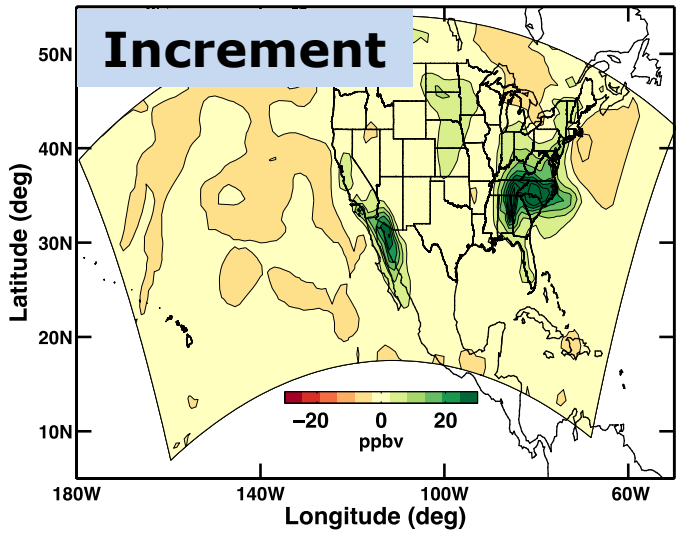


IASI CO assimilation in WRF-Chem/DART









18 UTC June 9, 2008 @ 900 hPa

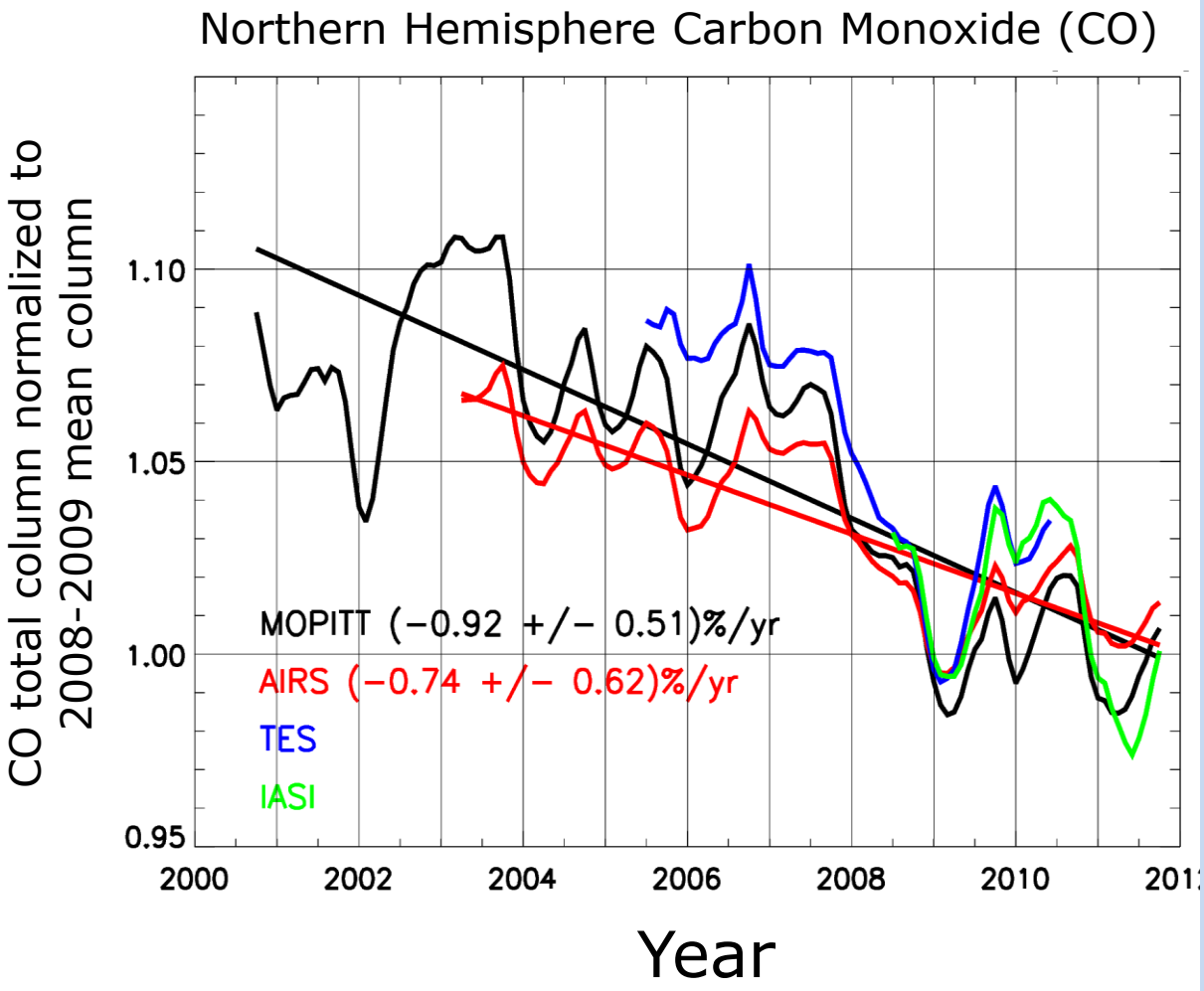
Courtesy A. Mizzi, NCAR

Summary

- Assimilation of MOPITT and IASI provide evaluation of the updated NCAR DA system
- Data coverage is key: IASI provides much better global constraint than MOPTT
- Multispectral MOPITT retrievals with independent near-surface CO estimates improve joint retrievals, especially near to source regions
- DA is being used to diagnose CAM Chem process uncertainty in CO sources, lifetime & vertical transport
- Moving onto regional assimilation

Thank you!

Decreasing carbon monoxide observed in satellite decadal records



Worden et al., ACP, 2013

- All nadir-viewing satellites measuring total column CO using thermal infrared (TIR) absorption show consistent inter-annual variability.
- Year-to-year fluctuations are mostly due to fires and the global recession in late 2008 – 2009.
- Decreasing CO emissions are expected in N. America and Europe, but not China, where decreasing CO is also observed.
- Longer data records are required to determine significant trends.