From Storms to Hotspots: Large-Scale Coastal Anomaly Detection

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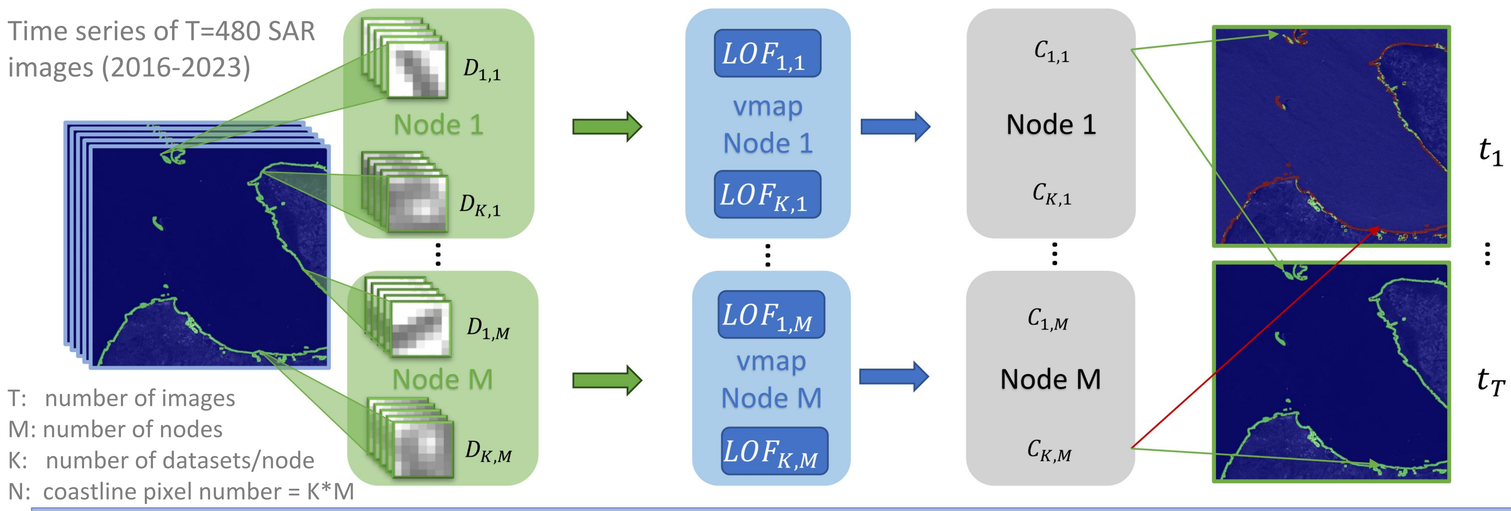
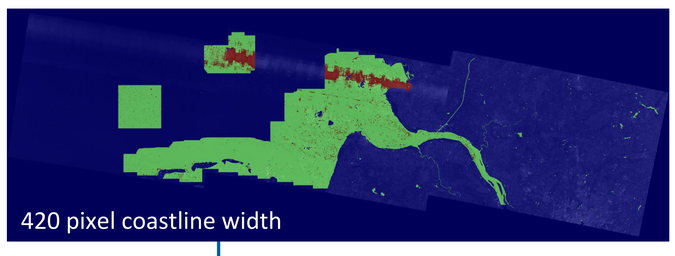
Anomaly Detection and Parallelization



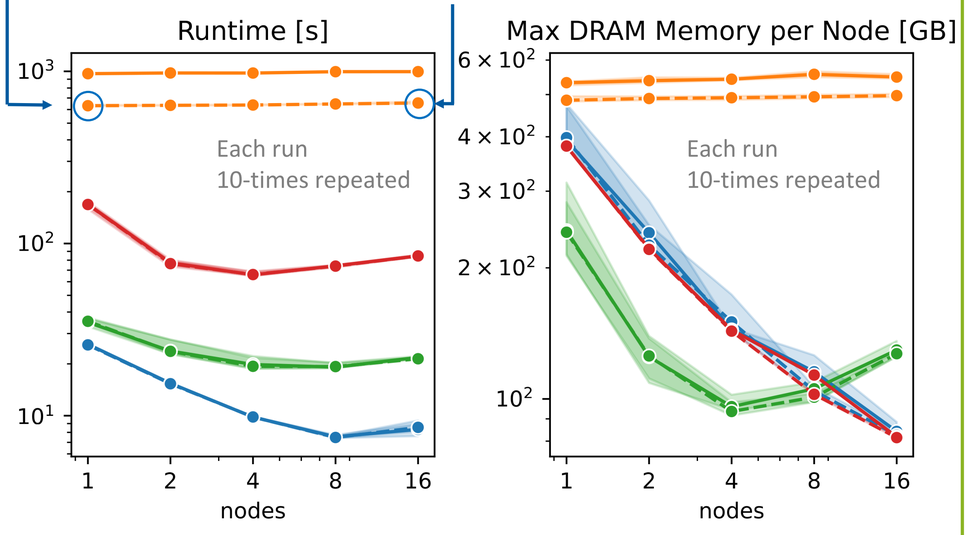
T Images → T×K×M Patches $D_{i,j}$ → Local Outlier Factor (LOF) → T×K×M Anomaly Classifiers $C_{i,j}$ → T Anomaly Maps

- Dataset: Synthetic Aperture Radar (SAR) time series 2016-2023 (every 6 days).
- Density-based algorithms: Local Outlier Factor (LOF) and Local Outlier Probabilities (LoOP) with Mahalanobis distance measure.
- Validation on artificial anomalies (accuracy): LOF: 95%, LoOP: 86%, Reed-Xiaoli: 87% (baseline)
- Our novel patch-wise LOF/LoOP method allows to detect spatially localized anomalies.
- Temporal trajectory of each pixel is analyzed independently within a small window (7 x 7 pixels).
- HPC upscaling with *Heat's vmap* implementation.

Weak scaling of Heat on CPU/GPU in real-world scenario



CPU results (1 node ≙ 80 cores)

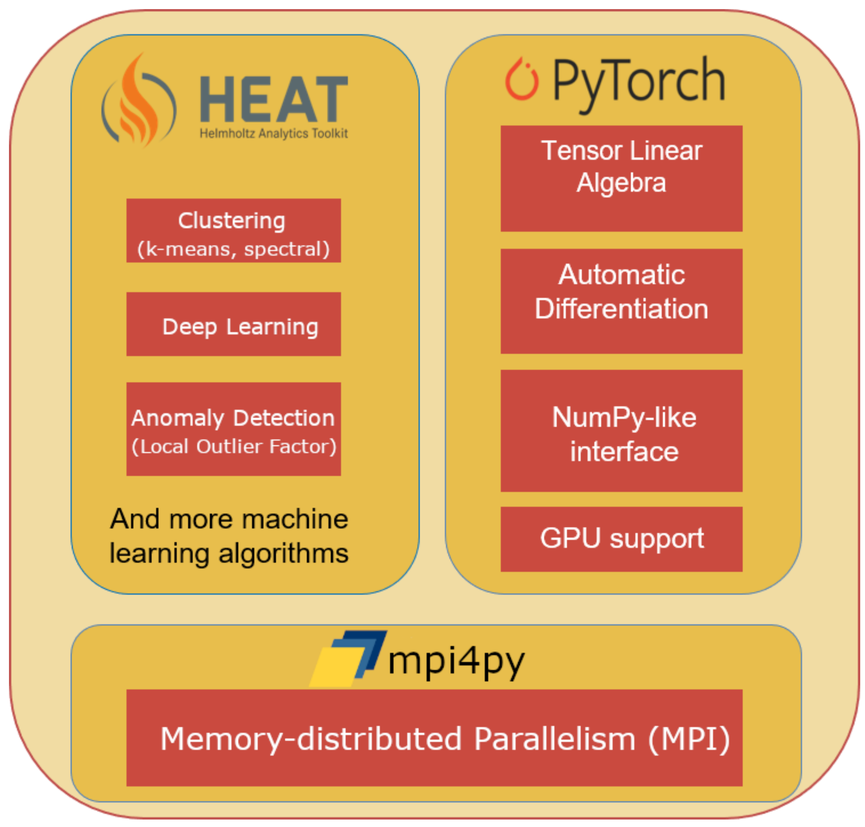


- Weak scaling was conducted on CPU and on GPU partition of DLR's HPC-system *terrabyte*.
- **CPU partition**: 2 x Intel Xeon Platinum 8380 40 Cores 270 W 2.3 GHz per node.
- **GPU partition**: 2 x Intel Xeon Gold 6336Y 24 Cores 185 W 2.4 GHz CPUs and 4 Nvidia HGX A100 80 GB 500 W GPUs per node.
- Weak scaling runtimes results on GPU are similar but anomaly detection is approx. ten times faster.

	on CPU			on GPU		
# nodes	coastline width	# pixels	scaling	coastline width	# pixels	scaling
1	13	504.501	NA	2	128.797	NA
2	31	1.012.474	2.006	5	252.427	1.959
4	71	2.027.481	2.002	13	504.501	1.998
8	152	4.055.690	2.0003	31	1.012.474	2.006
16	420	8.120.538	2.002			

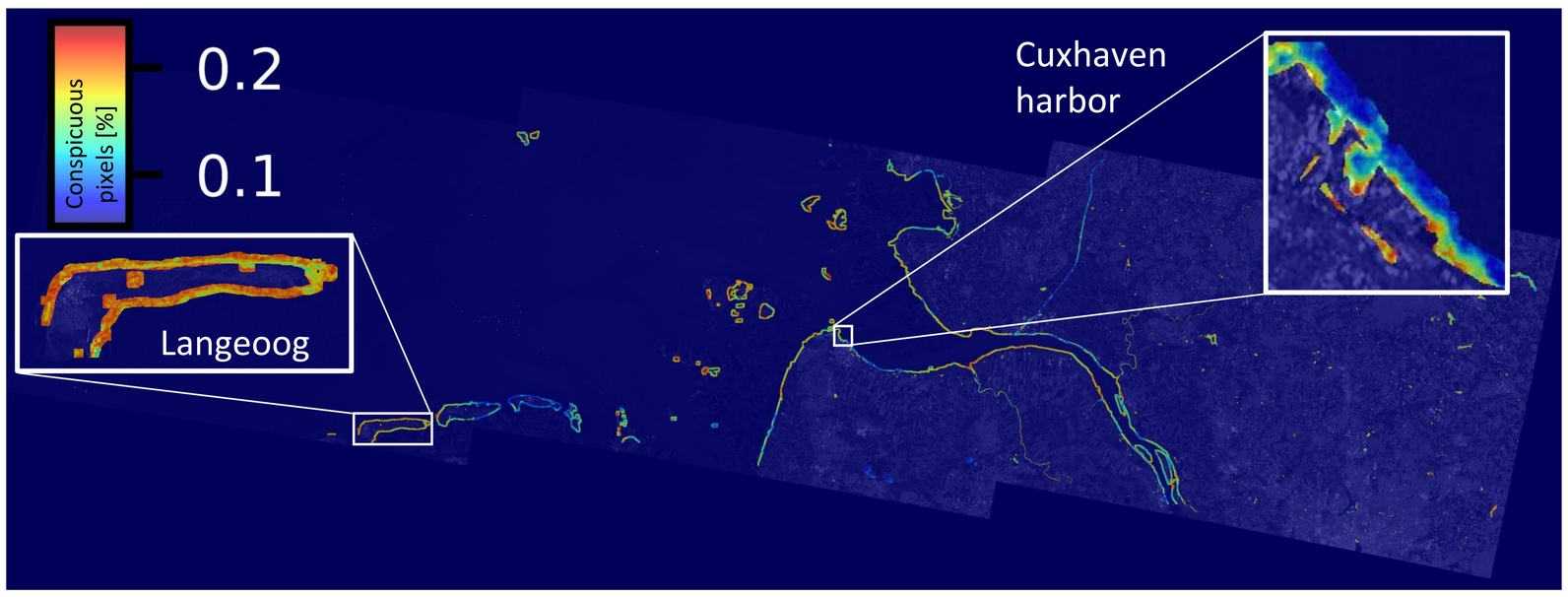
Data sizes for weak scaling on CPU and GPU nodes.

Heat – Helmholtz Analytics Toolkit



- Jointly developed by three Helmholtz centers:
  - Research Center Juelich (FZJ)
  - Karlsruhe Institute of Technology (KIT)
  - German Aerospace Center (DLR)
- Python library for parallel, distributed data analytics and machine learning.
- Open Source (MIT): https://github.com/helmholtz-analytics/heat

Result: Hotspot Map of German North Sea Coast (from 2016-2023)



- Hotspot map shows long-term activity along the German North Sea coast from 2016 to 2023.
- Hotspot map is an indicator of areas with potential coastal erosion.
- The color legend shows the percentage of conspicuous pixels in the time series.
- Island of Langeoog is severely affected by coastal erosion (magnified on the left).
- In general, harbors are also high activity regions (e.g. Cuxhaven harbor).