



# Characteristics of total column CO<sub>2</sub> 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  $X_{\text{CO}_2}$  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**



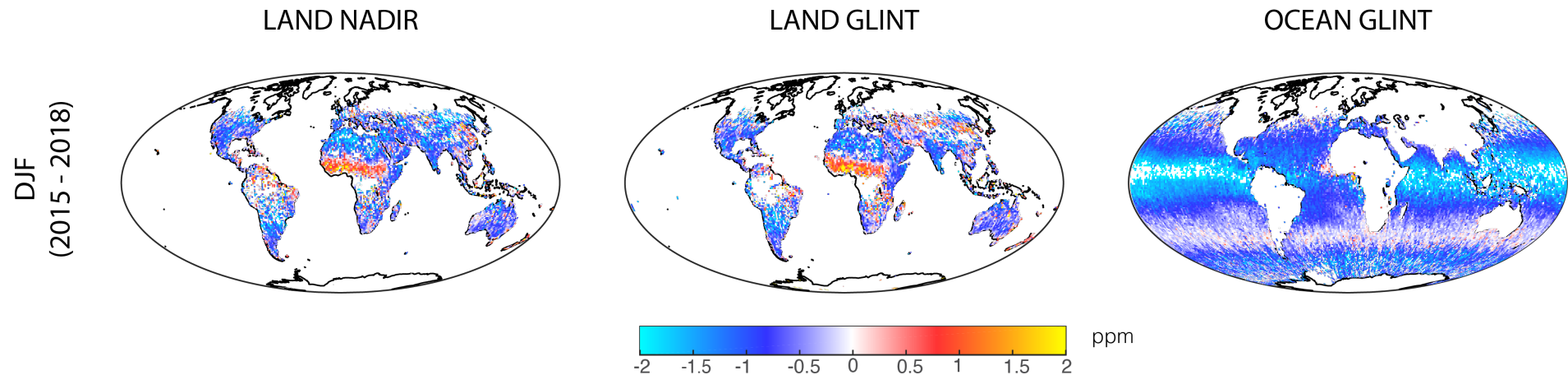
# Defining the “signal”

**Signal** = **v9**  $X_{CO_2}$  10s averages (r24) **minus** a reference  $X_{CO_2}$  field

## Reference $X_{CO_2}$ 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



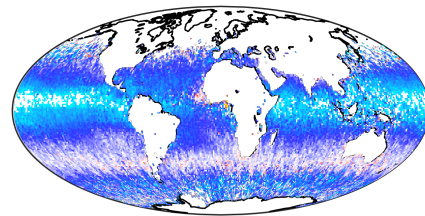
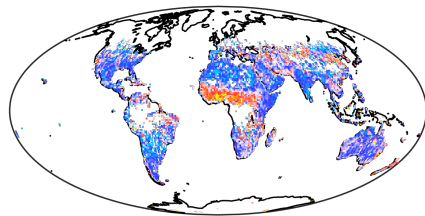
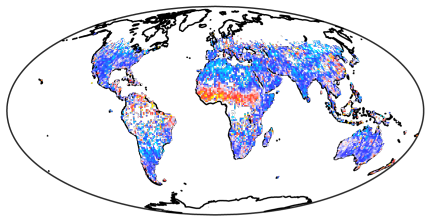
- ❑ Signal averaged over 4-years (2015-2018) plotted on a nominal 1° grid
- ❑ Provides a zeroth-order view of where largest differences between OCO-2 v9 and model fields (constrained by in situ data) lie
- ❑ Known regions turn up- North Africa for LN and LG, Tropical Ocean for OG

LAND NADIR

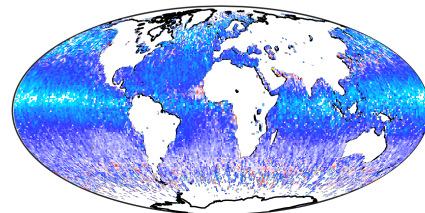
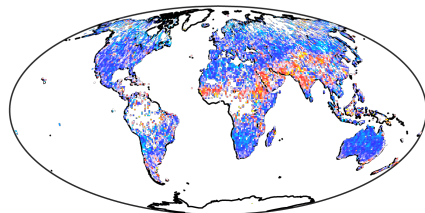
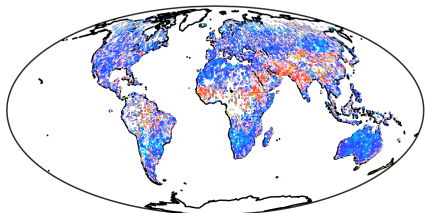
LAND GLINT

OCEAN GLINT

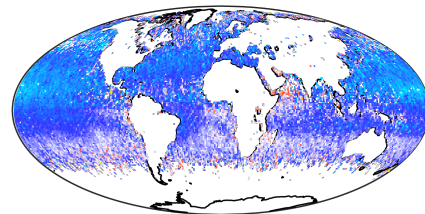
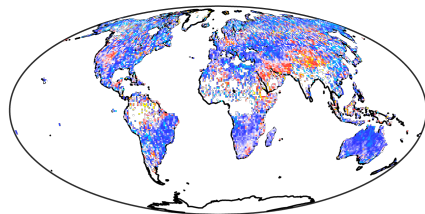
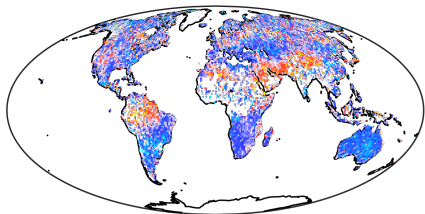
DJF  
(2015 - 2018)



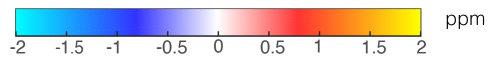
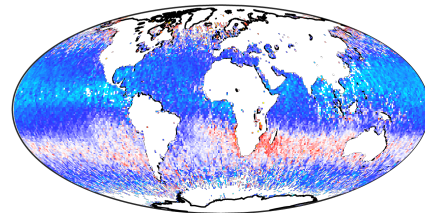
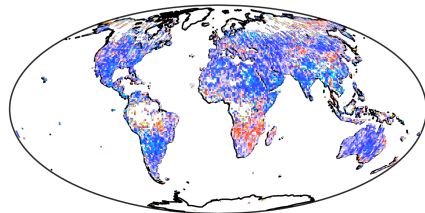
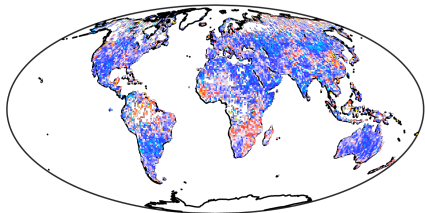
MAM  
(2015 - 2018)

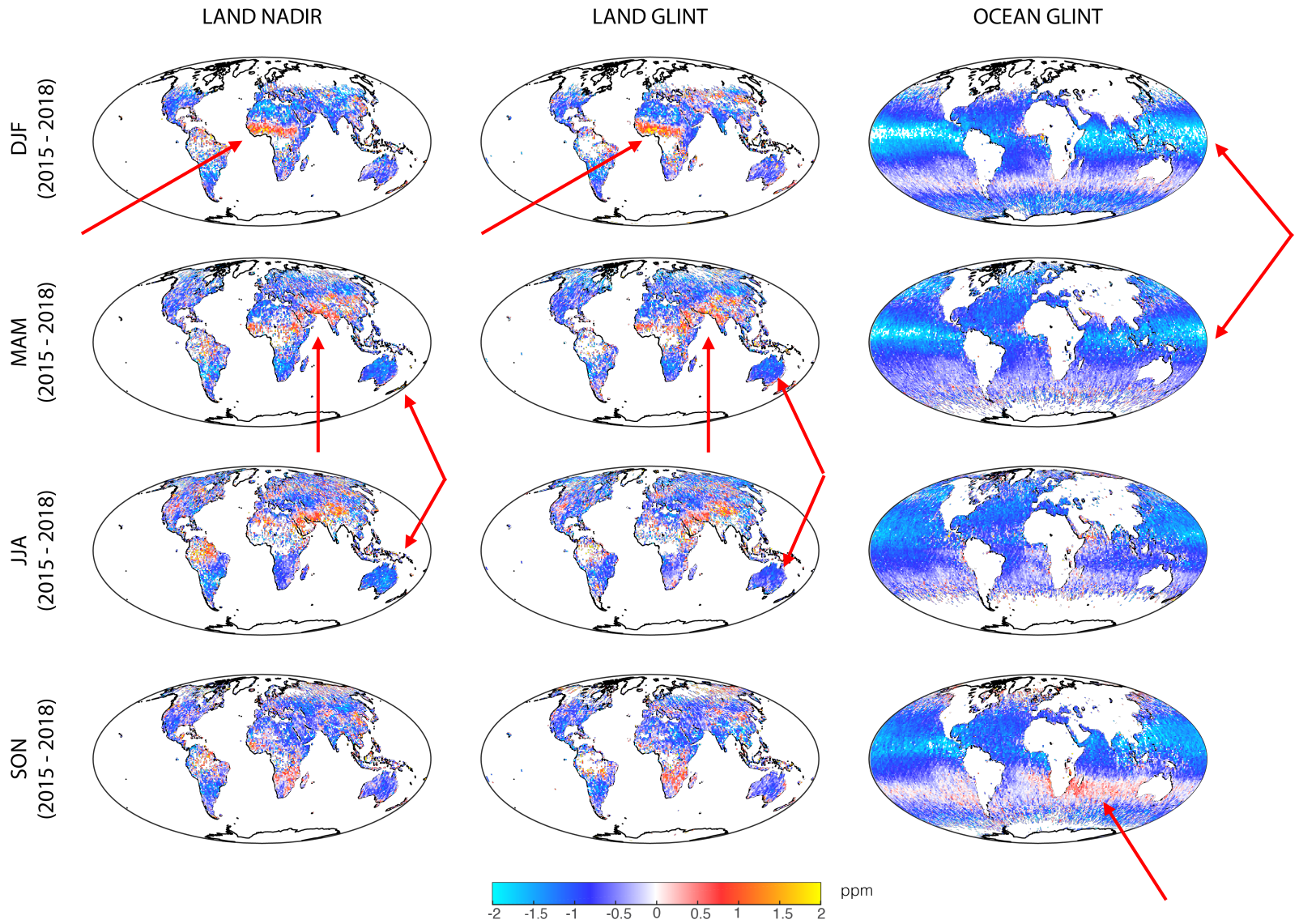


JJA  
(2015 - 2018)

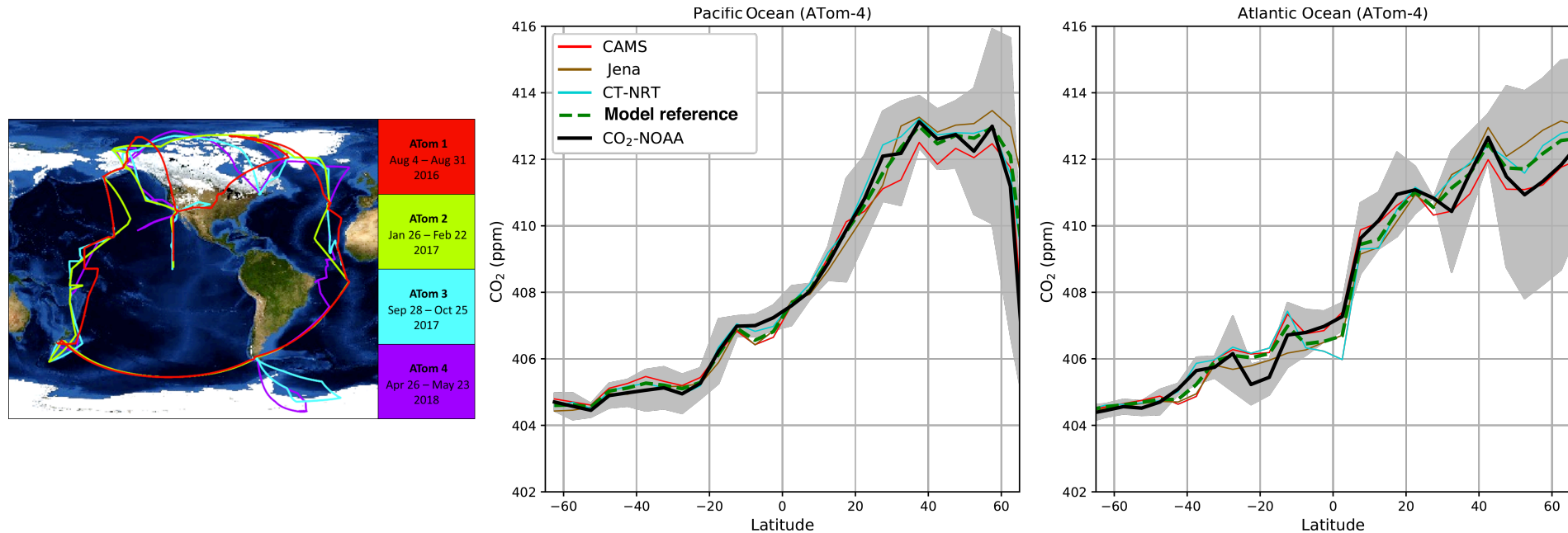


SON  
(2015 - 2018)





# Evaluation of the model reference field

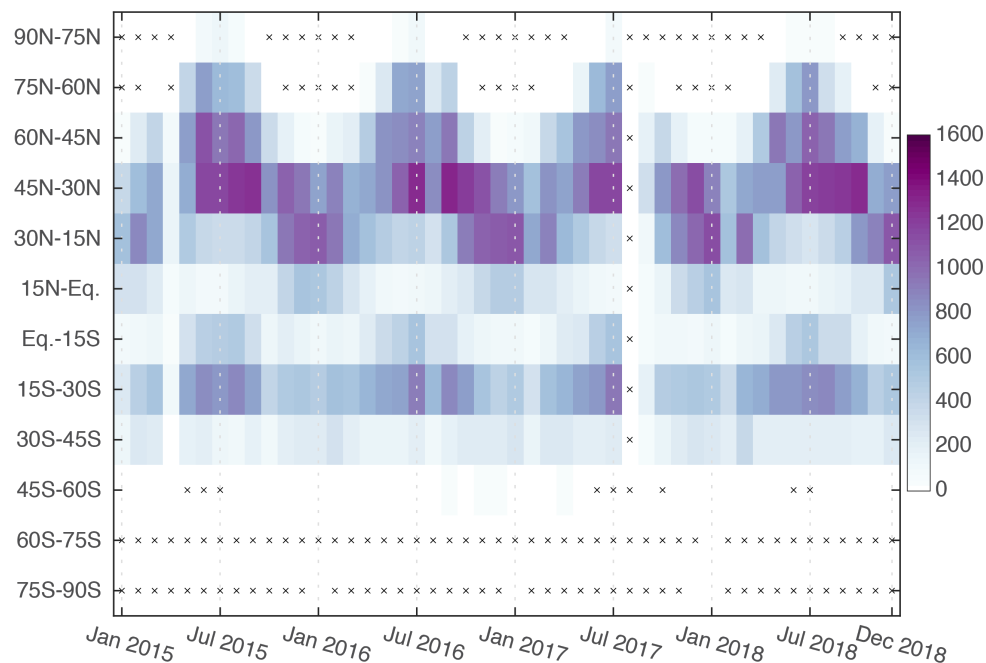


- Figure shows comparison of the model reference (dashed green) against independent ATom data (solid black) over the Pacific and the Atlantic Ocean

# Introducing minecraft plots



- ❑ Blocks are:
  - Monthly, 4 years from Jan. 2015 to December 2018
  - 15° latitude bins
  
- ❑ Example shown here  $\leadsto$  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



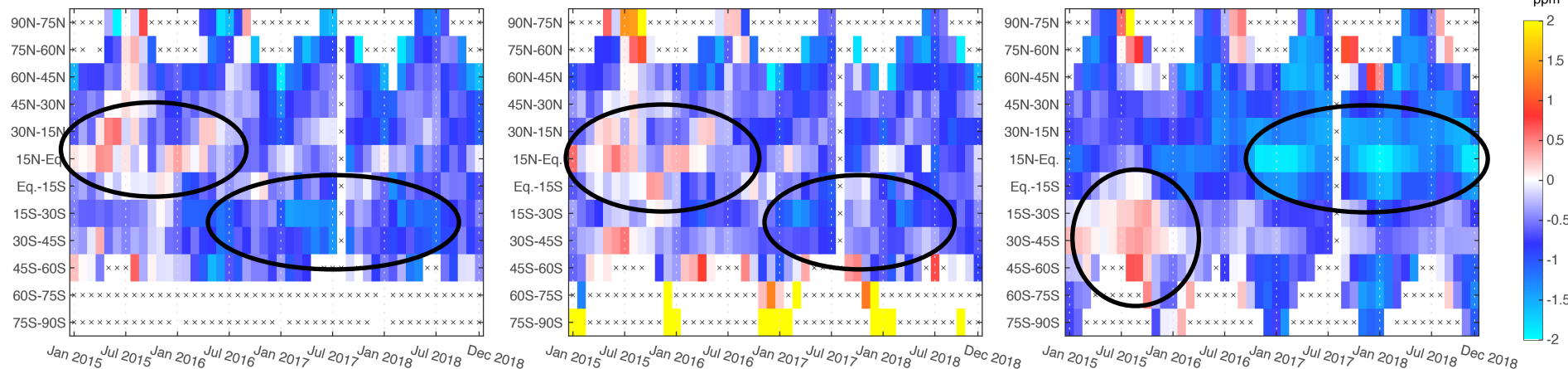


# Minecraft plots of the signal

LAND NADIR

LAND GLINT

OCEAN GLINT



Tropical “enhancement”

Tropical “enhancement”

Strong “drawdown” across  
Equatorial oceans

Extratropical SH  
“drawdown” - Australia

To lesser extent -  
“drawdown” signal in  
extratropical SH

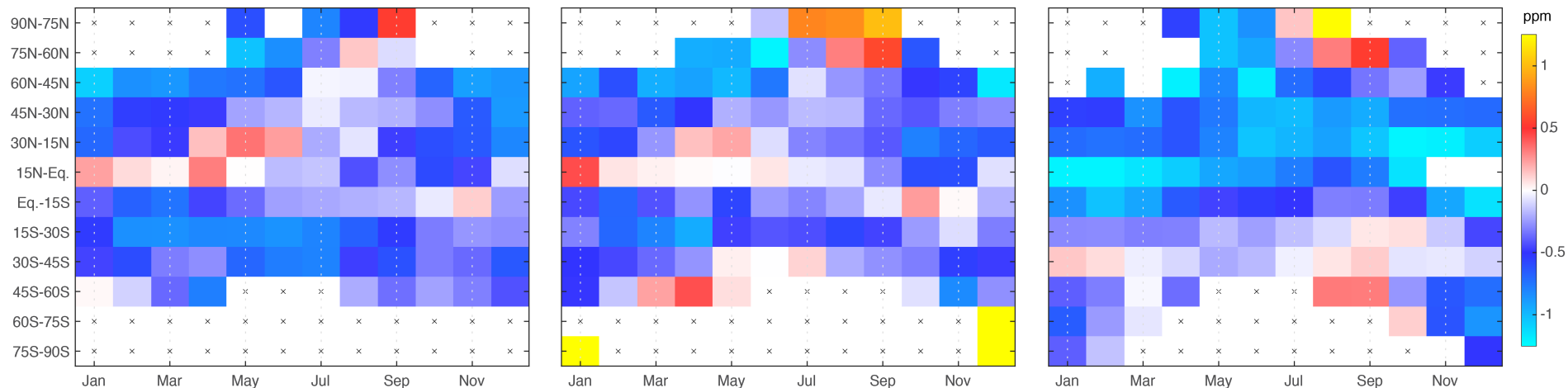
“Enhancement” in Indian ocean  
in 2015

# Averaged signal across 4 years of OCO2 data

LAND NADIR

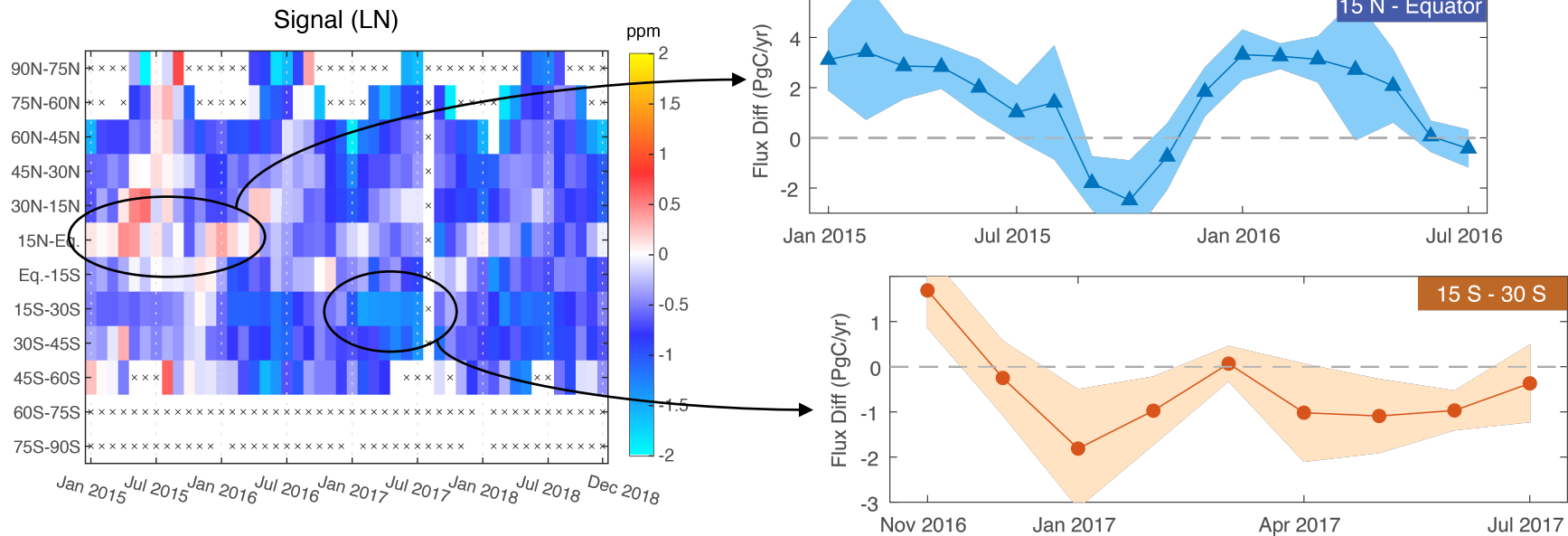
LAND GLINT

OCEAN GLINT



- ❑ 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



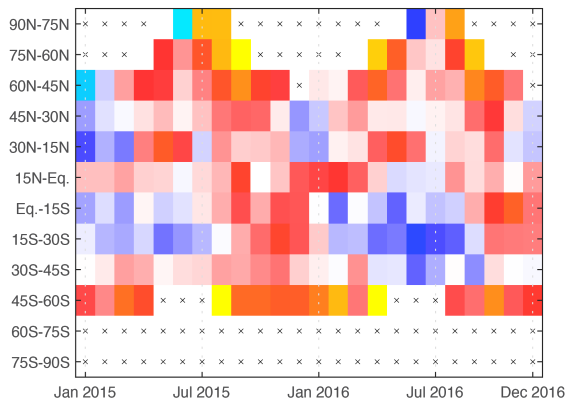
# Summary

- 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.,  $\text{OCO2 } X_{\text{CO2}} \leq \text{model ref } X_{\text{CO2}}$
  - 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

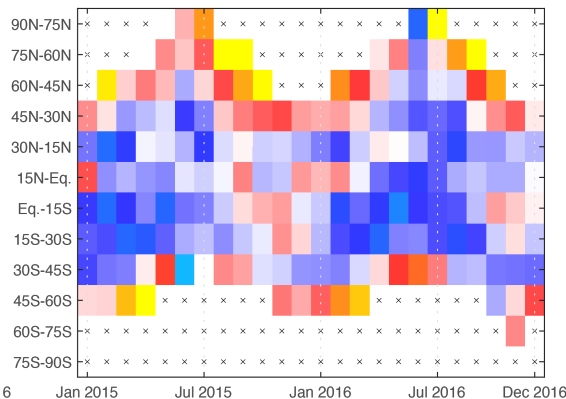
# Signal in v9 relative to signal in v7

v7 MIP  
Crowell et al. [2019]

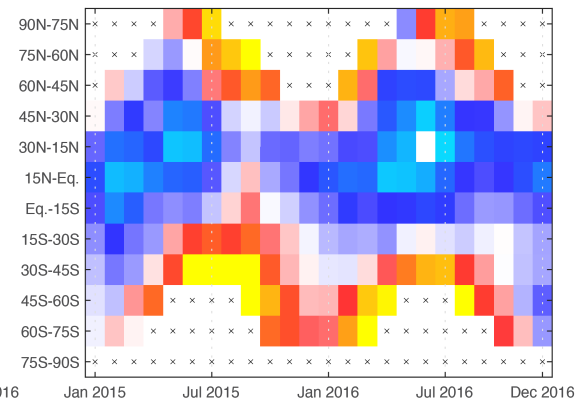
LAND NADIR



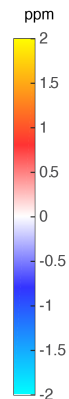
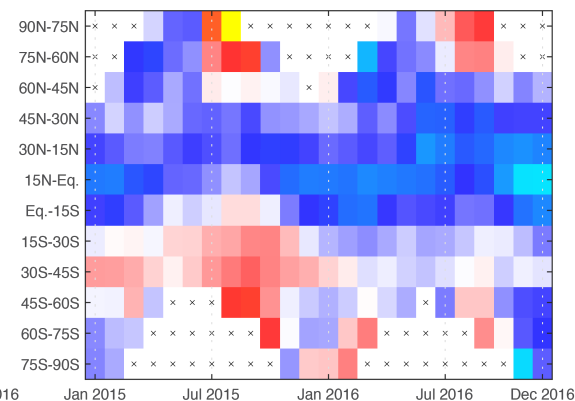
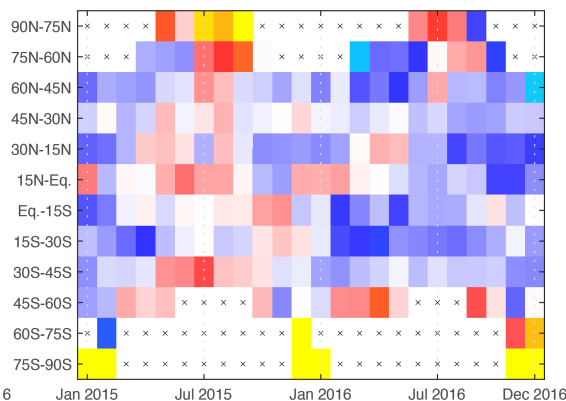
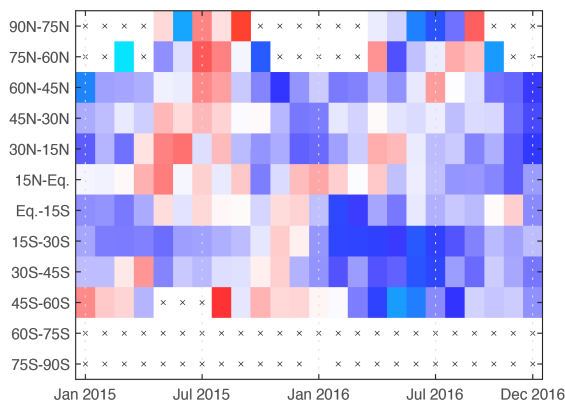
LAND GLINT



OCEAN GLINT



v9 r24





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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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