

**University of Texas  
Center for Space Research**

**ICESAT/GLAS  
CSR SCF Release Notes  
for  
Orbit and Attitude Determination**

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# CSR SCF Release Notes for Orbit and Attitude Determination

- Notes for ANC04, ANC08, and ANC09 ancillary files reported by UTCSR
- Includes descriptions of each ANC file type for each ANC release of each campaign
- Includes calibration level numbers used to determine the Y-code in the release naming convention for the elevation products GLA06 and GLA12-15. (See also *YXX Release Number Convention* document.)

## General Notes

### ANC04: ICRF to ITRF Transformation File

The transformation between the International Celestial Reference Frame (ICRF) and the International Terrestrial Reference Frame (ITRF) depends on Earth orientation parameters provided by the International Earth Rotation Service (IERS). It is critical that the same values used in ICESat precision orbit determination (POD) are used in the geolocation algorithm. Thus, UTCSR typically provides one product with the rapid POD products, generated during the laser operations campaign, and a second one with the final POD products, generated during data reprocessing after the completion of the campaign.

### ANC08: Precision Orbit Determination (POD) Ephemeris File

The differences between the ICESat rapid and final POD products are entirely related to the inputs from external sources. The most significant of these are the orbits of the GPS satellites, as determined by the International GPS Service (IGS), which provides its own rapid and final solutions. To generate the ICESat rapid POD products (*POD calibration level 1*), UTCSR uses the IGS rapid orbit solutions, along with preliminary IERS Earth orientation parameters (mentioned above), and rapid estimates of solar flux and geomagnetic indices obtained from the National Oceanic and Atmospheric Administration (NOAA) Space Environment Center. Unless otherwise noted, final POD products (*POD calibration level 2*) are generated using the final IGS orbit solutions for the GPS satellites, the final IERS Earth orientation parameters, and final estimates of solar flux and geomagnetic indices provided by the National Geophysical Data Center.

### ANC09: Precision Attitude Determination (PAD) File

During the course of the ICESat mission, the determination of the laser-pointing direction for each transmitted pulse has evolved significantly. As a result, however, there have been, and continue to be, multiple releases of these precision attitude determination (PAD) solutions for each campaign (comprising *PAD calibration levels 1 to 4*). In general, during a laser campaign, UTCSR computes instrument attitude solutions using an Extended Kalman Filter (EKF) to process gyro and uncorrected instrument star-tracker (IST) data, and then applies fixed laser biases to obtain the laser pointing directions. After a campaign concludes, UTCSR applies calibration corrections to account for IST and laser motion with respect to the instrument. For different campaigns, these corrections have been based on: (1) direct observations made in the on-board Laser Reference Sensor

(LRS); (2) models using limited LRS data; (3) differencing of the EKF and batch-derived attitude solutions; and (4) ocean and around-the-world scan maneuvers. New campaigns will likely be limited to the rapid solutions described above (*PAD calibration level 1*), and the fully calibrated solutions (*PAD calibration level 4*), which combine the last two corrections.

## Laser 1a

| I-SIPS Product Release(s) | Start Date (DOY)  | Stop Date (DOY)   | UTCSR ANC04 Release | UTCSR ANC08 Release/ Level | UTCSR ANC09 Release/ Level | Elevation Product Y-code |
|---------------------------|-------------------|-------------------|---------------------|----------------------------|----------------------------|--------------------------|
| 18                        | 20-Feb-2003 (051) | 21-Mar-2003 (080) | 2                   | 2/2                        | 11/3                       | 3                        |
| 17                        | 05-Mar-2003 (064) | 21-Mar-2003 (080) | 2                   | 2/2                        | 8/2                        | 2                        |
| 11-13                     | 20-Feb-2003 (051) | 21-Mar-2003 (080) | 2                   | 2/2                        | 2/1                        | 1                        |
| 8-10                      | 20-Feb-2003 (051) | 21-Mar-2003 (080) | 10*                 | 10*/1                      | 10*/1                      | 1                        |

\* UTCSR Release 10 was incorrectly used to label products that were actually Release 1.

### ANC04

#### Release 2

- Generated during final POD solutions
- Added RELEASE keyword to standard header
- Added USEBEG and USEEND keywords to file-specific header

#### Release 10 (see footnote in table above)

- Generated during rapid POD solutions

### ANC08

#### Release 2 (*POD calibration level 2*)

- Final POD solutions
- Added RELEASE keyword to standard header

#### Release 10 (see footnote in table above) (*POD calibration level 1*)

- Rapid POD solutions

## ANC09

### Release 11 (*PAD calibration level 3*)

- Applied 50-ms correction to gyro time tags and implemented gyro time-tag interpolation algorithm
- Added Laser Profiling Array (LPA) centroid (X,Y) and pulse orientation with respect to LPA X-axis at 40-Hz
- Applied Release 8 laser biases

### Release 8 (*PAD calibration level 2*)

- Applied modeled LRS corrections to compensate for IST motion with respect to the instrument
- Updated and applied laser biases to pre-launch alignment

### Release 2 (*PAD calibration level 1*)

- Tuned EKF parameters
- Changed LPA orientation to be measured with respect to topocentric North
- Added RELEASE keyword to standard header
- Added USEBEG and USEEND keywords to file-specific header
- Added DEGRADE\_INDEX\_START and DEGRADE\_INDEX\_STOP keywords to file-specific header
- Applied additional laser biases to pre-launch alignment based on range-residual analysis of ocean scans

### Release 10 (see footnote in table above) (*PAD calibration level 1*)

- Used pre-launch estimate of laser alignment (no additional biases)

## Laser 1b

| I-SIPS Product Release(s) | Start Date (DOY)  | Stop Date (DOY)   | UTCSR ANC04 Release | UTCSR ANC08 Release/ Level | UTCSR ANC09 Release/ Level | Elevation Product Y-code |
|---------------------------|-------------------|-------------------|---------------------|----------------------------|----------------------------|--------------------------|
| 8-10                      | 21-Mar-2003 (080) | 29-Mar-2003 (088) | 10*                 | 10*/1                      | 10*/1                      | 1                        |

\* UTCSR Release 10 was incorrectly used to label products that were actually Release 1.

### ANC04

Release 10 (see footnote in table above)

- Generated during rapid POD solutions

### ANC08

Release 10 (see footnote in table above) (*POD calibration level 1*)

- Rapid POD solutions

### ANC09

Release 10 (see footnote in table above) (*PAD calibration level 1*)

- Used pre-launch estimate of laser alignment (no additional biases)

## Laser 2a

| I-SIPS Product Release(s) | Start Date (DOY)  | Stop Date (DOY)   | UTCSR ANC04 Release | UTCSR ANC08 Release/ Level | UTCSR ANC09 Release/ Level | Elevation Product Y-code |
|---------------------------|-------------------|-------------------|---------------------|----------------------------|----------------------------|--------------------------|
| 26                        | 25-Sep-2003 (268) | 18-Nov-2003 (322) | 2 (v2)              | 4/2                        | 25/4                       | 4                        |
| 21,24                     | 25-Sep-2003 (268) | 18-Nov-2003 (322) | 2 (v2)              | 4/2                        | 15/4                       | 4                        |
| 19                        | 25-Sep-2003 (268) | 18-Nov-2003 (322) | 2 (v2)              | 4/2                        | 13/3                       | 3                        |
| 18                        | 25-Sep-2003 (268) | 18-Nov-2003 (322) | 2 (v2)              | 4/2                        | 9/3                        | 3                        |
| 14,17                     | 25-Sep-2003 (268) | 18-Nov-2003 (322) | 2 (v1)              | 3/1                        | 6/2                        | 2                        |
| 12                        | 25-Sep-2003 (268) | 18-Nov-2003 (322) | 2 (v1)              | 3/1                        | 2/1                        | 1                        |

### ANC04

#### Release 2 (v2)

- Generated during final POD solutions
- Maintained release number, but incremented version to 2

#### Release 2 (v1)

- Generated during rapid POD solutions
- Added RELEASE keyword to standard header
- Added USEBEG and USEEND keywords to file-specific header

### ANC08

#### Release 4 (*POD calibration level 2*)

- Final POD solutions
- Changed gravity field from GRACE31 to GGM01C

#### Release 3 (*POD calibration level 1*)

- Rapid POD solutions
- Changed gravity field from GRACE31 to GGM01C

## ANC09

### Release 25 (*PAD calibration level 4*)

- Updated Laser Profiling Array (LPA) spot characteristics to reflect  $1/e^2$ , rather than fixed, cutoff in intensity values

### Release 15 (*PAD calibration level 4*)

- Applied scan-maneuver calibrations
- Removed pre-launch laser alignment and subsequent biases

### Release 13 (*PAD calibration level 3*)

- Applied de-distortion map (L2a Version 1) to IST data
- Applied Release 6 laser biases

### Release 9 (*PAD calibration level 3*)

- Applied 50-ms correction to gyro time tags and implemented gyro time-tag interpolation algorithm
- Added LPA centroid (X,Y) and pulse orientation with respect to LPA X-axis to each 40-Hz record
- Applied Release 6 laser biases

### Release 6 (*PAD calibration level 2*)

- Applied direct LRS corrections to compensate for IST motion with respect to the instrument
- Corrected star catalog precession error
- Updated and applied laser biases to pre-launch alignment
- Removed incorrect adjustment of laser biases to account for velocity aberration

### Release 2 (*PAD calibration level 1*)

- Tuned EKF parameters
- Changed LPA orientation to be measured with respect to topocentric North
- Added RELEASE keyword to standard header
- Added USEBEG and USEEND keywords to file-specific header
- Added DEGRADE\_INDEX\_START and DEGRADE\_INDEX\_STOP keywords to file-specific header
- Applied Laser 1 Release 2 laser biases



## Laser 2b

| I-SIPS Product Release(s) | Start Date (DOY)  | Stop Date (DOY)   | UTCSR ANC04 Release | UTCSR ANC08 Release/ Level | UTCSR ANC09 Release/ Level | Elevation Product Y-code |
|---------------------------|-------------------|-------------------|---------------------|----------------------------|----------------------------|--------------------------|
| 26                        | 17-Feb-2004 (048) | 21-Mar-2004 (081) | 2 (v2)              | 6/2                        | 23/4                       | 4                        |
| 22                        | 17-Feb-2004 (048) | 21-Mar-2004 (081) | 2 (v2)              | 6/2                        | 20/3                       | 3                        |
| 15-17                     | 17-Feb-2004 (048) | 21-Mar-2004 (081) | 2 (v1)              | 3/1                        | 6/1                        | 1                        |

### ANC04

#### Release 2 (v2)

- Generated during final POD solutions
- Maintained release number, but incremented version to 2

#### Release 2 (v1)

- Generated during rapid POD solutions
- Added RELEASE keyword to standard header
- Added USEBEG and USEEND keywords to file-specific header

### ANC08

#### Release 6 (*POD calibration level 2*)

- Final POD solutions
- Changed zenith delay parameter estimation strategy for short passes

#### Release 3 (*POD calibration level 1*)

- Rapid POD solutions
- Changed gravity field from GRACE31 to GGM01C

## ANC09

### Release 23 (*PAD calibration level 4*)

- Applied scan-maneuver calibrations
- Removed pre-launch laser alignment and subsequent biases
- Updated LPA spot characteristics to reflect  $1/e^2$ , rather than fixed, cutoff in intensity values

### Release 20 (*PAD calibration level 3*)

- Replaced direct LRS corrections with batch-EKF corrections to compensate for IST motion with respect to the instrument
- Applied de-distortion map (L2a Version 1) to IST data
- Updated and applied laser biases to pre-launch alignment

### Release 6 (*PAD calibration level 1*)

- Applied direct LRS corrections to compensate for IST motion with respect to the instrument
- Corrected star catalog precession error
- Applied Laser 2a Release 6 laser biases
- Removed incorrect adjustment of laser biases to account for velocity aberration

## Laser 2c

| I-SIPS Product Release(s) | Start Date (DOY)  | Stop Date (DOY)   | UTCSR ANC04 Release | UTCSR ANC08 Release/ Level | UTCSR ANC09 Release/ Level | Elevation Product Y-code |
|---------------------------|-------------------|-------------------|---------------------|----------------------------|----------------------------|--------------------------|
| 17                        | 18-May-2004 (139) | 21-Jun-2004 (173) | 2 (v1)              | 3/1                        | 7/1                        | 1                        |

### ANC04

#### Release 2 (v1)

- Generated during rapid POD solutions
- Added RELEASE keyword to standard header
- Added USEBEG and USEEND keywords to file-specific header

### ANC08

#### Release 3 (*POD calibration level 1*)

- Rapid POD solutions
- Changed gravity field from GRACE31 to GGM01C

### ANC09

#### Release 7 (*PAD calibration level 1*)

- Applied Laser 2b Release 6 laser biases

## Laser 3a

| I-SIPS Product Release(s) | Start Date (DOY)  | Stop Date (DOY)   | UTCSR ANC04 Release | UTCSR ANC08 Release/ Level | UTCSR ANC09 Release/ Level | Elevation Product Y-code |
|---------------------------|-------------------|-------------------|---------------------|----------------------------|----------------------------|--------------------------|
| 23                        | 03-Oct-2004 (277) | 08-Nov-2004 (313) | 2 (v2)              | 6/2                        | 19/4                       | 4                        |
| 22                        | 03-Oct-2004 (277) | 08-Nov-2004 (313) | 2 (v2)              | 6/2                        | 17/3                       | 3                        |
| 18                        | 03-Oct-2004 (277) | 08-Nov-2004 (313) | 2 (v1)              | 5/1                        | 12/1                       | 1                        |

### ANC04

#### Release 2 (v2)

- Generated during final POD solutions
- Maintained release number, but incremented version to 2

#### Release 2 (v1)

- Generated during rapid POD solutions
- Added RELEASE keyword to standard header
- Added USEBEG and USEEND keywords to file-specific header

### ANC08

#### Release 6 (*POD calibration level 2*)

- Final POD solutions
- Changed zenith delay parameter estimation strategy for short passes

#### Release 5 (*POD calibration level 1*)

- Rapid POD solutions
- Changed zenith delay parameter estimation strategy for short passes

## ANC09

### Release 19 (*PAD calibration level 4*)

- Applied scan-maneuver calibrations
- Removed pre-launch laser alignment and subsequent biases

### Release 17 (*PAD calibration level 3*)

- Applied batch-EKF corrections to compensate for IST motion with respect to the instrument
- Applied de-distortion map (L3a Version 1) to IST data
- Updated and applied laser biases to pre-launch alignment

### Release 12 (*PAD calibration level 1*)

- Applied additional laser biases to pre-launch alignment based on range-residual analysis of ocean and around-the-world scans

## Laser 3b

| I-SIPS Product Release(s) | Start Date (DOY)  | Stop Date (DOY)   | UTCSR ANC04 Release | UTCSR ANC08 Release/ Level | UTCSR ANC09 Release/ Level | Elevation Product Y-code |
|---------------------------|-------------------|-------------------|---------------------|----------------------------|----------------------------|--------------------------|
| Y28                       | 17-Feb-2005 (048) | 24-Mar-2005 (083) | 2 (v2)              | 8/2                        | 28/4                       | 4                        |
| 19                        | 17-Feb-2005 (048) | 24-Mar-2005 (083) | 2 (v1)              | 5/1                        | 16/1                       | 1                        |

### ANC04

#### Release 2 (v2)

- Generated during final POD solutions
- Maintained release number, but incremented version to 2

#### Release 2 (v1)

- Generated during rapid POD solutions
- Added RELEASE keyword to standard header
- Added USEBEG and USEEND keywords to file-specific header

### ANC08

#### Release 8 (*POD calibration level 2*)

- Final POD solutions
- Corrected geomagnetic computation for low solar-flux periods

#### Release 5 (*POD calibration level 1*)

- Rapid POD solutions
- Changed zenith delay parameter estimation strategy for short passes

## ANC09

### Release 28 (*PAD calibration level 4*)

- Applied batch-EKF corrections to compensate for IST motion with respect to the instrument
- Applied scan-maneuver calibrations
- Removed pre-launch laser alignment and subsequent biases
- Updated LPA spot characteristics to reflect  $1/e^2$ , rather than fixed, cutoff in intensity values

### Release 16 (*PAD calibration level 1*)

- Applied de-distortion map (L3a Version 1) to IST data
- Applied additional laser biases to pre-launch alignment based on range-residual analysis of ocean and around-the-world scans

## Laser 3c

| I-SIPS Product Release(s) | Start Date (DOY)  | Stop Date (DOY)   | UTCSR ANC04 Release | UTCSR ANC08 Release/ Level | UTCSR ANC09 Release/ Level | Elevation Product Y-code |
|---------------------------|-------------------|-------------------|---------------------|----------------------------|----------------------------|--------------------------|
| 22                        | 20-May-2005 (140) | 22-Jun-2005 (173) | 2 (v1)              | 5/1                        | 18/1                       | 1                        |

### ANC04

#### Release 2 (v1)

- Generated during rapid POD solutions
- Added RELEASE keyword to standard header
- Added USEBEG and USEEND keywords to file-specific header

### ANC08

#### Release 5 (*POD calibration level 1*)

- Rapid POD solutions
- Changed zenith delay parameter estimation strategy for short passes

### ANC09

#### Release 18 (*PAD calibration level 1*)

- Applied de-distortion map (L3a Version 1) to IST data
- Applied additional laser biases to pre-launch alignment based on range-residual analysis of ocean and around-the-world scans



## Laser 3d

| I-SIPS Product Release(s) | Start Date (DOY)  | Stop Date (DOY)   | UTCSR ANC04 Release | UTCSR ANC08 Release/ Level | UTCSR ANC09 Release/ Level | Elevation Product Y-code |
|---------------------------|-------------------|-------------------|---------------------|----------------------------|----------------------------|--------------------------|
| 26                        | 21-Oct-2005 (294) | 24-Nov-2005 (328) | 2 (v2)              | 6/2                        | 22/4                       | 4                        |
| 25                        | 21-Oct-2005 (294) | 24-Nov-2005 (328) | 2 (v1)              | 5/1                        | 21/1                       | 1                        |

### ANC04

#### Release 2 (v2)

- Generated during final POD solutions
- Maintained release number, but incremented version to 2

#### Release 2 (v1)

- Generated during rapid POD solutions
- Added RELEASE keyword to standard header
- Added USEBEG and USEEND keywords to file-specific header

### ANC08

#### Release 6 (*POD calibration level 2*)

- Final POD solutions
- Changed zenith delay parameter estimation strategy for short passes
- Used preliminary solar flux and geomagnetic index data

#### Release 5 (*POD calibration level 1*)

- Rapid POD solutions
- Changed zenith delay parameter estimation strategy for short passes

## ANC09

### Release 22 (*PAD calibration level 4*)

- Applied batch-EKF corrections to compensate for IST motion with respect to the instrument
- Applied scan-maneuver calibrations
- Removed pre-launch laser alignment and subsequent biases
- Updated LPA spot characteristics to reflect  $1/e^2$ , rather than fixed, cutoff in intensity values

### Release 21 (*PAD calibration level 1*)

- Applied arctangent correction to GLA04 IST data
- Applied additional laser biases to pre-launch alignment based on range-residual analysis of ocean and around-the-world scans

## Laser 3e

| I-SIPS Product Release(s) | Start Date (DOY)  | Stop Date (DOY)   | UTCSR ANC04 Release | UTCSR ANC08 Release/ Level | UTCSR ANC09 Release/ Level | Elevation Product Y-code |
|---------------------------|-------------------|-------------------|---------------------|----------------------------|----------------------------|--------------------------|
| 27, Y28                   | 22-Feb-2006 (053) | 28-Mar-2006 (087) | 2 (v2)              | 8/2                        | 27/4                       | 4                        |
| 26                        | 22-Feb-2006 (053) | 28-Mar-2006 (087) | 2 (v1)              | 5/1                        | 24/1                       | 1                        |

### ANC04

#### Release 2 (v2)

- Generated during final POD solutions
- Maintained release number, but incremented version to 2

#### Release 2 (v1)

- Generated during rapid POD solutions
- Added RELEASE keyword to standard header
- Added USEBEG and USEEND keywords to file-specific header

### ANC08

#### Release 8 (*POD calibration level 2*)

- Final POD solutions
- Corrected geomagnetic computation for low solar-flux periods

#### Release 5 (*POD calibration level 1*)

- Rapid POD solutions
- Changed zenith delay parameter estimation strategy for short passes

## ANC09

### Release 27 (*PAD calibration level 4*)

- Applied batch-EKF corrections to compensate for IST motion with respect to the instrument
- Applied scan-maneuver calibrations
- Removed pre-launch laser alignment and subsequent biases
- Updated LPA spot characteristics to reflect  $1/e^2$ , rather than fixed, cutoff in intensity values

### Release 24 (*PAD calibration level 1*)

- Applied arctangent correction to GLA04 IST data
- Applied additional laser biases to pre-launch alignment based on range-residual analysis of ocean and around-the-world scans
- Updated LPA spot characteristics to reflect  $1/e^2$ , rather than fixed, cutoff in intensity values

## Laser 3f

| I-SIPS Product Release(s) | Start Date (DOY)  | Stop Date (DOY)   | UTCSR ANC04 Release | UTCSR ANC08 Release/ Level | UTCSR ANC09 Release/ Level | Elevation Product Y-code |
|---------------------------|-------------------|-------------------|---------------------|----------------------------|----------------------------|--------------------------|
| 26                        | 24-May-2006 (144) | 26-Jun-2006 (177) | 2 (v1)              | 7/1                        | 26/1                       | 1                        |

### ANC04

#### Release 2 (v1)

- Generated during rapid POD solutions
- Added RELEASE keyword to standard header
- Added USEBEG and USEEND keywords to file-specific header

### ANC08

#### Release 8 (*POD calibration level 1*)

- Rapid POD solutions
- Corrected geomagnetic computation for low solar-flux periods

### ANC09

#### Release 26 (*PAD calibration level 1*)

- Applied arctangent correction to GLA04 IST data
- Applied additional laser biases to pre-launch alignment based on range-residual analysis of ocean and around-the-world scans
- Updated LPA spot characteristics to reflect  $1/e^2$ , rather than fixed, cutoff in intensity values