Information Content in Reduced-Dimensional Retrievals of Precipitation from TMI

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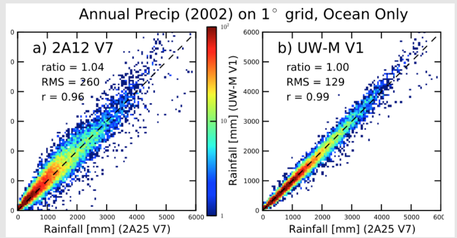
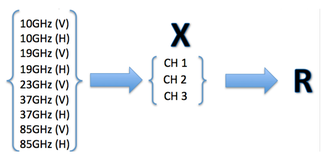
Background

Petty and Li (2013a) describe a dimensional reduction procedure that permits robust Bayesian retrievals of global precipitation using three "pseudochannels" derived from the original nine channels of the TRMM Microwave Imager (TMI). In addition to mean rain rates, the algorithm is unique in yielding complete posterior PDFs of rain rate.

An intercomparison by Petty and Li (2013b) with the official 2A12 (TMI) and 2A25 (PR) rain rate products reveals a roughly factor-of-two improvement in RMS error for all surface types; e.g.:



Motivation



What information do the three independent channels appear to contribute to the retrieval of rain rate? Over the ocean, our initial analysis suggests:

- CH1 is related to column rain water;
- CH2 is related ice scattering aloft;
- CH3 responds to edges and gradients.

Beyond that, the available of posterior PDFs from Bayesian retrievals based on one, two, or three pseudochannels allows us to quantitatively evaluate the information added by each successive channel.

Independent Channels-Hurricane Sandy

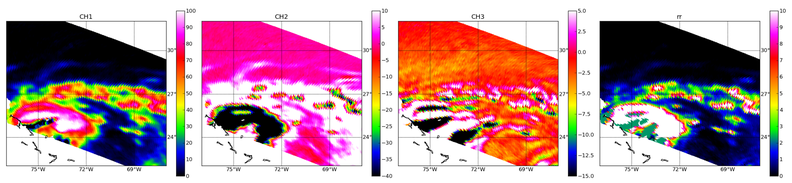


Figure 1: Example of three pseudochannel depictions (3 leftmost panels) obtained from nine-channel TMI observations of Hurricane Sandy, along with the retrieved rain rate (rightmost panel).

Information Content - Necessity and Sufficiency

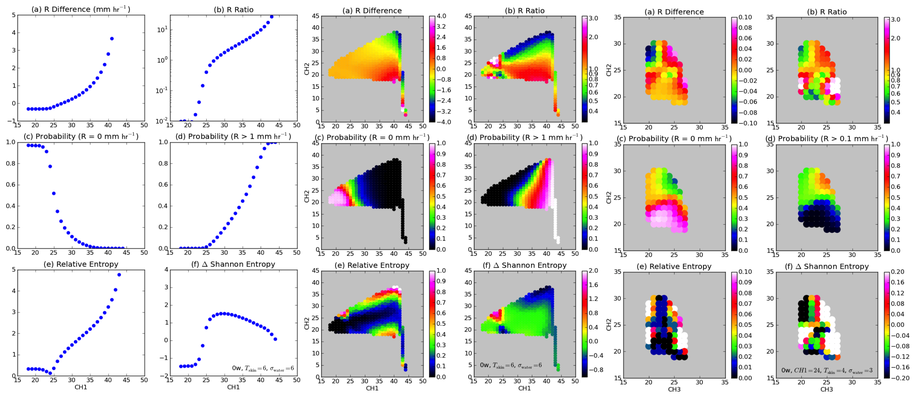


Figure 2: Examples of the modification of rain rate information with added pseudochannels, starting with single-channel retrievals compared to climatology (left), then adding a second channel (center), and finally a third channel (right).

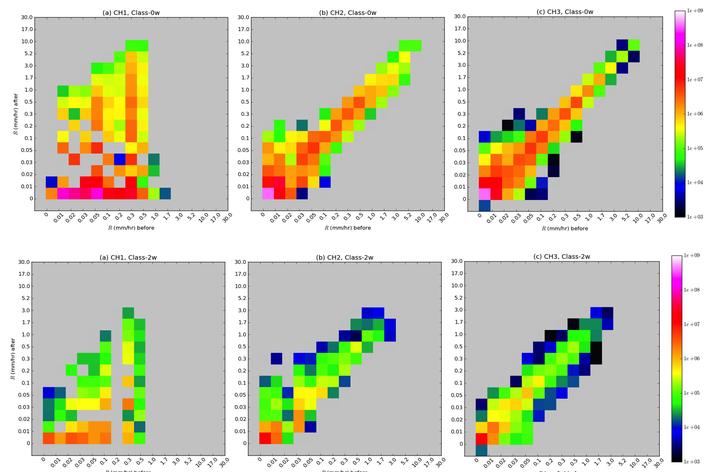


Figure 3: Bivariate histograms comparing distributions of rain rates prior to (horizontal axis) and following (vertical axis) the successive addition of channels, starting with Channel 1 relative to climatology (left), Channel 1+2 relative to Channel 1 only (center), and Channels 1–3 relative to 1+2 (right).

Measuring Information Content

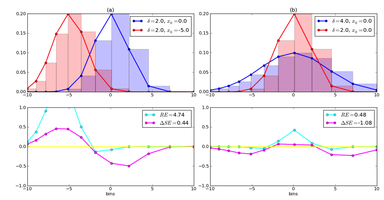


Figure 4: Shannon entropy difference and Relative entropy measuring Gaussian distributions on changes of (left) signal change and (right) dispersion.

- Shannon Entropy[1] (SE) difference - 'certainty index':

$$SE \equiv -\sum p_i \ln p_i$$

$$\Delta SE(p \to q) = SE_p - SE_q$$

- Relative Entropy[5] (RE) - 'surprise index':

$$RE(p \to q) \equiv \sum q_i \ln [q_i/p_i]$$

Preliminary Conclusions

In most cases examined so far (mainly over ocean), it appears that the majority of information affecting the posterior PDF of rain rate is found in the first two pseudochannels – that is, dropping the third channel from the retrieval usually has only a minor effect on the retrieved PDF. But there are exceptions, especially for less-common combinations of the first two channels.

References

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Acknowledgements

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