

IGS Models for GNSS-Specific Effects

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Antenna Phase Model

- ***Accounts for non-ideal phase response of satellite transmit & ground receive antennas***
 - background in IGS Mail #5189 (17 Aug 2005)
 - current values in igs05.atx file at IGS Central Bureau
 - antex format documented at IGS CB also
 - note that values were determined empirically, based on fixed ITRF
 - different model for every antenna type (or even individual)
- ***Relation to other techniques***
 - limited to GNSS
- ***Impact***
 - strongly affects network scale, scale-rate, & deformations
 - radome effects can be quite large, but are often uncalibrated
 - cm-level effect on station positions, including local ties
 - local site surveys should use consistent antenna models



Satellite Orbit Models

● *Accounts for dynamical motion of satellites*

- most problematic is Solar Radiation Pressure (SRP) effect
 - usually treated highly empirically, with extra nuisance parameters (up to 9), velocity breaks, or stochastically
- approaches differ among Analysis Centers
 - limits any attempts to make “rigorous” combinations

● *Relation to other techniques*

- analogous for any satellite technique

● *Impact*

- SRP models strongly affect geocenter & LOD estimates, esp
- documentation in IERS Conventions would be desirable
 - but probably very difficult
- for higher accuracy new approaches may be needed
 - e.g., reduce systematic errors, eclipsing, albedo, etc



Satellite Attitude Models

● *Accounts for yaw variations, esp during eclipses*

- current treatments are poorly documented
- mostly affects phase observations
 - strongly mitigated by double-differencing
- undifferenced methods require model and/or data editing
 - yaw rate parameters adjusted by some groups, fixed by others

● *Relation to other techniques*

- analogous for any satellite technique that tracks signal phase

● *Impact*

- can influence orbit parameters, clocks, & large-scale frame distortions
- better documentation would be desirable
- problems greatly reduced for newest IIR & later satellites
 - satellite yaw behavior simplified



Satellite Polarization Models

- ***Accounts for variation in RHC phase rotation***
 - often called “phase wind-up”
 - varies as relative satellite-ground perspective changes
 - model by Wu et al. (1993) widely used
 - mitigated by double-differencing

- ***Relation to other techniques***
 - limited to GNSS

- ***Impact***
 - effects very similar to attitude changes
 - must be properly included to modeled carrier phase data
 - could be documented in IERS Conventions



Ionospheric Delay Modeling

Removes propagation delay/advance due to charged particles in Earth's atmosphere

- use frequency-dependence to measure effect directly with multi-frequency signals
 - usually, only lowest-order effect considered via linear combination of L1 & L2 data – increases obs errors
 - lowest-order effect equal for phase & code but opposite sign
- neglected higher-order effects can be significant (~1 cm errors)
 - higher-order effects & models somewhat controversial

Relation to other techniques

- analogous for VLBI, DORIS, other radiometric techniques

Impact

- neglected effects can distort frame & bias satellite clocks (esp)
- documentation in IERS Conventions would be helpful



Inter-modulation Signal Biases

Accounts for signal delays in satellite transmit & ground receive systems

- mostly limits ability to mix data types from diverse receiver models
- also relevant for ionosphere mapping & time transfer
- problem will become much more complex as new GNSS signals become available

Relation to other techniques

- in principle, applies to VLBI but absolute delays usually ignored

Impact

- affects clock estimates & time transfer
- relevant for absolute ionosphere TEC measurements
- can also limit ability to resolve phase ambiguities



SP3 File Orbit Frame

● *By IGS convention, orbits in crust-fixed frame*

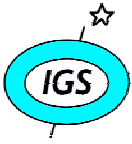
- eases user analysis without transforming to inertial frame
- requires that sub-daily Earth motions be projected into satellite positions
- with higher accuracy, increasing number of effects to track
 - SP3 format limits internal documentation

● *Relation to other techniques*

- analogous for any satellite technique using SP3 format

● *Impact*

- how best to document analysis models completely for users
- highest accuracy requires consistent treatment of effects by users
- inflexibility of SP3 format probably requires more generic approach in future
 - could be applied for other techniques & combinations



Relativistic Effects for GPS Clocks

● *IGS follows IS-GPS-200 modeling*

- 1st-order time dilation & gravitation potential frequency shift applied in GPS oscillators (to be consistent with TT timescales)
- 2nd-order effect of non-circular orbits must be applied by users
- other dynamical effects follow IERS Conventions
- but higher-order time transformation effects are neglected
 - most important is due to Earth's oblateness (order 100 ps)

● *Relation to other techniques*

- analogous for any satellite technique with onboard clocks

● *Impact*

- neglected effects only impact clock estimates (w.r.t. TT)
- “errors” are purely conventional
 - no problems if everybody follows same conventions
- IGS models probably should be documented in IERS Conventions



END