



Southwest Desert to Las Vegas Ozone Transport Study (SLOTS)

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2008 National Air Quality Conference

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Overview

- Background
- Objectives of the study
- Design of the measurement program
- Summary of field measurements
- What we learned

*Study performed for the Clark County Department of
Air Quality and Environmental Management*

Background

- Prior study transport documentation
 - Source areas in southern and central California
 - Wildfires
- Transported ozone is significant
- NPS studies in Joshua Tree
- SLOTS measurements to further enhance knowledge



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Objectives

- Improve our understanding of transport
 - Inter-basin
 - Wildfire
- Generate an improved database to support planning
- Identify criteria and procedures for flagging ozone concentrations due to exceptional events

Measurement Program Design

- June – August 2007
- Enhanced continuous ozone and winds
- Enhanced upper air measurements
 - 3 sodars
 - Radar wind profiler
 - Profiling radiometer
 - Mobile rawinsonde
- Aircraft sampling of ozone, PM_{2.5} and temperature structure
- Forecasted intensive studies

Monitoring Network



T. B. Seitz

Monitoring Network



- Ozone
- Winds
- Solar Power



T. B. Seitzman

Monitoring Network



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- Ozone
- Winds
- T, RH
- UA Winds
- Real-time
- Solar power



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- UA Winds
- Solar Power
- Real-time



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- UA Winds
- UA T/RH
- Surface Winds
- Time-lapse pictures
- Real-time



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Mobile Monitoring Network



- Temperature
- Ozone
- Optical PM_{2.5}
- Visual Documentation



- UA Winds
- UA T/RH



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Avionics Wind Displays



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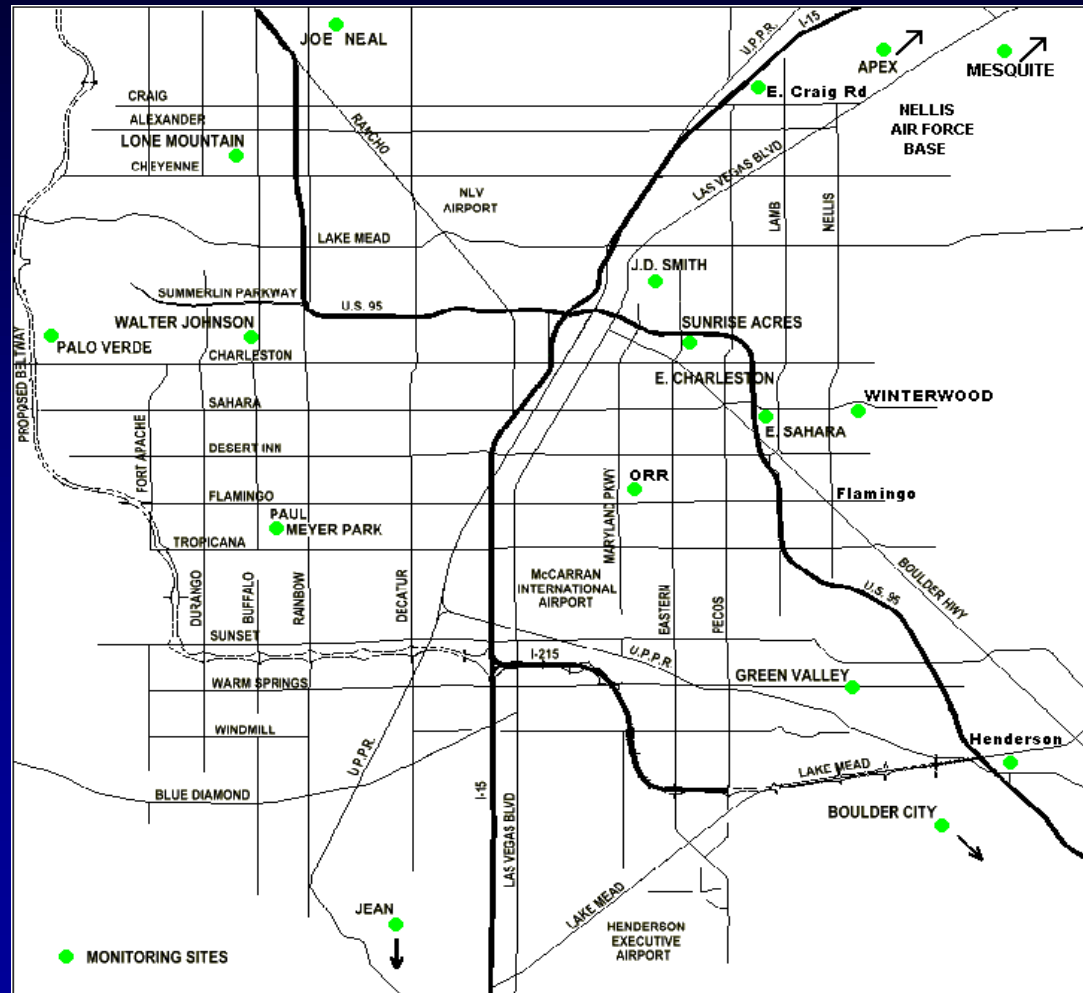
Field Measurement Summary

- Continuous data set June through August 2007
- Inter-basin transport IOPs
 - June 22, 23, 24
 - July 16, 17
- Wildfire IOPs
 - June 25, 26
 - August 8, 9
- Additional analyses
 - Likely transport events on June 15, 16, 27
 - Preliminary smoke impact August 4, 5, 21

What We Learned

- Ozone season overview
- Inter-basin transport example – June 23
- Wildfire ozone transport – August 8

DAQEM Monitoring Network

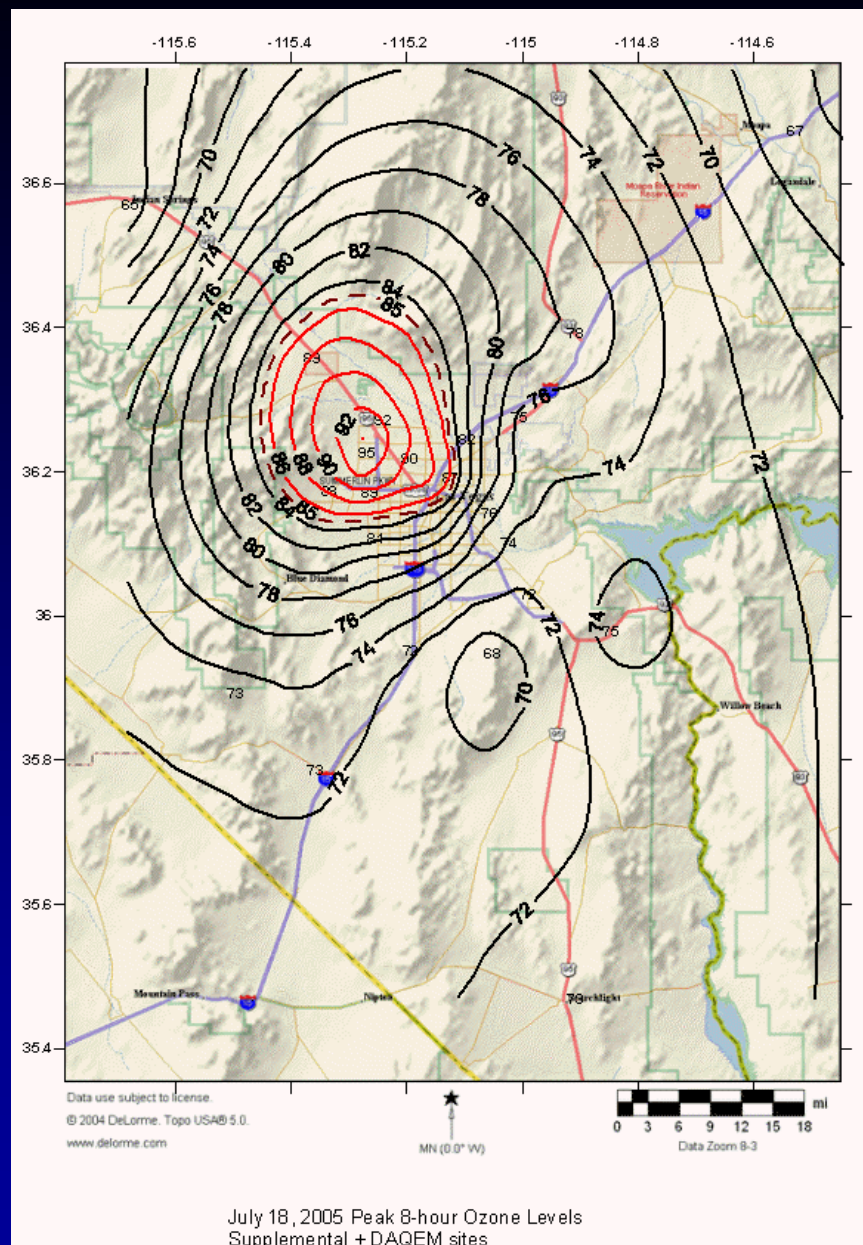


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Local Ozone Contributions

- High pressure over Clark County, with stagnant conditions and surface winds generally below 2 m/s
- Surface winds dominated by downslope drainage towards Lake Mead during night, and upslope flow towards the northwest during daytime
- High ozone concentrations limited to sites in northwest quadrant of the Las Vegas Valley
- Peak ozone concentrations at ~1500 hr

Local Ozone Contributions



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Peak 8-hour average – July 2007

July	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SE Valley	67	51	59	66	64	61	60	55	51	49	50	49	60	61	54
E. Craig Road	68	43	60	64	66	56	55	54	49	52	44	44	61	67	59
Apex	72	54	61	59	62	64	63	56	56	55			61	65	62
Paul Meyer	73	52	65	70	71	73	66	61	59	57	54	56	68	67	63
Walter Johnson	75	52	71	70	78	72	66	62	60	60	54	57	69	69	70
Joe Neal	72	47	69	68	77	68	60	58	58	56	50	52	66	69	67
Winterwood	65	47	56	67	62	59	59	53	51	49	48	45	60	62	53
Jean	66	48	51	60	58	70	59	53	53	52	54	49	60	60	53
JD Smith	69	48	66	69	68	62	60	55	55	54	49	49	65	66	54
Mt Pass	76	58	67	68	71	69	59	59	51	50	48	51	56	60	52
MOP	78	63	66	71	70	79	68	65	68	65	68	64	72	78	65

July	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
SE Valley	51	51	57	48	48	46	50	54	51	54	55	57	62	64	55	52
E. Craig Road	51	47	49	37	42	45	56	55	53	59	51	64	67	66	56	60
Apex	55	53	60	53	53	47	53	56	53	56	53	58	58	64	59	53
Paul Meyer	59	53	53	49	51	60	68	65	56	63	65	66	85	77	64	63
Walter Johnson	61	52	54	48	53	61	70	68	55	64	67	70	91	82	66	62
Joe Neal	58	51	48	45	50	57	67	67	61	65	60	72	81	78	68	63
Winterwood	52	49	56	47	48	43	49	54	47	56	52	59	59	61	48	54
Jean	54	51	50	46	45	54	59	52	49	56	61	61	64	68	58	52
JD Smith	57	52	53	45	49	47	57	60	55	62	57	67	73	70	60	62
Mt Pass	51	60	51	44	52	54	56	53	60	59	63	59	69	67	55	53
MOP	67	65	67	61	65	67	74	63	66	72	79	74	76	77	69	64

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Transport Contributions

- Stagnation over California, resulting in high ozone concentrations at downwind sources (Las Angeles basin and/or Southern San Joaquin Valley) on prior day
- Passing of weak upper-level trough through region, initiating steady, relatively strong southwesterly flow.
- Southwesterly synoptic flow impacts Las Vegas Valley
- Regionally high ozone concentrations, particularly notable at monitoring sites upwind of the Las Vegas Valley (Jean)
- Timing of peak ozone concentrations can occur at atypical times

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Peak 8-hour average – August 2007

August	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SE Valley	45	58	77	73	71	58	52	52	48	45	46	44	47		
E. Craig Road	38	59	60	74	61	45	46	52	48	44	49	46	44	46	58
Apex	44	61	71	76	70	55	55	56	52	44	47	45	55	51	60
Paul Meyer	52	71	72	81	73	61	52	58	55	53	54	49			59
Walter Johnson	50	65	69	82	71	62	52	58	54	53	55	50	52	56	59
Joe Neal	48	62	59	79	71			61	54	53	55	50	52	58	62
Winterwood	44	60	72	70	65	51	47	51	49	45	47	43	48	48	55
Jean	49	61	67	74	71	58	48	52	48	45	48	45	47	50	54
JD Smith	45	63	71	79	67	53	52	58	53	50	53	49	51	53	63
Mt Pass	56	61	65	74	73	58	53	50	51	52	46	46	44	51	61
MOP	54	71	69	86	80	70	61	66	63	62	58	56	55	60	67

August	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
SE Valley	62	66	61	61	60	79	78							69	55	71
E. Craig Road	59	65	61	51	56	78	70	64	56	43	49	55	63	64	52	73
Apex	61	66	62	59	64	85	72	61	55	44	46	55	54	57	60	60
Paul Meyer	63	64	62	62	62	78	73	63	60	47	53	67	69	76	56	84
Walter Johnson	63	64	62	61	63	78	69	64	61	47	53					87
Joe Neal	68	68	63	58	62	77	70	63	63	46	52	62	68	68	58	77
Winterwood	56	60	56	52	55	77	68	62	53	42	43	52	64	61	49	66
Jean	57	62	55	56	54	79	76	69	57	43	44	62	54	61	55	63
JD Smith	64	66	62	56	58	82	72	65	59	44	49	58	70	68	54	81
Mt Pass	69	65	53	50	65	72	90	74	55	51	48	55	55	56	53	57
MOP	71	75	69	68	70	90	82	72	65	60	53	66	67	80	63	73

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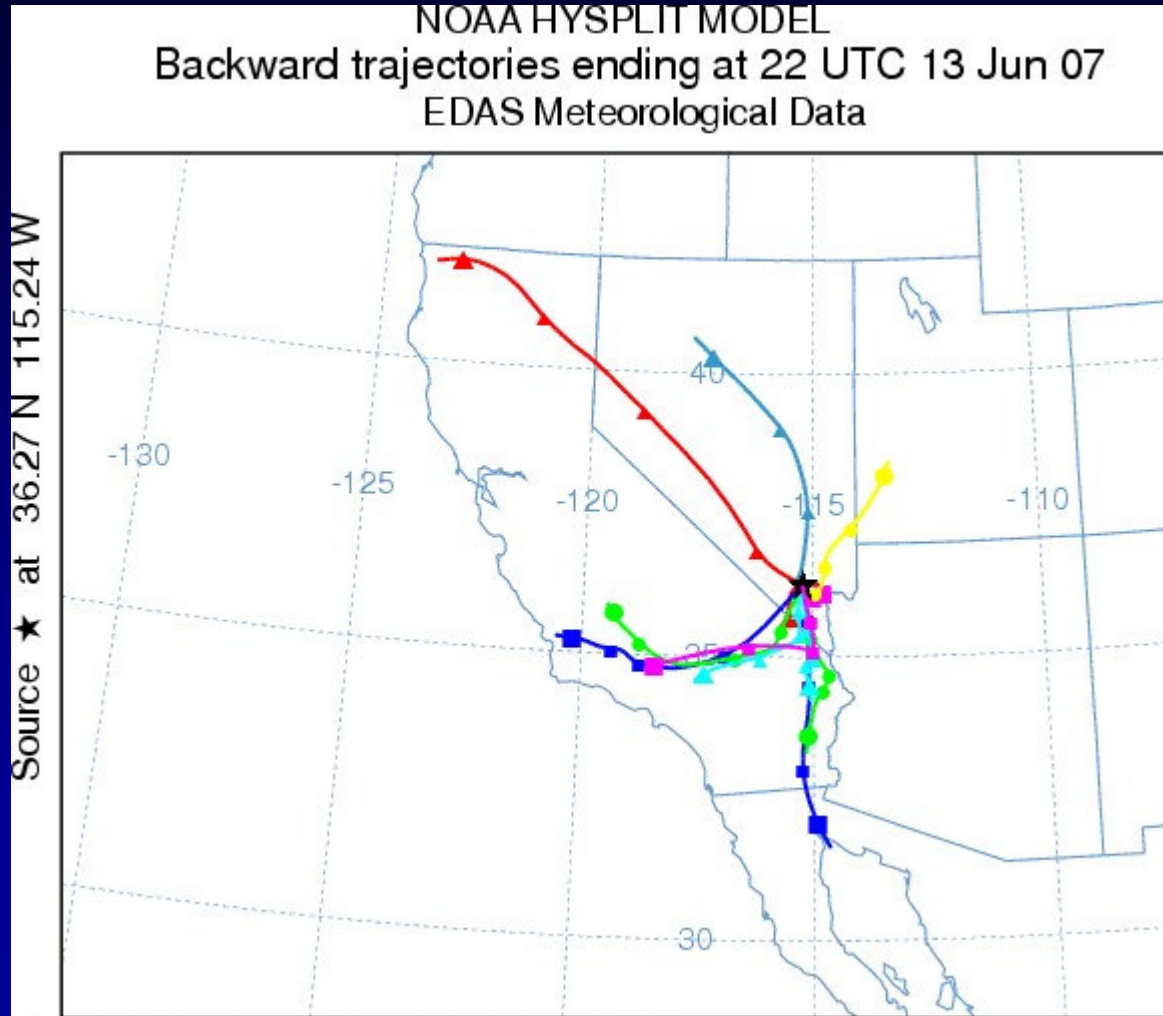
Peak 8-hour average – June 2007

June	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SE Valley	67	62	48	53	61	49	48	57	60	44	48	43	54	63	74
E. Craig Road	68	63	54	45	52	44	47	57	63	47	45	45	56	63	69
Apex	69	62	52	51	60	49	48	58	62	47	47	47	58	71	76
Paul Meyer	71	65	52	56	63	55	53	62	68	49	60	52	62	65	83
Walter Johnson					59	53	52	61	70	48	59	53	63	68	82
Joe Neal	73	64	55	50	54	48	47	59	66	46	52	51	62	74	77
Winterwood	65	61	48	48	59	49	50	59	59	45	48	45	55	62	74
Jean	74	67	55	59	69	57	57	63	70	57	63	56	61	67	85
JD Smith	68	62	52	48	59	49	51	59	64	46	50	48	60	65	75
Mt Pass	76	66	64	60	68	50							62	88	90
MOP	75	71	61	60	62	57	51						63	73	96

June	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
SE Valley	84	69	66	64	54	70	64	72	65	72	66	83	74	72	
E. Craig Road	81	76	65	61	48	74	73	63	46	76	60	72	76	61	
Apex	86	73	68	68	57	70	72	64	57	81	65	86	74	78	
Paul Meyer	86	79	74	67	53	72	73	74	66	79	71	87	83	69	
Walter Johnson	86	82	75	68	53	78	74	74	66	79	70	86	81	67	
Joe Neal	81	84	72	66	50	75	75	68	58	77	67	82	82	68	
Winterwood	82	70	71	66	46	66	70	65	56	75	63	79	77	69	
Jean	89	74	76	70	58	69	60	71	62	69	67	84	77	66	
JD Smith	83	78	69	65	50	73	75	66	53	77	67	80	82	68	
Mt Pass	100	78	85	80	61	73	74	86	74	85	83	98	86	77	59
MOP	94	79	86	82	62	77	78			85	85	100	93	89	65

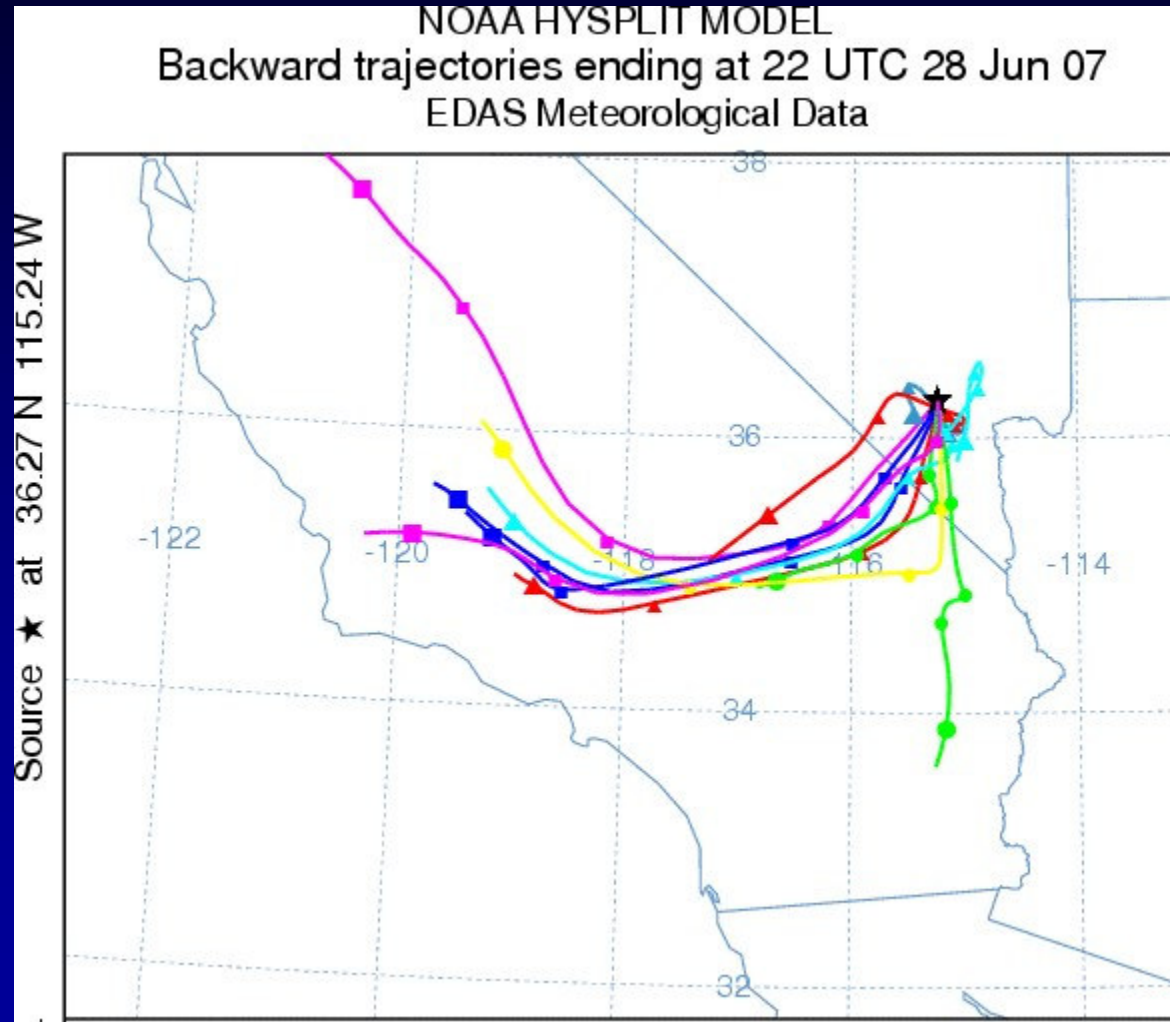
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24-hr Backtrajectories – June 2 - 13



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24-hr Backtrajectories – June 16 - 27

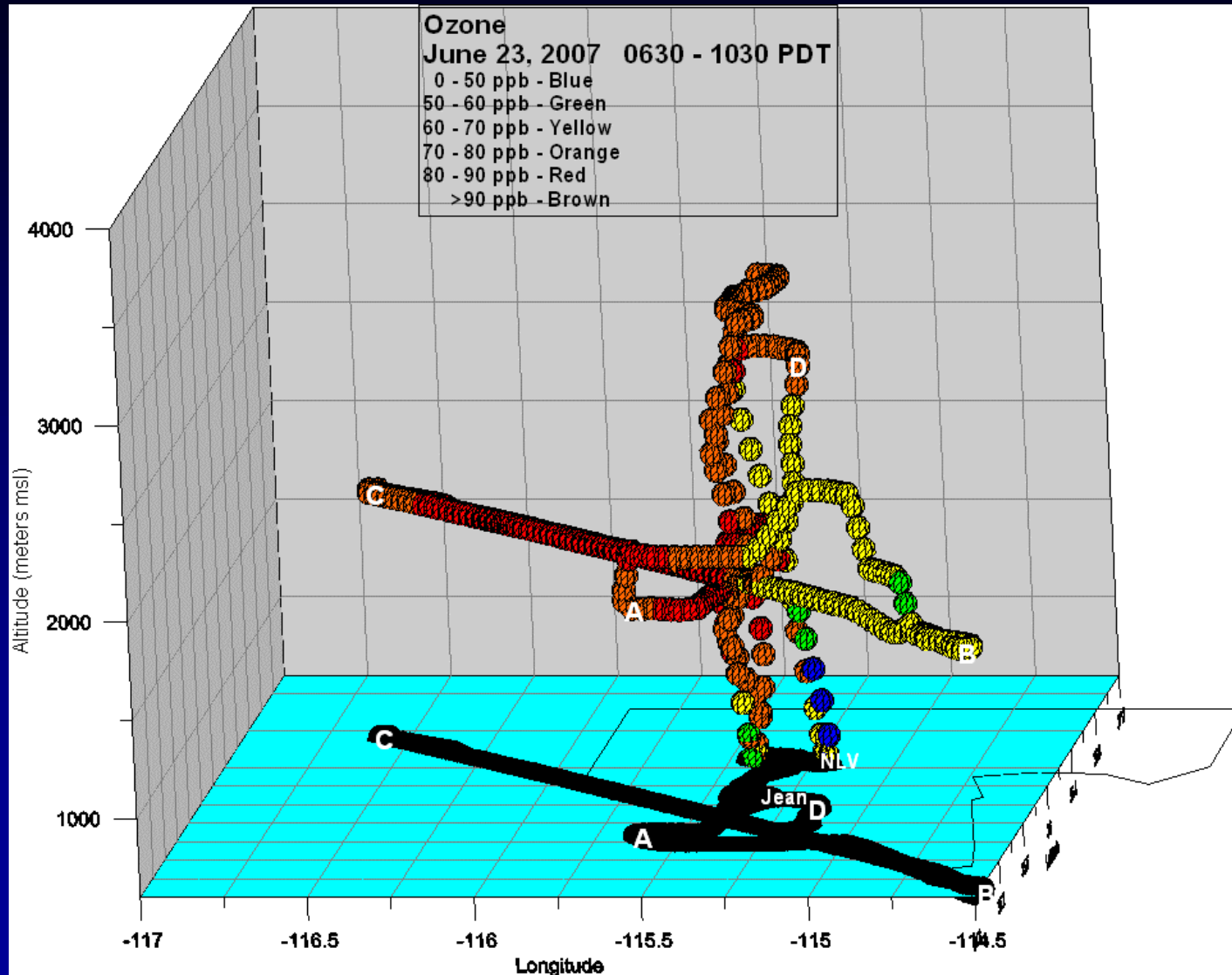


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Average Daily Peak 8-hr Average (ppb)

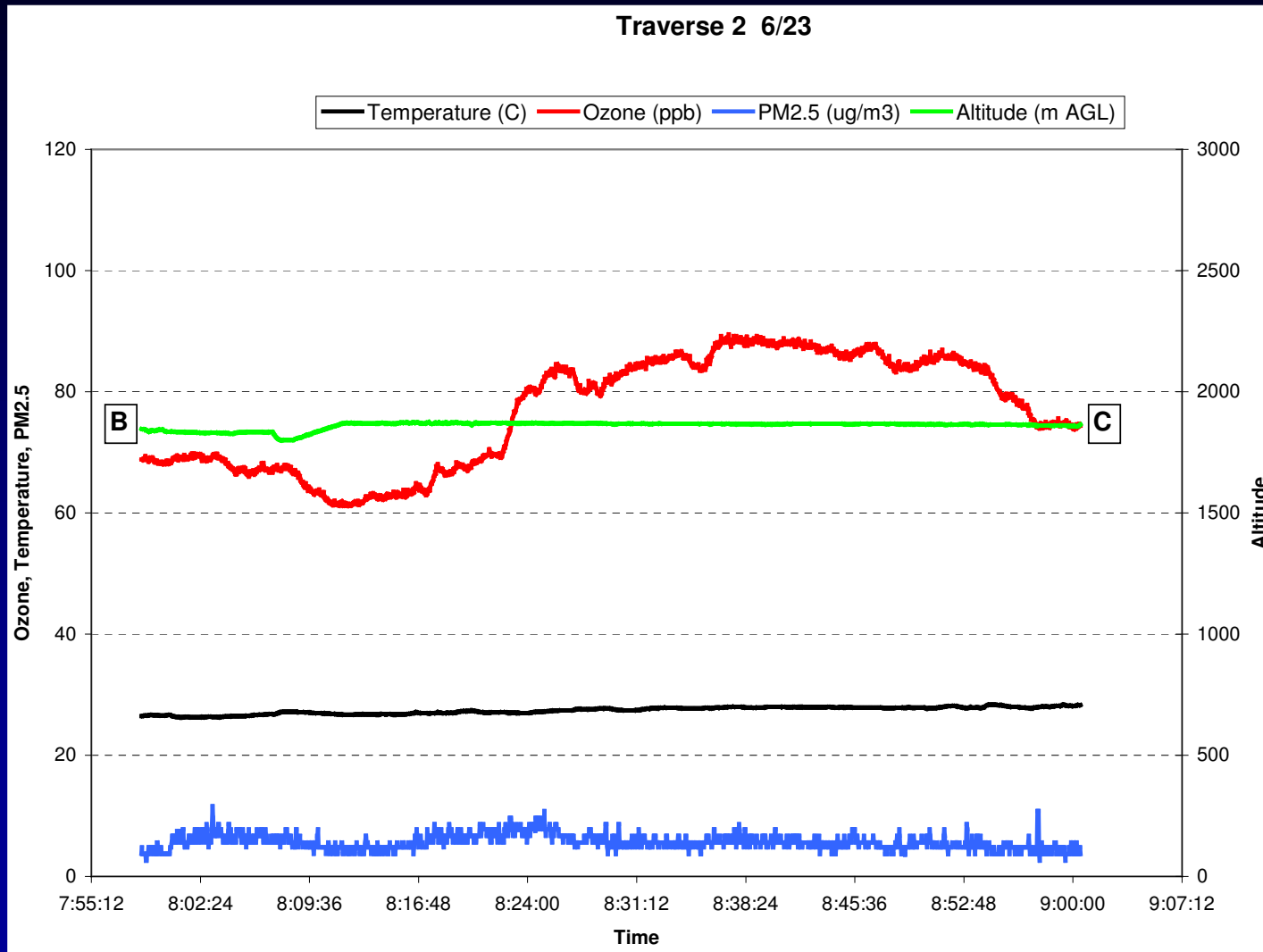
Site	6/2 – 6/13	6/16 – 6/27	Difference
Paul Meyer	58	74	16
Joe Neal	54	71	17
Jean	61	71	10
All sites (averaged)	53	69	14

Inter-basin Transport – June 23 AM



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June 23 AM Border Traverse



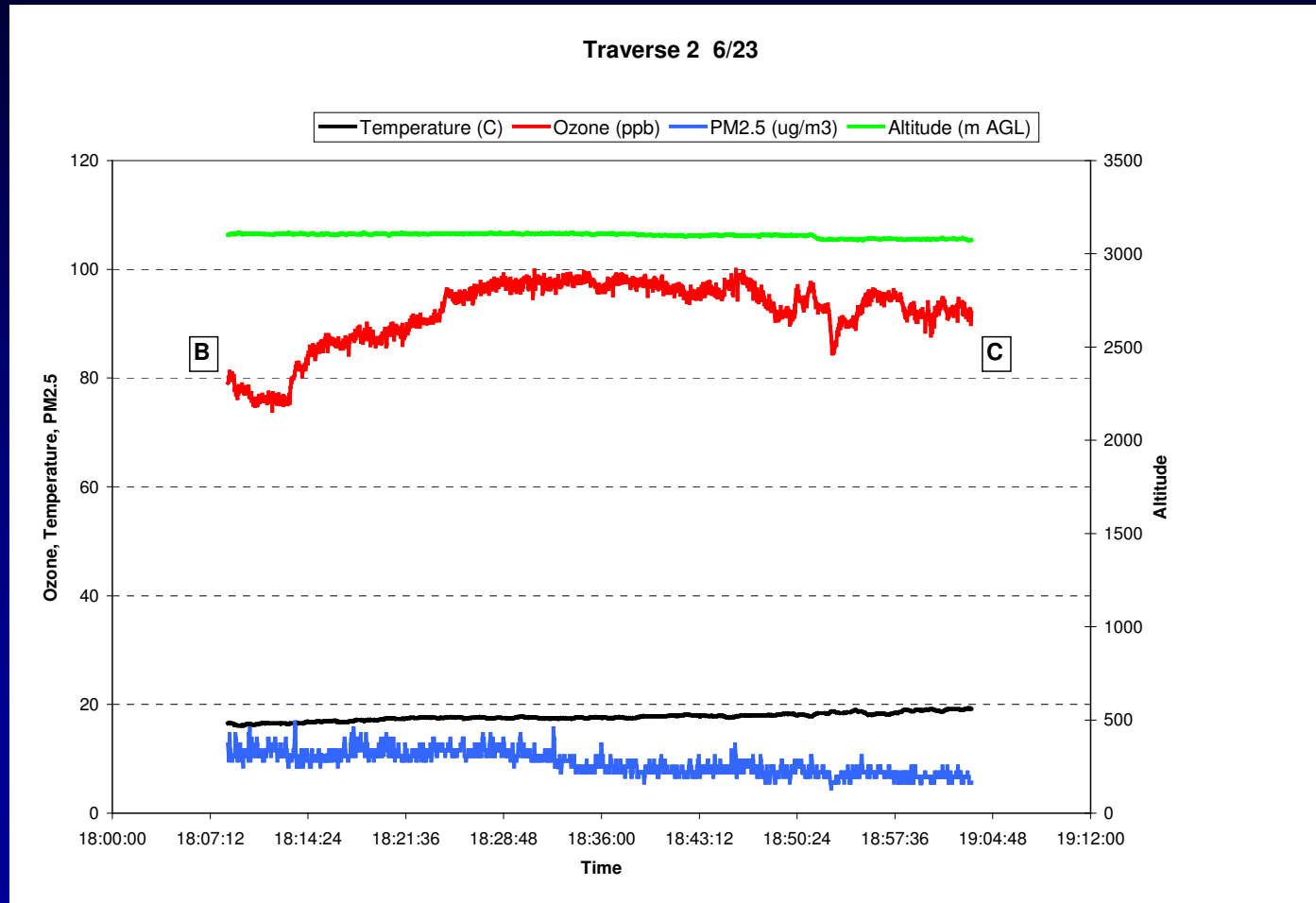
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June 23 AM Plume Boundary



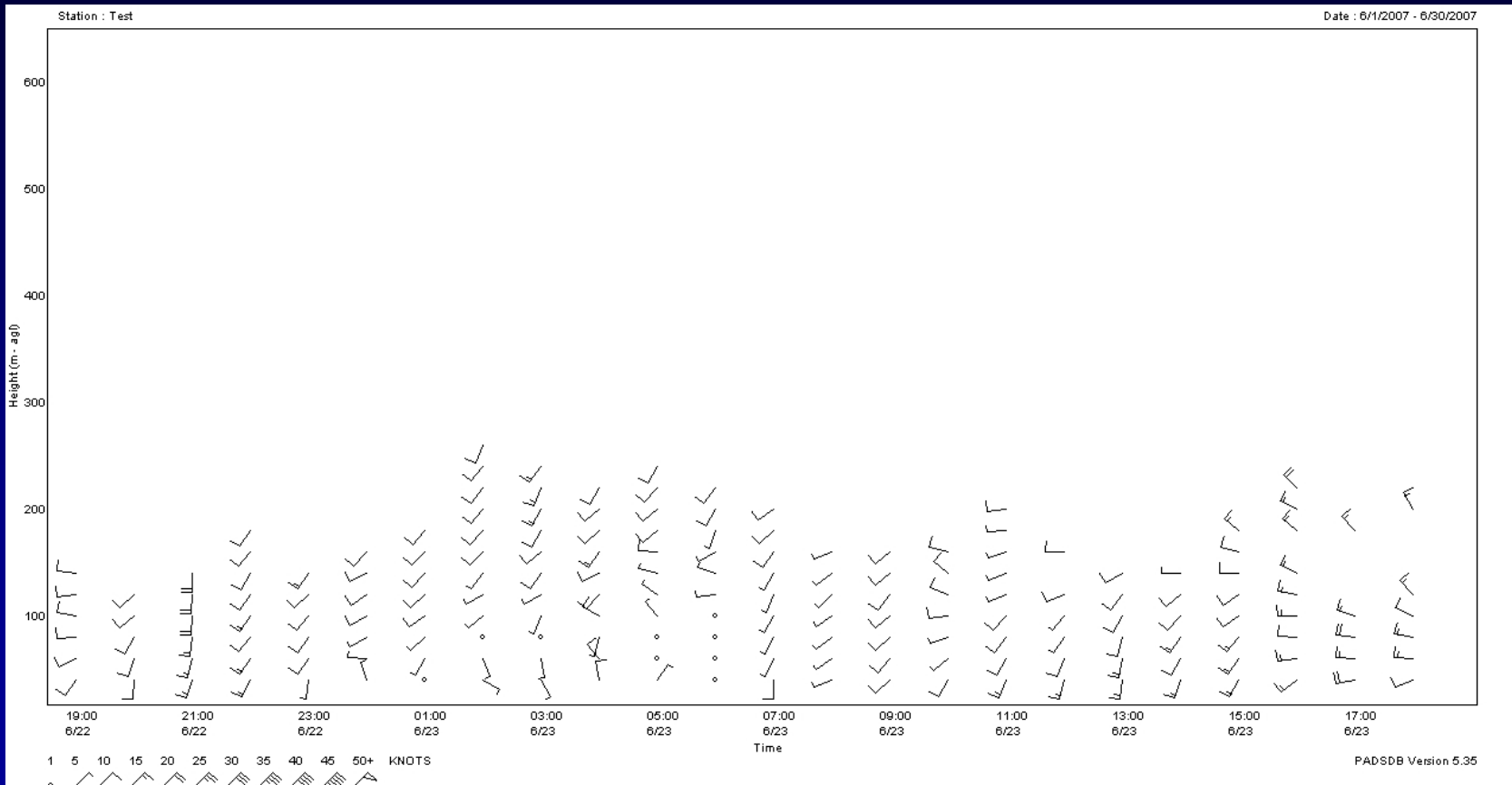
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June 23 PM Border Traverse



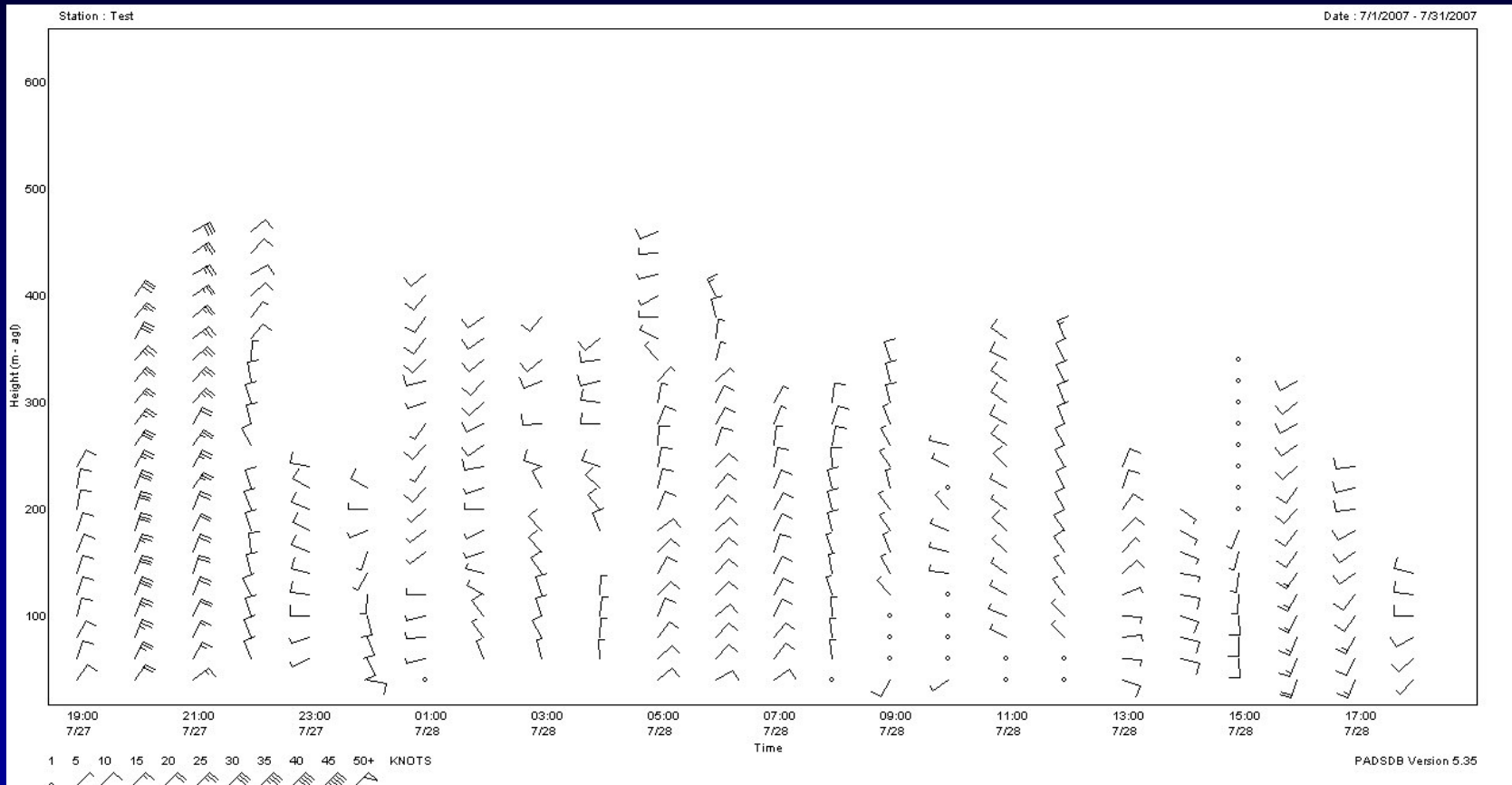
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Jean Sodar Data – June 23



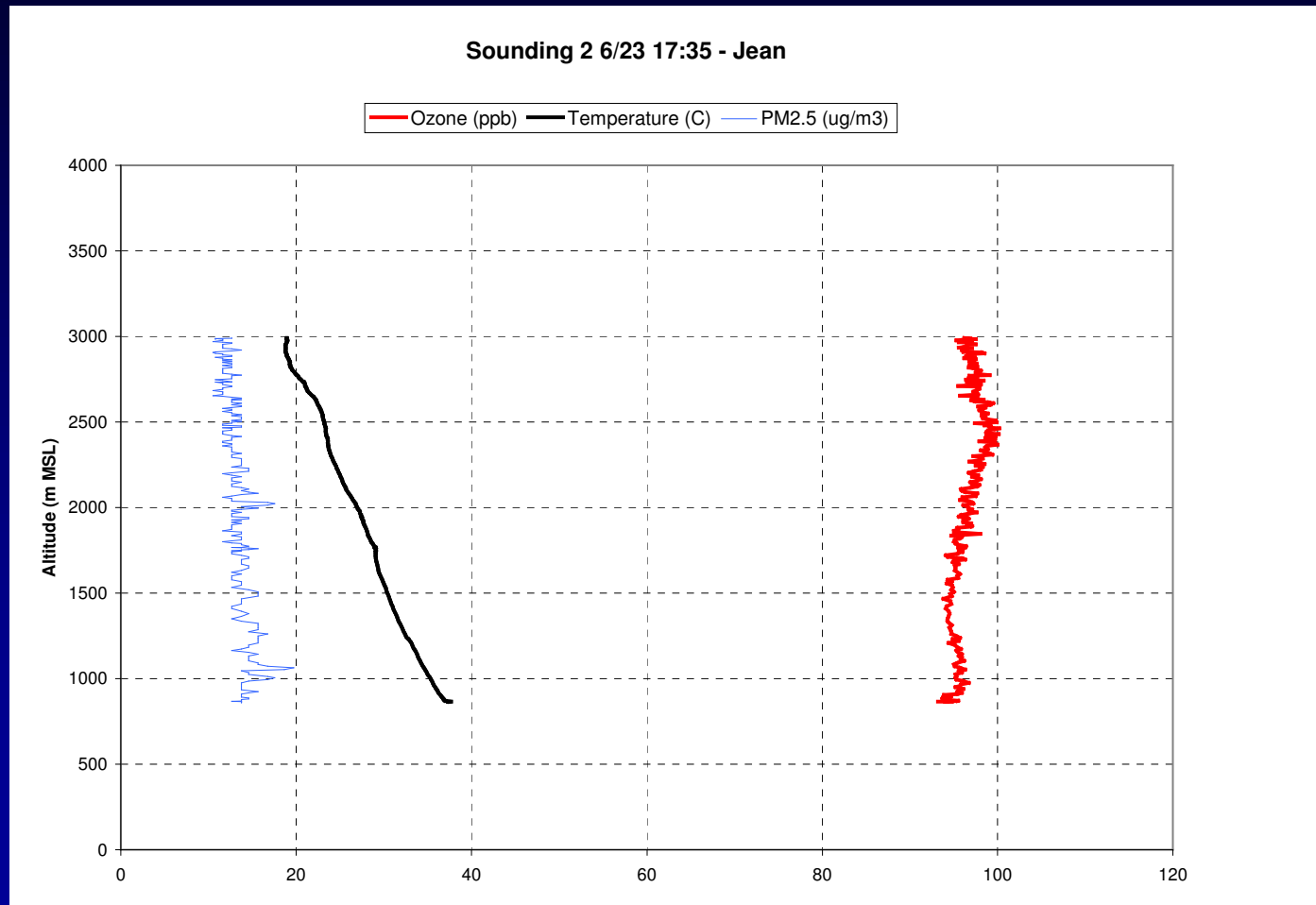
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Jean Sodar Data – July 28



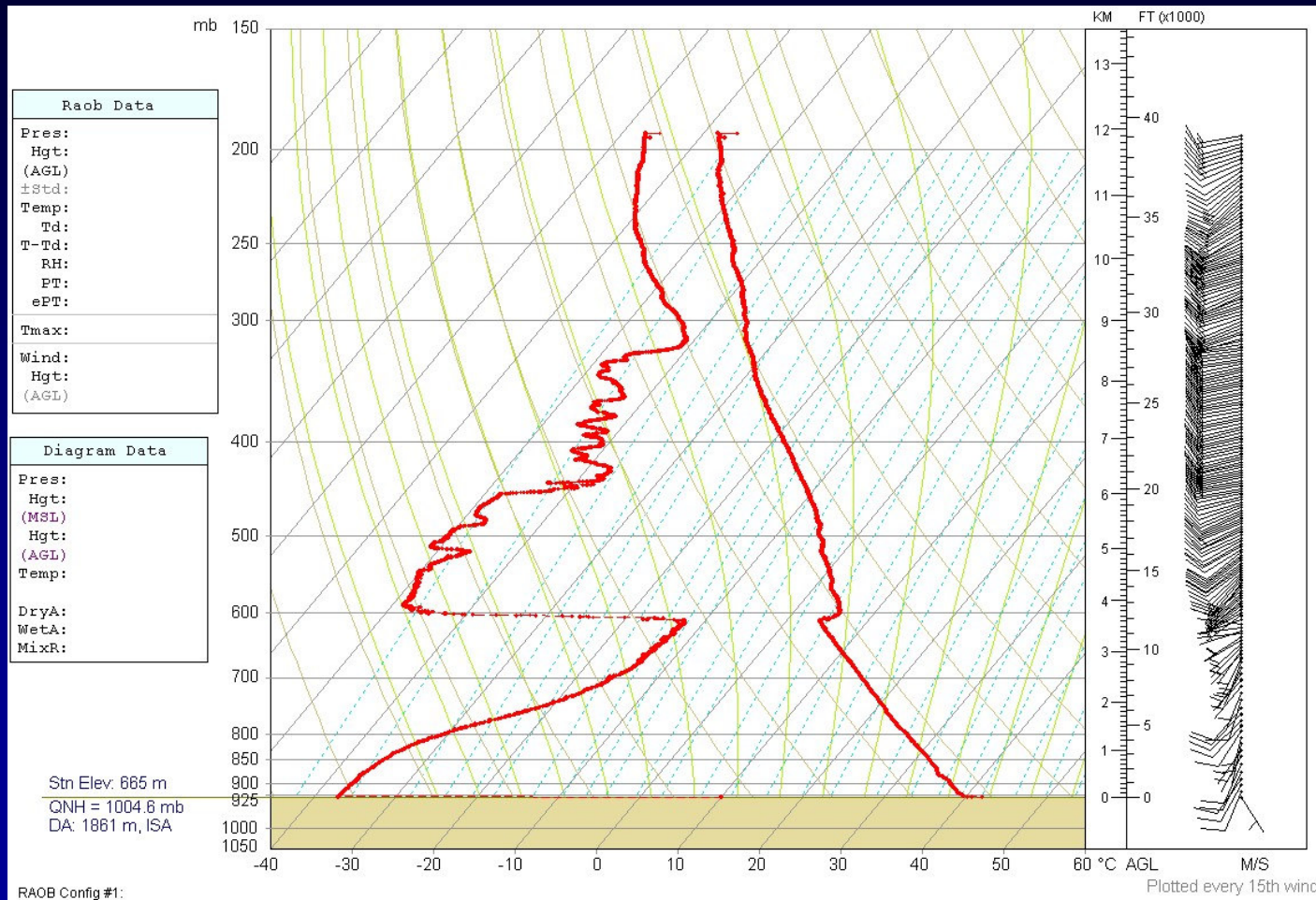
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June 23 PM Jean Aircraft Sounding



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June 23 1600 Jean Sounding



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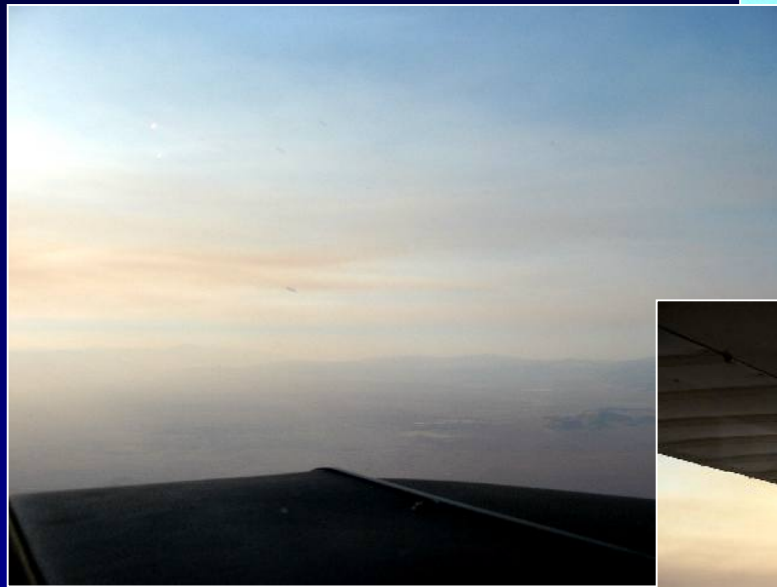
Inter-basin Transport

What Was Learned

- Aircraft-observed inter-basin plumes reaching the CA/NV border were typically more than 100 km wide
- Observed upper-air winds at Mountain Pass and Jean supported the observed impacts in Clark County from transport
- Even with deep mixing in the desert (3 km or more), ozone concentrations remain high for distances of 100s of kilometers
- Small changes in wind direction can make a big difference in the final transport to Clark County
- Timing and location of the plume is important
- 15 – 20 ppb contribution from transport – consistent with previous studies
- Exceedances on June 15, 16, and 27 fit transport scenario

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Wildfire Smoke



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Wildfire Transport – Zaca Fire



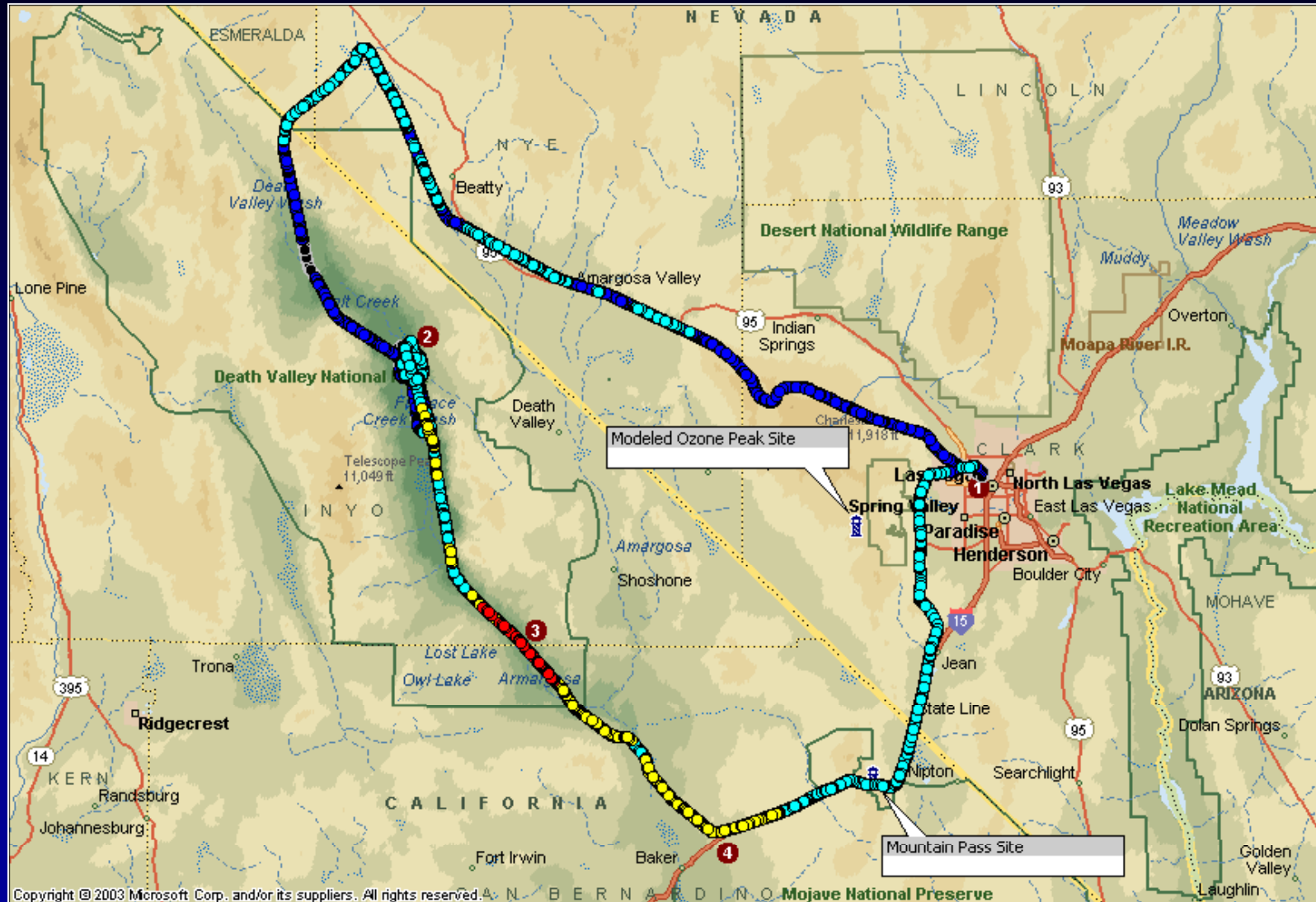
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Zaca Fire – August 8 PM Flight



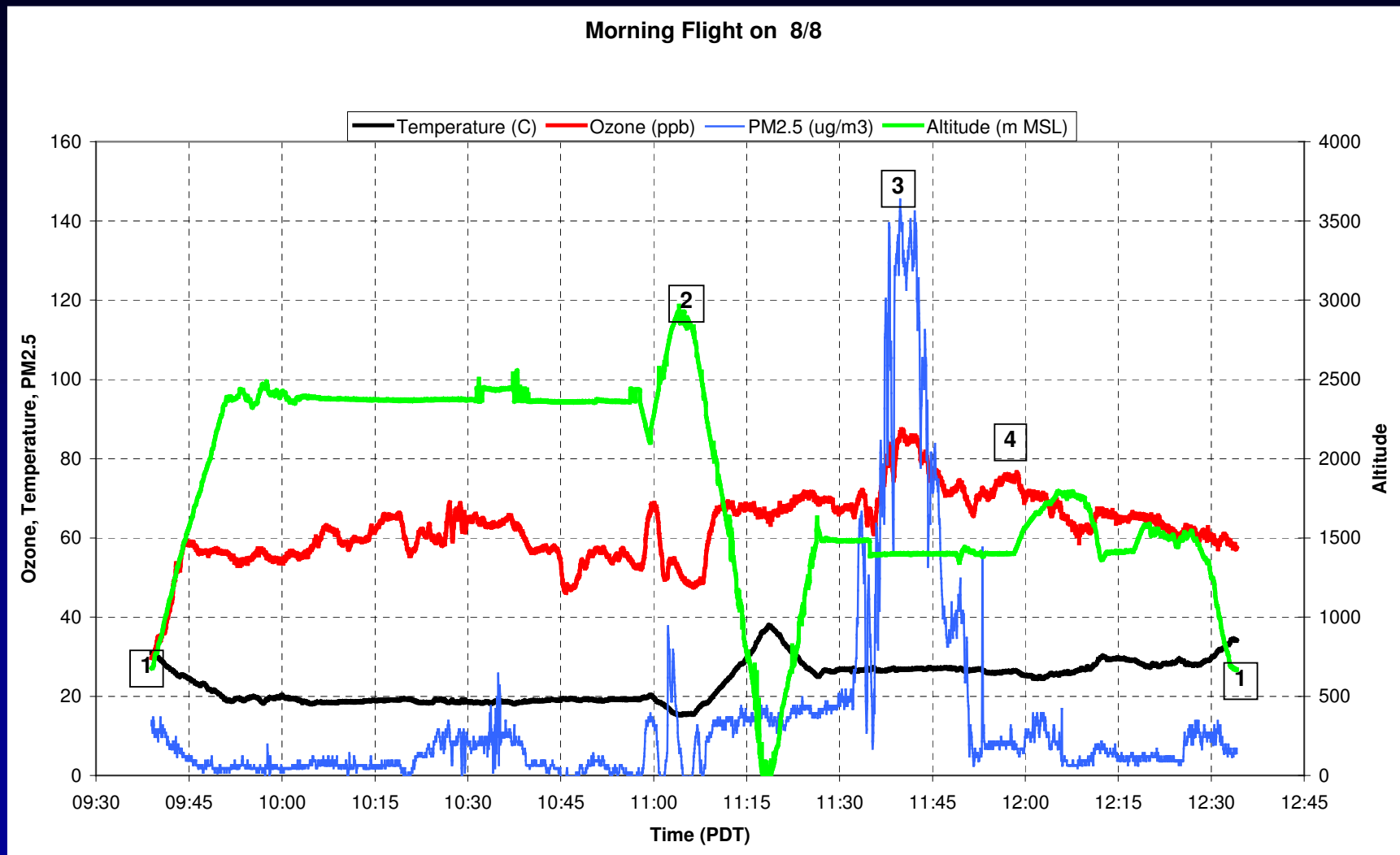
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Zaca Fire – August 8 PM Flight



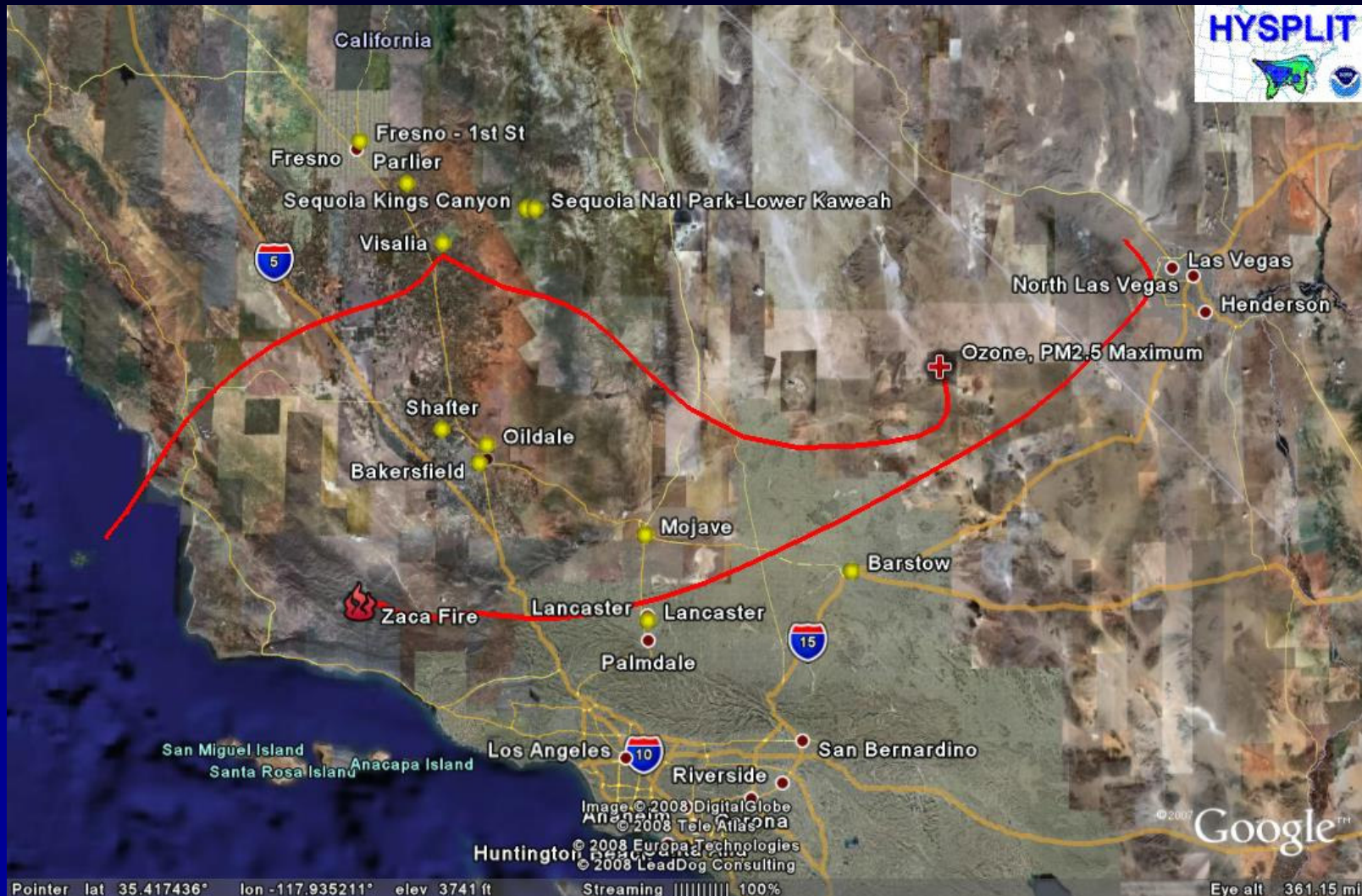
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Zaca Fire – August 8 PM Flight



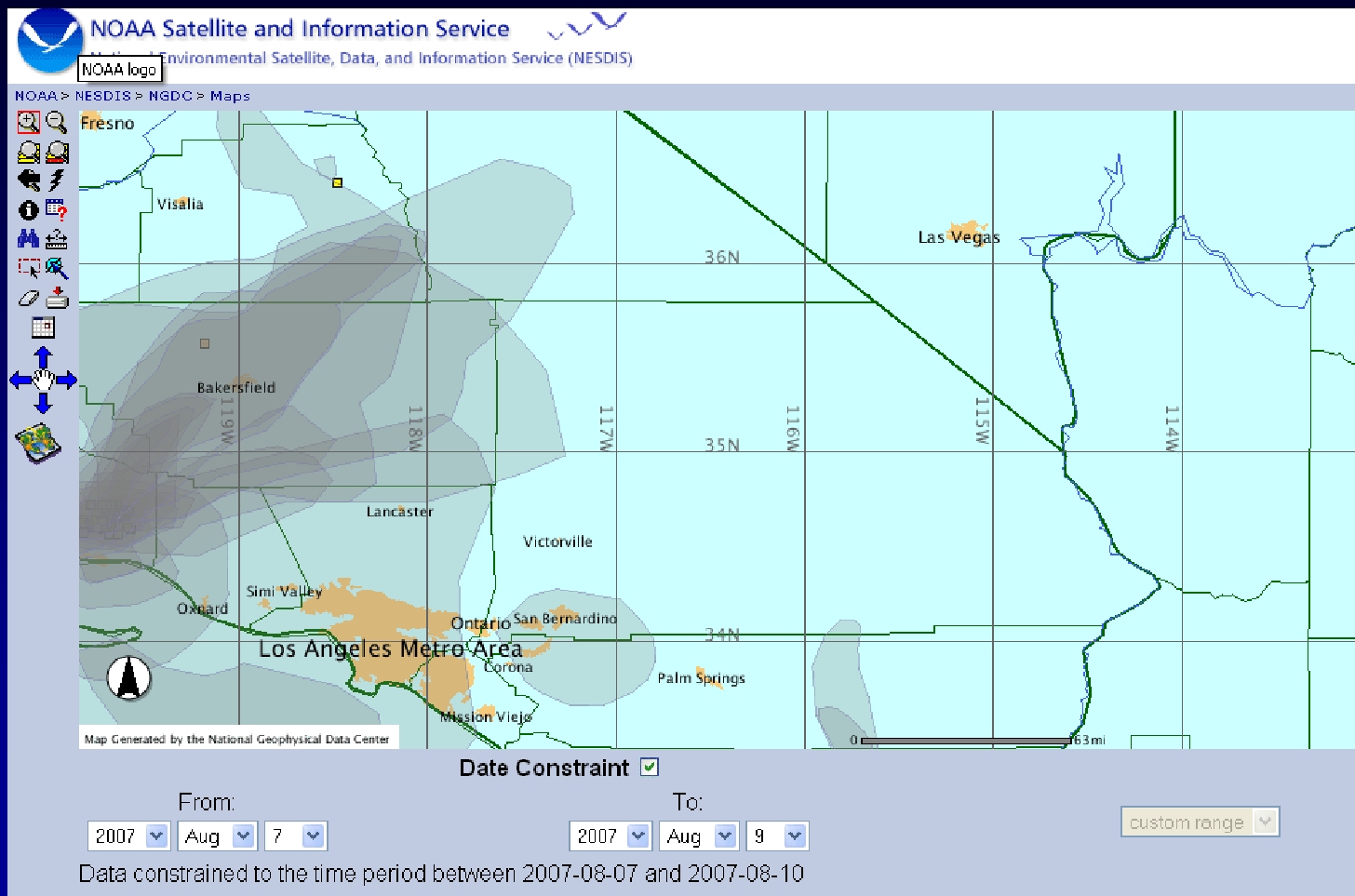
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36-hr Backward and Forward Trajectories



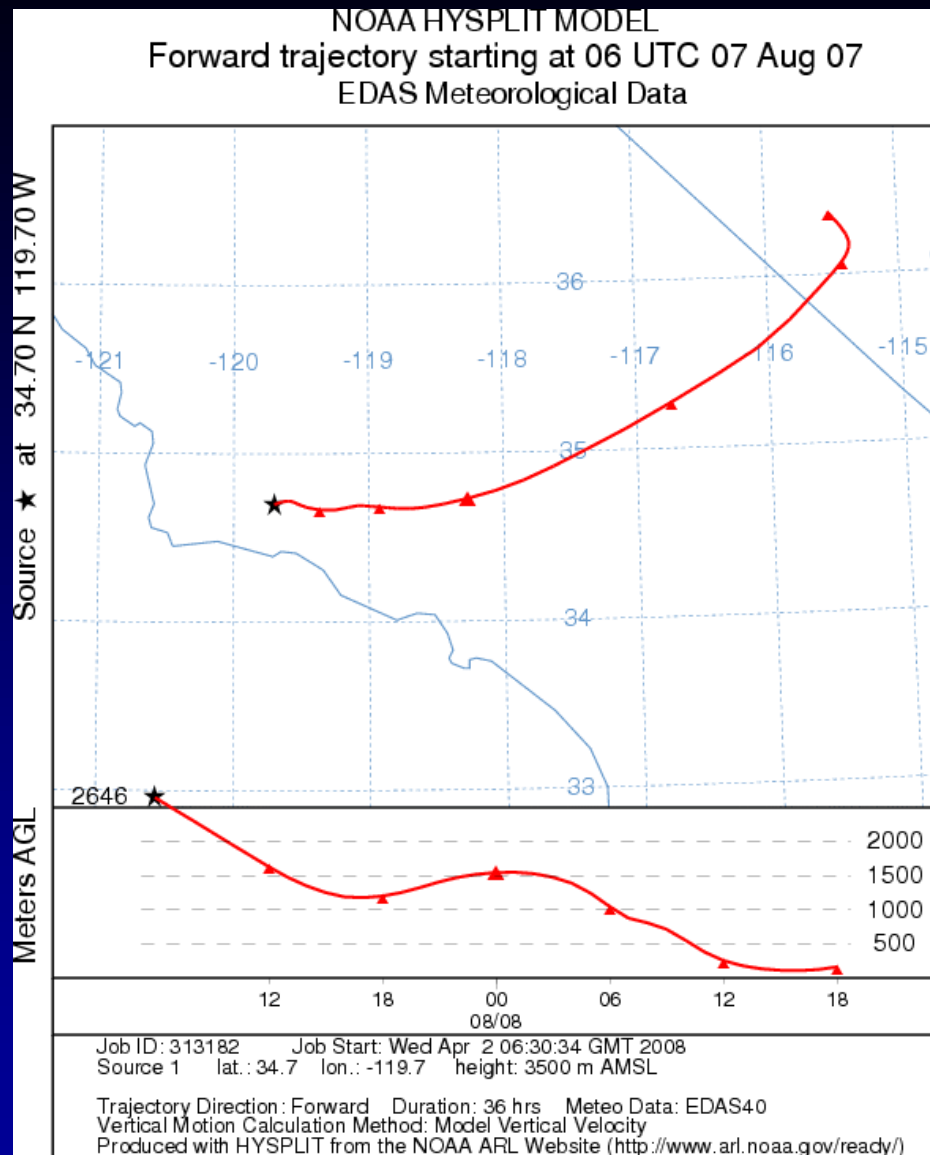
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Satellite Smoke Analysis – August 7 - 9



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36-hr Forward Trajectory – August 8



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Peak 1-hr Ozone (ppb)

Site	August 7	August 8	June 15
Fresno	57	59	95
Parlier	59	65	101
Sequoia Kings Canyon	78	87	97
Sequoia – Lower Kaweah	77	85	99
Visalia	56	65	82
Shafter	61	69	87
Oildale	67	72	89
Bakersfield	59	70	87
Lancaster	65	79	89
Barstow	68	66	94

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Wildfire Transport

What Was Learned

- Timing and 3D position of the plume is important
- Aircraft observed wildfire plumes that were intact and reaching the CA/NV border were typically less than 50 km wide
- Consistent correlation between ozone, optical $PM_{2.5}$, and visual observation in smoke plume, implying 15 – 20 ppb increase due to wildfire smoke
- Even with deep mixing in the desert (3 km or more), ozone concentrations remain high for distances of 100s of kilometers.
- Observed smoke plumes start out higher in altitude than urban plumes making the forecast of ground impact more difficult

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Conclusion

- Both inter-basin transport and wildfire smoke have a potentially significant impact on Clark County ozone concentrations
- Contributions of an additional 15 – 20 ppb likely
- These external contributions will likely impact the County's ability to meet the new 8-hr ozone standard



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