Air Force Research Laboratory

Generation of AE9/AP9 Runtime Tables

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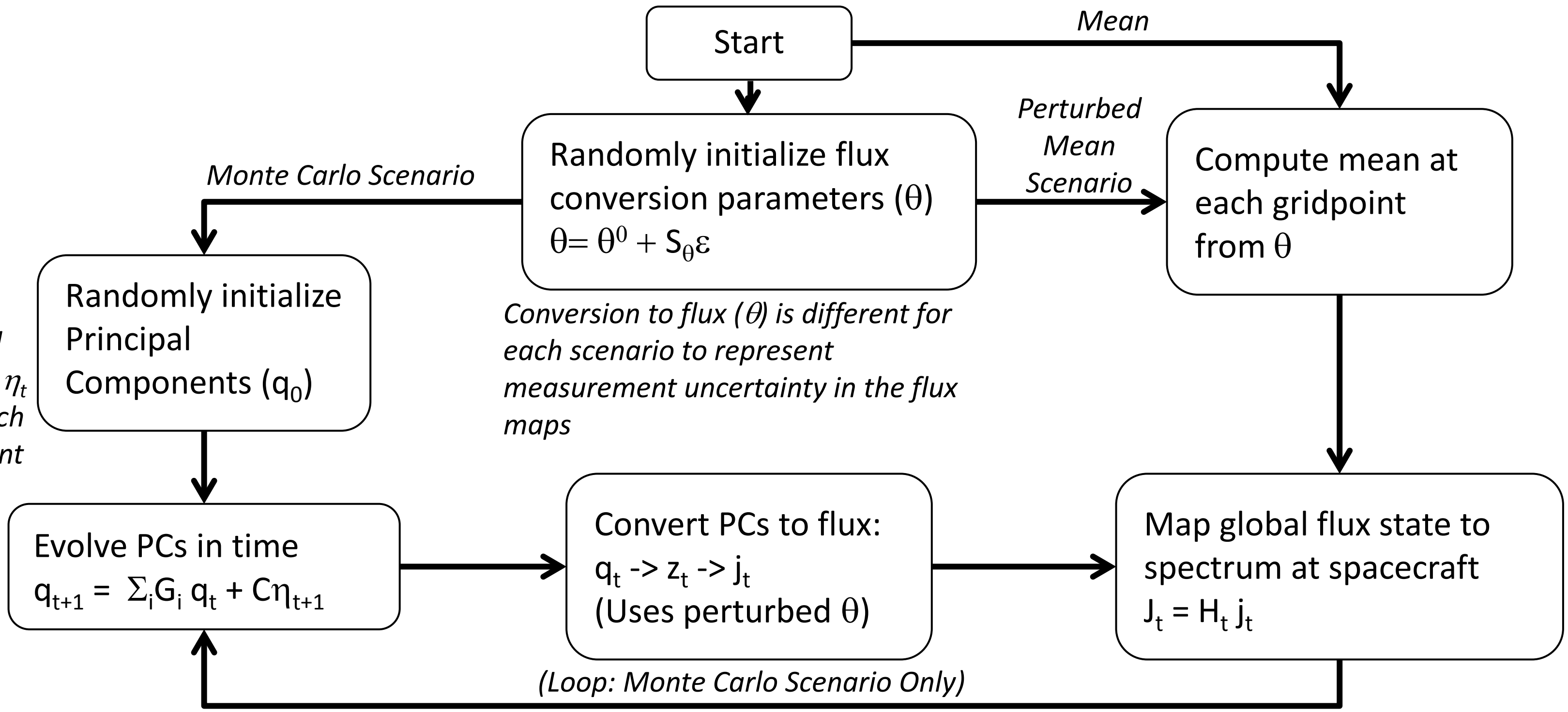
Outline

- List of Runtime Tables
- Runtime Process
- Flow chart of statistical processes
- Example of gap filling with templates
- Example results for one bin
- Correlations

Runtime Tables

Quantity	Symbol	Size	Purpose
Parameter map	$\theta(E,K,\Phi)$	~50,000 x 2	Represents transformed 50th and 95th percentile flux on coordinate grid (weather variation) θ_1 = ln(50% Flux), θ_2 = ln[(95% Flux)-(50% Flux)]
Parameter Perturbation Transform	$S_\theta(E,K,\Phi)$	~50,000 x 2 x ~10	Represents error covariance matrix for θ (measurement errors). $S_\theta S_\theta^T$ is the error covariance matrix for θ.
Principal Component Matrix	$Q(E,K,\Phi)$	~50,000 x 10	Represents principal components (q) of spatial variation (spatial correlation). QQ^T is the spatial covariance matrix for normalized flux (z).
Time Evolution Matrix	G's	~10 x 10 x 5	Represents persistence of principal components (temporal correlation)
Noise Conditioning Matrix	C	~10 x 10	Allocates white noise driver to principal components (Monte Carlo dynamics)
Marginal Distribution Type	N/A	N/A	Weibull (electrons) or Lognormal (protons) used for converting 50th and 95th percentiles into mean or other percentiles

Runtime Process



Initialization q_0 and white noise drivers η_t are different for each scenario to represent unpredictable dynamics

Conversion to flux (θ) is different for each scenario to represent measurement uncertainty in the flux maps

G, C, and the parameters of the conversion from PCs to flux are derived from statistical properties of empirical data and physics-based simulations

The measurement matrix H is derived from the location of the spacecraft and the energies/angles of interest

To obtain percentiles and confidence intervals for a given mission, one runs many Monte Carlo or Perturbed Mean scenarios and post-processes the flux time series to compute statistics on the estimated radiation effects across scenarios.

Generating the Runtime Tables

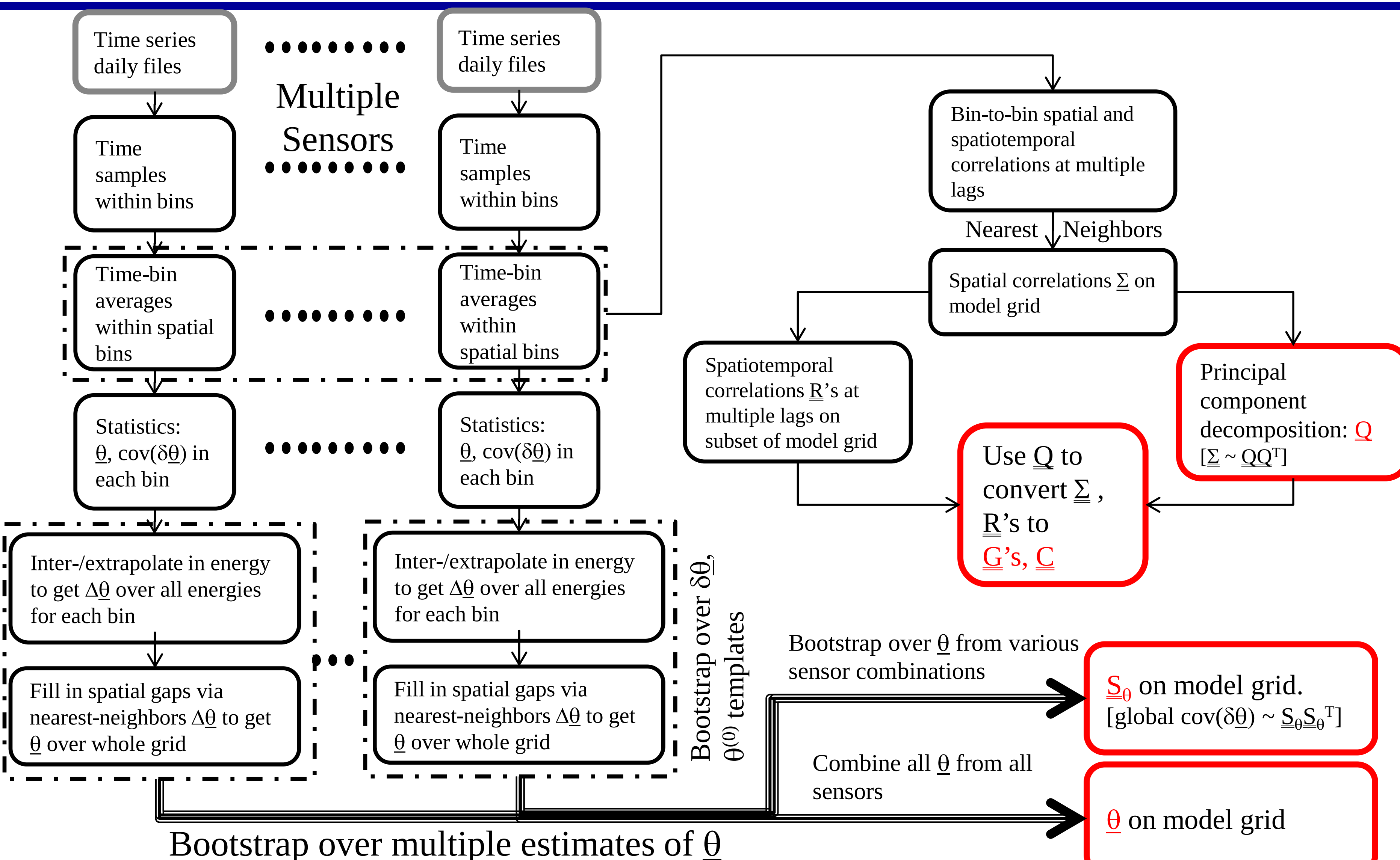
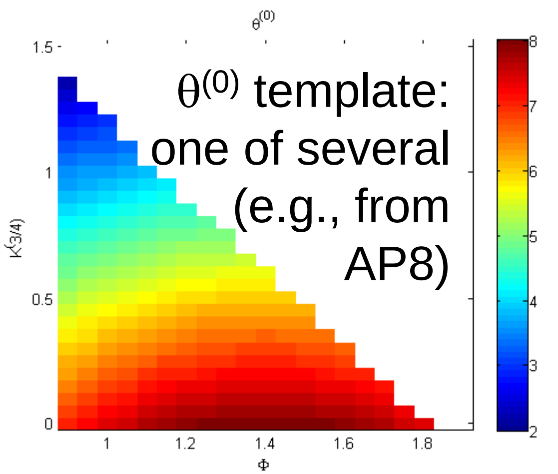
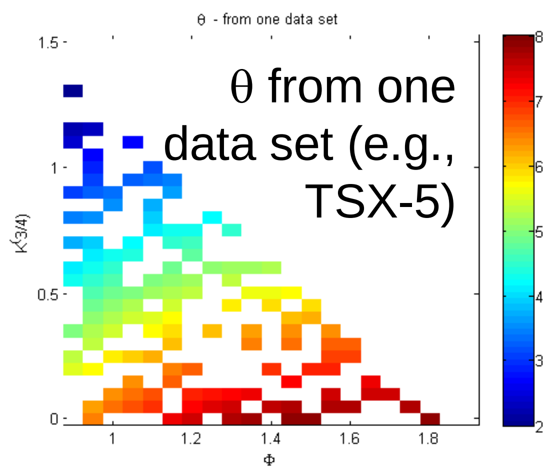
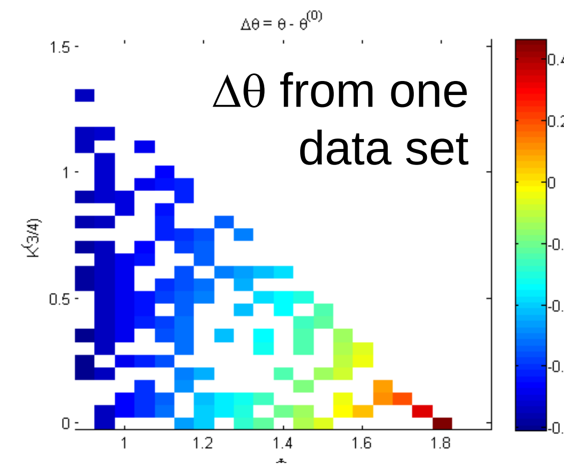
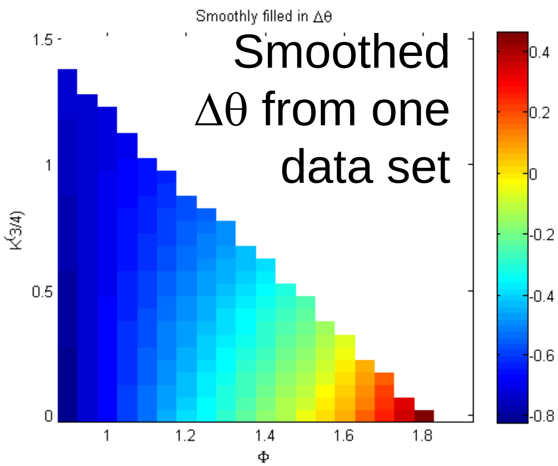


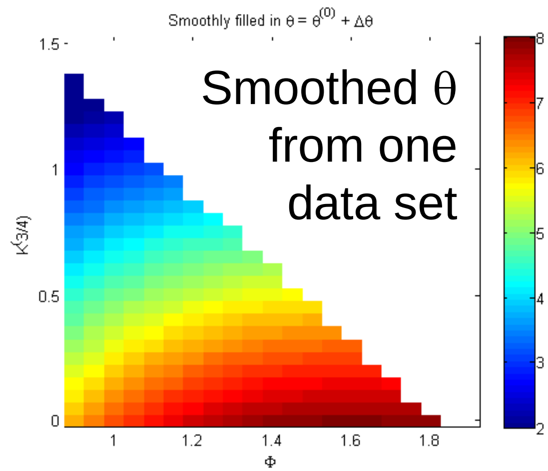
Illustration of Building a Whole Flux Map from One Data Set





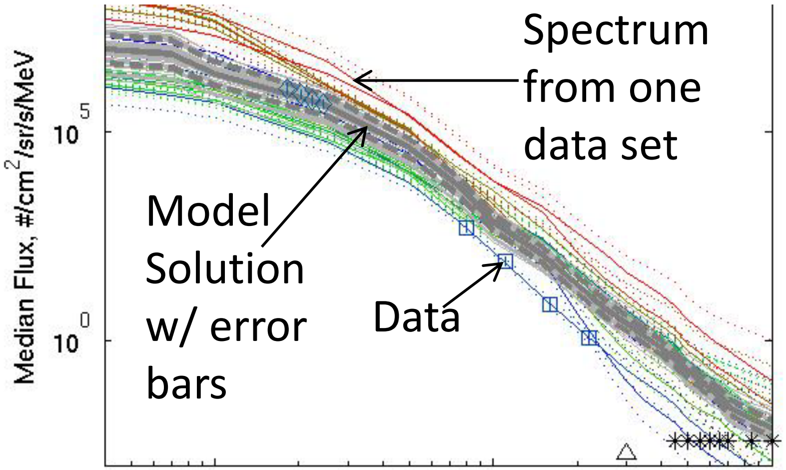


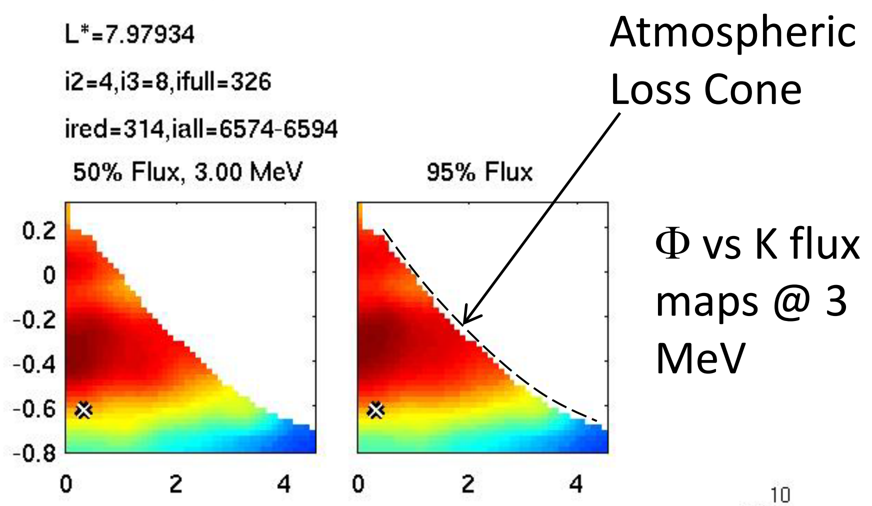


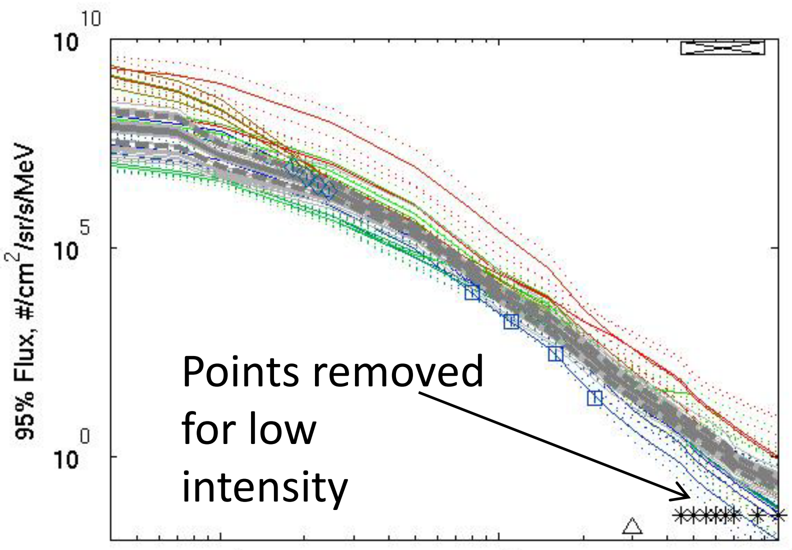


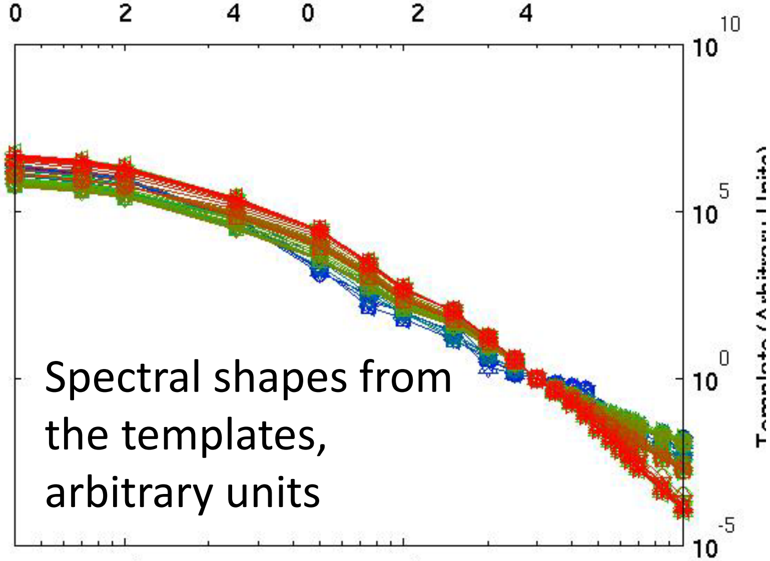
- The $\Delta\theta$ smoothing/filling algorithm is a nearest-neighbors average
- For each combination of template and sensor data set we make several filled-in flux maps
- We bootstrap over templates, errors in θ ($\delta\theta$) and combinations of data sets to estimate the error in the filled-in flux map
- We combine these filled-in flux maps over all sensors to get a best estimate flux map and its errors ($\underline{\underline{S}}_\theta$)

Spectra in One Bin, AE9









Correlations (1)

- Correlations in fluxes and in model/data errors have a significant impact on any results obtained from the model
- Correlations are very hard to measure and quantify
- The use of templates allows us to address correlated errors (e.g., some particular sensor is a little higher than the others in some regions of space). These correlated errors end up in $\underline{\underline{S}}_{\theta}$.
- The use of principal components ($\underline{\underline{Q}}$) allows us to address spatial correlations in the fluxes. However, the principal components are derived from an empirical estimate of spatial correlations

Correlations (2)

- Empirical flux correlations are sparse (rarely do we have two satellites in any given pair of grid points)
- Empirical correlations can be artificially large due to sample size limitations
- We would like to explore obtaining spatial correlations from long-term simulations, especially data assimilative ones (reanalyses)
- This would also allow us to obtain better spatiotemporal correlations for the monte carlo dynamics ($\underline{\underline{G}}$'s, $\underline{\underline{C}}$)
    - e.g., solar rotation, semiannual, and, someday, solar cycle timescales
    - AP9: 1, 4, 26, 52 weeks
    - AE9: 1, 7, 14, 27, 183, 365 days

Questions & Discussion