Regional Cloud Products over the Middle East during the Iraqi Freedom Campaign – Comparison with MODIS and CDFS II

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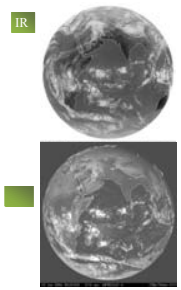
Abstract

Visible and Infrared Satellite Imagery from the Meteosat-5 Satellite are used to produce a regional-scale cloud analysis. A description is given of the cloud analysis algorithm, including several new and innovative techniques. Examples of input, intermediate, and final output products are shown, as well as several cloud climatology products that are produced from the hourly cloud analysis. "Frequency of Occurrence of Cloud" composites from these data are then compared similar products from CDFS II and twice-a-day Moderate Resolution Imaging Spectrometer (MODIS) data.

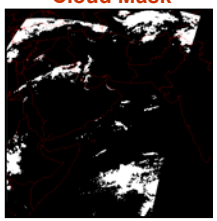
Data

Meteosat 5

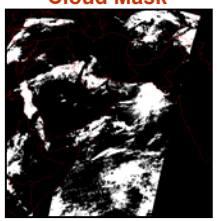
Imagery used in this study are from the Meteosat-5 satellite. Hourly, 5 km resolution, visible and infrared radiance image sectors were extracted from the full-disk half-hourly data that were collected and stored by the CIRA Earthstation. Each sector is 1024 X 1024 pixels, representing approximately a 5000-km X 5000-km region which covers approximately three time zones.



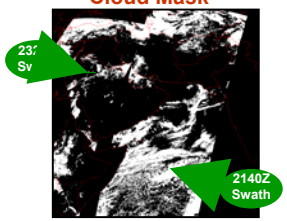
CDFS II WWMCA Cloud Mask



Regional Prod Cloud Mask



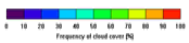
MODIS Cloud Mask



Comparison with MODIS and CDFS II

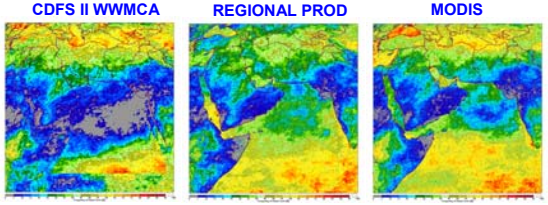
March 8 – April 17, 2003

FREQUENCY OF OCCURRENCE OF CLOUD PRODUCTS WERE CONSTRUCTED FROM MODIS DATA AND ALSO FROM THE REGIONAL PRODUCTS DATA AT TIMES THAT MATCHED MODIS OVERFLIGHTS.



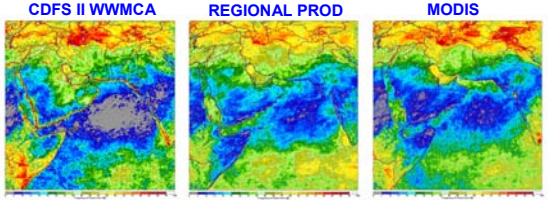
40 Day Nighttime Cloud Climatologies

CDFS II WWMCA | REGIONAL PROD | MODIS



40 Day Daytime Cloud Climatologies

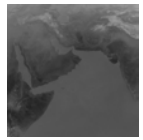
CDFS II WWMCA | REGIONAL PROD | MODIS



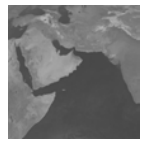
Regional Cloud Product Development

Visible and Infrared "Backgrounds"

PROCESSING BEGINS WITH THE GENERATION OF VISIBLE AND INFRARED RADIANCE (CLOUD-FREE) BACKGROUDS. THE VISIBLE BACKGROUND IS BUILT BY RECORDING THE 2ND WARMEST (DARKEST) PIXEL RECORDED DURING THE MONTH (TO MINIMIZE NOISE AND SHADOW EFFECTS). THE INFRARED BACKGROUND IS BUILT IN A SIMILAR MANNER, BUT OVER A SHORTER (NORMALLY 10-DAY) WINDOW.

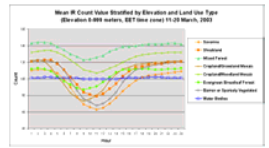


Infrared Background



Visible Background

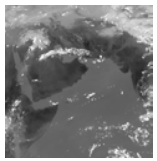
Cloud From "Temporal Variance"



Diurnal change of IR background for various land use types - in the elevation range of 0-1000 m

USGS-EROS Land Use 1-km horiz

GTOPO30 Elevation 1-km horiz by 1-m vert



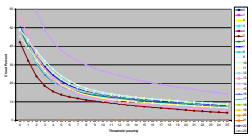
Example of Cloud Detected by Temporal Variance test

"DIURNAL CHANGE" CURVES ARE CONSTRUCTED FOR EACH LAND-USE TYPE WITHIN EACH 1-KM ELEVATION BIN AND WITHIN A GIVEN TIME ZONE. A DIURNAL VARIANCE TEST IS THEN PERFORMED TO DETERMINE IF EACH INFRARED PIXEL UNDERGOES A TEMPERATURE CHANGE FROM ONE HOUR TO THE NEXT THAT IS CONSISTENT WITH THE CHANGE THAT WOULD BE EXPECTED IF IT IS A CLOUD-FREE PIXEL. IF NOT, IT IS TAGGED AS CLOUDY FOR THIS TEST.

Cloud From "Threshold-Over-Background"

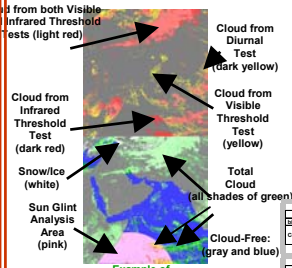
Raw Infrared Image | Infrared cloud-free "background" | Cloud (green)

IF A GIVEN PIXEL IS COLDER THAN THE BACKGROUND PLUS A THRESHOLD, THE PIXEL IS IDENTIFIED AS "CLOUDY".



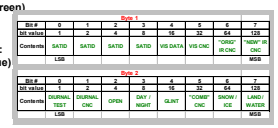
THRESHOLDS ARE DETERMINED BY SENSITIVITY TESTS (EXAMPLE TO LEFT) AND VISUAL INSPECTION OF CLOUD TEST RESULTS AGAINST THE RAW IMAGES.

Cloud / No Cloud Database

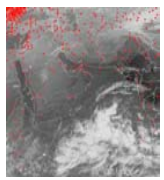


Example of Regional Cloud Database

THE IMAGE TO THE LEFT IS A DISPLAY OF THE 16-BIT "QA" WORD THAT IS BUILT AT EACH AT EACH PIXEL IN THE RP SECTOR. EACH COLOR REPRESENTS THE RESULT OF A SPECIFIC CLOUD TEST OR A DATA OR CONDITION FLAG. THE COMPLETE CONTENT OF THE DATABASE IS SHOWN IN THE TABLE BELOW.

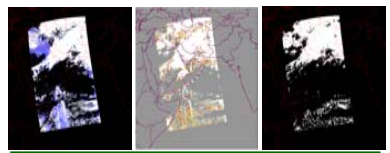


Motivation



Typical Surface Observation Coverage for a "Synoptic" (3-hrly) reporting time

Data Comparison – Sampling Strategy



WWMCA and CIRA cloud masks are sampled to match MODIS cloud mask footprint. Satellite data used in this research are from 8 March through 17 April 2003

Snow / Ice Mask

Snow / Ice analysis (grey area)