Fire Research Report

Climate and Severe Fire Seasons: Part II – New Zealand Fire Regions

NIWA

March 2002

This report summarises climatic patterns giving rise to severe fire seasons at a number of locations throughout New Zealand. Analysis also includes factors contributing to high fire seasons nationally. This report defines regions of coherent change in monthly fire severity in relation to short-term climate variability. Based on fire severity ratings a total of 15 fire regions have been identified for New Zealand. Seven fire regions occur in each of the North and South Islands with a region straddling the North-South Island. For each region a description their key linkages between fire severity rating and climate predictors are described.

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Climate and Severe Fire Seasons: Part II - New Zealand Fire Regions

A report on climatic factors contributing to severe fire seasons in New Zealand

Prepared for

National Rural Fire Authority

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NIWA Report AK02045

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Executive Summary

1. Severe fire seasons experienced in New Zealand have been attributed to various synoptic climatic features. The National Rural Fire Authority has for a number of years been working towards an improved fire risk forecasting regime. The present National Institute of Water and Atmospheric Research (NIWA) report forms part of investigation to define coherent fire regions based on variability of risk as a result of climate circulation patterns.

2. NIWA have previously investigated linkages between climate predictors and severe fire seasons Salinger et al (1998), Heydenrych et al (2001). This report defines regions of coherent change in monthly fire severity in relation to short-term climate variability.

3. A total of 128 National Rural Fire Authority weather station data have been used to establish monthly severity ratings for a 21-month period (ie 3 fire seasons). The station MSR data has been analysed via statistical techniques to distinct fire regions.

4. Based on fire severity ratings a total of 15 fire regions have been identified for New Zealand. Seven fire regions occur in each of the North and South Islands with a region straddling the North-South Island. For each region a description their key linkages between fire severity rating and climate predictors are described.

5. Most fire regions form quite distinct regions based on climate patterns. However this is less clear for the extreme north and south of New Zealand. Furthermore some boundaries are seen as less coherent in the Auckland region, central North Island and the Kaikoura region.

6. In four regions further analysis is required between MSR/SSR at key stations with climate indices and weather patterns to define relationships more clearly. The regions are Auckland West/Waikato, Northern Canterbury, McKenzie Basin and Central Otago/Inland Southland.

Contents

Background and Part I of present study

Severe fire seasons experienced in New Zealand have been attributed to various synoptic climatic features, such as the presence of El Niño and La Niña events. The National Rural Fire Authority has reported variable success in their endeavour to uncover factors that cause high seasonal fire risk (Pearce et al., 1995). This is important because detection of discernible trends coupled with seasonal climate prediction would allow some anticipation of possible higher region fire risk seasons. The National Institute of Water and Atmospheric Research (NIWA) have investigated linkages between climate predictors and severe fire seasons for 10 stations in New Zealand up to the year 1995 (Salinger, 1998).

The present report details the second year of a three-year programme undertaken by the NIWA on Climate and Fire Severity for the National Rural Fire Authority (NRFA). The first year of the programme analyzed linkages between regional circulation indices and synoptic weather patterns with the monthly (MSR) and seasonal (SSR) fire severity ratings of 21 stations around New Zealand (Heydenrych et al 2001). The analysis focused on stations with long-term daily severity ratings (DSR) of greater than 20 years.

Key findings from the 2001 report indicated the following:

- *Climate predictor of circulation and wind flow shave been linked to high SSR and MSR for different areas of New Zealand*[1]*. For example; SOI is positively correlated to west coast stations of Hokitika, New Plymouth and Westport. Zonal predictors (Z1, Z2 etc.) are positively correlated to east coast stations Coromandel, Gisborne, Christchurch and Kaikoura and are negatively correlated to Hokitika and Westport. Meridional predictors (M1, M2 etc) are positively correlated to stations sheltered from the south and southwest; Tauranga, Rotorua, Nelson and Wellington.*
- *Similar correlations have been shown with daily weather patterns and high SSR and MSR. For example anticyclones centered to the north west (HNW) of the country resulting in high fire risk with east coast stations Coromandel, Tauranga, Gisborne, Wellington and Kaikoura. Anticyclones centered to the south east (HSE) of the country result in high fire risk with west coast stations Hokitika, Westport, New Plymouth and Paraparaumu.*
- *Onshore flow and troughs result in low SSR and MSR values or reduced fire risk. For example; northeast flow (NE) is negatively correlated with Corromandel, Tauranga and Kaikoura; troughs with moist north and northwest flow (TNW) are negatively correlated with most stations and particularly Coromandel, Nelson, Taupo, Tauranga and Wanganui.*
- *Significant correlations at the 5% level, and prediction equations have been developed for most stations for seasonal SSR and monthly MSR periods. Several stations had no or weak significant correlations (at 10% level) for SSR and MSR (Auckland, Coromandel, Dargaville, Wanganui, Taupo, Dunedin and Invercargill.*
- *Seasonal SSR and months October, November, December and January MSR values tended to have higher significant correlations with predictors than during February, March and April.*

[1] For a description of climate predictors see Appendix 1 and long-term correlations with station SSR is given in Appendix 2. For MSR data refer to Heydenrych et al (2001).

Scope of Part II of the study

Part I of the study explored the long-term relationships between MSR and SSR and regional circulation indices and weather types. Part II follows on from that study to focus on the inter-regional associations of the different fire regions throughout New Zealand.

New Zealand's mountains ensure great variations in local climate through their interaction with the prevailing westerly wind circulation. As a result, seasonal fire risk responds strongly to changes in large-scale circulation patterns. The present report defines regions of coherent change in monthly fire severity in relation to short-term climate variability. This has been undertaken by clustering weather stations based on similarities of their monthly severity ratings in relationship to local and regional climate variations. A total of 128 stations with a continuous record of daily severity ratings (DSR) over 21 months (ie 3 fire seasons) have been analysed. Using statistical techniques the stations have been grouped into different fire regions in New Zealand. The regions and their severity rating are then discussed in terms of their key long-term linkages to regional circulation indices and weather types, established in Part I of the present study.

The scope of this work is to improve the knowledge of climatic factors influencing fire season severity. The present report extends work presented in Salinger (1998), Heydenrych et al. (2001). The study will:

1. Identify fire region regions for New Zealand using DSR data from 128 stations.
2. Provide key fire risk indicators for fire region regions based on long-term climate and circulation indices.
3. Recommend further work required.

Methodology

Station DSR data

Daily severity ratings of 177 stations throughout New Zealand were obtained from the NFRA for the years October 1991 to April 2001. Appendix 3 lists the names and locations of the 177 stations. Only 156 stations were operational at April 2001.

As in the previous study (Heydenrych et al., 2001), the daily severity ratings (DSR) were converted to monthly (MSR) severity ratings. Less than 2% of the 177 stations had MSR data for the whole 10-year period (74 months). To enable statistical comparisons between stations with continuous data, the period October 1998 to April 2001 (ie three seasons or 21 months) were used.

Of the total NFRA 177 stations, 128 stations were identified to have complete data coverage for analysis during the three summer seasons. A list of the 128 stations and their MSR values used in the study is given in Appendix 4. The Chatham Island station was also excluded from the mainland New Zealand data set. The MSR for the 128 stations were then standardized to allow for later analysis.

Statistical analysis

The 128 station data was subject to the following analysis to define spatial homogeneity.

Principle Component Analysis (PCA)

A Pearson correlation coefficient matrix for the 128 station standardized MSR values was prepared with SYSTAT (Version 10). The correlation matrix was then subject to rotated PCA using SYSTAT. The percent of the total variance explained by the rotated components were then obtained for the top 15 components.

Cluster Analysis

The standardized correlation matrix was then subjected to various clustering techniques that provide exclusive groups of data. SYSTAT was again used to obtain additive tree, hierarchical and partitioned cluster groups. Additive trees use a graphical representation in which distances along the branches reflect similarities among the objects. Hierarchical clusters consist of clusters that completely contain other clusters that contain other clusters etc., while partitioned clusters contain no other clusters (SPSS, 2000). The statistical techniques used in SYSTAT include:

Tree/Hierarchical

Single (distance between closest pairs of clusters), *complete* (distance between furthest pairs), a*verage* (average distance between all pairs), *median* (median distance between all pairs) and *Ward* (averages all distances between pairs of objects in different clusters with adjustments for covariance) were computed.

K-Means (Partitioned)

K-means clustering, which splits a group into clusters by maximizing between-cluster variations relative to within-cluster variations, was also undertaken.

Results

PCA

The rotated variance and percentage of each component explained by PCA is shown in **Table 1**. The total variance of the first 15 components is explained by 98.1% of the rotated components.

Table 1: Total variance explained by rotated components.

Component	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Variance	38.1	23.1	6.8	10.7	13.9	11.3	2.9	3.1	3.1	2.3	3.3	2.1	1.8	1.6	1.7
Percent	29.8	18.1	5.3	8.3	10.9	8.8	2.2	2.4	2.4	1.8	2.5	1.6	1.4	1.3	1.3

Tree Cluster

The different Tree/Hierarchical cluster analysis indicates the following clusters:

- Single 4,7,16
- Complete 5,10,15
- Average 4,8,14,21
- Centroid 8,17
- Ward 4,12,24

The above clustering seemed to indicate groups of approximate 4, 7-10, 14-15, 21-24

K-means

K-means clustering forces the user to use specific iterations (or groups). The following groups or clusters were examined; 6,7,8,9,10,12,15,17 and 20. By increasing the clustering up to 15 iterations, continued to show improved clustering. Above this size, further clustering did not show any more meaningful results and many of the cluster groups consisted of less than 5 stations, which gave increased distance variability within the group.

Combination

The combination of the PCA and clustering analysis seems to indicate the most realistic components/clustering of 15 groups. This includes 7 regions in each North and South Island and one straddling the Nelson-Wellington region (see

Figure 1).

Figure 1. Fire regions for New Zealand based on MSR values for 128 stations

Fire Climate Regions for New Zealand

The 15 fire regions based on MSR values for the 128 stations used in the study are described below. Included in each fire region is one (or more) of the stations with long term correlations of SSR and MSR to climate predictors established by Heydenrych et al (2001) in Part I of the current study. The long-term stations can be seen to provide region wide indicators of MSR and SSR with climate predictors. The correlations between station SSR values for the 21 long-term stations is provided in Appendix 2 (Heydenrych et al. 2001).

Far North

The Far North region is generally characterized by weak associations between station SSR/MSR values and climate predictors. A weak positive correlation (0.4) is also found between Kaitaia and Dargaville SSR. For this region anticyclones associated with southwest and southeast flow five high fire risk as demonstrated with correlations with HNW, -Z1 and –SOI.

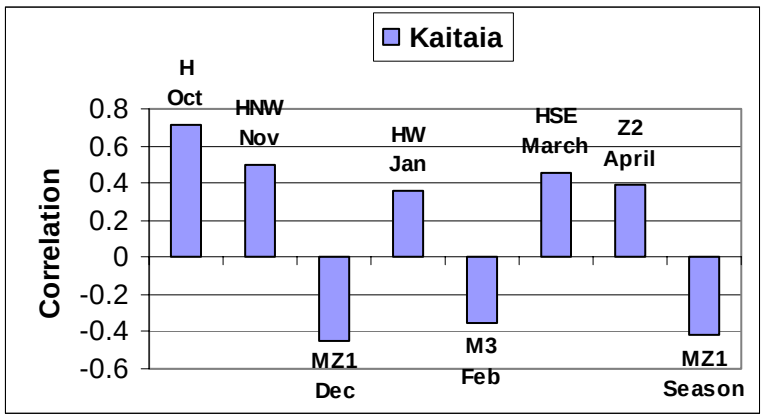
High SSR values to the north of the region (Kaitaia) tend to be associated with southeasterly (-MZ2) wind flow, while further south (Dargaville) high SSR is associated with more westerly to south westerly (Z2,MZ3) wind flow.

Between November to January high monthly MSR occur under westerly to southwesterly flow (Z2,Z3,Z4,MZ2,MZ3) for the whole region. In early and late summer there is considerable variability of high MSR in the region. Dargaville to the south has high MSR under northerly (-M3) flow during October and February, while Kaitaia to the north has high MSR with southerly and westerly (Z2,M2) wind flow. Dargaville MSR has no significant correlations (at 5% level) with climate predictors in March and April.

Kaitaia

Significant correlation between Kaitaia SSR and MSR values and climate predictors are shown in Figure 2.

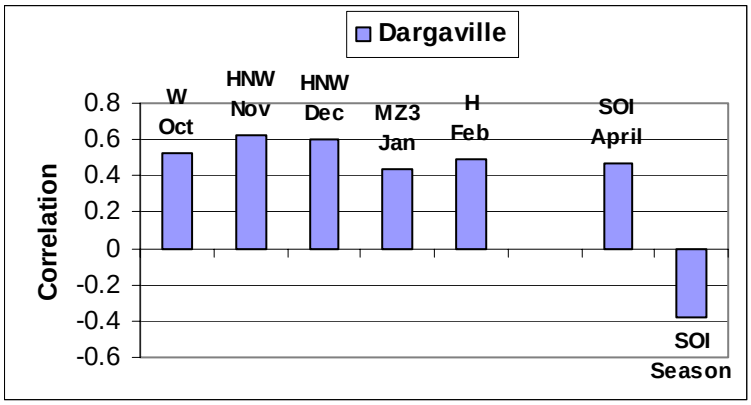
Figure 2. Highest significant correlation for Kaitaia SSR/MSR and climate predictors



Dargaville

Significant correlation between Dargaville SSR and MSR values and climate predictors are shown in Figure 3. Note the correlation is only significant at 10% level between SSR values and climate predictors (–SOI,Z1,–NE). Also March and April however have no significant association between MSR and wind flow.

Figure 3. Highest correlations for Dargaville SSR/MSR and climate predictors



Auckland West-Waikato

Due to the narrow isthmus in the Auckland region, the area is influenced by both westerly and easterly wind flow and the region shows similarities and differences with other local west and east coast sites. The PCA and cluster analysis indicates that there is good ground to consider a "Auckland West" and an "Auckland East". The Auckland West-Waikato extends south of Dargaville down to about the Marakopa River.

High SSR values in Auckland West-Waikato are associated with southeasterly (-MZ2) wind flow and low SSR seasons with troughs to the northwest (TNW).

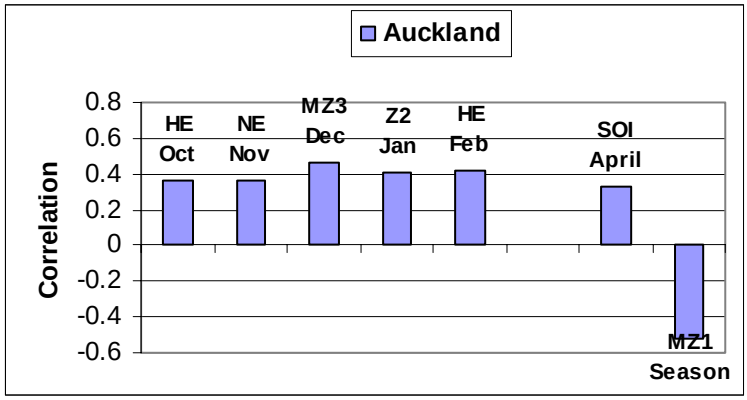
High MSR values are linked to dry northerly to westerly quarter winds (HE, NE, MZ3, Z2) for October to February. March and April have no significant correlations with wind flow. Low MSRs occurred in December and January with southwesterly to northwesterly troughs (TSW, TNW) and in February with northerly troughs (T, M1).

Further analysis should be performed for this region to clarify relationships.

Auckland

Significant correlations between Auckland SSR and MSR values and climate predictors are shown in Figure 4.

Figure 4. Highest significant correlation for Auckland SSR/MSR and climate predictors.



Auckland East - Coromandel

Auckland East-Coromandel extends south from Whangarei down to Waihi Beach. A long-term positive correlation (0.51) is found between the Auckland SSR and Corromandle SSR. High fire risk seasons occur with westerly quarter winds and anticyclones in the North Tasman Sea.

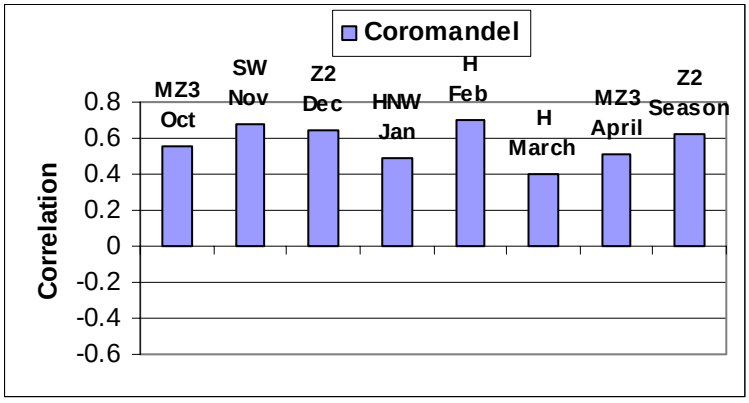
Significant correlations occur between Coromandel SSR values with westerly (Z1, Z2, Z3), northwesterly (MZ2) wind flow and anticyclones to the northwest (HNW). Low SSR are associated with northeasterly flow (NE) and a trough over New Zealand with northwesterly flow (TNW).

High MSR occur under southerly (M2) and southwesterly (SW) wind flow for the months October to February and westerly flow (Z1,Z2,Z3) from November to February. Furthermore high MSR is also associated with anticyclones over the Tasman Sea (HNW) from October through to February. In March there are no significant correlations, and in April only SOI and southwesterly flow are associated with MSR and climate predictors. Low MSR is found with troughs to the northwest (TNW) and southwest (SW).

Coromandel

Significant correlations between Auckland SSR and MSR values and climate predictors are shown in Figure 5.

Figure 5. Highest significant correlation for Coromandel SSR/MSR and climate predictors



Bay of Plenty

The region has three long-term stations of Tauranga, Rotorua and Taupo in the region. The SSR values of the three stations all have strong positive correlations (>0.6).

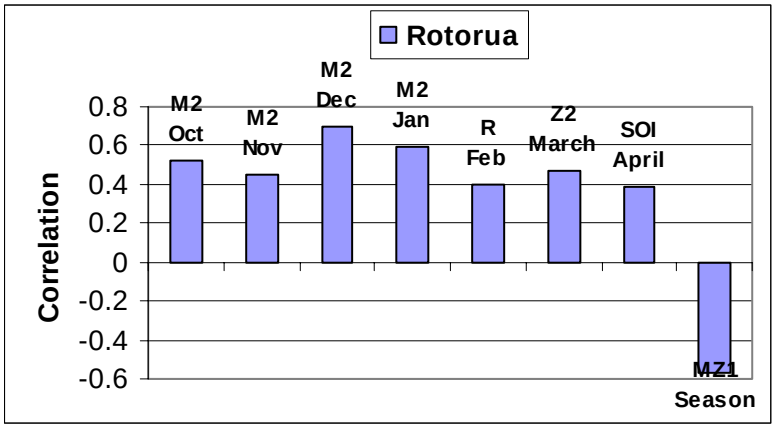
The region has high SSR values generally with southerly to westerly wind flow (Z2,M2,-MZ1) and under anticyclones over the North Island with associated light winds (HNW,H).

High MSR values over the months October to March are generally associated with southeasterly (-MZ1), southerly (M1,M2), southwesterly, and westerly (Z2) wind flow for most of the region. During these months high MSR values are also found with anticyclones over the central (H), northwest (HNW) and west (HW) of the North Island and troughs to the southwest of the country (SW). In April the coastal areas of the region (Tauranga) still have high MSR with westerly and southeasterly wind flow (Z2,-MZ1) but central areas are only weakly positively correlated to high SOI. Low MSR values tend to be associated for most months with troughs to the northwest (TNW) and southwest (SW) and northeast flow along the coast (NE).

Rotorua

Significant correlations between Rotorua SSR and MSR values and climate predictors are shown in Figure 6.

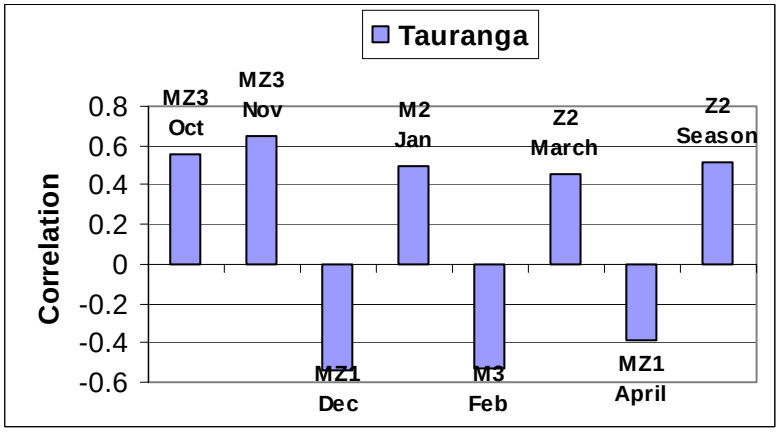
Figure 6. Highest significant correlation for Rotorua SSR/MSR and climate predictors



Tauranga

Significant correlations between Tauranga SSR and MSR values and climate predictors are shown in Figure 7.

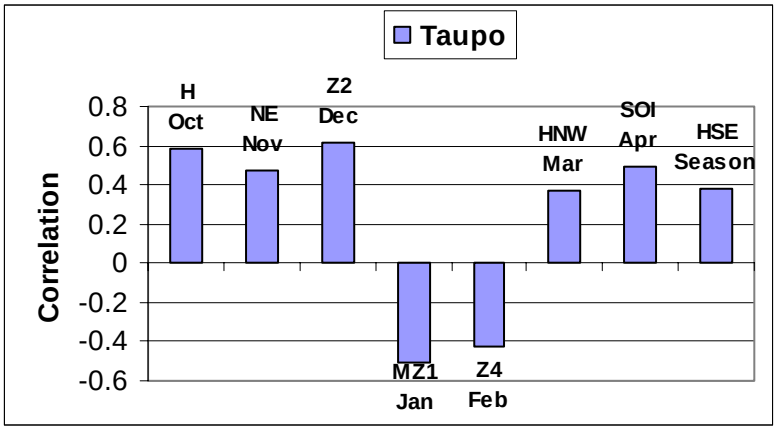
Figure 7. Highest significant correlation for Tauranga SSR/MSR and climate predictors



Taupo

Significant correlations between Taupo SSR and MSR values and climate predictors are shown in Figure 8.

Figure 8. Highest significant correlation for Taupo SSR/MSR and climate predictors



East Coast

The East Coast region extends from East Cape to Waipukutau with a long-term station at Gisborne. Although Gisborne and Kaikoura have been identified in different fire regions they have a high positive correlation (0.7) with their long-term SSR values.

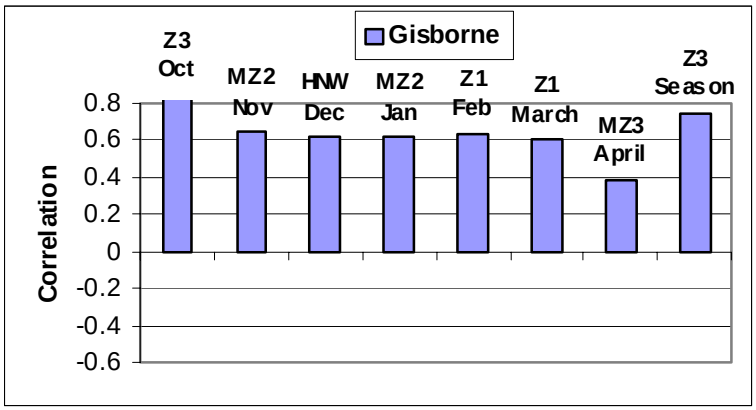
High SSR values and climate predictors are found with westerly quarter wind flow (Z1,Z2,Z3,Z4,M2,MZ2,MZ3), associated with troughs to the south and anticyclones over the north Tasman Sea (TSW,T,SW,-NE,R,-HW,HNW). Low SSR seasons occur with troughs over the South Island and ridging of anticyclone over the South Island (T,R).

For most months high monthly MSR occur under southwesterly to northwesterly wind flow (MZ1,MZ3,Z1,Z2,Z3,Z4) with troughs to the south of the South Island (T) and anticyclones over the north Tasman Sea (HNW). Low MSR values are associated with troughs to the northwest (TNW) and ridging anticyclones (R, HSE) over the South Island.

Gisborne

Significant correlations between Gisborne SSR and MSR values and climate predictors are shown in Figure 9.

Figure 9. Highest significant correlation for Gisborne SSR/MSR and climate predictors



Taranaki – Wanganui

The Taranaki – Wanganui region has two long-term stations of New Plymouth and Wanganui which have a strong positive correlation (0.76) between their SSR values. In the present study, Taupo area has been included with the Rotorua region but also shows strong positive correlations (>0.6) with New Plymouth and Wanganui SSR values.

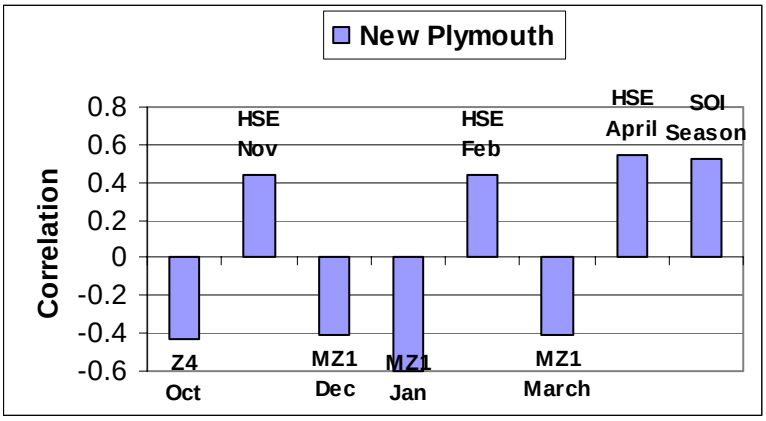
High SSR within the region varies slightly from the northwest (New Plymouth) to southeast (Wanganui). High SSR at New Plymouth is associated with light easterly wind flow (HSE) and the SOI, while at Wanganui it tends to be more westerly wind flow (Z2,W). In both cases anticyclones predominate. The whole region has a high positive correlation of SSR with SST. Low SSR is associated with anticyclones to the west and troughs to the southeast (SW,TNW).

From October to February high MSR in the region tends to be associated with south, southeasterly wind flow (-MZ2,-MZ3). Weaker positive correlations are also found between MSR and anticyclones situated to the northwest (HNW) and southeast (HSE) and over central North Island (H). High MSR at Wanganui is also associated with westerly flow (Z2) during November and December. Low MSR tends to be associated with troughs to the northwest and southwest (TNW,SW).

New Plymouth

Significant correlations between New Plymouth SSR and MSR values and climate predictors are shown in Figure 10.

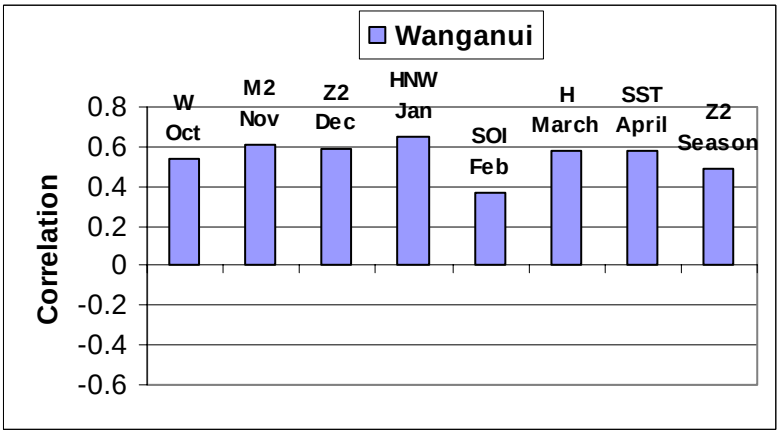
Figure 10. Highest significant correlation for New Plymouth SSR/MSR and climate predictors



Wanganui

Significant correlations between Wanganui SSR and MSR values and climate predictors are shown in Figure 11.

Figure 11. Highest significant correlation for Wanganui SSR/MSR and climate predictors



Manawatu - Wairarapa

This region covers the whole of the central southern North Island except for Wellington. Included in the region are two long-term stations of Ohakea and Paraparaumu, which have a high positive correlation (0.76) of their SSR values.

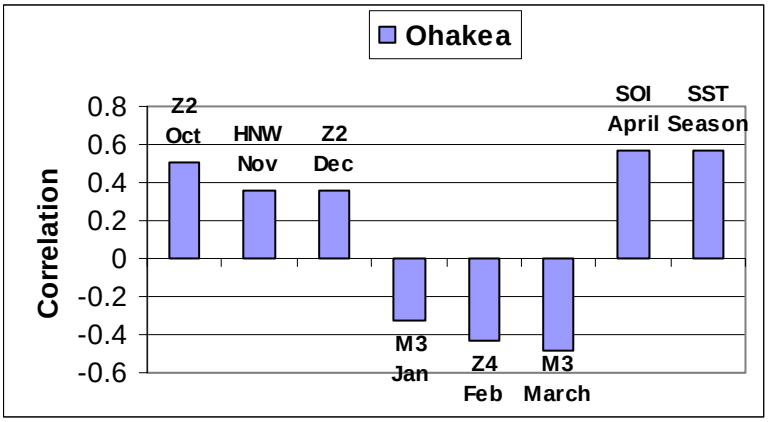
High SSR values in the region are found with northerly (-M1,-M3) and anticylonic easterly (-Z4,HSE) wind flow. Furthermore high SSR in the region has a significant positive correlation to SST values. Low SSR is weakly associated with troughs to the south of New Zealand (T) with disturbed westerly wind flow.

For most months in this region, high MSR are frequently associated with high pressures situated over North Island (H,R) to the northwest (HNW), and the southeast (HSE). The predominant wind flow found with high MSR is from the southeast and south-southeast (-MZ1,-MZ2). However high MSR can also occur with wind flow from the east (-Z1,-Z4), west (Z2), south (M1,M2) and the north (-M1,-M2,-M3), especially the latter towards the north of the region (Ohakea). This region also has a significant correlation with SST for most months and the SOI in April. Low MSR values occur with troughs to the south and northwest (T,TNW).

Ohakea

Significant correlations between Ohakea SSR and MSR values and climate predictors are shown in Figure 12.

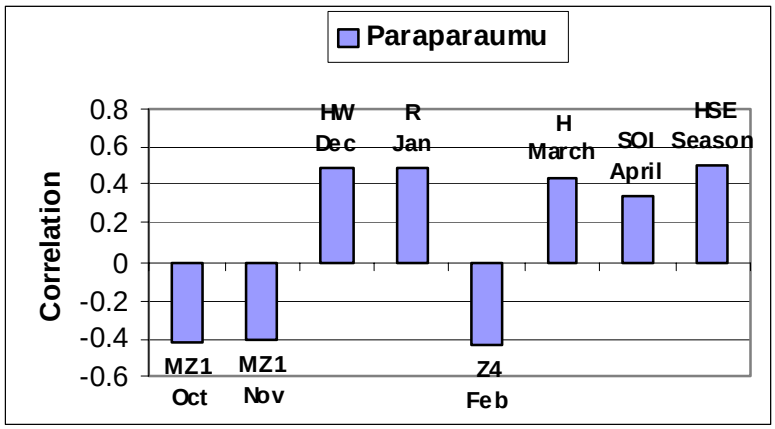
Figure 12. Highest significant correlation for Ohakea SSR/MSR and climate predictors



Paraparaumu

Significant correlations between Paraparaumu SSR and MSR values and climate predictors are shown in Figure 13.

Figure 13. Highest significant correlation for Paraparaumu SSR/MSR and climate predictors



Wellington – Nelson/Marlborough

The analysis undertaken has shown that the southern North Island and northern South Island have relatively strong associations with their long-term SSR/MSR values and spatial homogeneity. Further the SSR values of Wellington, Nelson and Kaikoura have significant positive correlations (>0.5). The PCA and cluster analysis however indicates that Kaikoura is on the edge and could be included with Northern Canterbury or Wellington/Nelson regions. In this report Kaikoura has been classified as part of the Northern Canterbury region.

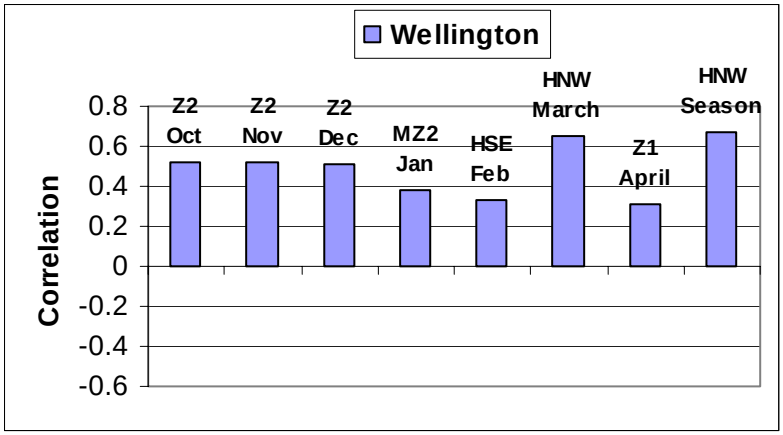
High fire risk is associated with anticylonic southwest flow over New Zealand. High SSR values occur with westerly (Z1,Z2,Z3,Z4), northwesterly (MZ2,MZ3), southerly (M2) wind flow and anticyclones to the north west of North Island (HNW). Low SSR occurs with troughs to the northwest (TNW).

From October to January high MSR occurs with westerly (Z1,Z2,Z3) southwesterly (-MZ3,HNW,SW), southerly (M2) and southeasterly (-MZ1,-MZ2) wind flow. The region has generally very weak associations in February with high MSR. From March to April, high MSR is re-established with westerly (Z2) and southwesterly flow associated with a high to the northwest (HNW). For most months low MSR is associated with troughs to the northwest (TNW) and in some months with northeast flow (NE) and troughs to the southwest (SW).

Wellington

Significant correlations between Wellington SSR and MSR values and climate predictors are shown in Figure 14.

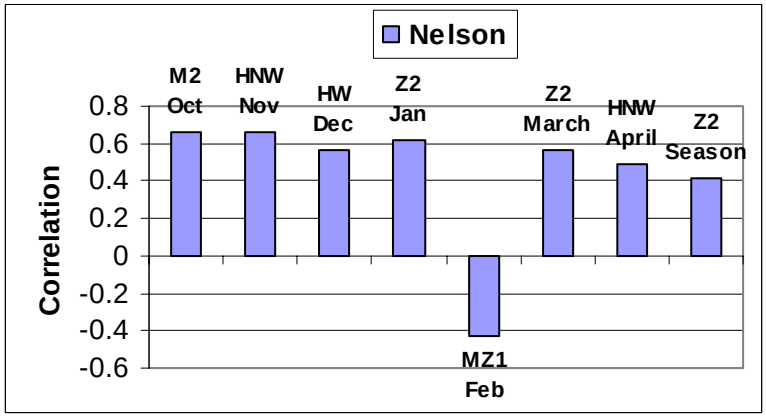
Figure 14. Highest significant correlation for Wellington SSR/MSR and climate predictors



Nelson

Significant correlations between Nelson SSR and MSR values and climate predictors are shown in Figure 15.

Figure 15. Highest significant correlation for Nelson SSR/MSR and climate predictors



Northern Canterbury

Northern Canterbury is represented by the long-term station of Kaikoura and covers coastal and inland northern and central Canterbury. Kaikoura SSR has strong positive correlations (>0.7) with Gisborne and Corromandel.

Generally high fire risk is associated with anticylonic westerly wind flow. High SSR values occur with westerly (Z1,Z2,Z3,Z4,W), northwesterly (MZ2) and southwesterly (MZ3,SW) wind flow, and high pressure to the north west (HNW). Low SSR is found with troughs to the south west (SW) and north east wind flow (NE).

For the months October to March high MSR occur in the region with westerly (Z1,Z2,Z3,Z4) and northwesterly (MZ2) wind flow, troughs to the south (SW,T,W) and anticyclones to the

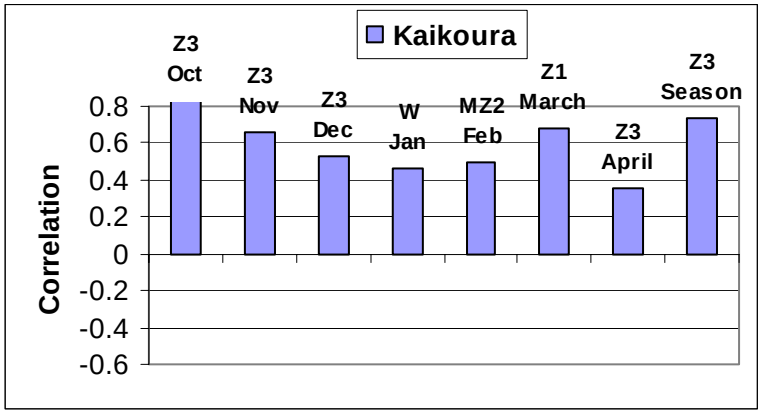
northwest (HNW). In April MSR has only a weaker association with westerly flow. Low MSR values occur with troughs to the south west (SW), anticyclone to the south east (HSE) and north east wind flow (NE).

Further analysis of relationships is required from stations in the Northern Canterbury region.

Kaikoura

Significant correlations between Kaikoura SSR and MSR values and climate predictors are shown in Figure 16.

Figure 16. Highest significant correlation for Kaikoura SSR/MSR and climate predictors



West Coast

The West Coast region extends over the majority of the West Coast and includes the long-term stations of Westport and Hokitika who have a positive correlation (0.6) between their SSR values.

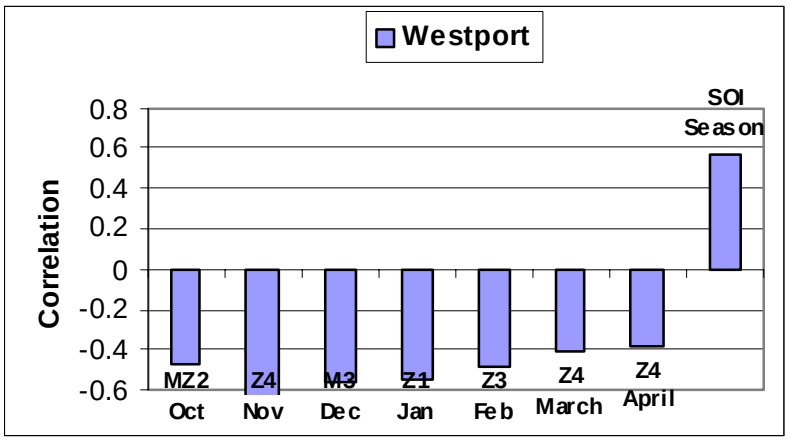
In this region high fire risk is strongly associated with periods of easterlies. High SSR values occur with easterly (-Z1,-Z2,-Z3,–Z4), southeasterly (MZ3), northeasterly (MZ2,NE) and northerly (-M1,-M2) wind flow. High SSR is also associated with anticyclone to the southeast (HSE) and the SOI and SST indicies. Low SSR is found with westerly and southwesterly flow associated with troughs to the south (W,SW).

High monthly MSR occurs for all months between October and April under easterly (-Z1,-Z2,-Z3,-Z4), southeasterly(MZ2) and northeasterly (MZ3,NE) wind flow. High MSR is also associated with some months with anticyclones to the southeast (HSE) and to the west (HW,R). In January high MSR is positively correlated to SOI and SST. Low MSR months are generally associated with troughs to the southwest (SW,TSW) and anticyclone to the north west (HNW).

Westport

Significant correlations between Wesport SSR and MSR values and climate predictors are shown in Figure 17.

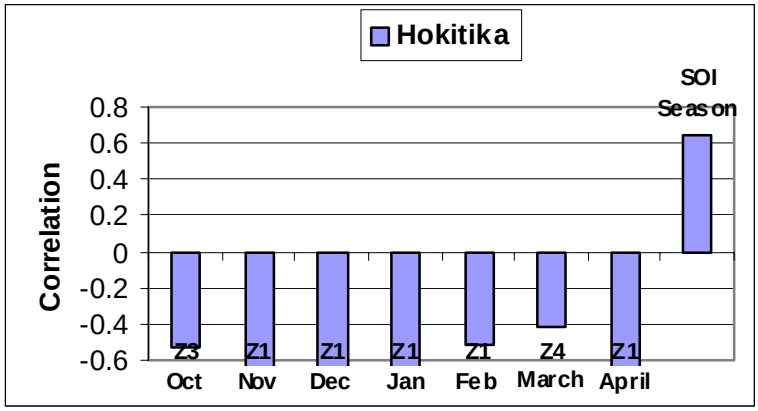
Figure 17. Highest significant correlation for Westport SSR/MSR and climate predictors



Hokitika

Significant correlations between Hokitika SSR and MSR values and climate predictors are shown in Figure 18.

Figure 18. Highest significant correlation for Hokitika of monthly SSR and climate predictors



Coastal Mid/South Canterbury

Coastal Mid/South Canterbury region extends from Christchurch along the coast to about Waimate and includes the long-term station of Christchurch. Christchurch SSR values have positive correlation with several east coast areas (Kaikoura, Gisborne, Coromandel) and Wellington/Nelson.

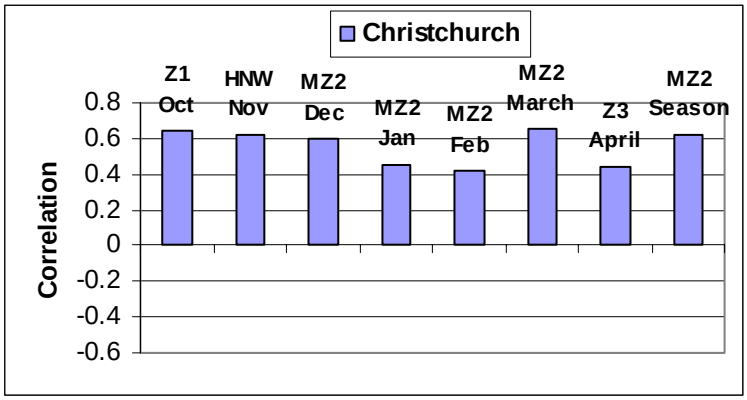
In this region high fire risk is strongly associated with westerly to north westerly wind flow. High SSR values occur with northwesterly (MZ2) and westerly (Z1,Z2,Z3) wind flow and anticyclones to the northwest (HNW). Low SSR values are associated with northeasterly wind flow (NE) and troughs over the South Island associated with northwesterly flow (TNW).

High MSR occur under westerly (Z1,Z2,Z3) and northwesterly (MZ2) for most months October through to April. High MSR are also associated with anticyclones to the northwest (HNW), troughs to the south (T) and westerly flow (W). Low MSR values are found with troughs to the northwest (TNW)

Christchurch

Significant correlations between Wanganui SSR and MSR values and climate predictors are shown in Figure 19.

Figure 19. Highest significant correlation for Christchurch SSR/MSR and climate predictors



Mckenzie Basin

The McKenzie Basin which includes the towns of Wanaka and Omarama , does not have any long-term DSR data. The long-term association between the region SSR/MSR and climate predictors is based on a modified Queenstown data.

As for the Queenstown-Lumsden region, no clear linkage between high SSR for the Mckenzie Basin and wind flow climate predictors is expected. High SSR should be associated with the climate predictor SST. Low SSR is however also likely to be associated with troughs in the northwest wind flow (TNW).

The region is likely to be fairly variable and only have moderate high MSR correlations to climate predictors. Wind flow from the west (Z2) and east (-Z2) and anticyclones over central New Zealand and to the southeast (H,HSE) are likely to be linked to high MSR. The region is not likely to have any consistent correlations with low MSR over the season.
It is recommended that a site in this region be analysed to ascertain long-term relationships.

Central Otago – Inland Southland

The Central Otago – Inland Southland region includes the long-term station of Queenstown. Queenstown SSR is positively correlated (>0.5) to Dunedin and Invercargill.

The region does not show any significant correlations between high SSR and wind flow although there is a tendency towards higher fire risk with anticyclones east of the South Island. Moderate SSR is linked to the climatic predictor SST. Low SSR is weakly correlated with a trough to the northwest (TNW) and associated northwesterly wind flow.

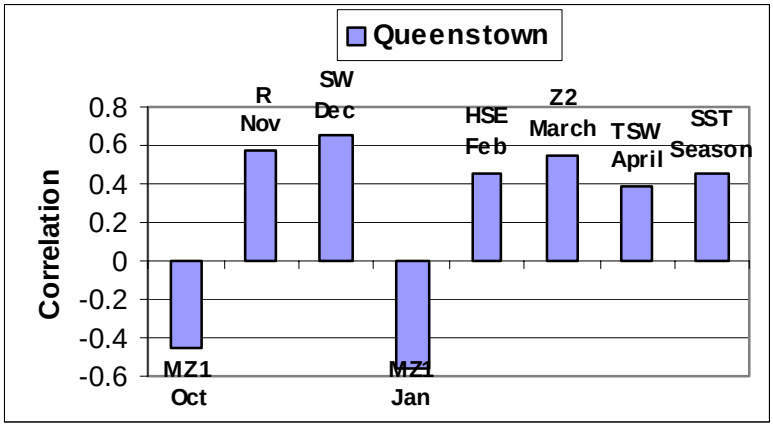
High MSR has strong variability from month to month. In October and November high MSR is associated with anticyclones over New Zealand (H,R) and east to southeast (-Z3,-MZ1) wind flow. December and January tend to have higher MSR with southerly to westerly wind flow (Z2,SW,M2). In February and March high MSR is found with anticyclones over New Zealand and to the southeast (H,HSE) and westerly wind flow (Z2). In April there are no significant correlations with climate predictors. There is no consistent significant correlation for low MSR throughout the season.

In this district further analysis should be performed on a more central site in the district to establish long-term relationships for the region.

Queenstown

Significant correlations between Queenstown SSR and MSR values and climate predictors are shown in Figure 20.

Figure 20. Highest significant correlation for Queenstown SSR/MSR and climate predictors



Coastal Otago

Coastal Otago extends from Oamaru down to the Catlins and includes the long-term station of Dunedin. Dunedin SSR is positively correlated (0.5) to Queenstown and Invercargill.

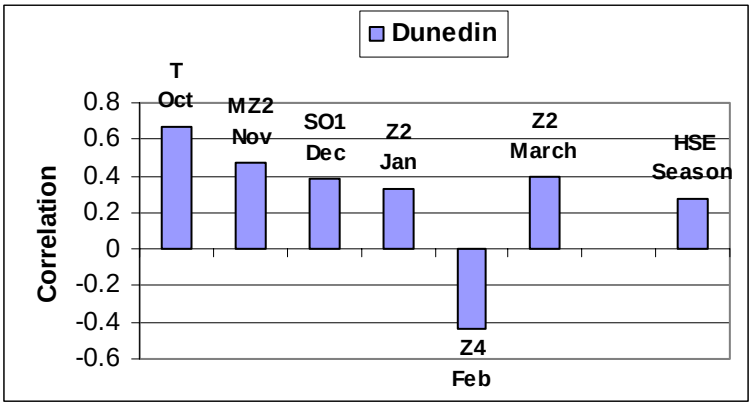
High SSR for the region is only weakly correlated to westerly winds flow (Z2) and anticyclones to the southeast (HSE). There are no significant correlations between low SSR and climate predictors.

This region shows variable linkages between high MSR and climate predictors. During October – November high MSR occurs with southwesterly to northwesterly flow (MZ3,Z2,MZ2), troughs to the south (T). In December and January, high MSR is only moderately correlated to westerly wind flow (Z2) and the SOI. In February there is a reversal and high MSR is linked to easterly and northerly (-Z4, -M3) wind flow and in March back to westerly and northerly wind flow (Z2,-M3). In April there are no significant relationships with MSR. Low MSR is weakly associated with troughs to the southwest (TSW) over most months.

Dunedin

Significant correlations between Dunedin SSR and MSR values and climate predictors are shown in Figure 21.

Figure 21. Highest significant correlation for Dunedin SSR/MSR and climate predictors



Southland - Fiordland

Coastal Southland and Fjordland includes the long-term station of Invercargill whose SSR is positively correlated (0.5) to Dunedin and Queenstown.

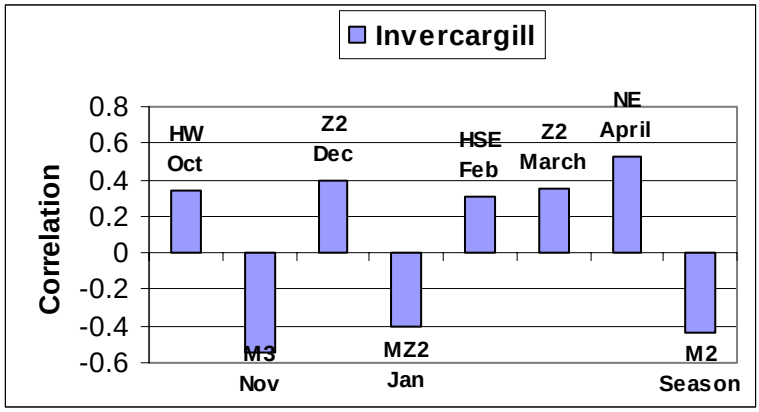
Moderately high SSR values correlations are found with easterly and northeasterly wind flow (-Z4,MZ3,-M1,-M2). No significant correlations are found for low SSR and climate predictors.

This region shows variable linkages between high MSR and climate predictors. High MSR occur with anticyclones centered to the west or to the east of the South Island (HW,HE,HSE,H) between October and December. MSR is associated with northerly and easterly wind flow (M1,-M3,-Z3) between November and January. February has no significant correlations, March a weak correlation with westerly (Z2) wind flow and by April high MSR is established with northeasterly flow. For most months low MSR tend to be associated with troughs to the south and southwest of the South Island (TSW,T,SW).

Invercargill

Significant correlations between Invercargill SSR and MSR values and climate predictors are shown in see Figure 22.

Figure 22. Highest significant correlation for Invercargill SSR/MSR and climate predictors



Discussion

This study has grouped 128 NRFA stations, based on monthly severity rating (MSR) data, into homogenous regions based on climate predictors. The analysis has been undertaken with two statistical techniques, namely principal component analysis (PCA) and clustering (6 different methods). The results presented earlier in this document, indicate that some areas are clearly defined and others have less coherent boundaries. Seven fire regions have been identified in each of North and South Island and one region straddling the two islands across central New Zeland.

North Island

North Island fire regions break down into five distinct areas, namely the North, East Coast, Taranaki-Wanganui, Manawatu-Wairararapa and Wellington. However the North can be subdivide into three areas as identified in this report of Far North, Auckland West-Waikato and Auckland East-Coromandel. Moderate topography and coastal influences, only make for subtle differences especially in the Auckland City region. The central North Island is another area that the boundaries are less clear. While Taupo has been allocated to the Bay of Plenty region, Taupo's SSR values are positively correlated to both Tauranga (0.62) and New Plymouth (0.67). Wellington SSR clearly correlates to the Nelson-Marlbourough region (0.58) rather than to Paraparaumu (0.19) and hence is joined with the northern South Island in a separate fire region.

South Island

Based on the long-term SSR and MSR data, the South Island classifies into four broader regions of North, East, West and South. However the cluster and PCA analysis indicates more regions and a total of 7 regions plus the Wellington-Nelson/Marlbourough region have been identified. The northern boundary of Northern Canterbury is loosely defined to include Kaikoura. However Kaikoura SSR values have higher correlations with Corromandel (0.8) and Gisborne (0.7) than with Christchurch (0.59) or Wellington (0.58). Inland Otago-Southland has been separated into northern and southern regions due to strong differences in the cluster analysis. The Southland-Fjordland region also has weak intra-region MSR

linkages. For example, Invercargill SSR has a higher positive correlation with Ohakea (0.54) than with Queenstown (0.53).

In four regions of Auckland West-Waikato, Northern Canterbury, Central Otago-Inland Southland and McKenzie Basin, further analysis is required to clarify regional boundaries and relationships between SSR and MSR values and climate predictors.

A summary for each fire region is presented in Table 2. The Table shows for each fire region:

- The key long-term stations
- Wind flow associated with high SSR
- Climate predictors associated with high SSR
- Correlation between region station SSR with other long-term stations.

Table 2. Fire Region Summary Table

Region	Key Long-term Stations	Wind direction with high SSR	Climate predictors with high SSR	Highest correlated stations (SSR)
Far North	Kaitaia, Dargaville	SE, SW, W	Z2, -MZ1, HNW	Rotoura, Coromandel, Taupo, Tauranga
Auckland West-Waikato	Auckland	SE, W	-MZ1, HE	Kaitaia, Rotorua Coromandel
Auckland East-Coromandel	(Auckland), Corromandel	S, SW, W, NW	Z1/2/3, HNW, MZ2, HE	Kaikoura, Gisborne, Rotorua
Bay of Plenty	Rotorua, Tauranga, Taupo	S, SW, W, NW	Z2, M2, MZ1, SW	Coromandel, Kaitaia, Dargaville
East Coast	Gisborne	S, SW, W, NW	Z1/2/3/4, M2, MZ2/3, SW HNW,	Kaikoura, Christch, Coromandel
Taranaki-Wanganui	New Plymouth, Wanganui	E, S, W,	SST, Z2, W, HSE	Taupo
Manawatu-Wairarapa	Ohakea, Pararaumu	E, S	SST, -Z4, -M1/3, HSE,	Westport, Hokitika
Wellington- Nelson	Wellington, Nelson	S, SW, W	Z2/3, M2, MZ3, HNW,	Coromandel, Christchurch
Northern Canterbury	Kaikoura	SW, W, NW	Z1/2/3/4, MZ2/3, SW, HNW,	Gisborne, Christch, Coromandel
West Coast	Westport, Hokitika	N, NE, E, SE	SOI, SST, -Z1/4, -M1, -MZ3, NE, HSE	Ohakea, Pararaumu
Coastal Mid/South Canterbury	Christchurch	W, NW, N	SST, Z1/2/3, M1/2/3, HE, MZ2/3, W, T, HNW, H	Coromandel, Kaikoura, Gisborne
McKenzie Basin	-	SE, S, SW, W	SST, Z2, M2, -MZ1, SW, HSE, H	-
Central Otago-Inland Southland	Queenstown	SE, S, SW, W	SST, Z2, M2, -MZ1, SW, HSE, H	Dunedin, Invercargill
Coastal Otago	Dunedin	N, W	Z2, -M3	Queenstown
Southland-Fiordland	Invercargill	N, NE, E	SOI, -Z4, -M1/2, -MZ3, NE	Ohakea, Queenstown

Directions for future and ongoing work

The present report completes the work from the second year of a three-year program on Integrated Climate and Fire Season Severity Forecasting. Associations between seasonal SSR and monthly MSR and climate predictors have been established for 21 long-term stations around the country (Heydenrych et al, 2001). This report has analysed a larger network (128) of station MSR data from around New Zealand and identified 15 different fire regions based on the regions response to fire severity with climate circulation and daily weather patterns.

Based on our understanding of the seasonality of high fire risk within and between fire regions, other daily weather features such as daily mean sea level pressure will be investigated for linkages with high MSR periods. This work will focus on two distinct climate regions in the third year of the programme.

For some of the newly identified fire climate regions in this report, further analysis of fire risks with climate indices and daily weather patterns would improve predictive relationships.

NIWA is the key agency involved with seasonal and monthly climate forecasting in New Zealand. The seasonal climate forecasting techniques utilised by NIWA and new relationships uncovered here, will be used in the production of seasonal fire danger outlooks for specific indicator stations in the key fire climate regions.

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Appendix 1:
Regional Circulation Indices

As a way of characterising predominant weather patterns on monthly time-scales, a number of circulation indices for the Australia-New Zealand region are used in this study. Circulation indices were first developed by Trenberth (1975, 1976), added to by Salinger and Mullan (1992) and more recently extended by Kidson (2000). A monthly index for a pair of stations is simply the monthly mean pressure difference between the stations less the long-term mean monthly pressure difference calculated over a 30-year "normal" period. . A non-zero index implies an anomalous pressure gradient between the stations and hence an anomalous windflow perpendicular to the gradient. Hence, a north-south pressure difference indicates the strength of the wind in the west-east direction, while an east-west difference indicates north-south wind strength, and so on. The indices can be interpreted as a measure or indicator of the prevalent wind speed and directionThe indices can also be interpreted as a measure or indicator of the prevalent wind speed and direction.

Table A1 gives a list of circulation indices, the first seven of which were defined originally by Trenberth (1975, 1976). The three indices (MZ1, MZ2 and MZ3) were derived to capture aspects of New Zealand's circulation that are neither directly zonal (east/west) nor meridional (north/south). The synoptic circulation types described by Kidson (2000) and listed as the next 12 indices from TSW, T, etc. are also shown in Table A1, A2 and Figure A1.

Typical wind flow and strength patterns for each of these circulation indices are given in Table A2. Taking the Z1 index for example, a positive anomaly leads to an increase in the strength and frequency of westerlies across New Zealand, while a negative anomaly indicates an increase on the frequency of easterly winds across New Zealand (and by implication reduced westerlies.

In contrast, the daily weather patterns identified represent specific synoptic types. Thus a positive correlation with these indicates high fire risk associated with its *presence*, and likewise a negative correlation suggests a low fire risk associated with the occurrence of the type.

Table A1. Indices of circulation in the New Zealand region

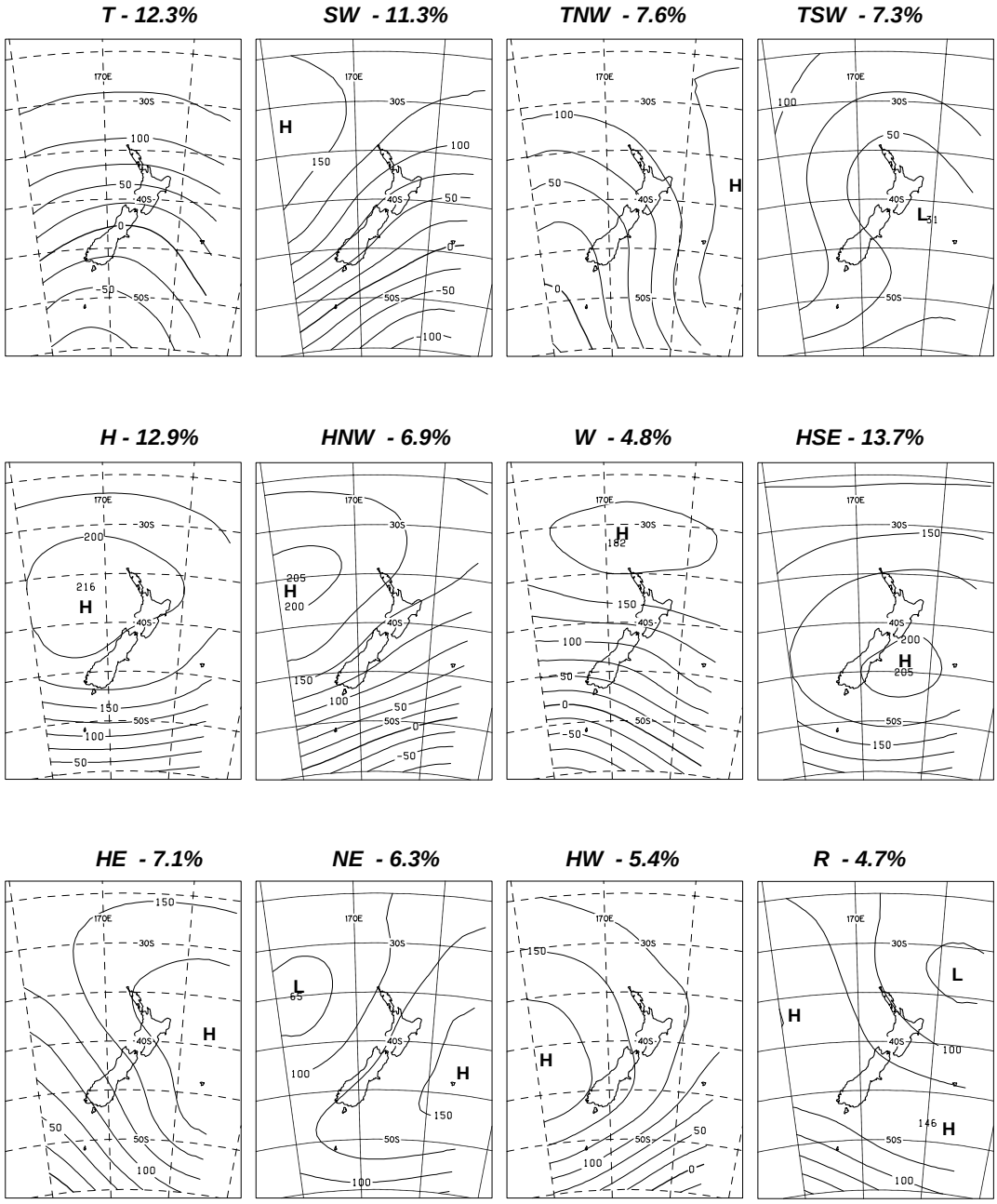
Index	Pressure difference/Synoptic Type*	Type
Z1	Auckland-Christchurch	Zonal westerlies
Z2	Christchurch-Campbell Island	Zonal westerlies
Z3	Auckland-Invercargill	Zonal westerlies
Z4	Raoul Island- Chatham Island	Zonal westerlies
M1	Hobart-Chatham Islands	Meridional southerlies
M2	Hokitika-Chatham Island	Meridional southerlies
M3	Hobart-Hokitika	Meridional southerlies
MZ1	Gisborne-Hokitika	North-westerly flows
MZ2	Gisborne-Invercargill	North-westerly flows
MZ3	New Plymouth-Chatham Island	South-westerly flows
TSW	* Trough/southwesterly	Trough in southwest flow crossing New Zealand
T	* Trough	Trough in westerly flow crossing New Zealand
SW	* Southwesterly	Southwesterly flows
NE	* Northeasterly	Northeasterly flows
R	* Ridge	Ridge – light winds over the sotuh, easterlies over the north
HW	* High to southwest	High to west of the South Island with light south – southwesterly flows
HE	* High to east	High to the east with developing northwesterly flow
W	* Westerly	Westerly flow
HNW	* High to northwest	High west of the North Island with southwesterly flow
TNW	* Trough in northwest	Trough to the west preceeded by northwesterly flow
HSE	* High to southeast	High east of the South Island with easterly flow for the North Island and light winds elsewhere
H	* High	Light winds – North Island Westerly flow – far south

Synoptic Types: T indicates a trough in the flow
H indicates an anticyclone or ‘high’
R indicates a ridge of high pressure

Table A2. Typical flow patterns associated with circulation index anomalies.

Index	Positive anomaly	Negative anomaly
Z1	Stronger westerlies over NZ	Stronger easterlies (weaker westerlies)
Z2	Stronger westerlies south of NZ	Easterlies south of NZ
Z3	Stronger west-northwest flow over NZ	East-southeast flow over NZ
Z4	Stronger westerlies northeast of NZ	Easterlies to northeast of NZ
M1	Stronger southerly flow NZ/Tasman	Northerlies over NZ/Tasman
M2	Enhanced southerlies east of NZ	Northerly airflow east of NZ
M3	Stronger southerlies in Tasman	Northerlies in Tasman
MZ1	Stronger NNW especially over central NZ	SSE airflow especially over central NZ
MZ2	Stronger north-westerlies over NZ	South-easterly winds over NZ
MZ3	Stronger south-westerlies over NZ	North-easterlies over NZ
TSW	Westerly flows – North Island Easterly flows – South Island	
T	Westerly flows	
SW	Southwesterly flows	
NE	Northeasterly flows	
R	Light winds	
HW	South – southwesterly flows	
HE	Developing northwesterly flows	
W	Westerly flows	
HNW	Southwesterly flows	
TNW	Northwesterly flows	
HSE	Easterly flows – North Island Light winds – South Island	
H	Light winds – North Island Southwesterly flows – South Island	

Figure A1. Cluster-mean (1000hPa) flow patterns used to categorise daily weather patterns (Kidson 2000). Percentage values represent the frequency of each type each year over the period studied.



Appendix 2:
21 long term station correlations with climate indices

Table 3. Correlation coefficients between the 21 stations and seasonal predictors (October – April). Correlation coefficients which are are greater than 5% level are bolded.

	SOI	SST	Z1	Z2	Z3	Z4	M1	M2	M3	MZ1	MZ2	MZ3	TSW	T	SW	NE	R	HW	HE	W	HNW	TNW	HSE	H
Auck	0.00	0.15	-0.09	0.17	-0.11	-0.04	0.15	0.20	0.04	**-0.51**	-0.27	0.07	-0.20	-0.33	0.18	-0.16	0.23	0.18	0.34	-0.09	0.08	**-0.39**	0.10	0.00
Christ	-0.18	0.14	**0.55**	**0.46**	**0.61**	0.29	-0.07	0.24	**-0.34**	0.03	**0.62**	**0.30**	-0.28	0.06	0.23	**-0.38**	**-0.36**	-0.03	0.30	0.19	**0.34**	**-0.38**	0.08	0.11
Corom	-0.37	0.25	**0.51**	**0.63**	**0.59**	0.40	0.05	0.35	-0.31	-0.35	**0.48**	0.34	-0.39	0.01	0.38	**-0.57**	-0.29	-0.26	0.49	0.31	**0.54**	**-0.52**	-0.07	0.17
Darg	-0.38	-0.16	0.37	0.28	0.36	0.27	0.02	0.24	-0.23	-0.17	0.24	0.30	-0.23	0.01	0.31	-0.43	-0.24	-0.13	0.18	0.18	0.22	-0.17	0.17	-0.11
Dun	0.25	0.17	0.02	0.28	0.02	-0.26	-0.20	-0.08	-0.24	0.02	0.14	-0.16	-0.24	-0.10	-0.09	-0.15	0.02	0.09	0.13	-0.16	0.02	-0.15	0.29	0.19
Gisb	**-0.39**	-0.15	**0.77**	**0.52**	**0.75**	**0.55**	0.21	**0.40**	-0.08	-0.03	**0.64**	**0.53**	**-0.40**	**0.34**	**0.56**	**-0.43**	**-0.39**	**-0.31**	0.12	0.24	**0.52**	-0.25	-0.25	0.19
Hok	**0.65**	**0.44**	**-0.60**	**-0.41**	**-0.55**	**-0.52**	**-0.35**	-0.31	-0.25	0.07	**-0.38**	**-0.45**	0.25	-0.24	**-0.44**	**0.52**	0.36	**0.32**	-0.29	-0.32	**-0.55**	0.07	**0.47**	-0.34
Inver	**0.37**	0.30	-0.24	-0.04	-0.16	**-0.43**	**-0.37**	**-0.42**	-0.16	**0.32**	0.06	**-0.42**	-0.10	-0.12	-0.30	0.30	0.14	0.17	-0.04	-0.23	-0.26	-0.02	0.24	0.12
Kaik	**-0.39**	0.06	**0.72**	**0.42**	**0.73**	**0.55**	0.20	0.29	0.01	0.04	**0.64**	**0.43**	**-0.34**	0.19	**0.47**	**-0.49**	-0.33	-0.25	0.28	**0.39**	**0.52**	-0.35	-0.20	0.13
Kait	0.27	0.26	-0.16	0.23	-0.12	-0.18	0.01	0.18	-0.17	**-0.41**	-0.19	0.09	-0.22	-0.10	-0.10	-0.15	0.28	0.23	0.05	-0.19	0.23	-0.32	0.28	-0.11
Nel	-0.23	0.14	0.24	**0.42**	0.24	0.17	0.08	**0.40**	-0.28	-0.38	0.10	**0.34**	-0.26	-0.18	0.23	**-0.35**	-0.13	0.06	**0.33**	0.04	**0.39**	**-0.45**	0.07	0.17
New P	**0.52**	**0.46**	-0.33	0.07	-0.18	-0.40	-0.21	-0.32	0.01	0.14	0.03	-0.37	0.21	0.08	**-0.45**	0.04	0.08	**-0.53**	-0.24	0.30	-0.30	-0.33	**0.52**	0.20
Ohak	0.16	**0.57**	-0.12	0.13	-0.01	-0.30	**-0.38**	-0.11	**-0.46**	-0.09	0.13	-0.16	-0.22	-0.24	-0.19	0.14	0.04	-0.08	-0.03	-0.15	0.13	-0.07	**0.38**	0.13
Parap	0.18	**0.44**	-0.29	-0.03	-0.27	**-0.34**	-0.32	-0.03	**-0.48**	-0.22	-0.24	-0.16	-0.12	**-0.47**	-0.28	0.10	0.14	0.22	0.21	-0.17	-0.08	-0.15	**0.47**	0.00
Queen	0.25	**0.45**	-0.08	0.29	0.04	-0.25	-0.09	-0.17	0.03	0.03	0.23	-0.21	-0.09	0.11	0.00	0.06	-0.03	-0.14	-0.23	0.00	-0.05	-0.42	0.25	0.22
Rotor	-0.19	0.09	0.07	0.25	0.05	0.13	0.17	0.38	-0.12	**-0.56**	-0.14	0.27	-0.22	-0.27	0.26	-0.27	0.22	-0.15	0.25	0.13	0.16	-0.31	0.06	0.05
Taupo	0.01	0.34	-0.02	0.24	0.08	-0.02	0.10	0.05	0.11	-0.20	0.08	0.01	0.03	0.03	0.08	-0.35	0.00	0.02	-0.17	0.18	0.07	**-0.56**	0.38	0.22
Taur	-0.36	-0.06	0.27	**0.52**	0.31	0.28	0.15	**0.39**	-0.17	**-0.44**	0.13	0.37	-0.31	-0.18	**0.38**	**-0.49**	-0.12	-0.23	0.35	0.21	**0.41**	**-0.50**	0.06	0.20
Wang	0.14	**0.47**	0.16	**0.49**	0.32	0.10	0.03	0.08	-0.04	-0.08	0.39	0.08	-0.01	0.15	-0.04	-0.30	-0.21	**-0.55**	-0.06	**0.48**	0.15	**-0.68**	0.20	0.42
Well	-0.22	0.07	**0.49**	**0.54**	**0.53**	**0.37**	0.13	**0.47**	-0.25	-0.26	**0.44**	**0.50**	-0.34	0.08	**0.33**	-0.24	-0.35	0.06	0.05	-0.02	**0.69**	-0.29	-0.15	0.18
West	**0.57**	**0.52**	-0.28	-0.29	-0.23	**-0.51**	**-0.39**	-0.36	-0.24	0.25	-0.02	**-0.41**	-0.09	-0.13	-0.29	**0.39**	0.26	0.17	-0.14	**-0.43**	-0.16	0.04	**0.52**	-0.26

Table 4. Significance levels [Pr(>|t|)] for linear regression with a single predictor variable for season (October – April). Values which are less than 5% are bolded.

	SOI	SST	Z1	Z2	Z3	Z4	M1	M2	M3	MZ1	MZ2	MZ3	TSW	T	SW	NE	R	HW	HE	W	HNW	TNW	HSE	H
Auck	0.995	0.403	0.590	0.307	0.529	0.817	0.373	0.226	0.851	**0.002**	0.129	0.552	0.242	0.059	0.299	0.352	0.278	0.274	0.051	0.605	0.517	**0.021**	0.553	0.975
Christ	0.282	0.389	**0.000**	**0.003**	**0.000**	0.073	0.687	0.127	**0.034**	0.869	**0.000**	**0.038**	0.076	0.753	0.158	**0.015**	**0.016**	0.884	0.065	0.244	**0.020**	**0.016**	0.585	0.515
Corom	0.100	0.266	**0.018**	**0.002**	**0.005**	0.074	0.843	0.121	0.171	0.125	**0.028**	0.128	0.078	0.977	0.088	**0.007**	0.204	0.255	0.025	0.173	**0.011**	**0.015**	0.761	0.457
Darg	0.089	0.485	0.098	0.211	0.105	0.238	0.922	0.288	0.312	0.449	0.295	0.192	0.307	0.972	0.169	0.052	0.288	0.561	0.445	0.447	0.337	0.458	0.474	0.632
Dun	0.142	0.320	0.957	0.074	0.903	0.121	0.259	0.749	0.143	0.968	0.418	0.505	0.136	0.524	0.609	0.354	0.879	0.543	0.426	0.333	0.710	0.331	0.076	0.256
Gisb	**0.017**	0.385	**0.000**	**0.001**	**0.000**	**0.000**	0.244	**0.023**	0.653	0.908	**0.000**	**0.001**	**0.020**	**0.037**	**0.000**	**0.009**	**0.032**	**0.050**	0.489	0.139	**0.002**	0.150	0.130	0.275
Hok	**0.000**	**0.008**	**0.000**	**0.017**	**0.001**	**0.001**	**0.045**	0.107	0.135	0.718	**0.024**	**0.014**	0.195	0.153	**0.009**	**0.002**	0.065	**0.047**	0.095	0.056	**0.002**	0.754	**0.004**	0.051
Inver	**0.020**	0.064	0.141	0.823	0.325	**0.006**	**0.021**	**0.009**	0.325	**0.044**	0.702	**0.007**	0.549	0.461	0.067	0.059	0.395	0.297	0.800	0.161	0.102	0.906	0.151	0.484
Kaik	**0.020**	0.735	**0.000**	**0.010**	**0.000**	**0.001**	0.254	0.081	0.950	0.820	**0.000**	**0.007**	**0.045**	0.289	**0.004**	**0.003**	**0.048**	0.157	0.098	**0.022**	**0.001**	**0.038**	0.271	0.448
Kait	0.130	0.151	0.421	0.247	0.541	0.328	0.986	0.424	0.381	0.025	0.312	0.868	0.303	0.618	0.551	0.437	0.062	0.268	0.782	0.337	0.342	0.094	0.143	0.545
Nel	0.170	0.421	0.159	**0.009**	0.161	0.313	0.623	**0.016**	0.098	**0.021**	0.538	**0.038**	0.133	0.287	0.164	**0.031**	0.464	0.734	**0.048**	0.829	**0.018**	**0.005**	0.689	0.311
NewP	0.009	**0.023**	0.115	0.759	0.413	0.052	0.333	0.122	0.970	0.520	0.872	0.072	0.333	0.695	**0.028**	0.853	0.727	**0.008**	0.260	0.150	0.150	0.113	**0.009**	0.355
Ohak	0.366	**0.000**	0.536	0.503	0.972	0.082	**0.022**	0.469	**0.005**	0.657	0.452	0.246	0.244	0.174	0.268	0.401	0.687	0.575	0.844	0.418	0.571	0.723	**0.032**	0.467
Parap	0.301	**0.007**	0.076	0.889	0.102	**0.037**	0.059	0.954	**0.002**	0.181	0.159	0.440	0.440	**0.003**	0.095	0.551	0.500	0.174	0.210	0.291	0.771	0.340	**0.003**	0.989
Queen	0.280	**0.042**	0.743	0.209	0.863	0.270	0.689	0.472	0.896	0.912	0.326	0.353	0.685	0.645	0.994	0.798	0.887	0.548	0.305	0.992	0.826	0.060	0.281	0.328
Rotor	0.275	0.596	0.700	0.142	0.778	0.456	0.329	**0.024**	0.504	**0.000**	0.431	0.096	0.200	0.117	0.124	0.110	0.216	0.386	0.142	0.442	0.325	0.074	0.732	0.792
Taupo	0.151	0.119	0.248	0.293	0.389	0.320	0.936	0.861	0.952	0.114	0.299	0.763	0.922	0.218	0.761	0.475	0.232	0.937	0.735	0.433	0.568	**0.004**	0.077	0.893
Taur	0.056	0.753	0.162	**0.004**	0.106	0.144	0.430	**0.034**	0.372	**0.017**	0.514	0.051	0.106	0.343	**0.045**	**0.008**	0.548	0.222	0.063	0.268	**0.026**	**0.006**	0.746	0.298
Wang	0.534	**0.033**	0.494	**0.023**	0.157	0.653	0.903	0.728	0.854	0.729	0.082	0.739	0.965	0.509	0.850	0.185	0.359	**0.010**	0.795	**0.028**	0.503	**0.001**	0.389	0.059
Well	0.171	0.664	**0.001**	**0.001**	**0.000**	**0.019**	0.486	**0.005**	0.130	0.124	**0.005**	**0.004**	0.056	0.571	**0.044**	0.156	0.065	0.834	0.799	0.924	**0.000**	0.100	0.339	0.278
West	**0.001**	**0.004**	0.148	0.128	0.231	**0.005**	**0.039**	0.052	0.212	0.186	0.915	**0.028**	0.643	0.487	0.123	**0.036**	0.167	0.373	0.475	**0.020**	0.421	0.833	**0.004**	0.172

Appendix 3:
177 NRFA Stations

Station Code	Station Name	RRFC Area	Height (m)	NZMap Easting	NZMap Northing
APA	Taupo Aero	Central North Island	407	2776674	6270140
APP	Aupouri Peninsula	Northland	40	2513200	6722800
ASH	Ashburton Plains	Canterbury	103	2409400	5700450
ASY	Ashley	Canterbury	280	2470300	5781700
ATH	Athol	Waikato	0	2755597	6325934
AWH	Awhitu	Auckland	0	2651000	6455000
AWV	Awatere Valley	Marlborough	80	2599400	5950600
BEL	Belmont	Wellington	260	2668416	6001077
BGO	Bendigo	Otago	0	2220620	5579819
BML	Balmoral	Canterbury	205	2489700	5816100
BMT	Blackmount	Southland	275	2096300	5480400
BOD	Bodley Road	Waikato	240	2704956	6309298
BPO	Big Pokoroa	Nelson	630	2505000	5996500
BRP	Bridge Pa	Eastern	25	2833196	6166140
BTL	Bottle Lake	Canterbury	5	2484300	5748700
BUR	Burnham	Canterbury	66	2454100	5732464
CAN	Cannington	South Canterbury	180	2345300	5649100
CAT	Cat Creek	Marlborough	600	2550347	5965661
CDT	Cornwallis Depot	Auckland	20	2653000	6465800
CHA	Christchurh Aero	Canterbury	30	2472269	5747203
CLV	Clevedon Coast	Auckland	100	2689300	6473800
CLY	Clyde	Otago	0	2220627	5550157
COX	Cape Colville	Waikato	22	2719566	6521695
CPX	Castle Point	Wairarapa	120	2779577	6029332
CRK	Cricklewood	Eastern	440	2869742	6240210
CRT	Crownthorpe	Eastern	220	2817056	6174213
CYB	Glenledi	Otago	100	2283200	5443900
DAR	Dargaville	Northland	30	2586325	6582642
DNA	Dunedin Aero	Otago	0	2291359	5473219
DNP	Dansey Pass	Otago	495	2294700	5571500
DOV	Dovedale	Nelson	320	2509200	5985200
DPS	Deep Stream	Otago	700	2264743	5492656
DV	Dargaville	Northland	15	2585806	6583387
ELT	Eltham	Taranaki	260	2622300	6193100
FPL	Darfield	Canterbury	190	2441300	5745650
GAL	Galatea	Central North Island	160	2841400	6311400
GBI	Great Barrier Island	Auckland	8	2732300	6547700
GCE	Gore	Southland	123	2191612	5448650
GDE	Goudies	Central North Island	238	2816600	6289900
GLD	Glendhu	Otago	660	2254446	5490403
GSA	Gisborne Aero	Eastern	5	2943663	6271897
GWA	Gwavas	Eastern	350	2805100	6158200
HAN	Hanmer	Canterbury	350	2497700	5852500
HAU	Haurangi	Wairarapa	200	2698710	5971659

HIR	Hira	Nelson	180	2538200	5991800
HIX	Hicks Bay	Eastern	0	2978339	6391380
HKA	Hokitika Aero	West Coast	45	2344792	5832342
HNA	Hamilton Aero	Waikato	52	2715546	6370083
HNE	Hunua East	Auckland	25	2713867	6441669
HNW	Hunua West	Auckland	100	2694240	6456946
HOK	Hokianga	Northland	80	2544864	6634934
HTX	Haast	West Coast	3	2188506	5698834
HVE	Havelock North	Hawkes Bay	9	2841770	6165772
HWT	Holdsworth Station	Wairarapa	240	2722950	6031700
INE	Invermay	Otago	30	2306637	5481131
KAI	Kaipara	Northland	120	2620700	6523200
KAW	Kawerau	Central North Island	20	2837750	6343649
KHD	Keneperu Head	Marlborough	20	2604200	6004200
KIX	Kaikoura	Marlborough	105	2566257	5865589
KOE	Kaikohe	Northland	204	2584943	6642584
KTK	Kaitoke	Wellington	180	2693000	6011000
KWK	Kaiwaka	Eastern	400	2844100	6207350
KX	Kaitaia Observatory	Northland	0	2533600	6674400
LAE	Lauder	Otago	370	2248667	5569881
LAU	Lauder	Otago	370	2248677	5569881
LBX	Le Bons Bay	Canterbury	237	2519423	5719523
LEV	Lees Valley	Canterbury	480	2446900	5788000
LHX	Lower Hutt	Wellington	0	2670711	5997324
LIS	Lismore	Wanganui/Manawatu	292	2698427	6150160
LNX	Levin	Wanganui/Manawatu	45	2701681	6059530
LTF	Lake Taupo Forest	Central North Island	0	2765100	6251700
LUX	Lumsden	Southland	193	2156002	5485728
MAH	Mahurangi	Auckland	300	2638898	6530296
MAT	Matawaia	Northland	170	2593741	6631141
MGF	Mangatu Forest	Eastern	475	2937765	6317160
MHX	Mahia	Eastern	136	2937917	6220323
MIN	Minginui	Central North Island	569	2830438	6279769
MLX	Molesworth	Marlborough	881	2530694	5902805
MOA	Manapouri Aero	Southland	209	2090999	5505917
MOL	Molesworth	Marlborough	900	2530695	5902805
MOS	Barn Hill	Southland	400	2140216	5489126
MSX	East Taratahi	Wairarapa	91	2730114	6019857
MTB	Mount Benger	Otago	1167	2217328	5507365
MTC	Mount Cook	South Canterbury	765	2276300	5714900
MTE	Matea	Central North Island	682	2806400	6264200
MTK	Motukarara	Canterbury	30	2476982	5720809
MTS	Mount Somers	Canterbury	460	2379095	5724806
MTX	Motu	Gisborne	487	2905135	6314690
MUR	Murchison	Nelson	160	2454369	5934079
NAT	National Park	Wanganui/Manawatu	825	2719300	6223900
NCR	Nelson Creek	West Coast	110	2387896	5866576
NGA	Ngapaenga	Waikato	38	2677671	6315494
NGU	Ngaruru	Marlborough	620	2526652	5945391
NGX	Nugget Point	Otago	129	2265198	5412952
NMU	Ngaumu	Wairarapa	50	2752300	6014700
NOE	Normanby	Taranaki	122	2617551	6188919
NPA	New Plymouth Aero	Taranaki	30	2611138	6244519
NRA	Napier Aero	Eastern	2	2841299	6188019
NSA	Nelson Aero	Nelson	5	2528147	5989811

NTA	Ngamatea	Wanganui/Manawatu	980	2785050	6190300
NVA	Invercargill Aero	Southland	0	2151145	5411242
NWX	Ngawihi	Wairarapa	6	2696218	5955982
OHA	Ohakea	Wanganui/Manawatu	0	0	0
OKT	Okato	Taranaki	90	2586786	6217059
OMT	Omataroa	Central North Island	205	2847800	6337600
ONG	Ongaonga	Eastern	200	2802747	6137555
OPO	Opouteke	Northland	110	2584152	6611336
OSN	Opua Bay	Marlborough	5	2611700	5992300
OUA	Oamaru Aero	South Canterbury	30	2358761	5580756
PAX	Paeroa	Waikato	17	2748013	6424671
PEX	Pureroa	Northland	82	2603538	6675654
PKA	Pukaki Aero	South Canterbury	480	2279701	5659998
PKE	Pukekohe	Auckland	82	2674562	6443219
PMA	Palmerston North Aero	Wanganui/Manawatu	45	2730955	6095747
PPA	Paraparaumu	Wellington	0	2677098	6032357
PTU	Pouto	Northland	125	2605200	6549200
QNA	Queenstown Aero	Otago	357	2173794	5568294
RAI	Rai Valley	Marlborough	0	2559617	5999229
RAU	Raumai	Wanganui/Manawatu	18	2699154	6109237
REF	Reefton	West Coast	0	2415600	5898400
RFP	Rimutaka Forest Park	Wellington	40	2669900	5982200
RHU	Rotoehu	Central North Island	160	2818400	6356200
RIP	Ruatoria	Eastern	724	2956440	6362645
RLY	Ranfurly	Otago	450	2281800	5560900
RNP	Rock and Pillar	Otago	270	2291100	5532000
ROA	Rotorua Aero	Central North Island	285	2801006	6339605
ROT	Rotoaira	Central North Island	630	2735726	6257876
RTF	Porapora	Eastern	470	2974140	6363890
RUX	Waiouru Aero	Wanganui/Manawatu	821	2740900	6189858
SDN	Snowdon	Canterbury	560	2402600	5748100
SLP	Slopedown	Southland	140	2212300	5417150
SPR	Spriggins Park	Wanganui/Manawatu	0	2684786	6138995
STO	Stony Creek	Wairarapa	130	2717324	5972821
TAH	Tahorakuri	Central North Island	440	2785350	6285850
TEH	Te Horo	Wellington	0	2691409	6043127
TEK	Tekapo	South Canterbury	0	2301800	5686600
TEP	Te Pohue	Eastern	370	2827698	6208625
TGA	Tauranga Aero	Central North Island	4	2792505	6388038
THA	Te Haroto	Eastern	554	2822095	6221191
THE	Tara Hills	South Canterbury	488	2263580	5627913
TNI	Totaranui	Nelson	2	2510100	6042500
TPE	Te Puke	Central North Island	91	2802173	6370128
TPN	Tapanui	Otago	200	2218200	5470500
TPU	Tapuae	Wanganui/Manawatu	590	2742500	6131000
TRQ	Traquair	Otago	425	2286900	5484800
TRX	Port Taharoa	Waikato	0	2659136	6336231
TTA	Toatoa	Central North Island	700	2905700	6333600
TTB	Titahi Bay	Wellington	30	2663643	6009000
TUA	Timaru Aero	South Canterbury	27	2369031	5655083
TUT	Tuatapere	Southland	85	2109100	5445500
WAF	Waimarino Forest	Wanganui/Manawatu	625	2698600	6198500
WAH	Waihau	Eastern	350	2816660	6195340
WAO	Waione	Wanganui/Manawatu	100	2790387	6077710
WAV	Waverly	Taranaki	80	2647073	6156979

WAX	Chatham Island	Wellington	46	0	0
WBA	Woodbourne Aero	Marlborough	33	2580952	5965427
WBD	Western Boundary	Nelson	660	2495397	5964520
WCP	Waiouru Camp	Wanganui/Manawatu	800	2740900	6189400
WDH	Woodhill	Auckland	220	2633740	6498656
WFA	Wanaka	Otago	348	2211637	5603514
WGF	Waitangi Forest	Northland	60	2600500	6657300
WGM	Whangamata	Waikato	220	2757781	6439359
WGO	Waihi Gold	Waikato	115	2764500	6419900
WHG	Marco	Taranaki	160	2662600	6232500
WHR	Waihaorunga	South Canterbury	420	2333666	5609314
WKA	Whakatane Aero	Central North Island	6	2854473	6357809
WKB	Waikawau Bay	Waikato	10	2730314	6490041
WNA	Wellington Aero	Wellington	6	2662058	5984549
WND	Windsor	Otago	81	2338400	5575400
WPK	Waipukurau	Eastern	143	2811800	6128200
WRA	Whangarei Aero	Northland	37	2634261	6603070
WRY	Wreys Bush	Southland	110	2131500	5453300
WSA	Westport	West Coast	4	2390755	5940695
WTA	Whitianga Aero	Waikato	4	2748149	6478329
WTF	Waitarere Forest	Wanganui/Manawatu	1	2696700	6070600
WUA	Wanganui Aero	Wanganui/Manawatu	8	2682286	6135895

Appendix 4:
128 Stations with MSR values for period Oct 1998 to Apr 2001

STATION	No	Oct-98	Nov-98	Dec-98	Jan-99	Feb-99	Mar-99	Apr-99	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01
APA	1	0.136	1.123	1.480	3.393	2.650	1.309	0.598	0.841	0.566	0.381	0.853	3.371	3.425	0.243	0.170	1.525	0.732	1.539	1.422	0.526	0.415
APP	2	0.382	1.585	1.043	1.384	10.037	1.081	0.085	0.797	0.131	0.838	1.353	1.808	1.349	0.449	0.624	0.954	2.261	1.772	1.866	2.512	0.748
ASH	3	1.447	0.855	2.679	2.990	2.940	2.115	0.490	0.985	0.562	0.591	0.493	1.591	0.915	0.322	1.397	0.777	4.780	1.969	2.964	4.955	9.165
ASY	4	2.637	0.418	2.896	4.489	4.611	1.515	0.625	0.874	0.286	0.509	0.558	2.266	1.499	0.590	0.649	0.525	9.385	2.034	3.977	5.636	7.770
ATH	5	0.027	0.425	0.498	1.265	1.291	0.335	0.064	0.105	0.031	0.153	0.054	0.529	0.452	0.011	0.074	0.065	0.164	0.151	0.153	0.170	0.022
AWV	6	1.238	1.636	3.094	7.567	6.279	2.959	3.095	2.849	1.534	2.771	3.300	6.973	7.692	2.131	4.783	11.075	25.342	18.821	17.087	14.495	12.312
BEL	7	0.001	1.416	1.228	1.870	2.546	0.783	0.262	0.472	0.317	0.791	0.624	1.107	1.162	0.058	0.394	1.868	0.908	4.212	5.094	1.999	0.269
BML	8	2.711	2.894	6.053	12.639	11.257	3.859	1.029	2.208	0.658	1.602	2.546	7.067	4.299	2.107	2.101	2.960	13.161	10.566	14.524	10.852	11.017
BMT	9	0.626	1.424	1.874	4.442	6.926	3.101	0.202	1.454	0.628	2.098	0.909	4.930	4.244	0.945	0.937	0.742	0.769	1.773	5.823	3.131	1.641
BRP	10	11.306	4.843	8.536	7.973	3.405	2.831	0.849	3.326	5.171	2.327	5.147	9.741	5.872	0.788	5.506	1.264	5.200	7.207	3.789	2.757	1.528
BTL	11	0.712	1.109	1.912	3.843	4.593	0.998	0.524	0.669	0.667	1.375	1.222	2.880	2.445	0.598	0.365	0.708	2.692	1.097	3.040	4.950	4.784
CDT	12	0.190	1.134	1.514	2.047	4.000	1.916	0.444	0.573	0.263	1.245	1.775	2.455	1.755	0.200	0.528	1.160	1.253	1.370	0.849	1.415	0.453
CHA	13	1.091	3.226	6.351	10.096	9.315	1.684	1.122	1.292	1.011	2.747	1.907	5.903	3.565	1.164	1.133	2.278	8.295	4.206	6.240	8.622	10.298
CLV	14	0.458	1.141	1.268	2.180	3.757	2.338	0.407	0.479	0.195	0.967	1.065	1.986	1.864	0.171	0.301	0.649	1.487	1.393	0.775	1.048	0.278
CLY	15	0.302	1.784	1.512	3.798	4.560	3.286	0.422	2.675	0.741	1.807	1.357	3.449	1.838	0.356	0.288	2.469	2.365	0.726	2.255	1.530	1.450
CPX	16	14.562	3.349	8.324	3.065	6.939	4.472	3.812	6.867	3.467	3.210	4.169	14.939	5.756	2.772	4.958	2.581	10.616	9.732	6.530	9.786	11.600
CRK	17	4.388	1.382	1.795	1.565	1.884	1.282	0.002	1.101	2.608	2.570	1.421	2.249	0.340	0.183	2.485	0.396	1.292	2.358	0.835	0.389	0.392
CYB	18	0.823	0.641	0.094	0.451	4.347	0.392	0.119	0.597	0.158	0.932	0.309	1.219	1.159	1.036	0.553	0.444	2.066	0.352	1.319	2.446	1.708
DAR	19	0.456	1.863	2.193	2.329	5.112	2.179	0.490	0.667	0.307	1.231	4.091	1.746	2.100	0.821	1.450	1.446	3.613	1.629	0.810	1.933	0.577
DNA	20	2.393	2.887	1.150	2.131	8.261	3.523	1.164	2.197	1.060	2.038	0.429	1.202	0.939	0.891	0.897	0.830	4.137	0.981	2.127	3.499	2.462
DNP	21	2.962	4.288	8.786	10.866	9.463	5.763	0.789	5.708	2.423	1.909	1.105	3.623	3.201	1.647	2.517	4.256	11.063	2.767	6.137	13.870	17.141
DOV	22	0.007	0.633	0.616	2.267	1.906	0.405	0.130	0.082	0.022	0.301	0.156	0.298	0.767	0.075	0.023	0.548	1.015	0.932	3.961	3.751	0.622
DPS	23	2.241	2.960	2.403	4.834	21.203	3.440	0.597	2.834	2.219	2.491	1.195	7.781	6.937	6.461	0.100	0.507	6.595	1.338	2.553	8.027	4.164
FPL	24	2.340	1.985	6.784	6.313	6.883	2.324	0.406	2.373	1.616	1.572	1.989	5.456	2.417	1.468	1.800	1.591	13.047	4.022	6.027	9.061	13.019
GBI	25	0.201	0.177	0.456	0.538	1.283	0.668	0.035	0.115	0.023	0.361	0.176	1.036	0.365	0.111	0.277	0.464	0.540	0.461	0.107	0.046	0.070
GCE	26	0.481	1.552	1.640	2.229	3.746	0.425	0.133	0.603	0.127	0.883	0.437	1.528	1.005	0.357	0.145	0.112	1.220	0.106	1.034	6.206	0.132
GSA	27	8.510	4.778	3.529	4.164	4.527	2.587	0.598	1.432	3.943	1.545	1.577	3.535	0.381	0.217	3.630	0.715	3.553	3.525	0.760	0.724	0.633
HAN	28	2.040	1.119	3.932	6.616	3.919	1.673	0.393	0.617	0.751	1.331	0.780	3.391	2.518	1.001	0.925	1.498	6.570	3.371	10.866	7.727	3.778
HAU	29	0.333	0.699	1.021	3.620	2.626	0.477	0.594	0.189	0.148	0.456	0.473	1.054	1.272	0.129	0.145	0.102	0.907	0.858	1.797	2.284	2.277
HIR	30	0.062	2.239	1.660	2.717	1.162	0.789	0.471	1.385	0.002	0.275	0.186	0.523	0.503	0.033	0.033	1.908	3.025	2.665	7.155	3.575	1.193
HIX	31	0.996	1.331	1.348	2.421	3.296	0.961	0.640	1.338	0.247	0.501	1.353	2.997	1.663	1.730	1.102	0.746	0.843	2.623	0.535	1.188	0.893

HKA	32	0.004	0.444	0.052	0.606	0.698	0.091	0.123	0.056	0.109	0.462	0.342	0.011	0.093	0.037	0.015	0.362	0.093	0.192	0.053	0.336	0.035
HNA	33	0.244	1.576	1.925	2.969	6.271	3.300	0.949	0.448	0.231	0.659	0.674	2.155	2.688	0.324	0.417	0.672	0.910	0.910	1.138	0.535	0.361
HNE	34	0.106	1.174	0.478	1.181	1.736	0.427	0.045	0.190	0.049	0.185	0.147	1.412	1.115	0.021	0.101	0.166	0.368	0.572	0.296	0.740	0.755
HNW	35	0.472	1.052	0.906	1.463	2.490	0.837	0.157	0.062	0.048	0.348	0.395	1.280	1.113	0.106	0.136	0.275	0.336	0.575	0.365	0.979	0.115
HTX	36	0.014	0.111	0.024	0.140	0.361	0.019	0.008	0.057	0.057	0.115	0.258	0.018	0.058	0.005	0.006	0.639	0.004	1.608	0.078	0.264	0.010
HWT	37	0.431	0.824	0.989	2.639	2.295	0.960	0.765	0.425	0.451	0.261	1.083	0.989	1.199	0.250	0.248	0.351	1.691	1.012	1.769	1.004	0.741
KAW	38	0.641	1.595	1.456	2.905	4.026	1.543	0.548	0.873	0.586	1.145	1.516	4.169	2.707	0.186	0.923	1.478	0.812	3.598	0.769	0.767	0.318
KHD	39	0.751	1.131	0.945	1.888	1.720	0.593	0.136	0.048	0.034	0.190	0.735	1.429	1.884	0.089	0.166	1.071	2.846	2.382	3.969	3.143	1.762
KIX	40	1.947	1.132	1.300	2.077	2.477	0.833	1.113	1.172	0.678	0.600	0.910	1.044	1.302	0.514	2.521	0.789	4.115	2.436	1.525	5.456	6.010
KOE	41	0.312	0.407	0.711	0.501	2.525	0.387	0.115	0.431	0.123	0.589	0.436	1.039	1.324	0.447	0.407	0.338	0.681	1.097	0.513	0.148	0.092
KWK	42	11.006	1.380	1.855	3.036	3.055	2.561	0.482	1.849	1.921	0.411	1.065	1.755	0.316	0.510	0.942	0.290	3.321	3.845	0.268	0.673	0.459
LAE	43	2.107	4.172	10.875	12.637	13.868	13.356	1.077	7.810	0.978	2.048	1.316	4.263	3.421	0.821	2.822	9.034	17.855	4.553	5.577	16.215	8.998
LBX	44	2.573	1.458	5.339	4.502	9.210	2.348	1.457	0.365	2.041	1.413	0.633	2.596	1.627	0.593	2.548	0.712	2.477	2.016	0.894	2.880	13.262
LEV	45	0.789	4.248	8.465	22.700	21.598	5.551	1.755	13.441	5.208	3.659	3.474	5.088	7.660	2.880	1.180	3.175	19.348	10.248	16.601	17.906	9.754
LHX	46	1.099	1.078	1.163	2.911	2.263	0.916	0.334	0.247	0.082	0.820	0.748	1.211	1.386	0.095	0.277	1.246	0.773	2.790	3.166	1.882	1.770
LIS	47	0.748	1.019	2.425	4.805	6.238	3.112	0.794	0.891	0.926	1.005	2.378	1.938	3.516	1.160	0.398	0.838	2.449	2.767	2.072	2.241	0.653
LNX	48	0.351	0.810	0.957	2.059	3.798	2.427	1.113	0.305	0.232	0.390	1.039	0.831	0.718	0.066	0.052	1.358	0.767	1.895	2.339	1.488	1.066
LTF	49	0.059	1.205	0.717	1.190	1.357	0.323	0.098	0.164	0.119	0.240	0.179	1.008	1.099	0.015	0.103	0.332	0.145	1.236	0.749	0.225	0.192
MAH	50	0.284	0.137	0.366	0.502	0.753	0.279	0.015	0.089	0.037	0.187	0.132	0.440	0.820	0.122	0.092	0.217	0.372	0.367	0.115	0.361	0.185
MGF	51	0.933	0.362	0.874	1.774	1.093	0.583	0.266	0.345	0.545	0.110	0.504	2.070	0.089	0.050	0.472	0.120	0.365	2.085	0.337	0.095	0.107
MHX	52	6.330	3.375	3.087	2.950	2.576	0.953	0.293	0.405	0.892	0.219	0.627	1.505	0.066	0.117	1.339	0.332	1.420	2.472	1.456	1.053	0.624
MIN	53	0.105	0.789	2.011	3.529	3.307	1.553	0.320	0.964	0.394	0.369	0.473	2.474	1.615	0.023	0.494	0.322	0.211	0.861	0.329	0.432	0.293
MLX	54	0.416	1.812	6.667	15.080	14.949	4.008	0.817	2.118	0.309	2.726	2.551	4.766	5.267	0.677	0.392	2.275	5.387	4.231	14.779	11.134	6.462
MOA	55	0.080	0.435	0.410	2.245	4.295	0.987	0.025	0.324	0.164	1.122	0.830	1.263	1.648	0.515	0.206	0.914	0.814	0.830	1.802	0.497	0.151
MOS	56	1.317	2.381	2.280	6.486	14.176	4.454	0.264	2.716	0.370	1.121	1.176	5.880	4.144	3.473	1.300	1.126	5.885	2.240	6.493	5.549	1.787
MSX	57	0.726	0.938	2.812	5.834	3.686	2.280	2.591	1.250	0.615	0.374	2.157	1.761	2.384	0.378	0.540	0.831	4.213	2.601	6.076	3.776	3.820
MTS	58	0.764	1.122	1.882	1.782	1.241	0.879	0.243	0.059	0.002	0.004	0.345	1.832	0.708	0.848	0.893	0.631	6.525	1.280	1.521	1.993	4.285
MUR	59	0.009	1.690	0.990	5.026	3.653	0.720	0.040	0.165	0.118	1.537	1.203	0.577	1.510	0.024	0.255	1.386	3.355	2.614	4.791	3.514	0.429
NAT	60	0.011	0.361	0.276	1.543	1.639	0.205	0.132	0.101	0.085	0.333	0.283	0.395	1.003	0.009	0.258	1.266	1.010	0.147	0.282	0.370	0.083
NGA	61	0.110	0.854	0.527	1.481	1.506	0.679	0.231	0.125	0.062	0.180	0.174	0.274	0.502	0.023	0.067	0.119	0.313	0.194	0.206	0.253	0.096
NMU	62	1.697	1.094	1.893	3.033	2.686	2.545	0.894	0.941	0.677	0.569	1.519	1.506	1.050	0.317	0.520	0.501	2.536	3.036	3.698	6.041	5.377
NOE	63	0.275	0.811	0.774	2.215	4.113	2.201	0.541	0.436	0.471	0.302	0.802	1.689	2.076	0.337	0.414	1.021	1.579	2.888	1.580	1.409	0.388
NPA	64	0.119	0.746	0.689	1.568	3.258	1.920	0.411	0.170	0.147	0.905	0.392	1.304	2.942	0.270	0.206	1.386	0.775	1.450	1.926	0.790	0.542

NRA	65	12.284	2.055	4.546	4.408	2.781	3.070	0.729	2.623	3.770	2.453	5.638	9.839	3.453	0.487	4.977	1.727	3.875	4.693	2.999	2.344	0.930
NSA	66	0.228	1.668	1.834	3.491	3.244	2.857	1.265	0.913	0.309	1.085	0.938	1.666	1.732	0.478	0.205	2.679	3.444	4.738	8.414	7.476	3.052
NTA	67	4.179	0.749	2.255	3.837	2.095	2.645	0.408	0.620	0.571	0.722	0.662	1.027	1.679	0.194	0.929	0.140	0.917	1.378	0.214	0.442	0.564
NVA	68	0.251	1.072	0.705	1.633	5.921	0.597	0.083	0.133	0.156	0.407	0.549	1.897	0.213	0.440	0.155	0.234	0.509	0.401	0.863	0.989	0.106
NWX	69	0.875	0.690	4.378	4.094	3.186	1.395	2.322	3.427	2.323	1.732	3.137	4.867	2.238	2.082	1.552	1.247	6.524	4.304	8.558	8.331	9.680
OKT	70	0.072	1.010	0.560	1.750	3.351	1.125	0.402	0.402	0.212	1.810	0.867	0.986	3.344	0.575	0.331	0.525	0.620	1.362	1.711	0.604	0.557
OMT	71	0.214	0.894	0.791	1.895	2.379	0.674	0.039	0.611	0.064	0.526	0.469	1.455	1.043	0.046	0.429	0.705	0.409	1.405	0.243	0.453	0.169
ONG	72	4.877	1.652	3.123	8.797	3.694	1.840	0.646	1.412	1.597	2.102	0.818	1.456	0.926	0.193	1.948	0.807	2.609	3.486	2.486	4.464	2.234
OPO	73	0.063	0.197	0.357	0.380	0.446	0.136	0.008	0.067	0.027	0.150	0.235	0.353	0.399	0.047	0.259	0.134	0.815	0.723	0.222	0.102	0.042
OSN	74	0.445	1.260	1.150	1.217	1.828	0.675	0.328	0.001	0.085	0.164	0.501	0.724	0.413	0.049	0.092	0.478	1.524	1.234	4.529	3.851	2.189
OUA	75	1.139	1.077	0.579	2.119	1.938	0.936	0.115	0.600	0.400	0.955	0.456	1.623	1.075	0.342	1.517	1.423	3.151	1.343	1.285	5.932	9.936
PAX	76	0.324	1.158	0.995	2.321	2.543	1.099	0.186	0.274	0.123	0.376	0.758	2.686	1.981	0.366	0.350	0.890	1.030	1.599	0.950	0.593	0.481
PMA	77	0.455	2.000	2.314	6.359	7.798	5.065	2.180	1.287	0.723	0.896	3.027	2.489	3.609	0.770	0.478	1.085	2.917	2.630	3.689	6.421	1.184
PPA	78	0.294	1.190	1.668	2.486	2.178	1.163	0.808	0.319	0.215	0.645	1.385	1.724	2.063	0.201	0.304	2.120	0.944	3.193	4.470	1.760	0.998
PTU	79	0.569	1.388	0.965	1.561	3.843	2.138	0.697	0.405	0.139	1.337	2.225	2.247	2.053	0.341	0.756	1.545	2.178	1.435	0.691	3.337	1.161
QNA	80	0.382	1.261	1.094	7.166	8.620	3.631	0.331	1.474	0.303	1.767	1.208	2.391	2.447	0.567	0.364	3.326	4.462	1.410	4.259	2.291	1.449
RAI	81	0.159	1.845	1.441	3.033	1.350	0.396	0.256	0.160	0.022	0.461	0.518	1.157	1.625	0.065	0.176	0.923	1.502	2.639	5.736	4.330	1.387
RAU	82	0.165	1.156	1.099	2.285	2.637	2.173	1.142	0.514	0.371	0.337	0.904	1.265	1.549	0.267	0.328	1.809	1.569	3.324	2.695	2.811	1.418
RFP	83	0.250	1.104	1.498	2.891	2.171	0.584	0.185	0.319	0.108	1.012	1.083	1.167	1.468	0.239	0.542	0.862	1.617	3.673	5.063	3.460	3.198
RNP	84	3.209	4.316	2.689	10.901	42.059	6.000	0.374	5.715	9.985	1.871	0.456	3.167	4.573	2.339	2.125	2.029	9.602	2.316	2.756	6.924	6.137
ROA	85	0.245	1.155	1.006	2.231	2.869	0.896	0.259	0.389	0.142	0.670	0.655	2.080	2.070	0.131	0.335	0.634	0.341	1.809	0.450	0.560	0.249
ROT	86	0.055	0.993	0.689	2.227	2.542	0.690	0.367	0.240	0.249	0.265	0.309	1.041	2.675	0.072	0.075	0.014	0.220	0.473	0.205	0.467	0.142
RTF	87	2.574	0.264	1.051	1.083	1.611	0.700	0.123	1.163	0.322	0.559	0.678	1.573	0.337	0.118	0.808	0.118	1.075	1.756	0.490	0.301	0.130
RUX	88	0.060	0.432	0.731	1.640	1.923	0.621	0.037	0.383	0.244	0.339	0.374	0.641	1.833	0.349	0.201	0.146	0.211	0.398	0.265	0.335	0.130
SDN	89	1.452	1.595	4.645	6.260	6.786	2.401	0.862	0.884	0.481	0.472	0.443	2.184	1.895	0.861	1.032	1.477	10.246	4.959	7.743	13.626	14.385
SLP	90	0.788	0.694	0.365	1.422	3.956	0.502	0.064	0.291	0.179	0.508	0.633	0.543	0.362	0.222	0.192	0.142	0.828	0.135	0.240	2.805	0.028
SPR	91	0.112	1.080	2.017	3.651	3.194	3.106	1.318	0.887	0.687	0.851	1.840	1.624	1.128	0.819	0.514	1.984	2.997	4.299	2.795	2.965	1.096
STO	92	0.531	0.768	1.189	1.978	1.807	0.496	0.280	0.391	0.603	0.230	0.690	0.996	0.799	0.175	0.236	0.243	1.284	1.058	1.790	1.922	2.342
TAH	93	0.110	0.940	1.023	2.396	2.036	0.622	0.134	0.323	0.088	0.220	0.364	2.460	1.940	0.089	0.228	0.553	0.308	0.512	0.912	0.264	0.095
TEP	94	2.450	0.721	1.255	2.935	0.922	0.681	0.122	0.464	0.255	0.249	0.599	1.376	0.251	0.113	0.727	0.135	1.086	1.153	0.411	0.480	0.242
TGA	95	0.735	1.652	1.631	3.285	4.328	2.585	0.733	0.561	0.287	2.022	1.239	4.121	2.318	0.574	0.794	1.243	2.702	9.136	1.676	1.204	0.822
THA	96	3.332	1.390	3.449	4.889	4.964	4.711	0.998	1.714	0.912	0.379	1.181	2.972	1.156	0.274	1.194	0.212	1.483	1.910	1.193	1.462	0.839
THE	97	4.255	6.991	10.942	15.857	15.511	10.539	1.729	6.908	1.156	5.862	3.095	9.071	13.413	1.232	1.825	8.787	18.223	6.141	18.084	16.179	12.769

TNI	98	0.019	0.597	0.617	1.032	0.600	0.189	0.161	0.063	0.010	0.169	0.246	0.146	0.251	0.008	0.041	0.954	1.047	0.477	1.863	2.488	0.973
TPE	99	0.012	0.000	0.254	0.681	1.053	0.233	0.067	0.098	0.010	0.114	0.023	0.239	0.225	0.079	0.001	0.027	0.000	0.011	0.013	0.175	0.081
TPN	100	0.774	0.666	0.269	0.585	4.061	0.895	0.035	0.756	0.084	0.614	0.123	0.855	0.202	0.055	0.613	0.437	1.954	0.105	1.065	4.050	0.898
TPU	101	0.000	0.210	2.920	0.000	3.583	3.227	1.565	0.225	0.151	0.062	0.015	0.034	0.215	0.002	0.189	0.242	1.169	0.563	0.671	1.562	0.517
TRQ	102	3.538	1.605	1.279	2.294	13.463	1.889	0.359	2.778	2.463	2.419	0.167	2.083	1.396	2.023	0.602	0.471	5.399	0.488	0.860	5.700	6.734
TRX	103	0.062	1.439	0.809	1.888	2.379	1.620	0.463	0.235	0.378	0.822	0.625	1.189	1.015	0.291	0.349	0.500	0.687	0.670	1.062	0.460	0.917
TTA	104	0.094	0.560	0.485	1.570	1.664	0.168	0.091	0.228	0.023	0.141	0.233	1.051	0.208	0.059	0.155	0.115	0.152	0.450	0.219	0.246	0.085
TTB	105	4.490	3.029	7.987	9.187	13.403	0.788	0.263	0.440	0.155	0.017	0.199	3.440	2.441	0.037	0.566	2.427	1.230	2.998	4.435	2.596	0.936
TUA	106	2.145	0.735	2.387	3.088	4.042	1.833	0.406	1.072	0.377	0.389	0.204	1.320	1.116	0.493	2.088	0.815	4.601	2.141	3.758	6.861	21.356
TUT	107	0.231	0.472	0.691	1.135	2.879	1.049	0.098	0.352	0.126	1.171	0.506	1.987	1.047	0.377	0.258	0.505	1.152	0.583	2.168	1.363	0.235
WAF	108	0.011	0.361	0.242	0.978	0.836	0.080	0.132	0.020	0.012	0.120	0.053	0.122	0.508	0.005	0.053	0.042	0.013	0.009	0.041	0.171	0.001
WAH	109	3.683	1.148	2.870	4.700	1.051	1.870	0.255	0.836	0.794	0.427	1.016	2.515	1.002	0.296	1.894	0.286	0.872	1.843	1.131	0.660	0.733
WAO	110	0.142	0.959	1.263	3.022	2.106	0.554	0.363	0.884	0.487	1.230	1.359	2.232	1.080	0.193	0.364	0.223	0.930	1.410	1.227	1.237	0.888
WAV	111	0.059	0.208	0.217	0.777	1.160	1.001	0.330	0.058	0.114	0.085	0.184	0.291	0.820	0.320	0.307	0.841	0.937	2.142	1.310	1.269	0.592
WAX	112	0.222	0.972	0.321	0.834	1.520	1.288	0.454	0.320	0.902	0.725	2.762	1.648	0.791	0.450	0.231	0.348	1.943	1.115	0.564	0.963	1.953
WBA	113	2.115	3.164	6.113	8.899	12.096	8.715	2.009	2.371	1.069	1.876	2.759	3.591	5.440	1.835	1.764	5.820	24.910	21.670	25.801	18.784	10.868
WDH	114	0.349	1.176	1.474	2.680	6.271	2.737	0.544	0.161	0.035	0.112	0.115	0.460	0.354	0.095	0.088	0.255	0.326	0.239	0.225	0.442	0.075
WFA	115	1.290	2.359	3.416	13.044	15.302	6.652	0.777	3.417	0.289	3.498	2.657	6.233	5.965	1.210	0.767	5.300	6.640	5.329	12.369	6.737	5.682
WGF	116	0.933	1.161	1.019	1.243	3.725	0.534	0.176	0.796	0.432	1.085	0.928	2.246	3.345	0.863	1.071	0.726	1.692	2.184	1.119	0.185	0.252
WGM	117	0.063	0.219	0.205	0.701	0.572	0.327	0.001	0.012	0.013	0.100	0.010	0.396	0.085	0.017	0.151	0.236	0.362	0.473	0.105	0.003	0.004
WGO	118	0.239	0.896	0.831	2.018	1.504	1.236	0.075	0.155	0.033	0.459	0.317	1.702	1.261	0.380	0.477	0.607	1.569	5.810	2.510	0.159	0.121
WHG	119	0.000	0.040	0.003	0.002	0.372	0.874	0.108	0.078	0.100	0.661	0.475	0.830	1.626	0.177	0.149	0.498	0.387	0.721	1.041	0.702	0.186
WKA	120	0.806	1.920	1.461	4.445	5.616	1.924	1.150	0.908	0.430	1.326	1.195	3.145	1.335	0.181	0.938	1.667	1.707	4.809	0.910	0.715	0.336
WNA	121	0.965	2.505	3.527	5.290	4.814	1.506	0.605	1.316	0.511	1.564	2.278	2.729	2.925	1.132	1.101	3.161	3.310	8.411	12.180	6.211	6.960
WPK	122	4.305	3.230	4.314	9.038	2.433	1.393	0.429	1.359	1.702	2.282	2.014	6.855	3.504	0.364	1.363	1.060	4.331	5.294	3.614	3.995	2.417
WRA	123	0.415	1.300	1.637	1.575	1.899	0.919	0.070	0.724	0.267	1.157	1.246	1.649	1.543	0.706	1.090	1.058	1.288	1.717	0.676	0.221	0.156
WRY	124	5.174	0.827	1.242	1.764	8.829	3.163	0.242	0.990	0.246	1.504	0.840	3.509	1.607	1.138	0.918	0.700	1.527	0.451	1.773	4.022	0.297
WSA	125	0.001	0.983	0.076	0.466	0.919	0.374	0.135	0.031	0.088	0.133	0.219	0.038	0.127	0.034	0.030	0.054	0.047	0.156	0.170	0.313	0.081
WTA	126	0.314	0.749	1.021	1.508	1.886	1.295	0.308	0.525	0.515	3.085	1.043	1.961	0.718	0.145	3.215	0.718	1.014	1.045	0.598	0.610	0.277
WTF	127	0.058	0.935	0.585	1.844	2.223	1.061	0.996	0.280	0.209	0.296	1.195	0.842	1.804	0.088	0.085	0.926	0.400	1.065	1.039	1.268	0.619
WUA	128	0.345	1.378	1.409	2.682	3.935	3.708	1.449	1.023	0.650	1.236	2.318	2.439	2.656	0.861	0.356	3.079	2.340	5.150	2.741	2.092	0.962