Realtime CII (1 minute)

Multiply by 1000 to convert Fuel Density to "g" units.
Fuel Densityの単位を"g"に合わせるために1000を掛ける

HFO
重油

Fuel Oil Consumption
燃料消費量

Fuel Density
燃料密度

CO2 Coefficient
CO2係数

$$CII\_1min = \frac{F\_L[L/min] \times \rho[kg/L] \times 1000 \times EF[g/g]}{DWT[ton] \times Lr \times V[knot] \times (1/60)} = \frac{F\_L[L/min] \times 0.991[kg/L] \times 1000 \times 3.114[g/g]}{6950[ton] \times 1.0 \times V[knot] \times (1/60)}$$

Deadweight tonnage

Loading Ratio
積載率

Ship Speed
船速

A knot indicates how many nautical miles traveled per hour, so multiply by 1/60 to convert to one minute.
knotは一時間あたりに何海里進むかを示すので、1分間に換算するために1/60を掛ける

🔧 前提条件（与えられている情報）

項目	内容
船型	Ro-Ro船（DWT = 6,950 トン）
燃料	C重油（HFO）
燃料単位	**リットル/分**（1分あたりの消費量）
船速	ノット（knot） = **海里/時**
サンプリング	1分ごとのデータロガー記録
出力したい値	1分単位での CII（gCO_2 / (t·nm)）

✅ CIIの定義式（基本形）

CIIは次のように定義されます：

$$\text{CII} = \frac{\text{CO}_2\text{排出量 (g)}}{\text{輸送量 (t・nm)}}$$

🔢 各要素の算出方法（1分あたり）

① 燃料消費量 → CO_2排出量に変換

- C重油のCO_2排出係数：
  3.114 gCO_2 / g燃料（IMO規定）
- C重油の密度：
  0.991 kg/L = 991 g/L

したがって：

$$\text{CO}_2\text{排出量（g）} = \text{燃料消費量（L）} \times 991\,\frac{\text{g}}{\text{L}} \times 3.114\,\frac{\text{gCO}_2}{\text{g燃料}}$$

例：24L/分 の場合：

$$24 \times 991 \times 3.114 \approx 74,000\,\text{gCO}_2$$

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② 輸送量（t･nm）

1分あたりに進む距離（nm）：

$$\text{船速（knots）} \times \frac{1}{60} = \text{1分あたりの海里}$$

輸送量：

$$\text{DWT（t）} \times \text{1分間の移動距離（nm）} = DWT \times \left(\frac{\text{船速}}{60}\right)$$

✅ CIIの1分値をまとめると：

$$\mathrm{CII}_{1分} = \frac{\text{燃料（}L\text{）} \times 991 \times 3.114}{DWT \times \left(\frac{\text{船速（knot）}}{60}\right)}$$

これを簡略化すると：

$$\mathrm{CII}_{1分} = \frac{\text{燃料（}L\text{）} \times 991 \times 3.114 \times 60}{DWT \times \text{船速}}$$

🔍 具体例（24L/分、DWT = 6,950トン、17knot）

$$\mathrm{CII} = \frac{24 \times 991 \times 3.114 \times 60}{6,950 \times 17} \approx \frac{4,445,000}{118,150} \approx 37.6$$

この「37.6」が「1分間におけるCII（gCO_2 / t·nm）」です。
（これは年間CIIと比べると「瞬間CII」的な使い方になります）

📘 備考

- 上記CII値は**単位が正しければ正確**に算出できます。
- 実務では、1分ごとのCIIを蓄積して平均化することで、1日・1航海単位の**運航効率の可視化**が可能になります。
- DWTは固定、変動するのは「燃費」と「船速」です。

🔹 Real-time CII Calculation (1-minute Interval) – Explanation in English

We are trying to calculate the **Carbon Intensity Indicator (CII)** using data collected every **1 minute** from a **Ro-Ro vessel**.
Here is the setup:

📌 Available Data:

- **Fuel consumption**: 24 liters **per minute**
- **Fuel type**: Heavy fuel oil (specifically C-fuel oil)
- **Ship speed**: 17 knots (measured in nautical miles per hour)
- **Deadweight (DWT)**: 6,950 tons
- **Sampling interval**: 1 minute

🔸 Step-by-Step CII Calculation (Per 1 Minute):

1. Convert fuel to CO_2 emissions

Use the IMO emission factor for C-fuel oil:

👉 3.114 kg CO_2 / liter

So:

sql コピーする 編集する

```
CO₂ emitted per minute = 24 liters × 3.114 kg/liter = 74.736 kg CO₂
```

---

2. Convert speed to distance in 1 minute

Speed is 17 knots → 17 nautical miles per hour

1 minute = 1/60 hour

So:

sql コピーする 編集する

```
Distance traveled in 1 minute = 17 / 60 ≈ 0.2833 nautical miles
```

3. CII formula (per minute)

CII is:

```ini
CII = CO₂ emitted / (DWT × Distance)
```

So:

```makefile
CII = 74.736 kg / (6950 tons × 0.2833 nm)
    ≈ 74.736 / 1969.04
    ≈ 0.03796 kg CO₂ / (ton × nautical mile)
```

Or in grams:

```objectivec
CII ≈ 37.96 g CO₂ / (ton × nautical mile)
```

🔸 Notes:

- This is a **real-time CII** approximation. The official IMO CII is calculated annually, but this method is useful for monitoring and analysis.
- 24 liters/min is a reasonable fuel rate for a Ro-Ro ship cruising at 17 knots.
- The CO_2 emission factor depends on the fuel type; for C-fuel, it's 3.114 kg/liter.

- These are the results :Duration: 2024-03-04 00:01:00 to 2025-03-29 11:49:00Data points: 338485 Total Fuel (L): 8,412,591.00 Total CO_2 (g): 25,961,037,098.63 Total Distance (NM): 97,037.80 Final Annual CII (Full Year): 19.0389 Estimated CII (1 Week × 52): 19.2276Even after all these corrections, the CII remains around 19.
- I also wanted to recheck if our calculation process is right, I took this CII document as reference for IMO CII Reference Line formula, CIIref=a×DWT^c, taking GT = 14,052DWT≈GT×1.5⇒DWT≈14,052×1.5=21,078CIIref=19.92×(21078)^(−0.471) = CIIref ≈ 5.75 CIIreq=CIIref×(1−r) r is the reduction rate for the year which is 11%CIIreq=5.75×(1−0.11)=5.75×0.89 = CIIreq ≈ 5.12 CII Ratio (CII Attained / CII Required) = 19.0389/5.12 = 3.72 The ship falls into E rating if the CII Ration is greater than 1.46.

- From the above reference website, I also found that RO-RO ships generally have poor CII ratings because:They have low cargo capacity relative to size, making emissions per capacity high.They require large ramp openings and decks, which impact fuel efficiency.Most RO-ROs were not designed with CII in mind, especially older models.As you mentioned, some data might be missing, especially for days when the ship traveled longer distances.
- Because of this, the fuel used may look higher compared to the distance.
- Combined with the missing data and the generally high CII values for RO-RO ships,
- this could be why our CII is also coming out high. Anyway, For now, I'll continue exploring this further,
- but I believe the values we're getting are realistic based on the data we have.
- I'll use these values to train the model and start building the website using this model as the backend.
- If we're able to get more accurate data in the future, our calculation logic and model structure are already correct,
- so it should work well with the new and complete data, and we may get accurate results.

- The attached graphs are the derivatives of FO_ME_CONS and FO_GE_CONS (FO_ME_CONS_DIF, FO_GE_CONS_DIF). Are you able to confirm the same data?
- Looking at these graphs, there are clearly outliers. This is likely due to a large amount of missing data for a certain period.
- If extremely large FO_ME_CONS and FO_GE_CONS are added to the annual fuel consumption calculation, the fuel consumption ratio will increase even though the distance is not added, which will tend to worsen the CII.
- Have you already taken the above into consideration?

- 添付のグラフはFO_ME_CONS, FO_GE_CONSを微分したもの(FO_ME_CONS_DIF, FO_GE_CONS_DIF)です。同じデータが確認できていますか？
- これらのグラフを見ると明らかに外れ値が入っていますこれは特定期間のデータが大きく欠損していることが影響していると思われます
- 極端に大きいFO_ME_CONS, FO_GE_CONSを年間の燃料消費量計算に加えてしまうと, 距離が加算されていないのに燃料消費量の比率が増えてしまうため, CIIが悪くなってしまう傾向があると思われます。
- 上記の内容はすでに考慮されていますか？


X:Time,Y:FO_ME_CONS_DIF & FO_ME_Cons
FO_ME_CONS_DIF
FO_ME_Cons
FO_ME_CONS
FO_ME_CONS_DIF
30000
20000
10000
0
200000
150000
100000
50000
0
2024/03
2024/05
2024/07
2024/09
2024/11
2025/01
2025/03
Time

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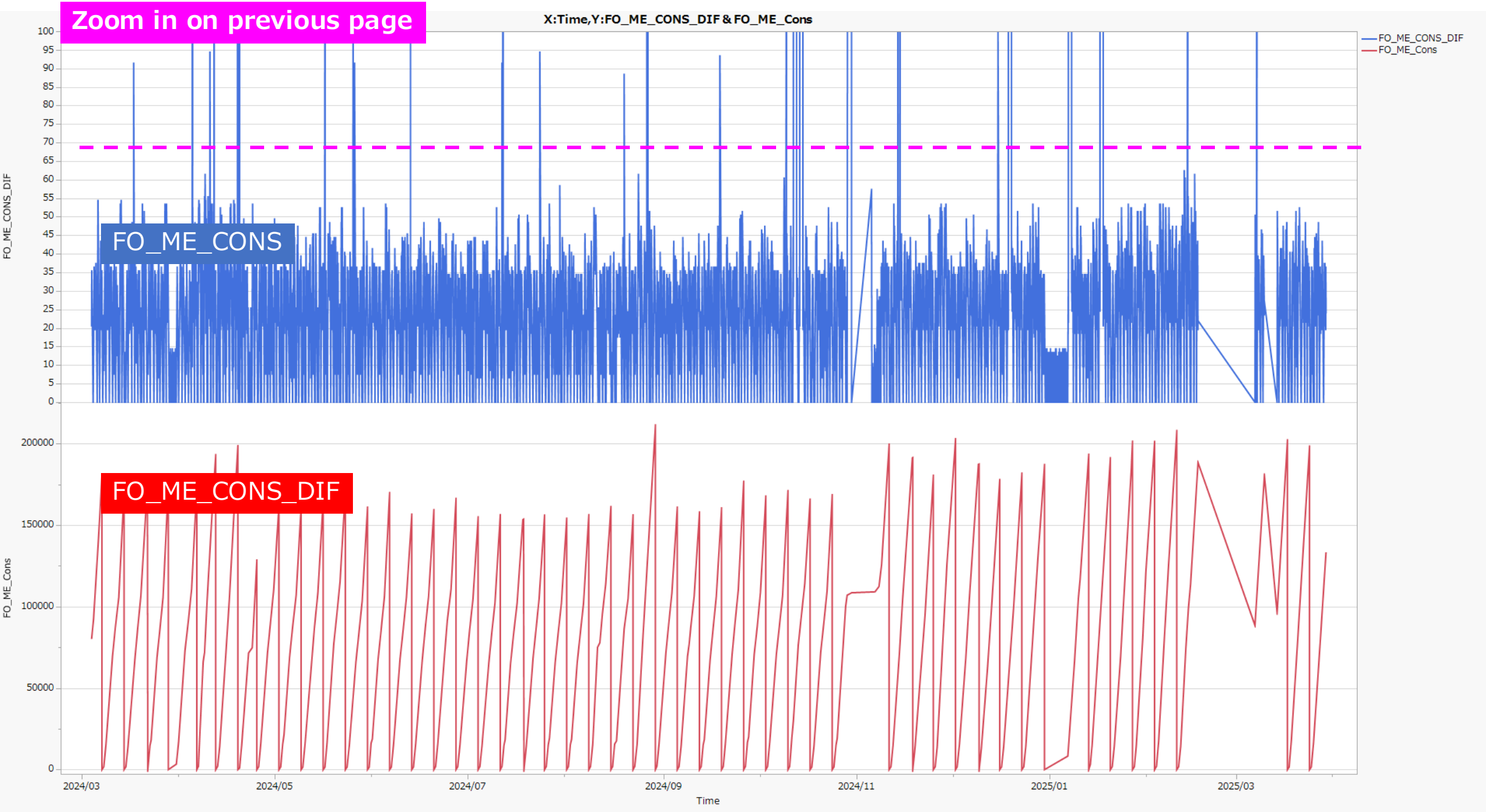

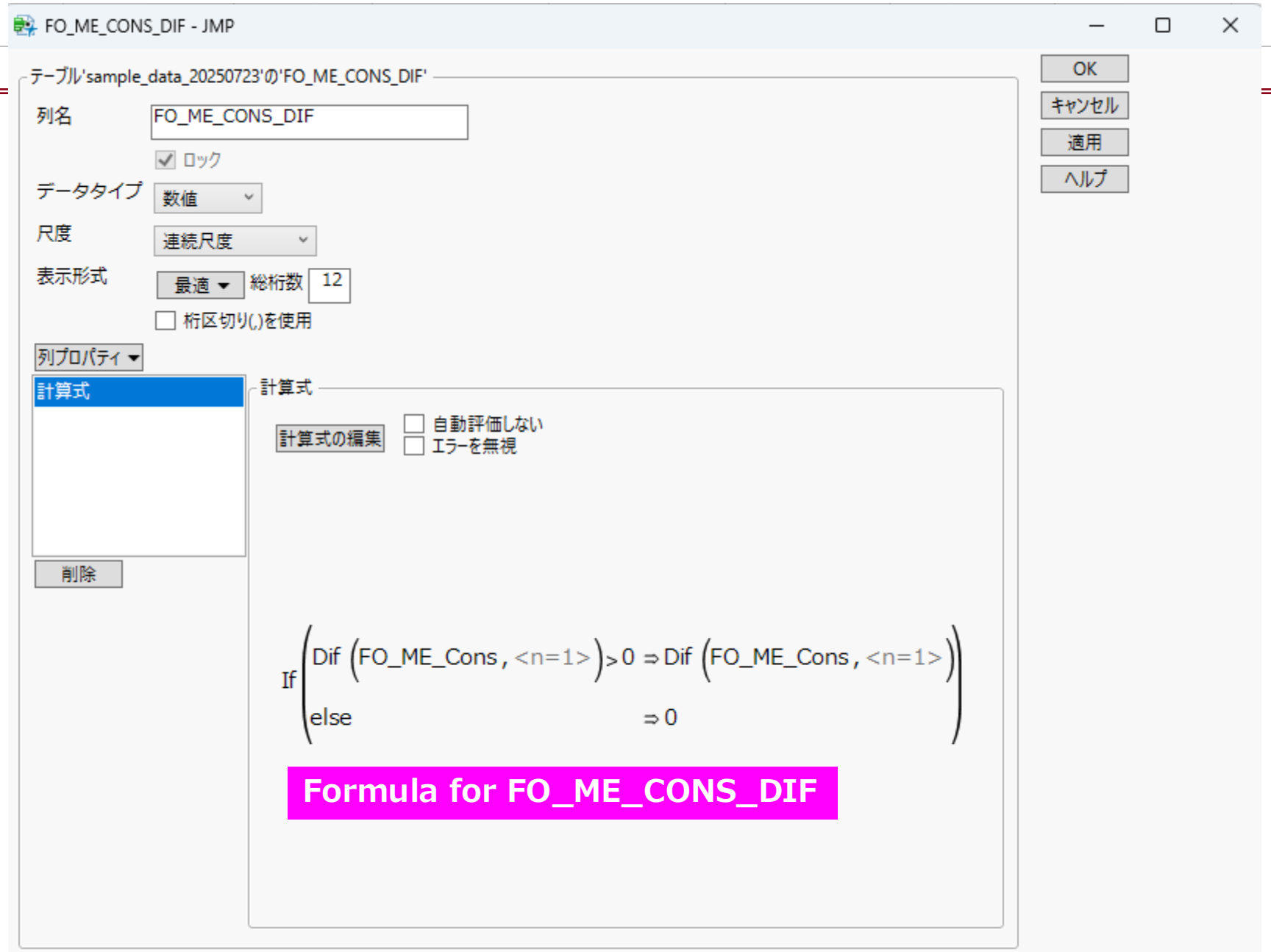


X:Time,Y:FO_GE_CONS_DIF & FO_GE_Cons
FO_GE_CONS_DIF
FO_GE_Cons
FO_GE_CONS
FO_ME_CONS_DIF
FO_GE_CONS_DIF
FO_GE_Cons
3000
2500
2000
1500
1000
500
0
20000
15000
10000
5000
0
2024/03
2024/05
2024/07
2024/09
2024/11
2025/01
2025/03
Time

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