Jet Propulsion Laboratory
California Institute of Technology

Spatial Aggregation of Level 2 OCO-2 Data via Geostatistical Interpolation

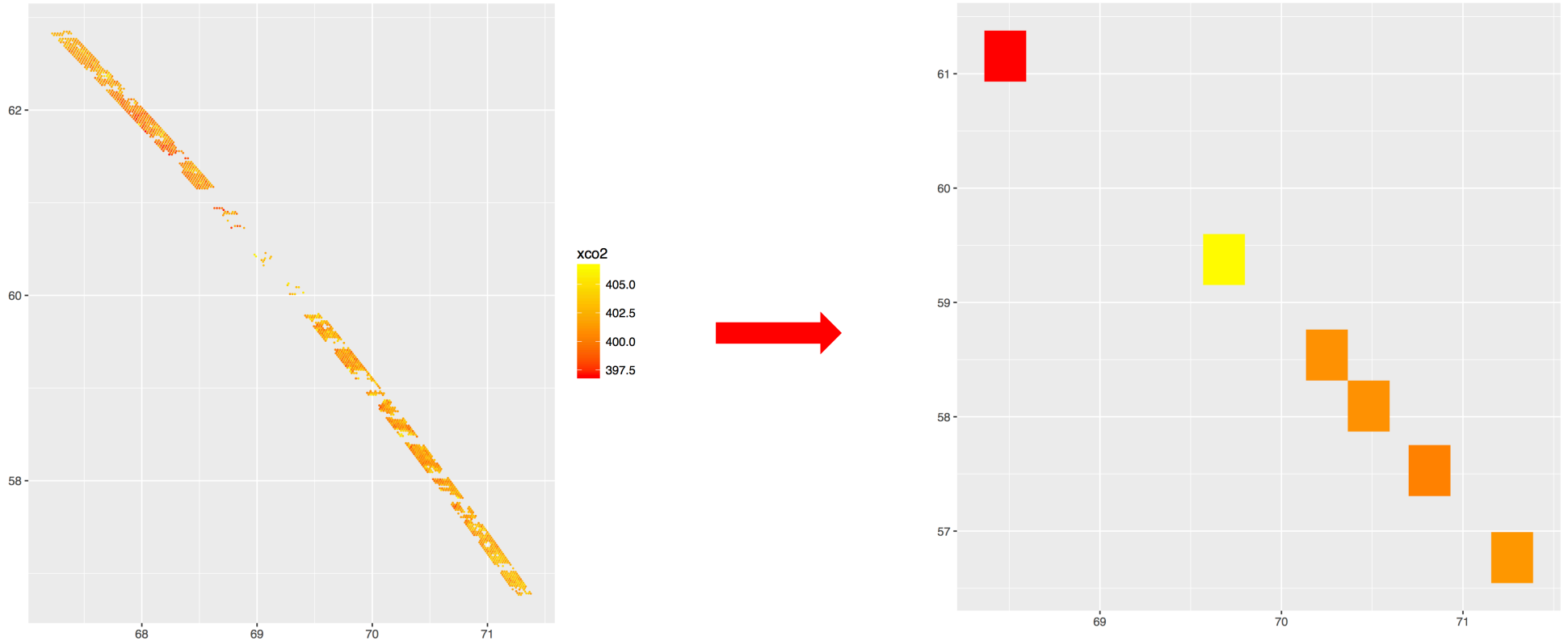
Joaquim Teixeira, Hai Nguyen

Overview

- Motivation
- Theory
- Implementation
- Results

Motivation: Objective

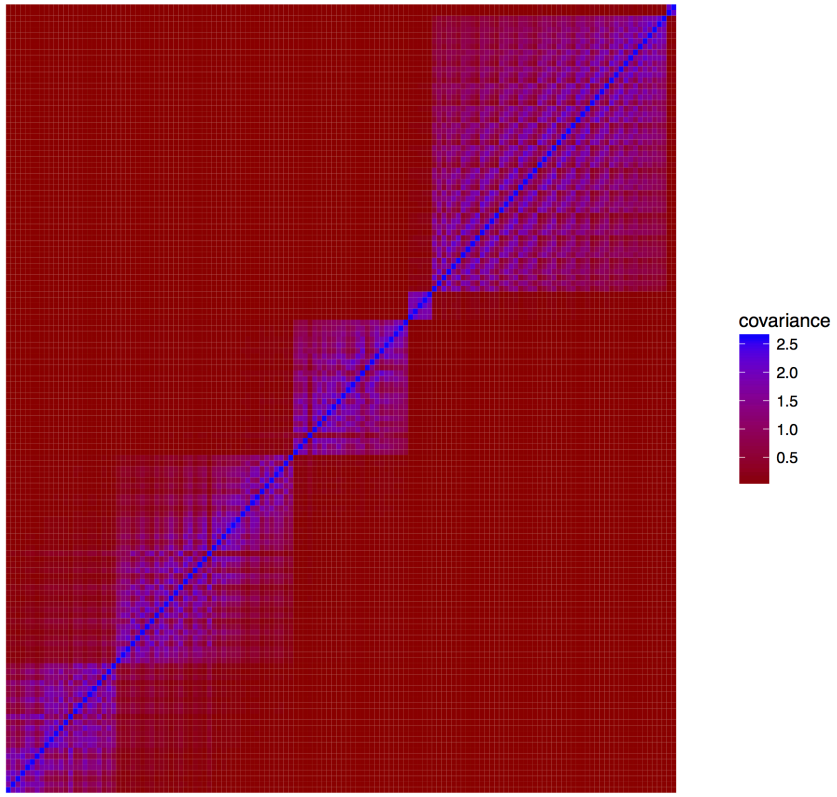
- Aggregating level-2 OCO2 Data into 1°x1° blocks for global flux inversion



Motivation: Why use spatial interpolation?

- Simple Average is fine but suboptimal
- Take advantage of underlying spatial structures
- Kriging is the Best Linear Unbiased Predictor (BLUP)
- Provides 1°-block uncertainty independent of individual retrieval uncertainties

Example of spatial covariance



Theory: Kriging Basics

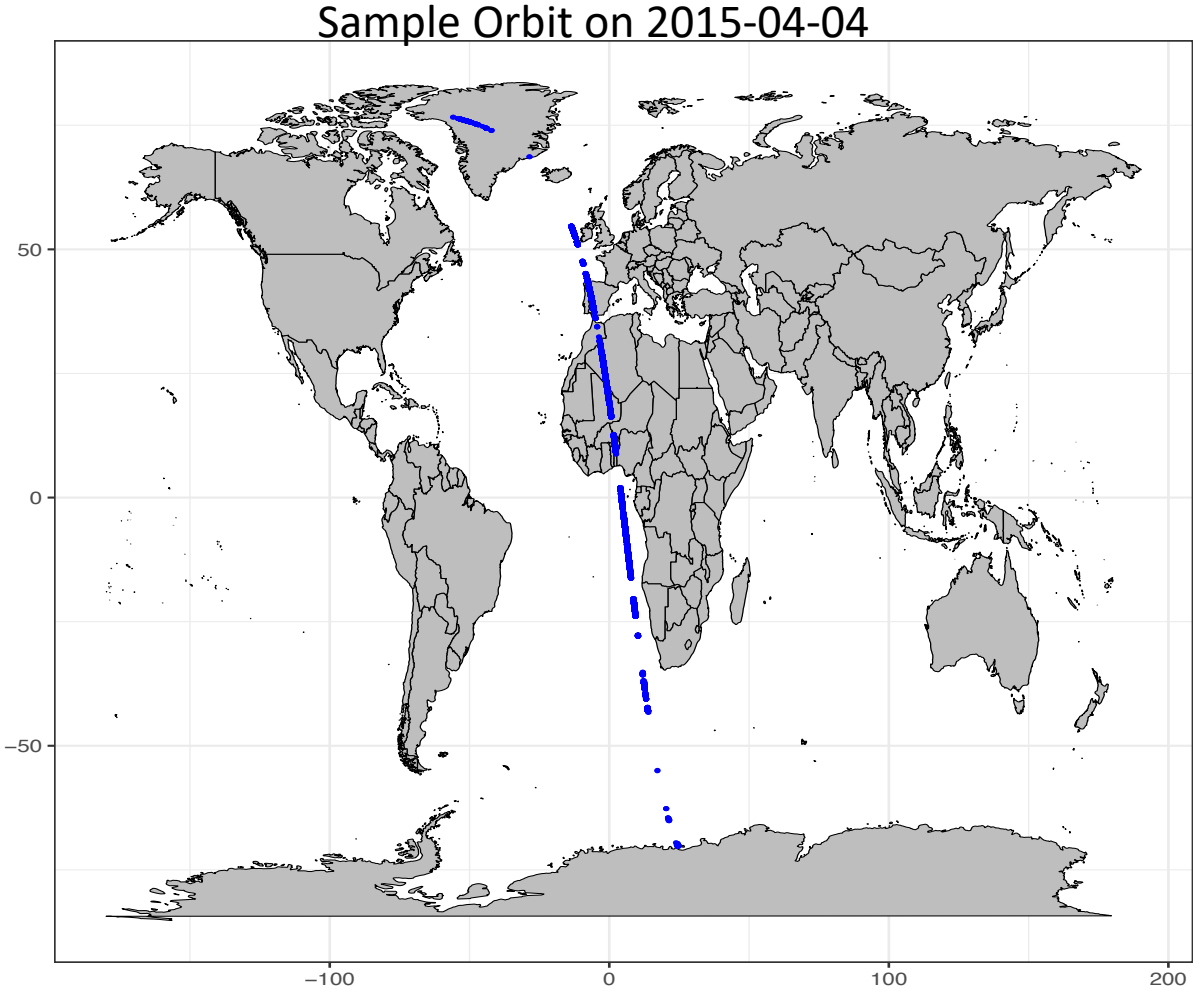
- Kriging is a linear estimator of point value
- Coefficients determined by distance from interpolation point
- Founding principle: retrievals that are closer are more similar

Theory: Kriging

- Estimate covariance function $C(s_j, s_i)$ between points s_j, s_i and covariance matrix Σ
- $a_i = C(s^*, s_i)\,\Sigma^{-1}$
- $\hat{Z}(s^*) = (\frac{1}{n})(a_1 Z(s_1) + \cdots + a_i Z(s_i) + \cdots + a_n Z(s_n))$
- $\widehat{\sigma^*} = C(s^*, s_i)^T\,\Sigma^{-1}\,C(s^*, s_i)$
- Block Kriging:
  - $\hat{Z}(v) = \frac{1}{v}\int_v Z(s)ds,\ v \subset V, s \in V$
  - $\widehat{\sigma^*}(v) = \frac{1}{v}\int_v \sigma(s)ds,\ v \subset V, s \in V$

Implementation: Overview of Kriging Aggregation Tool

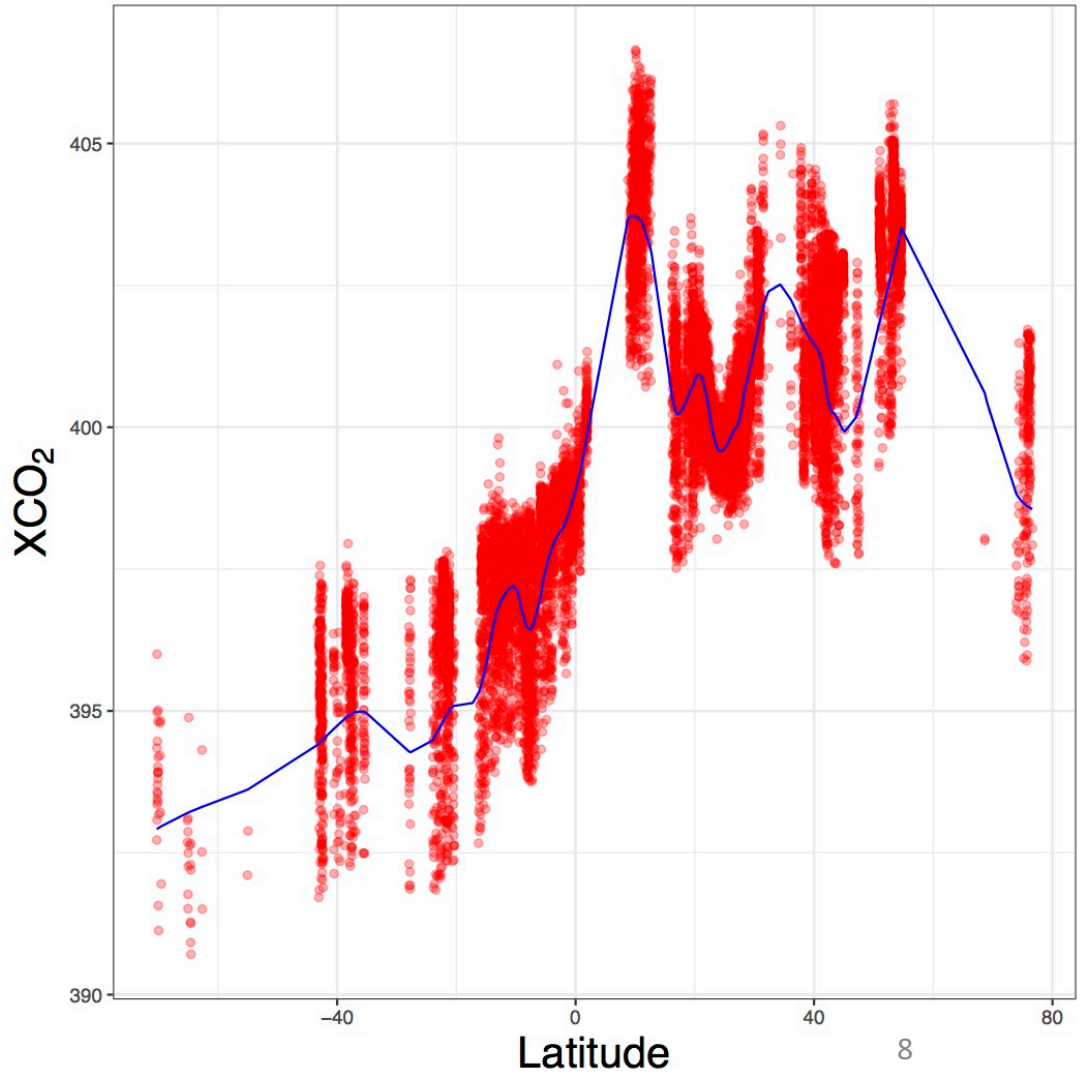
- Krige by orbit
- 4 Step process:
  - Estimate and remove latitude-dependent trend
  - Define spatial field
  - Estimate local covariance
  - Krige



Implementation: Detrending

- Kriging estimation requires stationary data
- Detrend XCO_2 with respect to latitude using LOESS
- Outlier removal

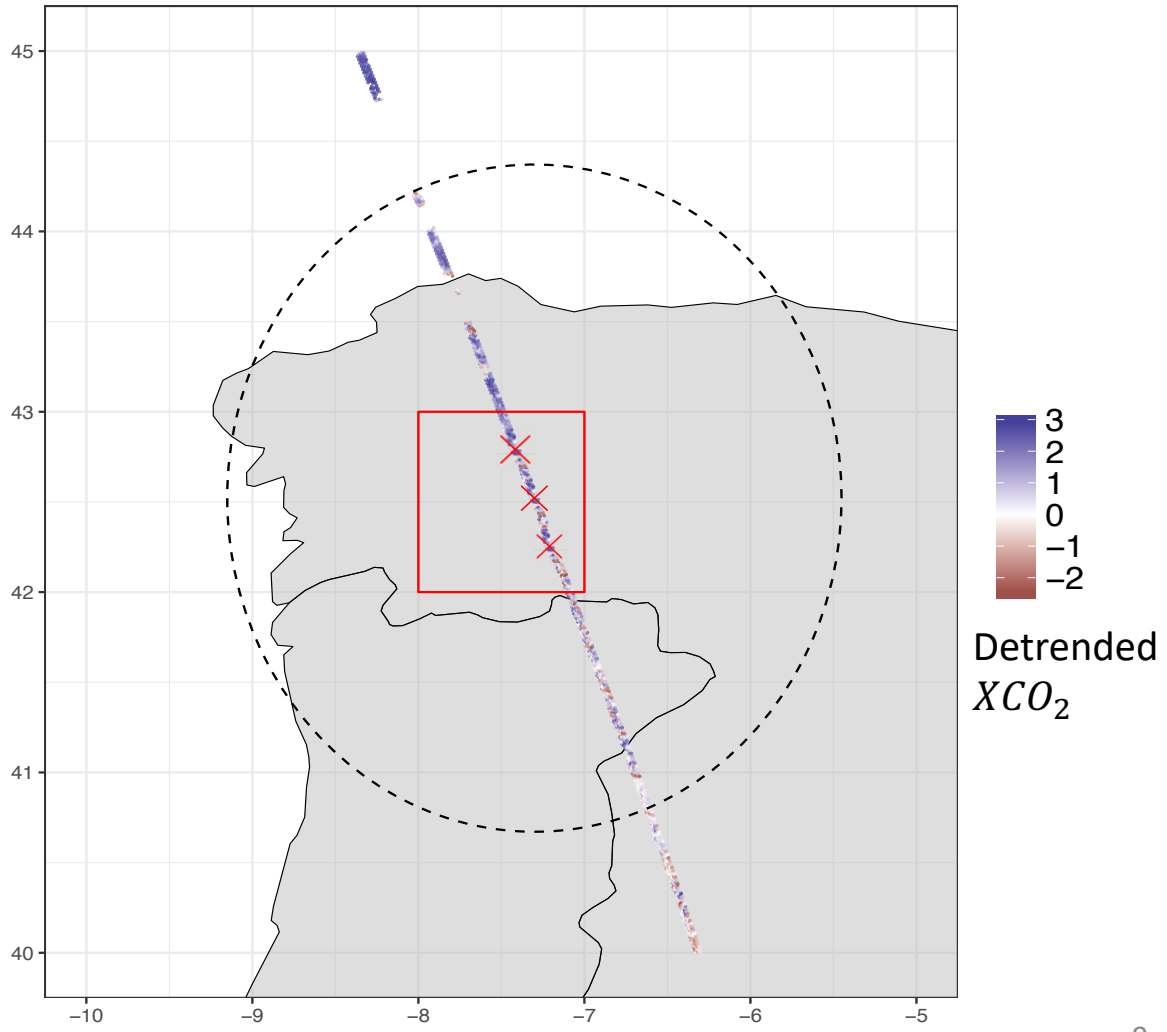
XCO_2 for all sample orbit footprints and latitude-dependent trend



Implementation: Definition of Spatial Field

- Retrievals inside circle within ~100Km of center point
- Block Krige over degree box

Spatial field for sample degree box



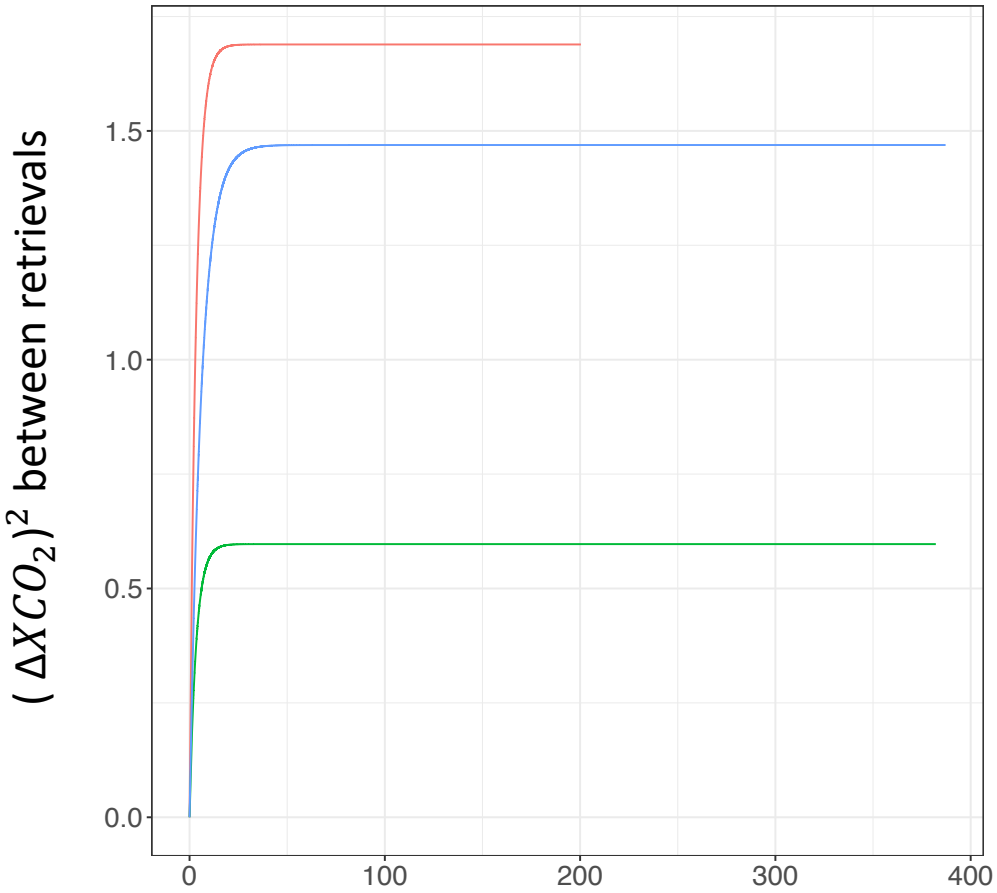
Implementation: Empirical Covariance Estimation

- Estimate covariance from empirical variogram of spatial field
- Assume variogram (γ) has exponential form:
  - Plot difference in XCO_2 value against distance for each retrieval
  - Fit exponential regression
- Covariance:

$$C(h) = C(0) - \gamma(h)$$

where h is the distance between two points

Fitted Empirical Variogram for different spatial fields in sample orbit

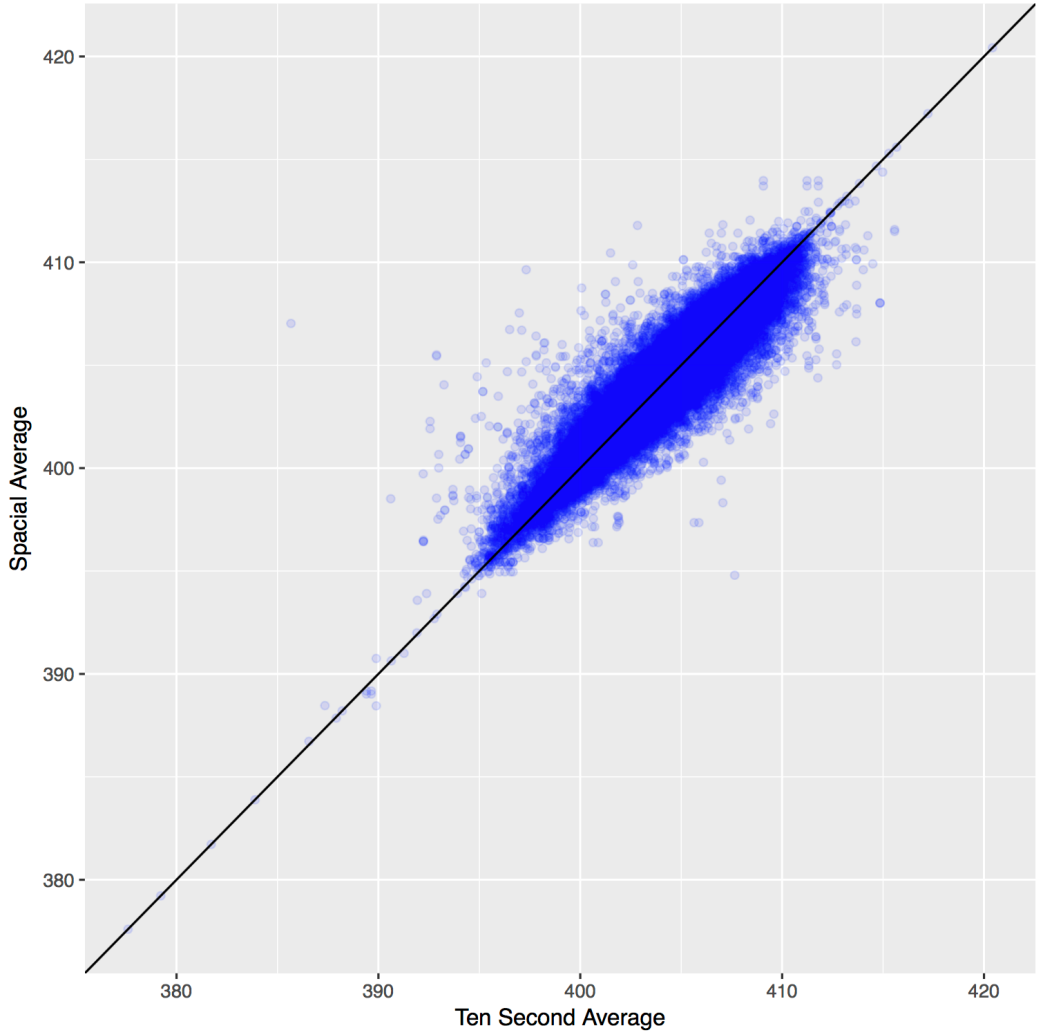


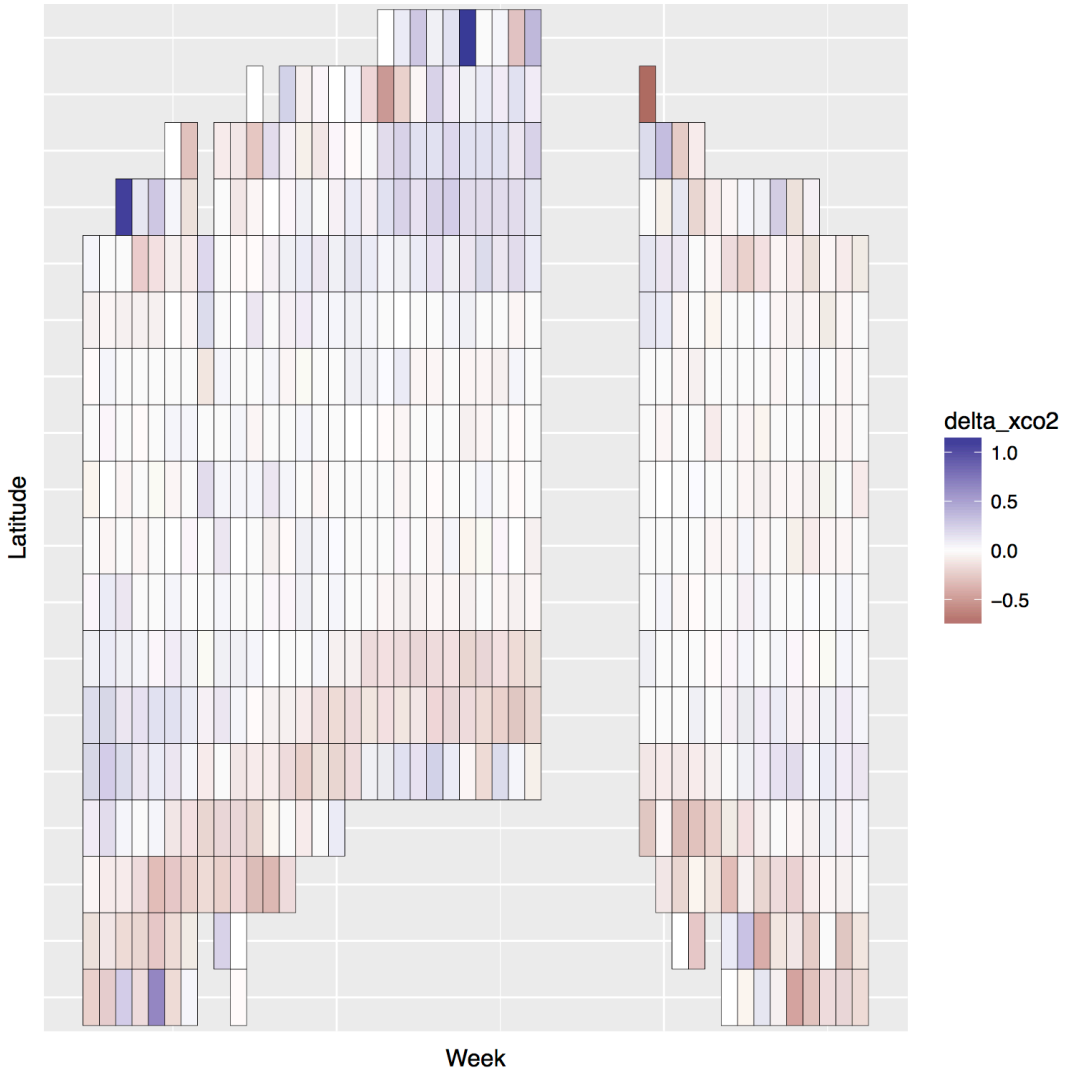
Results: Comparison with Ten Second Average

- 2017 Version 9 Lite files
- Quality Flag=0
- All viewing modes processed together
- Comparison with collocated 10 Second Average values from OCO2_b91_10sec_WL05_GOOD_v4.nc4 file courtesy of David Baker

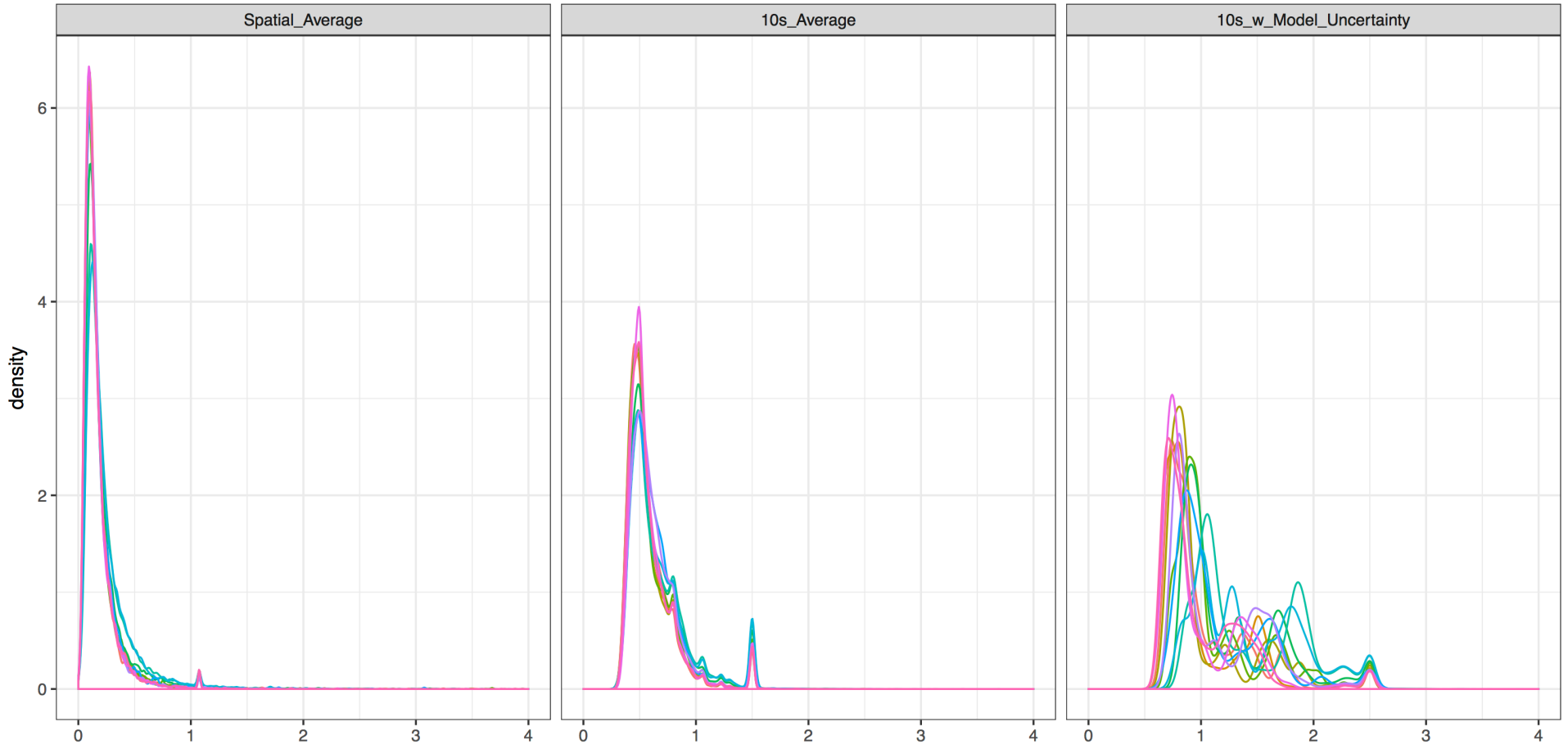
Results: Means

2017





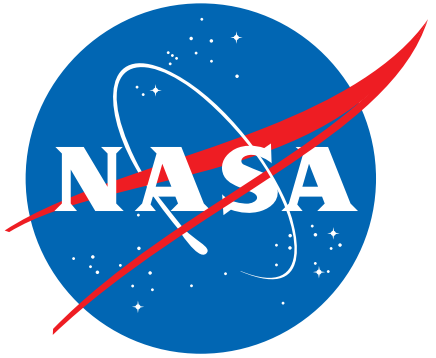
Results: Uncertainties



Moving Forward

- Process entire Version 9 dataset
- Use different filtering approaches
- Additional metadata as needed
- Feedback from user community?

National Aeronautics and Space Administration



National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Joaquim.p.Teixeira@jpl.nasa.gov