P-04-313

Forsmark site investigation

Hydro monitoring program

Report for June 2002 – July 2004

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Geosigma

Per-Olof Johansson, Artesia

August 2004

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ISSN 1651-4416
SKB P-04-313

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Keywords: AP PF 400-04-31, Groundwater, Borehole, Instrumentation, Measurement methods, Monitoring, Forsmark.

Abstract

This document reports data obtained within the hydro monitoring program, which is one of the activities performed within the site investigation at Forsmark. The objective of the hydrogeological investigations is to document the groundwater conditions before, during and after a possible establishment of a deep repository.

Data presented in this report are collected from the beginning of the activity, i.e. June 2002, until July 2004 and include groundwater levels in boreholes and water levels in two flumes at the earliest installed out of three planned runoff stations. Meteorological data and some service parameters have also been collected within the scope of this activity, but are not presented in this report.

The data collecting system in HMS (Hydro Monitoring System) consists of one measurement station (computer) which communicates with and collects data from a number of dataloggers. The computer is connected to the SKB Ethernet LAN. All data are collected by means of different transducers connected to different types of data loggers: GeoNordic, Minitroll, Mitec and Datataker.

In order to calibrate registrations from the data loggers, manual levelling of all sections is made, normally once every month. The logger data are converted to water levels using the calibration constants. All data collected are quality checked once every three months. During this work, obviously erroneous data are removed and calibration constants are corrected so that the monitored data correspond with the manual levelling. At these occasions the status of the equipment is also controlled and service might be initiated.

Annual diagrams of groundwater levels for the years 2002–2004 (one data point per section and twenty-four hours) are presented in Appendix 1. The original data are stored in the primary data base SICADA. The data in this data base may then be used for further analysis.

Flow measurement is performed in two flumes with different ranges, but located at the same runoff station. Values of water level, water temperature and electrical conductivity are monitored and presented in Appendix 2–4.

There are no nonconformities with respect to the activity plan or the method description.

Sammanfattning

Denna rapport redovisar data erhållna inom programmet för grundvattenmonitering vilket är en av aktiviteterna inom platsundersökningen i Forsmark. Syftet med de hydrogeologiska undersökningarna är att dokumentera grundvattenförhållanden före, under och efter en eventuell etablering av ett djupförvar.

De data som presenteras i rapporten är insamlade från början av aktiviteten, dvs juni 2002, till och med juli 2004 och består av grundvattennivåer i borrhål och vattennivåer i två vattenrännor i den första av tre planerade avrinningsstationer. Meteorologiska data och några serviceparametrar insamlas likaså inom ramen för aktiviteten men presenteras inte i denna rapport.

Datainsamlingssystemet i HMS (Hydro Monitoring System) består av en mätstation (dator) vilken kommunicerar med och samlar in data från ett antal dataloggrar. Datorn är förbunden med SKB:s nätverk. Alla data samlas in med hjälp av givare förbundna med olika typer av dataloggrar: GeoNordic, Minitroll, Mitec och Datataker.

För att kunna kalibrera registreringarna från dataloggrarna utförs, vanligtvis en gång i månaden, manuell nivåregistrering (lodning) i alla sektioner. Loggerdata omvandlas till vattennivåer genom applicering av kalibreringskonstanter. Alla insamlade data kvalitetskontrolleras en gång i kvartalet. Under detta arbete tas uppenbart felaktiga data bort och kalibreringskonstanterna korrigeras så att automatiskt registrerade data överensstämmer med manuella nivåregistreringar. Vid dessa tillfällen kontrolleras utrustningens status och service kan initieras.

Årliga diagram över grundvattennivåerna för åren 2002–2004 (en datapunkt per sektion och 24 timmar) visas i Appendix 1. Originaldata lagras i primärdatabasen SICADA. Data från denna databas kan användas för vidare analyser.

Flödesmätning utförs i två vattenrännor med olika mätområden i samma avrinningsstation. Värden på vattennivå, vattentemperatur och elektrisk konduktivitet registreras och presenteras i Appendix 2–4.

Aktiviteten har utförts i överensstämmelse med aktivitetsplanen och metodbeskrivningen.

Contents

1 Introduction

This document reports data collected within the hydro monitoring program, which is one of the activities performed within the site investigation at Forsmark. The work was carried out in accordance with activity plan SKB AP PF 400-04-31. In Table 1-1, controlling documents for this activity are listed. Both the activity plan and the method descriptions are SKB's internal controlling documents. The site investigation internal report presents the results from the quality check performed once every three months, see Chapter 4.4.

Data presented in this report were collected from the beginning of the activity, i.e. June 2002, until July 2004. Ground water levels from boreholes and some surface water levels are included in the data set. In addition, data from measurements of surface water discharge, electrical conductivity and temperature performed in a brook with a runoff station are performed.

The HMS (Hydro Monitoring System) is used to collect and store all data.

Table 1-1. Controlling documents.

Activity plan	**Number**	**Version**
Platsundersökning i Forsmark – Moniteringsprogram för hydrogeologi, hydrologi och meteorologi 2004	AP PF 400-04-31	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för grundvattenmonitering vid SKB:s platsundersökningar	SKB MD 360.002	1.0
Platsundersökning Intern Rapport (in Swedish)	**Number**	
Platsundersökning i Forsmark – Kvalitetskontroll av yt- och grundvattenmonitering	PIR-04-15	
Platsundersökning i Forsmark – Kvalitetskontroll av yt- och grundvattenmonitering Period: April 2004 – Augusti 2004	PIR-04-21	

2 Objective and scope

The objective of the part of the hydro monitoring program presented in this report is to document hydrological and hydrogeological conditions before, during and after a possible establishment of a deep repository. Data collected within this activity are:

- Groundwater level in boreholes (including monitoring wells in soil).
- Water levels, water temperature and electrical conductivity of surface water measured in flumes at a runoff station.
- Meteorological data from SMHI (Swedish Meteorological and Hydrological Institute), although not presented in this report.

There are also some parameters that are used for monitoring of the function of the hardware and the environment in which the hardware is used. However, these are not reported herein.

The following number of boreholes, monitoring wells in soil and runoff stations were included in the Forsmark monitoring system at the end of August 2004:

- 5 core boreholes.
- 21 percussion boreholes.
- 52 monitoring wells in soil.
- 1 runoff station (with two flumes in the same stream).

The locations of the boreholes and the runoff station are shown in Figure 2-1.

Some of the objects denominated “monitoring wells in soil” are, in fact, not wells, but surface water level gauges. These are SFM0038, SFM0039, SFM0040, SFM0041, SFM0042 SFM0043, SFM0064 and SFM0066. In the following, both types of level measurements are treated in the same way.

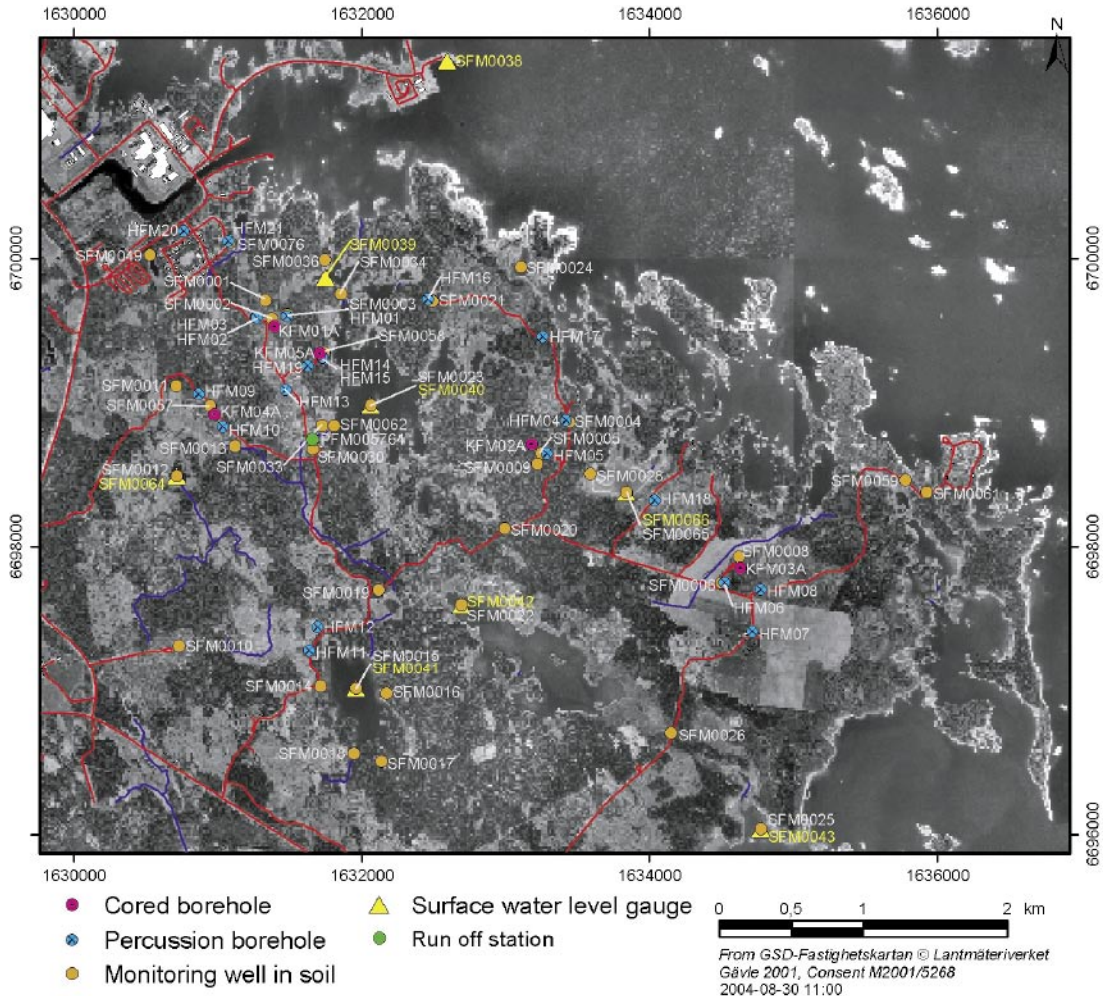


Figure 2-1. *General overview over Forsmark site investigation area with boreholes of different categories, surface water level gauges and a runoff station.*

3 Equipment

3.1 Description

A detailed description of the equipment used for groundwater level monitoring in core drilled respectively percussion drilled boreholes is given in SKB MD 368.001.

A drawing of the borehole equipment for a permanent instrumentation in percussion boreholes is shown in Figure 3-1, whereas a temporary instrumentation in core boreholes or percussion boreholes is displayed in Figure 3-2.

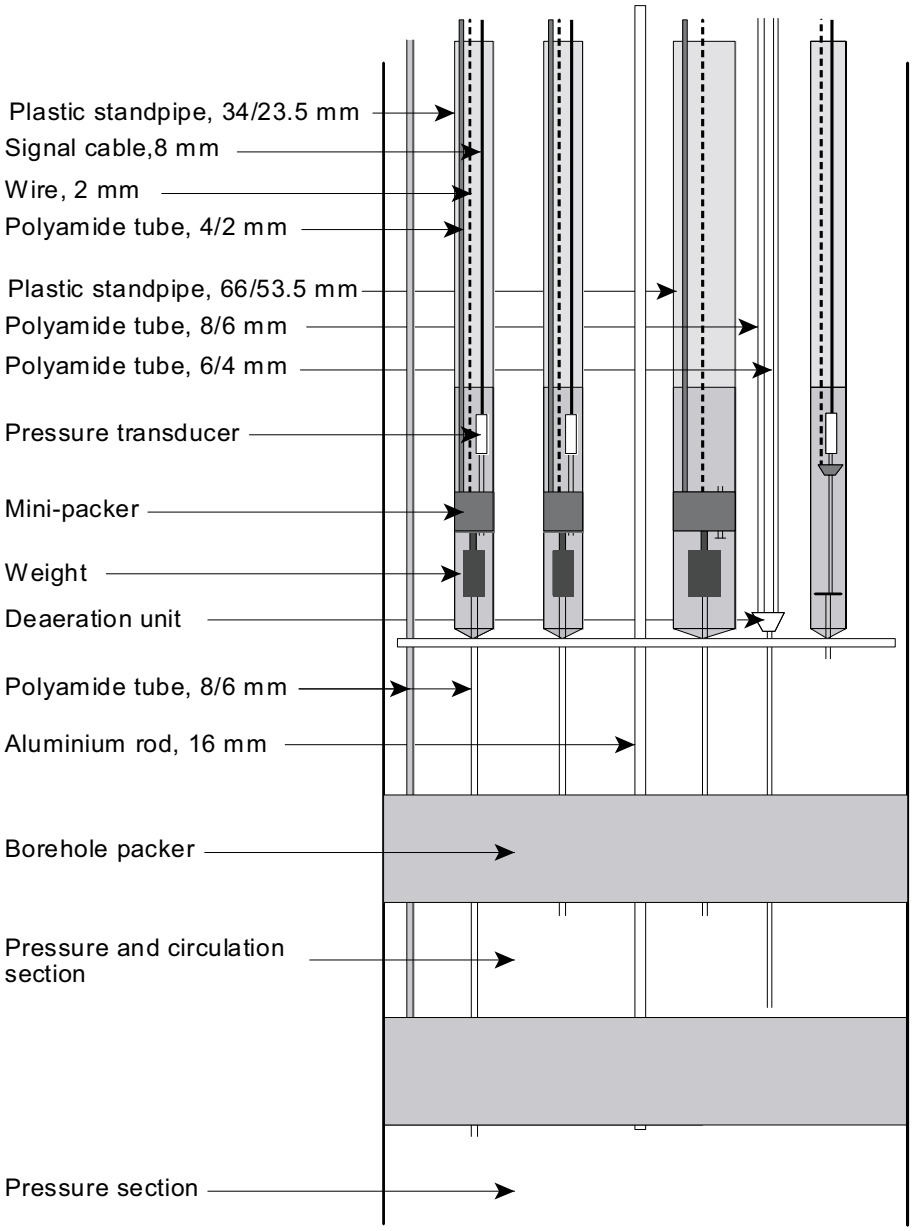


Figure 3-1. *Example of a permanent instrumentation in percussion boreholes with a circulation section.*

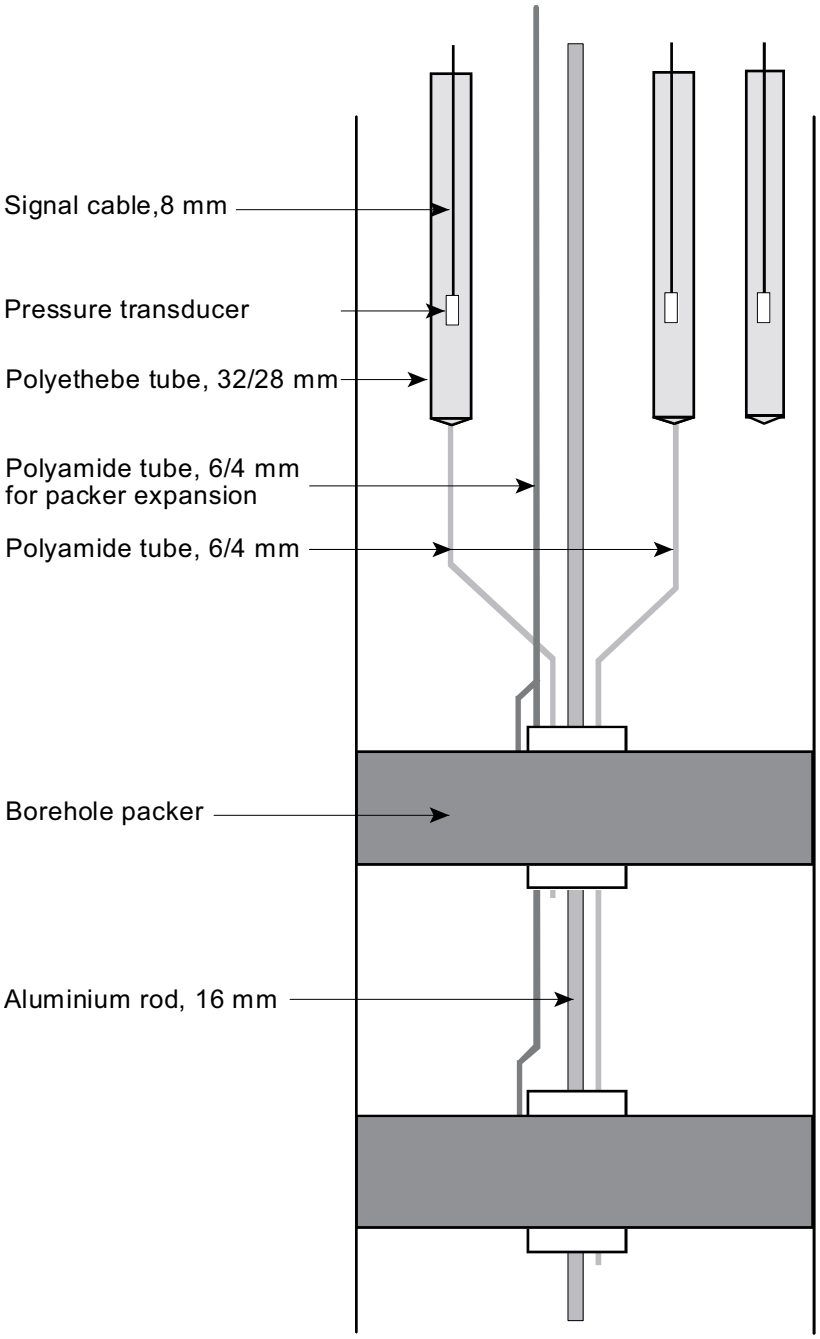


Figure 3-2. *Example of a temporary instrumentation in core boreholes or percussion boreholes.*

In open boreholes, a transducer or data logger is submerged in the groundwater without any other equipment. Examples of open boreholes in Forsmark are monitoring wells in soil, and most of the core boreholes and percussion boreholes. No drawing is presented.

Runoff is measured in long-throated flumes. The runoff station PFM005764 is constructed according to SKB Activity Plan AP PF 400-02-32. The runoff station has two flumes with different measurement ranges. The water levels in the flumes are recorded by Druck PTX 1830 pressure sensors (full scale pressure range 1.5 m H_2O, accuracy 0.1% of full scale). At the runoff station also electrical conductivity (by a GLI International PRO-C3, range 0–200 mS/m, accuracy 0.1% of full scale) and temperature (by a Mitec MSTE106, range 0–120°C, accuracy ±0.3 °C) are measured.

3.2 Data collection

The data collecting system, which is a part of the Hydro Monitoring System (HMS), consists of one measurement station (computer) which communicates with and collects data from a number of data loggers. The computer is connected to the SKB Ethernet LAN.

The on-line system is designed to be able to handle short interruptions in the communication. Data can be stored for, at least, a couple of hours in the loggers. All data are finally stored in the measurement station. A tape backup is made of all data collected to the measurement station.

All data are collected by means of different types of transducers (pressure transducer, electrical conductivity transducer and temperature transducer) connected to different types of data loggers. The following data loggers are used:

GeoNordic: a data logger of stand-alone type used only in beginning of the activity.

Minitroll: a single channel data logger of stand-alone type where the transducer is integrated in the logger. The logger is submerged in the groundwater.

Mitec: a data logger connected on-line by means of GSM telephony. A pressure transducer of the type Druck PDCR is connected to the logger. Only the transducer is submerged in the groundwater. The logger has eight channels, but during monitoring in boreholes, only one channel is used for pressure monitoring and one for monitoring of the battery voltage. At the runoff station, transducers for monitoring temperature and electrical conductivity are used as well.

Datataker: a data logger connected on-line by means of SKB-LAN. The logger has 42 channels and is used only for monitoring in percussion drilled and cored boreholes.

4 Execution

4.1 General

Data are collcted to the measurement system, HMS, as described in Chapter 3.

4.2 Field work

Manual levelling is generally carried out once a month. At the same time, the equipment is checked and maintenance is performed.

All data from stand-alone type loggers are manually dumped into a portable PC and then transmitted to the measurement station, normally once every three months.

At the runoff station the water level has in general been measured manually once a week.

4.3 Data handling

4.3.1 Calibration method

Manual levelling of all sections is made, normally once every month, in order to calibrate the registrations from the data loggers.

The logger data are converted to water levels by means of a linear calibration equation. It is also necessary to subtract the air pressure since all transducers give the absolute pressure. Converted logger data are compared with results from manual levelling. If the two differ, calibration constants are adjusted until an acceptable agreement is obtained.

At the runoff station the monitored levels are calibrated versus manual level measurements generally performed once a week. The temperature sensor was calibrated in an ice-bath before installation, whereas the electrical conductivity sensor was calibrated by the manufacturer before delivery. The temperature and conductivity sensors were checked in the field on September 3, 2004 by the Forsmark field laboratory's calibrated thermometer and a 0.01 D KCl standard solution. The deviations were < 1ºC and < 1 mS/m, respectively.

4.3.2 Recording interval

For stand-alone and GSM-connected data loggers, a measurement of the groundwater level is made with intervals of five minutes. Measured values are not stored unless they differ from the previously stored value by more than 0.1 m for percussion boreholes and 0.05 m for monitoring wells in soil. In addition to this, a value is stored every two hours.

For all other data loggers connected on-line, levels are measured at least once every ten seconds. In addition to this, a value is stored every two hours.

4.4 Analysis and interpretation

All data collected are subject to a quality check once every three months, by which obviously erroneous data are removed and calibration constants are corrected so that the monitored data correspond with the manual levelling data.

At this occasion, the status of the equipment is also checked and service might be initiated.

4.5 Nonconformities

There are no nonconformities with respect to the activity plan or the method description.

5 Results

5.1 General

The results are stored in the primary data base SICADA. The data in this data base is available for further analysis.

5.2 Groundwater levels

Annual diagrams of groundwater levels are presented in Appendix 1. All levels in the diagrams are given as metres above sea level in the national elevation system (RT90-RHB70).

In the diagrams, one data point per section and twenty-four hours is displayed. That data point shown is the first stored data point after midnight. When registrations are missing, manually levelled data, if available, are inserted.

Boreholes included in the monitoring system in Forsmark:

- Core boreholes (5): KFM01A – KFM05A
- Percussion boreholes (21):
  HFM01 – HFM21
- Monitoring wells in soil (52): SFM0001 - SFM0030, SFM0032 - SFM0034, SFM0036, SFM0038 - SFM0043, SFM0049, SFM0057 - SFM0062, SFM0064 - SFM0067, SFM0076

5.2.1 General comments

Results from monitoring in boreholes are presented in annually based diagrams. Level data from all sections in each borehole are presented in annual diagrams for the years 2002, 2003 and 2004. Because the boreholes have been drilled successively during the period 2002–2004, very few of them provide data from all three years, and if all data for one year is missing, the diagram is not presented.

The symbols used in the diagrams are:

The lowest section = Section 1 ○○○○○○○○○○
Section 2 ++++++++++
Section 3 xxxxxxxxxx

Sometimes it is difficult to differentiate registrations from individual sections in the diagrams. However, since the main purpose of this report is to present an overall view of the long-term changes, it was not found advantageous to show more detailed diagrams from individual sections. Such diagrams, representing periods of hydraulic tests performed in the investigation area, are presented in reports from the different tests.

5.2.2 Comments on some of the diagrams

Due to failures in the mechanical or electronic equipment, data are sometimes missing for longer or shorter periods. This is not commented on below. For more comments on diagrams, see Platsundersökning Intern Rapport, Table 1-1.

Remarks are given when the registration for some reason has a deviating appearance. When registrations are missing, manually levelled data, if available, are inserted.

In many boreholes, the groundwater level shows large and rapid variations. This is often due to nearby drilling.

The groundwater in many of the monitoring wells in soil has been reported to be frozen from January to April 2004.

Packers may deflate due to leakage, which can be difficult to discover. If a section in a borehole suddenly indicates a pressure that is close to the pressure in a neighbouring section, the reason might be deflated packers.

KFM01A: Three sections have been installed from June 2003 until at least December 2003. However, data is missing at the end of this period.

SFM0006: From July to October 2003 the borehole is reported to be dry.

SFM0007: From April to August 2003 and in March 2004 the borehole is reported to be dry.

SFM0042: The water level during 2002 is measured by means of a water level gauge, which was removed before any reference elevation level was measured. The data presented therefore represents only relative values.

SFM0076: From June to August 2004 the borehole is reported to be dry.

5.3 Water in the runoff station

Monitoring is performed in two flumes with different ranges located at the same runoff station. Values of water level, water temperature and electrical conductivity are monitored and presented in Appendix 2–4.

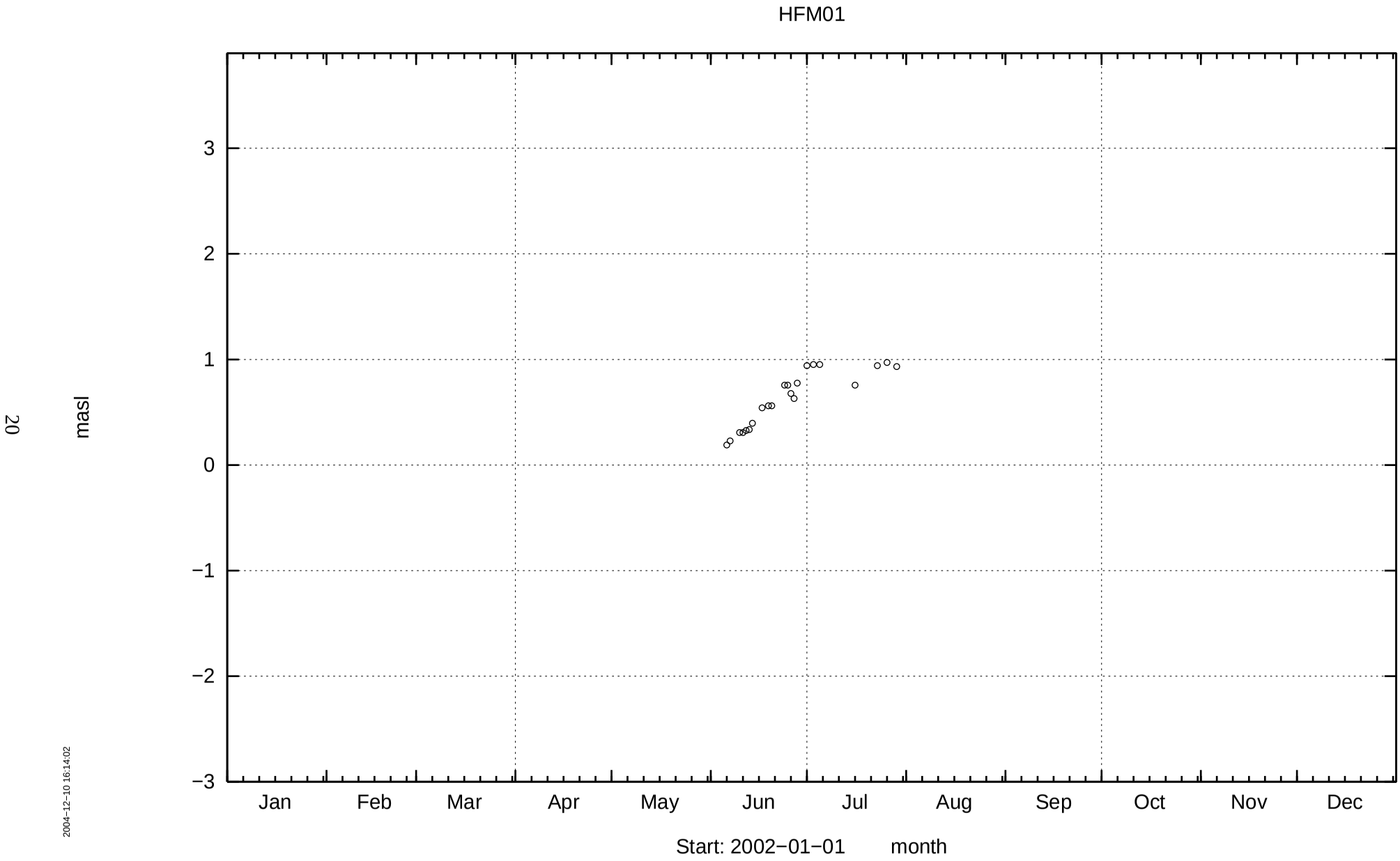
The water flow is calculated from the water level using the stage-discharge relation. The small flume is valid for values below 21 l/s. The accuracy of the results from the large flume was not satisfactory since critical flow was not reached, i.e. the stage-flow relationship was disturbed by downstream conditions. No results are therefore presented from the large flume. The flume will be re-installed during the autumn 2004.

Data are presented as daily means.

Appendix

Groundwater level

Water in Runoff stations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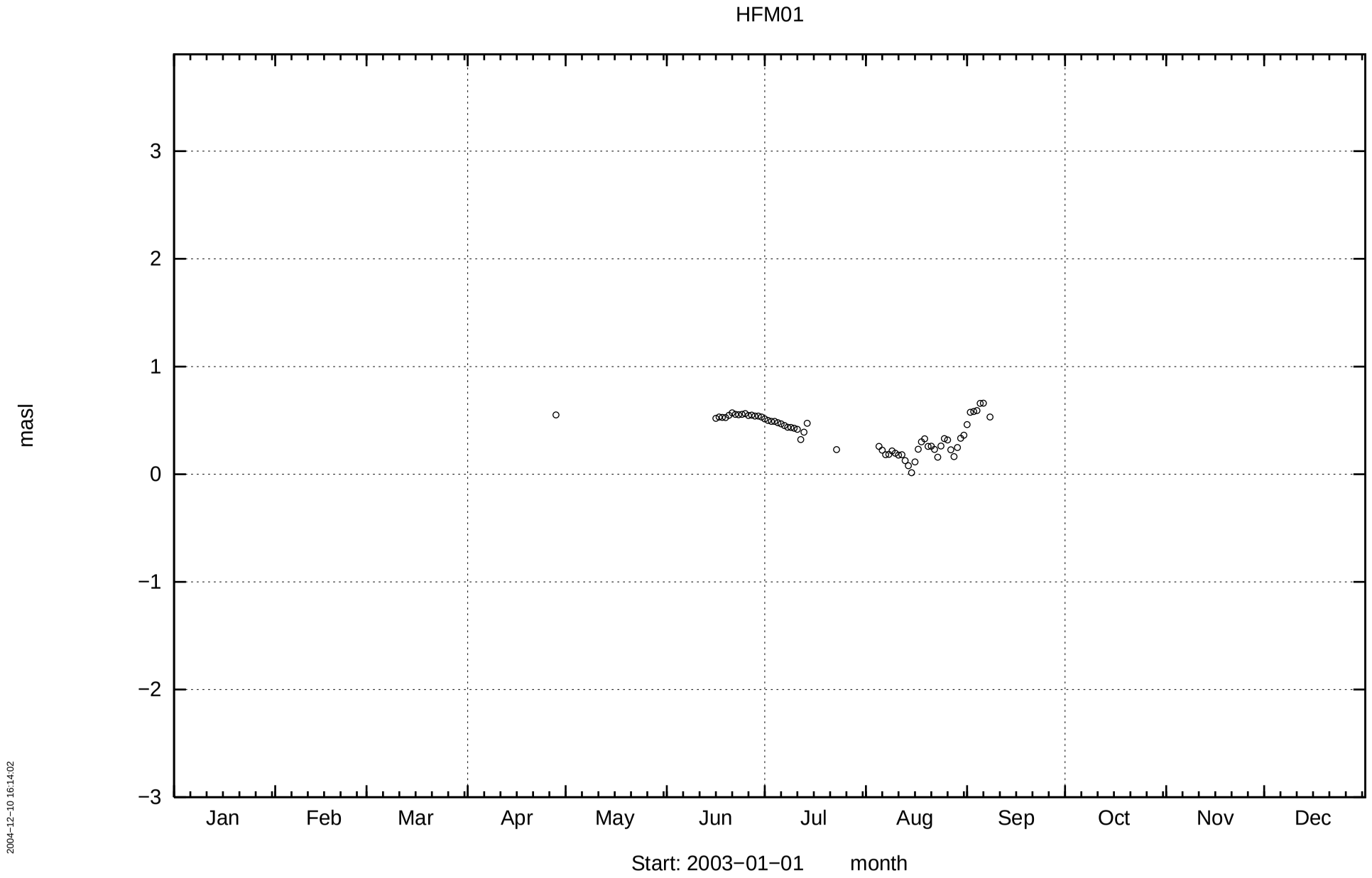
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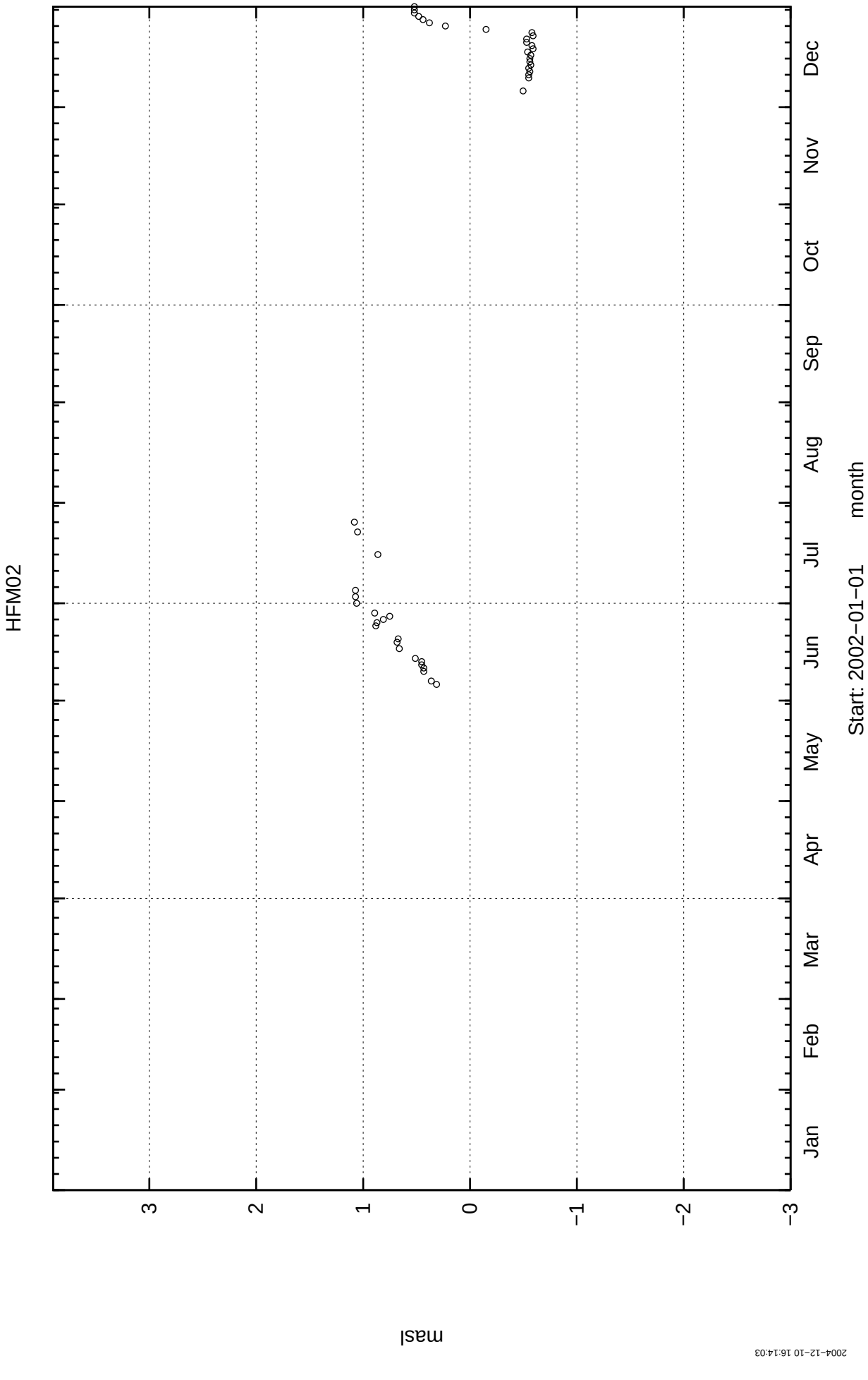
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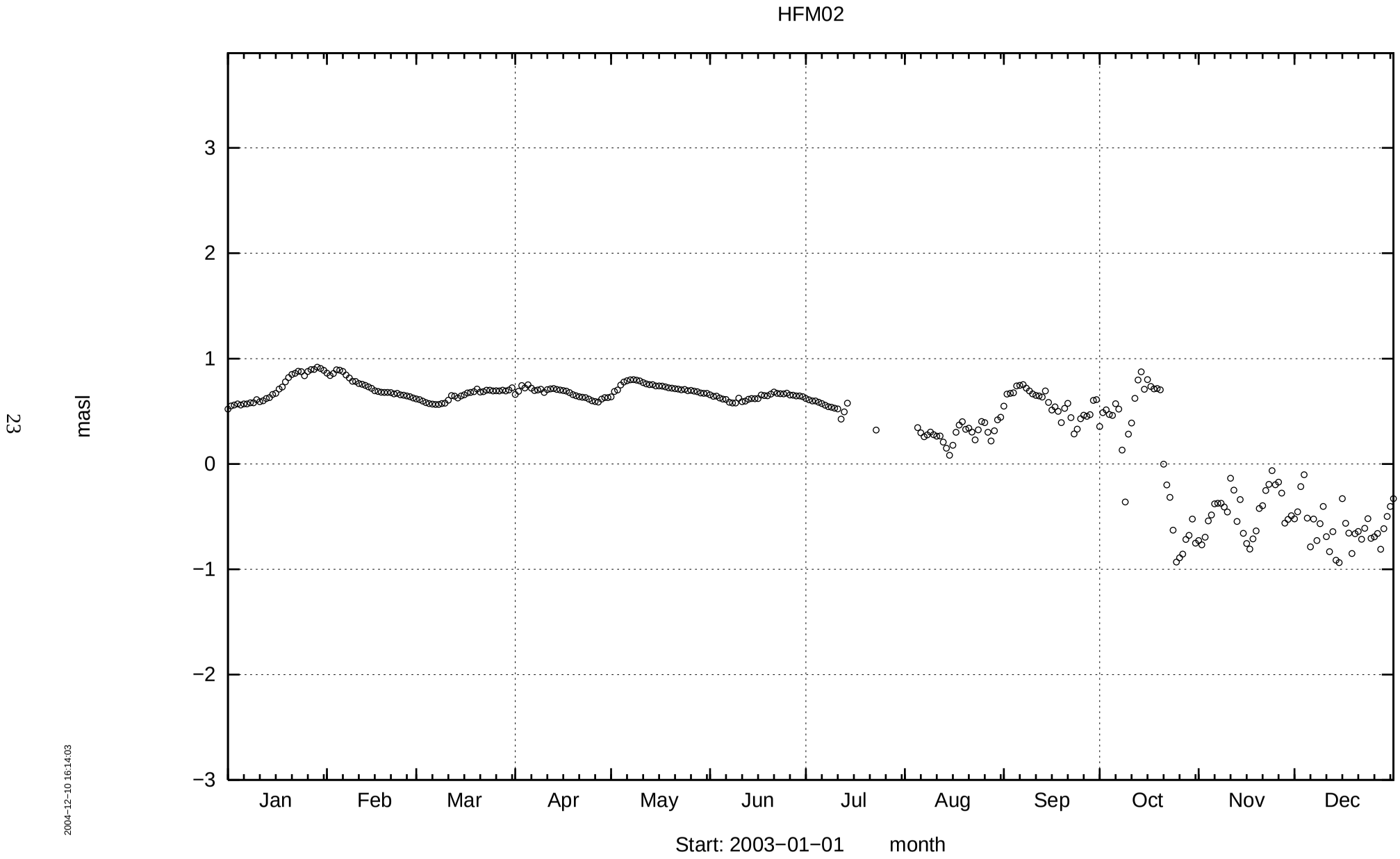
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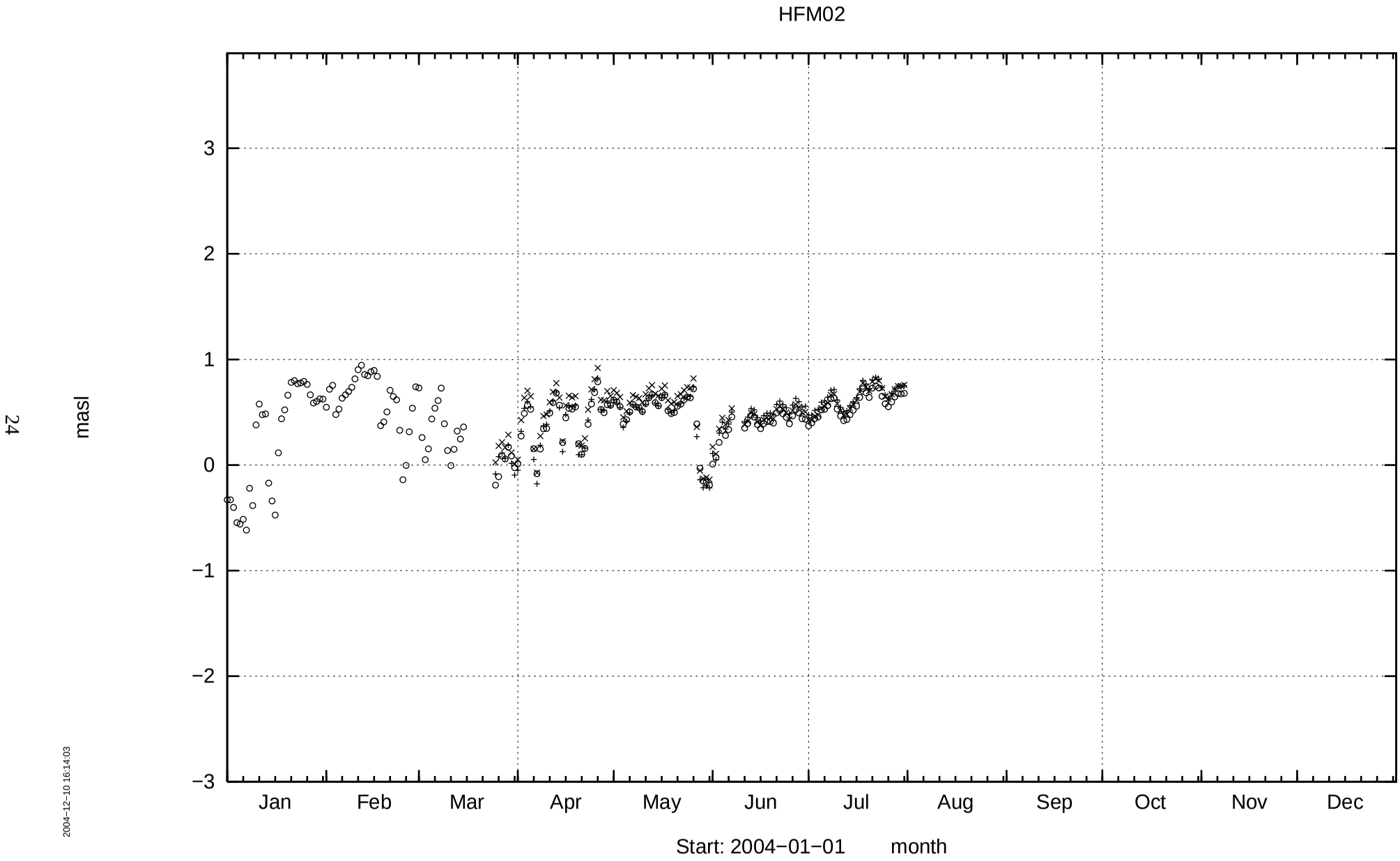
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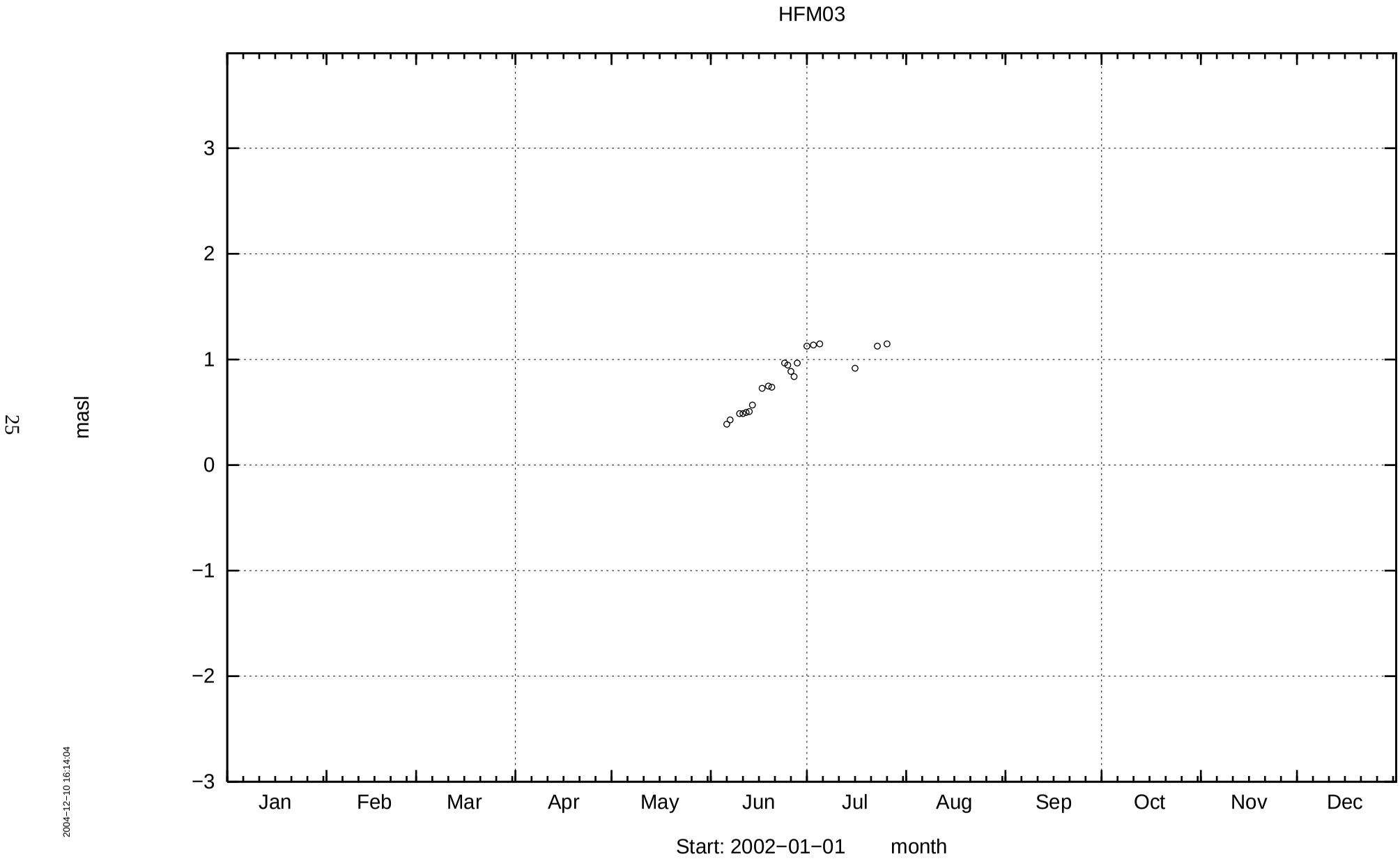
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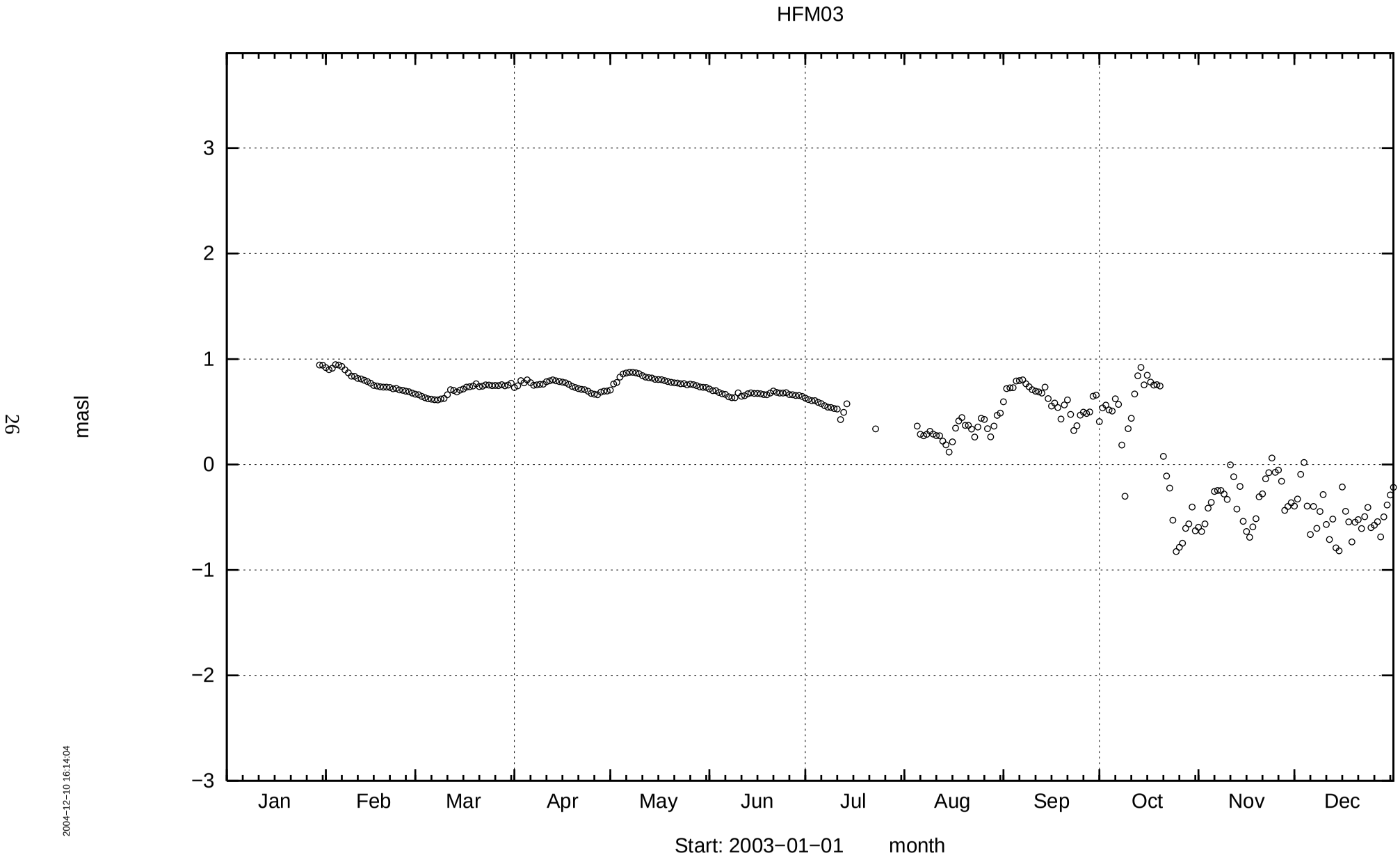
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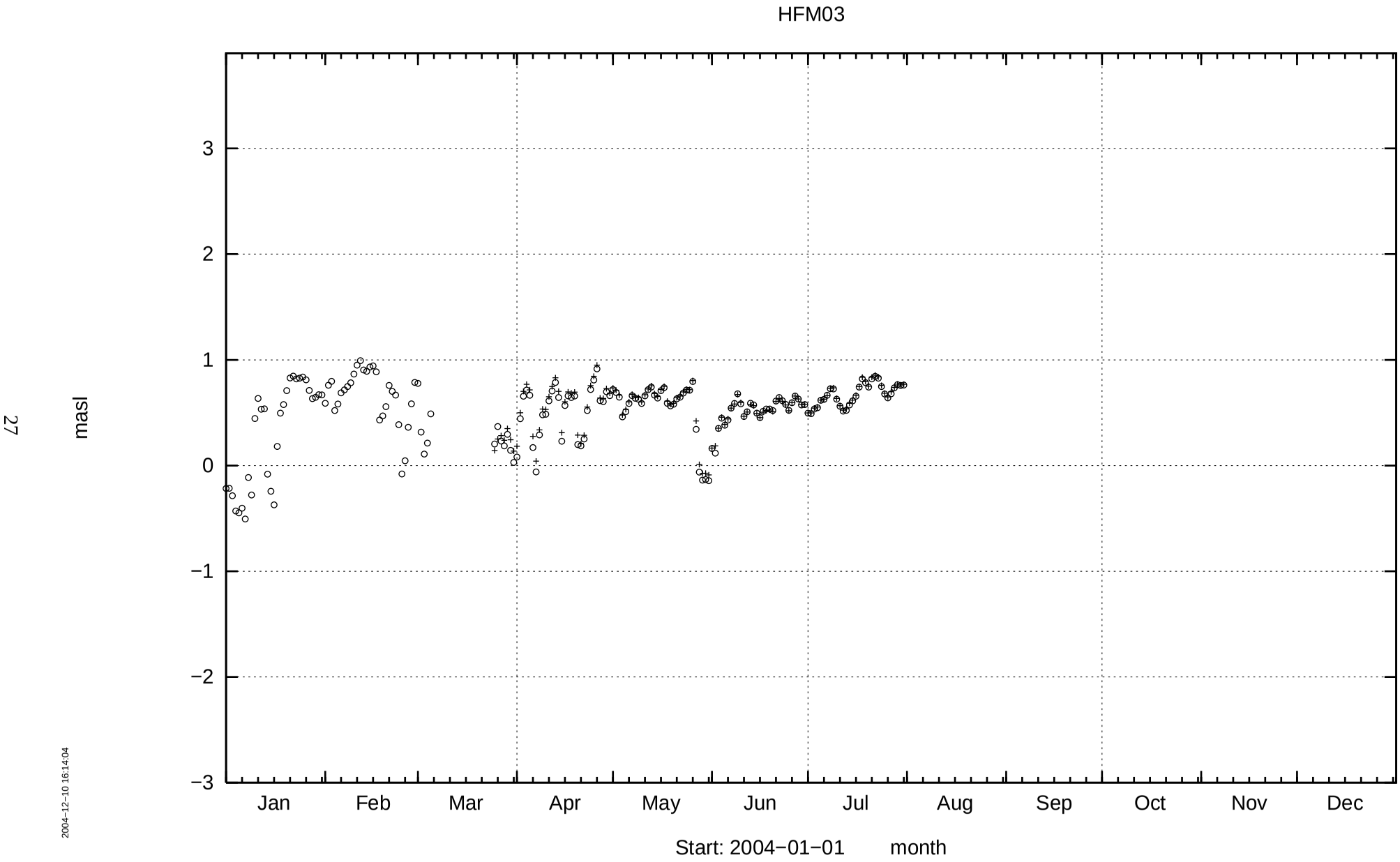
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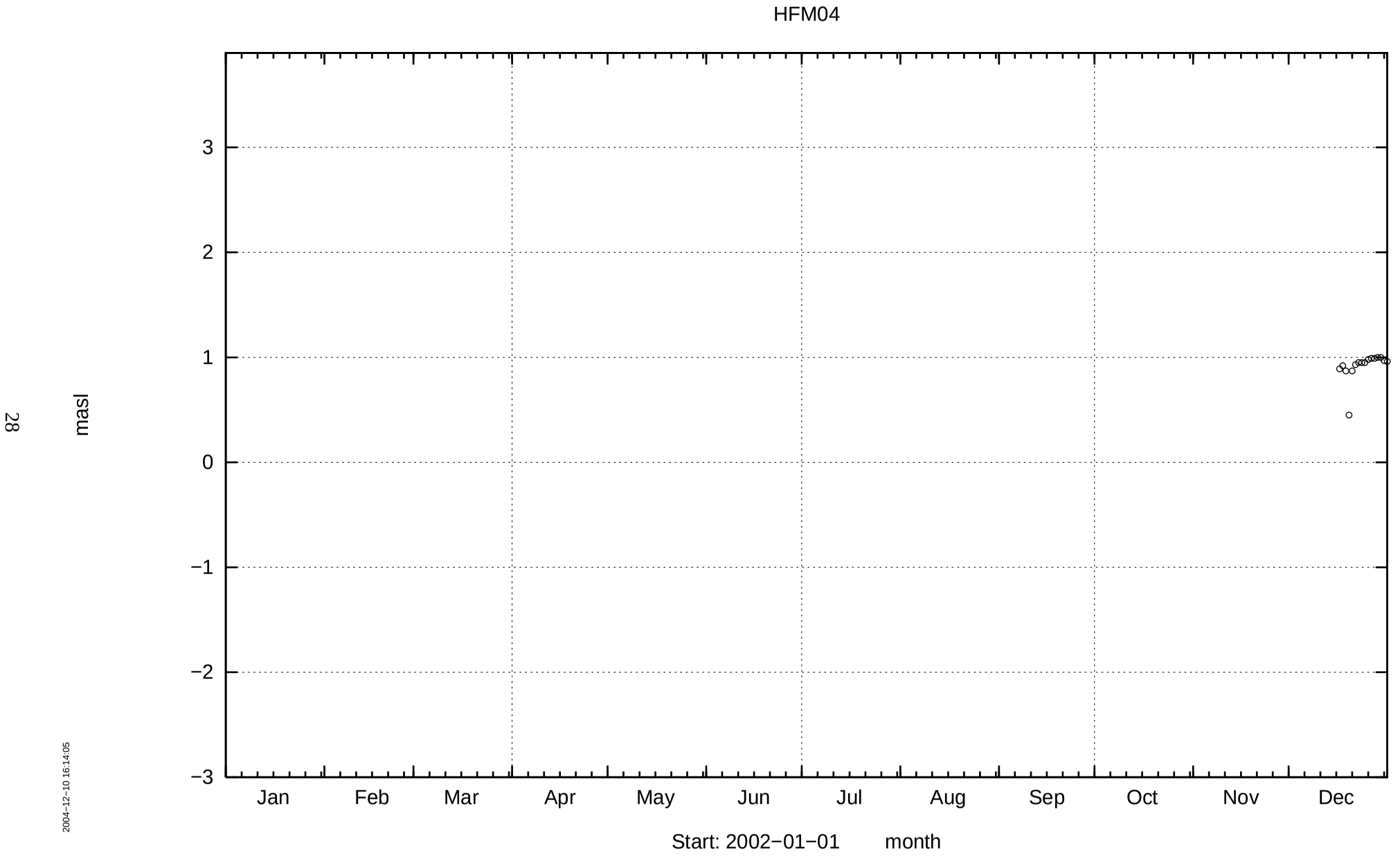
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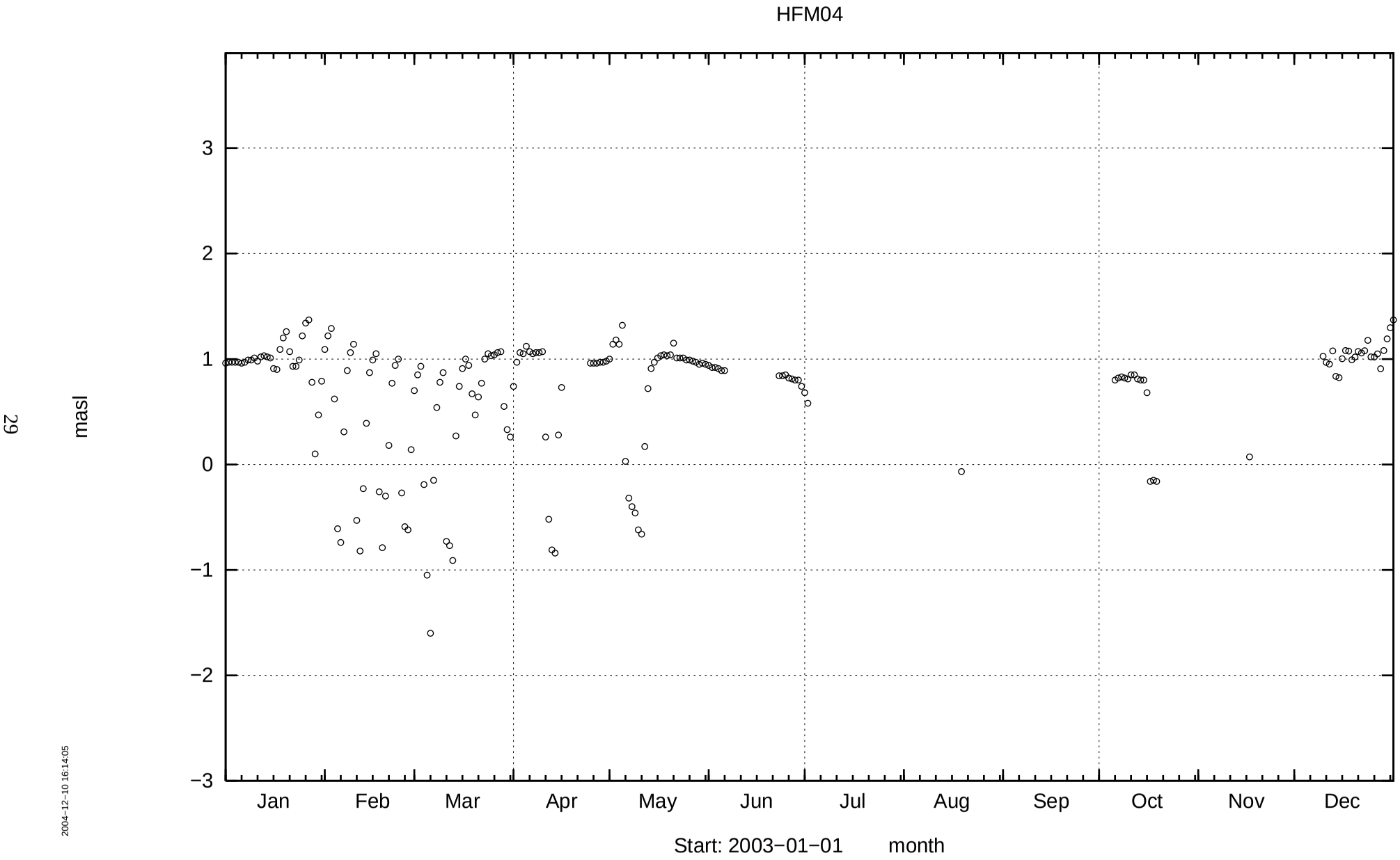
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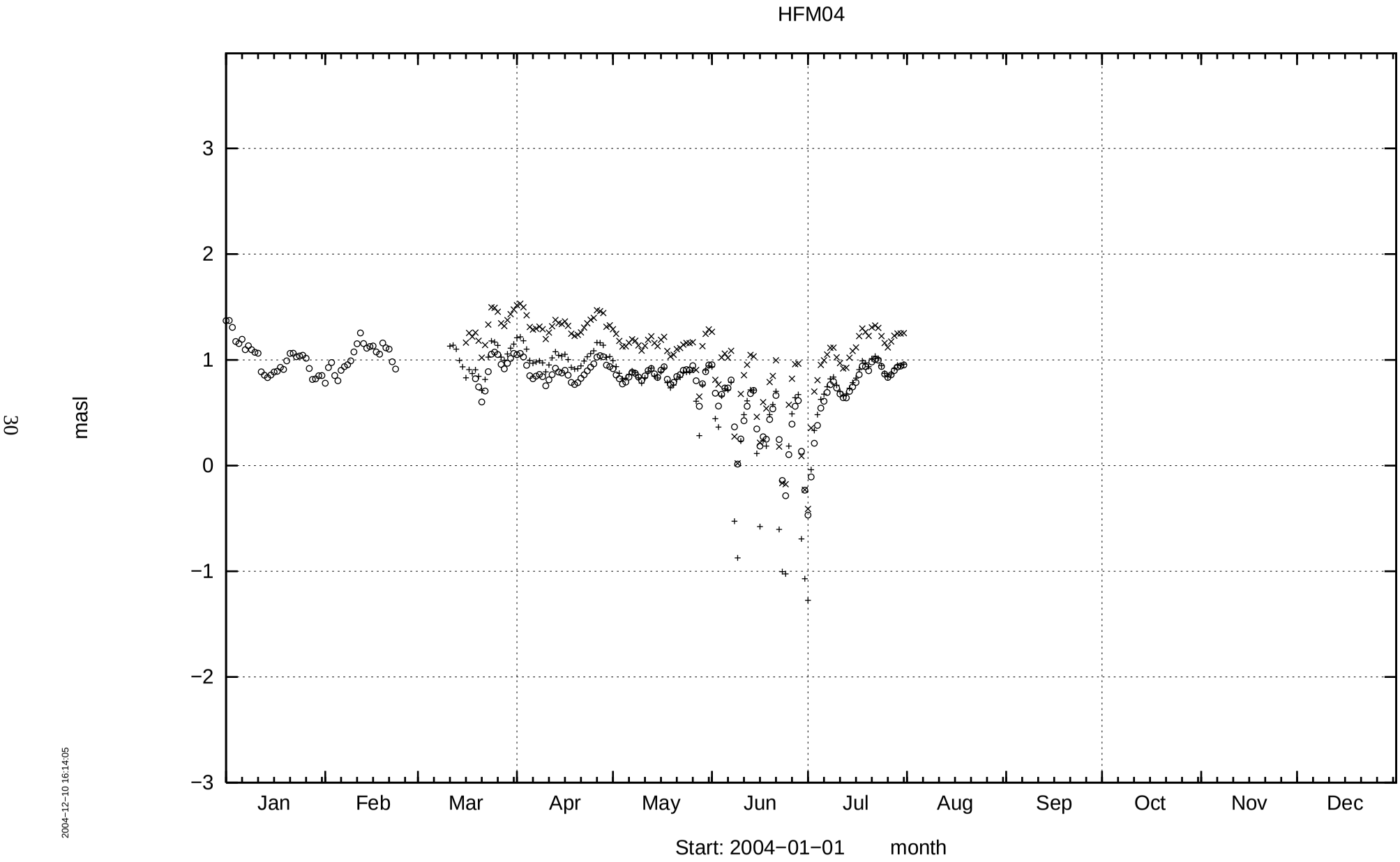
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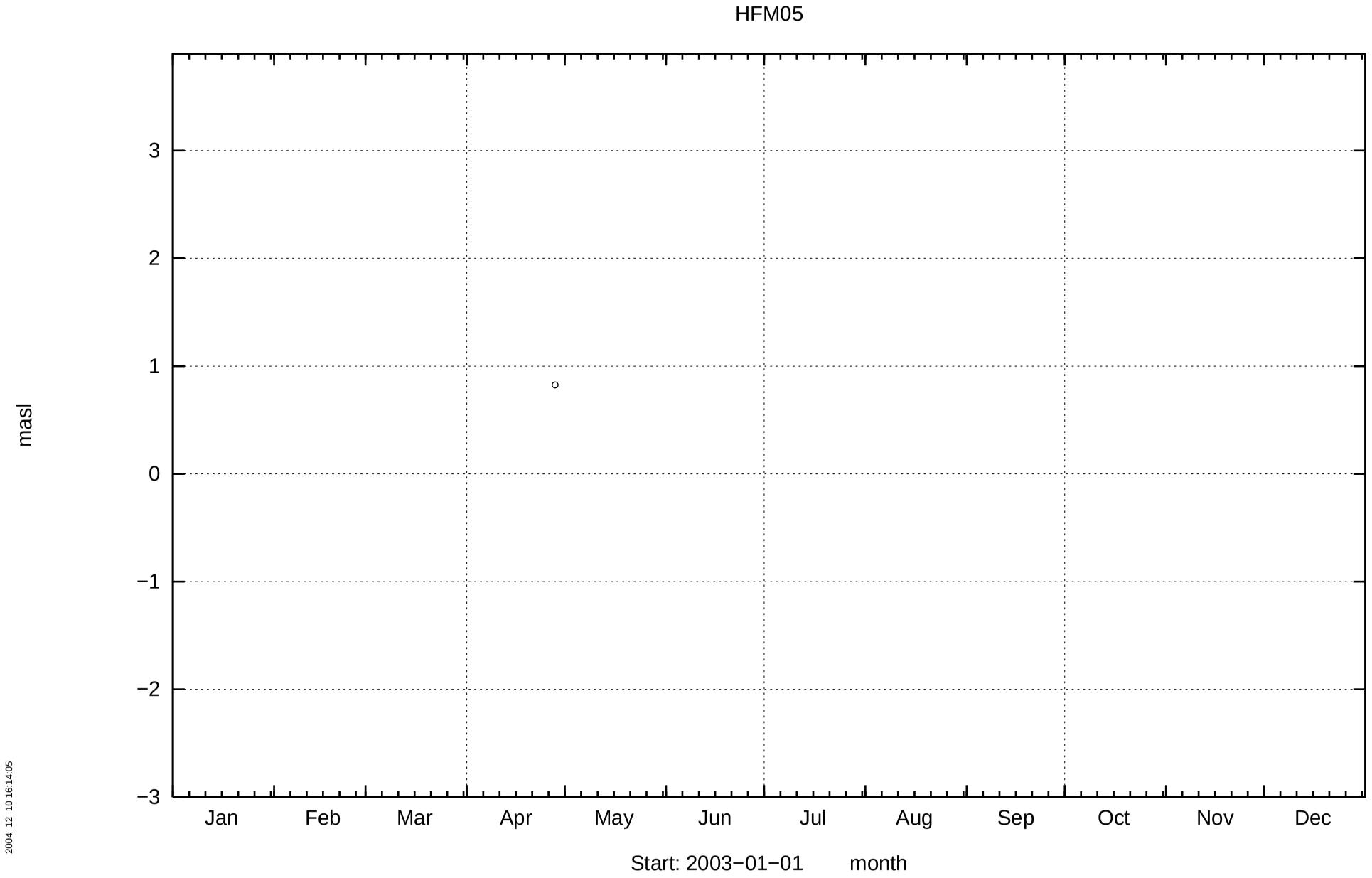
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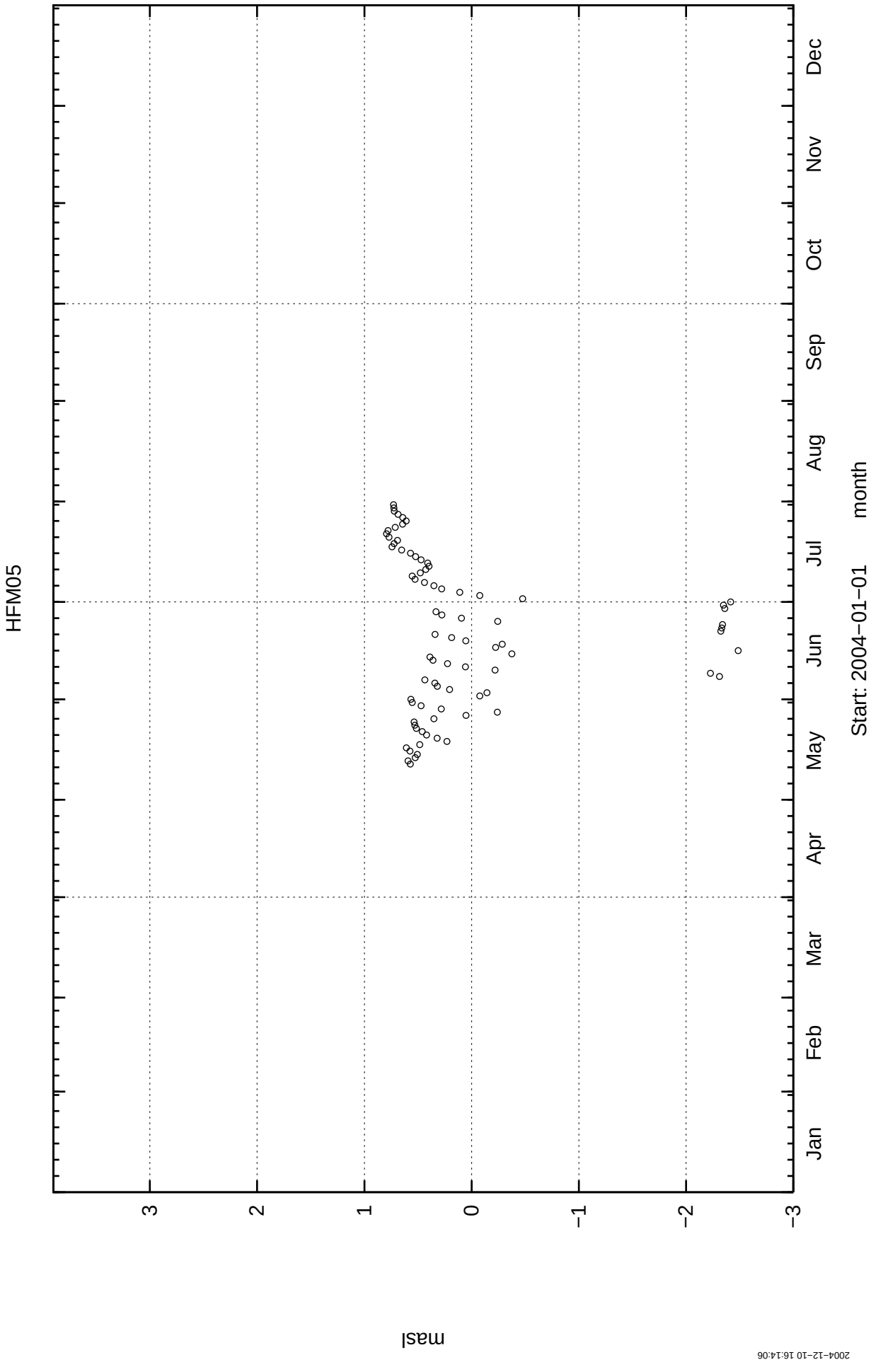
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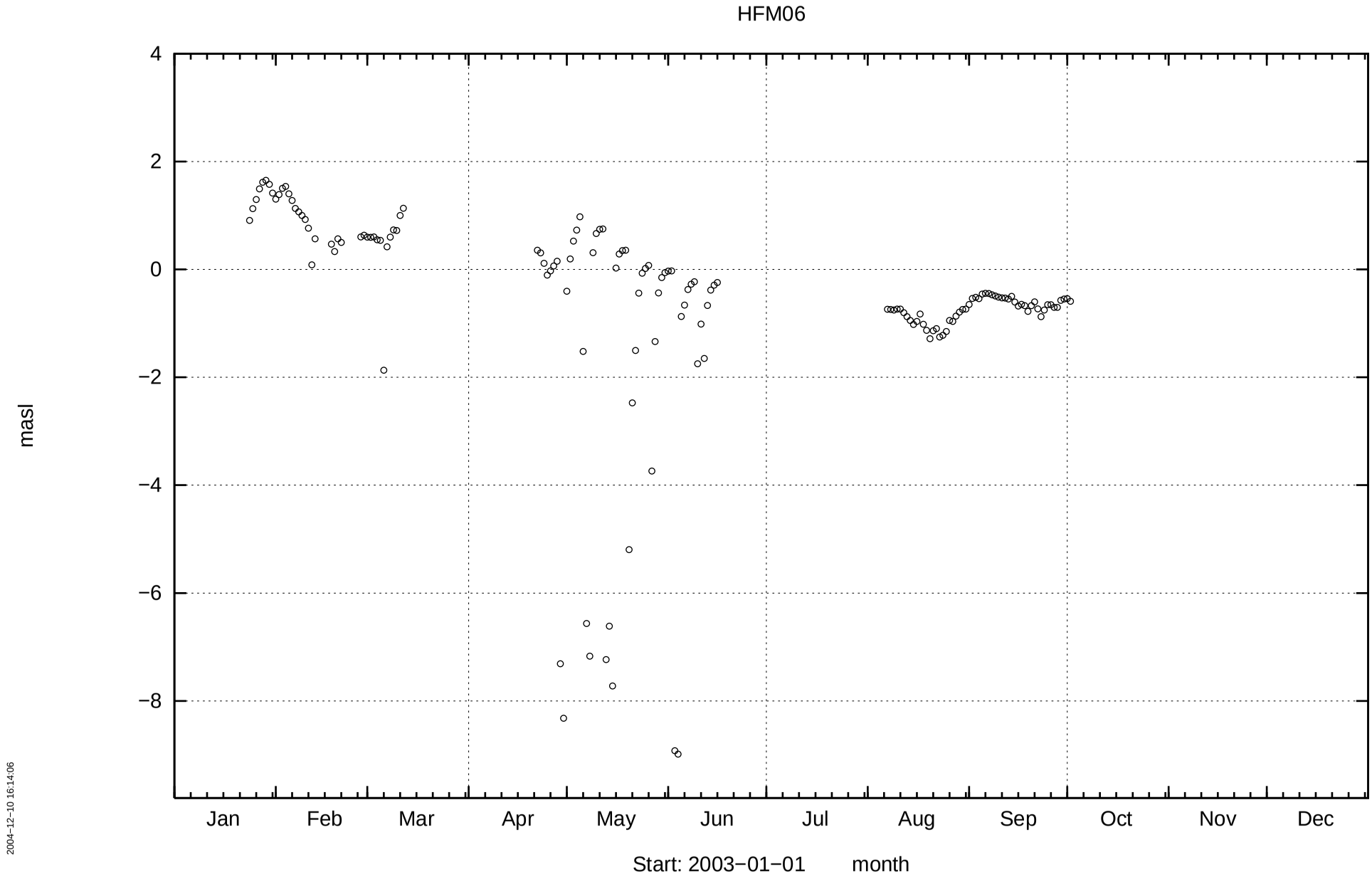

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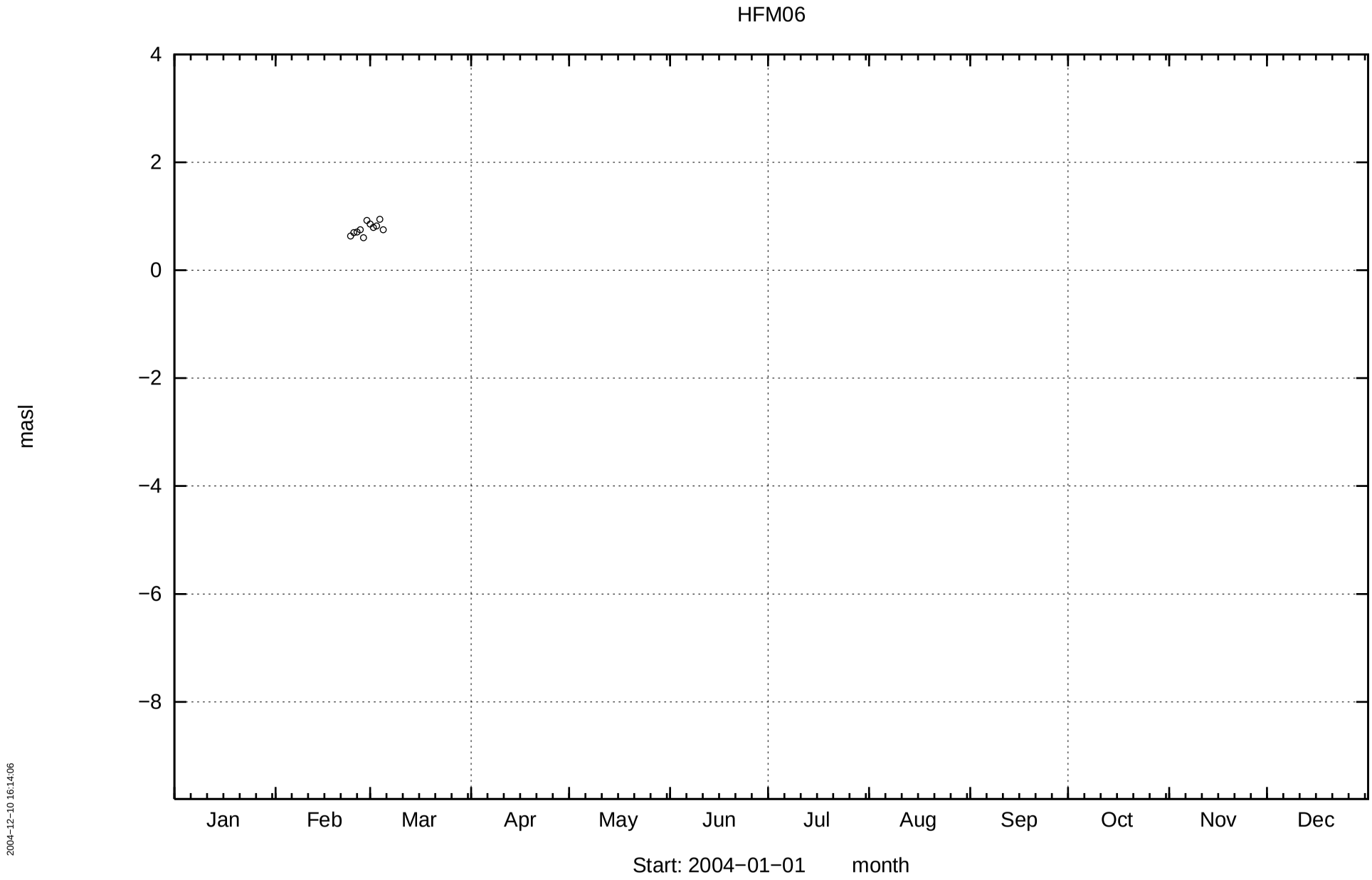

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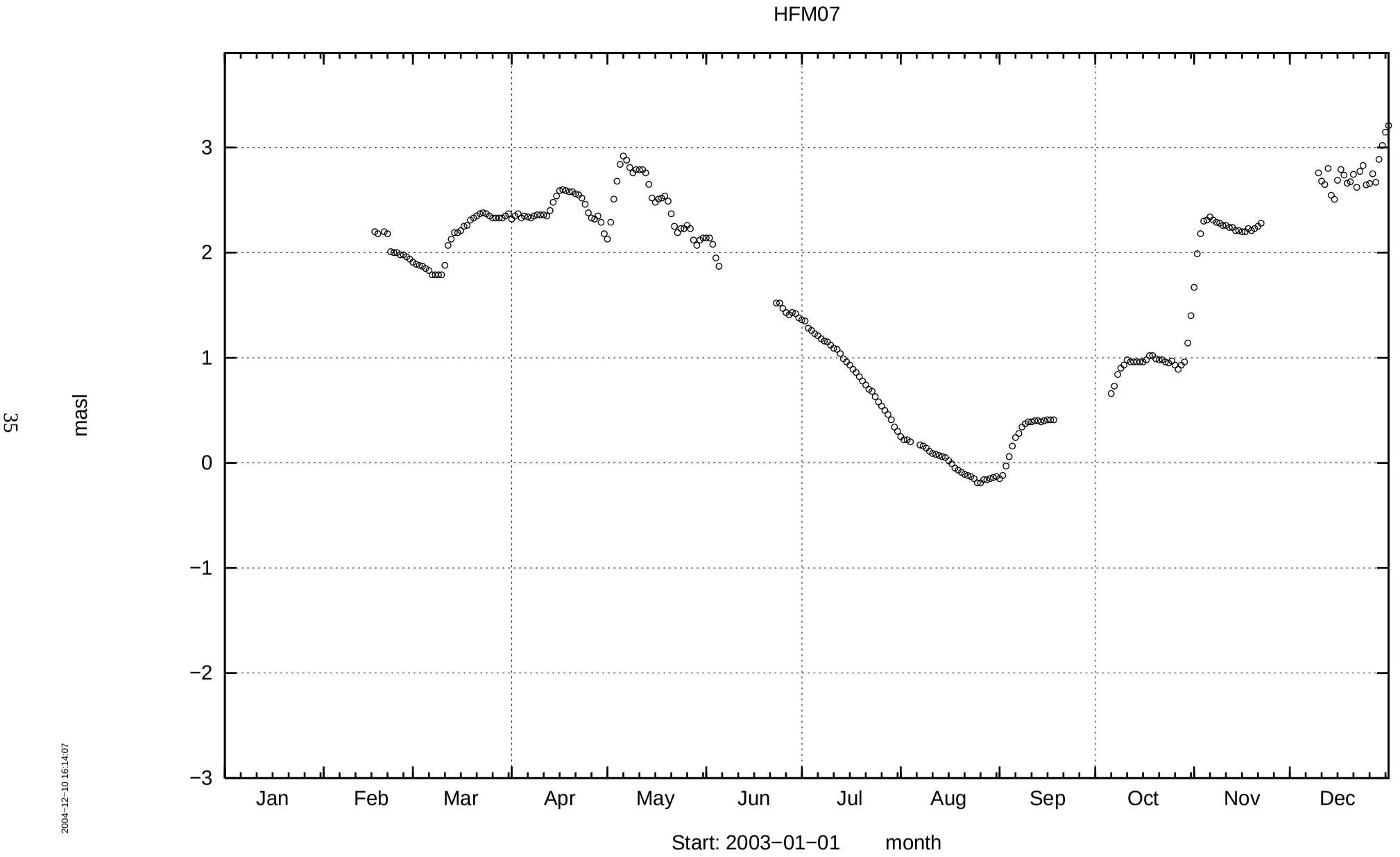
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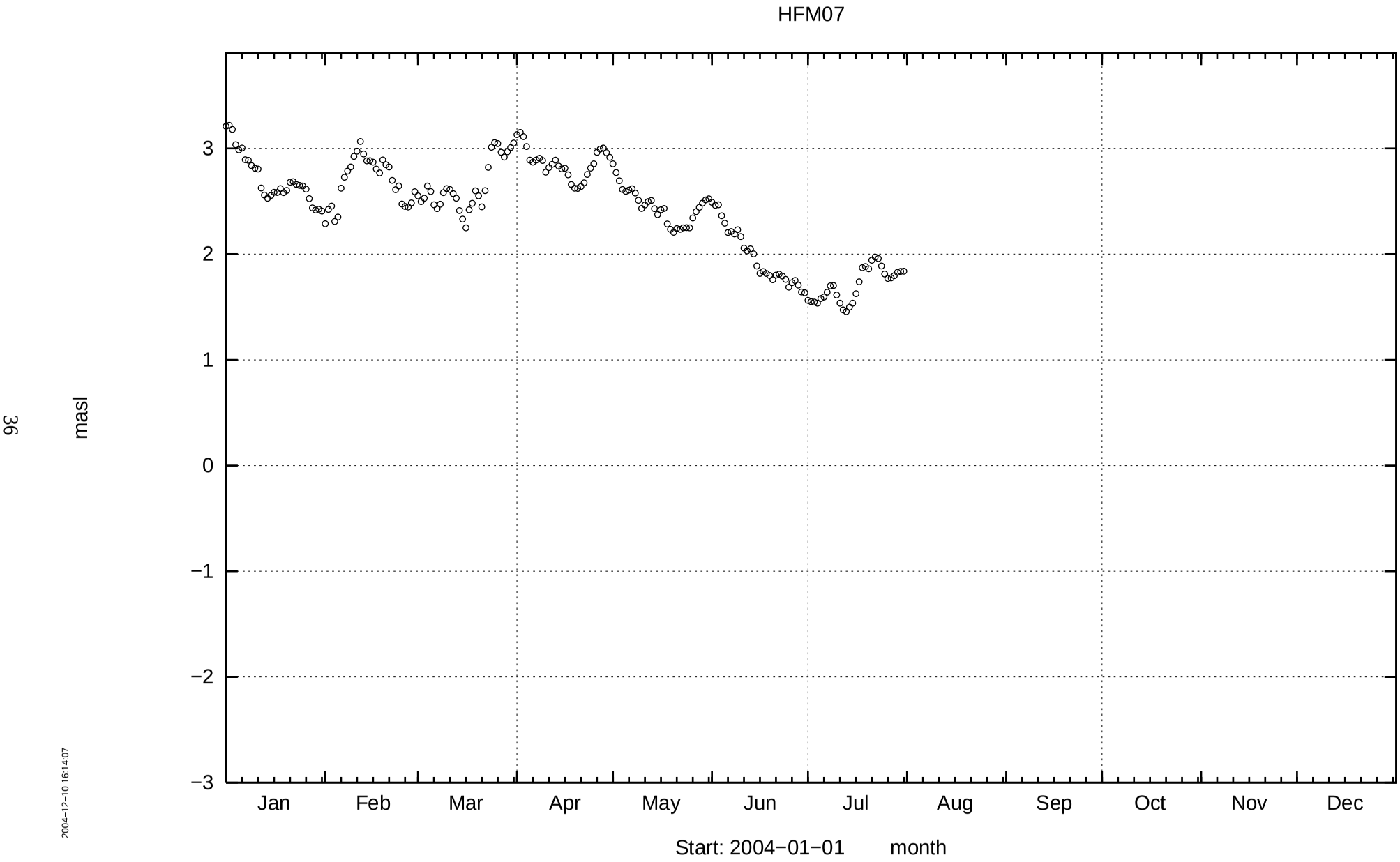
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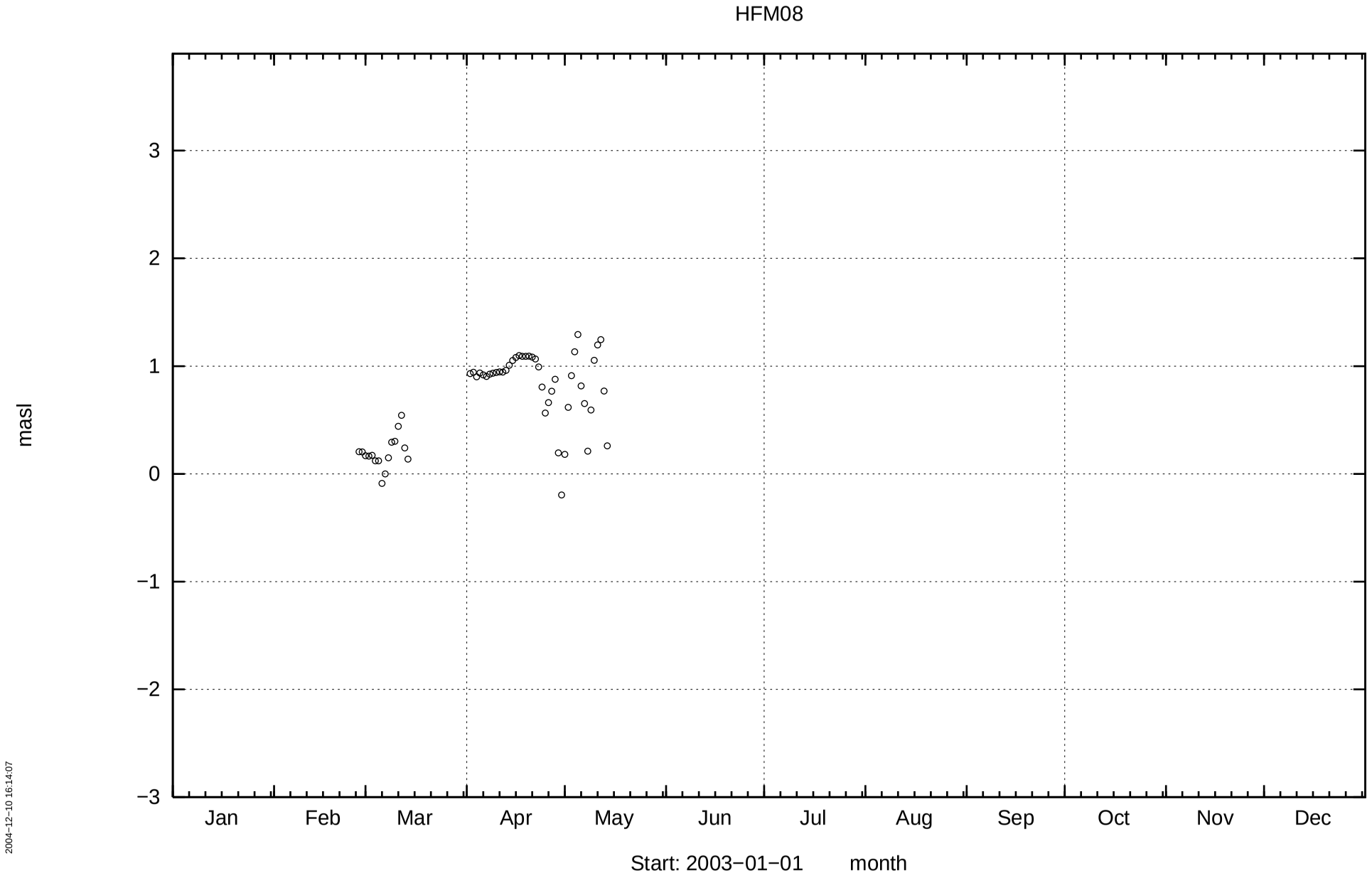
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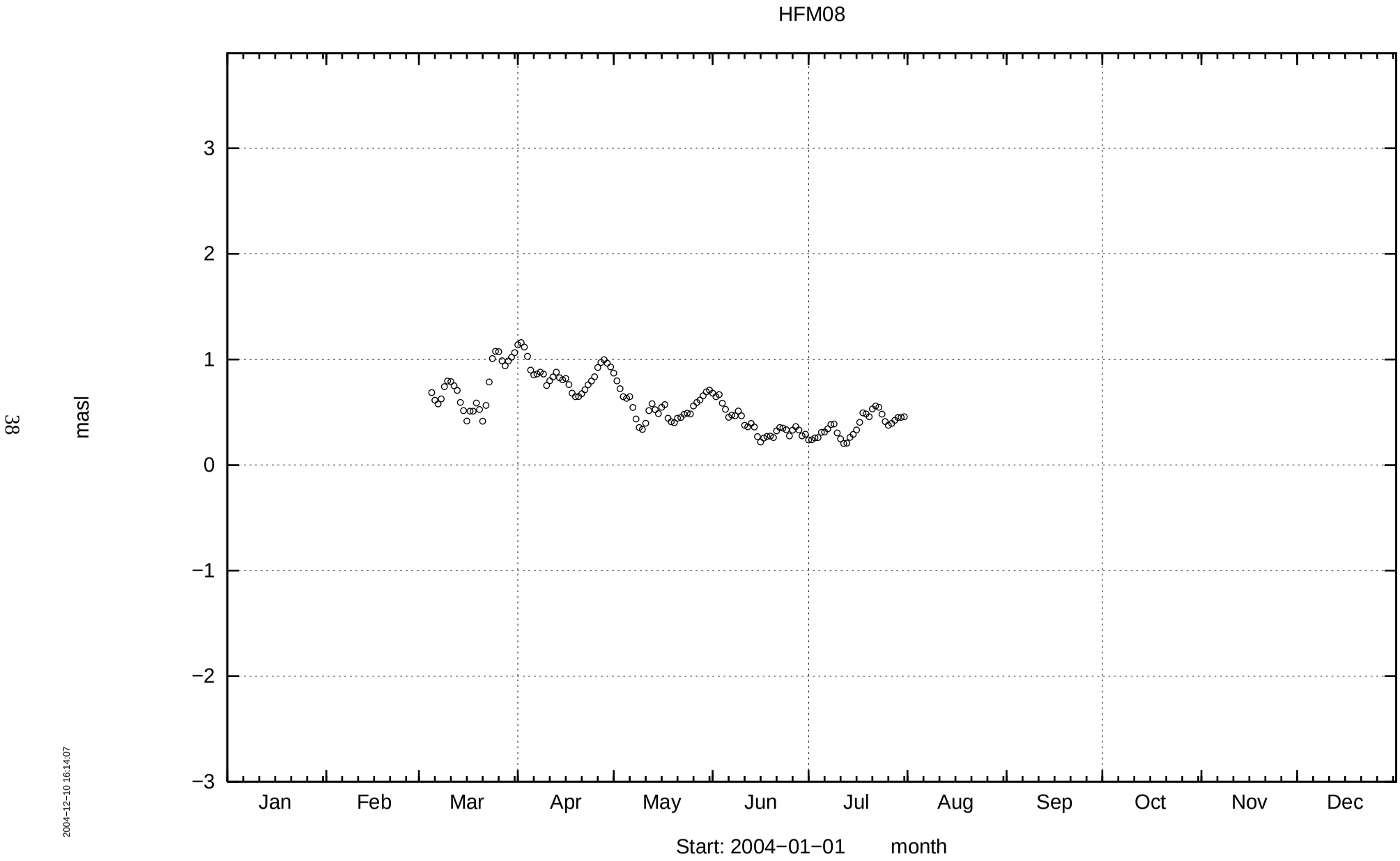
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38
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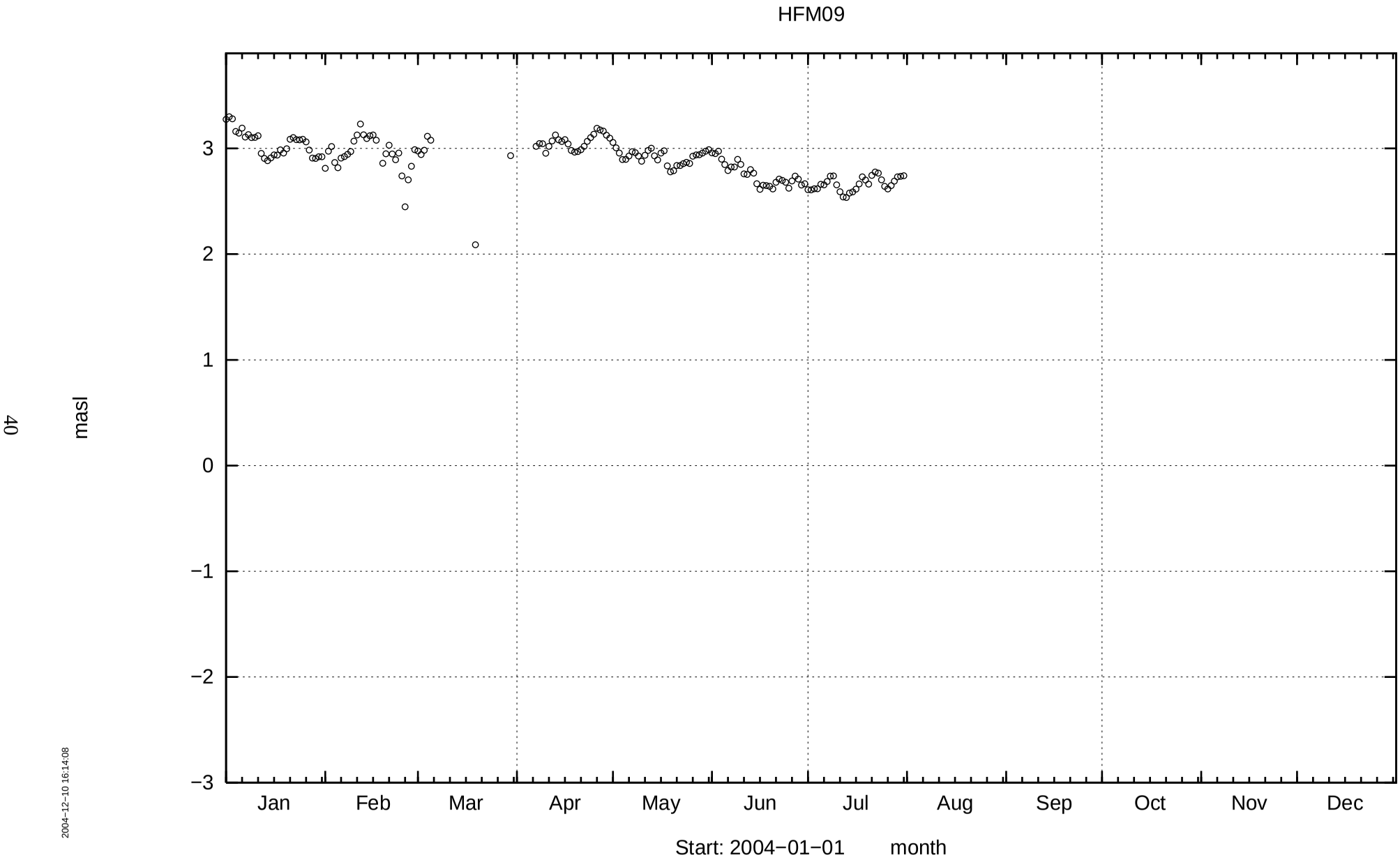
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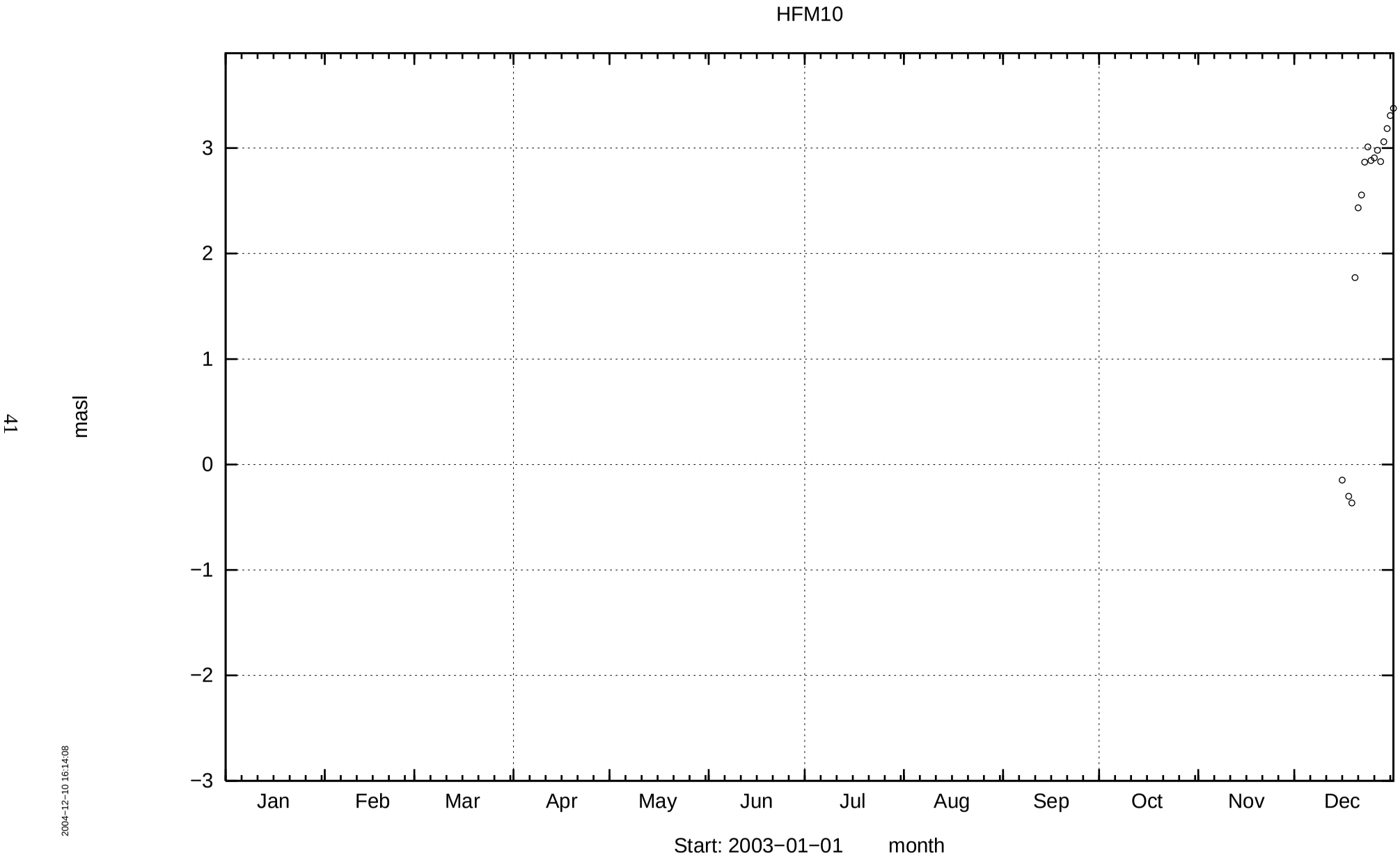
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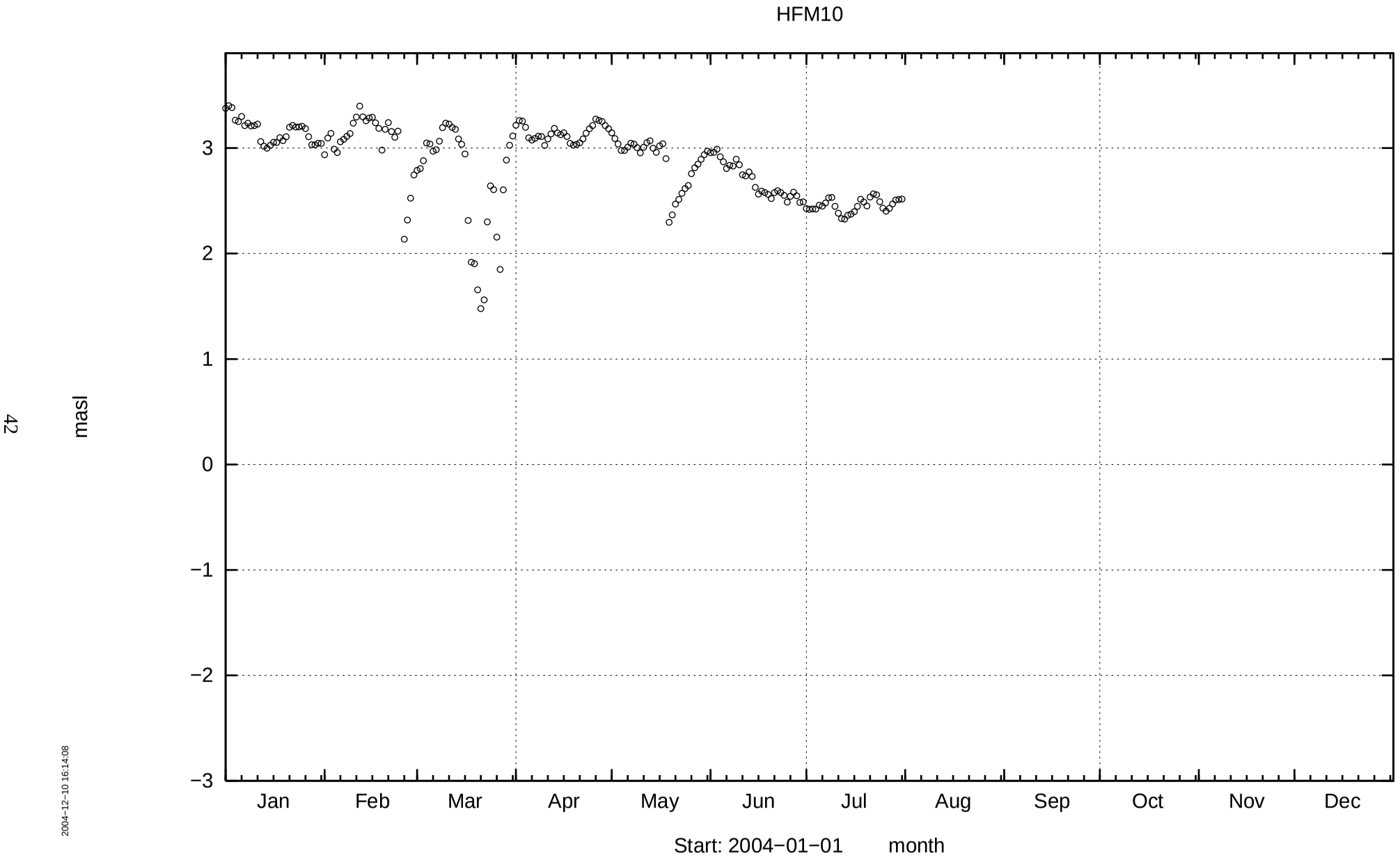
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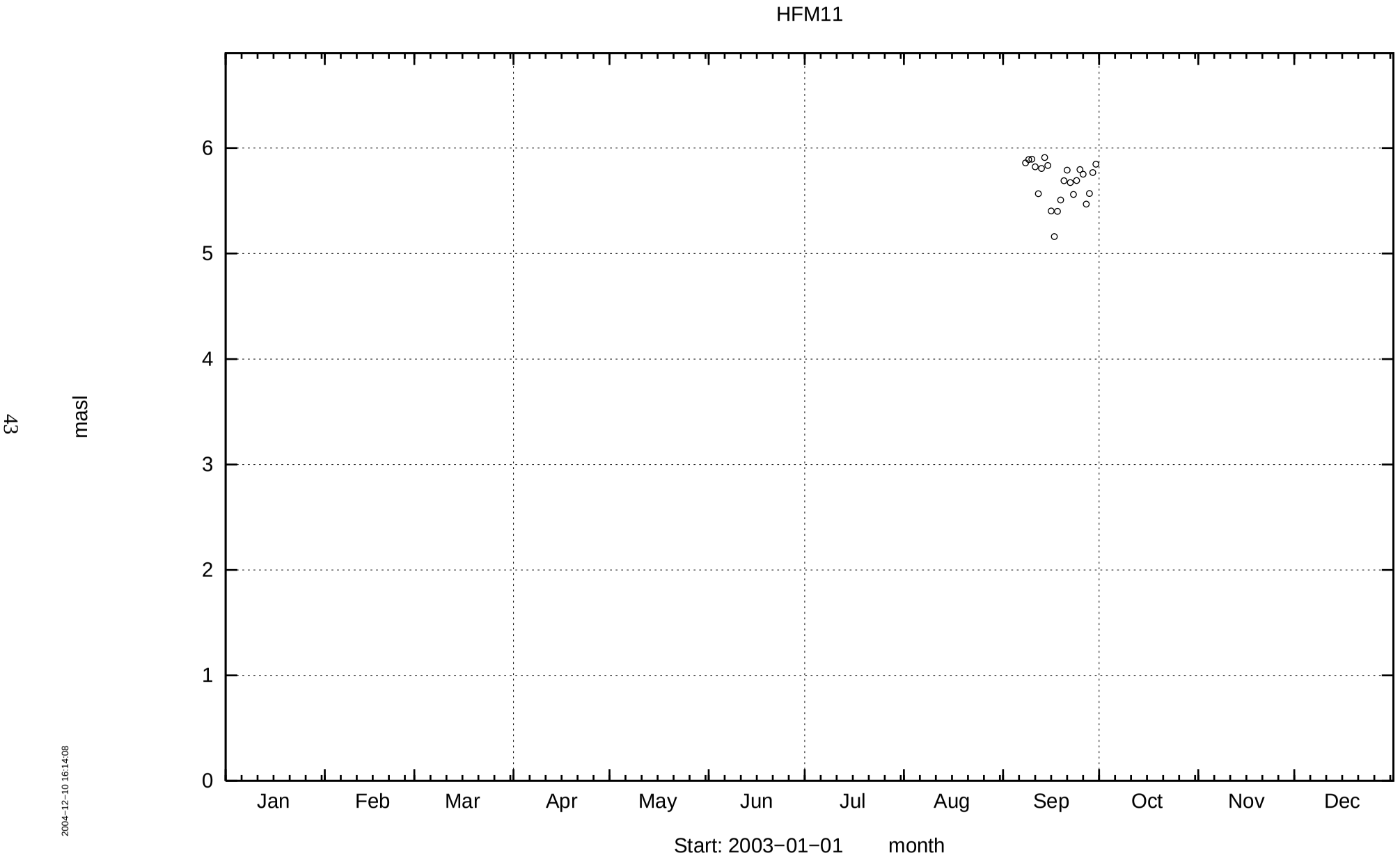
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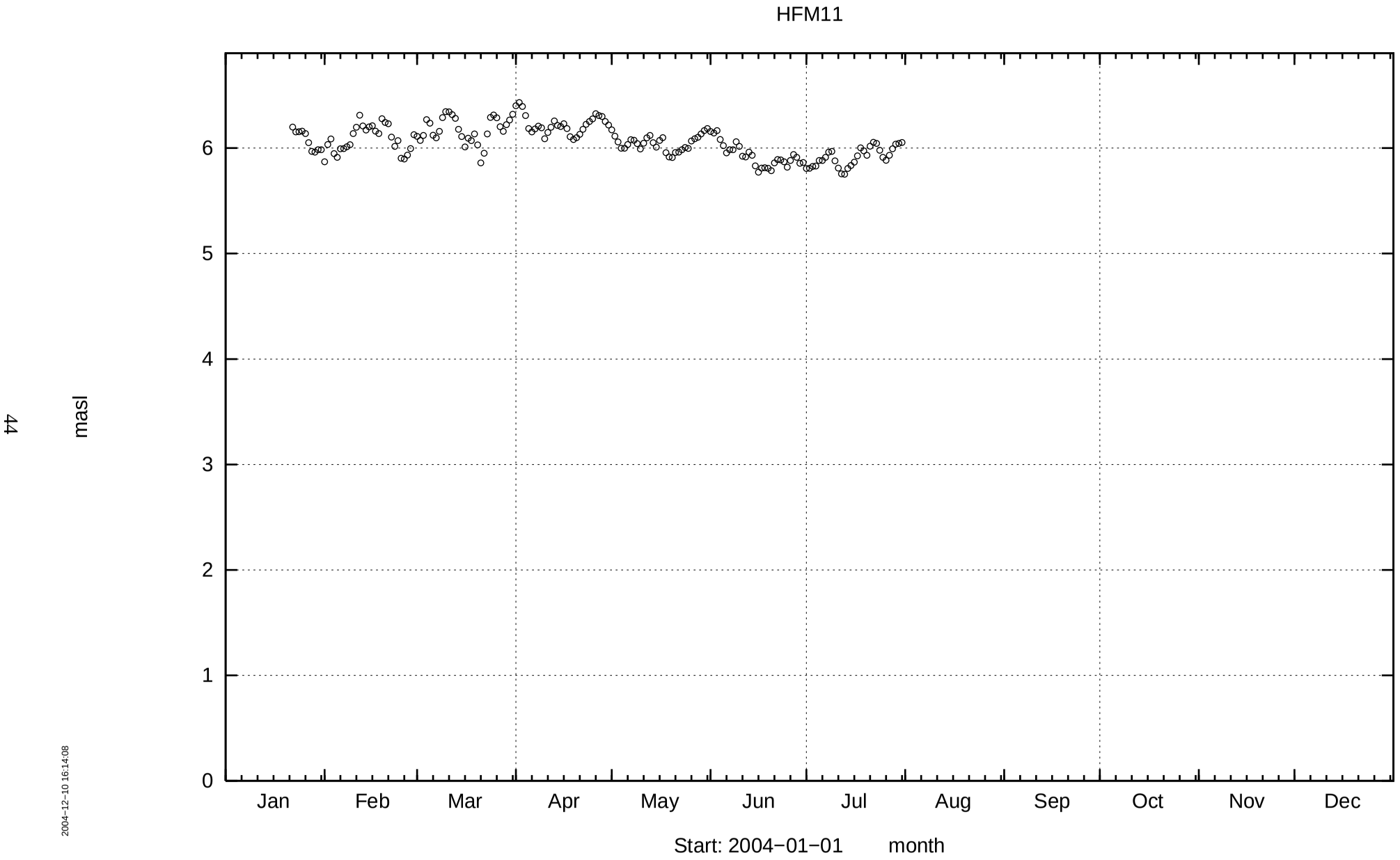
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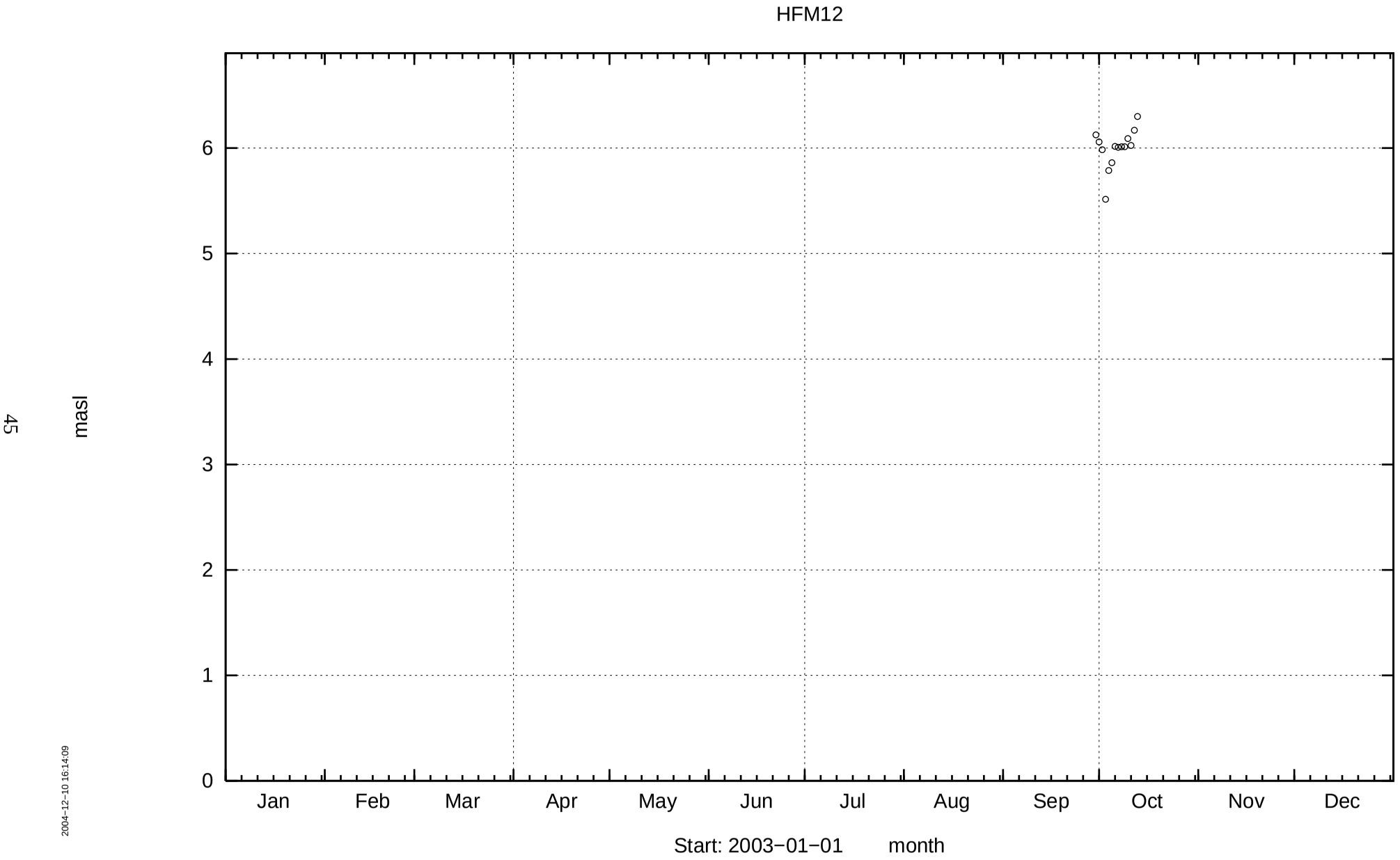
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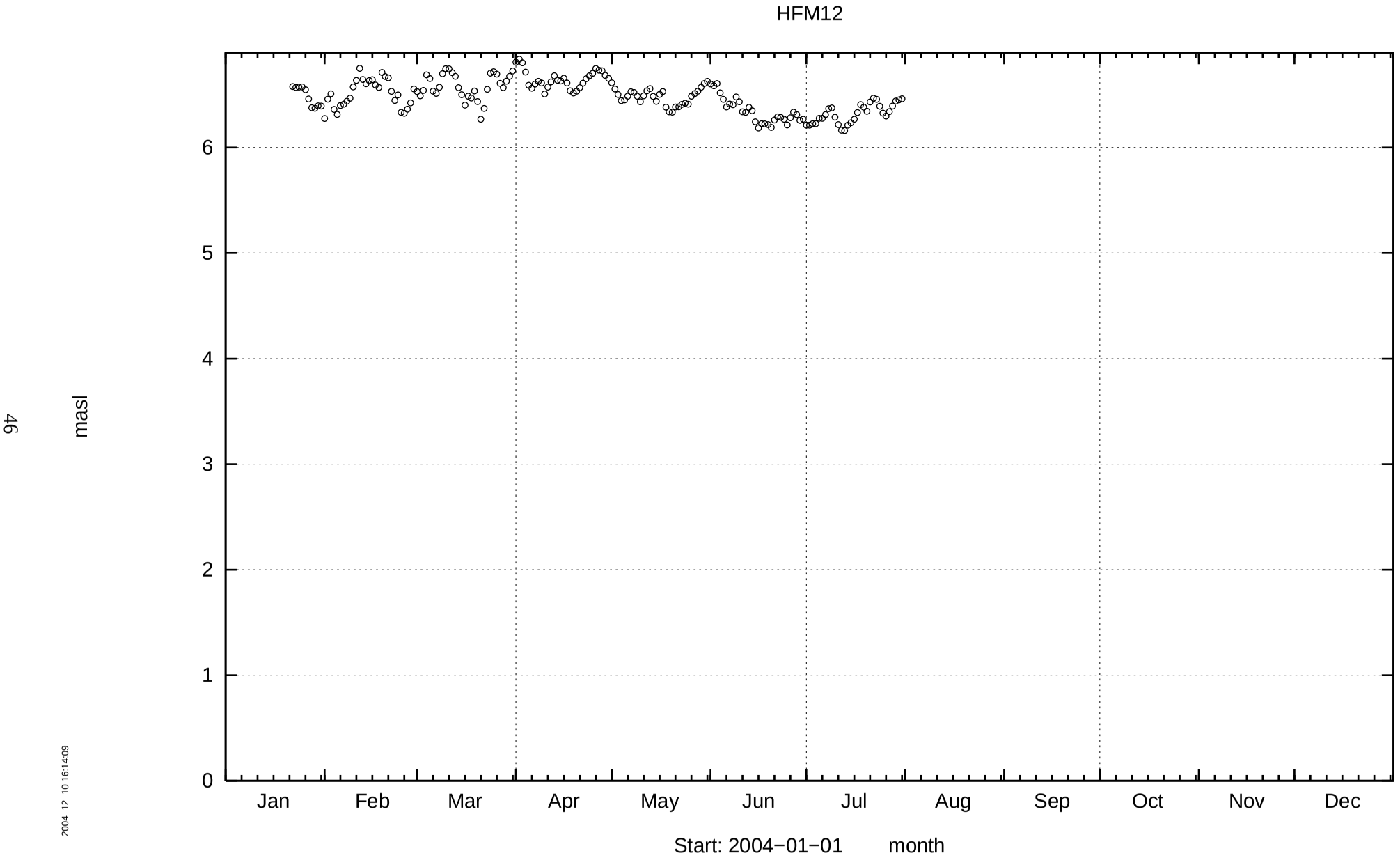
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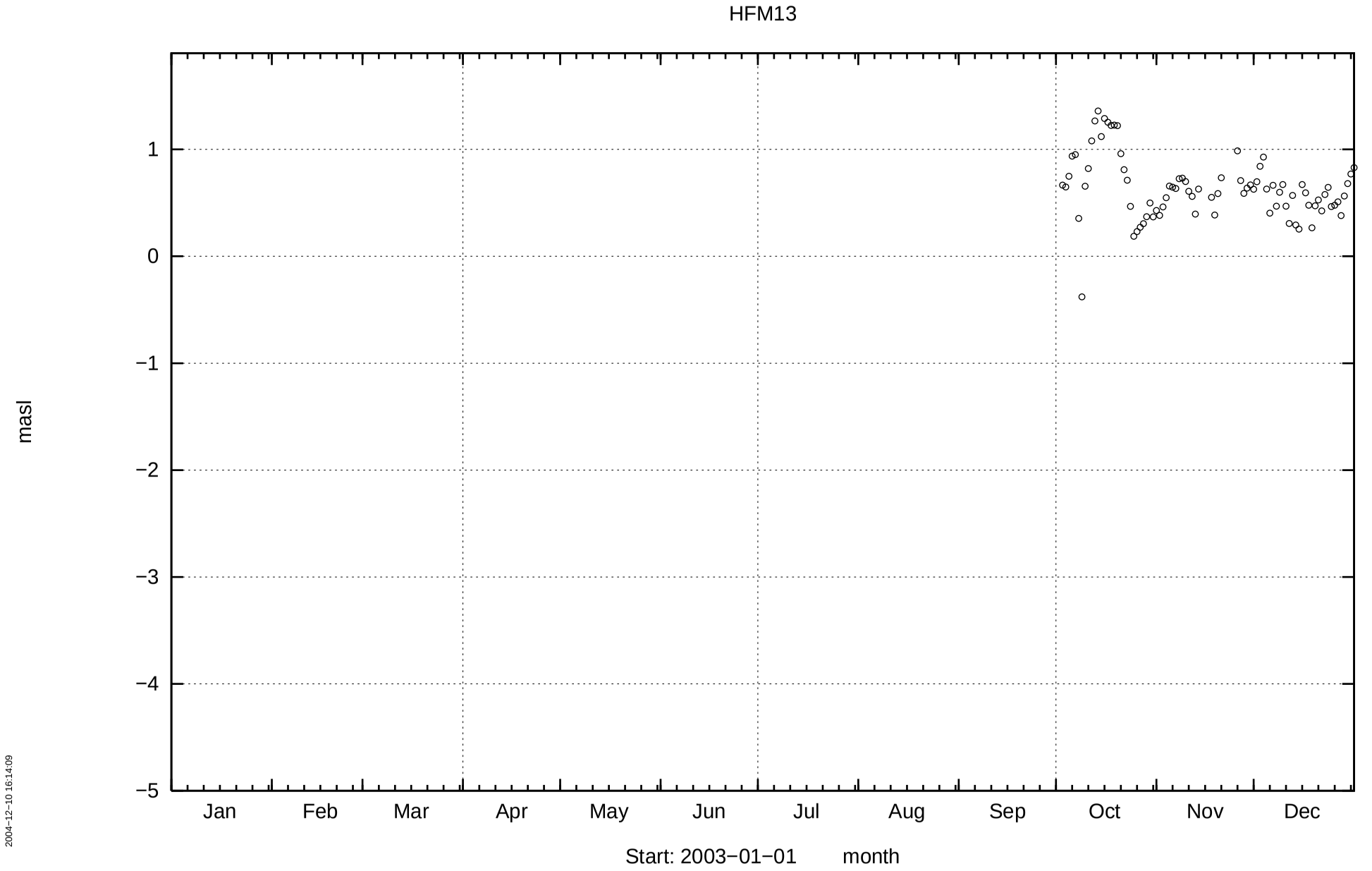

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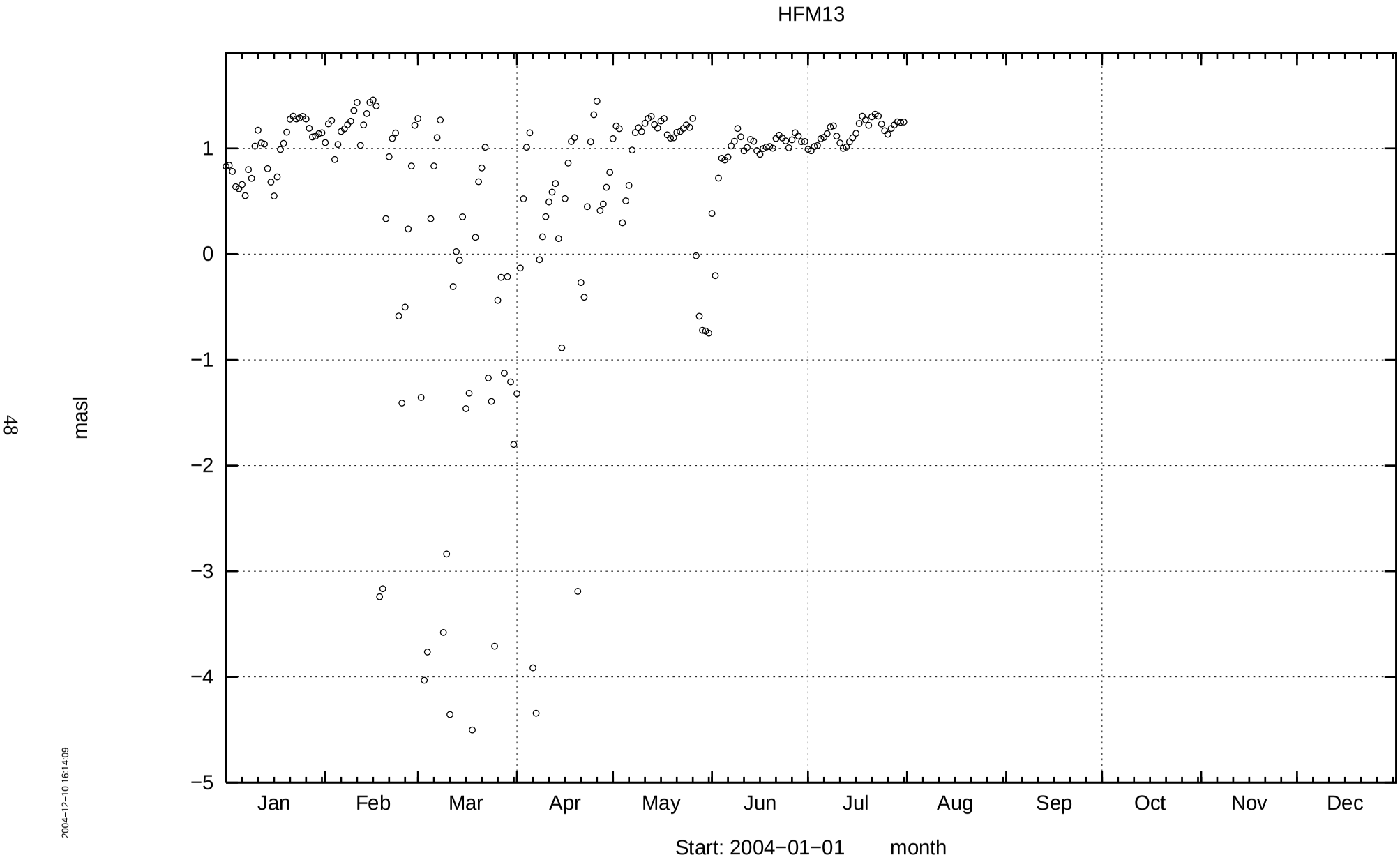
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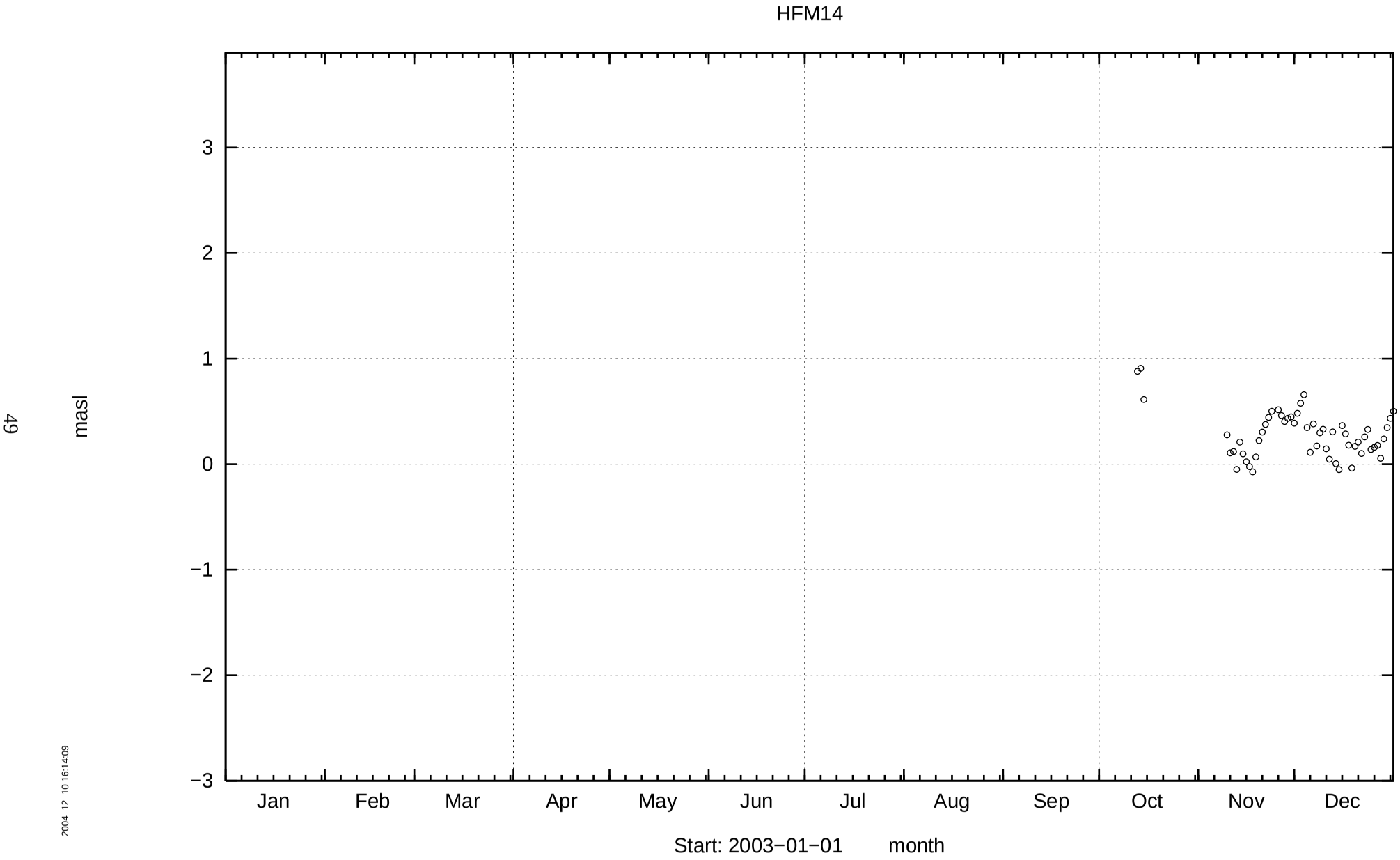
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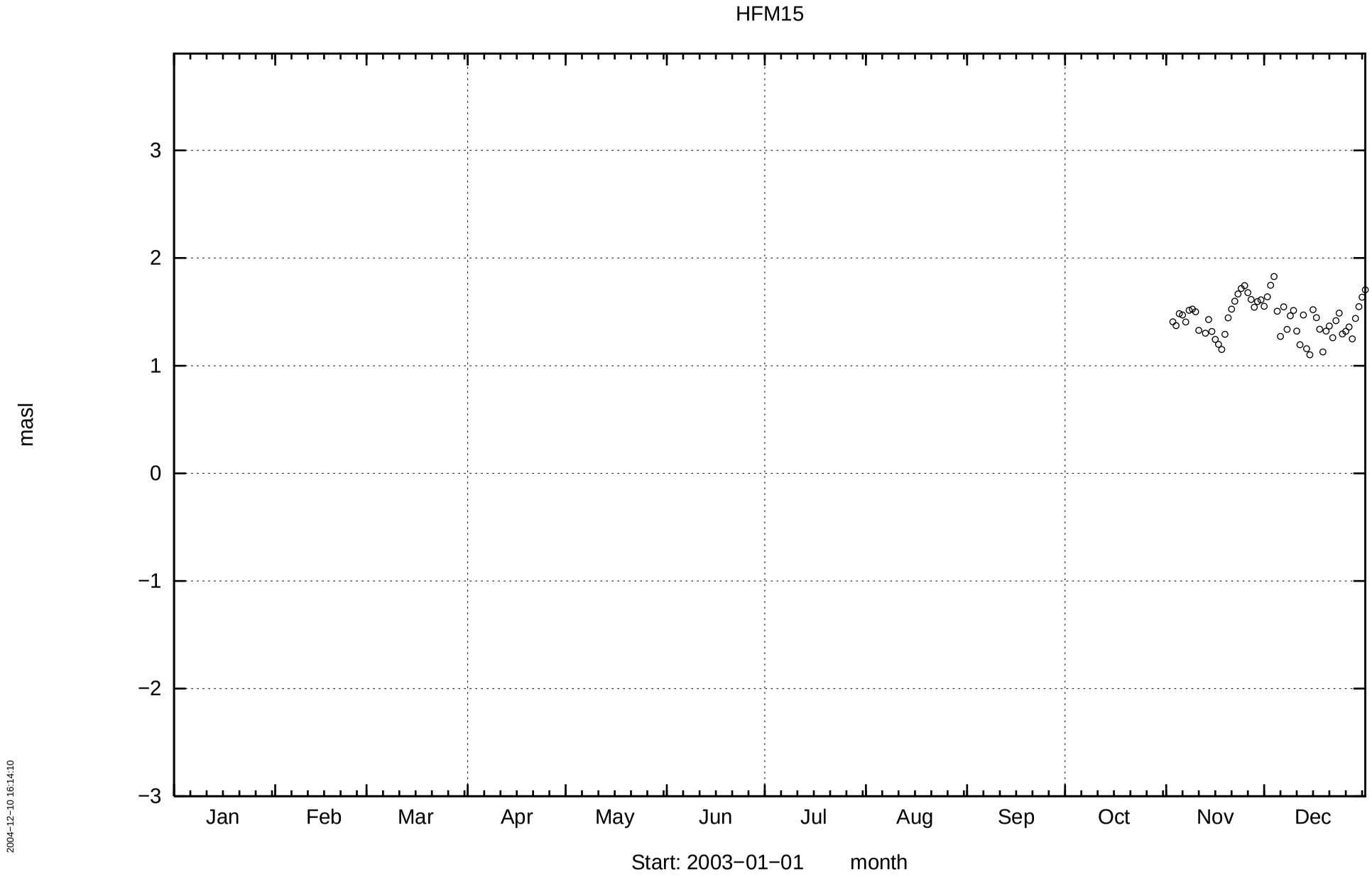

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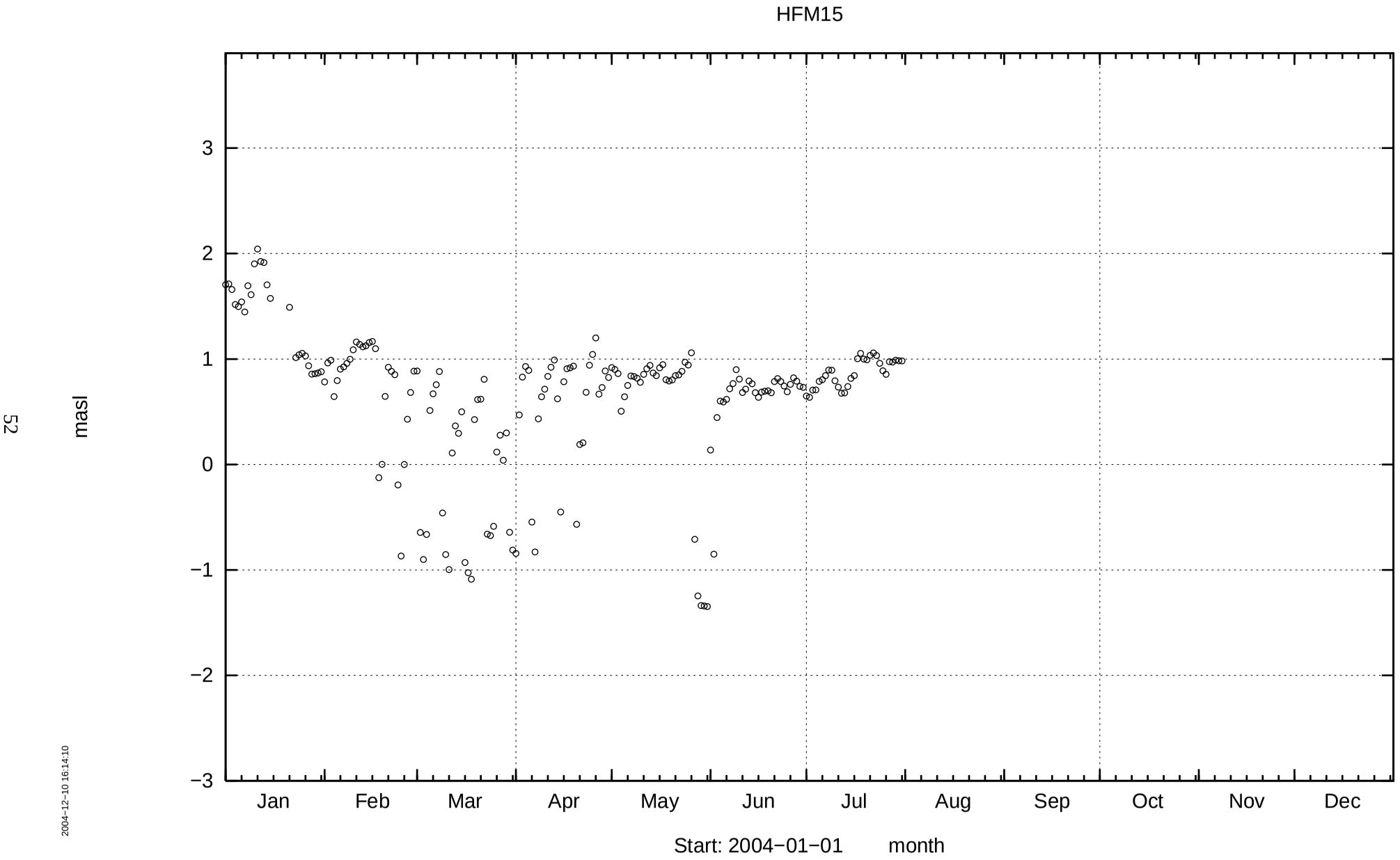
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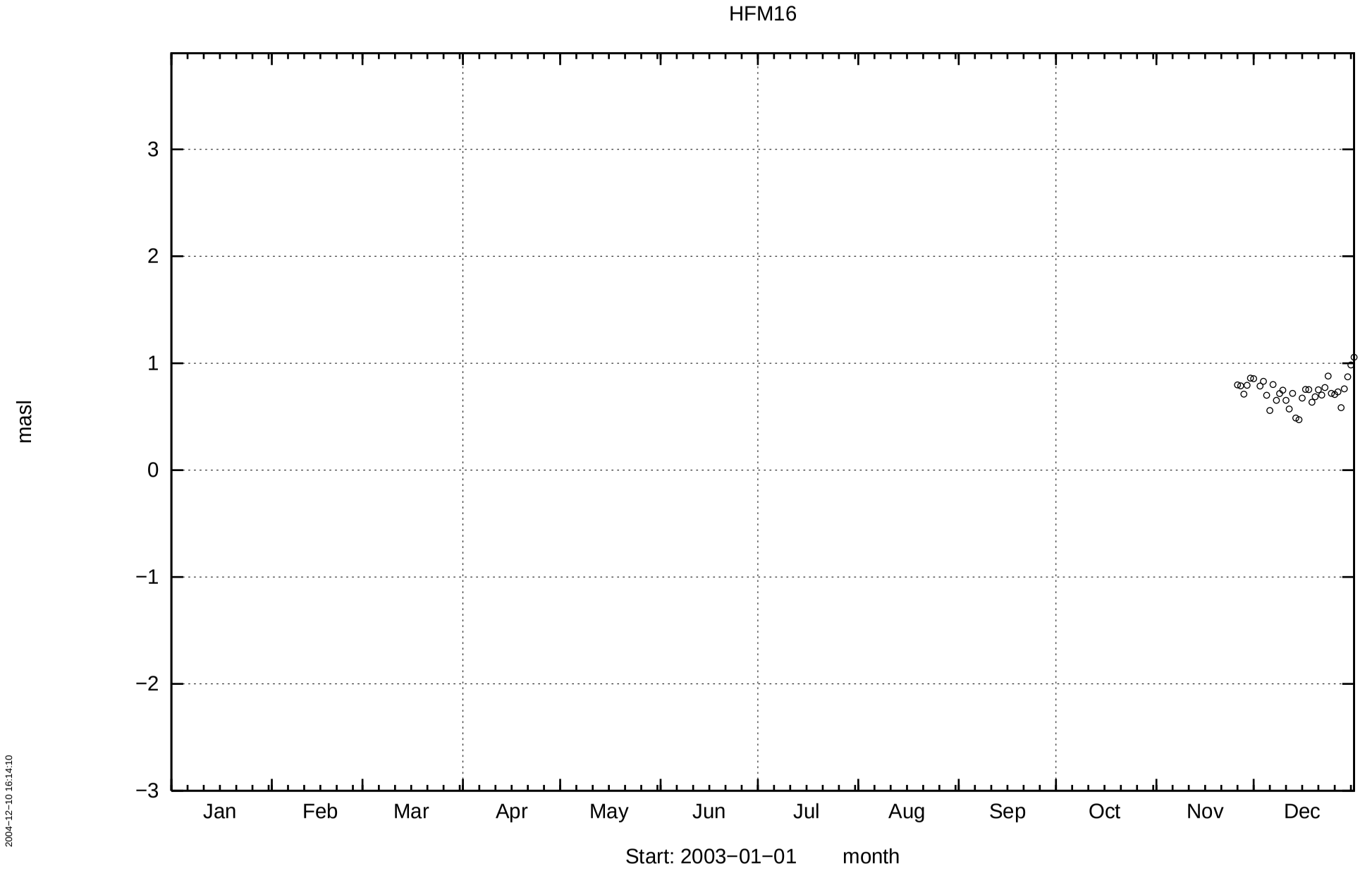
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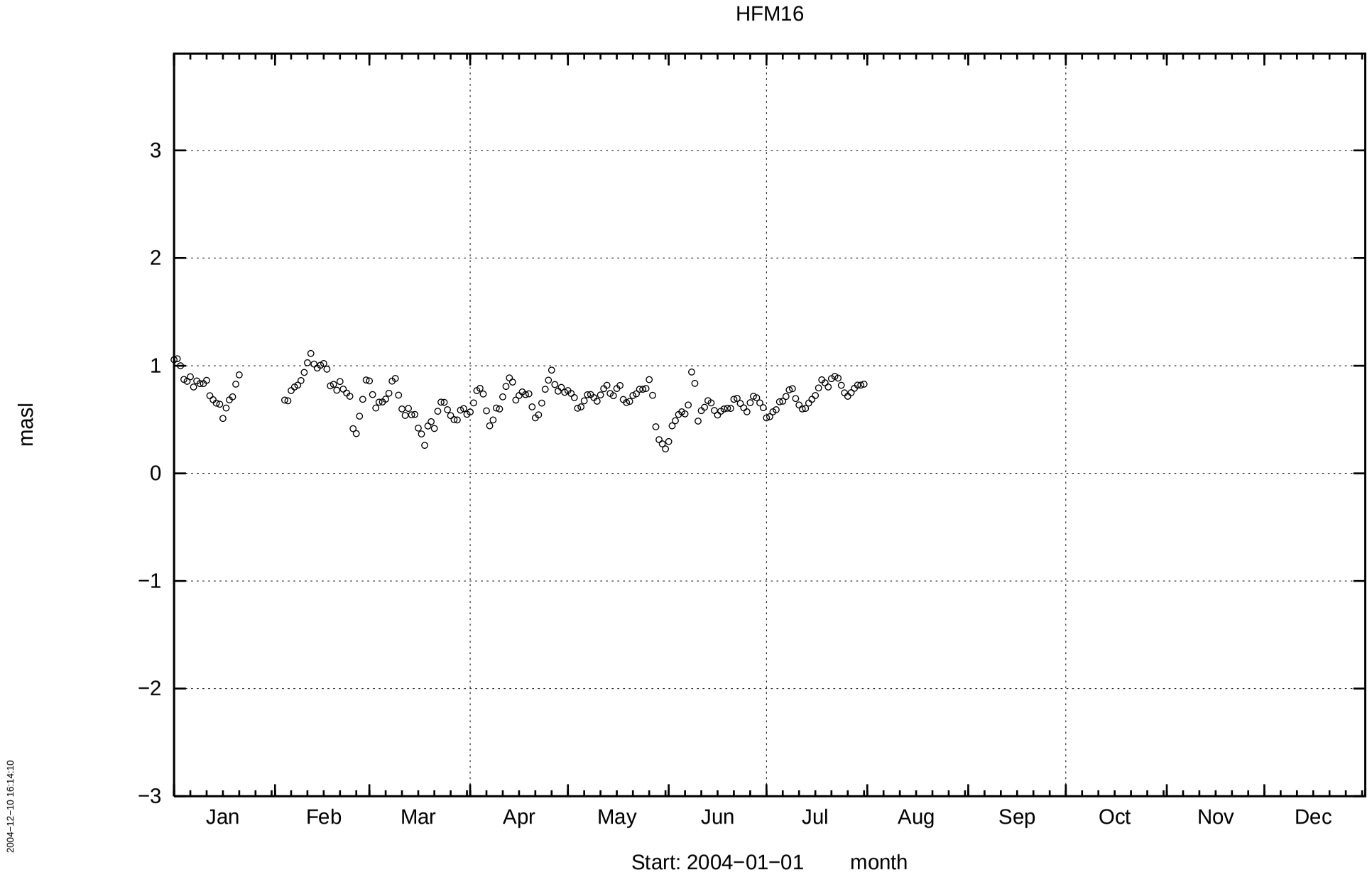
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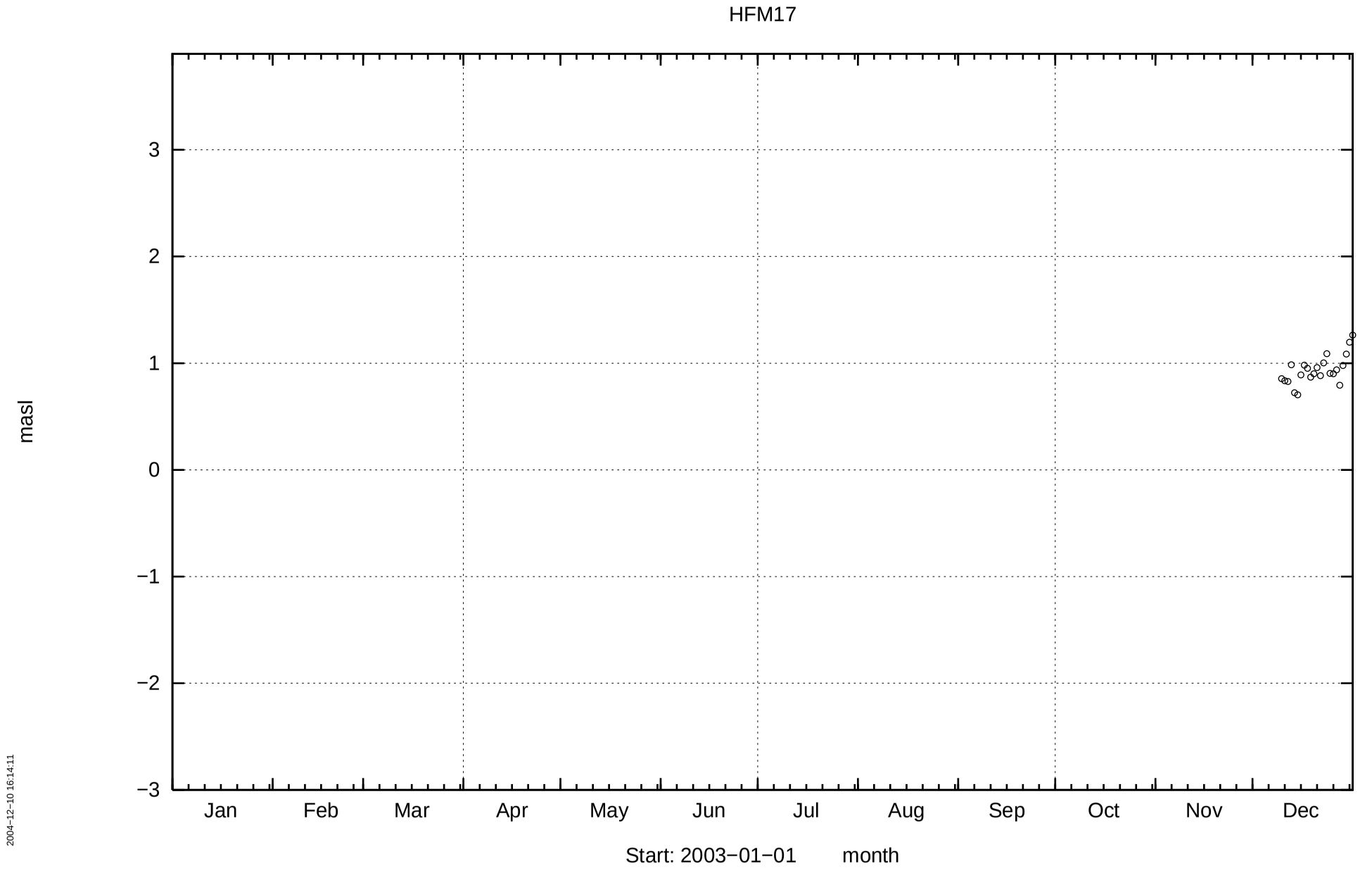
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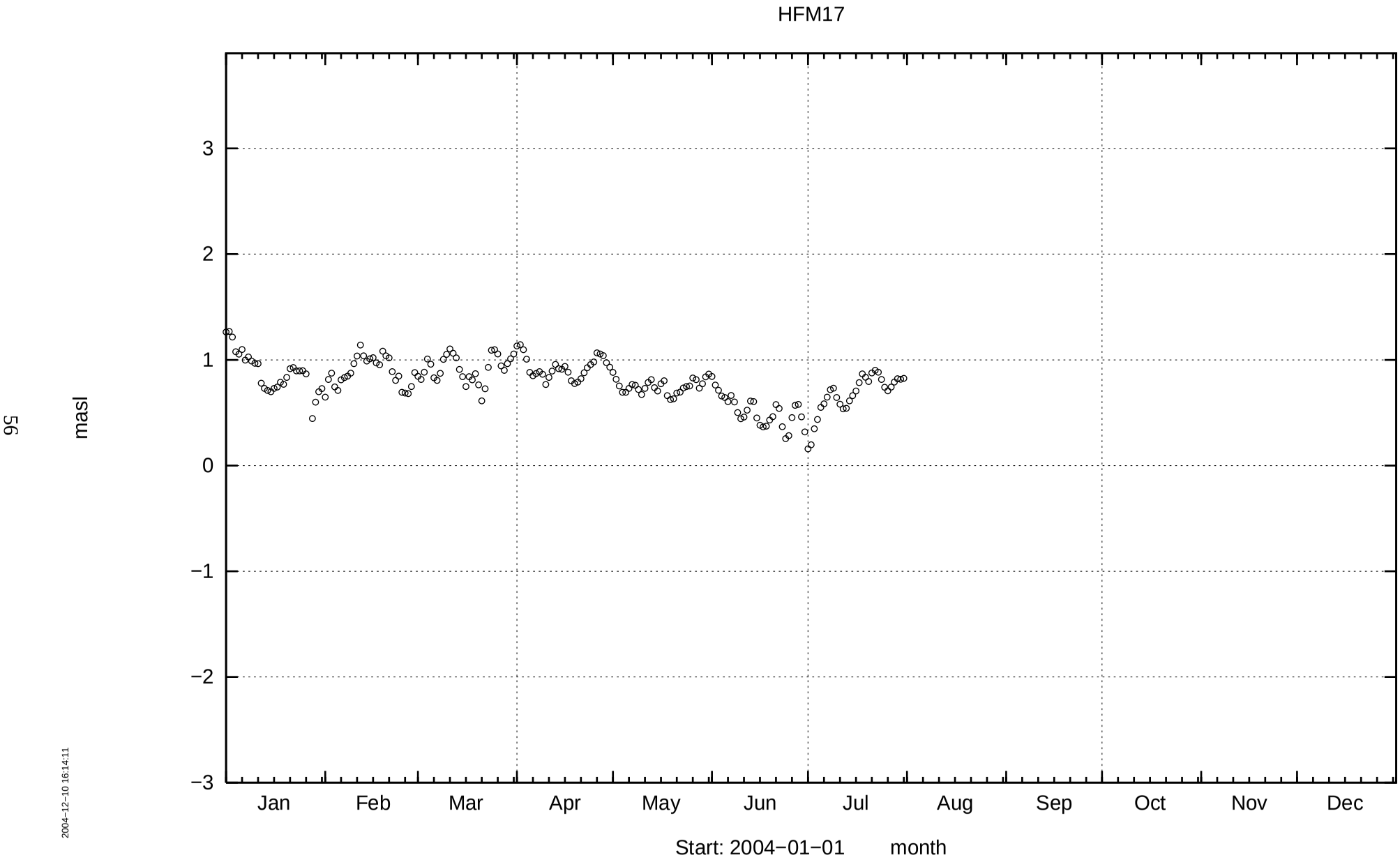
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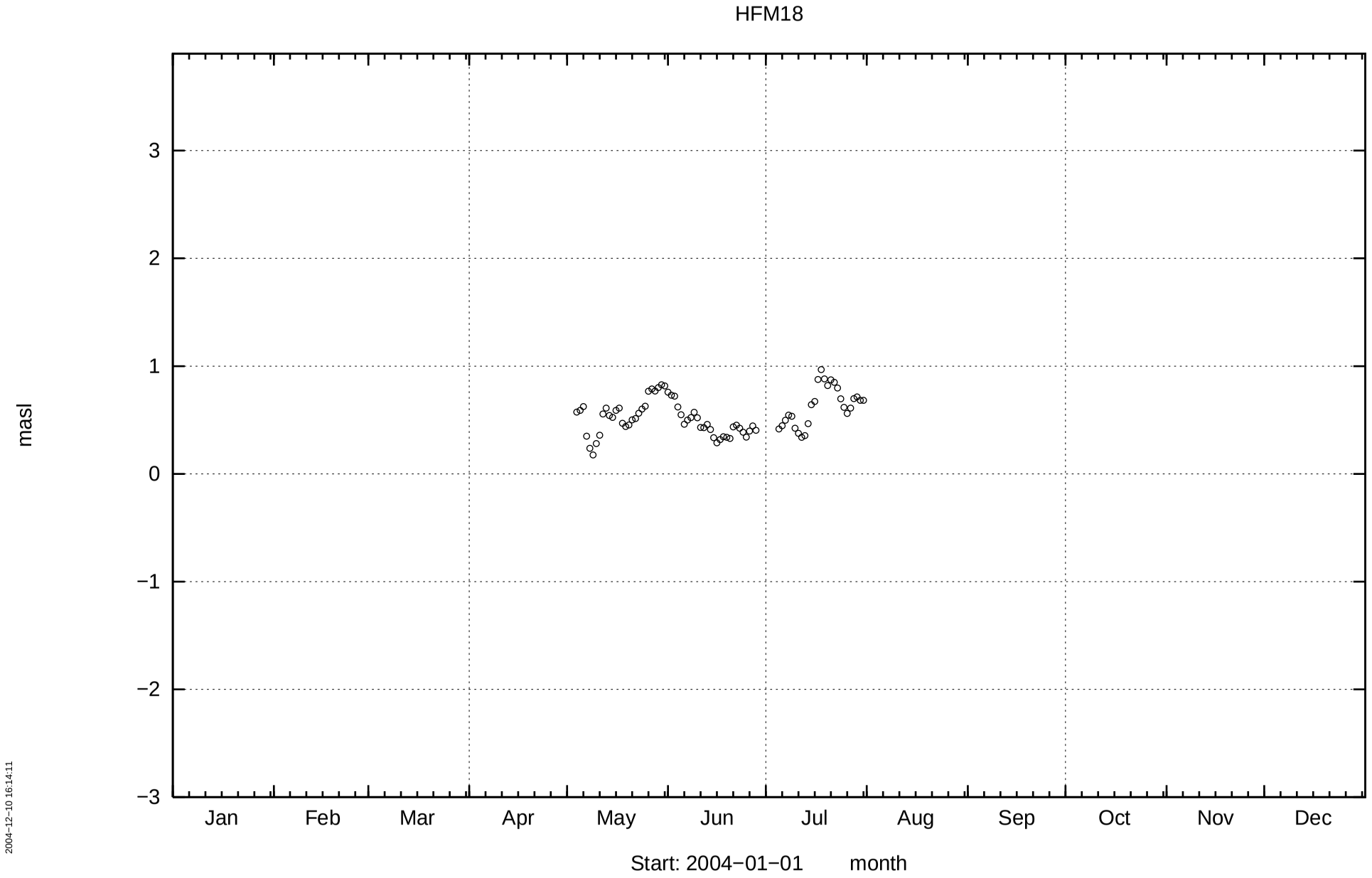
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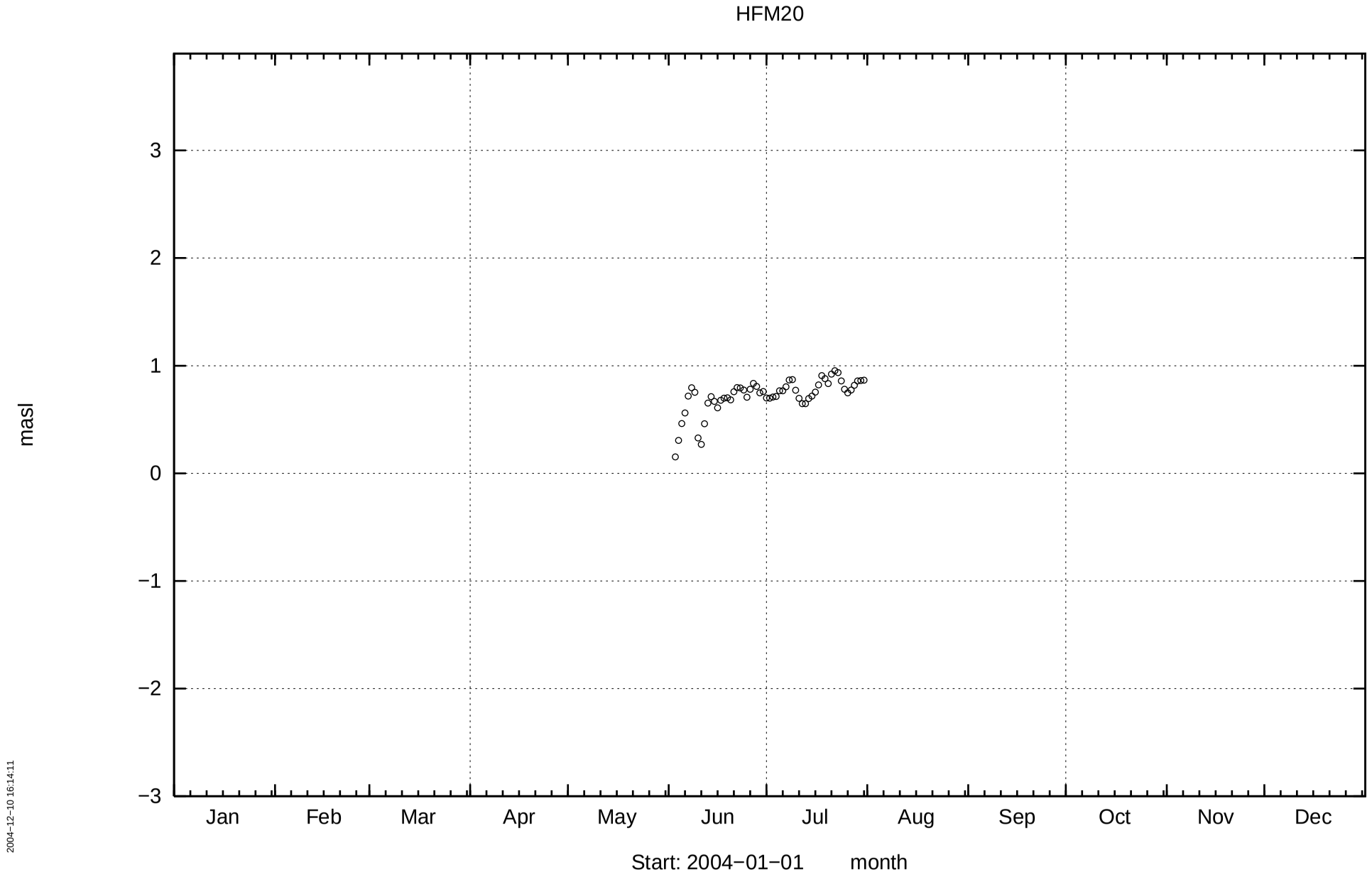
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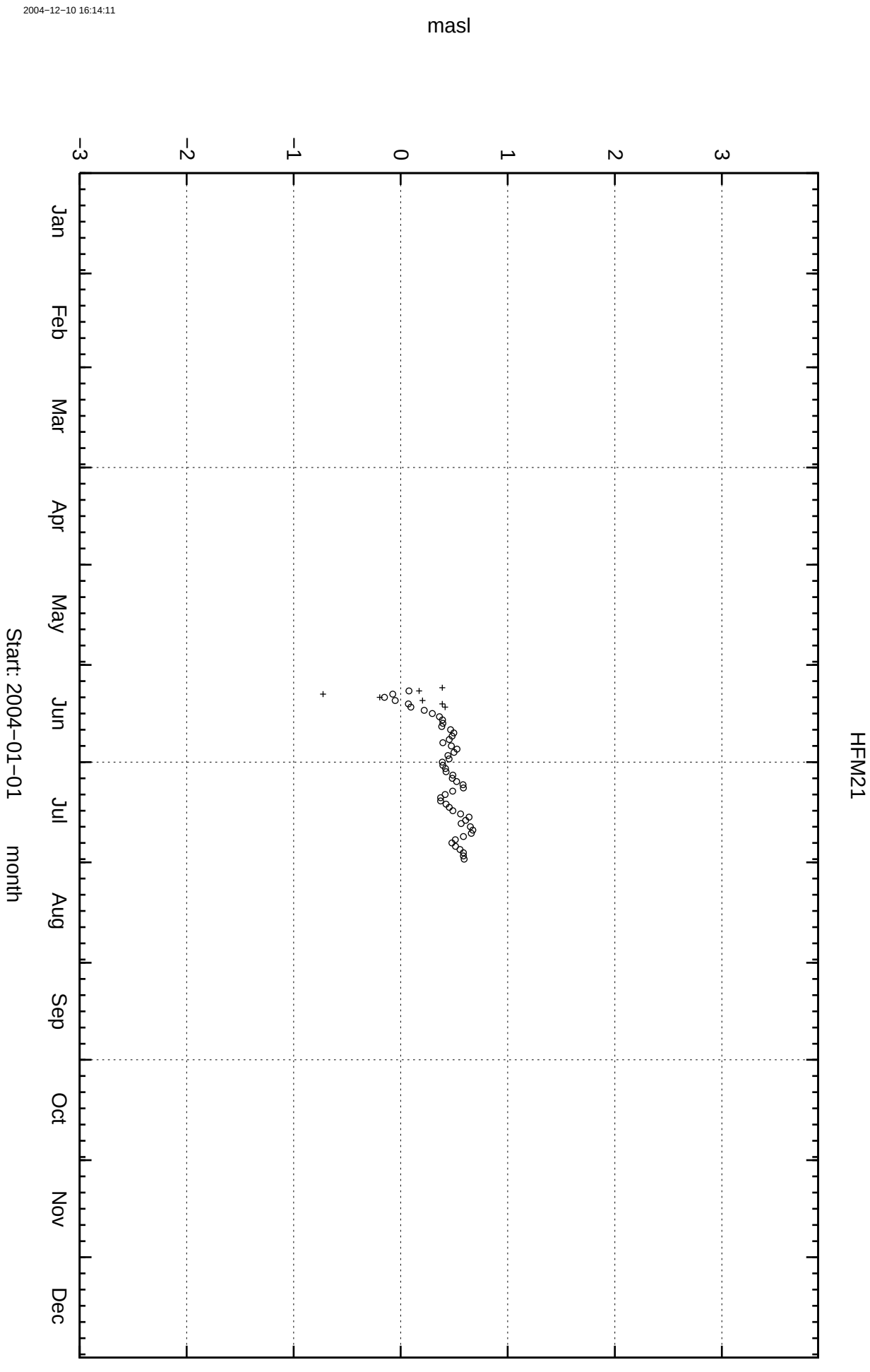
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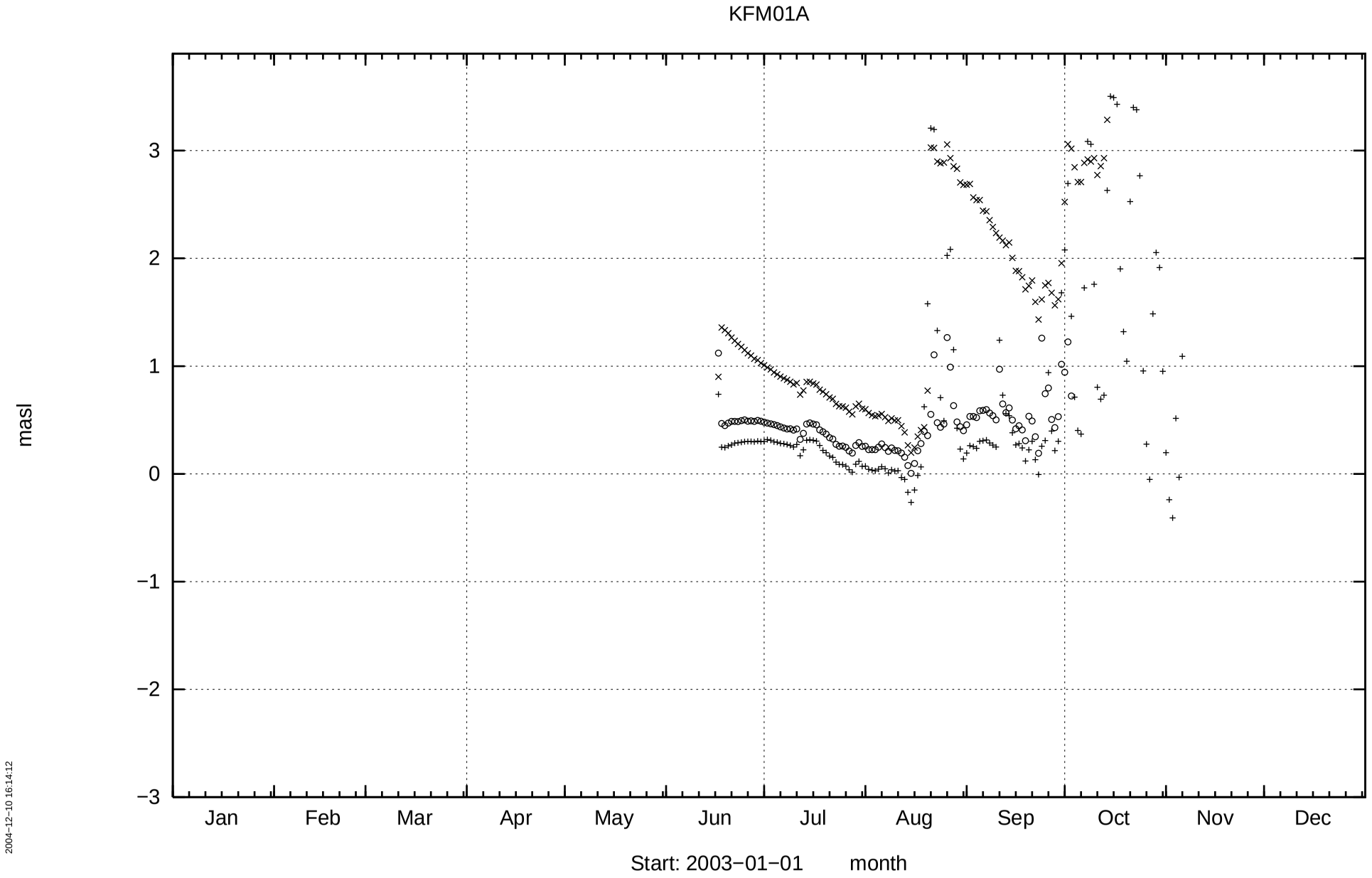
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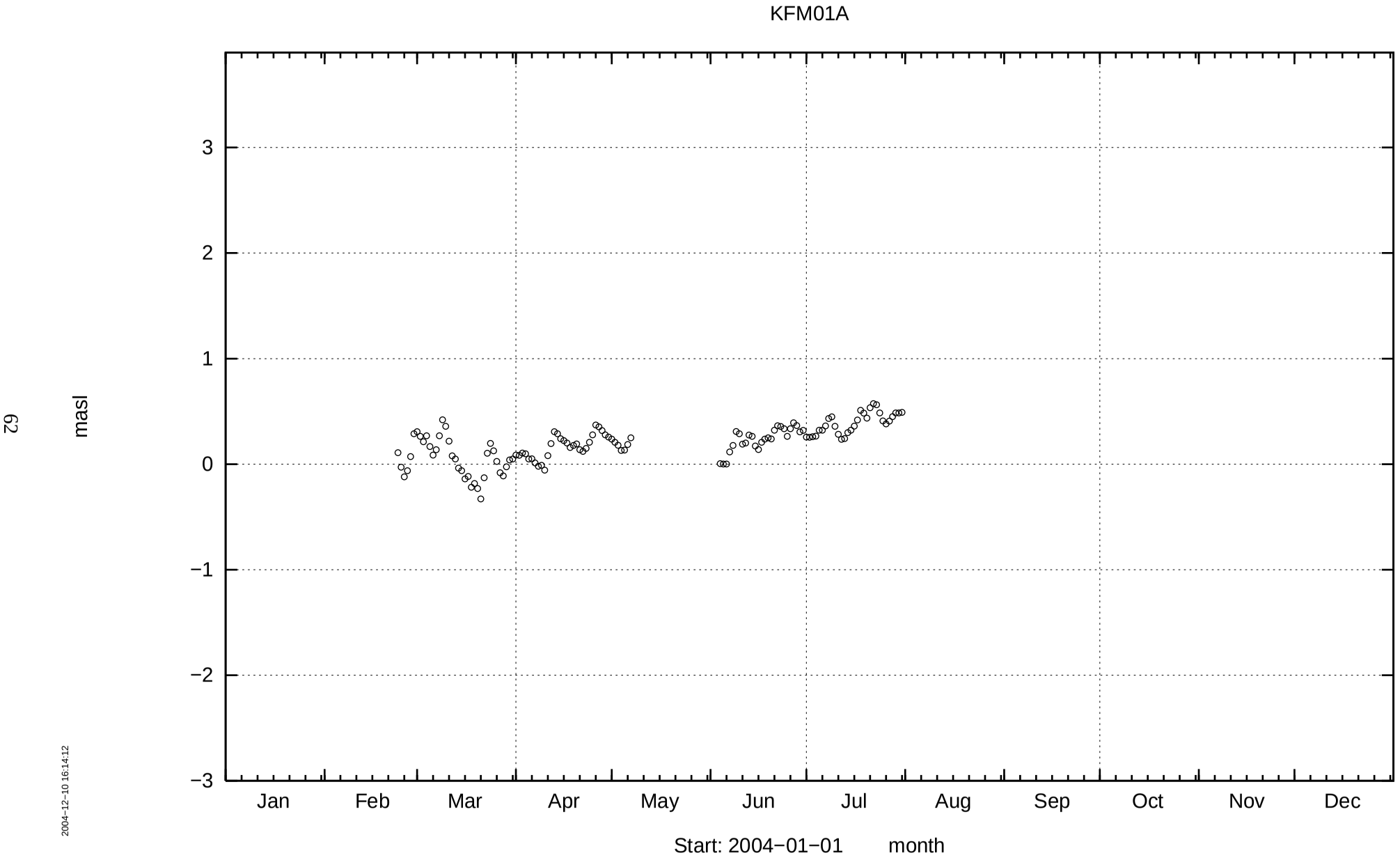
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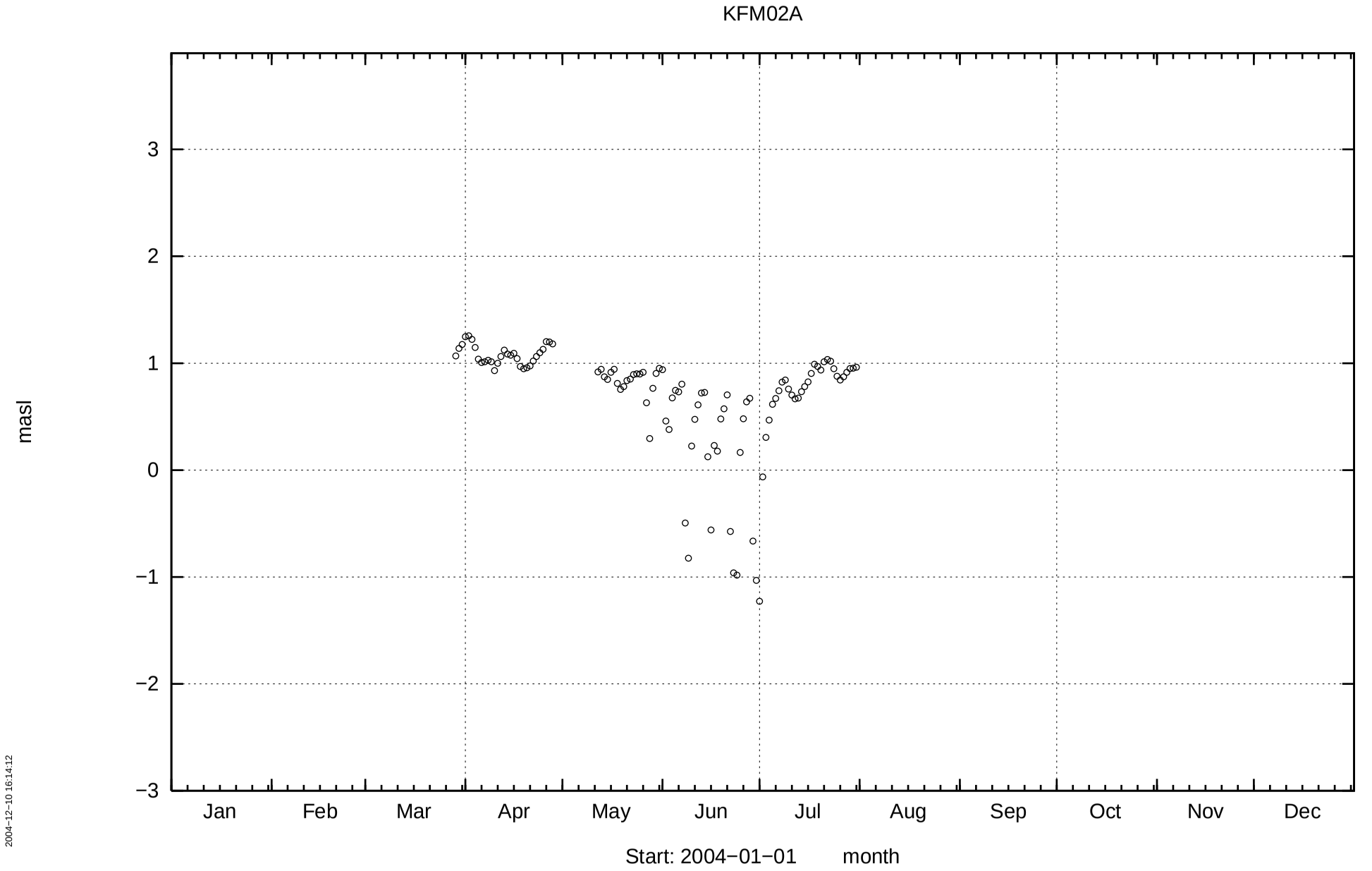
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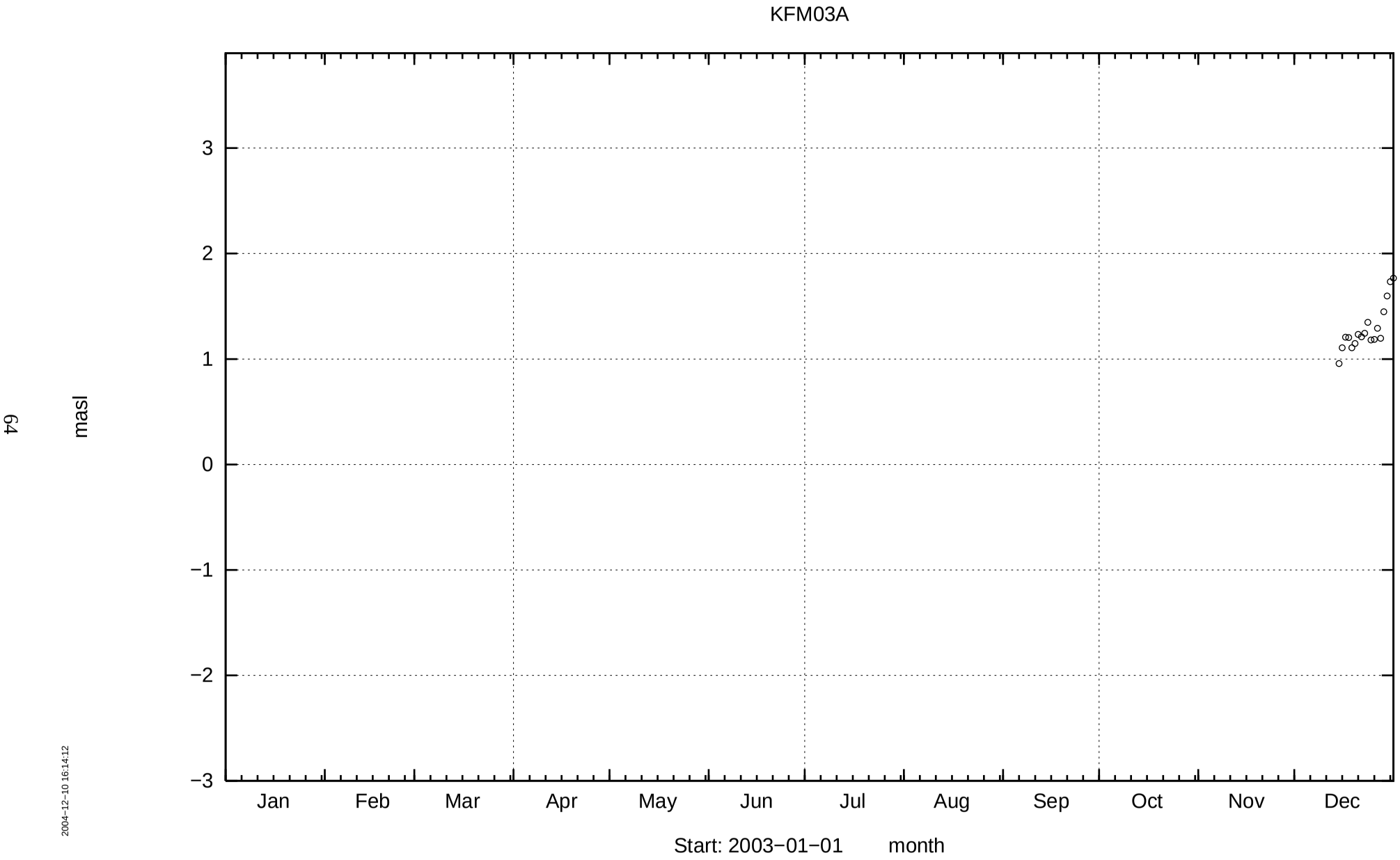
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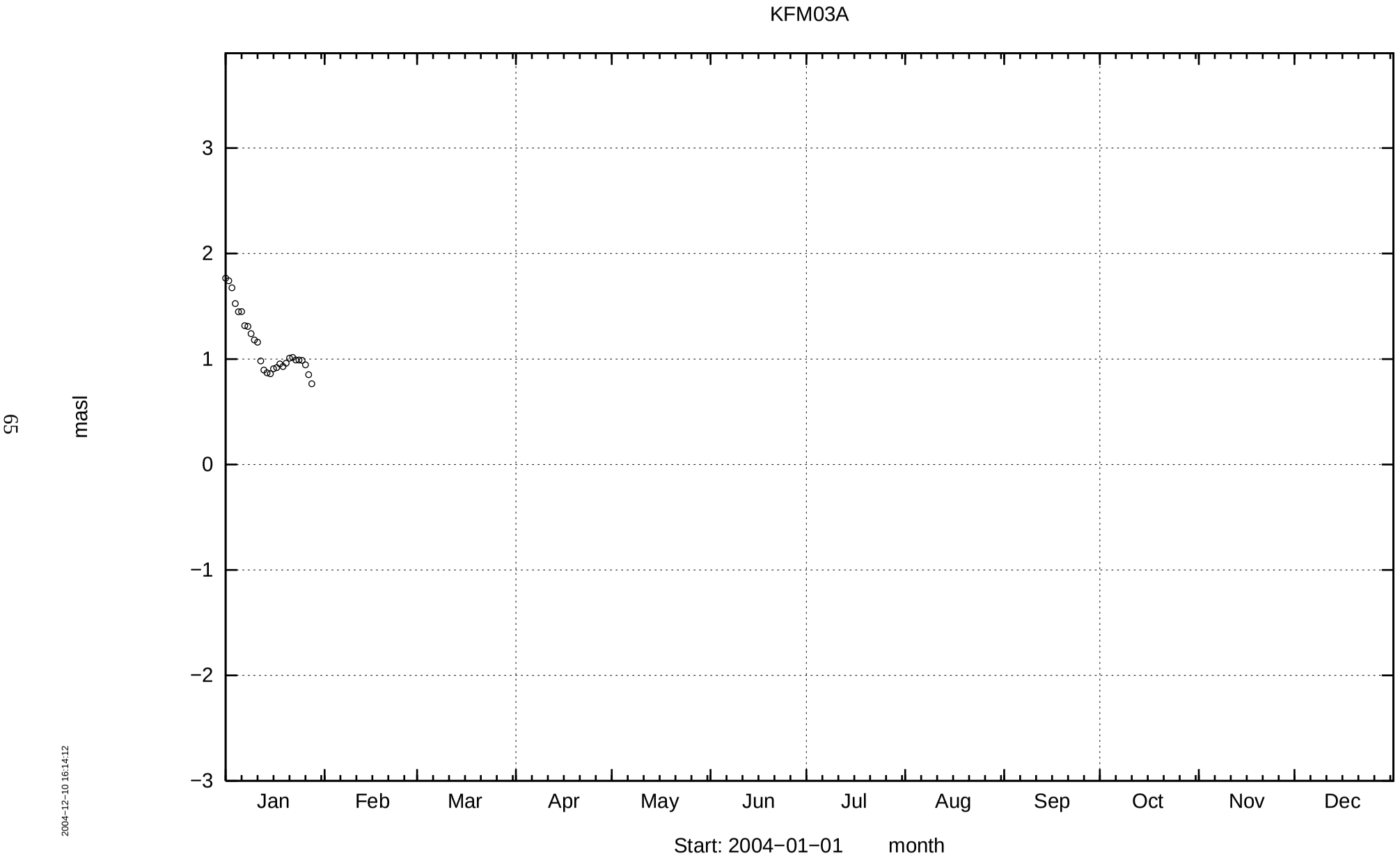
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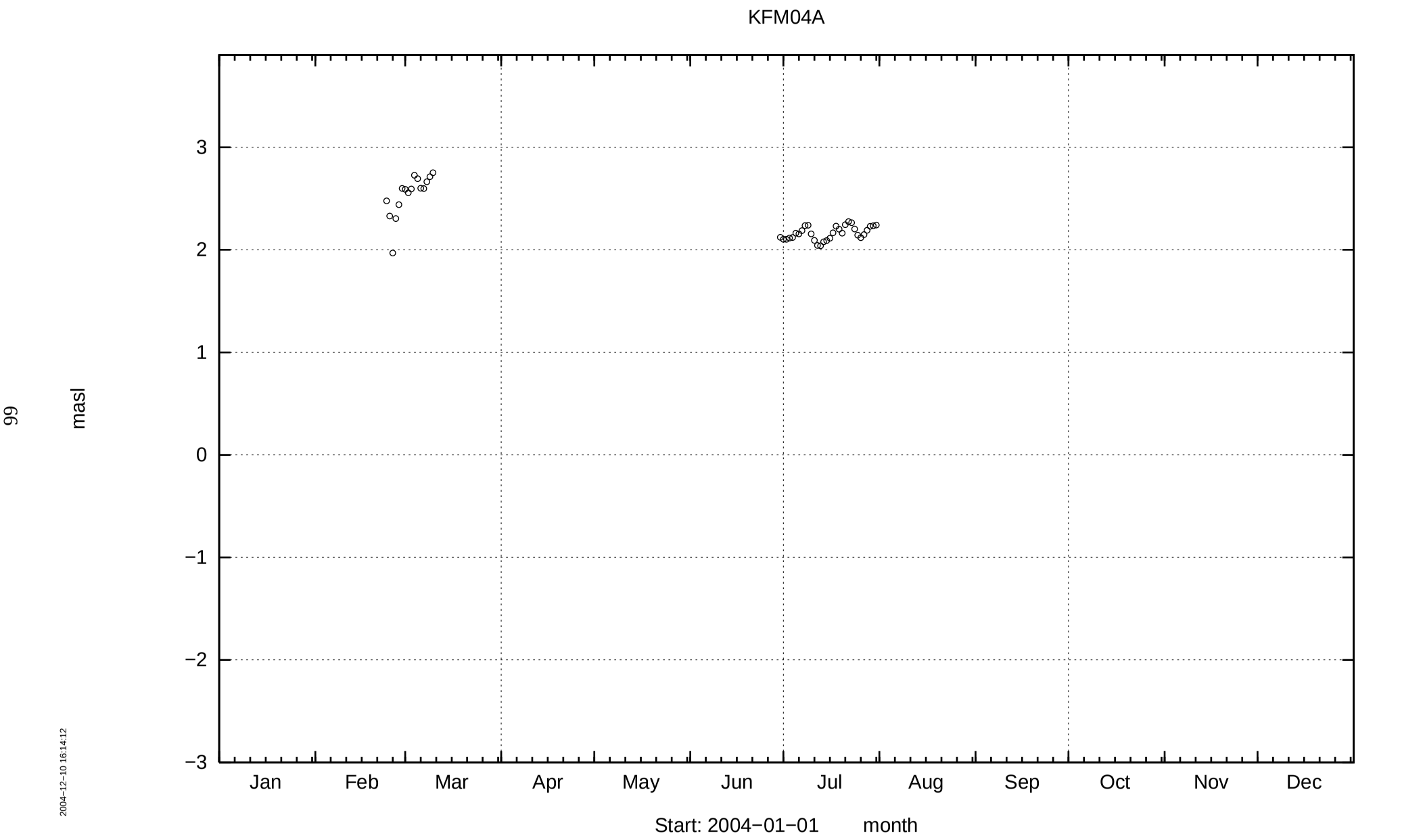
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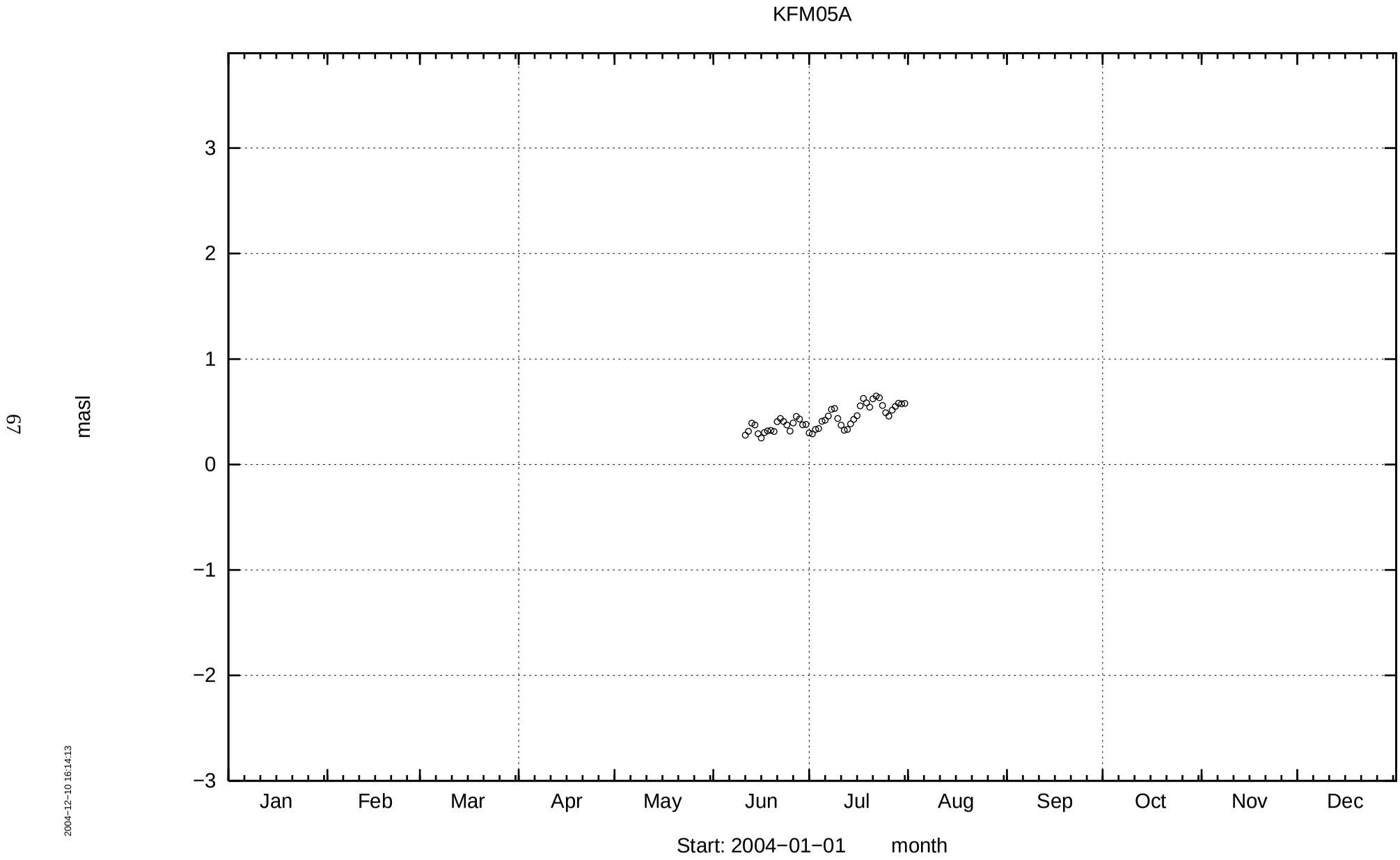
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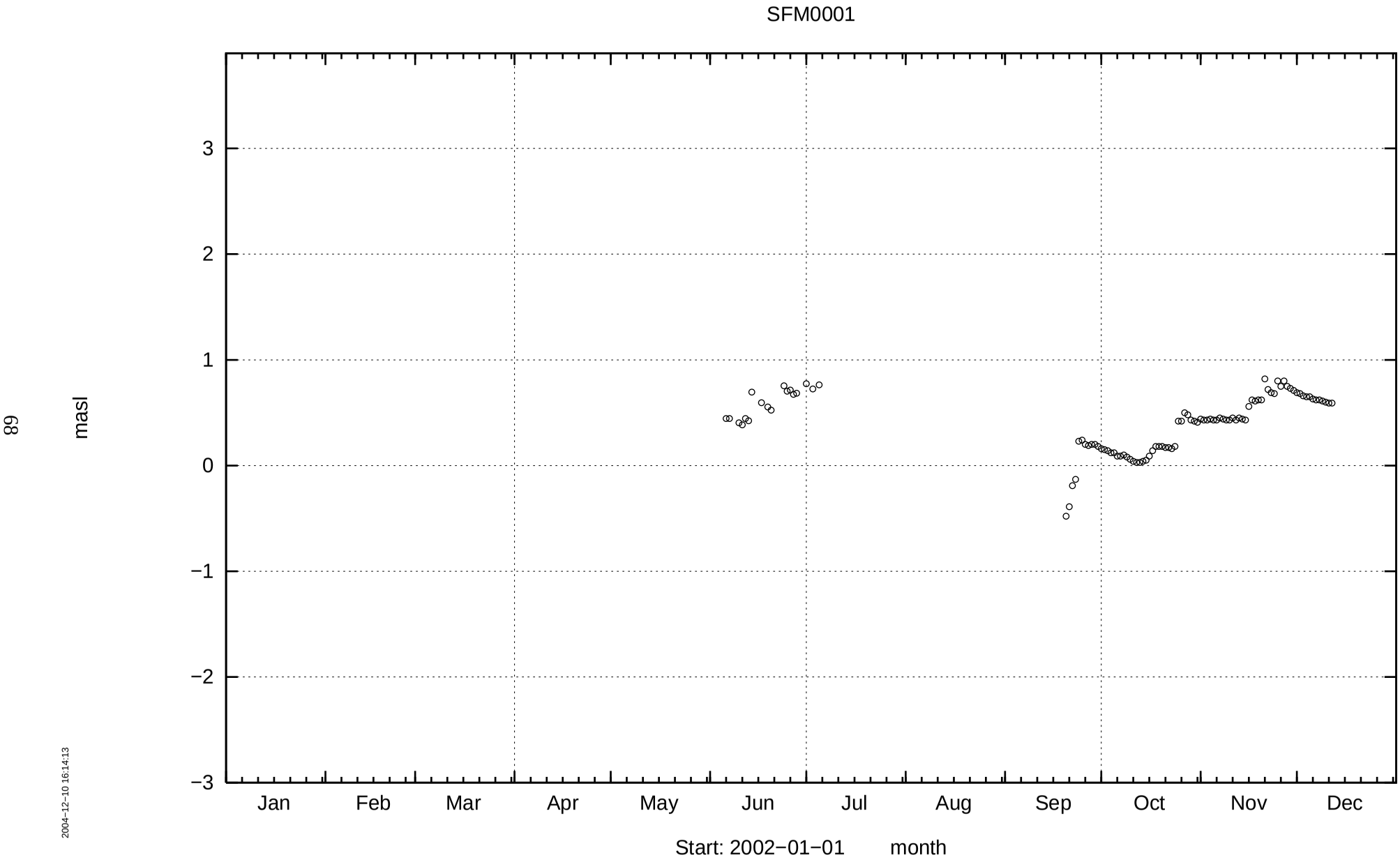
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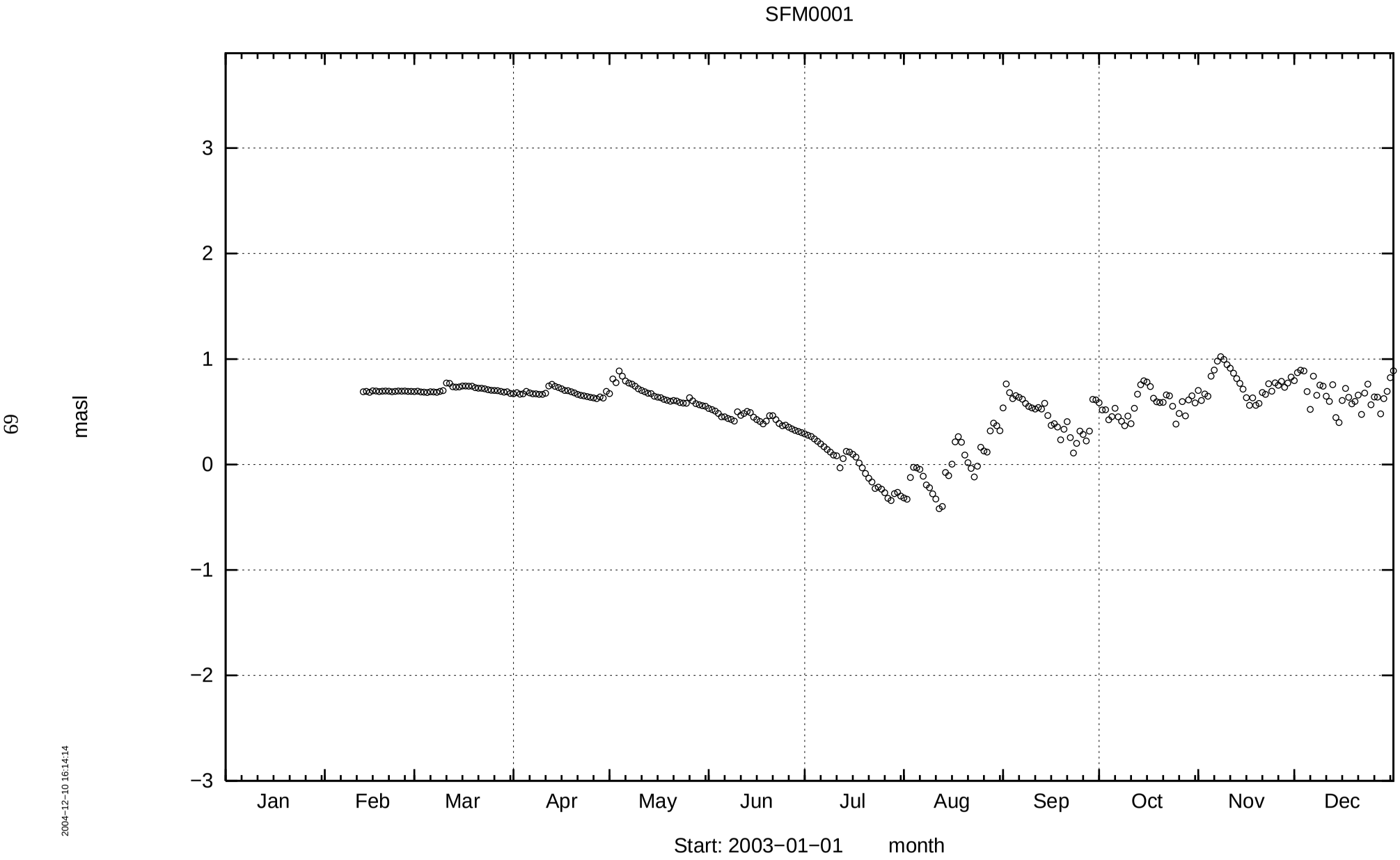
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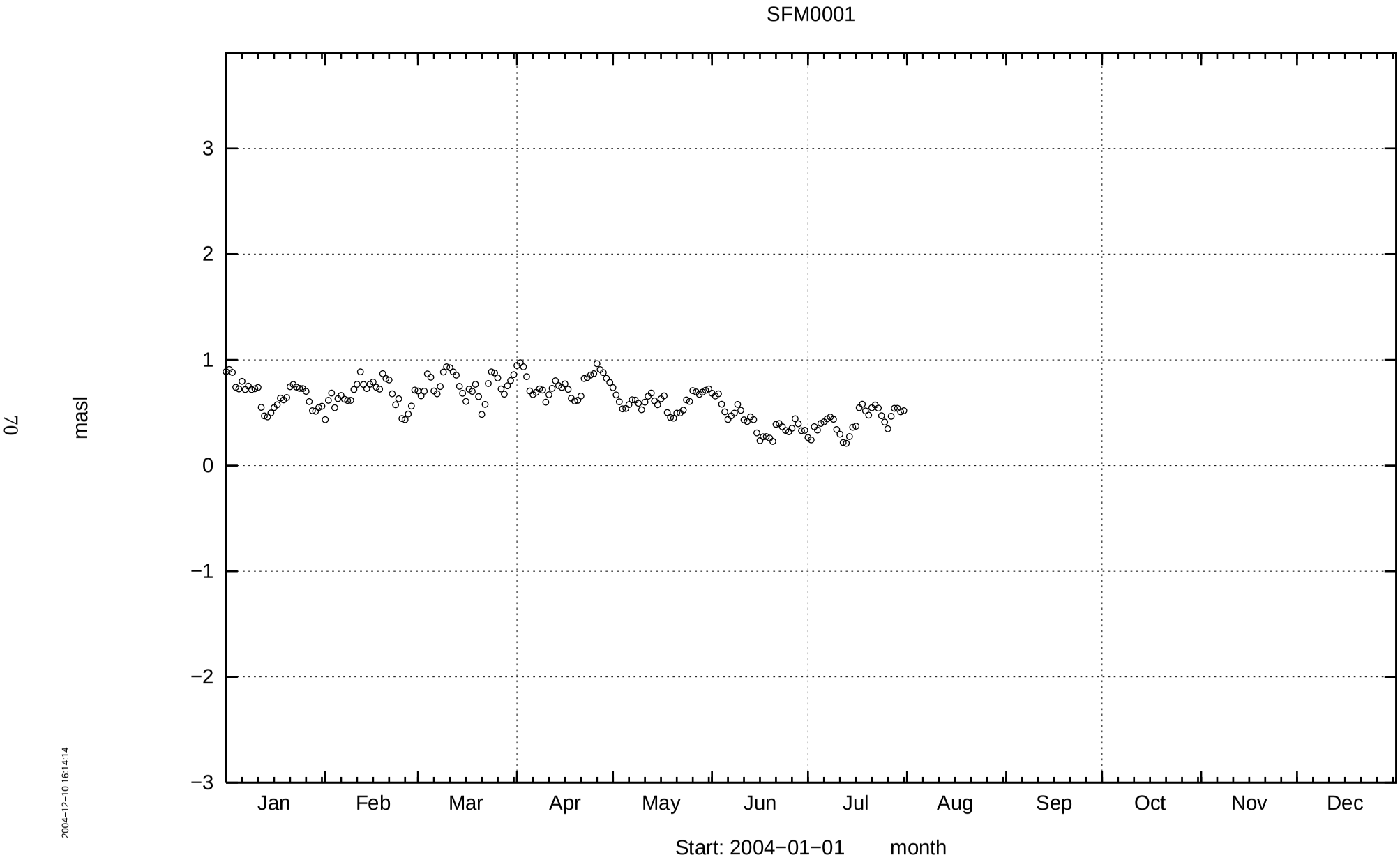
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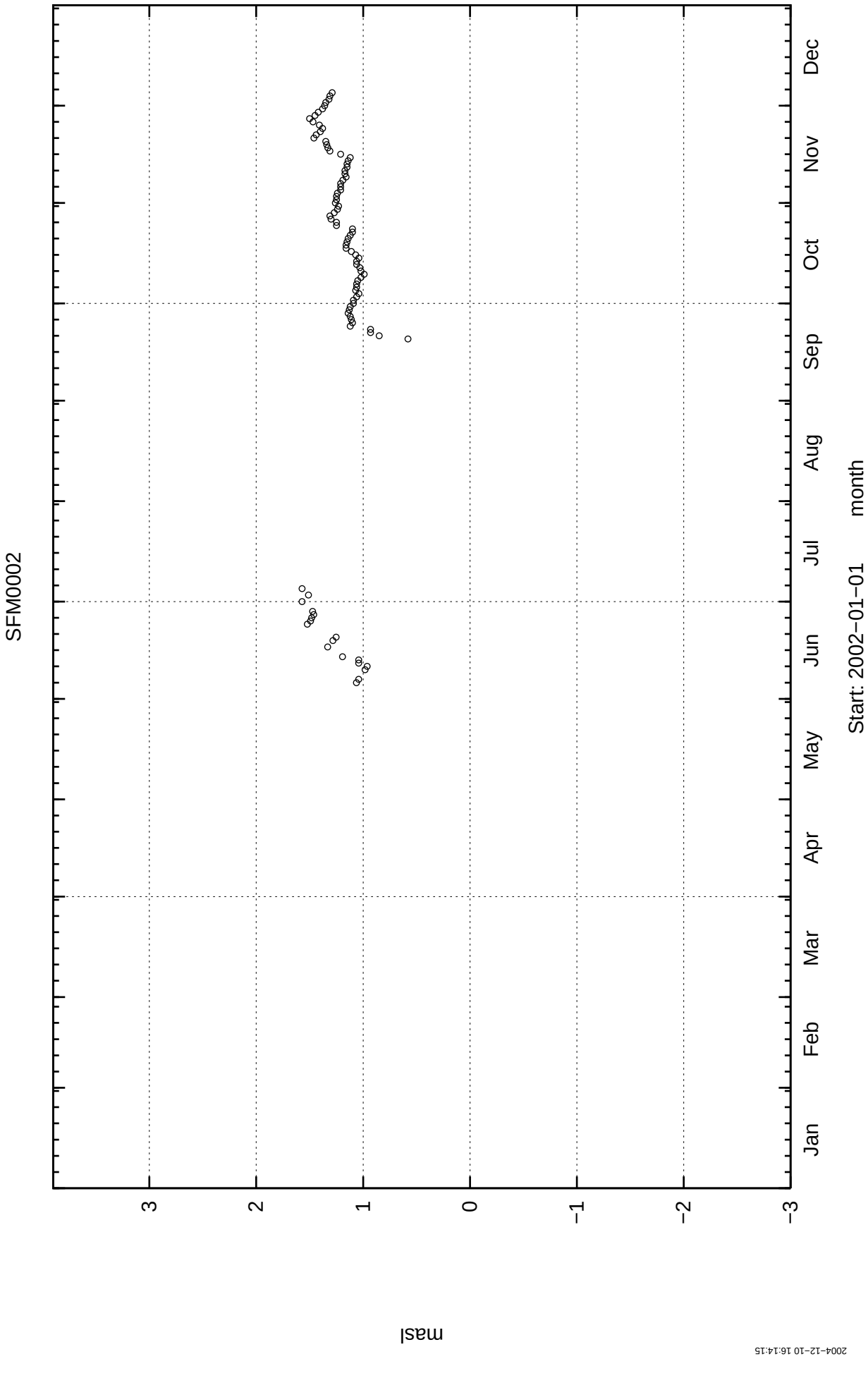
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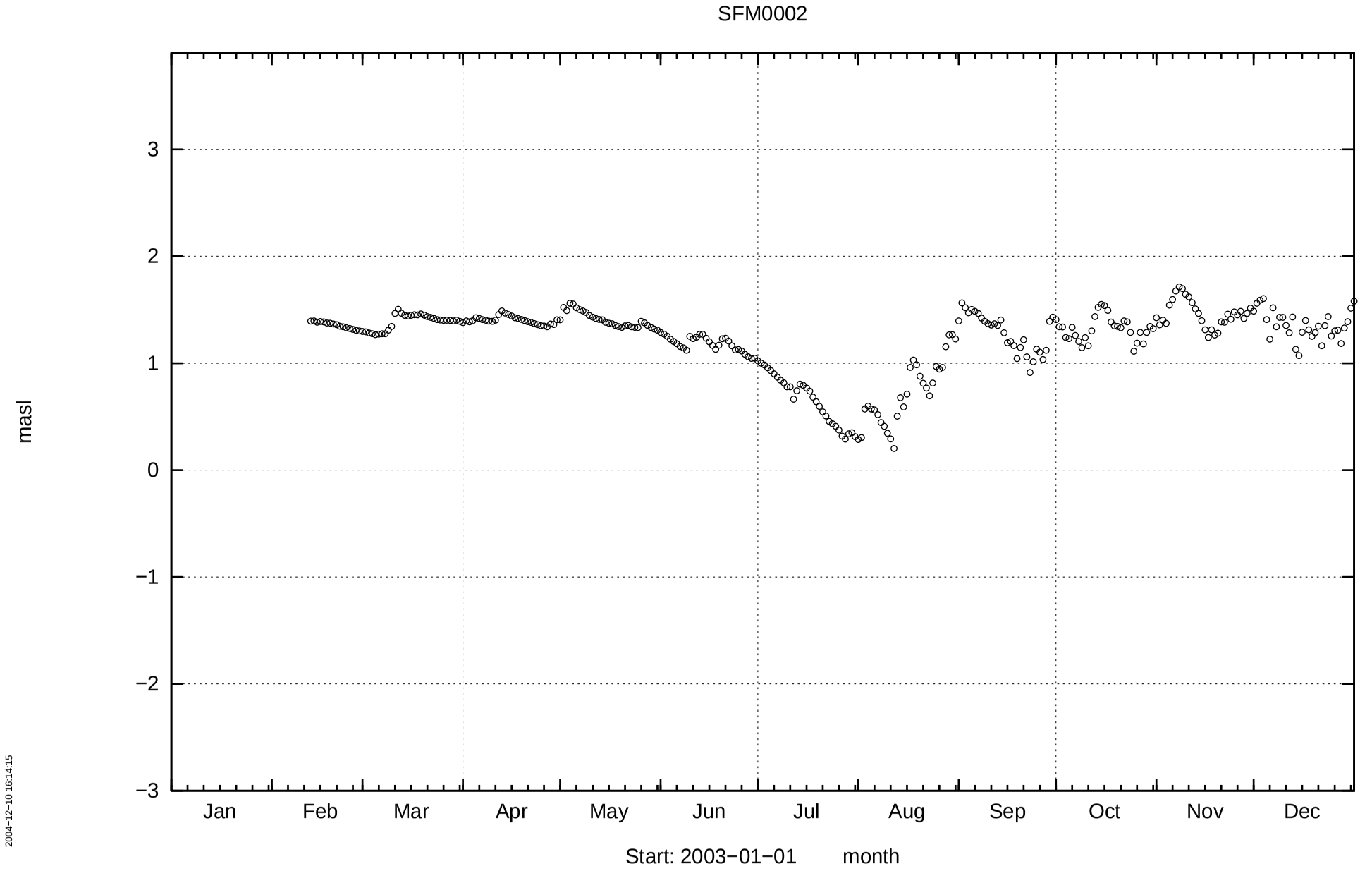
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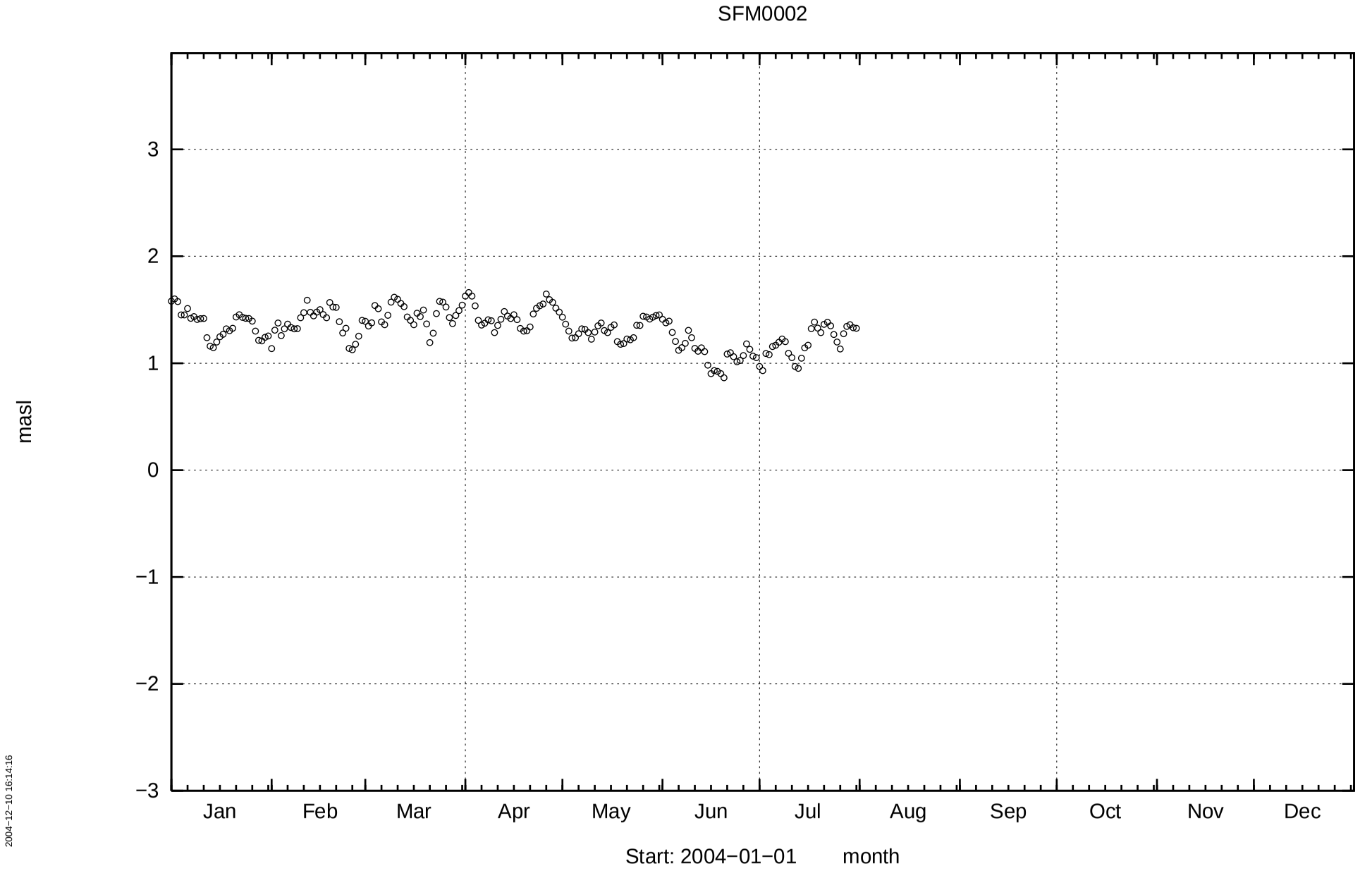
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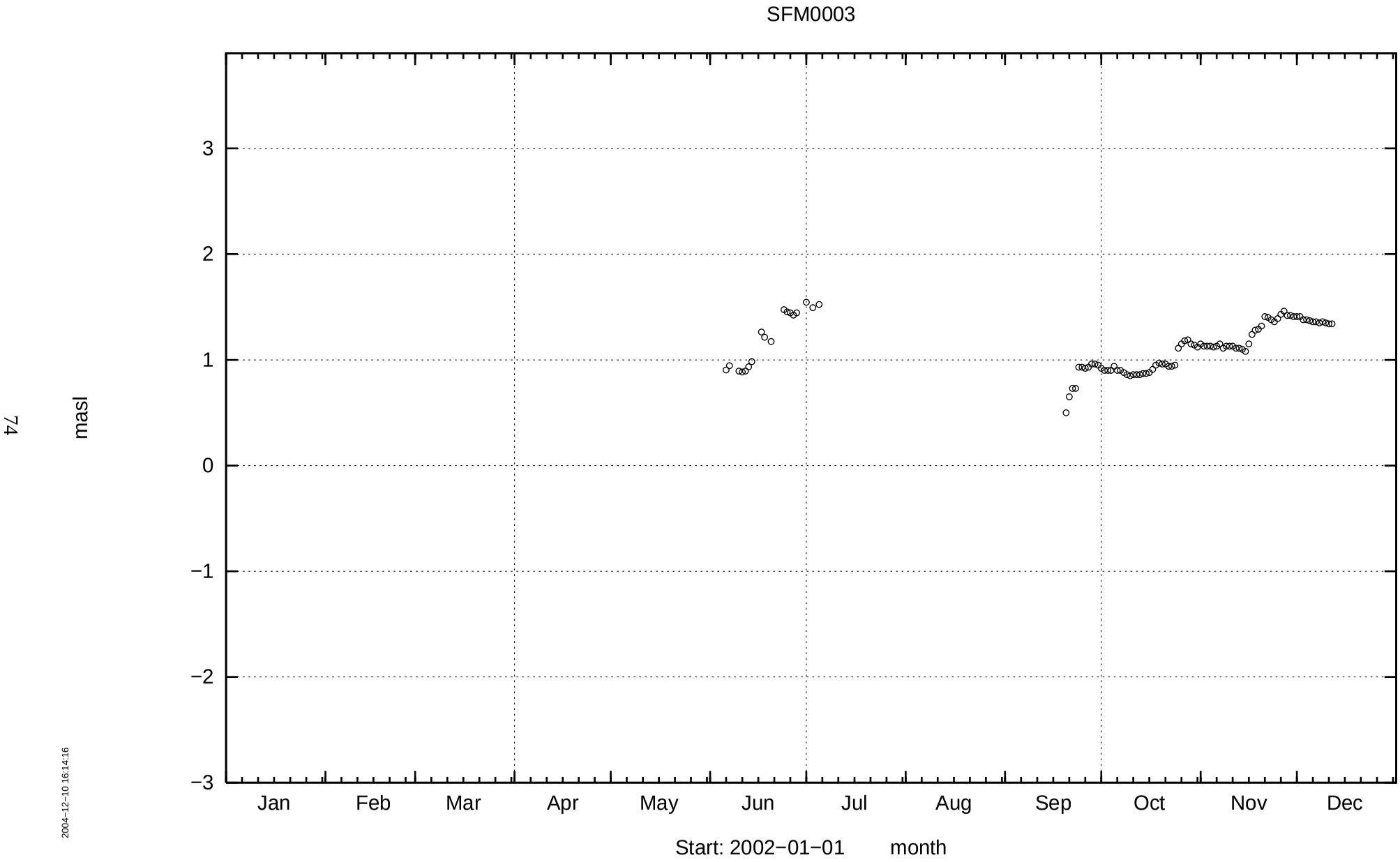
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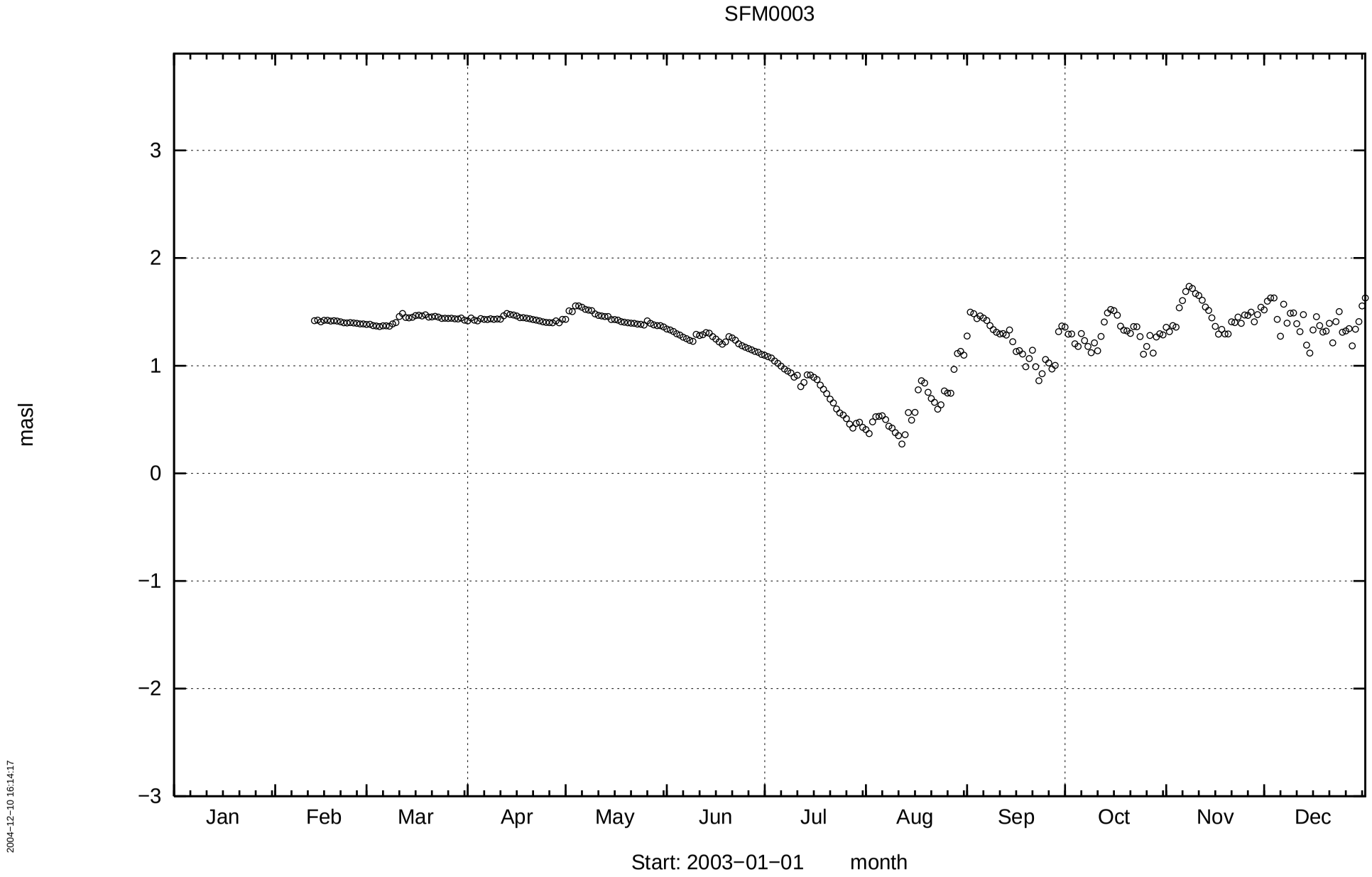
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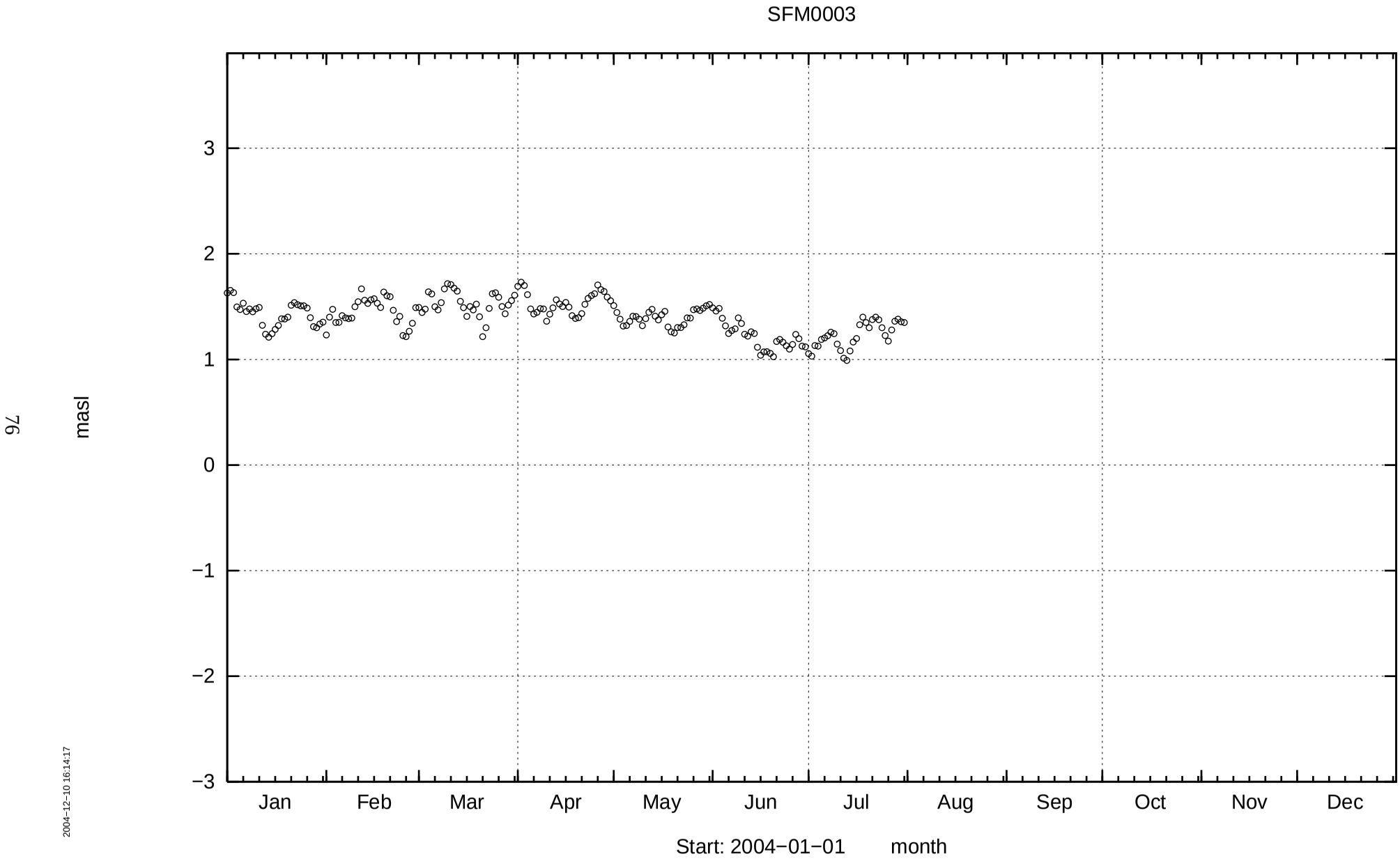
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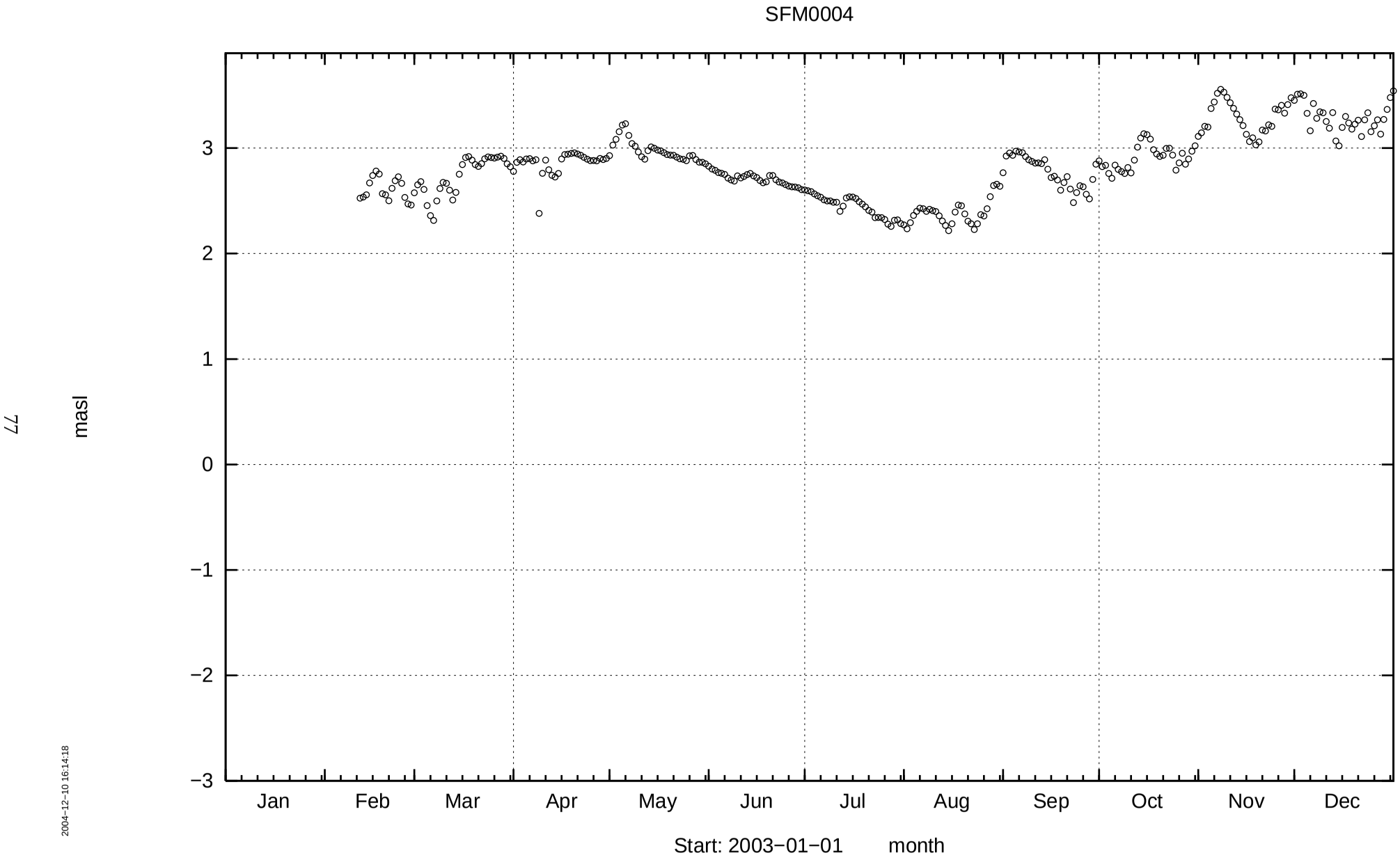
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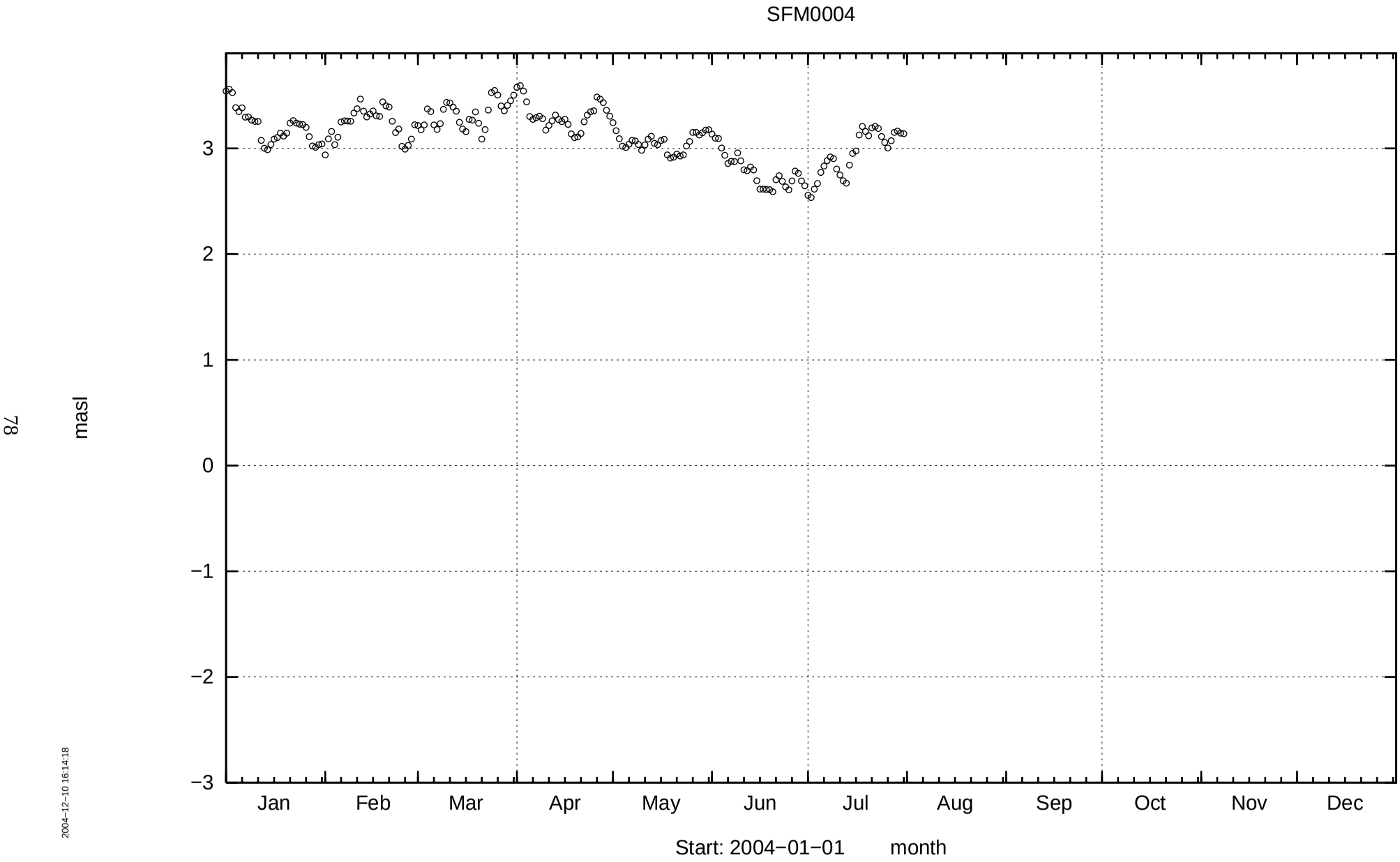
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78
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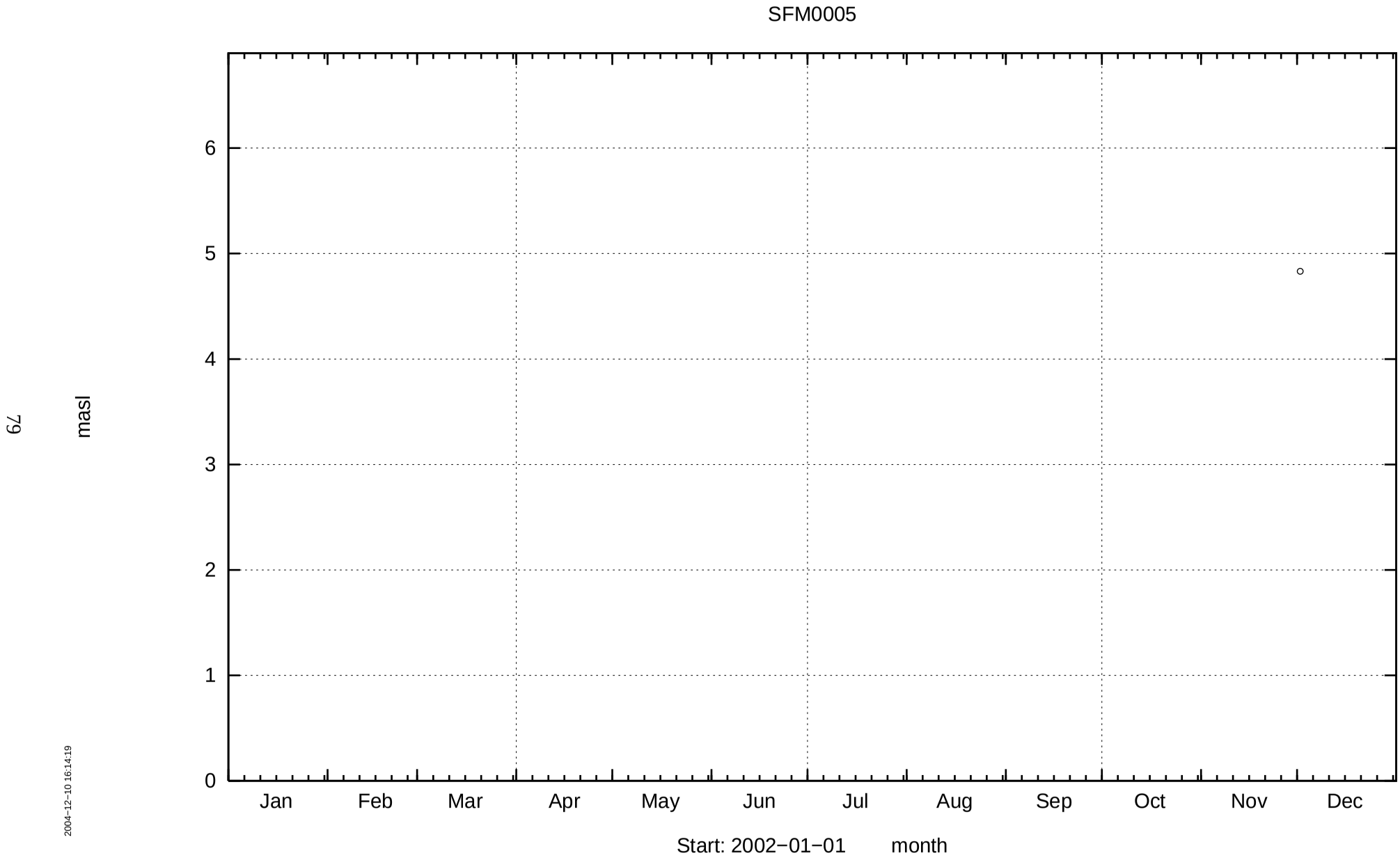
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SFM0005
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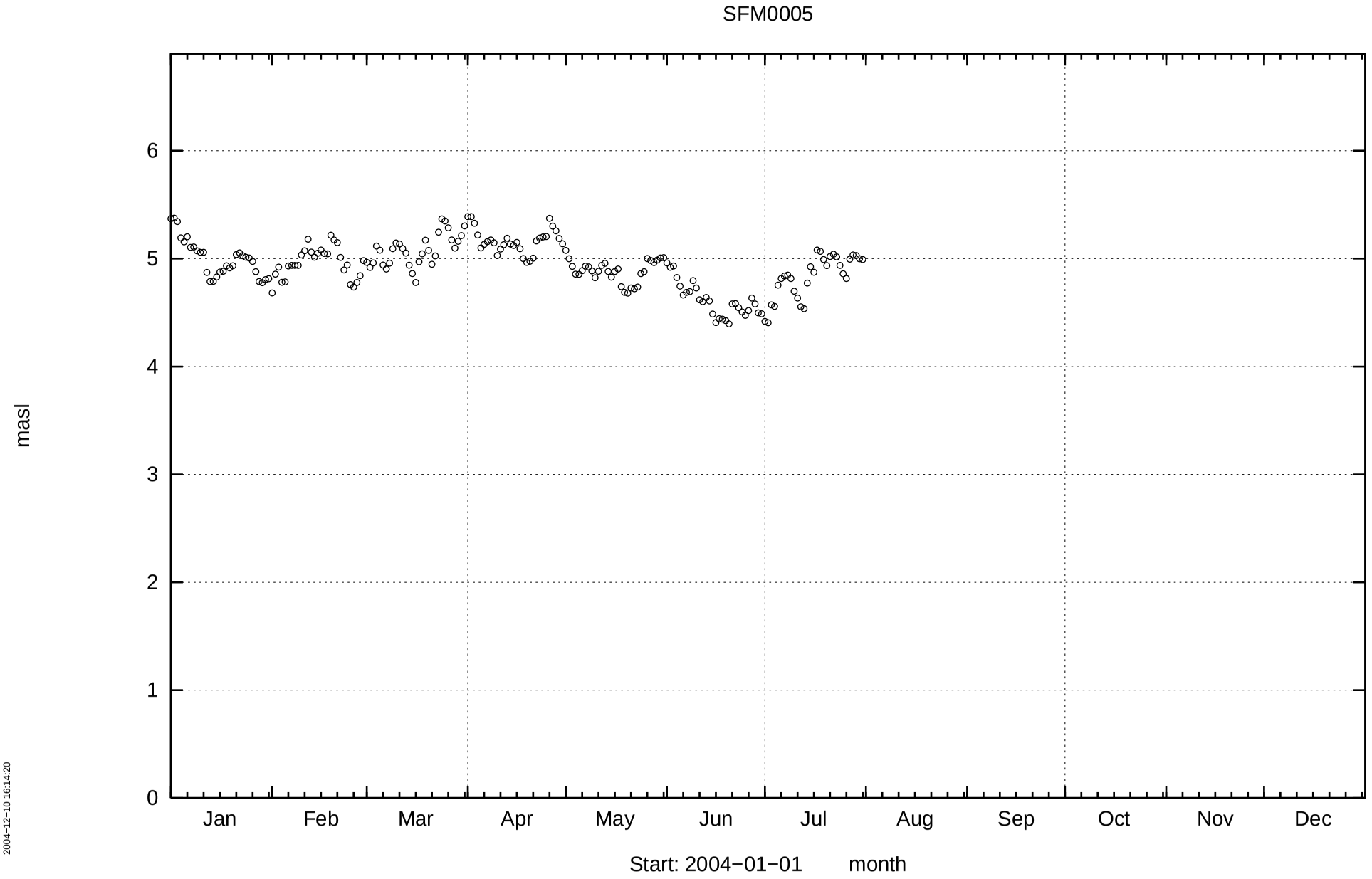
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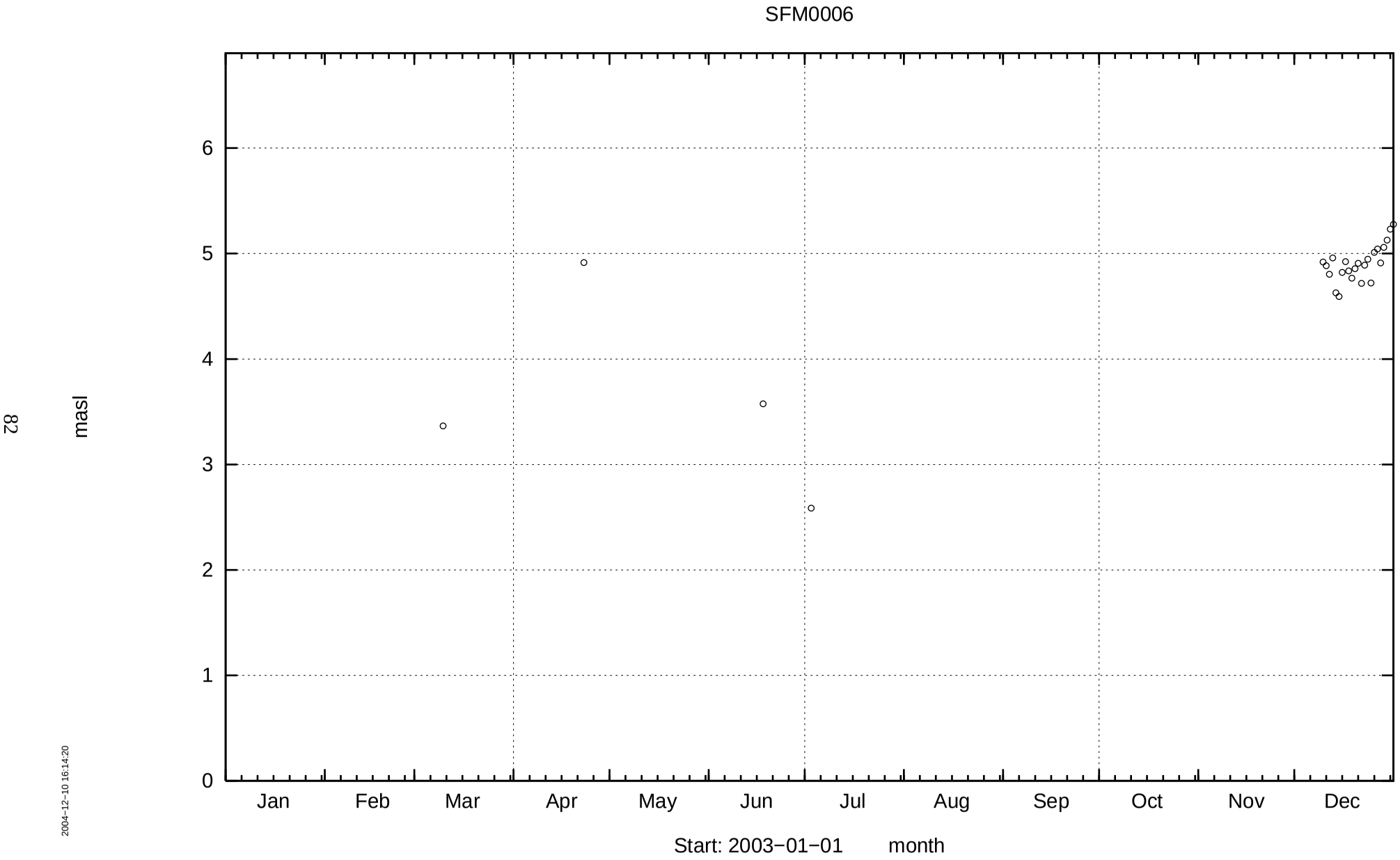
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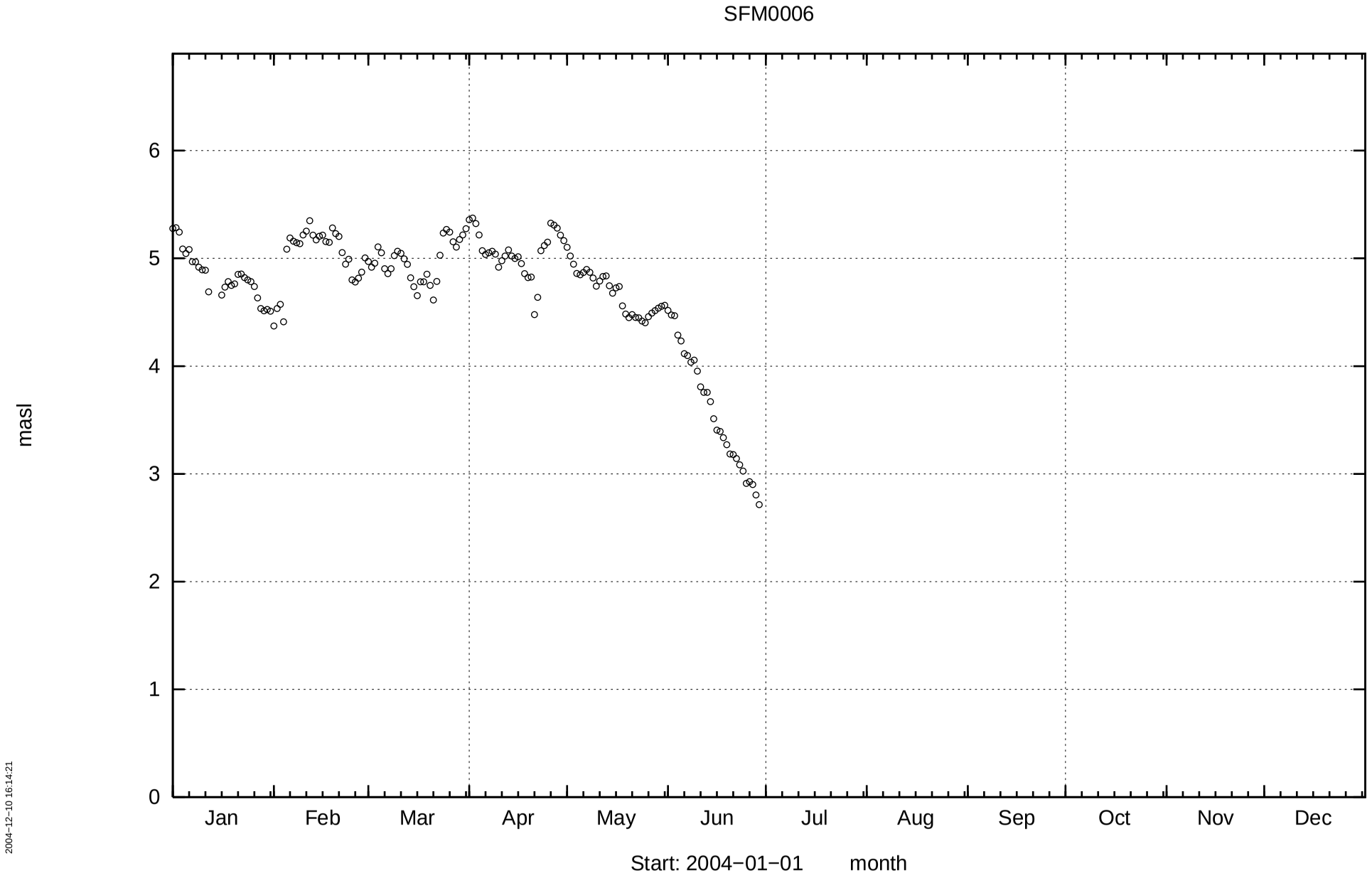
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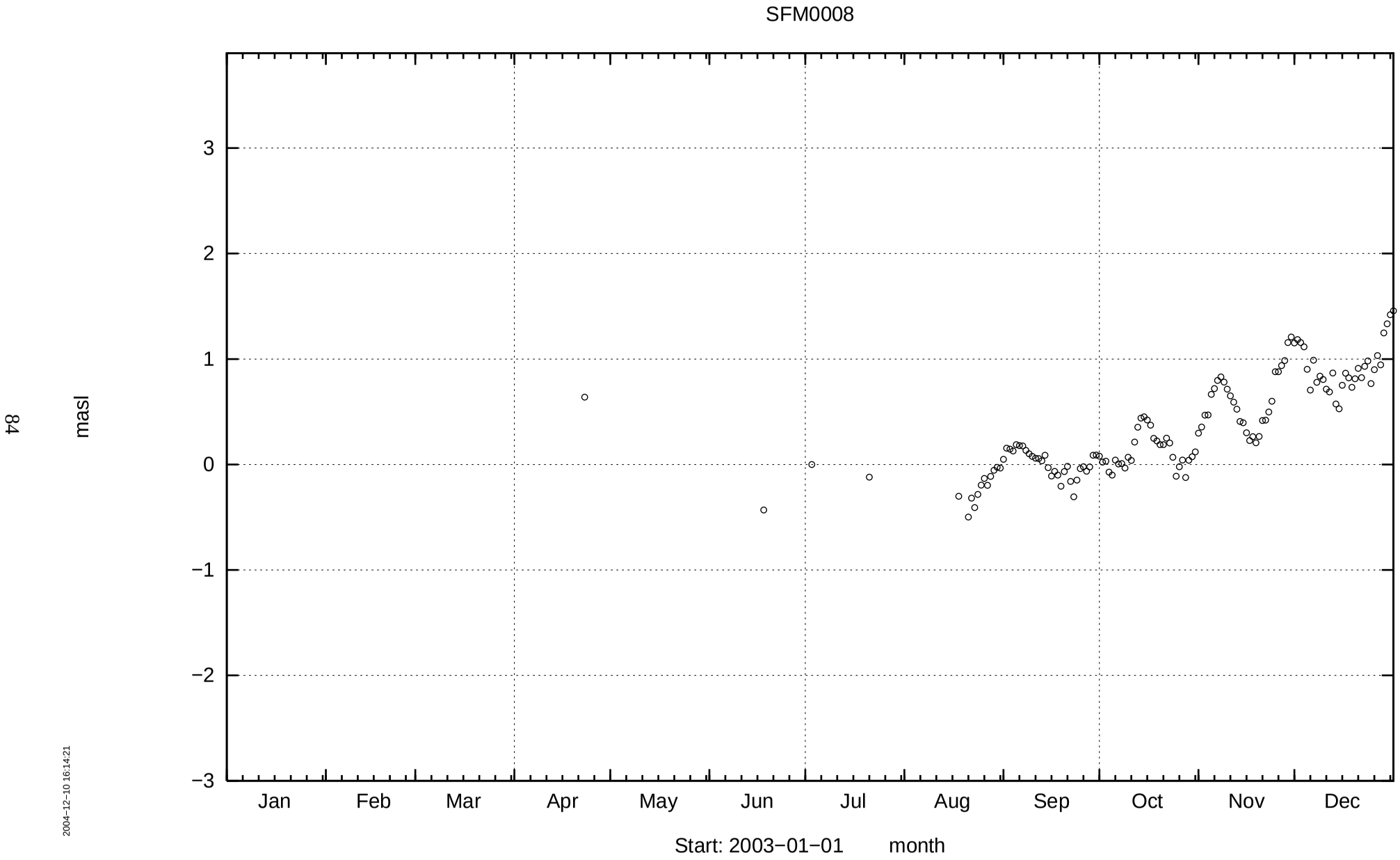
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84
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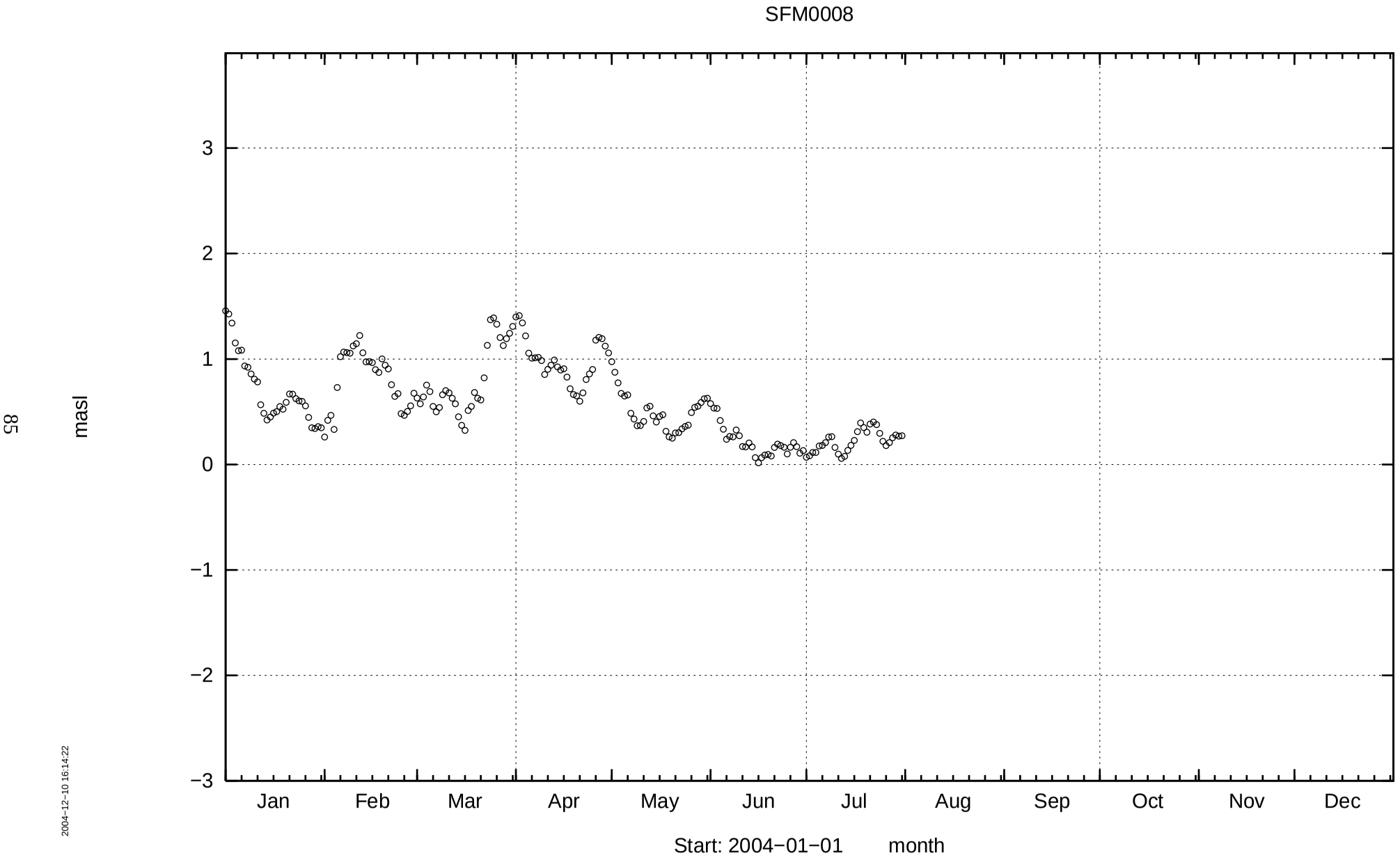
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SFM0009
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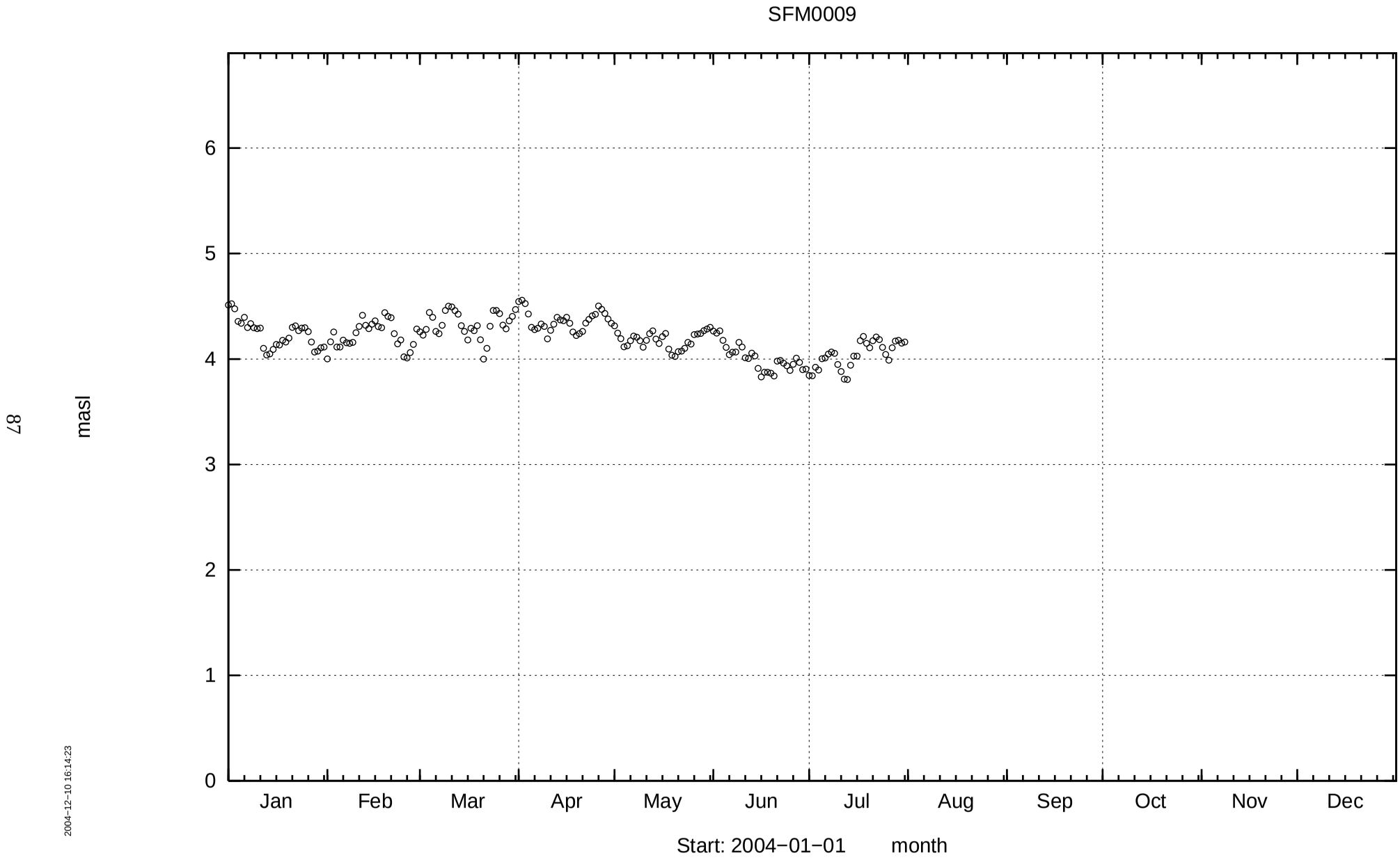
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SFM0010
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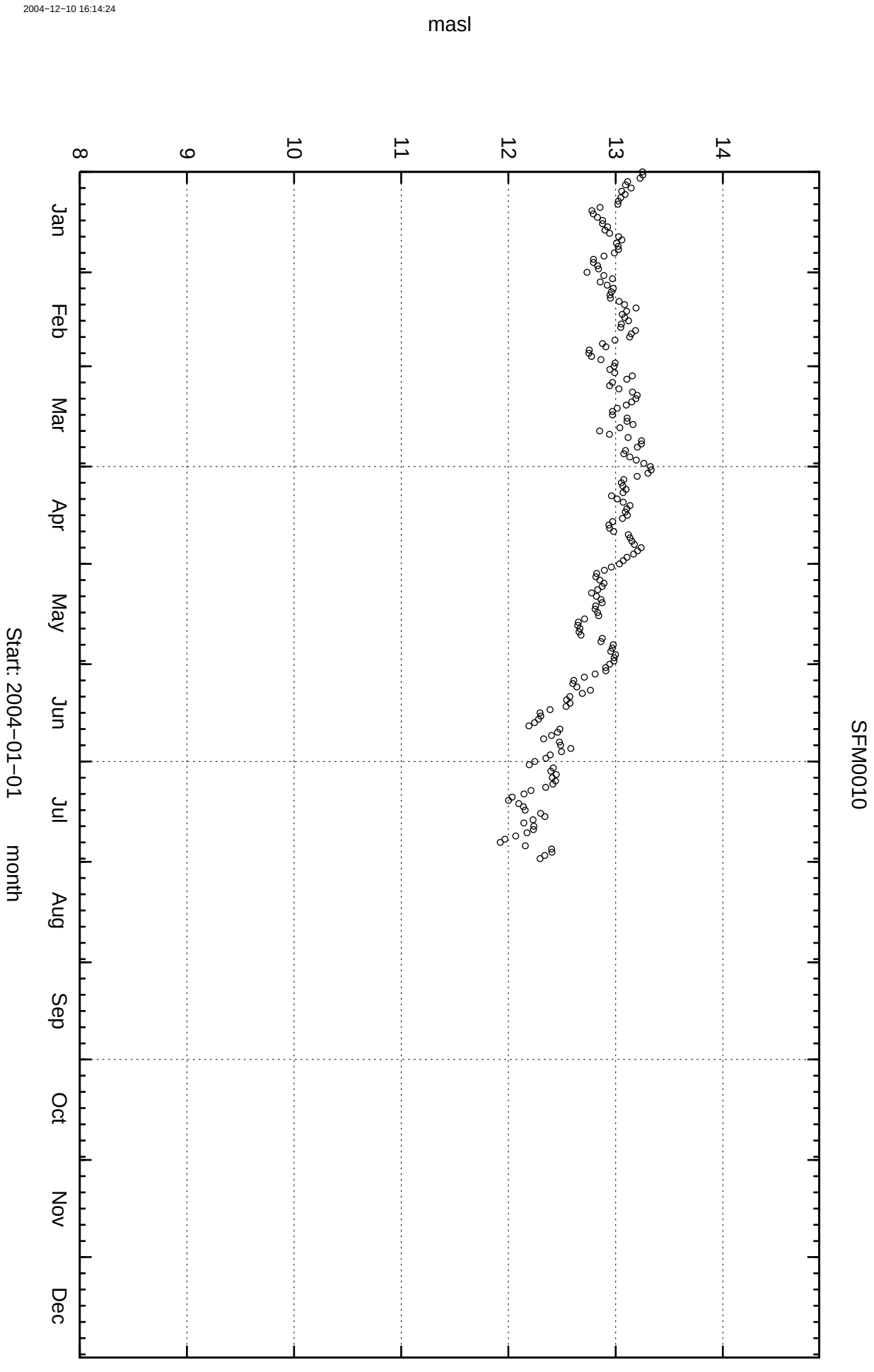
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SFM0010
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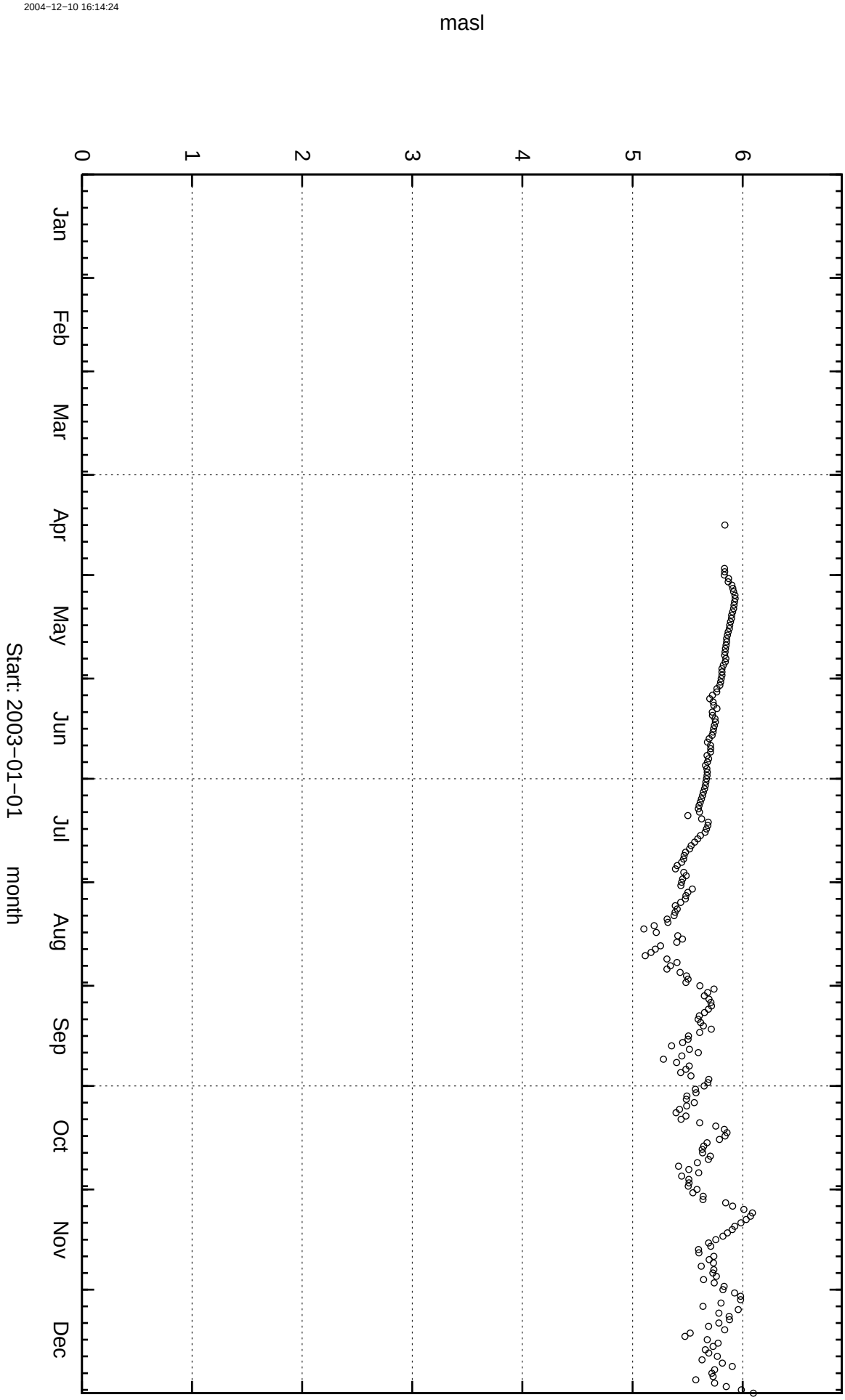

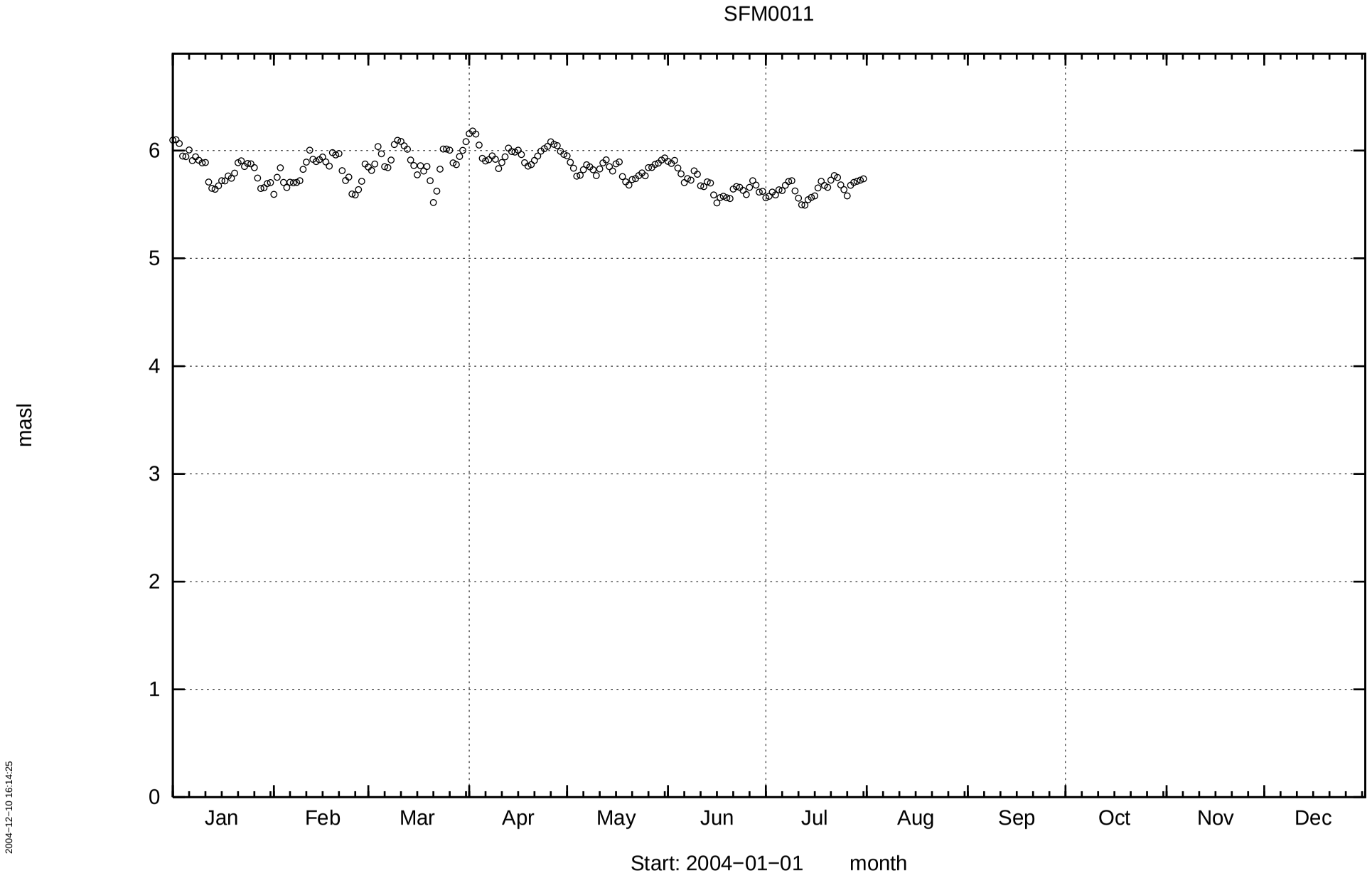
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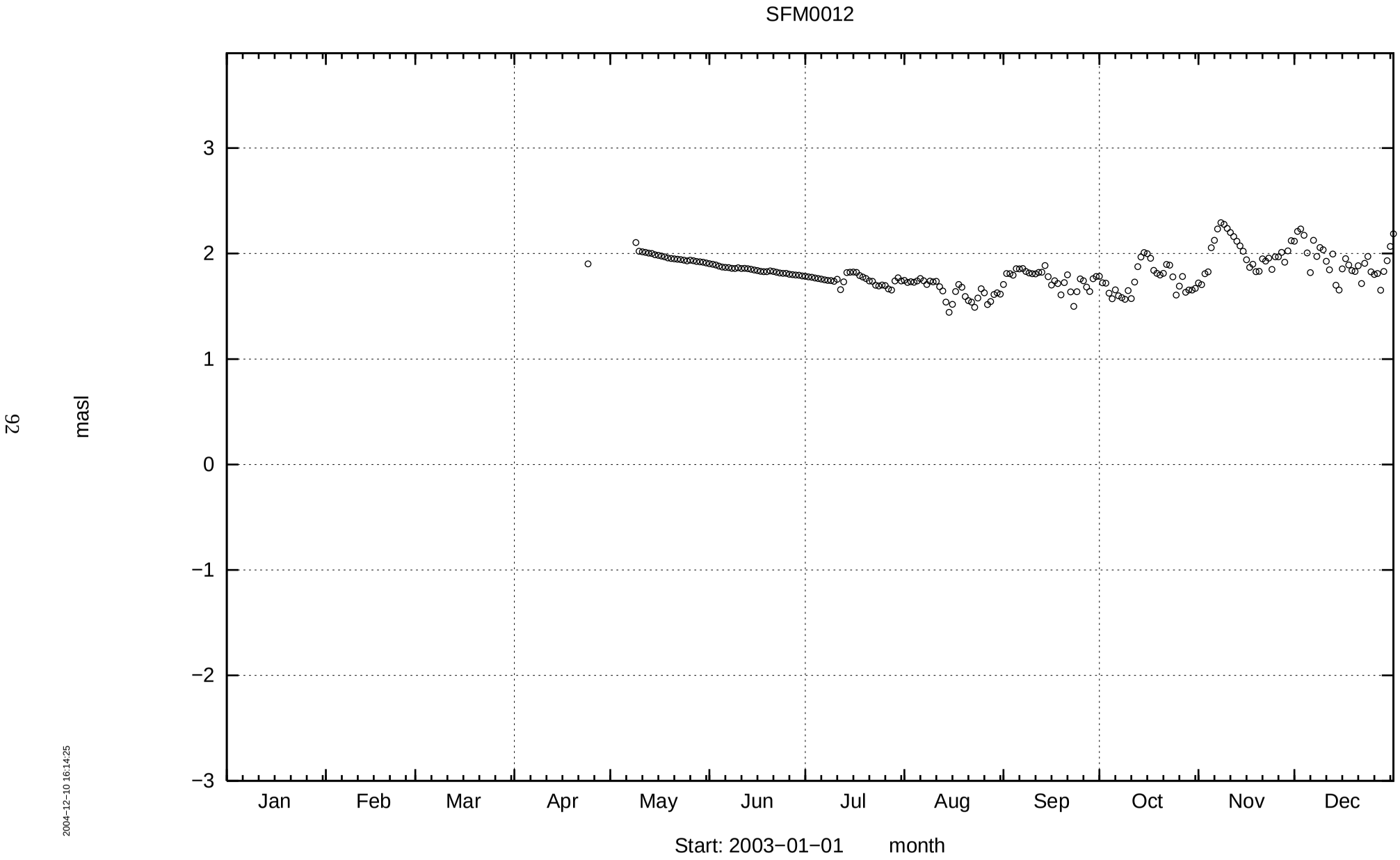
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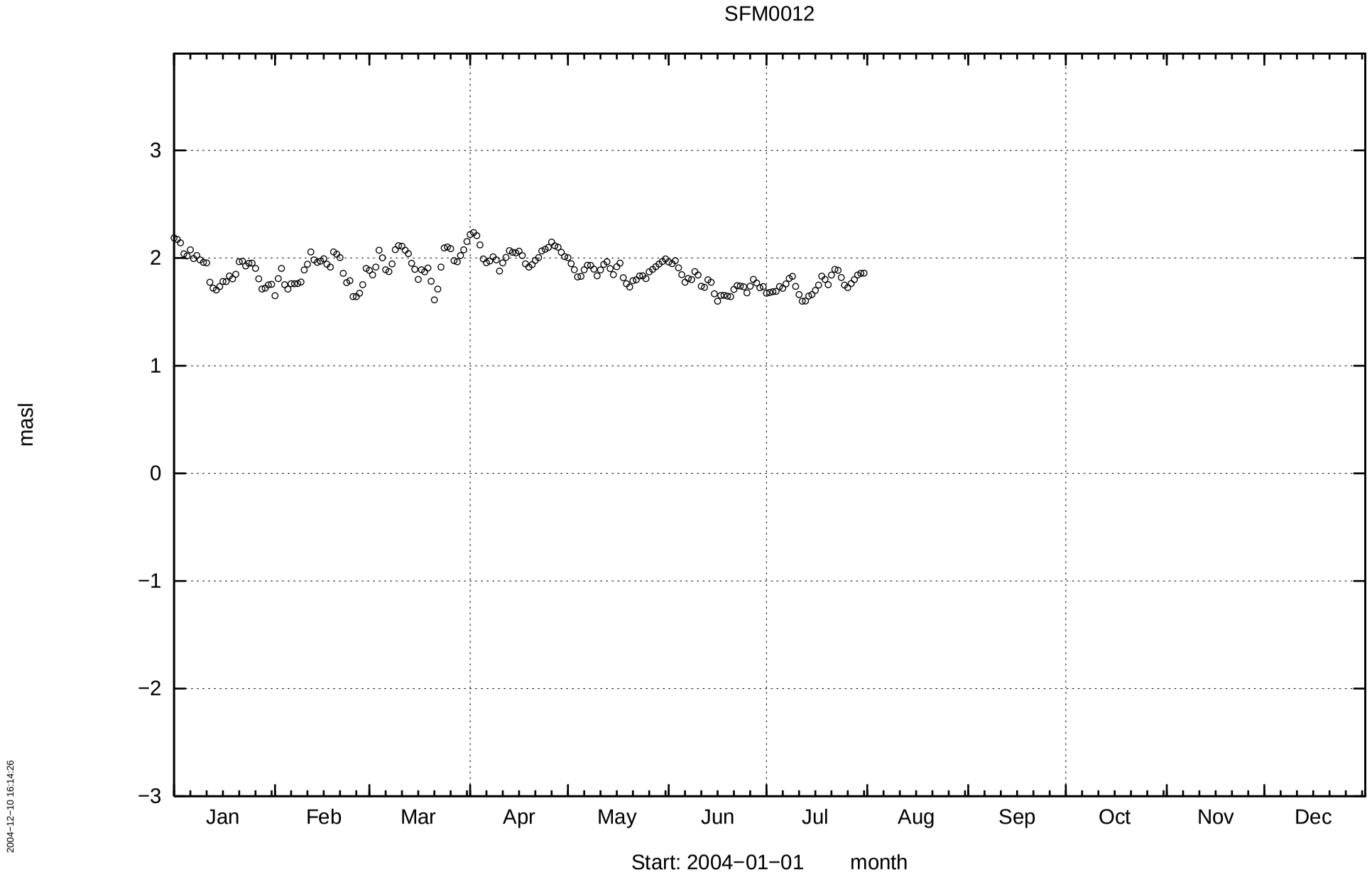
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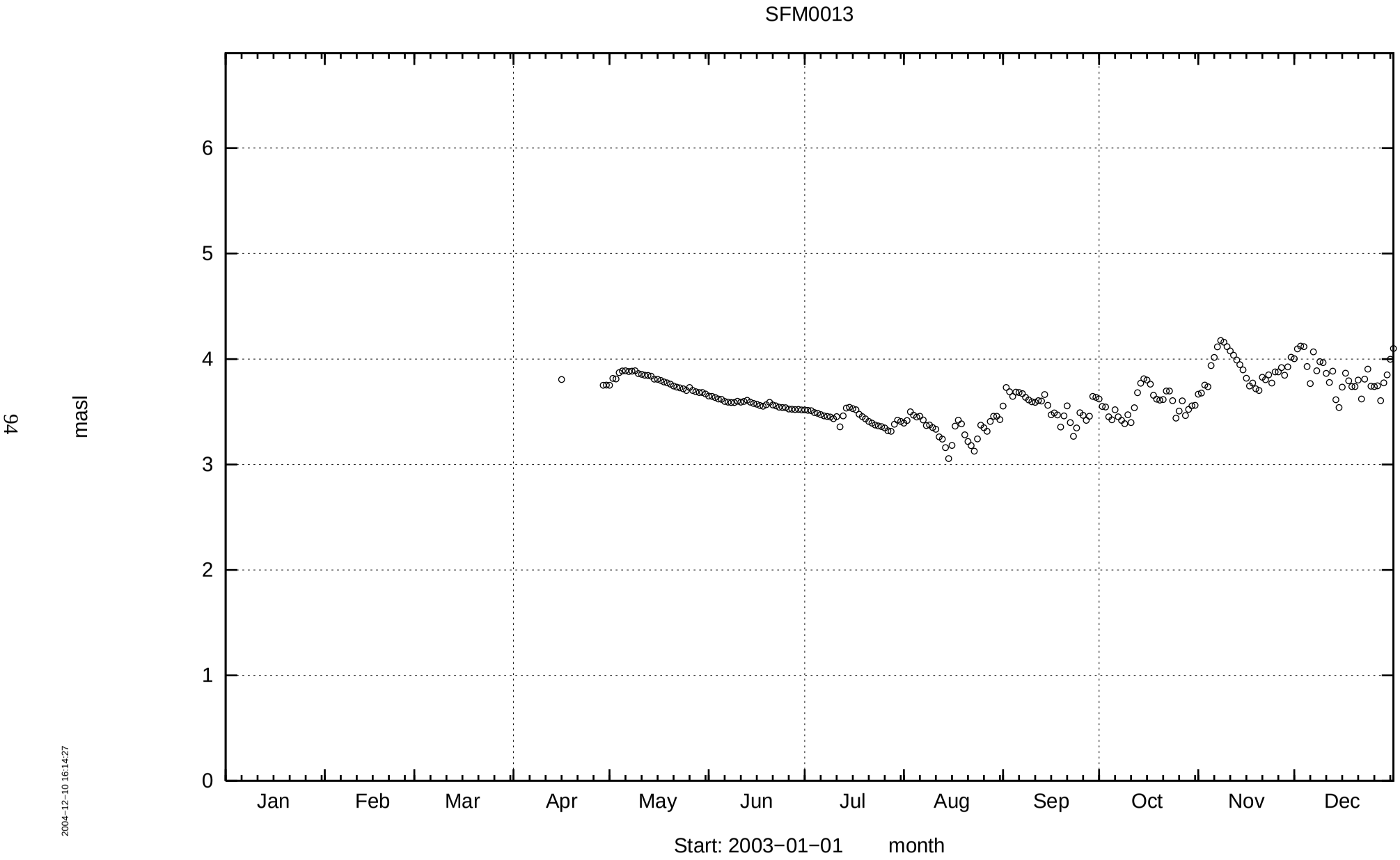
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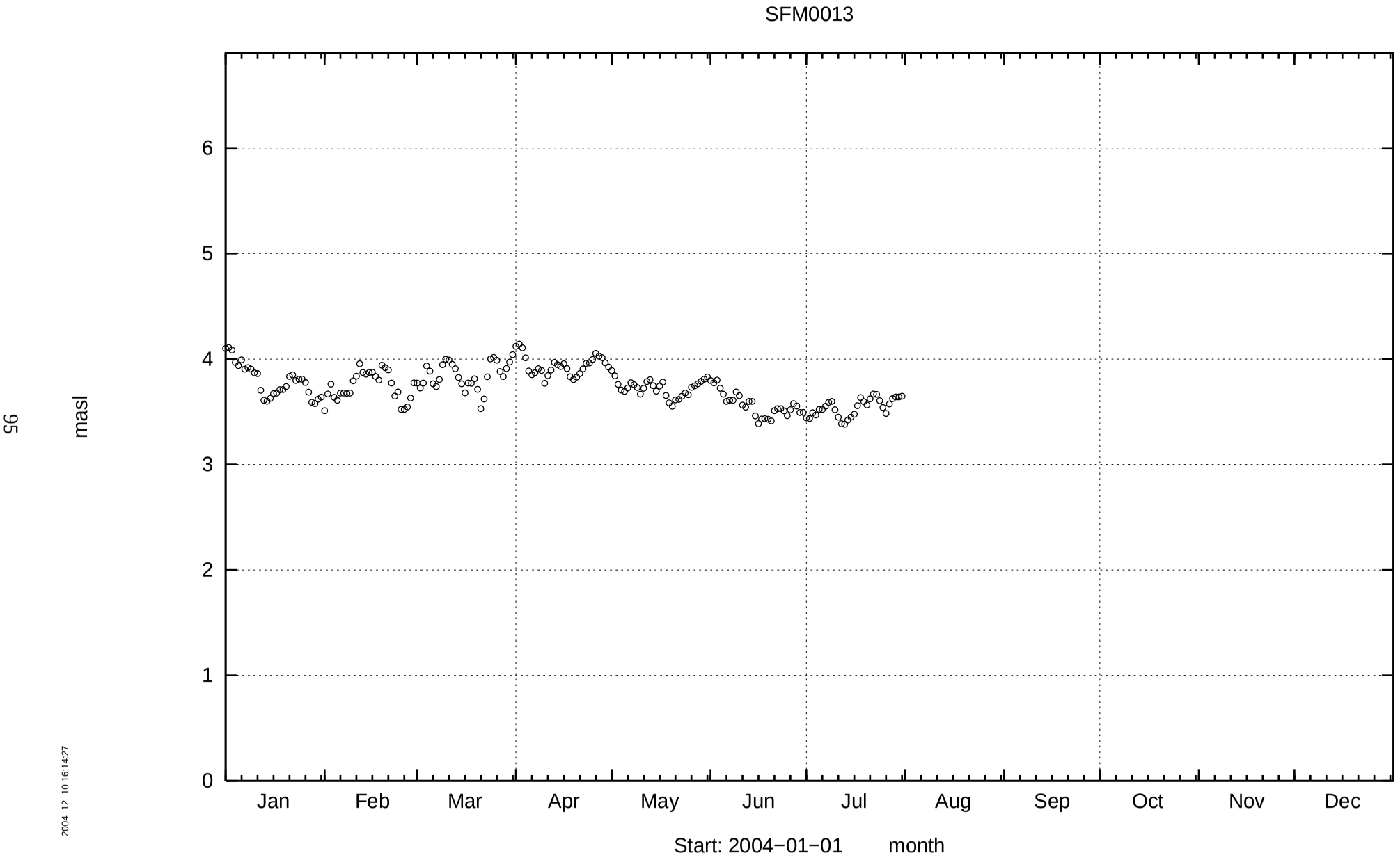
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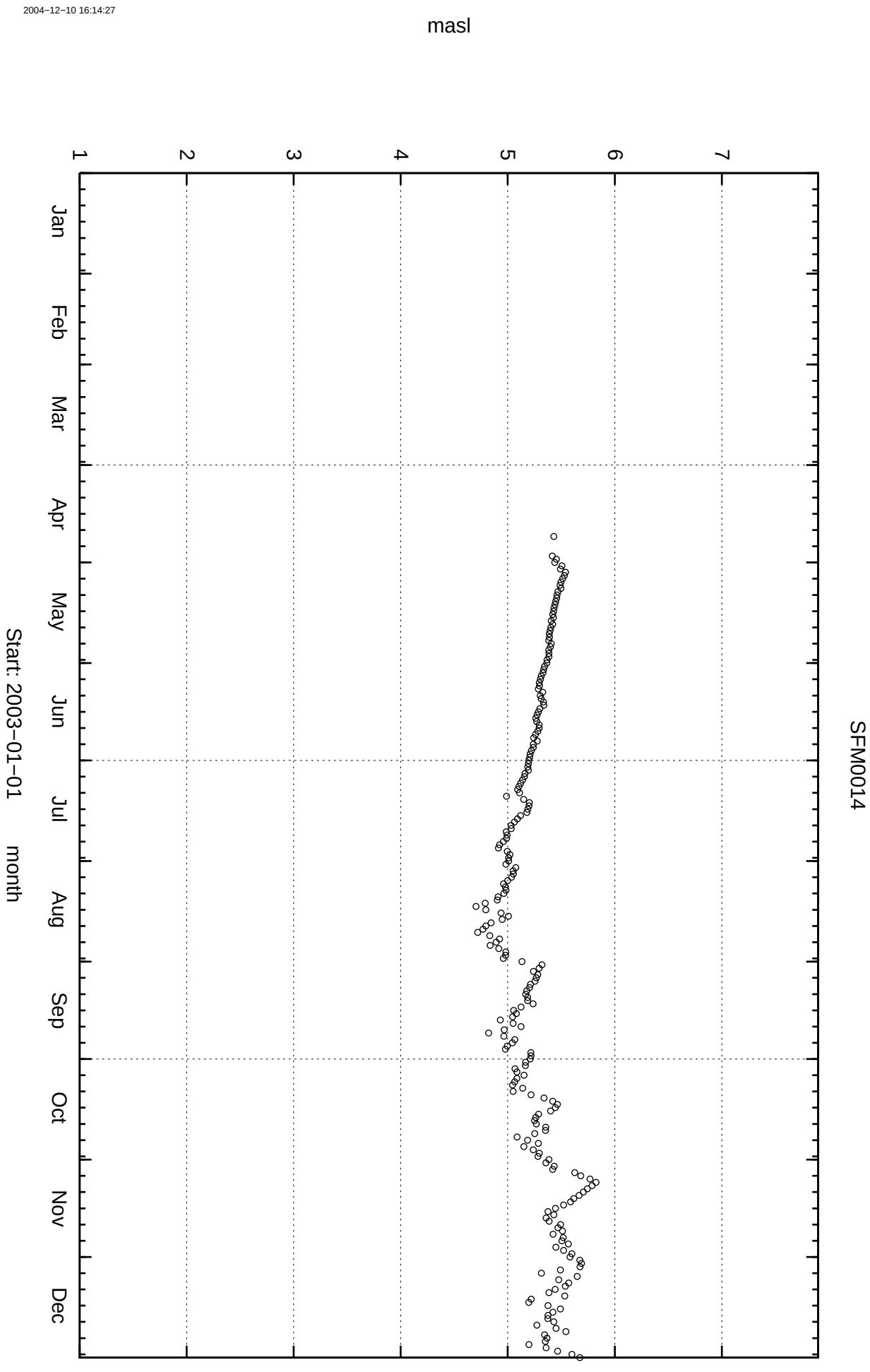
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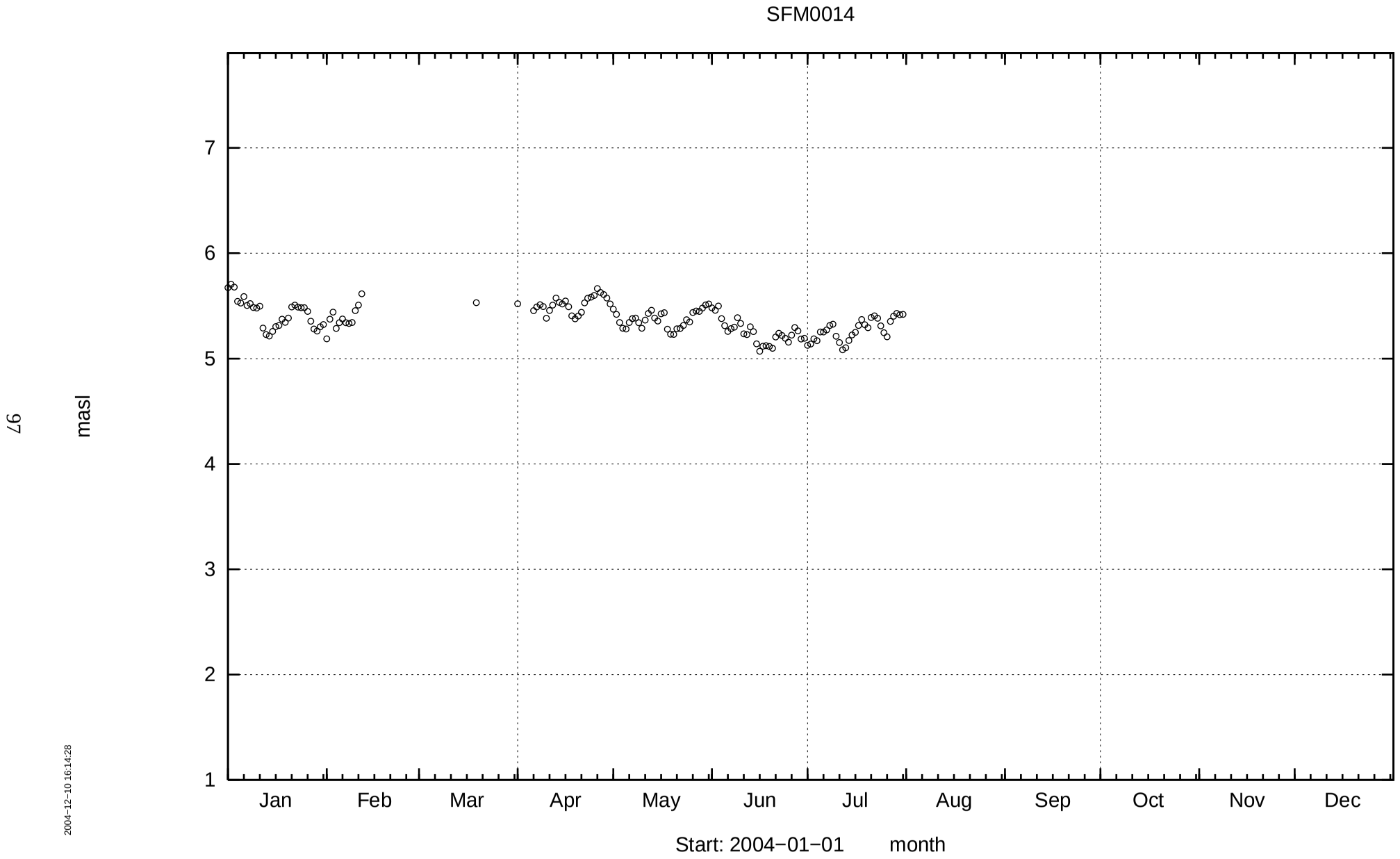
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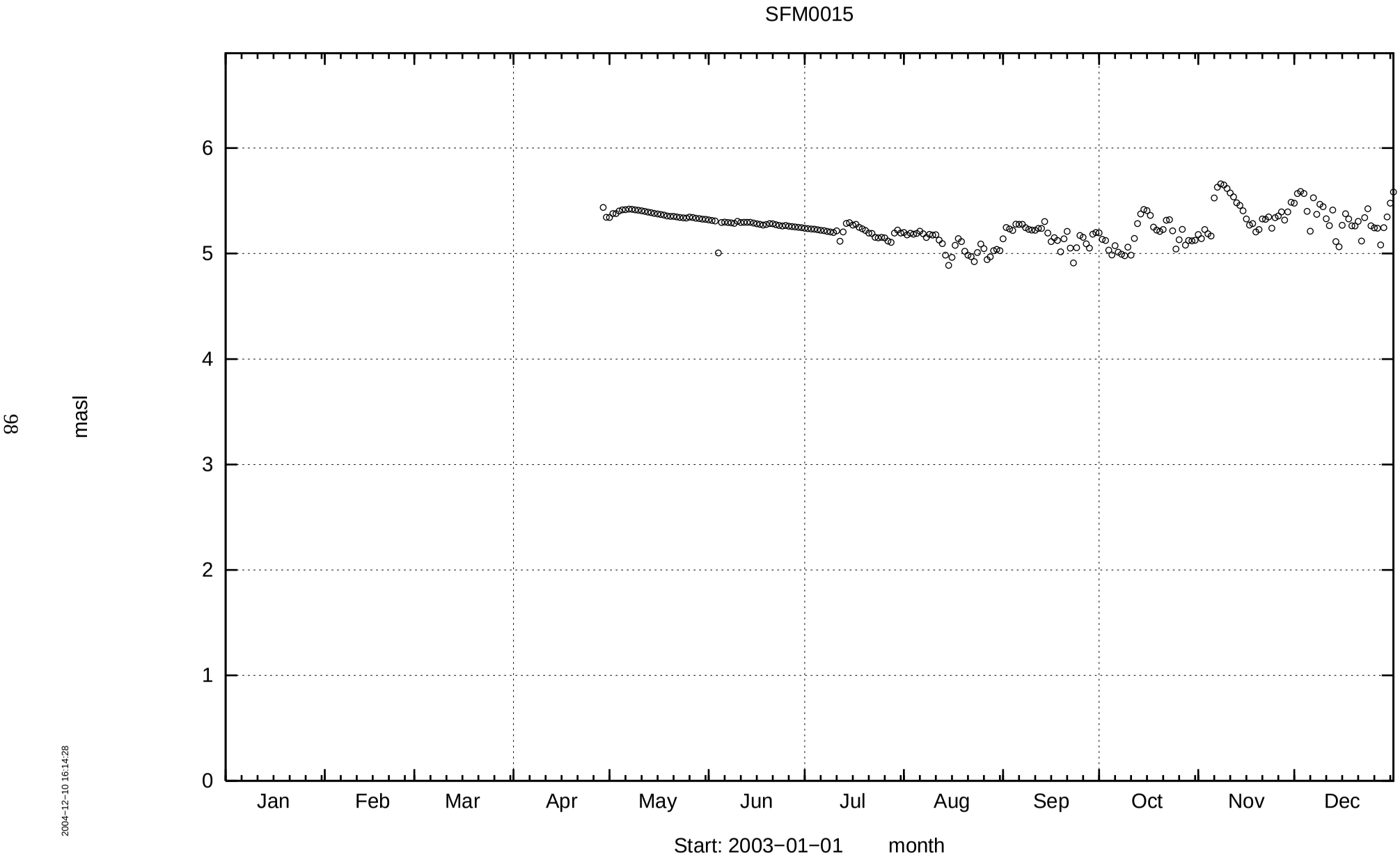
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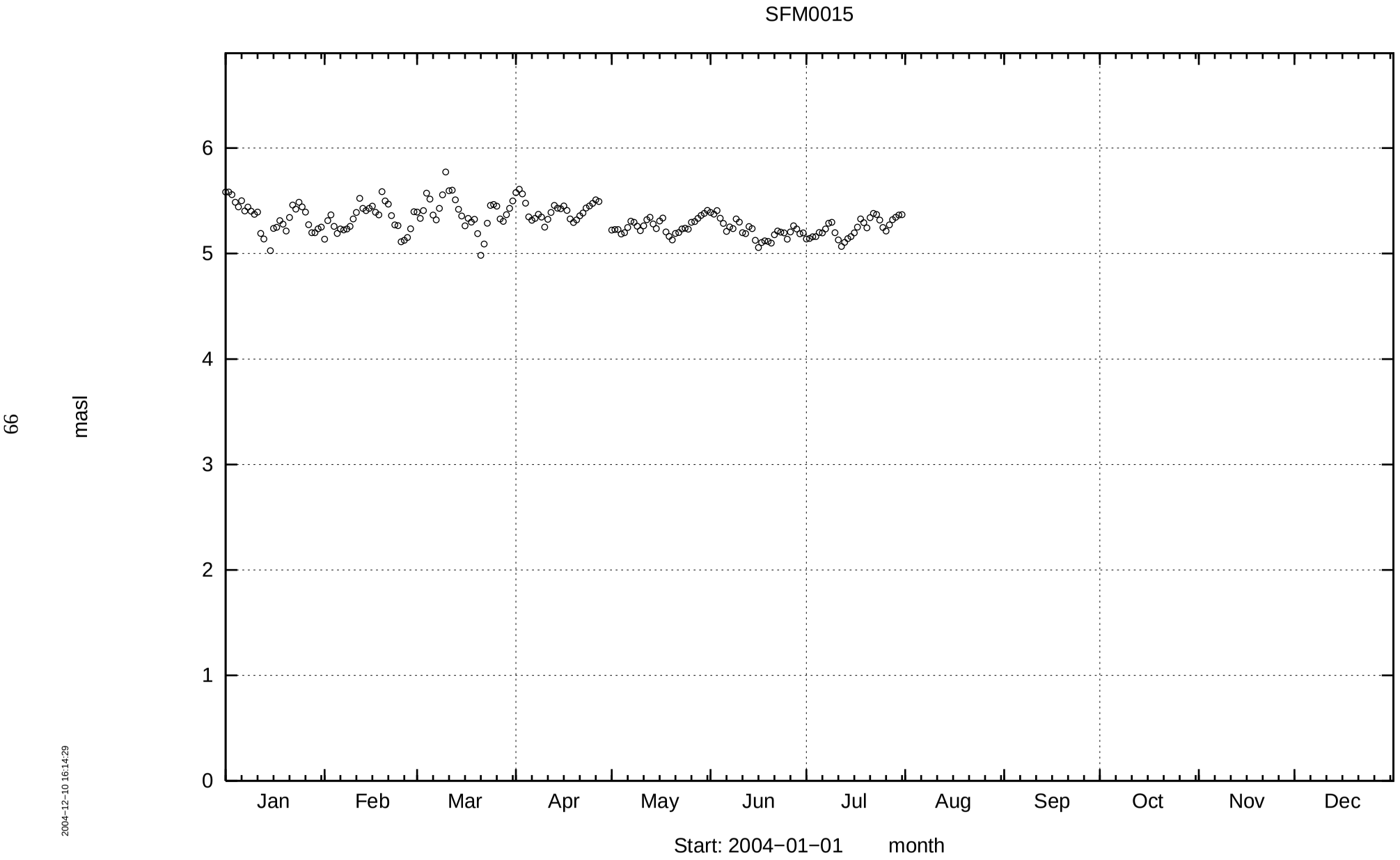
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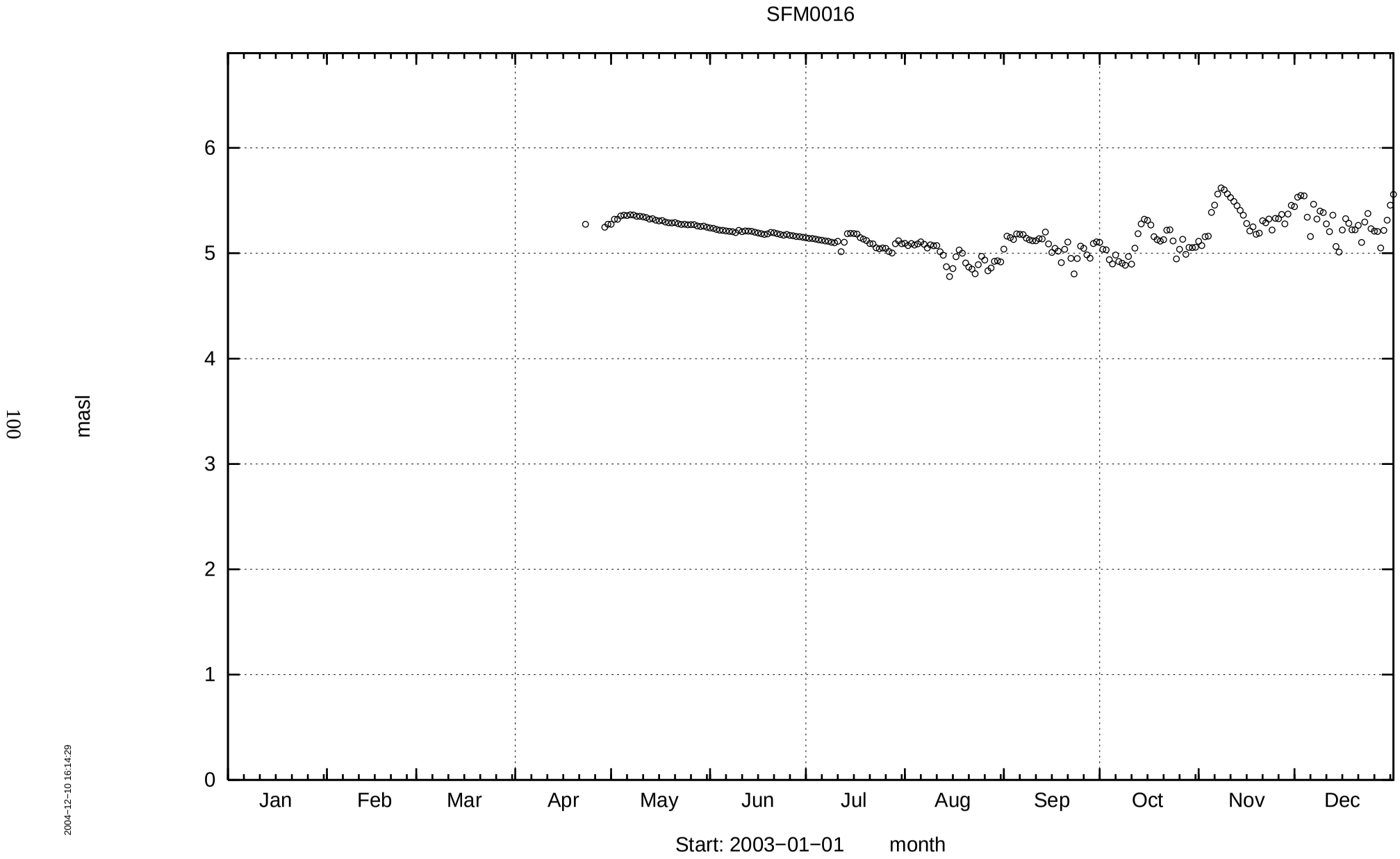
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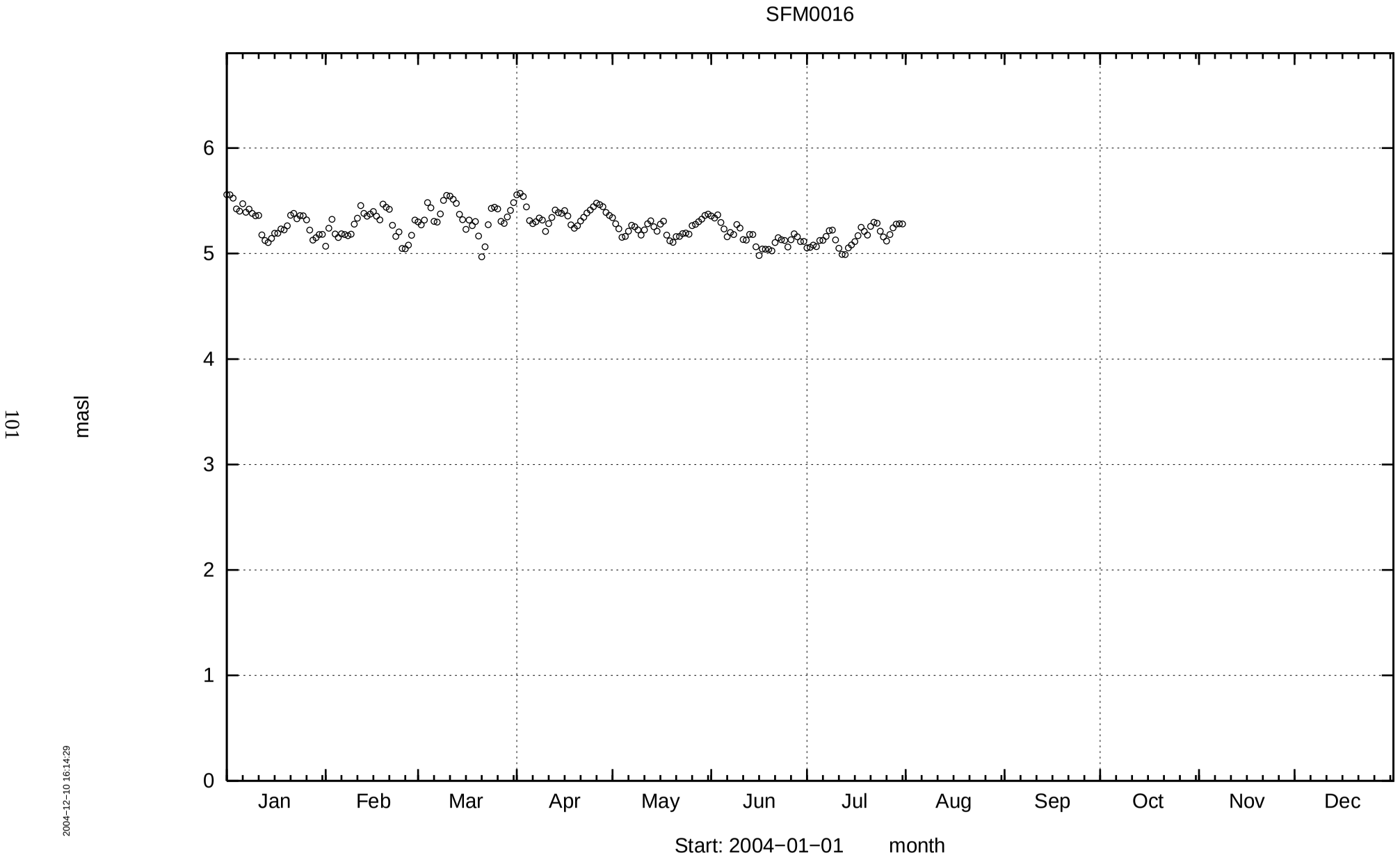
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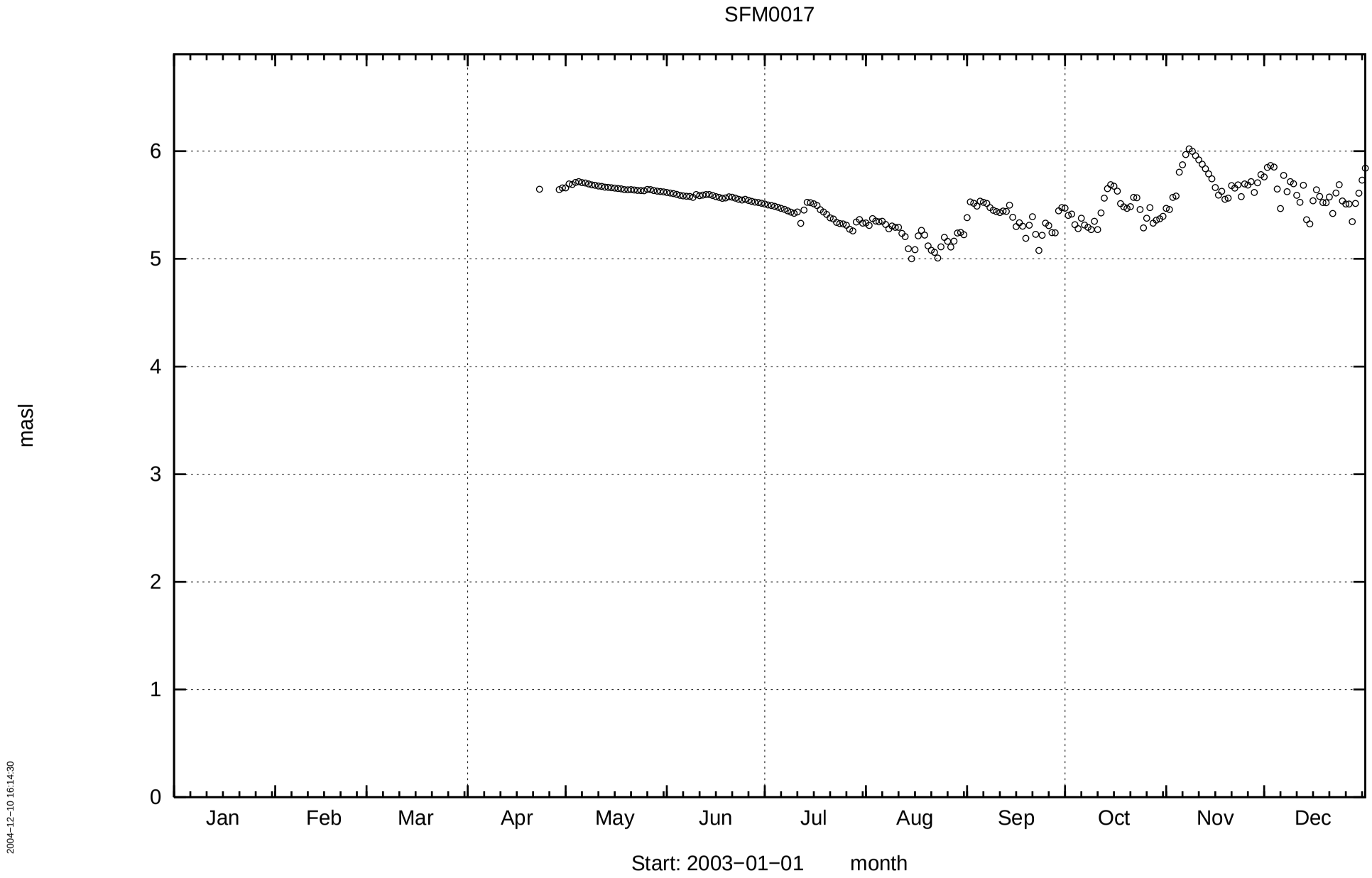
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102
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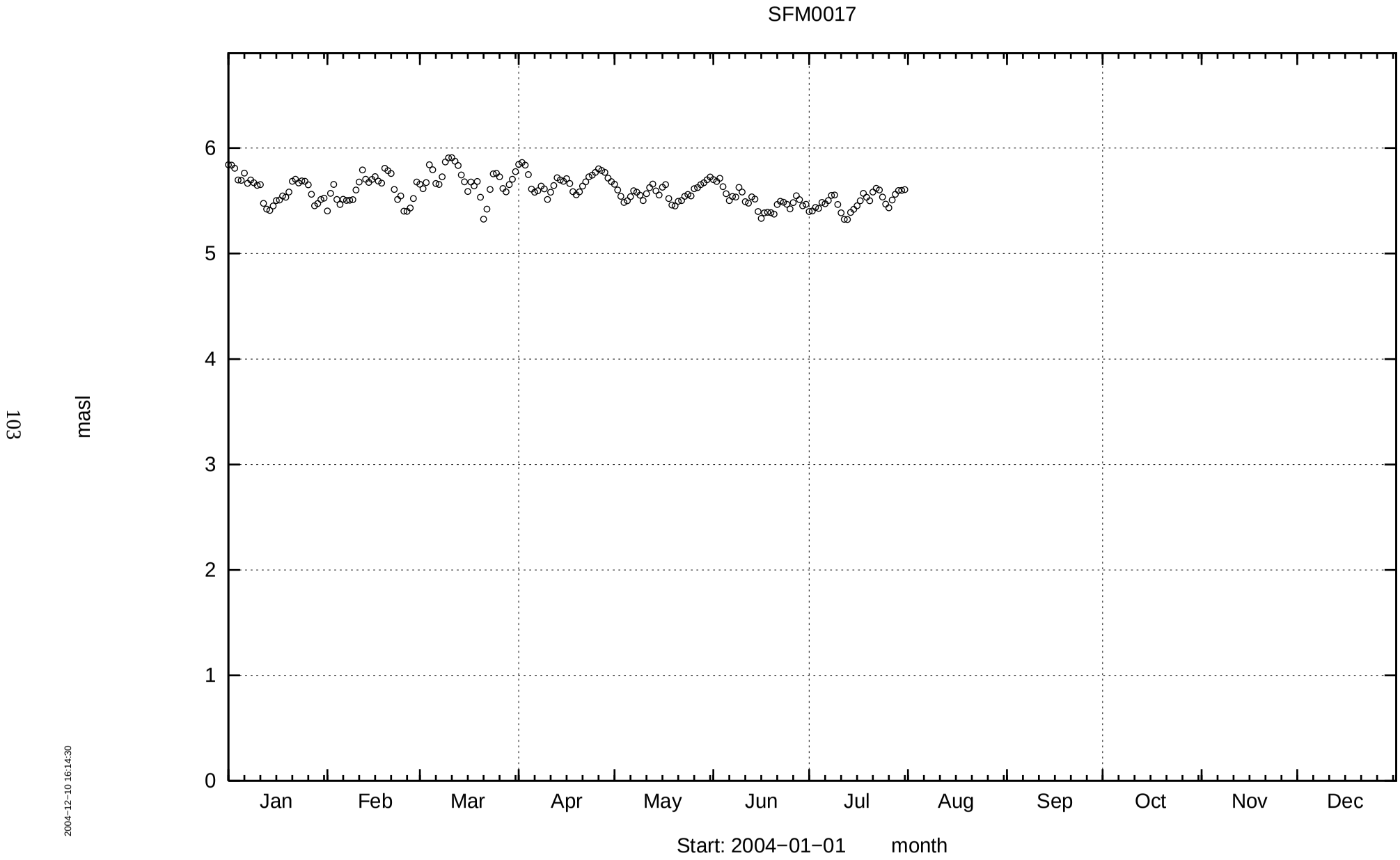
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103
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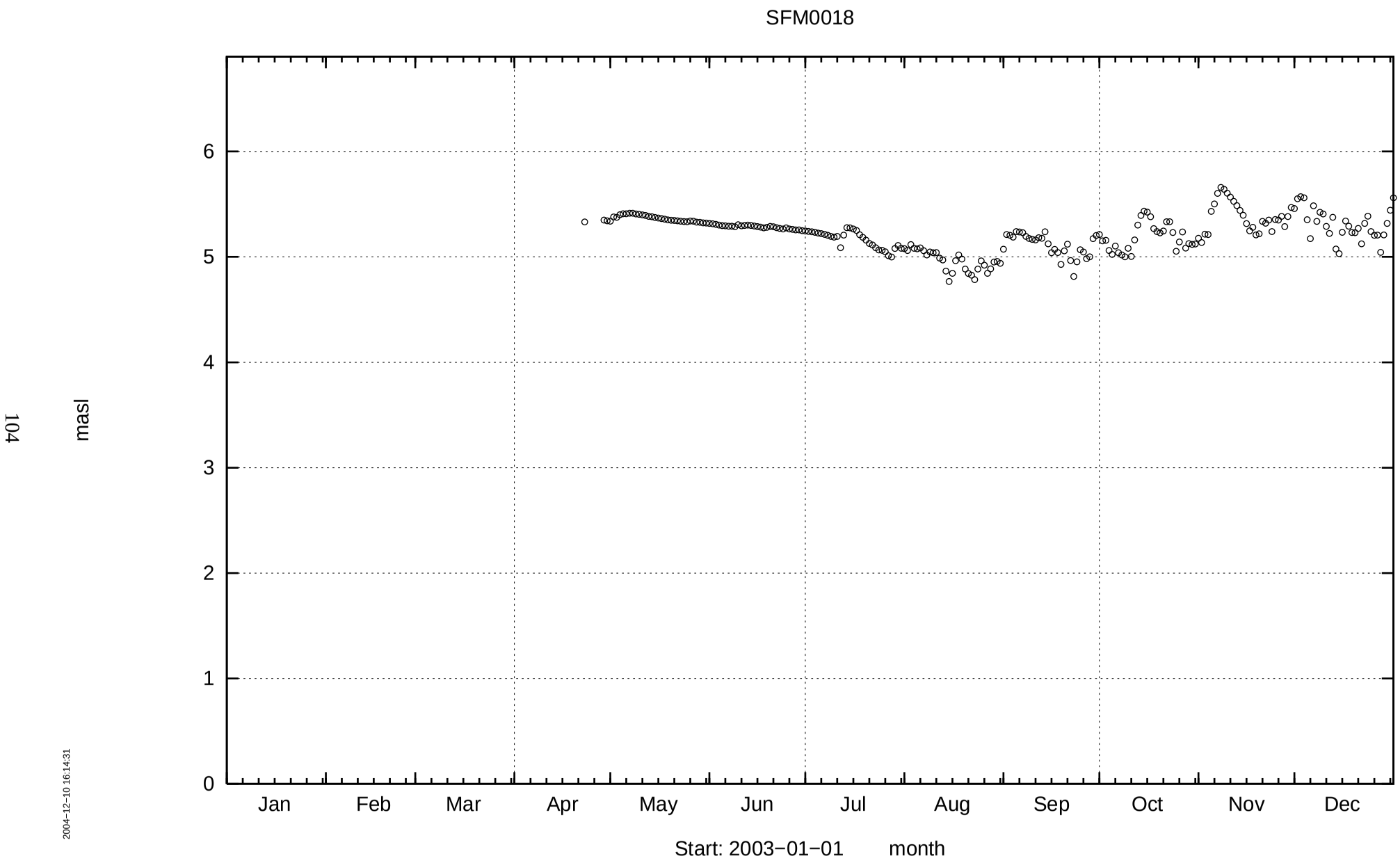
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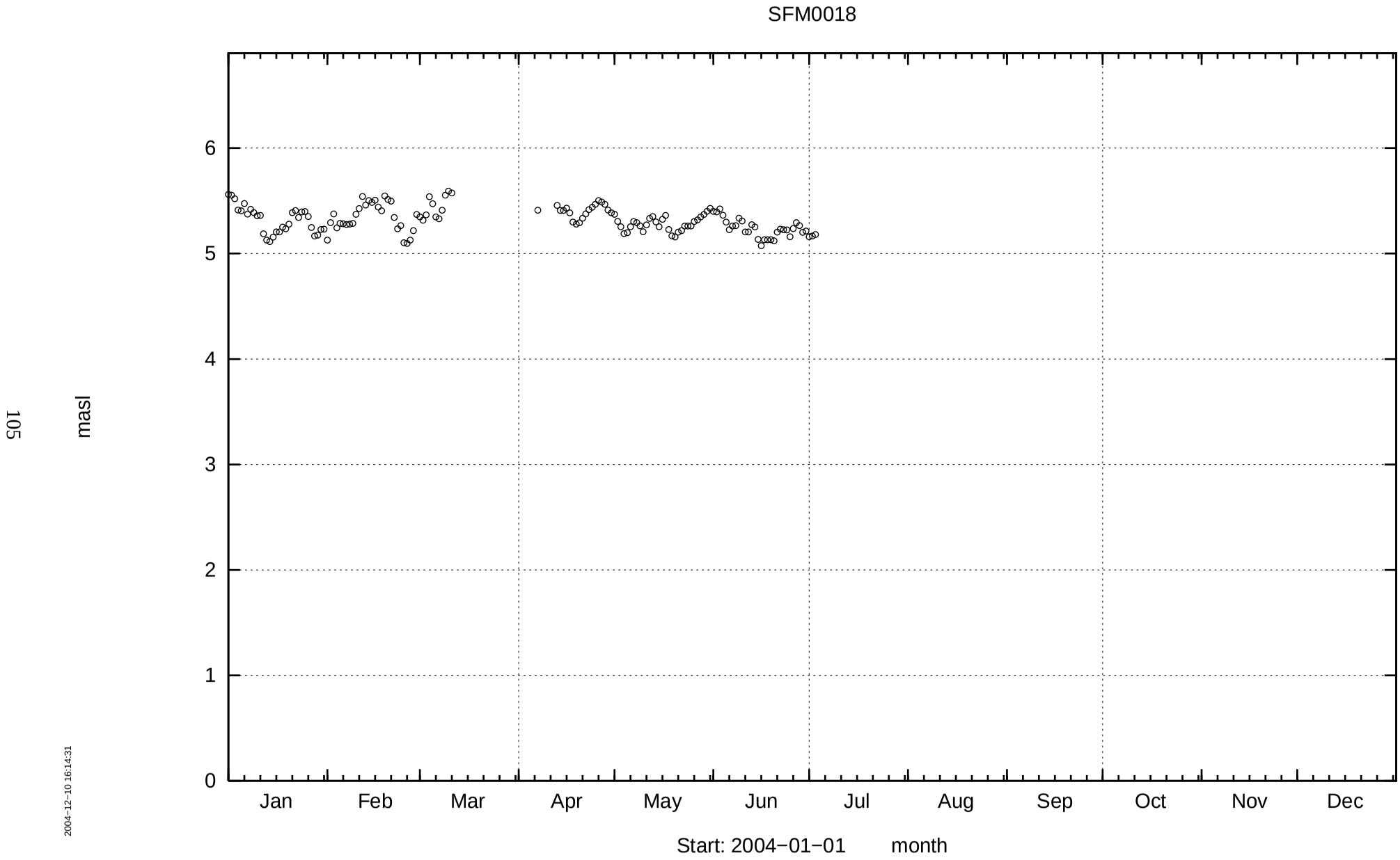
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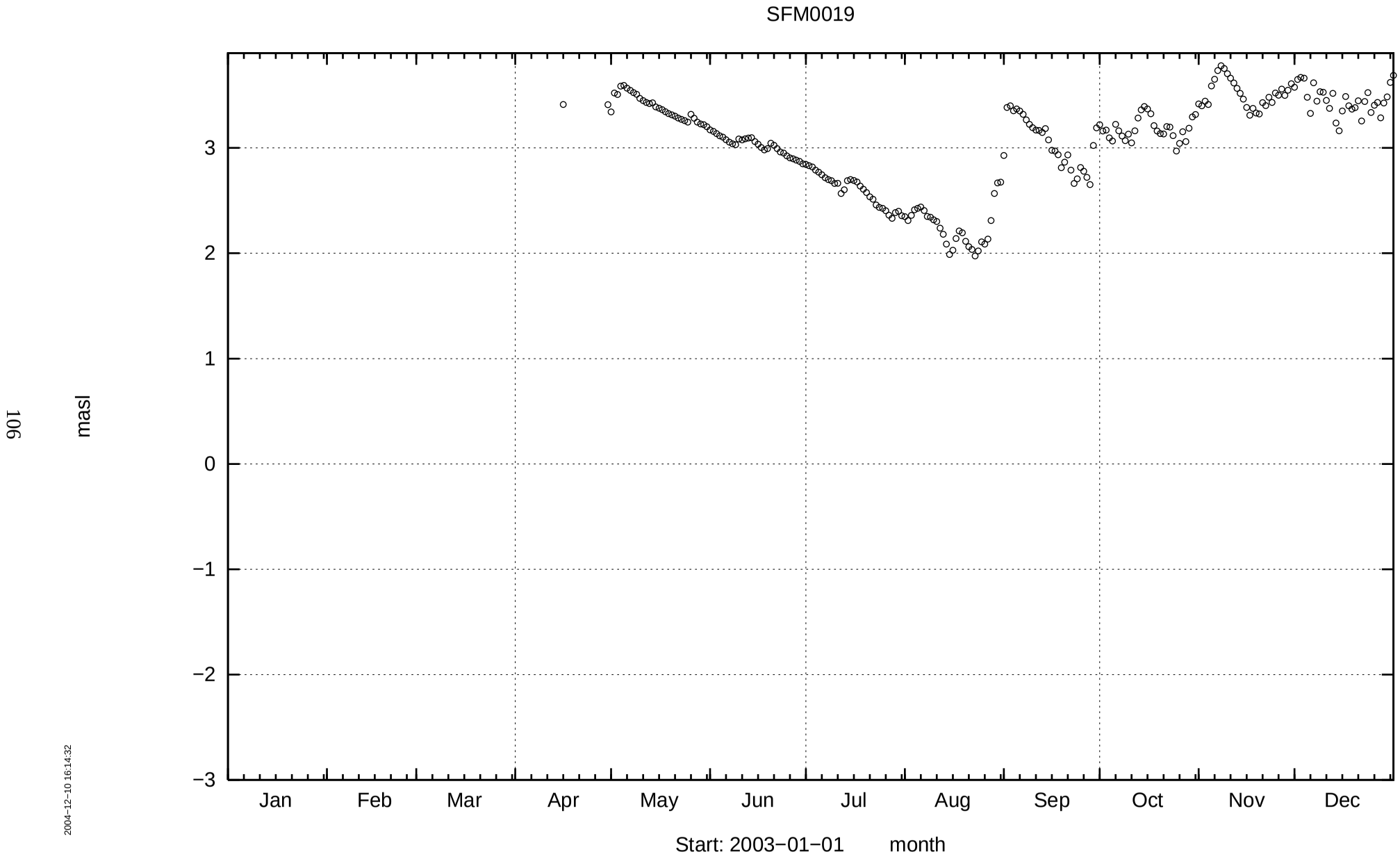
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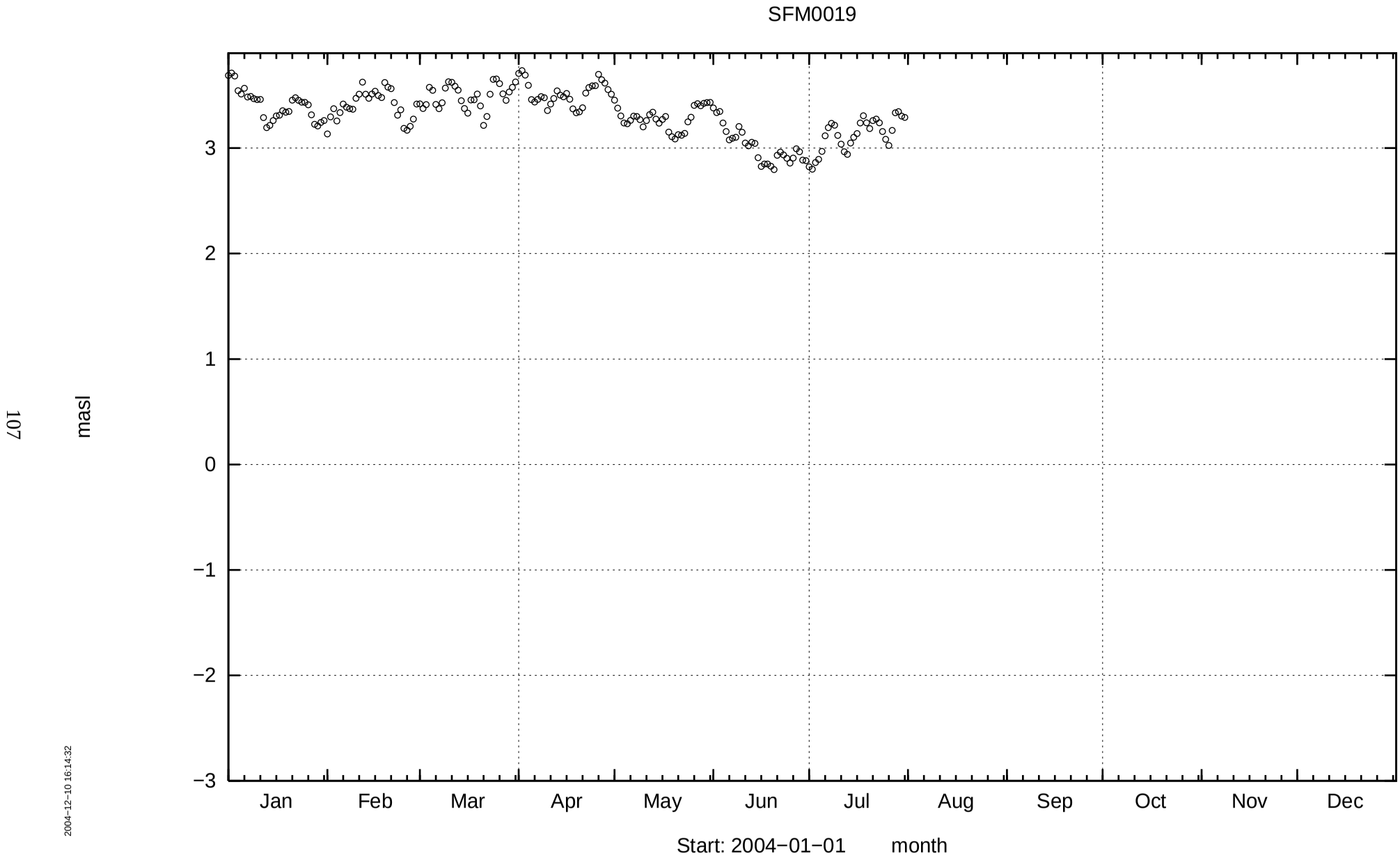
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107
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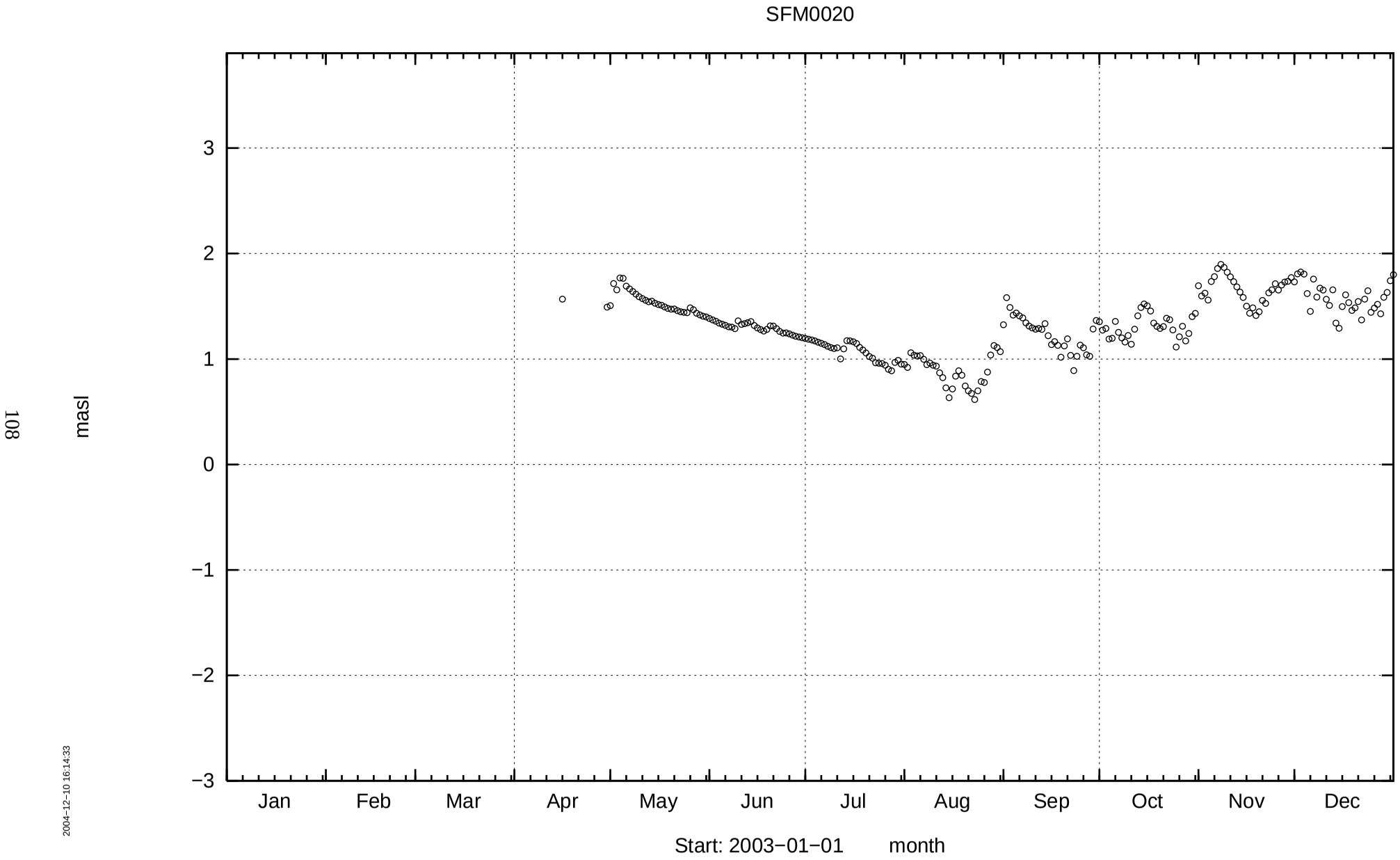
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108
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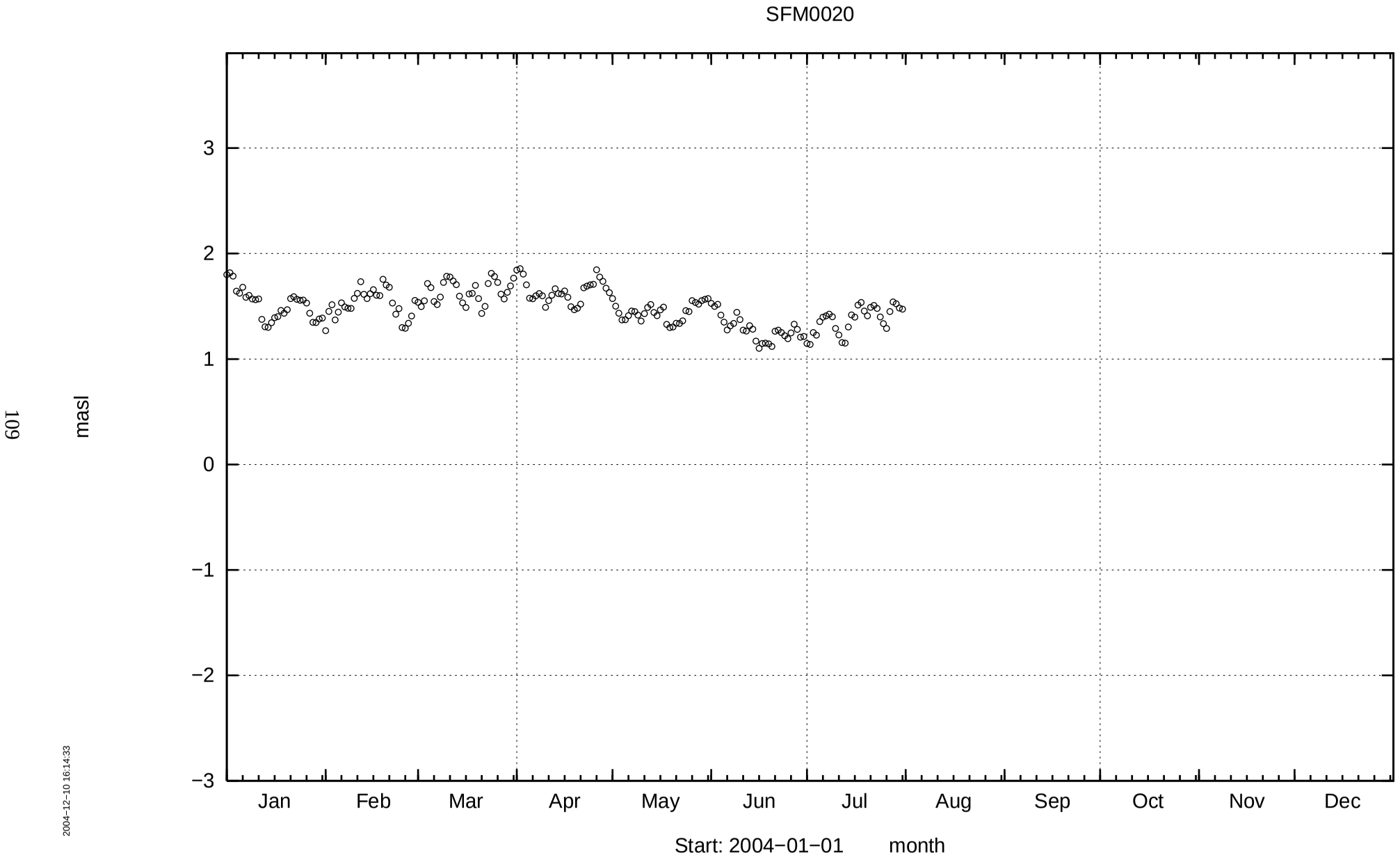
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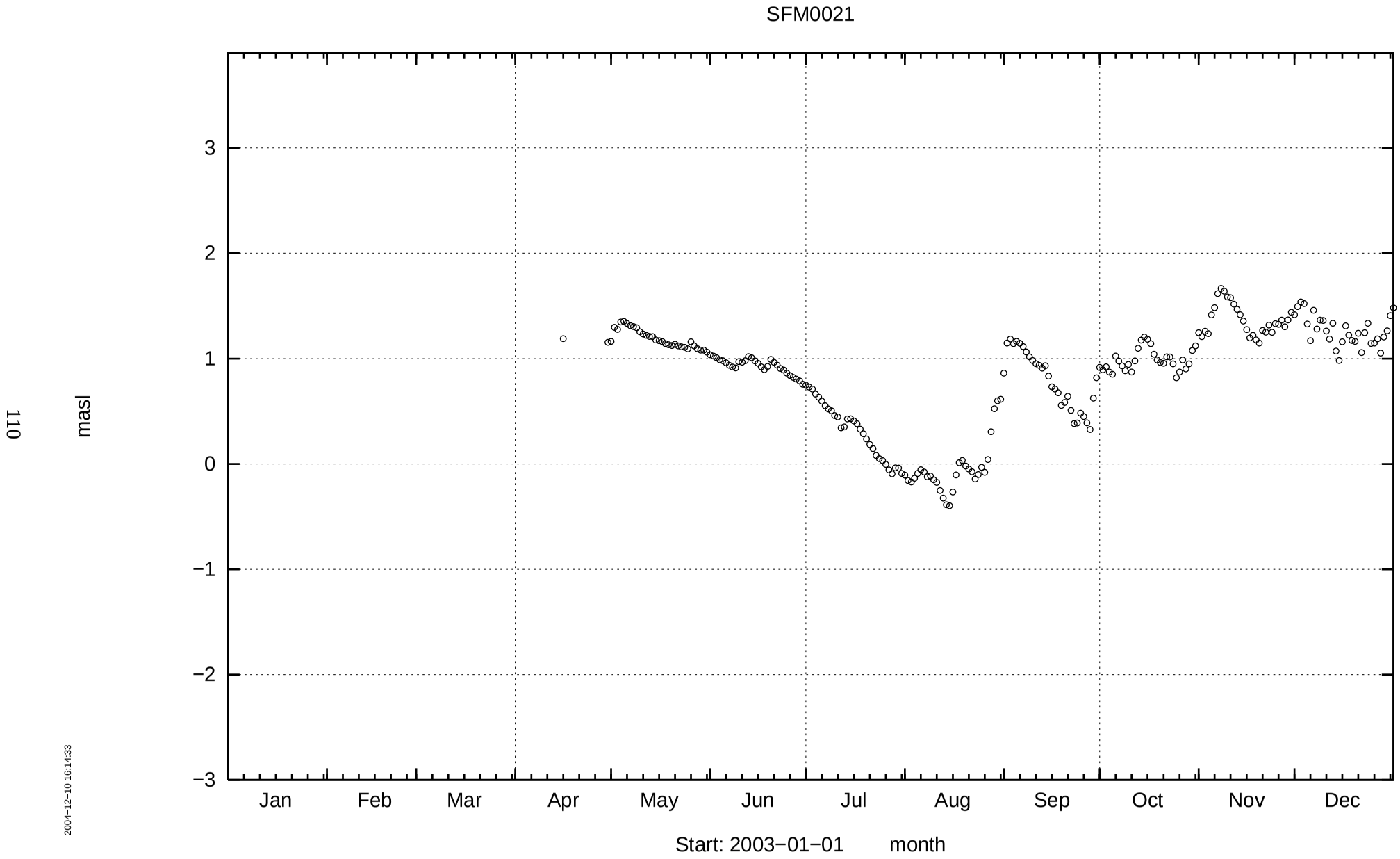
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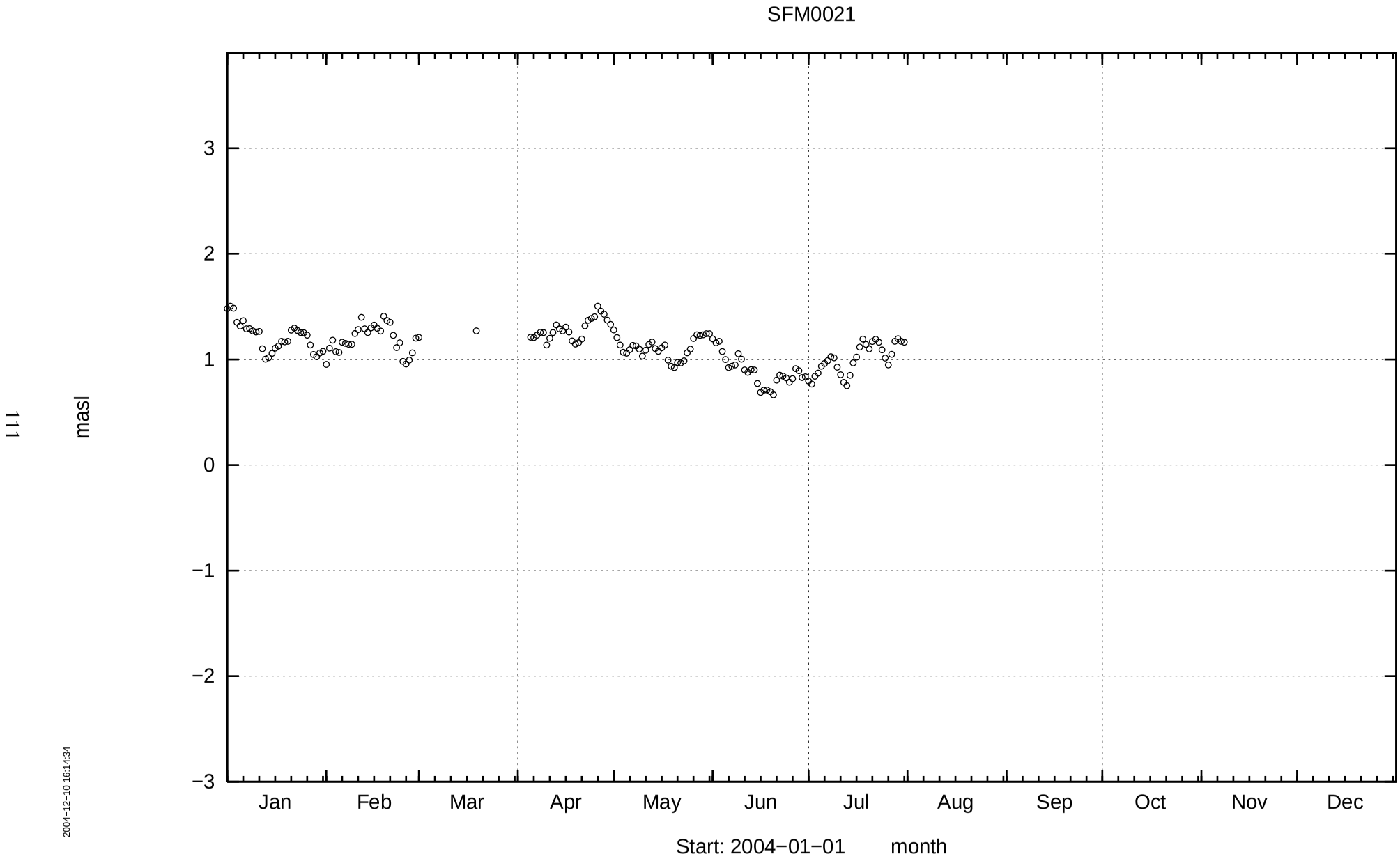
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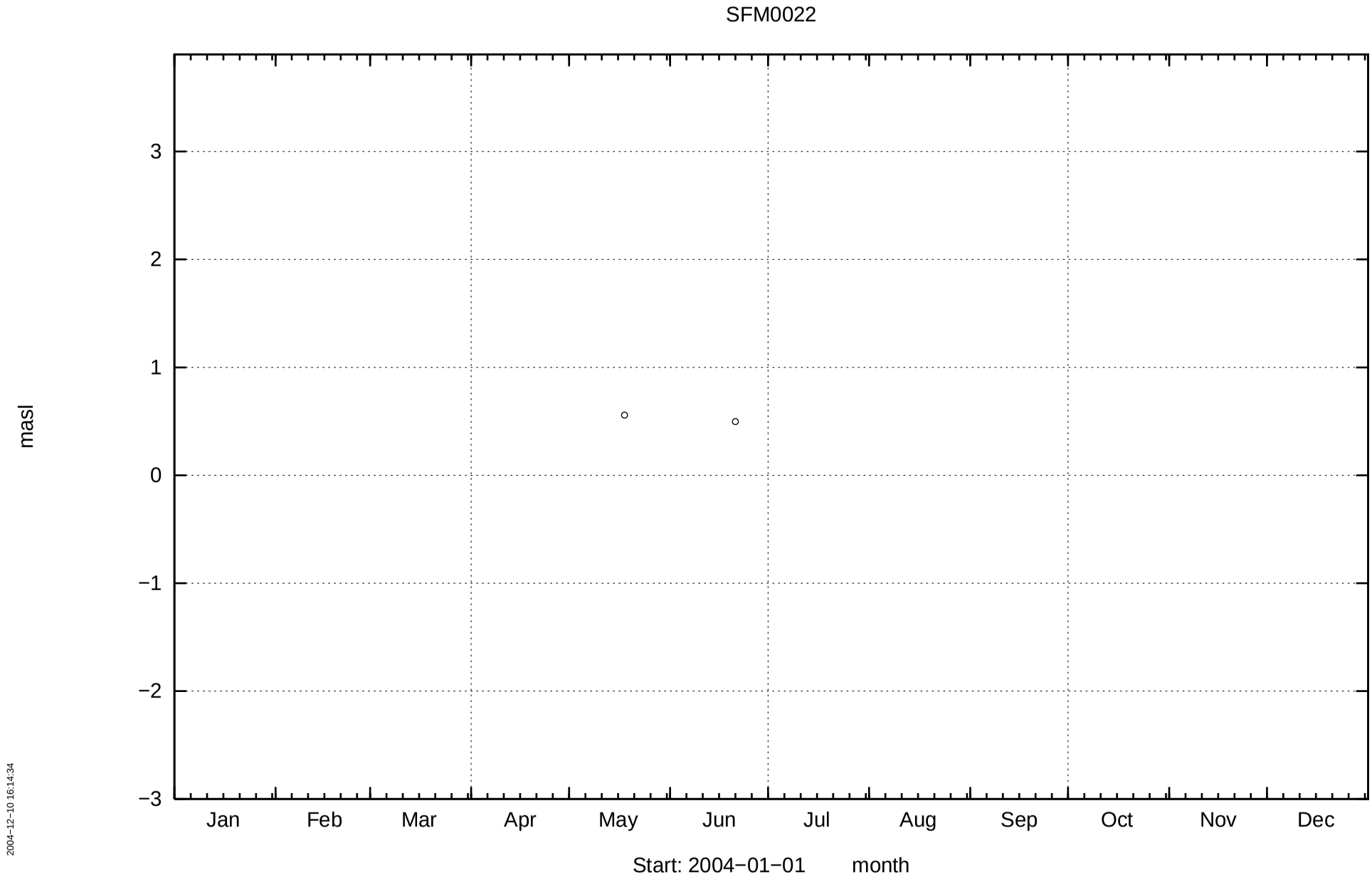
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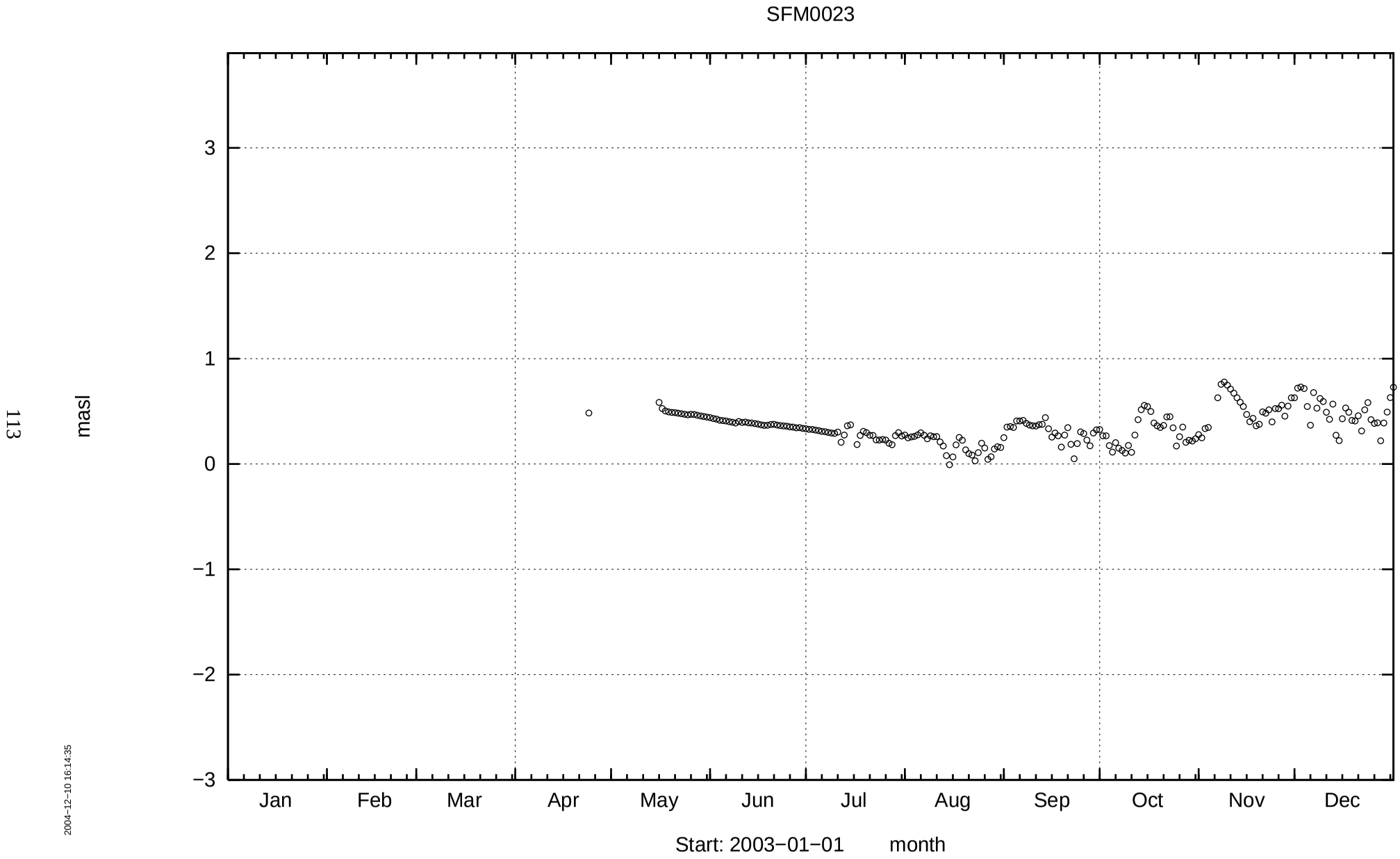
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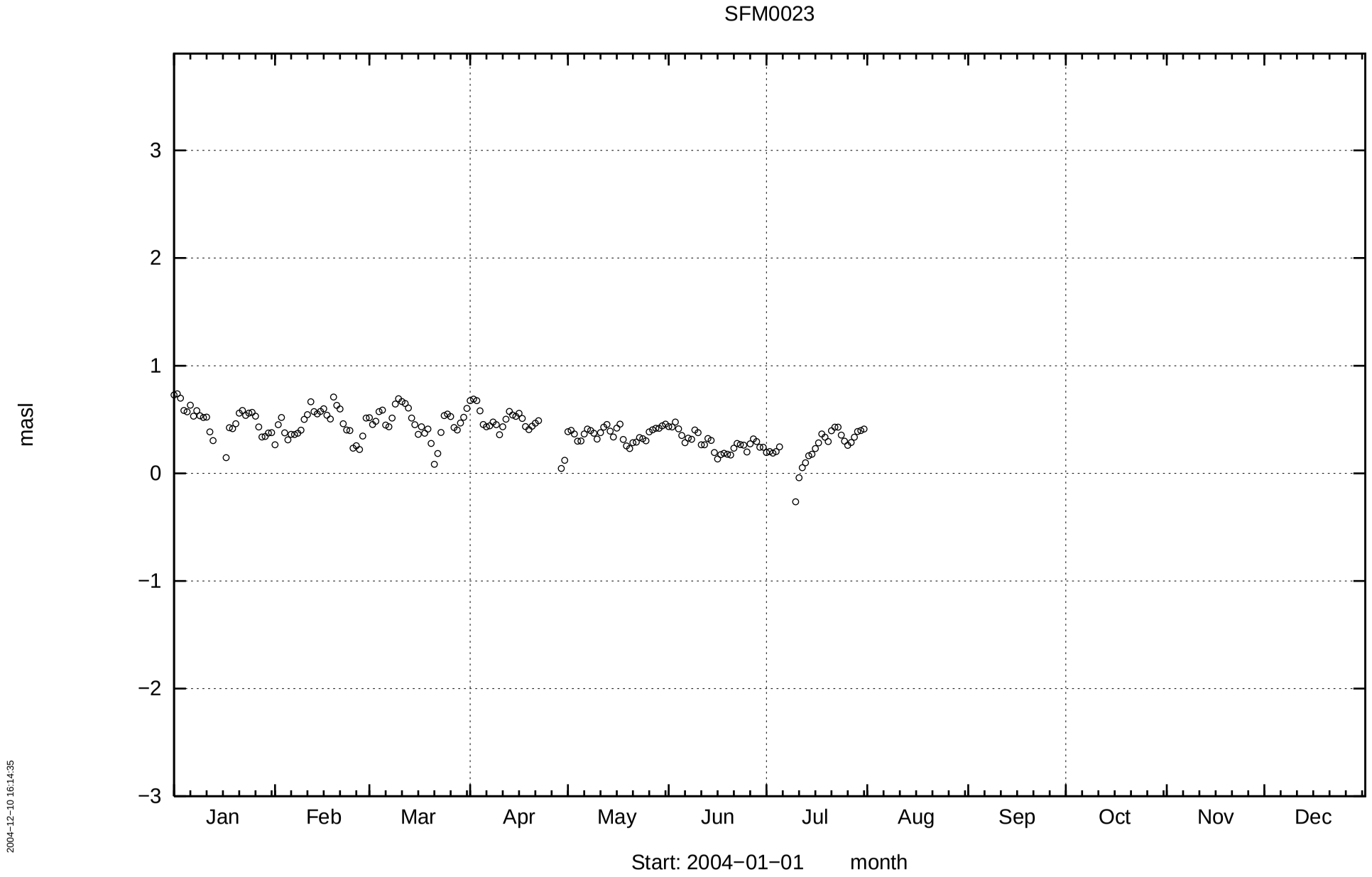
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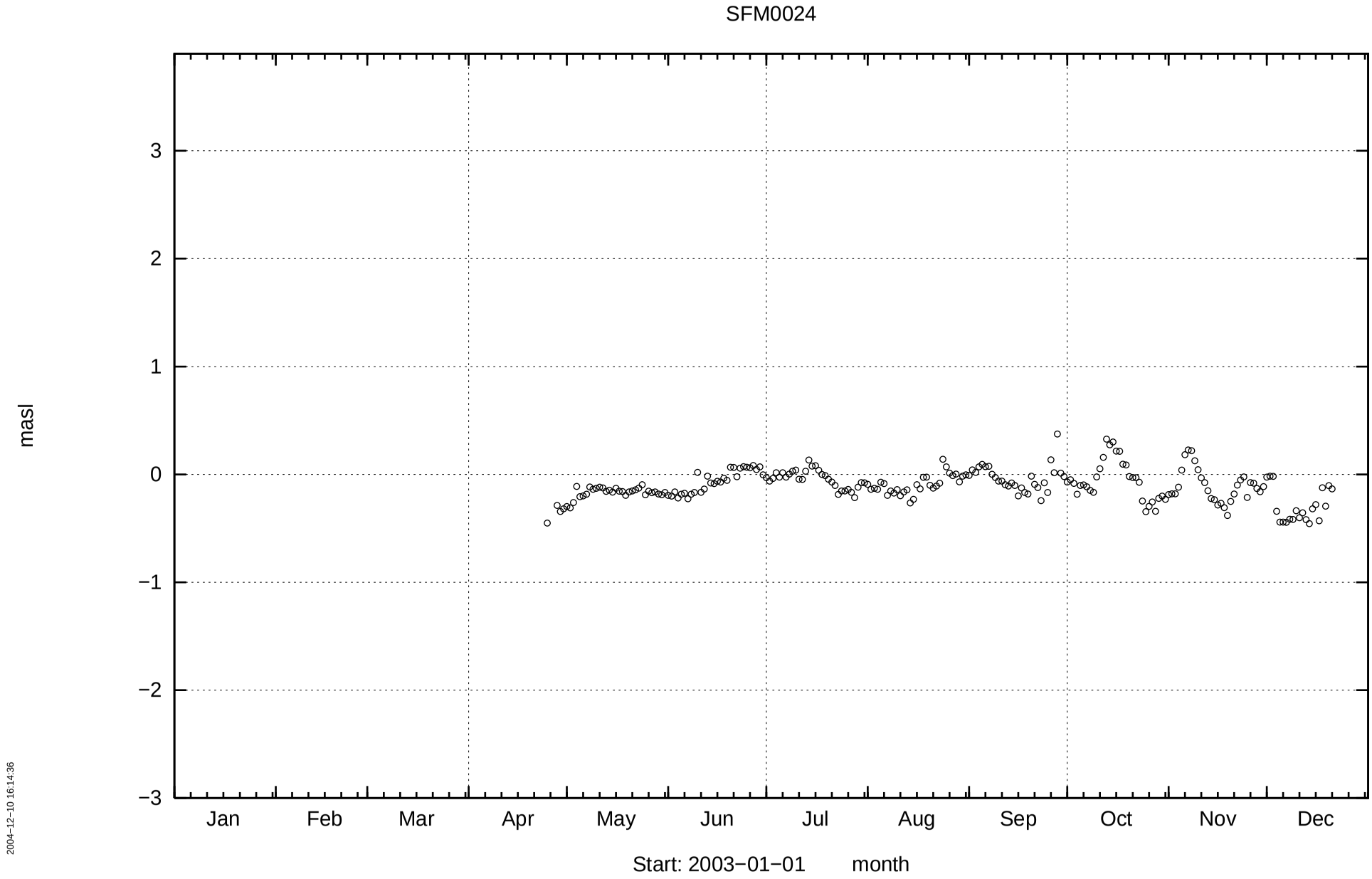

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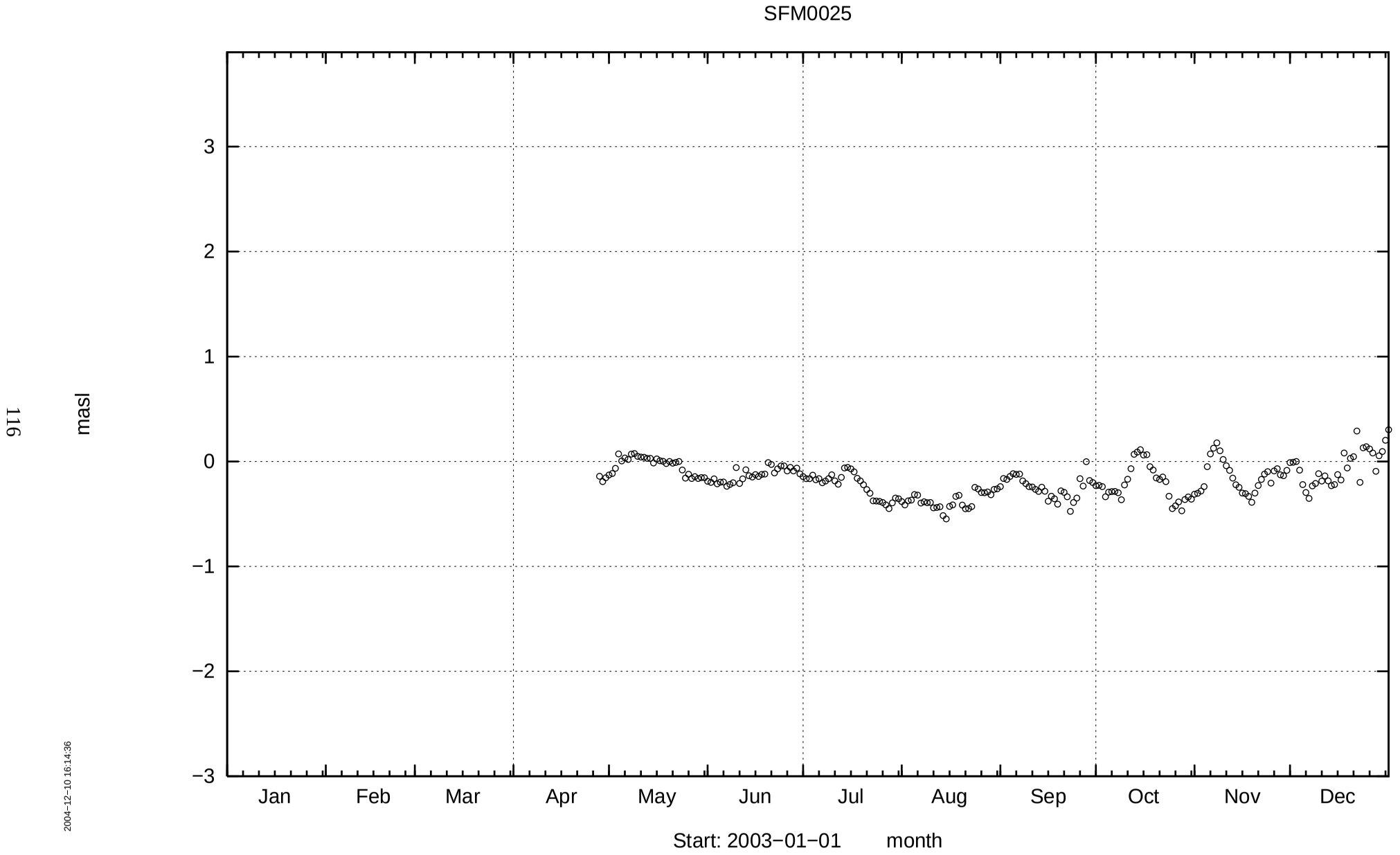
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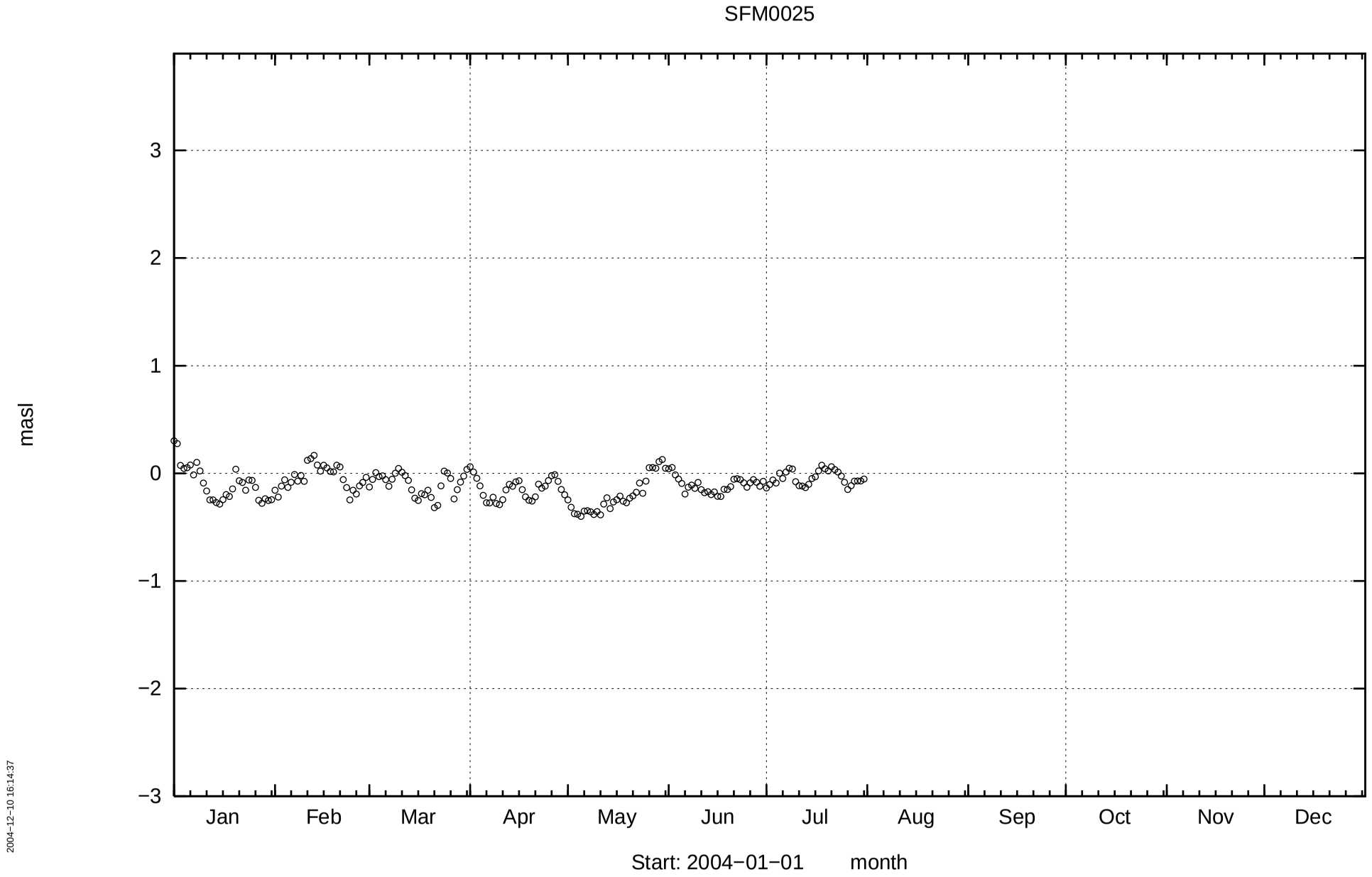

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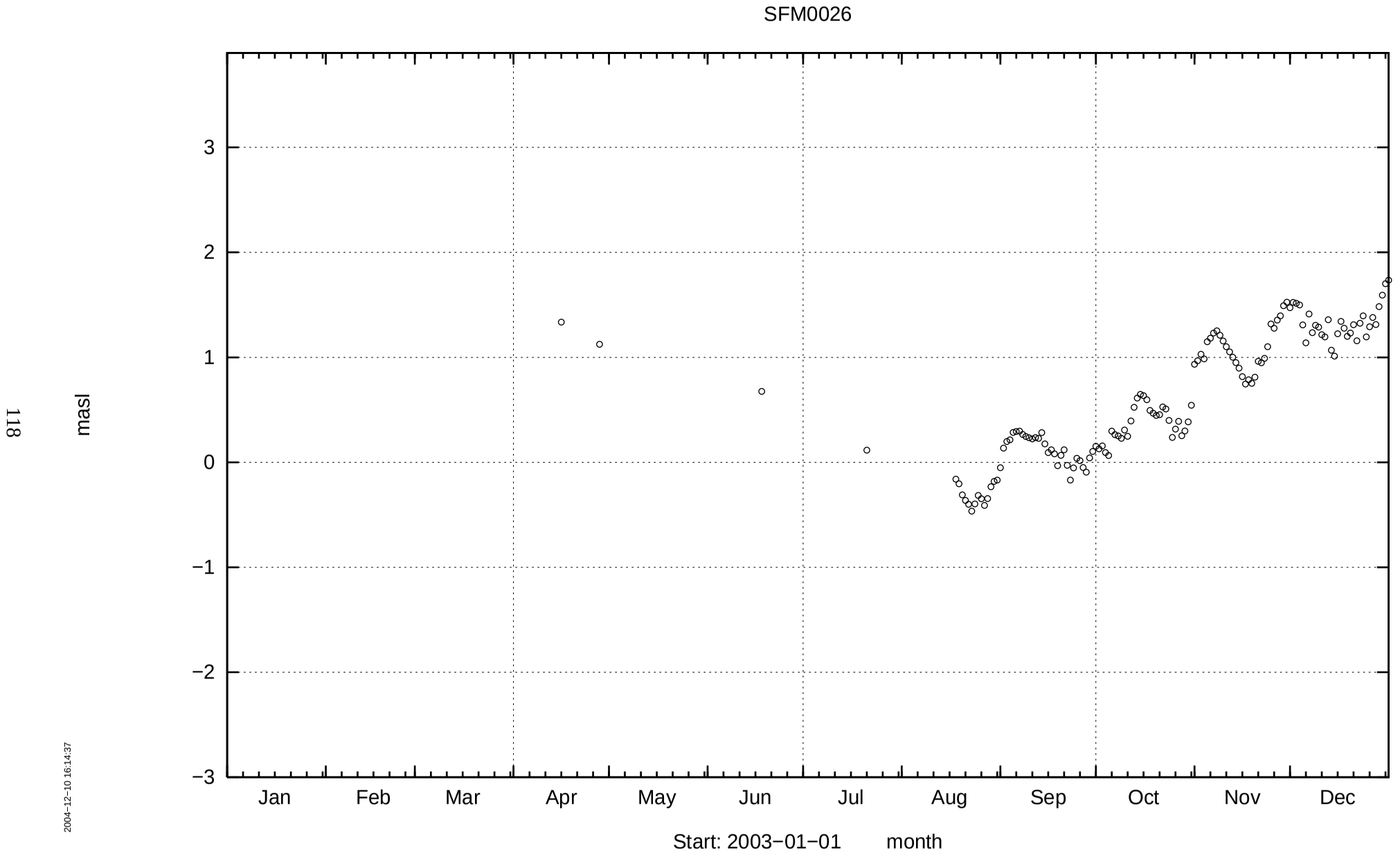
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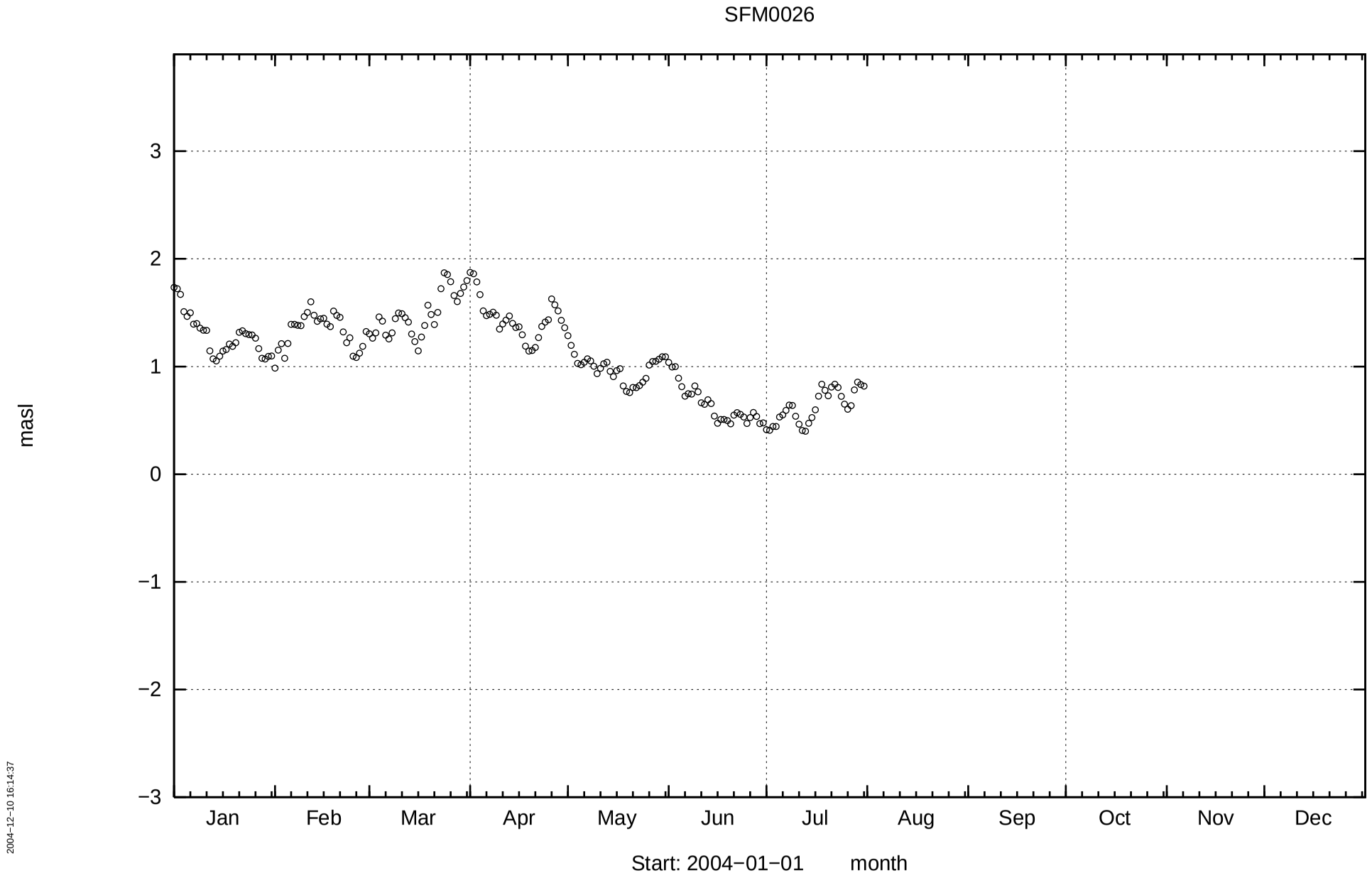

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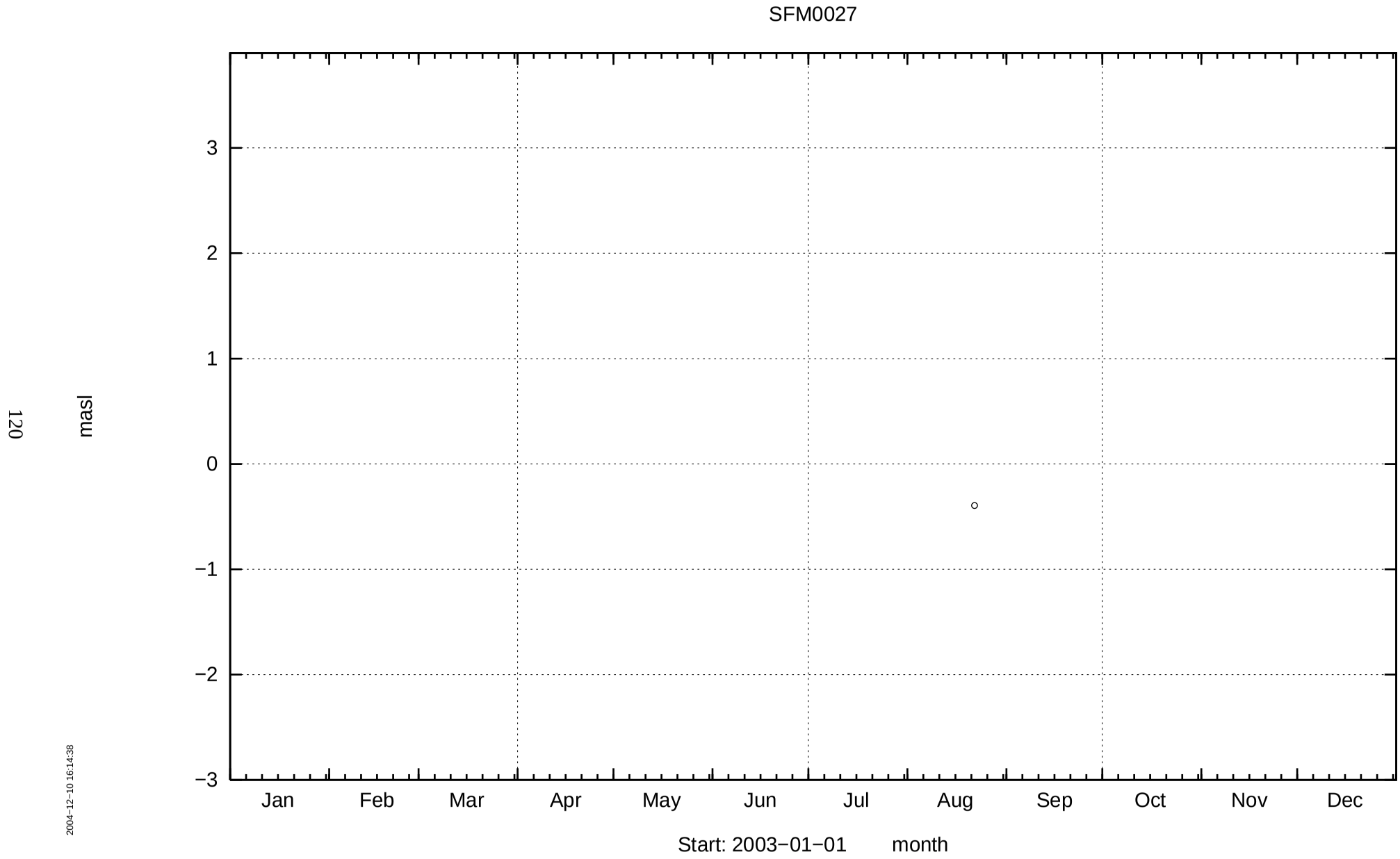
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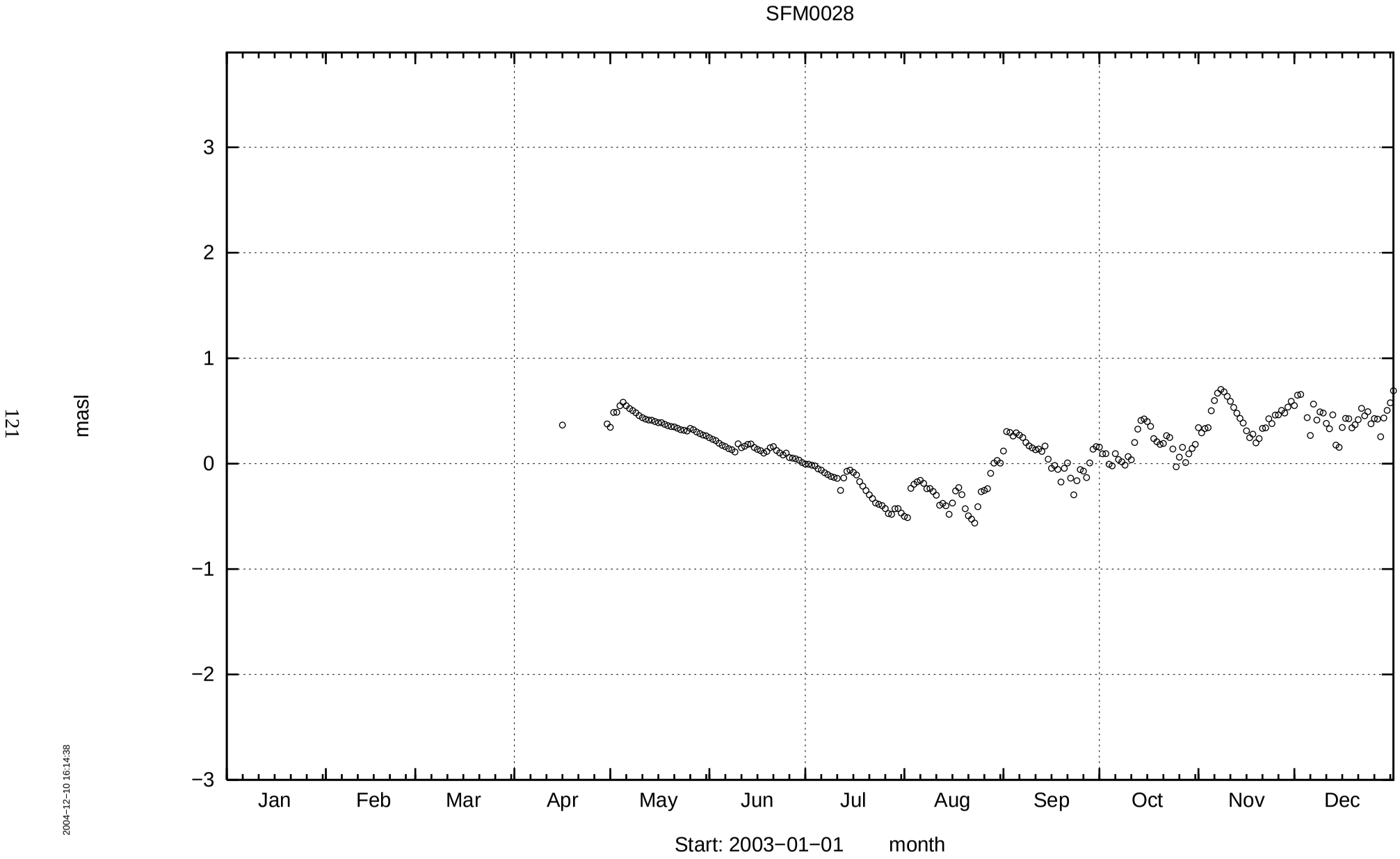
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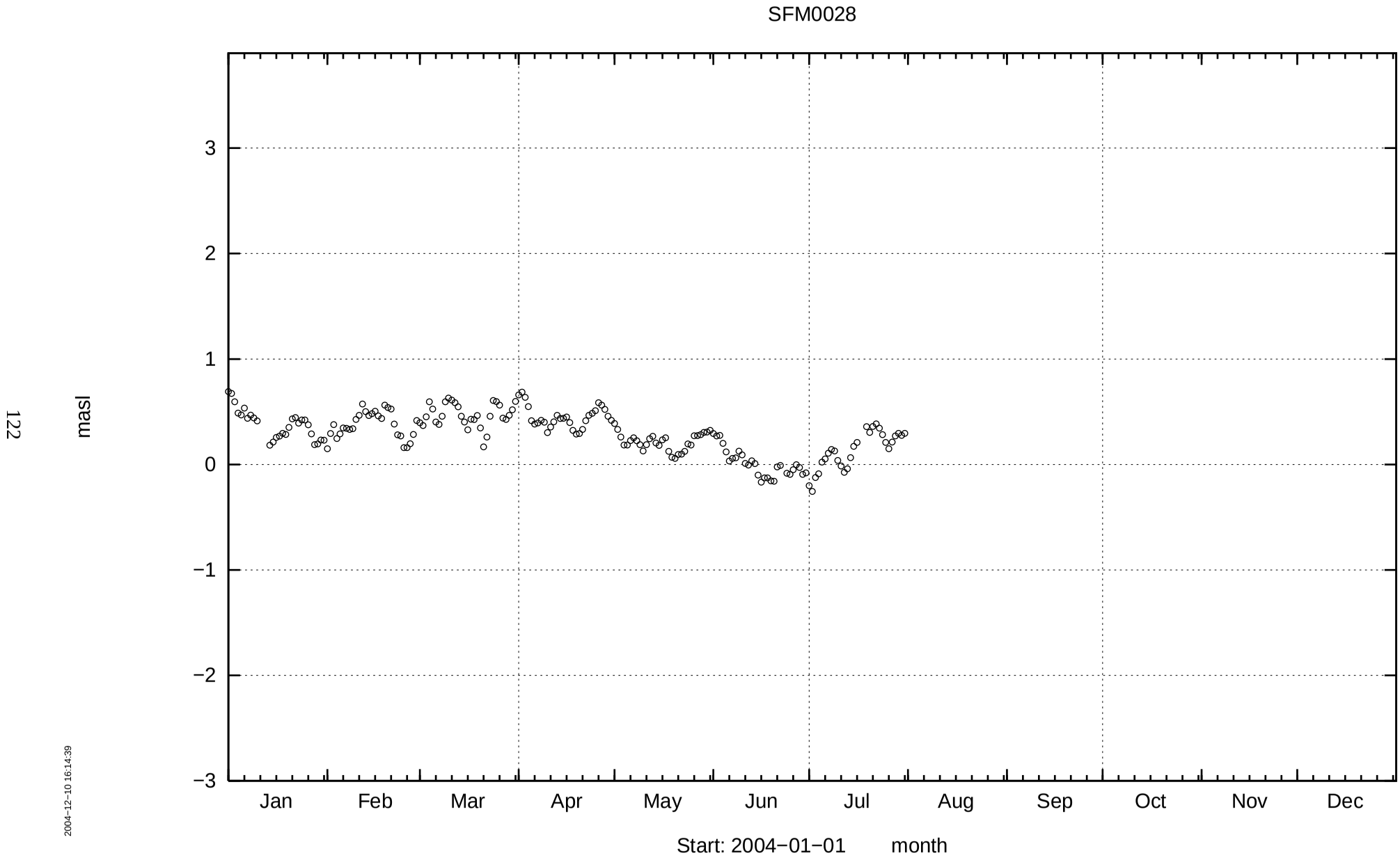
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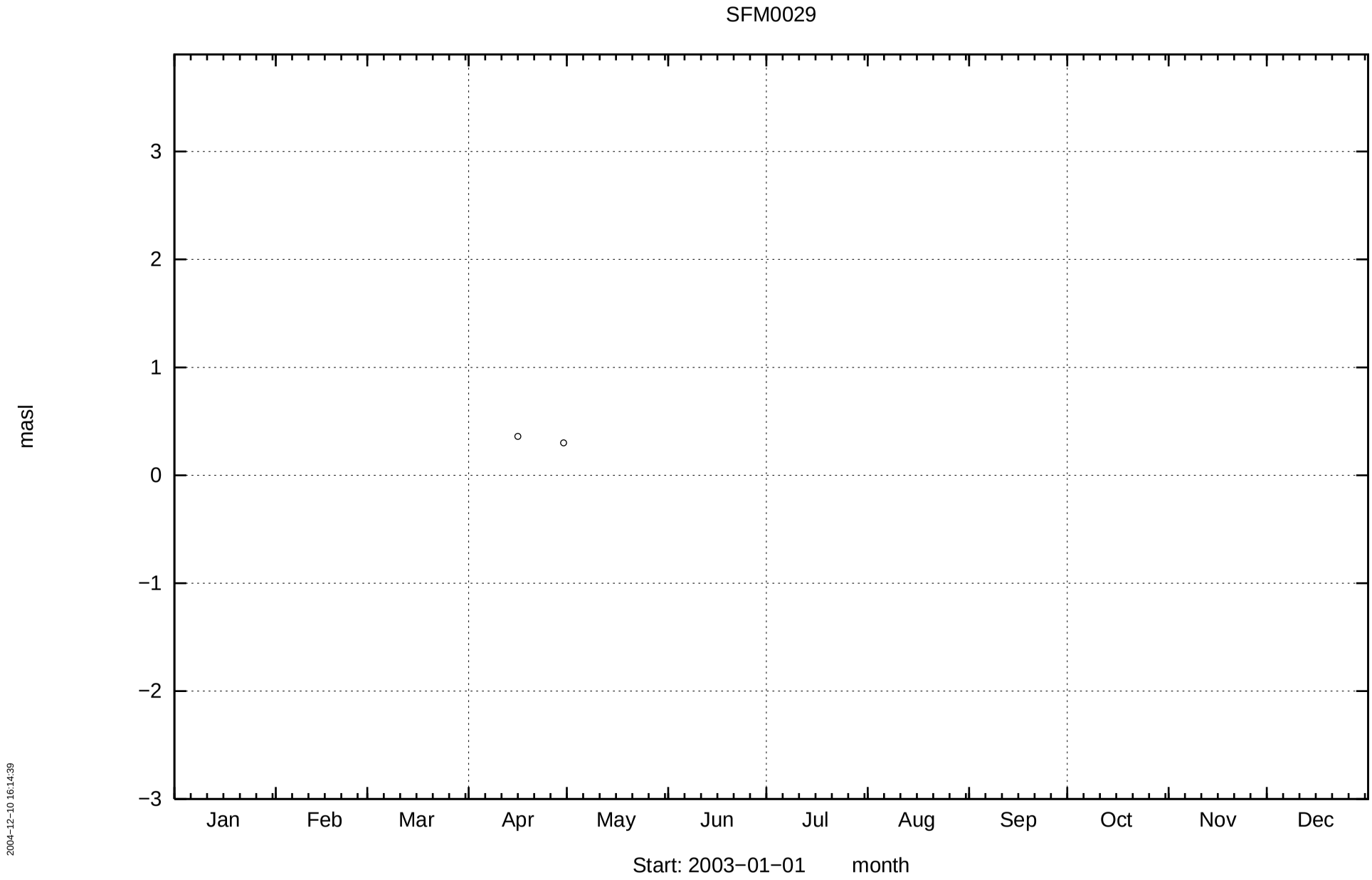
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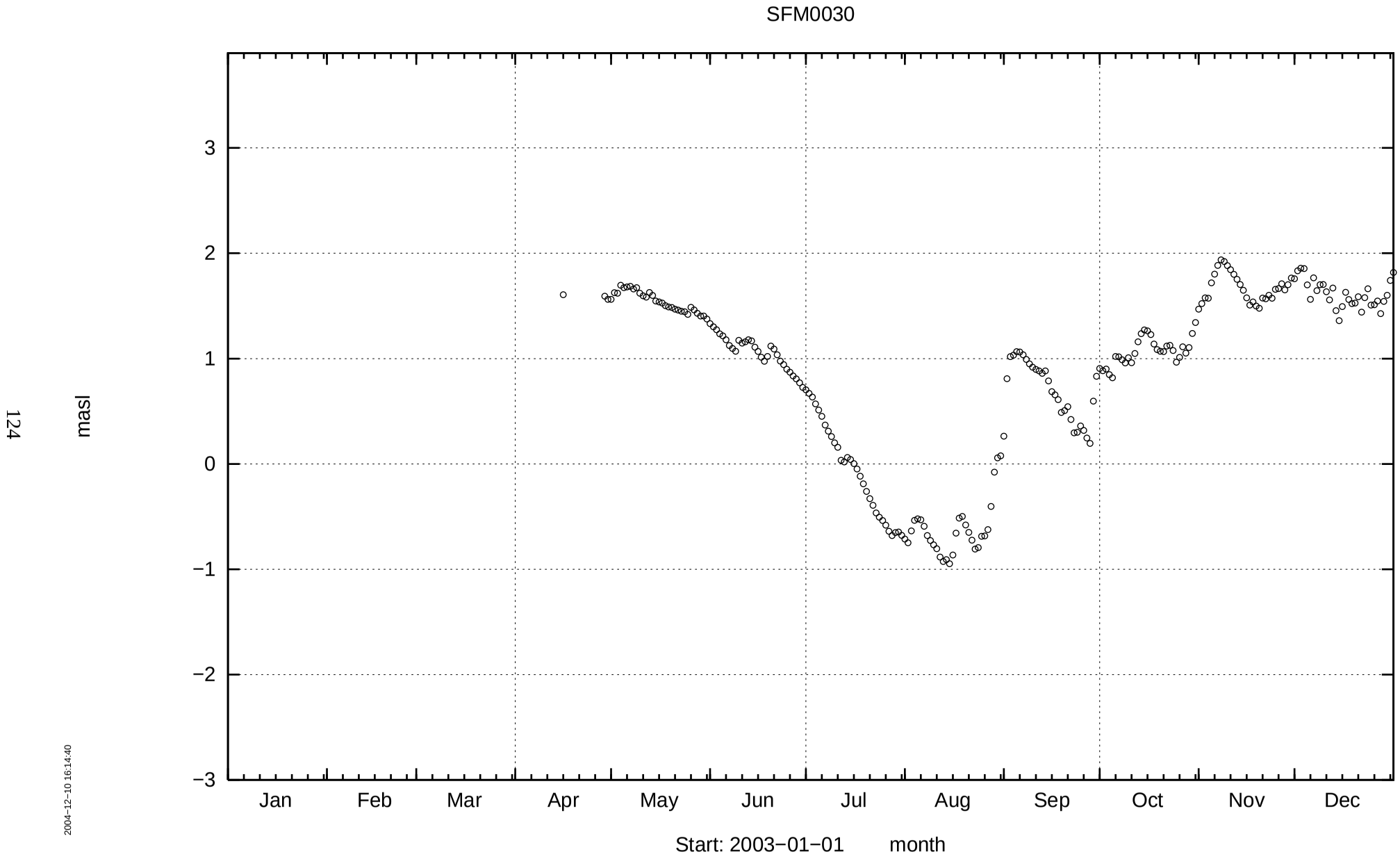
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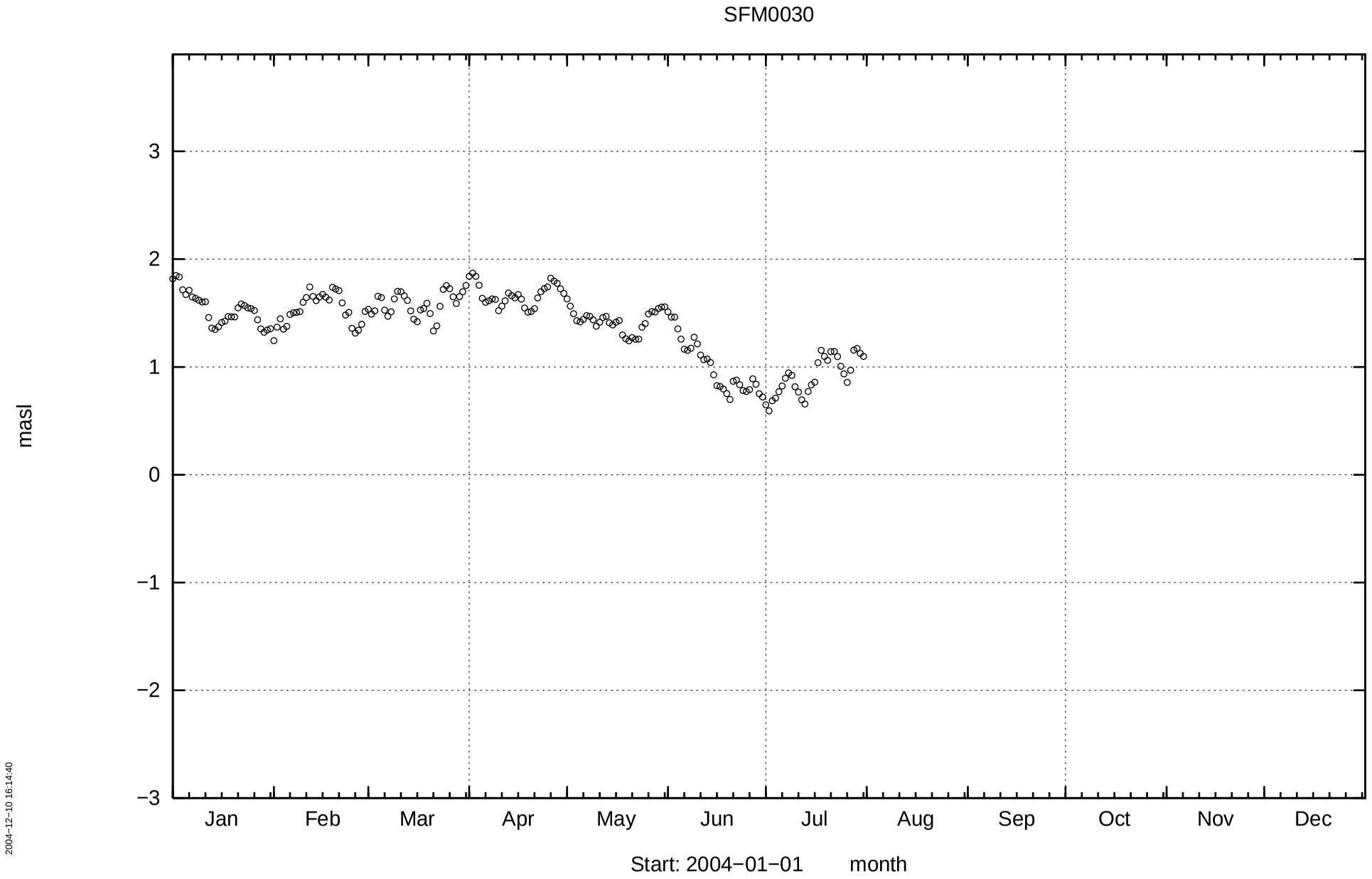

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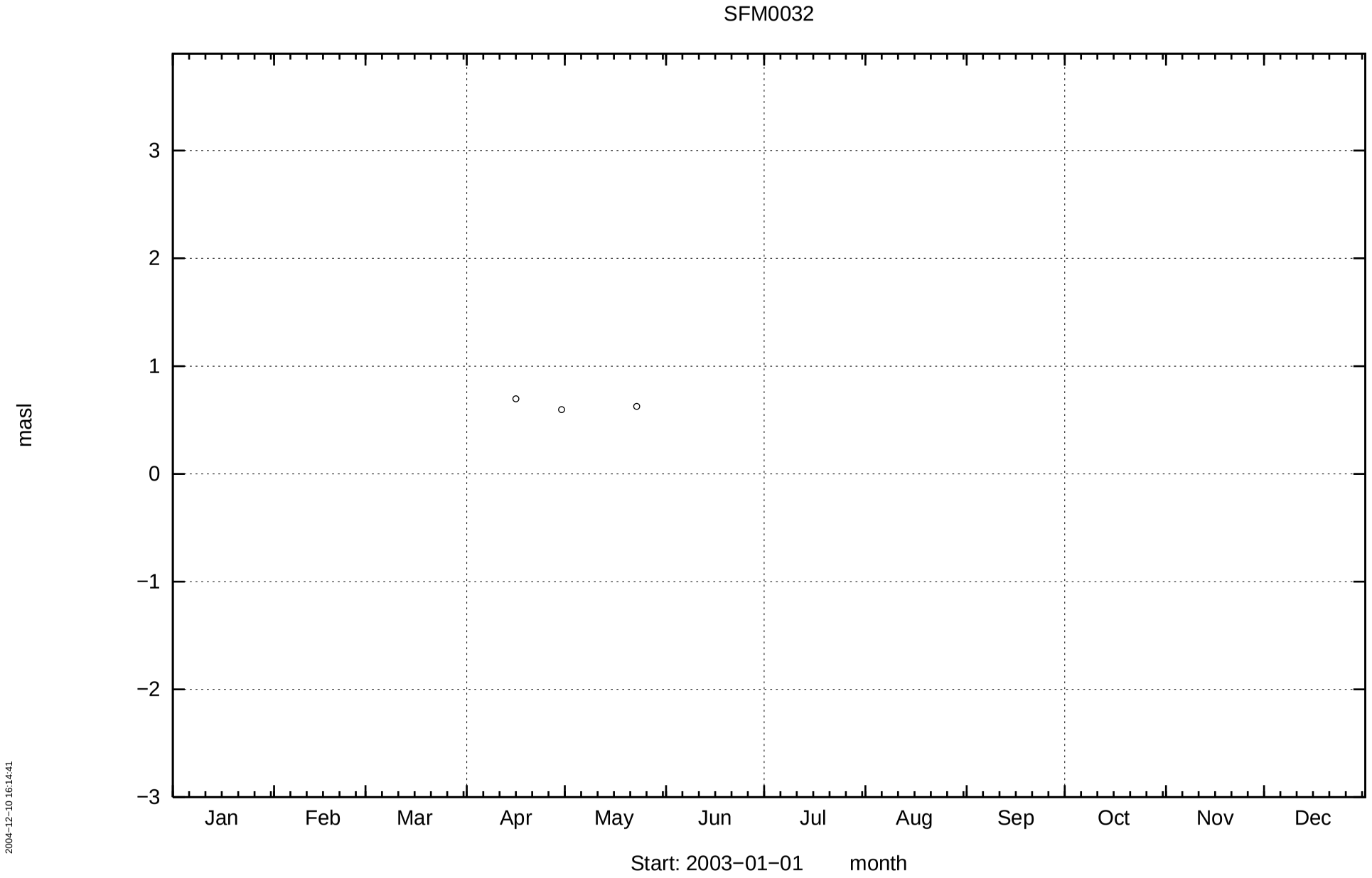
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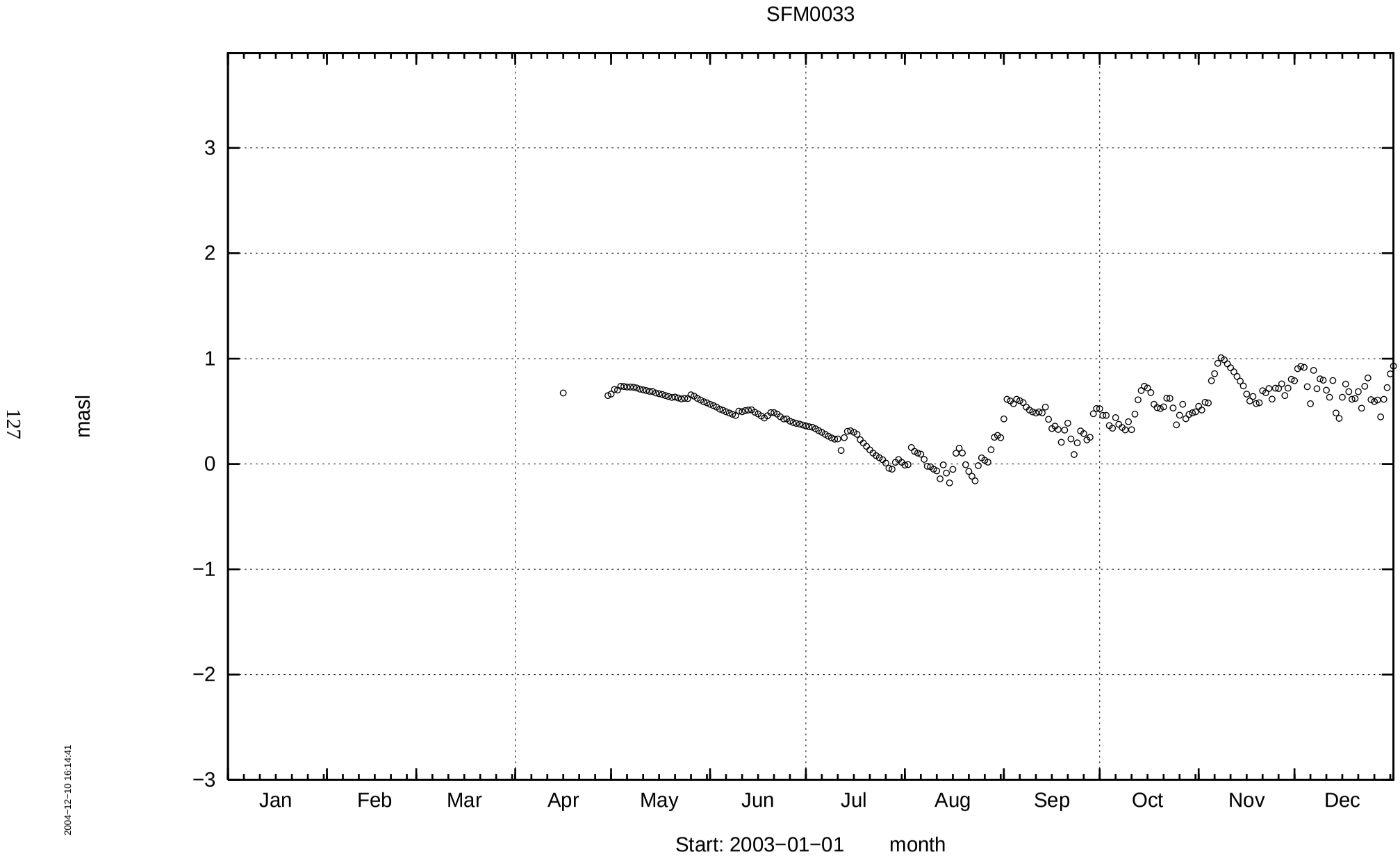
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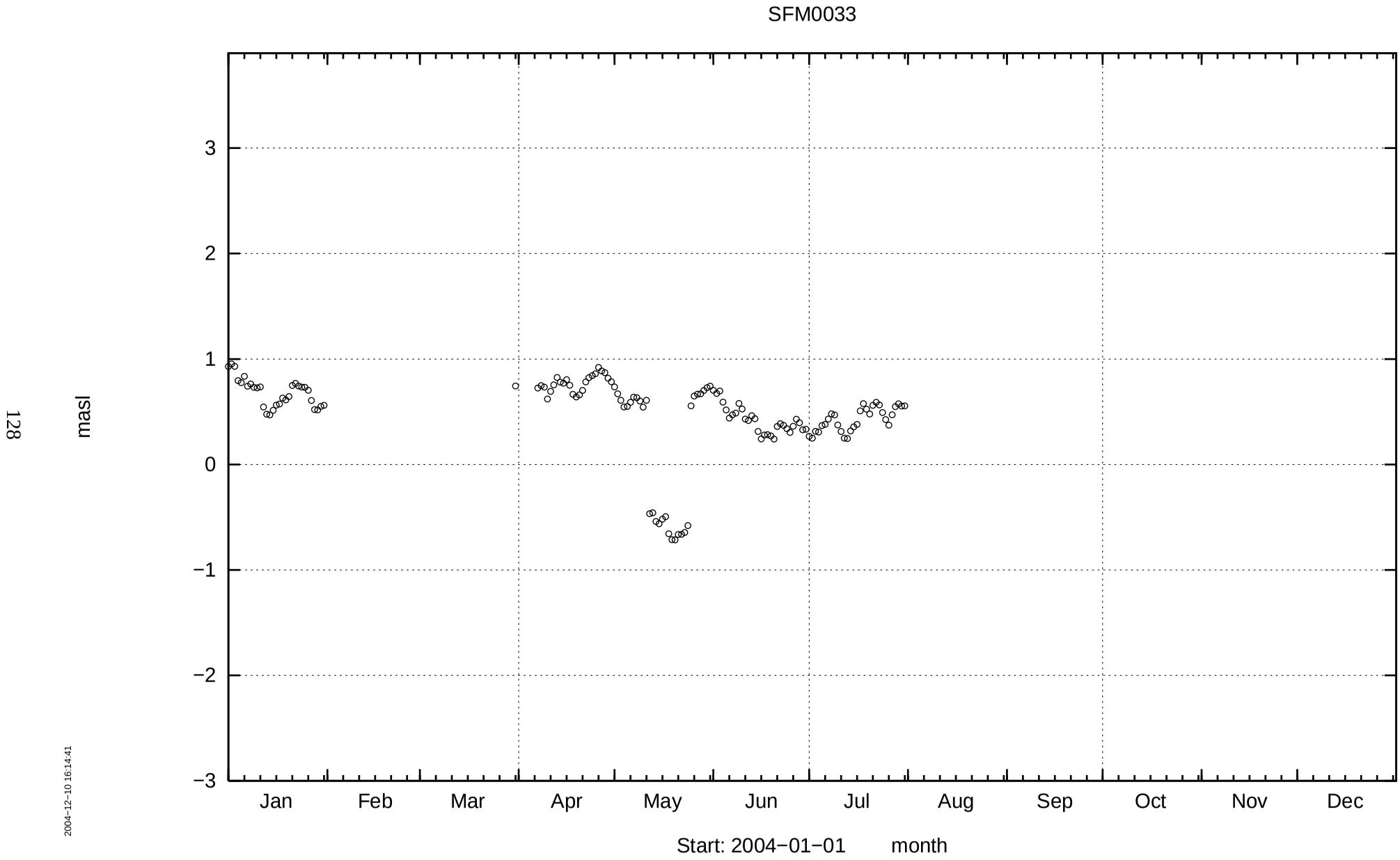
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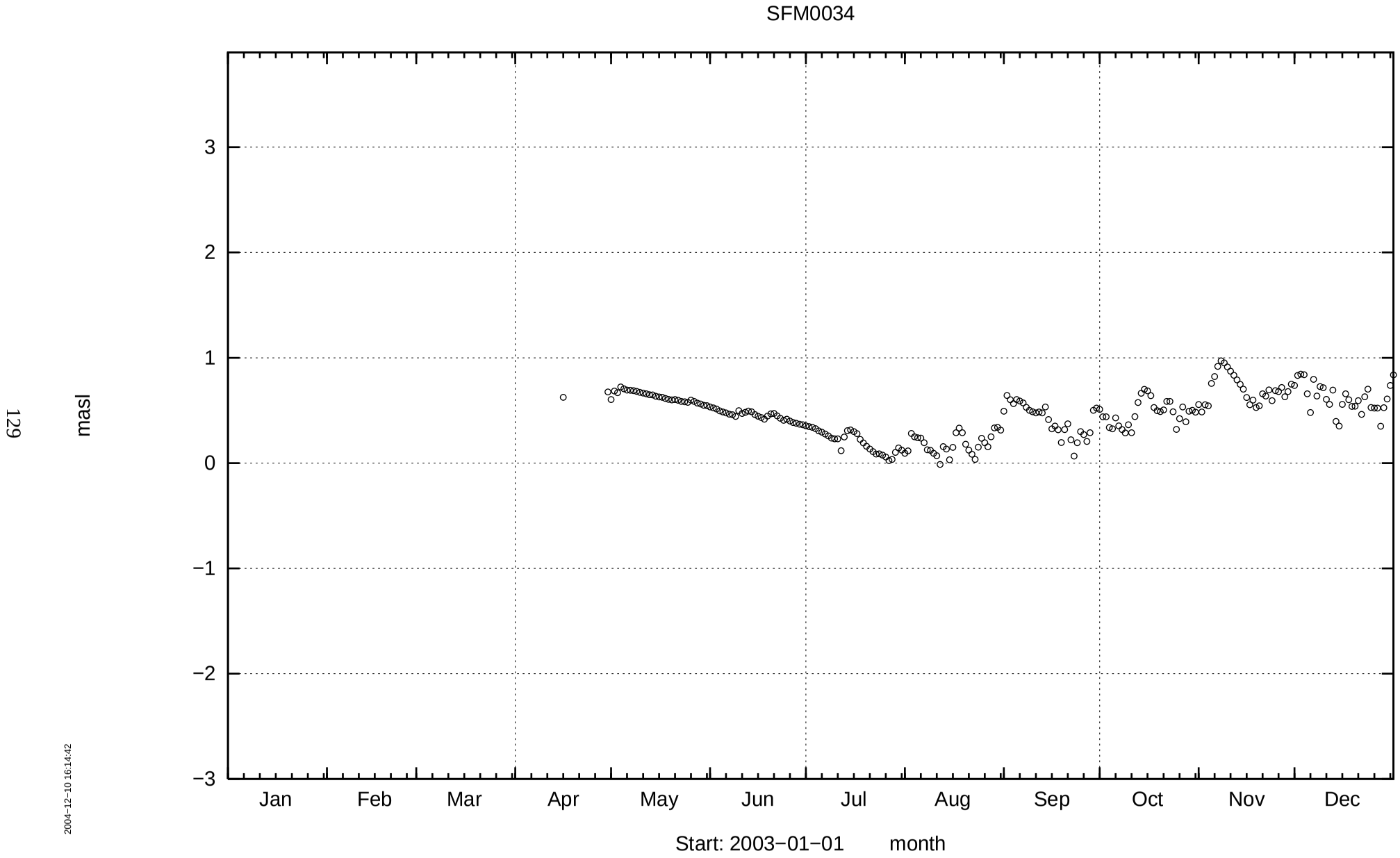
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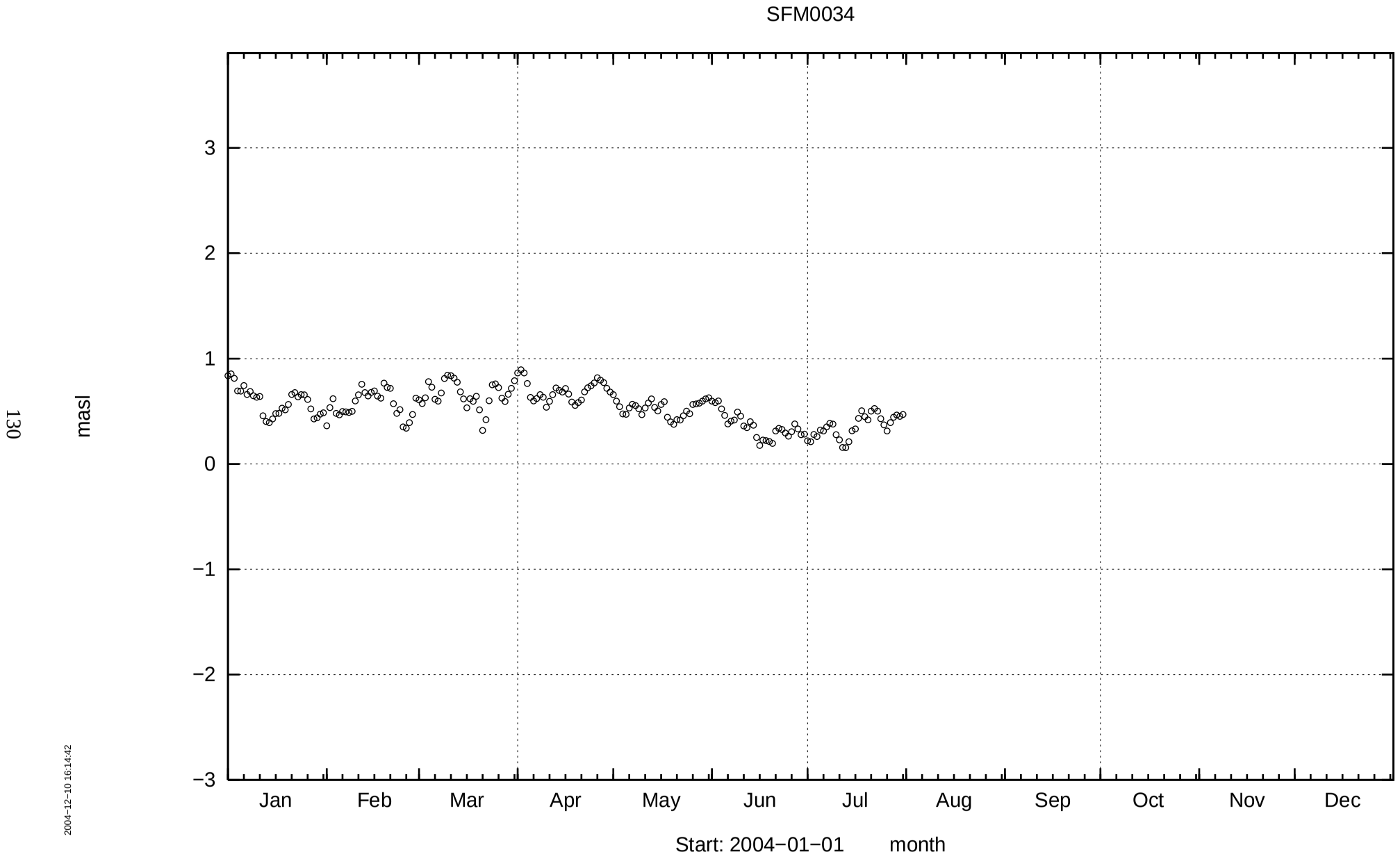
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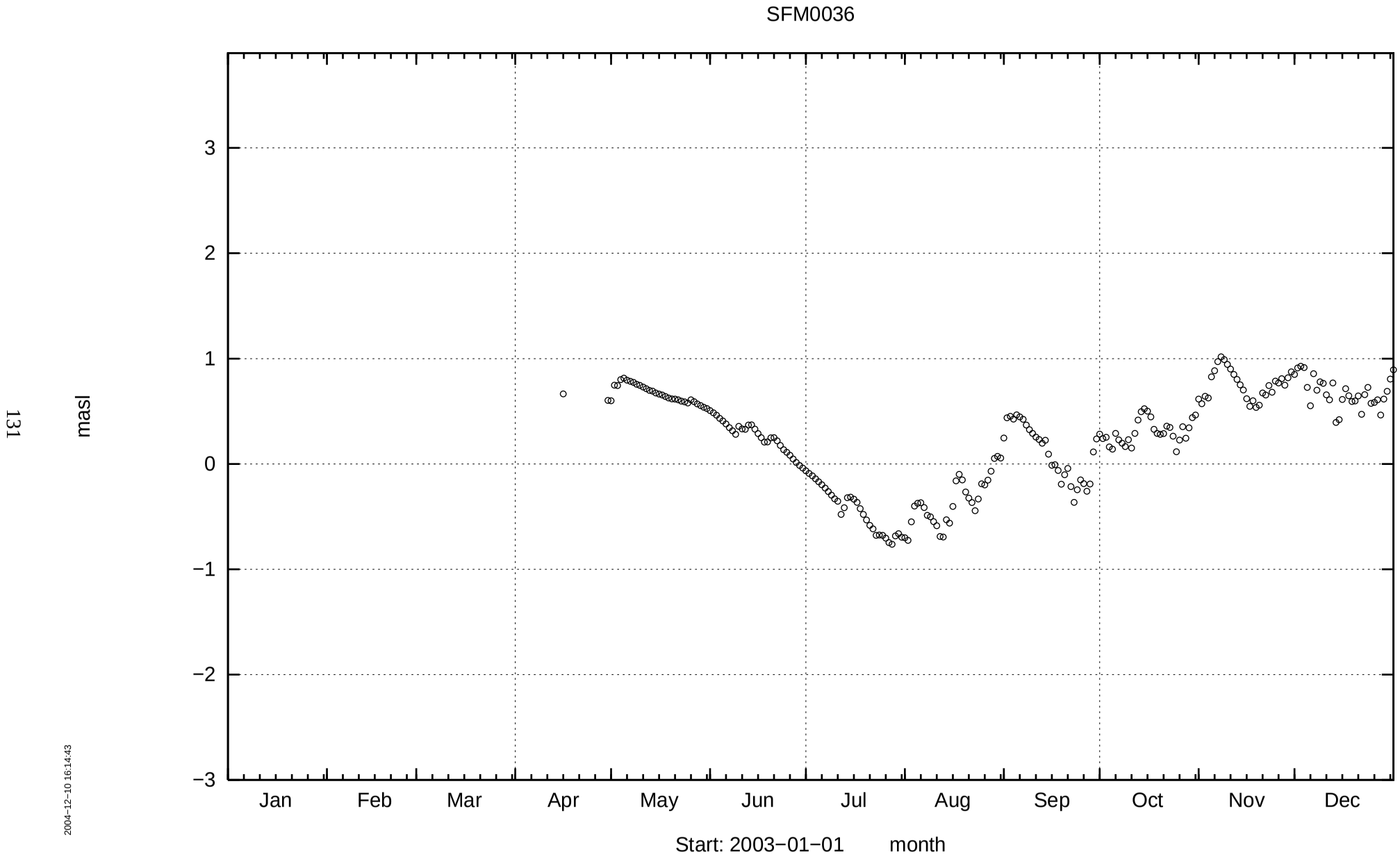
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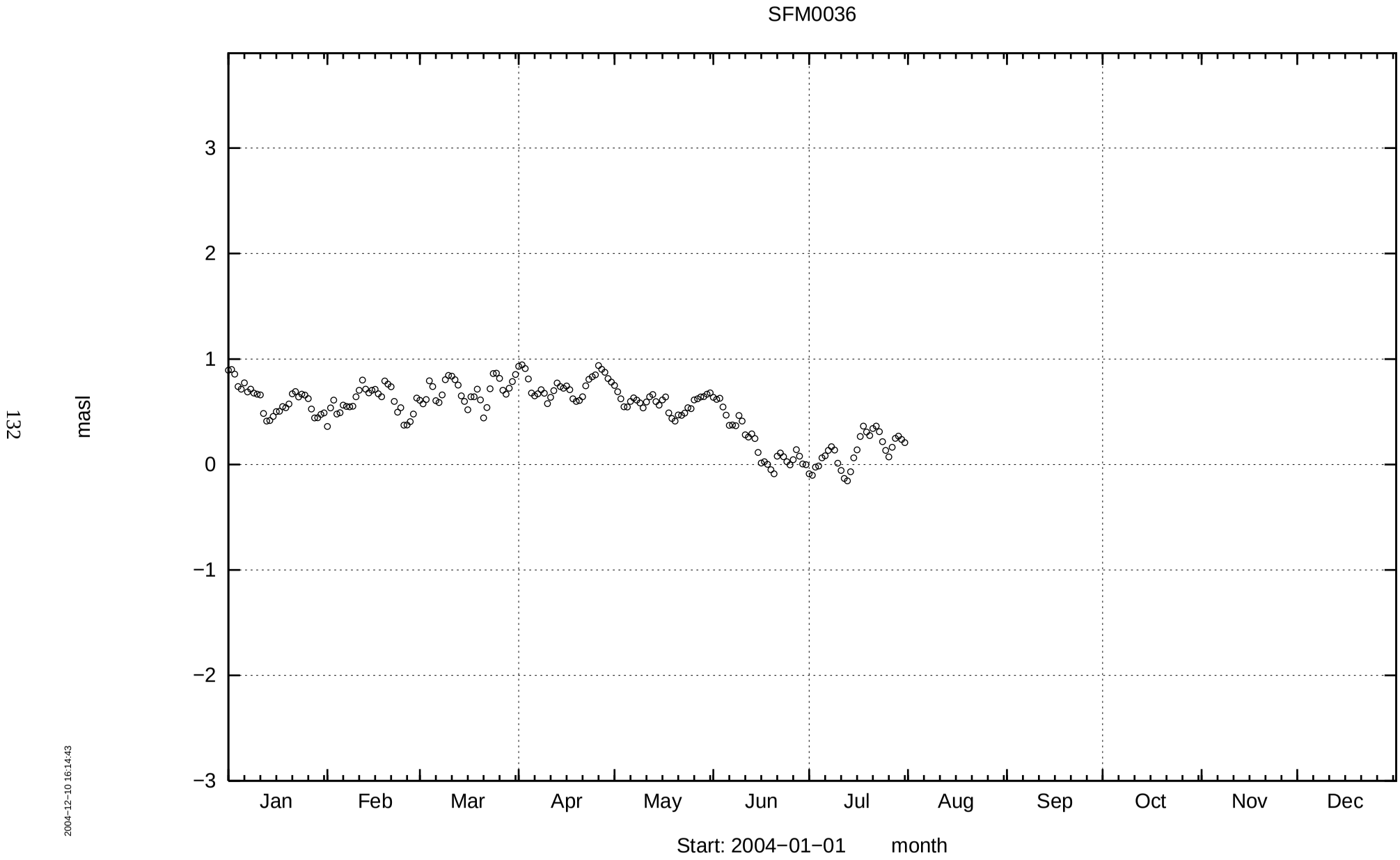
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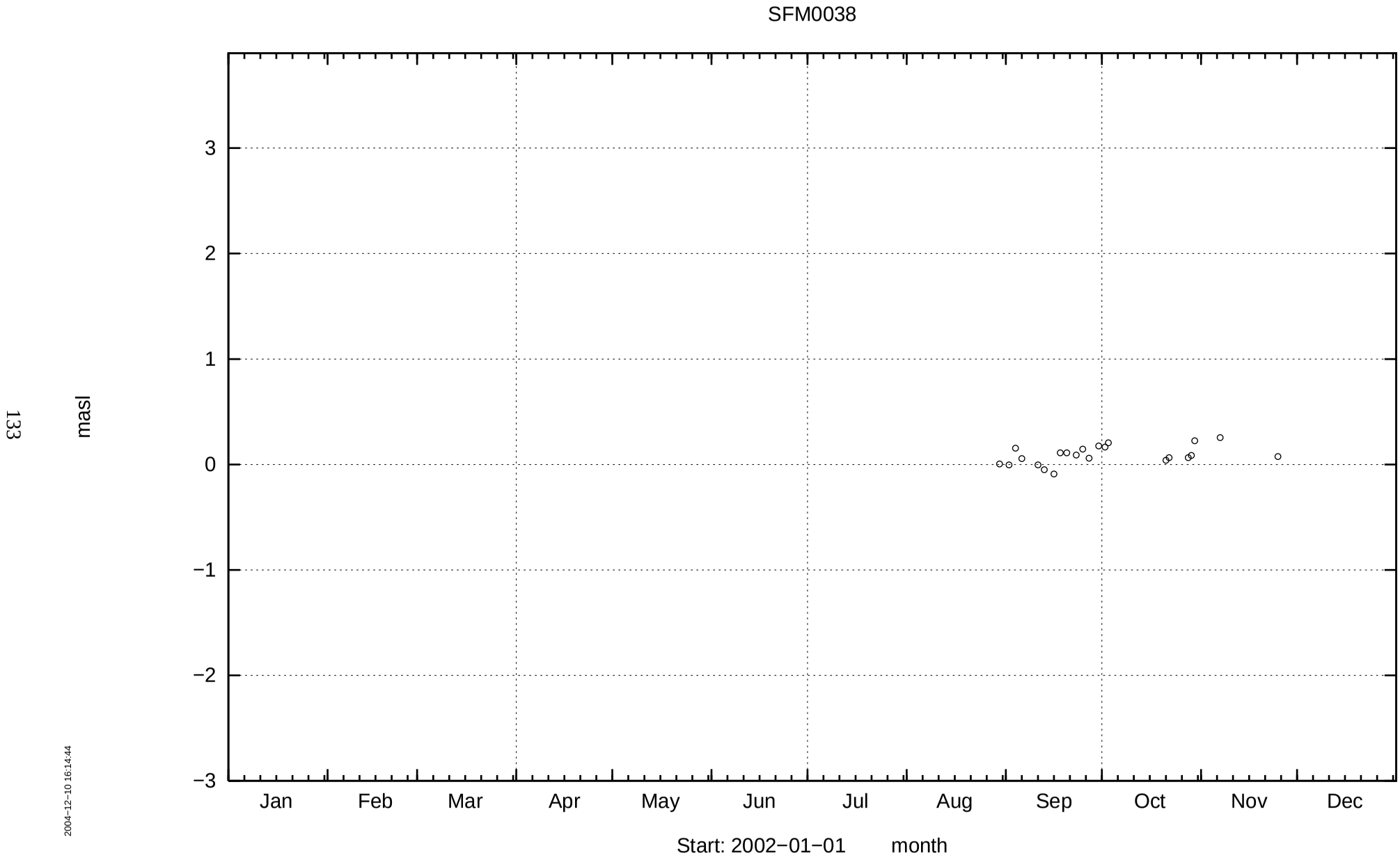
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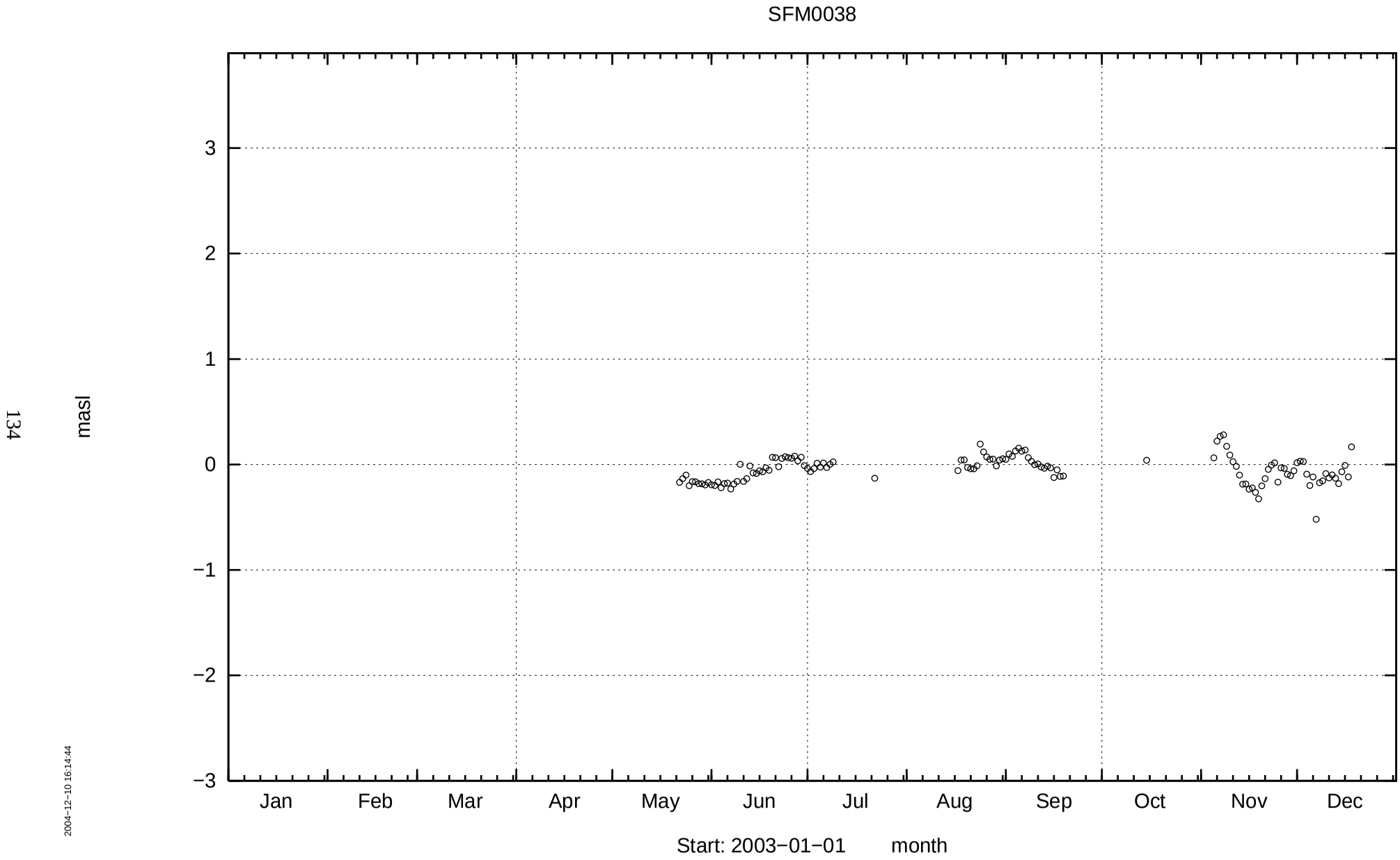
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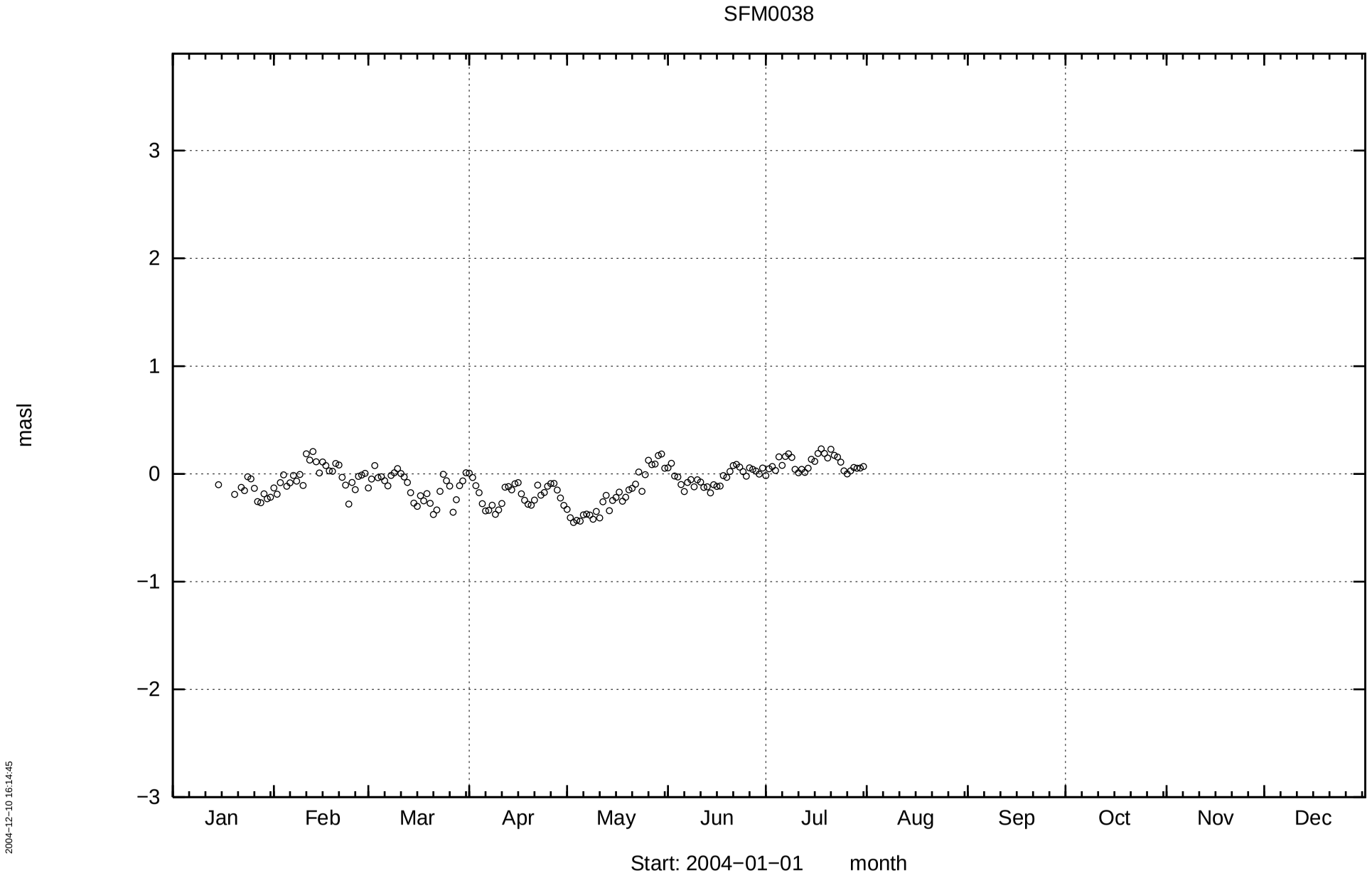
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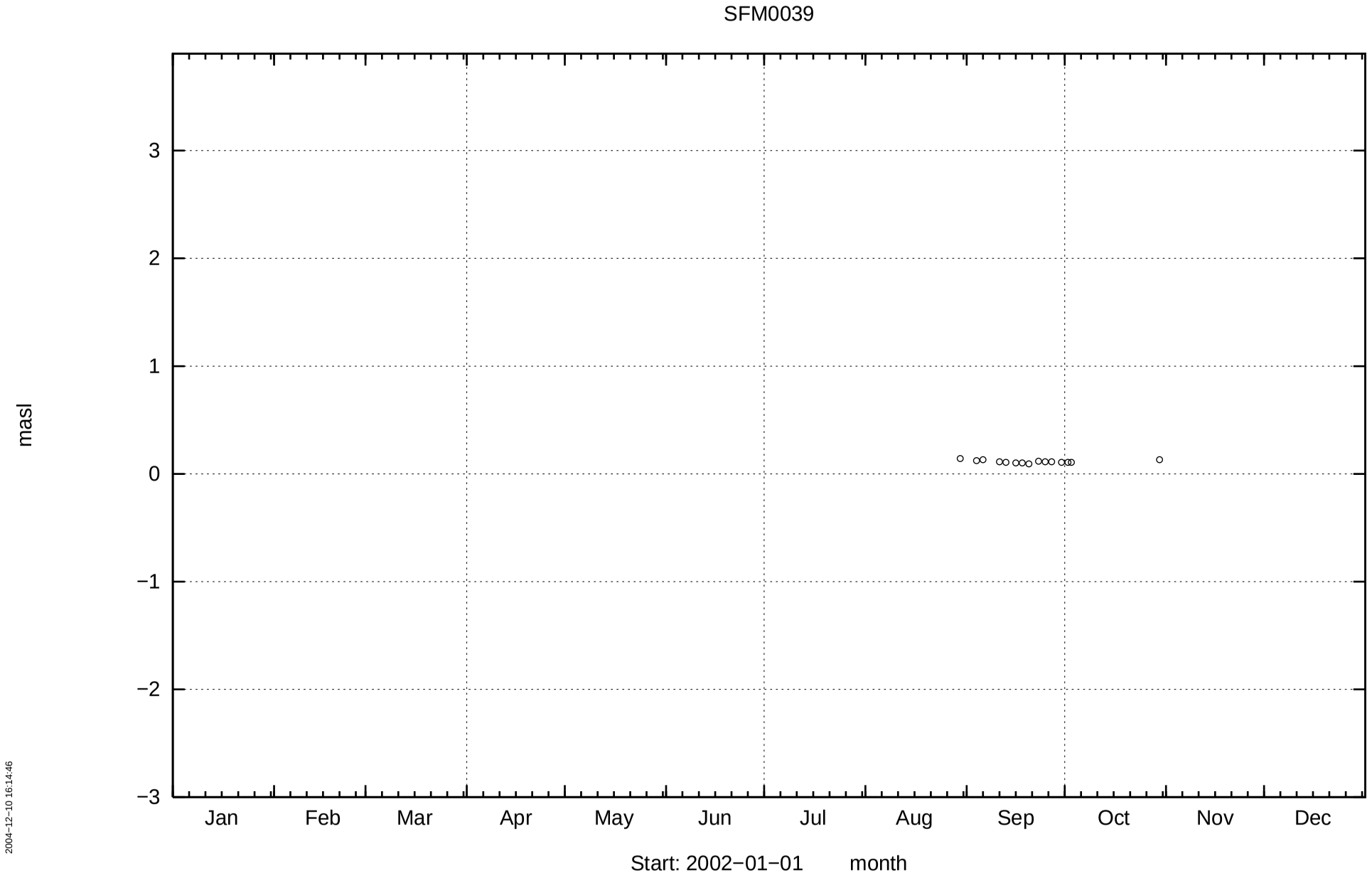
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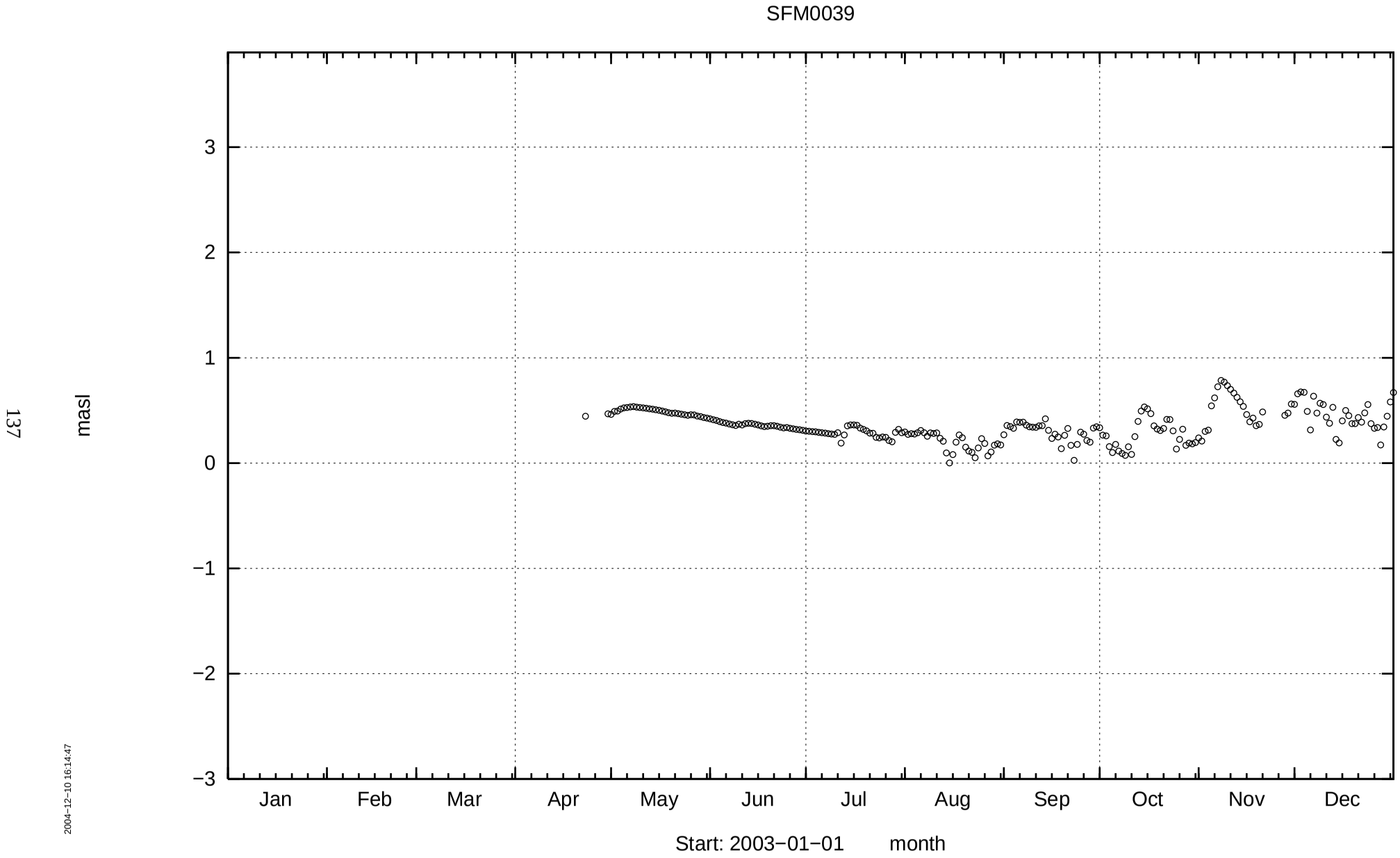
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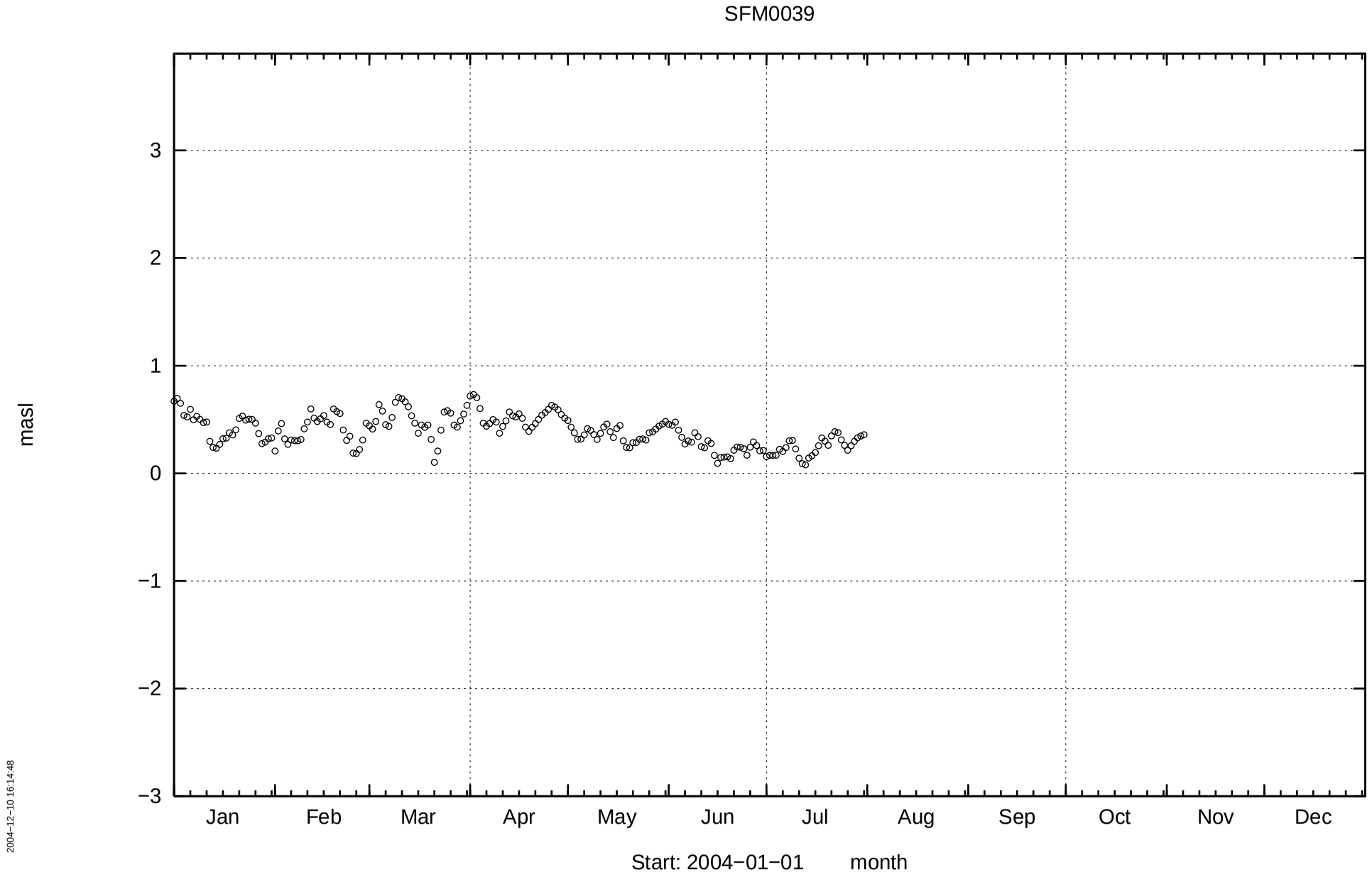
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138
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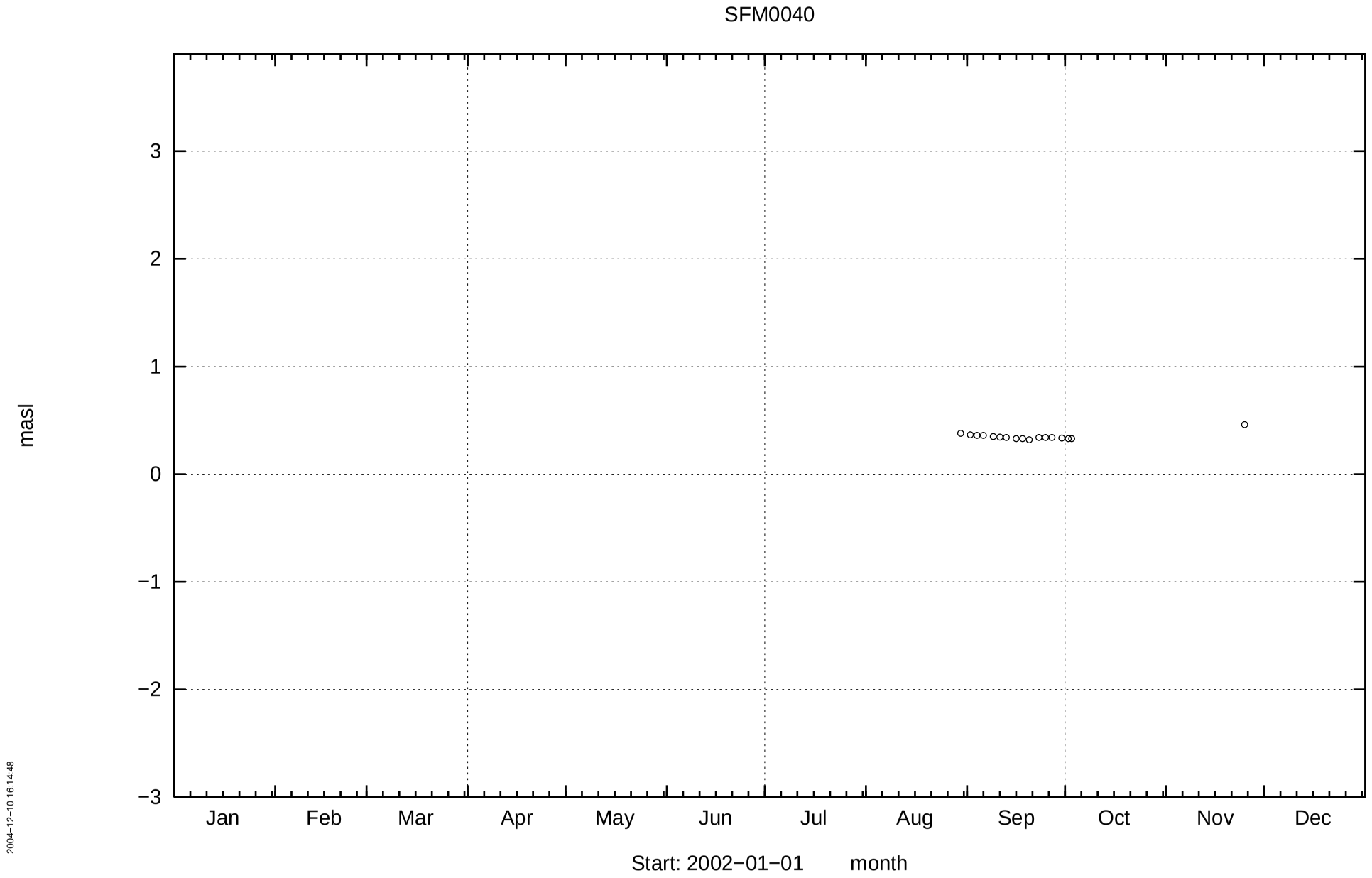
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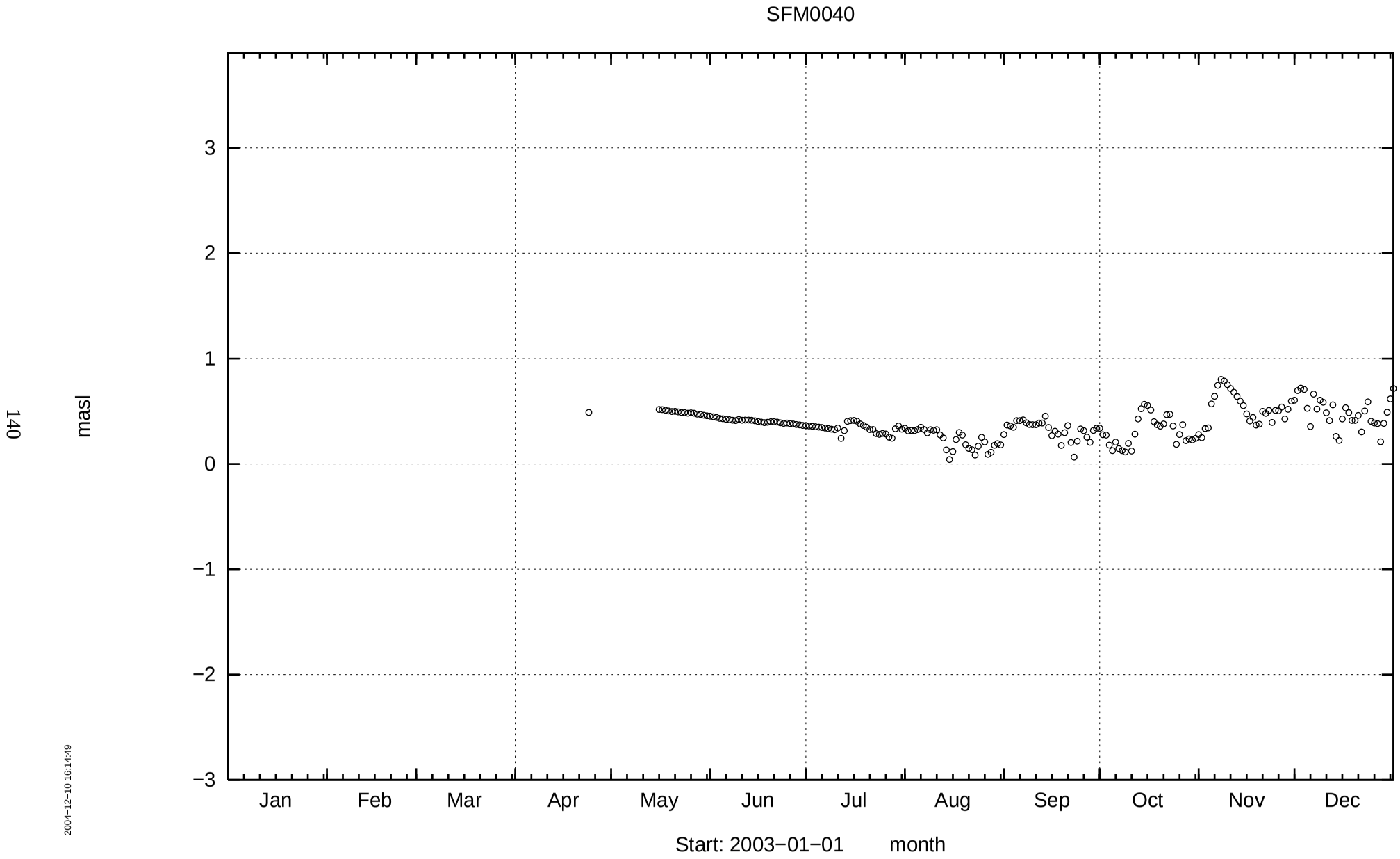
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140
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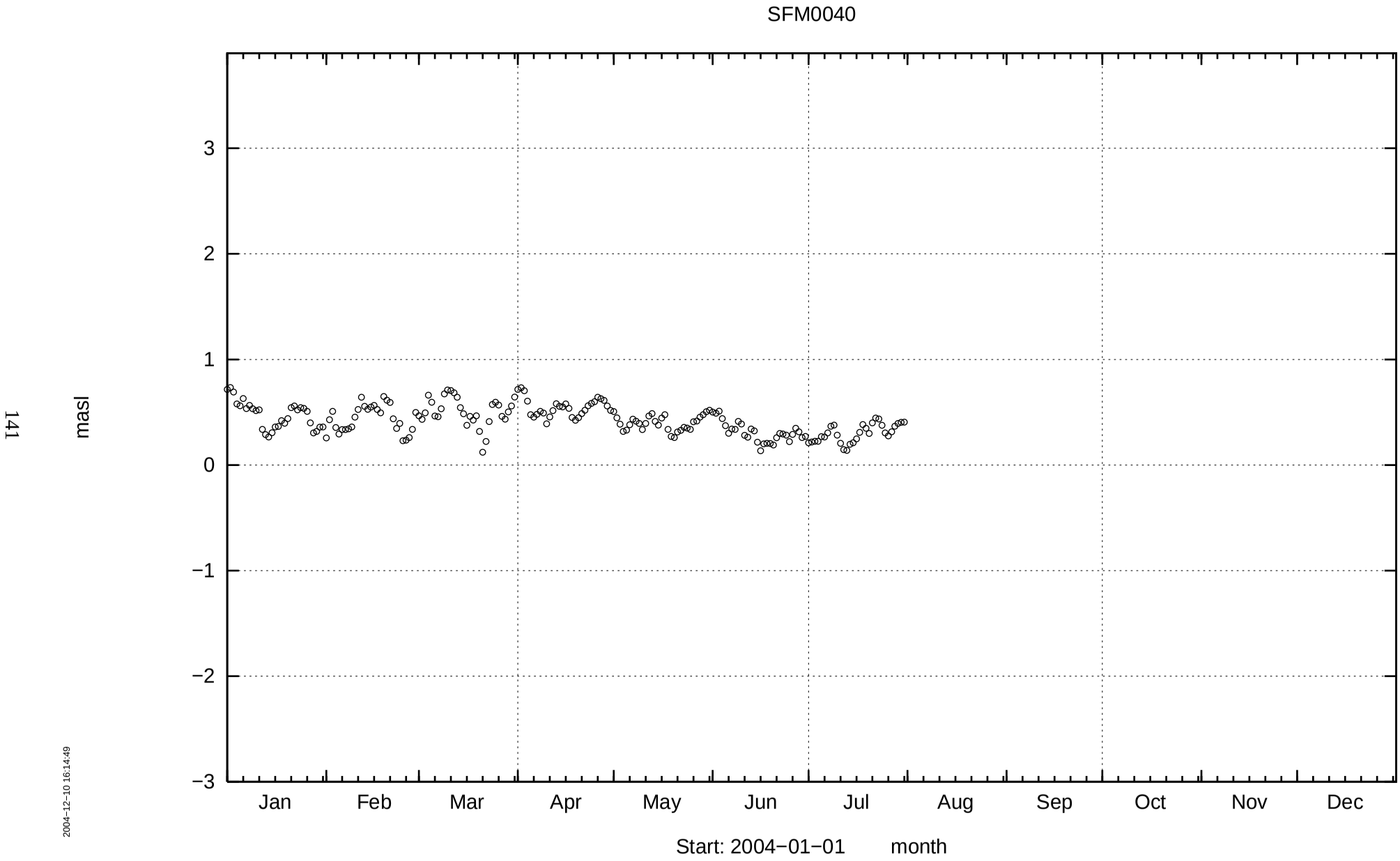
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141
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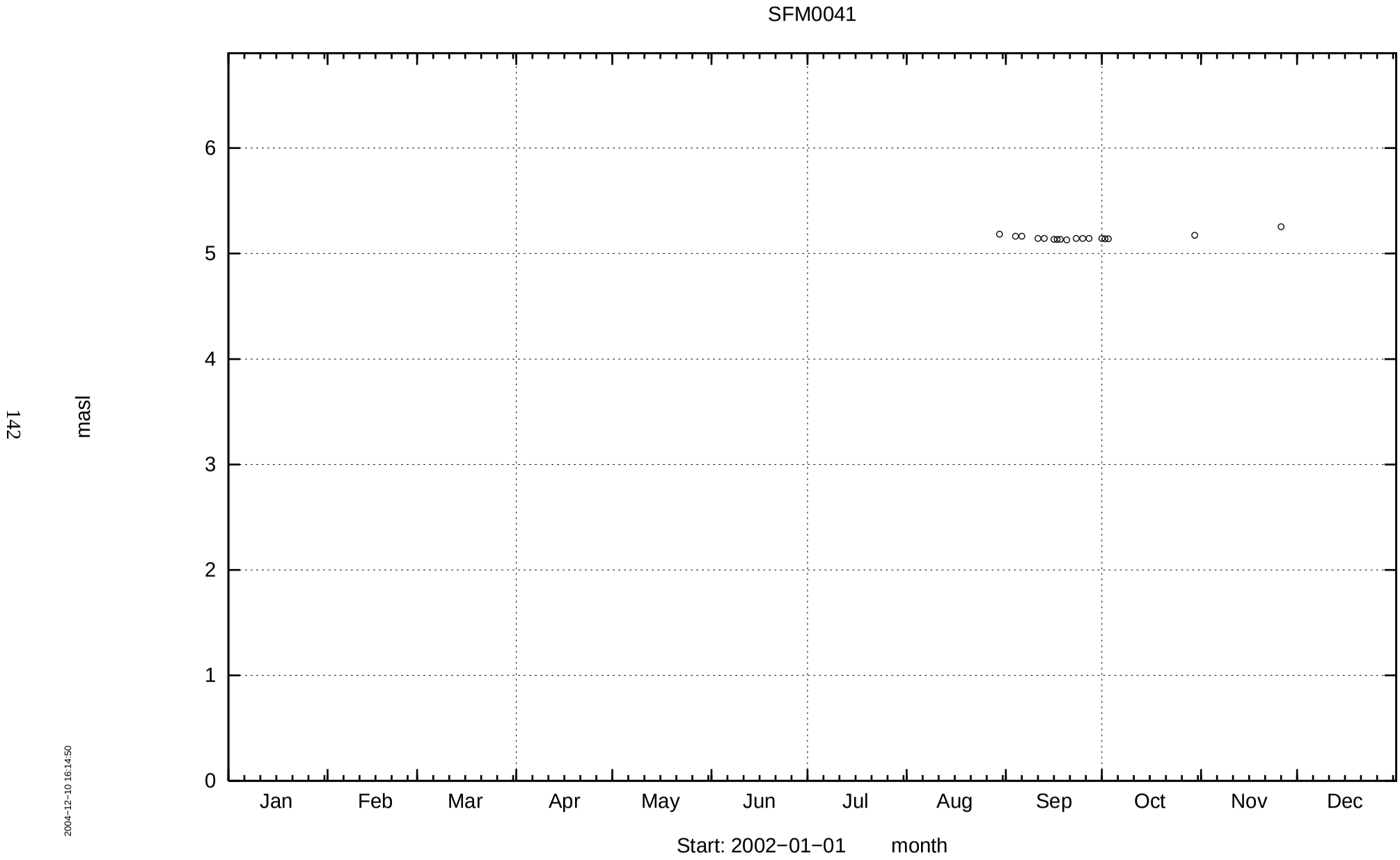
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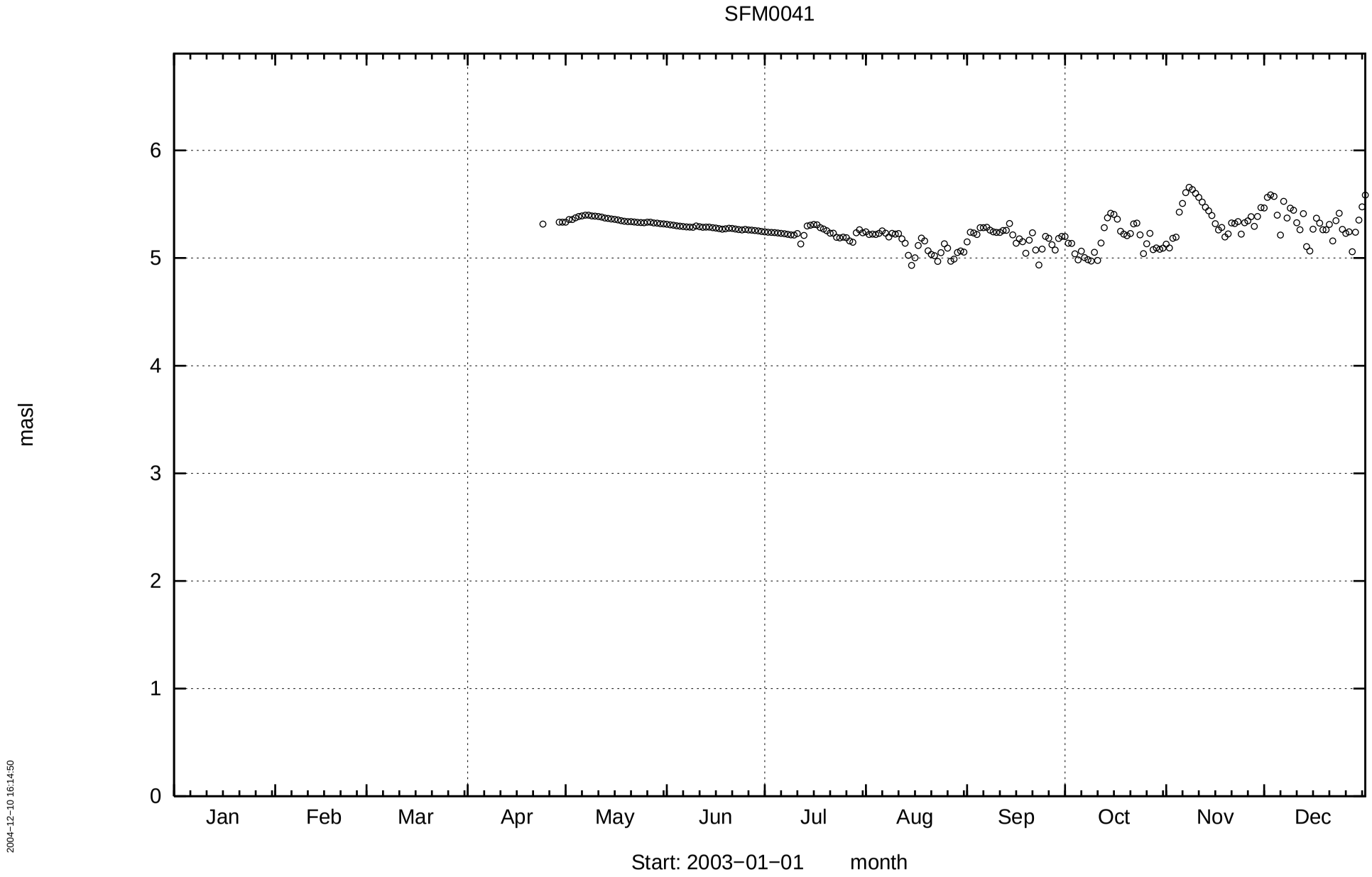

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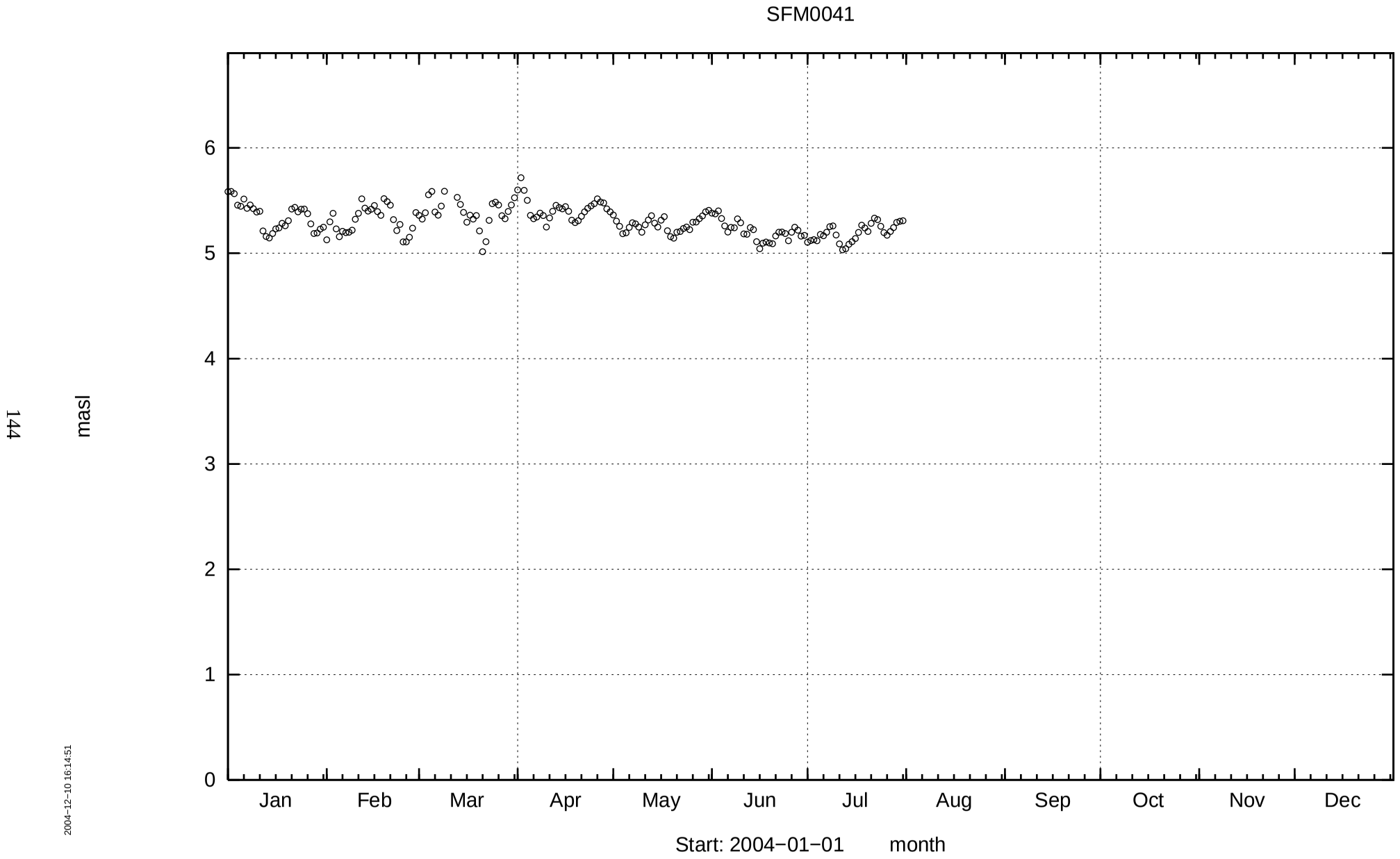
2004−12−10 16:14:50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144
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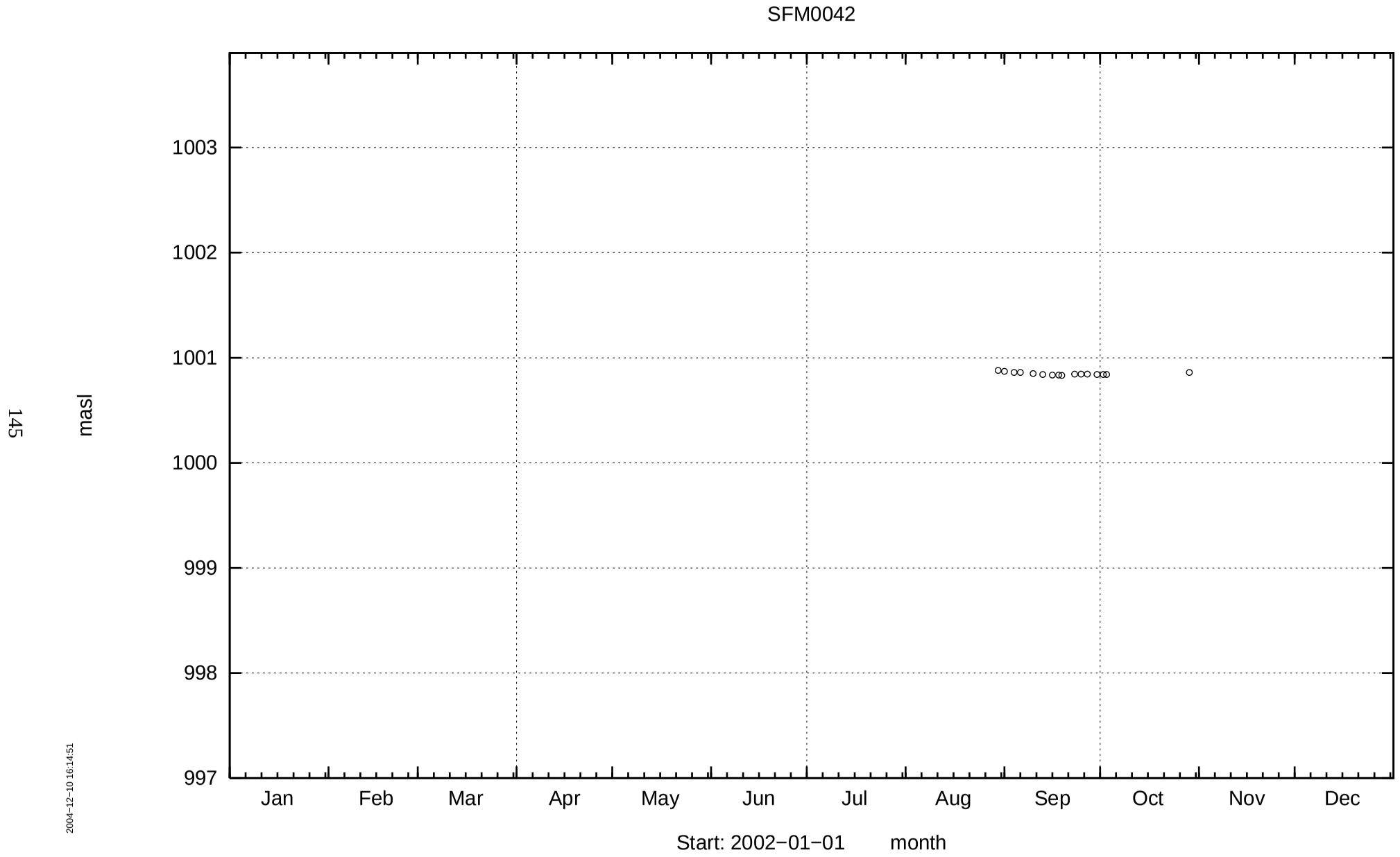
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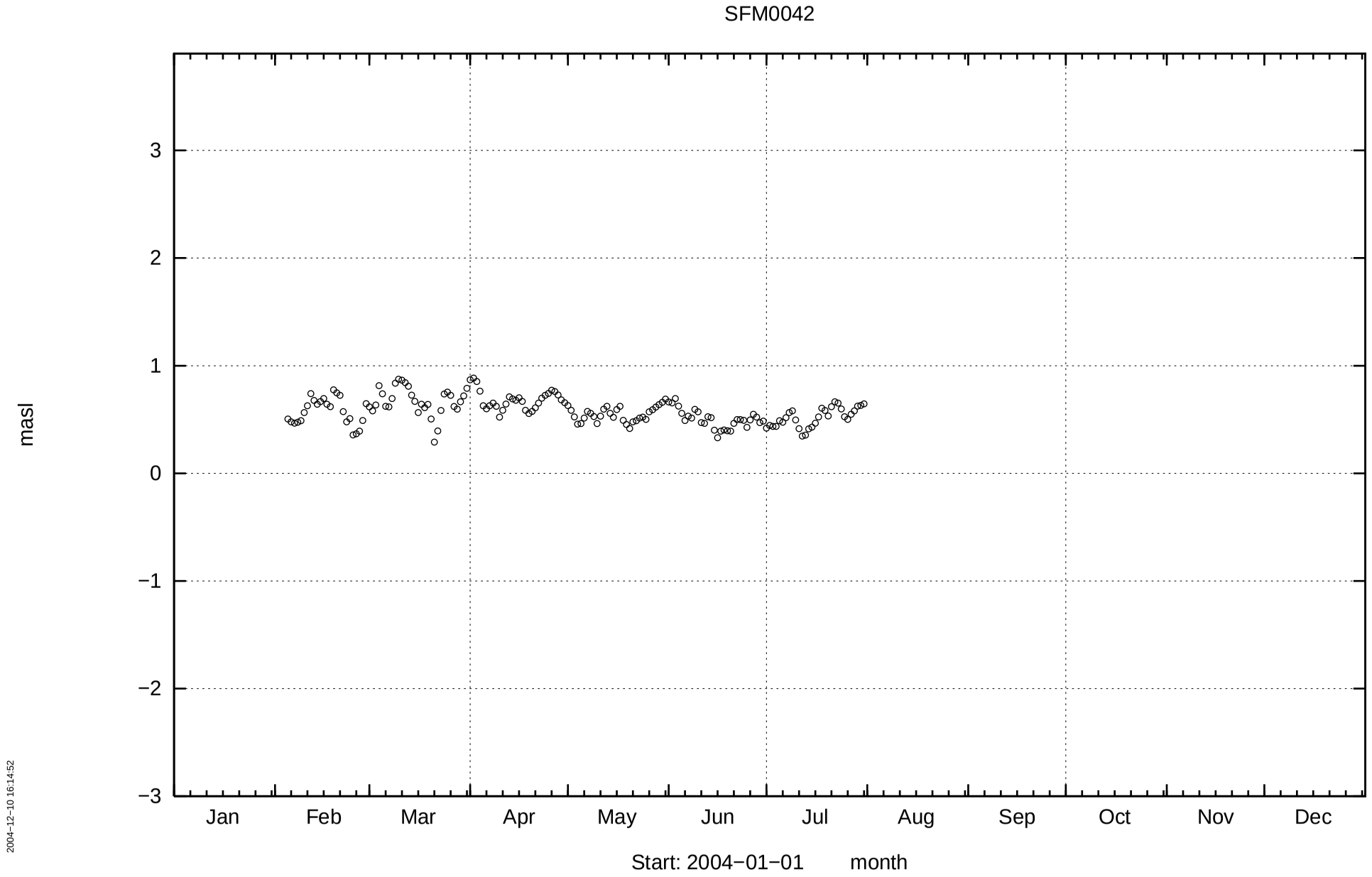
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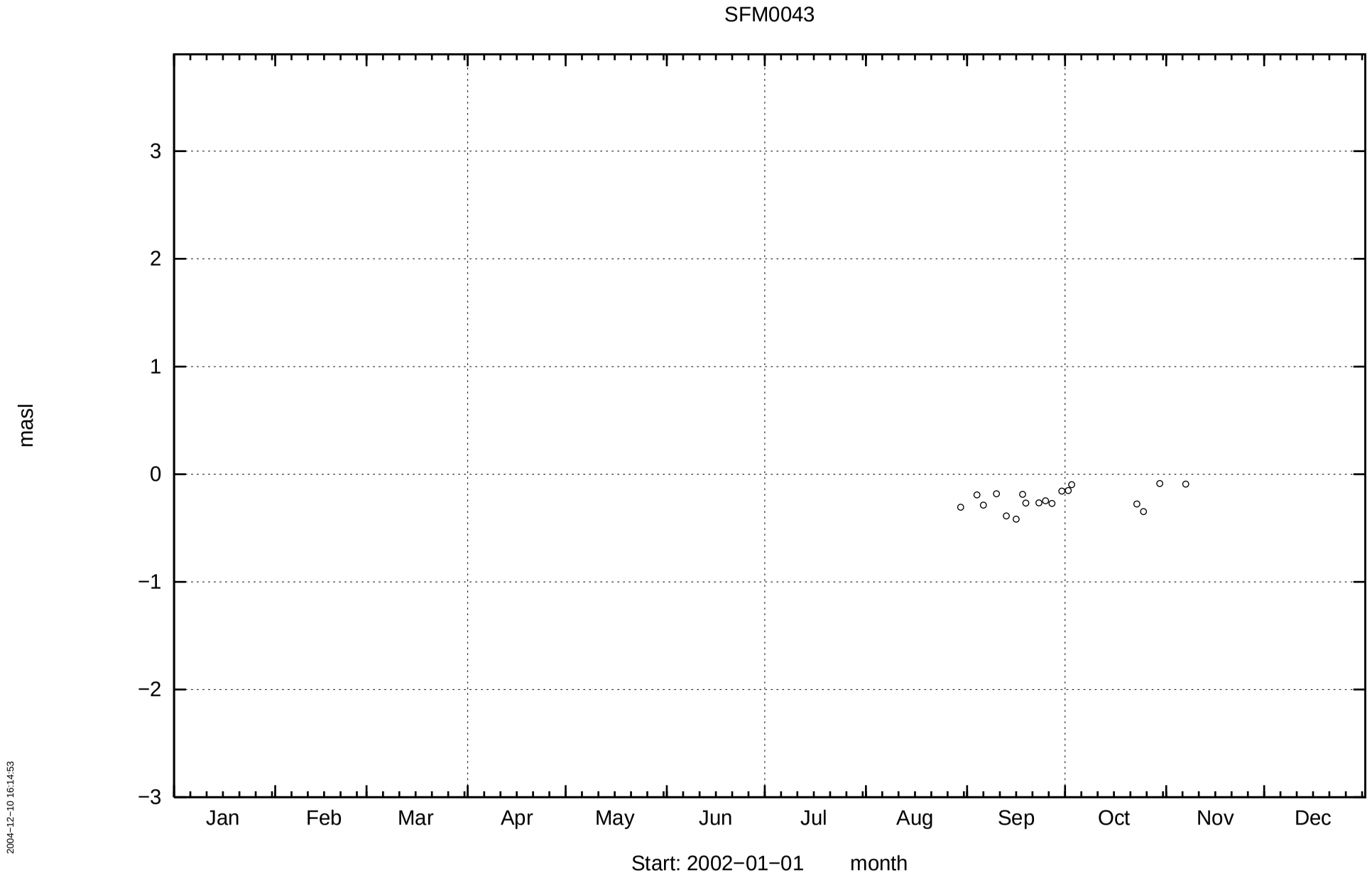
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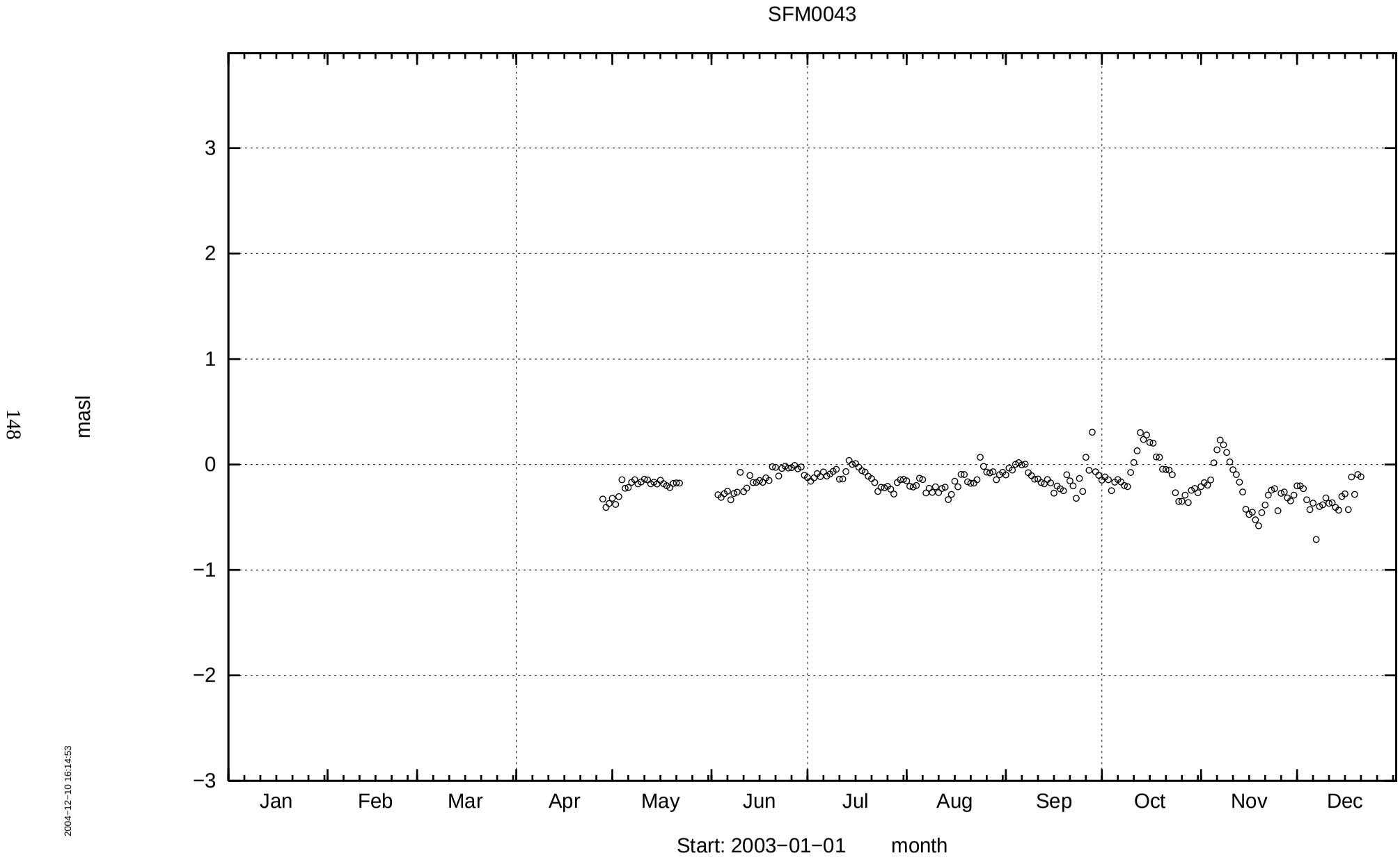
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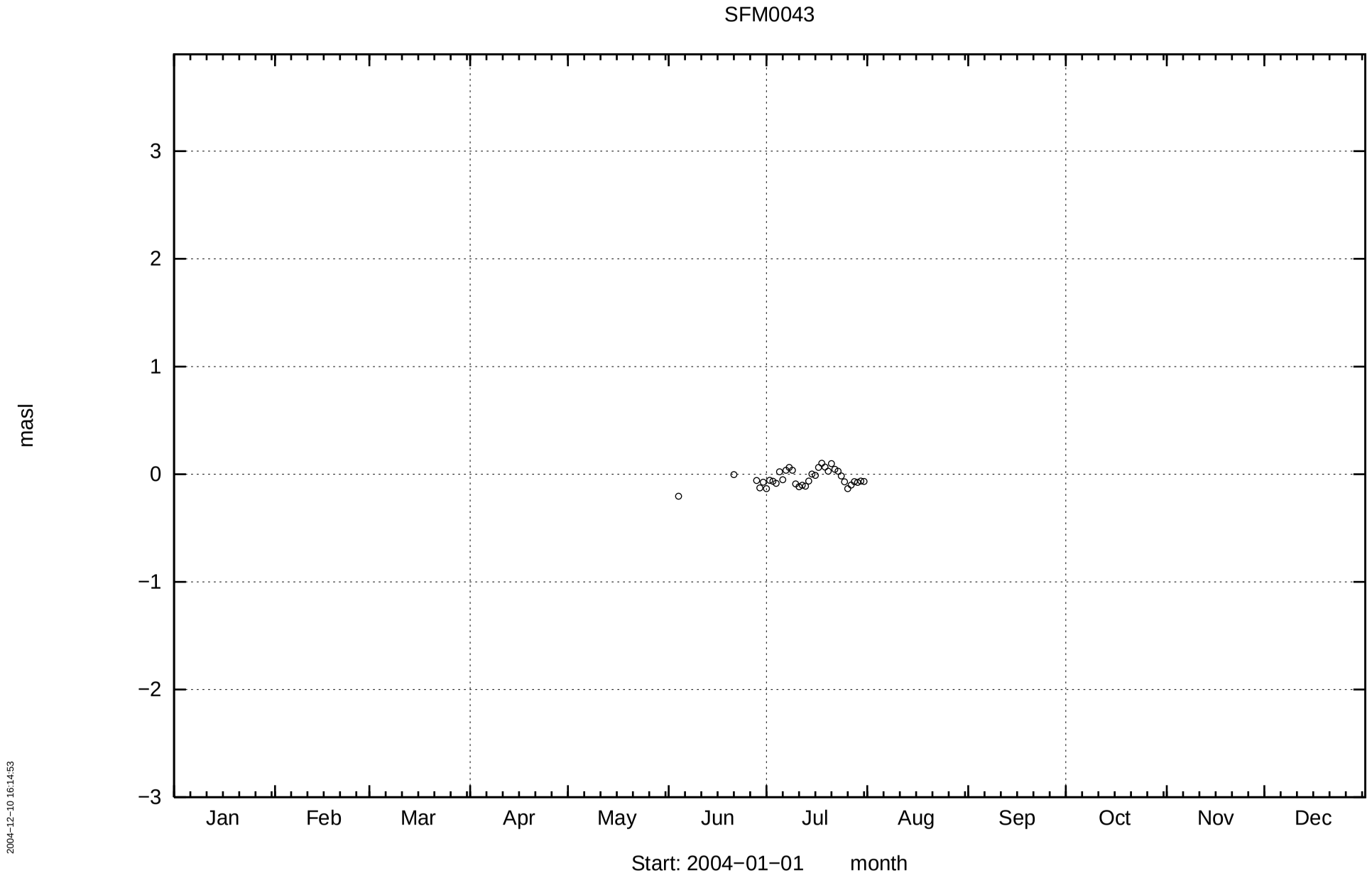
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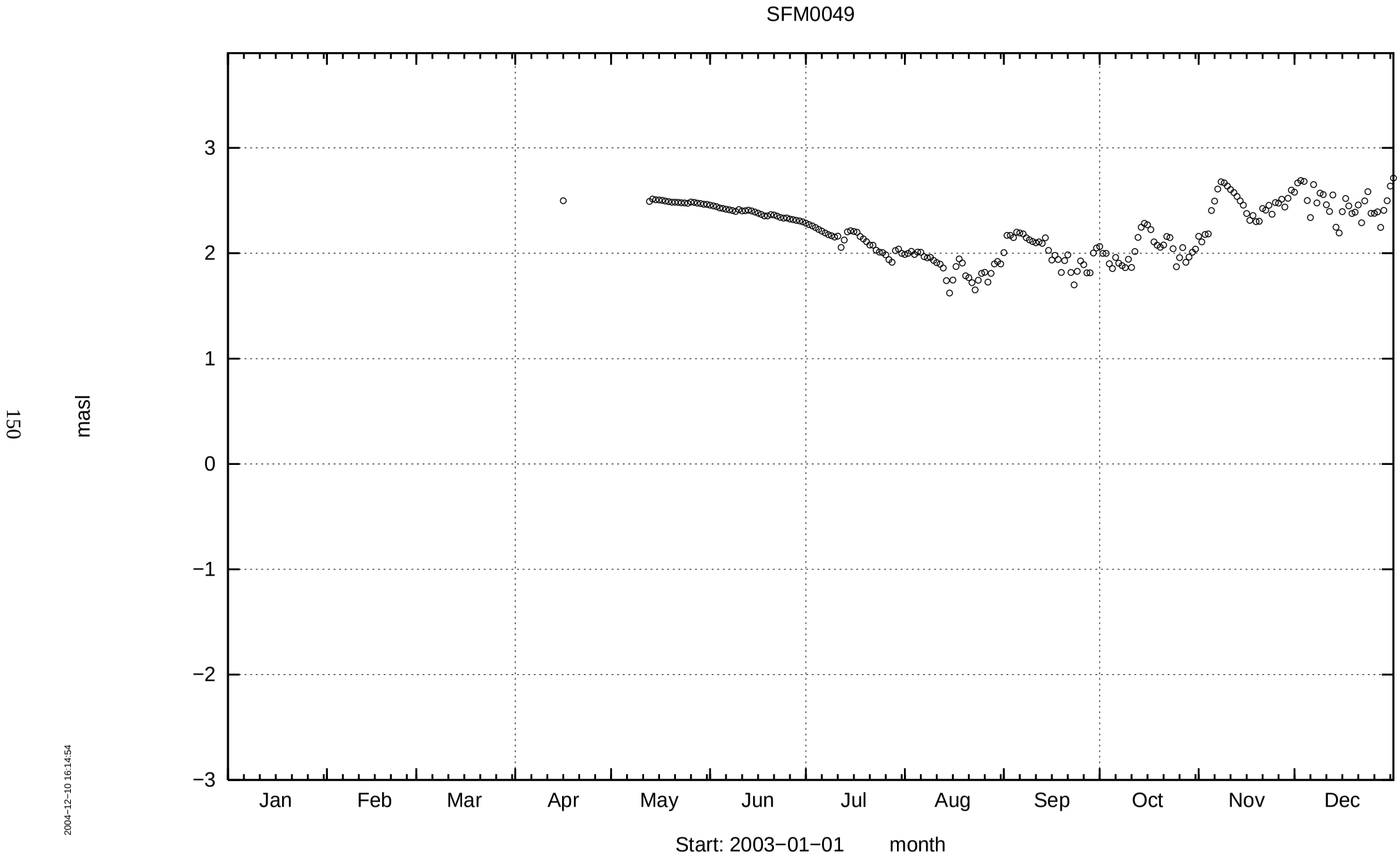
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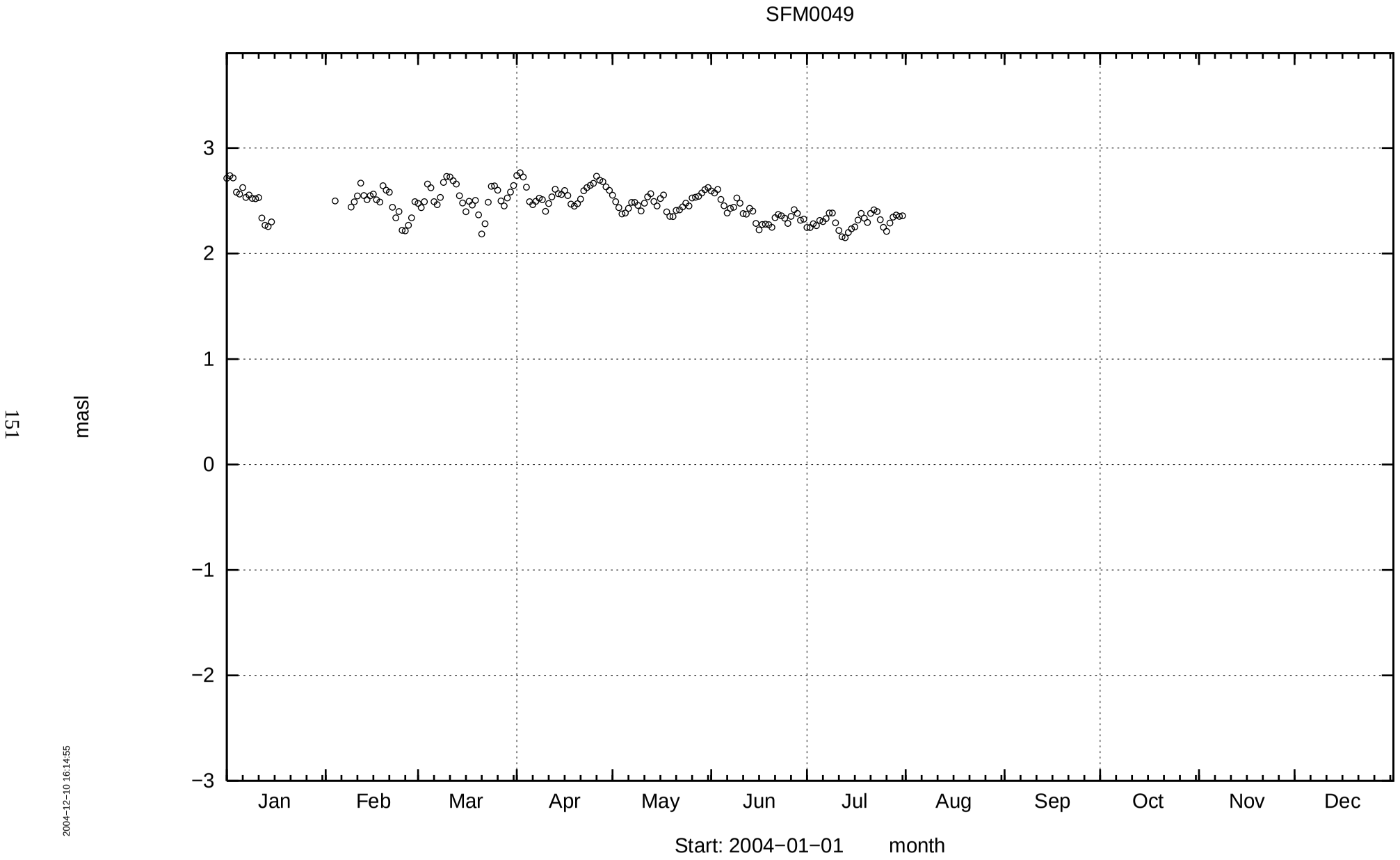
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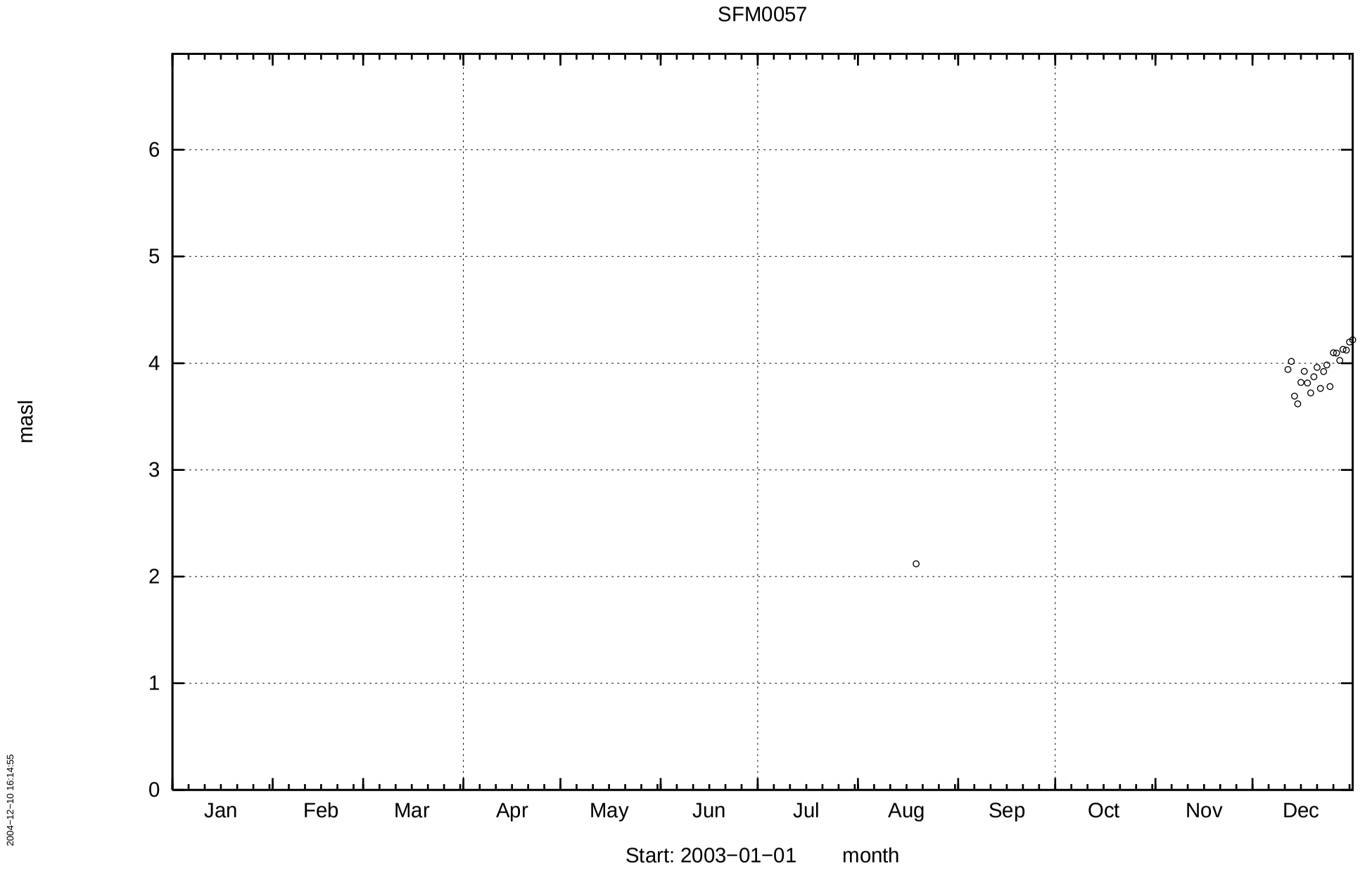

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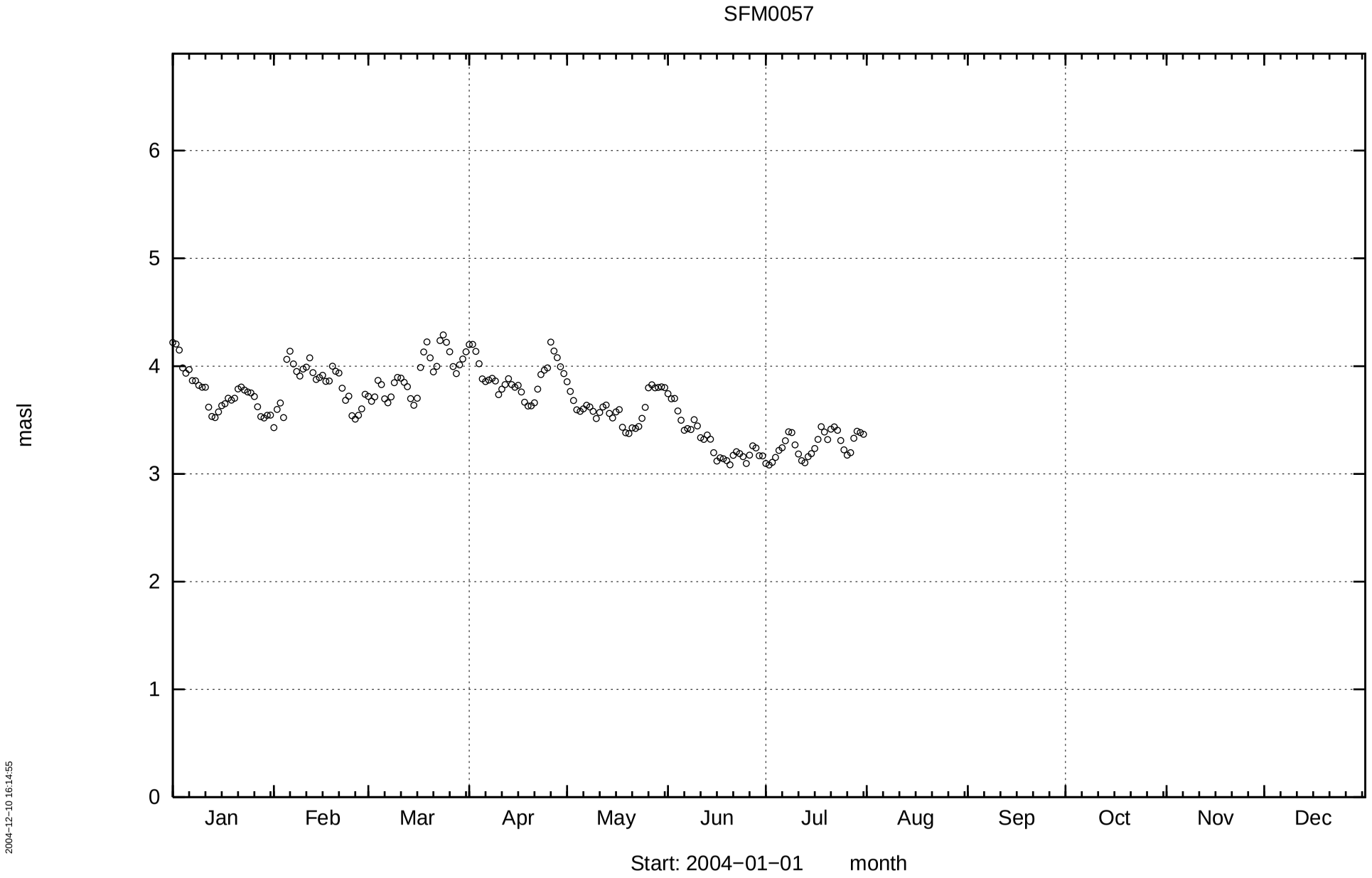
SFM0057
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153
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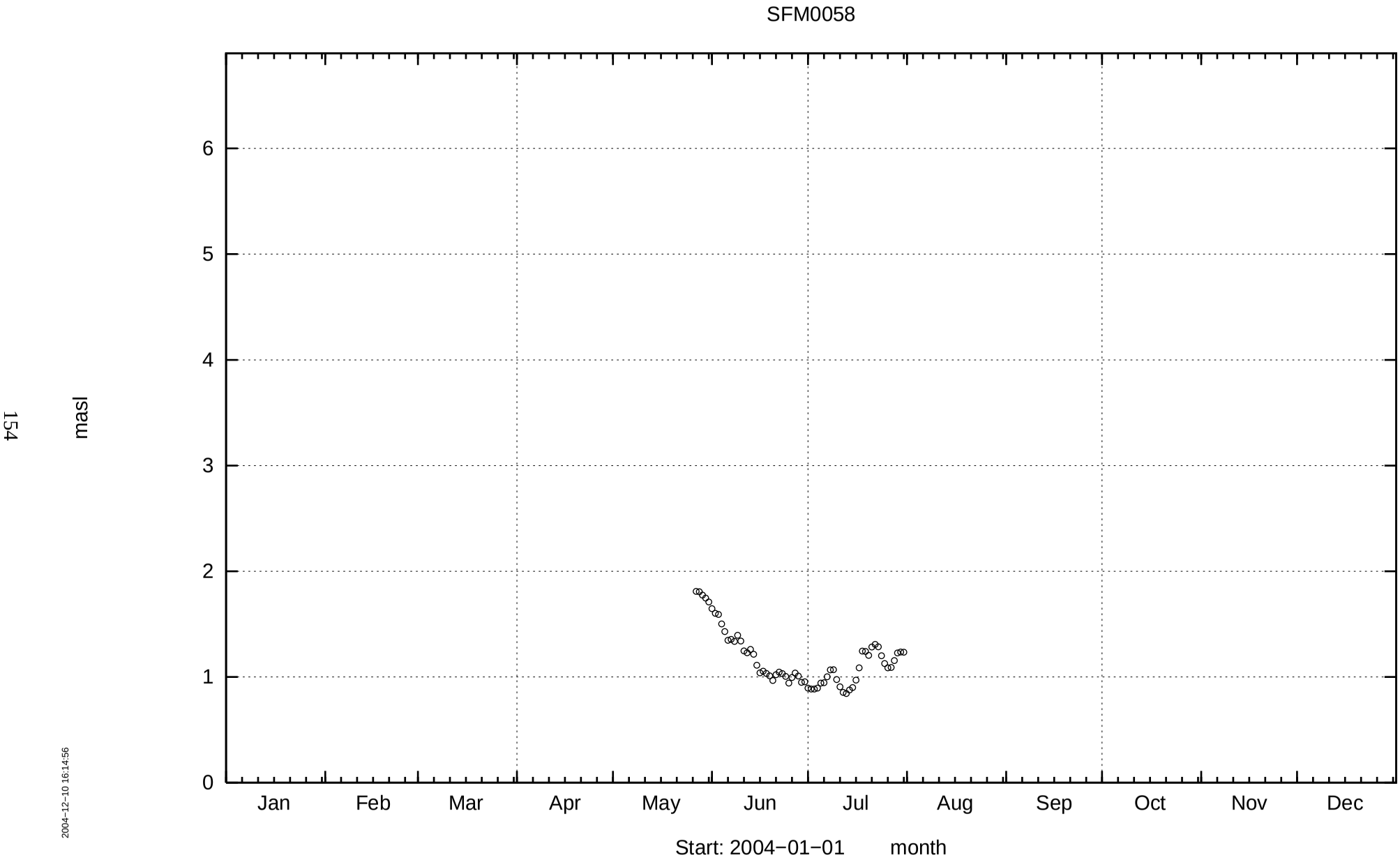
SFM0058
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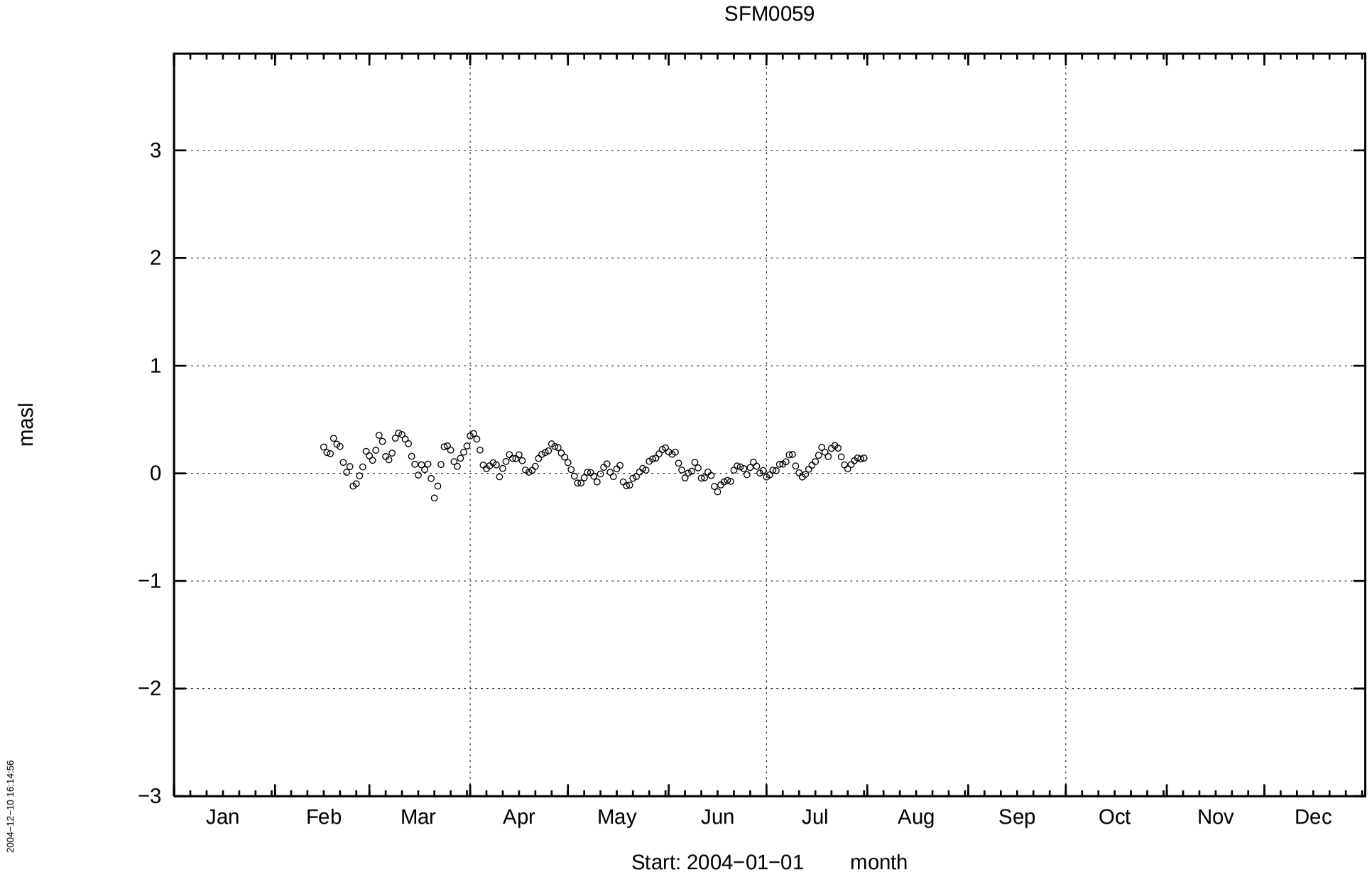
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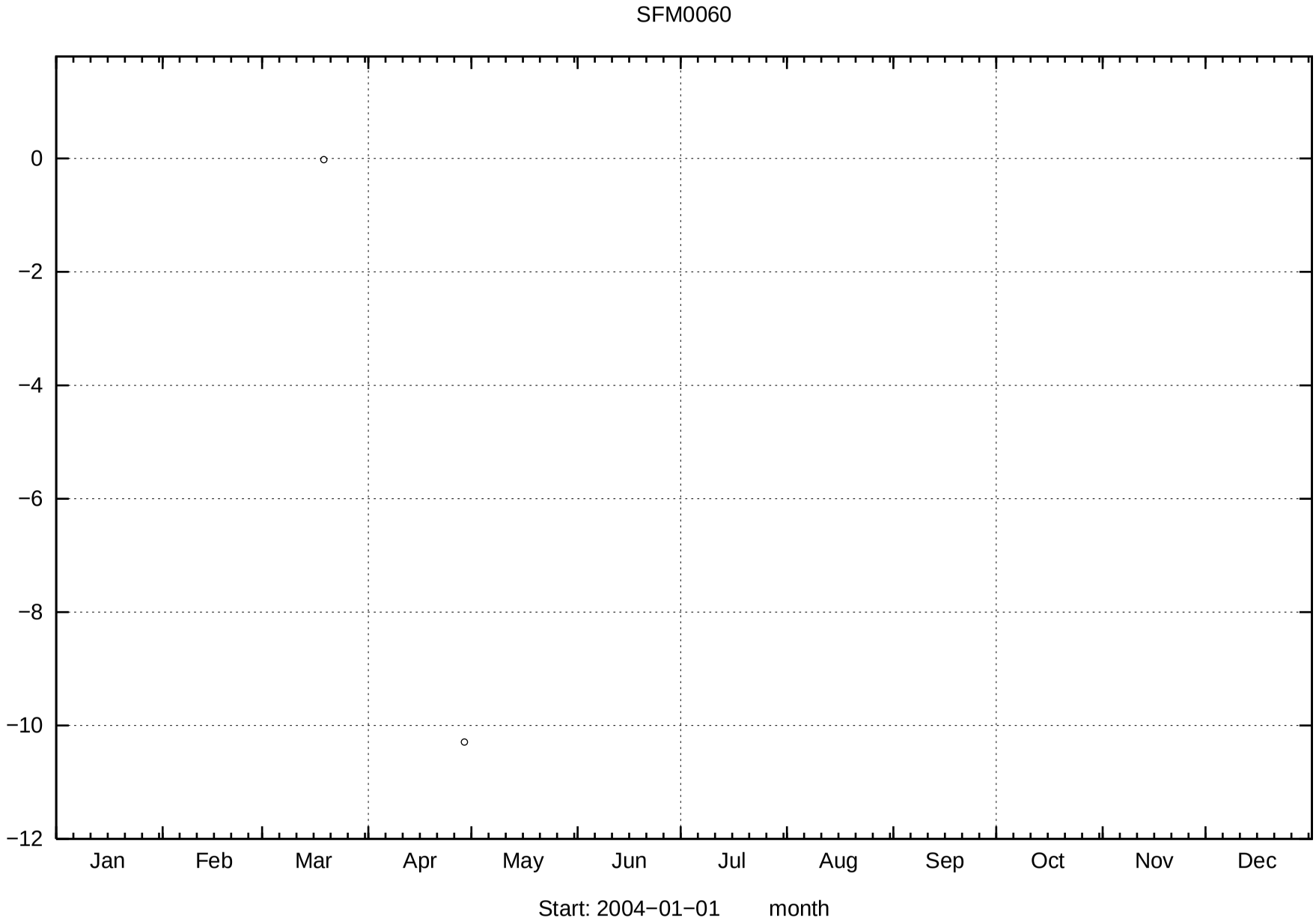

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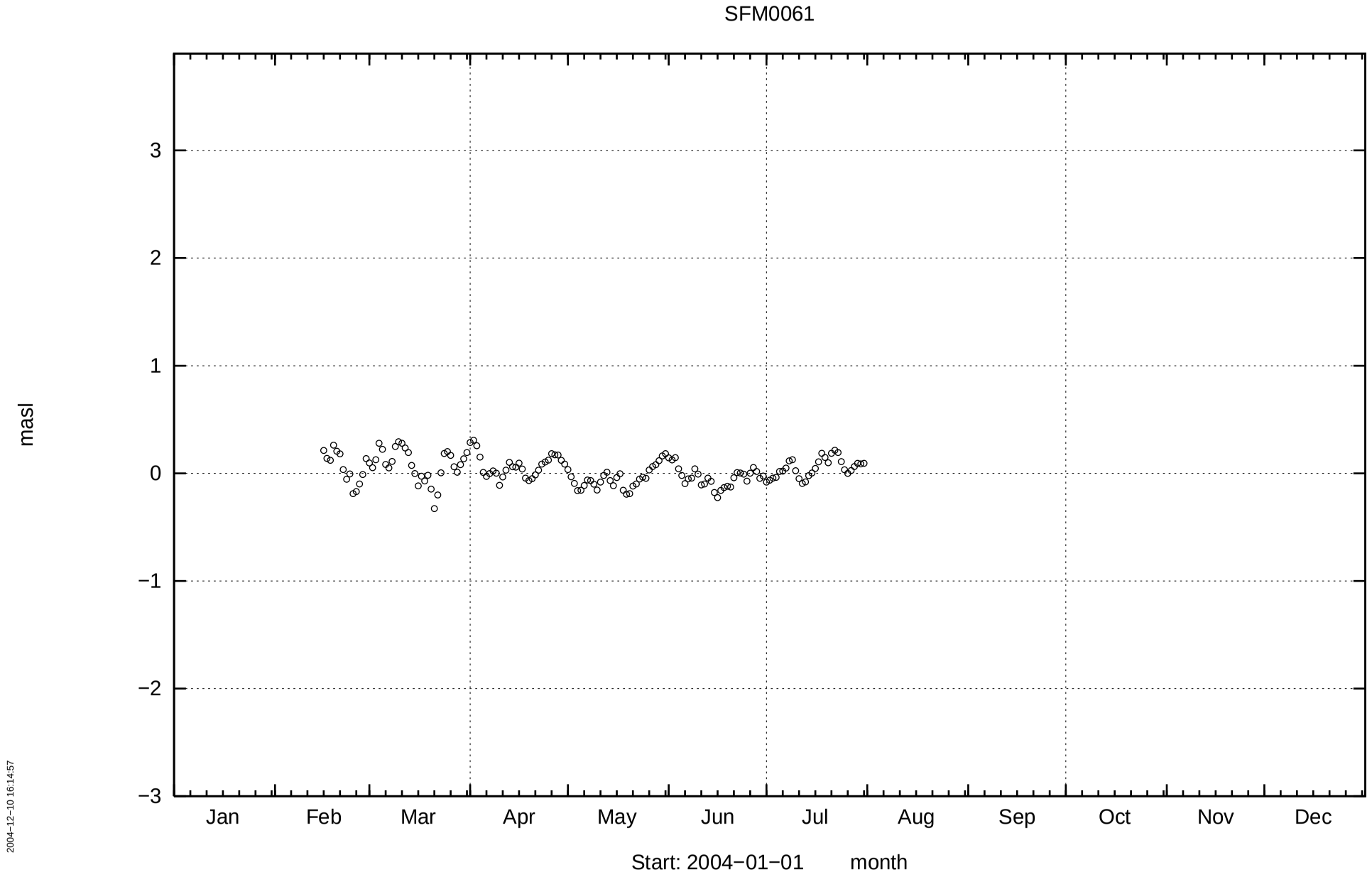
SFM0061
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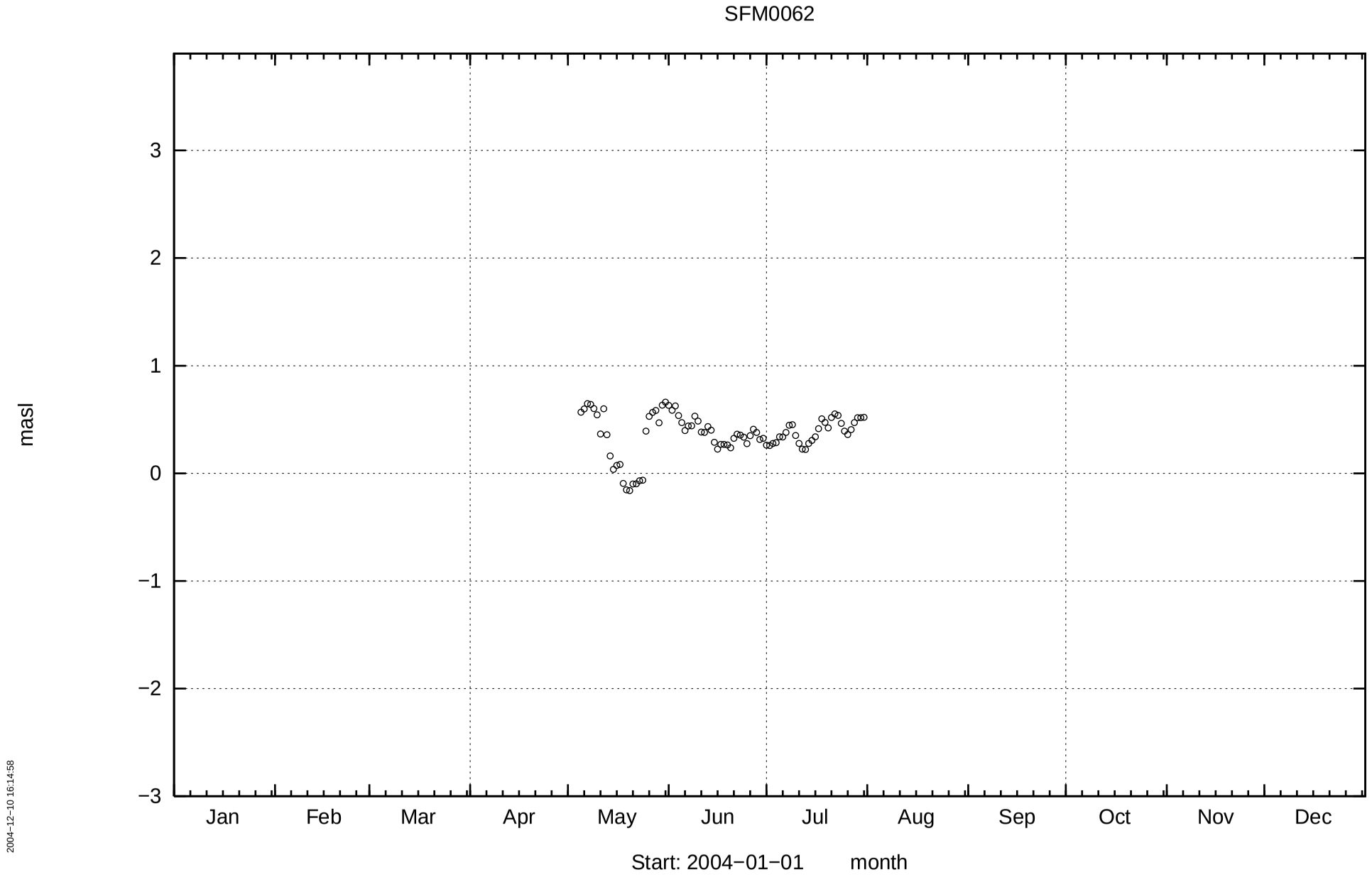
SFM0062
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Start: 2004−01−01
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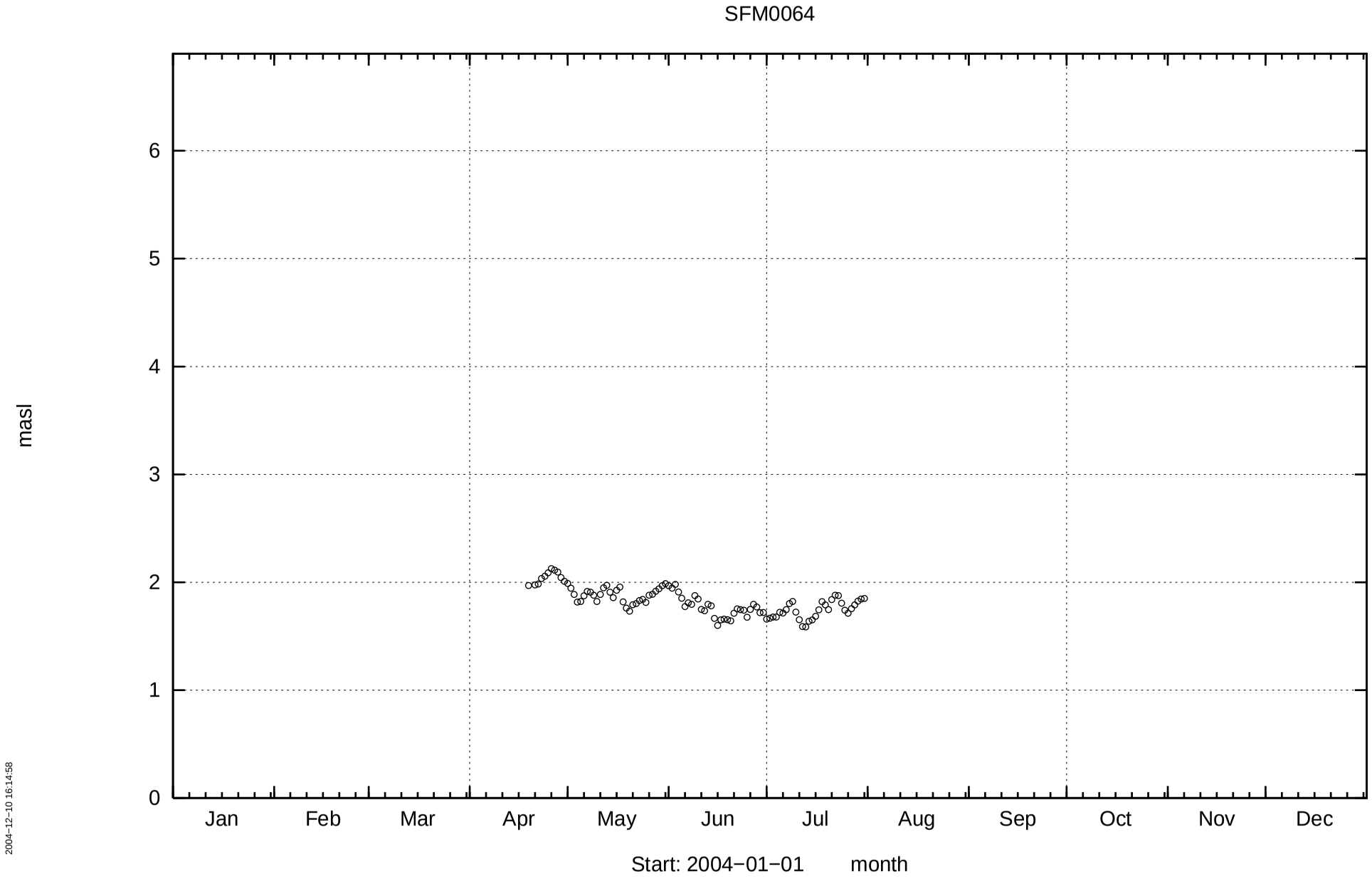
158
2004−12−10 16:14:58



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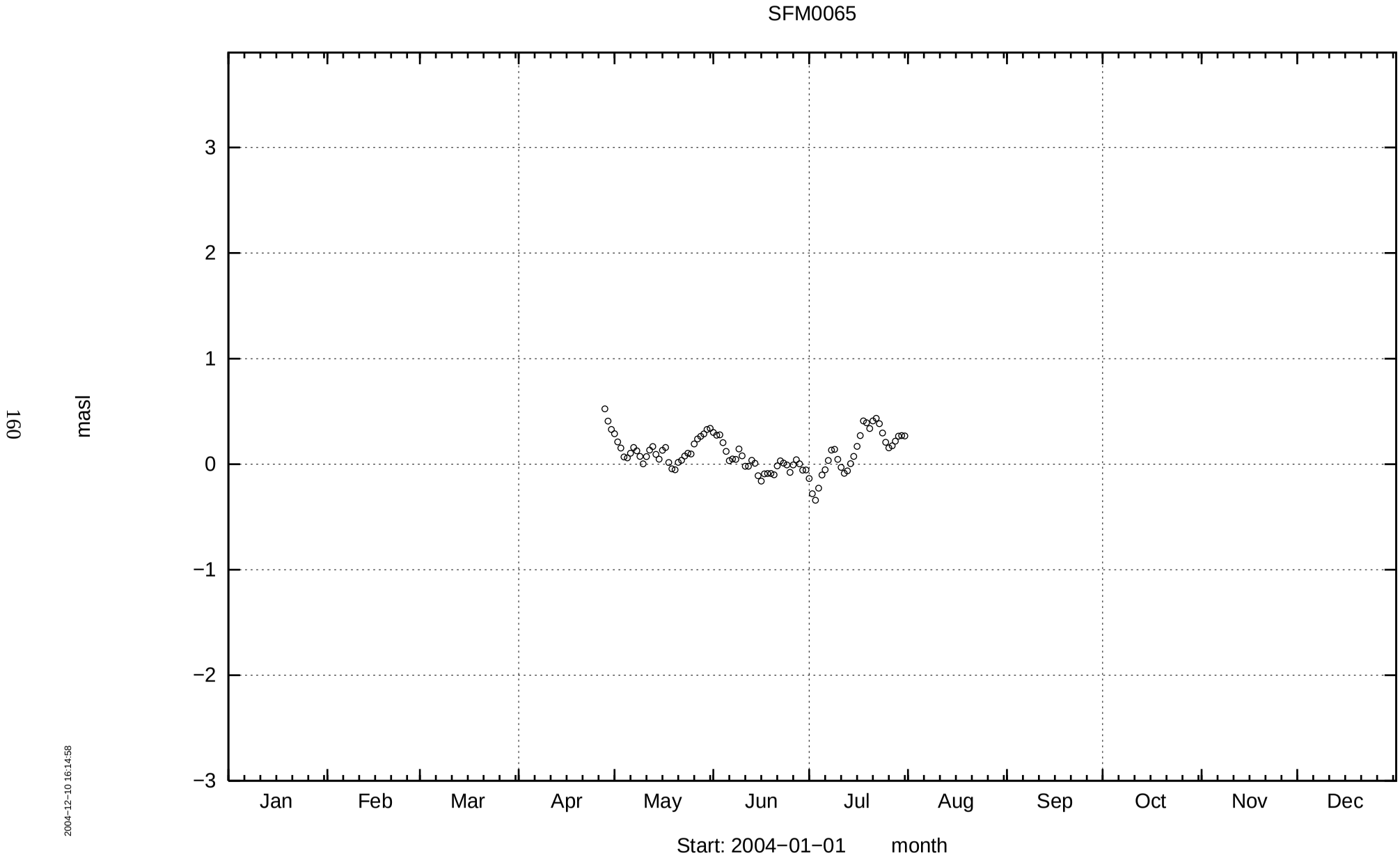
SFM0065
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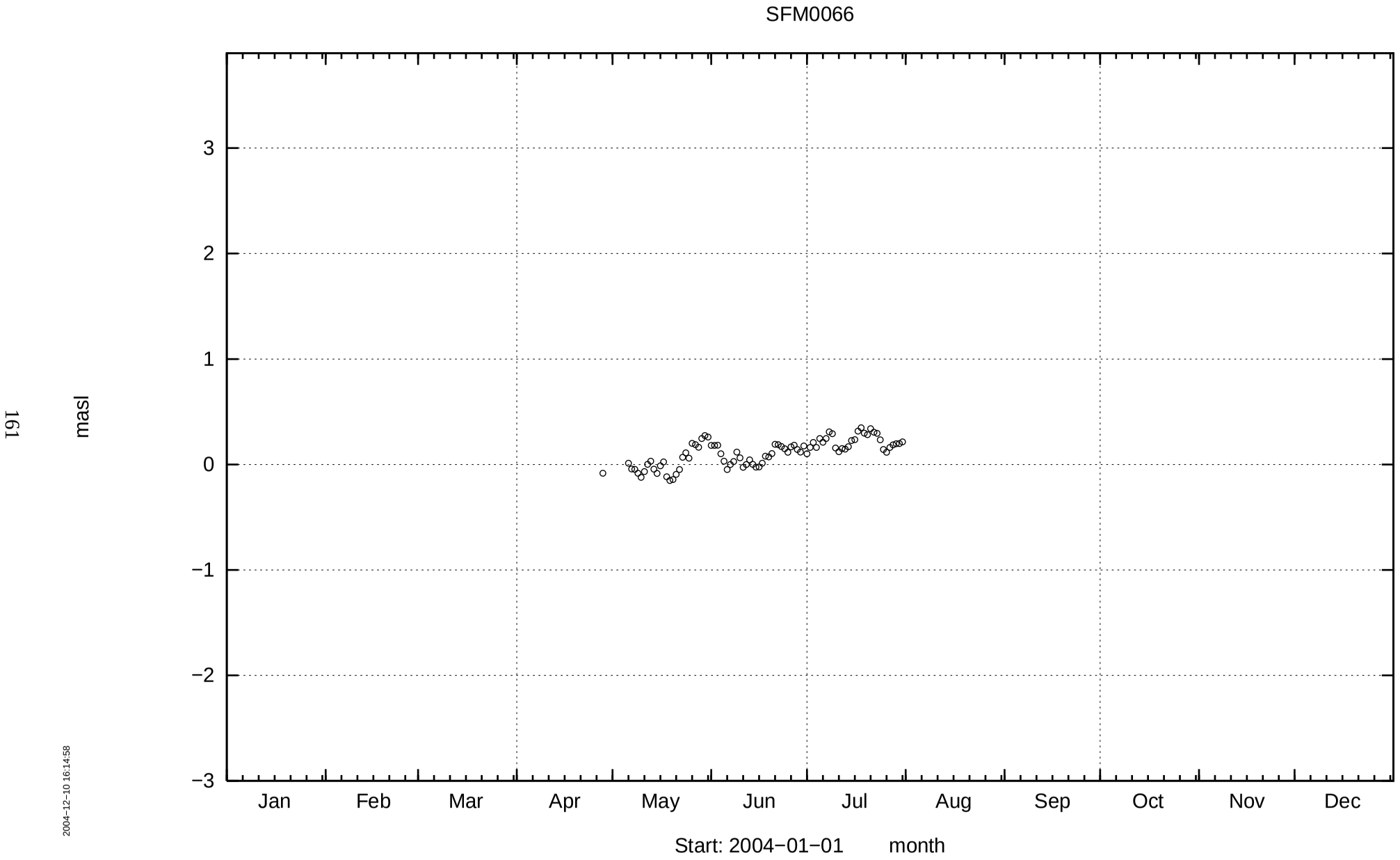
SFM0066
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Start: 2004−01−01
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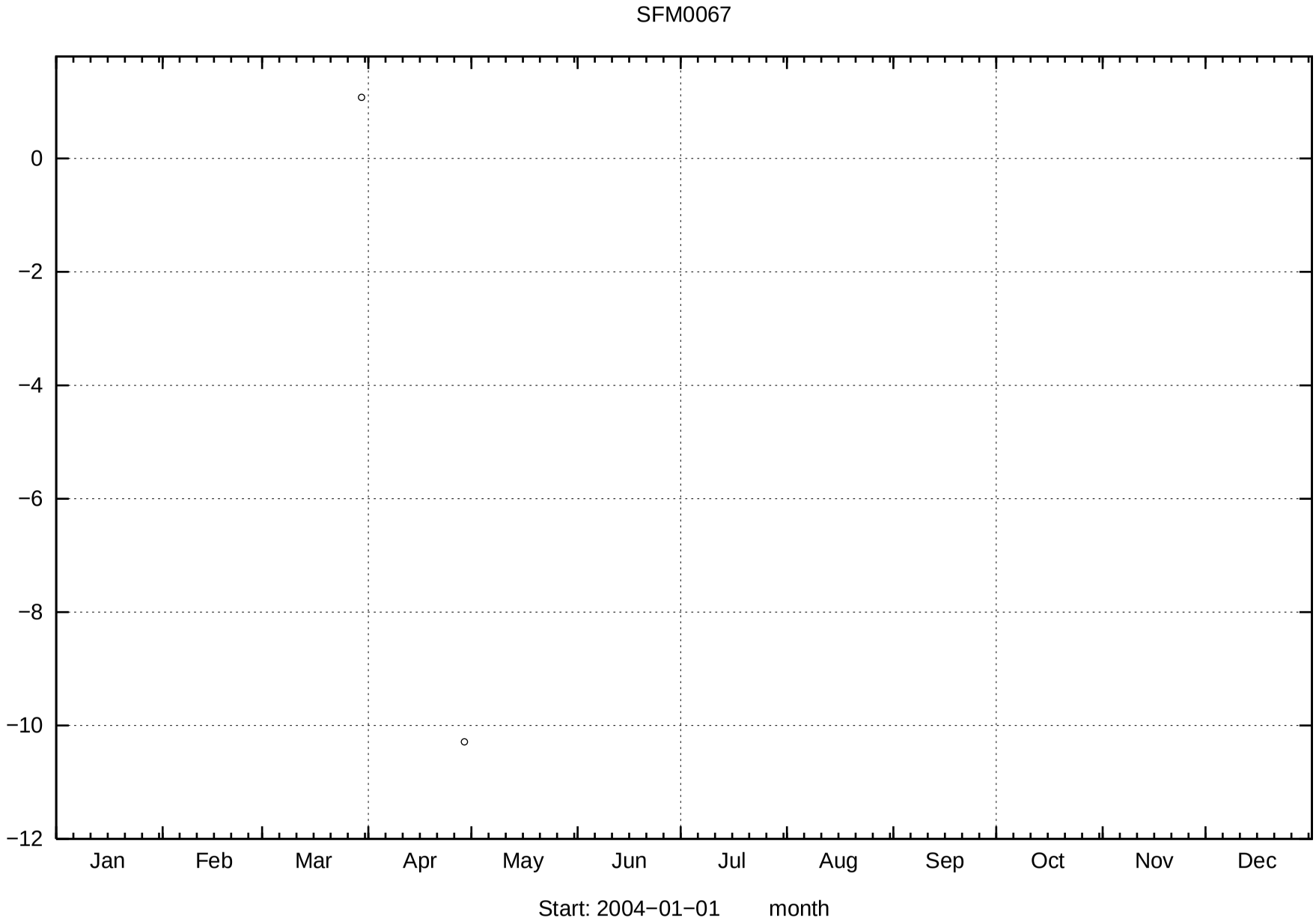
161
2004−12−10 16:14:58



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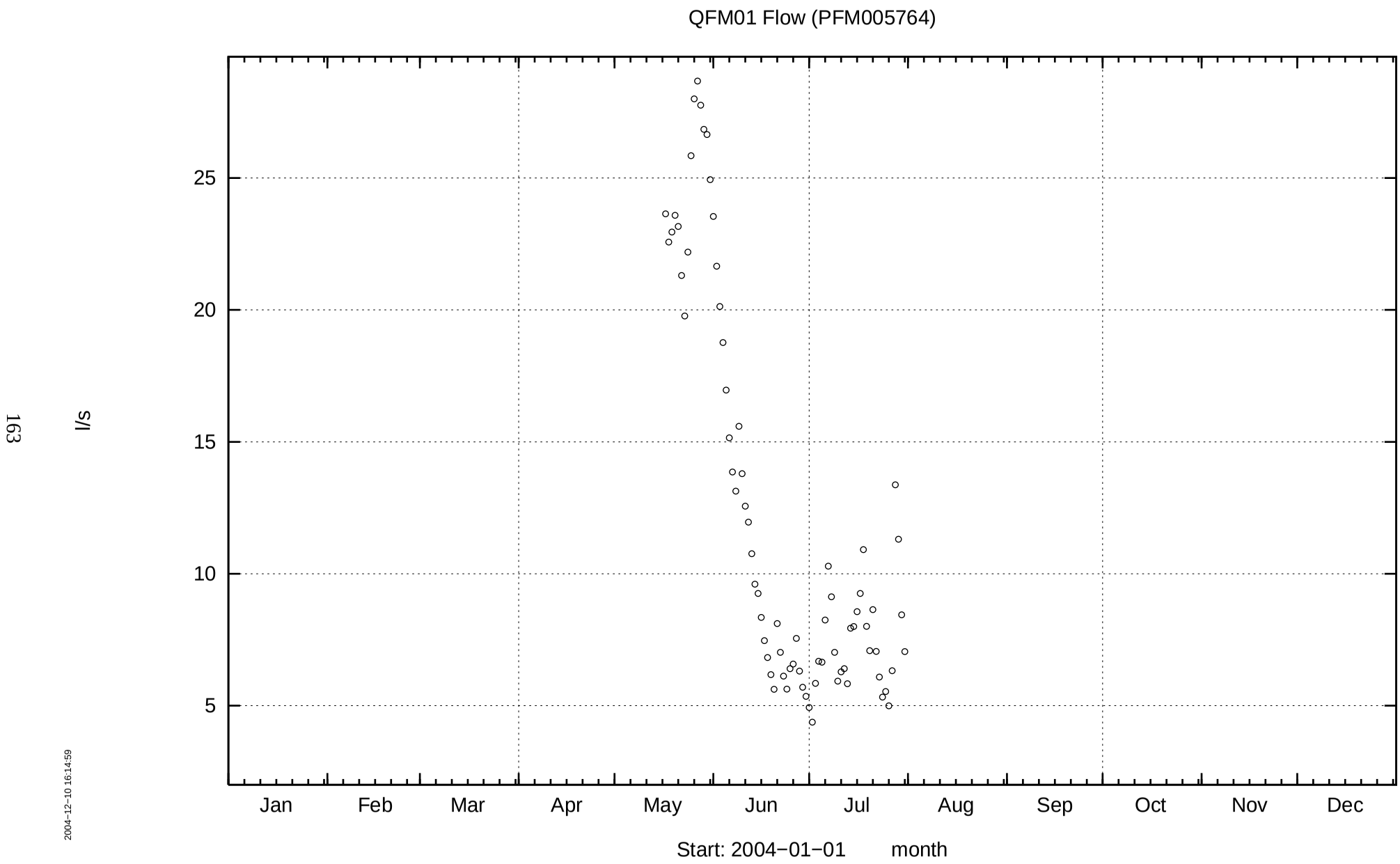
QFM01 Flow (PFM005764)
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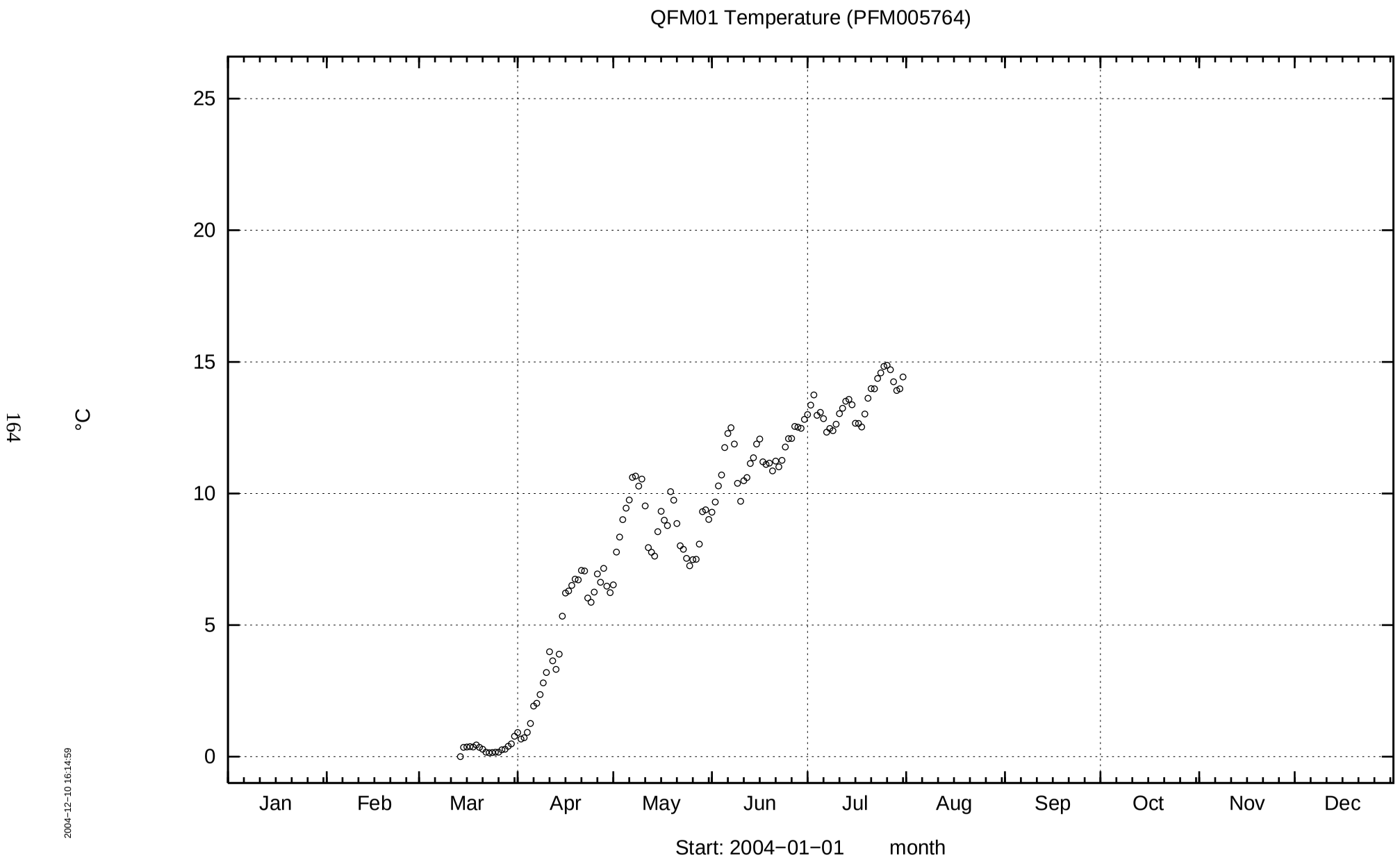
Start: 2004−01−01
month
163
2004−12−10 16:14:59


QFM01 Temperature (PFM005764)
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C°
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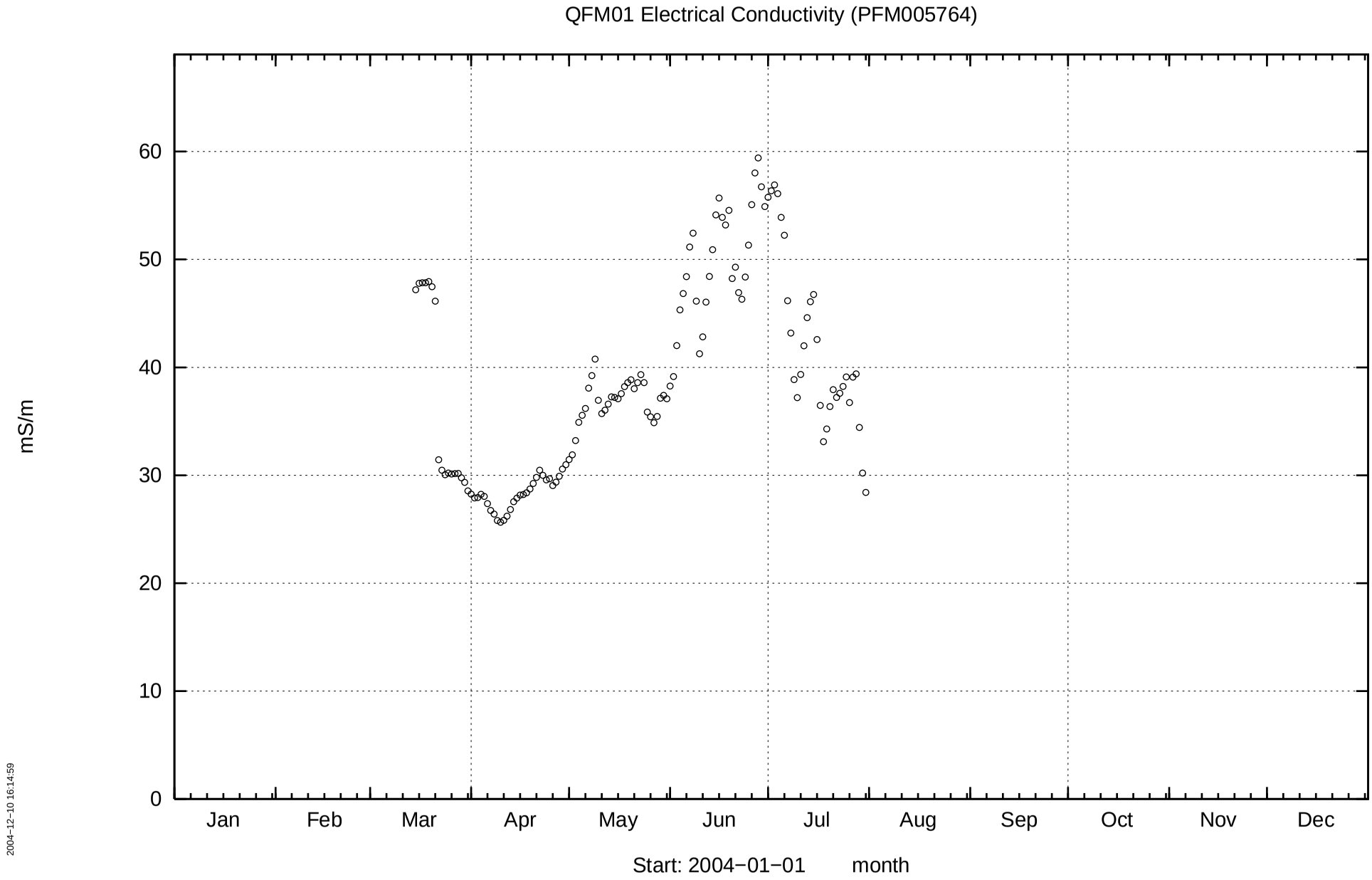
Start: 2004−01−01
month
164
2004−12−10 16:14:59



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