Determination of the Optimized Observation Angle of ISUAL Imager

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Abstract

We briefly discuss the problem of finding an angle that covers the maximum of possibility in the occurrence of sprites. A volume equally represent this possibility based on geometry is determined. The result of calculation work on computer is finally shown as a diagram of the volume to angle. This indeed tell us some information that we should take care during the process of observation of sprites.

I. Introduction

In performing the observation of occurring of sprites, knowing the nadir angle that decides the maximum volume containing the possibility of emergence of sprites becomes an economic measure in the scientific loaded task. Therefore, this note mainly concerns how to derive a volume function of various geometry parameters that help us in finding the value of the optimized angle.

II. The parameters needed in calculating the optimized angle:

	Item	Symbol	Value
1	Satellite height	h_0	891km
2	Interval of sprites occur	h_1~h_2	20~100 km
3	Radius of earth	R_e	6378 km
4	Nadir angle of imager	α	To be determined
5	Vertical field of views of imager	$\Delta\alpha$	5.8 degree
6	Horizontal field of views of imager	$\Delta\beta$	34.0 degree

III. Deriving the truncated volume function:

Consider the profile of pyramid of fields of view that truncates with the two concentric shells within which sprites occur (see Fig.1). Suppose we first calculate the bounded area by two rays of vertical fields of view r_1, r_2 and the inner and outer curves with which the rays cut off the shells (see Fig.2). Then the volume could be determined by sweeping this area as a function of φ over the horizontal field of view $\Delta\varphi$.

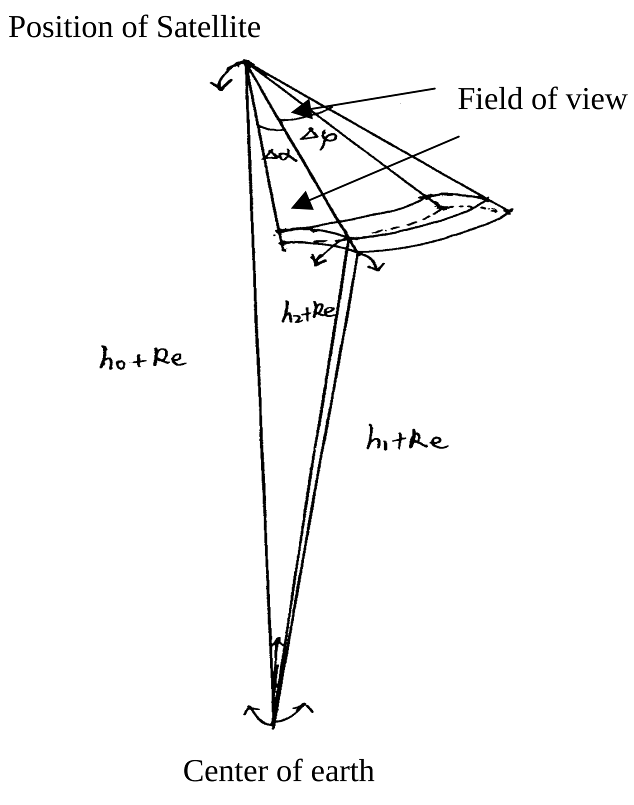

Fig.1 The pyramid of field of view of ISUAL imager.

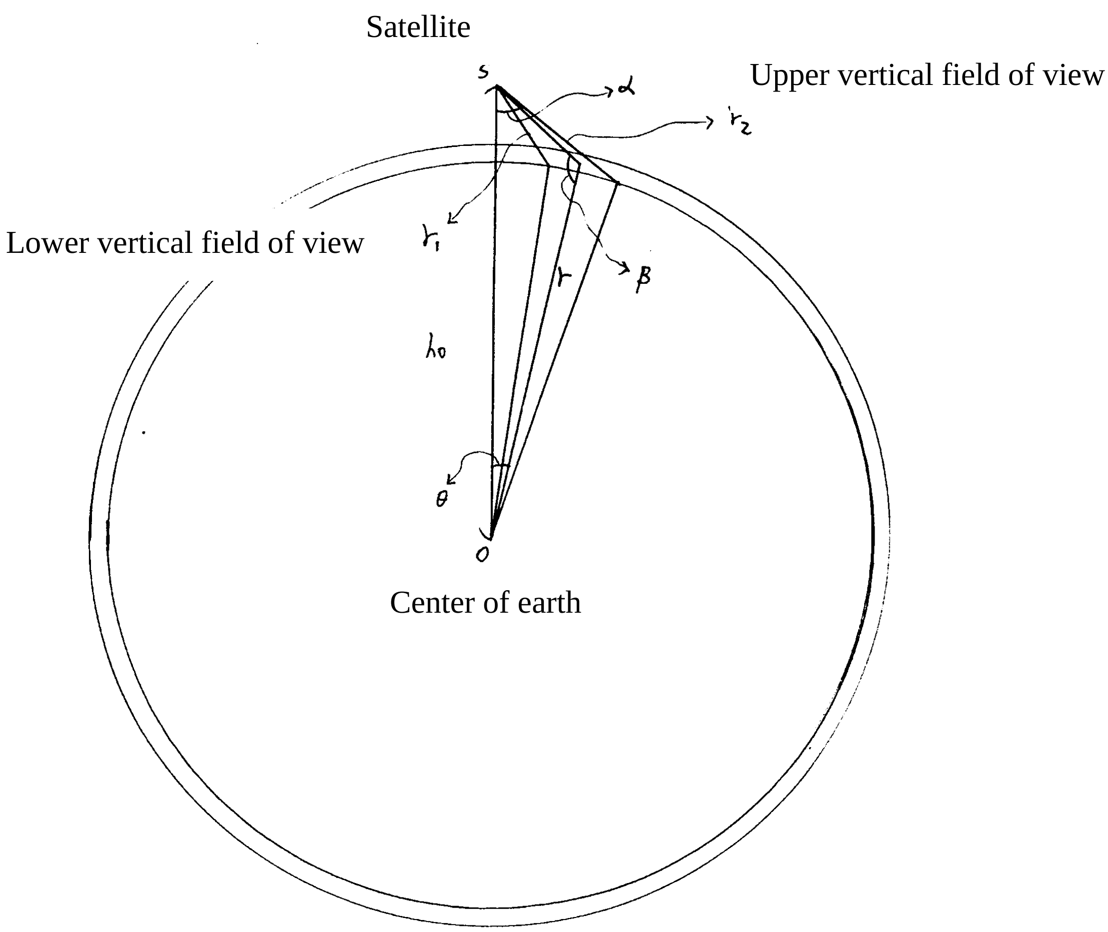

Fig.2 The profile of vertical field of view of ISUAL imager.

The analytic result in terms of spherical coordinates we obtained is,

$$v = r^2 \frac{\sec^2\varphi}{\dfrac{\sin\theta}{\left[\sin^2\theta+\left(\frac{h_0}{r}-\cos\theta\right)^2\right]^{1/2}} + \dfrac{\tan^2\varphi}{\dfrac{\sin\theta}{\left[\sin^2\theta+\left(\frac{h_0}{r}-\cos\theta\right)^2\right]^{1/2}}}} \sin\theta r dr d\varphi d\theta$$

The rest numerically calculating work has been done as shown in the next section, and the details of it could also refer to a report.

IV. Numerical Result:

In performing the calculation of optimized angle, we use various geometry relationships that enable us to reduce the integral boundaries of three coordinate dependence to a single one α. By virtue of Simpson integral method, this triplet integration is computed literately. The result could be readily seen in the following diagram, where we varied slightly the height of satellite ($\pm$10km) due to its instability along its motion. Furthermore, we also study the effect of uncertainty of clouds by little changes in their altitude h_1, h_2 ($\pm$10km) as referred to Fig.4 and Fig.5 respectively.

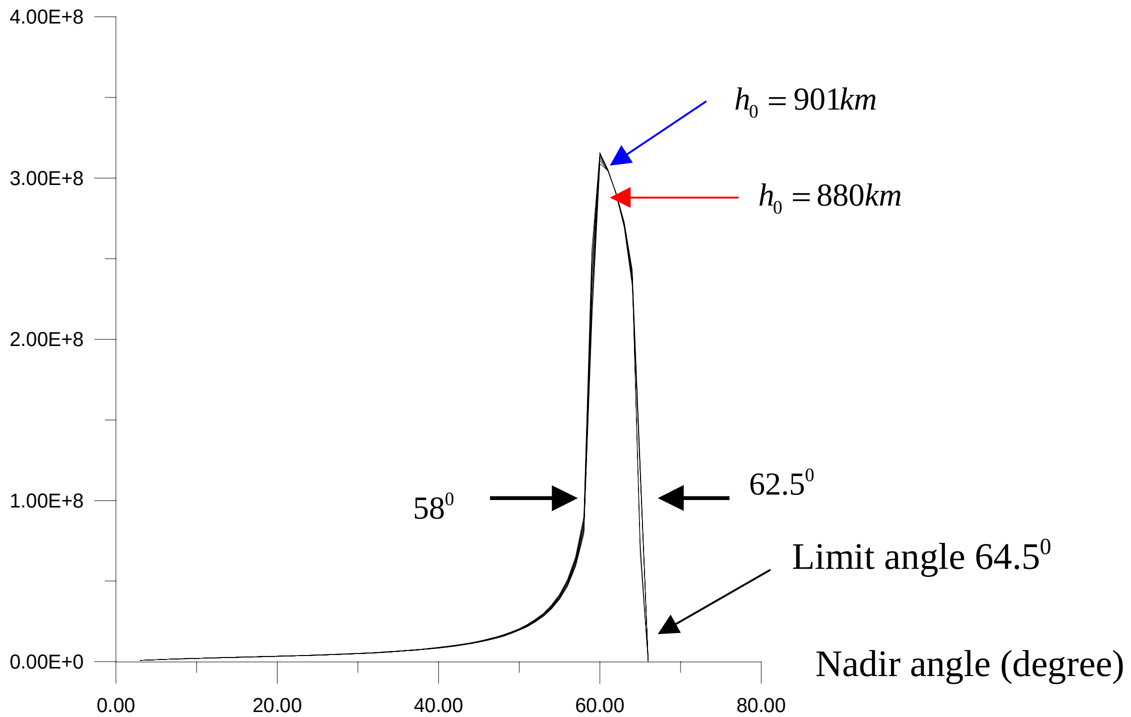

Fig.3 The influence of satellite height h_0 on the observation volume

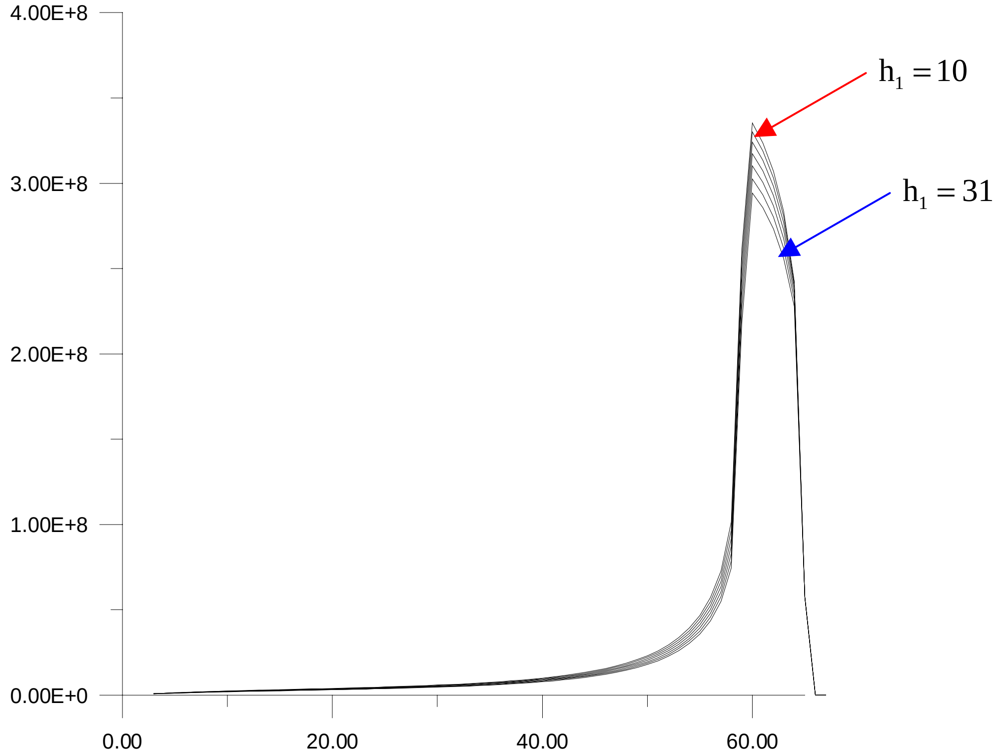

Fig.4 Various heights of h_1 (lower altitude bound of sprites) to volume

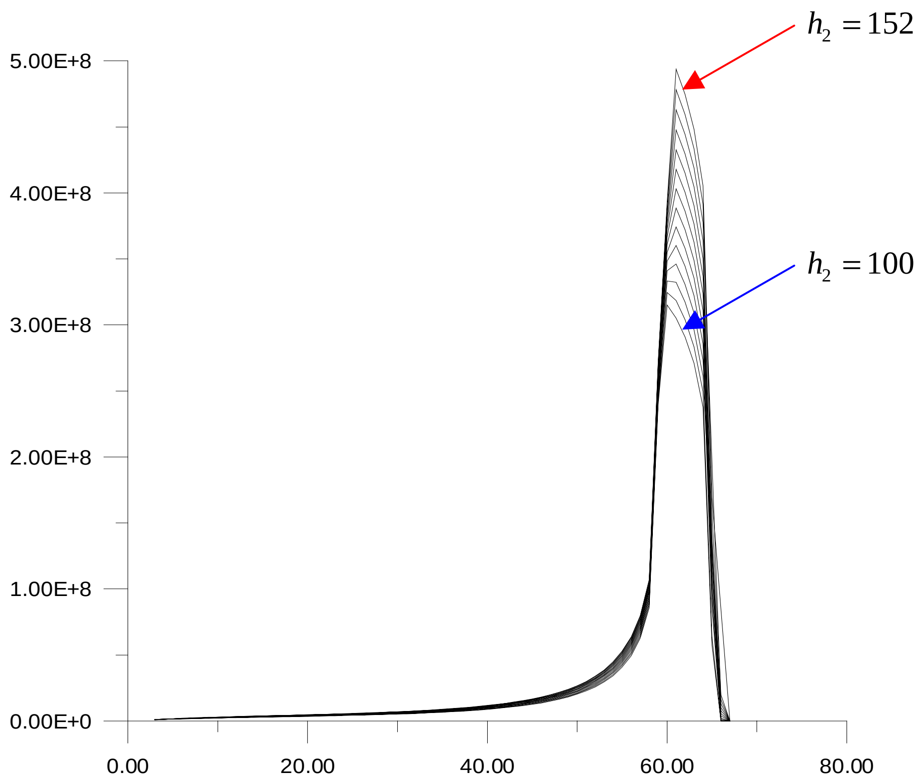

Fig.5 Various heights of h_2 (upper altitude bound of sprites) to volume

V. Conclusion:

From the above volume-angle diagrams, it shows that the optimized Nadir Angle is around 58~60 degree, and a chosen of over 64 degree would lose image of sprites. Furthermore, slight changes of satellite altitude during its traveling won't affect the observation of sprites as shown in Fig.3.