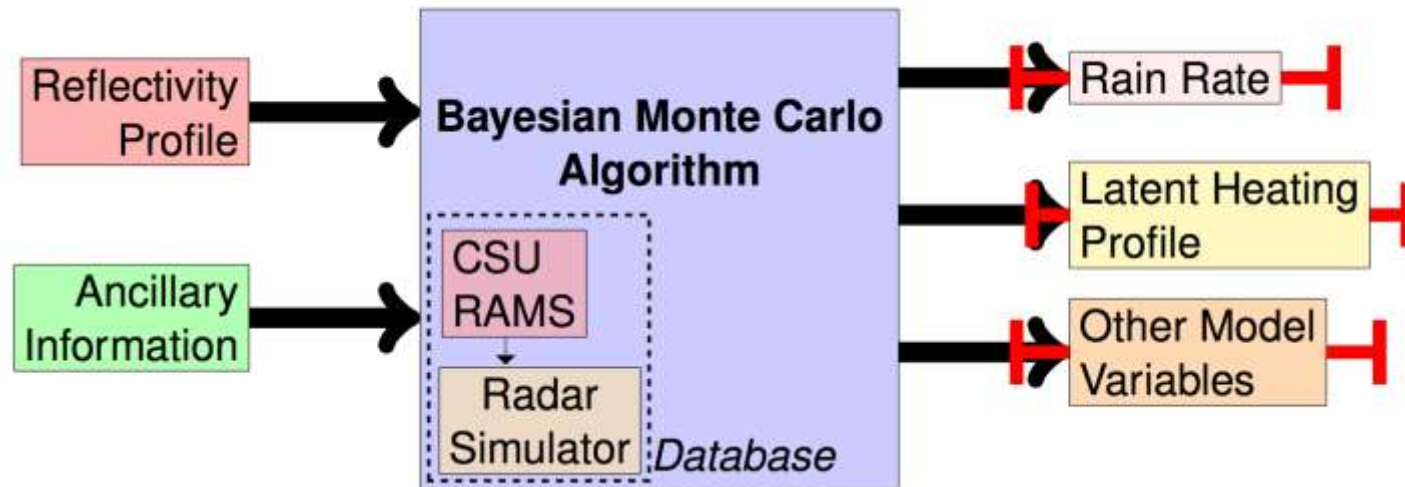
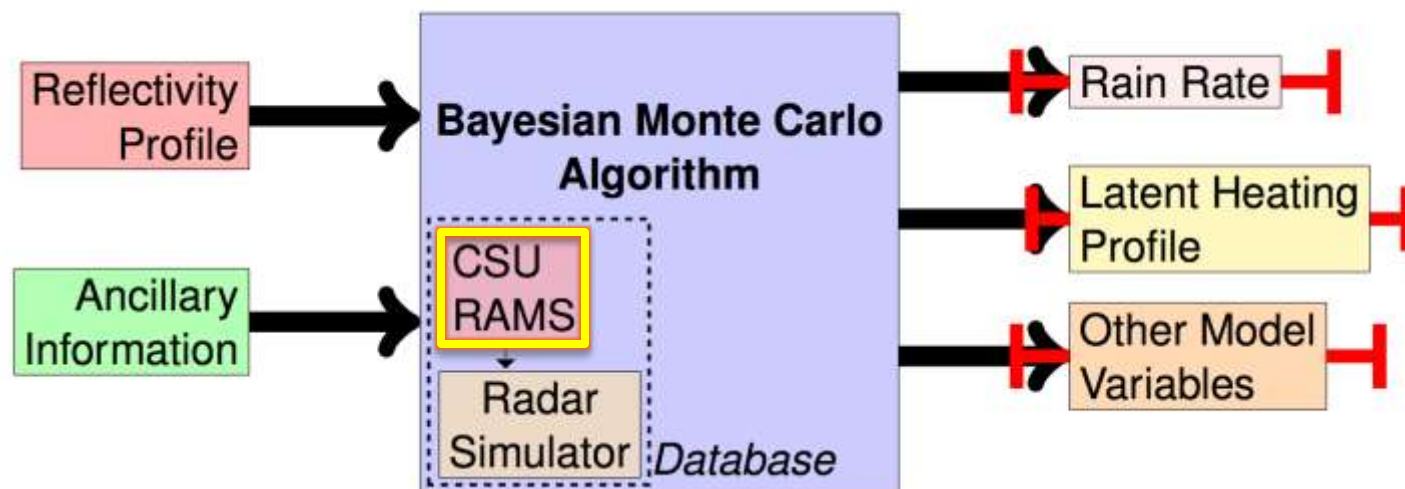


## Algorithm Design

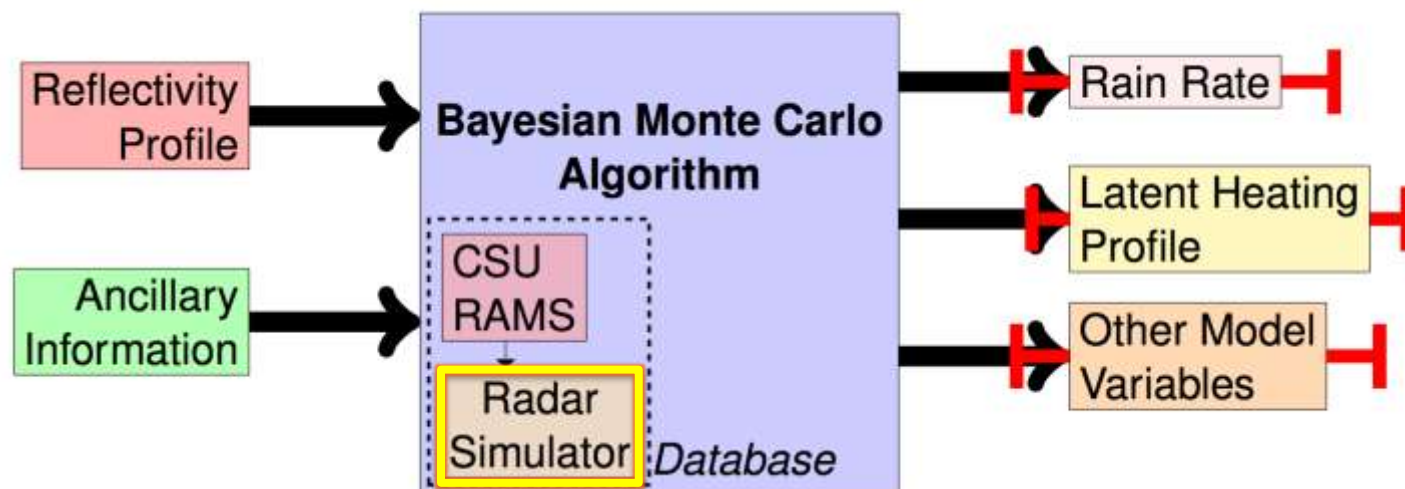


## Algorithm Design: Model Simulations



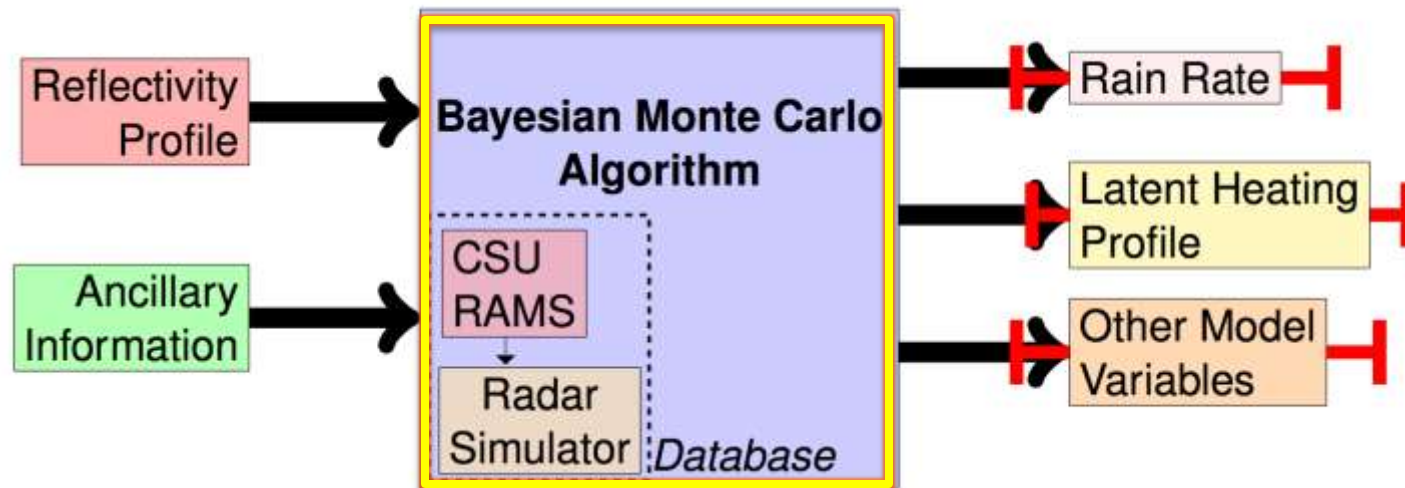
- RAMS tropical oceanic convection simulations are employed to populate the algorithm database (Saleeby 2015).
- 250 m H x 100 m V resolution; 100 km H x 4 km V length.
- 9 model runs, each with a distinct SST and max CCN:
  - 293 K, 298 K, 303K SST; 100 cc, 400 cc, 800 cc CCN
- 3 more runs at 303 K rerun with a 6 km V length are added.
- Only liquid phase hydrometeors are modeled.

## Algorithm Design: CloudSat Simulator



- QuickBeam simulates W band reflectivities of RAMS data.
- Attenuation profiles are also created with reflectivities.
- The model resolution is then degraded to one similar to CloudSat: 1.5 km H, 300 m V.

## Algorithm Design: Calculation



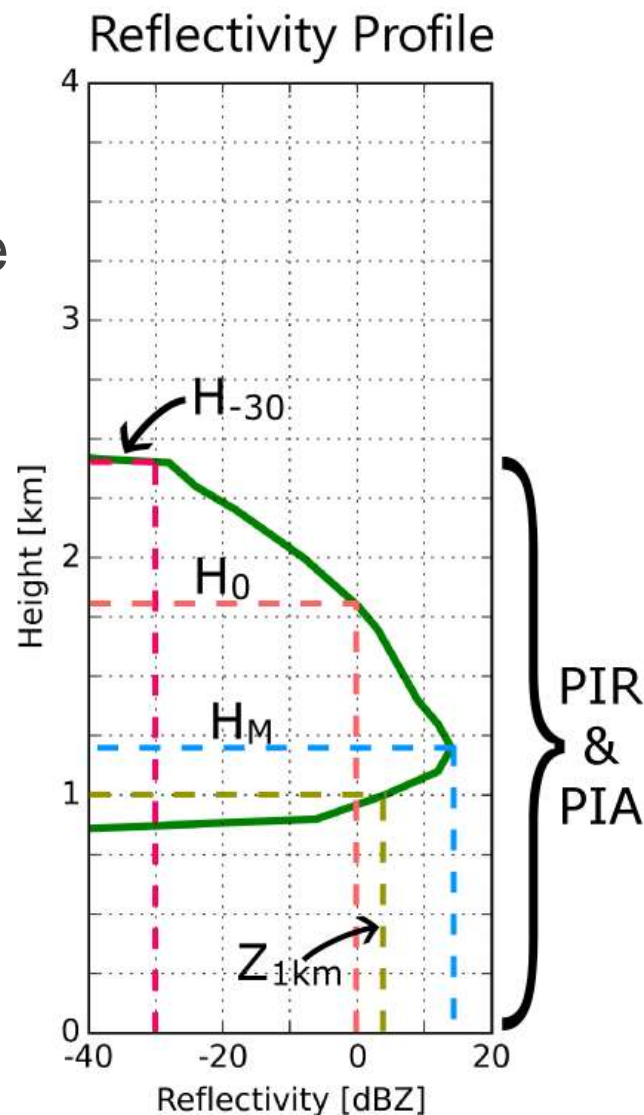
- The algorithm computes an *a posteriori* distribution by comparing an input vector of observations to each database member, i.e.

$$p_i = \frac{\exp \left\{ -\frac{1}{2} (\mathbf{y}_o - \mathbf{y}_{s,i})^T \mathbf{C}^{-1} (\mathbf{y}_o - \mathbf{y}_{s,i}) \right\}}{\sum_j^N \exp \left\{ -\frac{1}{2} (\mathbf{y}_o - \mathbf{y}_{s,j})^T \mathbf{C}^{-1} (\mathbf{y}_o - \mathbf{y}_{s,j}) \right\}}$$

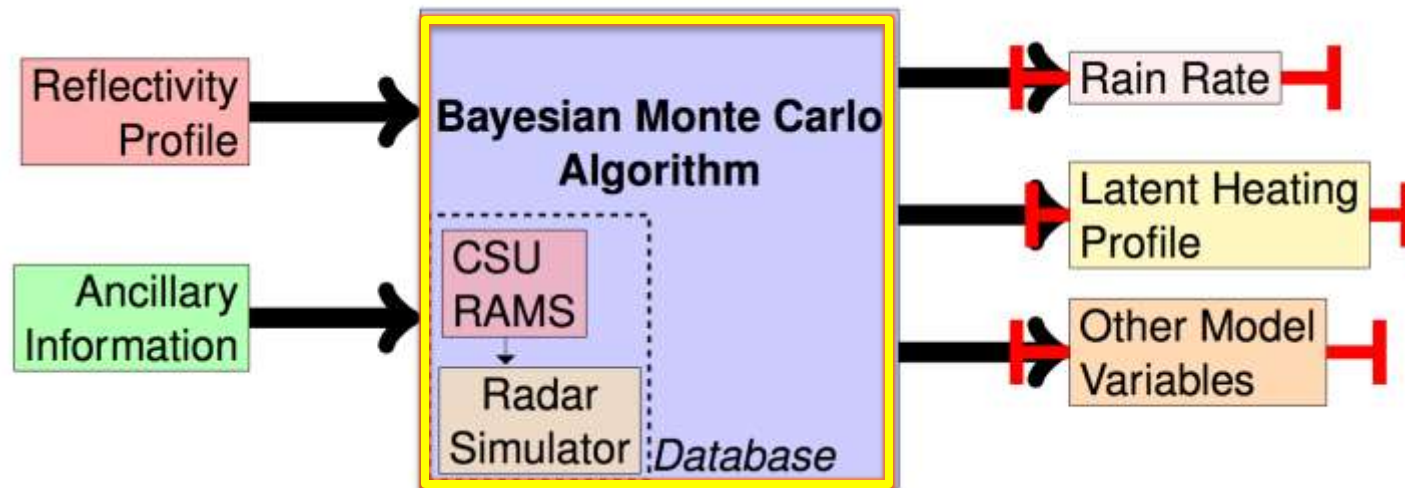
- The weighted mean is the output of the algorithm.

## Algorithm Design: Observation Vector

- Comparing each range bin takes a great amount of computing time.
- We instead pick characteristics of the profile that maximize information while minimizing dimensionality.
- Height information:
  - Cloud top
  - Rain top
  - Reflectivity maximum
- Intensity information:
  - Path integrated attenuation
  - Path integrated reflectivity
  - Near-surface reflectivity



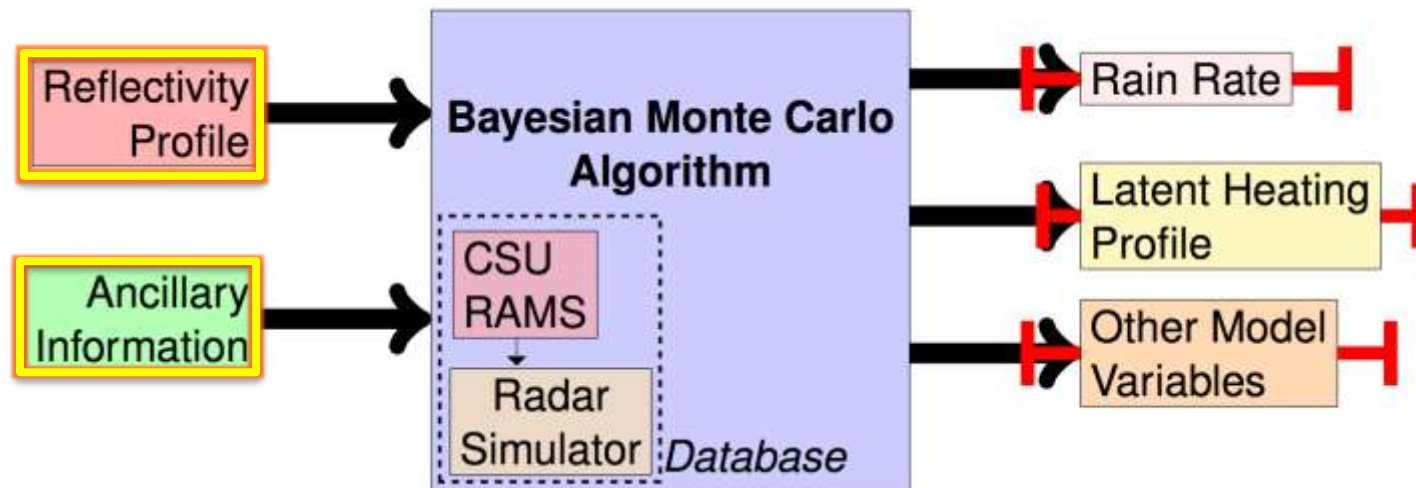
## Algorithm Design: Covariance Matrix



- The diagonal of the covariance matrix consists of variances chosen to match either CloudSat uncertainties or the degraded model resolution:
  - 1 dBZ reflectivity
  - 2 dB attenuation
  - 300 m height
- Off-diagonals contain the uncertainties scaled by the correlation coefficient between variables in the database.

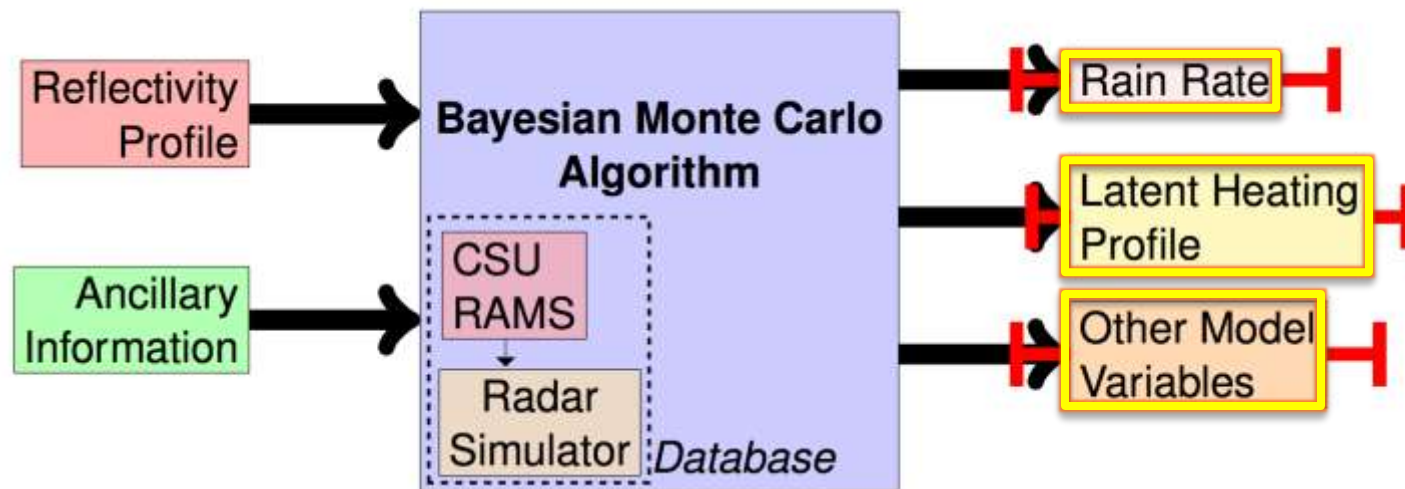


## Algorithm Design: Algorithm Inputs



- Reflectivities are taken from *Radar\_Reflectivity*.
- PIAs are the *PIA\_hydrometeor* two-way values between the satellite and the surface.
- Profiles are screened based on the following conditions:
  - The profile must be over ocean (*Surface\_type*).
  - Cloud top height must be lower than 6 km.
  - Freezing level must be higher than cloud top (*Freezing\_level*).

## Algorithm Design: Algorithm Outputs



- With the algorithmic setup, any variable from the RAMS runs can be retrieved by the algorithm.
- This includes rain rate, latent heating profiles, liquid water path, environmental variables, hydrometeor profiles, radiative fluxes, and so on.
- All variables also have an associated retrieval uncertainty.