Monitoring Satellite Thermal Pinnacle in Relation to Spacial Spectrum of Sea Surface Waves

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Abstract— In order to realize a satellite thermal pinnacle and a satellite thermal Plateau found on the sea surface, a simple model of an infrared radiation out of the water wave facet on the sea water surface is introduced.

In order to realize a satellite thermal pinnacle and a satellite thermal plateau found on the sea surface, a model of an infrared radiation out of water surface wave facet is introduced in this work.

First, a frame of a modeling in this work is introduced. When a flat sea surface is on the co-ordinate x horizontally, a position of a satellite above the sea surface can be expressed as $(x, z) = (0, H)$ in the orthogonal system of the co-ordinates with the axis z for the axis to be positive upward. In this work, for convenience, a two dimensional problem is considered. This frame can be taken as an approximation at considering a small sea area under a satellite in a polar orbital motion, then, it can be taken to be acceptable to consider one pixel size of 4 km square in a satellite thermal pattern to be a flat plane in the foot print comparing to the radius of the Earth. If the sea surface on the earth everywhere could be taken to be as a black body, then, it can be a case of thermodynamics which tells us a radiation out of the sea surface as a beam of an electromagnetic wave in the infrared band.

When a sensor mounted on the satellite is directed vertically downward, the sensor detects the beam radiated vertically out of the flat sea surface.

Assuming an arbitrary function of the sea surface,

$$F = F(x, z; t), \tag{1}$$

then,

$$H = H\cos\theta + F, \quad \text{for } x = x, \text{ at an arbitrary time } t. \tag{2}$$

This could be a most simplified model of a satellite thermal pinnacle.

As the tangent of F for the position $(X, Z) = (x, z)$ at time t is to be $F' = \partial F/\partial x$, the orthogonal of the tangent is described as

$$(Z - z) = -(1/F')(X - x). \tag{3}$$

This normal line is taken to be corresponding to the direction of the beam radiated at (x, z). When this normal line hits the point $(X, Z) = (0, H)$, the sensor catches the beam as a signal from the sea surface. At any other cases of $Z \neq H$, the hitting beam can not be expected. When this pattern can be taken as a model for a beam radiated out of the sea surface, the beam can be found only at a single pixel in a thermal pattern which was reduced after directly receiving of an interested satellite's signals related to the sea surface thermal pattern.

The function F introduced above can be transformed mathematically to express it in a form of spectral function $S_s = S_s(\omega; t)$ at a fixed position x. That is,

$$S_s = \int_0^\infty F(x, z; t)\, \exp(i\omega t)\, \mathrm{d}\omega, \tag{4}$$

where, the notation ω is for frequency.

This spectral expression has been widely used for studying wave developing process at a fixed position at a time t. Though, this spectral form is not effective for a spacial pattern of the waves or of a wave facet on the sea surface.

Then, it should be introduced a spacial spectral function S, which is expressed as

$$S = S(k; t), \quad \text{at } t = t,$$

and, introducing a notation k for wave number,

$$S = \int_0^\infty F(x,\, z;\, t)\, \exp(ikx)\, \mathrm{d}k, \quad \text{at} \quad t = t, \tag{5}$$

Then,

$$F = \int_0^\infty S(k;\, t)\, \exp(-ikx)\, \mathrm{d}x, \quad \text{at} \quad t = t. \tag{6}$$

Substituting (6) into (3), it is obtained that

$$(Z - z) = (X - x)\partial/\partial x \left[\int_0^\infty S(k;\, t)\, \exp(-ikx)\, \mathrm{d}x \right]^{-1}. \tag{7}$$

When this normal line to the tangent at $(x,\, z)$ hits the position $(x,\, z) = (0,\, H)$,

$$(Z - H) = (X)\partial/\partial x \left[\int_0^\infty S(k;\, t)\, \exp(ikx)\, \mathrm{d}x \right]^{-1}. \tag{8}$$

This shows a single beam hitting at the point $(x,\, z) = (0,\, H)$ for an arbitrary form of the spectral function $S(k;\, t)$.

When this is taken as a model for a infrared beam radiated to hit at a sensor for the sea surface thermal pattern, a single pixel in a sea surface thermal pattern could be as a thermal pinnacle of an impulse form. Nevertheless, this model is hard to be even a simplified model for help to see any one of the sea surface thermal pinnacles actually found in the satellite sea surface thermal pattern.

Following what tells us the geomery for a plane, the radius of curvature in this work is for the wave facet on the sea surface. That is, expressed as follows referring to the sensor's position $(x,\, z) = (0,\, H)$ which stated above. Then,

$$(1/R) = (\mathrm{d}\theta/\mathrm{d}s), \tag{9}$$

where, the notation R is the radius of curvature of the wave facet, and the notation $\mathrm{d}\theta$ is for the angle length of the wave facet at the sensor. The length segment $\mathrm{d}s$ is;

$$(\mathrm{d}s)^2 = (\mathrm{d}x)^2 + (\mathrm{d}z)^2, \tag{10}$$

where, $\mathrm{d}z$ and $\mathrm{d}x$ are for the wave facet at the position $(X,\, Z)$. The relation of X and Z is described as shown in a form of (8).

With what the author has studied above, The relation between X and Z is obtained in a simple form, and spacial spectral function at a time t is a function of wave number k in this case. Thence, the expression (8) should be rewritten for the problem on the energy flux or energy transfer of the beam out of the facet concentrates just near at the sensor where the beam is focusing as an electromagnetic wave with a consideration. The factor of interferometry is simply effective at decaying of the beam intensity, then,the author considers that this interferometry problem is outside of this work. The SAR system (Synthetic Aperture Rader) is for a faint thermal difference so that the author takes it also outside of his interest in this work.

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