Constructing Rain-Free Surface Cross Section Data Sets for the Estimation of Path Attenuation

Hyokyung Kim[1,2], Robert Meneghini[2], Liang Liao[1,2]
[1]GESTAR / Morgan State Univ., [2]NASA Goddard Space Flight Center

INTRODUCTION

It has long been recognized that the path-integrated attenuation (PIA) can be used to improve precipitation estimates from high frequency space-borne radar. One approach that provides an estimate of PIA is the surface reference technique (SRT) that has been used as one of the standard retrieval algorithms for the Global Precipitation Measurement (GPM) Dual-frequency Precipitation Radar (DPR) as well as for the Tropical Rain Measuring Mission (TRMM) Precipitation Radar (PR).

The SRT relies on the assumption that the difference between the normalized radar cross section of the surface (NRCS or σ^0) in rain and a rain-free reference value can be attributed to the PIA associated with precipitation along the radar beam. The rain-free reference data are either spatial or temporal: in the former case, the reference data are generally taken over rain-free field of view (FOV) adjacent to the raining FOV at the same incidence angle; in the latter case, the sample mean and standard deviation are computed over a latitude-longitude-incidence angle grid based on prior rain-free measurements. The temporal reference data are particularly useful around islands, rivers and coastlines where spatial reference data are often sparse or missing.

Using the TRMM PR data, it has been shown that the size of the resolution cell (latitude-longitude) for the temporal reference data is directly related to the accuracy of PIA estimates. As the resolution is decreased from a $1.0^0 \times 1.0^0$ to $0.1^0 \times 0.1^0$, temporal data become more useful because the sample variance associated with the σ^0 data is decreased. However, as the GPM satellite was only recently launched, the DPR data volume is still not large enough to build a temporal reference data set at high resolution. Nevertheless, there are sufficient data to construct a temporal reference look-up table over a fixed latitude-longitude grid of $0.5^0 \times 0.5^0$.

We are exploring some ideas on constructing lower variance temporal look-up tables that should lead to more accurate estimates of PIA.

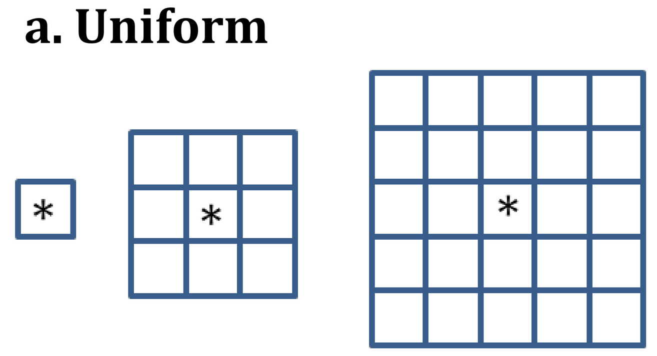
Contact: Hyokyung Kim, Ph.D ,
MSU and NASA/GSFC
Email: hyokyung.Kim@nasa.gov

METHODS & PROCEDURES

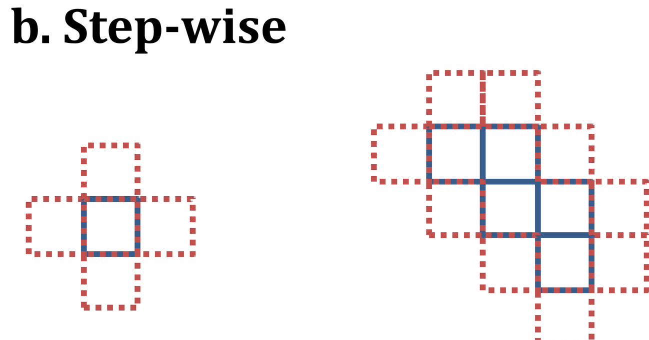
The first attempt to decrease the variance of reference data is to make separate look-up tables for land, ocean and coast at the same grid resolution (0.5 degree). This reduces the high variance in pixels at land-water boundaries. Next main strategy is to begin the construction over a high resolution grid (in our case 0.25 degree) and then expand the sampling area at each grid cell until a sufficient number of data points is obtained. There are several ways to proceed including **uniform** and **step-wise expansion** from the initial area. The final strategy is to construct **templates** that include all possible area permutations for a given set of pixels. Although the template approach guarantees the minimum variance solution, the search procedure becomes prohibitive for large numbers of pixels. We start with computing mean, mean-square & number of data points at high resolution grid (0.25^0 x 0.25^0) and use separate grids for land, ocean & coast.

- **Uniform Expansion**
  - Simple expansion from 1 box to 3x3 to 5x5, etc
  - Stop when $N \geq N_{th}$ and standard deviation is a local minimum
- **Step-wise Expansion**
  - Add one box to the area, at each step, in such a way that the stand deviation of the data in the enlarged area is minimum
  - Stop when $N \geq N_{th}$ and standard deviation is a local minimum
- **Template Method**
  - For given number of boxes, construct all possible permutations
  - choose those permutations for which $N \geq N_{th}$; among these select the one with the smallest stand deviation
  - In particular with 2, 3, 4, 5, 6, 7, 8 and 9 cells, it can be shown that the number of distinct contiguous areas that can be constructed is, respectively: 4, 18, 76, 315, 1296, 5320, 21800 and 89190. As this must be done at each grid point for each incidence angle and each 'channel' (Ku, Ka, KaHS and the Ku/Ka difference), the computations are not within our present computational capabilities for cell numbers greater than about 6

a. Uniform

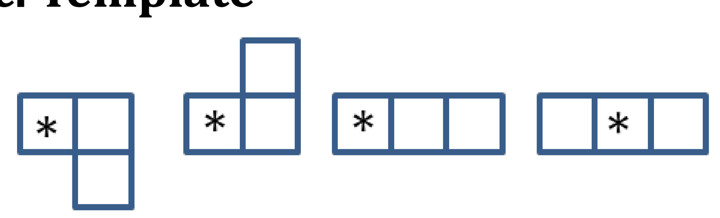


b. Step-wise



1 to 2 boxes 5 to 6 boxes

c. Template

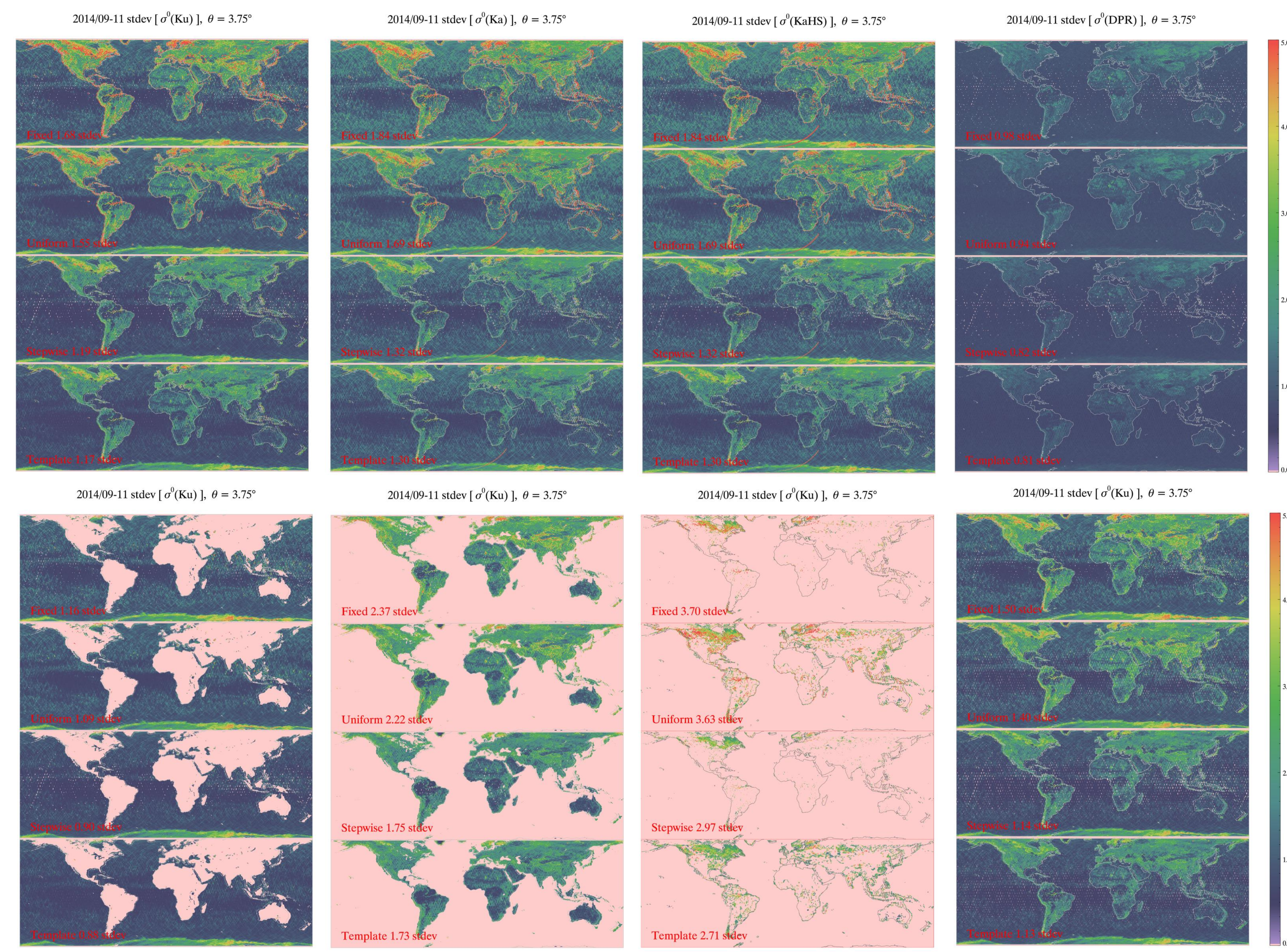


etc.

RESULTS

To filter out the statistically unreliable grids where the sample data points are not sufficient, N_{th} is fixed as 20 points in this study. The results from the different approaches using rain-free σ^0 data from a 3-month period (Sep.-Nov.), 2014 at an incidence angle of 3.75^0 are shown below. The upper plots display maps of the standard deviation of the σ^0 (Ku, Ka, KaHS and Differential) data over a fixed grid of 0.5^0x0.5^0 as compared with results obtained from the uniform, step-wise and template expansion methods over 0.25^0x0.25^0 grids over all surfaces.

About a 30% decrease in the sample average standard deviation of the gridded data is obtained by using the step-wise and template methods from using either the fixed grid or the uniform expansion approach. The average standard deviation obtained from using 3 surface categories (Lower Right) is found to be smaller than that obtained from a single surface category (Upper Left) .



CONCLUSIONS & PLANS

- We will continue to study
  - Hybrid method (template method up to 6 boxes , after that step-wise expansion) implementation
  - Step-wise: variability of average standard deviation with larger numbers of boxes (now maximum 6 boxes)
  - Comparisons with other classification methods
  - Investigation of the impact on the PIA estimates by use of these alternative temporal files