Prediction of Universal Time and LOD Variations

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Why performing UT1 predictions?

- UT1: stellar angle determining the Earth orientation
- No real-time UT1 determination available
- Different applications
  - Ephemeris computation
  - Celestial navigation
  - Astronomical softwares
  - Space geodesy orbitography
  - Need of temporal series of DUT1 = UT1-UTC for automatic procedures

Description of the variations of the Earth Rotation

Length of day Variations

Secular drift

Energy dissipation (~ 2.4 ms/century)

Post-glacial rebound (~ -.5 ms/cy)

Decadal fluctuations

Core/mantle torque (amplitude ~ 5 ms)

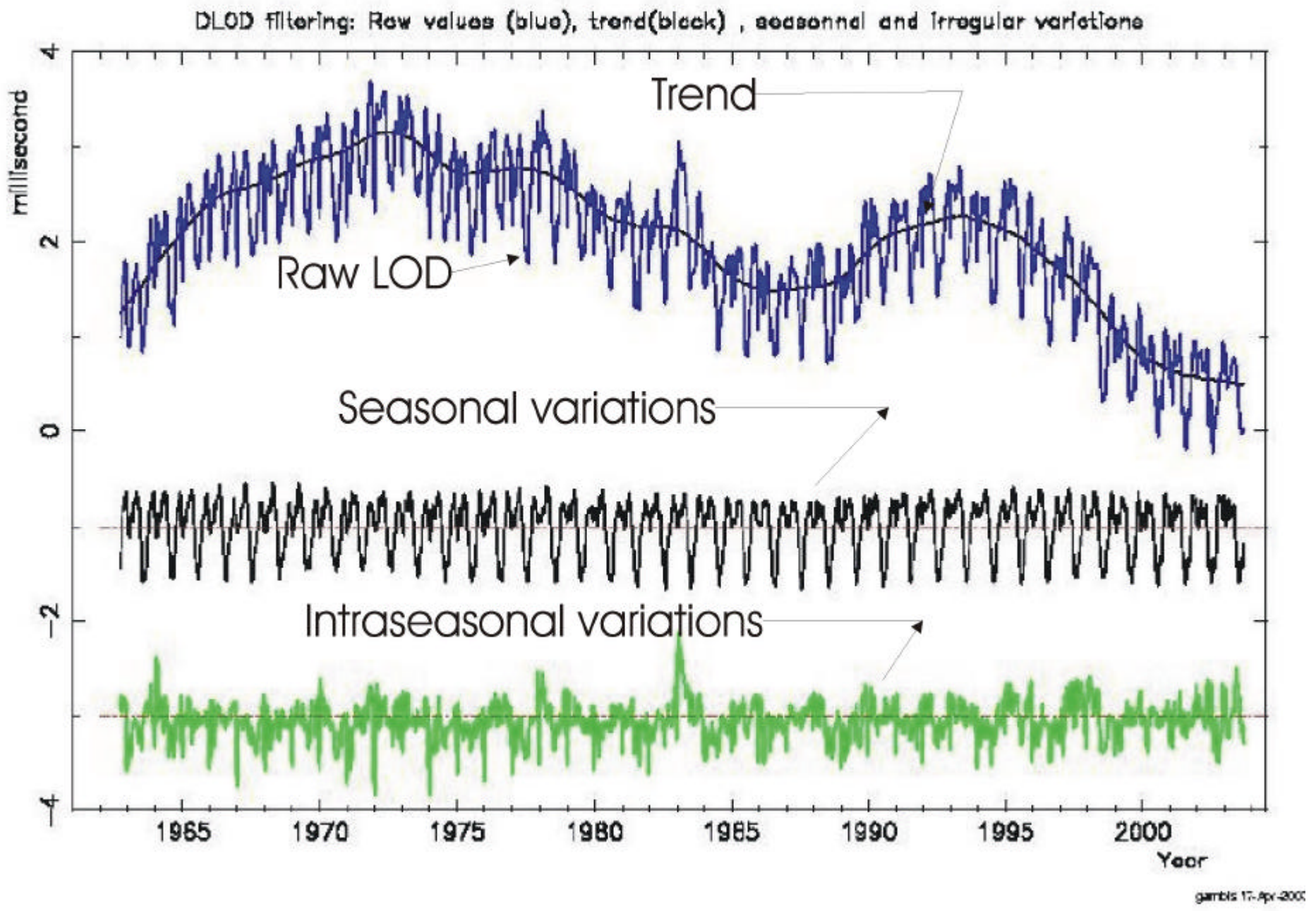
Global ocean-atmosphere processes

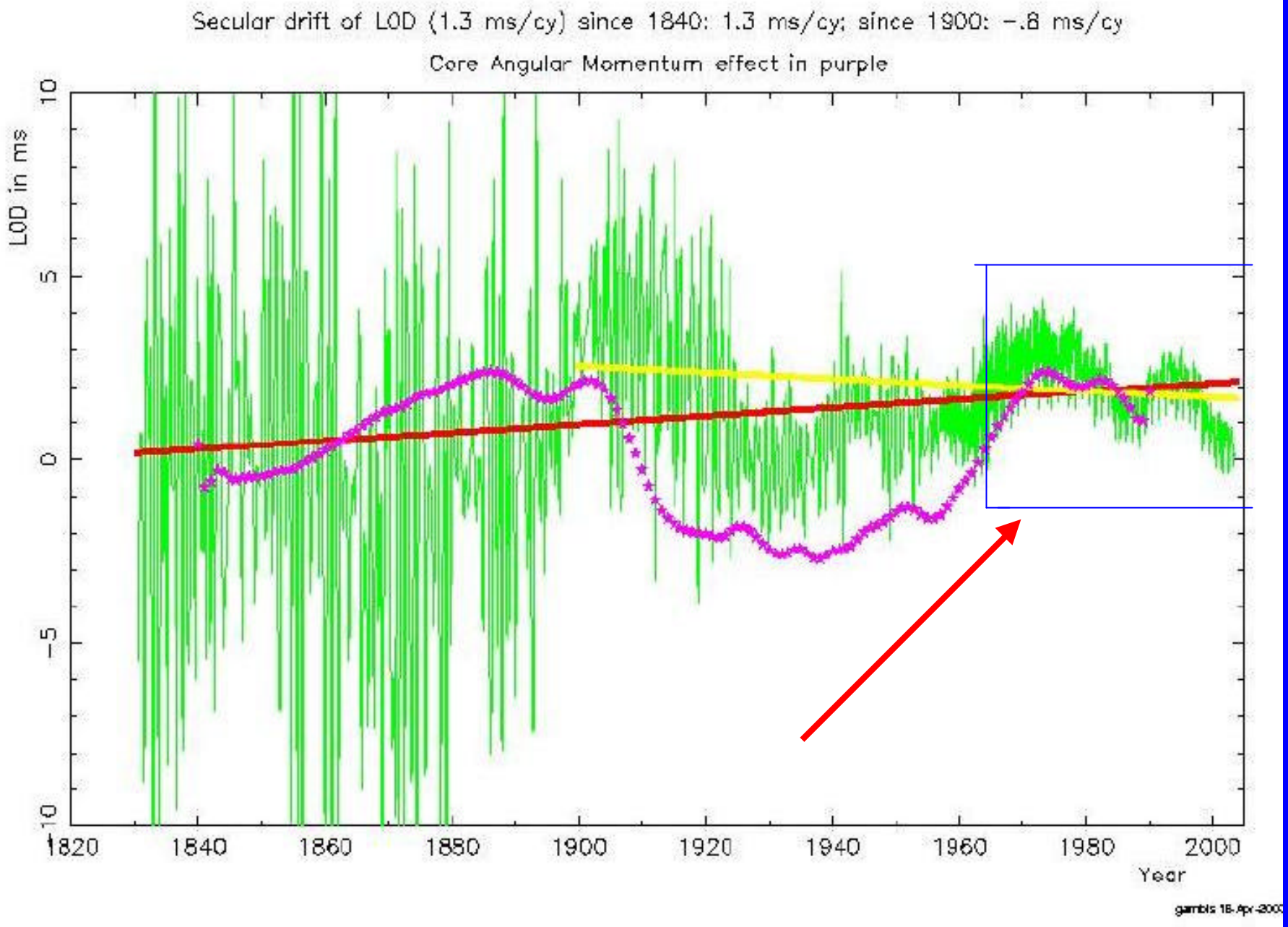
Variations from a few hours to about 2 years

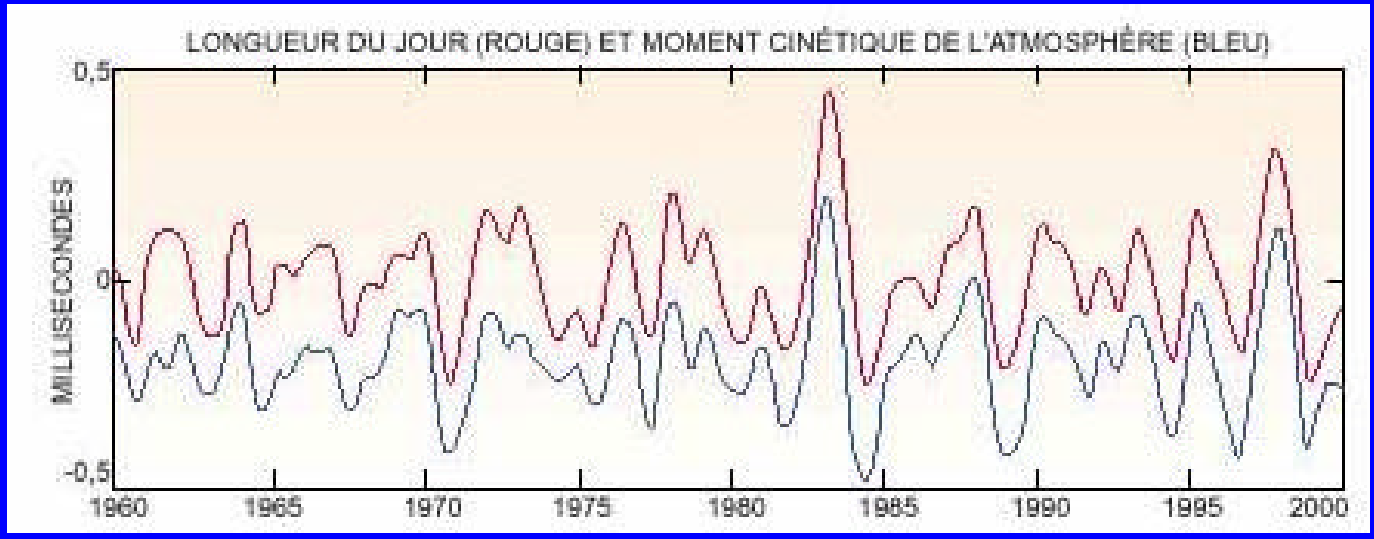
Atmospheric causes (zonal winds) (amplitude ~ 1 ms)

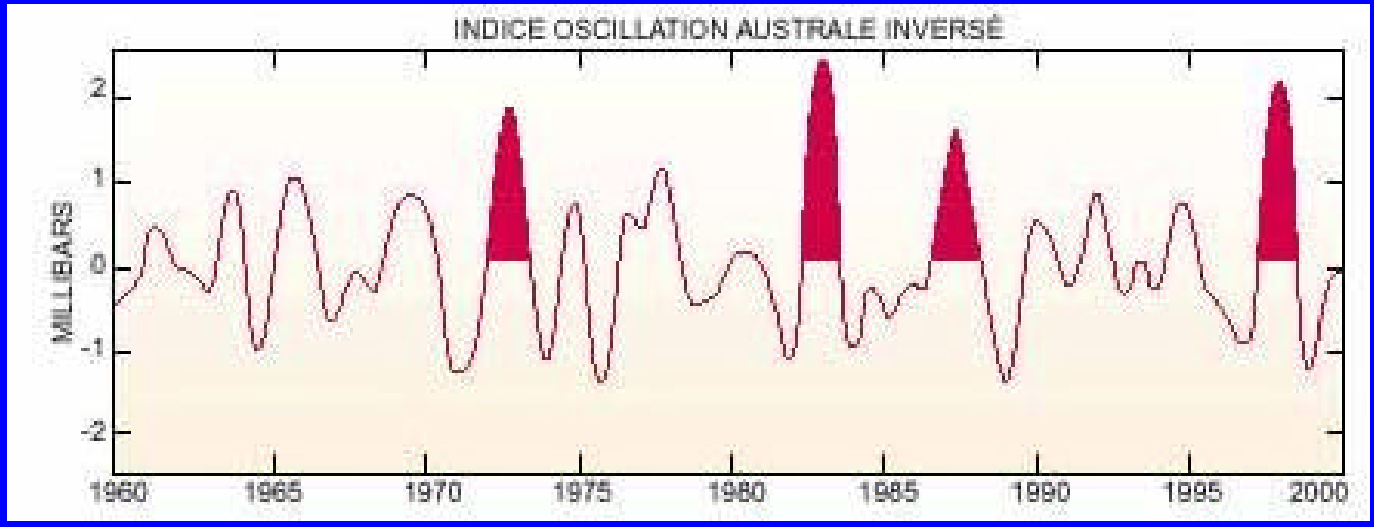
Diurnal and sub-diurnal variations

Ocean, atmosphere (amplitude ~200 ms)


DLOD filtering: Raw values (blue), trend(black) , seasonal and irregular variations
millisecond
4
2
0
−2
−4
Trend
Raw LOD
Seasonal variations
Intraseasonal variations
1965
1970
1975
1980
1985
1990
1995
2000
Year


Secular drift of LOD (1.3 ms/cy) since 1840: 1.3 ms/cy; since 1900: -.8 ms/cy
Core Angular Momentum effect in purple
LOD in ms
10
5
0
-5
-10
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000
Year


LONGUEUR DU JOUR (ROUGE) ET MOMENT CINÉTIQUE DE L'ATMOSPHÈRE (BLEU)
MILLISECONDES
0,5
0
-0,5
1960
1965
1970
1975
1980
1985
1990
1995
2000


INDICE OSCILLATION AUSTRALE INVERSÉ
MILLIBARS
2
1
0
-1
-2
1960
1965
1970
1975
1980
1985
1990
1995
2000

IERS products

Current IERS Products

Earth rotation

Polar motion (precision: 100 μas), Universal Time (precision : 15μs) and LOD (precision : 20μs)

One-day smoothed solution (1962-now)

One and five-day normal point solution

Long-term solution (1/20 year) 1846-now

Bulletins concerning time dissemination

Bulletin C : Announcement of the leap seconds in UTC

Bulletin D: Announcement of the value of DUT1 truncated at 0.1s for transmission with time signals

- The Earth Orientation Center of the IERS at Paris Observatory is in charge of the leap second prediction and announcement

Long term series of UT1-UTC and LOD

1891 – 1954: One-lunation series computed from occultations (Jordi et al solution)

1956 – 1990: astrometric-based series derived in Hipparcos reference frame (Vondrak

1955 – 1961 Universal time scale computed from optical instruments (Guinot, personal communication)

1962 until now: BIH and IERS solutions.

- Only optical observations between 1962 and 1972.
- Only LLR and Very Long Baseline Interferometry (VLBI) since 1983

Predictions of UT1-UTC

Current UT1-UTC prediction procedure

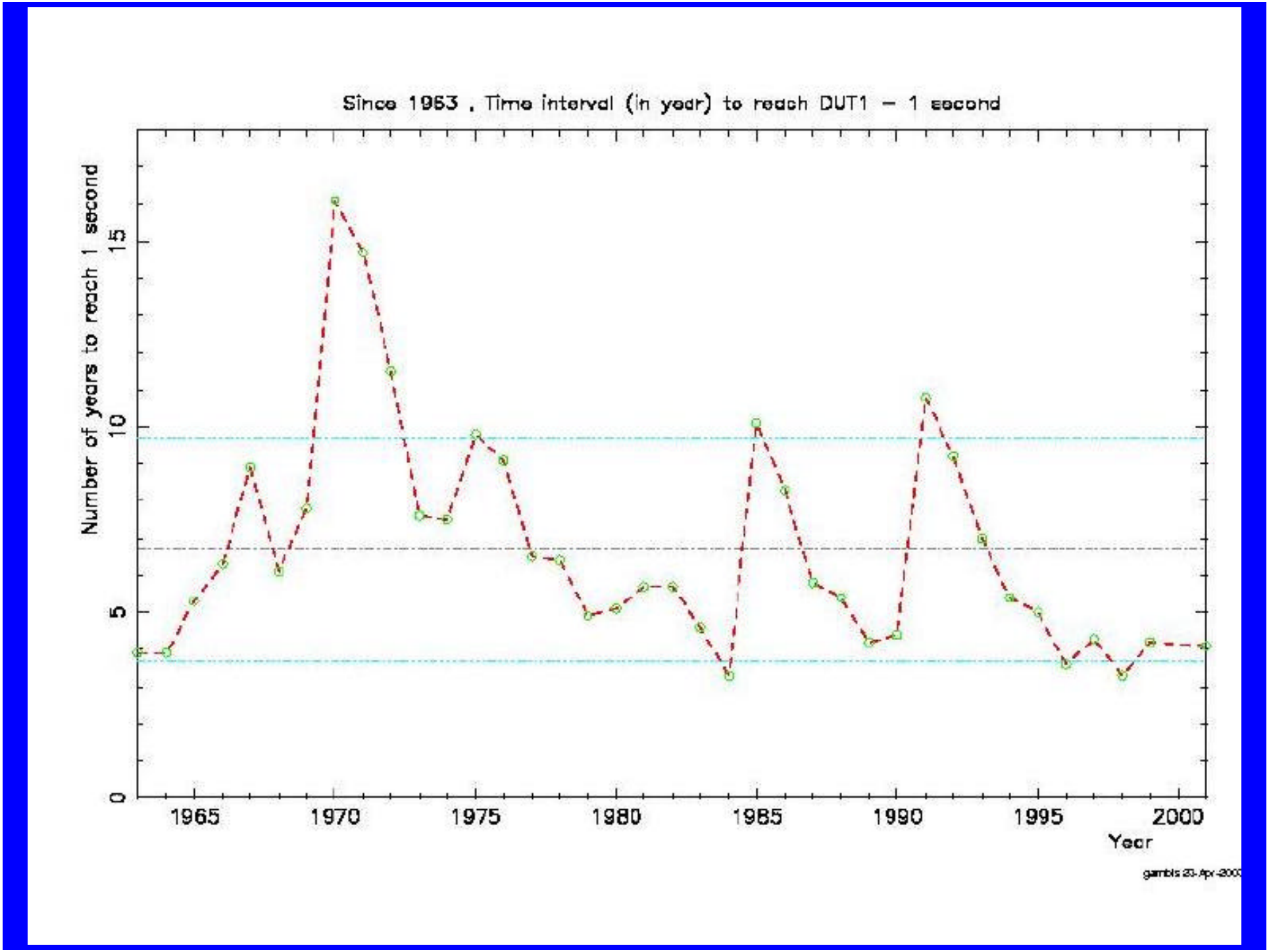
- Modeling includes a bias, a linear trend and seasonal terms, annual and semi-annual

- Residuals are modeled and predicted as an autoregressive process

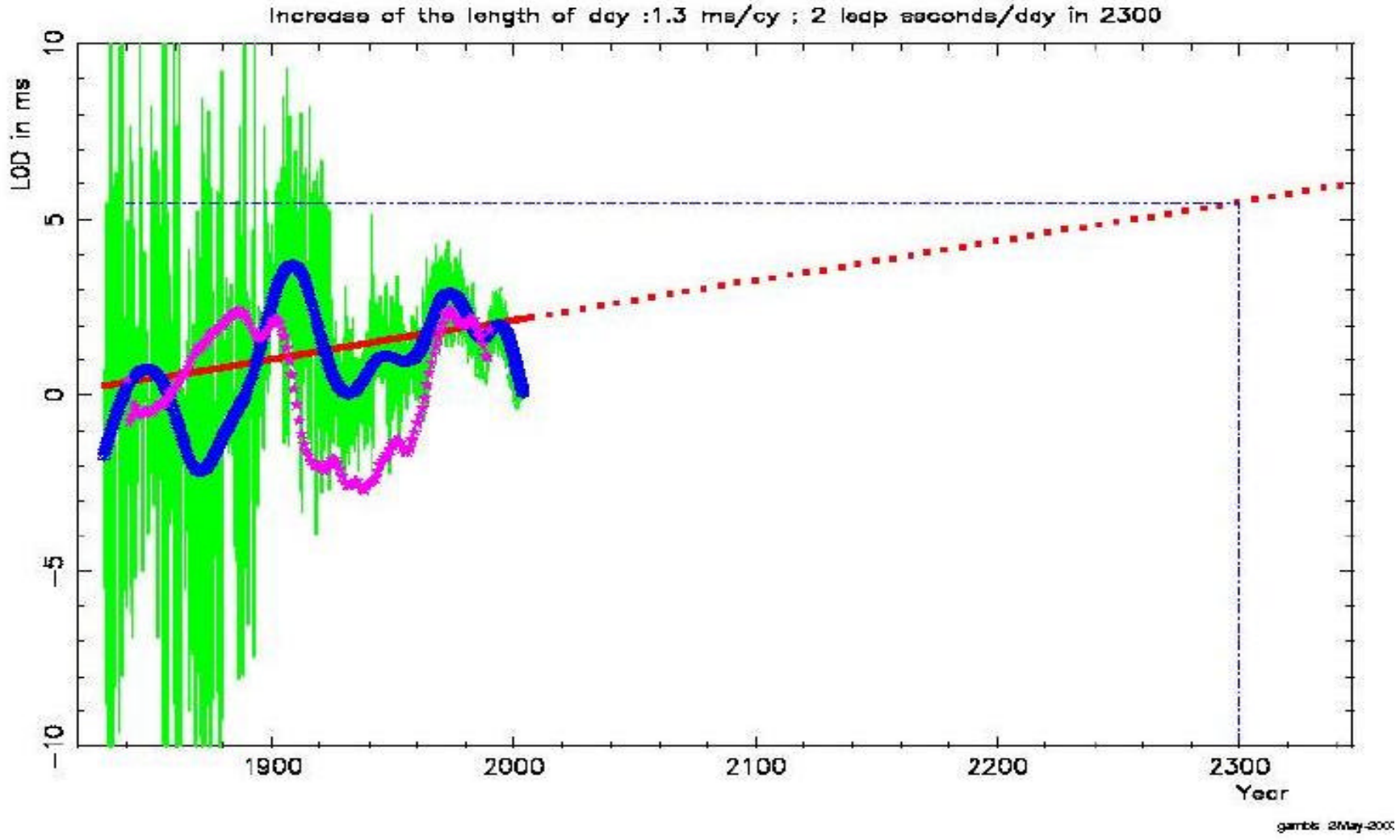
  Short term prediction of UT1-UTC avaible on a real time basis

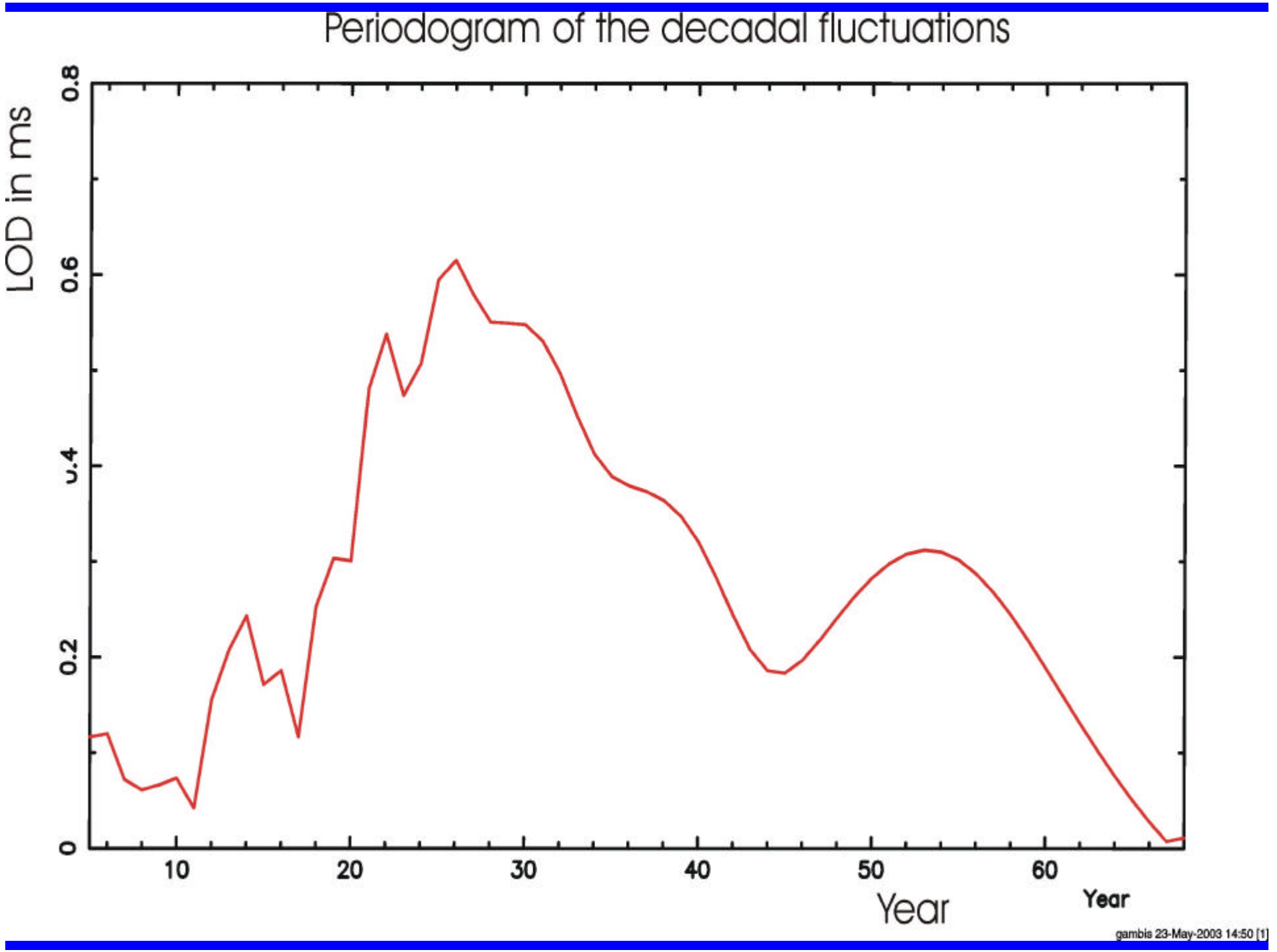
Skill of the UT1 prediction statistics over 1963-2003

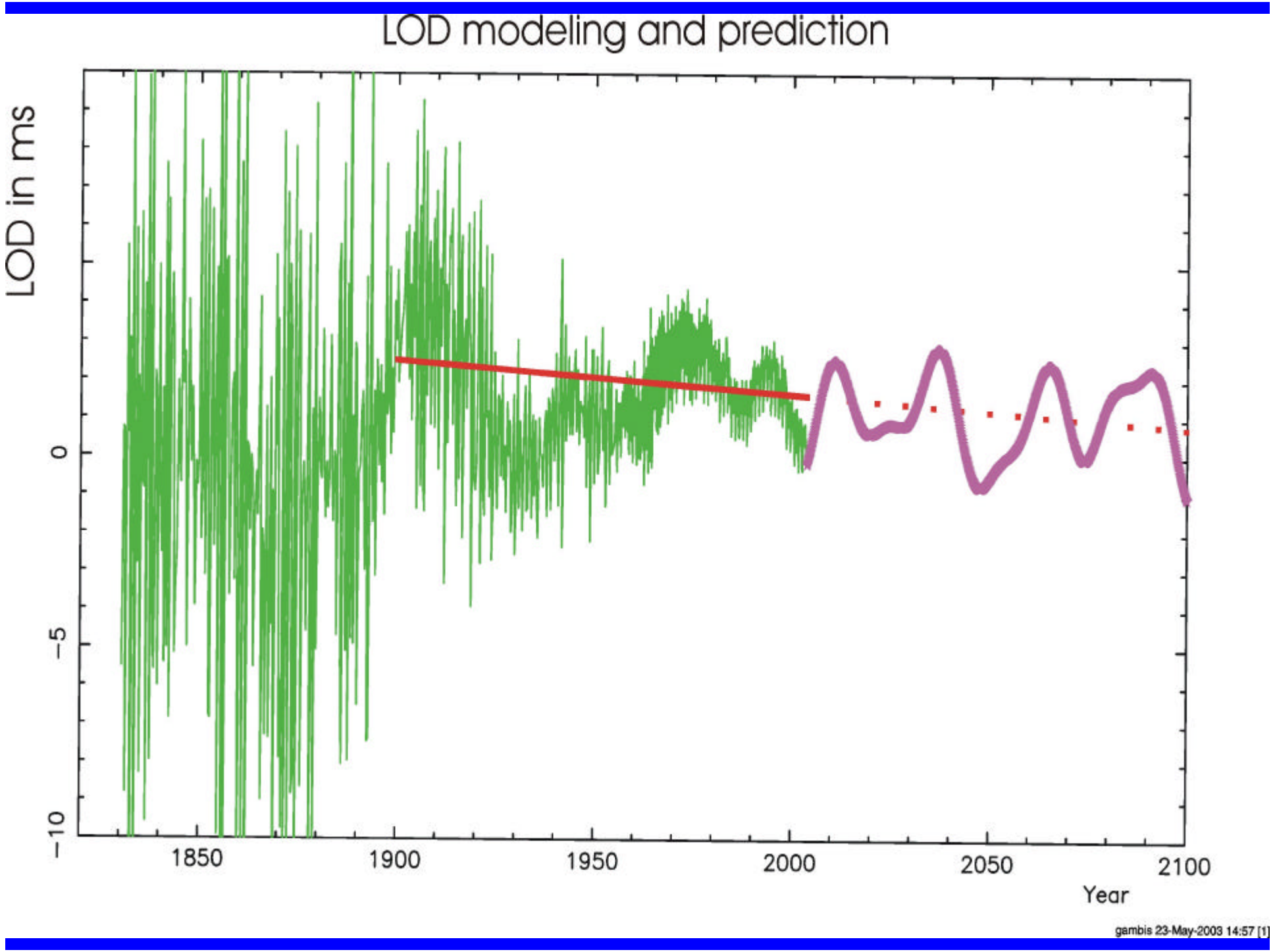
Horizon	Prediction accuracy in ms
10 days	3
30 days	7
90 days	21
180 days	36
1 year	68
2 years	163
3 years	308

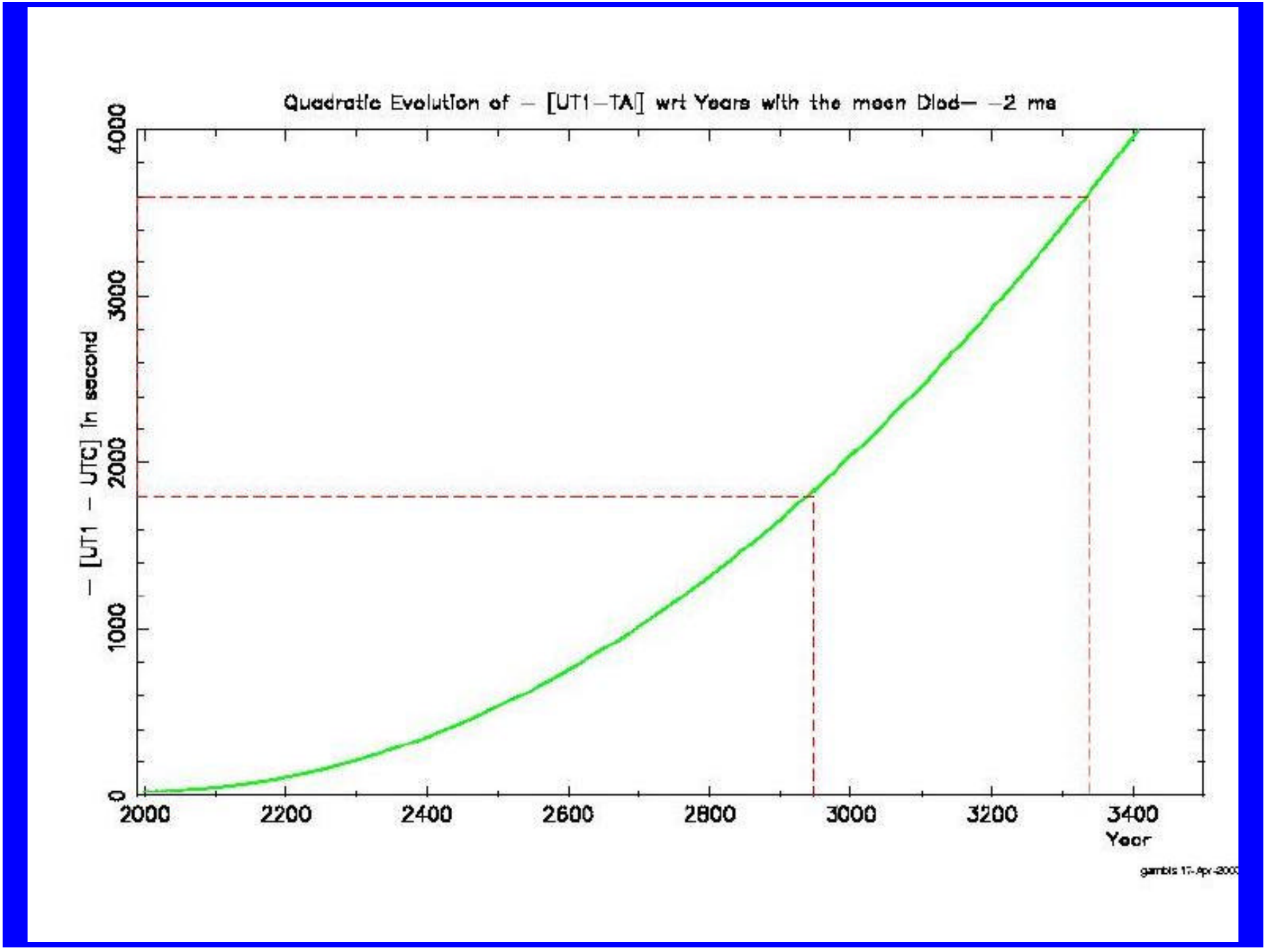

Since 1963 , Time interval (in year) to reach DUT1 – 1 second
Number of years to reach 1 second
0
5
10
15
1965
1970
1975
1980
1985
1990
1995
2000
Year
gambis 23-Apr-2003

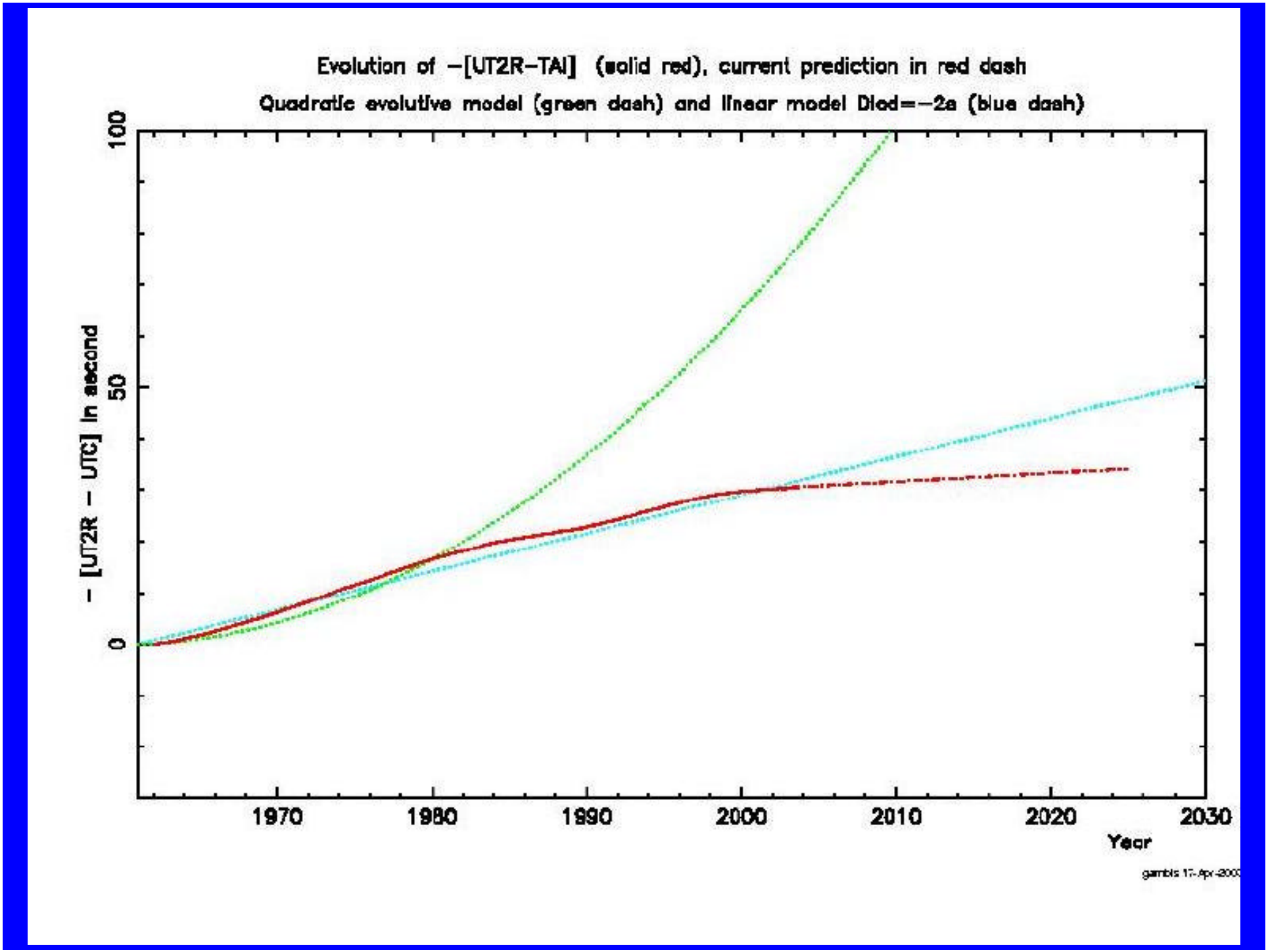
Long-term predictability variations of LOD and UT1-UTC




Periodogram of the decadal fluctuations
LOD in ms
0.8
0.6
0.4
0.2
0
10
20
30
40
50
60
Year
Year
gambis 23-May-2003 14:50 [1]


LOD modeling and prediction
LOD in ms
0
−5
−10
1850
1900
1950
2000
2050
2100
Year
gambis 23-May-2003 14:57 [1]


Quadratic Evolution of – [UT1–TA] wrt Years with the mean Dlod= –2 ms
– [UT1 – UTC] in second
0
1000
2000
3000
4000
2000
2200
2400
2600
2800
3000
3200
3400
Year
gambis 17-Apr-2000


Evolution of −[UT2R−TAI] (solid red), current prediction in red dash
Quadratic evolutive model (green dash) and linear model Dlod=−2a (blue dash)
100
50
0
− [UT2R − UTC] in second
1970
1980
1990
2000
2010
2020
2030
Year
gambis 17-Apr-2003

Conclusions

- Possibility to predict UT1 with a 1s accuracy at least over 4 years using a simple method : seasonal, bias and drift.
- New prediction methods are under investigation (Singular Spectrum Analysis, neural network,..)
- Possibility to use Core Angular Momentum prediction for decadal modeling
- The IERS EOP Center makes now available UT1 on a real-time basis