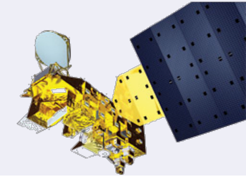

AIRS Mid-Tropospheric CO_2 Climatology Product

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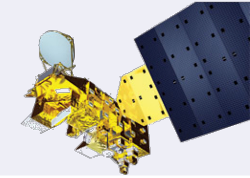
Agenda



- AIRS Mid-tropospheric CO_2 climatology dataset created
- Product uncertainties included
- Product validation underway
  - This talk examines the seasonal cycle
  - Results: NH Dampening and Phase Lag, SH Reversal
    - T. Pagano, E. Olsen, H. Nguyen, A. Ruzmaikin, X. Jiang, L. Perkins, "Global variability of midtropospheric carbon dioxide as measured by the Atmospheric Infrared Sounder," J. Appl. Remote Sens., 8(1), 084984 (2014). doi:10.1117/1.JRS.8.084984.
- Conclusions

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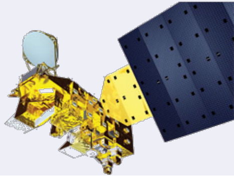
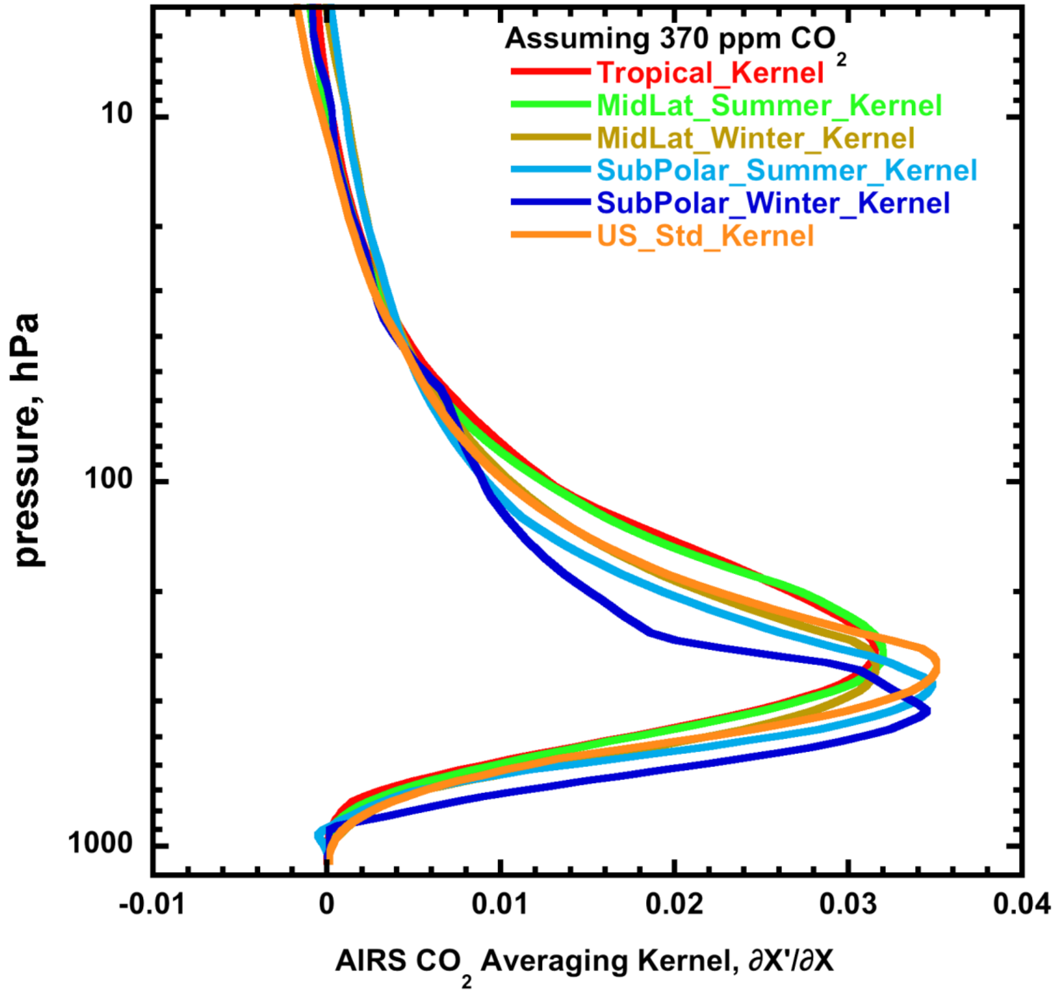
AIRS Retrieves CO_2 in the Mid to Upper Troposphere



- <u>AIRS Sensitivity</u>
- Peak sensitivity altitude varies slightly with latitude and season:
  - Tropics: 285 hPa
  - Poles: 425 hPa
- Width at half-maximum is ~ 400 hPa, spanning:
  - Tropics: 120 hPa to 515 hPa
  - Poles: 235 hPa to 640 hPa
- Tails of averaging kernels intrude into stratosphere, where air is older than in troposphere by an amount that varies with latitude (~ 1 yr in tropics; ~5 yrs at poles).
- Impact: ~3 ppm increase in retrieved CO_2 near the poles if correction is applied.



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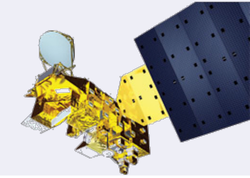
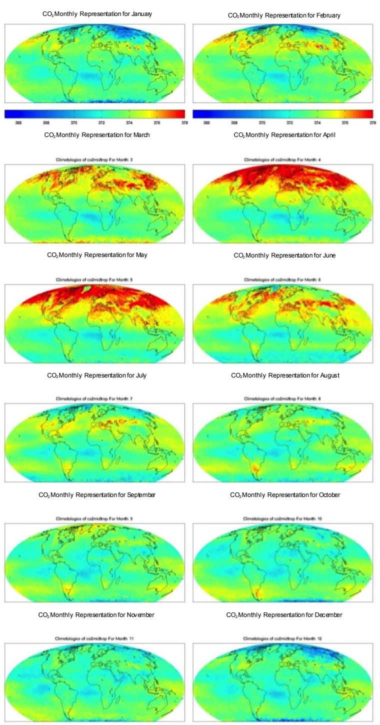
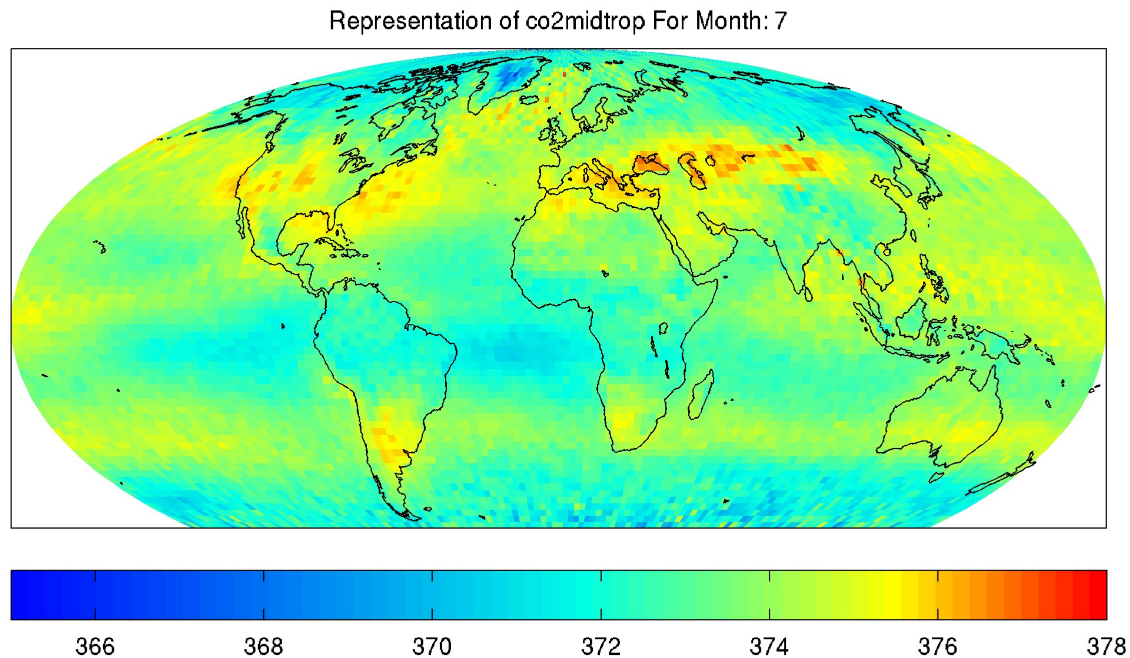
AIRS Mid-Tropospheric CO_2 Climatologies



- AIRS CO_2 Climatology: Average of AIRS L3 Monthly CO_2 over years 2003-2010





$$D_{ijm} = \sum_{k=1}^{8} N_{ijkm} D_{ijkm} \; / \sum_k$$

<u>Simple Monthly Climatology</u>

- V5 L3 Monthly CO_2 for Years: 2003-2010
- QC on -9999
- Detrend CO_2 using linear fit to all years for each grid cell
- Average CO_2 values for individual months (e.g. all January's. Gives 12 files)
- Preserve Grid of input L3

Pagano, T. S., Olsen, E. T., Chahine, M. T., Ruzmaikin, A., Nguyen, H., Jiang, X., "Monthly representations of mid-tropospheric carbon dioxide from the Atmospheric Infrared Sounder," Proc. SPIE 8158-11, San Diego, CA (2011).

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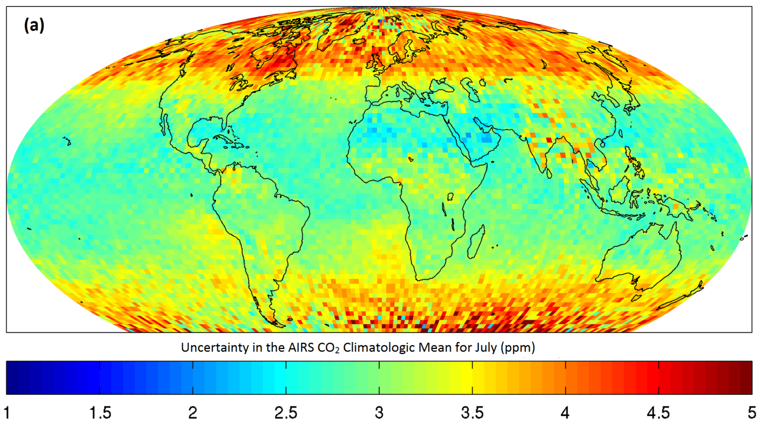
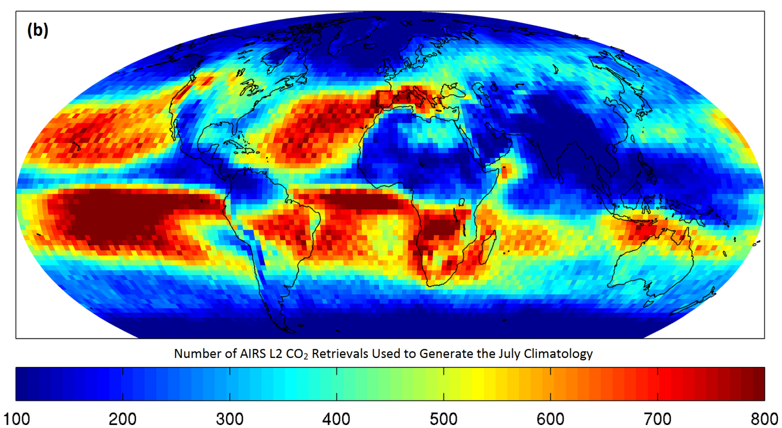
Climatologies include combined statistics for each month

Standard deviation and number of samples for each month from all years is combined into single value

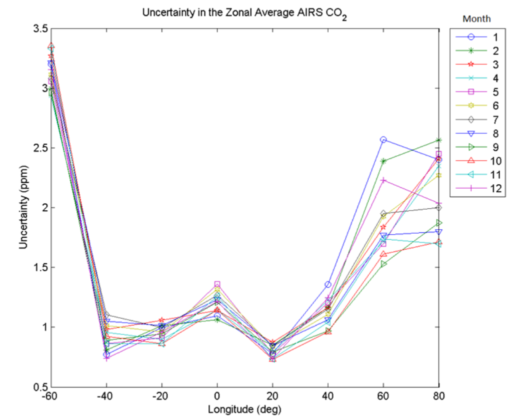
July Climatology Statistics
a) Uncertainty, σ_{ij7}
b) Number of Data Points included in the mean, N_{ij7}



Uncertainty in the AIRS CO_2 Climatologic Mean for July (ppm)



Number of AIRS L2 CO_2 Retrievals Used to Generate the July Climatology



$$\sigma_{ijm} = \sqrt{\sum_{k=1}^{8} N_{ijkm} [D_{ijkm}$$

$$N_{ijm} = \sum_{k=1}^{8} N_{ijkm}$$

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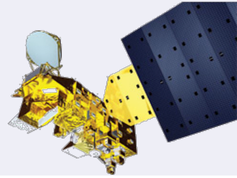
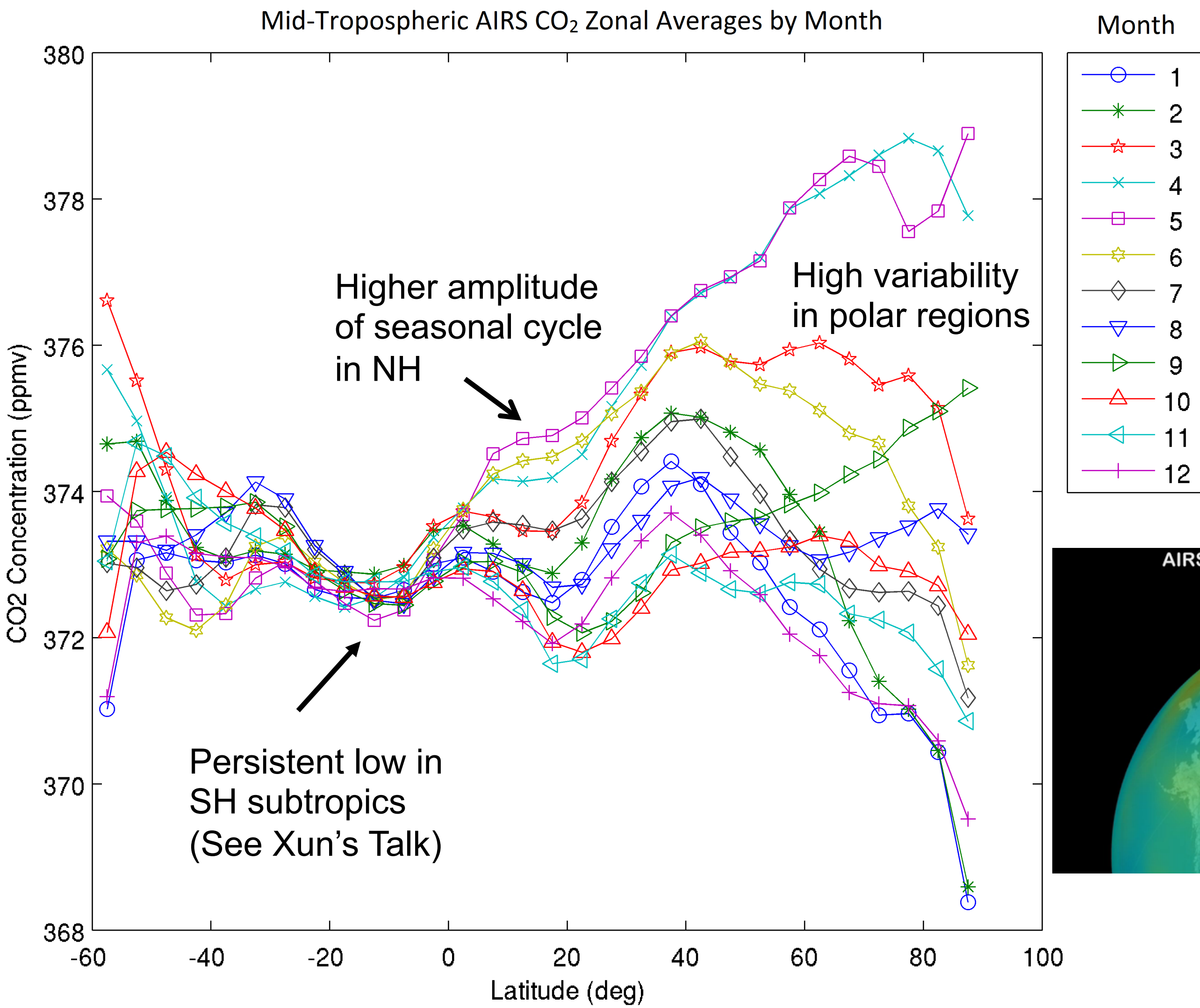
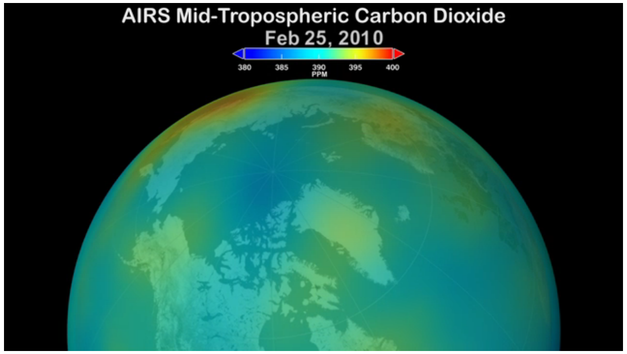
Zonal average of AIRS CO_2 climatologies show many features







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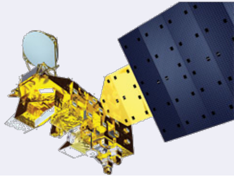
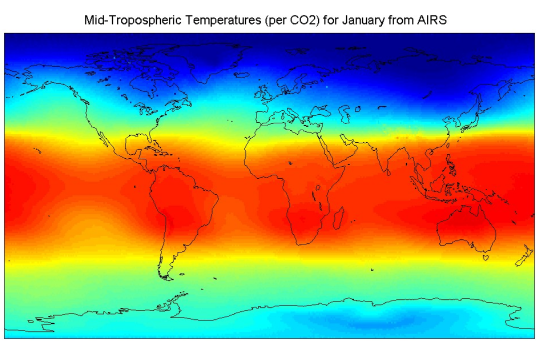
Product Validation: Seasonal Cycle Comparison Datasets

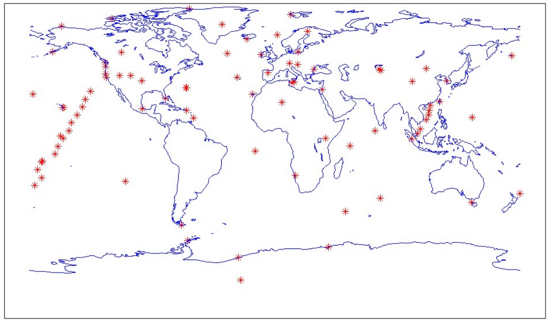


Comparison Product	Instrument	Level	Source
Mid-Trop CO_2, T_{500mb}, T_{surf}	AIRS	L3	GES/DISC
Surface CO_2	In-Situ/Flask	N/A	NOAA ESRL*
EVI, T_{surf} (for GPP)	MODIS	L3	GES/DISC

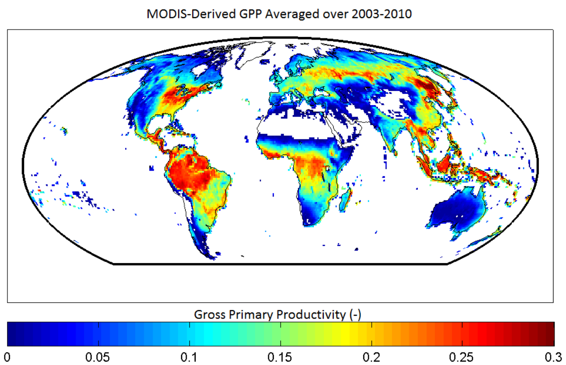
AIRS Mid-Trop and Surface Temperatures



87 NOAA CO_2 Surface Sites Worldwide



GPP from MODIS EVI and T_{surf}

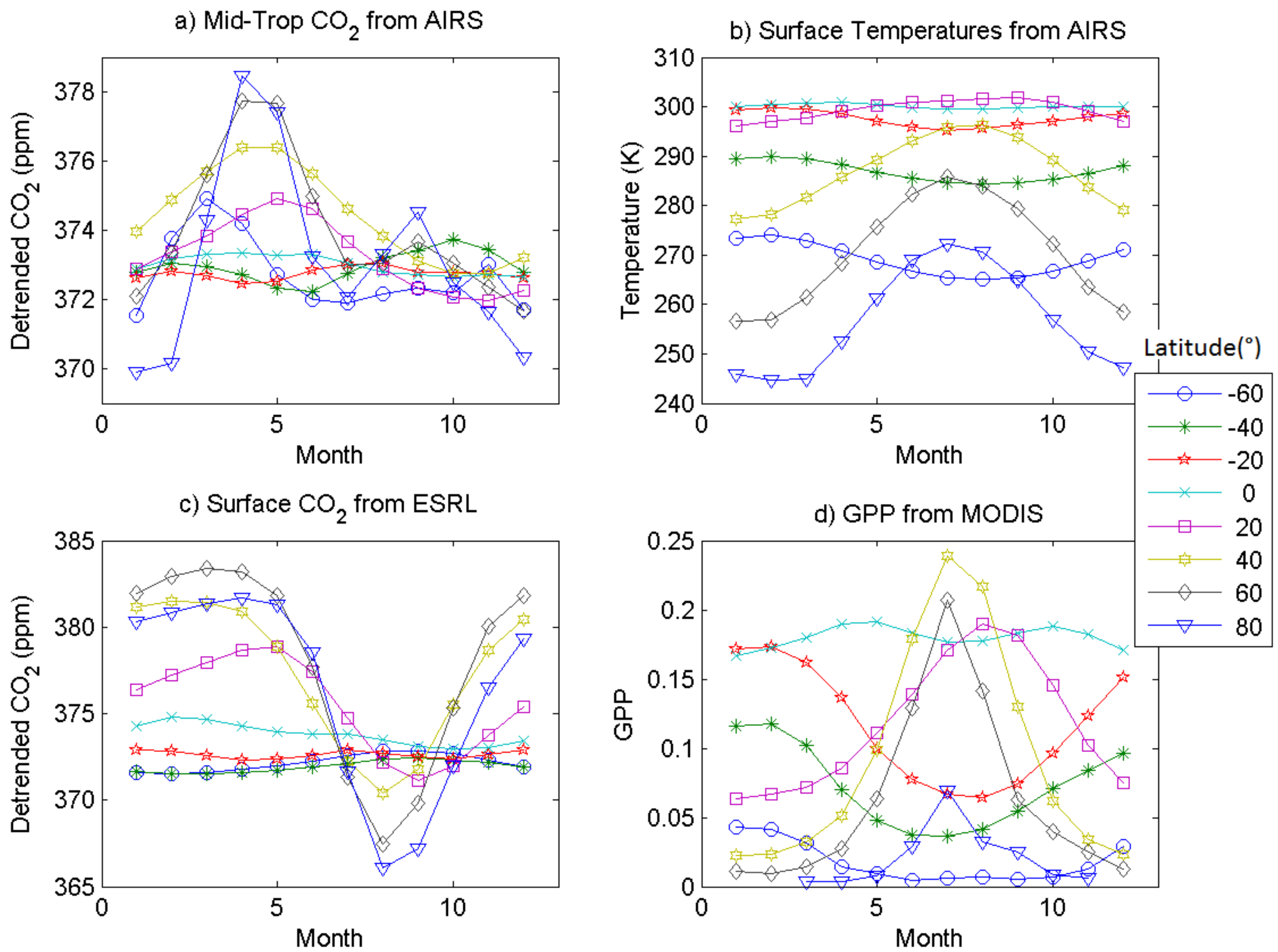


*Conway, T.J., P.M. Lang, and K.A. Masarie (2011), Atmospheric Carbon Dioxide Dry Air Mole Fractions from the NOAA ESRL Carbon Cycle Cooperative Global Air Sampling Network, 1968-2010, Version: 2011-10-14, Path: http://ftp.cmdl.noaa.gov/ccg/co2/flask/event/.

Seasonal Cycle Revealed in Zonal Averages

Monthly climatology made for each product by combining L3 from 2003-2010

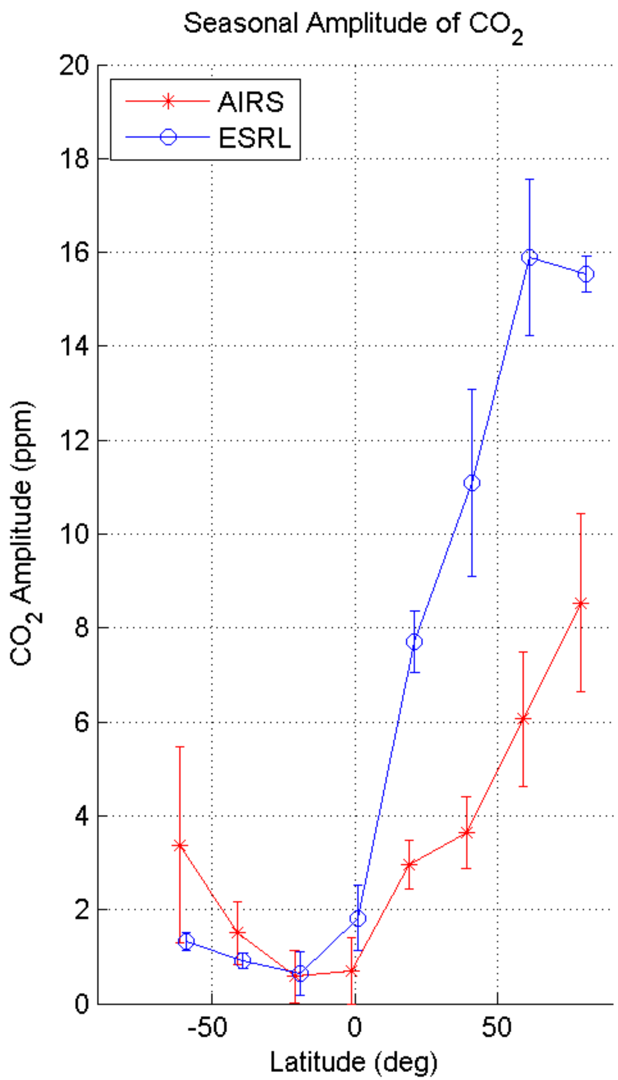
Zonal averages made of each climatology in 20 degree bins

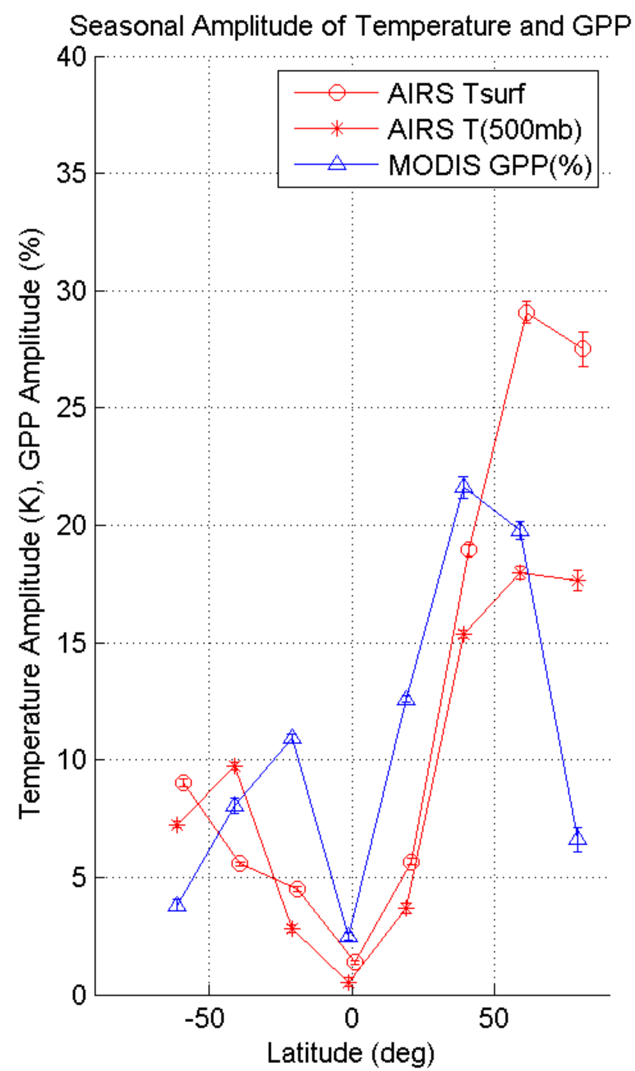


AIRS Mid-Trop CO_2 Climatology Seasonal Cycle Amplitude

Mid-tropo CO_2 NH: Damped seasonal amplitude compared to surface

SH: Higher seasonal amplitude. Inter-hemispheric transport?

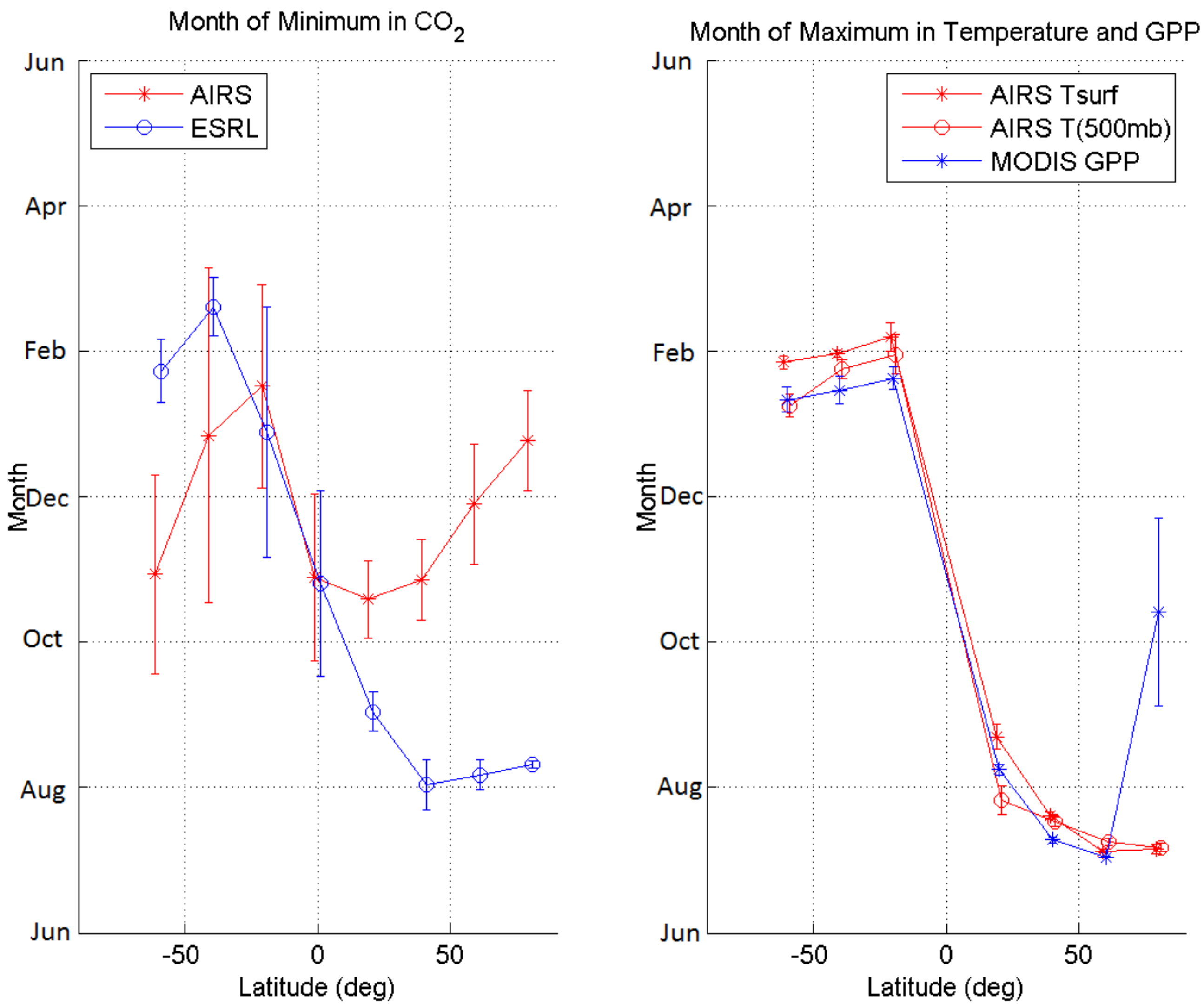




AIRS Mid-Trop CO_2 Climatology Seasonal Cycle Phase

Mid-tropo CO_2
NH: Lags the surface due to mixing

SH: Leads the surface due to interzonal transport?



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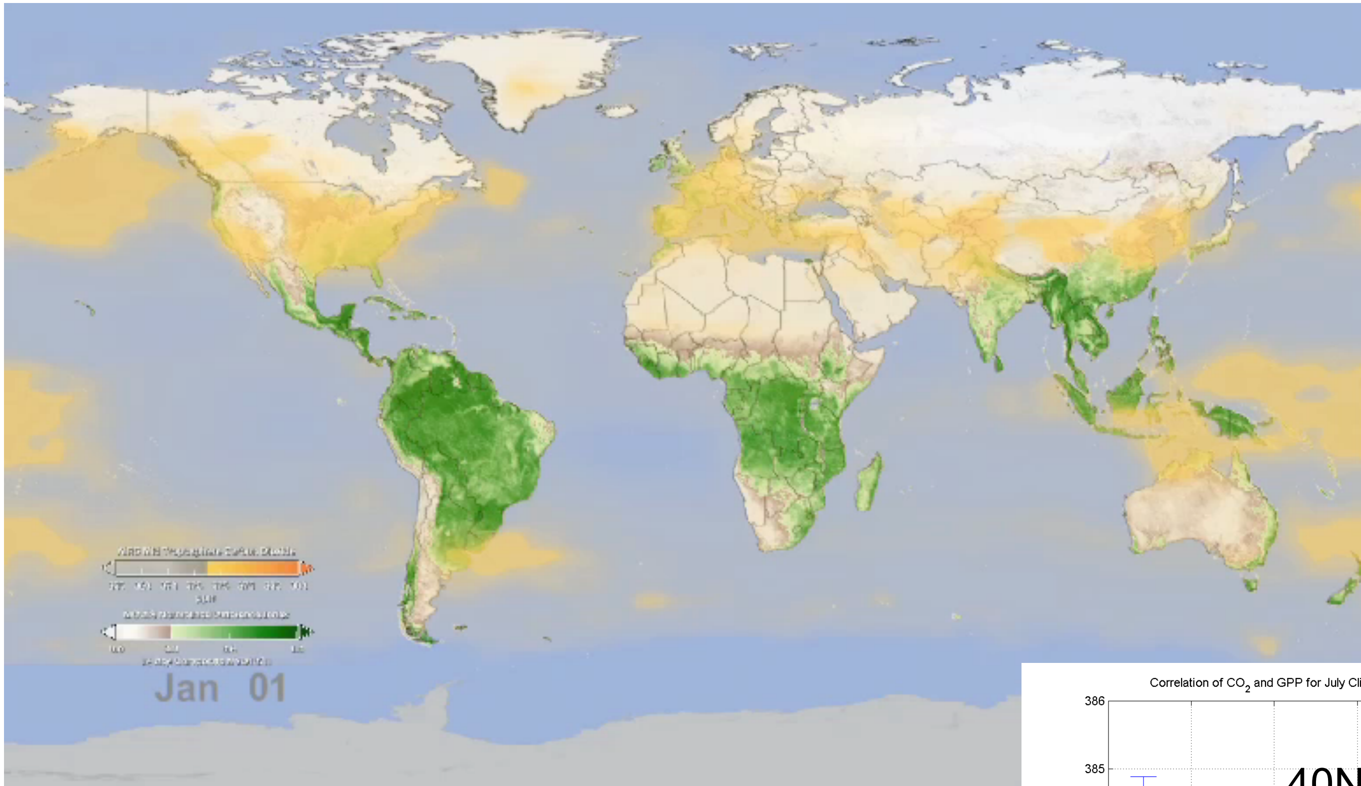
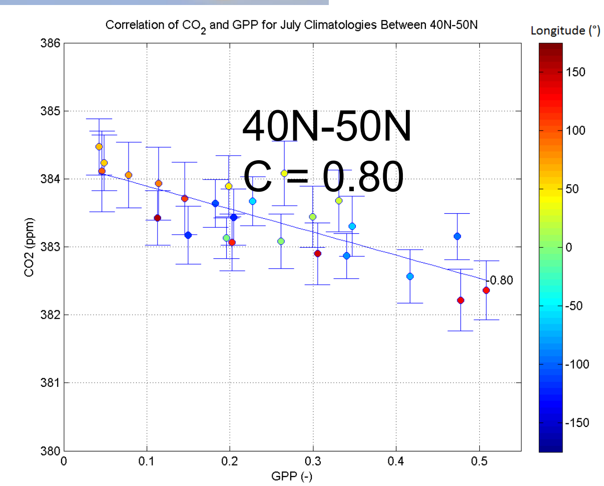
AIRS CO_2 Shows Significant Influence of Surface in addition to Atmospheric Transport





High Correlation of CO_2 and GPP for July in NH Boreal Forests

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Summary and Future Work

- Summary
  - AIRS mid-tropospheric CO_2 monthly climatology generated
  - Recently reprocessed for 2003-2014
  - Climatology available at co2.jpl.nasa.gov this summer
  - Distinctive seasonal cycle seen in the mid-tropospheric CO_2 from AIRS
    - Amplitude damped in NH relative to surface flask measurements
    - Phase lag relative to surface flask in NH
    - Phase preceeds, and amplitude higher than surface in SH
  - Influence of boreal forest drawdown in summer seen in spatial variability of AIRS mid-tropospheric CO2
- Future work
  - Climatology with Version 6 to increase yield and accuracy

- Acknowledgements
  - Dr. Mous Chahine (CO2 VPD Algorithm,
    AIRS Science Team Lead to 2011)
  - Dr. Ramesh Kakar (Aqua Program Scientist)

AIRS CO_2 Climatology Animation