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On Accuracy of IWV Determinations

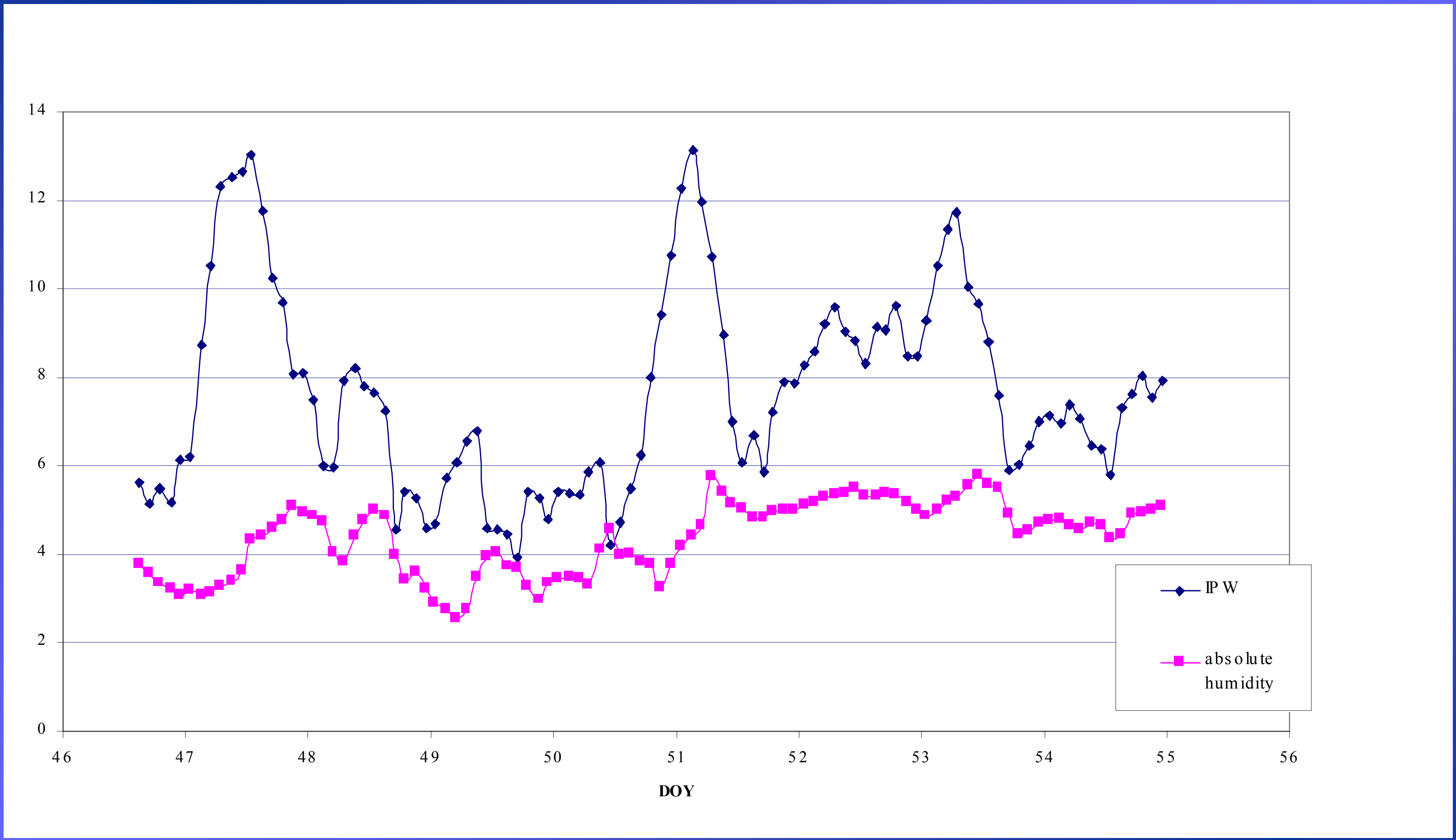
The following issues will be tackled here:

- factors affecting (IWV/PW) determination
- mean temperature model for Poland
- comparision of IPWV from GPS and radiosounding
- accuracy of radiosounding data
- comparision of GPS-derived IPWV and UMPL numerical weather model input fields

Major factors affecting (IWV/PW) determination

- GPS solution quality (different centers solutions used)
- Mean temperature model
- ZHD model used for wet part separation
  Zenith Wet Delay = Total Delay - Hydrostatic Delay
- Accuracy of the independent technique necessary to GPS IPWV evaluation (e.g. completency of radiosounding profile)

IPWV as a source of water vapour information in the whole troposphere



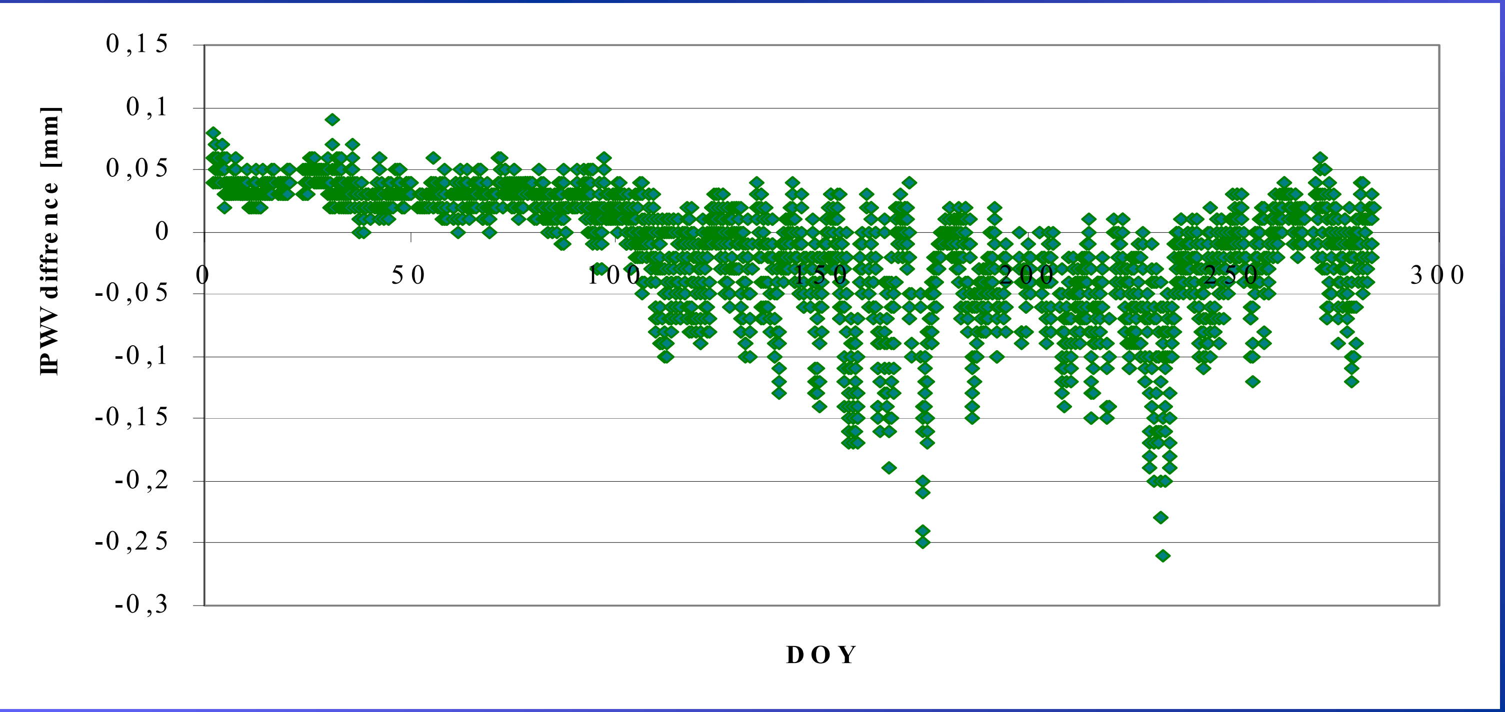
Mean temperature model

Vertical profiles of temperature and humidity from three radiosounding points in Poland (Legionowo near Warsaw, Wroclaw and Leba - all conducted by Polish Institute of Meteorology and Water Management) were used to create linear regression model > Polish model

$$T_m = (88.8 + 0.647 * T_s \pm 3.3)\mathrm{K}$$

difference RMS 0.05 mm

$$T_m = 55.8 + 0.77 \cdot T_s$$ - for US



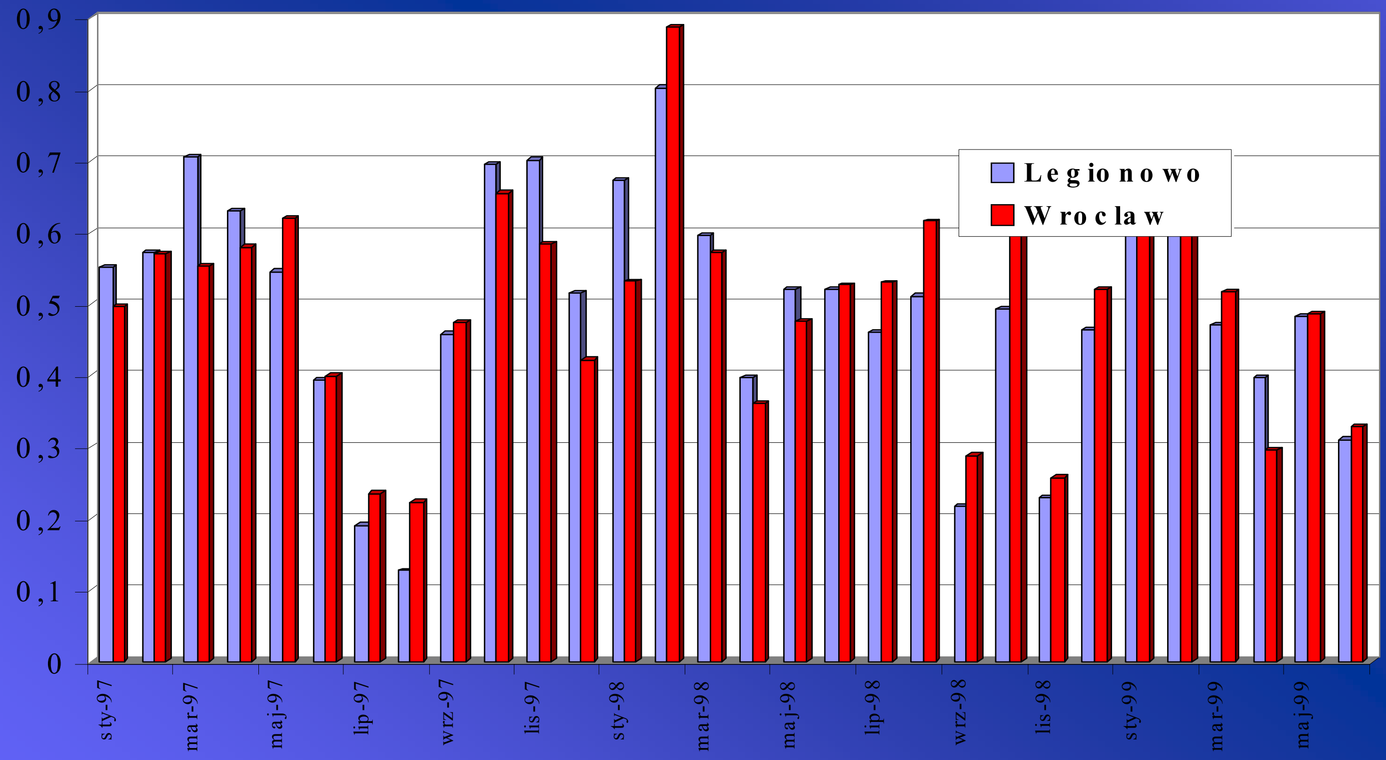
Influence of mean temperature model used for ZWD → IPWV transformation (difference between American formula (Bevis, 1992) and above obtained for Legionowo

Good consistency of Legionowo and Wroclaw results

Legionowo (2903 soundings) $T_m = (88.8 + 0.647 * T_s \pm 3.3)\mathrm{K}$

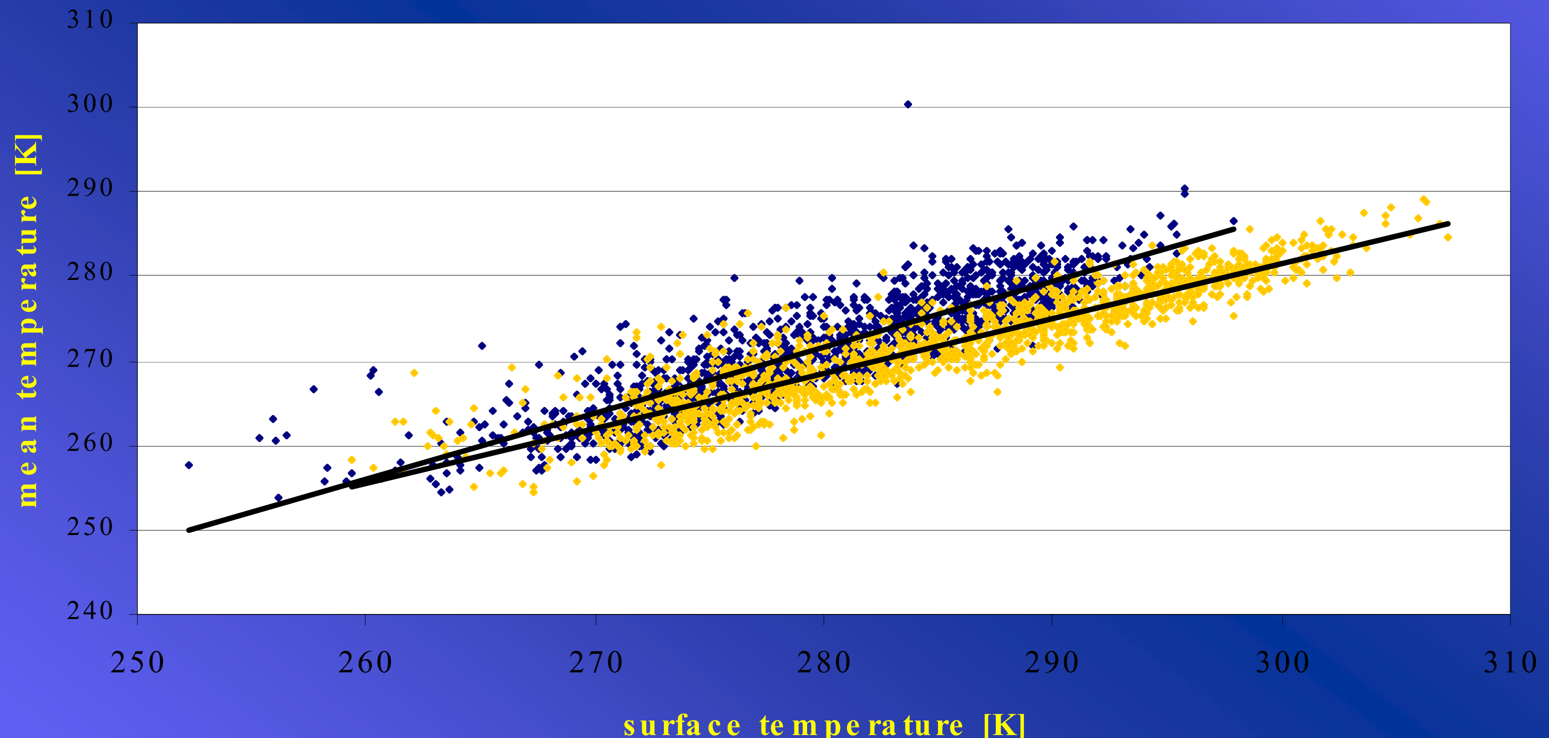
Wrocław (2356 soundings) $T_m = (88.5 + 0.647 * T_s \pm 3.9)\mathrm{K}$

Mean temperature and regression coefficient has also distinct short-term dependence



Mean temperature and regression coefficient has daily change

station	noon	night	both
Legionowo	87.2 + 0.648*T ± 2.5 K	51.7 + 0.786*T ± 3.2 K	88.9 + 0.647*T ± 3.3 K
Wrocław	86.9 + 0.648*T ± 2.9 K	59.4 + 0.757*T ± 3.7 K	88.3 + 0.645*T ± 3.8 K
Łeba	70.6 + 0.709*T ± 2.7 K	56.6 + 0.767*T ± 3.4 K	76.1 + 0.693*T ± 3.2 K

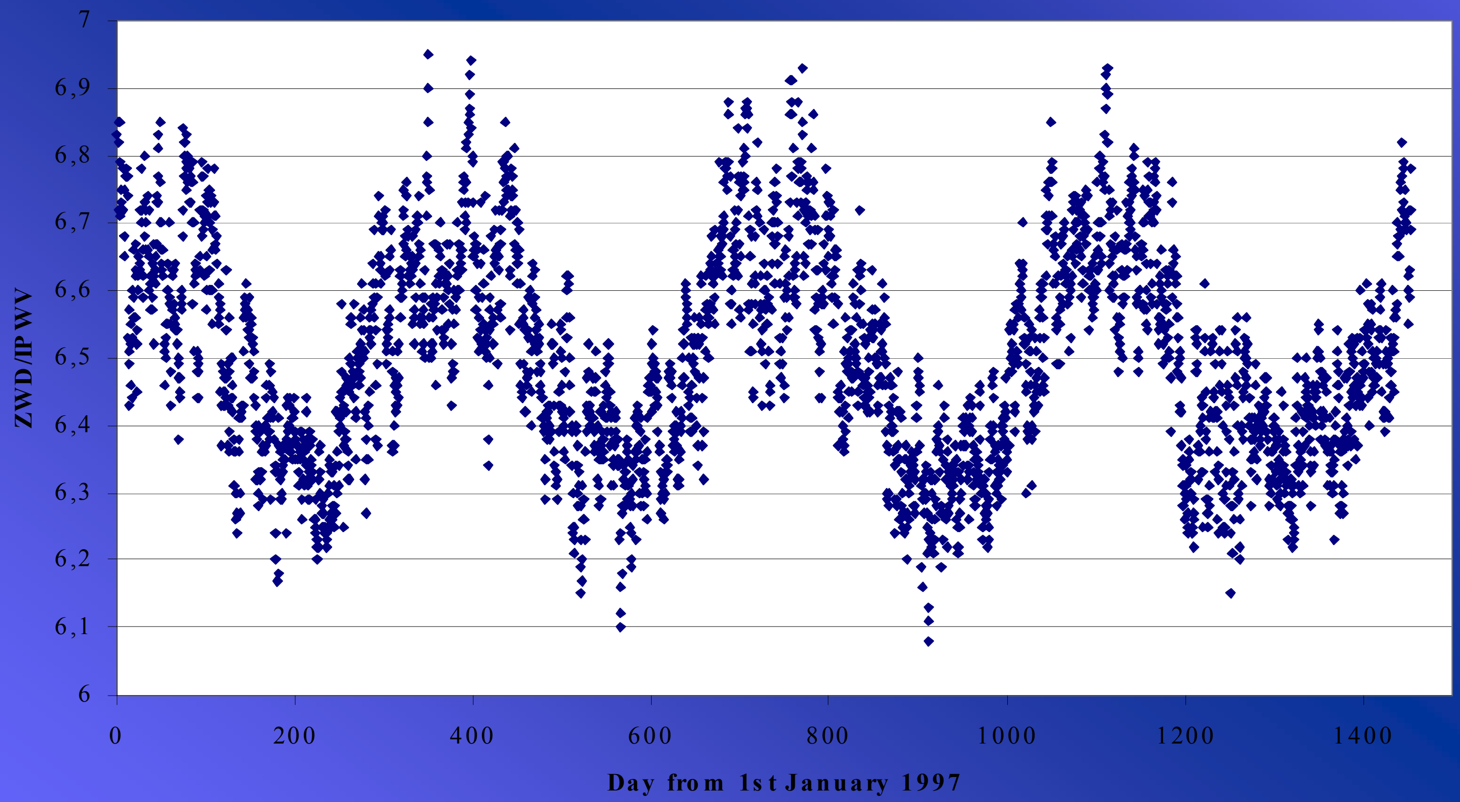


Mean temperature from the radiosounding profiles plotted against the temperature on the Earth surface - Legionowo 1997-2000 (yellow dots – noon soundings, dark – midnight)

Accuracy of the linear model adopted (~ 3 K) influences ZWD/IPWV on

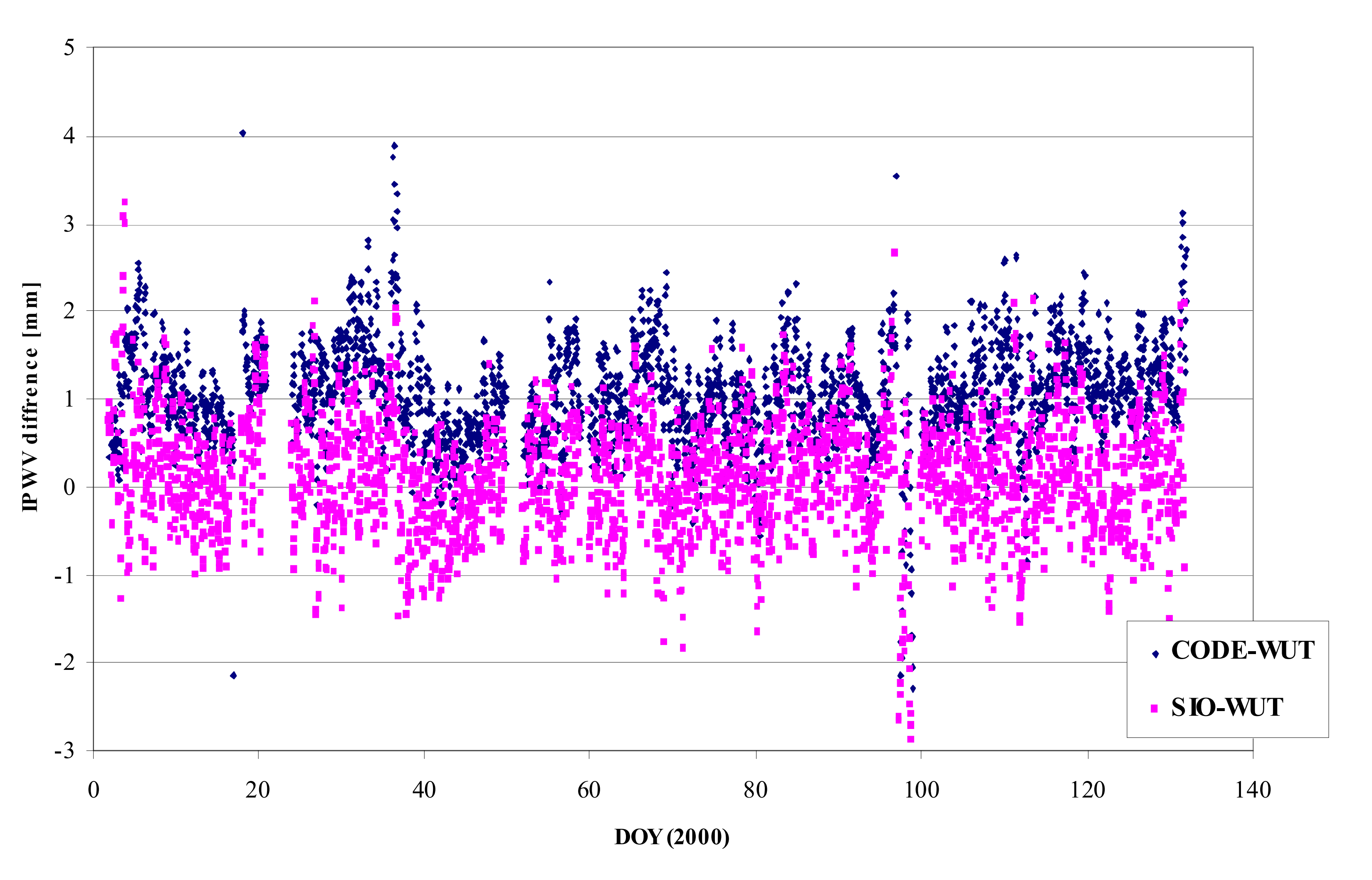
2.4 % level and about 0.37 IPWV difference (mean for JOZE 2000)

$$ZWD/IPWV = \frac{\rho}{\kappa} = 10^{-6}\left(\frac{C_3}{T_m} + C_2'\right)R_V$$



ZWD/IPWV coefficient from radiosounding - Legionowo

Example of differences between standard daily solutions from three ACs WUT and CODE are better correlated but 1 mm bias is present, WUT and SIO on the other hand only 0.1 mm medium difference but greater difference RMS



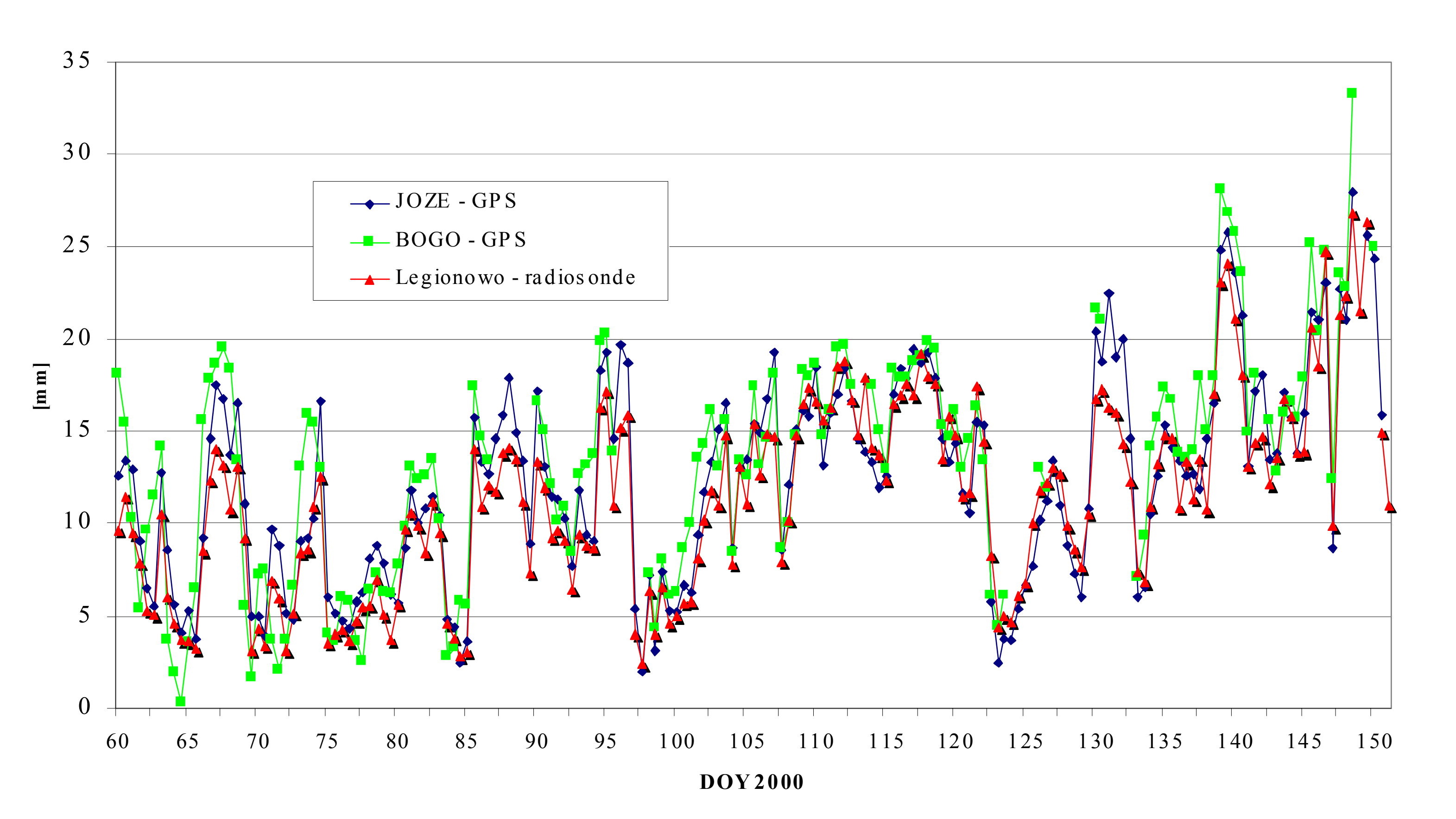
Comparision of IPWV daily values with radiosoundings (RAOBs)

We get :

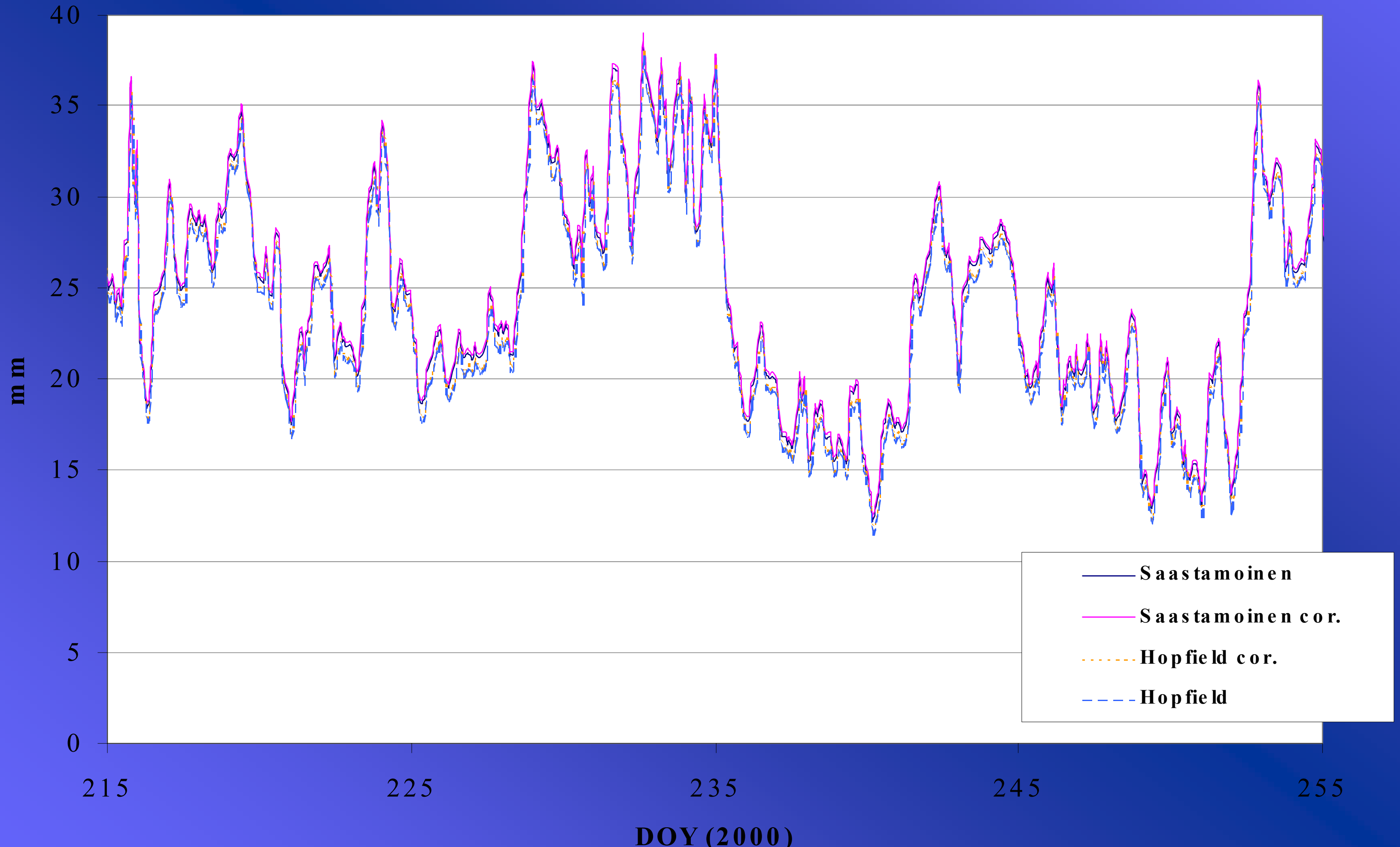
- RAOB - GPS IPWV negative bias of about 2 mm
- good correlation (0.98 - 0.99)
- 1 mm difference RMS

year		JOZE		BOGO		WROC	
	[mm]	Saast	Hopf	Saast	Hopf	Saast	Hopf
1997	average difference	2,9	2,1				
	mean absolute difference	3	2,2				
1998	average difference	2,7	1,8	2,5	1,6		
	mean absolute difference	2,7	2	2,7	2,1		
1999	average difference	2,4	1,5	2	1,2	3,1	2,1
	mean absolute difference	2,5	1,8	2,1	1,4	3,3	2,5
2000	average difference	2.3	1.6	2.5	1.7	2.9	2.4
	mean absolute difference	2.5	1.9	2.9	2.3	3.4	3.1

In the vicinity of Warsaw we can use two permanent GPS stations BOGO and JOZE (at 10 and 30 km distance respectively to the radiosounding point)



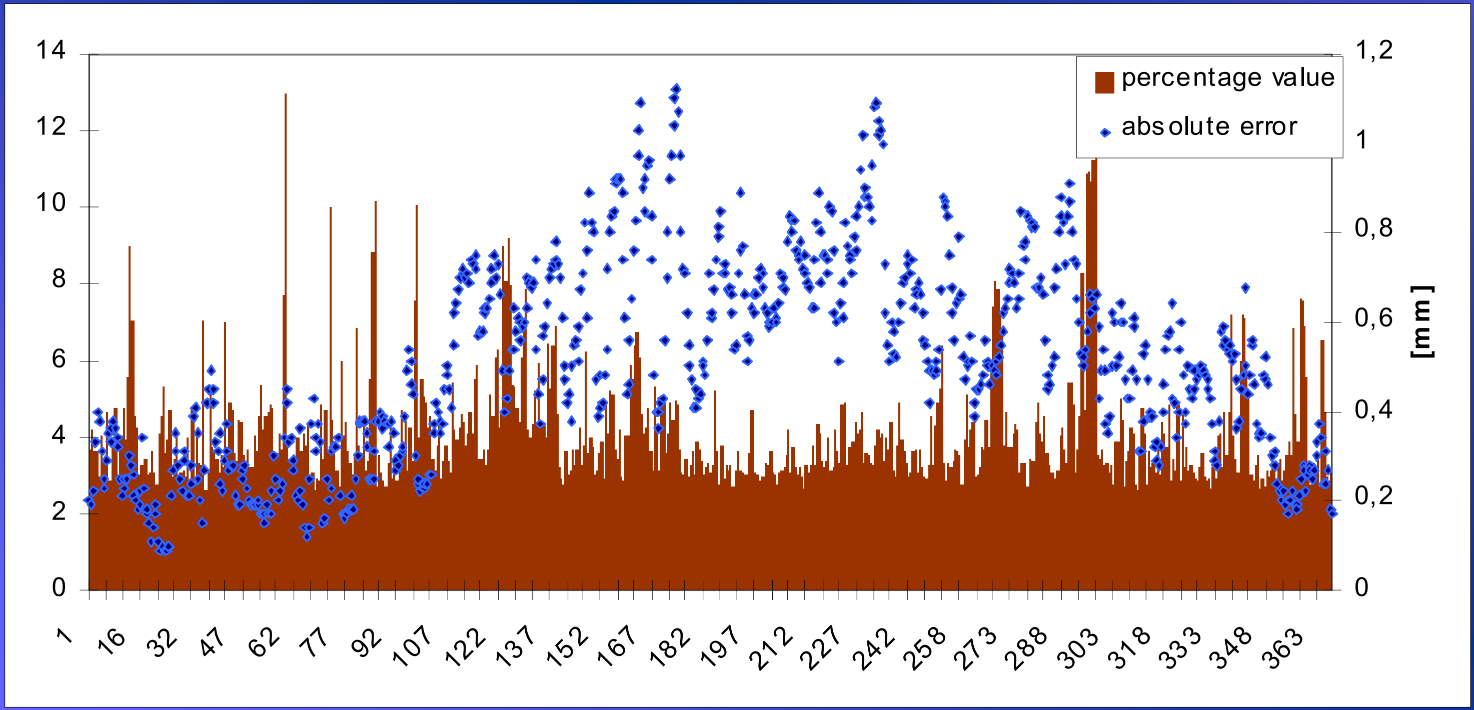
The choice of the hydrostatic model for ZWD (Zenith Wet Delay) separation from ZTD (Zenith Total Delay) influences the IPWV value on 1 mm level



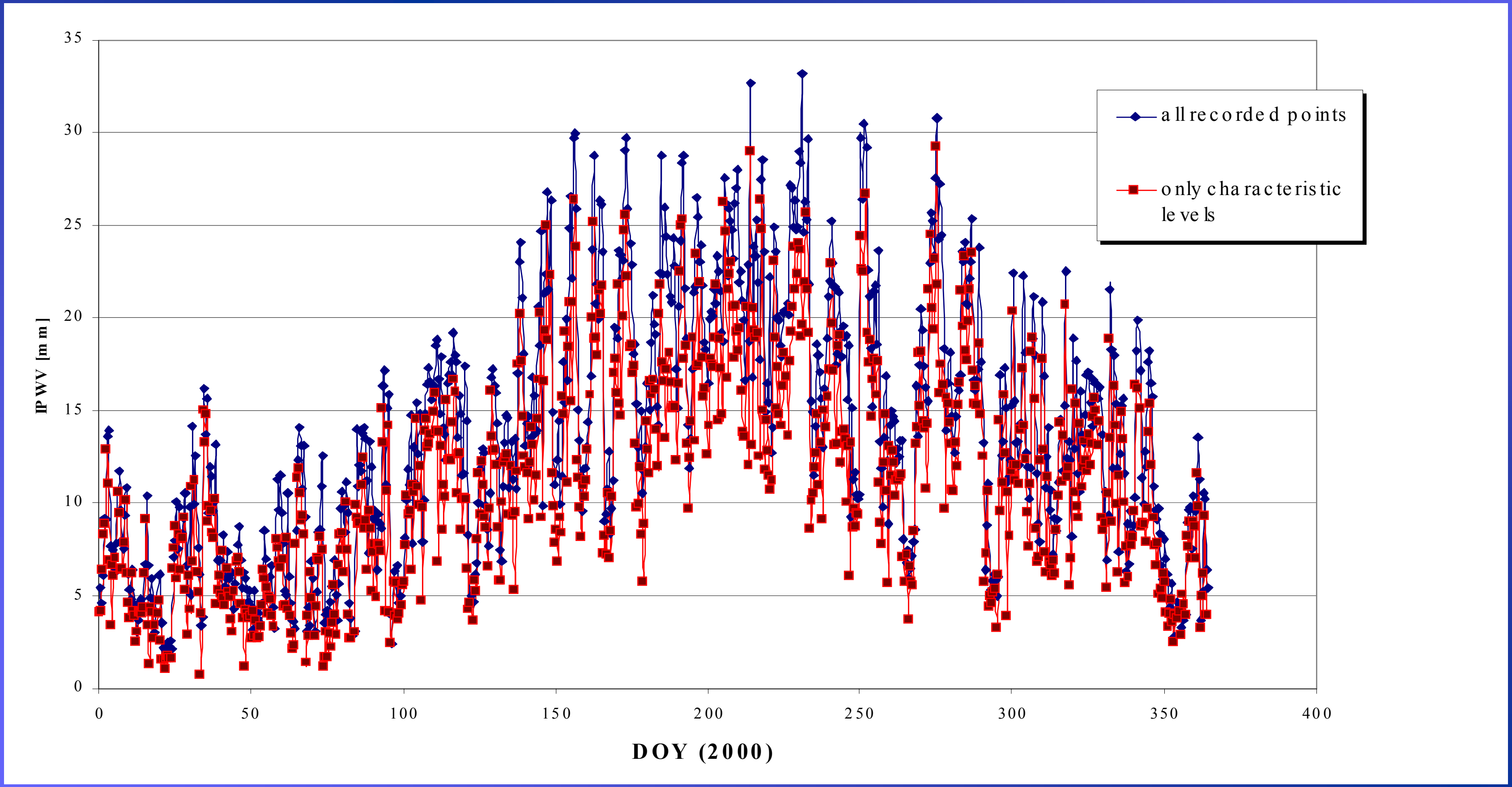
IPWV for JOZE using different hydrostatic models (same solution)

Pondering nominal radiosonde sensors reading accuracies, integration error values on each level one can get nominal error of the every sounding

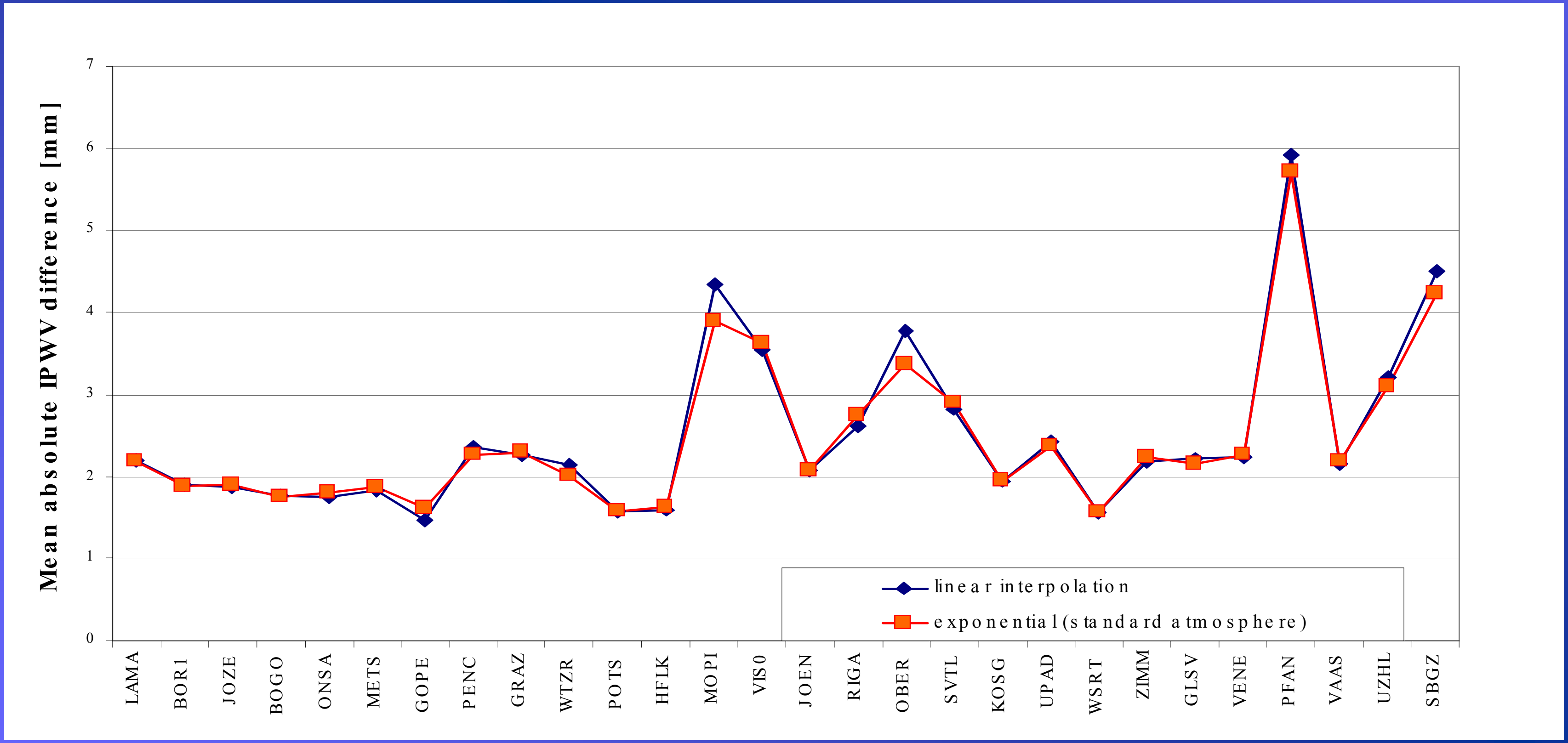
Mean values obtained for Legionowo 2000 soundings:
0.5 mm and 4%

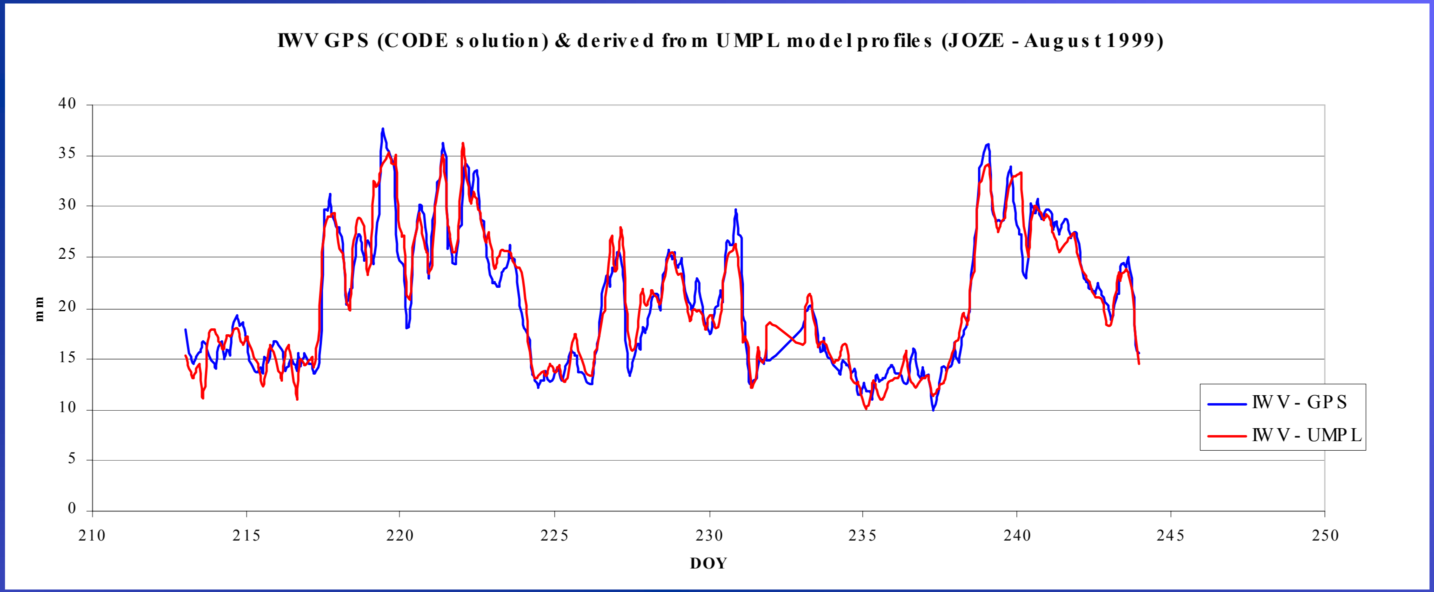


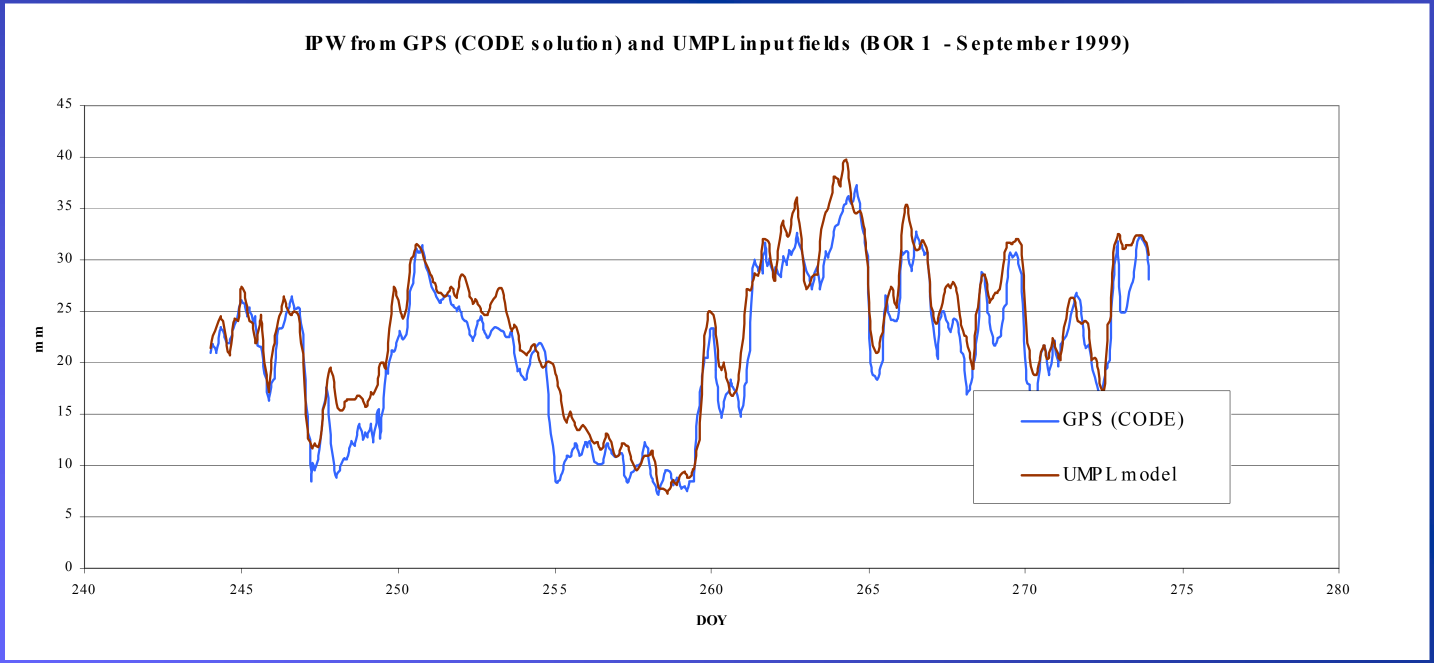
Differences between IWV values in GPS solution and radiosounding depend upon character of RAOB profile (which are filtered by device in search for characteristic points and mandatory levels)



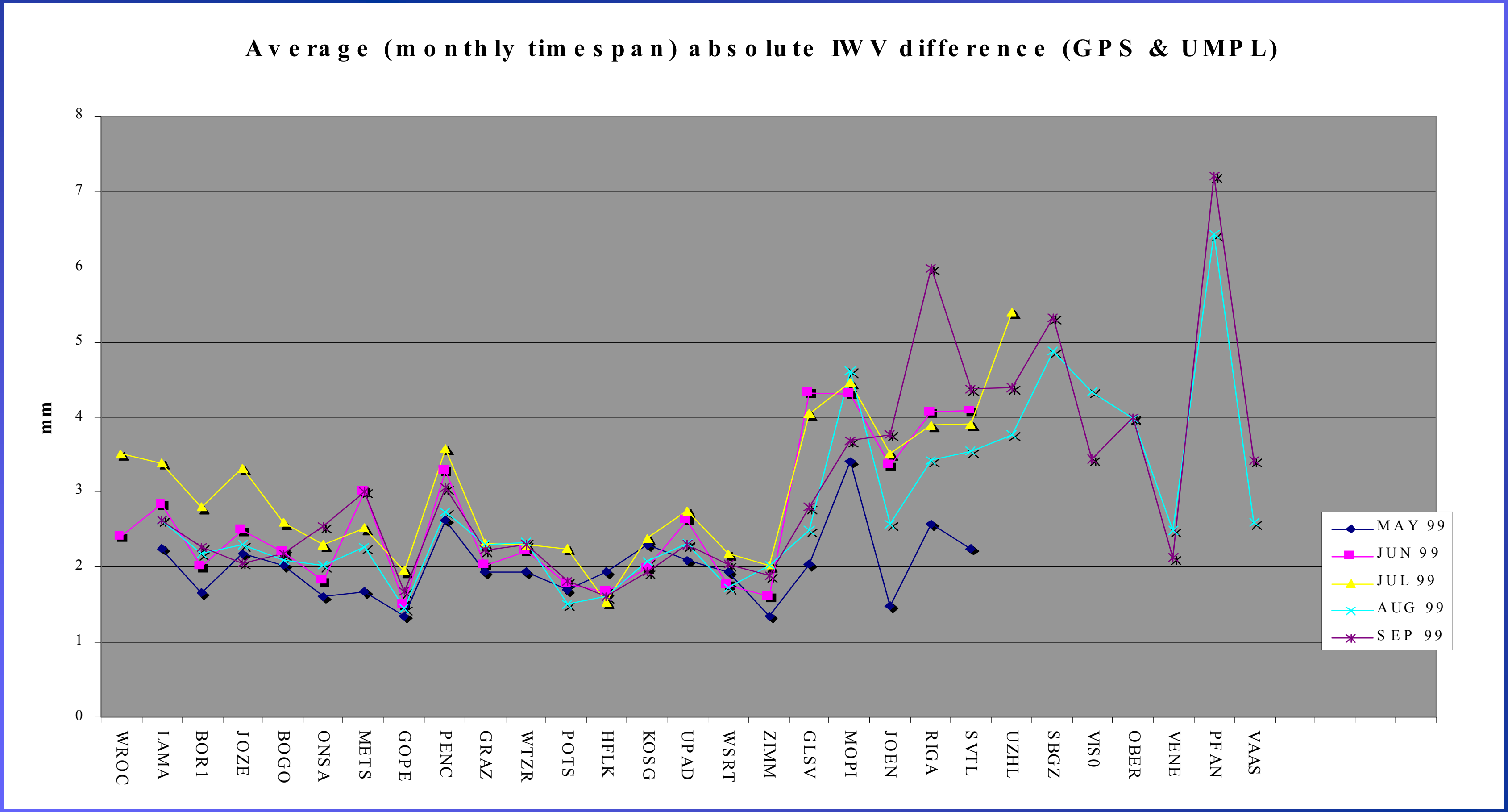
Next input fields for numerical weather model UMPL (version of UK Meteo Office maintained in Poland by Interdisciplinary Center for Mathematical and Computational Modelling, Warsaw University) both as a source of surface meteorological data for all stations in the area and source of humidity profiles for IPWV numerical integration. Interpolation from model grid in time and space was necessary. Influence of interpolation in height is shown below (one month).



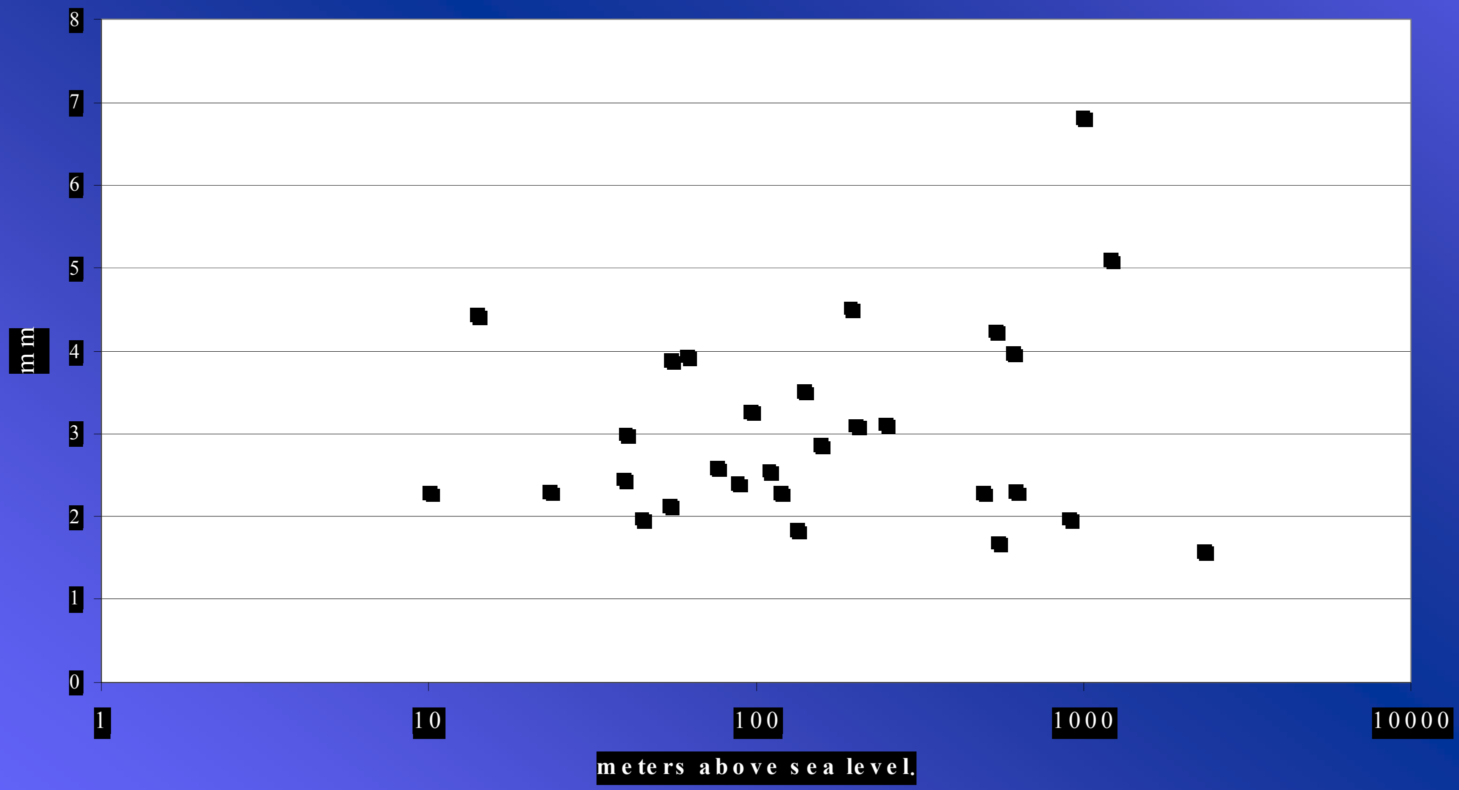

IWV GPS (CODE solution) & derived from UMPL model profiles (JOZE - August 1999)
mm
DOY
IWV - GPS
IWV - UMPL
0
5
10
15
20
25
30
35
40
210
215
220
225
230
235
240
245
250


IPW from GPS (CODE solution) and UMPL input fields (BOR1 - September 1999)
mm
DOY
GPS (CODE)
UMPL model
0
5
10
15
20
25
30
35
40
45
240
245
250
255
260
265
270
275
280

In the contrary to the RAOB profiles we get mostly negative GPS-UMPL IPWV biases (various from site to site, and changing with time)



Height dependence of mean absolute difference IPWV (GPS and UMPL NWP model) for three months (logarytmic scale height)



IPWV distribution maps from CODE and WUT solution

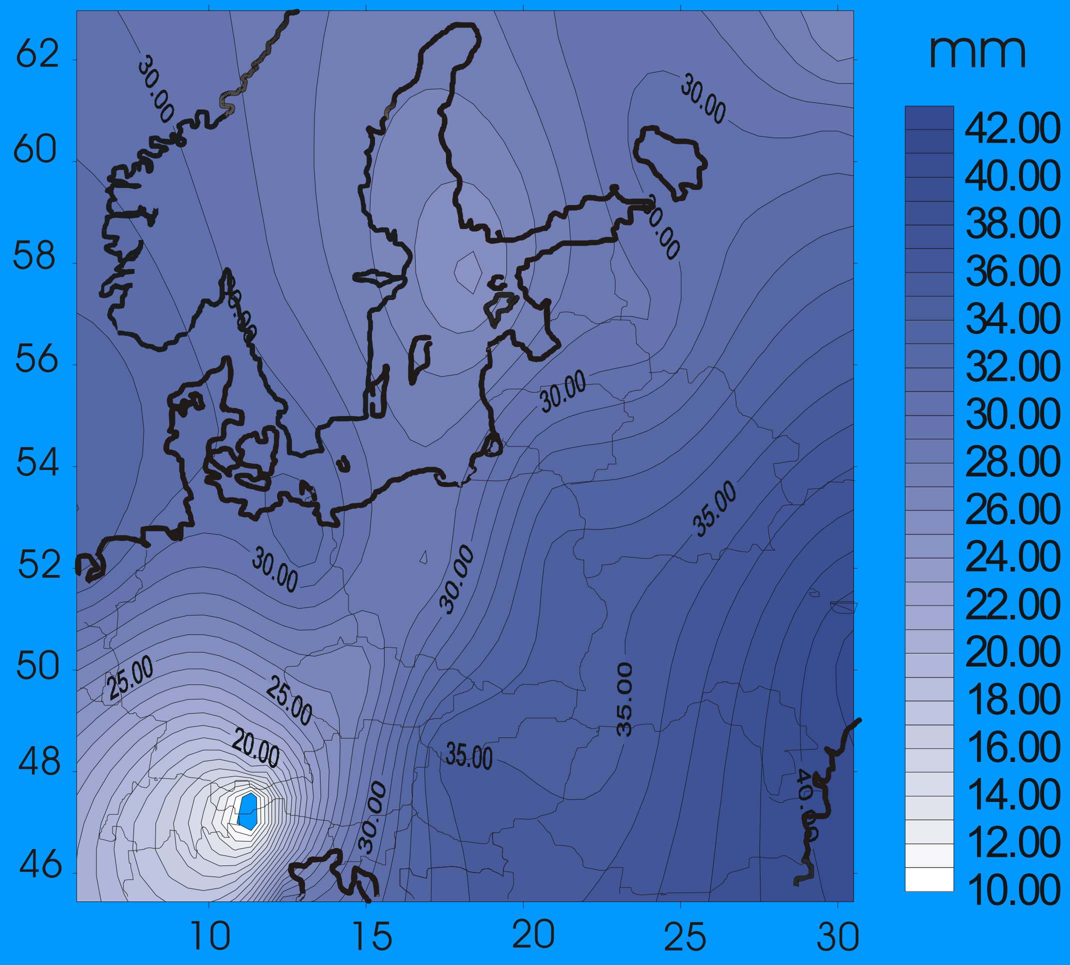
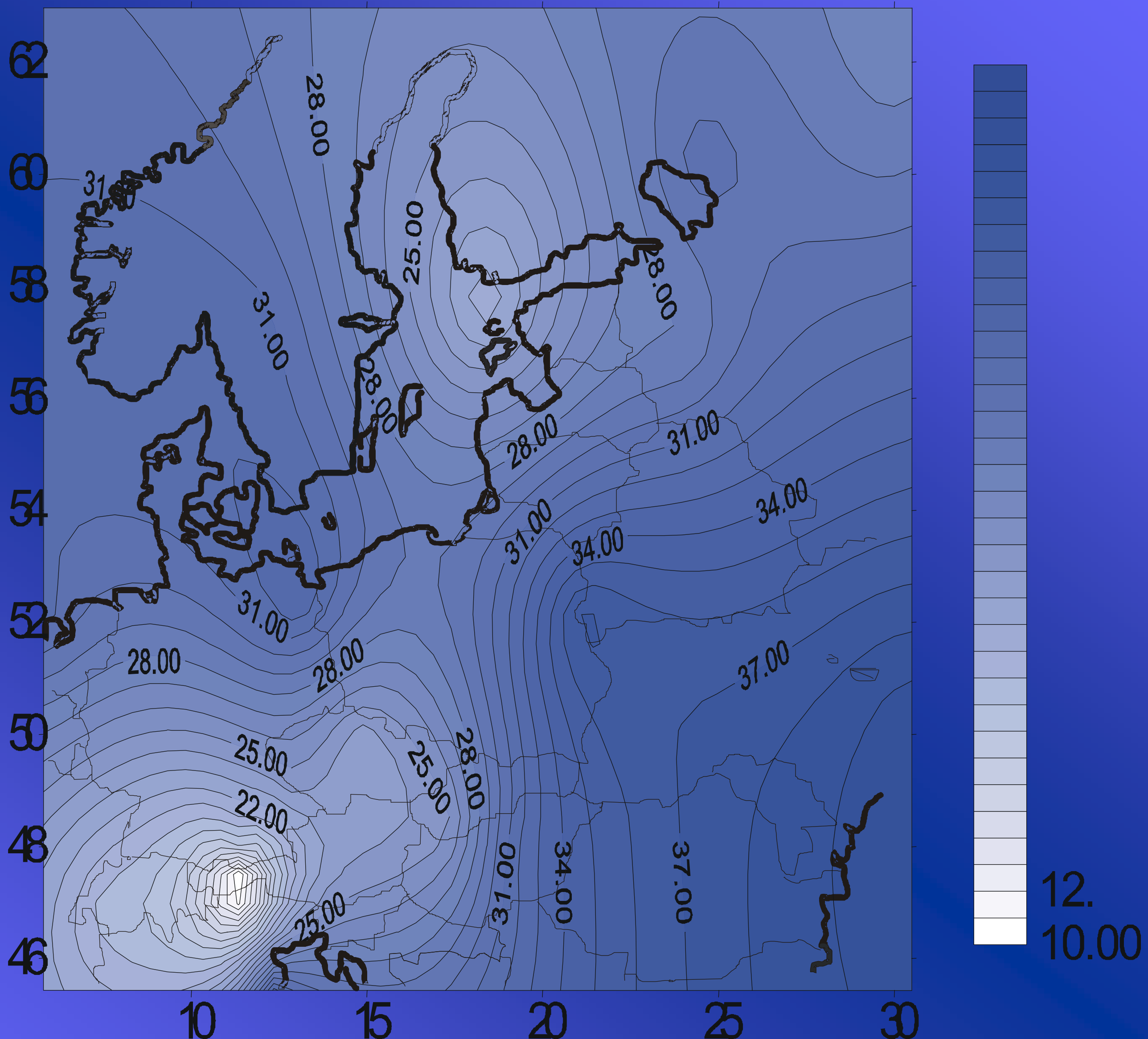
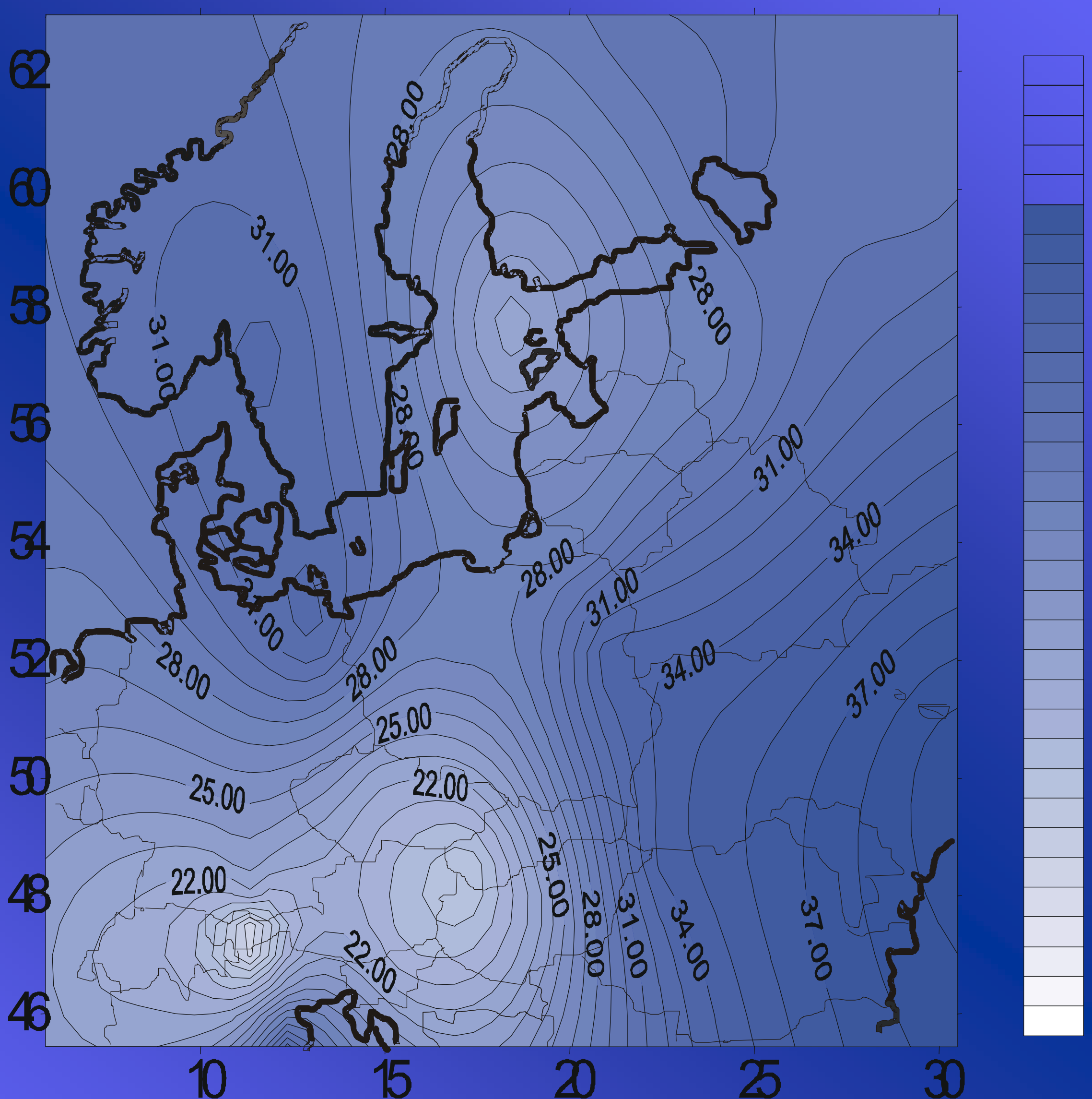


Fig. 7 IWV(GPS) 10 August 1999 15:00 UT

Daily tropospheric SINEX from two EUREF Analysis Centers has been used (here with 30-station grid). For points without surface meteorological measurements I used interpolated data from NWP UMPL model for input fields (T=0 prognosis, after analysis).

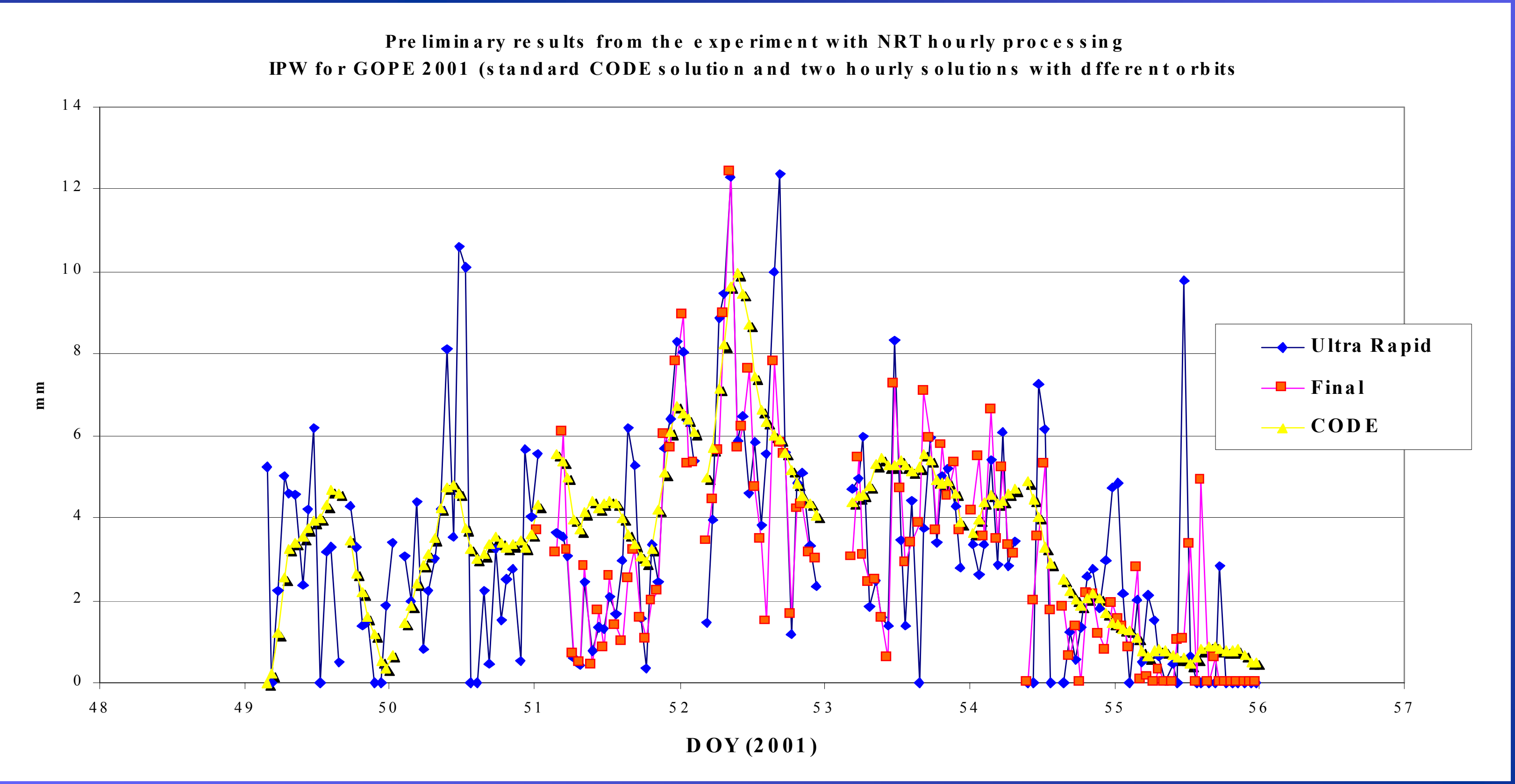


IPWV for 10 August 1999 19:00 TU



IPWV for 10 August 1999 23:00 TU

Preliminaly results of Near Real-Time precessing experiment on pure monthly basis



Conformity of the various IWV results

		Correlation	difference RMS [mm] (typical)
IPWV – GPS (CODE)	IPWV – GPS (WUT – LAC)	0.99	0.7-0.9
IPWV – radiosounding (Legionowo)	IPWV – GPS (BOGO)	0.985	2.0
IPWV – radiosounding (Legionowo)	IPWV – GPS (JOZE)	0.985	2.1
IPWV – NWP UMPL	IPWV – GPS	0.96-0.67	1.5
IPWV – local meteo	IPWV – meteo from UMPL NWP model	0.98	0.5-1.0
IWV - GPS	IWV – a priori ZWD model	0.9-0.91	

Conclusion

- **Conformity of radiosonde and GPS estimate depend upon GPS solution quality and ‘dry model’ for hydrostatic part of tropospheric delay**
- **RAOBs are ideally precise source of IPWV, comparisons with GPS values should be very careful**
- **Numerical Weather Model data can serve as the source of data for IWV analysis; they are better than ‘a priori’ models and can serve in GPS processing**
- **Stable NRT IWV processing including IGS ultra-rapid orbits requires longer solution span then single hour**