Beyond <u>supervised</u> learning —> self- & semi-supervised ML

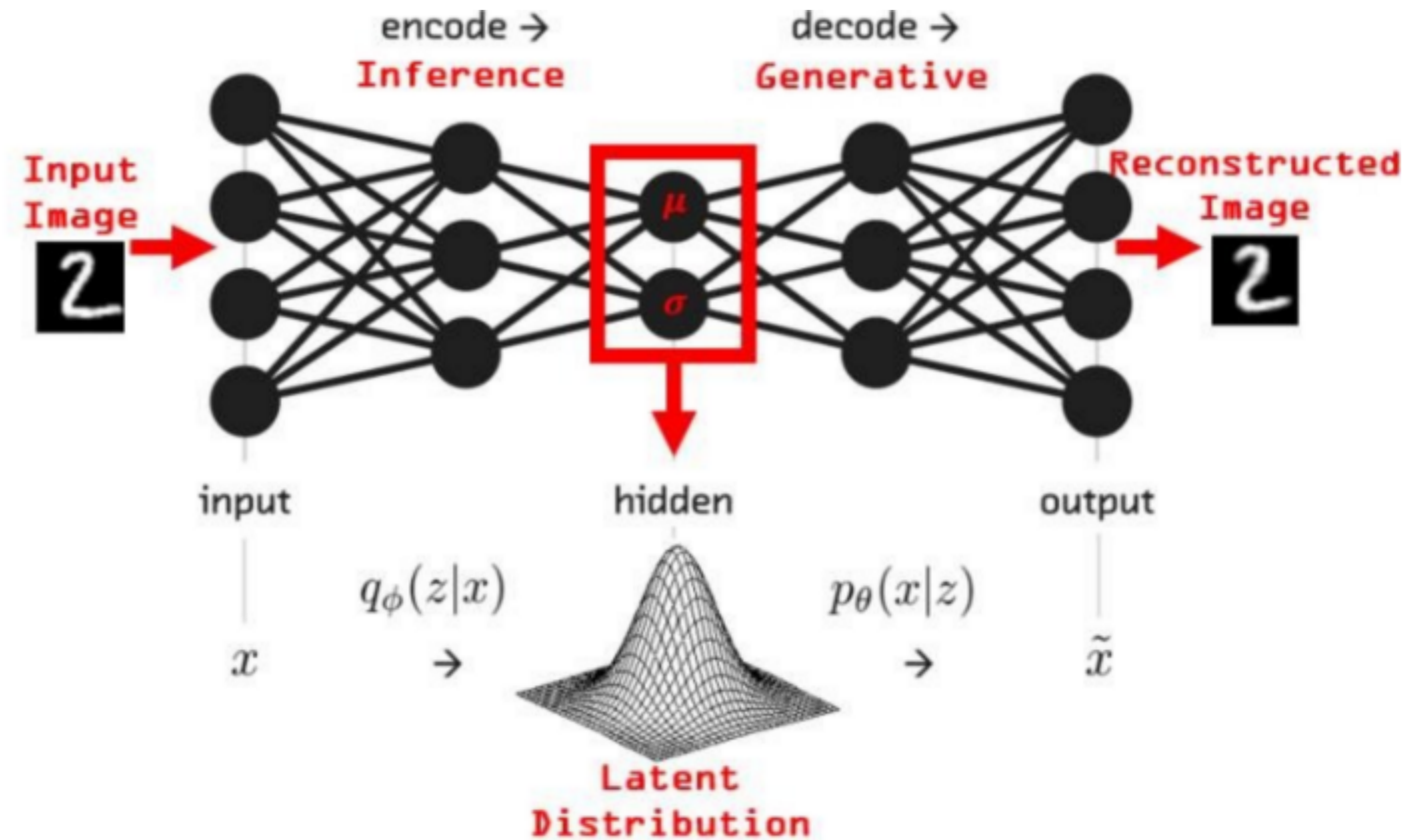(Input —> output)   (Input —> Input)
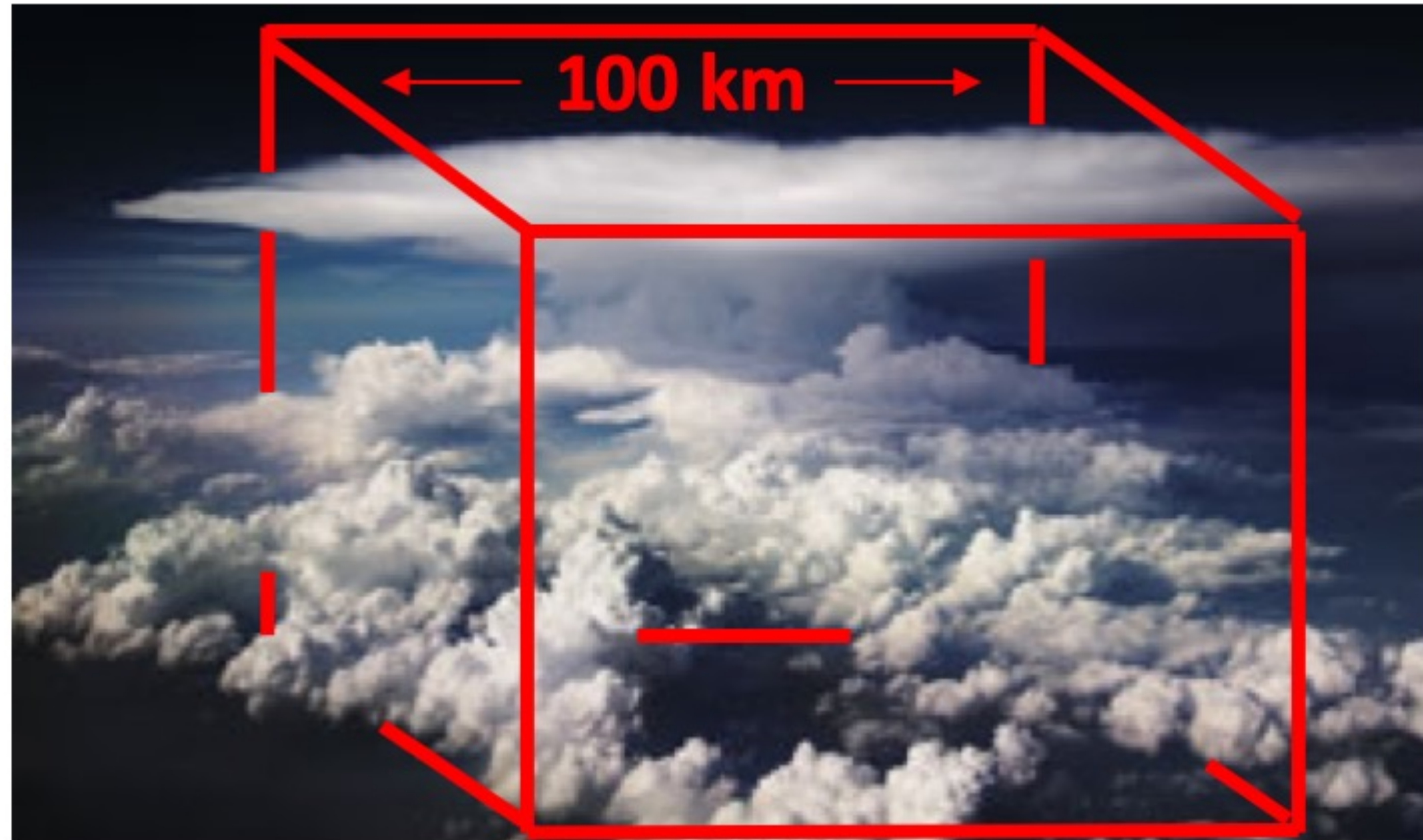
Vision: NN-assisted analysis of the finest scales of complexity in large domain CRMs?

Variational Autoencoders uncover "latent spaces" that are interesting to analyze

(Aside: VAE decoder also then a building-block for conditionally generative stochastic parameterization)

Example: VAE reconstructing intra-CRM details of convective organization in SP-GCMs
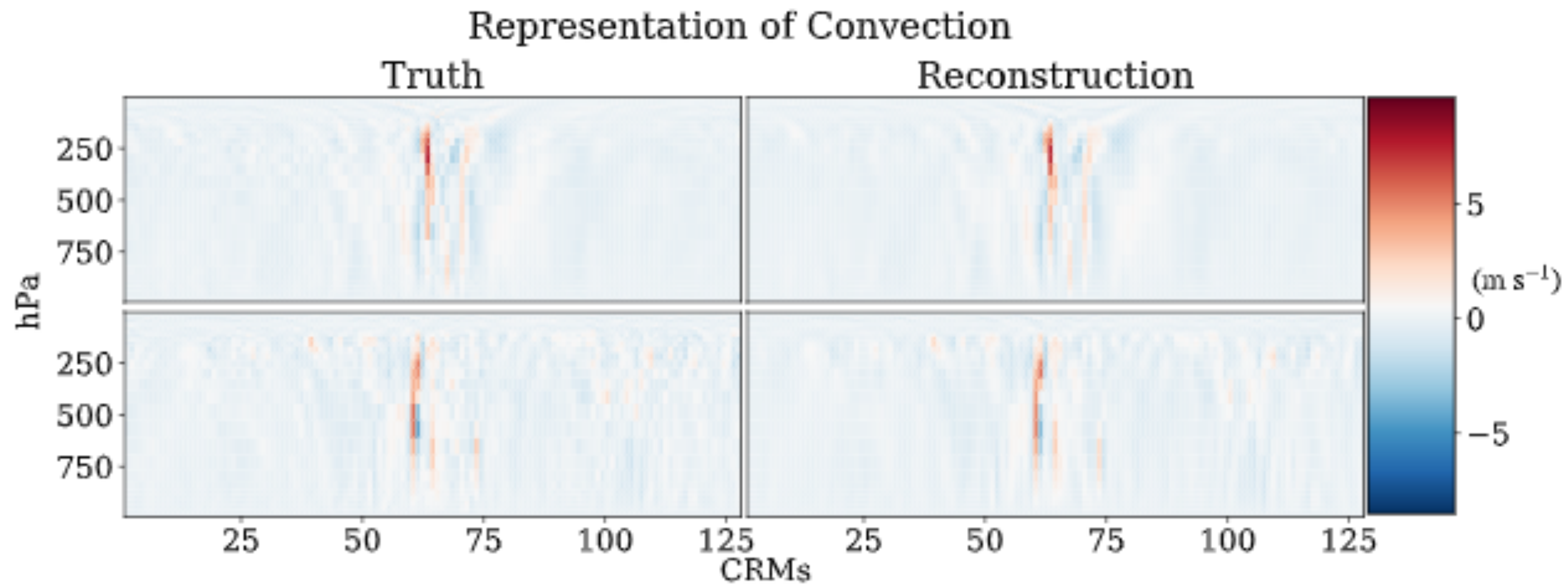

Fig. 4: **Reconstructions** The trained VAE reconstructions closely resemble those from the test dataset and accurately predict the location, magnitude and spatial structure of convective plumes.

A new interpretable "latent space" of convective organization?

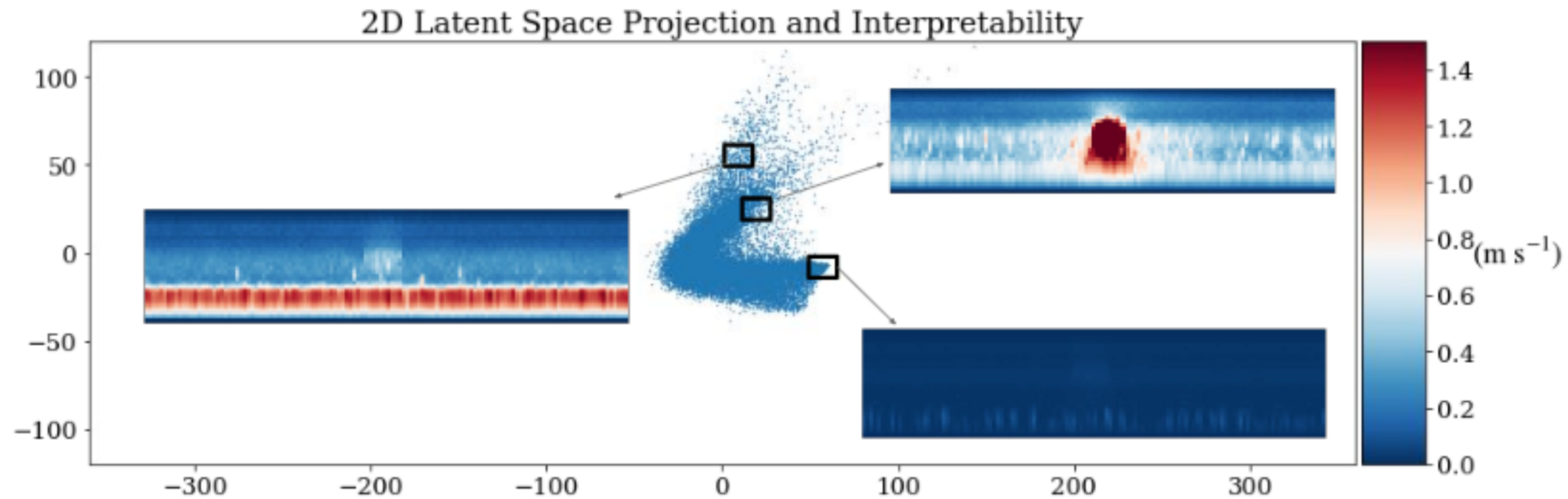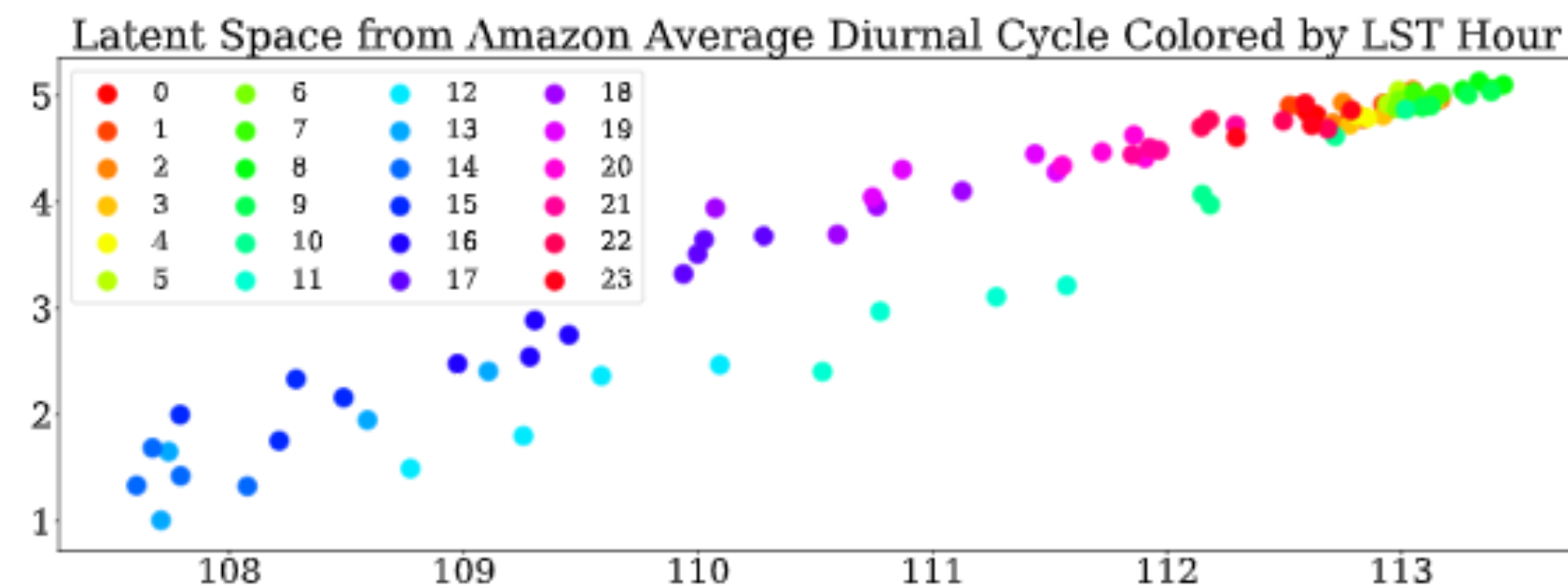2D Latent Space Projection and Interpretability

Fig. 1: **Visualization of the latent space** originally in dimension 1024, but reduced to dimension 2 by Principle Component Analysis (PCA) [36]. The standard deviations of different types of convection the VAE learns to cluster are embedded near corresponding clusters. This suggests the VAE learns an interpretable clustering of the data, with means and variances both contributing to the results.

Latent Space from Amazon Average Diurnal Cycle Colored by LST Hour

Mooers et al., *Climate Informatics*, 2020

http://arxiv.org/abs/2007.01444

Let the data define what is "extreme" & "rare" not humans!
(including human-like attention to spatial coherence details but for large, superhuman datasets)

VAE anomaly detection: Two MCS co-existing in a single CRM array
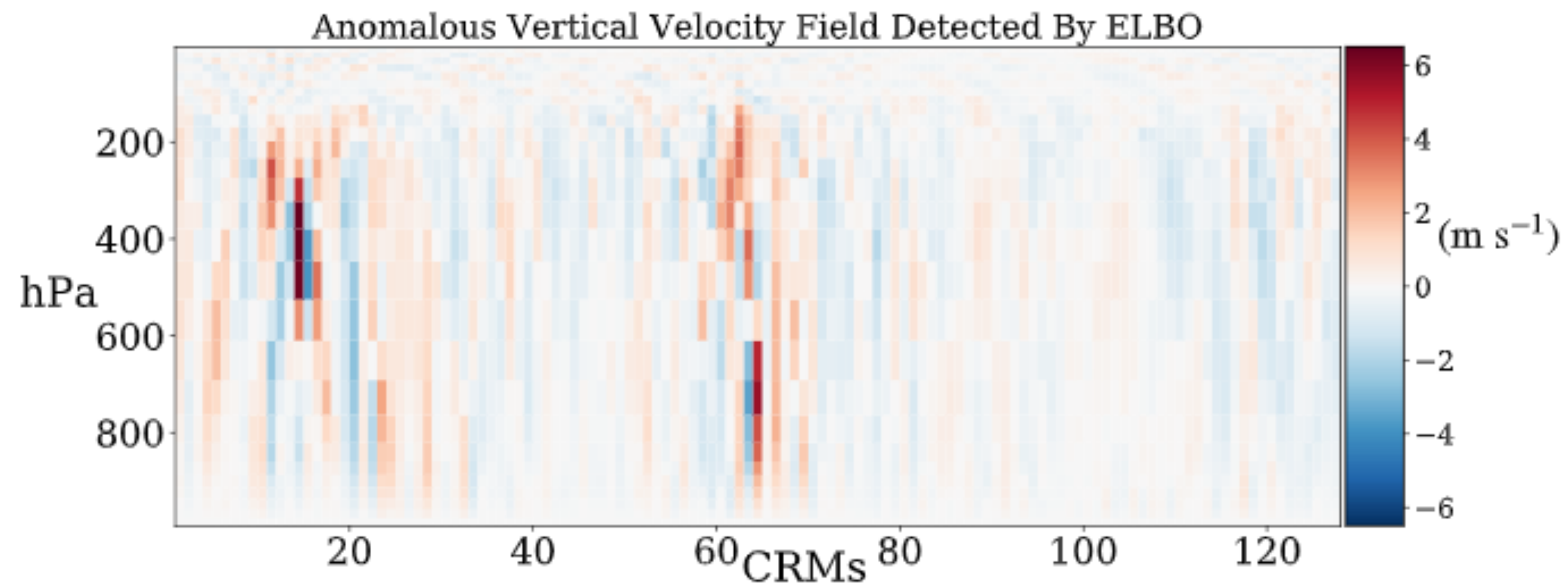(I wouldn't have hunted for this with percentiles but agree it's rare)

Fig. 6: **Anomaly Detection** We use the ELBO in the VAE Loss function to identify the most anomalous vertical velocity fields. We show the 9th most anomalous field because it exhibits multiple deep convective plumes.

Linked ML Infrastructure challenge.

Penetrating the single-GPU training frontier.

- Input vectors in this context should become big (e.g. 3D volumes of q,T,w etc)

- Requires hefty NN architectures (3D convolutions, multiple channels)

- Implies challenges with training speed due to sheer NN model size.

- How to equip grad students to day-dream beyond the limits of a single GPU?

- DOE's copious GPUs make it well-positioned to push this frontier, in theory…