A DART/CAM-Chem reanalysis of MOPITT observations

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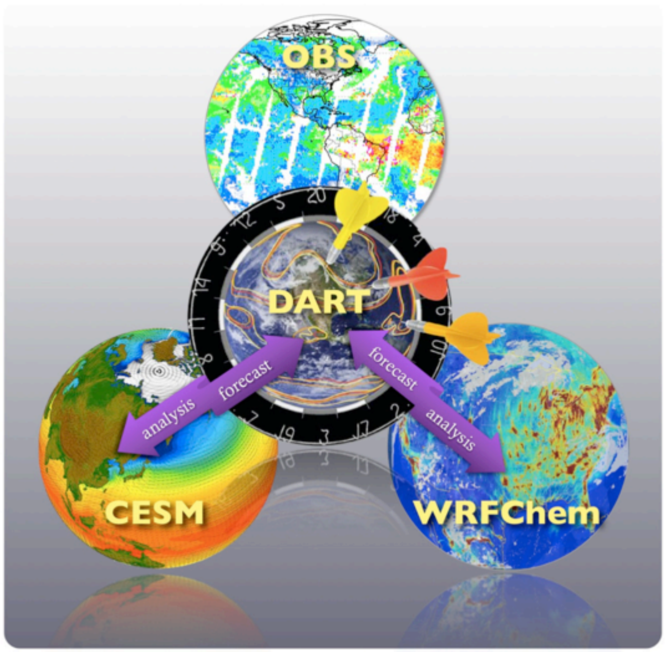
CESM Chemistry Climate Working Group Meeting
9 February 2016
NCAR, Boulder, Colorado

Satellite CO assimilation : tools



➢Data Assimilation Research Testbed (DART)

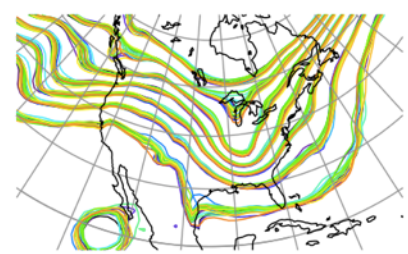
- ❖Open source community software for ensemble (EAKF) DA (Anderson et al. 2009)

➢Community Atmosphere Model (CAM)

- ❖Reanalysis of meteorological observations in DART/CAM4 (Raeder et al. 2012)

➢CAM-Chem : CAM with Chemistry

- ❖MOPITT-CO assimilation (Arellano et al. 2006, 2010)
- ❖Joint MOPITT and IASI CO assimilation (Barré et al. 2015, JGR)
- ❖MOPITT-Reanalysis: Frozen version CESM122/CAM4Chem



Independent observations for evaluation
in-situ aircraft and surface measurement,
ground-based infra-red spectrometer

CESM / CAM-CHEM

CESM122 (updated Tilmes et al. 2015)
CAM 4 physics / Free running run
MOZART tropospheric chemistry, Bulk Aerosol Model
1.9×2.5^{o} / 26 vertical levels

- **Ensemble of emissions (+CO tags)**
- **Ensemble of transport**
- **Ensemble of deposition (land model)**
- **Ensemble of Chemistry**

Ensemble of optimized initial conditions every 6 hours

DART

Assimilation
-> update CO concentration
And Meteorology
Weighted mean of observations and model knowing respective errors

Ensemble of forecast
best CO estimate (Ensemble mean)
and CO errors
(Ensemble standard deviation)

Observations, plus errors

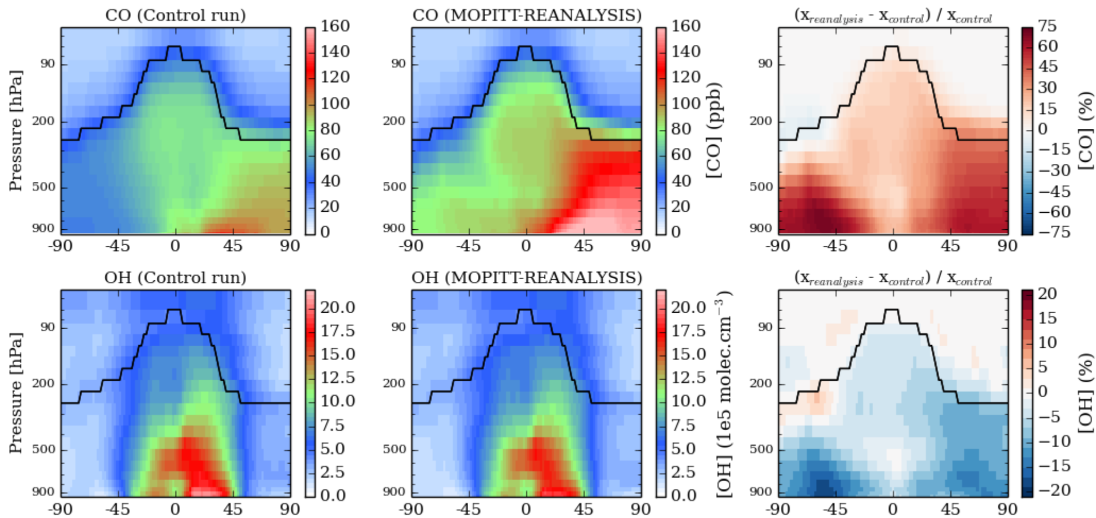
Observations

- **MOPITT-CO V5J daytime retrievals**
- **Meteorological observations**

MOPITT Reanalysis run

Reanalysis First year : Control-Run vs. Reanalysis
Impact of assimilation on chemistry

- **Increase in CO by assimilating MOPITT reduces OH**
- **As for SD assimilating meteorology diminished the CH4 lifetime**
- **<u>Improved CH_4 lifetime</u>**



	Model configurations	CH_4 lifetime (yr)
Tilmes et al. 2015	CAM5-Chem	8.4
	CAM5-Chem (SD)	7.83
	CAM4-Chem	8.82
	CAM4-Chem (SD)	8.4
This study	**CAM4-Chem (DART)**	**8.7**
	MOPITT Reanalysis	**9.3**

Reanalysis First year : Control-Run vs. Reanalysis

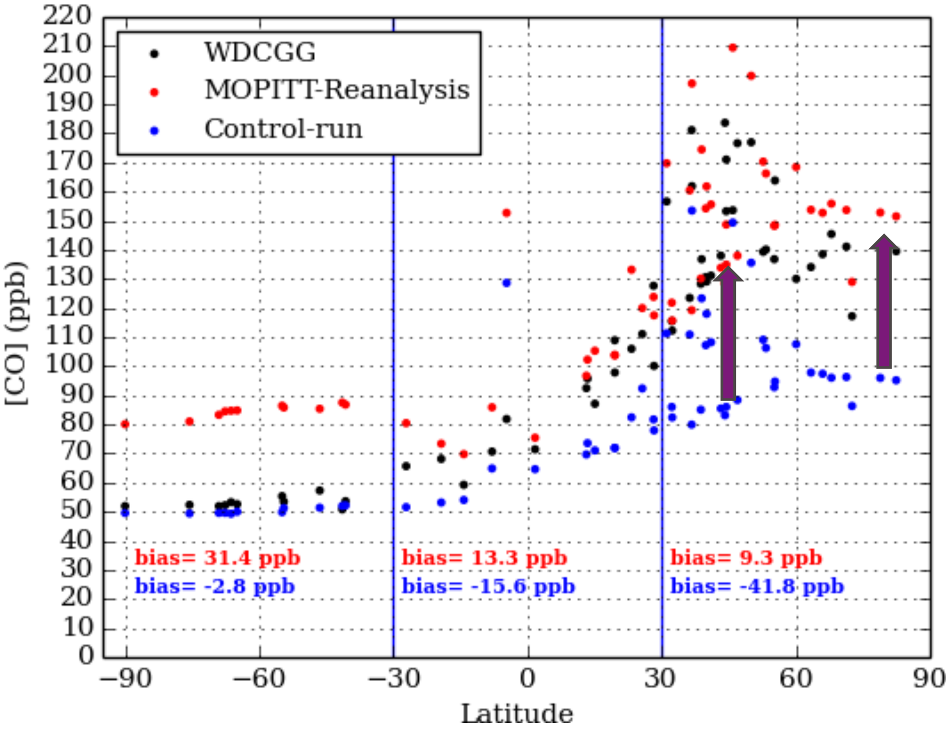
- Exact same runs with assimilated meteorology, Reanalysis assimilates MOPITT-CO (Gaubert et al. submitted to JGR)

- Evaluation against MOPITT, NDACC FTS, WDCGG sites, MOZAIC aircraft profiles, SMOCC aircraft campaign over the amazon.

- Slight overestimation high latitudes, clear bias extra-tropical SH

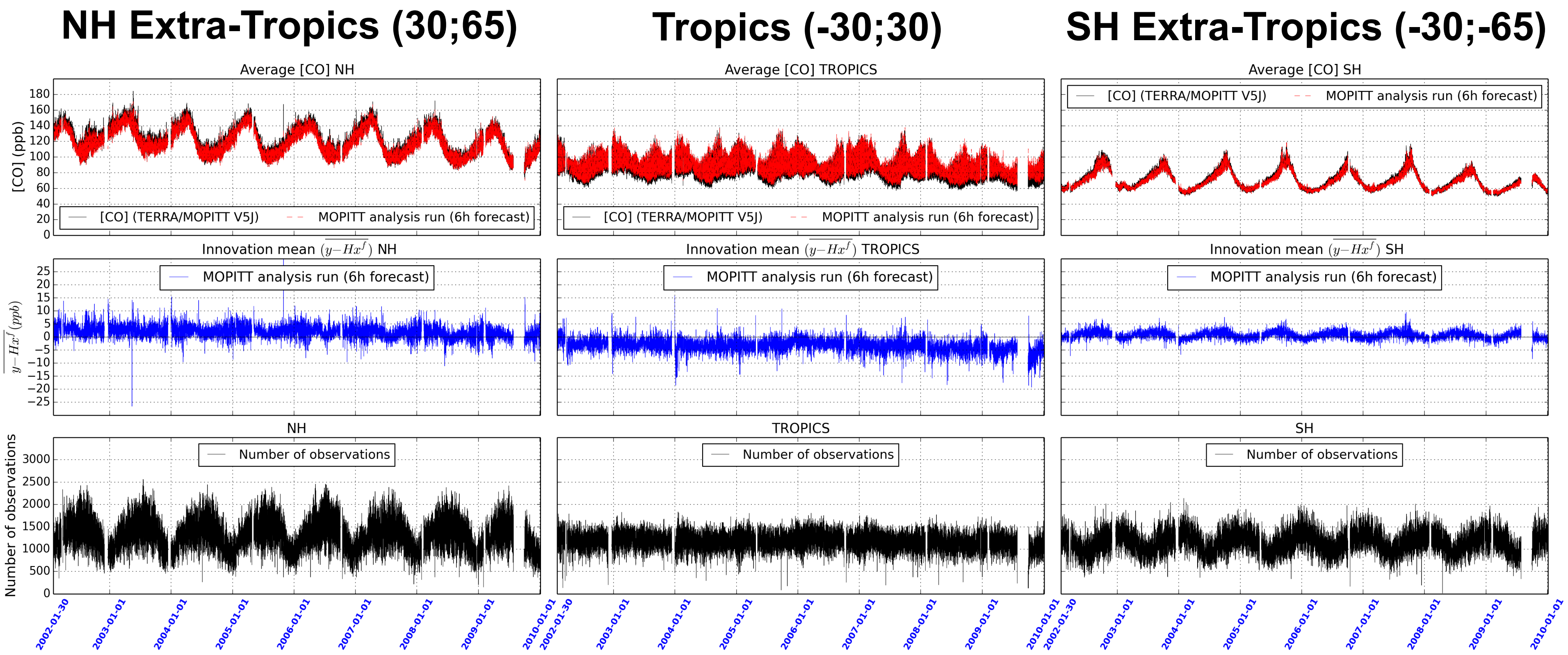
- Usual (but not always) underestimation of BB in the tropics

- Best improvement in the lower/ middle troposphere over land (Satellite accuracy) and during the winter/spring bias (higher model errors)



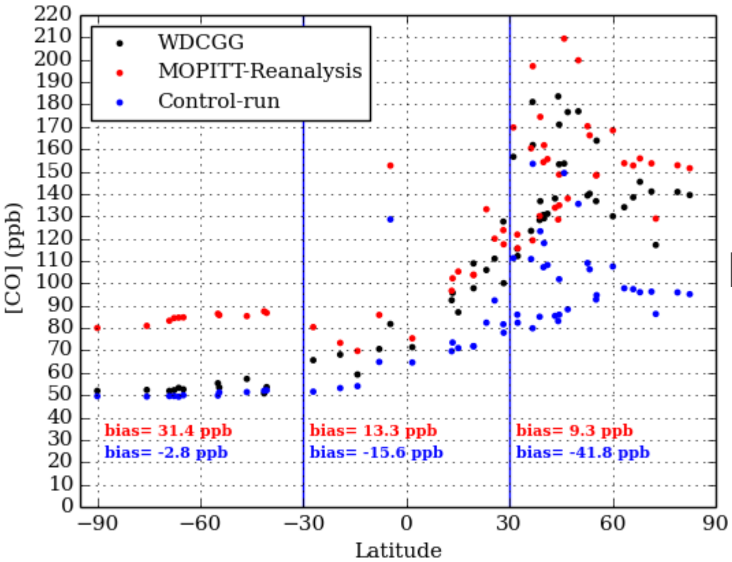
Comparison against surface observations

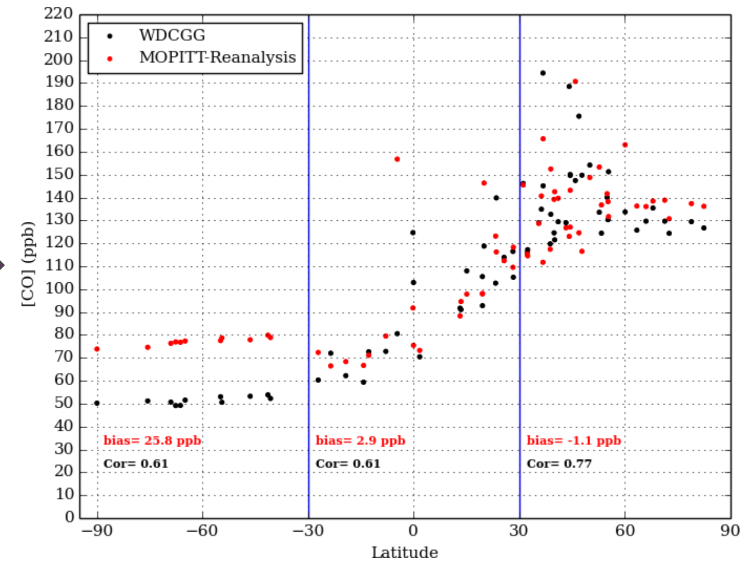
Comparison against assimilated MOPITT observations (MOPITT-Reanalysis)



- ➢ Stable number of assimilated observations and of the bias values
- ➢ Slight underestimation in the NH extra-tropics / overestimation tropics
- ➢ Bias is lower than the observation error

MOPITT-Reanalysis @ Surface

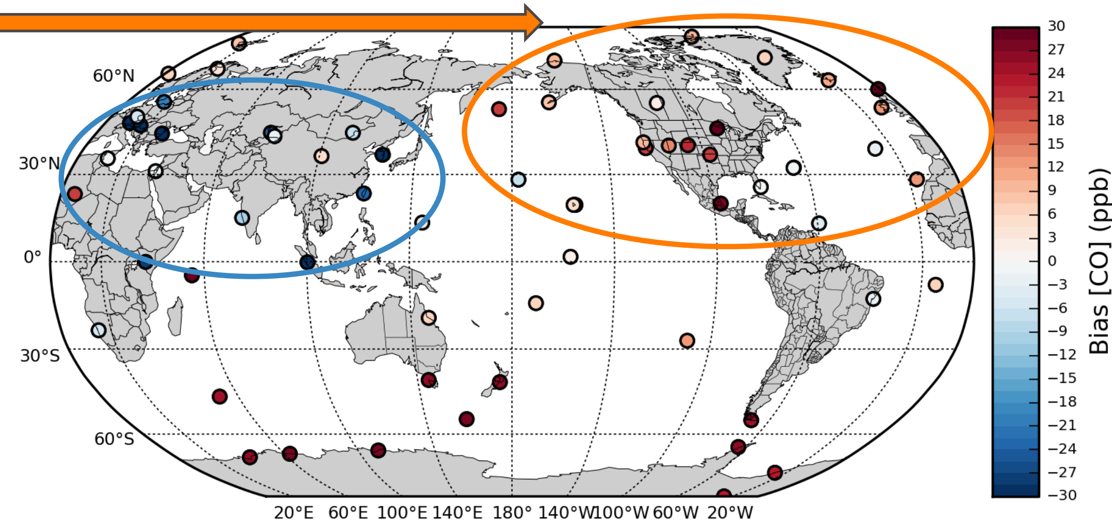




WDCGG surface observations

April 2002 to April 2003 | **Feb 2002 to October 2009**

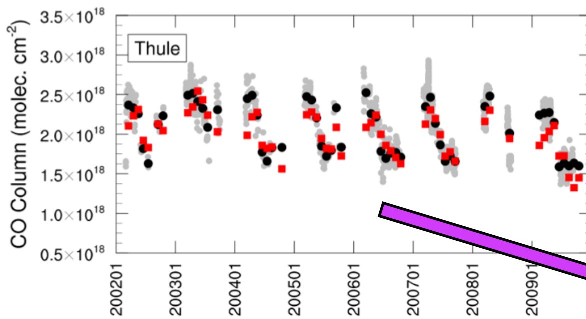
- **Actually positive or null bias**
- **While it is negative in Europe and East Asia**

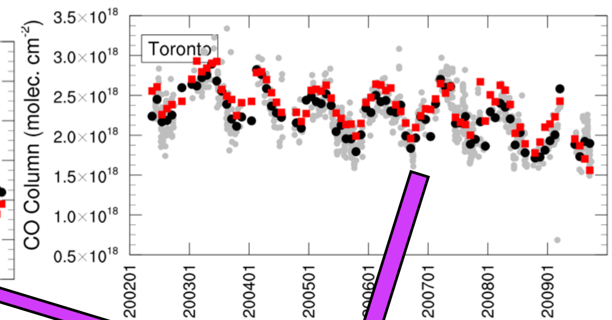


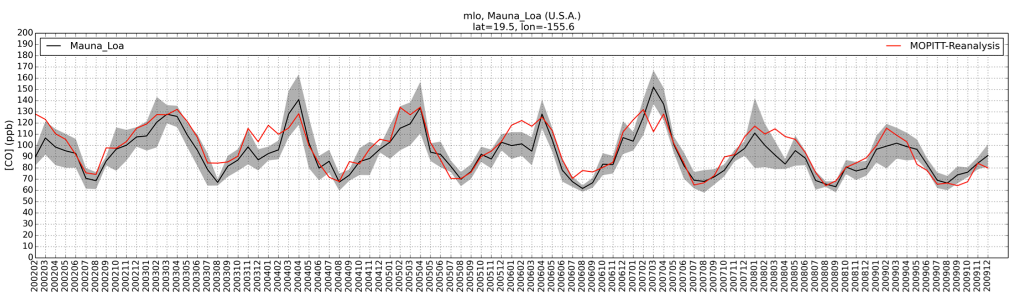
MOPITT-Reanalysis

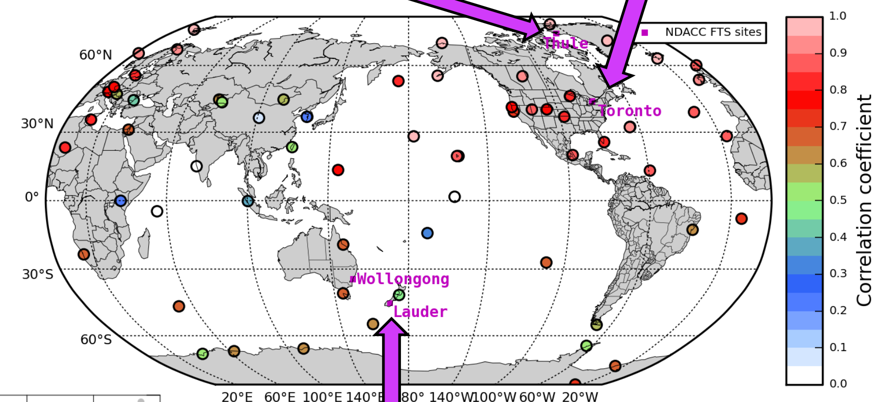
Variability @ WDCGG + NDACC sites

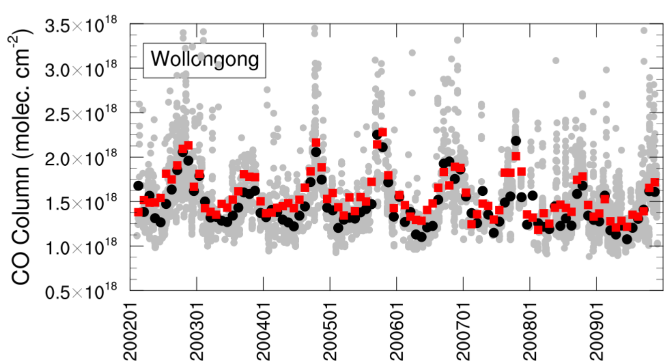
- ➢Excellent variability in the NH
- ➢More complicated SH / Indian ocean,
- ➢Even if transport of BB sources is usually improved

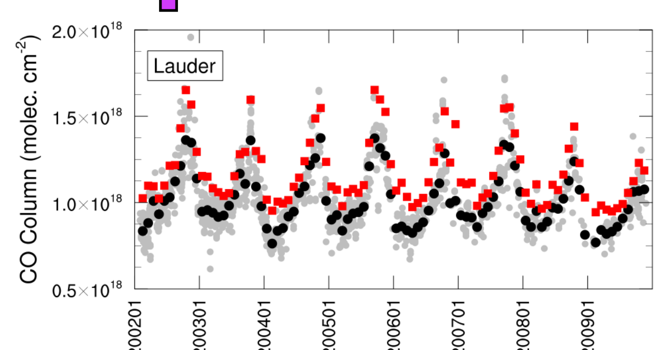












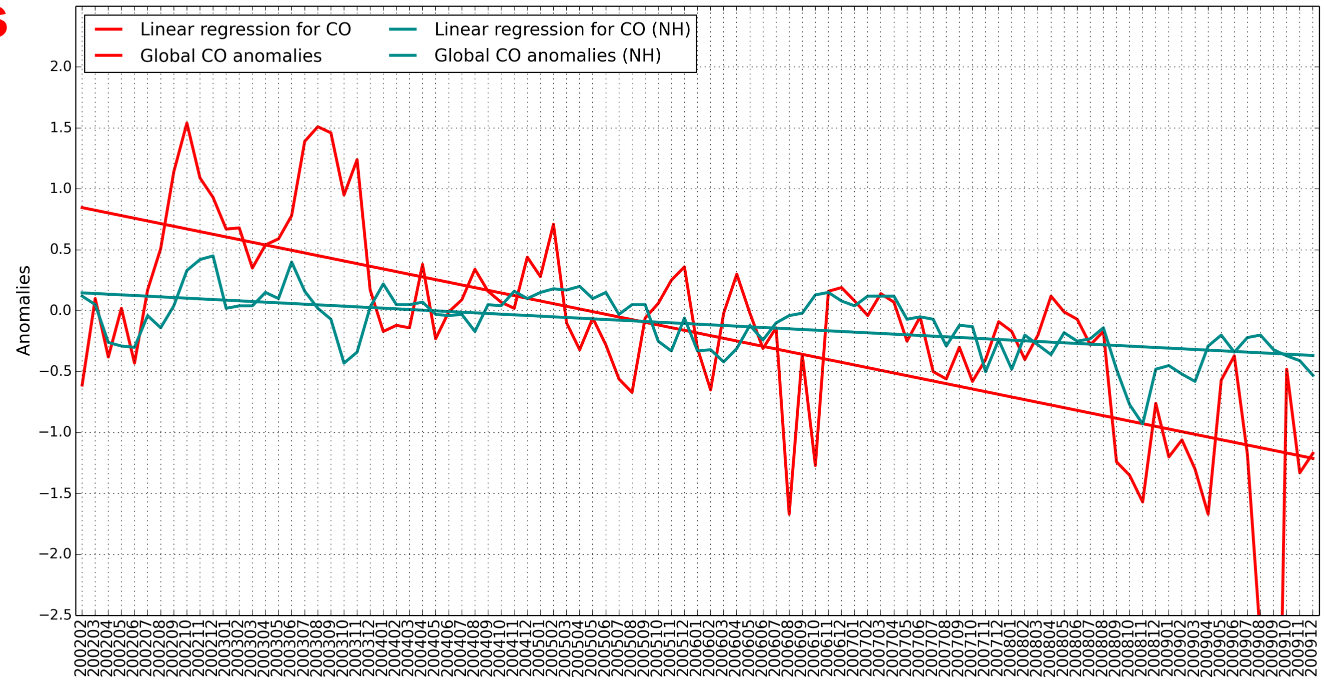
MOPITT-Reanalysis

Preliminary results

Anomalies @ Surface level

February 2002 to December 2009

- ➢ **Global : -2.2 %/yr**
- ➢ **El Nino leads to negative anomalies and aggravating the trends (2009)**
- ➢ **NH : -0.55 %/yr**
- ➢ **2008 Financial crisis**
- ➢ **Interannual variability is driven by BB**



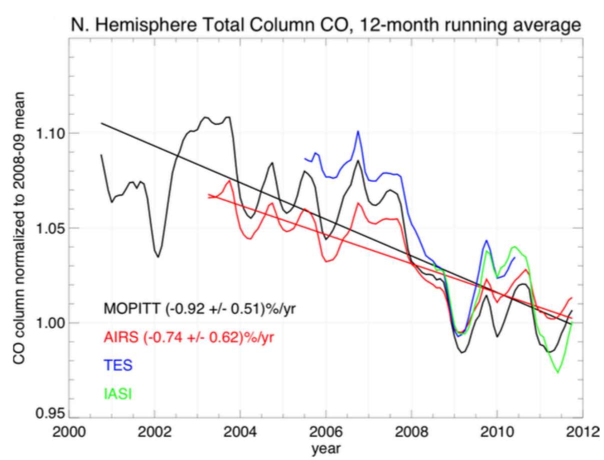


Fig. 6. 12-month running averages for N. Hemisphere total column CO measurements normalized by the 08/2008–07/2009 average CO column for each instrument.

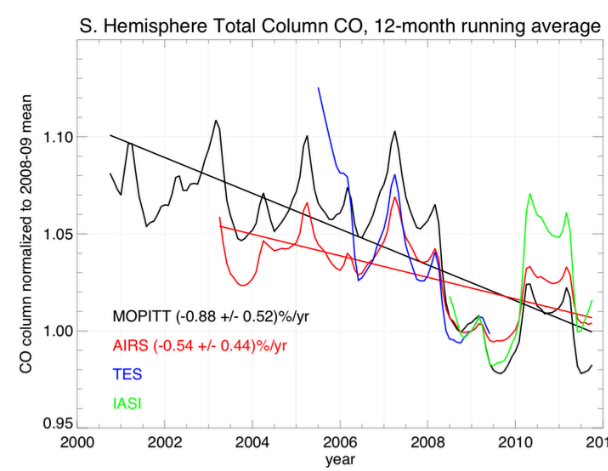
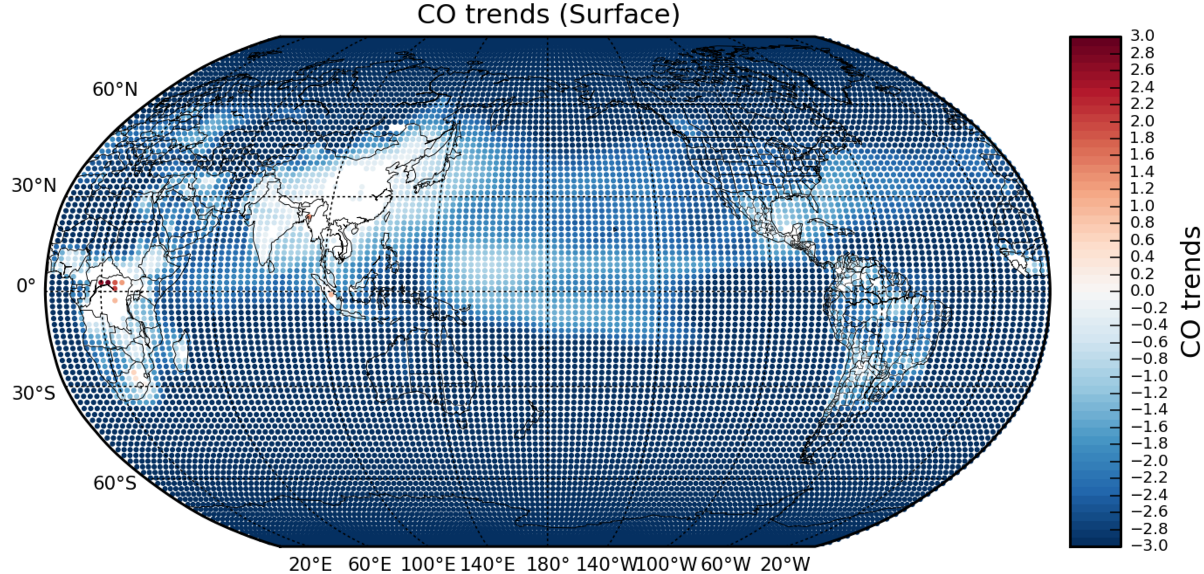


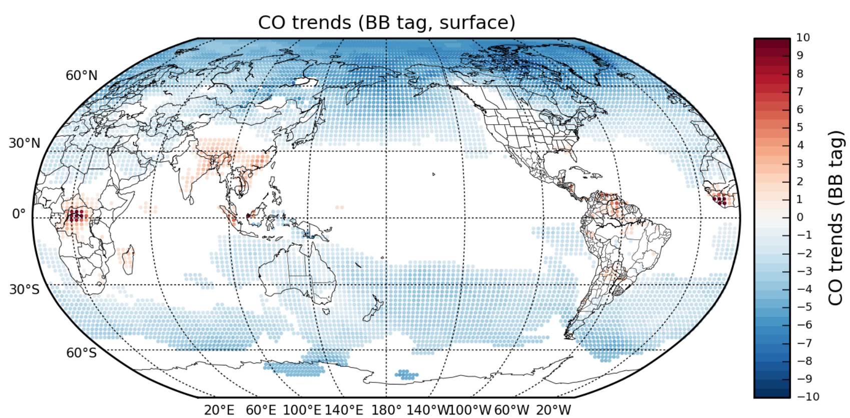
Fig. 7. 12-month running averages for S. Hemisphere total column CO measurements normalized by the 08/2008–07/2009 average CO column for each instrument.

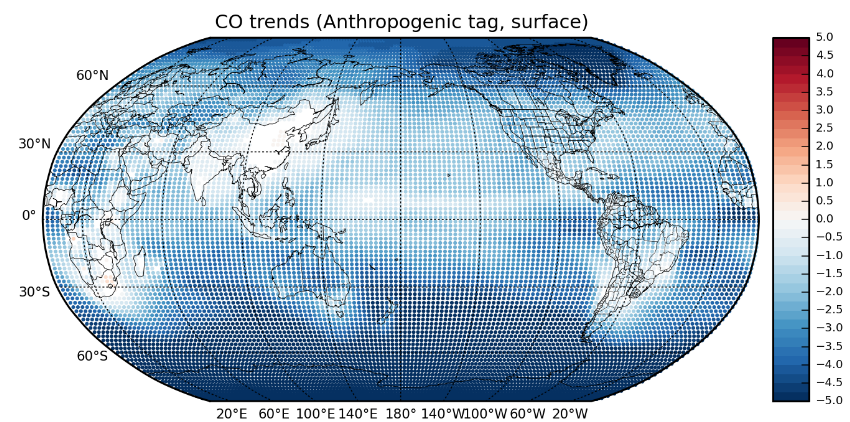
MOPITT-Reanalysis
Preliminary results



- Consistent with MOPITT observations
- Tags indicates that local increase are related to BB

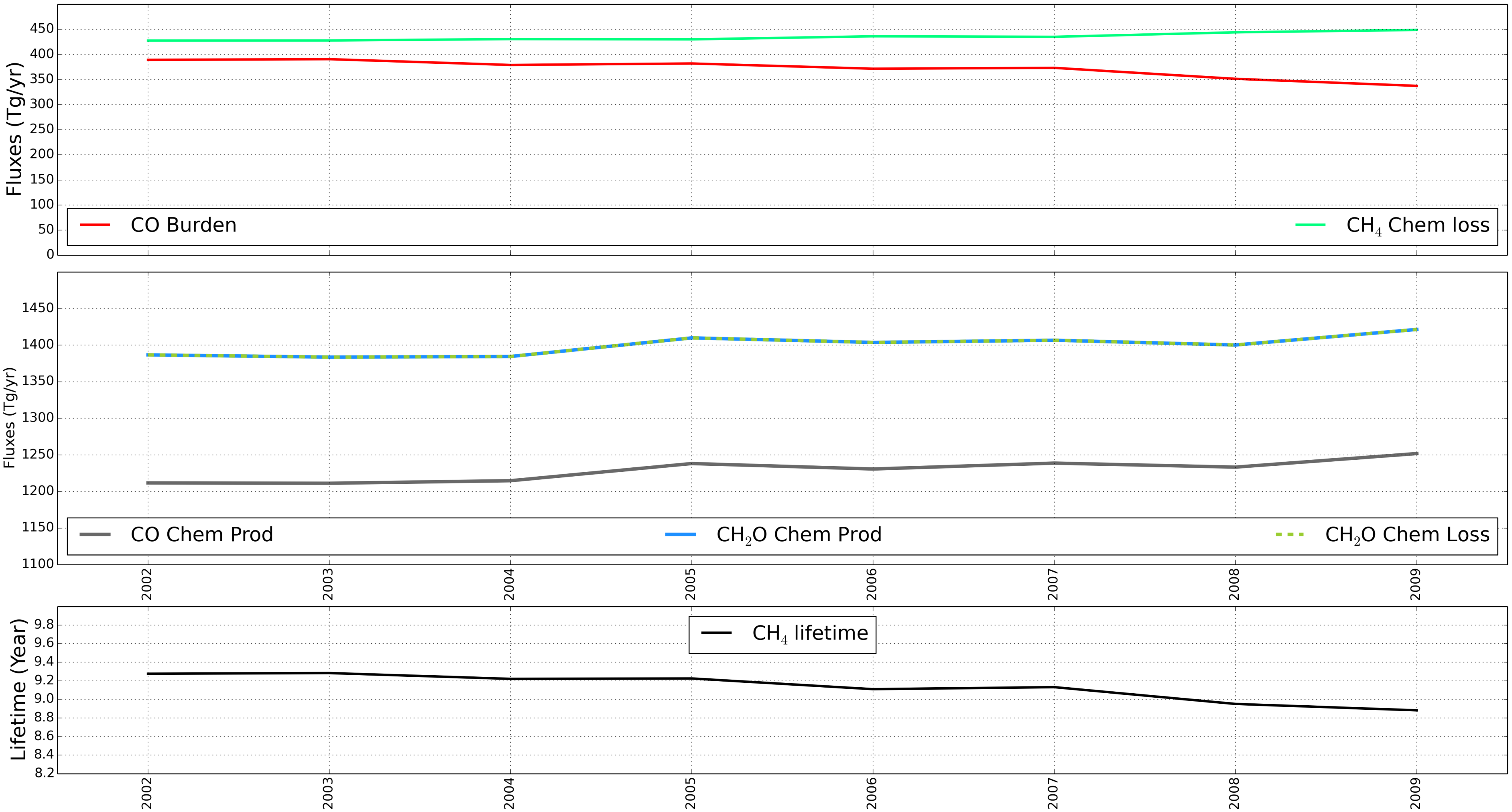
Slope of the regression in percentage
@ Surface level
Shown if p-value < 0.05
February 2002 to December 2009





MOPITT-Reanalysis Preliminary results

- Decrease in CO increases CO chemical production (at the high end)
- Decrease Methane lifetime by 4 months



- Efficient assimilation, in particular over the NH
  - ✓ Allows bridging the gaps between the model and observations, in particular in the NH.
  - ✓ Can be use as a reference instead of a MOPITT comparison (in particular for high temporal resolution)

- Brings complementary information as opposed to other assimilation techniques (Yin et al. 2015 shows negative trends in chemical production)

- Emission inversion step

- **NCAR-CISL** for computational ressources
- **DART team**
- **NASA**
- **NOAA**
- **NDACC**
- **MOPITT data are available at:**

https://www2.acd.ucar.edu/mopitt