Ocean Surface Topography Science Team Meeting
Precision Orbit Determination Splinter

Reducing the Dependency of Precise Orbits on Time Varying Gravity Field Modeling Errors

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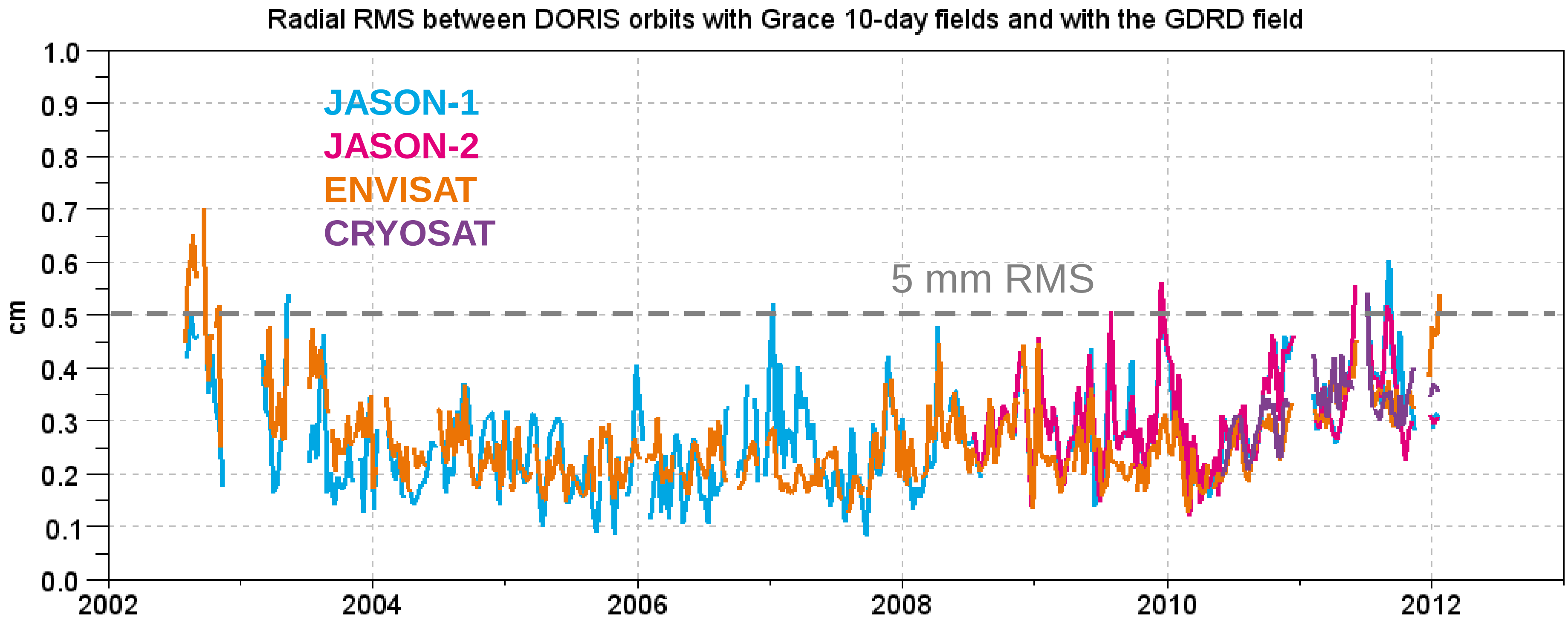
Context , Scope and Objectives

- Errors in the modeling of **secular variations of the gravity field** cause **signatures which are significant for regional MSL applications**

- Current approach (GDR – D)
  - **GDR orbits are DORIS+SLR solutions including GPS when available**
    - **Same approach for Jason-1,Jason-2,Envisat,Cryosat, HY2A**
  - **Secular variations in gravity field are taken into account by 50x50 drifts included EIGEN-GRGS_RL02bis_MEAN-FIELD field**
  - **This linear model provides significant improvement in the orbit performance wrt to the previous generation of orbits**
    - **Altimetry, SLR residuals comparison with reduced-dynamic GPS orbits (Jason)**
    - **Comparison with orbits obtained using the 10-day time series of GRACE derived fields**

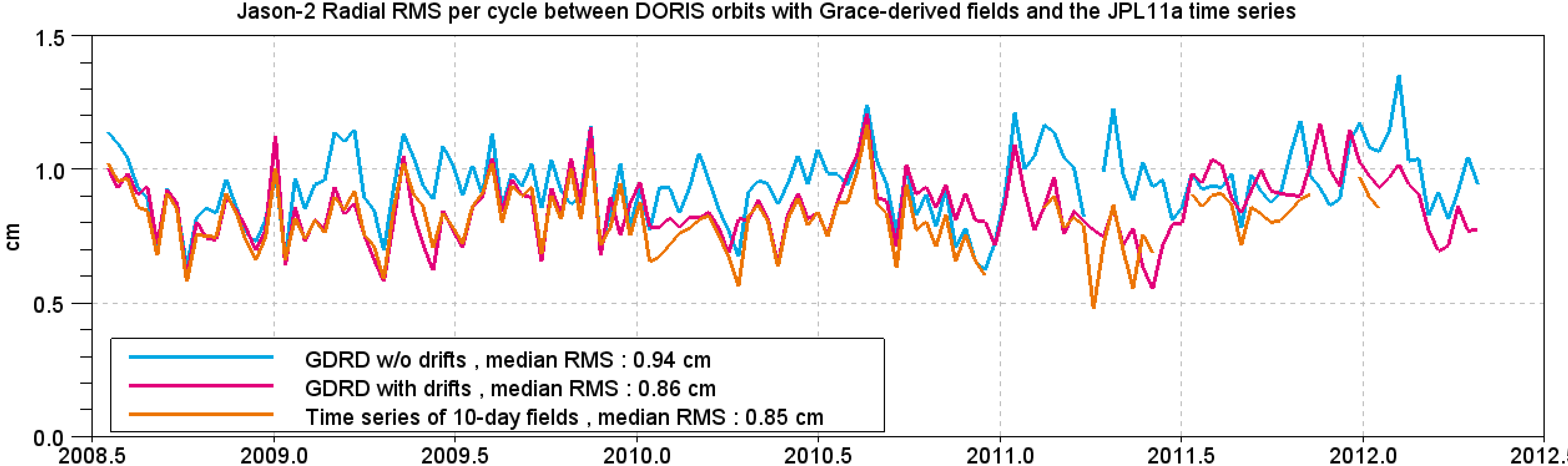
Context , Scope and Objectives

- The difference between orbits using the mean model (GDRD) and the time series of 10-day fields is quite stable
  (expected radial accuracy of DORIS-only dynamic orbits is < 1.5 cm RMS)



Context , Scope and Objectives

- Stable RMS of radial orbit difference between GDRD DORIS-only dynamic orbits (24hr 1/rev) and JPL reduced dynamic GPS orbits
  - Orbit difference increases when drifts are removed
  - Stable orbit differences (RMS) between Grace-based TVG orbits and JPL11A



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Context , Scope and Objectives

- Limitations :
  - We **cannot safely extrapolate linear trends** if the underlying geophysical processes are not linear; we **need a solution for POD in case GRACE data were lost**
  - Several potential contributors to MSL trends estimates (Cryosat-2 and SARAL-AltiKa) **rely only on DORIS+SLR data** : reduced-dynamic approach is limited by observability
  - The performance of GPS-based reduced-dynamic orbits with Sentinel-3 GPS receiver remains to be assessed

- **Interest in assessing the capability of DORIS to observe local mass variations on the long-term**
  - **DORIS-only dynamic orbits** (24hr 1/rev , 1 drag coeff every 3 revs)

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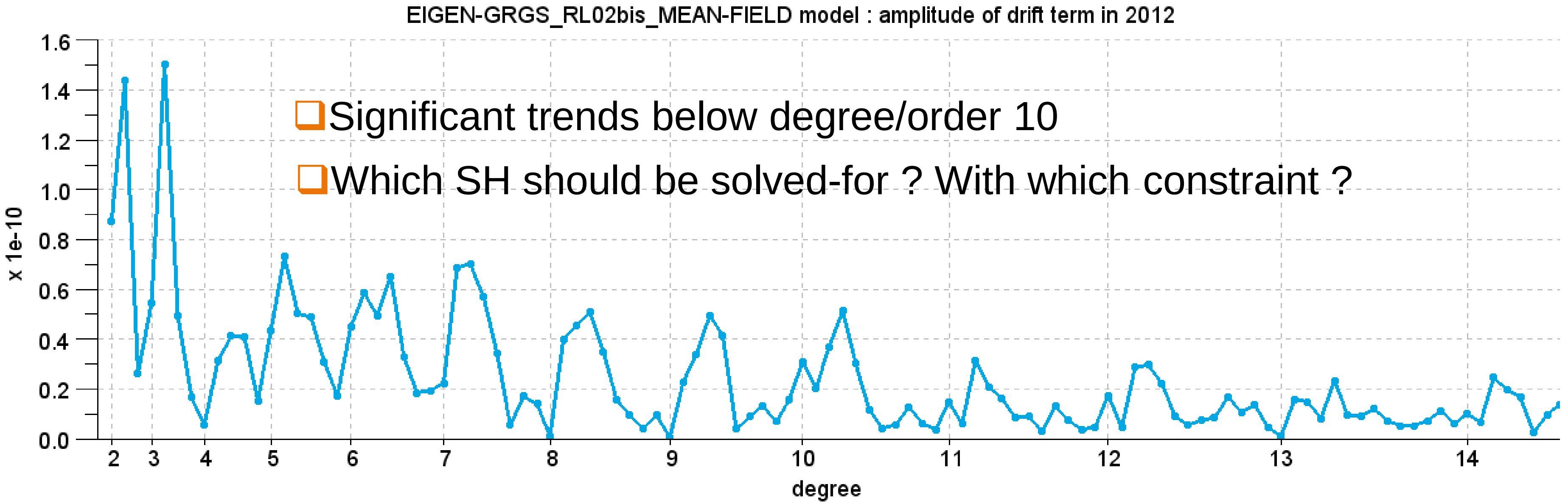
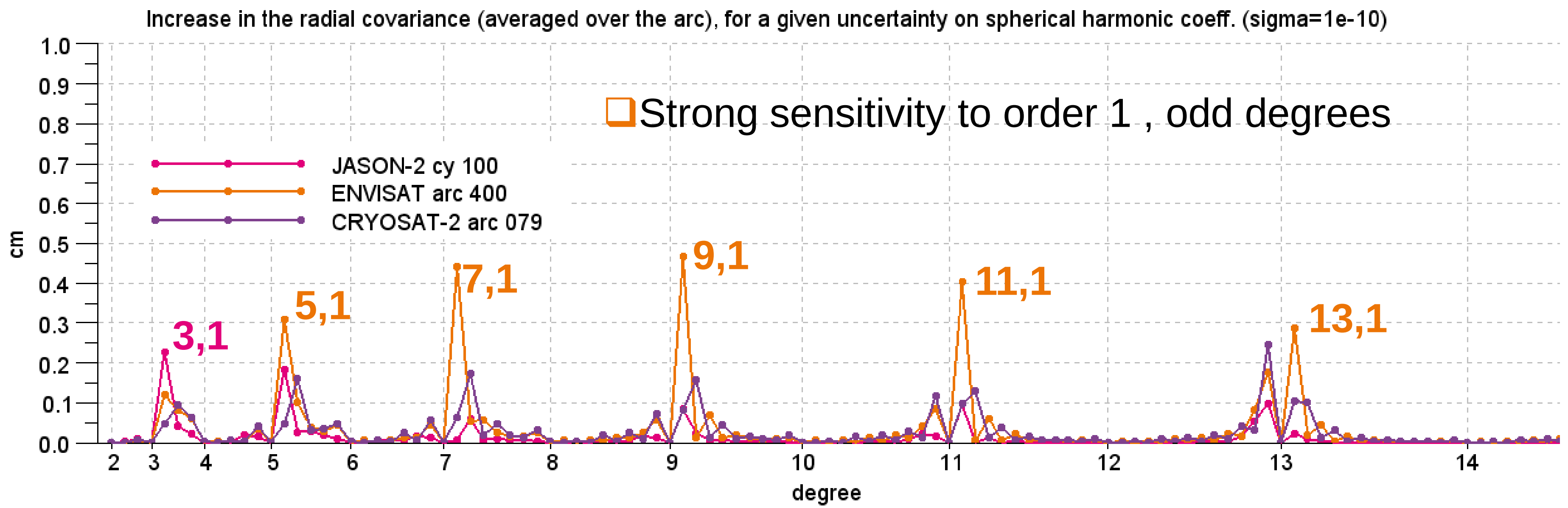
Sensitivity to variations in spherical harmonics





Point Mascon Model : a simpler approach

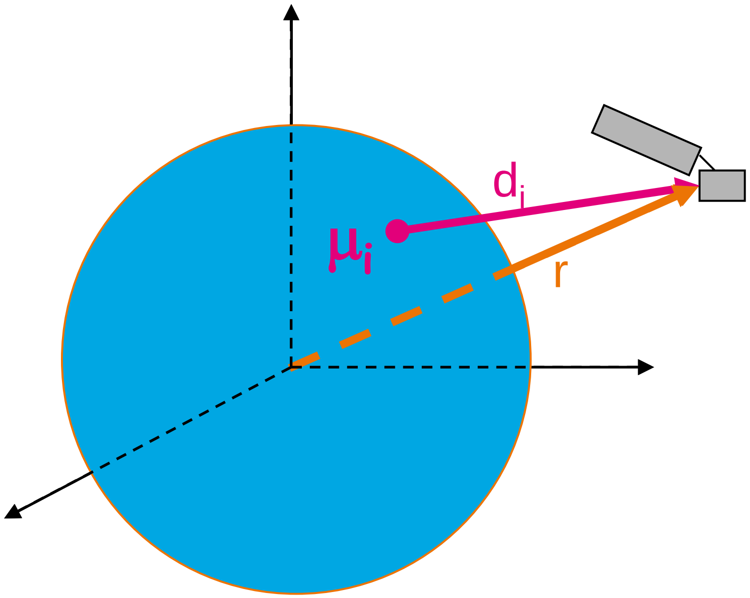
- Alternative: **solve for the mass of *N* point mascons at known locations**

- Acceleration on the satellite induced by the *i-th* point mascon

$$f_i = -\frac{\mu_i}{d_i^3}\vec{d}_i + \frac{\mu_i}{r^3}\vec{r}$$

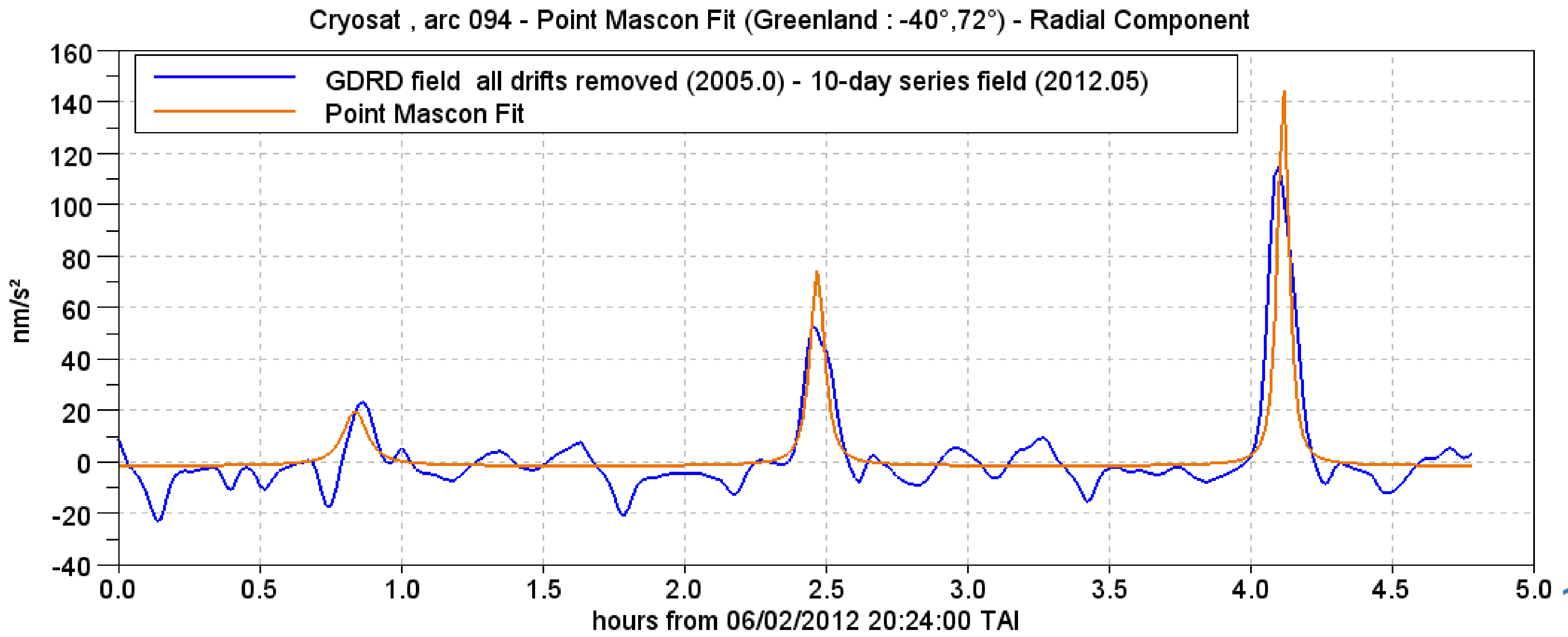
- Additional term ensures total mass conservation

- No constraint applied to conserve the center of mass position – verified a posteriori (see backups)



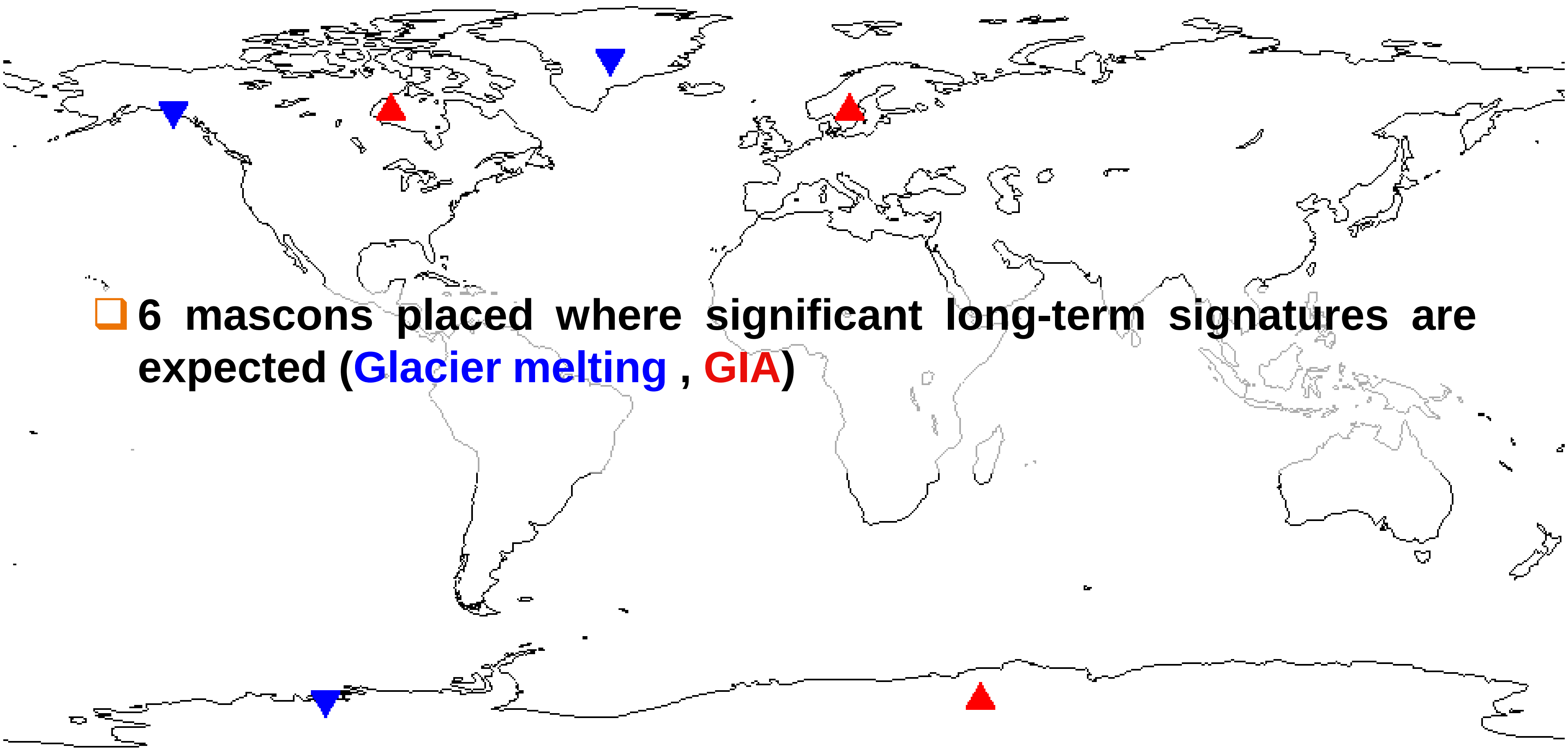
Point Mascon Model : motivation

- Even a single Point Mascon (Greenland) is quite representative of the difference in the geopotential acceleration between 2005 and 2012



Point Mascon Model : method

- 6 mascons placed where significant long-term signatures are expected (Glacier melting , GIA)



Point Mascon Model : method

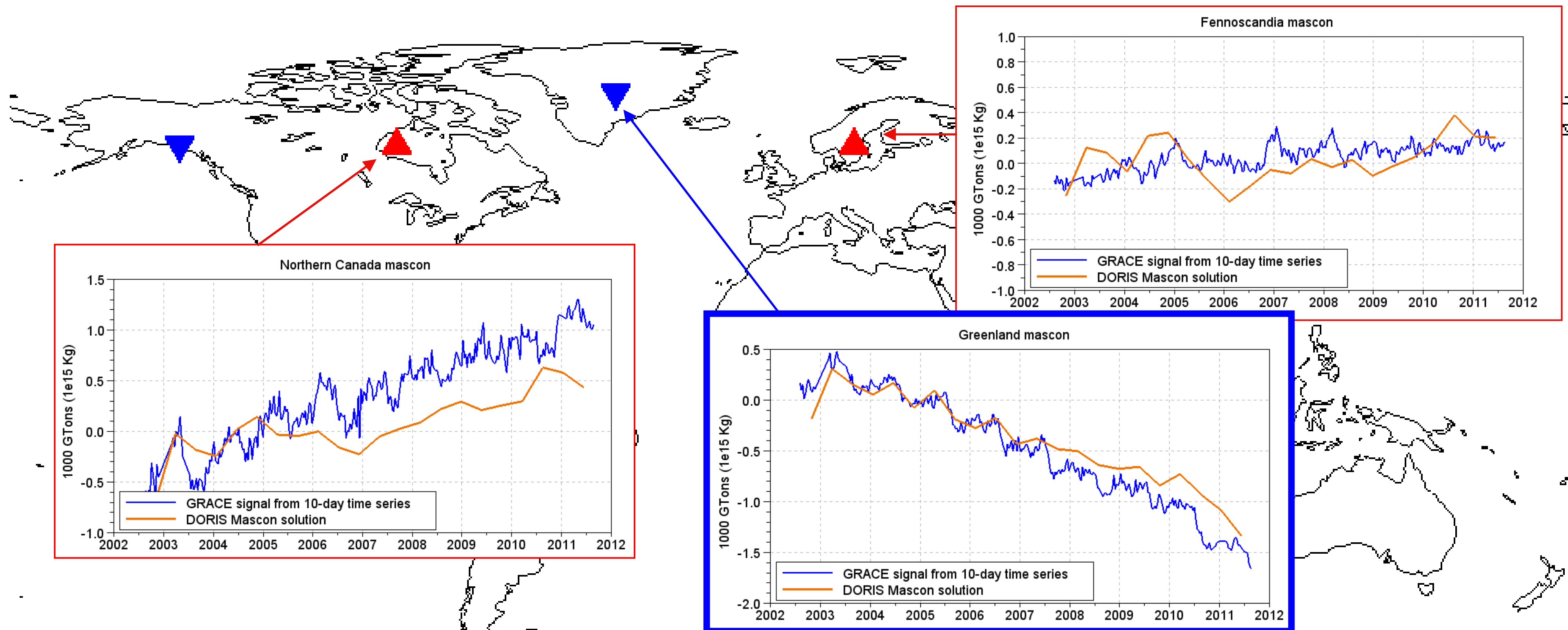
- We use **only DORIS data** from **Jason-1, Jason-2, Cryosat-2, Envisat** - Observability is brought by the low-altitude-high-inclination satellites (Envisat + Cryosat span 2002 – 2012 period)

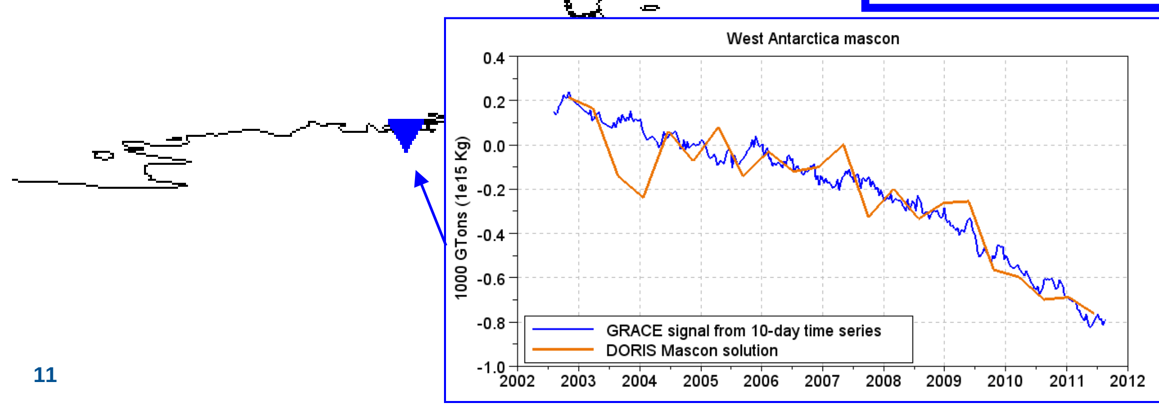
- The normal equations from all satellites are **stacked over 180-day intervals** to obtain a time series of mass values

- This **Point Mascon model is then used in Doris-only dynamic POD** : mass values are solved-for on an arc-by-arc basis, but tightly constrained to this empirical model

- Validation :
  - Mascon **mass trends compared to GRACE EWH time series**
  - **Comparison to orbits using the 10-day time series of GRACE fields**
  - **Independent SLR residuals on DORIS orbits**

DORIS Mascons Vs GRACE time series of EWH

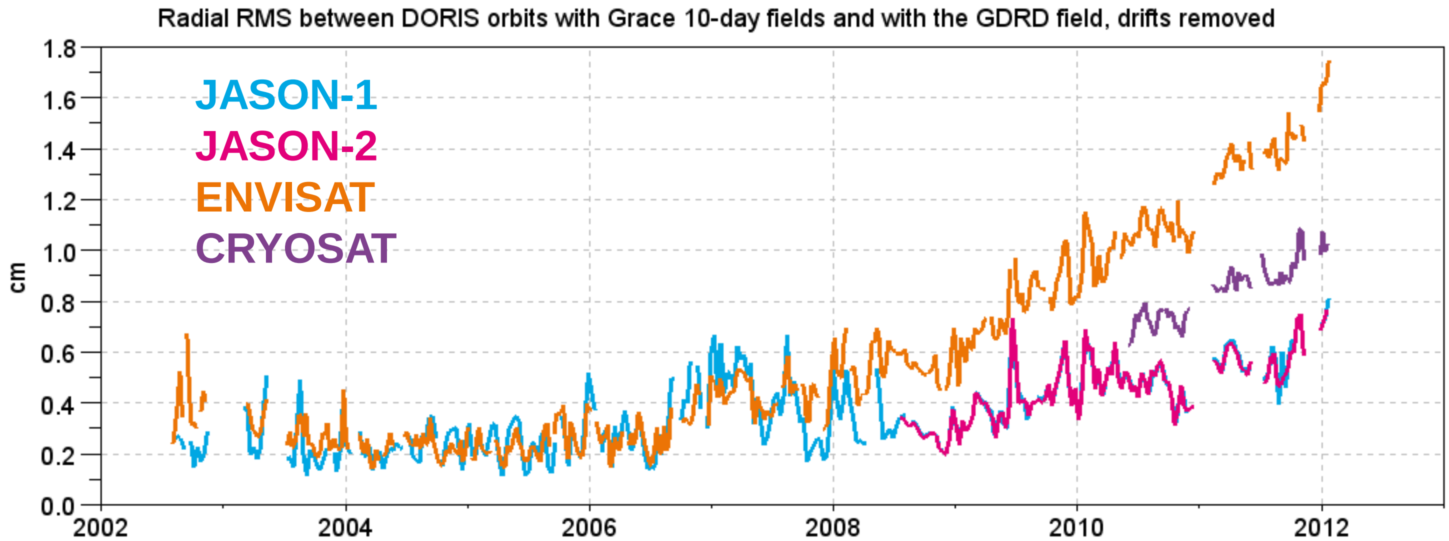


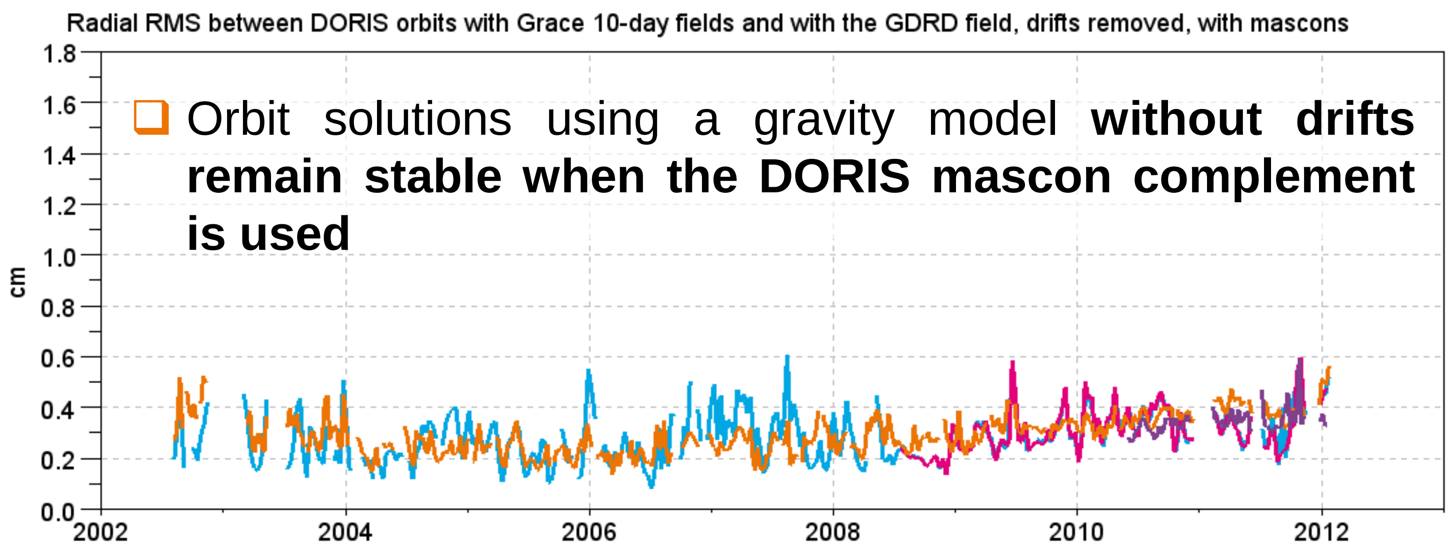


- GRACE-derived EWH is integrated over a given surface for each basin to obtain local mass variation

Alaska and East Antarctica mascons in the backup slides

Orbit solutions using the Point Mascon Model

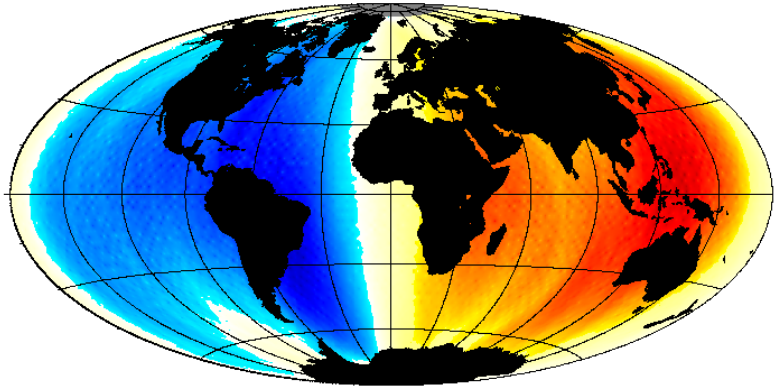




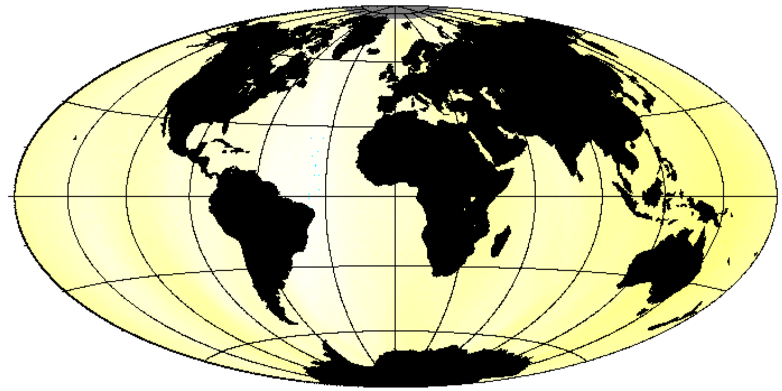
- Orbit solutions using a gravity model **without drifts remain stable when the DORIS mascon complement is used**

Orbit solutions using the Point Mascon Model

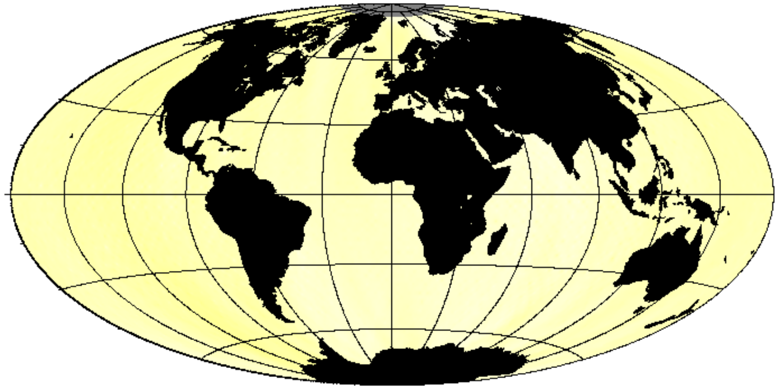
Envisat: 10-day series – GDRD w/o drifts



Envisat: 10-day series – GDRD w/o drifts + DORIS mascon model

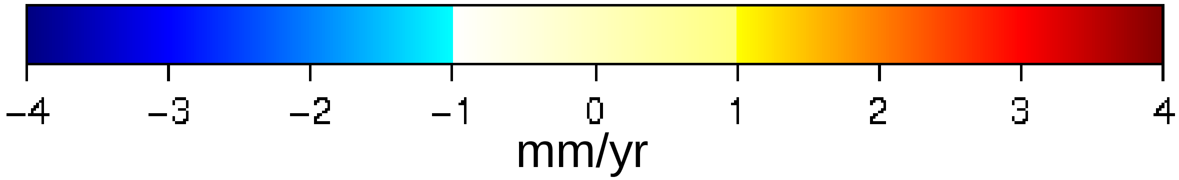


Envisat: 10-day series – GDRD

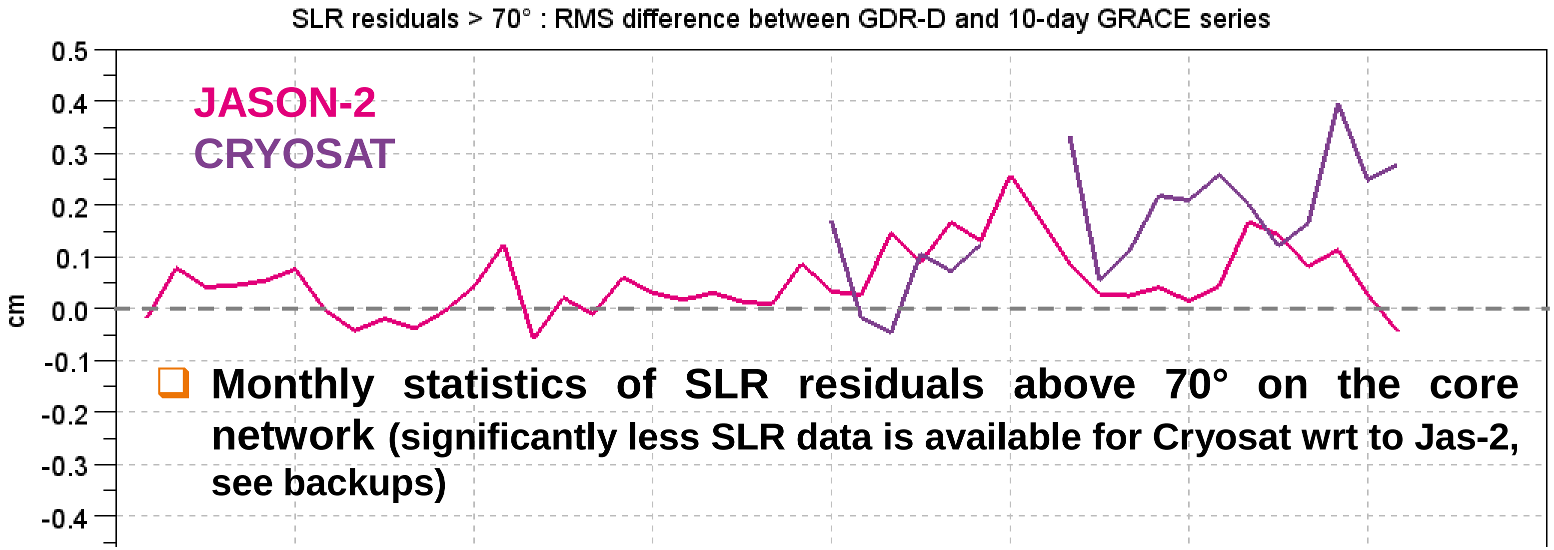


- Trends in the hemispheric radial differences of Envisat orbits **without Grace-derived drifts** are **reduced from 3 mm/yr to <1** mm/yr **when the mascon model is used**

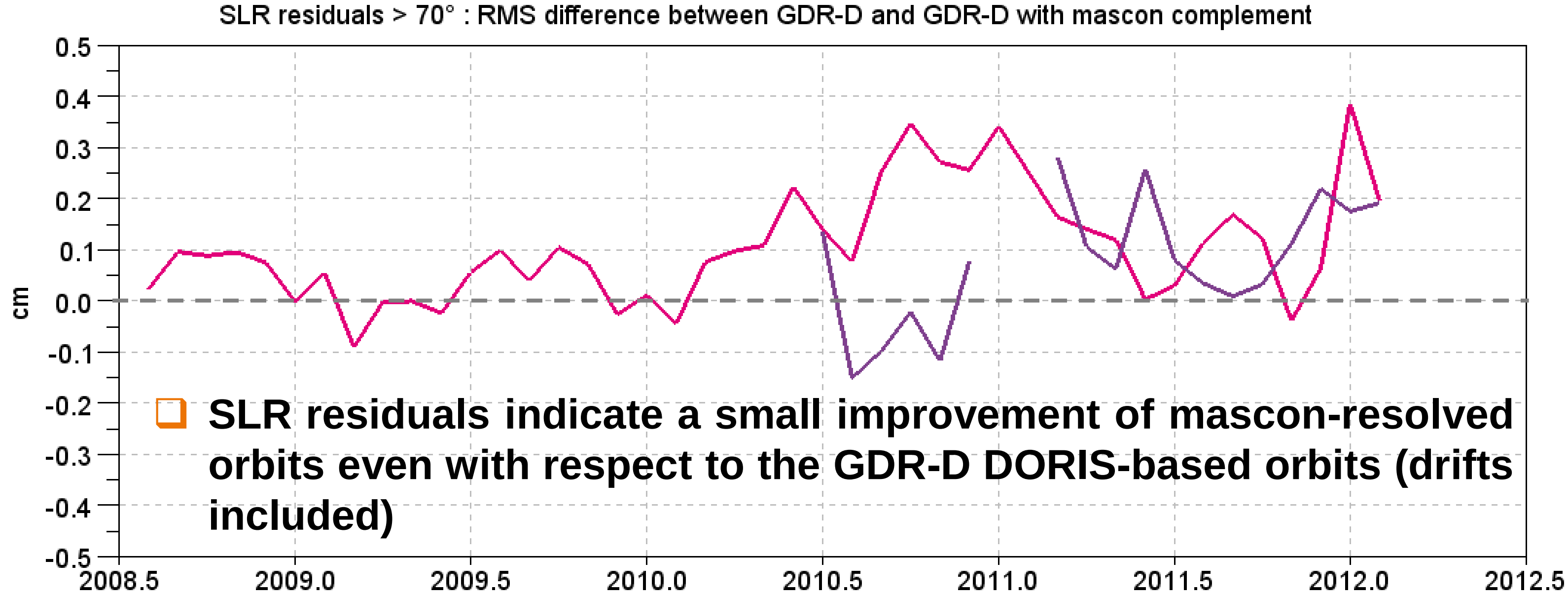
- Orbit solutions using mascon model without drifts are close to GDRD solutions



Orbit solutions using the Point Mascon Model



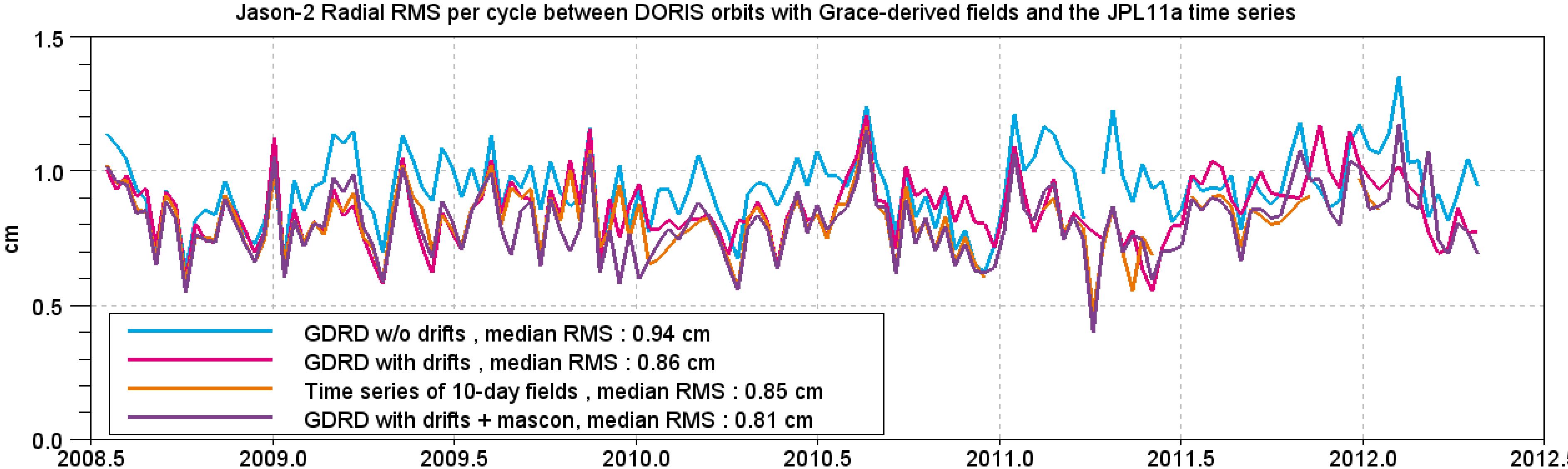
- Monthly statistics of SLR residuals above 70° on the core network (significantly less SLR data is available for Cryosat wrt to Jas-2, see backups)



- SLR residuals indicate a small improvement of mascon-resolved orbits even with respect to the GDR-D DORIS-based orbits (drifts included)

Orbit solutions using the Point Mascon Model

- Radial orbit difference with respect to JPL11A reduced-dynamic GPS orbits is also slightly reduced when the mascon complement is used



Summary and Conclusions

- DORIS measurements from all altimeter satellites **provide sufficient observability to solve for a 6-mascon complement** to the standard GRACE-derived fields

- This approach **improves the orbit solutions over the 2002-2012 time span, especially when GRACE-derived drifts are removed** from the gravity model

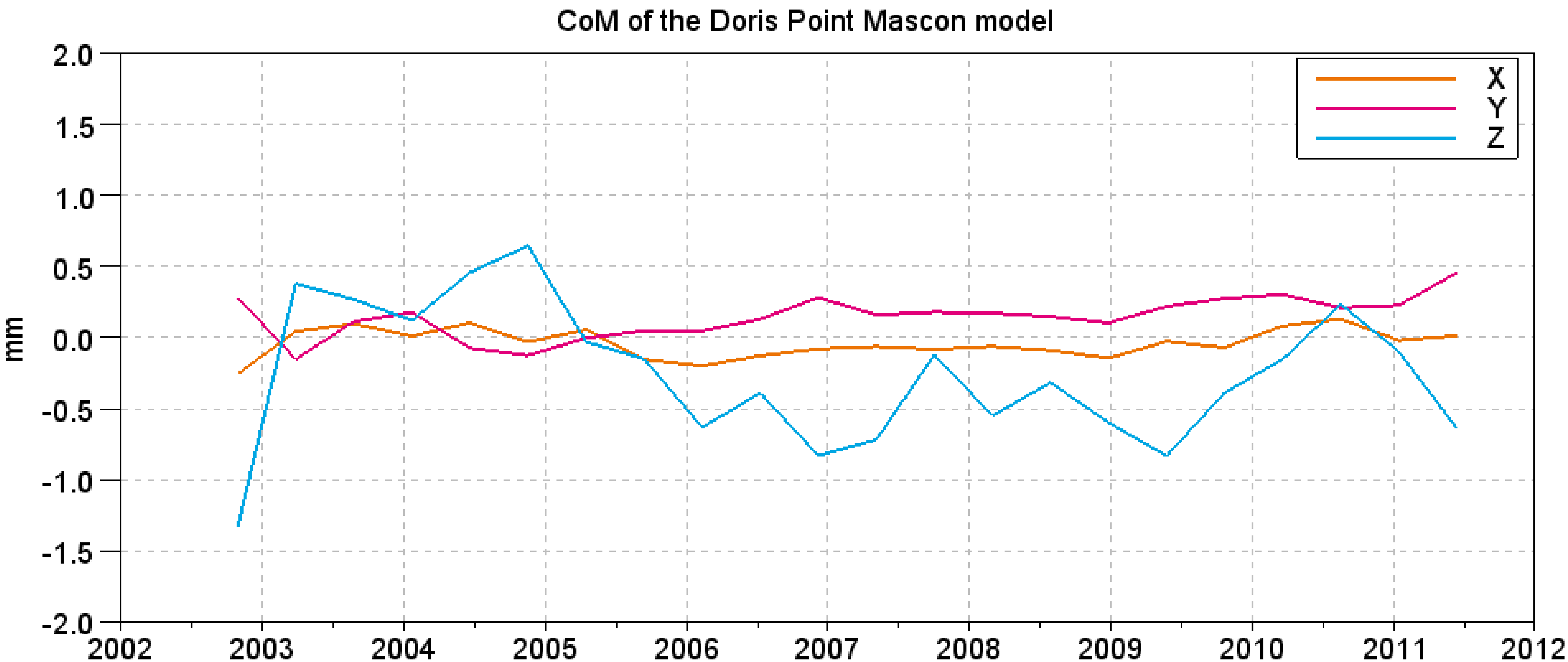
- As a result, **the mascon empirical approach is promising in maintaining and monitoring the DORIS-based orbit performance in case of loss of the GRACE time series**, to the extent that locations where the strongest long-term variations occur remain known over a 3-4 year time-span

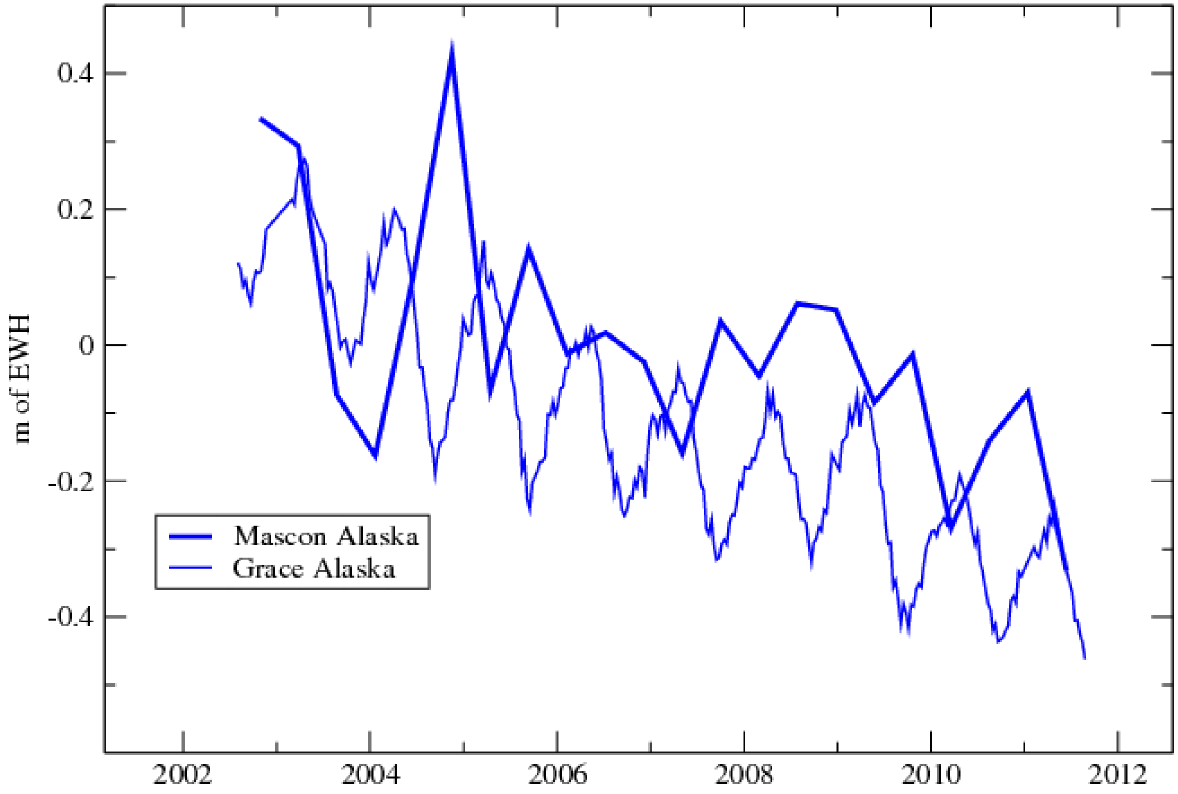
- Prospects : include SPOT data (SPOT-2 overlaps with TOPEX), GPS and SLR when available, compare to classic SH approach

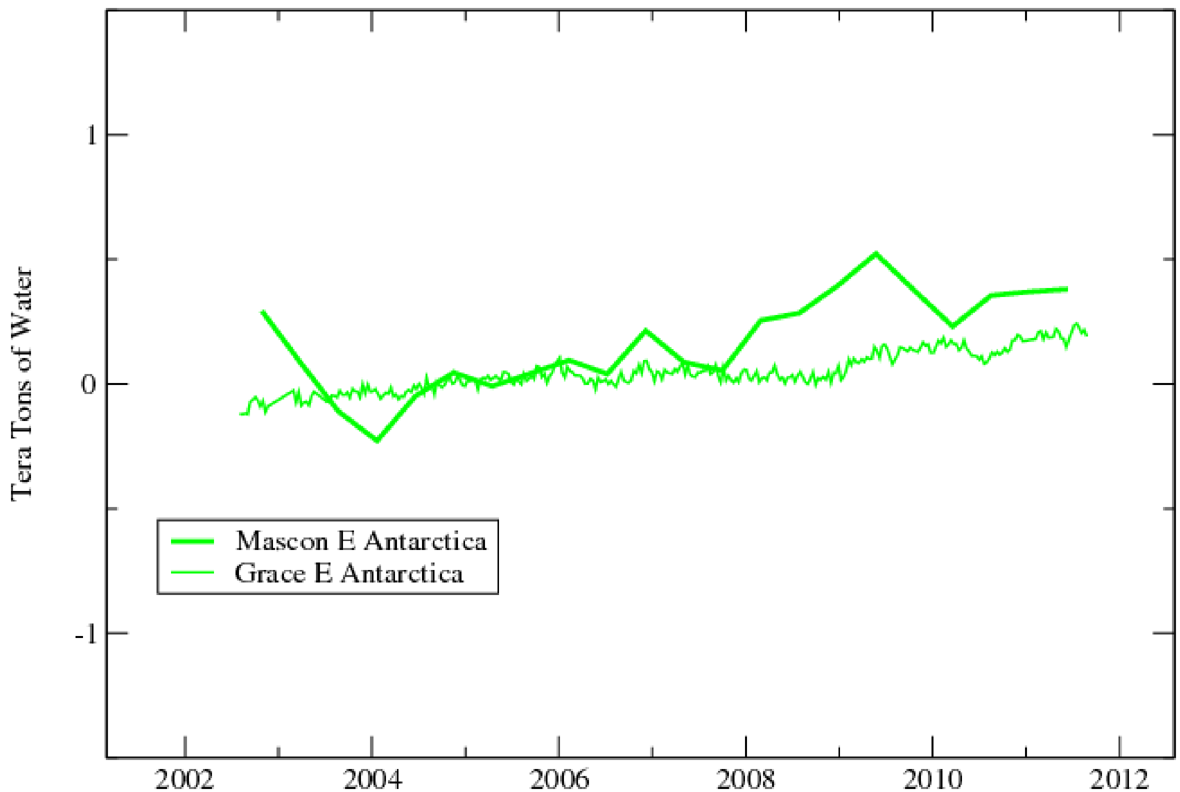
Backups

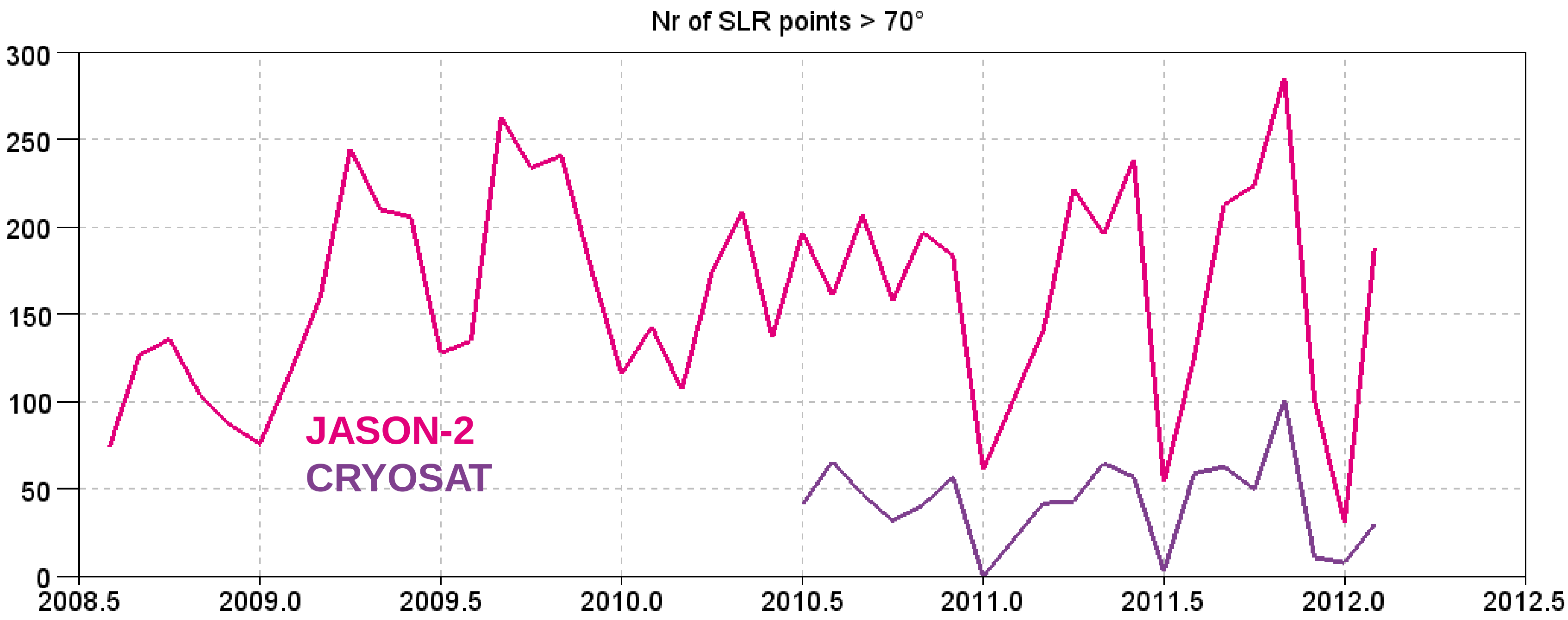
DORIS Mascon model

- Center of mass position of the DORIS Mascon model




0.4
0.2
0
-0.2
-0.4
m of EWH
2002
2004
2006
2008
2010
2012
Mascon Alaska
Grace Alaska


Tera Tons of Water
1
0
-1
2002
2004
2006
2008
2010
2012
Mascon E Antarctica
Grace E Antarctica


Nr of SLR points > 70°
300
250
200
150
100
50
0
2008.5
2009.0
2009.5
2010.0
2010.5
2011.0
2011.5
2012.0
2012.5
JASON-2
CRYOSAT