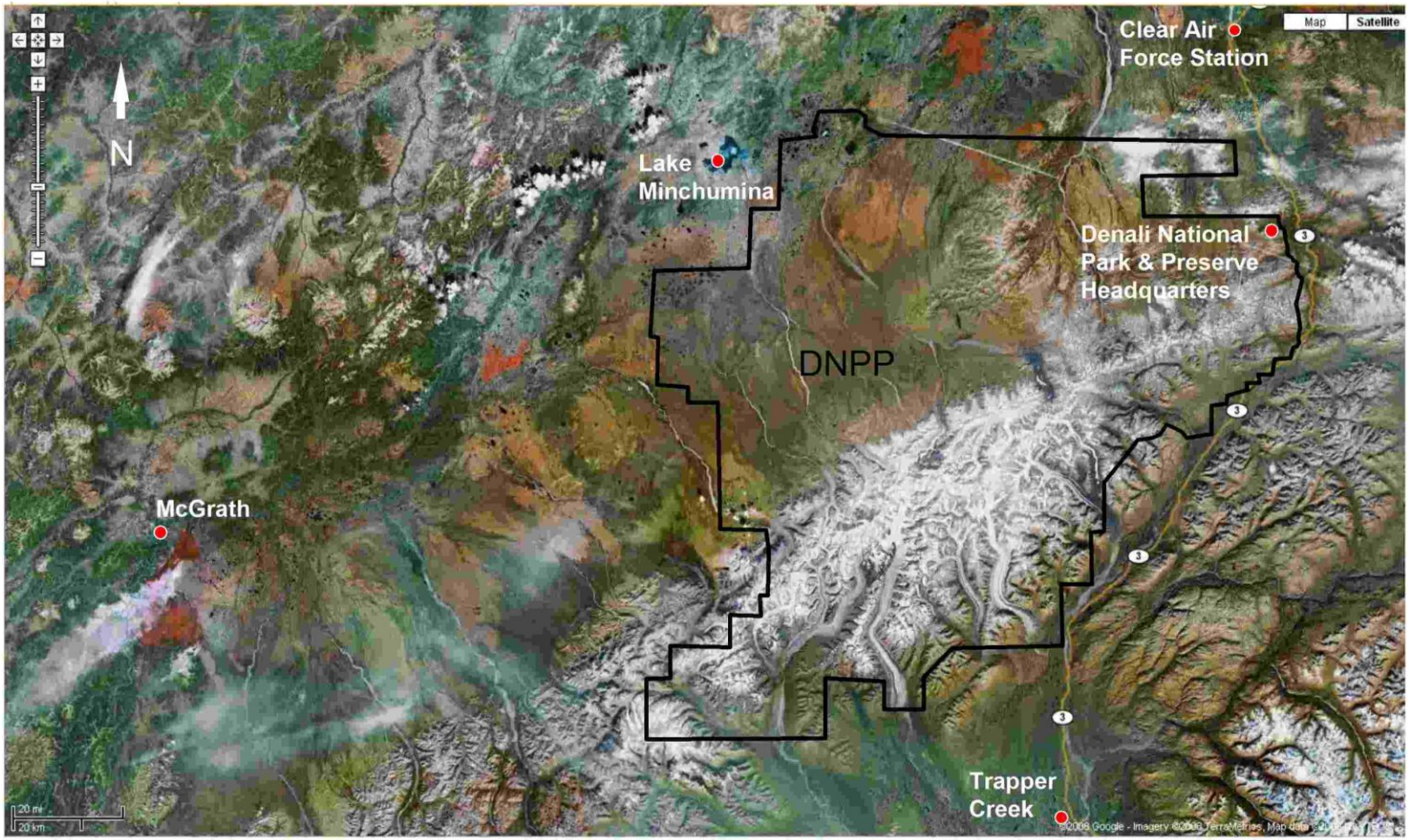
6 Appendices

6.1 Appendix A: Site Locations, Characteristics and Photographs

A-1 Satellite image of the DNPP area including site locations and Park boundary



A-2 Summary of site characteristics

Monitoring Site Characteristics				
	DENA	LAMI	MCGR	TRCR
Installed per QAPP	Yes	Yes	Yes	Yes
Location	63º 43.398’ N 148 º 58.05’ W 658 m	63º 54.69’ N 152 º 16.870’ W 7 m	62º 57.331’ N 155 36.179’ W 155 m	62º 18.917’ N 150º 18.900’ W 155 m
DRUM	Yes	Yes	Yes	Yes
Collocated DRUMS	No	No	No	Yes
Partisol 2000	No	Yes	Yes	No
IMPROVE	Yes	No	No	yes
Site Characteristics	Regional scale, semi rural, wilderness oriented	Regional scale, semi rural, wilderness oriented	Regional scale, semi rural, wilderness oriented	Regional scale, rural to wilderness site
Meteorological instrumentation	Included at IMPROVE site	Installed by DEC	National Weather Service site	Included at IMPROVE site
Monitoring data useable?	Yes	Yes, limited	Yes, limited	No

Abbreviations:
LAMI – Lake Minchumina
DENA – Denali Headquarters
MCGR – McGrath
TRCR – Trapper Creek
DEC – Department of Environmental Conservation
DRUM – Davis Rotating-drum Unit for Monitoring
IMPROVE – Interagency Monitoring of Protected Visual Environments
QAPP – Quality Assurance Project Plan

A-3 Instrument configurations and analysis methods for the final four sites.

Instrument Configurations, Analysis Methods, and QA/QC References								
Method	Sites	Schedule	Flow rate	Filter media	Particulate analysis method	Chemical analysis method	Monitoring QA/QC	Laboratory QA/QC
Partisol	LAMI MCGR	Once every three days[1] 24 hrs starting @ midnight	16.7 L/min	Teflon™	Gravimetric	ED XRF	See *Regional Haze Monitoring Study QAPP* (SOA ADEC AMQA, 2008)and Appendix B for MQO tables	See SOP Laboratory *Gravimetric Analysis of Fine Particulate Matter ($PM_{2.5}$) Air Quality Filter Samples* (SOA DEC AMQAa, 2009) and Appendix B: *X-Ray Fluorescence (XRF) Analysis of Aerosol Filter Samples* (DRI, 2010)
IMPROVE	DENA TRCR	Once every three days 24 hrs starting @ midnight	22.8 L/min	Teflon (pore size 3.0 µm)	Gravimetric	Synchrotron XRF	See IMPROVE QAPP (IMPROVE, 2001)	See IMPROVE QAPP & SOPs (IMPROVE, 2001 & 1996-2006)
DRUM	DENA LAMI MCGR TRCR	Continuous 6 week sample strip @ 3-hour resolution	23 L/min 3mm slit size; 10 L/min, 6mm slit size	Apiezon ™ coated mylar strips	Beta gage	Synchrotron XRF	Not much field QA/QC possible; See *Alaska Regional Haze Monitoring Study QAPP* (SOA ADEC AMQA, 2008)	See Appendix A: *Quality Assurance Summary and Size Resolved Mass Data Archive* (Delta Group, 2012)

[1] All reasonable attempts were made to adhere to the EPA's published year sampling schedule however, many samples did not fall on scheduled run days and thus many of the Partisol samples were not directly comparable to IMPROVE samples.

Abbreviations:

DRUM – Davis Rotating-drum Unit for Monitoring

DENA – Denali Headquarters

ED XRF – Energy Dispersive X-ray Fluorescence

IMPROVE – Interagency Monitoring of Protected Visual Environments

LAMI – Lake Minchumina

MCGR – McGrath

MQO – Measurement Quality Objective

QAPP – Quality Assurance Project Plan

TRCR – Trapper Creek

MQO – Measurement Quality Objective

A-4 Site descriptions and photographs

Denali National Park and Preserve Headquarters (DENA)

The Denali National Park and Preserve Headquarters (DENA) site is located in the Park Headquarters area just north of the offices at the IMPROVE site at latitude 63.7233º and longitude -148.9675, and 658 meters (1974 feet) above sea level.

The site is located on the edge of the park headquarter buildings and is a regional scale, semi-rural site. It is in the Jenny Creek valley which runs east-west and is bounded on the north and south by mountains reaching elevations of approximately 6000 feet. Jenny Creek drains into the Nenana River approximately 2.5 miles east of the site. The town of Healy, population 971 (2007 census), is approximately 15 miles north of the site. Healy has a coal power plant. The pollution sources outside the valley are limited to Fairbanks and long ranging particulate and gases from forest fires in Alaska, Canada and northeast Asia, and intra continental industrial pollution and dust sources. The sources of particulate matter near DNPP Headquarters include: residential wood smoke, dust from the Denali Park Road, coal plant emissions from Healy and vehicle exhaust from the Parks Highway that runs along the east side of the park

The DNPP Headquarters site was equipped with $PM_{2.5}$ IMPROVE and a DRUM sampler running on a 6 week cycle with 3 hour sampling frequency. The DRUM sampler was installed on the roof of the IMPROVE trailer, approximately 2 meters (6 feet) above the ground. The nearest IMPROVE inlet head was greater than 1 meter from the DRUM sampler inlet head. The IMPROVE samplers are installed approximately 5 meters (15feet) from the dirt parking lot for the site. There is a row of trees approximately 50 meters (160 feet), at the closest point, skirting the southern and eastern exposures of the site. The trees are approximately 3-8 meters (9-24 feet) tall. Airflow is generally uninterrupted with the exception of the trees to the north-northeast. These trees are not considered to be a barrier because of their distance from the site. The DNPP Headquarters site is approximately 2 miles north of the unpaved Denali Park Road which receives constant traffic during the summer tourist season.

North	East	South	West
Views in four cardinal directions from the Denali Headquarters Site			
Views in four cardinal directions toward the Denali Headquarters Site			

Lake Minchumina (LAMI)

Lake Minchumina is located north of Mount McKinley in Interior Alaska. It lies at 63.88278° N Latitude and -152.31222° W Longitude. (Sec. 08, T012S, R024W, Fairbanks Meridian.) Lake Minchumina is located in the Fairbanks Recording District.

Lake Minchumina is a small settlement of approximately 32 residents, roughly 10 miles outside the northwest edge of the park. This location has an airfield, a small Native Alaskan village, a lodge and store. A post office was established in 1930. The school was closed for the 1999-2000 year due to insufficient students. The Park Service, lodge and school provide the majority of employment in this small community. Due to its isolation, subsistence activities, trapping and dog mushing are also pursued. Half of all households have individual wells; the remainder haul water from untreated surface sources. No homes are fully plumbed; the majority use outhouses or honeybuckets. A private company, Lake Minchumina Power, provides electrical services. A new landfill site has been developed. A State-owned 4,200' gravel airstrip is available. The lake may be accessed by boat in the summer. There is no road connection.

Lake Minchumina and other sites in interior Alaska experience seasonal temperature extremes (lows of –40 ^{o}F to –50 ^{o}F). January temperatures range from –22°F to -2 ^{o}F; July temperatures range from 50 ^{o}F to 72 ^{o}F. Average annual precipitation is 11.3 inches. Ice fog is common during the winter. The National Weather Service (NWS) operates a weather observation site (PAMH) in town. This site will provide data for monitoring low level air flow from the north to northwest into the park.

North	East	South	West
Views in four cardinal directions from the Lake Minchumina Site			
Views in four cardinal directions toward the Lake Minchumina Site			

McGrath (MCGR)

McGrath is located 221 miles northwest of Anchorage and 269 miles southwest of Fairbanks in Interior Alaska. It is adjacent to the Kuskokwim River directly south of its confluence with the Takotna River. It lies at 62.95639° N Latitude and -155.59583° W Longitude. (Sec. 18, T033N, R033W, Seward Meridian.) McGrath is located in the Mt. McKinley Recording District. McGrath was a seasonal Upper Kuskokwim Athabascan village which was used as a meeting and trading place for Big River, Nikolai, Telida and Lake Minchumina residents. The Old Town McGrath site, was originally located across the river. In 1940, an airstrip was cleared, the FAA built a communications complex, and a school was opened. McGrath became an important refueling stop during World War II, as part of the Lend-Lease Program between the U.S. and Russia. In 1964, a new high school was built, attracting boarding students from nearby villages. The City was incorporated in 1975 and is home to 401 residents. A little less than half of the population are Native Alaskans. As a regional center, McGrath offers a variety of employment opportunities, but subsistence remains an important part of the local culture. McGrath functions as a transportation, communications, and supply center in Interior Alaska. It has a diverse cash economy, and many families rely upon subsistence. Salmon, moose, caribou, bear, and rabbits are utilized. McGrath operates a piped water system that serves nearly all 178 households; a few homes have individual wells or haul water. The FAA operates its own water system. Individual septic tanks are used by the majority of residents; a limited City sewage system serves approximately 34 homes. There are no road connections to McGrath, but local roads are used by ATVs and trucks. Winter trails are marked to Nikolai (50 mi.) and Takotna (20 mi.) Residents rely on air service and barges to deliver cargo. Air facilities include a State-owned 5,435' paved runway with a 1,700' crosswind landing strip, and a seaplane base on the Kuskokwim River.

The McGrath area has a cold, continental climate. Average summer temperatures range from 62°F to 80 ^{o}F, winter's temperatures can range from -64 ^{o}F to 0 ^{o}F. Precipitation is light, averaging 10 inches per year, including an average snowfall of 86 inches. The Kuskokwim River is generally ice-free from June through October. The NWS operates a weather observations site in McGrath.

North	East	South	West
Views in four cardinal directions from the McGrath Site			
Views in four cardinal directions toward the McGrath Site			

Trapper Creek (TRCR)

The Trapper Creek site is located near Trapper Creek Elementary School at IMPROVE site at latitude 62.3153º, longitude -150.315, and 155 meters (465 feet) above sea level. The site is located in a lightly populated residential area with a population of 423 (2000 Census). The Chulitna and Susitna Rivers and the village of Talkeetna, population 876 (2010 Census), are approximately 7 miles east of the site. The site is protected by the Alaska Range to the west and north and sits in the Susitna River valley which runs north to south. In summer it can receive flow from Cook Inlet and the southern part of the Susitna River to the mouth of the river. Trapper Creek is a regional-scale, rural to wilderness site. Trapper Creek is a small village providing minimal sources, wood smoke and road dust. Other sources outside the local area could include forest fire smoke, small particulate from winds off of nearby glaciers, industrial and dust particulates from Asia and/or Europe.

The Trapper Creek site was equipped with $PM_{2.5}$ IMPROVE monitors and two collocated Davis Rotating-drum Unit for Monitoring (DRUM) samplers running on a 6 week cycle with 3 hour sampling frequency. The DRUM sampler was installed on a 1.5 meter high stand approximately 1 meter from the IMPROVE shed. The nearest IMPROVE inlet head was on the other side of the shed from the DRUM sampler inlet head. The sampler was installed approximately 50 (150feet) from the dirt parking lot for the site. There is a row of trees approximately 50 meters (150 feet), at the closest point, skirting the southern and eastern exposures of the site. The trees are approximately 3-8 meters (9-24 feet) tall. Airflow is generally uninterrupted with the exception of the trees to the north-northeast.

The Trapper Creek Site is located approximately 0.2 miles southwest of Trapper Creek Elementary School and 2.5 miles west of the Parks Highway on Petersville Road. Traffic is light on the Petersville Road and moderate to heavy on the Parks highway during tourist season in the summer.

North	East	South	West
Views in four cardinal directions from the Trapper Creek Site			
Views in four cardinal directions toward the Trapper Creek Site			

6.2 Appendix B Quality Assurance/Quality Control documents

B-1 Example Field log sheet: DRUM sampler (Lake Minchumina site)

LK. Minchumina

Regional Haze Site Operator Check List - DRUM Sampler: Lake Minchumina Site - 2008

1 Record Date and vacuum gauge reading: *(Open DRUM Sampler lid, record gauge reading with pump connected)*

2 Disconnect the hose from the pump to the DRUM Sampler, place tube in place where it is unlikely to get dirty.

3 **With DRUM Sampler lid open, remove lid from drum "A" and record the tape placement on image below**

Date:	Date:	Date:	Date:
Gauge Reading:	Gauge Reading:	Gauge Reading:	Gauge Reading:
Start	Start	Start	Start
Record tape placement	Record tape placement	Record tape placement	Record tape placement
Date:	Date:	Date:	Date:
Gauge Reading:	Gauge Reading:	Gauge Reading:	Gauge Reading:
Start	Start	Start	Start
Record tape placement	Record tape placement	Record tape placement	Record tape placement

new one installed

4 **Connect hose from pump back to DRUM sampler and close sampler lid.**

B-2 DRI Standard Operating Procedure #2-209.6 B-3

EDXRF Analysis for Elements

Energy Dispersive X-ray Fluorescence (EDXRF) analysis is performed on Teflon-membrane filters for the following 48 elements currently reported to AQS for the EPA speciation trends sites: sodium (Na), magnesium (Mg), aluminum (Al), silicon (Si), phosphorus (P), sulfur (S), chlorine (Cl), potassium (K), calcium (Ca), scandium (Sc), titanium (Ti), vanadium (V), chromium (Cr), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), gallium (Ga), arsenic (As), selenium (Se), bromine (Br), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), niobium (Nb), molybdenum (Mo), silver (Ag), cadmium (Cd), indium (In), tin (Sn), antimony (Sb), cesium (Cs), barium (Ba), lanthanum (La), cerium (Ce), samarium (Sm), europium (Eu), terbium (Tb), hafnium (Hf), tantalum (Ta), tungsten or wolfram (W), iridium (Ir), gold (Au), mercury (Hg), and lead (Pb). In addition, the elements palladium (Pd), Thallium (Tl), and uranium (U) will also be measured although they are currently not reported to AQS. XRF analyses are performed on a PANalytical Epsilon 5 EDXRF analyzer. Eight separate XRF conditions are used by the PANalytical instrument on each sample to optimize the detection limits for the specified elements. These conditions are summarized in Table 1. Table 2 shows the method detection limits and lower quantifiable limits for the elements in $\mu g/m^3$, based on an assumed filter deposit area of 11.78 cm^2 and a flow rate of 16.67 L/min for 24 hours (24 m^3 sampled air volume). Calibration against the same standards and regular cross-checks between excitation conditions assures comparability of the results.

Two types of EDXRF standards are used for calibration, performance testing, and auditing: (1) vacuum-deposited thin-film elements and compounds from Micromatter Co. (Vancouver, BC), and (2) polymer films. The vacuum deposit standards cover most elements and are used as calibration standards. The polymer film and National Institute of Standards and Technology (NIST) standards are used as QC standards. During EDXRF analysis, filters are removed from their Petri slides, and loaded into holders for entry into the x-ray analysis chamber. The vacuum in the x-ray chamber and the heat induced by the absorption of x-rays may evaporate some materials, such as ammonium nitrate. A QC standard and a replicate from a previous analysis will be analyzed with each set of 10 filters. When a QC value differs from specifications by ± 10% or more, or when a replicate value differs from the original value (where values exceed 10 times the detection limits) by ±10% or more, the problem is identified and filters may be reanalyzed. If further tests of standards show that the system calibration has changed by more than ±5%, the instrument is recalibrated. In addition, DRI will maintain a set of laboratory blanks that will be analyzed periodically (~1 blank for every 20 filters analyzed) to test for baseline shifts in blank values. Also, as part of Level II data validation, field blank values for each shipment will be plotted by element as time series to check for potential shifts in baselines and potential contamination.

After EDXRF analysis, the Teflon-membrane filters are returned to their Petri slides and stored until the XRF data validation is completed and indicates that the runs were acceptable. Detailed information on

the EDXRF analysis of Teflon-membrane filters is given in SOP #2-209, X-Ray Fluorescence (XRF) Analysis of Aerosol Filter Samples (PANalytical Epsilon 5).

Table 1. Analytical Conditions for EDXRF Elements.

Element	Symbol	Atomic No.	AQS Parameter	DRI ID	Condition No.	Condition	Analysis Time (sec)	Line	ROI[a] (LL) (Kev)	ROI[a] (UL) (Kev)	TubeVoltage (kV)	Tube Current (mA)	Secondary Target
Sodium	Na	11	88184	NAXC	1	@CaF_2	400	K_α	0.983	1.098	40	15	CaF_2
Magnesium	Mg	12	88140	MGXC	1	@CaF_2	400	K_α	1.195	1.313	40	15	CaF_2
Aluminum	Al	13	88104	ALXC	1	@CaF_2	400	K_α	1.426	1.547	40	15	CaF_2
Silicon	Si	14	88165	SIXC	1	@CaF_2	400	K_α	1.677	1.802	40	15	CaF_2
Phosphorous	P	15	88152	PHXC	1	@CaF_2	400	K_α	1.945	2.075	40	15	CaF_2
Sulfur	S	16	88169	SUXC	1	@CaF_2	400	K_α	2.242	2.376	40	15	CaF_2
Chlorine	Cl	17	88115	CLXC	1	@CaF_2	400	K_α	2.552	2.690	40	15	CaF_2
Potassium	K	19	88180	KPXC	1	@CaF_2	400	K_α	3.239	3.386	40	15	CaF_2
Calcium	Ca	20	88111	CAXC	2	@Fe	400	K_α	3.614	3.767	40	15	Fe
Scandium	Sc	21	88163	SCXC	2	@Fe	400	K_α	4.011	4.170	40	15	Fe
Titanium	Ti	22	88161	TIXC	2	@Fe	400	K_α	4.415	4.603	40	15	Fe
Vanadium	V	23	88164	VAXC	2	@Fe	400	K_α	4.853	5.046	40	15	Fe
Chromium	Cr	24	88112	CRXC	2	@Fe	400	K_α	5.310	5.510	40	15	Fe
Manganese	Mn	25	88132	MNXC	3	@Ge	200	K_α	5.792	5.998	75	8	Ge
Iron	Fe	26	88126	FEXC	3	@Ge	200	K_α	6.292	6.505	75	8	Ge
Cobalt	Co	27	88113	COXC	3	@Ge	200	K_α	6.814	7.033	75	8	Ge
Nickel	Ni	28	88136	NIXC	3	@Ge	200	K_α	7.358	7.585	75	8	Ge
Copper	Cu	29	88114	CUXC	3	@Ge	200	K_α	7.920	8.153	75	8	Ge
Zinc	Zn	30	88167	ZNXC	3	@Ge	200	K_α	8.504	8.747	75	8	Ge
Gallium	Ga	31	88124	GAXC	4	@Zr	200	K_α	9.112	9.363	100	6	Zr
Arsenic	As	33	88103	ASXC	4	@Zr	200	K_α	10.390	10.661	100	6	Zr
Selenium	Se	34	88154	SEXC	4	@Zr	200	K_α	11.064	11.344	100	6	Zr
Bromine	Br	35	88109	BRXC	4	@Zr	200	K_α	11.755	12.047	100	6	Zr
Rubidium	Ru	37	88176	RBXC	4	@Zr	200	K_α	13.208	13.525	100	6	Zr
Strontium	Sr	38	88168	SRXC	5	@Mo	200	K_α	13.967	14.296	100	6	Mo
Yttrium	Y	39	88183	YTXC	5	@Mo	200	K_α	14.748	15.092	100	6	Mo
Zirconium	Zr	40	88185	ZRXC	6	@Ag	200	K_α	15.554	15.912	100	6	Ag
Niobium	Nb	41	88147	NBXC	6	@Ag	200	K_α	16.382	16.755	100	6	Ag
Molybdenum	Mo	42	88134	MOXC	6	@Ag	200	K_α	17.233	17.623	100	6	Ag
Palladium	Pd	46		PDXC	7	@BaF_2	200	K_α	20.866	21.331	100	6	BaF_2
Silver	Ag	47	88166	AGXC	7	@BaF_2	200	K_α	21.833	22.320	100	6	BaF_2
Cadmium	Cd	48	88110	CDXC	7	@BaF_2	200	K_α	22.824	23.333	100	6	BaF_2
Indium	In	49	88131	INXC	7	@BaF_2	200	K_α	23.839	24.373	100	6	BaF_2
Tin	Sn	50	88160	SNXC	7	@BaF_2	200	K_α	24.878	25.437	100	6	BaF_2
Antimony	Sb	51	88102	SBXC	7	@BaF_2	200	K_α	25.942	26.528	100	6	BaF_2
Cesium	Cs	55	88118	CSXC	7	@BaF_2	200	K_α	4.182	4.375	100	6	BaF_2
Barium	Ba	56	88107	BAXC	8	@Al_2O_3	200	K_α	31.633	32.379	100	6	Al_2O_3
Lanthanum	La	57	88146	LAXC	8	@Al_2O_3	200	K_α	32.847	33.630	100	6	Al_2O_3
Cerium	Ce	58	88117	CRXC	8	@Al_2O_3	200	K_α	34.089	34.911	100	6	Al_2O_3
Samarium	Sm	62	88162	SMXC	8	@Al_2O_3	200	K_α	39.319	40.322	100	6	Al_2O_3
Europium	Eu	63	88121	EUXC	8	@Al_2O_3	200	K_α	40.696	41.750	100	6	Al_2O_3
Terbium	Tb	65	88172	TBXC	8	@Al_2O_3	200	K_α	43.532	44.696	100	6	Al_2O_3
Hafnium	Hf	72	88127	HFXC	4	@Zr	200	L_α	7.739	8.006	100	6	Zr
Tantalum	Ta	73	88170	TAXC	4	@Zr	200	L_α	7.981	8.254	100	6	Zr
Wolfram	W	74	88186	WOXC	4	@Zr	200	L_α	8.227	8.507	100	6	Zr
Iridium	Ir	77	88133	IRXC	4	@Zr	200	L_α	8.987	9.287	100	6	Zr
Gold	Au	79	88143	AUXC	4	@Zr	200	L_α	9.514	9.827	100	6	Zr
Mercury	Hg	80	88142	HGXC	4	@Zr	200	L_α	9.784	10.104	100	6	Zr
Thallium	Tl	81		TLXC	4	@Zr	200	L_α	10.057	10.386	100	6	Zr
Lead	Pb	82	88128	PBXC	4	@Zr	200	L_α	10.332	10.669	100	6	Zr
Uranium	U	92		URXC	5	@Mo	200	L_α	13.309	13.743	100	6	Mo

[a] ROI = Region of Interest

Table 13-3. Analytical Detection Limits for EDXRF Elements.

Element	Symbol	Atomic No.	AQS Parameter	DRI ID	Condition No.	MDL[a] (µg/m^3)	LQL[b] (µg/m^3)
Sodium	Na	11	88184	NAXC	1	0.1387	0.1010
Magnesium	Mg	12	88140	MGXC	1	0.0349	0.0297
Aluminum	Al	13	88104	ALXC	1	0.0178	0.0139
Silicon	Si	14	88165	SIXC	1	0.0095	0.0114
Phosphorous	P	15	88152	PHXC	1	0.0033	0.0028
Sulfur	S	16	88169	SUXC	1	0.0072	0.0123
Chlorine	Cl	17	88115	CLXC	1	0.0019	0.0055
Potassium	K	19	88180	KPXC	1	0.0028	0.0035
Calcium	Ca	20	88111	CAXC	2	0.0040	0.0093
Scandium	Sc	21	88163	SCXC	2	0.0073	0.0043
Titanium	Ti	22	88161	TIXC	2	0.0022	0.0018
Vanadium	V	23	88164	VAXC	2	0.0003	0.0004
Chromium	Cr	24	88112	CRXC	2	0.0012	0.0017
Manganese	Mn	25	88132	MNXC	3	0.0032	0.0025
Iron	Fe	26	88126	FEXC	3	0.0040	0.0093
Cobalt	Co	27	88113	COXC	3	0.0006	0.0003
Nickel	Ni	28	88136	NIXC	3	0.0009	0.0010
Copper	Cu	29	88114	CUXC	3	0.0018	0.0014
Zinc	Zn	30	88167	ZNXC	3	0.0015	0.0028
Gallium	Ga	31	88124	GAXC	4	0.0044	0.0030
Arsenic	As	33	88103	ASXC	4	0.0008	0.0005
Selenium	Se	34	88154	SEXC	4	0.0018	0.0015
Bromine	Br	35	88109	BRXC	4	0.0020	0.0017
Rubidium	Rb	37	88176	RBXC	4	0.0012	0.0013
Strontium	Sr	38	88168	SRXC	5	0.0022	0.0021
Yttrium	Y	39	88183	YTXC	5	0.0014	0.0014
Zirconium	Zr	40	88185	ZRXC	6	0.0041	0.0038
Niobium	Nb	41	88147	NBXC	6	0.0031	0.0021
Molybdenum	Mo	42	88134	MOXC	6	0.0032	0.0021
Palladium	Pd	46		PDXC	7	0.0060	
Silver	Ag	47	88166	AGXC	7	0.0057	0.0038
Cadmium	Cd	48	88110	CDXC	7	0.0056	0.0041
Indium	In	49	88131	INXC	7	0.0049	0.0038
Tin	Sn	50	88160	SNXC	7	0.0062	0.0042
Antimony	Sb	51	88102	SBXC	7	0.0086	0.0063
Cesium	Cs	55	88118	CSXC	7	0.0066	0.0045
Barium	Ba	56	88107	BAXC	8	0.0106	0.0071
Lanthanum	La	57	88146	LAXC	8	0.0187	0.0093
Cerium	Ce	58	88117	CEXC	8	0.0154	0.0094
Samarium	Sm	62	88162	SMXC	8	0.0210	0.0135
Europium	Eu	63	88121	EUXC	8	0.0289	0.0204
Terbium	Tb	65	88172	TBXC	8	0.0298	0.0192
Hafnium	Hf	72	88127	HFXC	4	0.0141	0.0085
Tantalum	Ta	73	88170	TAXC	4	0.0104	0.0068
Wolfram	W	74	88186	WOXC	4	0.0171	0.0106
Iridium	Ir	77	88133	IRXC	4	0.0045	0.0028
Gold	Au	79	88143	AUXC	4	0.0064	0.0038
Mercury	Hg	80	88142	HGXC	4	0.0024	0.0010
Thallium	Tl	81		TLXC	4	0.0030	
Lead	Pb	82	88128	PBXC	4	0.0039	0.0030
Uranium	U	92		URXC	5	0.0046	

[a] The MDL through 2010 is three times the standard deviation of mean concentrations of laboratory blanks, assuming a deposit area of 11.78 cm^2 and a sample volume of 24 m^3. The MDL is calculated and reported quarterly, but values here are averages for the period 2004 Q4 through 2010 Q4.

[a] The LQL is three times the standard deviation of mean concentrations of field blanks, assuming a deposit area of 11.78 cm^2 and a sample volume of 24 m^3. The LQL is calculated quarterly for parameters reported to AQS, but values here are averages for the period 2004 Q4 through 2010 Q4.

QC for EDXRF Elemental Analyses

Table 3 summarizes the QC measures for elemental analysis by EDXRF.

Two types of EDXRF standards are used for calibration, performance testing, and auditing: (1) vacuum-deposited thin-film elements and compounds from Micromatter Co. (Deer Harbor, WA), and (2) polymer films. The vacuum deposit standards cover all elements except for Ir, Ta, Zr, and Hf (which may be determined by interpolation) and are used as calibration standards. The polymer film and National Institute of Standards and Technology (NIST) standards are used as QC standards. During EDXRF analysis, filters are removed from their Petri slides, and loaded into the carousel for entry into the x-ray analysis chamber.

The vacuum in the x-ray chamber and the heat induced by the absorption of x-rays may evaporate some materials, such as ammonium nitrate. Two QC standards are run once per day. Ten percent replicates are also analyzed. When a QC value differs from specifications by ± 10% or more, or when a replicate value differs from the original value (where values exceed 10 times the detection limits) by ±10% or more, the previous filters are reanalyzed. If further tests of standards show that the system calibration has changed by more than ±5%, the instrument is recalibrated. In addition, DRI will maintain a set of laboratory blanks that will be analyzed periodically (~1 blank for every 20 filters analyzed) to test for baseline shifts in blank values. Also, as part of Level II data validation, field blank values for each shipment will be plotted by element as time series to check for potential shifts in baselines and potential contamination.

Table 3. DRI Elemental Analysis by EDXRF QC Measures.

Requirement	Frequency	Calibration Standard	Performed By	Acceptance Criteria	Corrective Action
Multipoint Calibrations	Annually	QC standards	XRF lab supervisor	± 5%	Recalibrate
Minimum Detection Limit (MDL)	Initially, then quarterly or after major instrument change	Lab blanks	XRF lab supervisor, Project Manager	Within ± 10% of previous limits	Troubleshoot instrument and check filter lots

Lower Quantifiable Limit (LQL)	Quarterly	Field blanks	XRF lab supervisor, Project Manager	Within ± 10% of previous limits	Troubleshoot instrument and check filters
QC Samples					
Lab blanks	1/20 samples	N/A	Analyst	Within 3 σ of MDLs	Check instrument and filter lots
QC standards	Daily	Micromatter thin films	Analyst	± 10%	Samples before QC standard and previous standards reanalyzed
NIST-traceable standards	Annually	Micromatter thin films	Analyst	± 10%	Samples before QC standard and previous standards reanalyzed
Replicates	10% of samples	N/A	Analyst	± 10% when value >10*MDL	Reanalysis of previous samples
Level 1 Review	Every sample	N/A	XRF lab supervisor	Per SOP	Reanalysis of problem samples or flagging per SOP

More detailed information on the QC measures for elemental analysis by EDXRF may be found in SOP #2-209, X-Ray Fluorescence (XRF) Analysis of Aerosol Filter Samples (PANalytical Epsilon 5).

B-3 DEC Regional Haze monitoring MQOS (RH QAPP, 2008)

7.5 Measurement Quality Objectives (MQOs)

Once a DQO is established, the quality of the data must be evaluated and controlled to ensure that it is maintained within the established acceptance criteria. MQOs are designed to evaluate and control various phases (sampling, preparation, and analysis) of the measurement process to ensure that total measurement uncertainty is within the range prescribed by the DQOs. MQOs can be defined in terms of precision, bias, representativeness, detectability, completeness and comparability.

Precision - Precision is a measure of mutual agreement among individual measurements of the same property usually under prescribed similar conditions, or how well side-by-side measurements of the same thing agree with each other. It is important that the measurements be as similar as possible, using the same equipment or equipment as similar as possible. Precision represents the random component of uncertainty. This random component is what changes randomly high or low, and which, try as you might, you cannot control with the equipment and the procedures you are using. Precision is estimated by various statistical techniques using the standard deviation or, if you only have two measurements, the percent difference.

Bias – Bias (accuracy) is the systematic or persistent distortion of a measurement process that causes uncertainty in one direction. (e.g., results are either higher than or lower than they should be). It is estimated by evaluating the instrument measured result against a known standard used as the "true" value. It is expressed as a positive or negative percentage of the "true" value. Bias is measured by conducting independent performance audit(s) of the monitoring equipment used to measure and report data. The audit standards used as well as the audit personnel must be completely independent from standards used to calibrate the monitoring equipment and the personnel responsible for site

Representativeness - Representativeness is defined as a measure of the degree which data really represent some characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. The representativeness of measurements made in this program is ensured by following EPA siting guidelines. The goal of our program is to measure the pollutant concentrations around the Class I area and to evaluate if the IMPROVE site truly represents the entire Class I area.

Detectability – Detectability is defined as the lowest value that a method procedure can reliably discern a measured response above background noise; in other words, that level below which the instrument cannot discriminate from zero. Because there is always variation in any measurement process (precision uncertainty), the level of detectability depends on how much precision error is in the process. Detection limits for ADEC-M&QA air quality instruments are consistent with the requirements listed in 40 CFR 53. For Federal Reference Methods (FRM) and Federal Equivalent Methods (FEM), the detection limits are specified with the respective EPA FRM/FEM designation.

Completeness - Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct, normal conditions. Data completeness requirements are included in the reference methods (40 CFR 50) and 40 CFR 58 Appendix A.

Comparability – Comparability is a measure of confidence with which one set of data can be compared to another. Comparability is important so that data sets within one part of area of the country can be compared with another area or data from another year.

Various parts of 40 CFR have identified acceptance criteria for some of these attributes as well as U.S. EPA Quality Assurance Guidance Documents and additional DEC ambient air regulatory monitoring methods. These Ambient Air Quality parameter MQOs are listed in **Table 7-1**. **Table 7-2** lists MQOs for meteorological parameters. More detailed descriptions of these MQO's and how they will be used to control and assess measurement uncertainty are described in method specific data validation tables. Method specific data validation tables may be found in **Appendix A.**

40 CFR 58 Appendix A.

Comparability – Comparability is a measure of confidence with which one set of data can be compared to another. Comparability is important so that data sets within one part of area of the country can be compared with another area or data from another year.

Various parts of 40 CFR have identified acceptance criteria for some of these attributes as well as U.S. EPA Quality Assurance Guidance Documents and additional DEC ambient air regulatory monitoring methods. These Ambient Air Quality parameter MQOs are listed in **Table 7-1**. **Table 7-2** lists MQOs for meteorological parameters. More detailed descriptions of these MQO's and how they will be used to control and assess measurement uncertainty are described in method specific data validation tables. Method specific data validation tables may be found in **Appendix A.**

Table 7-1 Alaska Ambient Air Quality Monitoring MQOs

Parameter	Comparability		Completeness			Bias	Precision	Representativeness	
	Equipment	Reference/ Method	Hourly	Daily	Quarter			Sampling Frequency	Siting
$PM_{2.5}$ FRM	EPA $PM_{2.5}$ FRM sampler,	EPA QA Handbook Vol II method 2.12, ADEC $PM_{2.5}$ QAPP		24-hr ± 1hr	N/A	**Flow audit** Design Flow: ≤±5% Δ (16.7lpm), Accuracy Flow: ≤±4% Δ	CV≤ 10% for paired values≥3 ug/m^3	1/3 day, 1/12 collocated 15% of sites	EPA siting guidelines for PM_{10} and $PM_{2.5}$
DRUM sampler	UC Davis 3 stage Drum samplers	Compare to IMPROVE sampler		8 x 3 hour intervals	50 % entire 6 week sampling period	**Flow audit** Accuracy Flow: ≤±20% Δ, preliminary	**Intra-method** preliminary < 20% Δ, Inter-method to be determined	continuous	EPA siting guidelines for PM_{10} and $PM_{2.5}$

Table 7-2 Alaska Meteorological Monitoring MQOs									
Parameter	**Comparability**			**Completeness**			**Accuracy**	**Representativeness**	
	Method & Measurement Resolution	Equipment	Reference/ Method	Hourly	Daily	Quarter		Sampling Frequency	Siting
WS	Cup or Sonic Anemometer 0.25 m/s	WS Range 0.5m/s – 50 m/s VWS Range -25.0 m/s – 25.0 m/s WS Threshold ≤ 0.5 m/s Accuracy ≤ (0.2m/s+5% obs) Dist Const. ≤ 5m/s at 1.2kg/m^3	Meets minimum specs per EPA-454/R-99-005 Section 5.1, Table 5.1 and appropriate for range of site environmental conditions	≥75 %	≥ 75% Aggregate hours/day	≥ 90% all sample days	± 0.2 m/s	Continuous, 1 min sample interval, hourly avg	EPA-454/R-99-005 Section 3.1 EPA QA Handbook Vol IV
Vertical WS	Cup or Sonic Anemometer 0.1 m/s						± 0.2 m/s	Continuous, 1 min sample interval, hourly avg	
WD	Vane or sonic anemometer 1.0 m/s	1 – 360° (540°) Threshold ≤ 0.5 m/s Accuracy ≤ 3° from sensor mount ≤ 5° absolute error Delay Distr. ≤ 5m/s at 1.2kg/m^3 Damping Ratio 0.4 at 1.2kg/m^3 or Overshoot ≤ 25% at 1.2kg/m^3					± 5° includes ± 3° from sensor mount	Continuous, 1 min sample interval, hourly avg	
Vector Data WS WD Sigma Theta (σθ) Sigma W (σΦ)	DAS Calculation 0.1 m/s 1.0 degree 1.0 degree 0.1 m/s	Range 0 – 50.0 m/s, Range 0° – 360° Range 0° – 105° Range 0 – 10 m/s					Vector Data WS ± 0.2 m/s WD ± 5° σθ ± 5° σΦ ± 0.2 m/s	Continuous, 1 min sample interval, hourly avg	
Ambient Temperature	Thermistor 0.1°C	Range -40°C - +40°C Meas. Resolution ≤ 0.1°C Accuracy ≤ ±0.5°C					± 0.5° C	Continuous, 1 min sample interval, hourly avg	
Temperature Radiation Shield	Motor aspirated	Range -100 to 1300W/m^2 Flow Rate ≥ 3 m/s Radiation error < 0.2°C							

8 Training

Air monitoring personnel will receive sufficient training in their appointed duties to contribute to the reporting of complete and high quality data. Dr. Cathy Cahill will provide training to DEC staff

B-4 Quality Assurance Summary and Size Resolved Mass Data Archive, Alaska DEC 3 DRUM Network

Quality Assurance Summary and Size Resolved Mass Data Archive,

Alaska Department of Environmental Conservation 3 DRUM Network

January 20, 2012

Prepared for

Prof. Catherine F. Cahill, U. Alaska, Fairbanks, AK, by

The University of California, Davis, DELTA Group, Dr. David E. Barnes, Prof. Thomas A. Cahill, and the DELTA Group staff

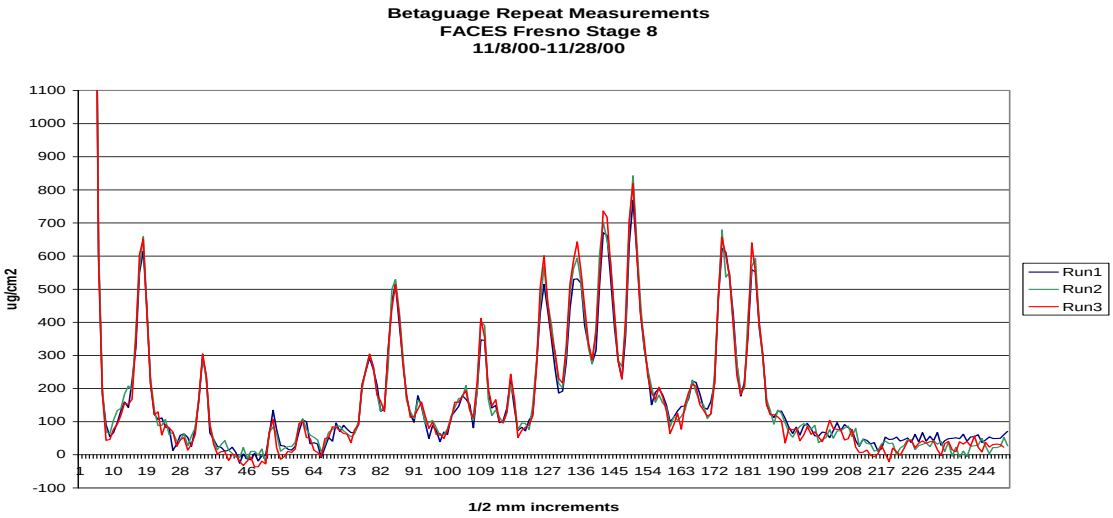
Executive Summary:

Sampling using DRUM impactors following UC Davis DELTA Group protocols and analysis for mass by soft beta ray transmission have now been shown by the California Air Resources Board after a 1 year side by side test to be equivalent to standard 24 hr Federal Reference Measurement (FRM) 2.5 µm filters. This result has been accepted by the US EPA in formal Joint QA/QC and QAPP protocols and published in the peer reviewed refereed literature

Newest information

1. **Precision of soft beta ray mass measurements**

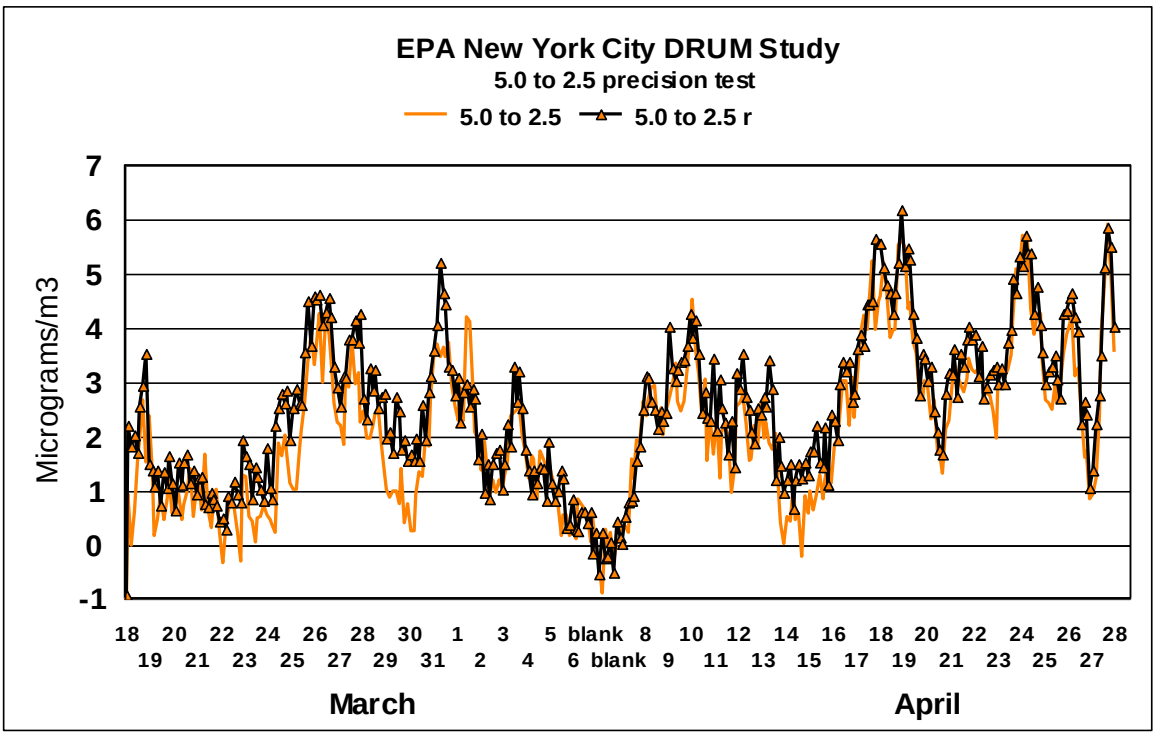
Through use of low energy beta particles matched to the impactor strips, mass is obtainable in air and at a very low cost. Below we show repeated analysis of the same DRUM strip showing the precision achieved in re-analysis. The MDL depends on a number of factors, but for a relatively clean sample operating at a 6 week rotation rate it is approximately 0.15 $\mu g/m^3$. Every DRUM stripped collected through this analysis.



This result was obtained by simply running the same strip twice without removal from the beta gauge system**.**

2. **Accuracy and Precision of DRUM sample mass via soft beta ray analysis**

   The soft beta ray mass measurement was used as part of a US EPA intercomparison in New York City. Below we show repeat analysis of a DRUM strip. In this case, the strip was removed, and then replaced for the repeated analysis.

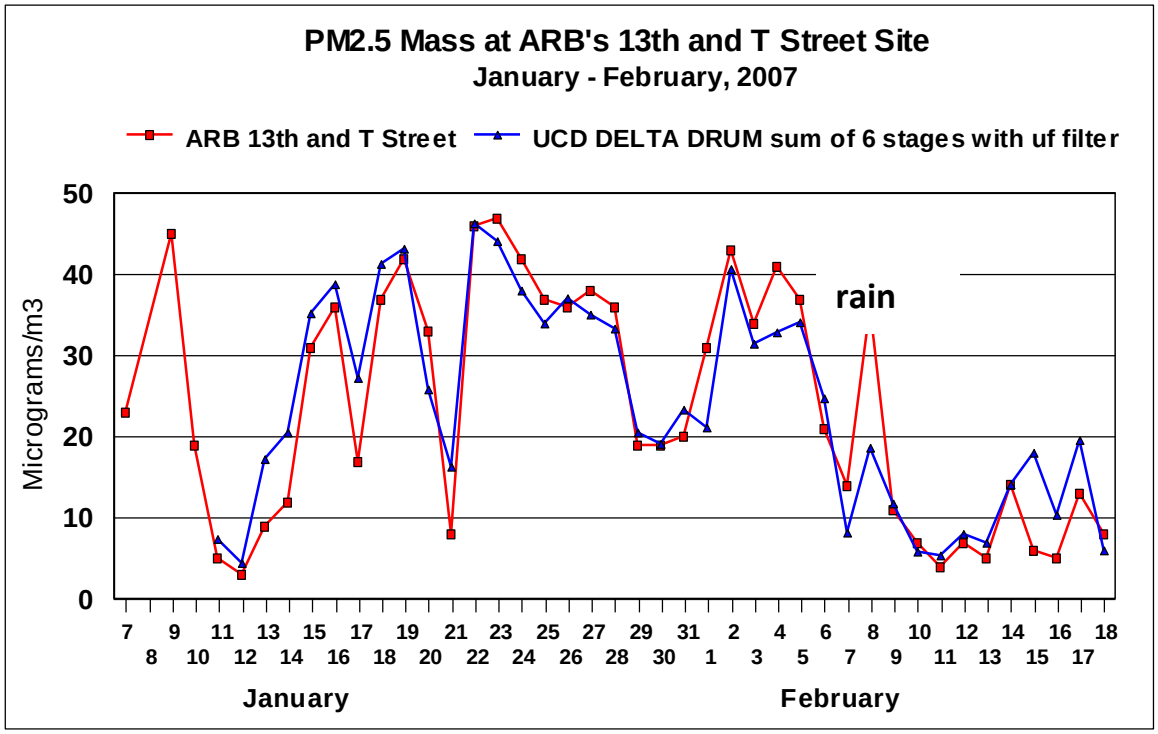


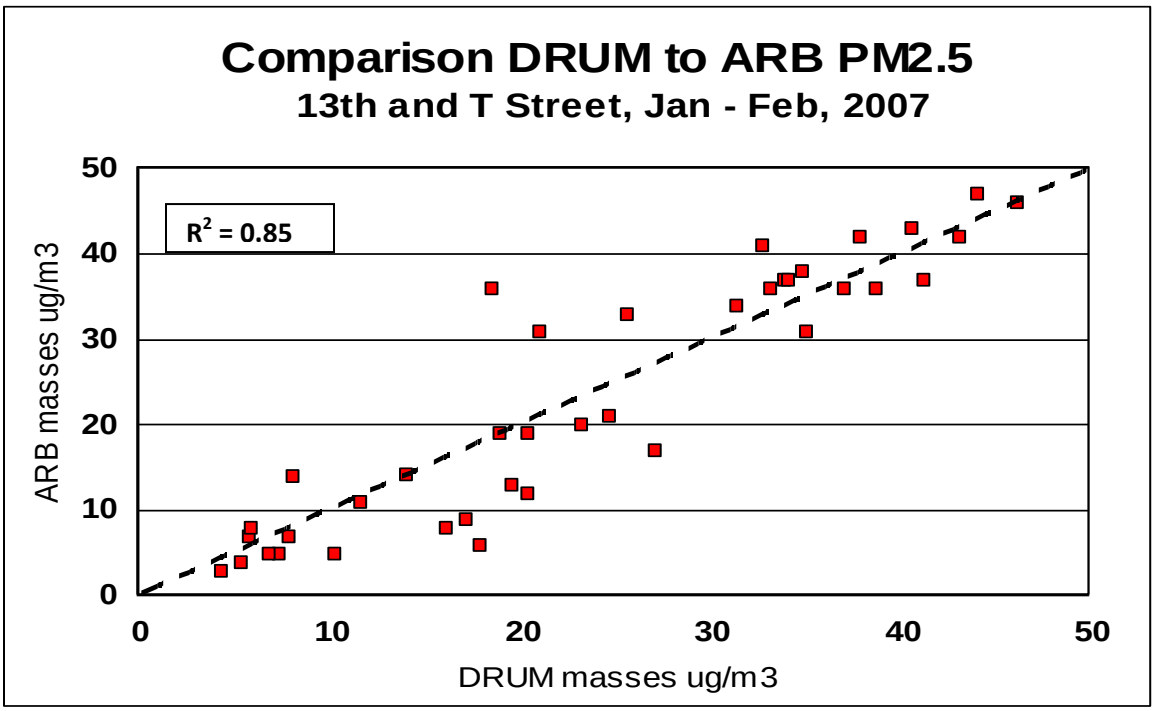
3. **New data on DRUM to FRM mass comparisons.**

The ultimate test must be comparison of DRUM mass data to standard federal and state filter networks. A side by side comparison was made between a DELTA Group 8 DRUM with integrating after filter and ARB FRM $PM_{2.5}$ 24 hr filters for 12 months in 2007. These data were then sent to the California Air Resources Board for staff analysis. The data are shown below for one period, with the correlation $r^2 = 0.85$ and a slope within 5% of unity. The mean values for this period were 23.2 ± 1.0 $\mu g/m^3$ DRUM, versus 22.1 $\mu g/m^3$ ARB. This easily achieves the US EPA criterion of ± 15% for equivalent samplers.

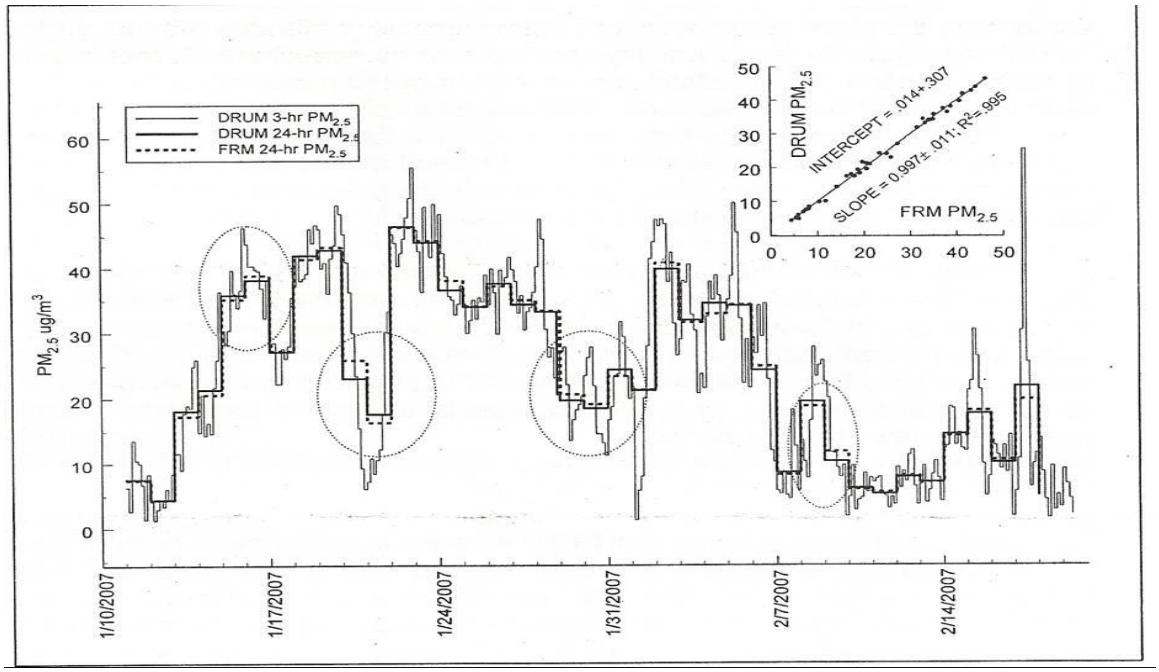
The fit was further improved by a slight shift in the time access that ARB had access to, resulting in raising the correlation r^2 from 0.85 (below) to 0.99, and a slope within 1% of unity. This is all the more impressive because the DRUM data were taken in multiple size regimes every 3 hr., yet compared to a single 24 hr $PM_{2.5}$ filter.

This is a validation of both DRUM sampling protocols and the accuracy and precision of the soft beta ray mass measurements used for the Alaska DEQ program.





Below we show the analysis done on the DELTA Group data by the ARB staff. The data were transmitted to the ARB and ARB staff, aided by their access to short-time aerosol data unavailable to UC Davis, re-did the analysis making a slight (3 hr) adjustment in the DELTA Group's start time. The results were sharply better agreement with the FRM (below) with slope = 0.99 and r^2 = 0.99.



Notes on data reduction:

The aersols mass data presented as µg/m^3 are final, but before presentation and interpreattion, several tasks had to be done. In the complete data set, not all these tasks have been done on all samples:

1. The portions of the data that were blocked by the frame before the aerosol data started, shown by large numbers and numerous overflows, must be delted.
2. Dates and times must be verified in some cases, in which the field logs are incomplete. Many give start times but not stop times, so these must be estimated until field log data are entered.
3. Flow data from field audits are not yet entered
4. Note any important comments for deployment that could affect analysis, e.g. field notes, sample defects, operational defects.
5. Convert from mass/cm^2 to mass/volume of air sampled, based on analysis aperture, sampler rotation rate, slit length and flow rate.
6. Raw data is mass/cm^2 of sample.

7. Once timing and relative alignment of stages is complete, data that does not represent actual values is removed from the data set:

8. Areas of known defects, data beyond the extent of sample, timing marks if any

Appendix A

Recent publications using DRUM sampling and soft beta ray mass measurements

11-1 Thomas A. Cahill , David E. Barnes, Earl Withycombe , and Mitchell Watnik, Very Fine and Ultra-Fine Metals and Ischemic Heart Disease in the California Central Valley 2: 1974 – 1991**, Aerosol Science and Technology 45, 1135-1142 (2011)**

11-2 Thomas A. Cahill, David E. Barnes, Nicholas J. Spada, Jonathan A. Lawton, and Thomas M. Cahill , Very Fine and Ultra-Fine Metals and Ischemic Heart Disease in the California Central Valley 1: 2003 – 2007**, Aerosol Science and Technology** 45**, 1125-1134 (2011)**

11-3 Thomas A. Cahill, Thomas M. Cahill, David E. Barnes, Nicholas J. Spada and Roger Miller , Inorganic and organic aerosols downwind of California's Roseville Railyard**, Aerosol Science and Technology** 45**, 1049-1059 (2011)**

10-1 Cahill, TM, Organic aerosols in the California Central Valley**, Environmental Science and Technology 44 2315 - 2312 (2010)**

10-2 Cahill, Catherine F., Peter G. Rinkleff, Jonathan Dehn, Peter V. Webley, Thomas A.Cahill, and David E. Barnes, Aerosol measurements from a recent Alaskan volcanic eruption: implications for ash transport predictions**, J. Volcanology and Geothermal Research 198, 76 - 80 (2010)**

08-1 Cahill, Catherine F, Thomas A. Cahill, and Kevin D. Perry. The size- and time resolved composition of aerosols from a sub-Arctic boreal fire prescribed burn**. *Atmospheric Environment* 42 7553-7559 (2008)**

07-1 Emma Pere-Trepat, Eugene Kim, Pentti Taatero, and Philp k. Hopke, Source Apportionment of time and size resolved ambient particulate matter measured with a rotating DRUM impactor, ***Atmospheric Environ.* 41: 5921–5933 (2007).**

Appendix B

US Environmental Protection Agency
Joint Quality Management and Quality Assurance Project Plan

Drum Sampler Demonstration of PM Mass and XRF Elements

U.S. Environmental Protection Agency
Office of Research and Development
National Center for Environmental Assessment

April 22, 2010

Approvals for Project Team

_____

Tom Cahill

Approvals for EPA

_____

William Wilson
Project Officer

_____

Beverly Comfort
Quality Assurance Manager

1. Project Organization and Responsibilities of Principal Investigator(s)
   The DELTA (Detection and Evaluation of Long-range Transport of Aerosols) group is a small organization associated with the University of California, Davis. The Director, Dr. Thomas Cahill, is responsible for all Quality Assurance activities.

   (Full report circa 50 pages)

Short summary from **DRUM Quality Assurance Protocols (1/2011)**

Newest information

Three new studies have enhanced our understanding of continuous sampling by size, time, and composition with DRUM impactors:

1. Final report to the California Air Resources Board, **Comparison of Fine Mass, UC Davis DRUM versus FRM, at the ARB 13th and T Street Site**, Thomas A. Cahill and David E. Barnes, UC Davis DELTA Group, and the Breathe California of Sacramento/Emigrant Trails Health Effects Task Force, April 25, 2009

2. Final Report, **Drum Sampler Demonstration of PM Mass and XRF Elements** Final Report to the US EPA ORD, , March 14, 2009, Thomas A. Cahill, David E. Barnes and Jonathan Lawton, University of California, Davis, with Thomas M. Cahill, Arizona State University, May, 2009,

and a third that emphasized the size resolved DRUM organics (including ultrafine) with comparison to DRUM S-XRF and mass (including ultrafine),

3. **Organic and Elemental Aerosols near Watt Avenue, Late Winter – Spring, 2007,** Draft prepared for The Health Effects Task Force, Breathe California of Sacramento-Emigrants Trails and the Sacramento Metropolitan Air Quality Management District, June 26, 2009.

The first two are available electronically from BC/SET and the UC Davis DELTA Group.

4. FRM mass, S-XRF potassium (wood smoke) and CO and NOX correlation as part of the Del Paso manor wood smoke study (Sac Metro AQMD, Nov, 2010)

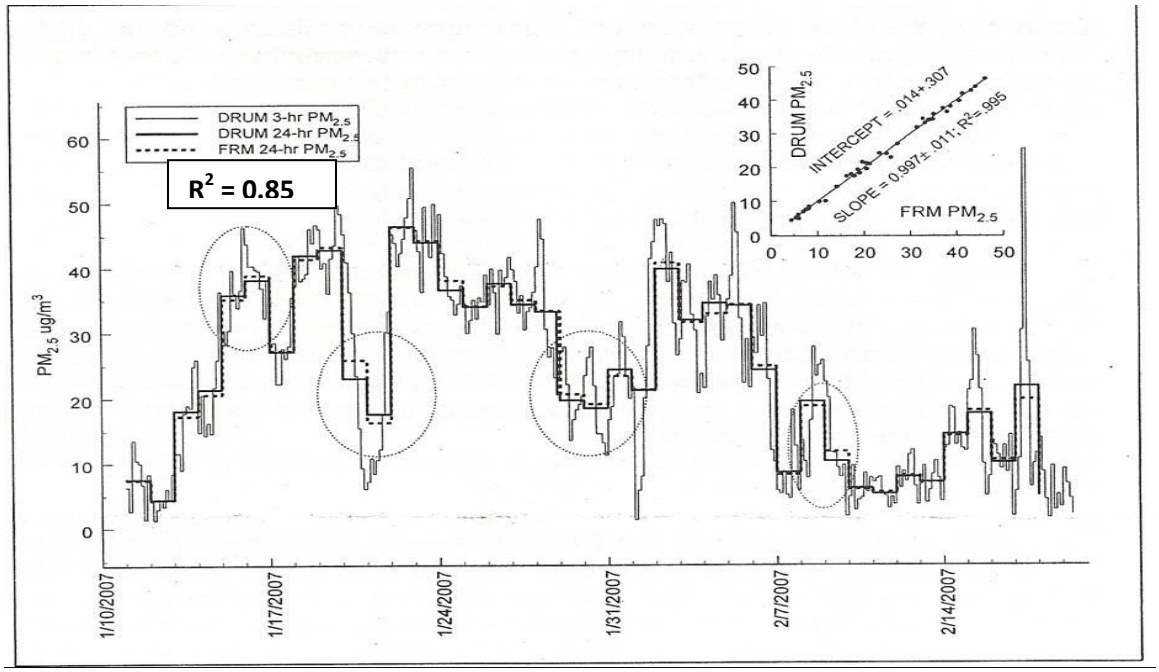
1 New data on DRUM to FRM mass comparisons from the ARB comparisons.

A side by side comparison a made between a DELTA Group 8 DRUM with integrating afterfilter and ARB FRM $PM_{2.5}$ 24 hr filters for 6 months in 2007. The mass was measured by soft beta ray transmission, so the test involved both the accuracy and precision of the DRUM sampler and soft beta ray mass analysis.

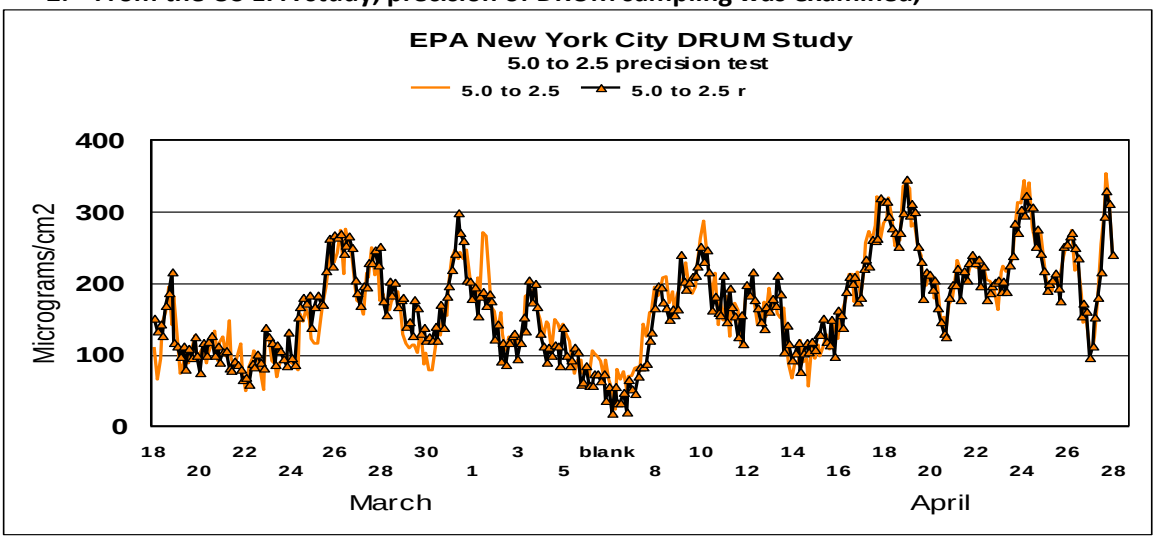
In summary, for Period I, January 12 – February 20, 2007, good agreement between ARB 24 hr filters and the sum of 49 individual DRUM stages and ultra fine after filter, 23.2 ± 1.0 $\mu g/m^3$ DRUM, 22.1 $\mu g/m^3$ ARB. For the entire 6 months, the ratio, DRUM/FRM, was 1.01 ± 0.21, with the uncertainty dominated by the need to take 49 individual DRUM mass measurements to equal one 24 hr filter.

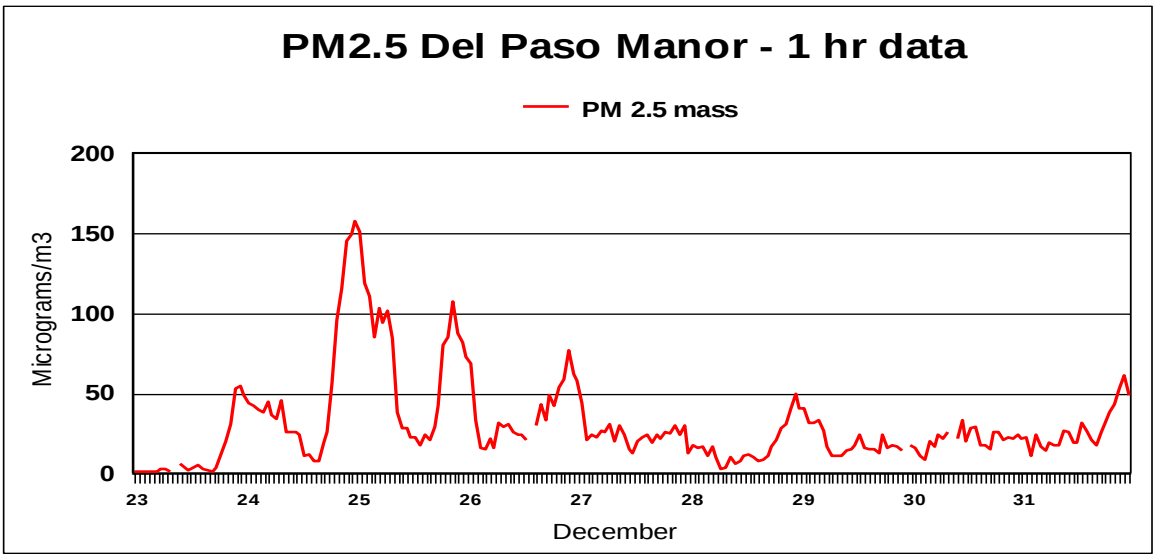
The data were transmitted to the SRB and SRB staff, aided by their access to short-time aerosol data unavailable to UC Davis, re-did the analysis making a slight (3 hr) adjustment in the DELTA Group's start time. The results were sharply better agreement with the FRM (below) with slope = 0.99 and r^2 = 0.99.

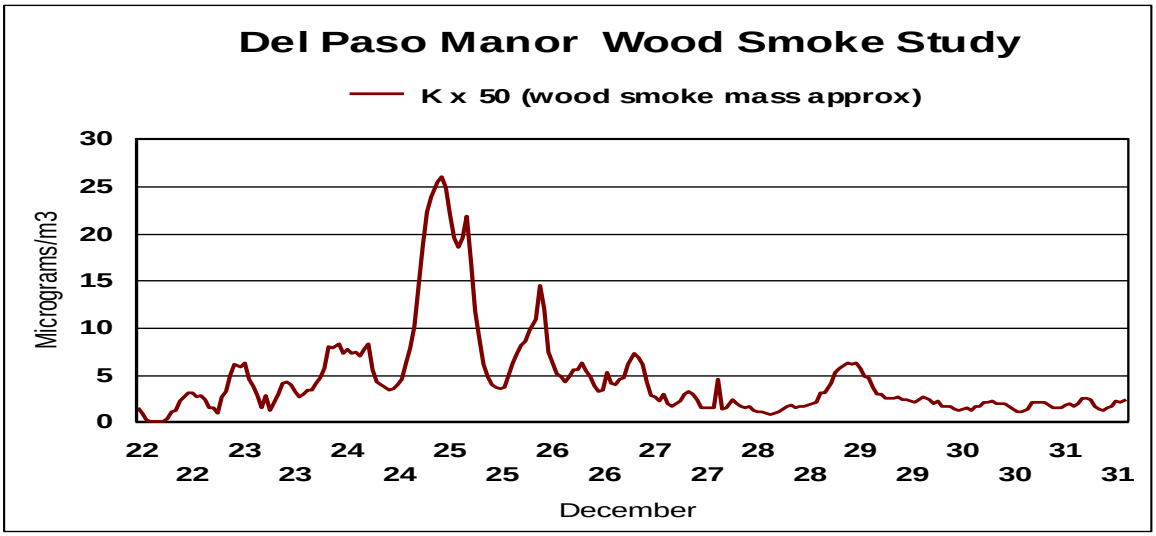
Based upon these efforts, a high time resolution Dust Trak nephelometer is now added at the start of every field campaign, guaranteeing an accurate start time. (In addition, we are using gas pollutant data to match times to the limit of the slot width, ± 30 min for a 1 hr resolution DRUM run.

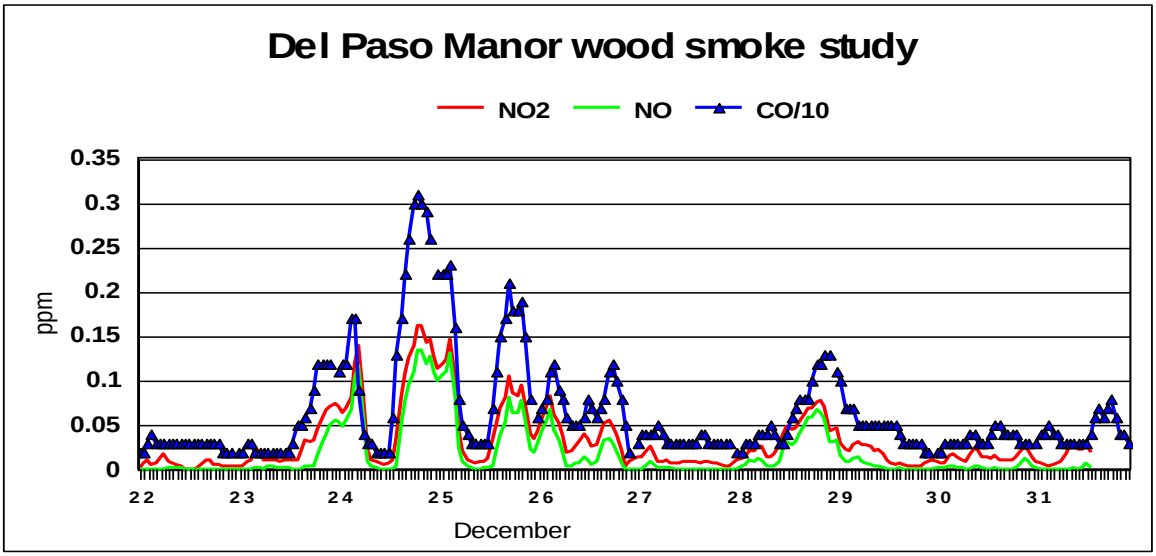


2. From the US EPA study, precision of DRUM sampling was examined,




PM2.5 Del Paso Manor - 1 hr data
PM 2.5 mass
Micrograms/m3
200
150
100
50
0
23
24
25
26
27
28
29
30
31
December


Del Paso Manor Wood Smoke Study
K x 50 (wood smoke mass approx)
Micrograms/m3
30
25
20
15
10
5
0
22
23
24
25
26
27
28
29
30
31
December

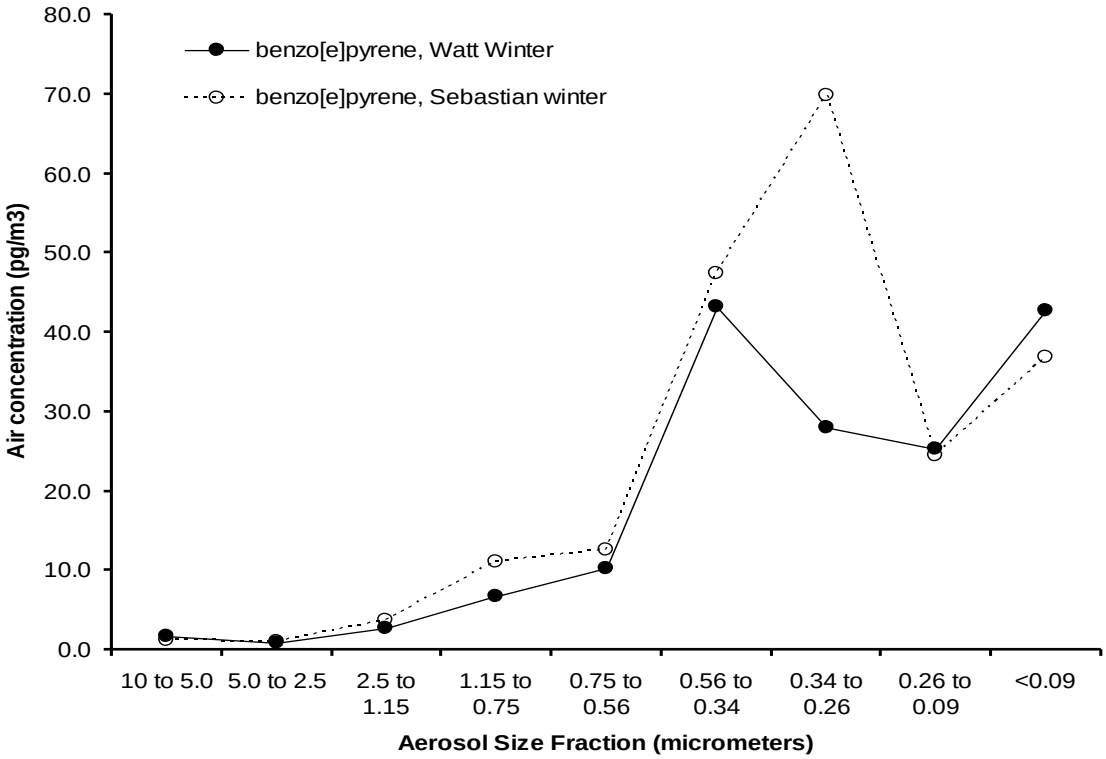

Del Paso Manor wood smoke study
NO2
NO
CO/10
ppm
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
22
23
24
25
26
27
28
29
30
31
December

Wood smoke episode at Del Paso manor, December, 2009

This work also showed mass balance on the ultra fine filters, the “Gold Standard” for QA.

Major components	**ug/m3**		**Minor components**	**ng/m3**
	filter			**filter**
Mass (gravimetric)	**2.04**		Phosphorus	2.4
Mass (reconstructed)	**2.15**		Vanadium	0.15
(note: No EC mass)			Chromium	0.45
Organic (PESA IMPROVE)	1.72		Nickel	3.5
Diesel PM (est.)	na		Copper	8.3
Ammonium Sulfates	0.34		Zinc	11.5
Salt	0.04		Arsenic	0.6
Soil	0.048		Selenium	0.3
K non	0.053		Bromine	3.7
Metals	0.035		Lead	4

3. From the Watt Avenue studies, the precision and accuracy of the organic data are shown by the agreement at 2 sites 500 m apart.



4. Summary comparison, all DELTA S-XRF double blind experiments

Below we summarize all DELTA Group S-XRF inter-comparisons in the past 5 years. Note that there were problems with the ARB RAAS analyses since the two internal ARB X-RF to ARB RAAS comparisons agreed only at the level 1.29 ± 0.63 for all co-measured elements. (DQAP v. 8.02, pg 32) We also give averages below without the ARB RAAS data. A comparison was also done with IMPROVE in the Yosemite study (2002) but this comparison is not included since IMPROVE has also since identified serious deficiencies in data from that period (White et al, AAAR 2004)

Study and date	Methods	**Average ratio, Al to Fe**	Std. dev.	**Average ratio, Cu to Pb**	Std. dev.
BRAVO, 1999	PIXE vs S-XRF	**0.99**	0.04		
BRAVO, 1999	CNL XRF vs S-XRF			**1.24**	0.14
FACES, 2001	ARB XRF vs S-XRF	**0.93**	0.21	**1.02**	0.08
FACES, 2001	ARB (alt) vs S-XRF	**(0.98)**	0.27	**(0.74)**	0.23
ARB LTAD 2005	DRI XRF vs S-XRF	**1.037**	0.085	**0.907**	0.009
All prior studies	**Average** (wo ARB alt)	**0.984**	**0.15**	**0.977**	**0.115**

Recent publications:

10 - 1 Cahill, T.M., **Size-Resolved Organic Speciation of Wintertime Aerosols in California's Central Valley (2010)** Environmental Science and Technology 44 2315- 2321

07-1 Emma Pere-Trepat, Eugene Kim, Pentti Taatero, and Philp k. Hopke**, Source Apportionment of time and size resolved ambient particulate matter measured with a rotating DRUM impactor**, Atmospheric Environment 41, 5921 – 5933 (2007)

10- 2 Cahill, Catherine F, et al, **Aerosol Measurements from a Recent Alaskan Volcanic Eruption: Implications for Volcanic Ash Transport Predictions** in press, J. Volcanology Geothermal Research (in press, 2010)

11- 1 Cahill, T. A., David E. Barnes, Nicholas J. Spada, Jonathan A. Lawton, and Thomas M. Cahill , **Very Fine and Ultra-Fine Metals and Ischemic Heart Disease in the California Central Valley 1: 2003 – 2007**, Manuscript AST-MS- 2010-118 (in press, 2011).

11 -2 Cahill, T.A. David E. Barnes[1], Earl Withycombe [2], and Mitchell Watnik [3]

Very Fine and Ultra-Fine Metals and Ischemic Heart Disease in the California Central Valley 2: 1974 – 1991 Manuscript AST-MS-2010-193 (in press, 2011).

11-3 Cahill, T.A., Thomas M. Cahill[3], David E. Barnes[1], Nicholas J. Spada[1] and Roger Miller[1]. **Inorganic and organic aerosols downwind of California's Roseville Rail Yard,** Manuscript AST-MS-2010-117 (in press, 2011).

Post AXIL Particle Size Corrections															
		MOUDI	**MOUDI**	**MOUDI**	**MOUDI**	**MOUDI**	**MOUDI**	**MOUDI**	**MOUDI**	**MOUDI**	**MOUDI**	**MOUDI**	**MOUDI**	**MOUDI**	**MOUDI**
		stage	**stage**	**stage**	**stage**	**stage**	**stage**	**stage**	**stage**	**stage**	**stage**	**stage**	**stage**	**stage**	**stage**
Element	Energy	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
	(keV)	18	10	5.6	3.2	1.8	1.0	0.56	0.32	0.18	0.10	0.056	0.032	0.018	0.01
Na	1.041	8.6	3.520	2.116	1.496	1.285	1.149	1.076	1.045	1.026	1.015	1.007	1.003	1.010	1.000
Mg	1.254	8.0	3.334	2.030	1.464	1.272	1.149	1.084	1.055	1.032	1.018	1.009	1.003	1.010	1.000
Al	1.487	6.2	2.732	1.745	1.341	1.203	1.112	1.063	1.041	1.023	1.012	1.006	1.003	1.010	1.000
Si	1.740	4.0	1.989	1.391	1.184	1.111	1.062	1.036	1.023	1.014	1.009	1.004	1.002	1.001	1.000
P	2.015	3.4	1.787	1.292	1.138	1.082	1.044	1.023	1.014	1.008	1.004	1.002	1.001	1.001	1.000
S	2.307	2.6	1.526	1.163	1.077	1.045	1.024	1.013	1.007	1.004	1.003	1.001	1.001	1.001	1.000
Cl	2.622	2.9	1.642	1.221	1.106	1.064	1.034	1.017	1.010	1.007	1.004	1.002	1.001	1.001	1.000
Ar	*2.957*	2.5	1.507	1.154	1.074	1.045	1.024	1.013	1.008	1.004	1.002	1.001	1.001	1.000	1.000
K	3.312	2.1	1.372	1.088	1.043	1.026	1.015	1.008	1.005	1.002	1.001	1.000	1.000	1.000	1.000
Ca	3.690	2.1	1.358	1.080	1.039	1.024	1.013	1.008	1.005	1.001	1.000	1.000	1.000	1.000	1.000
Sc	4.088	2.0	1.340	1.071	1.035	1.022	1.012	1.007	1.004	1.001	1.000	1.000	1.000	1.000	1.000
Ti	4.508	2.0	1.322	1.062	1.031	1.019	1.011	1.006	1.003	1.001	1.000	1.000	1.000	1.000	1.000
V	4.949	1.9	1.291	1.046	1.022	1.013	1.007	1.004	1.003	1.001	1.000	1.000	1.000	1.000	1.000
Cr	5.411	1.9	1.302	1.052	1.025	1.015	1.008	1.004	1.003	1.001	1.000	1.000	1.000	1.000	1.000
Mn	5.895	1.9	1.289	1.045	1.022	1.013	1.007	1.004	1.002	1.001	1.001	1.000	1.000	1.000	1.000
Fe	6.400	1.9	1.286	1.044	1.021	1.013	1.007	1.005	1.003	1.001	1.000	1.000	1.000	1.000	1.000
Co	6.925	1.9	1.288	1.045	1.022	1.013	1.007	1.004	1.003	1.001	1.000	1.000	1.000	1.000	1.000
Ni	7.472	1.9	1.291	1.046	1.022	1.013	1.007	1.004	1.002	1.001	1.001	1.000	1.000	1.000	1.000
Cu	8.041	1.8	1.274	1.038	1.018	1.011	1.006	1.003	1.002	1.001	1.001	1.000	1.000	1.000	1.000
Zn	8.631	1.8	1.265	1.033	1.016	1.009	1.005	1.003	1.002	1.001	1.001	1.000	1.000	1.000	1.000
Ga	9.243	1.8	1.274	1.038	1.018	1.011	1.006	1.003	1.002	1.001	1.001	1.000	1.000	1.000	1.000
Ge	9.876	1.8	1.274	1.038	1.018	1.011	1.006	1.003	1.002	1.001	1.001	1.000	1.000	1.000	1.000
As	10.532	1.8	1.274	1.038	1.018	1.011	1.006	1.003	1.002	1.001	1.001	1.000	1.000	1.000	1.000
Se	11.210	1.8	1.274	1.038	1.018	1.011	1.006	1.003	1.002	1.001	1.001	1.000	1.000	1.000	1.000
Br	11.907	1.9	1.284	1.042	1.020	1.012	1.006	1.003	1.002	1.001	1.001	1.000	1.000	1.000	1.000
Pb	10.543	1.9	1.313	1.058	1.028	1.016	1.009	1.005	1.003	1.002	1.002	1.000	1.000	1.000	1.000
		Note: The value for MOUDI Stage 1 is merely an estimate, +/- 30%.													

Appendix A - XRF NIST Traceable Calibration Standard Certification for S-XRF

1. 59 standards, 65 certified values

   Micromatter Co. NIST traceable standards Li -U

   jheagney@micromatter.com

2. NIST SRM # 1832, and 1833, 12 certified elements, Al – Pb

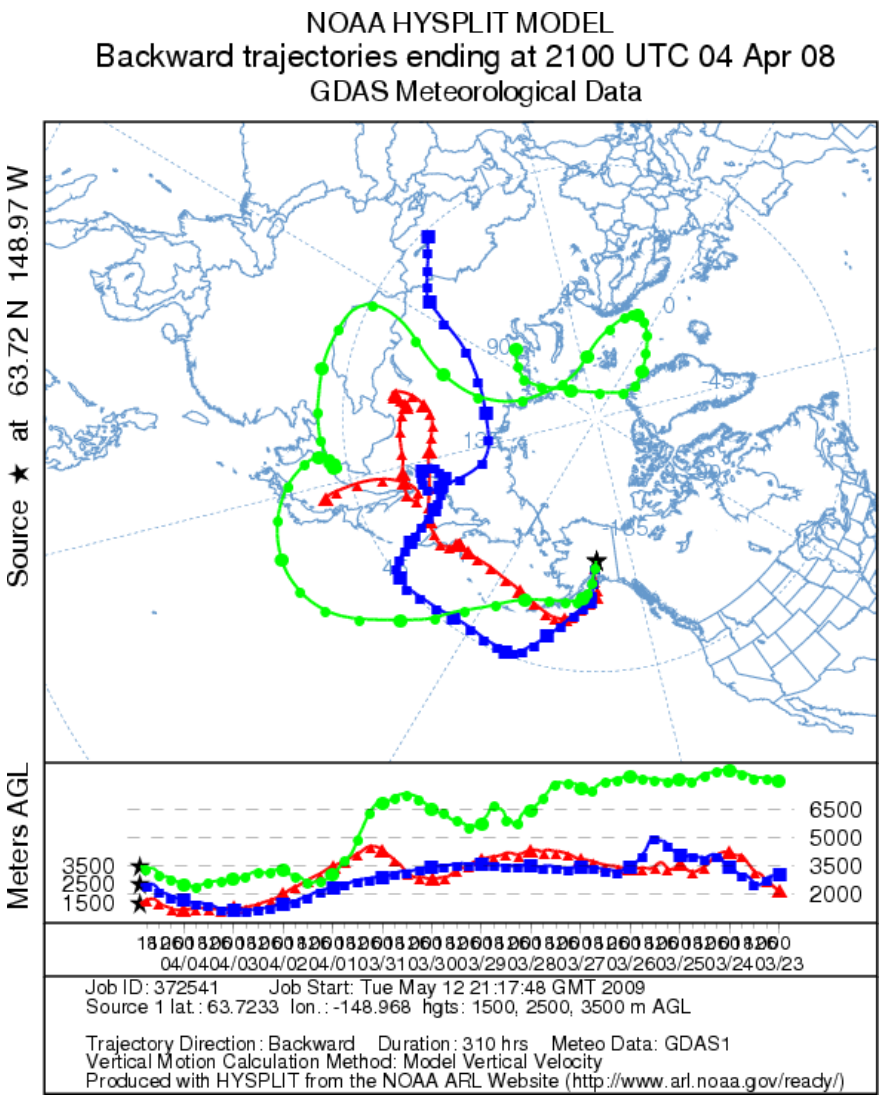
Standard Compound	Serial #	Aereal density $\mu g/cm^2$ +/- 5%	Element 1 $\mu g/cm^2$ +/- 5%	Element 2 $\mu g/cm^2$ +/- 5%
Lithium as LiF	12518	45.6		
Sodium Chloride	12519	46.0	18.1	27.9
Magnesium metal	12520	48.7		
Aluminum metal	12521	51.0		
Silicon as SiO	12522	45.1	28.7	
Phosphorus or gallium as GaP (not stoichiometric)	12523	43.7		
Sulfur, copper as CuS_x	12524	66.0	47.9	18.1
Chlorine or Potassium as KCl	12525	46.1	24.2	21.9
Potassium or Iodine as KI	12526	51.5	12.1	Not given
Calcium as CaF_2	12527	47.5	24.4	39.4
Scandium as ScF_3	12528	49.5		
Titanium as Ti metal	12529	44.5		
Vanadium as V metal	12530	47.5		
Chromium as Cr metal	12531	47.5		
Manganese as Mn metal	12532	42.8		
Iron as Fe metal	12533	48.2		
Cobalt as Co metal	12534	49.2		
Nickel as Ni metal	12535	50.7		
Copper as Cu metal	12536	44.5		
Zinc as ZnTe (not stoichiometric)	12537	53.4		
Germanium as Ge metal	12538	46.0		
Arsenic as GaAs (not stoichiometric)	12539	51.8		

Selenium as Se metal	12540	48.8		
Bromine or Cesium as CsBr	12541	50.4	31.5	18.9
Rubidium of Iodine as RbI	12542	52.0	20.9	31.1
Strontium as SrF_2	12543	47.6	33.2	
Yttrium as YF_3	12544	51.4	31.3	
Niobium as Nb_2O_3	12545	52.9	42.0	
Molybdenum as MoO_3	12546	52.2	34.8	
Rhodium as Rh metal	12547	44.3		
Palladium as Pd metal	12548	43.1		
Silver as Ag metal	12549	43.7		
Cadmium as CdSe (not stoichiometric)	12550	46.8		
Indium as In metal	12551	48.0		
Tin as Sn metal	12552	45.2		
Antimony as Sb metal	12553	50.8		
Tellurium as Te metal	12554	43.1		
Barium as BaF_2	12555	46.7		
Lanthanum as LaF_3	12556	44.1		
Cerium as CeF_3	12557	46.5		
Praseodymium as PrF_3	12558	47.2		
Neodymium as NdF_3	12559	51.2		
Samarium as SmF_3	12560	51.2		
Europium as EuF_3	12561	40.9		
Gadolinium as GdF_3	12562	50.2		
Terbium as TbF_3	12563	47.2		
Dysprosium as DyF_3	12564	48.8		
Holmium as HoF_3	12565	50.2		
Erbium as ErF_3	12566	47.3		
Thulium as TmF_3	12567	46.0		
Ytterbium as YbF_3	12568	50.0		
Lutetium as LuF_3	12569	46.0		
Tungsten as WO_3	12570	49.3		
Platinum as Pt metal	12571	45.1		
Gold as Au metal	12572	44.8		
Thallium as TlCl	12573	43.6		
Lead as Pb metal	12574	52.4		
Bismuth as Bi metal	12575	45.7		

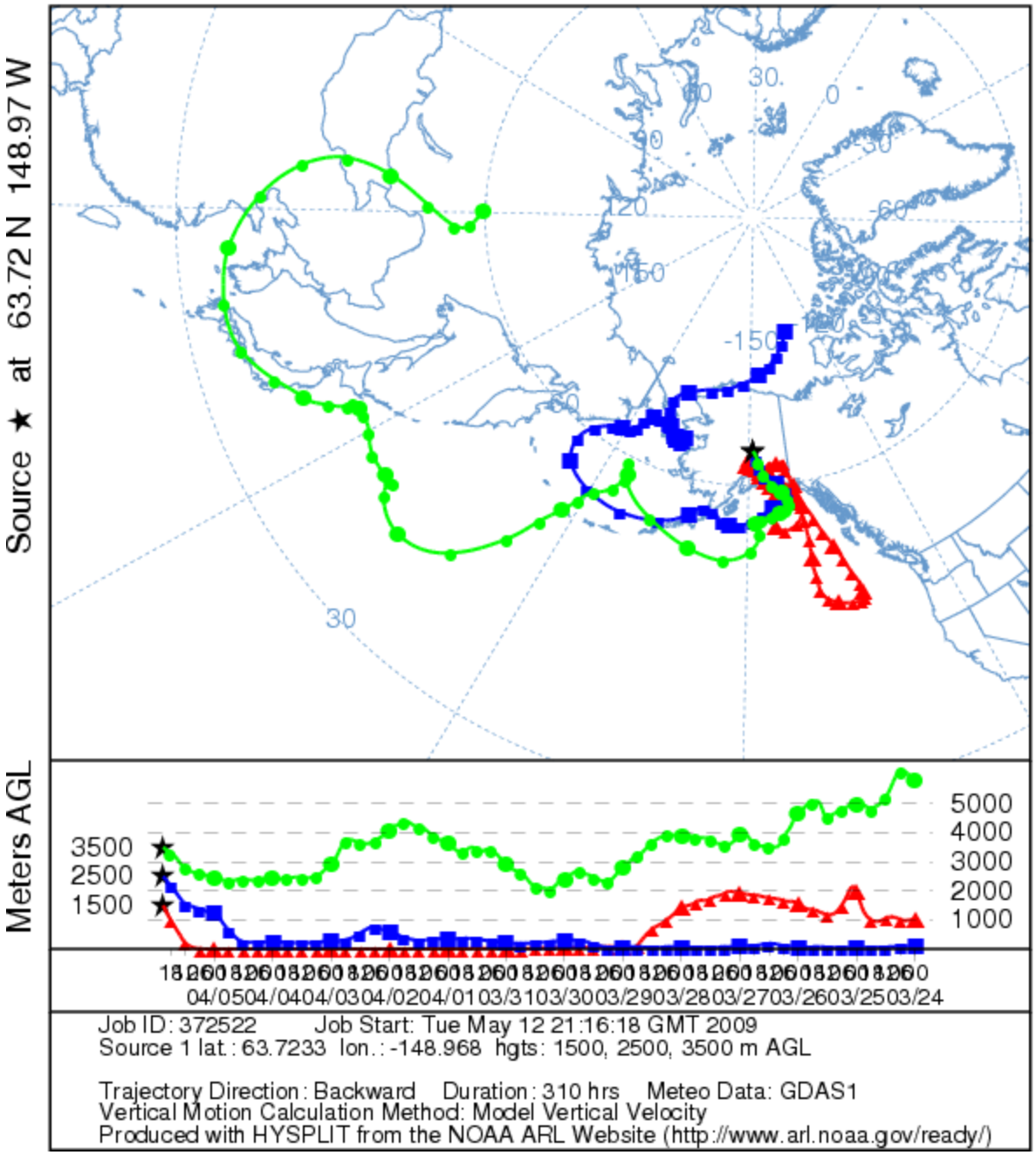
Thorium as ThF_4 (radioactive) ?!	12576	51.6		
Uranium as UF_4	12577	46.3		
Backing 6.3 micron Mylar, deposit to rings				
NIST 1832	Al 12.1	Si 28.7	Ca 18.1	V 4.5
	Mn 4.3	Co 0.98	Cu 2.3	
(note: requires abs corr.)				
NIST 1833	Si 29.1	K 16.5	Ti 12.6	Fe 14.2
	Zn 3.9			
(note: requires abs corr.)				

6.3 Appendix C HYSPLIT Models: April 3-26, 2008

C-1 Denali Headquarters- Low Level, 310 hours


NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 04 Apr 08
GDAS Meteorological Data
Source ★ at 63.72 N 148.97 W
Meters AGL
6500
5000
3500
2000
3500
2500
1500
04/0404/0304/0204/0103/3103/3003/2903/2803/2703/2603/2503/2403/23
Job ID: 372541 Job Start: Tue May 12 21:17:48 GMT 2009
Source 1 lat.: 63.7233 lon.: -148.968 hgts: 1500, 2500, 3500 m AGL
Trajectory Direction: Backward Duration: 310 hrs Meteo Data: GDAS1
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 05 Apr 08
GDAS Meteorological Data



NOAA HYSPLIT MODEL
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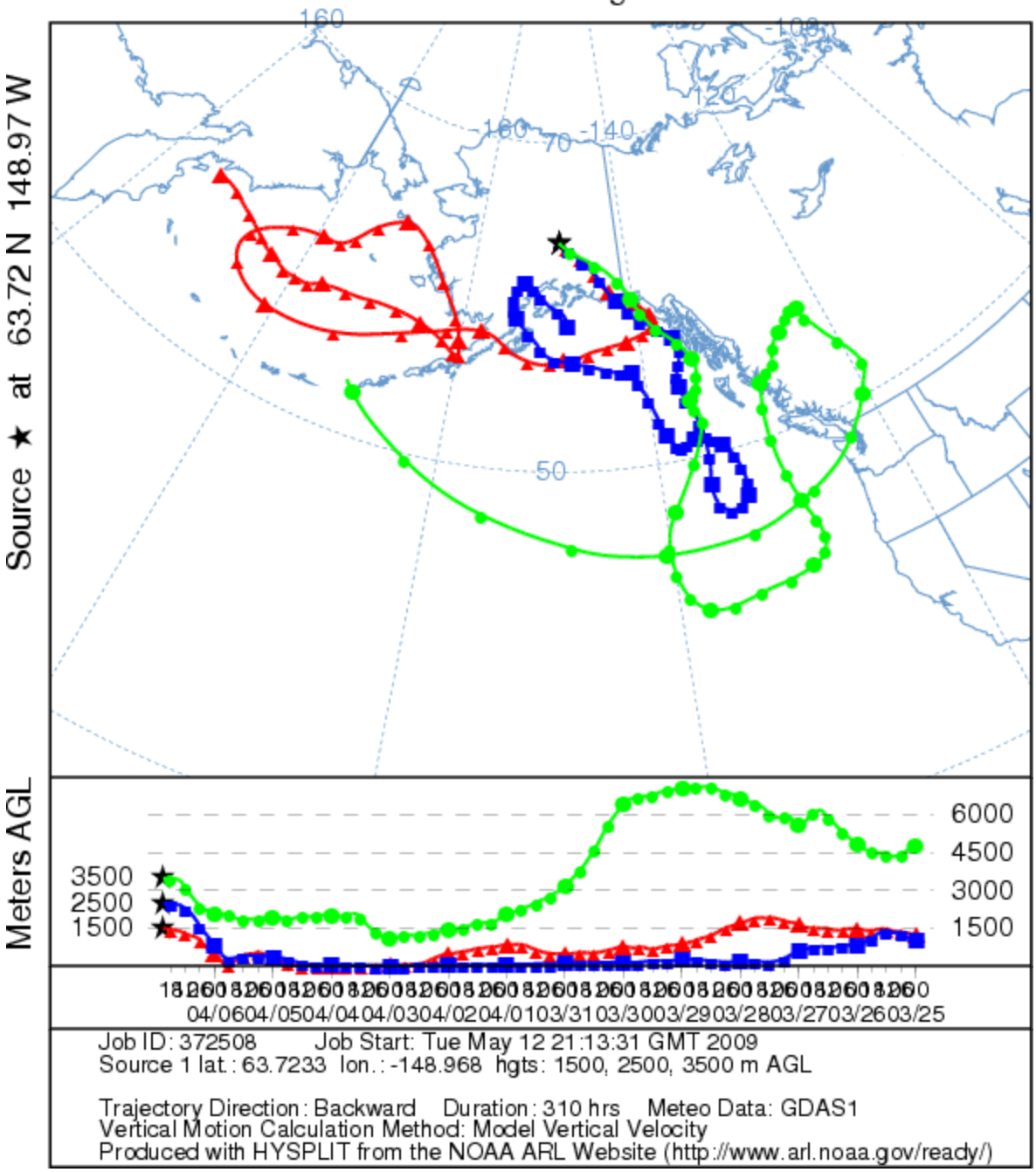
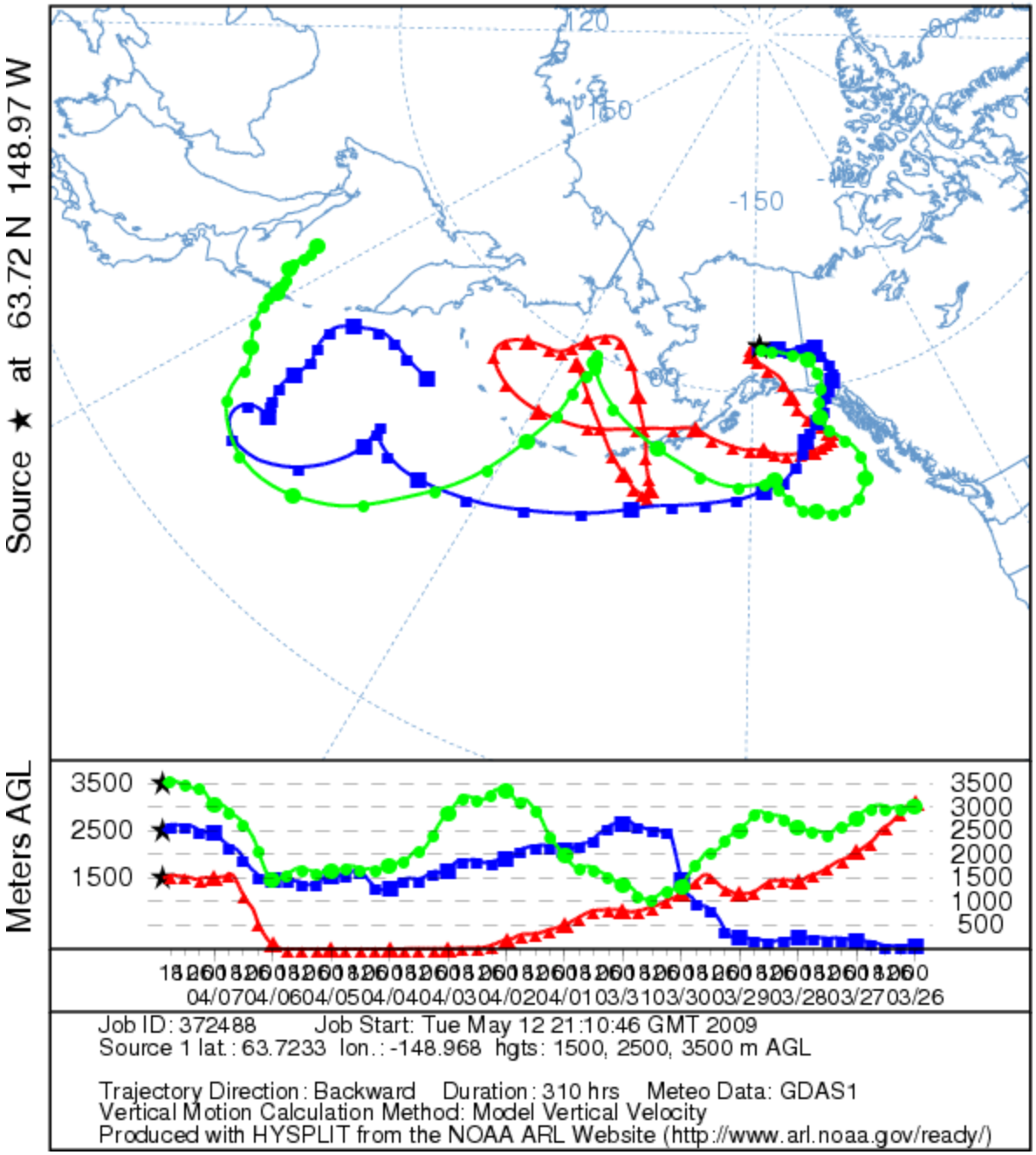
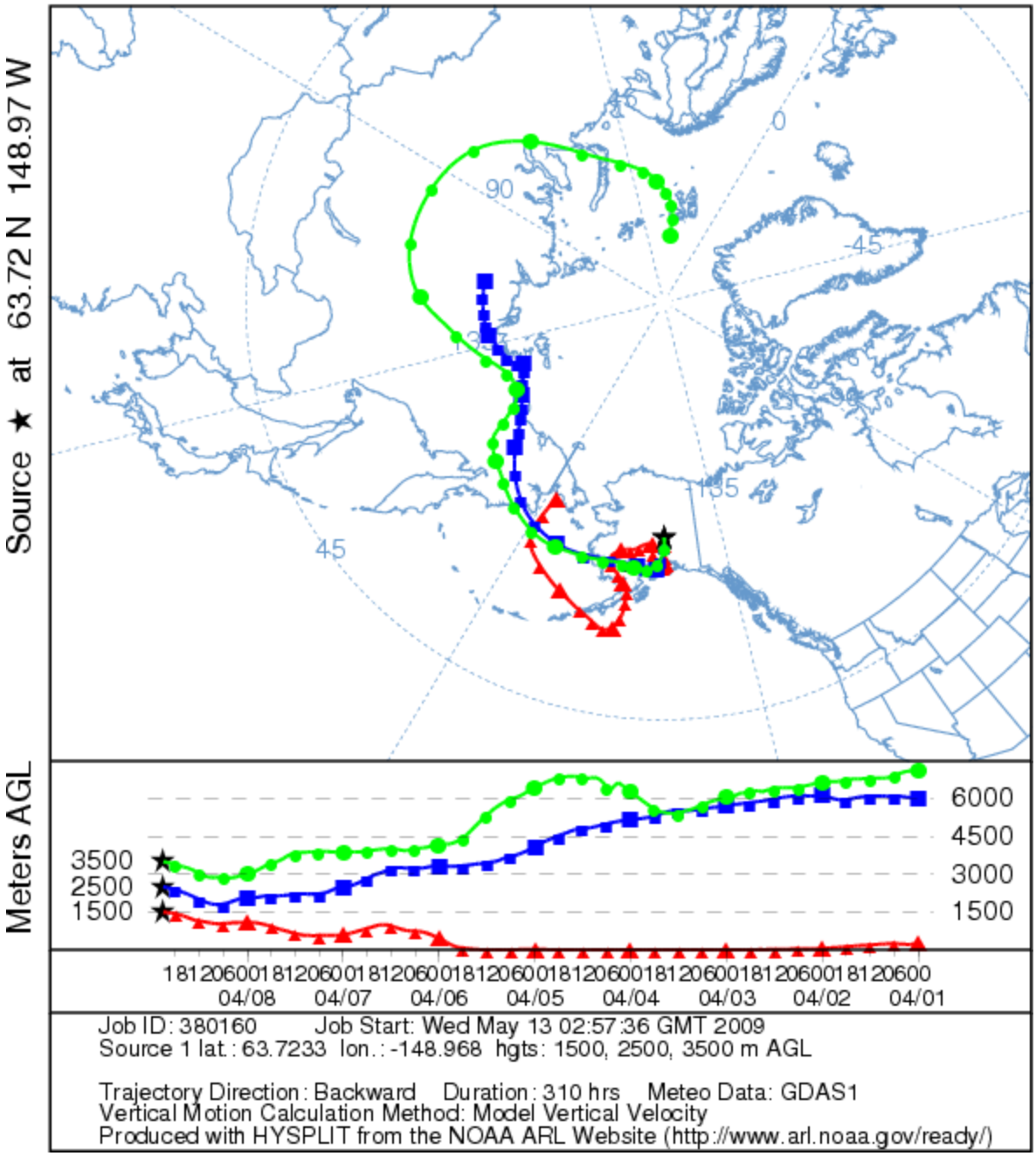
GDAS Meteorological Data



NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 07 Apr 08
GDAS Meteorological Data



NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 08 Apr 08
GDAS Meteorological Data



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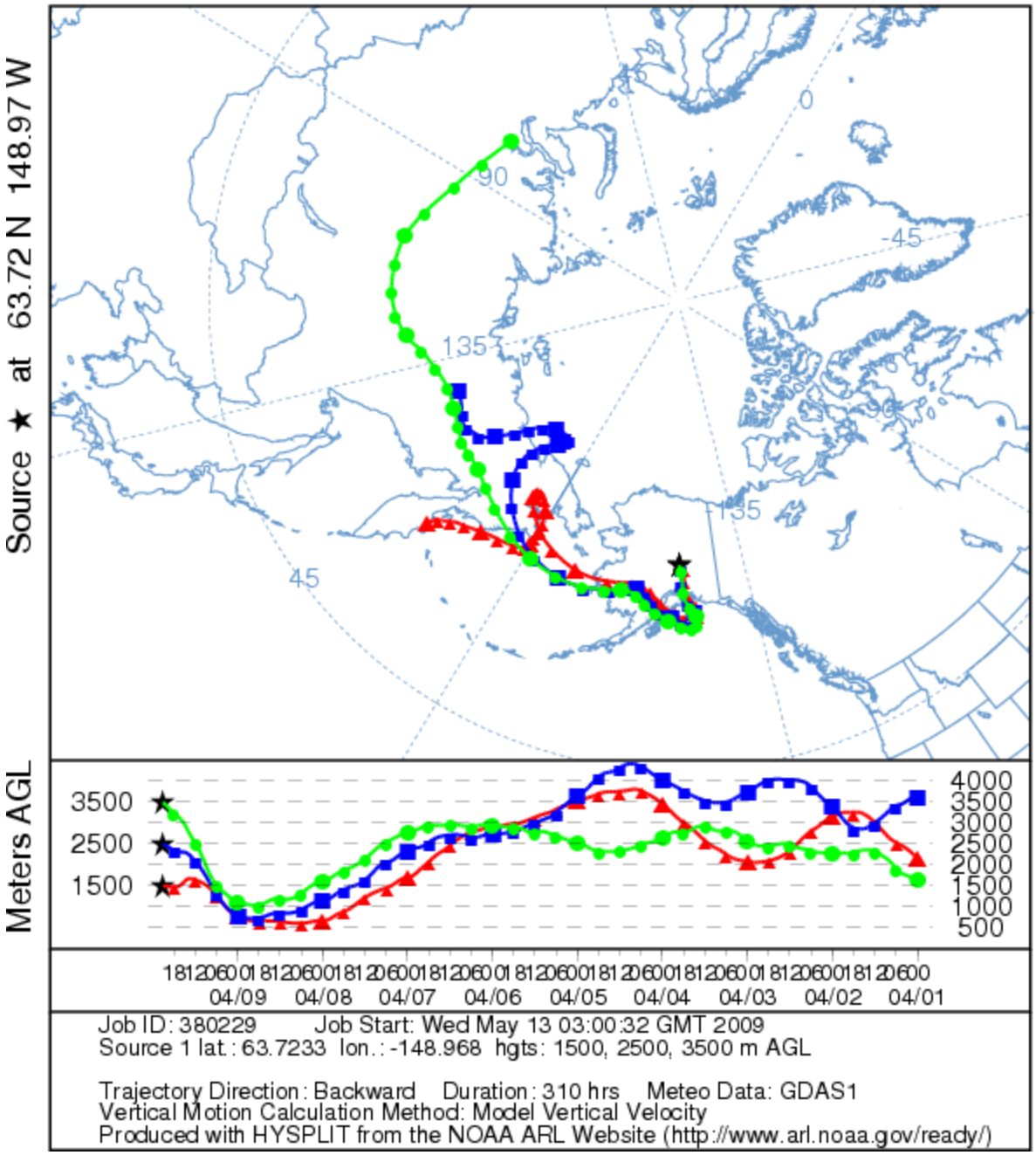
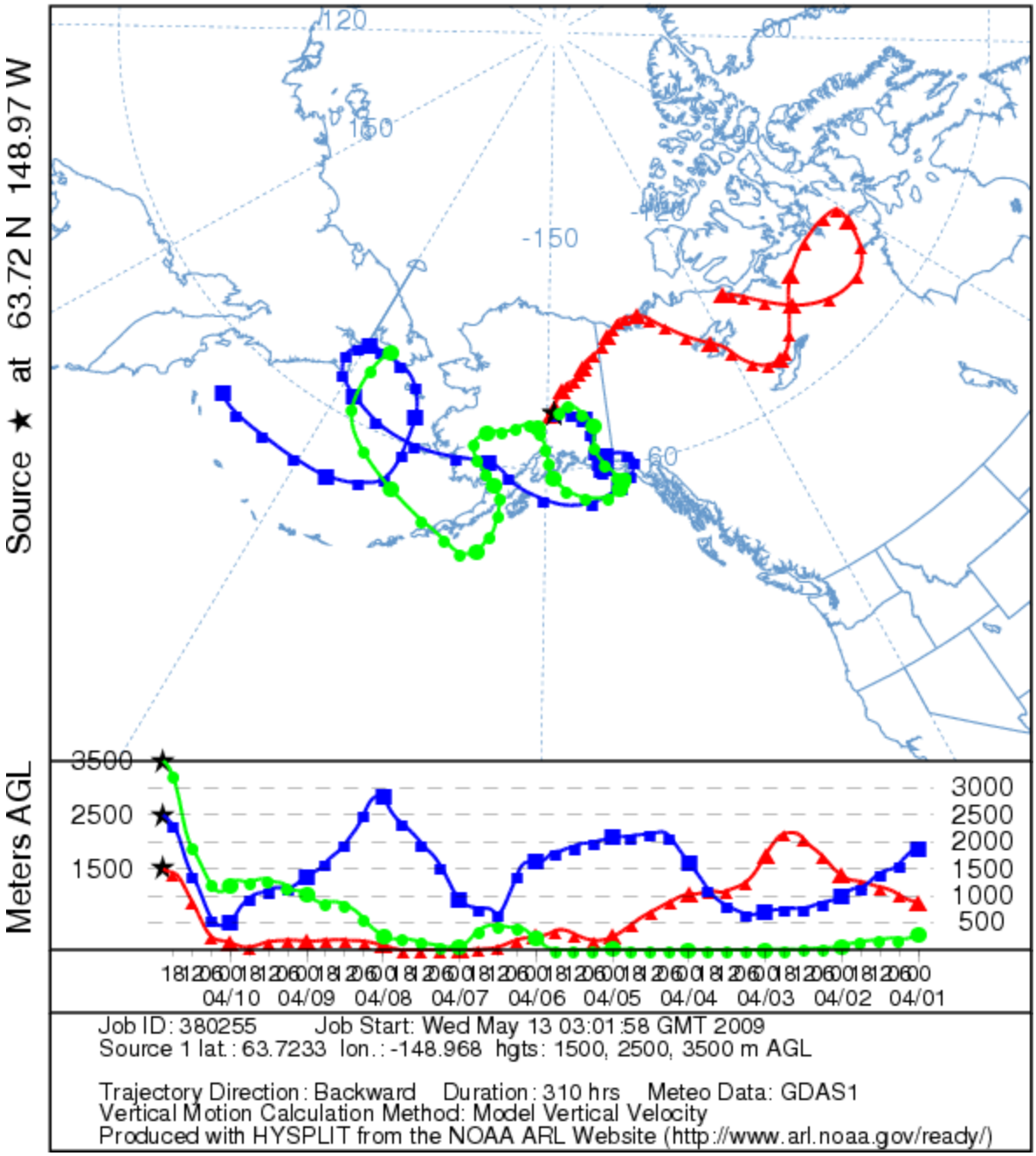
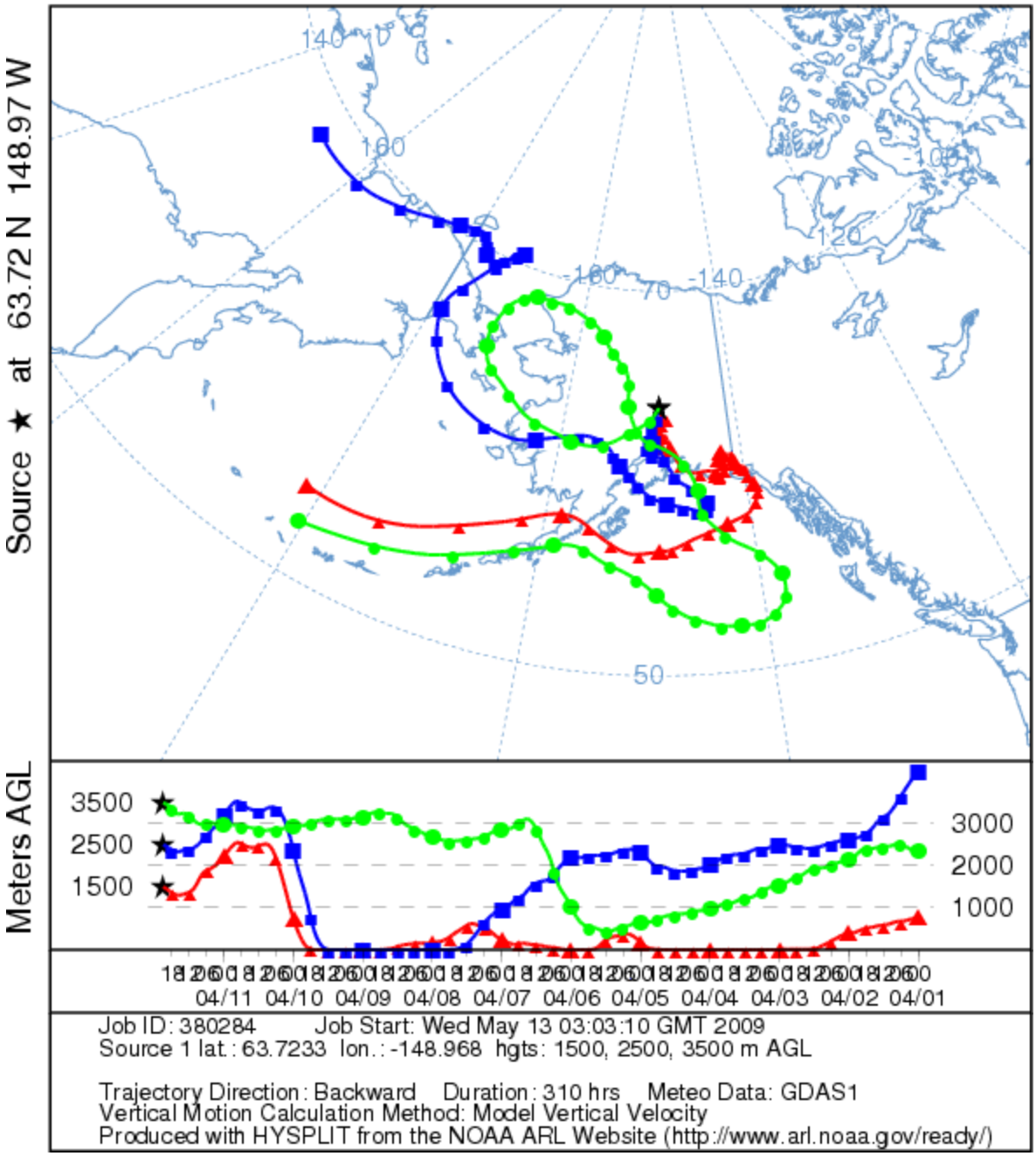
Backward trajectories ending at 2100 UTC 09 Apr 08
GDAS Meteorological Data



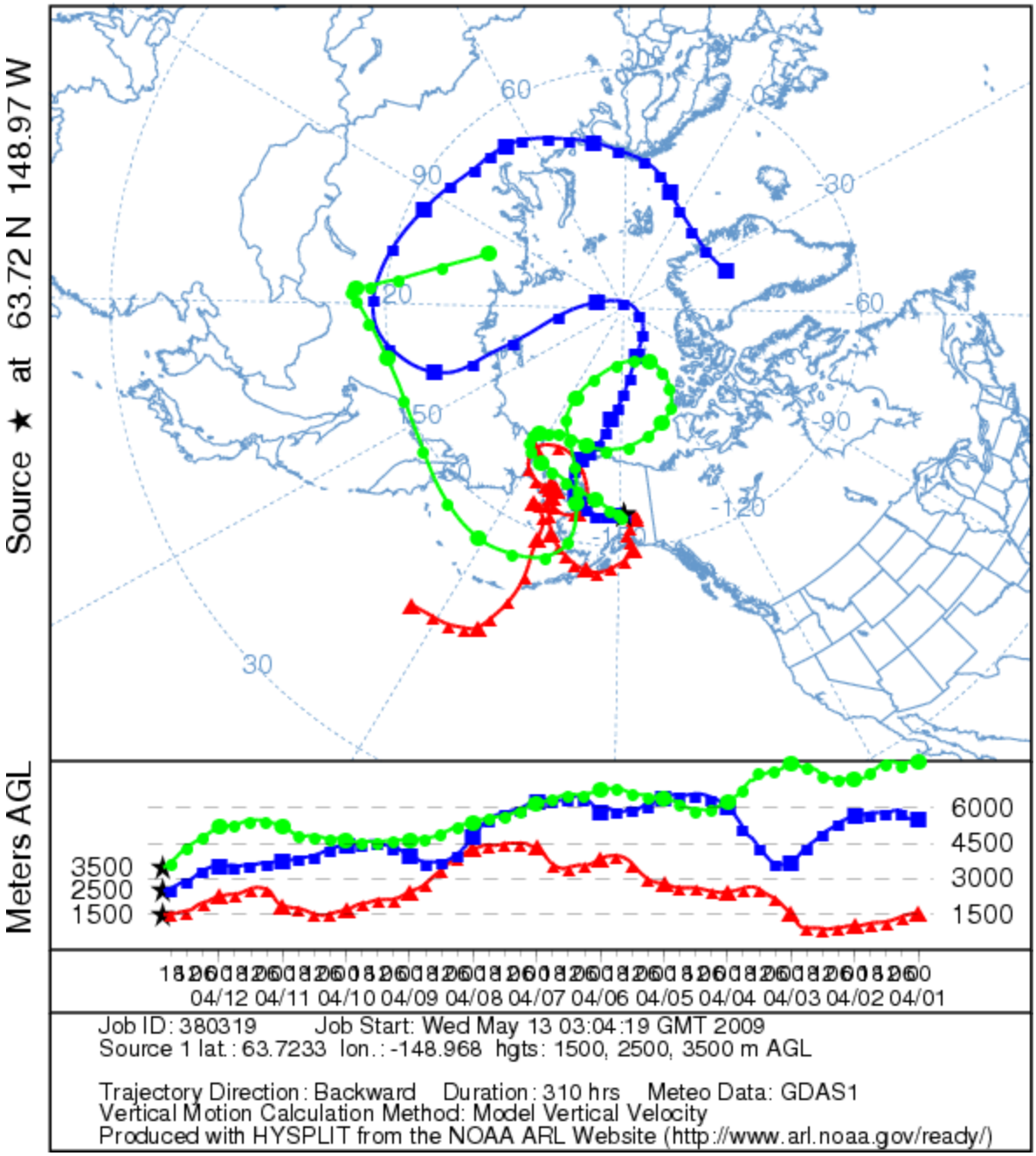
NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 10 Apr 08
GDAS Meteorological Data



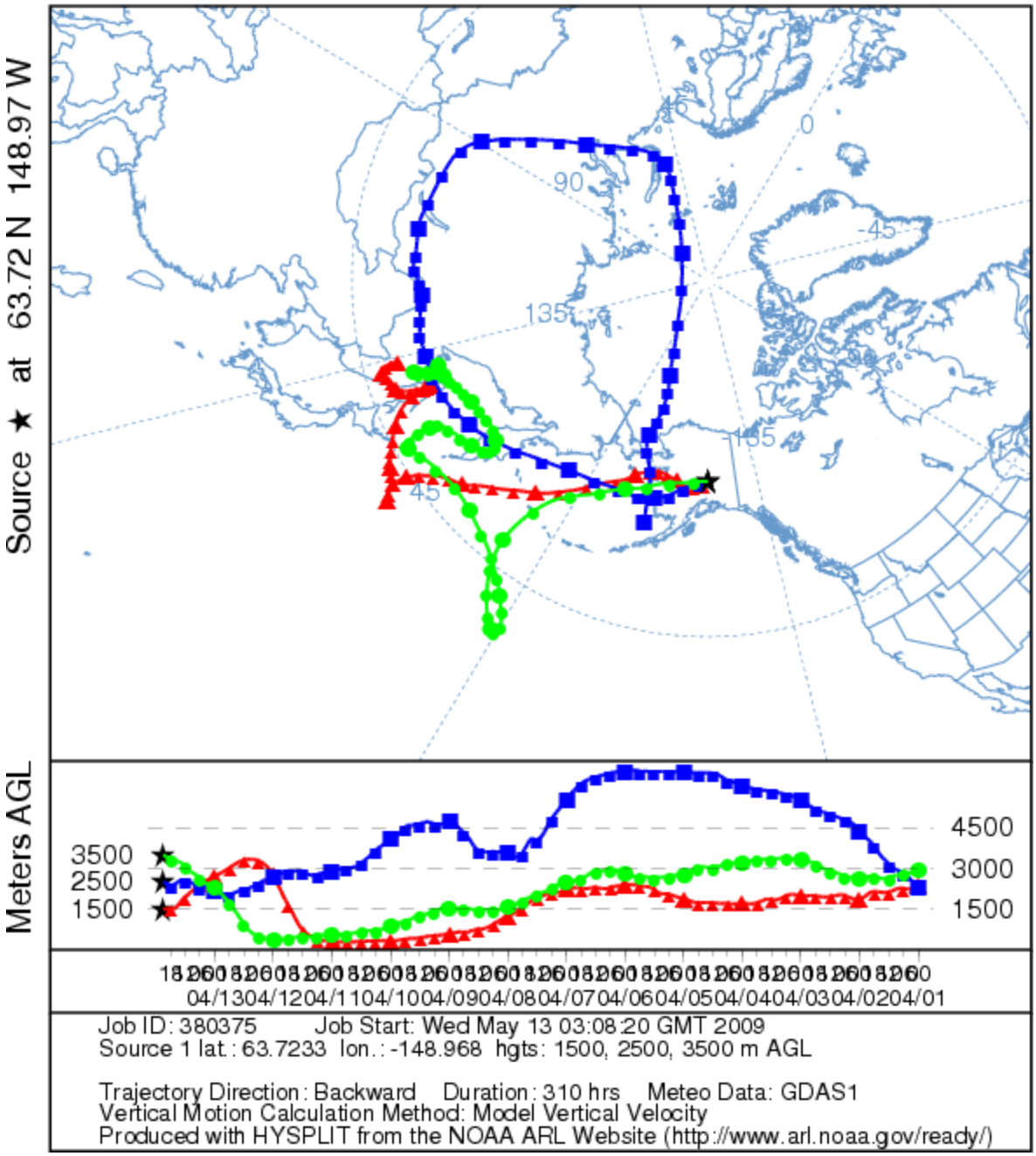
NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 11 Apr 08
GDAS Meteorological Data



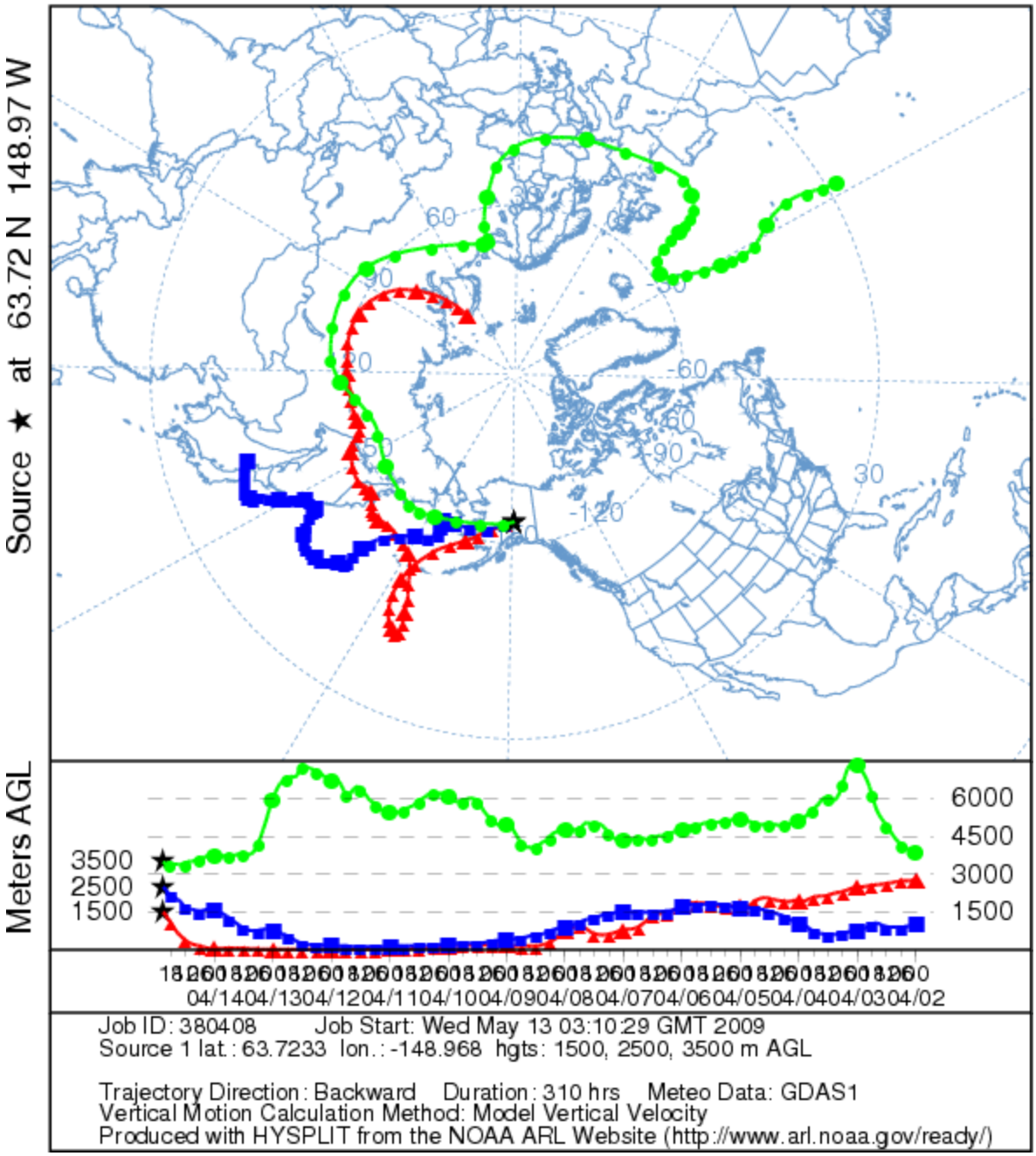
NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 12 Apr 08
GDAS Meteorological Data



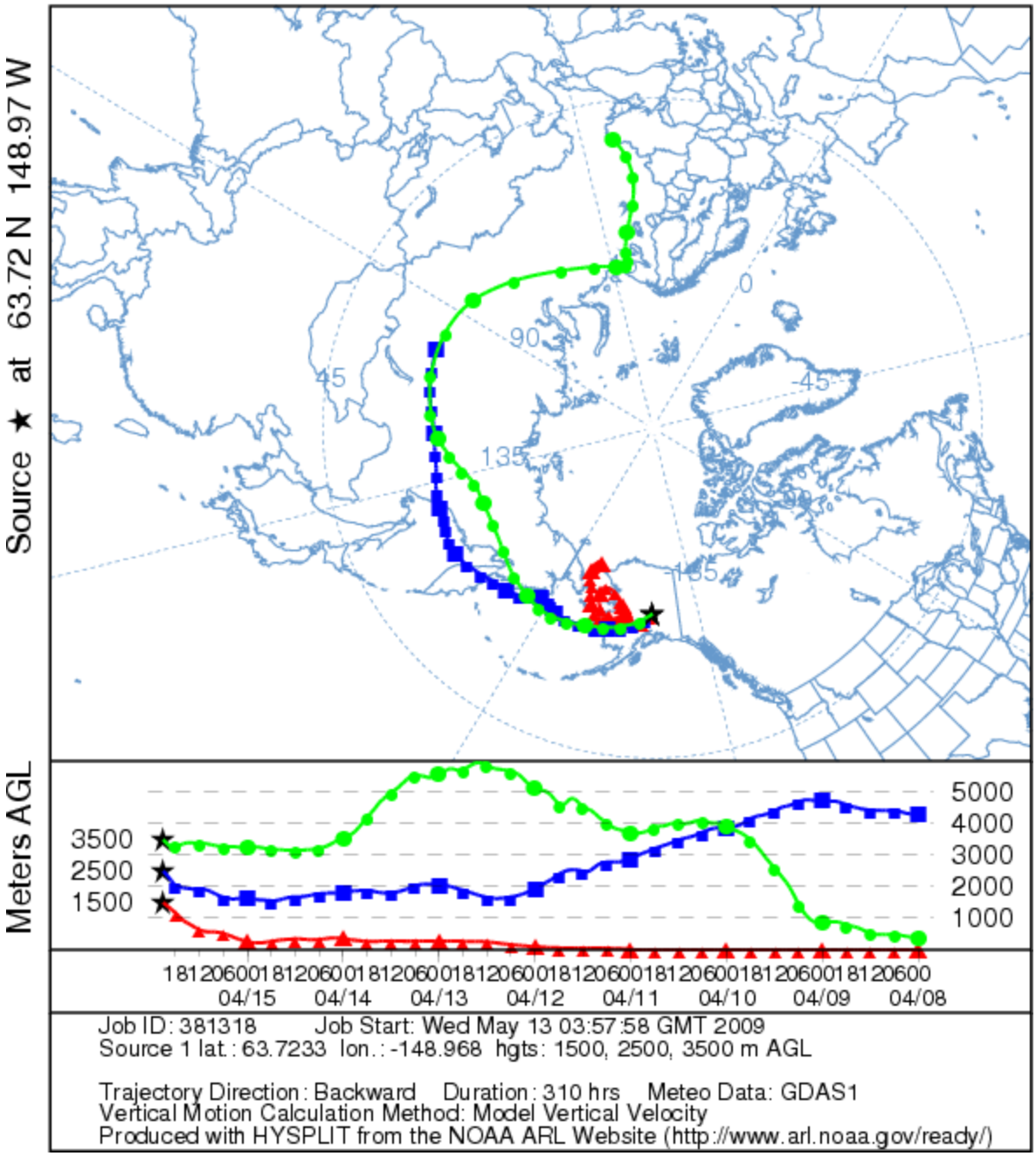
NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 13 Apr 08
GDAS Meteorological Data



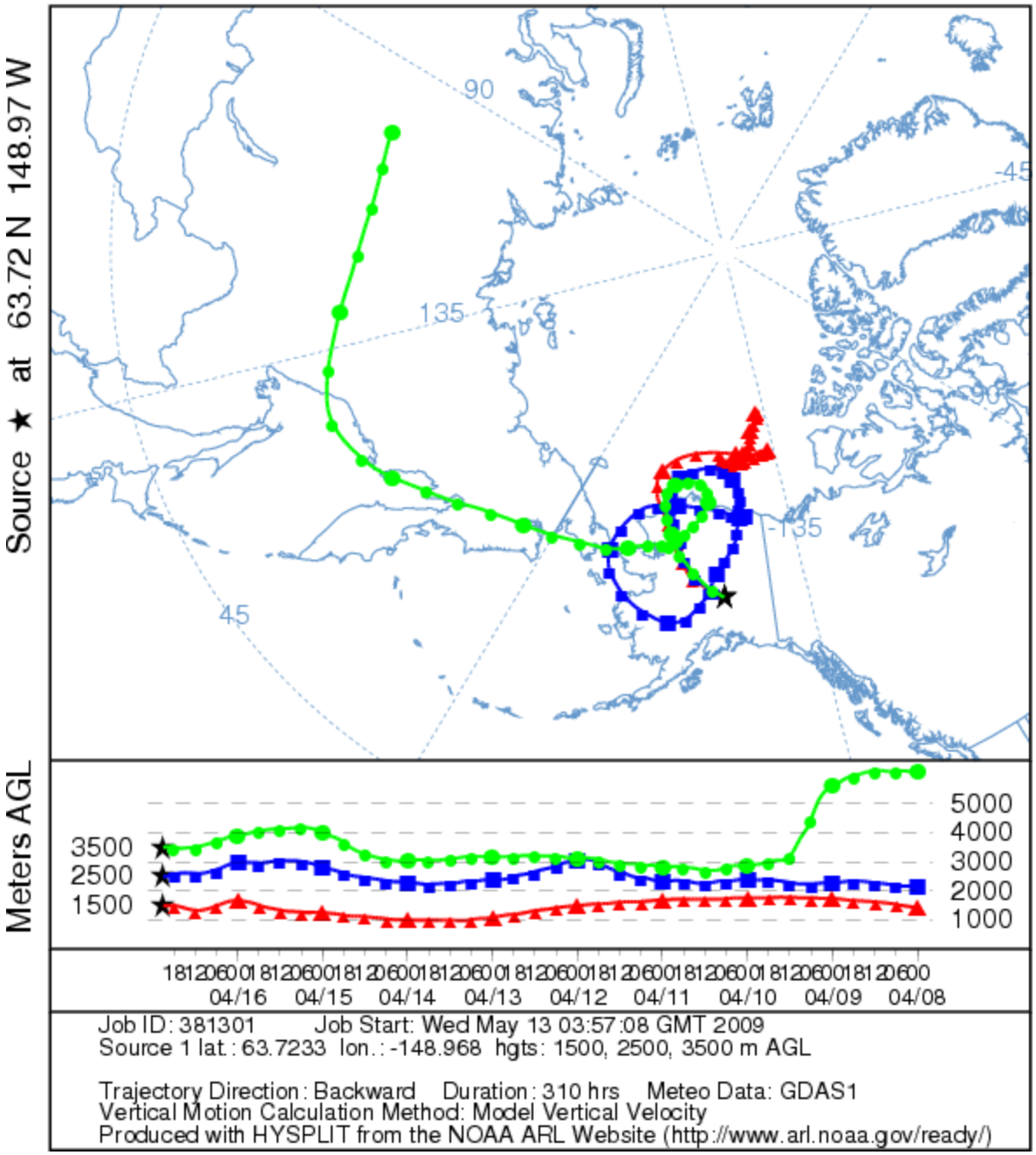
NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 14 Apr 08
GDAS Meteorological Data



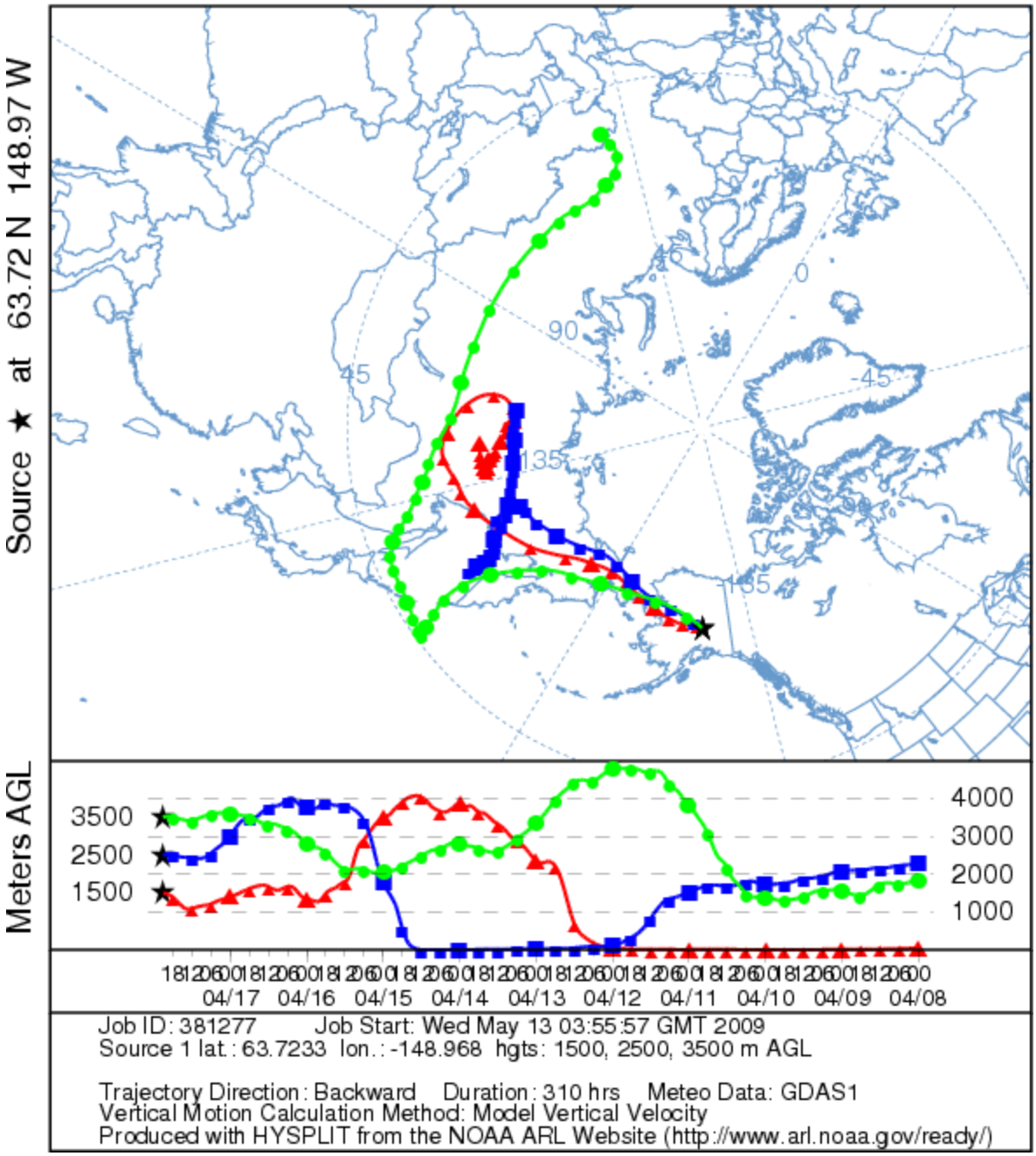
NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 15 Apr 08
GDAS Meteorological Data



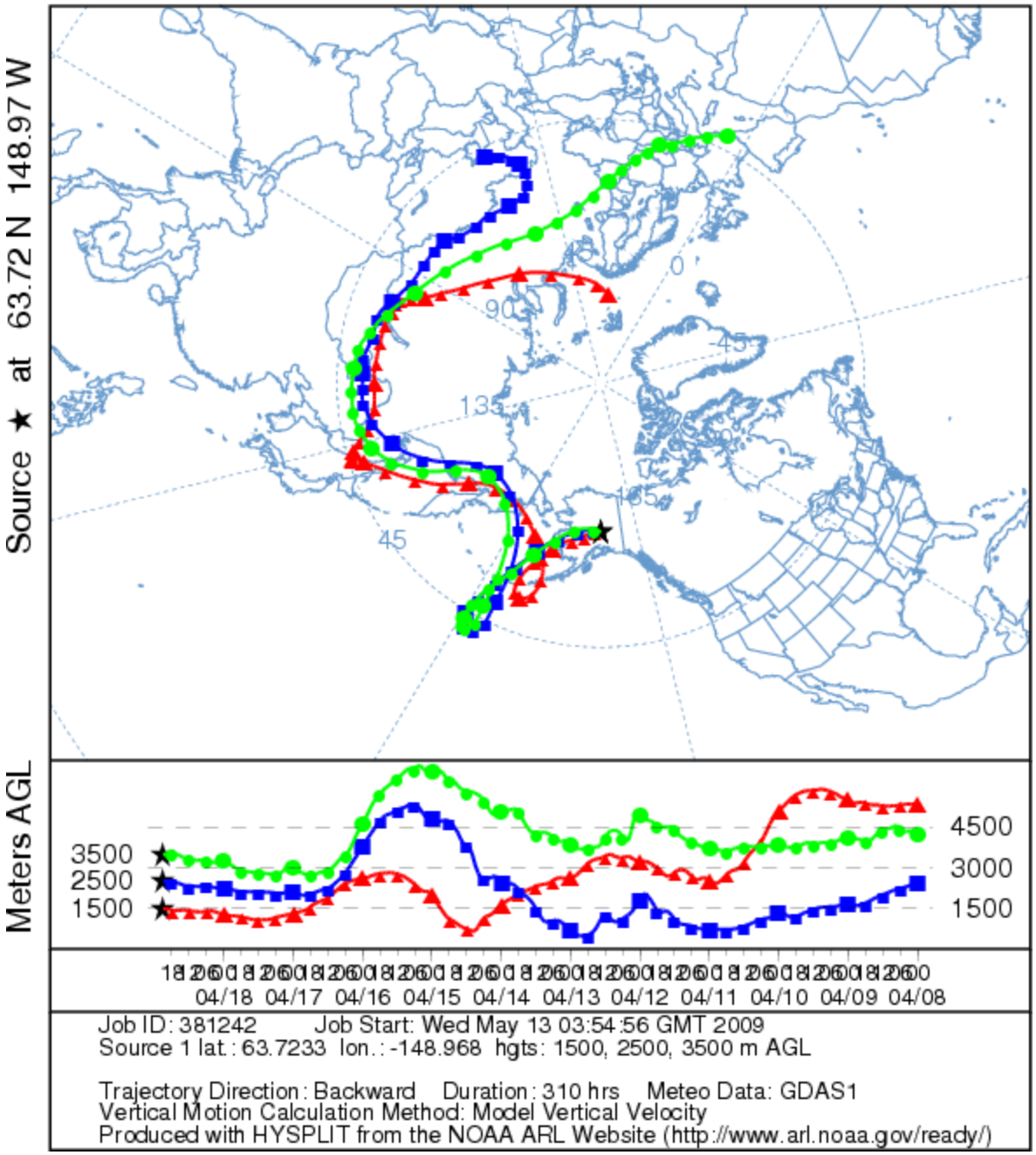
NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 16 Apr 08
GDAS Meteorological Data



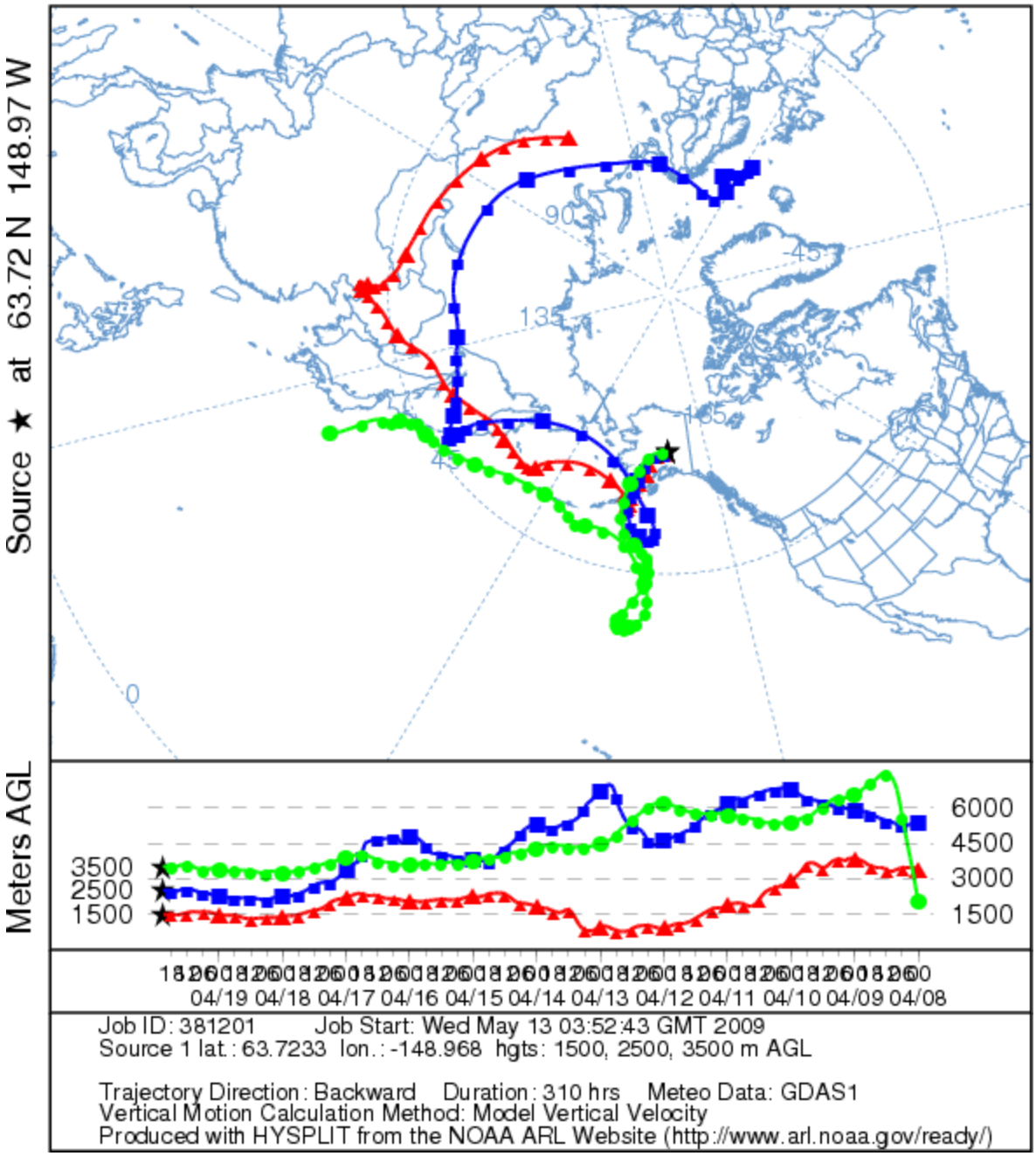
NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 17 Apr 08
GDAS Meteorological Data



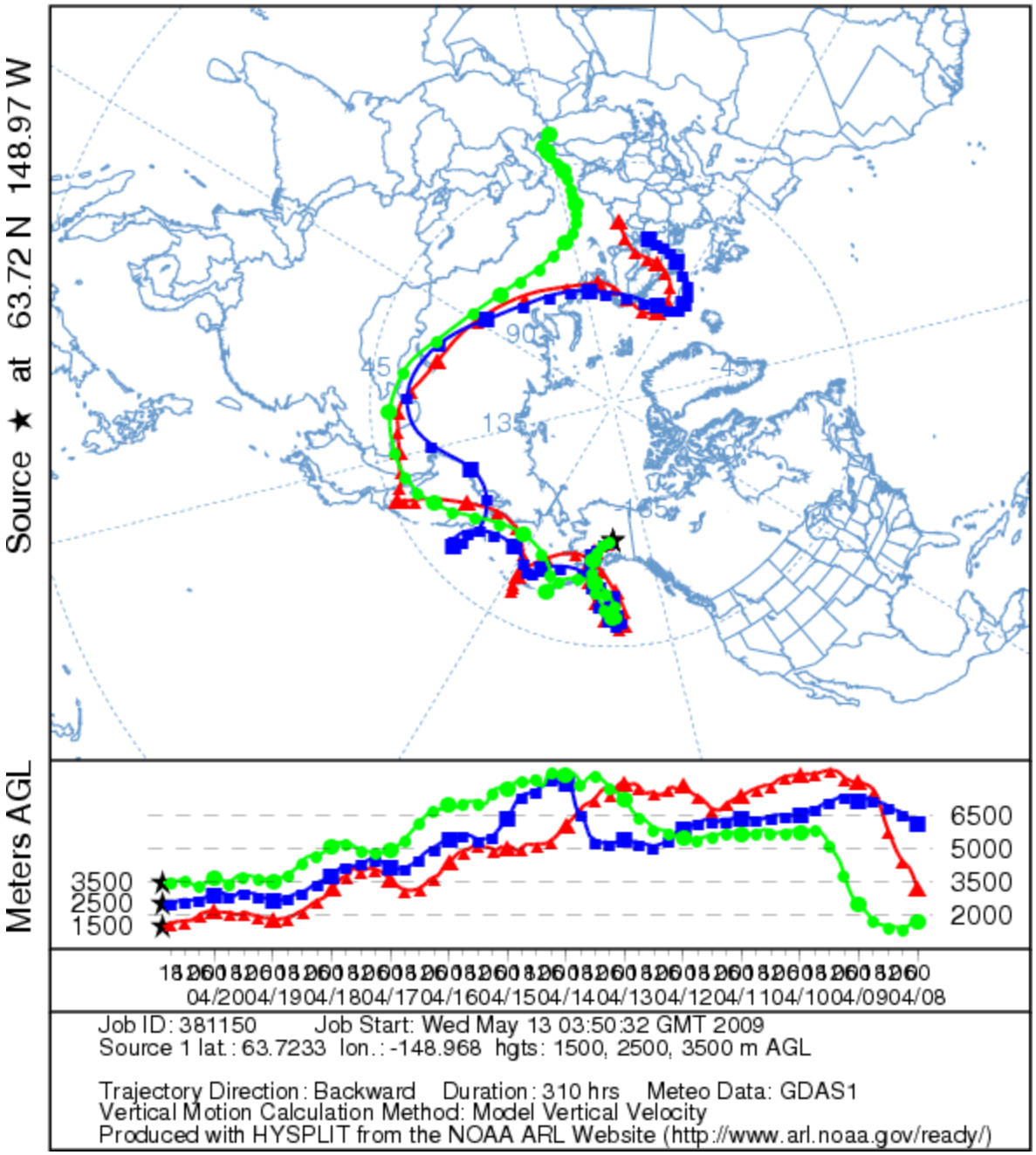
NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 18 Apr 08
GDAS Meteorological Data



NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 19 Apr 08
GDAS Meteorological Data



NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 20 Apr 08
GDAS Meteorological Data



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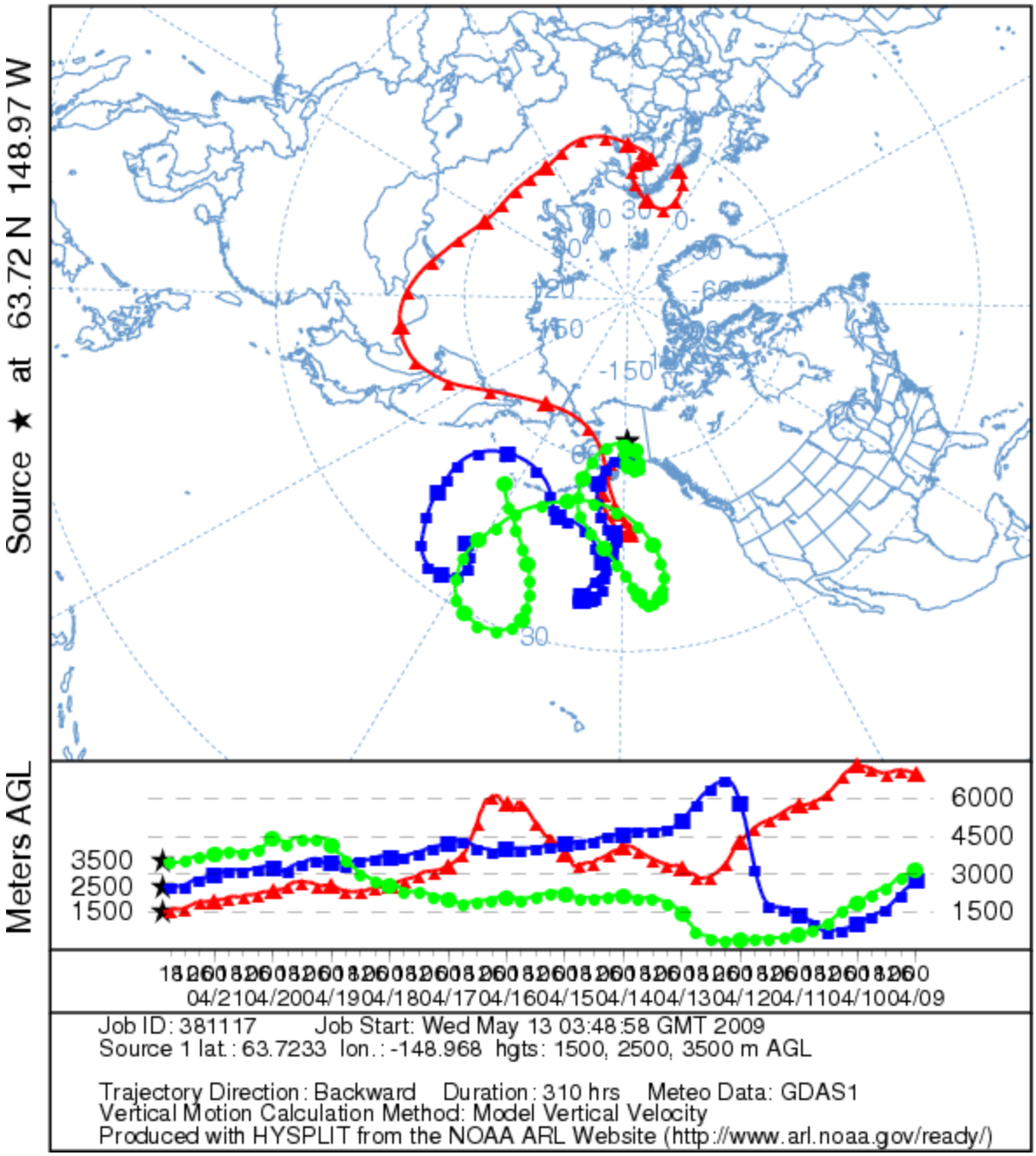
Backward trajectories ending at 2100 UTC 21 Apr 08
GDAS Meteorological Data



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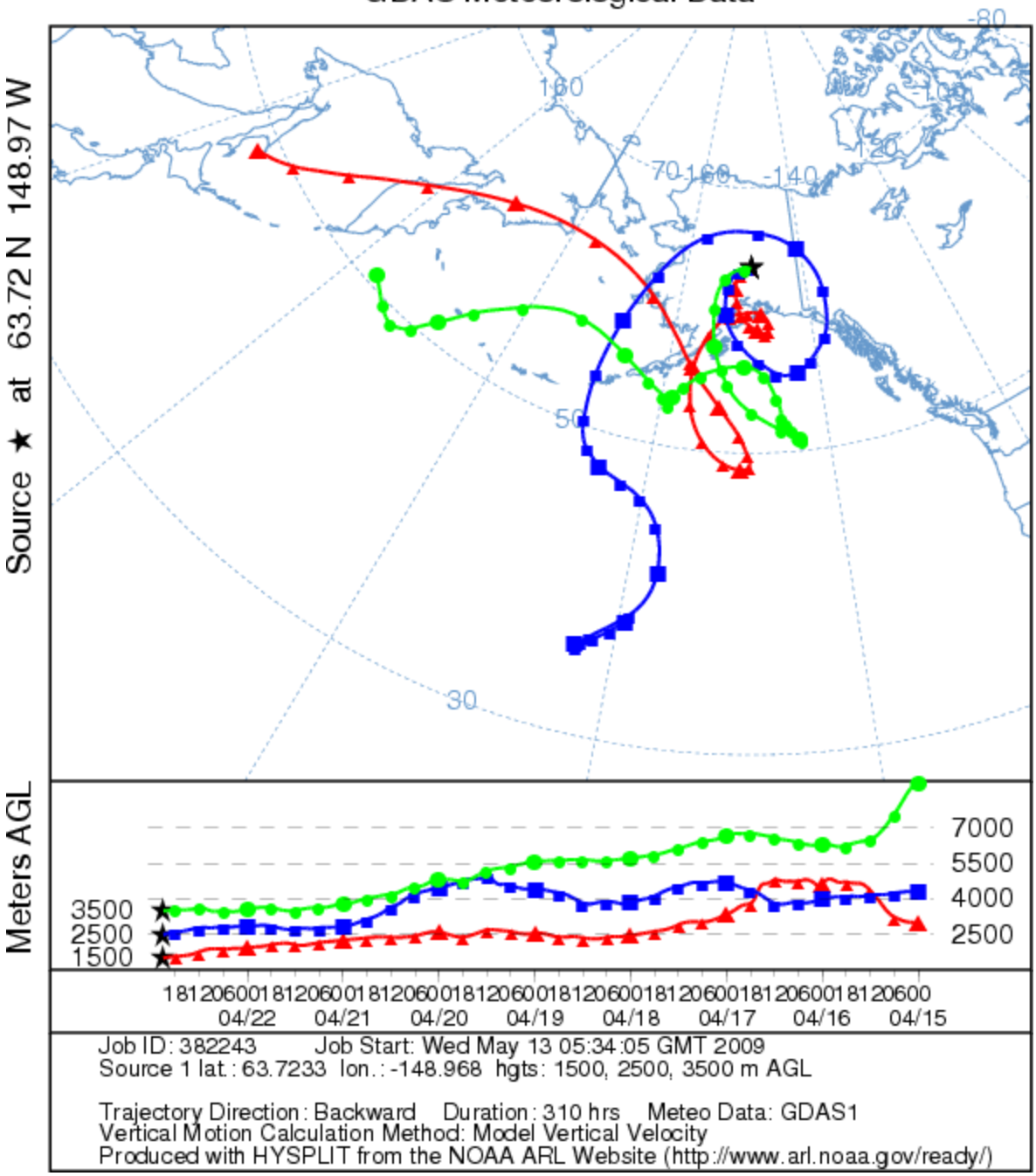
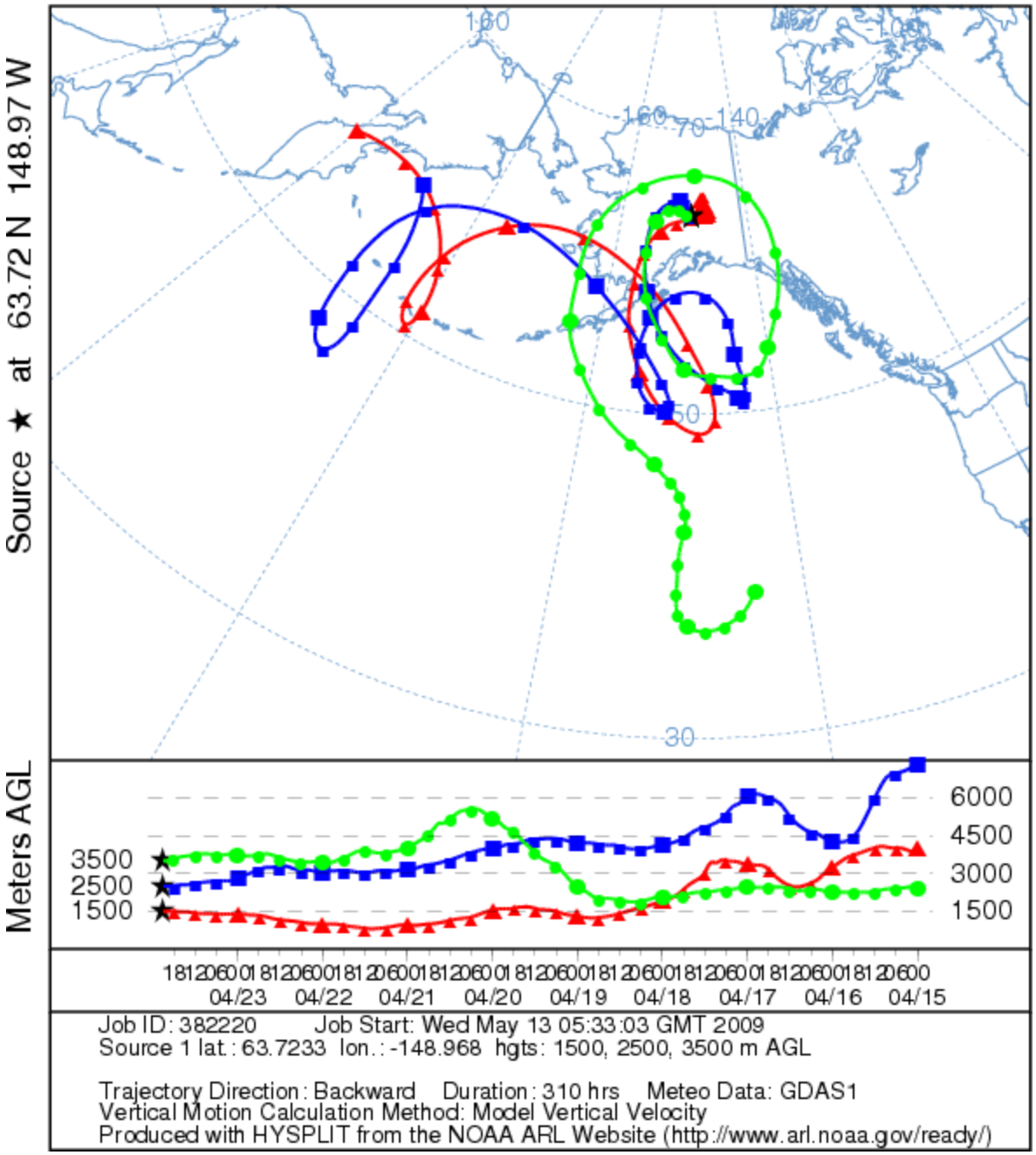
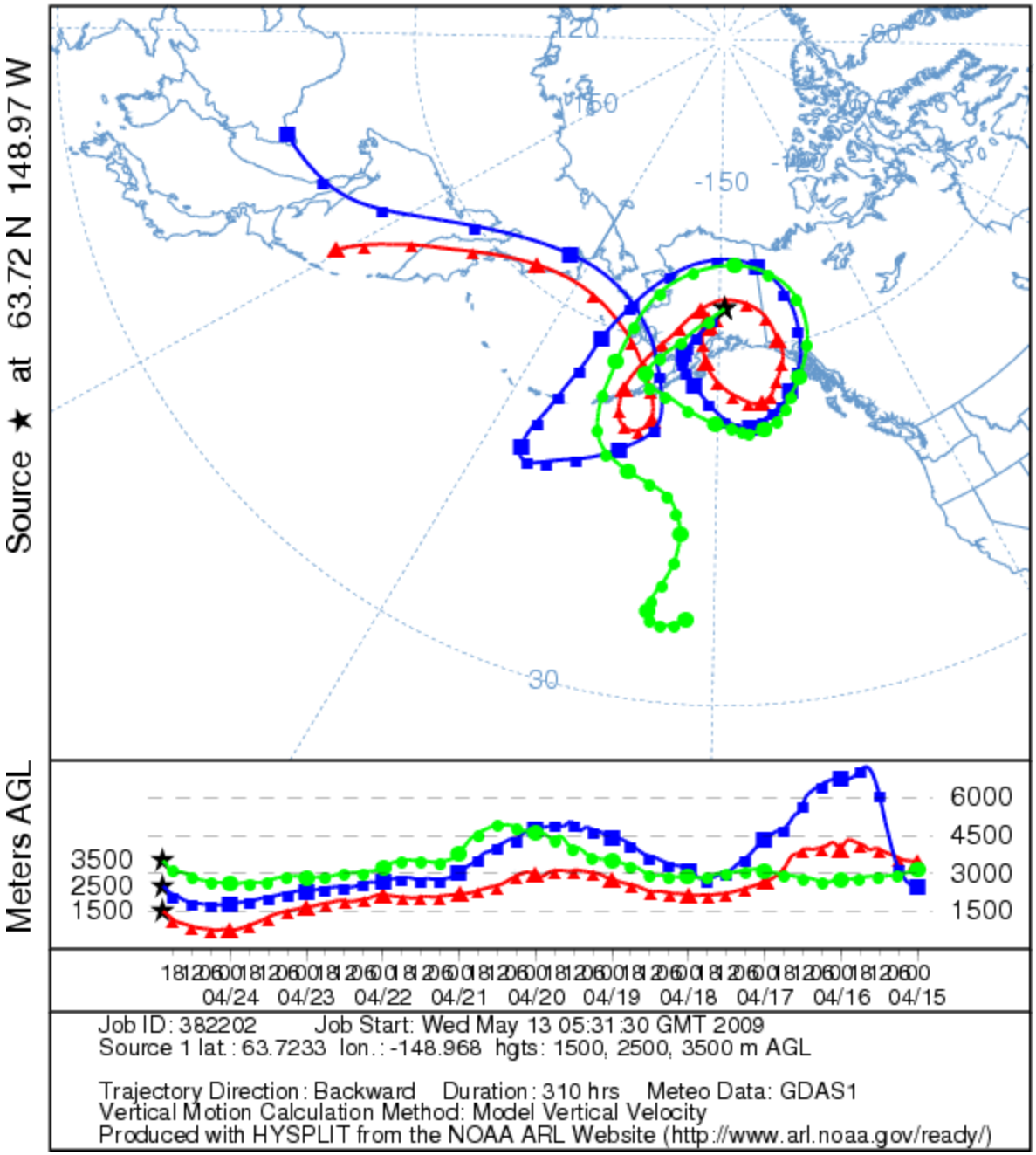
Backward trajectories ending at 2100 UTC 22 Apr 08
GDAS Meteorological Data



NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 23 Apr 08
GDAS Meteorological Data



NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 24 Apr 08
GDAS Meteorological Data



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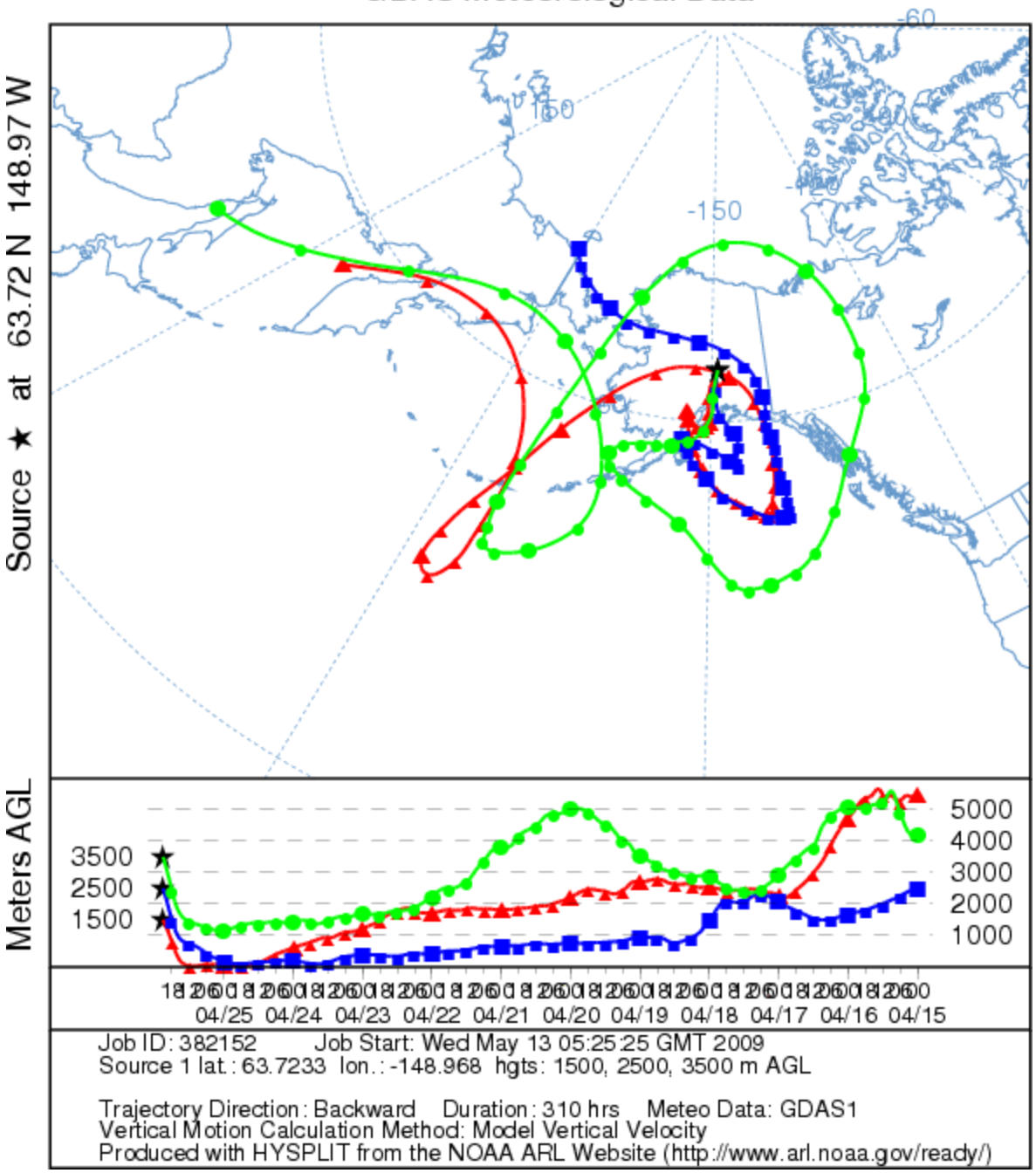
Backward trajectories ending at 2100 UTC 25 Apr 08
GDAS Meteorological Data



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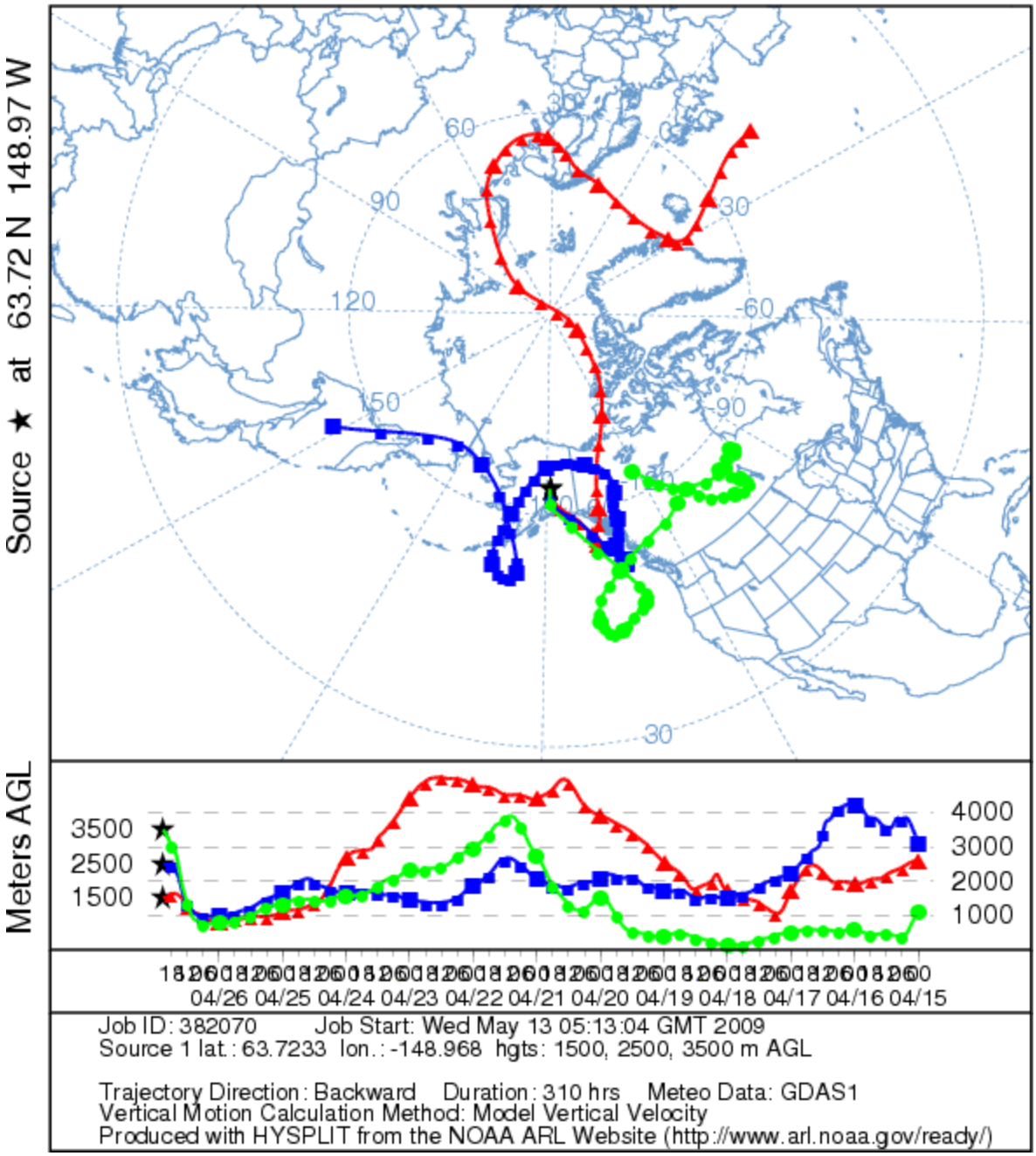
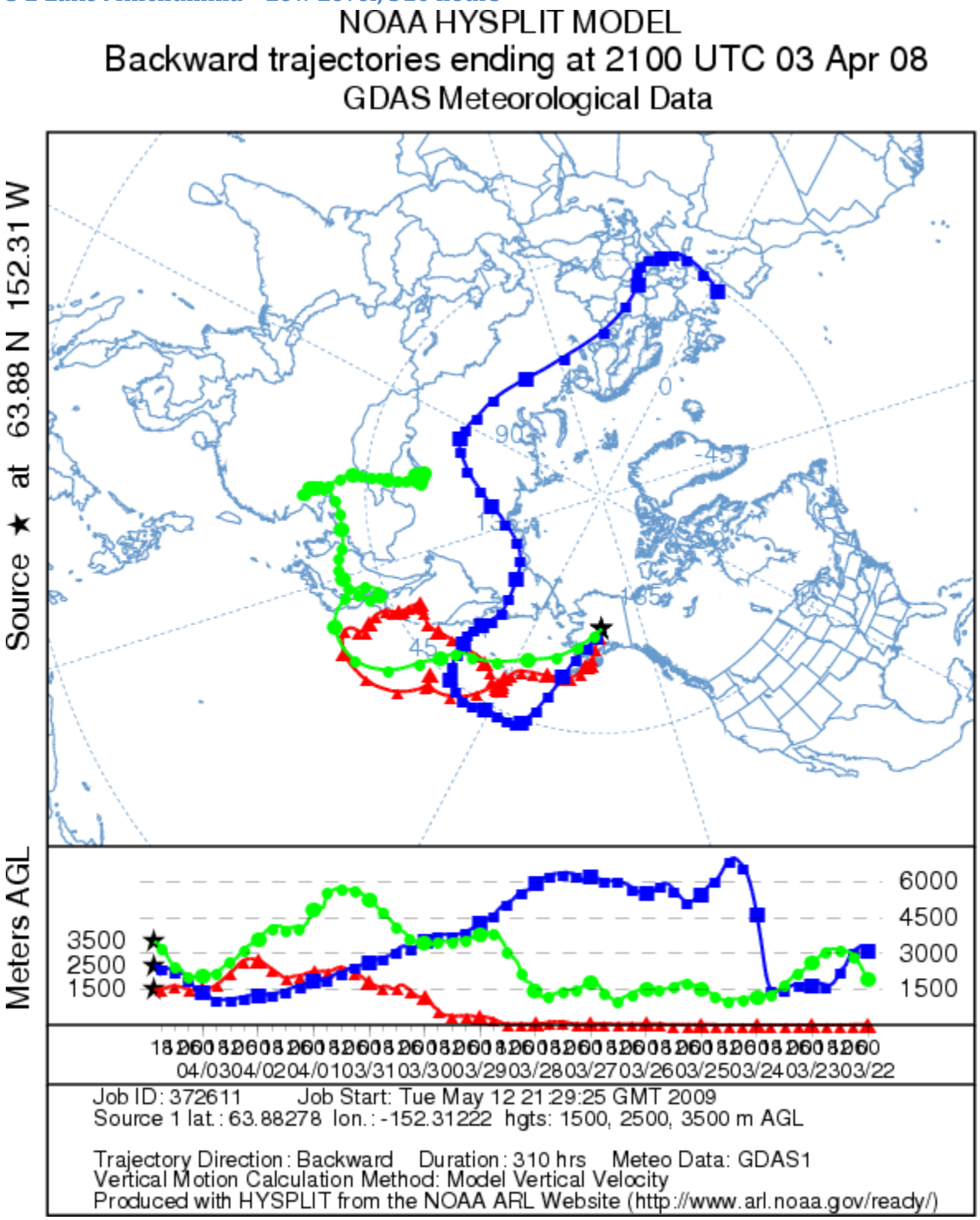
Backward trajectories ending at 2100 UTC 26 Apr 08
GDAS Meteorological Data



C-2 Lake Minchumina – Low Level, 310 hours



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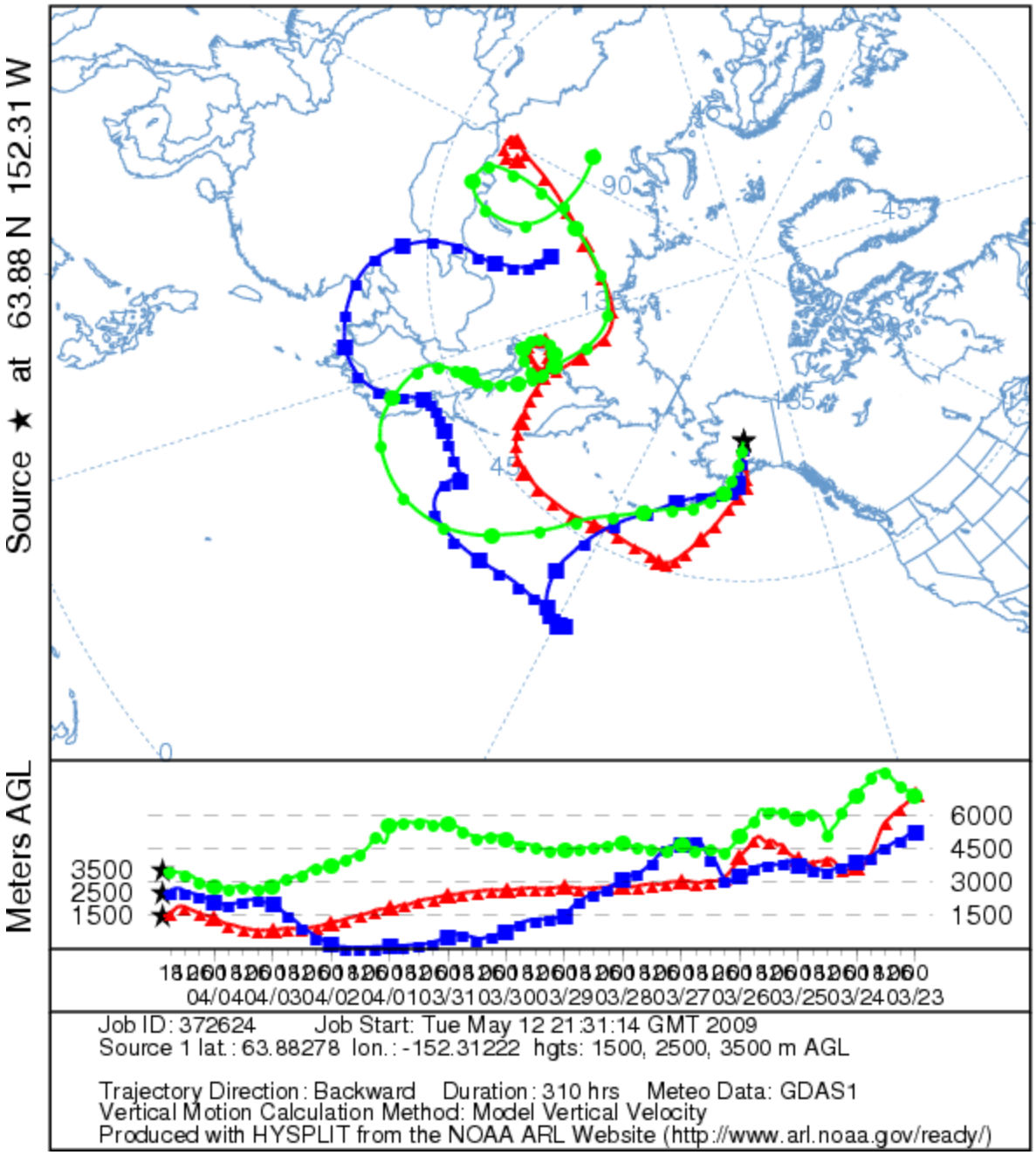
GDAS Meteorological Data



NOAA HYSPLIT MODEL
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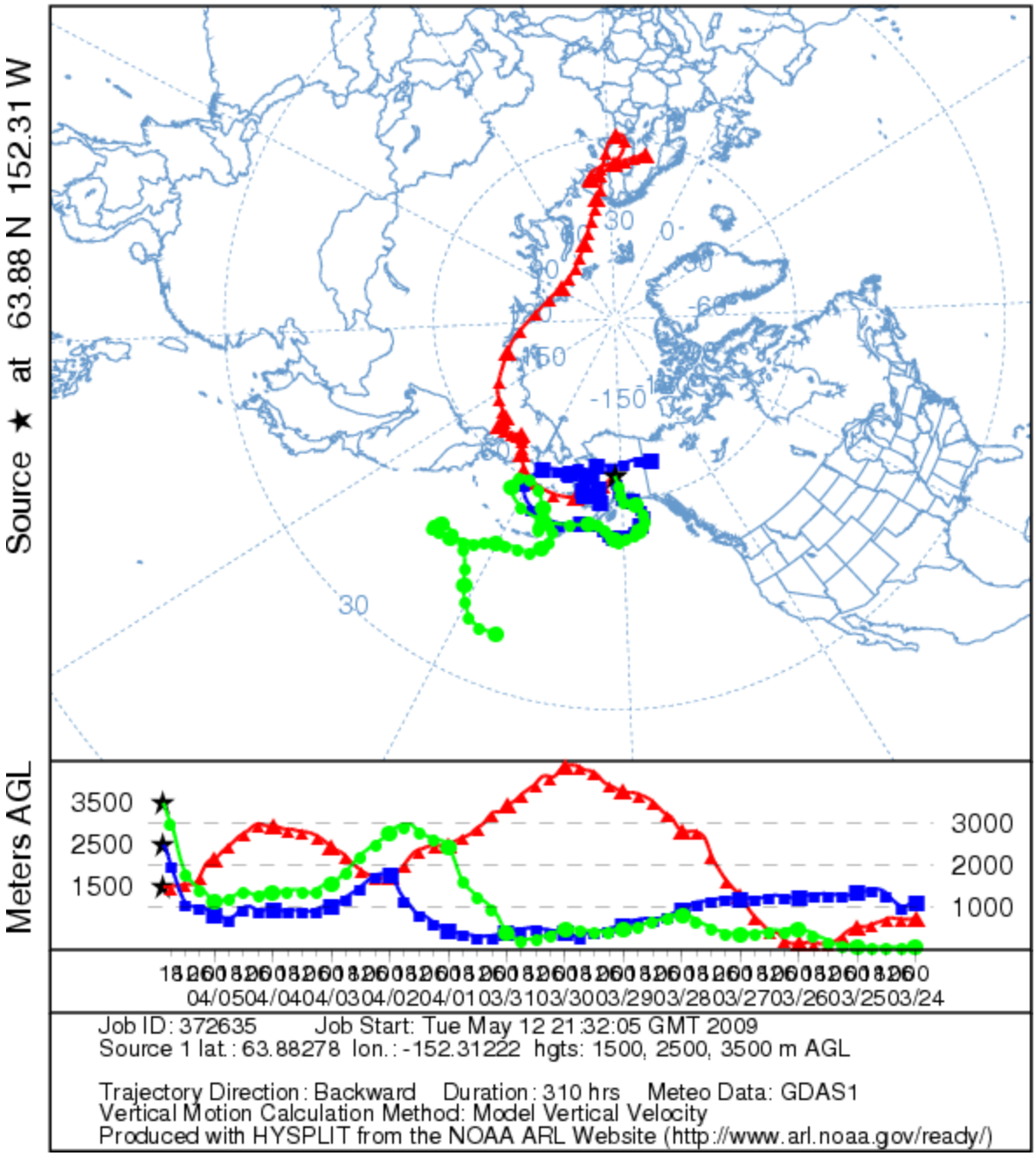
GDAS Meteorological Data



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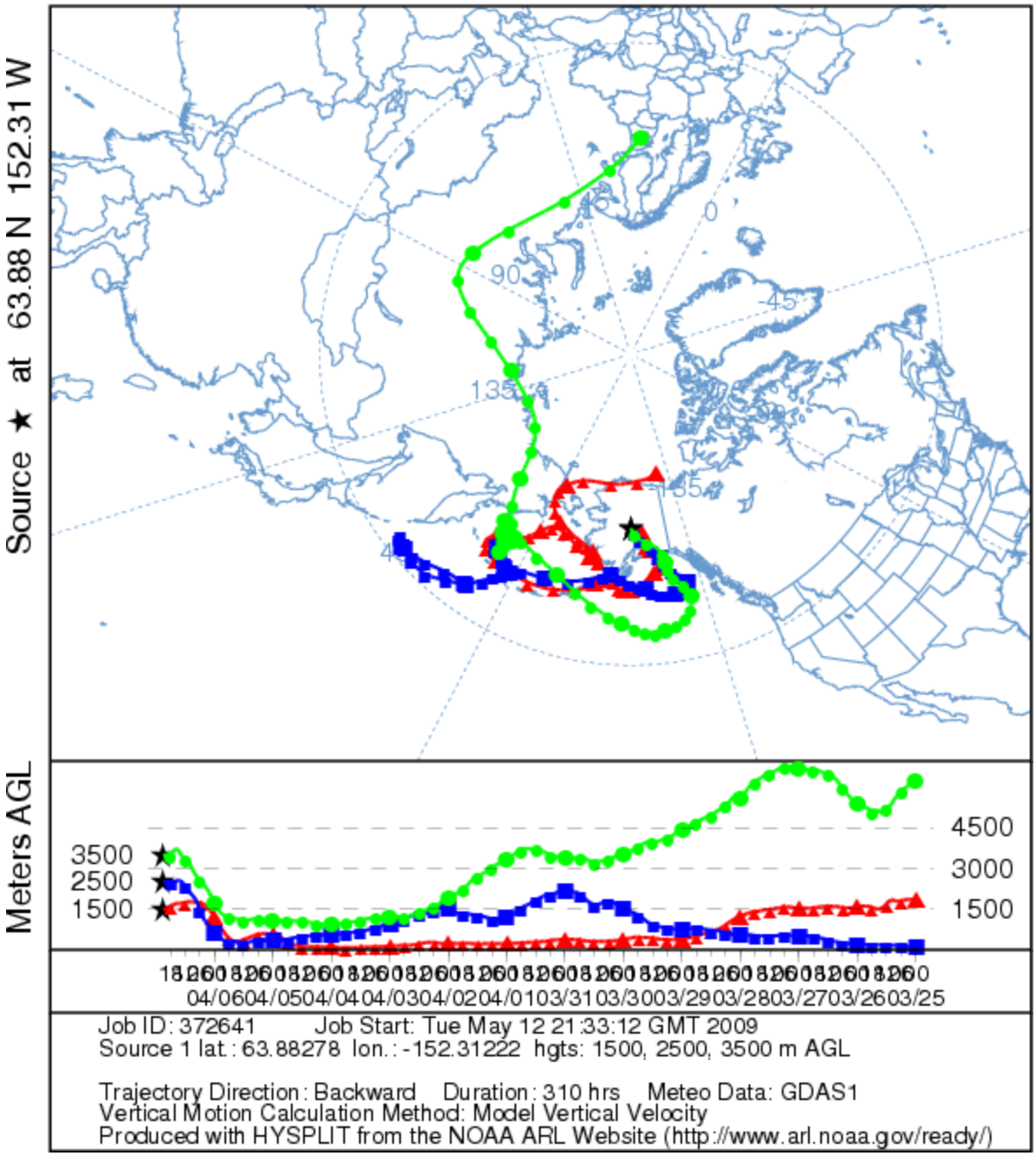
GDAS Meteorological Data



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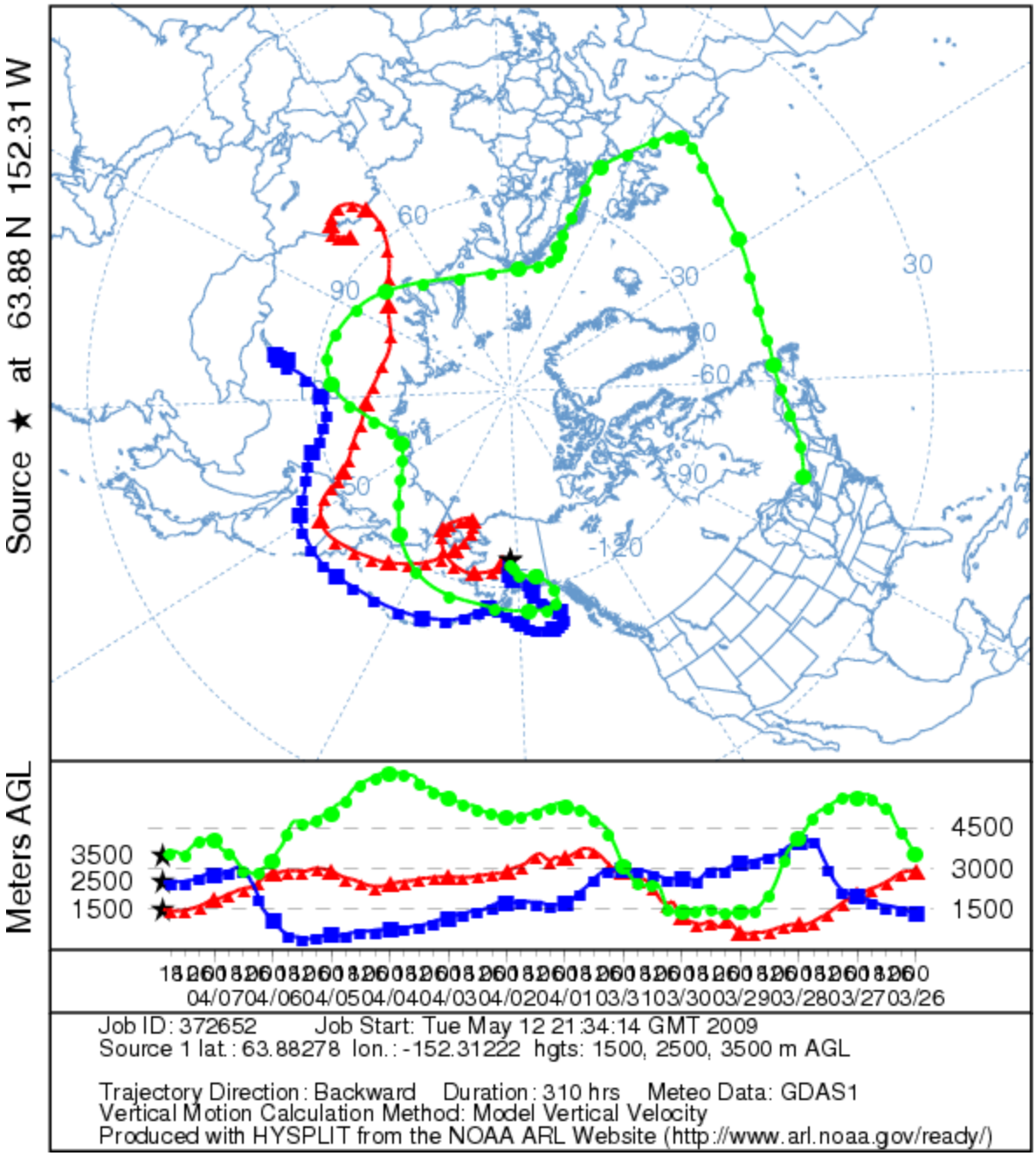
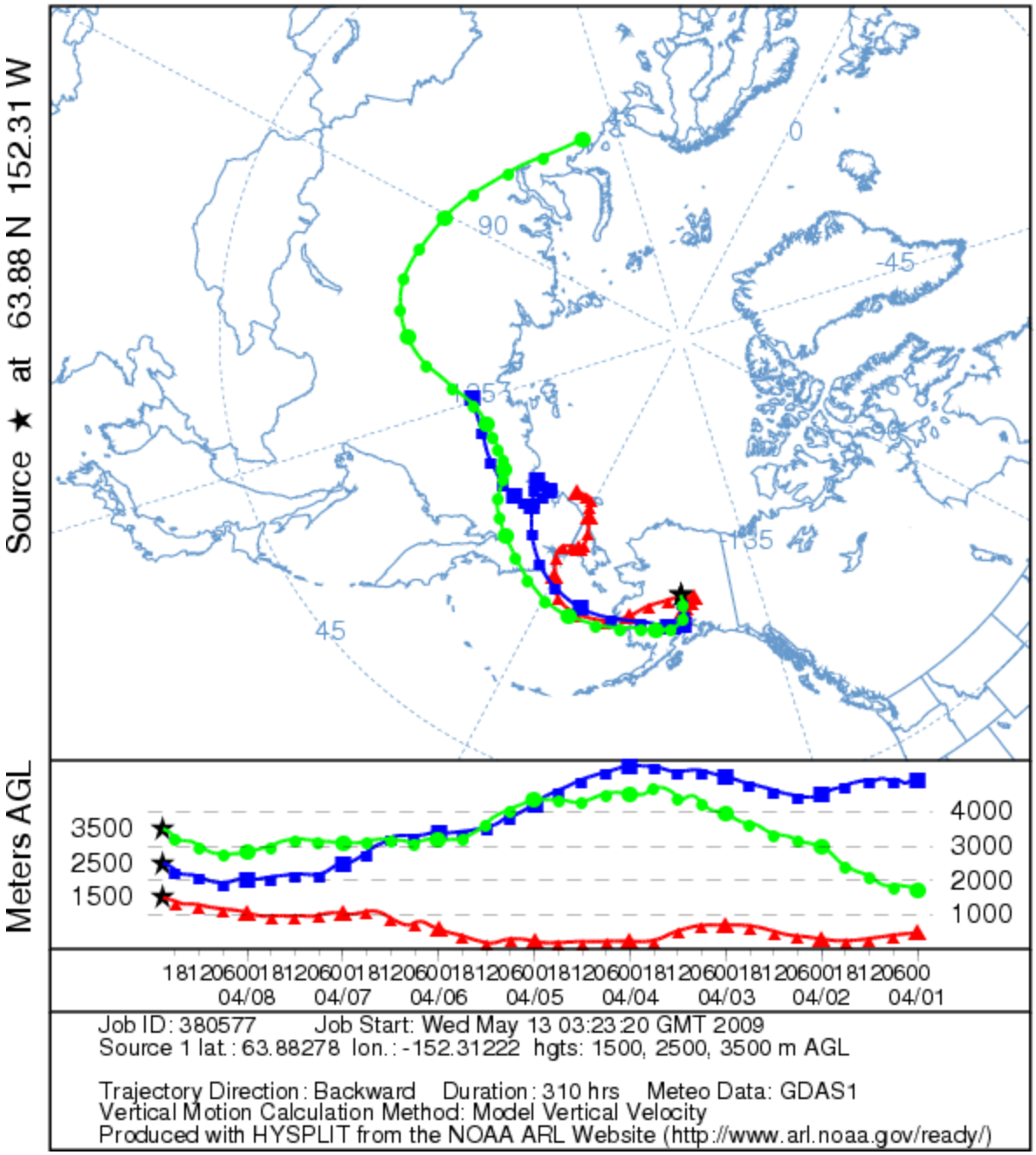
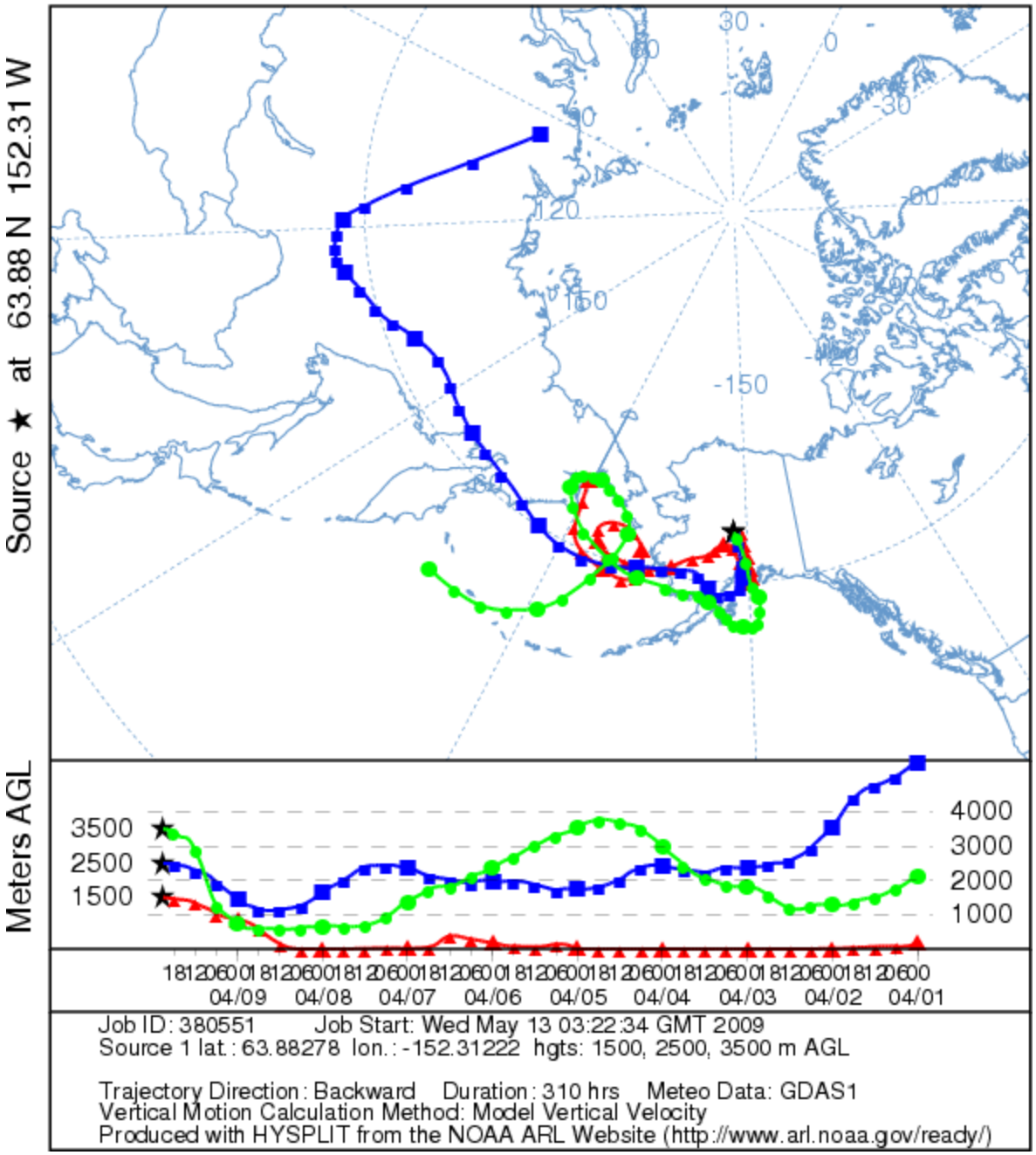


NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 08 Apr 08
GDAS Meteorological Data



NOAA HYSPLIT MODEL
Backward trajectories ending at 2100 UTC 09 Apr 08
GDAS Meteorological Data



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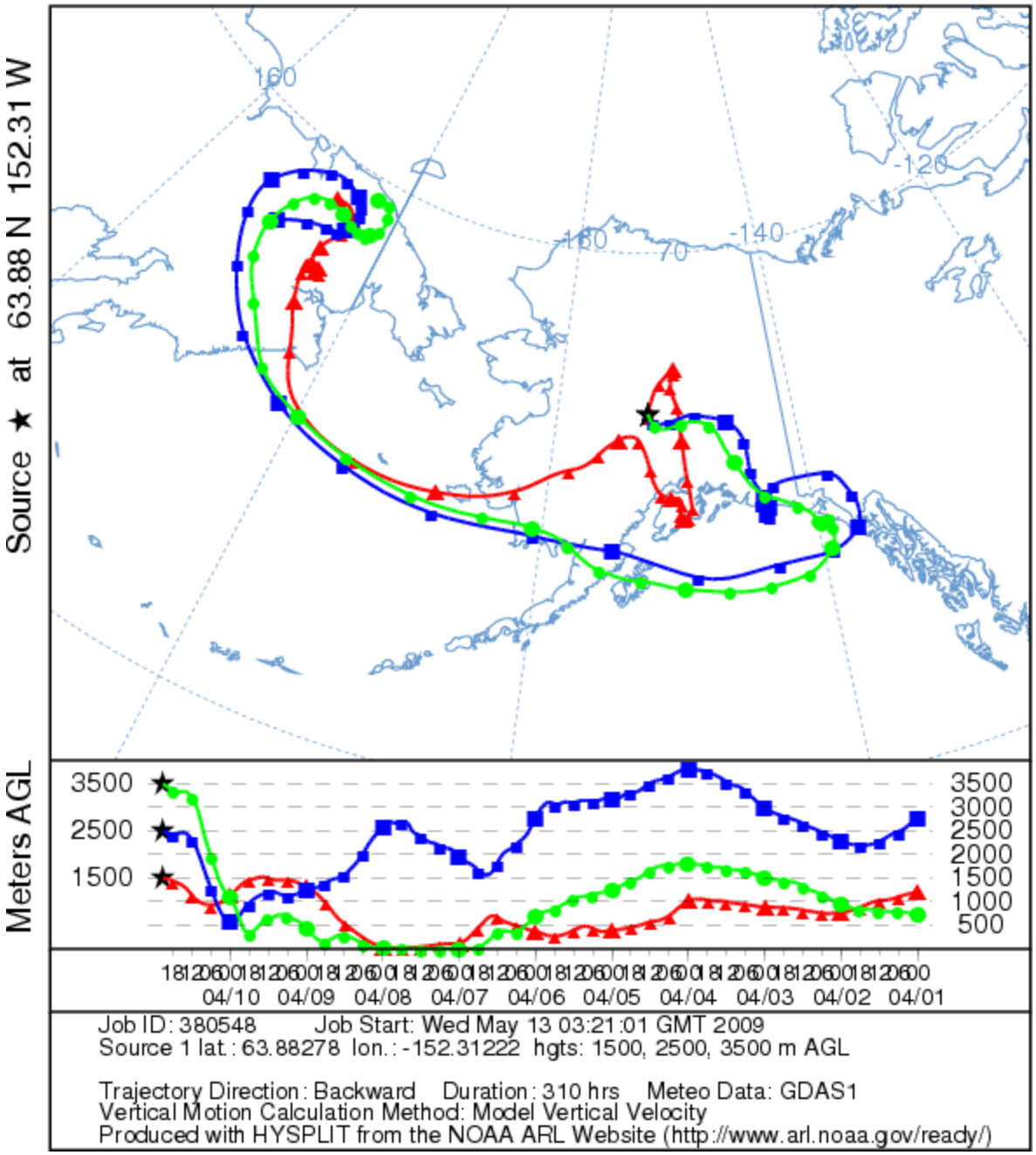
GDAS Meteorological Data



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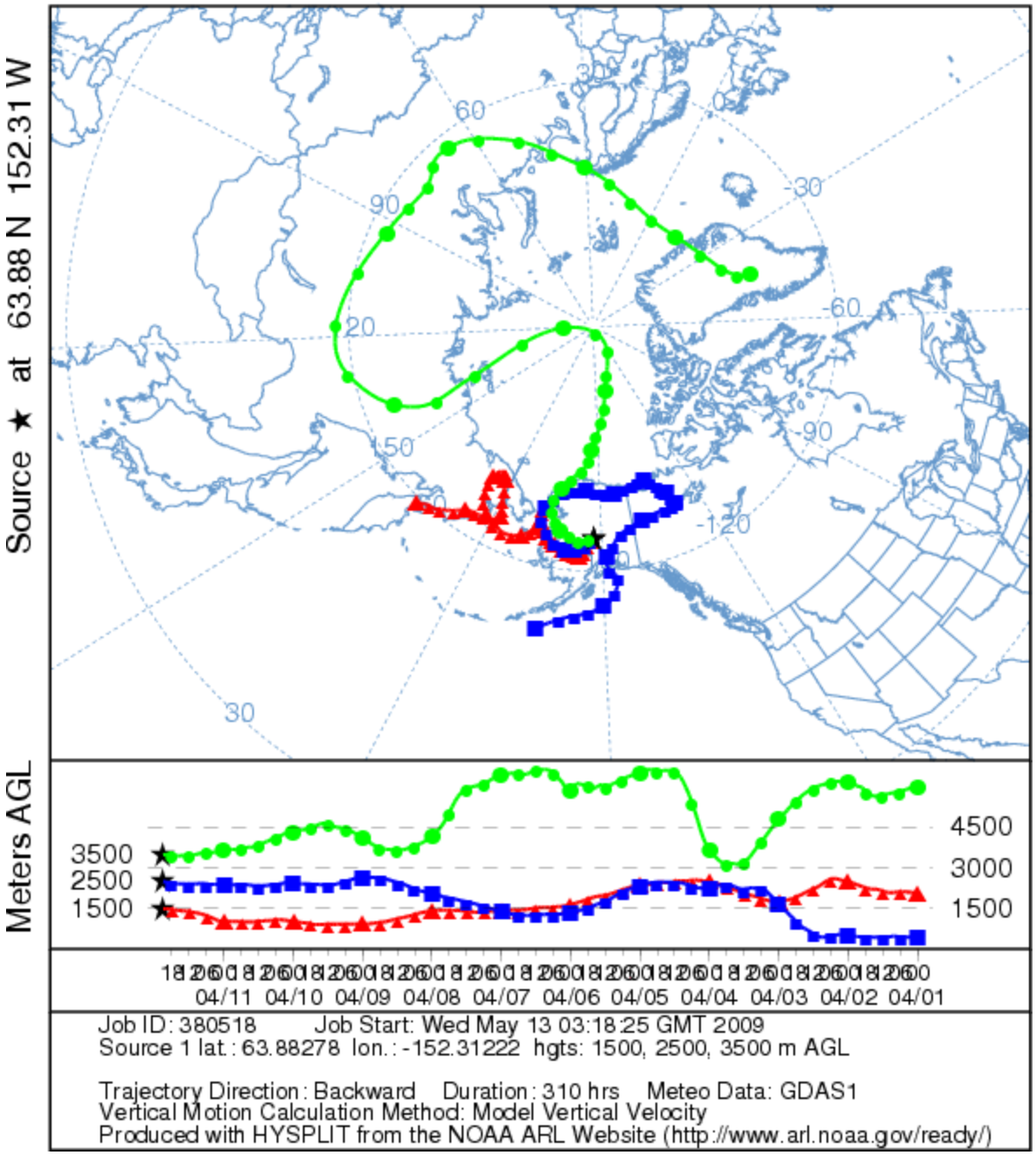
GDAS Meteorological Data



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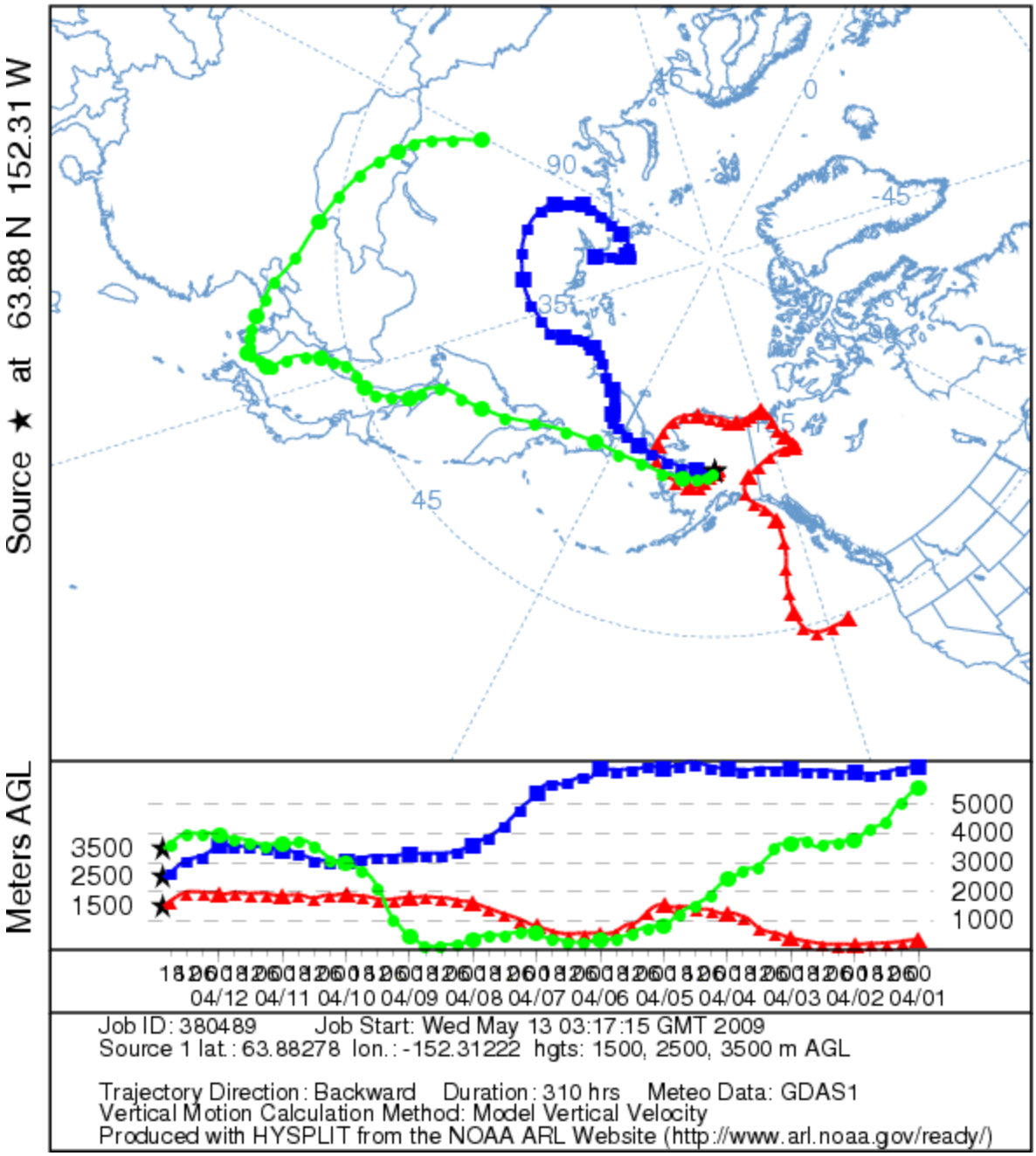

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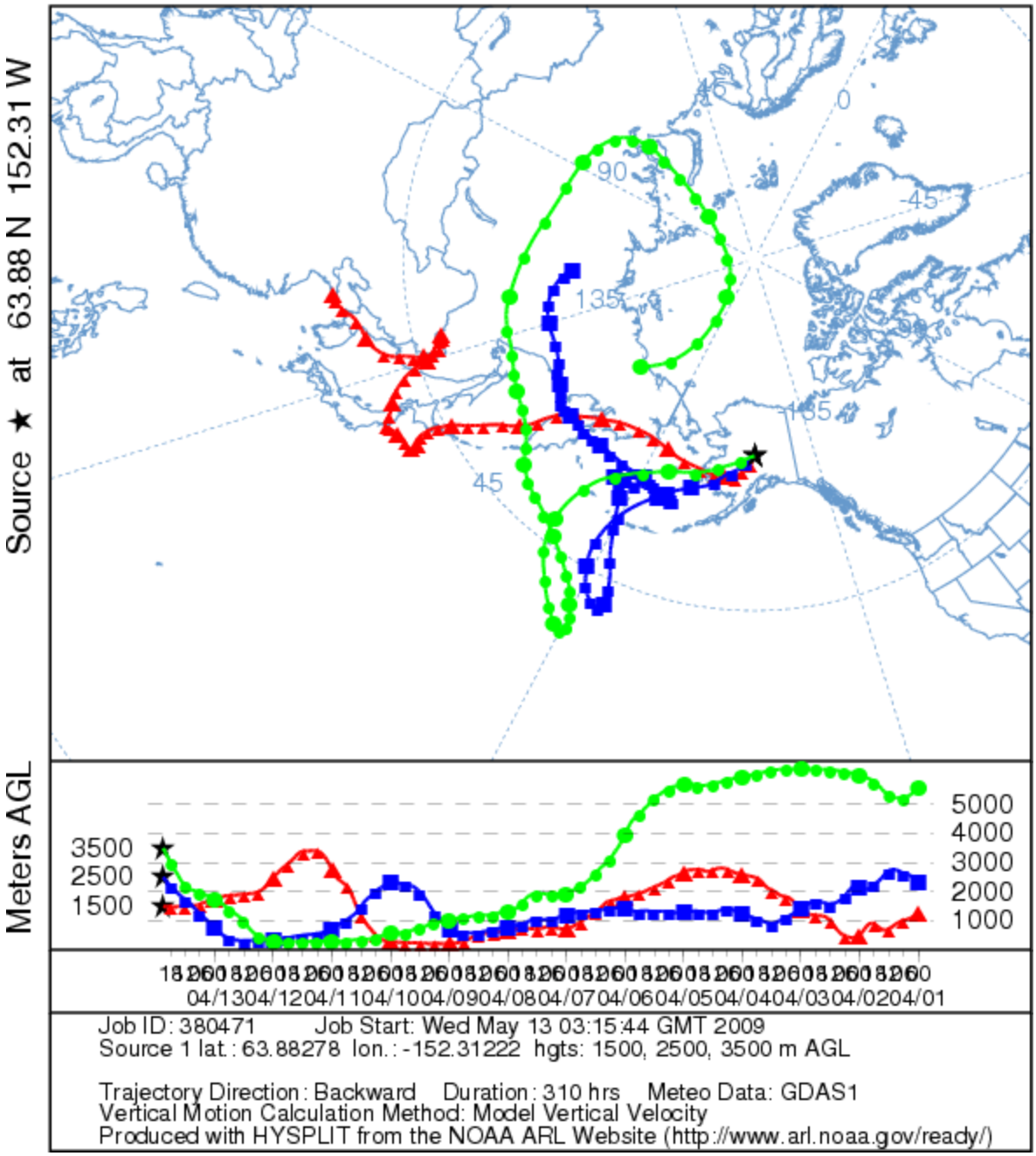
GDAS Meteorological Data



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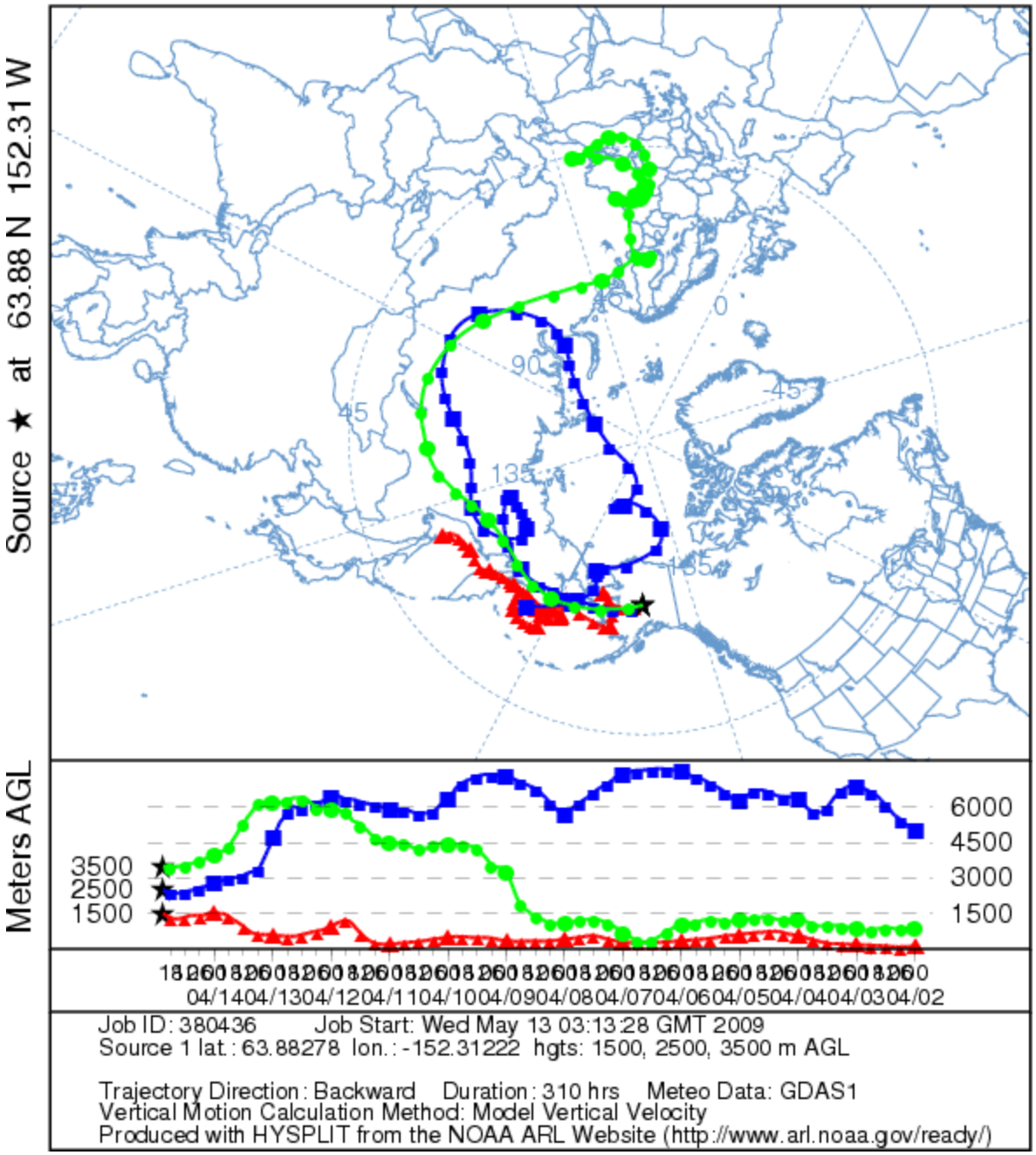

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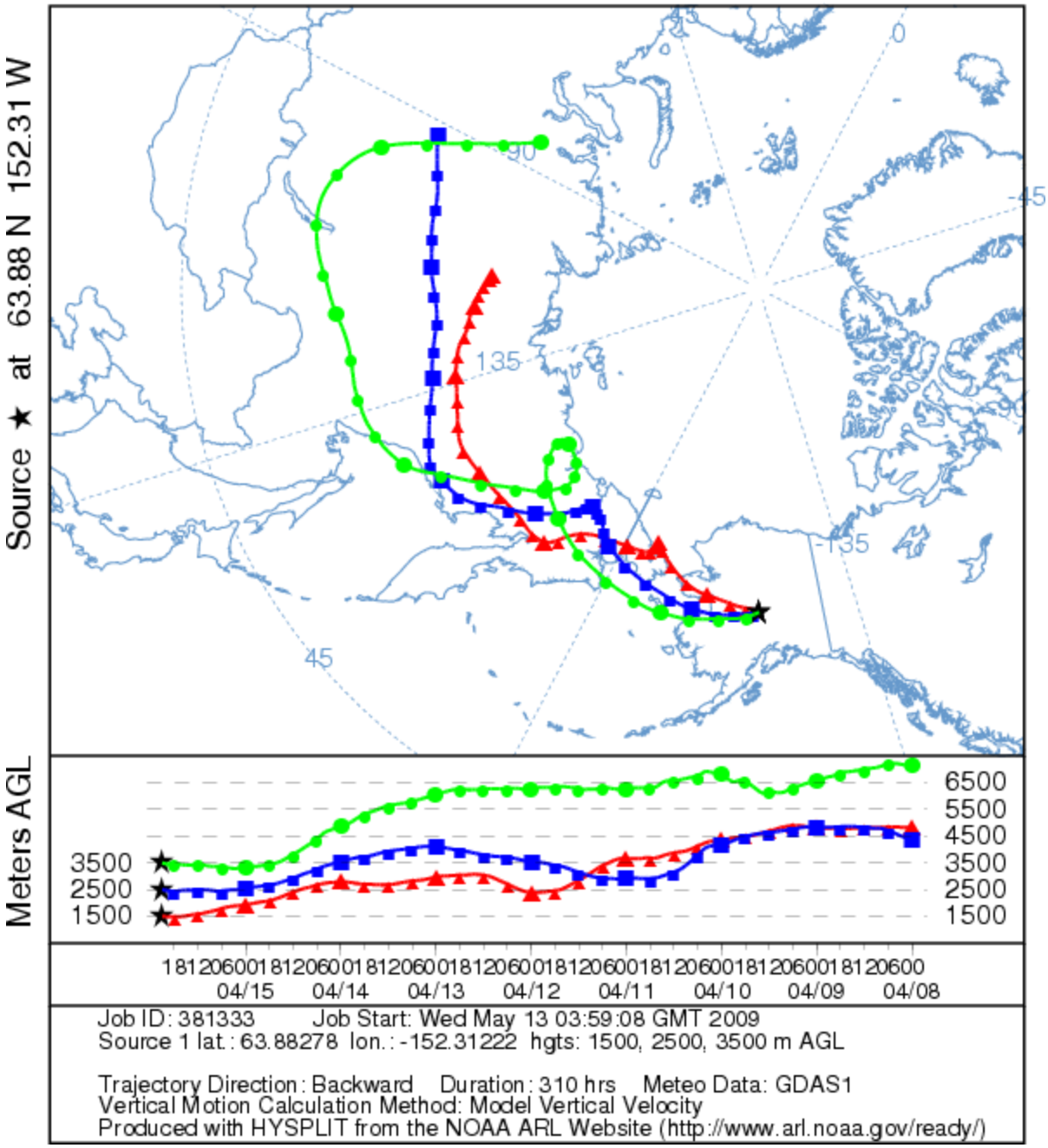

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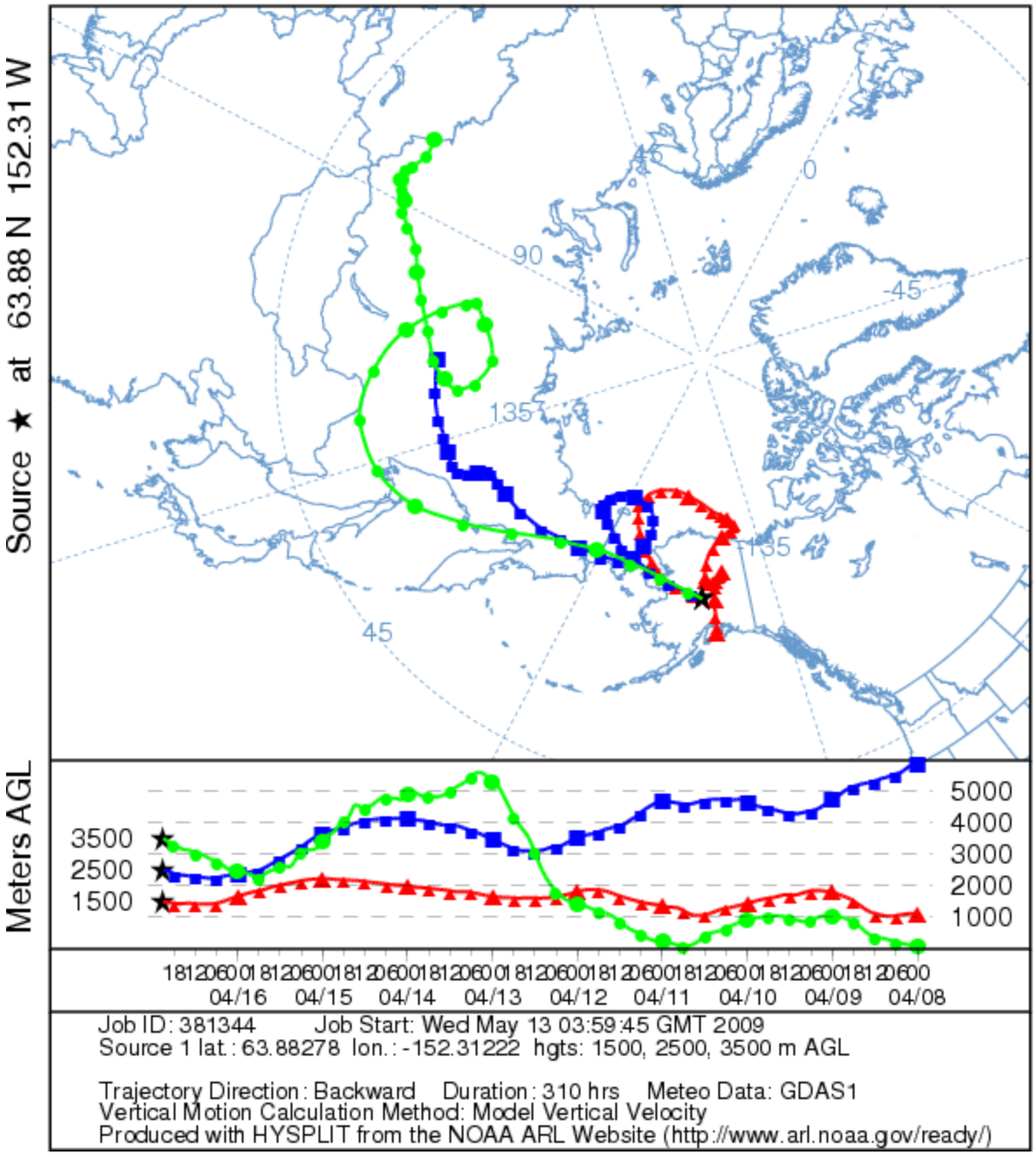

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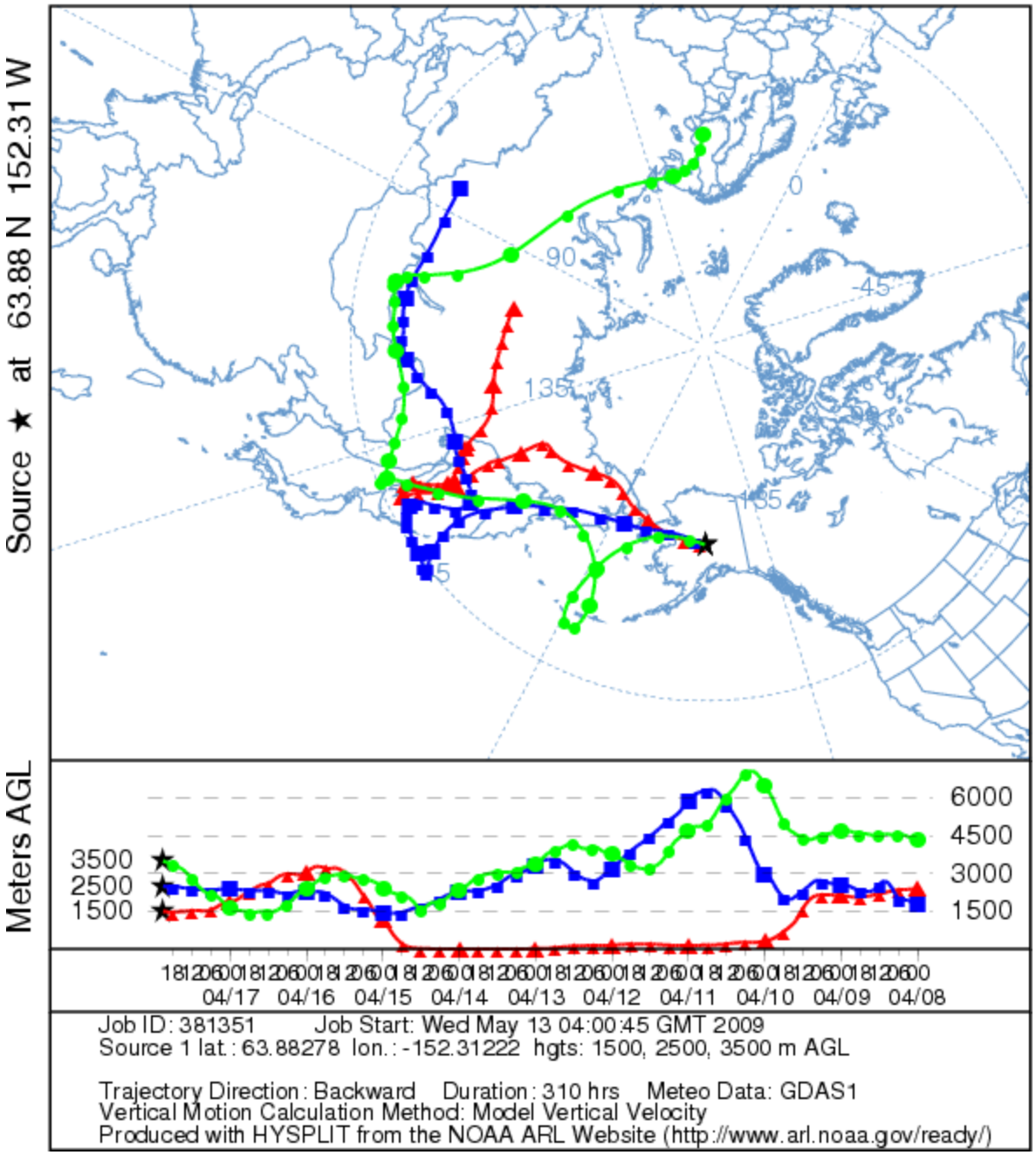

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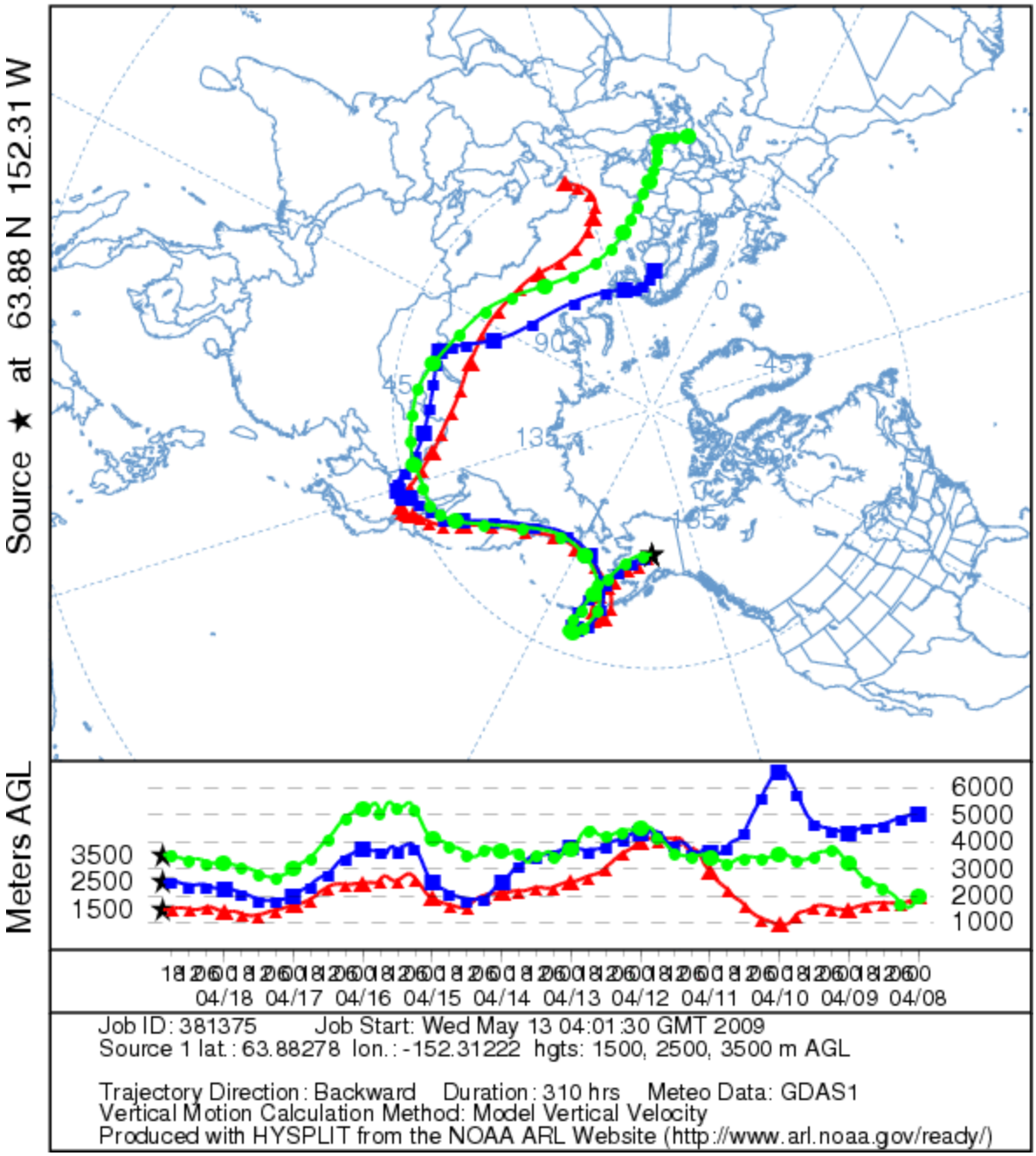

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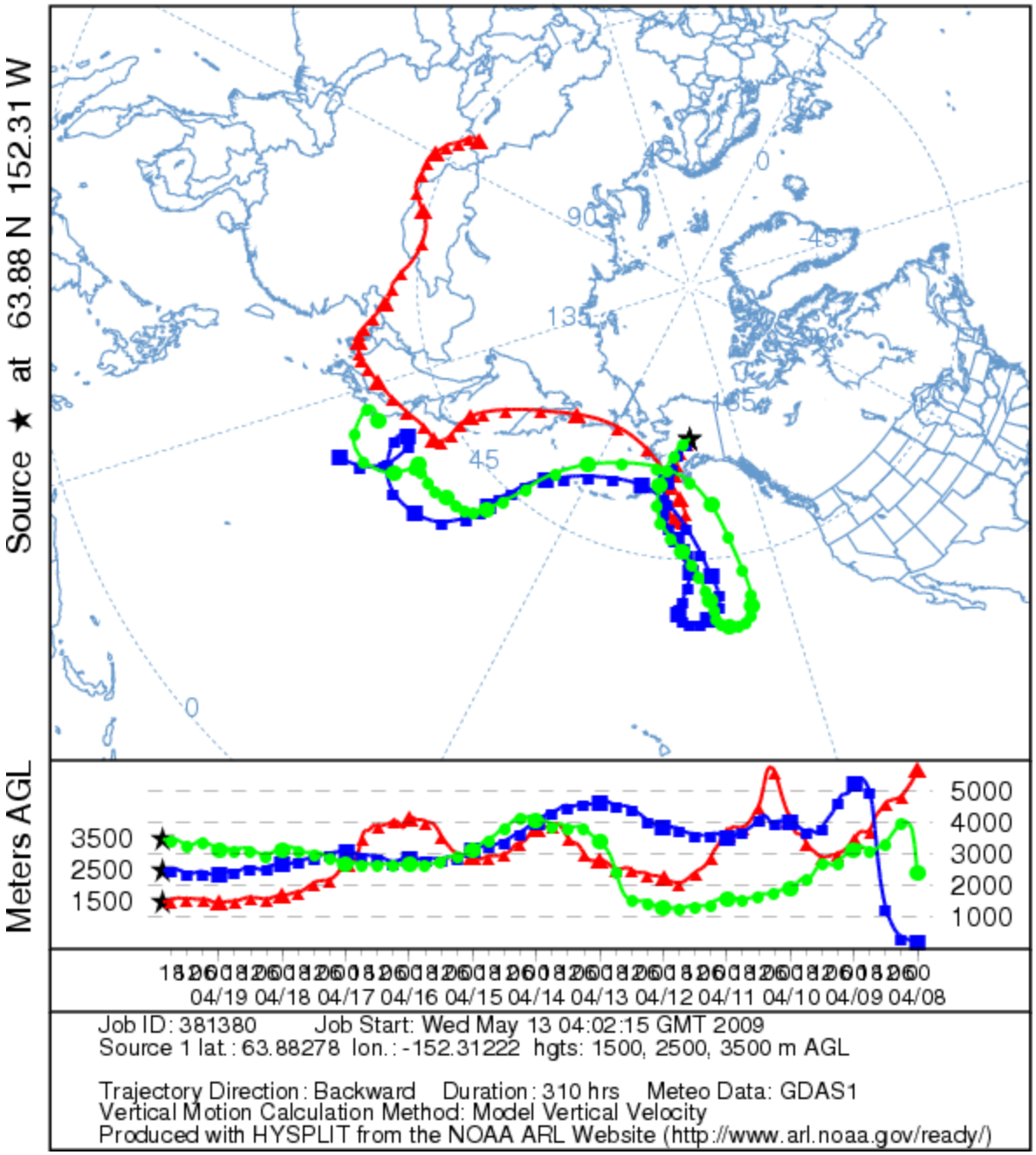

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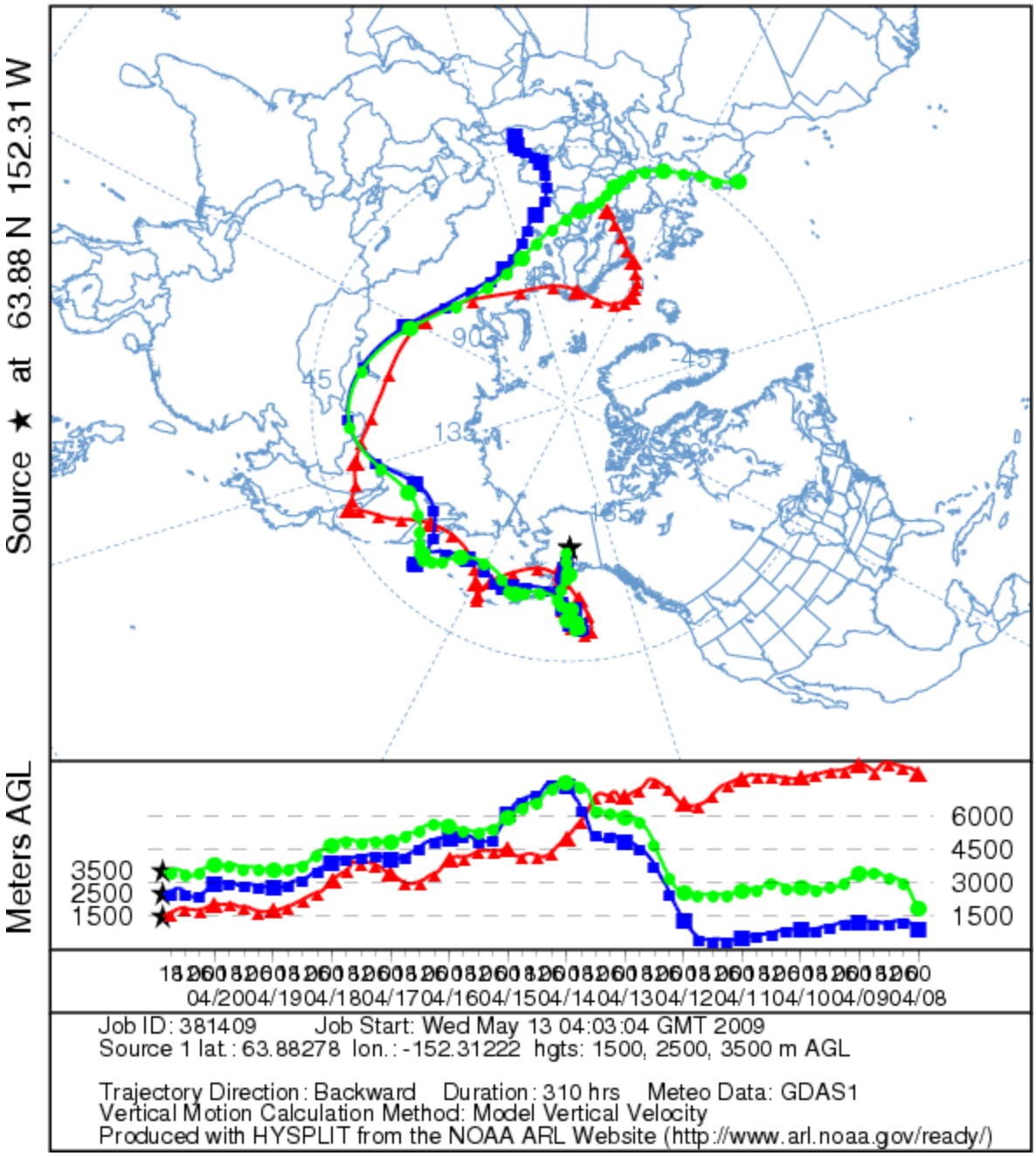

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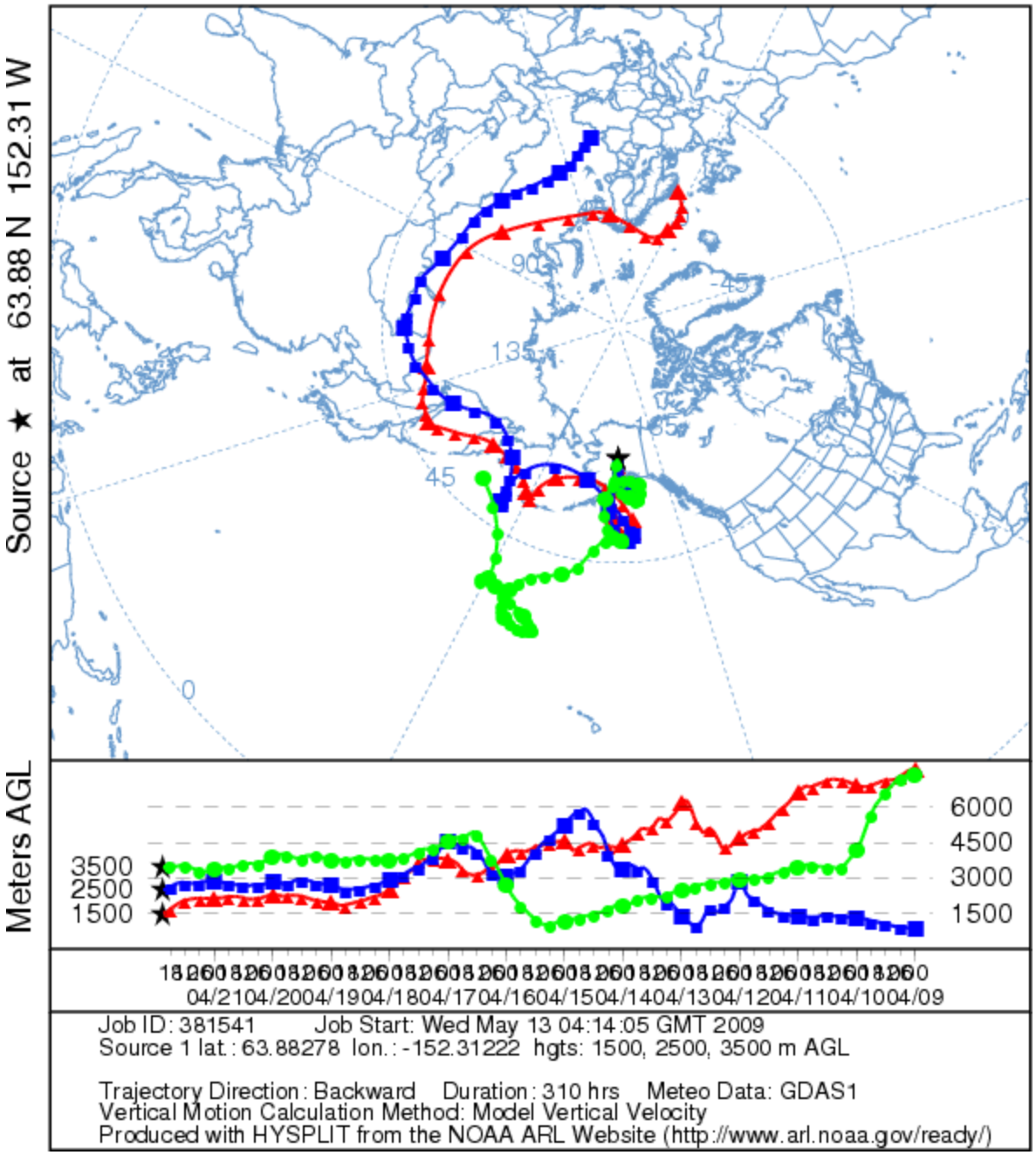

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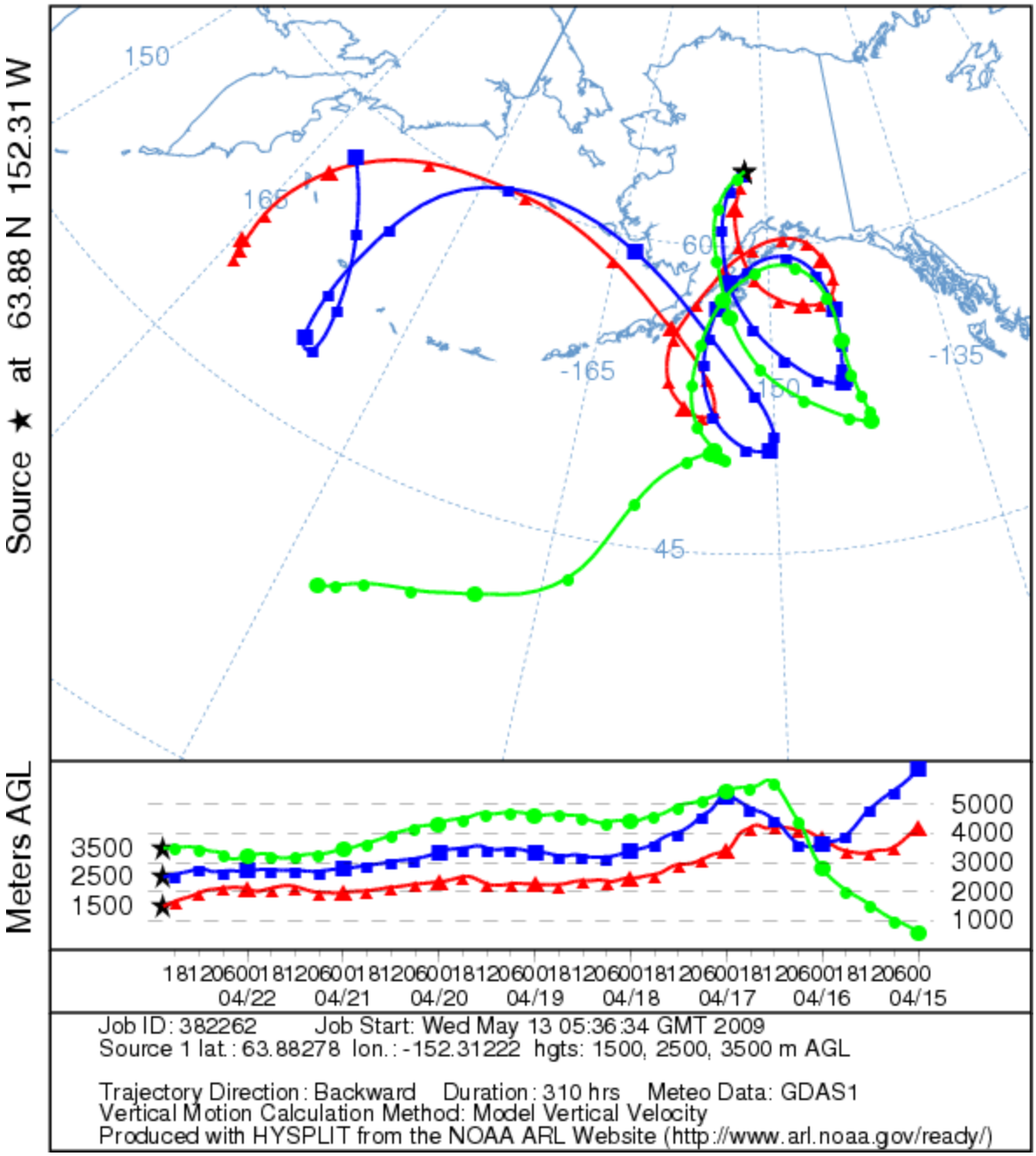

NOAA HYSPLIT MODEL
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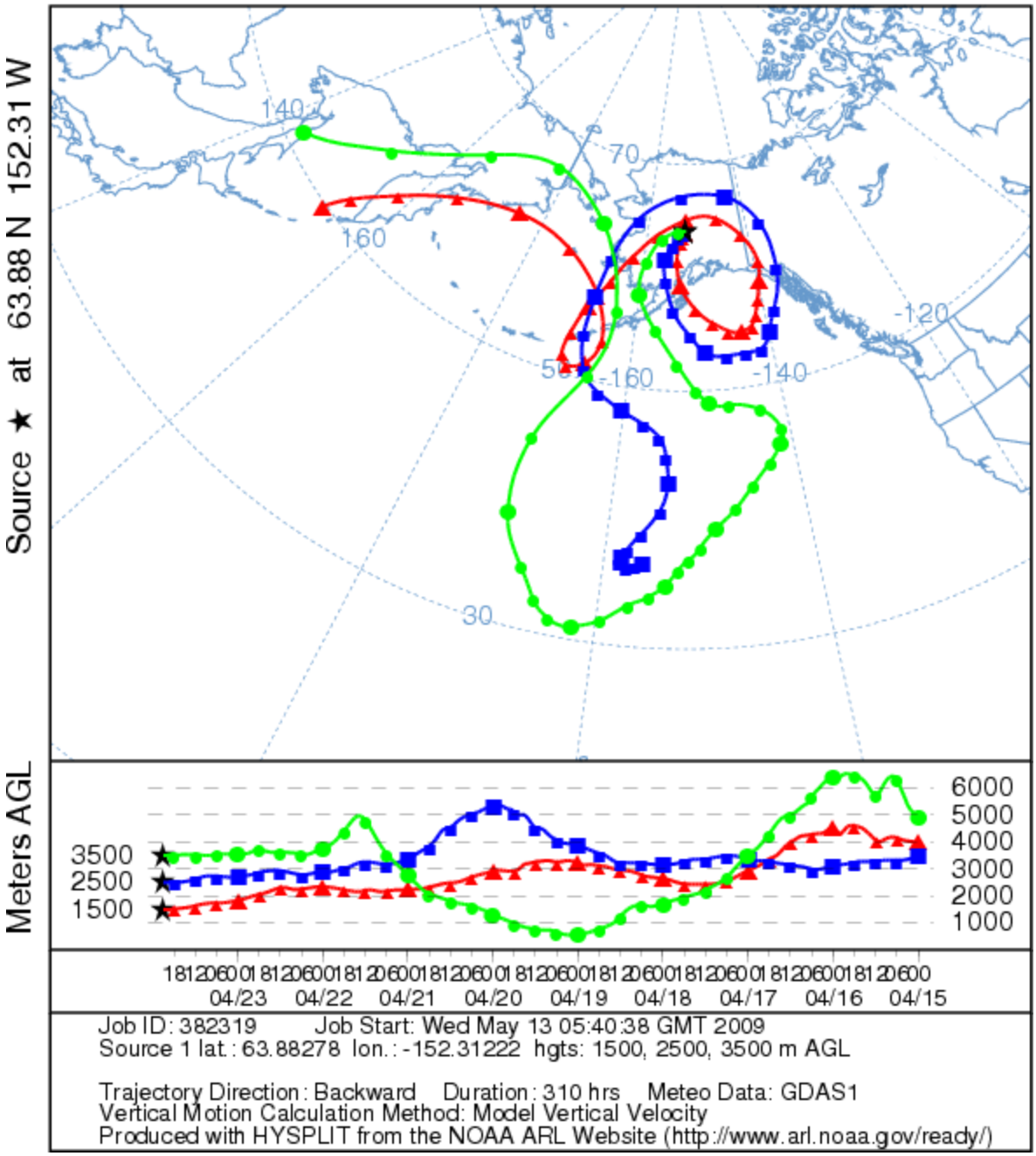

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Backward trajectories ending at 2100 UTC 24 Apr 08
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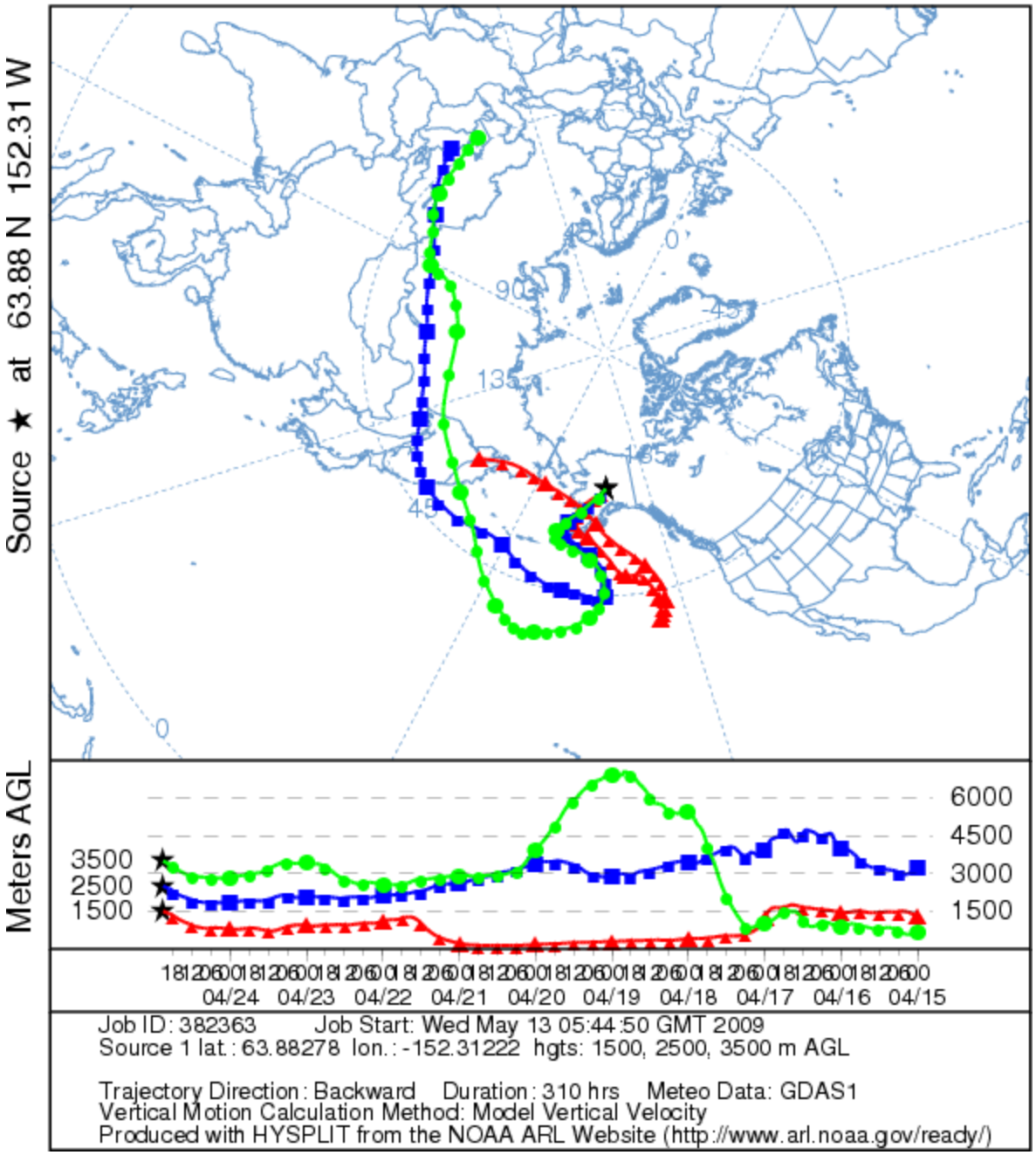

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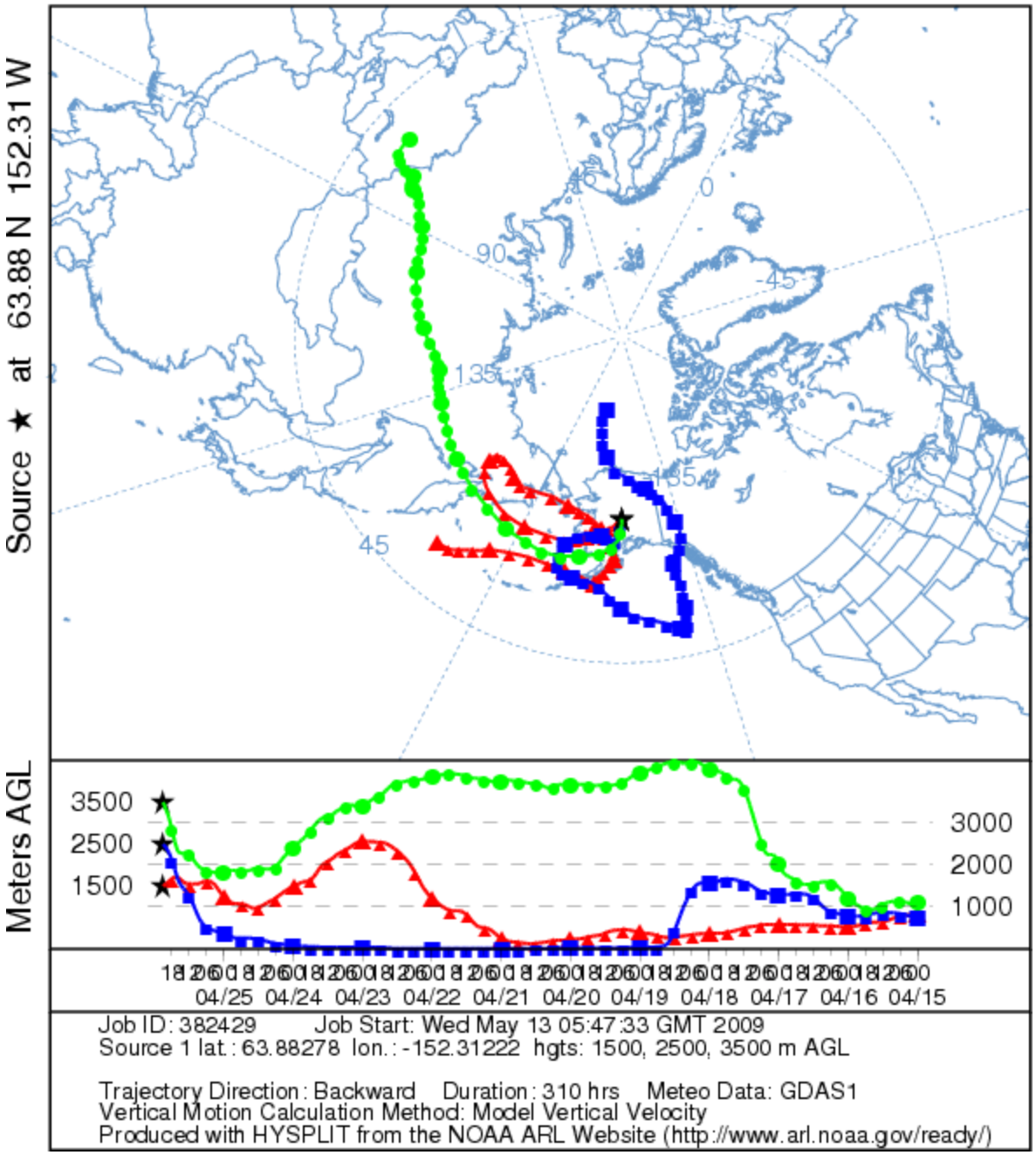

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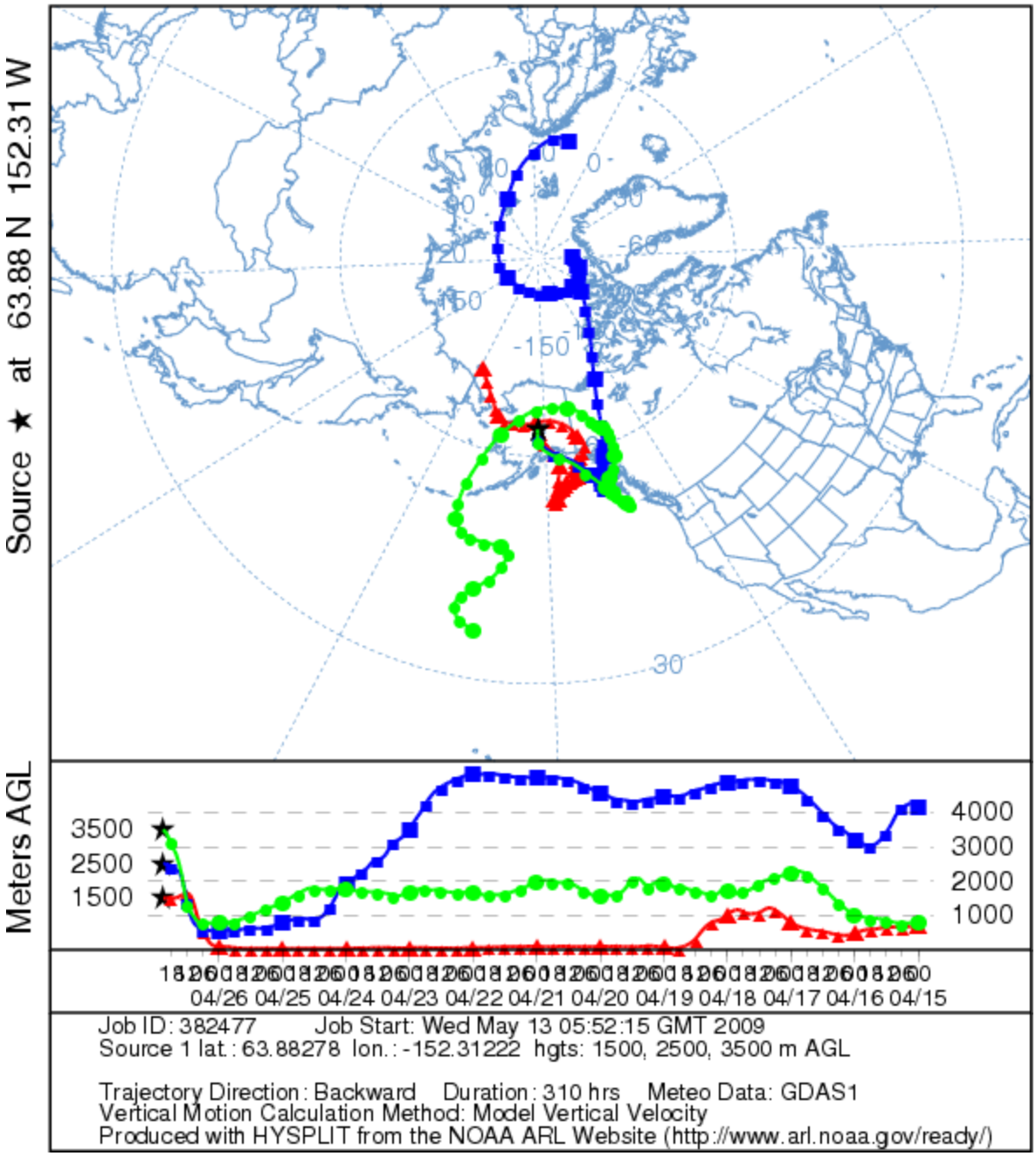
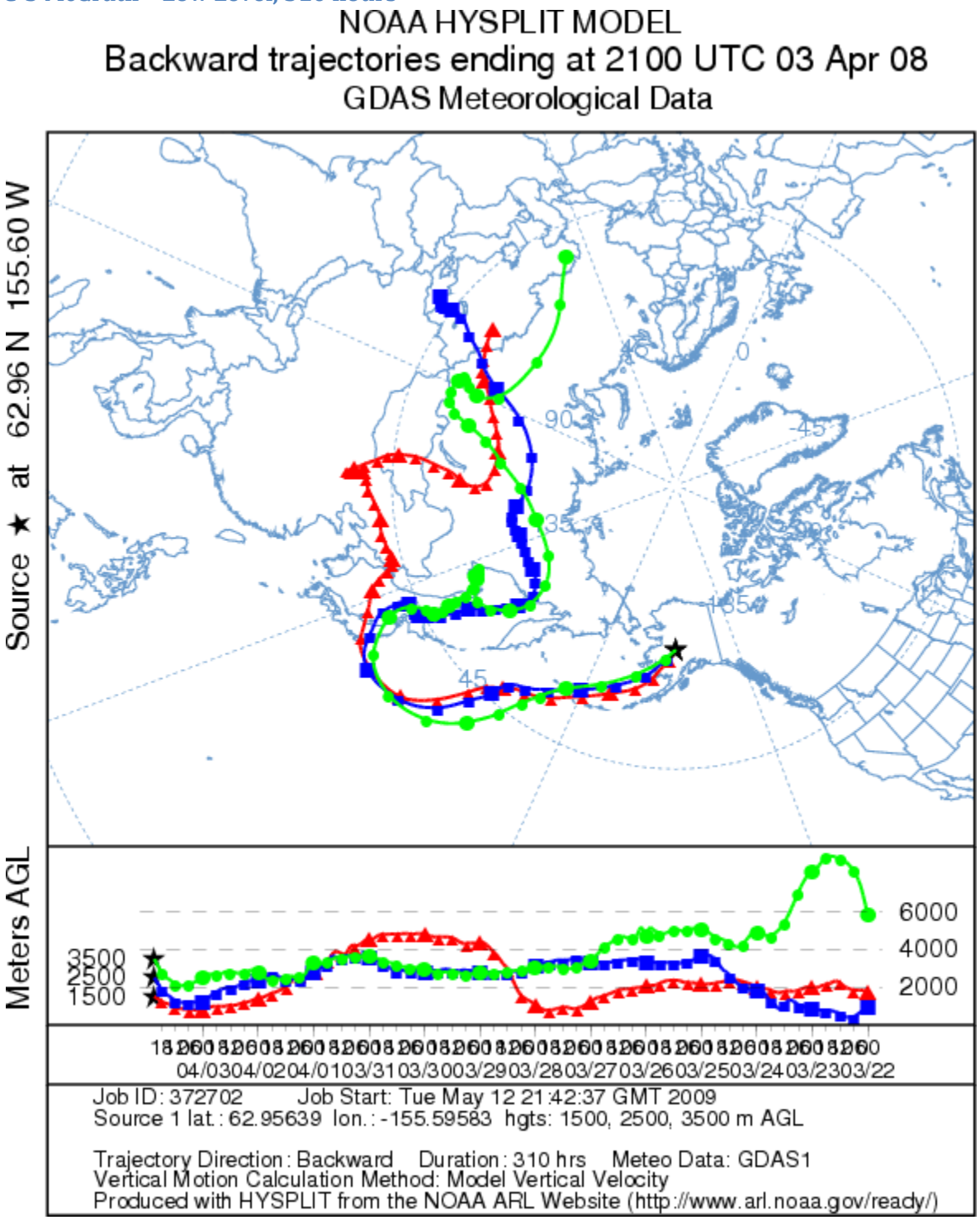


C-3 McGrath – Low Level, 310 hours



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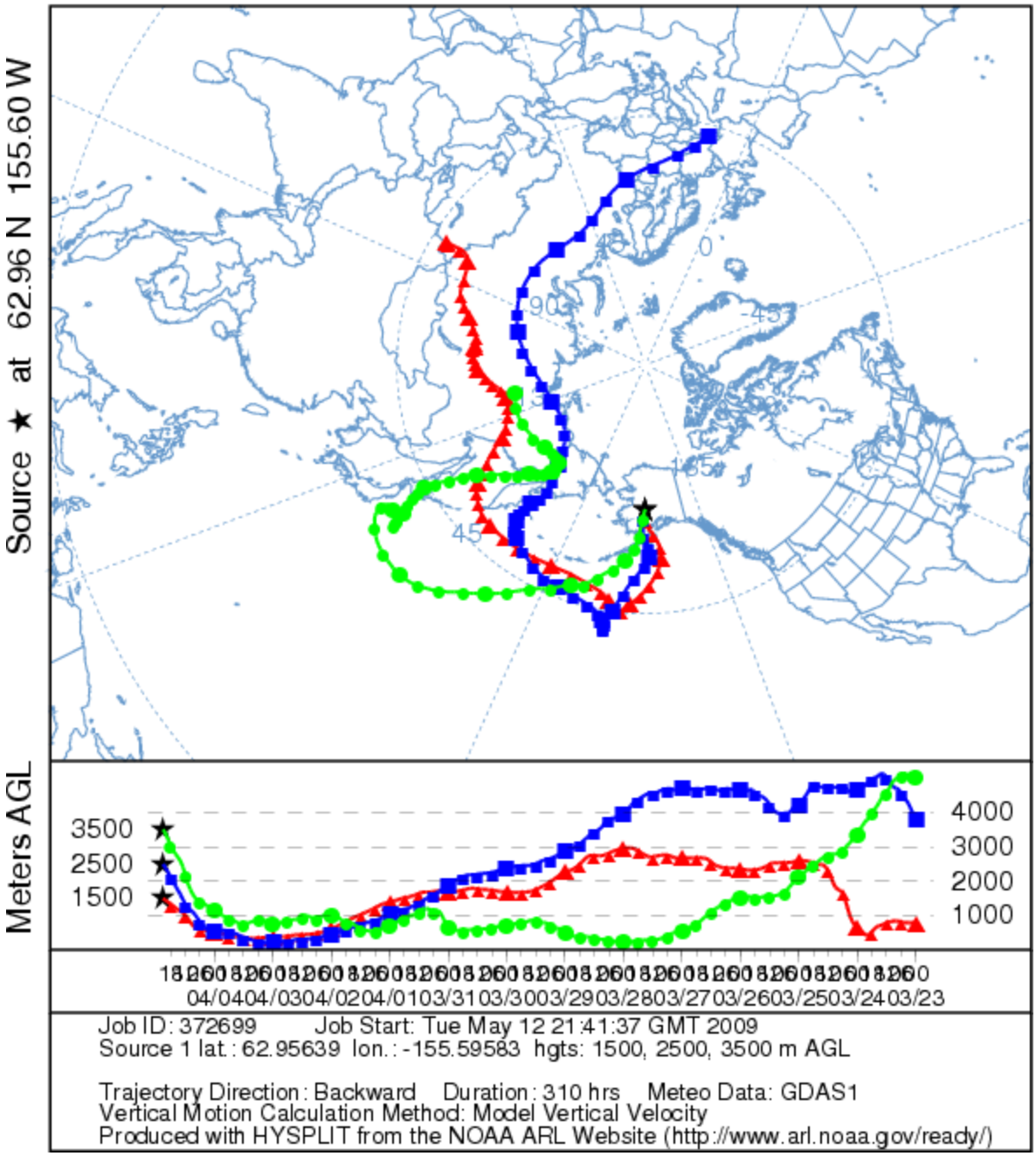

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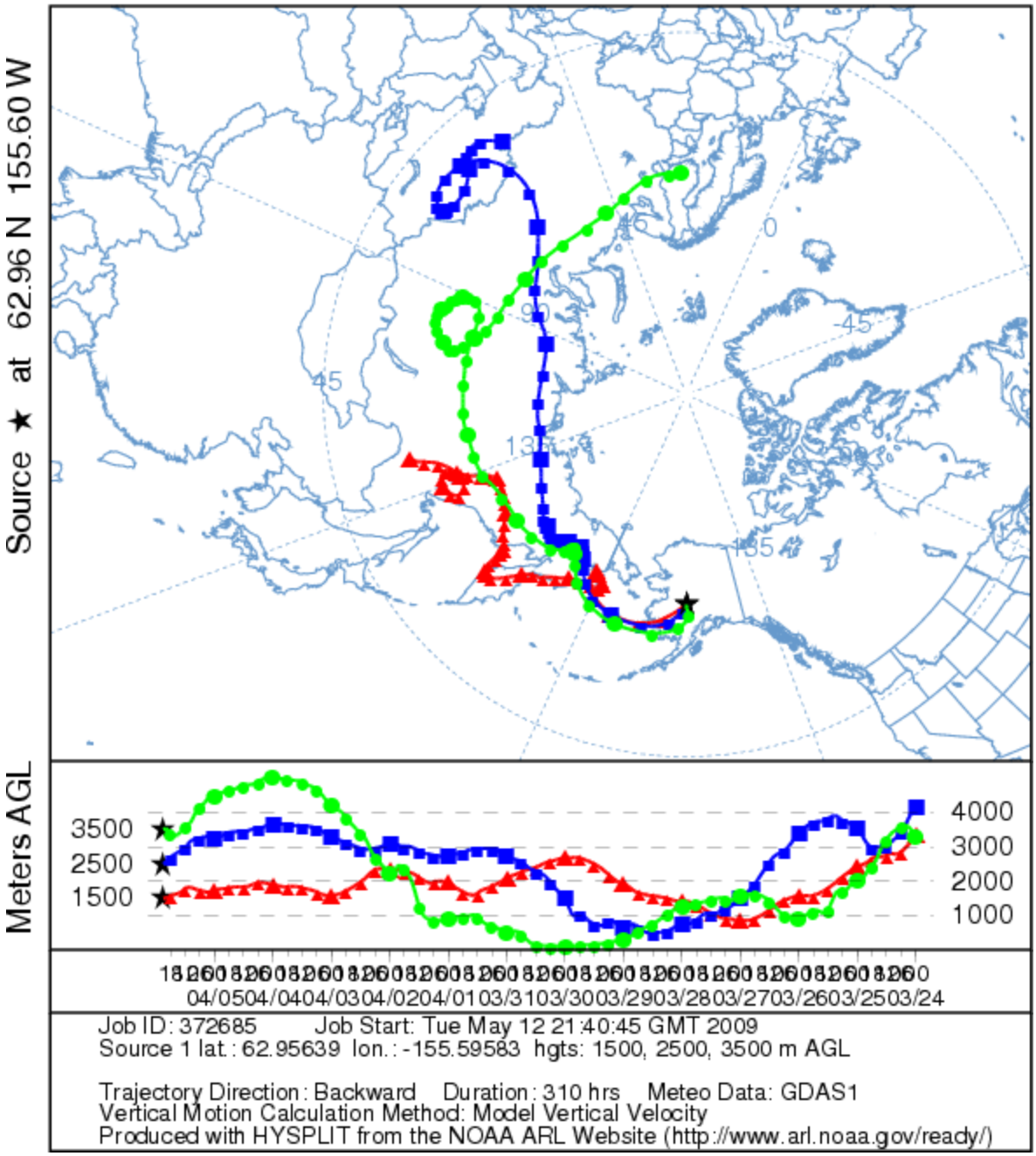

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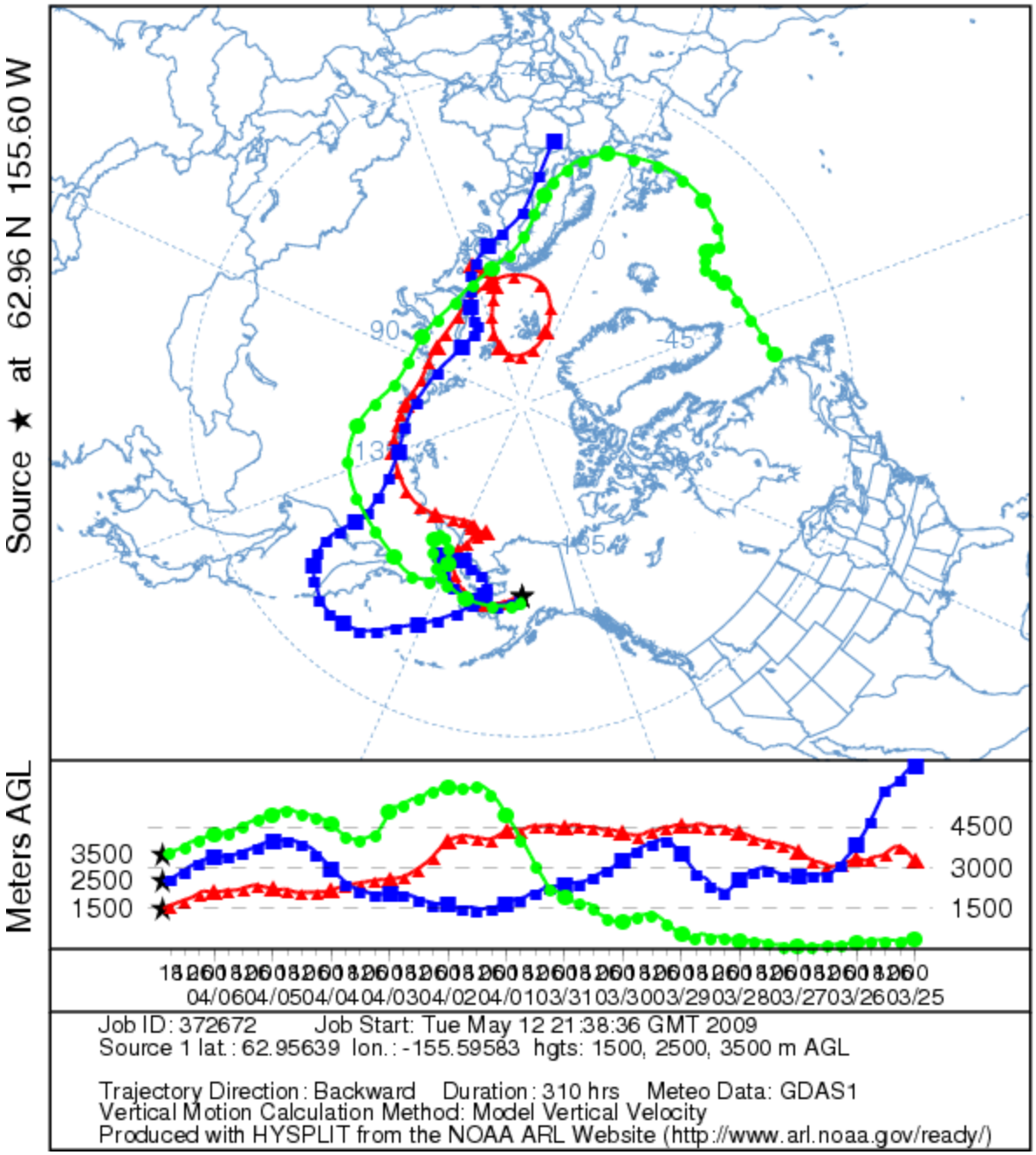

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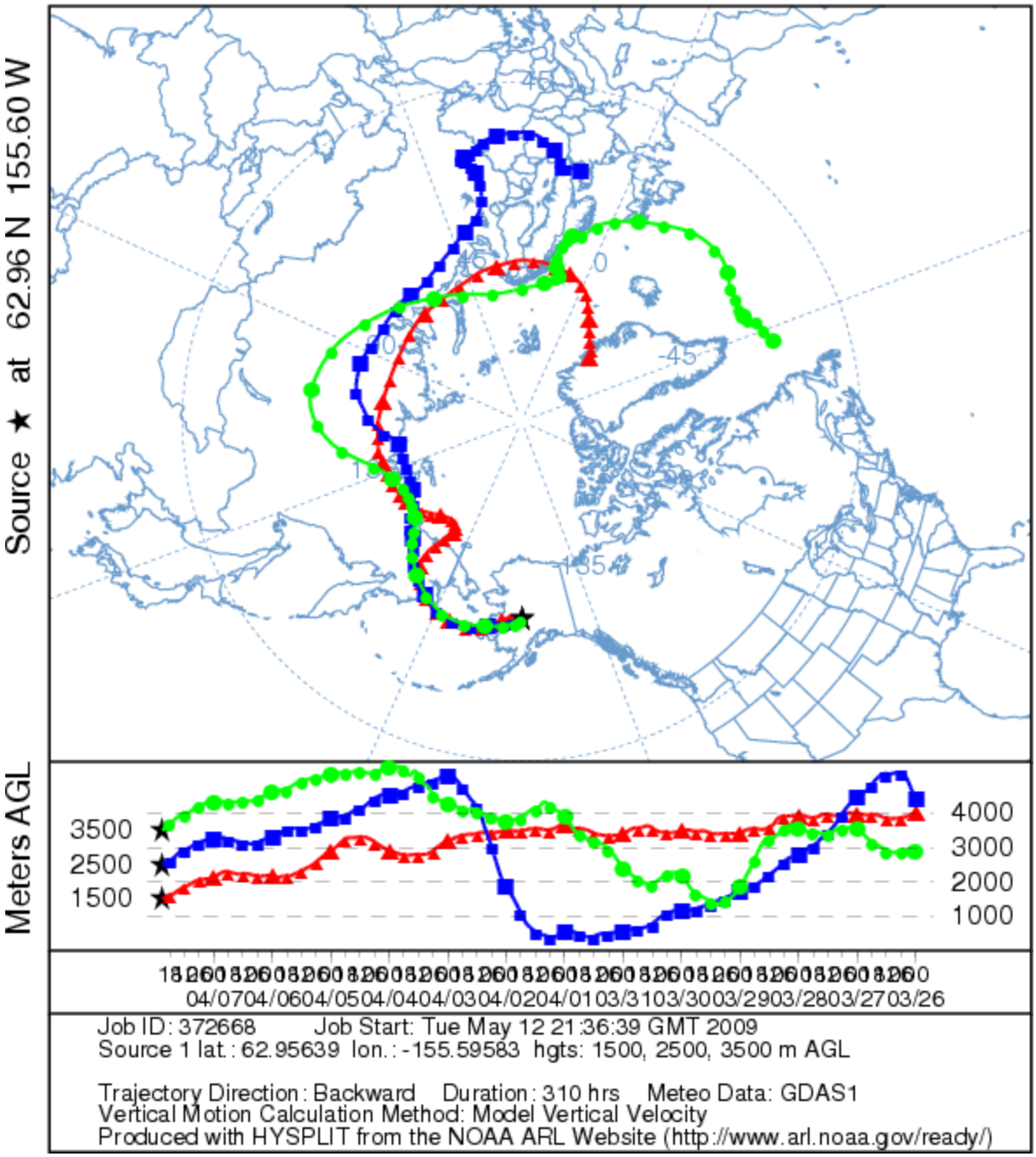

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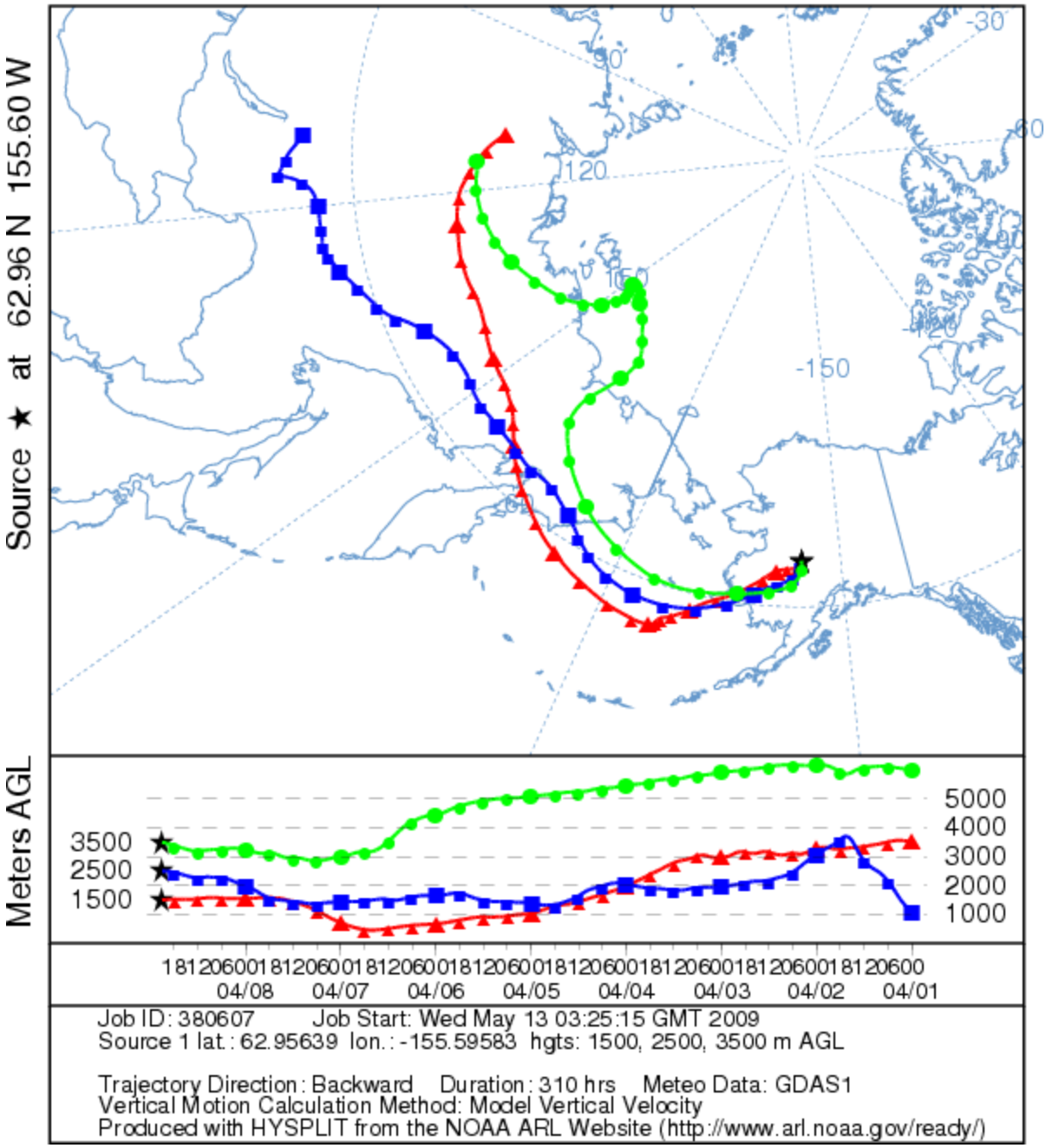

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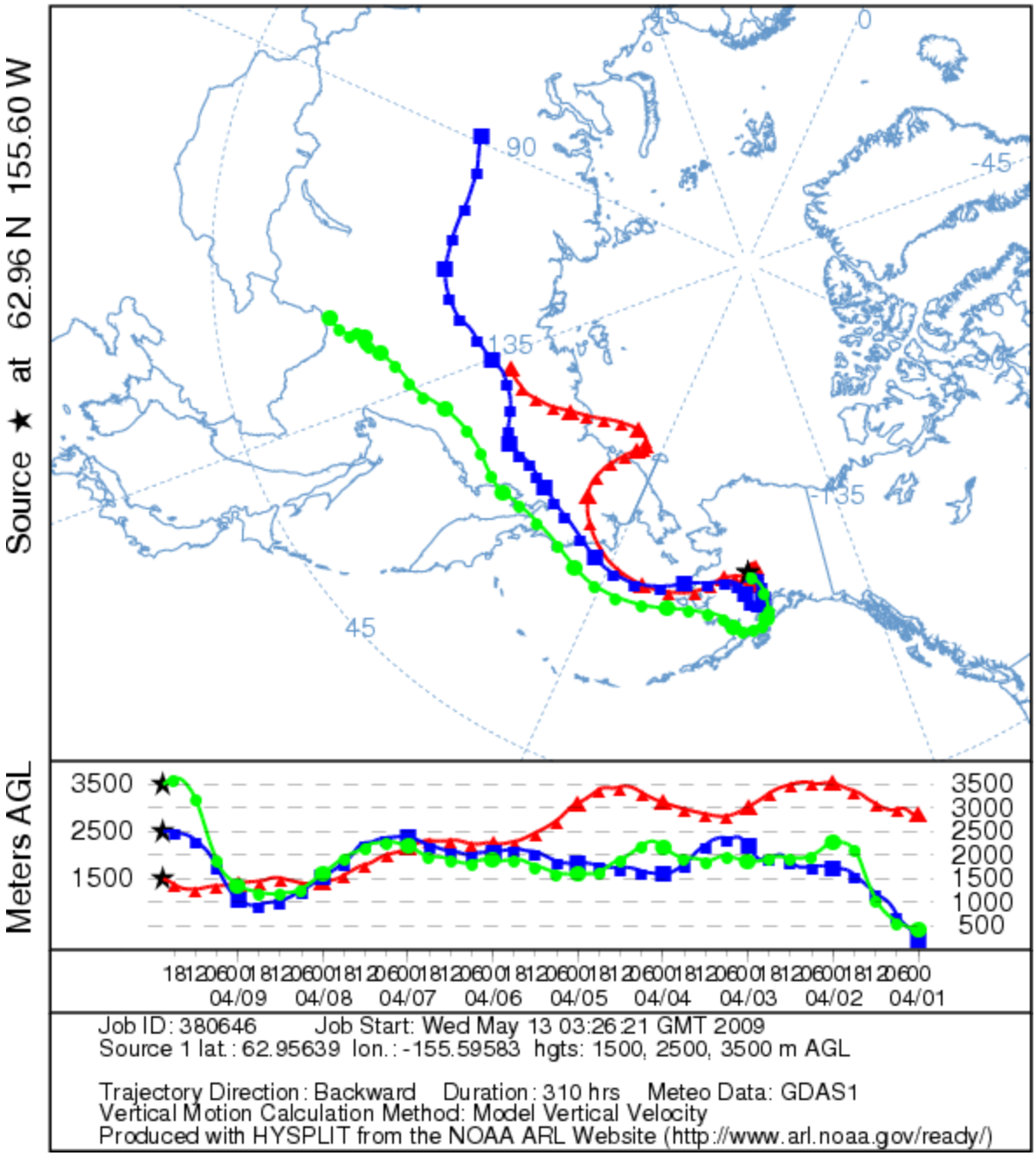

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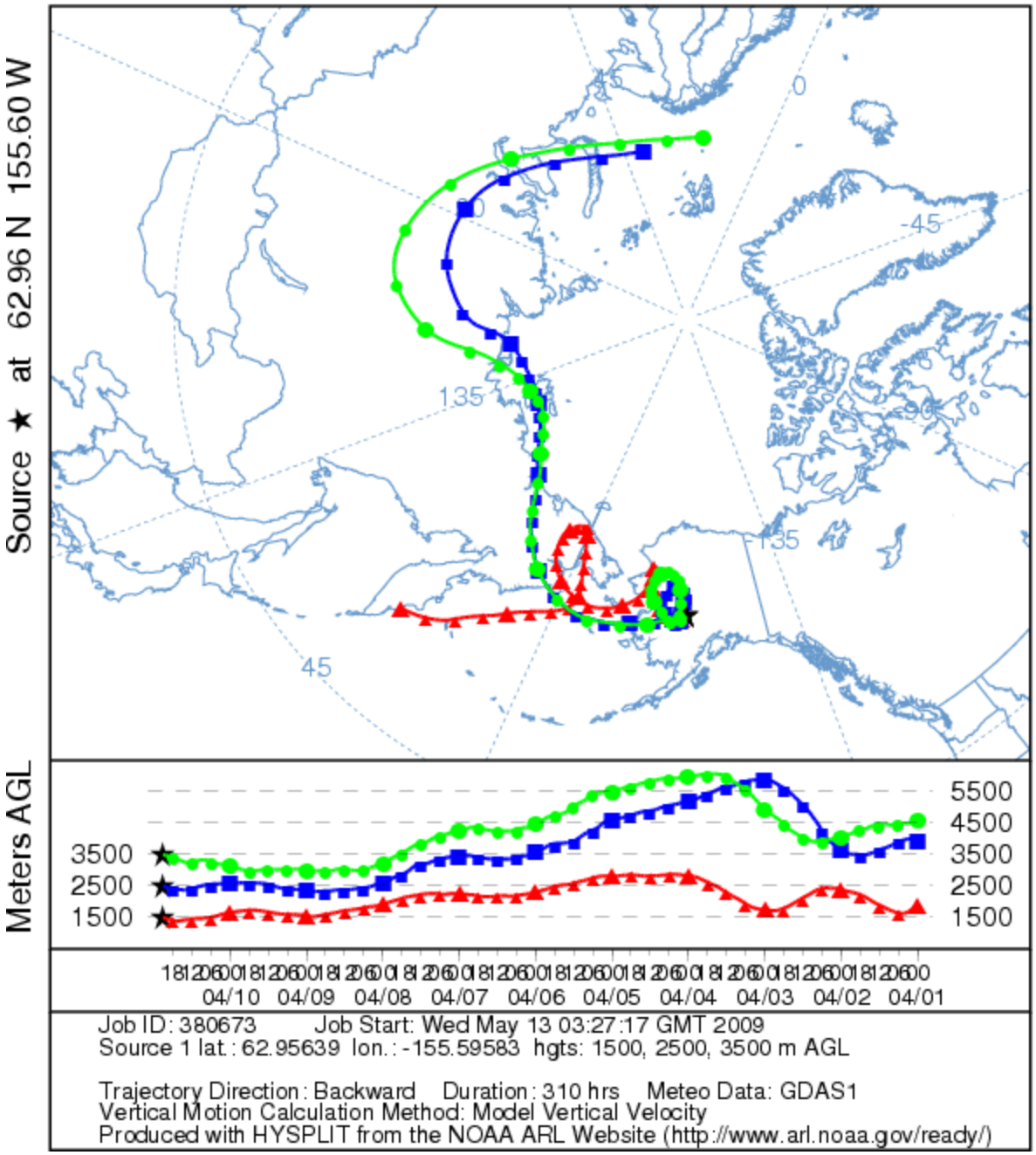

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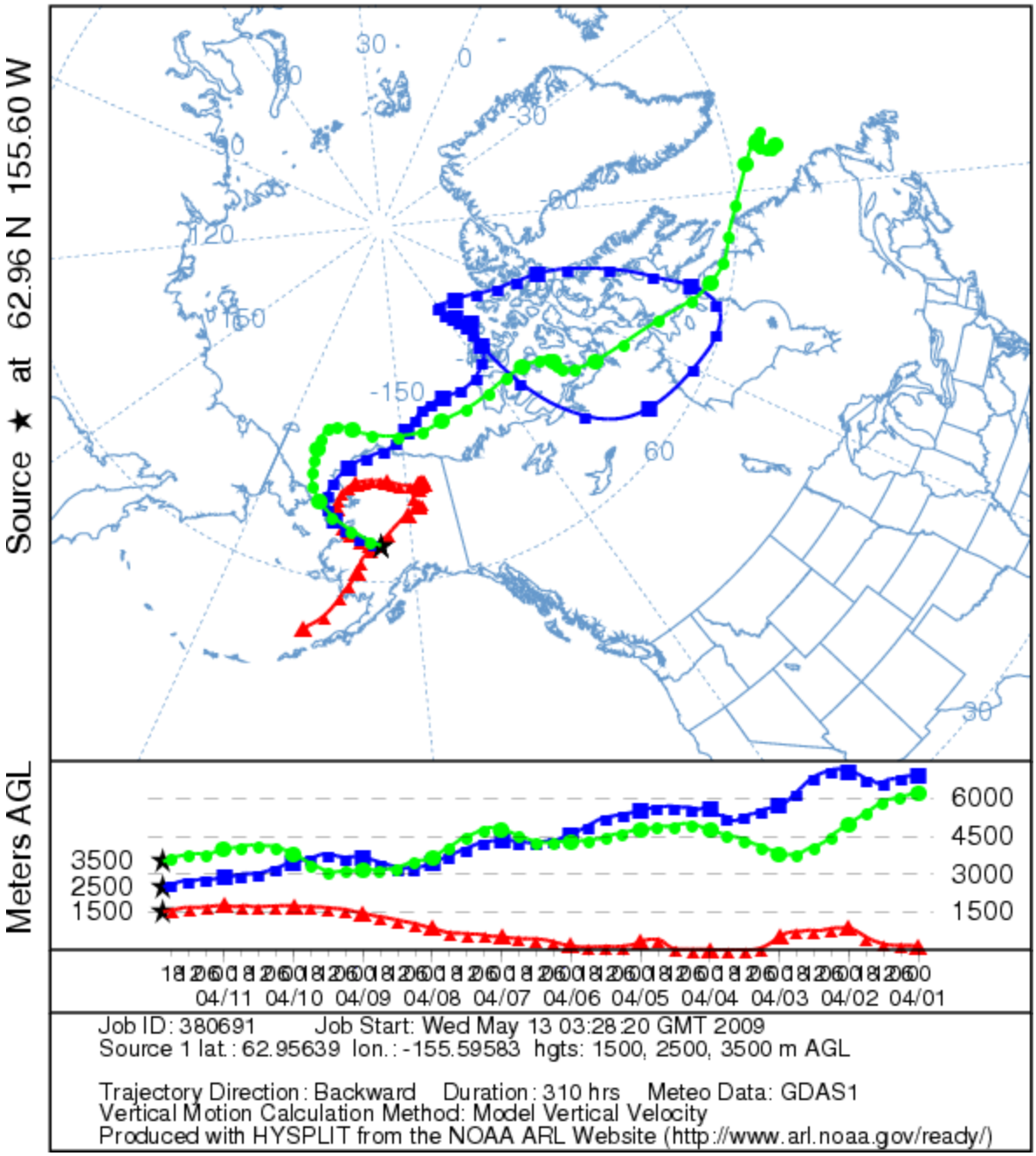

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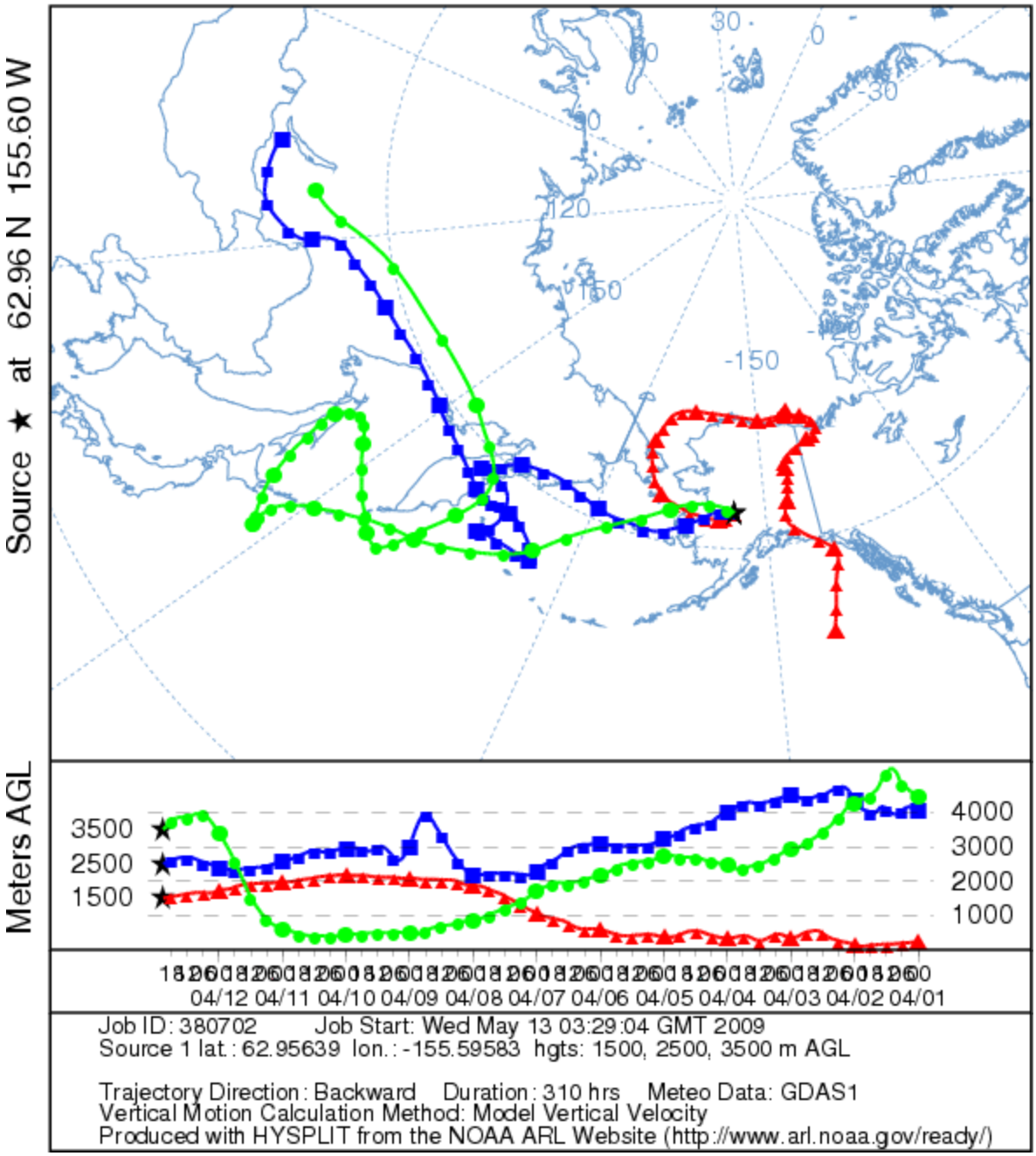

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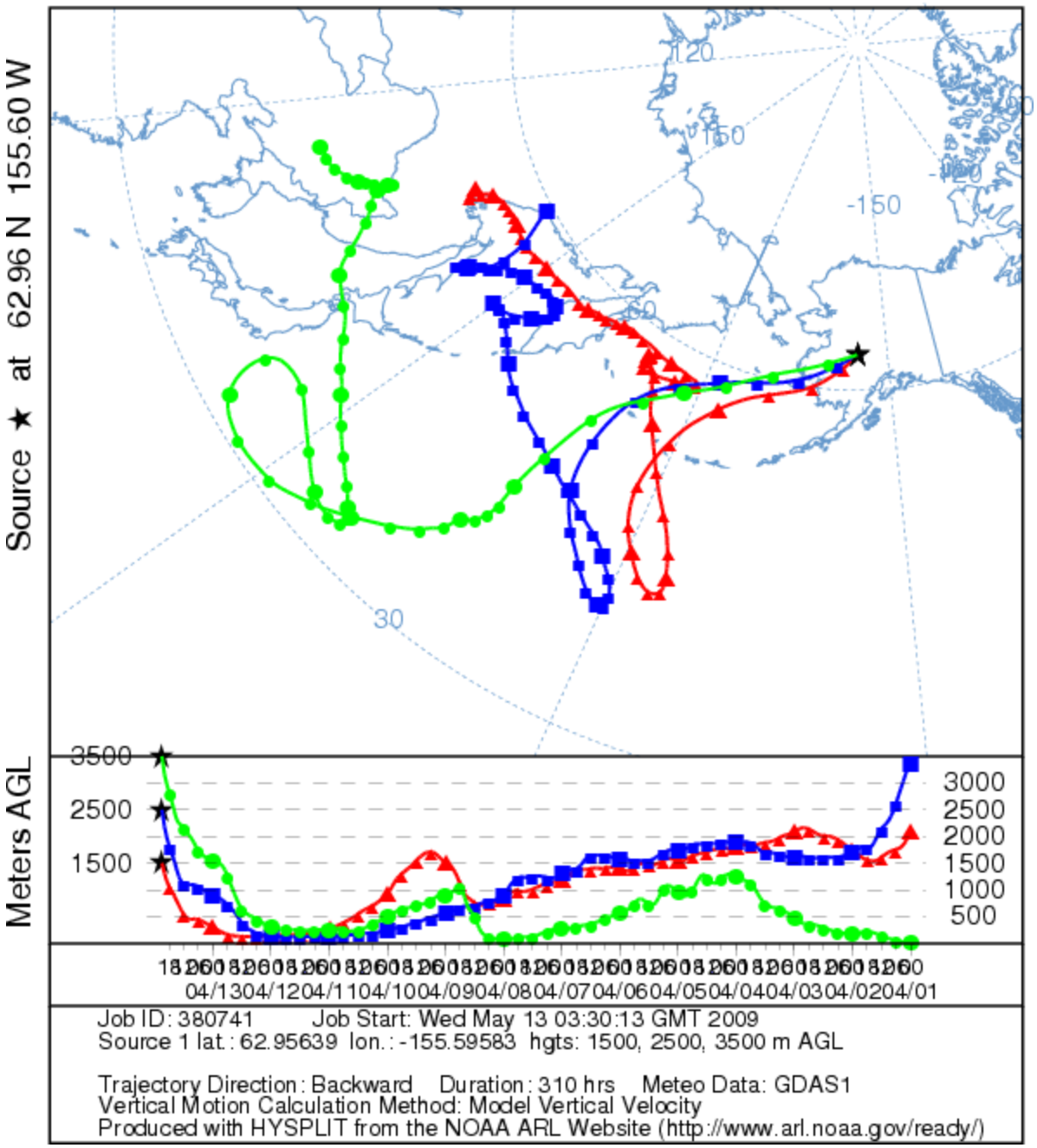

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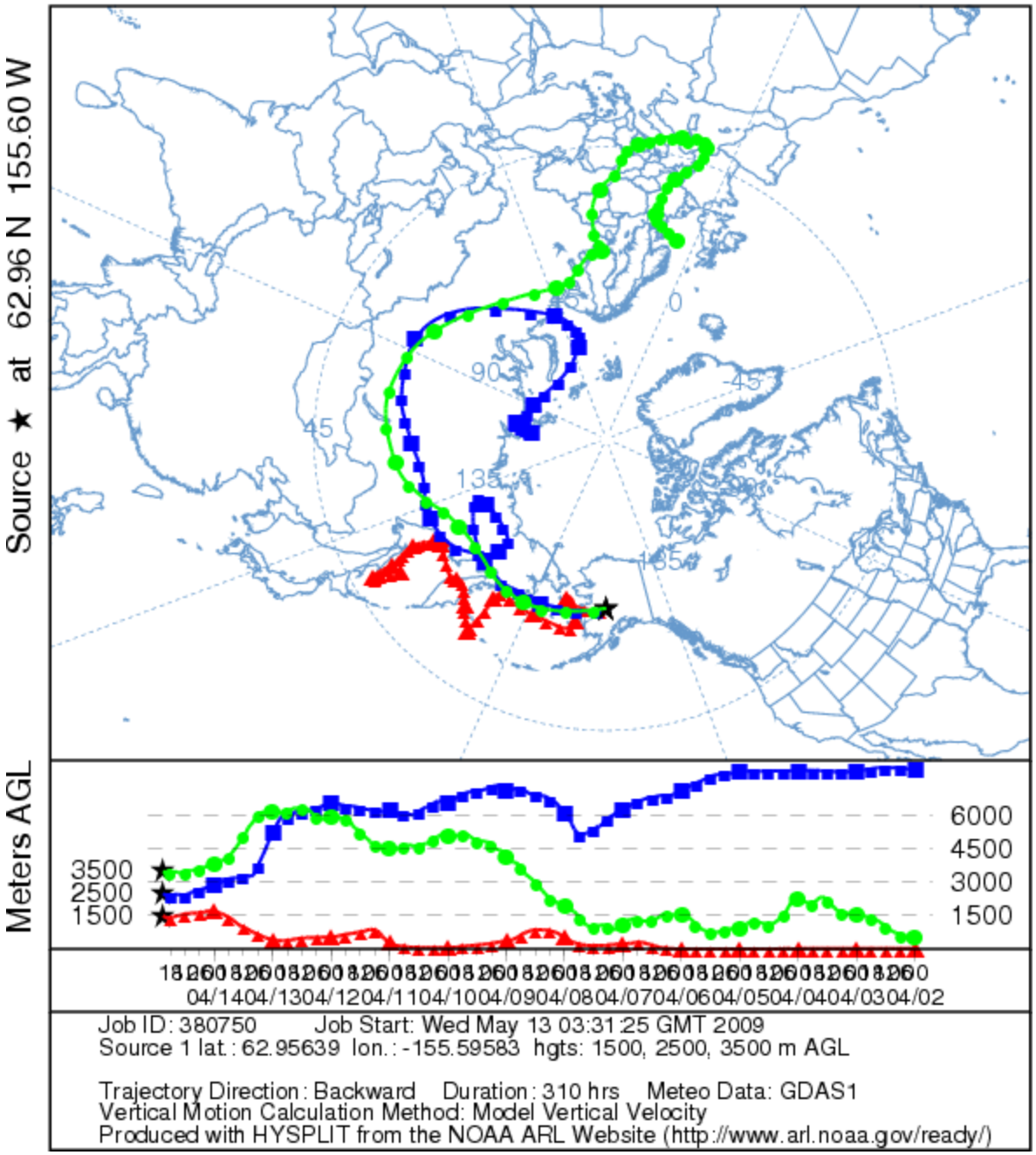

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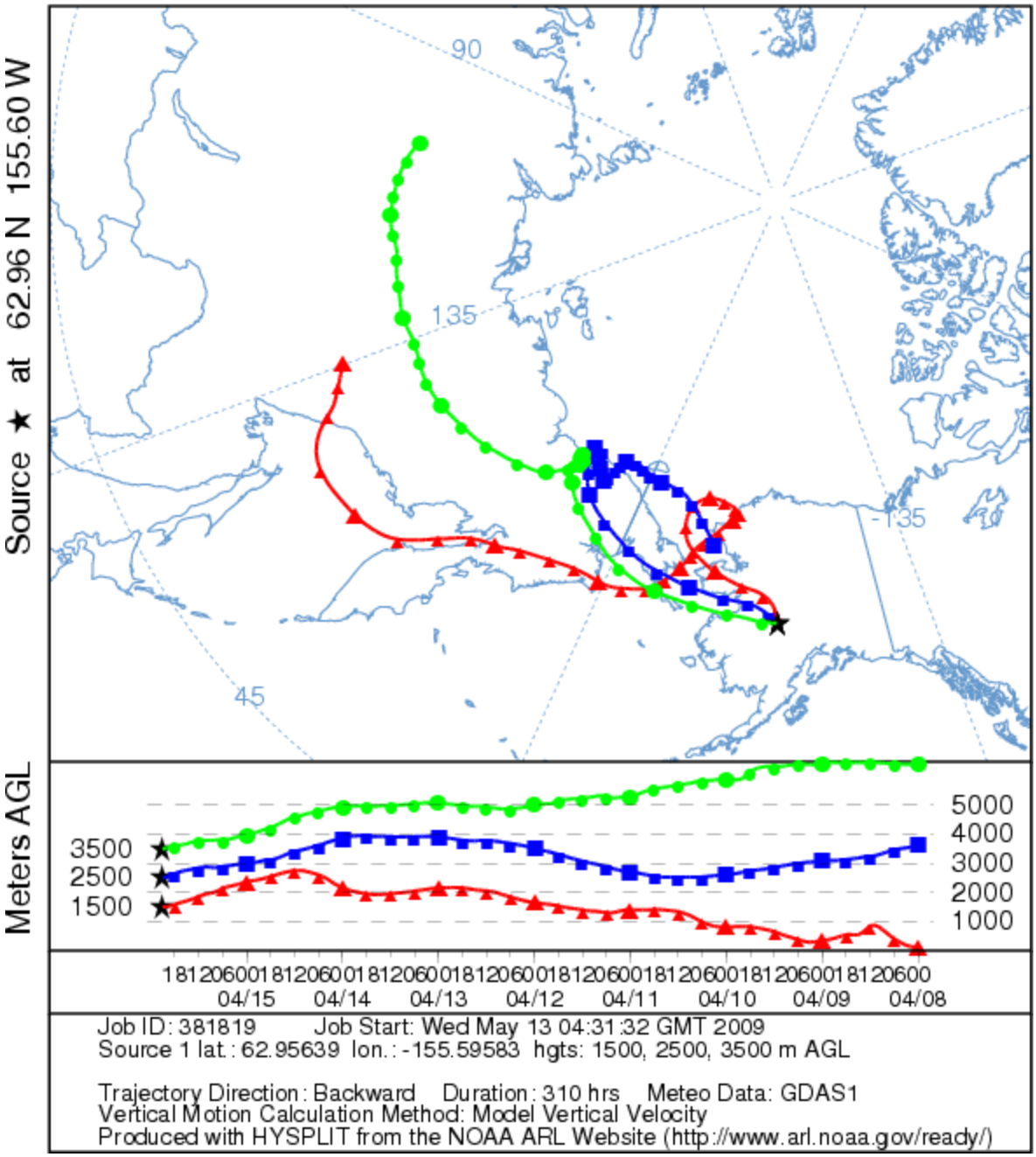

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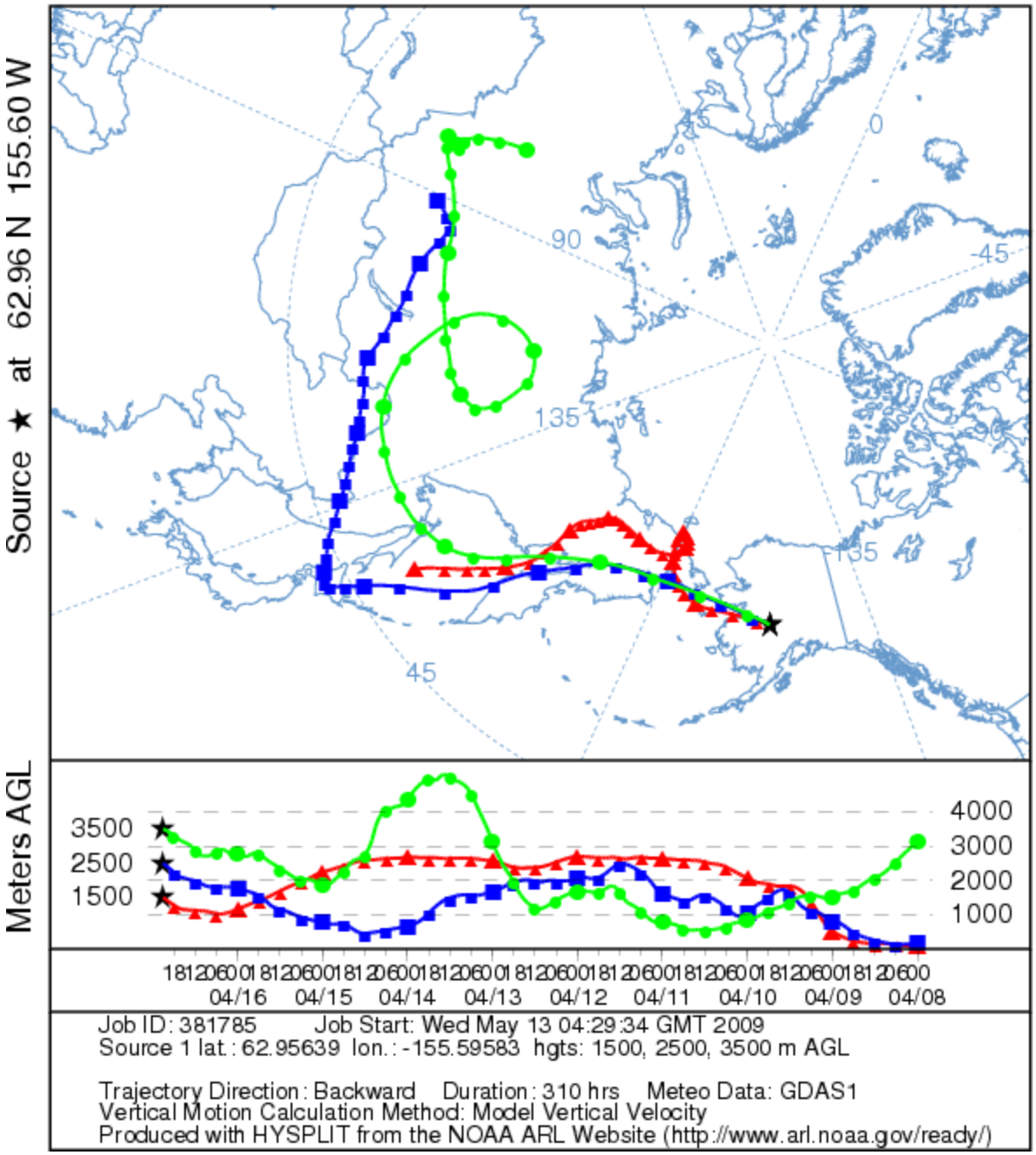

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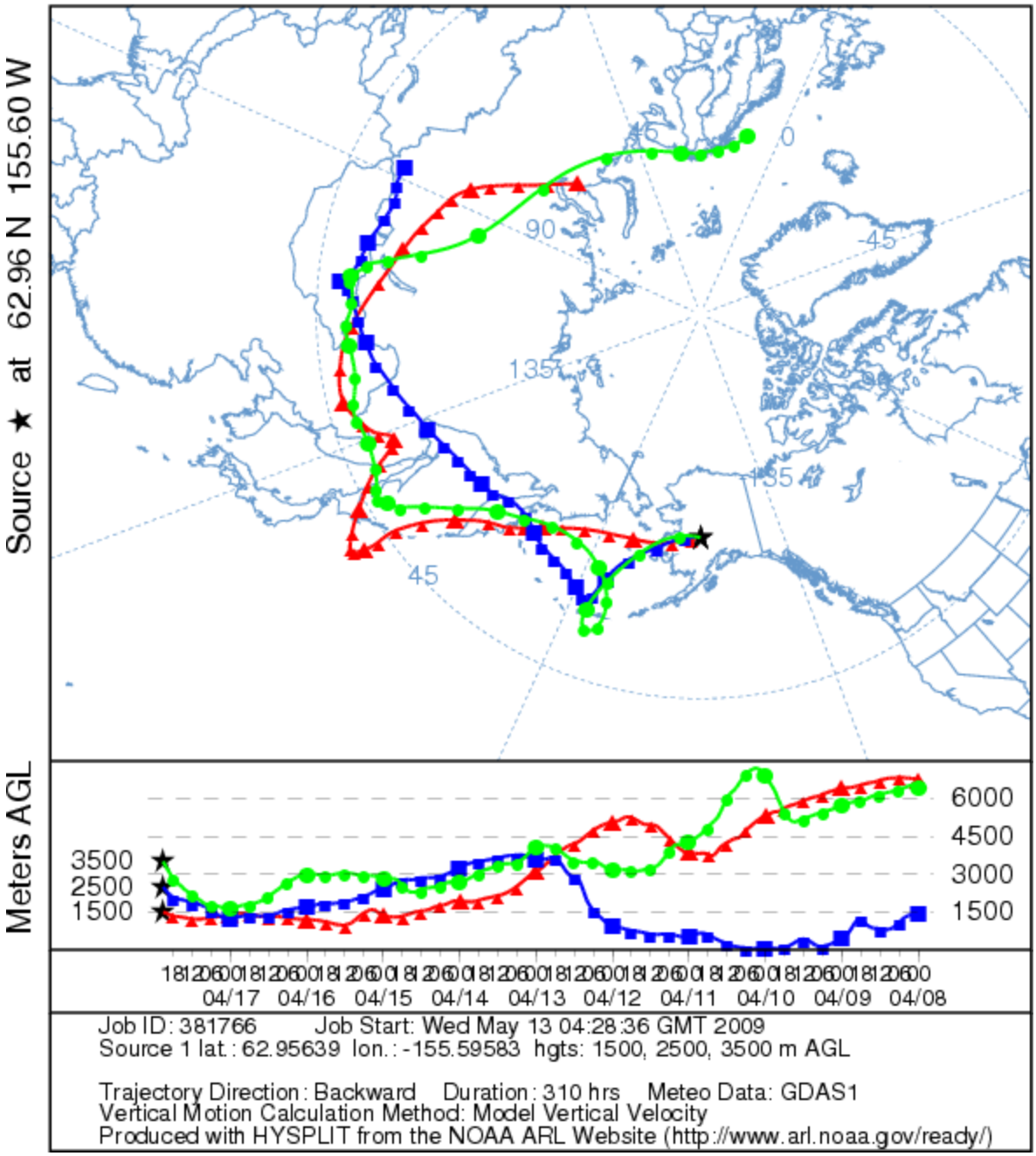

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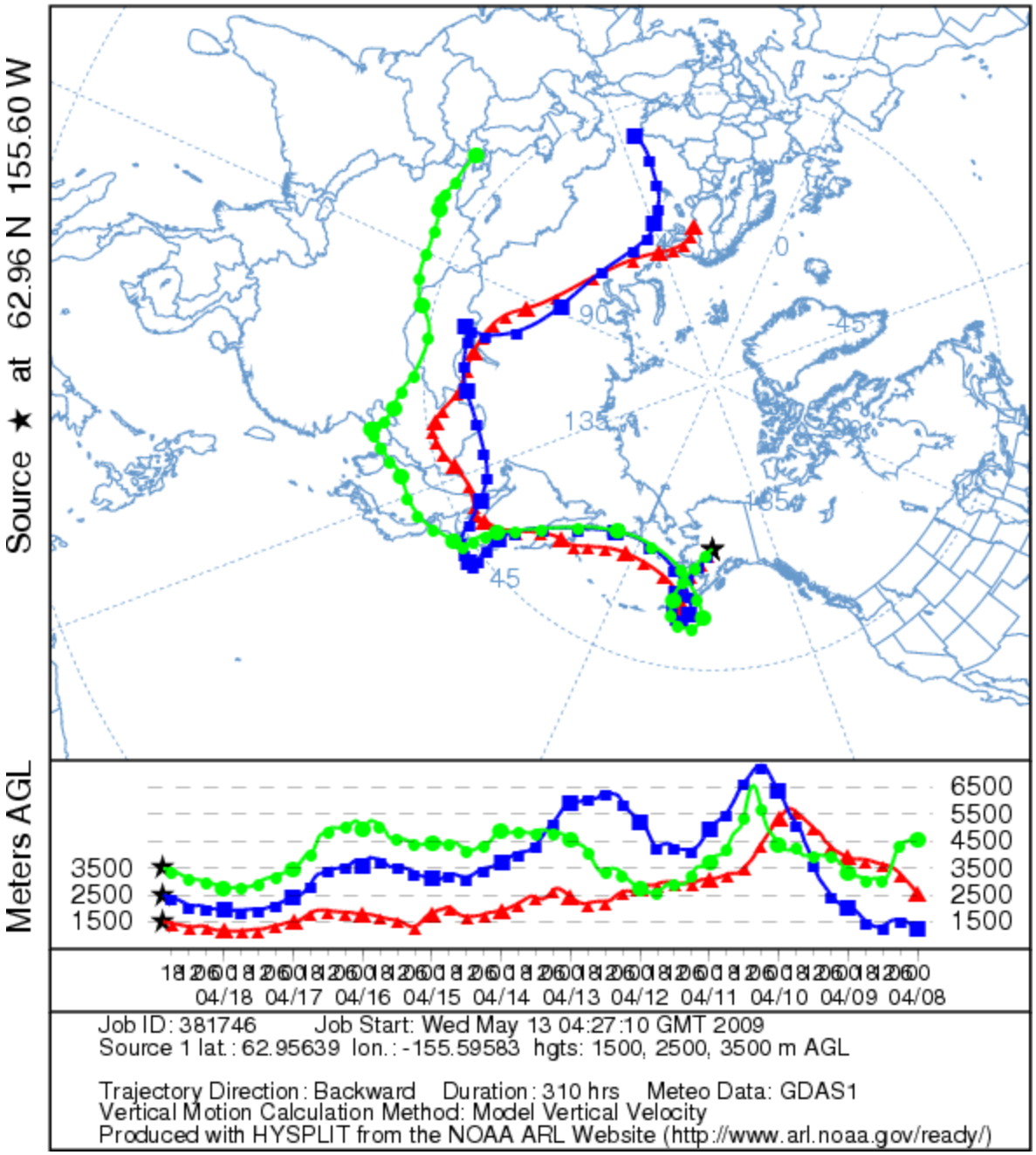

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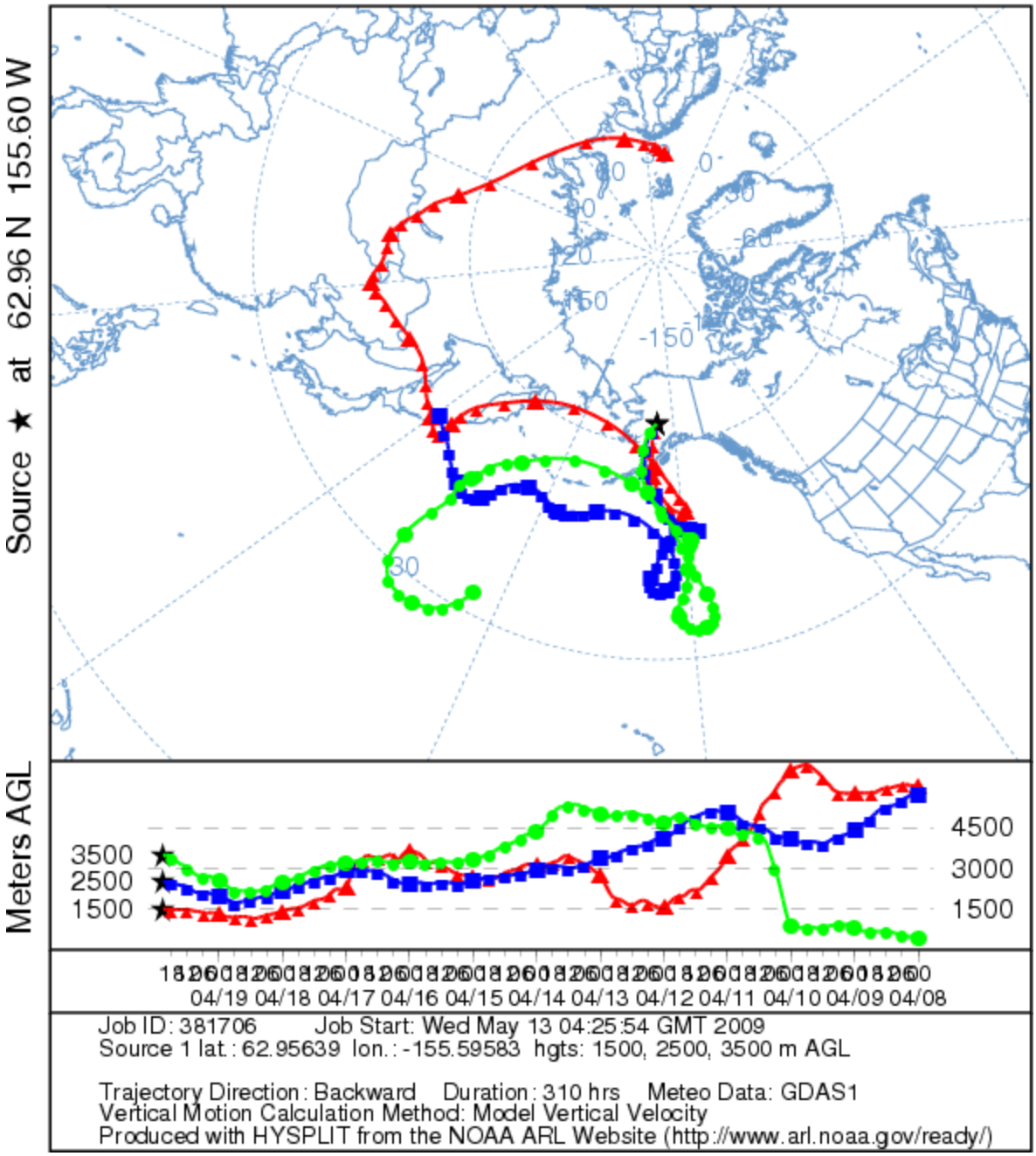

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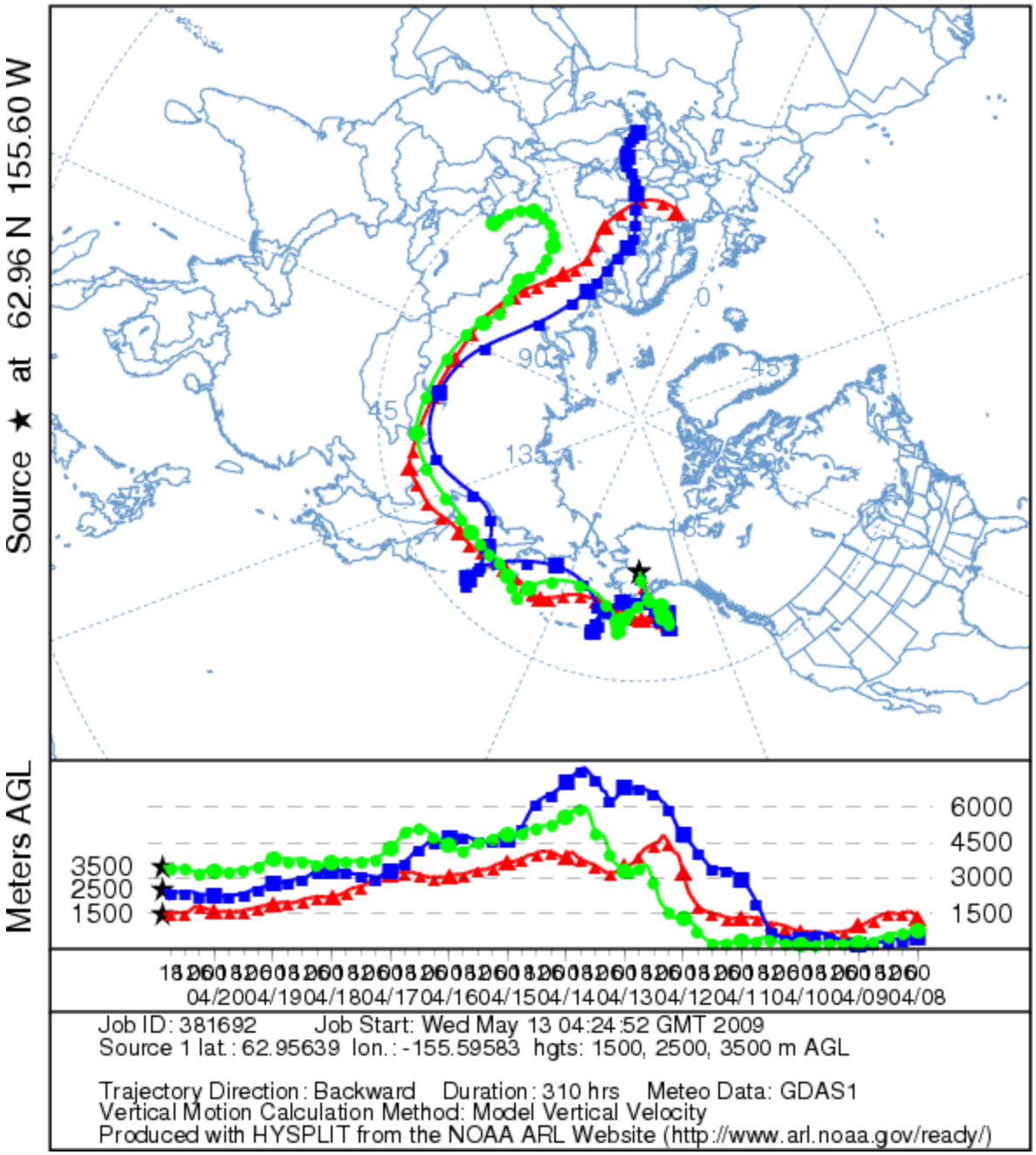

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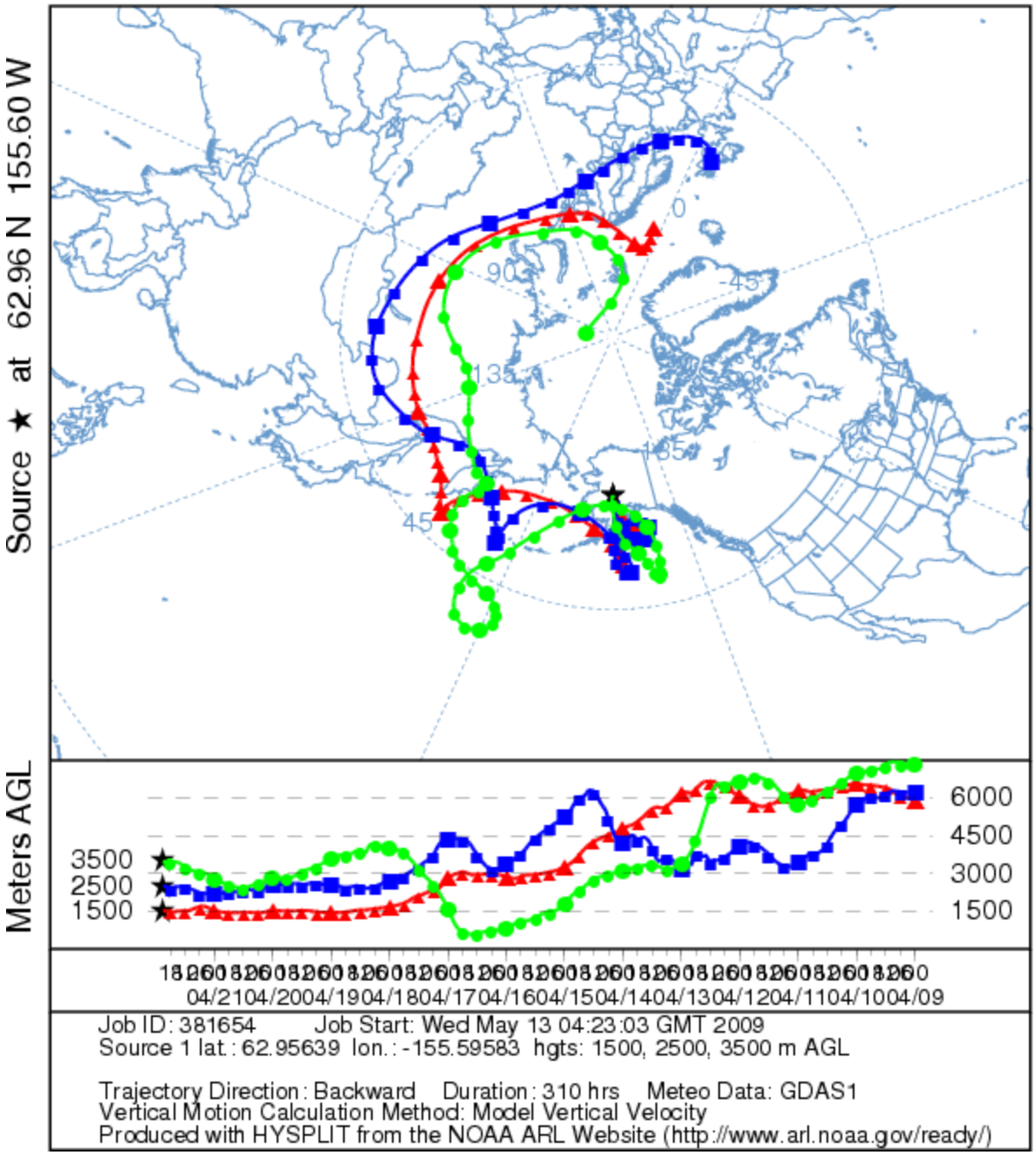

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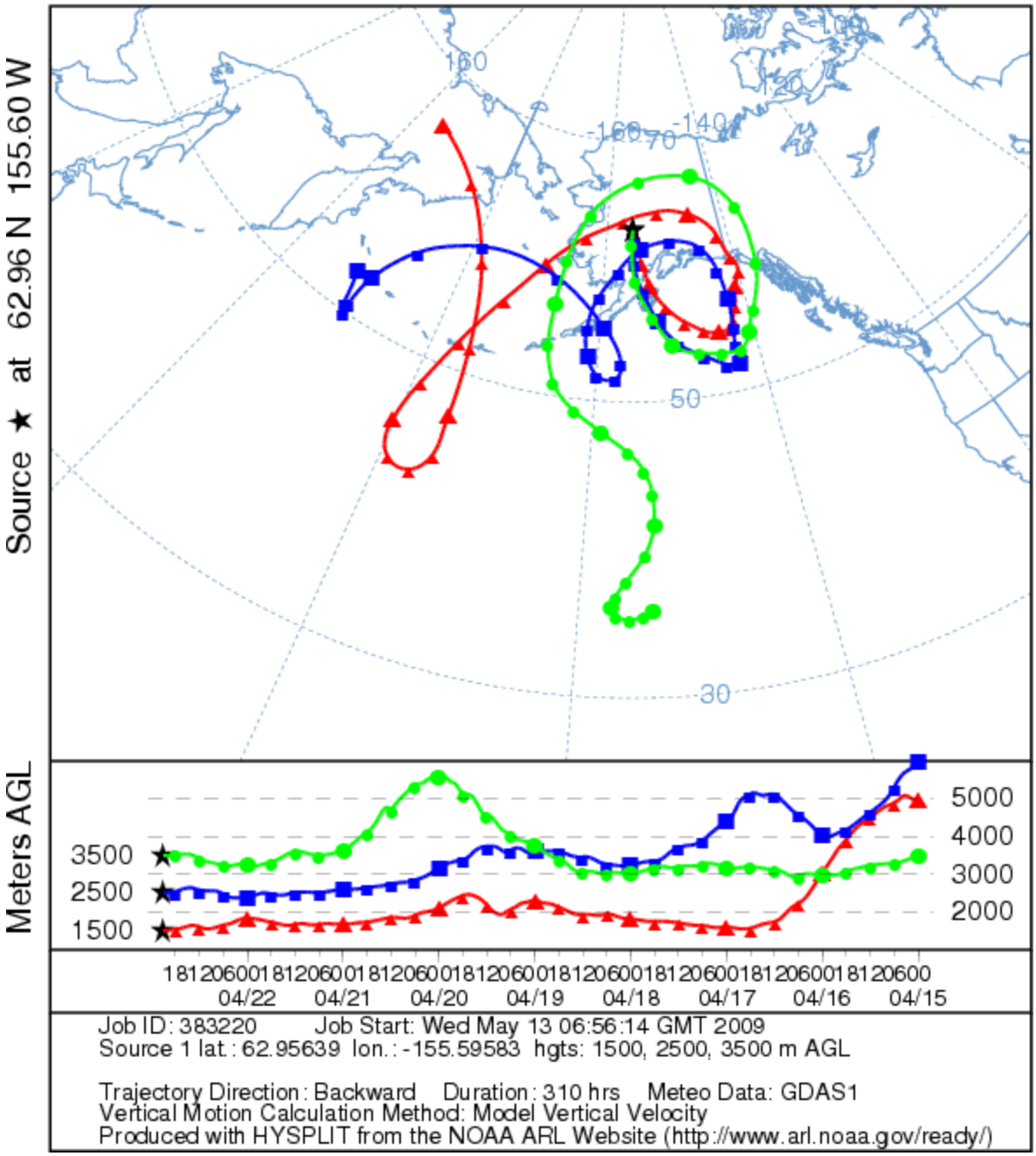

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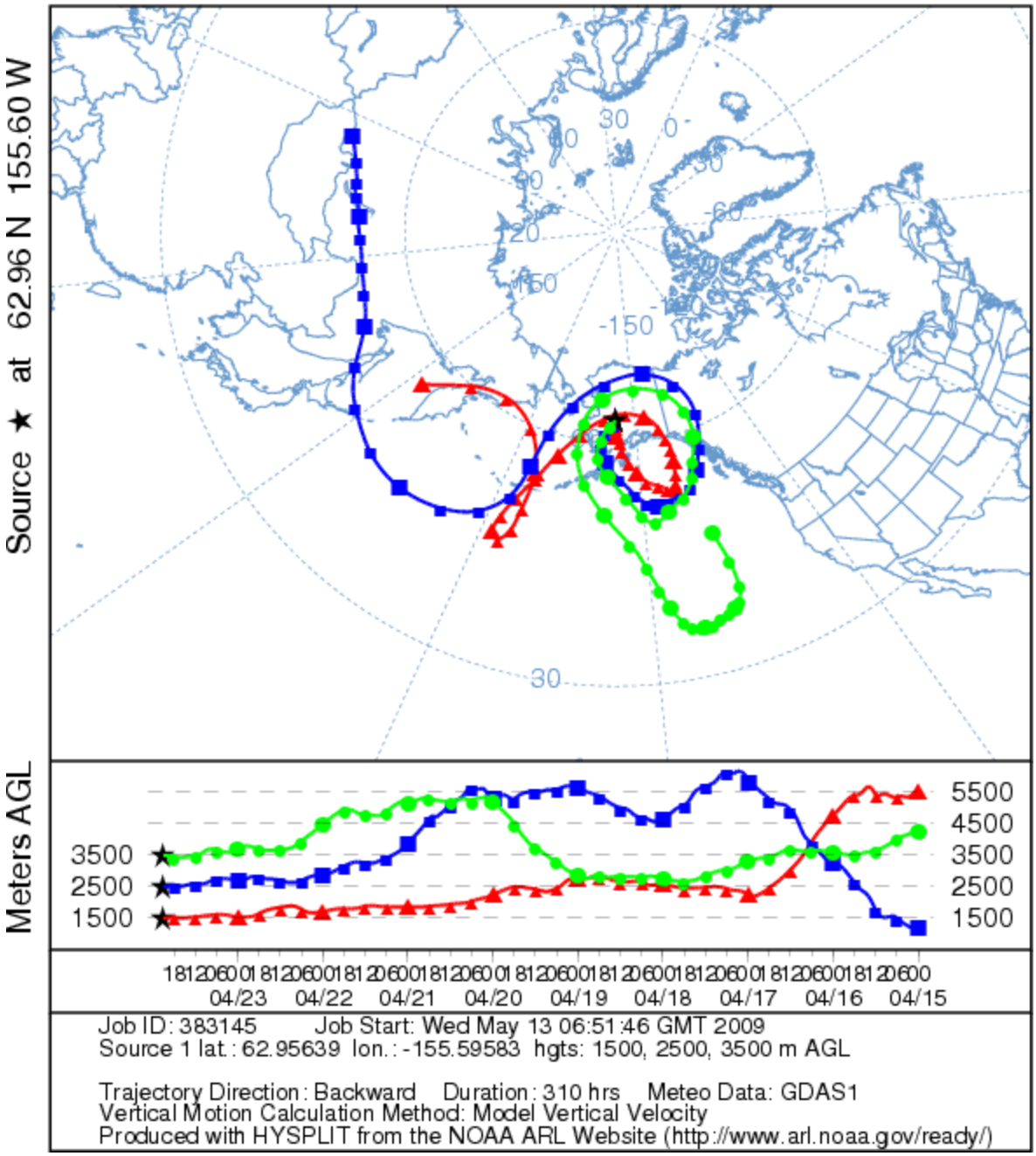

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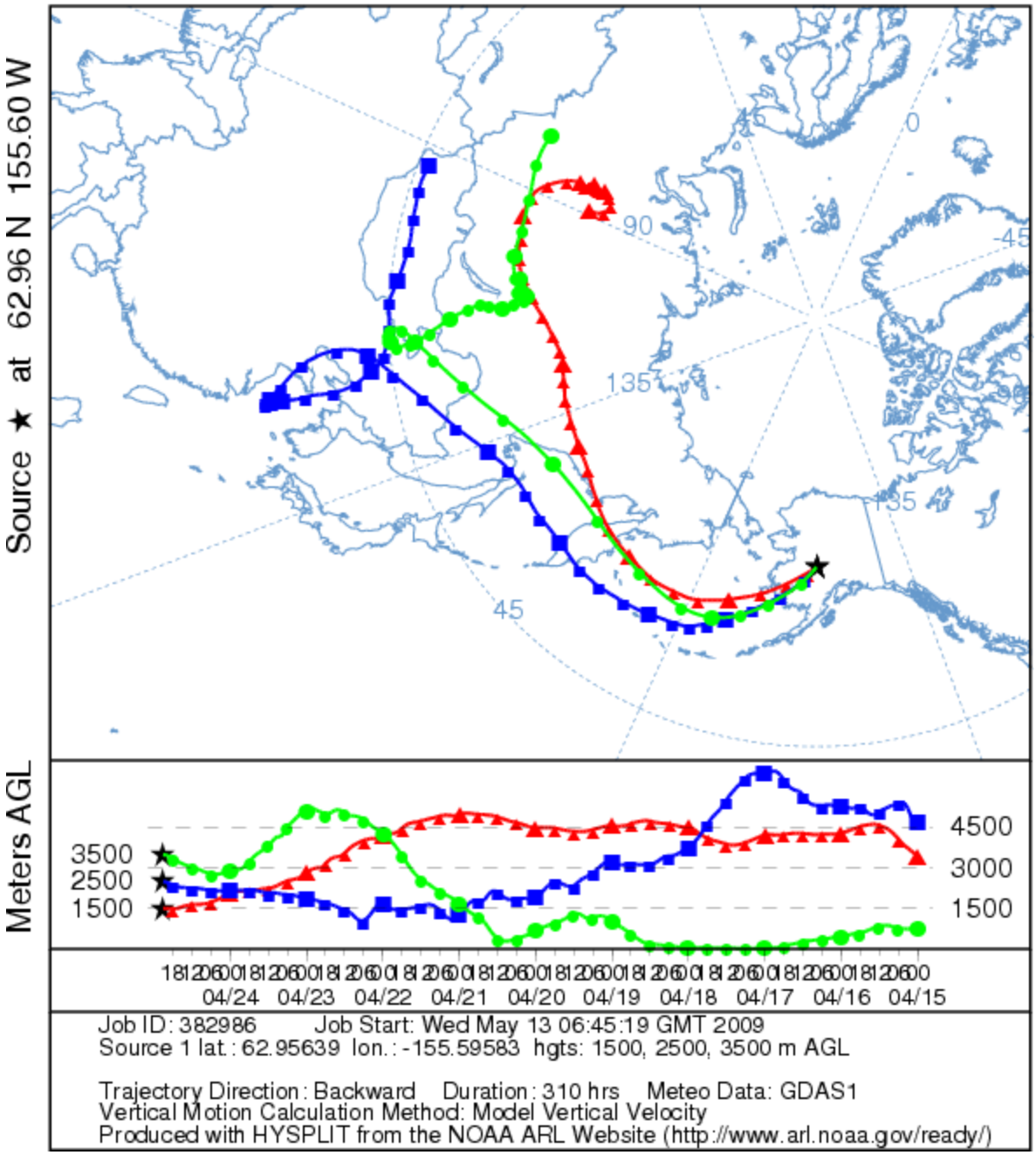

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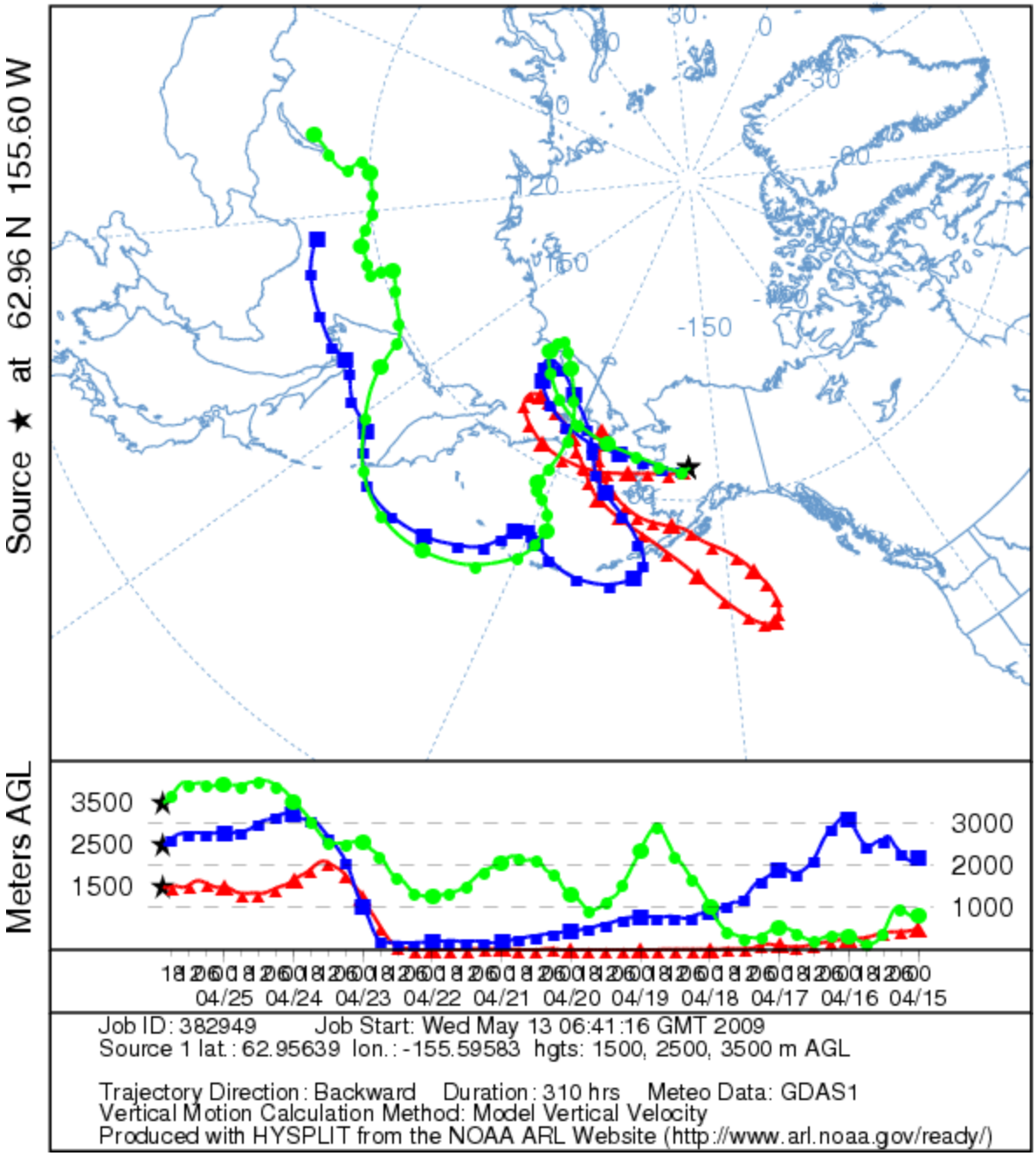

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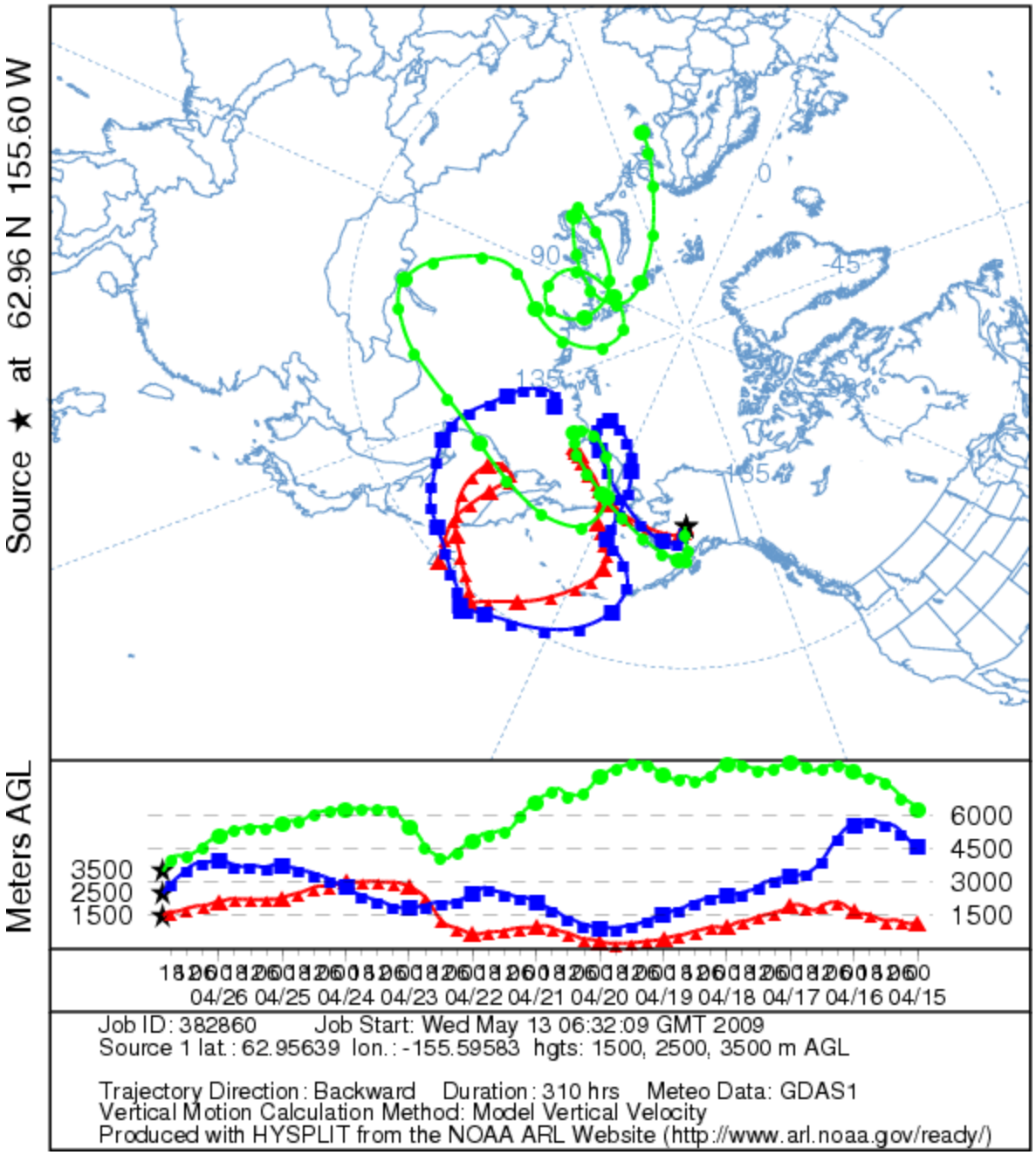
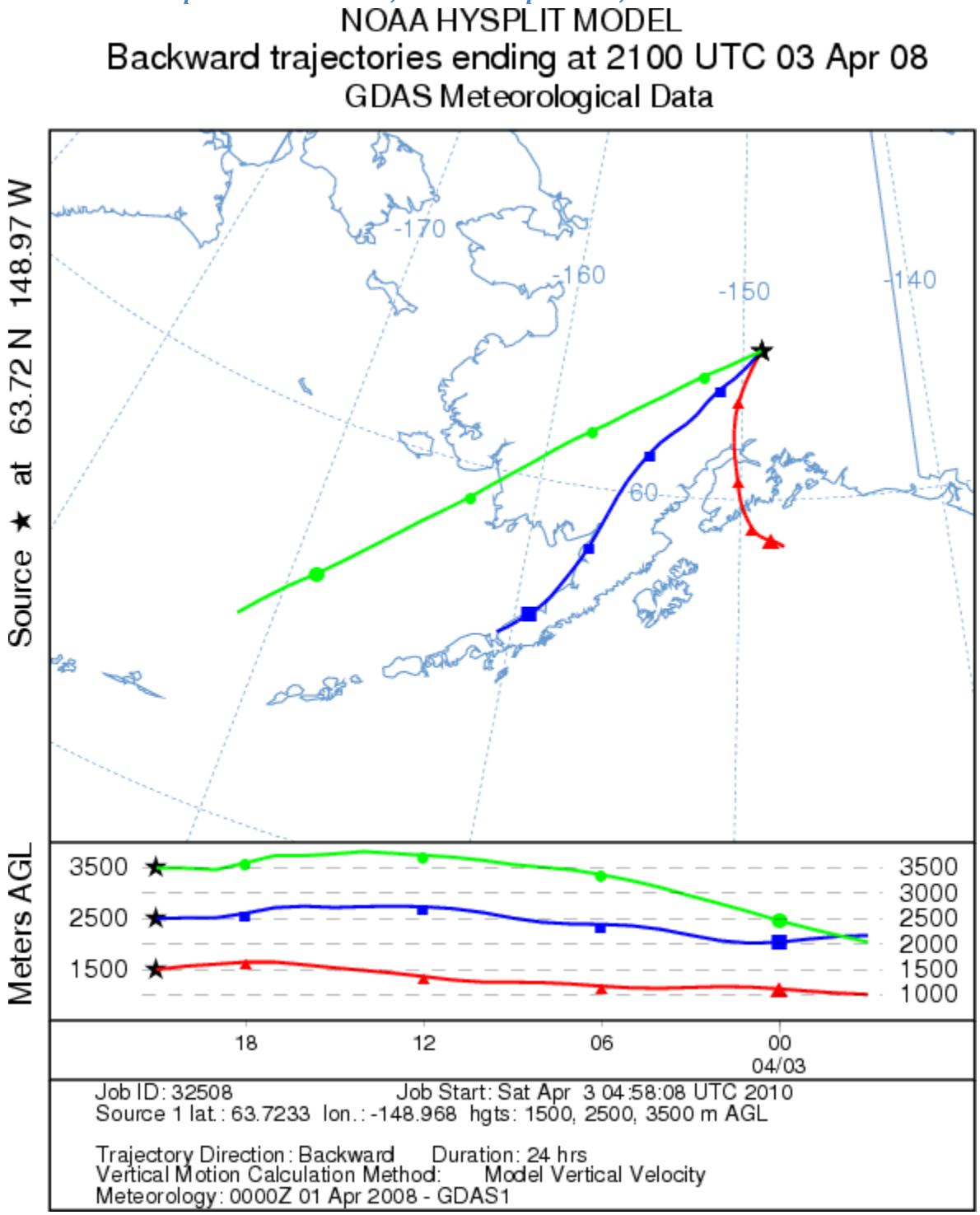


C-4 Denali Headquarters- Low Level, 24 hours- April 3-14, 2008



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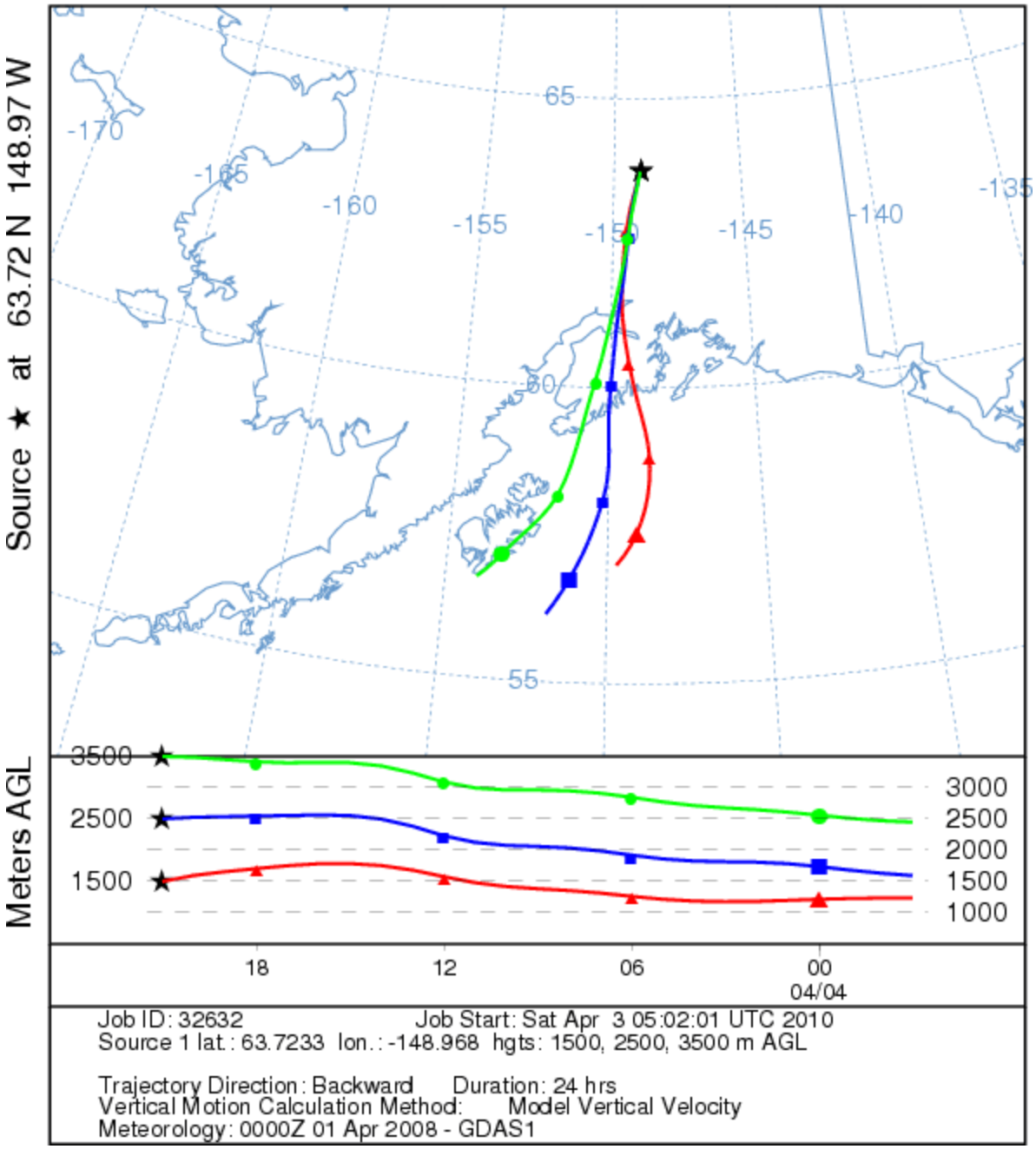

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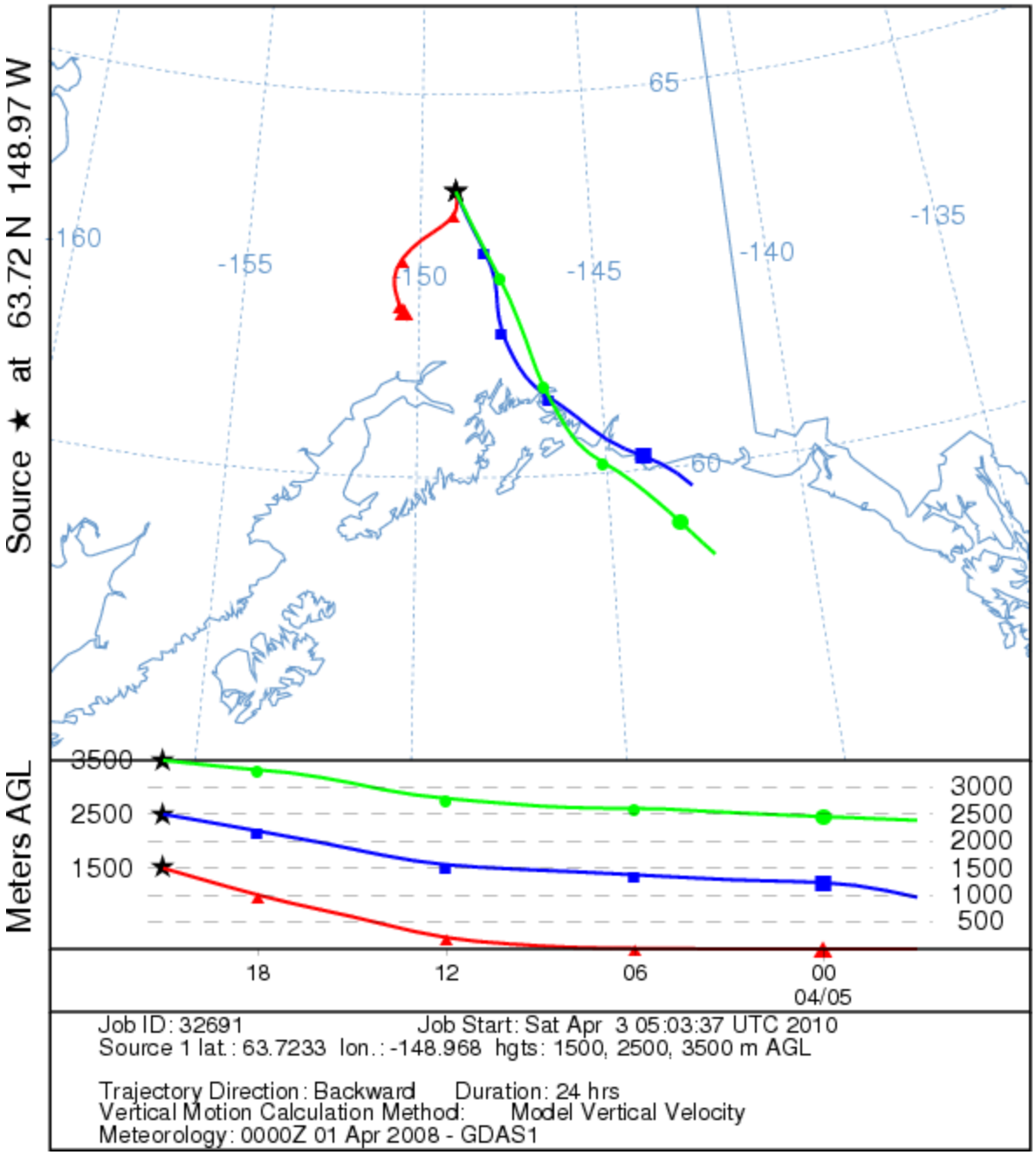

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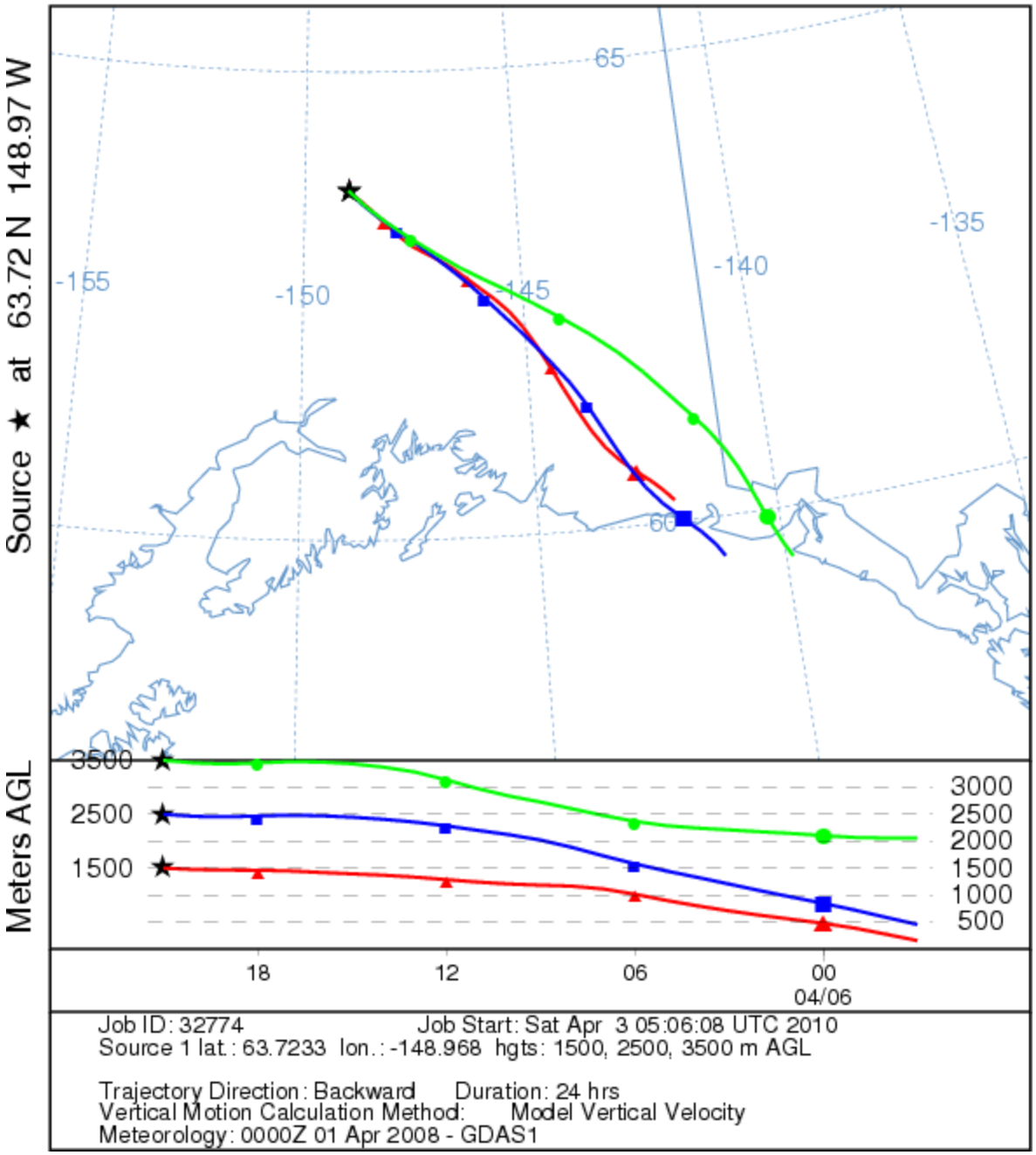

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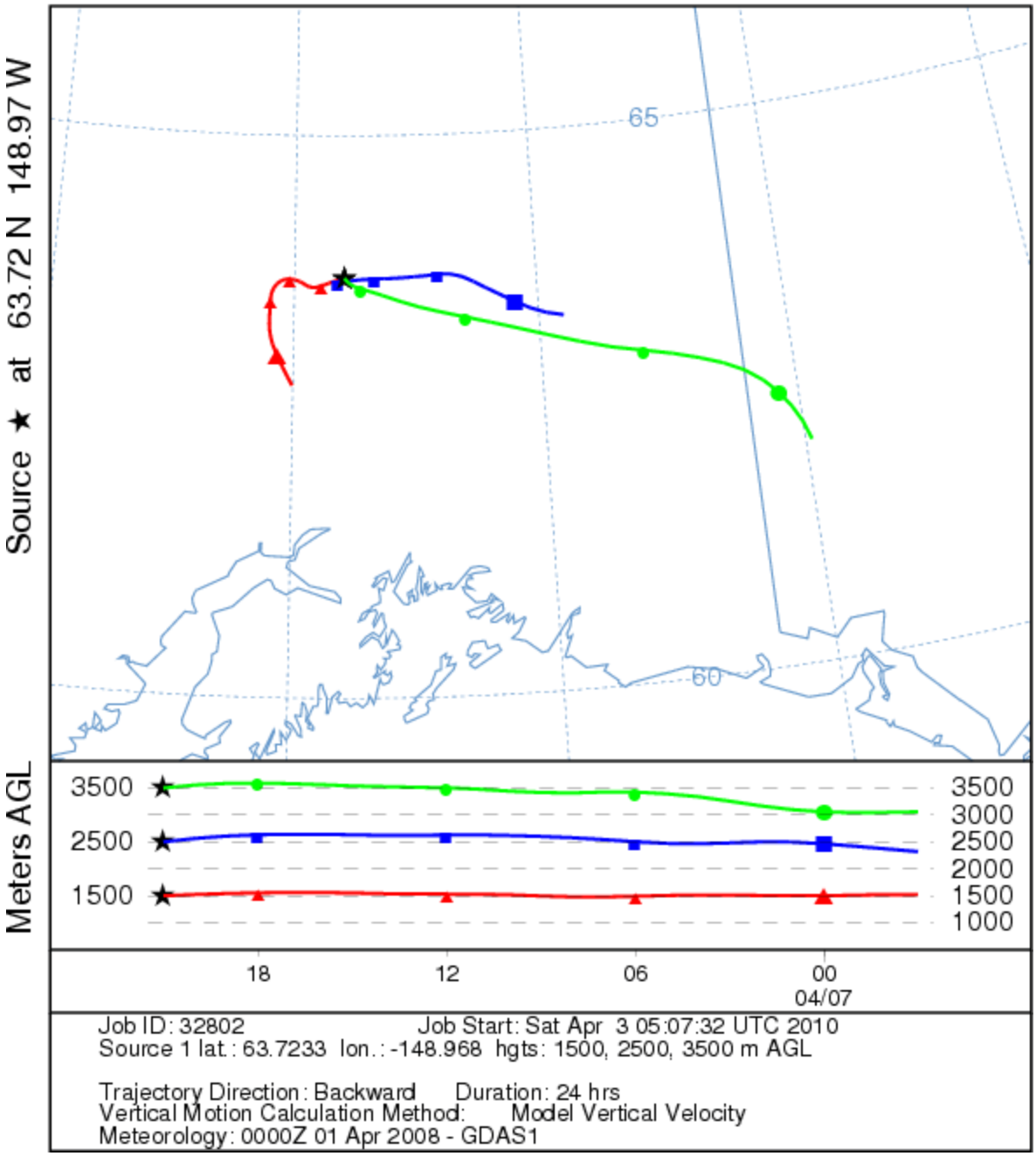

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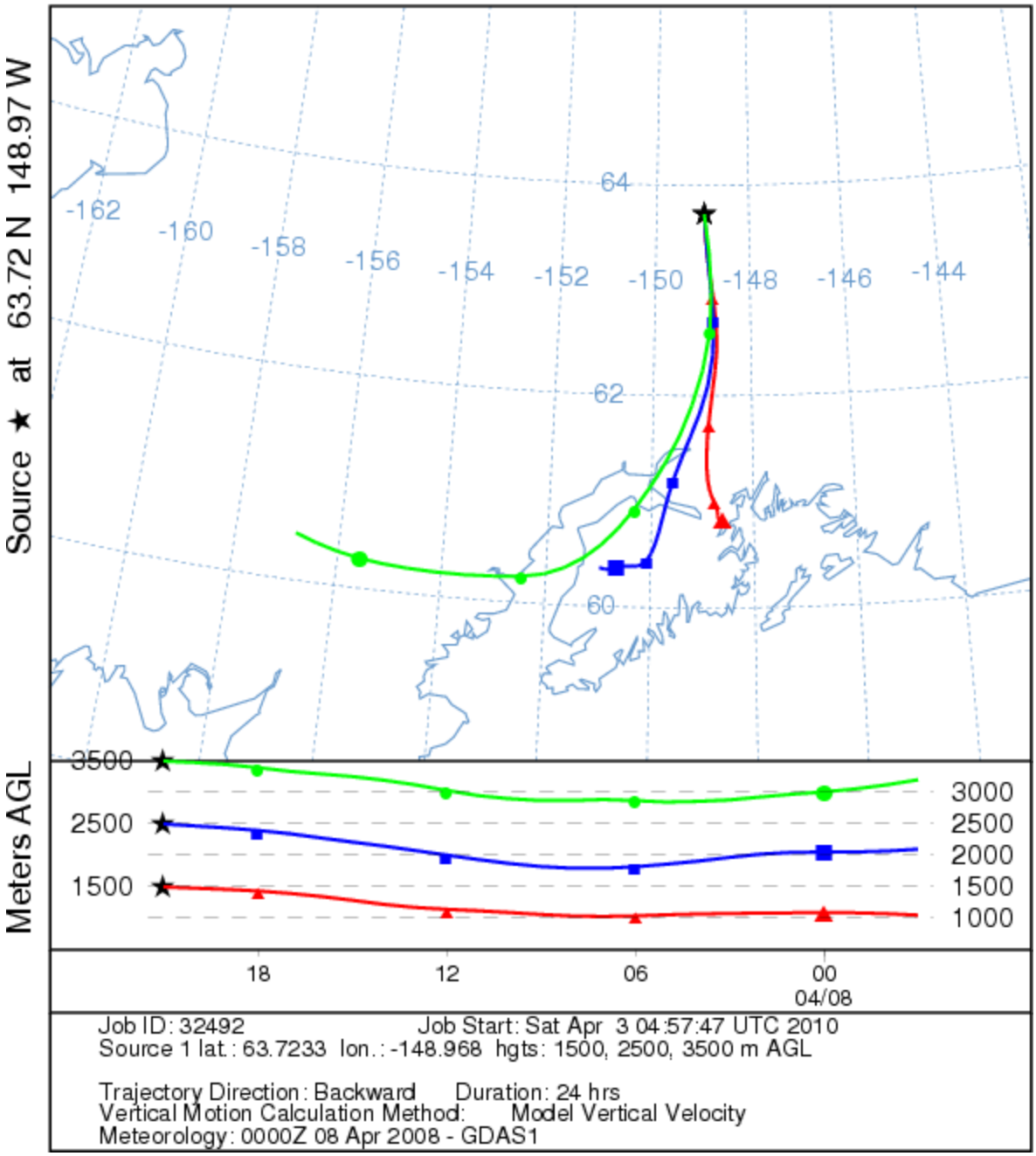

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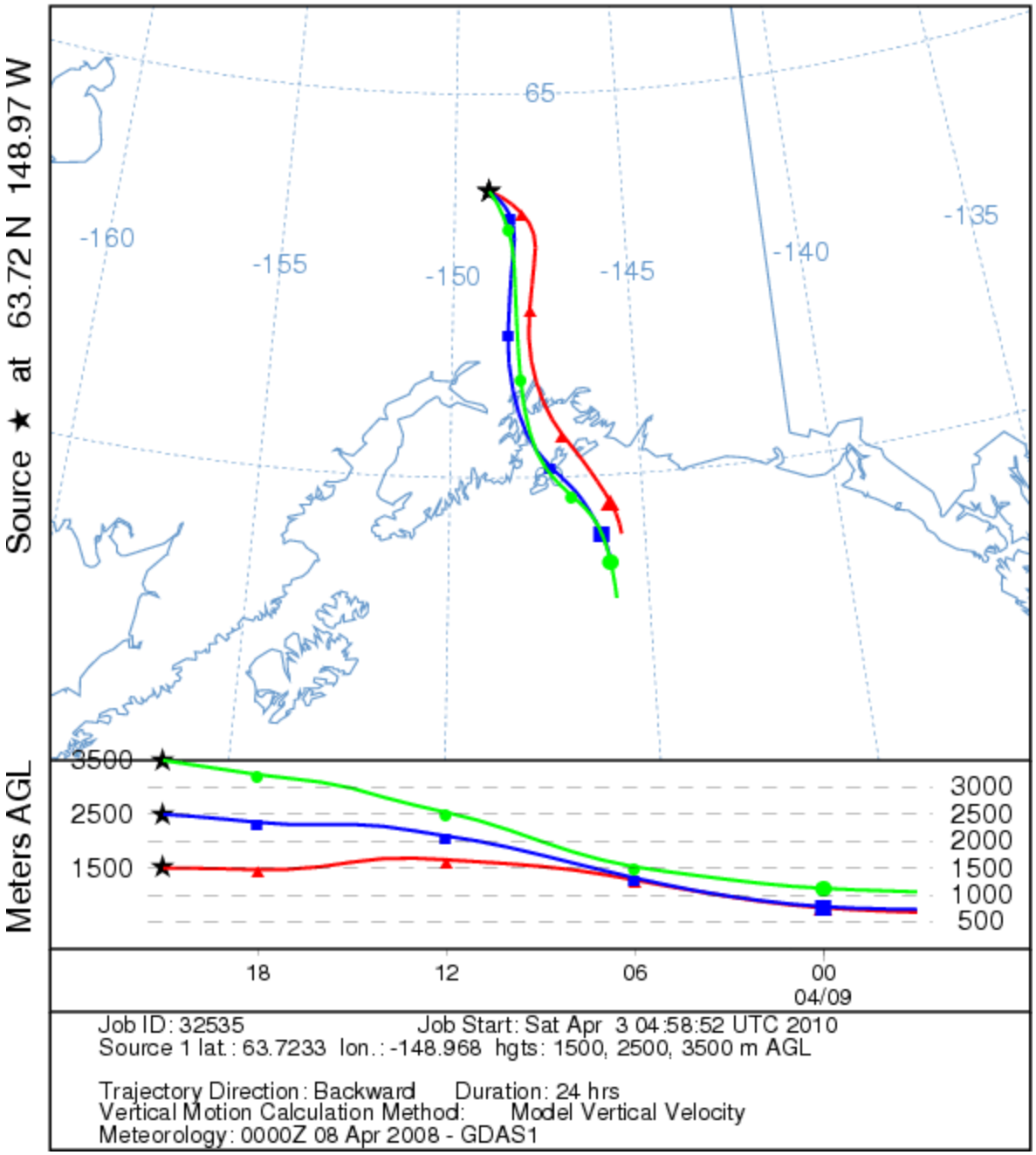

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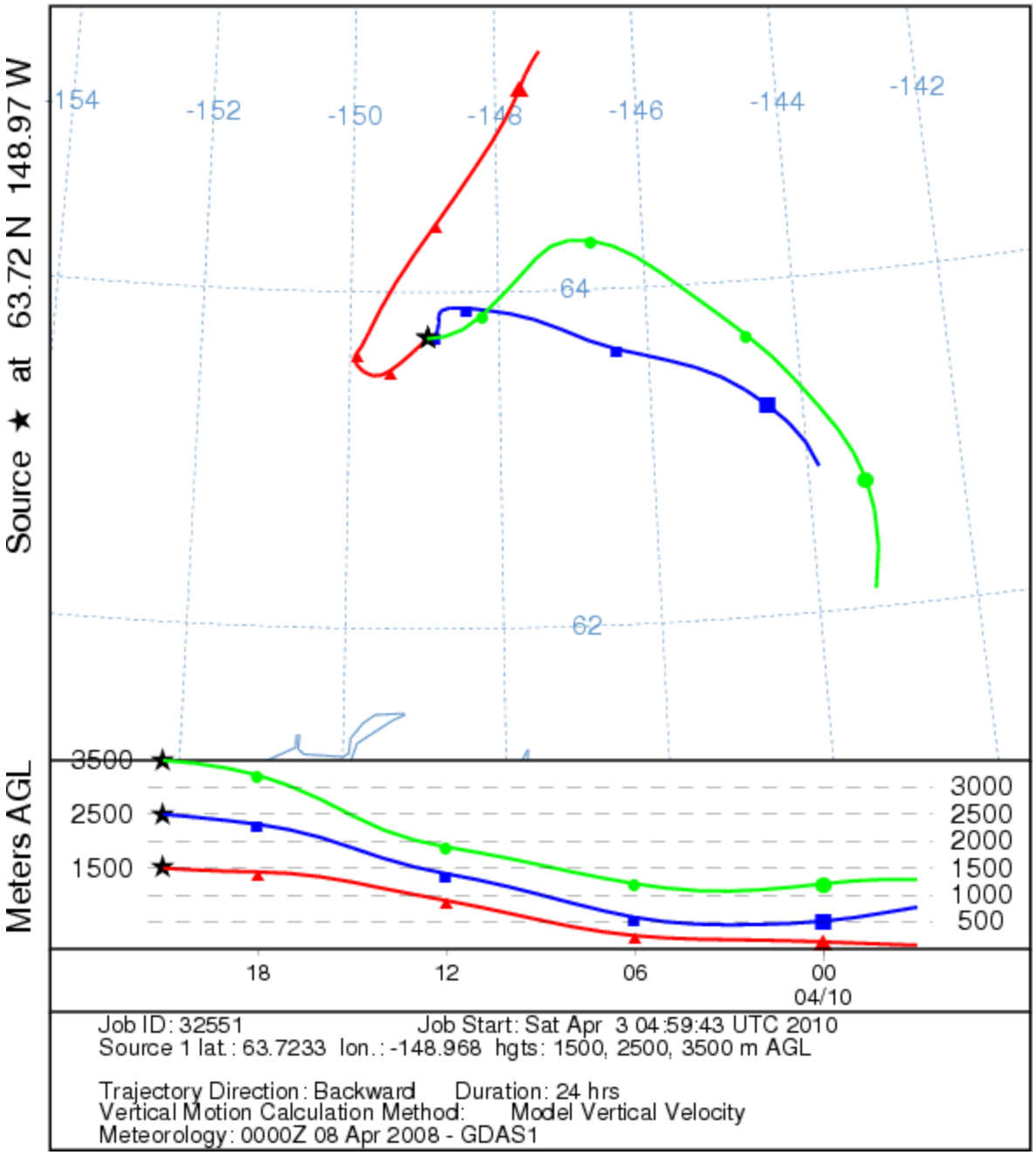

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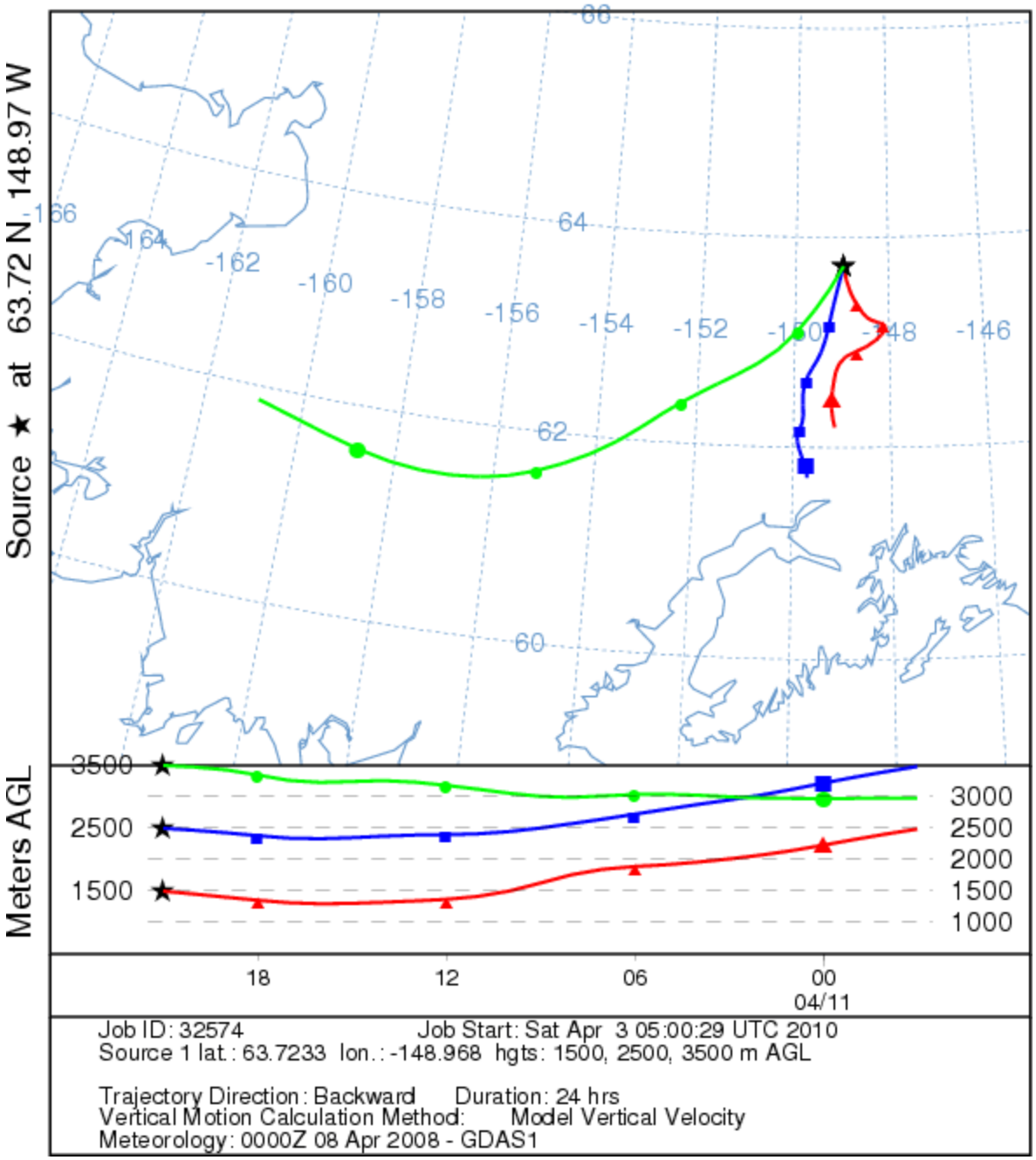
Backward trajectories ending at 2100 UTC 11 Apr 08
GDAS Meteorological Data



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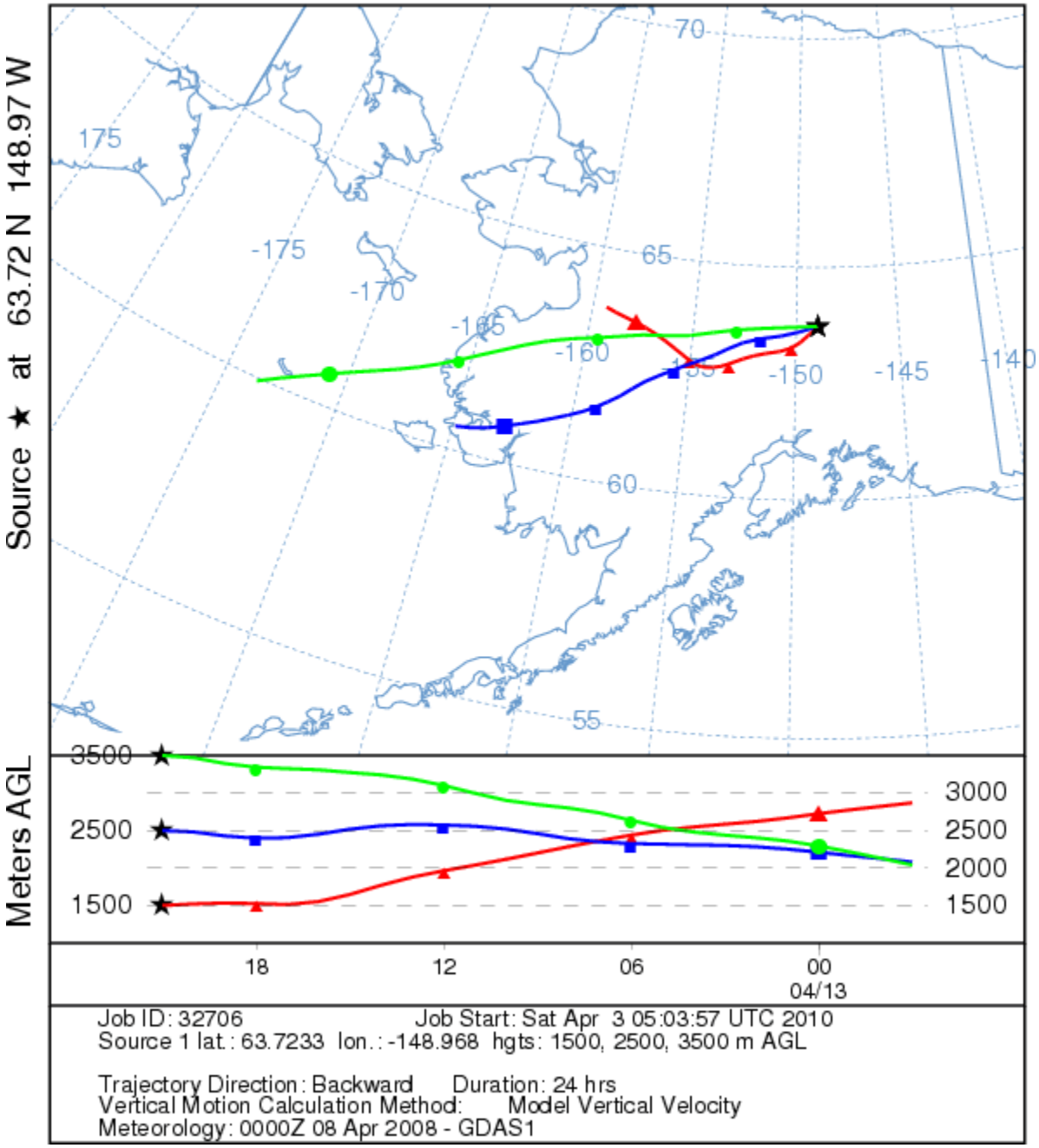

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Backward trajectories ending at 2100 UTC 14 Apr 08
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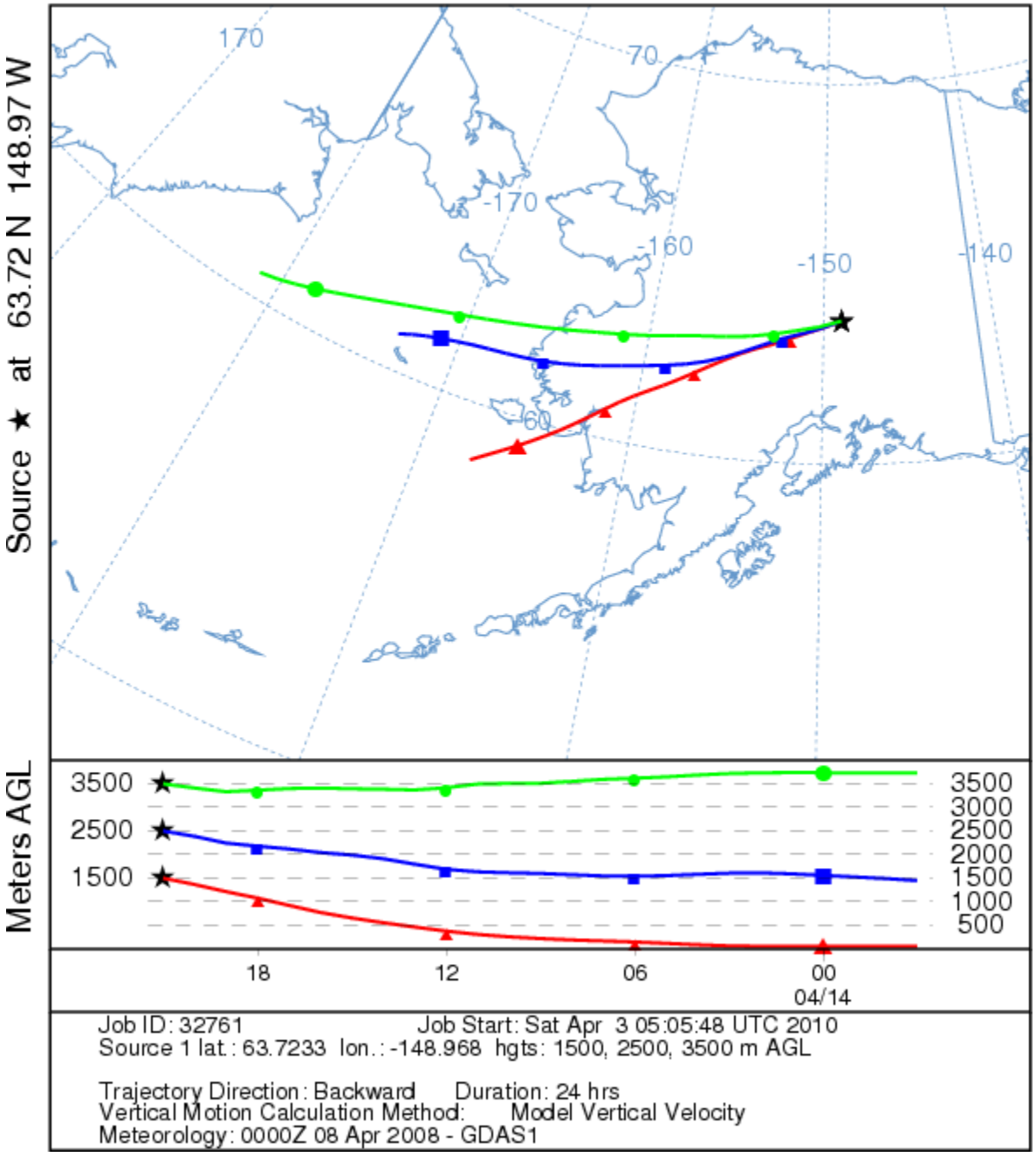


6.4 Appendix D Supporting Evidence for April 2008 Events

D-1 Jet lab cruises Alaska skies as scientist study bit of floating pollution

Jet lab cruises Alaska skies as scientists study bits of floating pollution

ARCTIC HAZE: Clues to global warming fix may be in air samples.

By DAN JOLING
The Associated Press

FAIRBANKS — Mike Cubison has been flying around in a haze for three weeks, by choice.

The University of Colorado postdoctoral student grabs air samples over Alaska skies, and using a mass spectrometer, measures floating particles of pollution before obliterating them into their constituent parts to determine what they're made of.

Farther back in the DC-8 commercial airliner that's been converted by NASA into a flying laboratory, atmospheric chemist Nicola Blake of the University of California, Irvine captures air samples that will be analyzed for more than 50 chemicals to identify what part of the globe has contributed to the Arctic haze.

Cubison, Blake and about 275 scientists and support staff are trying to solve a mystery: What's making the Arctic warmer than climate models say it should be.

Greenhouse gases such as carbon dioxide have been the focus of climate change. Scientists at Fairbanks and Barrow are focusing on another suspect: tiny floating particles known as aerosols.

Their air samples turn up dust from Asian deserts, salts that swell with moisture, particles from incomplete burning of organic material from forest and cooking fires and all manner of nasties emitted by automobile exhaust pipes, factory smokestacks and power plants.

POTPOURRI OF POLLUTION

Collectively, they're a United Nations of pollution. Through chemical analysis, the particles can be traced to sources throughout Asia, Europe and North America.

"The Arctic is a melting pot for mid-latitude pollution," said Harvard's Daniel Jacob, co-project scientist for NASA, which will spend $24 million on the mission over three years. "We have signatures of just about everything you can imagine flying around in the Arctic."

The particles change as they move, sometimes reacting with chemicals in the atmosphere as they age, sometimes growing or changing color.

HAZY SKIES A SURPRISE

The scientists are building on the work of a University of Alaska Fairbanks atmospheric scientist who arrived 35 years ago after finishing his dissertation at the University of Arizona. Glenn Shaw took a photometer to Barrow, America's northernmost community, figuring he could measure the clearest skies on the globe and perhaps get a mention in a scientific journal.

"I was expecting to set a record," he said, "because at the northern tip of Alaska, there's no industry, and the idea was, that this must be the cleanest place, essentially, almost, on planet Earth."

He was wrong. Shaw detected a phenomenon later dubbed Arctic Haze that indicated the skies above Barrow and all the way to the North Pole turned into a giant lint trap in late winter and early spring.

"The important thing was, and is, this is aerosol material that is traveling over three or four thousand miles, which was unprecedented at the time," he said.

The focus on greenhouse gases has made it difficult to bring other agents of climate change into the discussion, Jacob said. But the shortcomings in climate models, which did not foresee last summer's startling record sea ice melt-off, and the International Polar Year effort, a scientific program focused on the Arctic and Antarctic every 50 years or so, made the case for the research blitz now under way by NASA, the National Oceanic Atmospheric Administration and the Department of Energy.

Aerosols may have an effect far beyond their diminutive mass.

The Department of Energy is focused on what aerosols do to clouds, said Gary McFarquhar of the University of Illinois, one of the principal investigators. The size and density of particles alter the type and longevity of clouds and whether they reflect heat back into space or absorb it.

Jacob said there has been quite a bit of work on how soot on snow may act as a strong warming agent but less effort on the radiative properties of the haze. It's a focus for both NASA and NOAA.

In most of the world, particles lead to cooling by reflecting light before it reaches the Earth's darker surface, partially offsetting the warming effect of greenhouse gases, said A.R. Ravishankara of NOAA's Earth System Research Laboratory. That's not the case in the Arctic, where ice and snow already reflect much light. Some particles absorb the sun's energy and give off their own radiant heat, like blacktop on a summer day.

"How much of this aerosol is there?" Ravishankara said. "Do they absorb light? Do they scatter light? Do they make clouds brighter or dimmer? Are they getting to the ice surface? Because if you add these absorbing particles to the ice surface, it could actually enhance the melting. What are these particles made of? Where do they come from, but particularly focusing on aerosols that absorb light."

VERIFYING POLLUTANT INFO

NASA also is using the information from the flights to enhance the veracity of the information it collects from its satellites, which includes tracking pollution sources.

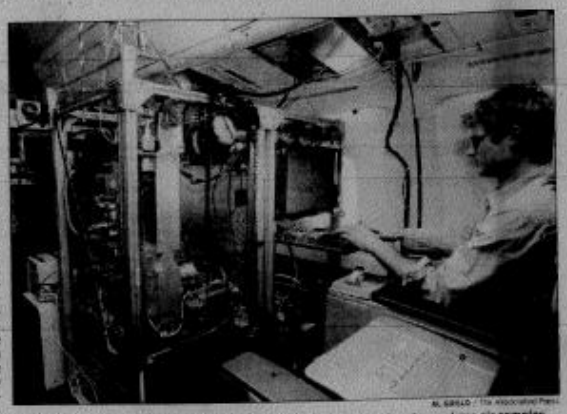
"We don't have to take China's word for how much a certain pollutant is emitted in the atmosphere," Jacob said.

NASA will be back to the Arctic in July for more flights to study the effects of forest fire smoke and the associated chemistry, said Jim Crawford, the agency's tropospheric chemistry program manager.

"We're really trying to understand the difference between the relative importance of these two very large and dramatic influxes of pollution to the Arctic," Crawford said.

If aerosol particles prove to be a major factor in warming, Ravishankara said, there could be a relatively fast benefit to removing them.

"It lasts only for a few days, and then it's removed from the atmosphere, unlike carbon dioxide, which stays with us for hundreds of years," he said. "Aerosols can be a way to do something very quickly."



AL GRAUS / The Associated Press

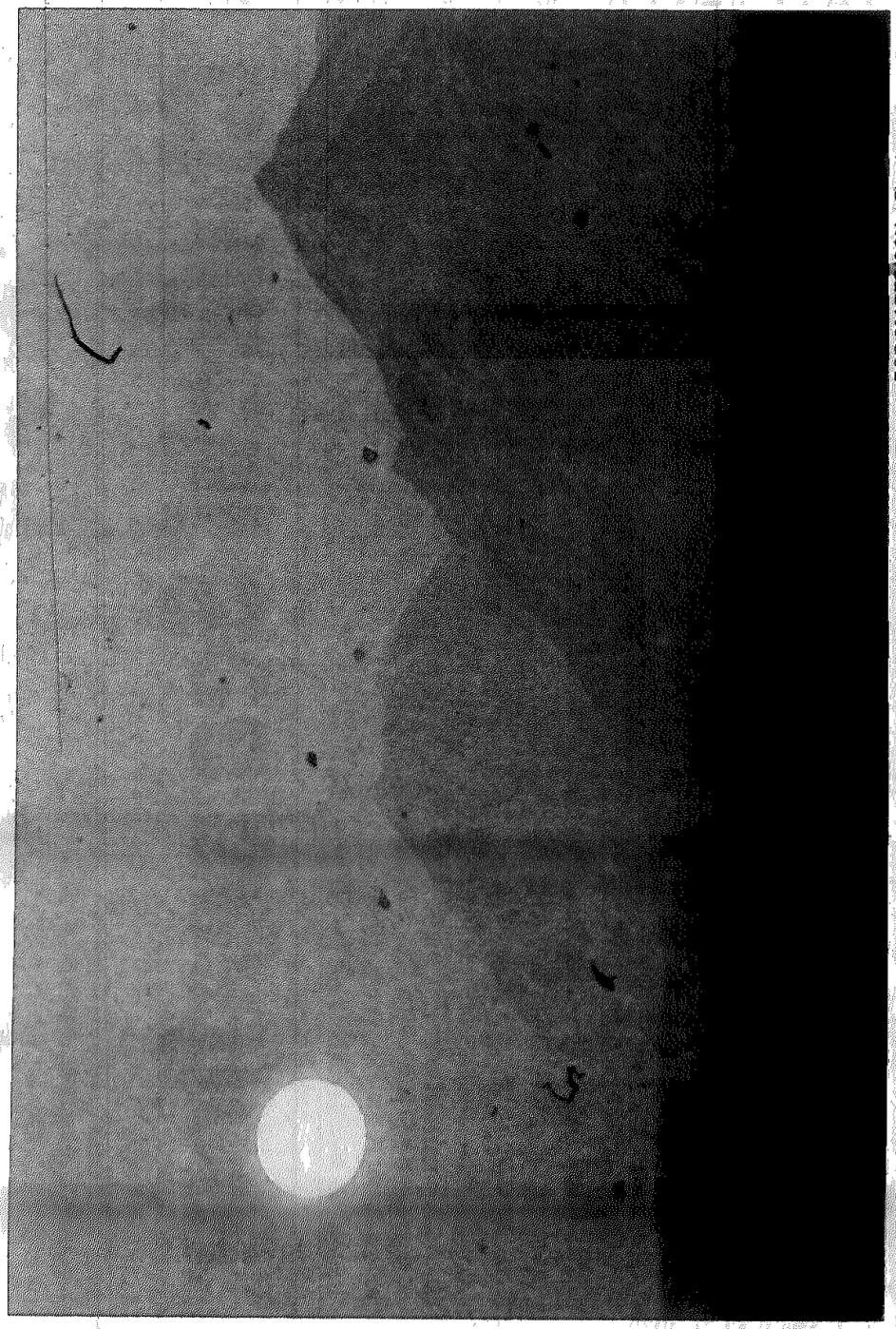
Mike Cubison, a University of Colorado postdoctoral student, shows how he analyzes air samples collected over Alaska's skies with a mass spectrometer on NASA's DC-8 flying laboratory in Fairbanks.

ERIC JAMES / NASA via The Associated Press

NASA's DC-8 flying laboratory is shown during a mission over Alaska on April 12. Scientists from three federal agencies are researching particles in the Arctic's lower atmosphere to determine whether they contribute to warming.

D-2 Asian Haze Colors Palmer Skies

ASIAN HAZE COLORS PALMER SKIES

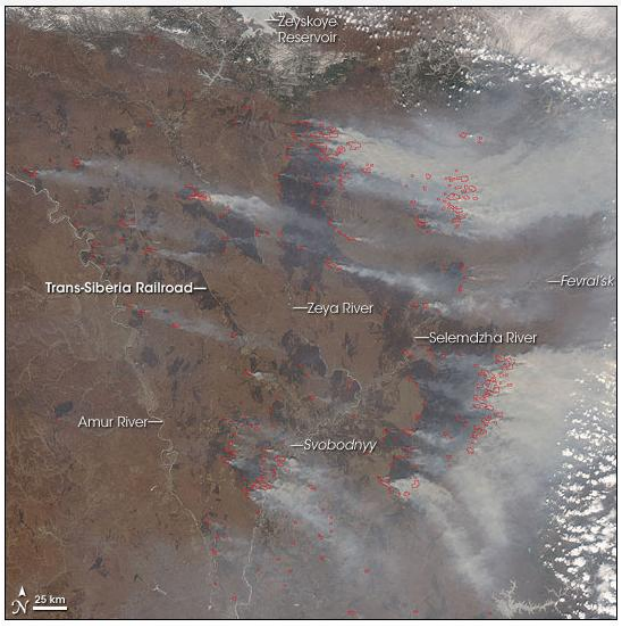


BOB MARTINSON / The Associated Press

The sun shines through a haze as it rises over King Mountain in the Matanuska Valley near Palmer on Wednesday. The haze is the result of smoke coming from Russian wildfires, and the dust is from sandstorms in Mongolia's Gobi Desert.

D-3 Satellite Images of Fires in East Russia

http://earthobservatory.nasa.gov/IOTD/view.php?id=8668



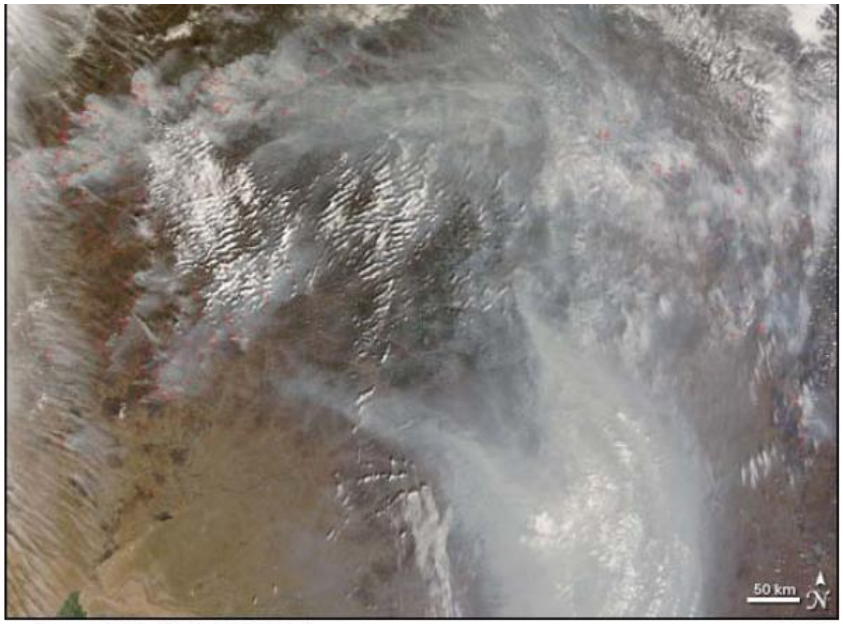
large image (1 MB, JPEG, 2600x3200) acquired April 15, 2008
Google Earth file (KML) acquired April 15, 2008

According to international news reports, Russian officials declared a state of emergency in southern and eastern parts of the country in mid-April 2008 due to numerous out-of-control fires sweeping across several regions. This image shows one of the regions that was ablaze: the Amur Oblast' in Russia's Far East. On April 15, 2008, the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite captured this image of dozens of active fires (locations outlined in red) and clouds of thick smoke over the area. Dark brown burn scars sprawl across the tan landscape.

Although this area is not densely populated, there are numerous small towns clustered along the banks of the area's many rivers. Two major railways also pass through the area. The Trans-Siberia Railroad makes a noticeable fire break northwest of the town of Svobodnyy. A second railroad, the Baikal-Amur Mainline also passes through the area, though it is not as noticeable. The Baikal-Amur is roughly parallel to but northeast of the Trans-Siberian Railroad; in this image, it connects the Zeyskoye Reservoir to the town of Fevral'sk.

The landscape in Amur Oblast' is largely a mosaic of agricultural land and mixed forests, though grassland (steppes) and boreal (evergreen) forests are also present. Early spring is not the season when most natural fires occur in the area; the peak of the natural fire season is generally later in the summer. However, spring *is* the season for people to clear and clean up agricultural land for the upcoming growing season, and many people use fire for that purpose. Accidental fires often escape control and burn into surrounding forests and other natural areas. It isn't possible to tell from satellite whether a particular fire is intentional or accidental, but it is likely that some of the larger fires in this scene are out-of-control wildfires. NASA image courtesy the MODIS Rapid Response Team. Caption by Rebecca Lindsey.

http://earthobservatory.nasa.gov/IOTD/view.php?id=8668



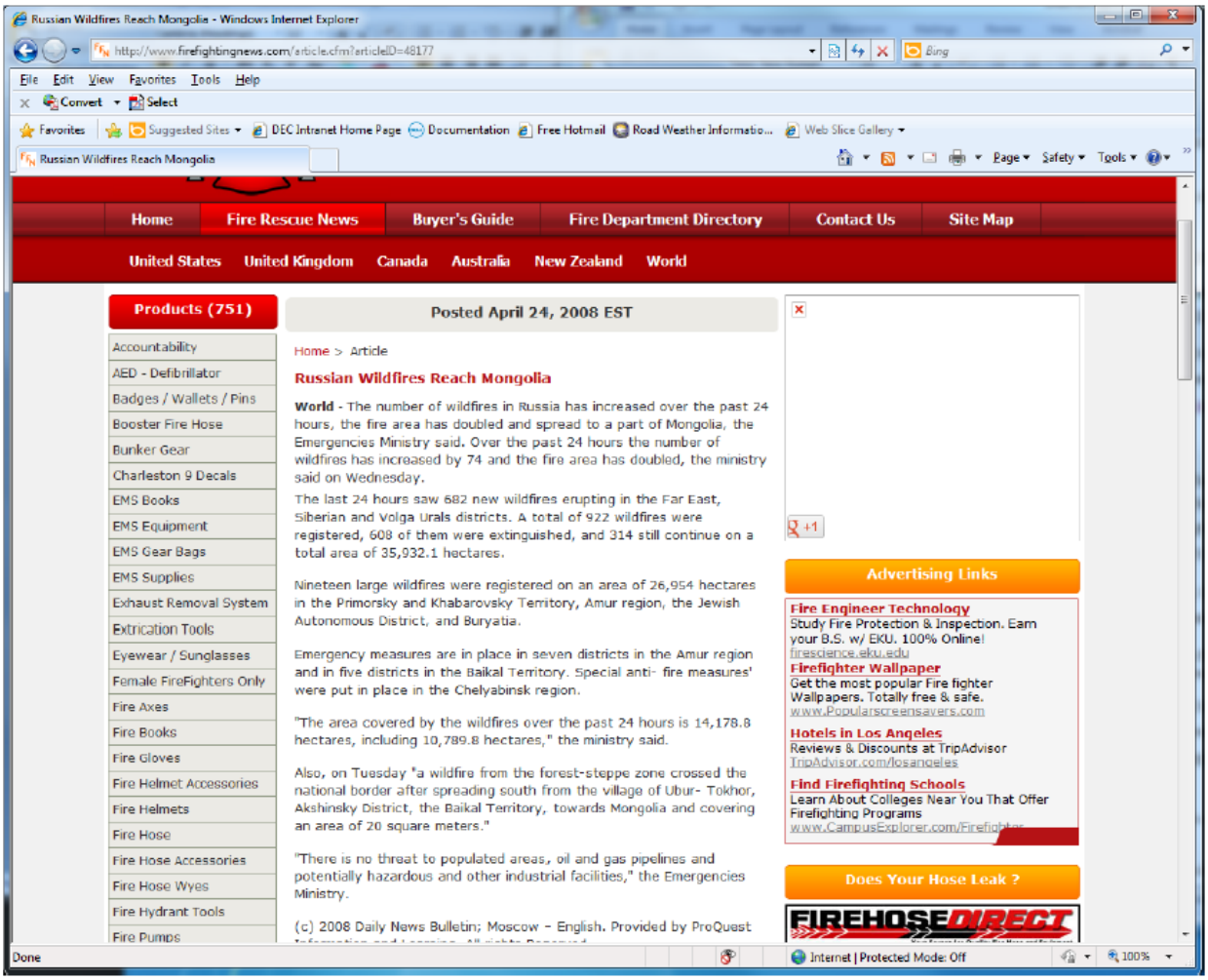
download large image (3 MB, JPEG, 4400x5600) acquired April 27, 2008

According to reports from Russia's ITAR-TASS news service, rain and sleet in southern and eastern Russia on Sunday, April 28, helped to quell many of the forest fires that had been raging in Amur Oblast' throughout much of April. This image of southern Russia shows that on April 27, 2008, numerous fires (locations marked in red) were still burning in the Chitin Oblast' (left-hand side of image), while thick smoke hung over a large area to the south and east. The large version of the image shows more of the Amur region to the east. The image was captured by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite.

NASA image courtesy Jeff Schmaltz, MODIS Rapid Response Team. Caption by Rebecca Lindsey.

Instrument: Aqua - MODIS

D-4 Russian Wildfires Reach Mongolia



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Posted April 24, 2008 EST

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Russian Wildfires Reach Mongolia

World - The number of wildfires in Russia has increased over the past 24 hours, the fire area has doubled and spread to a part of Mongolia, the Emergencies Ministry said. Over the past 24 hours the number of wildfires has increased by 74 and the fire area has doubled, the ministry said on Wednesday.

The last 24 hours saw 682 new wildfires erupting in the Far East, Siberian and Volga Urals districts. A total of 922 wildfires were registered, 608 of them were extinguished, and 314 still continue on a total area of 35,932.1 hectares.

Nineteen large wildfires were registered on an area of 26,954 hectares in the Primorsky and Khabarovsky Territory, Amur region, the Jewish Autonomous District, and Buryatia.

Emergency measures are in place in seven districts in the Amur region and in five districts in the Baikal Territory. Special anti- fire measures' were put in place in the Chelyabinsk region.

"The area covered by the wildfires over the past 24 hours is 14,178.8 hectares, including 10,789.8 hectares," the ministry said.

Also, on Tuesday "a wildfire from the forest-steppe zone crossed the national border after spreading south from the village of Ubur- Tokhor, Akshinsky District, the Baikal Territory, towards Mongolia and covering an area of 20 square meters."

"There is no threat to populated areas, oil and gas pipelines and potentially hazardous and other industrial facilities," the Emergencies Ministry.

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