SCALING IN THE VALIDATION OF QUANTITATIVE REMOTE SENSING PRODUCTS

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1. INTRODUCTION

Quantitative remote sensing (QRS) has the advantage of obtaining the spatially-distributed information for land surface variables with a certain frequency by the retrieval from electromagnetic signals. However, because of the insufficient study of the scaling theory on heterogeneous land surface variables and the validation of quantitative remote sensing products (QRSPs), the scale disparity could not be fixed between remotely sensed information at regional scales and ground-based measurements at field scales. This limits the further applications of remote sensing products. Therefore scaling is one of the major issues in the validation of QRSPs, and is perhaps the most challenging problem to solve.

2. THE SCALE-FREE PHENOMENA OF THE QRSPS

There is no scaling effect for remote sensing data derived from linear models because for the same area, the results of averaging the values measured at different pixel scales are identical. For the QRSPs such as LAI, NDVI, emissivity, surface fluxes and so on, because of the non-linearity of the models, the mean values retrieved at different pixel scales are not identical even for the same area. Therefore, these QRSPs have the same scale-free phenomenon as the coastline length measurement. However, the two phenomena are different, because the difference between the sum of the values retrieved at smaller scale and the value retrieved at larger pixel scale could be negative or positive corresponding to the same area for the QRSPs, while it is always positive for the coastline.

3. INFORMATION FRACTAL ALGORITHM

Information dimension can be expressed using the following equation:

$$\begin{aligned} D_f &= \left[\ln\left(\sum_{i=1}^{n}\frac{f_{2i}}{f_{1i}}\right)\right]\left(\ln(1/r)\right)^{-1} \\ &= \left[\ln\left(\sum_{i=1}^{n}\frac{f_{2i}}{\overline{F_1}}\right)\right]\left(\ln[(1/n)^{\frac{1}{2}}]\right)^{-1} \end{aligned} \qquad (4)$$

where f_{1i} and f_{2i} are the function values corresponding to the large pixel (retrieval after average) and the small pixel (average after retrieval), respectively. Because the areal mean values of f_{1i}, F_1 are identical. $f_{1i}=F_1/n=\overline{F}_1$, D_f is the information fractal dimension, N is the diminished multiple of the largest pixel area, r is the diminished multiple of the side length of the largest pixel. Suppose that the area of the largest pixel is 1, then $1/r=(1/n)^{1/2}$. Obviously, as for specific homogeneous surfaces, $f_{1i}=f_{2i}$, $F_2=F_1$, and D_f equals to 2. Scaling in the validation for the QRSPs was conducted. In a case study for LAI, when the fractal dimension is 2.16, the ratio of the LAI retrieval values obtained respectively from 30 m and 6 km remote sensing data can actually reach as high as 2.86 for the same 6km pixel using the same retrieval model.

4. FRACTAL RULE OF THE OTHER QRSPS

Among the QRSPs, not only the LAI but also the ground emissivity, reflectivity and the surface flux have scaling effect. Liang Sunling pointed out the difference of scaling effects between LAI and reflectivity. Kustas showed that the scaling effect of the surface flux is significant. Their conclusions are consistent with what our results calculated by the above mentioned approach. The QRS models play an importance role in scaling effect. Information fractal dimension and scaling value of any model can be computed using above equations. On-going studies of the scaling effects for other surface variables have been conducted based on the crop water stress index, crop transpiration model, and vegetation CO_2 assimilation model previously developed based on the Heihe quantitative remote sensing field experiment in 2009 in China. Information fractal dimension of QRSPs is strongly dependent on their function structures. The fractal rule of the QRSPs plays a vital role in the scaling of the QRSPs at different spatial resolutions and the their ground validation.

5. REFERENCES

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