INFLUENCE OF THE TYPE MEAN AND INDIVIDUAL ANTENNA CALIBRATIONS ON THE EPN COORDINATES – LESSON FROM REPRO2

Faculty of Civil Engineering and Geodesy

Military University of Technology

Bayerische Akademie der Wissenschaften

Andrzej Araszkiewicz (1), Christof Völksen (2)

(1) Military University of Technology, Faculty of Civil Engineering and Geodesy

(2) Commission for Geodesy and Glaciology, Bavarian Academy of Sciences and Humanities

contact: andrzej.araszkiewicz@wat.edu.pl

INTRODUCTION

The estimation of precise positions using the signals of the Global Position System (GPS) requires the correction between the point of reception (phase centre) and the antenna reference point (ARP). Sophisticated models to account for these phase errors are available and are widely used. These models are usually based on calibrations of several antennas of the same type and a mean model is derived. There is also the possibility to apply individual correction models that are derived for one single antenna, since the individual antennas may still vary by a few millimetres. To understand the impact using type mean or individual antenna correction models, we prepared two sets of station position time series. At first we estimated the station positions using the type mean model for the antenna corrections as it is provided by the IGS. Secondly, the same processing strategy was used but this time with individual antenna correction models given that they were available. Reference frame realization was done by minimizing the coordinate residuals at selected 57 stations (**Fig.2**). Then, based on these two solutions, we estimated difference time series for sites where individual antenna corrections were available.

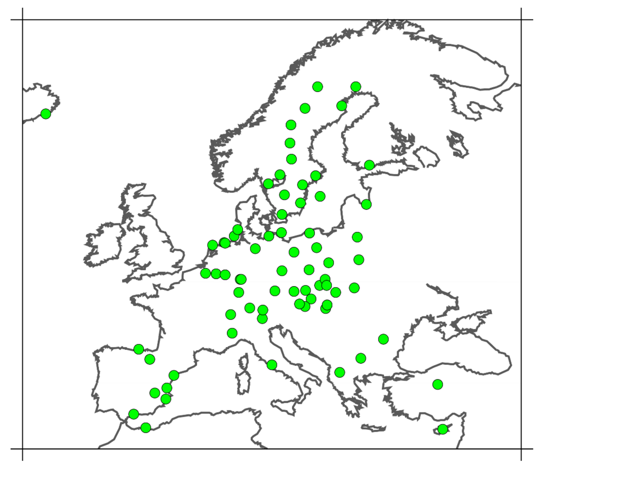

Fig. 1. Location of the individual calibrated antennas (valid for 2015).

	MU1	MU2
Software	GAMIT v. 10.50	
GNSS system	GPS only	
Orbits	CODE Repro2 products	
EOP	according to IERS2010 convention	
Satellite PCC	igs08_1840.atx	
Receiver PCC	igs08_1840.atx + epn_08.atx	igs08_1840.atx
Troposphere	1h ZTD + grad (24h), VMF1	
Ionosphere	"iono-free" + HOI	
Tides	according to IERS2010 convention	
Loadings	FES20104 for ocean loading,	
Reference frame	Stabilised by the set of 57 „not affected" stations. Translation only.	

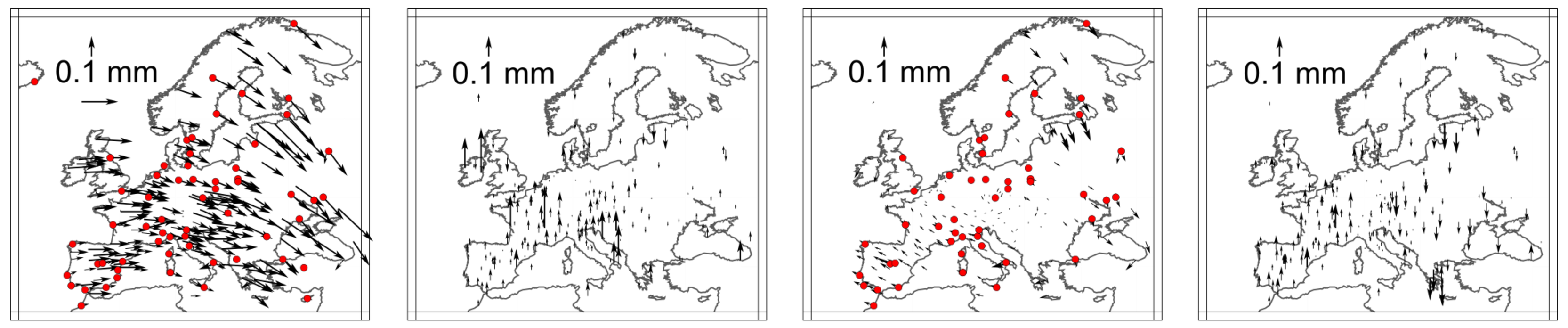

Fig. 2. Consistency between MU1 and MU2. Maps present offsets for 234 stations, that were modelled the same way in both solutions. First pair (horizontal and vertical) corresponds to solutions, where 71 reference stations (the same list as for routine EPN products – IGb08) were used. Second pair presents the offsets, while only 57 stations were used as reference (red points).

SUMMARY

Our results prove that for individual antennas mixing two kind of PCCs may cause discrepancy in the final position exceeding 10 mm for horizontal and vertical component. However, these are just single cases (see below or in table above). For most of the antennas offsets for horizontal components are below 2 mm and for vertical component below 4 mm. The impact is therefore small and manifold, but for almost all investigated antennas it is clearly visible. Therefore **it is necessary to investigate the difference between the type mean and individual calibration model whenever an individual calibration is available** and estimate its impact on the position.

DIFFERENCES BETWEEN USED PCCs

The impact of one set of specific phase centre corrections (PCCs) in GNSS analysis is particular important if different PCC sets are available. Within the EPN we have to deal with the type mean models (*provided by IGS*) and individual calibration (*compiled by the EPN CB*).

Depending on model the PCC of a GNSS antenna may differ up to several millimetres. These differences (here called dPCC) affect the final position as well as clock errors or troposphere parameters.

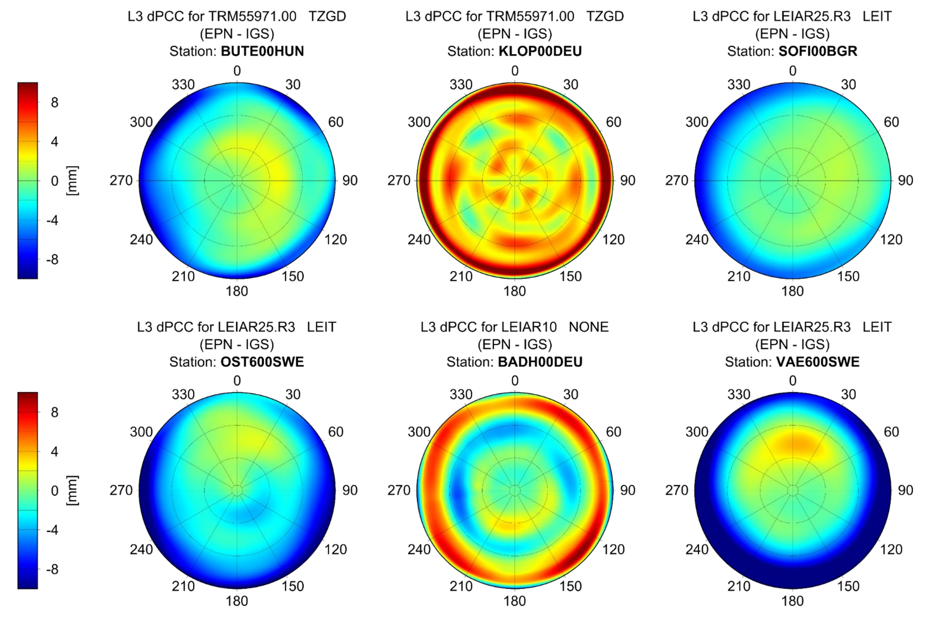

Fig. 3. Example of antennas (marked on blue in table) with elevation dependent dPCC. Such pattern impacts mostly the vertical component. In these three cases vertical offset exceed 10 mm. For these antennas we received greatest offsets for horizontal components.

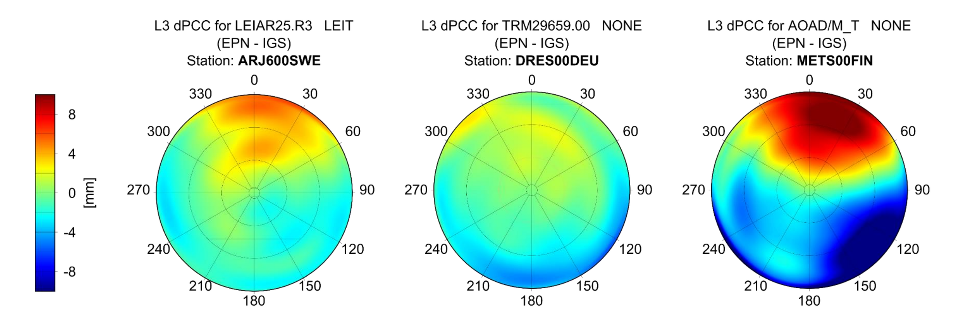

Fig. 3b. a. Example of antennas (marked on red in table) for which dPCC exhibits the dominant azimuthal asymmetry

RESULTS

Direct results of the conducted reanalysis, used in this study, were two sets of daily coordinate time series of 74 EPN stations each. For each station we generated time series of coordinate differences (DTS) between MU1 and MU2 solution by subtracting them (**Fig.4**). After outlier elimination (3 sigma) the repeatability of DTS for individual antennas was on average 0.3 mm for both horizontal components and 0.6 mm for vertical component. This confirms, that the impact of mixing two sources of PCC is rather stable over time. Next we estimated offsets in total of 110 antennas. The full list of them is presented in table on the right.

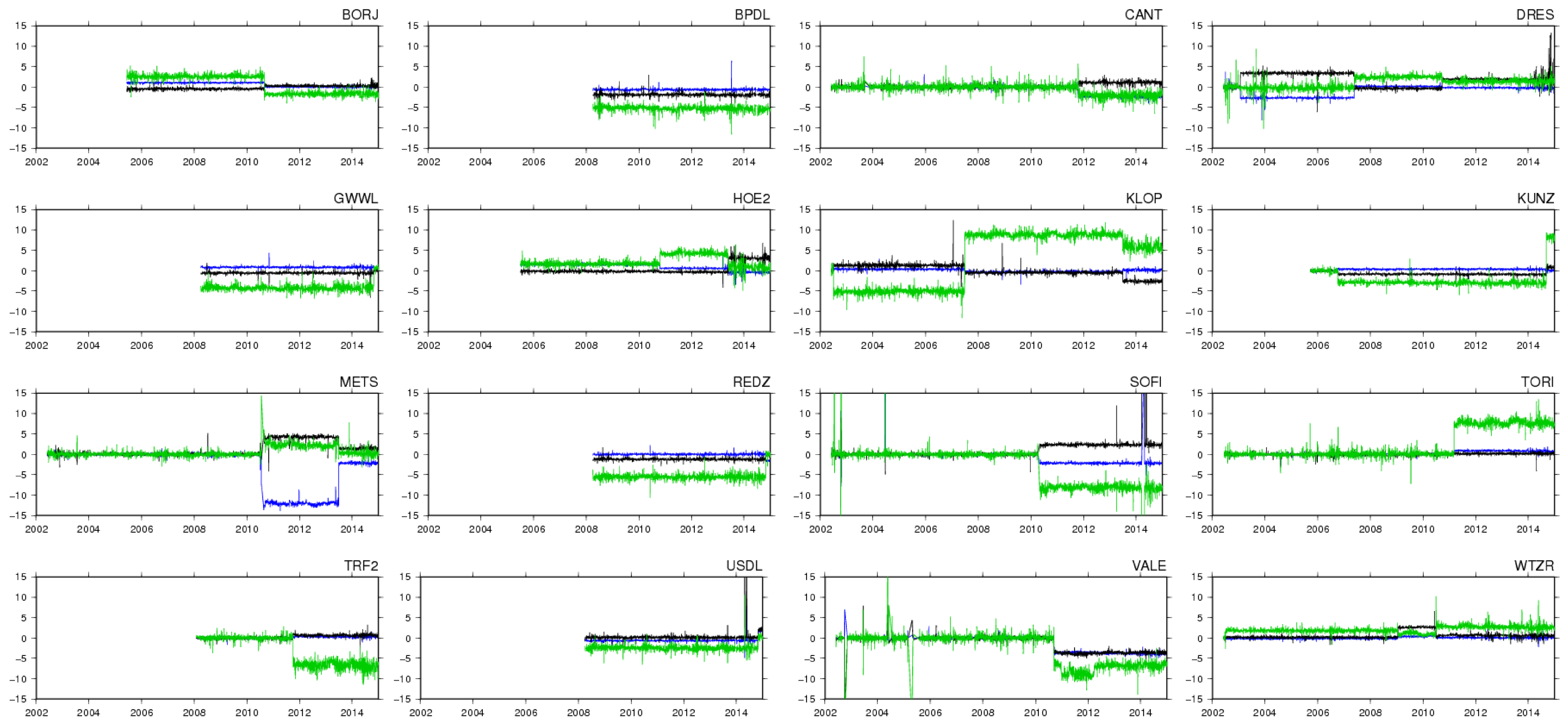

Fig. 4. Examples of the raw time series of coordinate differences (DTS). North- (blue), East-(black) and Up-component (green).

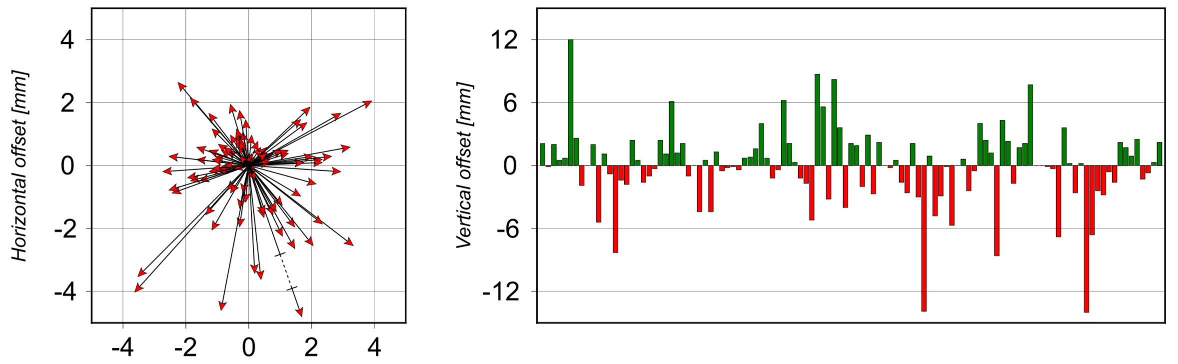

Fig. 5. Position offsets estimated for the analysed antennas. Horizontal offsets are displayed on the left, while the vertical offsets are displayed on the right. The largest horizontal offset was found for "AOAD/M_T NONE" mounted at METS00FIN, which transcended the figure boundaries (left) and was clipped to get fit whithin the box. Mean offsets are -0.26 mm for North-, 0.08 mm for East- and -0.06 mm for the vertical component, with the respectively variation of 1.8 mm, 1.5 mm and 3.7 mm

Station	Analysed period	Offsets (mm) North -	East -	Up -	Antenna + Radome	
ALAC00ESP	2010-09-15 : 2014-12-31	-2.7 ± 0.3	1.5 ± 0.3	2.0 ± 0.6	LEIAR25.R3	LEIT
ALBA00ESP	2010-09-14 : 2014-12-31	2.7 ± 0.3	-2.3 ± 0.3	-0.1 ± 0.5	LEIAR25.R3	LEIT
ANKR00TUR	2008-05-06 : 2014-12-31	0.4 ± 0.3	0.8 ± 0.3	2.0 ± 0.5	TPSCR3_GGD	CONE
ARJ600SWE	2011-07-29 : 2014-12-31	-4.1 ± 0.5	-3.7 ± 0.6	0.5 ± 0.8	LEIAR25.R3	LEIT
BADH00DEU	2005-01-18 : 2012-09-18	0.3 ± 0.3	-0.2 ± 0.3	0.7 ± 0.6	TRM41249.00	NONE
BADH00DEU	2012-09-18 : 2014-12-31	0.5 ± 0.3	-1.3 ± 0.3	11.9 ± 0.9	LEIAR10	NONE
BORJ00DEU	2005-06-09 : 2010-09-01	1.1 ± 0.2	-0.4 ± 0.2	2.6 ± 0.5	TPSCR3_GGD	CONE
BORJ00DEU	2010-09-01 : 2014-12-31	0.3 ± 0.2	0.2 ± 0.3	-1.9 ± 0.5	LEIAR25.R3	LEIT
BORK00DEU	2003-06-02 : 2003-07-01	-0.1 ± 0.3	0.1 ± 0.6	0.0 ± 0.7	TRM33429.20+GP	NONE
BORK00DEU	2003-07-01 : 2014-12-31	0.2 ± 0.2	2.4 ± 0.3	2.0 ± 0.6	TRM29659.00	SNOW
BPDL00POL	2007-12-04 : 2014-12-31	-0.5 ± 0.3	-1.9 ± 0.3	-5.4 ± 0.6	TRM55971.00	TZGD
BRUX00BEL	2011-03-07 : 2014-12-31	-0.2 ± 0.2	-1.2 ± 0.3	1.1 ± 0.5	JAVRINGANT_DM	NONE
BUCU00ROU	2008-10-31 : 2014-12-31	1.7 ± 0.3	-1.3 ± 0.2	-0.8 ± 0.5	LEIAT504GG	LEIS
BUTE00HUN	2007-07-31 : 2013-11-04	-1.2 ± 0.3	-0.1 ± 0.2	-8.3 ± 0.6	TRM55971.00	TZGD
BUTE00HUN	2013-11-04 : 2014-12-31	0.1 ± 0.3	1.8 ± 0.3	-1.5 ± 0.6	LEIAR25.R4	LEIT
BYDG00POL	2007-12-04 : 2014-09-09	-0.2 ± 0.3	-1.0 ± 0.3	-1.8 ± 0.5	TRM55971.00	TZGD
BYDG00POL	2014-09-09 : 2014-12-31	-0.2 ± 0.2	-0.1 ± 0.3	2.4 ± 0.5	TRM59900.00	SCIS
BZRG00ITA	2012-02-16 : 2014-12-31	1.4 ± 0.3	1.9 ± 0.3	0.5 ± 0.7	LEIAR25.R4	LEIT
CANT00ESP	2011-10-20 : 2014-12-31	-2.3 ± 0.3	1.2 ± 0.3	-1.6 ± 0.7	LEIAR25.R4	LEIT
CFRM00CZE	2012-04-25 : 2014-12-31	0.1 ± 0.3	2.4 ± 0.3	-1.0 ± 0.8	LEIAR25.R4	LEIT
DRES00DEU	2003-01-22 : 2007-05-23	-2.6 ± 0.2	3.4 ± 0.3	-0.3 ± 0.5	TRM29659.00	NONE
DRES00DEU	2007-05-23 : 2010-09-22	0.1 ± 0.2	-0.3 ± 0.2	2.4 ± 0.4	TPSCR3_GGD	CONE
DRES00DEU	2010-09-22 : 2014-12-31	0.1 ± 0.2	1.8 ± 0.4	1.1 ± 0.5	LEIAR25.R3	LEIT
EBRE00ESP	2014-12-09 : 2014-12-31	-0.5 ± 0.2	-1.6 ± 0.3	6.0 ± 0.4	TRM57971.00	NONE
EIJS00NLD	2014-04-14 : 2014-12-31	-0.6 ± 0.3	2.3 ± 0.4	1.1 ± 0.7	LEIAR25.R4	LEIT
EUSK00DEU	2009-11-17 : 2014-03-25	0.5 ± 0.3	-0.7 ± 0.2	2.1 ± 0.5	LEIAT504GG	LEIS
EUSK00DEU	2014-03-25 : 2014-12-31	-1.5 ± 0.3	0.9 ± 0.4	-1.1 ± 0.7	LEIAR25.R4	LEIT
GANP00SVK	2006-08-24 : 2014-12-31	0.5 ± 0.2	-0.7 ± 0.2	0.0 ± 0.5	TRM55971.00	NONE
GWWL00POL	2007-12-10 : 2014-10-28	1.0 ± 0.3	-0.6 ± 0.3	-4.4 ± 0.6	TRM55971.00	TZGD
GWWL00POL	2014-10-28 : 2014-12-31	0.4 ± 0.1	-0.1 ± 0.2	0.5 ± 0.3	TRM59900.00	SCIS
HAS600SWE	2011-06-15 : 2014-12-31	0.2 ± 0.3	-1.7 ± 0.4	-4.4 ± 0.6	LEIAR25.R3	LEIT
HELG00DEU	2008-09-02 : 2014-09-09	1.2 ± 0.3	-1.2 ± 0.2	1.3 ± 0.5	LEIAT504GG	LEIS
HELG00DEU	2014-09-09 : 2014-12-31	0.6 ± 0.3	3.3 ± 0.9	-0.6 ± 0.8	LEIAR25.R4	LEIT
HFL200AUT	2008-05-26 : 2014-12-31	0.1 ± 0.2	0.0 ± 0.2	-0.1 ± 0.4	TRM29659.00	OLGA
HOBU00DEU	2002-06-07 : 2002-06-21	0.1 ± 0.2	-0.3 ± 0.2	-0.1 ± 0.5	TRM33429.20+GP	NONE
HOBU00DEU	2002-06-21 : 2007-02-28	-0.1 ± 0.2	-1.0 ± 0.2	-0.4 ± 0.5	TRM29659.00	SNOW
HOBU00DEU	2007-02-28 : 2010-11-22	0.7 ± 0.2	-1.0 ± 0.2	0.7 ± 0.5	LEIAT504GG	LEIS
HOBU00DEU	2010-11-22 : 2014-12-31	-0.4 ± 0.2	-2.0 ± 0.3	0.8 ± 0.6	LEIAR25.R4	LEIT
HOE200DEU	2005-07-01 : 2010-10-20	1.5 ± 0.2	-0.1 ± 0.2	1.6 ± 0.4	TPSCR3_GGD	CONE
HOE200DEU	2010-10-20 : 2013-05-28	0.9 ± 0.2	-0.4 ± 0.2	4.0 ± 0.5	LEIAR25.R3	LEIT
HOE200DEU	2013-05-28 : 2014-12-31	-0.2 ± 0.4	3.0 ± 0.5	0.7 ± 0.7	LEIAR25.R4	LEIT
HOFN00ISL	2007-09-23 : 2013-05-05	0.3 ± 0.3	-1.1 ± 0.4	-1.2 ± 0.5	TPSCR3_GGD	CONE
HOFN00ISL	2013-05-05 : 2014-12-31	2.0 ± 0.4	-0.5 ± 0.6	-0.4 ± 0.7	LEIAR25.R4	LEIT
JON600SWE	2011-06-16 : 2014-12-31	-1.0 ± 0.3	1.8 ± 0.4	6.2 ± 0.6	LEIAR25.R3	LEIT
KAD600SWE	2011-06-15 : 2014-12-31	-0.9 ± 0.3	-2.5 ± 0.4	2.1 ± 0.7	LEIAR25.R3	LEIT
KARL00DEU	2012-02-29 : 2014-12-31	0.6 ± 0.2	0.5 ± 0.3	0.2 ± 0.6	LEIAR25.R4	LEIT
KATO00POL	2008-04-08 : 2010-12-17	0.3 ± 0.2	0.1 ± 0.2	-1.2 ± 0.5	TRM41249.00	TZGD
KATO00POL	2010-12-17 : 2014-12-31	1.2 ± 0.2	-0.4 ± 0.3	-1.7 ± 0.5	TRM57971.00	TZGD
KLOP00DEU	2002-07-02 : 2007-06-27	0.4 ± 0.2	1.3 ± 0.3	-5.2 ± 0.5	TRM29659.00	NONE
KLOP00DEU	2007-06-27 : 2013-06-28	-0.1 ± 0.3	-0.5 ± 0.3	8.7 ± 0.6	TRM55971.00	TZGD
KLOP00DEU	2013-06-28 : 2014-12-31	0.3 ± 0.2	-2.2 ± 0.6	5.1 ± 1.1	TRM57971.00	TZGD
KUNZ00CZE	2006-10-05 : 2014-09-09	0.5 ± 0.3	-0.9 ± 0.2	-3.2 ± 0.5	TRM41249.00	TZGD
KUNZ00CZE	2014-09-09 : 2014-12-31	0.2 ± 0.2	0.7 ± 0.3	8.2 ± 0.5	TRM57971.00	NONE
LEK600SWE	2011-06-15 : 2014-12-31	-1.5 ± 0.3	0.9 ± 0.4	3.7 ± 0.6	LEIAR25.R3	LEIT
LODZ00POL	2008-03-10 : 2014-10-30	-1.6 ± 0.3	-1.4 ± 0.3	-4.0 ± 0.6	TRM55971.00	TZGD
LODZ00POL	2014-10-30 : 2014-12-31	0.4 ± 0.2	0.0 ± 0.3	2.1 ± 0.5	TRM59900.00	SCIS
LOV600SWE	2011-08-16 : 2014-12-31	-2.0 ± 0.3	-0.3 ± 0.4	1.9 ± 0.7	LEIAR25.R3	LEIT
MOSE00ITA	2012-04-13 : 2014-12-31	-0.8 ± 0.3	-0.7 ± 0.4	-2.0 ± 0.6	LEIAR25.R4	LEIT
MALA00ESP	2013-03-13 : 2014-12-31	2.1 ± 0.3	4.0 ± 0.3	2.9 ± 0.7	LEIAR25.R4	LEIT
MELI00ESP	2011-12-14 : 2014-12-31	0.5 ± 0.3	1.1 ± 0.4	-2.7 ± 0.8	LEIAR25.R4	LEIT
METS00FIN	2010-08-19 : 2013-06-28	-11.7 ± 0.4	4.1 ± 0.3	2.2 ± 0.7	AOAD/M_T	NONE
METS00FIN	2013-06-28 : 2014-12-31	-2.0 ± 0.3	1.6 ± 0.4	0.0 ± 0.6	ASH700936C_M	NONE
MOP200SVK	2007-10-05 : 2014-12-31	0.6 ± 0.3	-0.8 ± 0.2	-0.2 ± 0.5	TRM55971.00	TZGD
NICO00CYP	2008-06-10 : 2013-07-16	-1.3 ± 0.3	1.1 ± 0.3	0.5 ± 0.7	LEIAT504GG	LEIS
NICO00CYP	2013-07-16 : 2014-12-31	-0.1 ± 0.3	0.2 ± 0.5	-1.7 ± 0.7	LEIAR25.R4	LEIT
NOR700SWE	2011-06-22 : 2014-12-31	0.7 ± 0.3	-0.3 ± 0.4	-2.6 ± 0.7	LEIAR25.R3	LEIT
ORID00MKD	2008-11-06 : 2014-12-31	0.8 ± 0.3	0.3 ± 0.3	2.1 ± 0.6	LEIAT504GG	LEIS
OSK600SWE	2011-06-18 : 2014-12-31	-1.7 ± 0.3	0.6 ± 0.4	-3.0 ± 0.6	LEIAR25.R3	LEIT
OST600SWE	2011-07-08 : 2014-12-31	-3.7 ± 0.4	0.4 ± 0.4	-13.9 ± 0.7	LEIAR25.R3	LEIT
OVE600SWE	2011-08-11 : 2014-12-31	-2.6 ± 0.4	2.1 ± 0.5	0.8 ± 0.6	LEIAR25.R3	LEIT
PEN200HUN	2012-10-11 : 2014-12-31	0.0 ± 0.2	-0.4 ± 0.3	-4.8 ± 0.7	LEIAR25.R4	LEIT
PENC00HUN	2007-07-12 : 2014-12-31	2.2 ± 0.3	-1.9 ± 0.2	-2.9 ± 0.5	LEIAT504GG	LEIS
PFA200AUT	2007-11-29 : 2014-12-31	0.0 ± 0.2	0.0 ± 0.2	0.0 ± 0.5	TPSCR3_GGD	PFAN
REDZ00POL	2007-12-07 : 2014-10-29	0.2 ± 0.3	-1.2 ± 0.3	-5.7 ± 0.5	TRM55971.00	TZGD
REDZ00POL	2014-10-29 : 2014-12-31	-1.4 ± 0.2	-0.3 ± 0.2	0.0 ± 0.4	TRM59900.00	SCIS
REYK00ISL	2008-03-13 : 2013-05-02	-0.3 ± 0.3	0.1 ± 0.4	0.6 ± 0.5	TPSCR.G3	TPSH
REYK00ISL	2013-05-02 : 2014-12-31	-0.2 ± 0.5	-2.8 ± 0.7	-2.4 ± 0.8	LEIAR25.R4	LEIT
RIGA00LVA	2013-12-11 : 2014-12-31	1.1 ± 0.3	-0.2 ± 0.4	-0.5 ± 0.7	LEIAR25.R4	LEIT
RIO100ESP	2012-01-31 : 2014-12-31	-0.8 ± 0.3	-2.5 ± 0.3	4.0 ± 0.6	LEIAR25.R4	LEIT
SASS00DEU	2003-09-26 : 2014-12-31	-0.9 ± 0.3	-0.2 ± 0.2	2.4 ± 0.5	TPSCR3_GGD	CONE
SKE800SWE	2011-07-08 : 2014-12-31	-3.5 ± 0.4	0.2 ± 0.5	1.2 ± 0.7	LEIAR25.R3	LEIT
SOFI00BGR	2010-04-29 : 2014-12-31	-1.9 ± 0.3	2.4 ± 0.3	-8.6 ± 0.7	LEIAR25.R3	LEIT
SPRN00HUN	2011-05-17 : 2014-12-31	-1.5 ± 0.2	0.9 ± 0.3	4.3 ± 0.4	LEIAR25.R3	LEIT
SVE600SWE	2011-07-08 : 2014-12-31	-2.1 ± 0.3	-1.2 ± 0.4	2.3 ± 0.5	LEIAR25.R3	LEIT
SWKI00POL	2007-12-05 : 2014-11-13	1.8 ± 0.3	-0.3 ± 0.3	-1.7 ± 0.6	TRM55971.00	TZGD
SWKI00POL	2014-11-13 : 2014-12-31	-0.9 ± 0.2	-0.6 ± 0.3	1.7 ± 0.5	TRM59900.00	SCIS
TERS00NLD	2014-06-07 : 2014-12-31	1.8 ± 0.3	3.1 ± 0.3	2.0 ± 0.6	LEIAR25.R4	LEIT
TORI00ITA	2011-03-08 : 2014-12-31	1.0 ± 0.2	0.1 ± 0.2	7.7 ± 0.7	LEIAR25.R3	NONE
TRF200AUT	2008-01-30 : 2008-06-10	0.0 ± 0.1	0.0 ± 0.2	0.0 ± 0.4	TPSCR3_GGD	OLGA
TRF200AUT	2008-06-10 : 2008-11-10	0.0 ± 0.2	0.0 ± 0.2	-0.1 ± 0.5	LEIAT504	OLGA
TRF200AUT	2011-10-05 : 2014-12-31	0.6 ± 0.3	0.6 ± 0.3	-6.8 ± 0.8	LEIAR25.R3	BEVA
TUBO00CZE	2005-12-15 : 2011-12-12	0.0 ± 0.2	-0.8 ± 0.2	3.6 ± 0.4	LEIAT504	LEIS
TUBO00CZE	2011-12-12 : 2014-12-31	0.3 ± 0.2	2.1 ± 0.3	0.2 ± 0.6	LEIAR25.R4	LEIT
USDL00POL	2007-12-03 : 2014-10-28	-0.5 ± 0.3	0.2 ± 0.3	-2.6 ± 0.6	TRM55971.00	TZGD
USDL00POL	2014-10-28 : 2014-12-31	1.9 ± 0.3	2.0 ± 0.3	0.2 ± 0.6	TRM59900.00	SCIS
VAE600SWE	2011-08-25 : 2014-12-31	-4.7 ± 0.3	-0.9 ± 0.4	-14.0 ± 0.8	LEIAR25.R3	LEIT
VALE00ESP	2010-09-16 : 2014-12-31	-3.6 ± 0.3	-3.6 ± 0.3	-6.7 ± 0.9	LEIAR25.R3	LEIT
VIL600SWE	2011-07-20 : 2014-12-31	1.5 ± 0.4	1.7 ± 0.4	-2.4 ± 0.6	LEIAR25.R3	LEIT
VIS600SWE	2011-05-18 : 2014-12-31	0.6 ± 0.3	-1.6 ± 0.4	-2.8 ± 0.7	LEIAR25.R3	LEIT
WARN00DEU	2003-10-22 : 2010-09-15	0.3 ± 0.2	-0.3 ± 0.2	-0.6 ± 0.5	TPSCR3_GGD	CONE
WARN00DEU	2010-09-15 : 2014-12-31	-1.6 ± 0.2	0.5 ± 0.2	-1.6 ± 0.5	LEIAR25.R3	LEIT
WROC00POL	2012-10-22 : 2014-12-31	0.1 ± 0.3	0.7 ± 0.4	2.2 ± 0.7	LEIAR25.R4	LEIT
WTZR00DEU	2002-07-02 : 2009-01-19	-0.1 ± 0.2	0.2 ± 0.2	1.7 ± 0.4	AOAD/M_T	NONE
WTZR00DEU	2009-01-19 : 2010-06-30	0.3 ± 0.2	2.7 ± 0.2	0.9 ± 0.5	LEIAR25	LEIT
WTZR00DEU	2010-06-30 : 2014-12-31	0.4 ± 0.3	0.6 ± 0.4	2.4 ± 0.5	LEIAR25.R3	LEIT
ZIM200CHE	2007-11-08 : 2009-05-12	0.9 ± 0.2	-0.3 ± 0.2	-1.3 ± 0.4	TRM55971.00	NONE
ZIM200CHE	2009-05-12 : 2014-12-31	-0.1 ± 0.2	-1.2 ± 0.2	-0.7 ± 0.5	TRM59800.00	NONE
ZYWI00POL	2007-11-27 : 2014-08-29	0.8 ± 0.3	-0.3 ± 0.2	0.3 ± 0.5	TRM55971.00	TZGD
ZYWI00POL	2014-08-29 : 2014-12-31	0.5 ± 0.1	1.3 ± 0.3	2.1 ± 0.5	TRM59900.00	SCIS

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