A reference model for ocean surface emissivity and backscatter from the microwave to the infrared

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Why do we need a reference model?

Fast radiative transfer models need to calculate emission and reflection at the earth’s surface. The GAIA-CLIM project of the European Commission provided a gap-analysis for reference quality satellite data and recommended the development of a reference quality surface emissivity model. This poster does not present a reference model. It makes the case to create one and discusses what is needed.

What already exists?

A fast model like Fastem is only as good as the reference model it attempts to replicate. Unlike atmospheric transmission we lack a state of the art reference model for surface emissivity.

Elements of a reference model

<table>
<thead>
<tr>
<th>Surface temperature (e.g. OSTA or coupled NWP)</th>
<th>Surface waves from wave model</th>
<th>Surface windspeed (from atmosphere)</th>
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</thead>
<tbody>
<tr>
<td>Dielectric model</td>
<td>Large scale ocean swell</td>
<td>Small scale ripples and waves</td>
</tr>
<tr>
<td>3D wave surface model</td>
<td>Foam model</td>
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<tr>
<td>Two scale solver</td>
<td>Ray tracing solver</td>
<td>Full-EM wave model solver</td>
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</tbody>
</table>

JCESA are developing CSEM [2]. This incorporates emissivity models, from visible to microwave, over both land and ocean. TESSEM2 [3] is similar to Fastem. The RSS model [4] is based on observations from instruments on the DMSP and Coriolis satellites. None provide a reference model.

An ocean emissivity model has three main components: The dielectric model A double Debye form is often used. Given the dielectric properties the Fresnel equation tells us the polarised reflection and refraction at the water surface. However even in this most basic component there is uncertainty. See Lawrence et al. (ITSC-21) for more detail.

The roughness model Ocean roughness arises both from wind induced ocean roughness and large scale ocean swell. Geometric optics can be applied to large scales. Smaller scales need a scattering model. A two scale model can be applied, but as the scale separation is arbitrary they have limitations. A more general solution is highly desirable for a model applicable to a wide range of wavelengths. Ideally the large scale swell should be estimated from a wave model, not the local wind speed.

The foam model Most models parameterise ocean foam coverage (F) as a function of the instantaneous wind (U), F=AU2 and then assume an emissivity model or assume foam is a blackbody. Efforts have begun to model foam from a wave model [5] as shown to the left which could allow full radiative transfer rather than artificial separation of coverage and emissivity. This could take into account foam asymmetry using a 3D wave slope model.

References