Locations


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60 Meters
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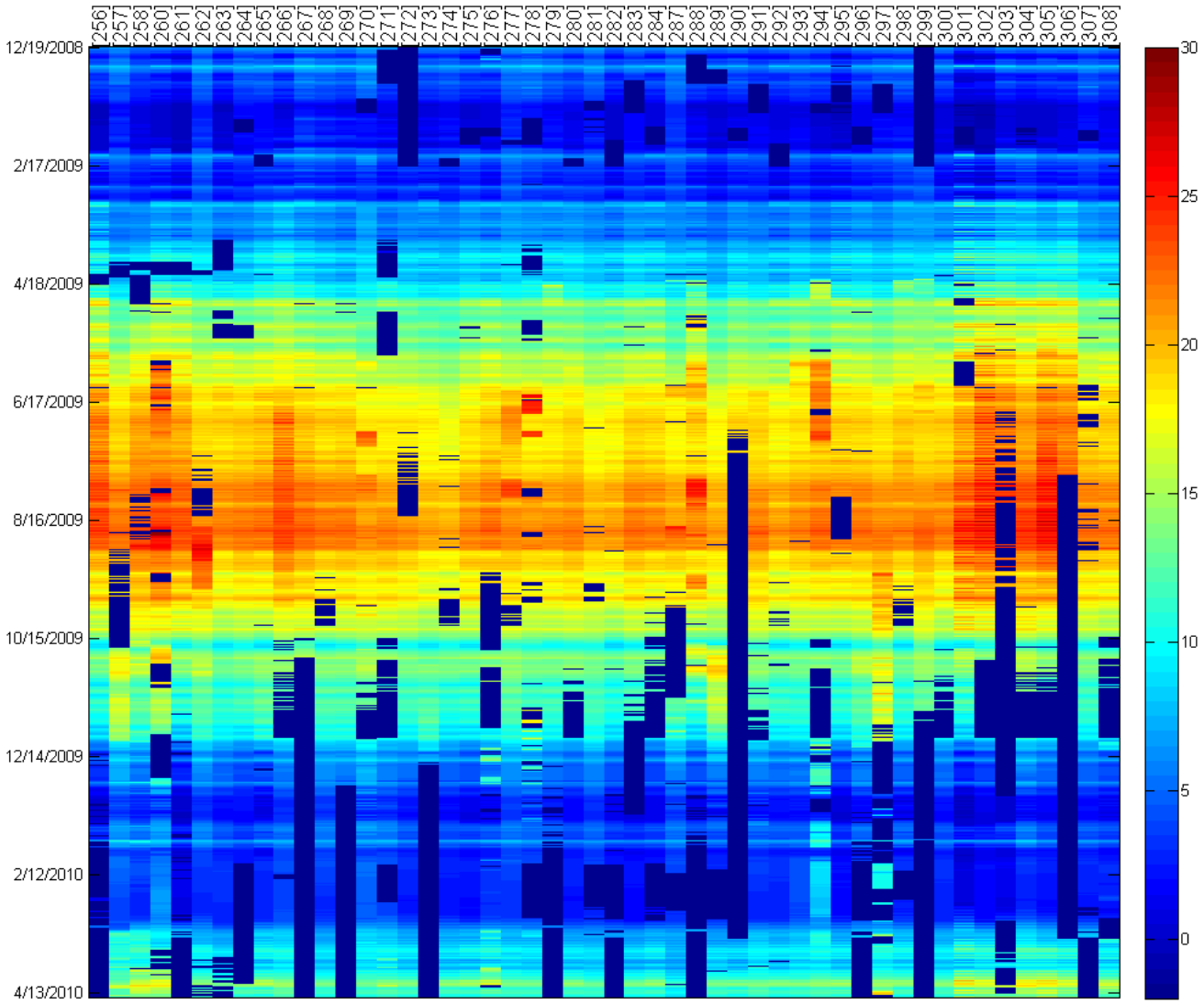
Soil Temperature Dataset



Observations

- Data is
  - Correlated in time and space
  - Evolving over time (seasons)
  - Gappy (Due to failures)
  - Faulty (Noise, Jumps in values)

Temporal Gap Filling

- Data is correlated in the temporal domain
- Data shows
  - Diurnal patterns
  - Trends
- Trends are modeled using slope and intercept
- Correlations captured using functional PCA

Gap Filling (Connolly & Szalay)[+]

$$f_\lambda = \sum_i a_i e_{i\lambda}$$

Original signal representation as a linear combination of orthogonal vectors

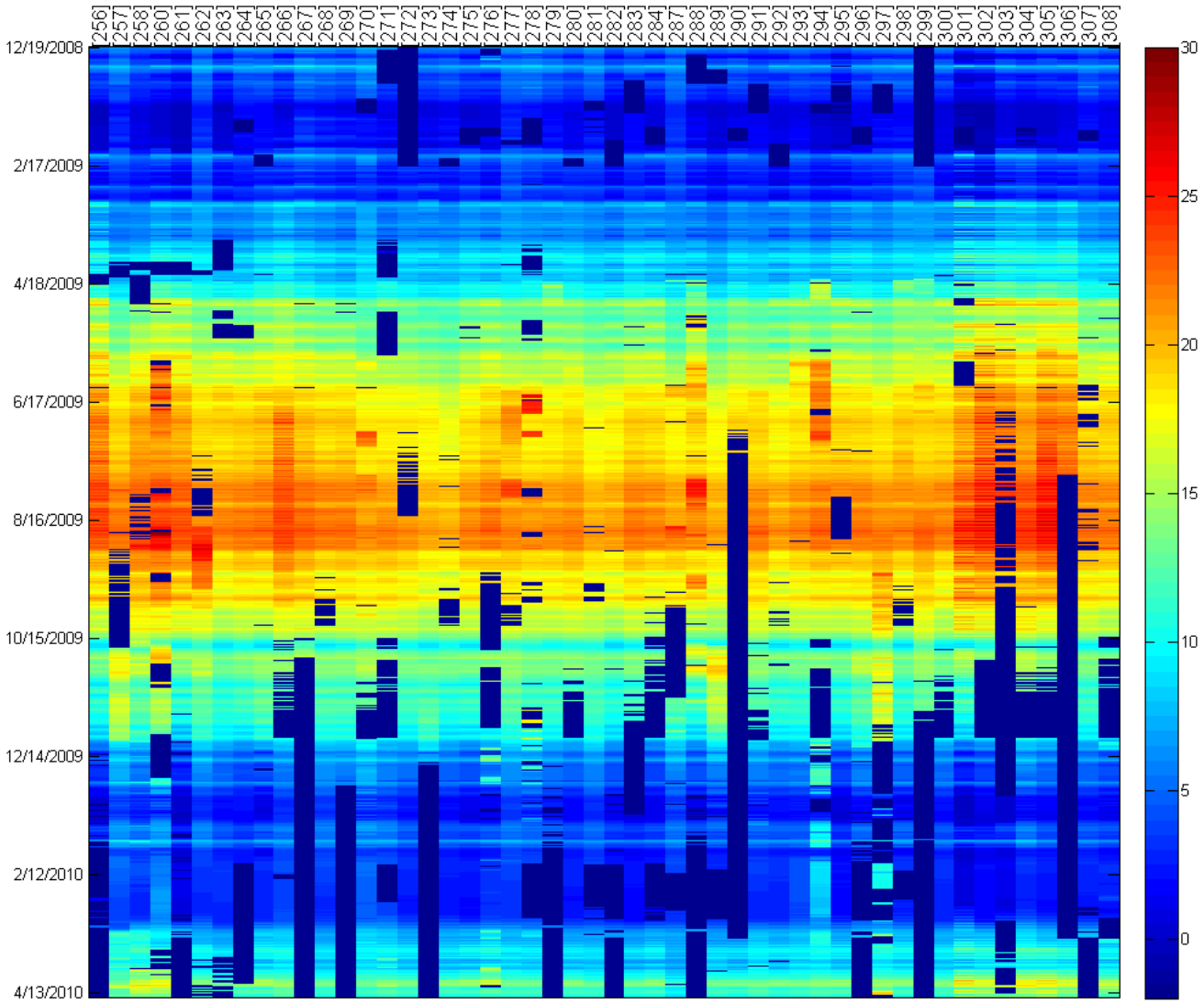
$$\chi^2 = \sum_\lambda w_\lambda (f_\lambda^o - \sum_i a_i e_{i\lambda})^2$$

Optimization function

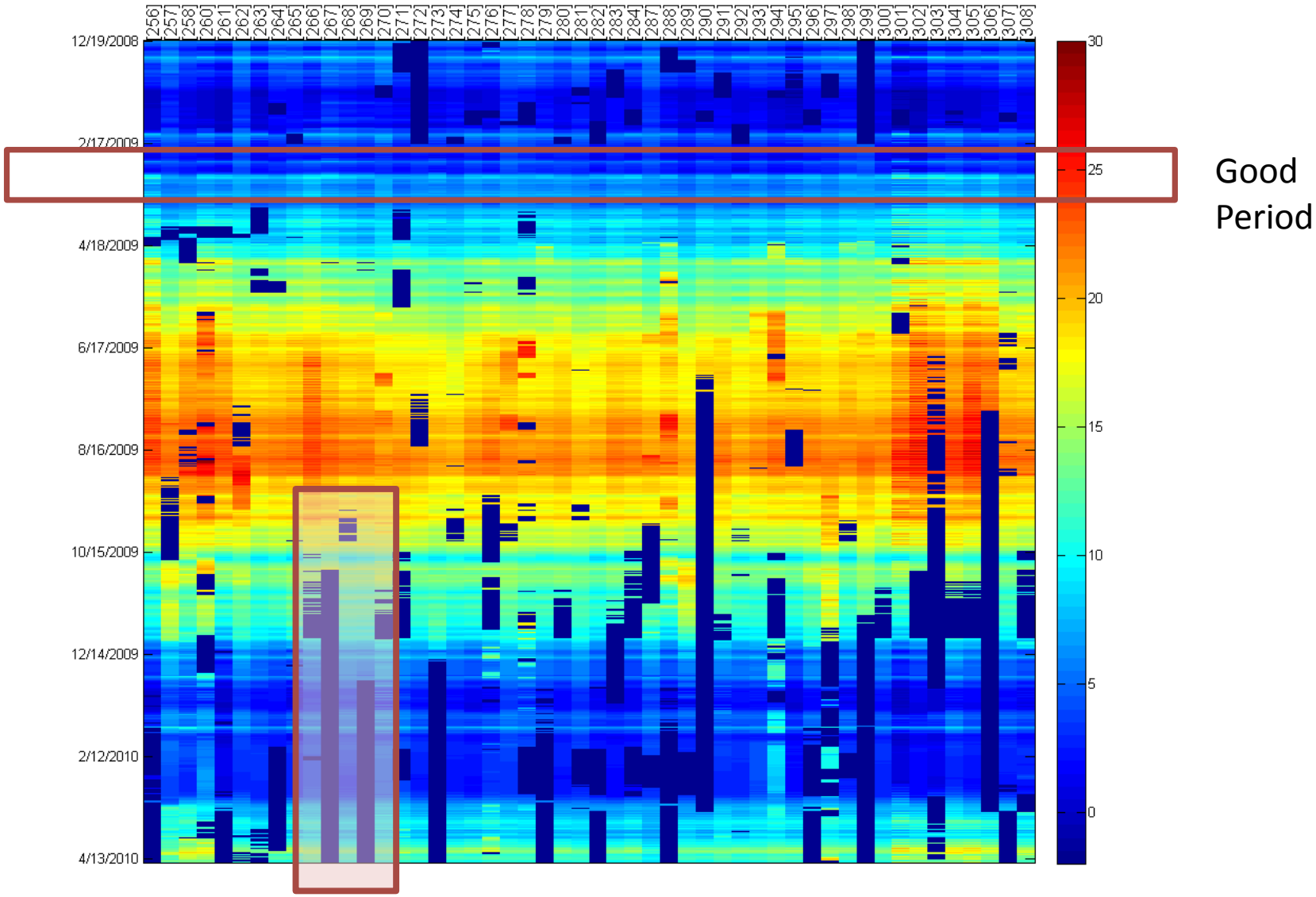
- $W_\lambda = 0$ if data is absent
- Find coefficients, a_i's, that minimize function.

[+] Connolly et al., **A Robust Classification of Galaxy Spectra: Dealing with Noisy and Incomplete Data,** http://arxiv.org/PS_cache/astro-ph/pdf/9901/9901300v1.pdf

Soil Temperature Dataset (same as slide 2)



Gap-filling using Daily Basis



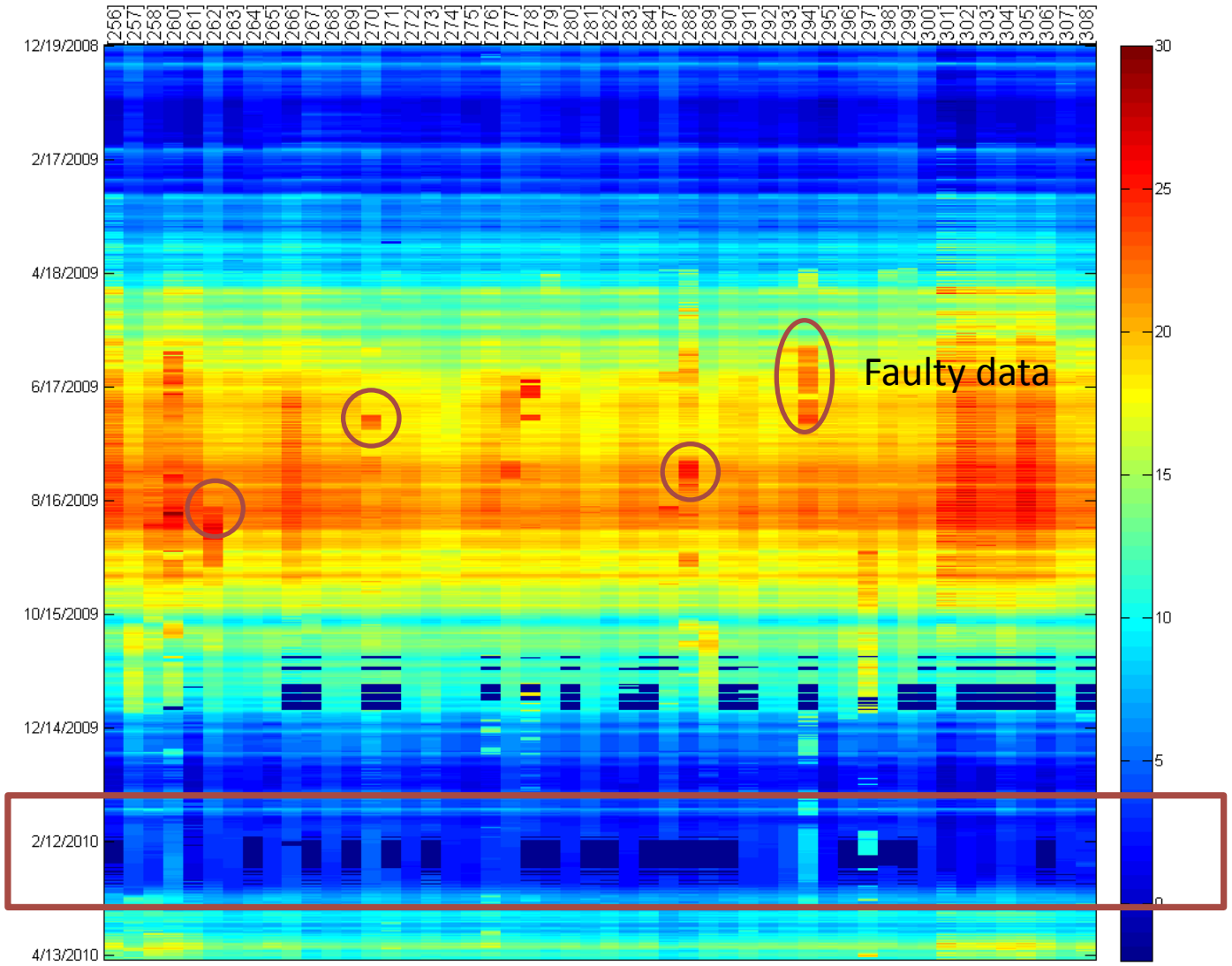
Only 2% of the data could be filled using daily model

Observations

- Hardware failures causes entire “days” of data to be missing
  - Temporal method (only using temporal correlation) is less effective

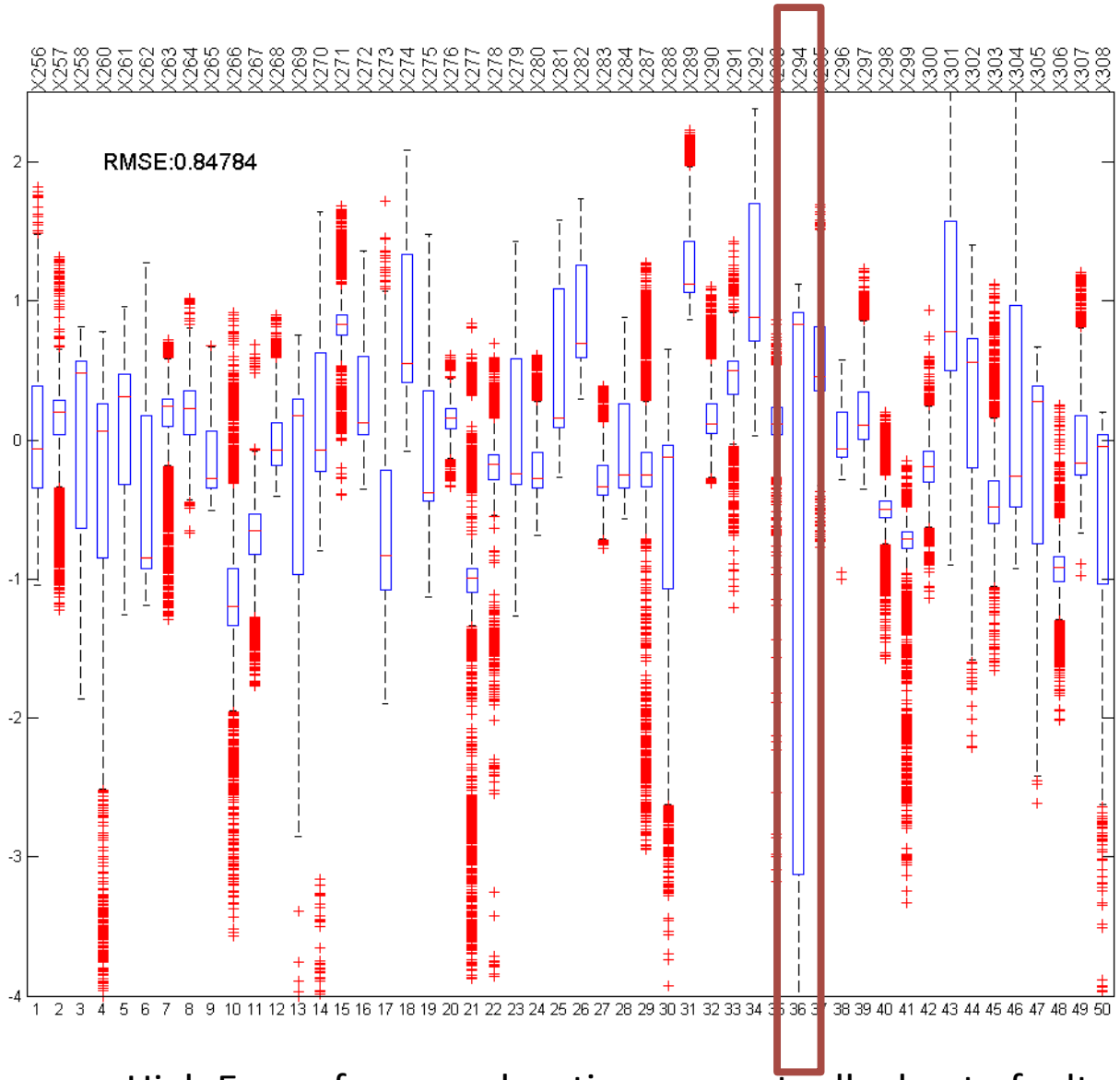
- If we look in the spatial domain,
  - For a given time, at least > 50% of the sensors are active
  - Use the spatial basis instead.
  - Initialize spatial basis using the period marked “good period” in previous slide

Gap-filling using sensor correlations



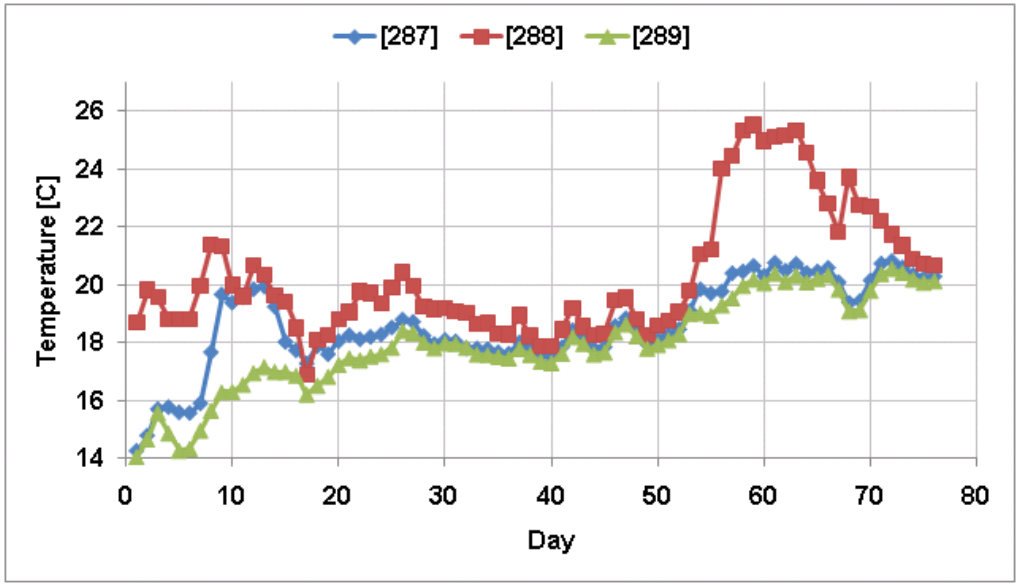
Too many missing readings for this period (Snow storm!)

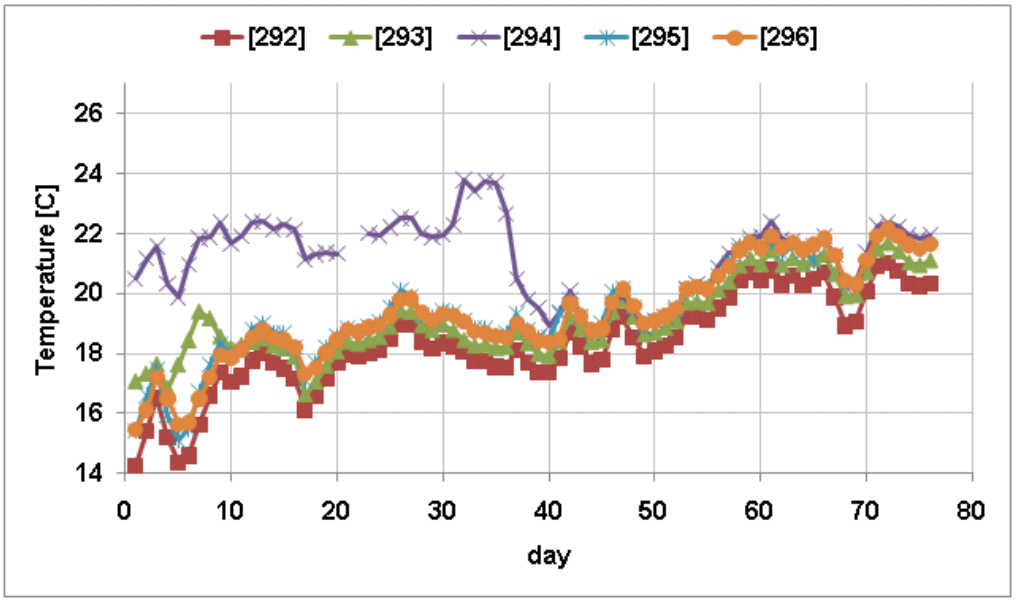
Accuracy of gap-filling



High Errors for some locations are actually due to faults
Not necessarily due to the gap-filling method

Examples of Faults



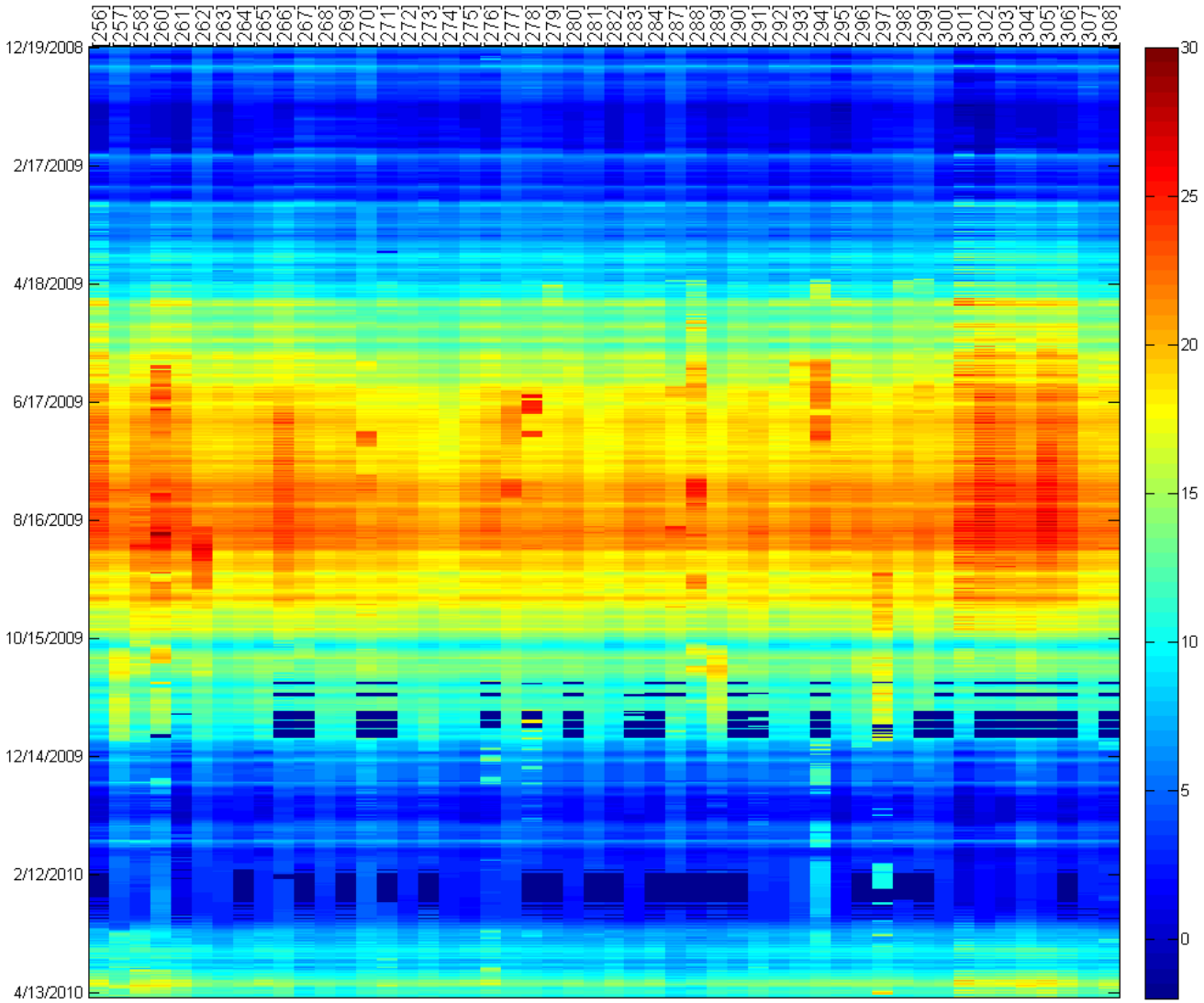


Observations & Incremental Robust PCA *

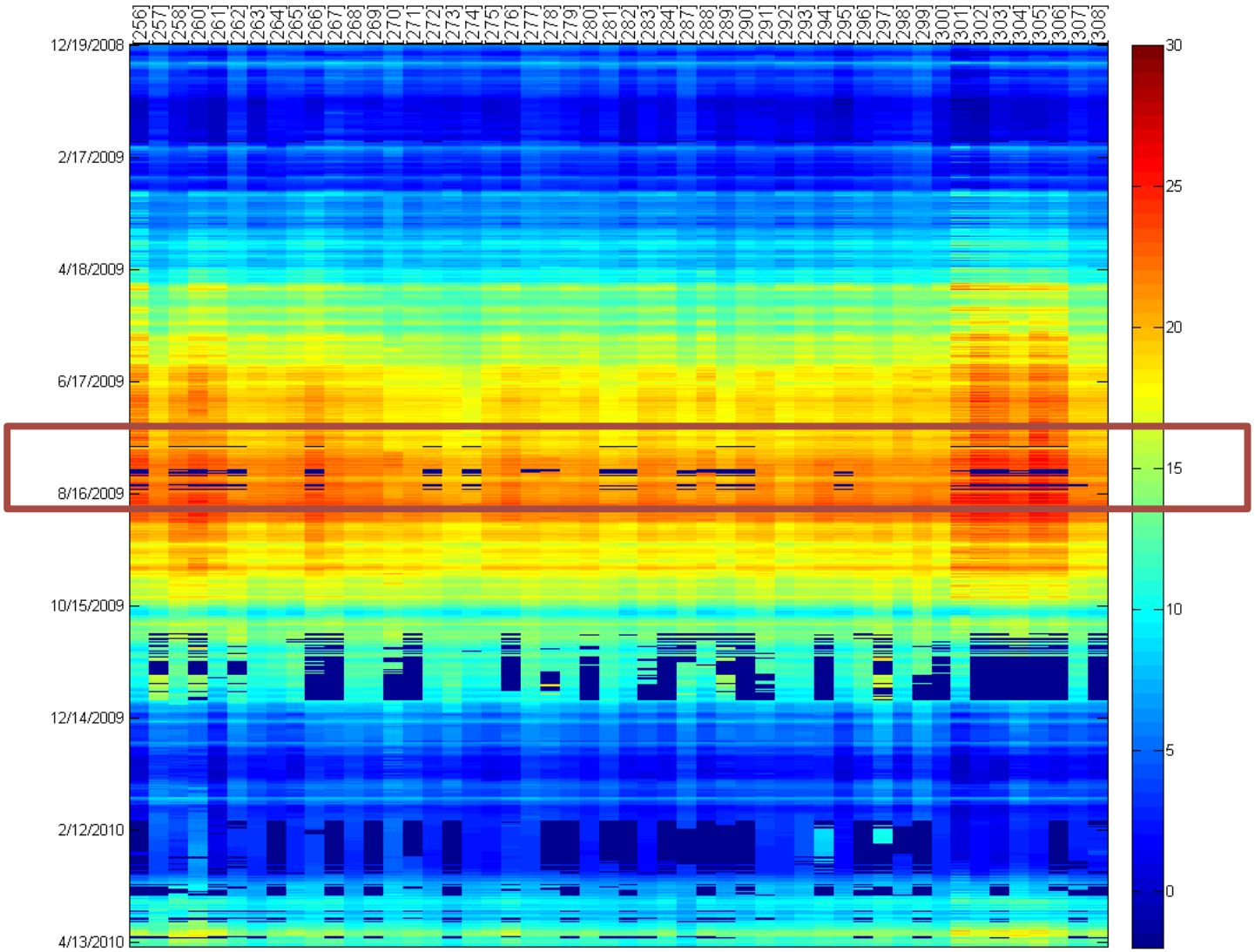
- Data are faulty
  - Pollutes the basis
  - Impacts the quality of gap-filling
- Basis is time-dependent
  - Correlations are changing over time
- Simultaneous fault-detection & gap-filling
  - Initialize basis using reliable data
  - Using basis at time t,
    - Detect and remove faulty readings
    - Weight new vectors depending on residuals
    - Update thresholds for declaring faults
  - Iterate over data to improve estimates

[+] Budavári, T., Wild, V., Szalay, A. S., Dobos, L., Yip, C.-W. 2009 *Monthly Notices of the Royal Astronomical Society*, 394, 1496, http://adsabs.harvard.edu/abs/2009MNRAS.394.1496B

Gap-filling using sensor correlations (same as slide 8)



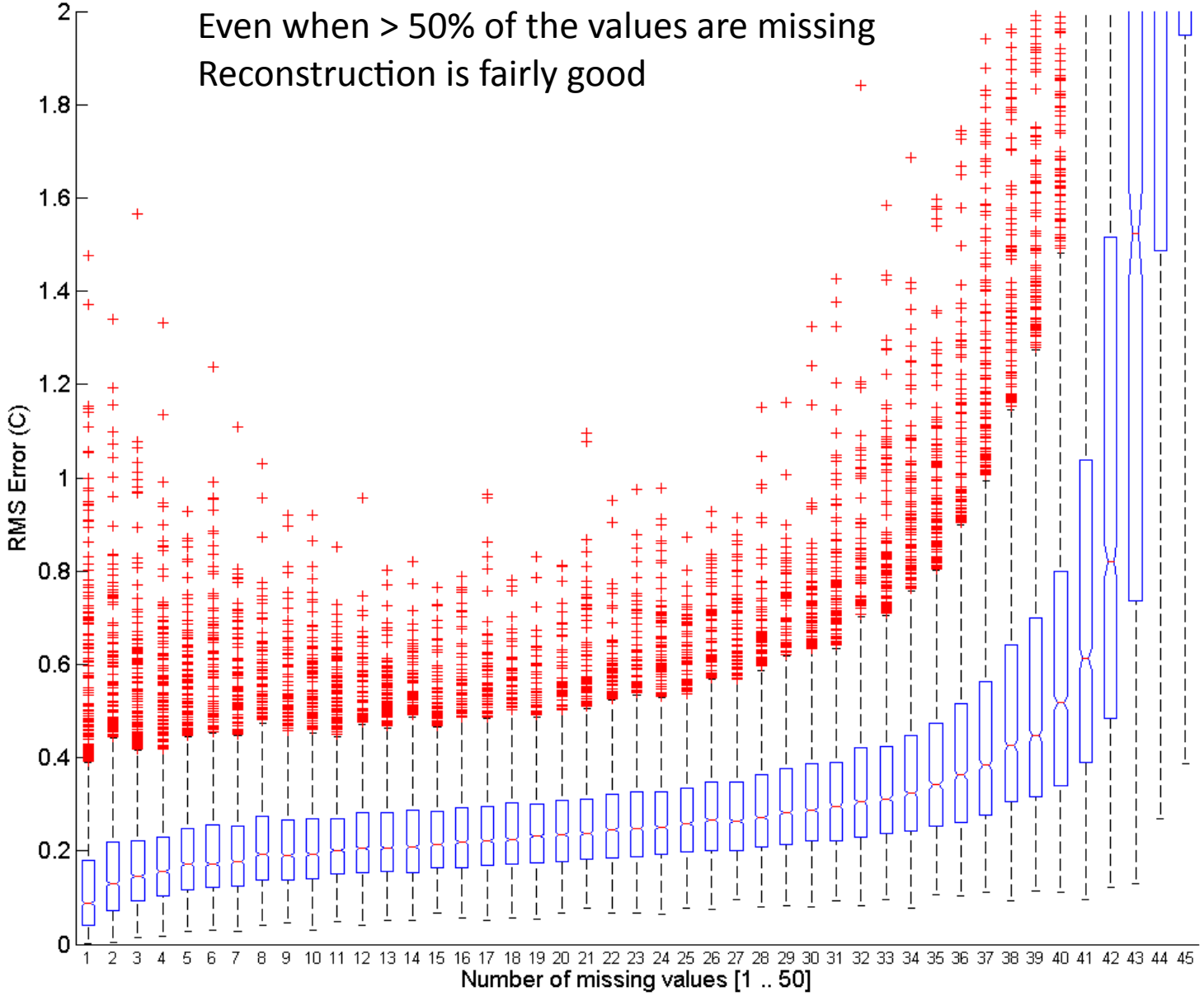
Iterative and Robust gap-filling



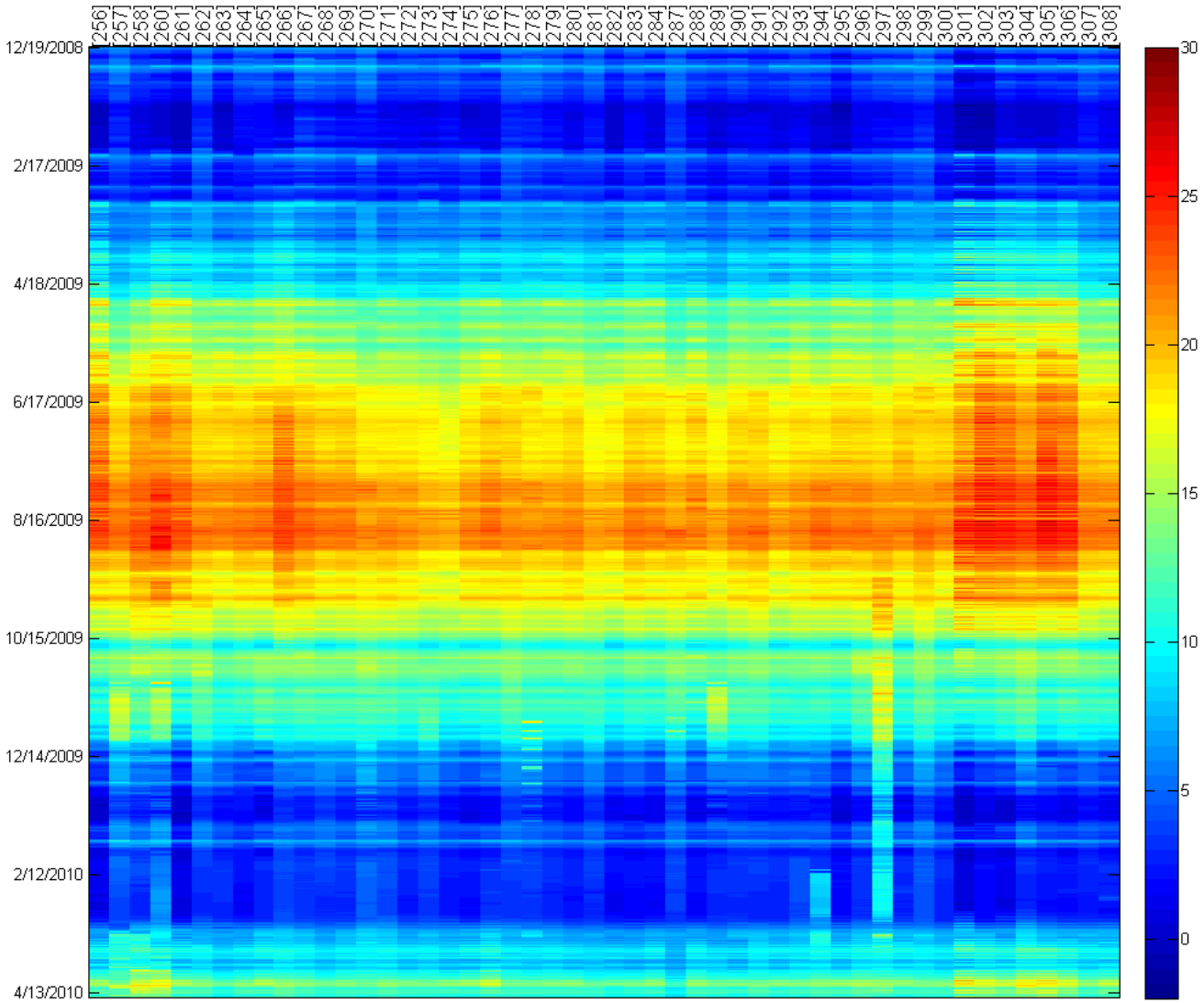
-Fault removal leads to more gaps and less data to work with

-However, data looks much cleaner.

Impact of number of missing values



Iteration - I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4/18/2009
6/17/2009
8/16/2009
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4/13/2010
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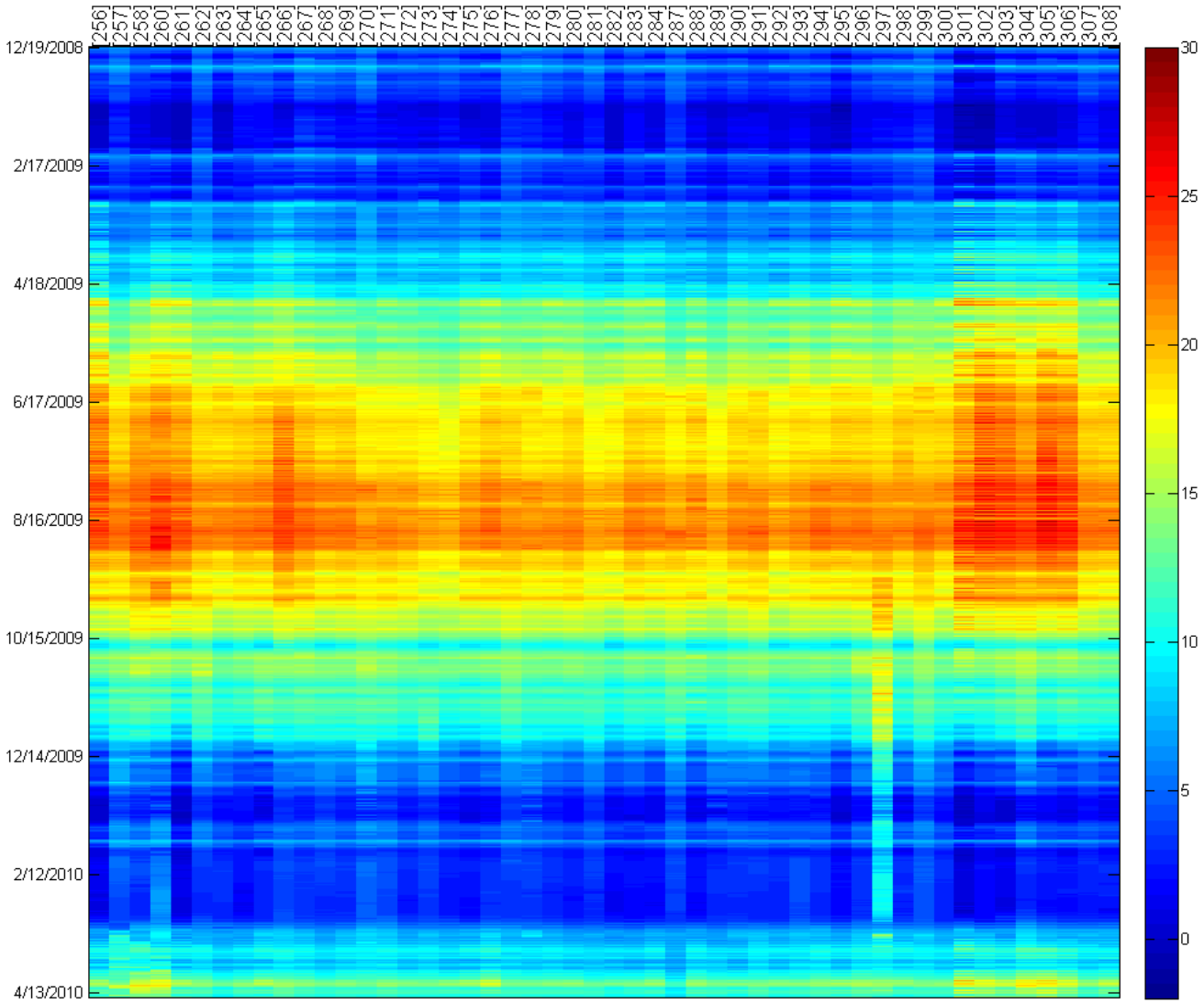
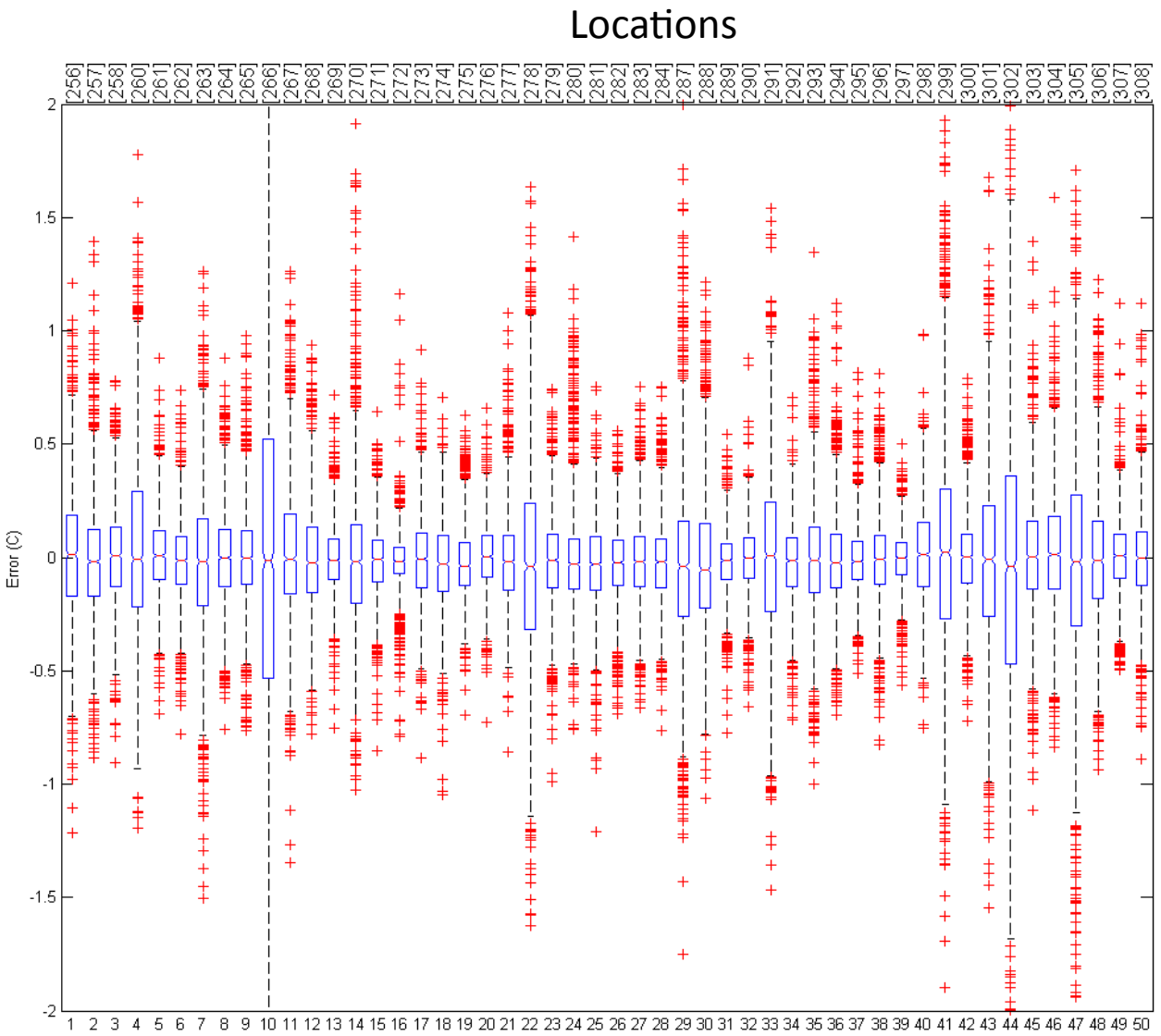
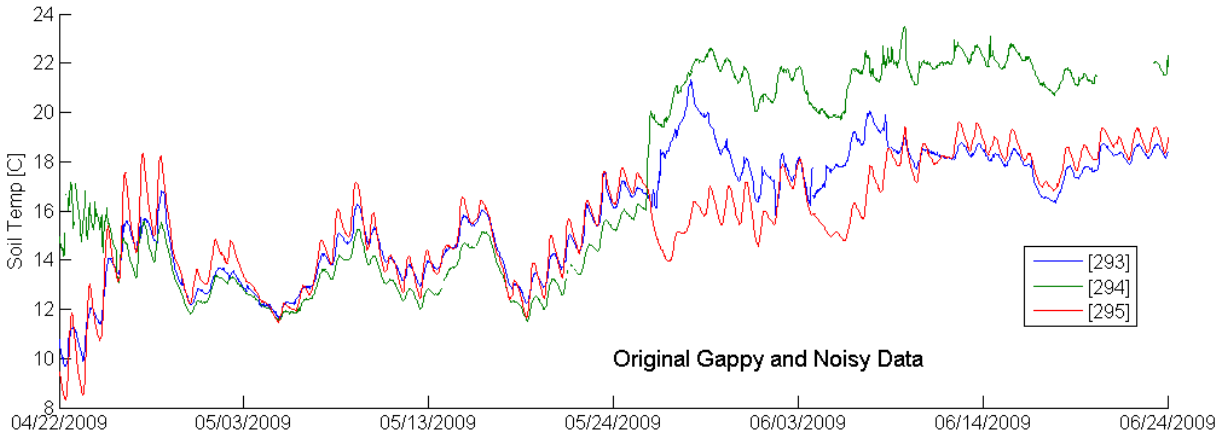
Iteration - II

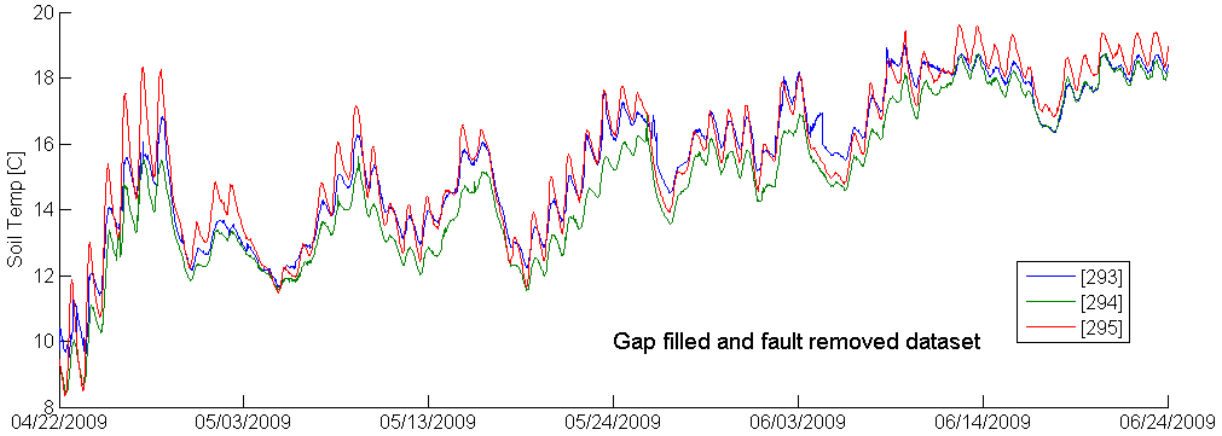


Accuracy using spatiotemporal gap-filling



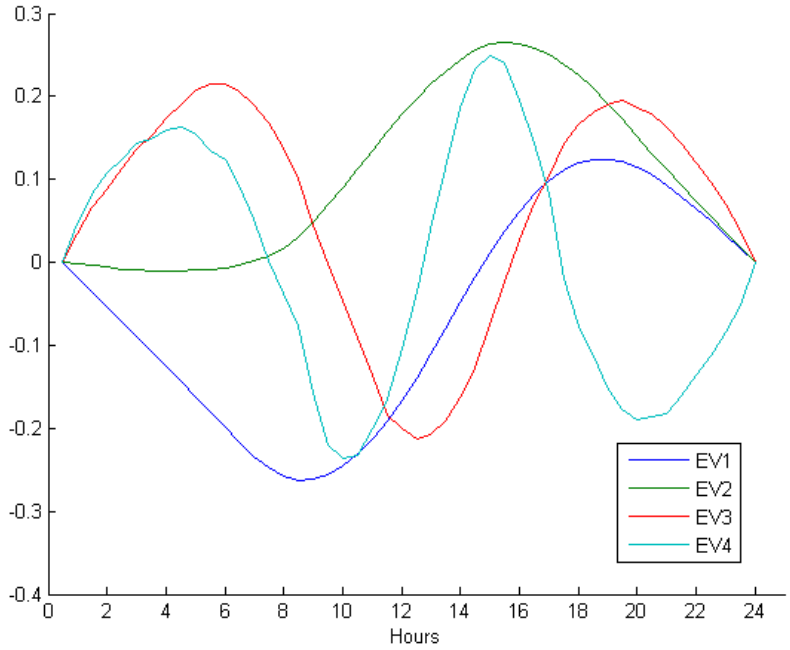
Example of running algorithm





ETC

Daily Basis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EV2
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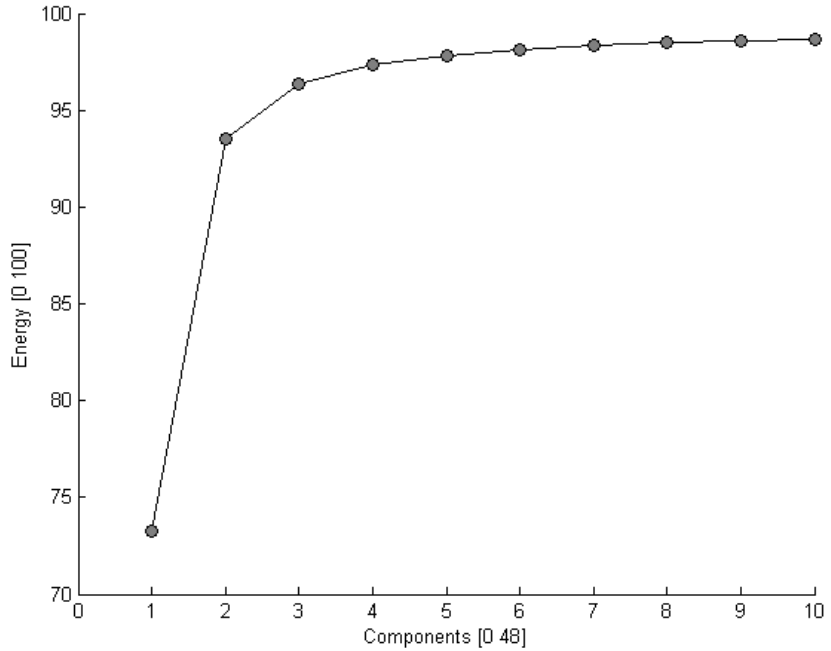
EV4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Energy [0 100]
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9
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Components [0 48]

Collected measurements