Land Surface Temperature Measurements From the Split Window Channels of the NOAA 7 Advanced Very High Resolution Radiometer

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Introduction

- The present work seeks to extend the capabilities of the AVHRR through more accurate estimates of land surface temperatures
- This will be achieved through application of the spectral enhancement of AVHRR data utilizing the Split Window Algorithm presented in this paper
- This equation used in conjunction with existing atmospheric correction algorithms and radiative transfer theory reduces potential errors introduced by cloud street formation and provides an effective method to estimating land surface temperatures
- This method has been applied to the identification of agriculturally related parameters

Advanced Very High Resolution Radiometer (AVHRR)

- **Improved satellite sensors are producing higher and higher quality data including AVHRR carried on NOAA operational satellites**
- **AVHRR sensor has been mounted to a variety of satellite platforms and has acquired data for decades**
- **Acquires 1.1-km spatial resolution data in ‘‘split window’’ channels at 10.8 and 11.9 μm.**
- **Has a sun-synchronous orbit capturing entire Earth in 12 hour period**
- **Joint venture between NASA and NOAA to image surface temperatures and atmospheric water vapor**
- **The AVHRR- data is particularly suited to monitoring seasonal and inter-annual changes in land cover/land use because of its low cost and temporal and spatial characteristics. There have been a number of studies which have directly linked AVHRR-NDVI to plant phenology**

(Price, 1984)

AVHRR Spectral Channels

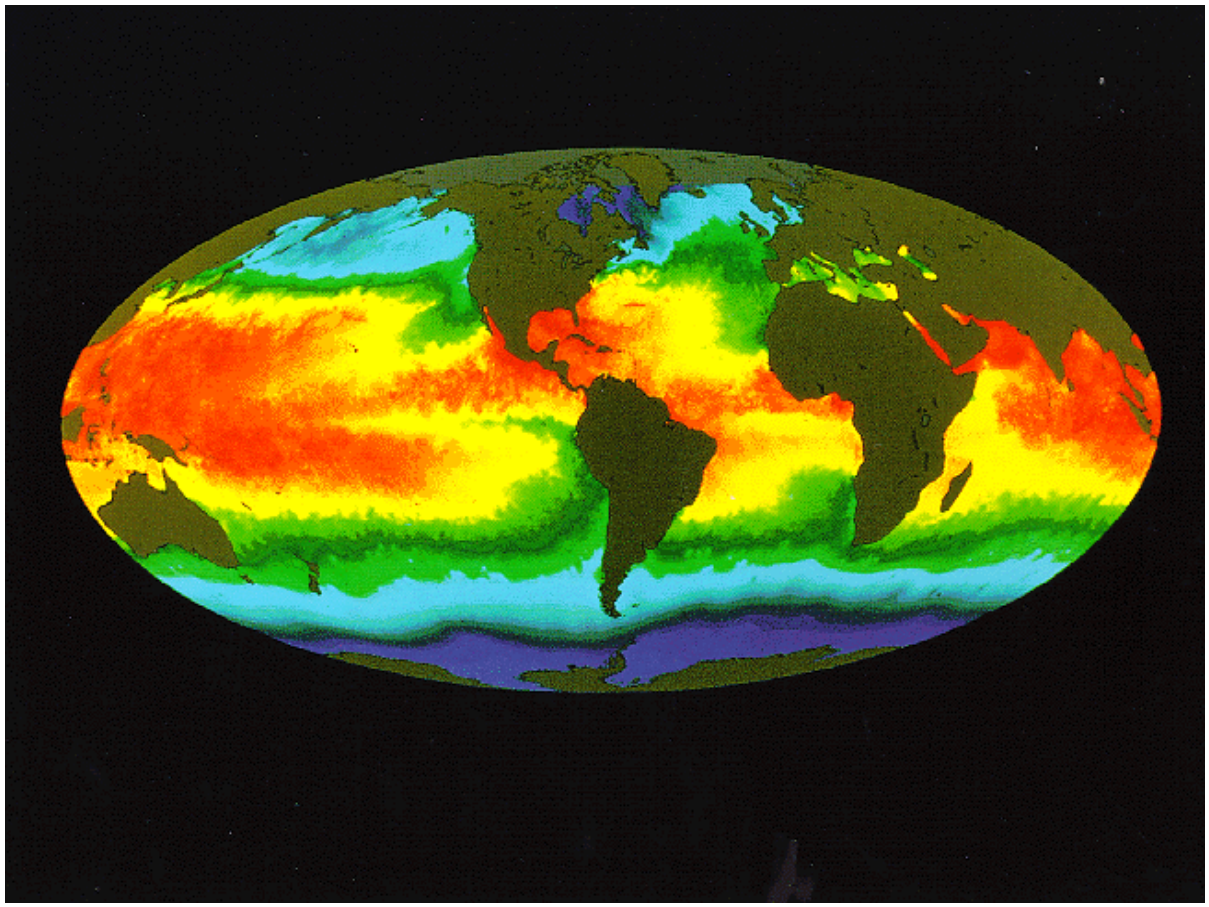
AVHRR/3 Channel Characteristics			
Channel Number	Resolution at Nadir	Wavelength (um)	Typical Use
1	1.09 km	0.58 - 0.68	Daytime cloud and surface mapping
2	1.09 km	0.725 - 1.00	Land-water boundaries
3A	1.09 km	1.58 - 1.64	Snow and ice detection
3B	1.09 km	3.55 - 3.93	Night cloud mapping, sea surface temperature
4	1.09 km	10.30 - 11.30	Night cloud mapping, sea surface temperature
5	1.09 km	11.50 - 12.50	Sea surface temperature

AVHRR carries visible and near-infrared channels as well as three thermal infrared channels

Data from these 5 spectral channels can be used to estimate surface temperature and the atmospheric correction to radiation from the earth's surface.

Data acquired represents a potentially valuable source of information concerning vegetation and moisture conditions in inhabited areas

Spectral Enhancement on Surface Temperature Data

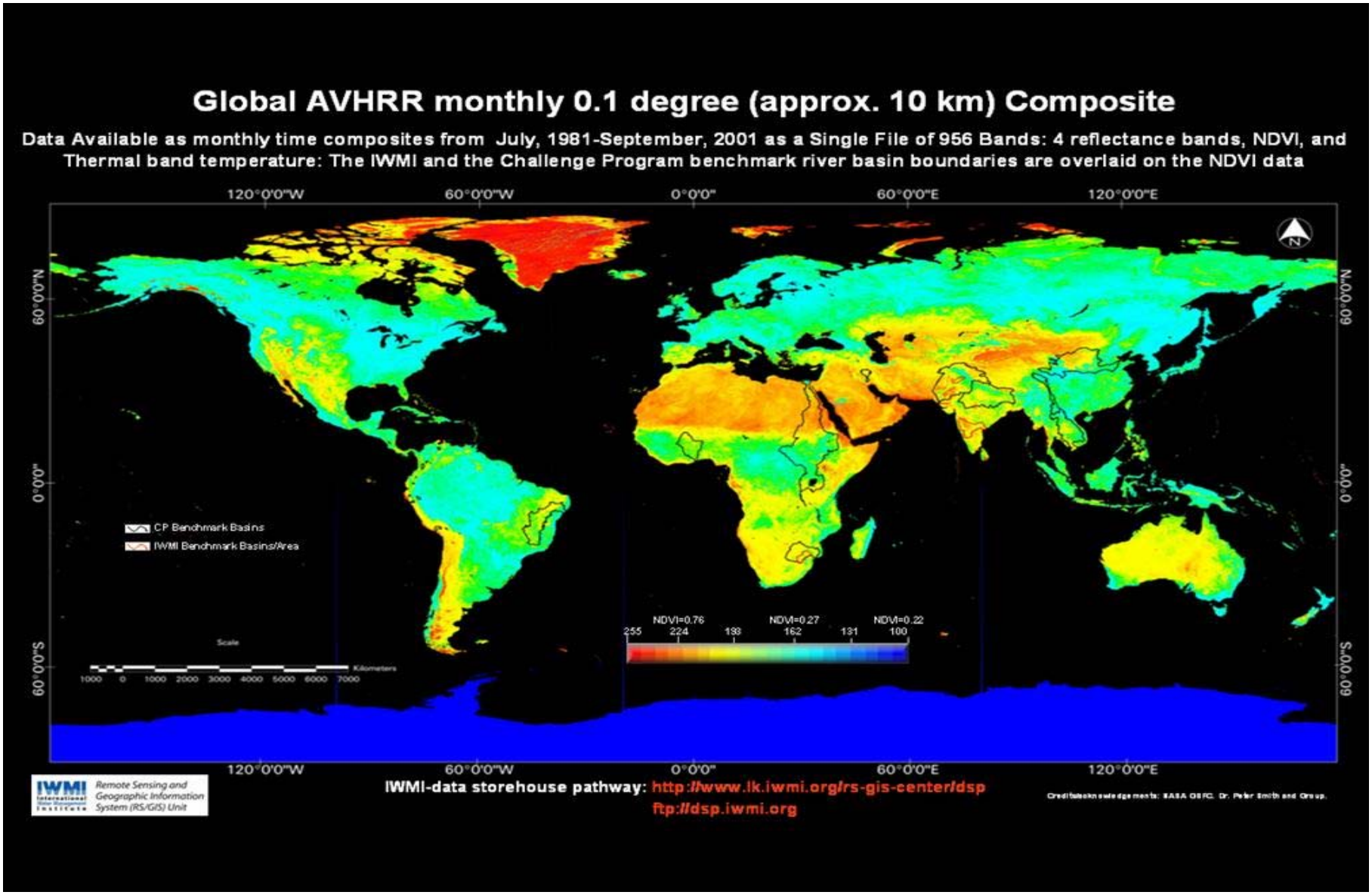


This illustration of Earth's sea surface temperature is part of NASA Goddard Space Flight Center's program of Earth-science research. It was obtained from two weeks of infrared observations by the Advanced Very High Resolution Radiometer (AVHRR), an instrument on board NOAA-7 during July 1984

Resolution Issues for obtaining Sea Surface Temperatures

- **1.1–km resolution at nadir better than required to resolve oceanographic surface features**
- **Due to relatively featureless ocean it is difficult to ground truth temperature data at this resolution**
- **Higher resolution is very useful for observing between cloud streets often present over oceans which produce low estimates of sea surface temperatures**
- **Do to relatively featureless ocean it is not possible to ground truth specific locations thus lower**

Land Surface Temperature



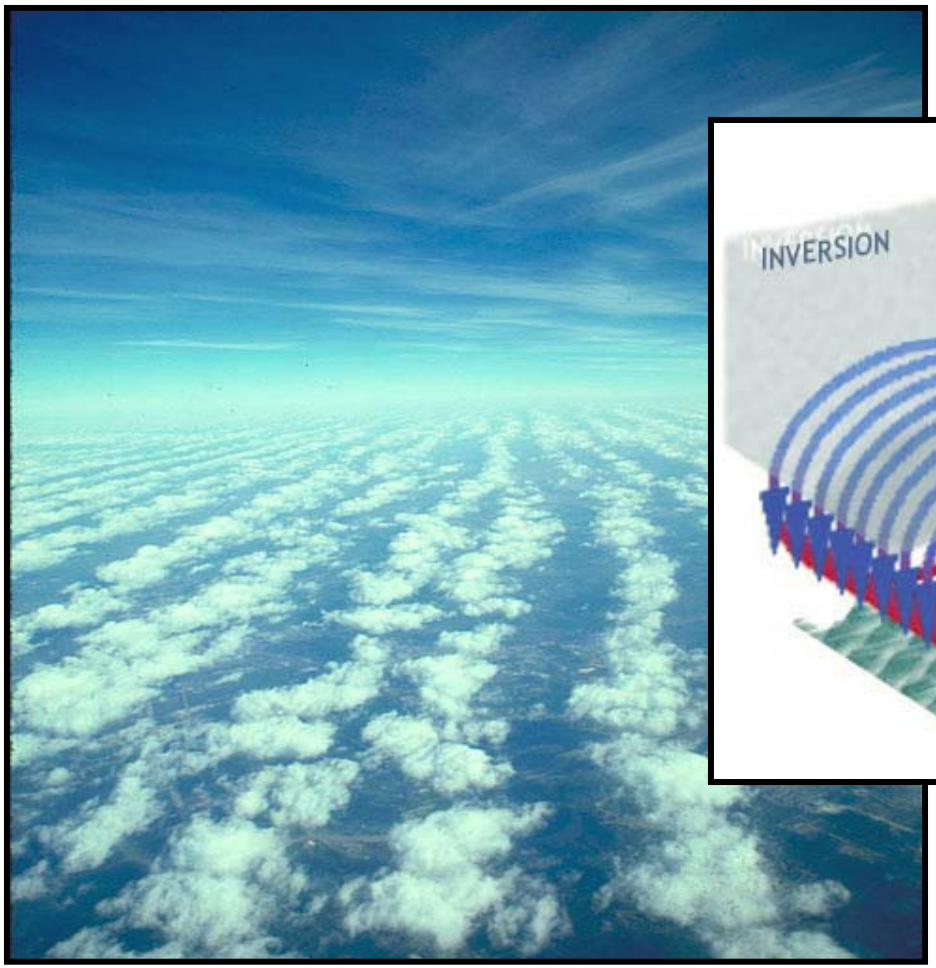
Resolution Issue for Obtaining Land Surface Temperatures

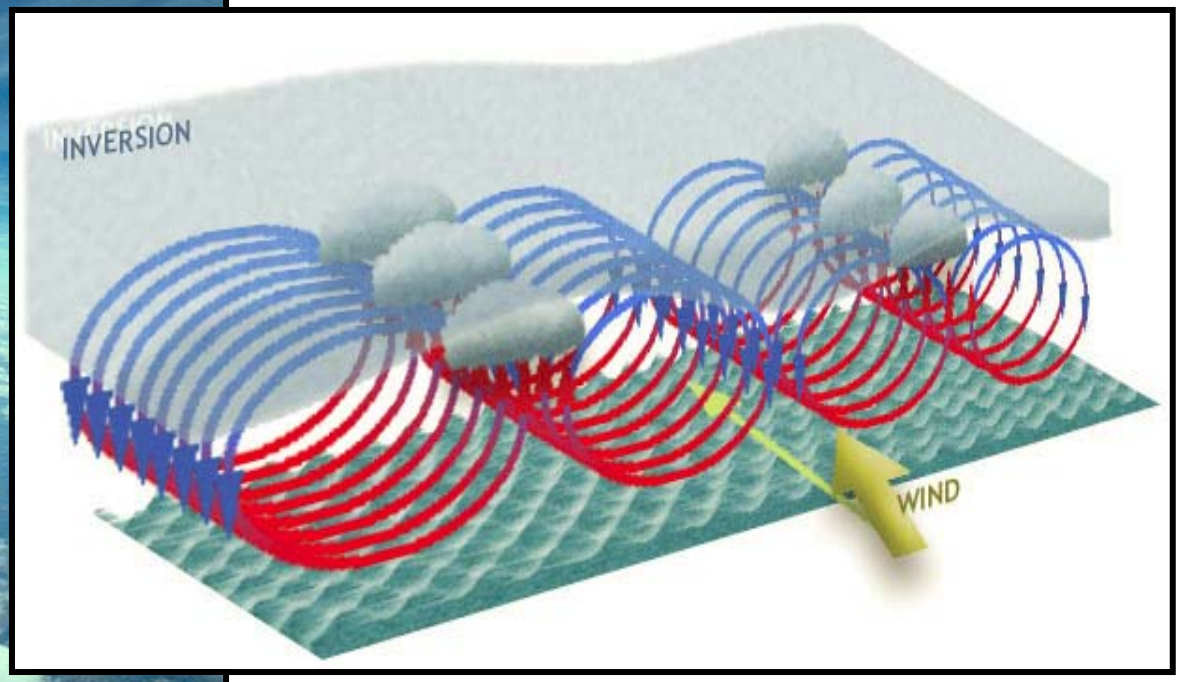
- **1.1 km field of view not adequate to resolve large variation in surface features as these can vary dramatically over 10's of meters**

- **High resolution data is required to identify variations of atmospheric moisture which produce temperature differences which requires**

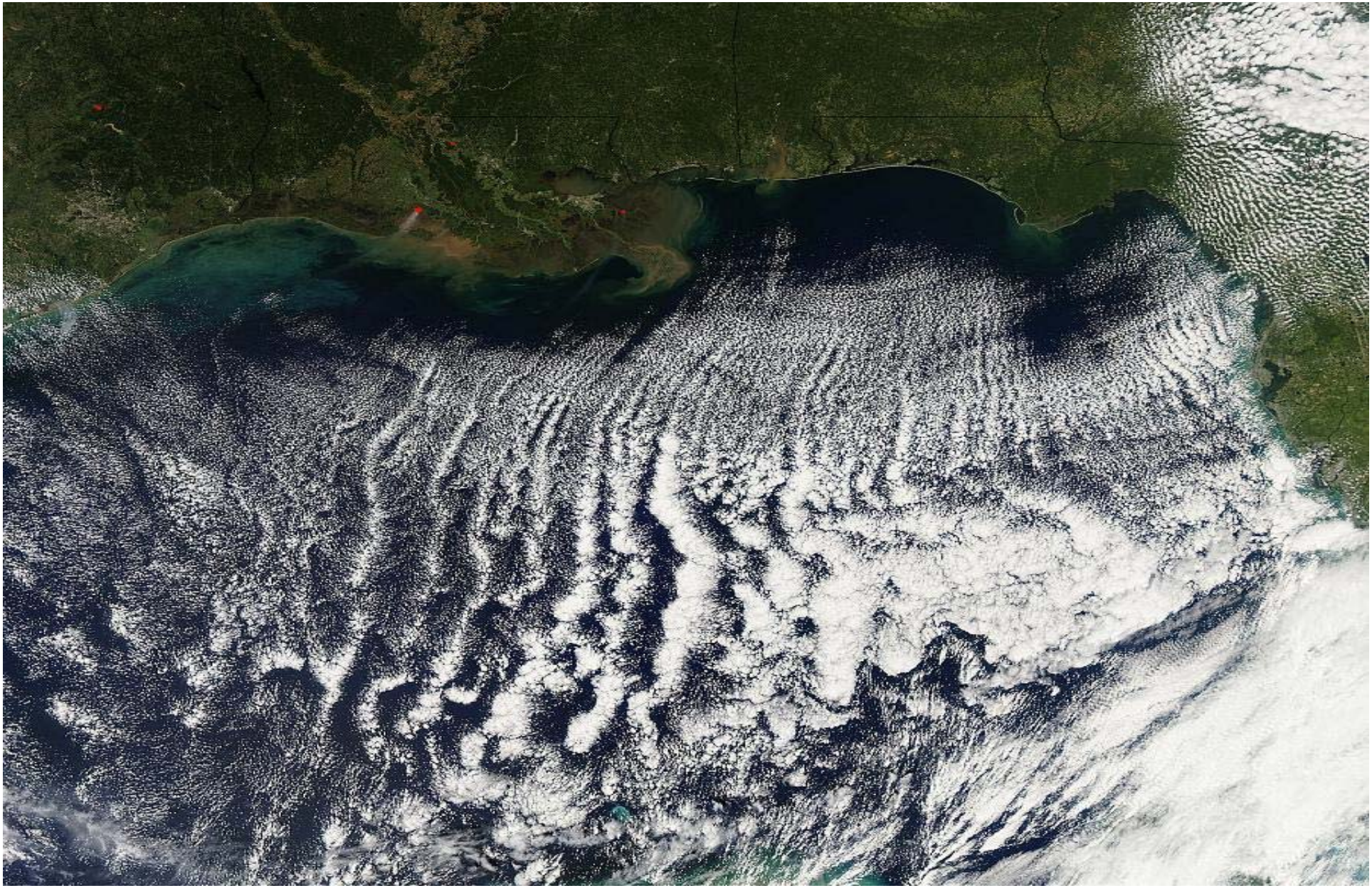
- **Unlike on with ocean temperature data, land surface satellite derived temperatures can be ground truethed and related to local conditions**

Cloud Street Formation





In areas of cloud street formation, variations of atmospheric moisture produce radiance temperature differences of order of 2-3 C, which if neglected cause errors in the derivation of surface thermal characteristics (Price, 1984)



Cloud Streets photographed over the Gulf of Mexico on October 18, 2009. This display is a prominent example of organized rows of cumulus clouds known as "cloud streets." Image Source: NASA MODIS

This image shows cloud streets as viewed from a plane flying just above the unstable air and within the inversion layer.

Split Window Algorithm (Price 1984)

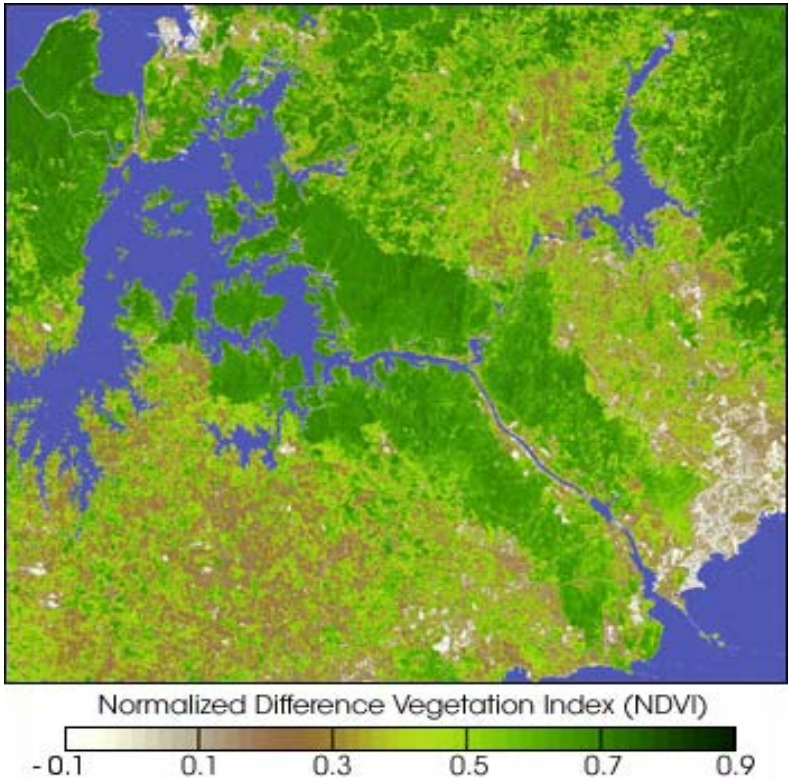
T_s = Split-Window Algorithm

$$T_S = TIR1 + 3.33\ (TIR1 - TIR2)$$

TIR1 = 10.8 µm

TIR2 = 11.9 µm

Price's contributions have been utilized for over 25 years for land surface vegetation analysis



Normalized Difference Vegetation Index (NDVI)

Brown areas indicate areas of low vegetation while green areas indicate high vegetation

- **Vegetation density can be obtained by the strong contrast in reflectance between the Red and Near Infrared EMR**
- **NDVI takes advantage of this characteristic**
- **The density of vegetation can be more accurately estimated due to the made by Price**

CONCLUSIONS

Satisfactory agreement between this algorithm and the statistically derived NOAA algorithm used to obtain sea surface temperatures from satellite data

Satisfactory agreement between the equation resulting from radiative transfer theory and the atmospheric correction algorithm obtained by analysis of an area of insipient cloud formation

In areas of cloud street formation, variations of atmospheric moisture produce radiance temperature differences of order of 2-3 C, which if neglected cause errors in the derivation of surface thermal characteristics