Comparisons of homogeneously reprocessed GPS and VLBI long-time series

Peter Steigenberger
Forschungseinrichtung Satellitengeodäsie (FESG), TU München

Volker Tesmer
Deutsches Geodätisches Forschungsinstitut (DGFI), München

Markus Rothacher
GeoForschungsZentrum Potsdam

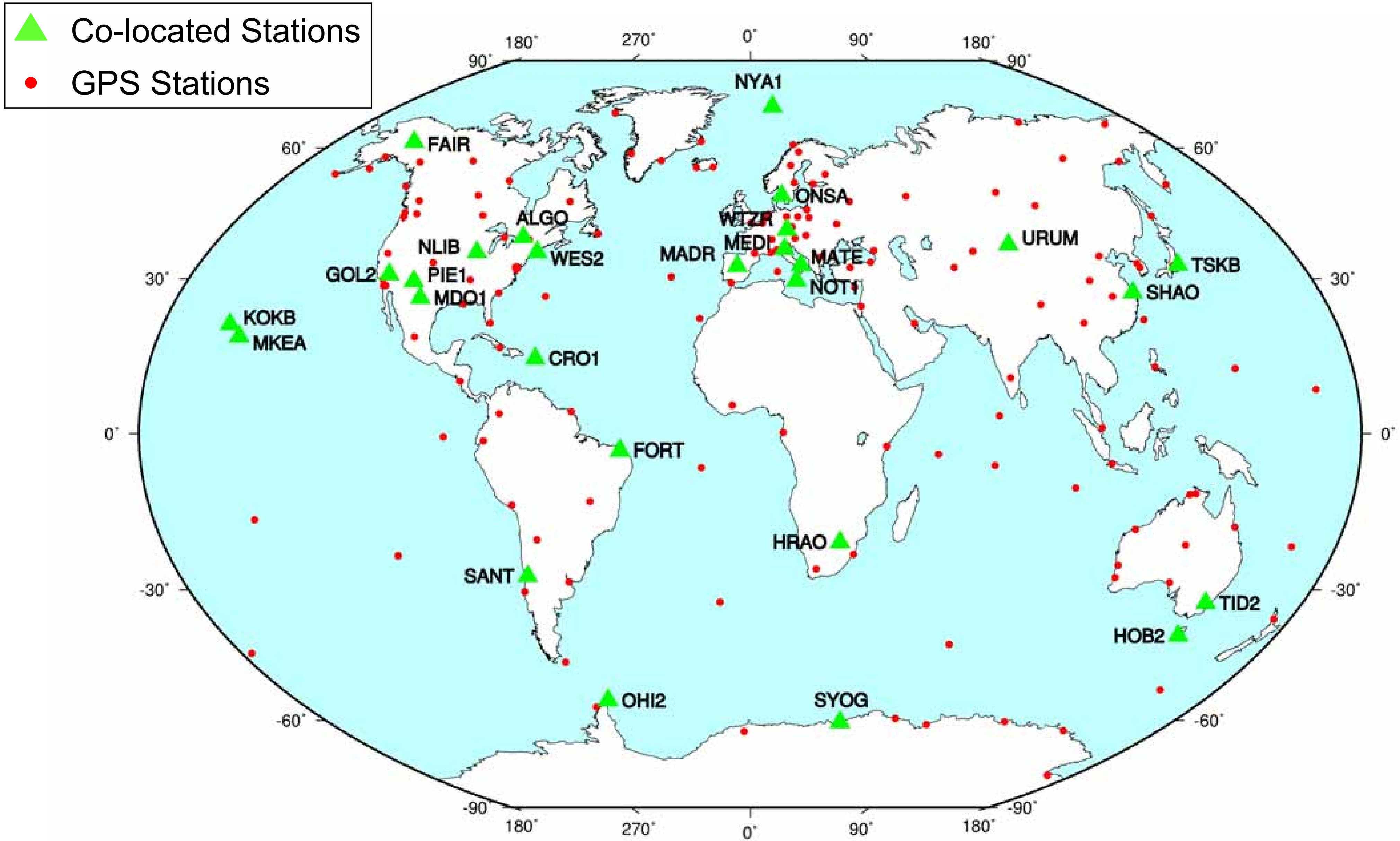
GPS and VLBI Processing

	GPS	VLBI
Institution(s)	TU München + TU Dresden	DGFI
Software	Bernese 5.0	OCCAM 6.1, DOGS-CS
Data	4017 daily solutions (1994-2004)	2613 24^h-sessions (1984-2005)
Time Period	1 January 1994 - 31 December 2004	
# Stations	195 (40 to 165 per day)	49 (3 to 20 per session)
Datum	NNR for 99 stations w.r.t IGb00	NNR/NNT for stations w.r.t ITRF2000
Solution Type	global solution including orbits, ERPs, station coordinates	TRF, EOP and CRF estimated simultaneously
Troposphere	2-hour resolution	1-hour resolution

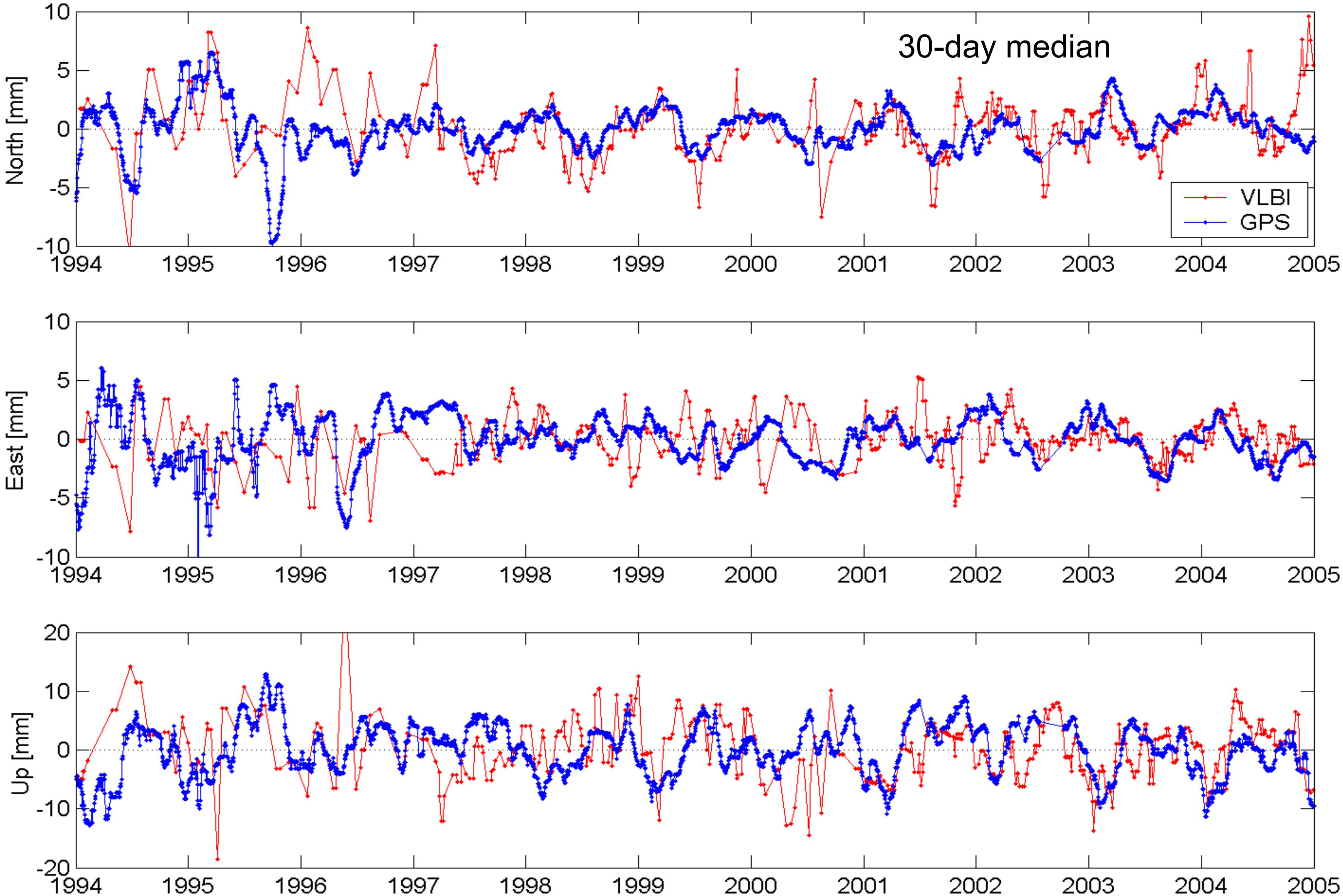
36 co-located GPS antennas at 27 sites

Exclusion of stations with few observations

Co-located Stations

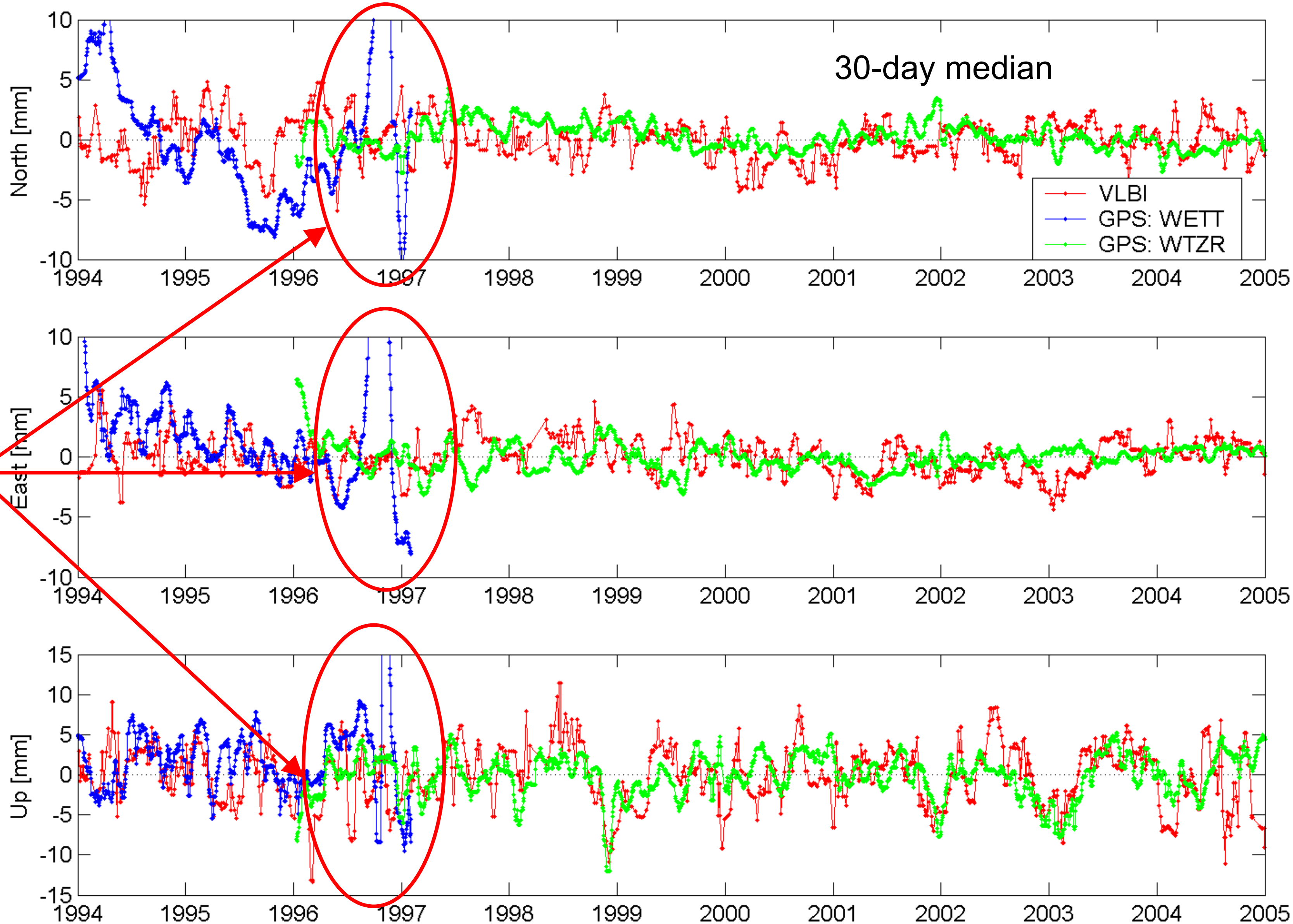


Coordinate Time Series: Westford

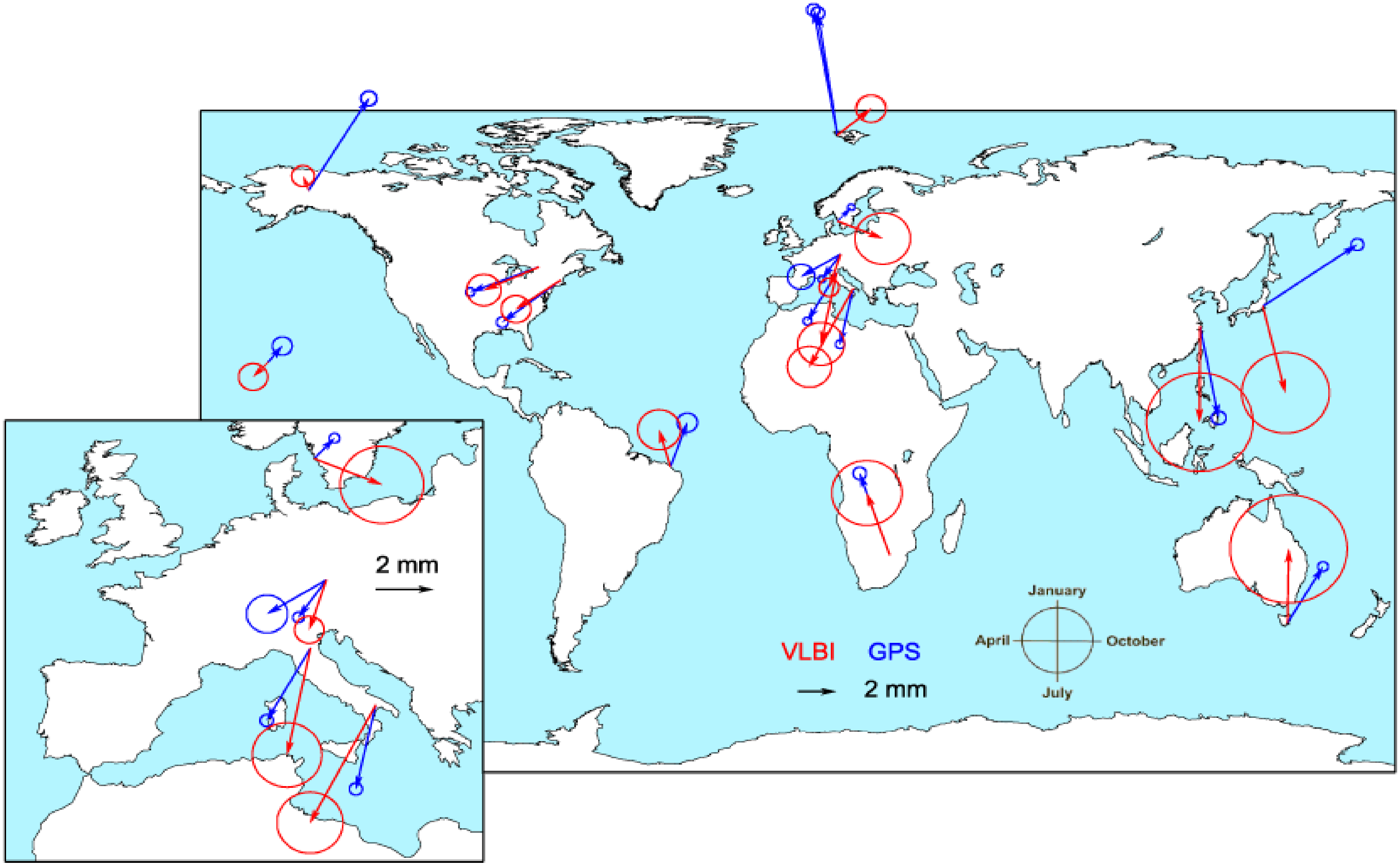


Coordinate Time Series: Wettzell

Degraded Tracking of WETT Receiver



Annual Signal in Radial Position Time Series



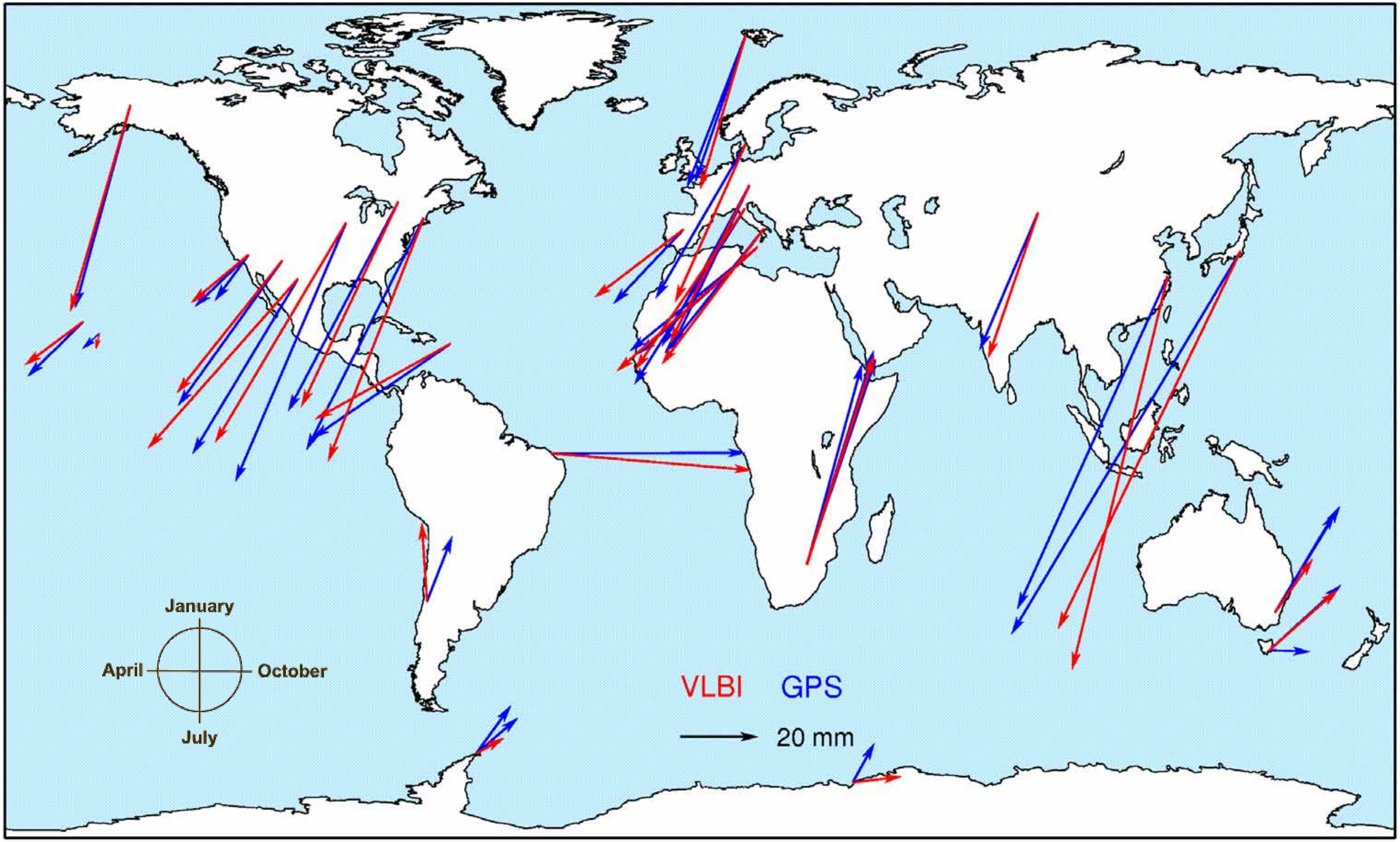
Troposphere Parameterization

Complete reprocessing of GPS and VLBI observations with **identical** modeling and parameterization

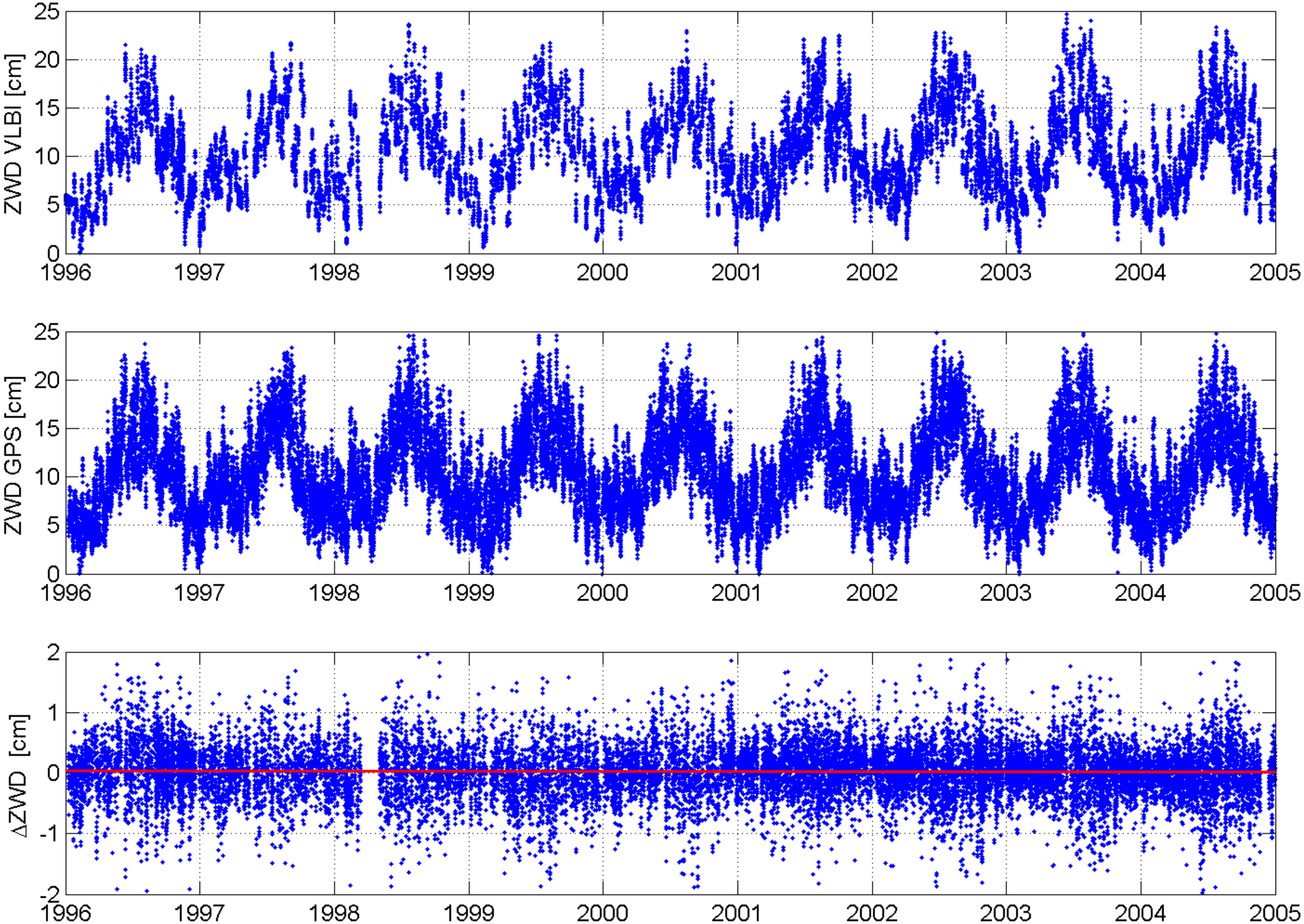
$$ZTD(z,A) = f_d(z)\cdot ZD_{apr} + f_w(z)\cdot ZD_{est} + N\frac{\partial f_w}{\partial z}\cos A + E\frac{\partial f_w}{\partial z}\sin A$$

ZTD	Zenith total delay
ZD_{apr}	A priori zenith dry delay (Saastamoinen, constant)
f_d	Dry Niell mapping function
ZD_{est}	Estimated zenith wet delay
f_w	Wet Niell mapping function
N,E	Estimated gradient parameters
z	Satellite zenith angle
A	Satellite azimuth

Annual Zenith Wet Delay Signals

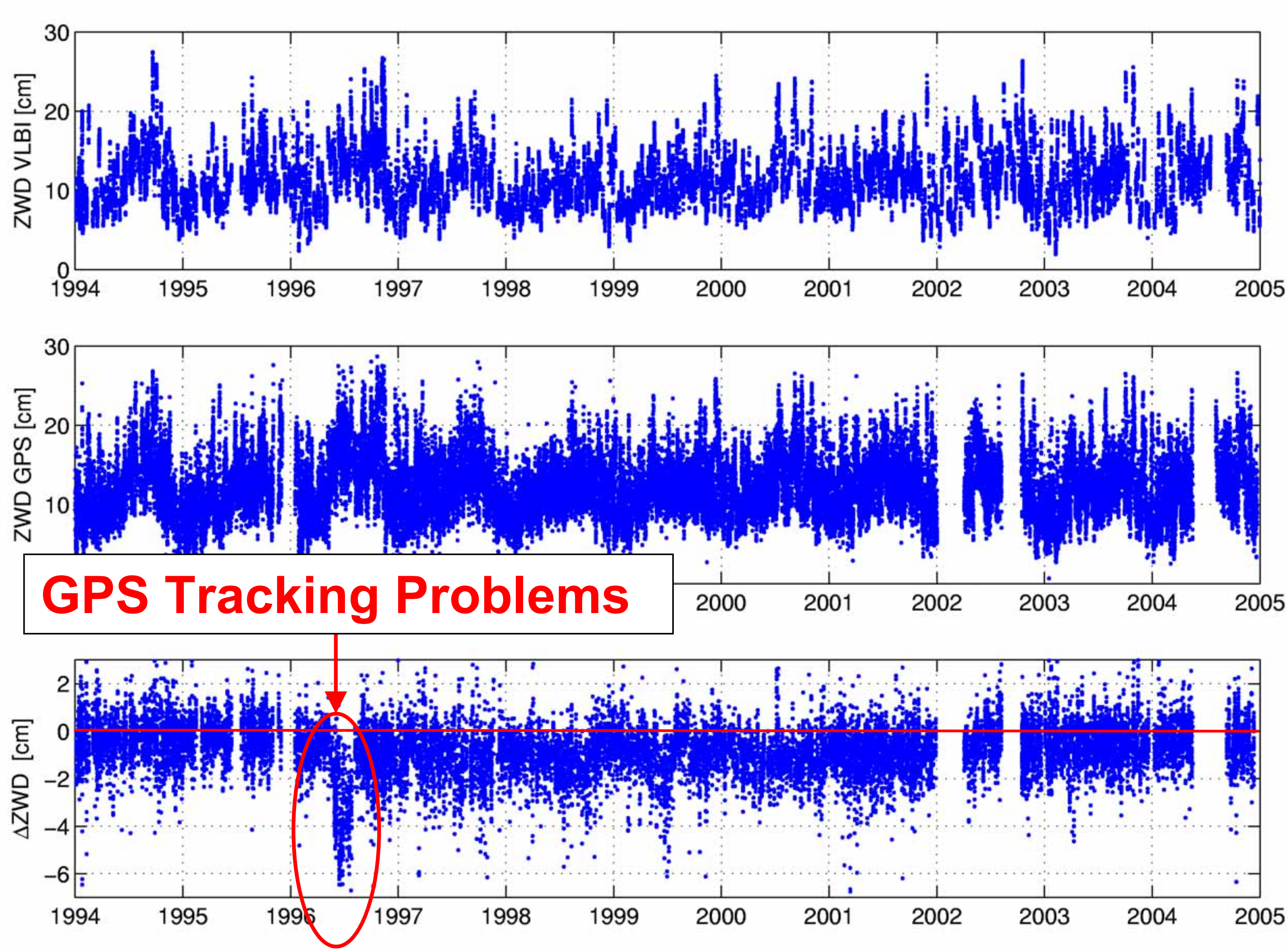


Zenith Wet Delay: Wettzell



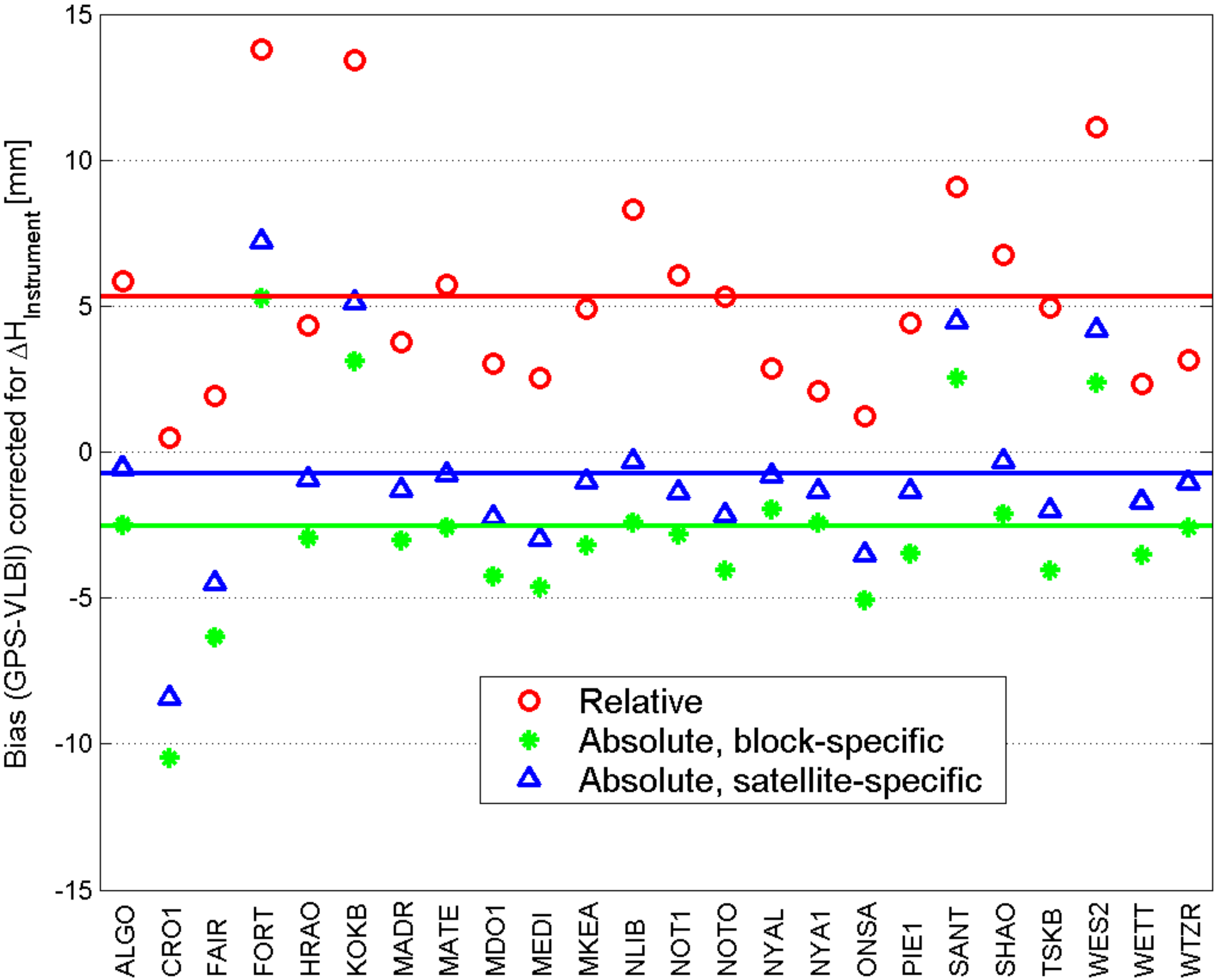
Correlation
0.994
Bias
0.1 mm
dH=3.1 m
$\text{Bias}_{\text{corrected}}$
1.1 mm
RMS
4.6 mm

Zenith Wet Delay: Kokee Park



Correlation
0.961
Bias
-7.7 mm
dH=9.2 m
$Bias_{corrected}$
-5.1 mm
RMS
10.9 mm

Effect of PCVs on Troposphere Parameters



Mean Biases

5.3 mm

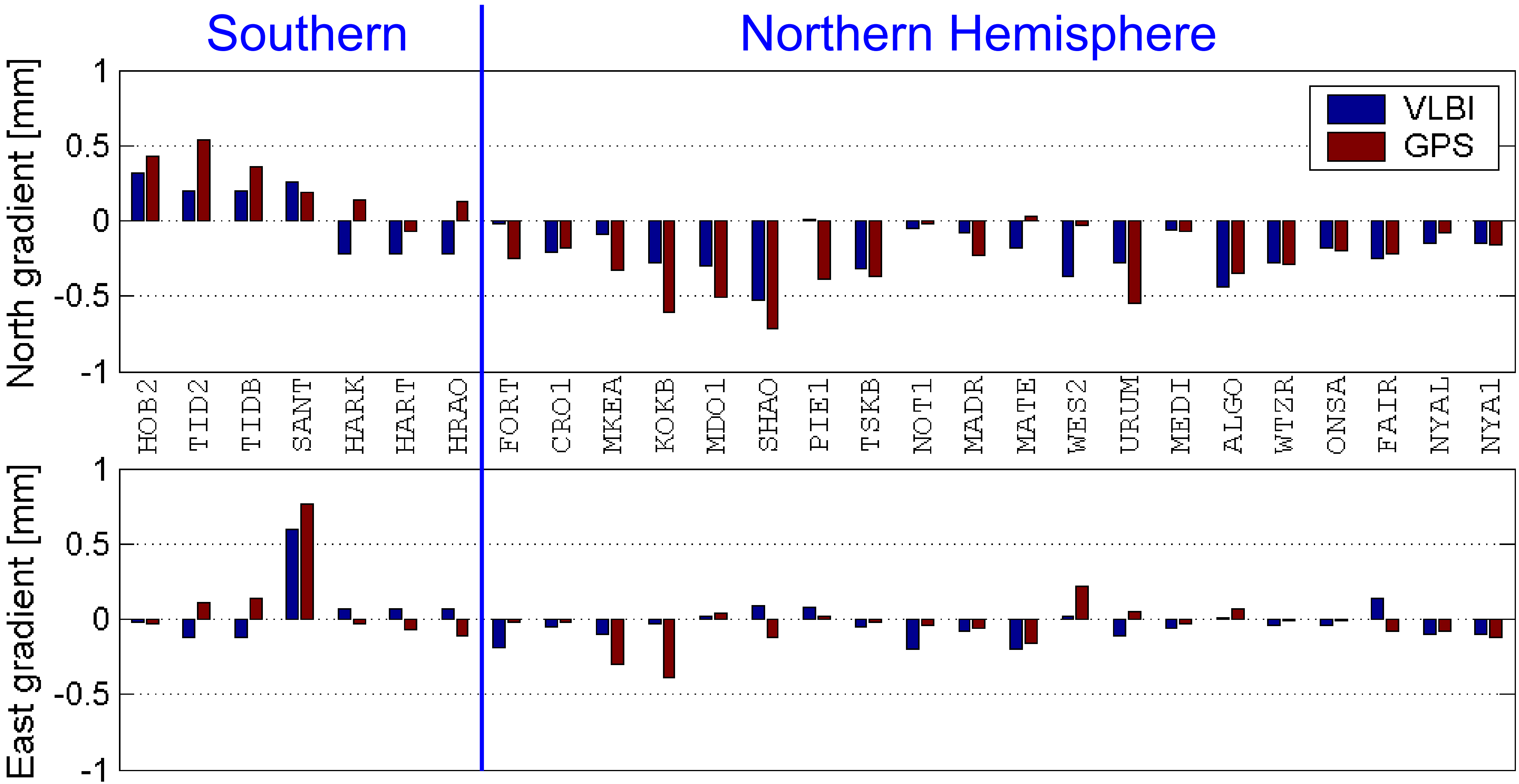
-2.5 mm

-0.8 mm

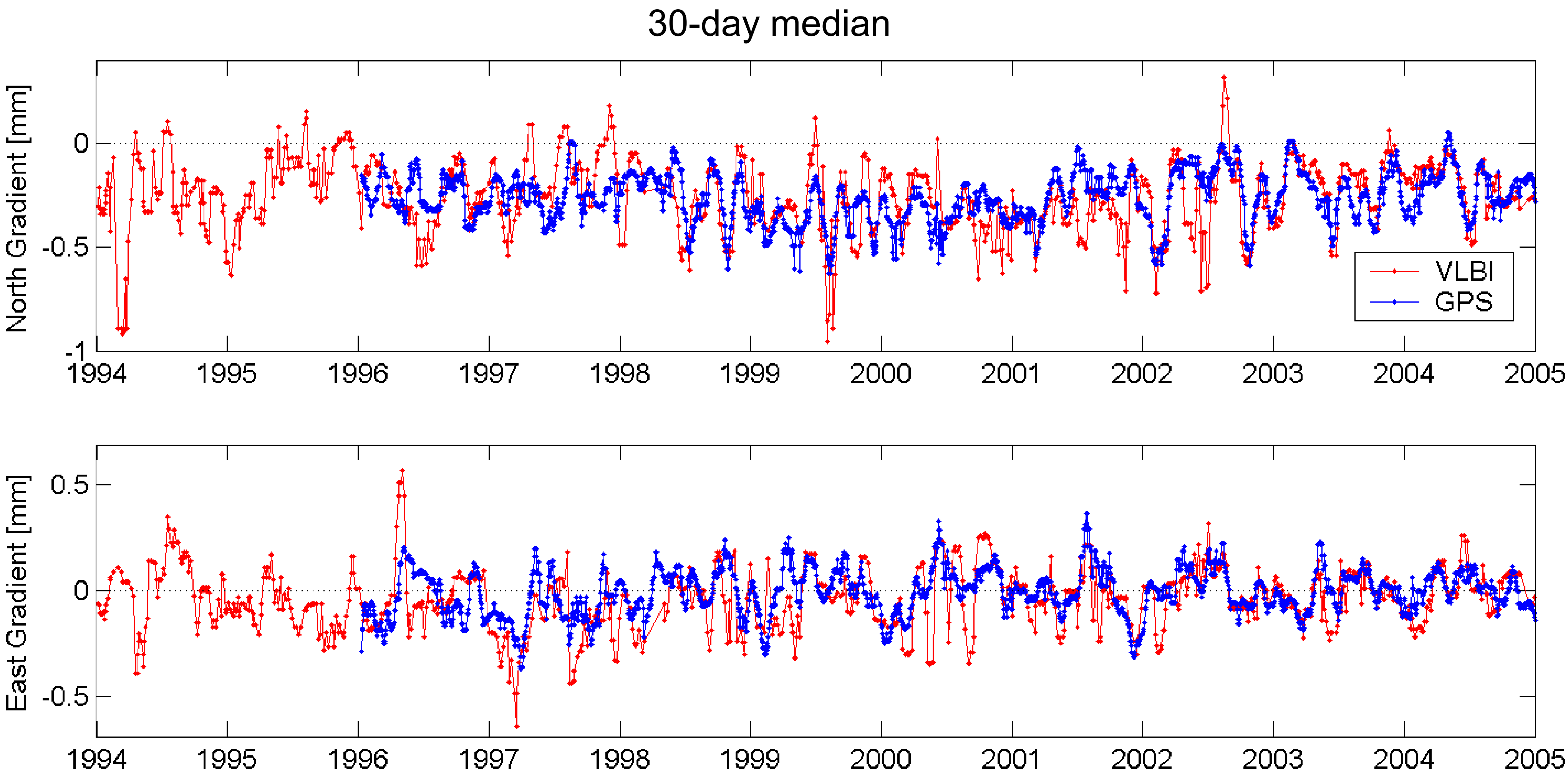
Excluded due to large dH:
HART,HARK
URUM

Tropospheric Gradients

Mean gradients; Constraints: 2 mm for VLBI, none for GPS



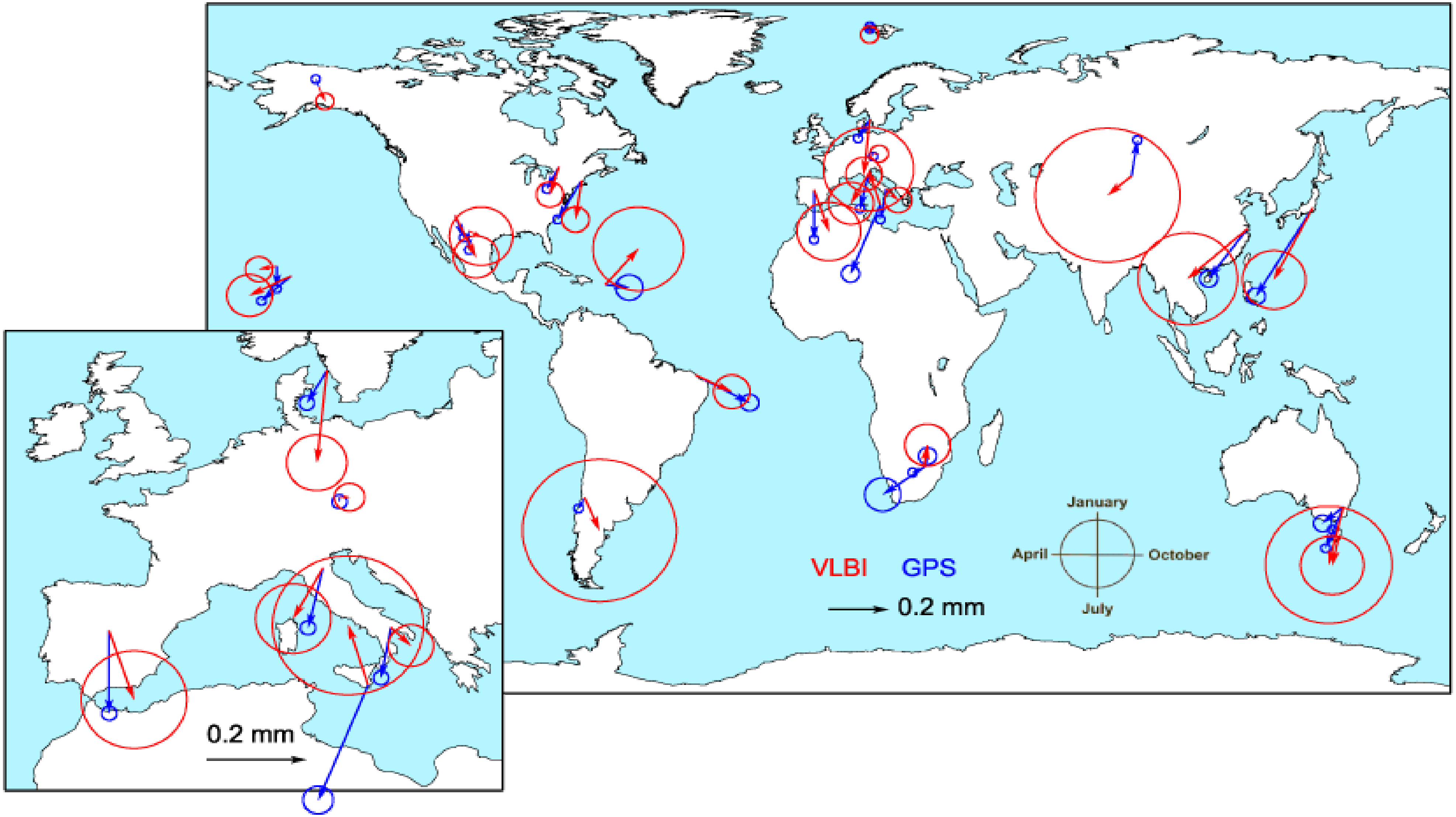
Tropospheric Gradient Time Series: Wettzell



Often good agreement, especially in the last years

Annual Signal in Tropospheric Gradients

North-component



Technique-specific systematic errors

GPS	- **sparse** tracking **networks** in the **early years** - **phase center corrections** (receiver and satellite antennas, radomes!) - **variable multipath** due to snow, soil moisture, buildings etc. - **equipment**, radome and firmware **changes** - **degraded tracking** - unstable antenna location - ???
VLBI	- **thermal deformation** of antennas - **gravitational deformations** of antennas - "few stations networks" => **datum instabilities** (station positions, EOP) - **technical problems** of antennas / correlators - antennas **not** built on solid **bedrock** - ???

Conclusions

- **Homogeneously reprocessed** VLBI and GPS long-time **station coordinate** and **troposphere** parameter time series show **common signals** on a high level of precision
- GPS/VLBI comparisons are a **very valuable** tool for **validation**:
  - **discontinuities** caused by equipment changes
  - GPS **tracking problems**
  - **Absolute** antenna phase center corrections help to **reduce systematic biases** between GPS and VLBI
- A **combination** of such homogeneously reprocessed series will **complement** strengths of techniques and though is expected to **stabilize** and **improve** the results (esp. “poor” VLBI networks/stations are expected to be significantly stabilized).