Characteristics of total column CO_2 retrievals from the OCO missions:

biases, information content and implications for flux inversions

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Background

Establish a framework (qualitative and/or quantitative) to evaluate the signal in the X_{CO2} retrievals

- ❑ serve as a precursor to flux inversions
- ❑ make results available to the community with low latency
- ❑ designed to address the following questions
  a. What are the distribution of retrievals in the different modes (LN, LG and OG)?
  b. What is the information being given to the inversions from the satellite retrievals? **Between data versions** (v7B, v9, v10) and **across datasets** (OCO-2, OCO-3, GOSAT-ACOS)?
  c. Inform choices for L4 flux activities

Not an alternative to flux inversions! Rather.. we are simply harmonizing the first step of different flux inversion schemes and assessing the information present in the retrievals

Defining the "signal"

Signal = **v9** X_{CO2} 10s averages (r24) **minus** a reference X_{CO2} field

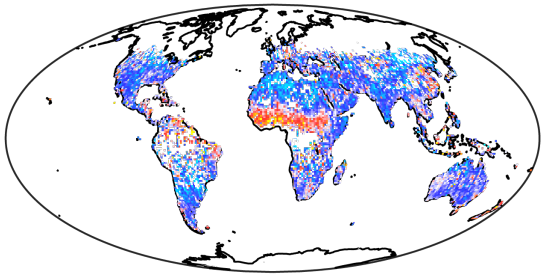
Reference X_{CO2} field

- reasonable portrayal of what we know about global atmospheric CO_2 distribution, i.e., captures seasonality, trends and interannual variability due to ENSO (critical for the 2015-2016 period)
- currently, mean of 3 publicly accessible model fields: CarbonTracker, CAMS, Jena CarboScope
- we have found little difference in the signal patterns when using this 3-model vs. a larger 7-model field (models that participated in Crowell et al. [2019])

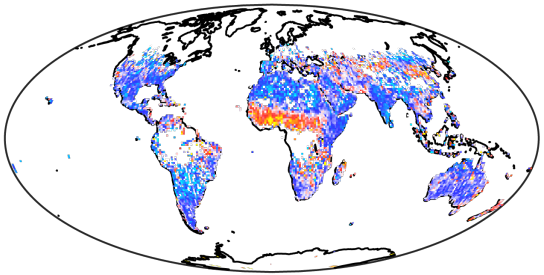
Signal maps across seasons

DJF (2015 - 2018)

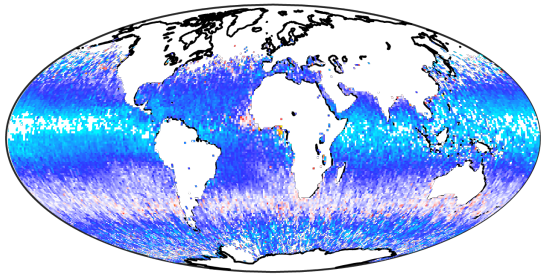
LAND NADIR

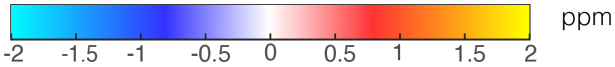


LAND GLINT

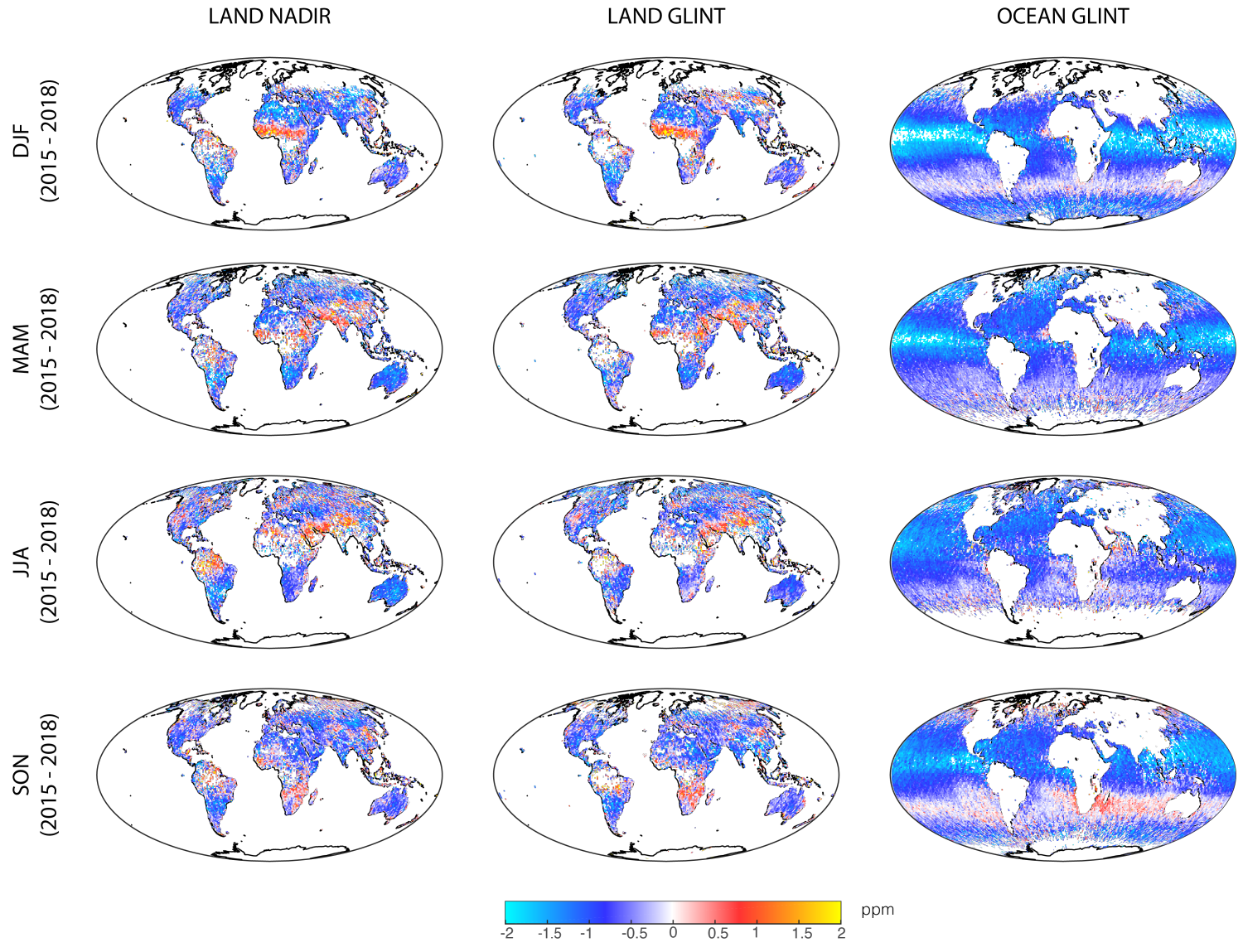


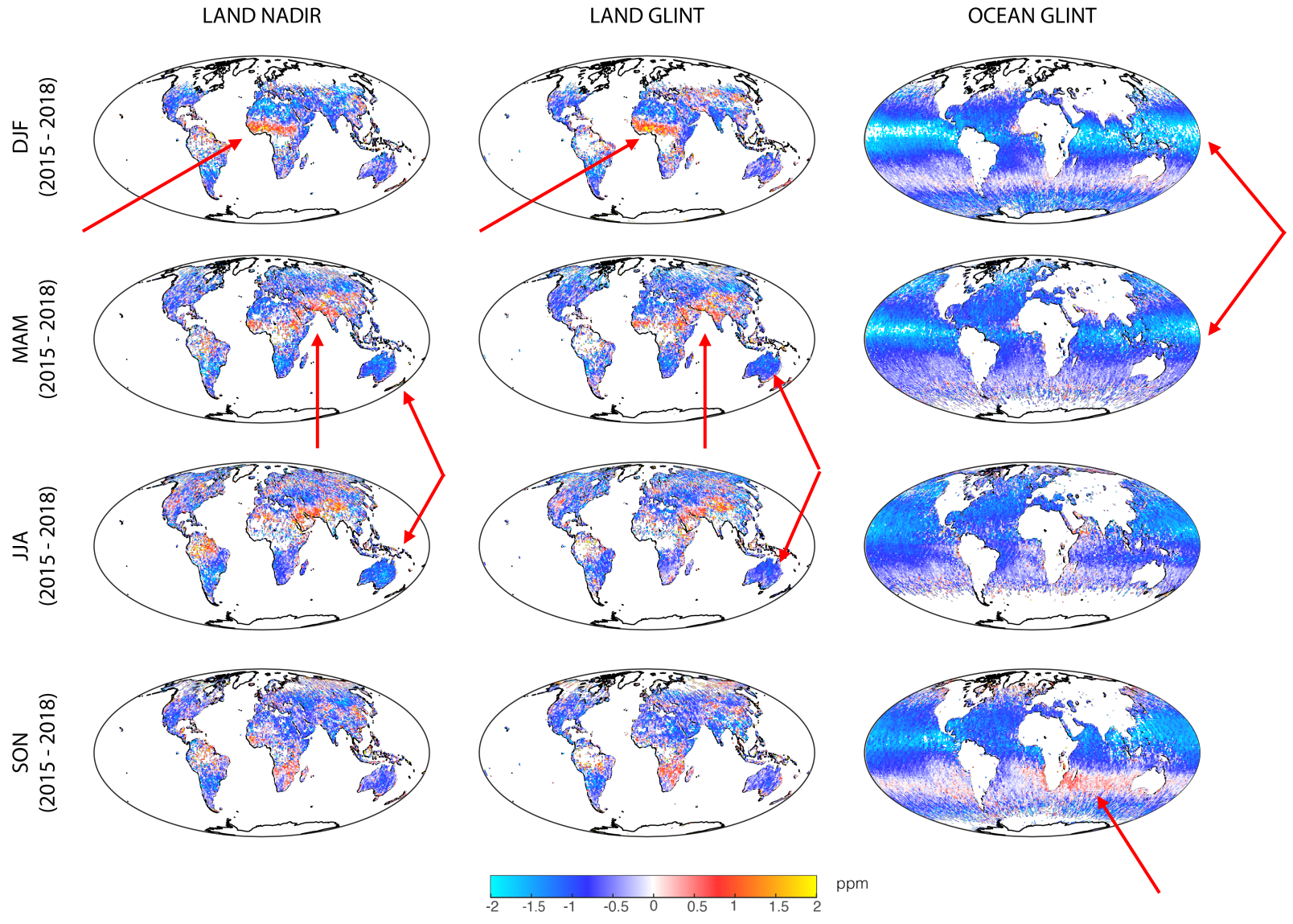
OCEAN GLINT





- Signal averaged over 4-years (2015-2018) plotted on a nominal 1° grid
- Provides a zeroth-order view of where largest differences between OCO-2 v9 and model fields (constrained by in situ data) lie
- Known regions turn up- North Africa for LN and LG, Tropical Ocean for OG


LAND NADIR
LAND GLINT
OCEAN GLINT
DJF
(2015 - 2018)
MAM
(2015 - 2018)
JJA
(2015 - 2018)
SON
(2015 - 2018)
ppm
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2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ppm
-2
-1.5
-1
-0.5
0
0.5
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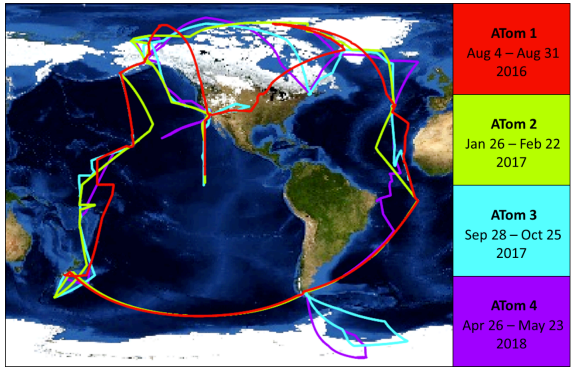
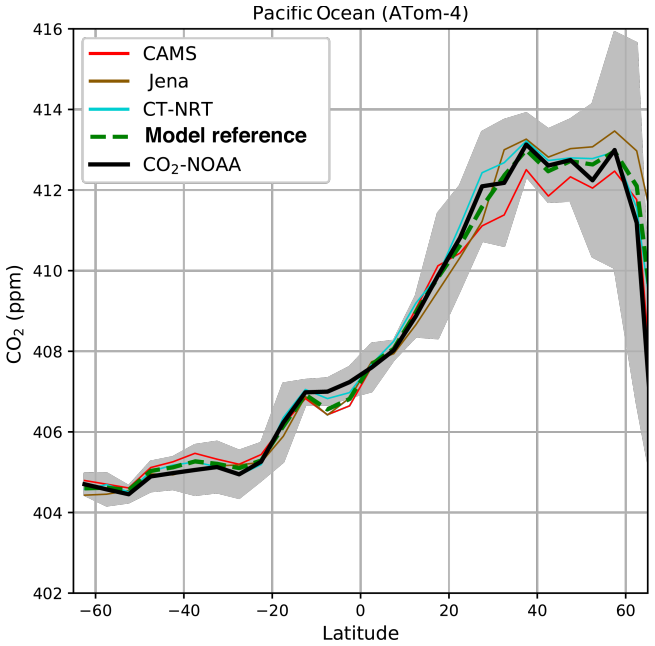
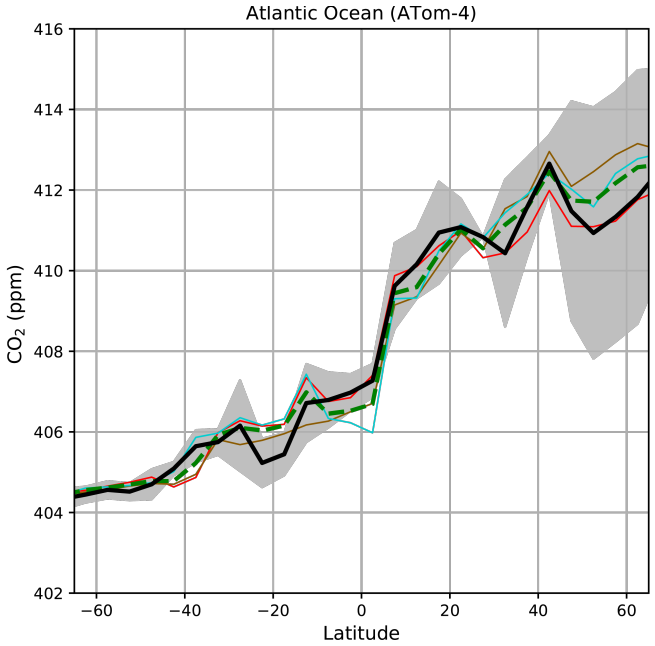
Evaluation of the model reference field

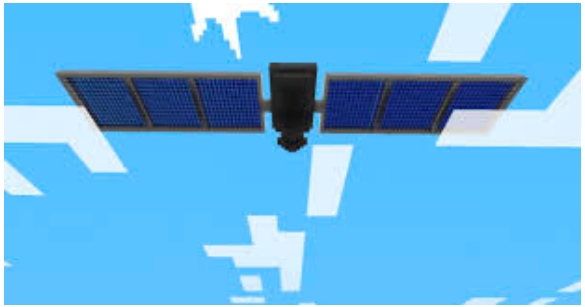




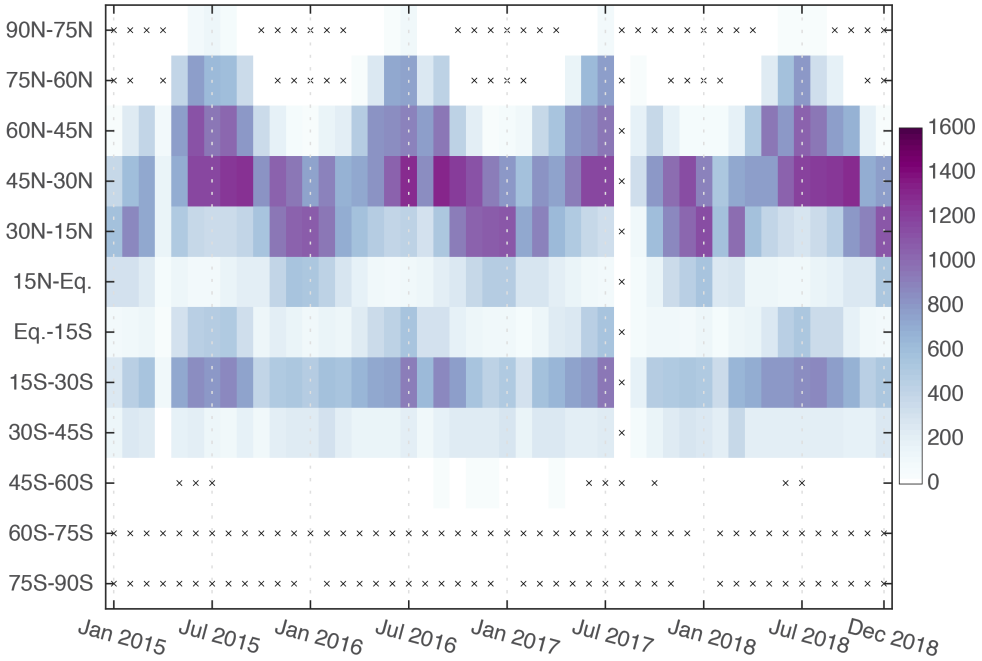


- Figure shows comparison of the model reference (dashed green) against independent AToM data (solid black) over the Pacific and the Atlantic Ocean

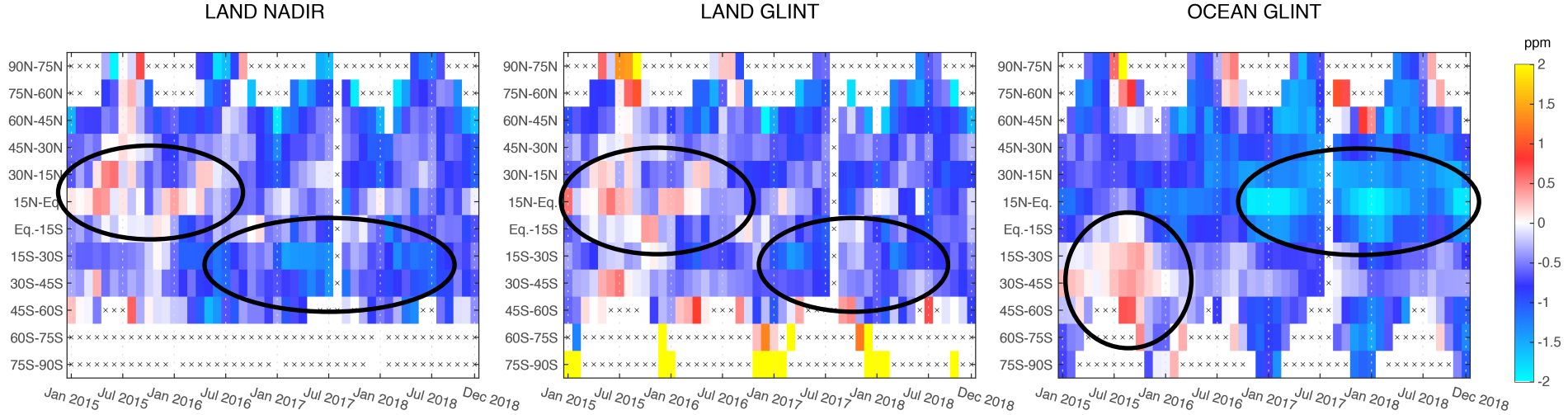
Introducing minecraft plots



- Blocks are:
  - Monthly, 4 years from Jan. 2015 to December 2018
  - 15° latitude bins
- Example shown here ⇝ number of 10s average retrievals for v9 Land Nadir, per month per 15° latitude bin
- The OCO2/3 flux team assimilates these 10s averages for generating the L4 product



Minecraft plots of the signal



Tropical "enhancement"

Extratropical SH "drawdown" - Australia

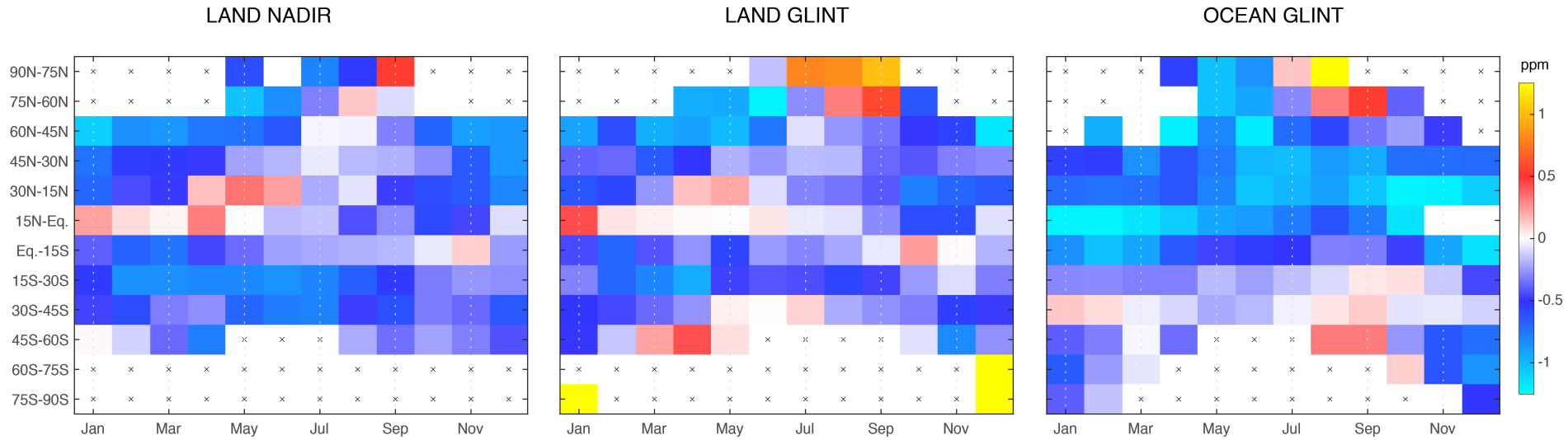
Tropical "enhancement"

To lesser extent - "drawdown" signal in extratropical SH

Strong "drawdown" across Equatorial oceans

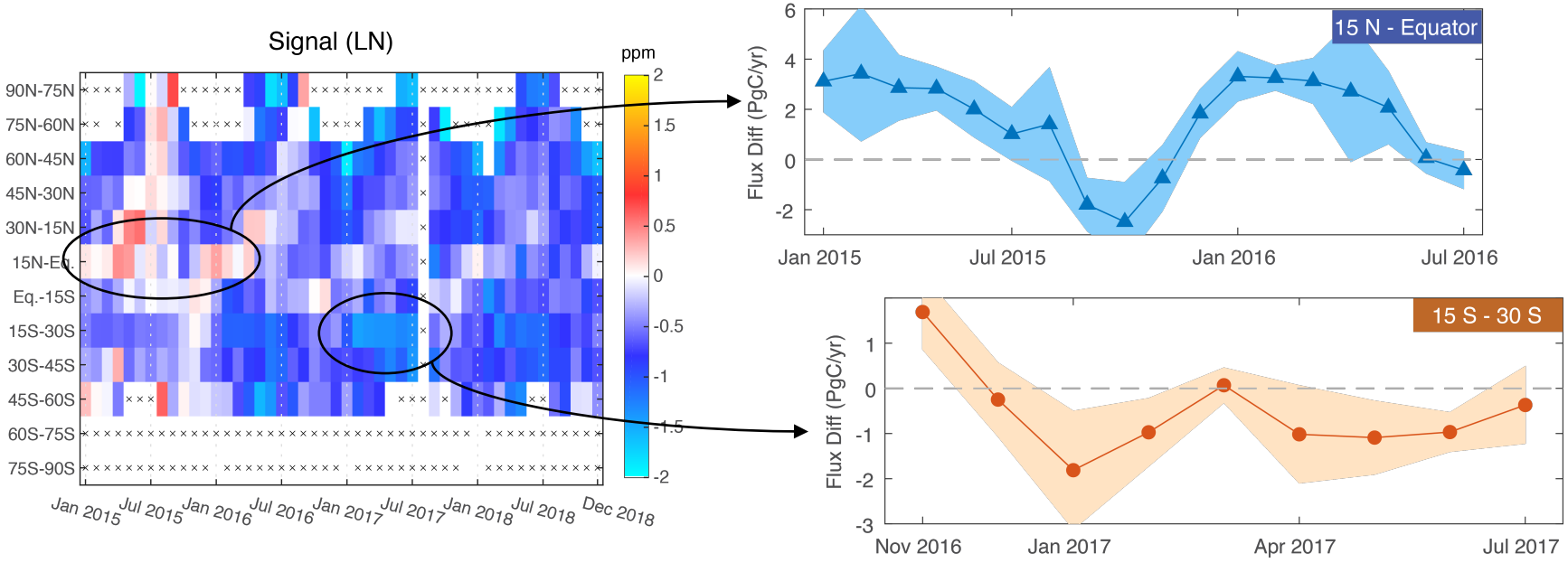
"Enhancement" in Indian ocean in 2015

Averaged signal across 4 years of OCO2 data



- while year-to-year "hotspots" drop out, certain key ones remain - tropical land ↑, extratropical SH ↓, extratropical NH in boreal winter ↓, eq. and Northern ocean ↓
- interesting aspect of signal/noise along the fringes (>45N or <45S) - retrieval bias or model deficiency?

How does the signal relate to flux inferences?



- Flux Diff. = OCO2 LN+LG (minus) IS flux estimates
- Currently, average of Basu, Crowell, Schuh, Baker - hence, independent of models that were used for generating the reference field

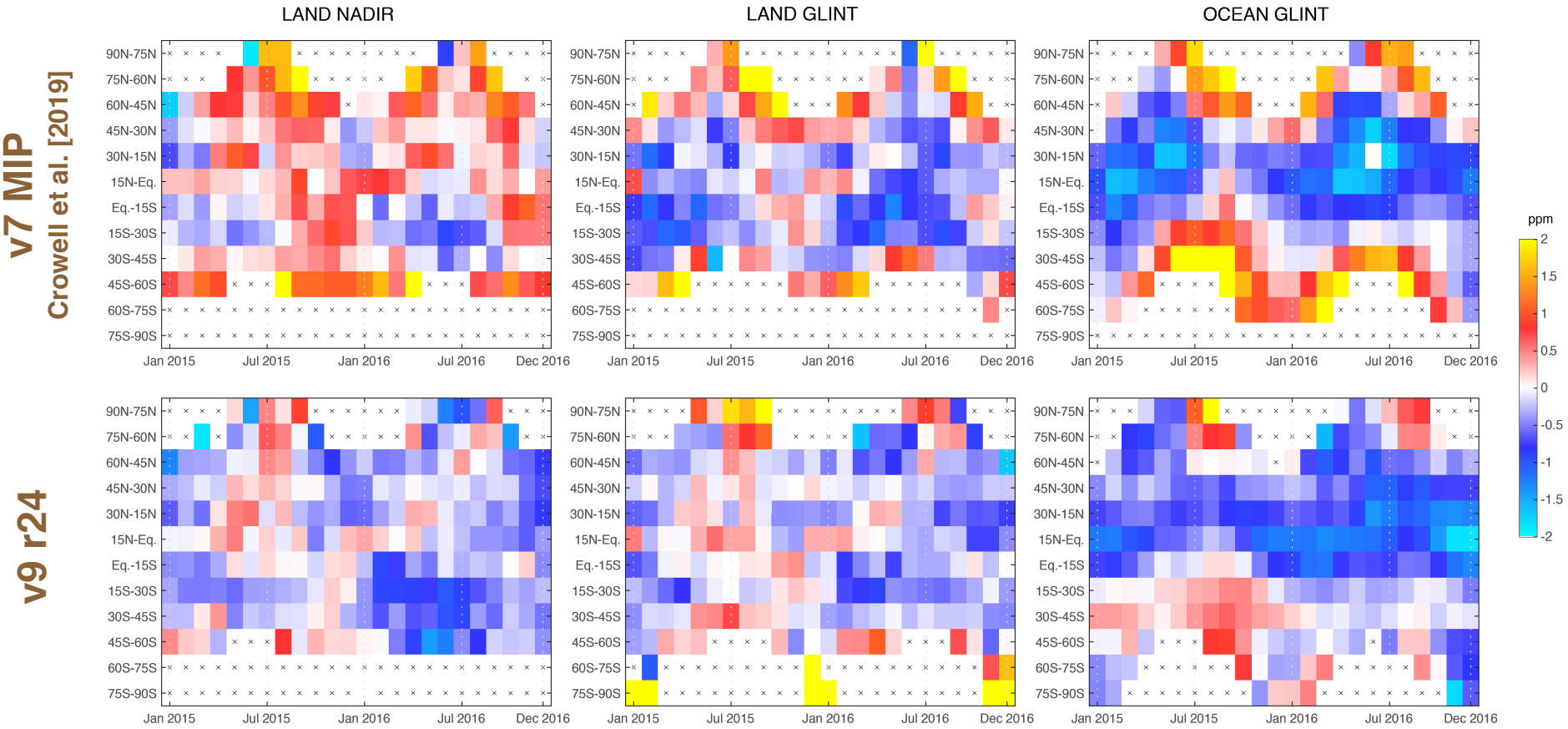
Summary

- Simple but extremely valuable framework (spatial maps and minecraft plots) provide first clues about regions and time-periods of interest. For example,
  - newer patterns emerging over the SH extratropics in Boreal summer of 2017 and 2018
  - tropical land signal has switched signs - positive in 2015-2016 (El Niño) but now slightly negative in 2017-2018, i.e., OCO2 $X_{CO2} \leqq$ model ref X_{CO2}
  - in-depth evaluation of high-latitude land glint retrievals is needed

- Inform researchers of data choices they need to make while using OCO-2/3 data

- Transitioning to an OCO project activity

Signal in v9 relative to signal in v7



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  - in-depth evaluation of high-latitude land glint retrievals is needed

- Inform researchers of data choices they need to make while using OCO-2/3 data

- Transitioning to an OCO project activity - routine checks as newer versions of data (v10) and/or new data streams (OCO3, GOSAT-2) become available

Questions?

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