THE SEVEN STATION SERIES

by

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Reprinted from

ENERGY &
ENVIRONMENT

VOLUME 22 No. 4 2011

MULTI-SCIENCE PUBLISHING CO. LTD.
5 Wates Way, Brentwood, Essex CM15 9TB, United Kingdom

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ABSTRACT
Historical evidence shows that the mean temperatures in the main cities in New Zealand have not changed significantly since records began in the 1860s[1-4].

Recently, the New Zealand Institute for Water and Air Research[11], after a thorough Review, has presented a revised temperature anomaly chart for the average temperatures of seven of the major urban centres in New Zealand which shows that there has been an increasing temperature trend of 0.91°C per century since 1909.

This paper analyses the Review and concludes that the results are compatible with the historic view of no significant change since records began. Although the trends found are explained by natural causes their statistical significance is very low because of the unsuitability of the "neighbour station" comparison used, and the inaccuracy of the measured and processed temperature measurements.

INTRODUCTION

Publications from 1868[1,] 1920[2] 1960[3] and contemporary records[4] indicate that mean temperatures in main New Zealand cities have not significantly changed since records began (Tables 1,2,3). Degrees Fahrenheit in the early figures have been converted to degrees Celsius.

TABLE 1
COMPARISON OF MEAN TEMPERATURES FOR NEW ZEALAND CITIES BEFORE 1868 AND 1971-2000[1,4]

STATION	Years of Data	BEFORE 1868 (NZ Institute)	Years of Data	1971-2000 (NIWA)
Auckland	15	15.7°C	25	15.1°C
Taranaki	12	13.7°C	20	13.6°C
Wellington	10	13.2°C	30	12.8°C
Nelson	16	12.8°C	25	12.6°C
Christchurch	11	12.8°C	26	12.1°C
Dunedin	15	10.4°C	26	11.0°C
Mean		13.1°C		12.9°C
NIWA Mean				12.6°C

In 1920 D C Bates [3] published figures for the mean temperature of nine towns in New Zealand. These are compared with current NIWA figures[2] in Table 2.

TABLE 2
COMPARISON BETWEEN MEAN TEMPERATURES FOR NEW ZEALAND CITIES BEFORE 1920 AND 1971-2000[2,4]

STATION	Years of Data before1920	Mean Temperature °C (Bates)	Years of data 1971-2000	Mean Temperature °C (NIWA)
Auckland	56	15.1	25	15.1
Rotorua	32	12.6	21	12.6
Napier	29	14.3	21	14.5
Wellington	56	12.9	30	12.8
Nelson	31	13.1	25	12.6
Hokitika	34	11.8	30	11.7
Dunedin	55	10.1	28	11.0
Queenstown	9	10.1	30	10.7
Invercargill	11	10.0	29	9.9
Mean		12.2		12.3

TABLE 3
COMPARISON BETWEEN MEAN TEMPERATURES FOR NEW ZEALAND CITIES BEFORE 1960[3] AND 1971-2000[4]

STATION	Years of Data	1960 Met Service	Years of Data	1971-2000 NIWA
Kaitaia	1949-1960	15.7°C	15	15.7°C
Auckland	1948-1960	15.1°C	25	15.1°C
Tauranga	1941-1960	14.1°C	16	14.5°C
Rotorua	1885-1947	12.8°C	21	12.8°C
Gisborne	1937-1960	13.9°C	21	14.3°C
Taupo	1949-1960	11.8°C	15	11.9°C
New Plymouth	1942-1960	13.5°C	27	13.6°C
Napier	1924-1960	13.9°C	21	14.5°C
Wanganui	1937-1960	13.4°C	24	14.0°C
Palmerston North	1928-1960	12.7°C	28	13.3°C
Wellington	1928-1960	12.4°C	30	12.8°C
Nelson	1943-1960	11.8°C	25	12.6°C
Blenheim	1941-1960	12.7°C	13	12.9°C
Westport	1945-1960	12.1°C	14	12.6°C
Hokitika	1943-1960	11.1°C	30	11.7°C
Christchurch	1905-1960	11.4°C	26	12.1°C
Lake Tekapo	1950-1960	9.2°C	23	8.8°C
Timaru	1909-1960	11.0°C	13	11.2°C

STATION	Years of Data	1960 Met Service	Years of Data	1971-2000 NIWA
Milford Sound	1934-1960	10.1°C	24	10.3°C
Queenstown	1929-1960	10.0C	30	10.7°C
Alexandra	1928-1960	10.4°C	12	10.8°C
Dunedin	1947-1960	11.0°C	26	11.0°C
Invercargill	1948-1960	9.7°C	29	9.9°C
Chatham Island	1939-1958	11.1°C	23	11.4°C
Mean		12.1°C		12.4°C

THE SEVEN STATION SERIES

Salinger[5-9], in a series of papers, has applied "corrections" for changes of site for many weather stations, based on a comparison with "neighbour" stations with continuous records, but the details of these corrections are not available.

He selected seven stations with fairly long records as the basis for a New Zealand-wise temperature record. The stations chosen were Auckland, Masterton, Wellington, Nelson, Hokitika, Lincoln, and Dunedin. This provided a temperature record for New Zealand which showed a positive upwards trend of less than one degree Celsius per century.

In 1980 Hessell[10], from the New Zealand Meteorological Service, Wellington, provided a paper entitled "Apparent trends of mean temperature in New Zealand since 1930".The Abstract is as follows:

"The evidence of apparent continuous warming over New Zealand since 1949 is examined from both physical and statistical standpoints. It is found that the exposures of most of the thermometers have been affected by changes in shelter, screenage, and/or urbanisation, all of which tend to increase the observed mean temperature. A systematic analysis of all New Zealand Climatological stations with sufficient length of record reveals that no important change in annual mean temperature since 1930 has been found at stations where the above factors are negligible. Neighbour station comparisons support these findings".

Amongst other conclusions, Hessell found that from the seven stations chosen by Salinger the weather stations at Auckland and Christchurch were affected by tree growth, urbanisation and screen changes in the period 1930-70 which gave an apparent temperature rise compared with stations not affected in this way.

Despite these considerations The National Institute of Water and Air Research (NIWA) recruited Salinger and adopted his temperature chart as a New Zealand temperature record, It has recently been converted into "temperature anomalies" by subtraction of each annual figure from the mean of all stations for a reference period of 1971-2000 Figure 1 shows the chart from 2009[11].

Although the stations chosen are spread around the country fairly evenly they can hardly be regarded as providing an average for New Zealand, but only for some of the major cities.

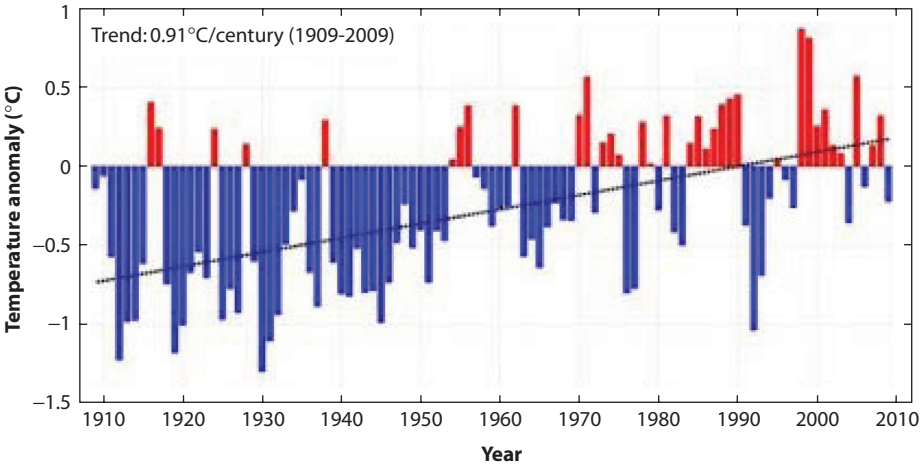

Figure 1. NIWA New Zealand Temperature Anomaly Chart 2009[11].

THE 2010 REVISION

Recently the mean annual temperature anomaly record has been extensively revised[11] as part of a 169 page Review Report prepared with the assistance of the Bureau of Meteorology of Australia.

The revised record is shown in Figure 2.

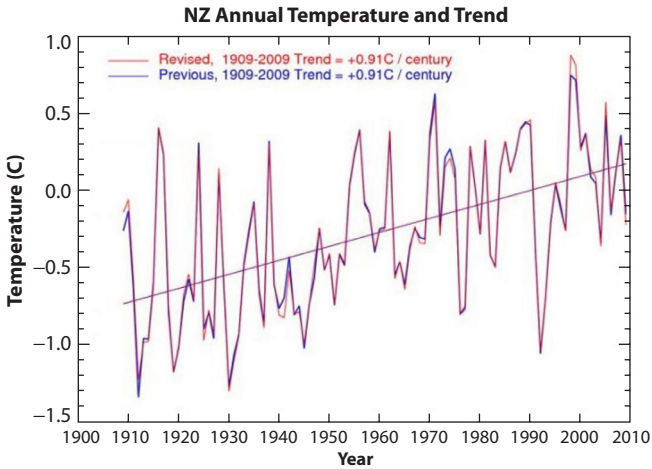

Figure 2. Mean Annual New Zealand Temperature Anomaly Record for Seven Stations[11].

The Review[11] has 169 pages and many diagrams. It contains the first photographs ever published of all the seven stations, taken from one direction.

Table 4 summarises the Review results. The note which was included below it show that all seven stations did not apply until 1913. The "trend" should therefore be 0.97°C per yr.

TABLE 4
SUMMARY OF REVIEW RESULTS[11]

Station (start year)	Previous Series Trend (° C/century)	Revised Series Trend (° C/century)
Auckland (1910)	1.34	1.53
Masterlon (1912)	0.80	0.88
Wellington	0.79	0.86
Nelson	0.81	0.76
Hokitika (1913)	1.07	1.11
Lincoln	0.99	0.83
Dunedin	0.58	0.58
Seven-Station Average	0.91	0.91*

"* This is the trend of the seven-station composite series (Figure 2), not the average of the 7 individual trends (which have different starting years). It is coincidental that the previous and revised trends agree exactly to the second decimal place. For example, had we chosen the period 1913-2009, the trends would be 0.95 °C/century (Previous) and 0.97 °C/century (Revised)."

DOUBTS OF VALIDITY

The Australian Bureau of Meteorology in their letter published in the Review expressed considerable doubts about the validity of their conclusions. They said:

"The data and methodology provided in the reports from NIWA are taken as an accurate representation of the actual analyses undertaken. We are not in a position to question all of the underlying analyses and data that have contributed to the final results, such as methods used to compile raw data taken at stations. We do, however, perform some independent analyses as appropriate to the aims of the review as outlined above.

The review does not constitute a reanalysis of the New Zealand 'seven station' temperature record. Such a reanalysis would be required to independently determine the sensitivity of, for example, New Zealand temperature trends to the choice of the underlying network, or the analysis methodology. Such a task would require full access to the raw and modified temperature data and metadata, and would be a major scientific undertaking. As such, the review will constrain itself to comment on the appropriateness of the methods used to undertake the 'seven station' temperature analysis, in accordance with the level of the information supplied."

These remarks tend to indicate doubts about the whole procedure they were induced to follow.

NATURAL EXPLANATION

The authors of the Review provide an explanation of the behaviour of the temperature anomaly record from natural events. One of their "Key Points" at the beginning is as follows:

"The variations in time of New Zealand temperature are consistent with completely independent measurements of regional sea temperatures. There is also a strong

correlation between variations in New Zealand temperature and prevailing wind flow, which relates closely to the abrupt warming in the mid 20th century, and the slower rate of warming since about 1960."

They give further details of these explanations in the text. What they are really saying is the the behaviour is best represented by several "trends" referring to the different climate behaviour over the period, as shown in Figure 3.[12]

The implication here is that there is no need to claim that the changes shown can be related to changes in atmospheric concentrations of greenhouse gases.

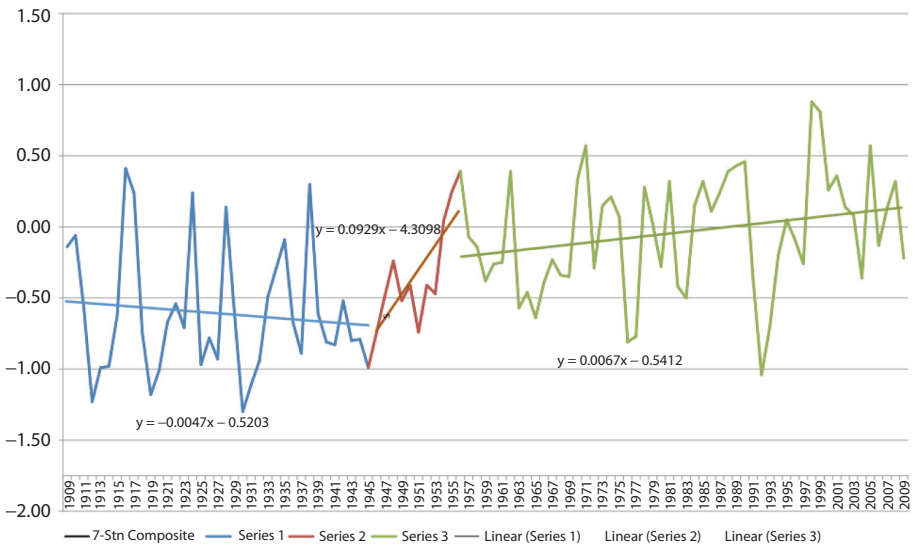

Figure 3. Revised trend analysis, showing a very slight downward trend from 1909-1943, a sudden rise from 1945-50 and a slow rise from 1950 to 2010[12].

NEIGHBOUR STATIONS

Most of the "corrections" to the "raw" averaged temperature measurements are made by comparing records that are broken by a change of site with so-called "neighbour" stations which recorded unchanged over the period. Every place in the whole of New Zealand were treated as if it was a close "neighbour" of every other place in New Zealand in order to justify these "corrections".

In a comprehensive paper on "Homogeneity adjustment" (of which Salinger was one of the joint authors) is this passage[13] describing the requirements for adjustment by comparison with "neighbour stations" in Australia.

"The use of only nearby stations ensured that stations with climates dissimilar to that of the candidate were not used.... Stations were excluded if they were within 6° of latitude and longitude but in a location likely to be climatologically dissimilar to the candidate station (according to a previously determined climate classification), such as on different sides of a mountain range. Stations with temperatures that were possibly affected by urbanization were not included in the reference series.... Only stations which were strongly, significantly and positively correlated with the candidate station

were used in the development of the neighbouring record ..... The total number of neighbour stations used to compile a median reference series was typically about 65, although the number was much less than this in sparse data areas. Only about half of these would be available in each year, because of missing data and because of the short periods of record at some neighbour stations".

The "Neighbour Station" adjustments made by the Review[11] are in complete conflict with these considerations. Figure 3 (from the Review) is the map showing the stations used to adjust site changes at Lincoln/Christchurch.

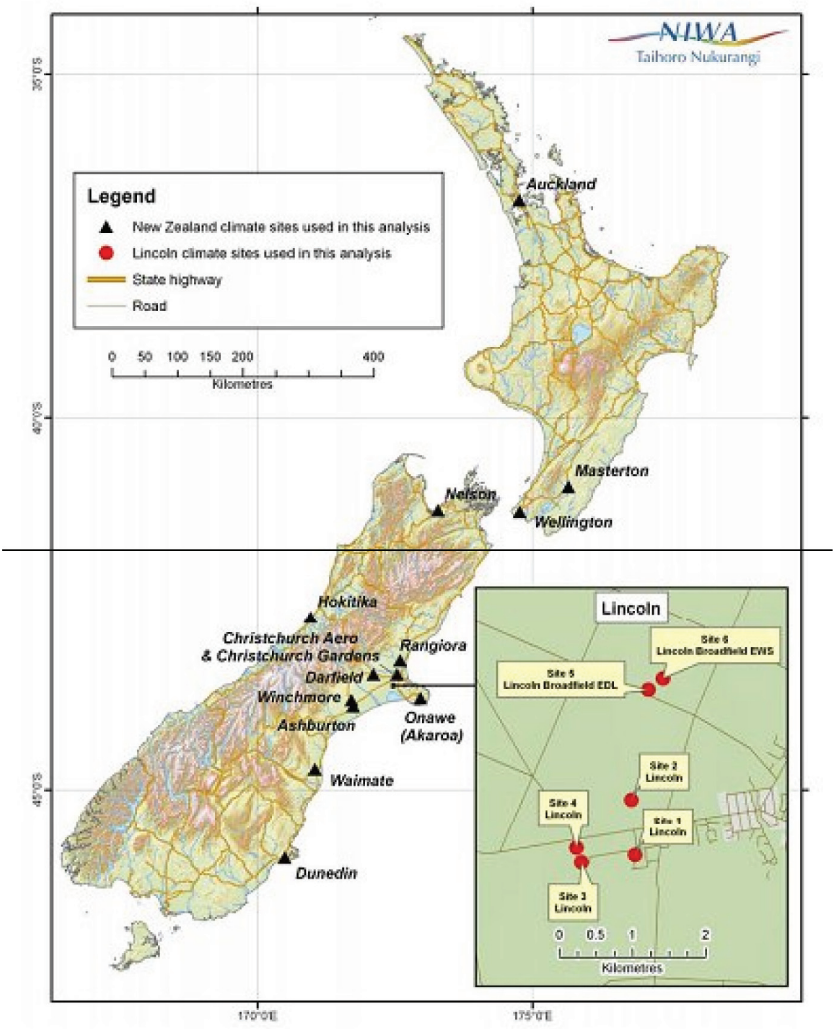

Figure 4. Map of New Zealand showing the "neighbour sites" used to adjust site changes around Lincoln/Christchurch[11].

Figure 4 shows that there were as many as six stations for which adjustments had to be made for a change of site, and 15 others, including all the chosen "Seven Stations" which were used for comparison and for decision on a suitable "adjustment".

NIWA[15] divides New Zealand into climate zones which separate most of the "seven stations". Several are on opposite sides of mountain ranges and the two islands. This well recognized variation in local climate may account for some of the differences between the "adjusted trends" for the seven stations shown in Table 4.

The adjustments made in the Review using "neighbour stations" including those from different zones, are without credibility and they impair the believability of the entire Review.

ACCURACY

Each "adjusted" annual temperature anomaly figure[14], now provided to two places of decimals, is treated as if it were a constant before being subjected to a linear regression. It is unacceptable in a supposedly scientific paper that deals with the results of a complex measurement and averaging process that there should be no attempt to provide an estimate of the accuracy of the individual temperature figures.

ACCURACY OF TEMPERATURE MEASUREMENT

In a study on 948 US weather stations Watts[16] recently found that only 2% were capable of measuring temperature to an accuracy less than 1°C and 69% had an inaccuracy of over 2°C.

Watts[17] has also recently evaluated the NIWA site at Kelburn, Wellington by using Google Earth photographs and he finds that it falls into category 4 of the NASA classification, meaning that the reliability of the temperature measurements there now is ≥2°C, a result which is confirmed by the photograph of the Kelburn site given in the Review[11].

Watts's survey shows that if the most advanced country with the most number of weather stations cannot measure temperature accuracy to these levels, it means that most other countries and all early results are unlikely to be better.

Frank[18] has recently calculated that even for an ideal temperature sensor an error of ±0.46°C between 1880 and 2000 would be indistinguishable from zero.

ACCURACY OF AVERAGES

Processing begins by assuming that the average of the maximum and minimum temperatures taken in a single day can be considered to be the average daily temperature.

An insight into the sort of error involved by using such an average can be obtained from the student exercise supplied by NIWA[19]. They provide two sets of hourly temperature measurements from twenty two New Zealand weather stations, one for a typical summer's day, and another for a typical winter's day.

For the summer's day, the mean difference between the Max/Min average and the 24 hour average was –0.3°C±1.0°C, for the winter's day it was +0.6°C±1.7°C, (95% confidence limits).

There is therefore an error of at least a degree in assuming that the max/min average is a true average temperature.

Besides the lack of statistical validity of the maximum/minimum average, other averages may also be defective because of skewed distributions.

Kerkin[20] has recently analysed 21,660 daily maxima and 21,648 daily minima from the NIWA database[14] for Albert Park, Auckland from 1930 to 1989 and 16,446 daily maxima and 16,508 daily minima for Te Aroha, 200 km SW of Auckland. The results are given in Figures 5 and 6.

The curves are bimodal, which means that there are two maximum values to each graph and the mean does not coincide with either of them,

For Albert Park

The mean maximum is 18.9°C with a standard deviation of 3.8°C.
The most probable value of the maximum is 16.9°C which is 2.0°C less than the mean.
The mean minimum is 12.1°C with a standard deviation of 3.7°C.
The most probable value of the minimum is 12.0°C which is close to the mean.

For Te Aroha

The mean maximum is 19.6°C with a standard deviation of 4.5°C.
The most probable value is 17.0°C which is 2.6°C lower than the mean.
The mean minimum is 9.9°C with a standard deviation of 5.1°C.
The most probable value of the minimum is 12.0°C which is 2.1°C above the mean.

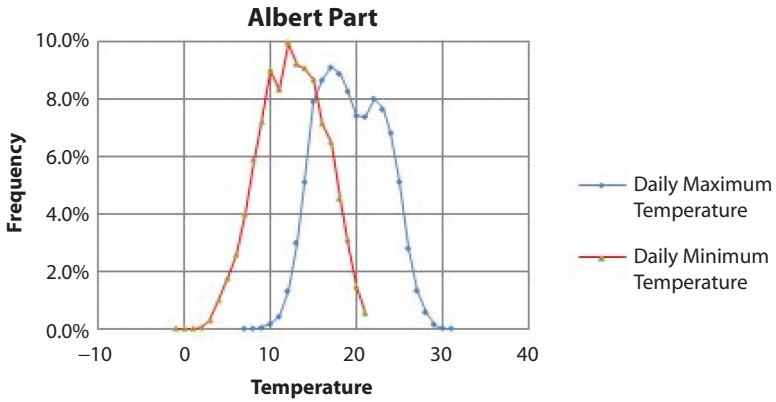

Figure 5. Distribution curves in °C of daily measurements of maximum temperature and minimum temperature at Albert Park, Auckland, from 1930 to 1989[20].

Each averaging process, daily into yearly, over seven stations and subtraction from the average of the "reference period, implies further errors, as does the interpolation of "missing figures" and the "adjustments " for site change.

No study has been made to discover the effect of recent automation of weather stations, one of which is that temperature is now recorded hourly, instead of a maximum and minimum so there is a different "daily average".

The combined inaccuracies from all these stages means that "trends" of less than 1°C over as long as 100 years have such a low level of statistical significance that they can be ignored.

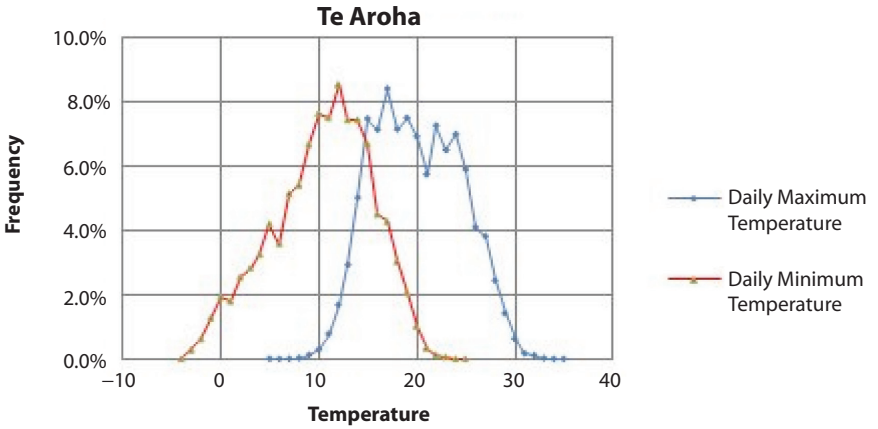

Figure 6. Distribution curves in °C of daily maximum and daily minimum temperatures at Te Aroha between 1951 and 1996[20].

The similar absence of realistic estimates of accuracy of other local or global temperature anomalies calls into doubt all such records.

CONCLUSIONS

Although the apparent temperature changes shown by the revised "Seven Station" New Zealand temperature chart seems to be satisfactorily explained by natural climate changes, the combined accuracy with which it has been obtained is so low that the whole chart has a very low level of statistical significance and it is therefore compatible with the historic evidence that New Zealand temperatures have not significantly changed since records began.

ACKNOWLEDGEMENTS

I would like to acknowledge the help I received from Terry Dunleavy, Barry Brill, Bryan Leyland, Gary Kerkin, Bob Dedekind, John McLean and Willem de Lange in the preparation of this article.

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