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GPCP AIP/2 PROPERTIES OF AVHRR DATA. PRELIMINARY RESULTS

by

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GPCP-AIP/2 PROPERTIES OF AVHRR DATA. PRELIMINARY RESULTS

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Abstract

For the GPCP-AIP/2 (Global Precipitation Climatology Project - Algorithm Intercomparison Project) data set, a statistical analysis of the AVHRR data has been carried out in order to:

- test the quality of the data;
- study the statistical properties of the data;
- help select interesting cases from the point of view of estimating precipitation.

A short description of the data set is given, including such bulk properties as the image size and position, the number of images and the amount of useful data. For each image and each channel the following quantities have been calculated:

- mean and standard deviation;
- correlation coefficients between single channels;
- frequency distribution of albedo/brightness temperature.

The results of the analyses are shown and discussed. Interesting cases have been selected and an example has been shown.

1. INTRODUCTION

The AVHRR data set of the GPCP-AIP/2 (Global Precipitation Climatology Project - Algorithm Intercomparison Project, WMO 1990) Campaign has been analysed in order to:
- test the quality of the data;
- study the statistical properties of the data;
- help select interesting cases from the point of view of estimating precipitation.

A short description of the GPCP-AIP/2 AVHRR data set is reported in Section 2. The statistical analyses applied are described in Section 3 and the results reported and discussed in Section 4. In Section 5, selection criteria for interesting cases are described and an example is shown. Some concluding remarks are made in Section 6.
This report is the first part of a study to assess the utility of the AVHRR data in retrievals of precipitation information compared with geostationary satellite-based methods.

2. THE DATA SET

The GPCP-AIP/2 (WMO 1990) began on February 1st 1991 and ended on April 9th 1991.
The GPCP-AIP/2 AVHRR frame of interest includes the area between 10W and 10E at 42N and between 14W and 14E at 55N: an approximate 44% of which is ocean (3 % is Mediterranean Sea). The western part of the Alps, presumably covered with snow during the campaign, is also included in the image frame and will be of particular interest in the analysis of the results from the rain retrieval algorithm.
The UK FRONTIERS (Conway and Browning 1988) radar network area occupies about 15% of the AVHRR area; the COST-73 (Collier et al. 1988) composite area occupies about 85%.

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Table 1: Number of *"good quality"* pixels for each channel with number of images in brackets

Month	*Channel*				
	1	*2*	*3*	*4*	*5*
February	19932894 (59)	20661019 (61)	39613606 (118)	41803905 (125)	19890598 (58)
March	36798339 (114)	36369715 (113)	75067918 (230)	75397055 (231)	38161745 (116)
April	10405098 (32)	10405098 (32)	20067014 (61)	20397879 (62)	10431256 (31)
Total	67138331 (205)	67435832 (206)	134748538 (409)	137598839 (418)	68483599 (205)

Imagery products, each having 600 lines of 720 pixels, were generated on the Meteorological Office's computer system known as Autosat-2 (Allam et al, 1990).
Because of the presence of *corrupted* pixels in the images, a first simple quality test has been applied to the data. Although a residual population of differently corrupted pixels may pass this test, the effect of this population on the results of the analysis is expected to be negligible. Table 1 shows the number of useful pixels and the number of images available for each single channel and each single month.

3. STATISTICAL ANALYSES

The following analyses have been carried out:

- Study of the mean temperature/albedo of the image and its standard deviation. Mean and standard deviation have been computed for each image. Single channel time series are shown in Figs.1.a-e, where the standard deviation is represented as an error bar to the mean value.
- Study of the frequency distribution of the pixel values (temperature/albedo) within each single image. Classes respectively of 5 K or 5% albedo have been defined, their frequency occurrence has been computed and corresponding histogram produced. For each channel, the time series of the percentage frequency of occurrence has been displayed in the time - pixel value plane as contoured maps (Fig.2). The effect of different *good pixels* population in the image series is significant only for very few cases with less than 10 % of the expected number of pixels and therefore can be easily detected and eliminated.
- Study of the correlation coefficient between single channel pixel values. Correlation coefficients and other linear correlation statistical parameters have been calculated for all the possible single channel combinations within each satellite passage. Time series of correlation coefficients are shown in Figs.3.a-j. The dependence of the correlation coefficient values versus the mean albedo/temperature value of the correspondent image has also been studied.

4. RESULTS AND DISCUSSION

In the following, the first results of the statistical analyses are reported and discussed channel by channel.

- *CH1*: The solar zenith angle correction applied seems to be excessive early in the morning, bringing the value to a saturation over bright clouds (see Fig.1.a). The frequency distribution study showed that some early morning cases have physically unacceptable distribution.
- *CH2*: As does CH1, the solar zenith angle correction affects the distribution, but less strongly. A high correlation is seen between CH1 and CH2 that appears to be greater for high values of average image albedo.
- *CH3*: Due to its position in the electromagnetic spectrum, this channel's measurements behave like 2 different channels, according to the time of the day: for example, the nighttime frequency distributions are similar to those of the other IR channels.
- *CH4*: From the frequency distribution shown in Fig.2 it is possible to observe:
  - diurnal variability, due mainly to the warming of land surface during the daytime;
  - stability of the maximum in the distribution, due to the sea surface portion of the image, except for a slight seasonal trend;
  - main perturbations during the campaign as revealed by the frequency distribution of the minimum.

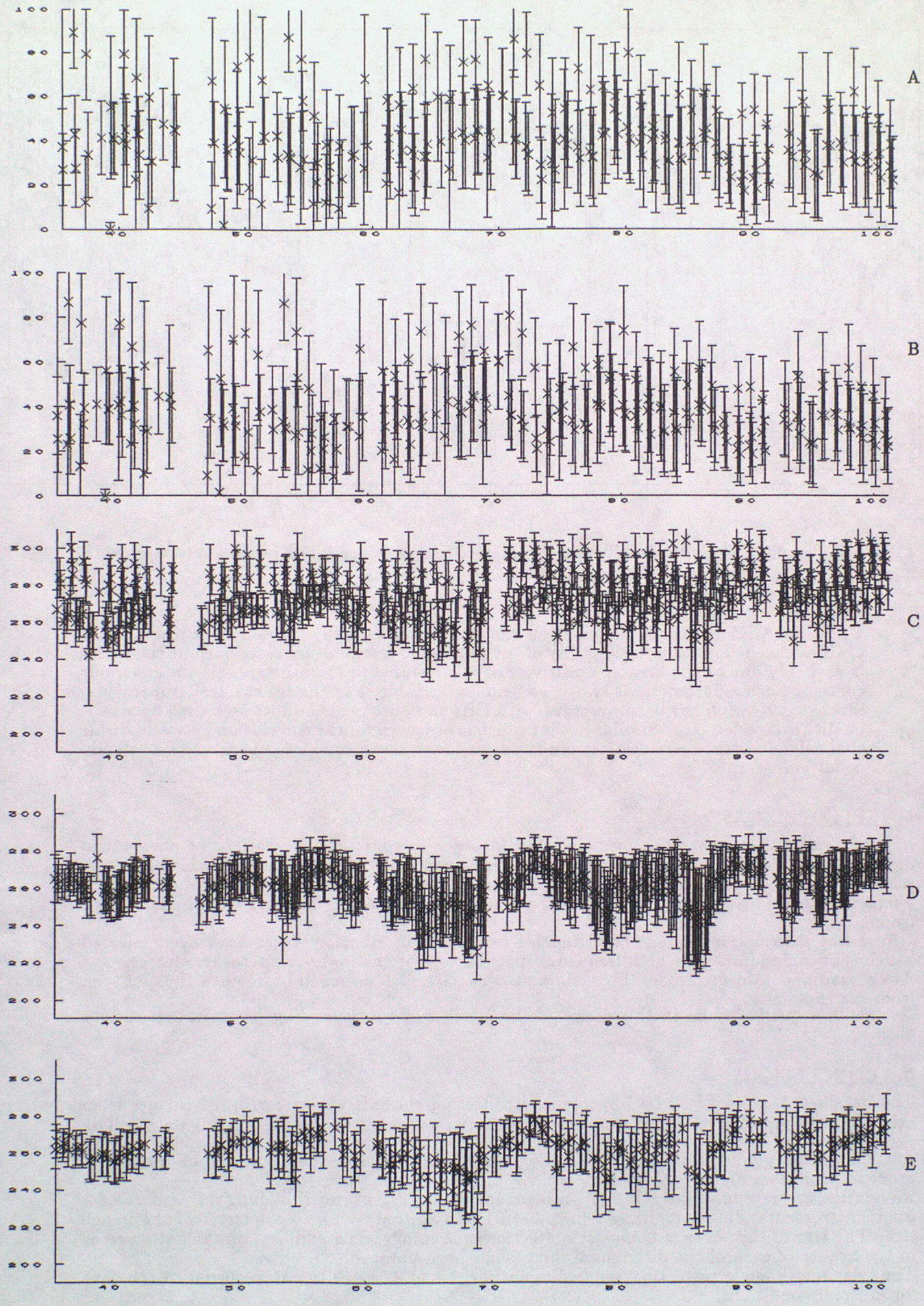

Figure 1: Temporal series of mean and standard deviation, as the error bar, of the *good pixels* value (albedo/temperature) for each image. CH1 (A), CH2 (B), CH3 (B), CH4 (D), CH5 (E).

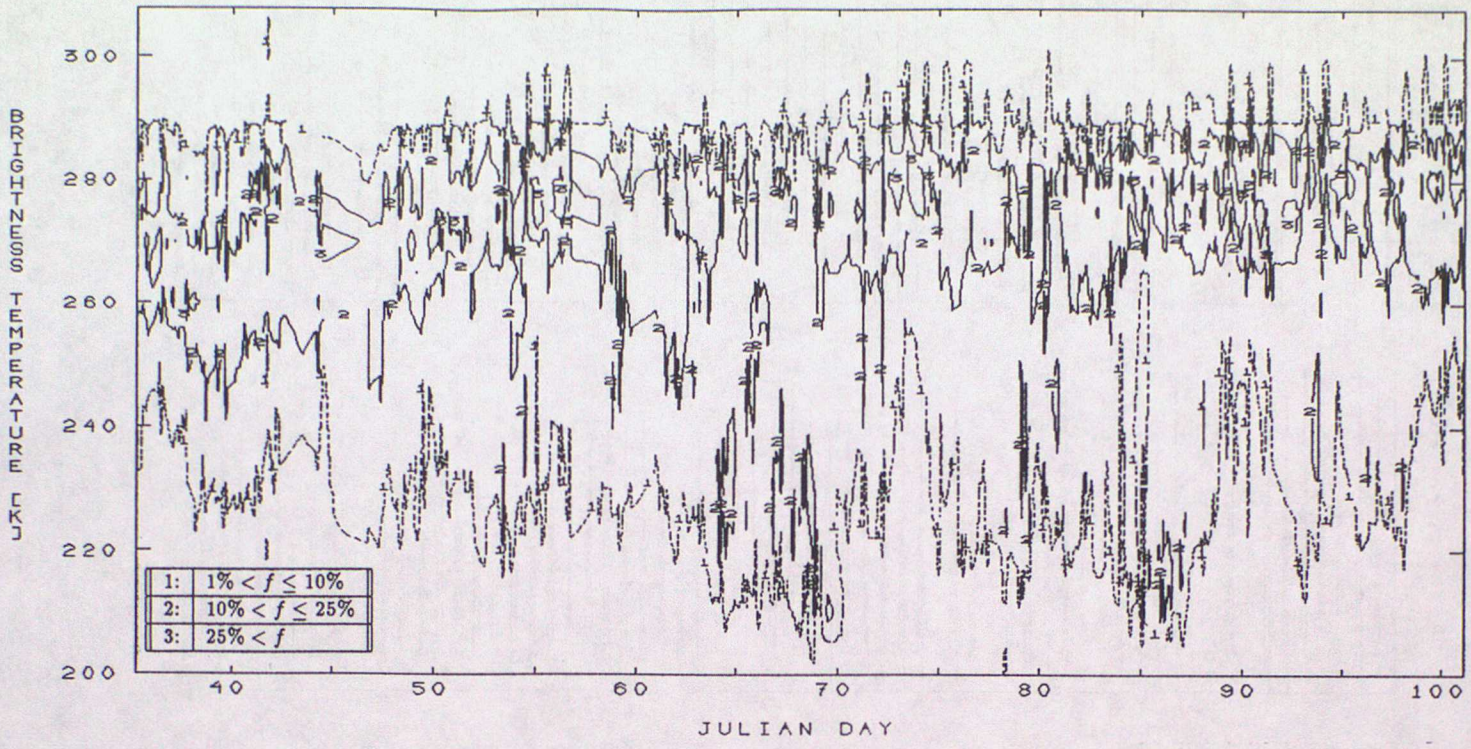

Figure 2: Percent frequency distribution (f) of *good pixels* values for channel 4 measurements. The contour key is reported in the table.

- *CH5.* The CH5 frequency distribution analysis shows basically the same features as that of CH4, except for a smaller stability of the maximum temperature distribution: this effect is probably due to the greater sensitivity of this channel to the atmospheric water vapour content. Such a parameter is known to be more variable than the sea surface temperature. Strong correlation has been observed with CH4 measurements and its lack used as a bad-quality image detector. Similar to that which is observed for the correlation between visible channels, a better correlation is observed for lower mean image temperature i.e. cloudy conditions.

5. SELECTED CASES

A preliminary set of cases has been selected in order to represent the variety of phenomena included in this data set and to allow a further detailed study of such cases. In this phase the selection was based only on a satellite data analyses. The criteria for such a selection have been:
- *image analysis*: cases have been selected when interesting clouds features were in the image frame;
- *frequency distribution*: using the channel 4 frequency distribution, cases have been selected which show an anomalously high frequency distribution for the lower temperature classes.
As an example of selected cases, Fig.4 shows a cyclone, which occurred March 8th 1991, as seen from the channel 4.
No mention can be made in this phase of the Project of corresponding precipitation surface data.

6. CONCLUSIONS

The data set described will be improved by collecting the missing or corrupted images from other sources (e.g. University of Dundee): it is likely that about half of the missing data will be recovered.
A second order quality test, based on some physical properties of the data, will be applied in order to produce a higher quality data set.
Navigation errors appear as a major problem for the future use of this data set as part of a multi-instrumental data set. Images have been found shifted by up to a quarter of the image size. The size of this error is being estimated for each image. The addition of navigation error in the header of each of the distributed images has been planned.
The solar zenith angle correction, applied to channel 1 and 2, seems to fail to normalize the data for all solar conditions.

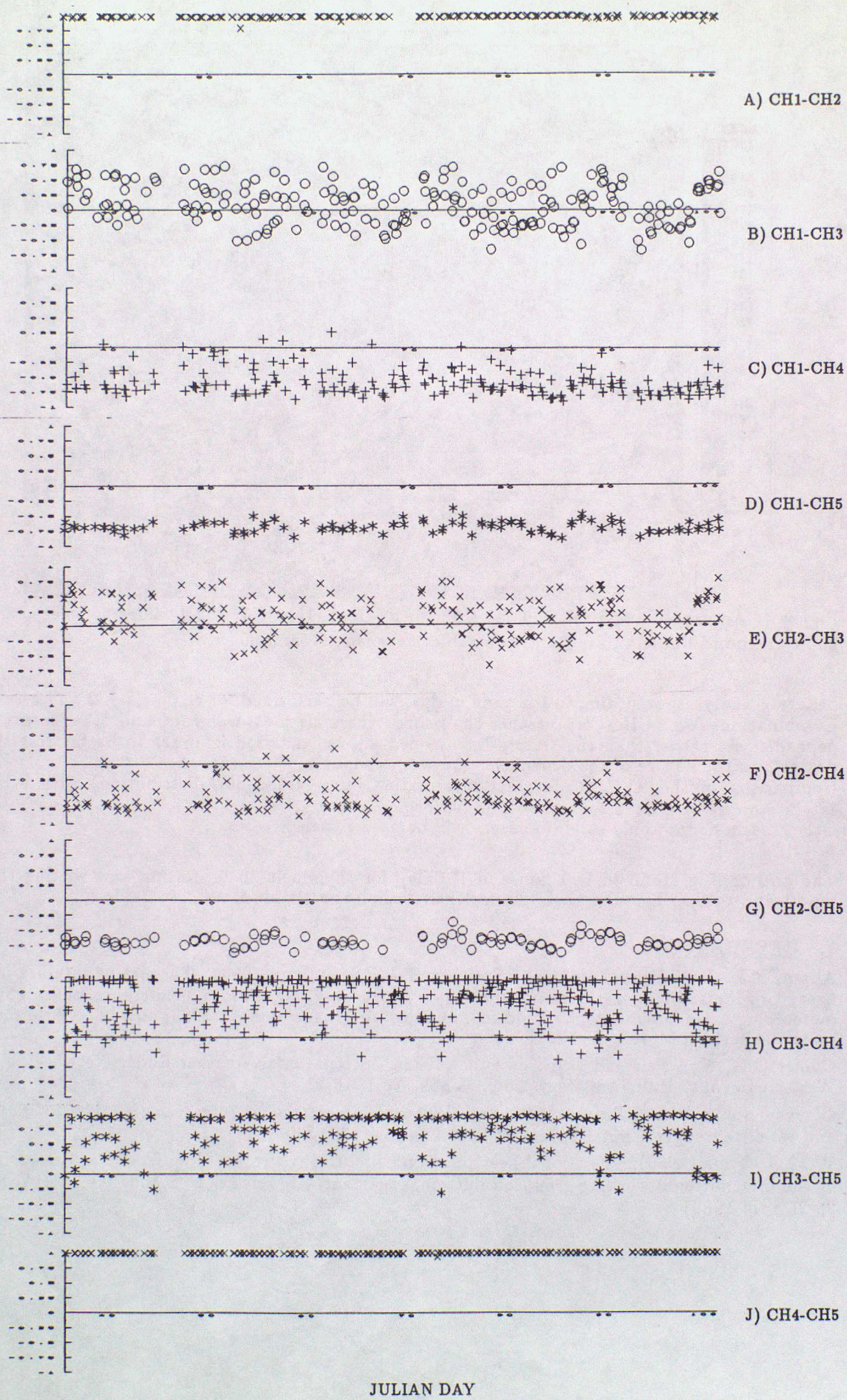

Figure 3: Temporal series of correlation coefficients between single channels measurements.

Figure 4: An example of a selected case: 02:46z 8-Mar-1991. CH4. Pixel values between 0 and 254 correspond linearly to temperature values between 198 and 308 K.

Separate analyses, according to the time of day, will be performed for channels 1, 2 and 3.
Combinations (e.g. CH4-CH5), rather than single channels measurements, and other forms of dependences, rather than the simply linear one, will be analysed in order to better test the degree and the nature of the dependence between channels.
Comparison of the AVHRR data set information (e.g. frequency distribution) with other satellite-borne or ground sources will be performed.
Other methods, not only satellite-based, will be used to select cases.

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