Uncertainty analysis of gravity time series reduction

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Motivation

- **Increasing demand to resolve small-scale signal** in emerging fields
  - Monitoring of geothermal fields and volcanoes,
  - Kilogram definition, co-seismic changes,
  - Measurement of water balance components, etc.

- **Is it really feasible to resolve such subtle gravity effects?**
  - Time series need to be reduced to the signal of interest
  - Different working groups "prefer" different reduction models

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How do you choose the reduction model?

- **Selection criteria:**
  - Cited/recognized approach or model
  - Sufficient temporal coverage, resolution and continuous operation
  - Available for your site (spatial coverage)
- **Implications of the above criteria for worldwide use:**
  - Atmosphere: EOST-Operation, EOST-Interim, mGlobe, (Atmacs)
  - Global hydrology: CLM, NOAH, MOS, VIC, ERA, MERRA, NCEP
  - Non-tidal ocean loading: ECCO, OMCT, TUGOm
  - Tides: Baytap08, ETERNA34, VAV06

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What model would you choose?

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How do you choose the reduction model?

- **Selection criteria:**
  - Cited/recognized approach or model
  - Sufficient temporal coverage and resolution
  - Available for your site (spatial coverage)
- **Residuals when resulting from different reduction models (CA)**
  - Atmosphere: EOST-Operation, **EOST-Interim–mGlobe** (Atmacs)
  - Global hydrology: **CLM–NOAH**, MOS, VIC, ERA, MERRA, NCEP
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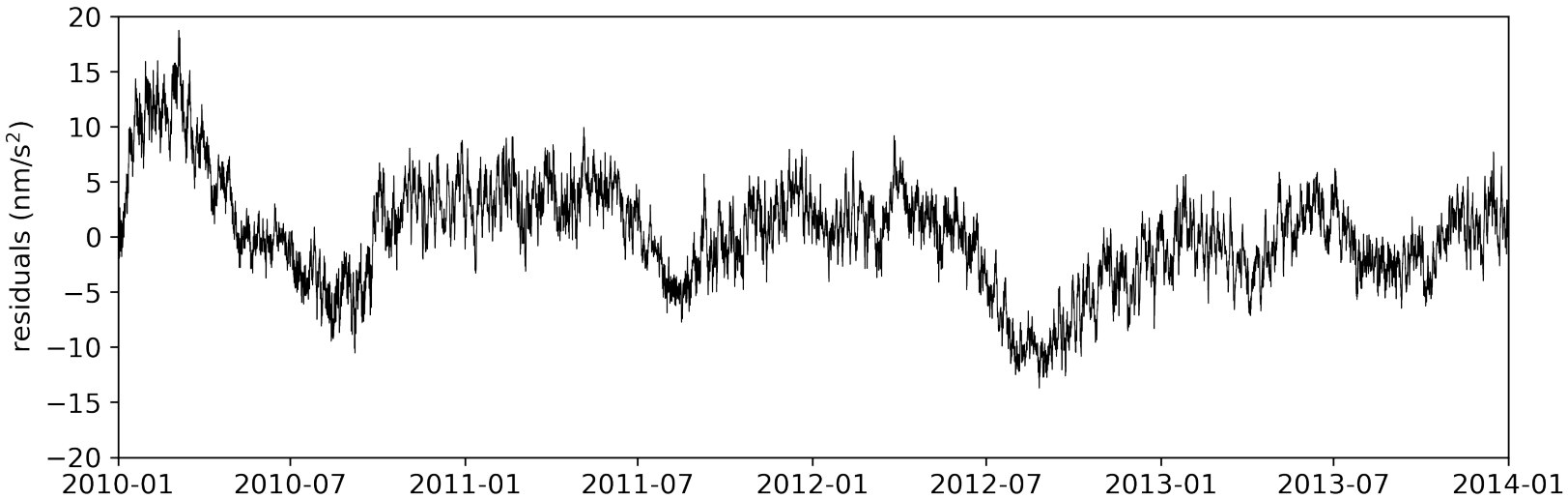

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Study set-up

- **Aim of this study:**
  - Assess uncertainty of residual small-scale signal at different frequencies
- **Approach:**
  - Take into account all available models (meeting presented criteria)
  - Treat each model as independent and with same weight
  - Look at different frequencies of interest, e.g.:
    - hourly differences: precipitation events
    - hours to weeks: volcanic activities
    - weeks to decades: local subsidence phenomena
    - long-term trend: tectonics

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- **Approach:**
  - Take into account all available models (fulfilling presented criteria)
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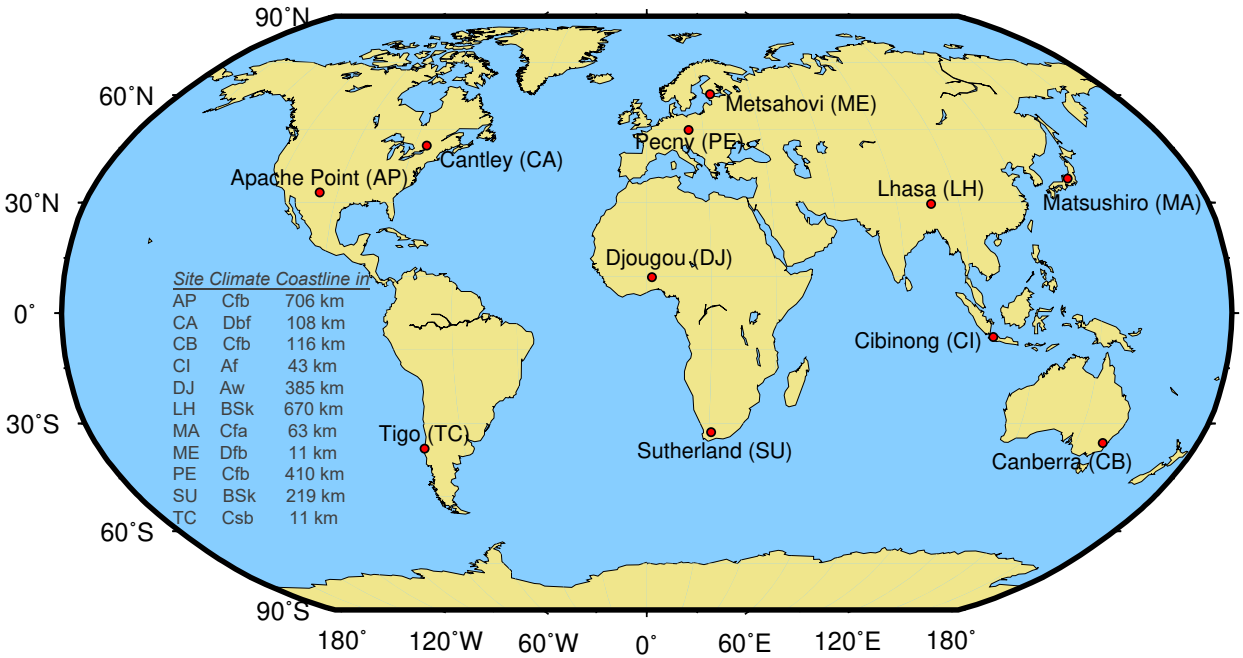
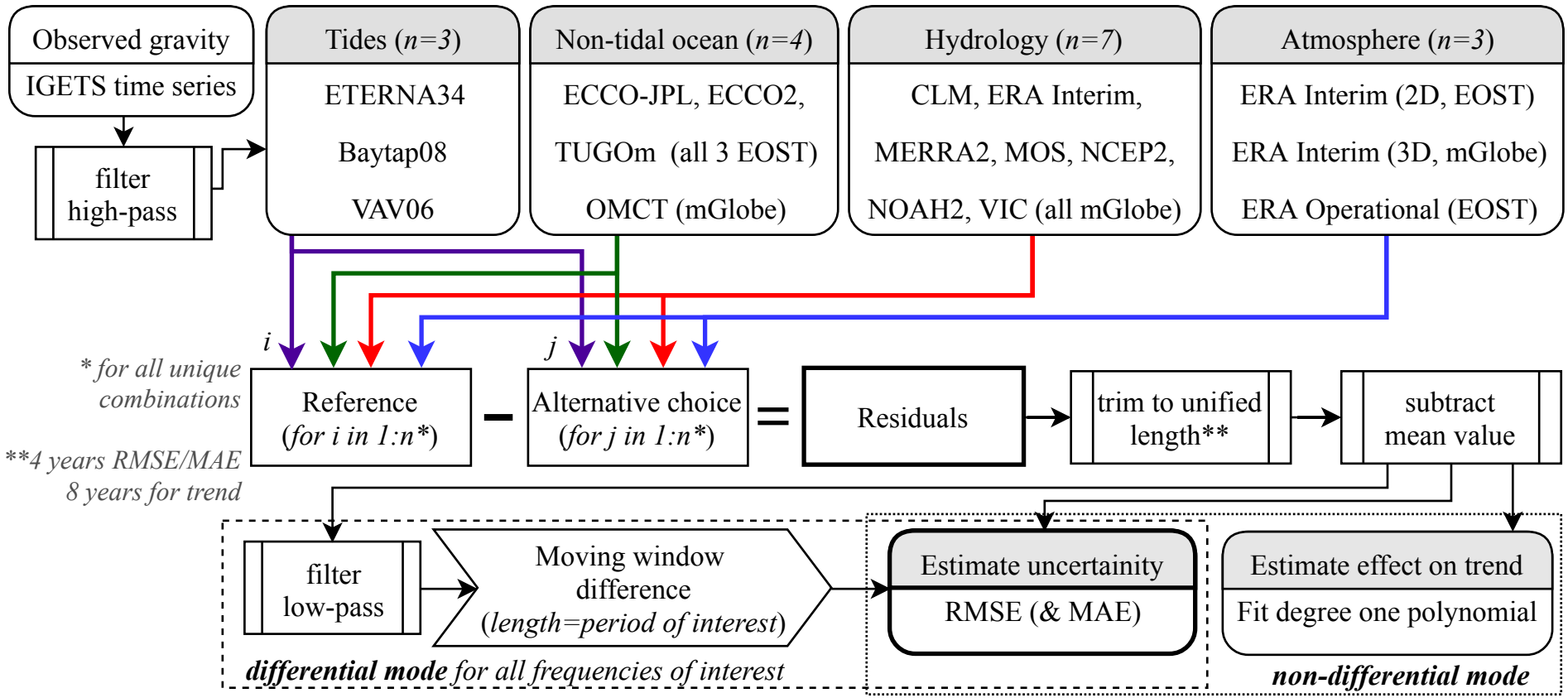
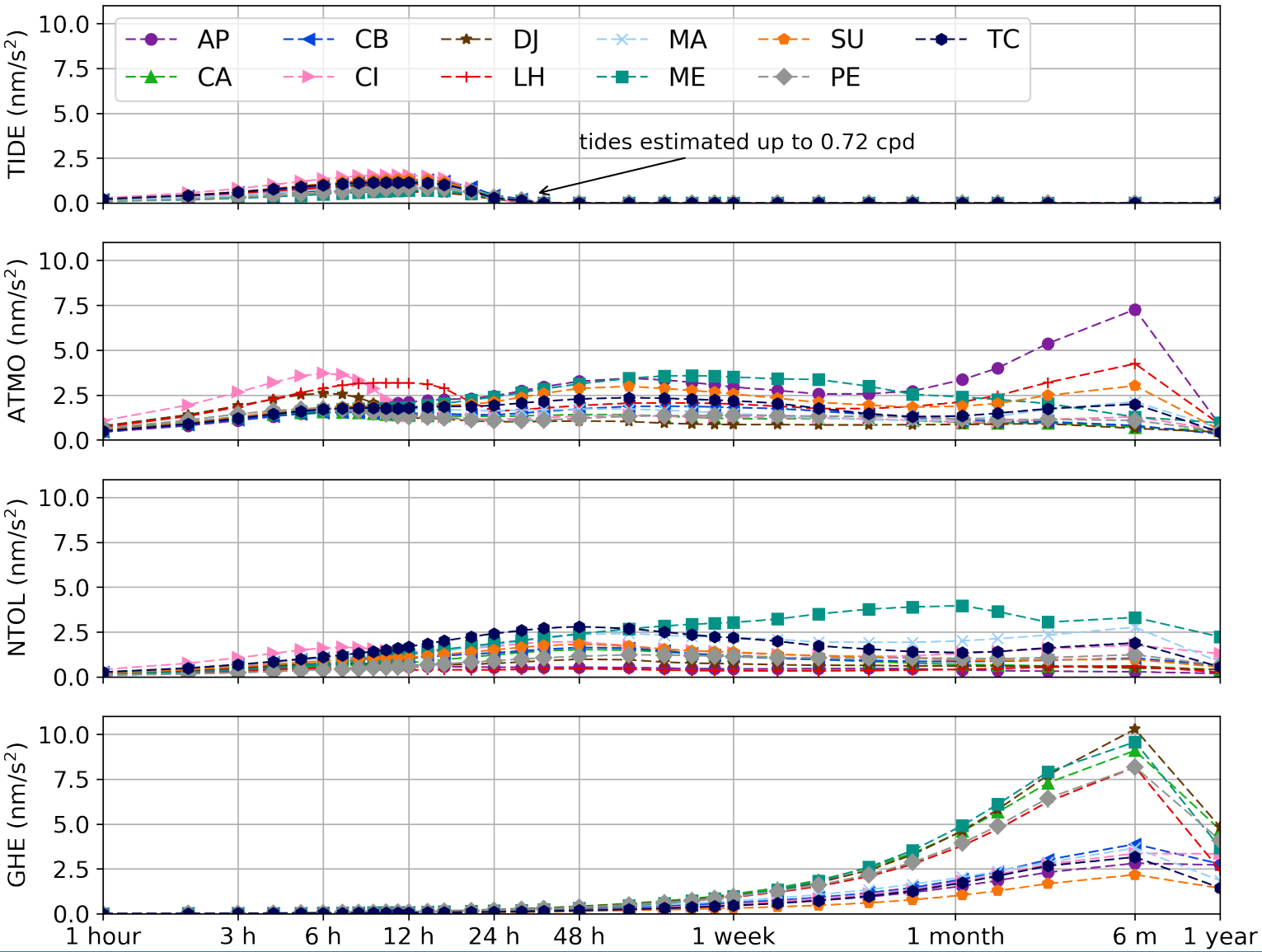
  - Look at different frequencies of interest
  - Apply at various sites



Methods/Workflow

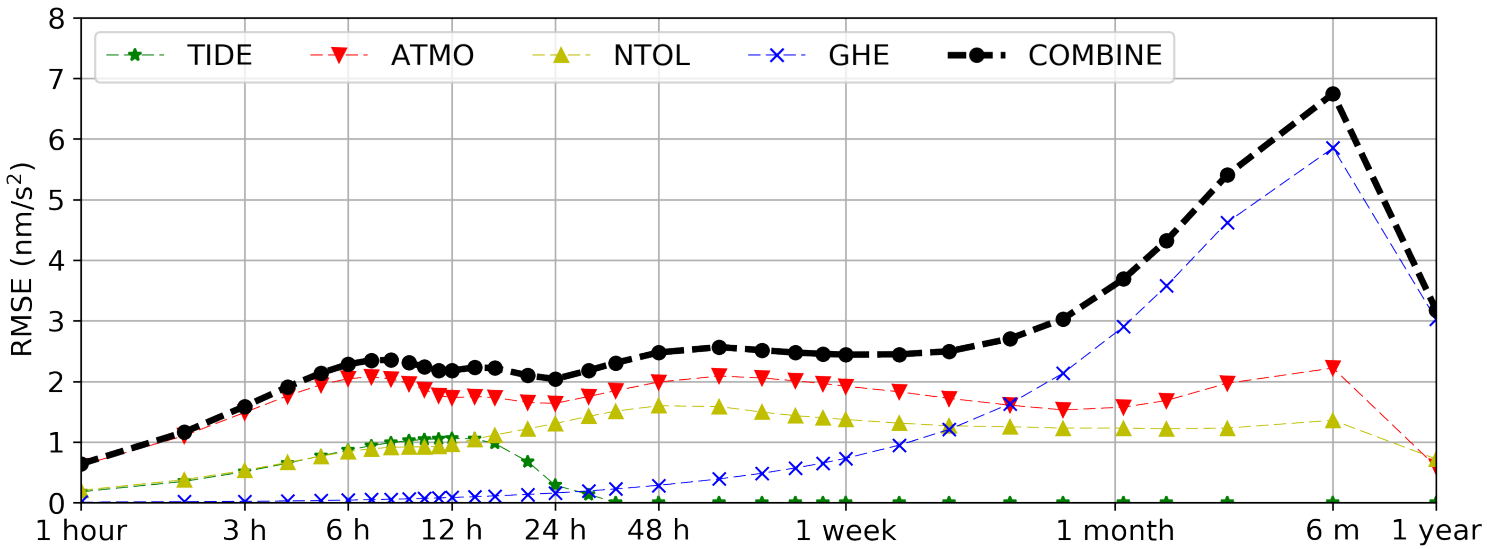


Differential mode: RMSE for each site & each component



Differential mode: RMSE for all sites

- Mean RMSE for all sites and components (=*COMBINE*)
  - Uncertainty at 1 hour $\approx 0.7\,\mathrm{nm/s^2}$
  - Uncertainty at 4 hours to 1 week $\approx 2\,\mathrm{nm/s^2}$
  - Maximum RMSE at 6 months $> 6.5\,\mathrm{nm/s^2}$
    - Always at half of dominant frequency



*x axis in log scale

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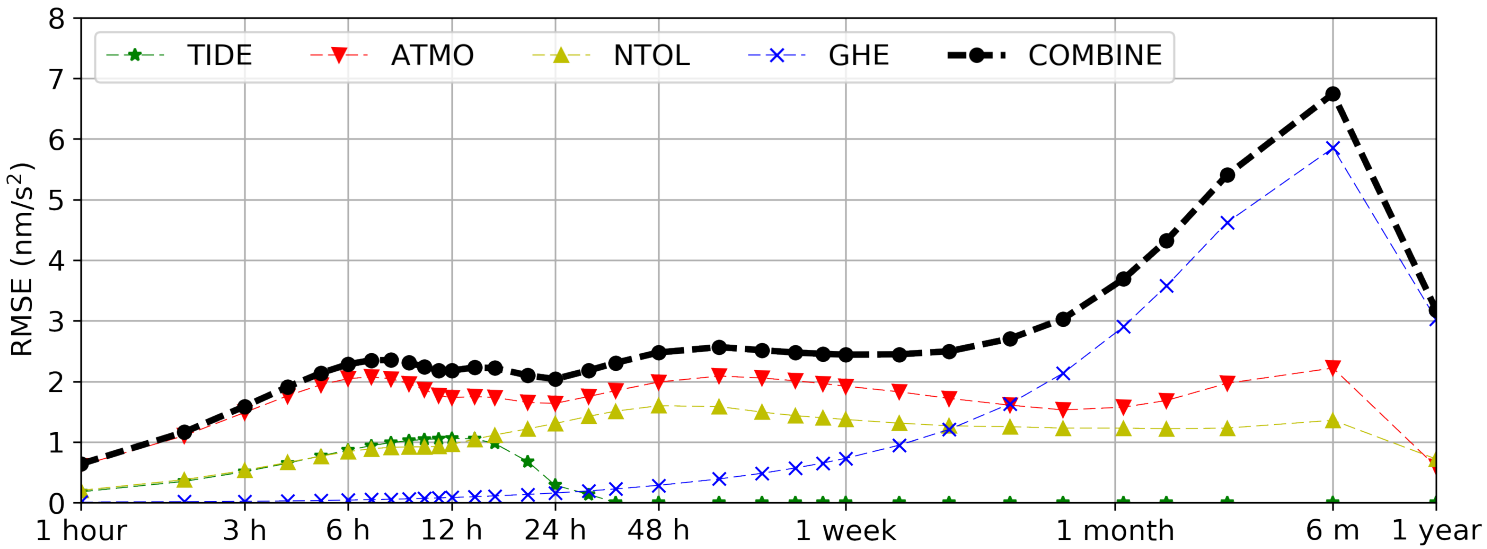

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Non-differential mode: RMSE & trend effect

- Average RMSE for all sites: $5.1\,\mathrm{nm\,s^{-2}}$
- *Boxplot with each sites:*
  - *median in orange, average in green (dashed)*
  - *box at 1st and 3rd quartile, whiskers showing range*

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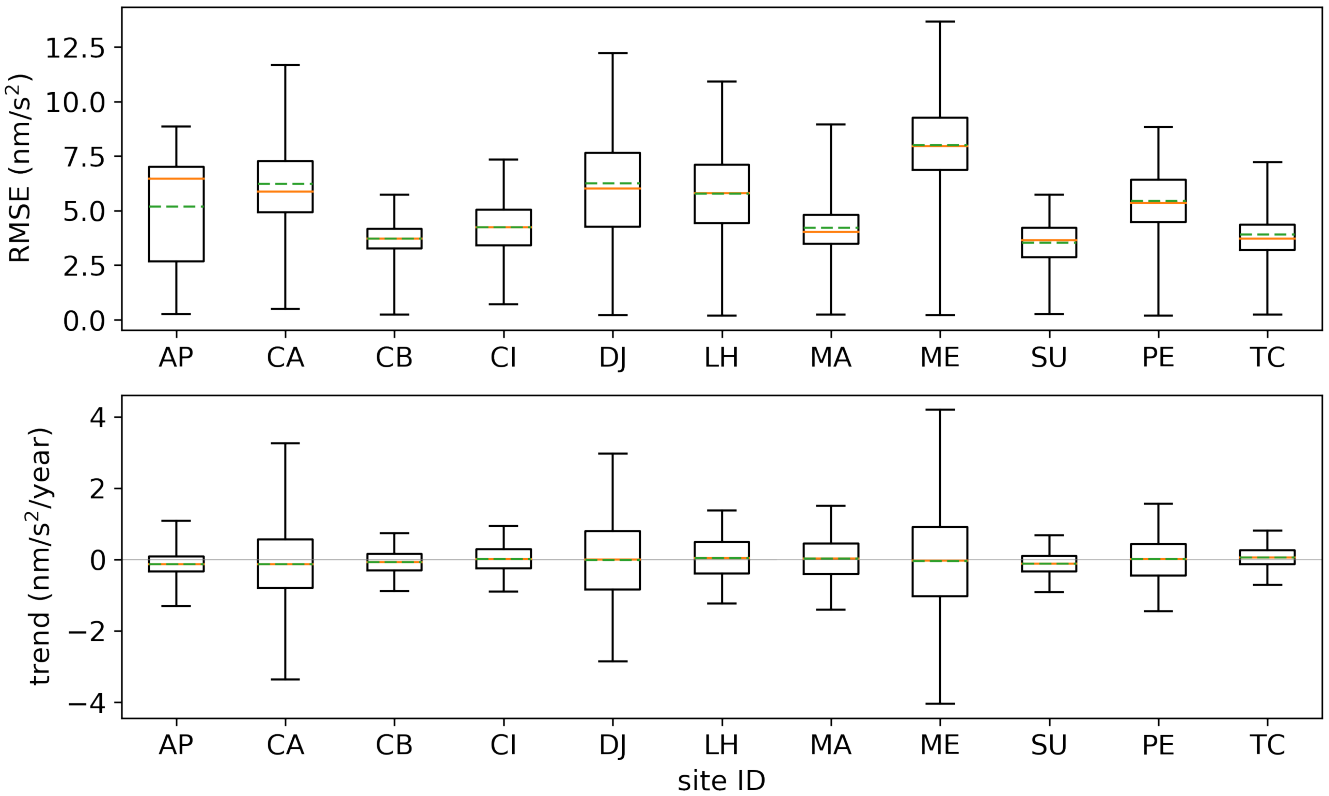

Conclusions

- Effect of individual components:
  - Global hydrology (GHE) has the largest impact (at longer periods)
  - Atmosphere & NTOL important across all frequencies (3x<GHE)
  - Minor influence of tide programs
  - Site dependent
- Combined contribution:
  - No systematic effect on linear trend
  - Significant effect ($> 2\,\mathrm{nm\,s^{-2}}$) on 4-hourly to yearly gravity differences
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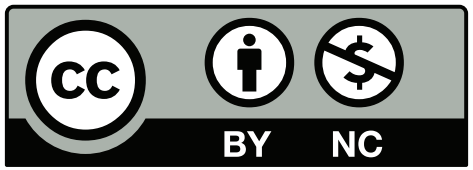

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