Technical Specifications for the procurement of Eddy covariance tower

Sensors and specifications:

1. **Open Path CO₂/H₂O gas Analyzer**
   - Should be capable of measuring at 10 and 20 Hz frequency (programmable by software)
   - Accuracy: Within 1% of measurement
   - RMS error for CO₂: Less than 0.15 PPM at 10 Hz and less than 0.2 PPM at 20 Hz
   - RMS error for H₂O: Less than 0.005 mmol mol⁻¹ at 10 Hz and less than 0.007 mmol mol⁻¹ at 20 Hz
   - Minimum range of measurement: CO₂: 0 to 2500 µmol mol⁻¹ and H₂O: 0 to 50 mmol mol⁻¹
   - Measurement drift should be within ±1 mmol mol⁻¹ of H₂O and ±3 µmol mol⁻¹ of CO₂

   Should include the calibration kit for the open path gas analyzer

2. **Precision digital 3D Sonic Anemometer and thermometer**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Range</th>
<th>Resolution</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Speed</td>
<td>0 to 60 ms⁻¹</td>
<td>0.01 ms⁻¹</td>
<td>RMS less than 1.5%</td>
</tr>
<tr>
<td>Wind Direction</td>
<td>0–359 Degrees</td>
<td>0.1°</td>
<td>1°</td>
</tr>
<tr>
<td>Speed of Sound</td>
<td>300–360 ms⁻¹</td>
<td>0.01 ms⁻¹</td>
<td>±0.5 ms⁻¹</td>
</tr>
<tr>
<td>Sonic Temperature</td>
<td>−35 °C to 65 °C</td>
<td>0.01 °C</td>
<td>-</td>
</tr>
</tbody>
</table>

   Should have an internal measuring frequency of more than 25 Hz.

3. **Air temperature and Relative humidity sensor with heat shield**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Range</th>
<th>Resolution</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air temperature</td>
<td>−20 °C to 60 °C</td>
<td>0.01 °C</td>
<td>±0.1 °C</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>0–100 % RH</td>
<td>0.1 %</td>
<td>±1 % RH (between 0–90% RH range) at 25 °C temperature</td>
</tr>
</tbody>
</table>

4. **Four component net radiometer**

   Should be able to measure and output incoming and outgoing components of the shortwave and longwave radiation components. The pyranometer and the pyrgeometer (for measuring the shortwave and longwave components respectively) should meet the specifications given below:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Pyranometer</th>
<th>Pyrgeometer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral range</td>
<td>0.3 to 2.5 µm</td>
<td>5 to 40 µm</td>
</tr>
<tr>
<td>Measurement range</td>
<td>0 to 2000 W m(^{-2})</td>
<td>−200 to 200 W m(^{-2})</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>&lt; 5% of daily total</td>
<td>&lt; 10% of daily total</td>
</tr>
<tr>
<td>Deviation from calibrated responsivity (non-linearity)</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Maximum change of sensitivity per year</td>
<td>&lt; 1%</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>&lt; 20 μV per W m(^{-2})</td>
<td>&lt; 15 μV per W m(^{-2})</td>
</tr>
</tbody>
</table>

The Net radiometer should have a heating and ventilation unit to prevent dew deposition on the pyrgeometer.

5. **Self-calibrating soil heat flux plates – 3 nos.**

Sensitivity: 50 μV per W m\(^{-2}\)

Temperature range: −25 °C to +65 °C

Accuracy: Maximum ±5 % of true value

6. **Tipping bucket rain gauge**

Resolution: 0.1 mm

Accuracy: with 1% with rainfall up to 50 mm per hour

7. **Probes for measuring the soil moisture and soil temperature – 3 nos.**

Preferred method of measurement: Coaxial impedance dielectric sensor

Accuracy of soil moisture measurement: < ± 3%

Accuracy of temperature measurement: ±0.1 °C

8. **Quantum Sensor for measuring the photosynthetically active radiation**

9. **Data logger for the fast and slow response sensors.** The data logger should be able to store all the high frequency EC data without any day loss. It should be possible to retrieve all the data from the data logger using a memory card/USB Stick or through connection with a laptop.

10. **All the sensors must have corresponding mounting brackets, crossbars, cables and fixtures required to fix the sensors to the tower structure and connect the sensors with the power source and the data logger.**

**Other components:**

- Solar panels and battery with charge controller for power supply to all the sensors.
- GSM communication modem to remotely transmit the data continuously to a server located at IIT Bombay.
- A 7m tall tower structure to hold the sensors. It should be possible to change the height of the EC sensors continuously from 2 m to 7 m height as and when needed.
- Suitable software to collect the stored data (raw data from all the sensors) and process the data into turbulent and radiative fluxes. The Software should also be able to gap fill the processed fluxes using multiple approaches.
**Delivery/installation and maintenance**

- The instruments should be delivered to the Department of Civil Engineering at IIT Bombay by the vendor.
- The instruments will then be transported to the field site by IIT Bombay.
- The vendor should install the tower structure and all the sensors and demonstrate the sensor working and data collection. In addition, the vendor should ensure that the data is transmitted through the GSM module and received remotely at the server at IIT Bombay.
- The vendor should provide annual maintenance of the sensors (3 years) and provide recalibration if some sensors drift away from their normal performance.
- The vendor should provide training to 2 researchers on the principles of eddy covariance measurements, data collection and data processing.

**Eligibility for vendor:**

- The vendor should be an authorised distributor and maintenance provider certified by the manufacturers of the different sensors placed in the EC tower.
- The sensors (both fast and slow response sensors) should be from manufacturer(s) who have demonstrated the reliability and accuracy of the sensors through deployment in at least 5 sites belonging to any of the global flux network such as AmeriFlux, Fluxnet, TERENO observatory in Germany, AsiaFlux etc. across the globe.
- The vendor should have demonstrated installation and maintenance of EC systems in at least 3 sites in India and maintaining them for at least 1 year. A support letter from PI of any of the EC tower will be required.