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## Thermography

The new term is proposed to replace "thermal infrared imagery."

### INTRODUCTION

THE GROWTH OF remote sensing research has seen a concomitant expansion in remote sensing nomenclature. Many of the words and phrases used in remote sensing literature have been carried intact from contributing engineering and scientific disciplines, but unwieldy phraseology and poorly defined words have also appeared.

Those words and terms that have been drawn from engineering and scientific disciplines have, for the most part, already passed the test of clarity through long-term

journals and which have been carried over and burdened remote sensing papers in the open scientific literature.

Even the term *remote sensing*, allegedly coined (ca. 1961) by Miss Evelyn Pruitt at the Office of Naval Research, has an exceptionally broad definition. To many scientists, it has, for all practical purposes, even reached the status of a separate *discipline*. This is rather odd, because remote sensing ought to be applied solely to a tool (remote sensor) or a technique, not to a separate discipline. The term *remote sensing* should be used in the same

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ABSTRACT: *The word, thermography, is proposed as a replacement for the cumbersome phrase, thermal infrared imagery. The term, thermography, because it would be restricted to the thermal infrared part of the electromagnetic spectrum, would be used in a way analogous to photography. No confusion would then exist between photograph (record of reflected solar energy) and thermograph (record of emitted thermal energy) as there now exists between infrared photography and infrared imagery. It is also suggested that a derivative term, thermograph, be restricted to mean a qualitative thermal infrared image, and that the derivative term, thermogram, be restricted to mean a quantitative thermal infrared image.*

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usage and review. Not so those many words, phrases, and acronyms that have been introduced from the lingo of the military reconnaissance community. Many terms of military origin entered the new field of remote sensing simply because much of the early research (1960-1965) in remote sensing was financially supported by the Department of Defense—either in-house, at commercial firms, or at universities. The great bulk of this early work was classified, hence never reviewed in the traditional scientific manner. This led to the use of many terms which would never have passed the scrutiny of referees for scientific

way as the word *microscopy*, which Webster's (1970) defines as, "The use of or investigation with the microscope." In like manner then the term remote sensing should be defined as, "The use of or investigation with a remote sensor (or sensing device)."

Another example is the term *ground truth* which entered the nomenclature of remote sensing from the jargon of the military reconnaissance community. It has a cloudy and uncertain origin and is a simplistic, meaningless, and misleading term which should be purged from remote sensing literature. It implies that the photointerpreter need only look at the feature on the ground to learn the *truth*. The term was best defined (ca. 1965) by Carl Molineux of Air Force Cambridge Research

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Laboratories as a *philosophical hamburger*. The term would best be replaced by *field observation(s)* or an equivalent term.

It is the responsibility of scientists and engineers to use correctly those words and terms that have a solid technical basis and to discard those that are worthless. It is not the objective of this brief discussion paper to delve into all the many ill-defined words and terms which plague remote sensing literature. The discussion of the terms *remote sensing* and *ground truth* was to give an example of a newly coined term and an example of a poorly defined term, respectively. An example of unwieldy phraseology is thermal infrared imagery.

#### THERMOGRAPHY

Just as papers on thermal infrared imagery and radar imagery began to appear in print, Robinove (1963) wrote a concise paper in *Photogrammetric Engineering* which cogently discussed the difference between photography and imagery. With the increasing use of thermal infrared monitoring devices by environmental scientists, it is appropriate to review the nomenclature on pictorial representation of thermal infrared energy. The expansion in the use of aerial infrared photography—and the advent of copious amounts of imagery from the Earth Resources Technology Satellite (ERTS) and imagery and photography from the Skylab Earth Resources Experiment Package (EREP)—make such a discussion timely.

Various quantitative thermal infrared systems, both terrestrial (ground) and airborne, are now on the market. The AGA Thermovision system is typical of the ground-based quantitative thermal infrared scanners. The Daedalus Enterprises, Inc. Q (Quantitative) Scanner is an airborne, quantitative, thermal infrared scanner. In both the ground and airborne scanners the end product is made by photographing a TV raster. Variation of gray tones on the resulting photograph are related to apparent (radiometric) or, in some instances, actual temperatures across the scene. Such a *photograph* should be called a *thermogram*.

Most scientific writers, when referring to the *photograph* of the TV raster of the devices which are manufactured by AGA, Barnes Engineering Co., or Bofors, etc., call it a *thermogram*. Svensson (1968) in his study of geologic phenomena in Sweden with an AGA Thermovision System, Clark (1969) in his study of the effect of thermal pollution on aquatic life,

and Whittier (1970) in his discussion of medical thermography all use the term *thermogram* in the same manner. Colwell (1968), however, in his fine paper on remote sensing in natural resources refers to a thermal infrared image, which was probably generated by a thermovision device, as a *thermograph*.

If the use of the term *thermogram* is to be restricted to a quantitative thermal infrared image which portrays, in its gray tone variation, the apparent (radiometric) or actual temperature of elements in the scene, then the term *thermograph* is recommended as its qualitative mate. A *thermograph*, then, is a qualitative thermal infrared image which portrays, in its gray tone variation, the general distribution of thermal radiation in the scene. This is essentially the way Morgan (1962) used the term *thermograph* and added that the depiction of apparent radiometric temperature on a *photograph* could only be qualitative.

Svensson, in his paper on "Remote Sensing" (1969), used the Swedish word *värmebild* which referred to airborne thermal infrared imagery. This can be translated variously as thermal picture or thermal image. It should be noted that Lattman (1963), in the first published geological study with thermal infrared, used the term airborne infrared imagery. It should also be emphasized that Svensson draws a distinction between the AGA Thermovision thermogram (1968) and a *värmebild*, hence drawing a distinction between quantitative and qualitative thermal infrared imagery. In a more recent paper, Sellin and Svensson (1970) use the terms *airborne thermography* (French, *thermographie aérienne* and German, *Thermographie aus der Luft*) and thermal mapping interchangeably. They do the same with thermal imagery and thermal image in the same article. In the French literature, Lévêque, *et al* (1971), use the terms *vue thermique ou thermographie*.

Whittier (1970) discussed the origin of the word *thermography*. It was used by Sir John Herschell, son of Sir William Herschell, in ca. 1840 to describe the formation of images on lamp-black and alcohol-coated paper after exposure to infrared radiation. Whittier (*op. cit.*, p. 40) also notes that the word *thermograph* is used to denote the instrument which collects thermal information, while the thermal picture is called a *thermogram*. Although in medical work the term *thermograph* is used to describe the instrument, it is thought that there will be no conflict with using the term *thermograph* to apply to a qualitative thermal infrared image in remote sensing technology.



It should be noted that the suffix *-graph* is used in other types of *photographs*, such as in the phrase *scanning electron micrograph*.

In remote sensing technology a continuing confusion, misuse, and interchange also exists between infrared photography and infrared imagery. One of the reasons for the confusion is that photographic technology frequently uses the word image (e.g., photographic image, latent image, etc.). If the word *thermography* were used by geologists and other environmental scientists in a way analogous to the way the word *photography* is employed, such confusion would be eliminated. The confusion will likely get worse with the launch of the ERTS-A satellite because the sensors will produce infrared imagery but will be only a *reflected* not a thermal (emitted) infrared energy record.

Photography, terrestrial (field) photography, aerial photography, satellite photography, etc., would have their thermographic counterparts as follows: *thermography*, terrestrial (field) *thermography*, aerial *thermography*, satellite *thermography*, etc. Therefore, it is proposed that the unwieldy phrase, *thermal infrared imagery*, be replaced by the word, *thermography*. It is further recommended that the word *thermograph* be applied only to a *qualitative* thermal infrared image, and that the word *thermogram* be applied solely to a *quantitative* thermal infrared image.

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