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

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GAIA-CLIM

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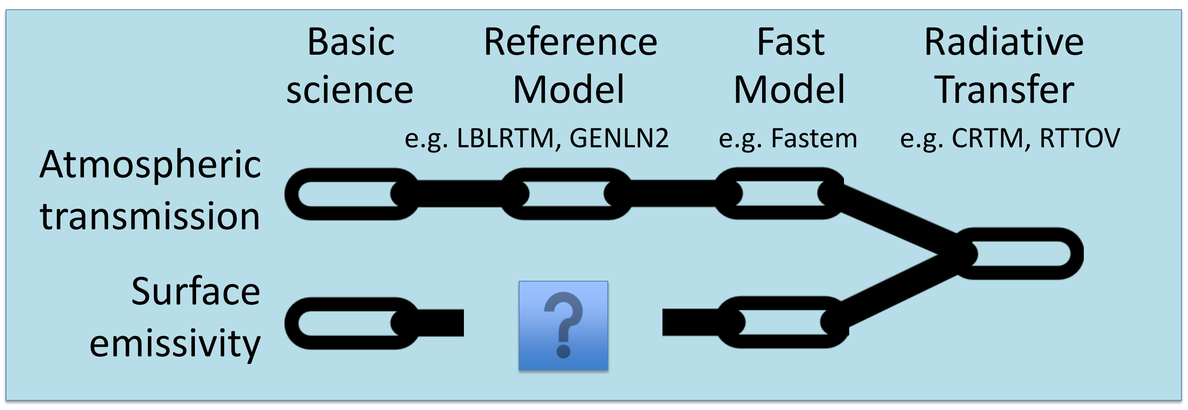
Why do we need a reference model?

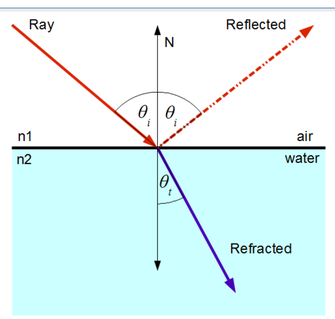
Fast radiative transfer models need to calculate emission and reflection at the earth's surface. The GAIA-CLIM project of the European Commission provided a gap-analysis for reference quality satellite data and recommended the development of a reference quality surface emissivity model. This poster does 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.



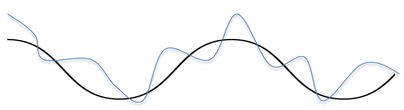
JCSDA are developing CSEM [**2**]. This incorporates emissivity models, from visible to microwave, over both land and ocean. TESSEM2 [**3**] is similar to Fastem. The RSS model [**4**] is based on observations from instruments on the DMSP and Coriolis satellites. None provide a reference model.



Reflection and refraction at ocean:water boundary for a flat surface. Even in this idealised scenario uncertainty is not fully characterised.

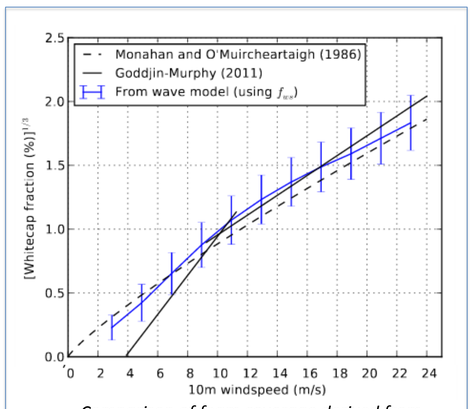
An ocean emissivity model has three main components:

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.**



Ocean waves have a large scale swell component with smaller waves driven by the local wind superimposed, as depicted above in stylised form and in a photograph

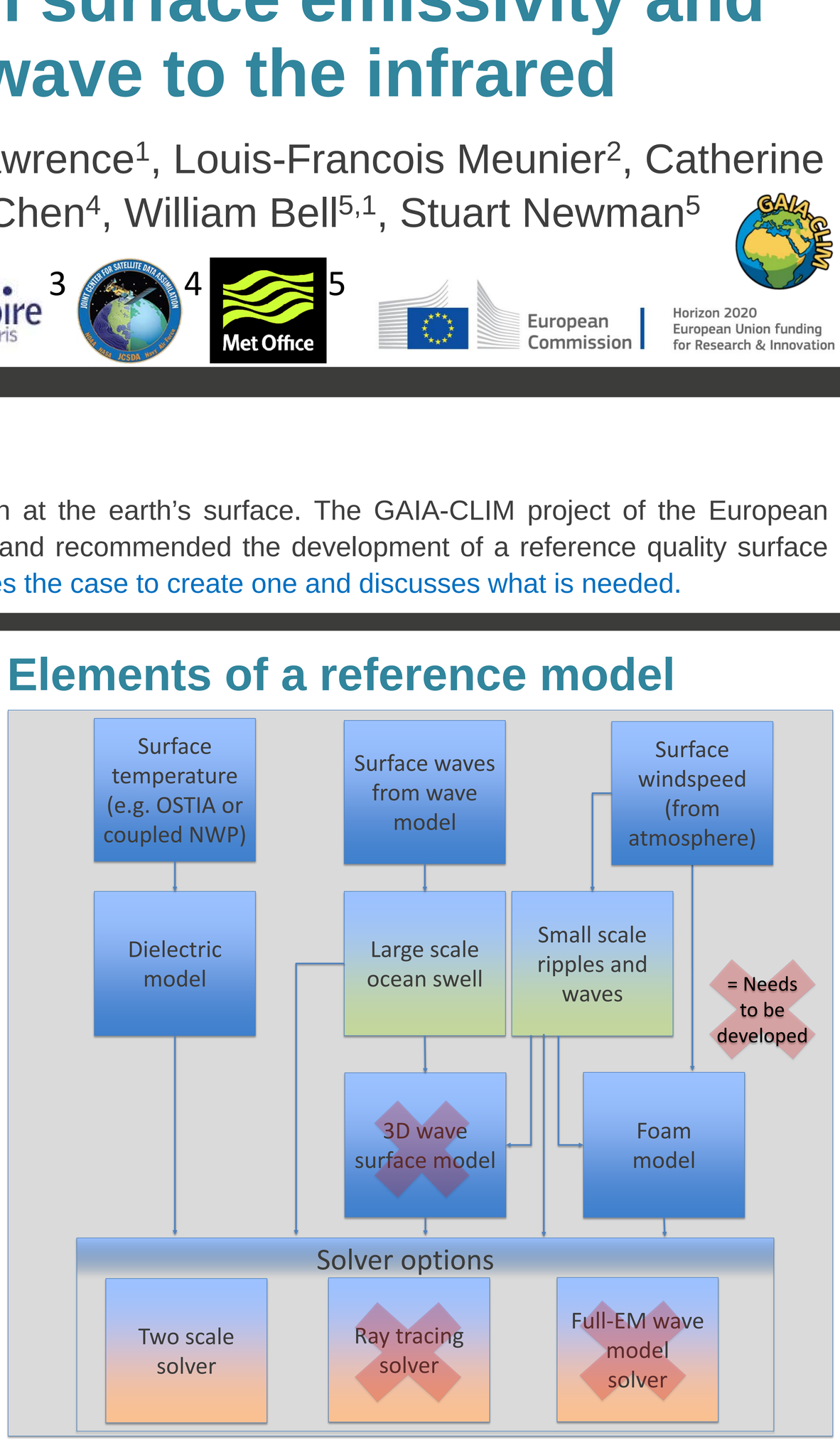
The roughness model Ocean roughness arises both from wind induced ocean roughness and large scale ocean swell. Geometric optics can be applied to large scales. Smaller scales need a scattering model. A two scale model can be applied, but as the scale separation is arbitrary they have limitations. A more 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.



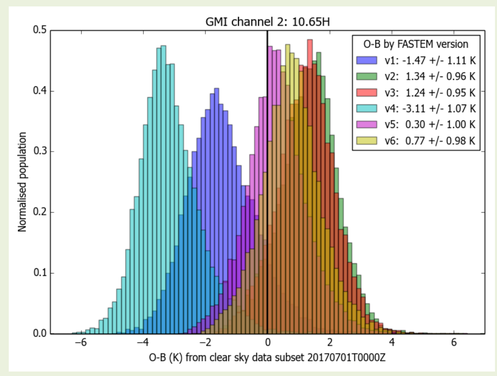
*Comparison of foam coverage derived from wave model [**5**] with wind speed models.*

The foam model Most models parameterise ocean foam coverage (F) as a function of the instantaneous wind (U), $F=aU^3$ 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 foam radiative transfer rather than artificial separation of coverage and emissivity. This could take into account foam asymmetry using a 3D wave slope model.

Elements of a reference model



GAIA-CLIM has shown the progression in fit of the Fastem model from version 1 to version 6 against the GMI 10.65 GHz horizontal polarisation, whose radiometric uncertainty is considered to be known. Lack of knowledge of the emissivity model uncertainty makes interpretation of this and any comparison to satellite observations difficult.



The priorities for the reference model are:

1. **Maintained and supported**.
2. **Traceable uncertainty estimation at each step.**
3. **Documented code freely available to research community.**
4. Add new science [**7**], [**8**], for IR to MW with BRDF capability (Rec from ECMWF-JCSDA workshop, Dec 2015).
5. Support passive and active applications.

Way forward

We encourage the ITWG remote sensing community to note the gap identified by GAIA-CLIM, consider how best to address this gap in the radiative transfer model capability and to support efforts underway to develop the components of such a reference model.

References

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