

*2016 International Conference & Workshop on
Winter Maintenance and Surface Transportation Weather*

Study on Winter Road Surface Friction Characteristics and Their Reproducibility

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- ✓ Background & purpose
- ✓ Friction monitoring on winter roads
- ✓ Variations in friction on a highway in winter
 - ✓ Under different weather conditions, and reproducibility of those variations
- ✓ Summary and future issues



Background & Purpose

- ✓ Winter road surface conditions are determined and assessed visually
 - ✓ But... it is difficult to achieve accountability for such public works
- ✓ A technique for monitoring roadway friction values has been developed...
 - ✓ However, constant monitoring of the road surface is difficult



Aim & Purpose

- ✓ The patterns of variation in friction values, and their reproducibility, are examined, based on monitoring data
- ✓ A technique to identify critical management sections more accurately and without constant monitoring can be established

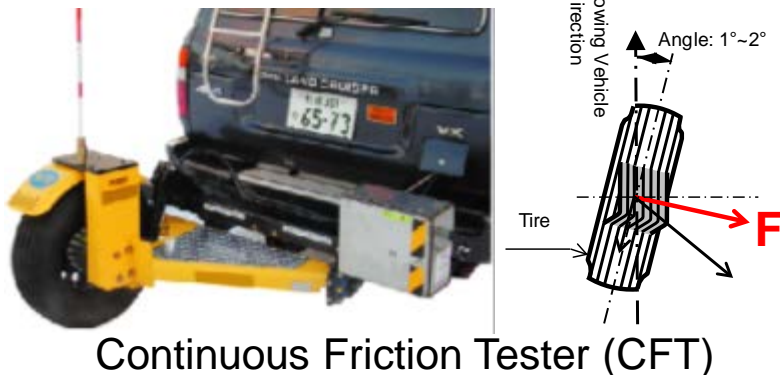
Monitoring of friction on winter roads

✓ Monitoring

- ✓ On a 44-km section of NH230 between downtown Sapporo and Nakayama Pass
- ✓ Monitored since 2007/2008 winter

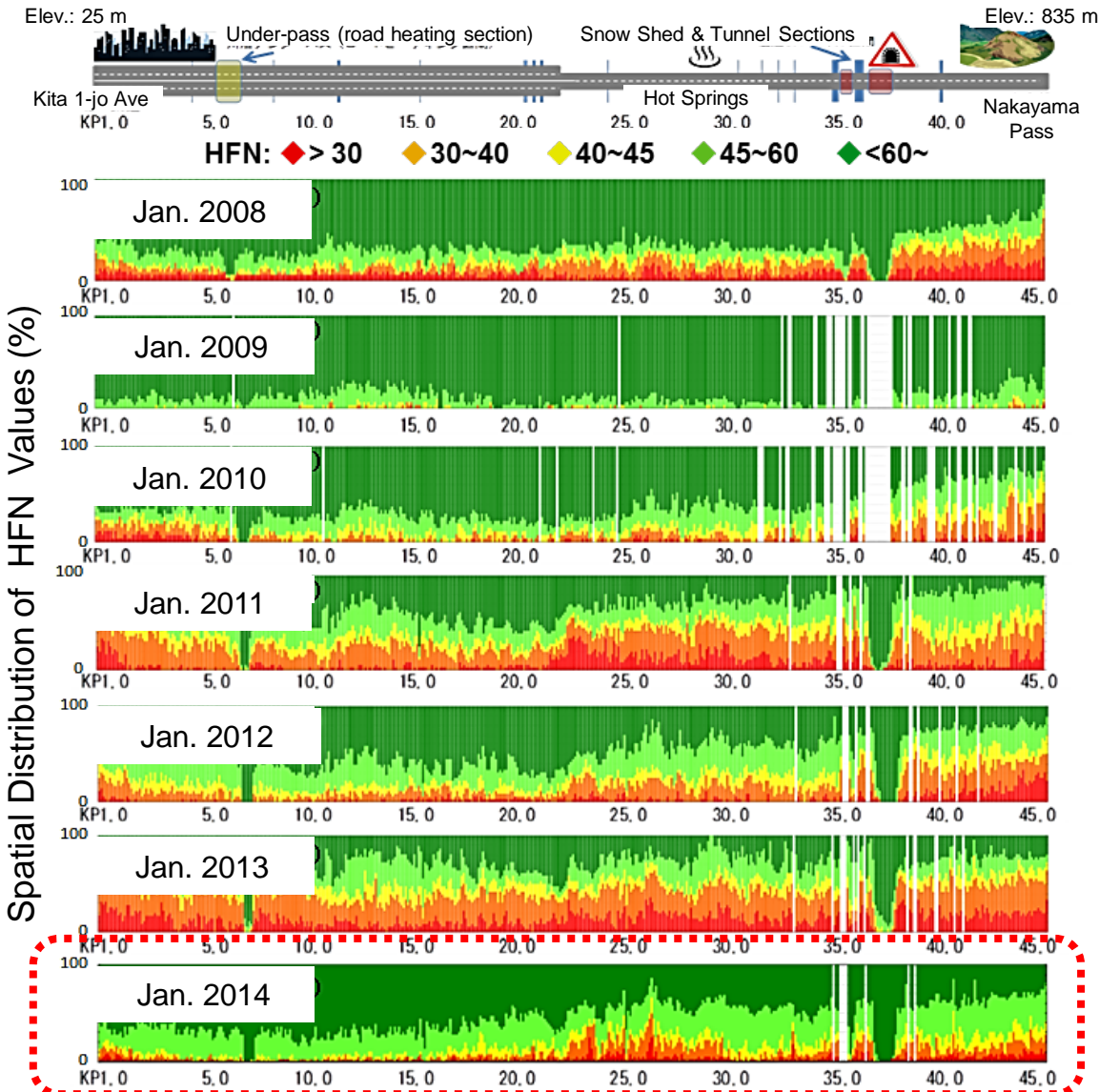
✓ Continuous Friction Tester (CFT)

- ✓ The CFT can be attached to a SUV
- ✓ This device calculates friction value by measuring the axial force created by installing a test tire 1-2 degrees off axis from the direction of travel

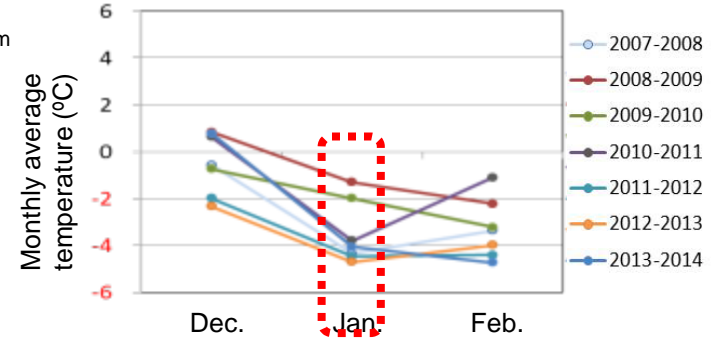


Monitored section of Natl. Hwy. 230

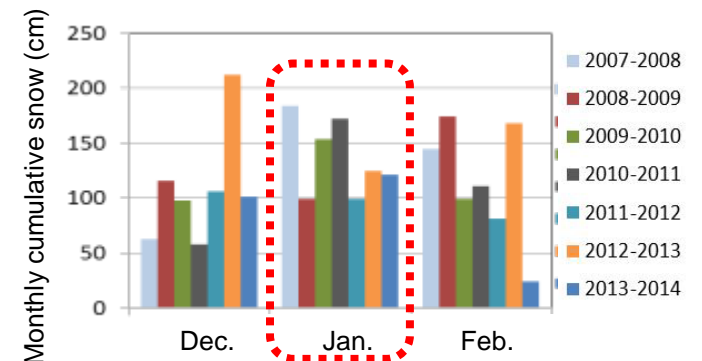
Spatial distribution of HFN values



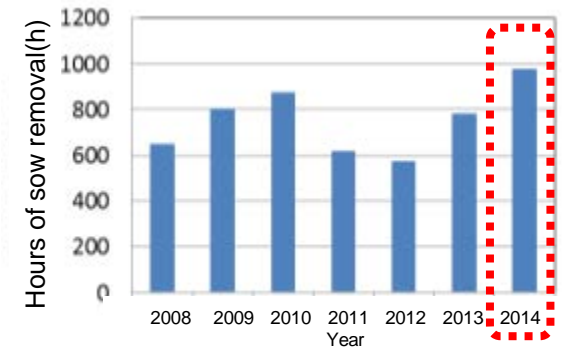
Spatial distribution of HFN values on NH230 (January)



Monthly average temperature in Sapporo area



Monthly Cumulative Snowfall in Sapporo area



Snow removal activities on NH230 (Jan.)

Variation of friction on winter road surface under different weather conditions

✓ Classification of weather conditions

- ✓ We used HFN values from KP0.9 to KP20.0, measured from predawn (3 a.m.) on weekdays in January 2014.
- ✓ Classification criteria
 - ✓ Daily minimum temperature and snowfall during 12 night-time hours
 - ✓ Temperatures thresholds at 0 °C & -8 °C¹
 - ✓ Snowfall thresholds at 0 cm & 5 cm²
- ✓ Data from Local Meteorological Observatory were used

Classification of weather conditions

| Temperature-based weather classifications | | Snowfall-based weather classifications | | |
|---|-------------------------------------|--|-------|--|
| Non-winter | 0°C < daily min. temperature | No snow | | Snowfall during 12 night-time hrs.: 0 cm |
| Normal | -8°C < daily min. temperature ≤ 0°C | Snow | Scant | Snowfall during 12 night-time hrs.: 0 cm ≤ 5cm |
| Severe | daily min. temperature ≤ -8°C | | Heavy | Snowfall during 12 night-time hrs.: >5cm |

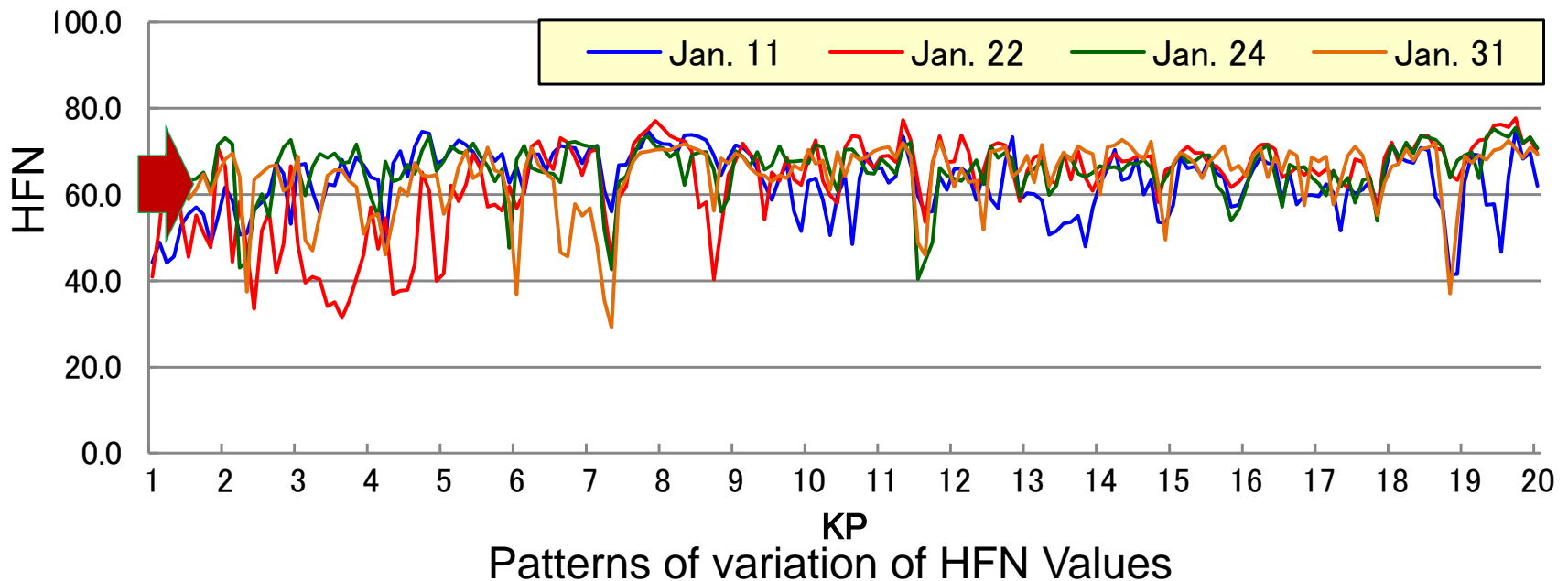
¹ Winter Road Surface Management Manual (Draft)

² Handbook for Snow Removal and Snow Control

HFN values for a specific weather condition (1)

(a) "No snowfall - normal winter day"

(daily min. temperature: -8 to 0°C, snowfall during 12 night-time hrs.: 0 cm)

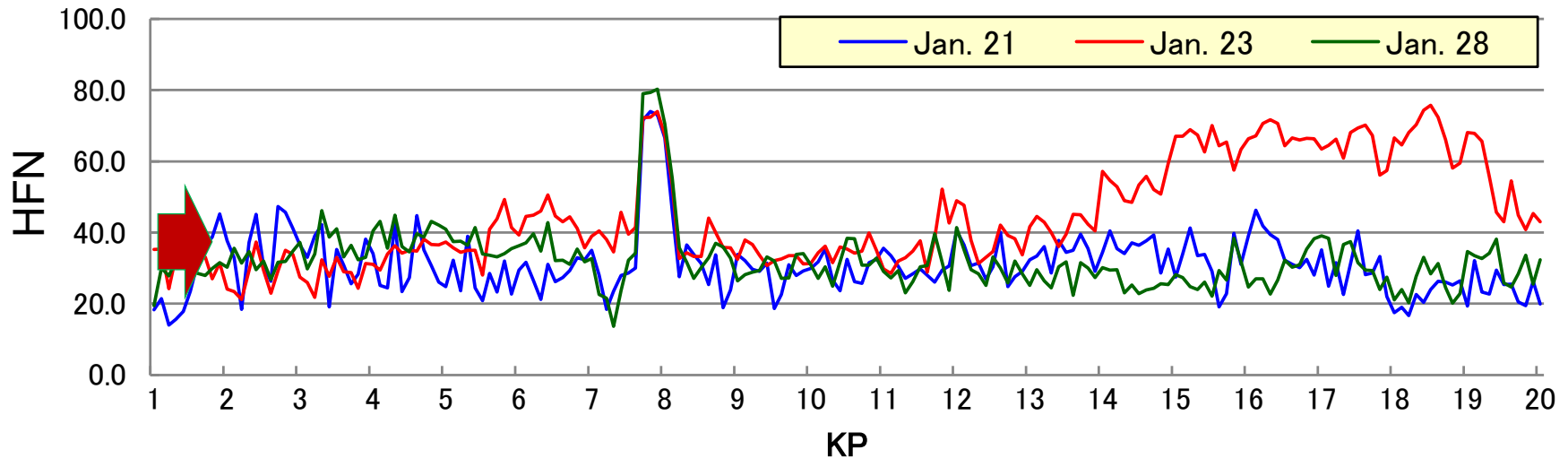


- ✓ The patterns of variation for HFN values resemble each other for these four days
- ✓ HFN values dropped below 40 at some spots for some days
 - ✓ Did road surface conditions of the previous day affect those of the next day?

HFN values for a specific weather condition (2)

(b) "Scant snowfall - normal winter day"

(daily min. temperature: -8 to 0°C , snowfall during 12 night-time hrs. : 0 – 5 cm)



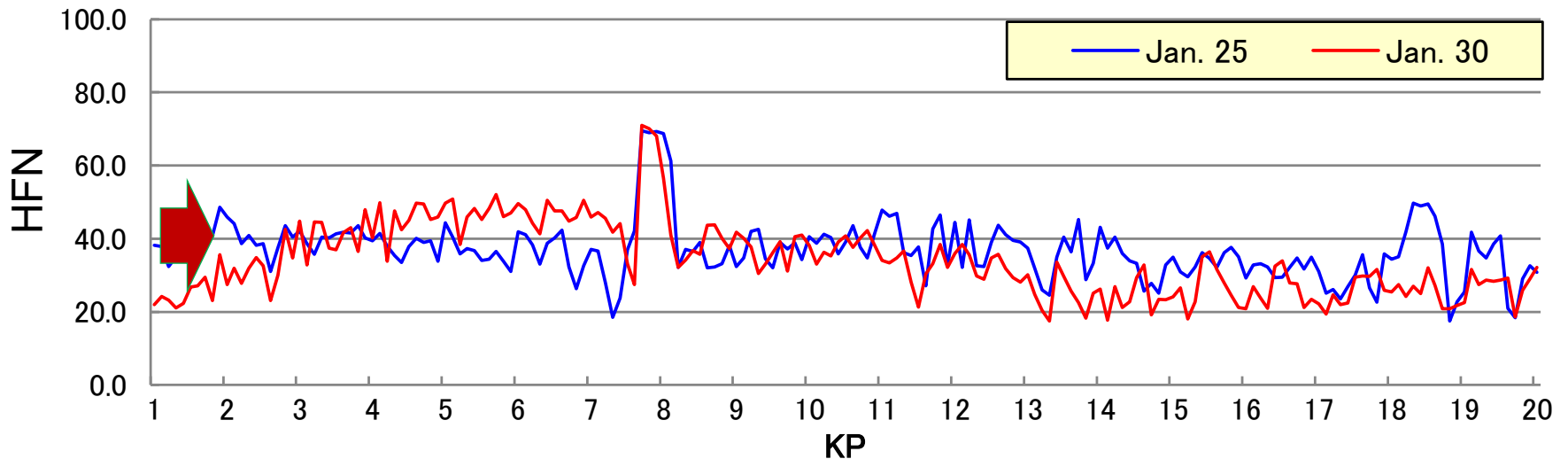
Patterns of variation of HFN Values

- ✓ As for Jan 21 & 28, the patterns of variation for HFN values resemble each other
- ✓ Overall, HFN values are lower (around 40) on these days than on non-snowfall normal winter days
- ✓ As for January 23, unlike other days, HFN values exceed 60 from KP14.0 onward
 - ✓ Do weather conditions vary within the section?

HFN values for a specific meteorological condition (3)

(c) "Heavy snowfall normal winter day"

(daily min. temperature: -8 to 0°C, snowfall during 12 night-time hrs.: 5 cm or more)



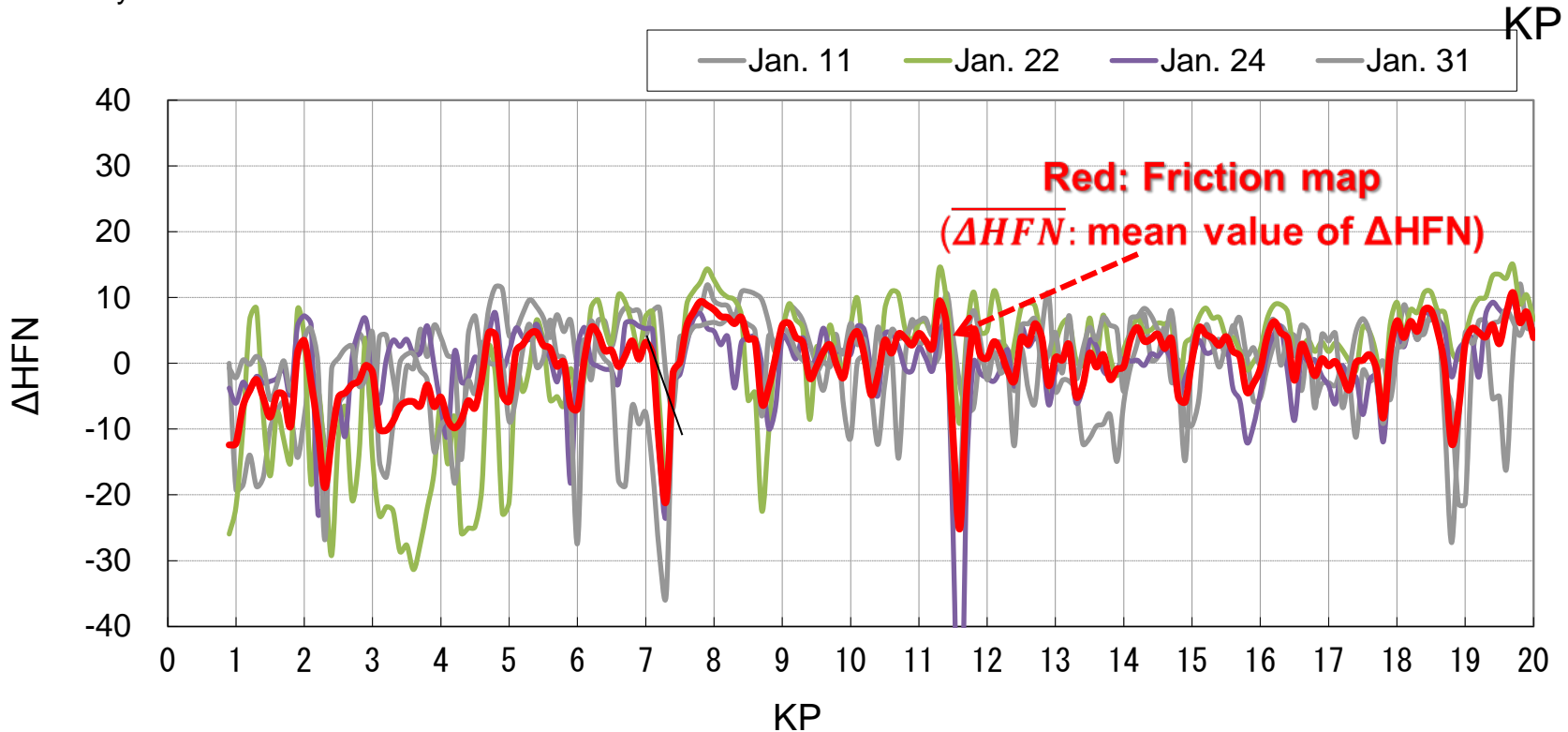
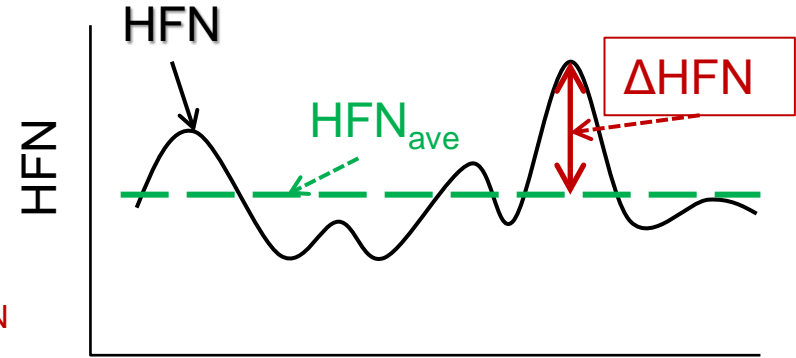
Patterns of variation of HFN Values

- ✓ Only two days fell into the sub-class of "heavy snowfall - normal winter day"
- ✓ The patterns of variation in HFN values are mutually similar
- ✓ Unlike the sub-class of "scant snowfall - normal winter day", no obvious difference is found between the two days

Reproducibility of the pattern of variation of HFN values

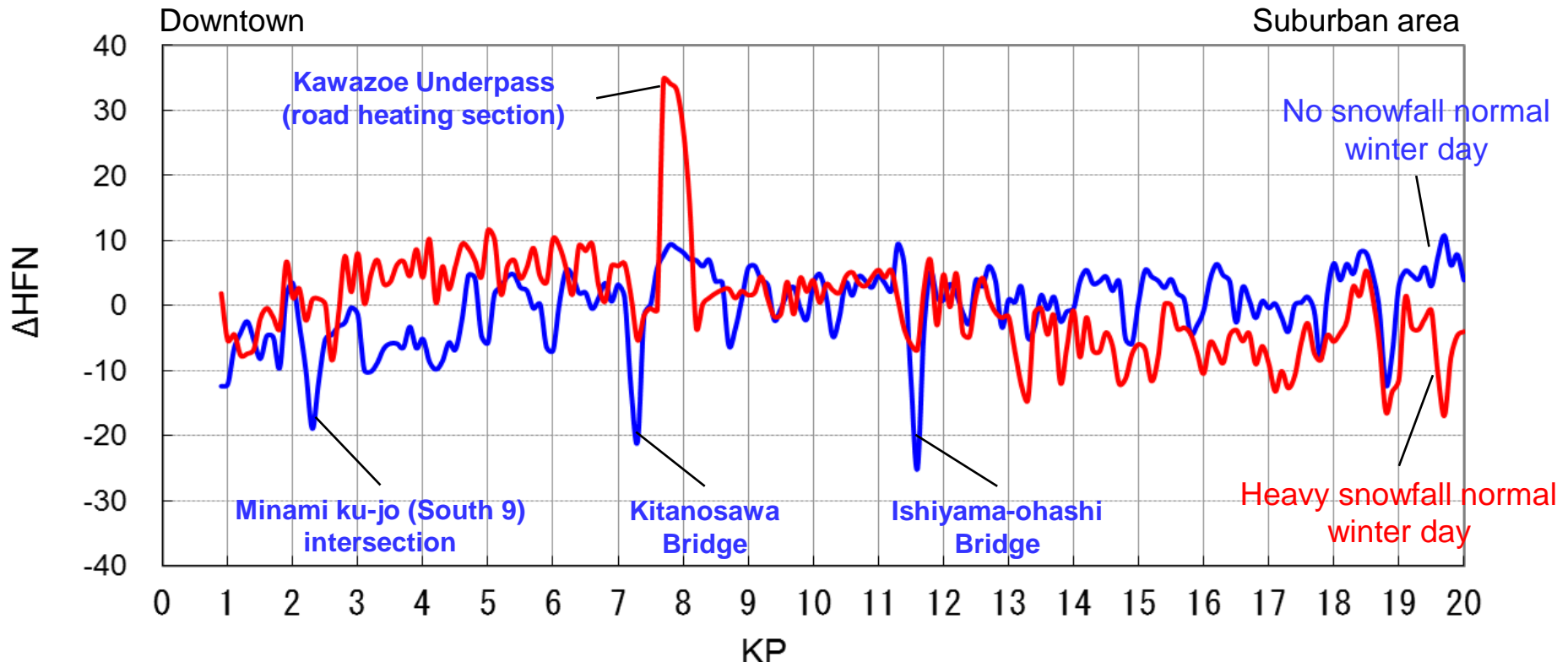
Based on Shao's method of making thermal maps of road surface temperature...

- ✓ First, determine the HFN_{ave} , the spatial mean value. Then, calculate the ΔHFN by subtracting the HFN_{ave} from each HFN value
- ✓ The $\overline{\Delta HFN}$, the mean value of ΔHFN , is determined from each ΔHFN of each day that fell into the same weather condition



Patterns of variation of ΔHFN and $\overline{\Delta HFN}$ for four days under “non snowfall - normal winter conditions” at a section of NH230

Reproducibility of patterns of variation in HFN values



Friction maps of a “heavy snowfall - normal winter day” and a “no snowfall - normal winter day” on a section of NH230

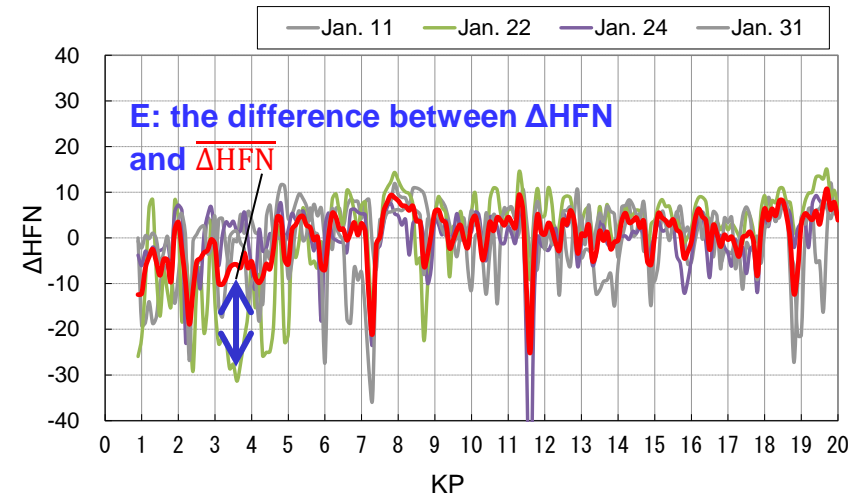
- ✓ Friction maps have distinguishing features.
- ✓ On the red curve in this friction map, values between KP7.6 and KP8.1 (with road heating) are markedly higher than values at other sections
- ✓ On the blue curve in this friction map, values fall significantly at certain points (intersections, bridges, etc.)

Reproducibility of the pattern of variation in HFN values (assessment)

Results of the assessment of their reproducibility

Non-snowfall - normal winter day

| | E | | | Reproducibility (%) | |
|------------|------|------|-------|---------------------|----------|
| | Avg. | Max. | Min. | ± 6 | ± 12 |
| Jan. 11 | 0.1 | 17.9 | -19.2 | 67.7 | 93.8 |
| Jan. 22 | 0.1 | 16.0 | -25.5 | 70.8 | 89.1 |
| Jan. 24 | -0.3 | 12.3 | -40.8 | 81.3 | 97.4 |
| Jan. 31 | 0.1 | 11.7 | -20.5 | 81.8 | 96.4 |
| Mean value | | | | 75.4 | 94.1 |



Scant snow - normal winter day

| | E | | | Reproducibility (%) | |
|------------|------|------|-------|---------------------|----------|
| | Avg. | Max. | Min. | ± 6 | ± 12 |
| Jan. 21 | -0.1 | 16.2 | -17.3 | 69.3 | 90.6 |
| Jan. 23 | 0.1 | 24.3 | -18.6 | 41.1 | 71.9 |
| Jan. 28 | 0.1 | 14.7 | -18.1 | 56.3 | 94.3 |
| Mean value | | | | 55.6 | 85.6 |

Differences within
 $E \pm 6$ ($\mu 0.05$)
 $E \pm 12$ ($\mu 0.10$)

Heavy snow - normal winter day

| | E | | | Reproducibility (%) | |
|------------|------|------|-------|---------------------|----------|
| | Avg. | Max. | Min. | ± 6 | ± 12 |
| Jan. 25 | 0.0 | 10.5 | -13.1 | 80.7 | 99.5 |
| Jan. 30 | 0.0 | 13.1 | -10.5 | 80.7 | 99.5 |
| Mean value | | | | 80.7 | 99.5 |

Overall accuracy
 ± 6 ± 12
 70.6% 91.8%

Summary and Future Issues

✓ Friction values

- ✓ Road surface conditions in the winter of 2014 were generally favorable in terms of HFN values, despite severe weather
 - ✓ Due to intensive maintenance work (snow removal activities)?

✓ Patterns of variation in HFN values

- ✓ The pattern of variation in HFN values varied by weather condition
- ✓ The patterns for different days resembled each other when the weather conditions were same
- ✓ However, no obvious differences of patterns were found between different weather conditions
 - ✓ Revision of the classification of weather conditions

✓ Reproducibility

- ✓ To some extent, we were able to quantitatively demonstrate the reproducibility of patterns of variation in HFN values under different weather conditions
 - ✓ More data accumulation and examining the accuracy of reproducibility

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Thank you for your interest & attention!

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