UNIVERSITY OF NAIROBI

METEOROLOGY

SMR 308 TERM PAPER

GROUP SIX

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QUESTION

Explain the importance of remote sensing in weather forecasting, highlighting the recent developments in the field: Compare and contrast remote based weather forecasting and the in situ method….

APPLICATION OF REMOTE SENSING IN WEATHER FORECASTING

WEATHER FORECASTING: This is the application of science and technology to predict the state of atmosphere for a given location. It covers predictions ranging from short-lived to long-term weather. It is done in two ways:

- In situ
- Remote sensing

REMOTE SENSING: **Remote sensing** refers to the activities of obtaining information about an object by a sensor without being in direct contact with the object. In the realm of meteorology, the information of interest includes, among others, the location and development of weather Systems such as clouds, rainstorms, tropical cyclones, cold and warm fronts. Information needs a physical carrier to travel from the object to the sensor through an intervening medium.

In remote sensing, the information carrier is the **electromagnetic radiation** the output of a remote sensing system is usually an image representing the object being observed.
The way the image look depends on the source of electromagnetic radiation from the object and on the interaction of the electromagnetic radiation with the intervening medium.
Applications of remote sensing span a wide range of
fields. These include

- Meteorological satellites that detect clouds and moisture in the atmosphere.
- Weather radars that probe rain areas.

METEOROLOGICAL SATELLITES:

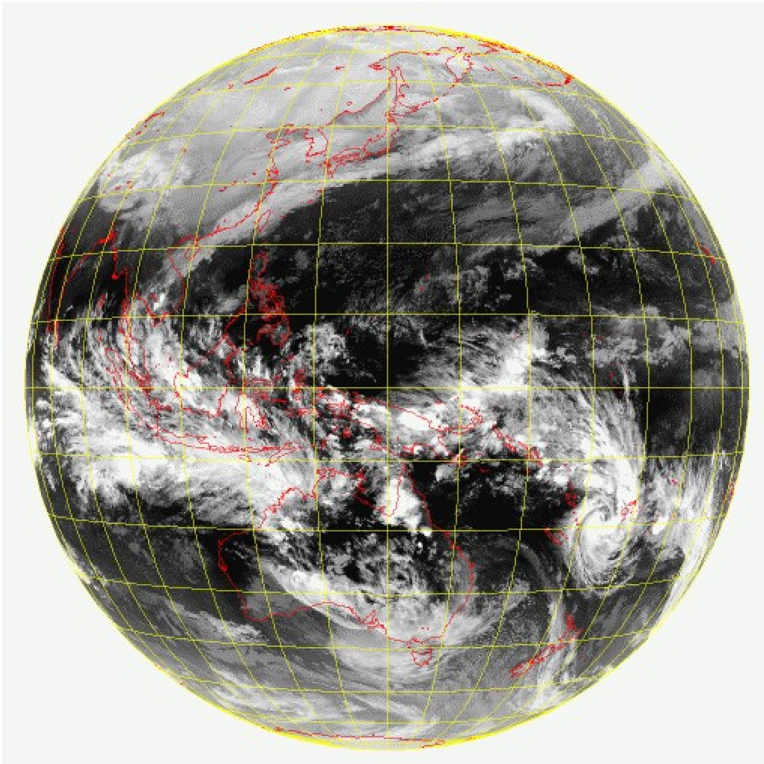
Meteorological satellites can be used to keep track of weather systems days before they come close to an area. This is particularly usefulin monitoring severe weather systems like tropical cyclones. The very basic application of meteorological satellite is in identification of clouds. Clouds can be broadly classified intothree categories according to the cloud base height, namely, low, medium and high clouds.Some clouds, such as cumulonimbus (a type of thundery clouds), span the three layers.

Sensors onboard meteorological satellites are pointing towards the ground, enabling them to have bird eye view of the globe from the space. There are two types of meteorological satellites characterized by their orbits. They are **geostationary** satellites and **polar-orbiting** satellites. As the name suggests, a geostationary satellite is stationary relative to the earth. That is, it moves above the equator at the same rate as the earth's rotation so that all the time it is above the same geographical area on the earth.

In this manner, it is capable of taking cloud images of the same area continuously, 24 hours a day. As it is some 35,800 kilometres from the earth, it is capable of taking cloud pictures covering part of the whole globe. These satellites together provide full coverage of the earth. Polar-orbiting satellites are low-flying satellites circling the earth in a nearly north-south orbit, at several hundred kilometers above the earth. Most of them pass over the same place a couple of times a day.

As they operate at a distance closer to the earth, theyare only capable of taking cloud images of a limited area of the earth each time. Compared with geostationary satellites, polar-orbiting satellites offer fewer and smaller cloud pictures. However, the advantage is that the cloud pictures obtained are of much higher resolution. Different clouds have different characteristics in terms of shape and pattern and have different tones in the visible and infrared images. These differences enable the identification of clouds using a combination of the visible and the infrared images.

For instance, fog and low dense clouds are characterized by their sharp boundary and smooth texture on satelliteimage. They appear in bright white to medium gray tone on the visible image, but in dark to medium gray colour on infrared image (Figure 12). Thundery clouds such as cumulonimbus, however, contains abundant moisture and extends to great height. They appear in globular shape and are in very bright tone on both the visible and infrared images.



Satellite cloud image in the IR1 channel captured by GMS-5 at 11:32UTC on 24 January 2001. Distribution of clouds over the western Pacific, Asia and Australia can be seen in a single image. (The image was originally captured by GMS-5 of Japan Meteorological Agency).

WEATHER RADARS;

Radar is a ground-based and active remote sensing equipment. It emits microwave radiation from a fixed location into the atmosphere and receives the reflected radiation called **echoes** from water droplets in the air. Microwave is not intense in the solar radiation and the earth's emission spectrum. Therefore the background radiation level in the microwave frequencies is not high and it usually does not affect the operation of the radar.

Microwave frequencies can be divided into a number of frequency bands. Many weather radars operate in the S and C bands. While weather radar can measure the distance of rain areas, there is a limit to theeffective range of detection of weather radar. The reason is as follows: weather radar transmits a pulse of microwave and waits for the pulse to return to determine the distance to a rain area.

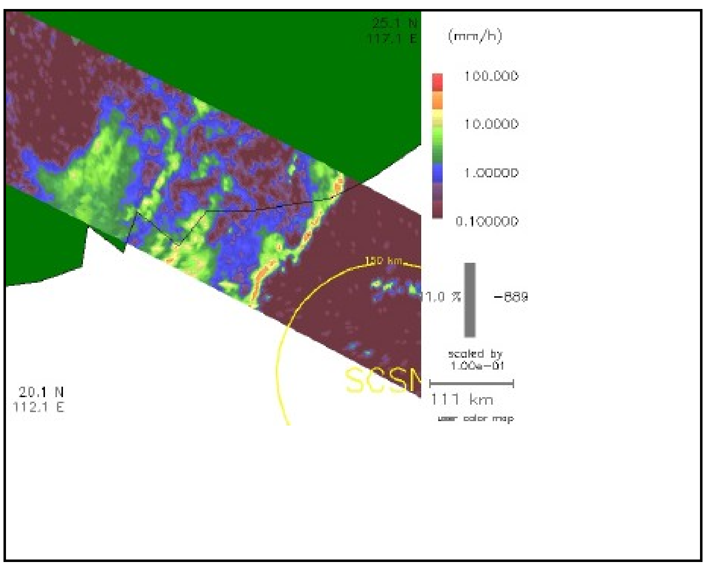
This microwave pulse shall come back before the next transmitted pulse to make the measurement meaningful. Weather radars can measure rain reflectivity as well as Doppler winds. Since weather radars have higher spatial resolution than many meteorological satellites (100-300 m for typical weather radars vs. 1-5 km for many meteorological satellites), weather radars can reveal finer details on the rainfall intensity variation within rain bands. Besides, weather radars usually take images more frequently than meteorological satellites.

Weather radars are therefore ideal for monitoring rapid change in rainfall intensity of rain areas, and prove to be very useful for short-range weather forecasting and warnings. Some common radar products are: rainfall rate of rain areas at constant height above the ground (**CAPPI** - Constant Altitude Plan Position Indicator), vertical scan of a section across rain areas (**RHI** - Range Height Indicator), and maximum height of rain echoes (ECHO TOPS).

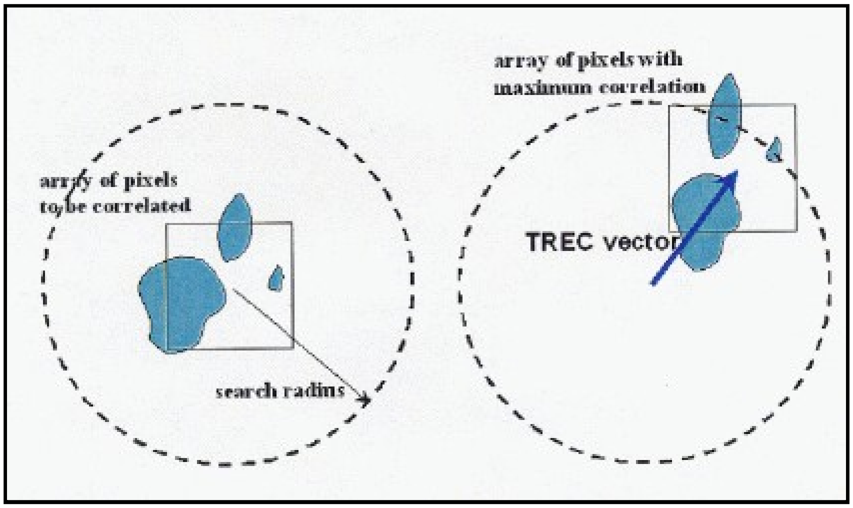
There are also other specific products. For instance, rain areas can be Represented in a 3-dimensional view by means of data processing technique. With advancements in signal processing technology, computer hardware and software, the Capability of radars in the observation of weather is ever expanding

RECENT ADVANCES IN RADAR AND SATELLITE METEOROLOGY:

Launched in 1997, the **TRMM** satellite is the first meteorological satellite ever to carry spaceborne radar. TRMM is a acronym for **T**ropical **R**ainfall **M**easuring **M**ission. One objective of this mission is to obtain and study the science data sets of tropical and subtropical rainfall measurements. The TRMM satellite is a polar-orbiting satellite that circles the earth at a height of about 403 km.
The radar onboard this satellite, called the **Precipitation Radar** , operates on the K_u band.While the horizontal resolution of this radar is not as fine as groundbased raders, PR provides radar images of not just a single location but almost every part of the equitorial, tropical and subtropical region.



Radar image of rainbands of Typhoon Sam at about 4:15 p.m. Hong Kong Time on 23 August 1999 as recorded by the PR on the TRMM satellite. Sam has made landfall near the Pearl River Estuary at this time. Its outer rainbands were still affecting Hong Kong and the neighbouring region. (This image was captured by the TRMM satellite).

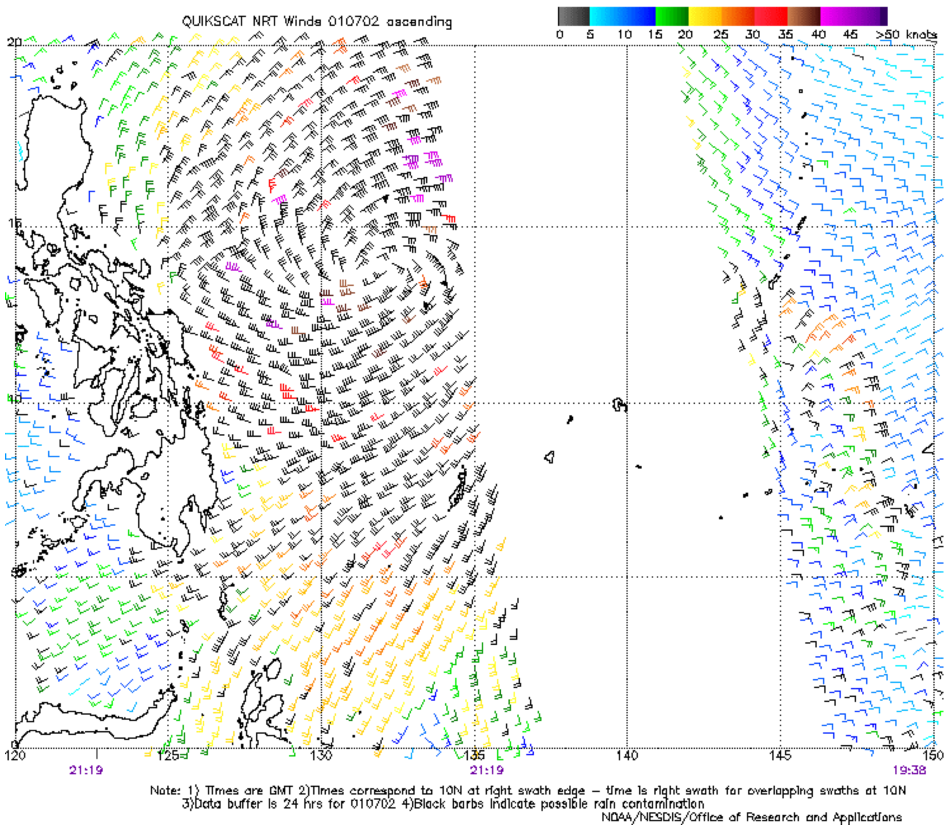


Time t Time t+6 min.

Figure 22 Schematic diagrams showing the computation of movement
Vector of rain areas (blue shade) by means of correlation.

While Doppler weather radar has the capability to detect winds, meteorological satellite nowadays can also estimate the winds near the sea surface from the space. The meteorological satellite with this capability is called QuikSCAT. This is also a polar-orbiting satellite tracking at a maximum altitude of about 800 km above the earth.

Launched in 1999, QuikSCAT carries microwave radar to measures the backscattered microwave signals from the sea waves to deduce near-surface wind speed and direction under all weather and cloud conditions. This is particularly useful to locating and tracking tropical cyclones on the oceans. The past few years have witnessed substantial boom in the field of radar and satellite meteorology. With the advent of new technology, weather radar and meteorological satellites are expected to find much wider applications in the area of weather forecasting and warnings.



For the reasons given above, remote sensing has been very helpful to supplement in situ method. However, in most cases it has proved worthwhile to exclusively use remote sensing, as the in situ method proves insufficient. The following are some advantages of Remote sensing technology in weather forecasting as compared to the in situ method.

a) The sensors used have the capacity to recall past events, thereby enabling animation, a very vital process for interpreting VIS and IR imagery.
b) The sensors have the capacity to hrighlight the specific features of a target.
c) Its possible to have proper storage capacity for archiving.
d) Wide and extensive coverage of the targeted area, which is not possile with in situ devices, since they deal with weather variables at a point.