A methodology to choose the orbit for a double-pair-scenario future gravity satellite mission

Experiences from the SC4MGV project

M. Weigelt, S. Iran Pour, M. Murböck, S. Tonetti

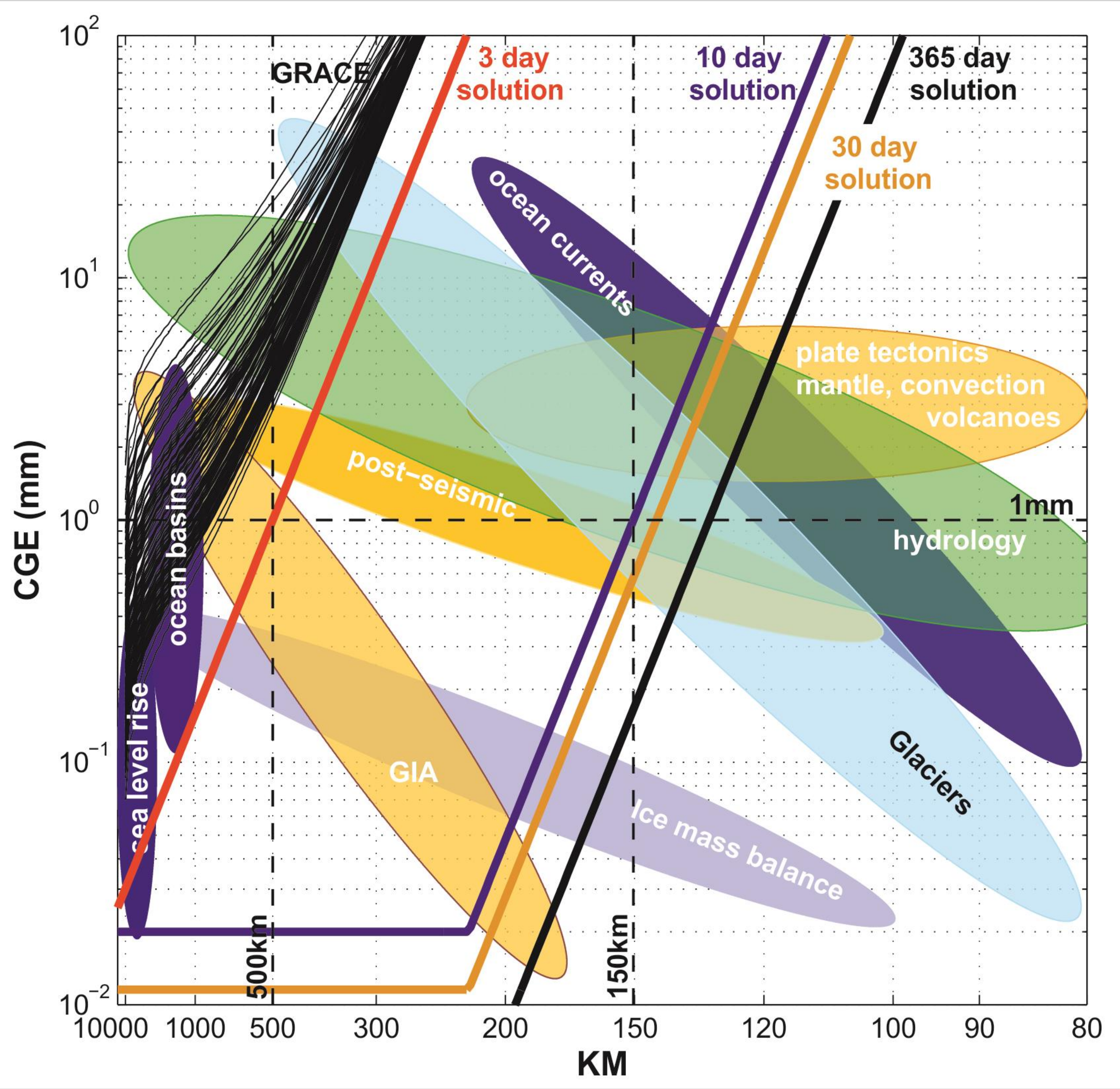
P. Visser, I. Daras, S. Cesare, J. de Teixeira da Encarnação

C. Siemes, J. van den IJssel, S. Cornara, T. Gruber

T. van Dam, R. Pail, N. Sneeuw, R. Haagmans

Orbit selection

Definition of scientific requirements

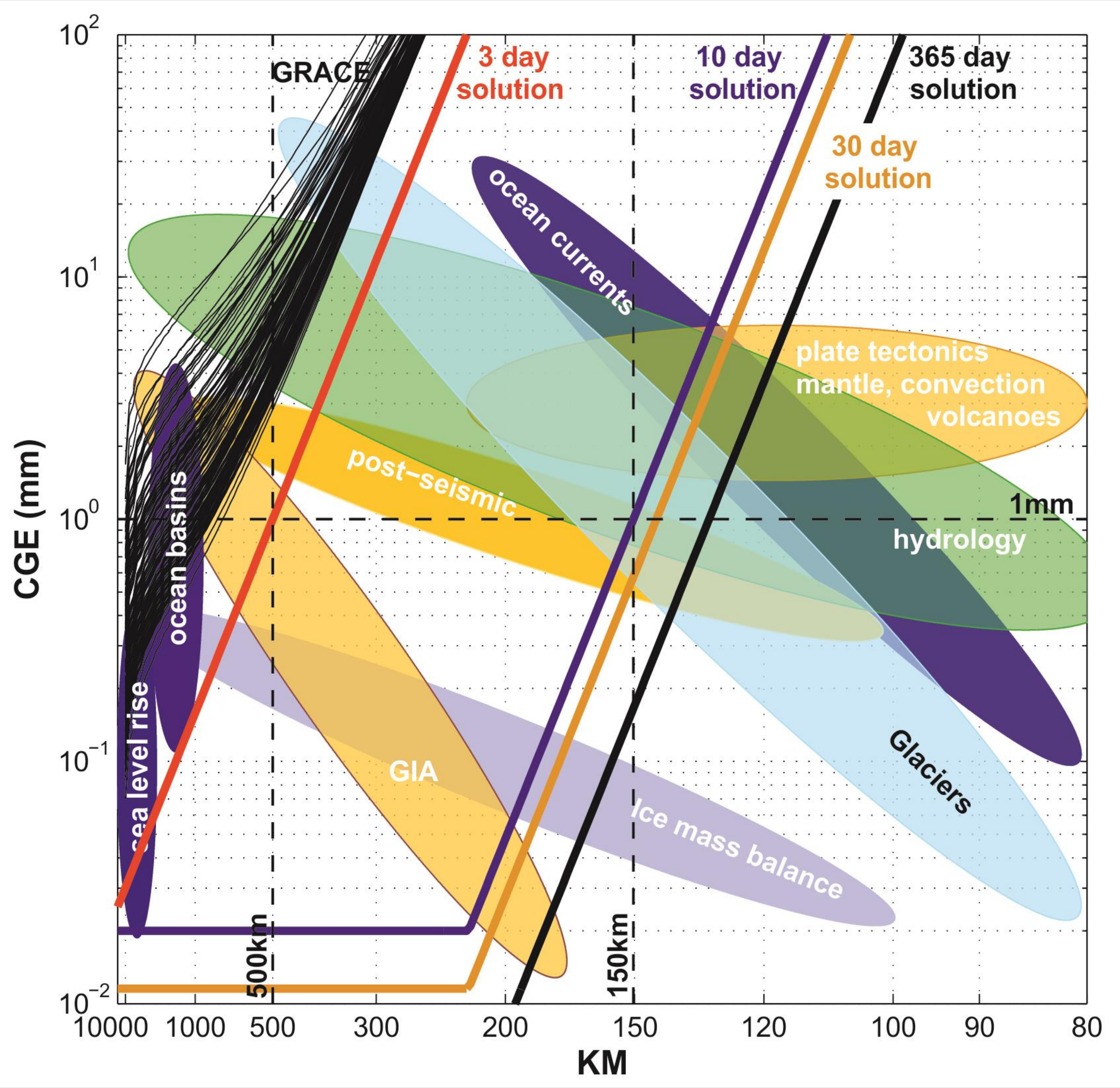


Basic scientific requirements:

3-day solutions with 1 mm precision and 500km spatial resolution

10-day solutions with 1 mm precision and 150 km spatial resolution

Definition of scientific requirements



Basic scientific requirements:

3-day solutions with
1 mm precision and
500km spatial resolution

10-day solutions with
1 mm precision and
150 km spatial resolution

Impact factors

Basic considerations

Based on experience of previous studies the search space can be limited to:

- repeat mode (β/α) of each pair
- *h ≥ 340* km *(air drag considerations)*
- inclination of polar pair between 88° and 92° *(minimizing polar gap)*
- inclination of inclined pair within 65°-75° or 105°-115°
- intersatellite distance between 75-100 km (*technical constraints*)

Genetic algorithm approach

The resulting search space is scanned using a genetic algorithm:

- Quick-look tool (no orbit integration but calculation along nominal orbit)
- Signal and error based on ESA mass transport model (Gruber et al. 2011)
    - *signal: hydrology + ice + solid Earth*
    - *error: GOT4.7-EOT08a + 10% of atmosphere and ocean + 5% random*
- Testing the global RMS of a single (first) 10-day solution
- Evaluation of 3000 candidates (massive numerical effort)

Orbit scenarios for baseline

Scenario	β/α [rev./nodal day]	Inclination [°]	Altitude [km]	Sub-cycle [nodal days]
1	484/31	89	363.3	13
	478/31	66	384.6	12
2	493/32	89	423.6	5
	249/16	70	347.6	7
3	493/32	91	427.1	5
	269/17	114	351.2	6
4	453/29	92	366.4	8
	311/20	70	351.2	9
5	172/11	92	361.9	3
	460/29	115	342.5	7

Scenario selection

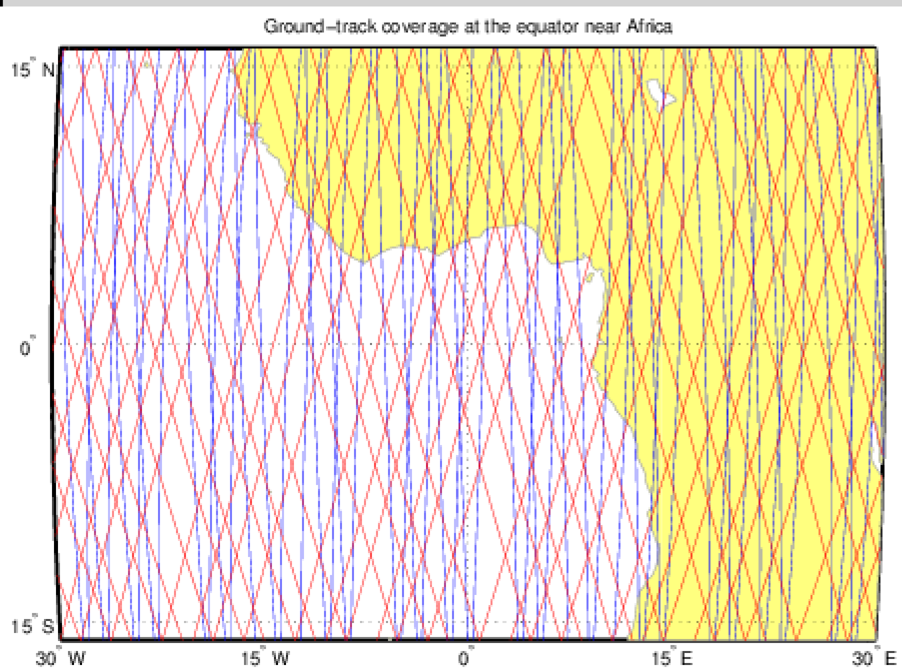
Evaluation criteria

Class	Measure	Level
Orbit	Orbit residuals	1
	Sampling and ground track coverage	
Spectral	Degree RMS (including spread of solution)	2
	Cumulative geoid errors	
	Signal-to-noise ratio	
	Isotropy	
Spatial	Global RMS	
	Basin RMS	
	Latitude and longitude dependent RMS	
	Correlation	
Time series	Equivalent water height	3
	Total water storage	
	Loading	

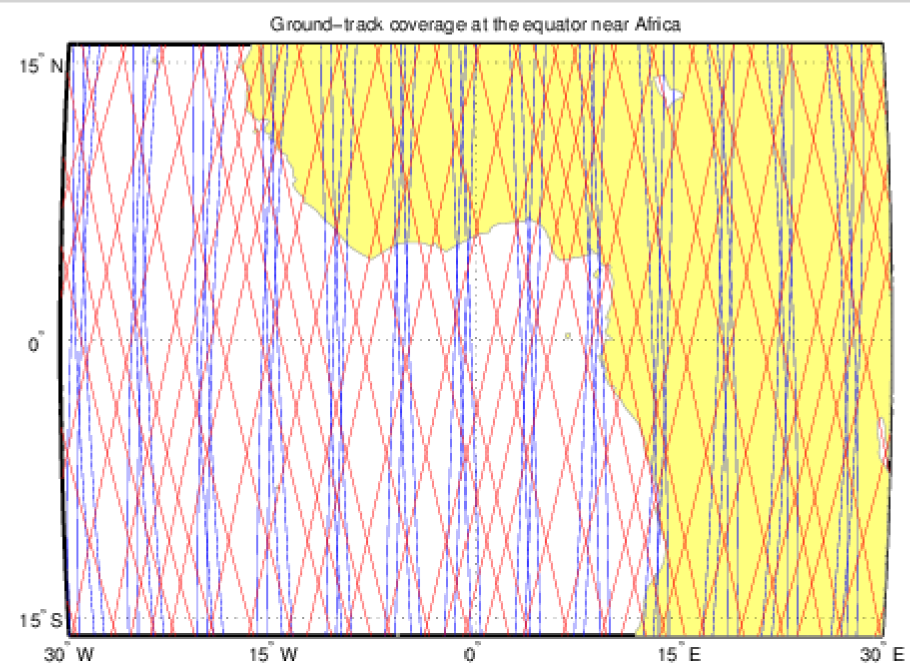
and many more …

Orbit configuration (sampling) (Level 1)

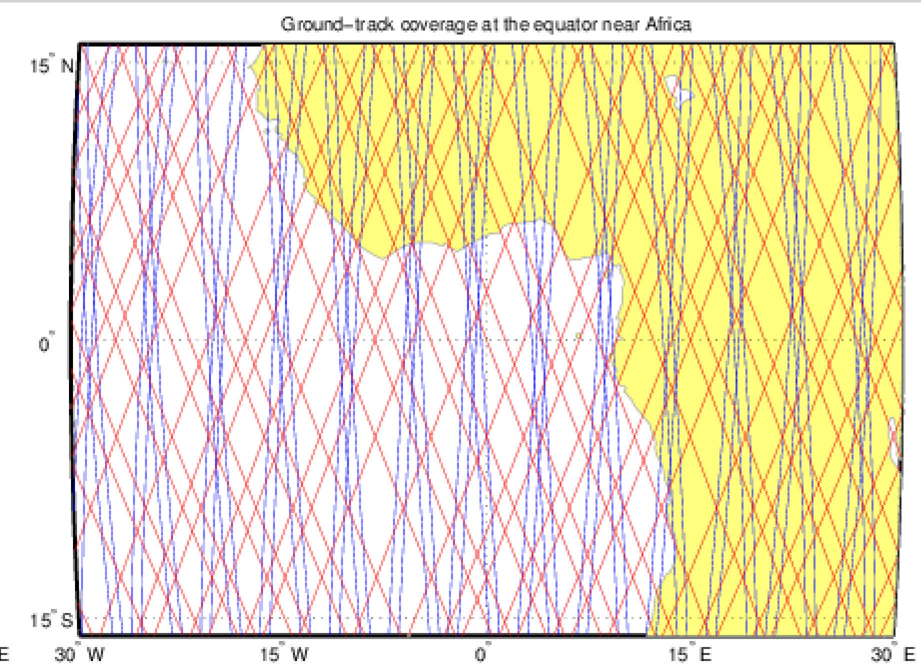
Groundtrack



Scenario 1



Scenario 2



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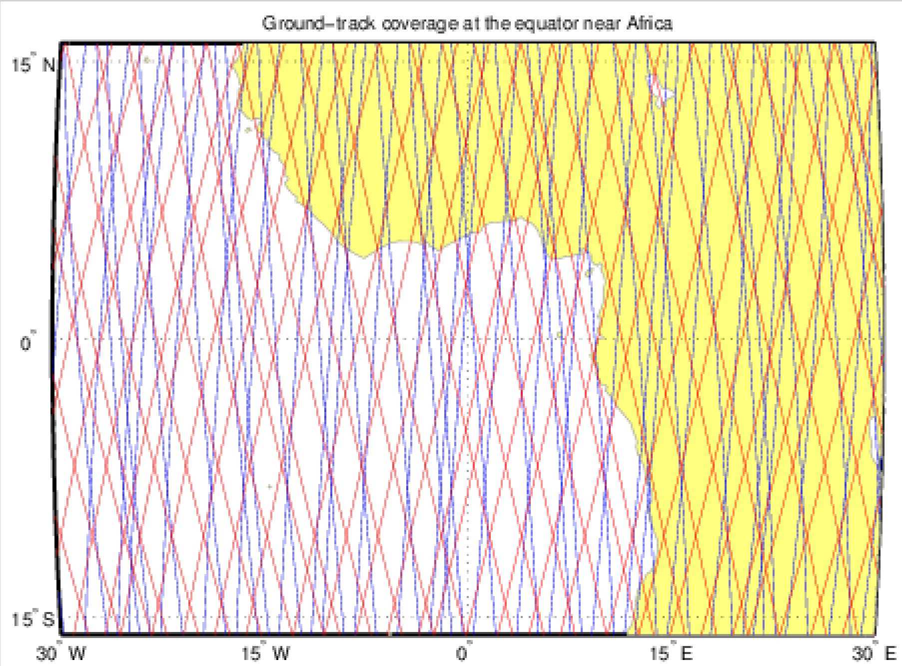
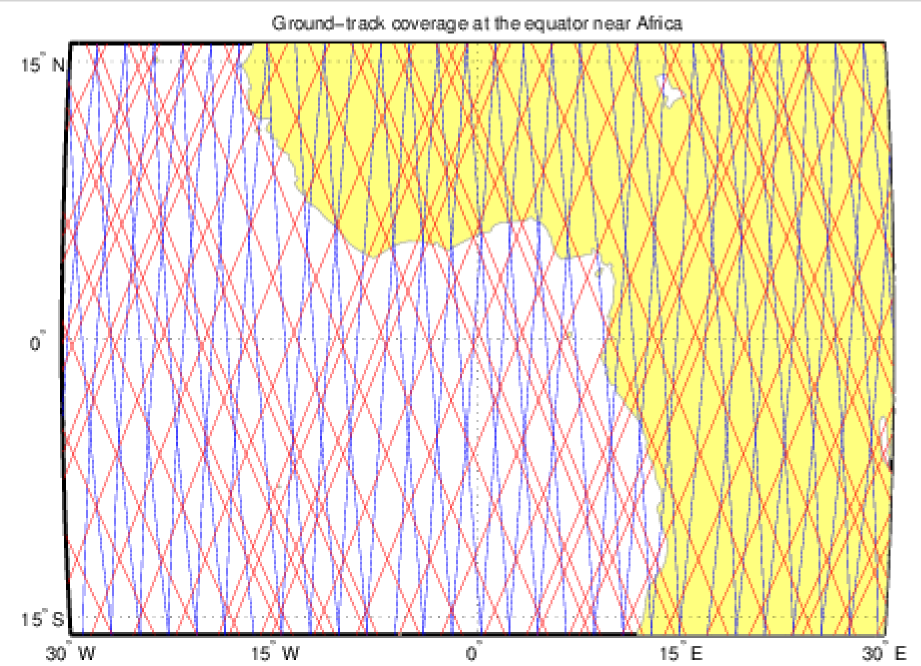
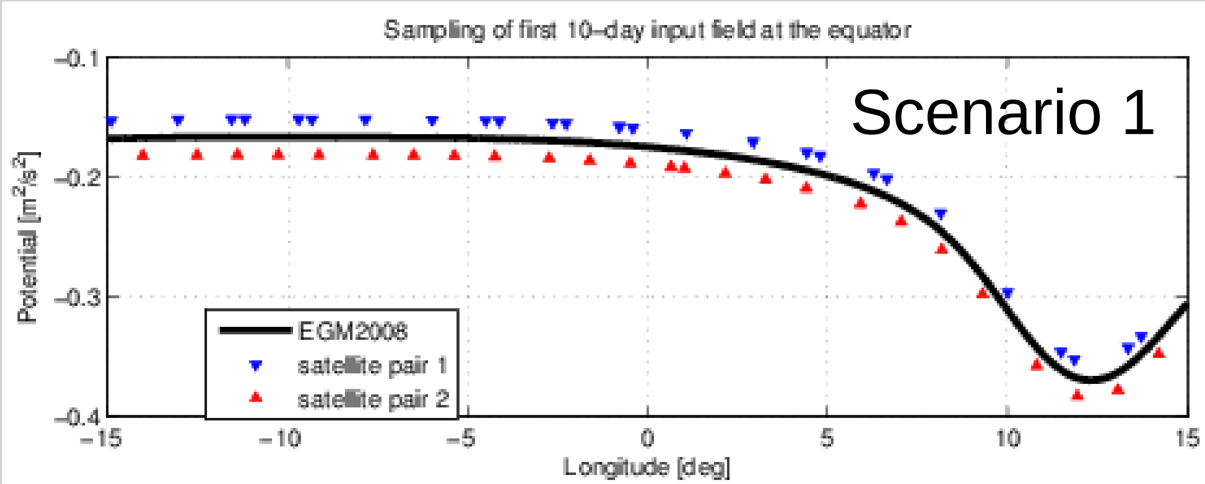


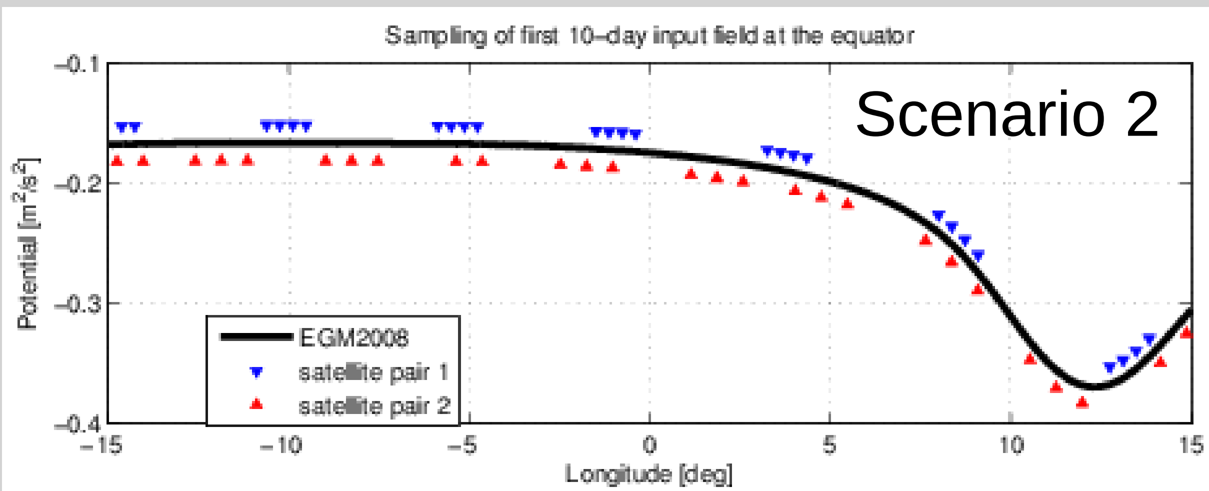
Scenario 4

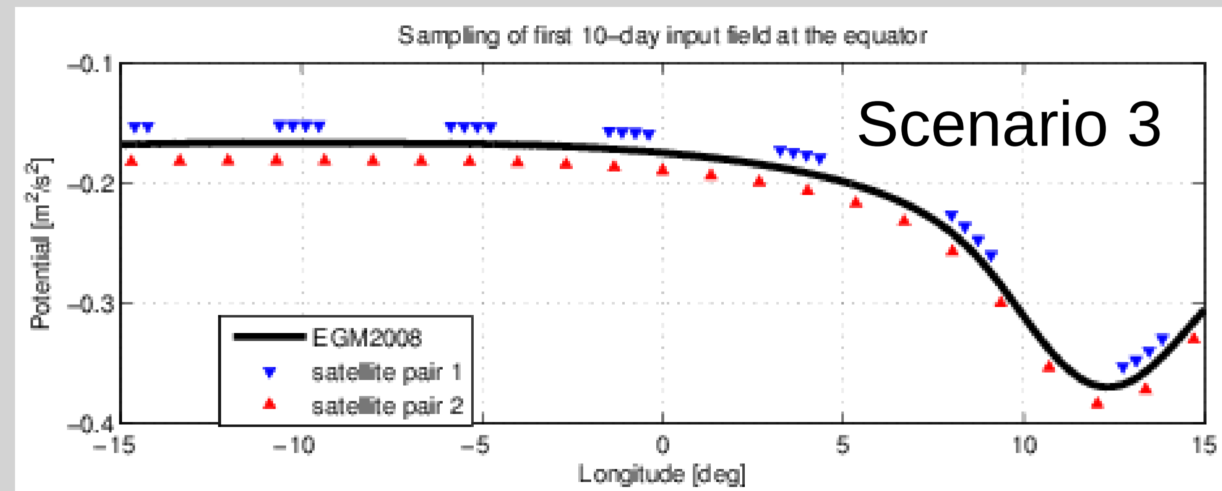


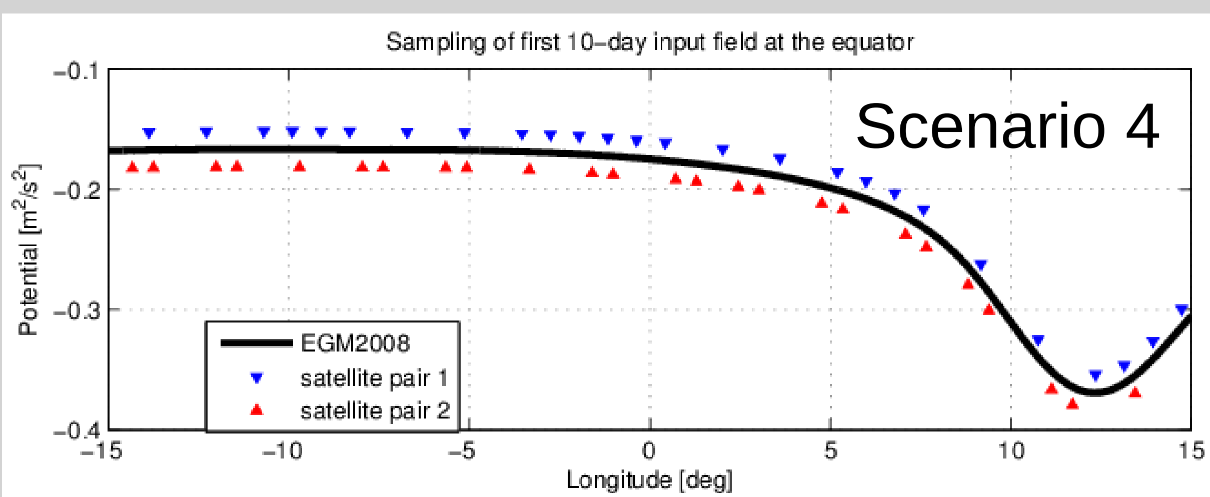
Scenario 5

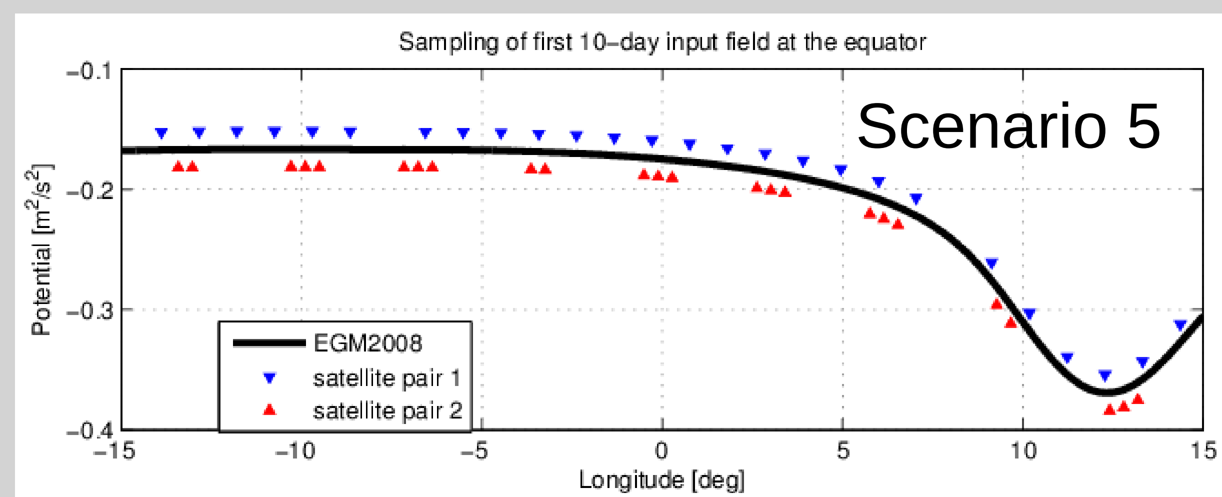
Equator sampling







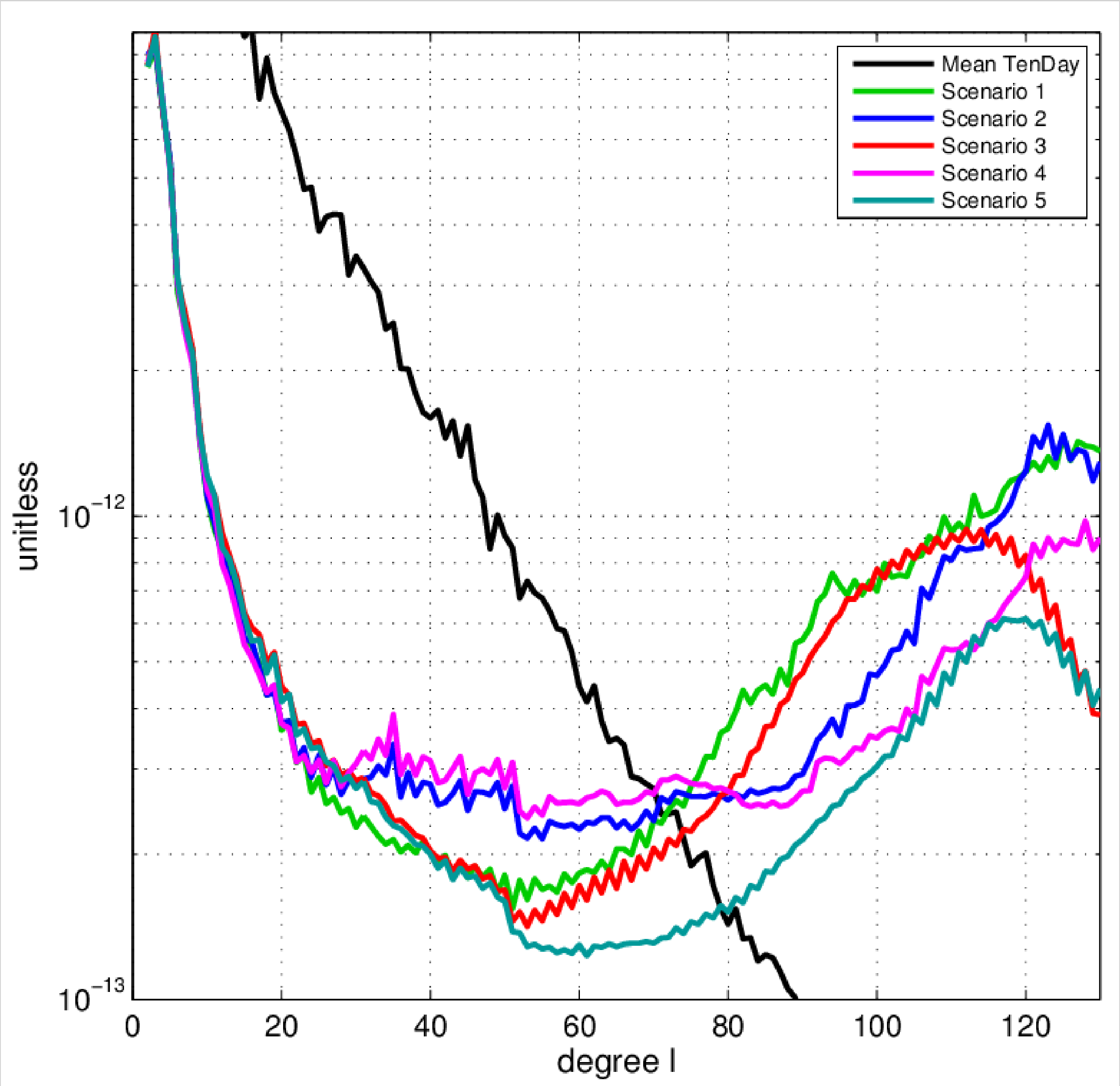




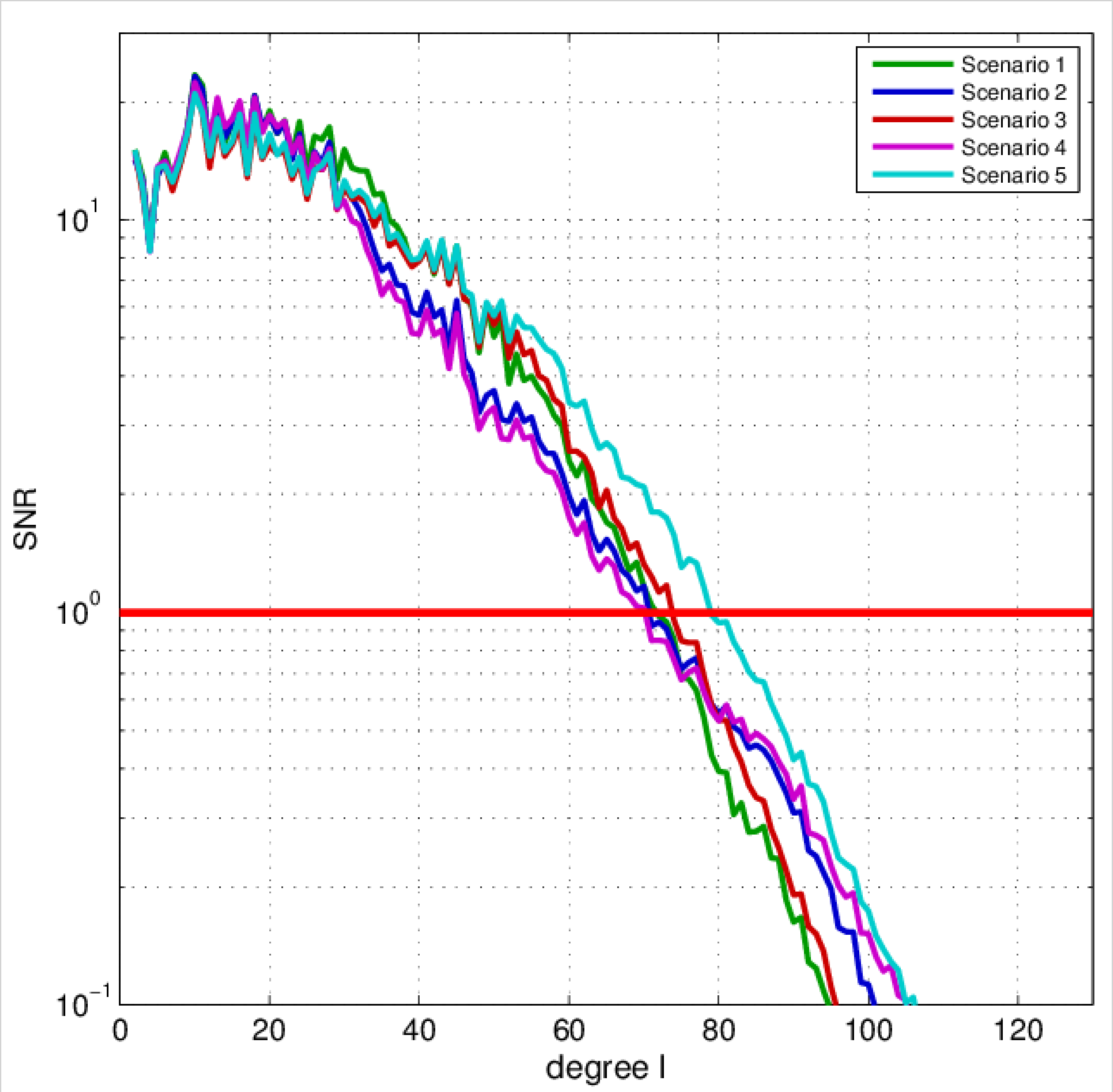
Degree RMS and Isotropy (Level 2)

Degree RMS

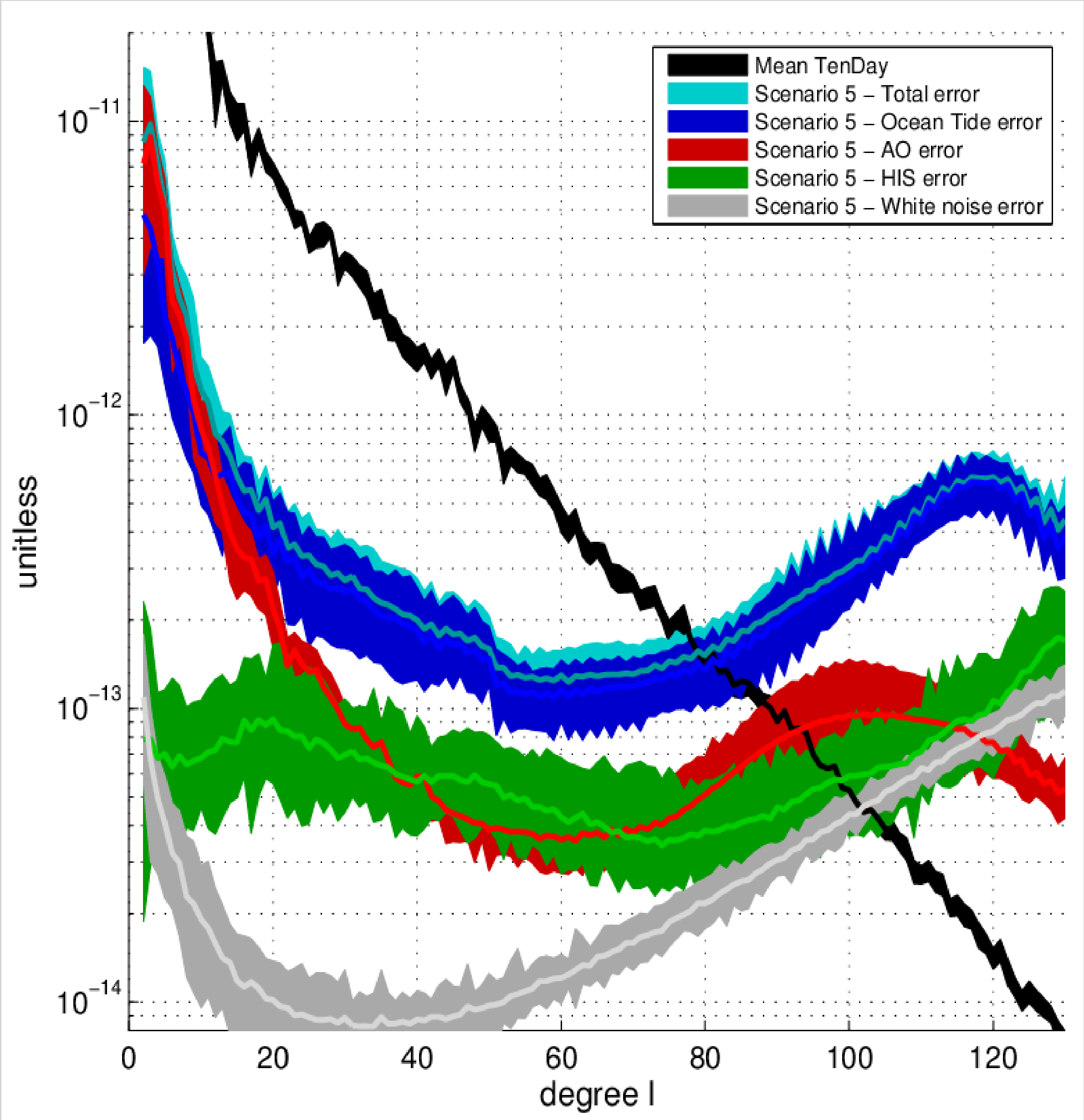
Degree RMS



Gain



Assignment of error sources



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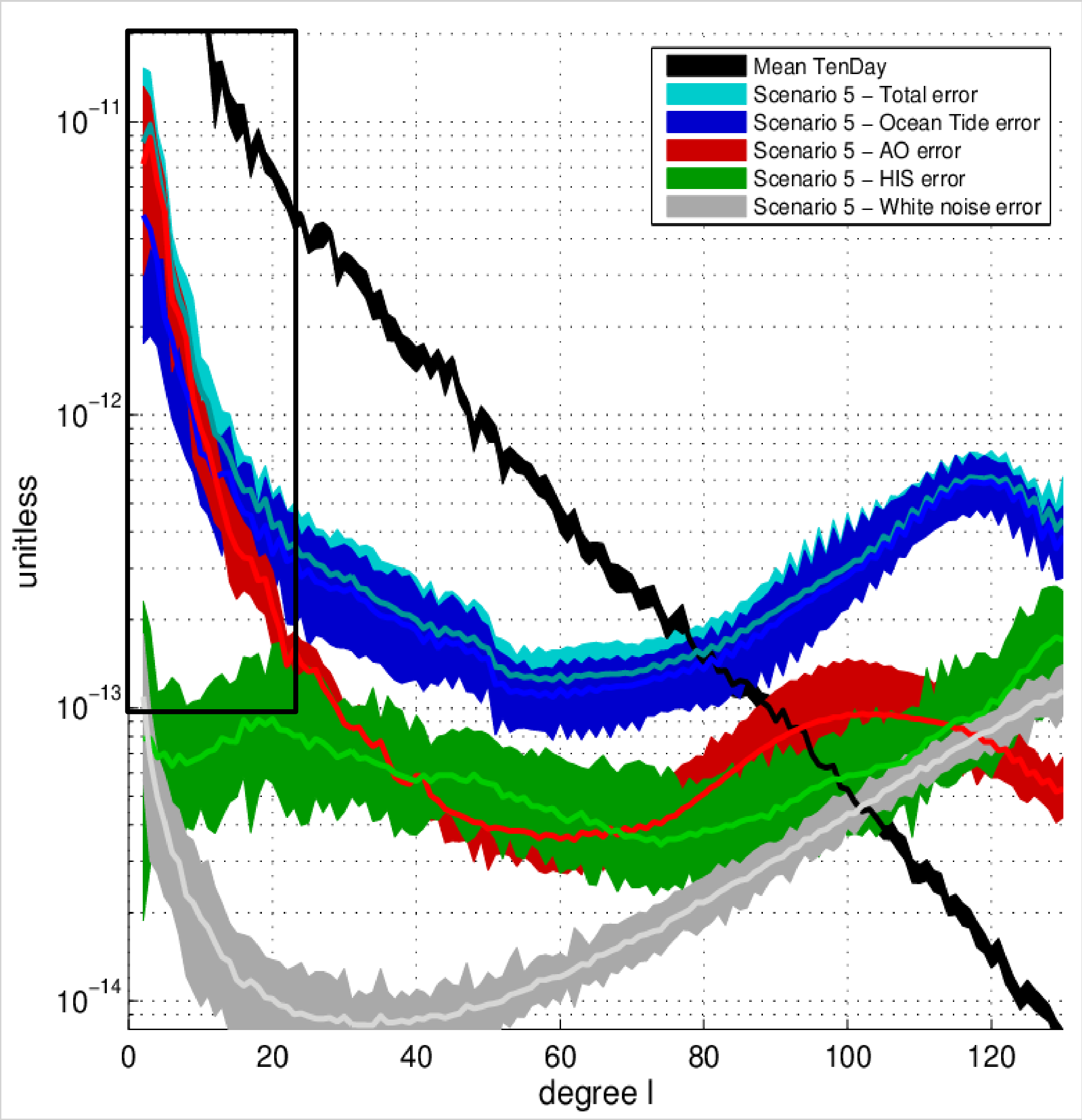

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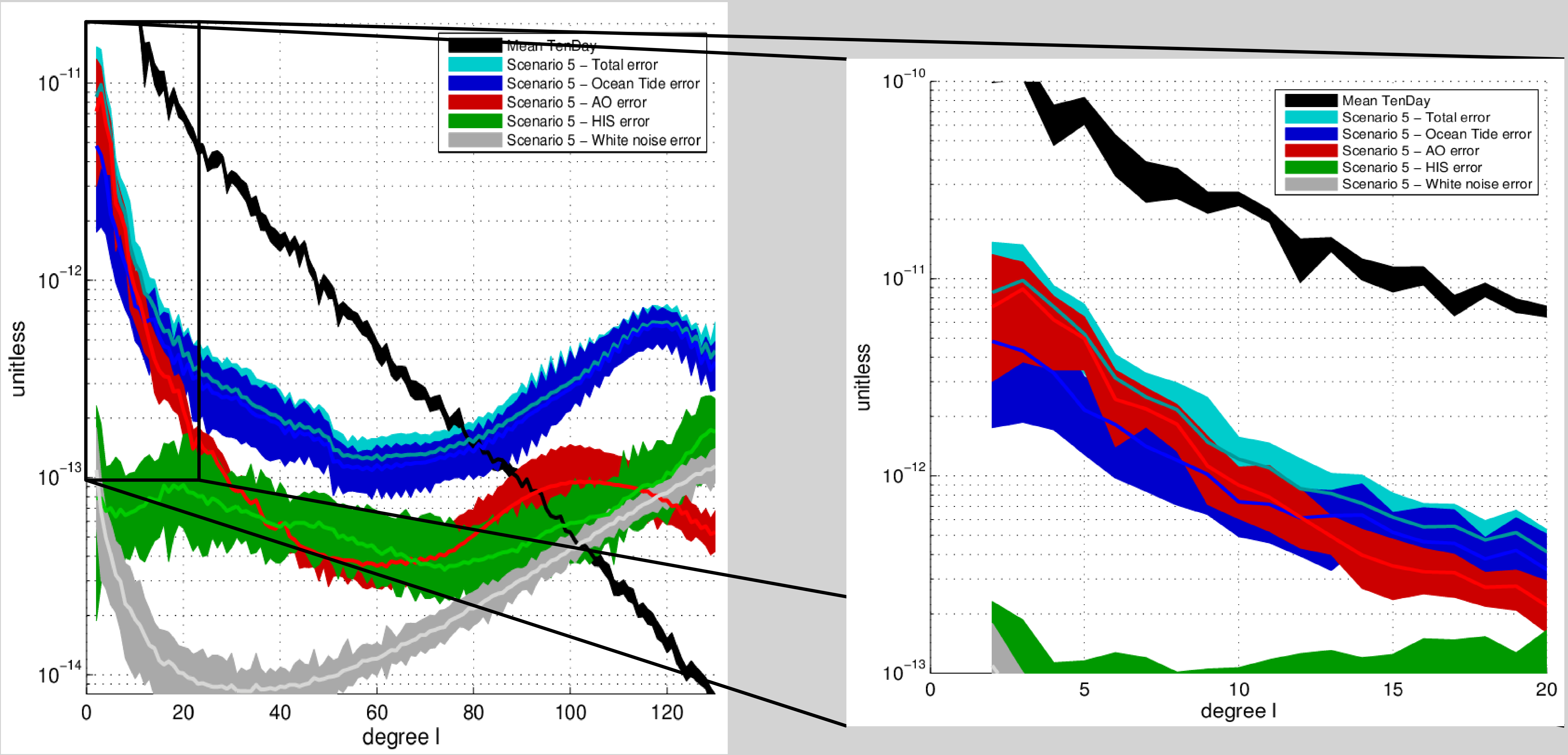
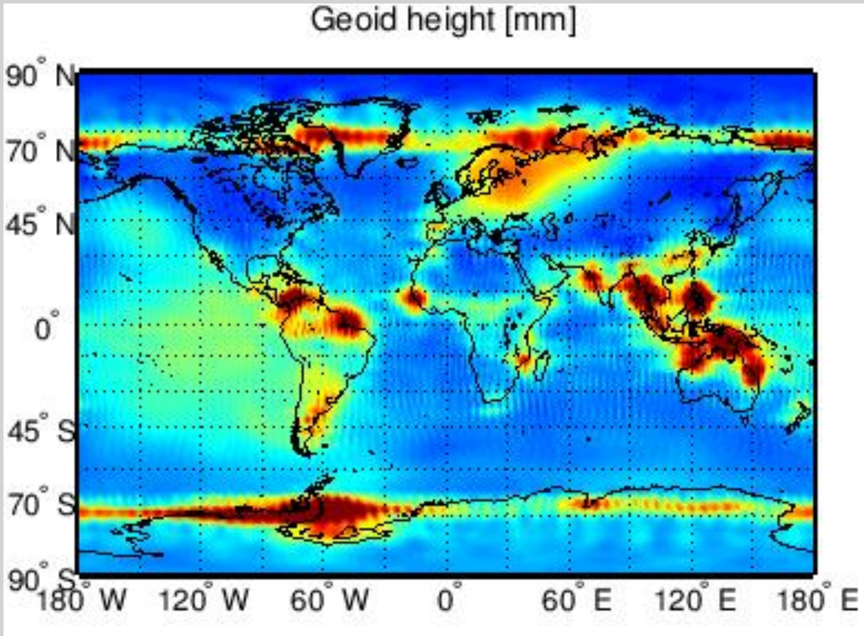
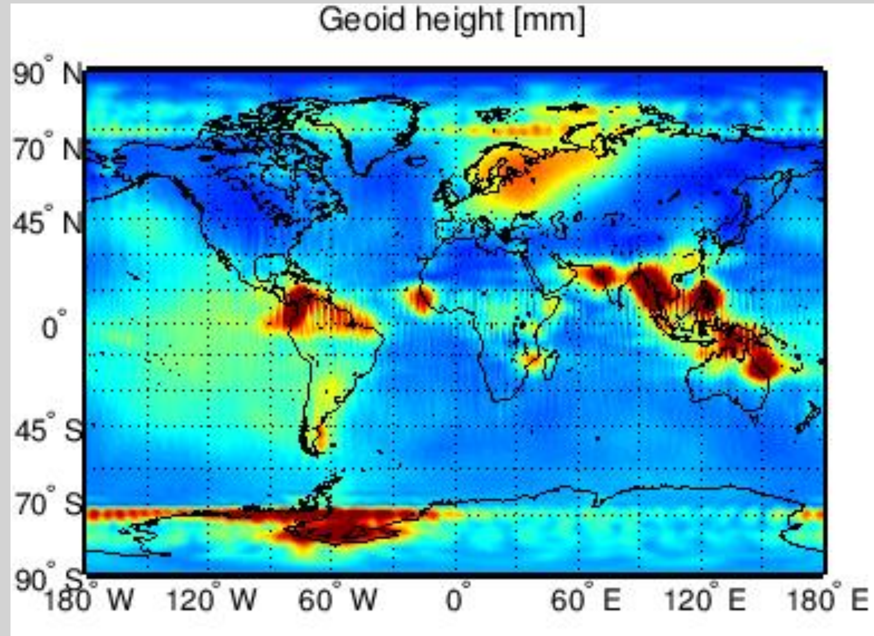


Spatial error pattern
(Level 2)

Unfiltered spatial pattern



Scenario 1



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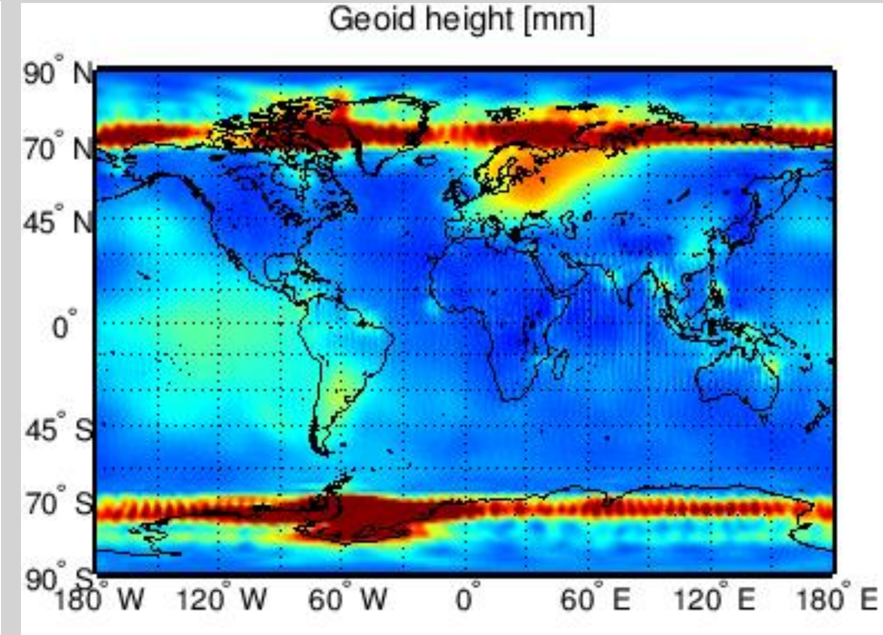

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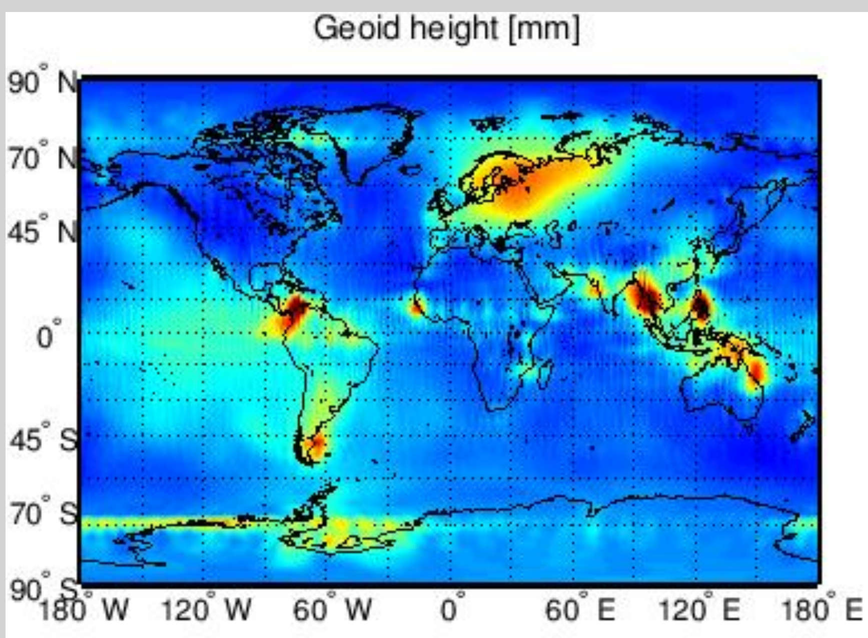
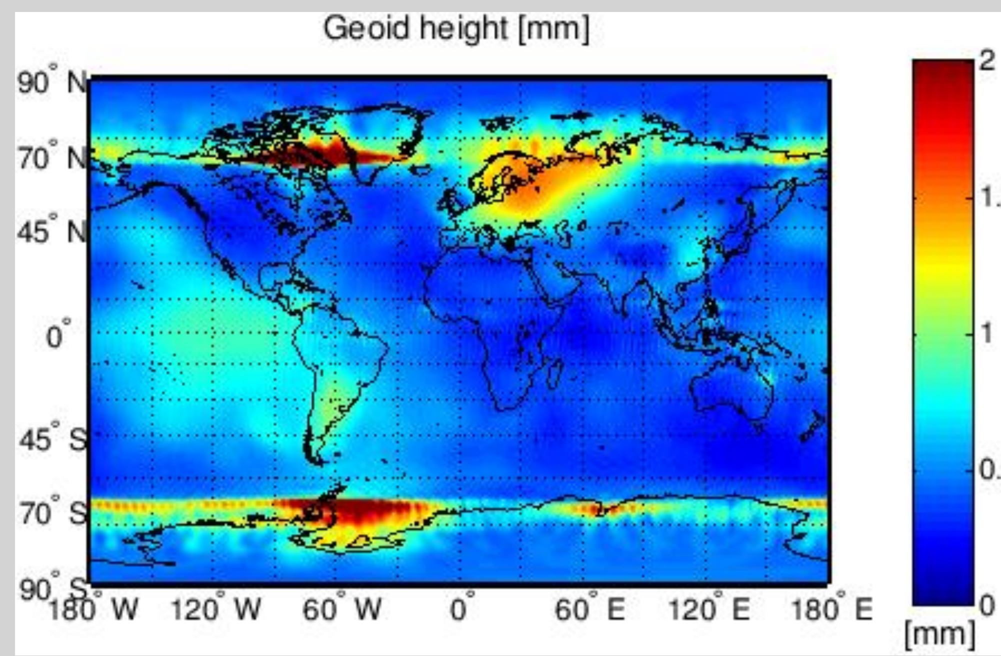
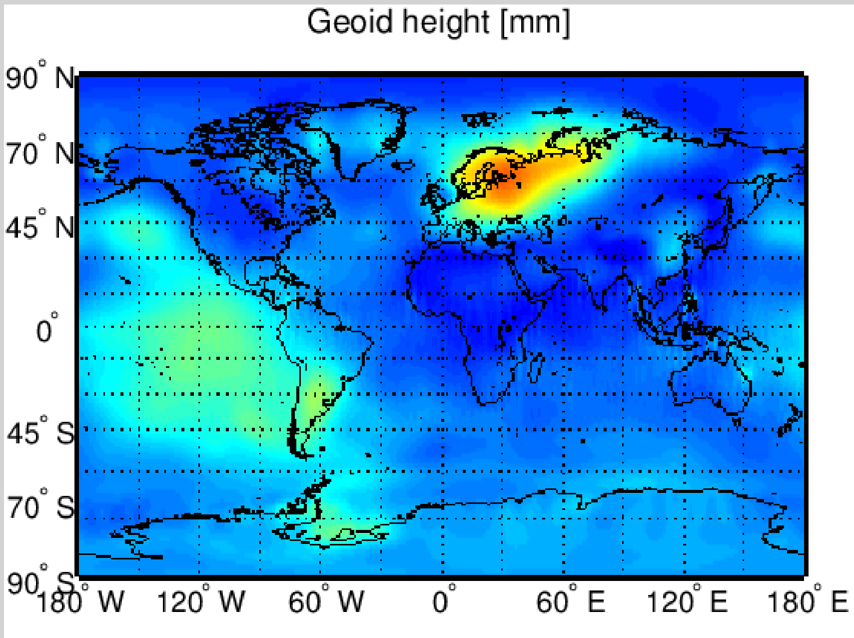


Scenario 4

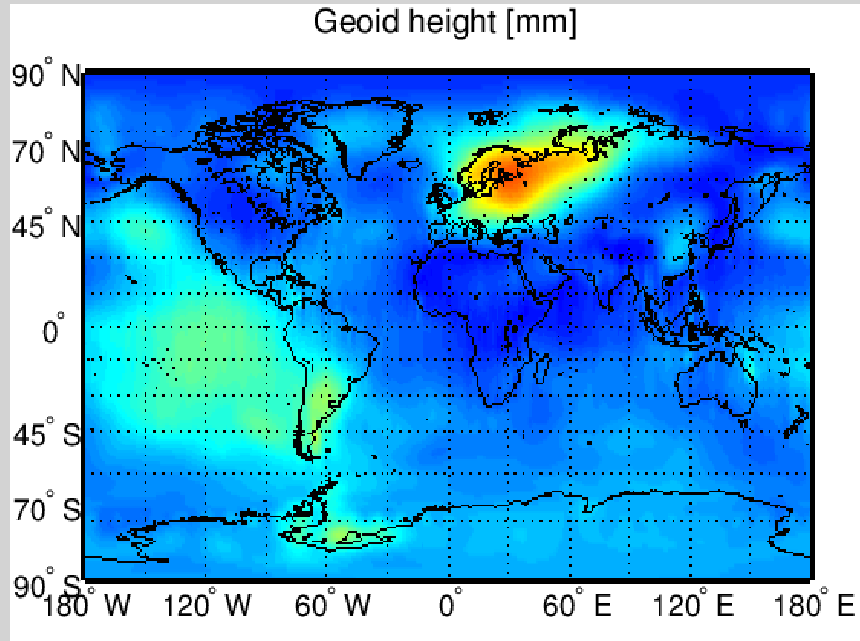


Scenario 5

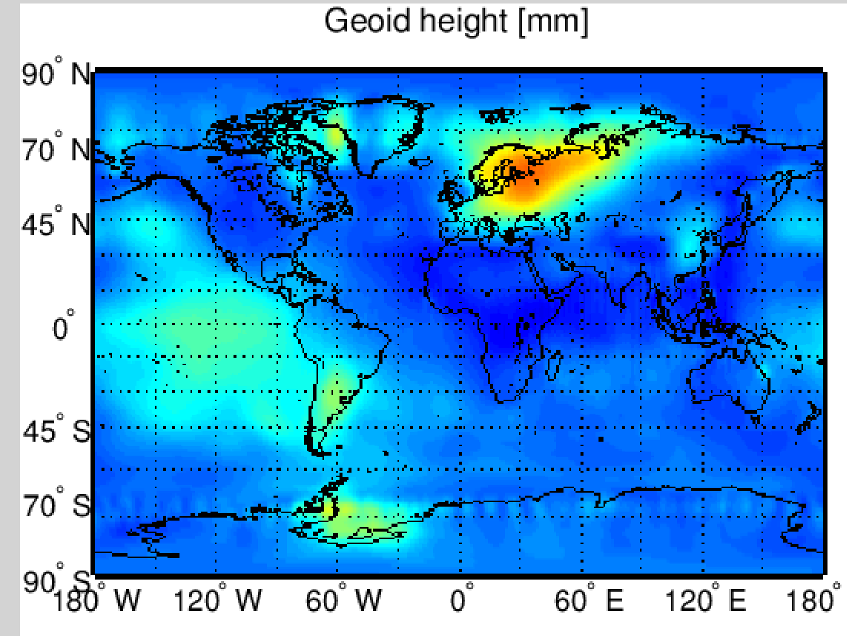
Filtered spatial pattern



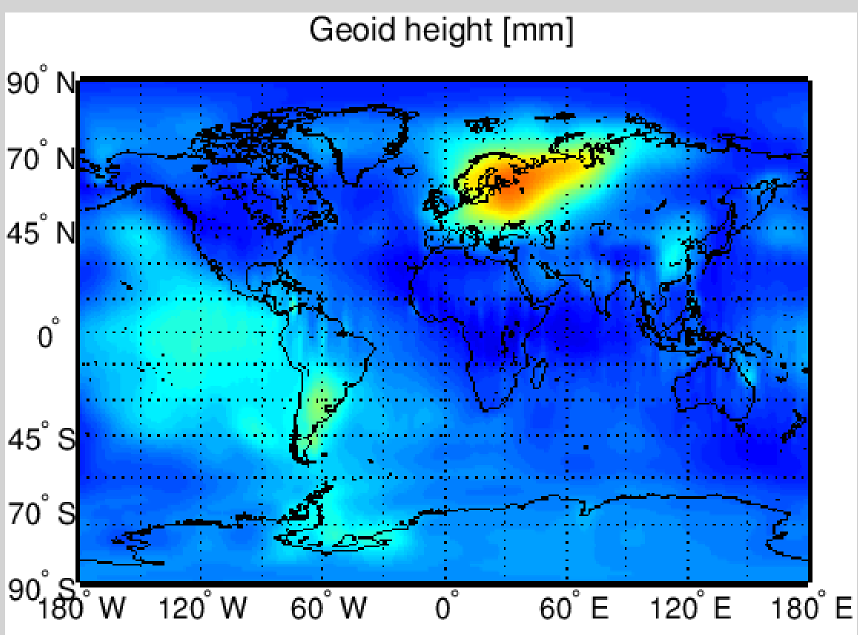
Scenario 1



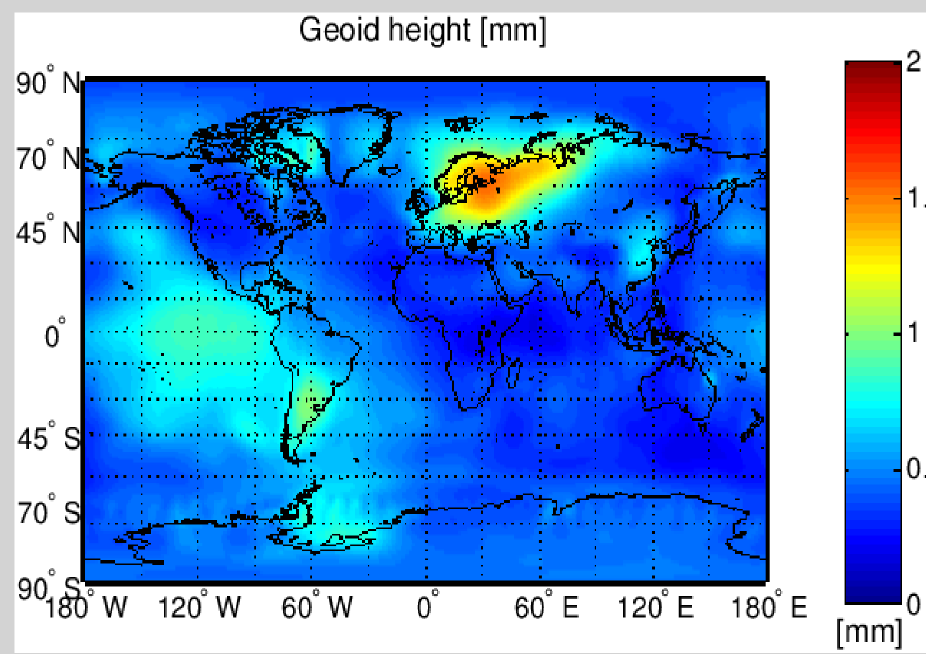
Scenario 2



Scenario 3

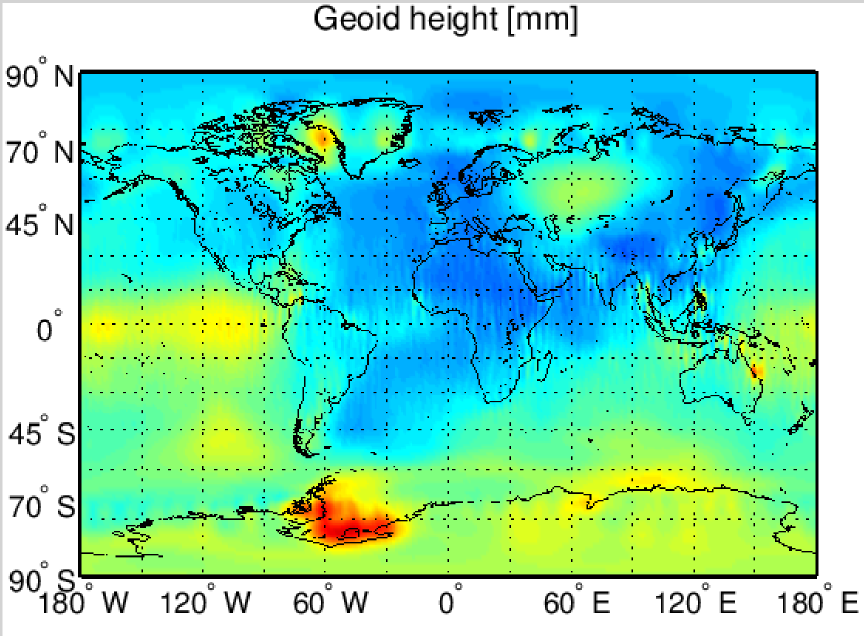


Scenario 4

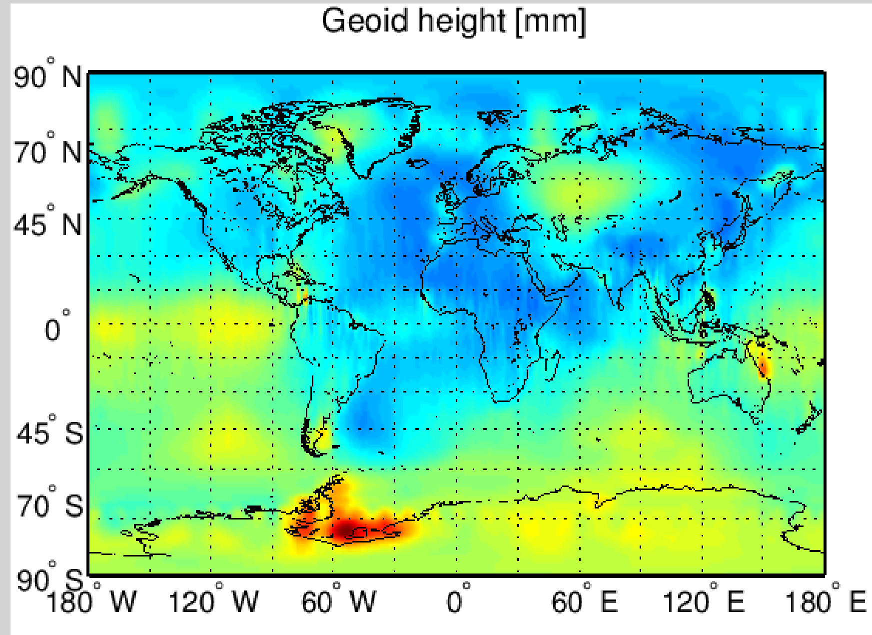


Scenario 5

Mean-filtered spatial pattern



Scenario 1



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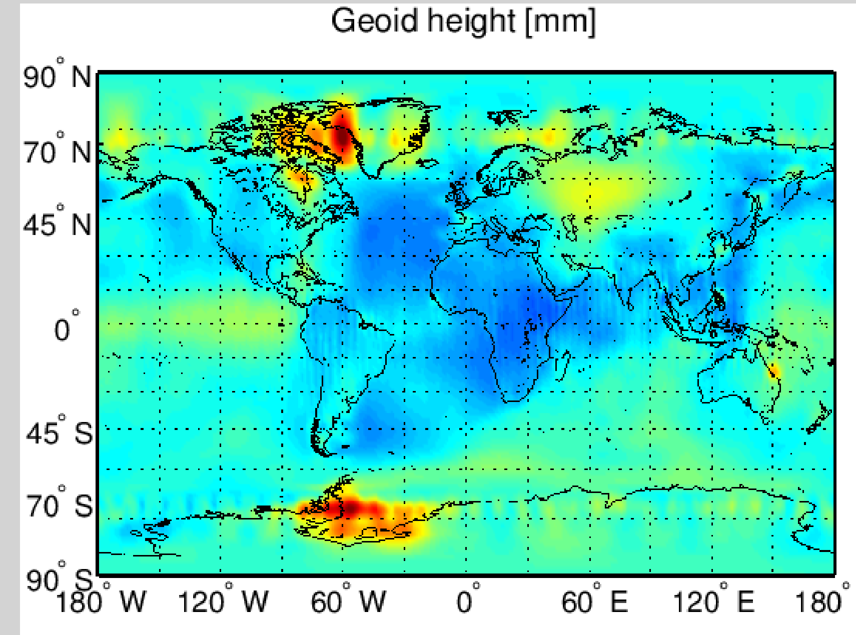
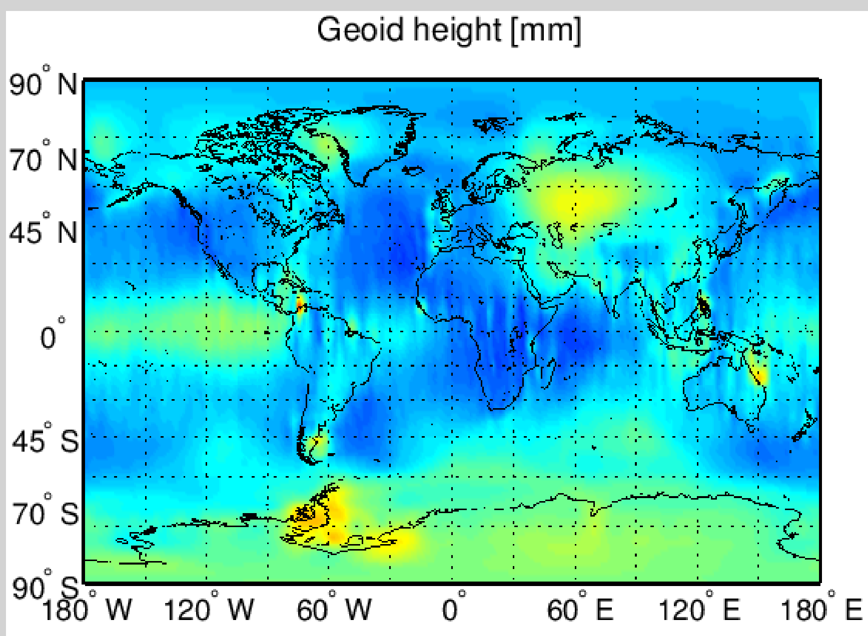
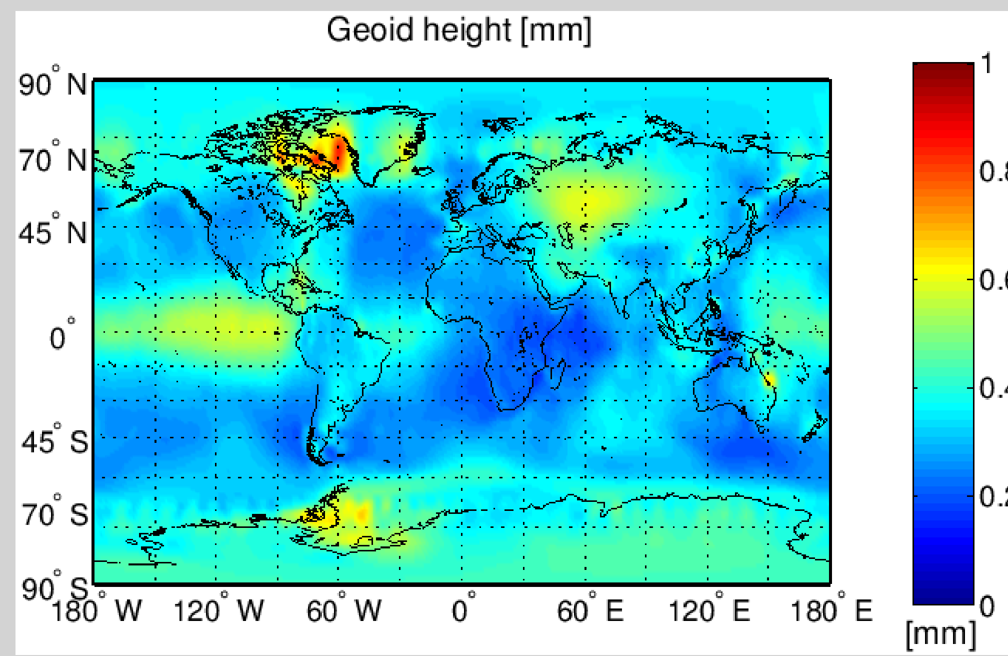


Scenario 3



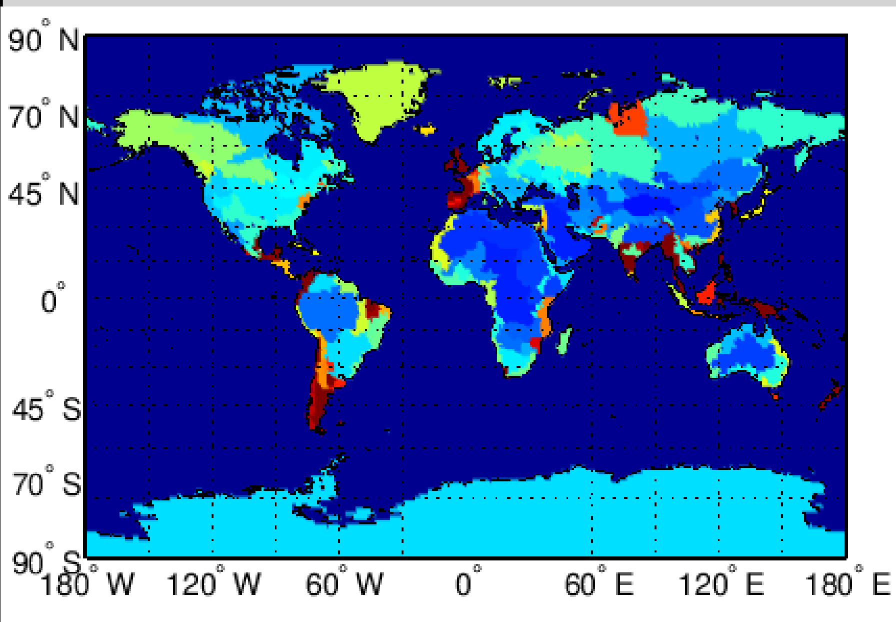
Scenario 4



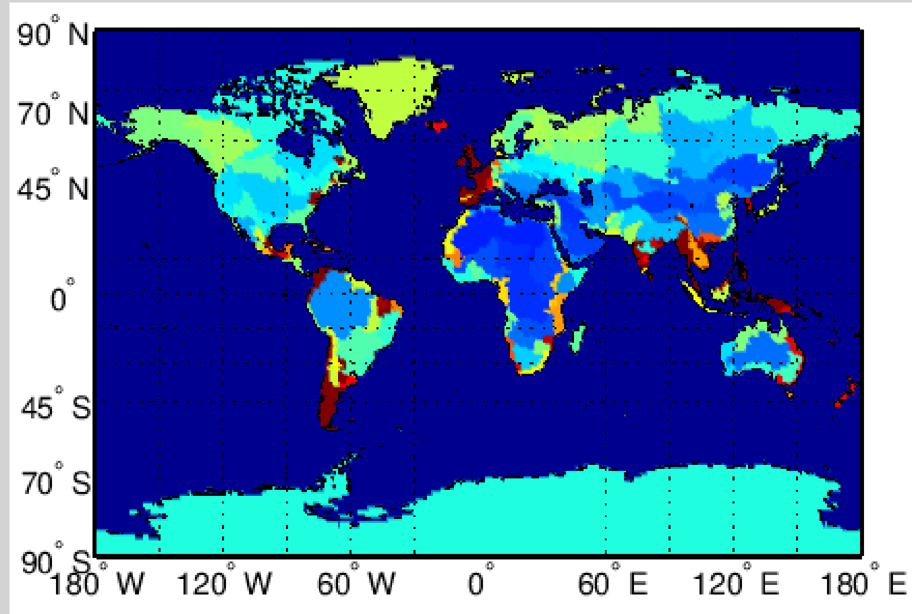
Scenario 5

Time series analysis
(Level 3)

Total water storage change



Scenario 1



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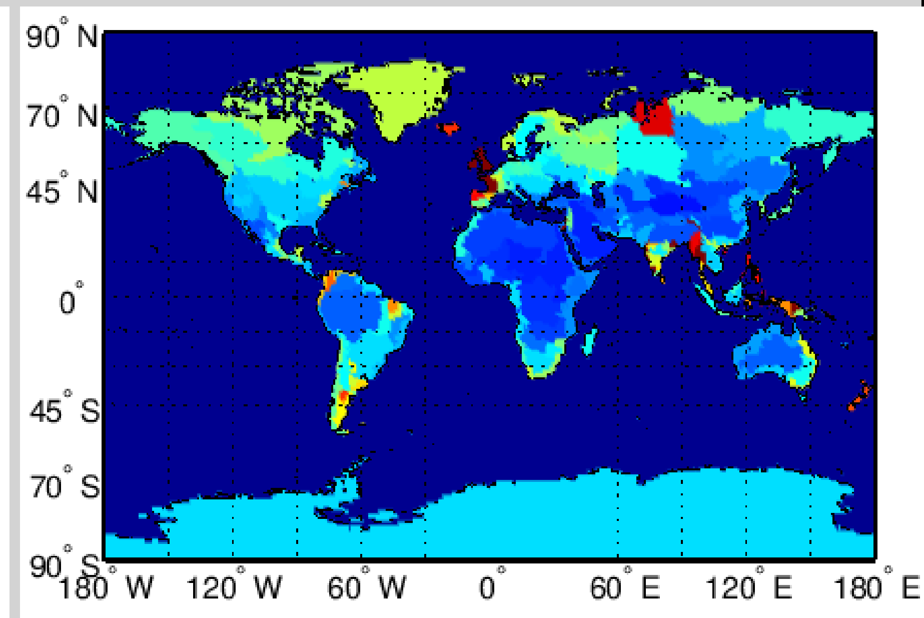
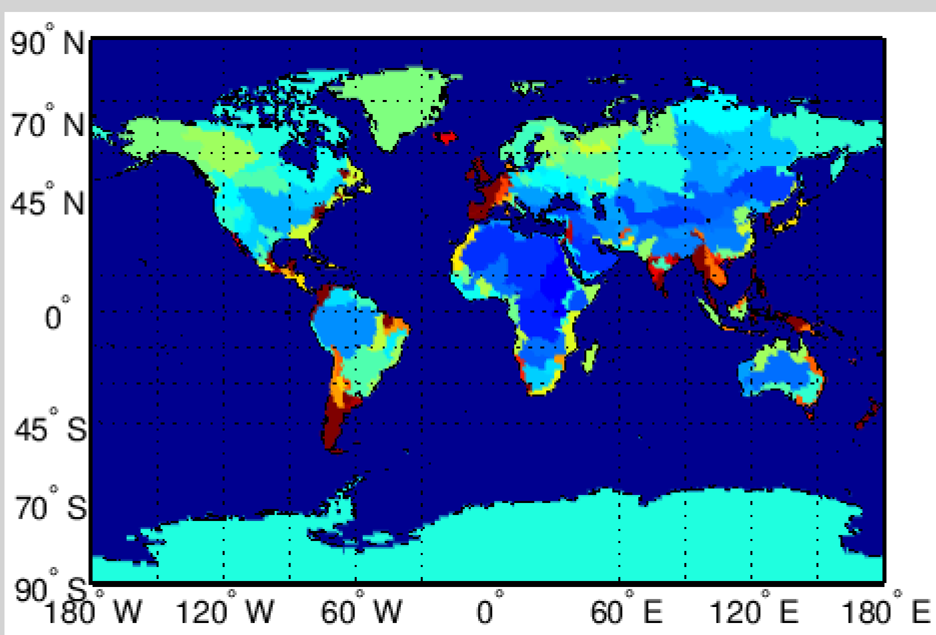
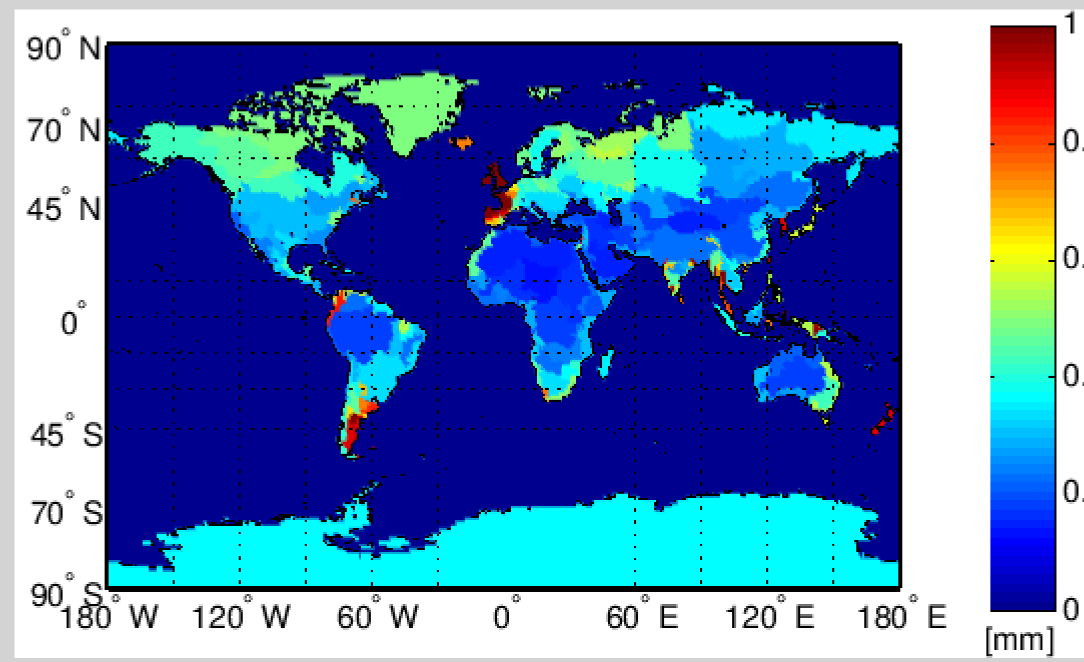


Scenario 3

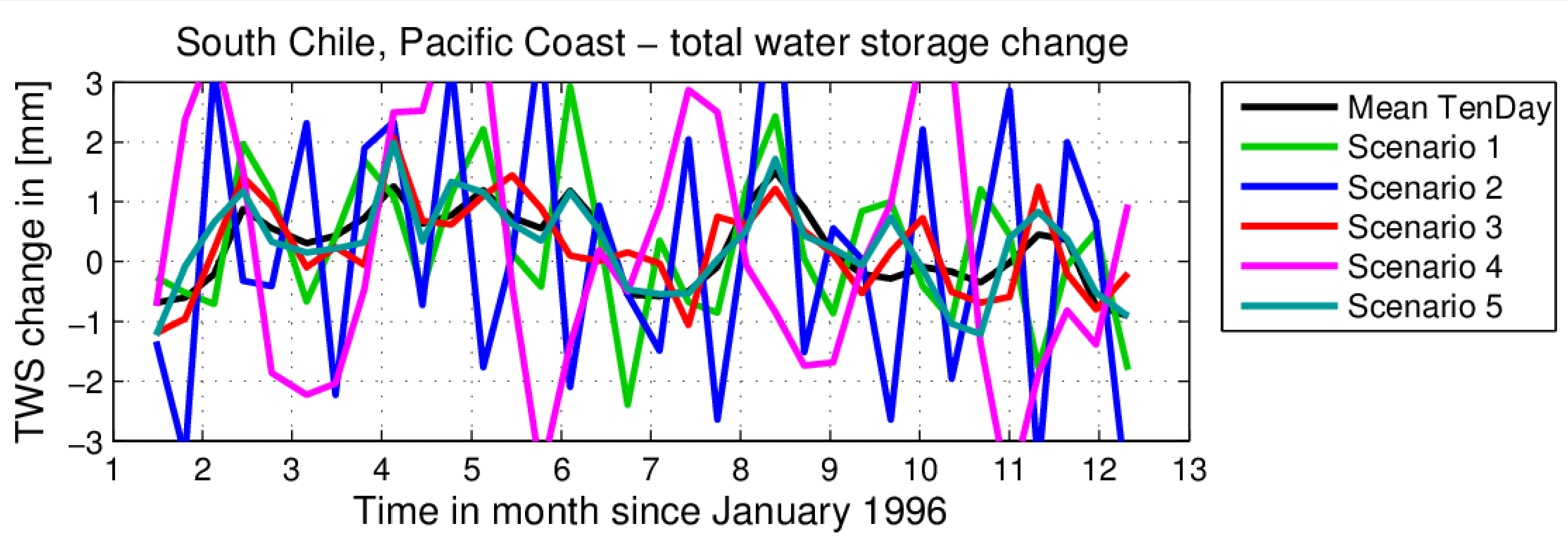


Scenario 4



Scenario 5

Southern Chile



	Trend [mm/yr.]	Annual amp. [mm]	Phase [days]	Semi-annual amp. [mm]	Phase [days]	Residual [mm]
Reference	0.61	0.65	333	0.38	299	0.49
Δ Scenario 1	-1.14	-0.23	-28	0.12	-11	0.63
Δ Scenario 2	-0.44	0.02	-19	0.24	-6	1.70
Δ Scenario 3	1.01	0.27	14	0.04	20	0.15
Δ Scenario 4	-3.52	-0.08	-110	-0.07	-56	1.65
Δ Scenario 5	0.23	0.05	10	-0.01	-11	0.16

Summary

- We choose scenario 5 as baseline scenario.
- GA needs better optimization criterion:
  - Testing a single solution is equivalent to testing a static field.
  - Time-variable signal needs to be tested.
- Impact of the sampling pattern needs to be understood. (e.g. isotropy, aliasing, …)
- Scenario selection needs evaluation on all levels of calculation and application.