MIKES

Joint work with the IAPWS: TOWARDS HARMONISED DEFINITION OF RELATIVE HUMIDITY

CCT Meeting

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Overview

- Introduction
- Problems with the definition of relative humidity
- Proposal
- Status and future
- Summary

Introduction

fundamental problems in humidity & moisture

Category	Problems
Terms	Not well defined Variations in use
Definitions of quantities	Ambiguous Different definitions Limited coverage
Symbols of quantities	Large variety of symbols in use
Units	Presentation of relative units Confusion in presenting uncertainty

Activities

Draft WG6 document
- Humidity terms and definitions
- Draft by Peter Huang and Martti Heinonen

WG6-IAPWS-WMO
- Focus in RH
- Covering humidity terms and definitions

EMRP METefnet

- Definitions for moisture

A joint effort of IAPWS, BIPM, SCOR, IAPSO and WMO, coordinated by the Joint Committee on Seawater (JCS)

- **IAPWS:** Develop and endorse highly accurate correlation equations, consistent with TEOS-10, that relate S, pH and RH to measurands defined within the SI
- **CIPM (CCT, CCQGM):** Develop and endorse uniform definitions and metrological standards for S, pH and RH in the framework of the SI
- **SCOR, IAPSO, WMO:** Guide and support the adoption of the new equations and standards in the atmospheric and oceanographic scientific and technical communities

Position paper on future cooperation activities between BIPM and IAPWS

To be published in Metrologia

Metrological challenges for measurements of key climatological observables: Oceanic salinity and pH, and atmospheric humidity

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Presentations etc.:

- J. Lovell-Smith, Toward a universal definition of relative humidity, 16th International Conference on the Properties of Water and Steam Greenwich, London 2013
- J. Lovell-Smith, R. Feistel, Refining the definition of relative humidity, TEMPMEKO 2013
- Olaf Hellmuth: Minutes of the BIPM , CCT -WG6/CCQM & JCS Joint Workshop on Metrological Aspects of Humidity, 3rd September 2013 (The International Association for the Properties of Water and Steam)

Problems with the definition of RH

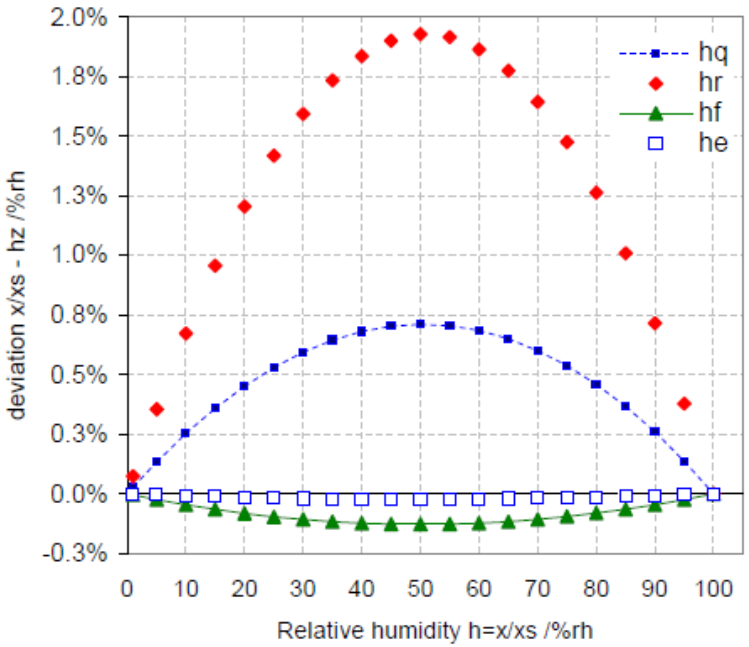
$$RH = \frac{f(p,t_d)e_v(t_d)}{f(p,t_g)e_v(t_g)} \times 100\ \%\text{rh}$$

Problem: many definitions

- Many definitions:
  but one "standard" definition?

$$\psi_x = \frac{x}{x^{\text{sat}}} = \frac{p_v}{p_v^{\text{sat}}} = \psi_{p_v}$$

Comparison of definitions at 40 °C and 0.1 Mpa



$$\psi_r = \frac{r}{r^{\text{sat}}}$$

$$\psi_q = \frac{q}{q^{\text{sat}}}$$

$$\psi_e = \frac{e}{e^{\text{sat}}}$$

Relative fugacity/activity

$$\psi_\lambda = \frac{\lambda}{\lambda^{\text{sat}}} = \frac{f_v}{f_v^{\text{sat}}}$$

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[J. Lovell-Smith, TEMPMEKO 2013]

Problems in practice

- Interpretation of reported RH results:
  - Temperature range below 0 °C (ambient pressure range)
  - Temperatures above the boiling point of water
    - t > 100 °C
    - vacuum

- WMO: Analysing RH data in long time series
- CCT: Presenting CMCs
- Industry

Proposal

- Develop a theoretically justified definition covering the full range
- Develop a formal basis for relative humidity outlining a hierarchy of definitions
  - Fundamental definition based on relative fugacity and differences in the chemical potential of water
  - The “full” definition as the ratio of partial pressures can be calculated with no more uncertainty than can the relative fugacity.
  - The “standard” definition for the condition $e_{sat} < p$

Proposal (cont.)

- Develop a mise en pratique for relative humidity
  - Methods for practical realisation
  - Calculation of quantities and uncertainties
  - Reference functions for saturation vapour pressure of water and water vapour enhancement factor for air
- Develop axiomatic approach to humidity (TEOS-10 approach)
- Develop standardised nomenclature and units
- Consider effects of gases other than standard air

Status and future

- The position paper will be finalised soon.
- CCT WG-6 will agree on the approach in this year.
- After the decision, WG-6 will start preparing the CCT documents

Summary

- Cooperation with IAPWS gave a boost to solving the problem with the RH definition
  - Theoretical input
  - New approach
  - Significantly wider involvement from different fields of science and industry
- Without the wide involvement outside the metrology community, progress with real impact is not possible.
- Analogous to development of SI base units, the proposed approach for the RH definition is more flexible for future developments.