MetService New Zealand Network Advances
to Meet Evolving Demands on Weather Data

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Abstract:

Over the last few years there have been significant increases in the demands placed on weather data collected by the Meteorological Service of New Zealand Limited (MetService) to meet: forecasting requirements (more accurate and timely warning, local area, meso-scale and long term forecasts); regulatory requirements (Aviation); and the needs of a steadily expanding customer base.

These increased demands have necessitated the following **changes and developments to the MetService Automatic Weather Station (AWS) and Weather Surveillance Radar (Radar) networks**:

❑ Expansion of aviation AWS sensor suites by the installation of supported sensors;

❑ New sensors on AWS e.g. precipitation detector, road surface, water level, heated RH, GPS;

❑ Development of AWS algorithms e.g. sea state, present weather, mobile platform (ship) corrections;

❑ Increase in the number of AWS to provide higher spatial observation densities at strategic locations;

❑ Implementation of low cost supplementary AWS e.g. Vaisala WXT and WMT series;

❑ Increase in the reporting frequency of METAR from aviation and climate AWS (hourly to half hourly);

❑ Supplementing AWS METAR with thunderstorm information to create aviation recognised METAR AUTO;

❑ Expansion of the Weather Surveillance Radar network and increased imagery frequency;

❑ Implementation of web camera (webcam);

❑ Backup communications systems (diversity) for delivery of primary AWS and radar data;

❑ Improved data delivery monitoring and fault alerting.

This paper presents some of the reasoning with benefits of the upgrades, statistics of the network upgrades, descriptions of newly interfaced sensors and algorithms, description of low cost AWS implementation. A snapshot of the current MetService networks (at the date of this paper) is also provided.
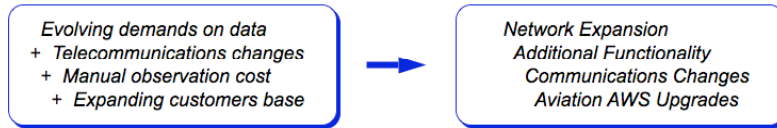
Key Phrases

❑ The world is <u>still</u> undergoing a data revolution - Volume and Quality.

❑ Rapid changes in the telecommunications market.

❑ Development of algorithms to add value to data.

Acronyms

❑	AWS	Automatic Weather Station
❑	GPRS	General Packet Radio Service - IP cellular network operated by Vodafone NZ
❑	IP	Internet Protocol (web based communications)
❑	IPSTAR	Commercial broadband Internet satellite
❑	LDN	Lightning detection network operated by MetService
❑	MetService	Meteorological Service of New Zealand (NZ) Limited
❑	PacNet	Packet Switch Network - Dial-up X25 packet switch network operated by Telecom NZ
❑	UDP	User Datagram Protocol - An IP network information transfer protocol
❑	Webcam	Digital cameras using IP network communications

Summary

The last 5 years have seen unprecedented growth and feature changes in the networks managed by MetService. These changes were driven by evolving demands on weather data (forecast and customer requirements), rapid changes in telecommunications, manual observation cost, and an expanding customer base e.g. Airways Corporation NZ, NZ Transport Agency, NZ Coast Guard, NZ Department of Conservation, energy companies, port operators, private airport operators, regional and local government.

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┌─────────────────────────────────┐        ┌──────────────────────────┐
│ Evolving demands on data        │        │  Network Expansion       │
│  + Telecommunications changes   │   ──▶   │  Additional Functionality│
│  + Manual observation cost      │        │  Communications Changes  │
│   + Expanding customers base    │        │  Aviation AWS Upgrades   │
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Network Expansion:

- ❑ AWS: <u>79</u> in 2005,   <u>150</u> now,   <u>171</u> by the end of 2010
- ❑ Weather Radar: <u>5</u> in 2008,   <u>7</u> in 2010,   <u>9</u> in 2012
- ❑ Webcam: <u>4</u> in 2010

Additional Functionality:

- ❑ AWS sensors: Precipitation (DRD), Road (ROSA + Lufft), Sea state (microwave), Heated RH (HMP155), GPS, Low cost (WXT/WMT), Ultrasonic wind.
- ❑ AWS algorithms: Sea state analysis, AWS on a moving platform, DRD rainfall, Visibility and RH to present weather, present weather combine, present to recent weather.
- ❑ Weather Radar: Non-Doppler to Doppler (NV 2005), Wind finding to weather surveillance (NP 2008) Image frequency double
- ❑ Monitoring: Improved data delivery monitoring and fault alerting
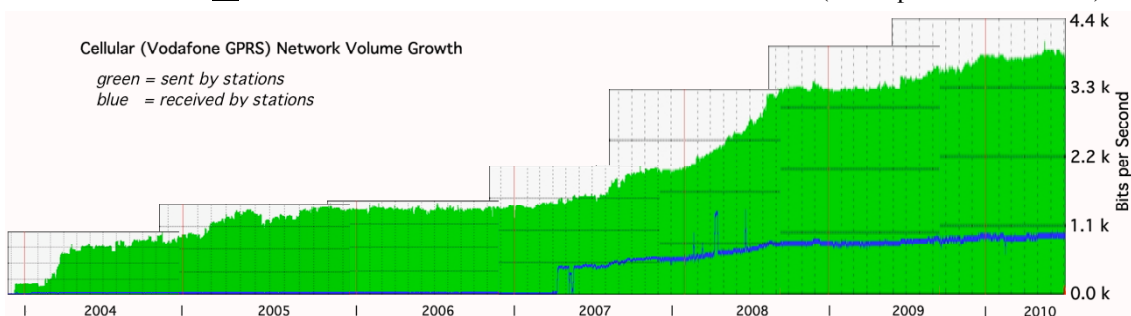
Communications Changes:

- ❑ Prior to 1980:   Telex, ARGOS
- ❑ 1980 to 2005:   *Telex, Dialup PacNet, Leased line*, MTSAT, ARGOS, AFTN
- ❑ 2005 to 2010:   <u>Cellular</u>, <u>DSL</u>, <u>LAN</u>, commercial satellite (<u>IPSTAR</u>),
  <- all Broadband

  <u>Cellular</u>, <u>Dialup IP</u>, <u>Radio modem</u>, <u>Iridium</u>, MTSAT, ARGOS, AFTN
  Dual path communications

Aviation AWS Upgrades:

- ❑ METAR: <u>12</u> Manual stations cease, <u>20</u> METAR AUTO (including TS) start in 2008/2009
- ❑ AWS: 1 minute real time data updates, changing from <u>hourly to half hourly METAR</u>
- ❑ AWS: <u>16</u> ceilometers, <u>20</u> visibility + present weather, <u>8</u> precipitation detectors in 2008/2009

Illustration of network/communications growth for cellular communications:

- ❑ 2004 to 2010   Stations operated for customers grows from <u>6</u> to <u>58</u>   (<u>79</u> by end of 2010)
- ❑ 2007   AWS time synchronisation implemented
- ❑ 2008   <u>64</u> stations converted from PacNet to DSL and/or GPRS (Backup communications)

Cellular (Vodafone GPRS) Network Volume Growth
green = sent by stations
blue = received by stations

Network Expansion

In recent times MetService weather forecast customers have required increases in frequency, resolution and accuracy of forecasts (warning, public and commercial). Other organisations have also experienced increasing demands on weather data to meet their own operational and prediction requirements, some of these organisations have engaged MetService to install and operate AWS for them and provide a contracted data service.

During this time there have also been significant beneficial changes in weather sensor features and costs, and telecommunications equipment and services.

These demands and changes have provided the stimulus and business cases for the expansion of the MetService AWS and Weather Radar networks, as well as increased data reporting frequencies and implementation of techniques to improve data delivery reliability. The cost benefit has even reached the point where it is possible to split one fully configured AWS with compromised exposure into two stations, each with a reduced sensor suite but with more representative exposures.

The increasing value of visual data and the implementation of broadband communications has meant that web cameras have become cost effective to purchase and operate.

__Automatic Weather Stations   79 in 2005,   150 now,   171 by the end of 2010__

The expansion to now has comprised: 23 Forecasting & Aviation; 48 Customer.

The advent of low cost fixed configuration AWS has made possible the installation of AWS as gap fillers that would have otherwise not been justifiable. These AWS e.g. Vaisala WXT and WMT series, measure only core weather forecast data parameters and have some compromises in exposure, however they are fit for purpose. These AWS have been configured to send simple 1 minute data summaries at 1 minute intervals similar to other MetService AWS. Sending such simple messages has required the implementation of algorithms on the central server to create longer period data values i.e. averages, maxima, minima, accumulated totals. These derived data processing algorithms are the same as implemented on AWS i.e. the same derived data processing is performed on AWS for supply of full data sets locally or when sending in messages (METAR, SYNOP etc.) at less frequent intervals e.g. half hourly or hourly.

For AWS 1 minute messaging the message sizes are typically: Non-aviation 250 characters; Aviation 500 characters. This gives monthly volumes of typically 11 to 22 MB

Minimum volume billing per connection provides a cost per AWS as typically:

- ❑   Vodafone cellular   NZ$ 12
- ❑   Telecom Cellular   NZ$ 6
- ❑   DSL   NZ$ 110
- ❑   IPSTAR   NZ$ 140

MetService New Zealand AWS Nework and Vodafone GPRS Coverage   January 2005

AWS Network 2005

METSERVICE
A world of valuable information

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AWS Key

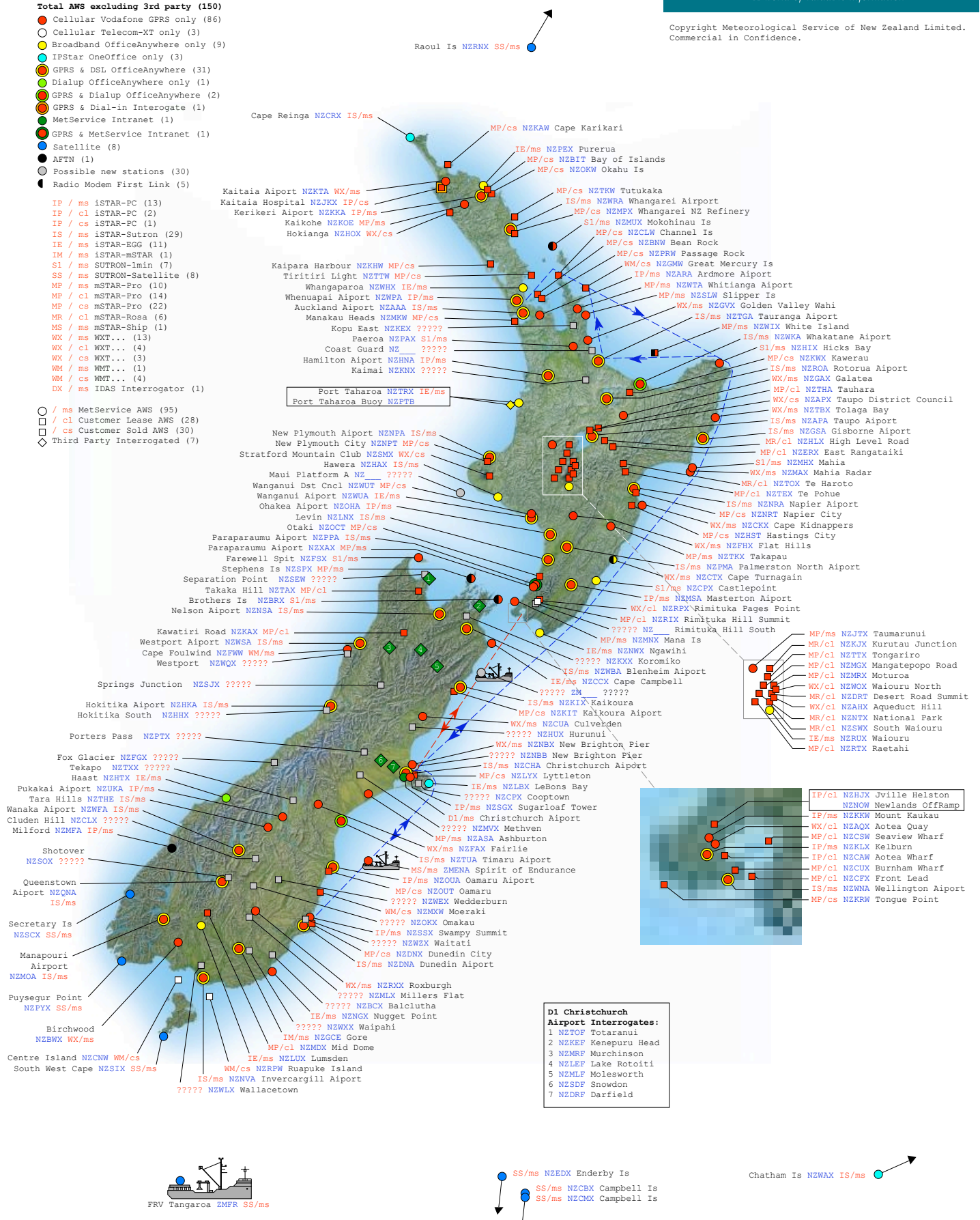Excludes overseas, test, demo, short term lease.

Total AWS excluding 3rd party (150)

- Cellular Vodafone GPRS only (86)
- Cellular Telecom-XT only (3)
- Broadband OfficeAnywhere only (9)
- IPStar OneOffice only (3)
- GPRS & DSL OfficeAnywhere (31)
- Dialup OfficeAnywhere only (1)
- GPRS & Dialup OfficeAnywhere (2)
- GPRS & Dial-in Interogate (1)
- MetService Intranet (1)
- GPRS & MetService Intranet (1)
- Satellite (8)
- AFTN (1)
- Possible new stations (30)
- Radio Modem First Link (5)

- IP / ms iSTAR-PC (13)
- IP / cl iSTAR-PC (2)
- IP / cs iSTAR-PC (1)
- IS / ms iSTAR-Sutron (29)
- IE / ms iSTAR-EGG (11)
- IM / ms iSTAR-mSTAR (1)
- S1 / ms SUTRON-1min (7)
- SS / ms SUTRON-Satellite (8)
- MP / ms mSTAR-Pro (10)
- MP / cl mSTAR-Pro (14)
- MP / cs mSTAR-Pro (22)
- MR / cl mSTAR-Rosa (6)
- MS / ms mSTAR-Ship (1)
- WX / ms WXT... (13)
- WX / cl WXT... (4)
- WX / cs WXT... (3)
- WM / ms WMT... (1)
- WM / cs WMT... (4)
- DX / ms IDAS Interrogator (1)

- ◯ / ms MetService AWS (95)
- ☐ / cl Customer Lease AWS (28)
- ☐ / cs Customer Sold AWS (30)
- ◇ Third Party Interrogated (7)

Raoul Is NZRNX SS/ms

Cape Reinga NZCRX IS/ms
MP/cs NZKAW Cape Karikari
IE/ms NZPEX Purerua
MP/cs NZBIT Bay of Islands
MP/cs NZOKW Okahu Is
MP/cs NZTKW Tutukaka
IS/ms NZWRA Whangarei Airport
Kaitaia Aiport NZKTA WX/ms
MP/cs NZMPX Whangarei NZ Refinery
Kaitaia Hospital NZJKX IP/cs
S1/ms NZMUX Mokohinau Is
Kerikeri Aiport NZKKA IP/ms
MP/cs NZCLW Channel Is
Kaikohe NZKOE MP/cs
MP/cs NZBNW Bean Rock
Hokianga NZHOX WX/cs
MP/cs NZPRW Passage Rock
WM/cs NZGMW Great Mercury Is
Kaipara Harbour NZKHW MP/cs
IP/ms NZARA Ardmore Aiport
Tiritiri Light NZTTW MP/cs
MP/ms NZWTA Whitianga Aiport
Whangaparoa NZWHX IE/ms
MP/ms NZSLW Slipper Is
Whenuapai Aiport NZWPA IP/ms
WX/ms NZGVX Golden Valley Wahi
Auckland Aiport NZAAA IP/ms
IS/ms NZTGA Tauranga Aiport
Manakau Heads NZMKW MP/cs
MP/ms NZWIX White Island
Kopu East NZKEX ?????
IS/ms NZWKA Whakatane Airport
Paeroa NZPAX S1/ms
S1/ms NZHIX Hicks Bay
Coast Guard NZ___ ?????
MP/cs NZKWX Kawerau
Hamilton Aiport NZHNA IP/ms
IS/ms NZROA Rotorua Aiport
Kaimai NZKNX ?????
WX/ms NZGAX Galatea
MP/cl NZTHA Tauhara

Port Taharoa NZTRX IE/ms
WX/cs NZAPX Taupo District Council
Port Taharoa Buoy NZPTB
IS/ms NZTBX Tolaga Bay
IS/ms NZAPA Taupo Aiport
IS/ms NZGSA Gisborne Aiport
MR/cl NZHLX High Level Road
New Plymouth Aiport NZNPA IS/ms
MP/cl NZERX East Rangataiki
New Plymouth City NZNPT MP/cs
S1/ms NZMHX Mahia
Stratford Mountain Club NZSMX WX/cs
WX/ms NZMAX Mahia Radar
Hawera NZHAX IS/ms
MR/cl NZTOX Te Haroto
Maui Platform A NZ___ ?????
MP/cl NZTEX Te Pohue
Wanganui Dst Cncl NZWUT MP/cs
IS/ms NZNRA Napier Aiport
Wanganui Aiport NZWUA IE/ms
MP/cs NZNRT Napier City
Ohakea Aiport NZOHA IP/ms
WX/ms NZCKX Cape Kidnappers
Levin NZLNX IS/ms
MP/cs NZHST Hastings City
Otaki NZOCT MP/cs
WX/ms NZFHX Flat Hills
Paraparaumu Aiport NZPPA IS/ms
MP/ms NZTKX Takapau
Paraparaumu Aiport NZXAX MP/ms
IS/ms NZPMA Palmerston North Airport
Farewell Spit NZFSX S1/ms
WX/ms NZCTX Cape Turnagain
Stephens Is NZSPX MP/ms
S1/ms NZCPX Castlepoint
Separation Point NZSEW ?????
WX/cl NZRPX Rimituka Pages Point
Takaka Hill NZTAX MP/cl
MP/cl NZRIX Rimituka Hill Summit
Brothers Is NZBRX S1/ms
????? NZ___ Rimituka Hill South
Nelson Aiport NZNSA IS/ms
MP/ms NZMNX Mana Is
IE/ms NZNWX Ngawihi
Kawatiri Road NZKAX MP/cl
????? NZKXX Koromiko
Westport Aiport NZWSA IS/ms
IS/ms NZWBA Blenheim Aiport
Cape Foulwind NZFWW WM/ms
IE/ms NZCCX Cape Campbell
Westport NZWQX ?????
????? ZM___ ?????
IS/ms NZKIX Kaikoura
Springs Junction NZSJX ?????
MP/cs NZKIT Kaikoura Aiport
WX/ms NZCUA Culverden
Hokitika Aiport NZHKA IS/ms
????? NZHUX Hurunui
Hokitika South NZHHX ?????
WX/ms NZNBX New Brighton Pier
????? NZNBB New Brighton Pier
Porters Pass NZPTX ?????
IS/ms NZCHA Christchurch Aiport
MP/cs NZLYX Lyttelton
Fox Glacier NZFGX ?????
IE/ms NZLBX LeBons Bay
Tekapo NZTXX ?????
MP/cs NZCPX Cooptown
Haast NZHTX IE/ms
IP/ms NZSGX Sugarloaf Tower
Pukakai Aiport NZUKA IP/ms
D1/ms NZMXX Christchurch Aiport
Tara Hills NZTHE IS/ms
????? NZMVX Methven
Wanaka Aiport NZWFA IS/ms
MP/ms NZASA Ashburton
Cluden Hill NZCLX ?????
WX/ms NZFAX Fairlie
Milford NZMFA IP/ms
IS/ms NZTUA Timaru Aiport
MS/ms ZMENA Spirit of Endurance
Shotover
IP/ms NZOUA Oamaru Aiport
NZSOX ?????
MP/cs NZOUT Oamaru
Queenstown
????? NZWEX Wedderburn
Aiport NZQNA
WM/cs NZMXW Moeraki
IS/ms
????? NZOKX Omakau
Secretary Is
IP/ms NZSSX Swampy Summit
NZSCX SS/ms
????? NZWZX Waitati
MP/cs NZDNX Dunedin City
Manapouri
IS/ms NZDNA Dunedin Aiport
Airport
NZMOA IS/ms
WX/ms NZRXX Roxburgh
????? NZMLX Millers Flat
Puysegur Point
????? NZBCX Balclutha
NZPYX ?????
IE/ms NZNGX Nugget Point
????? NZWXX Waipahi
Birchwood
IM/ms NZGCE Gore
NZBWX WX/ms
MP/cl NZMDX Mid Dome
Centre Island NZCNW WM/cs
IE/ms NZLUX Lumsden
South West Cape NZSIX SS/ms
WM/cs NZRPW Ruapuke Island
IS/ms NZNVA Invercargill Aiport
????? NZWLX Wallacetown

MP/ms NZJTX Taumarunui
MR/cl NZKJX Kurutau Junction
MP/cl NZTTX Tongariro
MP/cl NZMGX Mangatepopo Road
MP/cl NZMRX Moturoa
WX/cl NZWOX Waiouru North
MR/cl NZDRT Desert Road Summit
WX/cl NZAHX Aqueduct Hill
MR/cl NZNTX National Park
MR/cl NZSWX South Waiouru
IE/ms NZRUX Waiouru
MP/cl NZRTX Raetahi

IP/cl NZHJX Jville Helston
NZNOW Newlands OffRamp
IP/ms NZKKW Mount Kaukau
WX/cl NZAQX Aotea Quay
MP/cl NZCSW Seaview Wharf
IP/ms NZKLX Kelburn
IP/cl NZCAW Aotea Wharf
MP/cl NZCUX Burnham Wharf
MP/cl NZCFX Front Lead
IS/ms NZWNA Wellington Aiport
MP/cs NZKRW Tongue Point

D1 Christchurch Airport Interrogates:
1 NZTOF Totaranui
2 NZKEF Kenepuru Head
3 NZMRF Murchinson
4 NZLEF Lake Rotoiti
5 NZMLF Molesworth
6 NZSDF Snowdon
7 NZDRF Darfield

FRV Tangaroa ZMFR SS/ms

SS/ms NZEDX Enderby Is
SS/ms NZCBX Campbell Is
SS/ms NZCMX Campbell Is

Chatham Is NZWAX IS/ms

Meteorological Service of New Zealand Ltd
Automatic Weather Station (AWS) Network

AWS Information Last Updated: 15 July 2010

100   0   100   200
Kilometres

__Weather Surveillance Radar network   5 in 2008,   7 in 2010,   9 in 2012__

Increasing demands on the mesoscale and short range forecast warnings has been the driver for upgrading (refer to the section "Additional Functionality" below) and expanding the MetService weather surveillance radar network by installation of four new weather surveillance radar, 1 in each year 2009, 2010, 2011, 2012.

Note: All radar in the 2005 image below were Doppler capable but a coverage drawing has not been included.

Network expansion (dashed circles show the planned coverage for 2012)…

Non Doppler coverage - 2005   Non Doppler coverage - 2010   Doppler coverage - 2010
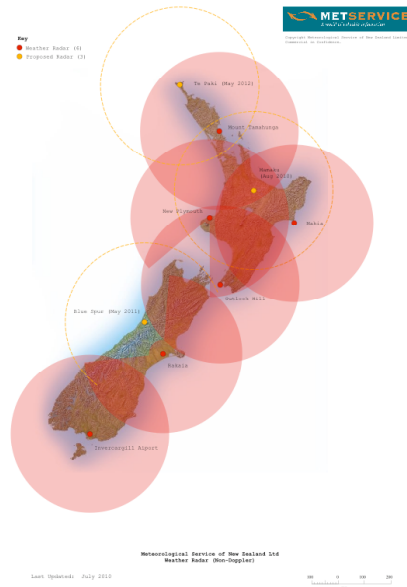
Image examples for the current network - 2010
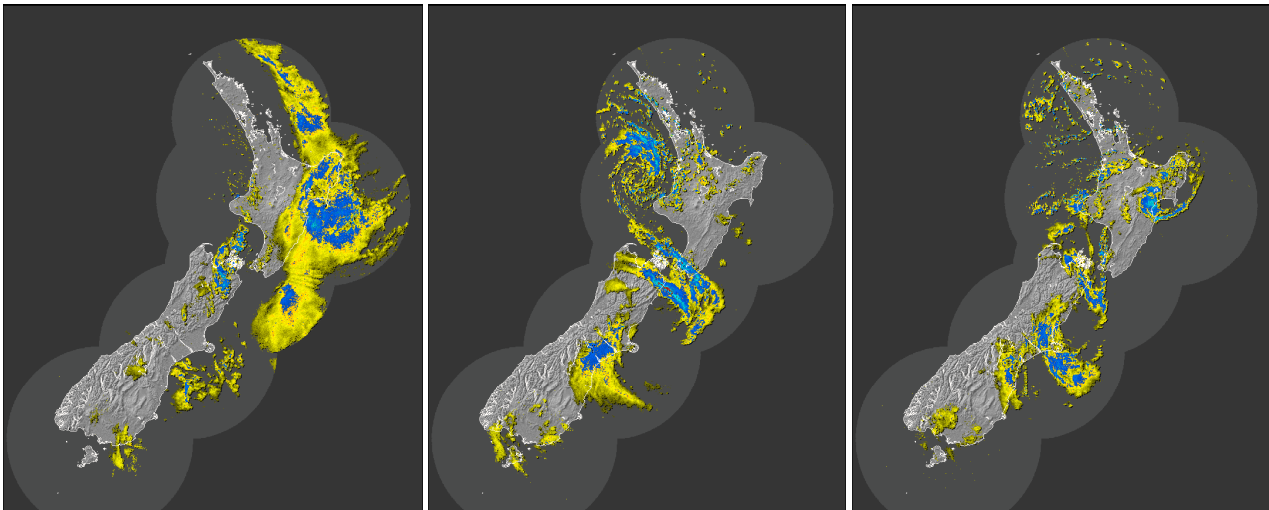
Implementation of Web Camera   4 in 2010

Webcam have become so feature rich that the cost and ease of implementation has become a near trivial exercise, particularly if existing image display tools (satellite and/or radar) can be used. It was decided to implement cameras with no moving parts (moving parts are typically the first point of failure) so the camera has a fixed field of view. If a single camera view at a site is insufficient then additional camera(s) at the same site can be implemented. An image size of 640 x 480 pixels and an image update interval of 10 minutes were chosen as a compromise between viewable quality, weather change detection and data volume (communications cost).

The following is a list of features of the Mobotix M12 webcam implemented by MetService:

- ➢ Broadband / Ethernet connection.
- ➢ HTTP server in camera - Simple web browser based camera setup and control (local or remote).
- ➢ FTP programmable schedule push of images to a central server (MetService uses a 10 minute interval).
- ➢ Camera view 90˚ horizontal x 67˚ vertical.
- ➢ Dual camera system (visible for daylight, infra-red for night).
- ➢ Webcam automatically reports faults by email.

For each camera: A colour image is pushed every 10 minutes, each image is 640 x 480 and typically 120 kB . The Monthly volume is therefore typically 500 MB with an approximate costs NZ$ 150.

At installation the camera are angled so that the foreground from approximately 50 meters is viewable. This is so that the ground condition can be viewed and in some circumstances this can aid with the determination of the present and recent weather e.g. the occurrence of rain (wet ground and puddles) or frost.

Examples of webcam images…
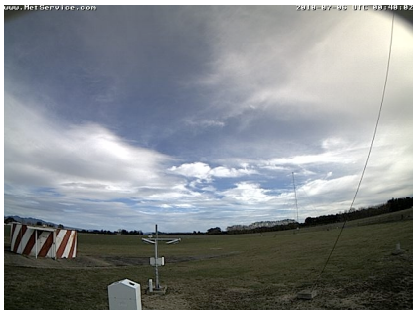
Complex cloud cover	Cover at station, clear in the distance, AWS reports OVC	infra-red image, City lights and moonlight

Dense cloud layer away from station, AWS reports NCD	VCFG and -4 degree frost	Artistic high cloud
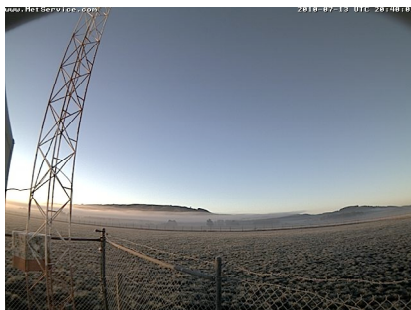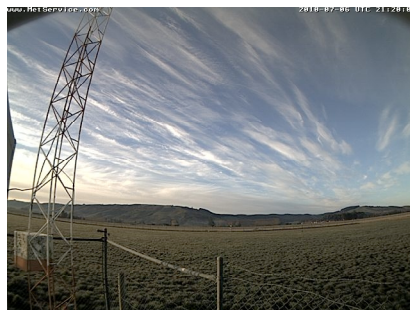
The camera horizontal view direction (90° wide) is pointed to where the most significant weather comes from at each station (determined by aviation forecasters).

Webcam typical elevation view

Additional Functionality

New AWS Sensors:

Over the last 5 years various demands on weather data have driven the implementation of sensor technologies not previously used by MetService. The following is a list of these sensors with the primary reason for the implementation:

- ❑ Precipitation (DRD)   Aviation AWS with visibility upgraded to present weather.
- ❑ Road (ROSA + Lufft)   Customer requirement.
- ❑ Sea state (microwave)   Customer requirement.
- ❑ Heated RH (HMP155)   RH data quality improvement near 100 %RH.
- ❑ GPS (various)   Ship AWS implementation. Satellite time slot synchronisation.
- ❑ Low cost (WXT/WMT)   Network gap fillers and customer sales. Stand alone and add-on to other AWS.
- ❑ Ultrasonic wind (WS425, Windsonic, WXT, WMT)   Improved reliability (sensors have no moving parts).

New AWS Algorithms:

New algorithms have been developed by MetService to support the implementation of new sensors and data requirements. The following is a brief description of each algorithm (more detail at the end of this paper):

- ❑ Sea state analysis: The water level from a downward pointing microwave sensor is processed over 512 one second samples (an 8.6 minute sample window) to derive traditional (scalar based) and spectral (energy based) sea state characteristics.

- ❑ Moving platform: The implementation of a stand alone AWS on a ship (the AWS is not connected to any ship data system) required the use of GPS and the computation of ship location, Course over Ground (COG), Speed Over Ground (SOG), and the correction of ship relative winds to True North relative values. Detection of exception conditions was incorporated e.g. ship near stationary. No allowance was made for ship roll or ship course difference from COG due to cross wind components or ocean currents.

- ❑ DRD rainfall: 1) The Vaisala DRD precipitation detector was interfaced to an AWS and an algorithm developed to convert the DRD analogue voltages to rainfall intensity in mm per hour. Due to the susceptible nature of the sensor to contamination the algorithm includes self calibration at both the dry and high rainfall rate ends of operation. 2) As the sensor has a high uncertainty the intensities are time processed and converted to the METAR qualitative values of –RA, RA, +RA (last 15 minutes data) and –SHRA, SHRA, +SHRA (last 60 minutes data) using a Rain Intensity to Present Weather algorithm.

- ❑ Visibility and relative humidity to present weather: This algorithm uses 1 minute average relative humidity (in %RH) and 10 minute average visibility (in meters) data to determine a METAR type present weather as follows:

	Vis < 1000	1000 ≤ Vis ≤ 5000	Vis > 5000
RH ≤ 95	HZ		//
RH > 95	FG	BR	//

- ❑ Present weather combine: Due to additional data sources and algorithms it is possible for an AWS to have multiple present weather data sources. It is therefore necessary to have an algorithm to quality control and combine these various sources, and where relevant to prioritise the sources i.e. in case conflicting present weather are available.

- ❑ Present to recent weather: Due to limitations found in the recent weather provided by present weather sensors e.g. non-programmable time period, and as MetService has implemented other present weather algorithms, a present weather to recent weather algorithm was developed. The algorithm uses the current present weather and the present weather from 15 (or 16) minutes ago, restricts the values to precipitation only, then applies the WMO METAR coding rules for recent weather.

Handar with Precipitation Detector

Road Weather Station

Sea state sensor housing

Weather Radar Changes: Non-Doppler to Doppler, Wind finding to weather surveillance, Image frequency double

The increasing demands that drove the weather radar network expansion also provided justification to upgrade one radar from non-Doppler to Doppler (Invercargill 2005) and to upgrade one wind finding only radar to a weather surveillance radar (New Plymouth 2008). Both these radar are still used for wind finding flights three times a day and during these periods totalling about 3 hours at each location no weather surveillance imagery is available.

The increasing demands, coupled with improvements in hardware, have made it cost effective to double the full volume scan frequency (scan interval decreased from 15 to 7.5 minutes). Appropriate infrastructure changes (telecommunications and central processing and archiving) were also implemented to handle the increased data/image rates and volumes.

Improved Data Delivery Monitoring and Fault Alerting:

MetService is continually looking for, developing and implementing upgrades to its network monitoring systems. Enhancements may be in the form of improved network statistics, simple self alerting from a piece of equipment, or equipment that monitors other equipment and perform remedial actions under fault conditions (a watchdog). As a result of recent equipment implementations and functionality changes the following have been implemented:

- ❑ Additional sensor status information included with 1 minute messages during warning and alarm conditions.

- ❑ Central software monitors all AWS messages and generates hourly summaries of: Warnings and alerts from AWS; 1 minute and METAR delivery statistics; Alerts on missing stations.

- ❑ LDN: Improved remote access with the upgrade from PacNet to DSL broadband.

- ❑ Devices such as: Uninterruptible Power Supply; Webcam; DSL router; IPSTAR router; Cellular modem
  - ➤ Simple web browser based setup and control (local or remote)
  - ➤ Automatic alert emails of alarm conditions

- ❑ IP Watchdog
  - ➤ Communications monitor and modem/router reset on timeout

Communications Changes

The rising performance, lowering costs and expanding features of IP communications has continued over the last few years. New telecommunications implementations and providers are emerging which are providing further reach into more remote locations, and driving data costs down. Upgrades to telecommunications networks are providing access to features that were once unaffordable. These changes provide opportunities for cost effective enhancement of communications methods e.g. implementation of broadband to sites.

The growth of new networks has meant that some older networks have or are about to be decommissioned. This has forced the implementation of upgrades to maintain service e.g. PacNet turned off in 2008, Cellular GPRS and Cellular CDMA soon to be turned off.

The major network feature changes that have occurred for MetService as a result of he above changes are:

❑ Almost the entire MetService AWS network reports 1 minute real time data (some 140 stations). Except for 3 AWS that report half hourly via dialup IP AWS (these are soon to be upgraded to IPSTAR or cellular broadband) and 8 remote AWS that report hourly via MTSAT.

❑ Individual AWS diversity (dual path communications): Due to the high rate of IP network implementation, and therefore the infant nature of these networks, their performance can sometimes be less than desired (the term "consumer grade" has been used, compared to earlier technologies such as PacNet that were "industrial grade"). This is not to say that industrial grade performance is not available, it just comes at a significant increase in cost. This coupled with the increasing value and reliance on data has lead MetService to implement individual AWS communications diversity at its high priority stations (aviation and climatology AWS, and weather surveillance radar).

❑ Network diversity: The availability of competing networks that are for the most part operated on separate paths has provided an opportunity for network diversity. That is to say an AWS network can be split (spatially intertwined) and the two or more parts operated on separate telecommunications networks. Then if only one telecommunications network fails the others should continue to deliver data.

❑ On-line remote maintenance: Those stations with broadband Internet can have remote maintenance performed as if the operator is sitting in front of the equipment. For computer based AWS, tools like RealVNC or Windows Remote Desktop can be used. Some equipment (modems, power supplies, watchdogs) have built in http web servers so they can be directly remotely linked to using a web browser.

❑ Security Issues: Equipment that is communicating via the Internet is vulnerable to malicious attack at both ends or eavesdropping and theft of information. MetService implements some or all of the following security measures for all equipment connected to the Internet: Virtual Private Networks, firewalls, restricted IP address lists and username/passwords.

Examples of recent Telecommunications upgrades performed by MetService:

❑ Broadband Direct to Stations (Cellular, DSL, LAN, IPSTAR):

➢ AWS and LDN: Telecom DSL broadband
➢ AWS and Radar: IPSTAR (mainland and local offshore islands - NZ spot beam)
➢ AWS: Telecom 3G broadband

❑ Dual communications:

➢ All remote unmanned radar use various primary terrestrial communications with automatic failover to IPSTAR as backup.

➢ 34 AWS use dual communications with both the primary and backup communications always on line and messages are always sent by both methods. The primary communications are 31 on DSL, 2 on dialup, 1 on LAN communications with 30 minute METAR sending by email. The backup communication is via Cellular 1 minute messages (send and forget). If the METAR is not received on timeout then it is created (off-site, by MetService central processing systems) from the 1 minute data feed.

➢ Where DSL broadband is not possible, cellular broadband is implemented if the AWS has an Ethernet interface for connection to the modem.

❑ Dialup IP has been used at 3 AWS where the site is beyond the range of wire-in-the-ground broadband.

❑ Radio modems have been used at several AWS as a first link to a site that has DSL or cellular access.

❑ Drifting buoys are being trialed on the global Iridium satellite network. Iridium provides more timely delivery of data and the potential for remote diagnostics and maintenance of systems.

Aviation AWS Upgrades

Increasing value/reliance on data availability for the aviation community (time density, time coverage, reliability), and the ability to make cost efficiencies have driven a change from manual observations at aerodromes to more frequent AWS generated METAR AUTO. To meet data quality demands for these stations they were upgraded by the installation of: additional sensors including ceilometers, visibility + present weather and precipitation detectors; the implementation of webcams; and development of present weather algorithms. The resulting increased reliance on the AWS data meant stations need to be upgraded to dual communications (with separate paths).

Detail of the changes are as follows:

❑ The METAR report frequency from aviation and climate AWS has been increased from hourly to half hourly;

❑ All aviation AWS now report 1 minute real time data as backup via a separate communications path.

❑ Aviation AWS METARs are enhanced by the addition of lightning counter data as TS or VCTS as follows:

➢ TS is added to the METAR present weather if there were > 1 lightning counts within 8 km radius from the Aerodrome reference point.

➢ VCTS is added to the METAR present weather if there were > 1 lightning counts outside 8 km and within 16 km radius from the Aerodrome reference point.

❑ 16 Aviation AWS without ceilometers had CL31 sensors installed. The MetService-implemented USA National Weather Service ASOS sky condition algorithm produces METAR coded cloud for inclusion in reports from these stations.

❑ 8 ageing Handar visibility sensors were replaced with present weather sensors (the Handar were relocated). Some AWS without visibility/present weather sensors were upgrade full present weather + visibility. In total 11 of the PWD22 and 9 of the FD12P new sensors were installed.

❑ The Handar visibility sensors were relocated to sites with less stringent data requirements. These AWS had a DRD precipitation detector added and the MetService developed DRD + visibility + relative humidity to present weather algorithms implemented to create a "low cost" present weather sensor.

❑ An additional 2 strategic AWS were installed that could provide supplementary data, in particular upper level winds, through the METAR remark at a nearby aviation AWS.

❑ After all of the above were in place it allowed the start of 26 METAR AUTO and the cessation of 14 comprehensive manual METAR. The only manual remaining manual METAR programmes are at Auckland, Wellington and Christchurch International Airports and at two Royal New Zealand Airforce (RNZAF) bases.

Near Future

MetService is continually looking for, developing and implementing upgrades to its network systems. Current projects include investigation and/or implementation of the following:

❑ 2 sites that currently use dialup IP will be upgraded to cellular broadband once the chosen modem has been approved for use in NZ.

❑ The remaining site that currently uses dialup IP will be upgraded to IPSTAR broadband.

❑ Most radio modem links used as first links to DSL or cellular accessible modems will be replaced with direct cellular communications. A recent upgrade of the Telecom NZ cellular network has removed the approximate 32 km range limit from cell sites enabling most radio modem sites to soon connect directly to cellular networks.

❑ Replacement of ageing satellite reporting solar powered AWS at very remote locations.

❑ Improved quality control and alarm reporting in AWS using data parameter cross checking algorithms.

❑ Upgrade of calibration systems for newly implemented sensors.

❑ Further network expansion as budgets allow.

Algorithm: Sea State

Traditional Analysis (zero crossing)	
TrLvl	Traditional analysis average water level. Usually above Datum
Hs/Hsig	Significant wave height = average height of the waves which comprise the highest 33% of waves
Hmax	Maximum wave height in a recorded burst of raw data
H10	Average height of the waves which comprise the top 10%
Tz	Zero crossing period = mean period
Ts / Tsig	Significant period = average period of the waves used to define Hsig
Spectral Analysis (Fourier)	
SpLvl	Spectral analysis DC water level. Usually above Datum
TP1/Tp	Period of the peak of the energy spectrum
HP1	Height of the peak of the energy spectrum
TP2	Period corresponding to the second biggest peak of the energy spectrum
HP2	Height corresponding to the second biggest peak of the energy spectrum

A resolution of 2 decimal places for tide and 1 decimal place for other values is used.

The 1 second raw data is saved in a rolling 512 second (8.6 minute) wave data record.

Traditional Analysis: The Traditional analysis is performed once every minute on the rolling 512 second (8.6 minute) wave data record. The data parameters are extracted for sending at this point.

Spectral Analysis: The Traditional analysis average water level is subtracted from each point in the 512 wave data record (so the TrLvl and the SpLvl are currently both the TrLvl). The data is then filtered (Hanning filter) to remove abrupt changes at the beginning and end of the data sequence. The data record is then passed through the FFT and Tp1/Tp2 and Hp1/Hp2 are extracted.

Note: The HP1 and HP2 data are calculated as **Power** by finding the spectral peak and root mean squaring the sums of the adjacent energy to the peak. If the spectra are relatively pure (e.g. one or two frequencies) only the energy greater than 10% of the peaks in adjacent frequency bins contributes to Hp1/Hp2. For more complex waves the energy >50% of the first peak and greater than the trough between the two peaks can contribute to the energy summed in Hp1 and Hp2.

Algorithm: Rainfall Intensity to METAR Present Weather

This algorithm is performed once per minute on an array of 60 one minute rainfall intensity (RI) values.

The last 15 minutes data is used to determine the present weather type (raining or not raining) and intensity, and the last 60 minutes data is used to determine if the rain is occurring as showers.

Determine raining in the last 15 minutes

Within the last 15 minutes rainfall intensity (RI) data if there are ≥ 12 minutes valid data then

If   (latest minute RI > 8.0 mm/hour)   Or   (≥ 3 minutes with > 8.0 mm/hour)   Then

PrWx = +RA

ElseIf   (latest minute RI > 2.0 mm/hour)   Or   (≥ 3 minutes with > 2.0 mm/hour)   Then

PrWx = RA

ElseIf   (latest minute RI > 0.0 mm/hour)   Or   (≥ 3 minutes with > 0.0 mm/hour)   Then

PrWx = -RA

Else

PrWx = Blank

End

Determine if Showers: 2 or More transitions between Raining and Not Raining in the last 60 minutes

If   (PrWx = -RA)   Or   (PrWx = RA)   Or   (PrWx = +RA)   Then

Transition count = 0

For each minute x with valid RI(x) from 60 minutes ago to now

If   (RI(x) = 0.0 mm/hr)   And   (RI(x-1) > 0.0 mm/hr)   Then

Found NotRaining-to-Raining so increment the Transition count

ElseIf   (RI(x) > 0.0 mm/hr)   And   (RI(x-1) = 0.0 mm/hr)   Then

Found Raining-to-NotRaining so increment the Transition count

End

Next

If Transition count ≥ 2 Then

Change the PrWx so that SH is included in the correct place

End

End

Algorithm: Present Weather to Recent Weather

This algorithm is performed once per minute on 1 minute present weather values are retrieved from the database

PrWx(now) is the current METAR present weather (up to 3 groups)

PrWx(-15) is the METAR present weather from 15 minutes ago (up to 3 groups)

The software is allowed to scan back 1 minute in the database if no valid present weather has been retrieved.

Both PrWx(now) and PrWx(-15) are parsed and restricted to:

[+/-]FZDZ   [+/-]FZRA

[+][SH]RA   [+][SH]SN   [+][SH]GR   [+][SH]GS

[+]DZ,   [+]SG   [+]PL

If PrWx(-15) contains any item(s), including intensity differences, that are not in PrWx(now) then

Put the PrWx(-15) item(s) into ReWx(now)

Tidy up the ReWx(now) groups so that they meet the METAR coding rules

EndIf

Examples.

If   PrWx(now) = FZDZ   and   PrWx(-15) = RA   then   ReWx(now) = RERA

If   PrWx(now) = SHRA   and   PrWx(-15) = SHRASN   then   ReWx(now) = RESHSN

If   PrWx(now) = SN   and   PrWx(-15) = SN   then   ReWx(now) = ""

If   PrWx(now) = +SN   and   PrWx(-15) = SN   then   ReWx(now) = RESN

If   PrWx(now) = SN   and   PrWx(-15) = +SN   then   ReWx(now) = RESN

If   PrWx(now) = -SN   and   PrWx(-15) = SN   then   ReWx(now) = RESN

If   PrWx(now) = -SN   and   PrWx(-15) = +SN   then   ReWx(now) = RESN

If   PrWx(now) = SN   and   PrWx(-15) = -SN   then   ReWx(now) = ""

If   PrWx(now) = +SN   and   PrWx(-15) = -SN   then   ReWx(now) = ""

Note: items enclosed in [ ] are optional. items separated by / indicate one option or another.

End