ESOC CHAMP Processing Strategy

This document summarizes the Processing Strategy of our published GNSS products. The prodcuts may be found on our web page.
If you have any additional questions, please contact us.

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Category	Topic	Value
Relativistic model	Schwarzschild terms	applied
	Lense-Thirring precession	applied, IERS 2010 conventions
	Geodetic (de Sitter) precession	applied, IERS 2010 conventions
	Relativistic clock effects	2nd order relativistic correction for non-zero orbit ellipticity.
Gravity field	Degree and order	12
Gravitational perturba	Gravity field (static)	EIGEN.GRGS.RL05.lmp.coef, C21 and S21 computed according to IERS 2010 conventions.
	Gravity field (time varying)	annual/semi-annual terms of the low coefficients
	Solid Earth tides	IERS 2010 conventions
	Permanent tide (tidal system)	IERS 2010 conventions
	Solid Earth pole tide	IERS 2010 conventions
	Ocean tides	FES-2022
	Ocean pole tide	applied, model by S. Desai for C21 and S21 terms only (IERS Conventions 2010).
	Lunar gravity	applied, only J2 effect considered
	Third bodies	JPL DE405: all planets, Sun and Moon
EOP	Precession-nutation	IAU 2006/2000A
	Celestial pole offsets	IAU 2006/2000A, daily dx and dy corrections from IERS Bulletin-A applied
	Celestial pole rates	interpolating between given offsets
	Subdaily nutation	prograde diurnal and semi-diurnal nutations in polar motion applied using IERS routine PMSDNUT2.F.
	UT1-UTC	interpolated from IERS Bulletin A (IERS rapids)
	UT1 libration	semi-diurnal UT1 libration applied using IERS routine UT1LIBR.F
	Subdaily pole/UT1	The sub-daily EOP tide model from Desai & Sibois (2016; https://doi.org/10.1002/2016JB013125)
	Secular pole	IERS secular pole model
	Terrestrial pole offsets	interpolated from IERS Bulletin A (IERS rapids)
Terrestrial reference fr	A priori frame	ITRF2020-u2023 (IGS0OPSSNX_1994002_00U_00U_SOL.SNX.gz)
	Post seismic deformation	ITRF2020-u2023
	Solid Earth tides	anelastic Earth model, IERS 2010 Conventions (dehanttideinel.f)
	Permanent tide	zero-frequency contribution left in tide model, NOT in site coordinates (conventional tide-free).
	Solid Earth pole tide	IERS 2010 conventions, mean pole removed by IERS 2010 mean pole model.
	Ocean tides	IERS 2010 conventions, site-dependent amps/phases from free ocean tide loading provider (Bos and Scherneck, 2017) for EOT11A tide model including centre of mass correction, NEU site displacements computed using HARDISP.F from D.Agnew
Troposphere	Hydrostatic a priori model	Saastamoinen, pressure and temperature from GPT model
	Hydrostatic mapping function	GMF dry (Boehm et. al, 2006)
	Wet mapping function	GMF wet (Boehm et. al, 2006)
	Gradient mapping functions	1/(sin(e) * tan(e) + 0.0032)
Ionosphere	First order effect	Accounted for by dual-frequency obs. in linear combination.
Observations	Sampling	300s (30s for clocks)
	Elevation cutoff angle	10degrees
	Weighting of observations	elevation-dependent
	Observation type	Ionosphere-free linear combination of dual-frequency.
	GNSS receiving antenna	igs20.atx (offsets from ARP and elevation- and azimuth dependent PCVs applied)
	Phase wind up	applied according to Wu et al. (1993)
Orbit integration	Integrator details	Adams-Bashforth/Adams-Moulton 8th order prediction-correction (multistep) method initialization: 8th order Runge Kutta (RKF).
	Integrator step size	120 steps per revolution
Parametrisation	Earth orientation	daily X-pole, Y-pole, pole rates, LOD
	Clock sampling	30s
	Transmitter & Receiver clocks	at each epoch, aligned to ESA UTC stations.
	Inter-System clock bias	Estimated per station per constellation. Zero-mean constraint over all stations. Galileo: ESA UTC station biases are constrained to calibration values. GLONASS: Estimated per station per satellite.
	Satellite orbits	deterministic positions and velocities (300s sampling)
	Arc length	24h
	Troposphere	Zenith delay estimated as linear parameters every 1 hrs, North and East gradients as linear parameter per day.
	Empirical accelerations	1 set per arc from the enhanced CODE orbit model (Springer, 1999): D0, Y0, B0, Bcos, Bsin
	1/rev empiricals (CPR)	1 set per arc in along-track: A0, Acos, Asin
	Phase cycle ambiguities	Adjusted except when double difference ambiguities can be resolved confidently. Integer ambiguity resolution scheme from GFZ.

Constellation	Galileo		GPS		GLONASS	BeiDou	QZSS		
Block	IOV	FOC	IIA	IIR/IIF/IIIA		BeiDou-3	QZSS-1R	QZSS-2I	QZSS-2G
Signals	L1C-L5Q		L1W-L2W		L1P-L2P (Rapid+Ultra: L1C-L2C)	L1P-L5P	L1L-L5Q		
Orbit estimation	Independent		Independent		Independent	Independent	Combined GPS+QZSS process		
Centre of Mass	GSC values		IGS Satellite Metadata		IGS Satellite Metadata	IGS Satellite Metadata	Cabinett Office values		
PCO			esa23.atx		esa23.atx	esa23.atx	esa23.atx		
PCV	esa23.atx		esa23.atx		esa23.atx	esa23.atx	esa23.atx		
Attitude model	Nominal yaw steering with noon/night turn model.		Nominal yaw steering	Nominal yaw steering with noon/night turn model (Kouba 2008, Dilssner 2010, Dilssner et al. 2023).	Nominal yaw steering with noon/shadow model (Dilssner et al. 2011).	Nominal yaw steering with noon/night turn model.	Nominal yaw steering with noon/night turn model.	Continuous orbit normal mode.	
A priori model (SRP, Albedo, IR)	Manufacturer values published by GSC (Box-Wing)		IGS Satellite Metadata (Box-Wing)		IGS Satellite Metadata (Box-Wing)	ESOC estimates (Box-Wing)	Cabinett Office values (Box-Wing)		
Power Thrust [W]	120	250	IGS Satellite Metadata		IGS Satellite Metadata	240	Cabinett Office values		
Applied Code Bias	-		P1C1 correction based on ESA0OPSFIN_DCB.BIA (zero-mean		-	-	-		
TEC estimation	used		used		used	MEOs used	-		

Filename	Period	Sampling	Latency [h]
ESA0OPSFIN_DCB.BIA			240
ESA0MGNFIN_YYYYDDD0000_01D_01D_ERP.ERP	01D	01D	240
ESA0MGNFIN_YYYYDDD0000_01D_01D_SOL.SNX	01D	01D	240
ESA0MGNFIN_YYYYDDD0000_01D_01D_SUM.SUM	01D	01D	240
ESA0MGNFIN_YYYYDDD0000_01D_01H_TRO.TRO	01D	01H	240
ESA0MGNFIN_YYYYDDD0000_01D_05M_ORB.SP3	01D	05M	240
ESA0MGNFIN_YYYYDDD0000_01D_30S_CLK.CLK	01D	30S	240
ESA0OPSFIN_YYYYDDD0000_01D_01D_ERP.ERP	01D	01D	240
ESA0OPSFIN_YYYYDDD0000_01D_01D_SOL.SNX	01D	01D	240
ESA0OPSFIN_YYYYDDD0000_01D_01D_SUM.SUM	01D	01D	240
ESA0OPSFIN_YYYYDDD0000_01D_01H_TRO.TRO	01D	01H	240
ESA0OPSFIN_YYYYDDD0000_01D_02H_GIM.INX	01D	02H	240
ESA0OPSFIN_YYYYDDD0000_01D_05M_ORB.SP3	01D	05M	240
ESA0OPSFIN_YYYYDDD0000_01D_30S_CLK.CLK	01D	30S	240
ESA0OPSRAP_YYYYDDD0000_01D_01D_ERP.ERP	01D	01D	2
ESA0OPSRAP_YYYYDDD0000_01D_01D_SUM.SUM	01D	01D	2
ESA0OPSRAP_YYYYDDD0000_01D_01D_SOL.SNX	01D	01D	2
ESA0OPSRAP_YYYYDDD0000_01D_01H_TRO.TRO	01D	01H	2
ESA0OPSRAP_YYYYDDD0000_01D_01H_GIM.INX	01D	01H	11
ESA0OPSRAP_YYYYDDD0000_01D_02H_GIM.INX	01D	02H	11
ESA0OPSRAP_YYYYDDD0000_01D_05M_ORB.SP3	01D	05M	2
ESA0OPSRAP_YYYYDDD0000_01D_30S_CLK.CLK	01D	30S	2
ESA0OPSULT_YYYYDDDHH00_01D_01D_SUM.SUM	01D	01D	2
ESA0OPSULT_YYYYDDDHH00_02D_01D_ERP.ERP	01D	01D	2
ESA0OPSULT_YYYYDDDHH00_02D_01D_SOL.SNX	02D	01D	2
ESA0OPSULT_YYYYDDDHH00_02D_05M_ORB.SP3	02D	05M	2