Telescopes and Earth’s Atmosphere

The drawing below illustrates the ability of different portions of the electromagnetic spectrum to penetrate Earth’s atmosphere. Along the bottom of the figure is a temperature scale that indicates the temperature of a blackbody whose output peaks in that part of the spectrum. Look carefully at what portions of the spectrum can penetrate to the surface, what portions can penetrate partially, and which portions are absorbed. Not shown in the figure is that visible telescopes in space get sharper images than on the ground because they avoid the turbulence in the atmosphere.

1) Which, if any, portion of the electromagnetic spectrum is able to penetrate entirely the Earth’s atmosphere and reach the surface?

Visible light and radio and a part of the infrared.

2) Which, if any, portion of the electromagnetic spectrum is able to penetrate only partially and would only reach high mountaintops?

some of the infrared and some of the millimeter- (mm)wave reach mountain tops

3) Which if any, portion of the electromagnetic spectrum is completely absorbed by the atmosphere?

All of the ultraviolet, x-ray and gamma-ray portions are completely absorbed. Much of the infrared and mm-wave are also completely absorbed.
4) Federal funding agencies such as NASA and the National Science Foundation form committees to decide which telescope projects will receive funding. When making these decisions the committees consider:

   i. How efficiently telescopes work at different wavelengths
   ii. Relative cost of the project – space telescopes usually have the highest costs, those on airplanes second highest, and ones on the ground are least expensive
   iii. That the atmospheres limits what can be done from the ground – some parts of the electromagnetic spectrum are absorbed by the atmosphere, the atmosphere may blur the images at some wavelengths, or the atmosphere may emit its own light at some wavelengths making detection of stars and galaxies difficult.
   iv. An important science topic must be the subject of the study [real committees use this criterion but for this exercise you can assume that all of the science topics are excellent]

Recalling what was stated in lecture and the picture above, apply these criteria to decide which proposal from each of these pairs you would fund, or if you would reject both of them. Explain your choices.

a) **Project Beta**: A x-ray telescope designed to study the Sun that would be located at the North Pole or **Project Alpha**: An infrared telescope to be launched on a satellite that would be used to study newly forming (cold: 30-300K) stars in the Milky Way.

*Project Alpha is by far the more attractive of these two proposals. X-rays are absorbed by the atmosphere and the Sun can’t be seen part of the year from the North Pole. A satellite is very useful for infrared observations since so much of the infrared portion of the spectrum is absorbed by the atmosphere.*

b) **Project Rho**: A radio telescope that would located on the floor of the Mojave desert to detect potential communications from other civilizations in the Milky Way galaxy or **Project Sigma**: A visible wavelength telescope used to observe binary stars to be launched on a satellite.

*Project Rho is the better bet here because radio waves do penetrate to the ground, and the Mojave is well away from most population centers so there wouldn’t be much radio interference. Project Sigma involves visible light which does reach the ground so a satellite is probably overkill (although getting above the blurring of the atmosphere might be beneficial).*

c) **Project Delta**: A gamma-ray telescope to be located in Antarctica to look for evidence of the presence of black holes or **Project Theta**: A visible wavelength telescope used in the search for planets outside the solar system. The telescope would be situated on a university campus in the middle of a city.

*Neither of these should be funded – gamma-rays are absorbed by the atmosphere so Project Delta has a fatal flaw. Project Theta at least would detect light from objects but searching for planets requires good conditions which are unlikely in the middle of a city.*