

APPARENT SEA LEVEL VARIABILITY AND TRENDS ARISING FROM THE CHOICE OF ORBIT

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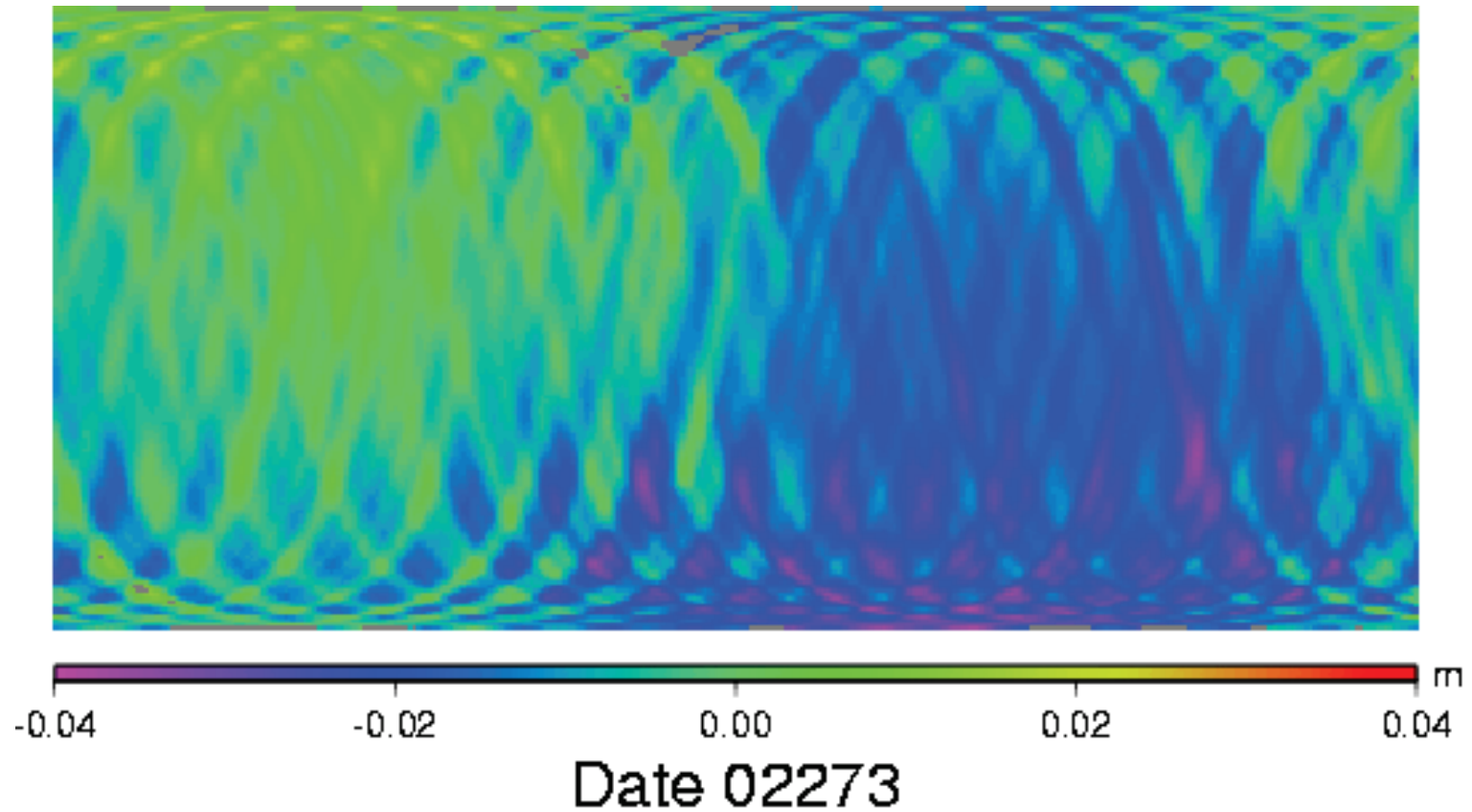
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Objectives

- Quantification of orbit uncertainty by studying radial orbit differences (orbit parametrization, gravity field, software)
- Focus on Envisat and Jason-1 (time series of 7+ years)
- Orbits for Jason-1: GDR-C, ESOC (ESA-CCI) and GSFC (std0905)
- Orbits for Envisat: GDR, ESOC (ESA-CCI) and GFZ (ESA-CCI)
- Orbit differences interpolated to $1^{\circ} \times 1^{\circ}$ grid for every cycle
- Estimation of trends and typical spatial-temporal patterns
- Analysis of Envisat orbits derived from different gravity fields

Envisat Radial Orbit Differences

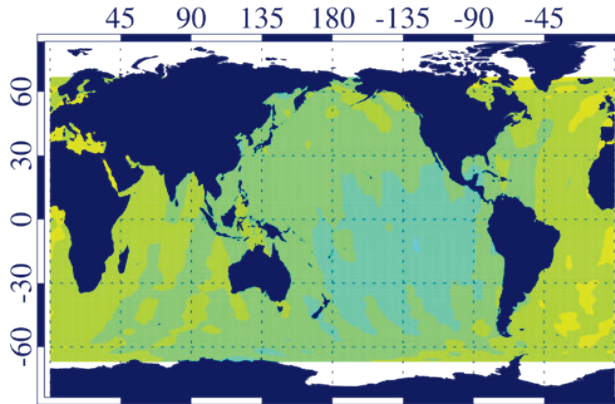
GDR minus GFZ (2002 to 2011)



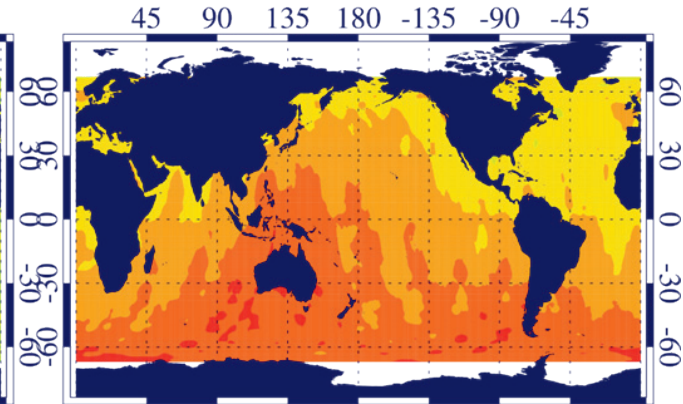
Mean Orbit Difference

Jason-1

a) GDR-ESOC

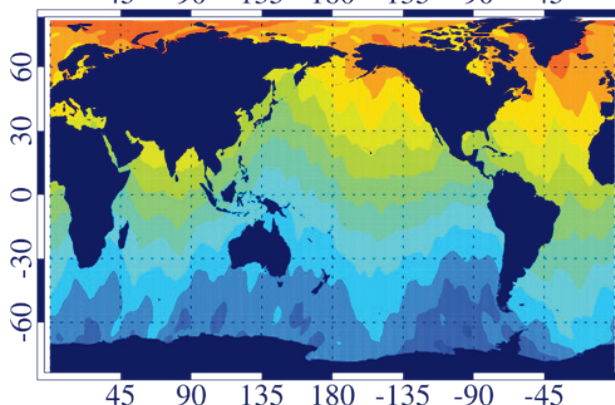


b) GDR-GSFC

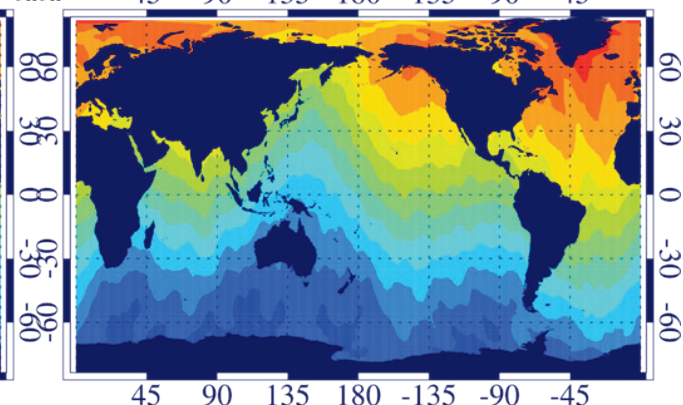


Envisat

c) GDR-ESOC



d) GDR-GFZ

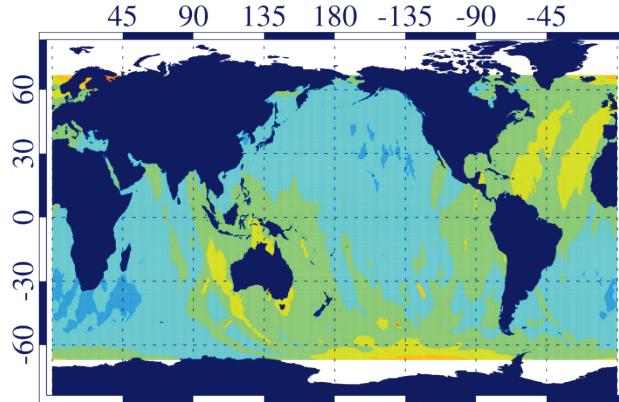


GDR-ESOC mean deviation [cm] GDR-GFZ

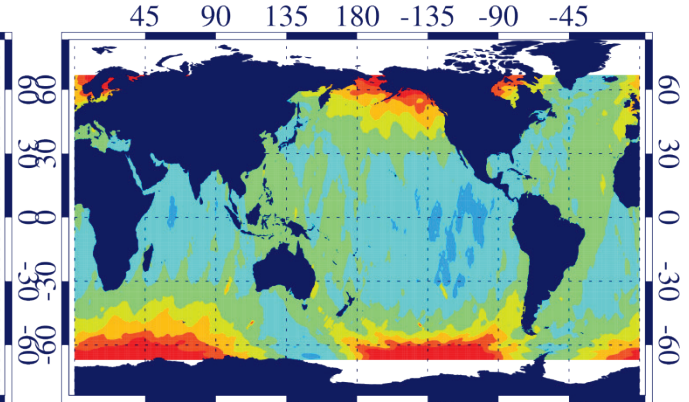
RMS of Orbit Difference

Jason-1

a) GDR-ESOC

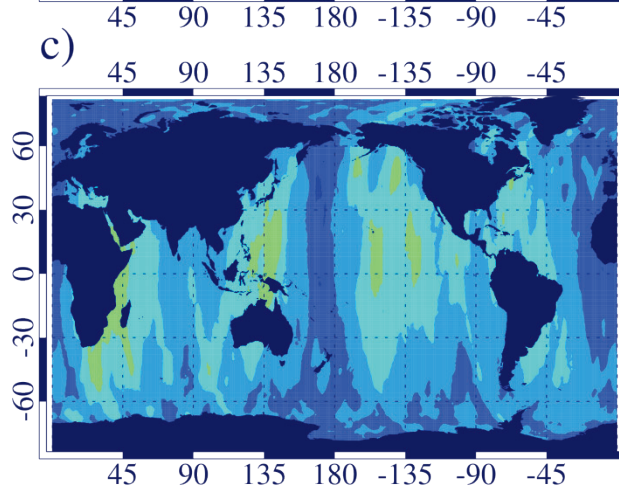


b) GDR-GSFC

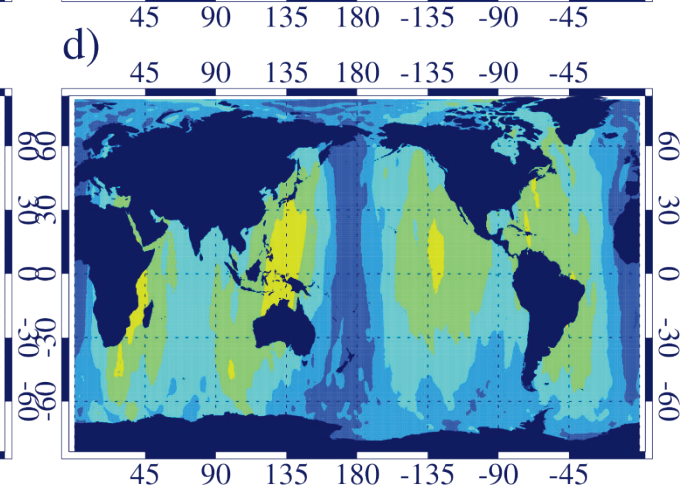


Envisat

c)



d)



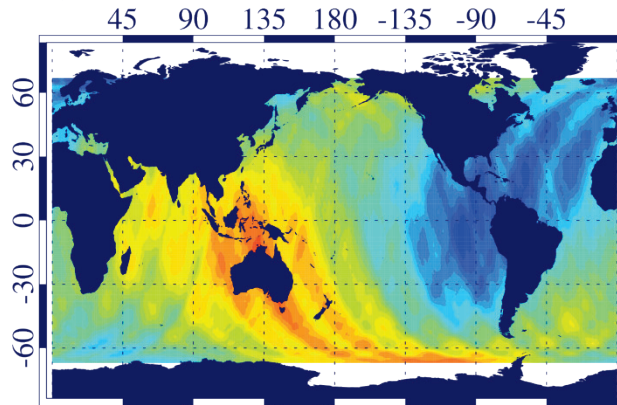
GDR-ESOC

RMS [m] GDR-GFZ

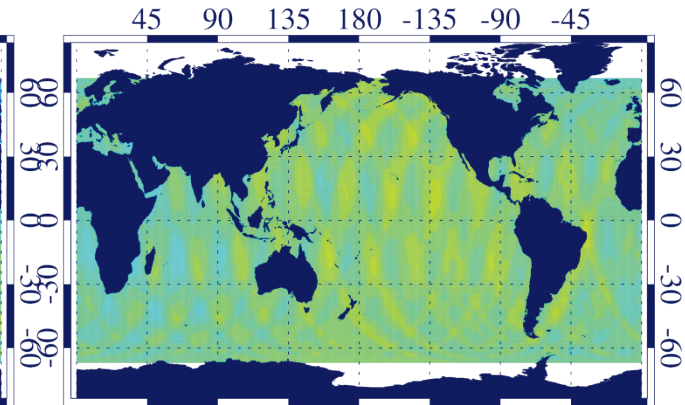
Trend of Orbit Difference

Jason-1

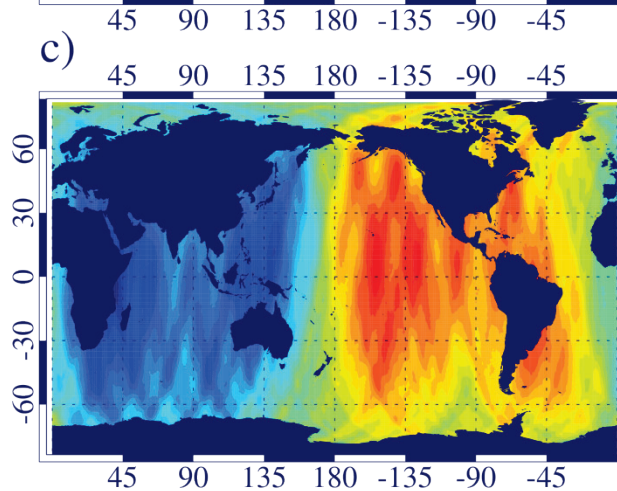
a) GDR-ESOC



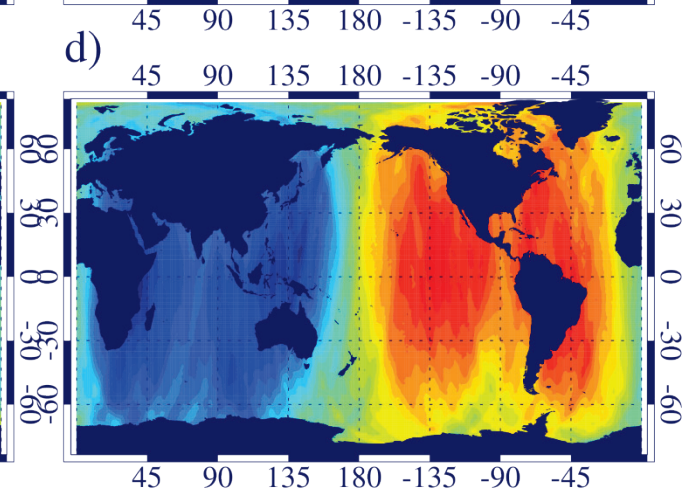
b) GDR-GSFC



c)



d)



GDR-ESOC

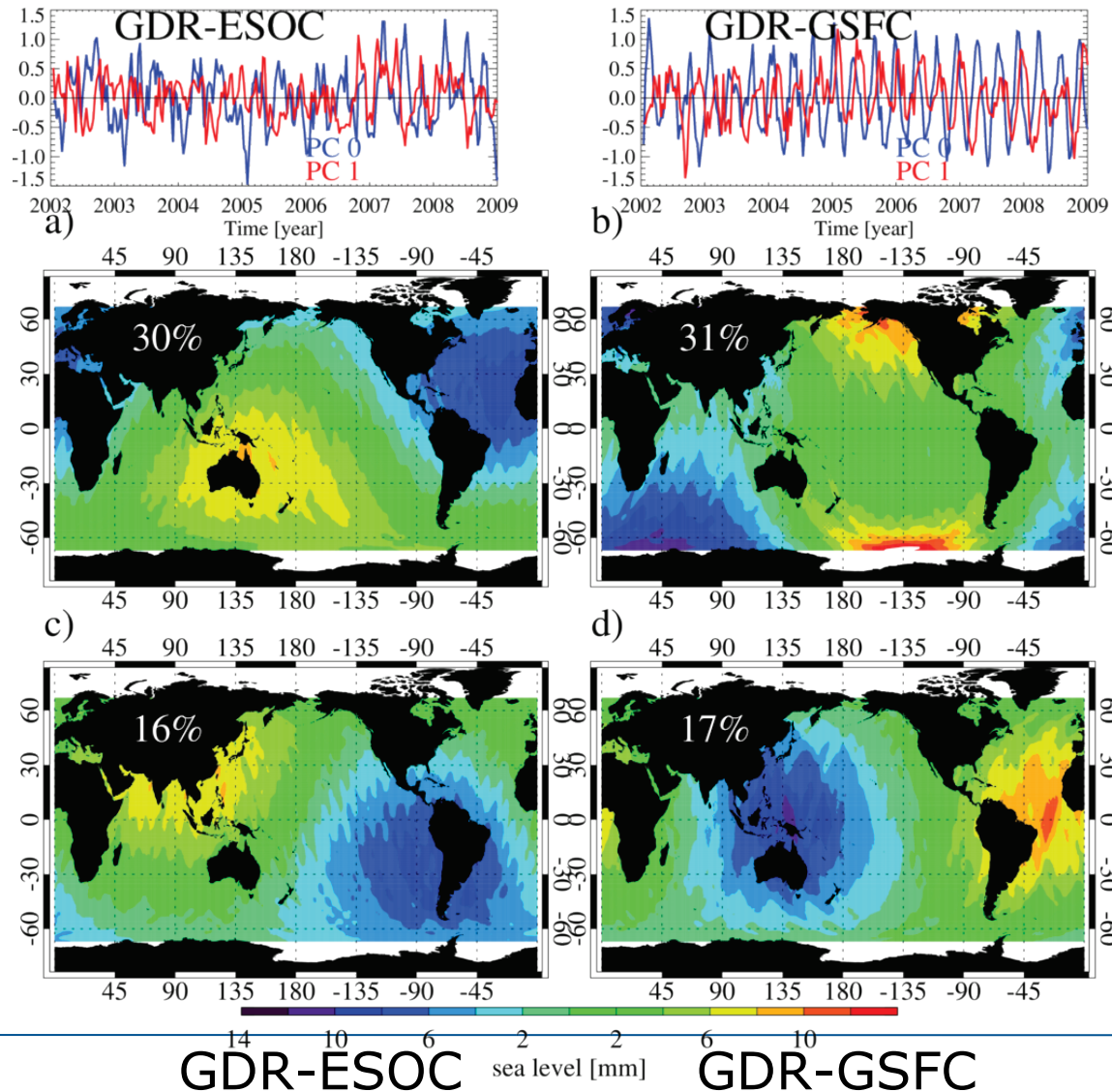
Trend [mm/year]

GDR-GFZ

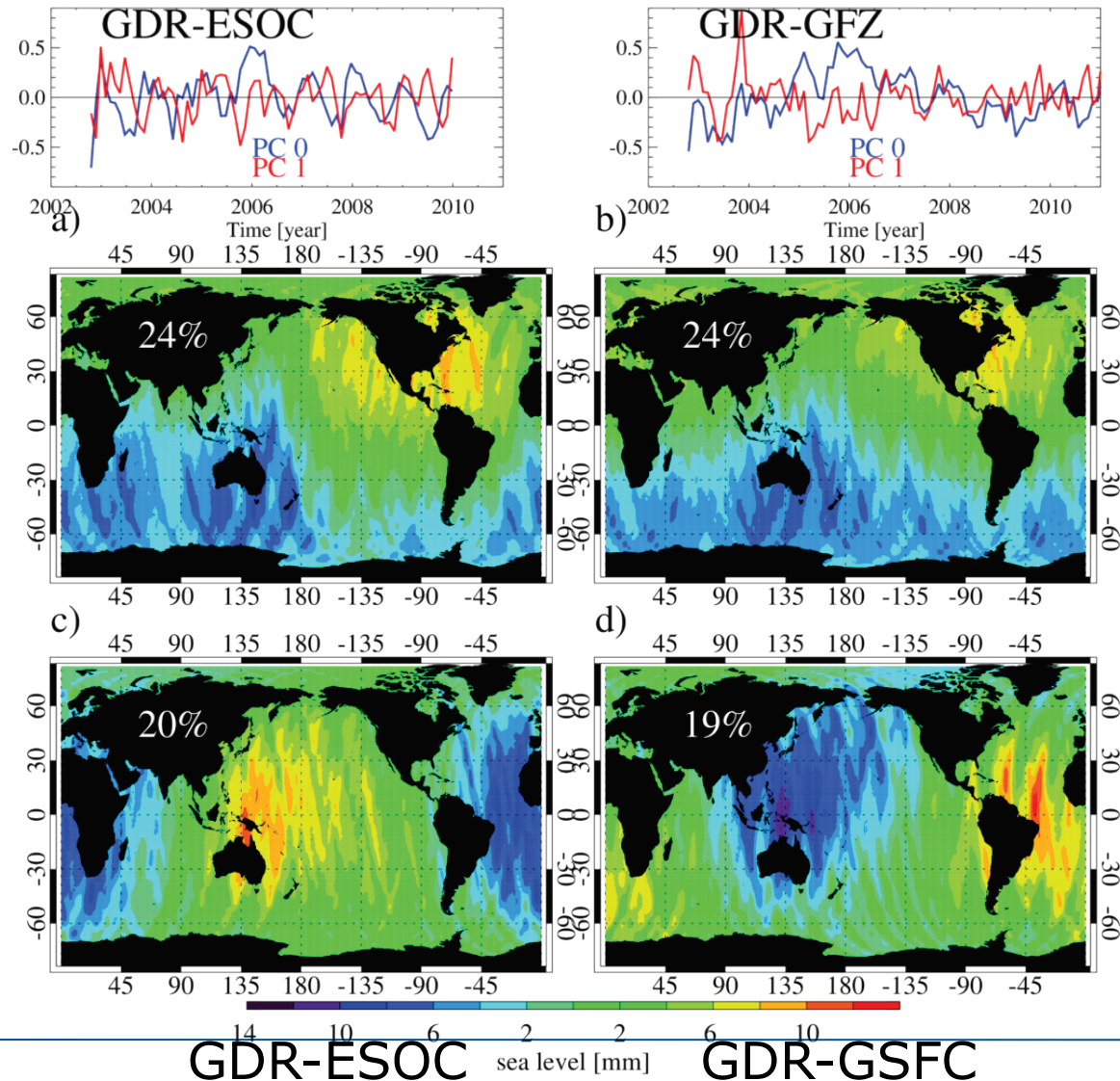
GFZ

Helmholtz-Zentrum
POTSDAM

Jason-1: EOF of Orbit Differences

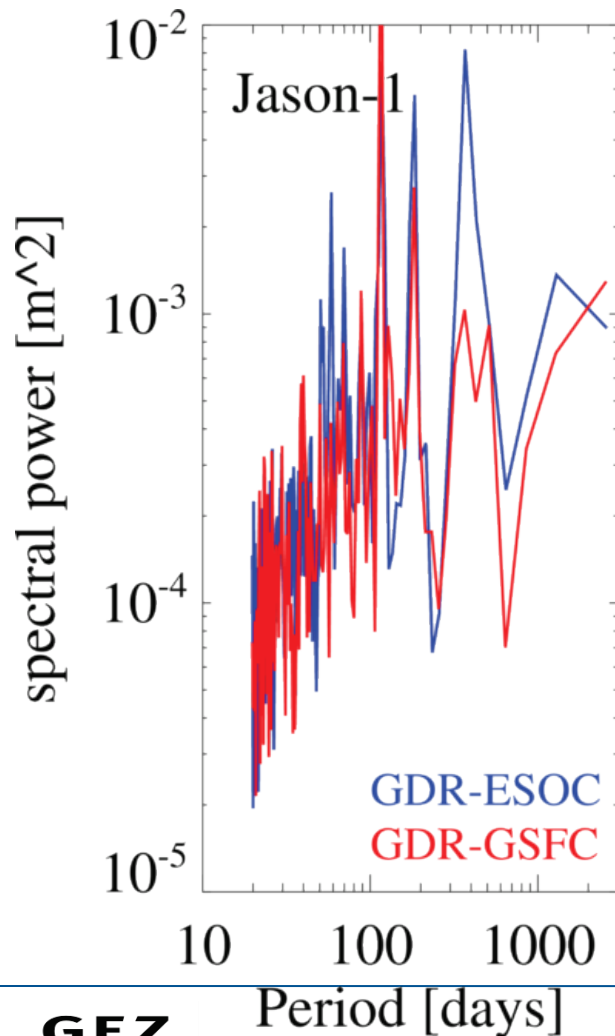


Envisat: EOF of Orbit Differences



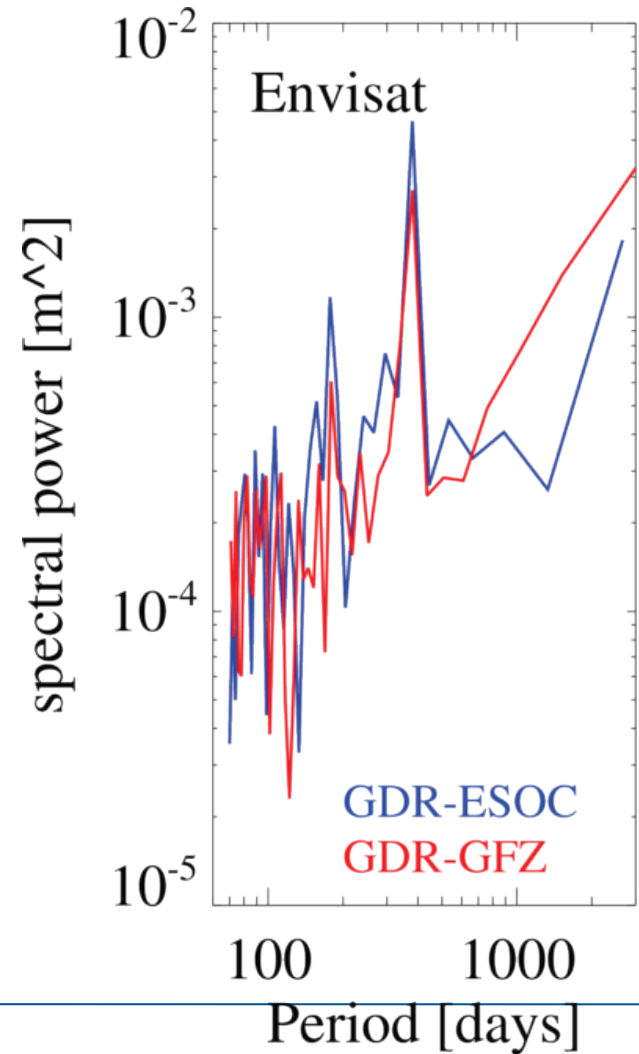
Spectra of Principal Components (1-3)

Jason-1 and ENVISAT

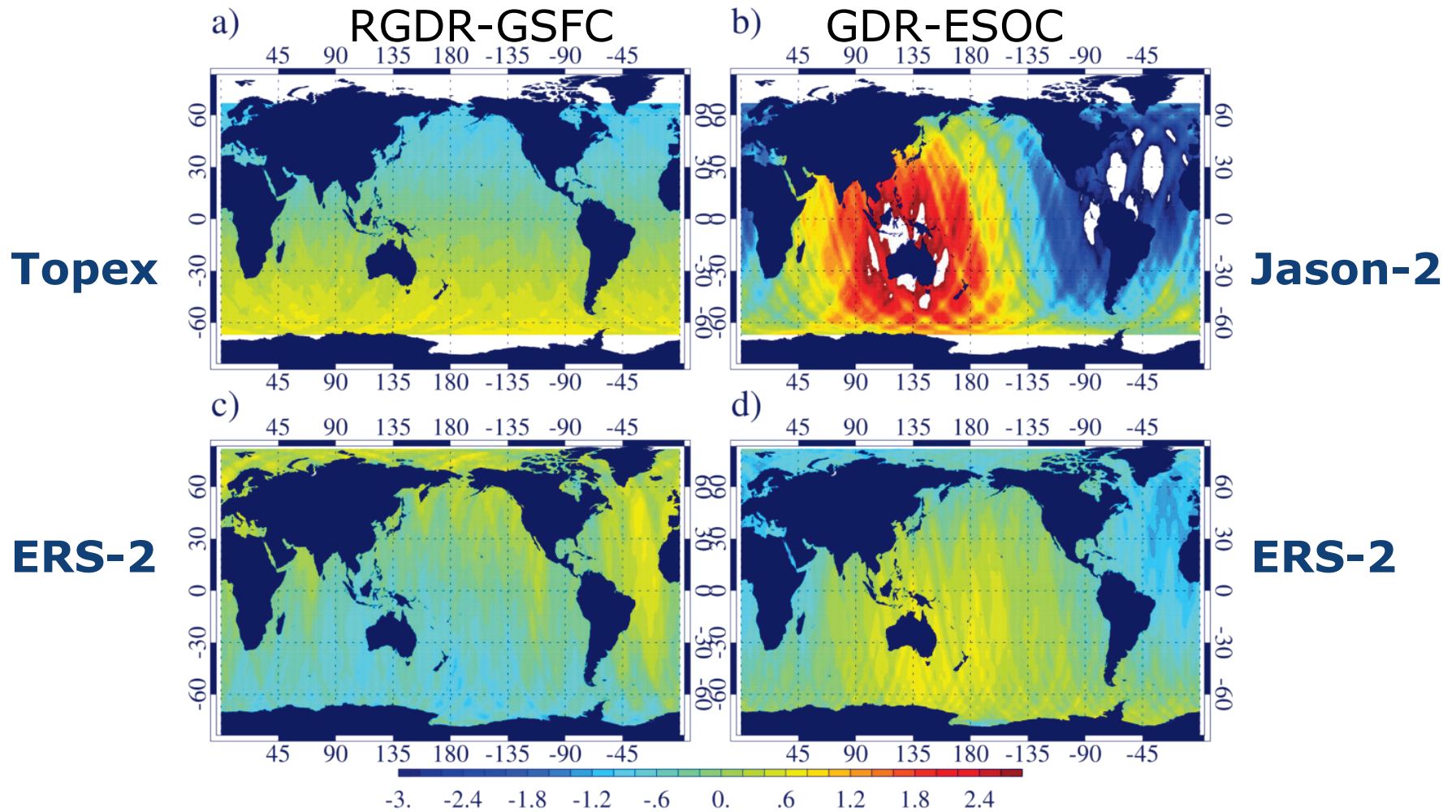


Peaks

- annual
semiannual
- 110 days
for Jason-1



Trend of Orbit Differences



REAPER C – REAPER GFZ

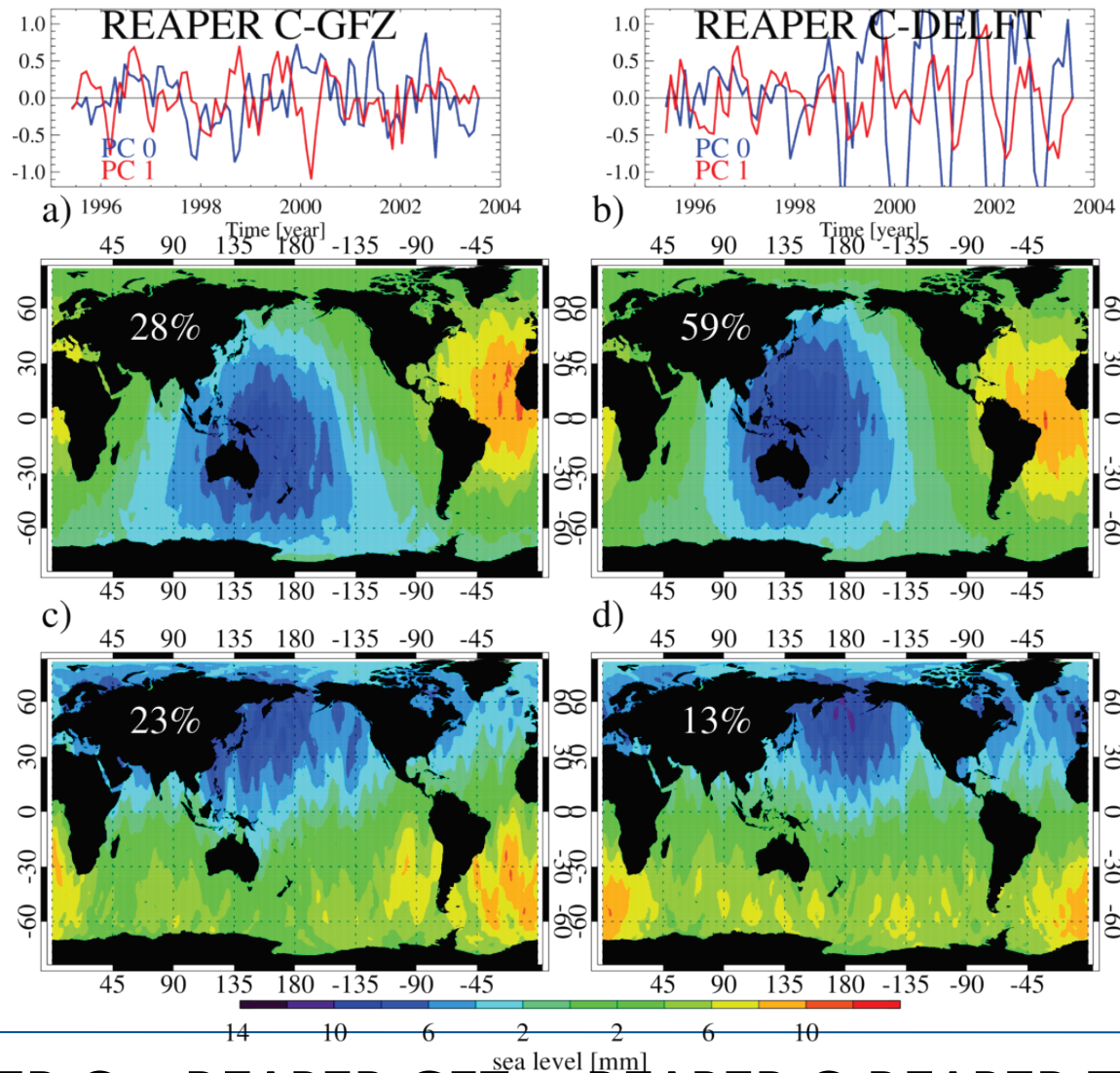
REAPER C-REAPER TU DELFT

GFZ

Helmholtz-Zentrum
POTSDAM

HELMHOLTZ
ASSOCIATION

ERS-2: EOF of Orbit Differences



Mode 1

Mode 2

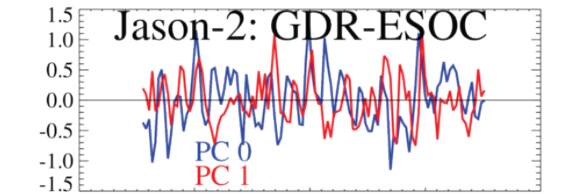
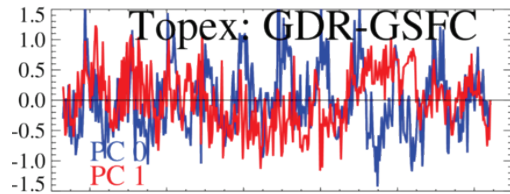
REAPER C – REAPER GFZ

REAPER C-REAPER TU DELFT

EOF of Orbit Differences

Topex

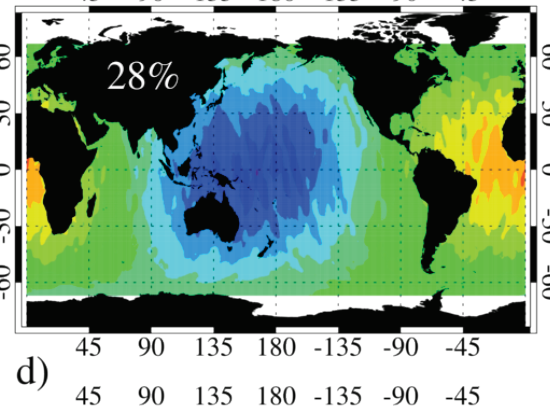
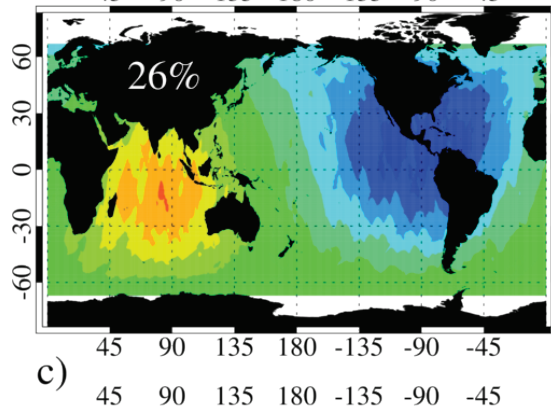
Jason-2



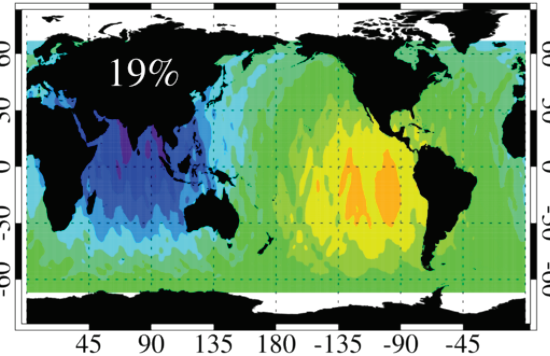
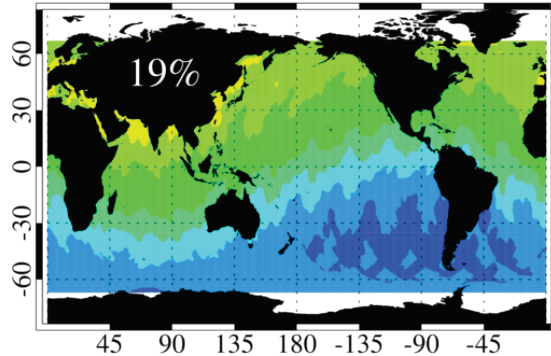
a) 1994 1996 1998 2000 2002 2004
Time [year]
45 90 135 180 -135 -90 -45

b) 2008 2009 2010 2011 2012
Time [year]
45 90 135 180 -135 -90 -45

Mode 1



Mode 2

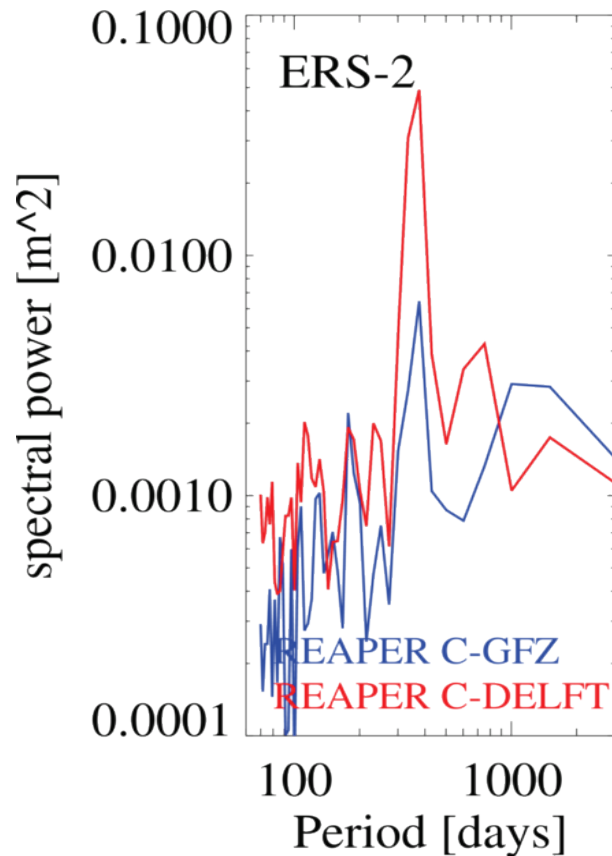


RGDR-GSFC sea level [mm]

GDR-ESOC

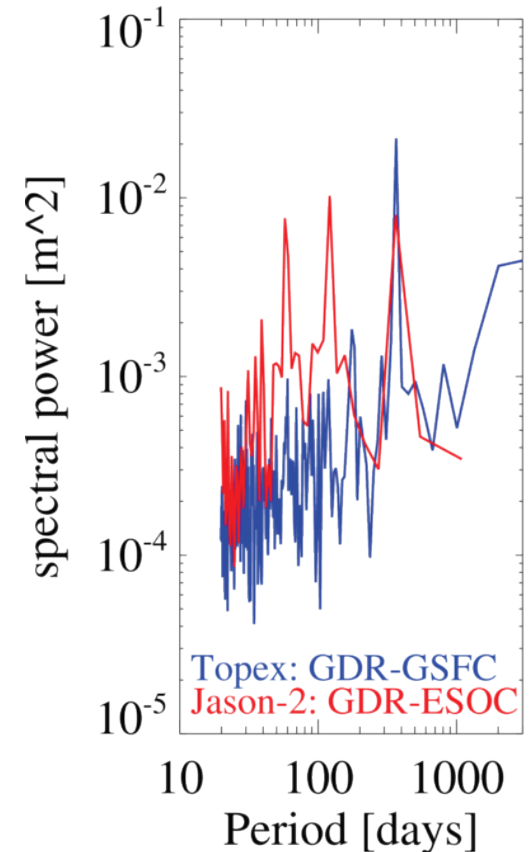
Spectra of Principal Components (1-3)

ERS-2, Topex and Jason-2



Peaks

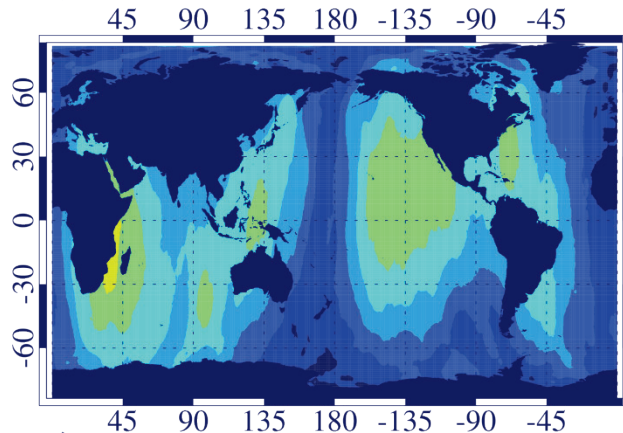
- annual
- around 110 and 50 days for Jason-2



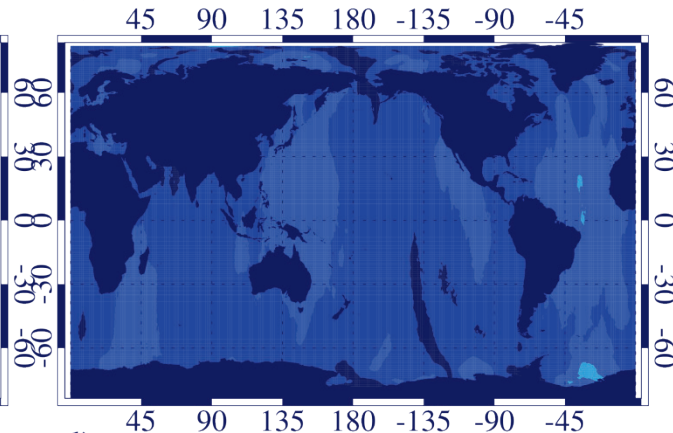
RMS of Orbit Differences

Envisat sensitivity study

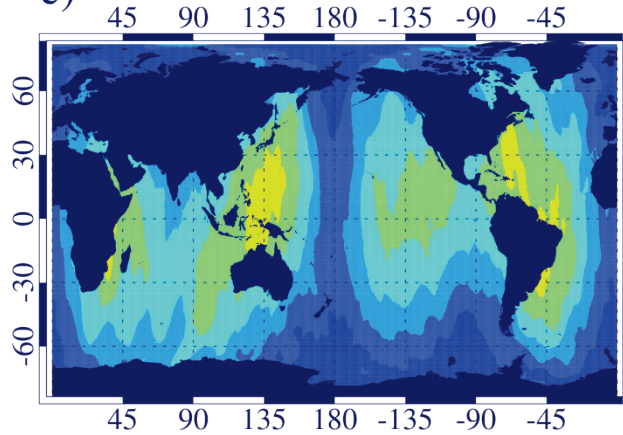
a) EIGEN-GL04S-EIGEN-6S



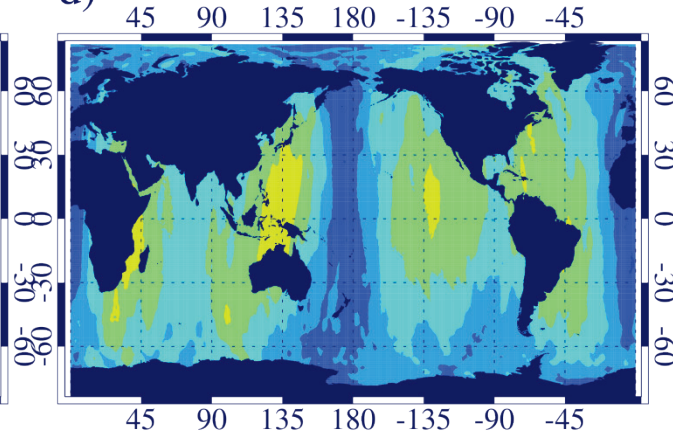
b) EIGEN-GL04S-EIGEN-6S static



c)



d)

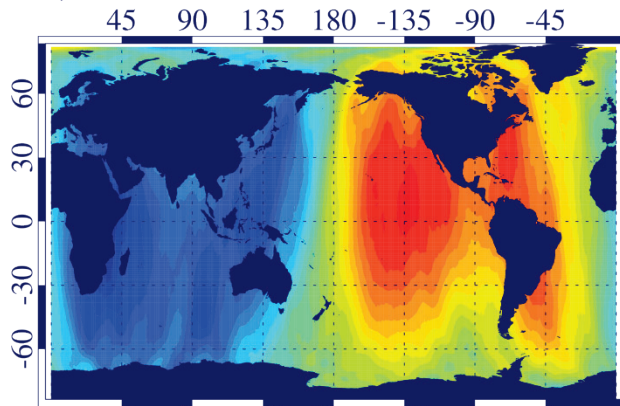


EIGEN-6S-EIGEN-6S static RMS [cm] GDR-GFZ(EIGEN-6S)

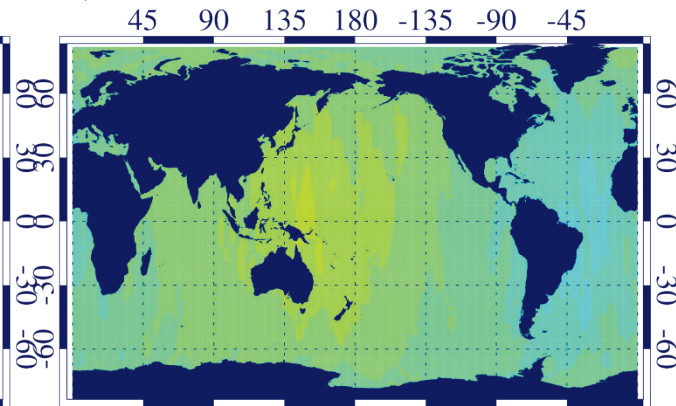
Trend of Orbit Differences

Envisat sensitivity study

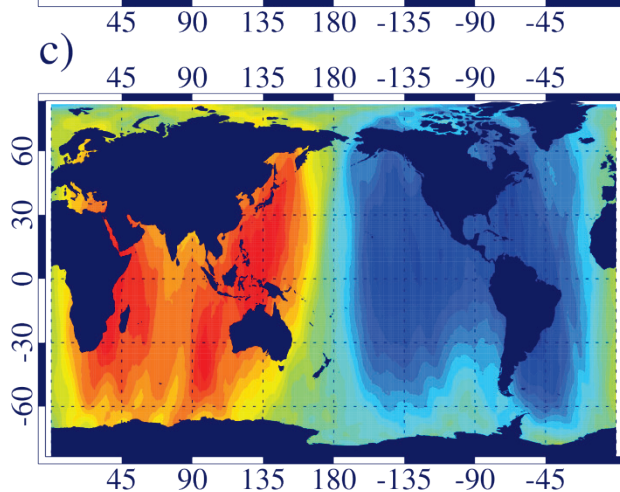
a) EIGEN-GL04S-EIGEN-6S



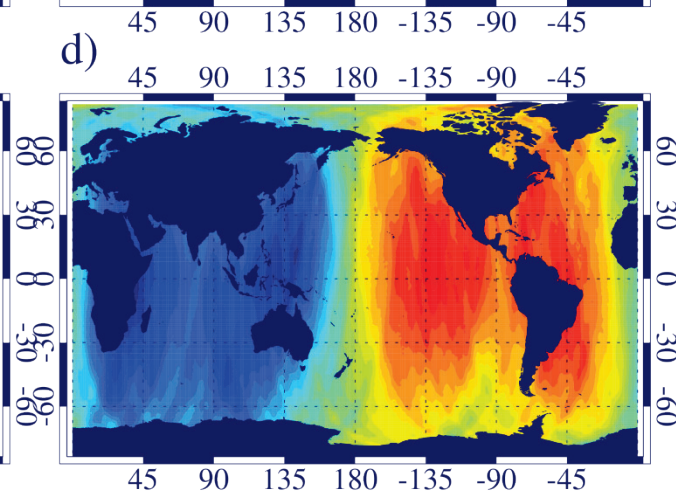
b) EIGEN-GL04S-EIGEN-6S static



c)



d)

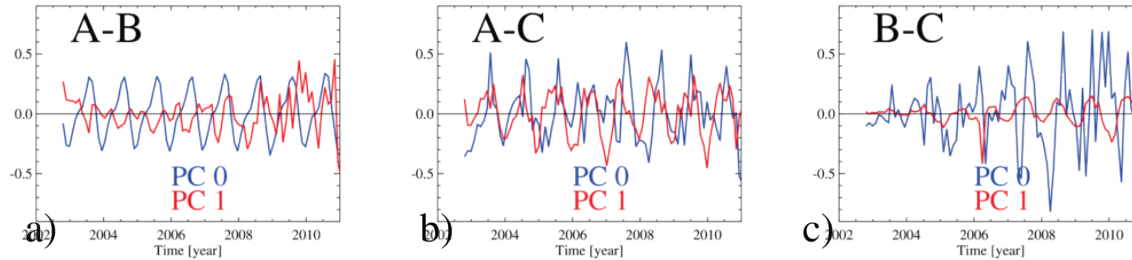


-3.0 -2.4 -1.8 -1.2 -0.6 0.0 0.6 1.2 1.8 2.4

EIGEN-6S-EIGEN-6S static Trend [mm/year] GDR-GFZ(EIGEN-6S)

EOF of Orbit Differences

Envisat sensitivity study



Left:

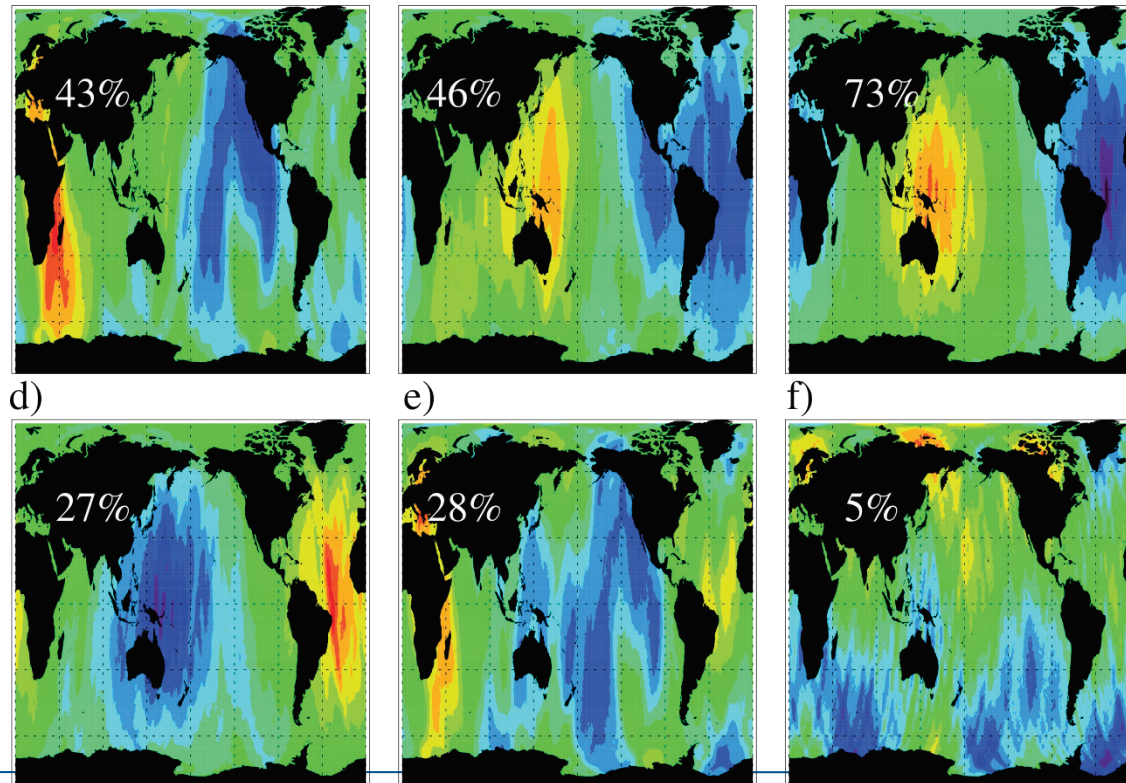
EIGEN-GL04S-
EIGEN-6S

Middle:

EIGEN-GL04S-
EIGEN-6Sstatic

Right:

EIGEN-6S-
EIGEN-6Sstatic



Mode 1

Mode 2

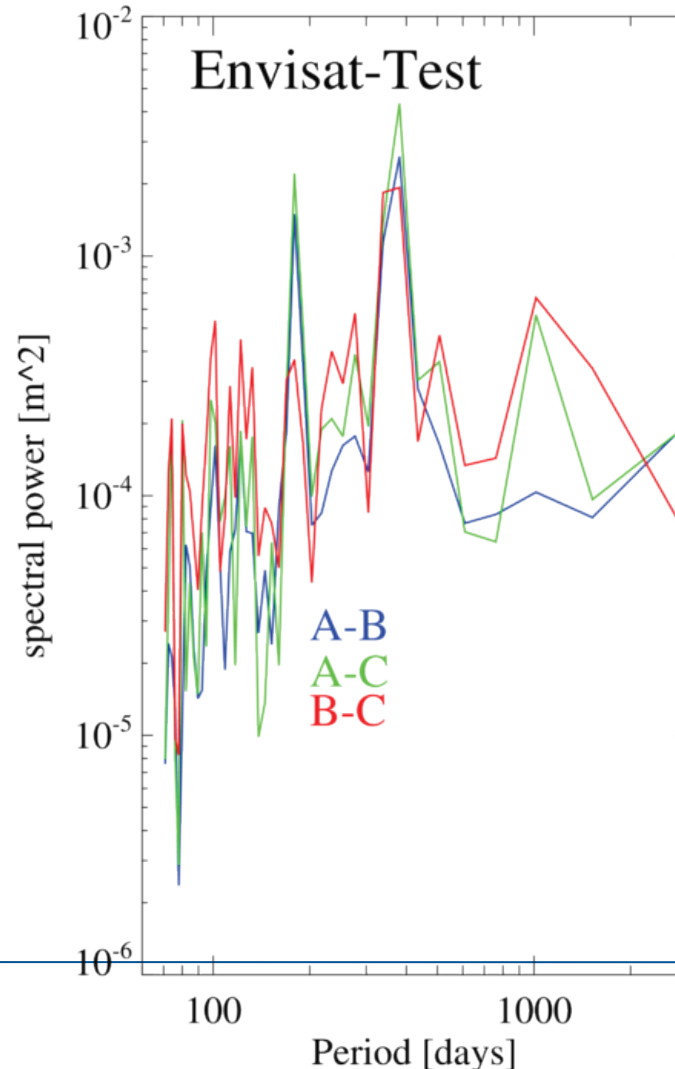
Spectra of Principal Components (1-3)

ENVISAT sensitivity test

Blue:
EIGEN-GL04S-
EIGEN-6S

Green:
EIGEN-GL04S-
EIGEN-6S static

Red:
EIGEN-6S-
EIGEN-6S static



Peaks

- annual
- semi annual
- > 3 years

Conclusions

- Current orbit models for Jason-1 and Envisat differ on large scales which seem to be related to shifts of the geocenter between the orbits
- Radial orbit differences exhibit trends up to 2.5 mm/year and annual amplitudes up to 1 cm.
- Similar patterns can be observed for ERS-2, Topex and Jason-2 orbits
- The main features can be reproduced by using different gravity models for the orbit calculation of Envisat.
- What could be a consistent gravity field model as basis for the calculation orbits for the whole altimetric time series ?

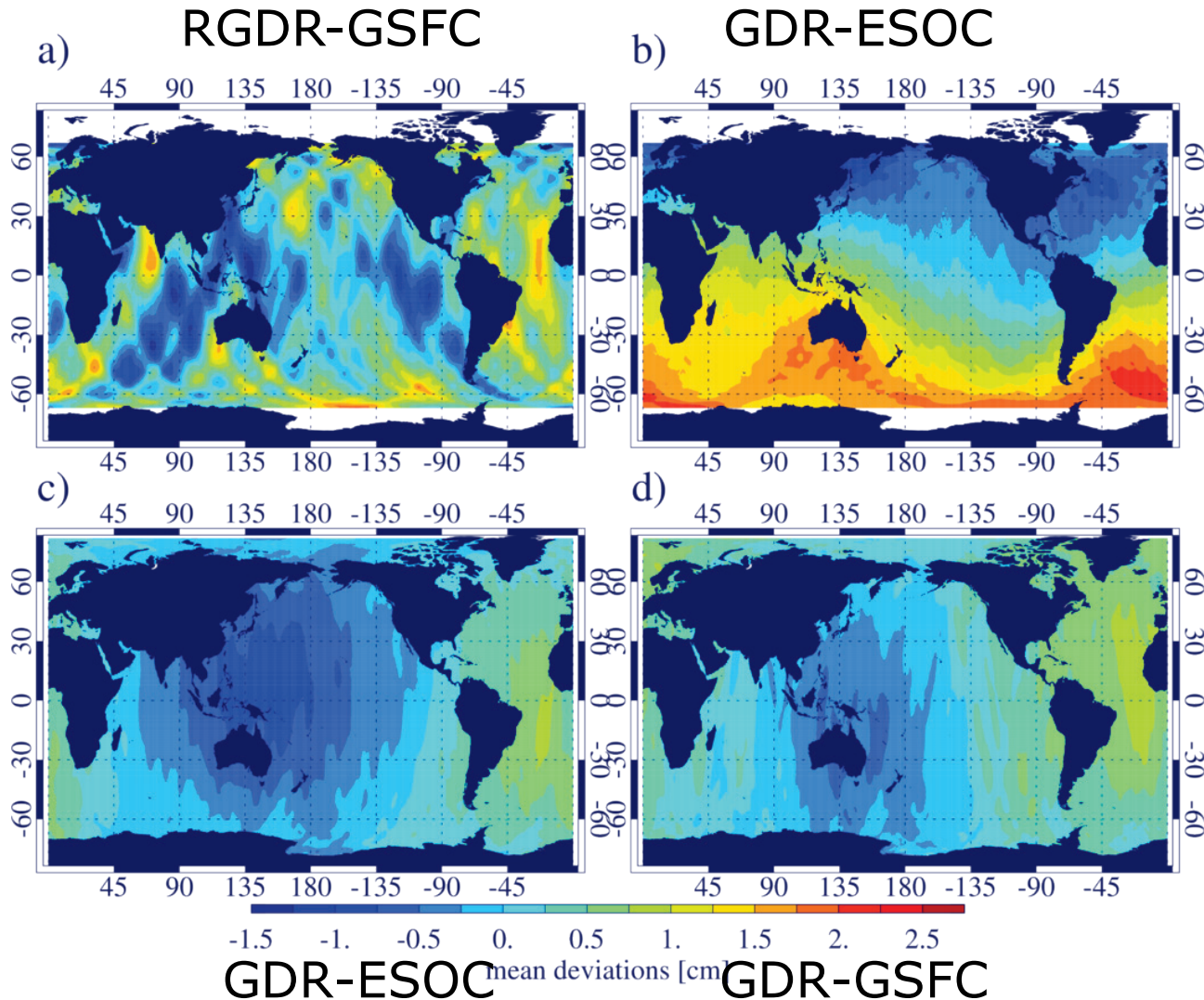
Mean Orbit Difference

Topex

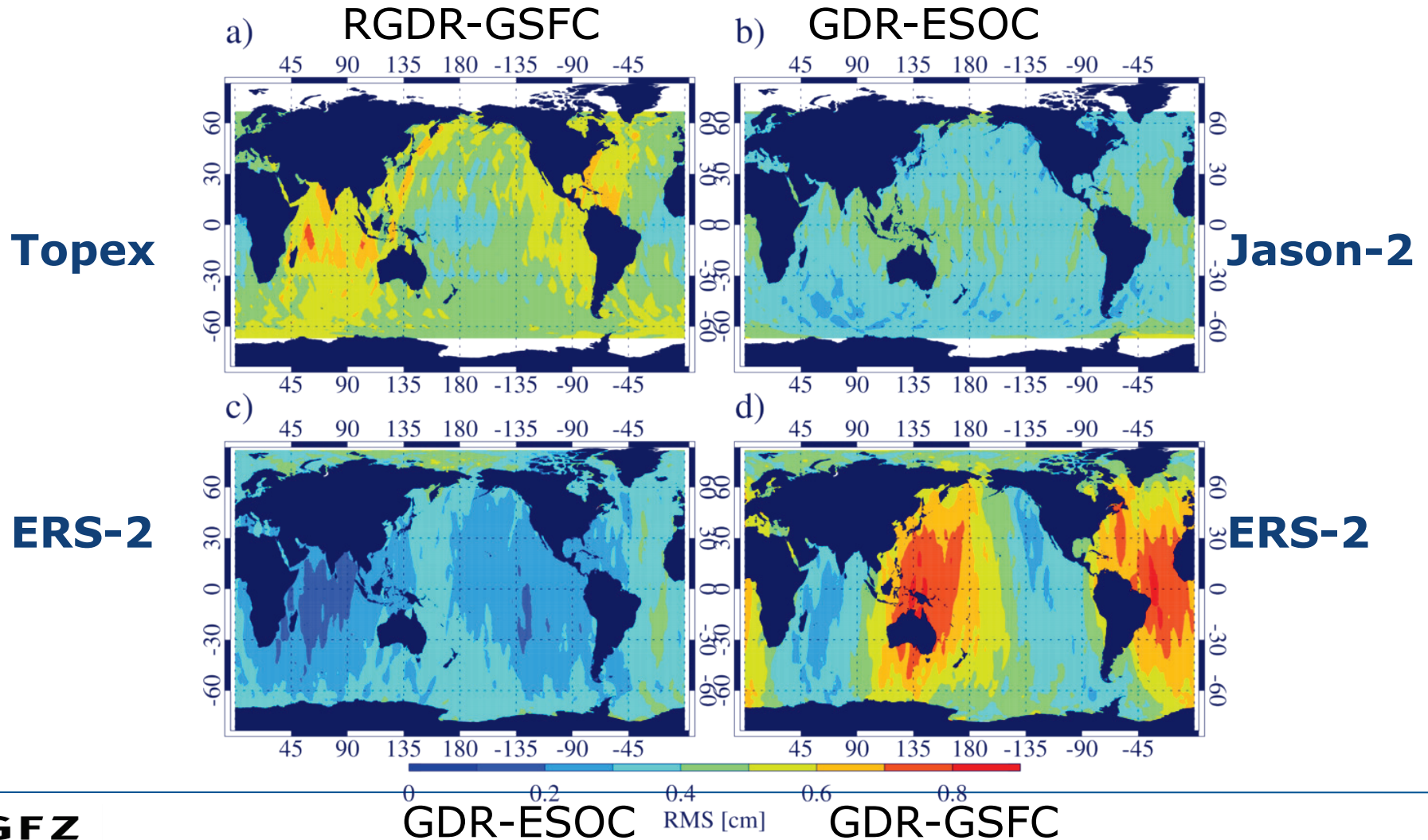
Jason-2

ERS-2

ERS-2



RMS of Orbit Differences



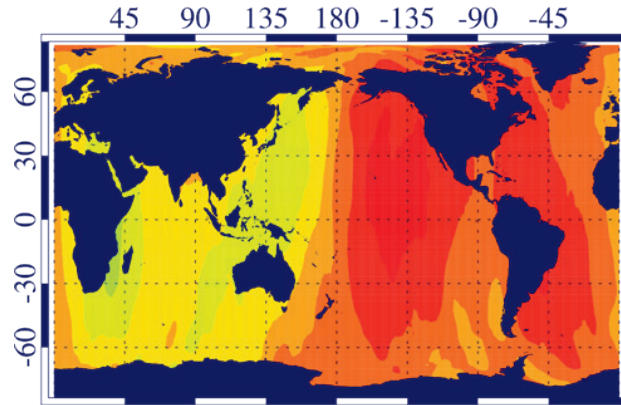
The main parameters of the geopotential models used

Parameter	EIGEN-GL04S- ANNUAL	EIGEN-6S_correct	EIGEN-6S_static (epoch 2000.0)
Maximal degree and order	150	240	240
Truncation level	90	90	90
Drifts of coefficients	no	For degree 2-50 terms	Only $C_{2,0}$
Annual and semi-annual variations	For degree 2-50 terms	For degree 2-50 terms	For degree 2-50 terms
Reference epoch	MJD 1460.5 (01.01.2004)	MJD 1826.5 (01.01.2005)	MJD -0.5 (01.01.2000)
GM value [m ³ /s ²]	3.986004415 E+14	3.986004415 E+14	3.986004415 E+14
Semi major axis [m]	6378136.46	6378136.46	6378136.46
$C_{2,0}$	-0.484165281 E-03	-0.484165300 E-03	-0.484165316 E-03
$\dot{C}_{2,0} + \Delta C_{2,0}$	0.0	3.182710000 E-12 + periodic terms	3.18271000 E-12 + periodic terms
$C_{1,0}, S_{1,0}, C_{1,1}, S_{1,1}$	0.0	0.0	0.0

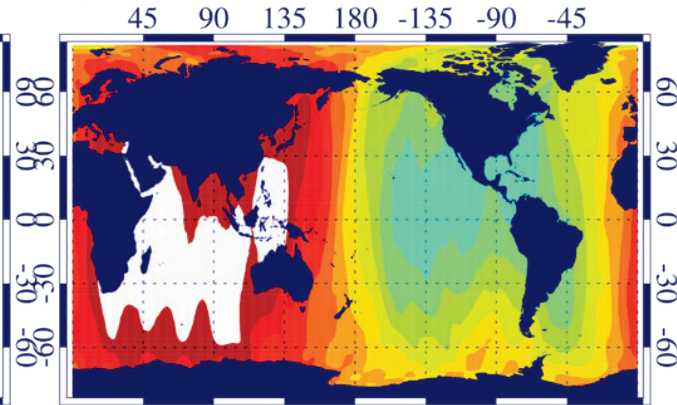
Mean Orbit Difference

Envisat sensitivity study

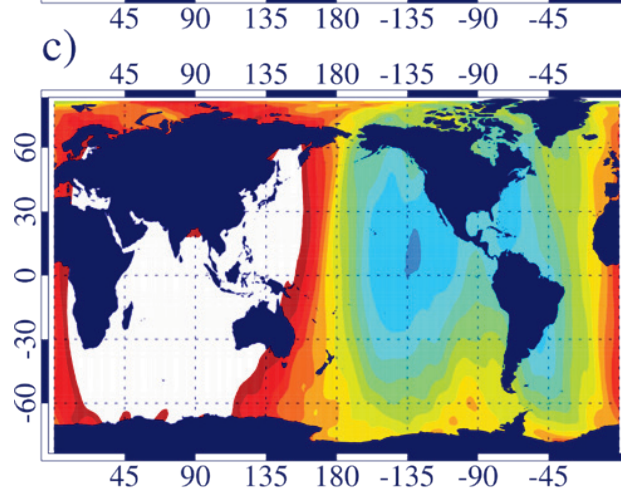
a) EIGEN-GL04S-EIGEN-6S



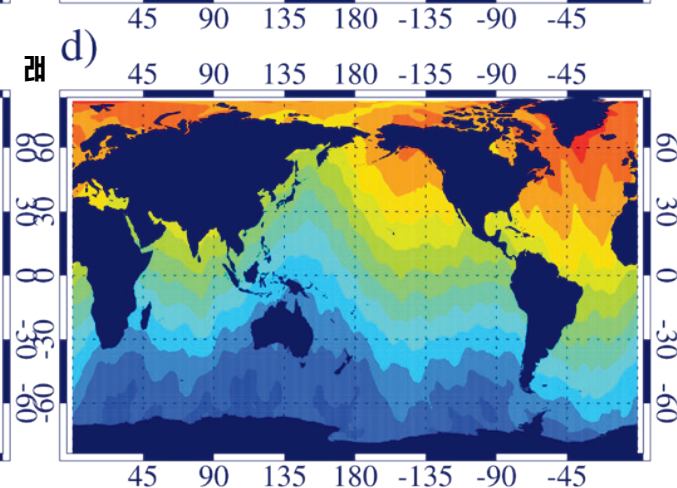
b) EIGEN-GL04S-EIGEN-6S static



c)



d)



EIGEN-6S-EIGEN-6S static GDR-GFZ(EIGEN-6S)

mean deviations [cm]