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# Heatwave Release Notes

## Abstract

This document contains release notes for the changes in each release of HeatWave.

For additional HeatWave documentation, see [MySQL HeatWave User Guide](#).

Updates to these notes occur as new product features are added, so that everybody can follow the development process. If a recent version is listed here that you cannot find on the download page (<https://dev.mysql.com/downloads/>), the version has not yet been released.

The documentation included in source and binary distributions may not be fully up to date with respect to release note entries because integration of the documentation occurs at release build time. For the most up-to-date release notes, please refer to the online documentation instead.

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For help with using MySQL, please visit the [MySQL Forums](#), where you can discuss your issues with other MySQL users.

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## Table of Contents

Preface and Legal Notices .....	2
Changes in MySQL HeatWave .....	3
Changes in HeatWave 8.3.0 (2024-01-17, General Availability) .....	3
Changes in HeatWave 8.2.0-u2 (2023-12-19, General Availability) .....	4
Changes in HeatWave 8.2.0-u1 (2023-12-05, General Availability) .....	4
Changes in HeatWave 8.2.0 (2023-10-25, General Availability) .....	5
Changes in HeatWave 8.1.0-u4 (2023-09-26, General Availability) .....	6
Changes in HeatWave 8.1.0-u3 (2023-09-12, General Availability) .....	7
Changes in HeatWave 8.1.0-u2 (2023-08-08, General Availability) .....	7
Changes in HeatWave 8.1.0-u1 (2023-07-25, General Availability) .....	8
Changes in HeatWave 8.1.0 (2023-07-18, General Availability) .....	8
Changes in HeatWave 8.0.34 (2023-07-18, General Availability) .....	9
Changes in HeatWave 8.0.33-u3 (2023-06-09, General Availability) .....	9
Changes in HeatWave 8.0.33 (2023-04-27, General Availability) .....	9
Changes in HeatWave 8.0.32-u2 (2023-02-21, General Availability) .....	10
Changes in HeatWave 8.0.32-u1 (2023-02-21, General Availability) .....	10
Changes in HeatWave 8.0.32 (2023-01-17, General Availability) .....	10
Changes in HeatWave 8.0.31 (2022-10-11, General Availability) .....	11
Changes in HeatWave 8.0.30-u1 (2022-09-06, General Availability) .....	12
Changes in HeatWave 8.0.30 (2022-07-26, General Availability) .....	13
Changes in HeatWave 8.0.28-u3 (2022-04-19, General Availability) .....	15
Changes in HeatWave 8.0.28-u2 (2022-03-29, General Availability) .....	15
Changes in HeatWave 8.0.28-u1 (2022-02-15, General Availability) .....	16
Changes in HeatWave 8.0.27-u3 (2021-12-15, General Availability) .....	16
Changes in HeatWave 8.0.27-u2 (2021-12-07, General Availability) .....	16
Changes in HeatWave 8.0.26-u2 (2021-09-21, General Availability) .....	17
Changes in HeatWave 8.0.26-u1 (2021-08-10, General Availability) .....	17
Changes in HeatWave 8.0.26 (2021-07-23, General Availability) .....	18

Changes in HeatWave 8.0.25 (2021-05-11, General Availability) .....	19
Changes in HeatWave 8.0.24 (2021-04-20, General Availability) .....	20
Changes in HeatWave 8.0.23-u2 (2021-03-15, General Availability) .....	21
Changes in HeatWave 8.0.23-u1 (2021-02-09, General Availability) .....	21
Index .....	22

## Preface and Legal Notices

This document contains release notes for the changes in each release of HeatWave.

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## Changes in MySQL HeatWave

### Changes in HeatWave 8.3.0 (2024-01-17, General Availability)

- [HeatWave Lakehouse](#)
- [Functionality Added or Changed](#)

## HeatWave Lakehouse

- HeatWave Lakehouse extends Auto Parallel Load support for external tables that have a pre-defined schema. It is now able to reconcile the inferred schema with the pre-defined table definition when there is a column type mismatch between the two. Schema inference adjusts this schema to prevent possible errors during data loading. See: [Lakehouse Auto Parallel Load](#). (WL #16040)
- HeatWave Lakehouse has improved error reporting. See: [HeatWave Lakehouse Error Messages](#). (WL #15951)

## Functionality Added or Changed

- [GREATEST\( \)](#) and [LEAST\( \)](#) comparison and string functions now support the [YEAR](#) data type. (WL #15910)

## Changes in HeatWave 8.2.0-u2 (2023-12-19, General Availability)

- [HeatWave Lakehouse](#)
- [HeatWave AutoML](#)

## HeatWave Lakehouse

- HeatWave Lakehouse now supports all queries that HeatWave supports. See: [HeatWave Lakehouse Limitations](#). (WL #15730)

## HeatWave AutoML

- The HeatWave AutoML recommendation task now supports content based recommendation models. See [Recommendations](#). (WL #15726)
- HeatWave AutoML introduces data drift detection for classification and regression models. (WL #15866)

## Changes in HeatWave 8.2.0-u1 (2023-12-05, General Availability)

- [HeatWave Lakehouse](#)
- [Functionality Added or Changed](#)

## HeatWave Lakehouse

- Lakehouse now uses Auto Parallel Load to load Avro files. (WL #15778)
- Lakehouse schema inference now includes support for unicode column headers. (WL #16011)

## Functionality Added or Changed

- Auto Data Compression dynamically determines which compression algorithm to use for each column based on its data characteristics. This provides the optimum balance between memory usage and query performance. See: [Data Load](#). (WL #15248)
- HeatWave now supports the following aggregate functions used as window functions:
  - [STD\( \)](#)
  - [STDDEV\( \)](#)

- `STDDEV_POP()`
- `STDDEV_SAMP()`
- `VAR_POP()`
- `VAR_SAMP()`
- `VARIANCE()`

(WL #15367)

- HeatWave now supports the HyperLogLog, `HLL()` aggregate function. This is similar to `COUNT(DISTINCT)`, but faster and with user defined precision. This is only available in HeatWave, see: [Aggregate Functions](#). (WL #15914)
- The `GROUP BY` clause permits a `CUBE` modifier. This is only available in HeatWave, see: [GROUP BY Modifiers](#). (WL #15843)
- HeatWave now supports the following JSON functions:
  - `-->`
  - `-->>`
  - `JSON_ARRAY()`
  - `JSON_DEPTH()`
  - `JSON_EXTRACT()`
  - `JSON_LENGTH()`
  - `JSON_OBJECT()`
  - `JSON_UNQUOTE()`

See: [JSON Functions](#). (WL #15355)

## Changes in HeatWave 8.2.0 (2023-10-25, General Availability)

### Functionality Added or Changed

- HeatWave Guided Load reduces the number of steps to manually load data, see [Loading Data Manually](#). (WL #15811)
- HeatWave now supports the following string functions:
  - `BIN()`
  - `BIT_LENGTH()`
  - `ELT()`
  - `EXPORT_SET()`
  - `FIELD()`

- [MAKE\\_SET\(\)](#)

These functions do not support [ENUM](#) type columns, see [Data Type Limitations](#). (WL #15628)

- HeatWave now supports full-table aggregation and group-by support for the following temporal data types:

- [DATE](#)
- [TIME](#)
- [DATETIME](#)
- [TIMESTAMP](#)
- [YEAR](#)

HeatWave now accelerates queries that contain the following functions with temporal data types:

- [SUM\(\)](#)
- [AVG\(\)](#)
- [STD\(\)](#)
- [STDDEV\(\)](#)
- [STDDEV\\_POP\(\)](#)
- [STDDEV\\_SAMP\(\)](#)
- [VAR\\_POP\(\)](#)
- [VAR\\_SAMP\(\)](#)
- [VARIANCE\(\)](#)

See: [Aggregate Functions](#). (WL #15637)

- HeatWave now enables the internal conversion of values from one data type to another, including all combinations of these different encodings:
  - Numeric values [INTEGER](#), [FLOAT](#), and [DECIMAL](#).
  - String values, excluding dictionary-encoded strings.
  - Temporal values [DATE](#), [TIME](#), [DATETIME](#), and [YEAR](#) data types.

This now permits HeatWave to offload queries that contain functions with unexpected data types by adding an internal cast from the unexpected data type to an expected data type. (WL #15465)

## Changes in HeatWave 8.1.0-u4 (2023-09-26, General Availability)

- [HeatWave Lakehouse](#)
- [HeatWave AutoML](#)
- [Functionality Added or Changed](#)

## HeatWave Lakehouse

- HeatWave Lakehouse now uses schema inference to create an external table, see [Loading Data from External Storage Using Auto Parallel Load](#). (WL #15851)
- HeatWave Lakehouse now includes support for HeatWave AutoML. See: [HeatWave AutoML and Lakehouse](#). (WL #15539)

## HeatWave AutoML

- The HeatWave AutoML recommendation task now supports implicit feedback. See [Recommendations](#). (WL #15802)

## Functionality Added or Changed

- MySQL InnoDB on MySQL HeatWave now has support for a bulk load extension to the `LOAD DATA` statement. This is only available on MySQL HeatWave on AWS. See: [MySQL Extensions for HeatWave](#) and [Bulk Ingest Data to MySQL Server](#). (WL #14717, WL #14772, WL #15131, WL #15132, WL #15133, WL #15612)

## Changes in HeatWave 8.1.0-u3 (2023-09-12, General Availability)

- [HeatWave Lakehouse](#)
- [HeatWave AutoML](#)
- [Functionality Added or Changed](#)

## HeatWave Lakehouse

- Lakehouse can now use a regular expression to define a set of files. (WL #15840)
- Lakehouse now uses Auto Parallel Load to load Parquet files. (WL #15656)
- Lakehouse now supports the Avro file format, see [HeatWave Lakehouse](#). (WL #15494)

## HeatWave AutoML

- HeatWave AutoML now supports text data types, see: [Supported Data Types](#). (WL #15743)

## Functionality Added or Changed

- Adaptive Query Execution dynamically adjusts the query execution plan based on runtime statistics to improve query execution time. See: [Query Execution](#). (WL #15368)

## Changes in HeatWave 8.1.0-u2 (2023-08-08, General Availability)

- [HeatWave AutoML](#)
- [Functionality Added or Changed](#)

## HeatWave AutoML

- HeatWave AutoML progress tracking can now track the progress with finer granularity, and show the overall progress as well as the progress of subcomponents, see: [Progress tracking](#). (WL #15531)

## Functionality Added or Changed

- HeatWave improves time zone support. When the time zone is set to [SYSTEM](#) or set to an offset from UTC, queries run in HeatWave. [DATE](#), [DATETIME](#), [TIMESTAMP](#), and [TIME](#) are processed based on the time-zone value. (Bug #35710134)

## Changes in HeatWave 8.1.0-u1 (2023-07-25, General Availability)

### Functionality Added or Changed

- HeatWave now accelerates queries with the following functions:

- [MID](#)
- [REGEXP\\_INSTR](#)
- [SOUNDEX](#)
- [SPACE](#)
- [WEIGHT\\_STRING](#)

(WL #15627)

## Changes in HeatWave 8.1.0 (2023-07-18, General Availability)

- [HeatWave AutoML](#)
- [Functionality Added or Changed](#)

### HeatWave AutoML

- HeatWave AutoML has enhanced recommendation systems that can now recommend new users who are similar to a specific user and new items that are similar to other items. See [Recommendations](#). (WL #15674)
- Improvements to HeatWave AutoML models, the model catalog, and [ML\\_MODEL\\_IMPORT](#) now fully support ONNX and HeatWave AutoML model import. (WL #15383, WL #15559)

### Functionality Added or Changed

- Memory-aware query optimization now automatically adjusts HeatWave to optimize query execution time or memory usage and reduce the likelihood of queries running out of memory without user intervention. (WL #15529)
- It is now possible to track the memory used by change propagation and the number of transactions committed to MySQL InnoDB that are waiting to be propagated to HeatWave. (WL #15326, WL #15688)
- HeatWave now accelerates queries with [INTERSECT](#) and [EXCEPT](#) clauses. With this support, HeatWave can now offload and accelerate all 97 TPC-DS queries. (WL #15362)
- HeatWave now supports the following temporal functions:
  - [GET\\_FORMAT\( \)](#)
  - [MAKETIME\( \)](#)
  - [PERIOD\\_ADD\( \)](#)



- `PERIOD_DIFF()`
- `SEC_TO_TIME()`
- `SUBTIME()`
- `SYSDATE()`
- `TIMEDIFF()`

(WL #14958)

## Changes in HeatWave 8.0.34 (2023-07-18, General Availability)

Version 8.0.34 has no release notes, or they have not been published because the product version has not been released.

## Changes in HeatWave 8.0.33-u3 (2023-06-09, General Availability)

### HeatWave Lakehouse

- MySQL HeatWave expands to include HeatWave Lakehouse, letting organizations process and query hundreds of terabytes of data residing in Object Storage—in a variety of file formats, such as CSV and Parquet.

The Lakehouse feature of MySQL HeatWave enables query processing on Object Storage-resident data. The source data is read from Object Storage, transformed to the HeatWave format, stored in the HeatWave persistence storage layer in OCI Object Storage, and then loaded to HeatWave Cluster memory.

- Provides in-memory query processing on Object Storage-resident data.
- Data is not loaded into the MySQL InnoDB storage layer.
- Supports structured and relational data in CSV and Parquet formats.
- With this feature, users can now analyse data in both MySQL InnoDB and an object store using familiar SQL syntax in the same query.

See [HeatWave Lakehouse](#). (WL #15526)

## Changes in HeatWave 8.0.33 (2023-04-27, General Availability)

- [HeatWave AutoML](#)
- [Functionality Added or Changed](#)

### HeatWave AutoML

- HeatWave AutoML now supports a recommendation task, see [Recommendations](#). (WL #15416)

### Functionality Added or Changed

- The new *HeatWave Auto Unload* utility automates the process of unloading tables from HeatWave. (WL #15447)

- The following columns were added to the `performance_schema.rpd_query_stats` table:
  - `CONNECTION_ID`: The ID of the connection.
  - `STATEMENT_ID`: The global query ID.

(WL #15526)

## Changes in HeatWave 8.0.32-u2 (2023-02-21, General Availability)

### HeatWave AutoML

- HeatWave AutoML now supports unsupervised anomaly detection, which is the data mining task that finds unusual patterns in data. (WL #15518)

## Changes in HeatWave 8.0.32-u1 (2023-02-21, General Availability)

- [HeatWave AutoML](#)
- [Functionality Added or Changed](#)

### HeatWave AutoML

- HeatWave AutoML adds support for multivariate endogenous forecasting models, and exogenous forecasting models. (WL #15511)

### Functionality Added or Changed

- The `rpdd_tables` table now supports recovery time measurement with `RECOVERY_SOURCE`, `RECOVERY_START_TIMESTAMP` and `RECOVERY_END_TIMESTAMP`. The `performance_schema.global_status` now includes the `rapid_recovery_time` variable. (WL #15441)
- Arithmetic operators are now supported with variable-length encoded string columns. Mathematical functions are now supported with variable-length columns. (WL #15405)

## Changes in HeatWave 8.0.32 (2023-01-17, General Availability)

- [Deprecation and Removal Notes](#)
- [HeatWave AutoML](#)
- [Functionality Added or Changed](#)

### Deprecation and Removal Notes

- MySQL 8.0.32 deprecates the `heatwave_load_report` and `heatwave_advisor_report` tables, and replaces them with the `heatwave_autopilot_report` table in the `sys` schema. A future release will remove them. (Bug #34727481)

### HeatWave AutoML

- MySQL 8.0.32 introduces a number of changes for HeatWave AutoML routines:
  - The routines: `ML_PREDICT_ROW`, `ML_PREDICT_TABLE`, `ML_EXPLAIN_ROW`, and `ML_EXPLAIN_TABLE` now include the `ml_results` column, which uses `JSON` format to return the results.

- The routines: `ML_PREDICT_ROW`, `ML_PREDICT_TABLE`, `ML_EXPLAIN_ROW`, and `ML_EXPLAIN_TABLE` now allow additional columns that are not required for prediction or explanation.
- The routines: `ML_PREDICT_ROW`, and `ML_PREDICT_TABLE` now allow an `options` parameter in `JSON` format.
- The `ML_TRAIN` routine also runs the `ML_EXPLAIN` routine with the default Permutation Importance model.

(WL #15420)

- MySQL 8.0.32 introduces progress tracking for `ML_TRAIN`. Use a second MySQL Client window to track the progress of `ML_TRAIN` with calls to the performance schema. It also introduces the `rapid_ml_operation_count` status variable. (WL #15384)

## Functionality Added or Changed

- HeatWave now supports the `COMPRESS()`, `MD5()`, `RANDOM_BYTES()`, `SHA()`, `SHA1()`, `SHA2()`, `UNCOMPRESS()`, and `UNCOMPRESSED_LENGTH()` encryption and compression functions. (WL #15283)
- HeatWave now supports the `CRC32()`, `LOG2()`, `LOG10()`, and `RAND()` mathematical functions. (WL #15256)

## Changes in HeatWave 8.0.31 (2022-10-11, General Availability)

- [HeatWave AutoML](#)
- [Functionality Added or Changed](#)

### HeatWave AutoML

- HeatWave AutoML queries are now monitored and recorded in the Performance Schema tables `rpq_query_stats` and `rpq_exec_stats`. Where a single HeatWave AutoML query contains a number of sub-queries, there is one record in `rpq_query_stats` and multiple records in `rpq_exec_stats`. (WL #15243)
- New functions have been added to HeatWave AutoML to help you manage models:
  - When you run the `ML_TRAIN` routine on a training dataset, you can now specify a model handle to use for the model instead of the generated one.
  - A new column `notes` has been added to the `MODEL_CATALOG` table, which you can use to record notes about the models in your model catalog.
  - The new column `model_metadata` in the `MODEL_CATALOG` table records metadata for models, such as the training score, training time, and information about the training dataset. If an error occurs during training or you cancel the training operation, HeatWave AutoML records the error status in this column.

(WL #15243)

- HeatWave AutoML now supports the upload of pre-trained models in ONNX (Open Neural Network Exchange) format to the model catalog. You can load them using the stored procedure `ML_MODEL_IMPORT` that provides the conversion required to store the model in a MySQL table. (WL #15243)

- A new stored procedure [ML\\_EXPLAIN](#) lets you train a variety of model explainers and prediction explainers for HeatWave AutoML, in addition to the default Permutation Importance model and prediction explainers:
  - The Partial Dependence model explainer shows how changing the values of one or more columns will change the value that the model predicts.
  - The SHAP model explainer produces global feature importance values based on Shapley values.
  - The Fast SHAP model explainer is a subsampling version of the SHAP model explainer which usually has a faster runtime.
  - The Permutation Importance prediction explainer explains the prediction for a single row or table.
  - The SHAP prediction explainer uses feature importance values to explain the prediction for a single row or table.

When you use the [ML\\_EXPLAIN\\_TABLE](#) and [ML\\_EXPLAIN\\_ROW](#) stored procedures to generate explanations for a prediction, you can now use the SHAP prediction explainer as an alternative to the default Permutation Importance prediction explainer. SHAP produces feature importance values (explanations) based on Shapley values. (WL #15243)

- HeatWave AutoML now supports timeseries forecasting using the existing stored procedures [ML\\_TRAIN](#), [ML\\_PREDICT\\_TABLE](#), and [ML\\_SCORE](#). You can create a forecast for a single column (a univariate endogenous variable) with a numeric data type. The forecasting task is specified as a JSON object when you call the [ML\\_TRAIN](#) stored procedure. (WL #15243)

## Functionality Added or Changed

- HeatWave uses dictionary encoding to compress string columns (CHAR, VARCHAR, TEXT). These dictionaries are built for each string column with the [RAPID\\_COLUMN=ENCODING=SORTED](#) keyword. HeatWave now supports 8.5 billion dictionary entries (up from 4 billion), which means HeatWave can now encode string columns with number of distinct value (NDV) up to 8.5 billion. (WL #14742)
- MySQL HeatWave now uses zone maps to exclude data chunks that are not relevant for a query. The zone map stores per chunk statistics for the minimum and maximum values of primary key columns. Queries using point and range filters to filter on values can now get accelerated by HeatWave by an order of magnitude. This is particularly useful for improving range queries in OLAP and mixed workloads. (WL #14713)
- A new hypergraph-based MySQL optimizer is introduced for HeatWave to provide a holistic cost model across MySQL and HeatWave, create better query plans based on statistics used in MySQL Autopilot, reduce compilation time, eliminate the need of query hints for join order, and improve join query performance. With the new optimizer, HeatWave can now run all 22 TPC-H queries without straight join hints. Before 8.0.31, a straight join hint is needed for 10 out of 22 TPC-H to reach peak performance. (WL #14449)
- DDL statements such as [ALTER TABLE](#), [RENAME TABLE](#), and [TRUNCATE TABLE](#) are now permitted on a table that has RAPID defined as the secondary engine. If a DDL operation is successfully carried out on a table that is loaded to a HeatWave Cluster at the time, HeatWave automatically reloads the table from MySQL InnoDB. Note that if the DDL operation makes the table's structure incompatible with HeatWave, the table is unloaded from the HeatWave Cluster. (WL #15129)

## Changes in HeatWave 8.0.30-u1 (2022-09-06, General Availability)

## Functionality Added or Changed

- HeatWave now supports the [ABS\(\)](#), [POWER\(\)](#), and [SIGN\(\)](#) mathematical functions. (WL #15246)
- HeatWave now supports the [GROUP\\_CONCAT\(\)](#) aggregation function with variable-length ([VARLEN](#)) string columns. (WL #14767)
- Change propagation memory management was enhanced to improve HeatWave shutdown time. (WL #15306)
- Query performance was optimized for compressed data. Decompression of data that is queried but does not participate in filter evaluation is delayed until after a filter is applied. With this optimization, decompression is avoided entirely for data that is filtered out. (WL #15169)

## Changes in HeatWave 8.0.30 (2022-07-26, General Availability)

- [Advisor](#)
- [HeatWave AutoML](#)
- [Functionality Added or Changed](#)

### Advisor

- HeatWave Advisor Auto Encoding, which recommends string column encodings, now provides encoding recommendations that optimize query performance. Recommendations are based on performance models that use query execution data. Previously, string column encoding recommendations were optimized for cluster memory usage only. A performance improvement estimate is provided with string column encoding recommendations. (Bug #34145862)

### HeatWave AutoML

- You can now train HeatWave AutoML models on tables containing [DATE](#), [TIME](#), [DATETIME](#), [TIMESTAMP](#), and [YEAR](#) data types. (Bug #33895503)
- HeatWave AutoML now generates a model explanation when you train a machine learning model. Model explanations help identify the features that are most important to a model. For more information, see [The Model Catalog](#).

The following columns were added to the [MODEL\\_CATALOG](#) table:

- [column\\_names](#): The feature columns used to train the model.
- [last\\_accessed](#): The last time the model was accessed. HeatWave AutoML routines update this value to the current timestamp when accessing the model.
- [model\\_explanation](#): The model explanation generated during training.
- [model\\_type](#): The type of model (algorithm) selected by [ML\\_TRAIN](#) to build the model.
- [task](#): The task type specified in the [ML\\_TRAIN](#) query ([classification](#) or [regression](#)).

[ML\\_PREDICT\\_\\*](#) and [ML\\_EXPLAIN\\_\\*](#) routine performance was improved, resulting in faster prediction and explanation processing. (WL #15088, WL #15014)

- The following HeatWave AutoML enhancements were implemented:

- `ML_TRAIN` options for advanced users. These options permit users to customize various aspects of the ML training pipeline including algorithm selection, feature selection, and hyperparameter optimization.
- The `model_list` option permits specifying the type of model to be trained.
- The `exclude_model_list` option specifies models types to exclude from consideration during model selection.
- The `optimization_metric` option specifies the scoring metric to optimize for when training a machine learning model.
- The `exclude_column_list` option specifies feature columns to exclude from consideration when training a machine learning model.

For more information, see [Advanced ML\\_TRAIN Options](#).

- Support was added for Support Vector Machine `SVC` and `LinearSVC` classification and regression models. For a complete list of supported model types, see [Model Types](#).
- The `ML_TRAIN` routine now reports a message if a trained model does not meet expected quality criteria.
- `ML_EXPLAIN_ROW` and `ML_EXPLAIN_TABLE` routines now provide information to help interpret explanations. The routines also report a warning when a model quality issue is detected, enabling users to revisit their data in order to improve model quality.

(WL #15089)

## Functionality Added or Changed

- The amount of heap memory allocated on the MySQL node for each table loaded into HeatWave was reduced, increasing the maximum number of tables that can be loaded. For `MySQL.HeatWave.VM.E3.Standard` shapes, the maximum was raised from 100k tables to 400k tables. For `MySQL.HeatWave.BM.E3.Standard` shapes, the maximum number was raised from 400k tables to 1600k tables. The actual number of tables that can be loaded is dependent on the table's data. (Bug #33951708)
- The `performance_schema.rpd_column_id` table was modified to remove redundant data. The `NAME`, `SCHEMA_NAME`, `TABLE_NAME` columns were removed, and a `TABLE_ID` column was added. (Bug #33899183)
- Support was added for the `FROM_DAYS( )` date and time function, and `GREATEST( )` and `LEAST( )` comparison and string functions now support `DATE`, `DATETIME`, `TIME`, and `TIMESTAMP` columns. (WL #14956)
- Support was added for built-in server-side data masking and de-identification to help protect sensitive data from unauthorized uses by hiding and replacing real values with substitutes. Data masking and de-identification operations are performed on the server, and queries involving data masking and de-identification functions are accelerated by HeatWave. The following data masking and de-identification functions are supported:
  - `gen_range( )`
  - `gen_rnd_email( )`

- `gen_rnd_pan()`
- `gen_rnd_ssn()`
- `gen_rnd_us_phone()`
- `mask_inner()`
- `mask_outer()`
- `mask_pan()`
- `mask_pan_relaxed()`
- `mask_ssn()`

See [Data Masking and De-Identification Functions](#). (WL #15143)

- Optimizations were implemented to improve performance for `JOIN` and `GROUP BY` queries with execution plans involving multiple consecutive rounds of data partitioning. (WL #15143)
- `expr IN (value,...)` comparisons, where the expression is a single value and compared values are constants of the same data type and encoding, have been optimized. For example, the following `IN()` comparison has been optimized:

```
SELECT * FROM Customers WHERE Country IN ('Germany', 'France', 'Spain');
```

(WL #14952)

## Changes in HeatWave 8.0.28-u3 (2022-04-19, General Availability)

### Functionality Added or Changed

- Tables that have become stale due to a change propagation failure resulting from an out-of-code error are now automatically reloaded. A check for stale tables is performed periodically when the HeatWave Cluster is idle. Previously, identifying and reloading stale tables was a manual process. See [Change Propagation](#). (WL #14914)

## Changes in HeatWave 8.0.28-u2 (2022-03-29, General Availability)

- [HeatWave AutoML](#)
- [Functionality Added or Changed](#)

### HeatWave AutoML

- HeatWave customers now have access to HeatWave AutoML, which is a fully managed, highly scalable, cost-efficient, machine learning solution for data stored in MySQL. HeatWave AutoML provides a simple SQL interface for training and using predictive machine learning models, which can be used by novice and experienced ML practitioners alike. With HeatWave AutoML, you can train a model with a single call to an SQL routine. Similarly, you can generate predictions with a single `CALL` or `SELECT` statement which can be easily integrated with your applications.

With HeatWave AutoML, data and models never leave the MySQL Database Service, saving you time and effort while keeping your data and models secure. HeatWave AutoML is optimized for HeatWave shapes and scaling, and all HeatWave AutoML processing is performed on the HeatWave Cluster. ML

computation is distributed among HeatWave nodes, taking advantage of HeatWave's scalability and massively parallel processing capabilities. For more information about HeatWave's machine learning capabilities, see [HeatWave AutoML](#). (WL #14661, WL #14836, WL #15014)

## Functionality Added or Changed

- HeatWave now compresses data as it is loaded, which permits HeatWave nodes to store more data. More data per node reduces costs by minimizing the size of the HeatWave Cluster required to store your data. Data compression is enabled by default but can be disabled at runtime using the `rapid_compression` session variable. For more information, see [Data Compression](#). (WL #14868)

## Changes in HeatWave 8.0.28-u1 (2022-02-15, General Availability)

### Functionality Added or Changed

- HeatWave now supports up to 1017 columns for base relations (tables as loaded into HeatWave), and up to 1800 columns for intermediate relations (intermediate tables used during query processing). The maximum column width for base relations and intermediate relations was increased to 65532 bytes. See [Column Limits](#). (WL #14918)

## Changes in HeatWave 8.0.27-u3 (2021-12-15, General Availability)

### Functionality Added or Changed

- Support was added for the `CONVERT_TZ( )` and `LAST_DAY( )` functions, which are used to manipulate temporal values. (WL #14768)
- The HeatWave Cluster recovery process was optimized to avoid applying a large volume of changelogs during recovery. Snapshots are now taken when the volume of changelogs and the time required to apply those changes exceed specific thresholds, and recovery from Object Storage is performed using those snapshots. (WL #14615)
- HeatWave now supports automatic data reload when the HeatWave Cluster is restarted. Previously, when a HeatWave Cluster was stopped by a stop or restart action, data had to be reloaded manually after the cluster was restarted. Now, when starting or restarting a HeatWave Cluster, data that was previously loaded is reloaded automatically. Data changes that occur on the DB System while the HeatWave Cluster is offline are included in the reloaded data.

Automatic data reload does not occur if the HeatWave Cluster was stopped as a result of a stop or restart action performed on the DB System to which the HeatWave Cluster is attached. In this case, data loaded in the HeatWave Cluster must be reloaded manually after the HeatWave Cluster is restarted. (WL #14729)

## Changes in HeatWave 8.0.27-u2 (2021-12-07, General Availability)

### Functionality Added or Changed

- HeatWave now supports querying views. See [Using Views](#). (WL #13568)
- Bloom filter join optimizations were introduced. For HeatWave queries that join large and small relations, bloom filters reduce the amount of data processed by early filtering and the amount of memory used during query processing. (WL #14752)
- The `rpq_query_stats` table, which stores HeatWave query history (compilation and execution statistics), now stores data for the last 1000 executed queries. Previously, data was stored for the last 200 queries.



The following columns were added to the `performance_schema.rpd_tables` table:

- `SIZE_BYTES`: The amount of data loaded per table, in bytes.
- `QUERY_COUNT`: The number of queries that referenced the table.
- `LAST_QUERIED`: The timestamp of the last query that referenced the table.
- `LOAD_END_TIMESTAMP`: The load completion timestamp for the table.

The following column was added to the `performance_schema.rpd_columns` table:

- `DICT_SIZE_BYTES`: The dictionary size per column, in bytes.

The following column was added to the `performance_schema.rpd_nodes` table:

- `BASEREL_MEMORY_USAGE`: The base relation memory footprint per node.

The `rapid_query_stats` and `rpdc_exec_stats` tables are now synchronized. If a query record is removed from the `rapid_query_stats` table, it is also removed from the `rpdc_exec_stats` table. (WL #14759)

## Changes in HeatWave 8.0.26-u2 (2021-09-21, General Availability)

### Functionality Added or Changed

- The following function support was added:
  - `YEARWEEK(date)`, `YEARWEEK(date, mode)`
  - The mode argument for the two-argument form of the `WEEK()` function: `WEEK(date[, mode])`
  - `MAKEDATE()`
  - “Zero” handling for dates such as '2001-11-00' was implemented for `WEEK()`, `YEARWEEK()`, and `MAKEDATE()` functions.
  - `CAST()` of `FLOAT` and `DOUBLE` values to `DECIMAL`

(Bug #33163625, Bug #33138534, WL #14714)

- The new `hw_data_scanned` global status variable tracks the total cumulative megabytes scanned by successfully executed HeatWave queries.

The number of megabytes scanned by an individual HeatWave query can be obtained by querying the `performance_schema.rpd_query_stats` table.

An estimated number of megabytes scanned by an individual query can be obtained by running the query with `EXPLAIN` and querying the `performance_schema.rpd_query_stats` table.

For more information, see [Scanned Data Monitoring](#). (WL #14738)

## Changes in HeatWave 8.0.26-u1 (2021-08-10, General Availability)

- [HeatWave Network Layer](#)
- [HeatWave Data Management Layer](#)

- [Functionality Added or Changed](#)

## HeatWave Network Layer

- HeatWave network layer optimizations have improved scalability and network performance. (WL #14513)

## HeatWave Data Management Layer

- Data loaded into HeatWave, including propagated changes, are now persisted to OCI Object Storage for recovery in case of a HeatWave node or cluster failure. Previously, data was recovered from the MySQL DB System. Loading data from OCI Object Storage is faster because data does not need to be converted to the HeatWave storage format, as is required when loading data from the MySQL DB System. If data recovery from OCI Object Storage fails, HeatWave falls back to recovering data from the MySQL DB System. Data removed from HeatWave when a table is unloaded is removed from OCI Object Storage in a background operation. For related information, see [HeatWave Cluster Failure and Recovery](#). (WL #14478, WL #14046, WL #14541)

## Functionality Added or Changed

- HeatWave now supports `COUNT(NULL)`, except in cases where it is used as an input argument for non-aggregate operators. (Bug #33005146)
- Full support was added for the `DISTINCT` modifier. Previously, multiple instances of (`DISTINCT value`) expressions in a query were only permitted if the same `value` was specified. (Bug #32865043, Bug #33007714, WL #14574)
- HeatWave now supports the `WITH ROLLUP` modifier in `GROUP BY` clauses. (WL #14533)
- HeatWave now supports window functions. For optimal performance, window functions in HeatWave utilize a massively parallel, partitioning-based algorithm. For more information, see [Window Functions](#). (WL #14674)

## Changes in HeatWave 8.0.26 (2021-07-23, General Availability)

- [Advisor](#)
- [Auto Parallel Load](#)
- [Auto Scheduling](#)
- [Functionality Added or Changed](#)

### Advisor

- The new *HeatWave Advisor* provides *string column encoding* and *data placement* key recommendations based on machine learning models, data analysis, and HeatWave query history. Implementing HeatWave Advisor recommendations can improve query performance and reduce the amount of memory required on HeatWave nodes.

The HeatWave Advisor also provides a *Query Insights* feature, which provides *runtimes* for successfully executed queries, and *runtime estimates* for `EXPLAIN` queries, queries canceled using `Ctrl+C`, and queries that fail due to out of memory errors. Runtime data is useful for query optimization, troubleshooting, and estimating the cost of running a particular query or workload.

The HeatWave Advisor is implemented as a stored procedure named `heatwave_advisor`, which resides in the MySQL `sys` schema. Running Advisor involves issuing a `CALL` statement for the stored procedure with optional arguments.

```
CALL sys.heatwave_advisor (options);
```

For more information about the HeatWave Advisor, see [Workload Optimization using Advisor](#). (WL #14328, WL #14510, WL #14431, WL #14328, WL #14651)

## Auto Parallel Load

- The new HeatWave Auto Parallel Load utility automates the process of preparing and loading tables into HeatWave and loads data using an optimized number of parallel load threads.

The HeatWave Auto Parallel Load utility is implemented as a stored procedure named `heatwave_load`, which resides in the MySQL `sys` schema. Running Auto Parallel Load involves issuing a `CALL` statement for the stored procedure, which takes a list of schemas and options as arguments.

```
CALL sys.heatwave_load (db_list, [options]);
```

For more information about the HeatWave Auto Parallel Load utility, see [Loading Data Using Auto Parallel Load](#). (WL #14149)

## Auto Scheduling

- The HeatWave query scheduling algorithm was improved. The revised algorithm prioritizes queries based on estimated cost and wait time in the queue, which enables dynamic, workload-aware query prioritization. Previously, queries were prioritized using a static cost-based prioritization model. (WL #14608)

## Functionality Added or Changed

- `DATE_ADD()` and `DATE_SUB()` functions now support precision `INTERVAL` values (`DECIMAL`, `DOUBLE`, and `FLOAT`). (Bug #32725985, Bug #32438123)
- Support was added for multiple instances of `COUNT(DISTINCT)` in a query. (Bug #32422984)
- Query compilation and processing was improved to permit combining aggregate operators into a single task in the physical query plan, which avoids fully materializing intermediate result sets. This enhancement reduces memory allocation and deallocation operations, memory usage, and execution time for affected queries. (WL #14614)
- The cost model that estimates HeatWave query runtimes can now use statistics from previously executed queries, which improves the accuracy of query runtime estimates. (WL #14546)
- HeatWave now supports `CREATE TABLE ... SELECT` statements where the `SELECT` query is offloaded to HeatWave and the table is created on the MySQL Database Service instance. This feature improves `CREATE TABLE ... SELECT` performance in cases where the `SELECT` portion of the statement is a long running, complex query. For more information, see [CREATE TABLE ... SELECT Statements](#). (WL #14516)
- Support was added for `REGEXP_REPLACE()` and `REGEXP_SUBSTR()` regular expression functions, and error messaging was improved for `REGEXP()` function syntax mismatches, expression errors, and input argument errors. (WL #14641)

## Changes in HeatWave 8.0.25 (2021-05-11, General Availability)

### Functionality Added or Changed

- Support was added for `CAST()` of `ENUM` column values to `CHAR` or `VARCHAR` where the `ENUM` value is cast to a `FLOAT` value, as in the following example:

```
SELECT CAST(CAST(enum\_col AS FLOAT) AS CHAR(3)) FROM tbl\_name;
```

(Bug #32618454)

- Support was added for [SELECT DISTINCT](#) queries that order the result set by a column that is not defined in the [SELECT](#) list. For example, the following query can now be offloaded to HeatWave for execution:

```
SELECT DISTINCT a FROM t1 ORDER BY c DESC;
```

(Bug #32583856)

- Query plan statistics are now collected and stored in a statistics cache when a query is executed in HeatWave. When a new query shares query execution plan nodes with previously executed queries, the actual statistics collected from previously executed queries are used instead of estimated statistics, which improves query execution plans, cost estimations, execution times, and memory efficiency.

The statistics cache is an LRU structure. When cache capacity is reached, the least recently used entries are evicted from the cache as new entries are added. The maximum number of entries permitted in the statistics cache is defined by the [rapid\\_stats\\_cache\\_max\\_entries](#) setting. The number of entries permitted by default is 65536, which is enough to store statistics for 4000 to 5000 unique queries of medium complexity. (WL #14503)

- Support was added for:
  - [CAST\(\) AS YEAR](#). Both variable-length and dictionary-encoded string columns values are supported.
  - The [FORMAT\(\)](#) function. Variable-length-encoded string columns are not supported.

(WL #14511)

## Changes in HeatWave 8.0.24 (2021-04-20, General Availability)

### Functionality Added or Changed

- Comparison of different temporal type values is now supported. For example, a query that compares [DATE](#) values to [TIMESTAMP](#) values can now be offloaded to HeatWave. (Bug #32420986)
- Range operators on [VARLEN](#)-encoded string columns are now supported. For example, the following query, where [L\\_LINESTATUS](#) is a [VARLEN](#)-encoded string column, can now be offloaded to HeatWave:

```
SELECT COUNT(*) FROM lineitem WHERE L_LINESTATUS >= 1 and L_LINESTATUS <= 10;
```

(Bug #31721399)

- HeatWave now supports [INSERT ... SELECT](#) statements where the [SELECT](#) query is offloaded to HeatWave and the result set is inserted into a table on the MySQL Database Service instance. This feature improves [INSERT ... SELECT](#) performance in cases where the [SELECT](#) portion of the statement is a long running, complex query. For more information, see [INSERT ... SELECT Statements](#). (WL #14299)
- [VARLEN](#)-encoded columns are now supported as data placement keys. For information about the data placement feature, see [Defining Data Placement Keys](#). (WL #14491)
- Failure handling was improved for queries involving unsupported internal data types. Such queries now exit with an error indicating that the internal data type of the query is not supported. (WL #14483)

## Changes in HeatWave 8.0.23-u2 (2021-03-15, General Availability)

### Functionality Added or Changed

- Support was added for the following aggregate functions:

- `STD()`
- `STDDEV()`
- `STDDEV_POP()`
- `STDDEV_SAMP()`
- `VAR_POP()`
- `VAR_SAMP()`
- `VARIANCE()`

See [Aggregate Functions](#). (WL #14479)

- HeatWave now uses a priority-based scheduling mechanism based on query cost estimates to schedule queries for execution. Previously, queries were executed in the order of arrival. The scheduling mechanism prioritizes short running queries over long running queries to reduce overall query execution wait times. For more information, see [Auto Scheduling](#). (WL #14423)

## Changes in HeatWave 8.0.23-u1 (2021-02-09, General Availability)

### Functionality Added or Changed

- String column encoding support was added for `TEXT`-type columns. See [Encoding String Columns](#). (WL #14430)
- `UNION` and `UNION ALL` support was extended. The clauses are now supported at any location in a query that is permitted by MySQL. (WL #14455)
- The following date and time functions are now supported:
  - `TO_SECONDS()`
  - `UNIX_TIMESTAMP()`
  - `FROM_UNIXTIME()`
  - `TIME_TO_SEC()`

See [Date and Time Functions](#).

The following date and time functions are now supported with `VARLEN`-encoded columns:

- `TO_DAYS()`
- `DAYOFYEAR()`
- `QUARTER()`
- `TO_SECONDS()`

See [Date and Time Functions](#).

The following string functions are now supported with `VARLEN`-encoded columns:

- `ORD()`
- `ASCII()`

See [String Functions and Operators](#).

`SET timezone = timezone` with the `timezone` value specified as an offset from UTC in the form of `[H]H:MM` and prefixed with a `+` or `-` is now supported with the `UNIX_TIMESTAMP()` and `FROM_UNIXTIME()` functions. (WL #14345)

- Offset is now supported with the `LIMIT` clause:

```
SELECT * FROM tbl LIMIT offset,row_count;
```

The PostgreSQL syntax is also supported:

```
SELECT * FROM tbl LIMIT row_count OFFSET offset;
```

(WL #14341)

- New Performance Schema tables provide access to query and execution statistics:

- `performance_schema.rpd_exec_stats`
- `performance_schema.rpd_query_stats`

Changes to HeatWave Performance Schema tables:

- An `NDV` (Number of Distinct Values) column was added to the `performance_schema.rpd_columns` table.
- A `ROWS` column that shows the total number of rows in a table was added to the `performance_schema.rpd_tables` table.
- A `MEMORY_USAGE` column that shows node memory usage was added to the `performance_schema.rpd_columns` table.
- The `performance_schema.rpd_nodes` `DRAM` column was renamed to `MEMORY_TOTAL`. The `MEMORY_TOTAL` column shows the total memory allocated to a HeatWave node.

See [HeatWave Performance Schema Tables](#). (WL #14386)

## Index

### A

`ABS()`, 12  
Advisor, 13, 18  
aggregate functions, 21  
`ASCII()`, 21  
Auto Encoding, 13  
Auto Parallel Load, 5, 18  
Auto Schema Advisor, 4

## **B**

bloom filter optimization, 16

## **C**

CAST(), 5, 17, 19  
change propagation, 12, 15  
column limits, 16  
comparisons, 13  
CONVERT\_TZ(), 16  
COUNT(DISTINCT), 18  
COUNT(NULL), 17  
CREATE TABLE ... SELECT, 18

## **D**

data compression, 12, 15  
data placement, 20  
data types, 20  
DATE\_ADD(), 18  
DATE\_SUB(), 18  
DAYOFYEAR(), 21  
DISTINCT, 17

## **E**

EXCEPT, 8

## **F**

FORMAT(), 19  
FROM\_DAYS(), 13  
FROM\_UNIXTIME(), 21

## **G**

GREATEST(), 3, 13  
GROUP BY, 17  
GROUP\_CONCAT(), 12

## **H**

heap segment size, 13

## **I**

IN(), 13  
INSERT ... SELECT, 20  
INTERSECT, 8

## **L**

LAST\_DAY, 16  
LEAST(), 3, 13  
LIMIT, 21  
loading data, 13

## **M**

machine learning, 4, 6, 7, 7, 8, 9, 10, 10, 10, 11, 13, 15  
MAKEDATE(), 17

MySQL InnoDB, 6

## **N**

networking, 17

## **O**

Object Storage, 16

OFFSET, 21

ORD(), 21

## **P**

partitioning, 13

Performance Schema, 13, 16

planned shutdown, 16

POWER(), 12

## **Q**

QUARTER(), 21

queries, 17, 20

query cost model, 18

query scheduling, 18, 21

## **R**

rapid\_stats\_cache\_max\_entries, 19

recovery, 16, 17

REGEXP\_REPLACE(), 18

REGEXP\_SUBSTR(), 18

rpd\_cloumns table, 21

rpd\_column\_id table, 13

rpd\_exec\_stats table, 21

rpd\_nodes table, 21

rpd\_query\_stats, 16

rpd\_query\_stats table, 9, 21

## **S**

scalability, 17

SELECT DISTINCT, 19

SET timezone, 21

SIGN(), 12

statistics, 19

string column encoding, 20

## **T**

temporal data types, 13

temporal type comparison, 20

TEXT, 21

TIME\_TO\_SEC(), 21

TO\_DAYS(), 21

TO\_SECONDS(), 21

## **U**

UNION, 21



UNION ALL, 21  
UNIX\_TIMESTAMP(), 21

## **V**

variable-length encoding, 20  
VARLEN encoding, 21  
views, 16

## **W**

WEEK(), 17  
window functions, 17  
WITH ROLLUP, 17

## **Y**

YEARWEEK(), 17

