REPROCESSING ACTIVITIES AT EUMETSAT FOR METOP-A/B, COSMIC AND CHAMP.

EUMETSAT

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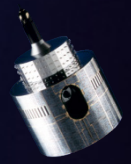


Outline

- Introduction
- Reprocessing Facility
- Timeline
- Tools/Processing Schema
- Metop
- Cosmic
- Champ
- Conclusions

Introduction

- European Re-Analysis of global CLIMate observations (ERA-CLIM) Frame of EU seventh framework program
  - Project headed by ECMWF
  - Re-analysis of in-situ and satellite observation data in generating consistent global model of Earth's climate system
  - Main objectives are to
    - improve on numerical weather forecasting
    - Prepare data sets and assimilation tools needed for global reanalysis
    - Provide information about data quality by means of pilot reanalyses
    - Develop an Observation Feedback Archive facility for users
    - Assess and reduce uncertainties in reanalysis data
- EUMETSAT RO activity in ERA-CLIM
  - Provide consistent reprocessed GPS RO observations (2001-present) from Metop, COSMIC, CHAMP, GRACE, etc
- There will be future reprocessing activities run by EUMETSAT.

Reprocessing Facility at EUM

- Intel based Linux system, Suse-Enterprise 11SP3 (R-INTEL)
- 64 CPUs – 4 machines of 16 CPUs / 256 GB RAM
- Specification: product generation software at optimally 50 days per day of processing, and at least 30 days per day of processing.
- Actual numbers for GRAS (24H):

1	Time correlation	< 1 minute
2	Level0R	360 minutes
3	RINEX	18 minutes
4	POD	~3 minutes
5	L0R2L1a	100 minutes
6	L1a2L1b	420 minutes(GO) 480 minutes (WO)

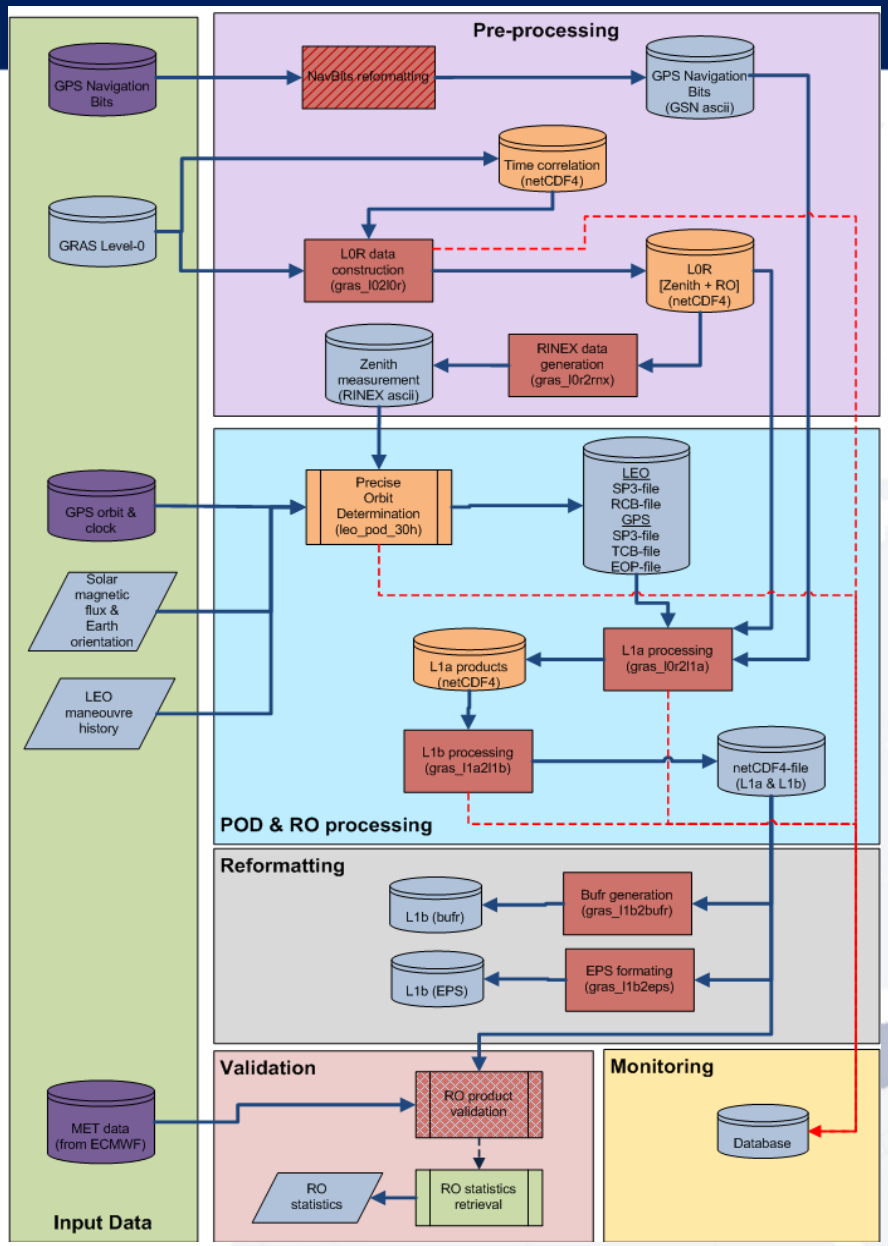
⇒ ~ 15-16 hours / day / core => ~ 95-102 days per day of processing

Timeline

- V0.9 => (Dec 2013) Metop-A processing GO
- V 1.0 => (Apr 2014) Fixed some issues (memory, RINEX generation in case of gaps, external Navbit data, georeferencing)
  => Validated and delivered to ECMWF in the frame of ERACLIM-1
- V 1.1 => (Aug 2014) Wave Optics implemented
  => Fixed various issues with metadata for EUM archive
  => Consistent raw sampling and open loop instantaneous Doppler
- V 1.2 => (Feb 2015) Format change to adapt to future EPS-SG EUM format, Metop-B added
  => Estimates IP manoeuvres
  => Re-factor Antenna Correction
- V 1.3 => (May 2015) Improved FSI
  => Second Order Systematic Ionospheric Correction
  (Healy and Culverwell 2015)
- V 2.0 => (End 2015) Cosmic and Champ (Implementation of SD)

Tools / Processing Schema

- Software:
  - YAROS => Generic package for RO processing from level0 to bending angle (python, Fortran, C)
  - NAPEOS => POD SW from ESA (called from/integrated with YAROS)
  - COSMIC reader => Perl SW taken from UCAR (small modifications)
  - CHAMP reader => C SW taken from NASA/JPL
- Daily/Hourly processing schemas
- Torque/PBS used as batch system



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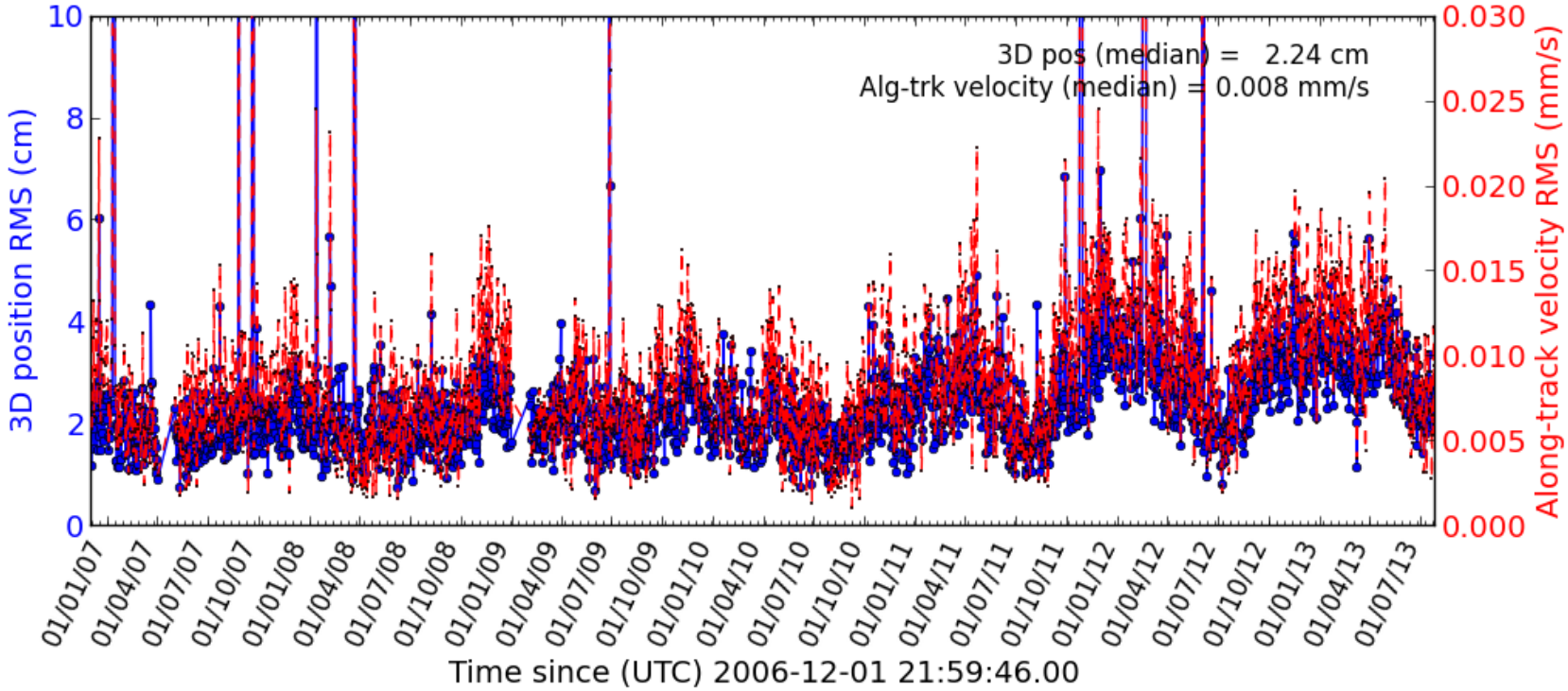
Metop-A results/validation (POD)

- Internal assessment (orbit overlaps)
- Periodic signal, need to be better understood and minimize.



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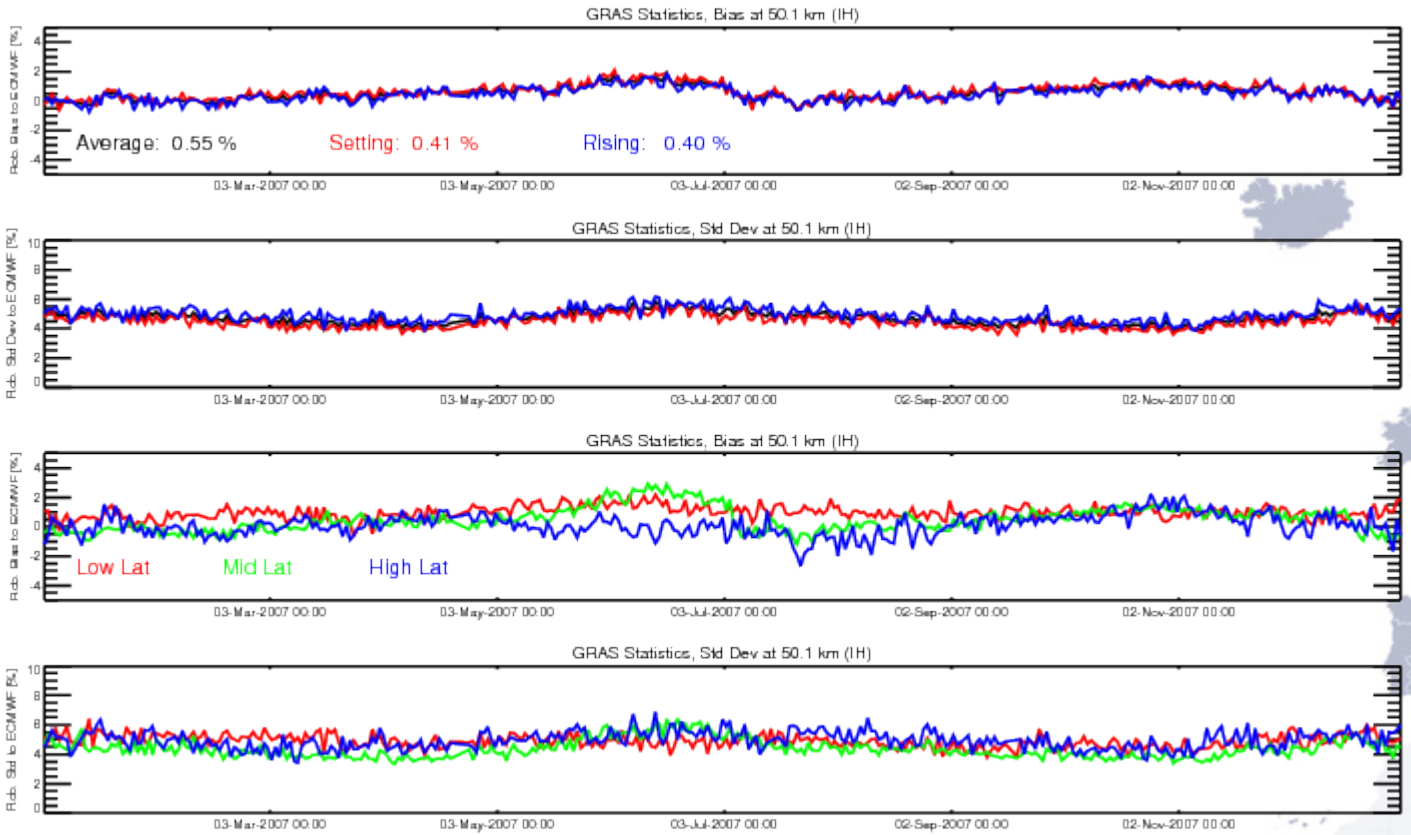
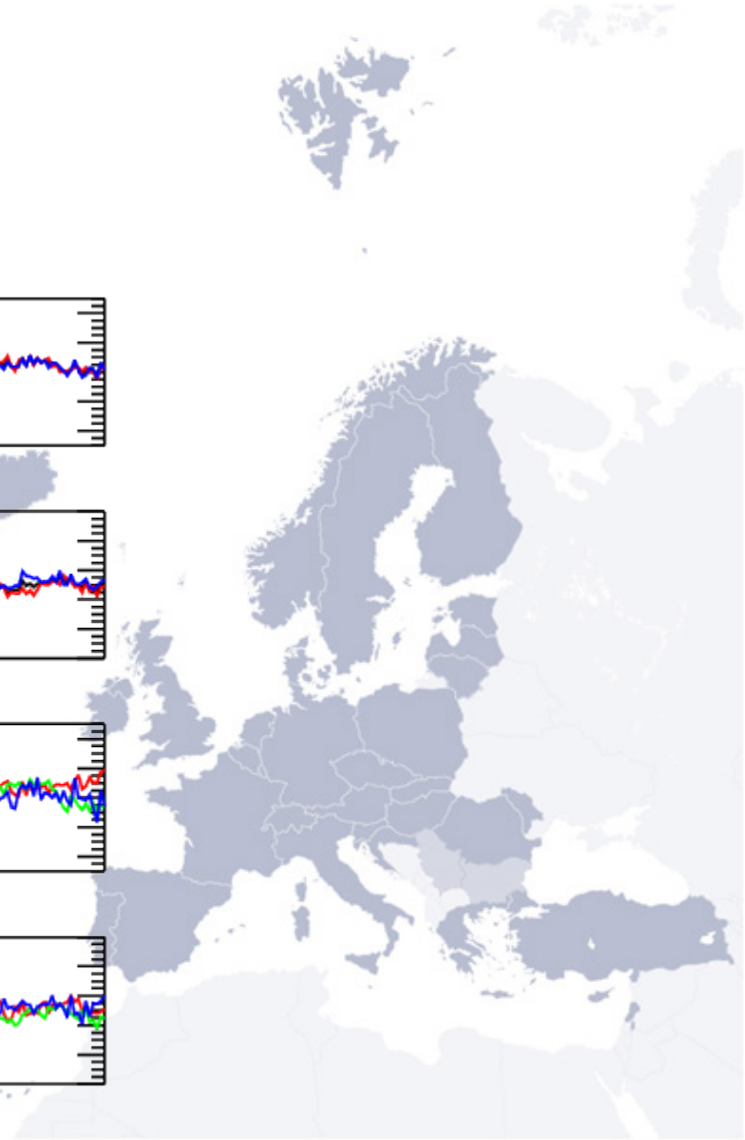
Metop-A results/validation

- Geometrical Optics BUFR delivered to ECMWF
- Currently processing with v 1.2
- V1.3 to be released shortly with FSI





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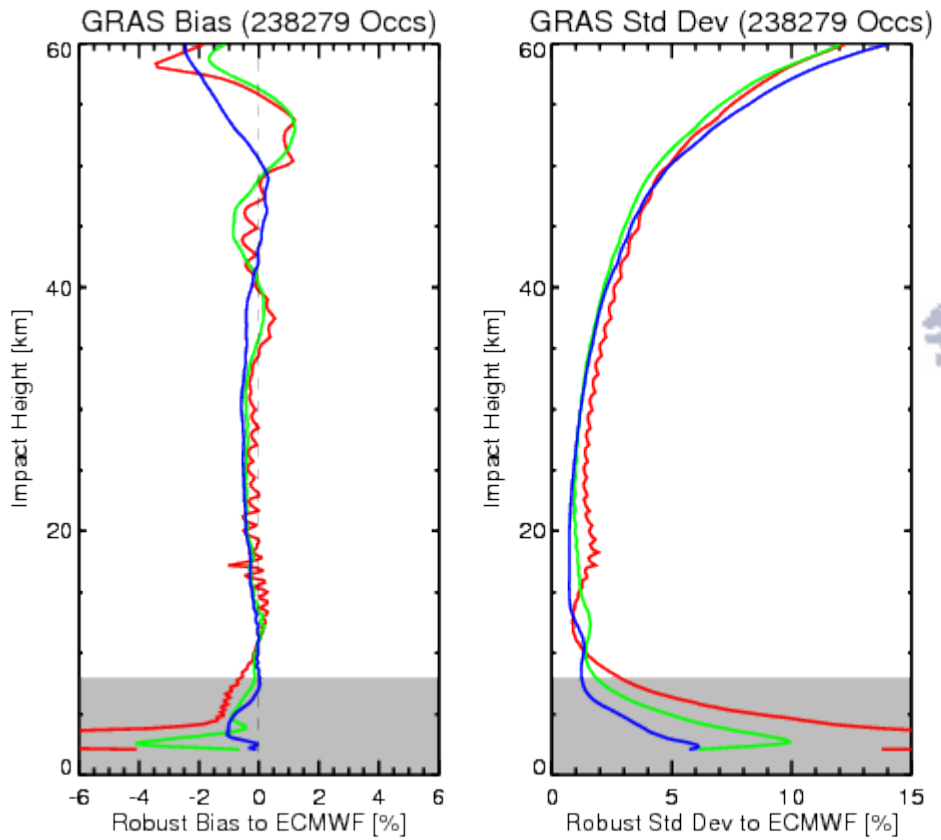
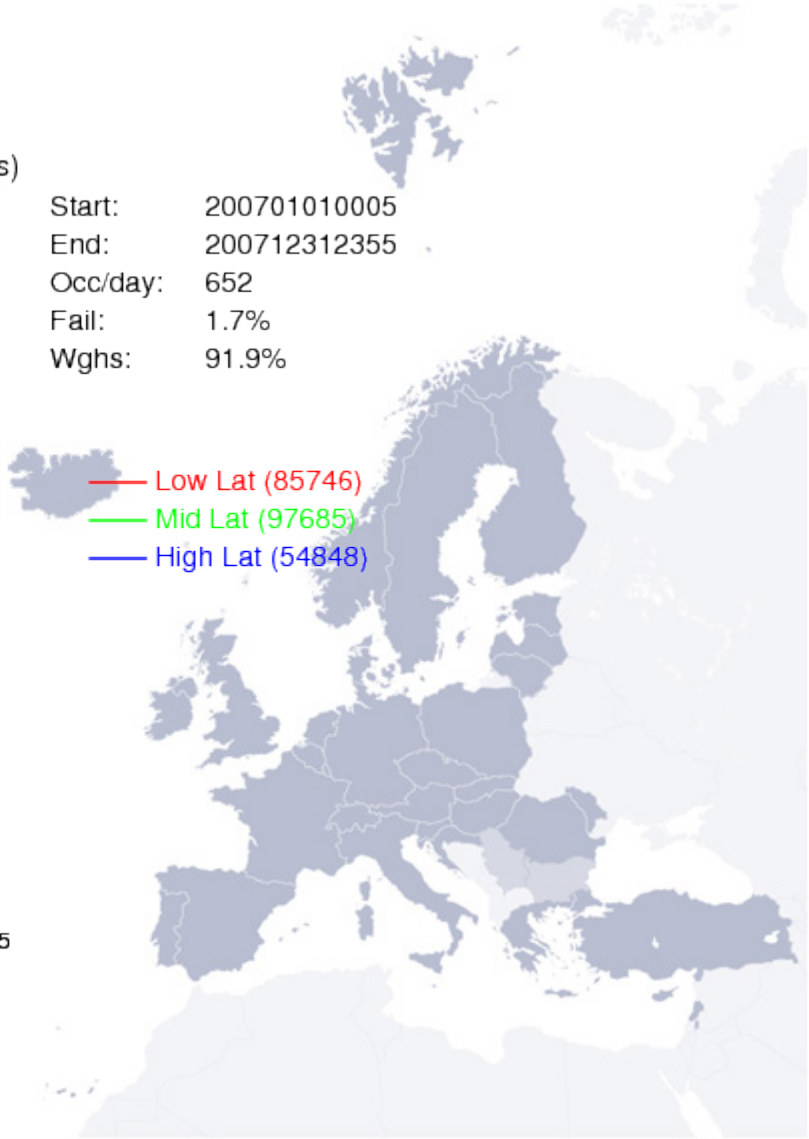
Metop-A (2007)



Start: 200701010005
End: 200712312355
Occ/day: 652
Fail: 1.7%
Wghs: 91.9%

Low Lat (85746)
Mid Lat (97685)
High Lat (54848)



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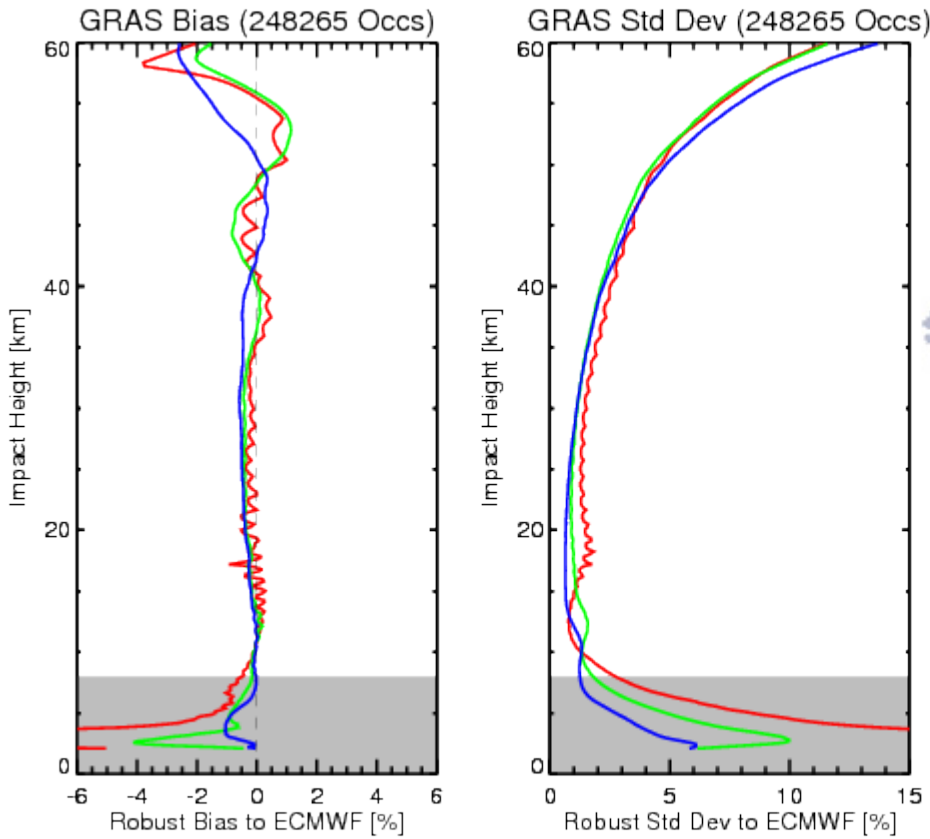
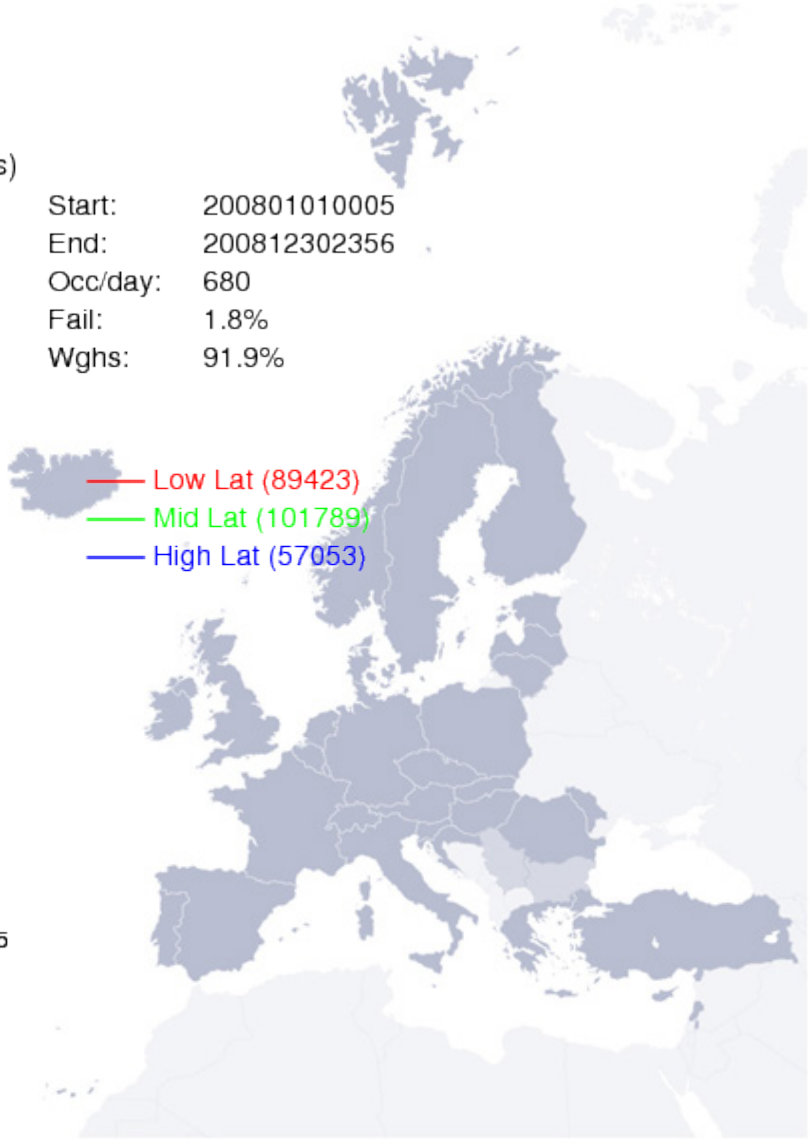
Metop-A (2008)



Start: 200801010005
End: 200812302356
Occ/day: 680
Fail: 1.8%
Wghs: 91.9%

Low Lat (89423)
Mid Lat (101789)
High Lat (57053)



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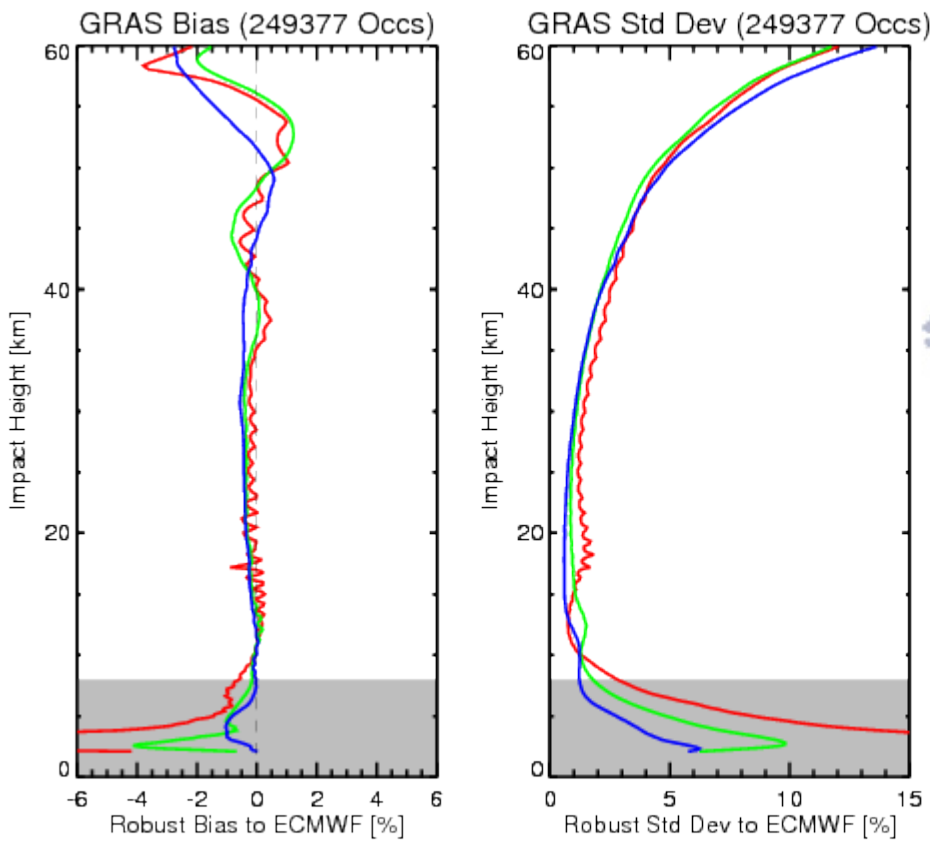
Metop-A (2009)



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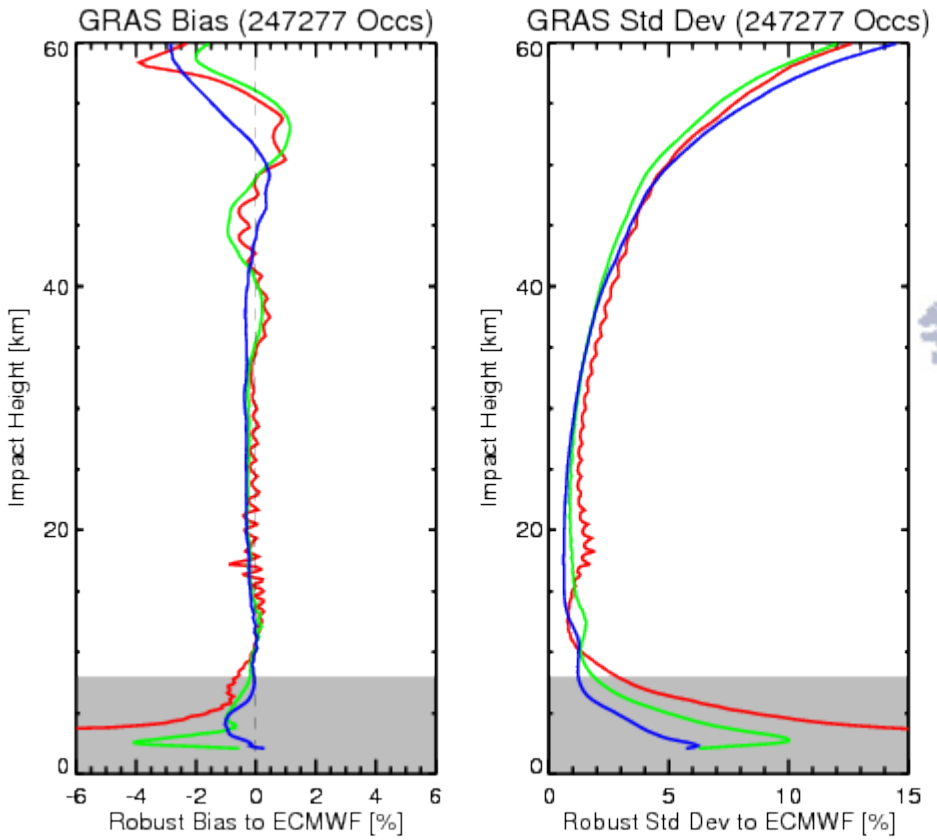
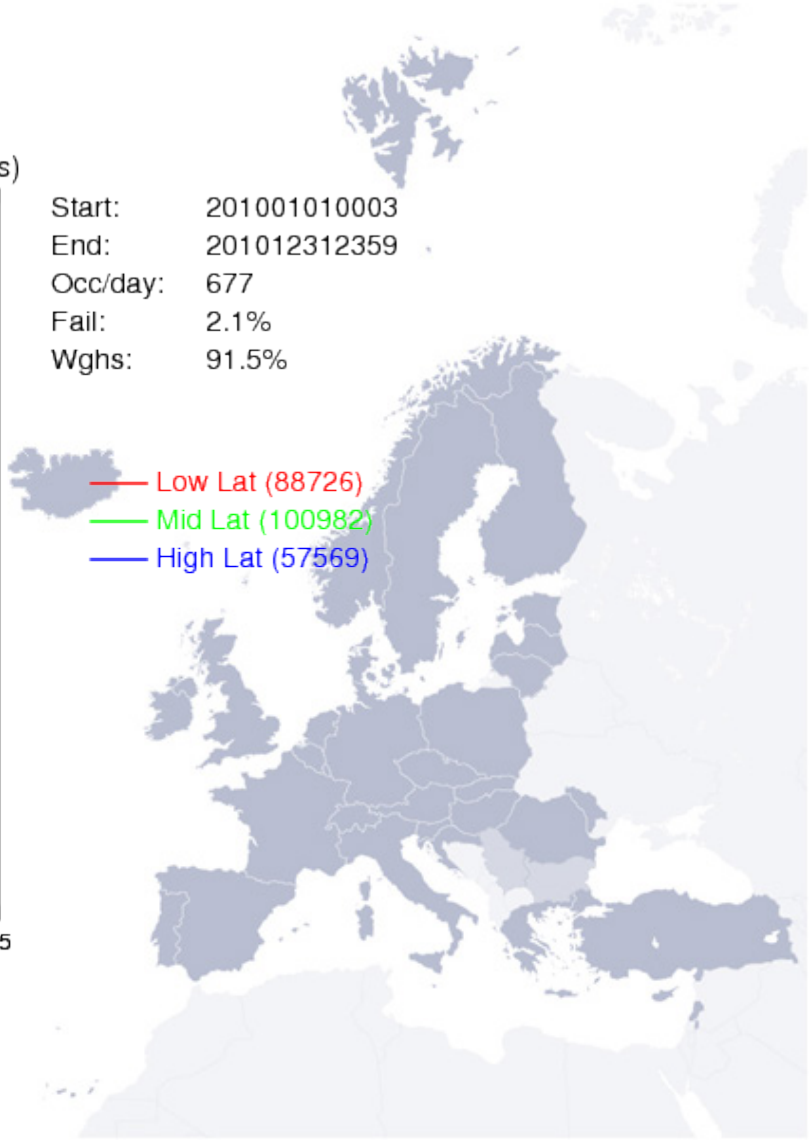
Metop-A (2010)



Start: 201001010003
End: 201012312359
Occ/day: 677
Fail: 2.1%
Wghs: 91.5%

Low Lat (88726)
Mid Lat (100982)
High Lat (57569)



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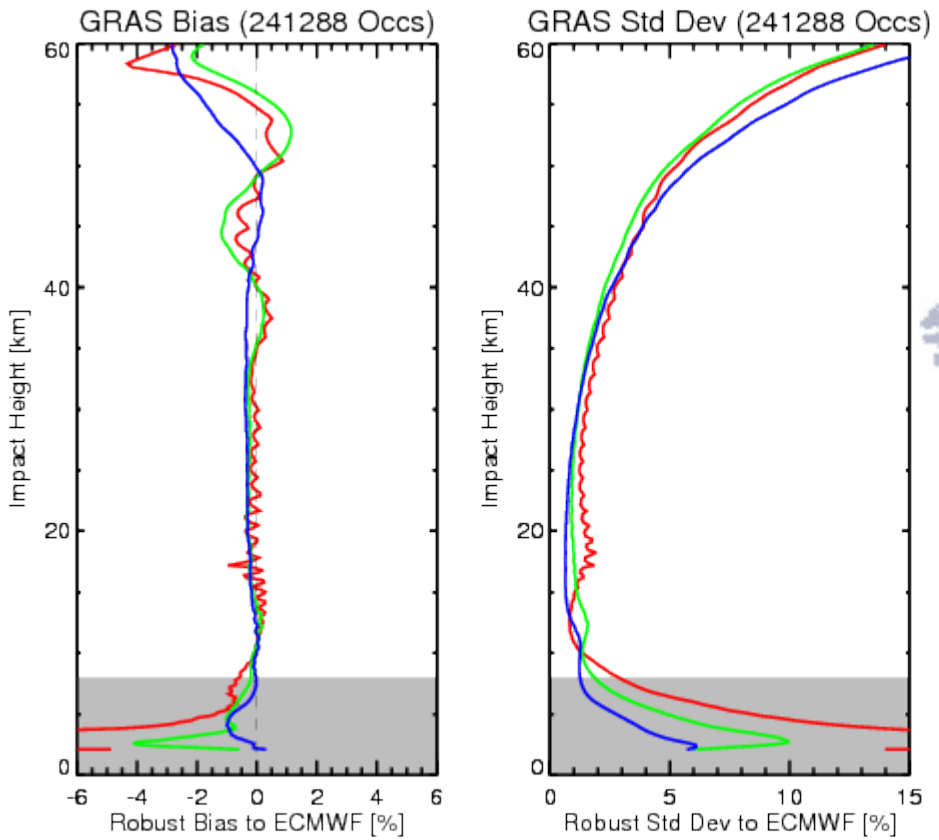
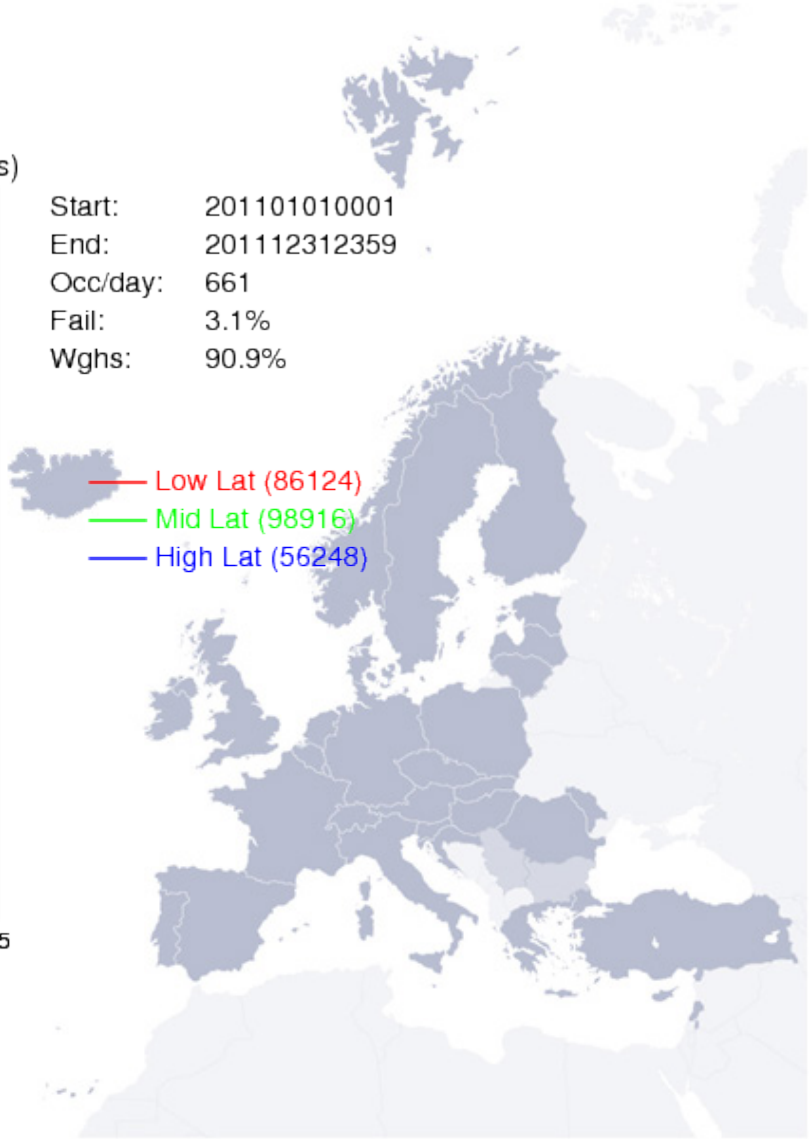
Metop-A (2011)



Start: 201101010001
End: 201112312359
Occ/day: 661
Fail: 3.1%
Wghs: 90.9%

Low Lat (86124)
Mid Lat (98916)
High Lat (56248)



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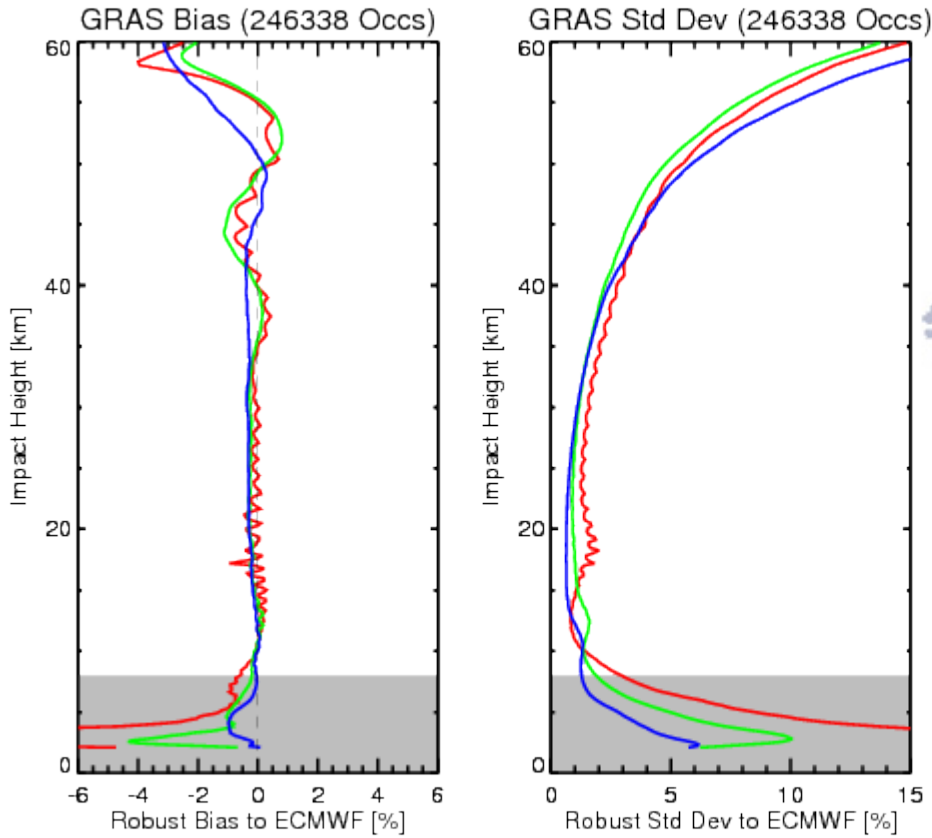
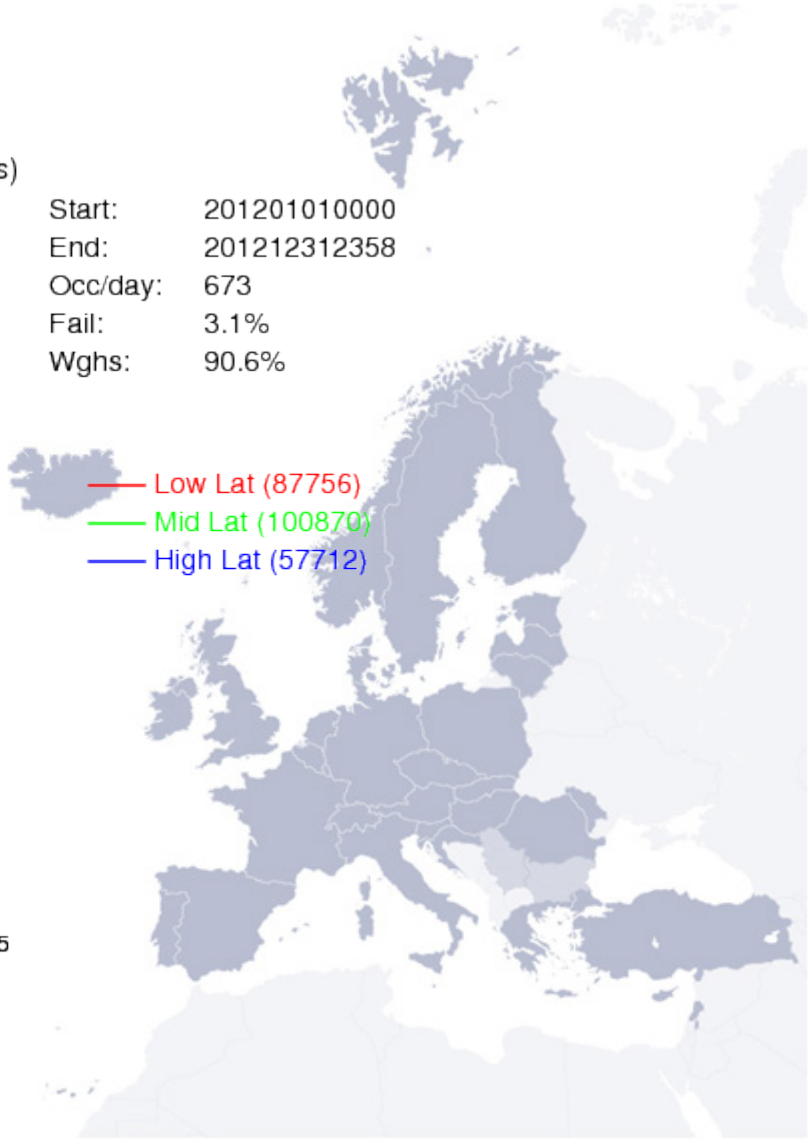
Metop-A (2012)



Start: 201201010000
End: 201212312358
Occ/day: 673
Fail: 3.1%
Wghs: 90.6%

Low Lat (87756)
Mid Lat (100870)
High Lat (57712)



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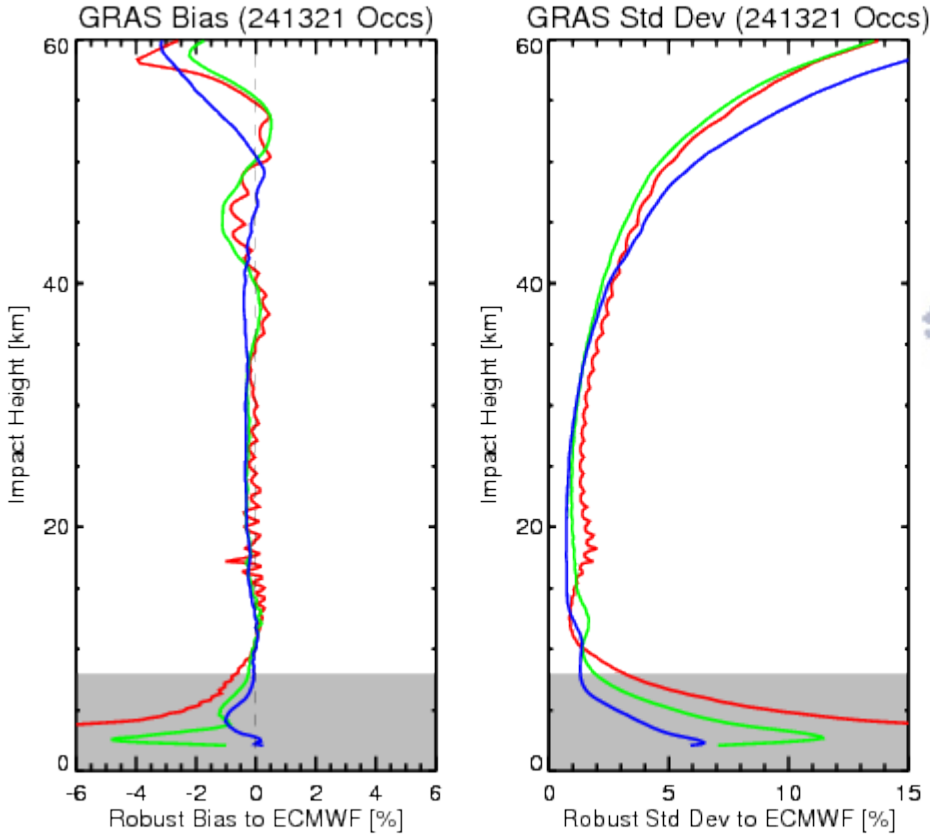
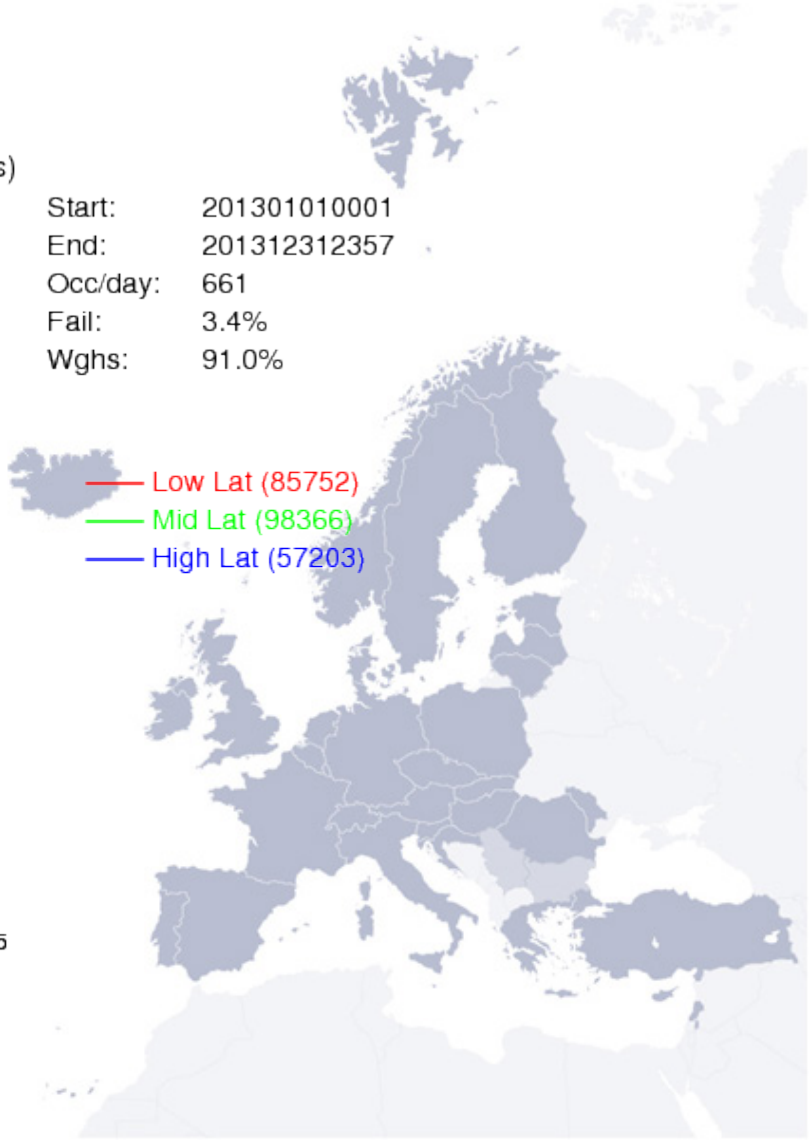
Metop-A (2013)



Start: 201301010001
End: 201312312357
Occ/day: 661
Fail: 3.4%
Wghs: 91.0%

Low Lat (85752)
Mid Lat (98366)
High Lat (57203)



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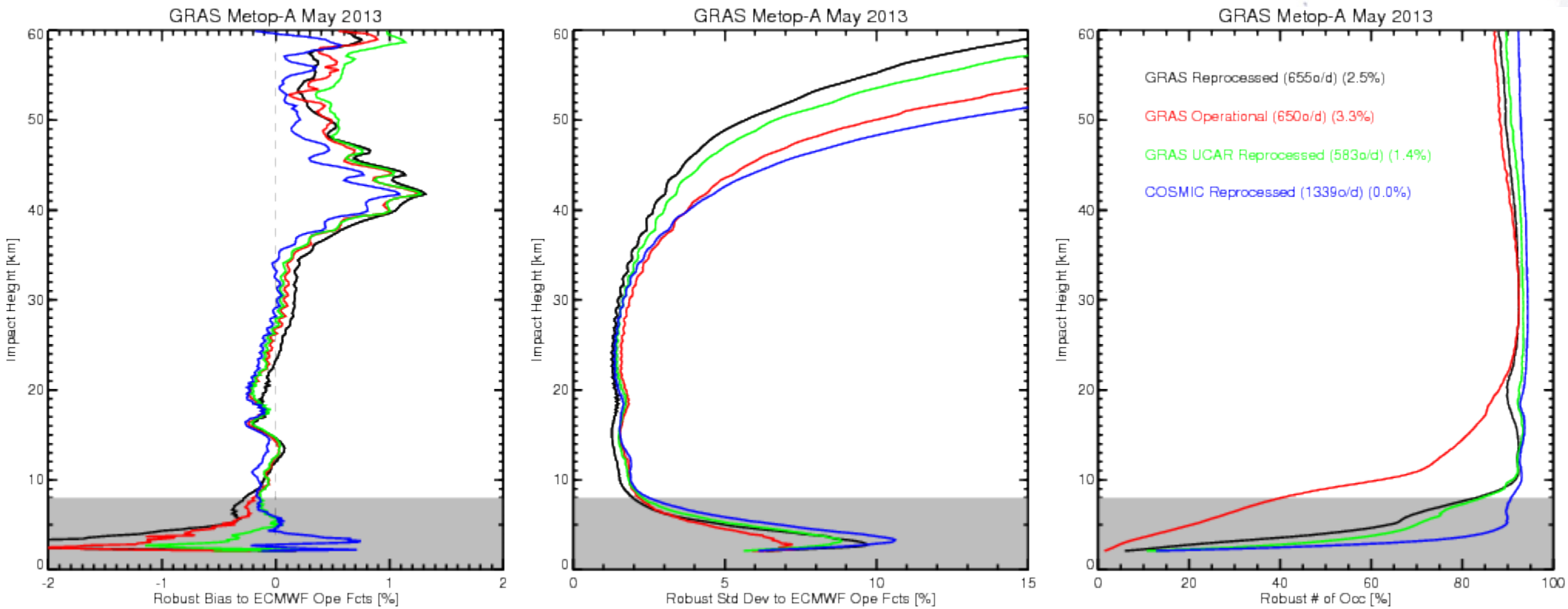
Metop-A v 1.2

- Reprocessing of this version still not finished
- One month of data for validation



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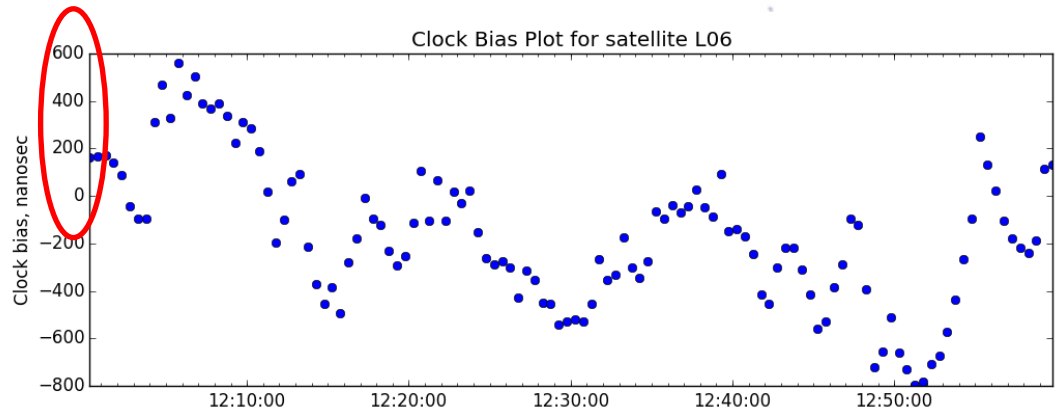
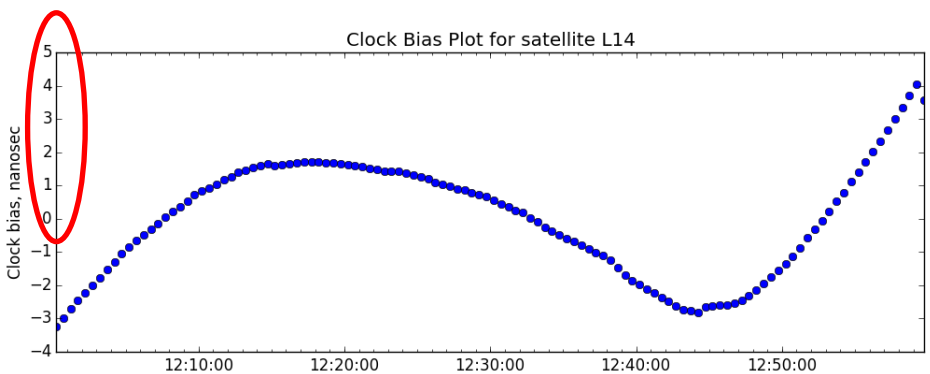
Cosmic / Champ processing

- Cannot use zero differencing algorithms
- Need of implementing single differencing approach removing LEO clock





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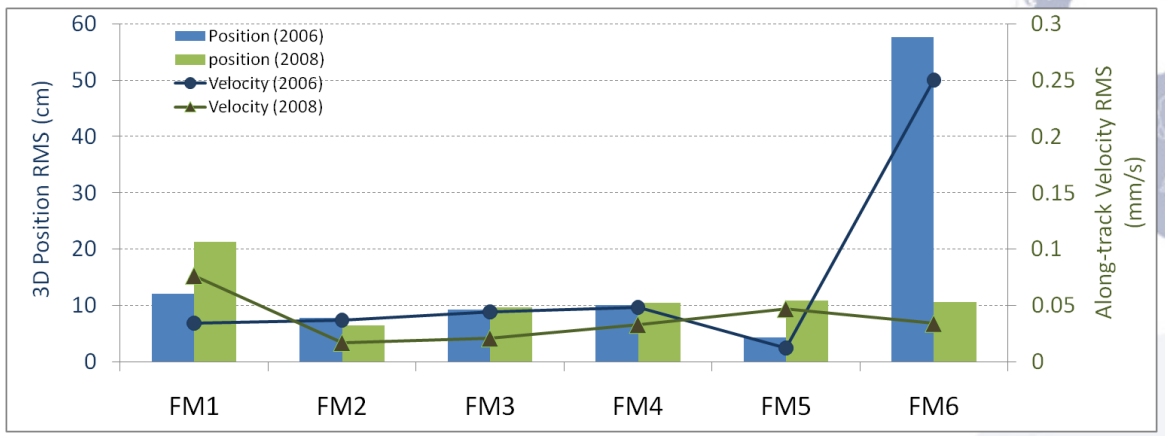
COSMIC

- Start from level0 files, but use SW provided by UCAR
- EUM POD accuracy is similar to other centres
- Two sets of statistics
  - 2-10 August 2006
  - 26 Nov – 3 Dec 2008
- Internal (orbit overlap) assessment (stats based on median)
  - 3D position (RMS) < 25 cm [exclude FM6 in 2006]
  - Along-track velocity (RMS) < 0.1 mm/s



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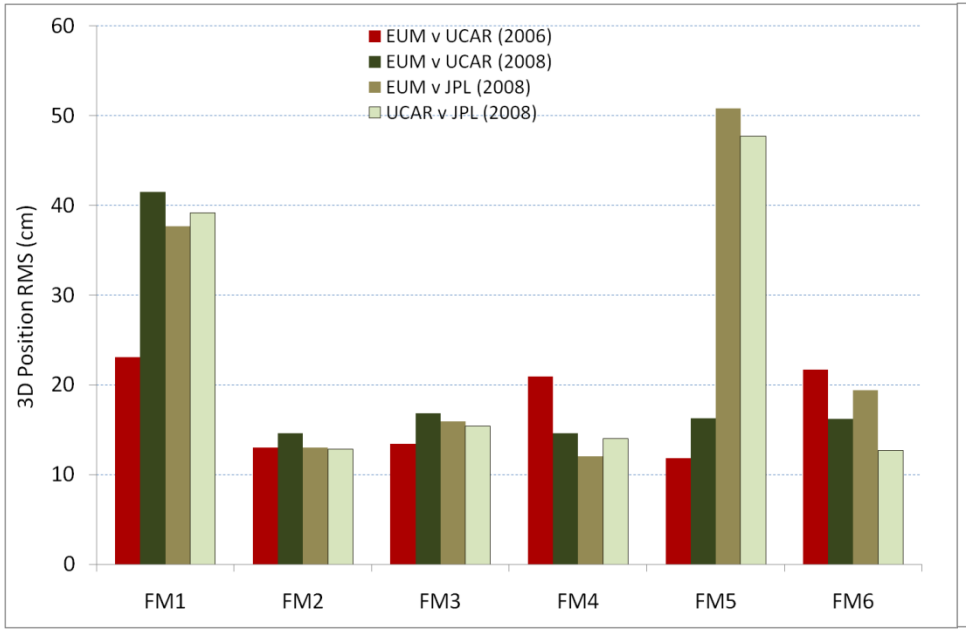
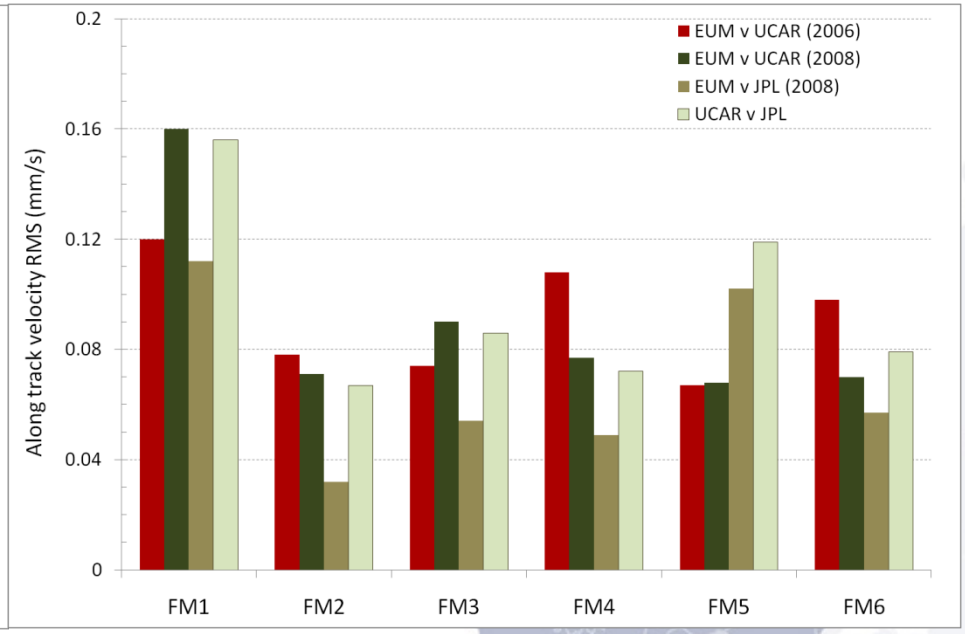
COSMIC

- External orbit assessment (stats based on median)





3D position < 60 cm

Along-track velocity < 0.2 mm/s

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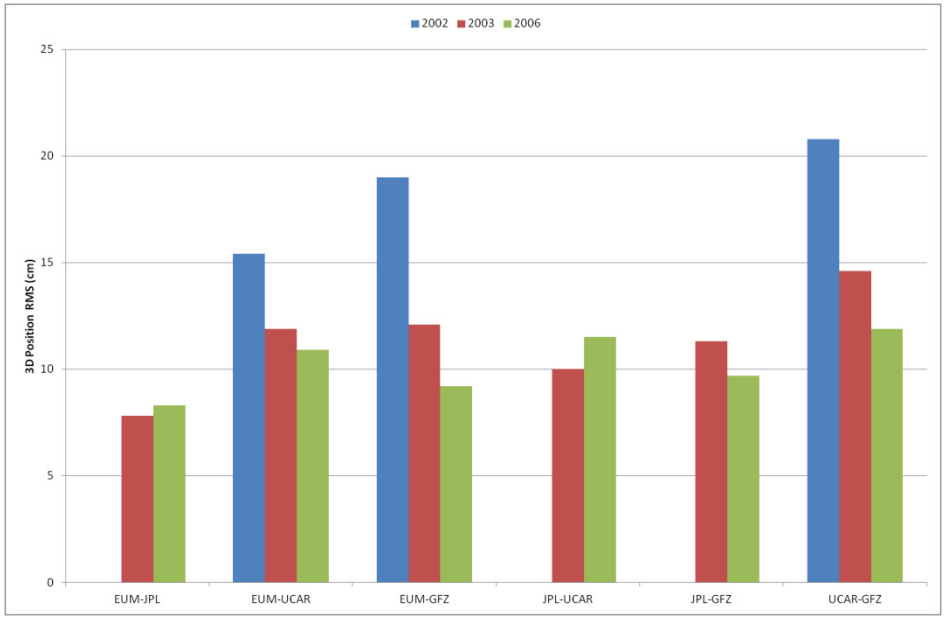
CHAMP

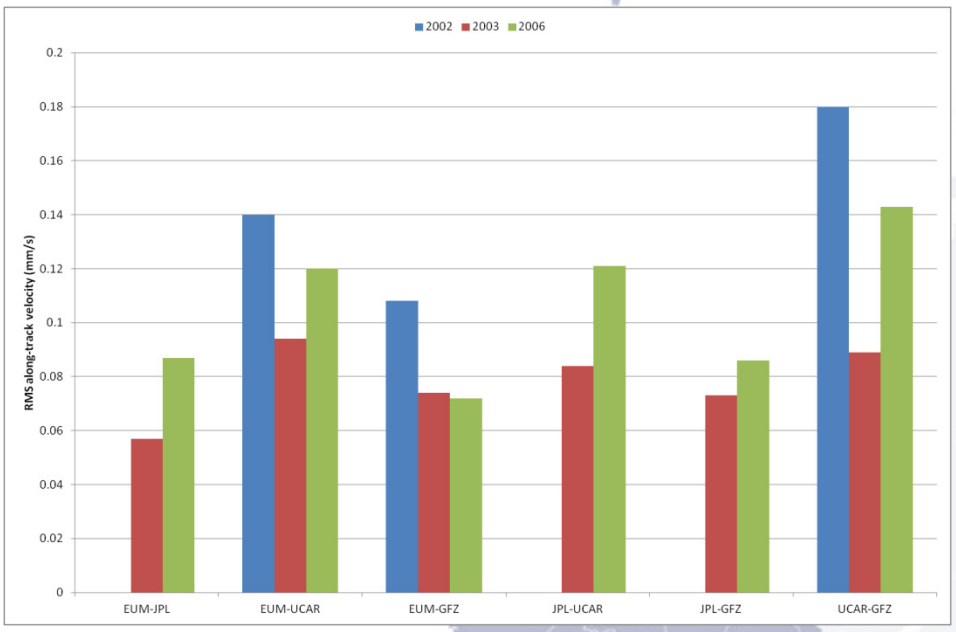
- Start from level0 files, but use SW provided by JPL
- EUM POD accuracy is similar to other centres
- Three sets of statistics (different updates to receiver)
  - 3-10 Jan 2002
  - 20-24 March 2003
  - 1-4 Jan 2006

DOY/Year	Position	Velocity
	3D RMS (cm)	*Alongtrack RMS (mm/s)*
003/2002	8.359	0.0614
004/2002	12.364	0.0457
005/2002	4.184	0.0275
006/2002	3.755	0.0297
007/2002	3.067	0.0169
008/2002	6.858	0.0244
009/2002	3.769	0.0227
079/2003	2.844	0.008
080/2003	1.475	0.008
081/2003	2.365	0.0165
082/2003	2.179	0.0152
001/2006	2.621	0.0299
002/2006	4.01	0.0335
003/2006	3.534	0.0278
004/2006	1.792	0.02

CHAMP

❑ External orbit assessment (stats based on median)





3D position < 10 cm

Along-track velocity < 0.1 mm/s

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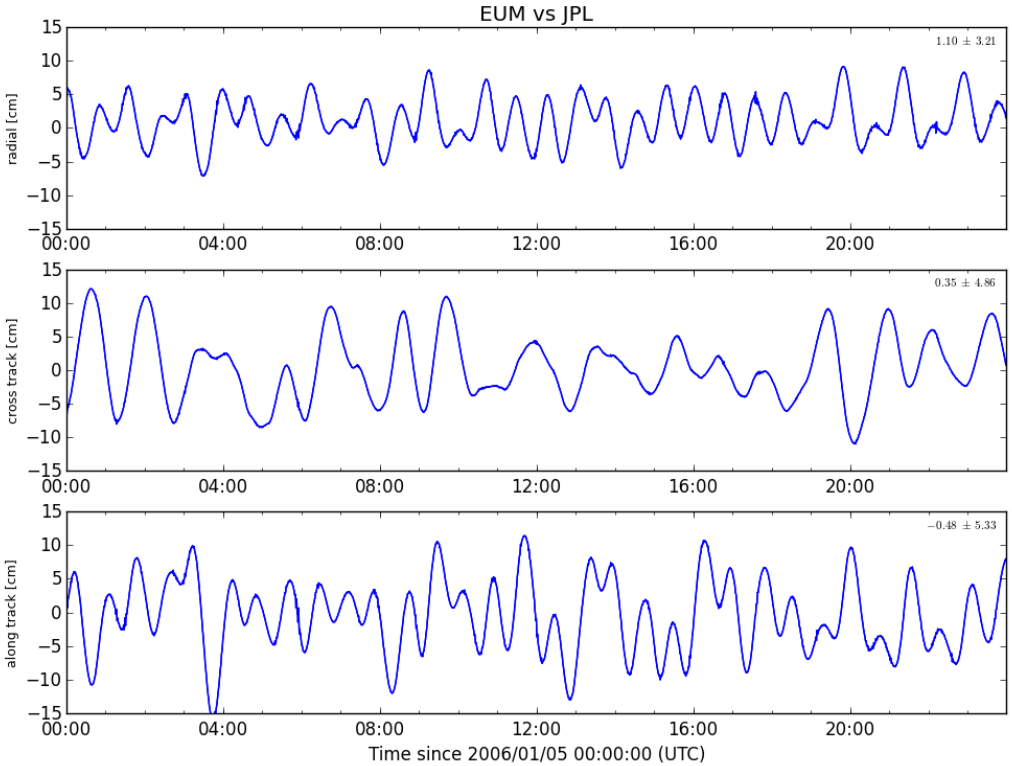
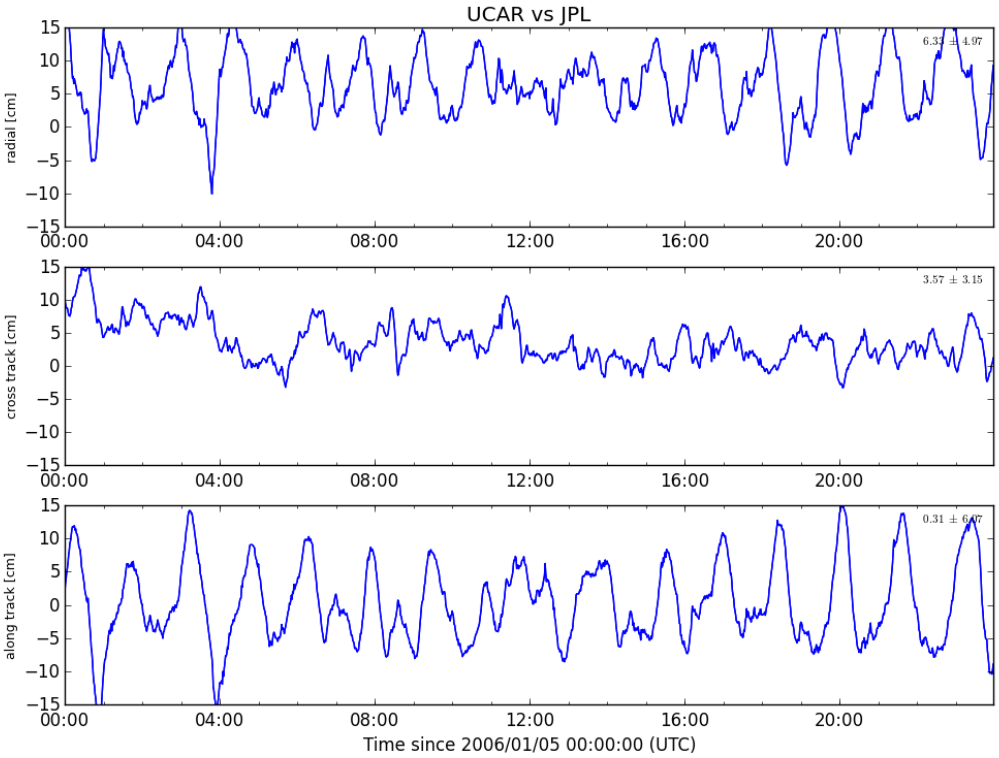
Champ

- Radial and cross track biases in the orbit comparisons

	EUM	JPL	UCAR	GFZ (RSO)
EUM		0.087	0.120	0.072
JPL	8.3		0.121	0.086
UCAR	10.9	11.5		0.143
GFZ (RSO)	9.2	9.7	11.9	





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Summary and Conclusions

- EUMETSAT on the way to produce and make available to users (almost) independent reprocessed RO L1A/L1B data starting from the level0 for different RO missions
- Metop products already generated (partially)
  - FSI to be finalized
  - POD might be further improved
- Cosmic/Champ still at POD level
  - COSMIC POD
    - Overall POD (EUM, UCAR, JPL) results show close agreement
    - Challenging due to many data gaps, FM2/FM5 had attitude problems
  - CHAMP POD
    - Overall POD (EUM, UCAR, GFZ, JPL) results show close agreement

Thank you!

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