VLBI Data Analysis 2007

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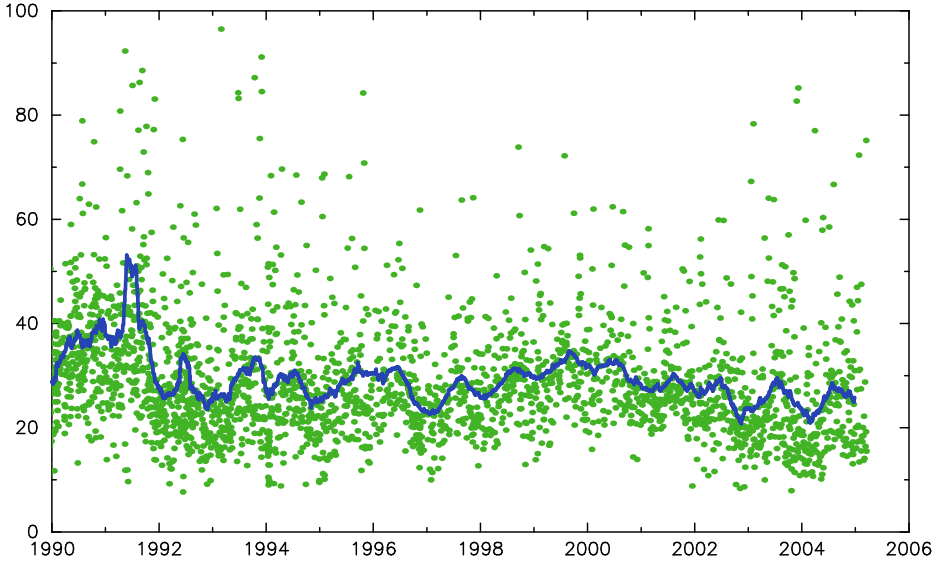
  - Did we hit a floor of precision/accuracy?
- What are the factors which hinder improvement of results?
- What kind of changes in analysis are needed in mid-term perspective (1–2 years)?

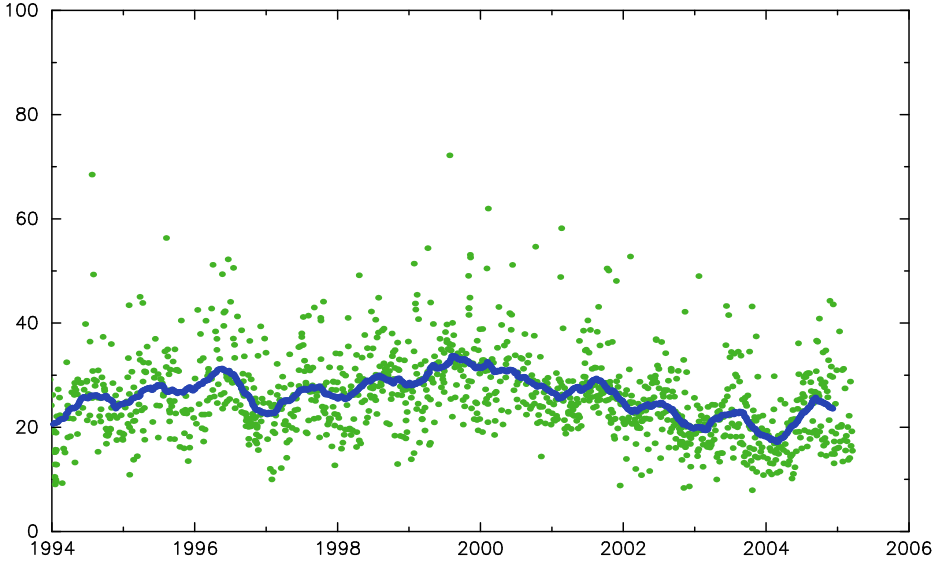
Were VLBI results improved in last 10 years?

Evolution of WRMS of post-fit residuals of individual experiments (on psec)

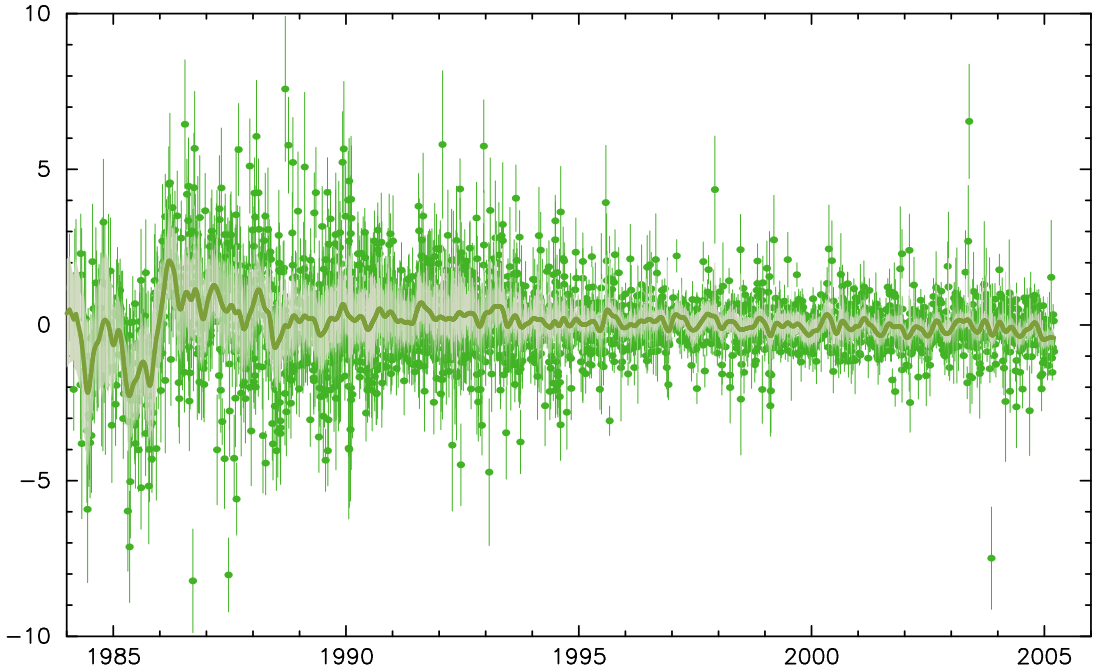
All data:



XA, XE **data:**



Differences: daily estimates of $\Delta\epsilon$ versus heo_05c (in nrad):

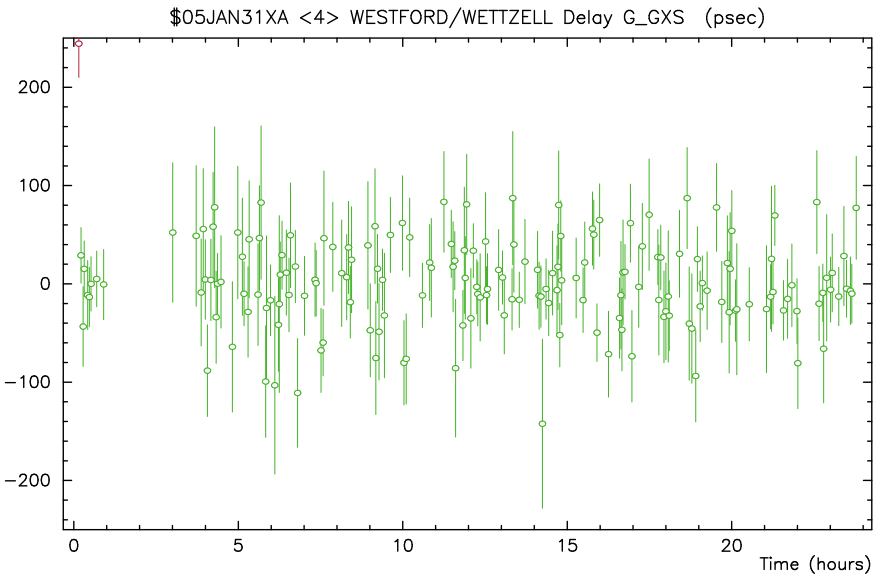


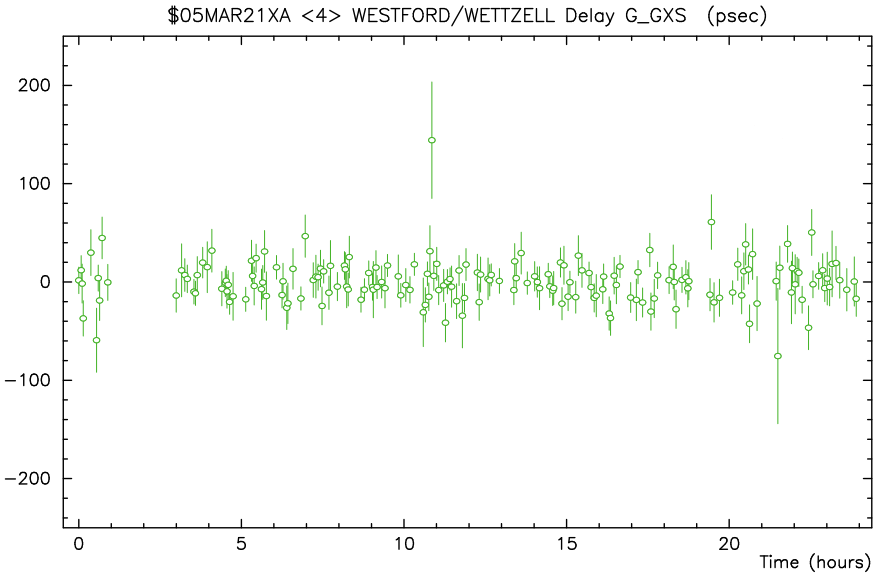
Year	σ nrad
1985–1987	1.80
1987–1989	1.68
1989–1991	1.15
1991–1993	0.83
1993–1995	0.70
1995–1997	0.56
1997–1999	0.49
1999–2001	0.45
2001–2003	0.46
2003–2005	0.47

Did we hit the floor?

The same stations, the same schedule type, but for one session the wrms is **38 psec**, for the second session the wrms is **16 psec**. No comments in log file. No comments in correlation report.

Why?





What is the limiting factor?

Troposphere sets the limit of wrms at a level of **15 psec** or less. This limit is approximately the same for all stations.

The major limiting factor is **instrumental errors**: phase instability of the system.

Can we reduce effect of error on results?

Answer: **unless we change analysis strategy, no**.

Main obstacle: old stereotypes.

Obstacles for improving the accuracy of VLBI results

- The infrastructure of scheduling $\longrightarrow$ correlation $\longrightarrow$ post-correlation analysis was designed in 70s, matured in 80s, reached its limit by 90s, and became inadequate in the 21st century.

  Scientific software has lifetime 10–15 years!

  - software consists of monstrous chunks which are not understood any more (Calc/Solve alone has more than 1 million line of code). Have a lot of abandoned features.
  - software development used techniques which was adequate to the moment of design (70x), but in archaic in 2005.
  - support of monstrous software does not leave resources for development.
  - very inflexible to incorporating input data
- The culture: *changes are undesirable*. Like a runner who instead of looking how close he is to the finish, looks how far he is from the start.
- Lack of complex approach. We can improve things only if everybody considers improvement as a priority.
- Insufficient amount of resources. The share of R&D VLBI experiments is 5%. What is the share of spending $$ for new software/new hardware?
- No hardware improvement targeted phase instability.

Structure of space geodesy software

- **Data import**
  - Reading correlator data;
  - Reading auxiliary data;
  - Reorganizing the data.
- **Data preprocessing**
  - Parsing control files;
  - Fringe fitting, computation of phases, amplitudes, delays;
  - Calibration the data;
  - Computation of theoretical delay and partial derivatives;
  - Ambiguity resolution;
  - Outliers elimination;
  - Quality control analysis;
  - Building data description tables;
  - Data export

- **Parameter estimation**
  - Parsing control files;
  - Building problem description tables;
  - Computation of normal matrices or their analogues;
  - Computation of normal matrices or constraints of their analogues;
  - Running solution and getting estimates, covariance matrices, residuals, statistics
  - Writing verbose output file
- **Preprocessor of results**
  - Parsing control files;
  - Reading parameter estimation output file;
  - Data transformation;
  - Writing final results in tables, making plots for publications.

What has changed during last 20 years?

- Cost of computers: from 10 person/years in 1980 to less than 1 person/week. Cost of 1 Gb operative memory, or 150 Gb hard-disk is 1–2 person/hour. ==>
  - no multi-platform support
  - no monstrous software programs
- 20 years ago we did not know how to analyze VLBI data, and learned it by tries and errors. Now we know. ==>
  - batch approach to analysis
  - new design
- Thermal noise was reduced, and made instrumental errors better visible.
- VLBI analysis from research work became a service.

Analysis 2007:

- Boundary correlator/post-processing analysis is drawn at the line where fringes are found. Correlator analyst decides whether re-correlation is needed, makes quality control checks and exports u–v data in a FITS-file.
- Preprocessing analysis starts from fringe searching, then computes delays, resolves ambiguities, performs quick analysis, outliers elimination, a loop of re-fringing $\longrightarrow$ geodesy/astrometry analysis, and writes files for post-processing analysis.
- Post-processing analysis is station-oriented instead of baseline-oriented.
- Field system is upgraded and exports standardized files with complete telemetry which is attached to exported FITS files. Telemetry includes, but not limited, meteo data, system temperature, phase cal — all information. Telemetry is propagated to databases.

  This should be the highest priority!!
- Analysis chain is designed for an unattended operation. Production mode is a batch run, test mode has an interactive interface to the batch language.

- Analysis software consists of compact universal, threads-friendly, 64bit compatible, well documented libraries.
- Analysis software has an integrated support of export to multi-technique analysis programs, such as Geodyne.
- Analysis allows processing phase-referencing observations.