Modeling atmospheric loading using BLQ files

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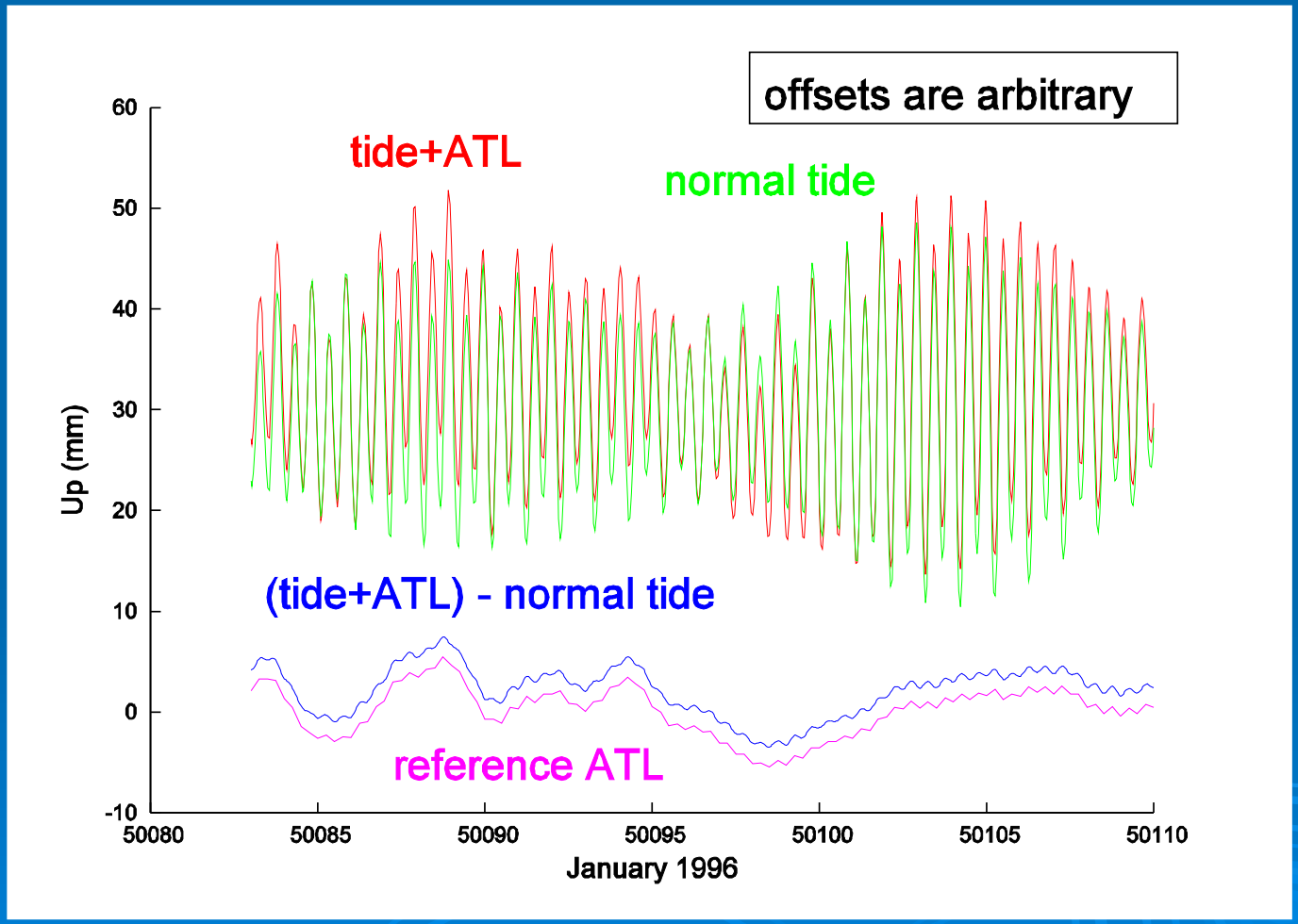
Contents of this talk

- The International Earth Rotation Service does not yet prescribe how to correct for atmospheric loading.
- Normally, one subtracts the atmospheric loading from the GPS position time-series.
- Tregoning & van Dam (GRL, 2005) show that better results are obtained when the loading is subtracted at the GPS processing level.
- How to do the same with the GPS analysis software GIPSY?

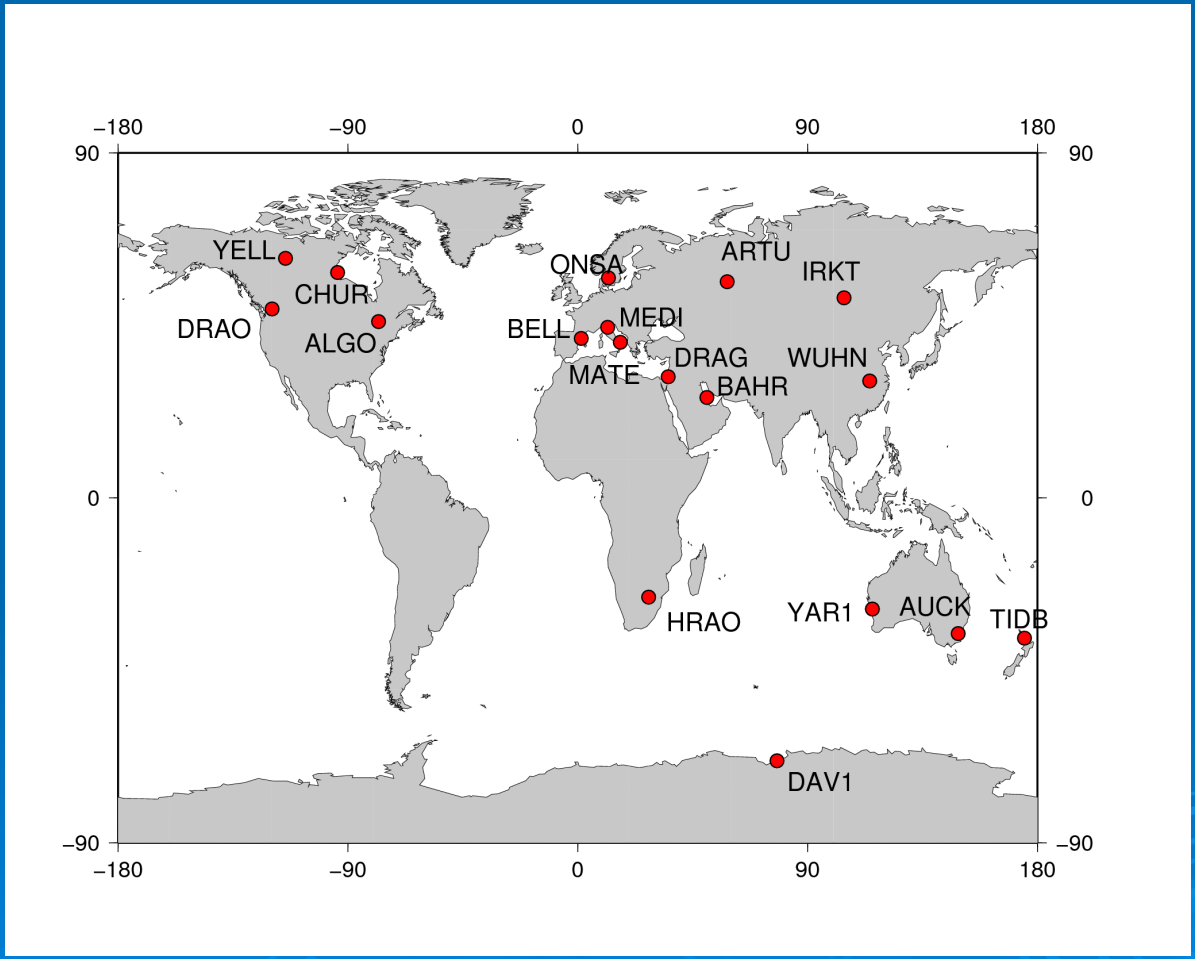
Our approach

- GIPSY can correct for ocean tide loading at the processing level.
- The ocean tide loading values are given in a so-called BLQ-file which contains, for each component, amplitudes and phase-lags for the 11 largest tidal periods.
- We adjust the BLQ-file values in such a way that they describe ocean tide *and* atmospheric loading.
- We do this for every day which produces a set of BLQ-files instead of only one file.

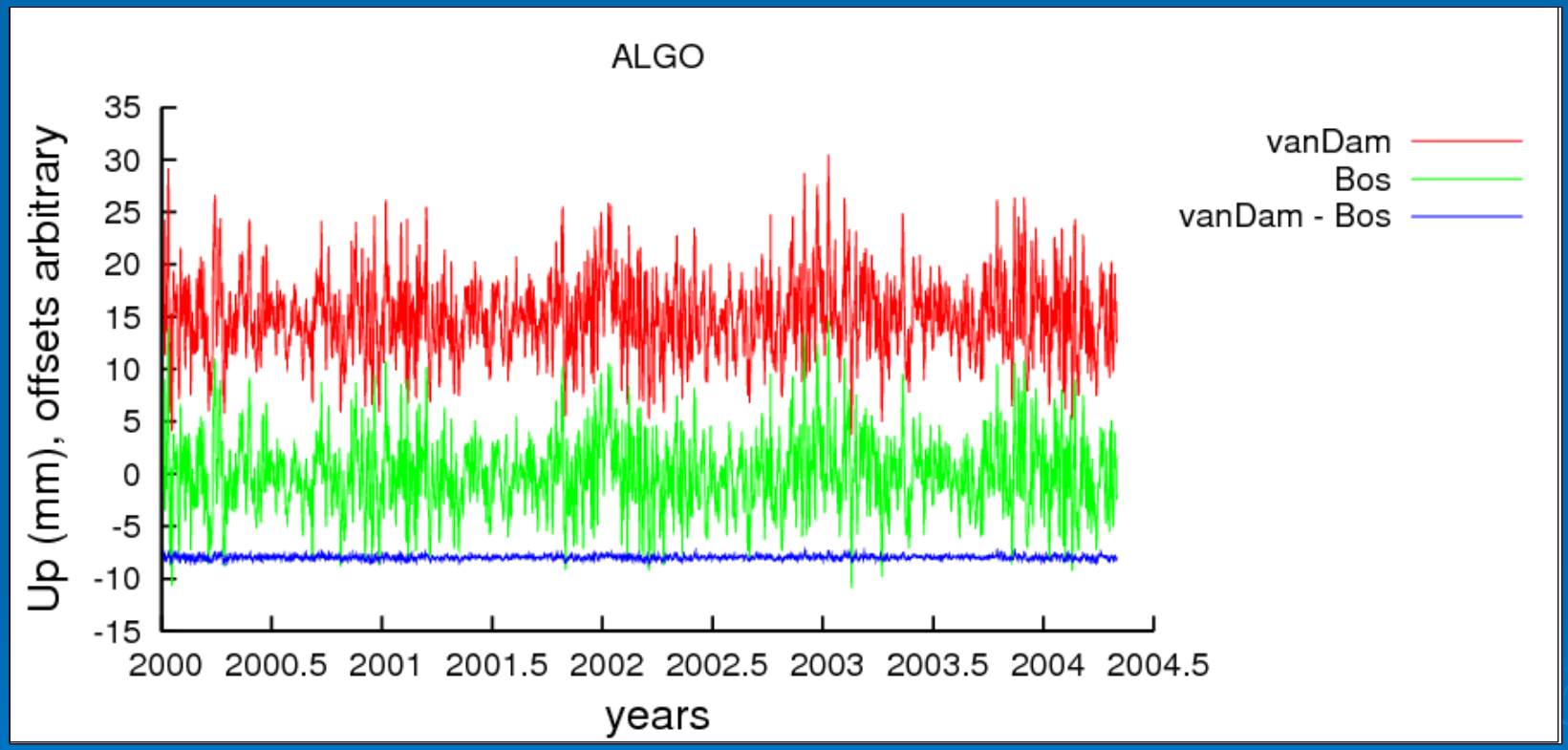
Example (BELL)



Stations used in reseach

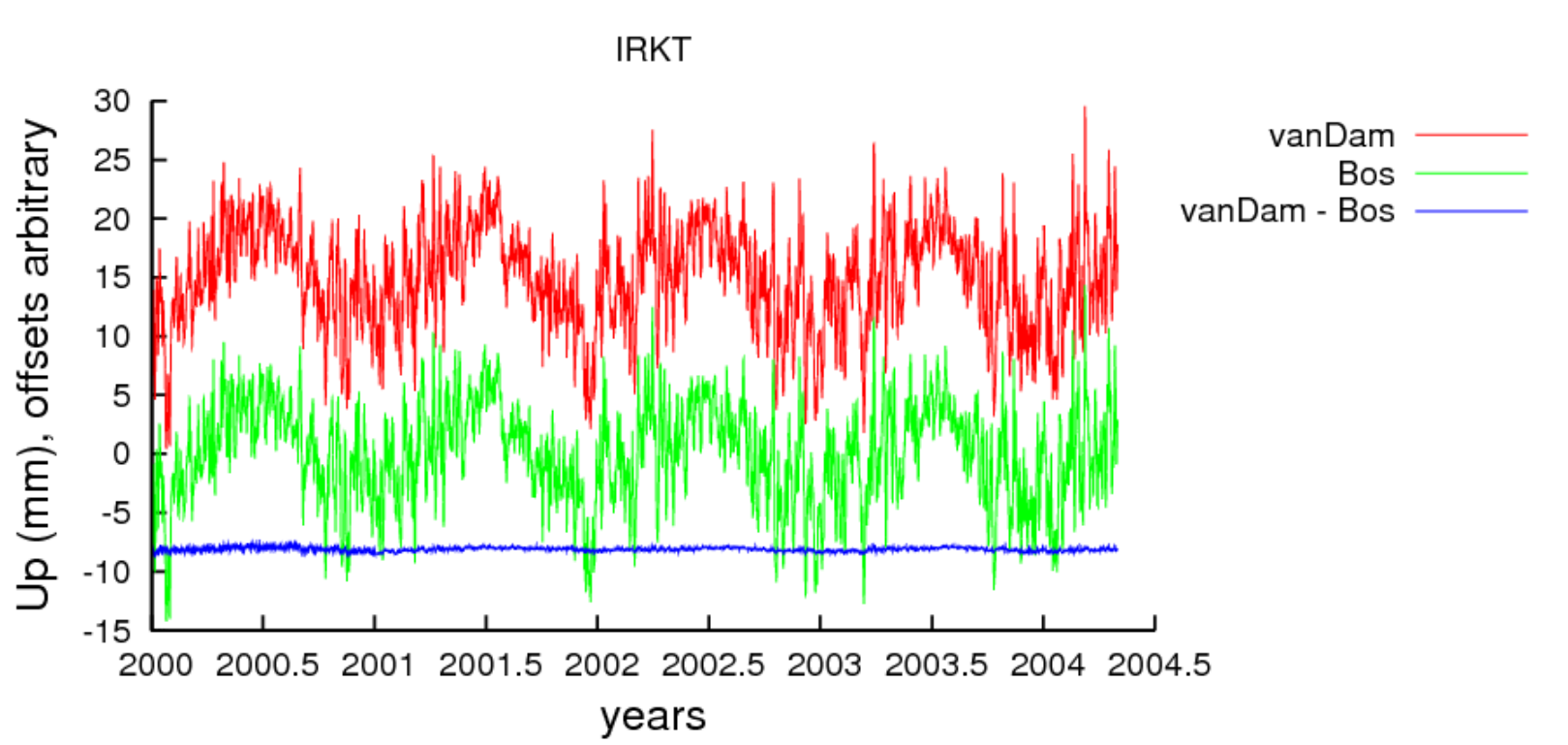


Comparison atmospheric loading



NCEP surface pressure,
modified inverted barometer,
PREM Green's function

Comparison atmospheric loading



NCEP surface pressure,
modified inverted barometer,
PREM Green's function

GIPSY processing

- PPP approach.
  - JPL orbits
  - no integer-ambiguity fixing
  - elevation cut-off: 8º
  - relative phase centers applied
  - GOT00.2 ocean tide loading model used

- Mapping
  - 7-parameters (Helmert) transformation
  - Global approach (~ 120 stations)
  - Same parameters applied in all tests

Example of the ocean tide loading provider output: BLQ-format - Microsoft Internet Explorer

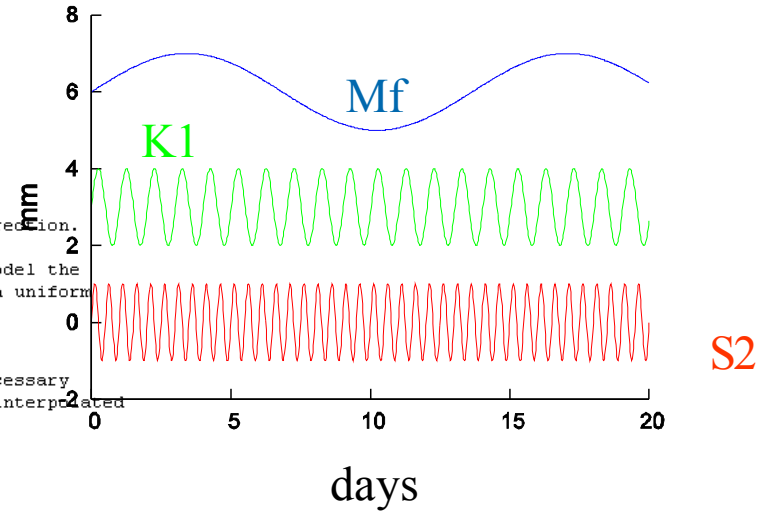
File Edit View Favorites Tools Help

Back Search Favorites

Address http://www.oso.chalmers.se/%7Eloading/example_blq.html

Google Search 6 blocked Check AutoLink AutoFill Options

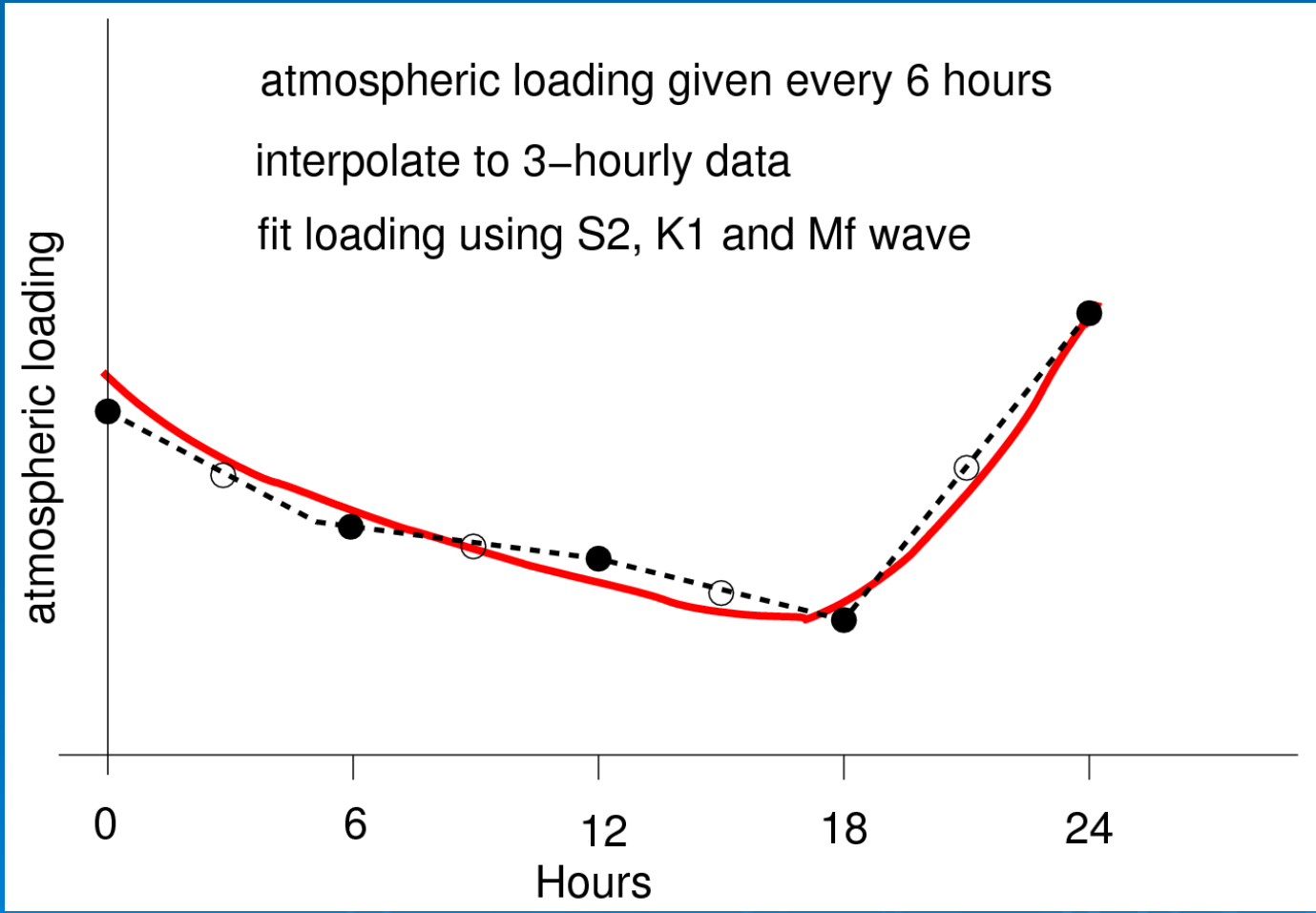
```
$$ COLUMN ORDER: M2 S2 N2 K2 K1 O1 P1 Q1 MF MM SSA
$$
$$ ROW ORDER:
$$ AMPLITUDES (m)
$$ RADIAL
$$ TANGENTL EW
$$ TANGENTL NS
$$ PHASES (degrees)
$$ RADIAL
$$ TANGENTL EW
$$ TANGENTL NS
$$
$$ Displacement is defined positive in upwards, South and West direction.
$$ The phase lag is relative to Greenwich and lags positive. The
$$ Gutenberg-Bullen Green's function is used. In the ocean tide model the
$$ deficit of tidal water mass has been corrected by subtracting a uniform
$$ layer of water with a certain phase lag globally.
$$
$$
$$ Complete <model name> : No interpolation of ocean model was necessary
$$ <model name>_PP       : Ocean model has near the station been interpolated
$$
$$ Ocean tide model: GOT00.2, long period tides from FES99
$$
$$
  Onsala
$$ GOT00.2_PP ID: Aug  16, 2001 13:35
$$ Computed by OLMPP by H G Scherneck, Onsala Space Observatory, 2001
$$ Onsala                                  RADI TANG lon/lat:   11.9264   57.3958
  .00366  .00123  .00089  .00032  .00223  .00115  .00071  .00009  .00091  .00048  .00042
  .00149  .00035  .00040  .00009  .00046  .00043  .00015  .00009  .00013  .00006  .00007
  .00069  .00027  .00020  .00004  .00029  .00014  .00009  .00004  .00003  .00002  .00001
   -62.3   -51.3   -94.8   -39.7   -57.7  -110.6   -60.3  -164.6     9.9     5.8     2.1
    87.0   114.0    57.2   126.4   102.3    35.4    97.0    -6.8  -166.3  -169.8  -177.7
   109.9   152.4    86.4   149.1    50.7   -59.4    47.7   173.6   -27.8    -1.5     7.3
```



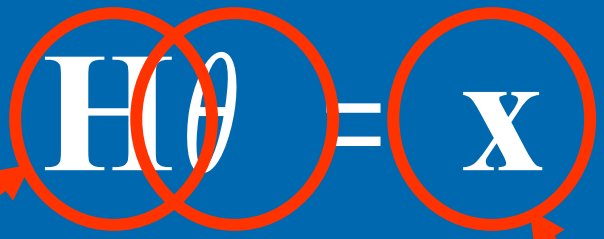
S2, 12 h K1, 23.93 h Mf, 13.66 days

Done Internet

One BLQ-file for each day



Fitting equation (for each day)



Design matrix, computed with hardisp.
(9 rows, 6 columns)

Vector with 9 ATL values

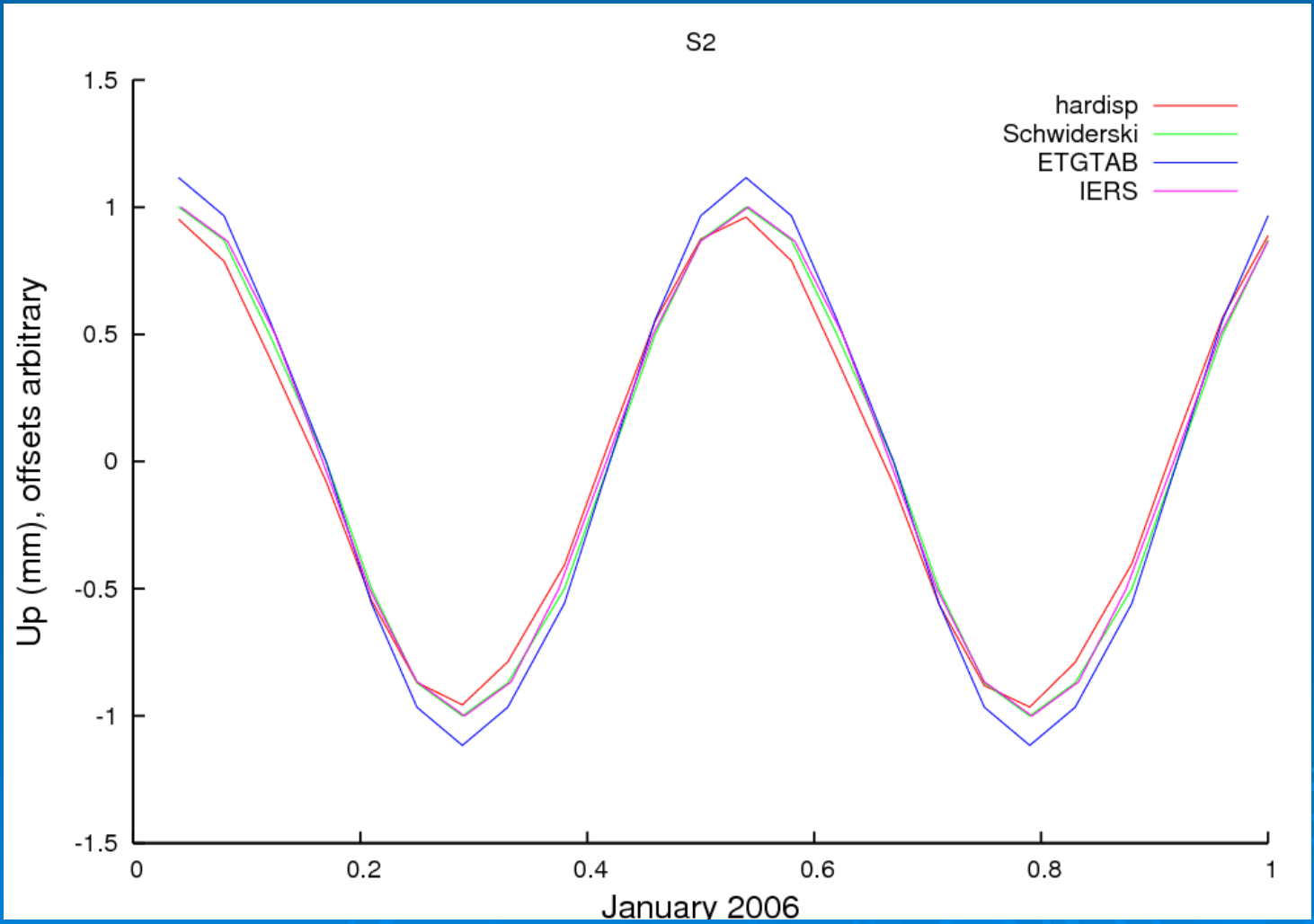
Vector with unknown parameters (amplitudes & phase-lags for S2, K1 and Mf : 6 unkowns)

How to compute the design matrix H?

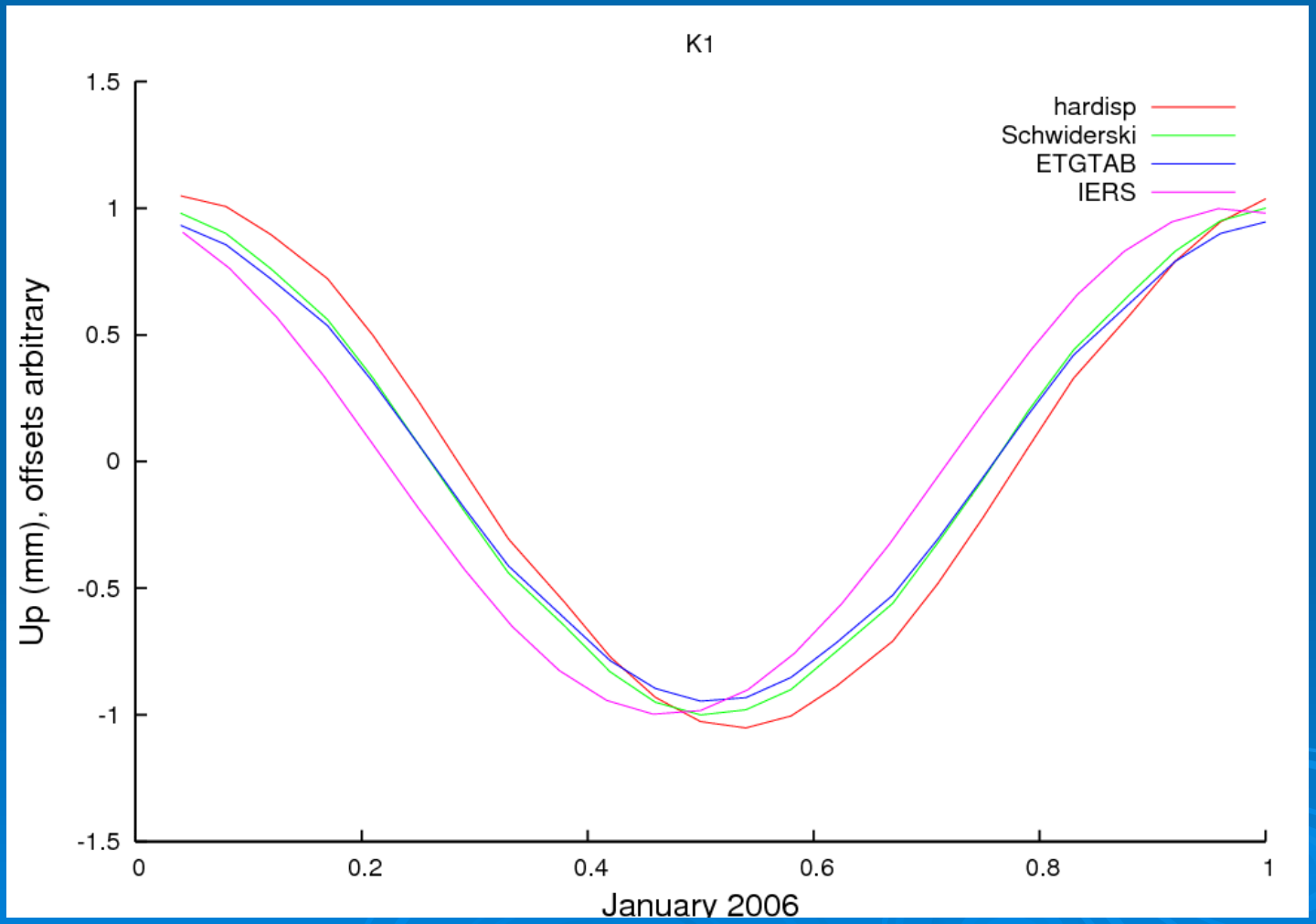
- Use the program hardisp.f of Prof. Duncan Agnew.
- Another program that does the same is ETGTAB.F which is part of the ETERNA tidal analysis package (Wenzel, 1996).
- Use the program ARG.F given in IERS convention 1996 (Scherneck):

$$x(t) = \sum_{i=1}^{11} A_i \cos(\omega_i t + \varphi_i)$$

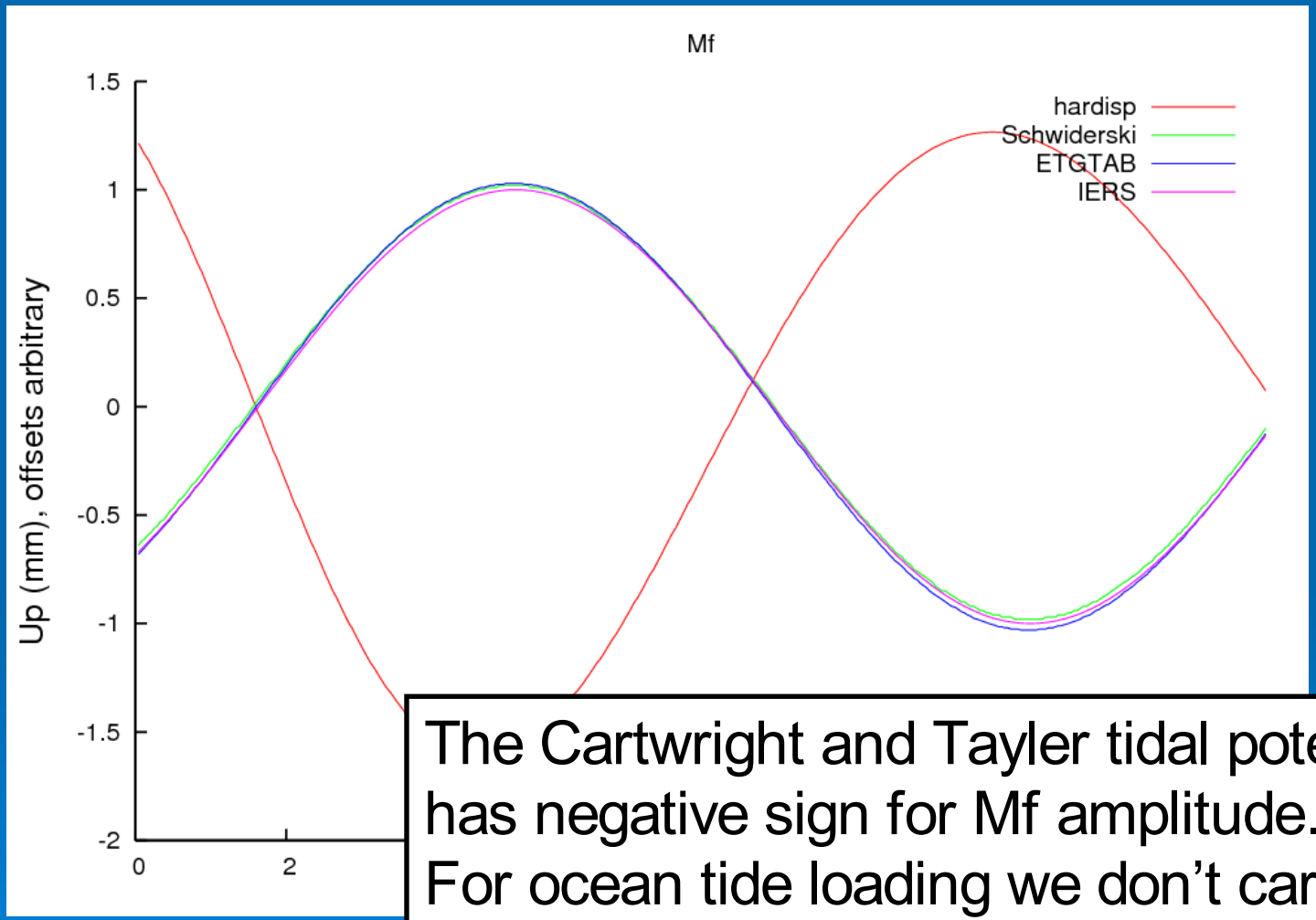
Example design matrix: S2



Example design matrix: K1



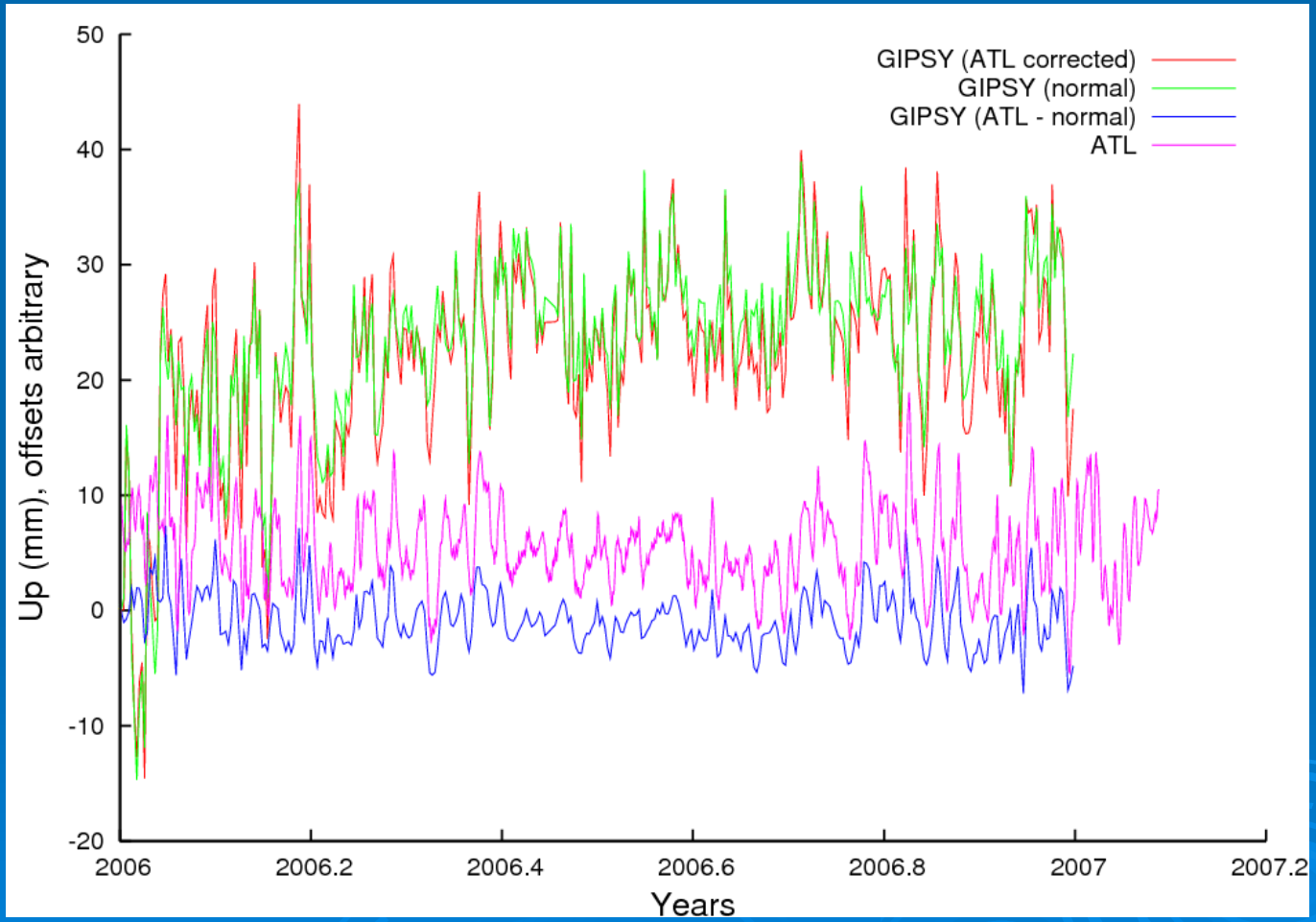
Example design matrix: Mf



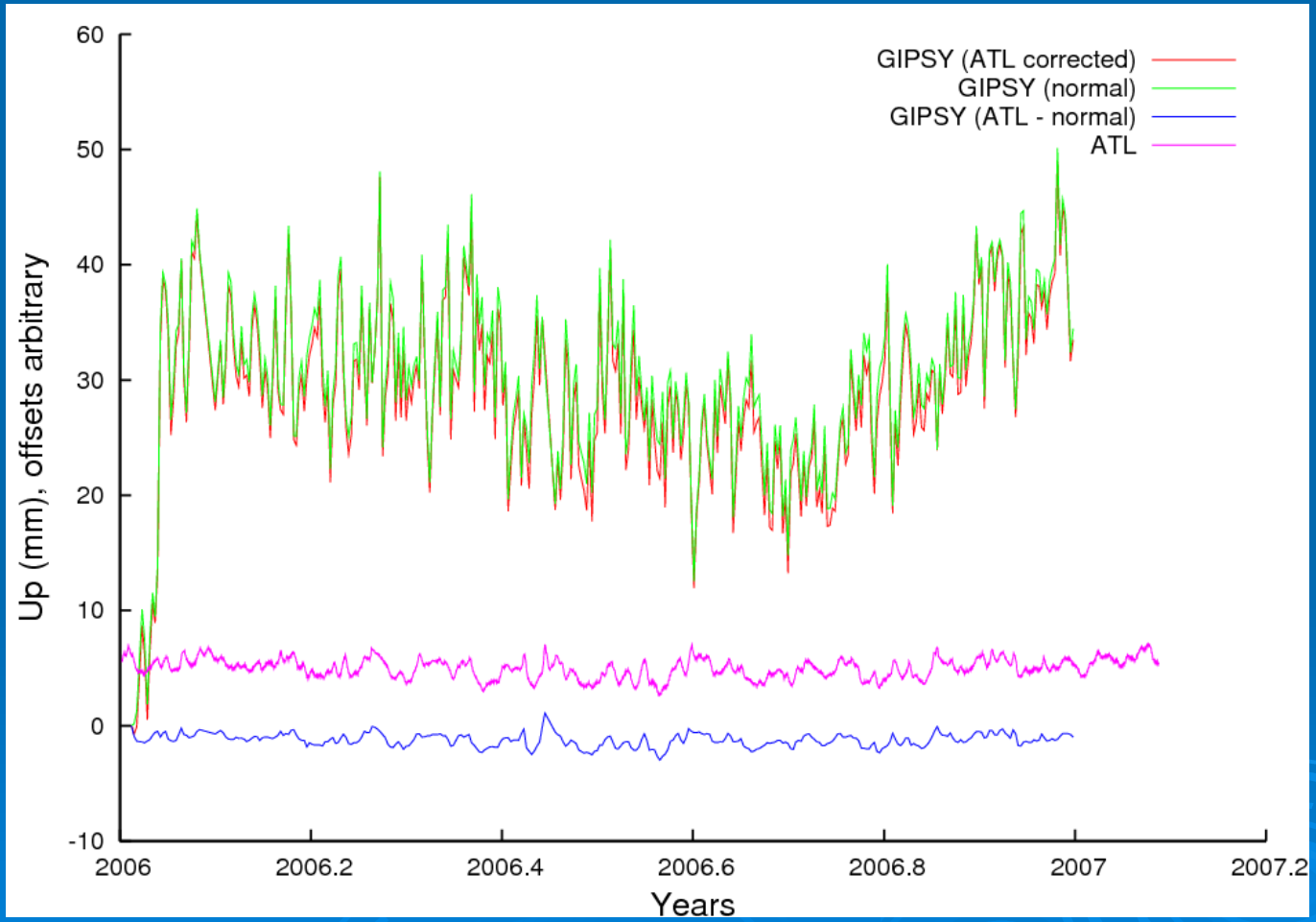
The Cartwright and Tayler tidal potential has negative sign for Mf amplitude. For ocean tide loading we don't care about that.

"Theoretically speaking,
there is no difference between theory and practise.
But in practise, there often is.."

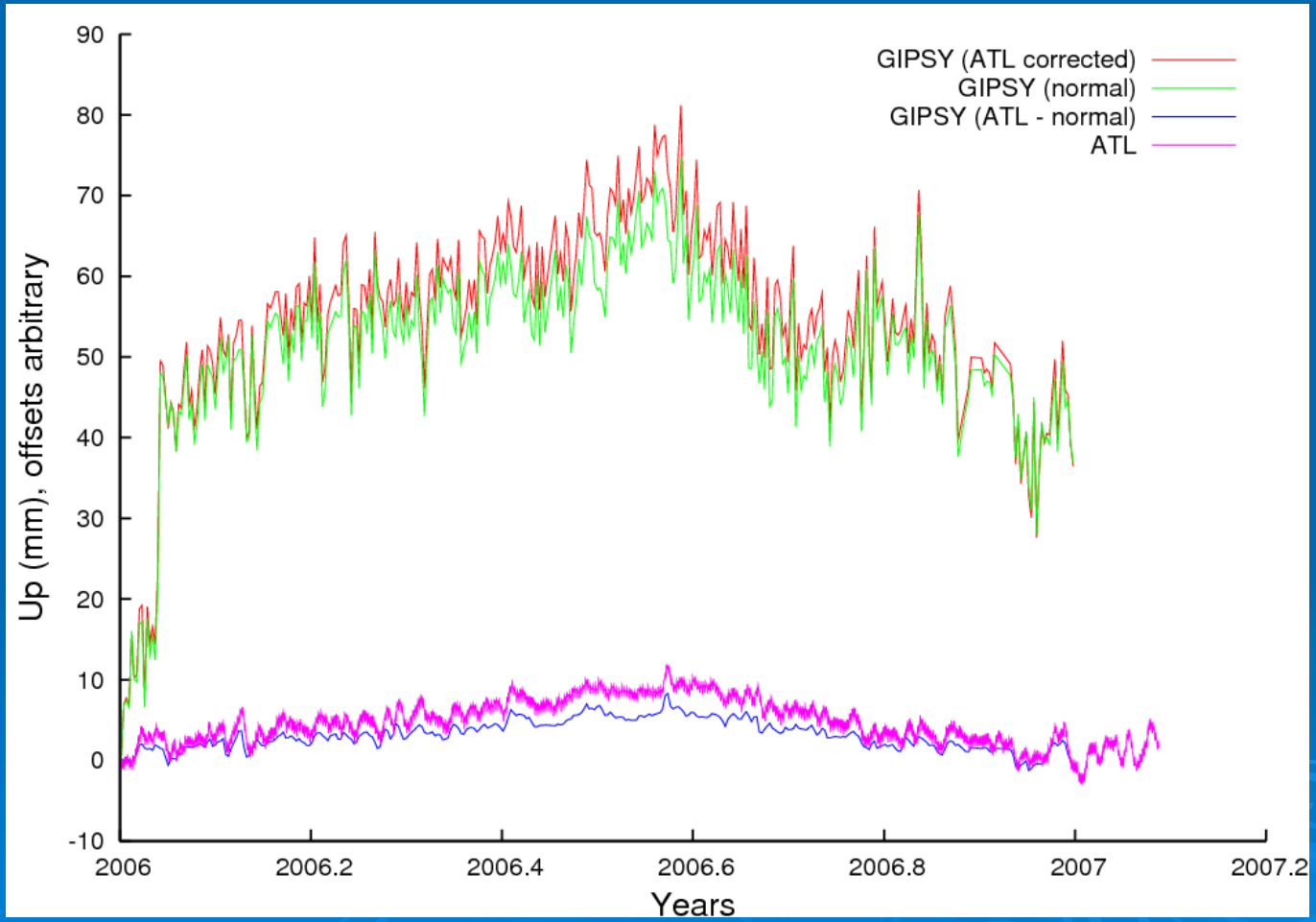
ALGO (Up)


GIPSY (ATL corrected)
GIPSY (normal)
GIPSY (ATL - normal)
ATL
Up (mm), offsets arbitrary
50
40
30
20
10
0
-10
-20
2006
2006.2
2006.4
2006.6
2006.8
2007
2007.2
Years

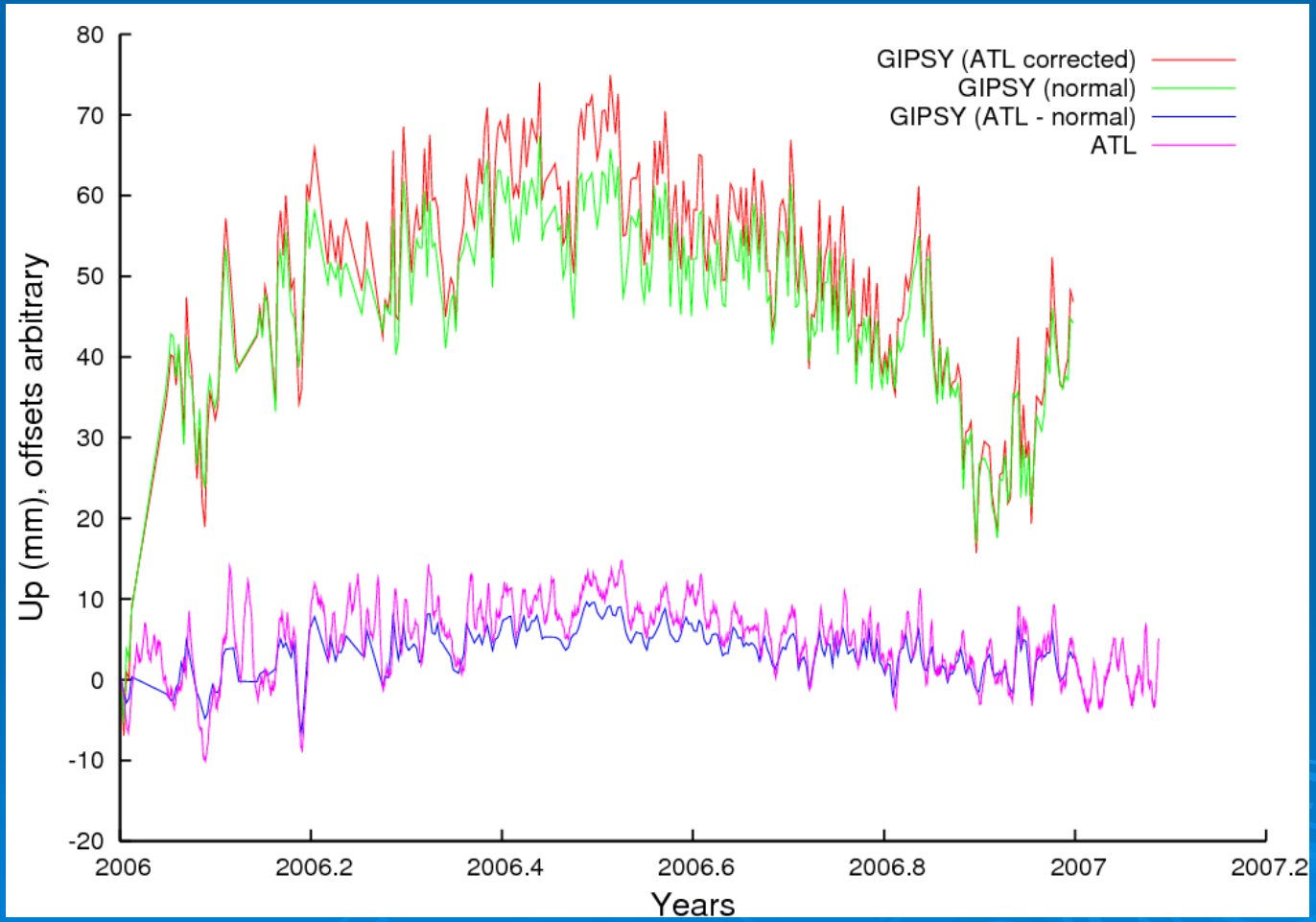
AUCK (Up)


GIPSY (ATL corrected)
GIPSY (normal)
GIPSY (ATL - normal)
ATL
Up (mm), offsets arbitrary
60
50
40
30
20
10
0
-10
2006
2006.2
2006.4
2006.6
2006.8
2007
2007.2
Years

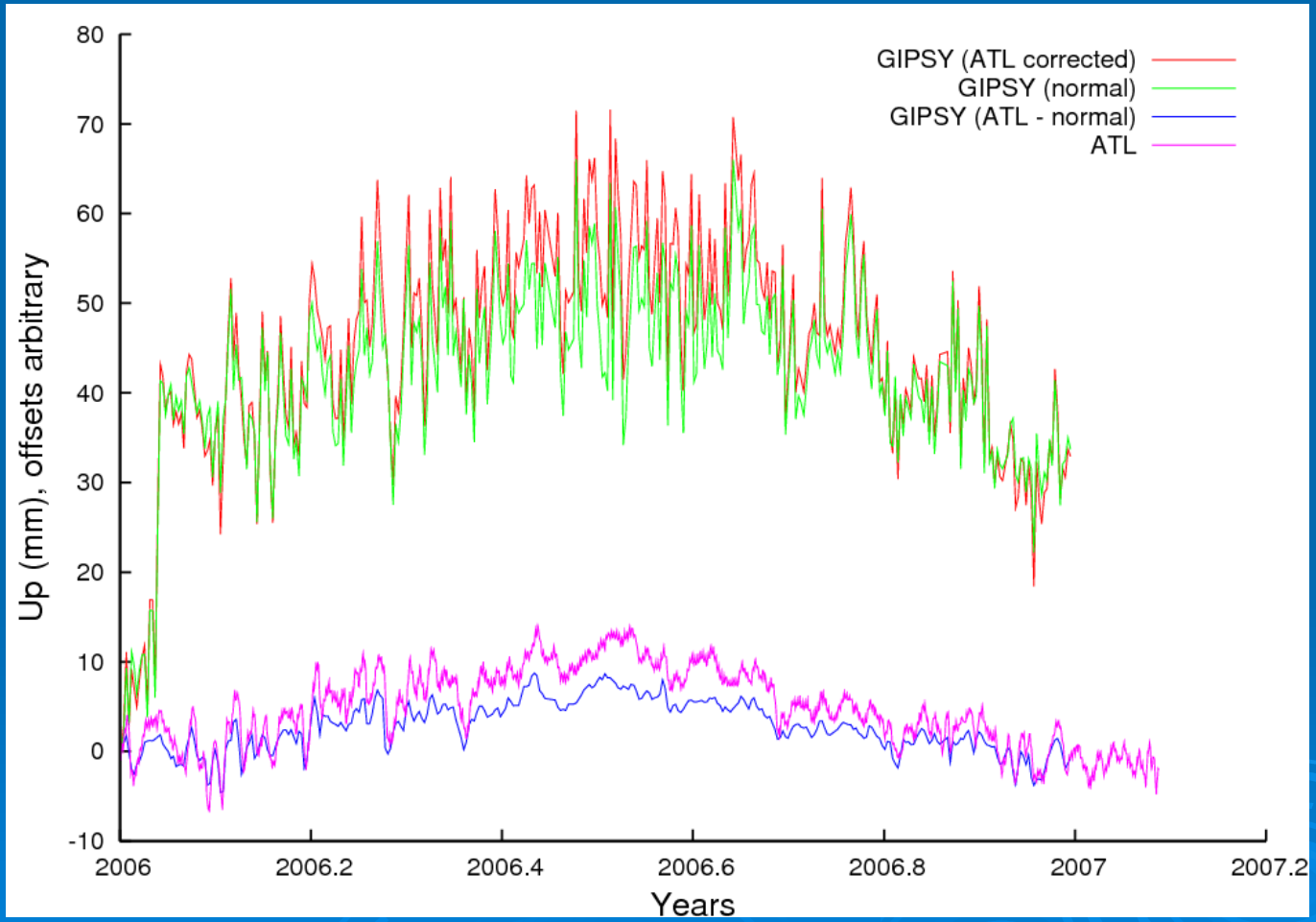
BAHR (Up)


GIPSY (ATL corrected)
GIPSY (normal)
GIPSY (ATL - normal)
ATL
Up (mm), offsets arbitrary
90
80
70
60
50
40
30
20
10
0
-10
2006
2006.2
2006.4
2006.6
2006.8
2007
2007.2
Years

IRKT (Up)


GIPSY (ATL corrected)
GIPSY (normal)
GIPSY (ATL - normal)
ATL
Up (mm), offsets arbitrary
Years
80
70
60
50
40
30
20
10
0
-10
-20
2006
2006.2
2006.4
2006.6
2006.8
2007
2007.2

WUHN (Up)


GIPSY (ATL corrected)
GIPSY (normal)
GIPSY (ATL - normal)
ATL
Up (mm), offsets arbitrary
Years
80
70
60
50
40
30
20
10
0
-10
2006
2006.2
2006.4
2006.6
2006.8
2007
2007.2

Conclusions

- Atmospheric loading has its largest power in the annual period.
- The BLQ-files can be used to model the atmospheric loading.
- Hardisp needs correction of long period tide Mf.

Not the end of the story...

- Nice Suggestions and/or Positive Comments
  - Now
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- Nasty Remarks
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