**Radiative Transfer-Based Effective Emissivity (after Nalli et al. 2018a,b)**

The directional emissivity of a terrestrial surface is defined as

\[ e_r(\Theta, \Theta') = \frac{R_r(\Theta')}{R_r(\Theta)} \]

where the surface-emitted radiance (numerator) is separated from the surface-reflecting radiance (as measured by a detector) by subtracting the surface-reflectance radiance

\[ R_r(\Theta') = \int \rho_1(\nu) (1 - \rho_1(\nu)) d\nu \]

The conical-directional reflectance for non-isotropic incident radiation (Nicodemus et al. 1977) for the sea surface reflectance may be written as

\[ R_r(\Theta') = \rho_1(\Theta) \sum_{\nu} \rho_1(\nu) \int \frac{(1 - \rho_1(\nu)) f(\Theta', \Theta) d\nu}{\Theta} \]

which, from the mean value theorem is equivalent to

\[ R_r(\Theta') = \rho_1(\Theta) \sum_{\nu} \rho_1(\nu) \int f(\Theta', \Theta) d\nu \]

The conical-directional reflectance is given by

\[ R_r(\Theta') = \rho_1(\Theta) \sum_{\nu} \rho_1(\nu) \int f(\Theta', \Theta) d\nu \]

where \( \Theta = \Theta(\nu) \) is a diffusivity angle, thus allowing simplification of the surface-reflectance radiance RTE as

\[ R_r(\Theta') = \rho_1(\Theta) \sum_{\nu} \rho_1(\nu) \int f(\Theta', \Theta) d\nu \]

\[ \Theta = \Theta(\nu) \]

where the effective-emissivity (with temperature dependence) may be written as

\[ \epsilon_r(\Theta, \Theta') = \frac{R_r(\Theta')}{R_r(\Theta)} \]

**Potential SARTA Implementation**

- We plan to extend this effort toward an upgrade of the ocean emissivity used by SARTA.
- We will explore implementing the IRSSE model within an ocean experimental SARTA version in collaboration with UMD.
- SARTA implementation would require modification of the “Reflected Downwelling Thermal Radiance” term.
- According to Strow et al. (2003), an empirical formulation is used based on Sunstone and Strow (1997) that may feature further improvements.
- It should be reasonably straightforward to conduct a test replacing this Lambertian representation within SARTA for the effective-emissivity (with temperature dependence) upgrade.

**Summary and Future Work**

- Ocean surface emissivity depends on wavenumber, zenith angle, surface wind speed, and surface temperature.
- Temperature dependence arises from changes in the IR radiative indices.
- The model is well-constrained at 1-3 km model levels. 
- We will continue our collaboration with UW/CIMSS and JSTAR Cal/Val Program.
- We plan to have the effective-emissivity (with temperature dependence) upgrade.
- We will continue our collaboration with UMD and JSTAR Cal/Val Program, including cold-water cruises.

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**Selected References**