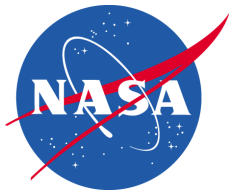


# Gravity Model Recommendations for the next ITRF

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# Background

• For ITRF2008, IDS AC's used models such as GGM03S, EIGEN-GL04S, GGM03C.
• The above models are no longer adequate:

I. Models determined over a finite interval; The total gravity field of the Earth (static + time-varying) has departed from the representation supplied by those models.

II. There are indications that the parsimonious representation of TVG wrt to a static model (as in the above models) is not adequate for DORIS LEO satellites, especially after 2008.

III. Newer models present issues – because although they are determined over the GRACE data period (2002 -2010 or 2002-2011) it is not clear how best to extrapolate them for periods prior to 2002.

# Classes of Available Gravity Models (1)

| Model | |
|---|---|
| Satellite-only or Combination (Comprehensive models) | **Data:** GRACE+Lageos; GRACE+GOCE+Lageos; or same models + surface gravity & altimetry.<br><br>**Representation**: Static field to high degree + Secular terms + Annual + Semiannual variations to lower degree.<br><br>**Problem:** How reliable is extrapolation of field to non-GRACE time period (> 2012, or < 2002)? |
| Time series | **Data:** GRACE + Lageos; GRACE-only (e.g. monthly or 10-day solutions); SLR+DORIS<br><br>**Representation:** 50x50, 60x60? + static field (GRACE-derived); 4x4 + static field (SLR+DORIS)<br>**Problems: (1) Latency; (2) Solution interval might be less than available DORIS data interval; (3) For 4x4 SLR +DORIS series, $C_{40}$ not reliable before launch of Stella (~Oct. 1993)** |

# Classes of Available Gravity Models (2)

| Model | |
|---|---|
| Time-series-derived (1) | **Data:** SLR+DORIS to multiple satellites<br><br>**Representation**: Static field to high degree + Secular terms + various periodic terms to 4x4.<br><br>**Problem:** (1) How reliable is extrapolation of field to non-data period(> 2012, or < 1993); |

# Gravity Models Available (1)

| Model | Description |
|---|---|
| **EIGEN-6C2** (GFZ/GRGS, Förste et al., 2012) | **Data:** GRACE (March 2003 – Dec. 2010), Lageos1+2 (1985-2010), GOCE (2009-2011), Surface Data.<br>**Type of Model:** Static terms (379x379) + secular + annual +semiannual to 50x50. |
| **EIGEN-6S** (GFZ/GRGS, Förste et al., 2011) | **Data:** Same as above. No Surface Data. (Satellite-only model).<br>**Type of Model:** Static terms (240x240) + secular + annual +semiannual to 50x50. |
| **GOCO2S** (Goiginger et al., 2011); **GOCO3S (xxx)** | **Data:** GRACE (7 yrs); CHAMP (8 yrs); GOCE (8 months); Lageos1+Lageos2 (5 years).<br>**Type of Model:** static model (280x280). Time-varying terms not publically available. |

# Gravity Models Available (2)

| Model | Description |
|---|---|
| **GRGS_RL02bis_MEAN-FIELD** (2011) | **Data:** ~1 year more data than EIGEN-6S.<br>**Type of Model:** Static terms (240x240) + secular + annual +semiannual to 50x50.<br>**COMMENT:** Model used in CNES GDR-D Standards (Jan. 2012). |
| GIFXXX | **Data:** GRACE …. |
| **Time Series. GRGS RL02, 10-day gravity fields** (Bruinsma et al., 2002). | **Data:** GRACE + Lageos1+Lageos2<br>**Type of Model:** 50x50 10-day time series; Accompanied by specific static model. Available Period: 2002 – 201X). |
| **Time Series. NASA GSFC, Weekly Smoothed gravity fields** (Lemoine et al., 2011). | **Data:** 11 SLR+DORIS Satellites: Lageos1, Lageos2, Starlette + Stella+Ajisai+ TOPEX+Envisat+Jason2+Westpac +Larets+Cryosat2<br>**Type of Model:**4x4 time series + static model (GOCO2S) |

# Gravity Models Available (3)

| Model | Description |
|---|---|
| **Time Series-Derived. NASA GSFC,** (Lemoine et al., 2012). | **Data:** 11 SLR+DORIS Satellites: Lageos1, Lageos2, Starlette + Stella+Ajisai+ TOPEX+Envisat+Jason2+Westpac +Larets+Cryosat2<br>**Type of Model:** Fitted terms (secular, annual, semiannual to 4x4; 18.6 yr for C20) + GOCO2S as static field.<br>**COMMENT:**<br>(1). Used in GSFC std1204 TOPEX/Jason1/Jason2 orbits; and in GSCWD15, 18 DORIS SINEX Time Series.<br>(2). Update Soon (new Time series being developed with data through December 2012; Various improvements; and More satellites). |

# Gravity Models Available (4)

| Model | Description |
|---|---|
| **GRACE-derived monthly solutions (CSR, GFZ, JPL)** | **Data:** GRACE-only<br>**Type of Model:** XXxXX monthly model.<br>**Comment:**<br>(1) C20 term not necessarily reliably determined from GRACE-data alone.<br>(2) No solutions available outside of GRACE-time period. |

# Recommendations

(1) Use a "fitted" model Determined over 1993-2012 (as with GSCWD15, 18).

(2) Use Different Gravity Models for Different Time Periods.

(2A) Before 2002. Use EIGEN-GL04S1 (*Förste et al., 2008*).
Advantage: This model was used in GDR-C standards (CNES), and with std1007 orbits (NASA GSFC) – and before 2002 – it had reasonable performance. It also has the virtue of simplicity.

(2B) Before 2002: Modified static comprehensive model (see 3A) without linear extrapolated terms and fix-ups for low degree terms (C20, C21, C22, S22, S21, C30).

# Recommendations

(3A)

After 2002. Many Different possibilities:

I. Static Comprehensive Model: **GRGS_RL02bis_MEAN-FIELD** (2011) or **EIGEN-6C2** (GFZ/GRGS, Förste et al., 2012).

II. Time Series: E.G. GRGS RL02;

Advantages: Highest fidelity gravity field representation; Models can be interpolated and made available on weekly basis.

Disadvantages: Solutions will not be available in time to compute solutions with 2013 DORIS data.