EGSIEM

European Gravity Service for Improved Emergency Management

Combination on Normal Equation Level of monthly GRACE GPS- and SWARM gravity fields

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UNIVERSITÄT BERN · UNIVERSITÉ DU LUXEMBOURG · GFZ Helmholtz Centre Potsdam · TU Graz Graz University of Technology · Leibniz Universität Hannover · cnes · DLR · géode&cie · Horizon2020

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Motivation

- The EGSIEM combination service provides monthly GRACE K-band gravity fields combined on Normal Equation (NEQ) Level.
- To ensure consistency, a set of common standards for reference frame, Earth rotation, force model and satellite geometry were defined.
- EGSIEM lately was extended to also include SLR and GPS-only NEQs.
- GRACE (GPS) + SWARM serves for demonstration.

EGSIEM Standards

- Reference frame: reprocessed GPS-constellations and high-rate clock corrections.
- Earth rotation: IERS 2010
- Force model:
  - relativistic corrections (Schwarzschild, Lense-Thirring, de Sitter)
  - Sun and all planets as point masses
- Satellite geometry: common antenna reference points

Force Model and Processing Strategy

- Not fixed, but for this study consistent (Celestial Mechanics Approach of AIUB):
  - AIUB-GRACE-03S (static part only) up to degree 90
  - EOT11A up do degree 100, including admittances
  - AOD1B-RL05 up to degree 100
  - Earth and pole tides according to IERS 2010
  - constrained stochastic accelerations every 15 minutes in radial (R), along-track (S), cross-track (W)
  - daily constant accelerations in R, S, W
  - 1/rev-accelerations in R, S, W (GRACE only).

Relative weighting

- For this study all satellites were processed using the same observation type:
  - kinematic postitions (10s-sampling)
- same type of noise model:
  - observations are considered as uncorrelated in time
  - constrained stochastic accelerations absorb model deficiencies

$\Rightarrow$ Generally easy to combine

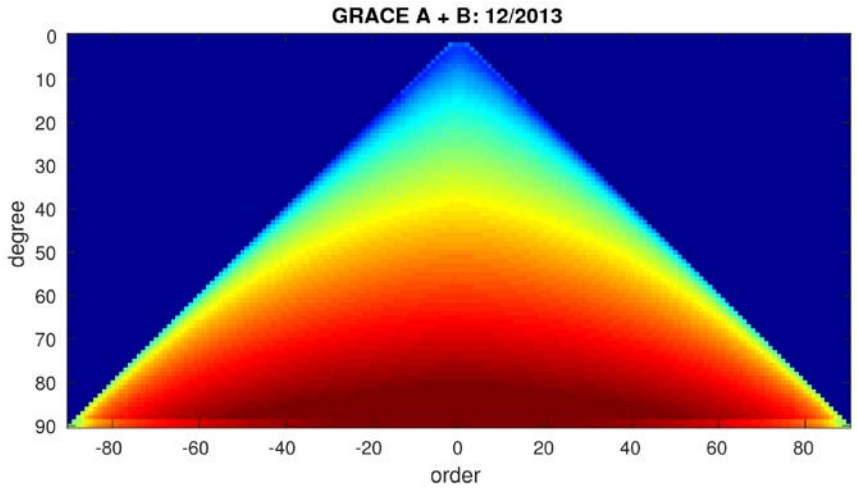
$\Rightarrow$ But: different sampling rate of SWARM (1s from July 2014 on) leads to over-weighting of SWARM.

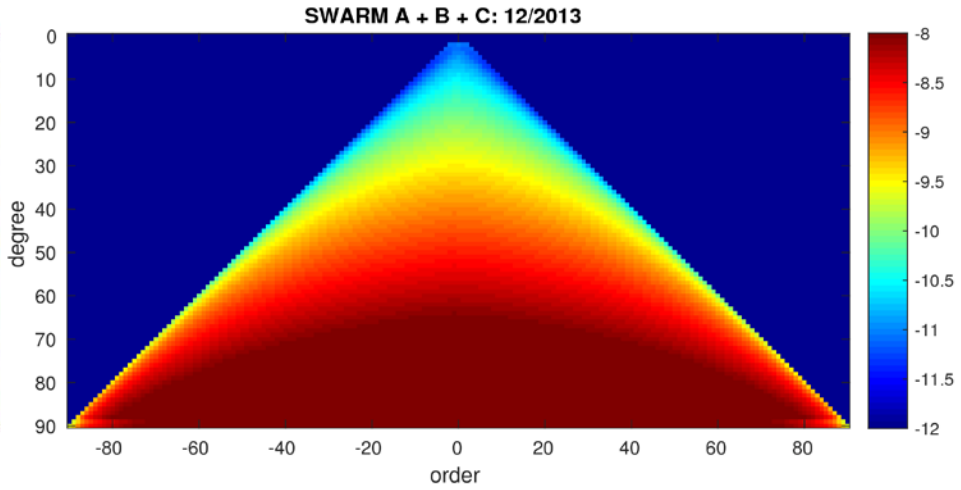
Variance factors for relative weighting:

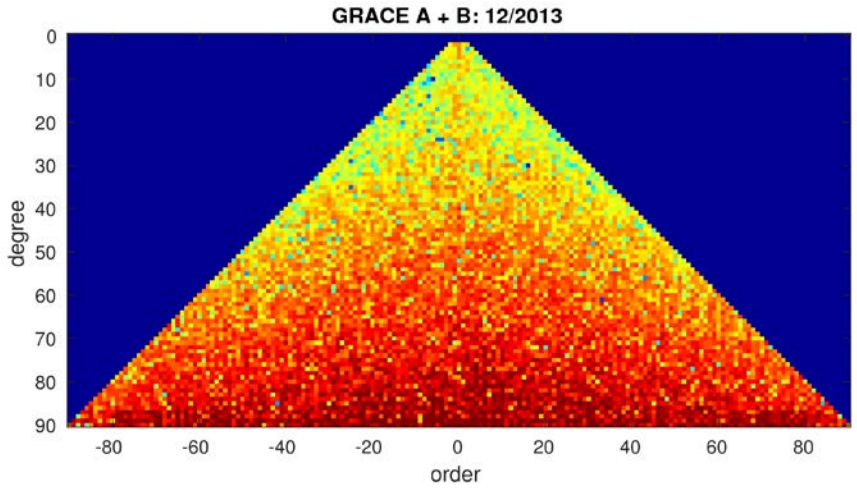
$$W = S_0^2 * DOF / v^T P v$$

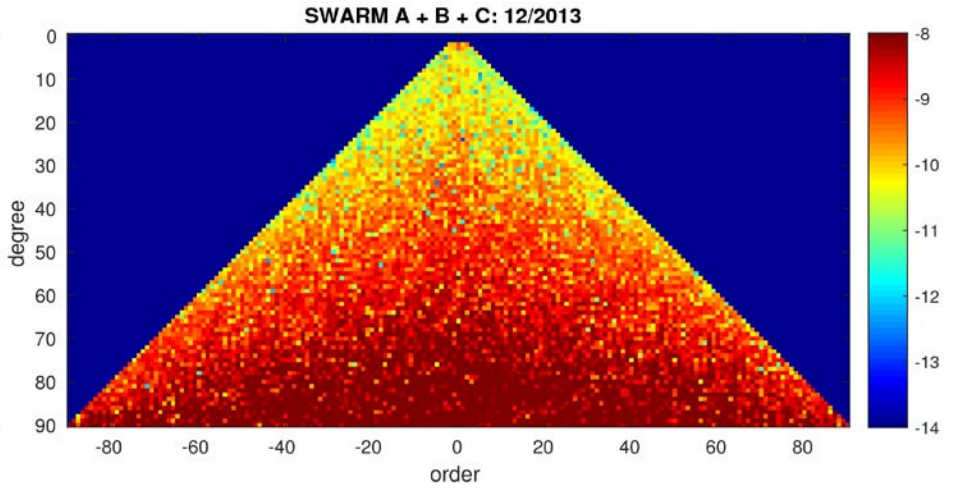
S_0 = 0.001 m ; DOF = Degree Of Freedom

Individual Combinations









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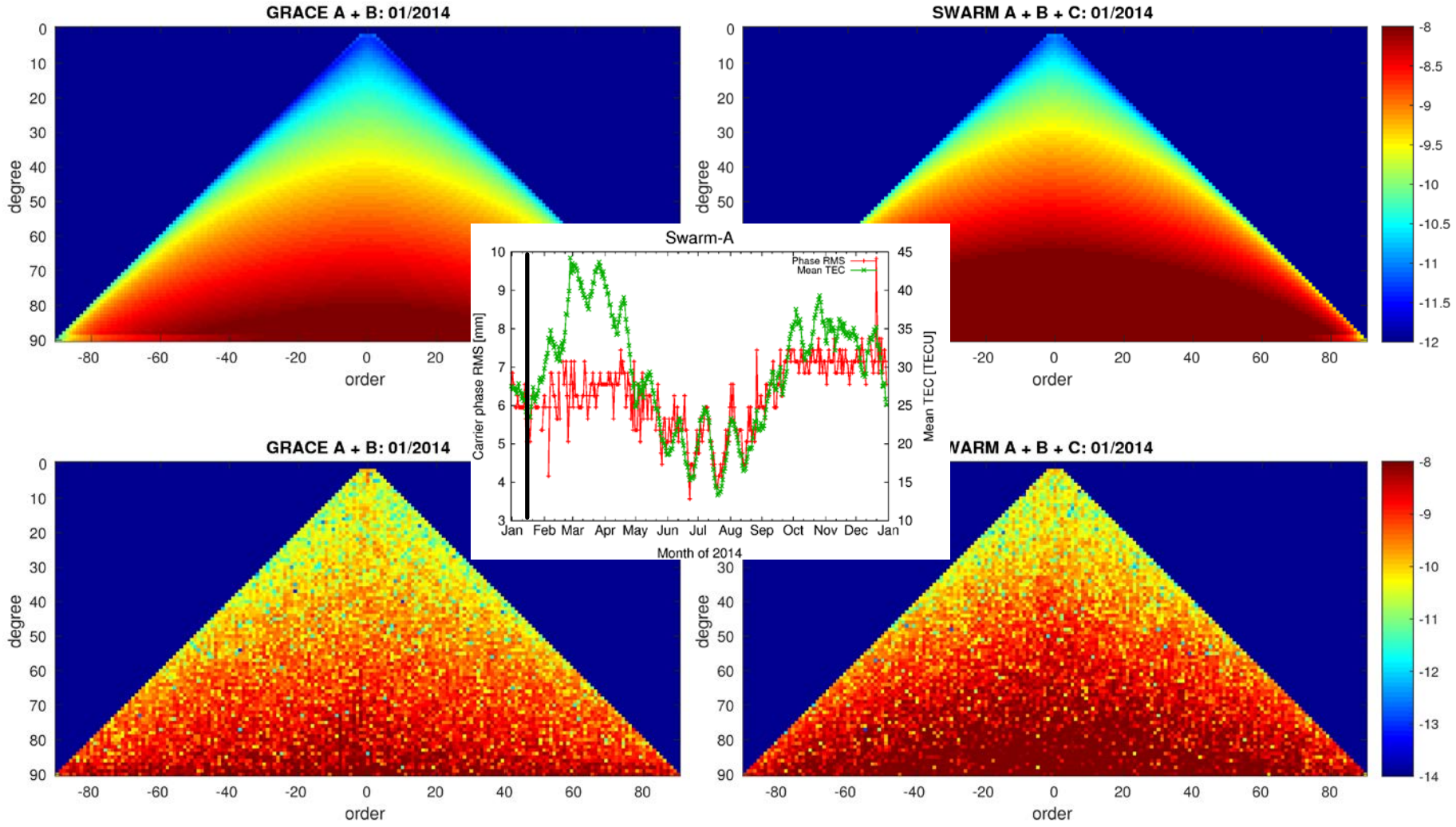

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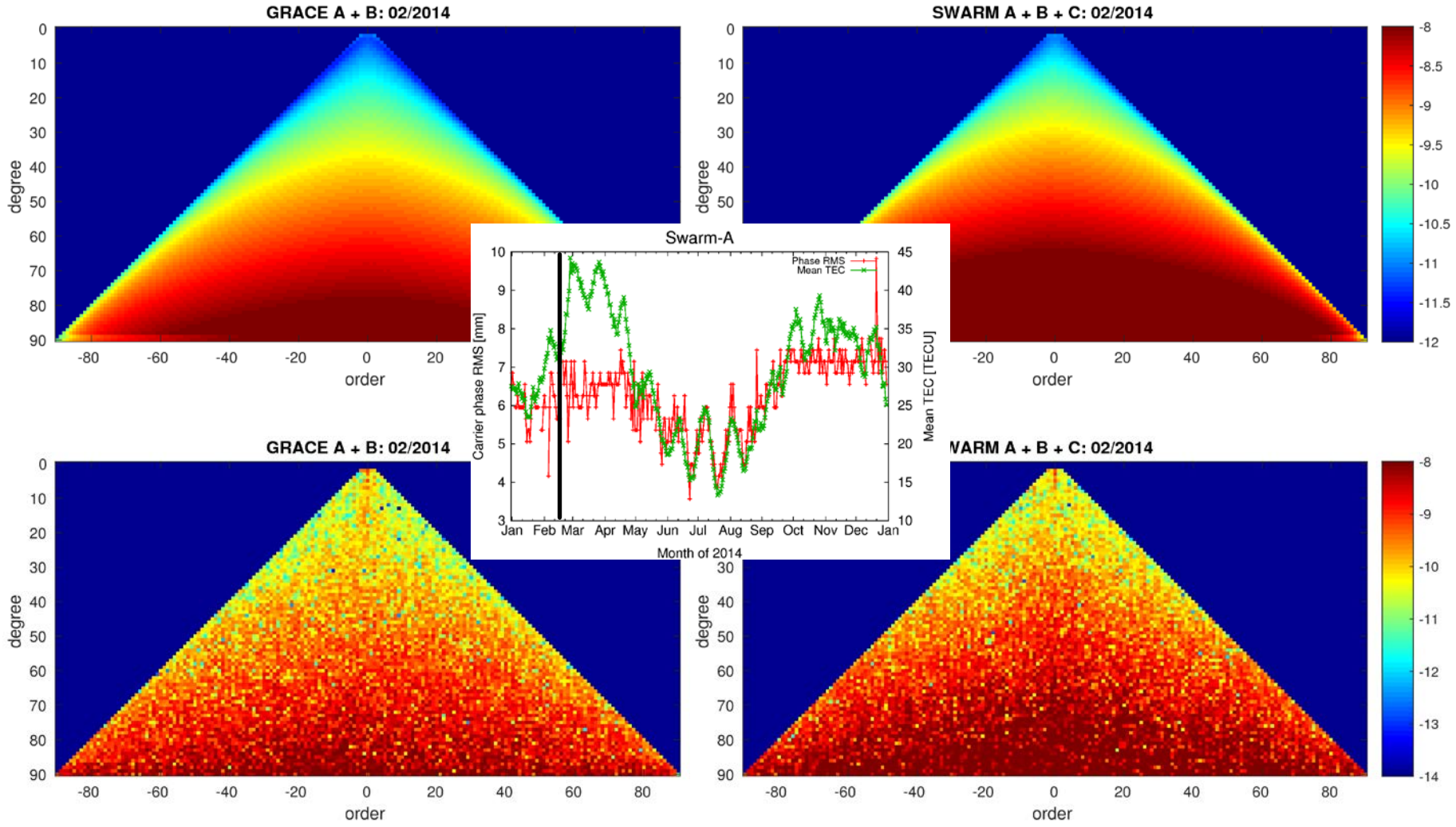

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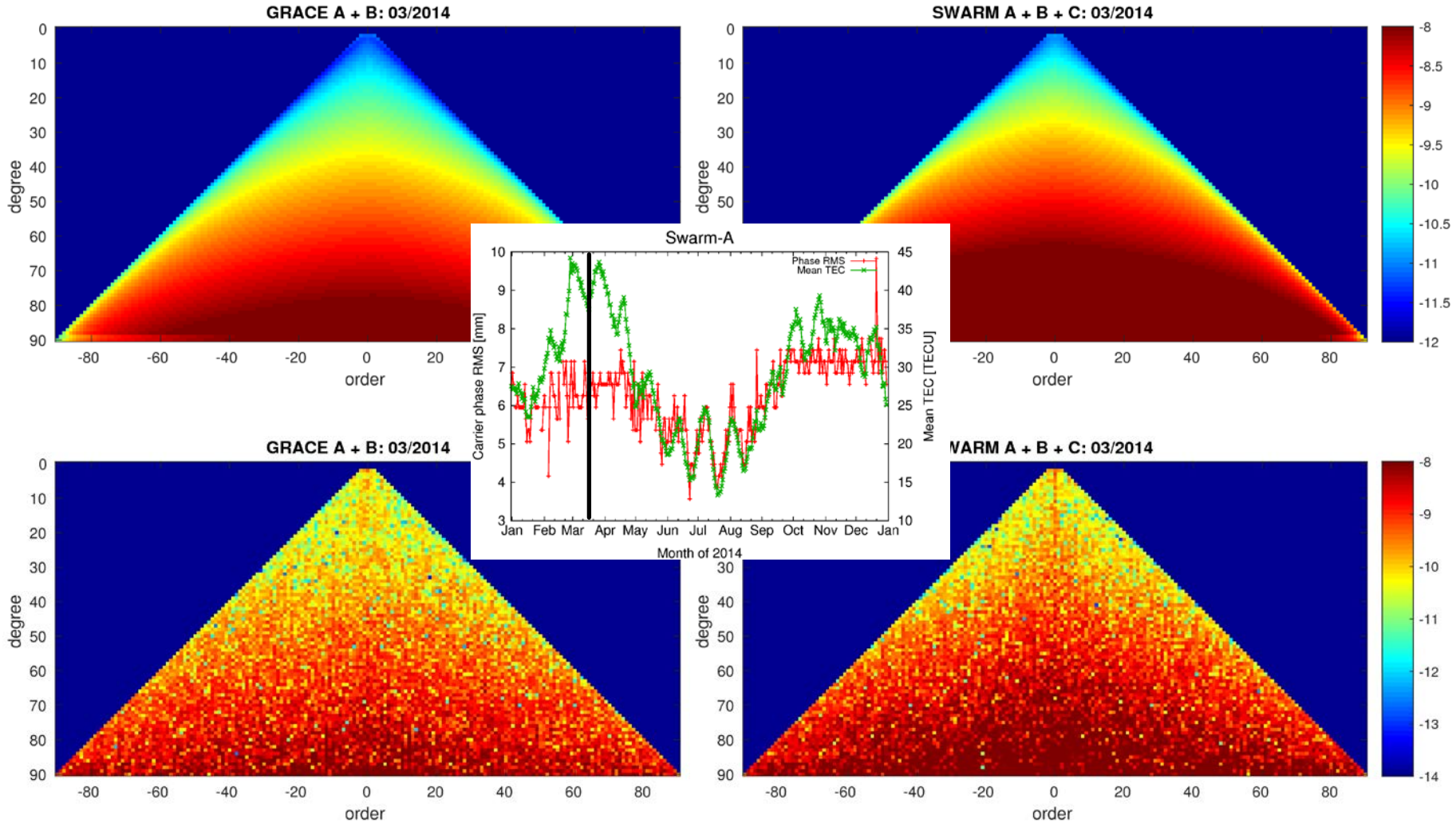

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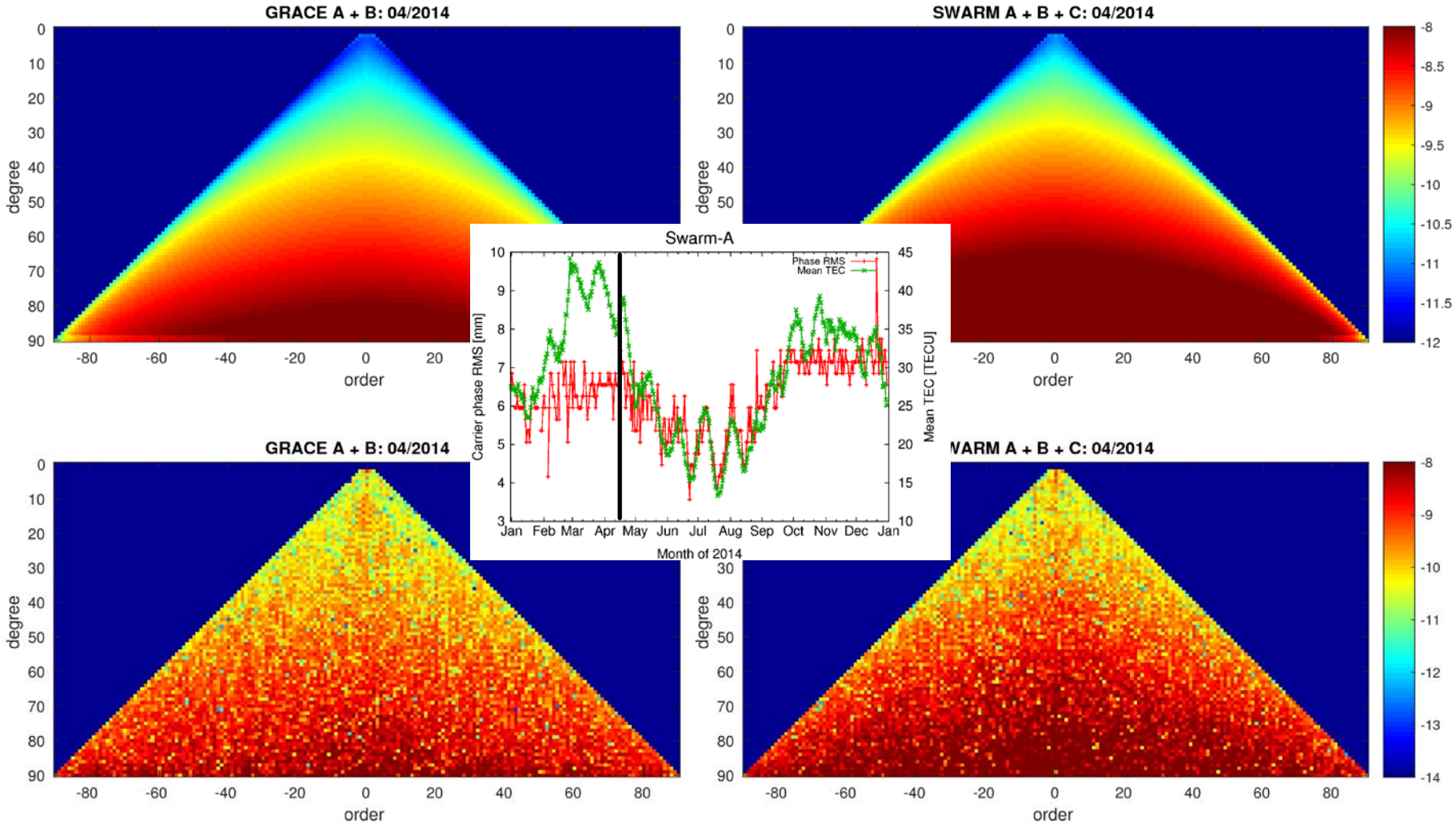

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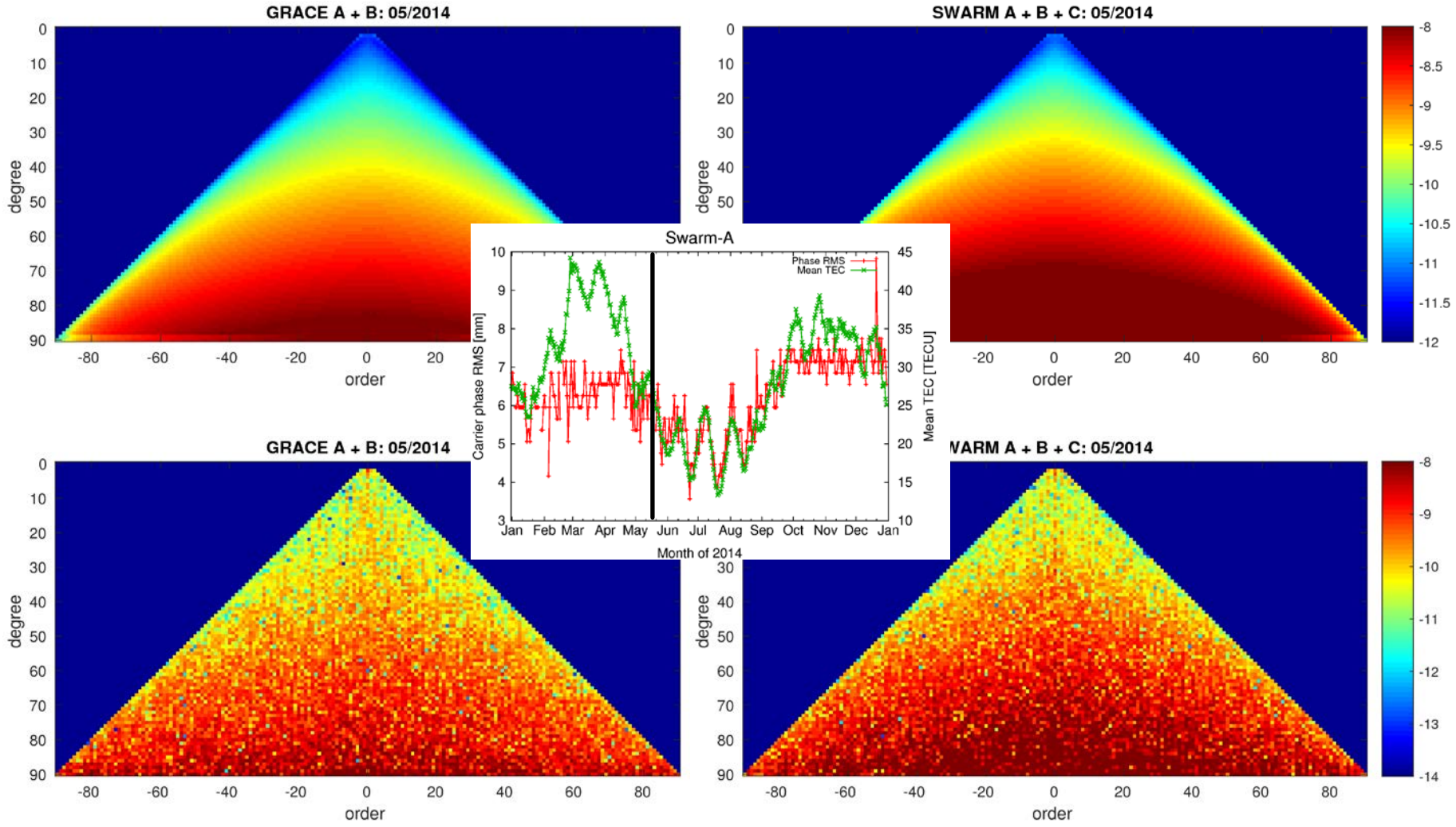

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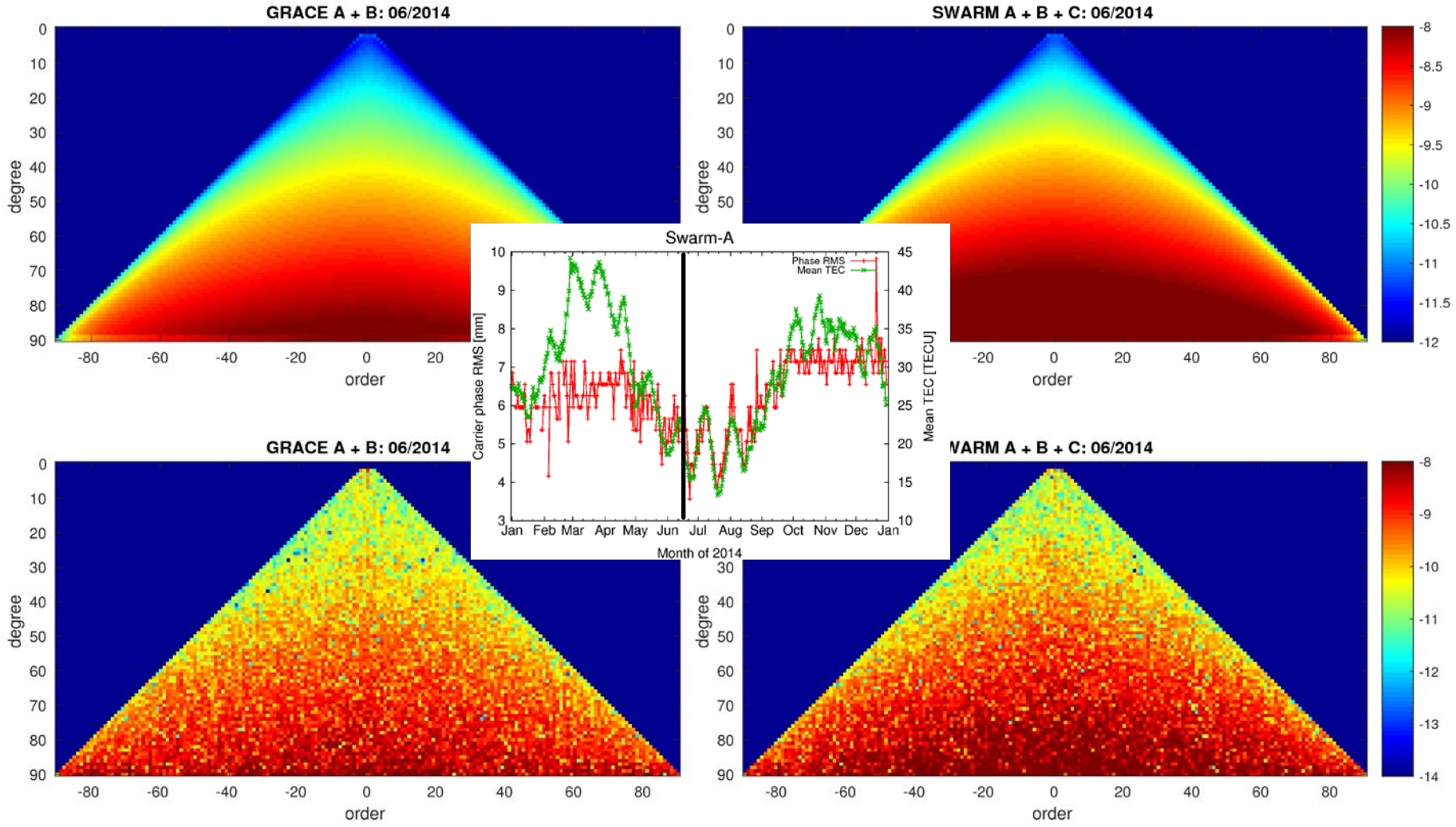

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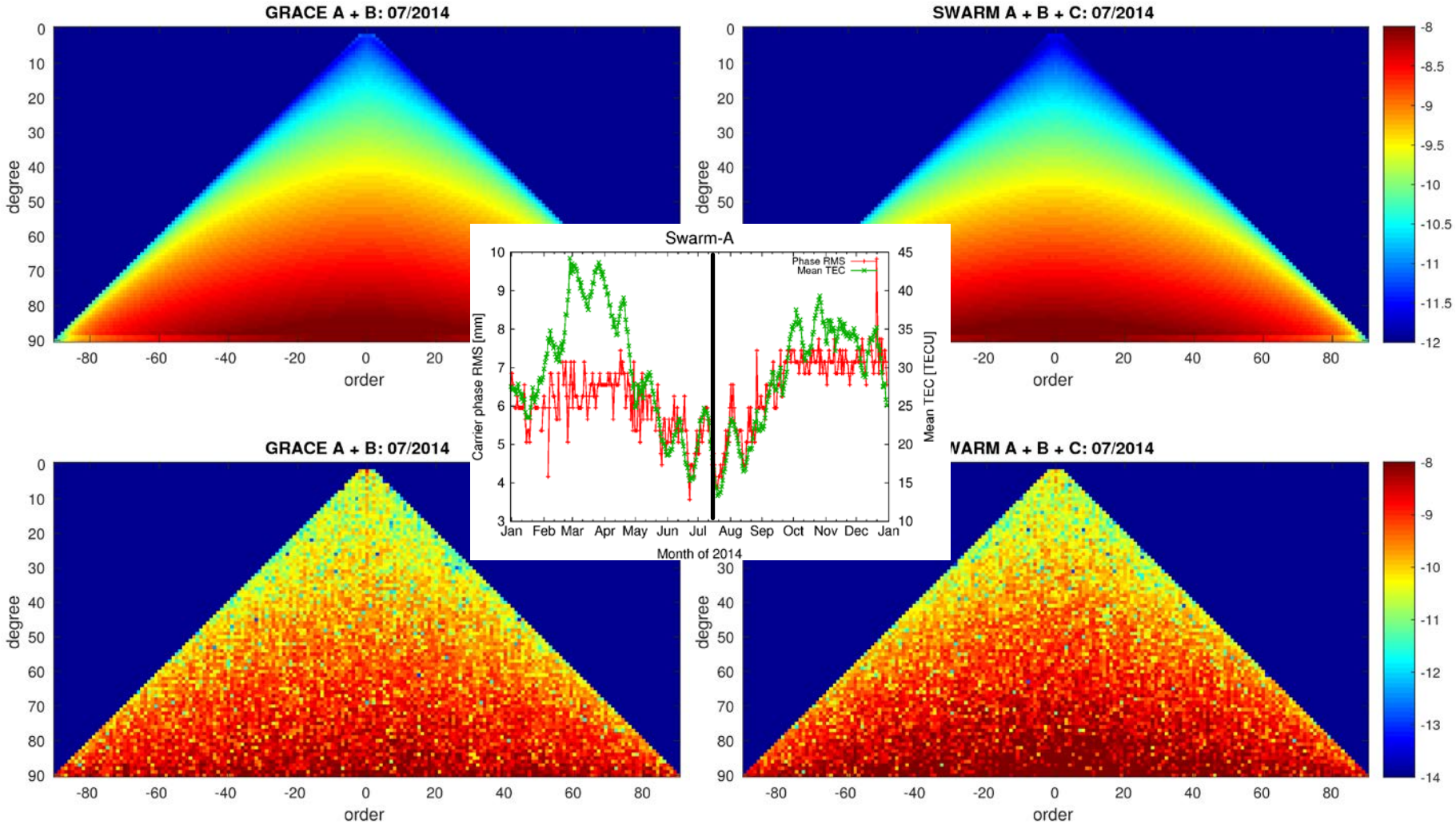

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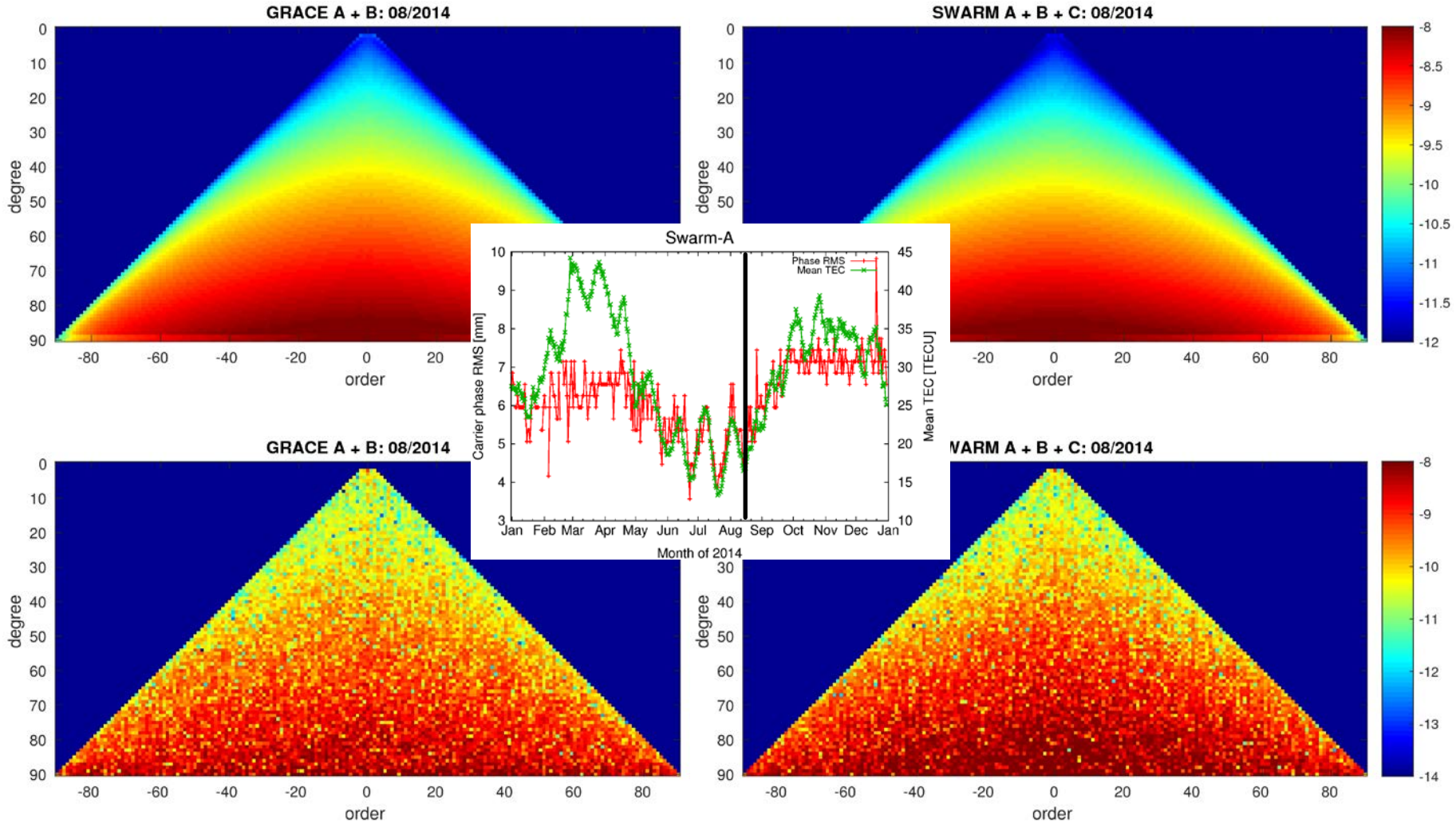

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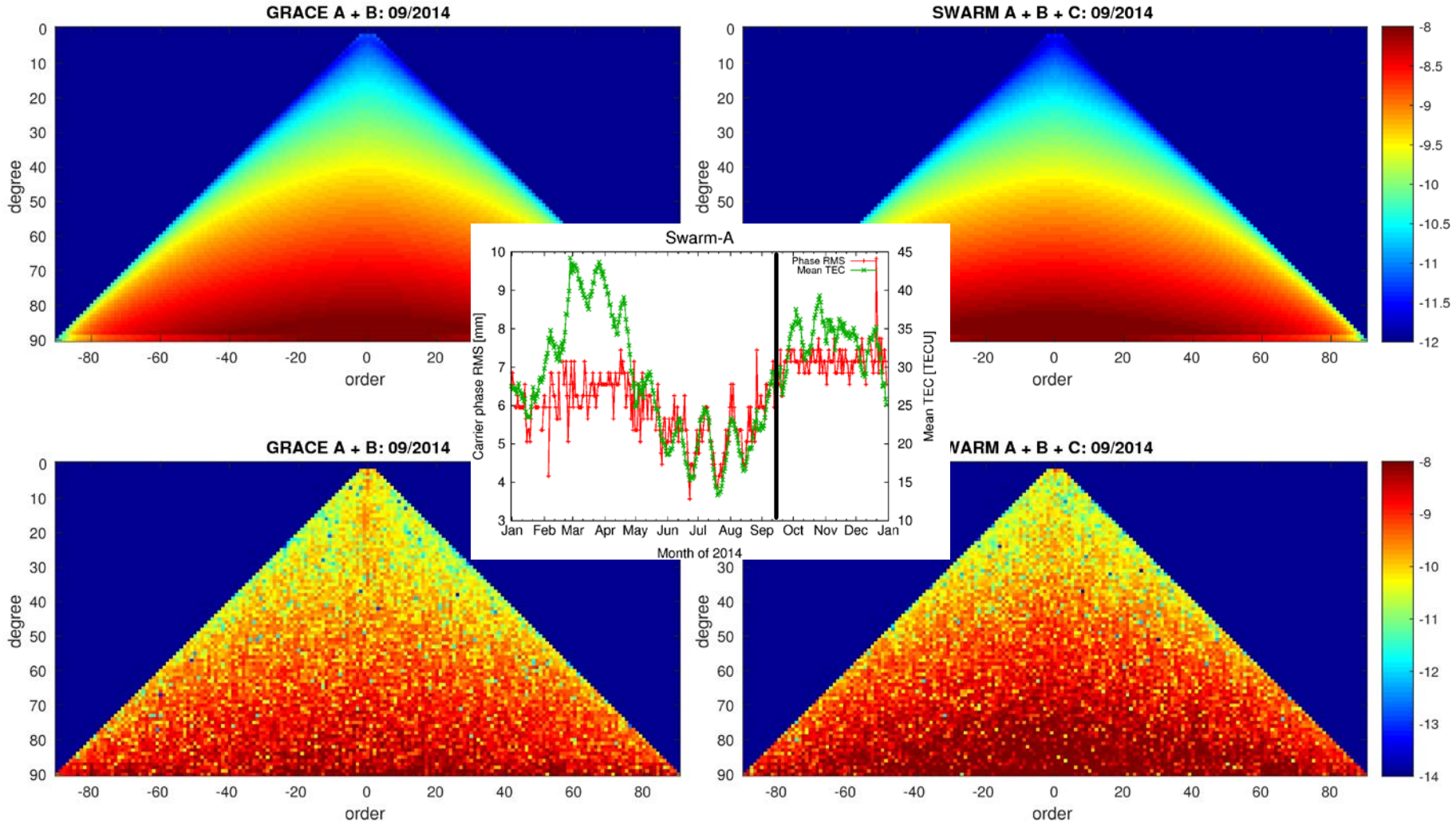

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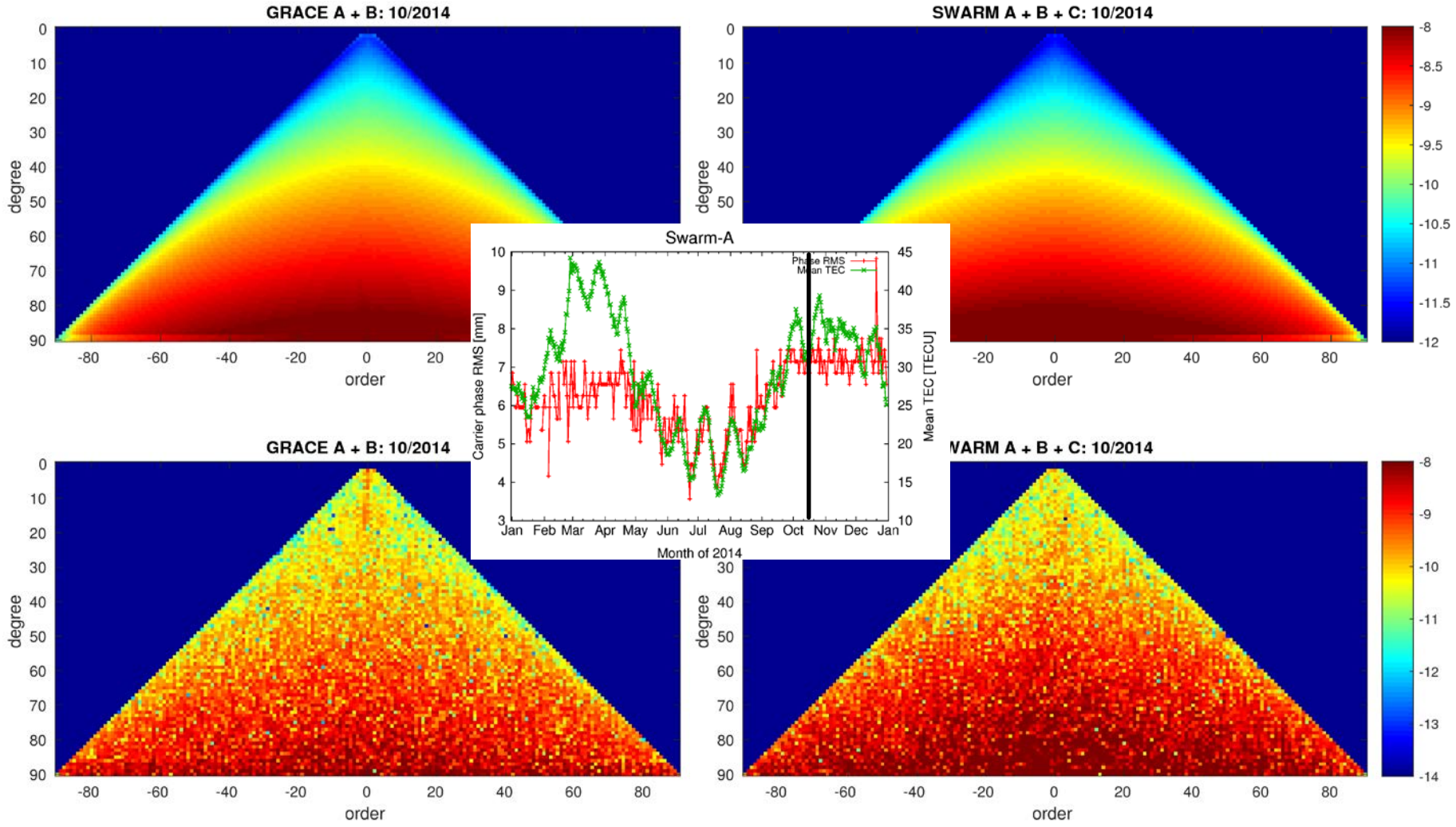

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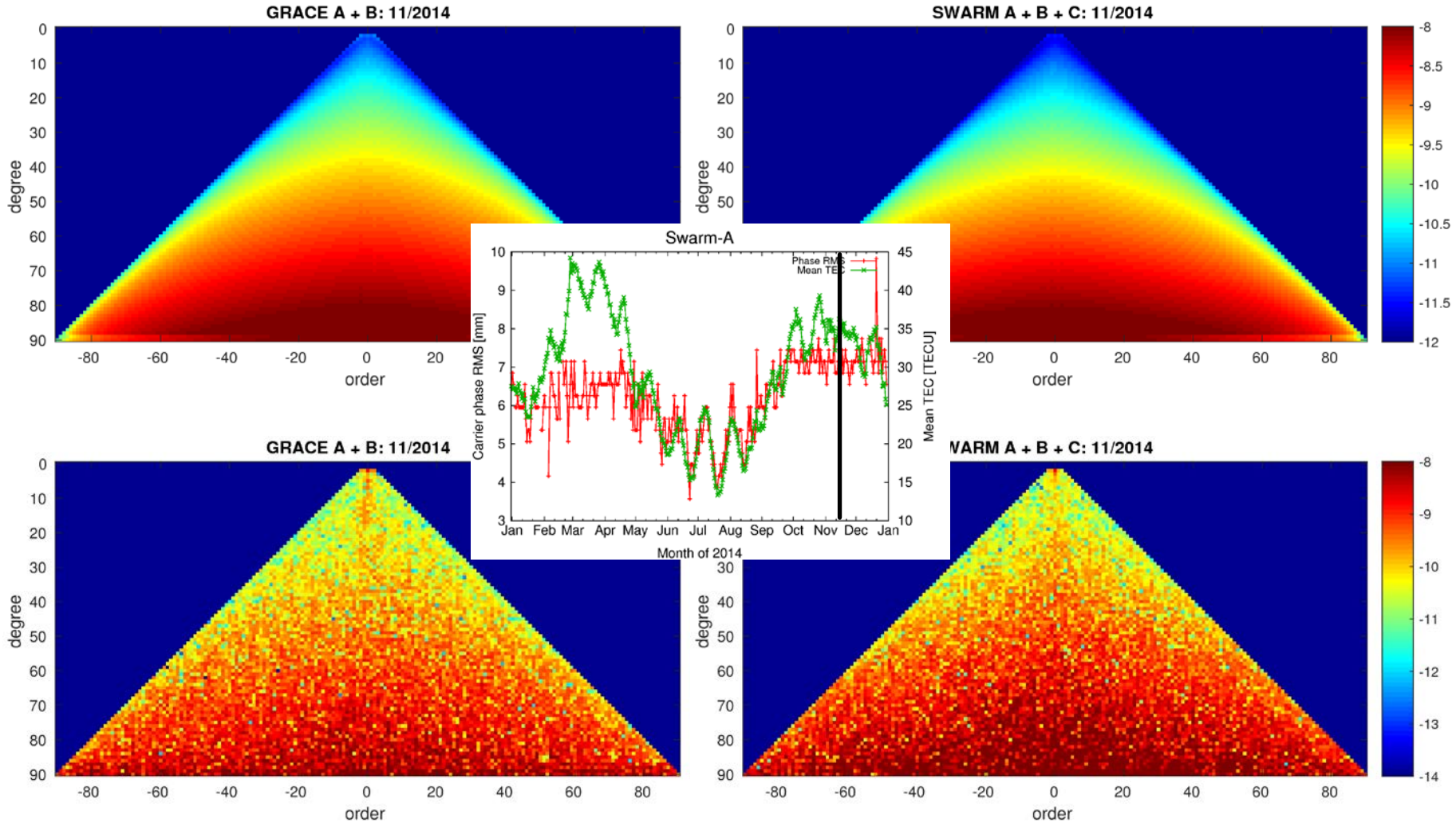

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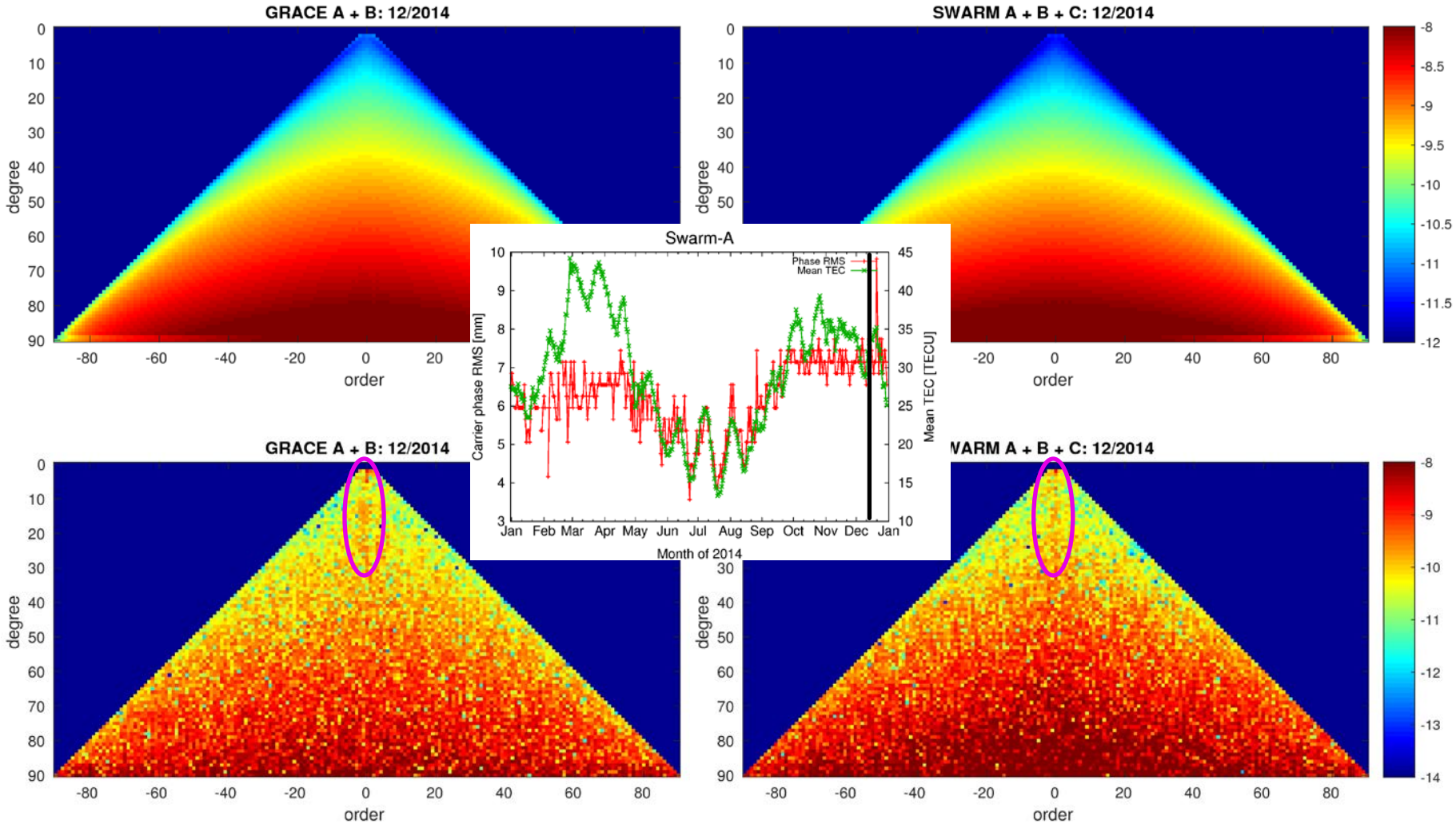

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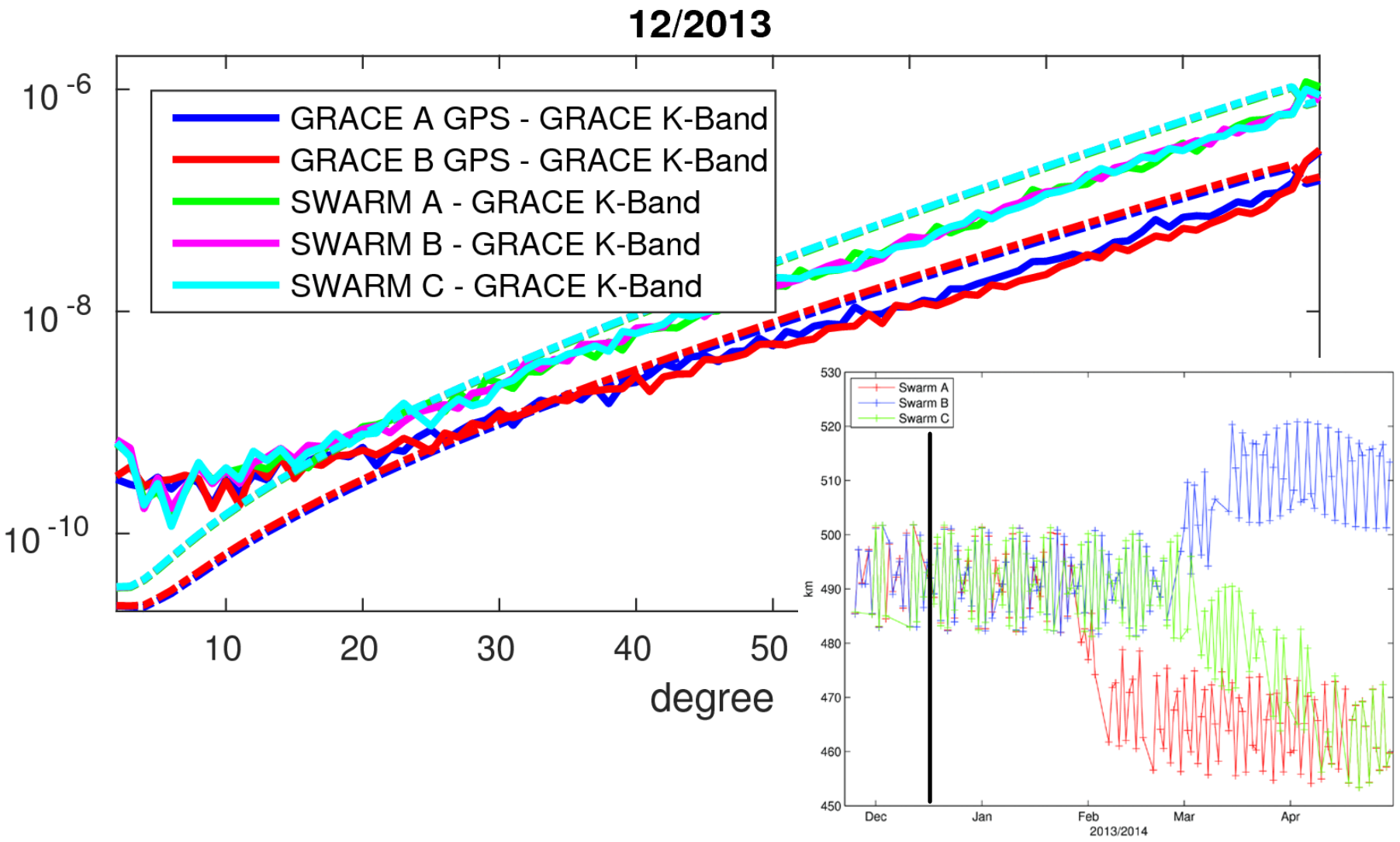

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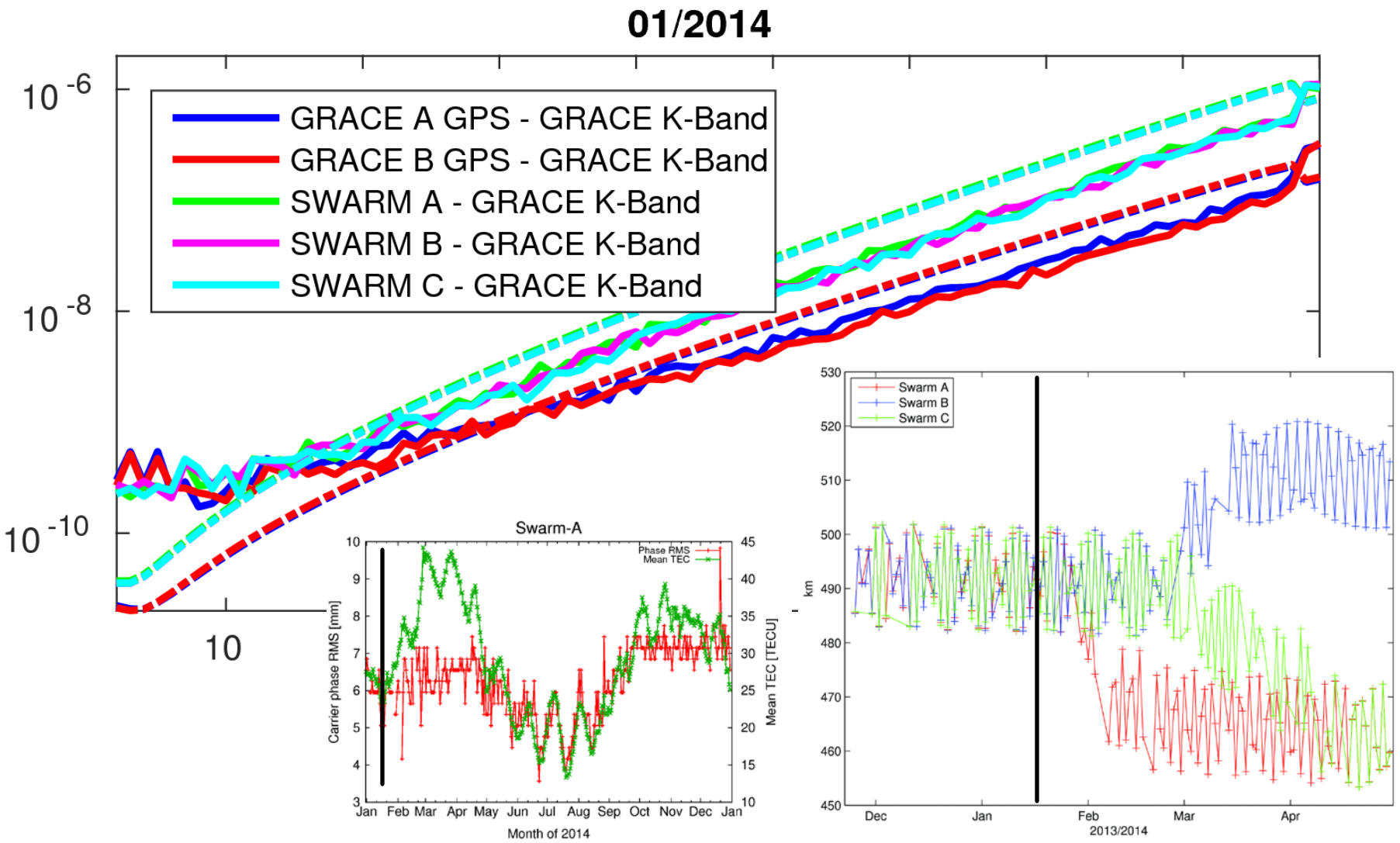

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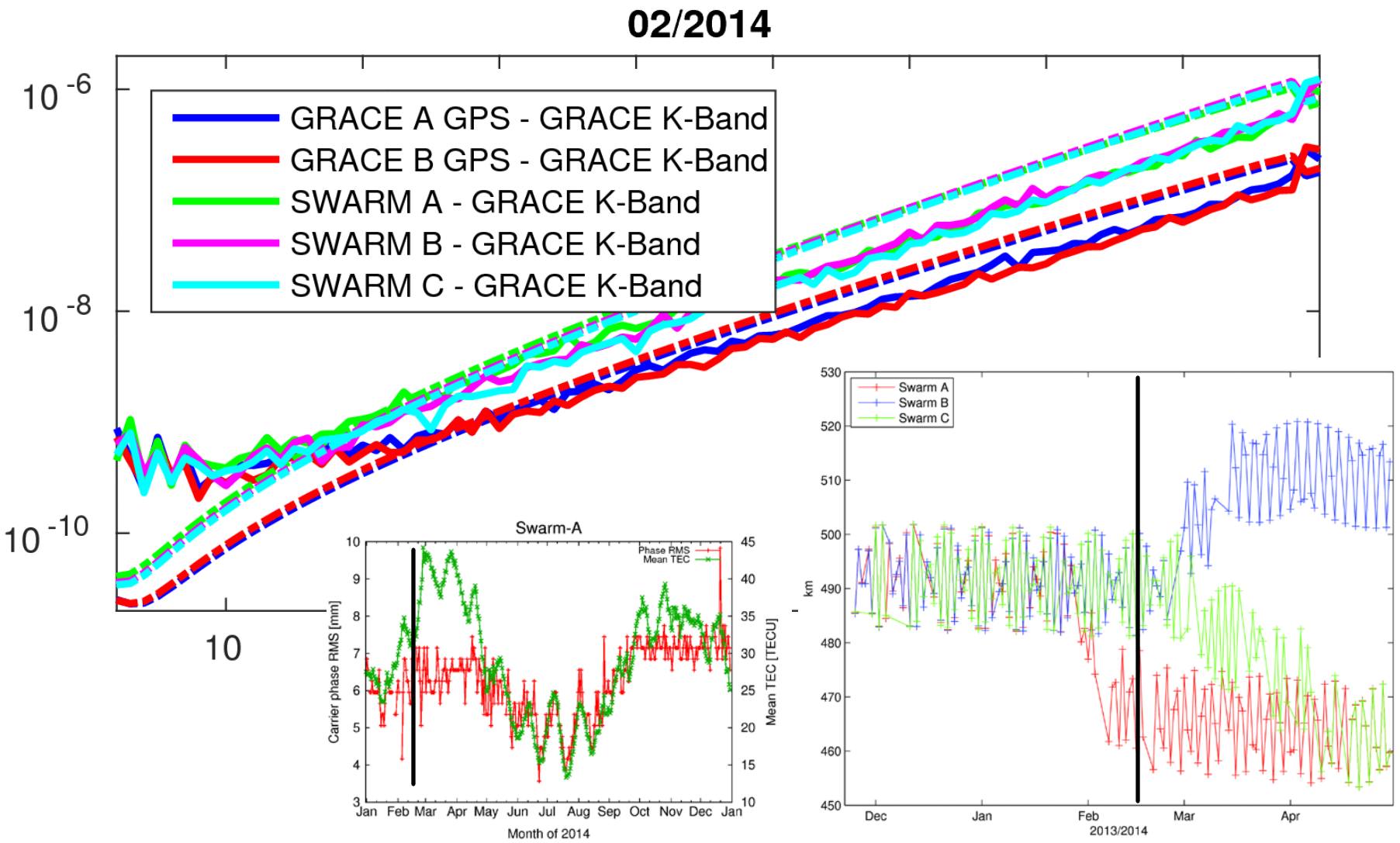

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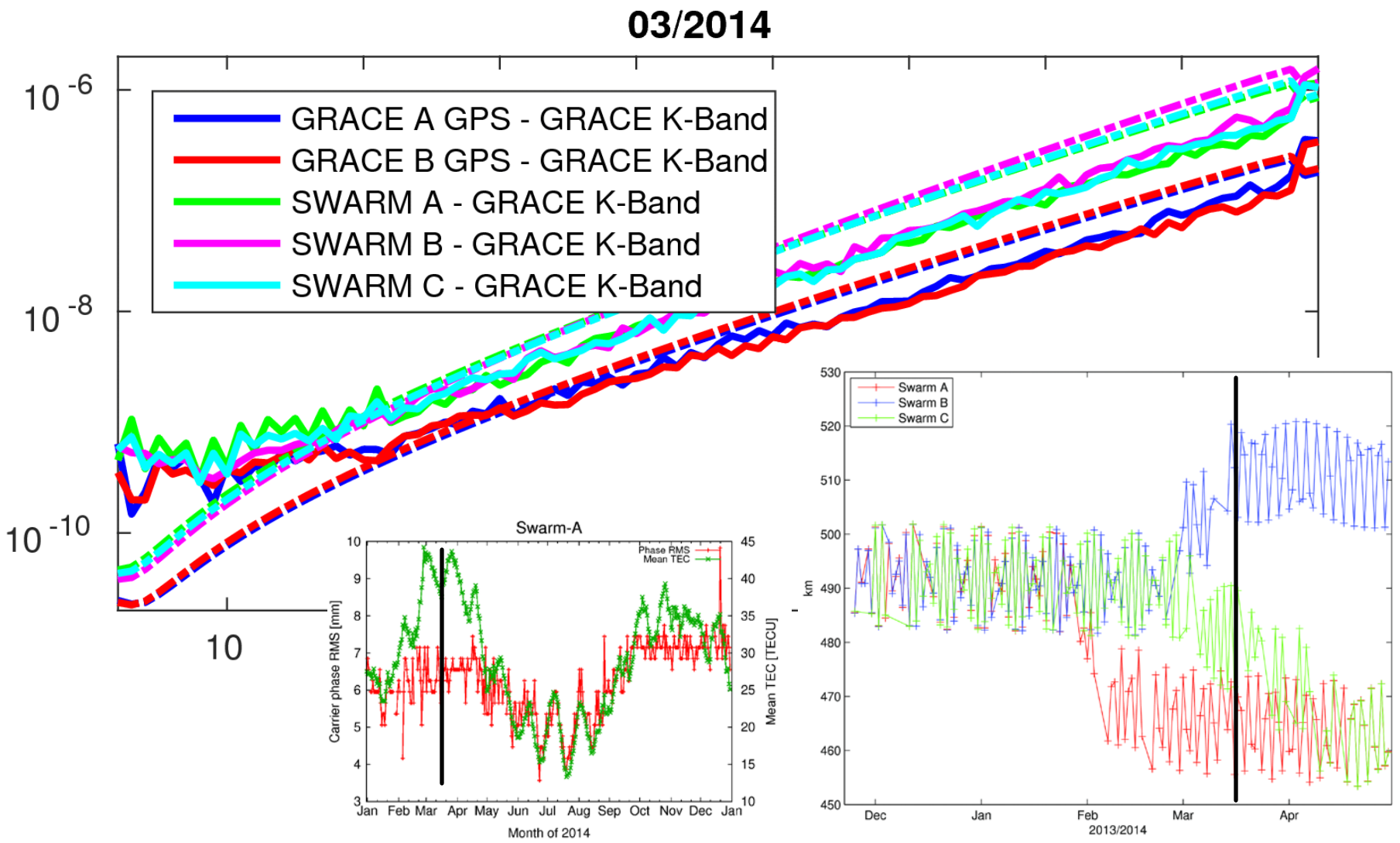

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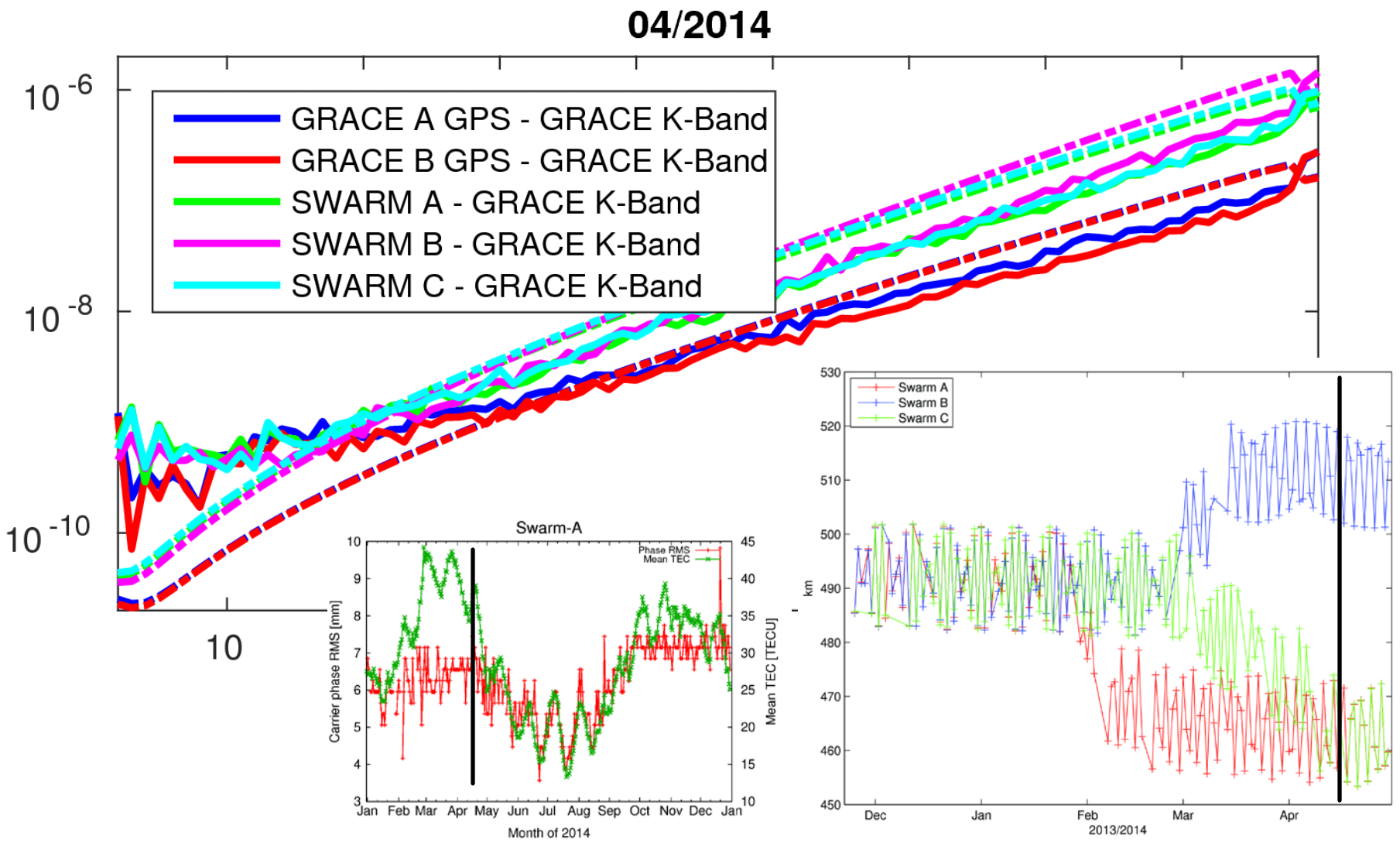

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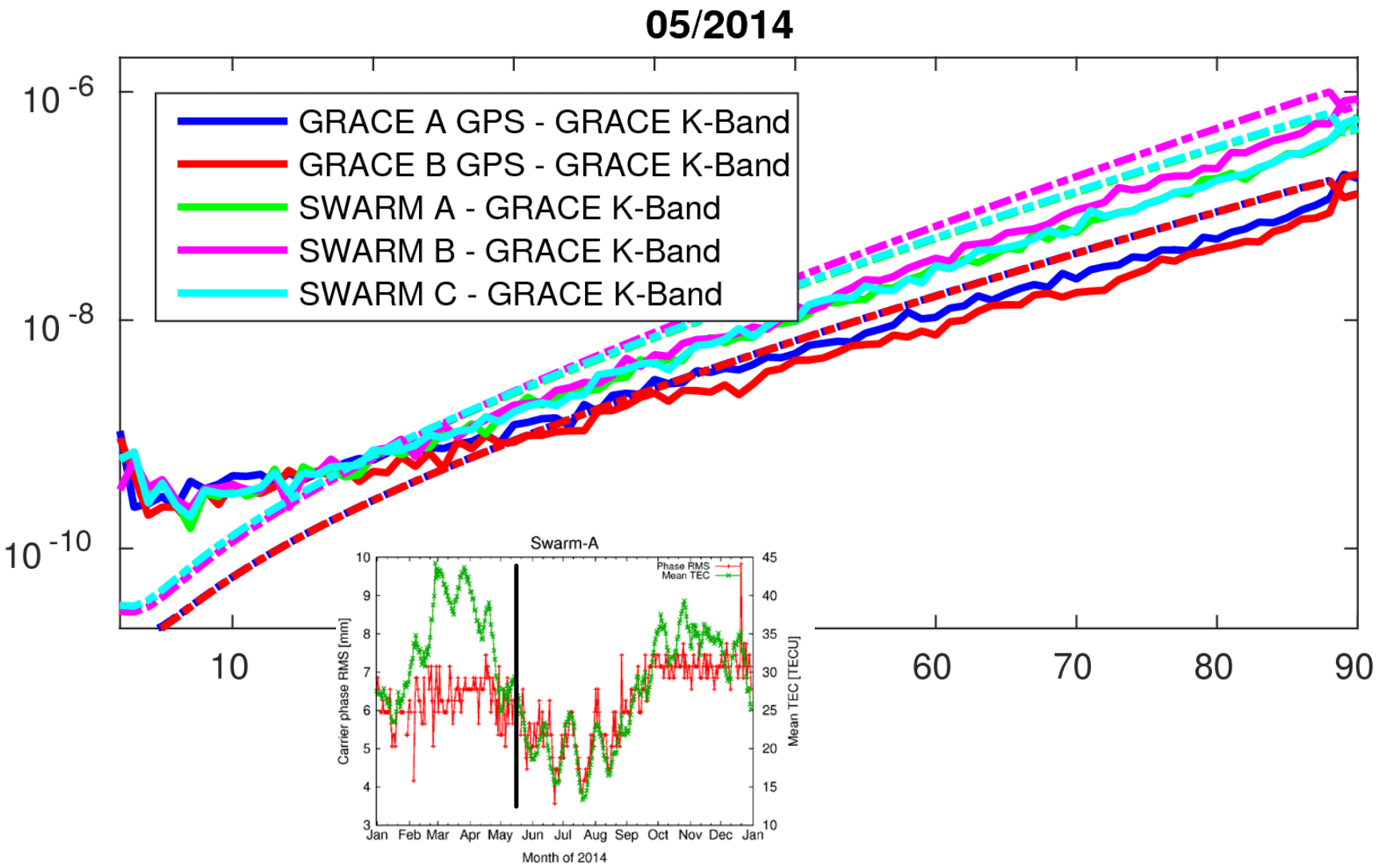

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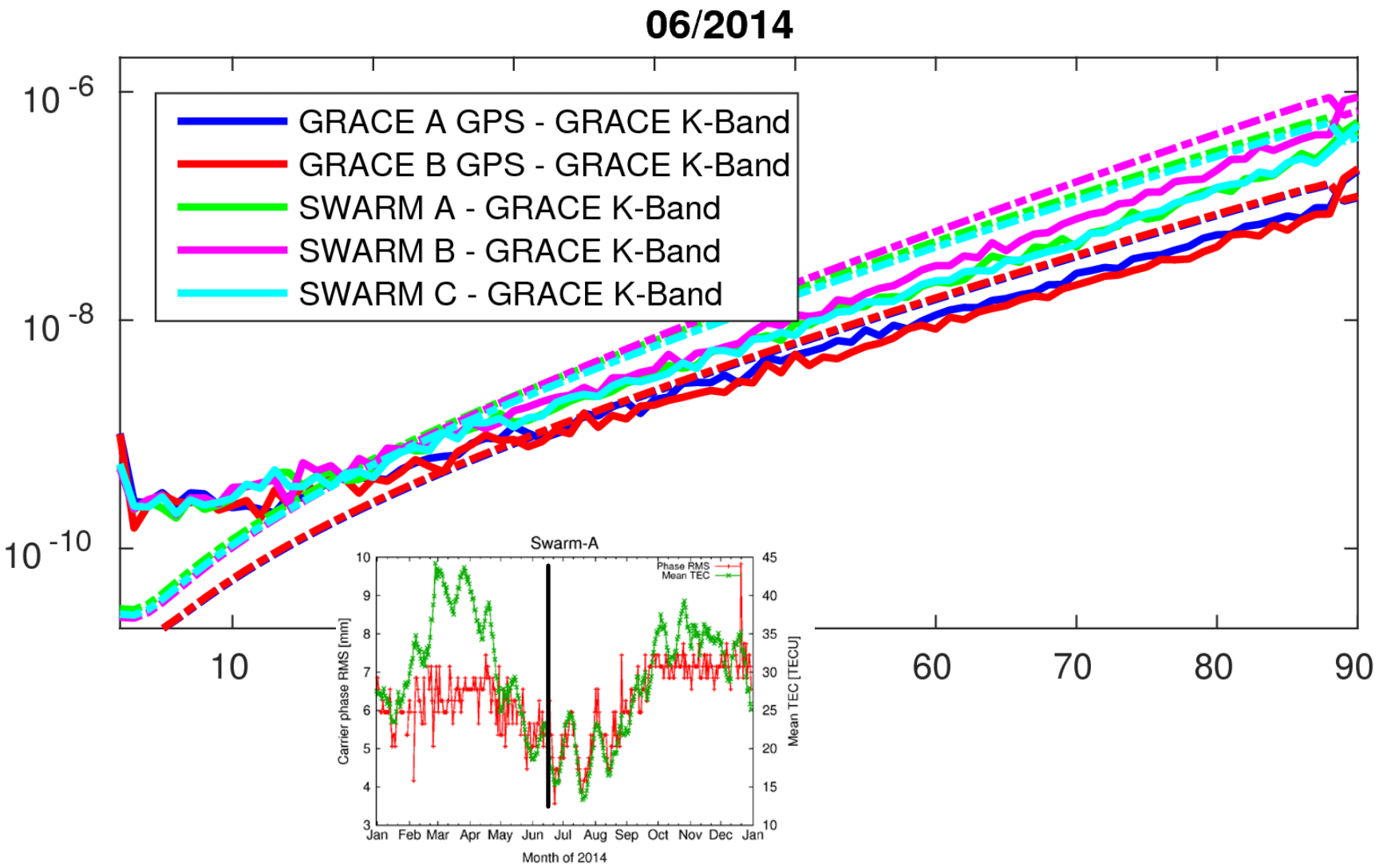

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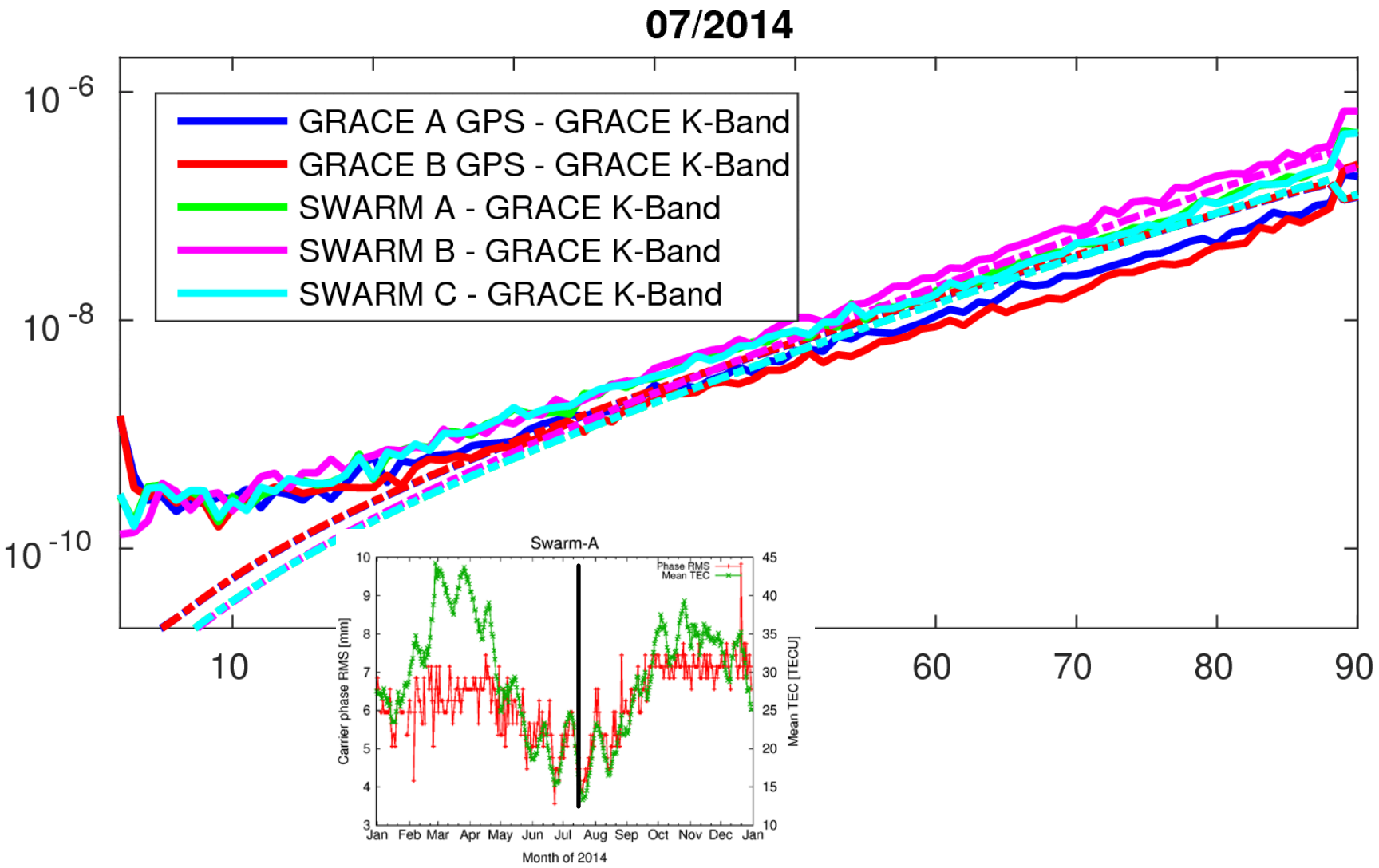

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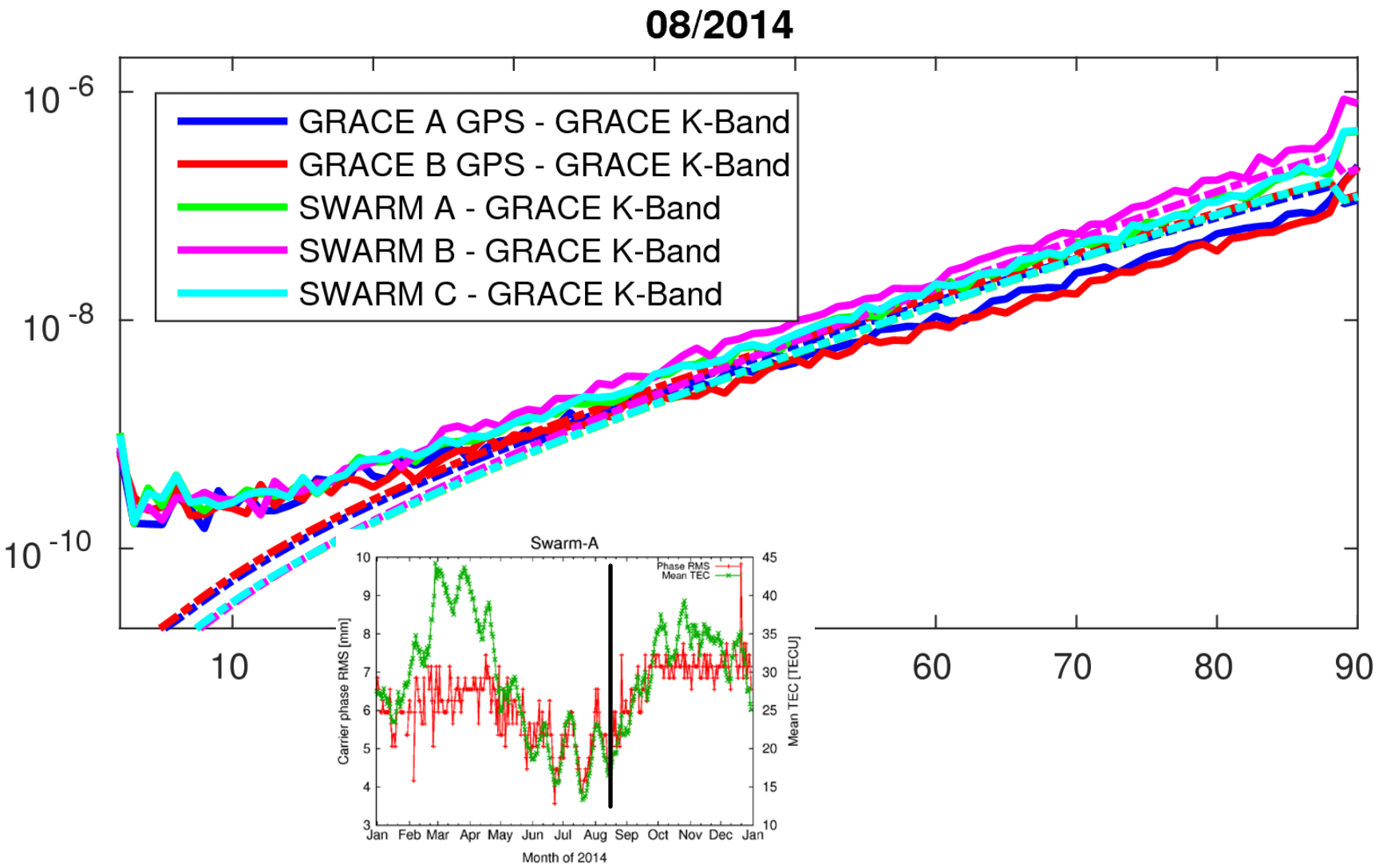

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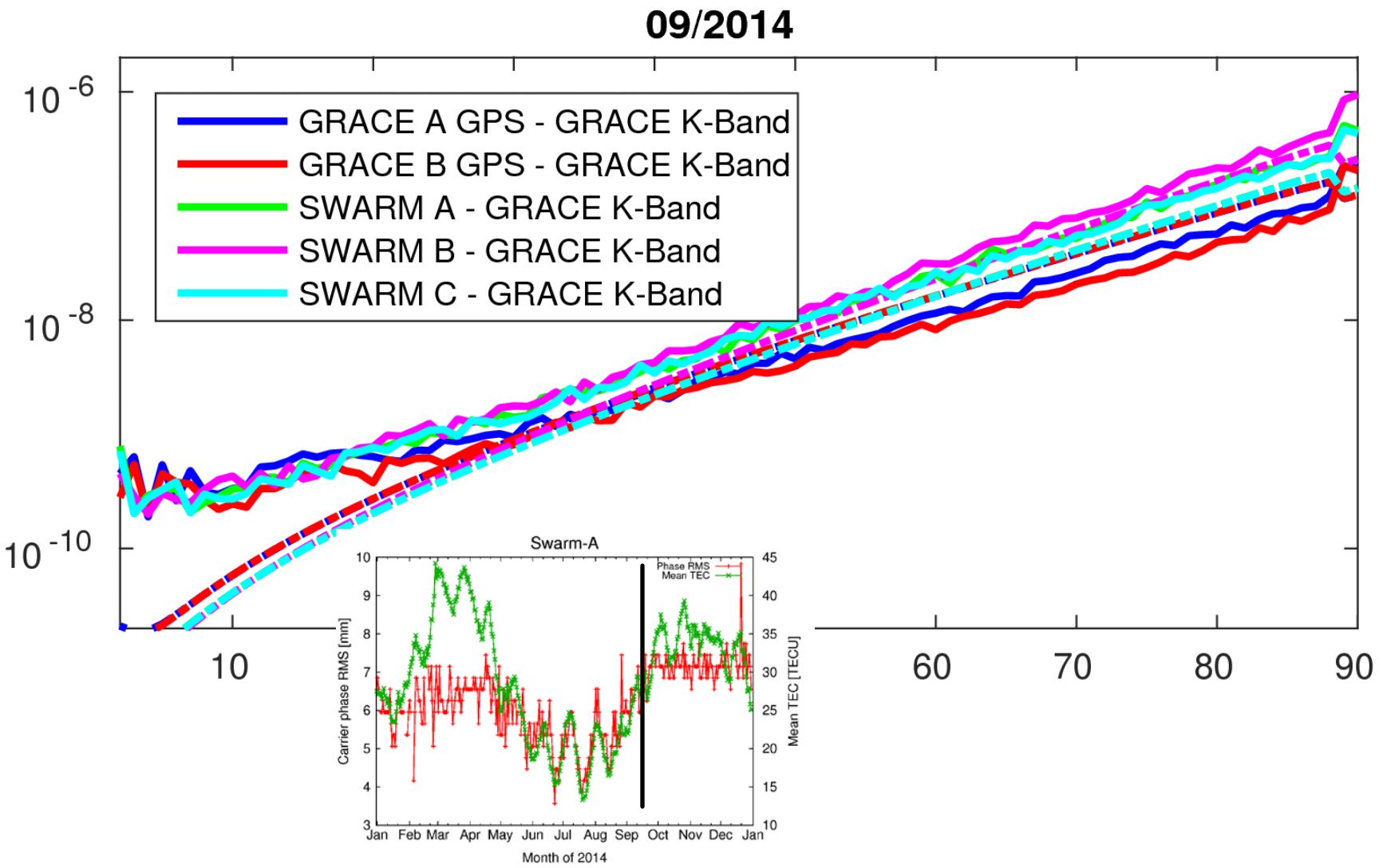

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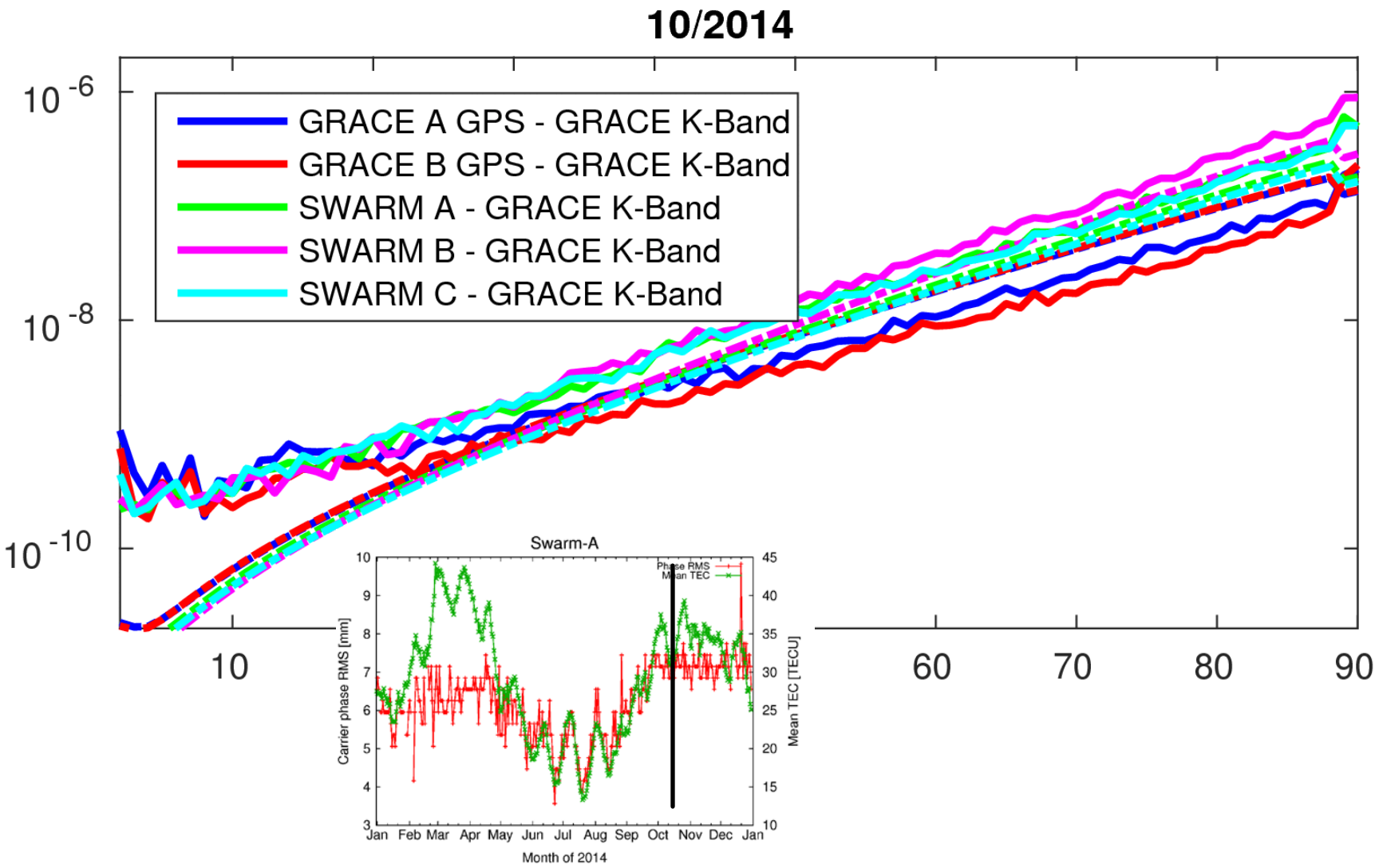

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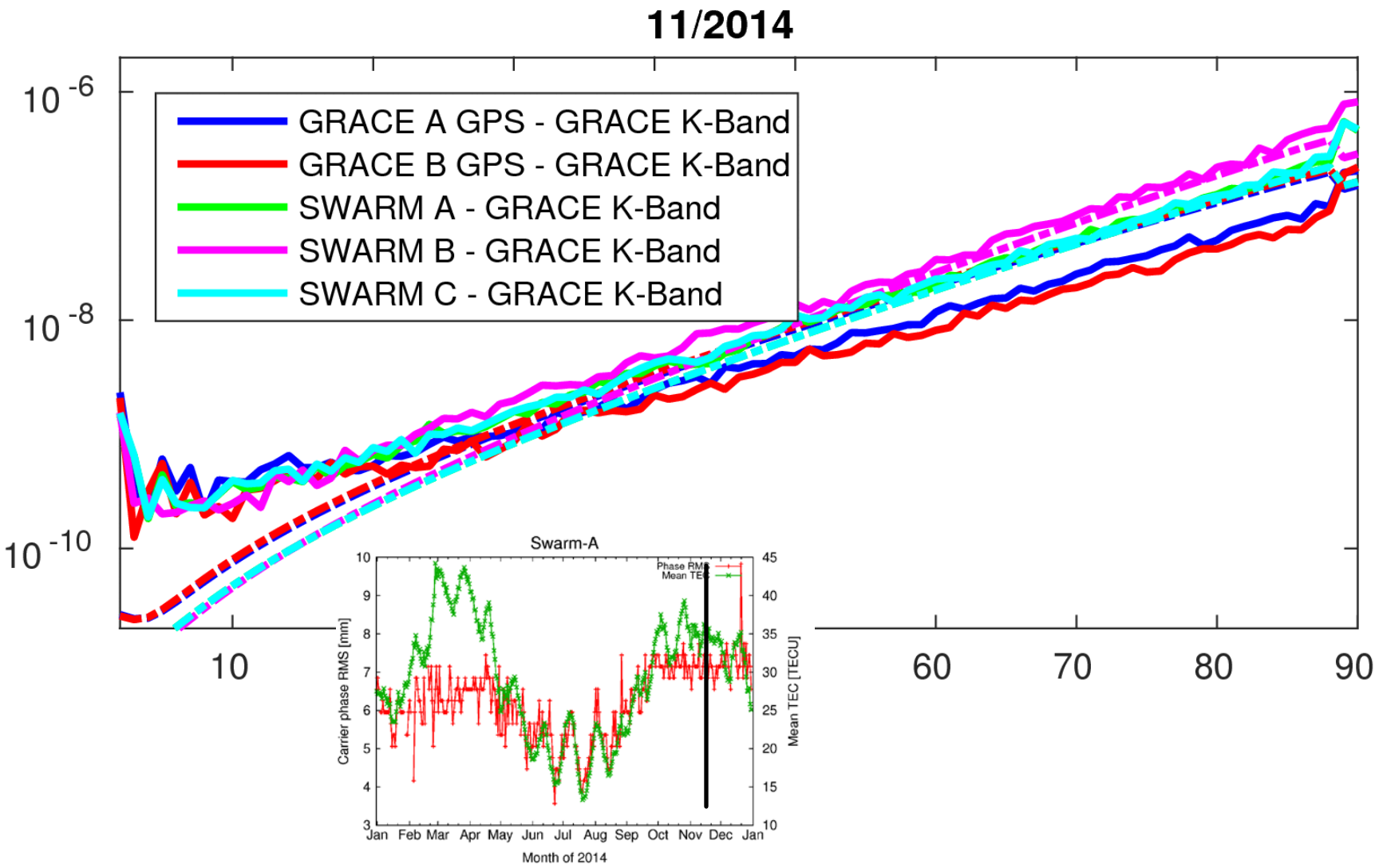

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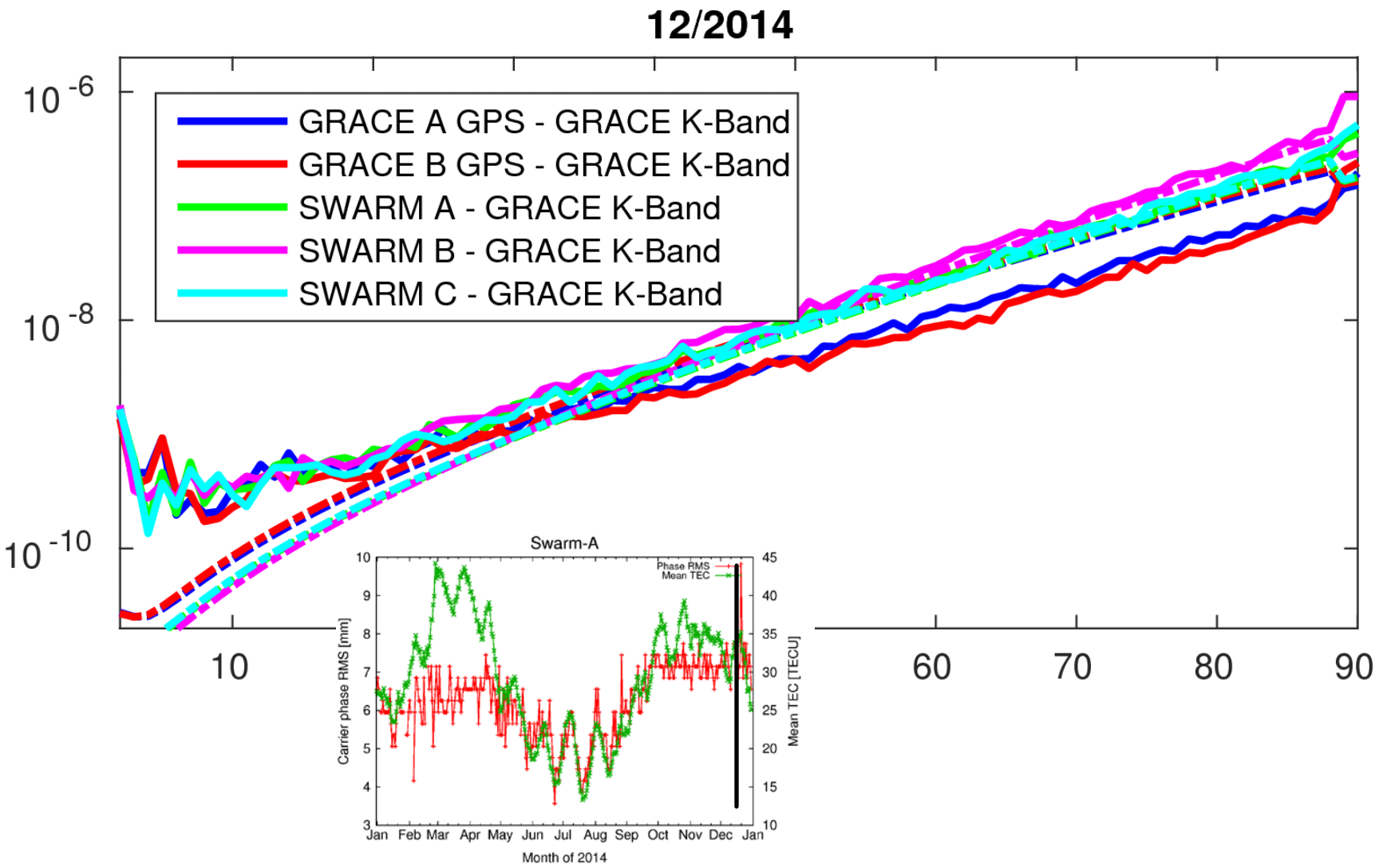
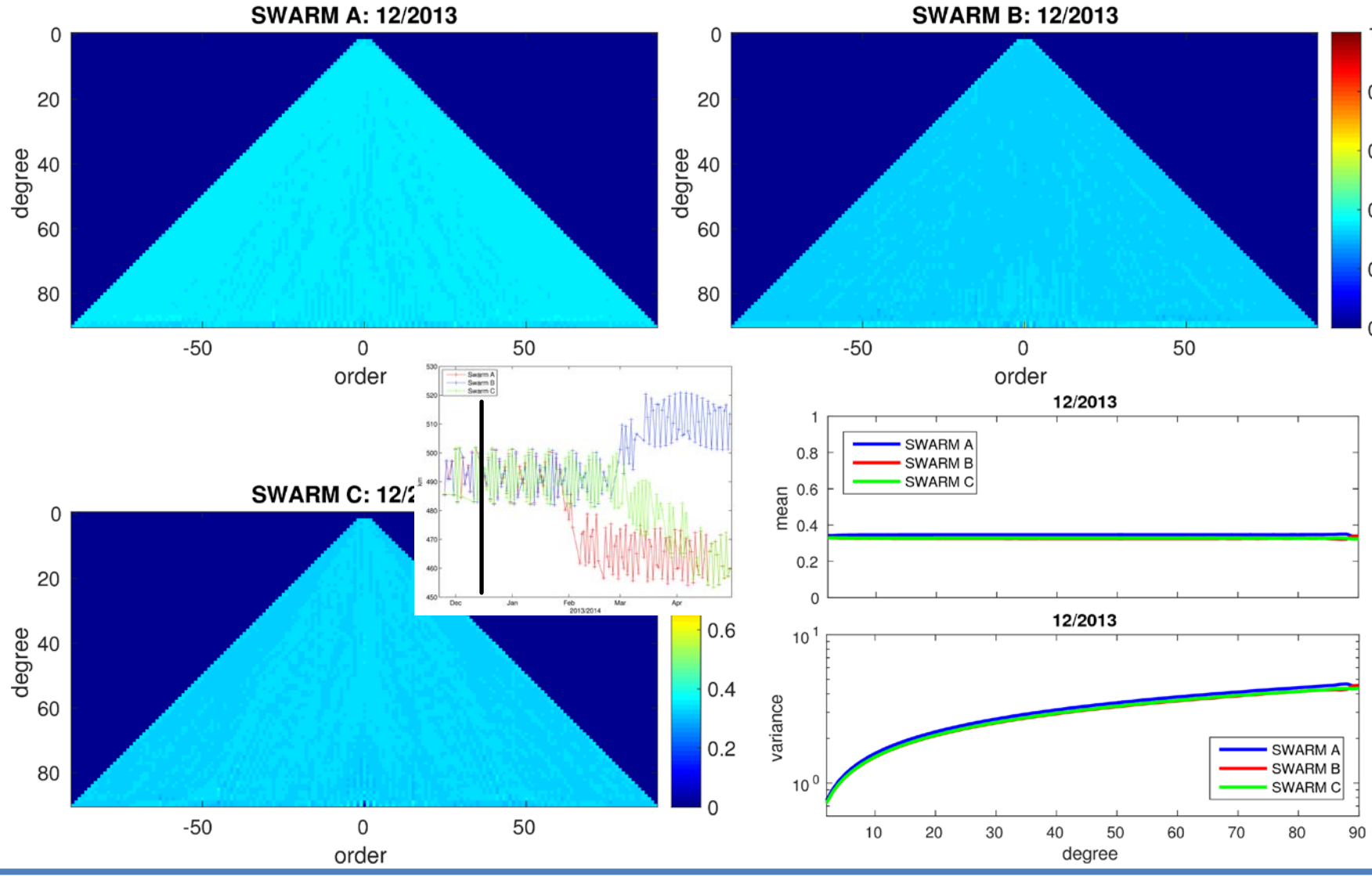


GRACE + SWARM: contribution analysis



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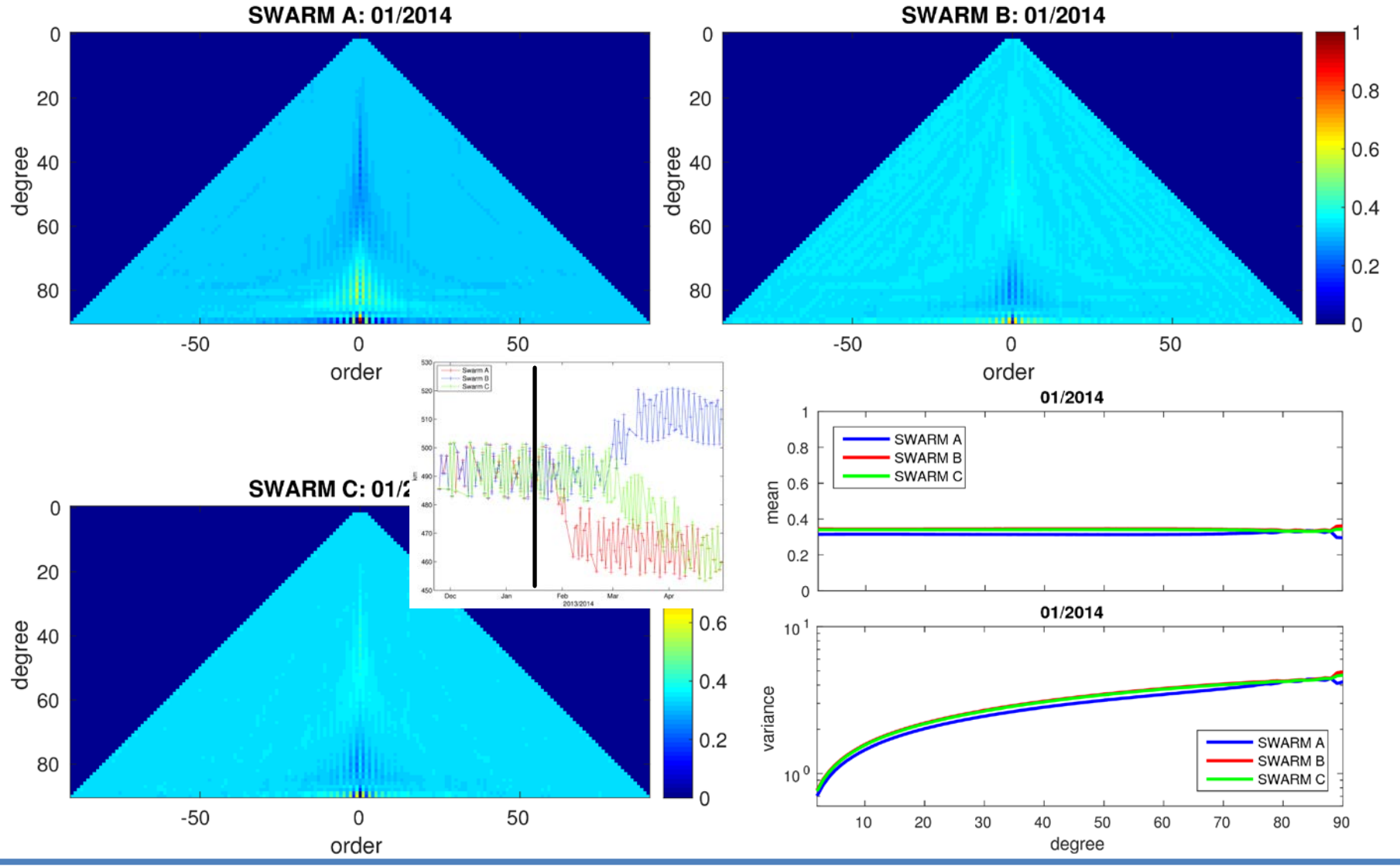

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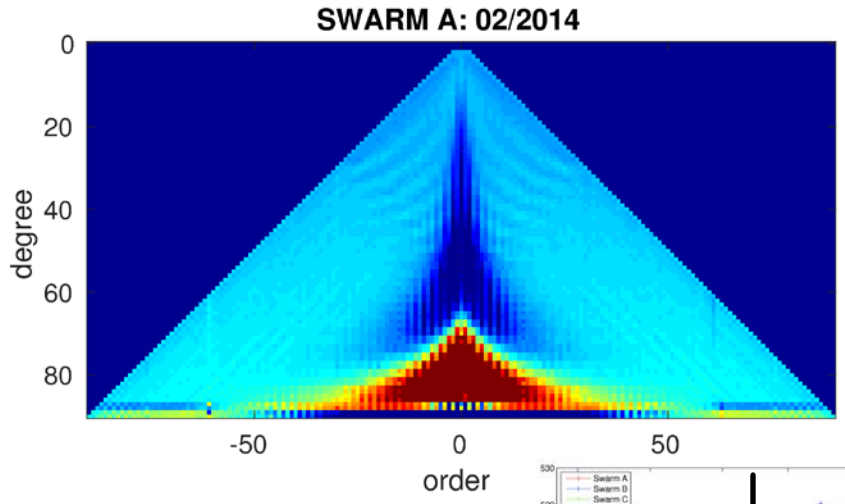

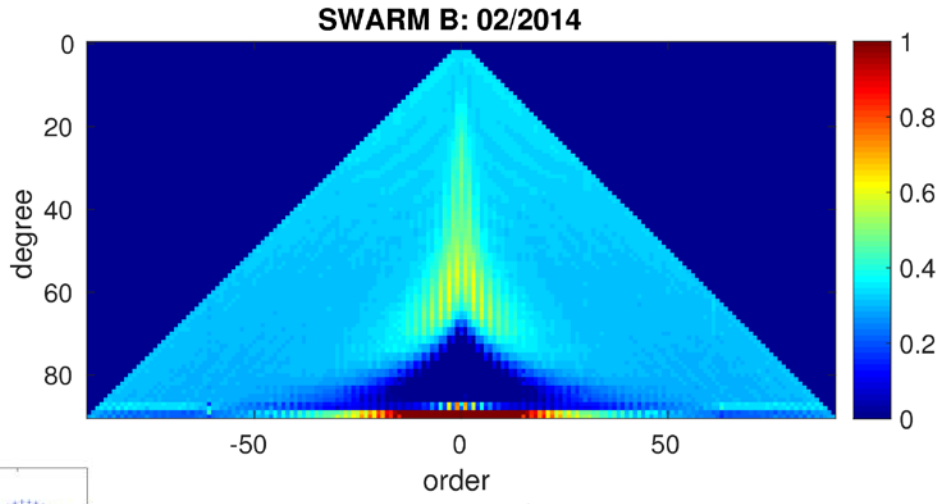

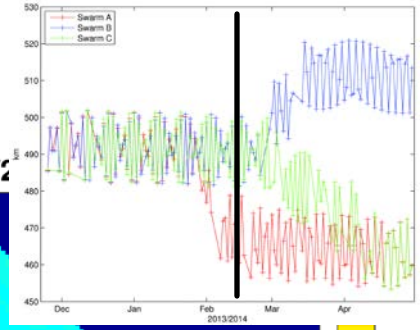

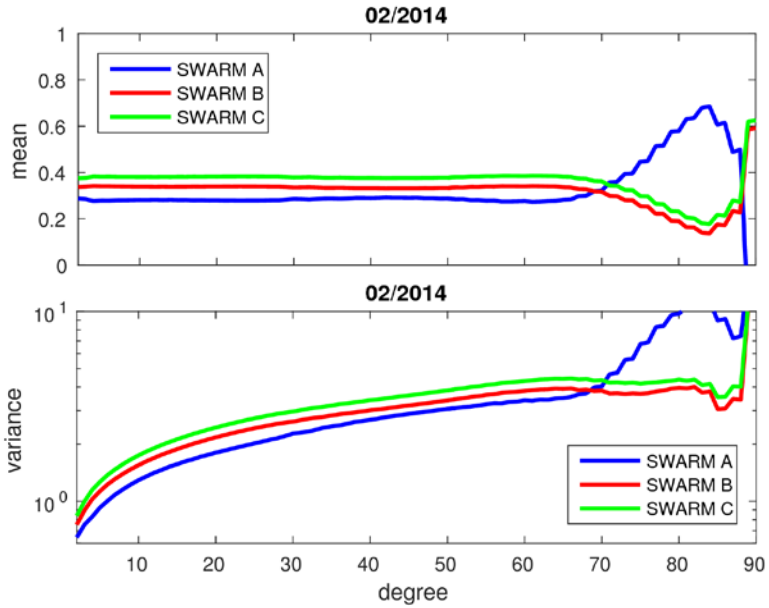

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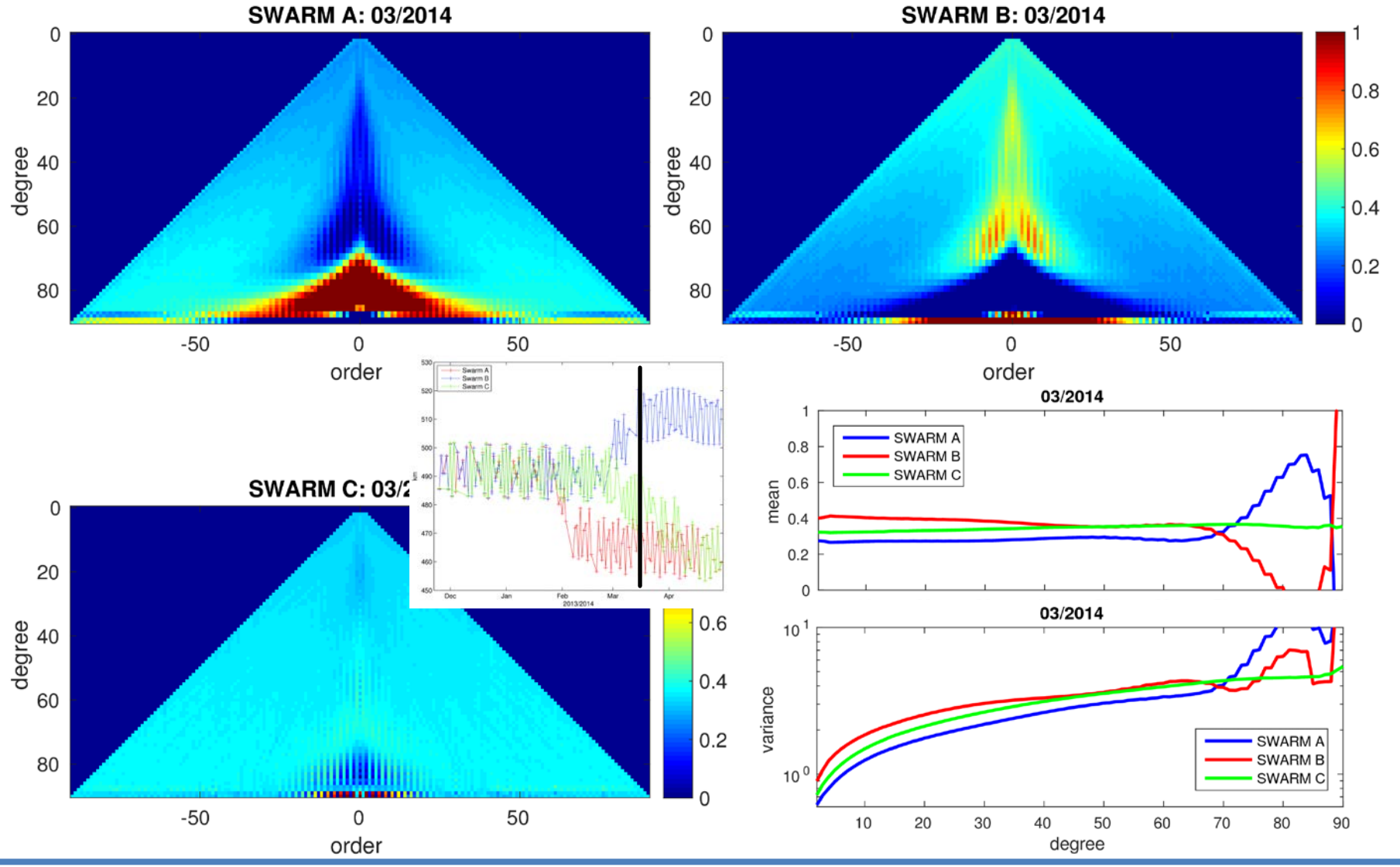

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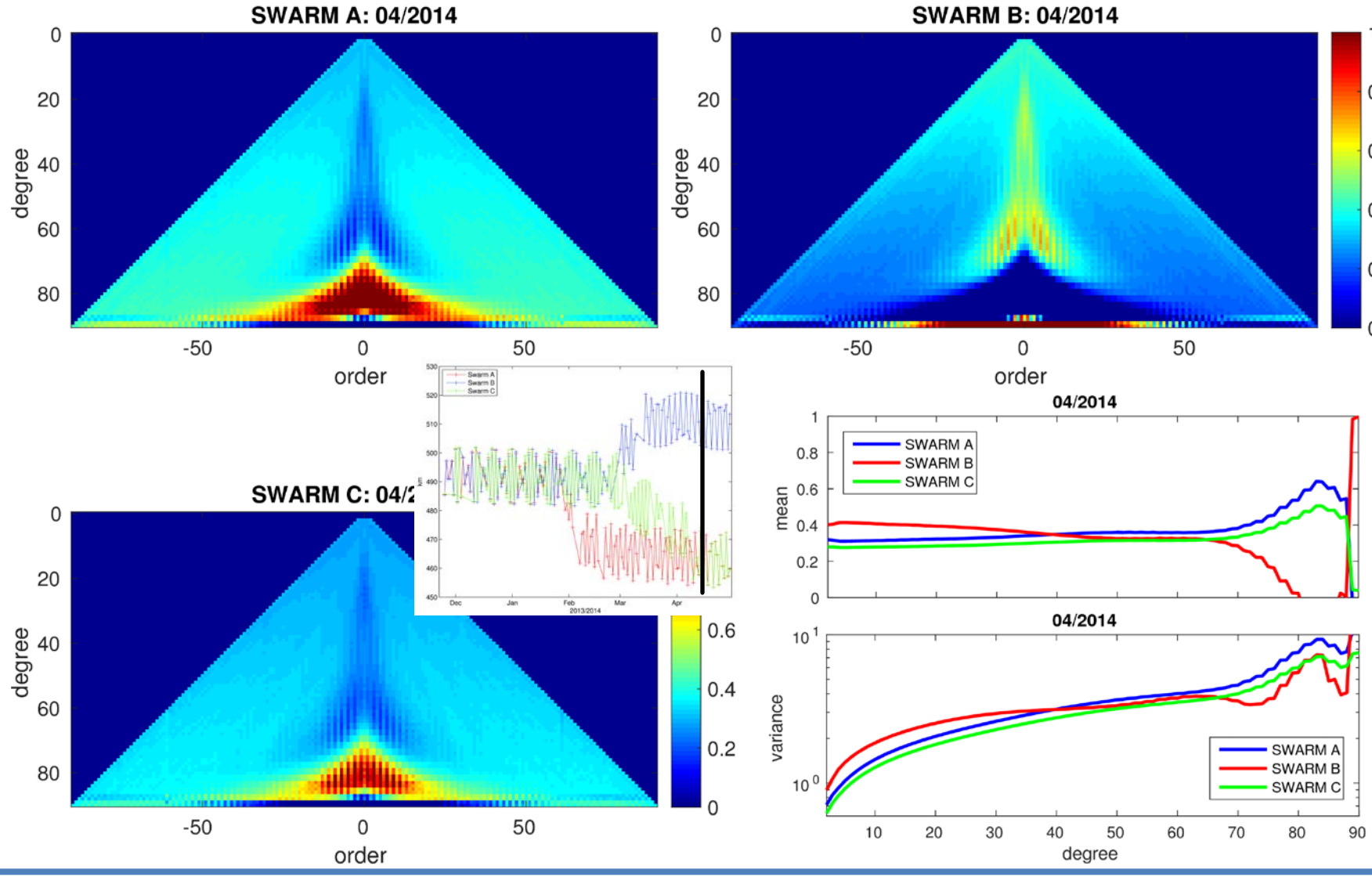

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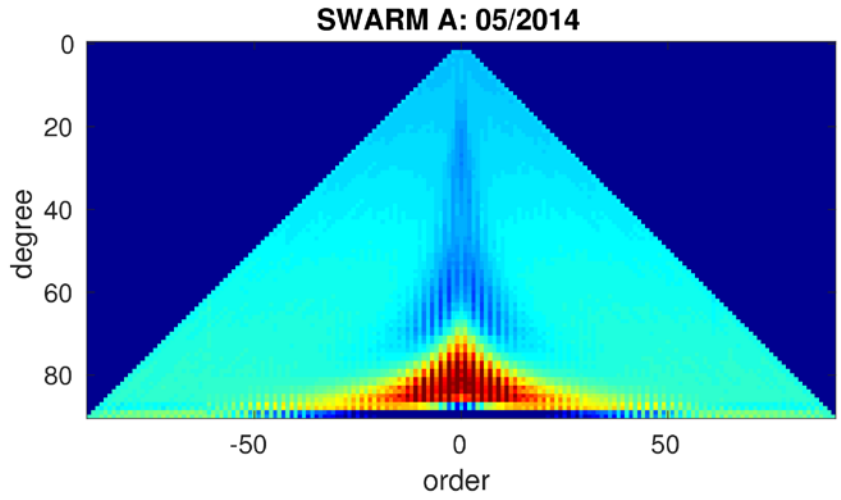

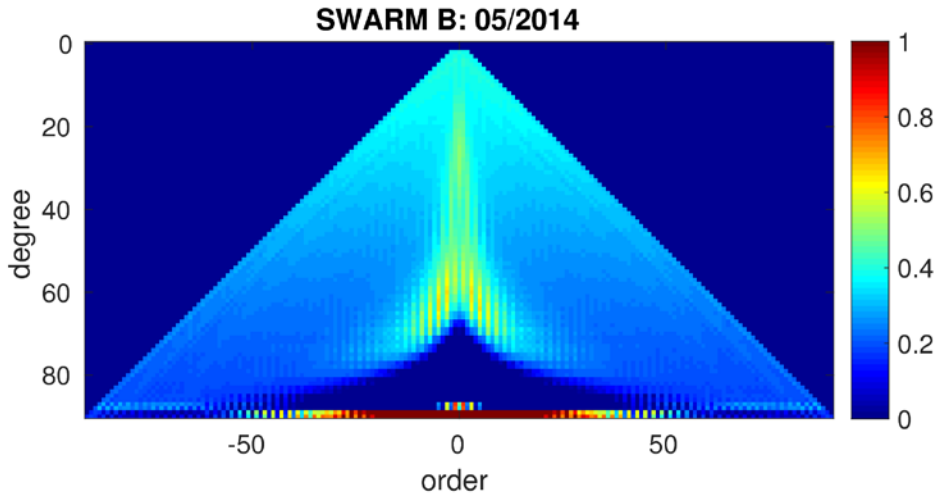

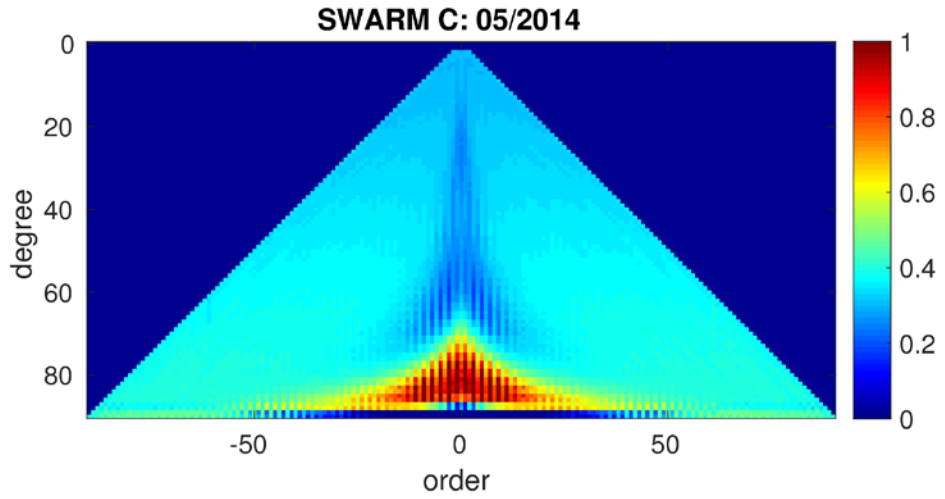

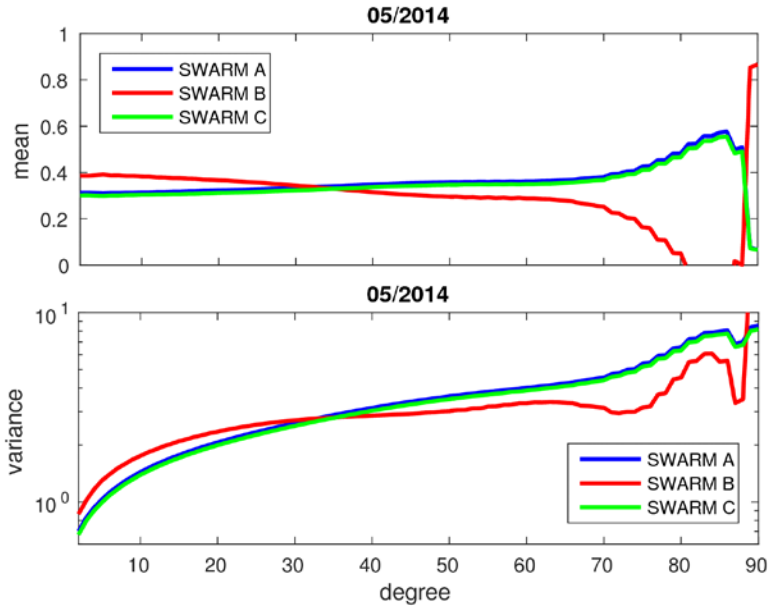

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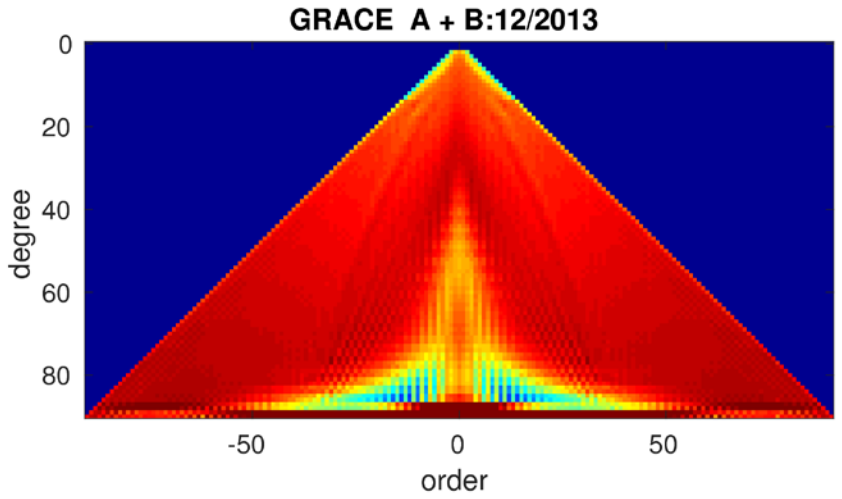

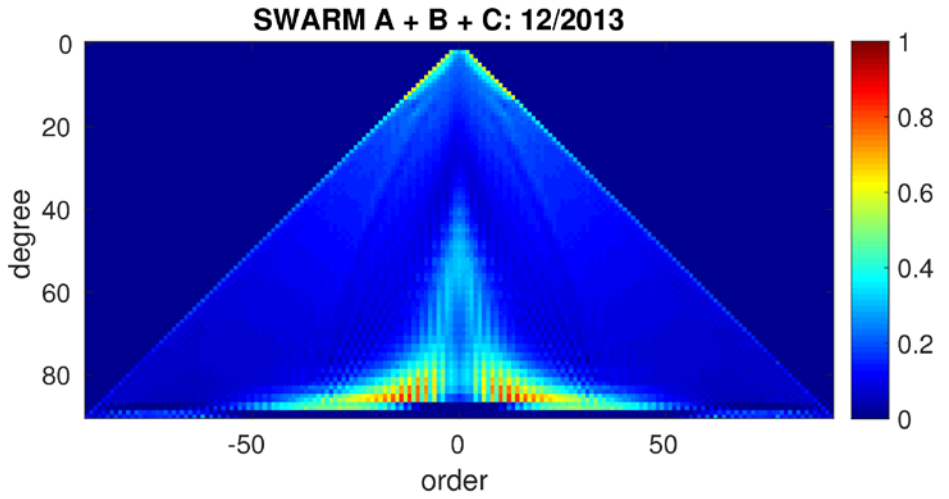

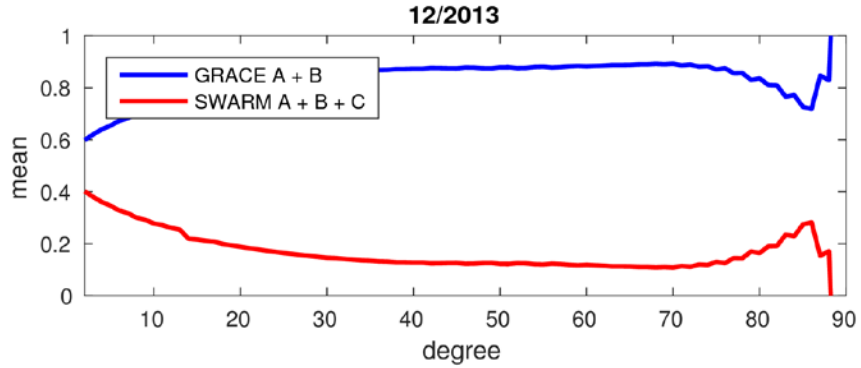

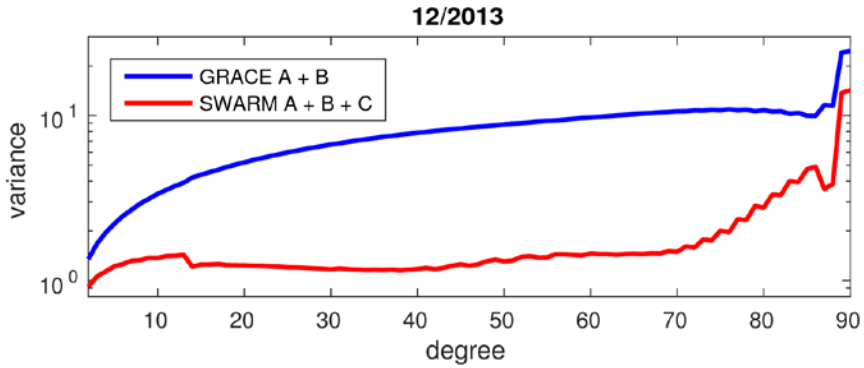

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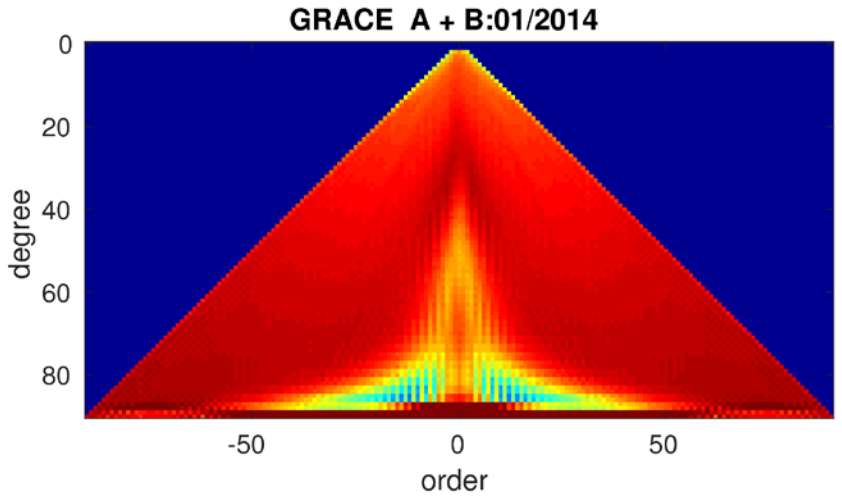

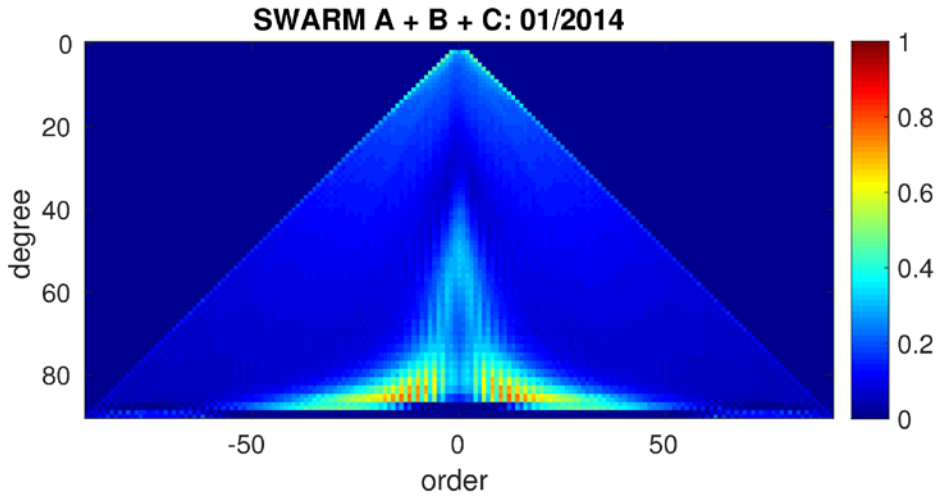

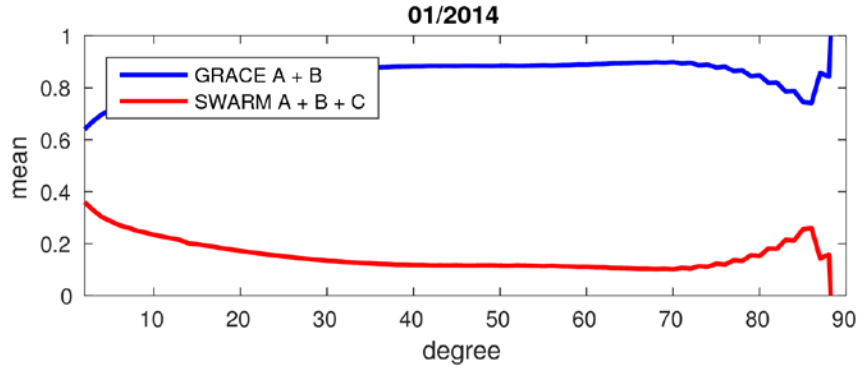

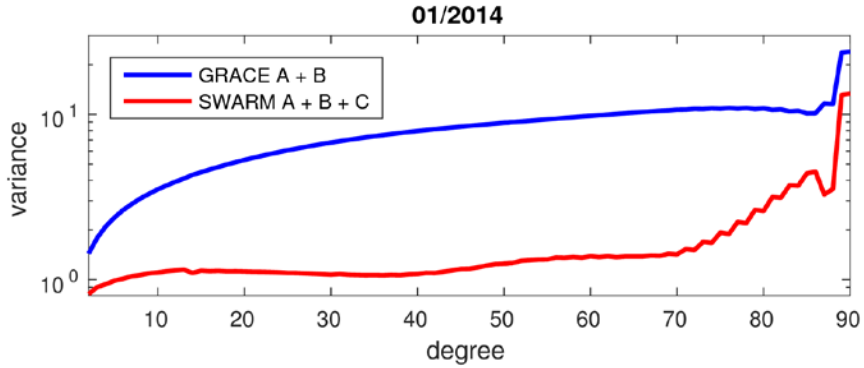

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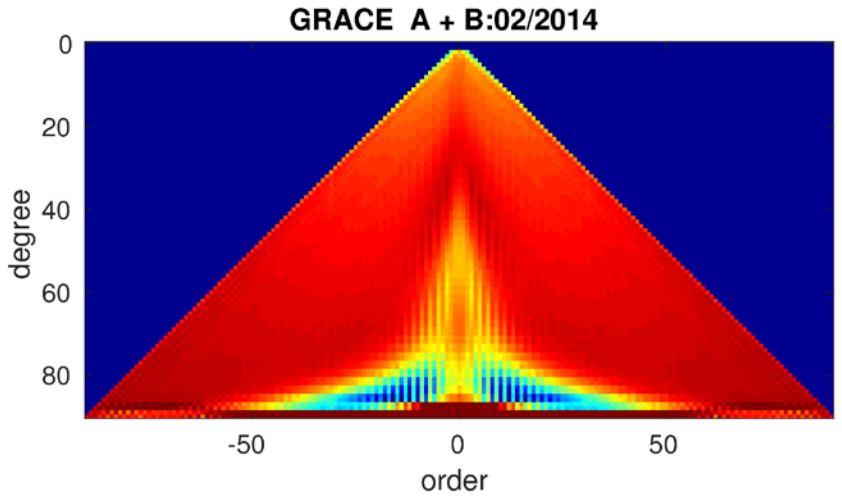

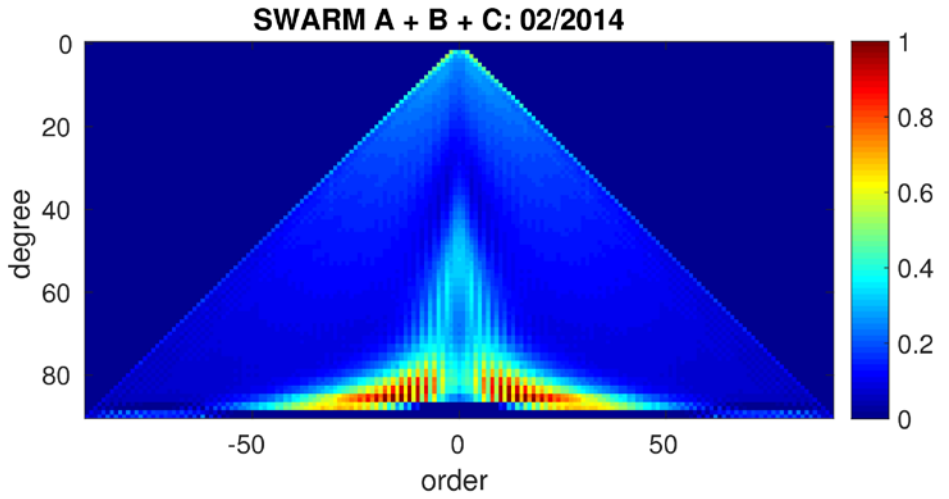

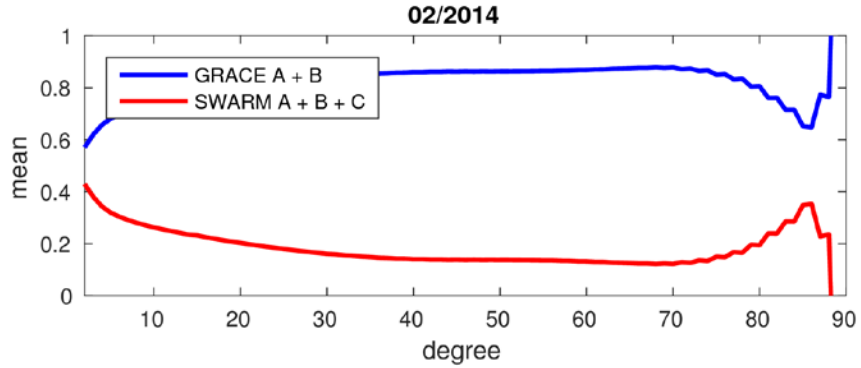

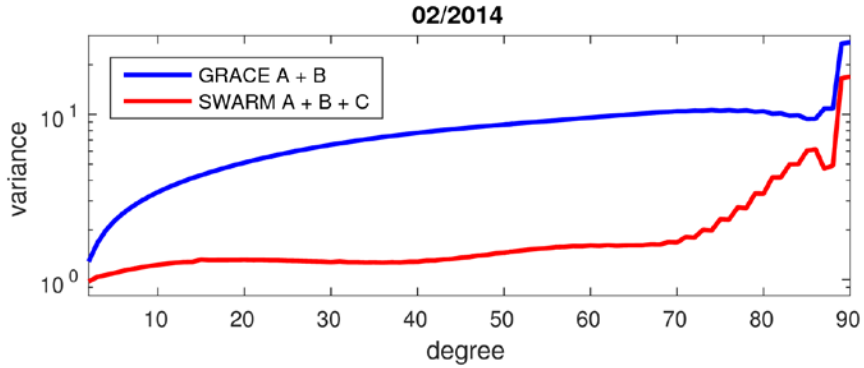

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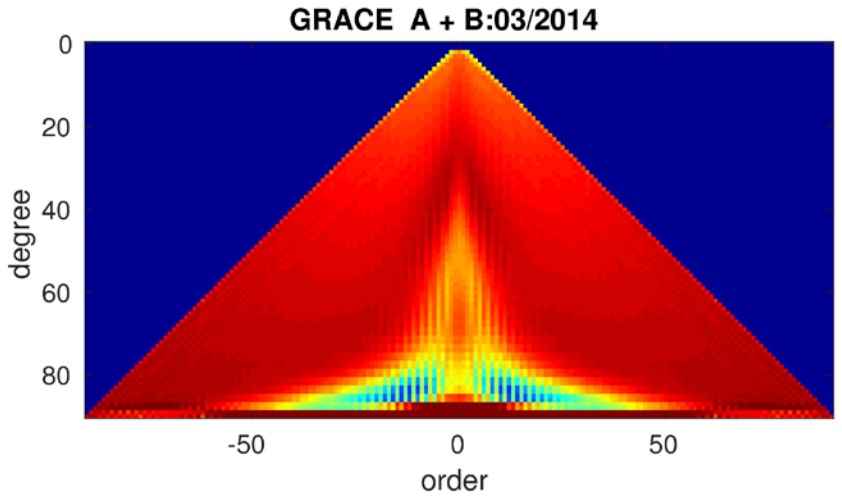
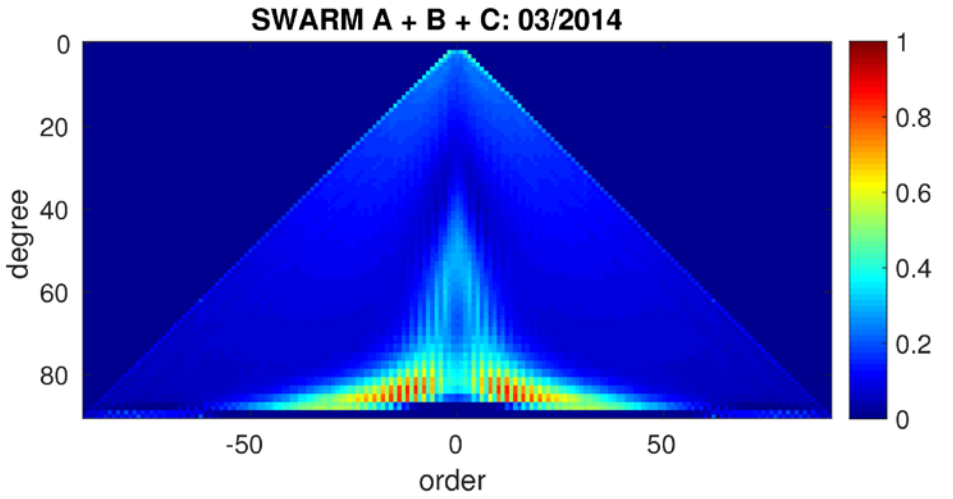
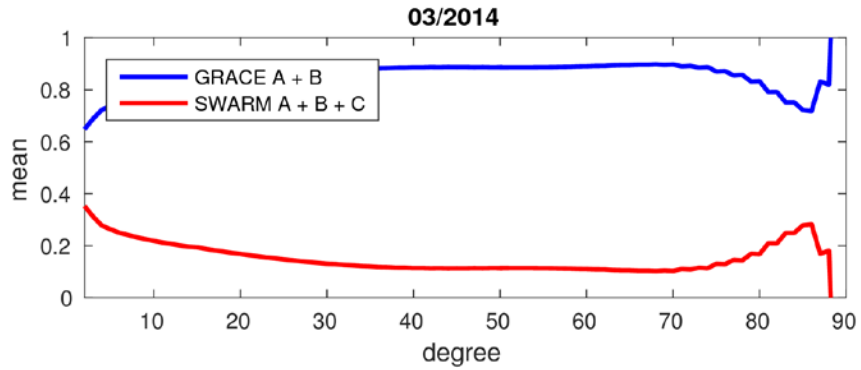
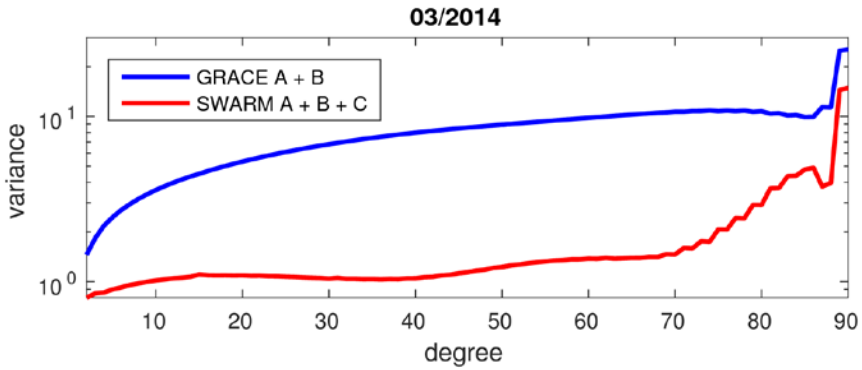
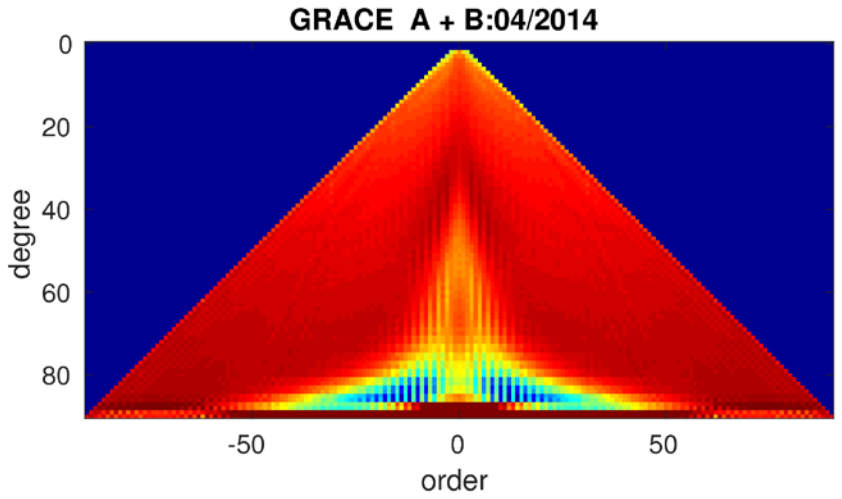


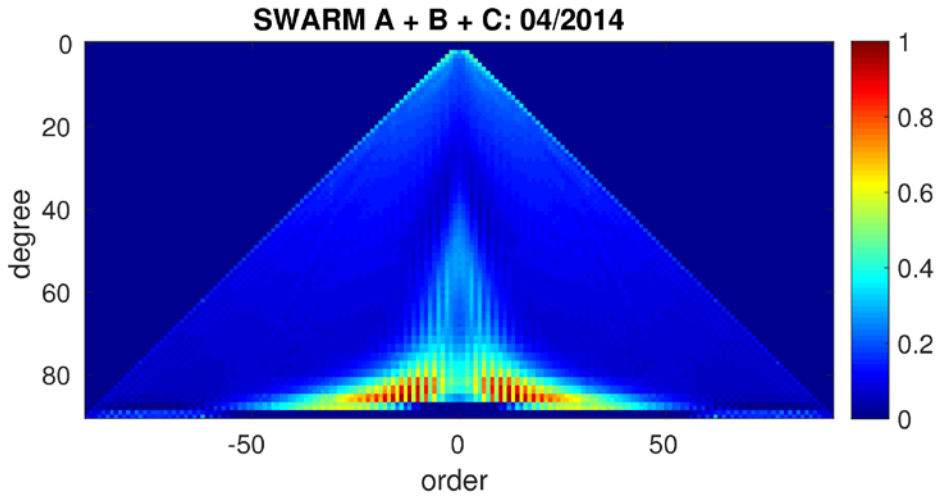


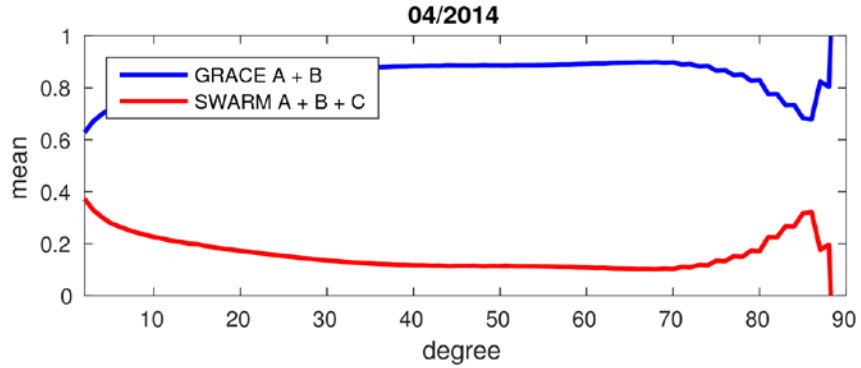


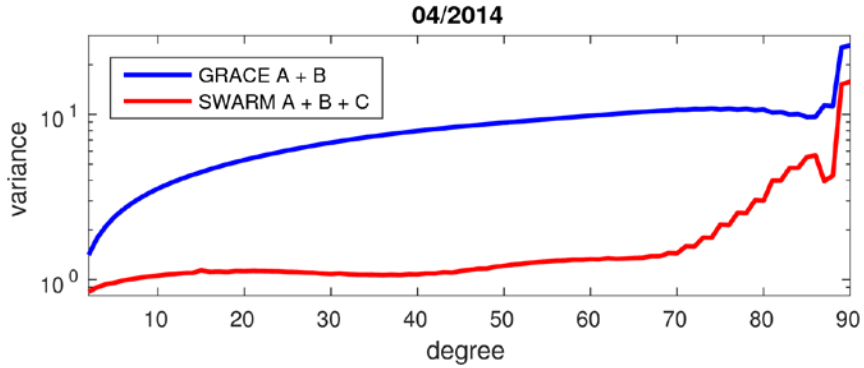


GRACE + SWARM: contribution analysis









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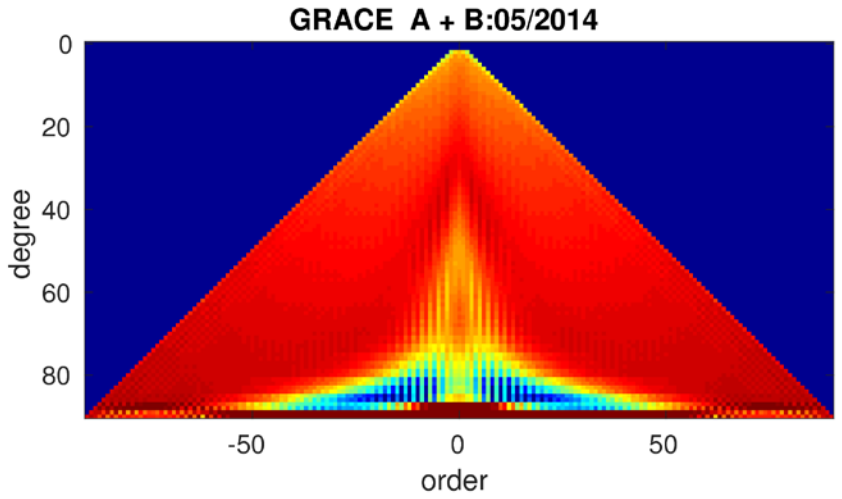

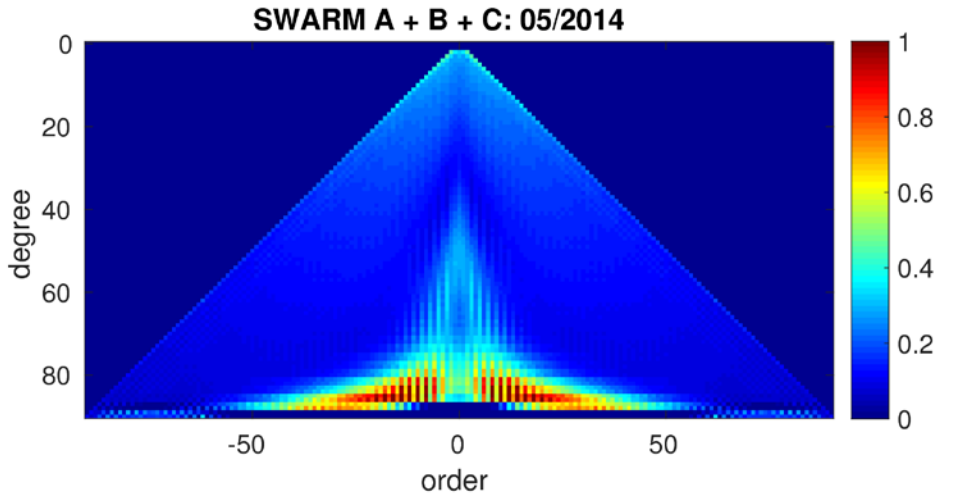

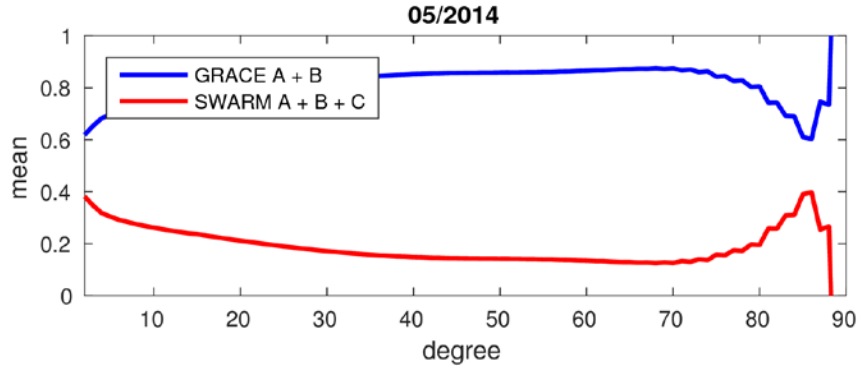

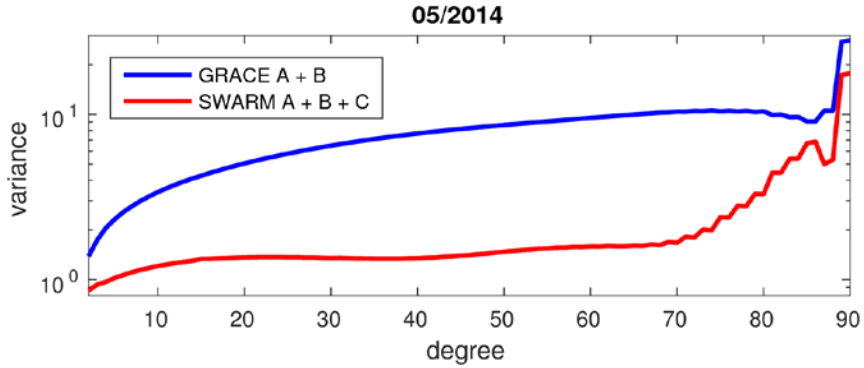

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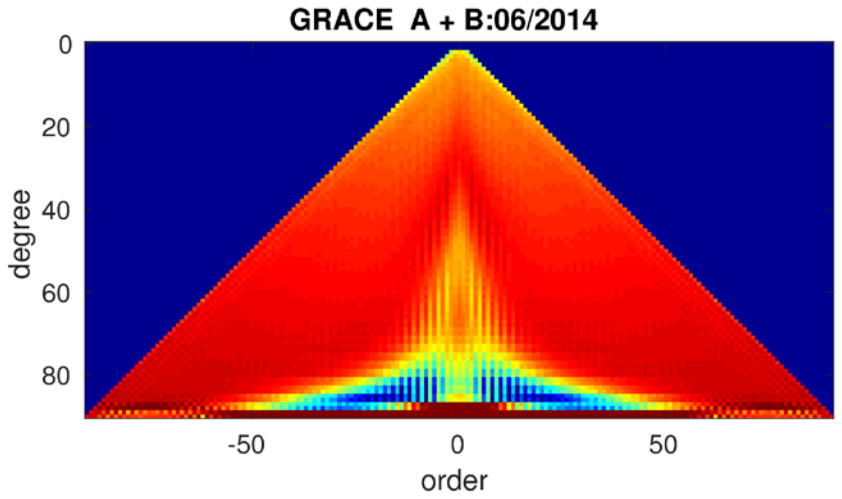

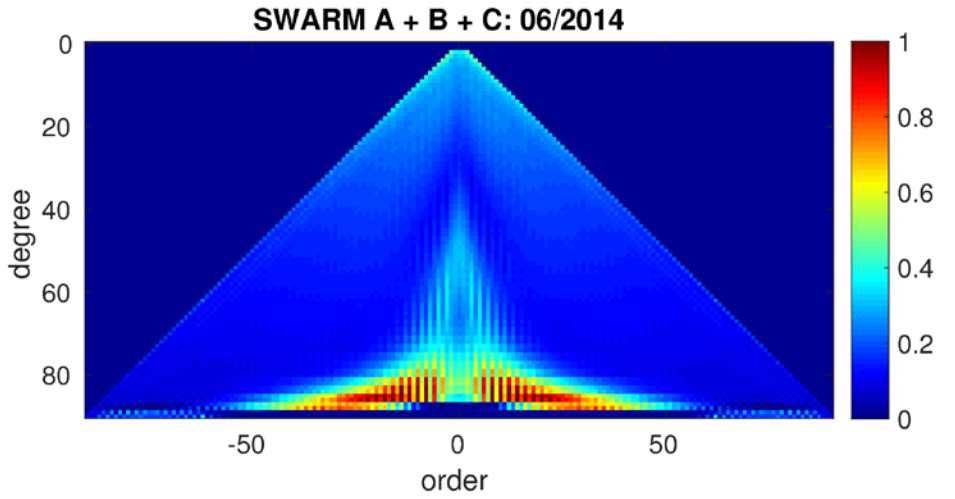

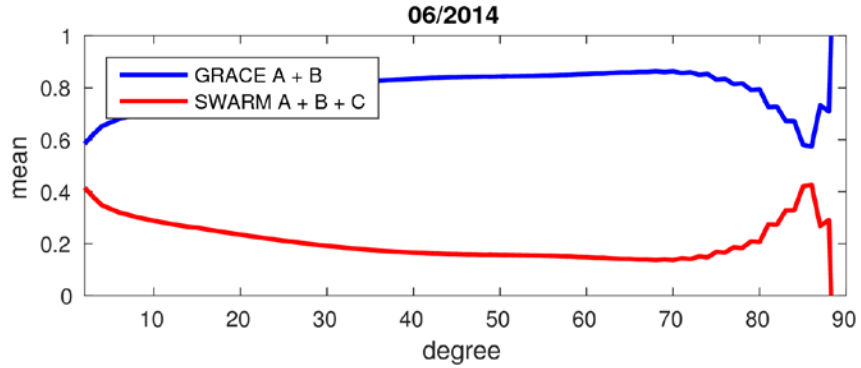

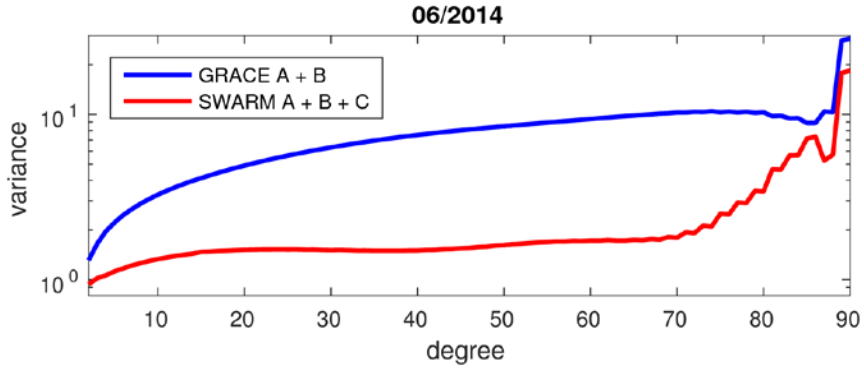

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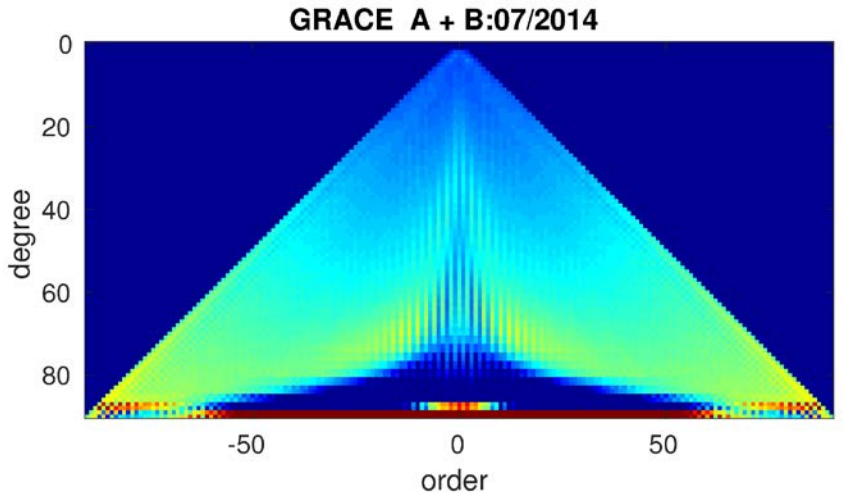

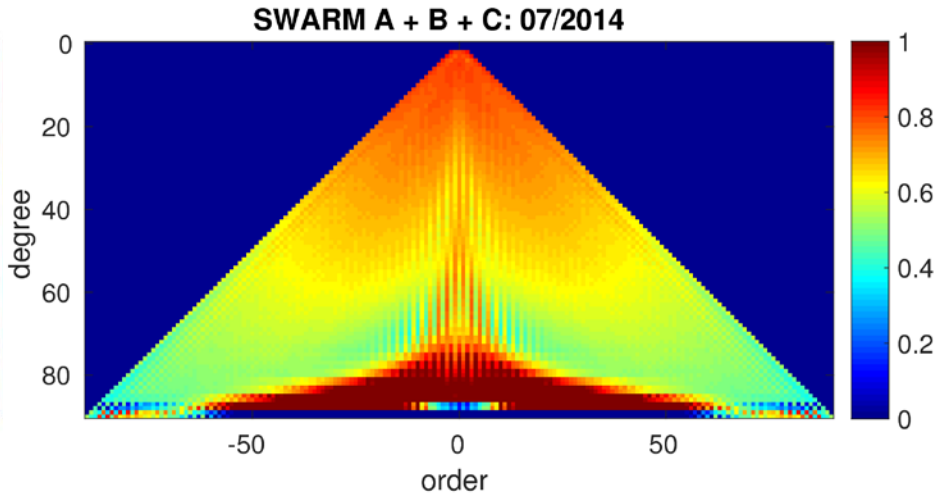

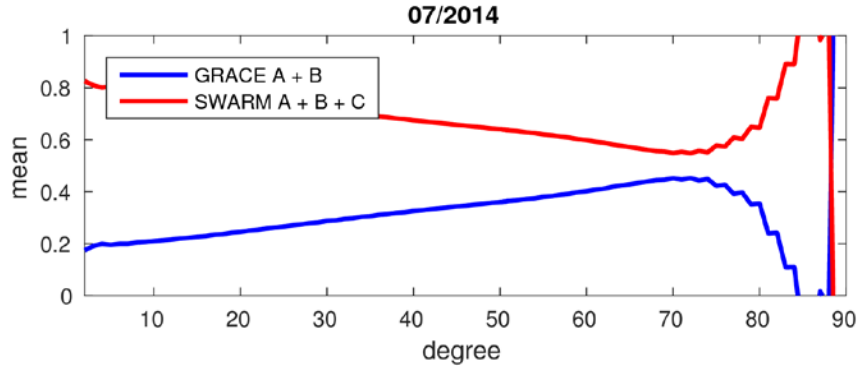

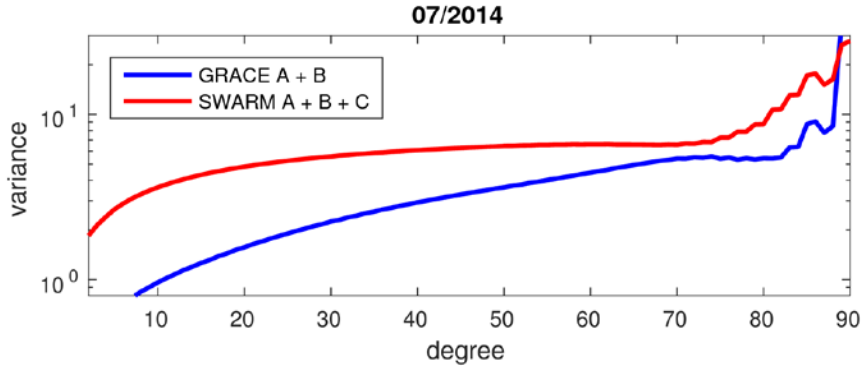

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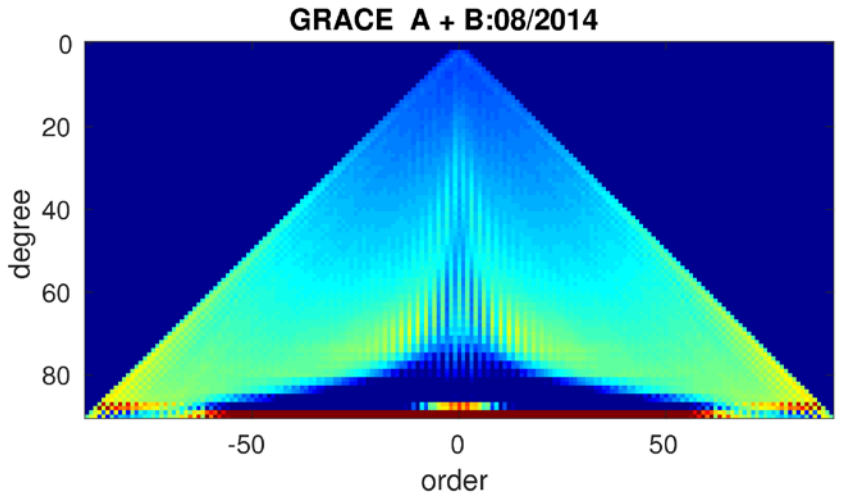

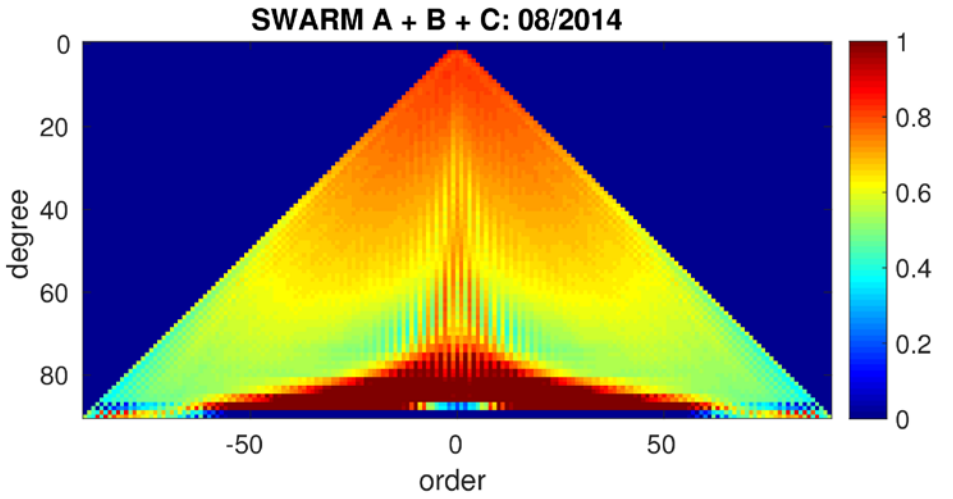

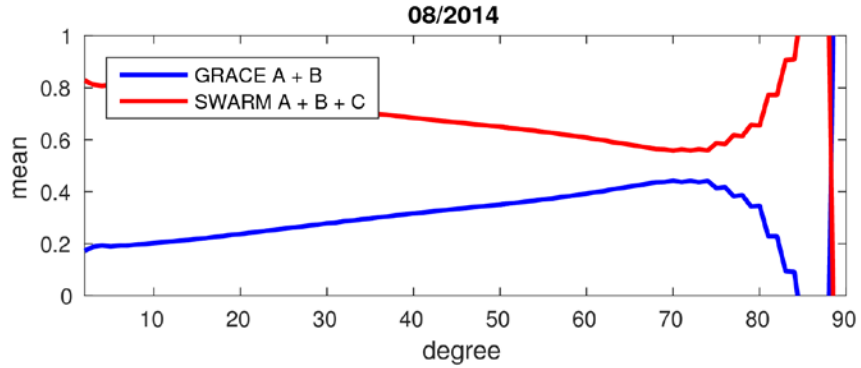

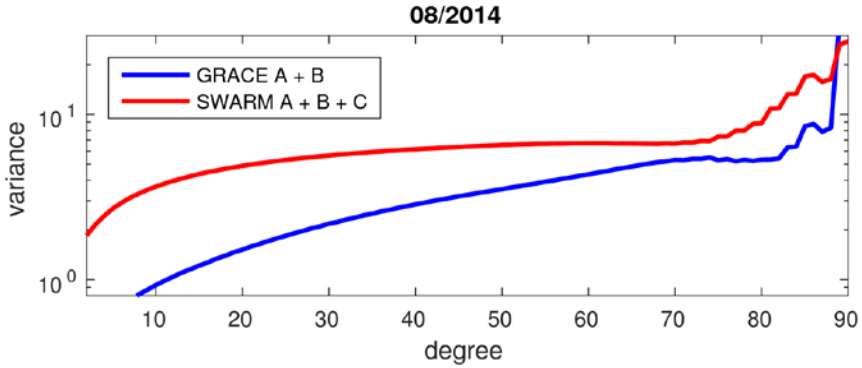

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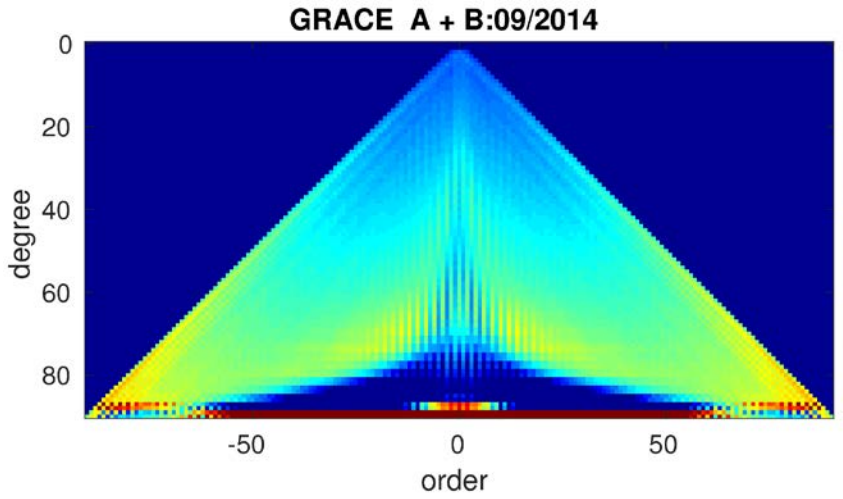

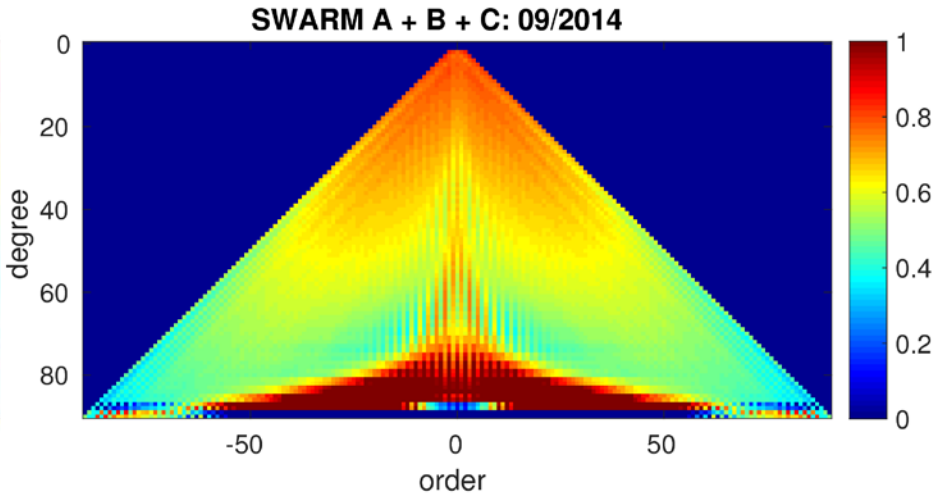

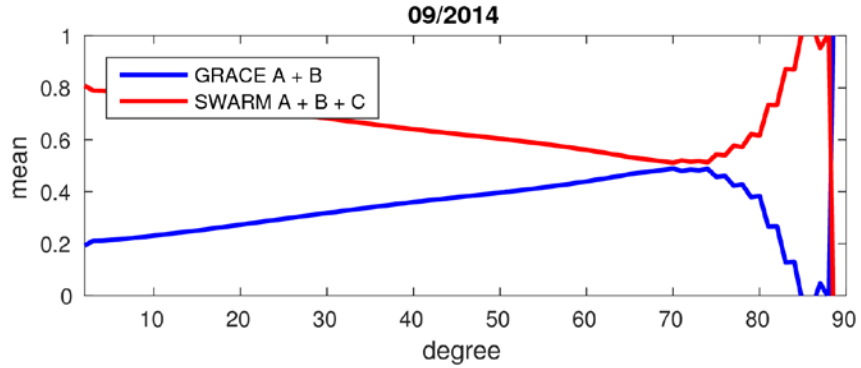

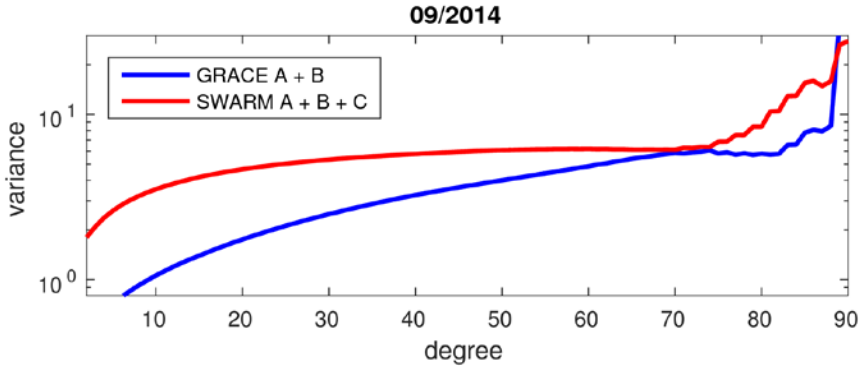

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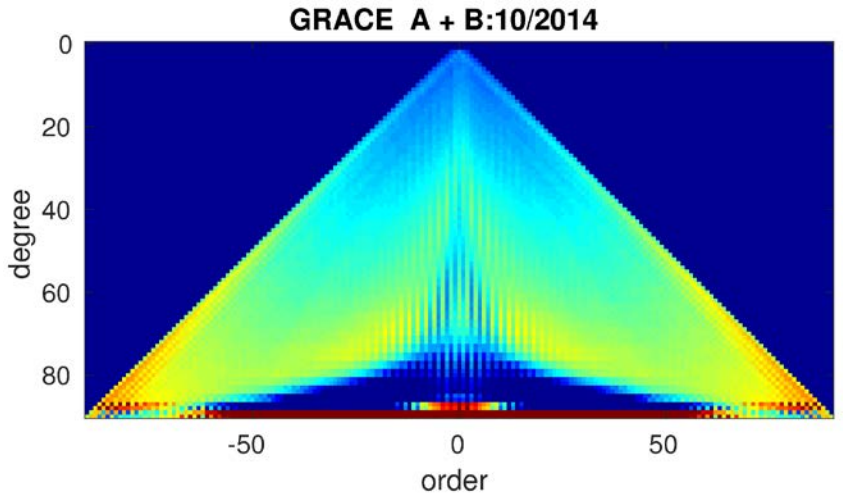

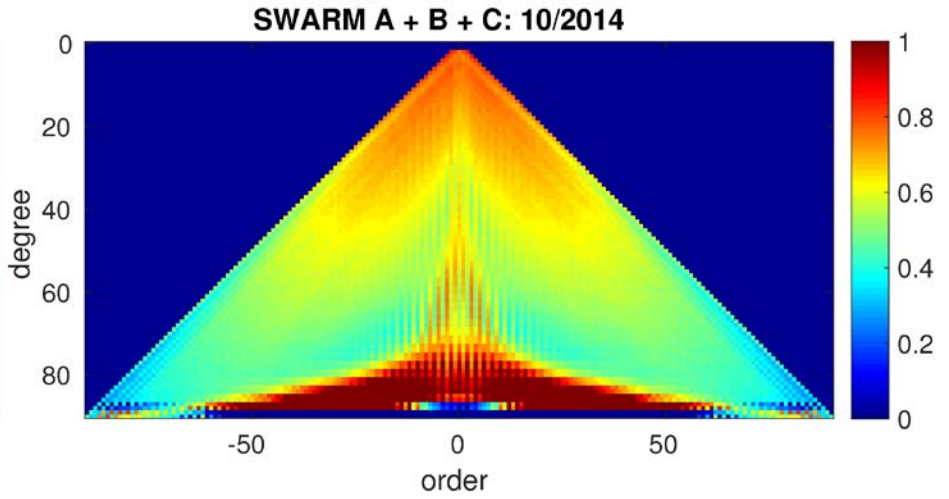

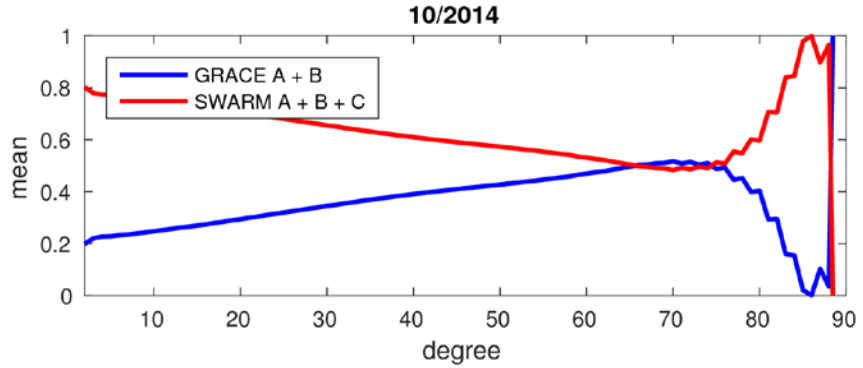

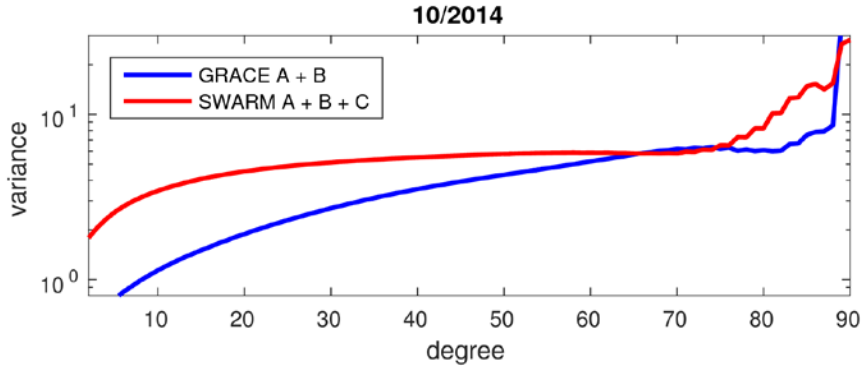

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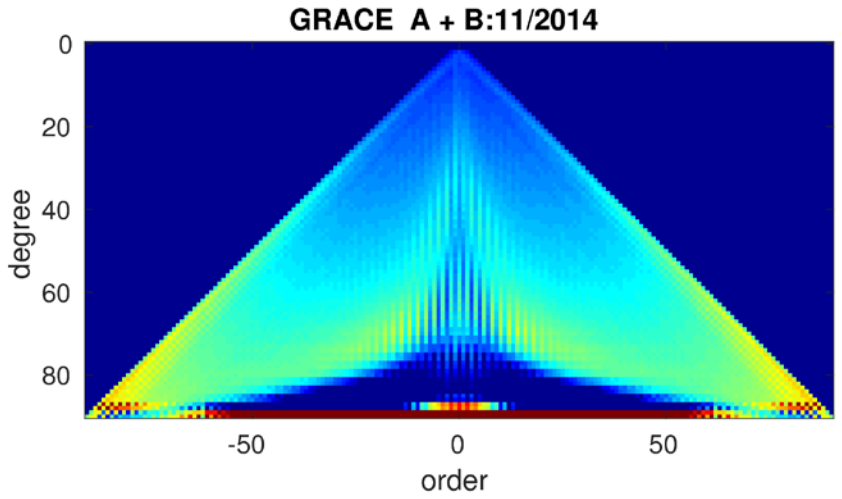

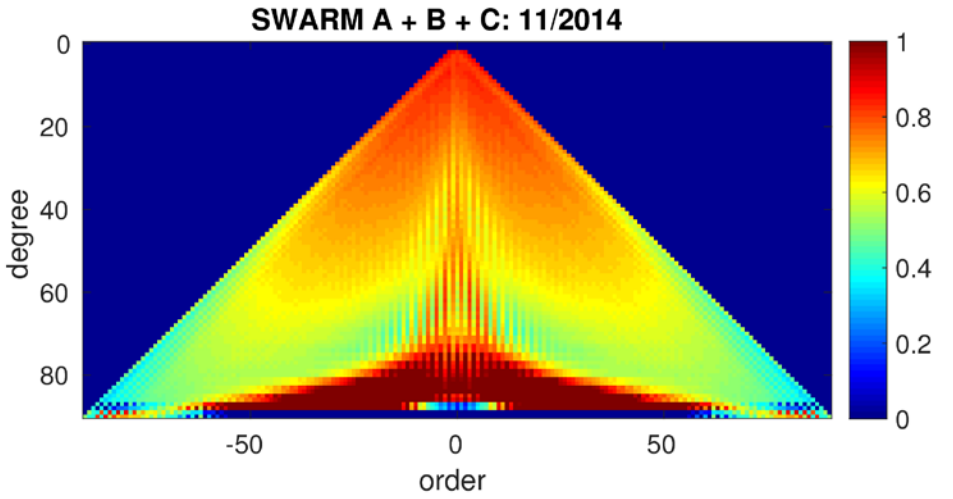

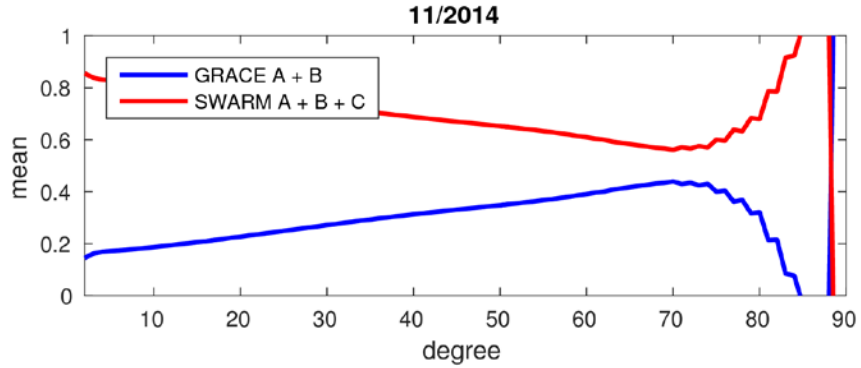

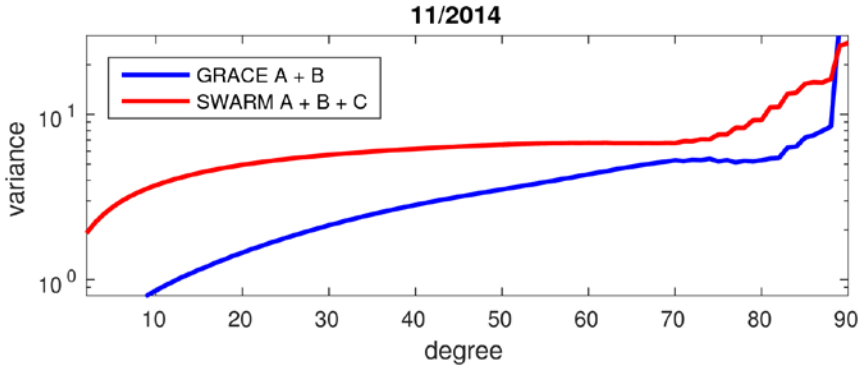

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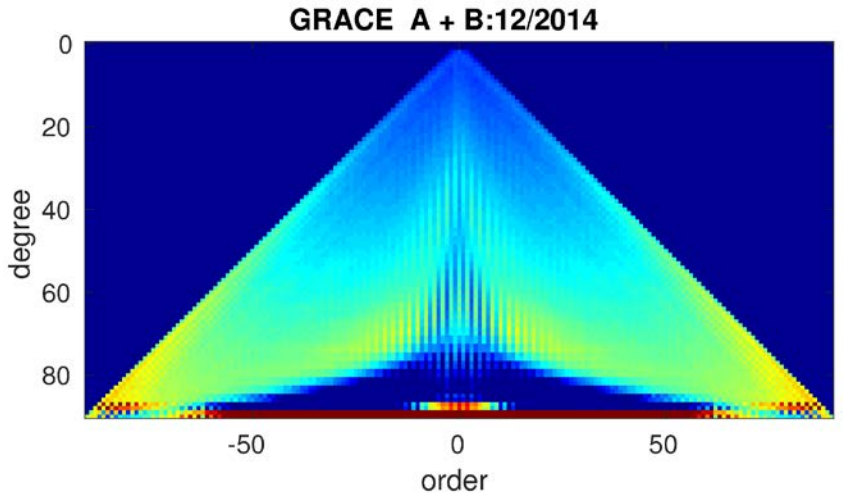
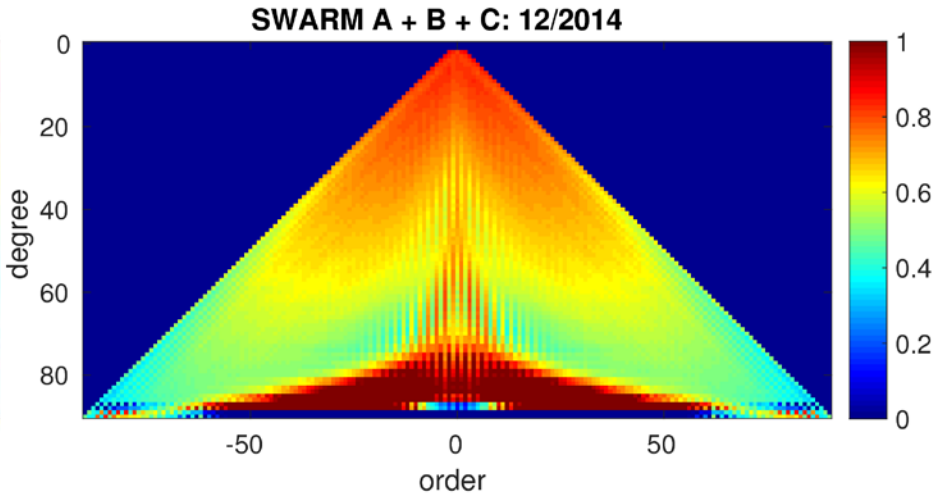
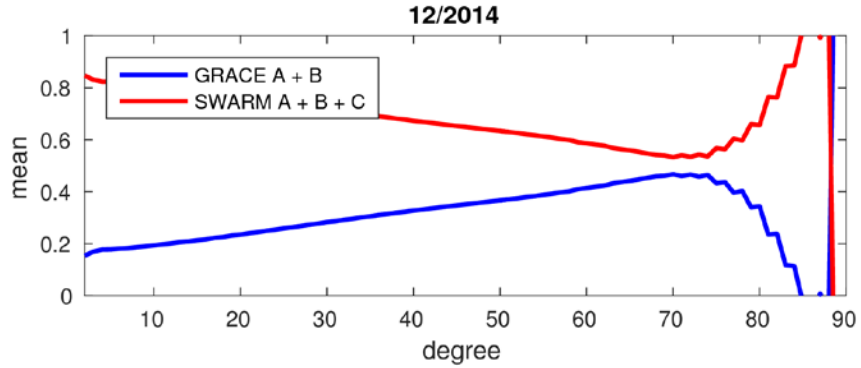
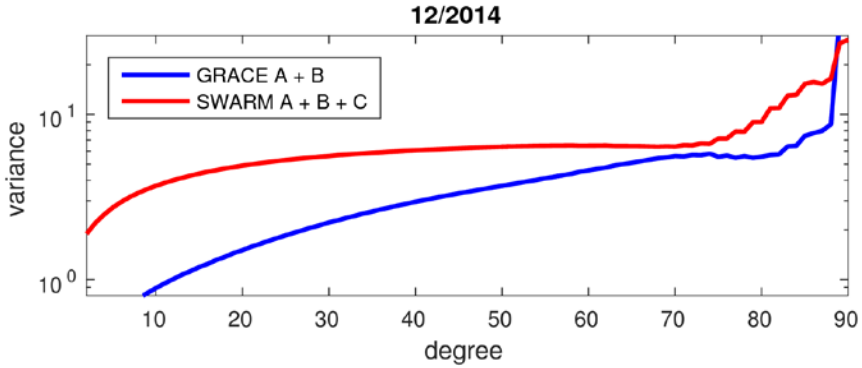
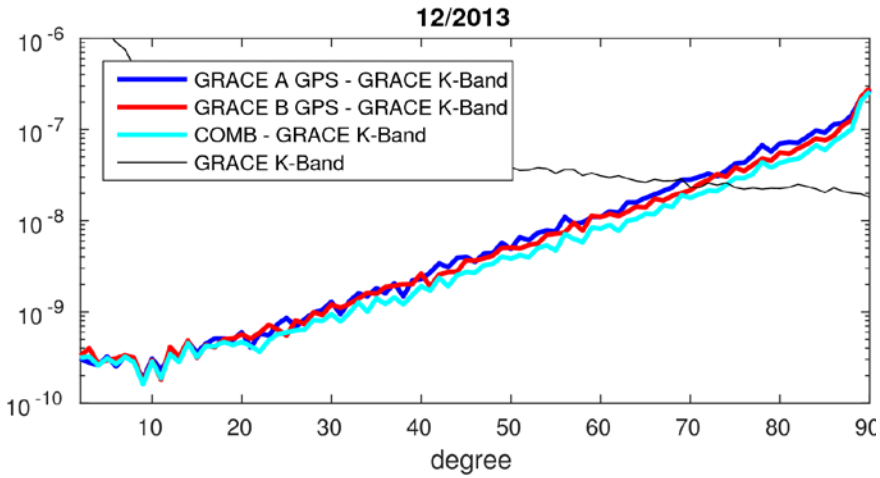


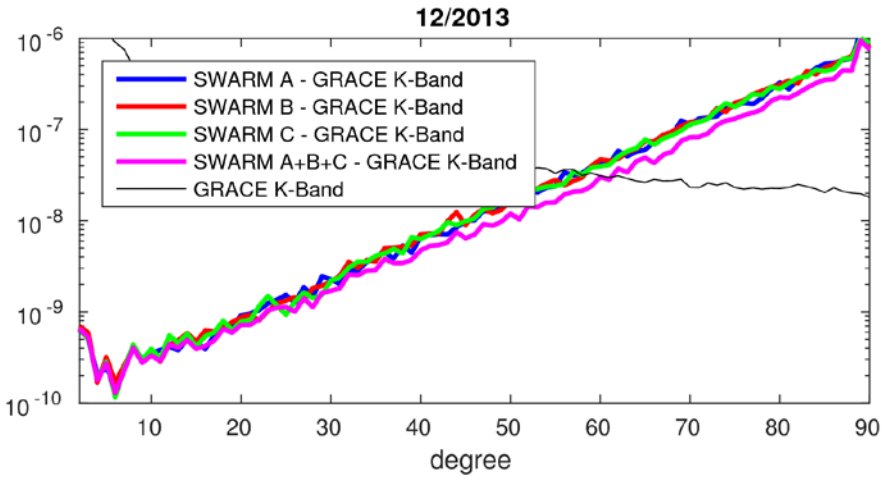


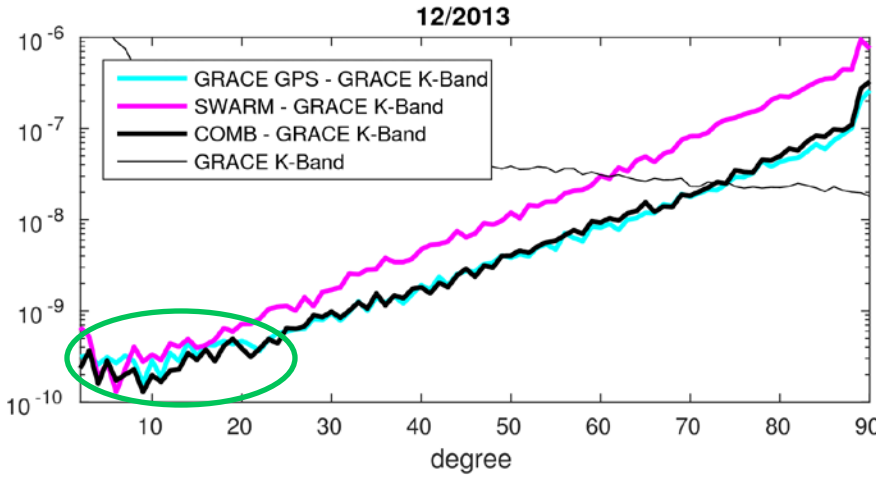


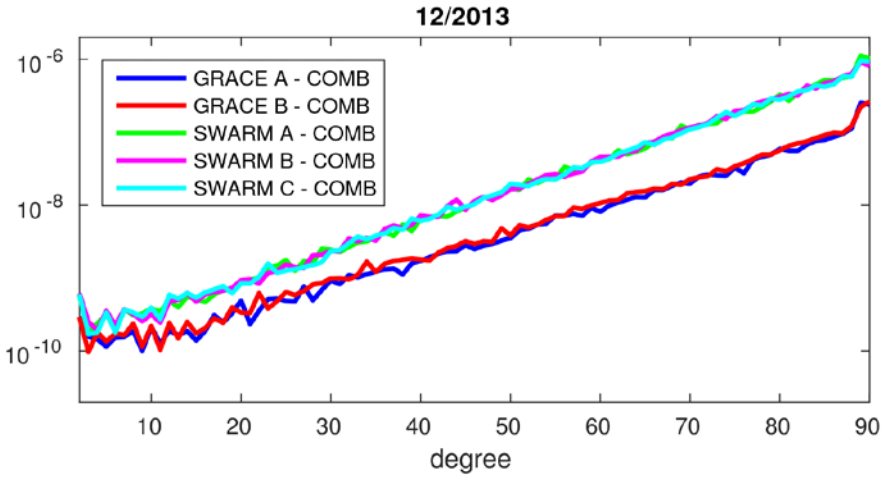


Validation against GRACE K-band









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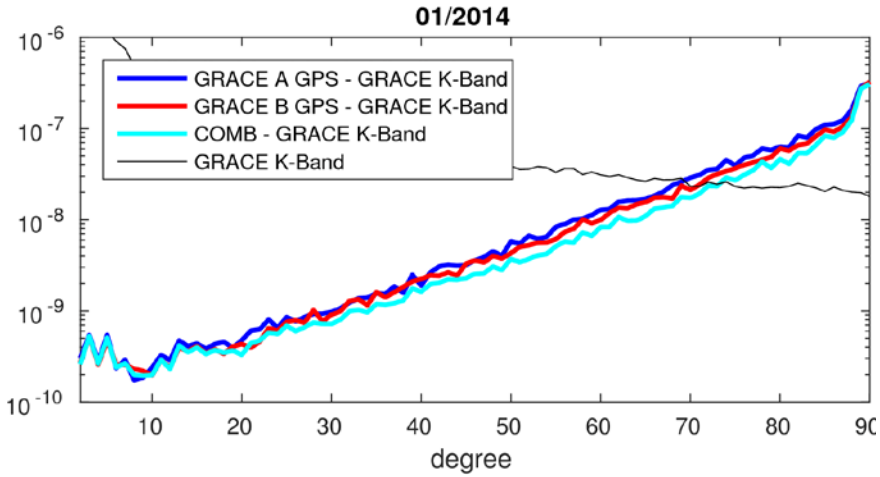

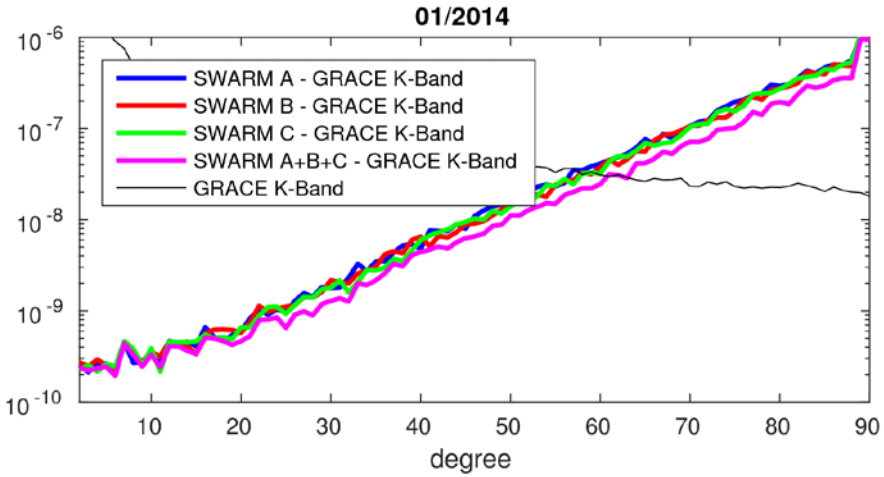

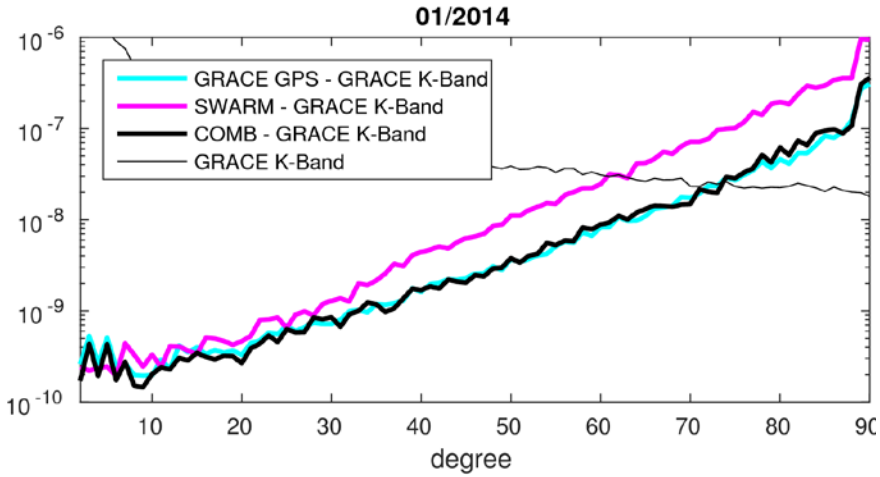

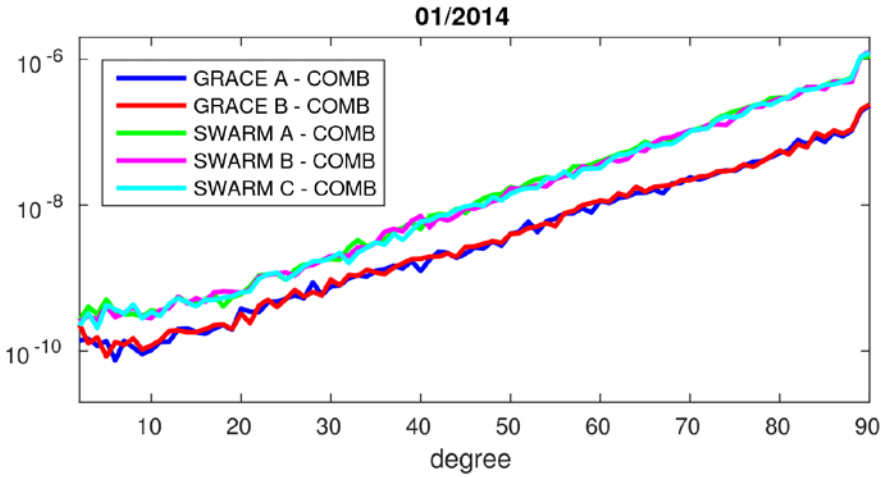

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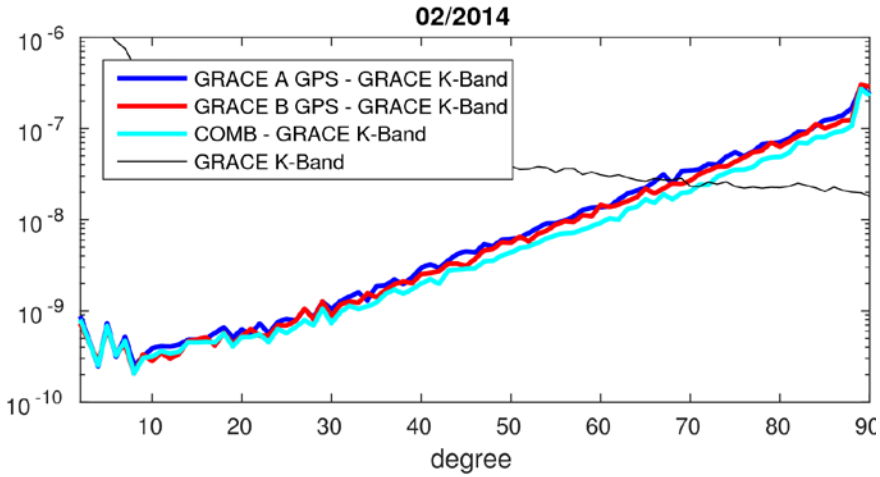

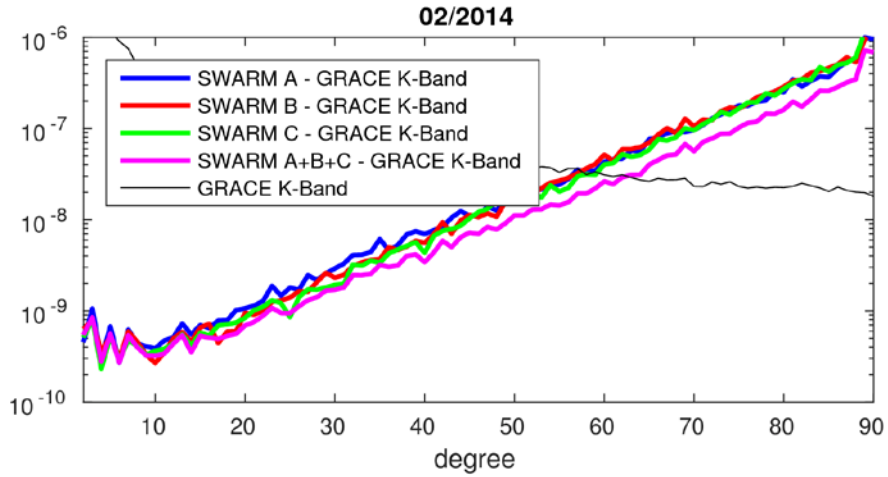

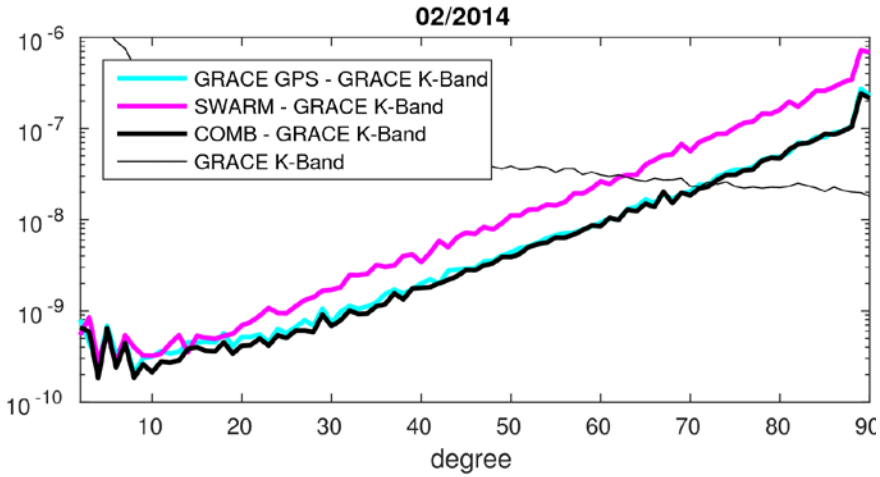

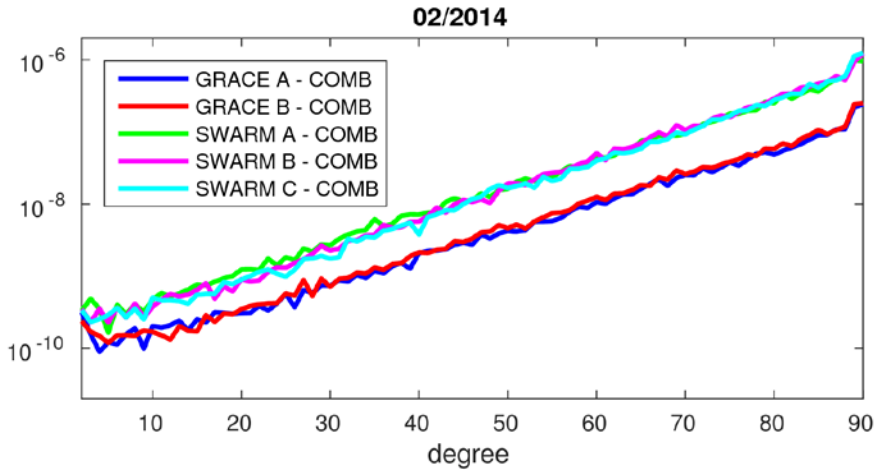

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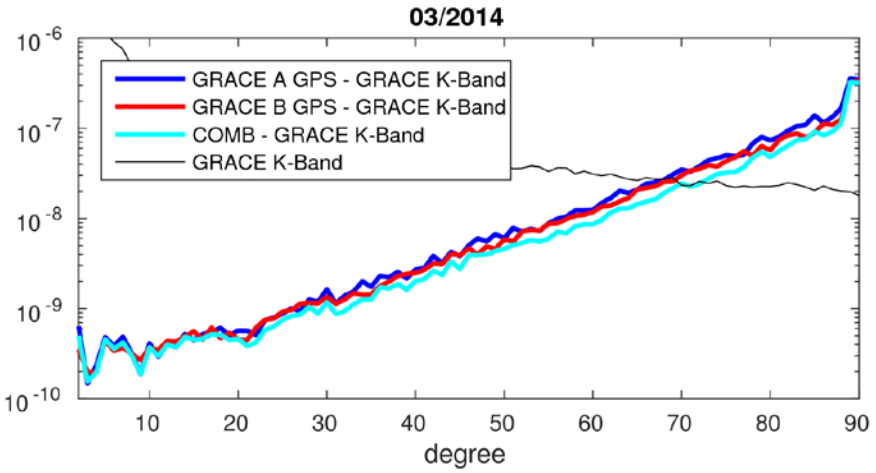

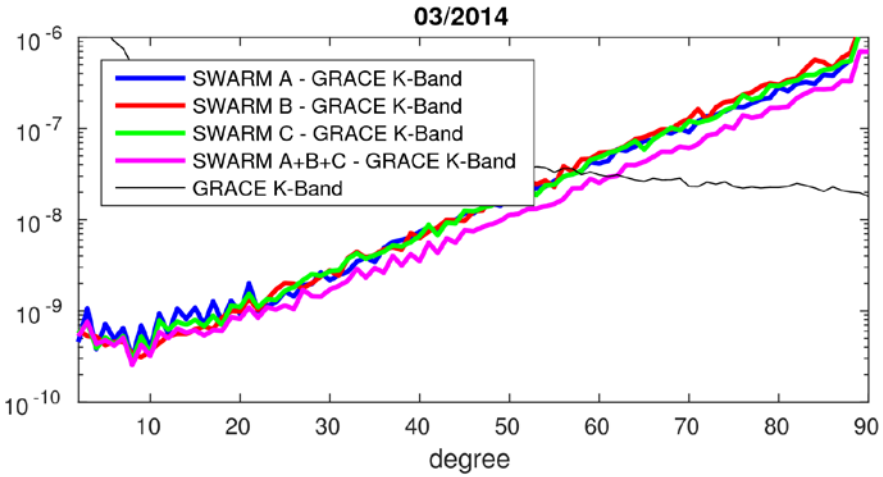

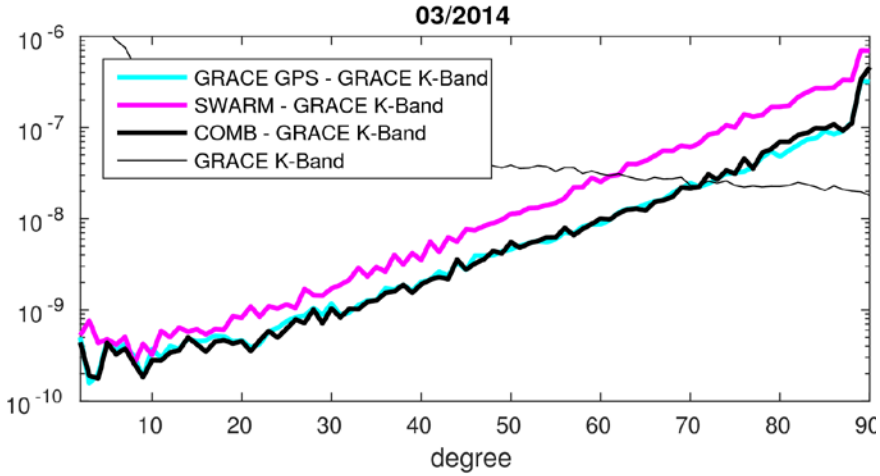

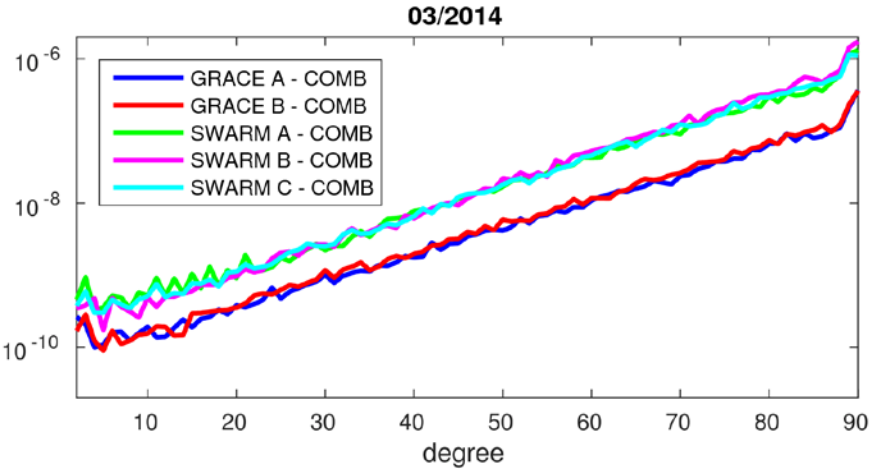

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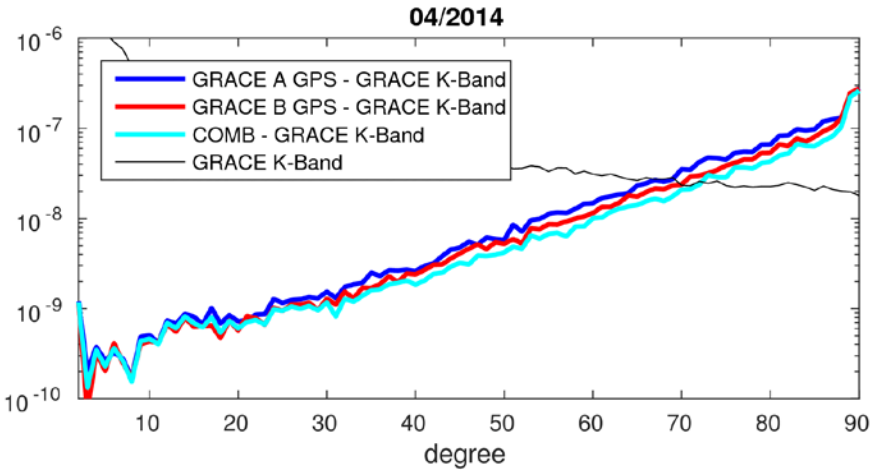

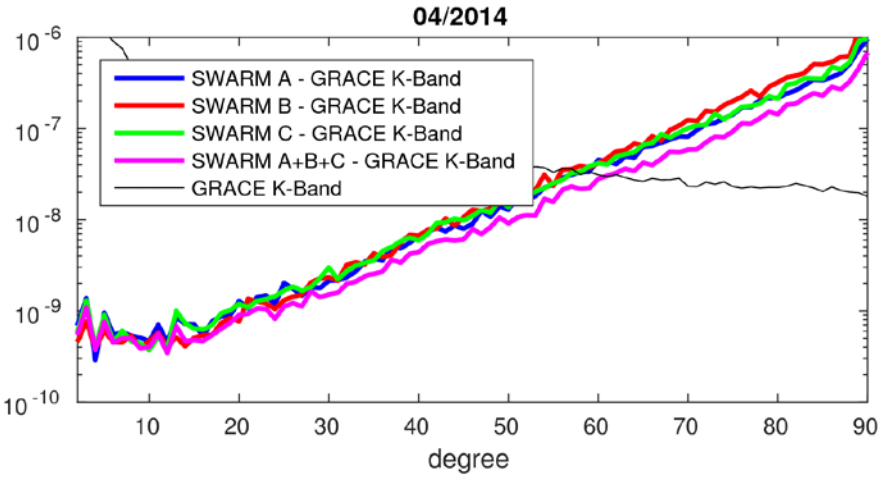

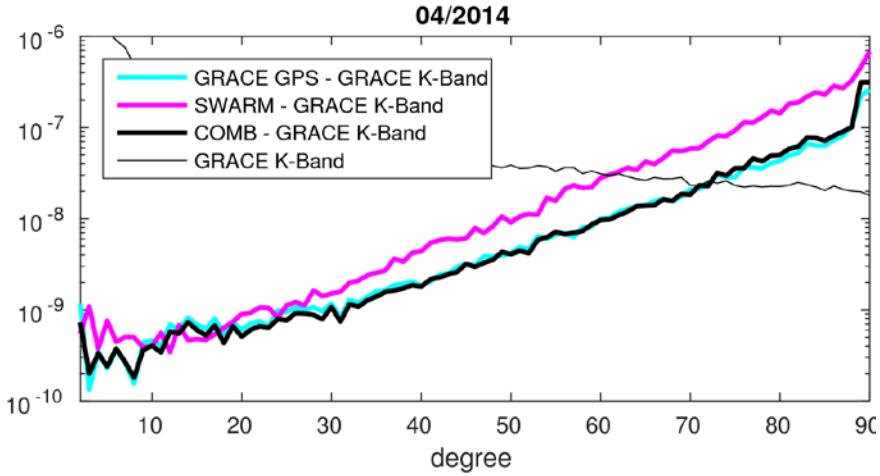

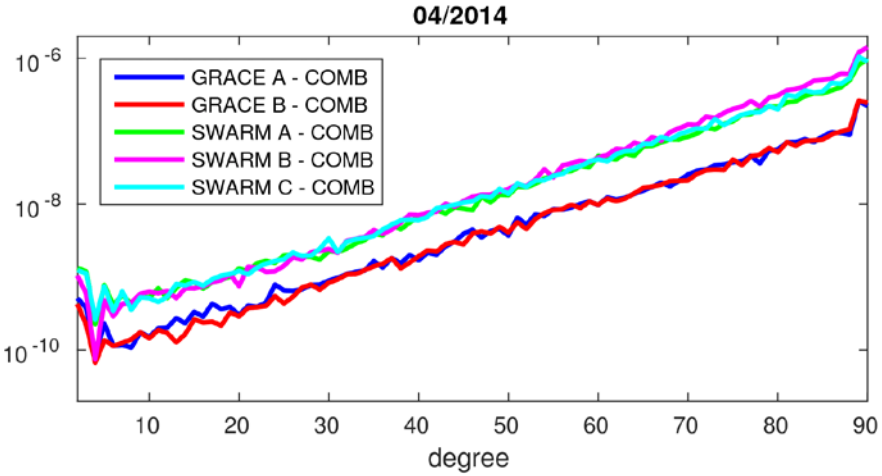

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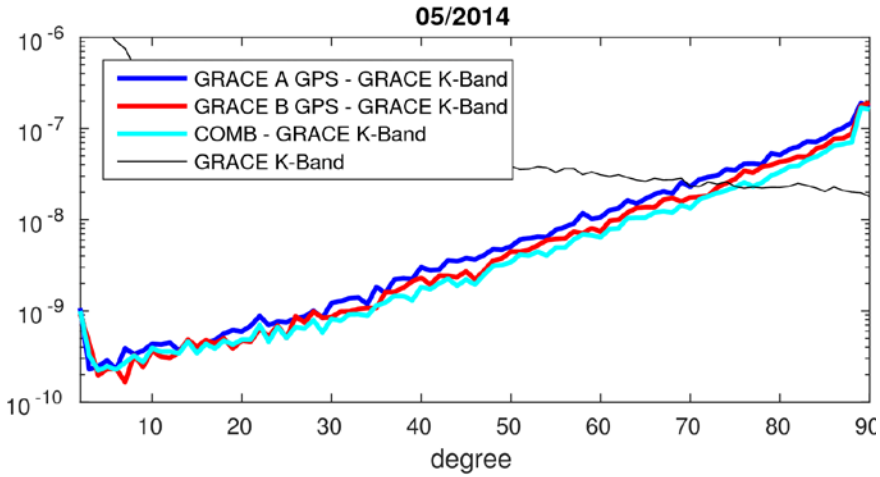
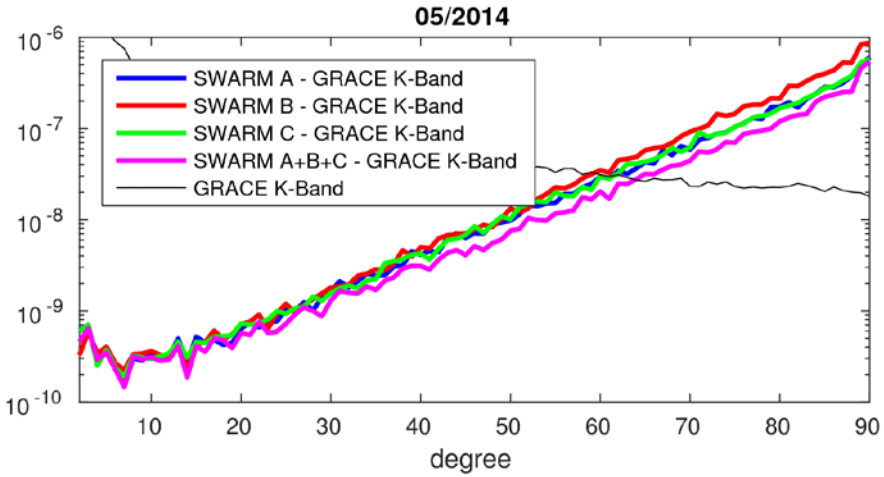
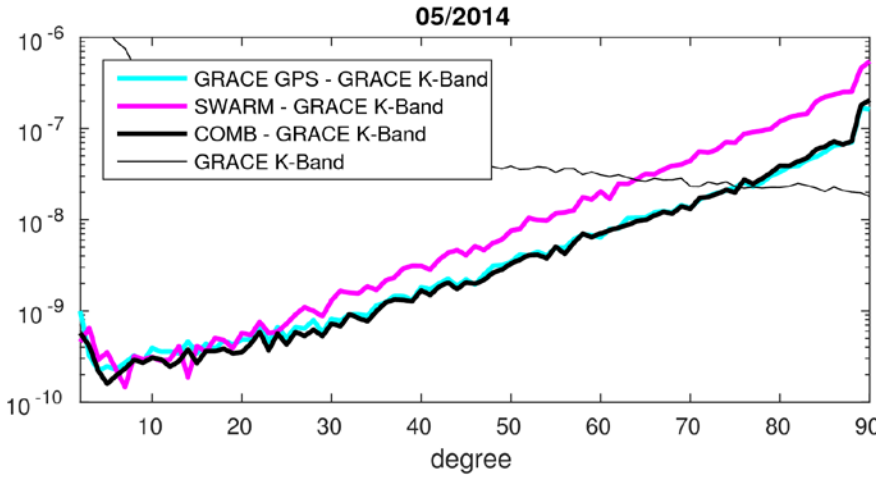
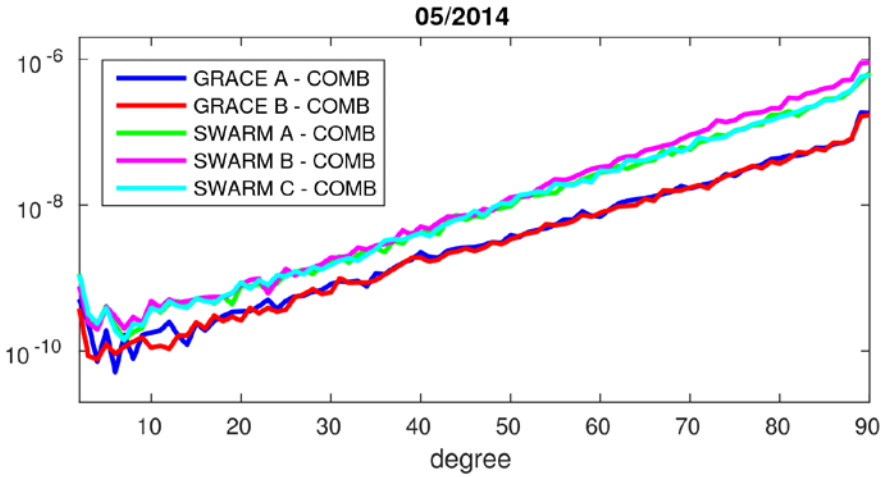
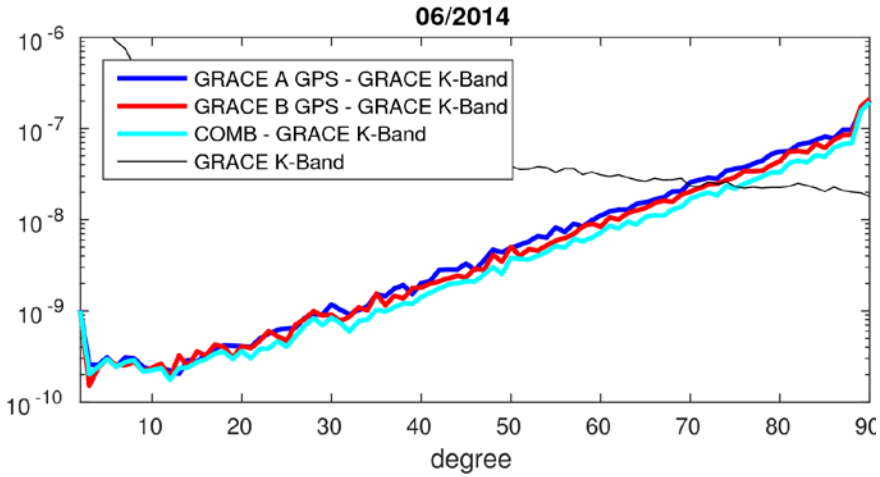


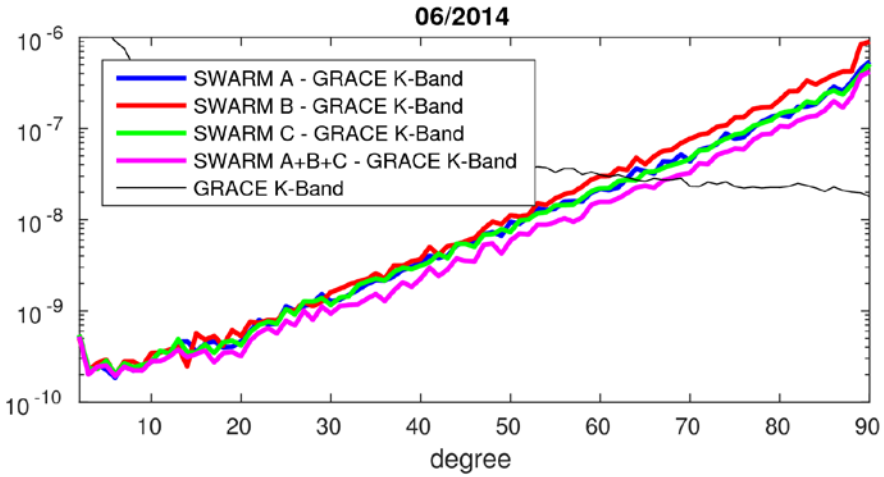


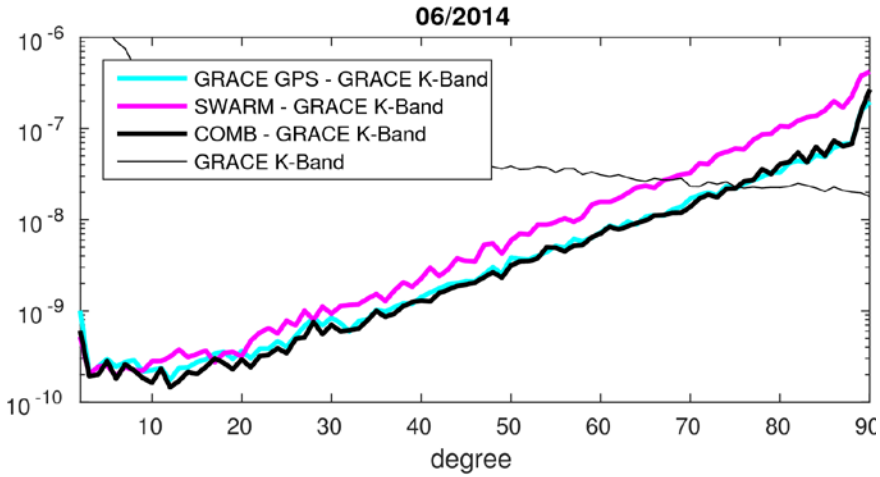


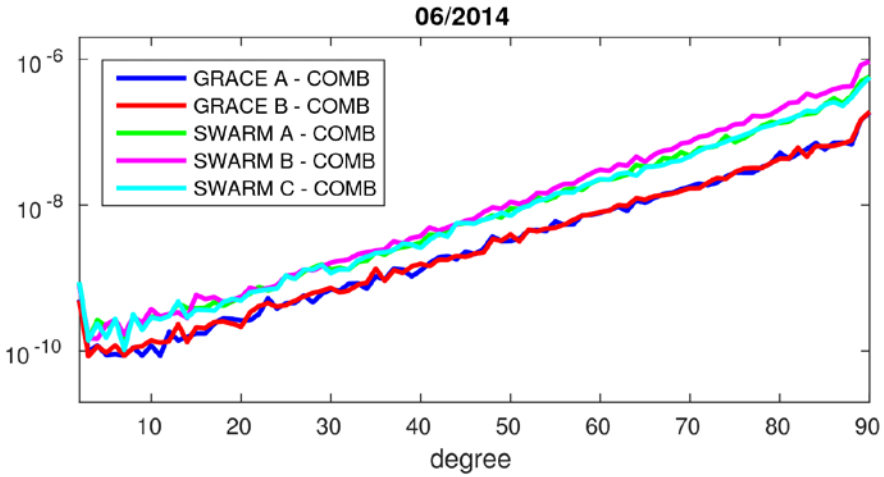


Validation against GRACE K-band









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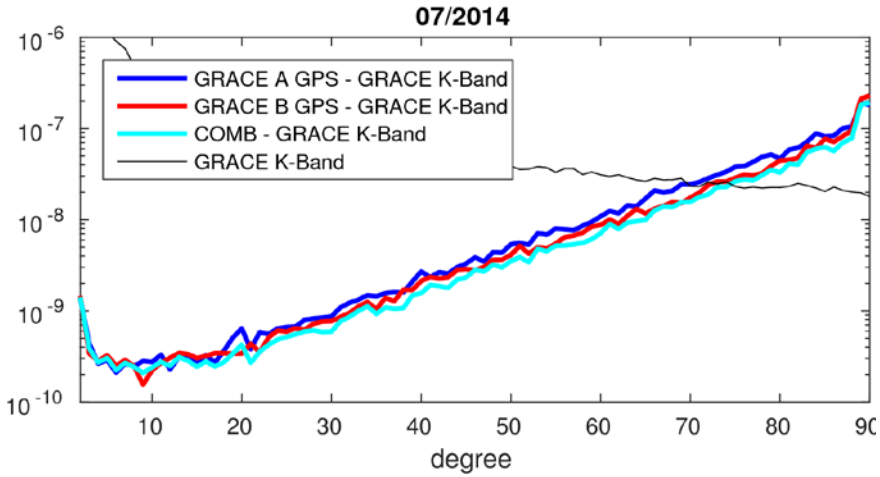

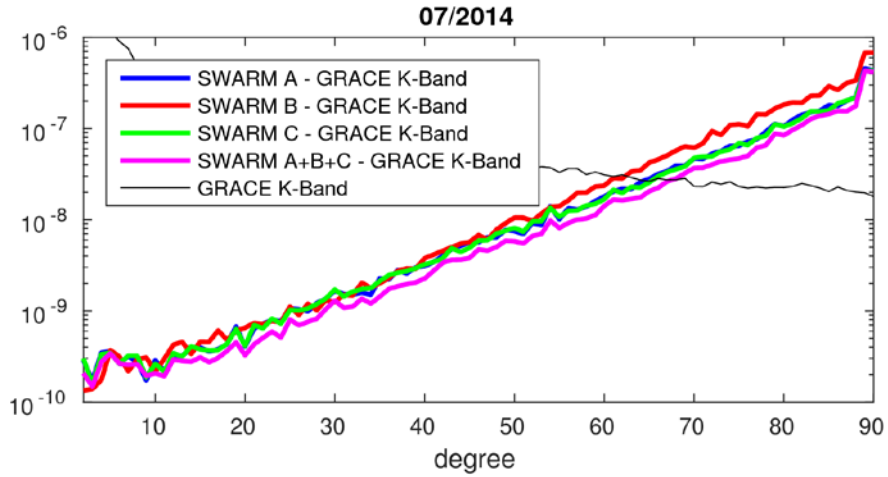

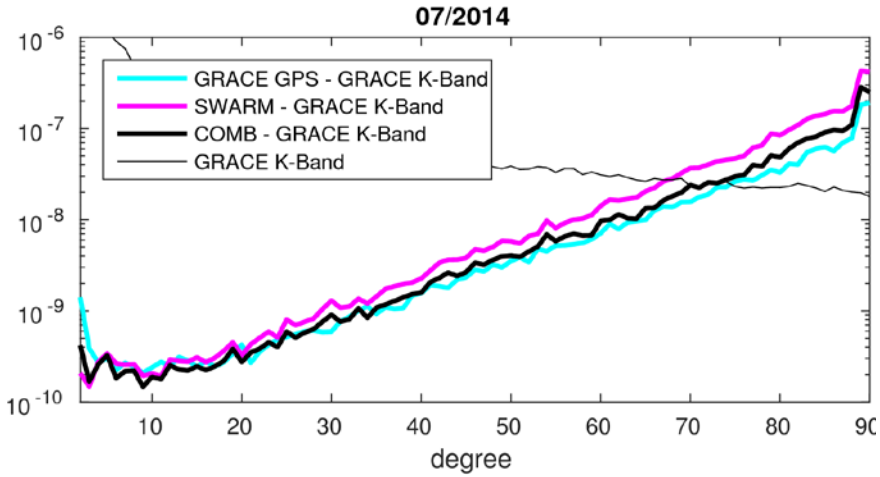

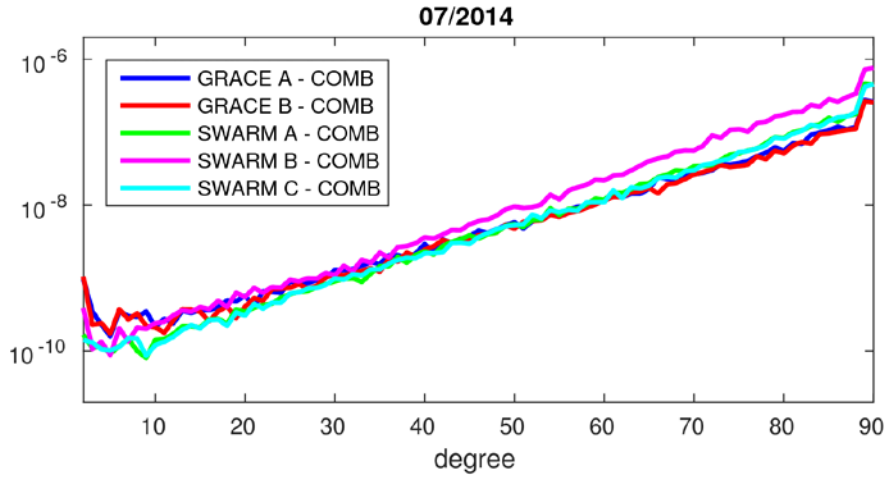

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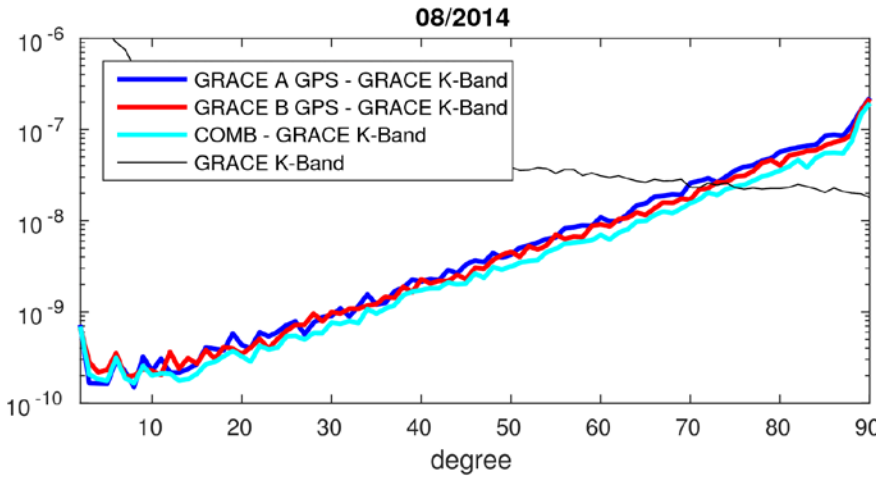

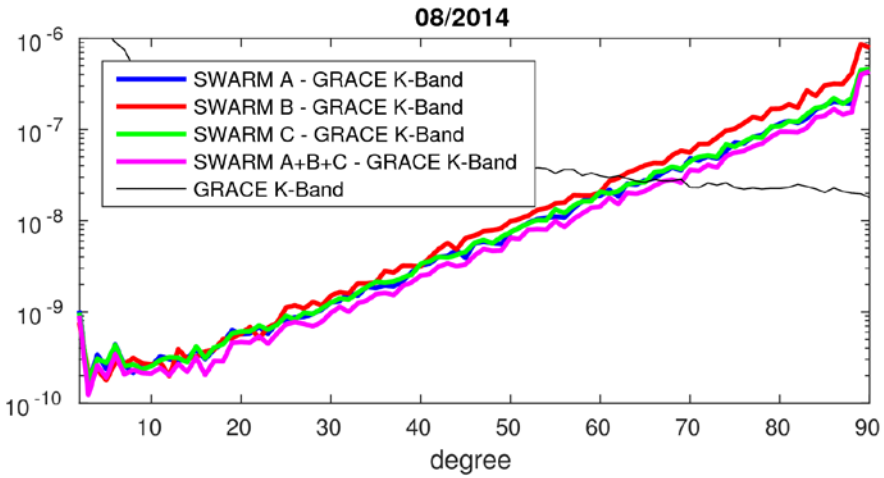

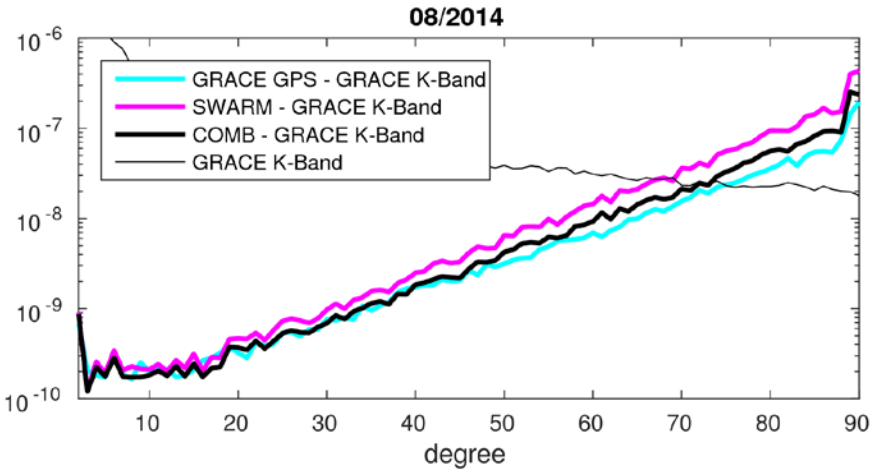

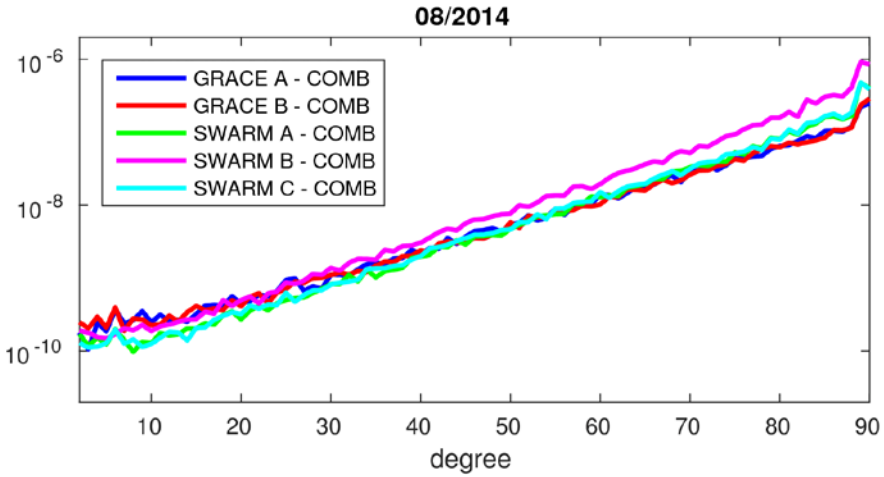

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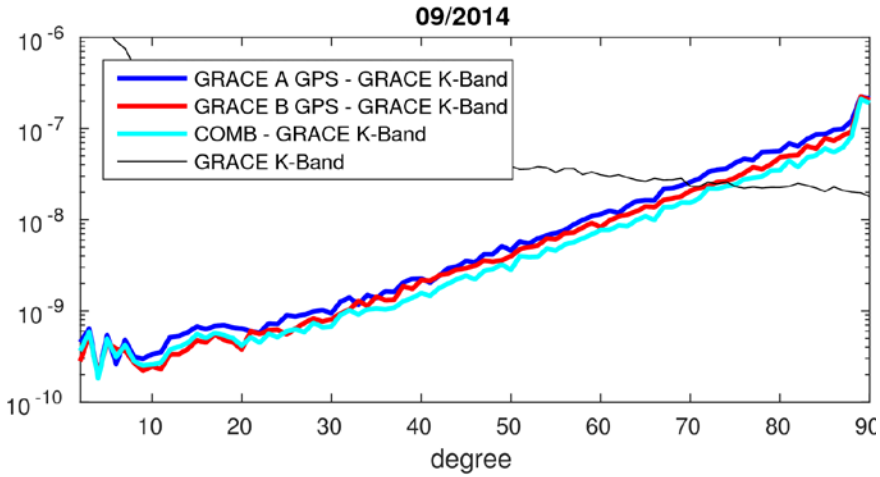

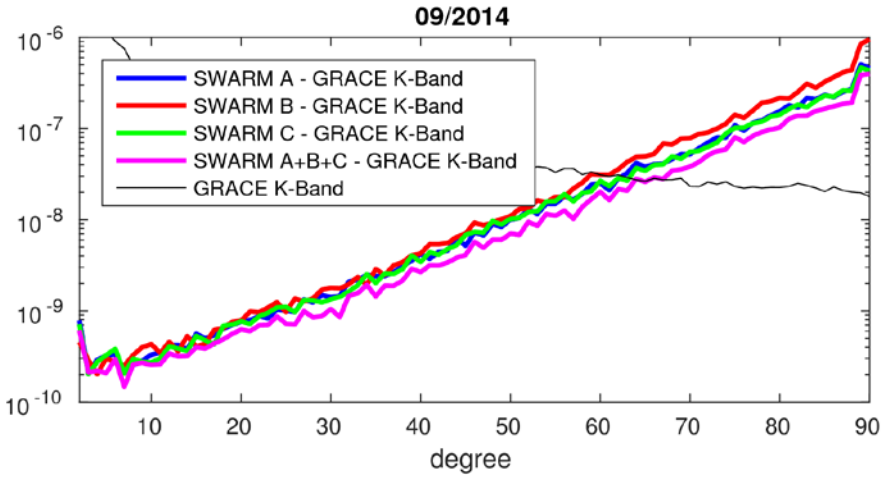

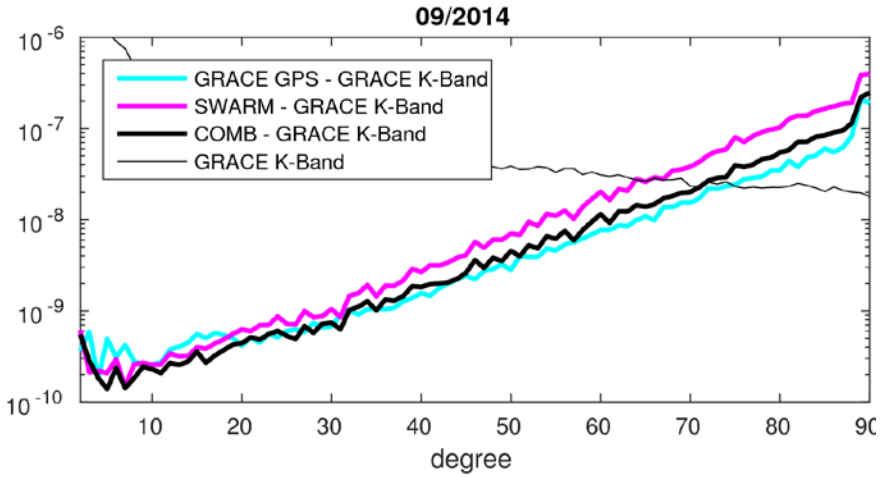

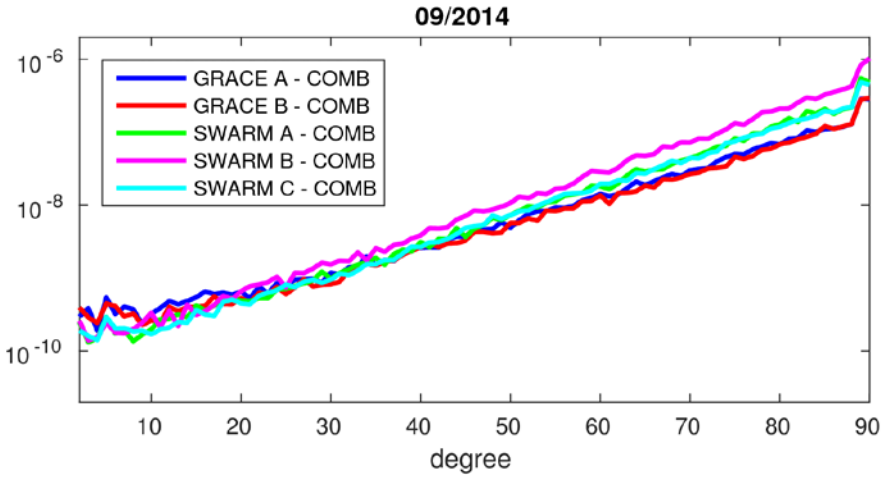

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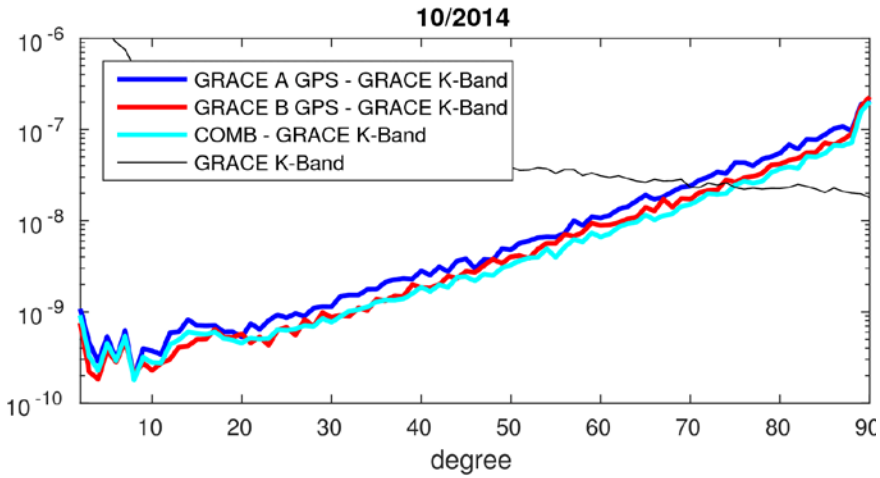
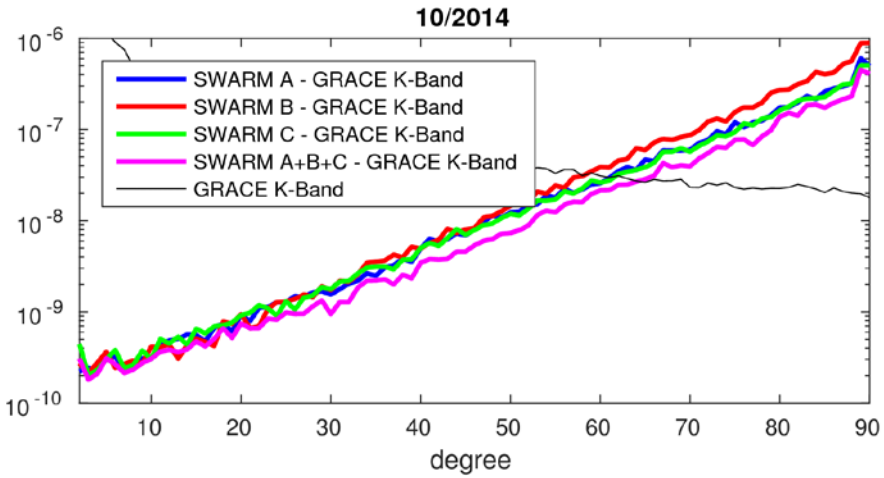
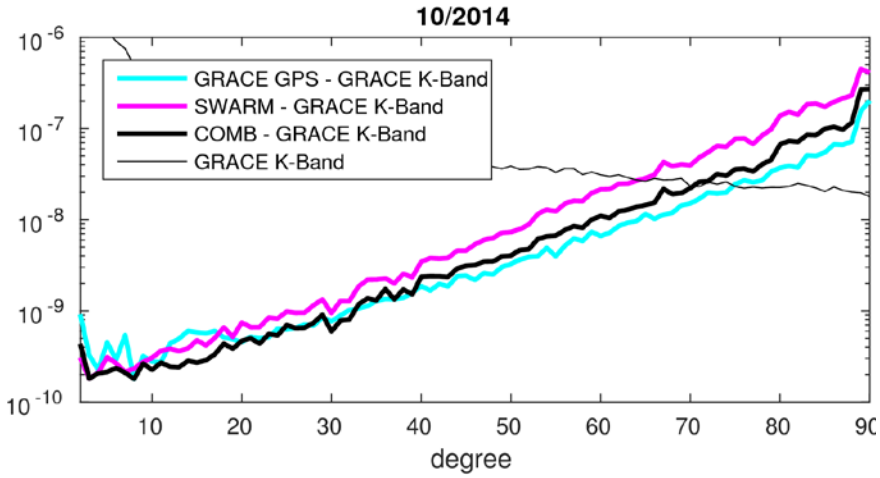
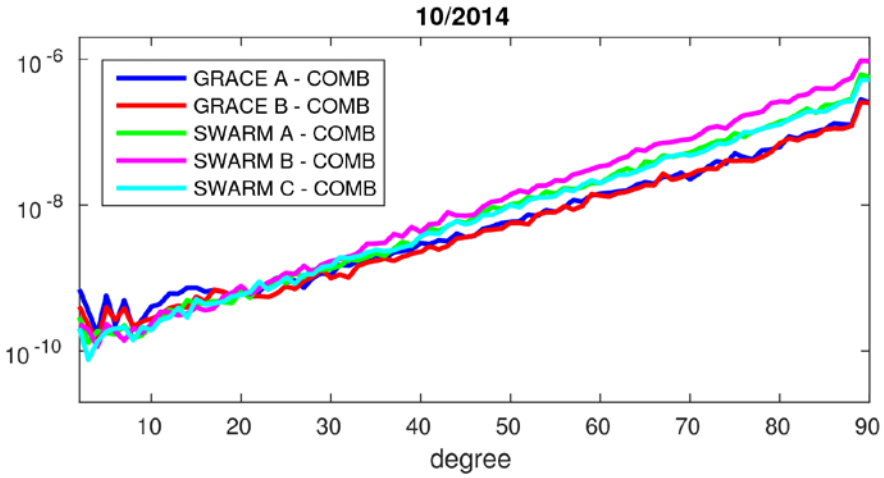
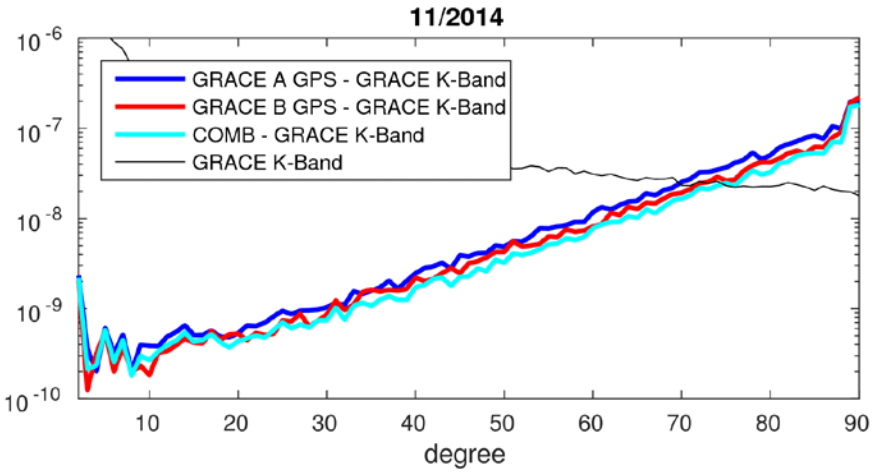


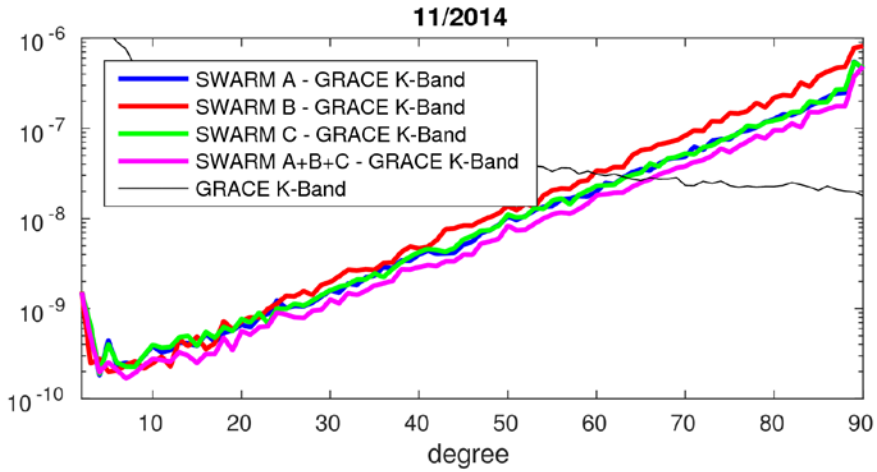


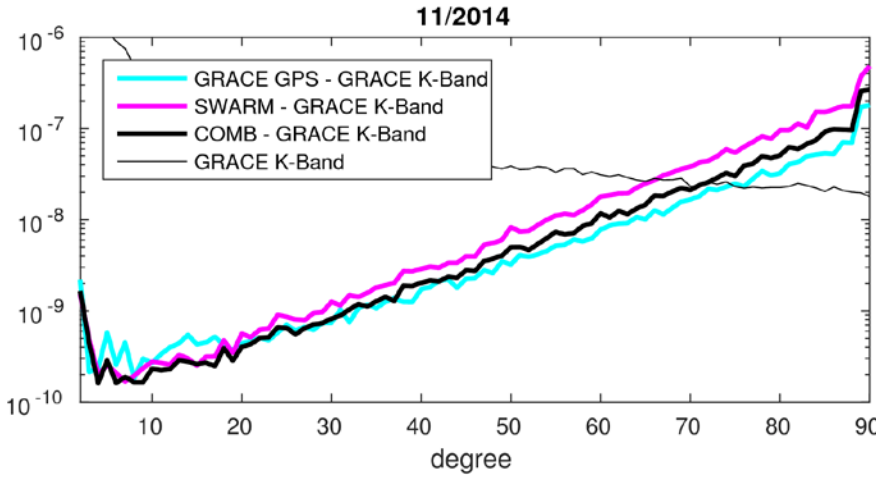


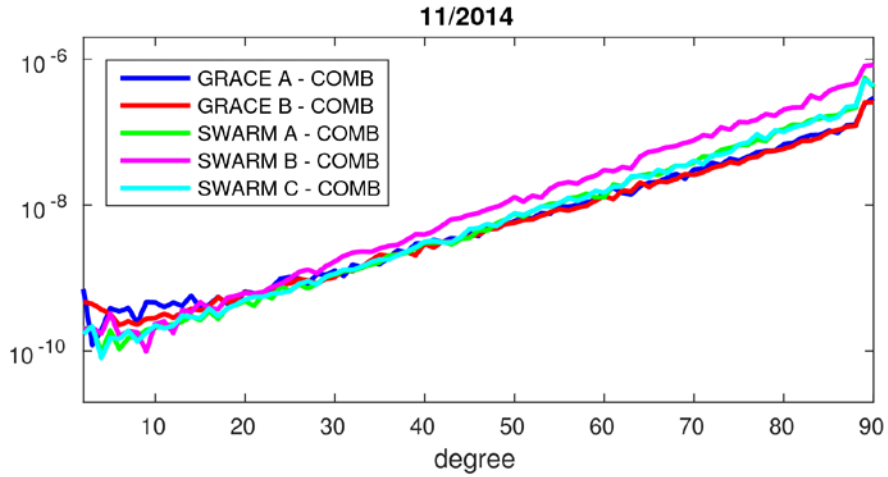


Validation against GRACE K-band

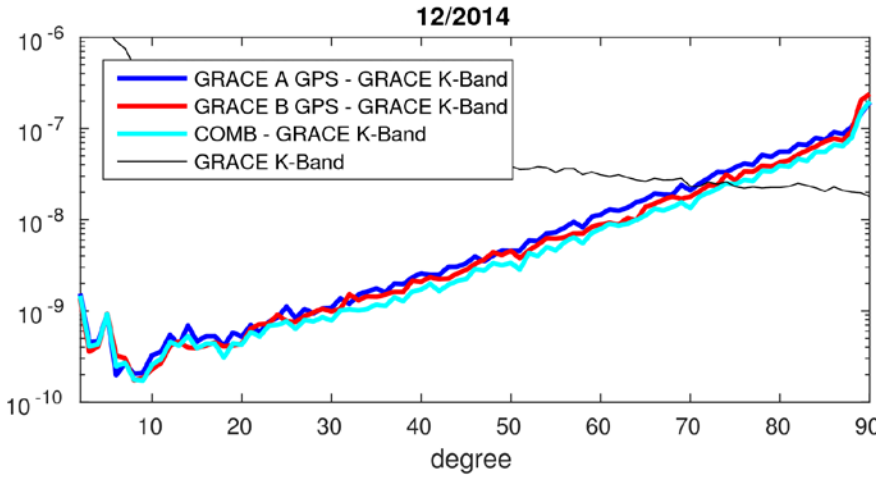


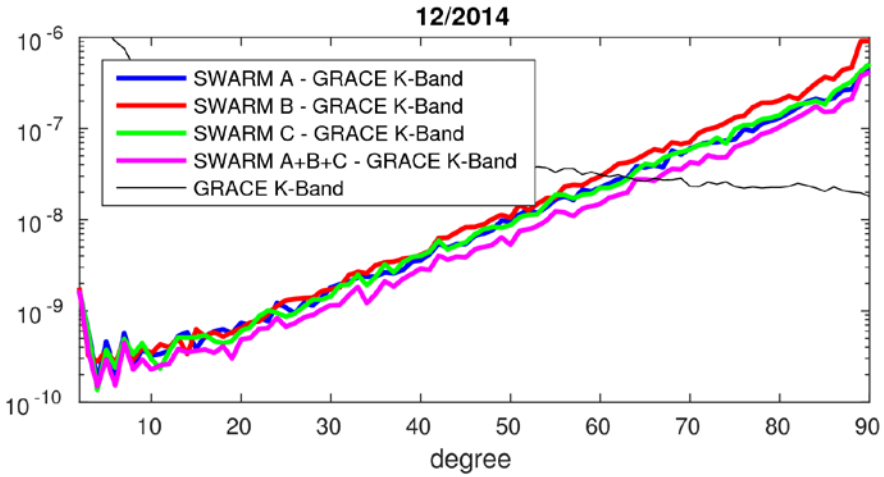


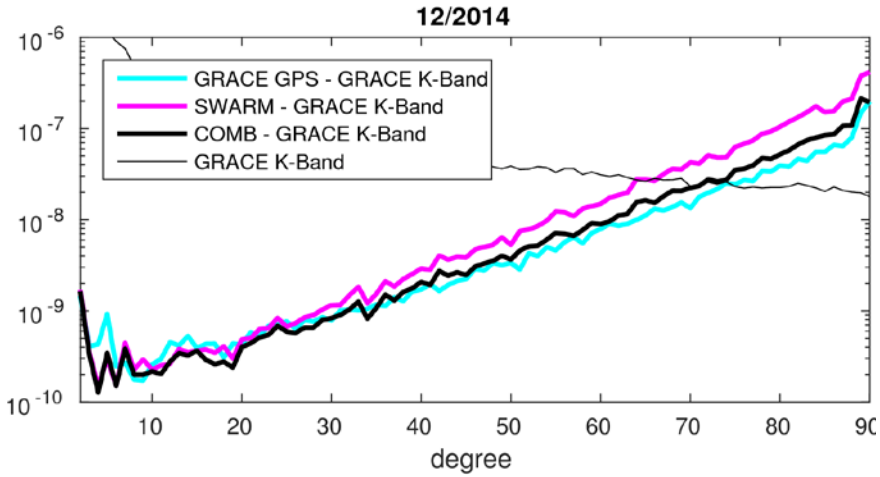


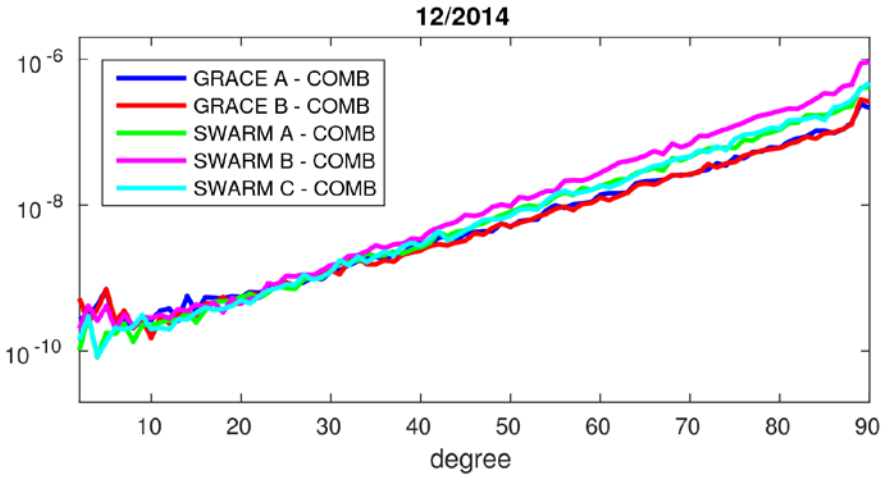


Validation against GRACE K-band



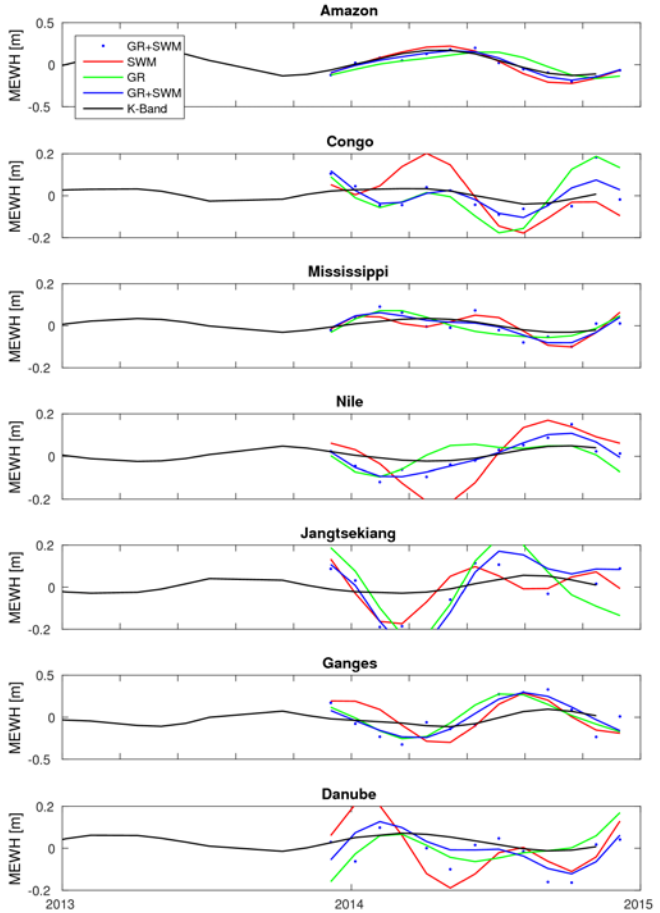




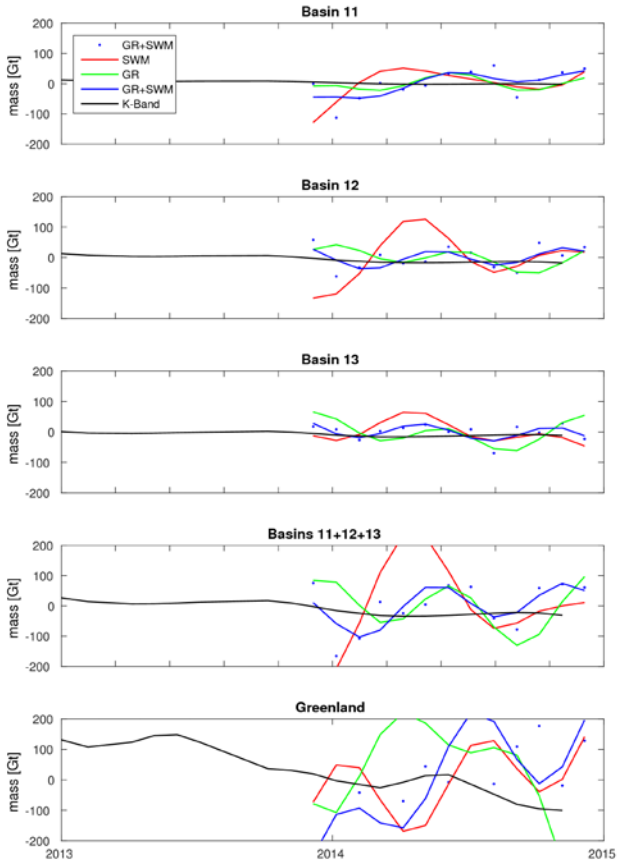


Evaluation

Seasonal variations in river basins



Ice mass loss in polar regions



Conclusions

- GRACE and SWARM NEQs can be combined „just like that“ till 06/2014.
- Low degree coefficients profit from the combination, while high degree coefficients are determined by the lower flying GRACE satellites.
- After 06/2014 the change in sampling rate of the SWARM satellites leads to over-weighting of SWARM.
- Combination of NEQs from different processing centers (with different noise models) will make an advanced relative weighting necessary.

=> Watch out for future EGSIEM presentations!