

**INTERCOMPARISON  
BETWEEN RA VI  
REGIONAL INSTRUMENT CENTRES**

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**ABSTRACT**

Australian Bureau of Meteorology has developed a transportable suite of reference meteorological instruments suitable for Regional Inter-comparisons of temperature, humidity and pressure. The instruments have uncertainties suitable for this application and can operate independently of local power supplies. This paper also outlines an inter-comparison between the three Regional Instruments Centres of AR VI, Slovakia, Slovenia and France using this suite. Results and uncertainties are presented.

**RESUMÉ**

Le bureau Australien de Météorologie a conçu et réalisé un ensemble transportable de références météorologiques convenant à la réalisation d'inter-comparaisons dans les domaines de la température, humidité et pression. Ces instruments présentent des incertitudes compatibles pour cette application et peuvent être utilisées indépendamment. Ce document également une inter-comparaison entre les trois Centres Régionaux d'Instrumentation de la région VI, la Slovaquie, la Slovénie et la France en utilisant cet ensemble. Les résultats et les incertitudes sont présentées.

## 1. Introduction

Pressure, temperature and humidity are important state parameters of the atmosphere. Meteorological requirements for temperature measurements primarily relate to the surface, the upper air and the surface levels of the sea and lakes. These measurements are required for input to numerical weather forecast models, for agriculture, hydrology or climatology. According to the CIMO Guide [1], valid observational data can only be obtained when a comprehensive quality control programme is applied to the instruments and the network. Inherent elements of such quality programmes are the calibration and testing of instruments. On an international scale, the extension of Quality Control programmes to include inter-comparisons is important to the establishment of compatible datasets.

Regional Instrument Centres have been established for calibration and maintenance needs. According to the new Terms Of Reference [2], a RIC must participate in, or organize inter-laboratory comparisons of standard calibration instruments and methods.

The Australian Bureau of Meteorology has developed a suitable set of instruments to allow such inter-comparisons to take place. The French Metrology Laboratory of Météo-France subsequently organized an inter-comparison within the AR VI with Slovakia and Slovenia to demonstrate the use of such a set. Results of the inter-comparison with the Australian Bureau of Meteorology are also available [3].

## 2. Description

### 2.1. Introduction

Transfer standards were purchased or developed for the parameters of Pressure, Temperature and Humidity. The devices chosen were selected on the basis of their uncertainty, transportability, cost and the ability to be powered from a wide range of sources. The total cost of the kit including case is approximately Euro 4000. The complete kit weighs approximately 6 kg.

The complete kit is composed of:

- a digital barometer PTB 220A with three independent cells from Vaisala (fig.2)
- a hand-held Humidity and Temperature meter HM70 manufactured by Vaisala. The chosen probe is a HMP75 (fig.3)

a thermometer from Instrulab 4312A-15-07 System composed of two PT100 Pt 100/ 15A-B5 probes and a display unit (fig.4).



*Figure 1. Assembled and packed inter-comparison kit*



Figure 2. Vaisala PTB220A barometer



Figure 3. Vaisala HM-70 humidity sensor



Figure 4. Instrulab 4312 PT100 temperature Indicator

### 3. Inter-comparison Results

#### 3.1. Normalised Bias

Normalised Bias  $B_N$  is used to analyze the inter-comparison results. The calibrations are uncorrelated as the only common factor is the instrument.

If we considered each bias of each calibration, the Normalized Bias is defined as:

$$B_N = \frac{|B_1 - B_2|}{\sqrt{U_1^2 + U_2^2}}$$

where  $B_1$  and  $B_2$  are respectively the bias (True value – Instrument value) for Lab N°1 and Lab N°2,

and  $U_1$  and  $U_2$  are the associated expanded uncertainties.

Lab N°1 or 2 are successively Slovakia, Slovenia and France.

The Normalized Bias should be lower than 1 or less.

### 3.2. Pressure

The results of calibrations are contained in:

- CERTIFICAT D'ETALONNAGE'' LM P 08023827 et LM P 08033852 for France;
- KALIBRACNY CERTIFIKAT c. 35/23/2008 for Slovakia;
- CERTIFIKAT O KALIBRACIJI N° 414/08 for Slovenia

The results reported in the calibration certificate are the average of the 3 pressure sensor cells.

The expanded uncertainties are calculated as expressed in the ISO Guide of Uncertainty Measurement [4] with a 95% confidence interval and a coverage factor of 1.98. Uncertainty  $U_i$  are reported in table 1. The Australian calibration is also plotted.

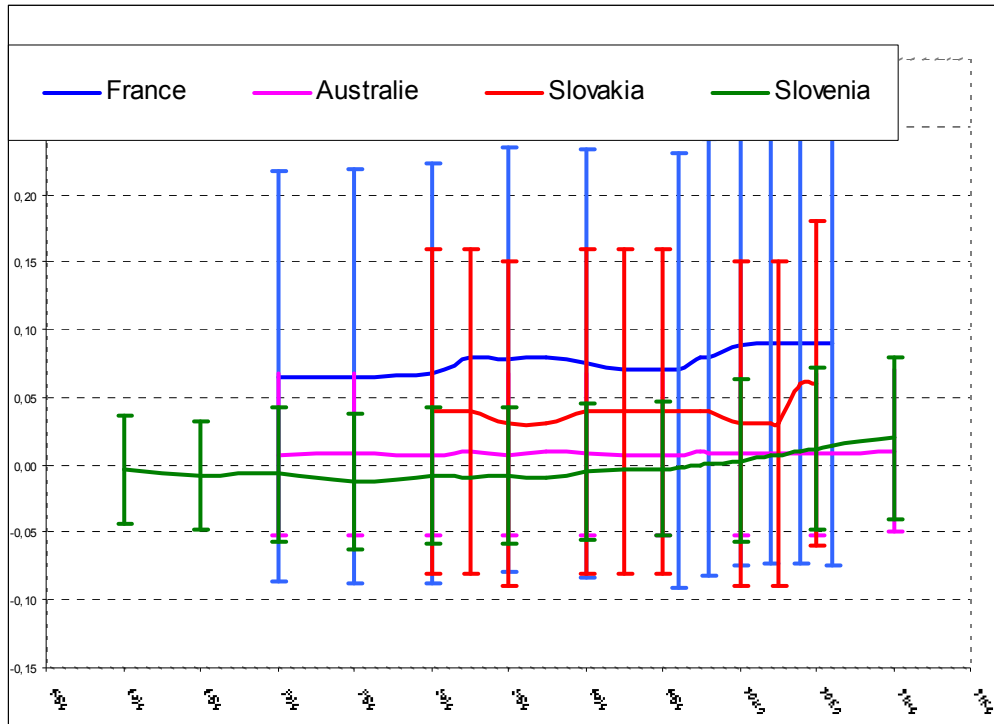


Figure 5: Compared bias versus pressure

| Pression | Corrections France | Uncertainty | Corrections Slovakia | Uncertainty | Corrections Slovenia | Uncertainty |
|----------|--------------------|-------------|----------------------|-------------|----------------------|-------------|
| 1050     | 0,09               | 0,16        | 0,06                 | 0,12        | 0,01                 | 0,06        |
| 1000     | 0,09               | 0,16        | 0,03                 | 0,12        | 0,00                 | 0,06        |
| 950      | 0,07               | 0,16        | 0,04                 | 0,12        | 0,00                 | 0,05        |
| 900      | 0,08               | 0,16        | 0,04                 | 0,12        | -0,01                | 0,05        |
| 850      | 0,08               | 0,16        | 0,03                 | 0,12        | -0,01                | 0,05        |
| 800      | 0,07               | 0,15        | 0,04                 | 0,12        | -0,01                | 0,05        |

Table 1. Results of RA VI Inter-Comparison

As seen in the worksheet, the bias between calibration are always less than 10 Pa; about 4 Pa in average. The maximum Normalised Bias is 0.54. The result is less than 1 and could be considered as good.

French and Australian calibrations with the same instrument set has given similar results [3]. Upon return to Australia, a second Australian calibration has been performed. Results are confirmed.

### 3.3. Humidity

The result of the French Metrology Laboratory are available through the :

- **CERTIFICAT D'ETALONNAGE n° LMHU0801003** 20/02/2008 and,
- **CONSTAT DE VERIFICATION n° LMHO08020212 14/03/2008** for France,
- **KALIBRACNY CERTFIKAT C 48/13/2008** 07/05/2008 for Slovakia,
- **CERTFIKAT O KALIBRACIJI C 473/08** 31/07/2008 for Slovenia.

French calibrations were performed using two different methods. The first used saturated salt solutions as the humidity generator and a Vaisala HMI 36 as the working reference standard. This method is accredited by the COFRAC (French accreditation body). The second calibration was performed using a two temperature bench.

The Slovakian calibration laboratory use a mixing generator C1 from General Eastern as generator and a dew point instrument as humidity standard.

In the Slovenian laboratory, the humidity is generated by a Thunder scientific generator and the standard is as well a dew point mirror.

The results use for this comparisons are the five values from 10.7 to 95.8 % obtained with the accredited method for the French laboratory. The Slovakian values are available from 10.2 to 97.2 % and the Slovenian from 9.1 to 95.3%, for more details see Table 2.

The uncertainties which are respectively equal to 2.5% for Meteo France, 2.6 or 2.7 for Slovakia and 2.4 for Slovenia.

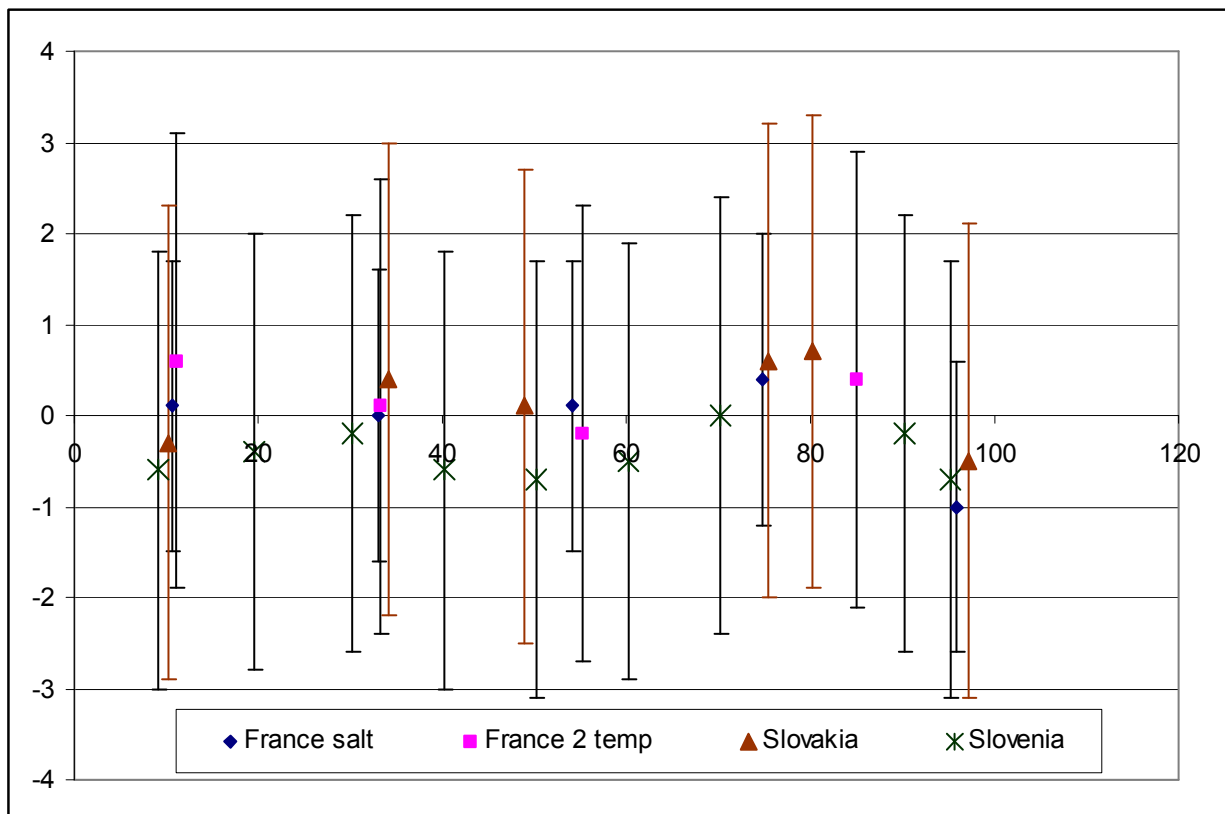


Figure 6: Humidity comparison

| Réf. | Correction MF (%) salt | Uncertainty | Correction MF (%) 2 temp | Uncertainty | Correction Slovakia | Uncertainty | Correction Slovenia | Incert. |
|------|------------------------|-------------|--------------------------|-------------|---------------------|-------------|---------------------|---------|
| 9,1  |                        |             |                          |             |                     |             | <b>-0,60</b>        | 2,4     |
| 10   |                        |             |                          |             |                     |             |                     |         |
| 10,2 |                        |             |                          |             | <b>-0,3</b>         | 2,72        |                     |         |
| 10,7 | <b>0,1</b>             | 2,5         |                          |             |                     |             |                     |         |
| 11,1 |                        |             | <b>0,6</b>               | 1,6         |                     |             |                     |         |
| 19,6 |                        |             |                          |             |                     |             | <b>-0,40</b>        | 2,4     |
| 30,3 |                        |             |                          |             |                     |             | <b>-0,20</b>        | 2,4     |
| 33   | <b>0</b>               | 2,5         |                          |             |                     |             |                     |         |
| 33,2 |                        |             | <b>0,1</b>               | 1,6         |                     |             |                     |         |
| 34,1 |                        |             |                          |             | <b>0,4</b>          | 2,6         |                     |         |
| 35   |                        |             |                          |             |                     |             |                     |         |
| 40,3 |                        |             |                          |             |                     |             | <b>-0,60</b>        | 2,4     |
| 48,9 |                        |             |                          |             | <b>0,1</b>          | 2,57        |                     |         |
| 50   |                        |             |                          |             |                     |             |                     |         |
| 50,2 |                        |             |                          |             |                     |             | <b>-0,70</b>        | 2,4     |
| 54,2 | <b>0,1</b>             | 2,5         |                          |             |                     |             |                     |         |
| 55,3 |                        |             | <b>-0,2</b>              | 1,6         |                     |             |                     |         |
| 60,3 |                        |             |                          |             |                     |             | <b>-0,50</b>        | 2,4     |
| 70,3 |                        |             |                          |             |                     |             | <b>0,00</b>         | 2,4     |
| 74,7 | <b>0,4</b>             | 2,5         |                          |             |                     |             |                     |         |
| 75,5 |                        |             |                          |             | <b>0,6</b>          | 2,59        |                     |         |
| 80   |                        |             |                          |             |                     |             |                     |         |
| 80,3 |                        |             |                          |             | <b>0,7</b>          | 2,6         |                     |         |
| 80,5 |                        |             |                          |             |                     |             |                     |         |
| 85   |                        |             | <b>0,4</b>               | 1,6         |                     |             |                     |         |
| 90,2 |                        |             |                          |             |                     |             | <b>-0,20</b>        | 2,4     |
| 95,3 |                        |             |                          |             |                     |             | <b>-0,70</b>        | 2,4     |
| 95,8 | <b>-1</b>              | 2,5         |                          |             |                     |             |                     |         |
| 97,2 |                        |             |                          |             | <b>-0,5</b>         | 2,68        |                     |         |

Table 2. Results of the RA VI RIC's humidity Inter-Comparison

|    | France-SLOVAKIA |       | France-SLOVENIA |       | SLOVAKIA-SLOVENIA |       |
|----|-----------------|-------|-----------------|-------|-------------------|-------|
| 10 | 0,400           | 0,108 | 0,700           | 0,189 | 0,300             | 0,083 |
| 30 | 0,400           | 0,111 | 0,200           | 0,058 | 0,600             | 0,170 |
| 50 | 0,000           | 0,000 | 0,800           | 0,231 | 0,800             | 0,228 |
| 80 | 0,200           | 0,056 | 0,400           | 0,115 | 0,700             | 0,198 |
| 90 | 0,500           | 0,136 | 0,200           | 0,058 | 0,200             | 0,056 |

Table 3: Normalised Bias

As shown in table 3, the Normalised Bias is quite low. Humidity results are consistent.

### 3.4. Temperature

The results are available through:

- CERTIFICAT D'ETALONNAGE N° LM T 08022548 and LM T08022549 for France;
- KALIBRACNY CERTIFIKAT c. 47/13/2008 and c. 48/13/2008 for Slovakia ;
- CERTIFIKAT O KALIBRACIJI St : 449/08 and St : 450/08 for Slovenia.

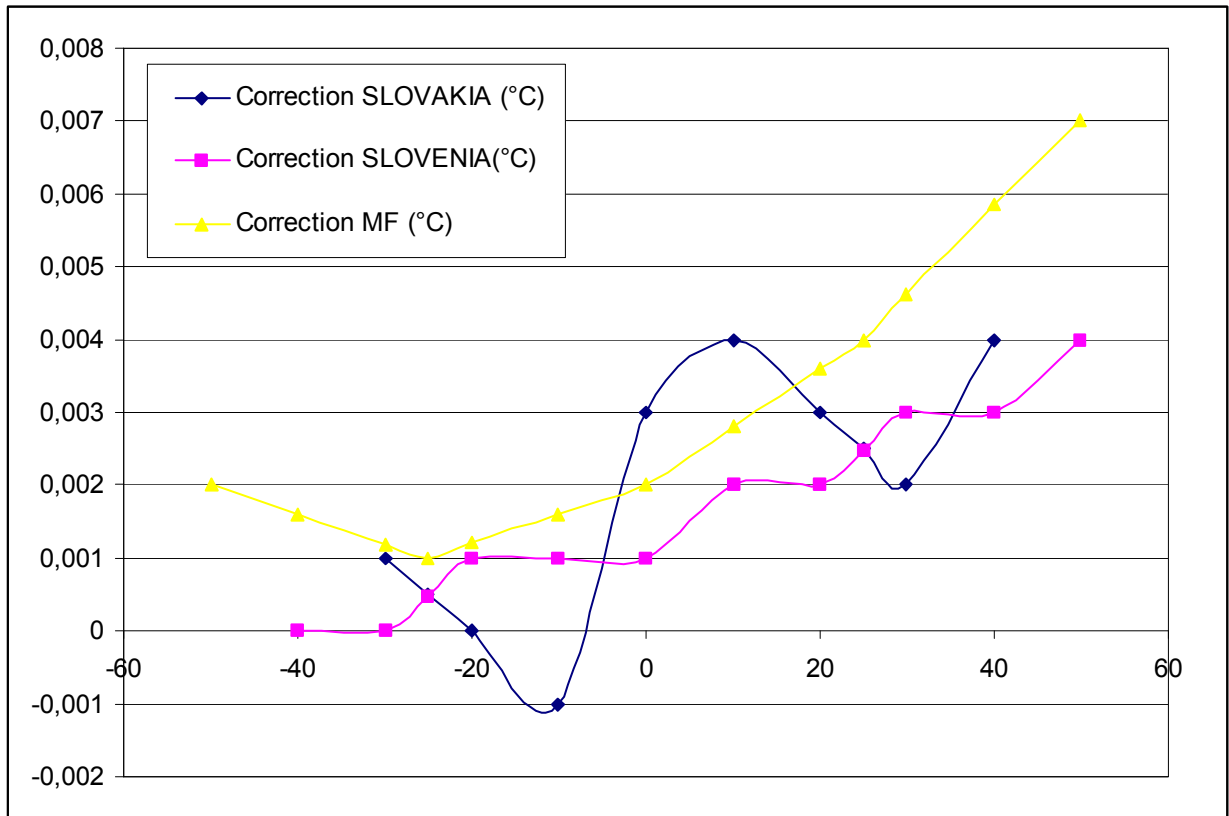


Figure 7: Temperature comparison

Differences are approximately 0.01°C. This is insignificant compared to the uncertainties which are 0.035 for France and 0.05 for Slovakia and 0.02 for Slovenia. The graphic (fig. 7) do not show the uncertainty because there are significantly larger than the differences between the two curves.

| Normalised Bias | France | Slovakia | Slovenia |
|-----------------|--------|----------|----------|
| France          | X      | 0.043    | 0.071    |
| Slovakia        | 0.043  | X        | 0.097    |
| Slovenia        | 0.114  | 0.243    | X        |

Table 4: Maximum Normalised Bias. The upper cells for Thermometer N° 0010, the lower cells for Thermometer N° 0001.

As shown in table 4, the Normalised Bias is very low. Result concerning temperature are excellent.

#### **4. Conclusion**

From these results it can be concluded that:

1. the RICs of RA VI are operating within their stated uncertainties with respect to temperature, pressure and humidity;
2. the instruments chosen for the inter-comparison are stable for international transport by air and are therefore suitable for future inter-comparisons between RICs and NMHS;
3. the procedures adopted for this inter-comparison are suitable for international inter-comparisons;
4. Inter-comparisons are always very helpful for all participants and should be organized by RIC and promoted by WMO.

#### **5. Bibliography**

[1] World Meteorological Organization, N°8 GUIDE TO METEOROLOGICAL INSTRUMENTS AND METHODS OF OBSERVATION, rev 7:

<http://www.wmo.int/pages/prog/www/IMOP/IMOP-home.html>

[2] Duvernoy, J. and J. Gorman: A REVIEW OF THE UPDATED TERMS OF REFERENCE FOR RIC; TECO 2008

[3] Duvernoy, J. and J. Gorman: INTERCOMPARISON BETWEEN METEO-FRANCE (RA VI RIC) AND AUSTRALIAN BUREAU OF METEOROLOGY (RA II) RIC; TECO 2008

[4] International Organization for Standardization: Guide to the expression of Uncertainty in Measurement (GUM) ISO/IEC Guide 98:1995