Effects of ICRF2 on estimates of Earth orientation parameters and of the terrestrial reference frame

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Outline

Test the effects of ICRF2 (IERS, 2009)

vs. ICRF-Ext.2 ('IEXT2'), Ma et al., (1998), Fey et al., (2004) by

(1) Comparing ICRF2 ('fix') vs. ICRF-Ext.2 ('fix')
(2) Comparing ICRF2 ('free') vs. ICRF-Ext.2 ('free')

(3) Comparing ICRF2 ('fix') vs. ICRF2 ('free')
(4) Comparing ICRF-Ext.2 ('fix') vs. ICRF-Ext.2('free')

not shown here!

DGFI global VLBI solution

Observations	~3300 X-band VLBI-sessions of the geodetic and astrometric programs from 1984.0 to 2010.0 (5.2 mill. delays)		
Models	IERS conventional models (McCarthy & Petit, 2004) + non-zero apriori gradients (MacMillan & Ma, 1998) + atmospheric loading corrections (Petrov & Boy, 2004) + thermal antenna deformations (Nothnagel, 2008)		
Parameters	EOP, atmosphere + clock parameters		
Solution type		‚fix‘	‚free‘
Time-series analysis	station coordinates NNR/NNT on all stations	no estimation of sources	sources estimated + session-wise NNR on all sources
Reference frame analysis	station coordinates and velocities + NNR/NNT on 27 stations (ICRF2)	sources estimated but fixed by datum condition	sources estimated + global NNR on 201 defining sources of ICRF/ICRF2

Helmert transformation parameters

Helmert transformation parameters between the TRFs for

1. ICRF2fix vs. IEXT2fix
2. ICRF2free vs. IEXT2free
3. ICRF2fix vs. ICRF2free
4. IEXT2fix vs. IEXT2free

are all very small !

- max. values are (case 1.) for 2010

dX	- 0.42 +/- 0.45 mm	}	no translation! is clear,
dY	- 0.21 +/- 0.45 mm		where should it come from?
dZ	- 0.40 +/- 0.43 mm		CRF is a pure orientational issue
α	- 7.74 +/- 17.34 μas	}	no significant rotations
β	21.71 +/- 17.32 μas		overall rotations are expressed
γ	12.04 +/- 15.71 μas		by the EOP
scale	0.17 +/- 0.07 ppb		significant network scale (≈ 1.1 mm @ Earth radius)

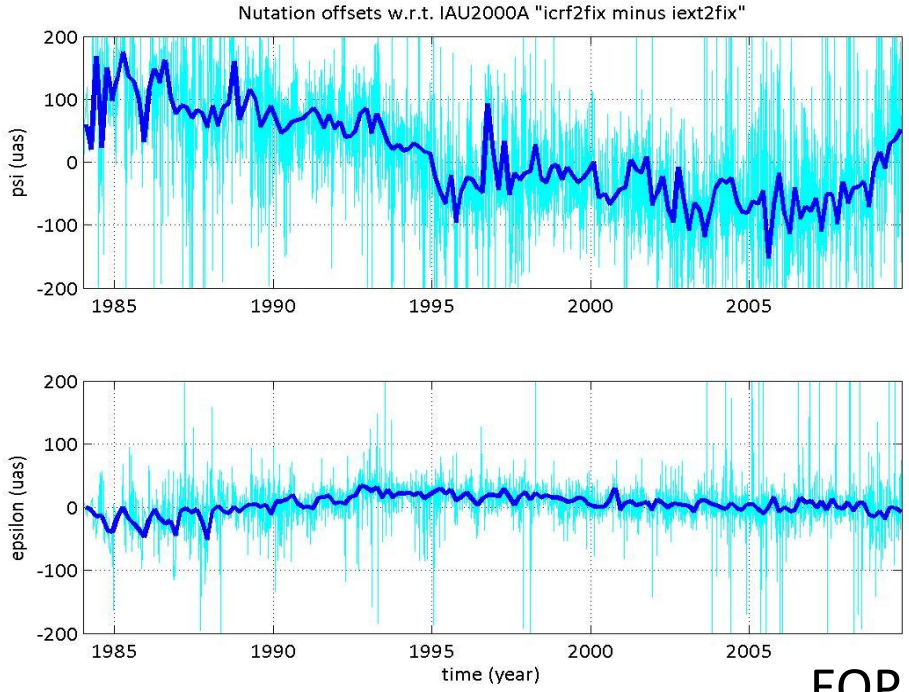
Earth Orientation Parameter comparison

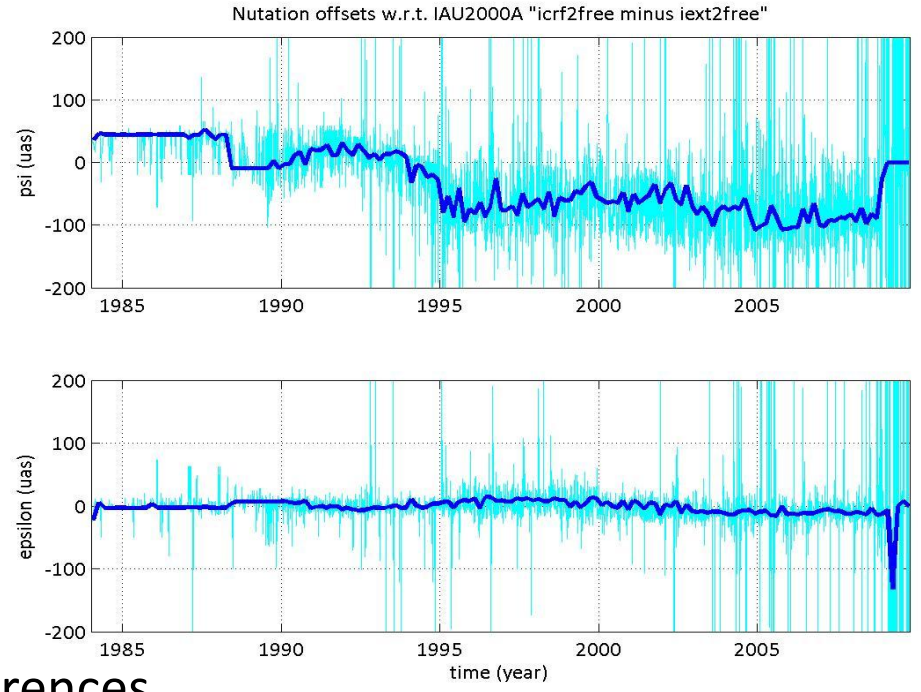
Earth orientation parameter differences between

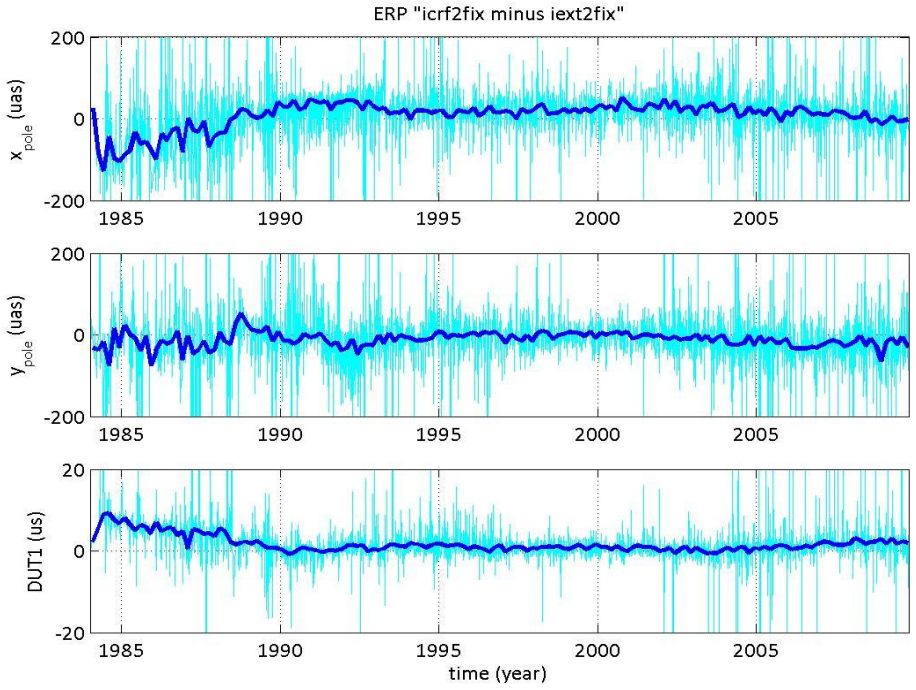
1. ICRF2fix – IEXT2fix
   psi: +/- 150 μas variations, kind of trend
   eps: +/- 40 μas variations
   xpole: kind of trend before 1990 starting at -100 μas
   DUT1: kind of trend before 1990 starting with 10 μs

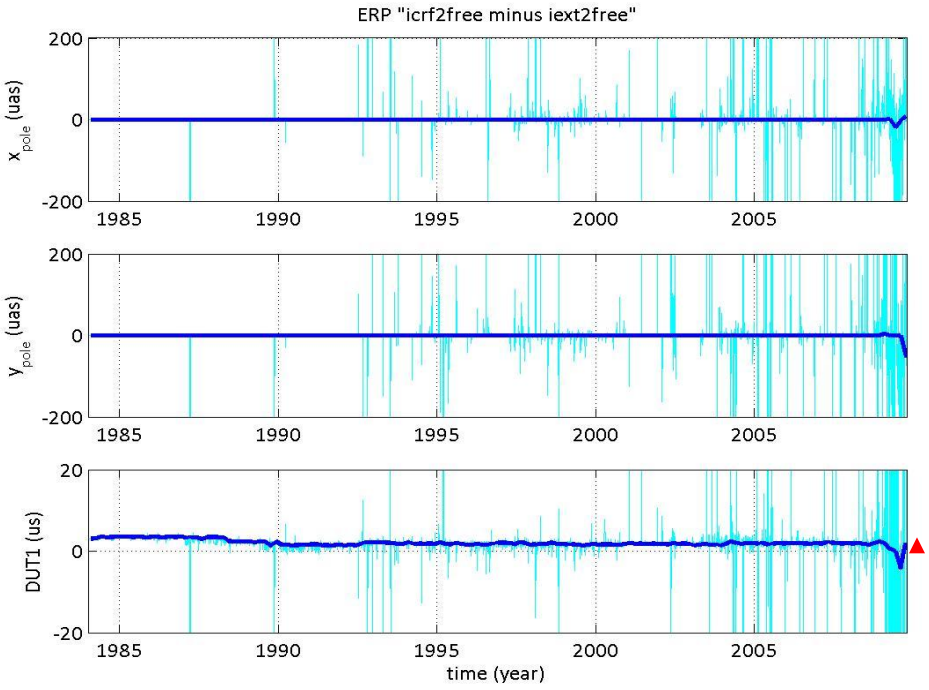
2. ICRF2free – IEXT2free
   differences are smaller in general
   psi: +50 μas to -100 μas variations
   there is a small but significant offset in DUT1 (2.5 μas)

EOP differences







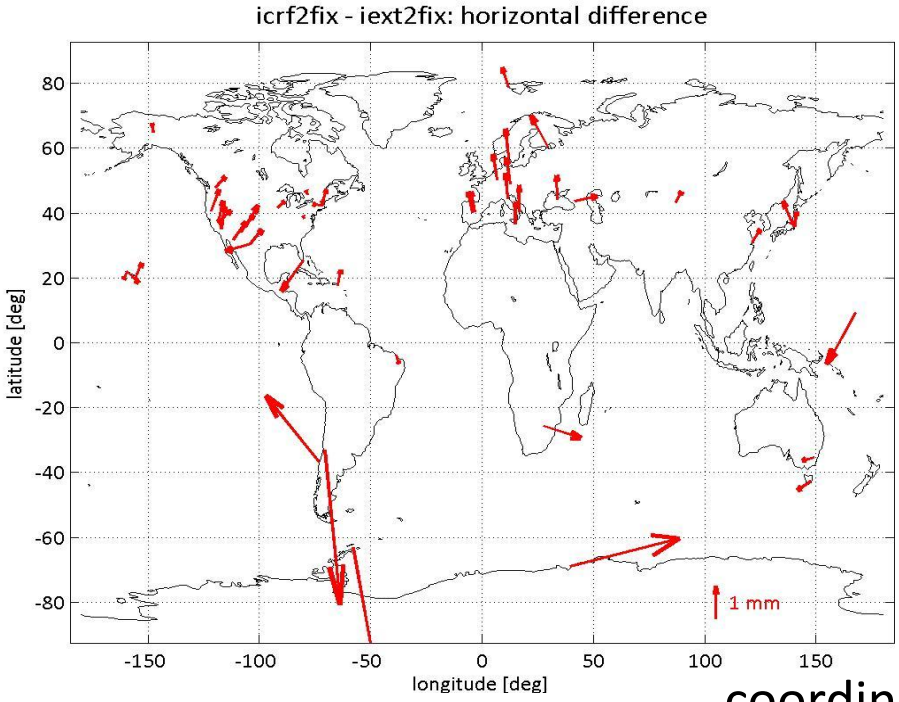


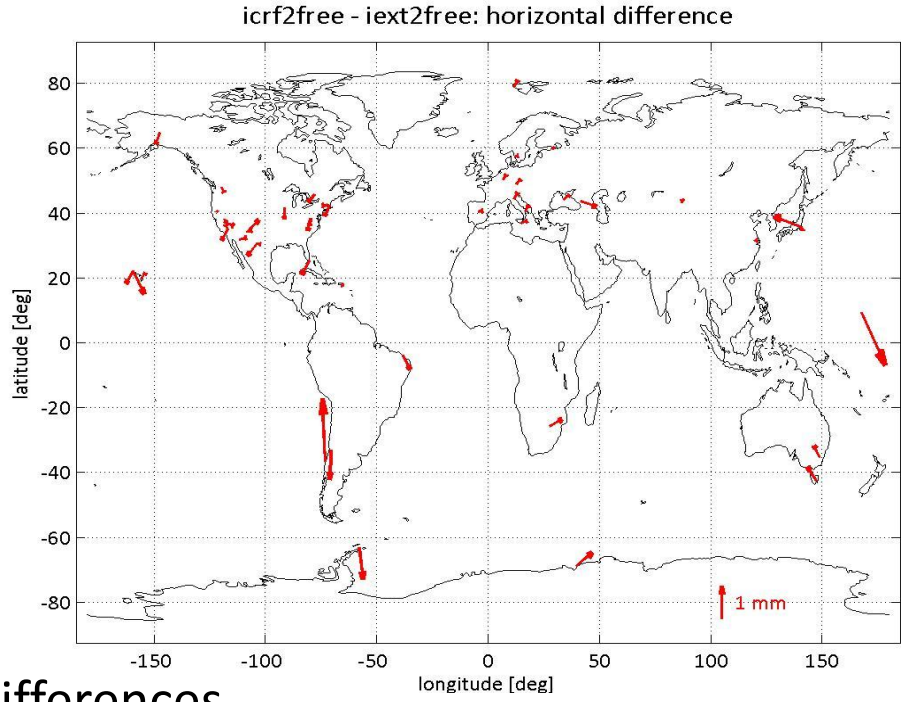
TRF comparison (coordinates)

1. ICRF2fix – IEXT2fix
   Coordinate differences:
   - station fields on the northern hemisphere
     - are shifted northwards
     - and downwards (that‘s where the scale difference comes from)
     - (an effect of the non-zero a priori gradients?)
   - sites on the southern hemisphere show no systematic behaviour

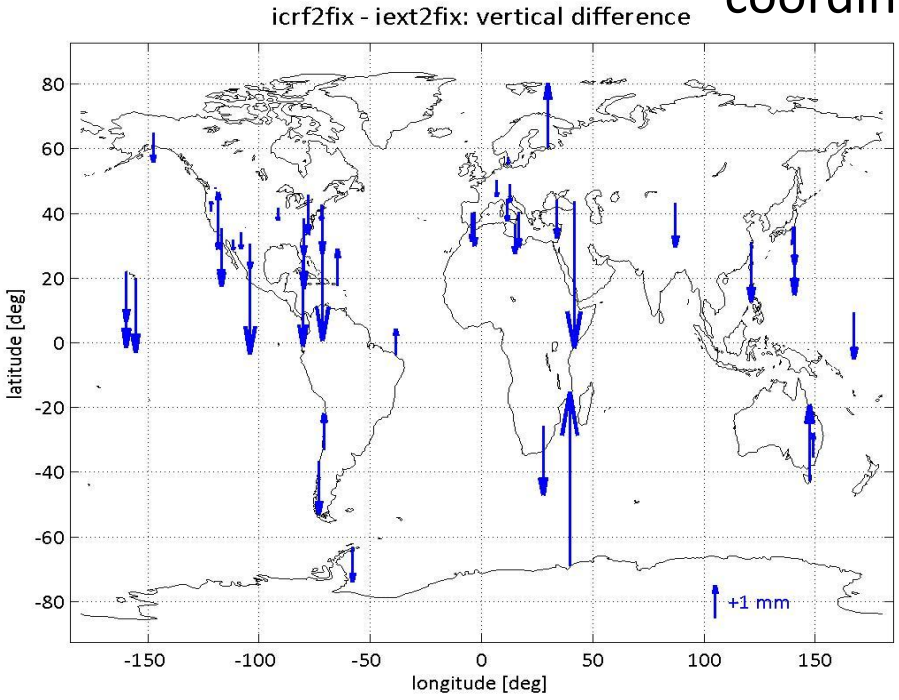
2. ICRF2free – IEXT2free

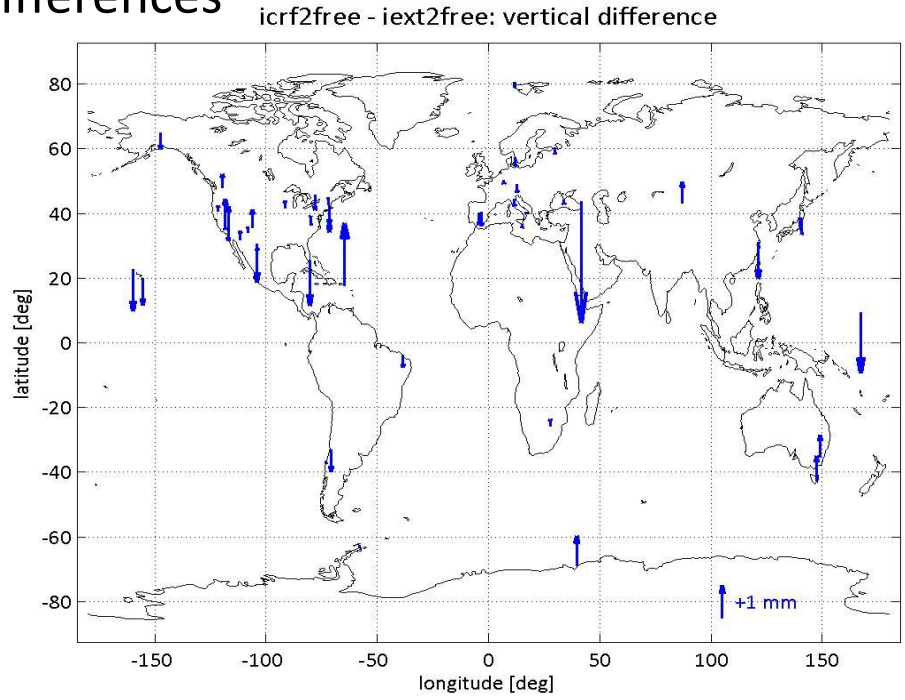
   Station coordinate differences are generally smaller but still significant
   northern hemispheric sites point in the same directions as (1.)
   southern sites show no systematic behaviour apart from (1.)





coordinate differences





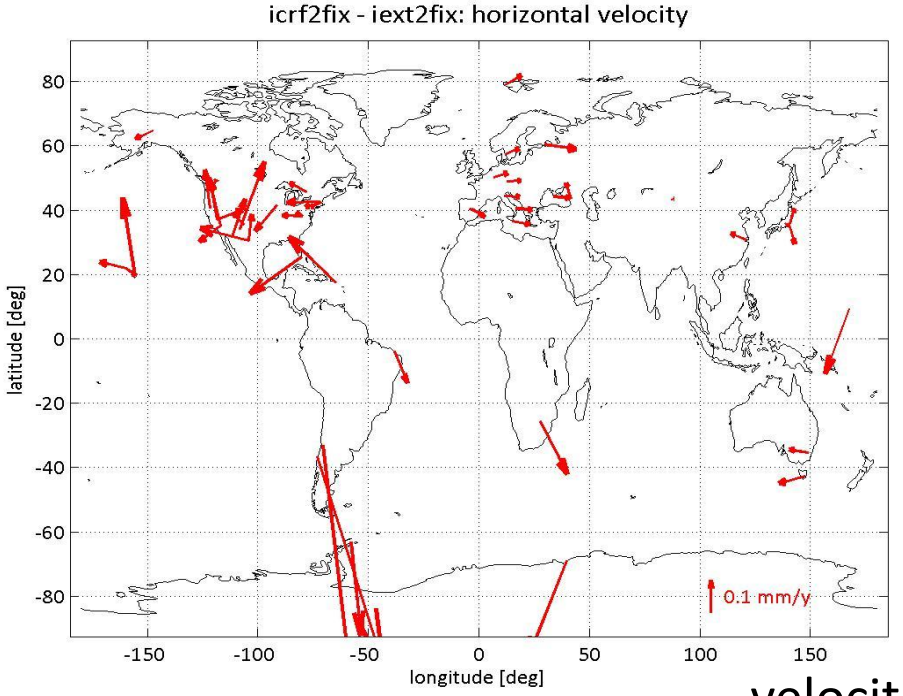
TRF comparison (velocities)

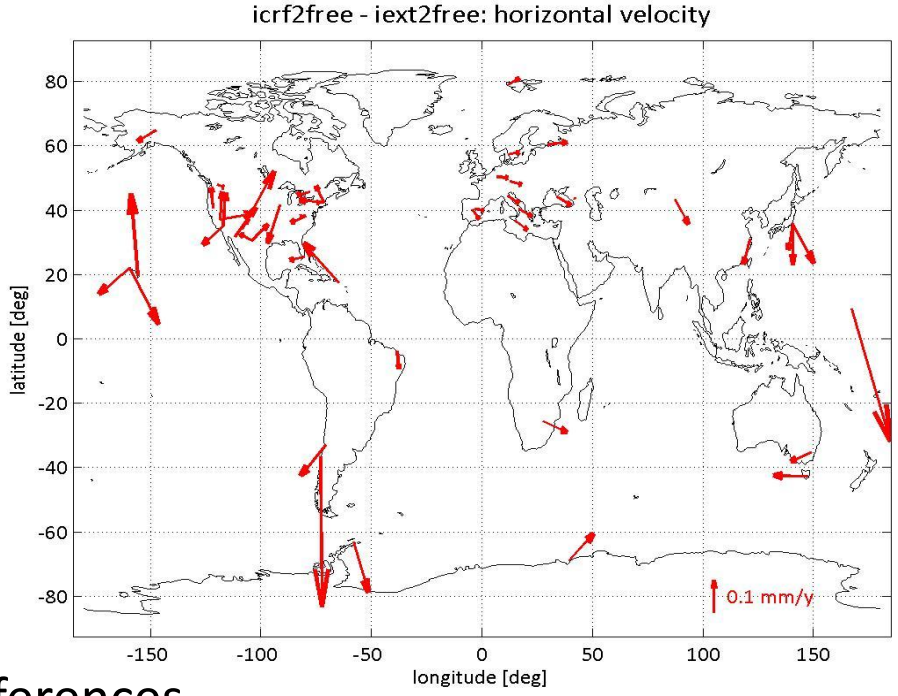
1. ICRF2fix – IEXT2fix

   Station velocity differences:
   most sites show insignificant small variations (below 0.2 mm/year) and no systematic directions, however neighbouring sites show common difference patterns

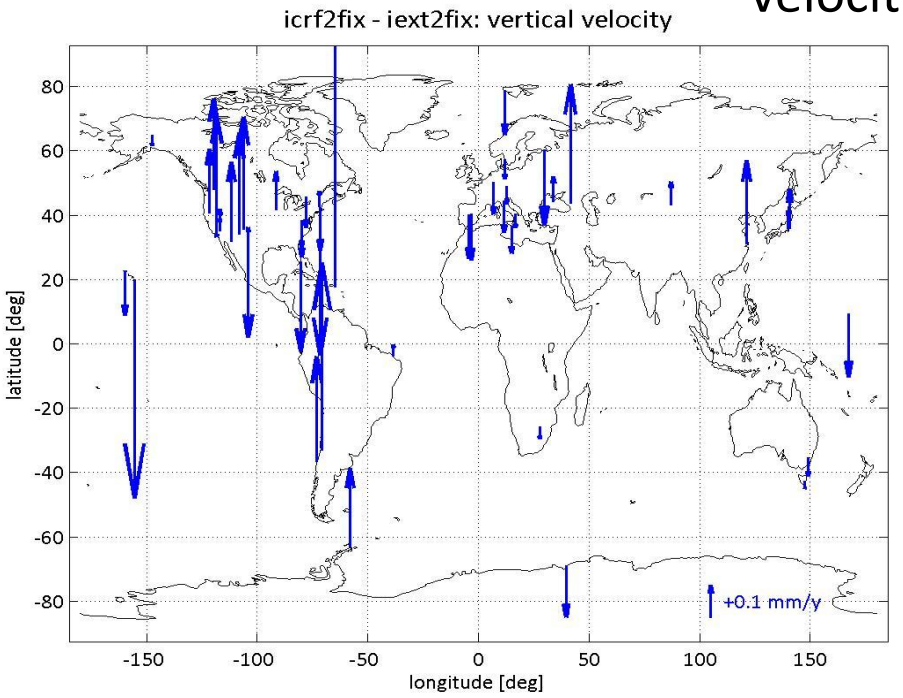
2. ICRF2free – IEXT2free

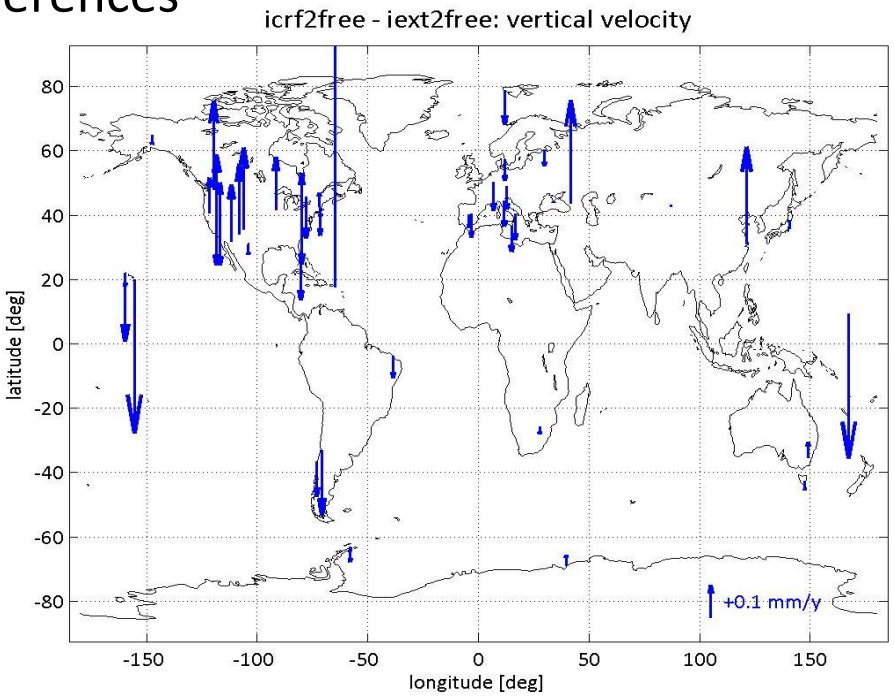
   Station velocity differences point in the same directions
   but are generally smaller, both insignificant





velocitiy differences

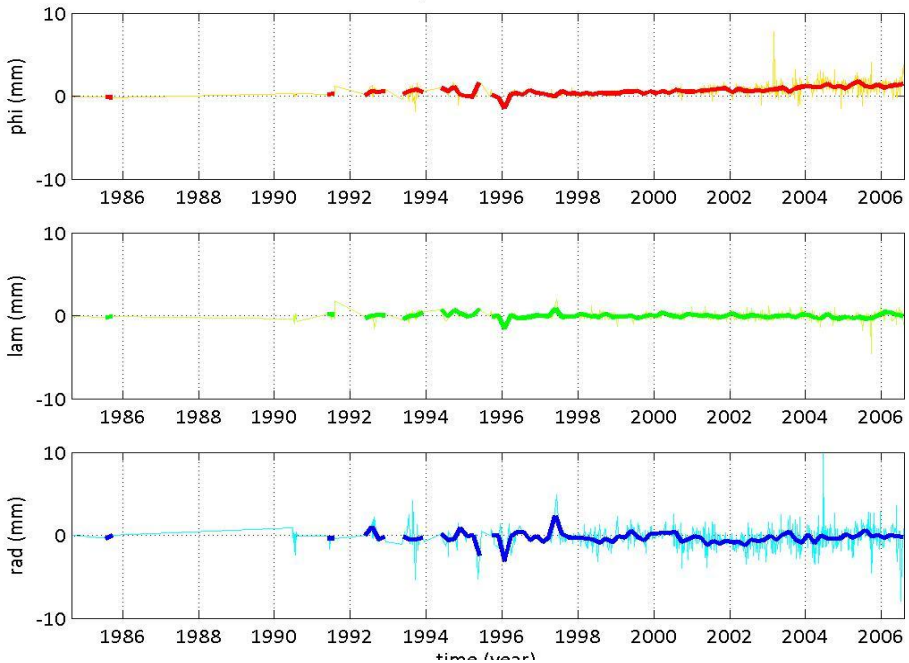


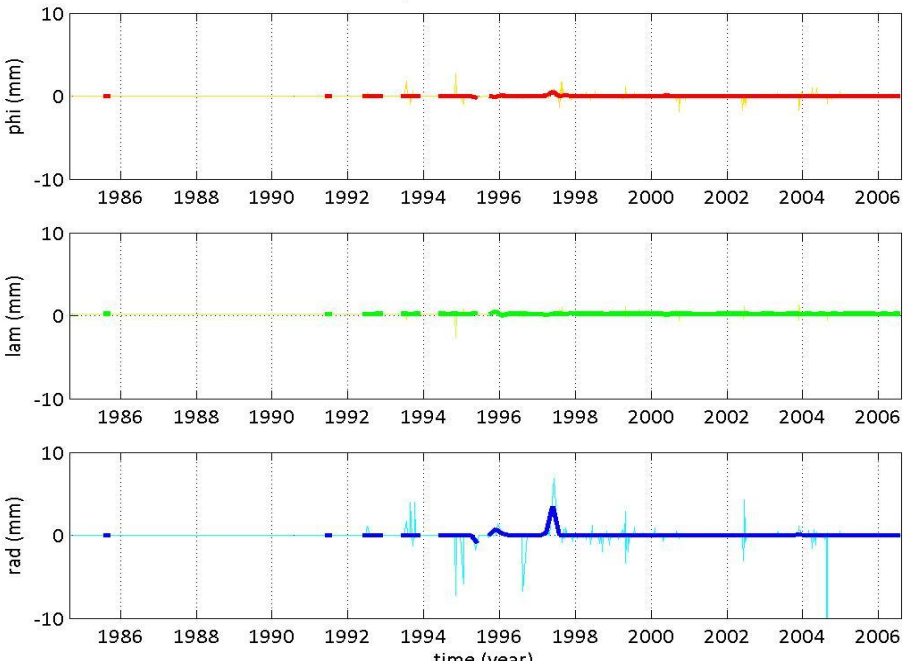


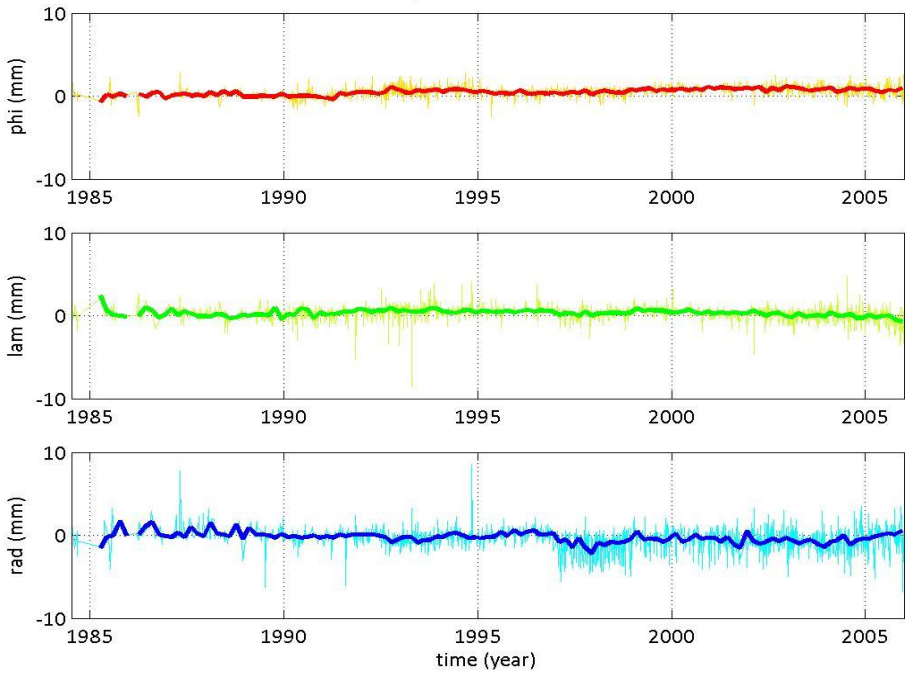
Time-series comparison (coordinates)

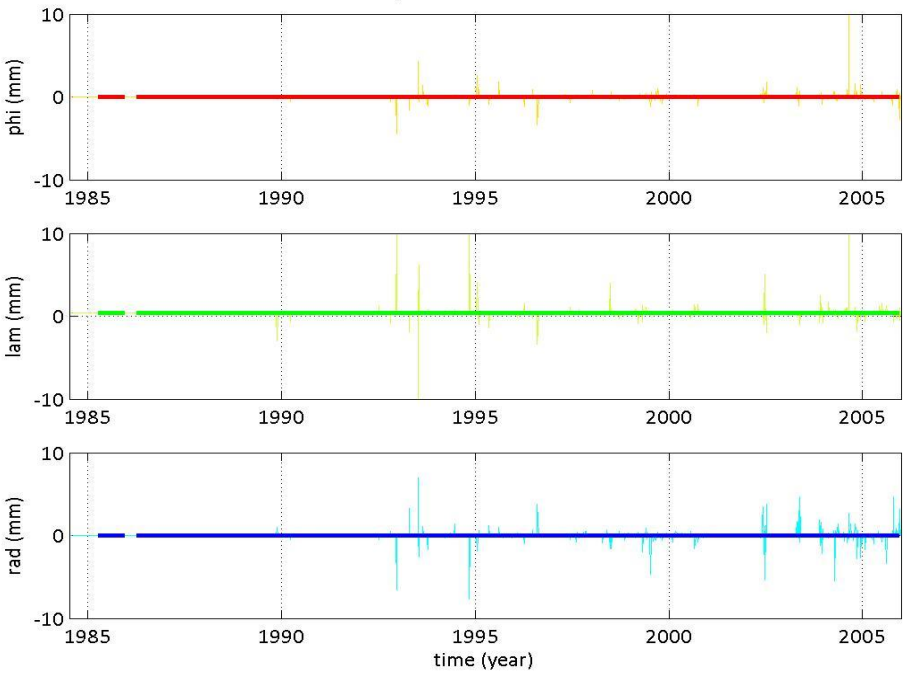
1. ICRF2fix – IEXT2fix
   time-series of station coordinate differences
   at the northern hemisphere are mostly negligable (below +/- 1 mm)
   at the southern hemisphere larger variations can be observed
      in the vertical components (max. +/- 7 mm) and
      in the horizontal components (+/- 2 mm)
      (which are most probably due to a significant gain of precission of southern hemisphere source positions in ICRF2)
   there are no significant trends
   (only ALGOPARK shows a very small trend, where does it come from?)

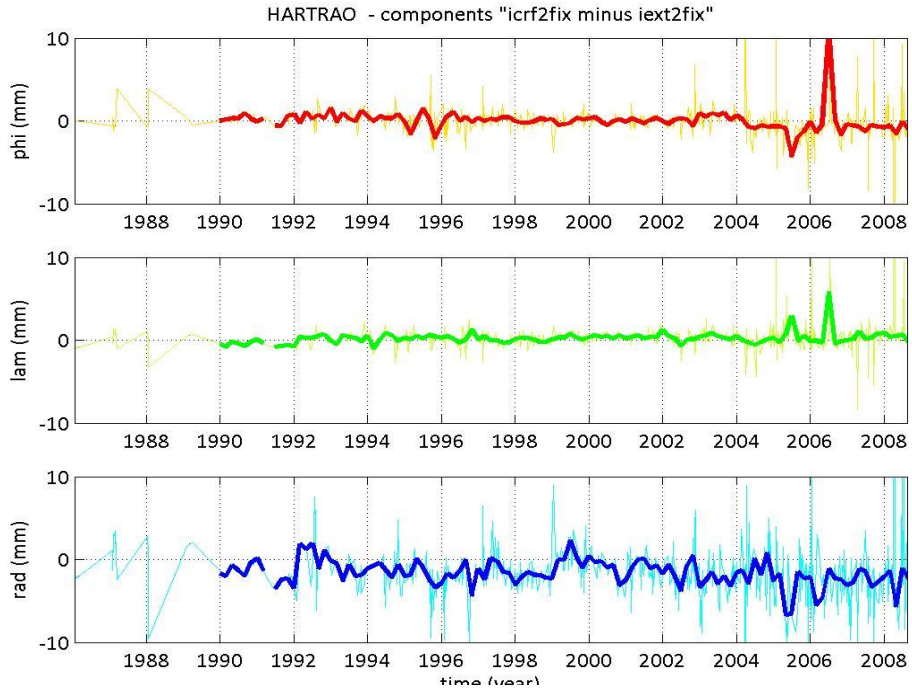
2. ICRF2free – IEXT2free
   no significant differences of station coordinate time-series

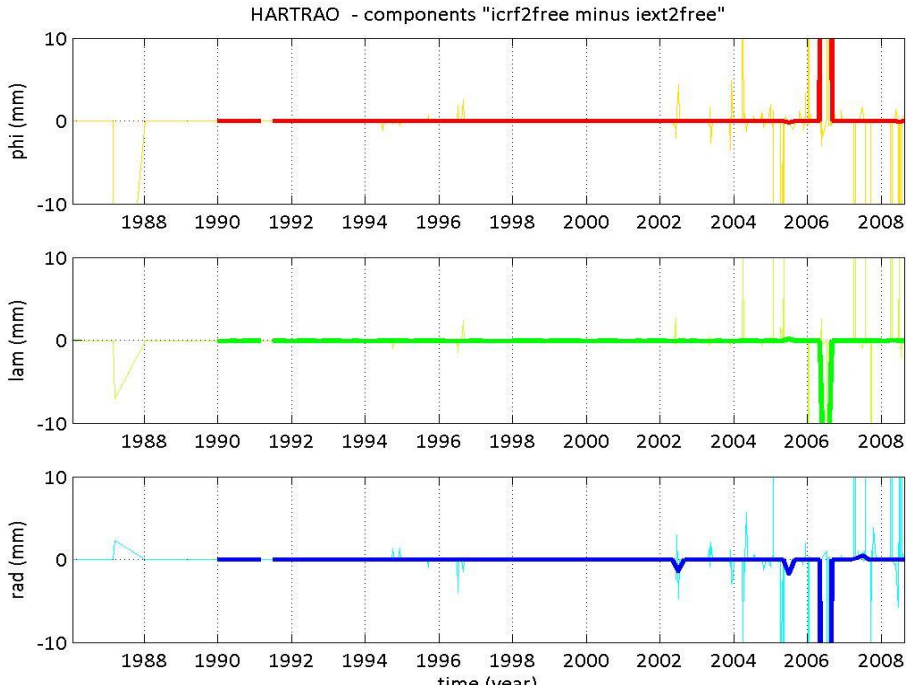

ALGOPARK - components "icrf2fix minus iext2fix"
phi (mm)
lam (mm)
rad (mm)
10
0
-10
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006

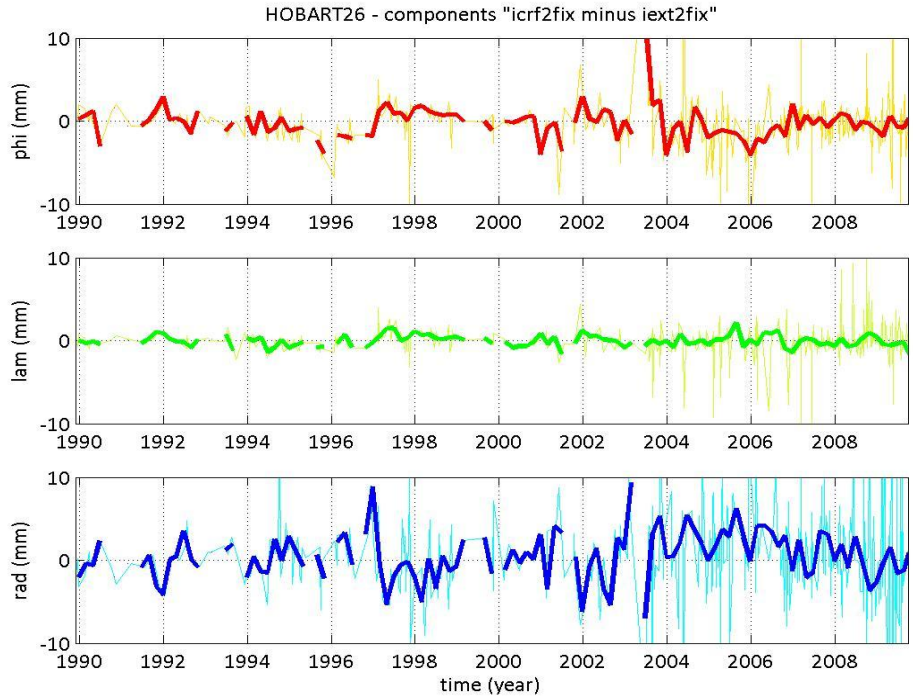

ALGOPARK - components "icrf2free minus iext2free"
phi (mm)
lam (mm)
rad (mm)
10
0
-10
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006

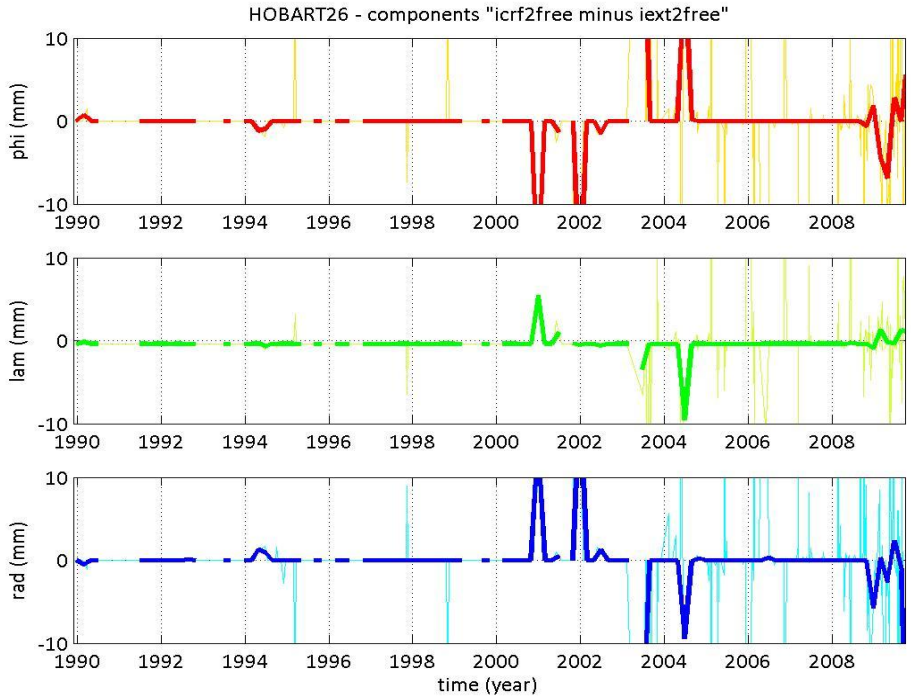

GILCREEK - components "icrf2fix minus iext2fix"
phi (mm)
lam (mm)
rad (mm)
10
0
-10
1985
1990
1995
2000
2005
time (year)


GILCREEK - components "icrf2free minus iext2free"
phi (mm)
lam (mm)
rad (mm)
10
0
-10
1985
1990
1995
2000
2005
time (year)


HARTRAO - components "icrf2fix minus iext2fix"
phi (mm)
lam (mm)
rad (mm)
10
0
-10
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
time (year)


HARTRAO - components "icrf2free minus iext2free"
phi (mm)
lam (mm)
rad (mm)
10
0
-10
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
time (year)


HOBART26 - components "icrf2fix minus iext2fix"
phi (mm)
lam (mm)
rad (mm)
10
0
-10
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
time (year)


HOBART26 - components "icrf2free minus iext2free"
phi (mm)
lam (mm)
rad (mm)
10
0
-10
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
time (year)

Summary

1. ICRF2fix – IEXT2fix

   nutation: psi shows some trend-like variations +/- 150 μas
   epsilon (+/- 40 μas) is below the error floor

   ERP: xpole (-100 μas) and DUT1 (10 μs) show trend-like behaviour before 1990
   ypole (+/- 40 μas) below the error floor

   TRF: velocities are mainly insignificant
   coordinates show some systematics:
   northern hemisphere is shifted northwards and downwards
   southern hemissphere no systematic directions

   time-series: southern hemisphere sites can significantly vary (+/- 7 mm)

2. ICRF2free – IEXT2free

   the effects are much smaller for free mode in general

   nutation: psi shows some variations (+50 μas to -100 μas)

   ERP: DUT1 shows an (unexplained!) small offset of about 2.5 μs

Further results and conclusions

3. ICRF2fix – ICRF2free shows smaller differences than
4. IEXT2fix – IEXT2free (not shown here)

- The smaller differences show that ICRF2 is significantly better than ICRF-Ext.2.
- There are significant differences in the station positions and EOP when applying ICRF2 or ICRF-Ext.2 as a priori celestial catalog.
- These differences become much smaller, if source coordinates are estimated as well (free mode).
- EOP differences become even a little bigger, if station coordinates are not estimated (e.g. single baseline applications, such as INT-sessions)
- The transition from ICRF-Ext.2 to ICRF2 should be done simultaneously, to prevent deformations of EOP and station coordinate combined solutions.

- The station coordinates and velocity fields could be compared to state of the art plate rotation and deformation models, such as APKIM2008 for validation!

Thank you for attention!