

# WVR's for Quasar network

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- *Main tasks*
- *Technical features*
- *Retrieval algorithm*
- *Metrology problems*
- *Preliminary results: comparison ZWD of GNSS, WVR, VLBI*
- *Nearest plans*



## **WVR's - additional instruments for "Quasar" colocation sites**

### **WVR's will be used for:**

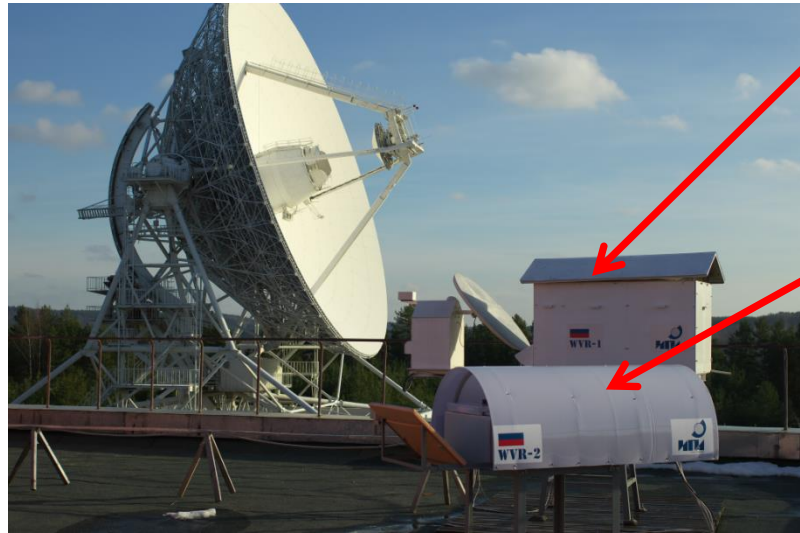
- **practically real-time ZWD monitoring,**
- **IWV / PWV monitoring**
- **VLBI data processing**

# WVR prototypes are installed in “Svetloe” observatory



WVR1 (since 2011)

WVR2 (June)2013



## Operation mode:

- zenith direction (WVR2)
- fully steerable (WVR1,WVR3,4,5)

WVR's provide quasi - real time  
data rate: one count every 6 seconds





- ***Presence of precise MW thermostable reference loads***
- ***Maximum temperature stability of all RF units***
- ***Temperature control (and logging) of all critical points***
- ***Total gain variation control of the RF units***
- ***Operation mode: “total power”+ fast switching (1kHz) of input signals***
- ***Guaranteed linearity of square law detector for input signals***
- ***“Industry” - standard electronics – cheap and reliable***
- ***Unified design of radiometric units***
- ***Remote access and control facilities***

# Unified thermo stable radiometric blocks

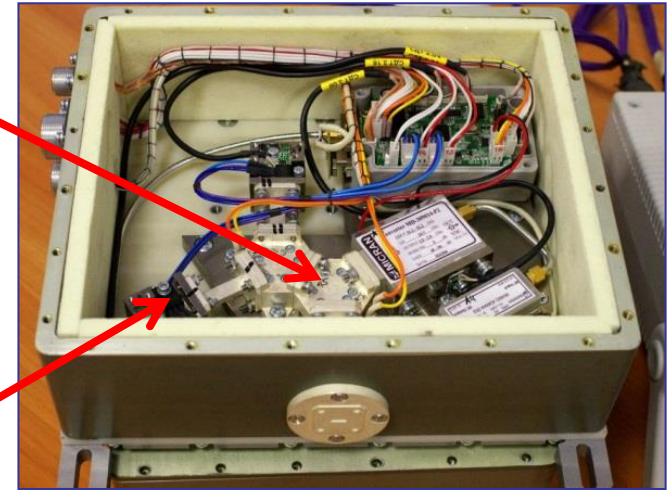


1. **DAS module: 16bit resolution ADC, 100kHz data rate, data processing (1s integration for all signals etc.)**
2. **Ferrite X-switch driver , 3 precise digital thermostat drivers, 3 temperature sensors.**
3. **RS 485**



**Radiometric Unit  
21 GHz (channel A)**

**Ferrite X-switch**

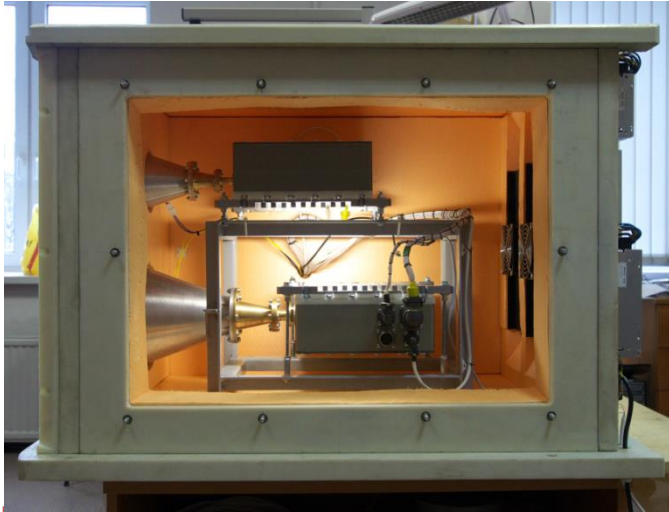


**“Cold” load**

**Radiometric Unit  
31GHz (channel B)**

**Up to 20 parameters** are placed into WVR log-file, 5MB/d

## WVR3. (New!)



Specifications:	Value
Frequency bandwidth 3 dB, GHz	
Channel A	20,7±0,25
Channel B	31,4±0,25
Noise temperature, at the input , K,	
A	<b>150</b>
B	<b>280</b>
Gain, up to Sq. law detector, dB	
A	65
B	65
Brightness temper. sensitivity, mK, t = 1s (Ta=10K)	
A	12
B	25
Relative gain instability, 24 h, , % , less than	0,03
HPBW(-3dB) / BW(-35dB)	6° / 22°
Angular resolution Az, El, arc min.	5

“Tip-cal.” is used for accurate measurement of calibration signals



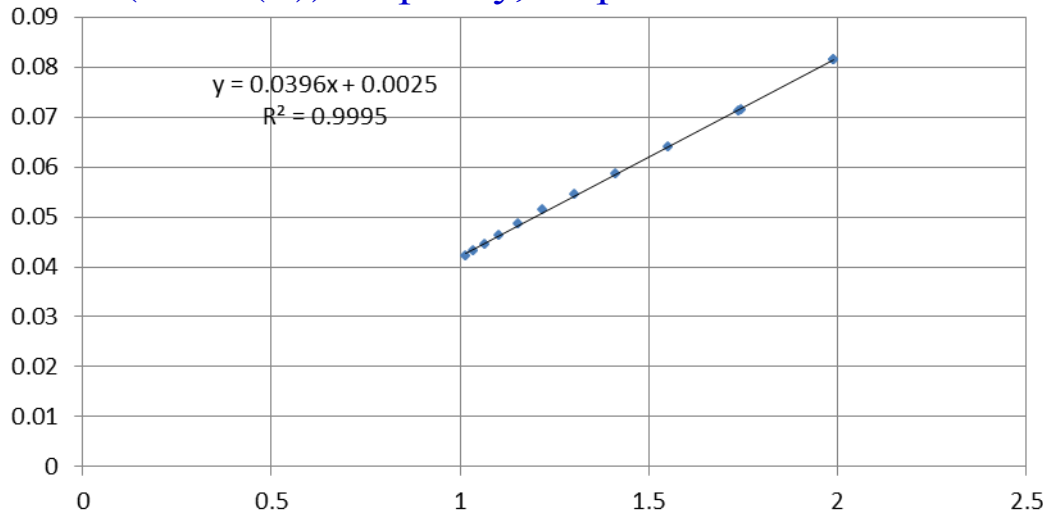
## WVR 1 in “Svetloe”

### Temperature of “Cold” loads:

Channel A “Cold” load:  $T_{cA} = 313,02\text{K} \pm 0,02 \text{ K}$  (r.m.s. , on 1.5 year interval)

Channel B “Cold” load:  $T_{cB} = (313,38 \pm 0,02) \text{ K}$  (r.m.s. , on 1.5 year interval)

$\tau = f(1/\text{Cos}(Z))$  – opacity, “tip-cal.”

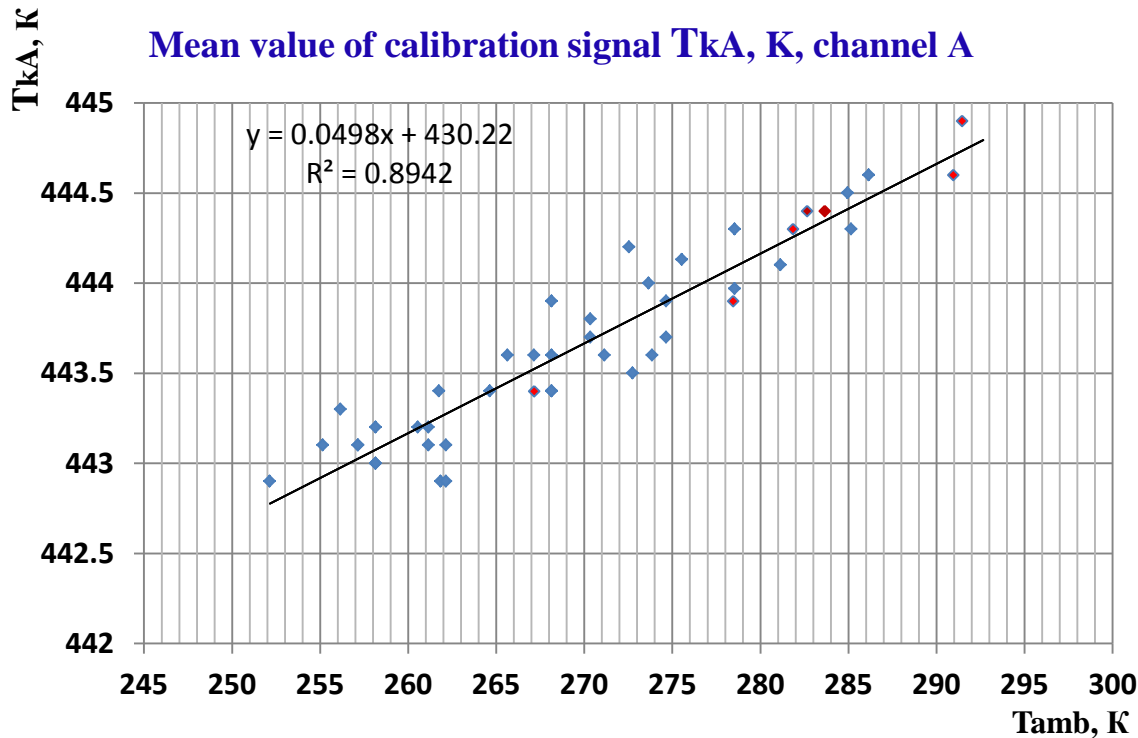


Calibration signals referred to the WVR input:

$$T_{kA} = T_{cA} + T_{rec.A}(T_{amb})$$

$$T_{kB} = T_{cB} + T_{rec.B}(T_{amb})$$

$T_{rec.A}(T_{amb})$  – receiver noise temperature depends on  $T_{amb}$ .



**WVR1:**

$$T_{kA} = 0.0498 \cdot T_{amb} + 430.22$$

**August 2012 – June 2013**

Ambient temperature interval:

$T_{amb} : -20^{\circ}C \div +20^{\circ}C$

$$T_{rec.A}(T_{amb}) = (0.0498 \cdot T_{amb} + 430.22) - T_{cA}$$

$$\{T_{bA}, T_{bB}\} \longrightarrow IWV(P, T) \longrightarrow ZWD$$
$$ZWD = \left( 0.106 + \frac{1722}{T_{eff}} \right) \cdot IWV \quad [1,2],$$

L: [cm], IWV: [g/cm<sup>2</sup>], meteo: P: [hPa], T: [K]

$T_{eff}$ , [K] – atmosphere mean temperature (*model based on radiosonde profiles*)

Now  $T_{eff}$  can be measured (!) by T-profiler (MTP-5, ATTEX)

Capacitive rain sensor data are used for WVR data correction

## Reference:

1. K.P.Gaikovich, N.N.Markina, A.P.Naumov, et al. Investigation of remote sensing possibilities of the low atmosphere in the microwave range and some aspects of statistical data use. *Int. Journal of Remote Sensing*, **1983**, v.4, No.2, p.419-431.

2. A.P. Naumov (**1968**), vol. 4, No.2, *Izvestiya, Atmospheric and Oceanic Physics*. (in Russian).

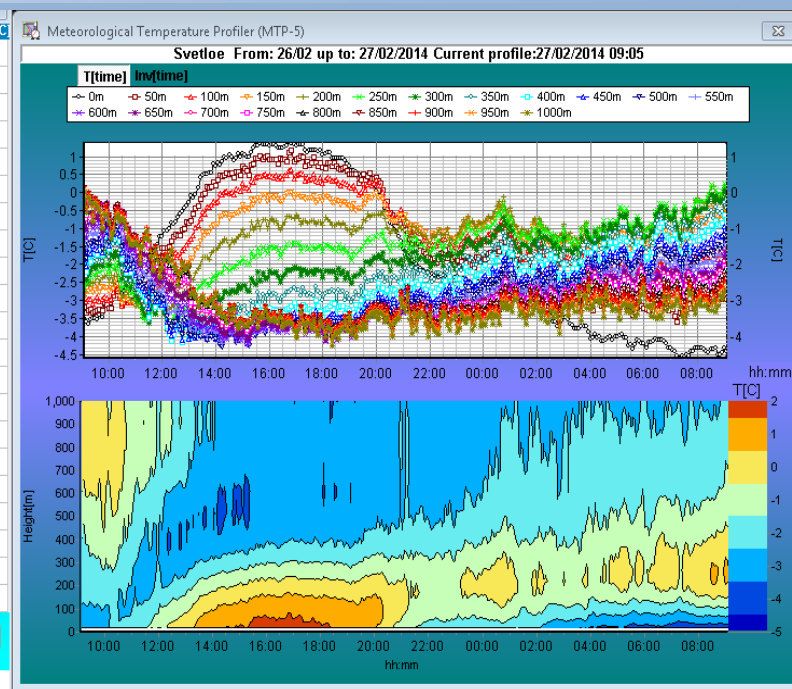
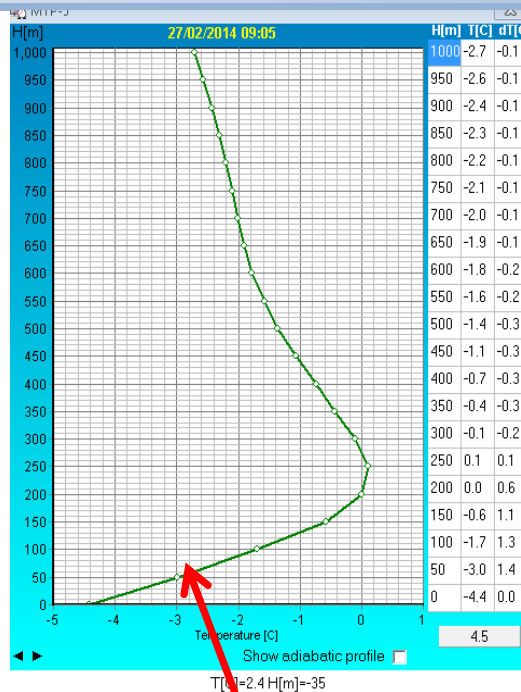
# Metrology: mean atmosphere temperature measurement + calibration IWV



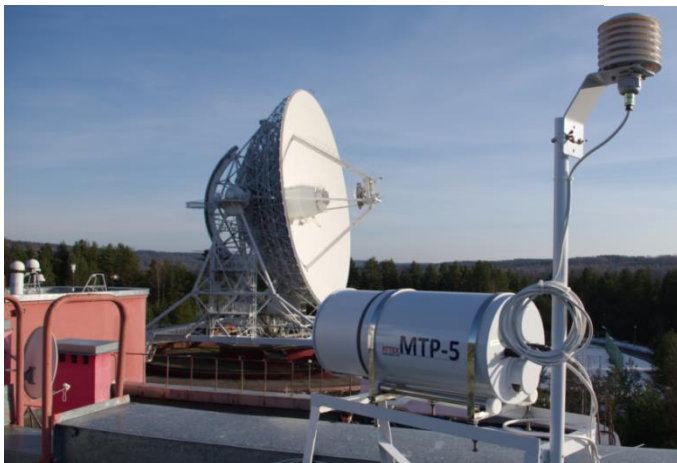
“Svetloe”  
27 Feb 2014,  
(UT: 05:20), T(h)

Atmosphere temperature profiler MTP-5:

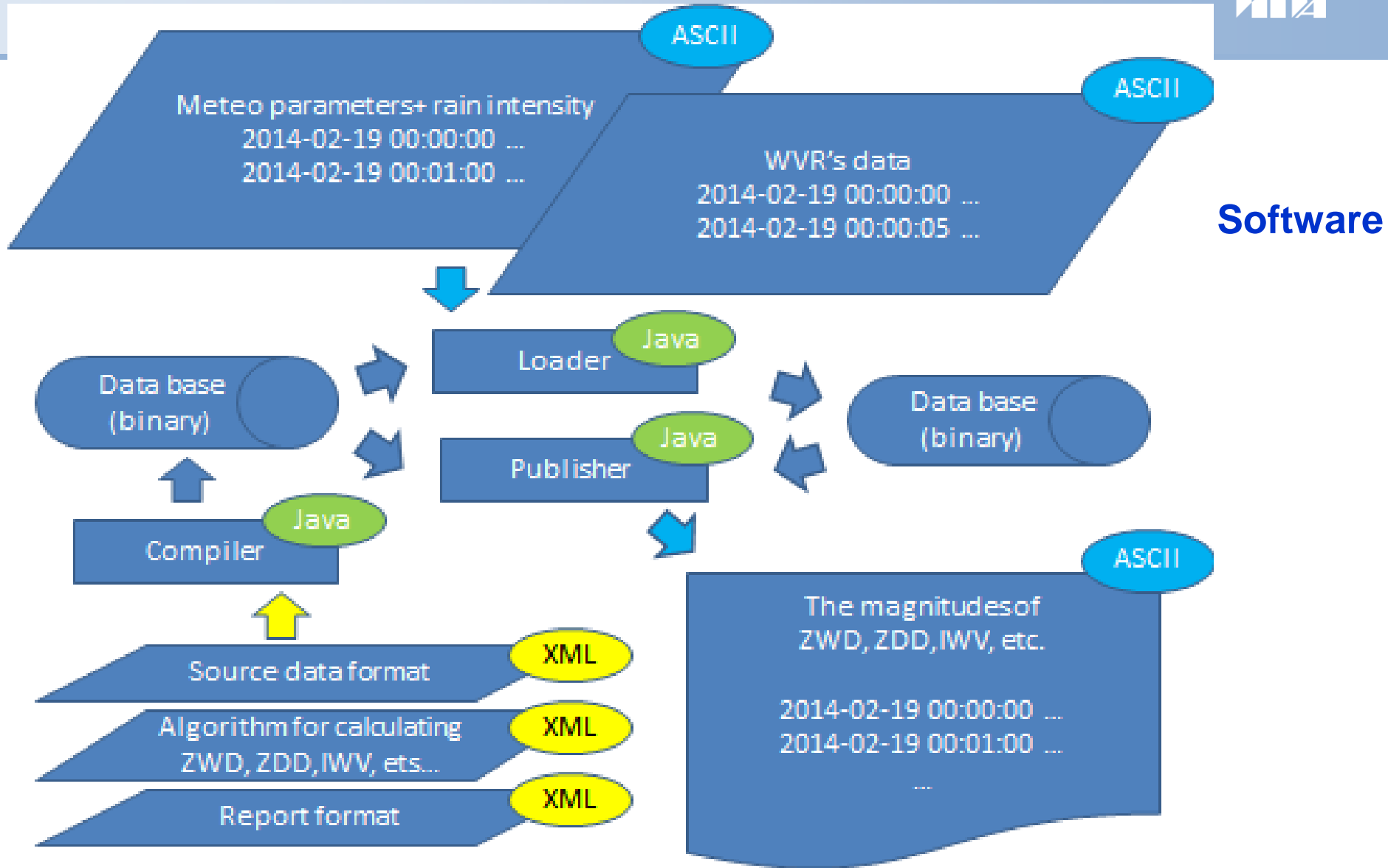
<http://mtp5.ru/>



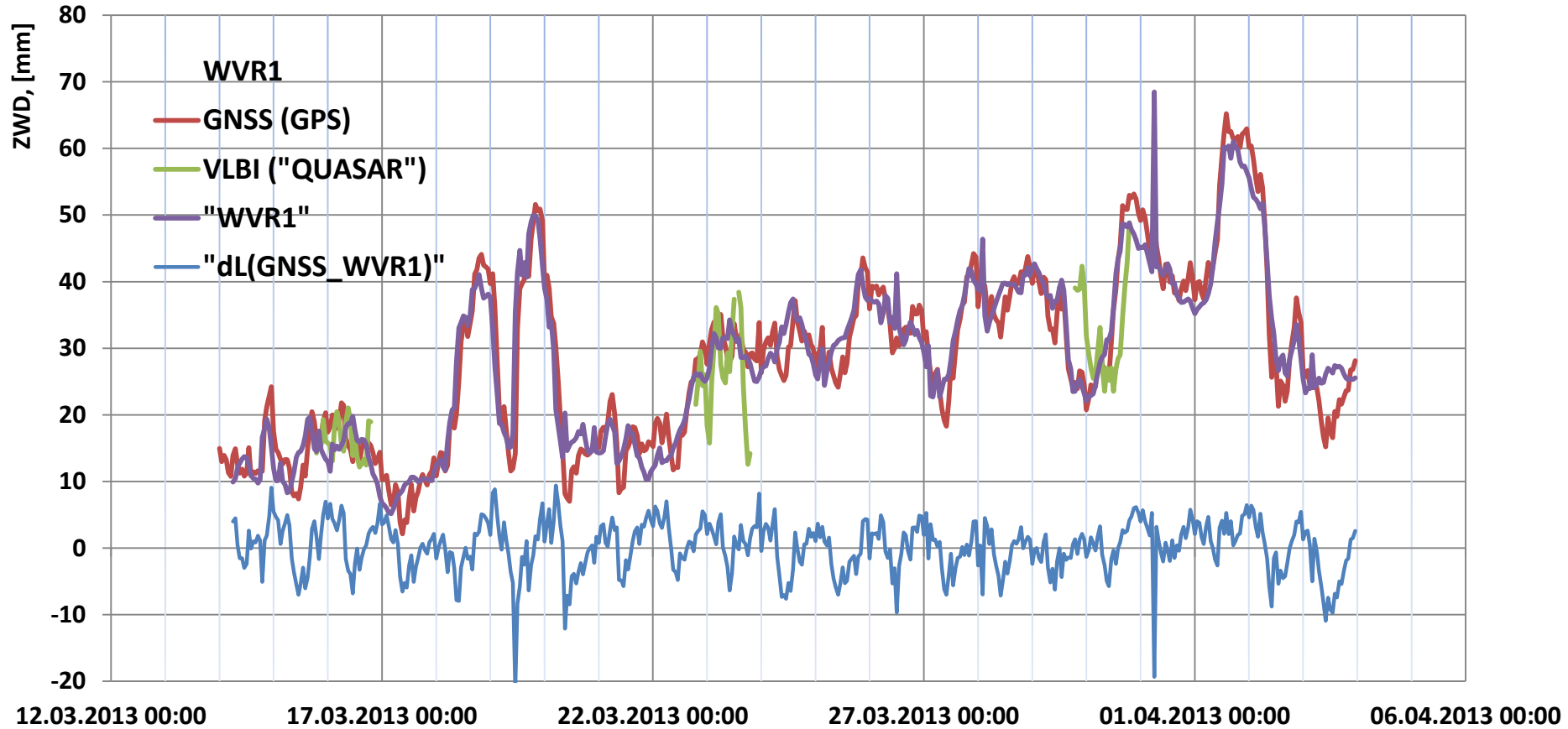
Measurements of T(h) with MTP-5:  
**T(h)** → **T<sub>eff</sub>**



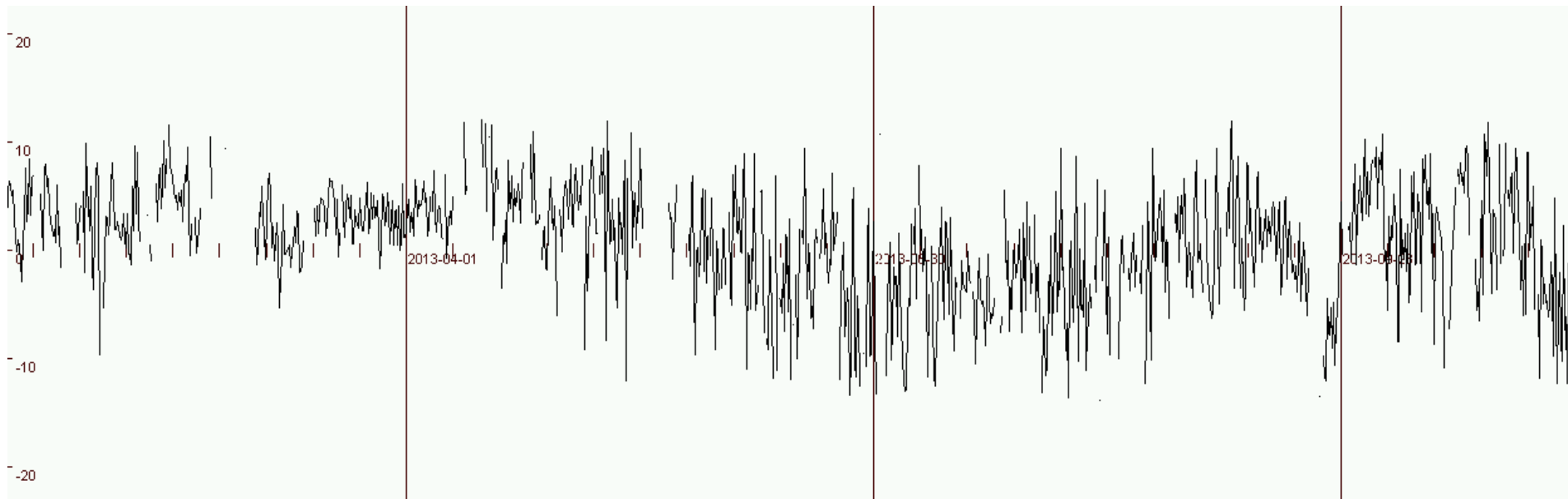
# Data processing : structure of software package



r.m.s. of  $dL \sim 3 \text{ mm}$  ( $dL = ZWD(WVR1) - ZWD(GNSS)$ )



**“Svetloe” ZWD (WVR1- GNSS)**  
**Bias: 1mm, r.m.s. ~ 5 mm, (~25% data removed)**  
**Small temperature dependence**



**Interval: from 2013-01-13 to 2013-11-11 (301 days)**  
**(~20% data removed : rainfall, snowfall, maintenance)**

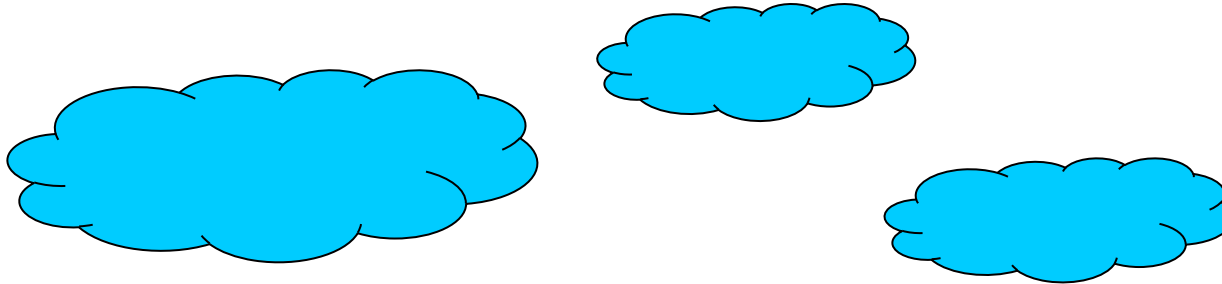
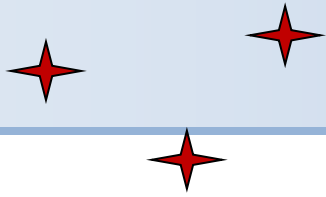


## **WVR1:**

- *Stable metrological parameters for a year period*
- *large interval between calibrations*
- *low operational expenses*
- *continuous , reliable, maintenance-free operation for several months interval*

## **Nearest plans:**

installation MTP-5 in “Zelenchukskaya”,  
installation WVR’s in “Zelenchukskaya” and “Badary”



**Thank you for your attention!**

