



# PsychroMoist

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www.fluidika.com  
support@fluidika.com

## USER GUIDE

### REQUIREMENTS:

Compatible with iPhone. Requires iOS 12.1 or later.

### VERSION: 3.2

## Description

**PsychroMoist** is an application that performs high-precision calculations of psychrometrics and thermodynamics properties of humid air. Given a combination of two humid air properties and a value of pressure, it calculates 39 thermodynamic properties of humid air, dry air, water, water vapor and ice.

Incorporates the latest mathematical models for the simulation of the physics of water vapor, dry air and humid air as real gases.

The numerical results obtained are suitable for scientific, industrial, HVAC, meteorology, engineering and related fields.

## Main Features

- Performs all the calculations implementing the latest mathematical models used to generate the tables for humid air properties and thermodynamic properties of water in the 2009 ASHRAE Handbook of Fundamentals, namely:
  - Thermodynamic and psychrometric property algorithms from the ASHRAE Research Project 1485.
  - Properties of steam, water and ice from the Industrial Formulation IAPWS-IF97, the Scientific Formulation IAPWS-95, IAPWS Formulation 2008 and IAPWS Formulation 2006. Properties of dry air are from the NIST Reference equation of Lemmon et al.
- Calculates 39 psychrometric and thermodynamic properties of humid air, dry air, war, water vapor and ice (see Table 2).
- It allows for 17 combinations of thermodynamic properties to be entered as input parameters:
  - Dry-bulb Temperature / Wet-bulb Temperature
  - Dry-bulb Temperature / Dew Point Temperature

- Dry-bulb Temperature / Relative Humidity
  - Dry-bulb Temperature / Humidity Ratio
  - Dry-bulb Temperature / Specific Enthalpy
  - Dry-bulb Temperature / Specific Volume
  - Wet-bulb Temperature / Dew Point Temperature
  - Wet-bulb Temperature / Relative Humidity
  - Wet-bulb Temperature / Humidity Ratio
  - Dew Point Temperature / Relative Humidity
  - Dew Point Temperature / Specific Enthalpy
  - Dew Point Temperature / Specific Volume
  - Relative Humidity / Humidity Ratio
  - Relative Humidity / Specific Enthalpy
  - Relative Humidity / Specific Volume
  - Humidity Ratio / Specific Enthalpy
  - Humidity Ratio / Specific Volume
- Supports input parameters and calculation results in both the SI (metric) and I-P (English) system of units.
  - For each combination of input thermodynamic properties, it calculates and provides the user with information about the appropriate input values in the valid range of calculations.
  - Results can be sent by email as an HTML file and a comma-separated value (CSV) file.

## Limited Range of Variables

Certain limitations apply to **PsychroMoist** when the application does not have access to the Full Range of Variables. These limitations are described in Table 1.

	<b>Full Range of Variables</b>	<b>Limited Range of Variables</b>
Range of value variables for calculation of properties	FULL RANGE	LIMITED
Combination of variables for calculation of properties	ALL COMBINATIONS	ALL COMBINATIONS
Calculation of thermodynamic and psychrometrics properties	ALL	LIMITED
Sending calculation results by email	ENABLED	DISABLED

**Table 1.** Limitations applied when the application does not have access to the Full Range of Variables.

## Output Result Properties and Units

The output thermodynamic and psychrometric properties that **PsychoMoist** calculates and their units are:

Result Property	SI Units	I-P Units
Dry-Bulb Temperature	°C, K	°F, °R
Wet-Bulb Temperature	°C, K	°F, °R
Dew Point Temperature	°C, K	°F, °R
Humid Air Pressure	Pa, kPa, bar, mmHg	psi, inHg, inH <sub>2</sub> O, atm
Water Vapor Pressure	Pa, kPa, bar, mmHg	psi, inHg, inH <sub>2</sub> O, atm
Saturation Water Vapor Pressure	Pa, kPa, bar, mmHg	psi, inHg, inH <sub>2</sub> O, atm
Saturation Pressure at Wet-Bulb Temperature	Pa, kPa, bar, mmHg	psi, inHg, inH <sub>2</sub> O, atm
Saturation Pressure at Dew Point Temperature	Pa, kPa, bar, mmHg	psi, inHg, inH <sub>2</sub> O, atm
Dry Air Mole Fraction	[-]	[-]
Water Mole Fraction	[-]	[-]
Dry Air Mass Fraction	[-]	[-]
Water Mass Fraction	[-]	[-]
Humidity Ratio	kg(w)/kg(da), g(w)/kg(da)	lb(w)/lb(da), gr(w)/lb(da)
Saturation Humidity Ratio	kg(w)/kg(da), g(w)/kg(da)	lb(w)/lb(da), gr(w)/lb(da)
Relative Humidity	[%]	[%]
Absolute Humidity	kg(w)/m <sup>3</sup>	lb(w)/ft <sup>3</sup>
Parts per million by weight	ppmw	ppmw
Parts per million by volume	ppmv	ppmv
Enhancement Factor	[-]	[-]
Specific Volume of Dry Air	m <sup>3</sup> /kg	ft <sup>3</sup> /lb
Specific Volume of Moist Air	m <sup>3</sup> /kg(da)	ft <sup>3</sup> /lb(da)
Specific Volume of Saturated Water	m <sup>3</sup> /kg	ft <sup>3</sup> /lb
Specific Volume of Saturated Ice	m <sup>3</sup> /kg	ft <sup>3</sup> /lb
Specific Volume of Saturated Water Vapor	m <sup>3</sup> /kg	ft <sup>3</sup> /lb
Density of Dry Air	kg/m <sup>3</sup>	lb/ft <sup>3</sup>
Density of Moist Air	kg/m <sup>3</sup>	lb/ft <sup>3</sup>
Density of Saturated Water	kg/m <sup>3</sup>	lb/ft <sup>3</sup>
Density of Saturated Ice	kg/m <sup>3</sup>	lb/ft <sup>3</sup>
Density of Saturated Water Vapor	kg/m <sup>3</sup>	lb/ft <sup>3</sup>
Specific Enthalpy of Dry Air	kJ/kg	Btu/lb
Specific Enthalpy of Moist Air	kJ/kg(da)	Btu/lb(da)
Specific Enthalpy of Saturated Water	kJ/kg	Btu/lb
Specific Enthalpy of Saturated Ice	kJ/kg	Btu/lb
Specific Enthalpy of Saturated Water Vapor	kJ/kg	Btu/lb
Specific Entropy of Dry Air	kJ/(kg·K)	Btu/(lb·°R)
Specific Entropy of Moist Air	kJ/(kg(da)·K)	Btu/(lb(da)·°R)
Specific Entropy of Saturated Water	kJ/(kg·K)	Btu/(lb·°R)
Specific Entropy of Saturated Ice	kJ/(kg·K)	Btu/(lb·°R)
Specific Entropy of Saturated Water Vapor	kJ/(kg·K)	Btu/(lb·°R)
Compressibility of Dry Air	[-]	[-]
Compressibility of Moist Air	[-]	[-]
Compressibility of Saturated Water Vapor	[-]	[-]

Table 2. Result Output Variables of **PsychoMoist**.

PsychroMoist main graphical user interface and a description of its interaction buttons is shown in Figure 1. The combination of input variables is described in Table 5.

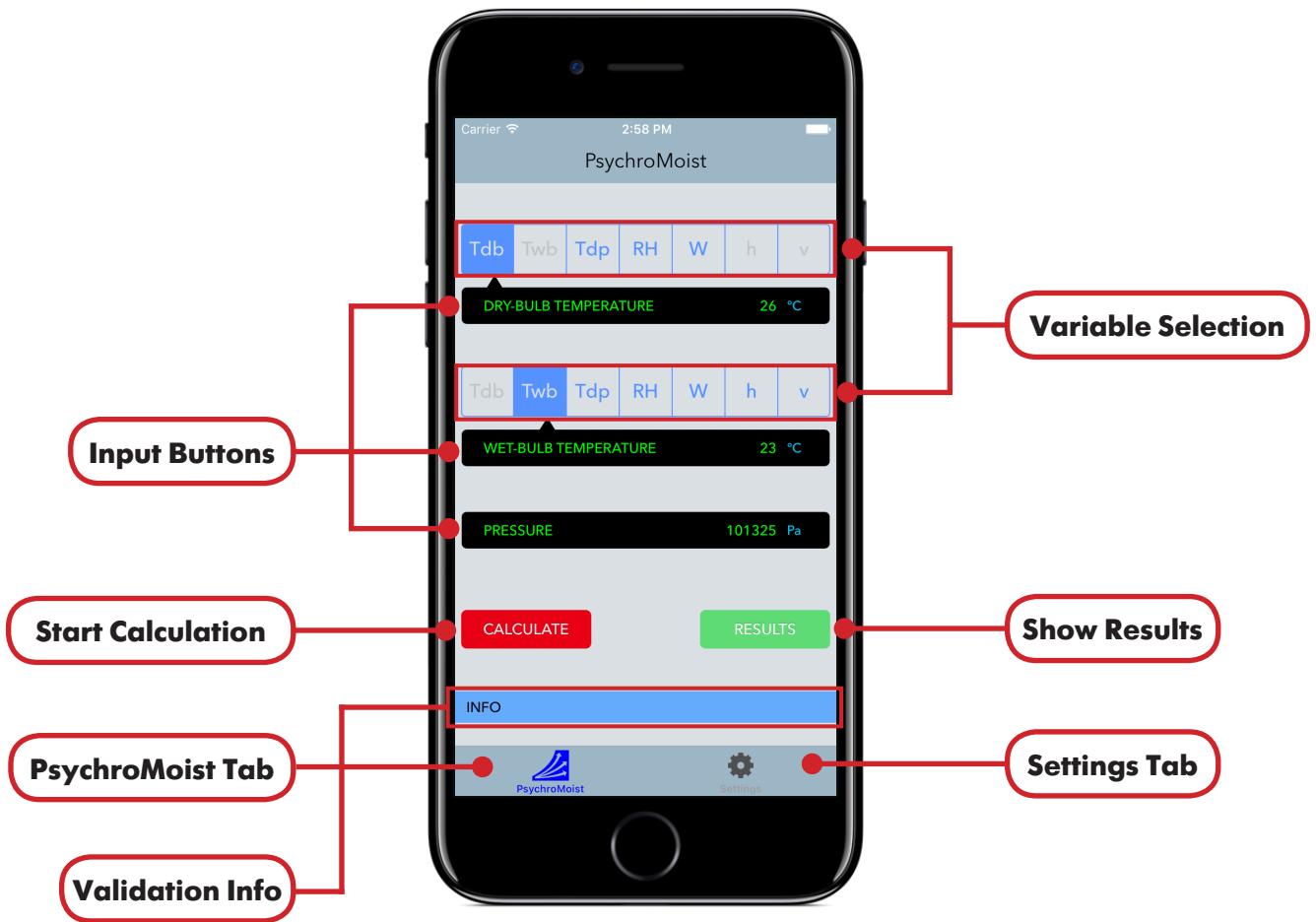


Figure 1. Graphical User Interface for PsychroMoist..

Dry-bulb Temperature	(Tdb)	Wet-bulb Temperature	(Tdb)
Dry-bulb Temperature	(Tdb)	Dew point Temperature	(Tdp)
Dry-bulb Temperature	(Tdb)	Relative Humidity	(RH)
Dry-bulb Temperature	(Tdb)	Humidity Ratio	(W)
Dry-bulb Temperature	(Tdb)	Specific Enthalpy	(h)
Dry-bulb Temperature	(Tdb)	Specific Volume	(v)
Wet-bulb Temperature	(Tdb)	Dew point Temperature	(Tdp)
Wet-bulb Temperature	(Tdb)	Relative Humidity	(RH)
Wet-bulb Temperature	(Tdb)	Humidity Ratio	(W)
Dew point Temperature	(Tdp)	Relative Humidity	(RH)
Dew point Temperature	(Tdp)	Specific Enthalpy	(h)
Dew point Temperature	(Tdp)	Specific Volume	(v)
Relative Humidity	(RH)	Humidity Ratio	(W)
Relative Humidity	(RH)	Specific Enthalpy	(h)
Relative Humidity	(RH)	Specific Volume	(v)
Humidity Ratio	(W)	Specific Enthalpy	(h)
Humidity Ratio	(W)	Specific Volume	(v)

Table 5. Combination of input variables in PsychroMoist.

The full ranges of input/output thermodynamic properties when entering and displaying values are:

Property		Range in SI Units	SI Units	Range in I-P Units	I-P Units
Dry-bulb Temperature	(Tdb)	$-143.15 \leq Tdb \leq 350.0$	°C	$-225.67 \leq Tdb \leq 662.0$	°F
Wet-bulb Temperature	(Twb)	$-143.15 \leq Twb \leq 350.0$	°C	$-225.67 \leq Tdb \leq 662.0$	°F
Dew Point Temperature	(Tdp)	$-143.15 \leq Tdp \leq 350.0$	°C	$-225.67 \leq Tdb \leq 662.0$	°F
Relative Humidity	(RH)	$0 \leq RH \leq 100.0$	[%]	$0 \leq RH \leq 100.0$	[%]
Humidity Ratio	(W)	$0 \leq W \leq 10.0$	kg/kg	$0 \leq W \leq 10.0$	lb/lb
Specific Enthalpy	(h)	$-311.357 \leq h \leq 32135.848$	kJ/kg	$-126.174 \leq h \leq 13823.61$	Btu/lbm
Specific Volume	(v)	$1.469E-3 \leq v \leq 3.054E5$	m <sup>3</sup> /kg	$2.353E-2 \leq v \leq 4.893E6$	ft <sup>3</sup> /lbm
Pressure	(P)	$10.0 \leq P \leq 10.0E6$	Pa	$0.00145 \leq P \leq 1450.37$	lb/lb

Table 3. Full Range of Input Variables for PsychroMoist.

The limited ranges of input/output thermodynamic properties are:

Property		Range in SI Units	SI Units	Range in I-P Units	I-P Units
Dry-bulb Temperature	(Tdb)	$-143.15 \leq Tdb \leq 350.0$	°C	$-225.67 \leq Tdb \leq 662.0$	°F
Wet-bulb Temperature	(Twb)	$-143.15 \leq Twb \leq 350.0$	°C	$-225.67 \leq Tdb \leq 662.0$	°F
Dew Point Temperature	(Tdp)	$-143.15 \leq Tdp \leq 350.0$	°C	$-225.67 \leq Tdb \leq 662.0$	°F
Relative Humidity	(RH)	$0 \leq RH \leq 100.0$	[%]	$0 \leq RH \leq 100.0$	[%]
Humidity Ratio	(W)	$0 \leq W \leq 10.0$	kg/kg	$0 \leq W \leq 10.0$	lb/lb
Specific Enthalpy	(h)	$-311.357 \leq h \leq 32135.848$	kJ/kg	$-126.174 \leq h \leq 13823.61$	Btu/lbm
Specific Volume	(v)	$1.469E-3 \leq v \leq 3.054E5$	m <sup>3</sup> /kg	$2.353E-2 \leq v \leq 4.893E6$	ft <sup>3</sup> /lbm
Pressure	(P)	<b>P = 700000</b>	Pa	<b>P = 101.526416</b>	psi

Table 4. Limited Range of Input Variables for PsychroMoist.

### Notes:

- The range of thermodynamic properties is bounded by the corresponding saturated values of moist air at a given pressure. In a psychrometric chart, it corresponds to the value of Relative Humidity = 100 %.

### Calculation of Psychrometric and Thermodynamic Properties

- Tap on the **PsychroMoist** tab to show the GUI for the calculation of properties of humid air.
- Select a combination of property variables. Possible combinations are shown in Table 5.
- Tap on the input buttons to introduce the desired values for the calculation. Numerical values that were just entered are in red color.
- Tap on the **CALCULATE** button to start the calculation.

### Calculation Validation

- In case the calculation cannot proceed, because one or both of the input variables are out of the boundaries defined as in [2], a message will be displayed in the INFO area showing the condition required for that particular calculation to be valid.

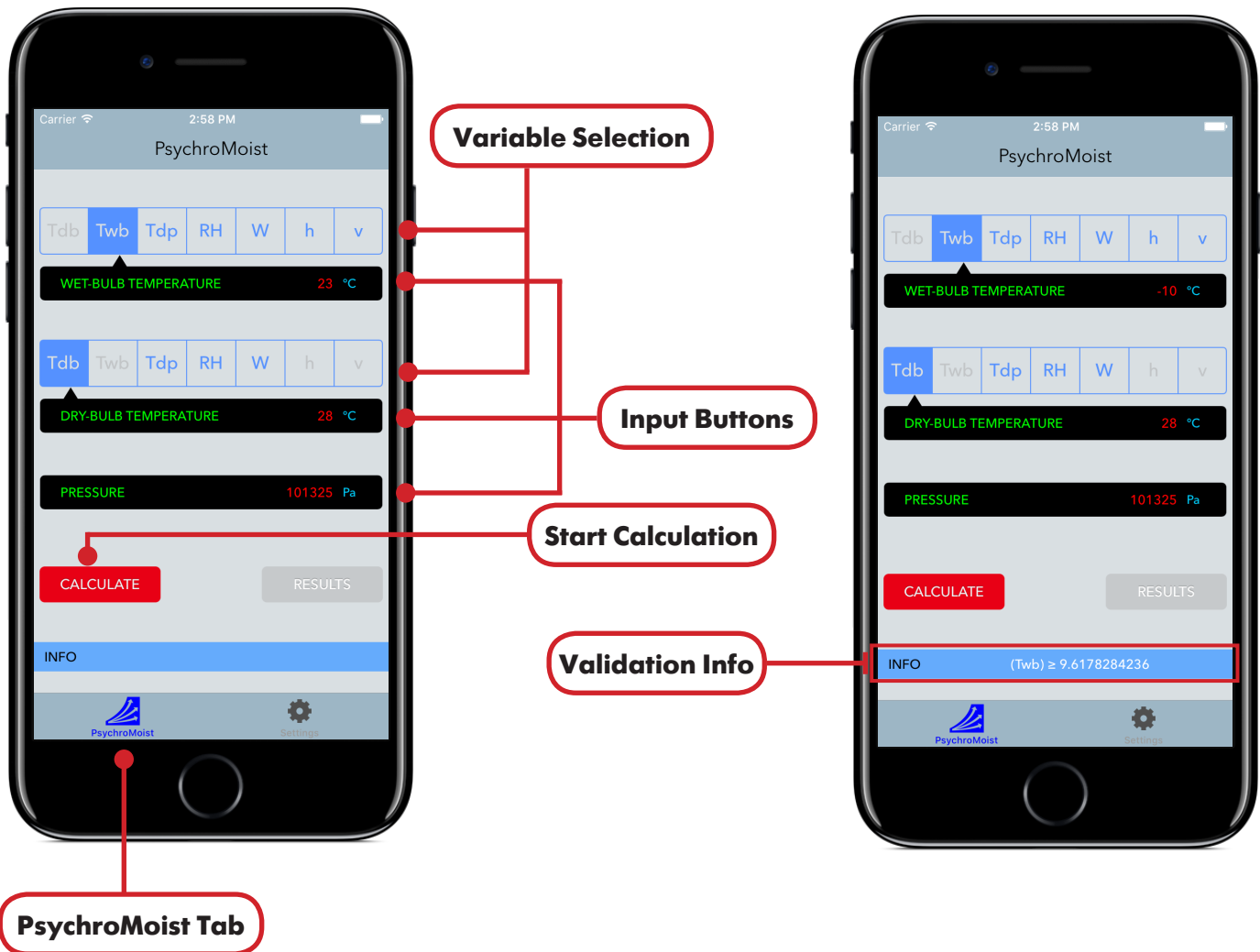


Figure 2. Calculation of psychrometric and thermodynamic properties in **PsychroMoist**.

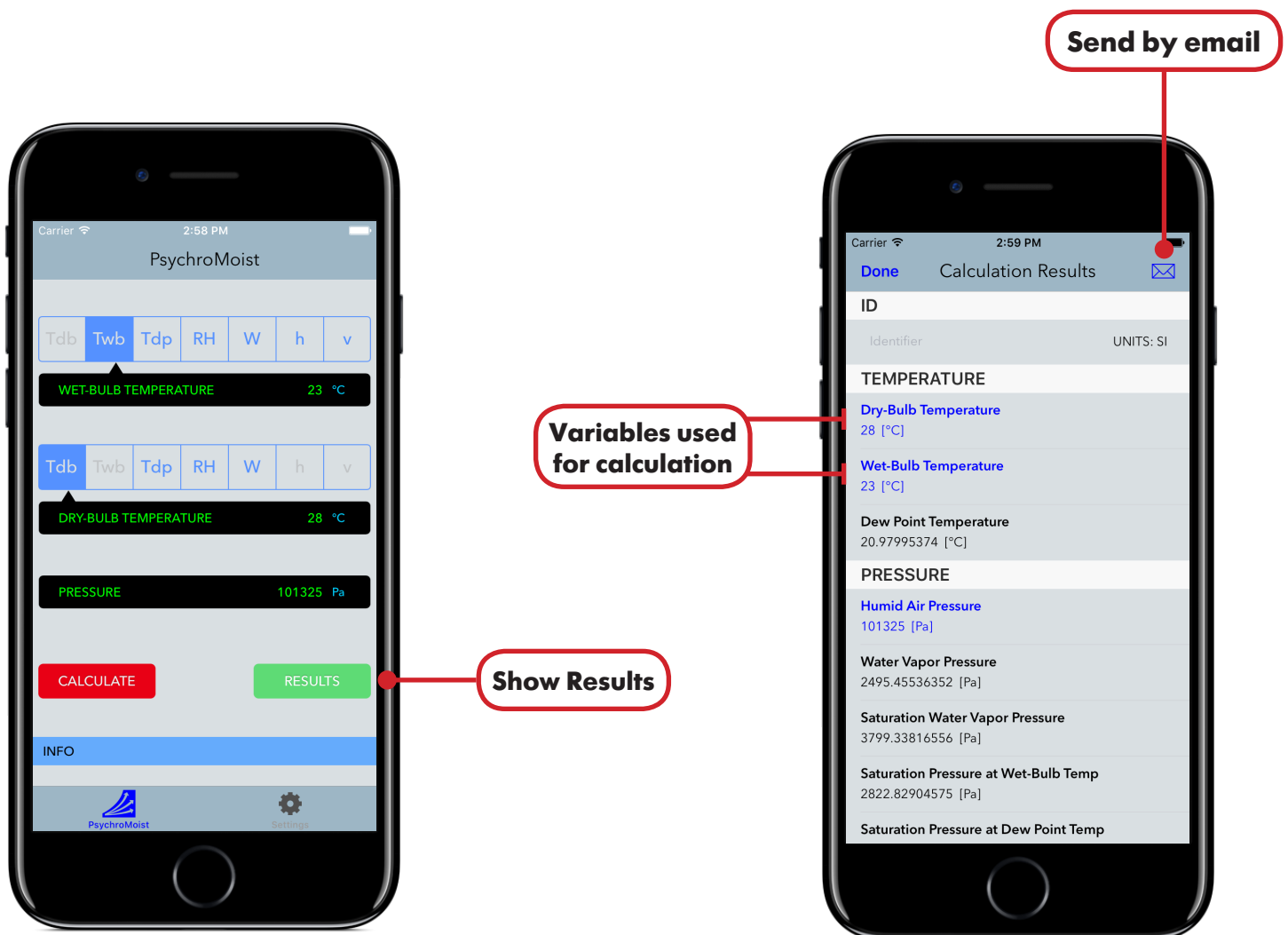
Figure 3. Calculation validation in **PsychroMoist**.

## Show Calculation Results

- Once a calculation has finished successfully, the **RESULTS** button is enabled and the numerical values in the input buttons are in green color, indicating that the application is ready to load the calculation results.
- Tap on the **RESULTS** button to load the calculation results into a table. The variables that were used for that particular calculation are in blue color.

## Send Calculation Results by email

- Tap on the **Send by email** button in the Calculation Results view to send the calculation results by email as an HTML and CSV files in case your device supports this feature. An identifier can be included for the calculation.



**Figure 4.** User Interface after the calculation has finished and is ready to load the calculation results.

**Figure 5.** Calculation results for the current input variables.

**Application Settings**

- Tap on the **Settings** Tab to modify the input/output units for the input variables and calculation results.
- Select the System of Units to used (SI or I-P) for the calculation and/or individual properties in order to set their correspondent units (Table 6).
- Changes to the calculation results and input variables are automatically updated after tapping on the **PsychroMoist** Tab.

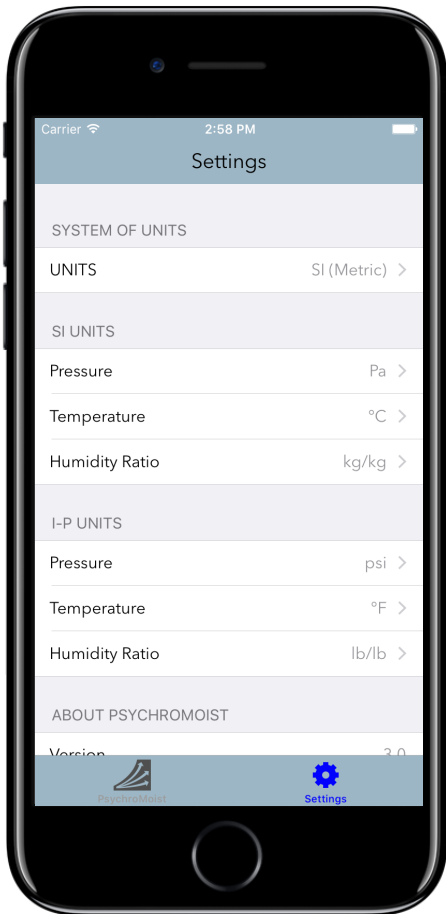


Figure 6. Settings Tab of PsychroMoist.

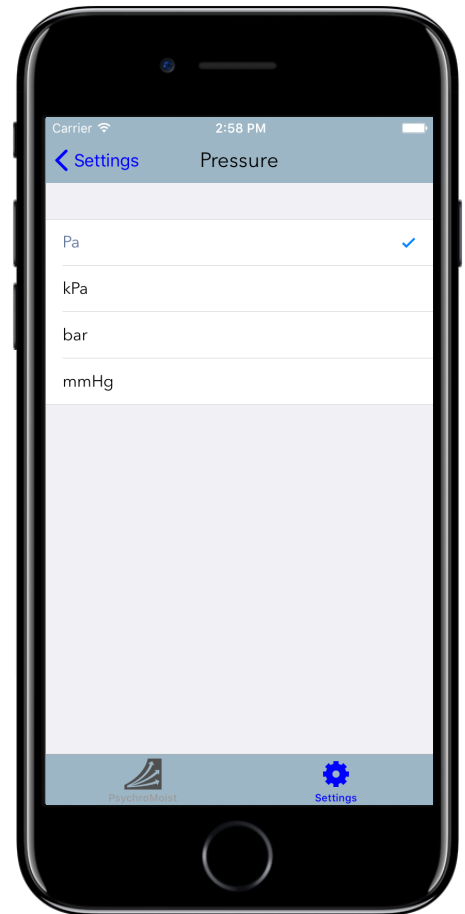


Figure 7. Example of setting the Pressure variable units for a calculation input and their correspondent results.

System of Units
Pressure
Temperature
Humidity Ratio

Table 6. Settings options of PsychroMoist.



## Purchase / Restore full range of variables

### Purchase access to the full range of variables

- In order to access the full range of variables for the application, tap on the **Settings** tab, and then tap on the [Purchase full range of variables](#) button. An internet connection and credentials for the iTunes Store are required to complete the transaction.

### Restore purchase to access the full range of variables

- Information of your purchase is stored in the iTunes Store if you have previously purchased access to the full range of variables, or a prior version of the application. If you require to reactivate full access once again (when for example, reinstalling the application), tap on the **Settings** tab and then tap on the [Restore your purchase](#) button. If the restore transaction is successful, access to the full range of variables will be activated. An internet connection and credentials for the iTunes Store are required to complete the restore transaction.

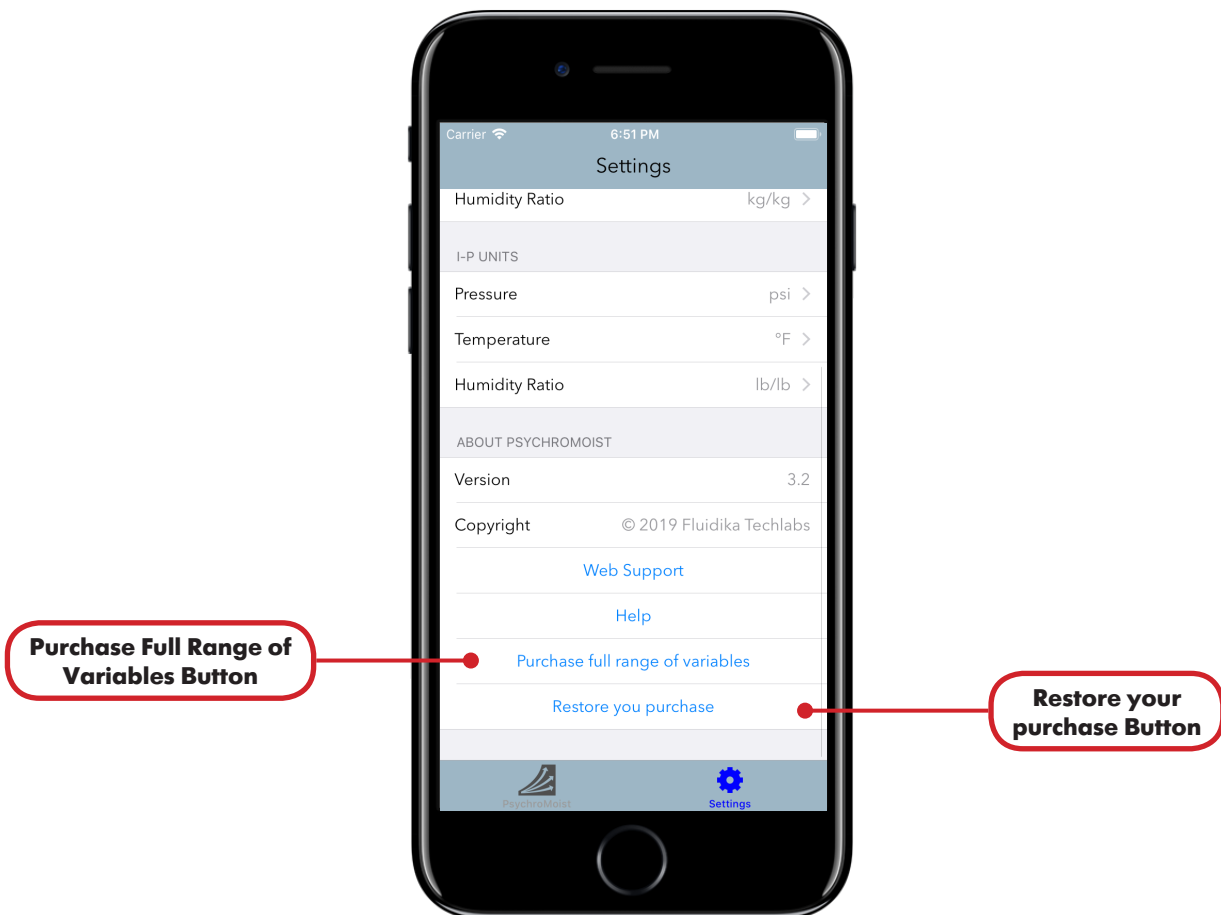


Figure 8. [Purchase full range of variables](#) and [Restore your purchase](#) buttons in the **Settings** tab.

## References

- [1] American Society of Heating; Owen, Mark. S.: *2009 ASHRAE Handbook: Fundamentals*. ASHRAE (2009)
- [2] Herrmann, Sebastian.; Kretzschmar, Hans-Joachim.; Gatley, Donald P.: *Thermodynamic properties of real moist air, dry air, steam, water, and ice (RP-1485)*. HVAC & R Research, (2011).
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