Jet Propulsion Laboratory
California Institute of Technology

Harmonizing the Jason-1, Jason-2, Jason-3 Time Series of Rain Flags

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Jeremy Bishop

Introduction

Background

- Radar waveforms are distorted by the presence of water vapor.
- Literature: Tournadre et al. (1998, 2009), Quartly et al. (1999, 2004, 2010), Cailliau et al. (2000), Tran et al. (2008), etc.

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Rain flag in Jason products

- Two different rain flags are provided in products: altimeter (“rain_flag”) and radiometer (“rad_rain_flag”).
- Altimeter rain flag typically set to rain for ~5% of points, while radiometer ~2%.
- SSHA editing criteria in Jason series handbook does not include use of rain flag.

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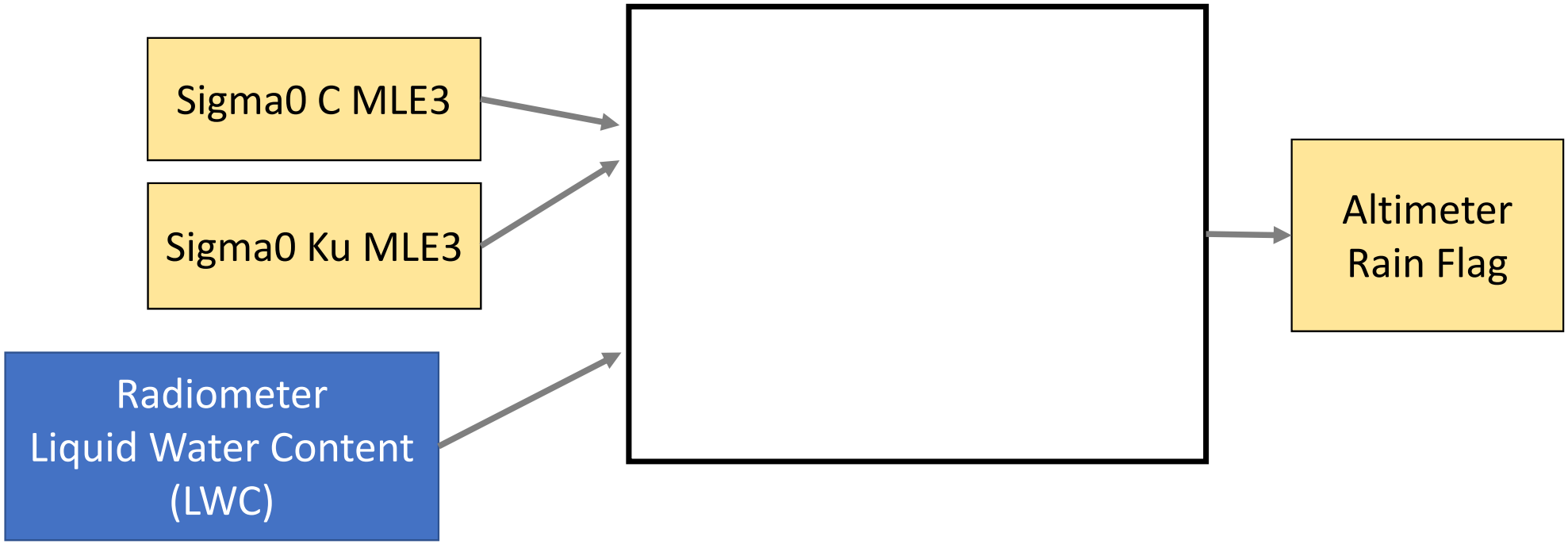
- SSHA editing criteria in Jason series handbook does not include use of rain flag.

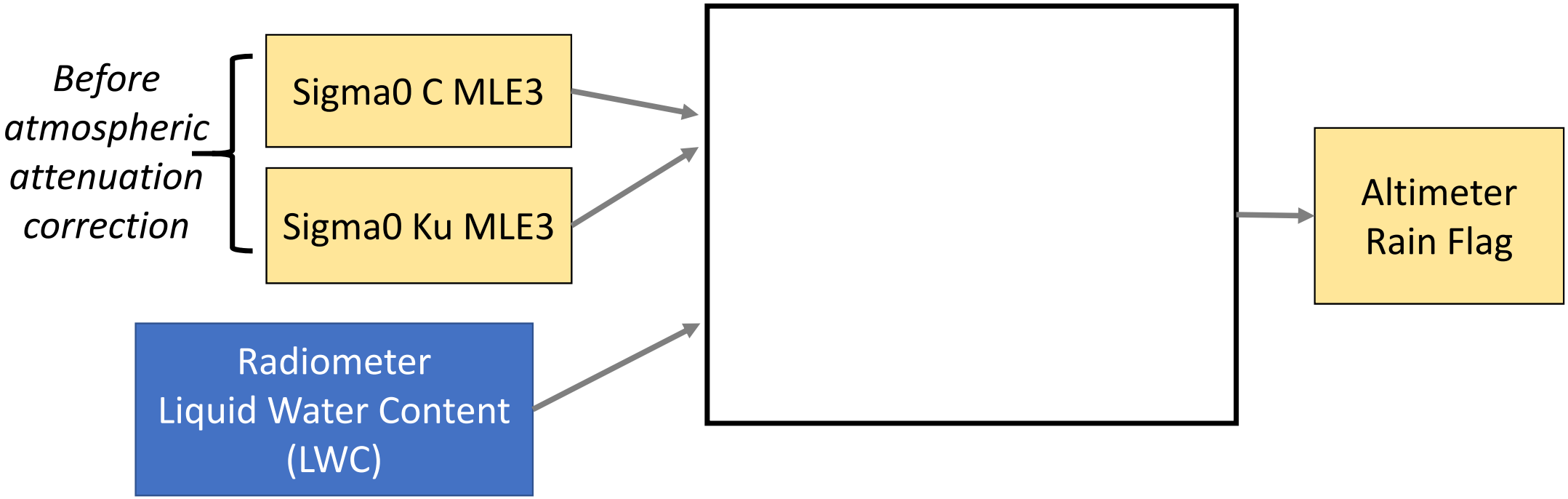
Goal of this study

➢ Examine the influence of rain flags in Jason products.

Altimeter rain flag algorithm



Altimeter rain flag algorithm



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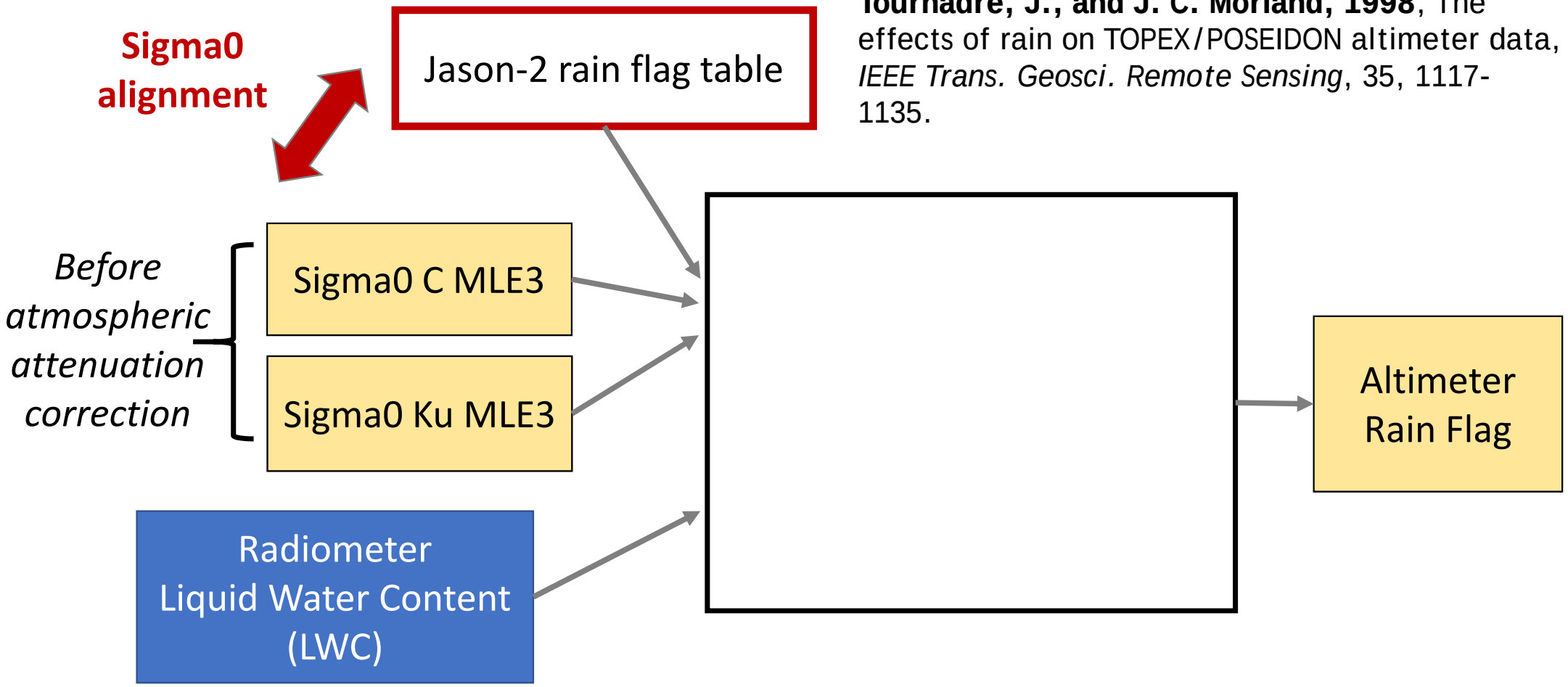

Tournadre, J., and J. C. Morland, 1998, The effects of rain on TOPEX/POSEIDON altimeter data, *IEEE Trans. Geosci. Remote Sensing*, 35, 1117-1135.

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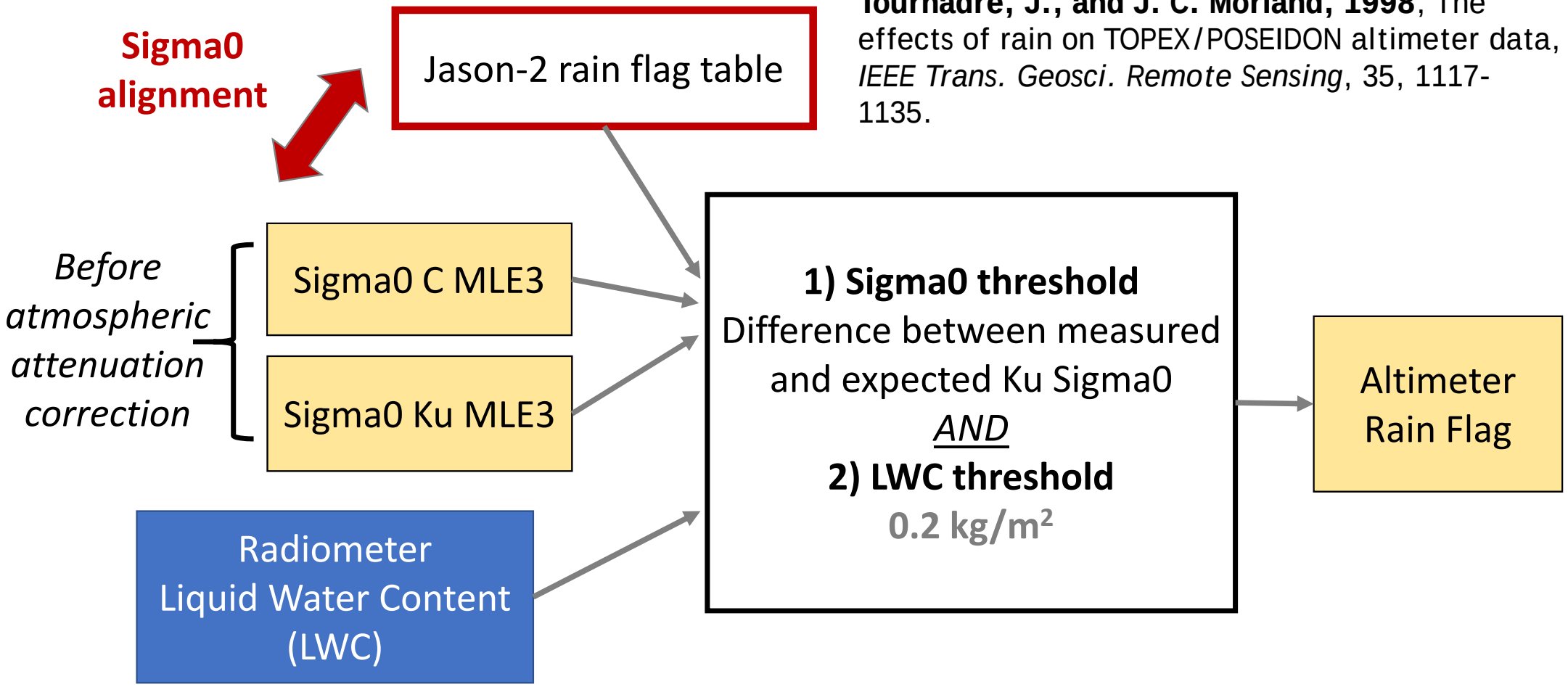

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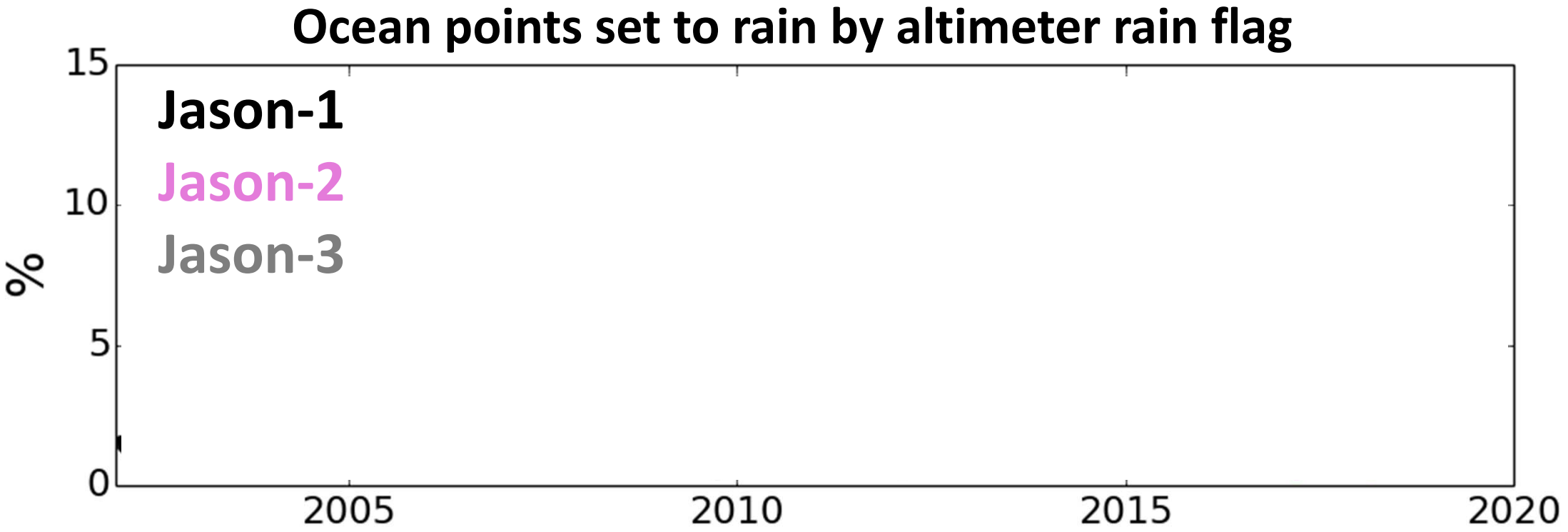
Multi-mission inconsistencies



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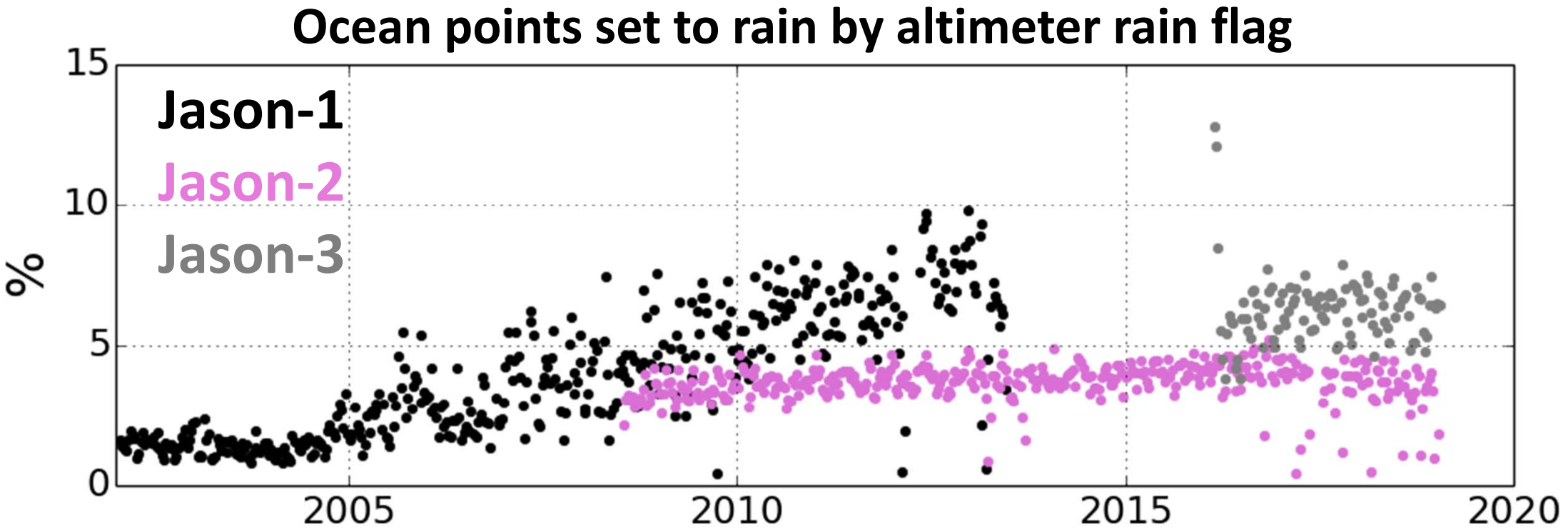
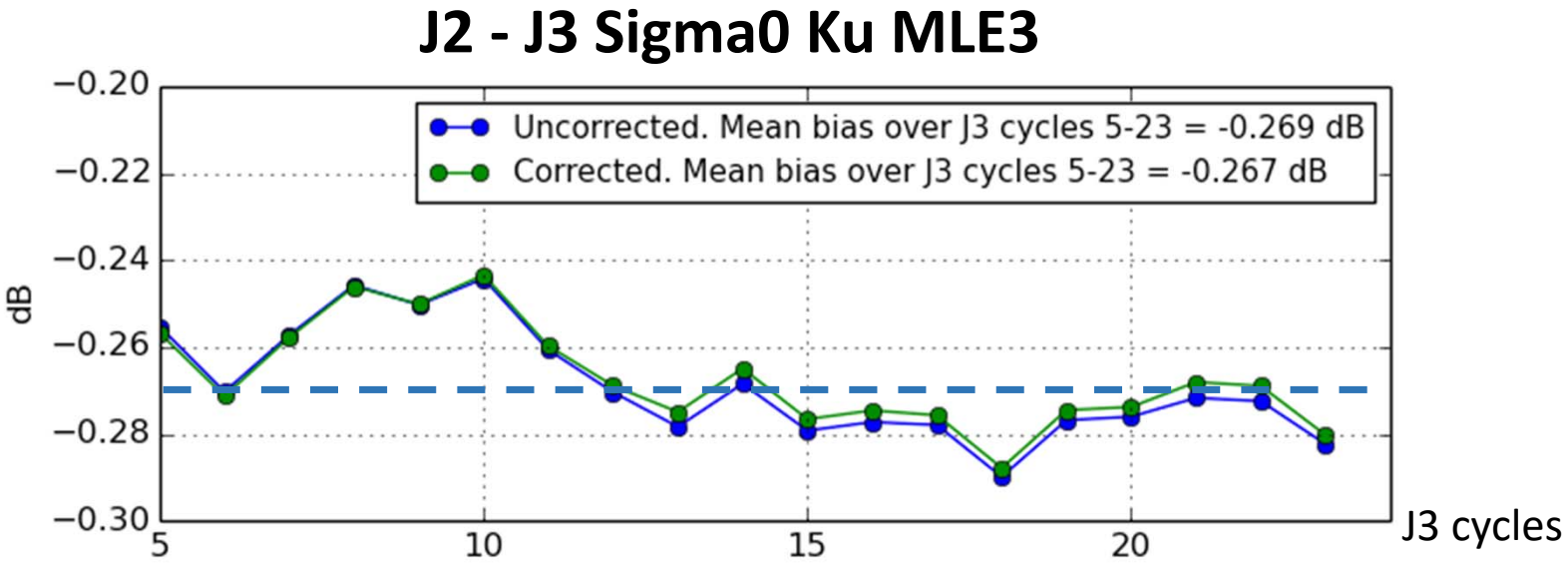


- Inconsistencies w.r.t. Jason-2 include a bias and scatter in Jason-3, and a trend, bias, and increasing scatter in Jason-1

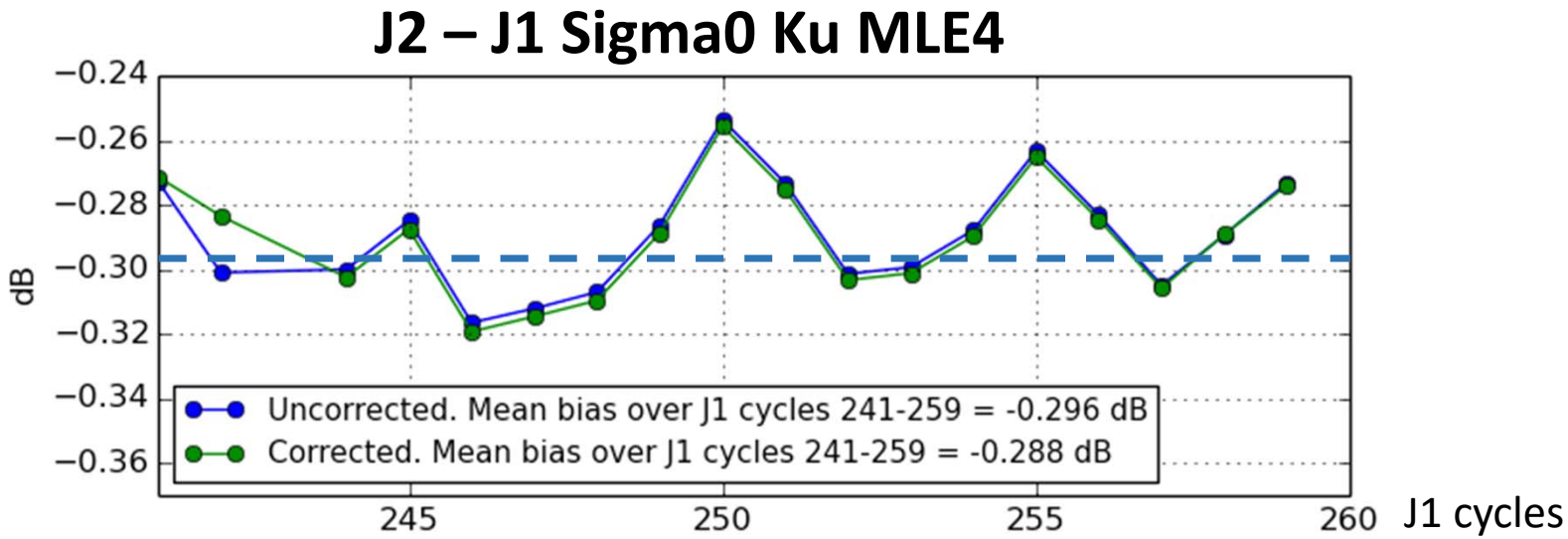
Sigma0 alignment over J2-J3 tandem phase



J3 Biases	J2 Ku MLE3 – J3 Ku MLE3	J2 C MLE3 – J3 C MLE3	J2 Ku MLE4 – J3 Ku MLE4
In J3 GDR-D product	**-0.231**	**-0.012**	NA
Computed (without atmos. att.)	**-0.269**	**-0.103**	-0.267
Computed (with atmos. att.)	-0.267	-0.103	-0.266

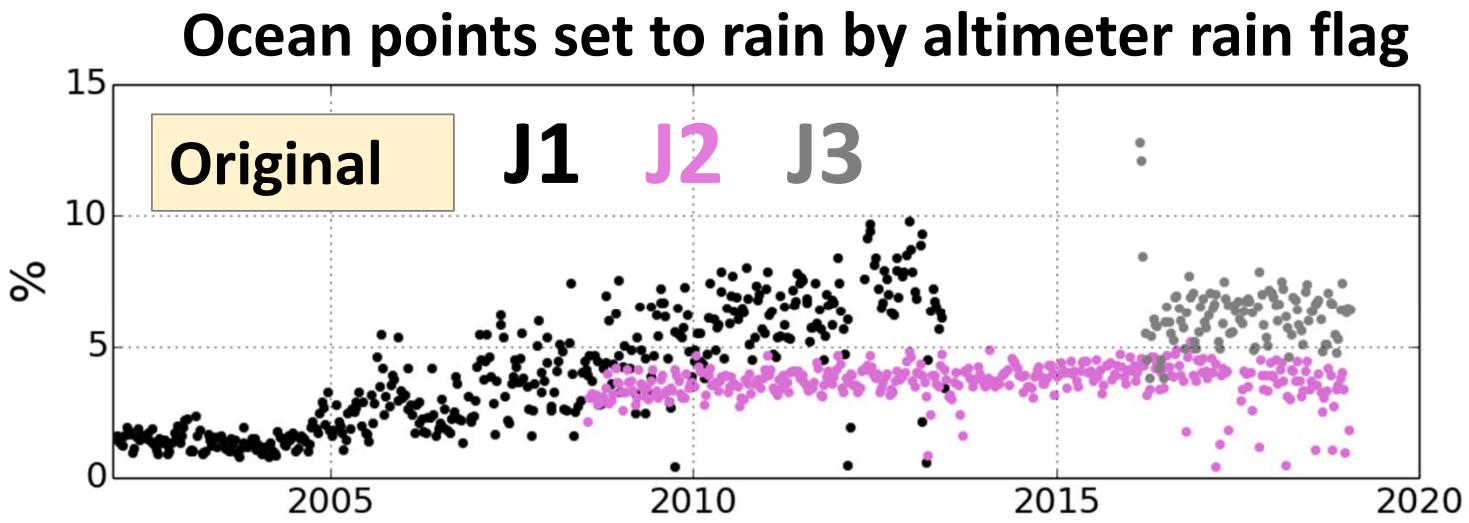
- The Sigma0 Ku and C biases computed in this study differ by -0.03 and -0.09 dB, respectively, w.r.t. the biases described in the product.

Alignment over J2-J1 tandem phase using Sigma0 instead of AGC



- In this study, the J1 rain flag utilizes Sigma0 instead of AGC, but only MLE4 estimates are available.

Better consistency with calibrated rain flag time series



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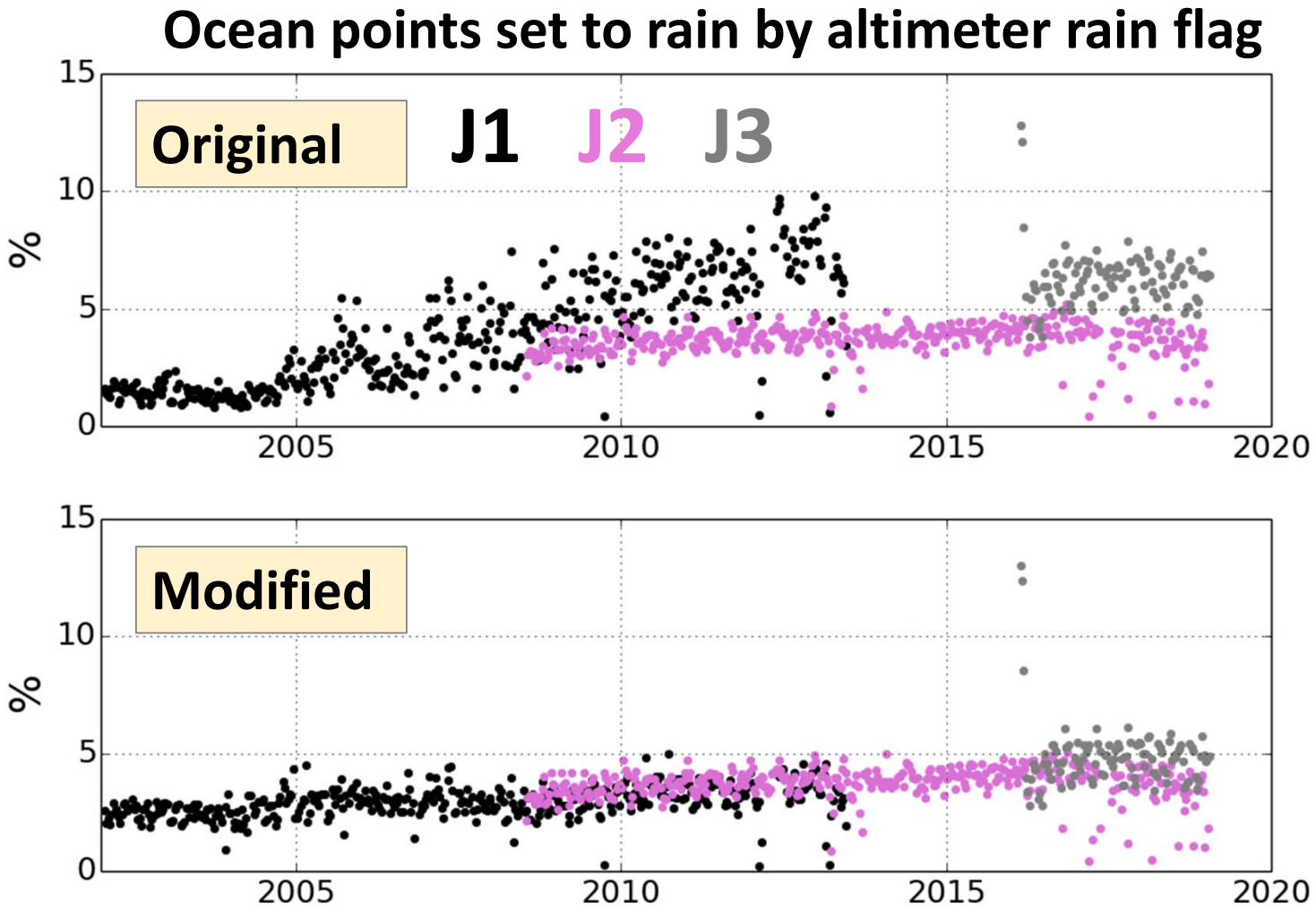
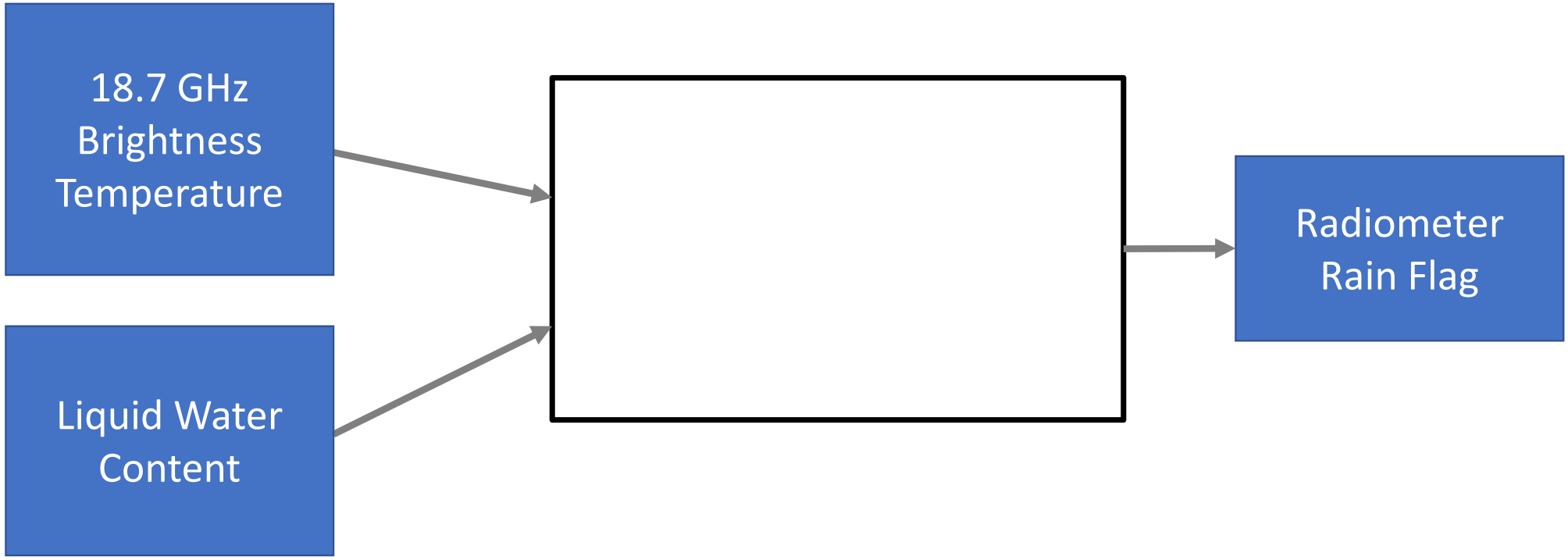


Summary

1. Mitigating altimeter rain flag inconsistencies:
    - Future Jason-3 reprocessing: Updated calibration values.
    - Future Jason-1 reprocessing: Sigma0 instead of AGC.

Radiometer rain flag algorithm



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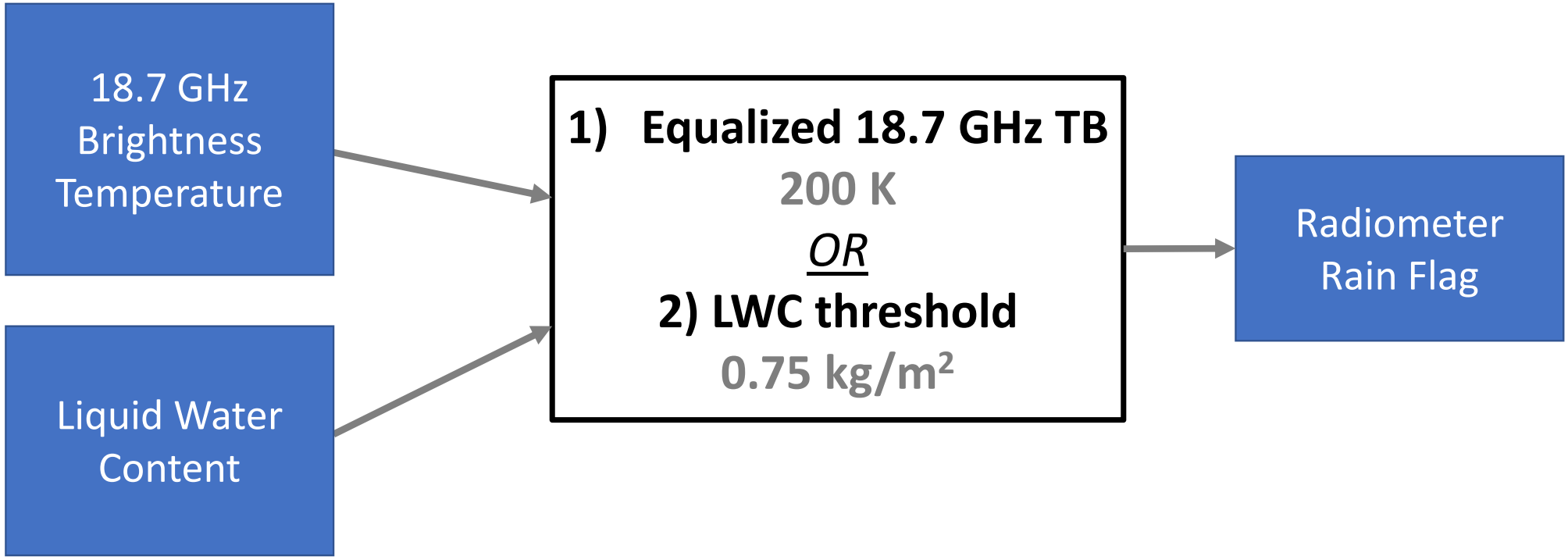

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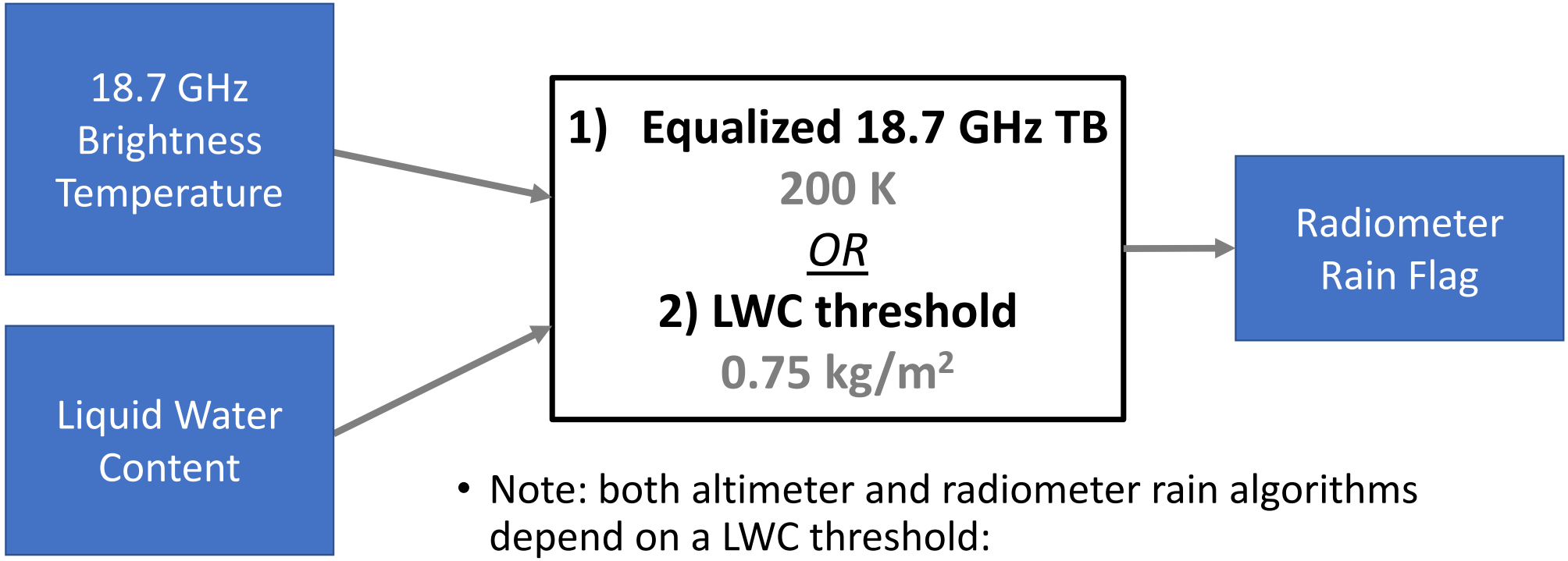
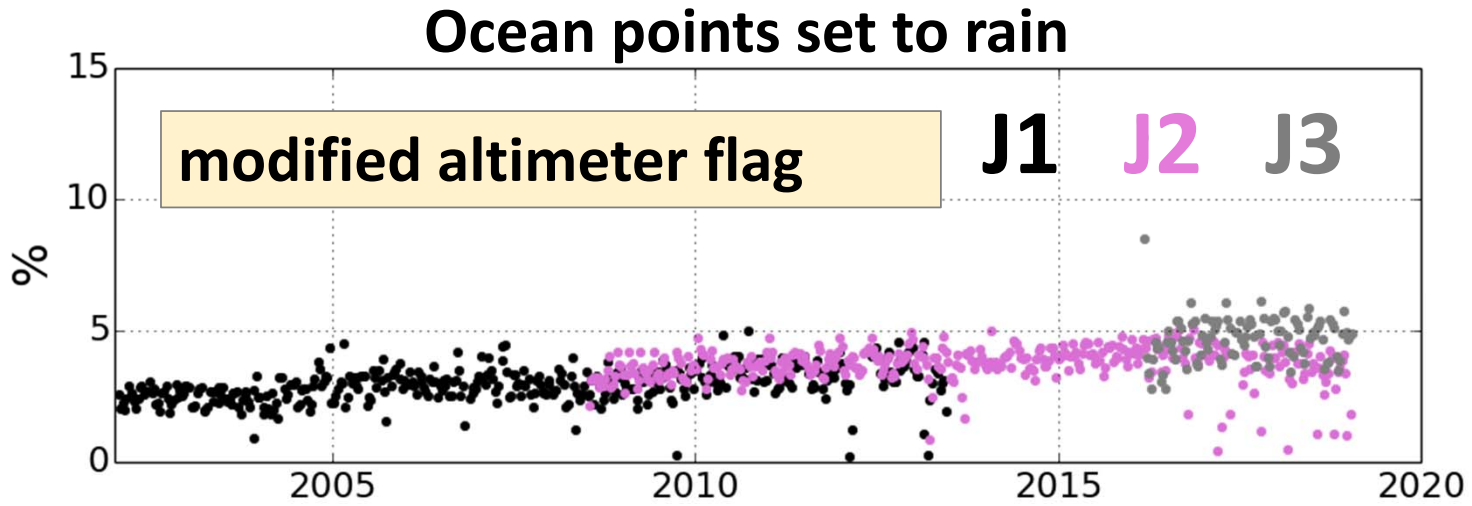


- Note: both altimeter and radiometer rain algorithms depend on a LWC threshold:
  - Altimeter: 0.2 kg/m^2
  - Radiometer: 0.75 kg/m^2

Comparison of altimeter vs radiometer



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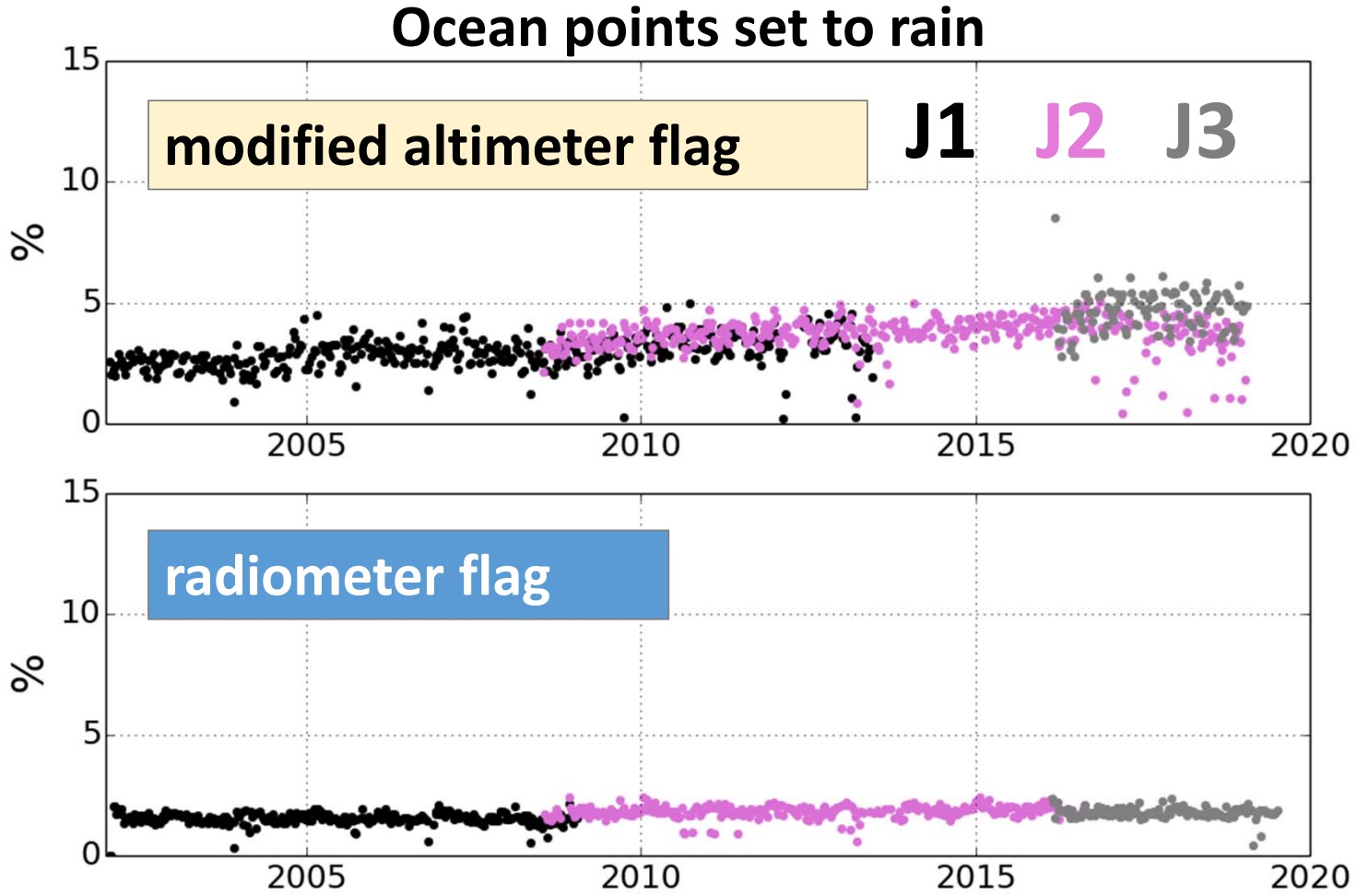
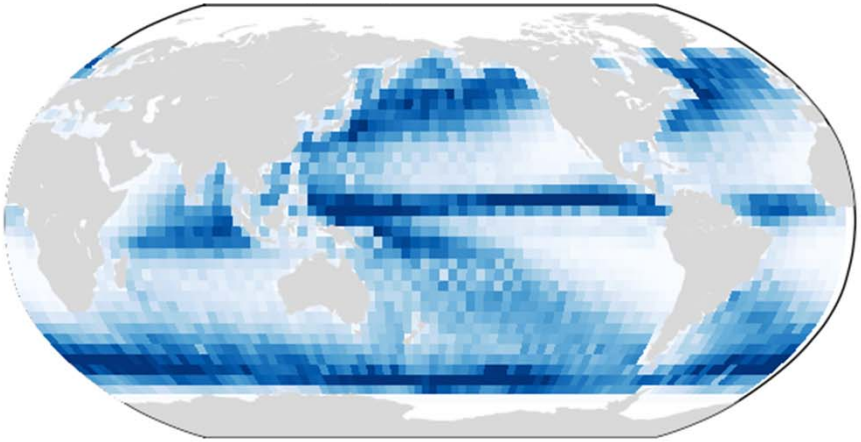


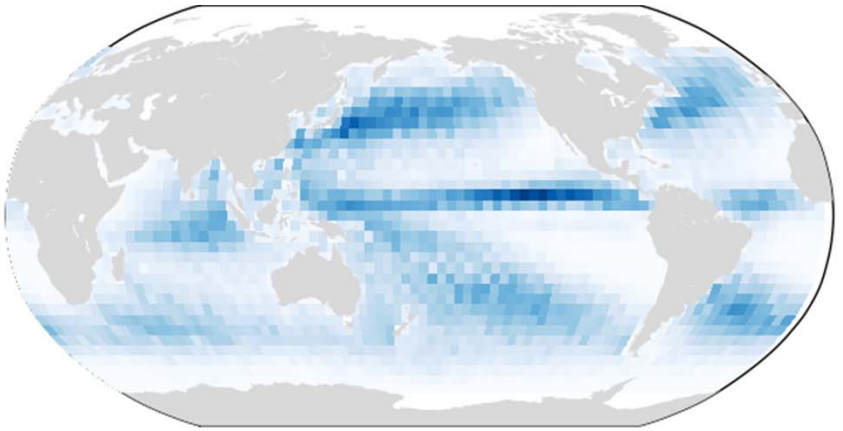
- The radiometer algorithm flags **~half as many points** as the altimeter algorithm.

Dissimilar geographic distribution at high latitudes

Altimeter rain flagging **ALT=rain**



Radiometer rain flagging **RAD=rain**



Ocean points flagged [%]

J2 cycles 1-303

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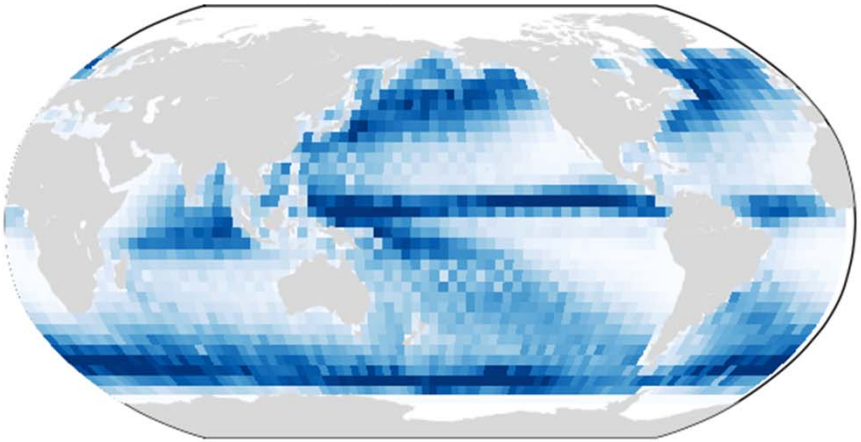

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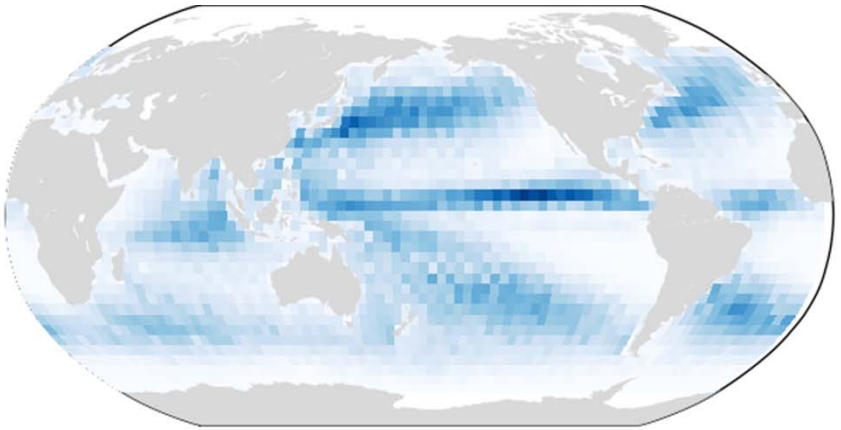
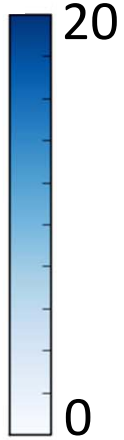
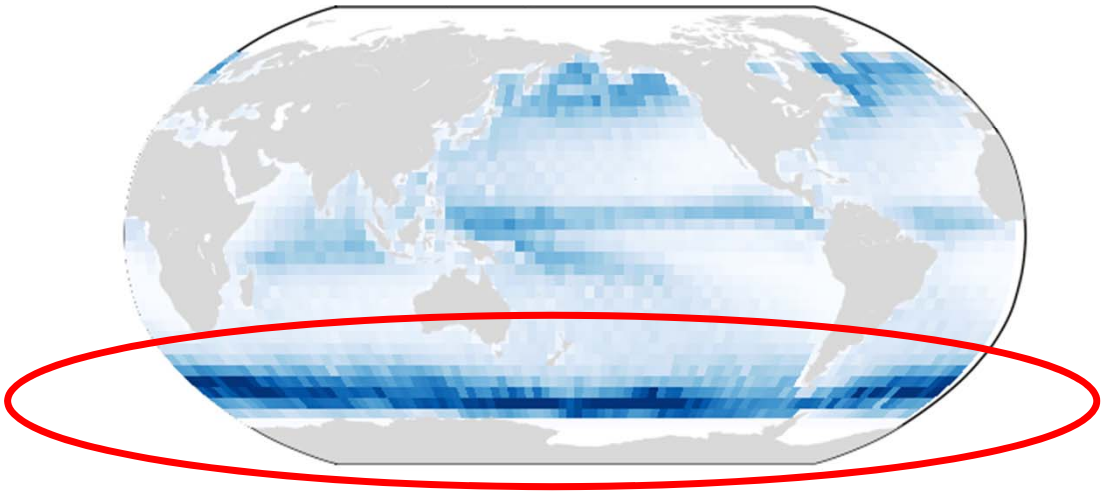




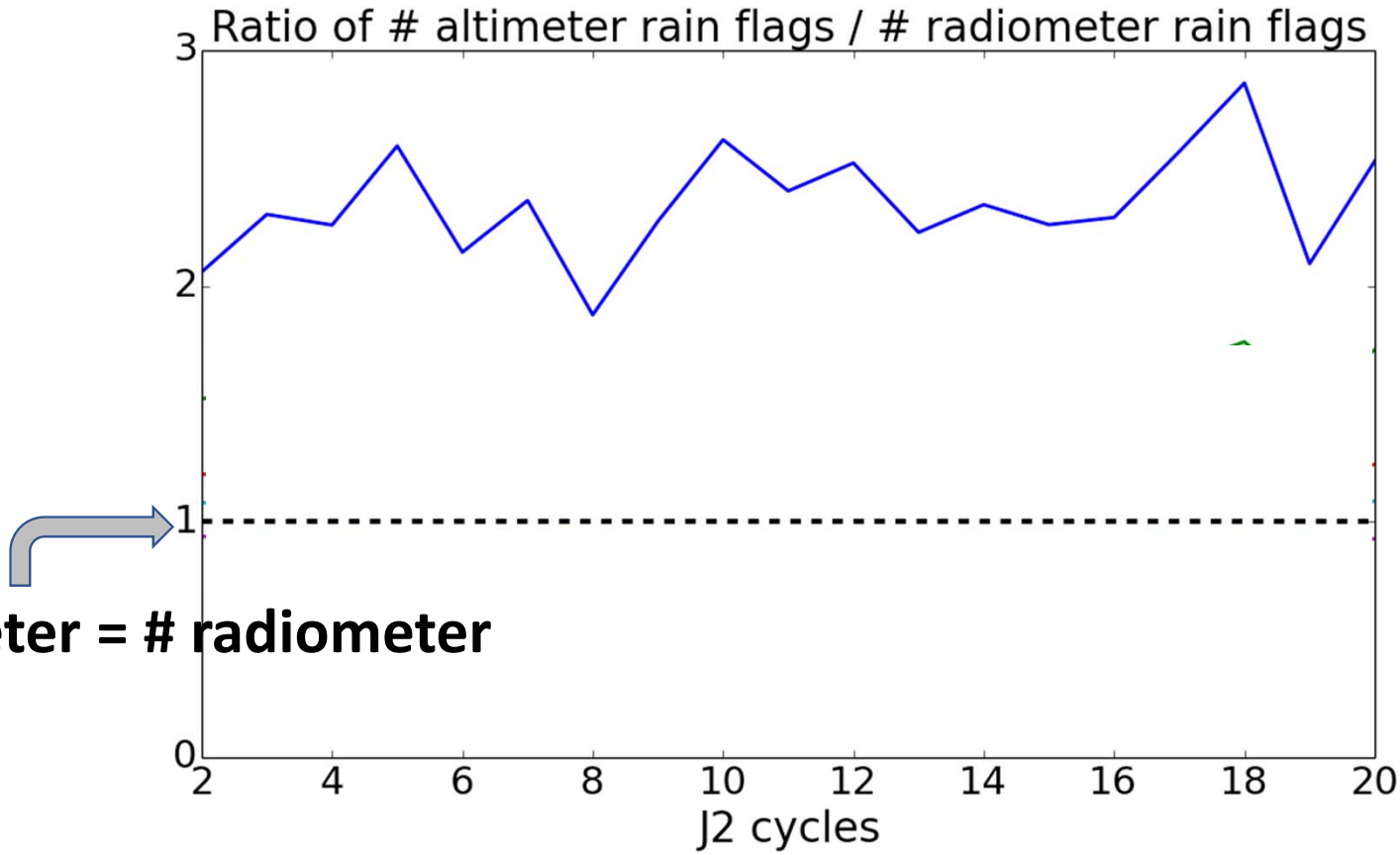
Ocean points flagged [%]

J2 cycles 1-303

Altimeter-only rain flagging **ALT=rain** **RAD=no rain**



Tuning the LWC threshold of altimeter rain flag



 # altimeter = # radiometer

Current algorithm

0.2 kg/m^2

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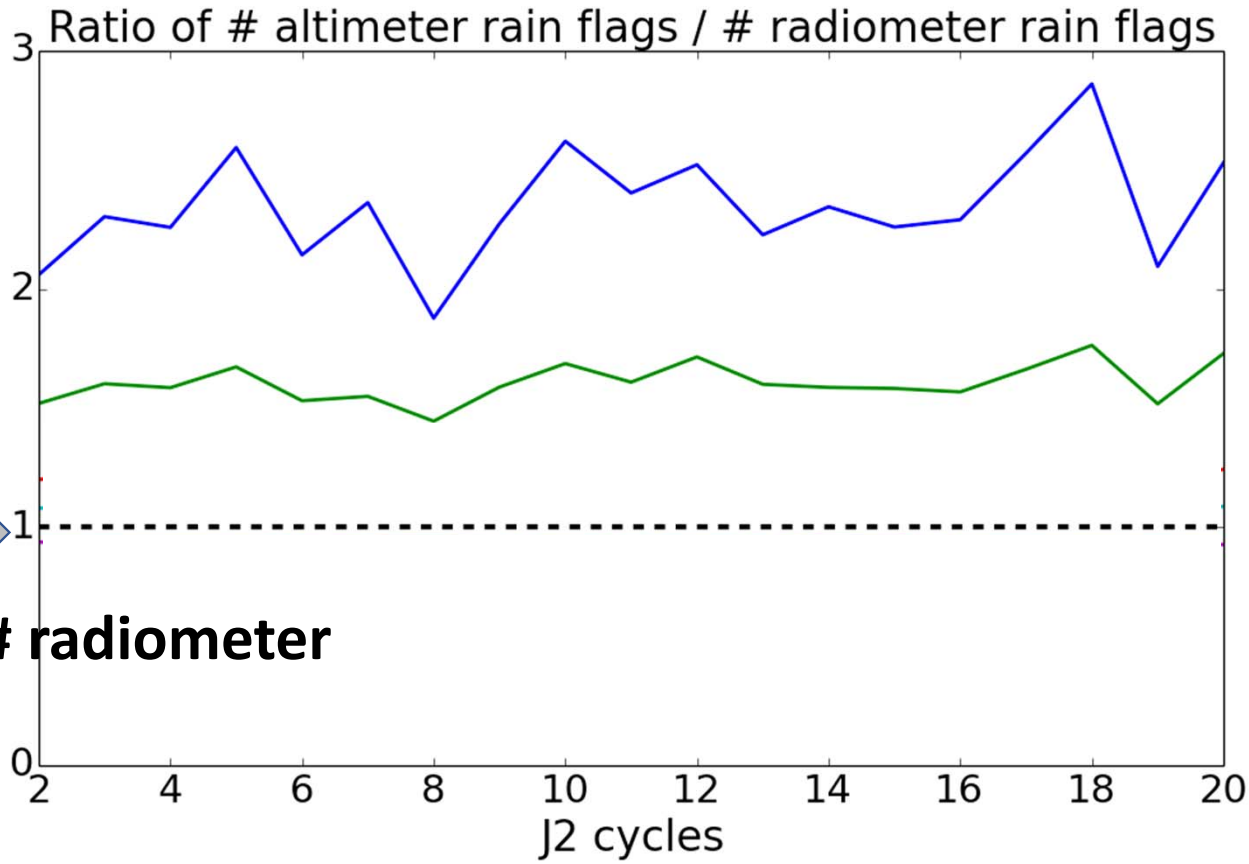

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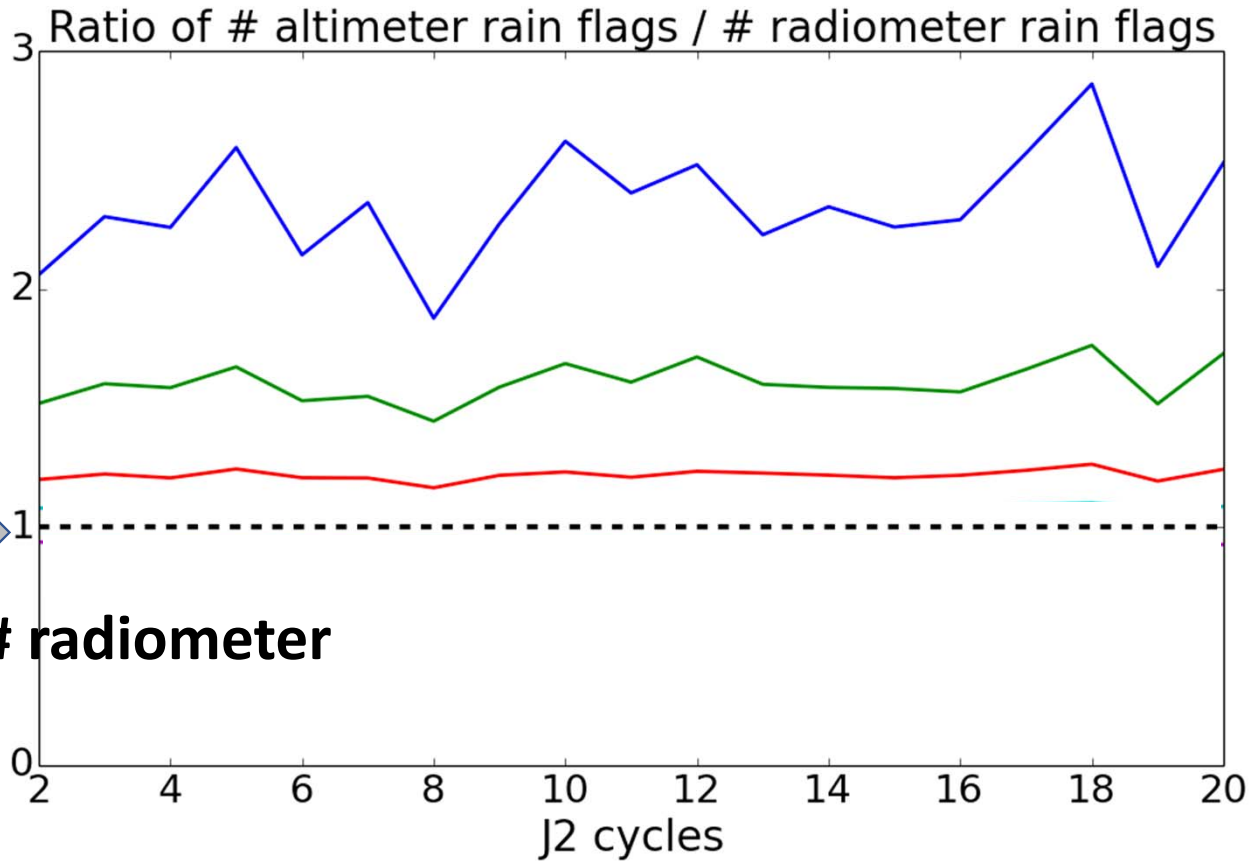

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0.6 kg/m^2

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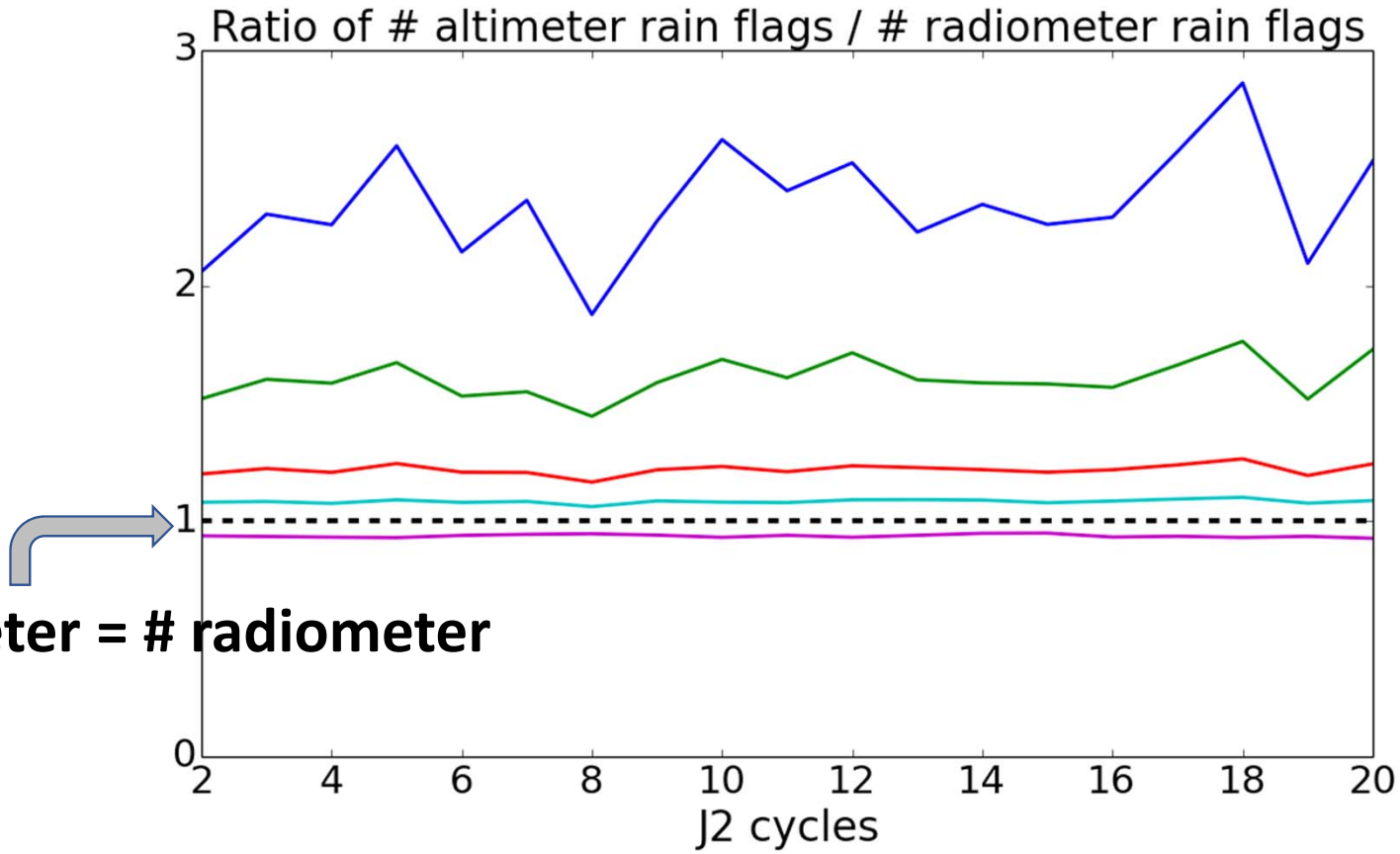

 # altimeter = # radiometer

Current algorithm

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0.4 kg/m^2

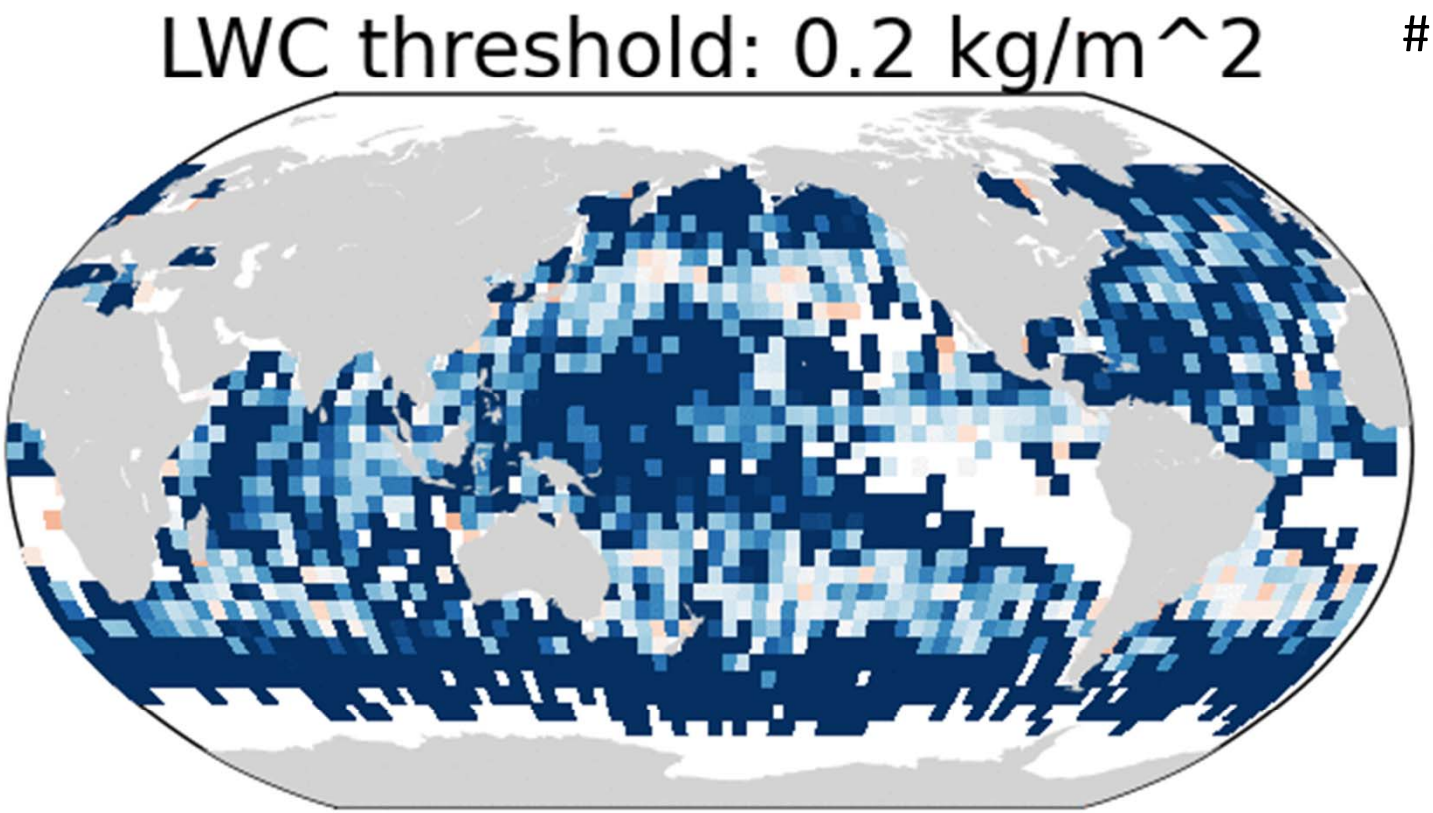
0.6 kg/m^2

0.7 kg/m^2

0.8 kg/m^2

- The best consistency between altimeter and radiometer rain flags is achieved with LWC threshold ~ 0.7 – 0.8 kg/m^2.

Tuning the LWC threshold of altimeter rain flag



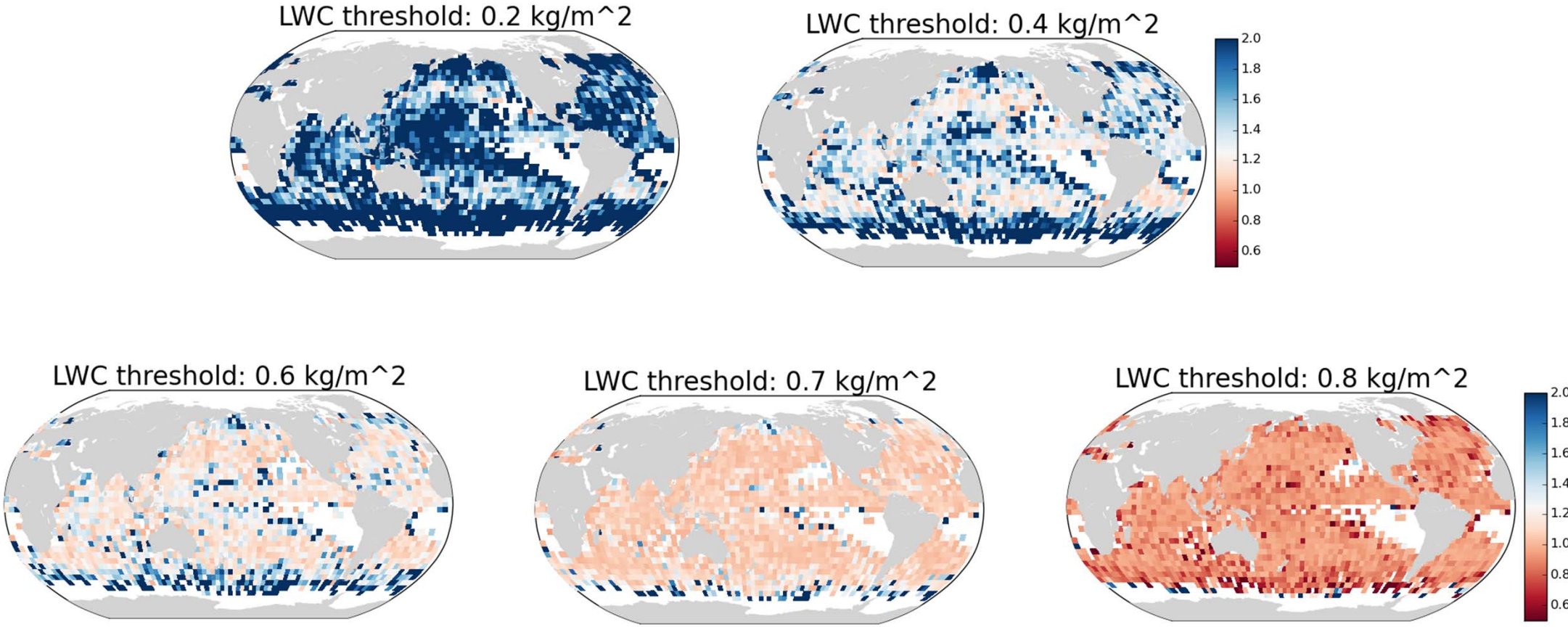
Ratio of points flagged:
altimeter / # radiometer

2 Altimeter-like

1 Radiometer-like

0.6

Tuning the LWC threshold of altimeter rain flag



- The geographic distribution of the altimeter rain flag resembles the geographic distribution of the radiometer rain flag when LWC is ~ 0.7 - 0.8 kg/m^2

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    - Future Jason-3 reprocessing: Updated calibration values.
    - Future Jason-1 reprocessing: Sigma0 instead of AGC.
2. Addressing radiometer vs altimeter discrepancy:
    - Setting **altimeter LWC threshold to 0.75 kg/m^2 ensures consistency** in number and geographic coverage.

Impact on Sea Level Anomaly for Jason-2

Difference:

SLA **with** alti+rad rain flags applied – SLA **without** alti+rad rain flags applied

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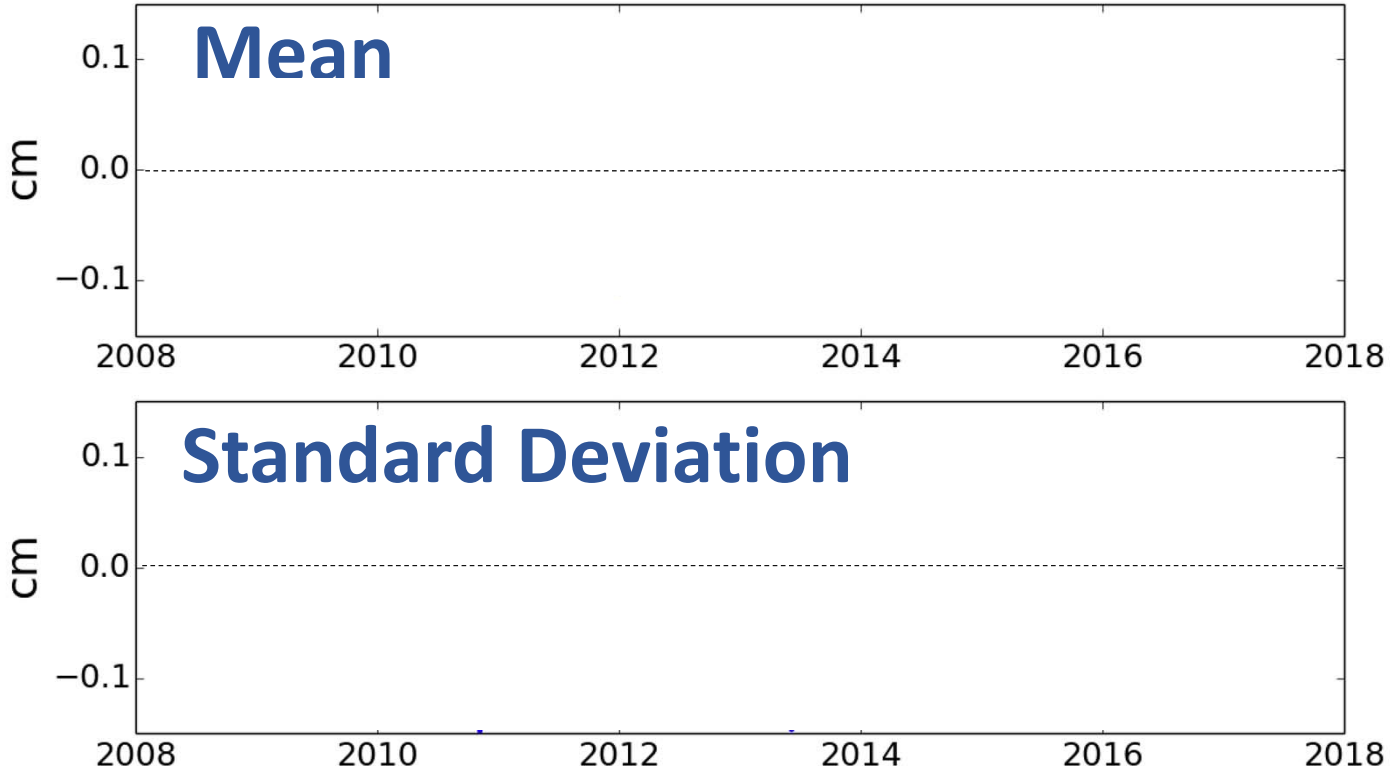

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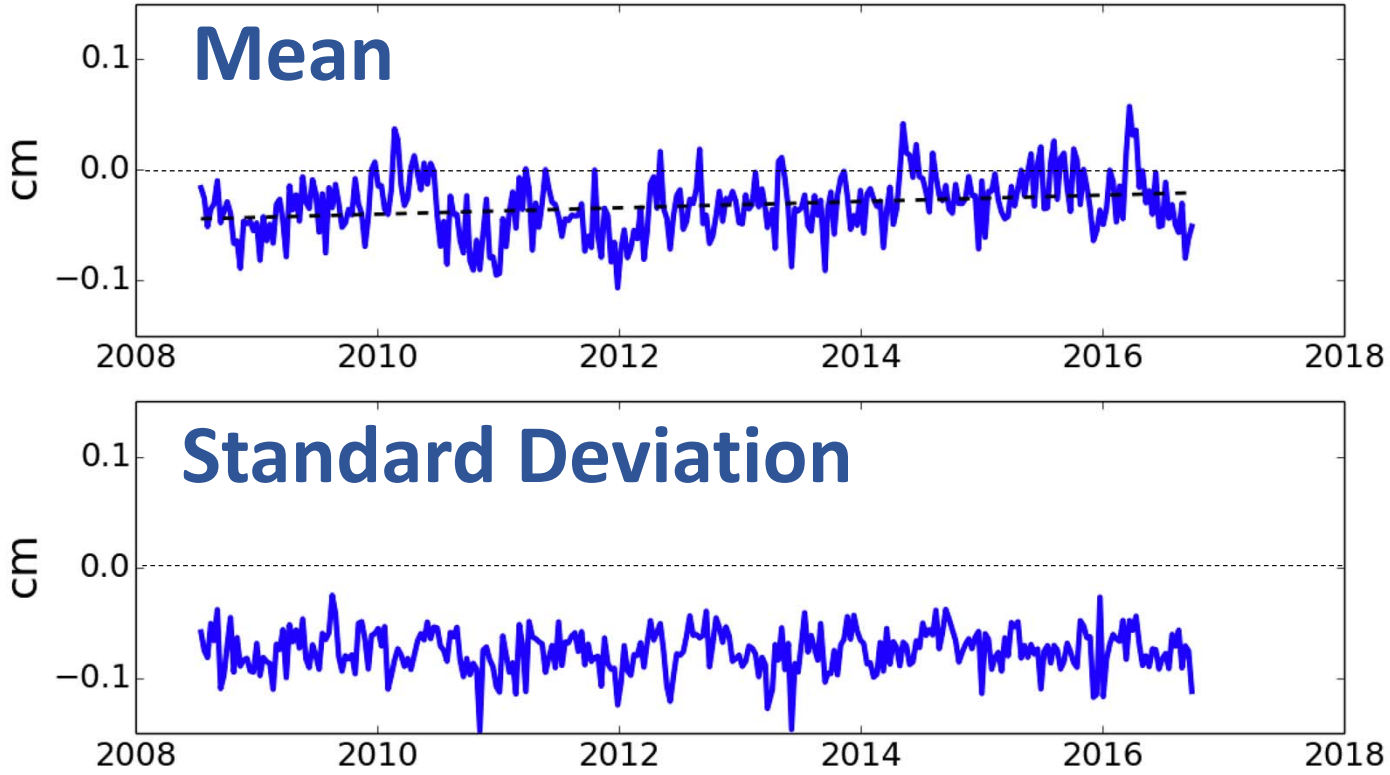

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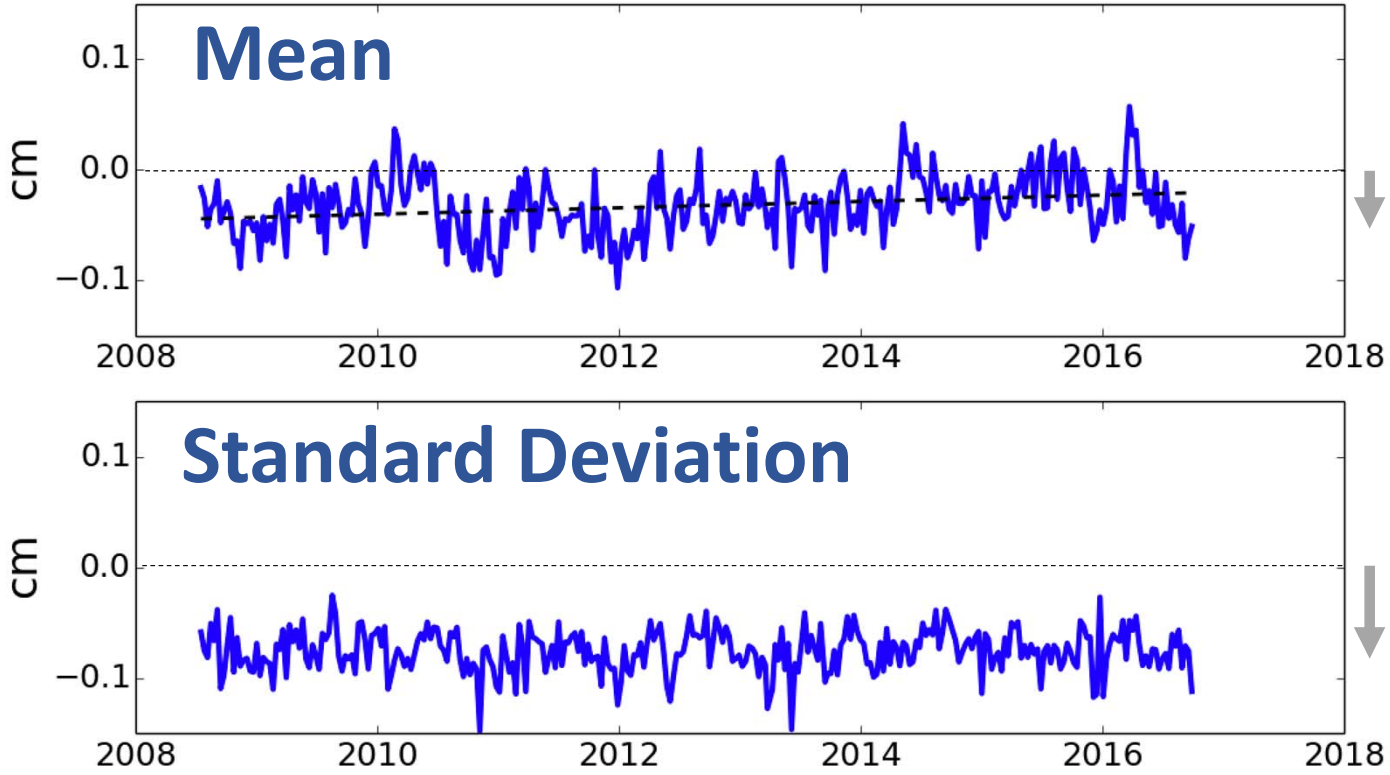

Bias ~0.3 mm
Trend ~0.03 mm/yr

Lower variability
by ~0.8 mm

- Removing points with altimeter and radiometer rain flags set to 1 influences the SLA by <1 mm over J2 as reference mission.

Conclusion

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Future Work

- Quantifying the impact of J1 and J3 discrepancies on the existing SLA curve.
- Comparing against rain "truth" (NASA's Global Precipitation Measurement mission, shipborne data, etc.).
- Refining altimeter rain flag: use of additional metrics (e.g., RMS of range).

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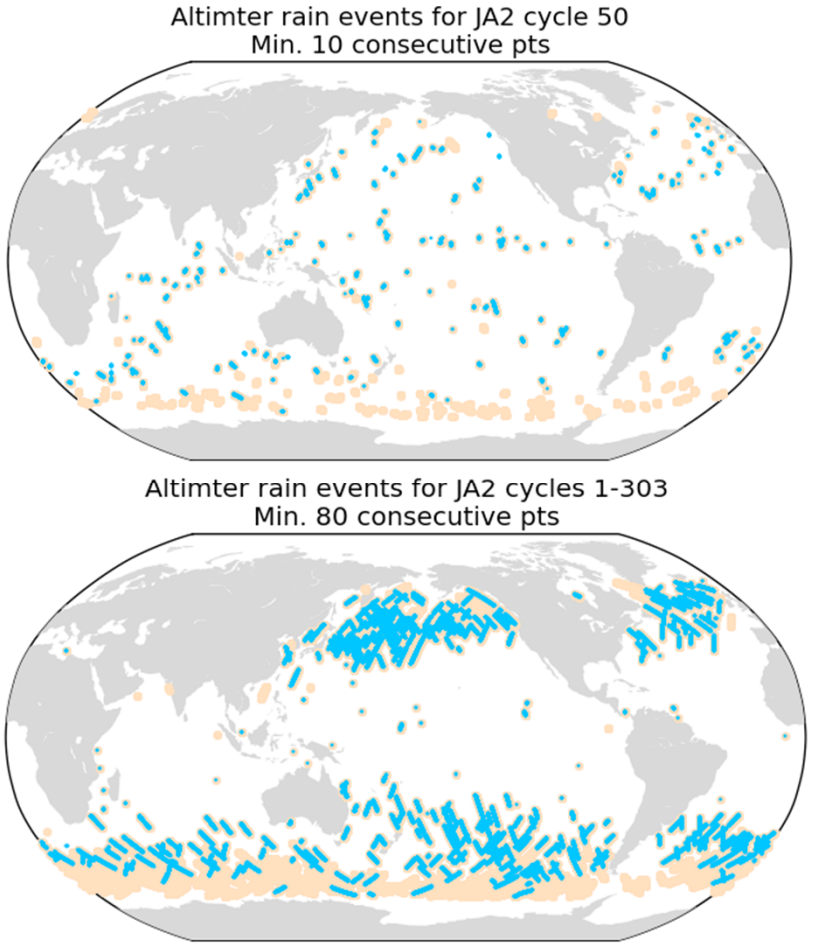
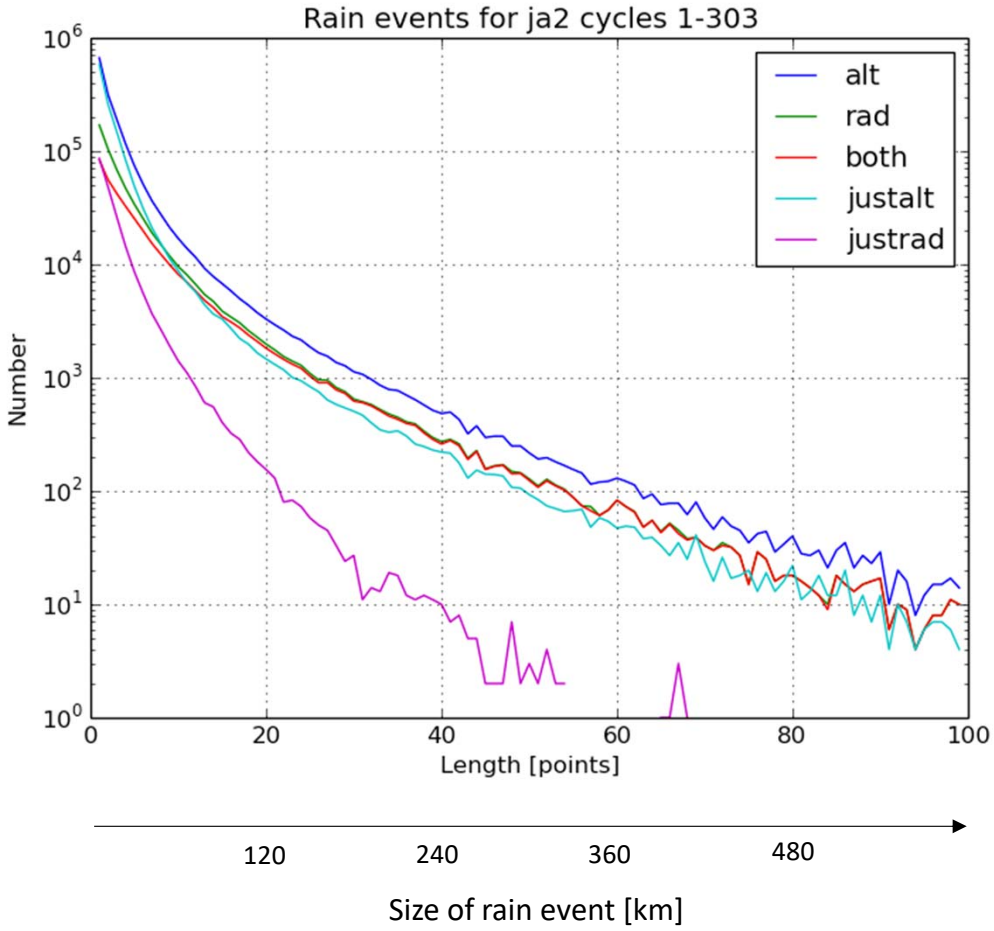
"Rain flag" = rain event detection?... or just a measurement quality flag?

- Current radiometer perspective: rain flag is triggered in extreme cases → more of a quality flag.
- Are the two algorithms truly independent? Both algorithms use LWC from the radiometer.
- Is the current altimeter algorithm over-flagging? By how much is the radiometer algorithm under-flagging?

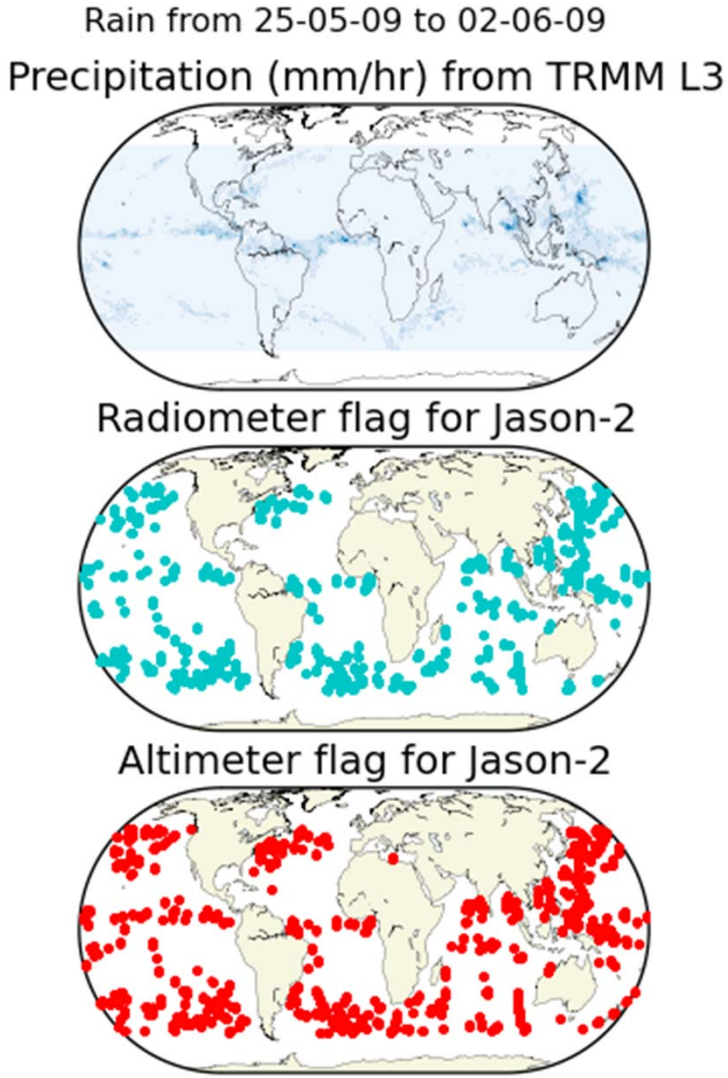

Questions?
Jeremy Bishop

Similar distribution in number of **rain events** and strong agreement in location



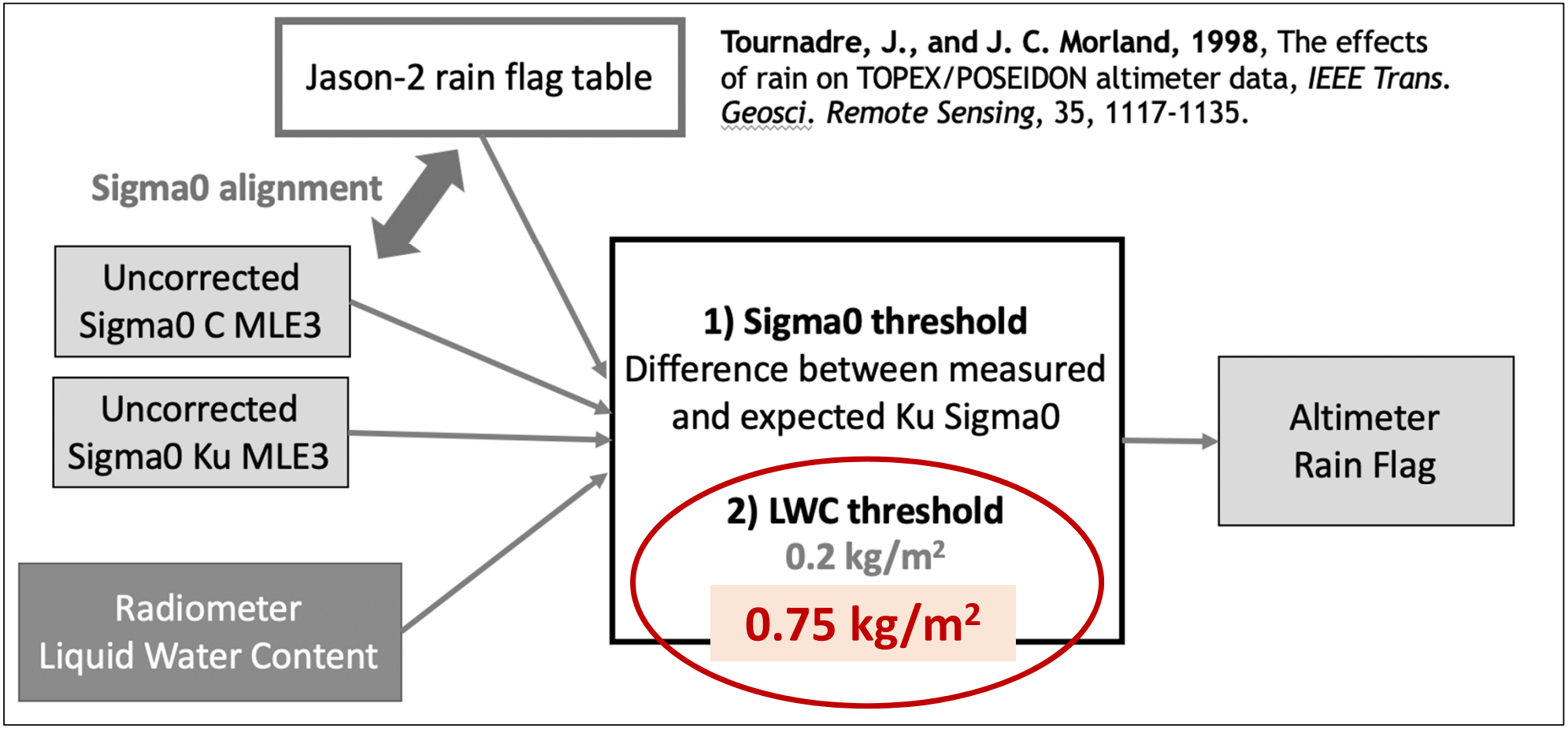


TRMM L3 also miss rain flags at higher latitudes



Suggested LCW threshold update to altimeter rain flag algorithm

Current rain flag algorithm shown on slide 4



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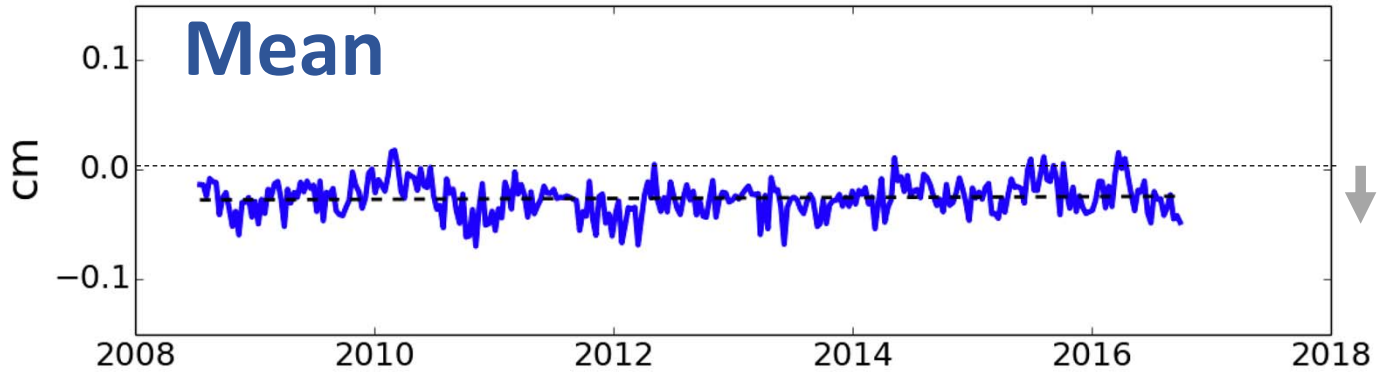
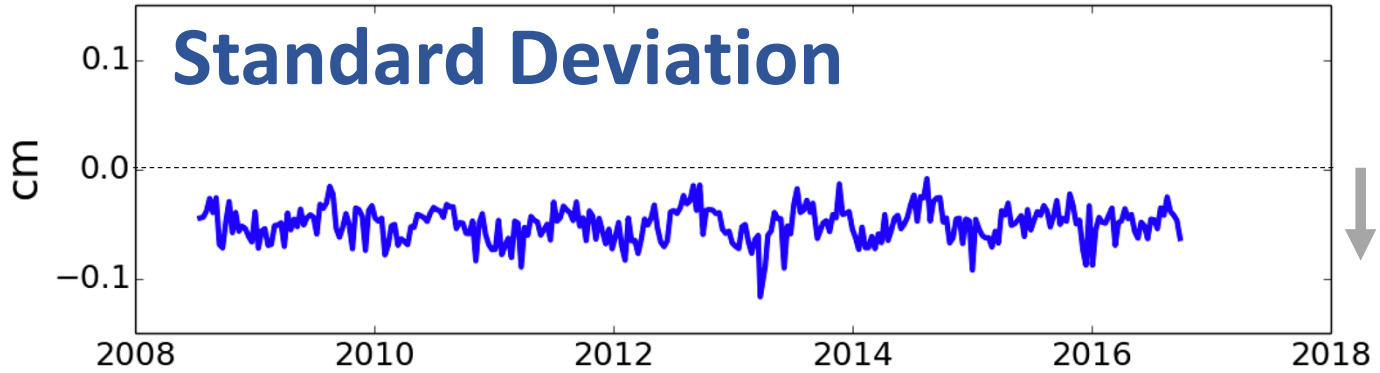


Bias ~0.25 mm
Trend ~0.004 mm/yr



Lower variability
by ~0.5 mm