

## FM 303-2024 WMO-CF Atmospheric Trajectory.

### **303.1 Scope**

- 303.1.1 This profile is intended for the reporting of meteorological, atmospheric chemistry and air quality observations along one or more trajectories from a single platform. The trajectory may follow an undulating profile.
- 303.1.2 The data shall be stored as either a single timeseries for the entire flight/trajectory, or using a multidimensional array representation for multiple trajectories.

*Note: see <https://cfconventions.org/Data/cf-conventions/cf-conventions-1.9/cf-conventions.html#trajectory-data> for further information on the multidimensional array representation.*

- 303.1.3 Only data for a single platform shall be included in the file.
- 303.1.4 Groups are not supported in this profile and groups other than the root group shall not be used.

### **303.2 Global scope / root group**

#### *303.2.1 Global attributes*

- 303.2.1.1 The rules for global attributes from the general regulations shall apply.
- 303.2.1.2 Table 303-1a lists the values that shall be used for the indicated mandatory attributes.

#### *303.2.2 Station / platform identifier*

- 303.2.2.1 The rules for station identifiers WMO-CF.4.5, WMO-CF.4.6, WMO-CF.6.10.6 and WMO-CF.6.10.7 shall be observed.
- 303.2.2.2 Table 303-1b lists additional global attributes that should be used to further identify the platform or station making the observations.

#### *303.2.3 Dimensions*

- 303.2.3.1 Files containing atmospheric profile trajectory data shall have the following dimensions:
  - 303.2.3.1.1 `obs`, the `obs` dimension shall be used to indicate the total number of observations per trajectory within the file.
  - 303.2.3.1.2 `trajectory`, the `trajectory` dimension shall be used to indicate the number of trajectories contained in the file and to index the observations to a trajectory. When there is a single trajectory in the file this dimension can be omitted.

#### *303.2.4 Coordinate Variables*

- 303.2.4.1 Table 303-2 lists the coordinate variables that shall be used with this profile.

#### *303.2.5 Trajectory identification*

- 303.2.5.1 When storing multiple trajectories in the same file, the trajectory dimension provides the identifier for a trajectory, and the number of trajectories in the file. See example 2.
- 303.2.5.2 Table 303-3 defines the variable and variable attributes that shall be used to identify the trajectories when more than one trajectory is included.
- 303.2.6 Data variables*
- 303.2.6.1 The general regulations for data variables, including mandatory attributes, defined in regulation WMO-CF.5 shall apply.
- 303.2.6.2 For files containing a single trajectory the data variables shall have a single dimension `obs`.
- 303.2.6.3 For files containing multiple trajectories the data variables shall have two dimensions, `trajectory` followed by `obs`.
- 303.2.6.4 The NetCDF variable names shall be interpreted as the short name for the variable.
- 303.2.6.5 Table 303-4a provides a list of names that should be used for the indicated geophysical parameters reported.
- 303.2.6.6 Table 303-4b provides guidance on the attributes for those variables.
- 303.2.6.7 Multiple variables sharing the same short name shall follow the following naming convention: `<measurement_short_name>_<n>`, where `<n>` is incremented for each additional variable sharing the same short name. For example, `humidity_1` and `humidity_2` in the case of two humidity sensors on an observing platform.
- 303.2.6.8 Table 303-5a provides a list of names that should be used for the reporting the platform trajectory and orientation.
- 303.2.6.9 Ancillary variables*
- 303.2.6.10 The naming of the ancillary variables shall take the form `<measurement_short_name>_<n>_<ancillary_variable>`
- 303.2.6.11 Table 303-7a lists the ancillary variables that should be reported for the observed / measured variables.
- 303.2.6.12 Table 303-7b lists the attributes that shall be included for those ancillary variables when reported.

## FM-303-2024 Tables

**Table 303-1a: Mandatory global attributes and required values**

Global attribute	Description / value
Conventions	A comma separated list of the conventions being followed "CF-1.8, WMO-CF-1.0"
wmo_cf_profile	"FM 303-2024"
featureType	"trajectory"

**Table 303-1b: Recommended global attributes**

Global attribute	Description
platform_name	Name / non WMO identifier of the platform(s) that supported the sensor data used to create this data set or product.
flight_id	Human readable unique identifier for data set

**Table 303-2a: Coordinate variables that shall be used in the trajectory/ profile. Attributes are given in Table 303-2b.**

Coordinate variable	dimensions	Type (recommended)	comments
/lat	(obs) [single trajectory] (obs, trajectory) [multiple trajectories]	Float	Latitude of the observations
/lon	(obs) [single trajectory] (obs, trajectory) [multiple trajectories]	Float	Longitude of the observations
/altitude	(obs) [single trajectory] (obs, trajectory) [multiple trajectories]	Any numeric	Vertical position of the platform relative to sea level, for example altitude in meters above sea level
/pressure	(obs) [single trajectory] (obs, trajectory) [multiple trajectories]	Float (could also be int or double depending on precision)	Pressure level as an alternative to altitude above sea level (hPA)
/time	(obs) [single trajectory] (obs, trajectory) [multiple trajectories]	double	Date and time of the observation

**Table 303-2b: Attributes for the coordinate variables given in Table 303-2a.**

Variable	attribute	value
/lat	standard_name	'latitude'
	units	'degrees_north'
	axis	'Y'
	valid_min	0.0f - optional – replace with correct value
	valid_max	0.0f - optional – replace with correct value
/lon	standard_name	'longitude'
	units	'degrees_east'
	axis	'X'
	valid_min	0.0f - optional – replace with correct value
	valid_max	0.0f - optional – replace with correct value
/altitude	standard_name	'altitude'
	units	'km'
	axis	'Z'
	positive	'up'
	long_name	'altitude_above_sea_level'
	valid_min	0.0f - optional – replace with correct value
	valid_max	0.0f - optional – replace with correct value
/pressure	standard_name	'pressure'
	units	'Pa'
	axis	'Z'
	positive	'up'
	long_name	'air_pressure'
	valid_min	0.0f - optional – replace with correct value
	valid_max	0.0f - optional – replace with correct value
/time	standard_name	'time'
	units	'seconds since <reftime> where <reftime> is ISO8601 time string of the form YYYY-MM-DDThh:mm:ssZ'
	axis	'T'
	calendar	'standard'

**Dimensions: Table 303-3a:** Variables defined to identify the trajectory an observation belongs to and that shall be included in atmospheric trajectory files. Attributes are listed in Table 303-3b.

Variable path/name	Dimensions	Type	Comments
/trajectory	(trajectory)	string	Identifier for trajectory

**Table 303-3b:** Attributes for the trajectory variables listed in Table 303-3a.

Variable path/ name	Attribute	Type	Value
/trajectory	cf_role	string	"trajectory_id"
	long_name	String	"trajectory name"

**Variables:**

**Table 303-4a:** Example geophysical variables. Dimensions shall be (obs) [single trajectory] or (obs, trajectory) [multiple trajectories].

Variable	Type	Value/ units
air_temperature	Float or double	K
air_pressure	Float or double	Pa
elapsed_time	Float or double	s
relative_humidity	Float or double	%
dew_point_temperature	Float or double	K
humidity_mixing_ratio	Float or double	kg kg <sup>-1</sup>
wind_speed	Float or double	m s <sup>-1</sup>
wind_direction	Float or double	degree
y_wind	Float or double	m s <sup>-1</sup> (positive north)
x_wind	Float or double	m s <sup>-1</sup> (positive east)
vertical_wind_component	Float or double	m s <sup>-1</sup> (positive up)
upward_air_velocity	Float or double	m s <sup>-1</sup>
turbulent_kinetic_energy	Float or double	m <sup>2</sup> s <sup>-2</sup>
eddy_dissipation_rate	Float or double	m <sup>2/3</sup> s <sup>-1</sup>
cloud_liquid_water_mixing_ratio	Float or double	kg kg <sup>-1</sup>

**Table 303-4b:** Example attributes for each geophysical variable

Variable	Attribute	Description
geophysical variable 1	standard_name	CF compliant standard name
	units	CF complaint appropriate unit
	scale_factor	If the data uses a scale factor other than 1. The data type should be the data type of the variable.
	add_offset	If the data uses an add offset other than 0. The data type should be the data type of the variable.
	_FillValue	If there could be missing values in the data
	valid_min	0.0f - optional – replace with correct value
	valid_max	0.0f - optional – replace with correct value
	coordinates	e.g., “time lat lon z”
	instrument_variable	Refers to name of variable containing information on the instrument from which this variable was collected.
	platform_variable	Refers to name of variable containing information on the platform from which this variable was collected.
	ancillary_variables	Identify the variable name(s) of the flag(s) and other ancillary variables relevant to this variable. Use a space-separated list.

**Table 303-5a: example platform variables.** Dimensions shall be (obs) [single trajectory] or (obs, trajectory) [multiple trajectories].

Variable	Type	Value/ units
platform_pitch	Float or double	degree
Platform_pitch_rate	Float or double	degree s-1
platform_yaw	Float or double	degree
Platform_yaw_rate	Float or double	degree s-1
platform_roll	Float or double	degree
platform_roll_rate	Float or double	degree s-1
platform_speed_wrt_ground	Float or double	m s-1
platform_course	Float or double	degree
platform_speed_wrt_air	Float or double	m s-1
platform_speed_wrt_ground_upward	Float or double	m s-1
platform_eastward_ground_speed	Float or double	m s-1
platform_northward_ground_speed	Float or double	m s-1

**Table 303-6a:** Conditional/ ancillary Variables that should be reported for each measured/observed variable. <prefix> has been used to represent <measurand\_short\_name>\_<n>. Dimensions shall be (obs) [single trajectory] or (obs, trajectory) [multiple trajectories].

Variable name	type	comments
<prefix>_sensor	string	Name of sensor
<prefix>_sensor_make	string	Manufacturer of sensor
<prefix>_sensor_model	string	Model of sensor
<prefix>_sensor_serial_number	string	Sensor serial number
<prefix>_sensor_calibration_date	string	Last calibration date of sensor

**Table 303-6b:** Attributes for the ancillary variables defined in Table 303-6a, <prefix> has been used to represent <measureand\_short\_name>\_<n>.

Variable name	attribute	type	value
<prefix>_sensor_calibration_date	standard_name	string	"time"
	units	string	"seconds since " where is an ISO8601 time string of the form YYYY-MMDDThh:mm:ss
	axis	string	"T"
	calendar	string	"standard"

**Table 303-7a:** Conditional/ optional ancillary variables defined and that should be reported for each measured/ observed variable when the described conditions are met. Attributes are given in Table 5b. <prefix> has been used to represent : measurand\_short\_name>\_<n>. Dimensions shall be (obs) [single trajectory] or (obs, trajectory) [multiple trajectories].

Variable path / name	Type	Comments
/<prefix>_sensor_installed_height	float	Value to be added to sensor_height to get vertical position of sensor relative to ground level
</prefix>_sensor_measurement_method	string	The method used by the sensor to measure the parameter, e.g. "capacitive humidity sensor"

**Table 303-7b:** Attributes for the ancillary variables defined in Table 303-7a. <prefix> has been used to represent <measurand\_short\_name>\_<n>

Variable path/ name	Attribute	Type	Value
/<prefix>_sensor_installed_height	units	string	"meters"
<prefix>_sensor_measurement_method	wmo__parameter_name	string	
	wmo__parameter_uri	string	

### Example 1: A single trajectory recording temperature and relative humidity

dimensions:

```
obs = 42;
```

variables:

```
double time(obs) ;
    time:standard_name = "time";
    time:long_name = "time" ;
    time:units = "days since 1970-01-01 00:00:00" ;
float lon(obs) ;
    lon:standard_name = "longitude";
    lon:long_name = "longitude" ;
    lon:units = "degrees_east" ;
float lat(obs) ;
    lat:standard_name = "latitude";
    lat:long_name = "latitude" ;
    lat:units = "degrees_north" ;
float z(obs) ;
    z:standard_name = "altitude";
    z:long_name = "height above mean sea level" ;
    z:units = "km" ;
    z:positive = "up" ;
    z:axis = "Z" ;

float temp(obs) ;
    temp:standard_name = "air_temperature";
    temp:long_name = "bulk temperature of the air" ;
    temp:units = "K" ;
    temp:coordinates = "time lon lat z" ;

float rh(obs) ;
    rh:standard_name = "relative_humidity";
    rh:long_name = "relative humidity - percentage water vapour
                    content of air" ;
    rh:units = "%" ;
    rh:coordinates = "time lon lat z" ;
```

attributes:

```
:featureType = "trajectory";
```



## Example 2: Trajectories recording temperature and relative humidity in a multidimensional array representation

dimensions:

```
obs = 1000 ;  
trajectory = 12 ;
```

variables:

```
string trajectory(trajectory) ;  
    trajectory:cf_role = "trajectory_id";  
    trajectory:long_name = "trajectory name" ;  
int trajectory_info(trajectory) ;  
    trajectory_info:long_name = "some kind of trajectory info"
```

```
double time(trajectory, obs) ;  
    time:standard_name = "time";  
    time:long_name = "time" ;  
    time:units = "days since 1970-01-01 00:00:00" ;
```

```
float lon(trajectory, obs) ;  
    lon:standard_name = "longitude";  
    lon:long_name = "longitude" ;  
    lon:units = "degrees_east" ;
```

```
float lat(trajectory, obs) ;  
    lat:standard_name = "latitude";  
    lat:long_name = "latitude" ;  
    lat:units = "degrees_north" ;
```

```
float z(trajectory, obs) ;  
    z:standard_name = "altitude";  
    z:long_name = "height above mean sea level" ;  
    z:units = "km" ;  
    z:positive = "up" ;  
    z:axis = "Z" ;
```

```
float temp(trajectory, obs) ;  
    temp:standard_name = "air_temperature";  
    temp:long_name = "bulk temperature of the air" ;  
    temp:units = "K" ;  
    temp:coordinates = "time lon lat z" ;
```

```
float rh(trajectory, obs) ;  
    rh:standard_name = "relative_humidity";  
    rh:long_name = "relative humidity - percentage water vapour  
                    content of air" ;  
    rh:units = "%" ;  
    rh:coordinates = "time lon lat z" ;
```

attributes:

```
:featureType = "trajectory";
```