Home assignment Spring 2024

FYS-3001 Physics of remote sensing

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Fundamentals [5 points /20]

1. List at least three properties or reasons why electro-magnetic (EM) radiation is useful for remote sensing from satellites. [1 point]
2. Briefly explain the meaning behind the relationship $\varepsilon = \tau = 1 - \rho$ from equation (4.11) in the textbook. Name all the terms and state any conditions or assumptions for this relation to hold. [1 point]
3. What is a BRDF? Why are they important for Earth observation from satellites? [1 point]
4. What is the difference between a scanning system and a pushbroom system? And why would one be preferable over the other? [1 point]
5. What is spectral and spatial resolution? And why are they connected? [1 point]

Thermal sensing [4 points / 20]

1. Define and describe Plank's blackbody formula (introduced as $S(\lambda)$ in equation 2.36 in the textbook). Include the meaning or use of the formula and its units. Choose and plot an interesting example to show the basic shape of the curve with respect to wavelength. [1 point]

2. Not all energy is reflected directly from the Earth. Why is that? And what are the two most important material properties that regulate this? And how do they vary? [1 point]

3. Do real objects behave according to Plank's equations? Explain how their behaviour may differ. [1 point]

4. Define the term brightness temperature that was introduced with the Rayleigh-Jean's equation. Why is this concept useful, and how does it relate to the actual temperature. [1 point]

Practical Surface Sensing [11 points / 20]

Passive microwave sensors are an important tool and data source when we establish daily sea ice maps for the Arctic and Antarctic. The long history also means that we can use the data for climatological modeling and assessment. Passive microwaves are often the source behind ice edge imagery, though difference in emissivity between different sea ice types mean that we can also use them for sea ice classification. One sensor frequently used is the Advanced Microwave Sounding Radiometer 2 (AMSR-2), which is a Japanese satellite. The satellite was launched in 2012 and is still providing data. Some sensor specifics can be found here: https://space.oscar.wmo.int/instruments/view/amsr2 and here: https://www.ospo.noaa.gov/Products/atmosphere/gpds/about_amsr2.html

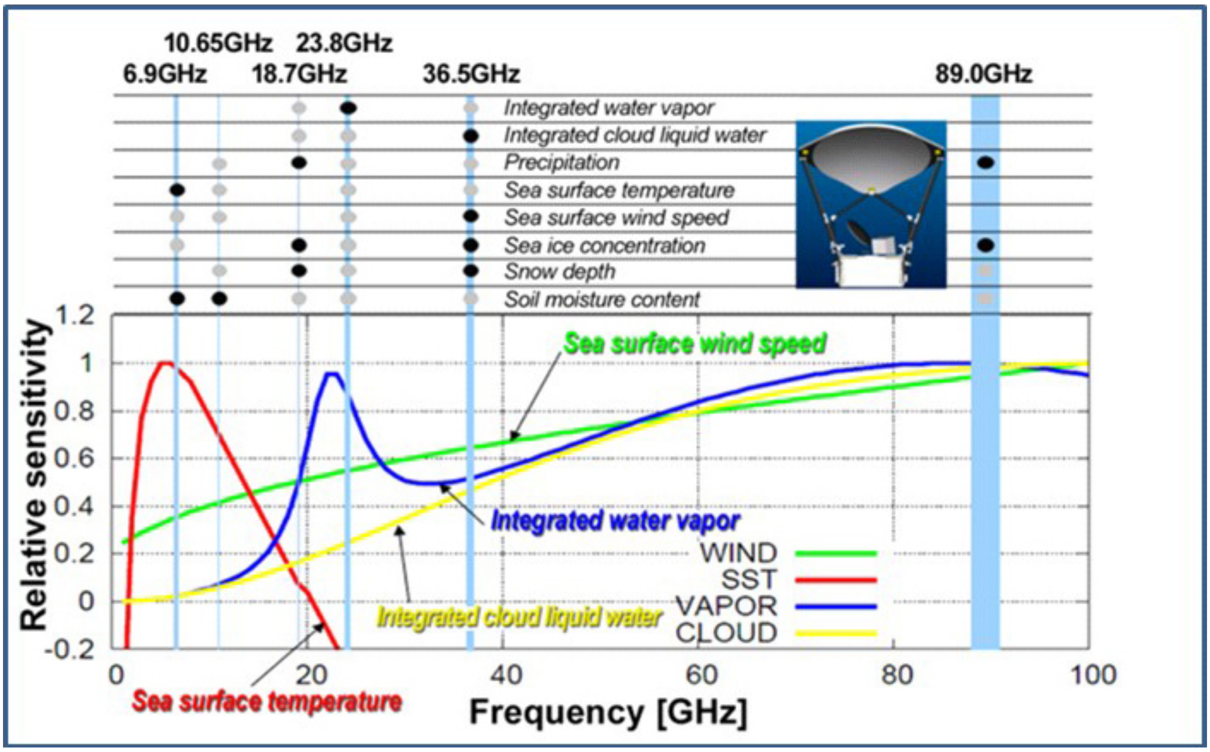


Figure taken from [*https://www.ospo.noaa.gov/Products/atmosphere/gpds/about_amsr2.html*](https://www.ospo.noaa.gov/Products/atmosphere/gpds/about_amsr2.html)

From this figure you can see that the cannels 18.7GHz, 36.5GHz and 89.0GHz is actively used in sea ice concentration mapping.

To answer the questions below there may be several different ways of achieving the desired result and any way is acceptable, because I am more interested in your logic and reasoning. Therefore, it is important to state the thinking behind your decisions.

1. Why can you use the AMSR-2 sensor to say anything about the sea ice? Why are these types of sensors preferable in the polar regions? What parameters are important to consider when using passive microwaves to derive sea ice information? [2 point]

2. Read and plot the different brightness temperatures. The data is given as netcdf, and there are data called Lat and Lon that contain the Latitude and Longitude data. For the respective temperature data use vertical data for 18.7GHz, 36.5GHz and 89.0GHz. We'll focus on an area centered over Svalbard so you should zoom in to include an area approx. 75°N -85°N and 20°W – 40°E. West is indicated as negative longitude values. What does the difference between the different frequencies tell you? [2 point]

3. Derive the sea ice concentration using an AMSR2 image, the range should be 0-100%. You should also make some statements as to why the equations and the approach outlined below works. You can use equation 3 below for the sea ice concentration estimates. What can the 89GHz channel contribute with?

   Please also try and apply a landmask to more Svalbard from the analysis, as Svalbard otherwise have the appearance of sea ice. You can look here for a landmask using Python: https://github.com/CryosphereVirtualLab/publicnotebooks/blob/main/S1_ice_water_classification/load_and_calibrate_S1_scene.ipynb [3 points].

4. Make a map where we can see the open water, new ice and older ice areas. Why are we using a range (0-15%) for the sea ice concentration when establishing the ice edge? [2 point]

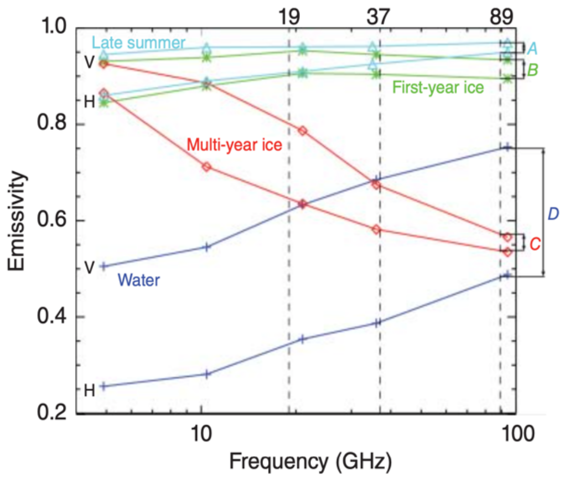
5. Using the relationships estimates (e.g. Fig 11) in Cho et al, 2024, for sea ice thickness and salinity. How large and area is dominated by sea ice below 5cm thickness? [2 point]

Here is a figure and some equations to help guide you, there is also a chapter about sea ice attached to the exercise. The ice edge is where we have between 0% and 15% sea ice.

To derive sea ice concentration (SIC) and sea ice edge we rely on the polarization ratio (PR) and the spectral gradient ratio (GR). For this exercise only a linear relationship is needed for the SIC estimate.

$PR(v) = [TB(vV) - TB(vH)] / [TB(vV) + TB(vH)]$ (1)
$GR(v1,v2) = [TB(v1) - TB(v2)] / [TB(v1) + TB(v2)]$ (2)
Where v is frequency.

There is also a well know relationship between the sea ice concentration and the brightness temperature:
$T_b = T_i C_I + T_O (1- C_I)$ (3)
Where;
T_b is the observed brightness temperature
T_i is the brightness temperature for 100% sea ice T_O is the brightness temperature for open water, use your knowledge gained during the course to identify such areas in the image.
C_I is the sea ice concentration. Consider using the 18.7 GHz for the estimate.



GR(36.5V, 18.7V) > 0.05 indicates that the sea ice concentration is between 0% and 15%, i.e. open water.

When GR (36.5V,18.7V) > -0.02 this indicates that we have new ice formation.

Total out of 20 points, to give 20% of your final grade.