Atmospheric CO_2 Observations from Space (ACOS): Preliminary Results from GOSAT Data Analysis

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OCO-2 Science Lead

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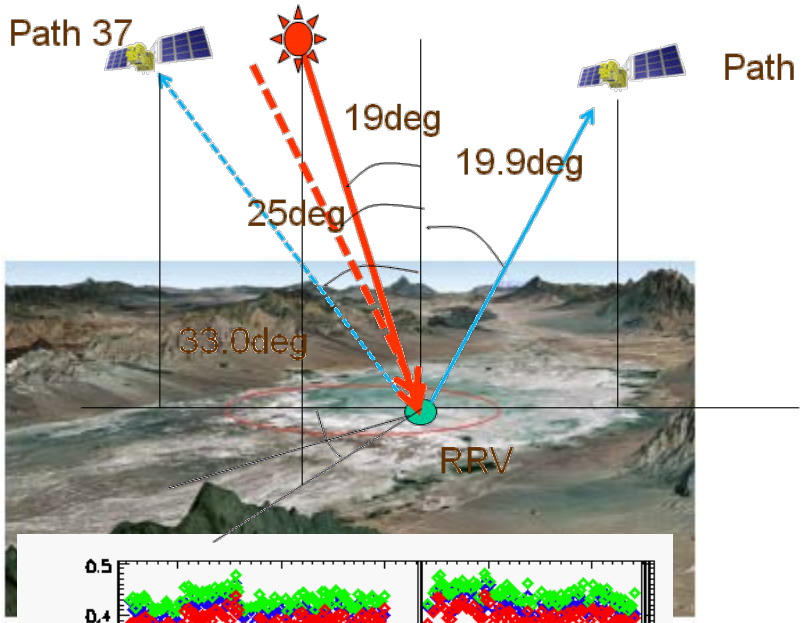
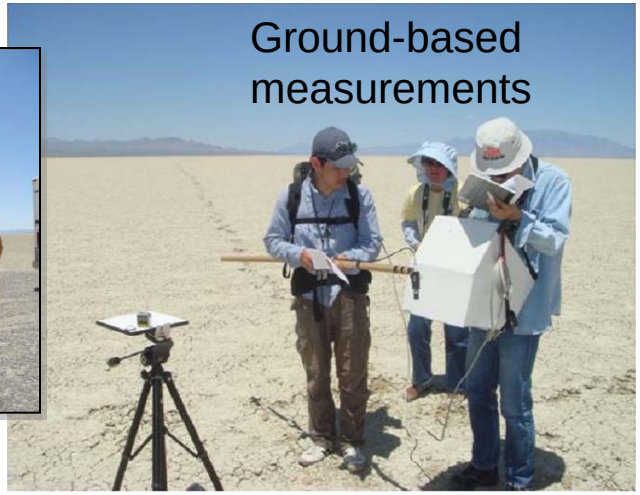
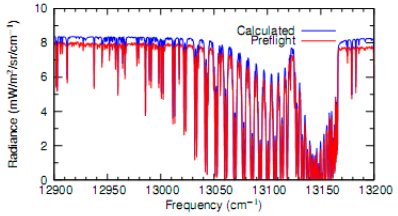
Atmospheric Carbon Observations from Space (ACOS)

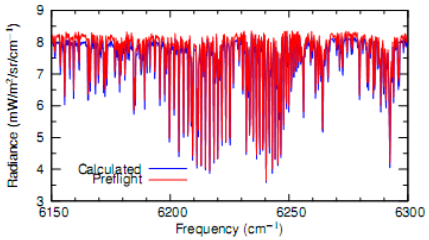
- The OCO and GOSAT teams formed a close partnership during the development phases of these two missions to:
  - Cross calibration the OCO instrument and TANSO-FTS
  - Cross validate the OCO and GOSAT data against a common standard
- After the loss of OCO, NASA reformulated the OCO science team as the Atmospheric Carbon Observations from Space (ACOS) task to
  - meet its obligations to its GOSAT partners
  - prepare for more rapid data delivery for OCO-2
- The ACOS program supports
  - Vicarious calibration campaigns in Railroad Valley, Nevada
    - first deployments: June 2009; AVIRIS over-flights: October 2009
  - Retrieval of X_{CO2} from GOSAT data
    - Model development, implementation, data production and delivery
  - Validation activities
    - Manage TCCON network and operate OCO TCCON stations
  - Participation in Technical Interface Meetings

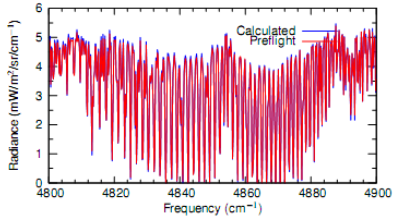
Vicarious Calibration Experiment Team
22 June – 6 July 2009









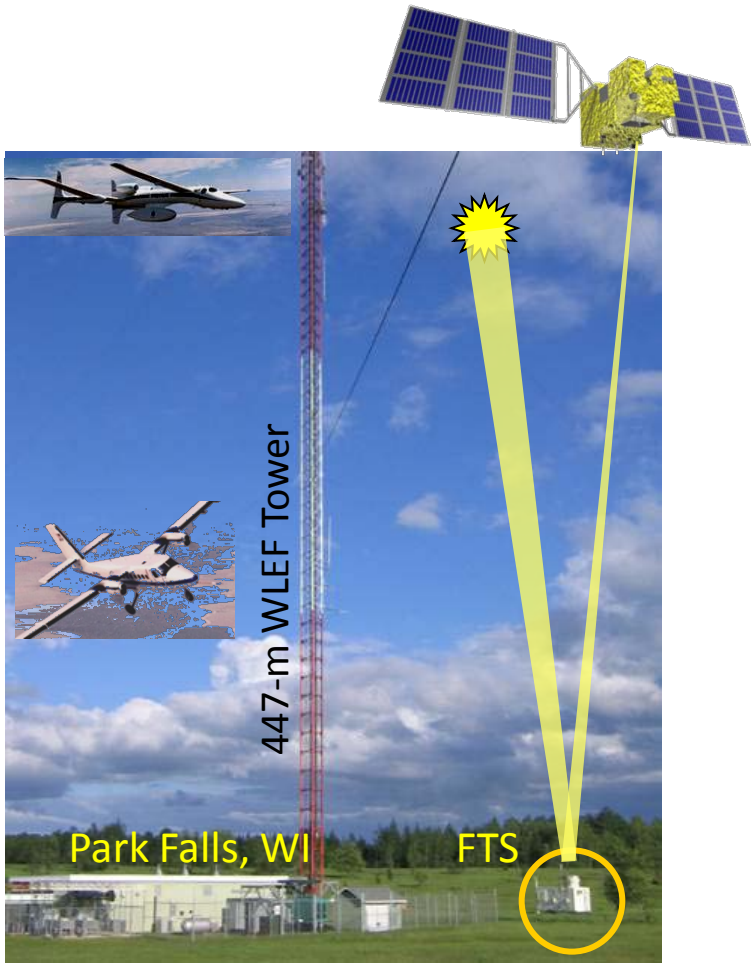


Simulated radiances indicate up to 6% degradation in A-band

Surface observations are used to simulate the top of atmosphere radiances, for comparison with satellite measurements.

Band 1	≈ 6% degradation in sensitivity
Band 2	≈ 2% increase in sensitivity
Band 3	≈ 1% degradation in sensitivity

Validating GOSAT X_{CO2} against the Ground-Based Standard: TCCON

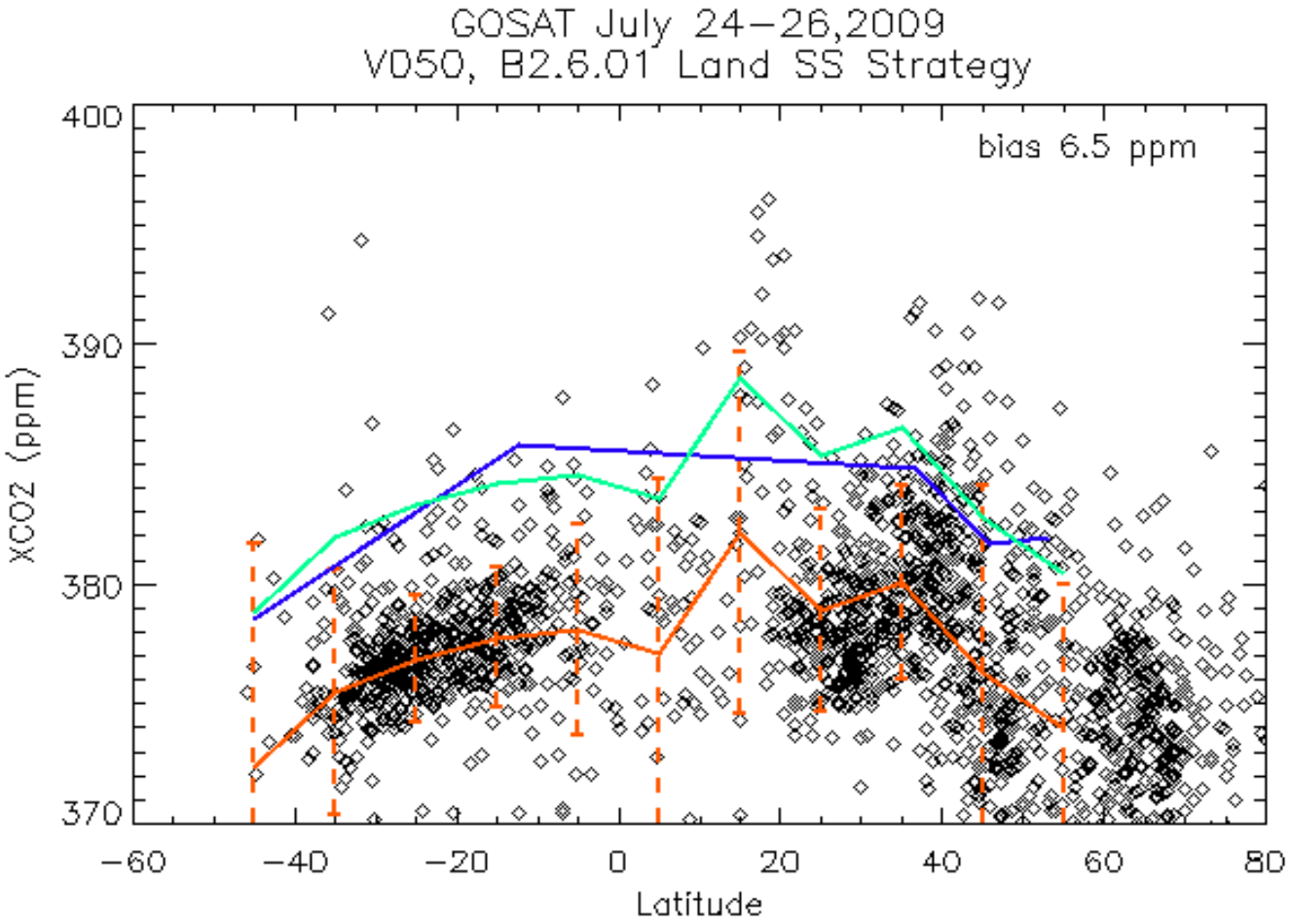


- A critical element of the validation strategy was the Total Carbon Column Observing Network (TCCON)
  - High resolution FTS's measure the absorption of direct sunlight by CO_2 and O_2, in the same spectral regions used by the TANSO-FTS.
  - Over-flights of TCCON stations by aircraft carrying *in situ* instruments calibrated with WMO referenced gases used to validate TCCON results.
    - Aircraft CO_2 profiles extending from the boundary layer to the middle troposphere are integrated to derive a value of X_{CO2}.
  - Simultaneous TCCON FTS and TANSO-FTS measurements will be compared to transfer the WMO standard to the spacecraft measurements.

Examples of Preliminary X_{CO2} Maps

- The Level 2 maps were generated using:
  - GOSAT Calibration version 050
    - Includes "low frequency" and polarization corrections
    - Data available for:
      - 23 – 25 April 2009
      - 24 – 26 July 2009
      - 14-16 November 2009
      - 15 – 17 January 2010
  - ACOS L2 algorithm version 2.6.01
    - Updated solar fluxes and absorption coefficients for 2.06 micron CO_2 band
- Pre- and post-processing filters were used to reject soundings:
  - over ocean
  - with $|P_s(\text{ret})-P_s(\text{a priori})| > 20$ hPa
  - $340 \leq X_{CO2} \leq 410$ ppm

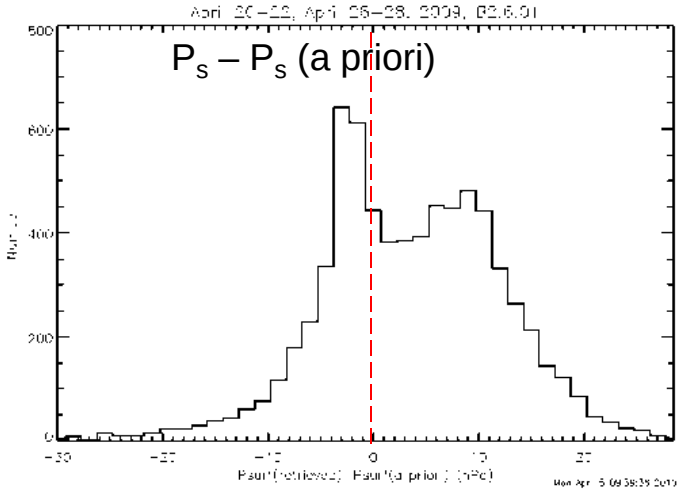
Preliminary Results

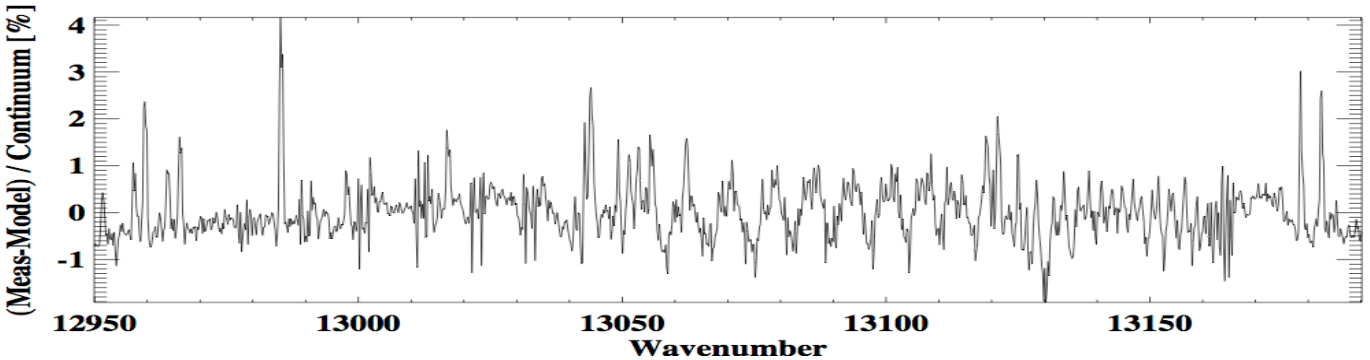


The current X_{CO2} retrievals have a (global) ~6.5 ppm (2%) low bias, when compared to bias-corrected TCCON data.

Biases in the X_{CO2} Maps

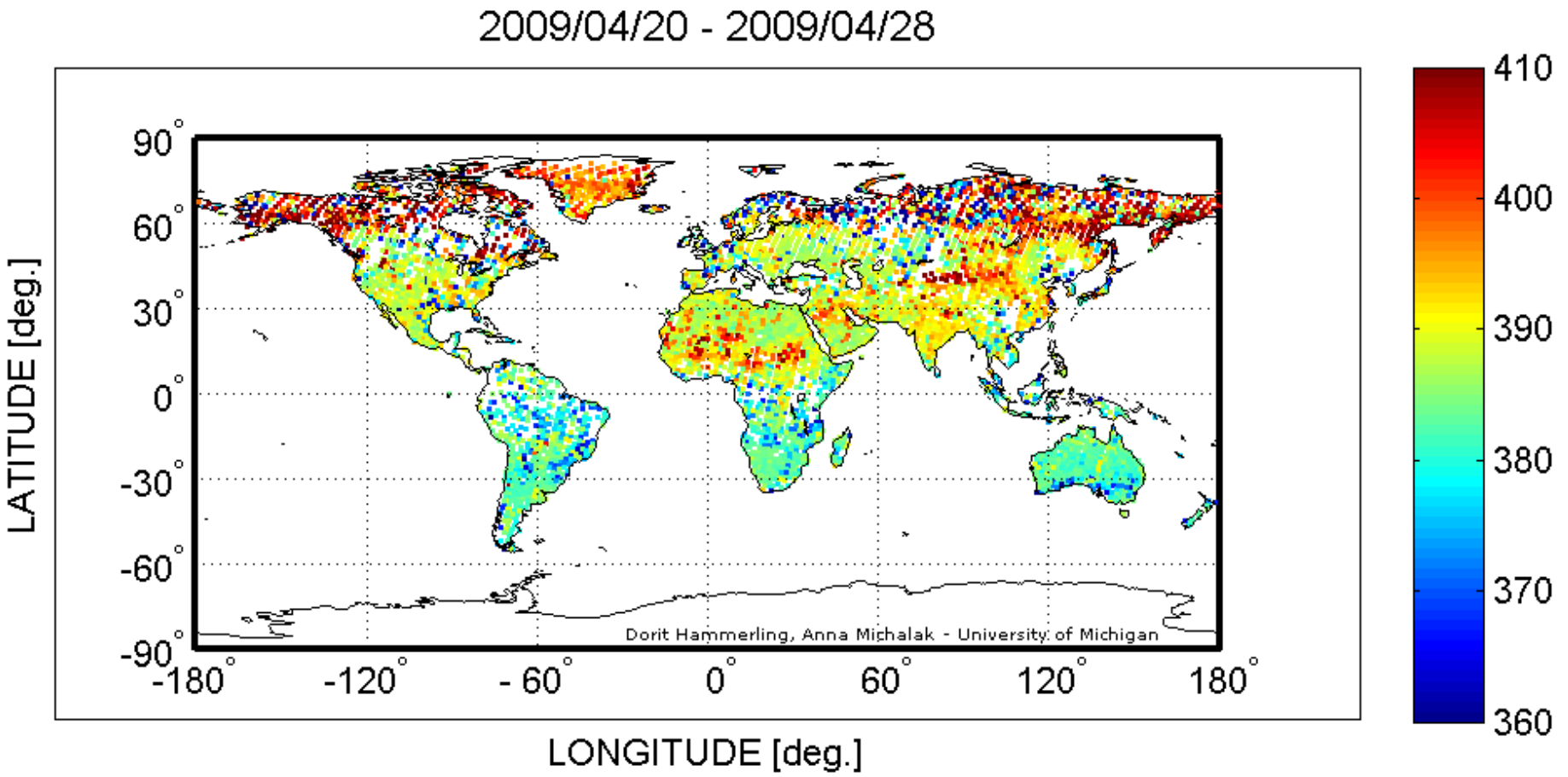
- A ~10 hPa (1%) high bias in the surface pressure retrievals contributes ~2/3 or this bias.
- This bias may be associated with
  - Calibration errors, including the lack of a low-frequency correction
  - Uncertainties in the O_2 continuum absorption underlying the A-band
  - Line mixing or other issues with the O_2 A-band absorption coefficients





Typical O_2 A-band retrieval residuals.

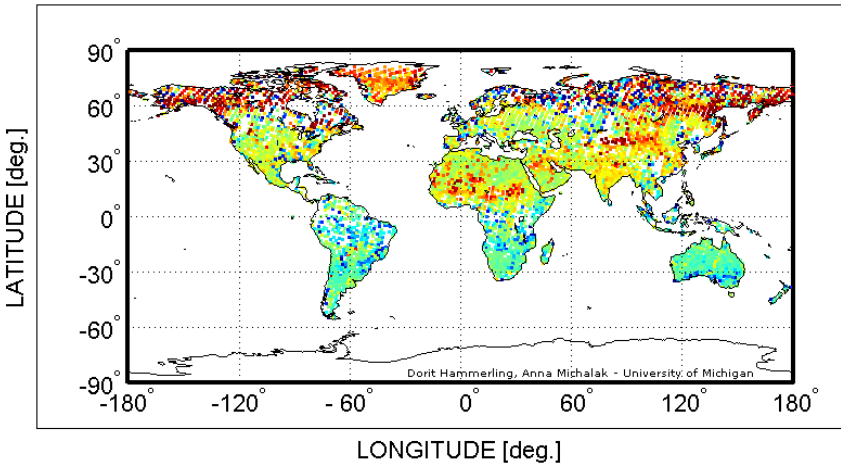
April 20-28 2009 Repeat Cycle



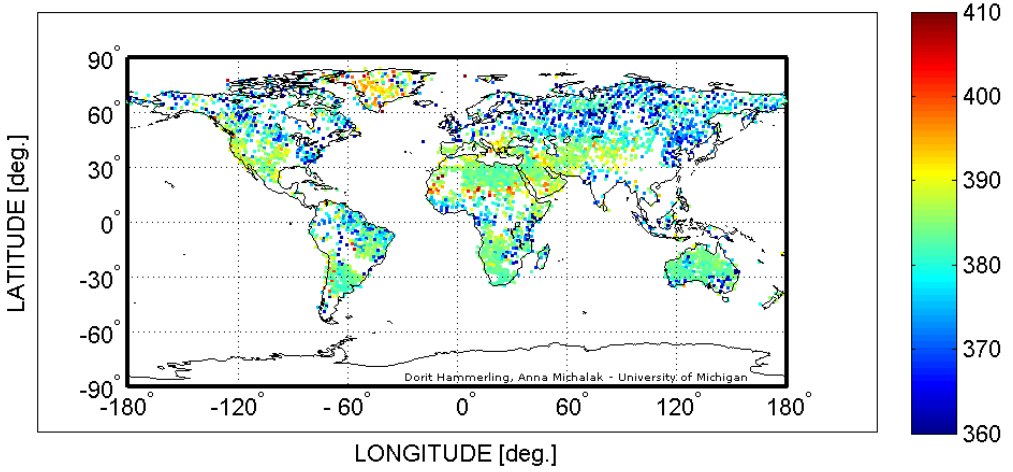
X_{CO2} retrievals from 3 global repeat cycles (4/20 – 4/22, 4/23 – 4/25, and 4/26 – 4/28) were combined to yield a global map.

GOSAT X_{CO2} over the Seasonal Cycle

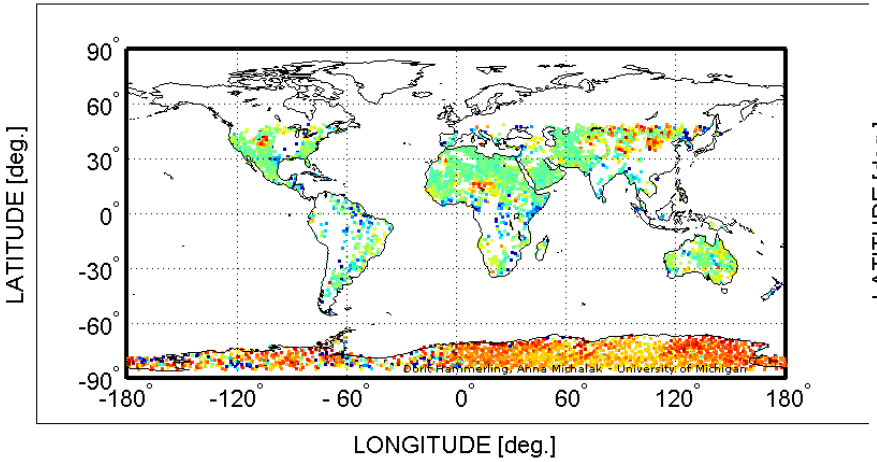
2009/04/20 - 2009/04/28



2009/07/24 - 2009/07/26



2009/11/15 - 2009/11/17



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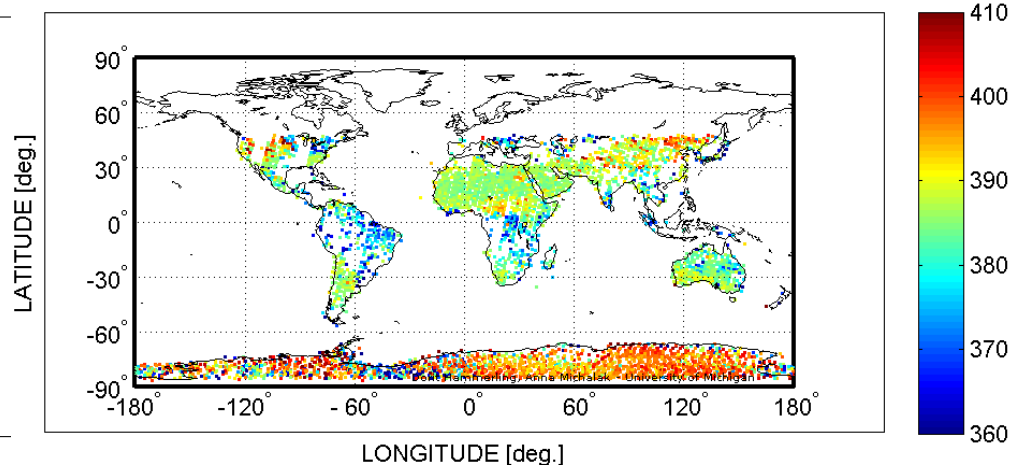
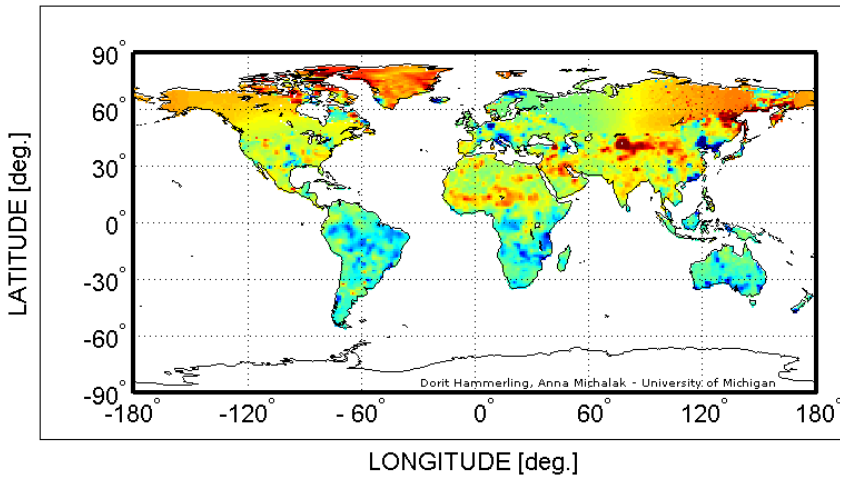
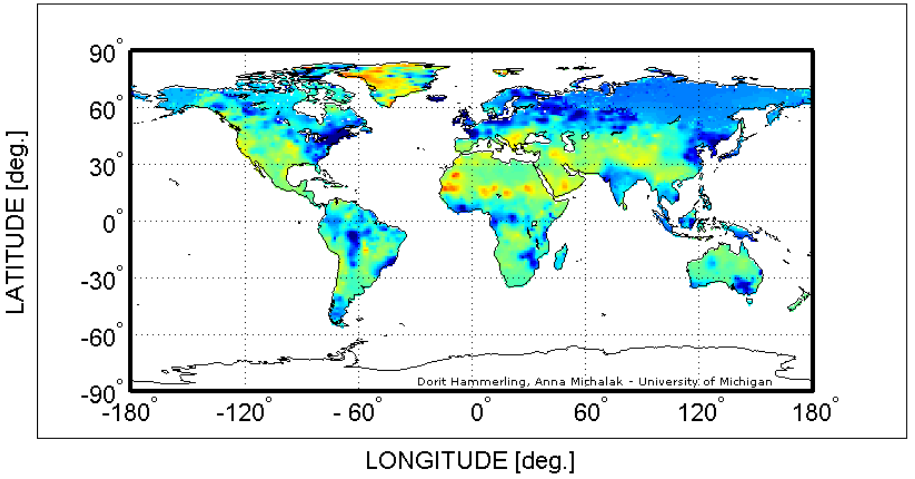


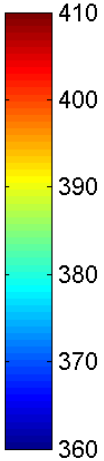
GOSAT X_{CO2} Level 3 Seasonal Cycle

2009/04/20 - 2009/04/28



2009/07/24 - 2009/07/26





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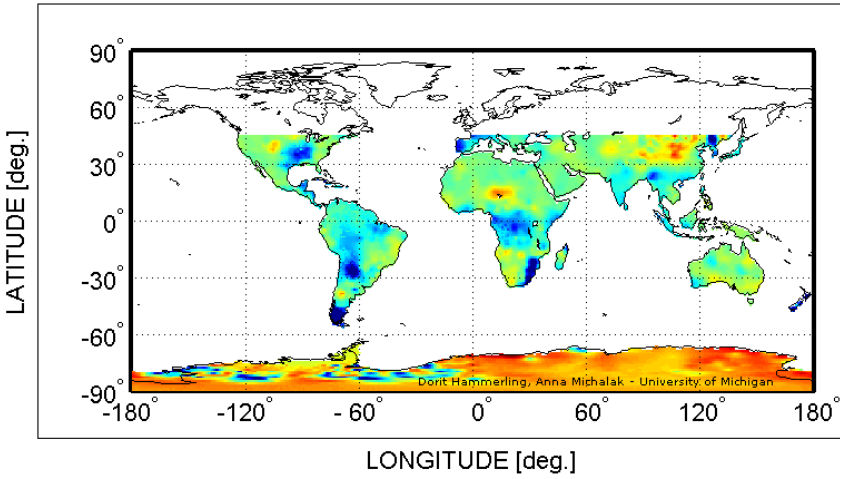

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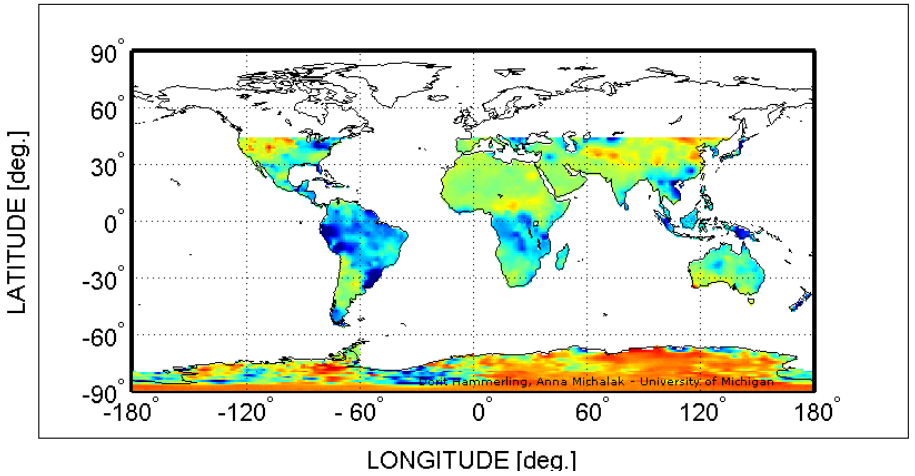

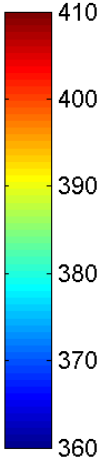

Preliminary Conclusions

- The ACOS/SDOS team is now routinely generating L2 products for two (2) GOSAT repeat cycles each month
  - One near the first of the month, and one near the middle
  - Only land values are available because L2 algorithm still cannot process glint data from GOSAT
  - The X_{CO2} retrievals currently have a global bias of ~6.5 ppm (2%)
  - The present version of the algorithm produces X_{CO2} estimates that are significantly higher than the a priori over ice-covered surfaces (especially Greenland and Antarctica)
  - There is no compelling reason to limit the SZA to < 70°
- Hammerling et al. have shown that it is possible to create gap-filled level 3 maps with a little as a single repeat cycle, but adding additional repeat cycles can substantially reduce the size of gaps associated with clouds
- These experiments are providing important insights and facilitating the development of the OCO-2 X_{CO2} retrieval algorithms.