Global Evaluation of the Jason-2/OSTM Data Products

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Outline

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California Institute of Technology

- Introduction
- Features of interest encountered in the AMR data
- ~60-day oscillation in Jason-1/OSTM SSH time series
- Possible sources of 60-day signal related to tide model
- Corrections to the Ocean Tide Model
- Topex CG analysis

Brightness Temperature

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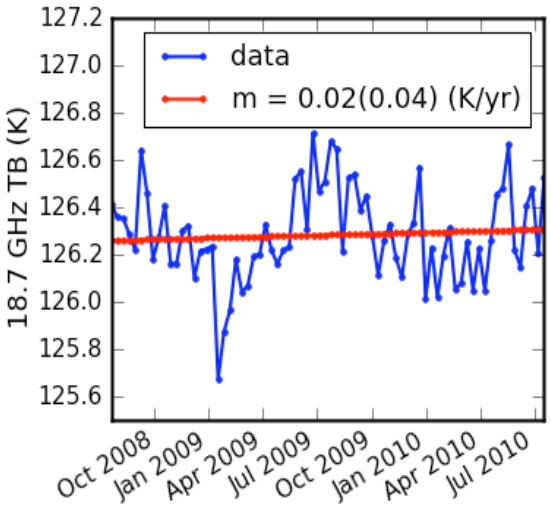
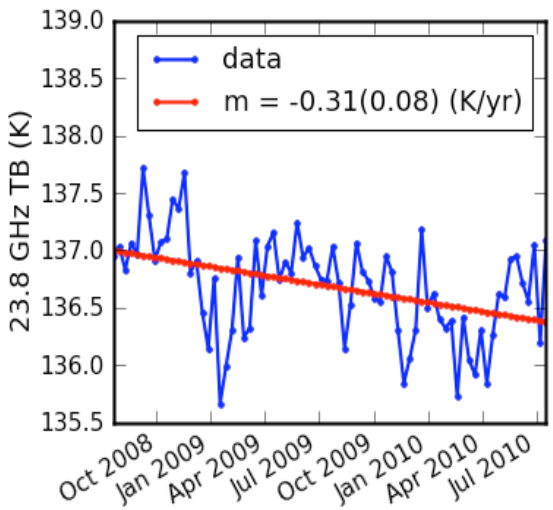
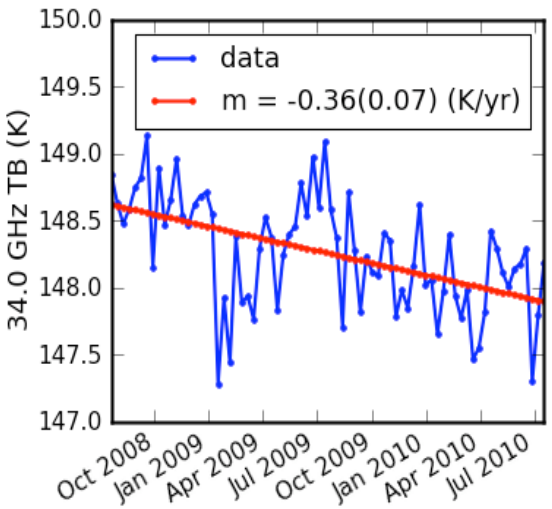
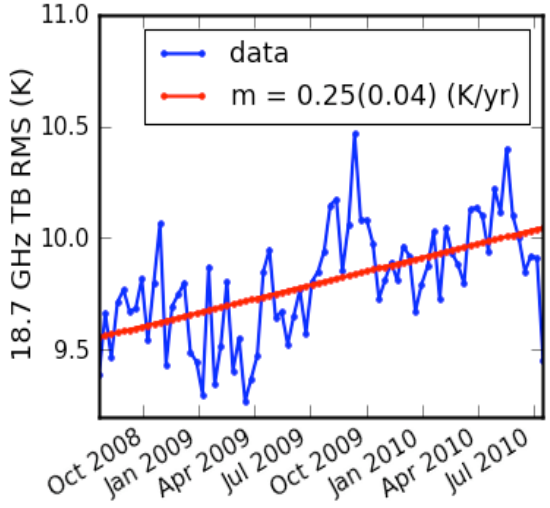
v.c. mean

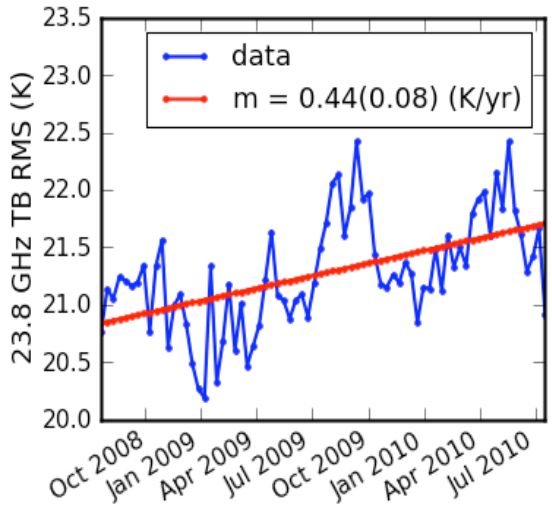


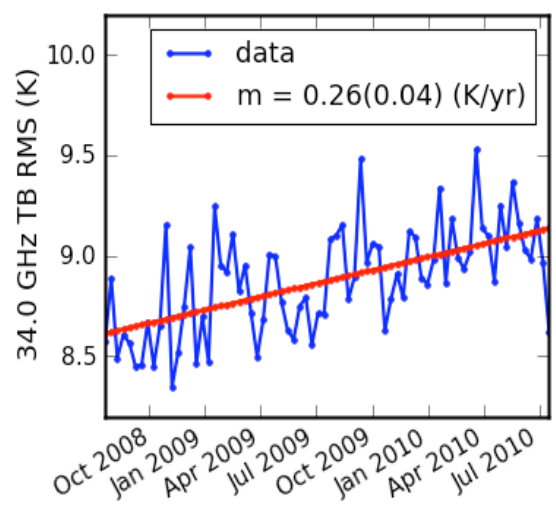




Std. dev.







18.7 GHz **23.8GHz** **34.0 GHz**

Radiometer – Model Wet Path Delay Statistics

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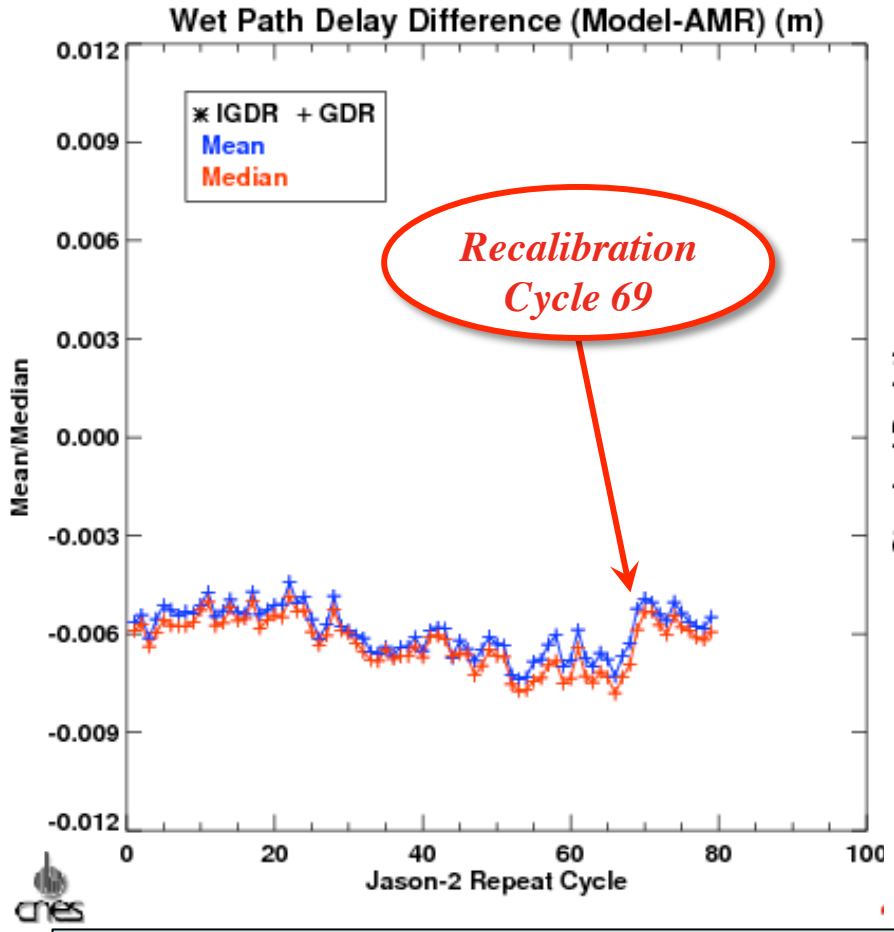
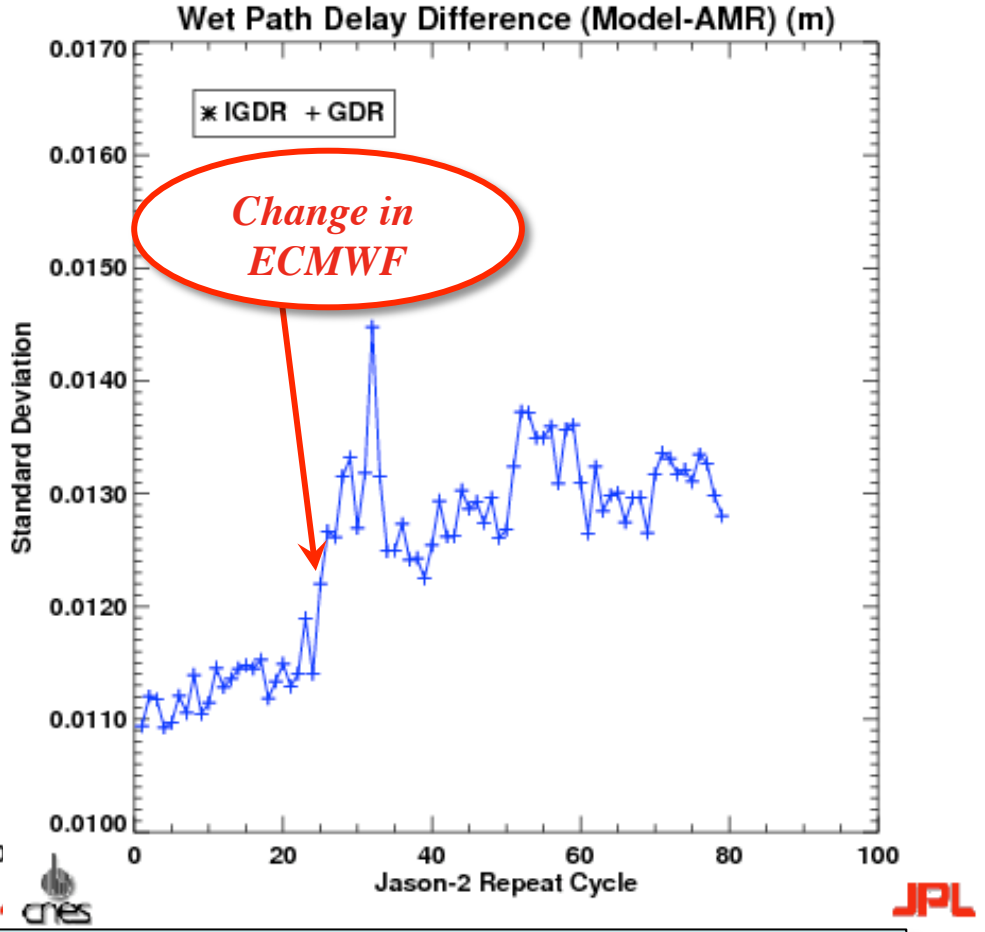
Mean

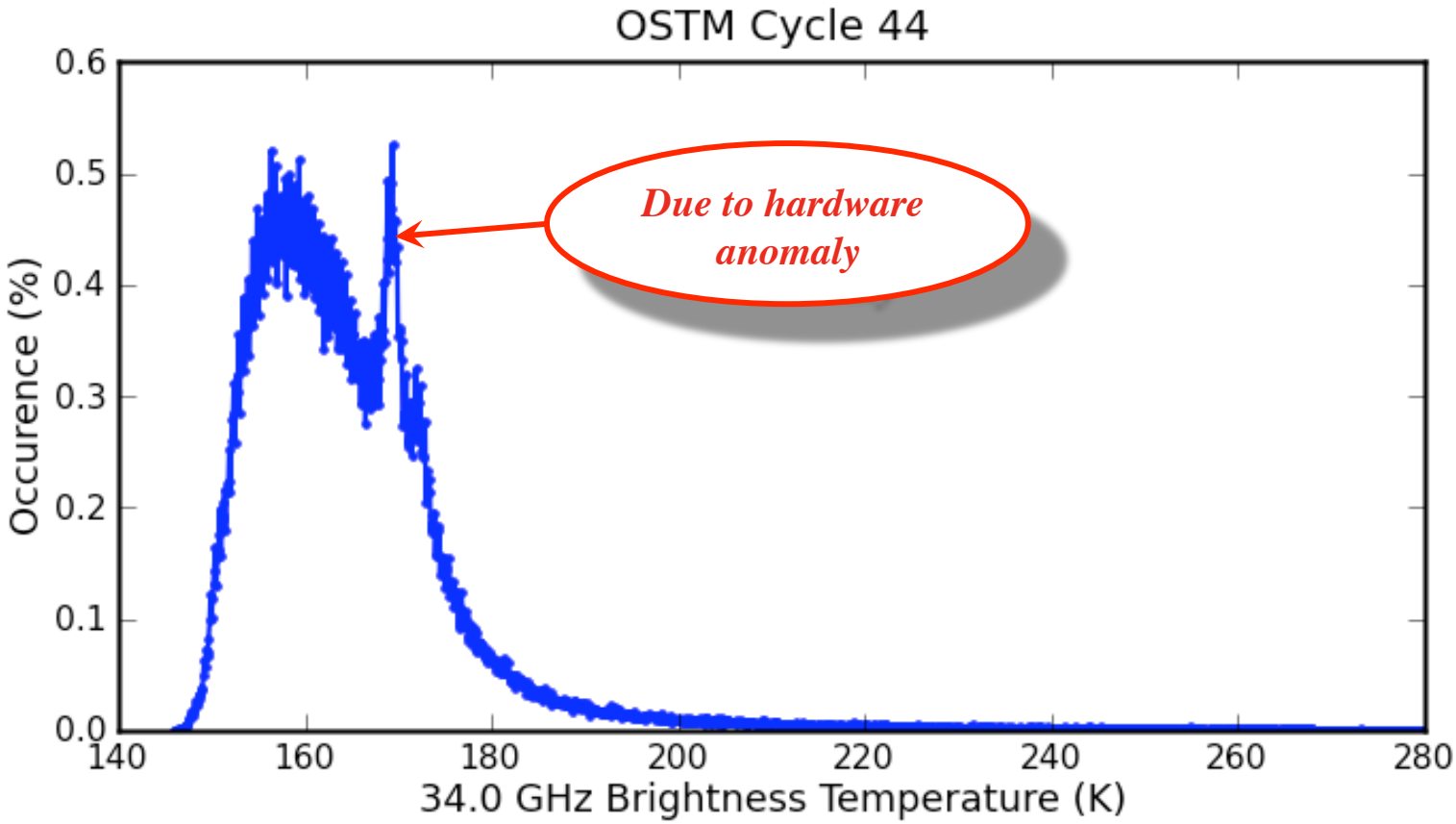


Standard Deviation



- Cycle 69 jump in wet path diff caused by recalibration
- Increase in std.dev. coincident with change to ECMWF model
- Increase in brightness temperature std. dev. may also contribute

34.0 GHz Brightness Temperature



- 34.0 GHz T_B histogram has anomalous spike near 163K.
- Due to hardware anomaly in voltage to frequency converter (VFC).
- Workaround developed for GDR-C reprocessing.
  - If uncorrected would create wet path delay error ~ 2 to 3 mm.

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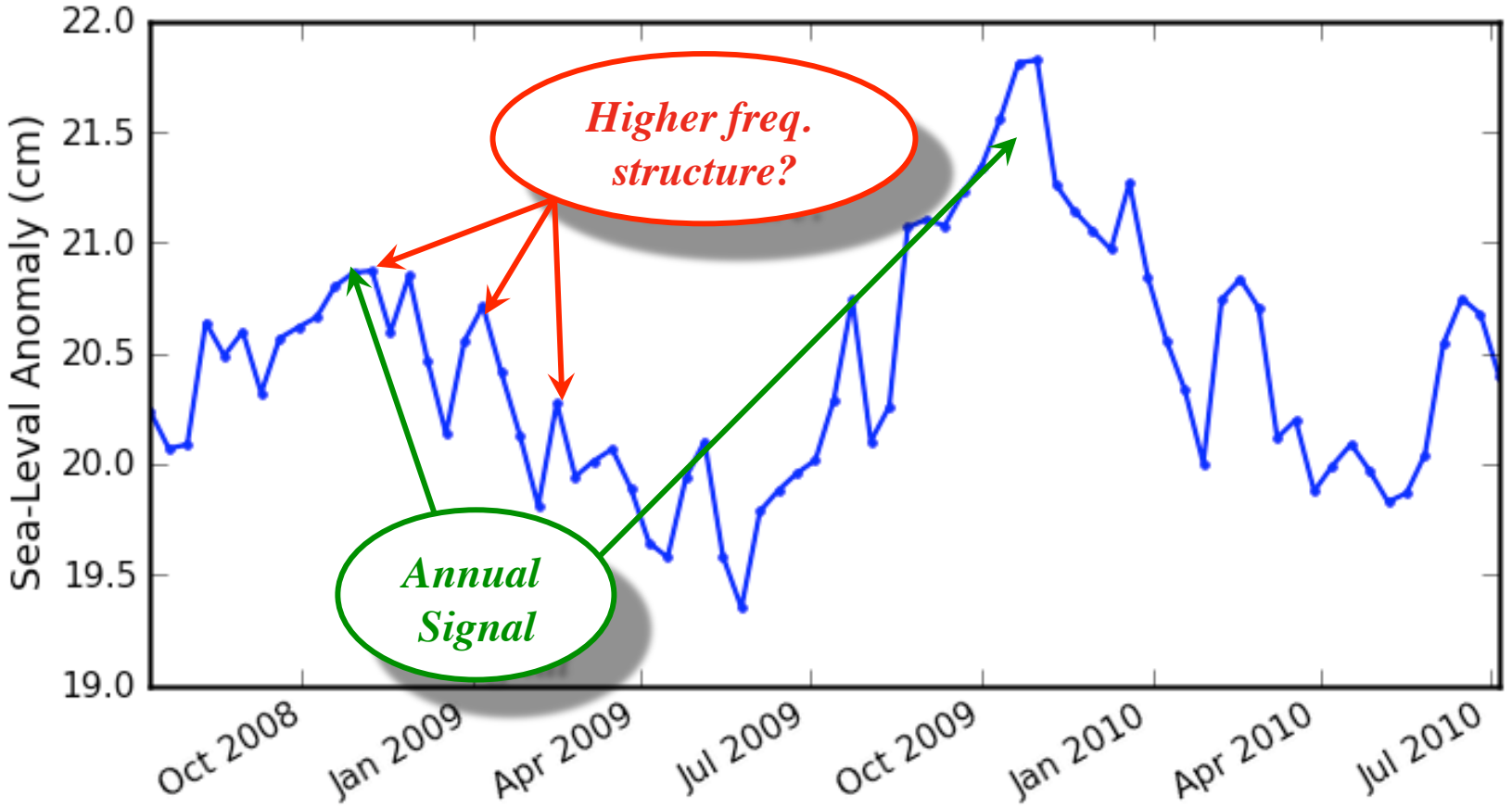
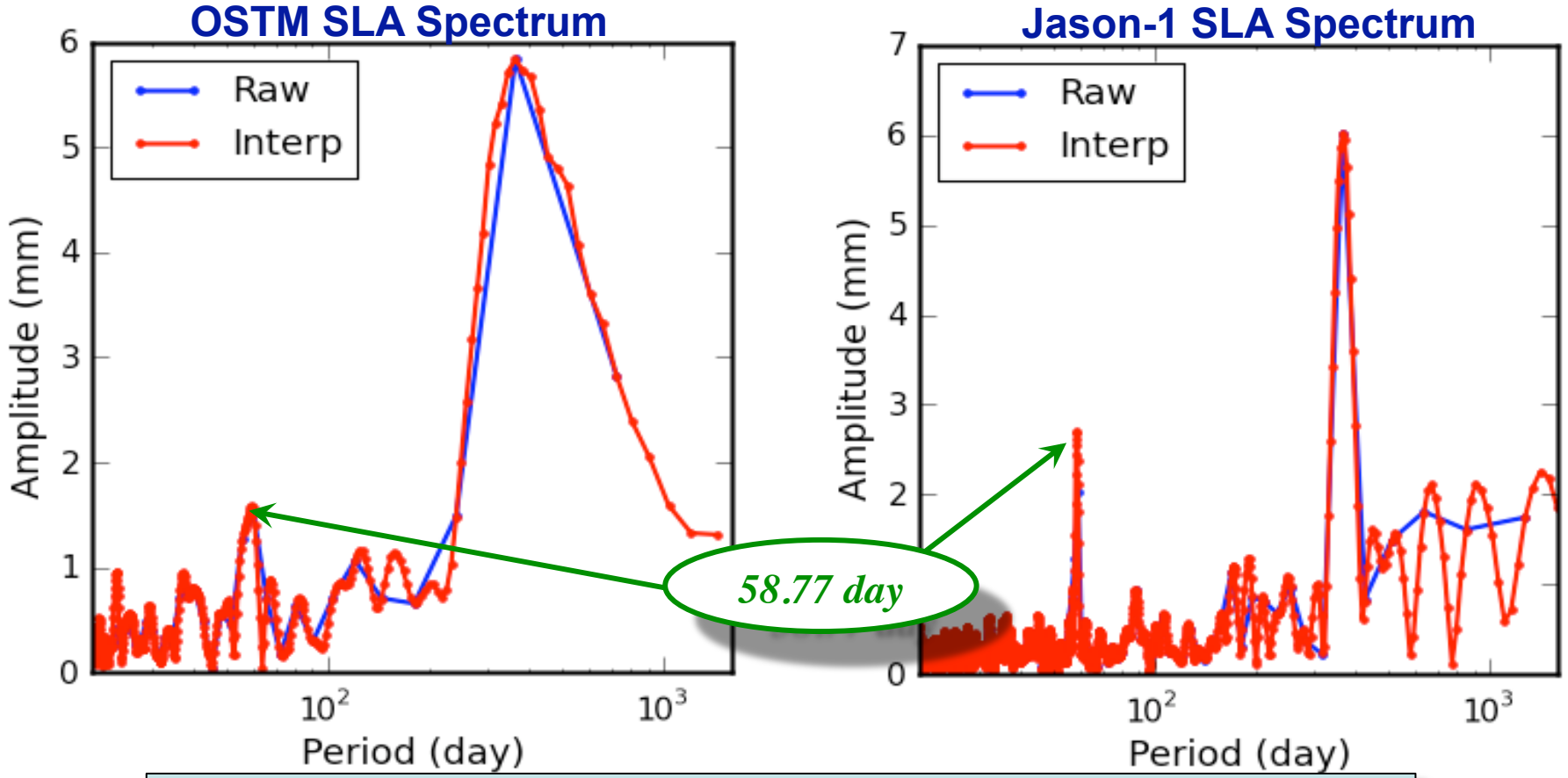
OSTM Sea-Level-Anomaly



- Each point represents cycle-average of sea level anomaly (SLA)
- Time-series has periodic structure on few-month time-scale
- Look at frequency spectrum to examine structure

OSTM Sea-Level Anomaly Periodogram



- 58.77 days is exactly the S2 tide alias frequency
- Amplitude of peaks are slightly different when using GOT00.2 and FES04 ocean tide models
- Suggests examining the ocean tide models

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Dry Troposphere Correction and Atmospheric Tides

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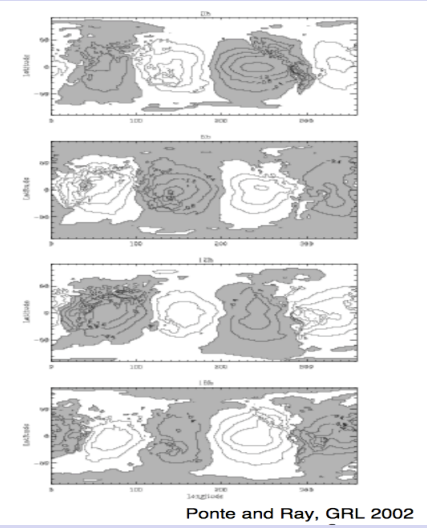
ECMWF Pressure Model



Ponte and Ray, GRL 2002

- Data at 0h 6h 12h 18h
- S2 alias ~ standing wave
- Requires strategy to handle air-tide. (Ponte and Ray, 2002)

Topex Strategy

- S1/S2 atmospheric tidal effects on dry troposphere range delay not applied to MGDR data

Jason/OSTM Strategy

- Remove climatologically signal from four daily ECMWF pressure data sets.
- Interpolate ECMWF – climatology to time/ position of altimeter measurement.
- Add S1/S2 air-tide corrections to interpolated pressure data.
- Compute dry troposphere correction.

- Inconsistent treatment of dry troposphere correction in Topex and Jason/OSTM GDRs.
- Potentially manifesting as error in Topex-derived S1 and S2 ocean tide models.

Center of Gravity Correction

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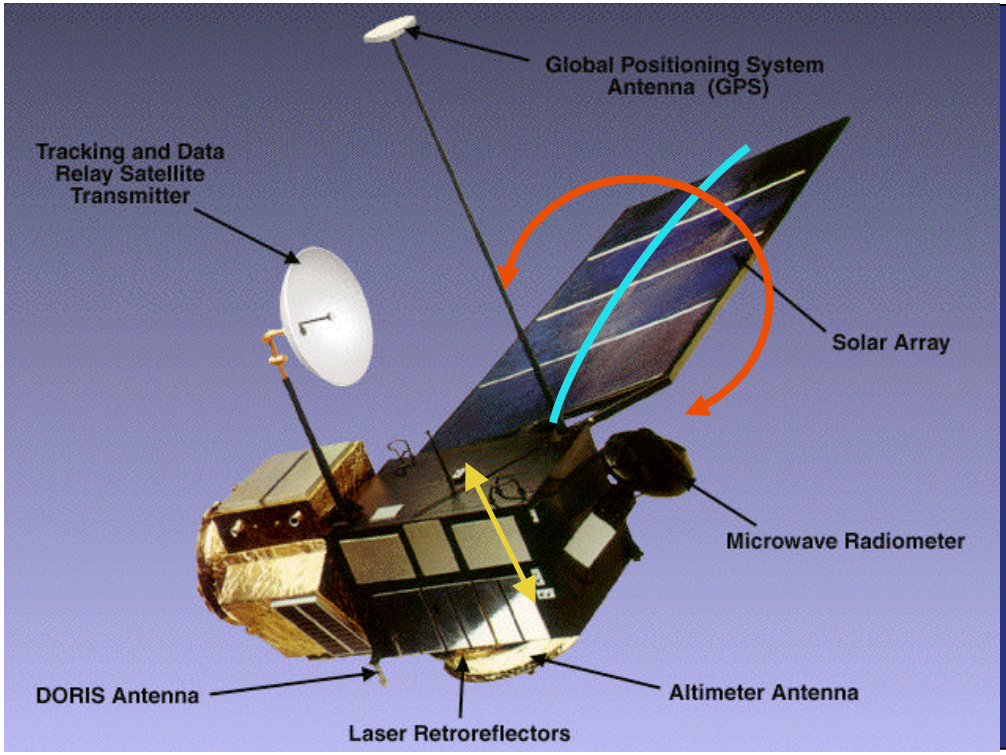
Topex/Poseidon Satellite



Cause of CG Variation

- Solar panel warps
- Rotates to track sun
- Causes COG shift

- Topex MGDRs have CG correction to account for this effect.
- This correction was not applied when generating GOT00.2 (maybe FES04?) ocean tide models.
- Omission error may be manifesting as error in Topex-derived ocean tide models, as with S1/S2 atmospheric tide effects on dry troposphere.

Our 60-Day Analysis Activities

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- **Focus attention on GOT00.2 ocean tide model**:
  - Empirical model – any errors should map linearly
  - Look explicitly at impact of both CG range correction and atmospheric tides.
- **Our Approach**: Develop corrections for errors in S1 and S2 ocean tide models.
  - Force consistent treatment of S1/S2 atmospheric tidal effects on dry troposphere correction for Jason-1/OSTM.
  - Account for omission of CG range correction in creating ocean tide model

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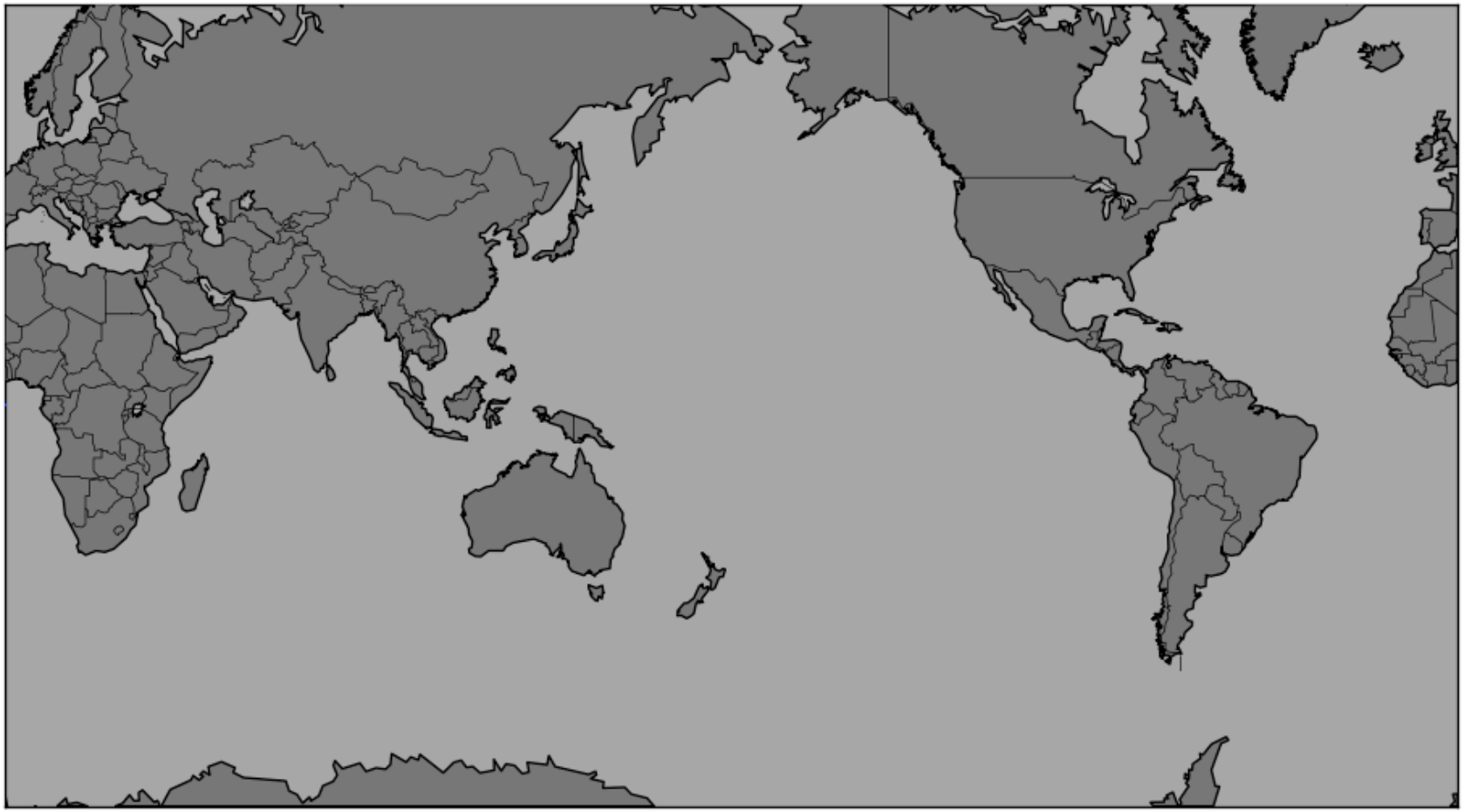
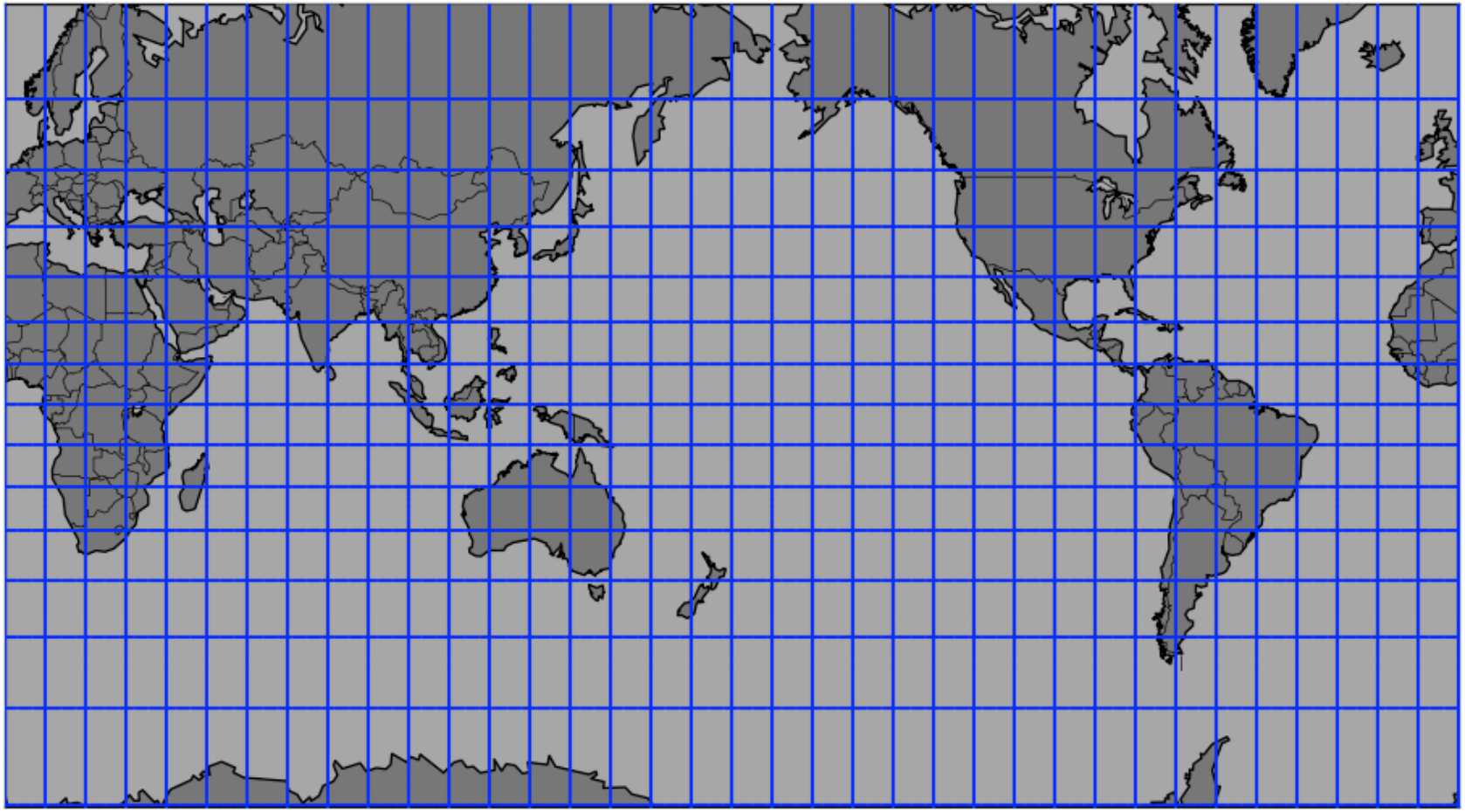
Creating Corrections to Ocean Tide Models



Goal: correction to global ocean tide model

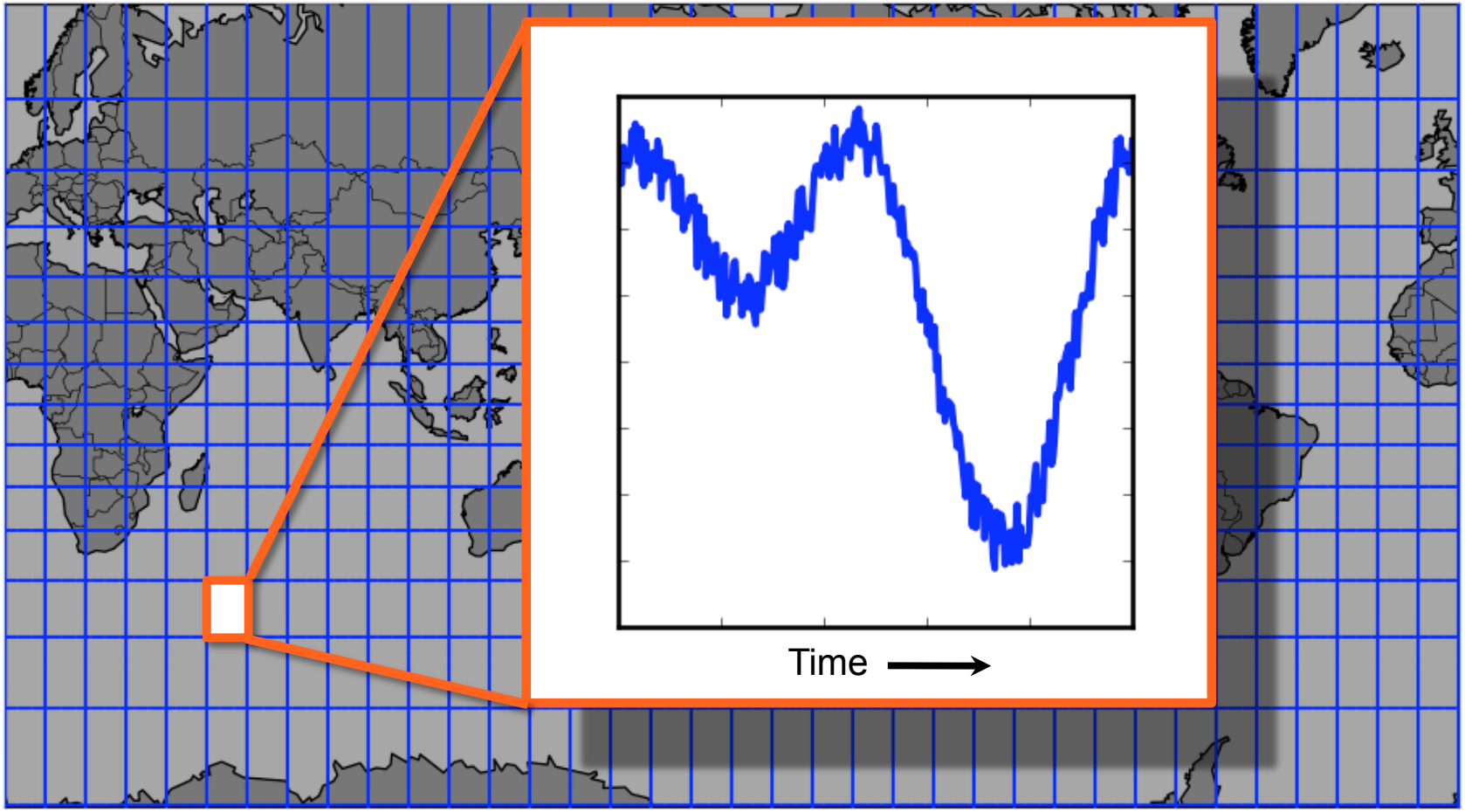
Creating Corrections to Ocean Tide Models



Goal: correction to global ocean tide model

- Partition ocean into 3° × 3° bins

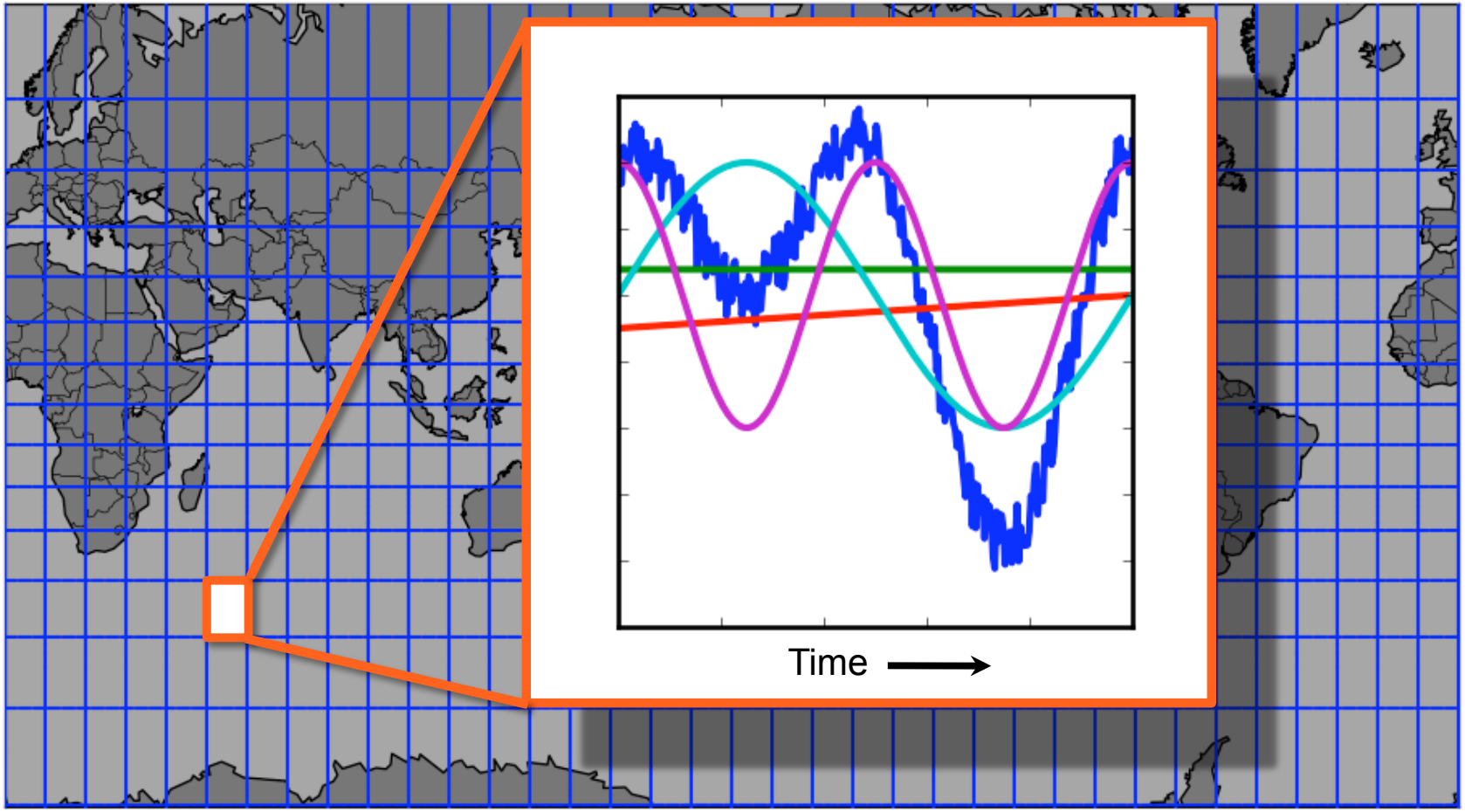
Creating Corrections to Ocean Tide Models



Goal: correction to global ocean tide model

- Partition ocean into 3° × 3° bins
- Make time-series of data in each grid

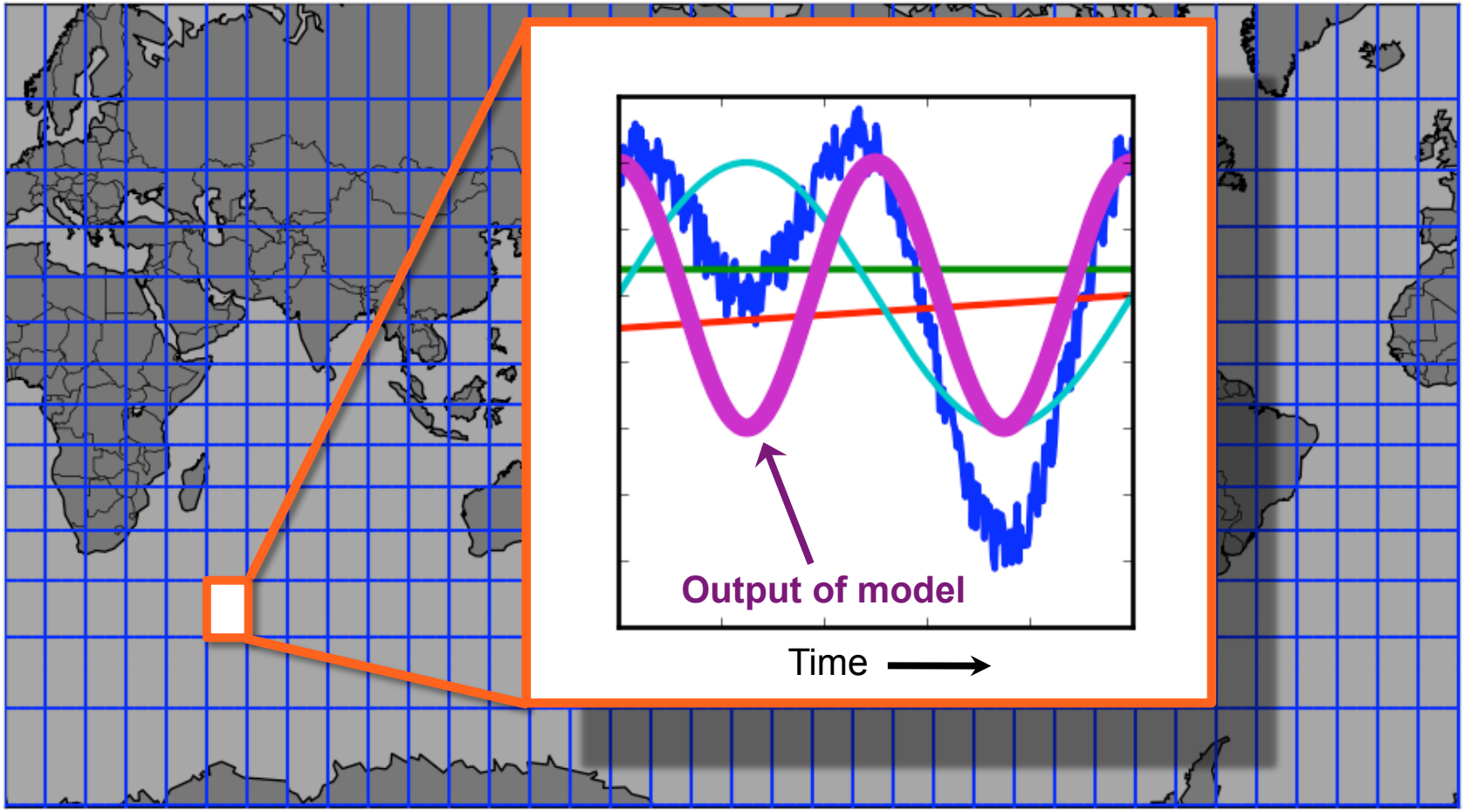
Creating Corrections to Ocean Tide Models



Goal: correction to global ocean tide model

- Partition ocean into 3° × 3° bins
- Make time-series of data in each grid
- Regress against: **bias**, **drift**, **S1**, **S2**

Creating Corrections to Ocean Tide Models



Goal: correction to global ocean tide model

- Partition ocean into 3° × 3° bins
- Make time-series of data in each grid
- Regress against: **bias**, **drift**, **S1**, **S2**
- Use S2 correction only.

Amplitudes of S2 Dry Troposphere Correction

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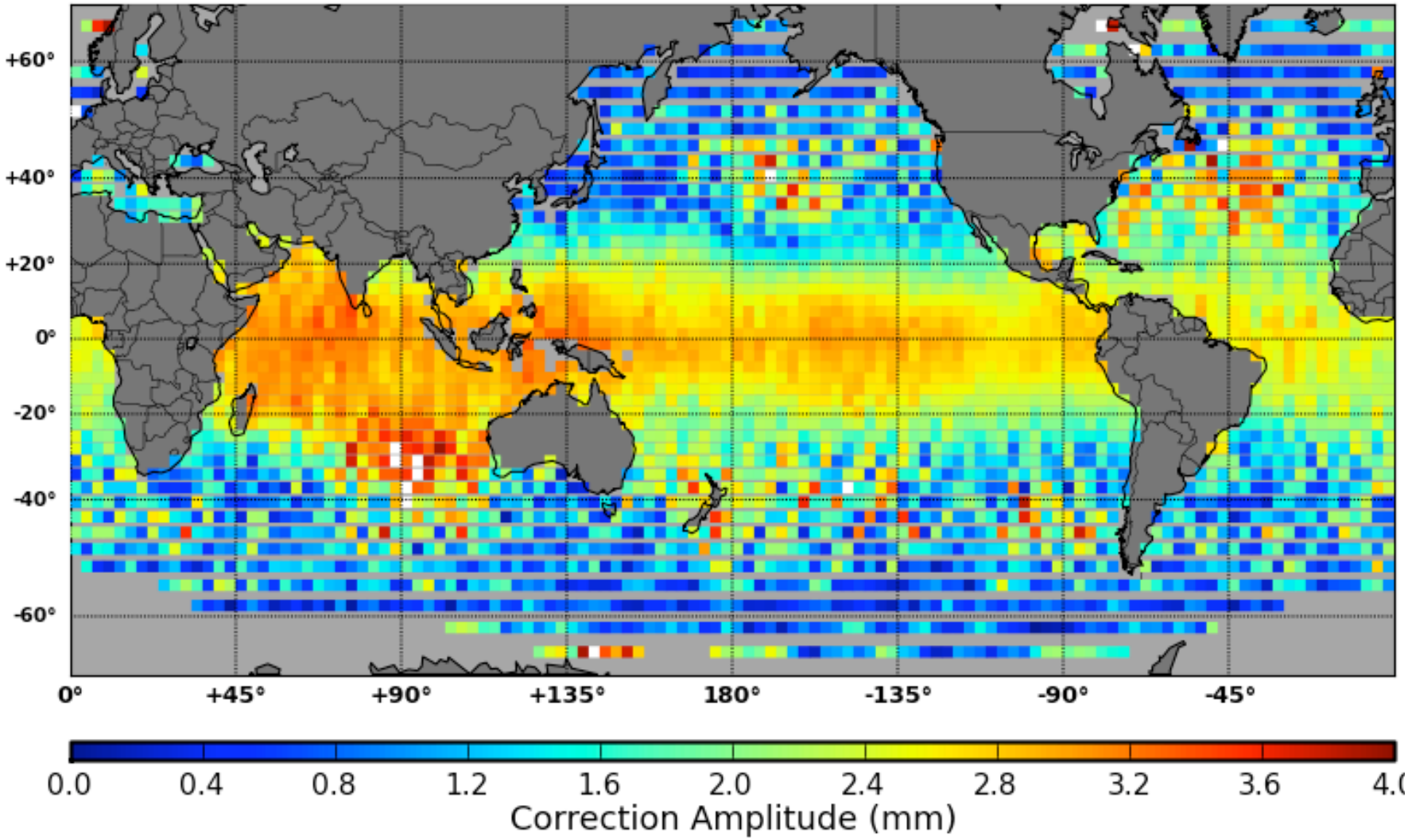
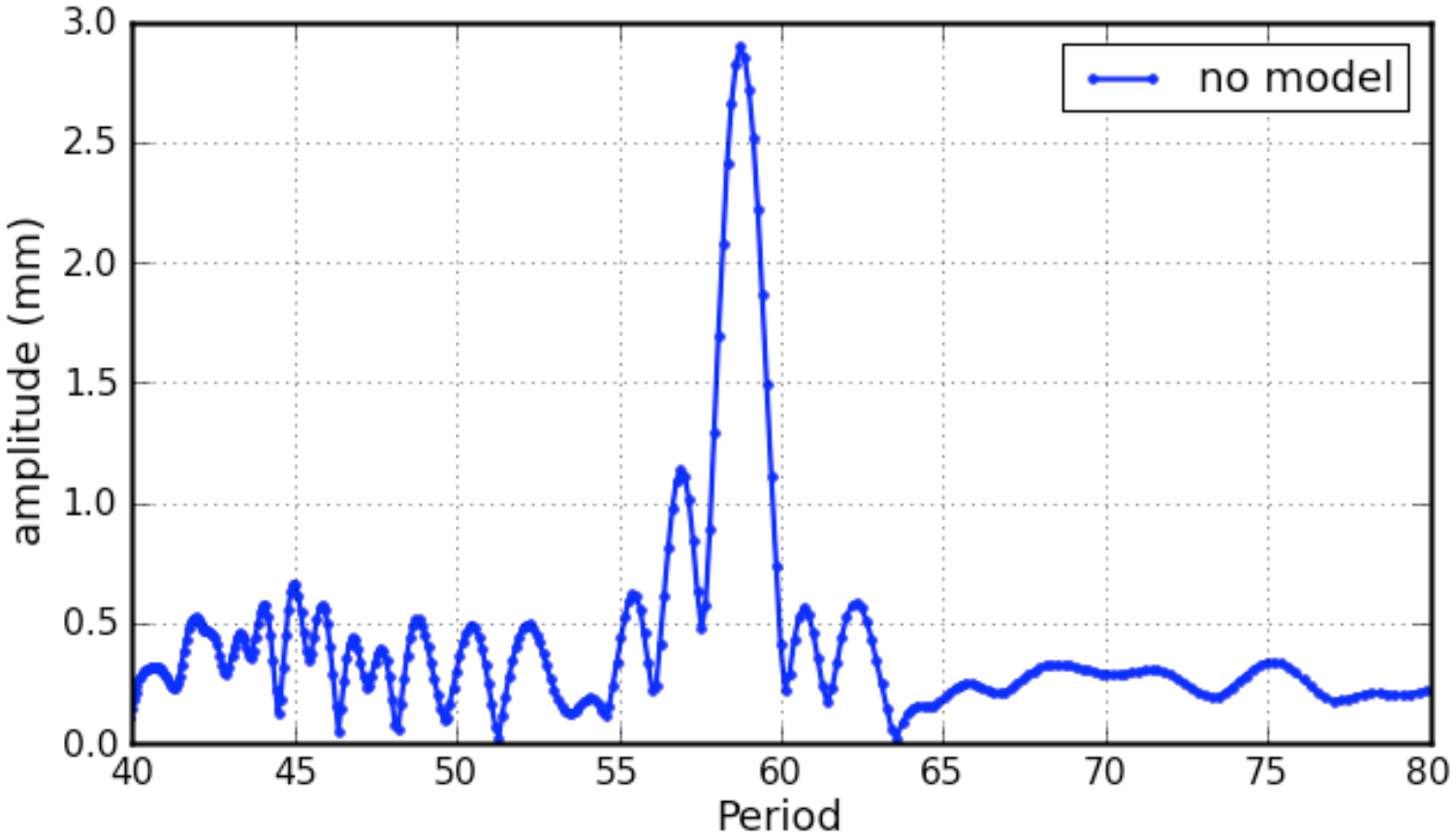
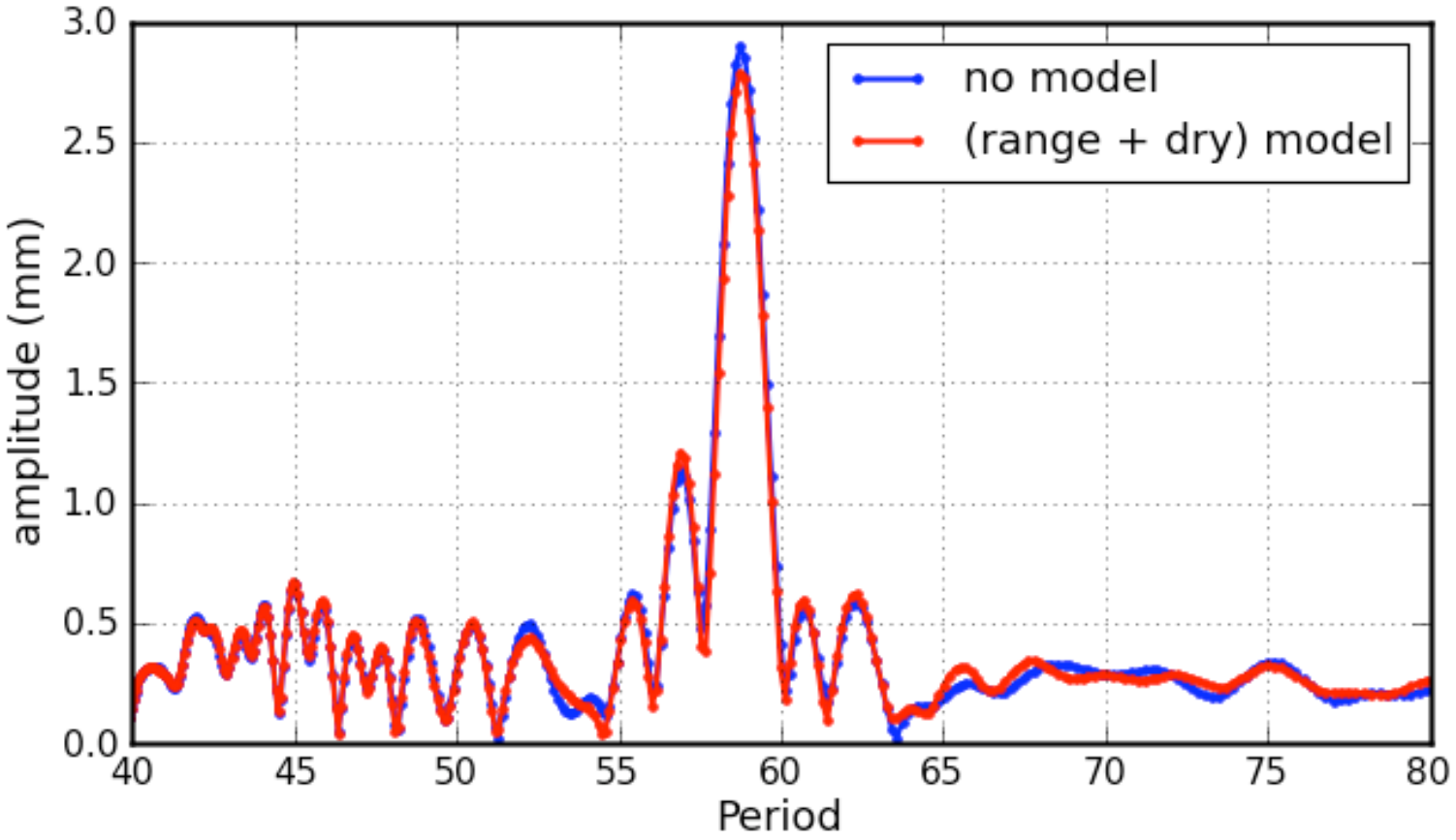


Impact of Dry Troposphere Correction



- Jason-1 sea-level-anomaly spectrum directly from GDR-C data.

Impact of Dry Troposphere Correction



- Jason-1 sea-level-anomaly spectrum directly from GDR-C data.
- Applying dry trop. correction derived from Jason-1 dry_tropo_corr data

- Applying dry tropo correction results in relatively small 60-day peak reduction

Amplitudes of S2 Component of Topex CG Error in Ocean Tide Models

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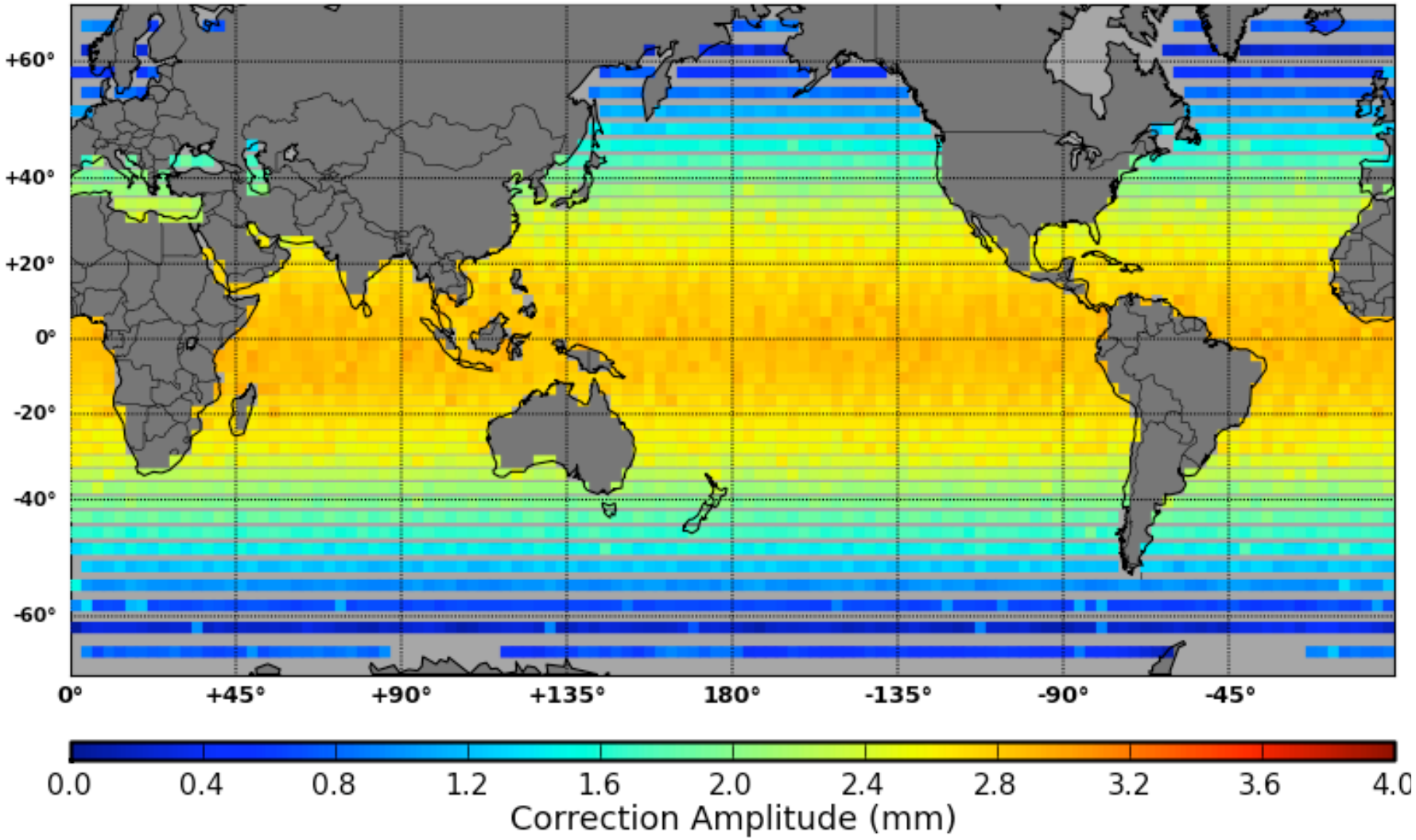
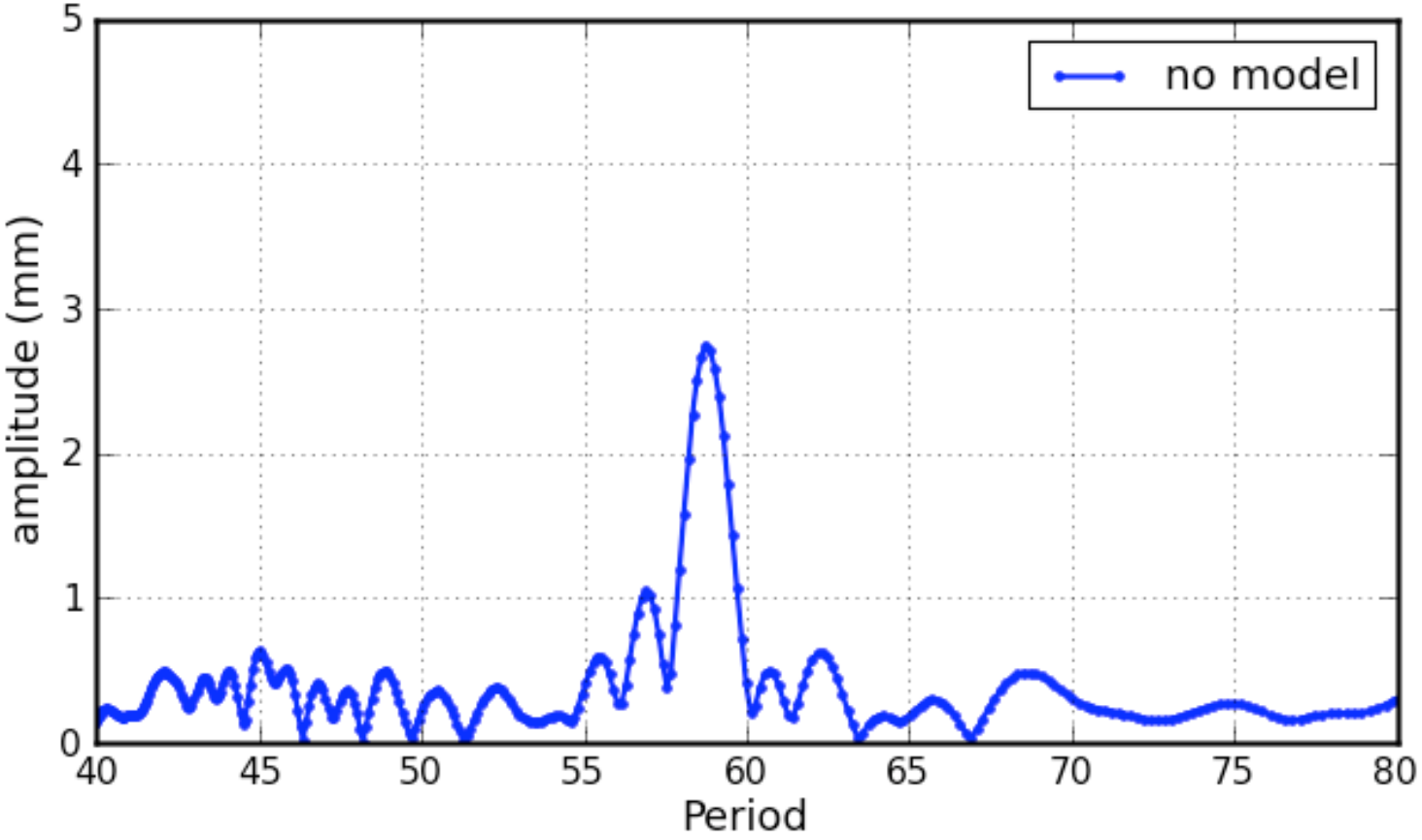


Impact of Topex CG Correction to Ocean Tide Model



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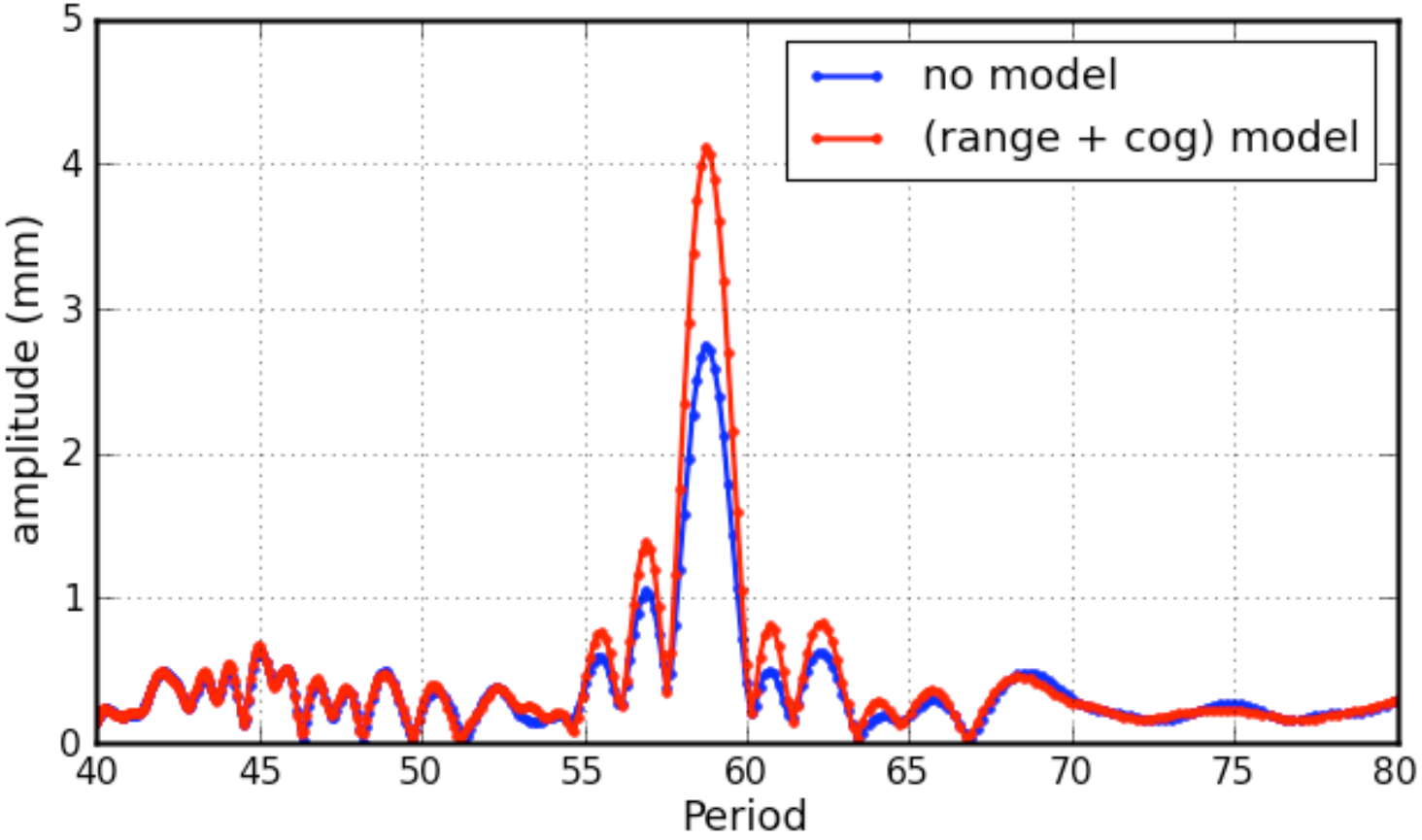
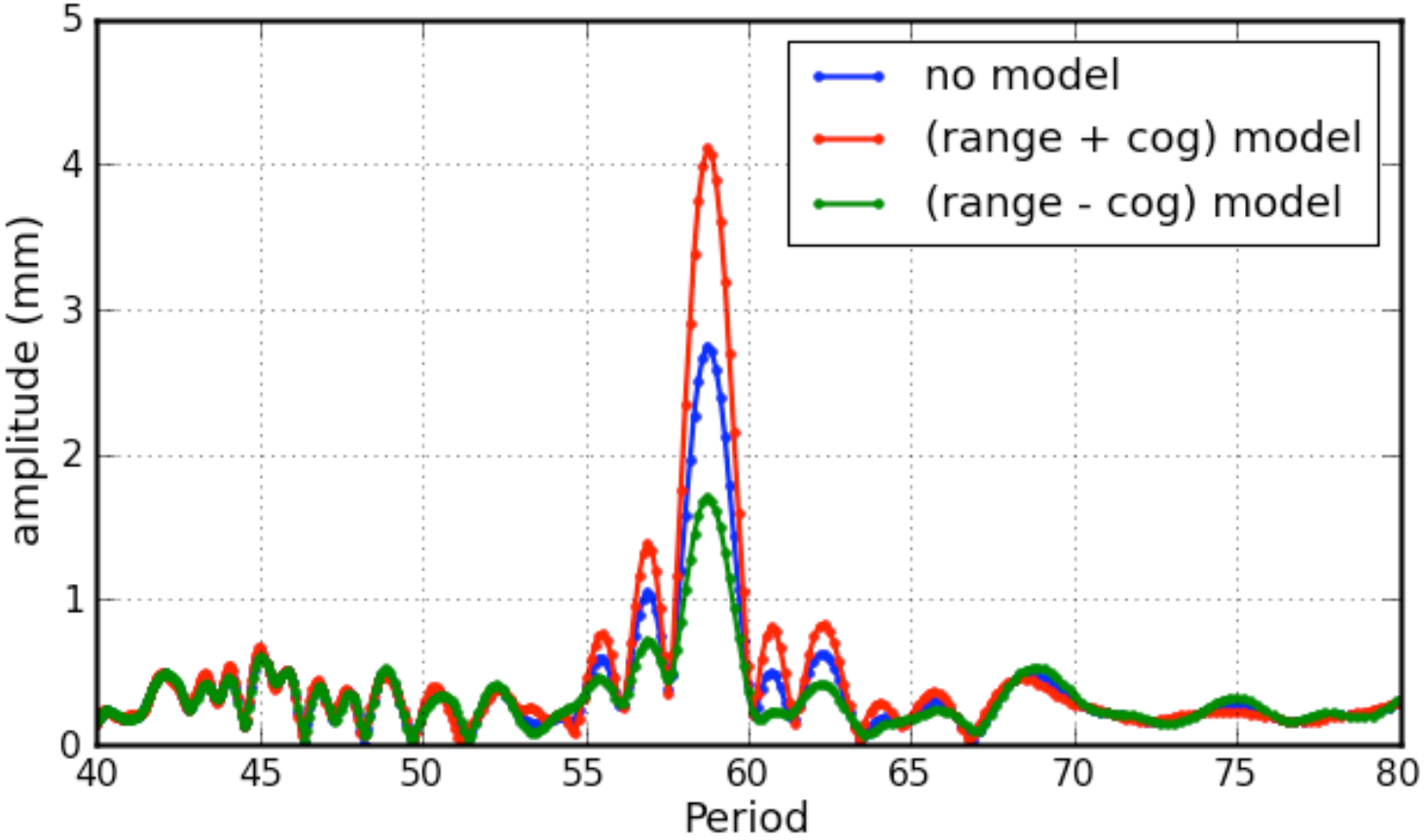
Impact of Topex CG Correction to Ocean Tide Model



- Jason-1 sea-level-anomaly spectrum directly from GDR-C data.
- Applying CG correction based on Topex (+ cg_corr) data

Impact of Topex CG Correction to Ocean Tide Model



- Jason-1 sea-level-anomaly spectrum directly from GDR-C data.
- Applying auxiliary tide model based on Topex (+ cg_corr) data
- Applying auxiliary tide model based on Topex (- cg_corr) data

- Applying CG model with “wrong” sign reduces 60-day SLA peak

Try Combination of Ocean Tide Model Corrections

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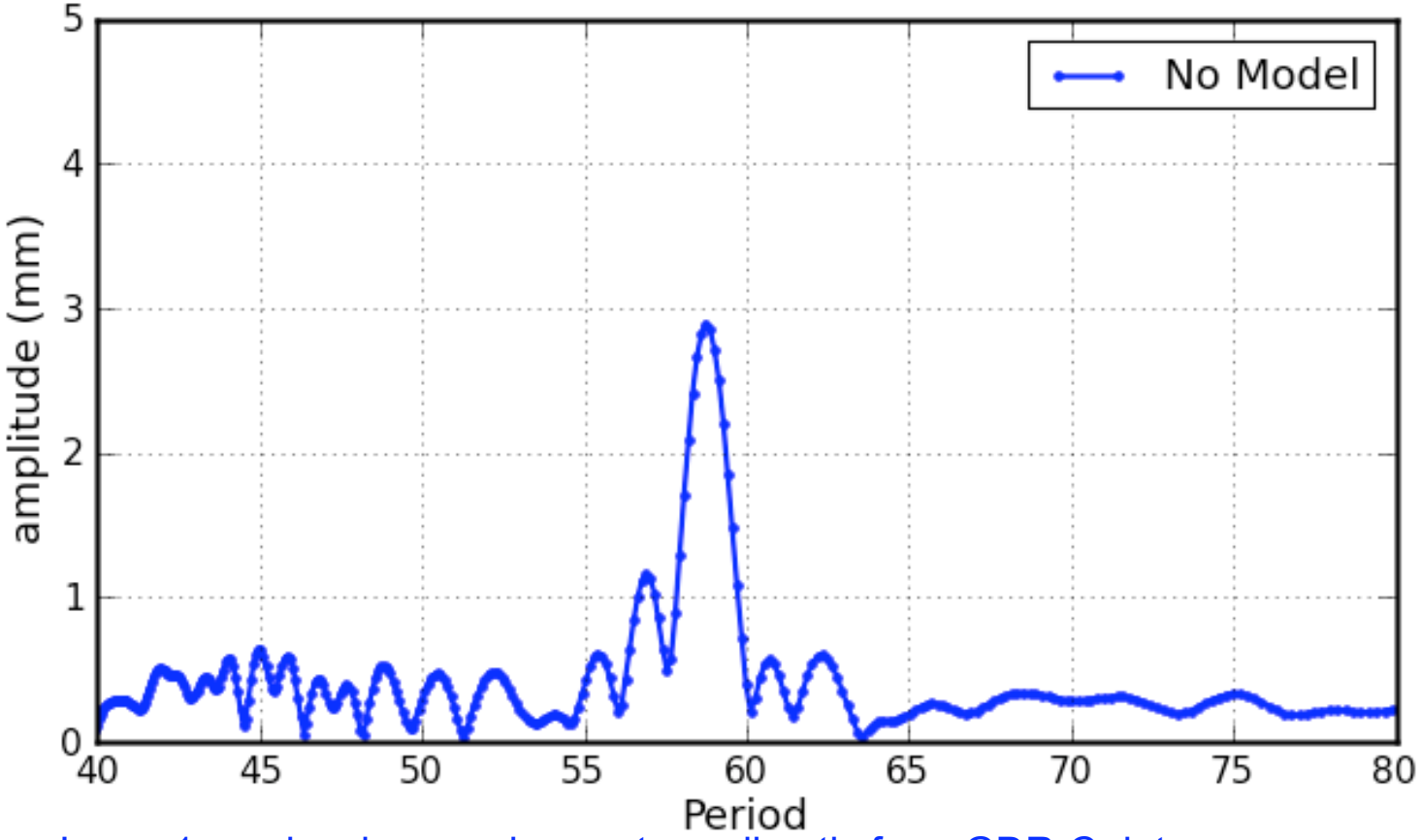
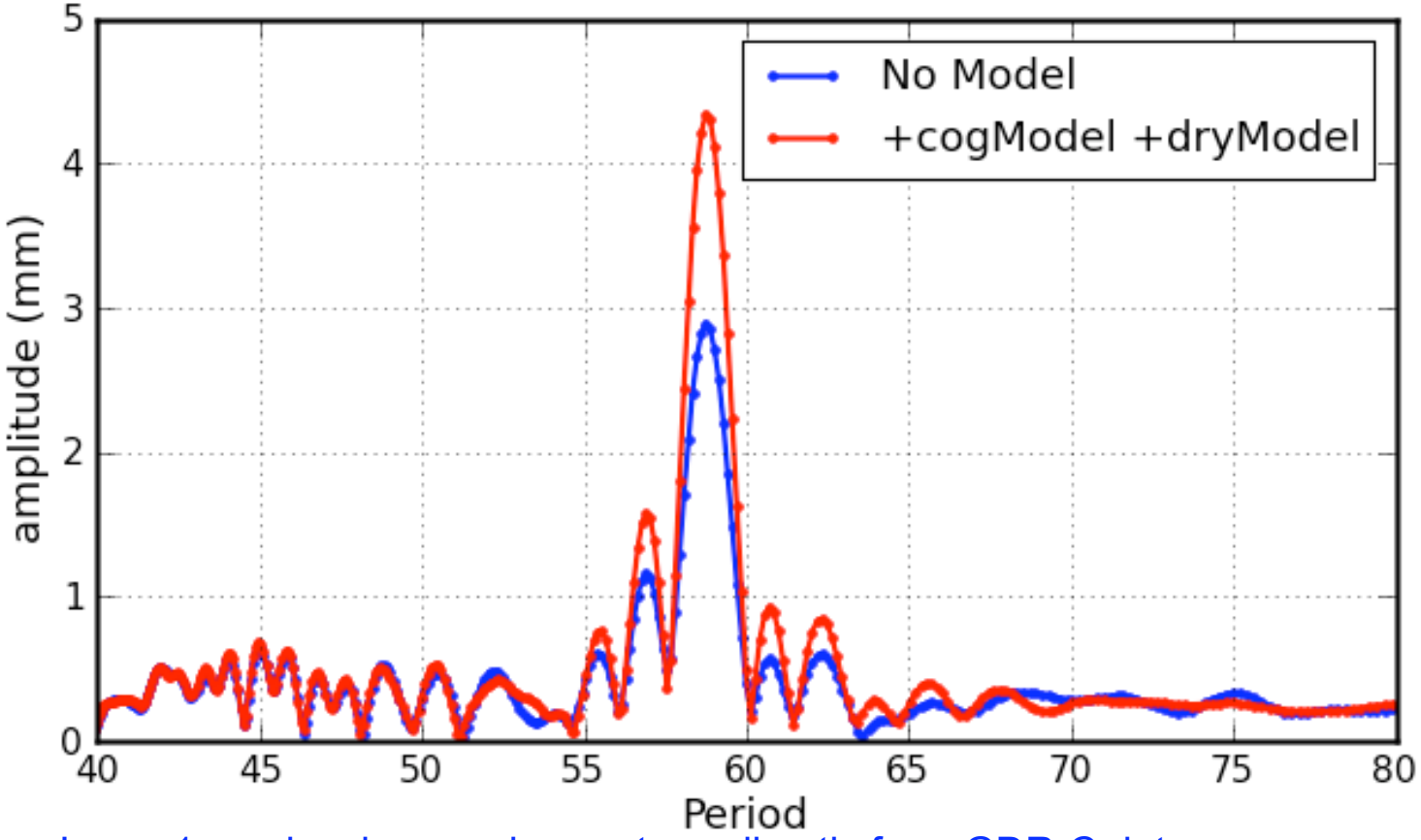
- Try both corrections to ocean tide model in combination

Application of Dry and CG Ocean Tide Model Corrections To Jason-1



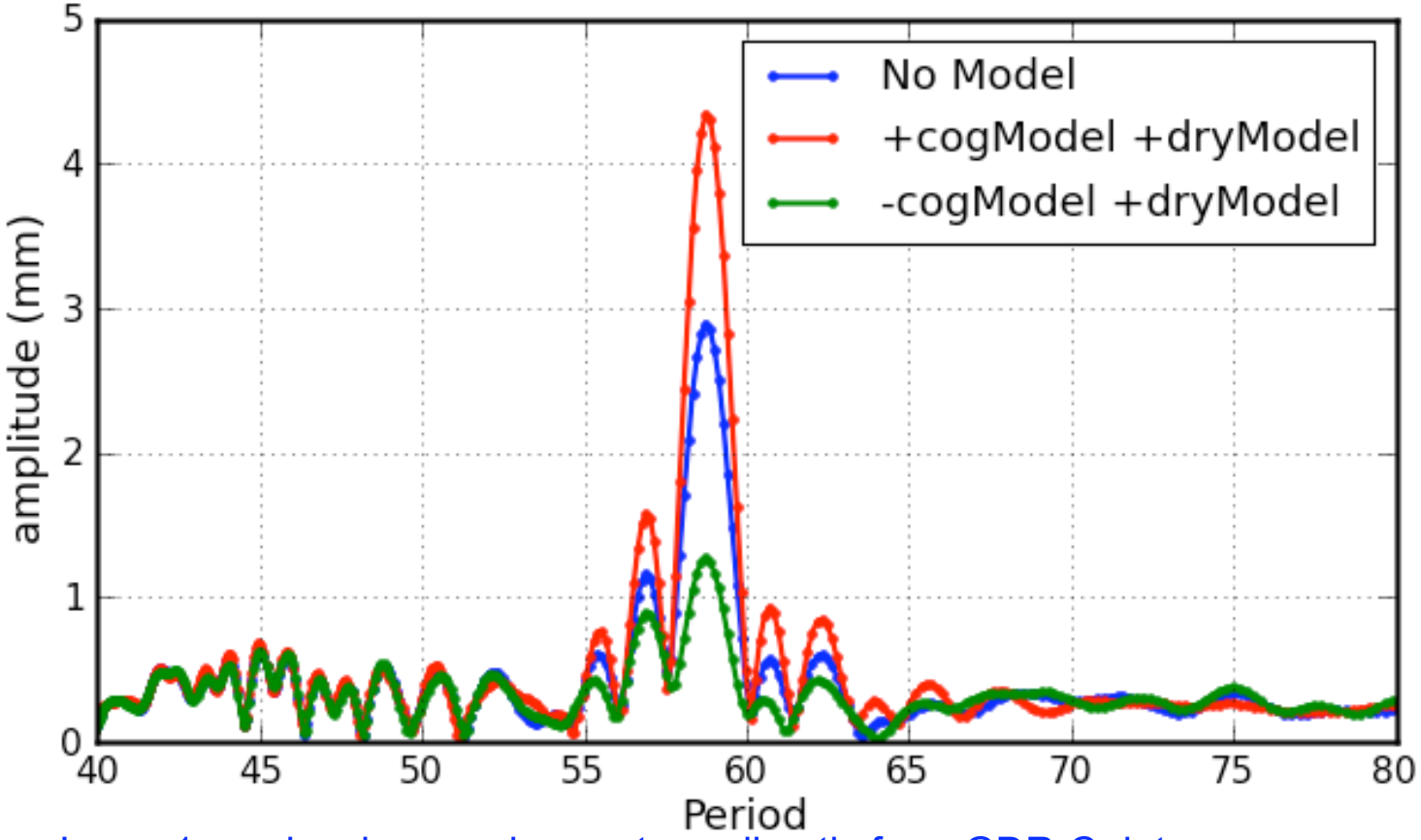
- Jason-1 sea-level-anomaly spectrum directly from GDR-C data.

Application of Dry and CG Ocean Tide Model Corrections To Jason-1



- Jason-1 sea-level-anomaly spectrum directly from GDR-C data.
- Aux tide models: + cg_corr and + dry_trop_corr

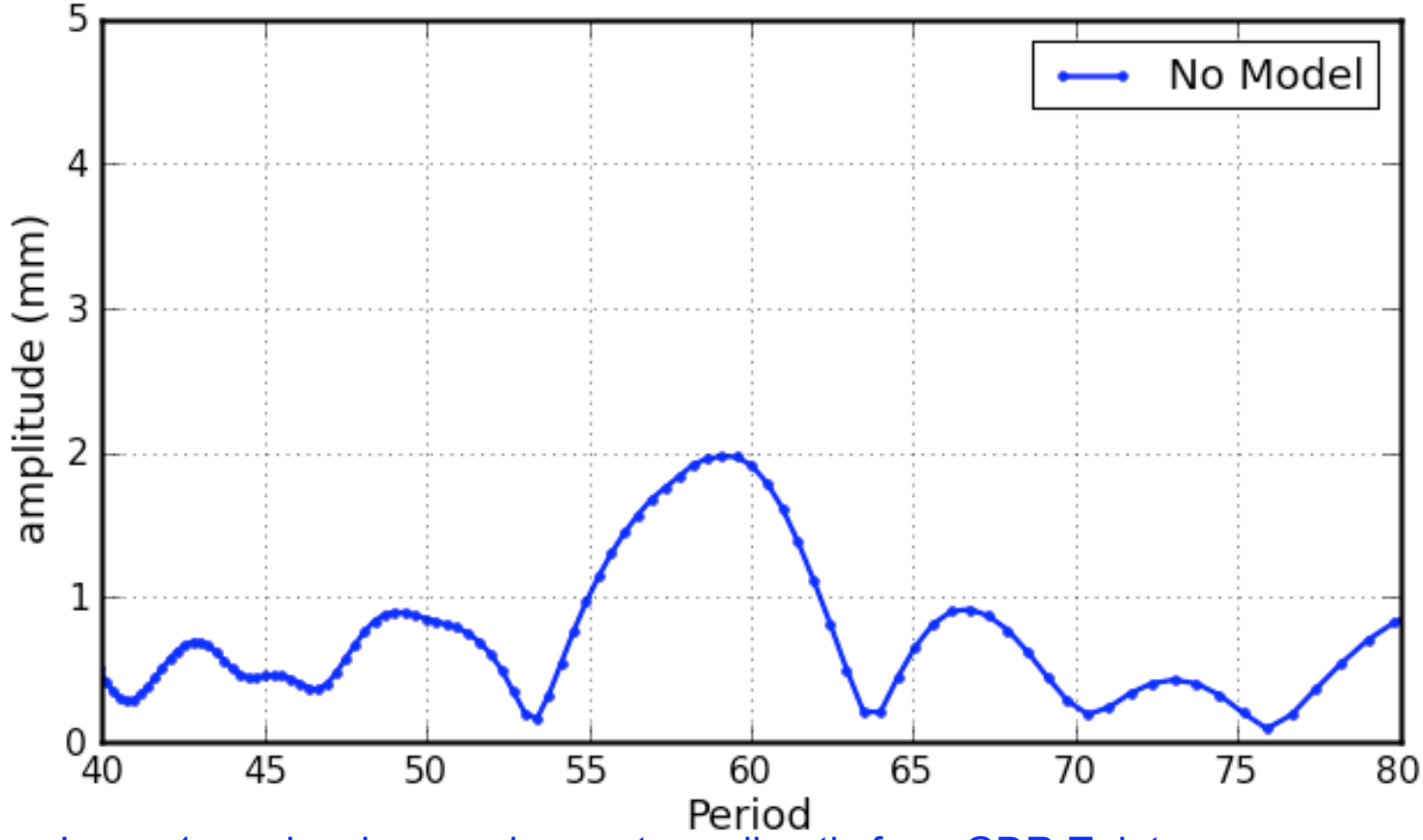
Application of Dry and COG Ocean Tide Model Corrections To Jason-1



- Jason-1 sea-level-anomaly spectrum directly from GDR-C data.
- Aux tide models: + cg_corr and + dry_trop_corr
- Aux tide models: - cg_corr and + dry_trop_corr

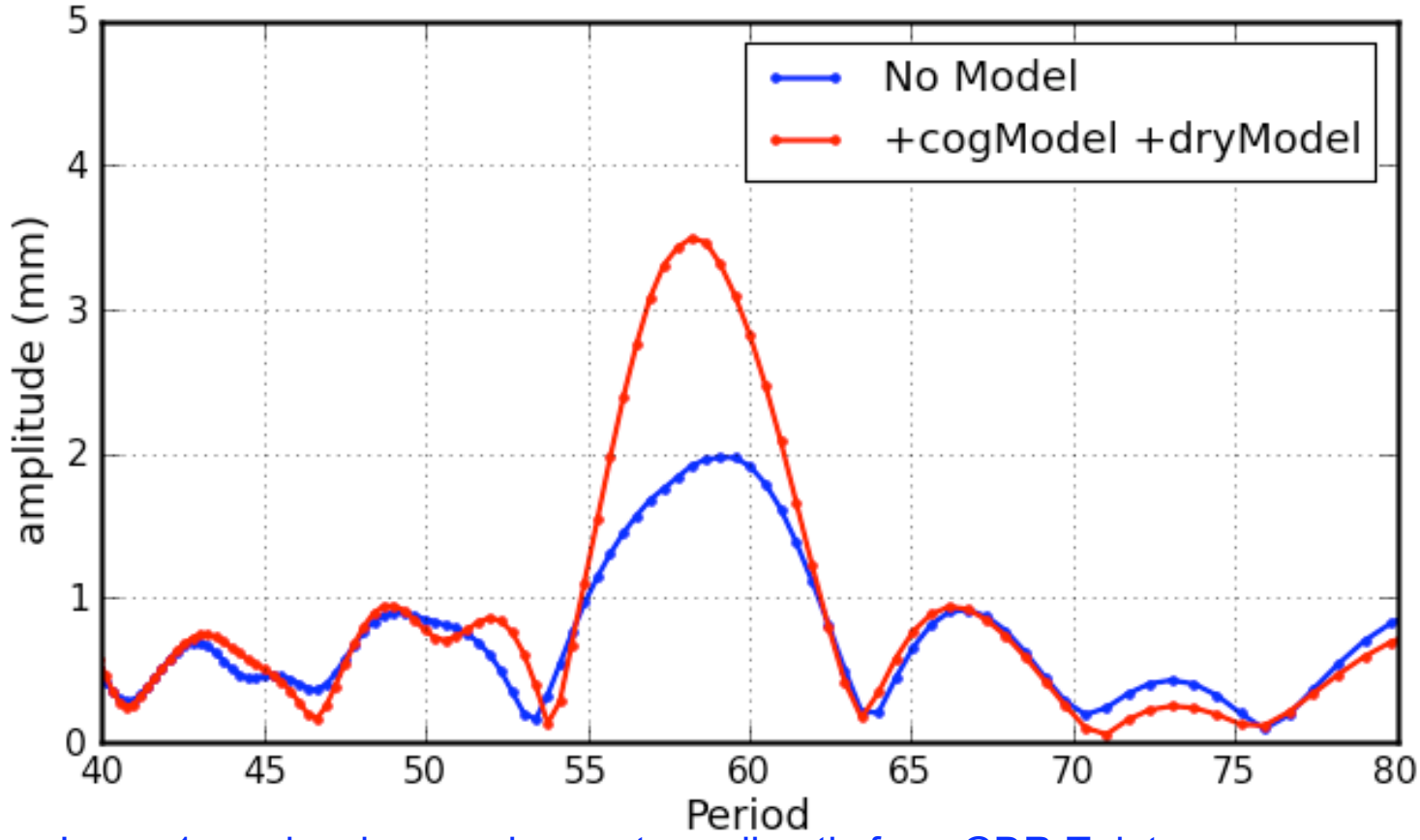
- Applying CG model with “wrong” sign almost eliminates 60-day peak

Application of Dry and CG Ocean Tide Model Corrections To Jason-2



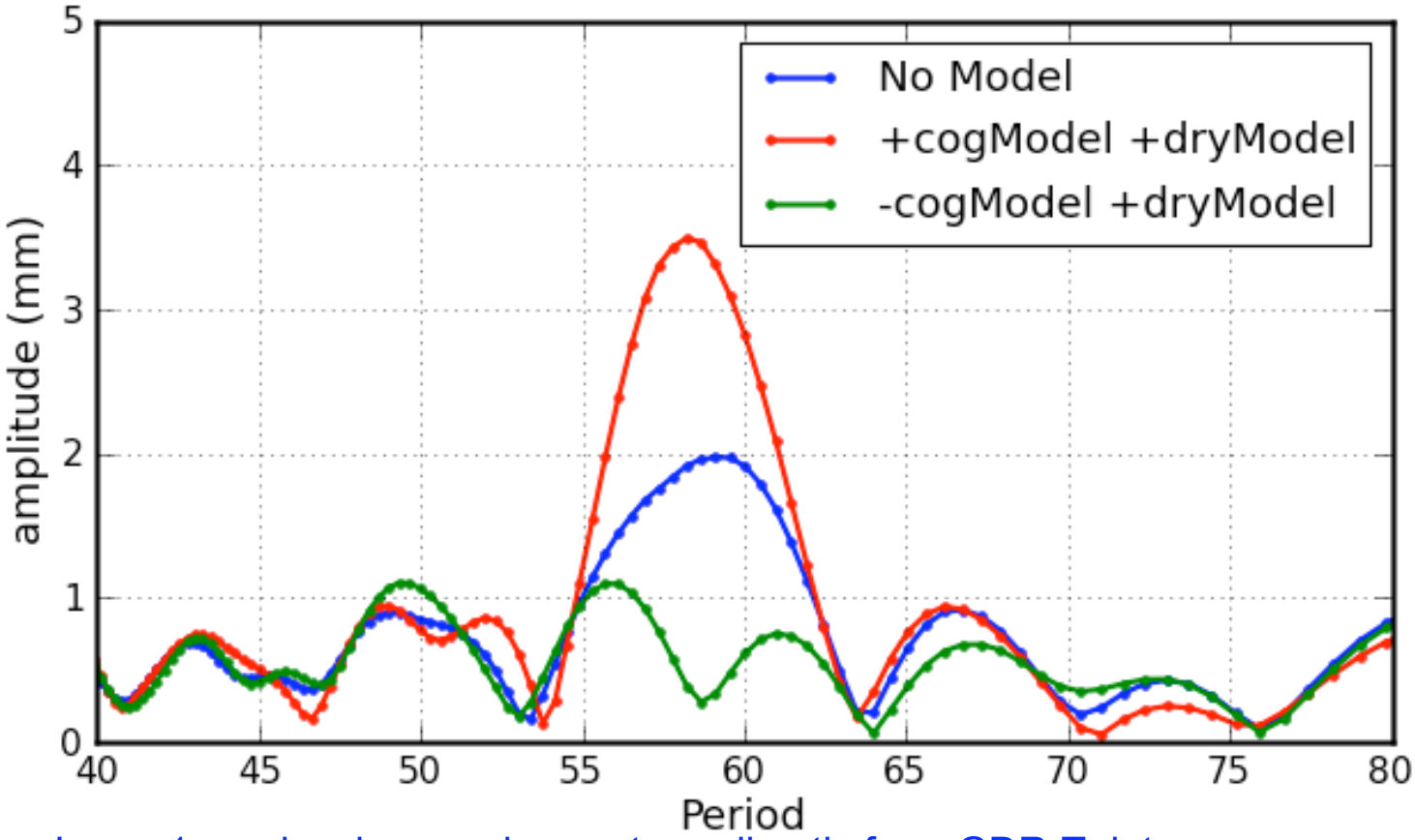
- Jason-1 sea-level-anomaly spectrum directly from GDR-T data.

Application of Dry and CG Ocean Tide Model Corrections To Jason-2



- Jason-1 sea-level-anomaly spectrum directly from GDR-T data.
- Aux tide models: + cg_corr and +dry_trop_corr

Application of Dry and CG Ocean Tide Model Corrections To Jason-2



- Jason-1 sea-level-anomaly spectrum directly from GDR-T data.
- Aux tide models: + cg_corr and +dry_trop_corr
- Aux tide models: -cg_corr and + dry_trop_corr

- Combined CG and DRY suppress 60-day peak below the noise

Harvest SSH Bias

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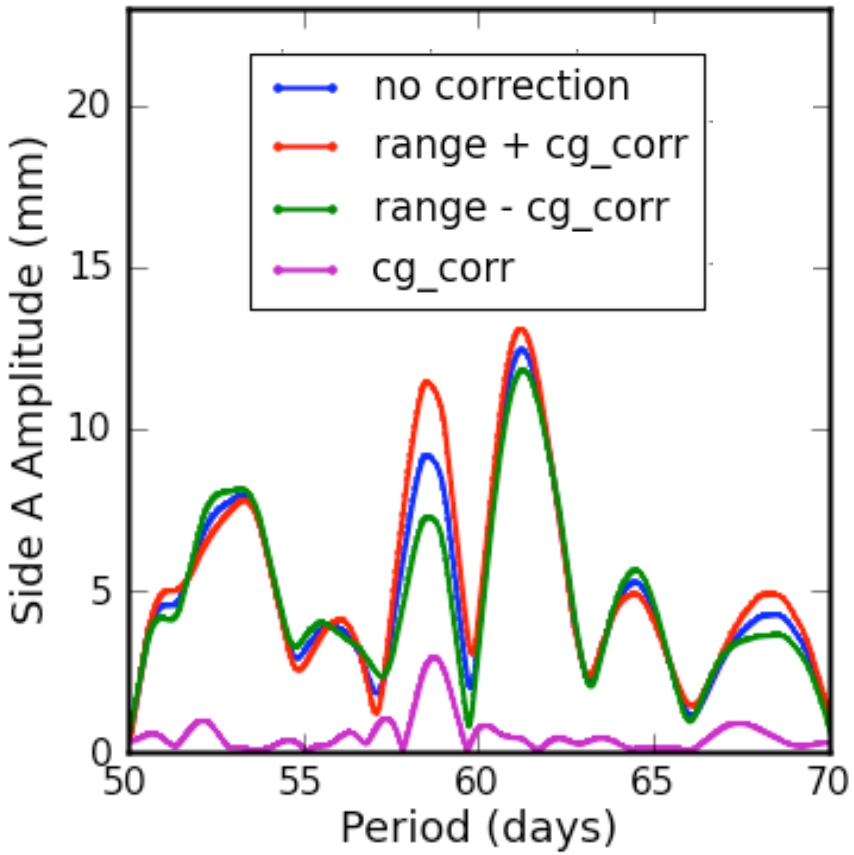
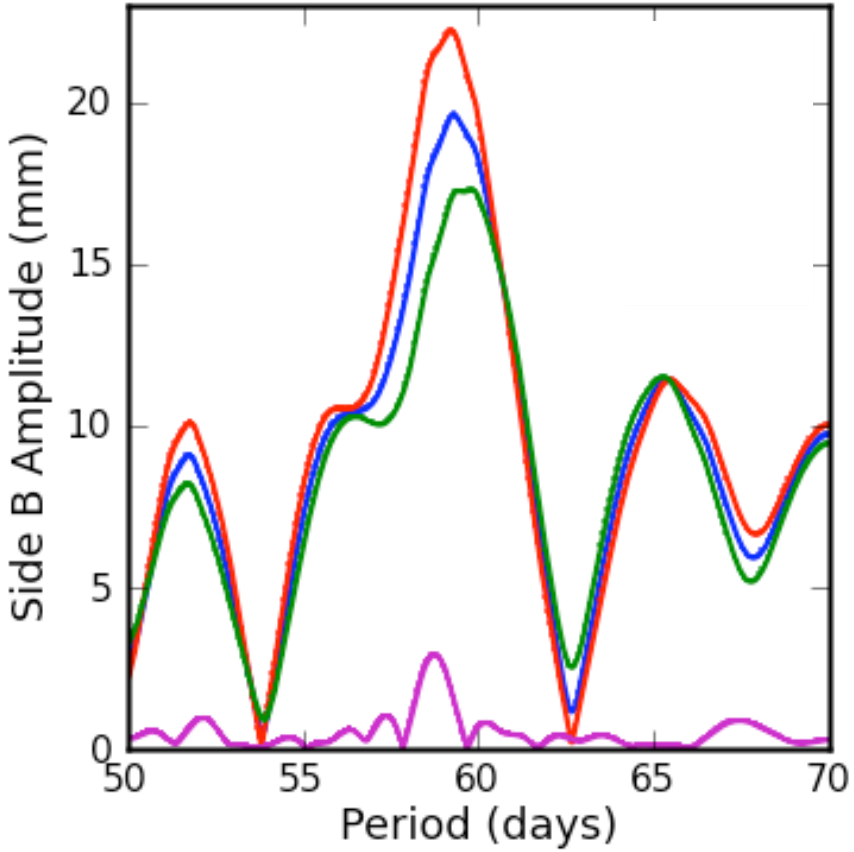
Side A



Side B



- Harvest SSH bias: (SSH_{Topex} – $SSH_{TideGauge}$)
- "Wrong" sign also makes Harvest 60-day peak smaller

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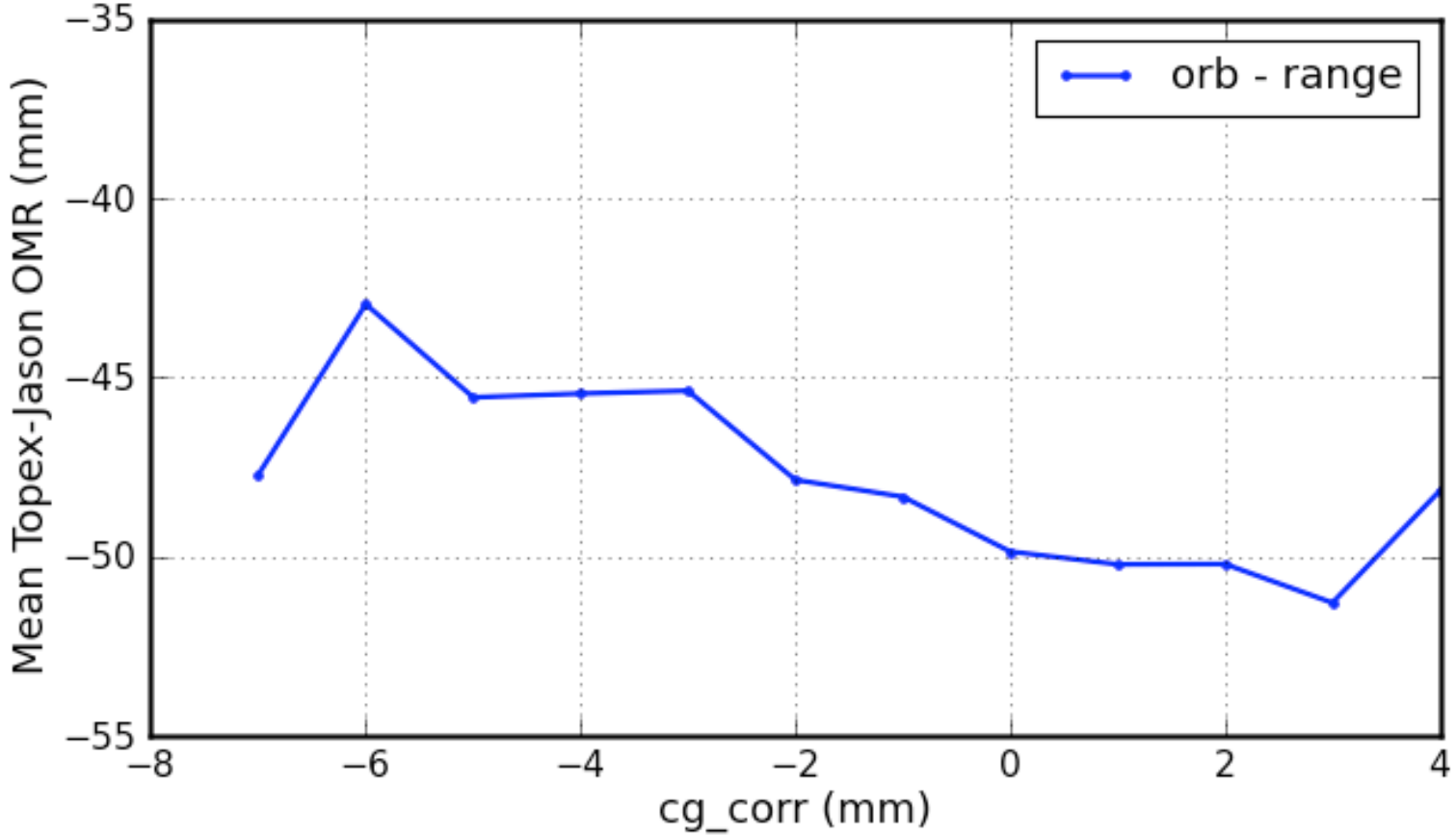
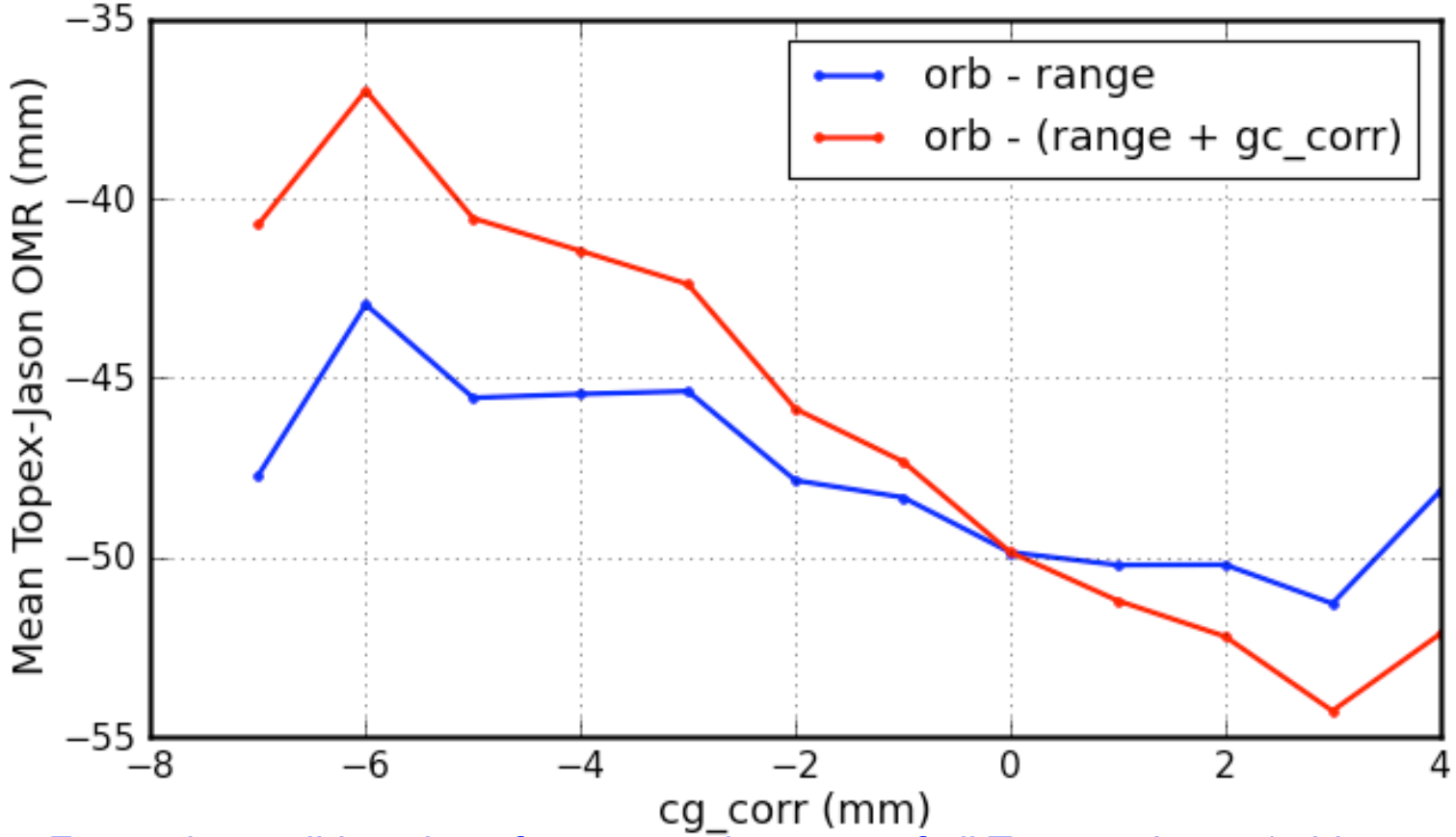
Topex – Jason-1
Orbit - Range - MSS



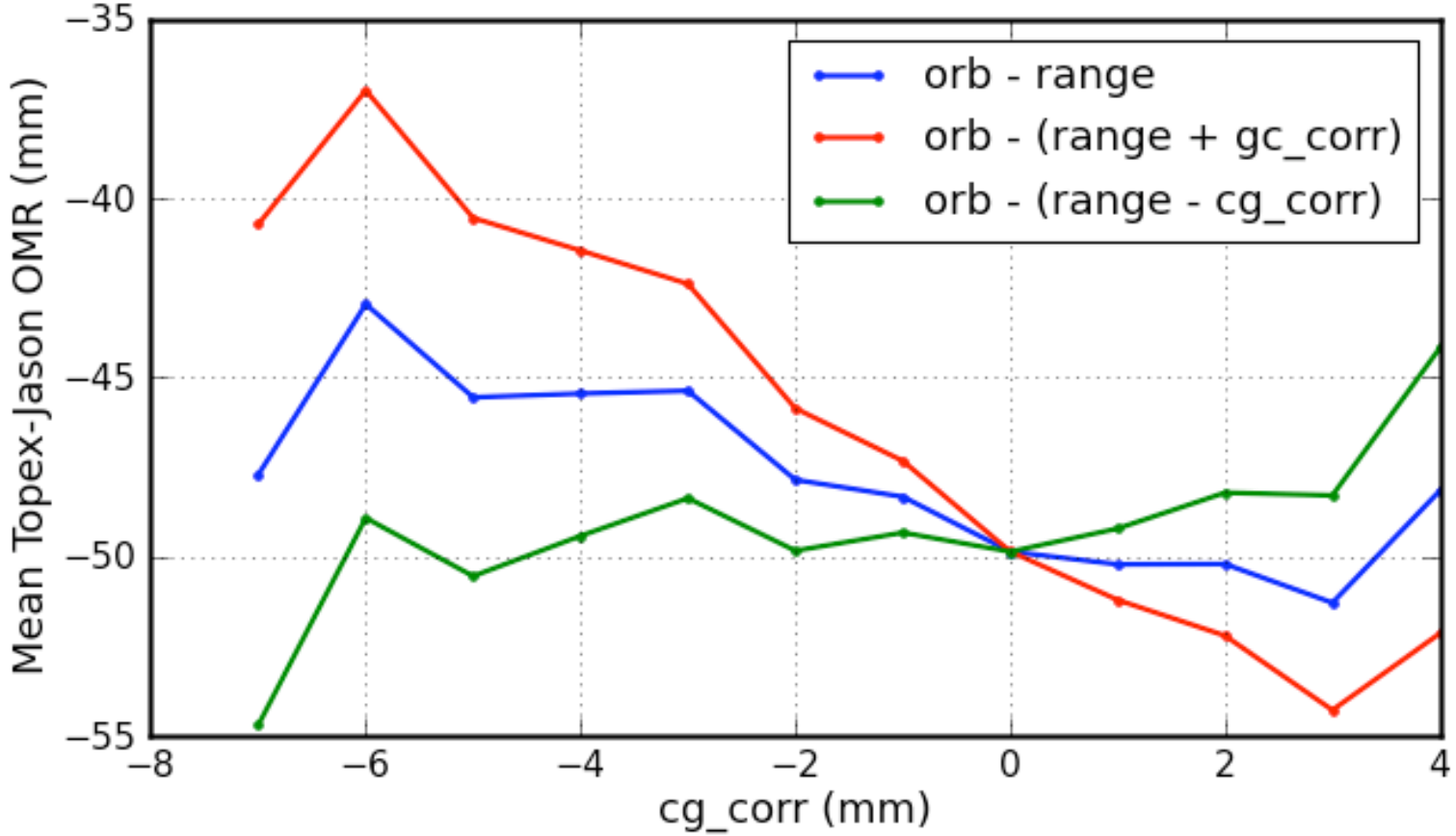
- For each possible value of cg_corr, take mean of all Topex – Jason (orbit-range-mss)

Topex/Jason Differences of Orbit - Range - MSS



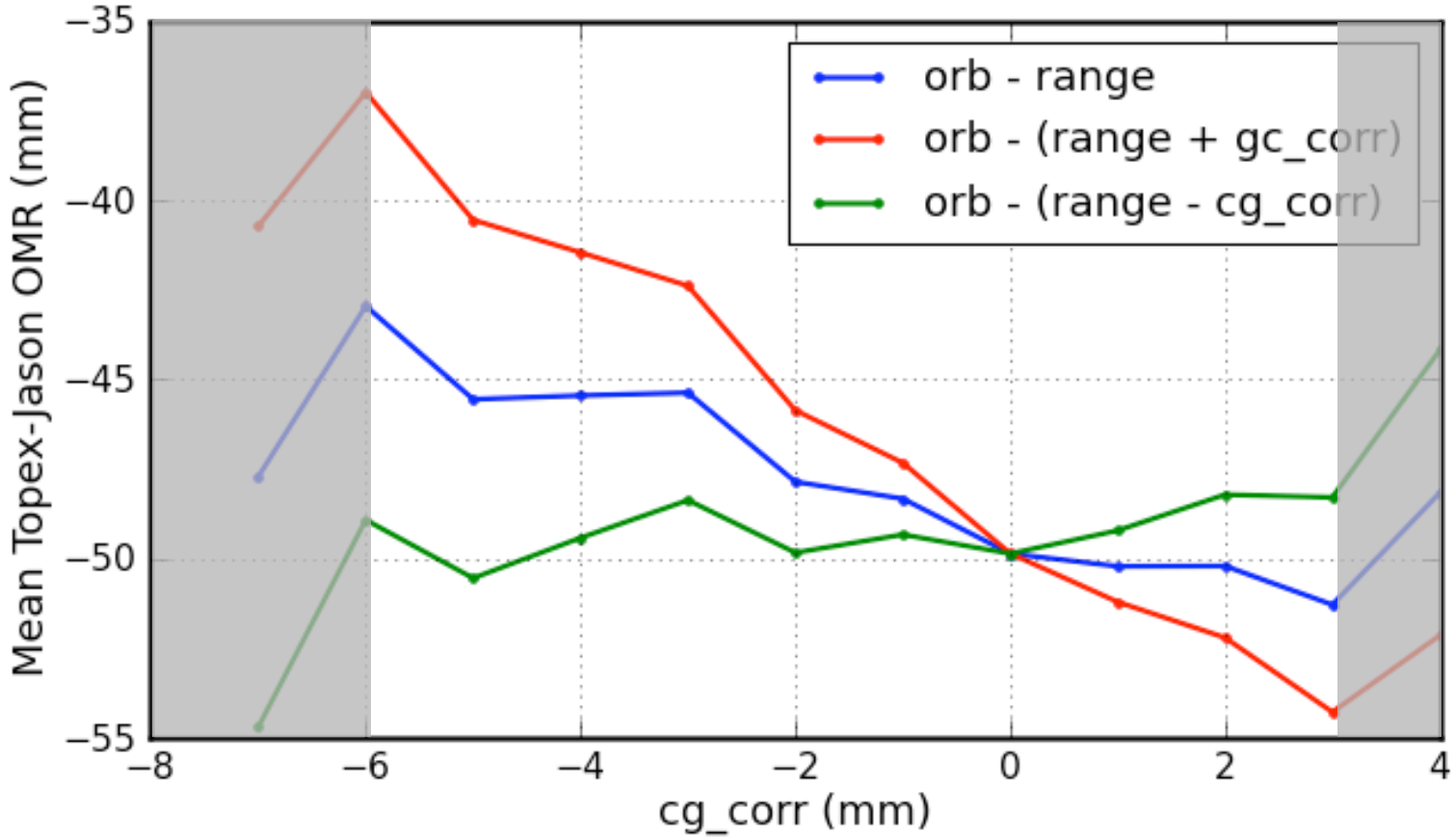
- For each possible value of cg_corr, take mean of all Topex – Jason (orbit-range-mss)
- Same calculation with Topex range + cg_corr

Topex – Jason Orbit Minus Range Minus MSS



- For each possible value of cg_corr, take mean of all Topex – Jason (orbit-range-mss)
- Same calculation with Topex range + cg_corr
- Same calculation with Topex range – cg_corr

Topex – Jason Orbit Minus Range Minus MSS



- For each possible value of cg_corr, take mean of all Topex – Jason (orbit-range-mss)
- Same calculation with Topex range + cg_corr
- Same calculation with Topex range – cg_corr

- "wrong" sign also improves this result.

Summary and Conclusions

- AMR calibration/validation observations
  - Increasing brightness temperature variance observed.
  - Variance of (model – AMR) wet delay increasing due to ECMWF
  - 34.0 GHz brightness temperature hardware anomaly causing anomalous spike in distribution.
    - Work-around to be applied for GDR-C reprocessing.
- 60-day SLA oscillation observed in OSTM and Jason-1
  - Investigated Topex CG correction
  - Investigated inconsistent application atmospheric tides
- Corrections to ocean tide model suppress 60-day oscillations
  - Best results obtained by applying dry trop., CG combined corrections.
- We see 60-day peak suppression when applying Topex CG correction with flipped sign. Possible explanations:
  - The sign of the Topex CG correction has a flipped sign
  - Some other unaccounted-for phenomena is phase locked with the CG correction and has the opposite sign.

The End

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Backup slides.

Sea Level Anomaly Components

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Measurement Driven Quantities

(Require data from on-board instruments)

- Altitude
- Ionosphere Correction
- Wet Troposphere Correction
- Sea State Bias
- Range Ku

Model Driven Quantities

(Require only time, lat, lon)

- Dry Troposphere Correction
- High Freq. Fluctuation Correction
- Ocean Tide
- Earth Tide
- Mean Sea Surface
- Inverse Barometer Correction

60-day observed
No 60-day observed
Too noisy to tell

Sea Level Anomaly Components

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Measurement Driven Quantities

(Require data from on-board instruments)

- Altitude
- Ionosphere Correction
- ~~Wet Troposphere Correction~~
- ~~Sea State Bias~~
- Range Ku

Model Driven Quantities

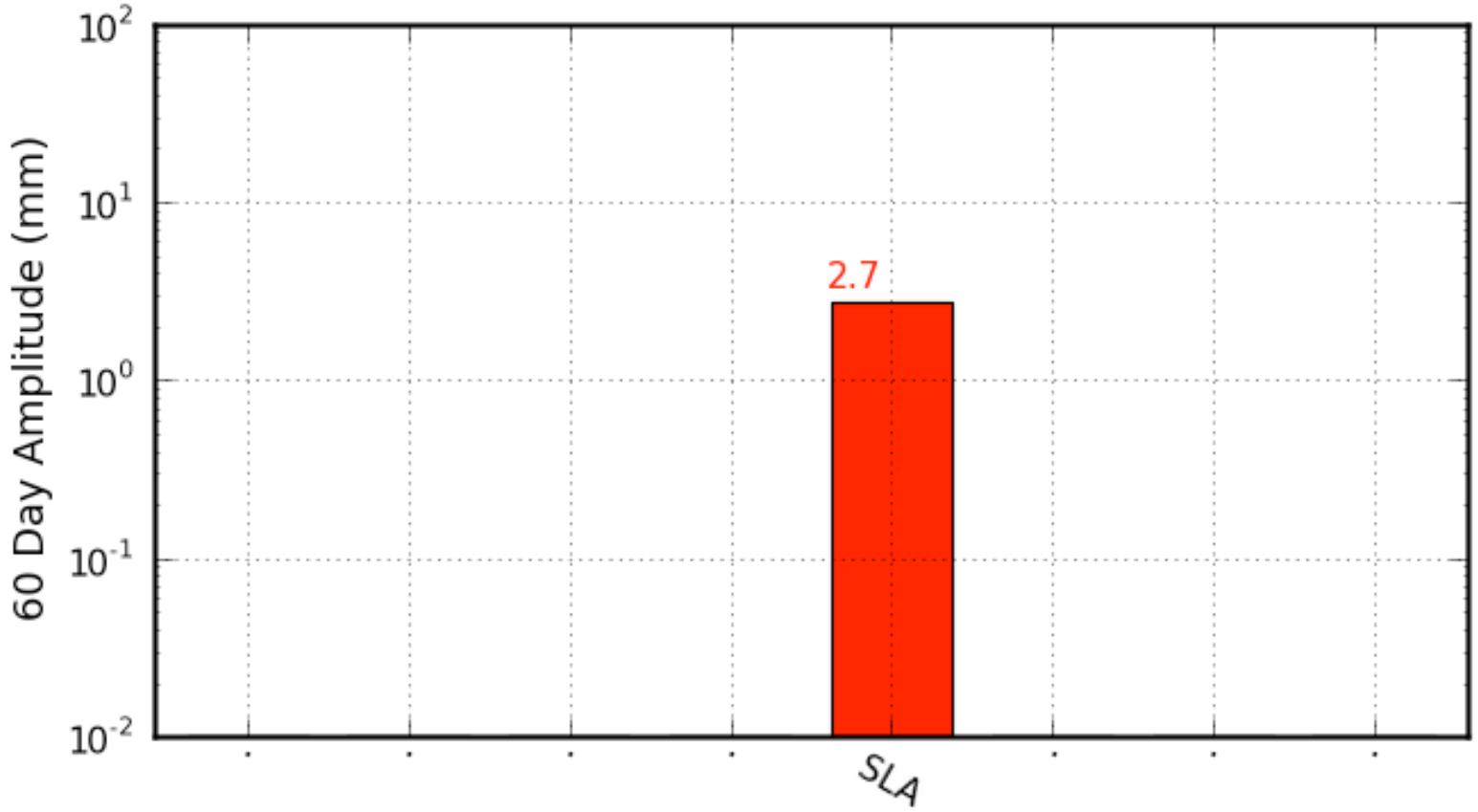
(Require only time, lat, lon)

- Dry Troposphere Correction
- High Freq. Fluctuation Correction
- Ocean Tide
- Earth Tide
- ~~Mean Sea Surface~~
- ~~Inverse Barometer Correction~~

Ruled out!

60-day observed
No 60-day observed
Too noisy to tell

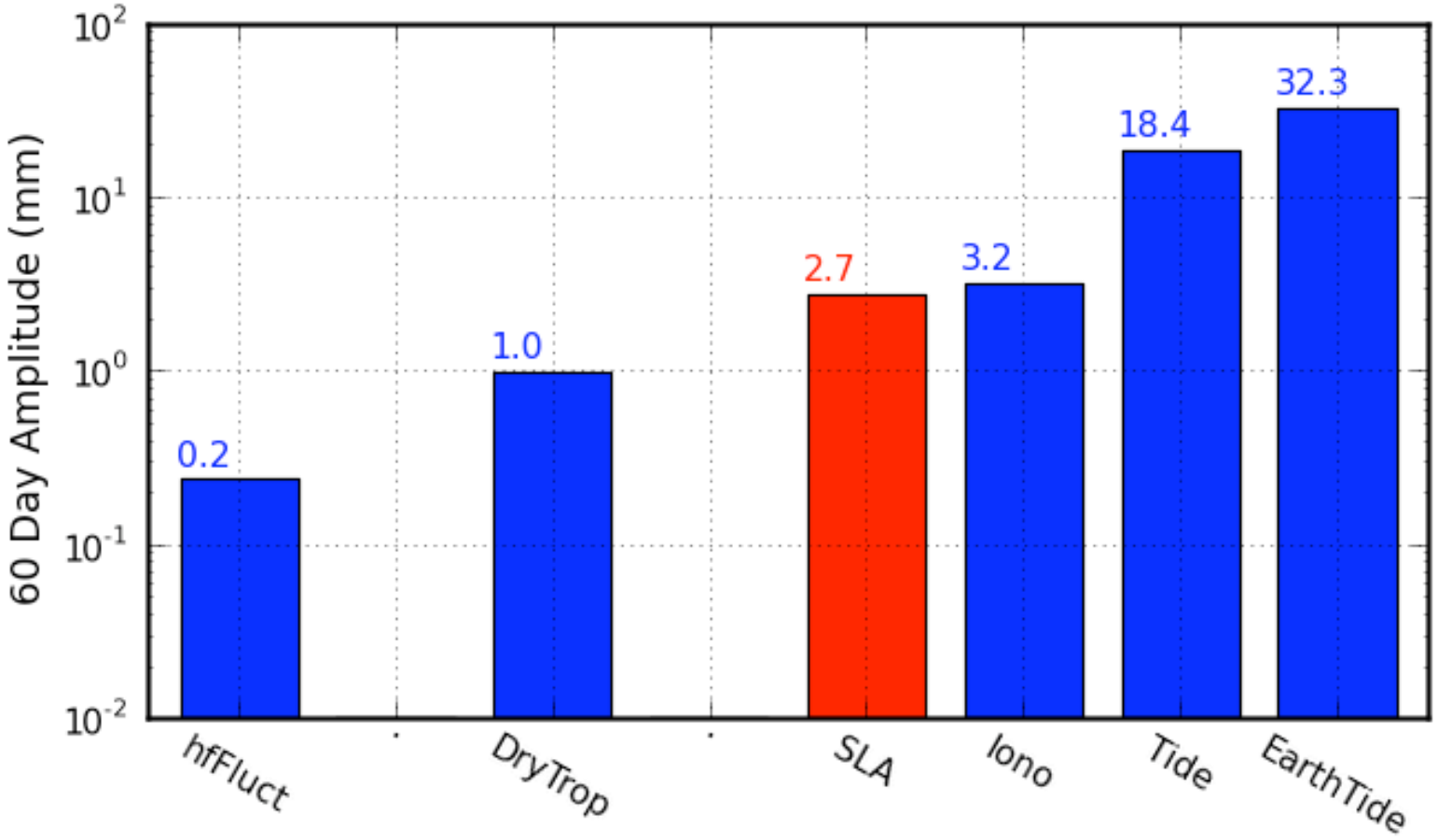
Summary of 60-Day Amplitudes



- Sea Level Anomaly

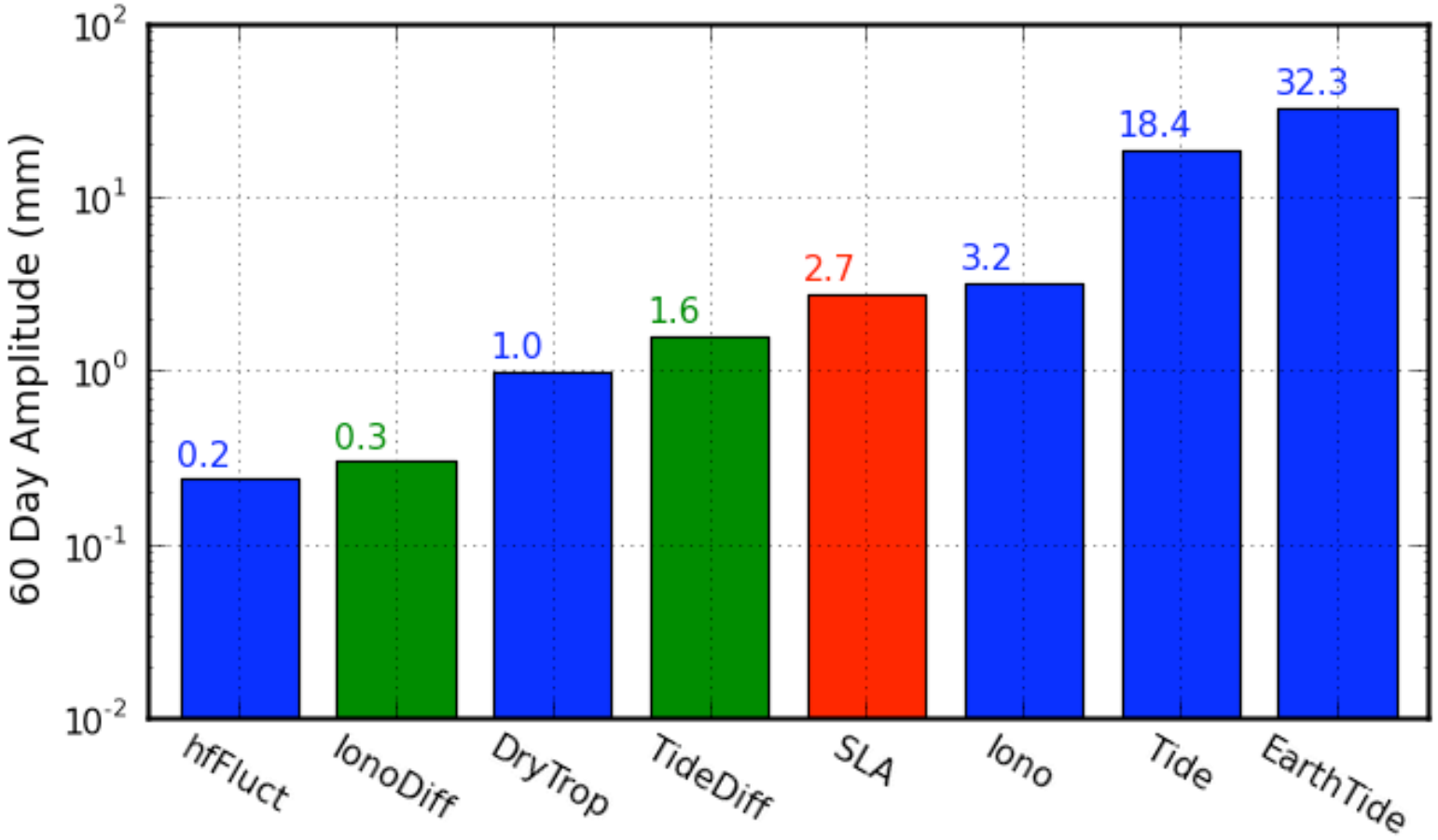
- Need to add alt_diff to this
- **********

Summary of 60-Day Amplitudes



- Sea Level Anomaly
- Components having a 60-day signal

Summary of 60-Day Amplitudes



- Sea Level Anomaly
- Components having a 60-day signal
- Model differences that show 60-signal

18.7 GHz Brightness Temperature

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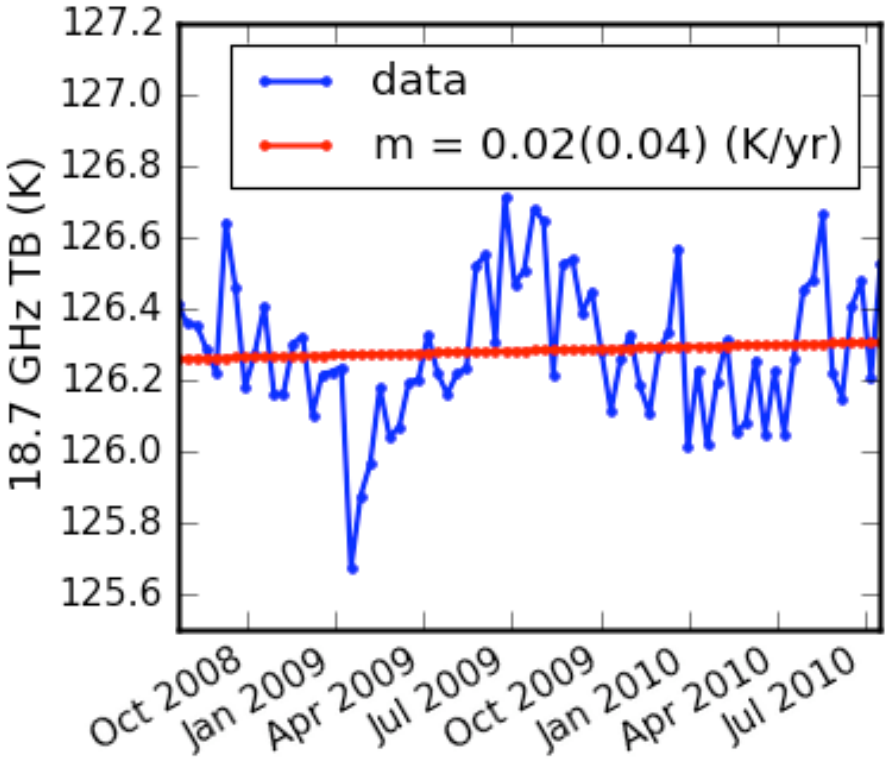
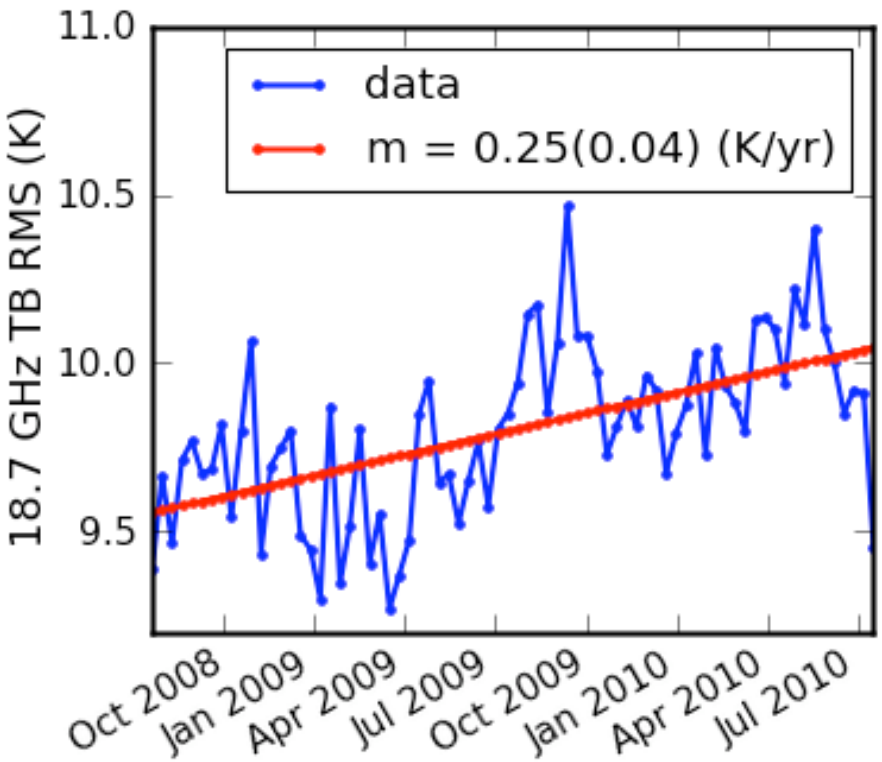
Vicarious Cold



Standard Deviation



- No vicarious cold drift
- Standard deviation increasing

23.8 GHz Brightness Temperature

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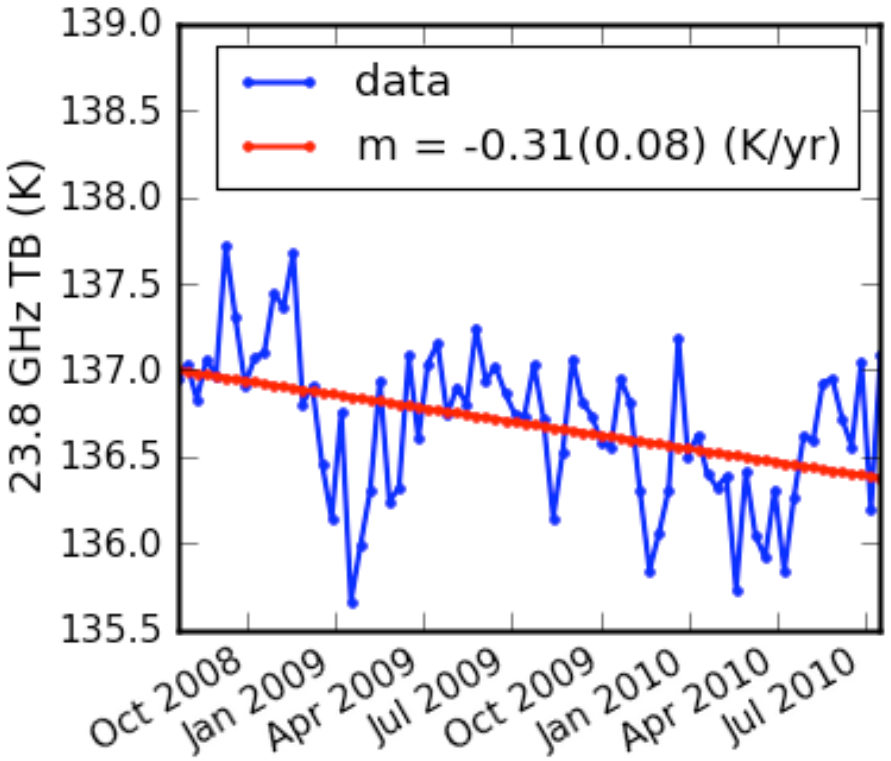
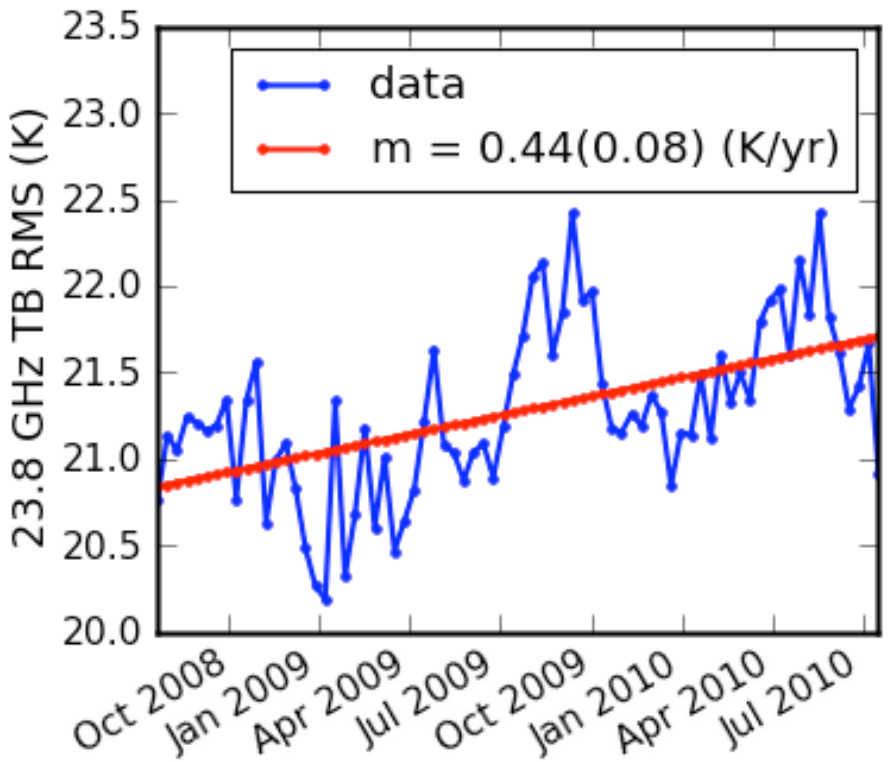
Vicarious Cold



Standard Deviation



- Drift in vicarious cold
- Standard deviation increasing

34.0 GHz Brightness Temperature

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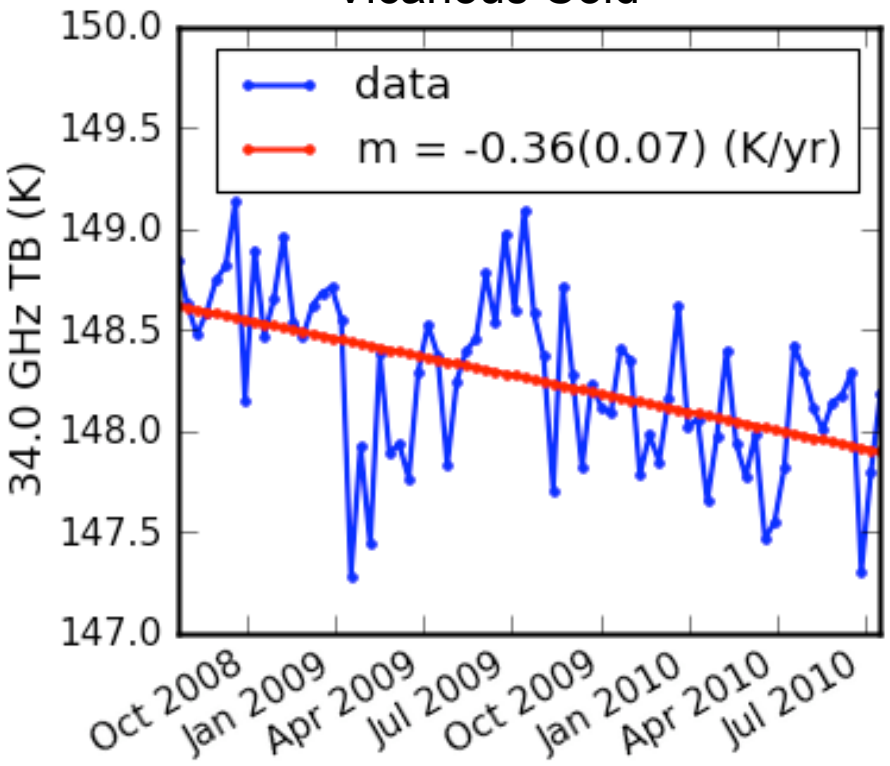
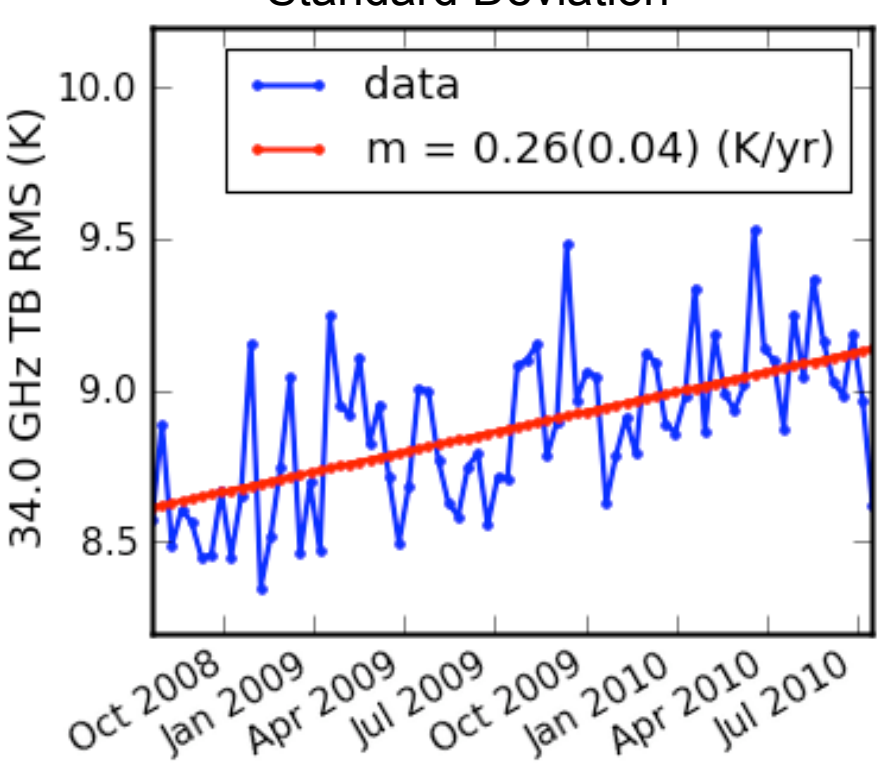
Vicarious Cold



Standard Deviation



- Drift in vicarious cold
- Standard deviation increasing

Radiometer Wet Path Delay Statistics

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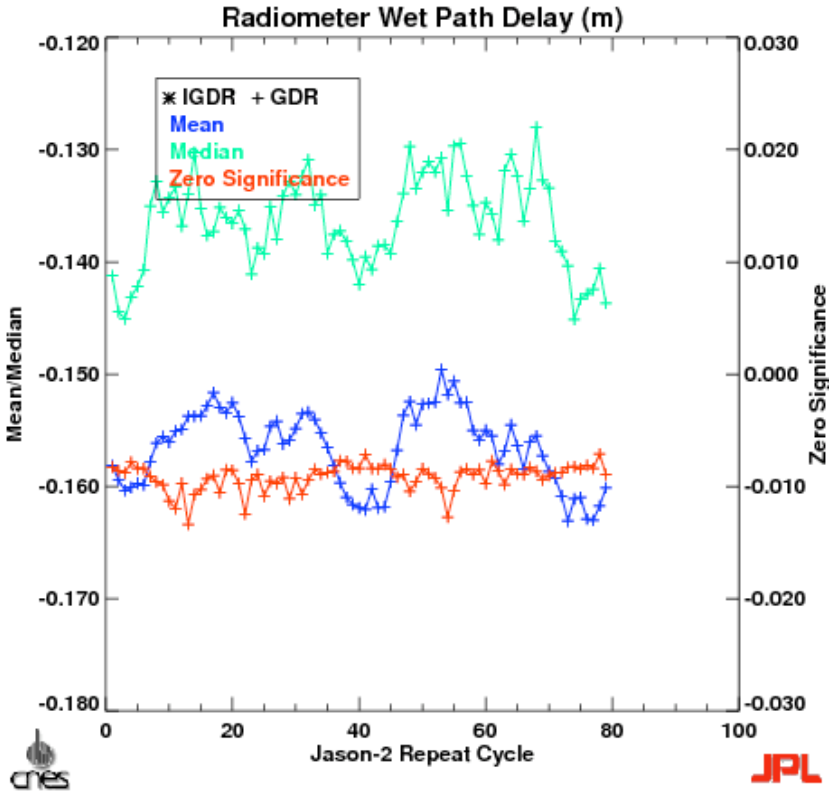
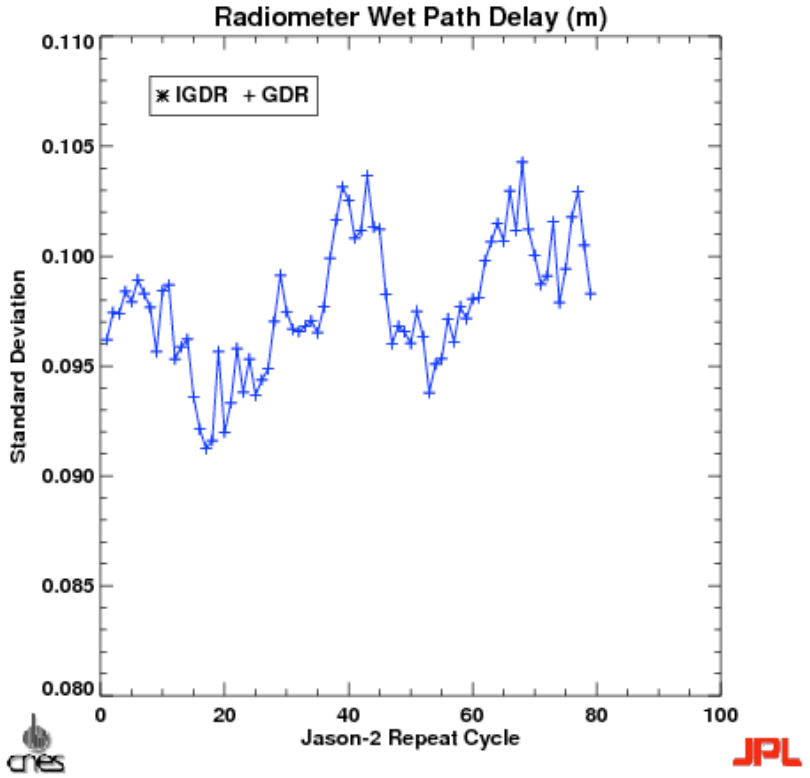
Mean, median, vicarious cold



Standard Deviation



- Vicarious cold appears stable
- Standard deviation may be slightly increasing but not significantly

Introduction

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Sea Surface Height Measurement System

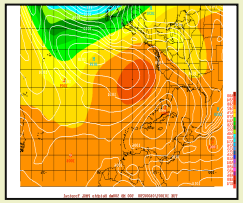
Instruments

- Altimeter
- Radiometer
- Doris Receiver
- GPS Receiver

Data input to models

Models

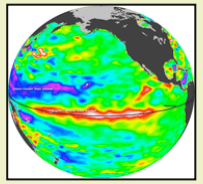
- Troposphere Delay
- Pressure Models
- Ionosphere Models
- Tide Models



Models + Data = measurements

Measurements

- Satellite position
- Waves / wind
- Atmospheric water
- **Sea Surface Height**



New measurements refine the models

- Cal-Val efforts must consider entire system
  - Validate instrument data
  - Ensure internal consistency of models

Sea-Level-Anomaly Statistics

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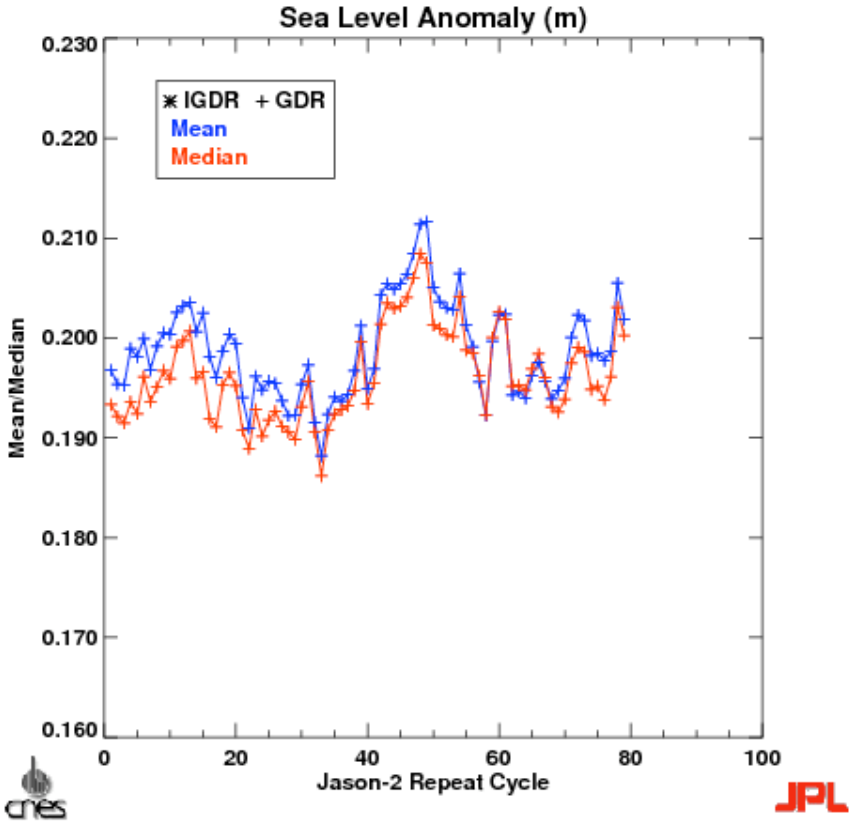
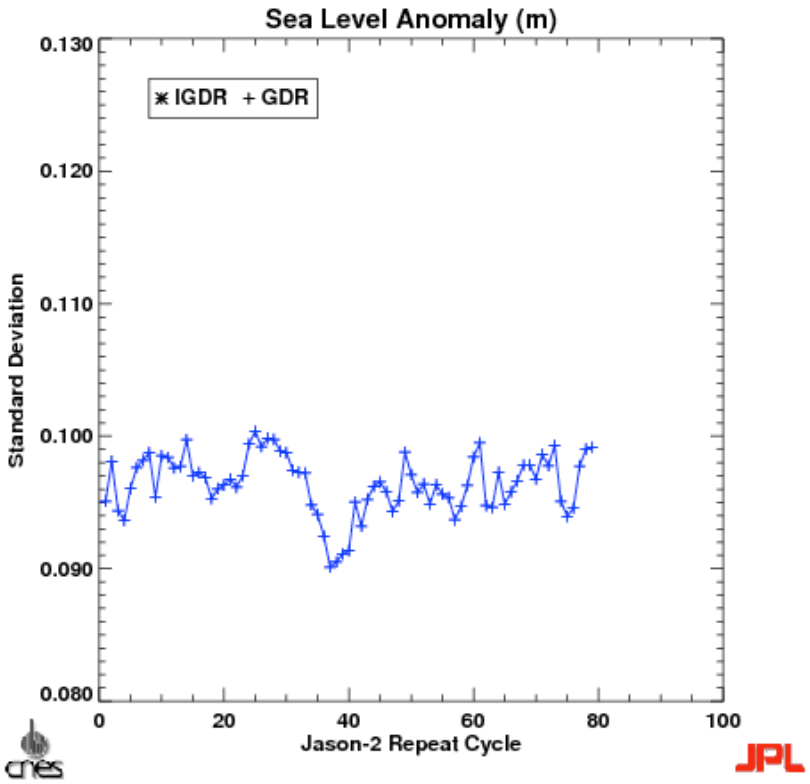
Mean/median



Standard Deviation



- Overall measurement system performance is good.
- viation appears stable

Our 60-Day Analysis Activities

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- **Focus attention on ocean tide models**:
  - Topex based ocean tide model (at least GOT00.2):
    - Did not apply the Topex CG range correction
    - Did not apply S1/S2 atmospheric tide contributions to dry troposphere range correction.
      - Inconsistent with Jason-1/OSTM.
    - Note, that GOT00.2 handled S1/S2 atmospheric effects on inverse barometer correction consistent with Jason-1/OSTM GDR approach.
      - Used daily averages of pressure to derive IB effects.
- **Our Approach**: Develop corrections for errors in S1 and S2 ocean tide models.
  - Force consistency between ocean tide model and treatment of S1/S2 atmospheric tidal effects on dry troposphere correction for Jason-1/OSTM.
  - Account for error in ocean tide model from not applying CG correction in Topex sea surface height measurements.
  - Only considered GOT00.2 ocean tide model because it is empirical model so errors map linearly.