Collocation Analysis of Radio Occultation Soundings and Passive Microwave Soundings for Profiling in the Marine Boundary Layer

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Outline

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- Technical approach
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- Path forward

Motivation & Science Background

- The Marine Boundary Layer (MBL) is crucial for climate and weather modeling, GNSS-RO has the unique ability to profile remote MBL regions that other remote sensing techniques cannot (Wang et al., 2017)
  - GNSS radio occultation profiling in the MBL is severely biased by super-refraction, refractivity by up to ~4%
  - Auxiliary data in conjunction with super-refraction parameterization (Xie et al. 2006) may remove the bias. We are considering a variety of passive nadir microwave sounders.
  - An enormous number of RO and MW collocations are probably necessary to impact weather analyses of water vapor, and RO and MW collocations do not happen very often.
- We will investigate the actual numbers of RO and MW collocations at present and then investigate how future constellations might be configured to maximize the number of collocations efficiently. Made possible by RO and MW in nano/micro-satellite forms.

Technical Approach

- Development of new method for colocation determination: Rotational Transformation Colocation Determination (RTCD)
  - Main idea: map the location and time of a radio occultation sounding into the coordinate system natural to a scanning microwave sounder.
- RTCD advantages
  - Typical Brute Force colocation determination can be computationally expensive whereas RTCD is extremely efficient
  - Brute Force method requires full MW dataset whereas RTCD only requires MW TLEs
- RTCD disadvantages
  - RTCD acts as a quick approximation for the number of colocations between two missions, less accurate than Brute Force method

Technical Approach

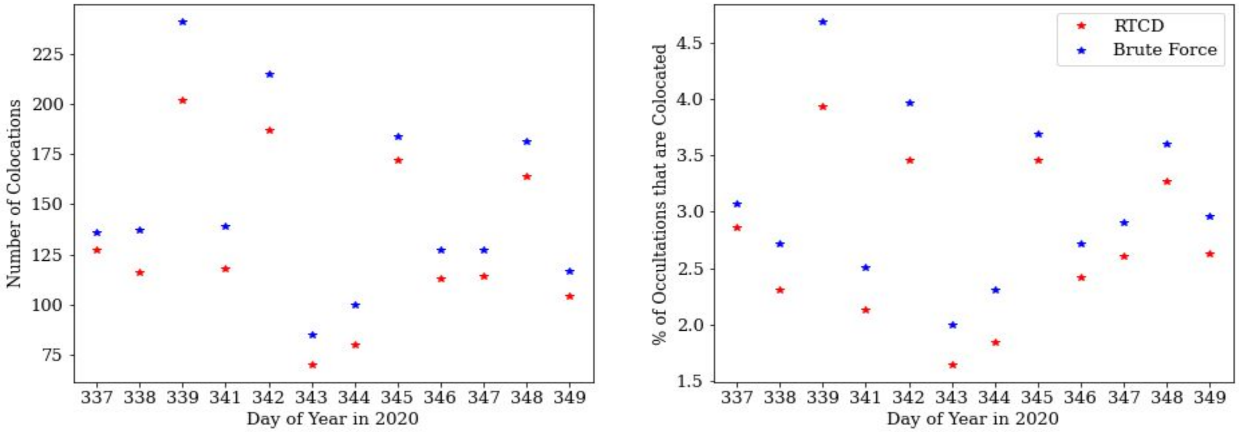
- Determine collocations happening amongst active missions and use to assess performance of RTCD
- Missions considered: NOAA-20, COSMIC-2, MetOp-C
  - NOAA-20/COSMIC-2
  - NOAA-20/MetOp-C-GRAS
  - MetOp-C-AMSU/COSMIC-2
  - MetOp-C-AMSU/MetOp-C-GRAS
- Requirements for colocations: measurements within 10 min, 150 km

Analyses

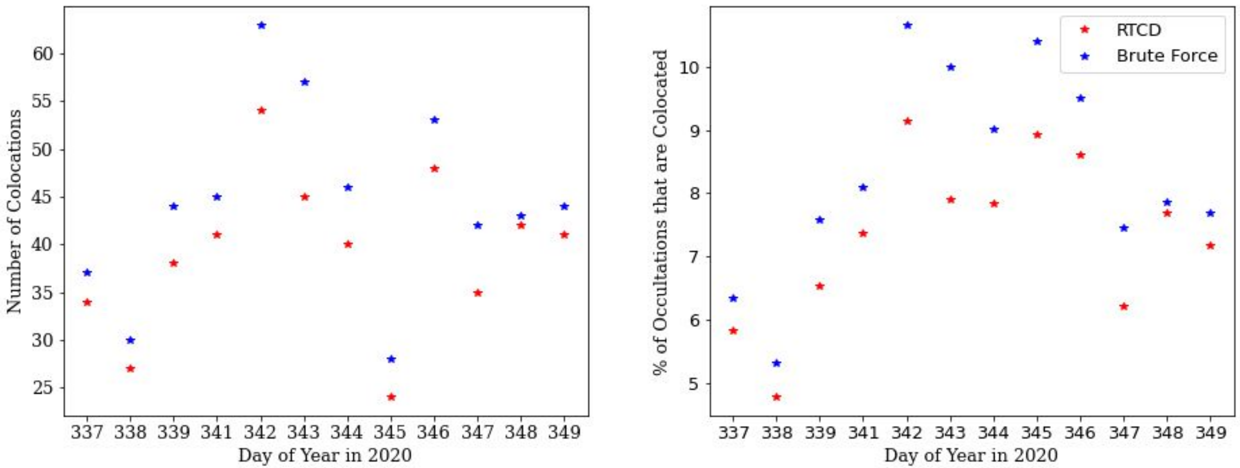
Daily colocations from December 1st, 2020 through December 14th, 2020

RTCD does a fairly good job of approximating colocations, but almost always underestimates

NOAA-20/COSMIC-2



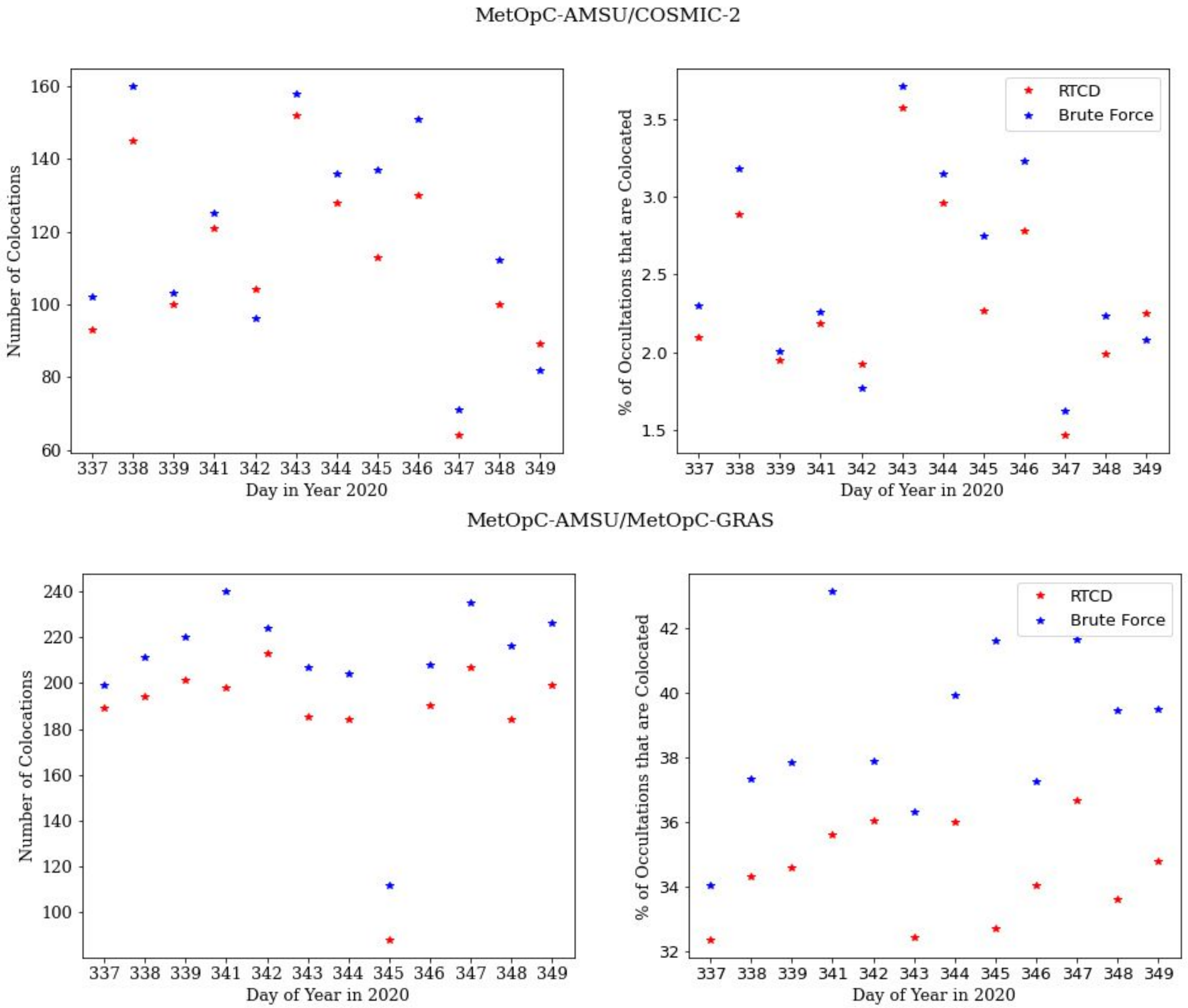
NOAA-20/MetOpC-GRAS



Analyses

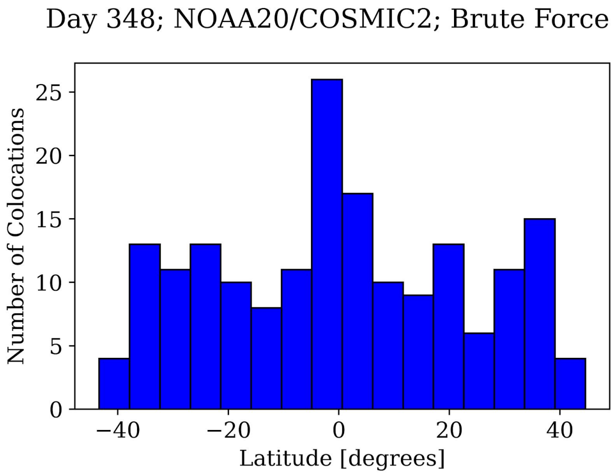
Across all four combinations, RTCD differs from the brute force method, on average, by:

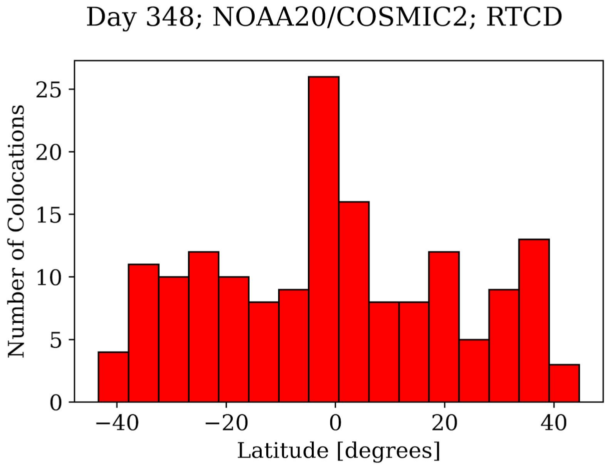
> ~14 colocations, with a standard deviation of ~9.5 colocations
>
> (~1.5% colocated occultations, with a standard deviation of ~2%)

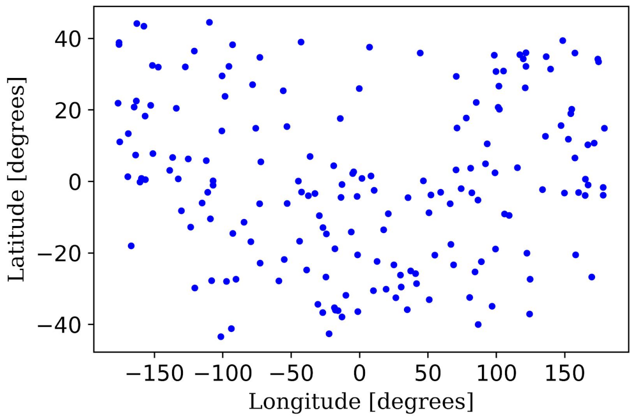


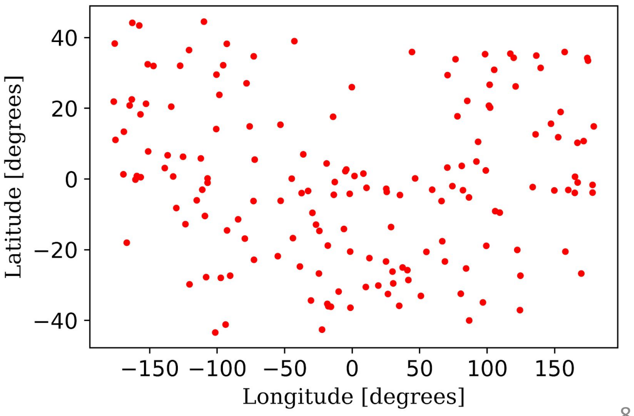
Analyses

RTCD finds similar distributions of colocations to those found by the brute force method









Analyses

Missions	Avg # of Colocations Found Per Day*	Avg % of Occultations Per Day that are Colocated*
NOAA-20/COSMIC-2	149.0	3.1
NOAA-20/MetOp-GRAS	44.3	8.3
MetOp-C-AMSU/MetOp-C-GRAS	208.5	38.8
MetOp-AMSU/COSMIC-2	119.4	2.5

*Found using brute force method

Conclusions

1) The RTCD method has potential to be a helpful tool for colocation determination, especially for approximating the number of colocations found between instruments in theoretical constellations
2) A much higher percentage of occultations are colocated with MW soundings when the two instruments are cohosted by the same satellite

Path Forward

- Continue optimization of RTCD method; apply RTCD method to analyze colocations among potential future constellations
- Design mission to maximize colocations in the Marine Boundary Layer (likely in the subtropics)
  - Investigate the use of CubeSat constellations for cohosted MW and RO instruments

Thank you for listening! Questions?