Receiving and Processing of Chinese Meteorological Satellites FengYun Data in the Regional Centre of Far-Eastern Branch of Russian Academy of Sciences.

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Abstract - This paper is devoted to description of some experience in reception and processing satellite information of the Chinese meteorological satellites FengYun. Geostationary satellite FY-2B is an analogue of satellite GMS-5, which finished the work in springtime 2001. Active using of satellite FY-2B images is blocked by problem of "noisy" lines. Polar-orbital satellites FengYun-1C/1D have ten spectral channels, five from which correspond to the NOAA/AVHRR channels and even have the same characteristics. In spite of advantages FY-1C\1D satellites have a few imperfections. Some of them are: spatial mismatching of scan lines of the channel sensors; absence of calibration and noise filtration algorithms; absence of algorithms for chlorophyll-a estimation. Satellite FengYun problems are considered in the paper.

Keywords: FengYun satellites, noise filtration, image correction, cross-calibration.

INTRODUCTION

The main purpose of the Regional Satellite Center of Environment Monitoring of Far-Eastern Branch of Russian Academy of Sciences (FEB RAS) is to receive, process, deliver and acquire satellite information in real time for non-interrupted operational monitoring of Far East marginal seas and adjacent areas.

The three antenna stations allowed to receive data of follow satellites: NOAA, FY-1C, FY-1D (polar-orbiting satellites); GMS-5, FY-2B, FY-2C, MTSAT (geostationary satellites, two satellites instantaneously). Joint processing of various satellite data allows to get more complete information in time and space about sea surface and atmosphere phenomena. Among satellites used by the Center, Chinese meteorological satellites FengYun are interesting for different scientific tasks such as the detection of sea surface temperature, chlorophyll-a concentration, detection of sea ice and so on.

FY-2B data format is similar to GMS-5 data format [1]. Differences between these satellites data formats consist in replacement of two infra-red split window channels by one wide infra-red channel and some DOC-sector format changes. The FY-2B satellite had low signal-noise ratio and, as a result, significant amount of image lines looked as noise only. Such information is needed in restoring. The correction of the telemetry is necessary too.

The polar-orbiting satellites FengYun-1C/1D (radiometer MVISR) have digital data of ten spectral channels, five of which are corresponded to NOAA/AVHRR channels. Other channels are follow: four visible channels and one near-infrared channel. Characteristics of MVISR channels permit to use this channel to retrieve sea surface temperature and chlorophyll-a concentration. Unfortunately FengYun satellites data are not used widely. Probably it is related with fact, that the FengYun radiometer has several peculiarities, such as spatial mismatching of the scan line of the channel sensors, absence of calibration and noise filtration procedures, absence of algorithms for chlorophyll-"a" estimation.

Our goal was to research following problems: noise filtration algorithms (FY-2); determination of the channel sensor angle orientations (FY1C\1D); calibration of IR-channels by using cross-calibration with NOAA IR-channels (FY-1C\1D); consideration of estimation problem of chlorophyll-a concentration (FY-1C\1D).

GEOSTATIONARY FENGYUN (FY-2B\2C) DATA PROCESSING PROBLEMS

The Chinese geostationary meteorological satellite FY-2B is an analogue to satellite GMS-5. The information line of S-VISSR format consists of eight sectors: the documentation (DOC) sector, three infrared (IR) image data sectors and four visible image (VIS) data sectors. The satellite data have significant amount of noisy lines. Such noisy lines are excluded from the images usually, or a filtration procedure is used for estimation of data lost. Lost information restored approximately on the base of interpolation procedures (Briedis,1999). Our research has detected the nature of this noise and an algorithm was presented for original data restoring. The reason of the noisy line appearance is in some bit missing during the data reception. The input of missing bit into the line allows to restore the real information of the line except one bite only. Missed bits within a

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sector line are determined with the displacement words-identifier of the next sector. Automatic procedure for noisy line detection is based on analysis of the correlation coefficient of image adjacent lines (fig. 1) (Bolovin, 2003). The correlation value for noisy line detection is derived automatically as the first local minimum of correlation histogram near value 1 (fig. 2). Correlation value for adjacent lines of image is near one if they have no noise. The real value is depended on characteristics of the image. Given method defines the value of correlation criterion dynamically.

The definition missing bit location is based on signal dispersion. The nature signal has small dispersion, but the noise signal has great dispersion. It allows to localize the place of the bit missing.

Algorithm contains two main steps:
1) Filtration for high-frequency component extraction (useful signal of image is removed).
2) Signal-noise boundary detection. The beginning of the noise sequence may be find on the appearance of a big values of the signal filtered. The hypothesis of the noise distribution of known characteristics is checked to prevent a failure.

The experiment has shown that the accuracy of signal/noise boundary detection is 1 word (pixel) in near 80% cases.

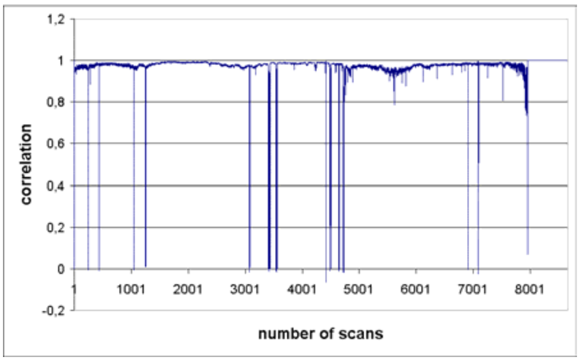


Figure 1. Correlation coefficients of adjacent lines of FY-2B image (visible channel).

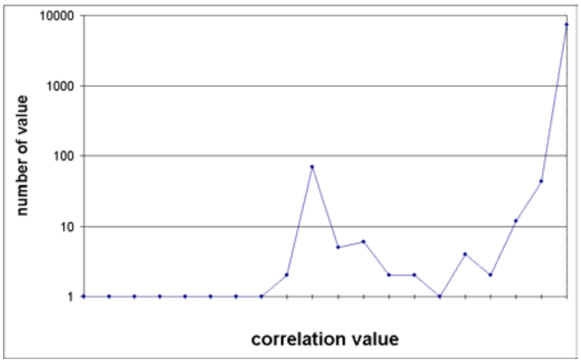


Figure 2. Typical histogram of correlation coefficient of adjacent lines.

POLAR-ORBITAL FENGYUN (FY-1C\1D) DATA PROCESSING PROBLEMS

Spatial mismatching of scan lines of the channel sensors
The first imperfection is related with the algorithm of gap detection based on the line time control. Internal FY-1 board clock is fast (FY-1D) or slow (FY-1C). The time discrepancy is near a second per day. This fact demands the board clock correction that lead to the sudden change in the time of image line.

The second imperfection is spatial mismatching of scan lines of different channel sensors. Sensor scans different Earth surface planes at different angles at the same time. Image discrepancy of different channels may be up to 5 pixels.

The best matching of different channel images is realized on the base of minimization of two channel cross-correlation function. The task is solved with nonlinear programming algorithms. The space deformation is described by polynomial of third degree for each direction.

The used method shows stable results (fig.3.). The accuracy of deformation is about 0.3 pixel. That accuracy is completely sufficient for the most tasks.

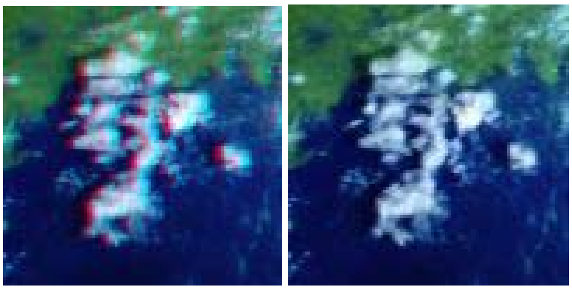


Figure 3. Fragment (FY-1D 16.09.2004, 21:52 UTC) of color satellite image, created on the base of three visible channels without correction (left) and after channel matching correction (right).

Cross-calibration of IR channels
The problem of FY-1D infra-red channel calibration is not solved. Meanwhile, its data are similar to the POES NOAA satellite data [2].

The format (CHRPT) of FY-1D data transmission is the similar to the format of POES NOAA data transmission [3, 4, 5]. The analysis of this format has shown, that each frame contains counts of scanning of space and the warm internal target for each channel. Similarity of FY-1D and NOAA frames structures allowed to make a conclusion that a procedure of calibration AVHRR NOAA KLM [4] can be used for calibration of data FY-1D. Thus, the problem is in determination of (a) position of telemetry in FY-1D data frame and b) coefficients of transformation of telemetry data into internal target temperature.

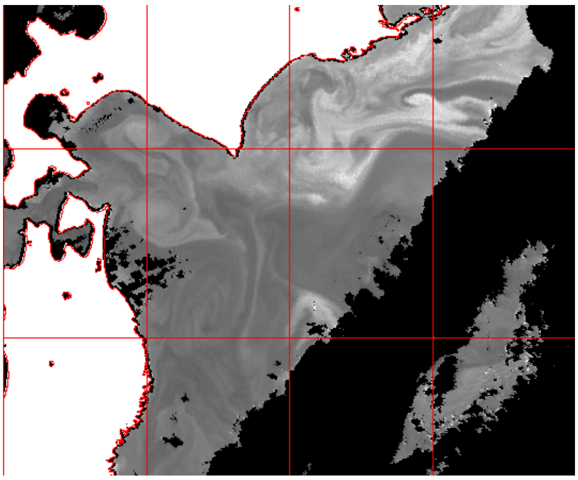
It was used cross-calibration with NOAA data for solution of the given problems. Cross-calibration was carried out as follows. Cloudy free images have been selected. Homogeneous areas of ocean scanned in nadir that counts were close to internal target counts were chose. Appropriate NOAA images were used to estimate the brightness temperature of the areas and to calculate the on board thermometer measurements.

It was detected, that thermometer counts are in from 29 to 32 bite positions from the frame beginning. The counts of various thermometers are stable. To obtain internal target temperature on Celsius on the base of average value of thermometer counts it may be used following dependence: $T=0.0682*C - 9.51$, where C is the value of averaged thermometer counts, and T is temperature on Celsius.

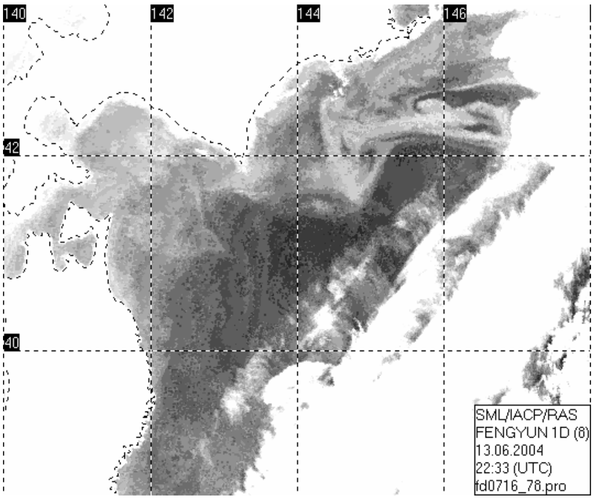
Determination of chlorophyll- a concentration

The opportunity of chlorophyll-a concentration estimation on FY-1D imagery was investigated. FY-1D satellite data have visual channels which may be use for creation of chlorophyll–a concentration charts [5]. These are spectral color channels (7 – 0.43-0.48mkm, 8 – 0.48-0.53mkm, 9 – 0.53-0.58mkm). Spectral band of the FY-1C\1D channels exceeds twice spectral band of correspondent SeaWiFS channels. The noise level and the reflectance step were not determined for these channels. Thus, the opportunity to monitor the phytoplankton fields on FY-1C\1D imagery was not obvious.

Some charts of FY-1C\1D reflectance ratio of 8 and 9 channels were calculated similarly to popular method OC2 used for determination of chlorophyll concentration on SeaWiFS radiometer data. The results of an experiment are demonstrated the possibility to use FY-1C\1D data for monitoring of phytoplankton fields (fig.4.). The comparison of chlorophyll-a concentration distribution calculated with SeaDAS software on SeaWiFS imagery with the chart created on FY-1D imagery is demonstrated a good correspondence.



(a)



(b)

Figure 4. Clorophyll-a concentration on(a) the SeaWiFS data and (b) FY-1D image (ratio of the 8th and 9th channels). Sangar Strait, Hokkaido island, 13.08.2004.

CONCLUSIONS

The nature of line noise had been detected for geostationary FY-2 satellite images. The method of raw data restoration had been created. The obtained results can be used for other satellite data.

The method was suggested to solve mismatching problem of images of different channels for polar-orbital satellite FY-1C/1D. The suggested method shows the accuracy 0.3 pixels for visual channel images.

FY-1D infra-red channels calibration has been done on the base of AVHRR NOAA KLM calibration procedure. Key coefficients of calibration have been determined.

Preliminary research of the opportunity to monitor the chlorophyll-a fields on FY-1C\1D imagery was carried out. It was showed good agreement of SeaWiFS and FY-1D charts.

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Acknowledgements and Appendix (optional)

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