Beryllium and Xenon Time Series Analysis: A New Methodological Approach for Atmospheric Transport Modelling at Small, Synoptic and Global Scales

Wolfango Plastino, Stefano Bianchi and Alessandro Longo

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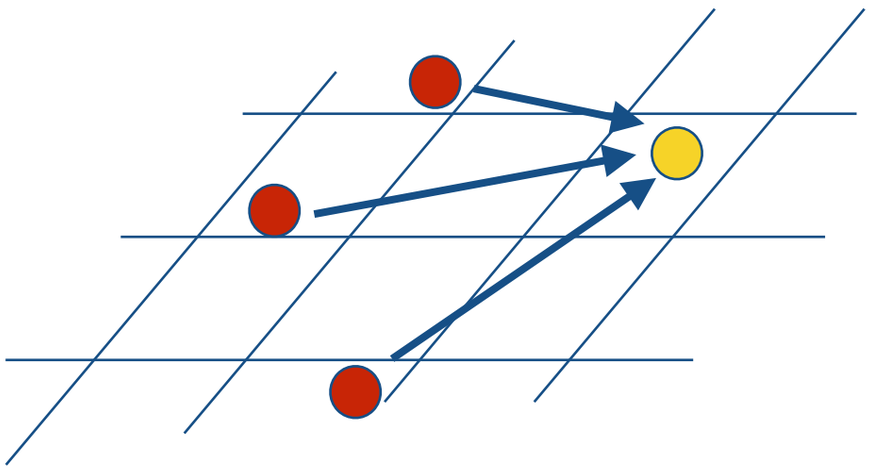
Motivation

- Comprehensive Nuclear Test Ban Treaty Organization (CTBTO)
  virtual Data Exploitation Centre Collaboration

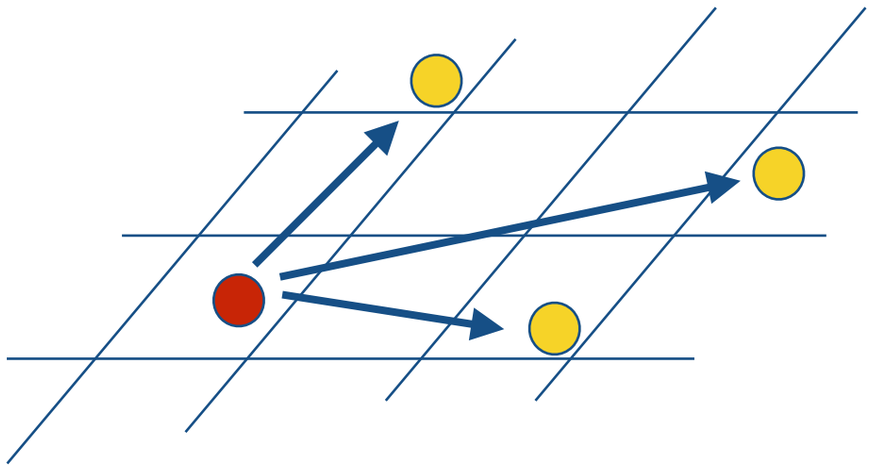
- Atmospheric Transport Modelling (ATM): CTBT event screening categorization based on preliminary characterization @ IMS Station [Receptor (backward modelling); Source (forward modelling)]

- Time Series Analysis @ IMS Stations: Beryllium, Xenon and Meteorological Data

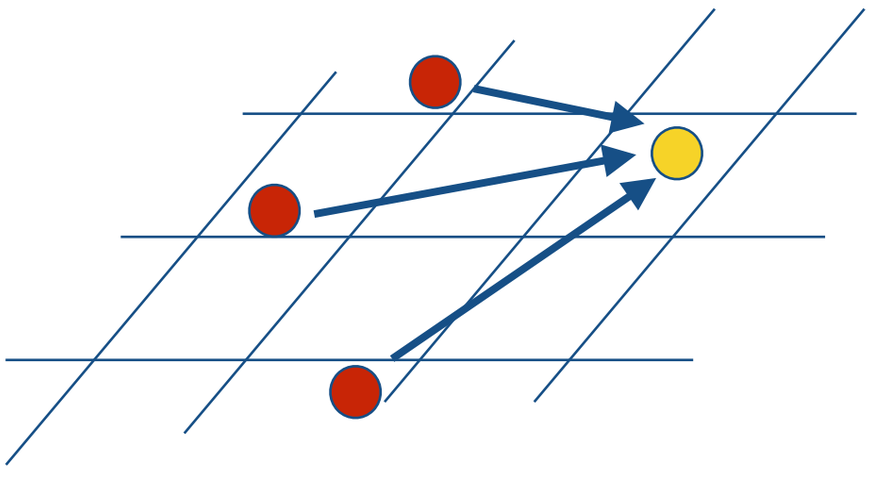
Multiple Sources - One Receptor



One Source - Multiple Receptors



Multiple Sources - One Receptor



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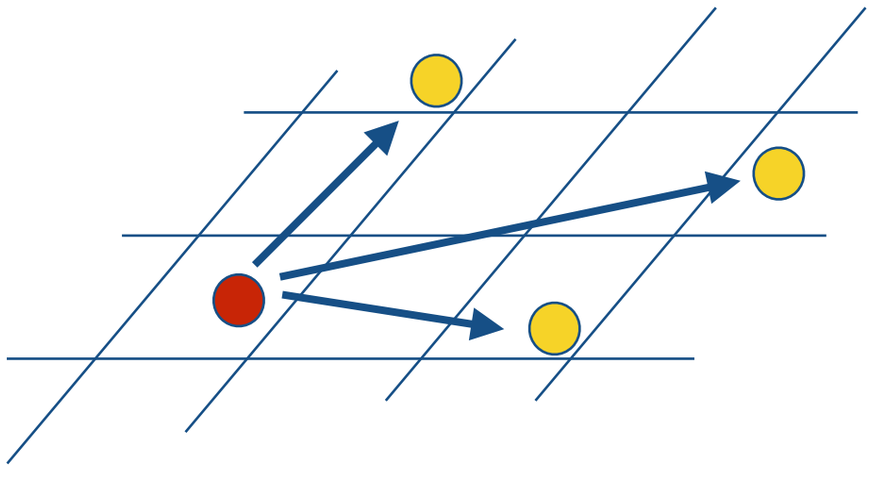
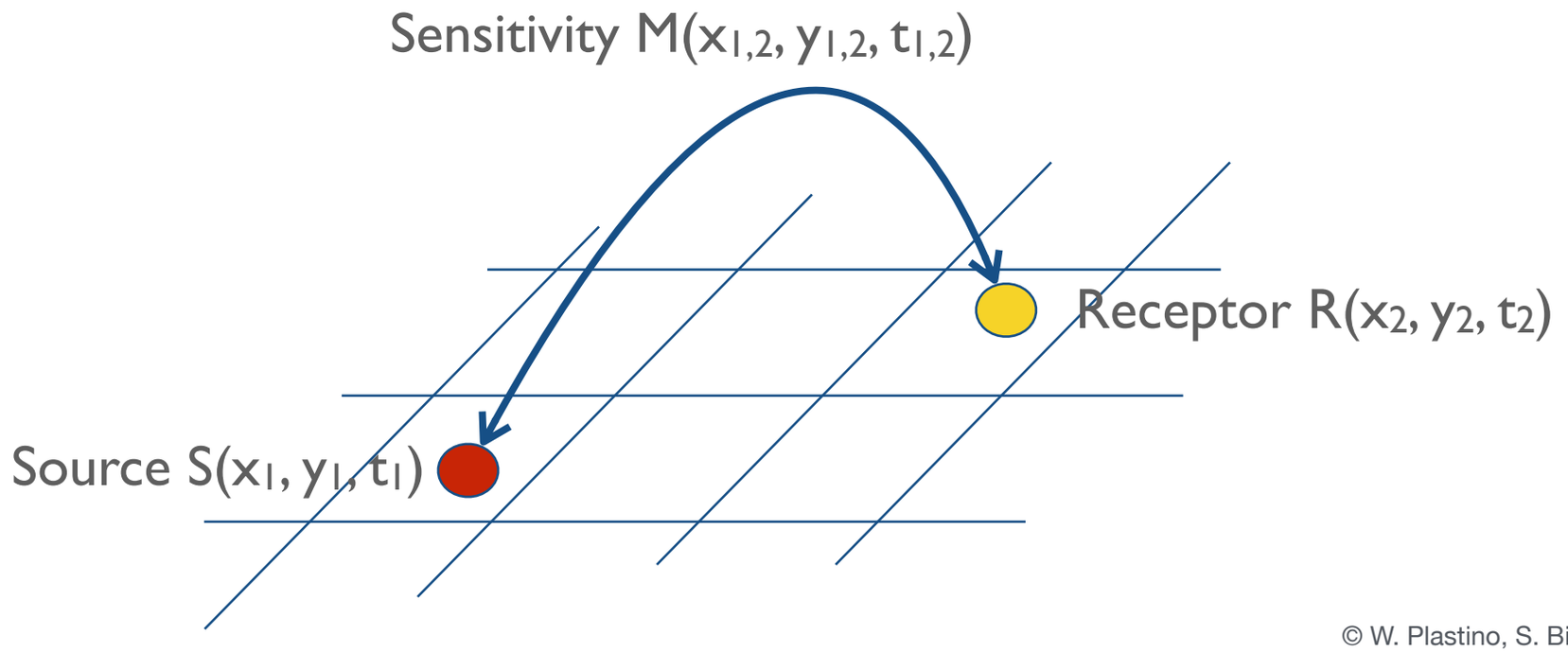
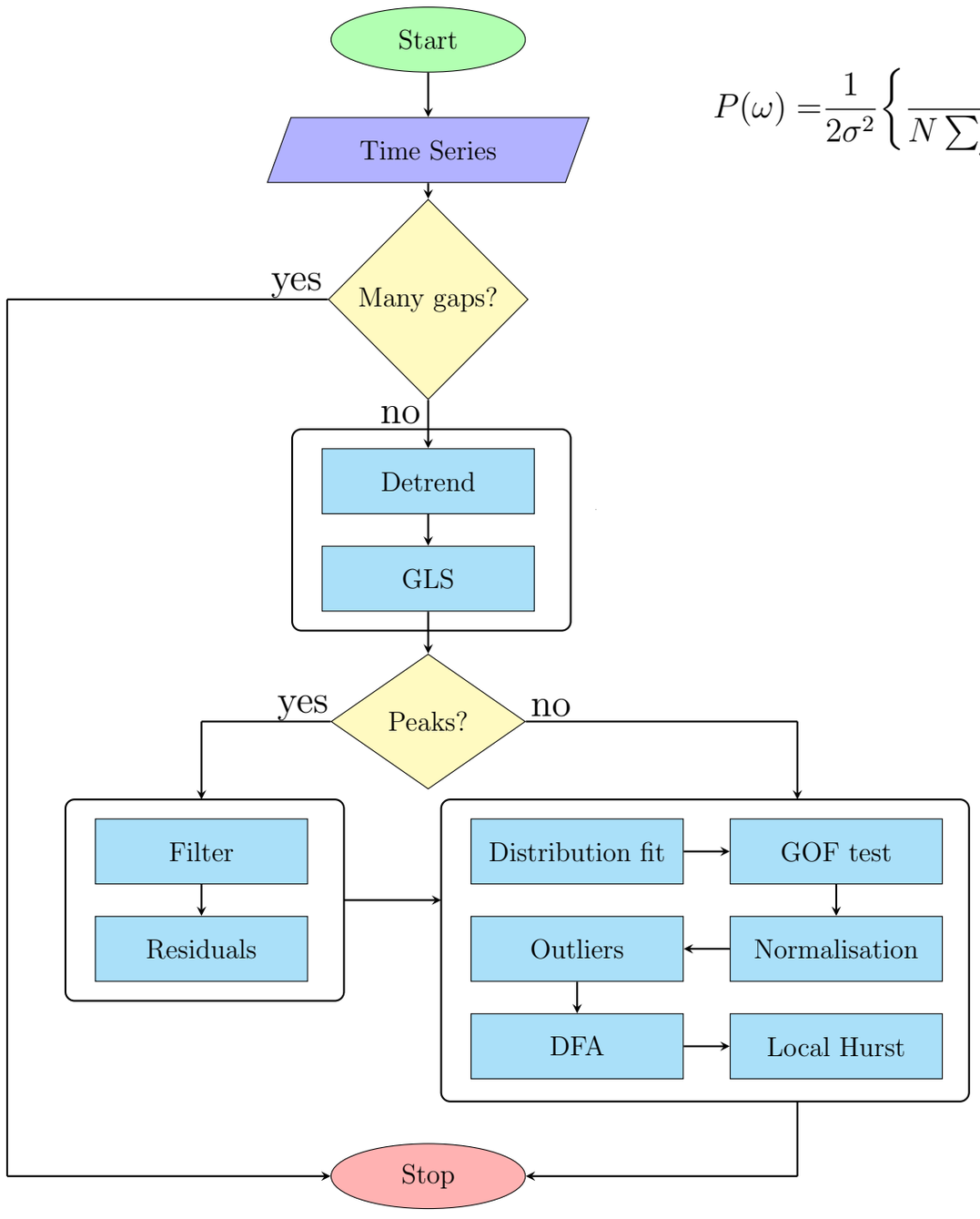






Generalised Lomb-Scargle spectrum (GLS)

$$P(\omega) = \frac{1}{2\sigma^2}\left\{\frac{N[\sum_j (X_j - \overline{X})\cos(\omega(t_j-\tau))]^2}{N\sum_j \cos^2(\omega(t_j-\tau)) - [\sum_j \cos(\omega(t_j-\tau))]^2} + \frac{[N\sum_j (X_j - \overline{X})\sin(\omega(t_j-\tau))]^2}{N\sum_j \sin^2(\omega(t_j-\tau)) - [\sum_j \sin(\omega(t_j-\tau))]^2}\right\}$$

$$\tau = \frac{1}{2\omega}\arctan\left\{\frac{N\sum_j \sin(2\omega t_j) - 2\sum_j \cos(\omega t_j)\sum_j \sin(\omega t_j)}{N\sum_j \cos(2\omega t_j) - [\sum_j \cos(\omega t_j)]^2 + [\sum_j \sin(\omega t_j)]^2}\right\}$$

Detrended Fluctuation Analysis

$$F(n) = \left[\frac{1}{N}\sum_{t=1}^{N}(M_t - L_t)^2\right]^{1/2}$$

Multifractal Detrended Fluctuation Analysis

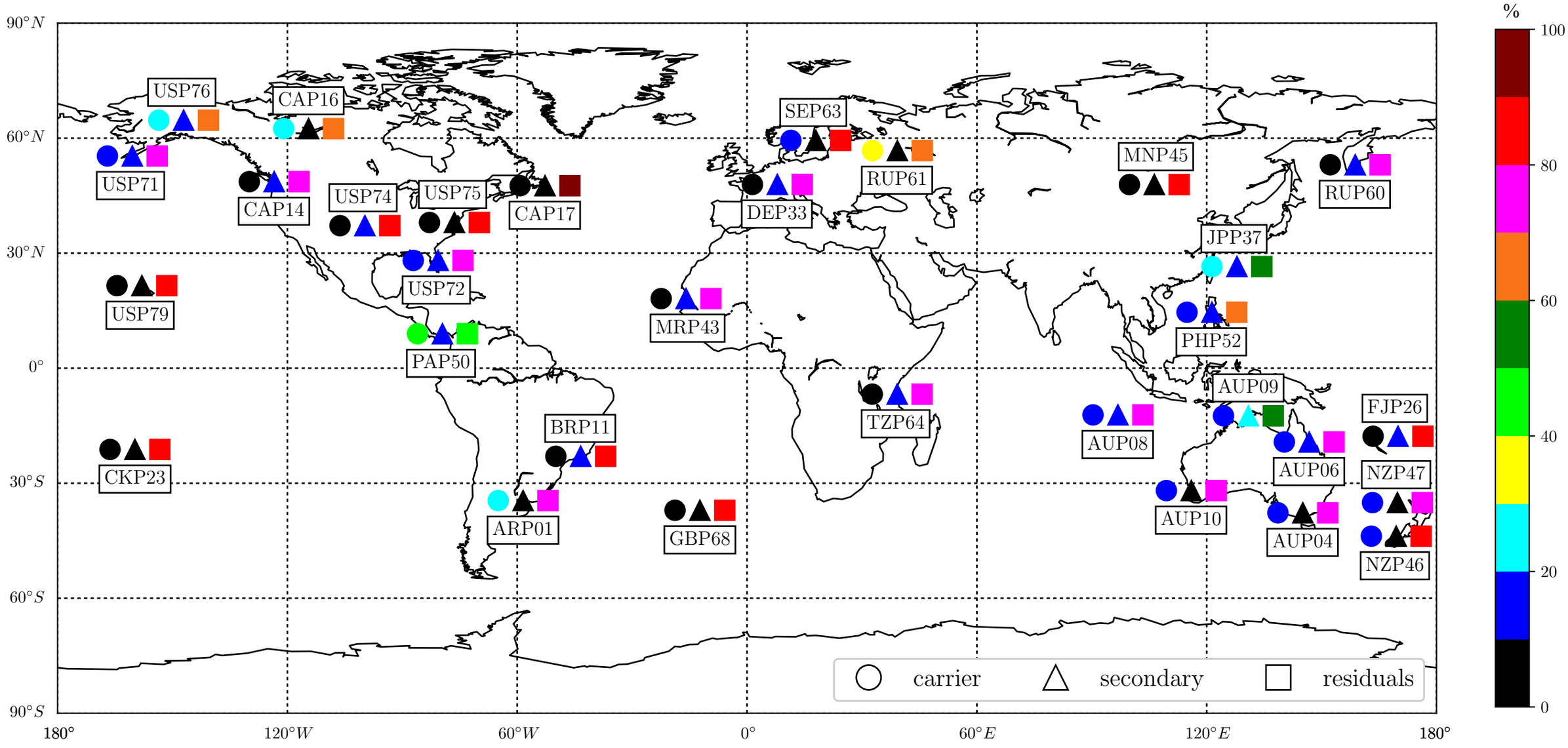
$$F_q(n) = \left[\frac{1}{\lfloor N/n \rfloor}\sum_{t=1}^{\lfloor N/n \rfloor} F(n,s)^q\right]^{1/q} \sim n^{h(q)}$$

Values of H between 0 and 0.5 indicate anticorrelation, H=0.5 corresponds to white noise, 0.5 < H < 1 indicates long range correlations, H=1 is the equivalent of pink noise (i.e. power spectrum going as the inverse of the frequency), 1 < H < 1.5 indicates stronger long range correlations, and H=1.5 corresponds to brownian noise.

Detrended Cross-Correlation Analysis

$$F_{xy}(n) = \left[\frac{1}{N}\sum_{t=1}^{N}(M_{t1} - L_{t1})(M_{t2} - L_{t2})\right]^{1/2}$$

Beryllium



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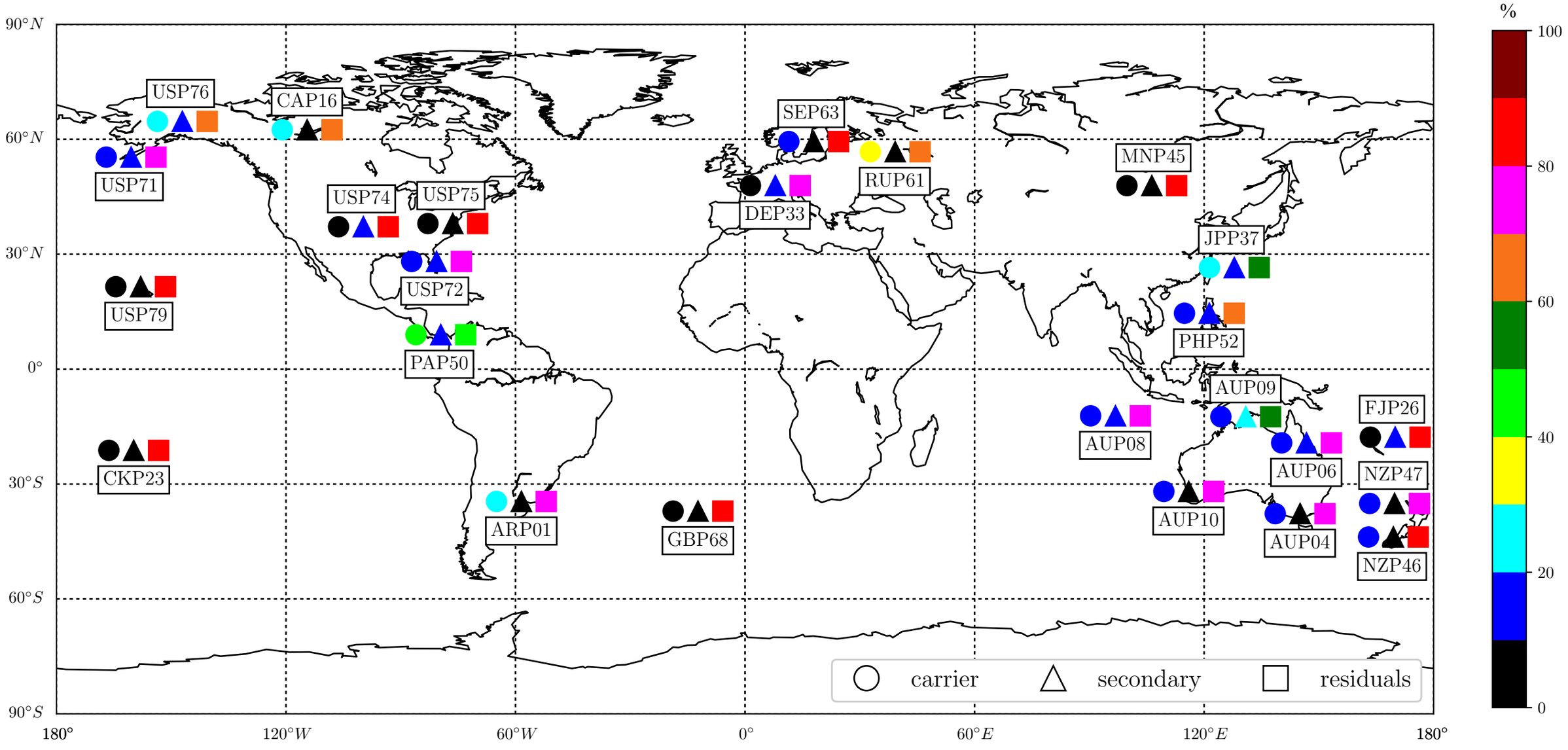

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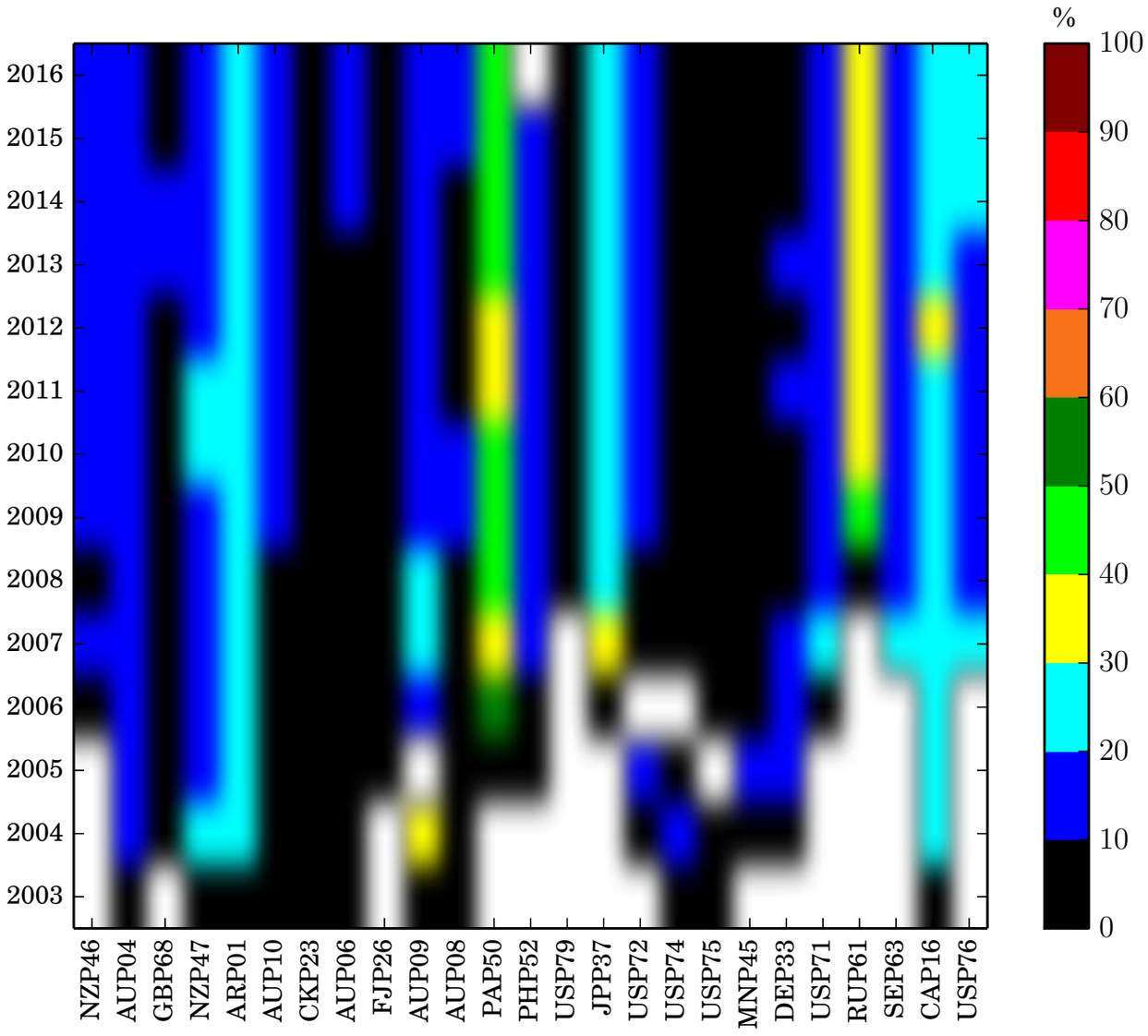

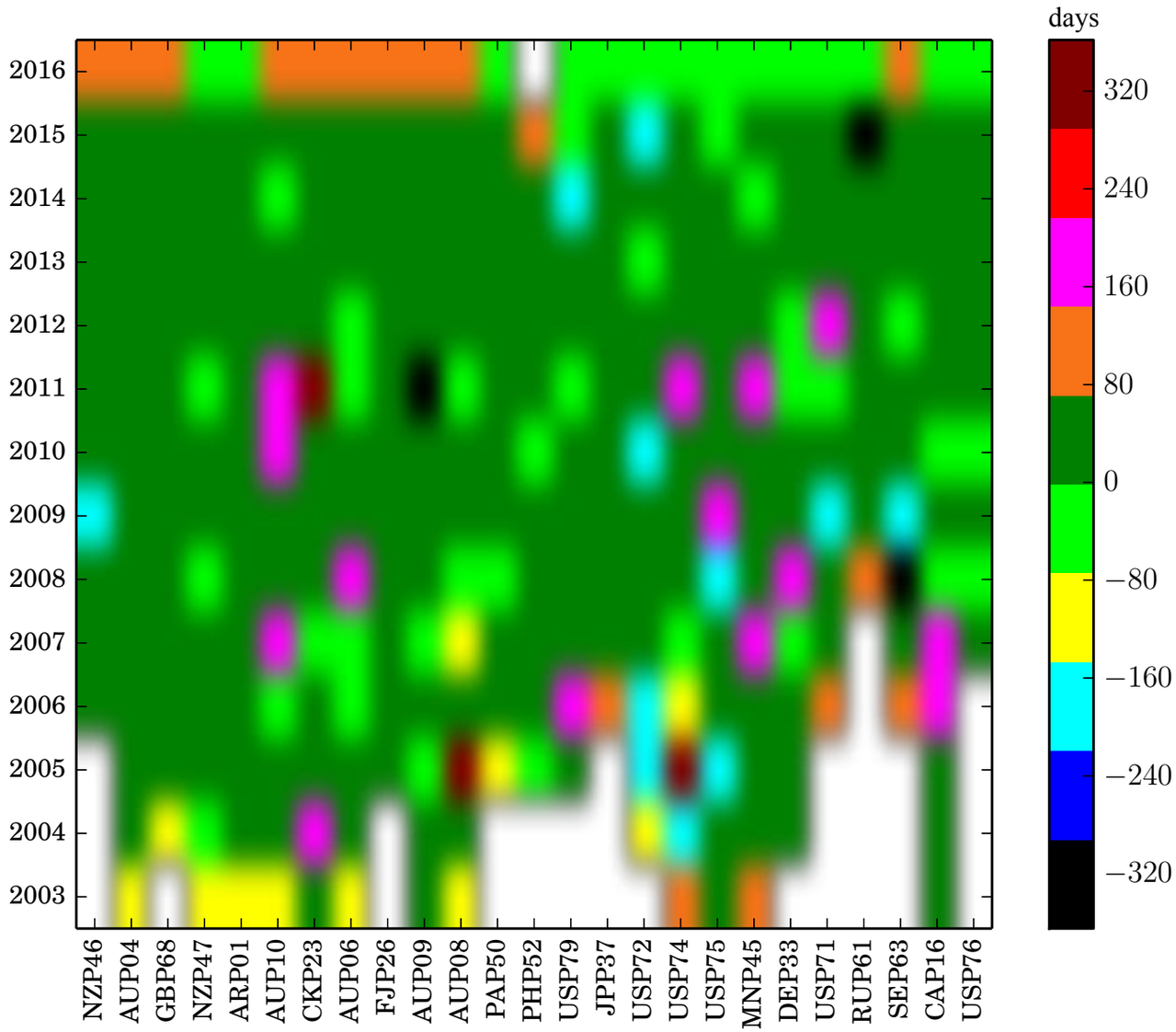

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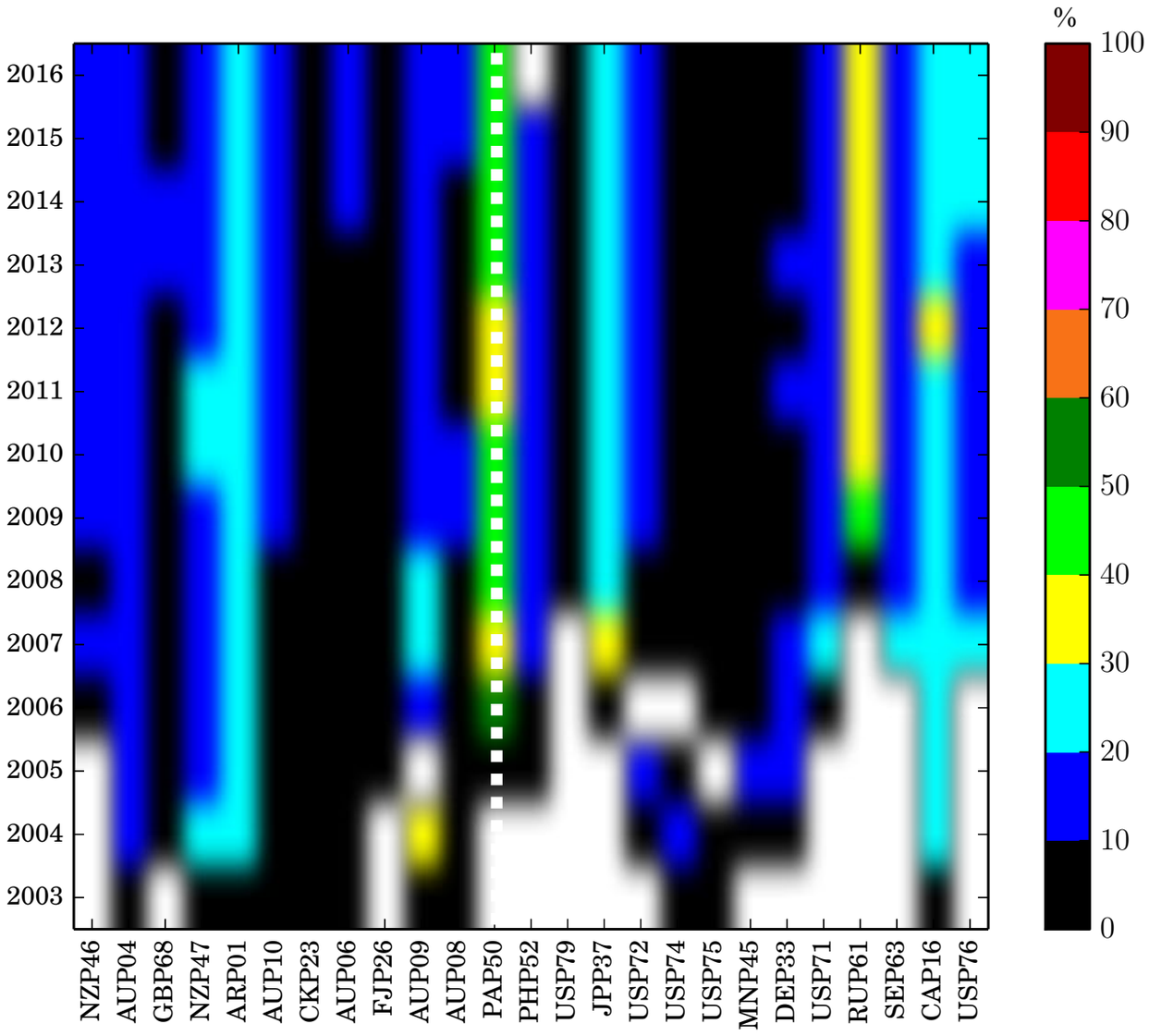
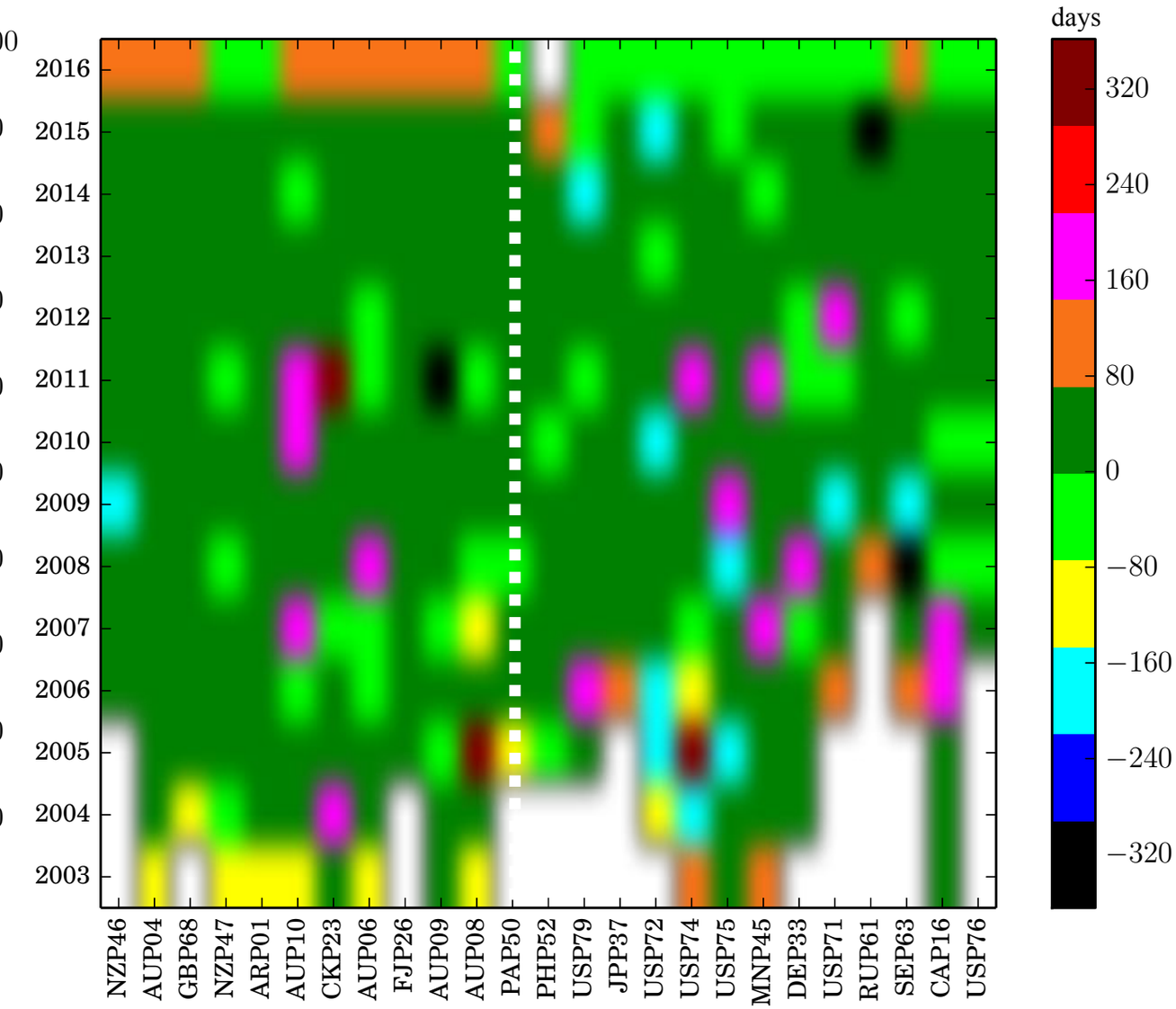
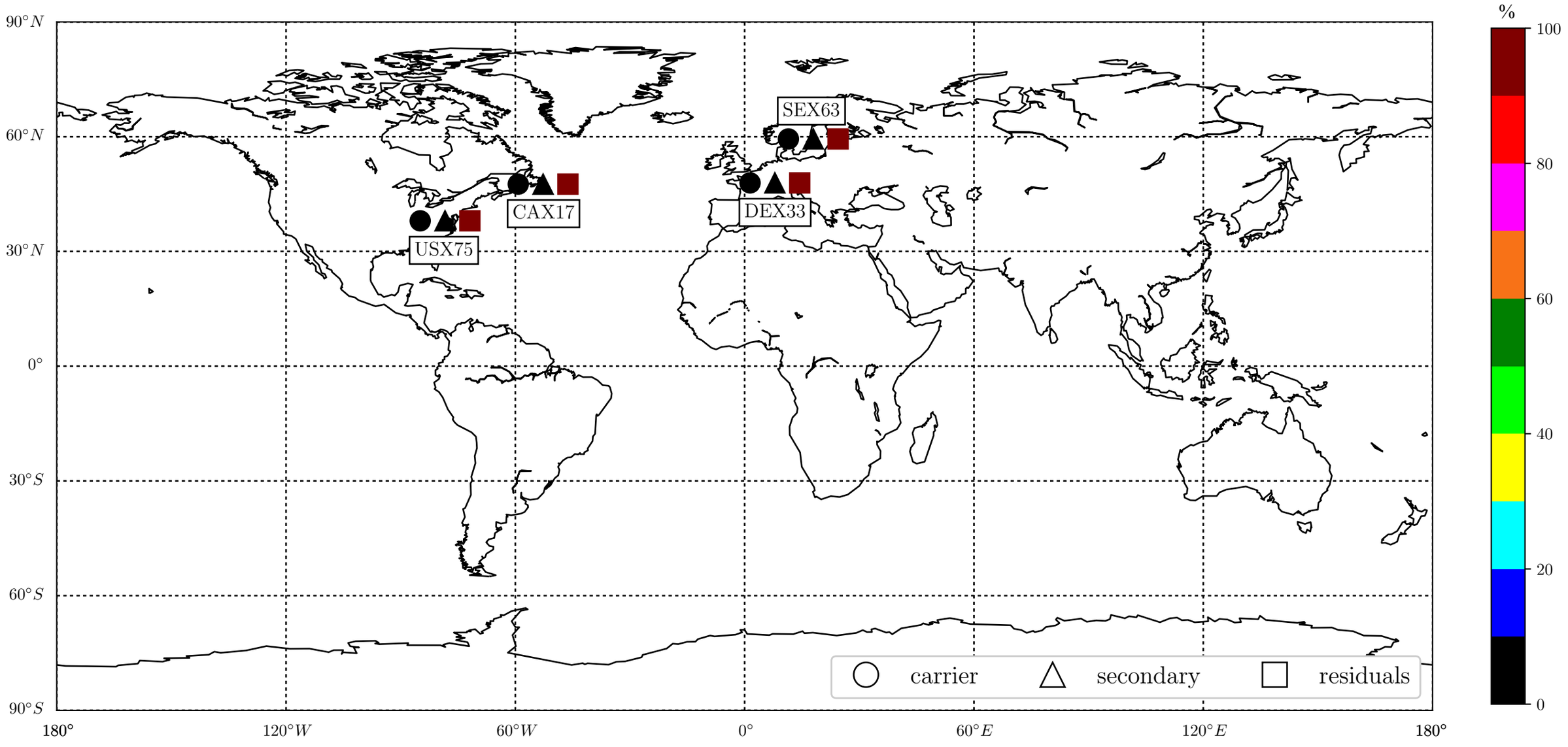




Xenon



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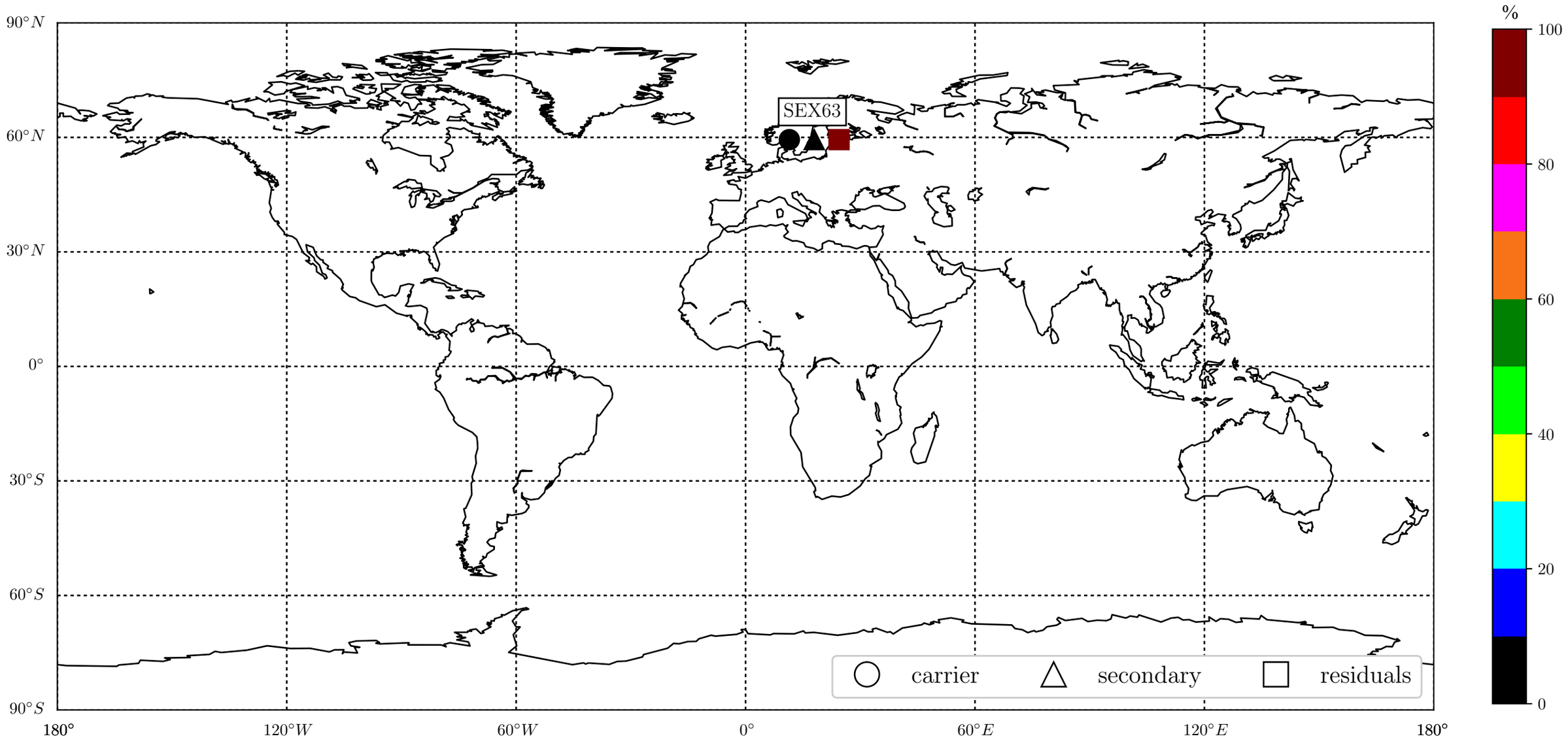
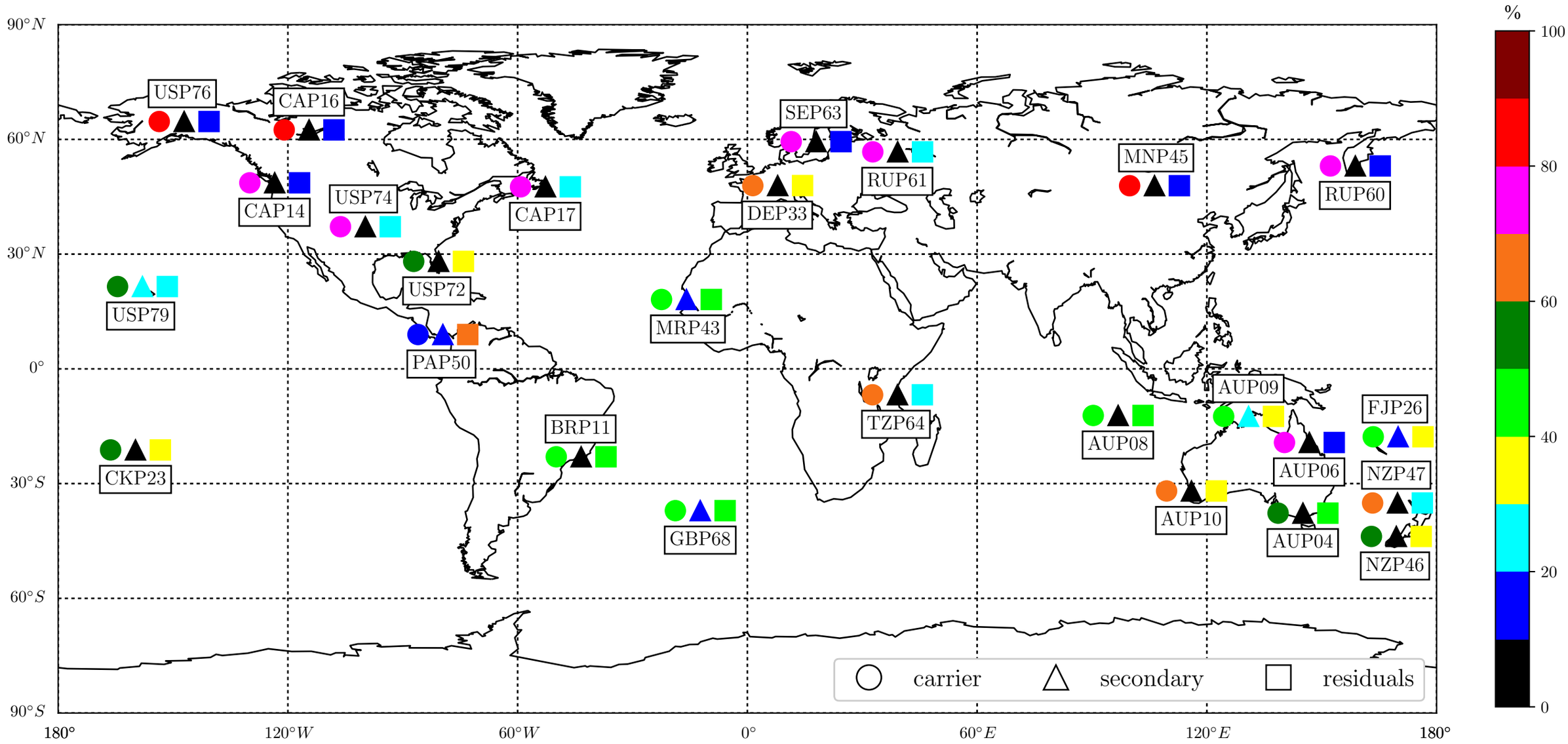


Air Temperature



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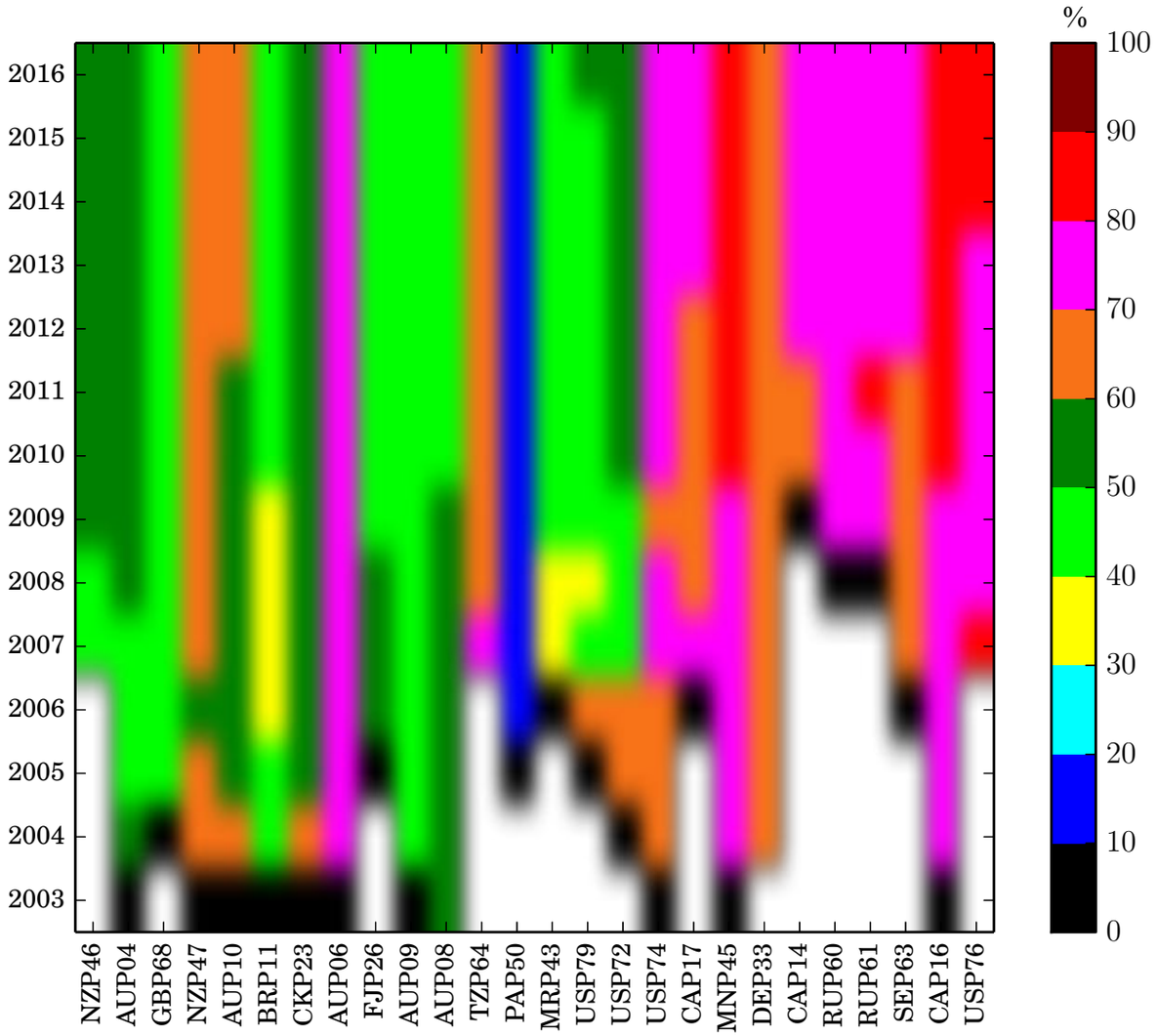

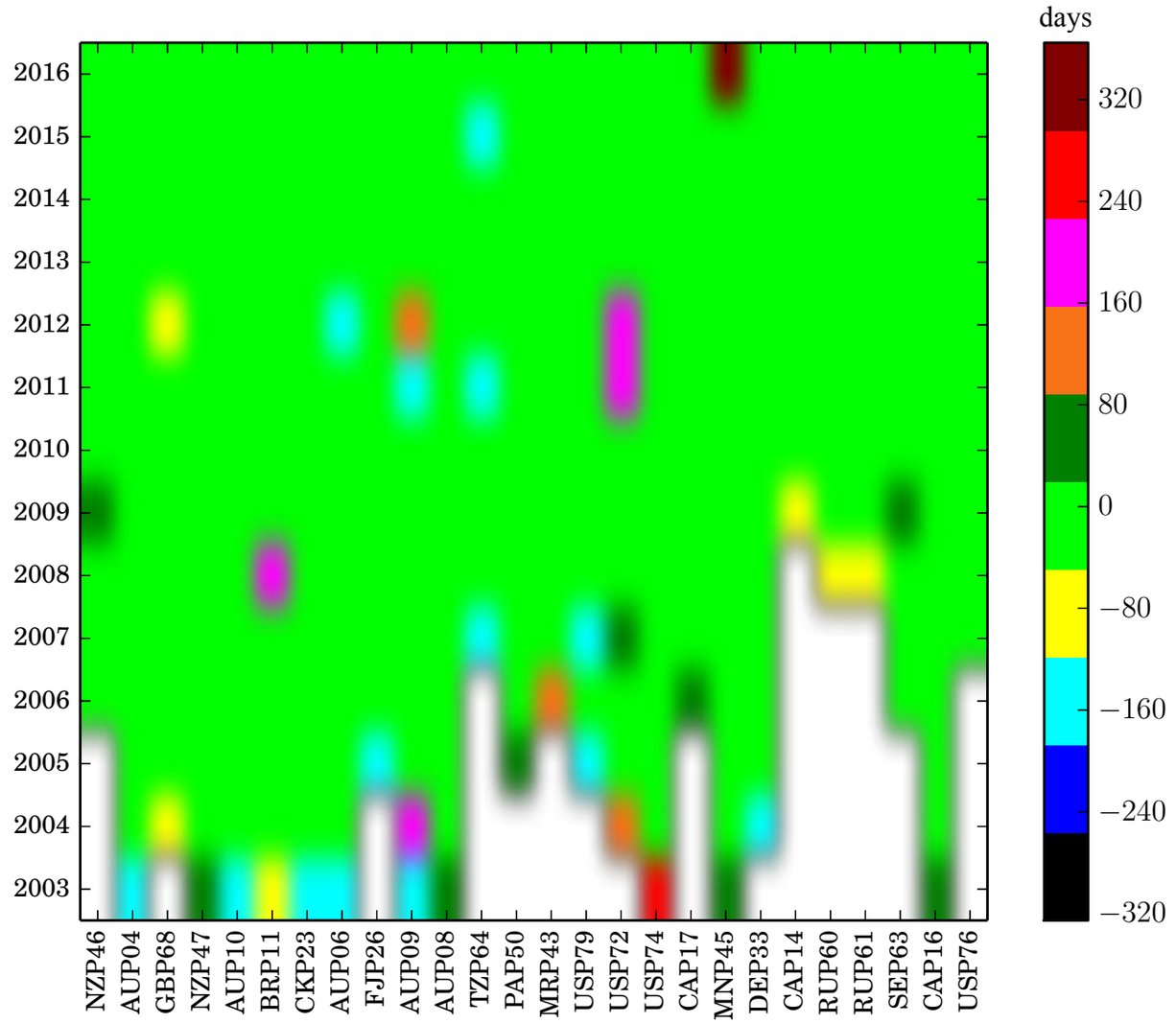

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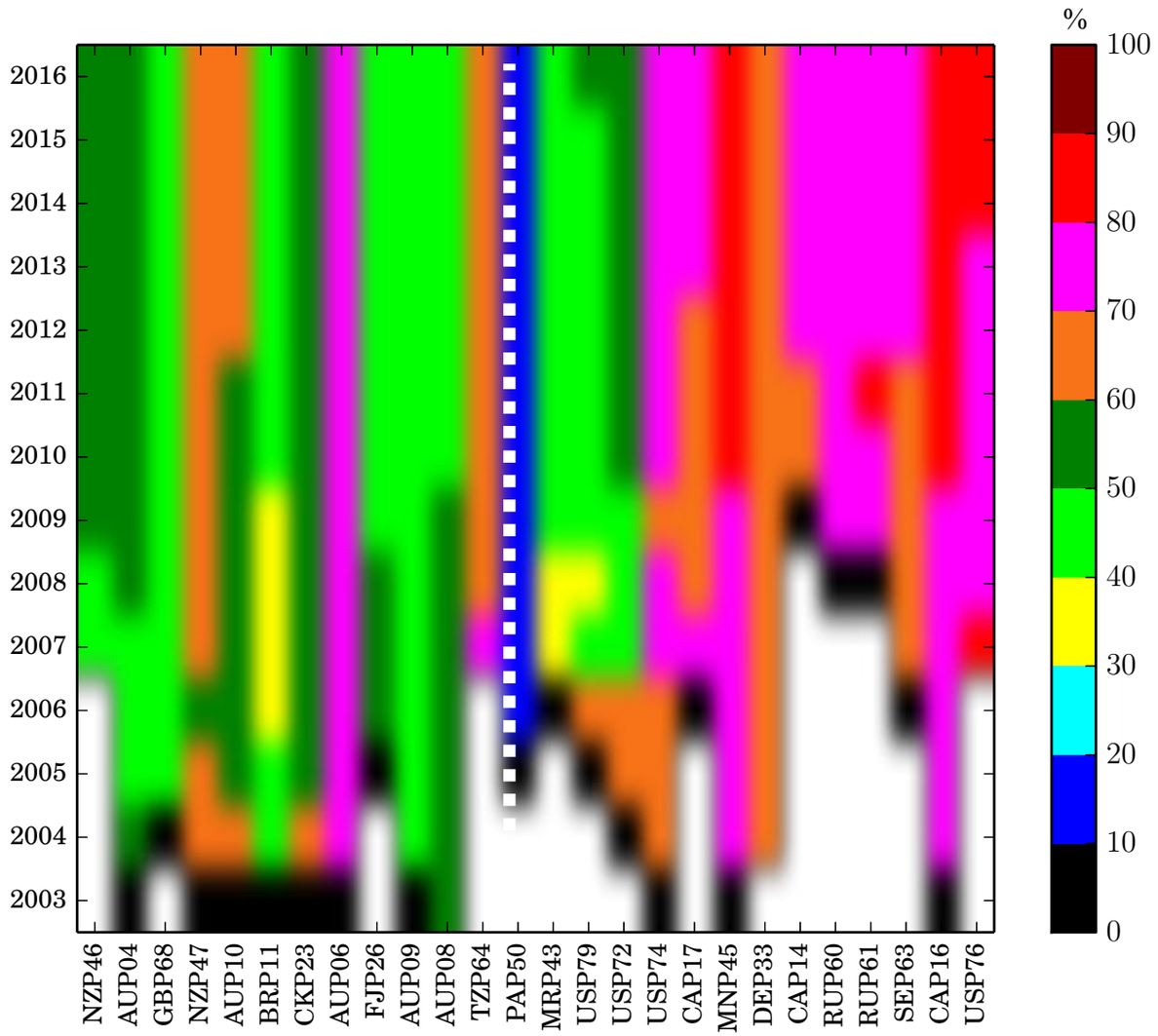
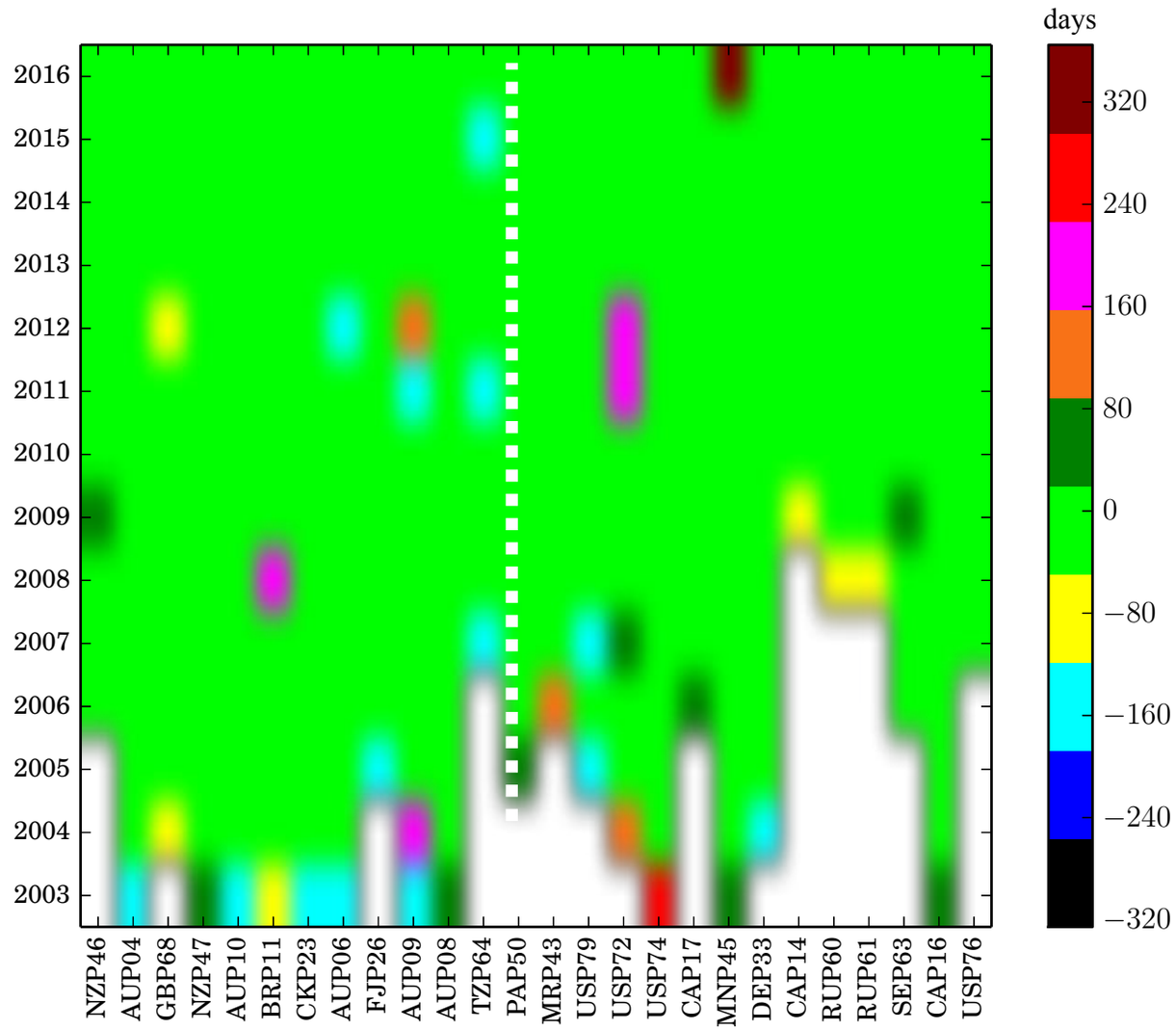
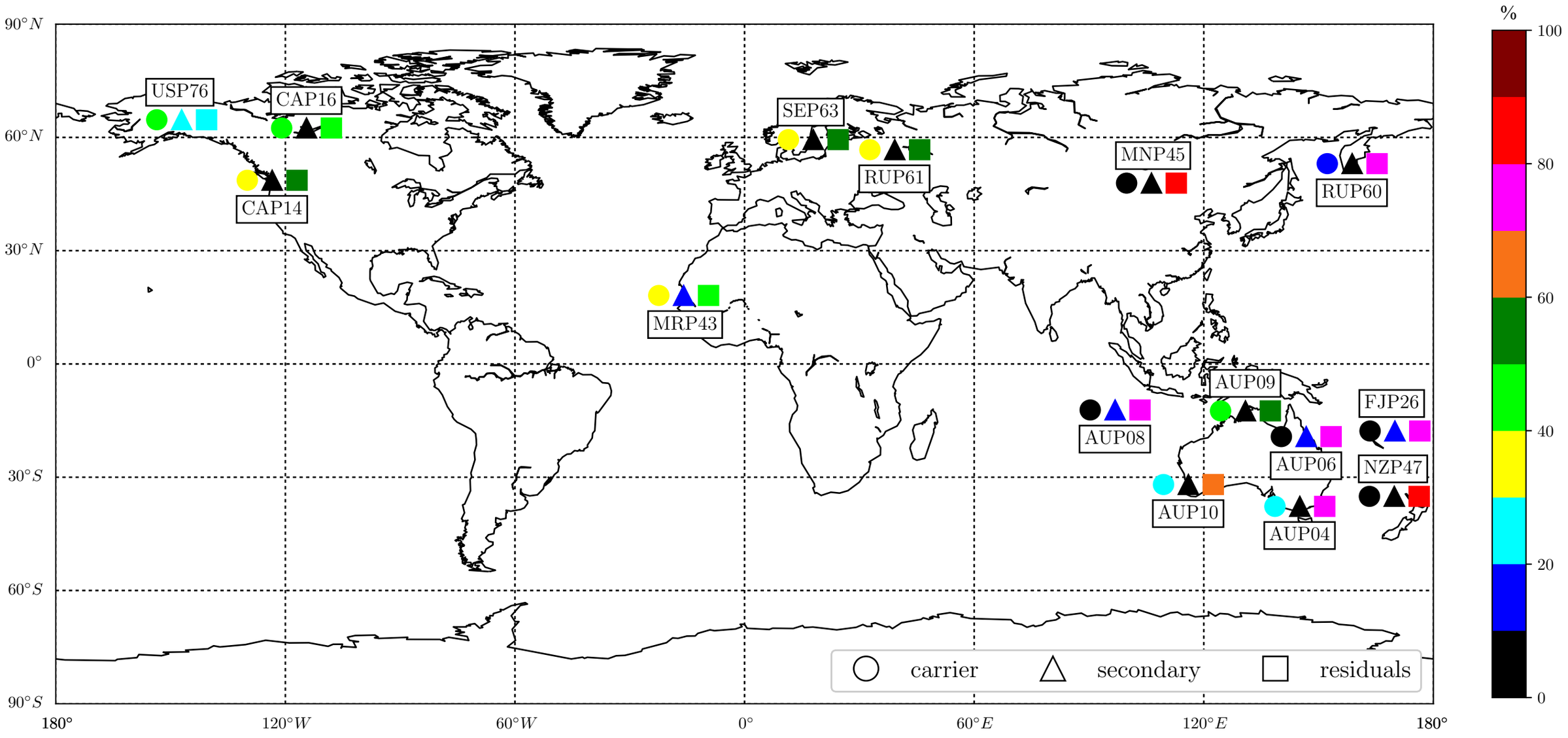




Air Humidity



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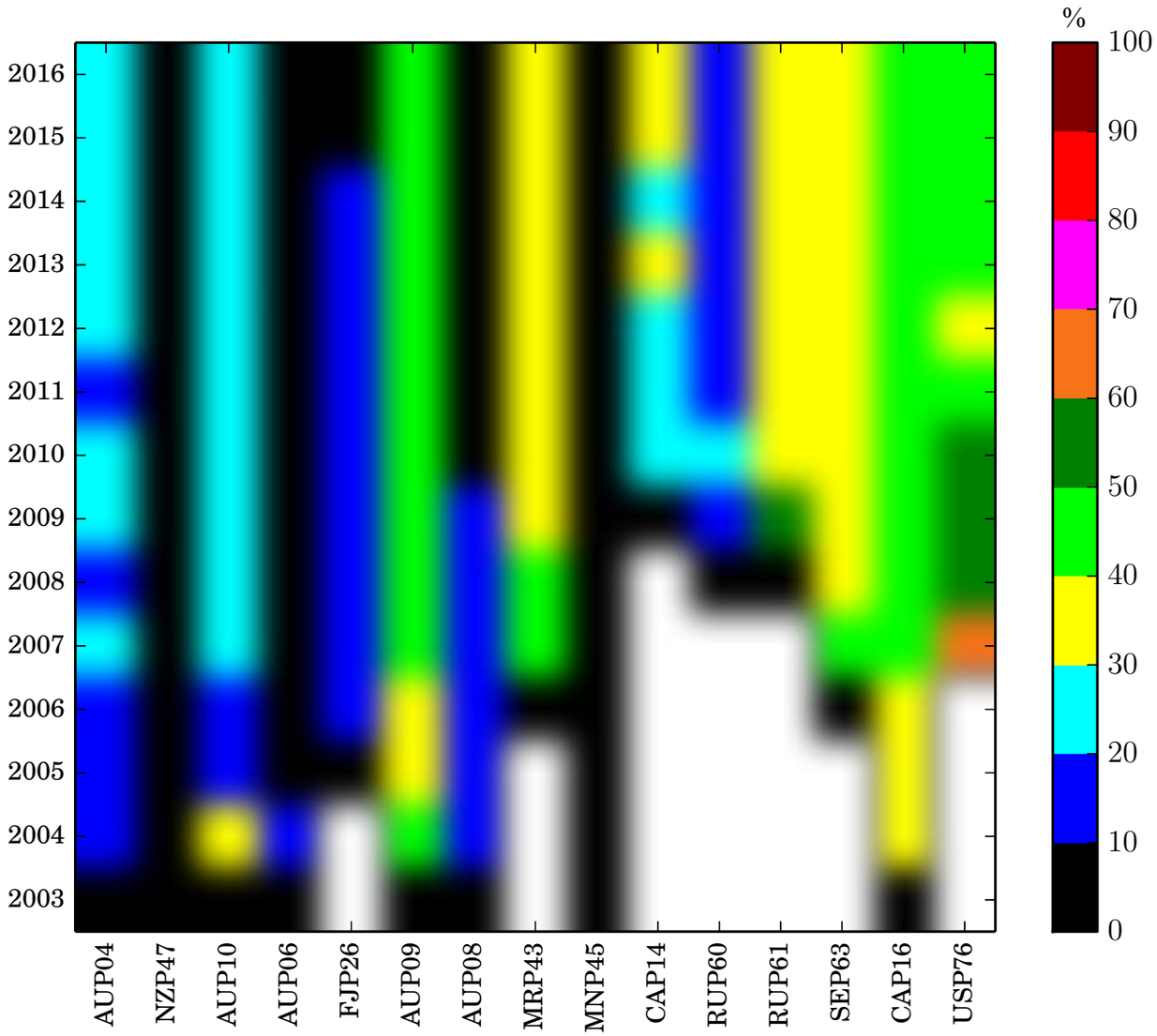

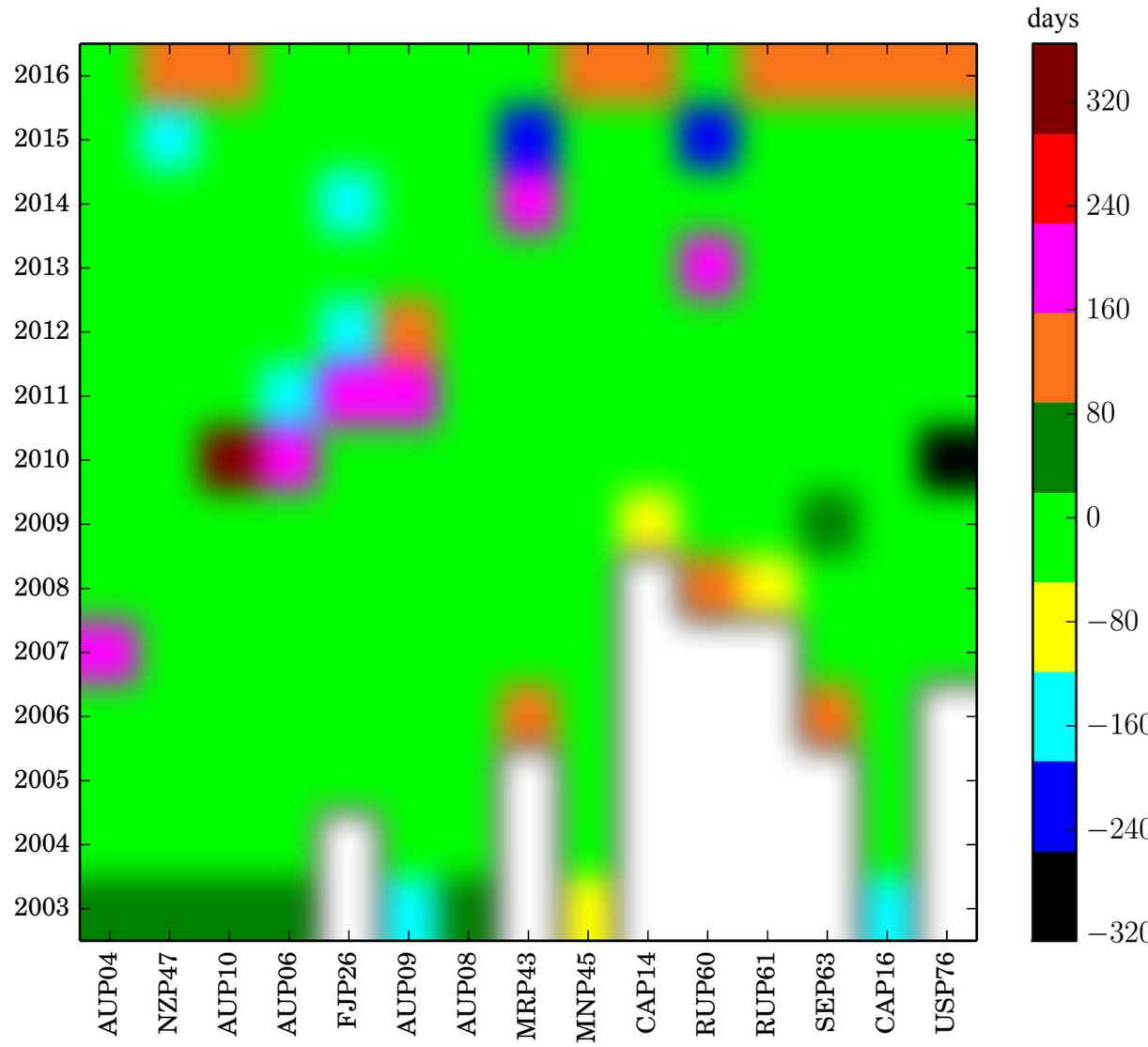

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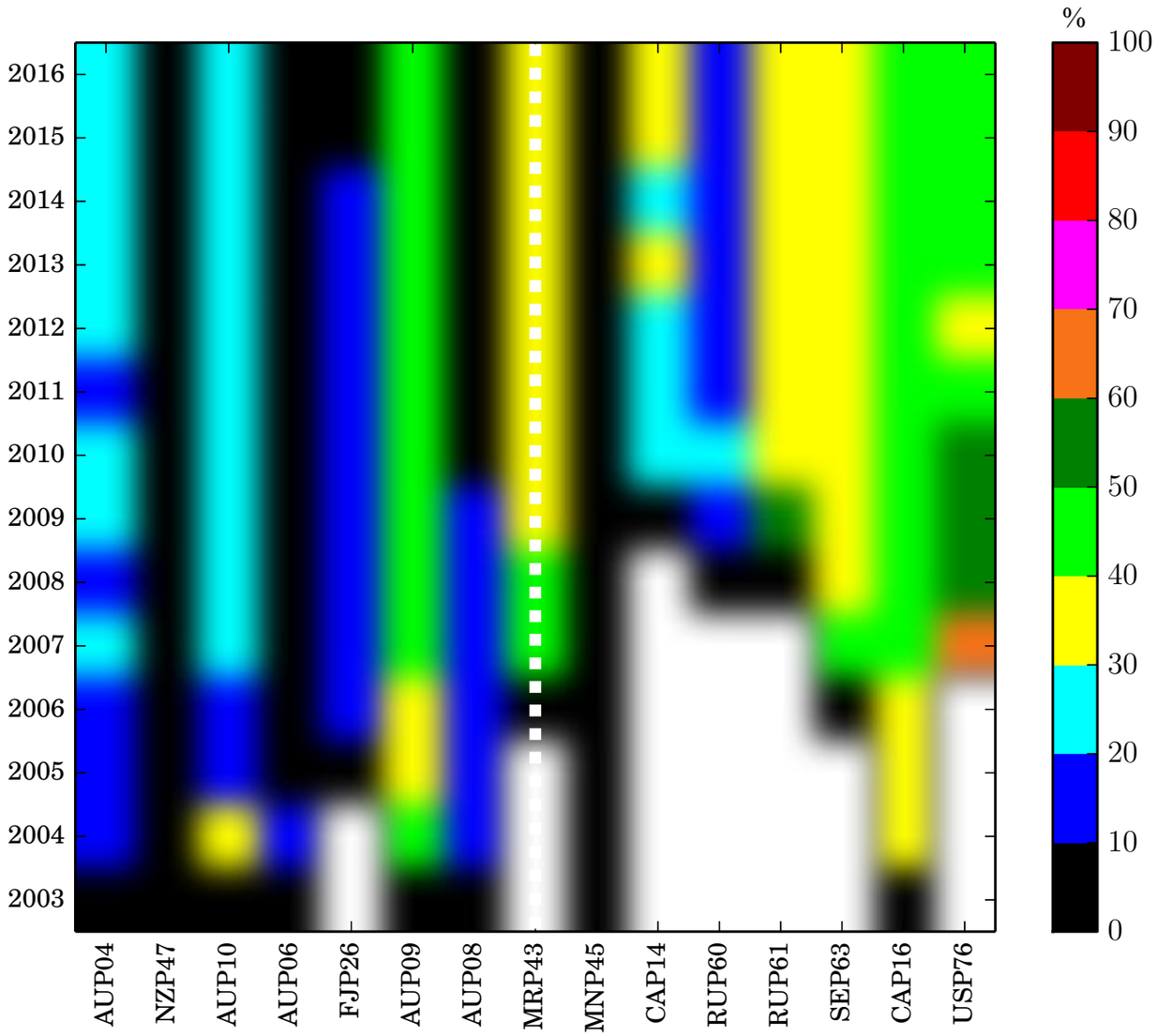
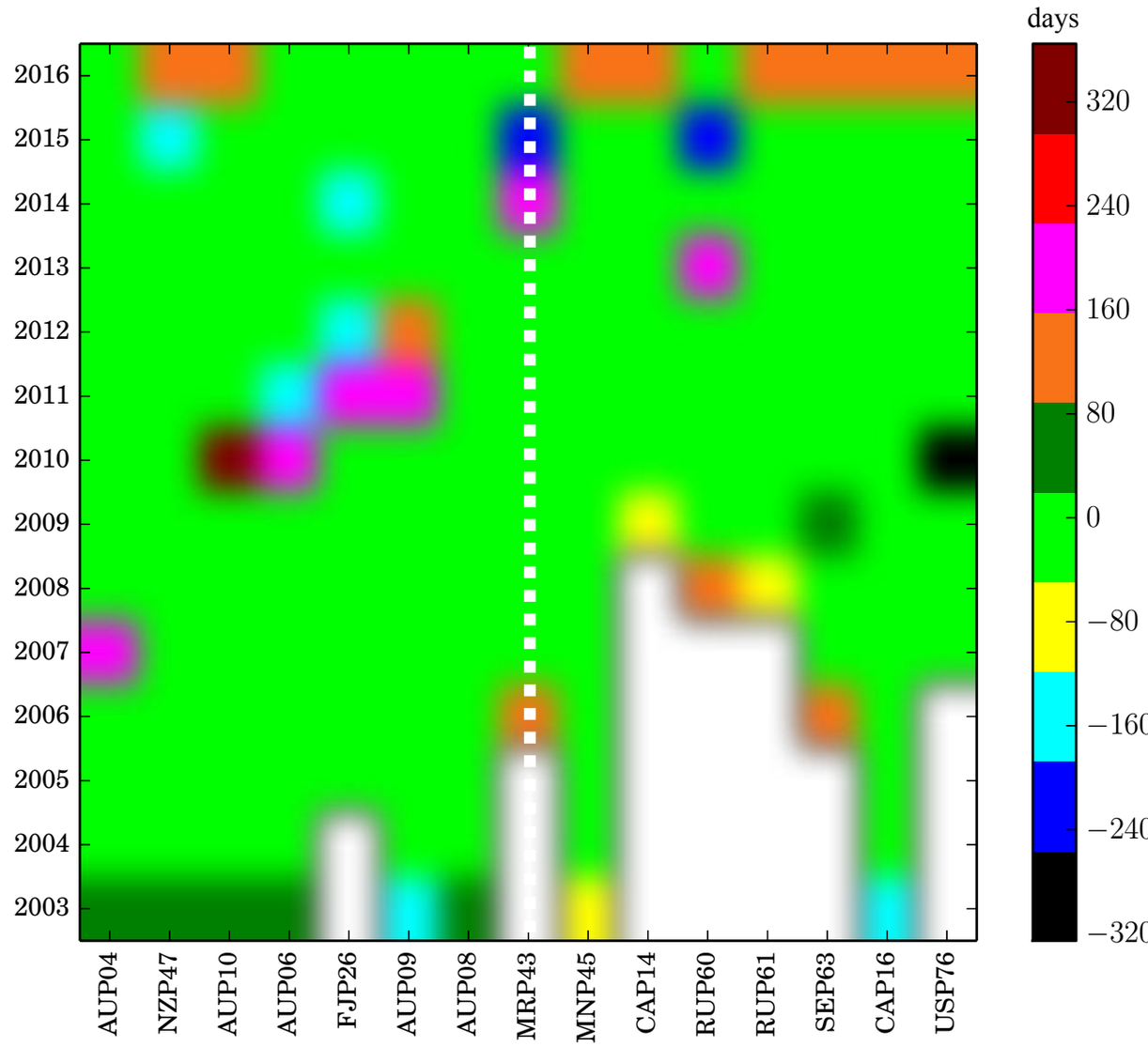
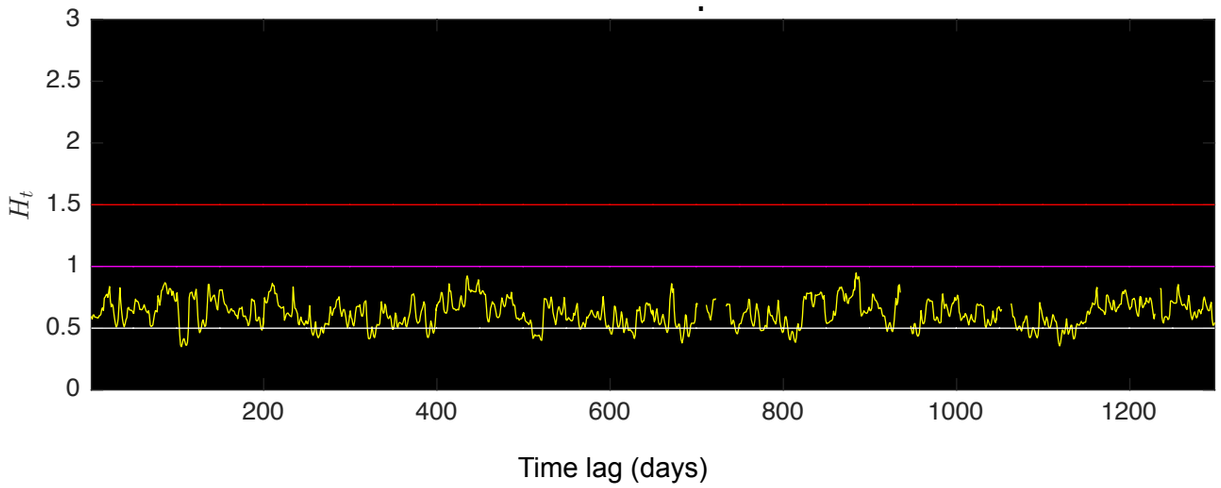
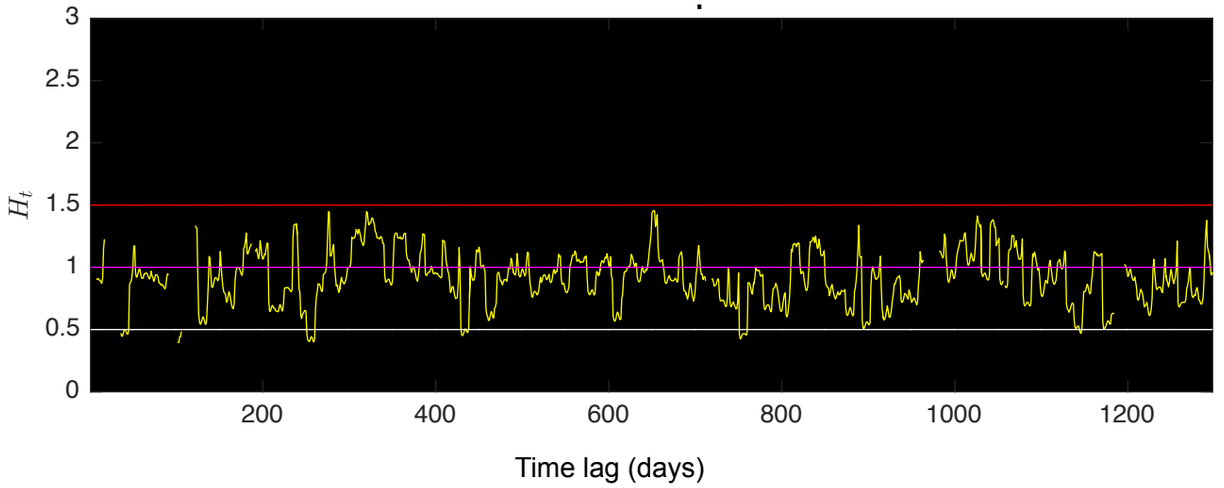




Beryllium



Xenon



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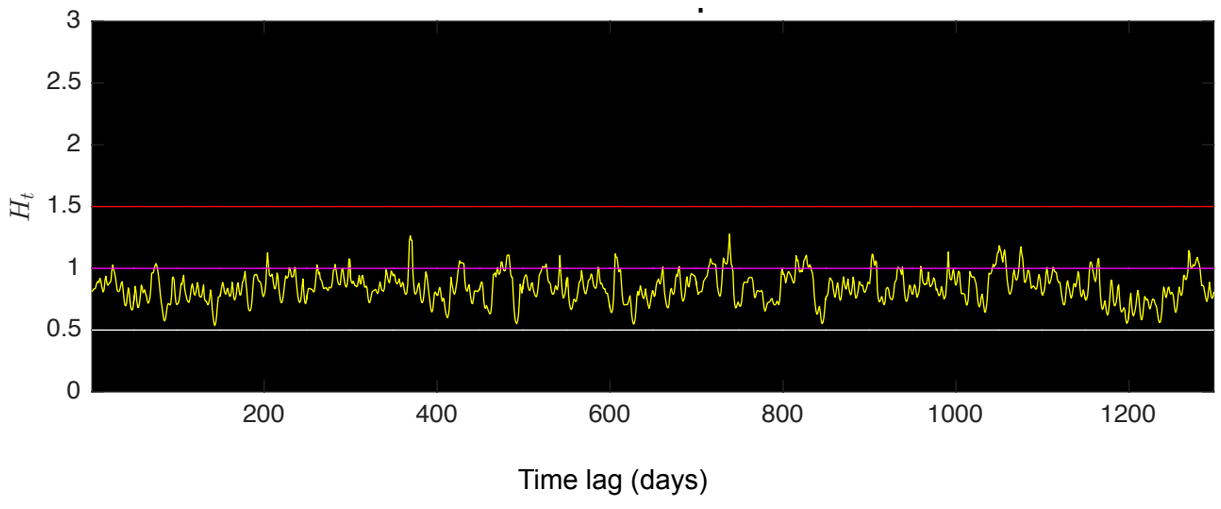

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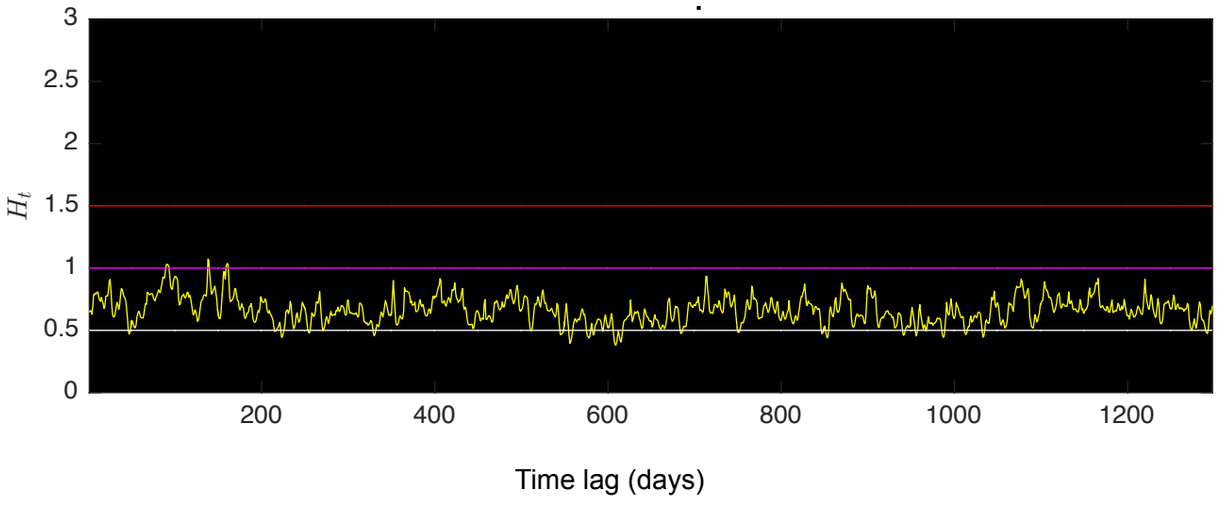

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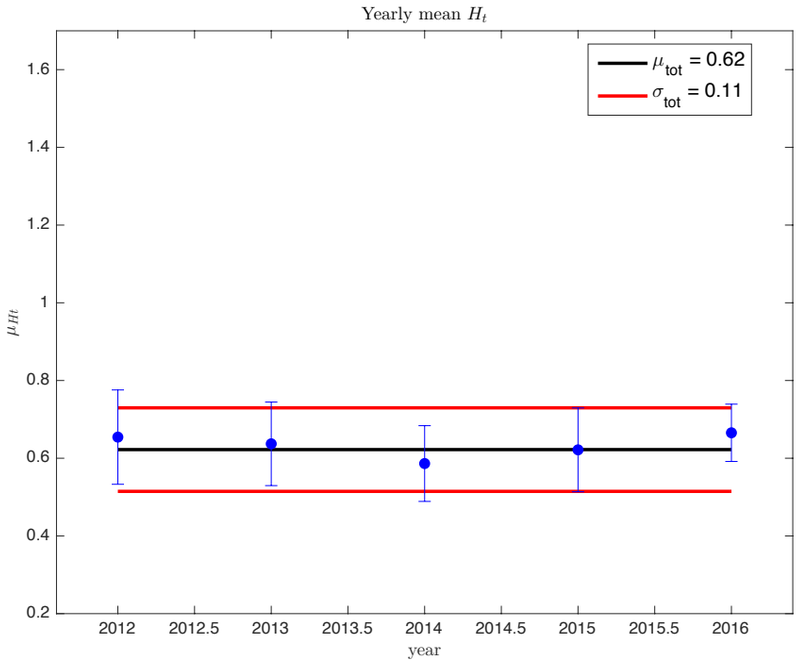

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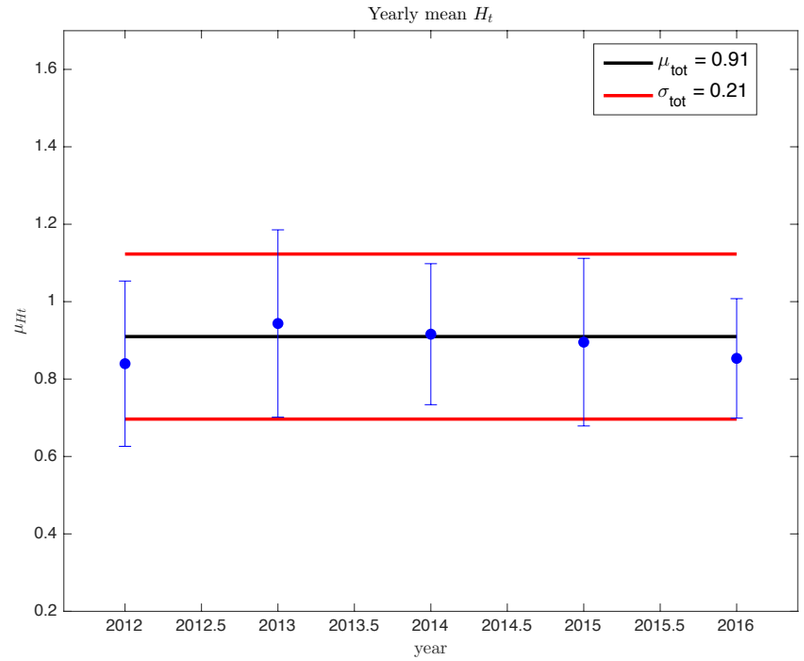

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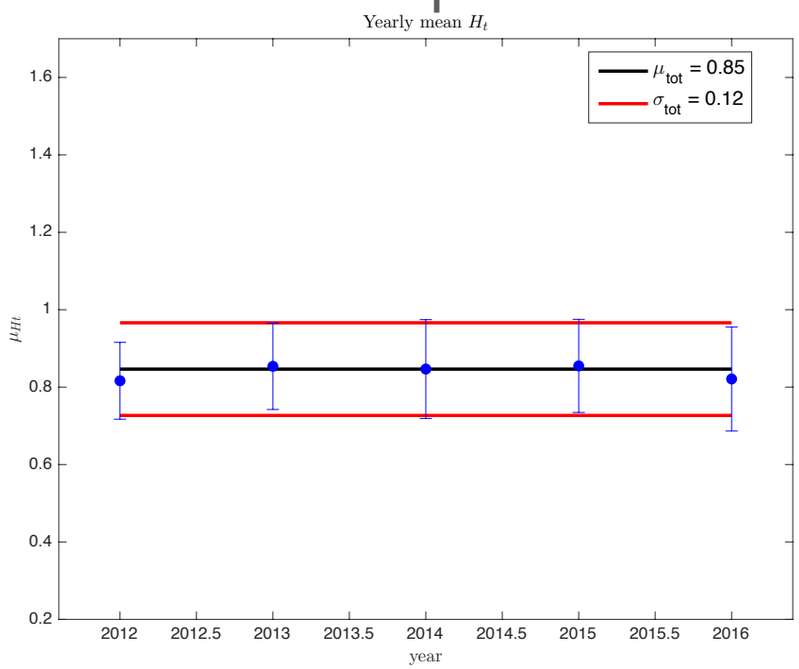

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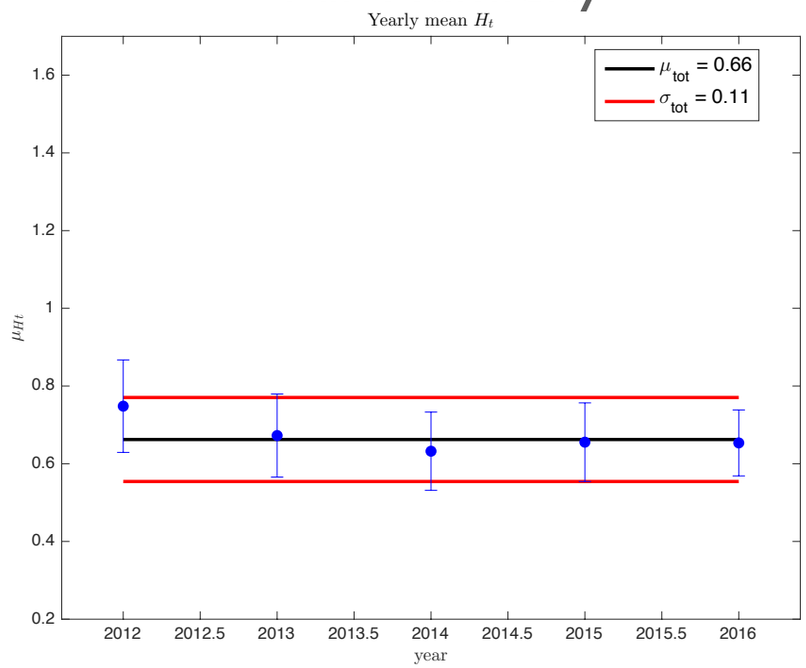

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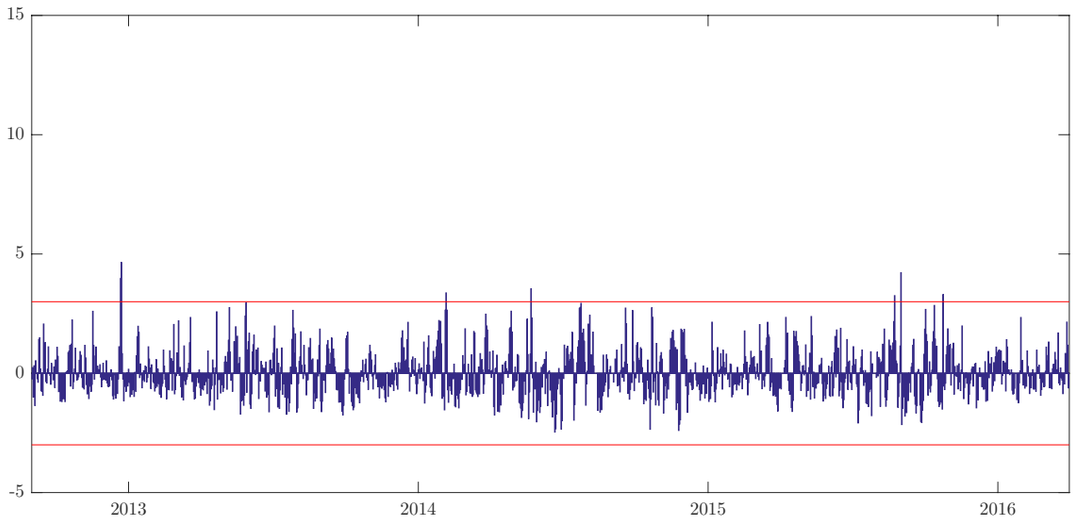

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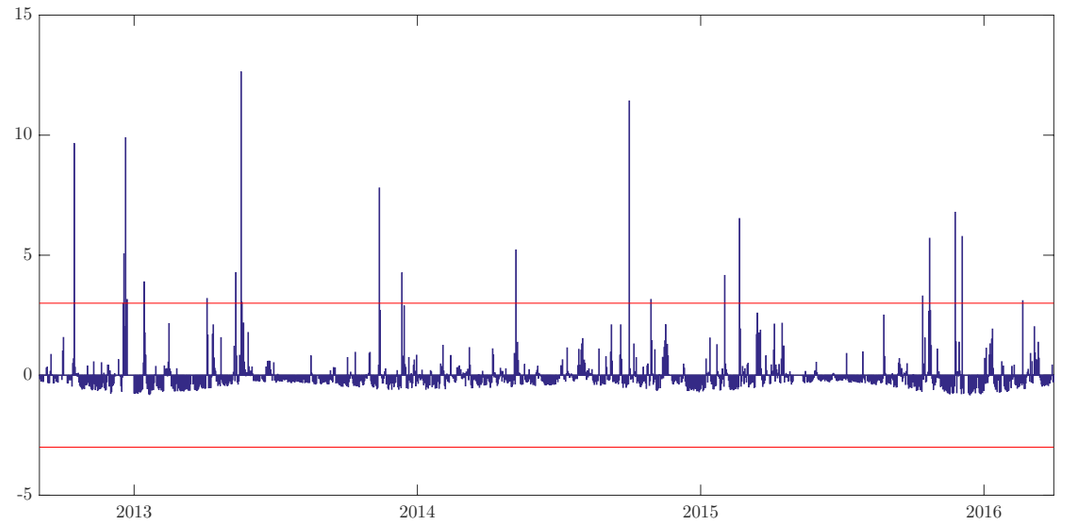

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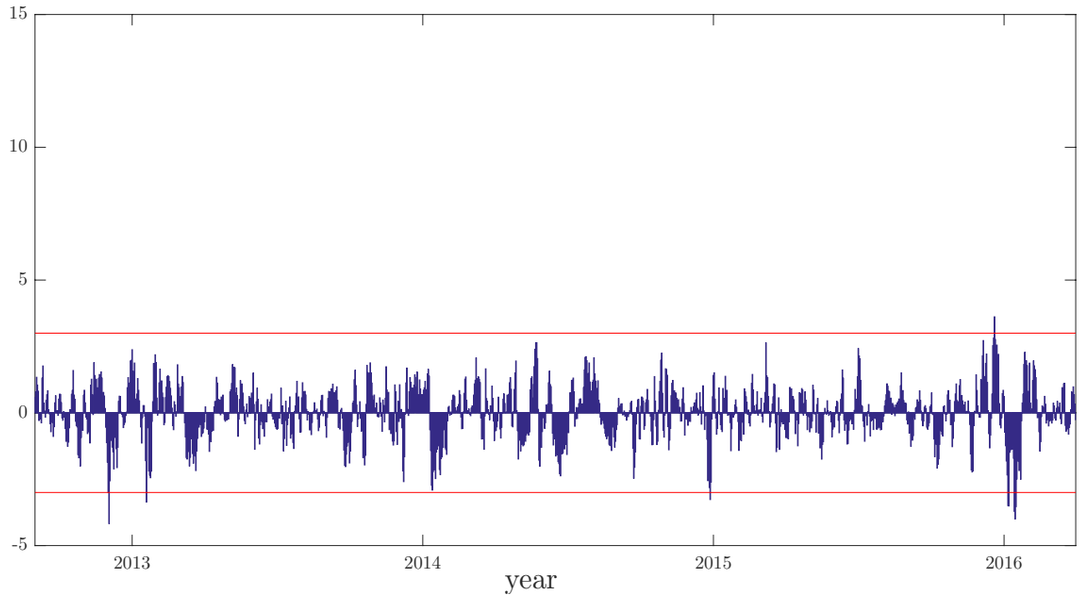

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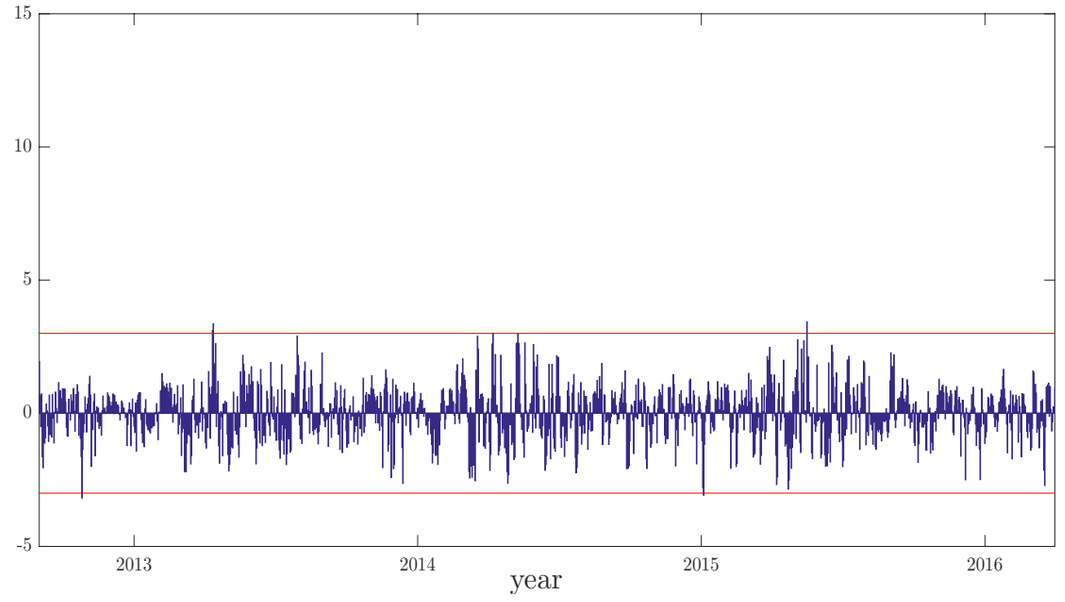

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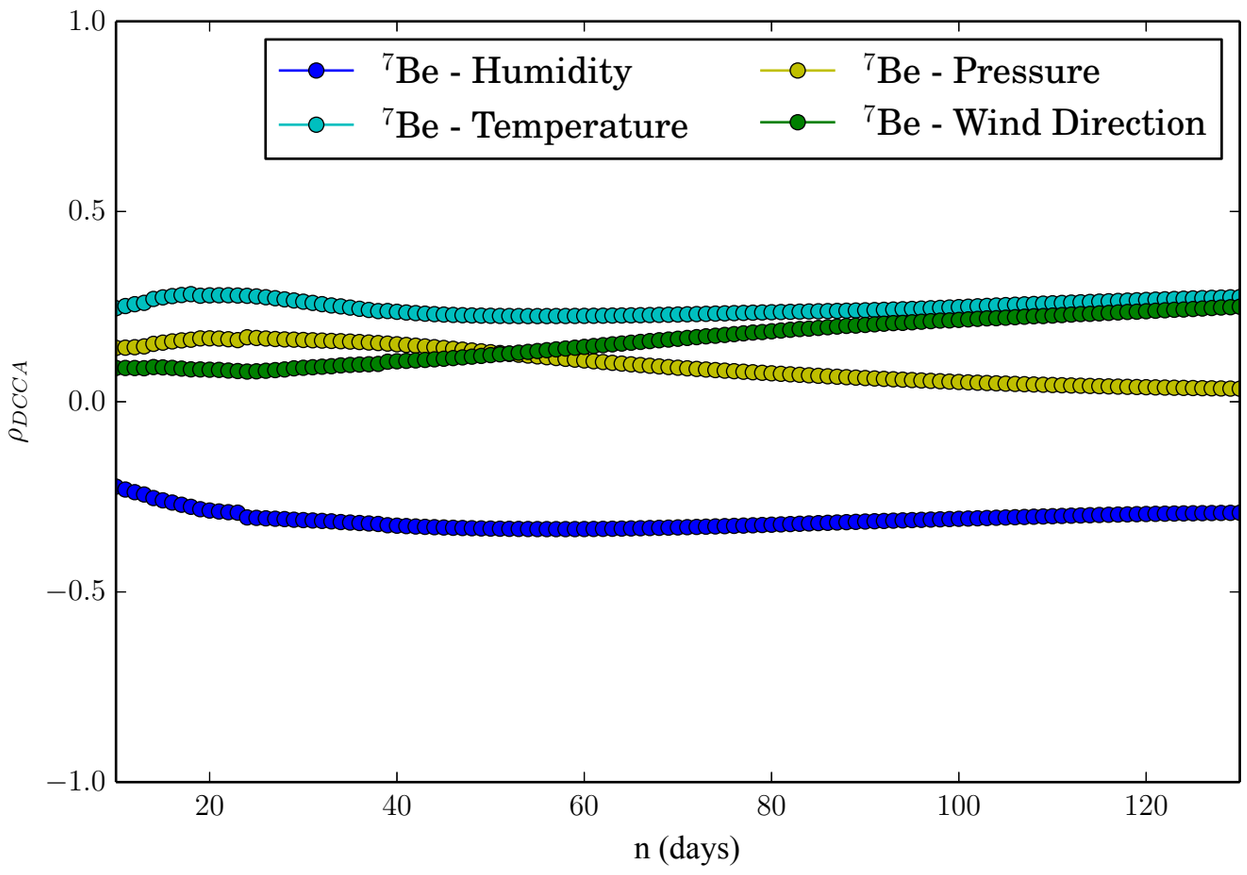

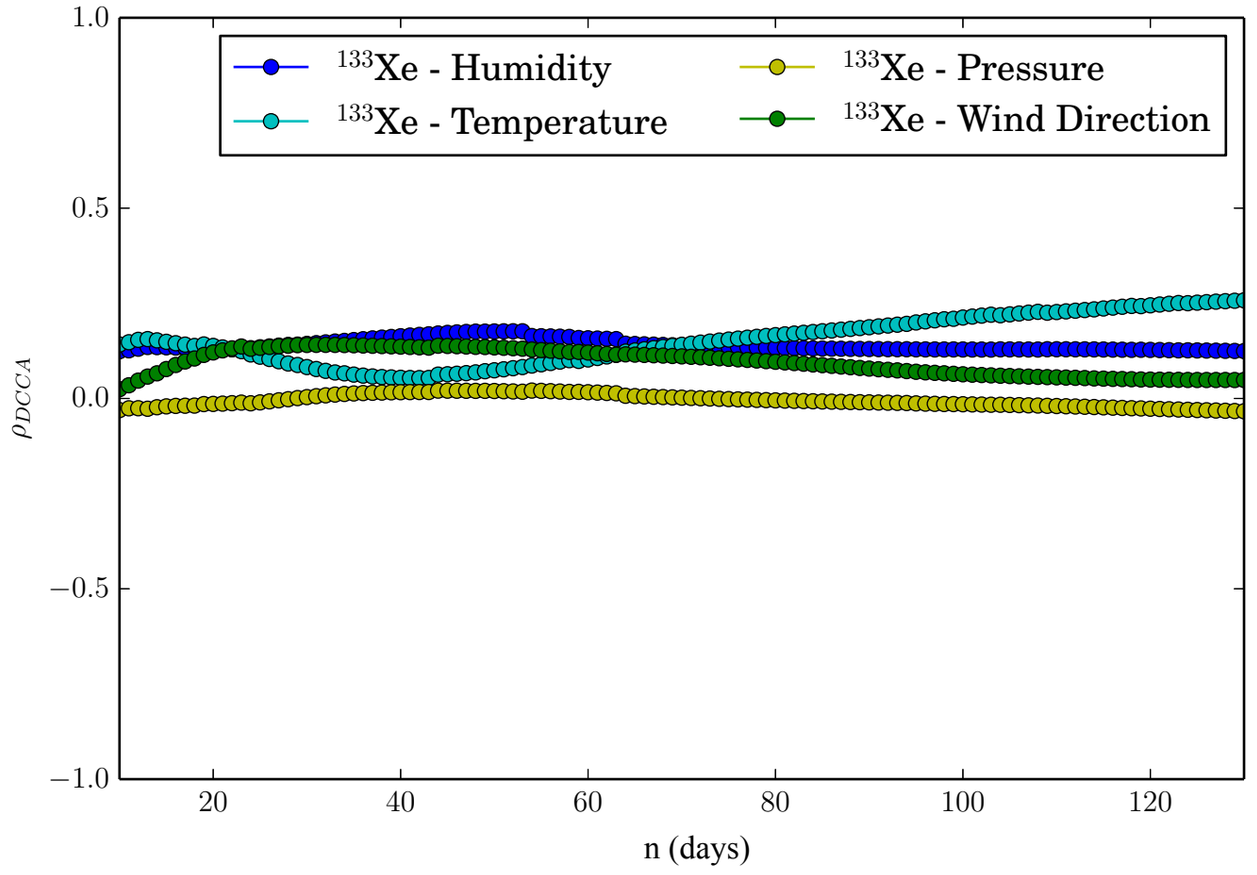

Conclusions

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- Forward and backward modelling for CTBTO network should be based on preliminary characterization of each relationship between IMS Stations — *from local to global scale* —

- Source - Receptor Modelling for CTBT event screening categorization should be normalized to local *vs* local-global scale approaches — *global scale* —

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Accidere ex una scintilla incendia passim
Titus Lucretius Carus (De Rerum Natura, Liber V, 609)

Widespread fires flare up by a single spark

Acknowledgments

All views expressed are under the sole responsibility of the Authors and not of the CTBTO/PTS.

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