

Exam is open-notes, open-testbook, open-Internet etc. However, we urge you not to spend too much time looking things up, copying-and-pasting, etc. Each question can be answered in no more than one page. You do not need to repeat the question; just indicate each question's number.

*You cannot ask another living person for help, either a classmate or other acquaintance.*

- (1) The satellite image below, from MODIS (Moderate-Resolution Imaging Spectroradiometer) shows fires and smoke in southern California on 26 October 2003, when these fires caused widespread air pollution and health problems. The image is a false-color composite; red shows the emitted radiation at  $3.7\mu\text{m}$ , green represents red, and blue represents green. The red areas are the fires.



The MODIS fire detection algorithm exploits the different responses of middle-infrared and long-wave-infrared bands to scenes containing hot subpixel targets. Specifically when the brightness temperature  $T_{11\mu\text{m}} > 305\text{K}$  and  $\Delta T = T_{3.7\mu\text{m}} - T_{11\mu\text{m}} > 10\text{K}$ , the algorithm classifies the pixel as likely containing a fire.

*Use the Planck equation to explain the conceptual basis of this algorithm. Include useful graphics to show why a hot surface causes a bigger change in the signal at  $3.7\mu\text{m}$  than at longer wavelengths?*

- (2) The *normalized difference vegetation index* (NDVI) is commonly used to remotely sense the “greenness” of vegetation.
- How is the NDVI defined?*
  - How does it work, i.e. what attribute of the vegetation is it sensitive to?*
  - We call it normalized because of the denominator in the equation? Why do we normalize?*

- (3) *SAR interferometry* is a method of using synthetic aperture radar to measure elevation. The Shuttle Radar Topography Mission (SRTM) mapped Earth's elevations (in all but the polar regions) using two antennas, one 60m away from the other. With repeat-pass interferometry, the technique can be used to measure elevation displacement.
- How does SAR interferometry work? Explain both the dual antenna configuration, like SRTM, and the repeat-pass approach.*
  - One source of error in SAR interferometry is shadowing. Why do shadows occur? What can you do about them (for example in SRTM)?*
- (4) At wavelengths shorter than  $1\mu\text{m}$ , snow and clouds have similar spectral signatures. In band 5 ( $1.55\text{-}1.75\mu\text{m}$ ) of the Landsat Thematic Mapper, however, snow is dark while clouds are bright.
- Explain why, in terms of scattering principles.*
  - Explain why the normalized difference snow index (NDSI) works, i.e. why does it discriminate snow from most other surface covers? The definition is*

$$NDSI = \frac{R_2 - R_5}{R_2 + R_5} \text{ (where } R_b \text{ is reflectance in band } b\text{)}$$

(band 2 is green)