# ESOC MGNSS Processing Strategy

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

**Software used:** NAPEOS 4.8
**Most recent changes:** Transition to ITRF2020

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# General



| Category | Topic | Value |
|---|---|---|
| **Relativistic model** | Schwarzschild terms | applied |
| | Lense-Thirring precession | applied, IERS 2010 conventions |
| | Geodesic (de Sitter) precession | applied, IERS 2010 conventions |
| | Relativistic clock effects | 2nd order relativistic correction for non-zero orbit ellipticity |
| | Gravitational time delay | applied, IERS 2010 conventions |
| **Gravity field** | Degree and order | 12 |
| **Gravitational perturbations** | Gravity field (static) | EIGEN.GRGS.RL04.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 | EOT11A |
| | 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 frame** | A priori frame | ITRF2020 |
| | Post seismic deformation | ITRF2020 |
| | 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 Observations** | First order effect | accounted for by dual-frequency obs. in linear combination |
| | Sampling | 30s |
| | 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 |
| | 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 |

# Constellations



| Constellation | Galileo | | GPS | GLONASS | BeiDou | | QZSS | | |
|---|---|---|---|---|---|---|---|---|---|
| Block | IOV | FOC | | | BeiDou-2 | BeiDou-3 | QZSS | QZSS-2I | QZSS-2G |
| Signals | L1-L5Q | | L1W-L2W | L1-L2 | B1-B3 (before 2019 B1-B2) | | L1-L2 | | |
| Centre of Mass | GSC values | | IGS Satellite Metadata | IGS Satellite Metadata | IGS Satellite Metadata | | Cabinett Office values | | |
| PCO | GSC values (GSAT_*.atx) | | igs20.atx | ESOC estimates | ESOC estimates | | igs20.atx | | |
| PCV | GSC values (GSAT_*.atx) | | igs20.atx | ESOC estimates | ESOC estimates | | igs20.atx | | |
| Attitude model | GSC values (Eclipse model) | | Nominal | Eclipse model using GLONASS yaw rates | Orbit normal modes for \|Beta\| < 4deg with smooth transition | Eclipse model (also for BeiDou 005/C04) | Orbit normal modes for \|Beta\| < 20deg | Eclipse model | Continuous orbit normal mode |
| A priori model (SRP, Albedo, IR) | GSC values (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 | IGS Satellite Metadata | IGS Satellite Metadata | IGS Satellite Metadata | ESOC estimates | 240 | Cabinett Office values | | |

# Products



| Content | Format | Sampling | Period | Delay | Comment | Filename |
|---|---|---|---|---|---|---|
| Orbits + Clocks | SP3 | 300 s | 24 h | 5 days | | ESA00FIN_YYYYDDDHHMM_01D_05M_ORB.SP3 |
| Clocks | Clock RINEX | 30 s | 24 h | 5 days | | ESA00FIN_YYYYDDDHHMM_01D_05M_CLK.CLK |
| Troposphere | Tropo SINEX | 24 h | 24 h | 5 days | not published | ESA00FIN_YYYYDDDHHMM_01D_01D_TRO.SNX |
| Earth Rotation Parameters | IGS ERP | 24 h | 24 h | 5 days | free format | ESA00FIN_YYYYDDDHHMM_01D_01D_ERP.ERP |
| Inter-System Biases | BIAS SINEX | 24 h | 24 h | 5 days | | ESA00FIN_YYYYDDDHHMM_01D_01D_ISB.ERP |
| Summary file | - | - | 168 h | 5 days | weekly | ESA00FIN_YYYYDDDHHMM_01D_01D_SUM.SUM |