A COMPUTATIONAL FLUID DYNAMICS METHOD FOR RADIOSONDE SOLAR RADIATION ERROR CORRECTION

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Introduction

- Upper-air temperature observation
  - Numerical weather forecast
  - Climate change research

- Solar radiation error
  - It may influence the observation accuracy of sounding temperature sensors.

Introduction

- Traditional correction method of solar radiation error
  - Disadvantages of the wind tunnel experiments
    - The intensity of radiation source is different from the sun.
    - The airflow speed may not uniform.
    - The low pressure environment is difficult to achieve.

Introduction

- Traditional correction method of solar radiation error
  - Disadvantages of the theoretical calculations
    - The Reynolds number is obtained by empirical estimation.
    - The material properties and structure parameters of the temperature sensor are not considered.
    - The analytic solution is difficult to obtain.

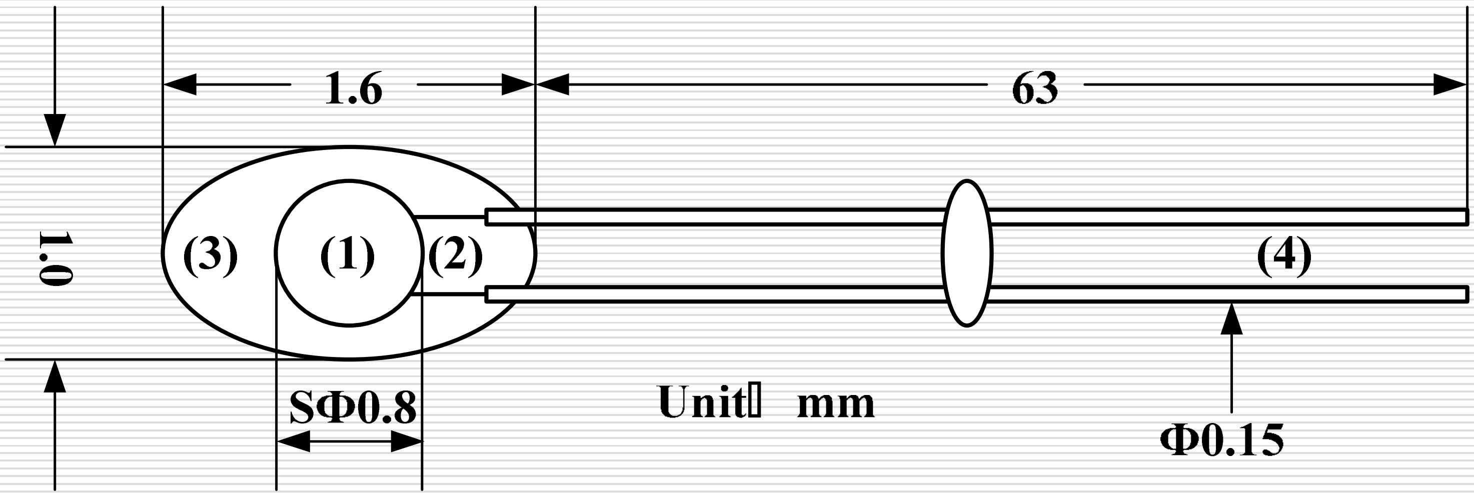
Introduction

- Computational fluid dynamics method
  - It may solve computational problems of complex flow and heat transfer.
  - It may simulate temperature field and flow field of the sounding temperature sensor from sea level to 32 km altitude.

Introduction

- Computational fluid dynamics method
  - Lead diameter, lead length, lead angles, lead materials, solar azimuths, solar elevation angles, the diameter size of the resistor body and the reflectivity of the surface coating which affect measurement precision can be analyzed.
  - It has a potential to scale the solar radiation errors down to roughly 0.1 K magnitude.

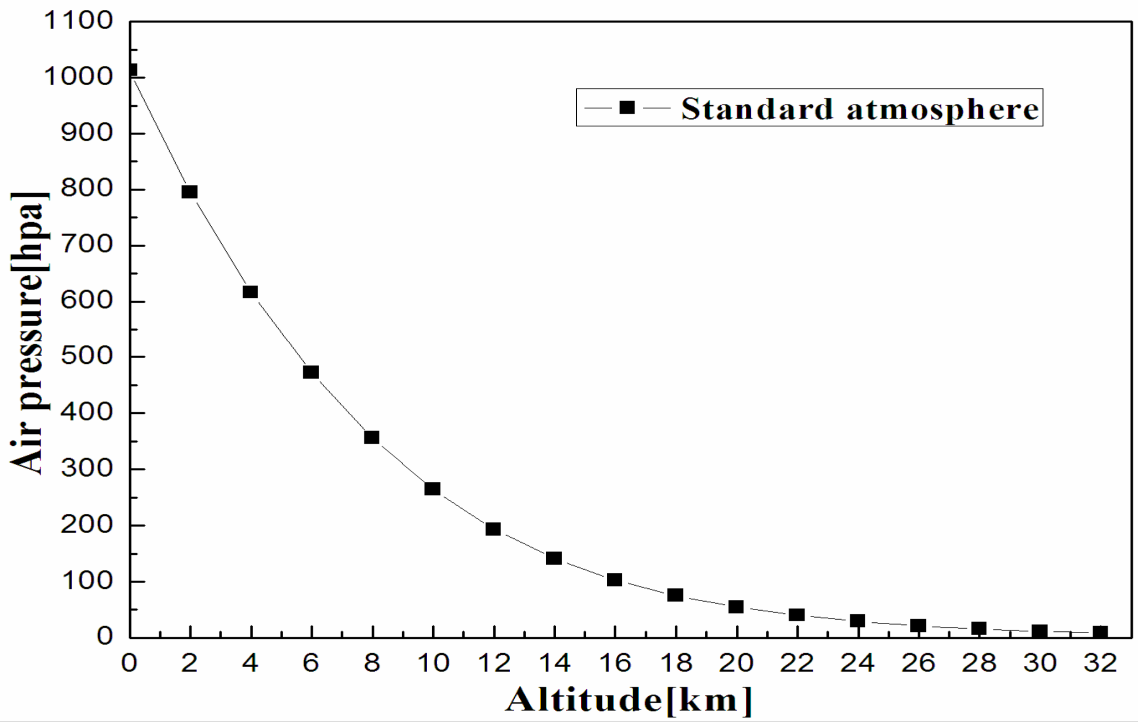
CFD model



(1.Resistor body, 2.Electrodes, 3.Insulating layer, 4.Lead)

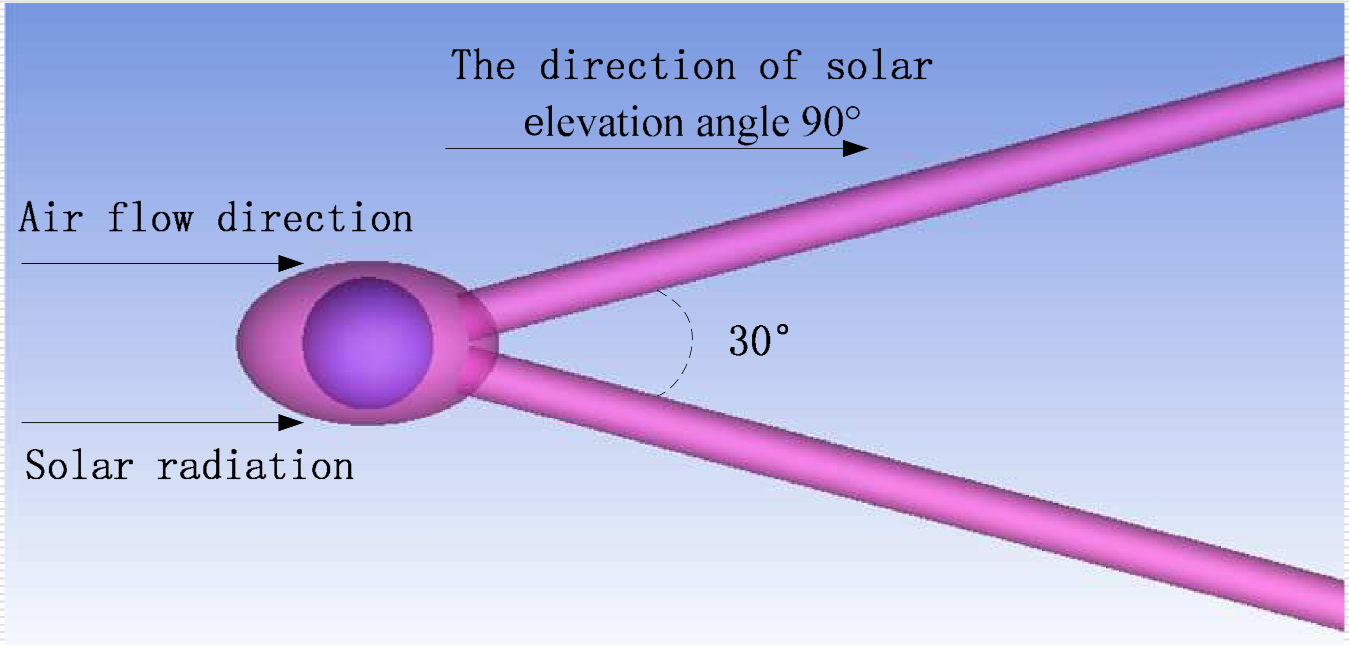
The bead thermistor is composed of a resistor body, a pair of electrodes, an insulating layer and a pair of leads.

CFD model



The relationship between the air pressure and the altitude
(The U.S. standard atmosphere published in 1976)

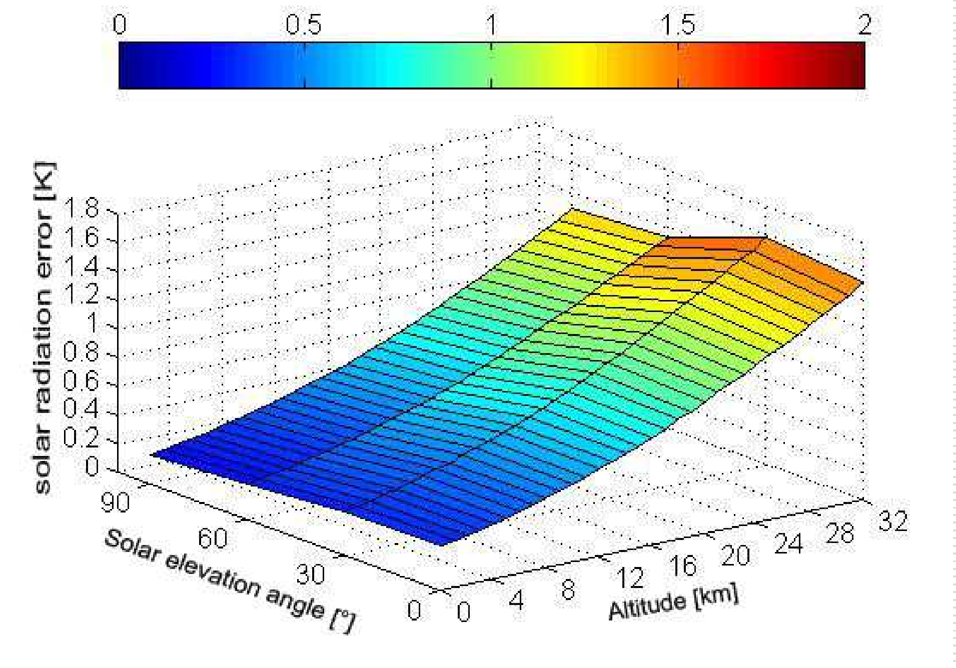
CFD model



The bead thermistor working at different altitudes are exposed to complicated thermal environment. The external thermal fluxes include the direct solar radiation and the convective heat flux.

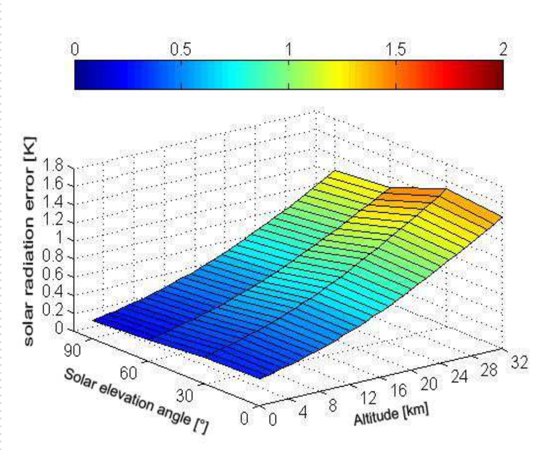
Results and analysis

In order to reveal the relationship among air thermal conductivities, solar elevation angles and solar radiation errors, a surface coating reflectivity of 70 %, a resistor body diameter size of 0.8 mm and a solar direct radiation of 1200 w/m^2 have been used. K, θ represent air thermal conductivity and solar elevation angle, respectively.

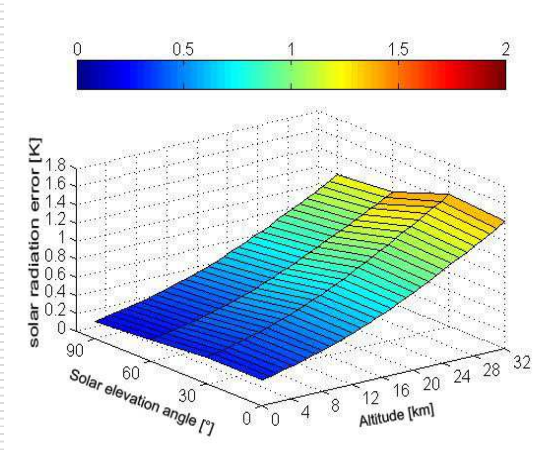


(a) K=0.018, θ =0 ~ 90^o

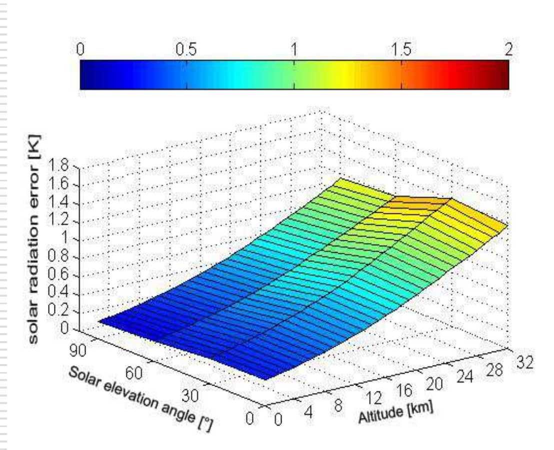
Results and analysis



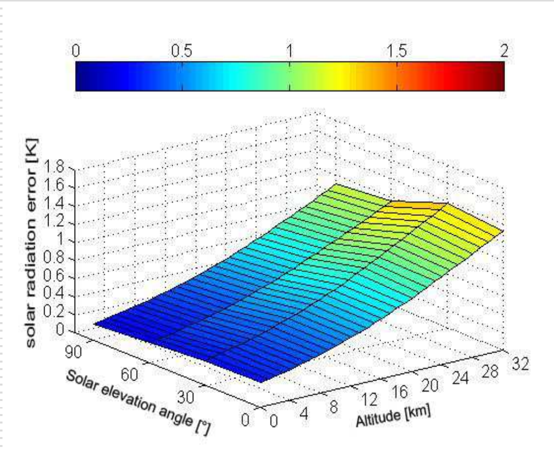
(b) K=0.019, θ = 0 ~ 90^o



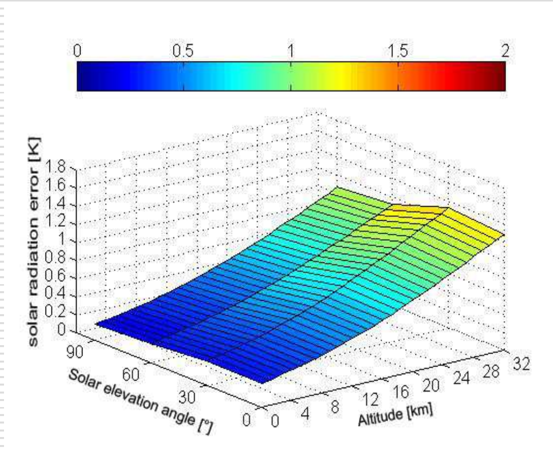
(c) K=0.02, θ = 0 ~ 90^o



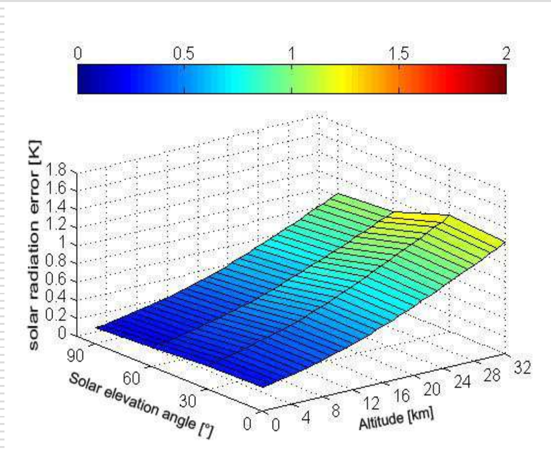
(d) K=0.021, θ = 0 ~ 90^o



(e) K=0.022, θ = 0 ~ 90^o

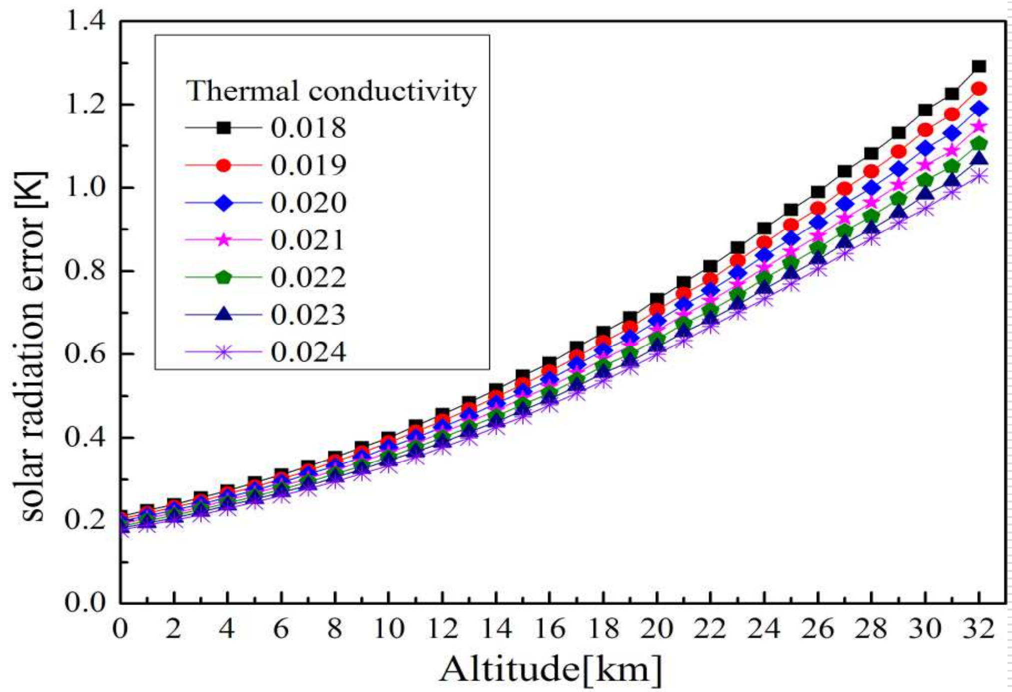


(f) K=0.023, θ = 0 ~ 90^o



(g) K=0.024, θ = 0 ~ 90^o

Results and analysis



(h) K=0.018 ~ 0.024, θ =90^o

It is clear that solar radiation error monotonically increases with altitude. When the altitude is up to 32 km, the discrepancy of the radiation error is up to 0.3 K, while air thermal conductivity is between 0.018 and 0.024 w/(m ·k).

Conclusions

- The heating effect of the solar radiation on the bead thermistor can cause significant temperature measurement error. Therefore, the error needs to be corrected.
- When solar elevation angle is 90^{o}, the solar radiation induces less error. This radiation direction is preferred in future radiosonde sensor applications.
- The change of air thermal conductivity can influence the observation accuracy of the bead thermister in the upper air. Therefore, the change of air thermal conductivity should not be neglected.

Thank you very much!