A Comparative Study of Contrail Frequency Indices and GOES-16 Contrail Data Set

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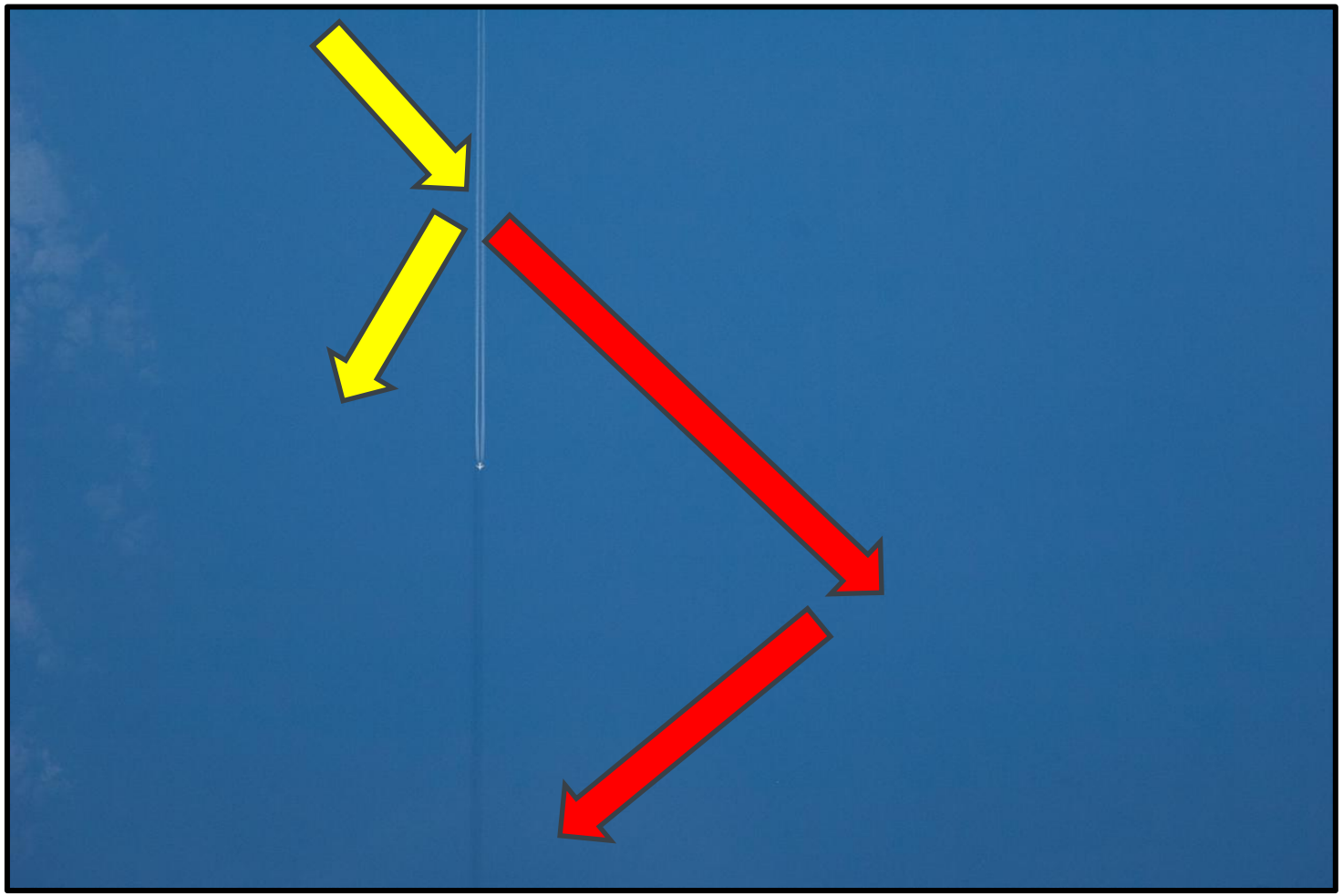
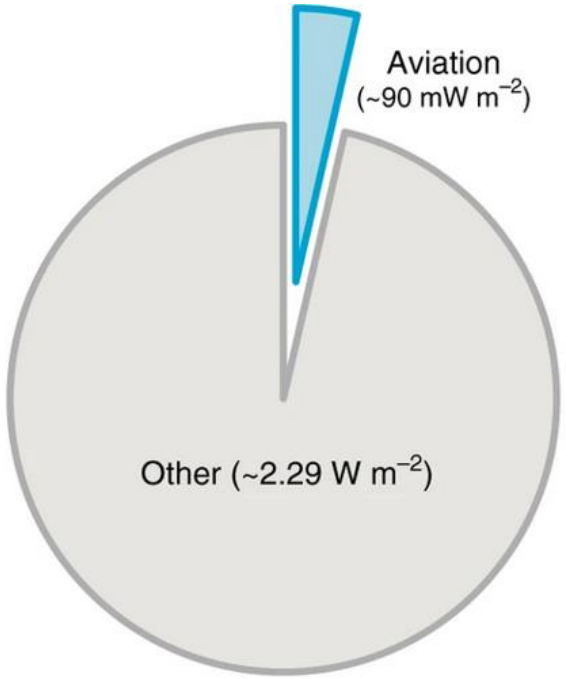
Introduction

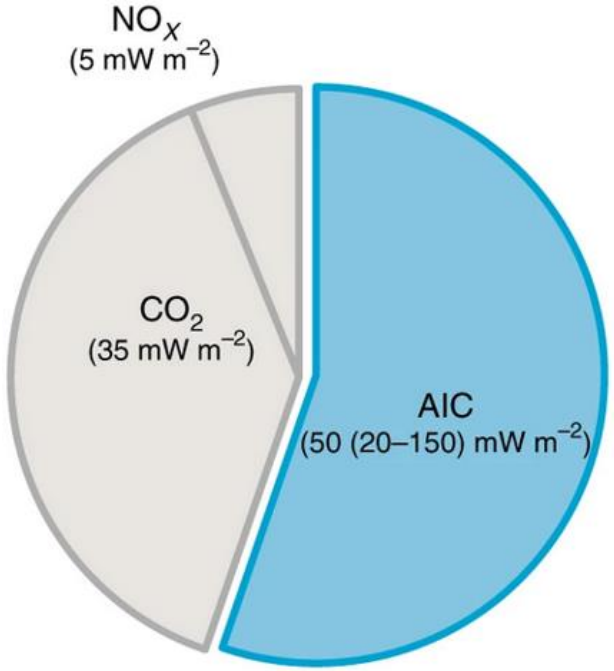


Motivation

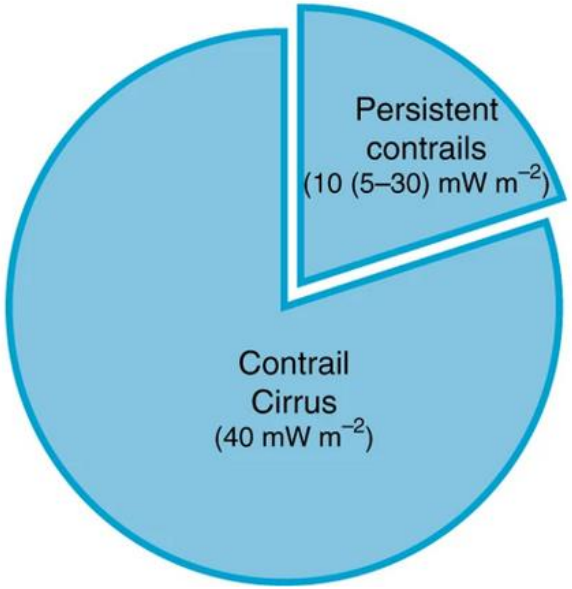
Global radiative forcing caused by aviation industry.



Aviation induced clouds (AICs) contributing to aviation radiative forcing.

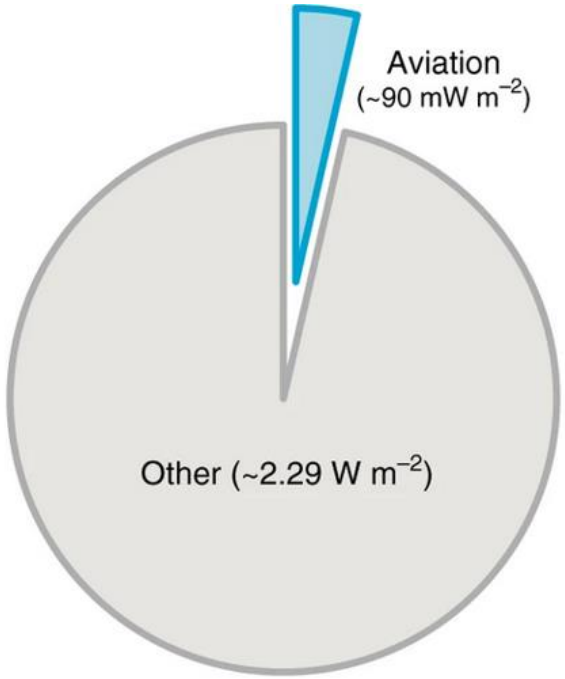


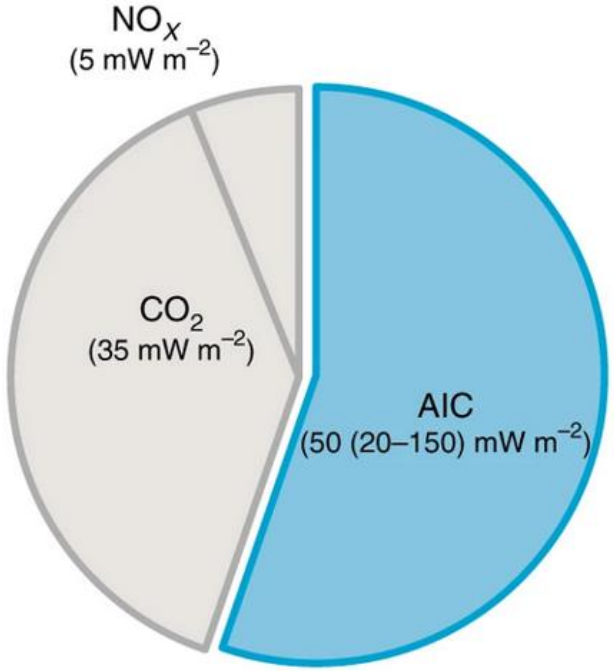
Persistent contrails contributing to AIC radiative forcing.

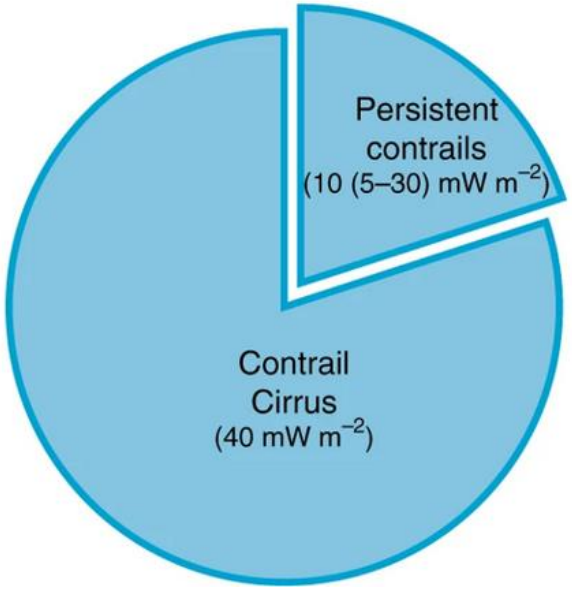


Motivation

Small but growing contribution to climate change! We can make changes now with current methods.







Current State-of-the-Art

ESA (CONTRAILS Project)

Google (Project Contrails)

American Airlines
(collaboration with Google)

Satellite Data Challenges

Drawbacks of Satellites:

1. Low fidelity/course spatial resolution.
2. Challenging to parse contrails at different elevations.
3. Lack of continuous data (time delay).

Credit: NOAA/Lockheed Martin

Important to develop accurate contrail formation algorithms that don't rely on satellites.

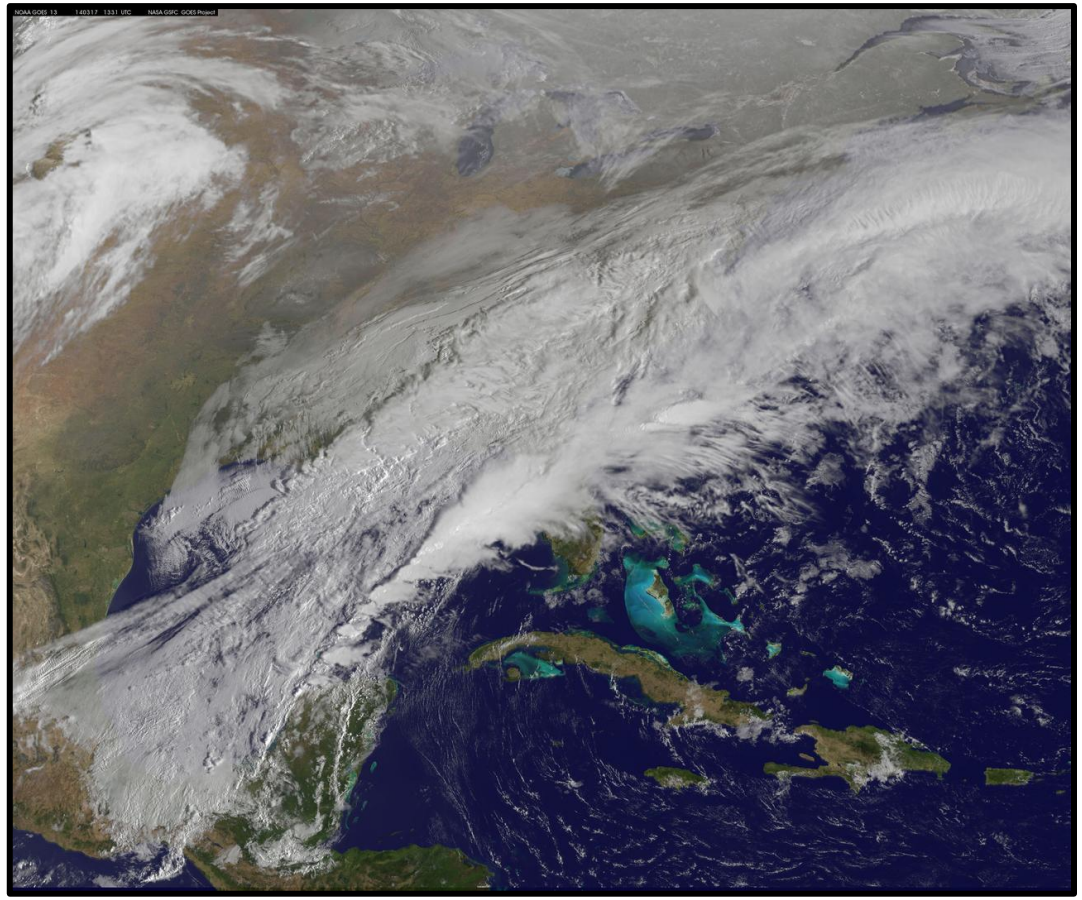
Contributions to the Literature

Goal: Compare our contrail frequency index (CFI) algorithm's accuracy with real-world contrail satellite data.

First comparison of CFIs with satellite dataset.

Developed easy method to compare CFIs and GOES-16.

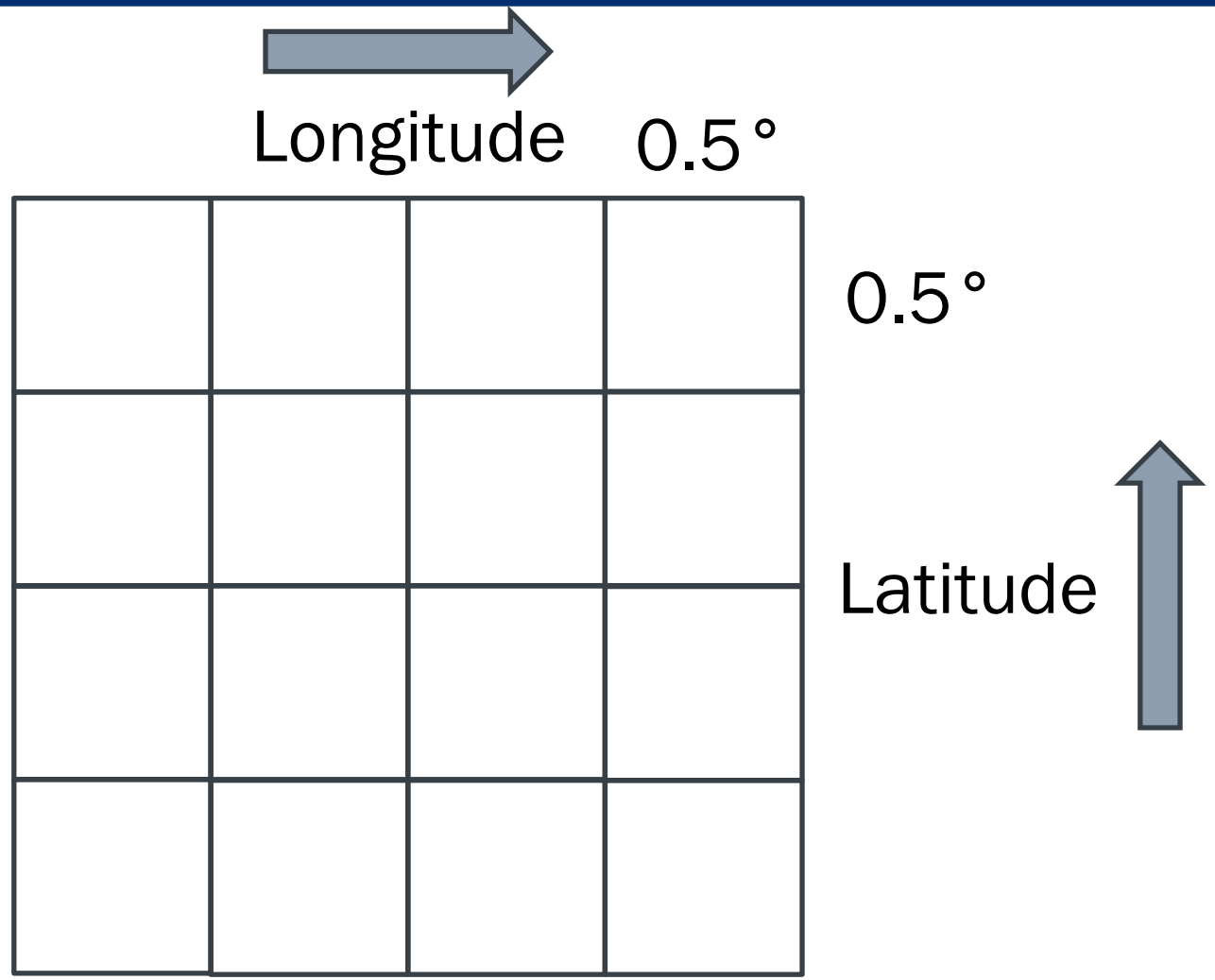
GOES-16 Dataset



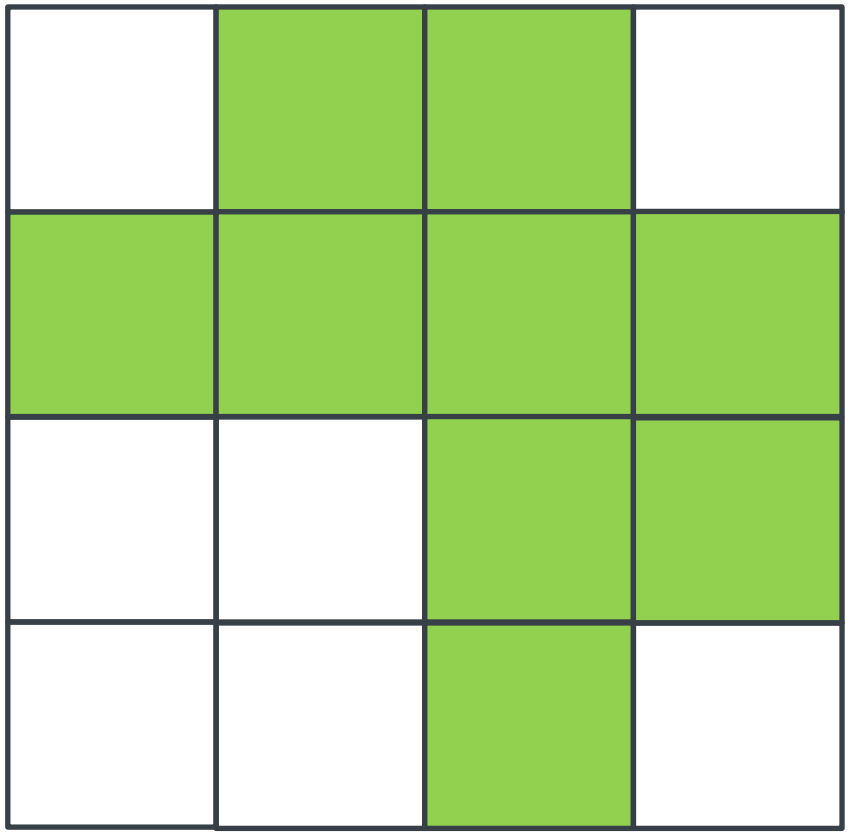
GOES-16 contrail masks from specific days and points were generated.

- One mask =~0.5 x 0.5 degree area.
- 256 x 256 binary labeled pixels.

Contrail Frequency Index (CFI) Computation

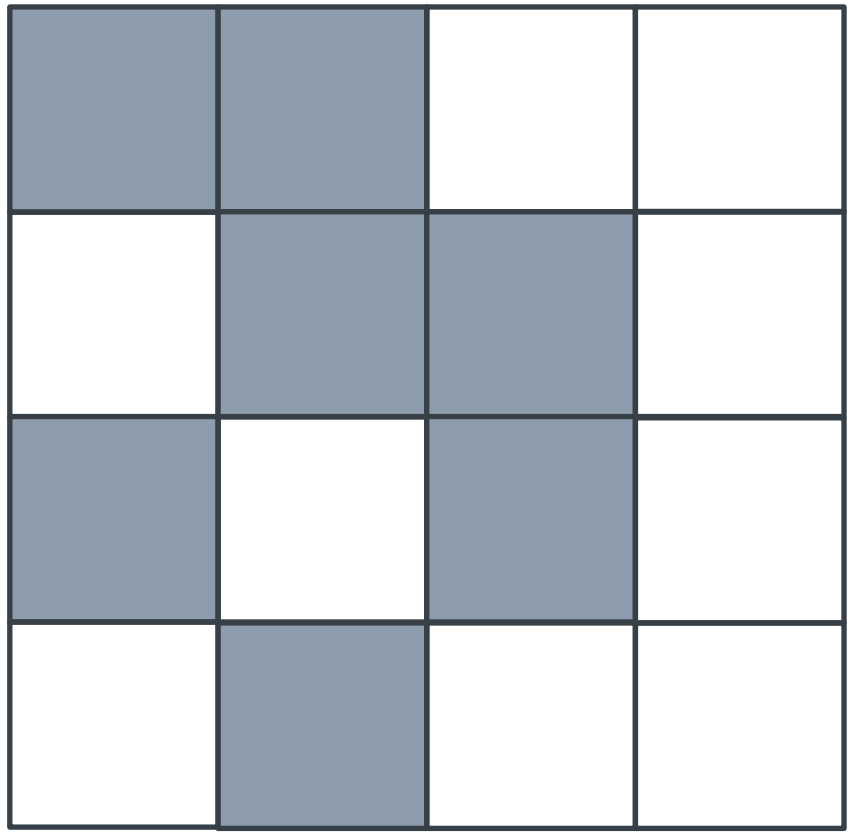


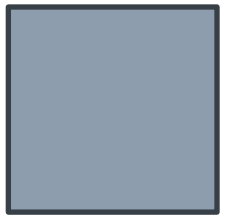
Contrail Frequency Index (CFI) Computation



Air Route Traffic Control Center (ARTCC)

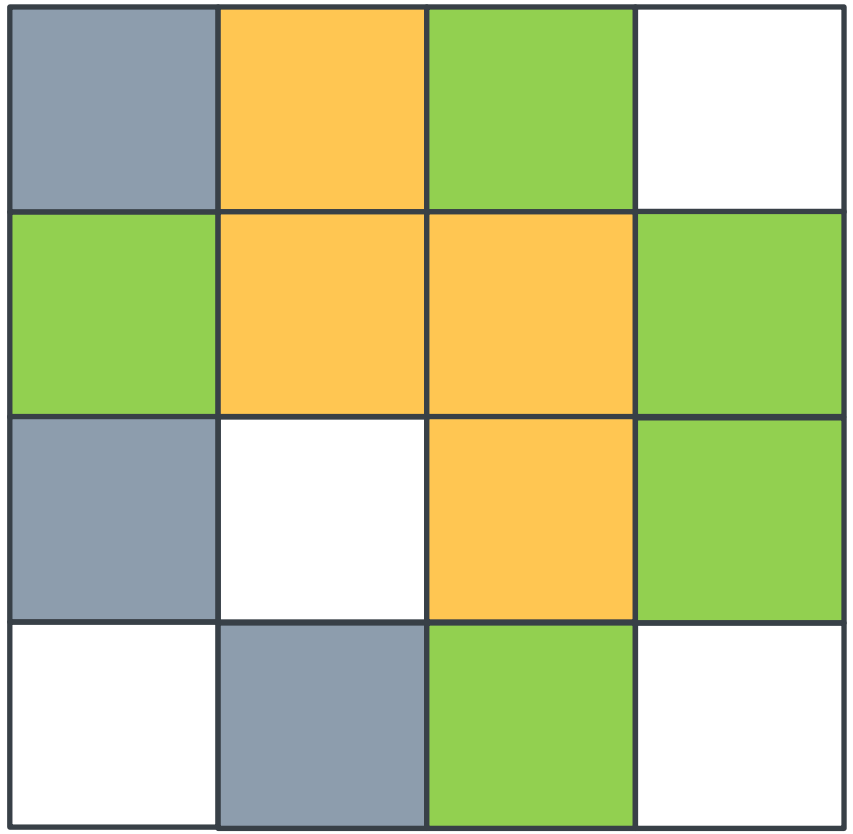
Contrail Frequency Index (CFI) Computation





Relative Humidity with Respect to Ice > 100%

Contrail Frequency Index (CFI) Computation

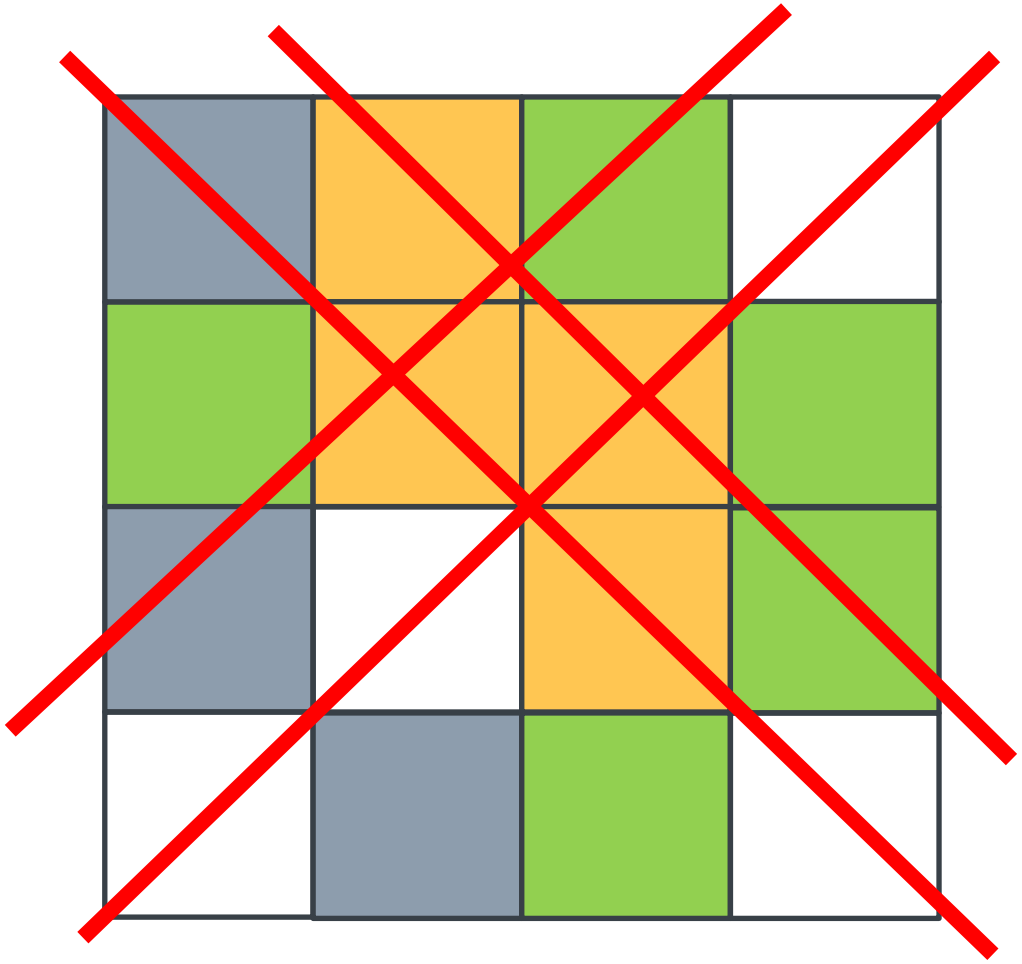


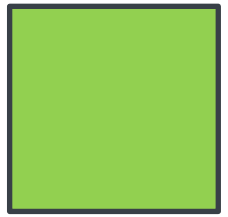
ARTCC

RHi > 100%

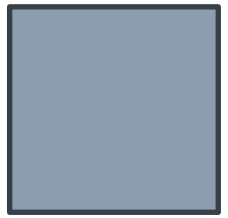
Both

Contrail Frequency Index (CFI) Computation





ARTCC



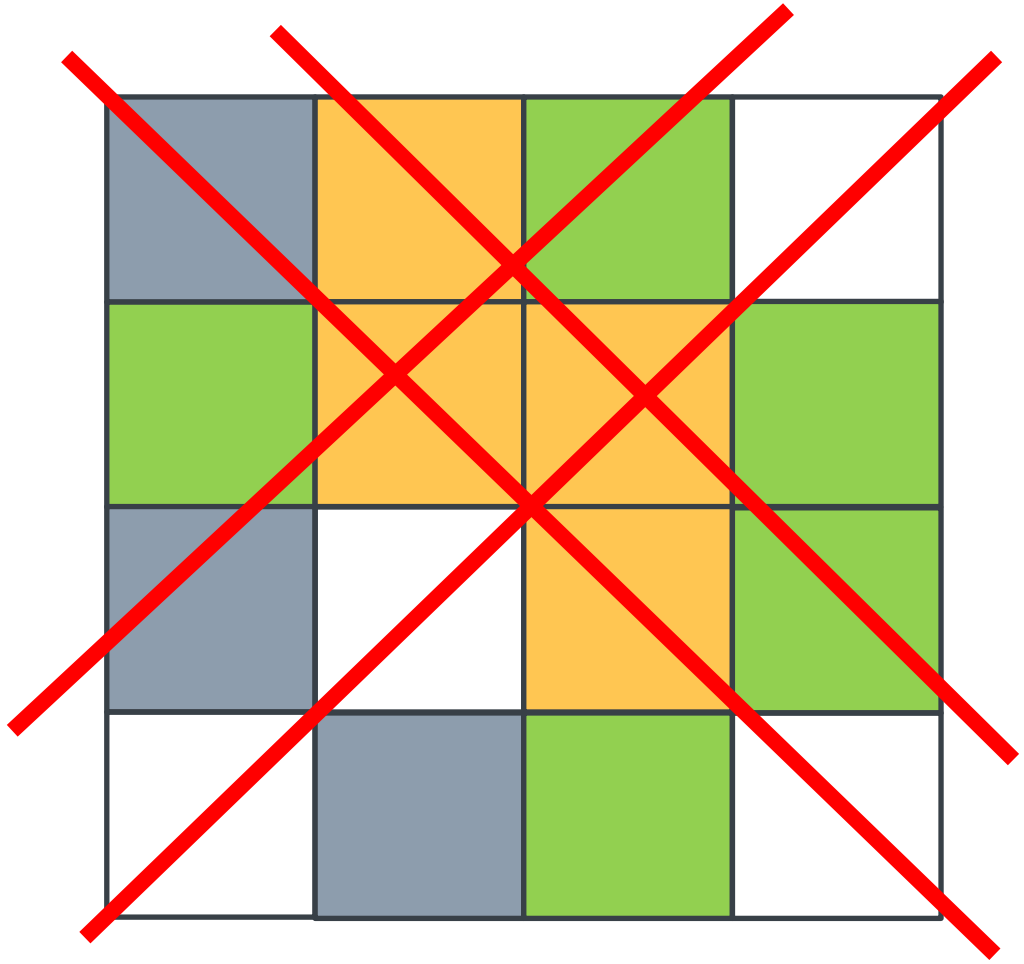
RHi > 100%

Both

Contrail Frequency Index (CFI) Computation

$$\sum_{i=1}^{m}\sum_{j=1}^{n} r_{i,j}c_{i,j}a_{i,j}$$

CFI = 7

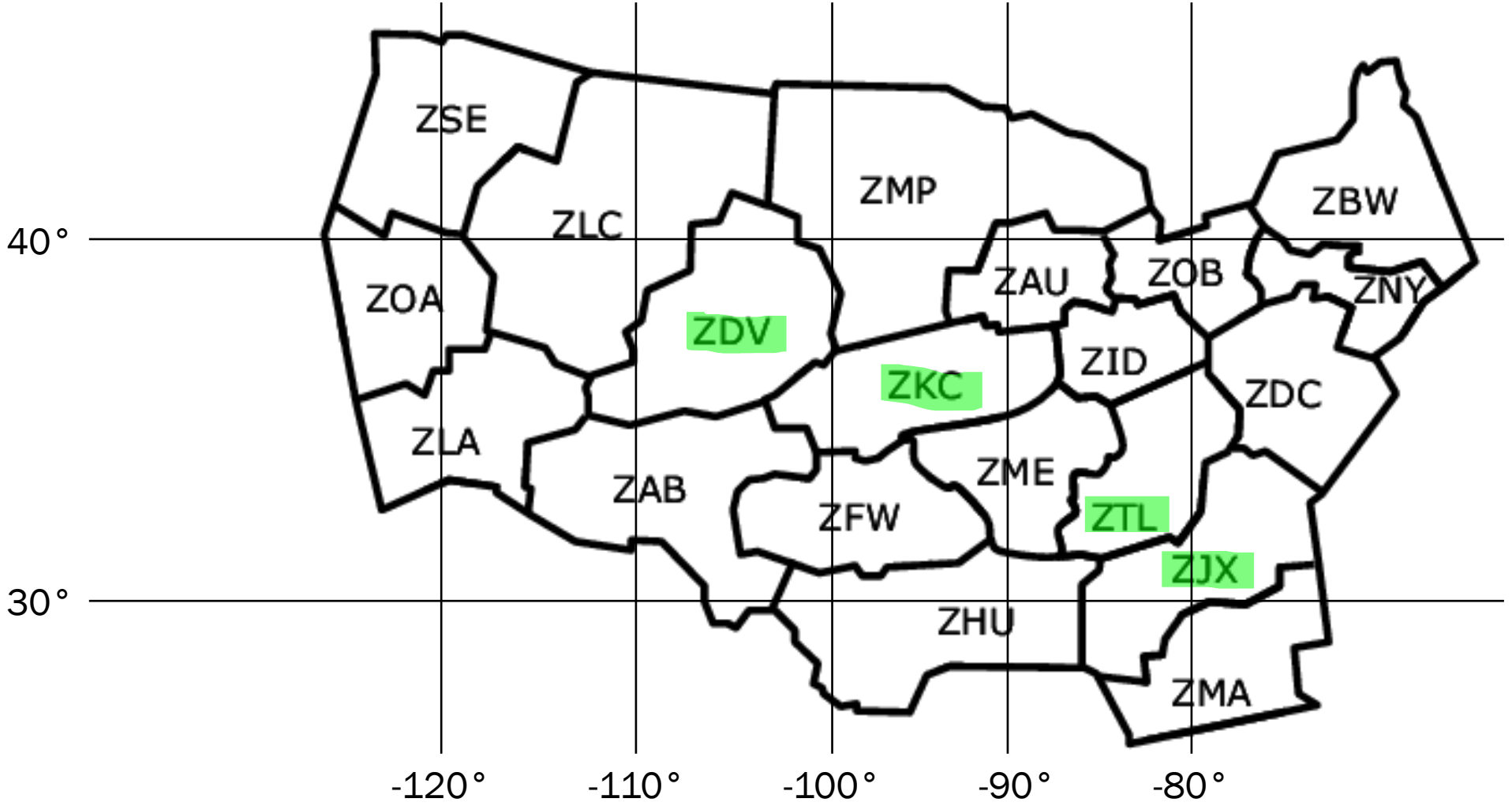


ARTCC ($c_{i,j}$)

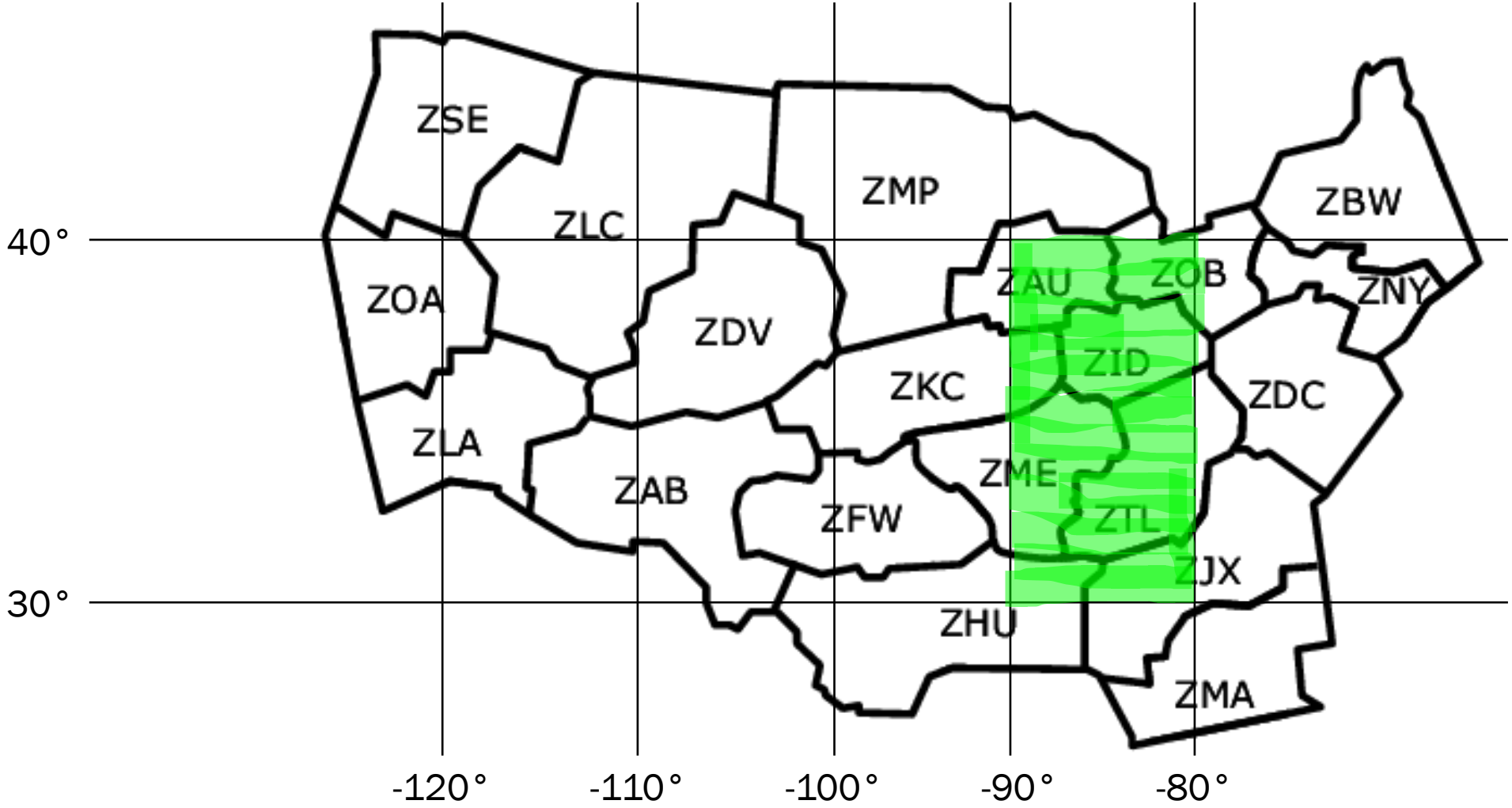
RHi > 100% ($r_{i,j}$)

Both

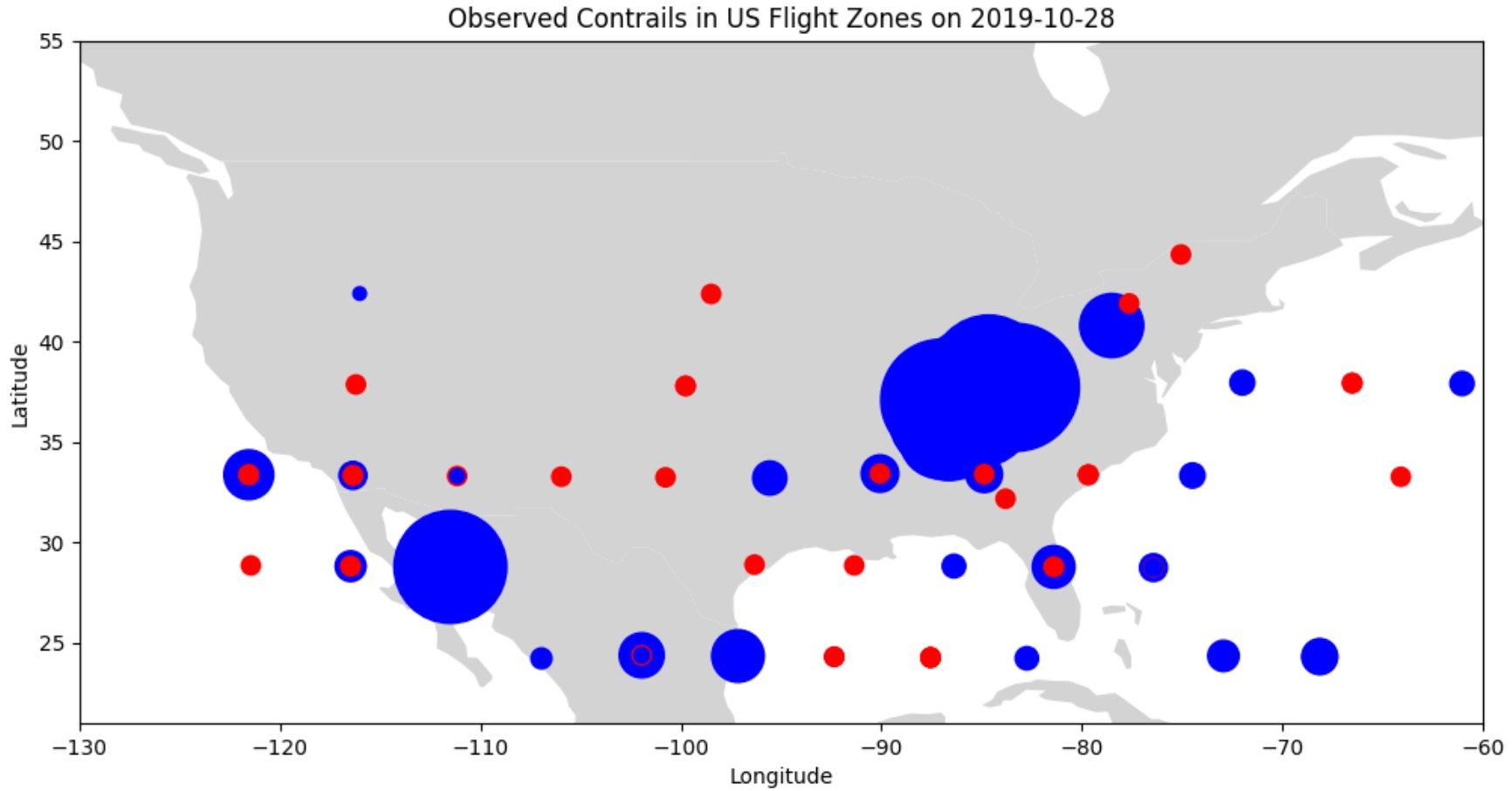
Big Picture Analysis: CFI Algorithm



Big Picture Analysis: GOES-16 Satellite



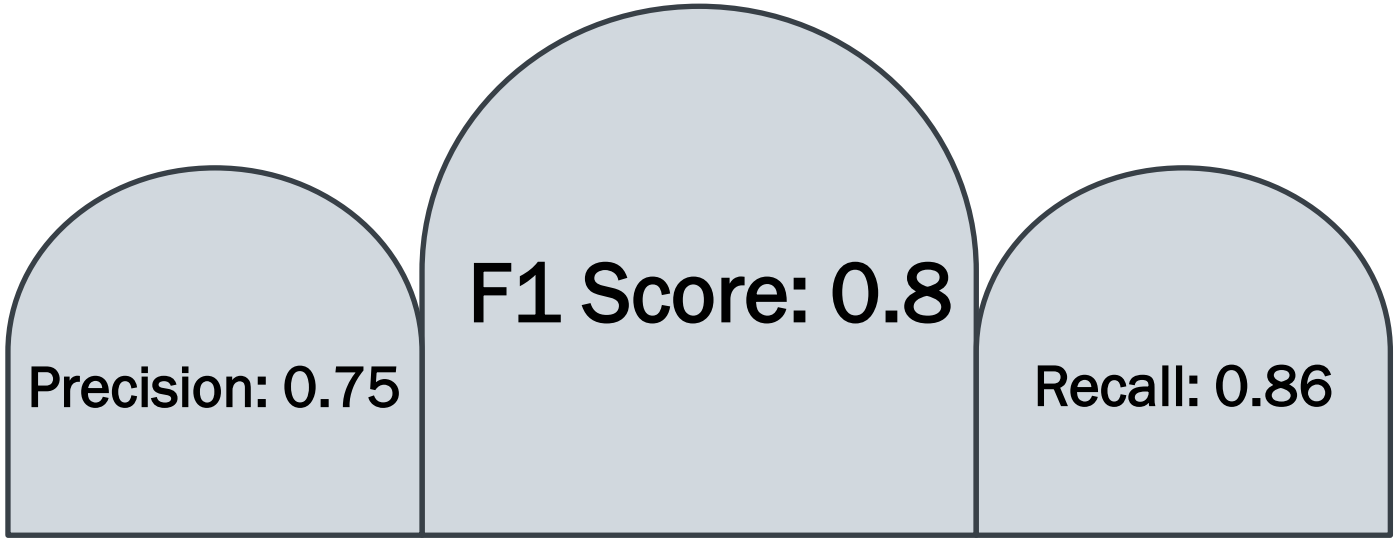
GOES-16 Contrail Masks



Red: Empty contrail masks

Blue: Non-empty contrail masks

Contrail Masks Analysis



Slightly higher number of false positives than false negatives.

High degree of correlation between nonzero CFIs and observed contrails.

Conclusions

Key Takeaways

Preliminary investigation suggests CFI results agree with observed contrails.

Similar macro and micro-scale trends.

Improvements

Overcome limitations on GOES-16 dataset size by building more contrail masks.

Analyze over elevation dimension.

Thank you!