# Evidence for a Geomagnetic Jerk after 2003 in LOD

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## ABSTRACT

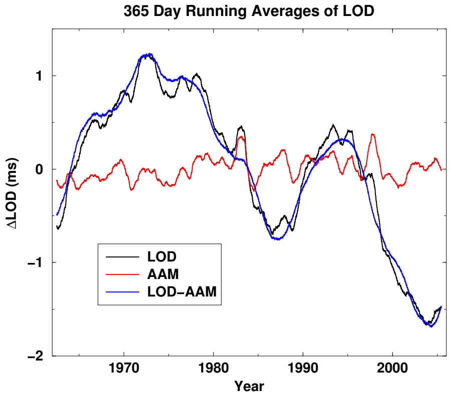
Geomagnetic jerks are well-known, but arguably still poorly understood, features of the temporal behaviour of the geomagnetic field. They consist of sharp changes in the secular acceleration of the field, in some cases seen globally, while in other cases only at some locations at the Earth's surface. Recently (Holme and de Viron, 2005), we have provided evidence for a correlated feature in the rotation of the Earth. Removing a detailed calculation of atmospheric angular momentum (AAM) from the geodetic signal produces a much smoother signal to examine for decadal changes in length of day (LOD), assumed to result from core-mantle angular momentum exchange. Fitting penalised least-squares splines to a simple yearly running average of the smoothed signal allows its easy numerical differentiation, yielding features preceding and correlated with jerks, consistent with a sharp change in the core-mantle torque. This observation provides support for recent claims that jerks are associated with torsional oscillations in the Earth's core.

Here we extend analysis of the rotation signal to the start of 2006. We find evidence of a jerk-like feature centred approximately in 2003, suggesting that a geomagnetic jerk may be visible in the time following this. Our study was motivated by suggestions (Olsen and Mandea, pers. comm.) that such a jerk can be detected in satellite observations of the geomagnetic field. Thus, our results provide support for the existence of a geomagnetic jerk in 2004, and also for the detection of such jerks in satellite magnetic data.

## Removing AAM from LOD

Subtract a direct calculation of AAM from LOD. Still much power at annual, biannual and terannual periods – eliminate this by taking a 365-day running average.

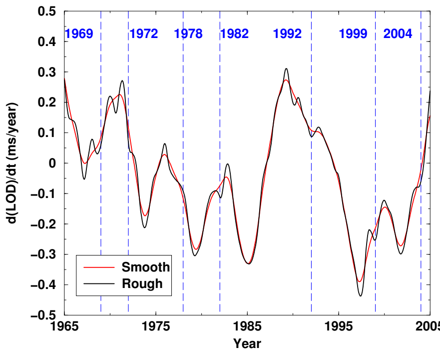
365 Day Running Averages of LOD




- Ocean angular momentum signal not removed – gave more noise at annual periods, although long-term trend may be more robust (R. Gross, pers. comm.)
- Signal with removed AAM clearly much cleaner than any attempt to filter numerically the raw LOD data
- Residual high-frequency (sub-annual) noise easily removed by fitting with penalised least-squares splines (Constable and Parker, 1988)
- Spline fit allows easy calculation of time derivative (e.g., for core-mantle torque calculations)

## Time derivative of smoothed LOD

Details of derivative depend on "taughtness" of splines. Plot two fits, one (rough) fitting data more closely than the other (smooth).

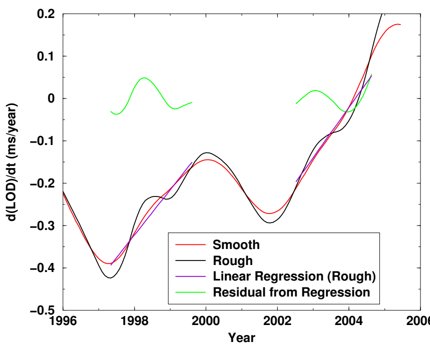



- Small details in the rough curve at the same time or preceding epochs of geomagnetic jerks
- Reasonable if geomagnetic jerks are associated with torsional oscillations (Bloxham *et al.*, 2002)
- (Le Huy *et al.*, 2000) predicted LOD signal from jerk – only visible with cleaner LOD time series

## A new geomagnetic jerk?

- Olsen and Mandea (pers. comm.) – evidence in satellite data for a jerk around 2004
- LOD series here (extended from Holme and de Viron (2005)) shows a feature just prior to this time
- Less clear than earlier features because of current steep gradient in LOD derivative
- Subtract a local linear trend from the "rough" curve

Difference of Curve Features from Linear Regression




- LOD jerk signal in 2003-4 of same order of magnitude as 1999 feature
- LOD analysis supports suggestion of jerk around 2004

## References

Bloxham, J., Zatman, S., and Dumberry, M. (2002). *Nature*, **420**, 65–68.

Constable, C. G. and Parker, R. L. (1988). *J. Comput. Phys.*, **78**, 493–508.

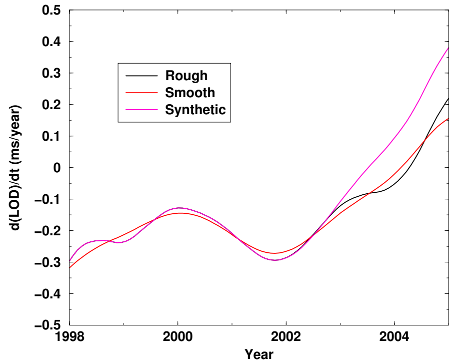
Holme, R. and de Viron, O. (2005). *Geophys. J. Int.*, **160**, 435–439.

Le Huy, M., Mandea, M., Le Mouël, J.-L., and Pais, A. (2000). *Earth Planets Space*, **52**, 163–173.

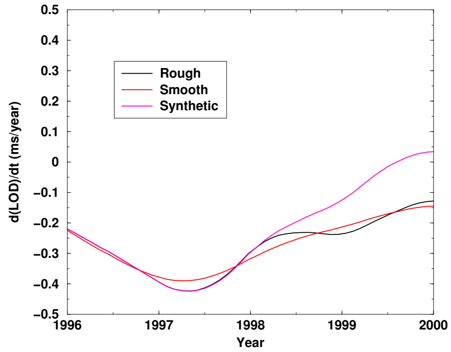
## Synthetic elimination of the jerk signal

- Direct analysis of signal shape difficult because of filtering (running average and smooth spline fit)
- Proceed by forward modelling – add signal to raw data, process in same way, look for changes in final signal
- Synthetics show jerk LOD features consistent with a discontinuity in gradient of LOD curve (torque)
- Add synthetic signals to eliminate two most recent jerks
- In both cases, add ramp function (discontinuity in gradient)
- Signal 0.16 ms / year, length 5 years
- Start approximately at time of jerk

Added Synthetic Signal, Start 2003.5




Added Synthetic Signal, Start 1998.8




- Broadly eliminate both jerk features
- ⇒ Features consistent with an discontinuity in LOD derivative of equal and opposite magnitude
- Interpretation highly non-unique
- Both features of same sign - unlike earlier features (e.g., 1969 and 1972) could not be regarded as equal and opposite (i.e., a top hat function in torque)

## Some open questions

- Why are some jerks (e.g., 1969) well-explained by a simple torsional oscillation model and some (e.g., 1972) not?
- Lag – evidence of mantle conductivity?
- Separation of 1969/1972, 1978/1982 jerks into two separate features – no evidence of lateral variation of mantle conductivity?
- Smaller features in rotation (just visible in rough curve) – are observed jerks merely the largest of a continuum of features?