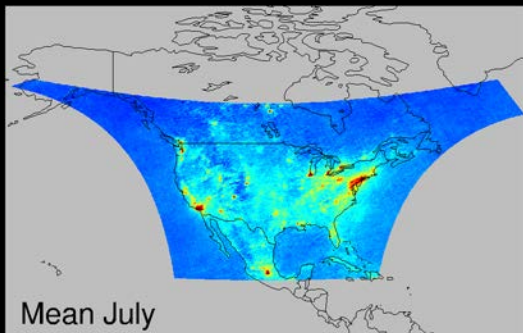
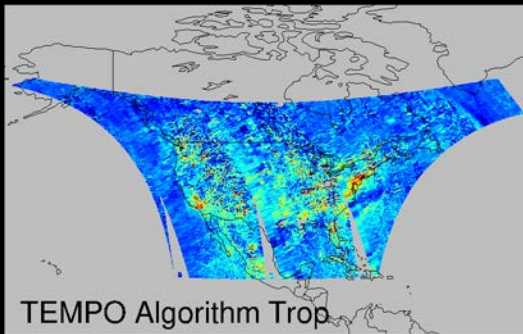
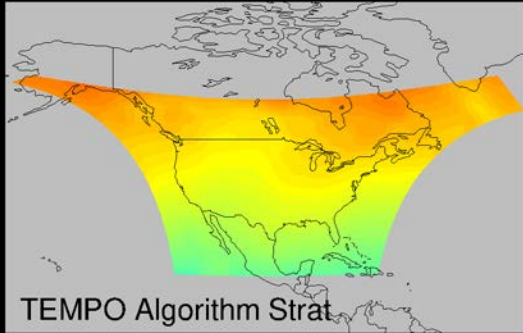


2018 GEMS Science Team Meeting

NO₂ Stratosphere-Troposphere Separation Strategy for TEMPO (and possible lessons for GEMS)



Jeffrey Geddes

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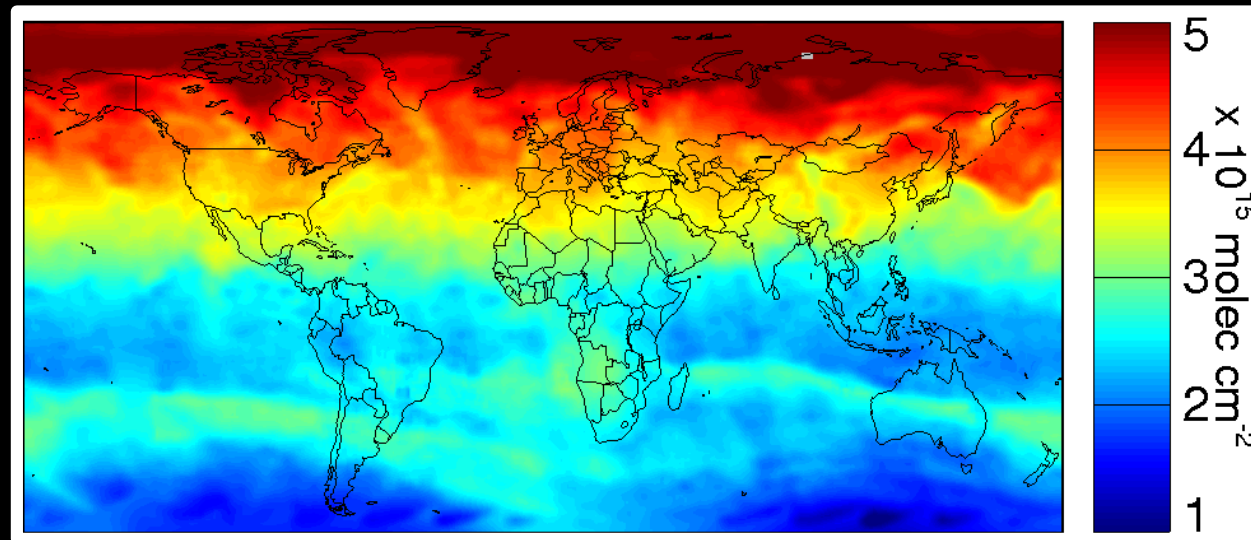
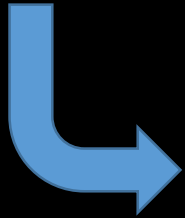
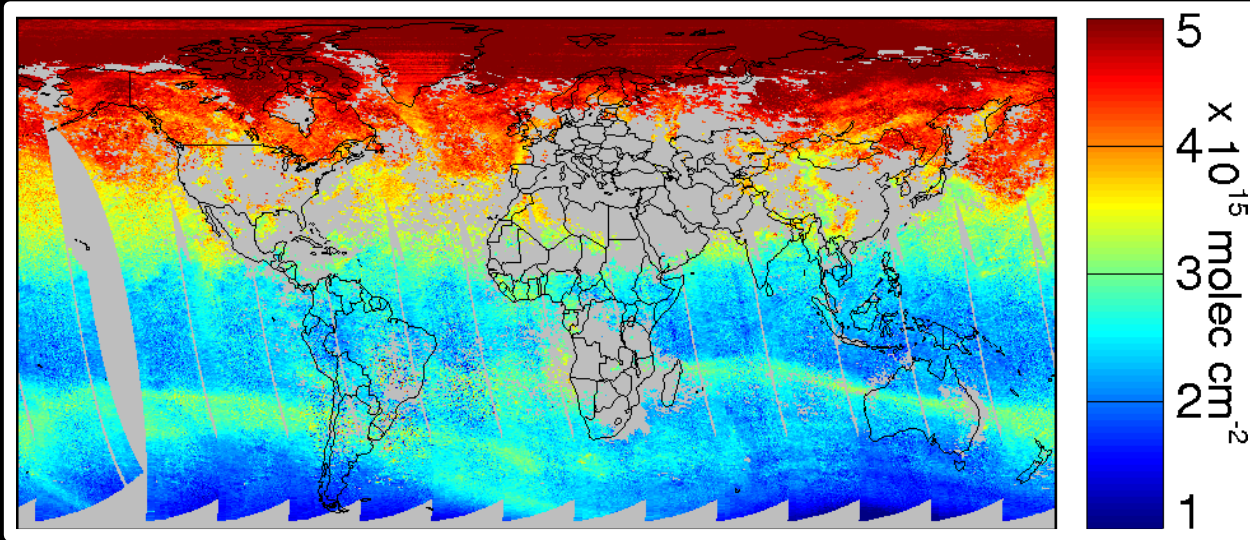
Environment and Climate Change Canada

Manuscript under review at AMT

“Stratosphere-troposphere separation of nitrogen dioxide columns from the TEMPO geostationary satellite instrument”

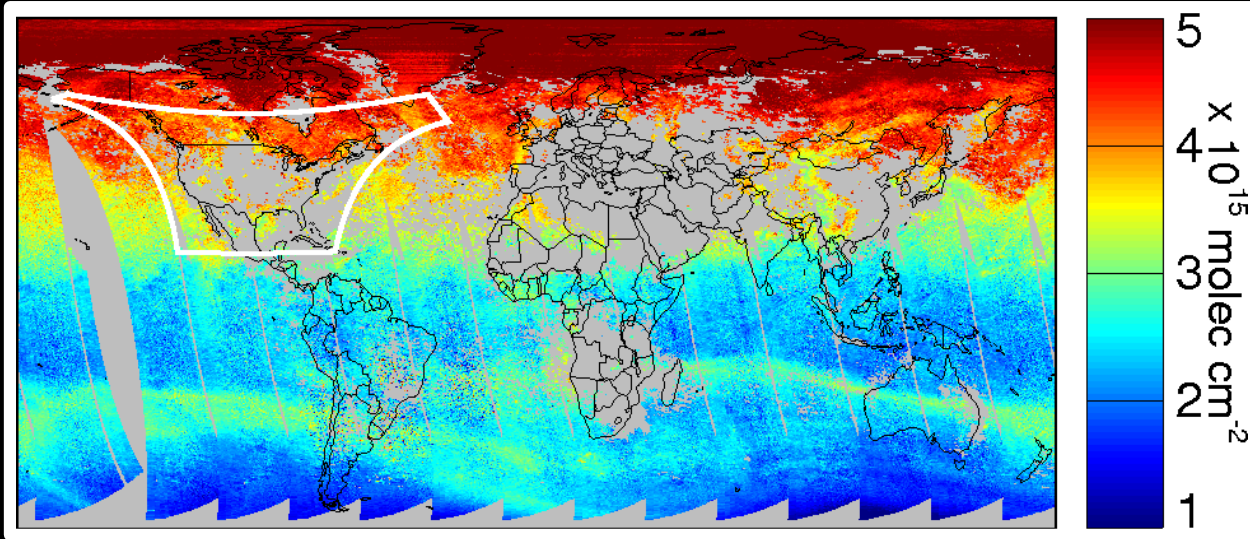
STS from Low-Earth Orbit Benefits from Global Observations

e.g. Operational STS for NASA OMI product:



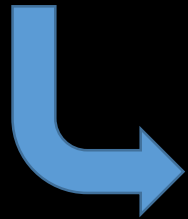
STS from Low-Earth Orbit Benefits from Global Observations

e.g. Operational STS for NASA OMI product:



Continental (polluted) field of regard

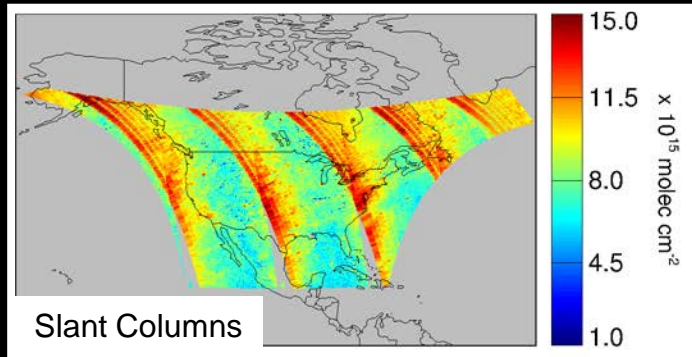
Temporally varying spatial domain



***Will a similar approach work
for STS from TEMPO?***

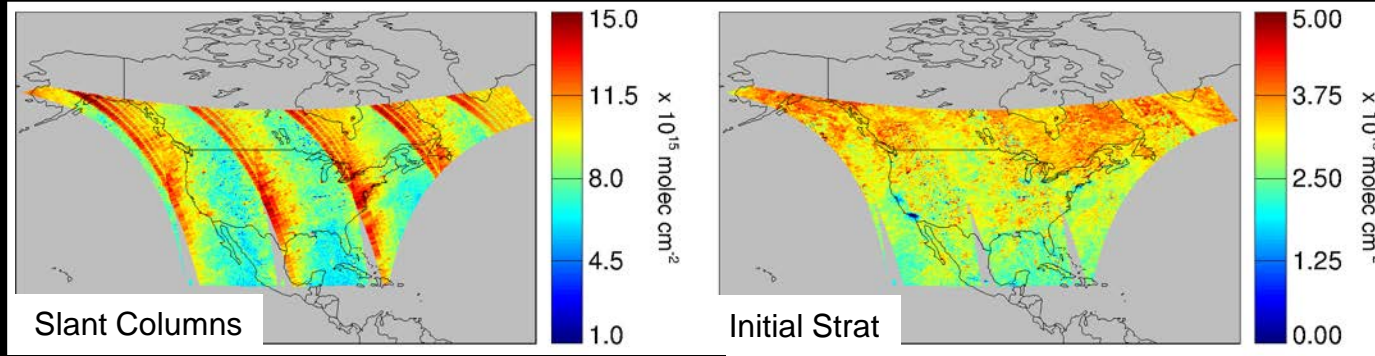
***What is the penalty of the
limited field of regard?***

Developing a Strategy for TEMPO



*OMI Observations as
TEMPO surrogate*

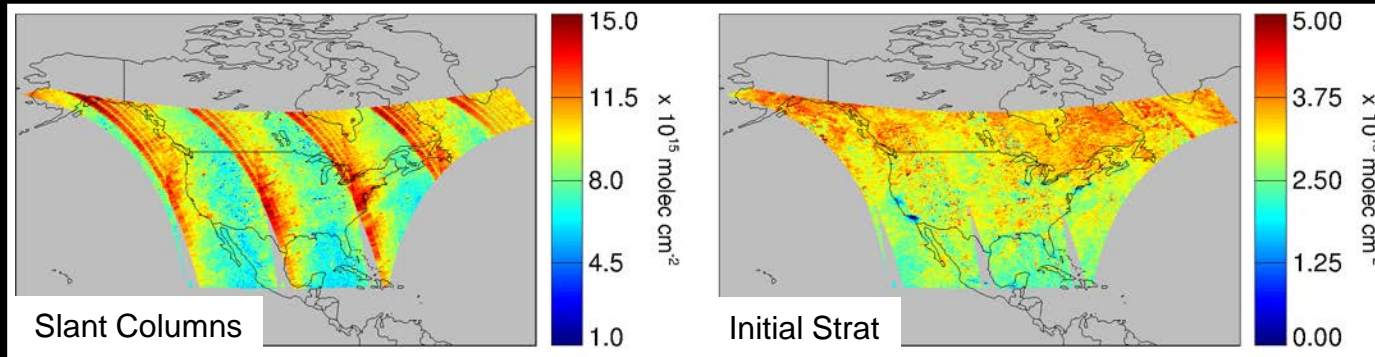
Developing a Strategy for TEMPO



$$V_{init} = \frac{(S - S_{trop,prior})}{A_{strat}}$$

where $S_{trop,prior} = V_{trop,prior} \cdot A_{trop}$

Developing a Strategy for TEMPO



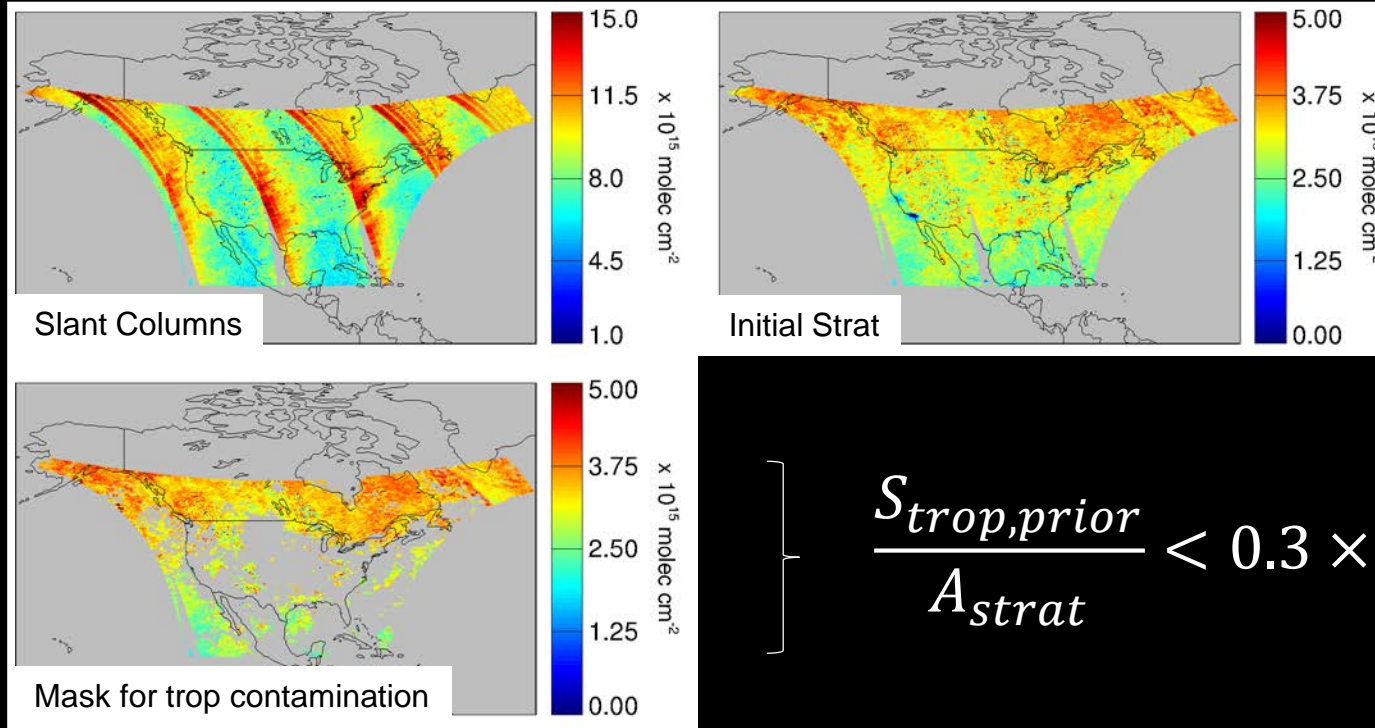
$$V_{init} = \frac{(S - S_{trop,prior})}{A_{strat}}$$

where $S_{trop,prior} = V_{trop,prior} \cdot A_{trop}$

GOME-2 (TROPOMI?)
monthly mean



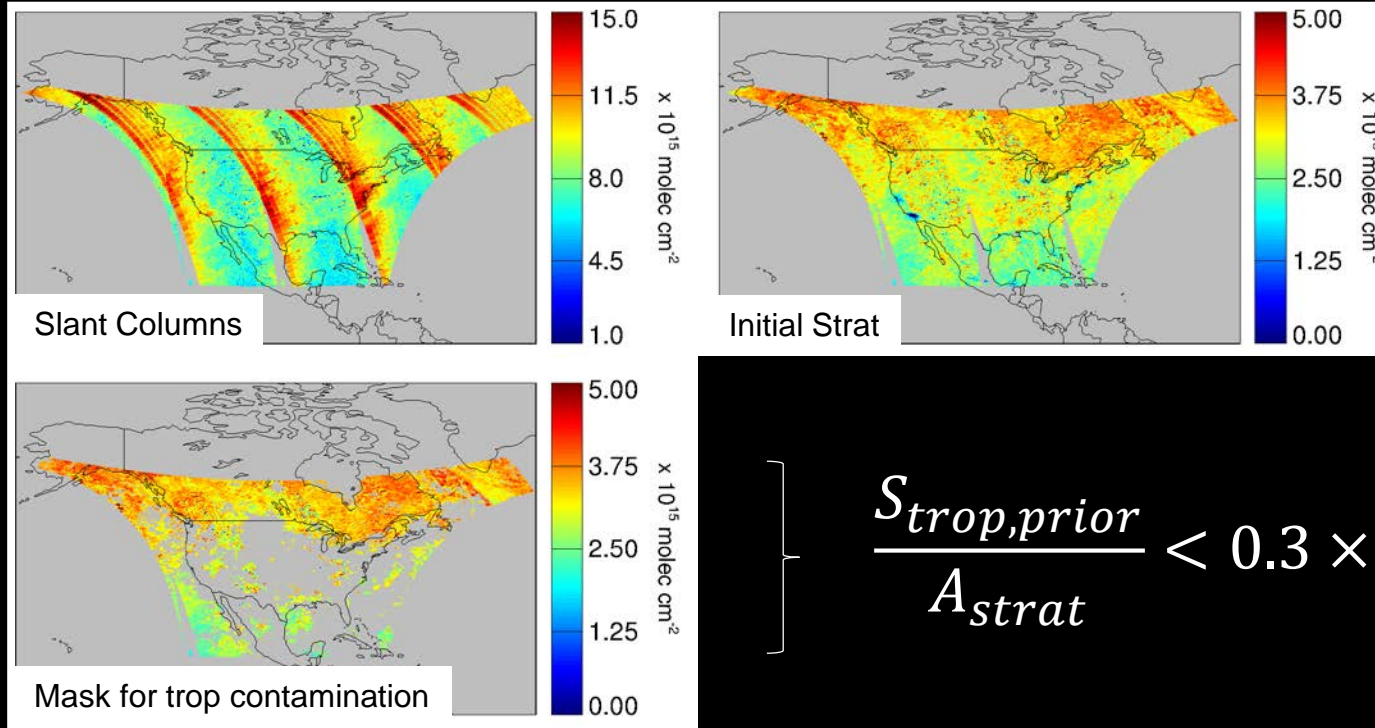
Developing a Strategy for TEMPO



$$\left. \frac{S_{trop,prior}}{A_{strat}} < 0.3 \times 10^{15} \text{ cm}^{-2} \right\}$$

(where $S_{trop,prior} = V_{trop,prior} \cdot A_{trop}$)

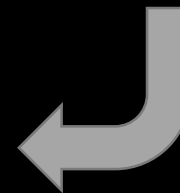
Developing a Strategy for TEMPO



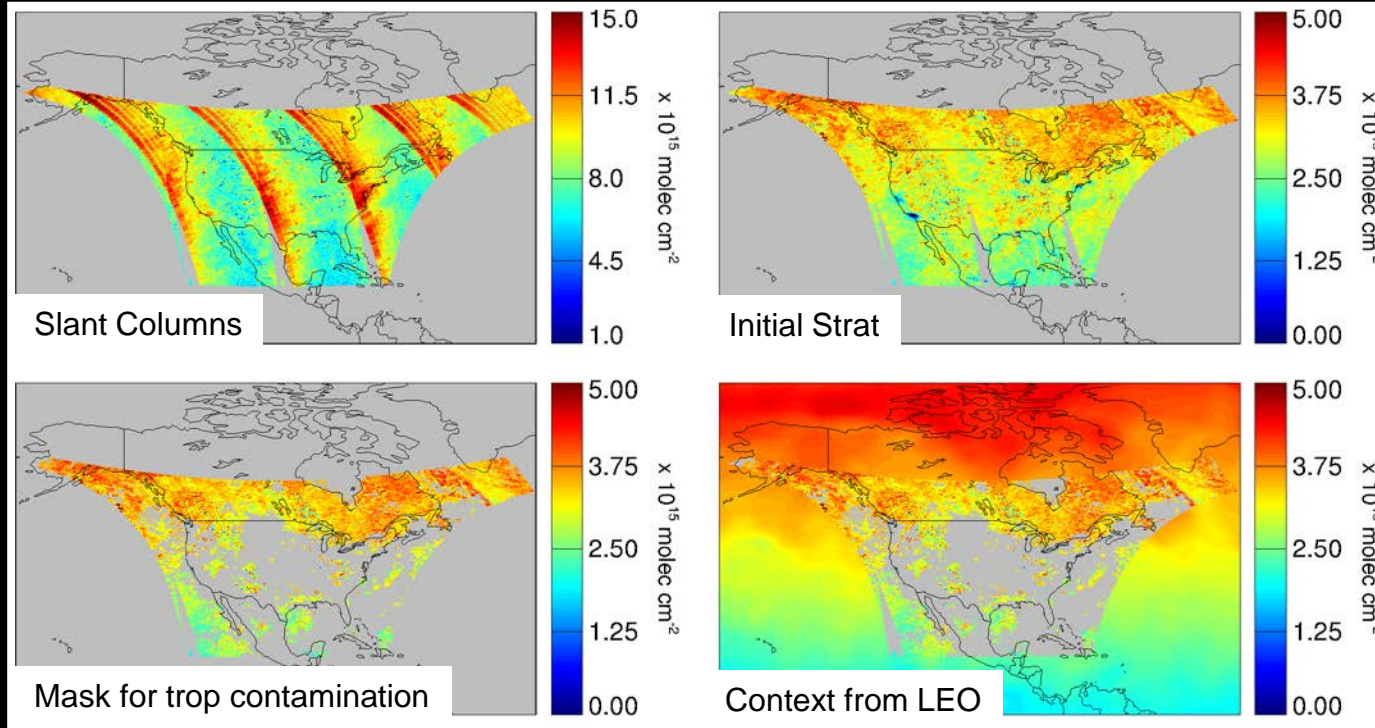
$$\frac{S_{trop,prior}}{A_{strat}} < 0.3 \times 10^{15} \text{ cm}^{-2}$$

(where $S_{trop,prior} = V_{trop,prior} \cdot A_{trop}$)

Retains observations where A_{trop} is small (cloudy)

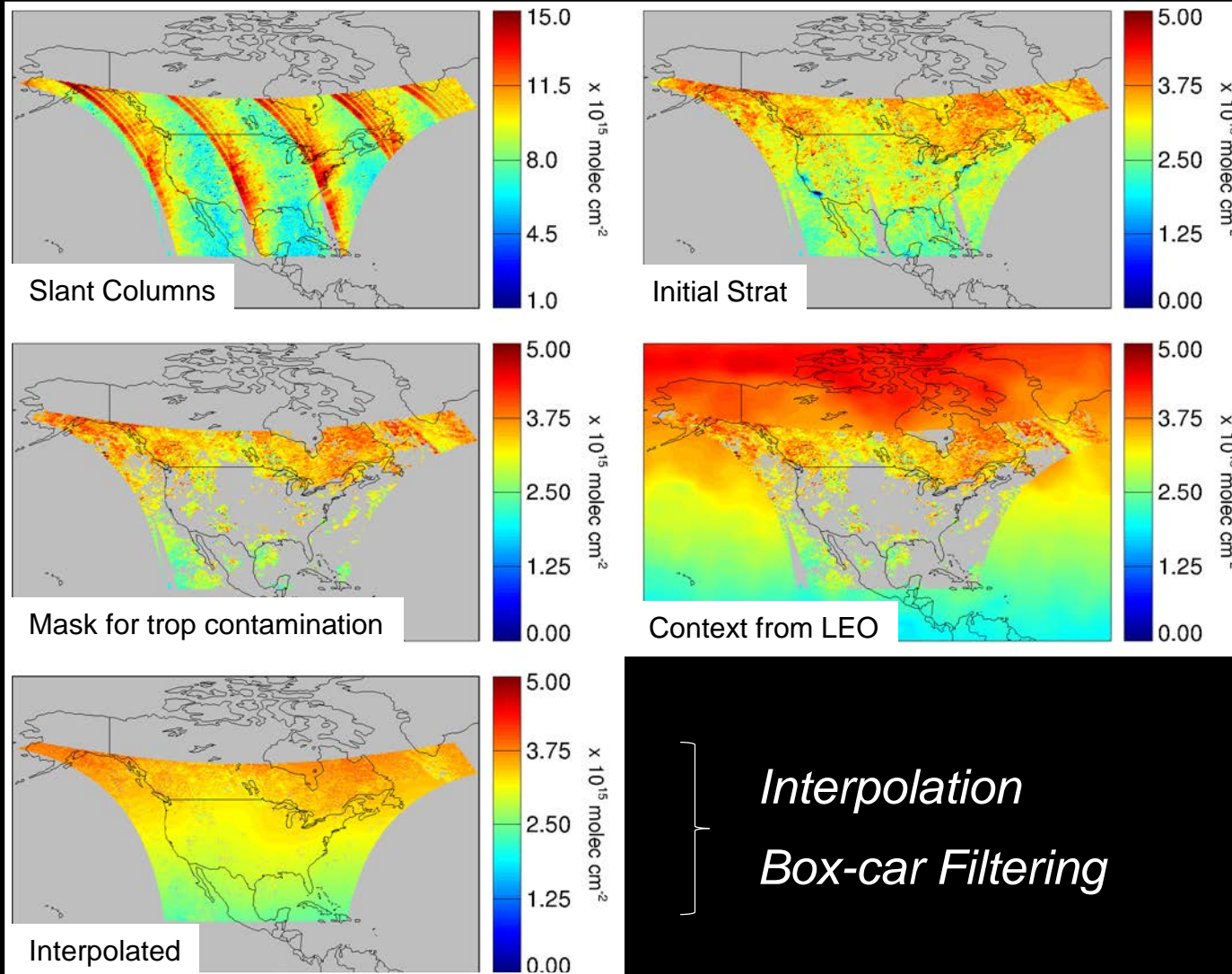


Developing a Strategy for TEMPO

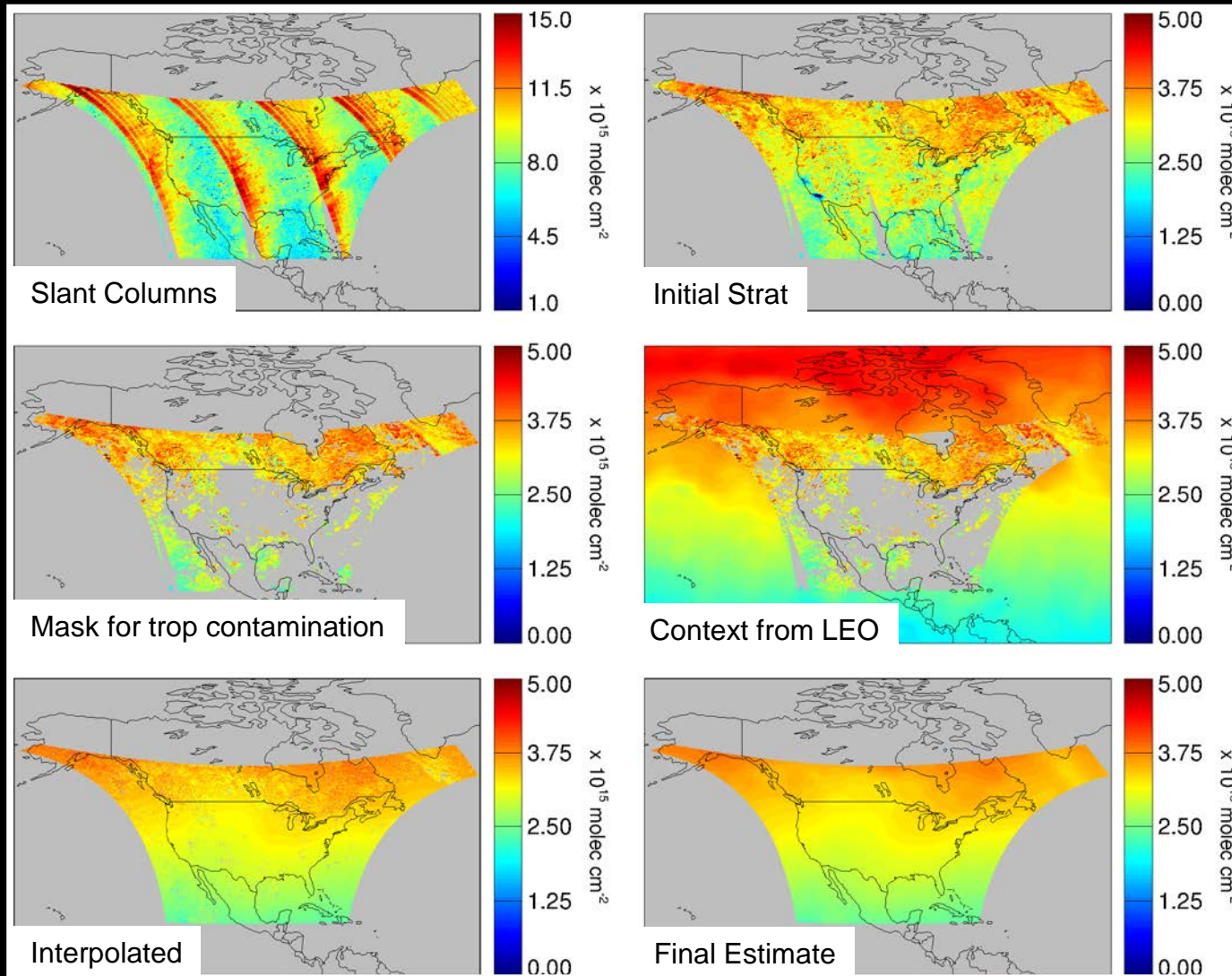


Same-day GOME-2 observations (corrected for time-of-day) provide supporting information outside domain

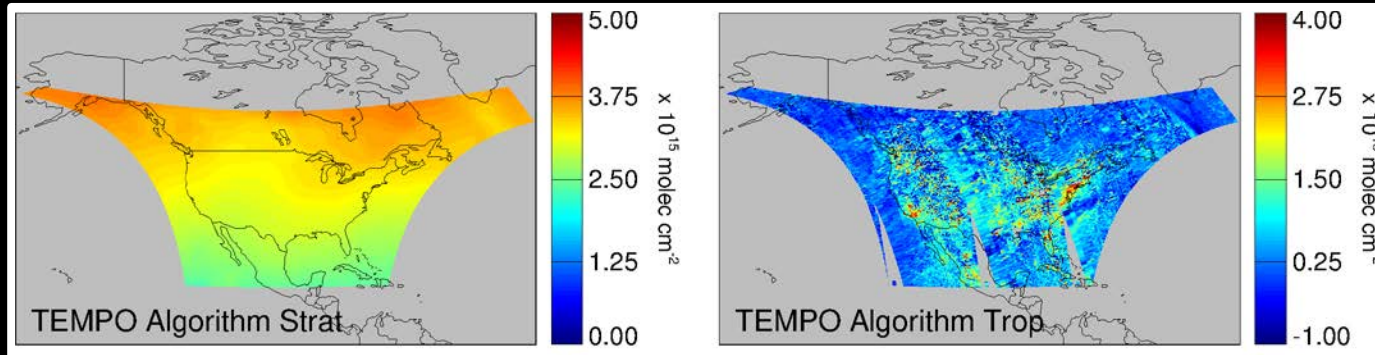
Developing a Strategy for TEMPO



Developing a Strategy for TEMPO

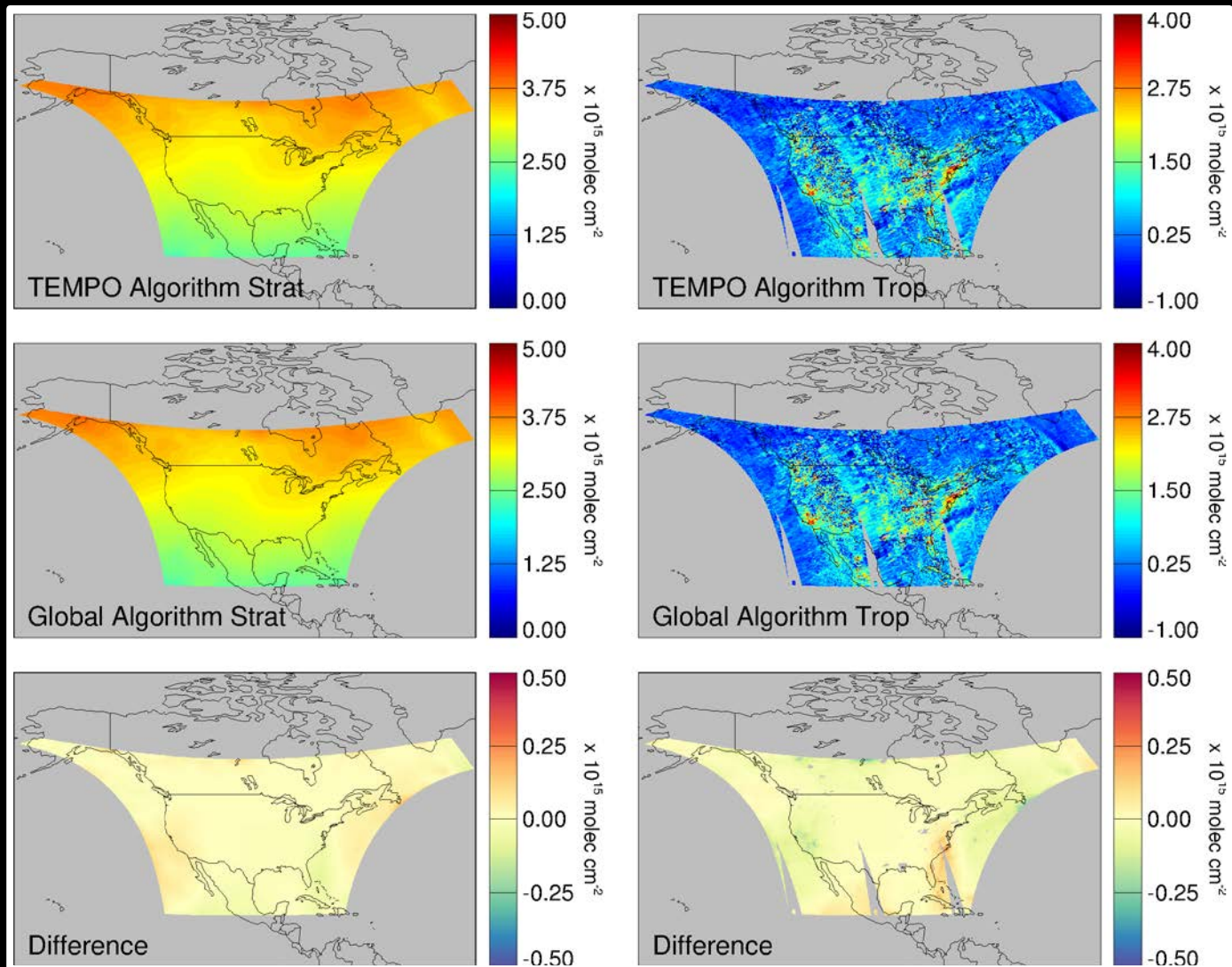


Tropospheric NO₂ from TEMPO



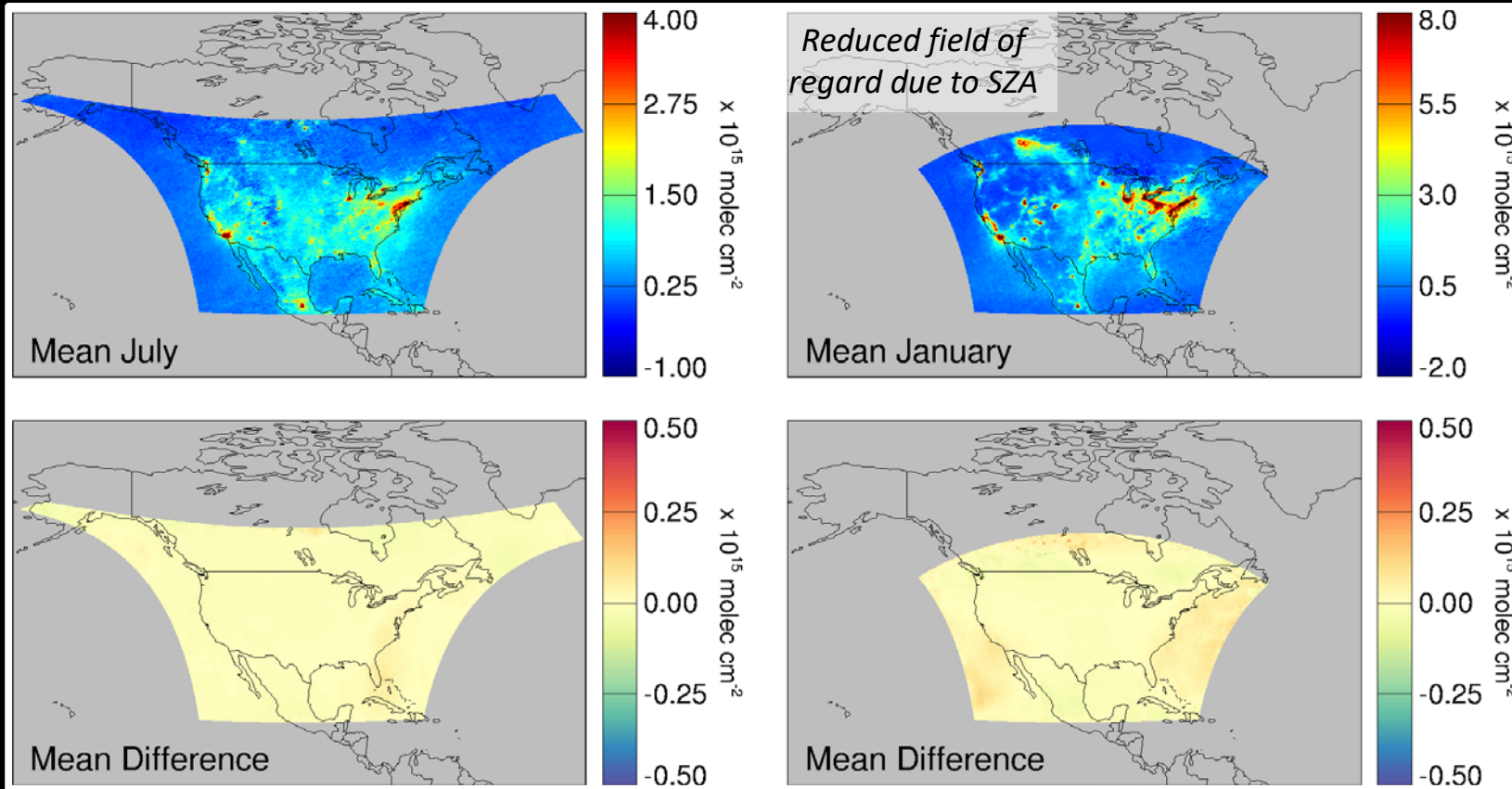
$$V_{trop} = \frac{(S - V_{strat} \cdot A_{strat})}{A_{trop}}$$

Tropospheric NO₂ from TEMPO



*Perform the same steps,
but with global data
(What is the penalty from
limited field of regard?)*

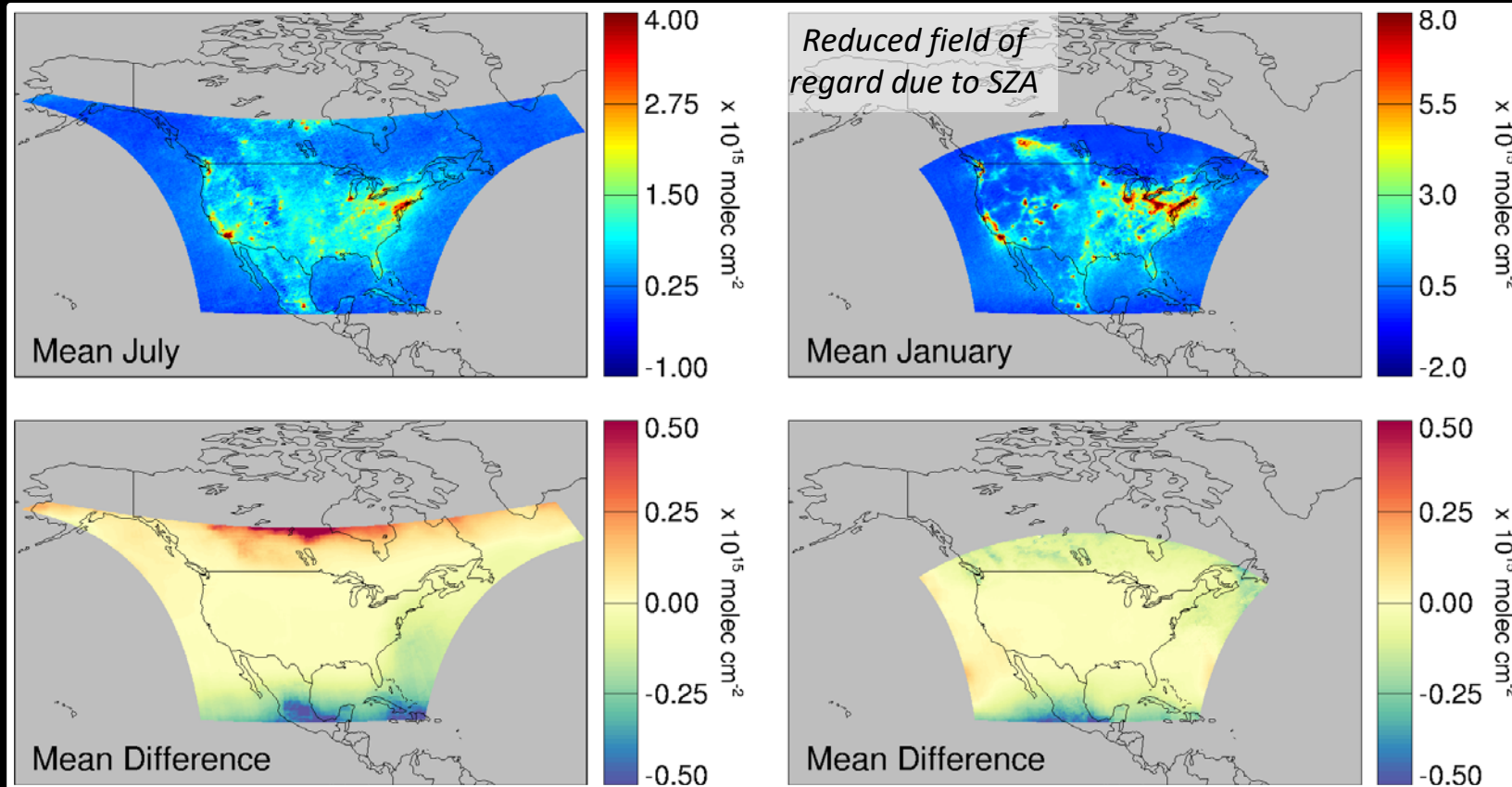
Monthly Mean NO₂ Agrees Very Well with Global Algorithm



$R^2 = 0.999$
Slope = 1.009

$R^2 = 0.998$
Slope = 0.999

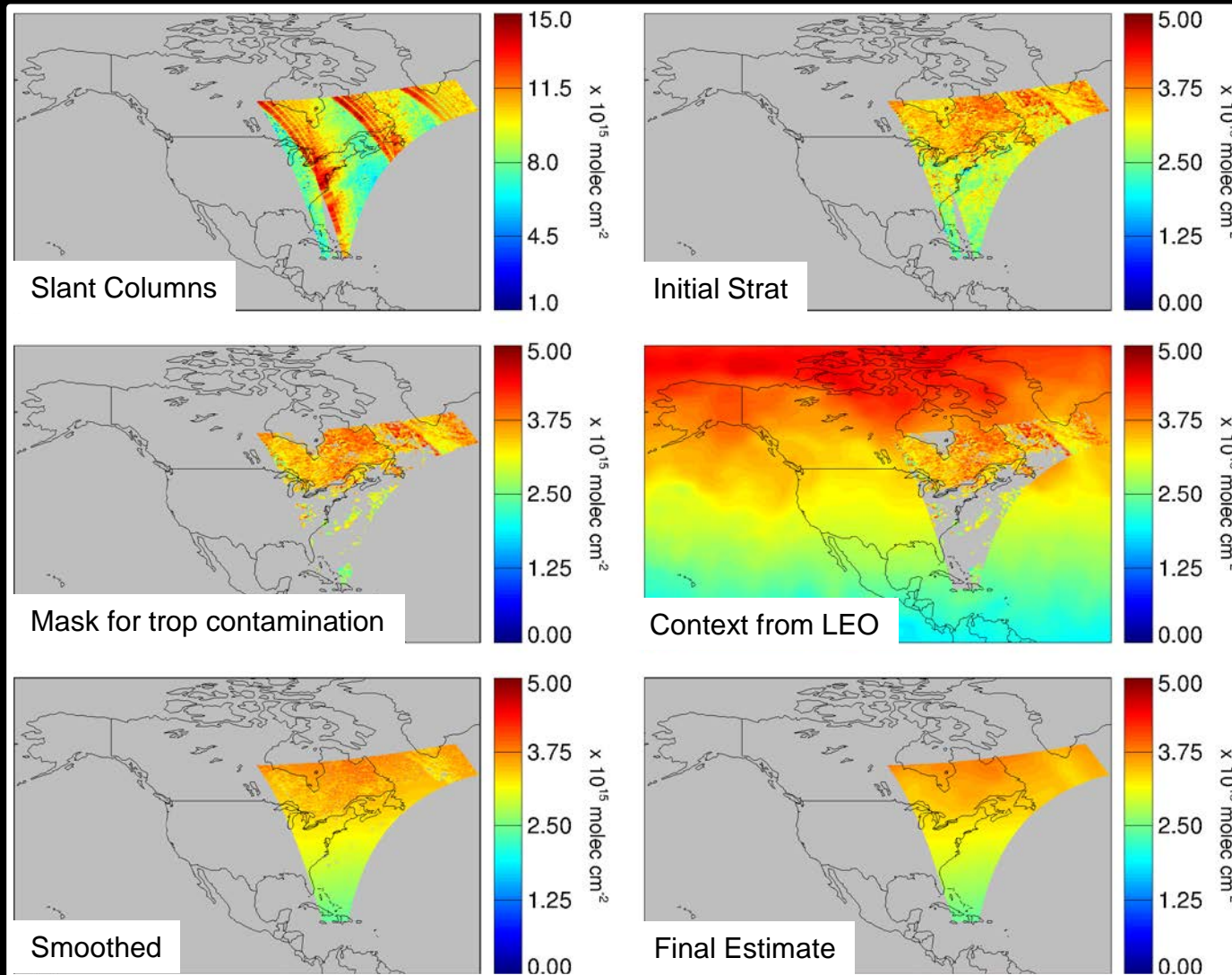
Removing Supporting Observations from LEO (NRT?)



$R^2 = 0.924$
Slope = 0.973

$R^2 = 0.996$
Slope = 1.008

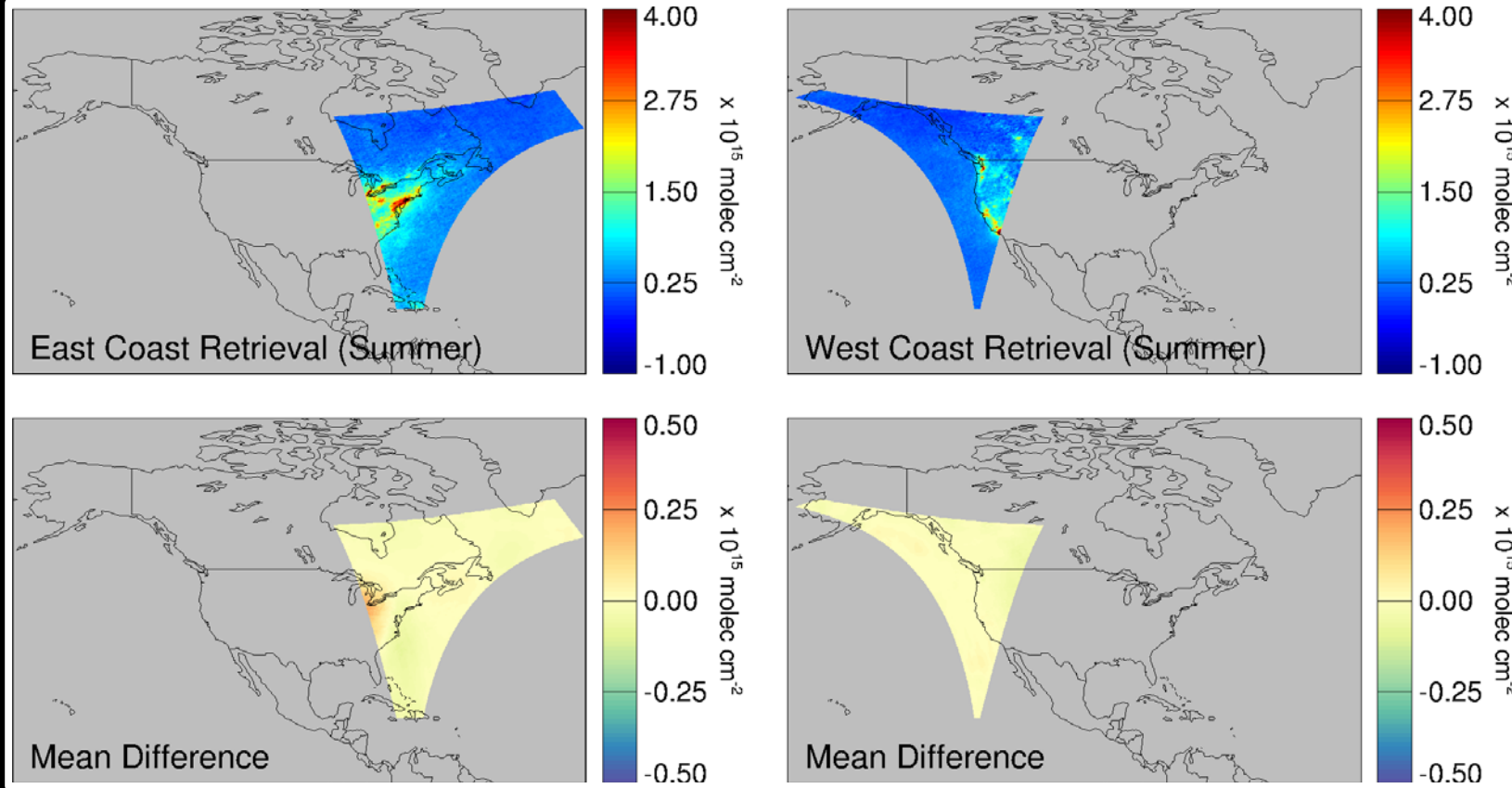
Temporally Varying Field of Regard, e.g. 1130 UTC



Temporally Varying Field of Regard, Trop NO₂ (Summer)

1130 UTC

0200 UTC



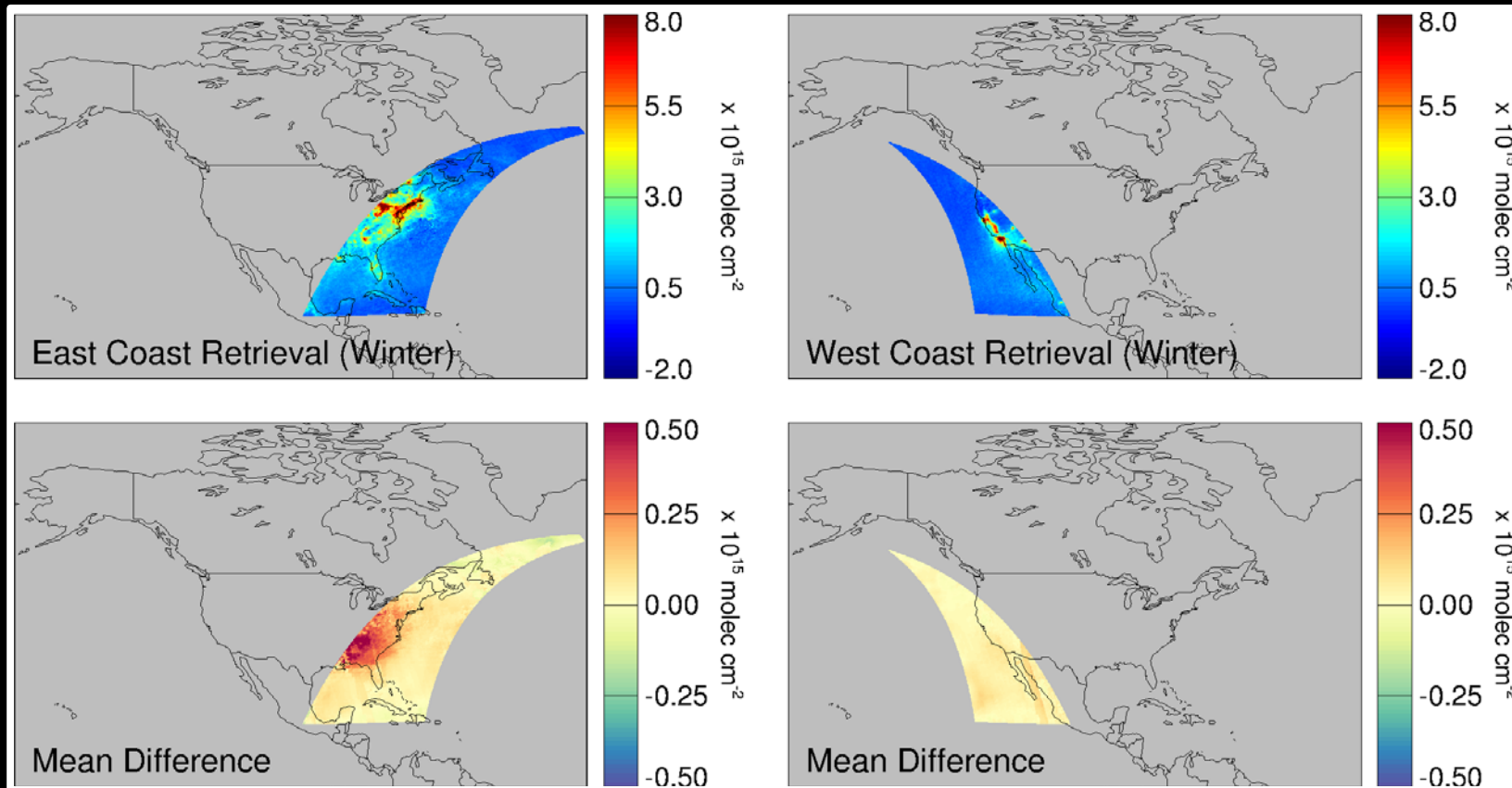
$R^2 = 0.996$
Slope = 1.015

$R^2 = 0.998$
Slope = 0.994

Temporally Varying Field of Regard, Trop NO₂ (Winter)

1400 UTC

2330 UTC



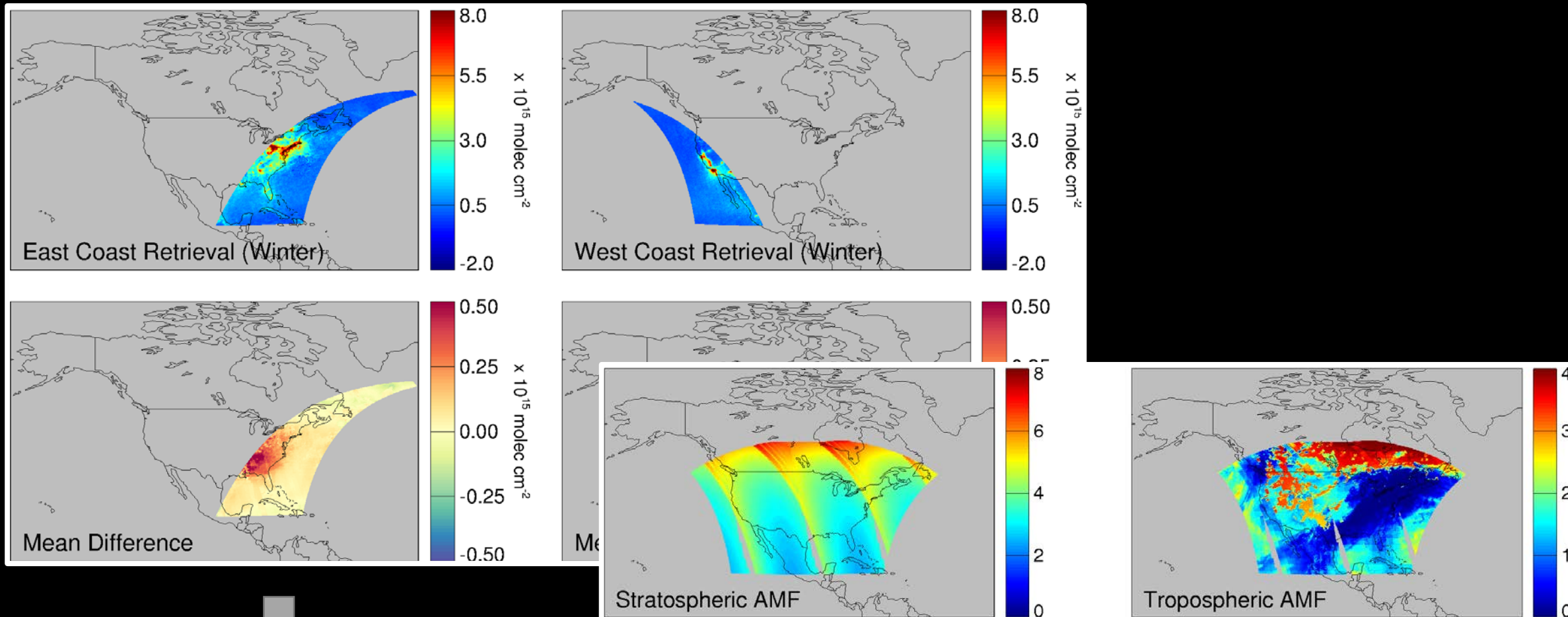
$R^2 = 0.995$
Slope = 1.038

$R^2 = 0.999$
Slope = 1.007

Temporally Varying Field of Regard, Trop NO₂ (Winter)

1400 UTC

2330 UTC

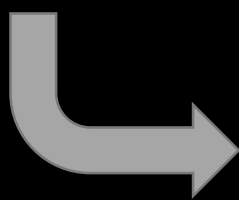
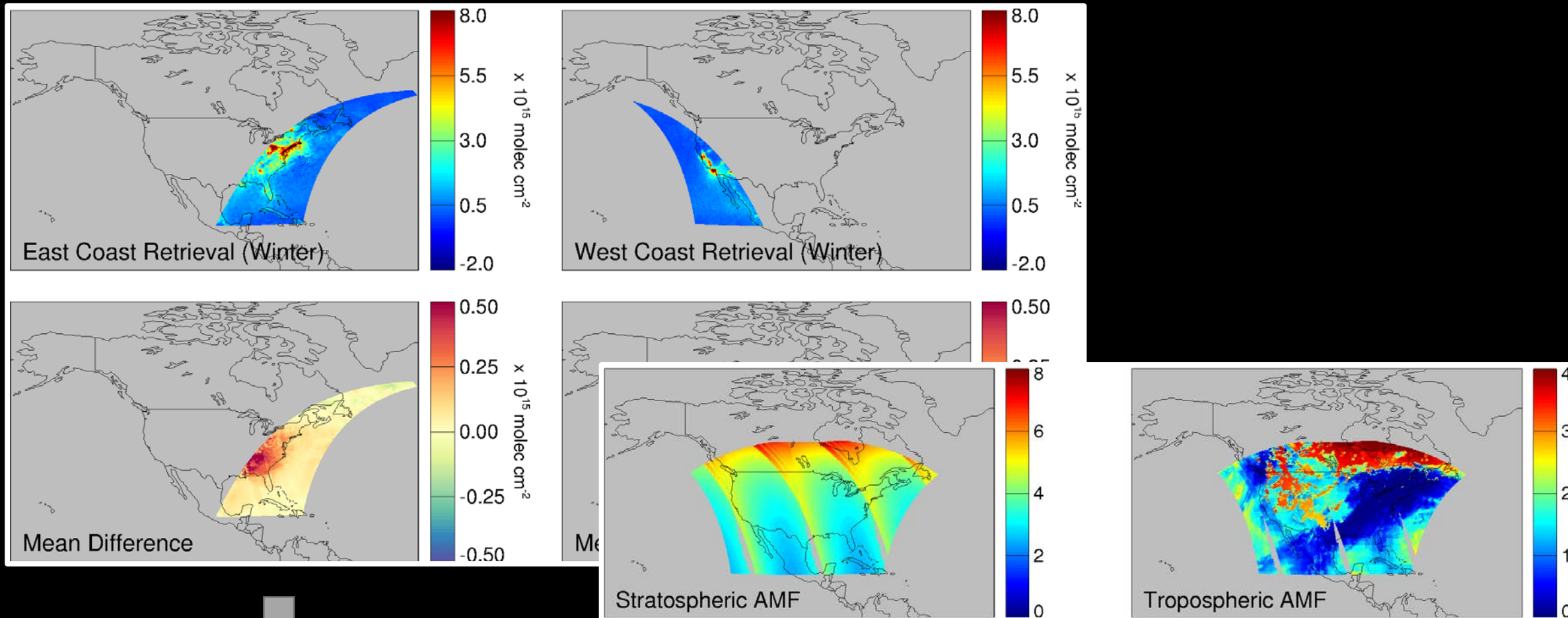


Error is proportional to $\frac{A_{strat}}{A_{trop}}$

Temporally Varying Field of Regard, Trop NO₂ (Winter)

1400 UTC

2330 UTC

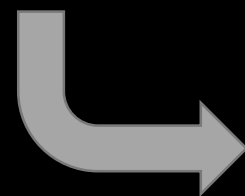
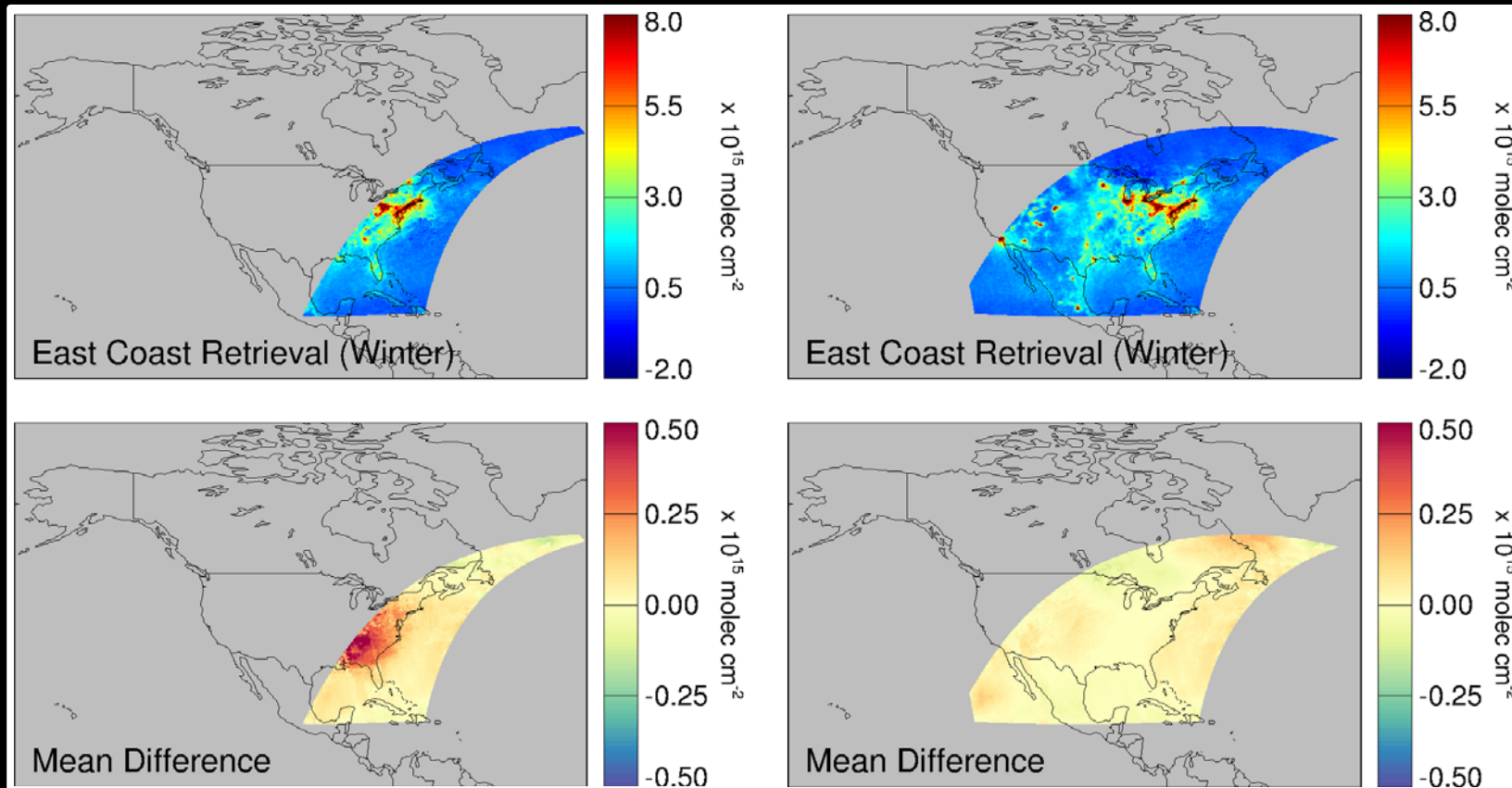


90% of pixels have differences smaller than $0.2 \times 10^{15} \text{ molec cm}^{-2}$

Temporally Varying Field of Regard, Trop NO₂ (Winter)

1400 UTC

1600 UTC



Performance improves as coverage increases ($R^2 = 0.999$)

Summary

Minimal information penalty associated with limited TEMPO field of regard compared to a global LEO algorithm

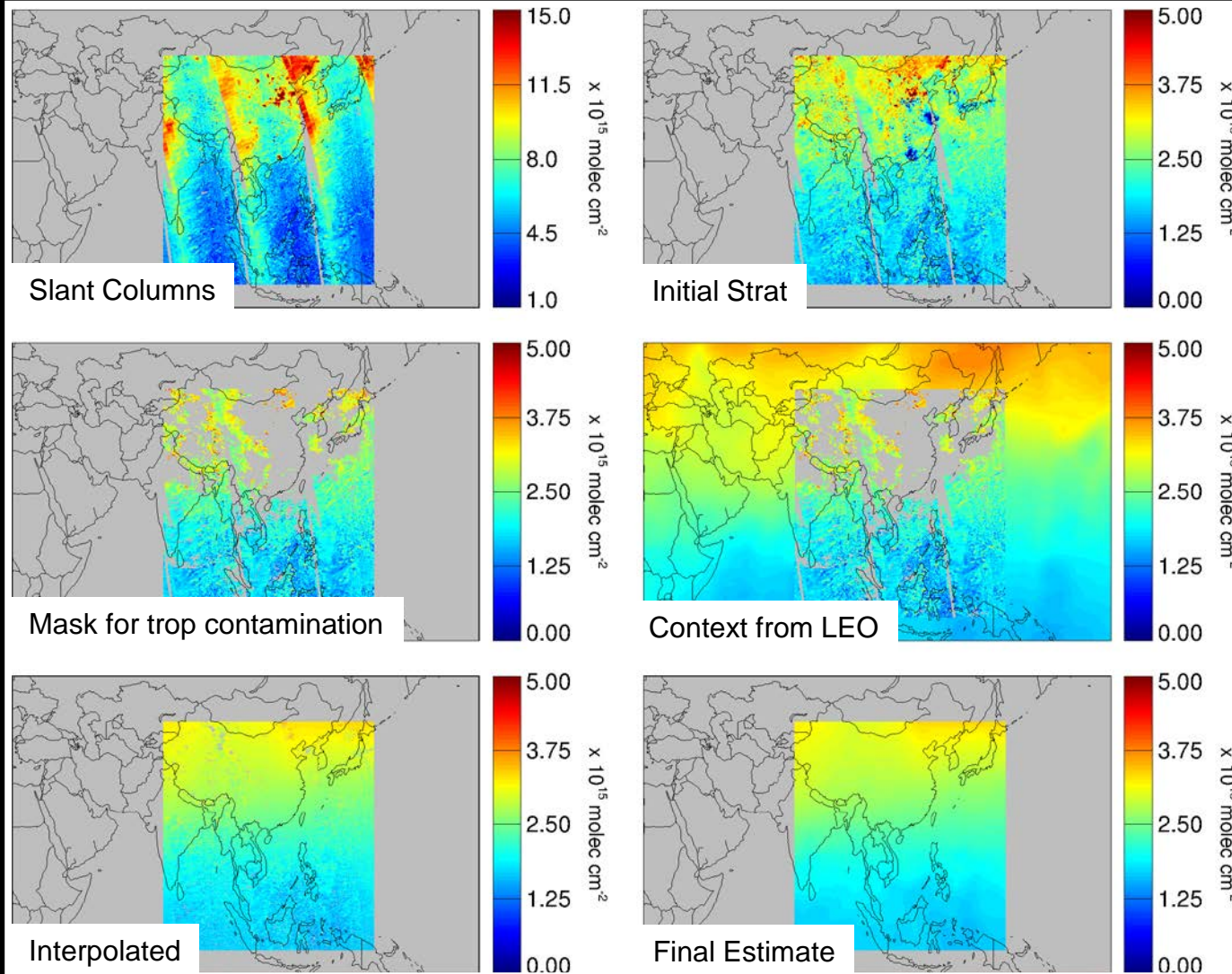
Supporting independent LEO observations avoid small biases near field of regard edges (a monthly climatology suffices when observations are unavailable)

Certain winter time retrievals challenged by large A_{strat}/A_{trop} (filtering helps, but biases remain)

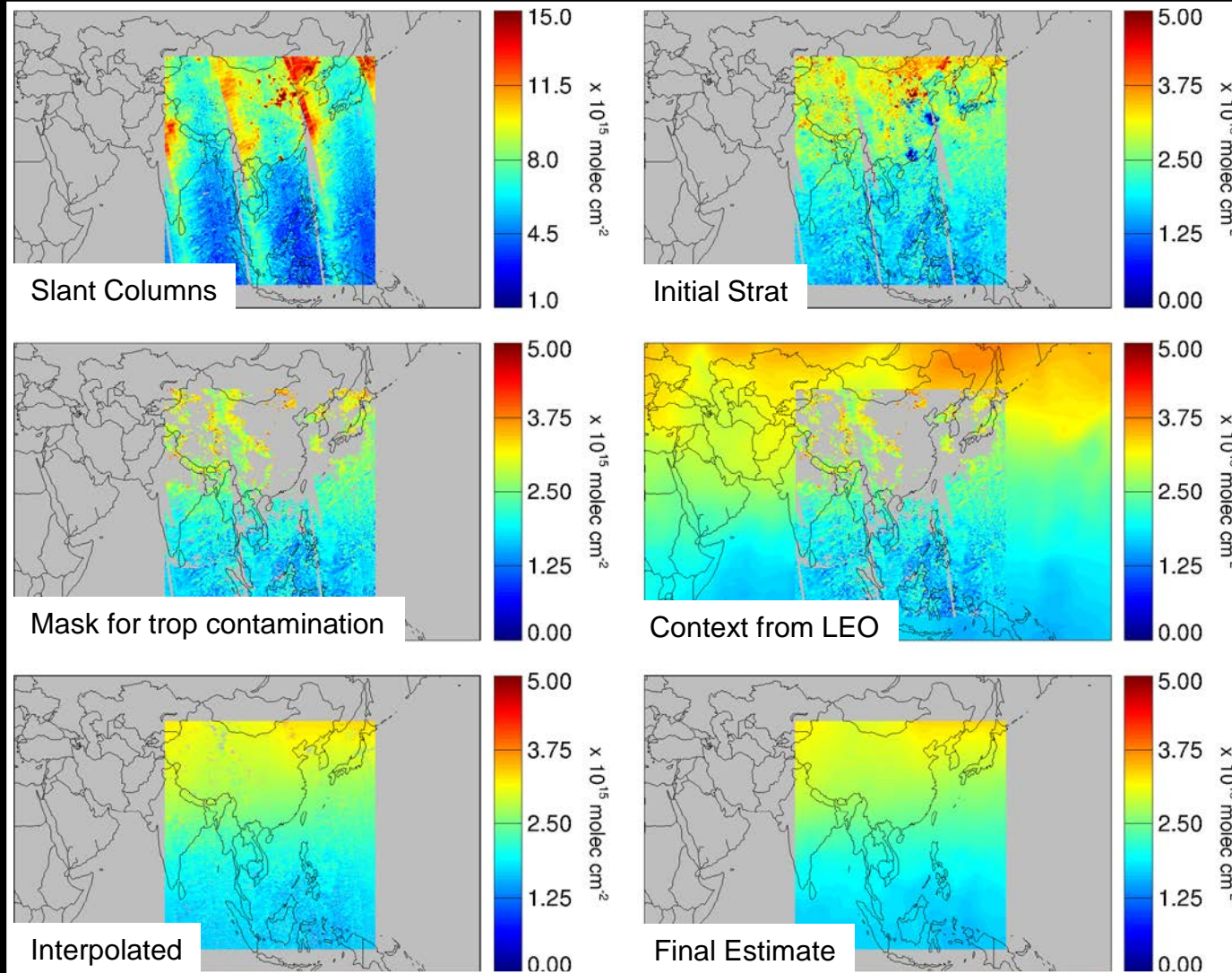
Expected errors are on the order of (usually much smaller than!) typical estimates due to STS separation algorithms ($\sim 0.2 \times 10^{15}$ molec cm^{-2})

Possible Lessons for GEMS

Possible Lessons for GEMS



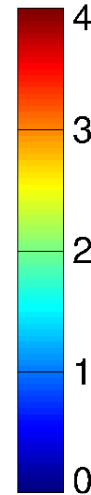
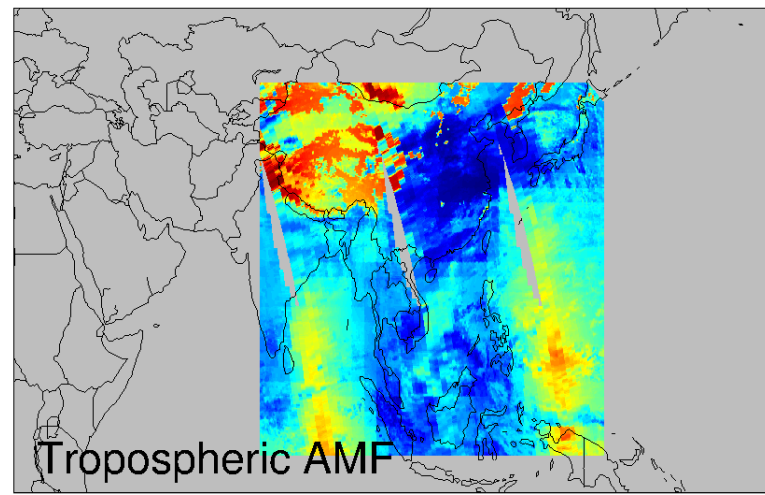
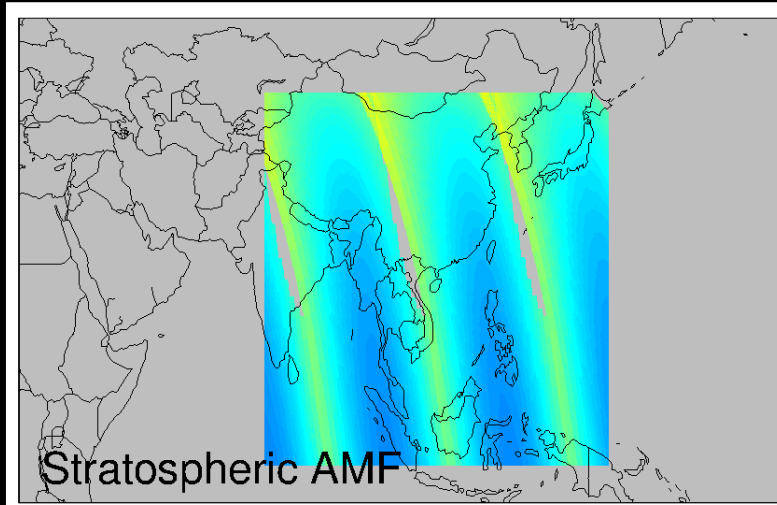
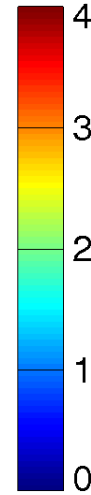
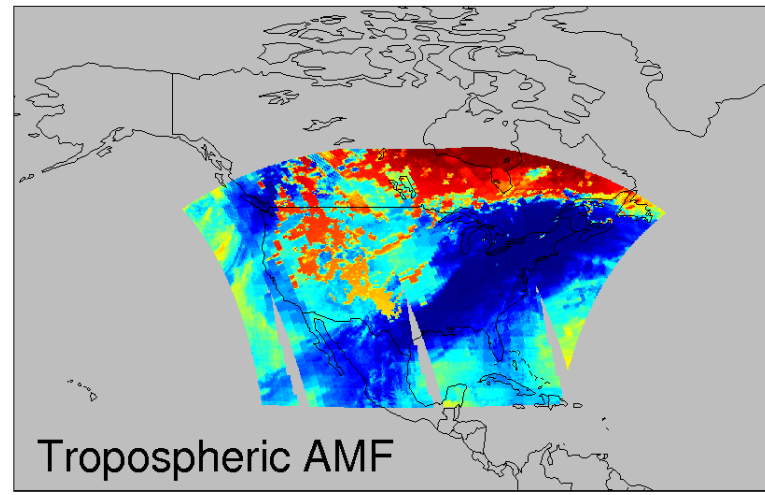
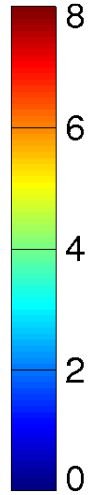
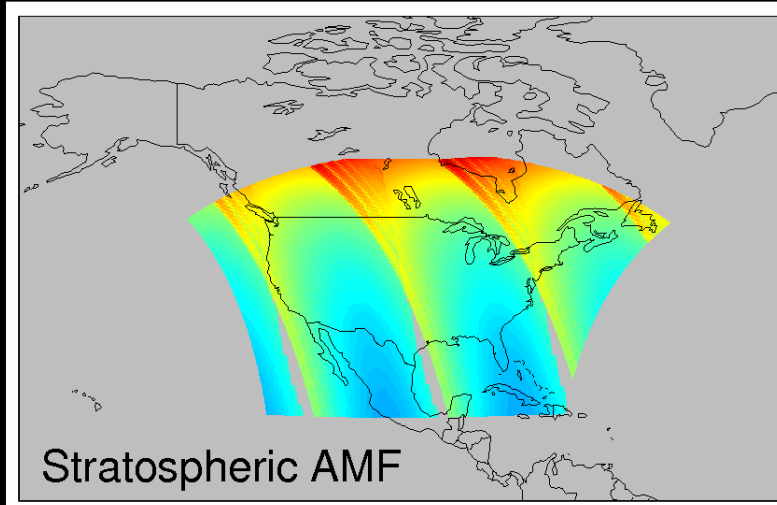
Possible Lessons for GEMS



More data is retained during filtering over GEMS field of regard than over TEMPO field of regard!

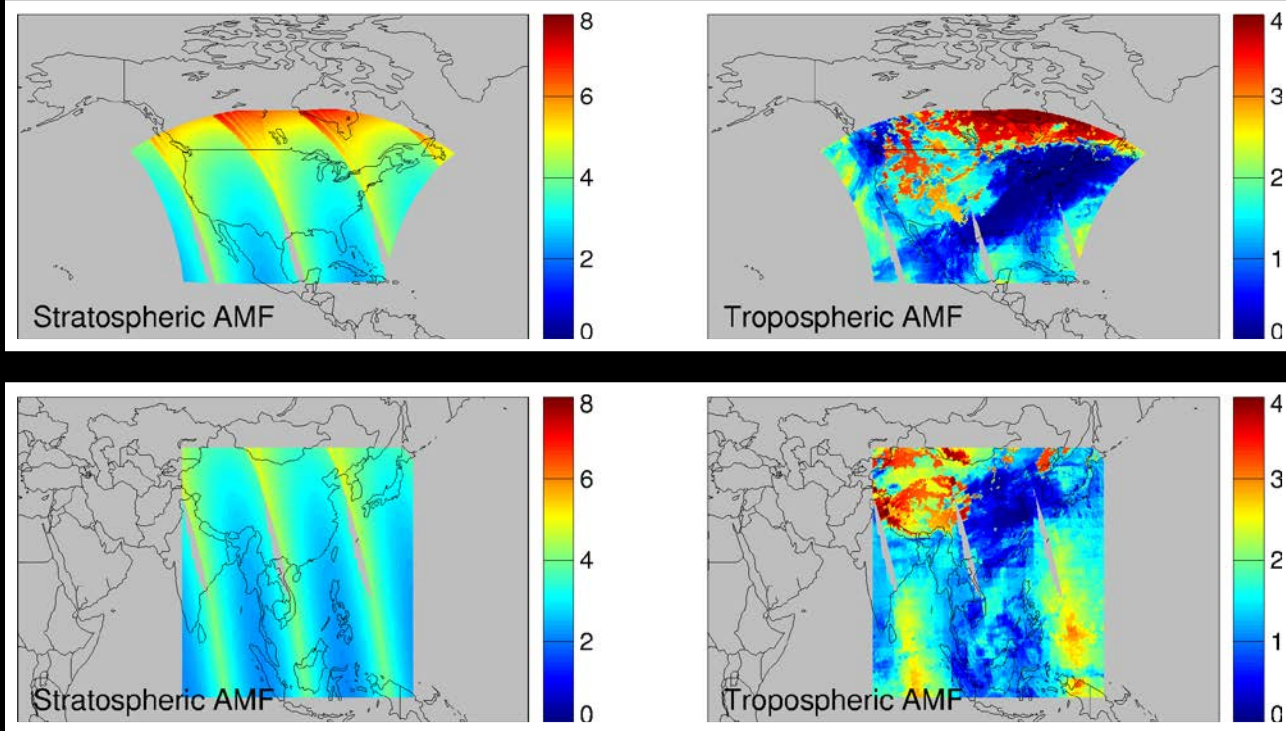
Should result in more robust stratospheric estimate.

Possible Lessons for GEMS



Example air mass factors in January

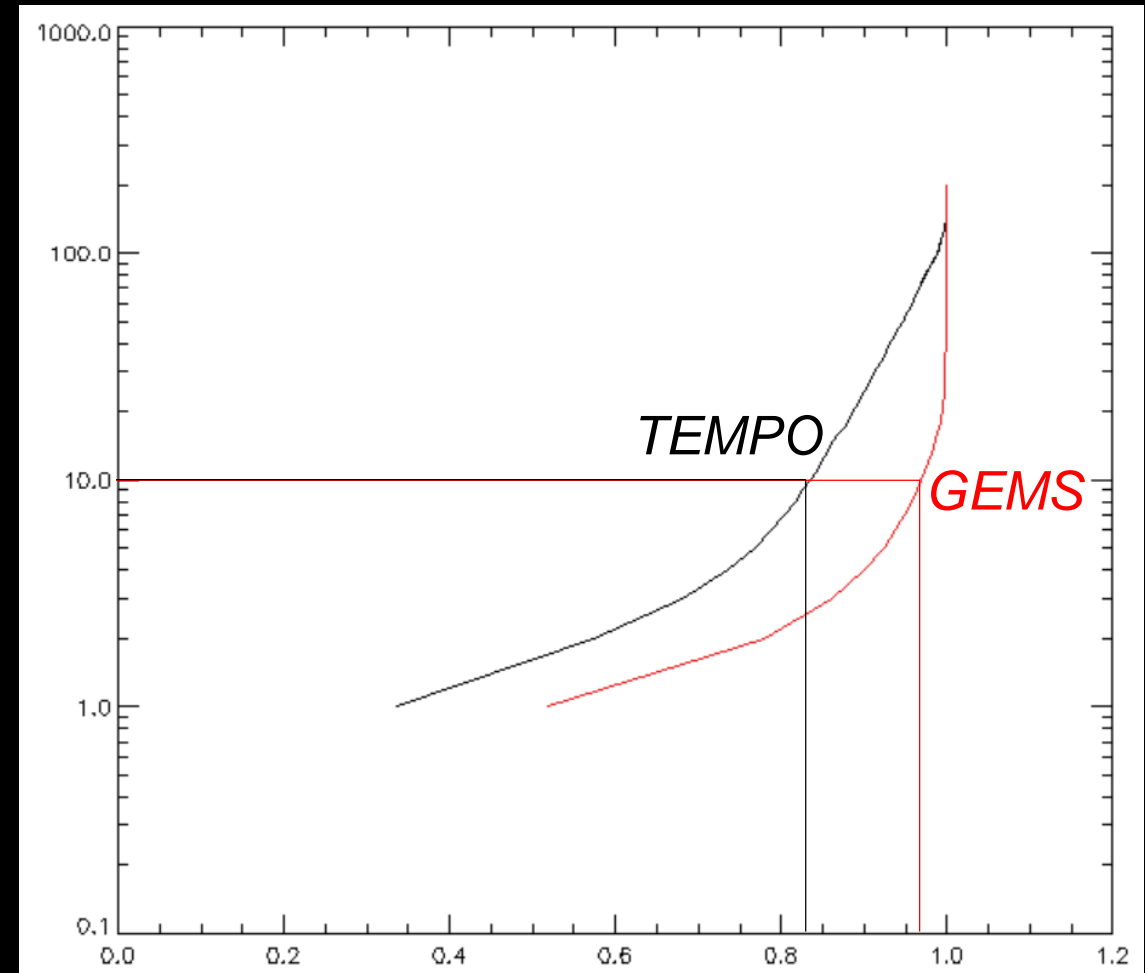
Possible Lessons for GEMS



Ratios tends to be much smaller over GEMS regard than over TEMPO.

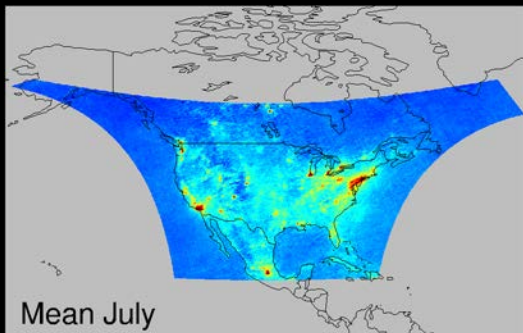
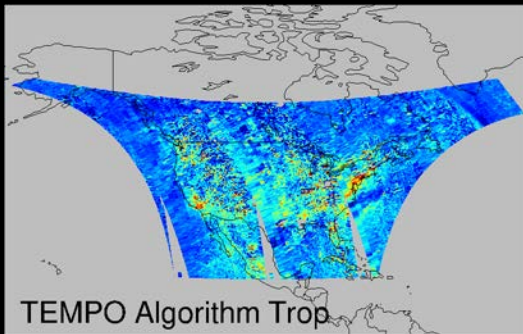
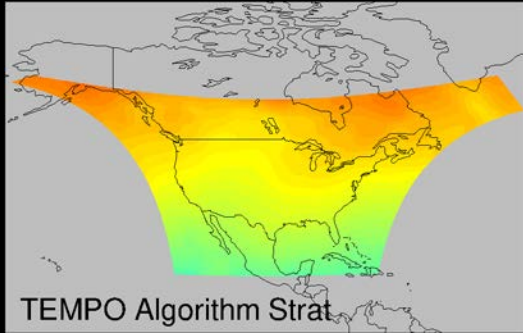
Should result in more robust retrieval.

Cumulative distribution of $\frac{A_{strat}}{A_{trop}}$



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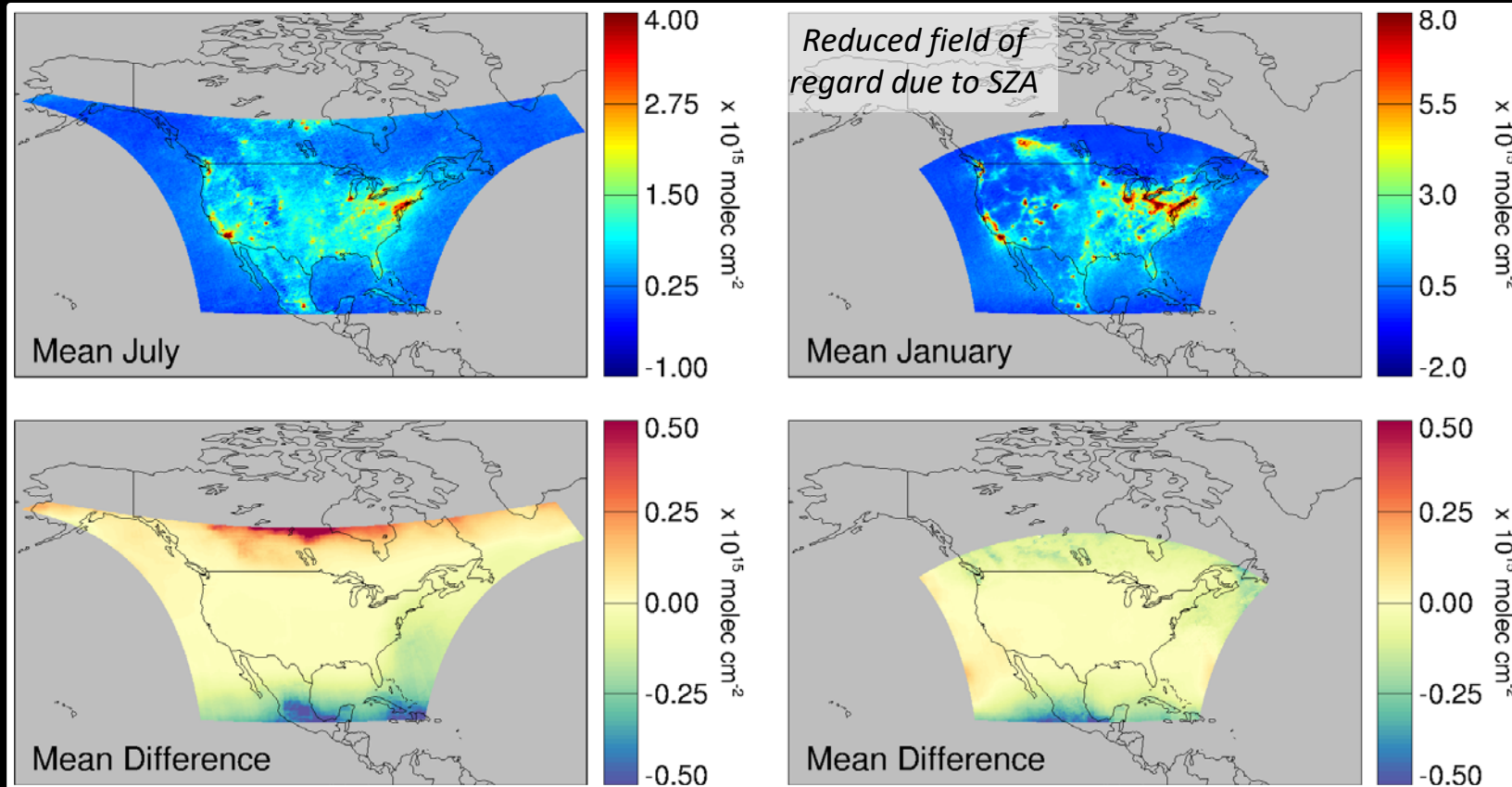
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Removing Supporting Observations from LEO (NRT?)



** When daily LEO observations are unavailable, a monthly global climatology can be used to improve performance ($R^2 = 0.999$)*

$R^2 = 0.999$
Slope = 0.999

$R^2 = 0.999$
Slope = 0.999