THE ERROR OF BRIGHTNESS TEMPERATURE OF SEA WATER CAUSED BY THE ERROR OF DIELECTRIC CONSTANT

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Abstract—Comparing three formulas of calculating complex dielectric constant of saline solutions shows that two of them will yield errors of no more than 5% at frequency 34.88GHz except at temperature 0°C. An expression of the relative error of brightness temperature has been developed, which claims that the relative error of brightness temperature is at least less than half of the relative error of complex dielectric constant.

Key words: dielectric constant, brightness temperature, relative error.

I. Introduction

Precision of brightness temperature and dielectric constant of sea water is important for passive microwave remote sensing of oceans. The brightness temperature of water surface equals the product of the emissivity and the physical temperature of the water [1]; and emissivity is a function of complex dielectric constant, incident angle and polarization, which is derived from electromagnetic theory. Three empirical formulas developed respectively by Paris [2], Stogryn [3] and Klein [4] can be used to calculate complex dielectric constant of saline solutions. A comparison of calculated results of three formulas with the data measured by Grant [2] at frequency 34.88GHz is made in this paper. And a formula is derived which connects the relative error of brightness temperature with the relative error of complex dielectric constant; it claims that the relative error of brightness temperature is at least less than half of the relative error of complex dielectric constant.

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II. The Error of Three Formulas for Calculating Dielectric Constant of Saline Solutions

Three empirical formulas developed respectively by Paris [2], Stogryn [3] and Klein [4] can be used to calculate complex dielectric constant of saline solutions. The errors of three formulas comparing with the data measured by Grant [2] at frequency 34.88GHz is given in table 1. The table shows that Paris formula produces a greater error than the two others. Stogryn and Klein’s formulas yield errors of no more than 5% except at temperature 0°C where the error is nearly 10%.

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>Paris</th>
<th>Stogryn</th>
<th>Klein</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-14.46</td>
<td>-10</td>
<td>-10.3</td>
</tr>
<tr>
<td>10</td>
<td>-9.65</td>
<td>-1.99</td>
<td>-1.72</td>
</tr>
<tr>
<td>20</td>
<td>-7.81</td>
<td>1.73</td>
<td>1.73</td>
</tr>
<tr>
<td>30</td>
<td>-1.26</td>
<td>4.06</td>
<td>4.02</td>
</tr>
</tbody>
</table>

Table 1. The errors of three formulas, Paris, Stogryn, and Klein’s

III. The Influence of the Error of Complex Dielectric Constant on Brightness Temperature

At millimeter wave band, penetration of microwave into water is very shallow; only the upper layer of water, a few centimeters below the water surface, can contribute to the brightness temperature. The physical temperature is nearly the same within such a thin layer of water. Thus, the surface of undisturbed seas, lakes, rivers, can be seen as the surface of seminfinite homogeneous isothermal media. For normal incidence, reflection coefficient at the surface is

$$\Gamma = \frac{1 - \sqrt{\varepsilon}}{1 + \sqrt{\varepsilon}}$$

where $\varepsilon = \varepsilon' + j\varepsilon''$ is relative complex dielectric constant.

The brightness temperature $T_B$ is [1]

$$T_B = eT = (1 - \Gamma)T$$

where $T$ is physical temperature.

It is seen from expressions (1) and (2) that the error of $\varepsilon$ causes the