Validation and inter comparisons of profiles from ATOVS and AIRS data over India and its surrounding regions

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Abstract

The Inversion Coupled with Imager (ICI3) scheme is used to retrieve vertical temperature and moisture profiles from ATOVS onboard NOAA-16 polar-orbiting satellite. In the present study, an attempt has been made to validate and intercompare the profiles retrieved from ATOVS and that of AIRS. The rms was computed using NCEP reanalysis data for ATOVS profiles for the period of January to March 2004. The rms errors in temperature profiles are found to be more over land about 3K in lower atmosphere compared to that of middle and upper atmosphere, where the differences are less than 2k respectively compared to sea areas. Regarding the comparisons of ATOVS and AIRS profiles, it has been observed that in general the temperature and moisture profiles are comparable. However, the best agreements have been observed over oceanic regions.

Introduction

Remarkable progress has been achieved during the last two decades in retrieving temperature profiles by means of passive infrared sensors. Recent efforts have been concentrated on the development of sensors with high spectral resolution. The AIRS (Advanced Infrared Sensor), with 2378 channels, is the first operational instrument with these characteristics. Concerning temperature and moisture profiles, it exhibits substantial improvements when compared with previous instruments (Parkinson 2003). The AIRS sensor was launched onboard the EOS-PM (AQUA) satellite in May 2002, together with microwave units AMSU-A and HSB (Humidity Sensor for Brazil). The AIRS sensor provides radiances in 2378 channels, yielding a significant increase in information about radiative emission/absorption of many secondary gases in Earth's atmosphere.

The microwaves sensors are useful in retrieving tropical cyclone data as cloud cover associated with non-precipitating cloud systems within tropical

cyclones are transparent to microwaves. The Advanced Microwave Sounding Unit (AMSU) onboard National Oceanographic and Atmospheric Administration (NOAA)-15 and NOAA-16 satellites have the capability to measure the main tropical cyclone parameters of interest to forecasters. While other satellite sensors can estimate thermal anomalies, wind speeds and rain rate, AMSU is the first instrument, which can measure these parameters (Kidder et al, 2000). The Singh et al. 2004 studied the intensity of tropical cyclones which formed over India using the AMSU measurements. They found that the magnitude of the warm core temperature anomaly at 250 hPa was 6 K for the Orissa super cyclone (October 1999). Sandeep et al. 2006, studied the impact of assimilation of AMSU temperature and moisture profiles for the prediction of a tropical cyclone over the Arabian Sea using the fifth generation Mesoscale Model (MM5). They found that the model simulation with the assimilation of AMSU data were in general agreement with the observations when compared to the model simulation without the AMSU data.

Models and Data sets

This work shows the ability of ATOVS for retrieving temperature and moisture profiles for different atmospheric conditions over India. The analysis was done using the Inversion Coupled with Image (ICI) model (Lavanant et al. 1999a). To accomplish this work we used nine months (January 2004 to September 2004) of NOAA-16 satellite data pre-processed with the ATOVS and AVHRR Processing Package (AAPP) model (Klaes 1997; Klaes et al. 1999). The obtained temperature and moisture retrieved profiles are compared with AIRS profiles data. Also the retrieved horizontal fields of temperature and moisture are analyzed for different pressure levels.

In this study, nine months (January 2004 to September 2004) of NOAA-16 satellite data over India and its surrounding regions were used for reconstructing temperature and moisture profiles. The meteorological data used in the initialization (numerical weather forecast data) were supplied by the LAM model run operationally by IMD at New Delhi and for validation process NCEP reanalysis data was used. Since the satellite raw data is received in the HRPT (High Resolution Picture Transmission) format, it is necessary to process it before the retrieval process. The AAPP model was used to perform the ingestion and pre-processing of the HRPT data. This procedure supplies calibrated data of brightness temperature for all ATOVS channels located in the terrestrial coordinates (latitude and longitude) and mapped in a common grid resolution.

The ICI inversion system was developed at the Centre de Météorologie Spatiale (CMS), where it has been operational since 1996. Its structure is based on independent modules, which work separately and could be easily replaced.

The key components are: initial profiles library, inversion module and the tuning module, which is responsible for the periodic ICI calibration (Lavanant et al. 1997; Lavanant et al. 1999a). The ICI version used in the current study uses the RTTOV-6 model, a fast radiative transference code (Eyre 1991; Sanders et al. 1998) to simulate the brightness temperature during the retrieval process.

Results and Discussions

Fig. 1 shows the error statistics concerning the mean (bias) and the standard deviation (stdev) of the difference between the simulated and measured brightness temperature. These errors are caused by factors such as forward models approximations and measurement errors, among others (McMillin et al. 1993). As expected, the error levels change considerably from channel to channel, and the model accuracy depends on the surface type (sea and land). Standard deviation values are higher over land, especially in the AMSU channels. This occurs because the surface parameters have lower variability and are easily estimated over sea.

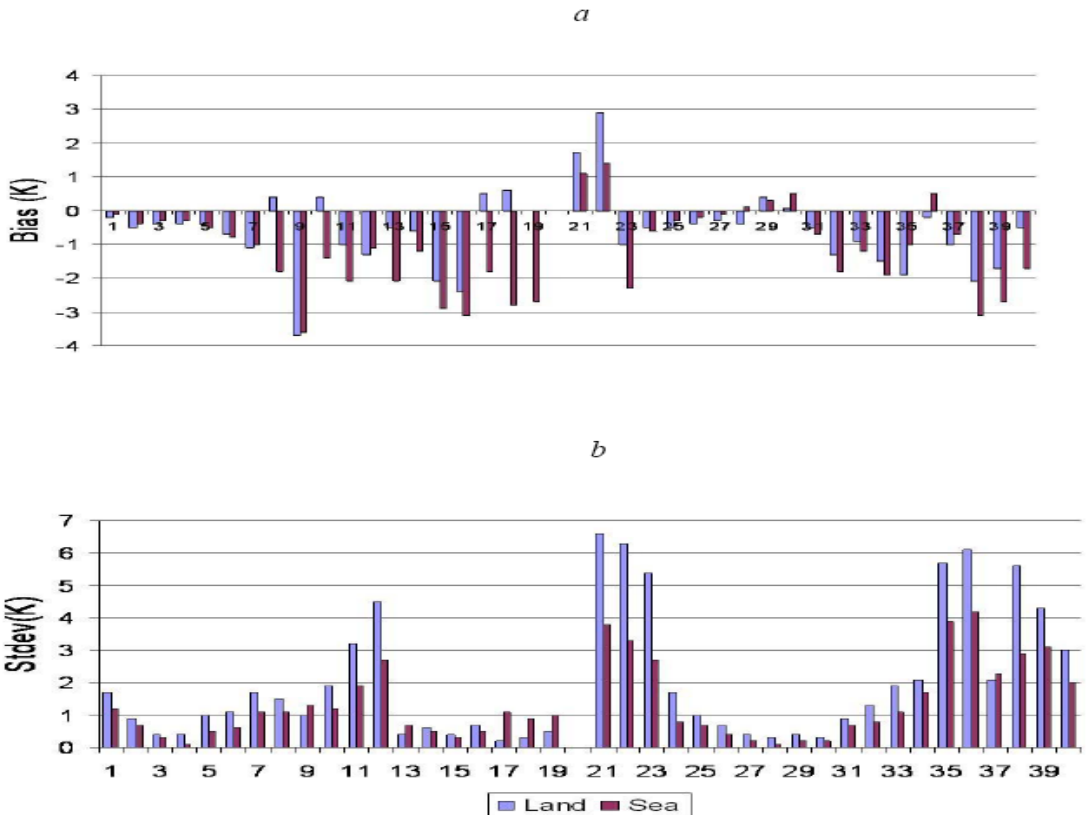

Fig- 1(a): Error statistics concerning the mean (bias) and (b): the standard deviation (stdev) of the difference between the simulated and measured brightness temperature. Statistics performed for the NOAA-16 satellite from 11/01/2004 to 20/01/2004.

The vertical accuracy statistics based on satellite and NCEP reanalysis were computed from the collocations for NOAA-16 satellite data for the period of January to March 2004. The statistics were made from total collocations, which include the types of land and sea, and clear and cloudy conditions. The results illustrated in the Figures 2 and 3 show rms error of temperature profiles retrieved using ICI over land and sea for January to March 2004 period. All of them had similar rms error in the lower troposphere (below 850 hPa) in clear and cloudy conditions with values about 3.2 K over land and about 2.0 K over sea. The rms errors are small over the sea compared to that of the land in both situations. This is because of constant emissivity over the sea compared to highly variable emissivity over land.

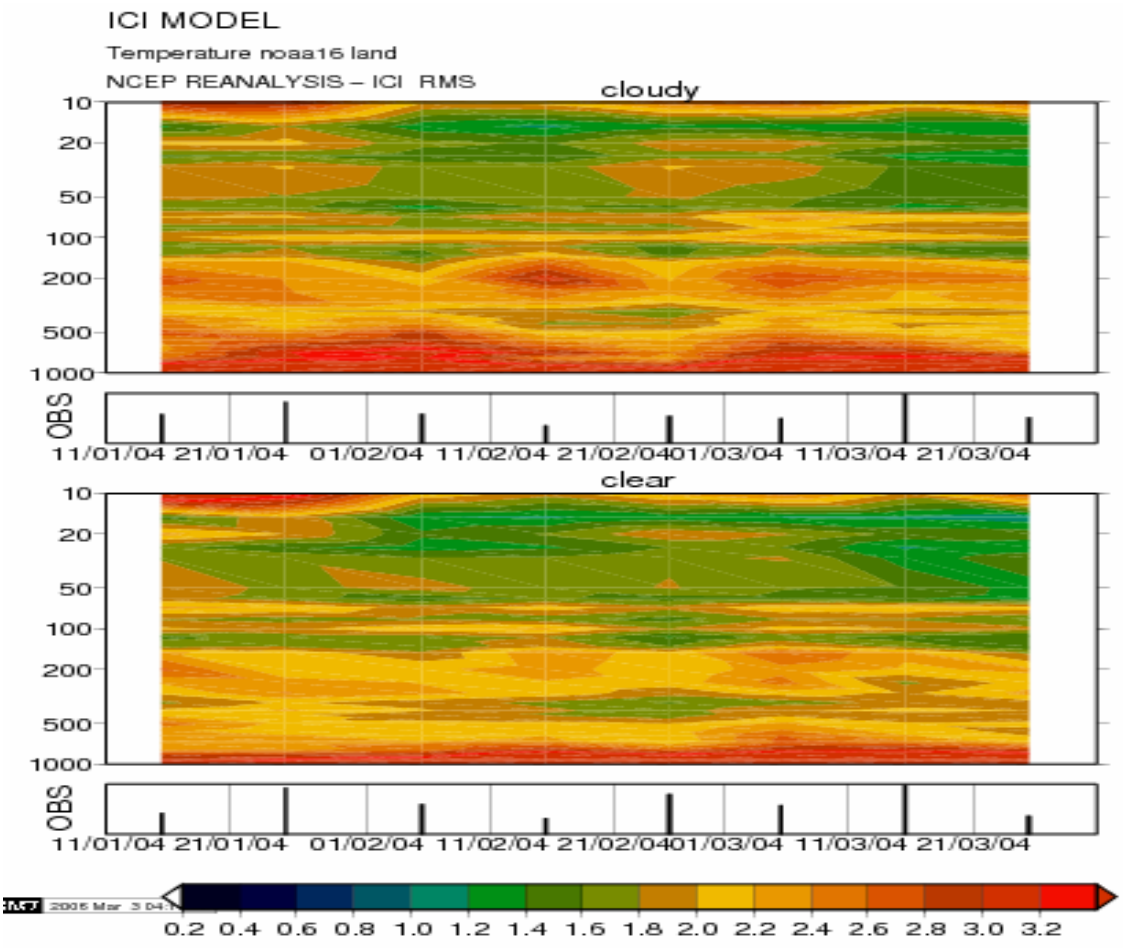

Fig-2

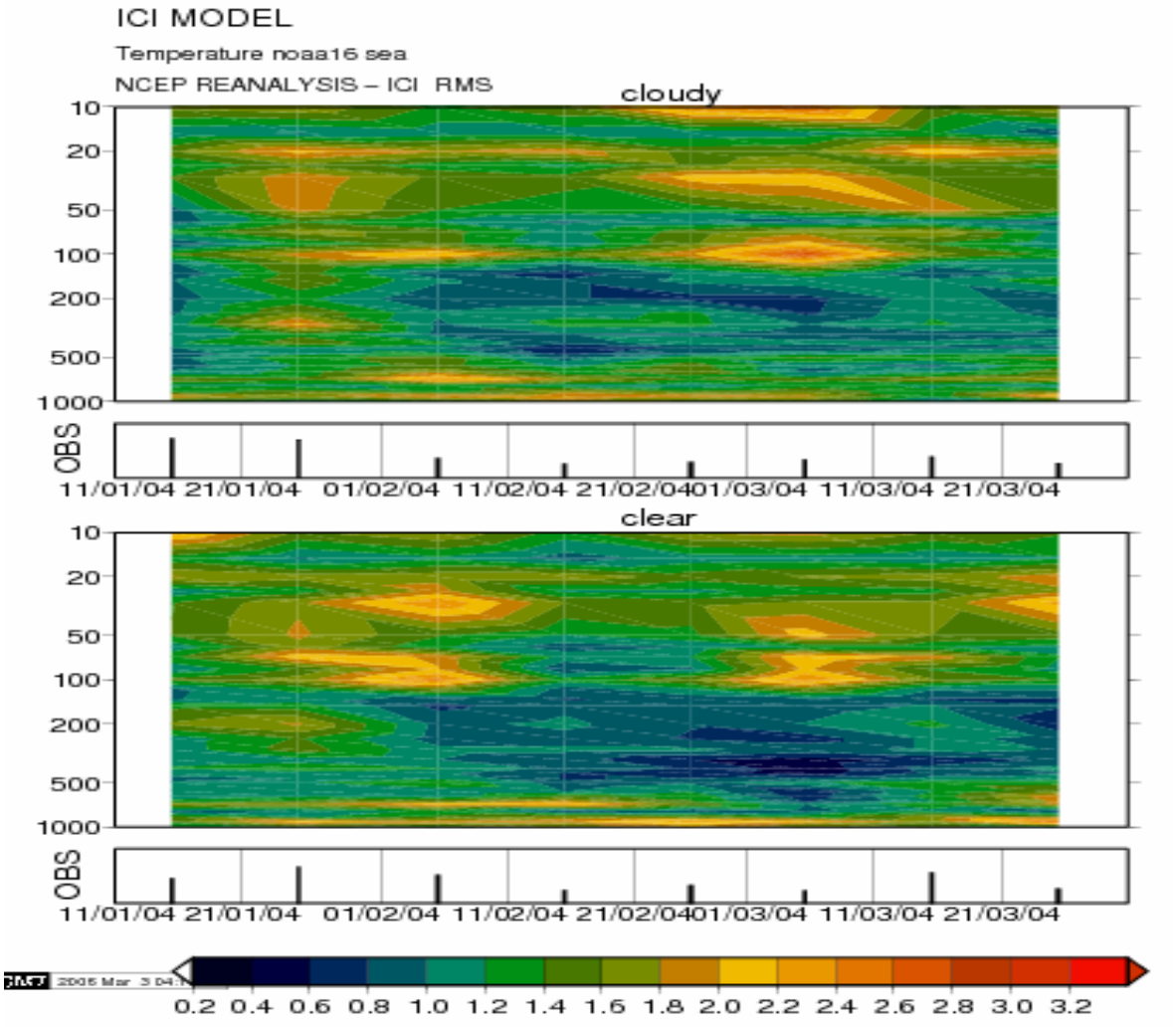

Fig-3

Intercomparsions of temperature profiles

An attempt has been made here to intercompare these profiles from AIRS to that of ATOVS. In order to study the differences in these two sets of profiles, spatial contour plots are prepared for the month of January 2004 at two different pressure levels. The color contour plots of temperature profiles at 850 and 500 are shown in fig-4 (a and b). It has been observed that in general the temperature profiles are comparable within 2 degree Kelvin to that of temperature profiles retrieved from AIRS measurements at DAAC/NASA. However, the large differences are observed at lower atmosphere (850 hPa) compared to that at middle (500 hPa).

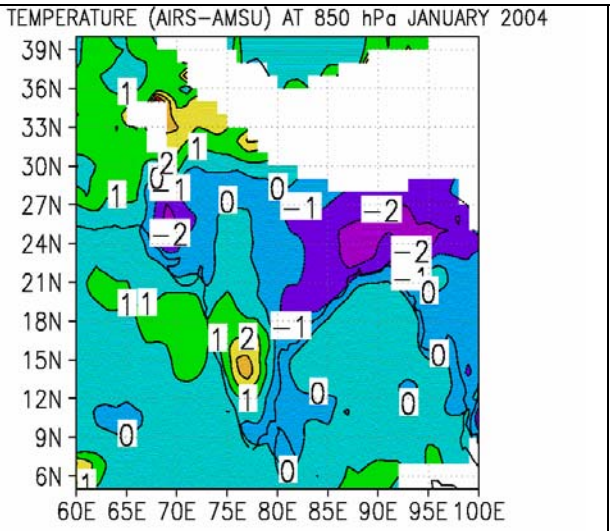

Fig-4(a)

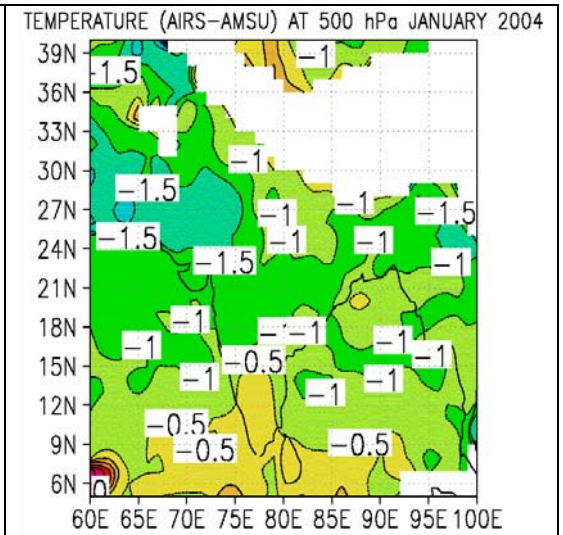

Fig-4(b)

Intercomparsions of specific humidity profiles

For the analysis of differences in specific humidity profiles from the aforesaid two data sets, spatial contour plots are prepared for the month of January 2004 at two different pressure levels. The color contour plots of specific humidity using ATOVS and AIRS data at 850 and 500 hPa are shown in fig-5 (a and b). It has been observed that in general the specific humidity profiles are comparable within 2gm/kg to that of specific humidity profiles from AIRS measurements at DAAC/NASA. However, the large differences are observed at lower atmosphere 850 hPa compared to those at the middle 500 hPa.

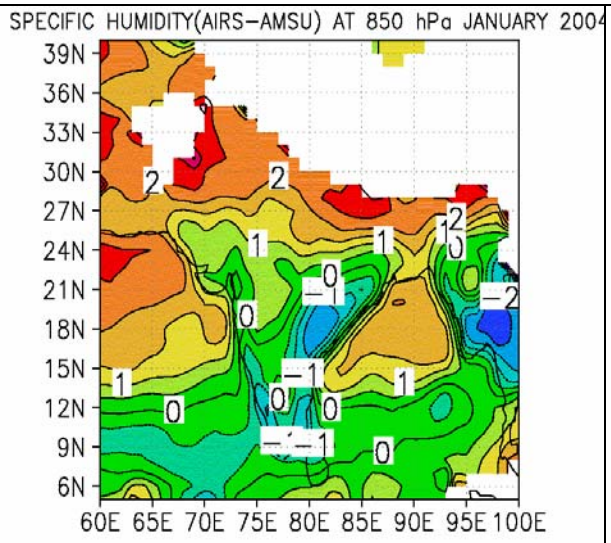

Fig-5(a)

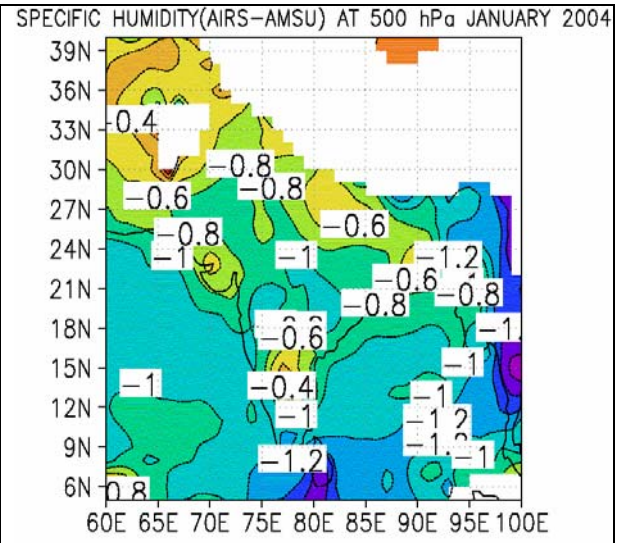

Fig-5(b)

Summary

The ICI model retrieved profiles are validated using NCEP reanalysis yields rms error about 3.2 K over land and 2k over Sea. Further the intercomparisions of ATOVS and AIRS profiles show the larger differences over land areas at few locations compared to oceanic areas. The order of the differences in temperature and moisture over land areas at surface and 850 hPa are about 4K and 3gm/kg respectively. However, these differences are very small in middle atmosphere.

Acknowledgements

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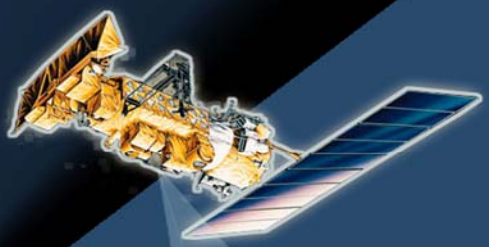

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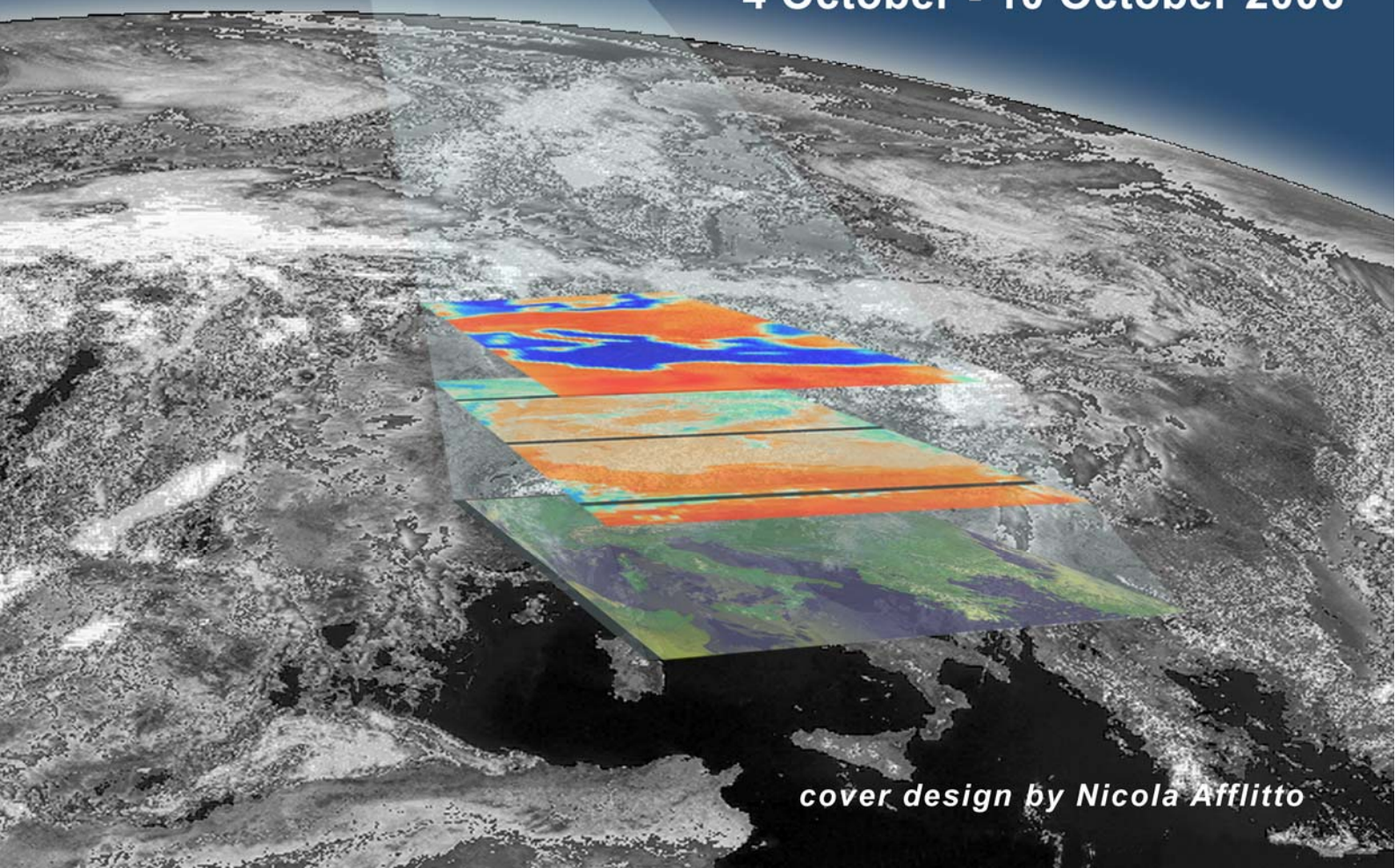

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