Increasing MODIS aerosol retrievals with image inpainting for 3D-AQS

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1. Purpose

To validate an “intelligent” spatial interpolation of satellite aerosol retrievals that tend to be very spotty around large data gaps due to cloudiness.

2. Introduction

The MODIS retrieval of aerosol optical depth (AOD; Remer et al., 2005) is an essential component of the 3D-AQS (3-Dimensional Air Quality System) collaborative project in 3D-AQS, satellite, ground and model observations of aerosol will be collected and displayed in real-time for state and local air quality applications (Engel-Cox et al., 2007, this conference). Although AOD is effective at displaying major aerosol events over the United States, large gaps due to cloudy conditions reduce the interpretability of the AOD imagery. This research explores the application of inpainting techniques to fill data gaps with interpolated values (Beltrán et al., 2001). Unlike conventional interpolation techniques, inpainting preserves edge boundaries in all directions, which minimizes the appearance of interpolation artifacts. Results will determine the upper limits of the data gap size that can be effectively restored with inpainting, as well as the relative accuracy of inpainted values.

We also have an immediate need for producing high-quality, interpolated AOD imagery, because the latest MODIS AOD algorithm (Engel-Cox et al., 2004), to calculate the greatest allowable gap size that can be interpolated with inpainting (Section 5).

3. What is inpainting?

“Inpainting” is a term originally used in painting and photograph restoration to describe the manual filling of small, damaged regions of a picture. Here, it describes a computational technique that fills areas of missing data with natural, fluid extensions of patterns in the surrounding image.

4. Validation with data denial

To test the relative improvement of inpainting over bilinear interpolation, each method was applied to a set of 51 MODIS AOD swaths (selected for completeness of coverage) that were artificially corrupted with a data mask (see the upper right image below).

5. Validation with ground station PM$_{2.5}$

Reconstructed images were correlated with hourly EPA-recorded ground station reports of PM$_{2.5}$ closest in space and time (Domain: United States east of 100°W, April 1 to Sept 30 2004; MODIS data Collection 5.2 AOD). The control variable is the maximum gap width allowed to be interpolated.

6. Conclusions

- Inpainting performs better than other interpolation options, both quantitatively and (especially) qualitatively.
- The optimized method described here (20-gridcell diameter inpainting, see images below) is an effective image for end users (including local, state and EPA air quality forecasters/analysts). It is much easier to interpret than the original retrieval, and it correlates with ground station PM$_{2.5}$ equally as well as the original retrieval.
- A discovery was made incidentally in this study: Smoothed AOD correlates even better with ground-level PM$_{2.5}$ than does the original AOD retrievals (due to noise in the retrieval, or perhaps extra dispersion at the ground level). Thus, some interpolation actually increases the correlation of AOD with ground-level PM$_{2.5}$.

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References


