Appendix F

Modeling Approach and Results

2013 Plan for the Revoked 1-Hour Ozone Standard
SJVUAPCD

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APPENDIX F: MODELING APPROACH AND RESULTS

Consistent with U.S. EPA guidelines, ARB modeled air quality to predict future 1-hour ozone (O_3) concentrations at each monitoring site in the Valley. This modeling shows attainment of the 1-hour O_3 standard by 2017 based on implementation of the ongoing control program.   This section summarizes these efforts and results. Additional information is available in the modeling protocol in Appendix E. Additional technical information can be found on the ARB's website:

http://www.arb.ca.gov/planning/sip/planarea/sanjqnvllysip.htm

1.1 Modeling Overview

The modeling analysis includes new emission reductions between now and 2017 from implementation of a combination of adopted ARB and District programs. Based on 2012 data, only three sites in the Valley still exceed the 1-hour O_3 standard. As required by U.S. EPA, the modeling replicates the base year 2007 meteorological conditions for each calendar day in the year 2017. The 2007 meteorological conditions included several periods of time especially conducive to the formation of O_3.

The U.S. EPA has not issued formal guidance that prescribes the attainment test for the revoked 1-hour O_3 standard. Following previous U.S. EPA guidance for the 8-hour O_3 standard (U.S. EPA, 2007), we have used the modeling results in a relative sense (i.e., using Relative Response Factors or RRFs) to demonstrate attainment of the 1-hour O_3 standard.

The traditional RRF-based approach has been to multiply each official site's design value (DV) by an average RRF to determine the future DV for demonstrating attainment. However experience has shown that the higher O_3 values (> 100 ppb) are more responsive to emission controls than the intermediate (between 80-100 ppb) or lower values (< 80 ppb).

A modified approach has been developed to construct RRF's for bands of concentrations and to apply this information in the determination of future DVs. These "band-RRFs" represent the model's response to similar concentrations averaged over different meteorological and emission conditions. Section 1.4.1 describes in detail the procedure implemented to calculate the band-RRFs.

The future DVs calculated based on the band-RRFs are compared with the 1-hour O_3 standard to determine the attainment status for each monitor. The benchmark for attainment is a DV that is equal to or less than 124 ppb.

1.2 Modeling Requirements

Following U.S. EPA guidance and procedures, the attainment demonstration was conducted using a modeled attainment test. A photochemical model simulates the observed O_3 levels, using precursor emissions and meteorology in the region. It also simulates future O_3 levels based on projected changes in emissions, while keeping the meteorology constant. This modeling is used to identify the relative benefits of controlling different O_3 precursor pollutants and the most expeditious attainment date. The following sections provide a brief summary of the meteorological and photochemical modeling performed and the results obtained. For more details on the modeling, the reader is referred to the Modeling Protocol in Appendix E.

1.3 General Methodology and Approach

The modeling approach draws heavily on the products of large-scale, scientific studies in the region, collaboration among technical staff of State and local regulatory agencies, as well as from participation in technical and policy groups within the region. It is also consistent with the modeling approach used for the 2012 24-hour $PM_{2.5}$ SIP that was submitted to the U.S. EPA in early 2013. The modeling period for this plan is from May to September 2007.

1.3.1 Meteorology Modeling

In the past, the ARB has applied prognostic, diagnostic, and hybrid models to prepare meteorological fields for photochemical modeling. Recent O_3 plans for both 1-hour and 8-hour standards were based on the Mesocale Model 5 (MM5)[1]. The ARB has applied the MM5 model over the past two decades, since it has been widely used and tested for various meteorological regimes over the world and has been supported by NCAR. NCAR terminated model development for MM5 in October 2006 and the code was frozen at the minor version of V3-7-4.

Since then NCAR has devoted its resources to the development of the Weather Research Forecast (WRF) model[2], which was designed to be the replacement for MM5. The WRF model is being continually updated, and WRF fields produced by ARB have shown comparable results with MM5. Therefore, the WRF numerical model was chosen to generate meteorological fields for this SIP.

Please see the Modeling Protocol in Appendix E for more details on WRF modeling for this plan.

1.3.2 Air Quality Modeling

The Community Multiscale Air Quality (CMAQ) Modeling System has been selected for modeling ozone in the SJV. The CMAQ model, a state-of-the-science "one-atmosphere" modeling system developed by U.S. EPA, was designed for applications ranging from regulatory and policy analysis to understanding of atmospheric chemistry

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[1] Grell, G. A., J. Dudhia and D. R. Stauffer, 1994: A description of the fifth-generation Penn State/NCAR mesoscale model (MM5). NCAR Technical Note, NCAR/TN-398+STR, 117 pp. National Center for Atmospheric Research. Boulder, CO. June, 1994.

[2] Skamarock, W. C., J. B. Klemp, J. Dudhia, G. O. Gill, D. M. Barker, W. Wang, and J. G. Powers, 2005: A description of the Advanced Research WRF Version 2. NCAR Technical Note NCAR/TN-468+STR, June 2005.

and physics. It is a three-dimensional Eulerian modeling system that simulates ozone, particulate matter, toxic air pollutants, visibility, and acidic pollutant species throughout the troposphere[3].

Staff at CARB has developed significant expertise in applying the CMAQ model, since it has been used at CARB for over a decade. In addition, technical support for the CMAQ model is readily available from the Community Modeling and Analysis System (CMAS) Center[4] established by the U.S. EPA. More information on regulatory applications of the CMAQ model in California and elsewhere can be found in the Modeling Protocol in Appendix E.

Other relevant information, including the modeling domain definition, chemical mechanism, initial and boundary conditions, emissions preparation, etc., can also be found in the Modeling Protocol in Appendix E.

1.4 Modeling results

1.4.1 Development of Relative Response Factors (RRFs) for the 1-hr ozone National Ambient Air Quality Standard (NAAQS):

As described in Section 1.1, there is no formal guidance that prescribes the attainment test for the 1-hour O_3 NAAQS. Following the guidance for the 8-hour O_3 NAAQS, provided by the U.S. EPA previously[5], we have used the modeling results in a relative sense (i.e., using RRFs) to demonstrate attainment of 1-hour O_3 NAAQS. As a result,

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[3] UNC, 2010, Operational Guidance for the Community Multiscale Air Quality (CMAQ) Modeling System Version 4.7.1., available at
http://www.cmascenter.org/help/model_docs/cmaq/4.7.1/CMAQ_4.7.1_OGD_28june10.pdf.

[4] http://www.cmascenter.org/

[5] U.S. EPA, 2007, Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze, EPA-454/B07-002.

the following procedure has been implemented to calculate the RRFs. These RRF's are an improvement to the traditional averaged RRFs used in the 8-hour analysis and are constructed for bands of simulated 1-hr daily maximum O_3 concentrations. These band-RRFs were used to determine the future Design Values based on three baseline years (2005-2007).

1. Model Performance Evaluation:
    - For the simulated hourly O_3 data, the model performance criterion threshold was set to 60 ppb along with the following constraints
        - peak prediction accuracy (PPPA) within ±20%
        - unpaired mean normalized bias (NB) within ±15% and
        - unpaired gross error (GE) less than 35%
    - Only the days that meet the model performance criteria were used in the subsequent analysis.
    - The top panel of Figure F-1F-1, which is for the Shafter – Walker Street monitoring site, highlights the subset of days during which the model performance is achieved for the daily maximum 1-hour O_3 concentrations, where the observed and predicted daily maximum concentrations are located at the monitor. For comparison, the maximum O_3 concentration predicted within a 15 km radius of the monitor is also shown.

2. Formation of RRF bands:
    - For the days that met model performance standards, the simulated 1-hr O_3 concentrations were stratified into 10 ppb bins in the 60-130 ppb range to span the entire range of simulated 1-hr daily maximum O_3 concentrations.
    - The average RRF was calculated for each 10 ppb bin for days where the model performance criteria were met.
    - If the RRF value for a given bin was not available from the simulation, the missing RRF bin values were calculated using parameters obtained by using a linear fit of the available RRF's and ozone bins. This procedure is shown on the bottom left panel of Figure F-1F-1. For example, the 110-119 ppb RRF band for Bakersfield – Golden State was missing and we estimated that

using the linear fit parameters. Similar figures for all other sites are shown at the end of this chapter (Figure F-2 to Figure F-19F-19).

3. Application of RRFs to determine the future Design Values:

- The form of the 1-hour O_3 NAAQS allows three violations at a given monitor within three consecutive years; a fourth violation would make the area represented by that monitor non-attainment.

- For each monitor, the top 10 observed daily maximum 1-hr O_3 concentrations during the three years starting from 2005 and ending in the base model year of 2007 were selected.

- To determine which band of RRF would correspond to each of the top observed daily maximum 1-hr O_3 concentrations, we have constructed a correlation diagram of simulated vs. observed 1-hr O_3 concentrations as shown in the bottom right panel of **Error! Reference source not found.**. For this purpose, we have only used simulated days with 1-hr daily maximum O_3 within ±20% of the measured value.

- The linear fit parameters form the above plot were then used to find the RRF bands that correspond to the top 10 observed values.

- The new future DVs were calculated by multiplying the top 10 observed 1-hr O_3 concentrations by their corresponding band RRF values. The future year values were then re-sorted and the 4th highest value was selected as the future Design Value for that monitor.

- The future Design Values were then compared with the 1-hour O_3 NAAQS (124.0 ppb in this case) to determine the attainment status for each monitor.
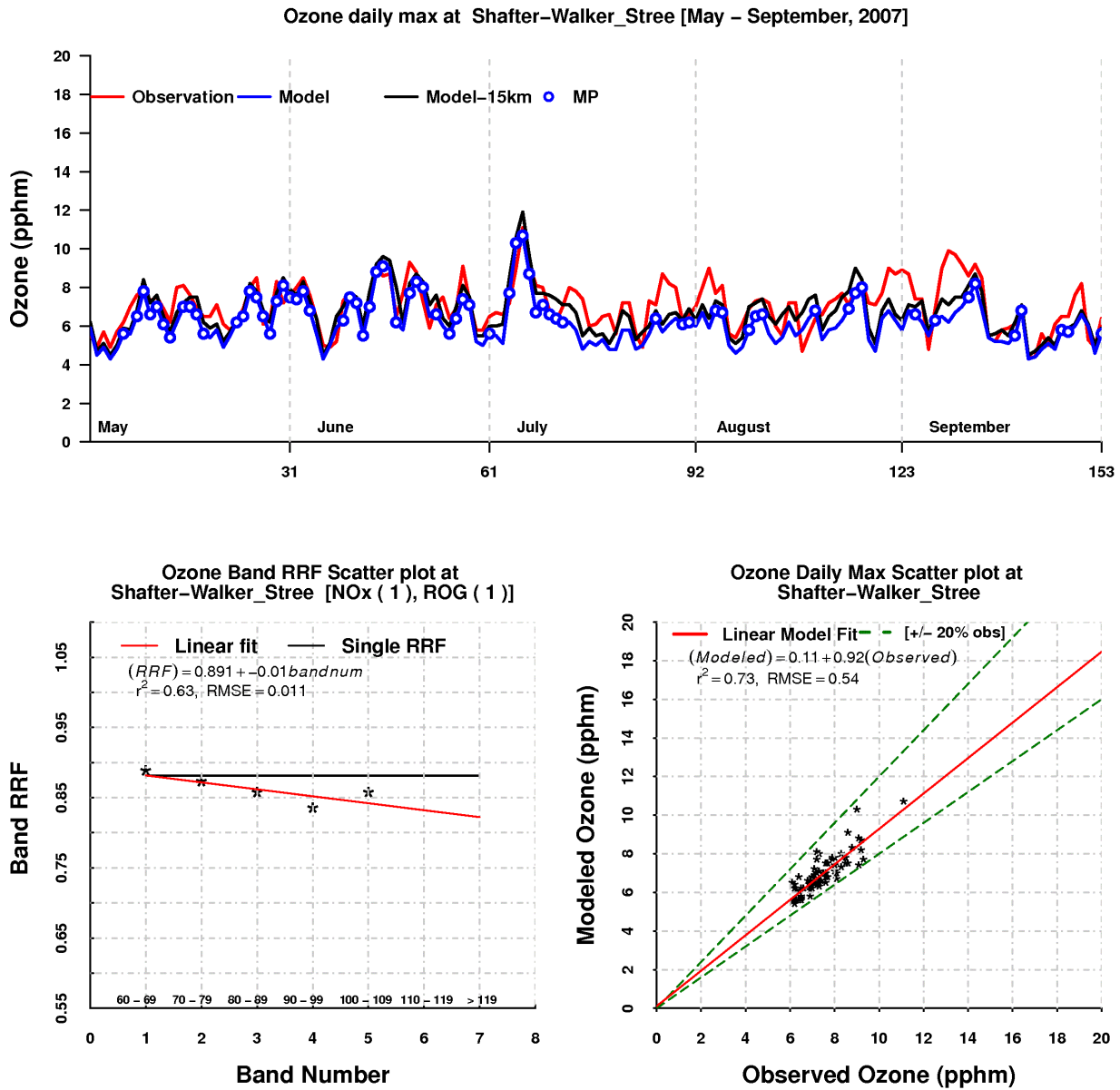
Figure F-1: The Band RRF procedure for Shafter – Walker Street monitoring site.

1.4.2 Attainment Demonstration

Using the above methodology, we have calculated the future DVs for O_3 sites in the San Joaquin Valley. The results are shown in Table F-1, in the descending order of 2007 DVs.

Table F-1: The 2007 and 2017 DVs for monitoring sites in the San Joaquin Valley.

Monitoring Station	DV (2005-07)	DV (2015-17)
Edison	135	119.3
Arvin-Bear_Mountain_Blvd	131	107.4
Fresno-1st_Street	130	103.7
Clovis-N_Villa_Avenue	125	104.1
Fresno-Sierra_Skypark_#2	124	98.8
Parlier	121	97.4
Sequoia_and_Kings_Canyon	118	102.4
Bakersfield-5558_Califor	117	98.0
Sequoia_Natl_Park-Lower	113	98.5
Visalia-N_Church_Street	112	94.5
Oildale-3311_Manor_Stree	112	95.2
Fresno-Drummond_Street	110	93.0
Hanford-S_Irwin_Street	110	92.6
Modesto-14th_Street	109	95.9
Shafter-Walker_Street	105	87.7
Turlock-S_Minaret_Street	104	91.8
Stockton-Hazelton_Street	101	86.3
Merced-S_Coffee_Avenue	102	85.4
Maricopa-Stanislaus_Stre	100	83.5
Madera-Pump_Yard	95	82.4

Table F-1F-1 shows that each site in the SJV has a future DV less than 124.0 ppb. The highest predicted future site, Edison, is 4.7 ppb below the standard, and other current high sites are 15 to 30 ppb below the standard. Therefore, the air quality simulations predict that the entire Valley will attain the standard by 2017.

1.4.3 Band RRF Figures for All Sites:

In this section, we show the figures comparable to Figure F-1F-1 for all monitoring sites that are listed in Table F-1.
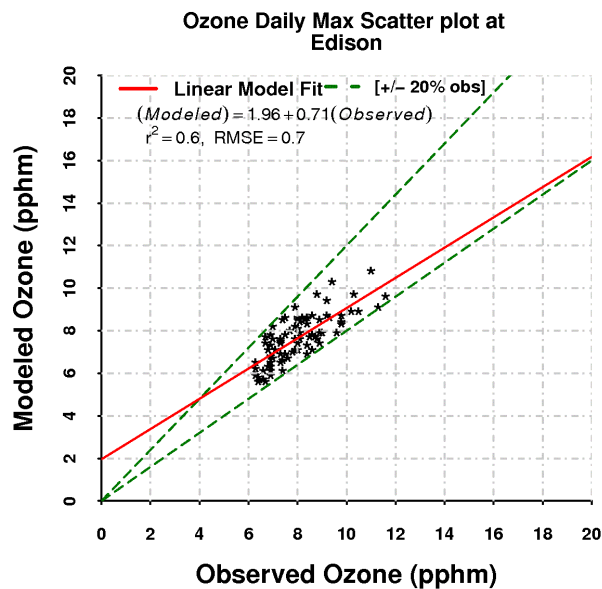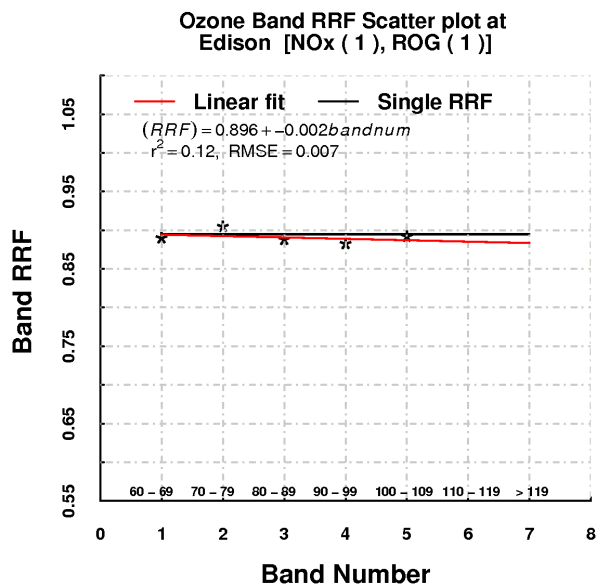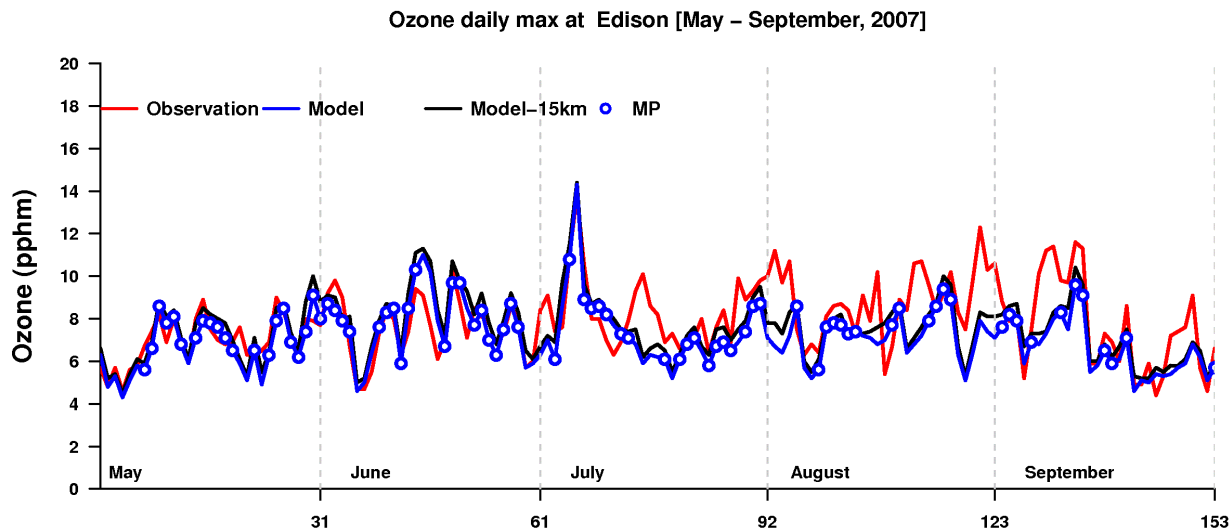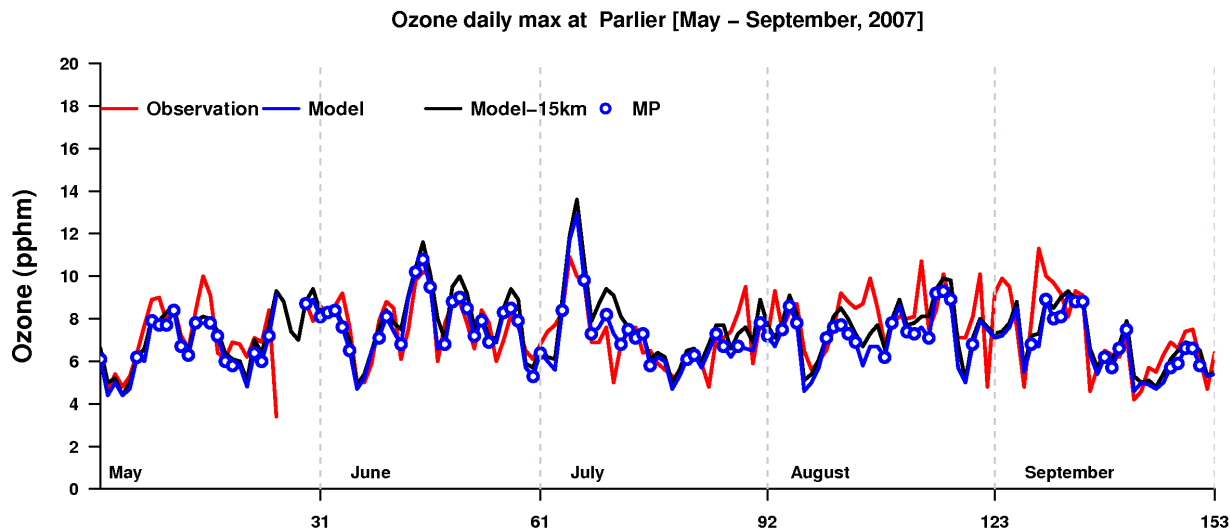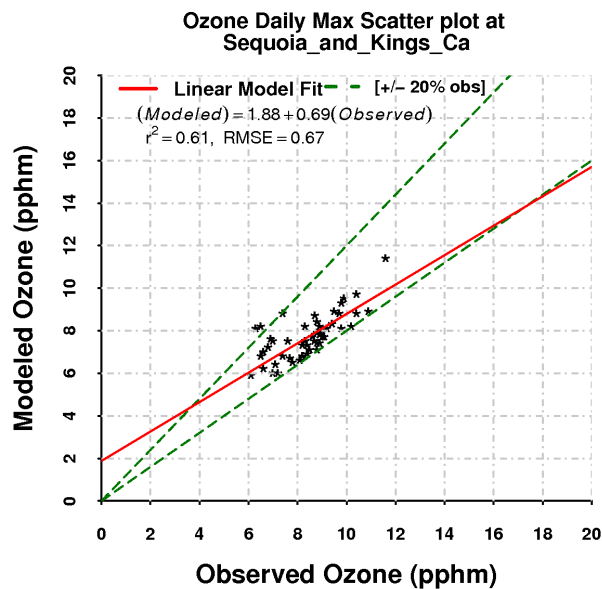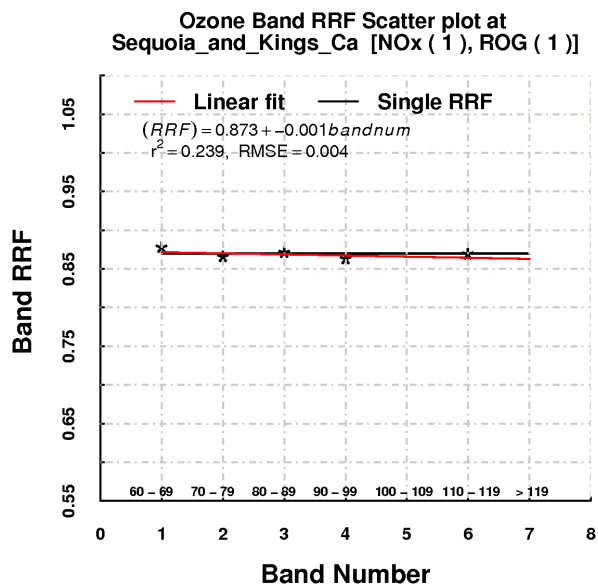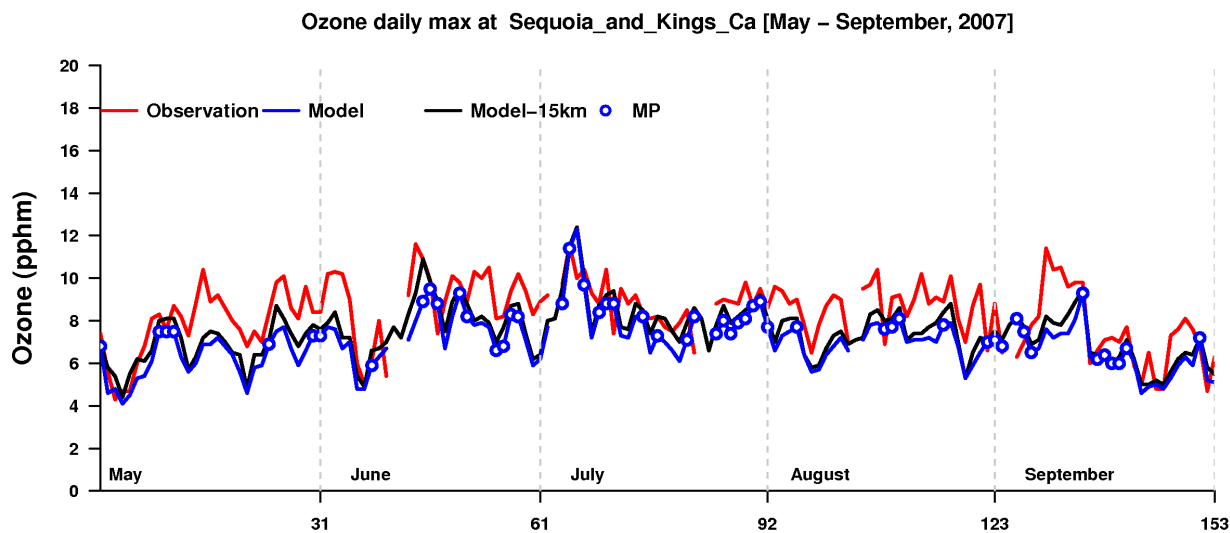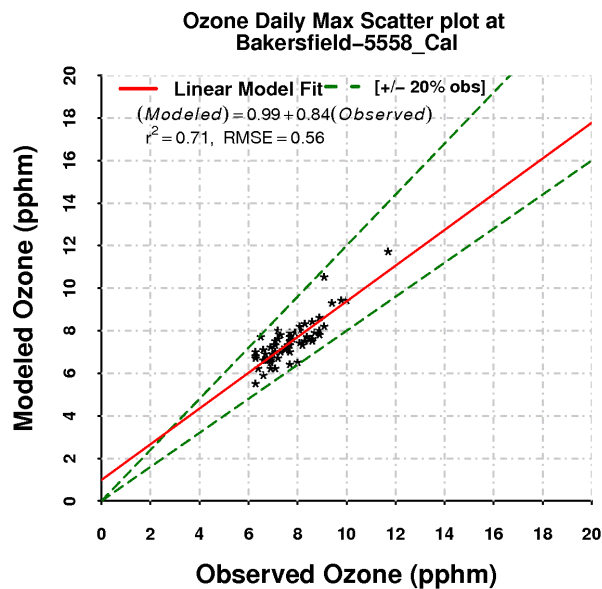
Figure F-2: The Band RRF procedure for Edison monitoring site.
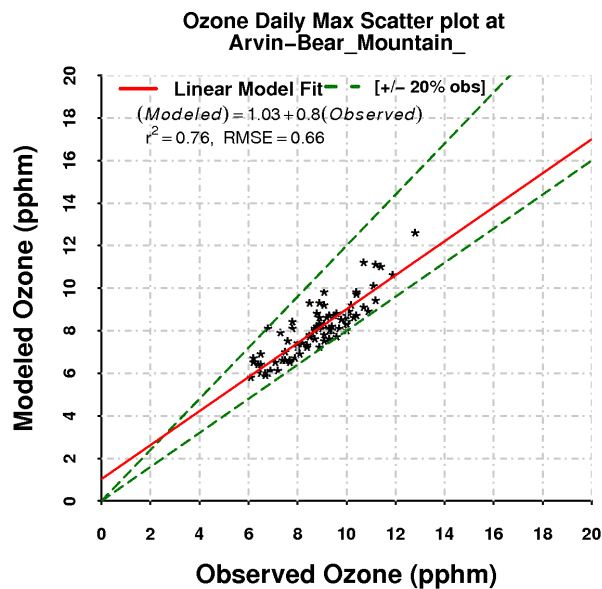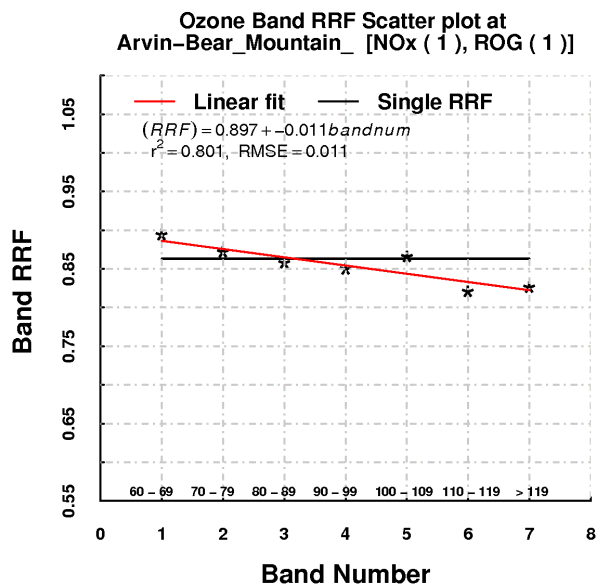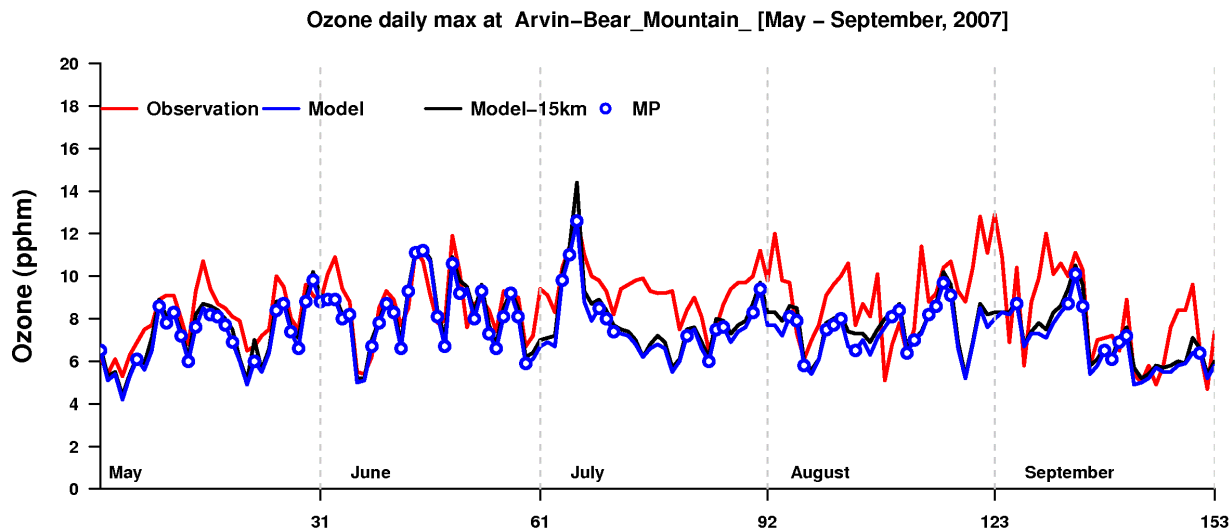
Figure F-3: The Band RRF procedure for Arvin – Bear Mountain monitoring site.

Ozone daily max at Fresno–1st_Street [May – September, 2007]

Ozone Band RRF Scatter plot at Fresno–1st_Street [NOx (1), ROG (1)]

Ozone Daily Max Scatter plot at Fresno–1st_Street
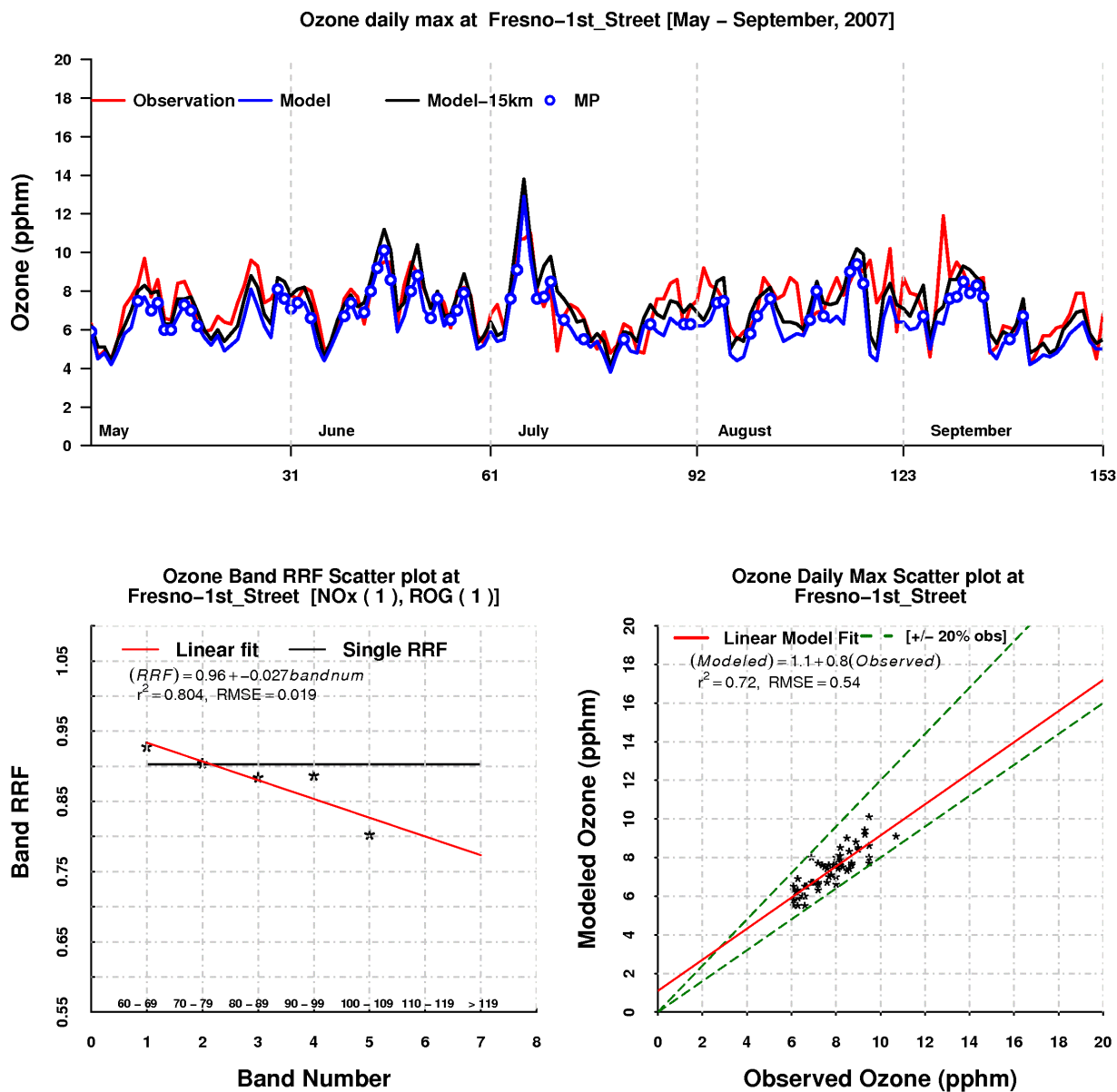
Figure F-4: The Band RRF procedure for Fresno – 1st Street monitoring site.
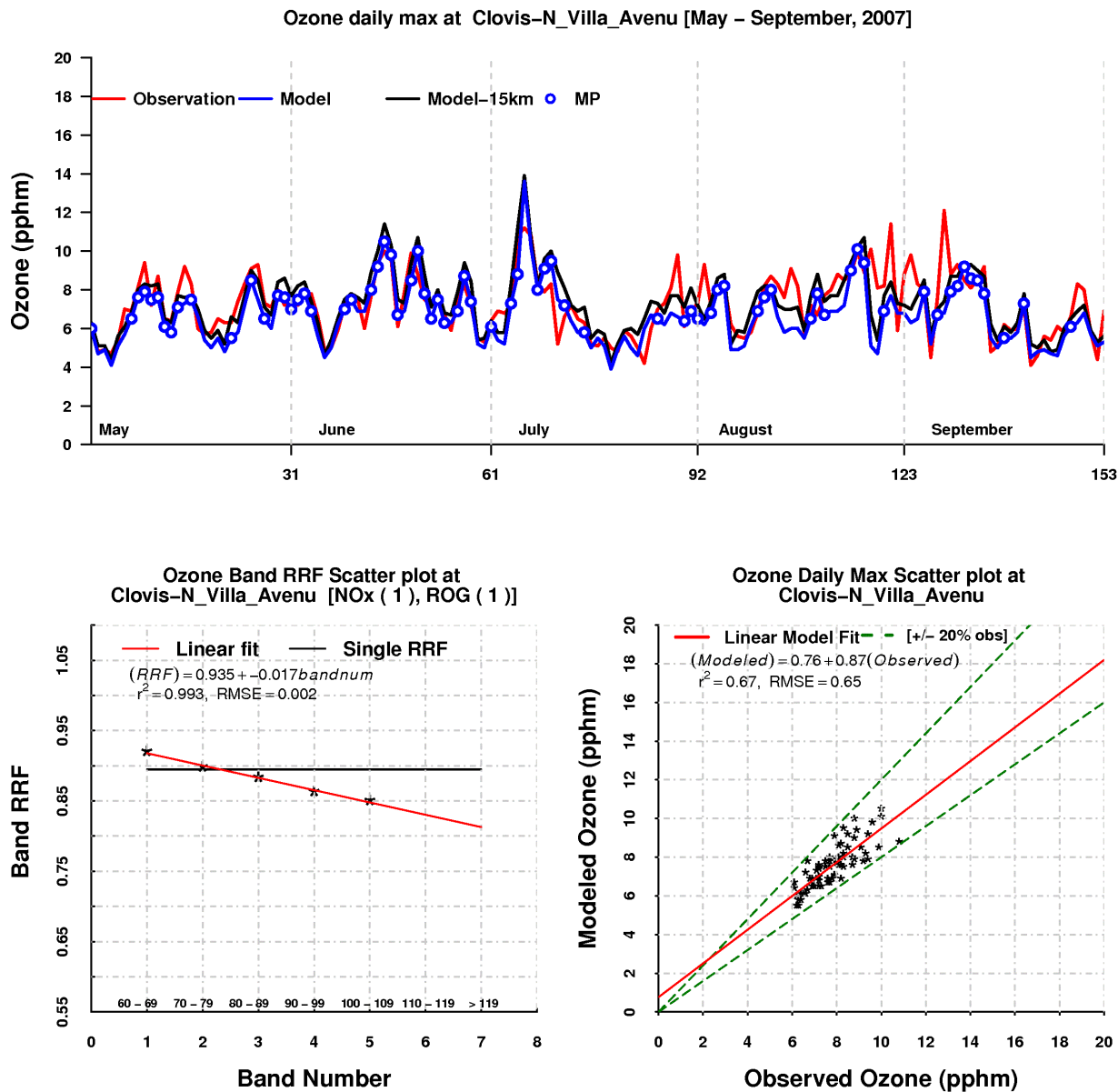
Figure F-5: The Band RRF procedure for Clovis – North Villa Avenue monitoring site.
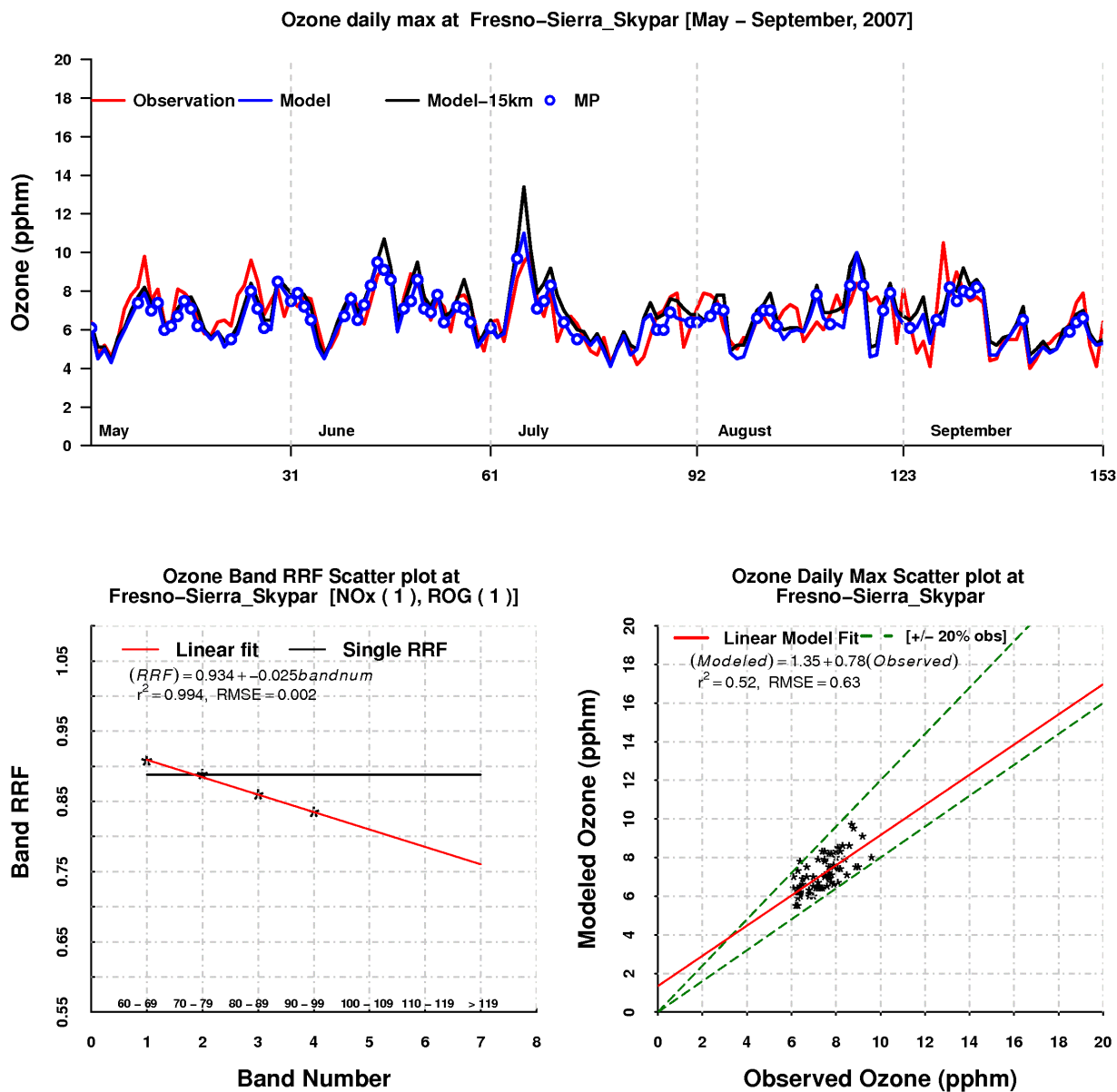
Figure F-6: The Band RRF procedure for Fresno – Sierra Sky Park monitoring site.

Ozone daily max at Parlier [May – September, 2007]

Ozone Band RRF Scatter plot at Parlier [NOx (1), ROG (1)]

Ozone Daily Max Scatter plot at Parlier
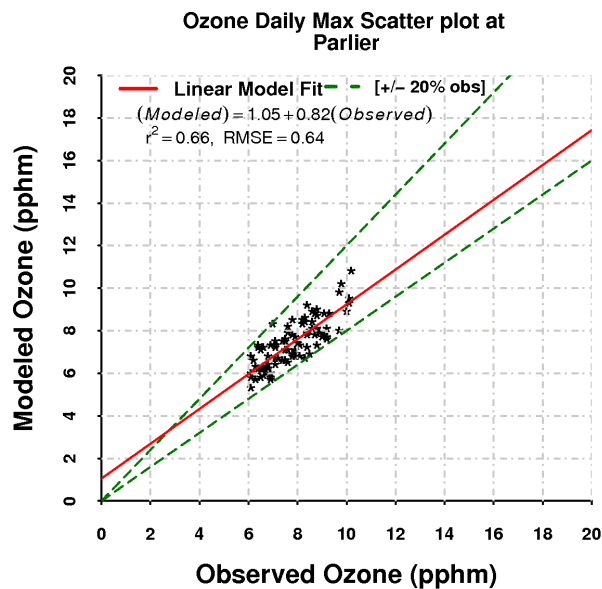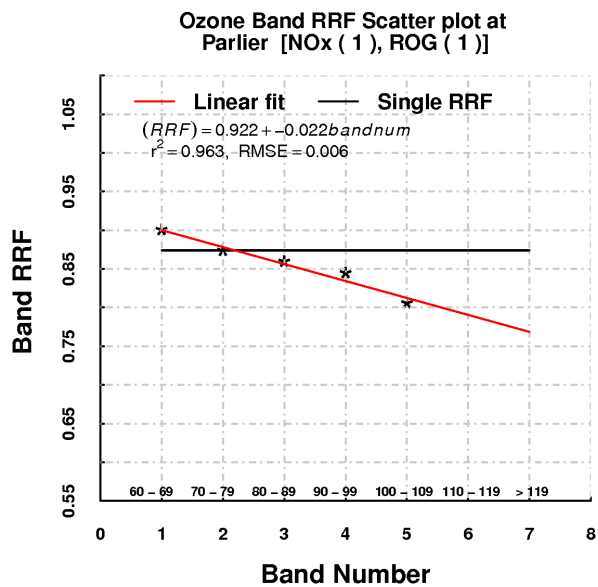
Figure F-7: The Band RRF procedure for Parlier monitoring site.

Figure F-8: The Band RRF procedure for Sequoia and Kings Canyon monitoring site.
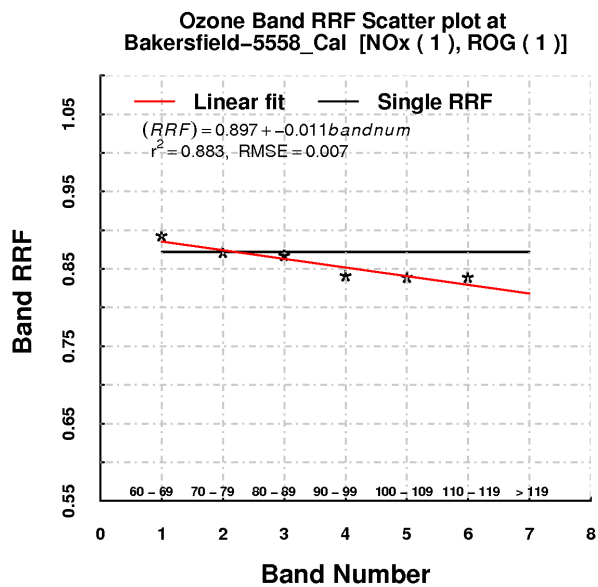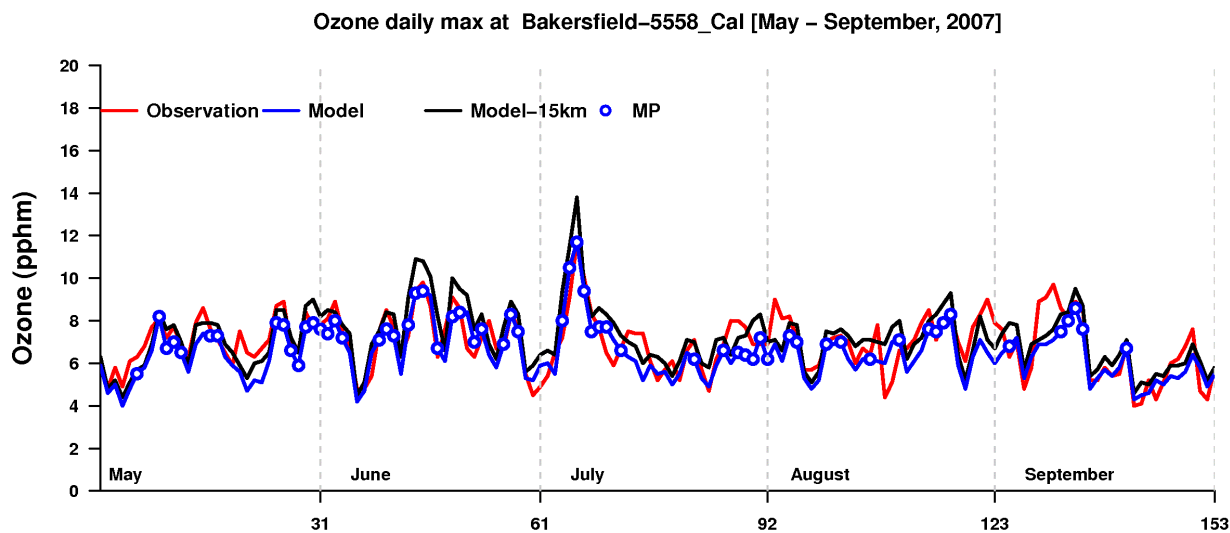
Figure F-9: The Band RRF procedure for Bakersfield – 5558 California Avenue monitoring site.
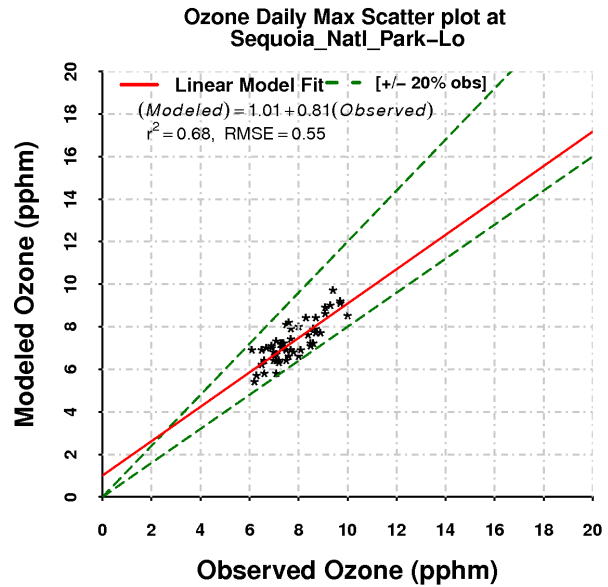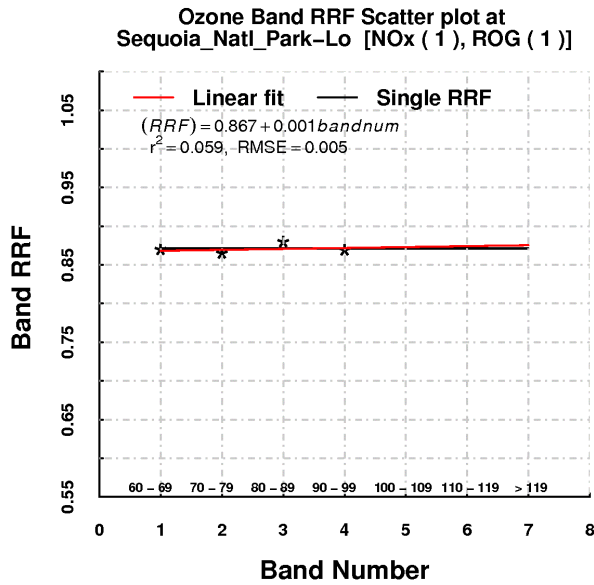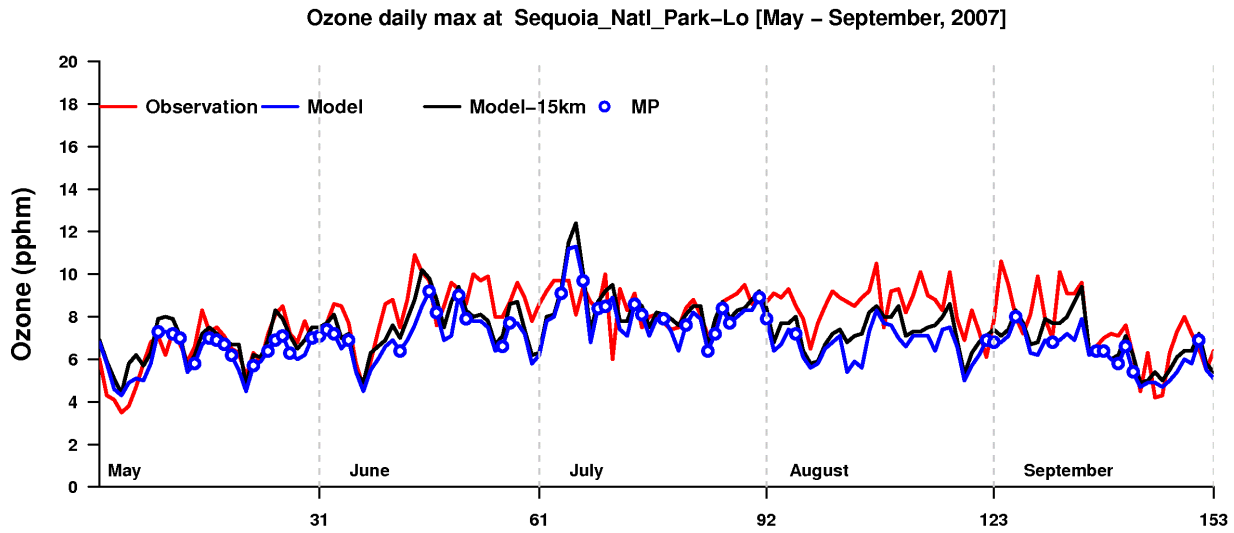
Figure F-10: The Band RRF procedure for Sequoia National Park – Lower Kiawah River monitoring site.

Ozone daily max at Visalia–N_Church_Str [May – September, 2007]

Ozone Band RRF Scatter plot at
Visalia–N_Church_Str [NOx (1), ROG (1)]

Ozone Daily Max Scatter plot at
Visalia–N_Church_Str
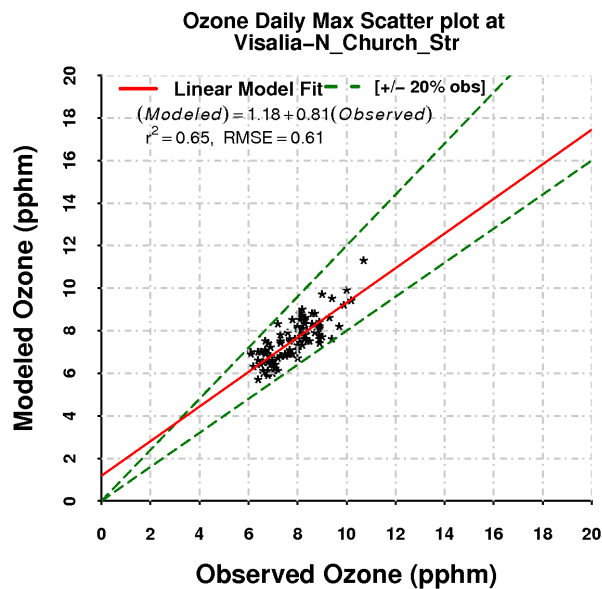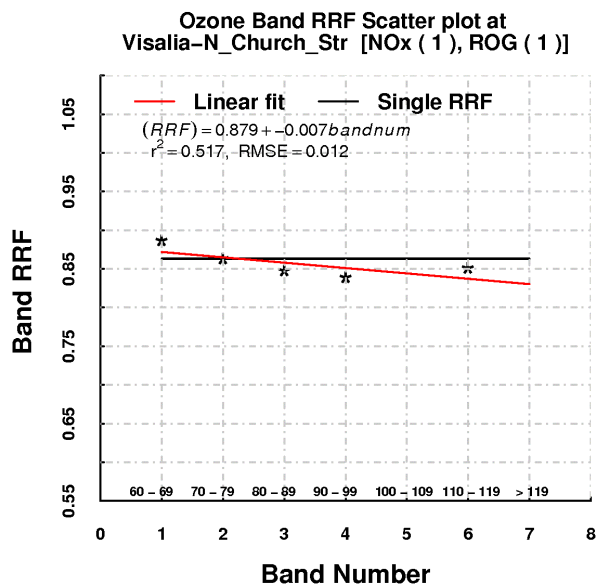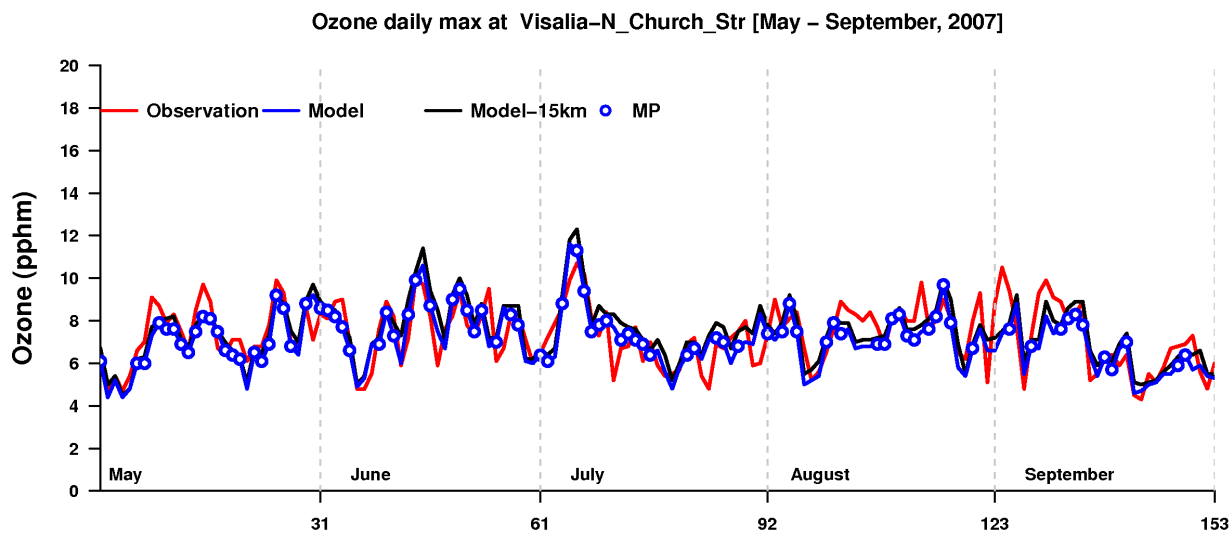
Figure F-11: The Band RRF procedure for Visalia – North Church Street monitoring site.

Ozone daily max at Oildale–3311_Manor_S [May – September, 2007]

Ozone Band RRF Scatter plot at
Oildale–3311_Manor_S [NOx (1), ROG (1)]

$(RRF) = 0.895 + -0.01 bandnum$
$r^2 = 0.94,\ RMSE = 0.005$

Ozone Daily Max Scatter plot at
Oildale–3311_Manor_S

$(Modeled) = 0.27 + 0.88 (Observed)$
$r^2 = 0.73,\ RMSE = 0.57$
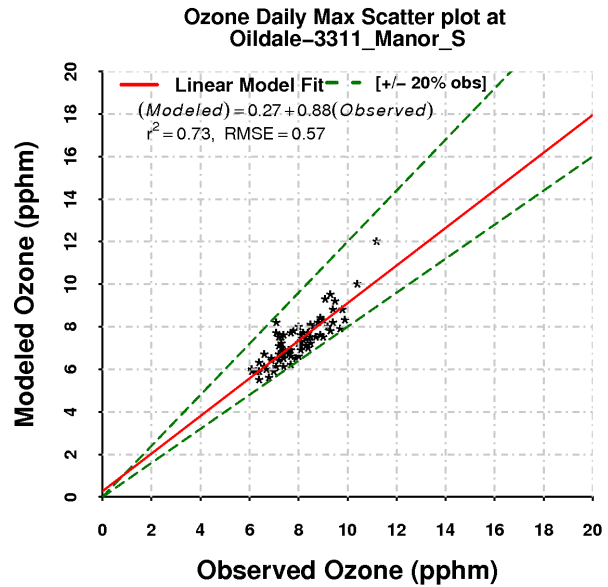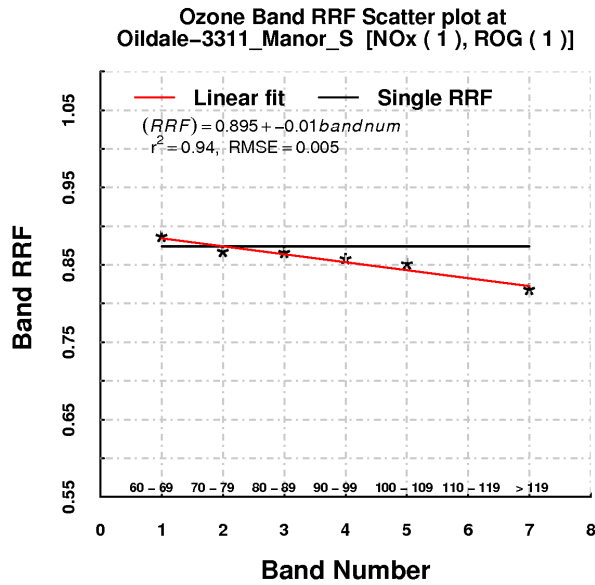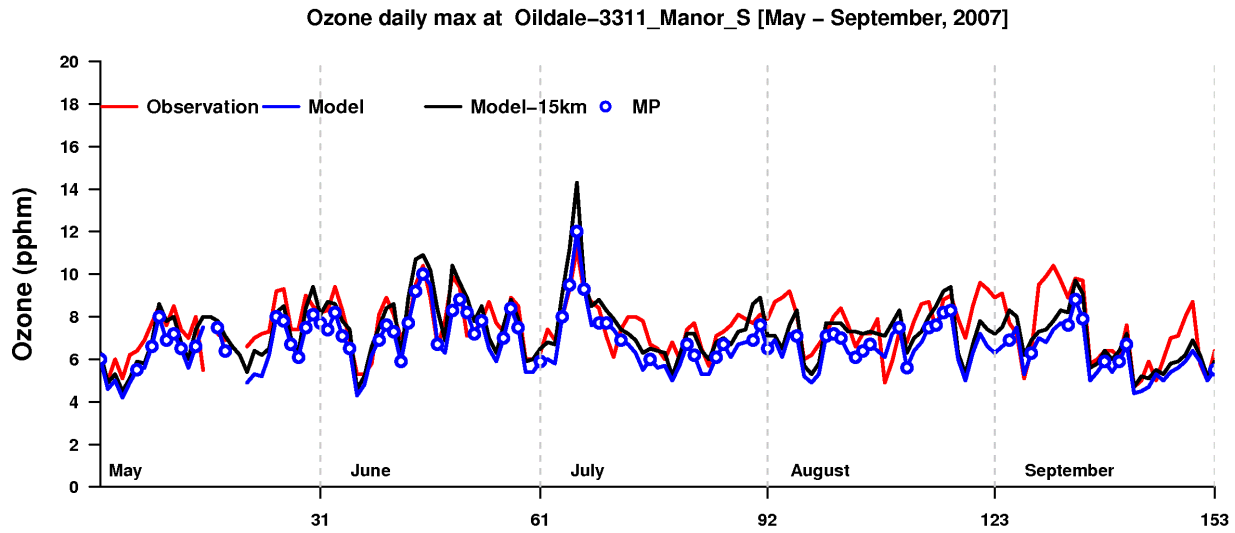
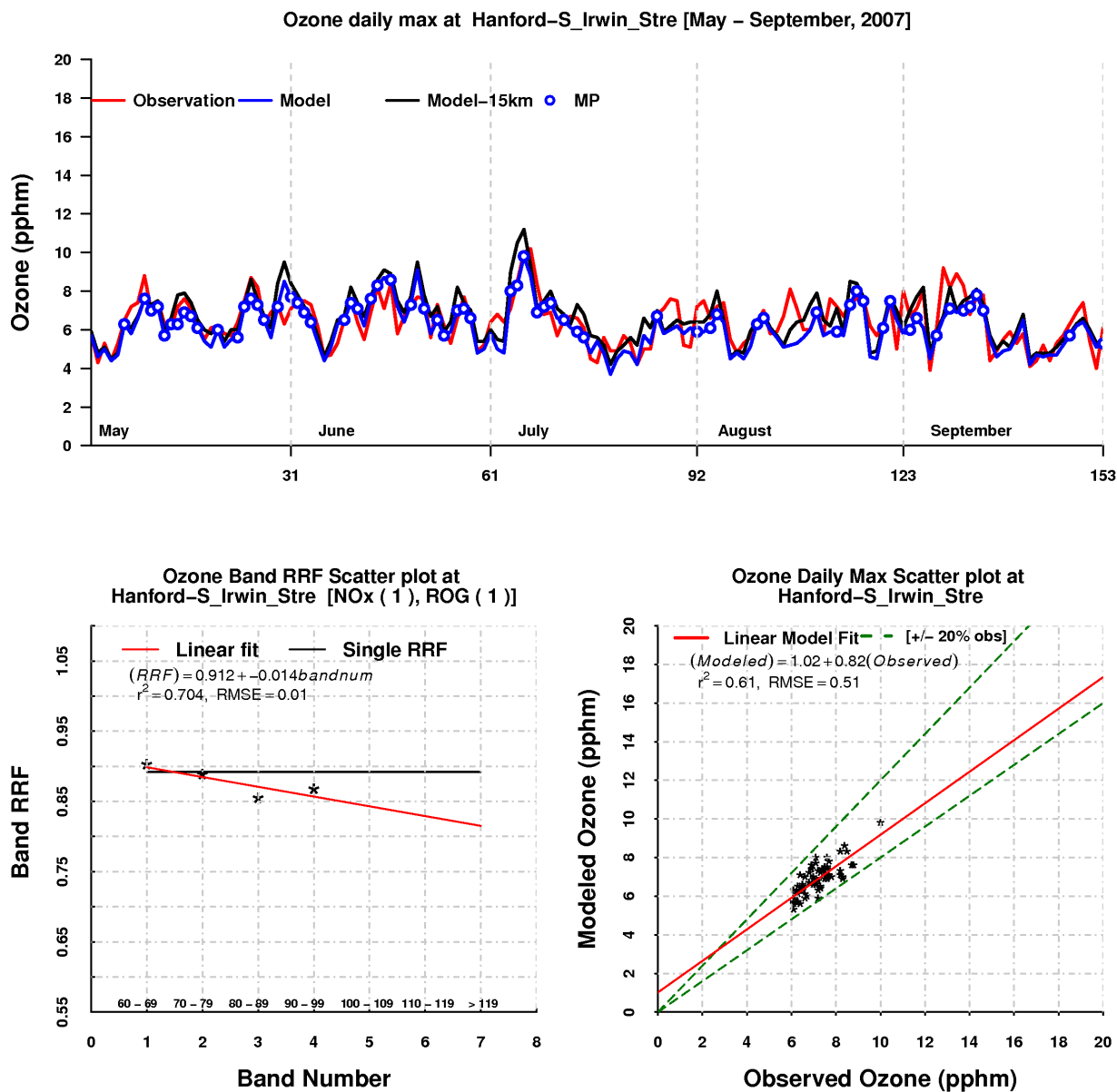**Figure F-12:** The Band RRF procedure for Oildale – 3311 Manor Street monitoring site.
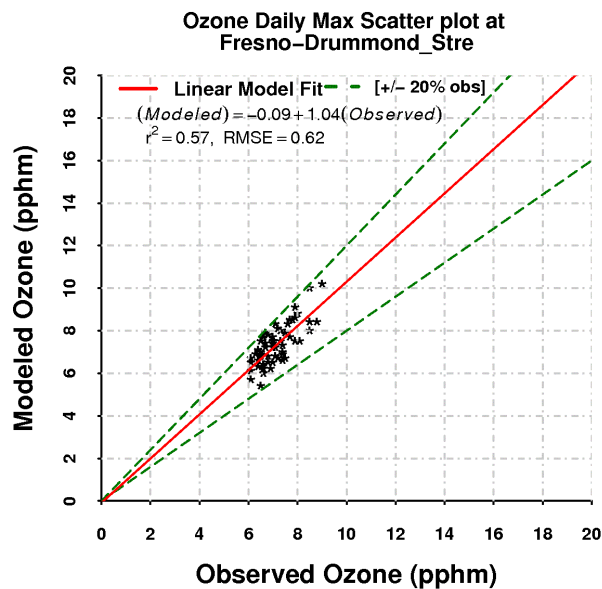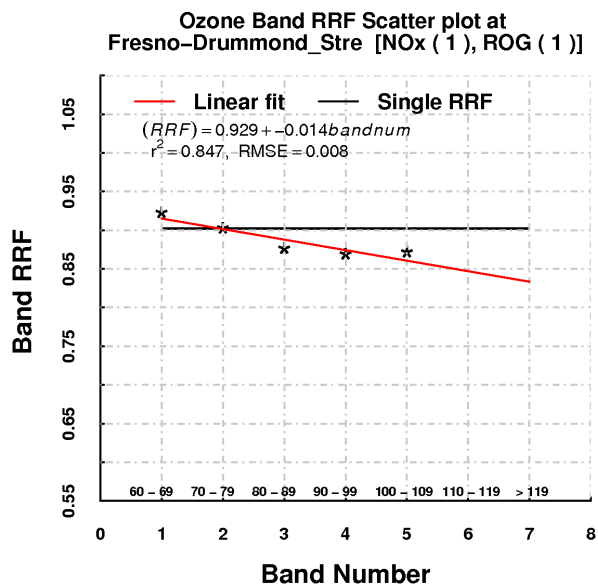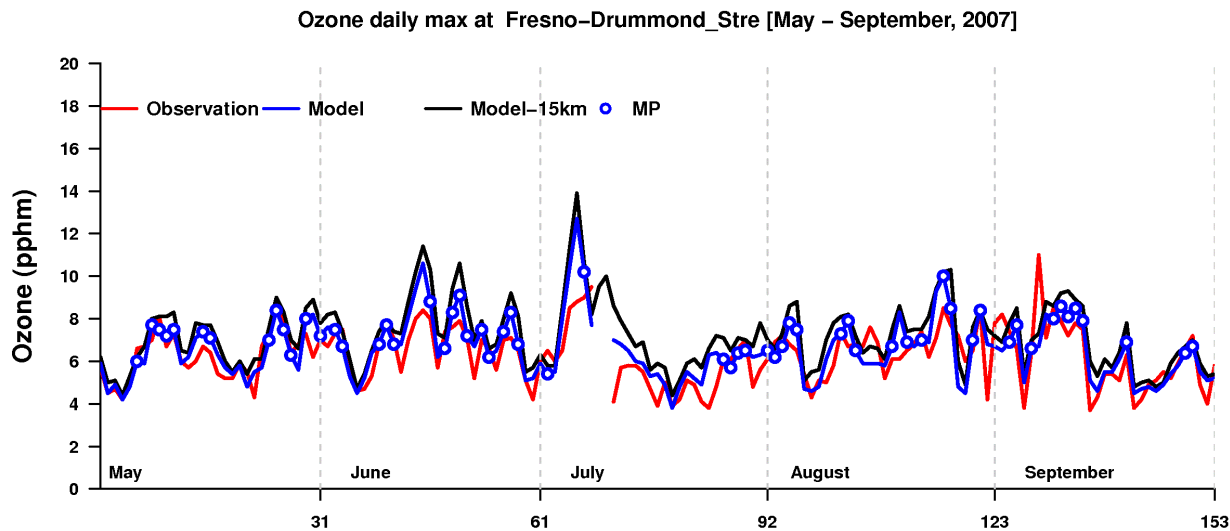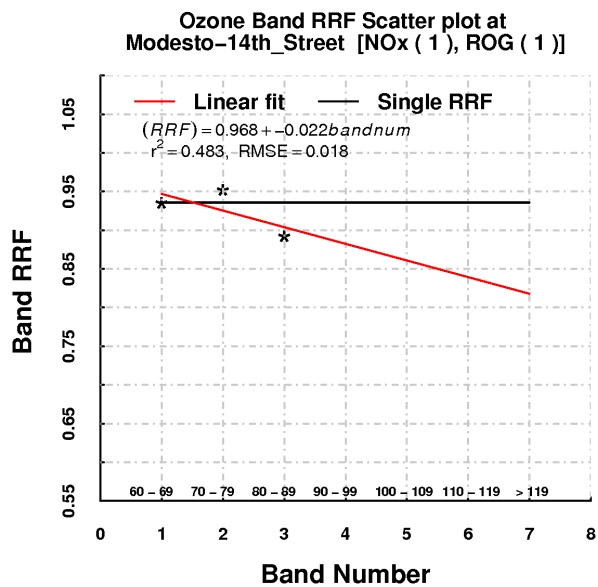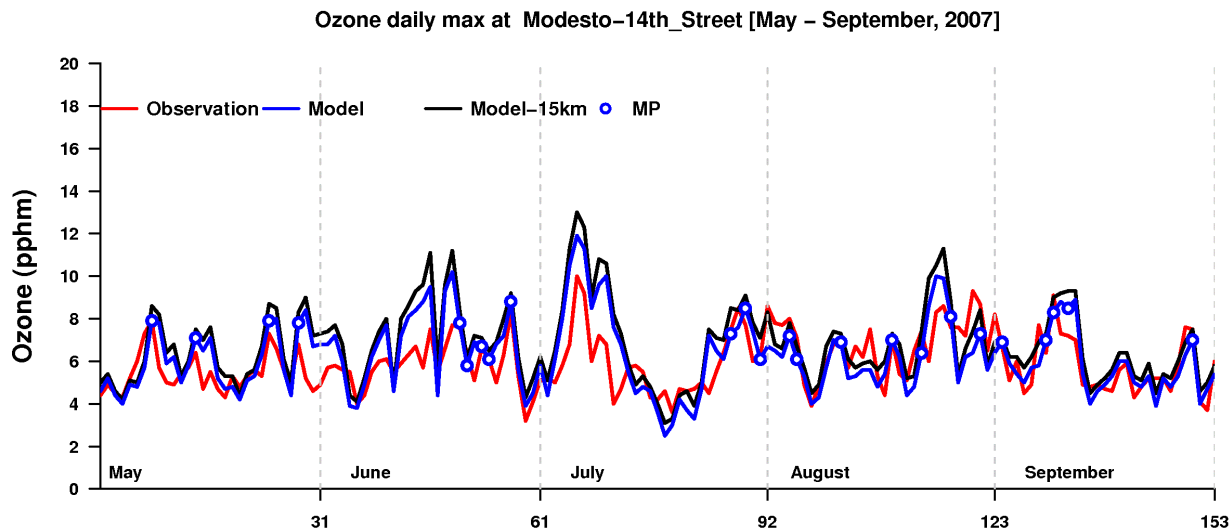
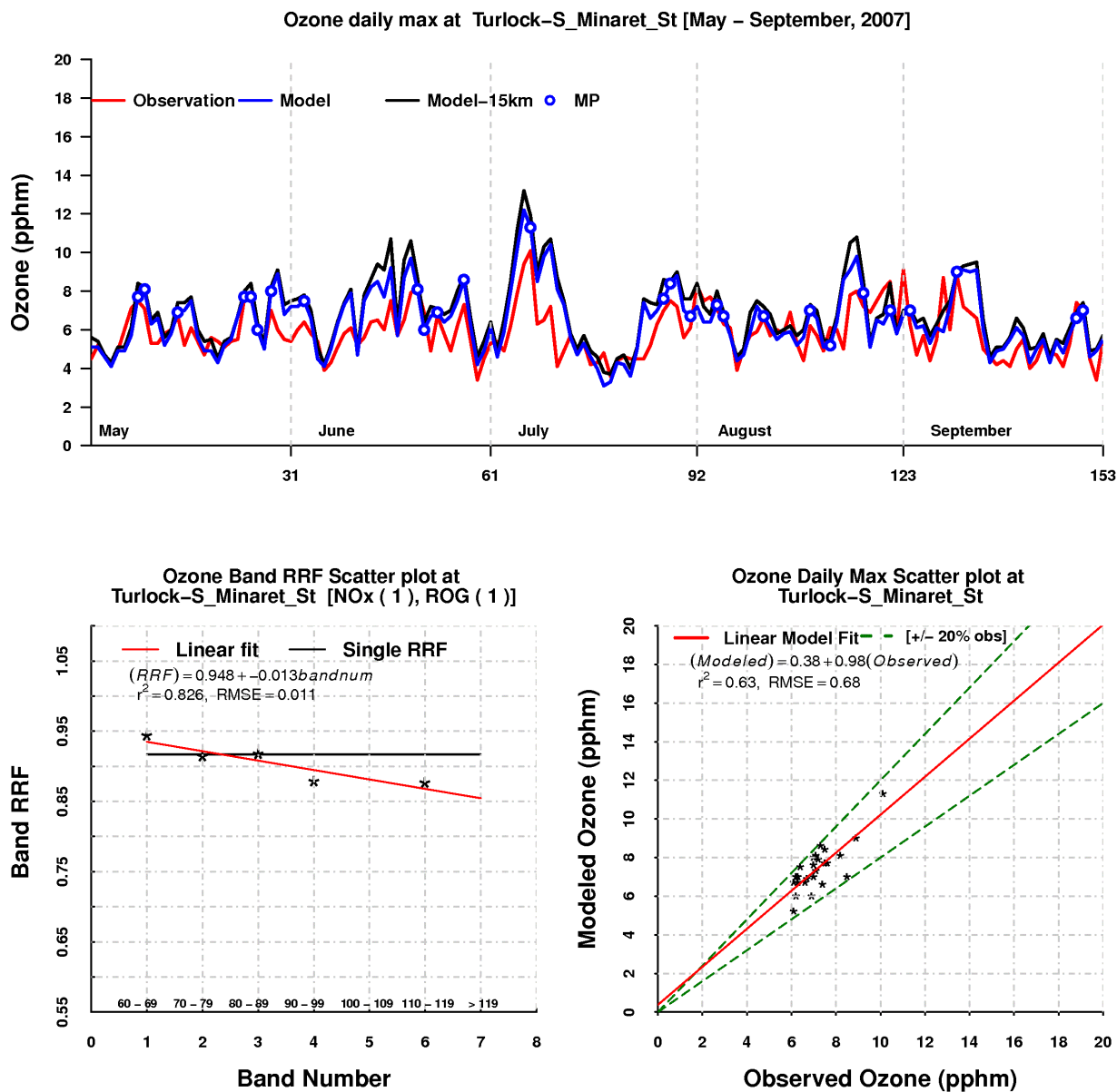**Figure F-13:** The Band RRF procedure for Fresno – Drummond Street monitoring site.

Figure F-14: The Band RRF procedure for Hanford – South Irwin Street monitoring site.

Ozone daily max at Modesto–14th_Street [May – September, 2007]

Ozone Band RRF Scatter plot at Modesto–14th_Street [NOx (1), ROG (1)]

$(RRF) = 0.968 + -0.022 bandnum$
$r^2 = 0.483, \ RMSE = 0.018$

Ozone Daily Max Scatter plot at Modesto–14th_Street

$(Modeled) = 2.28 + 0.69(Observed)$
$r^2 = 0.41, \ RMSE = 0.63$

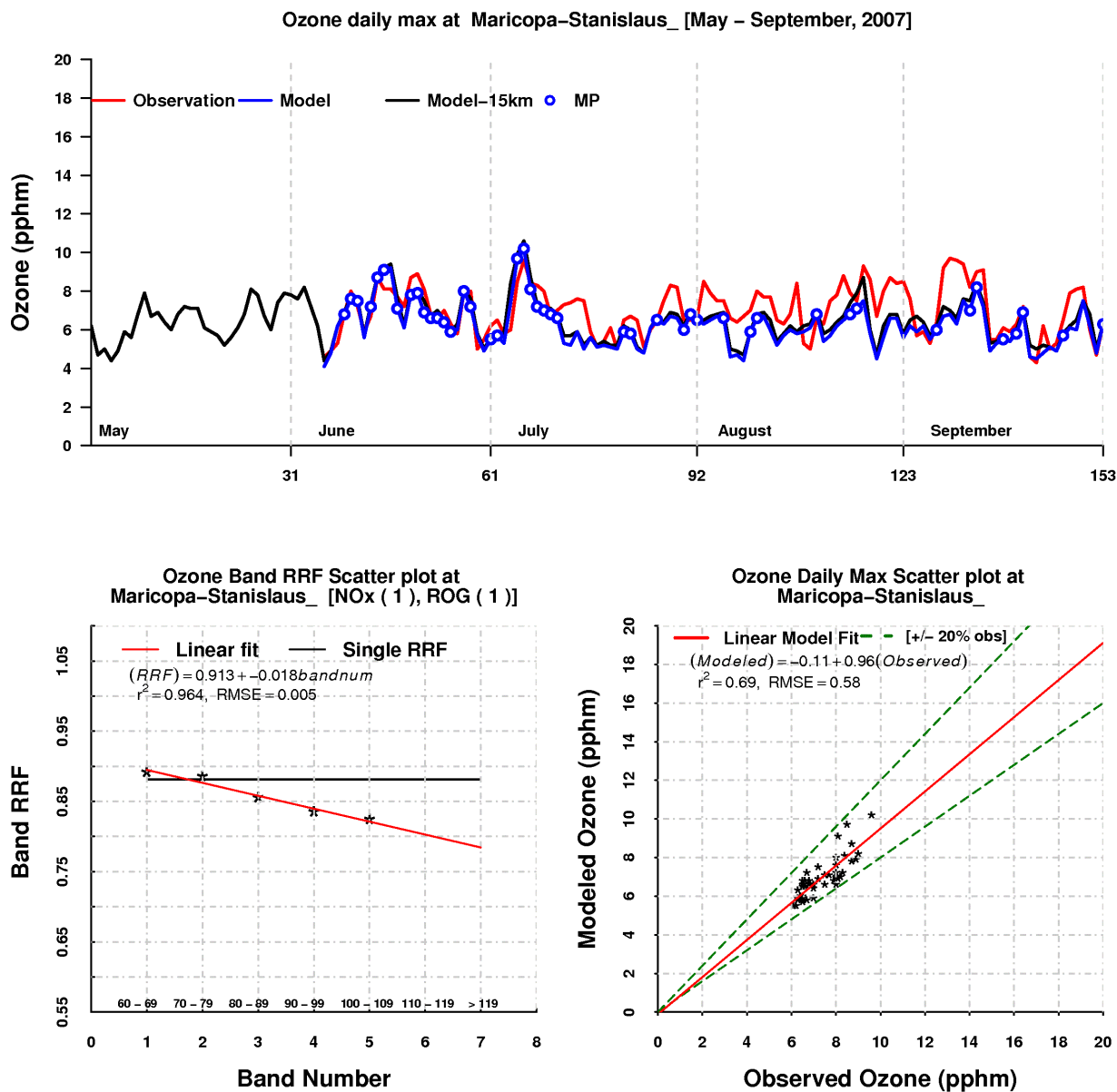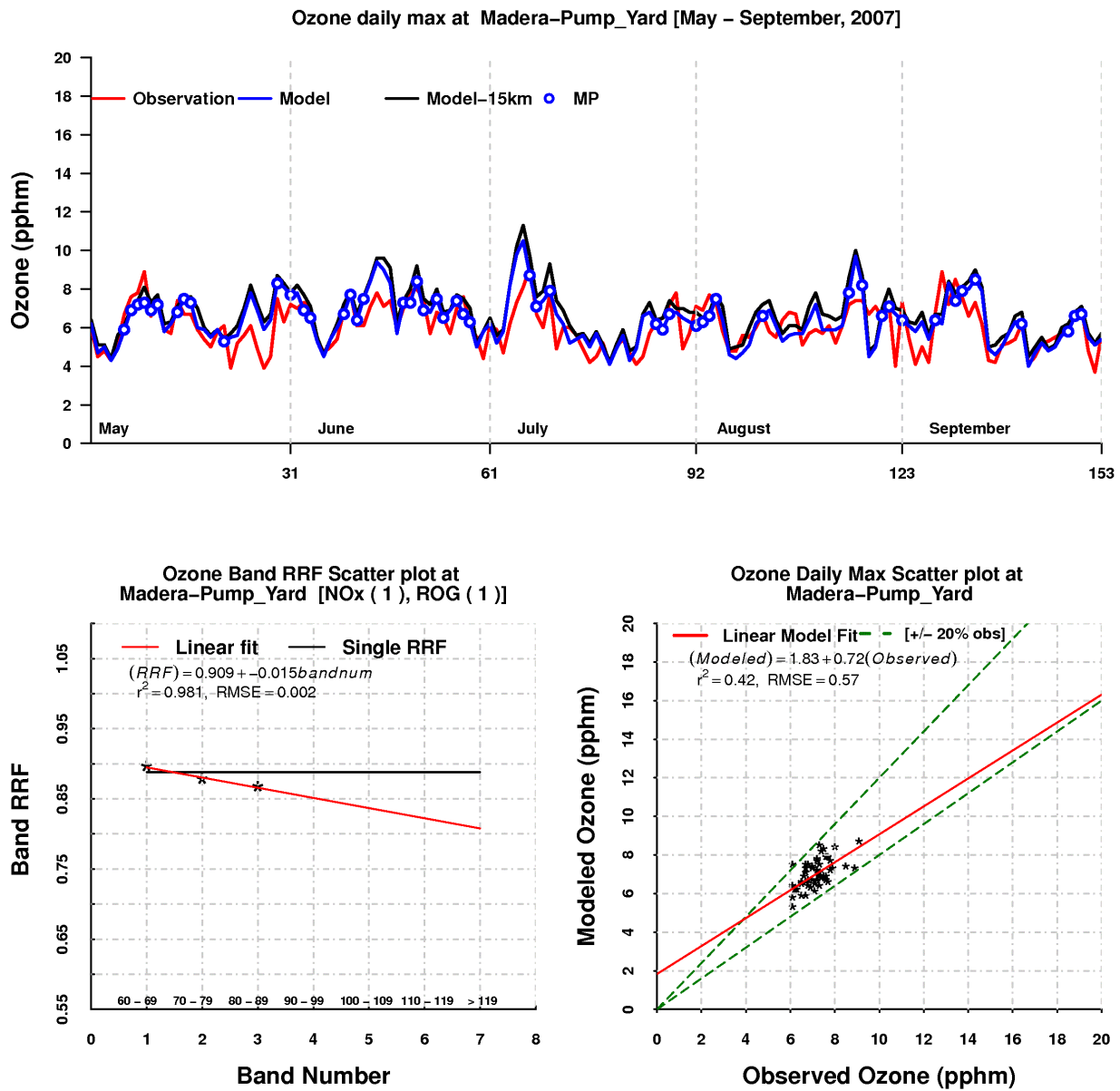**Figure F-15:** The Band RRF procedure for Modesto – 14th Street monitoring site.

Figure F-16: The Band RRF procedure for Turlock – South Minaret Street monitoring site.
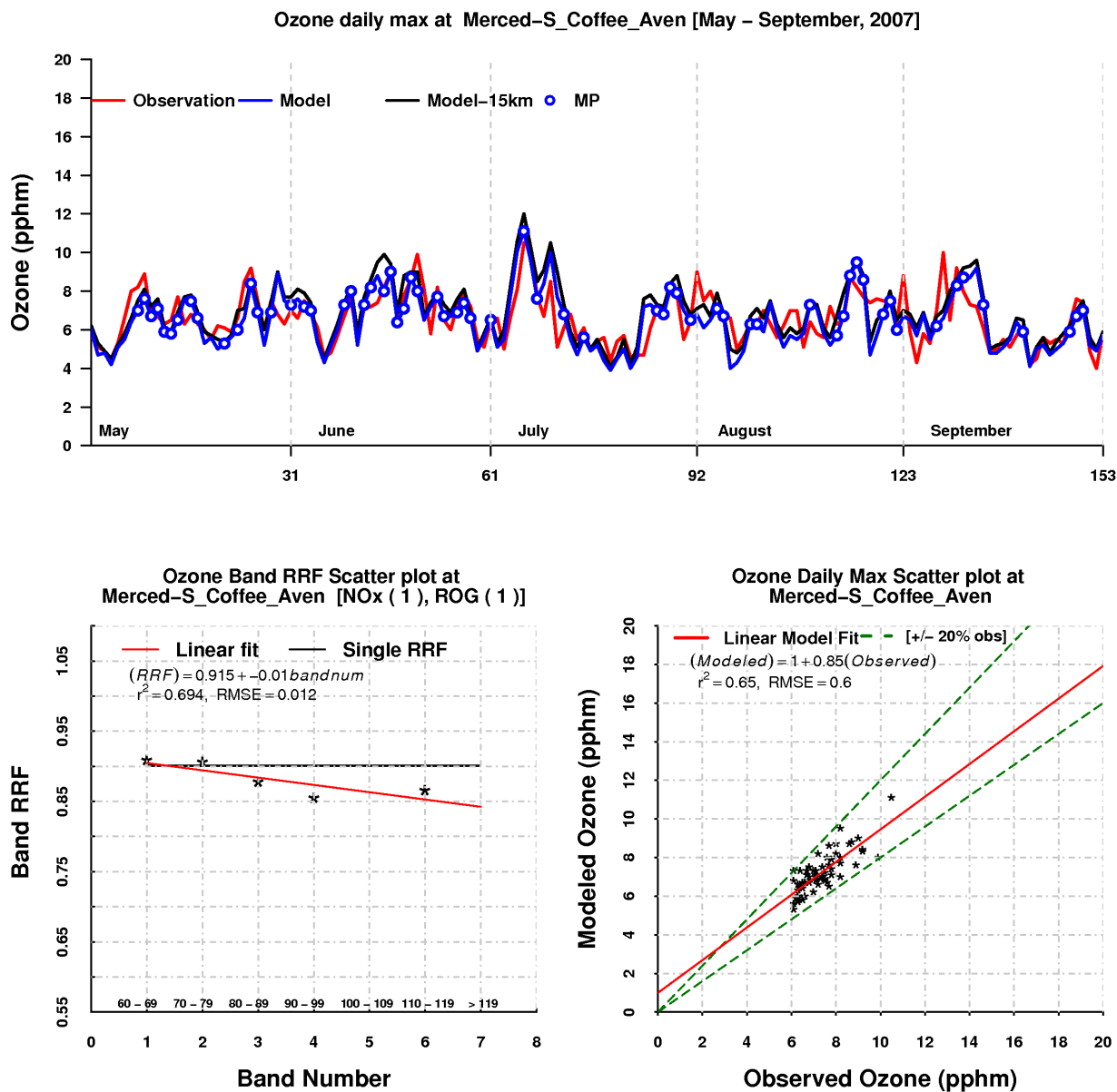
Figure F-17: The Band RRF procedure for Merced – South Coffee Avenue monitoring site.

Figure F-18: The Band RRF procedure for Maricopa – Stanislaus Street monitoring site.

Figure F-19: The Band RRF procedure for Madera – Pump Yard monitoring site.