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Summary of the Working Paper.

With FY-2D's successful launch, an active FY-2 dual-satellite constellation is in place with FY-2C at 105E and FY-2D at 86.5E. Overlapped observation ranges from 35 degree East to 156.5 degree East longitude, spanning 121.5 degrees. The ground station alternatively receives images from the two satellites every 15 minute during flood season, 30 minute off the flood season. Imagery animation is made. The report CMA-WP-07 briefs on the factors impacting the visual quality of animation due to spacing of two satellites, as well as the solutions to improve.

Dual-Satellite Observation Image Animation

Currently, China operates two meteorological satellites FY-2C and FY-2D in geostationary orbit.

FY-2C, which was launched at the China *Xichang* Satellite Launching Centre on 19 October 2004, is positioned at 105 degree East longitude. The effective observation ranges from approximately 35 degree East longitude to 175 degree East longitude and from 70 degree North latitude to 70 degree South latitude. FY-2C operates under two observation modes respectively for flood and non-flood season. Under the mode of non-flood season observation, 28 full-disc observations are made daily, starting at every hour, each lasting about 25 minutes; under the flood-season mode, a total of 48 observations are performed daily. On top of 28 non-flood season full-disc observations, another 20 observations of the northern hemisphere made half hourly are added.

FY-2D, which was launched on 8 December 2006, is positioned at 86.5 degree East longitude over the equator. The effective observation ranges from approximately 16.5 degree East longitude to 156.5 degree East longitude and from 70 degree North latitude to 70 degree South latitude.

FY-2D and FY-2C form a dual-satellite observing system. The zone of the dual-satellite overlapping observation ranges from 35 degree East longitude to 156.5 degree East longitude, the span of which is 121.5 degrees. It is for this geographical scope that the dual-satellite based animation is produced.

FY-2D is also functioning under two modes of observation for flood and non-flood seasons. Under the mode of non- flood season observation, a total of 28 full-disk observations are performed daily, and each observation is with 30 minutes lapse from that of FY-2C, namely starting from half an hourly, and cloud derived wind observations start at every hour sharp. In the mode of flood-season observation, a total of 48 observations are performed daily, and each observation is 15 minutes, which is different from that of Fengyun-2C.

With dual-satellite constellation in place, the zone of China is observed once every 15 minutes during flood season, and once every 30 minutes during non-flood season, which increases the temporal resolution of satellite observation over this region to a great extent and facilitates the weather forecasting and severe weather monitoring.

The advantage of animated double-satellite products is obvious. At the same time, there is a high requirement for the entire satellite-ground system: The two satellites must be completely well-conditioned, and the ground system must be of high accuracy and efficiency. The accurate positioning is particularly requested.

Even when the satellite-ground system is normal, the dual-satellite imagery still animates flickeringly. Detailed analysis show that the trouble is caused by three reasons and solutions are found as well:

1. The geometrical problem and its solution: When a being-observed object at a certain height, such as a cumulus cloud, is projected on map, the “print” of the object departs from the sub-satellite point due to the satellite viewing angle. The farther the object is from the sub-point of satellite, or higher the observed object is, the greater deviation shall be. Single-satellite animation sees no much influence of deviation. When it comes to double-satellite animation, the 18^{o} spacing between the two satellites makes the deviation noticeable and causes intense dithering or jittering to the edges of the image. Cloud height estimation and satellite position correction have been made to solve this geometric problem.

2. The flickering problem and its solution: When a geostationary satellite observes the earth, the distance from sub-satellite point determines the travelling path and strength of radiation through atmosphere. When the two satellites observe the same location in western part of China, the energy received by FY-2C satellite is weaker than that by FY-2D. Reflected in animation, the FY-2C imagery is brighter than the FY-2D's, and it is the other way round for eastern China, where FY-2C imagery is darker than FY-2D's. That is why the dual-satellite based animation flickers. This phenomenon is corrected through the brightness/temperature matching and grey histogram matching.

3. The resolution difference and its solution: When the two satellites observe the same area (other than the overlapping center), the longitudinal 18° spacing between the two satellites results in difference in spatial resolution and consequently the alternation of clarity and fuzziness in animation. The spatial filtering technology can remove the influence of difference in spatial resolution to a great extent.

The correction and optimization in geometry, brightness and spatial resolution help eliminate the image jittering and flickering, which makes the dual-satellite based animation look more smooth and fluid.