WAAS Ionospheric Research

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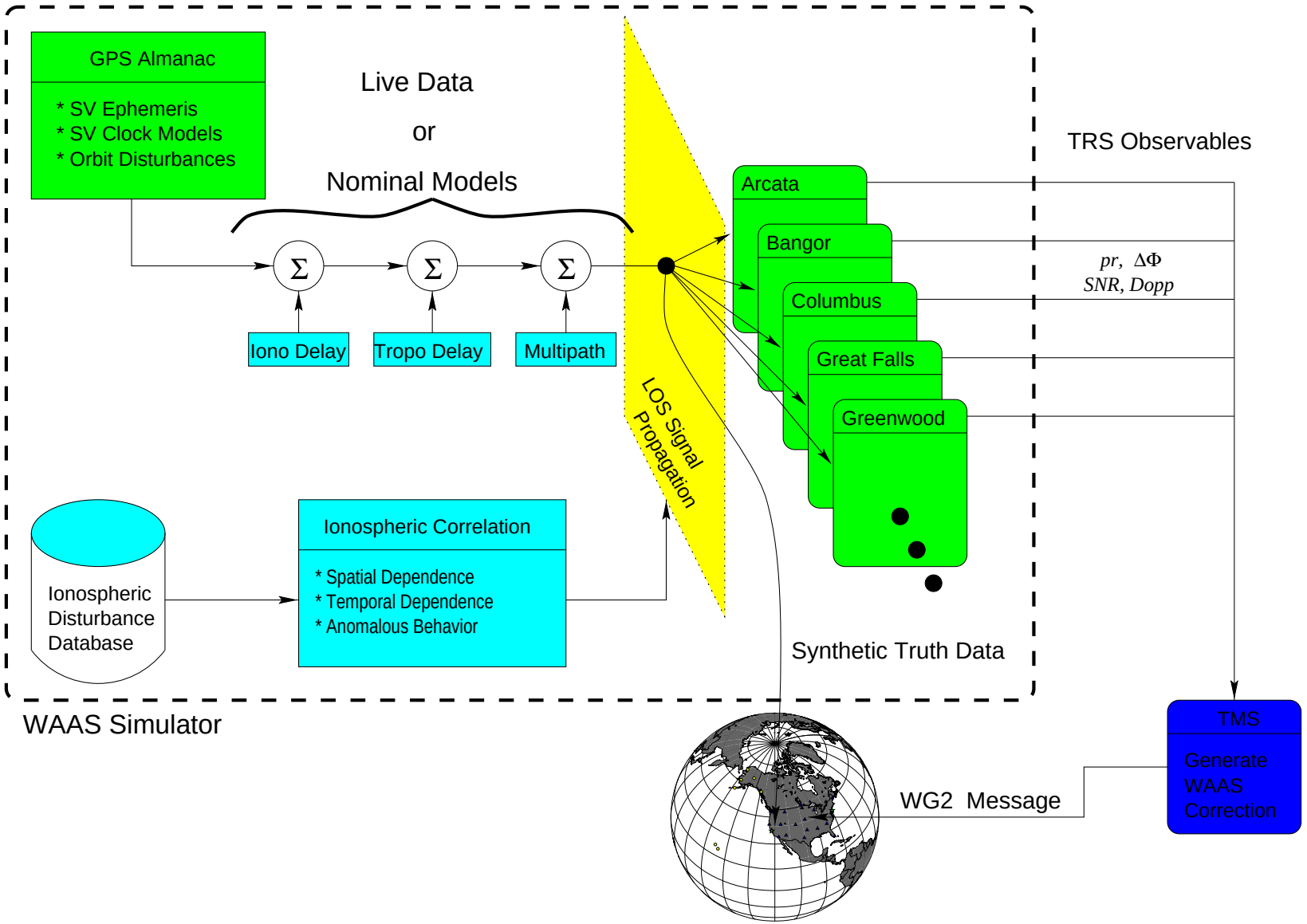
Abstract

This presentation summarizes a subset of the WAAS ionospheric research conducted by the WADGPS Laboratory at Stanford University estimation including high fidelity WAAS simulation and performance results during the 4 May 1998 ionospheric storm. The fundamental physical resource for the work is the National Satellite Test Bed (NSTB) reference network. The coupling of live data from the NSTB and the theoretical algorithms developed at Stanford has realized a working WAAS prototype with the capability of exploring operational difficulties and the sensitivities to natural variations such as the ionosphere. We present performance results for both live and synthetically disturbed conditions.

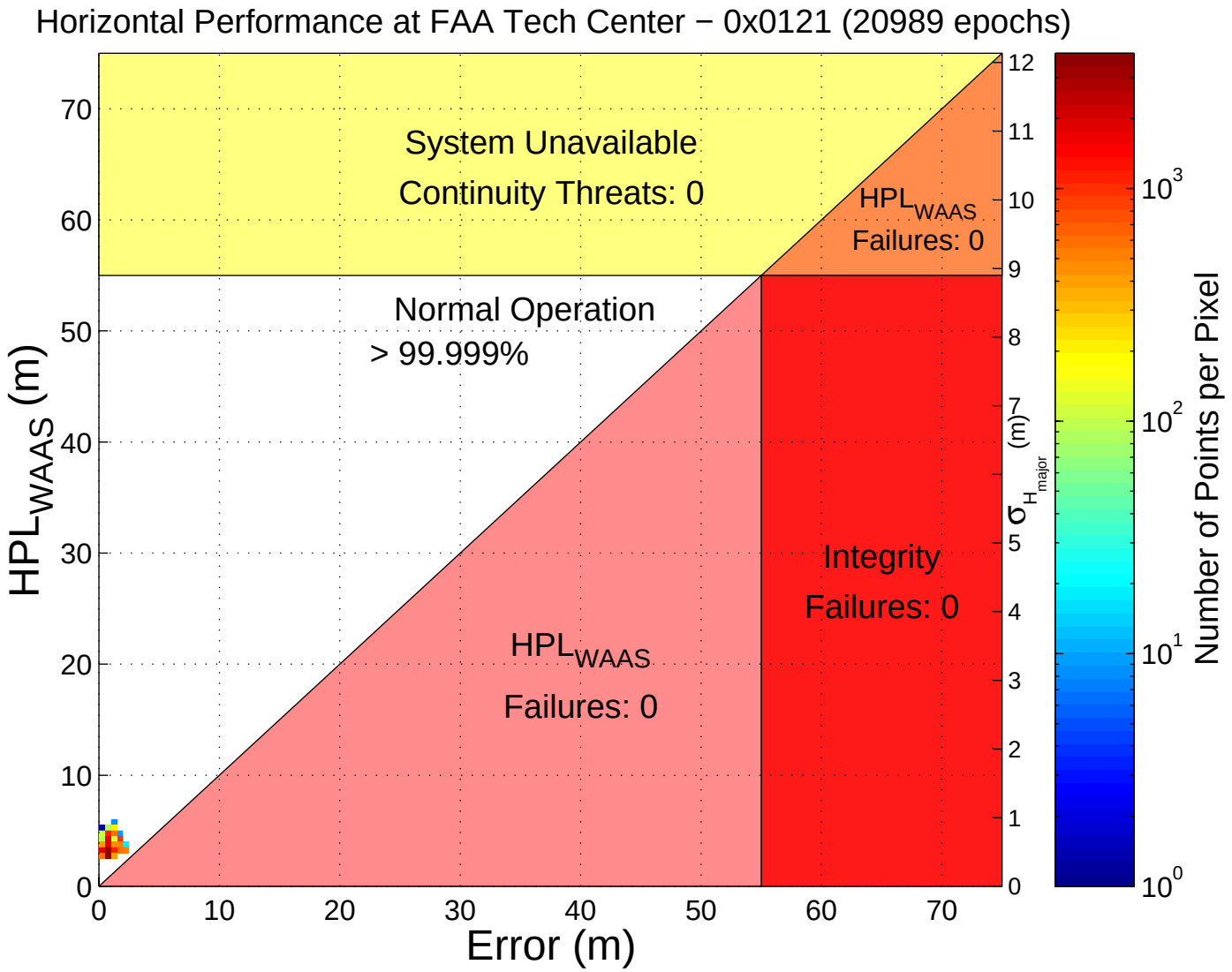
Software Simulator for WAAS



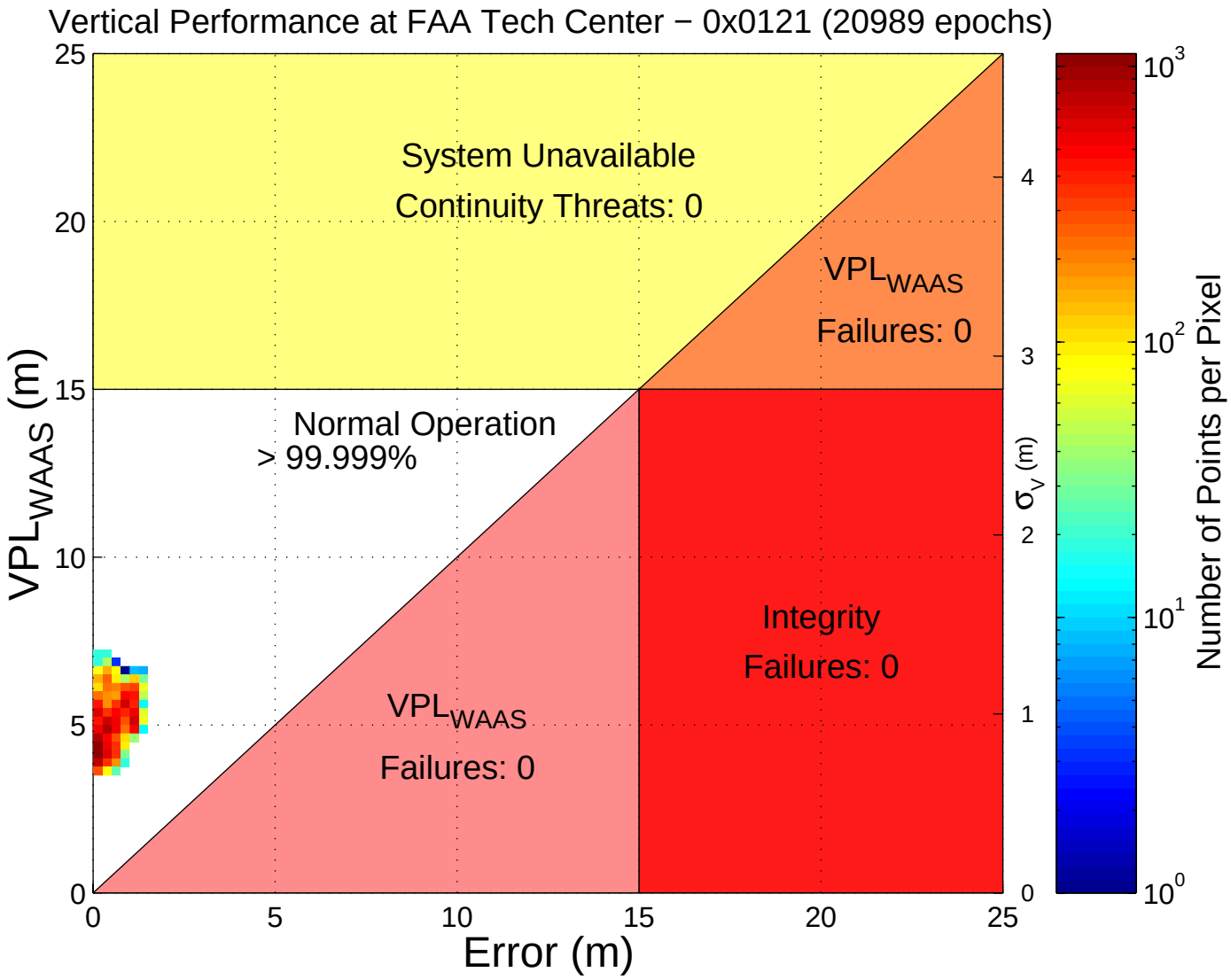
Simulated Ionospheric Disturbance Scenario

- Nominal models
  - 26 SV Constellation (no GEOs)
  - background iono model based on PIM
  - SNR receiver model with live data, Dai (IEEE PLANS, 1998)
  - tropo model from WAAS MOPS
  - multipath model, Enge, et.al (*Proc.* IEEE, 1995)
  - 27 reference receivers, 2 monitors
- Injected electron density enhancement
  - Gaussian bubble layer at 300(km)
  - 500 (km) 1-σ centered at 35N, 100W
  - amplitude is 25% of nominal
  - fixed in solar-magnetic coordinates
- Correction is tomographic estimate of vertical delay grid
- Truth available in both pseudo-range and position domain

Horiz. System Performance (Simulated Iono)



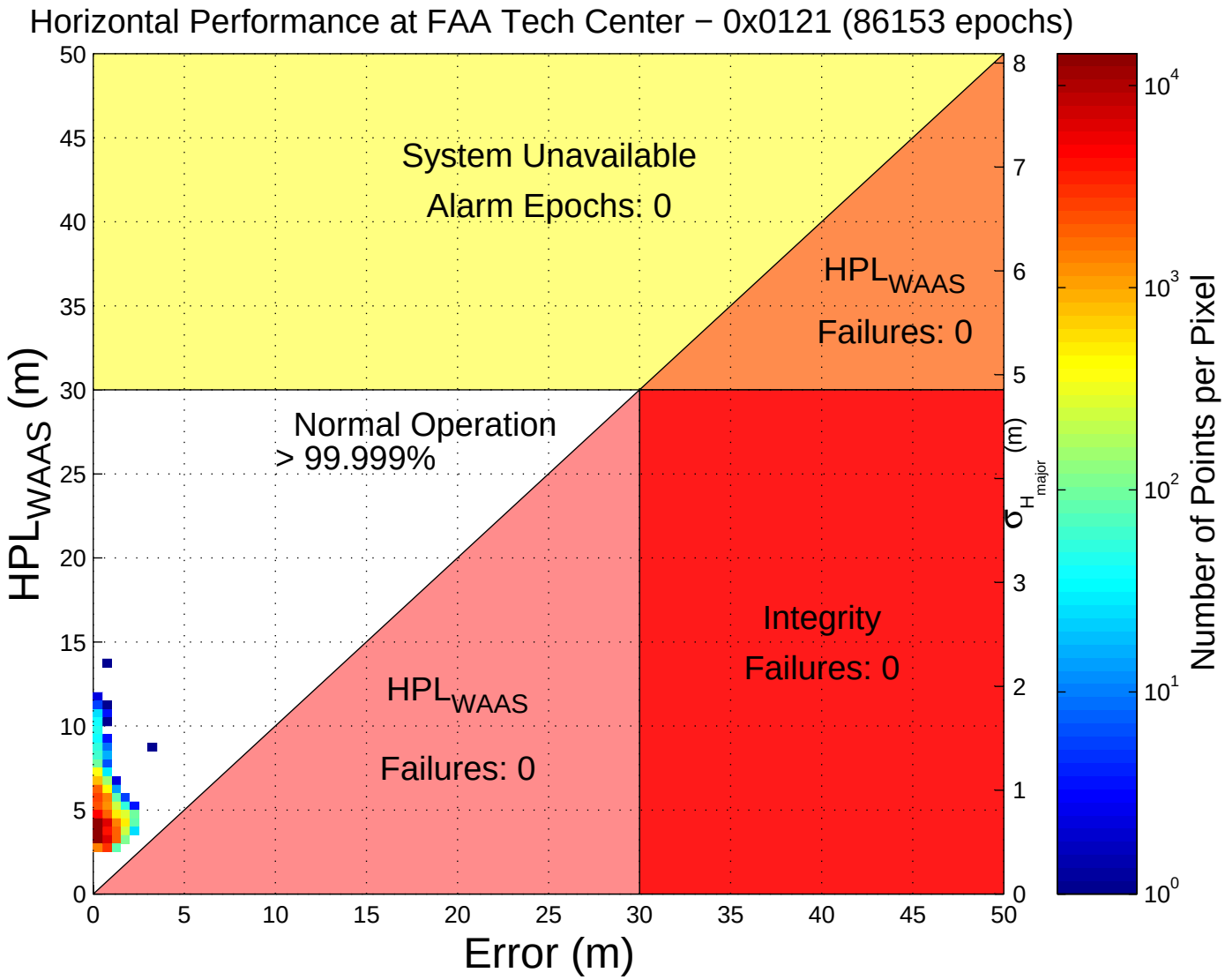
Vertical System Performance (Simulated Iono)



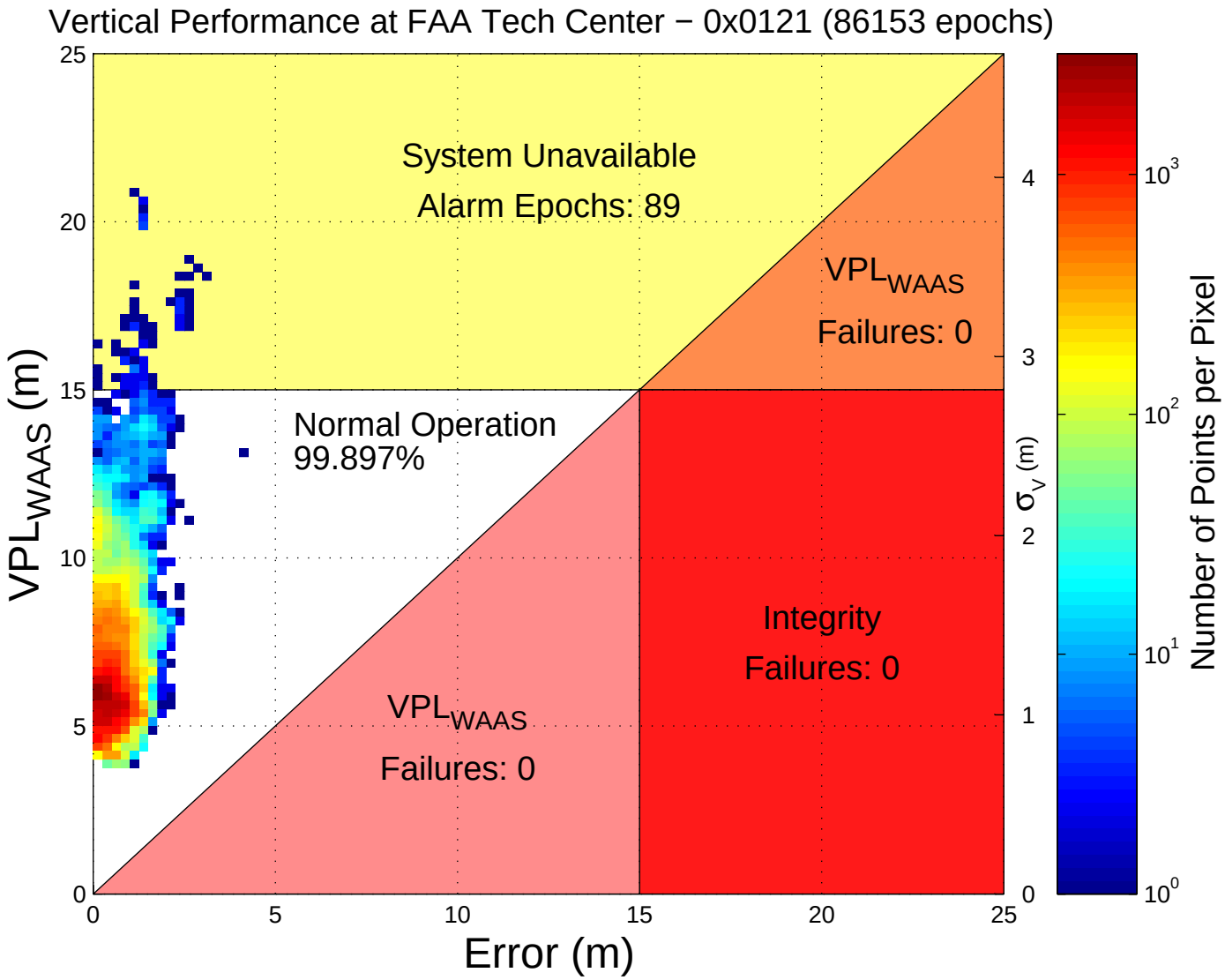
System Performance During Ionospheric Storm

- 24 hour live data set collected 4 May 1998
- Solar/Geomagnetic parameters (courtesy NOAA NGDC)
  - SSN approximately 80 for the day
  - K_p reached maximum of 8 around 02:00 UTC
  - A_p peaked at 120 (ranks 106^{th} highest since 1932)
- Corrections generated from 27 reference stations
- Iono correction is 2D estimate of vertical delay grid
- Truth available only in position domain at surveyed monitors

Horiz. Performance—Grid Correction (Storm 4 May 1998)



Vert. Performance—Grid Correction (Storm 4 May 1998)



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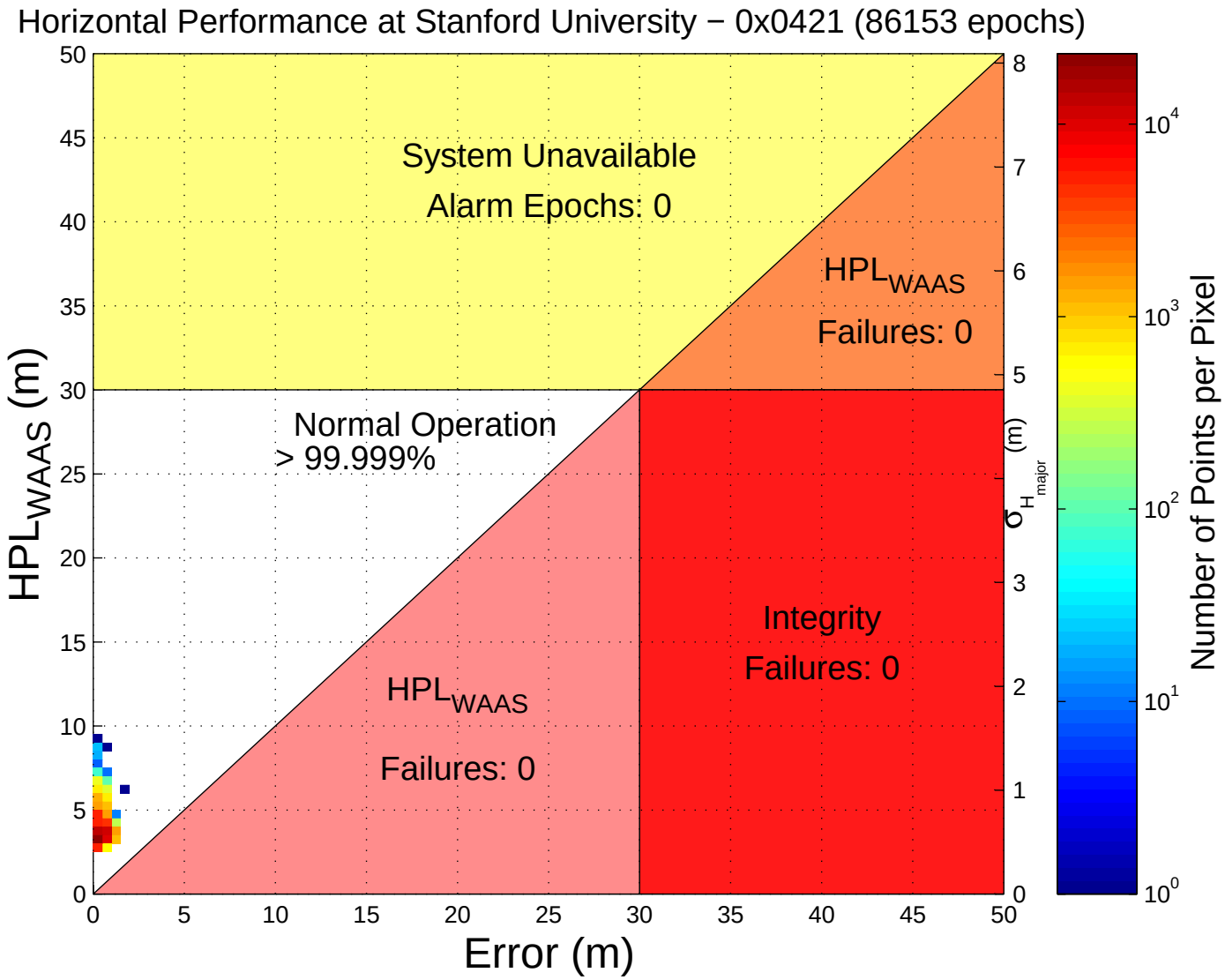

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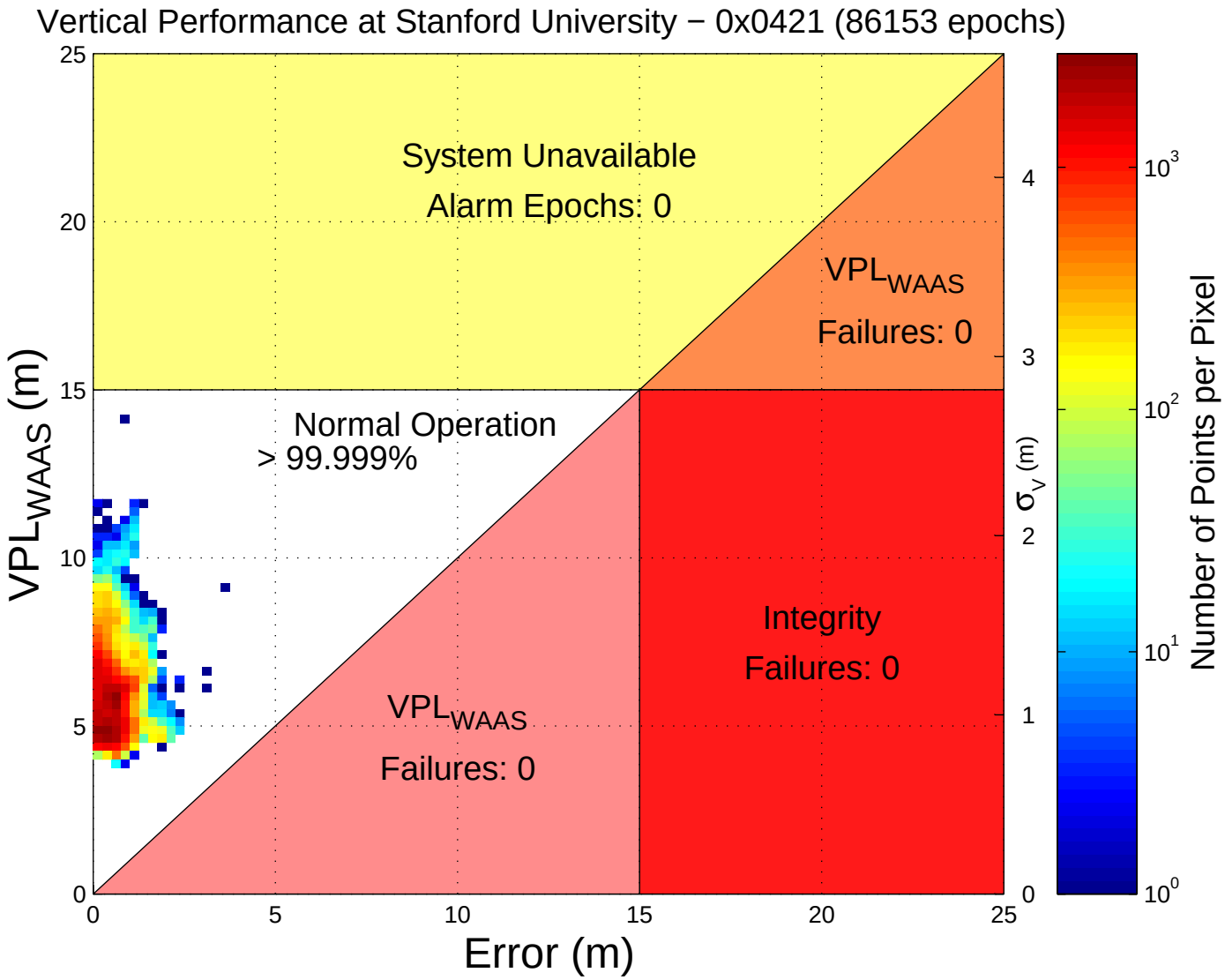

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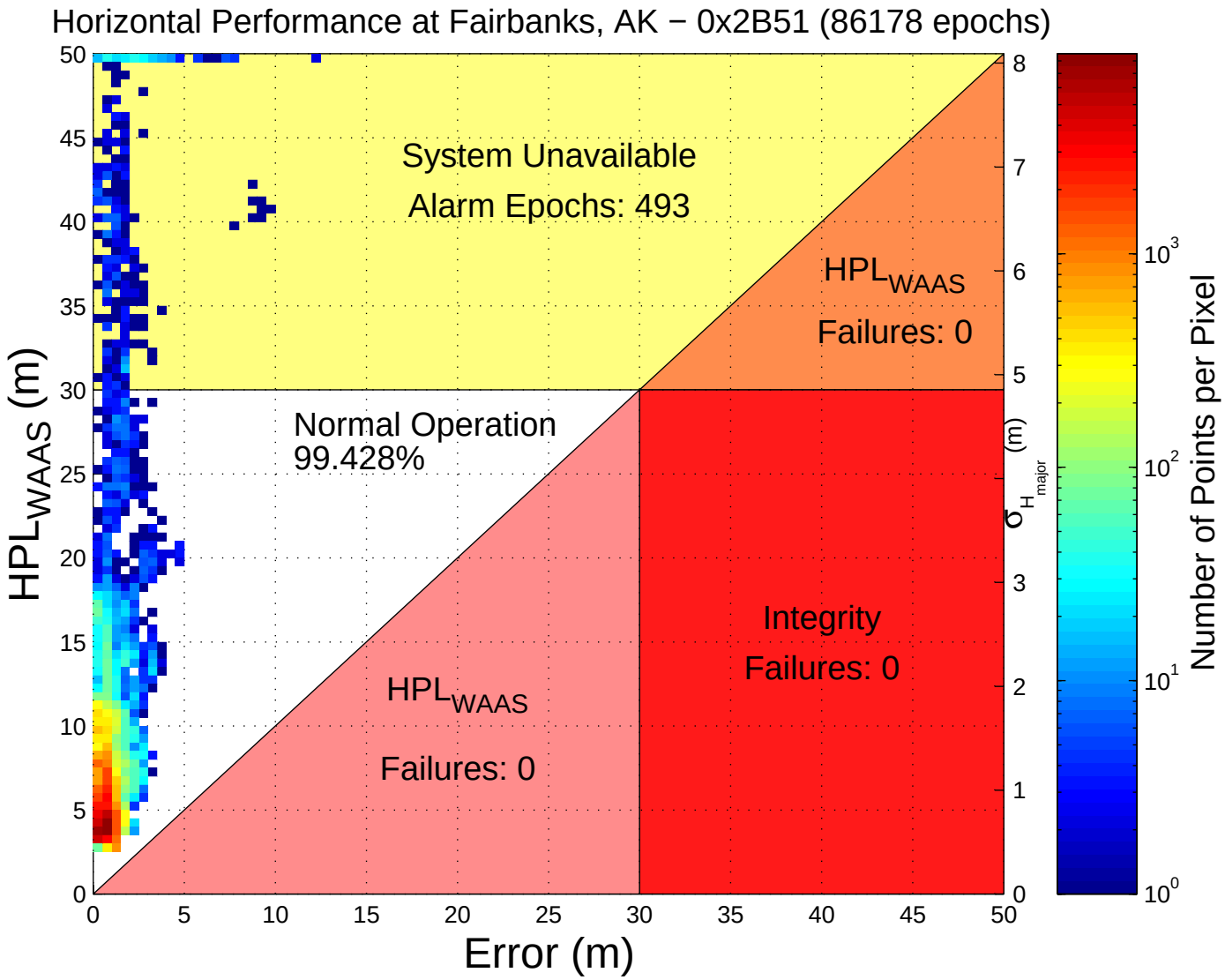

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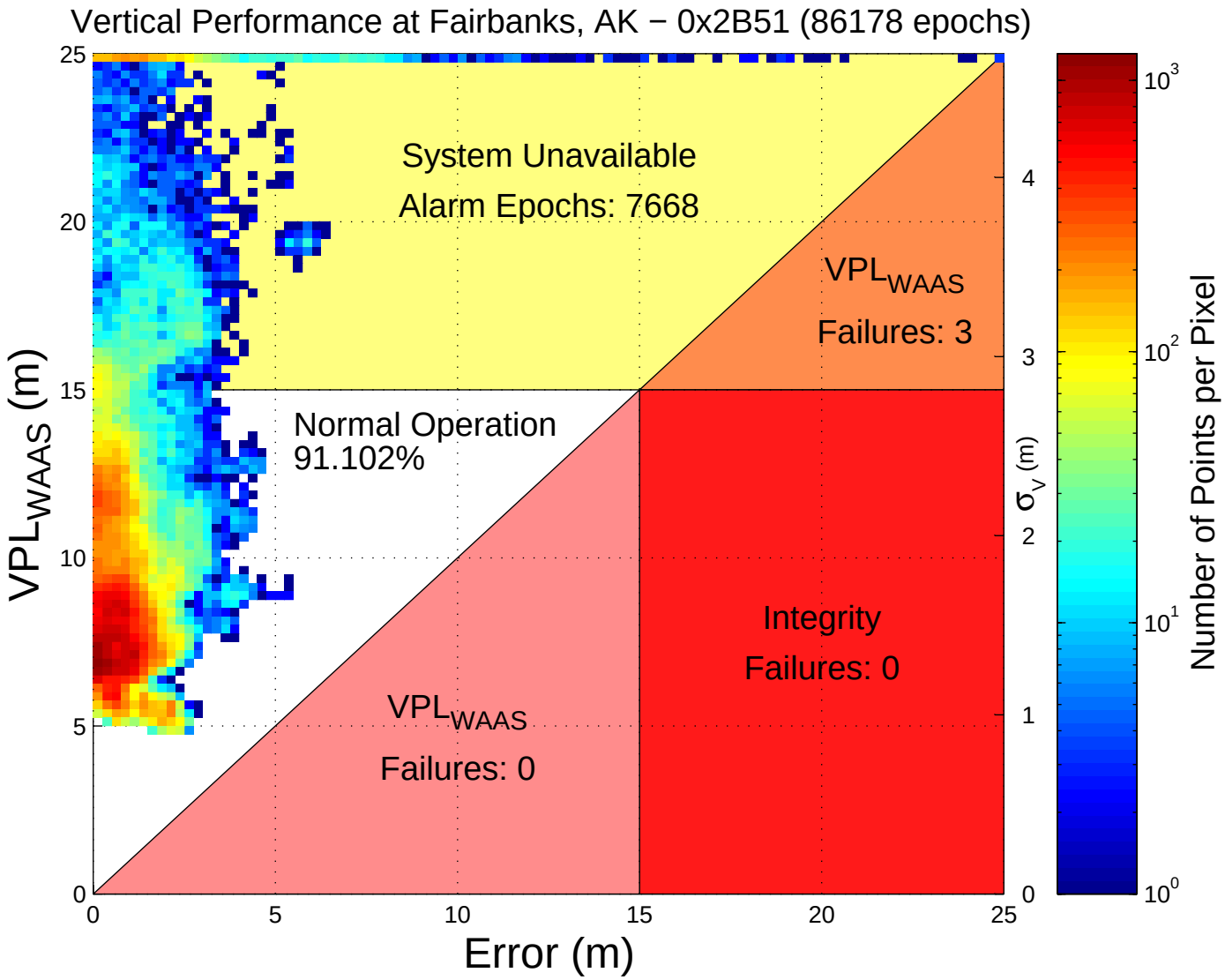

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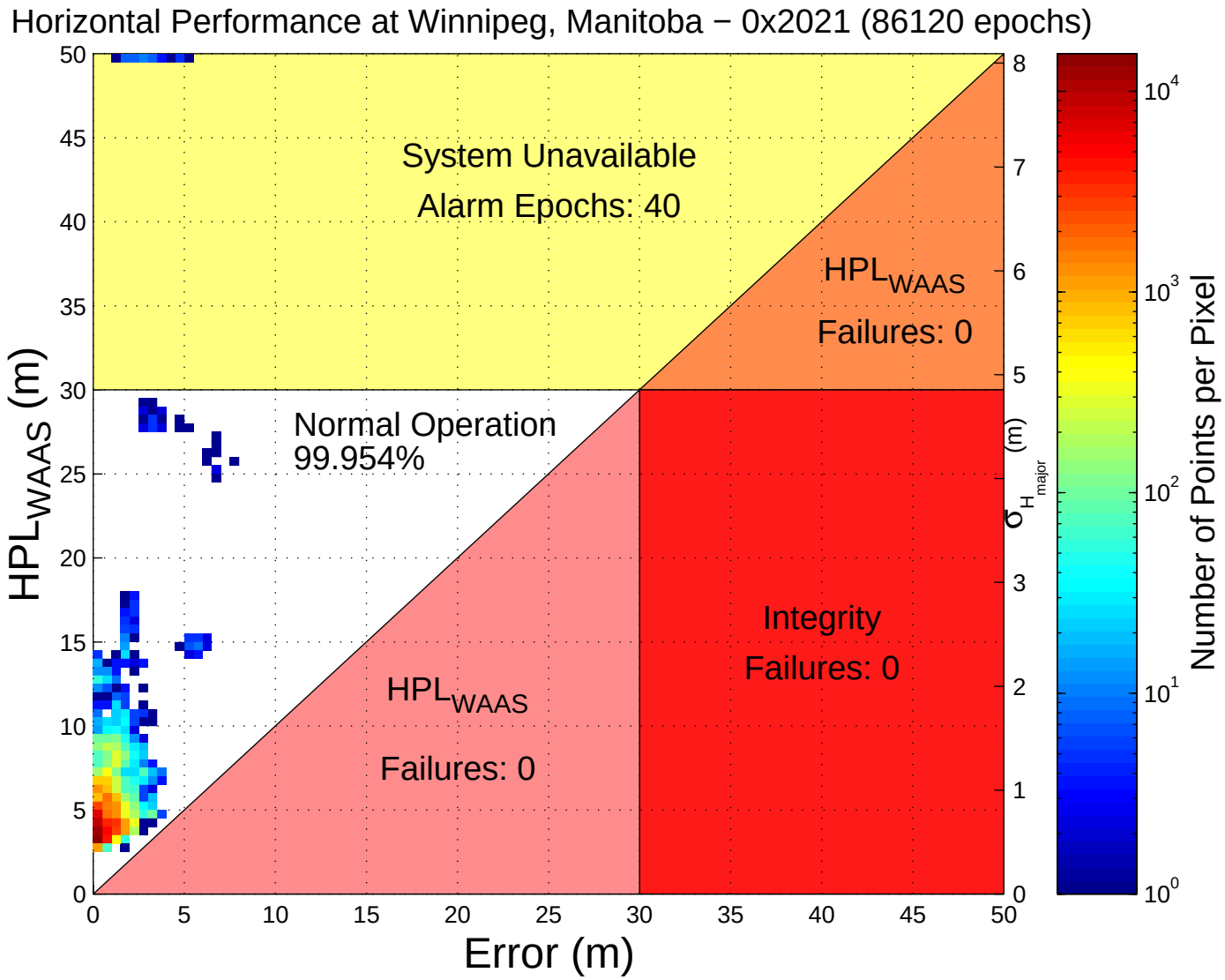

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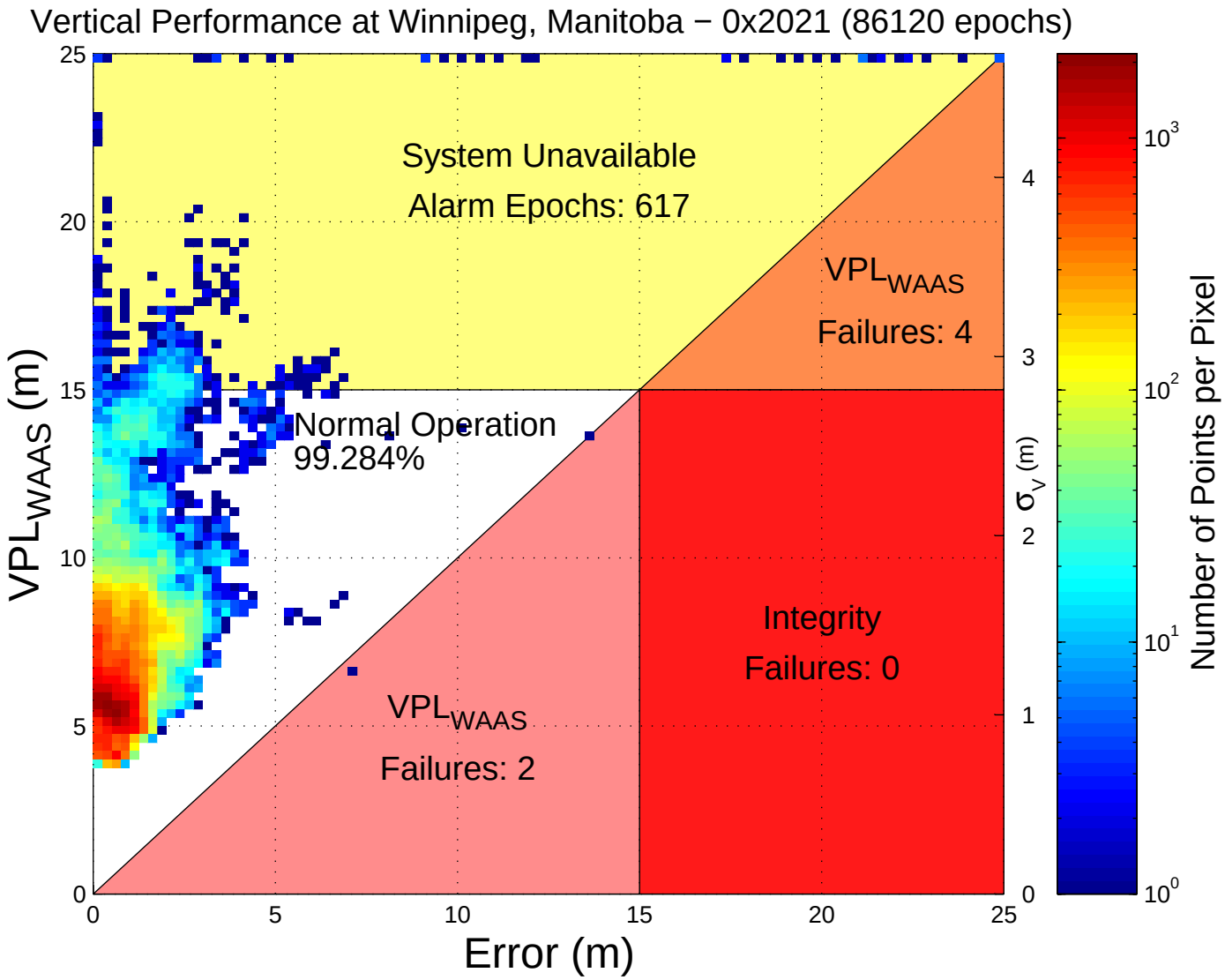
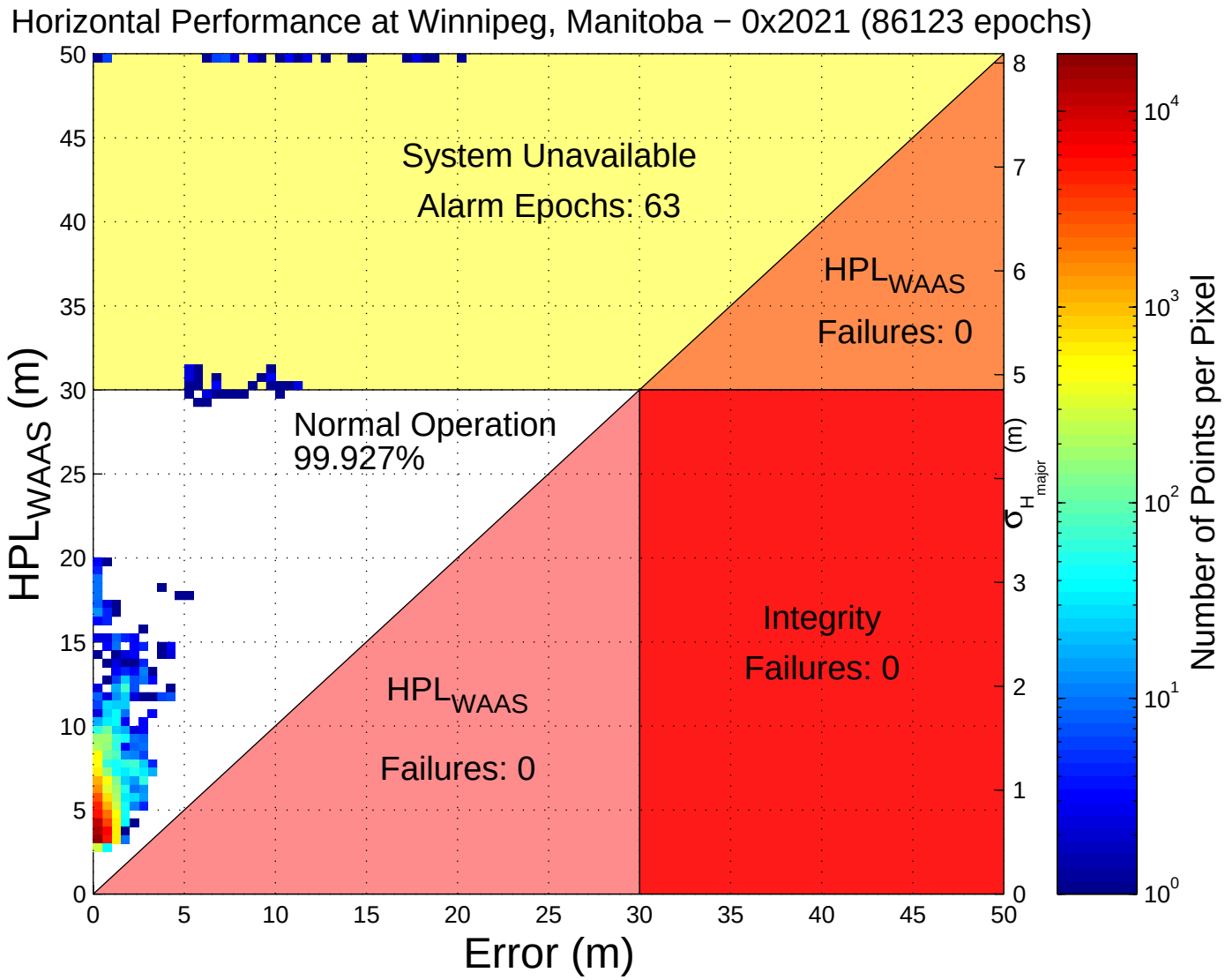


Horiz. Performance—Dual Freq XCorr (Storm 4 May 1998)



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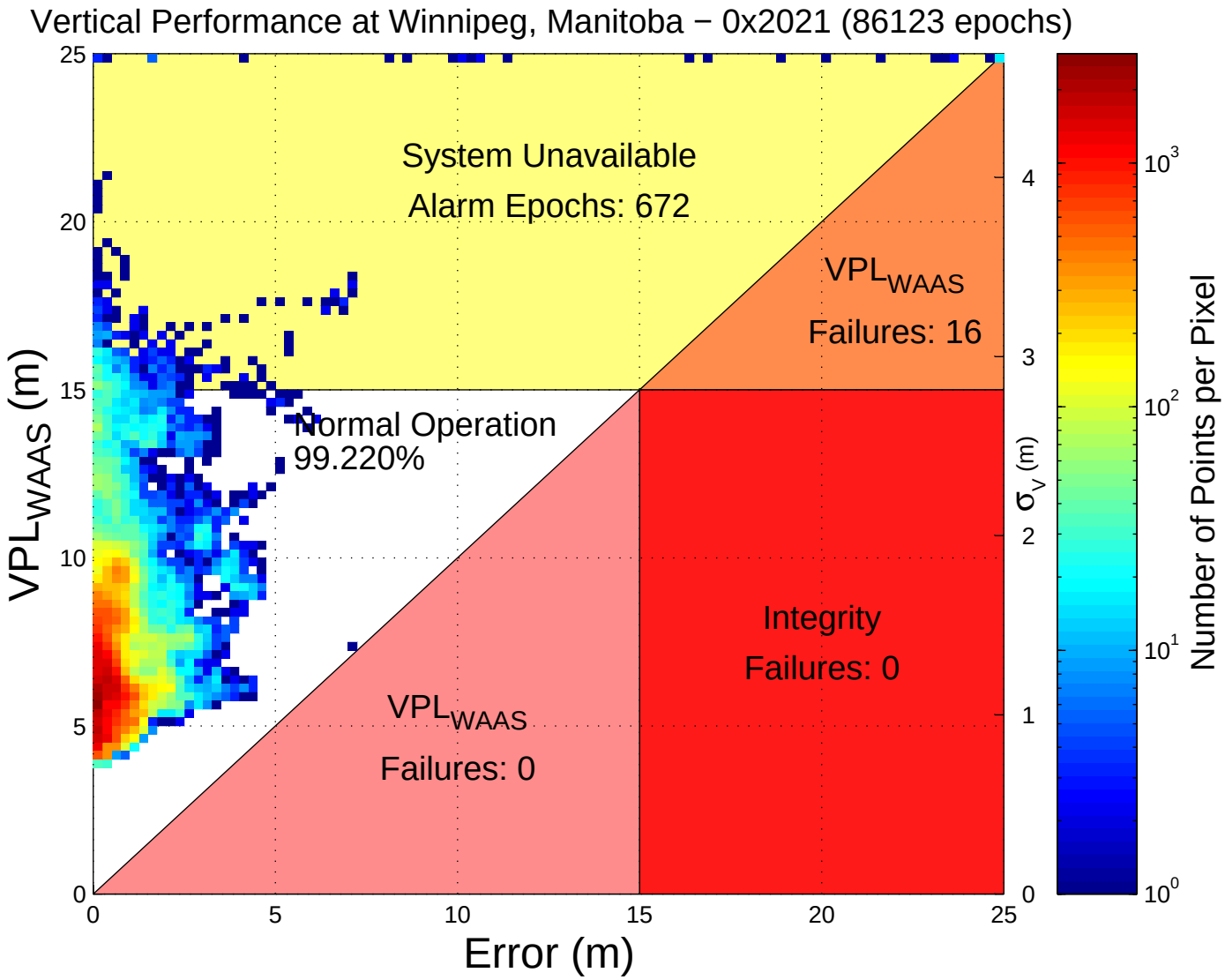

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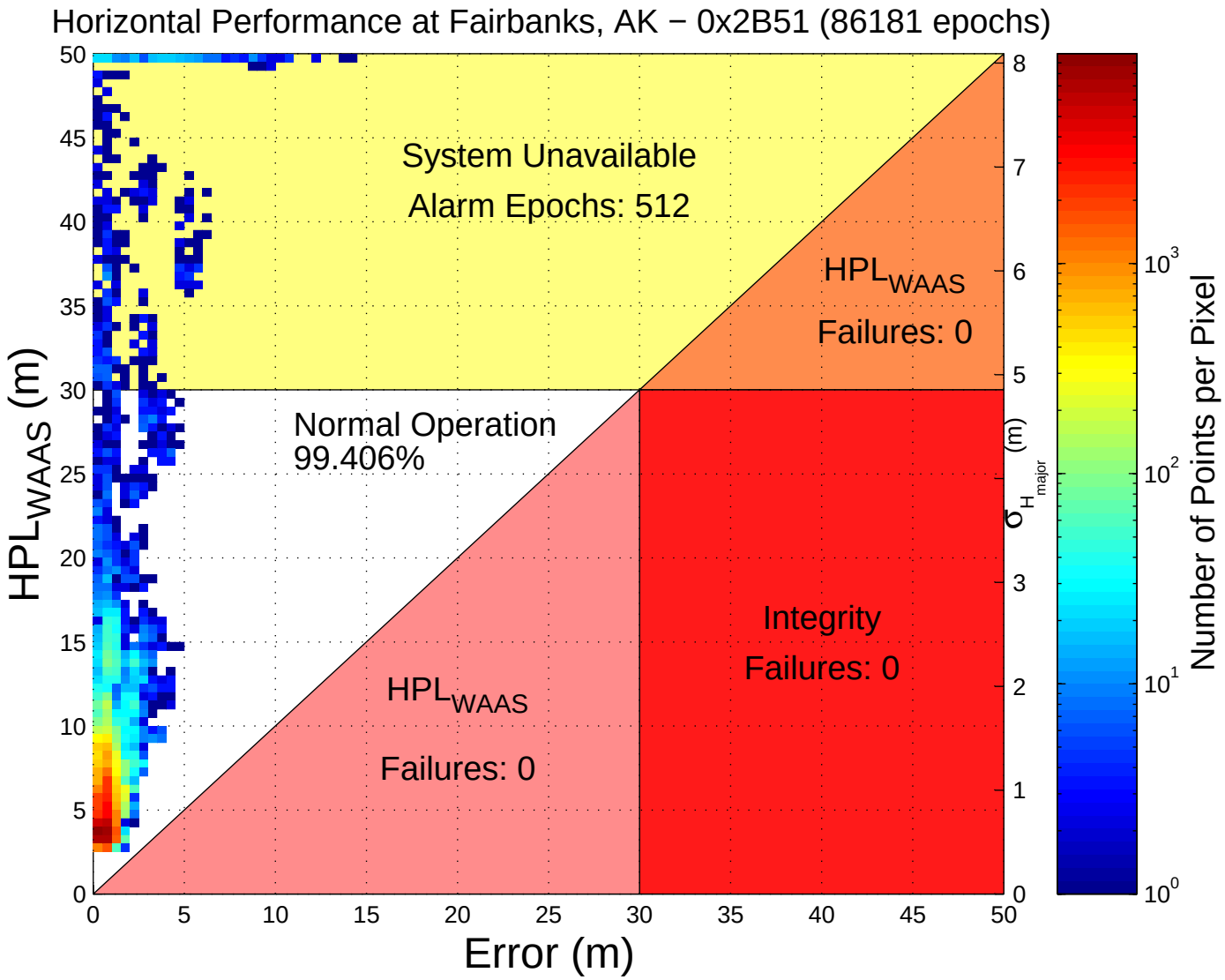

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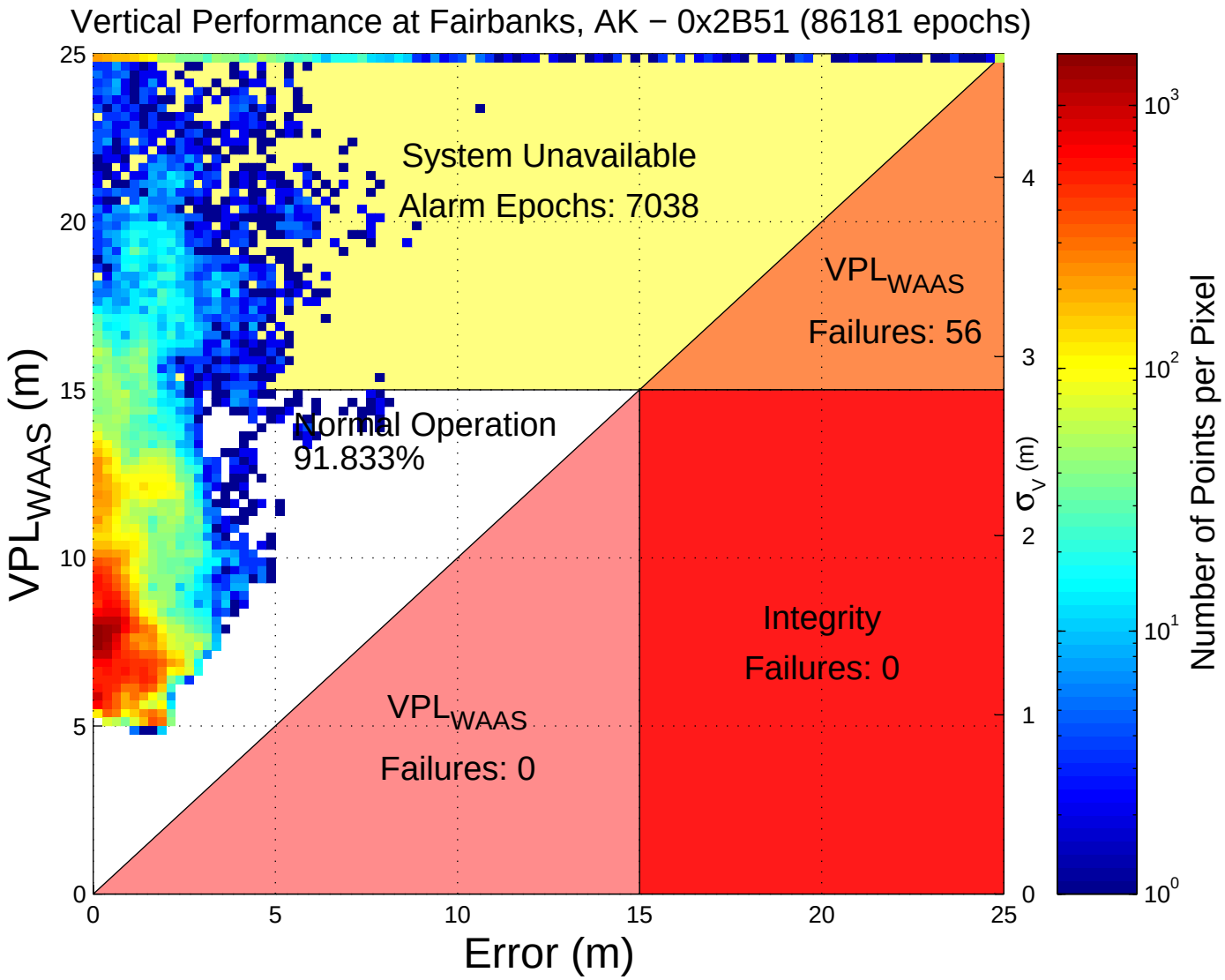
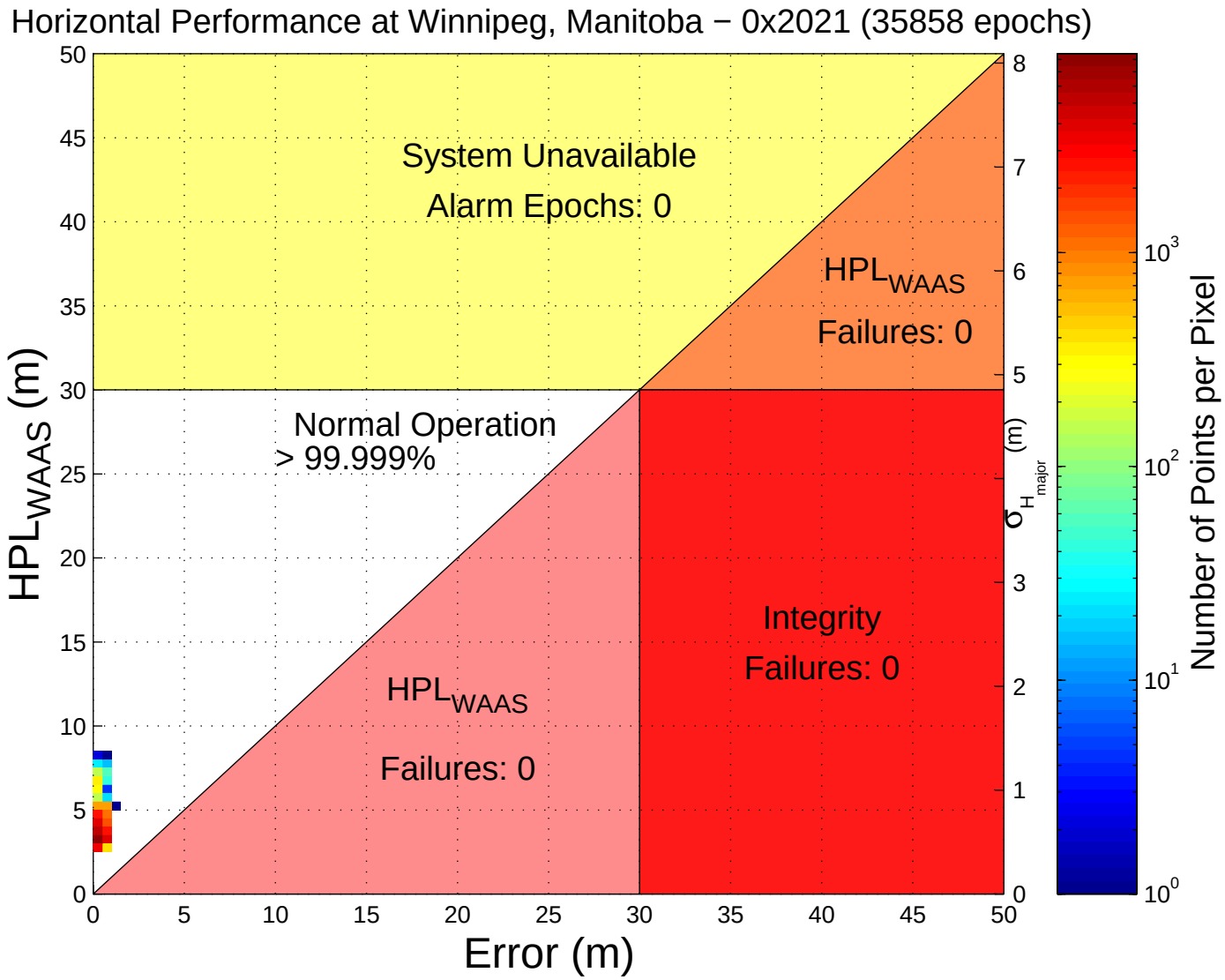
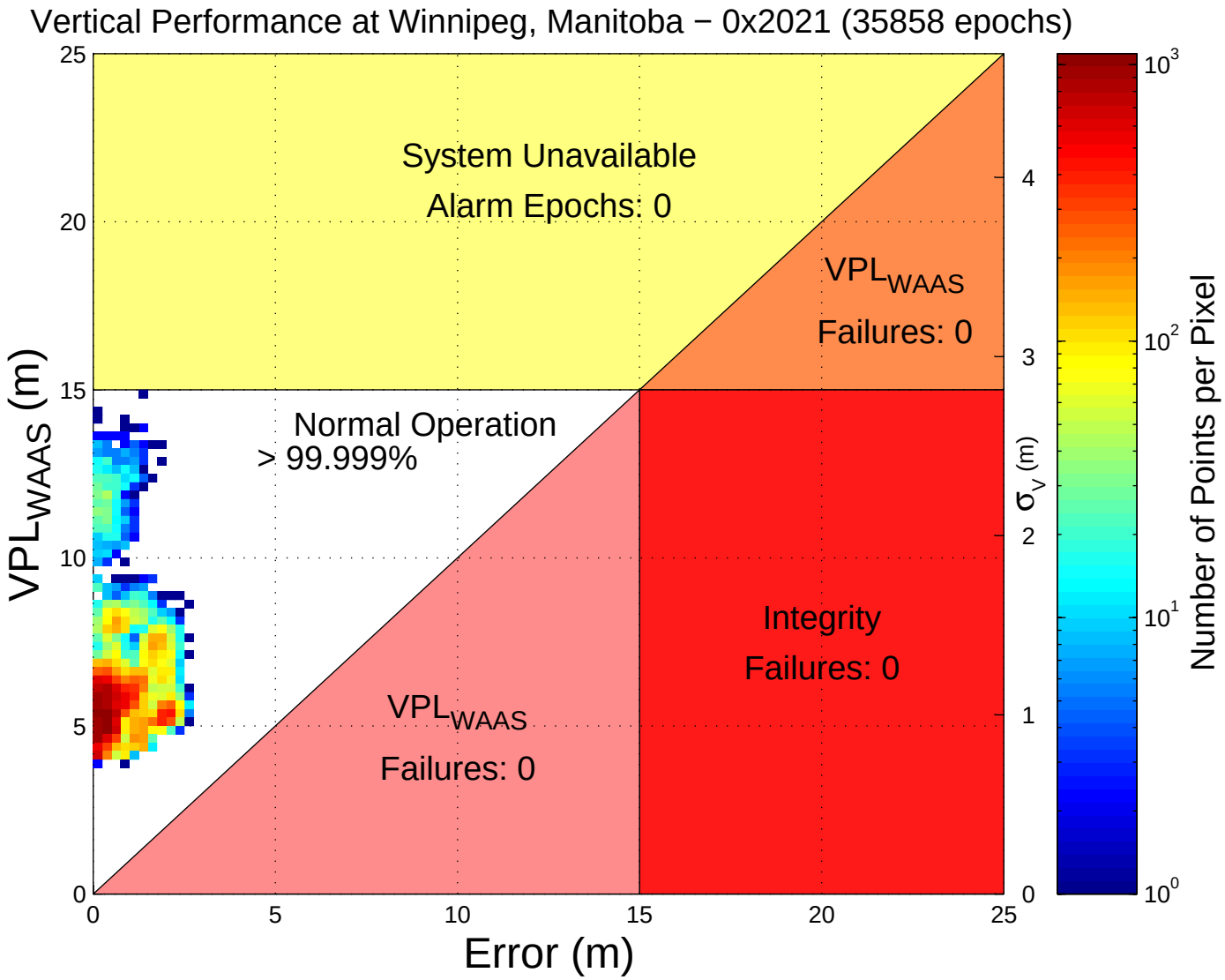


Nominal Horizontal Performance (23 June 1998)



Nominal Vertical Performance (23 June 1998)



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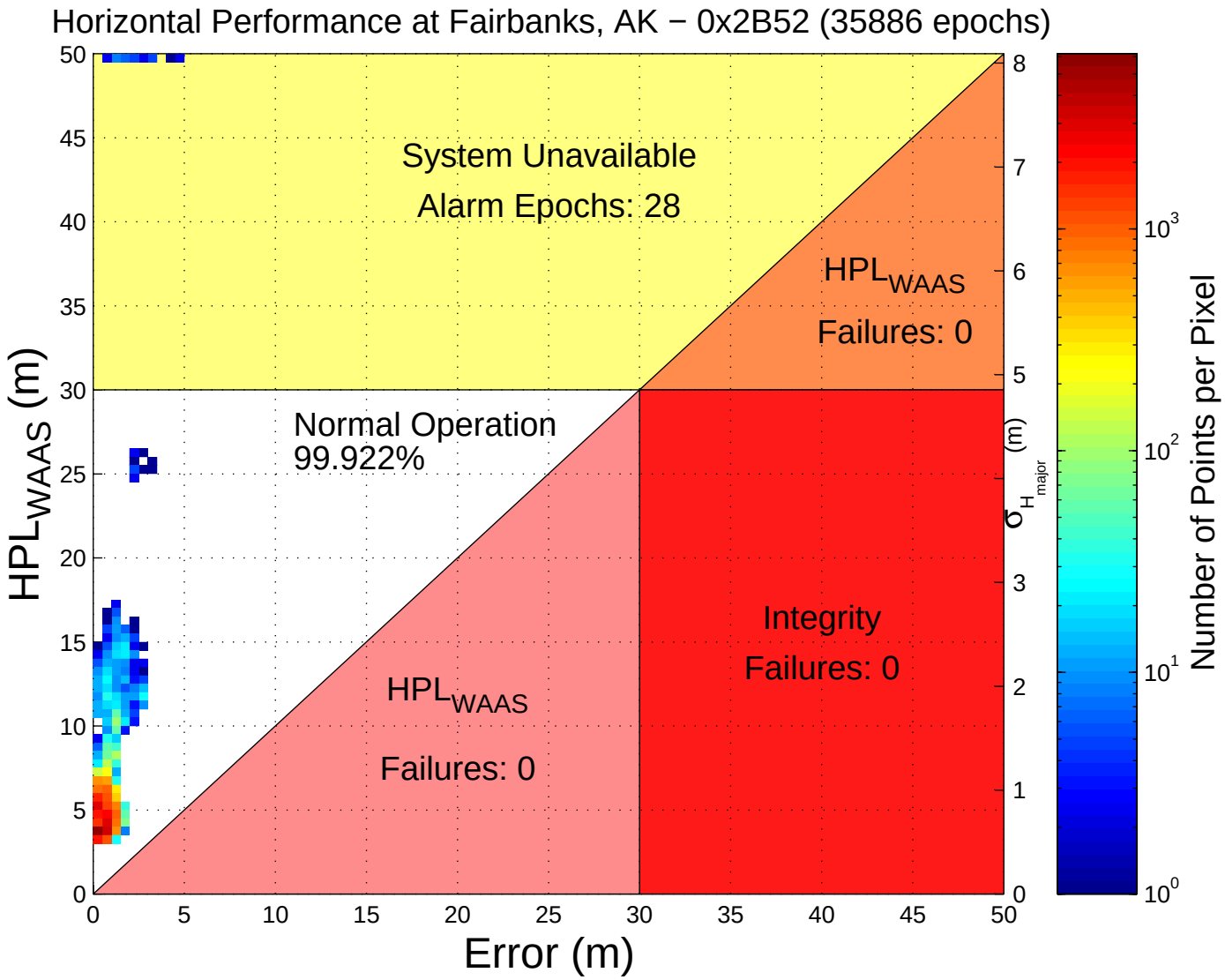

Nominal Vertical Performance (23 June 1998)