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Aliso Canyon Natural Gas Leak Measurement – July 27, 2017

The method we have been using to estimate the Aliso Canyon emissions for the last 2 years has been demonstrated over flat terrain, such as what we encounter under conditions of north winds where our downwind legs are over the relatively flat San Fernando valley. It has yet to be demonstrated over terrain like the hills north of the Aliso Canyon storage facility, where wind conditions forced the flight today. Climatological winds in the summer time are typically southerly by day, meaning that any mass balance flight would be required to operate north of the storage facility where the terrain is difficult. Given the desire to perform a background measurement prior to re-injection beginning, it was agreed that a flight would be attempted in hopes that the emission could be estimated with a reasonable uncertainty.

The first attempted fight path was a NE-SW leg roughly 2 km north of the Sunshine Canyon landfill. Unfortunately, it was not possible to separate the storage facility emissions from the landfill emissions, which were an order of magnitude greater and therefore dominated the measurement. In an attempt to eliminate the landfill outflow, the flight path was moved in close to the ridge where the aircraft remained upwind of the landfill at all times, as shown in Figure 1. This flight path was over an extremely uneven surface.

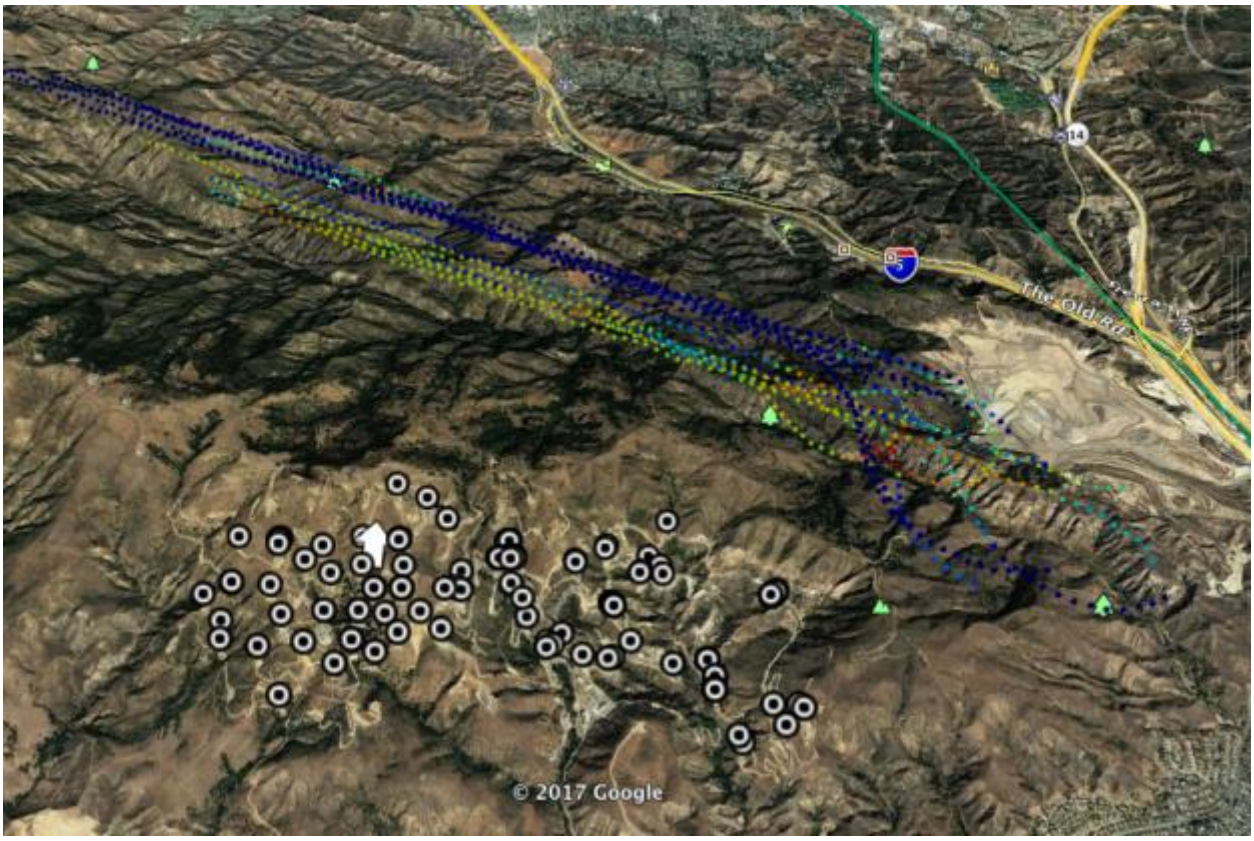

Figure 1 - Flight path from July 27. The black and white circles show the 114 facilities identified with the Aliso Canyon Storage facility. Mean wind direction is shown with the bold white arrow.

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The actual flight legs were considerably longer than what is shown in Figure 1 and included large enhancements that appeared to originate from facilities west of the storage field. Using the full extent of the legs, a total methane emission for all of the facilities on the hillside was estimated at 974±300 kg hr^{-1}. Given the goal of estimating emissions from the storage field alone, the legs were truncated, as shown in Figure 1, to include only the areas considered potential outflow regions for the 114 wells operating in the storage field. The boundary of each leg along with the methane mixing ratio during that leg is shown in Appendix 1.

As shown in Appendix 1, the legs still extend west of what would be considered a likely outflow boundary. Because the airplane method lacks great precision in geospatial location, the only solution to ensure we don't miss a substantial portion of the Aliso Canyon flux is to extend the legs in both directions beyond the expected limit of the outflow. Because of this, the flux estimated is assumed to be an upper limit, as it likely includes outflow from sources not associated with the storage facility. This issue is evident on some of the laps where hotspots can be seen well west of the facility (magenta dots on the map).

In this case, the complex terrain is both a challenge and a help. Flow is channeled through narrow valleys below where the aircraft can fly, which then requires extrapolation and increases uncertainty. Conversely, the hills tend to promote vertical mixing, which likely reduces the uncertainty in the extrapolation (i.e. values below the aircraft are expected to be similar since the air has been well mixed in the vertical). Winds varied from approximately 2 m s^{-1} near the surface to 5 m s^{-1} at the level of our highest legs (900 m).

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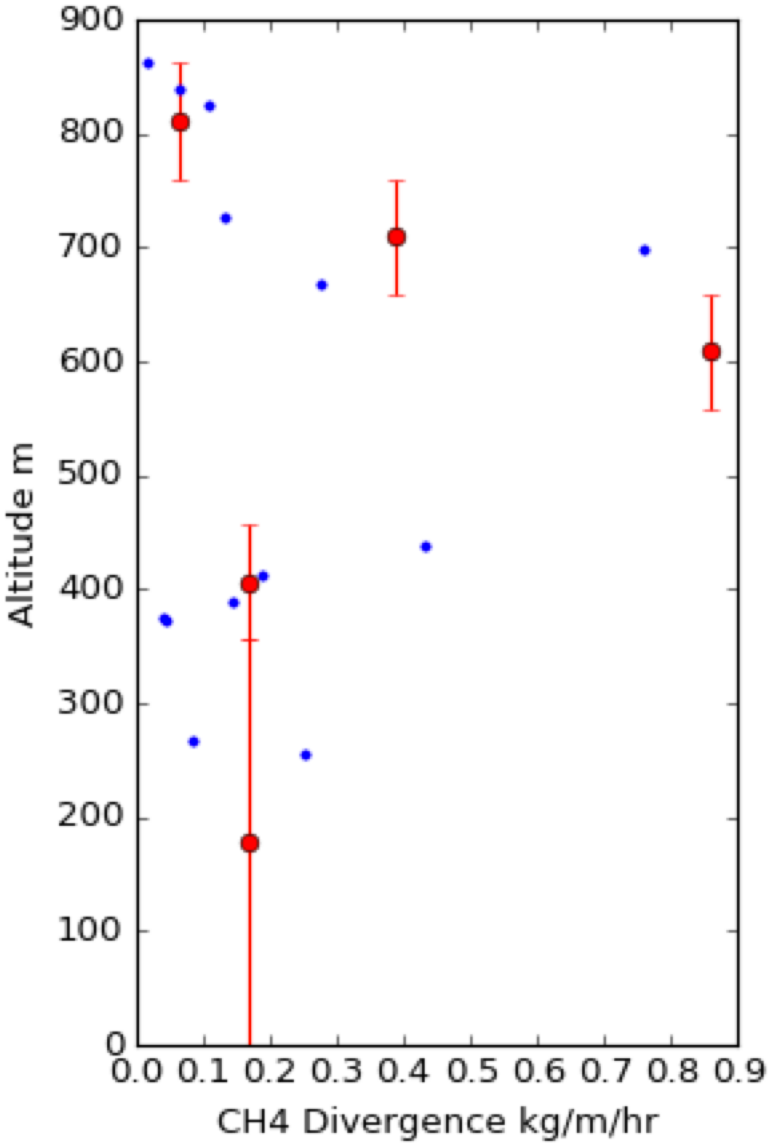

Figure 2 – Flux profile for methane for July 27. Blue dots show individual leg fluxes while red circles show the average for each vertical bin.

The maximum methane mixing ratio observed within the bounds of the Aliso outflow was 2.0 ppm. Extending the legs to include the facilities to the northwest of Aliso Canyon, methane levels were much higher, reaching 3.0 ppm. Background methane in the area appeared to be around 1.9 ppm, meaning the maximum enhancement downwind of the storage facility was 100 ppb, while it was 1.1 ppm (10x higher) when including the facilities to the northwest. Integrating the flux profile shown yields an emission estimate of 210±100 kg hr^{-1} for methane.

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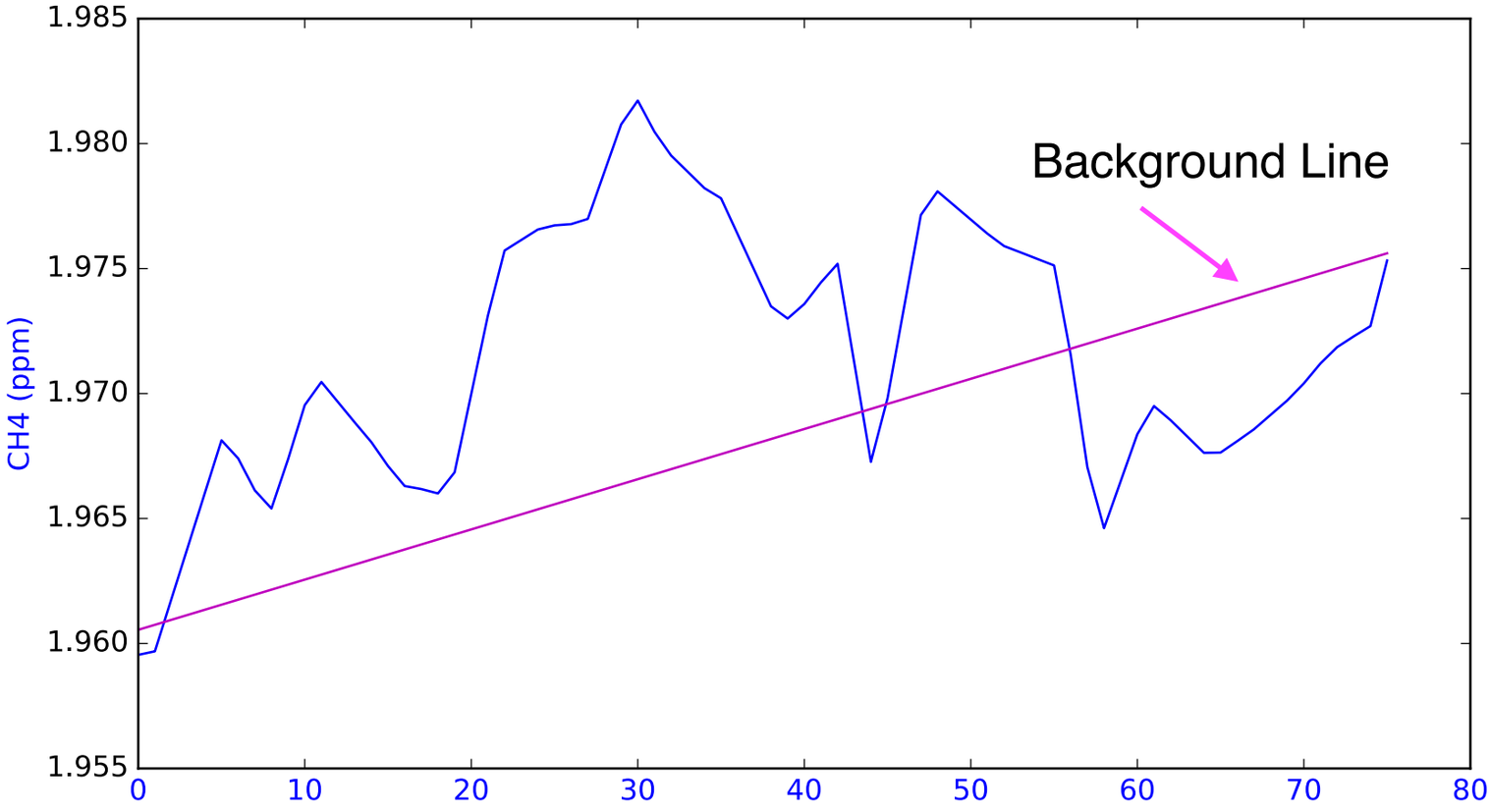
Emission rates from all the Aliso Canyon flights are shown in Table 1.

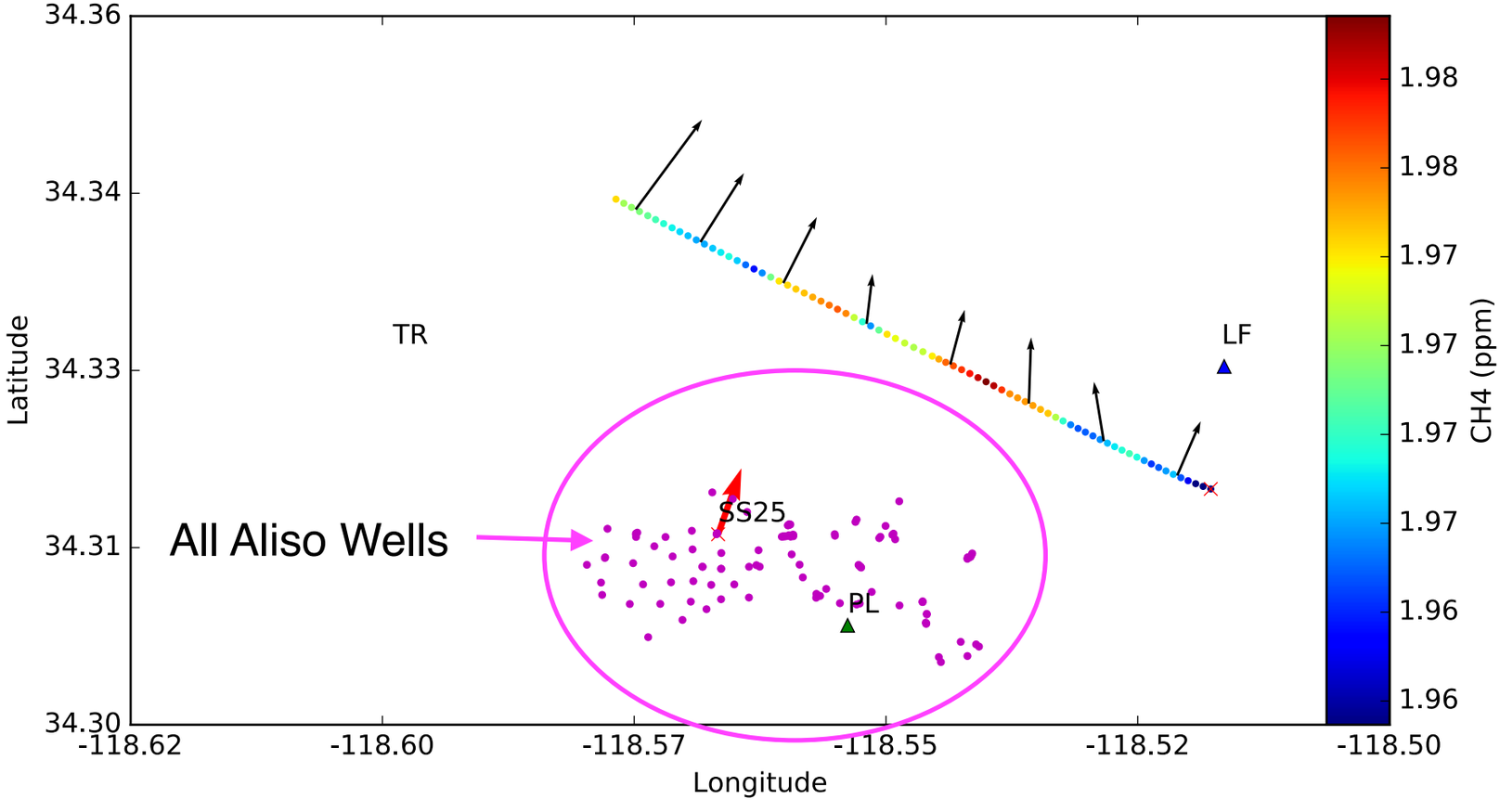
Date	Methane		Ethane		Flux Ratio (C1/C2)	Linear Fit (mass)	Total Passes
	Emission (kg hr^{-1})	Uncertainty (kg hr^{-1})	Emission (kg hr^{-1})	Uncertainty (kg hr^{-1})			
11/07	43,899	5,342	4,745	388	0.11	0.08	17
11/10	49,709	16,387	4,548	1,237	0.09	0.08	26
11/28	58,000	11,600	--	--	--	--	23
12/04	43,000	5,400	3,500	1030	0.09	0.08	17
12/12	36,000	6,800	2,400	460	0.07	0.07	26
12/23	30,300	6,100	1,990	400	0.07	0.06	20
01/08	23,400	4,600	1,640	330	0.07	0.06	19
01/12	21,500	4,300	--	--	--	--	27
01/21	19,600	3,700	1,540	310	0.08	0.07	23
01/26	20,700	4,100	1,210	240	0.06	0.06	30
02/04	20,600	5,000	1,360	315	0.07	0.06	22
02/11	950	200	57	12	0.06	0.05	35
02/13	660	200	34	6	0.05	0.05	25
02/21	310	60	15	3	0.05	0.05	16
03/08	182	36	8	2	0.04	0.04	19
03/24	207	33	9	2	0.05	0.03	22
04/05	400	200	22	4	0.05	0.05	16
10/06	139	29	--	--	--	--	39
02/15/17	55	12	6	8	0.06	0.04	12
07/27/17	**210**	**100**	**--**	**--**	**--**	**--**	**14**

Table 1- Comparison of Aliso Canyon Flights

ALISO - Altitude 268, Start = 85180,Div = 0.1 kg/m/hr, WS=2.0, Leg # 1

Appendix 1





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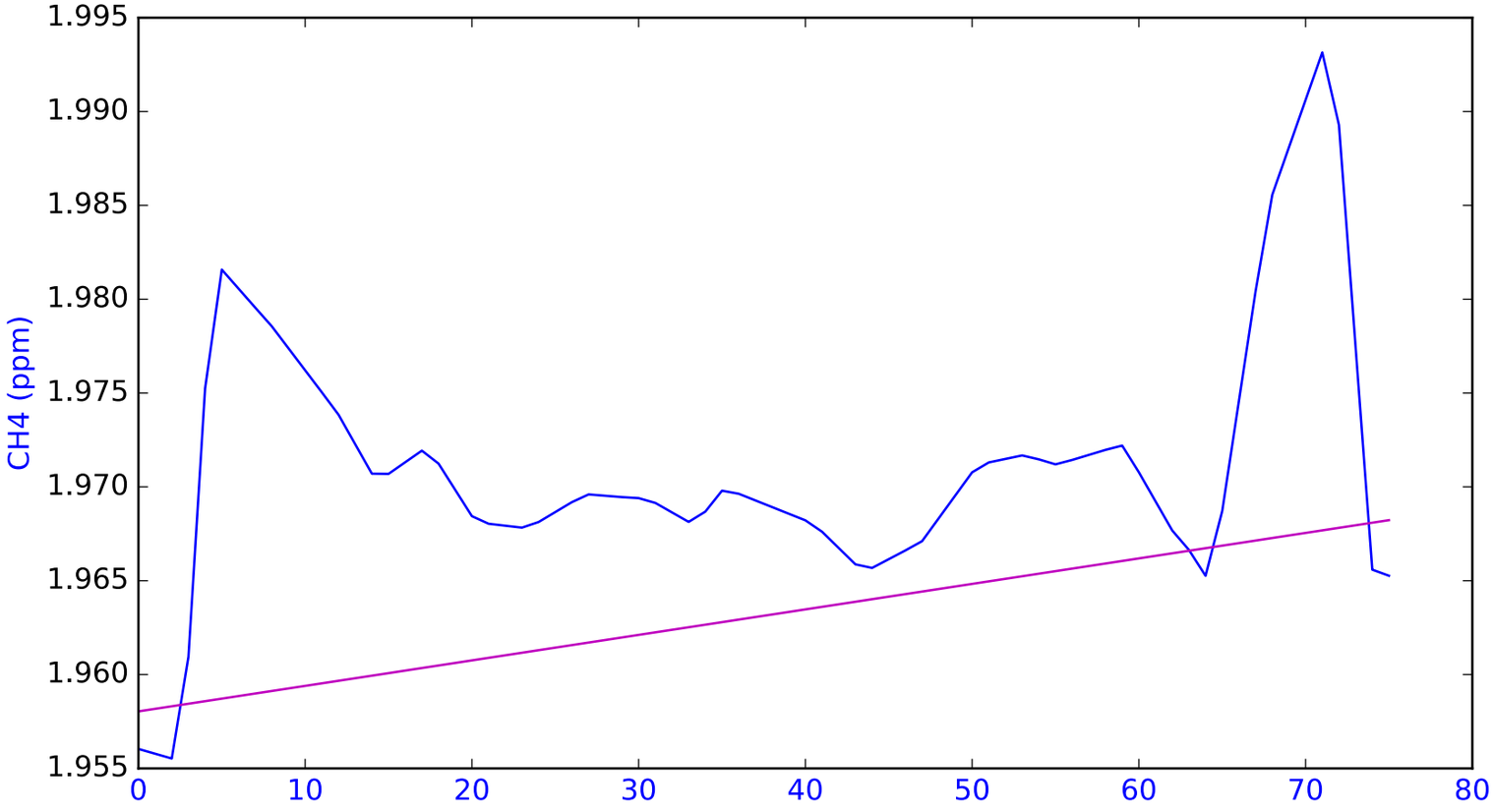

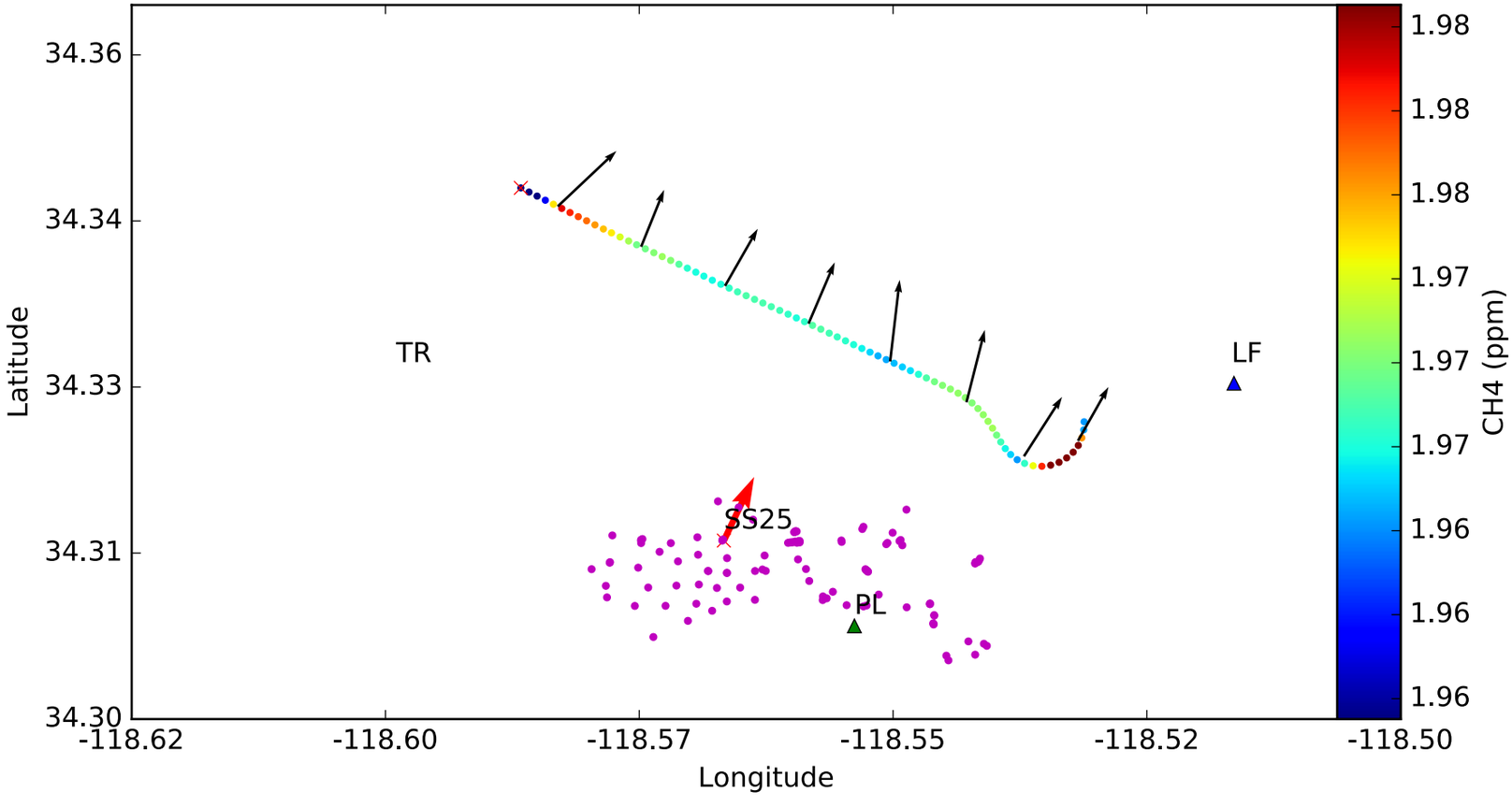

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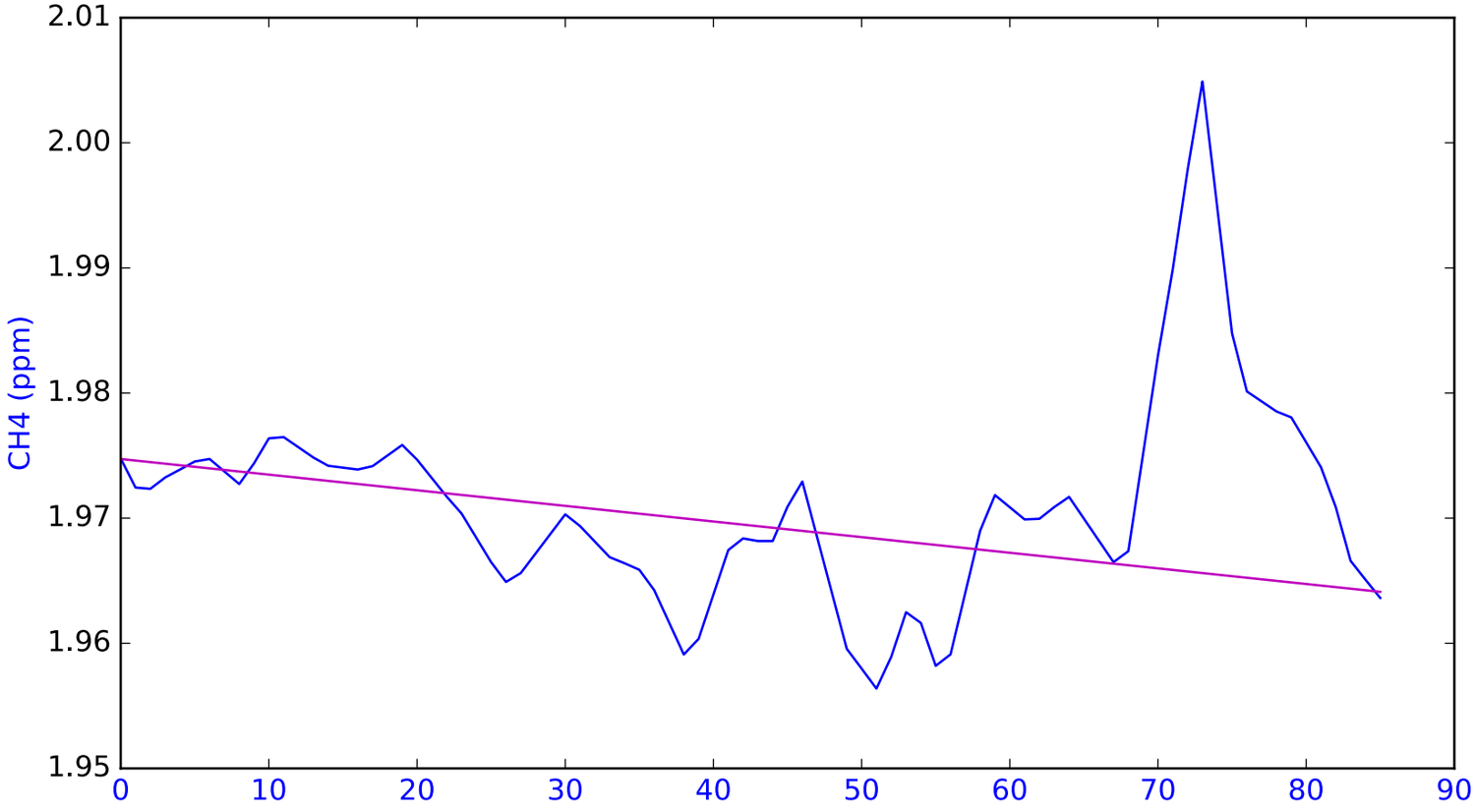

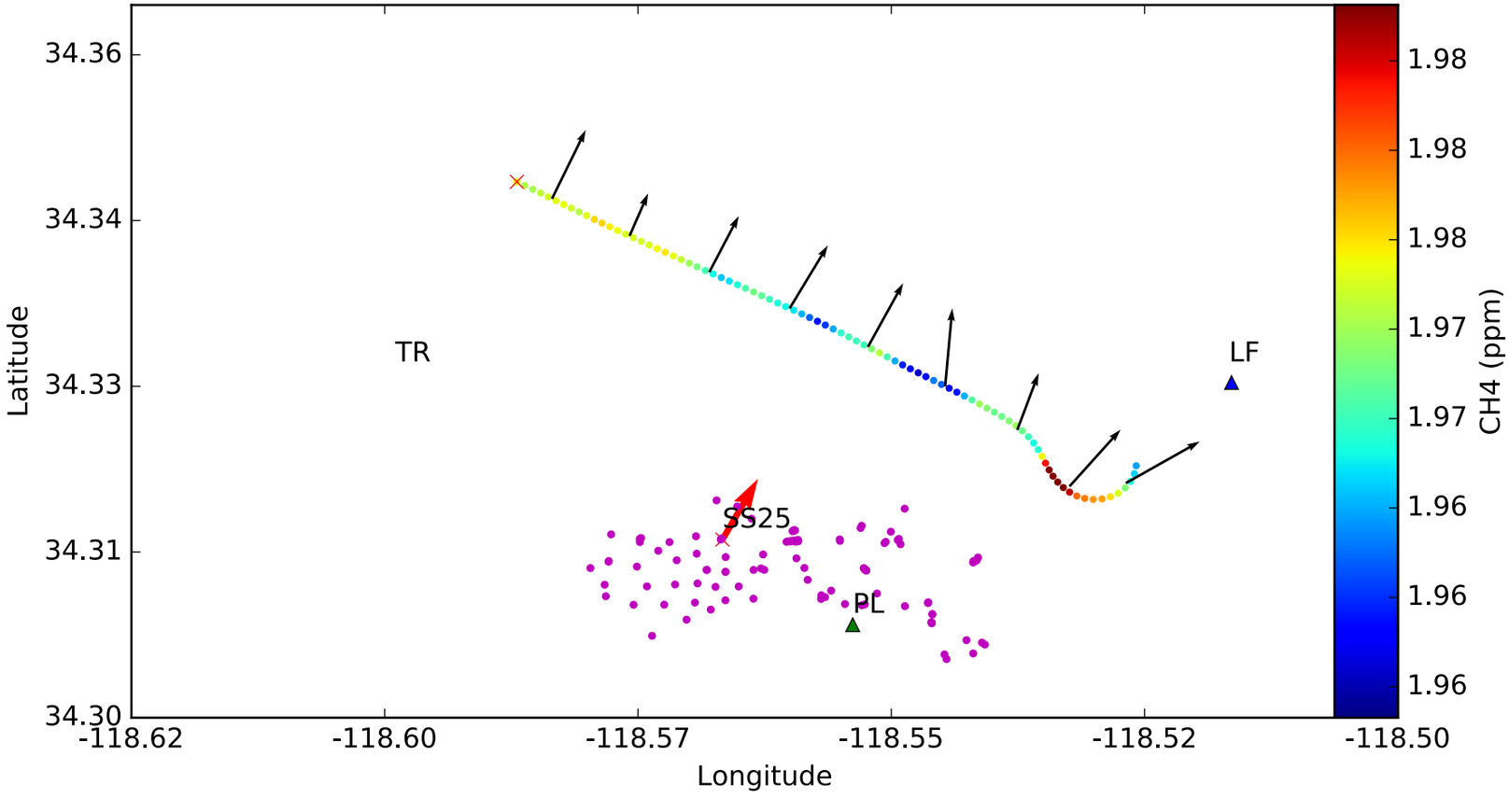

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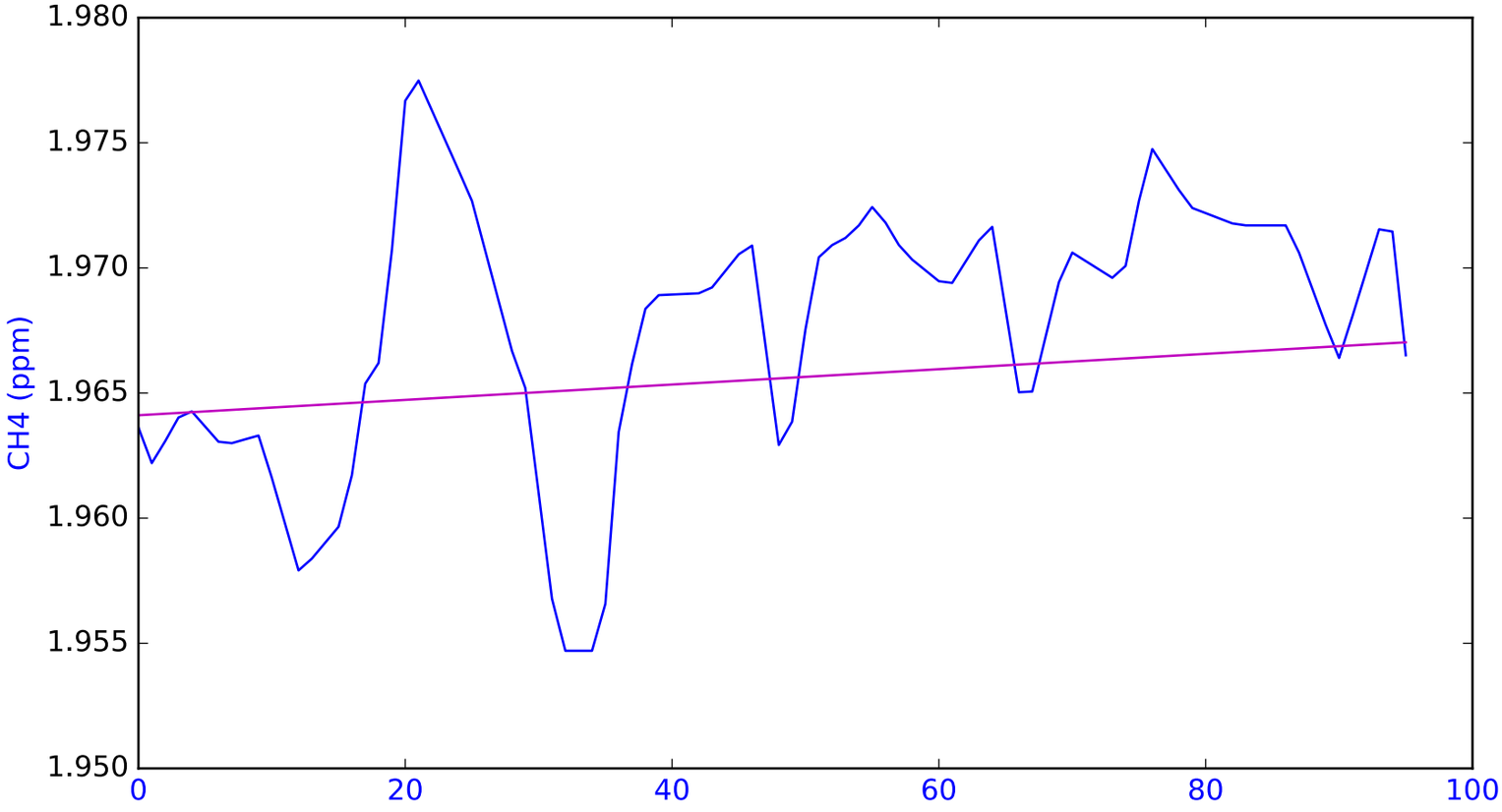

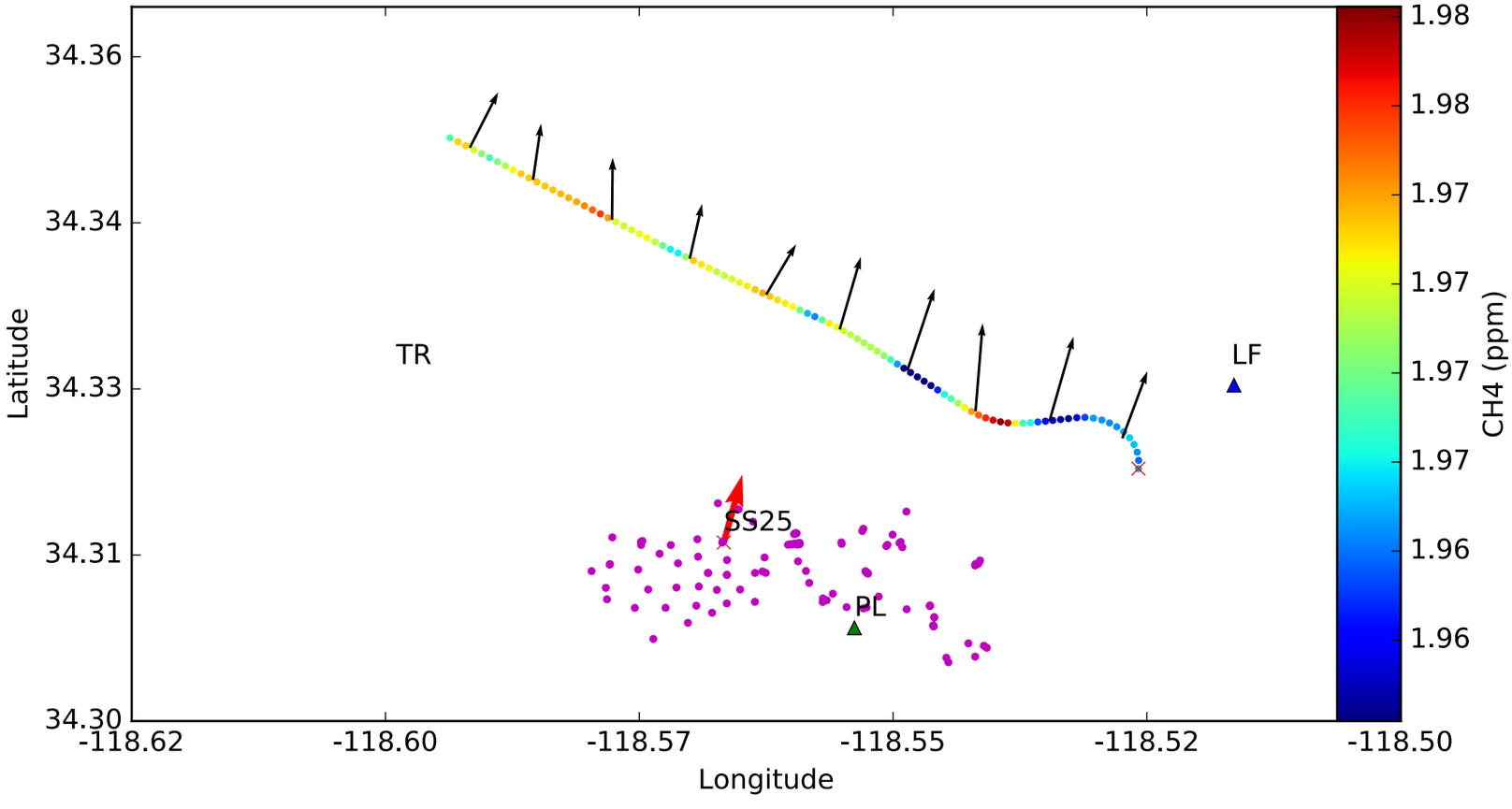

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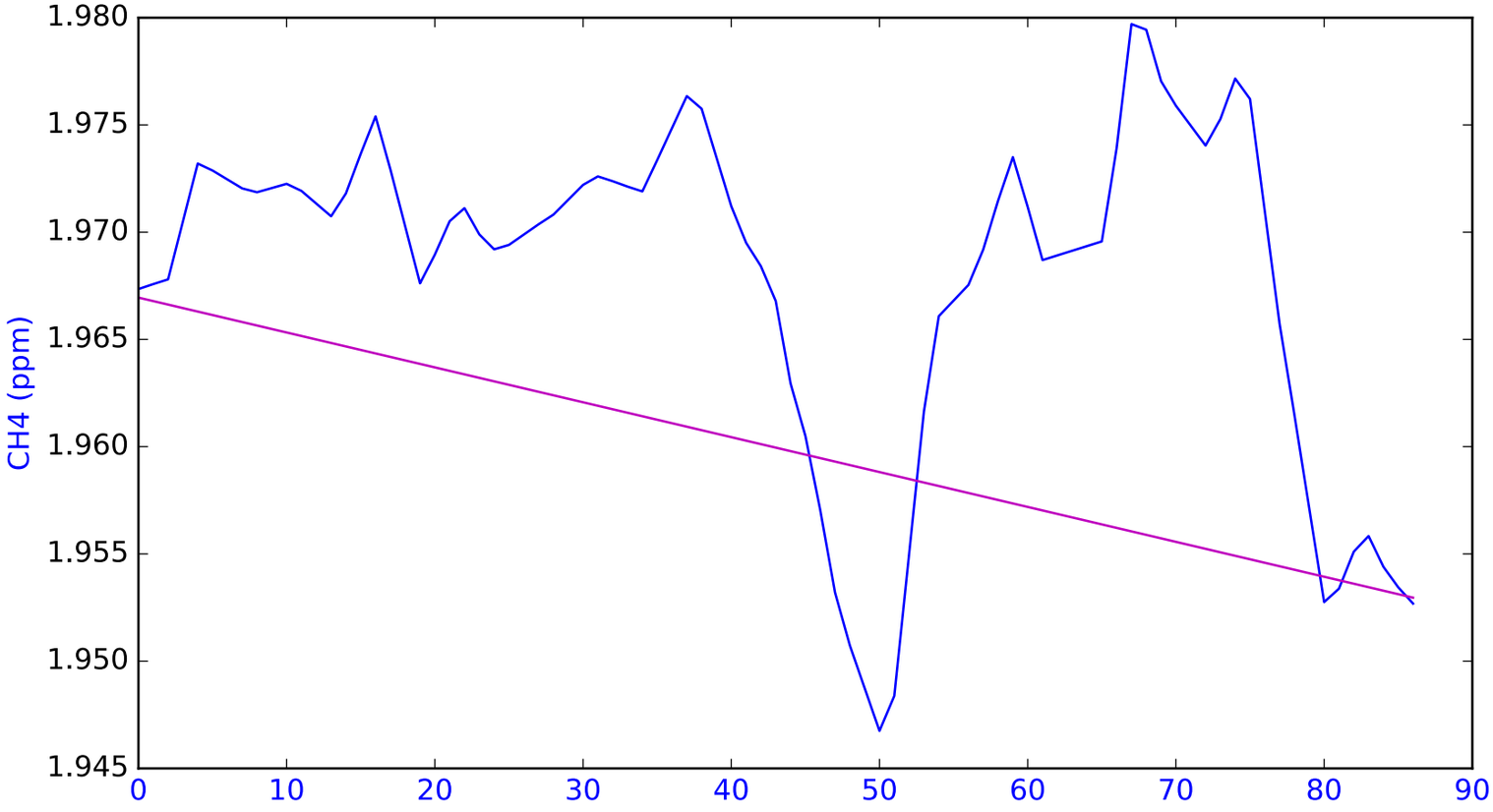

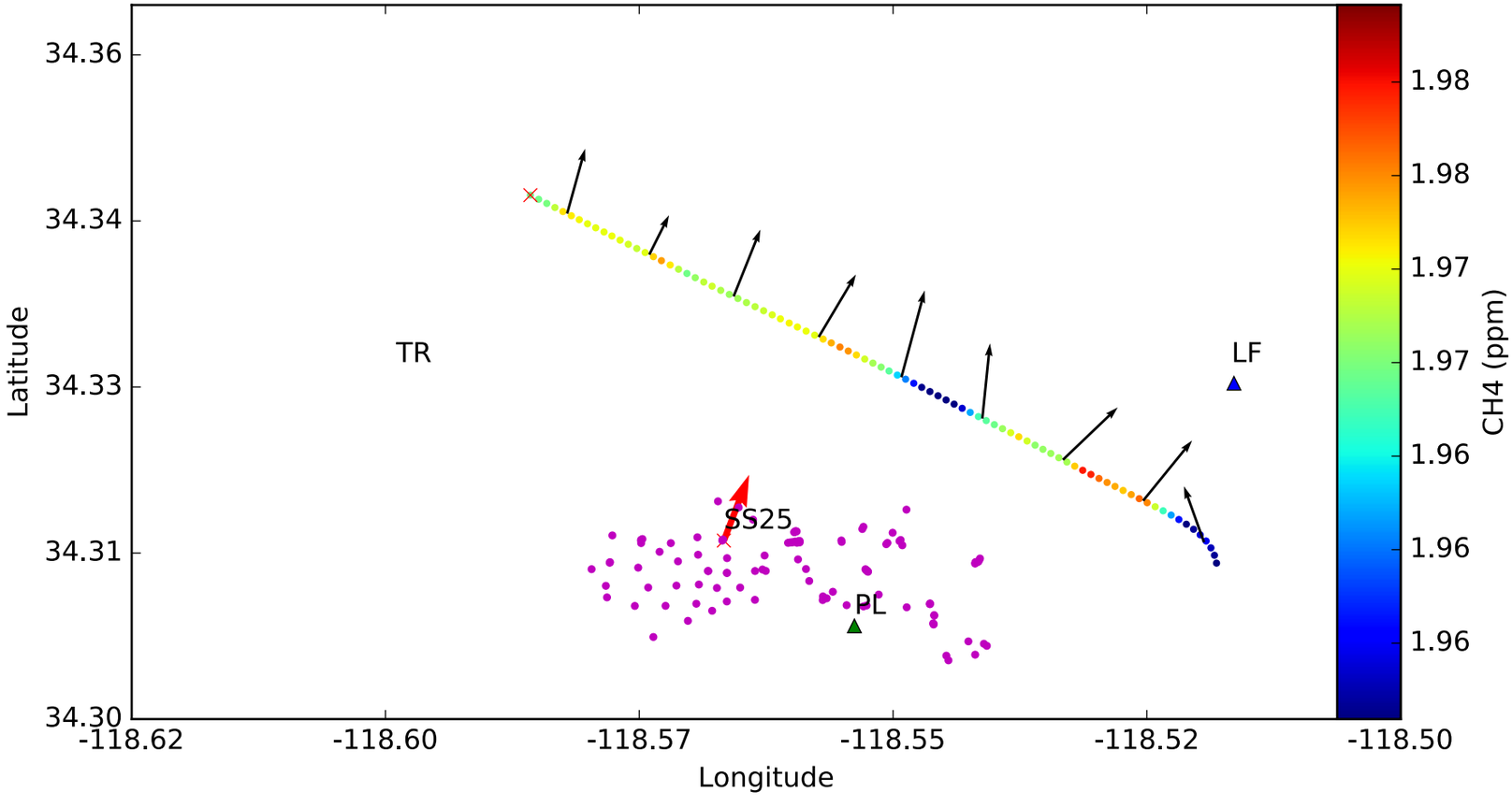

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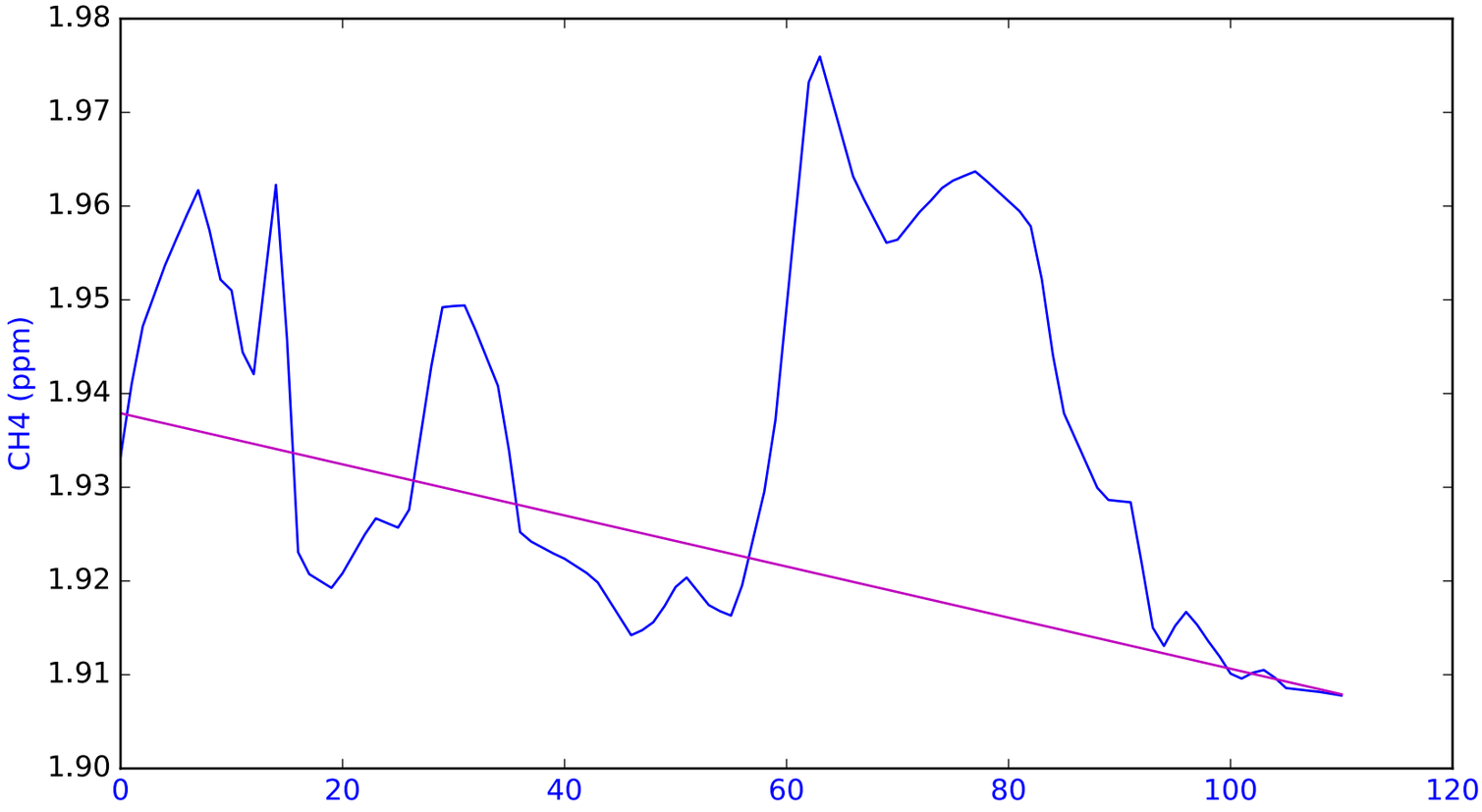

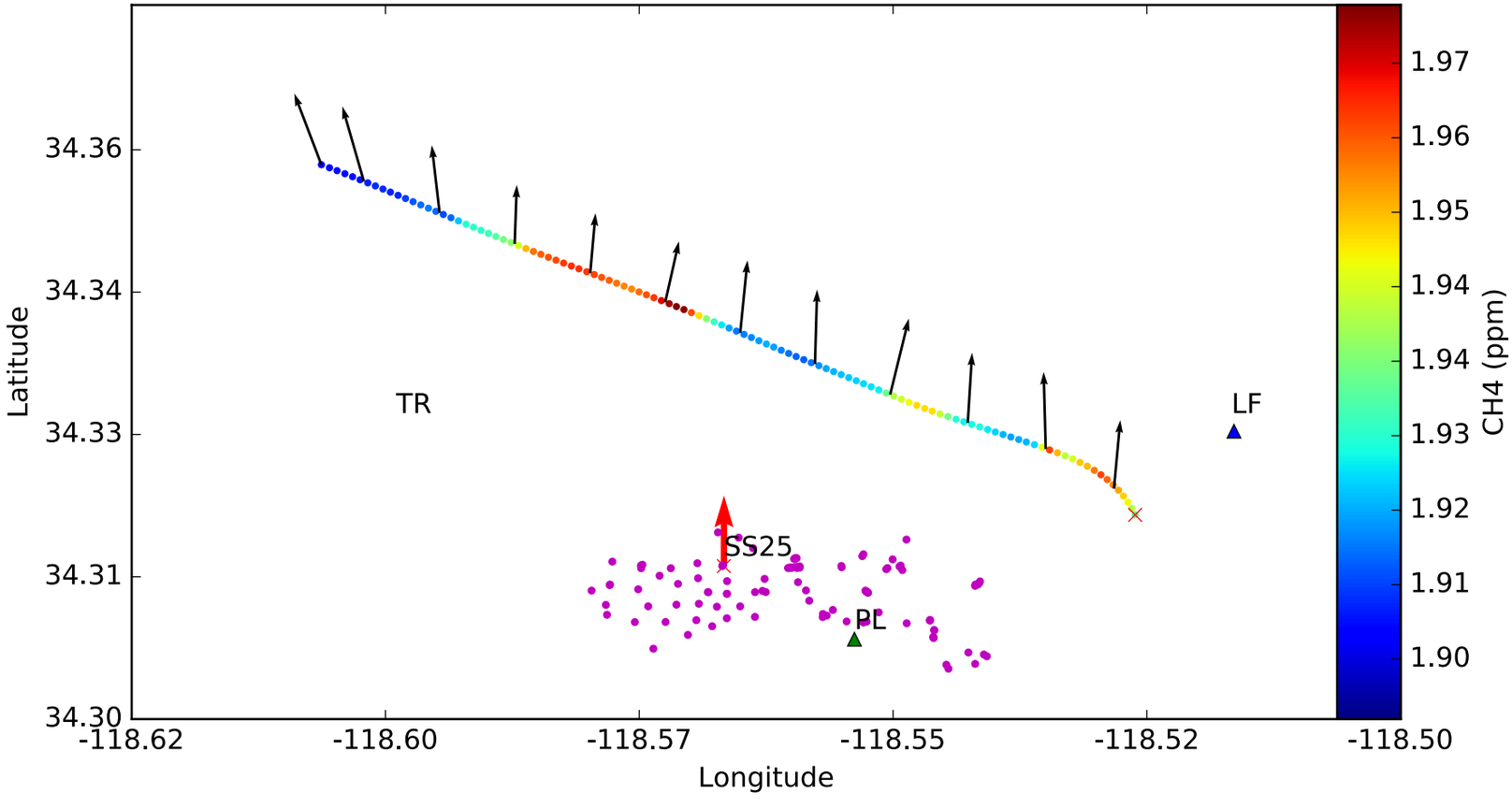

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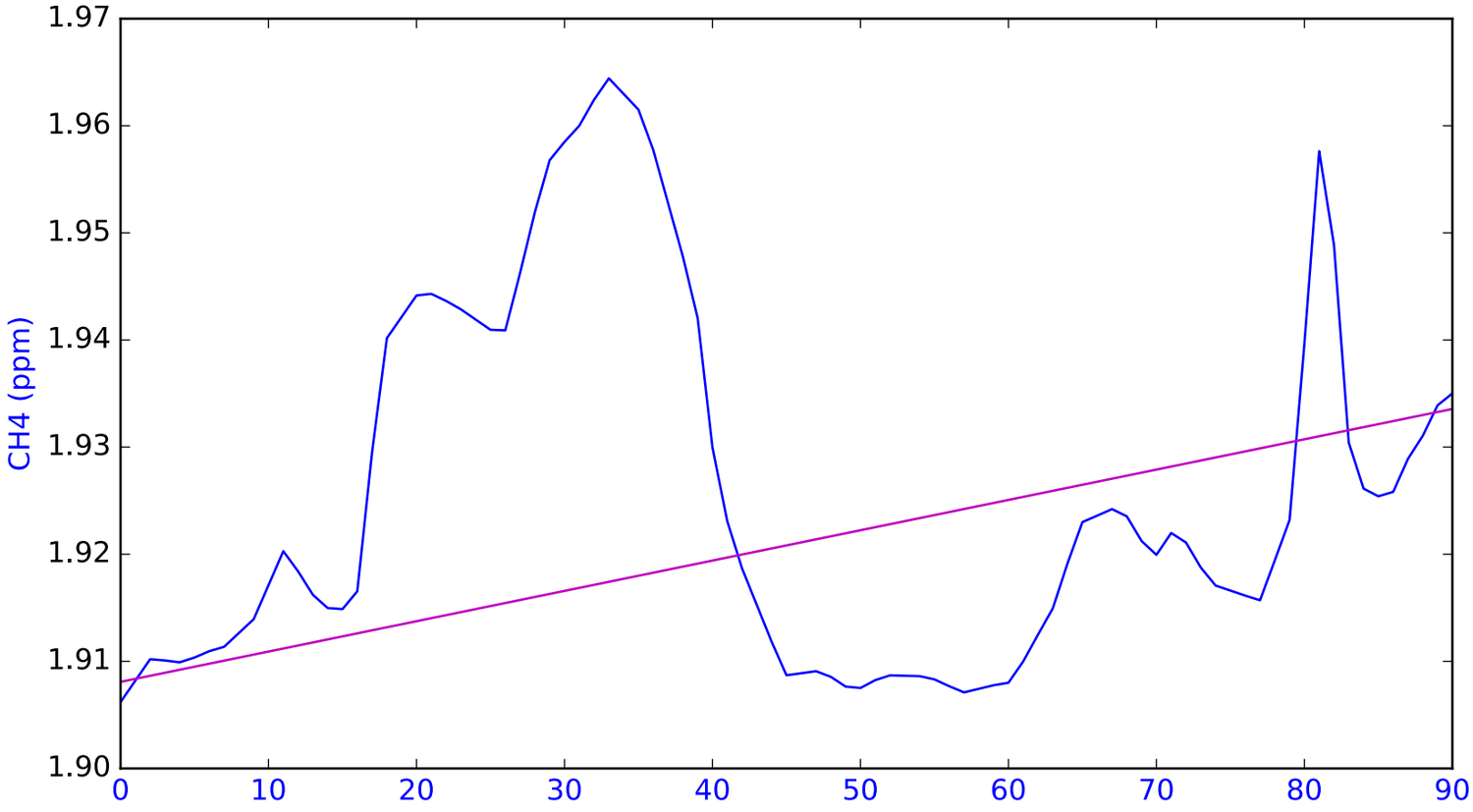

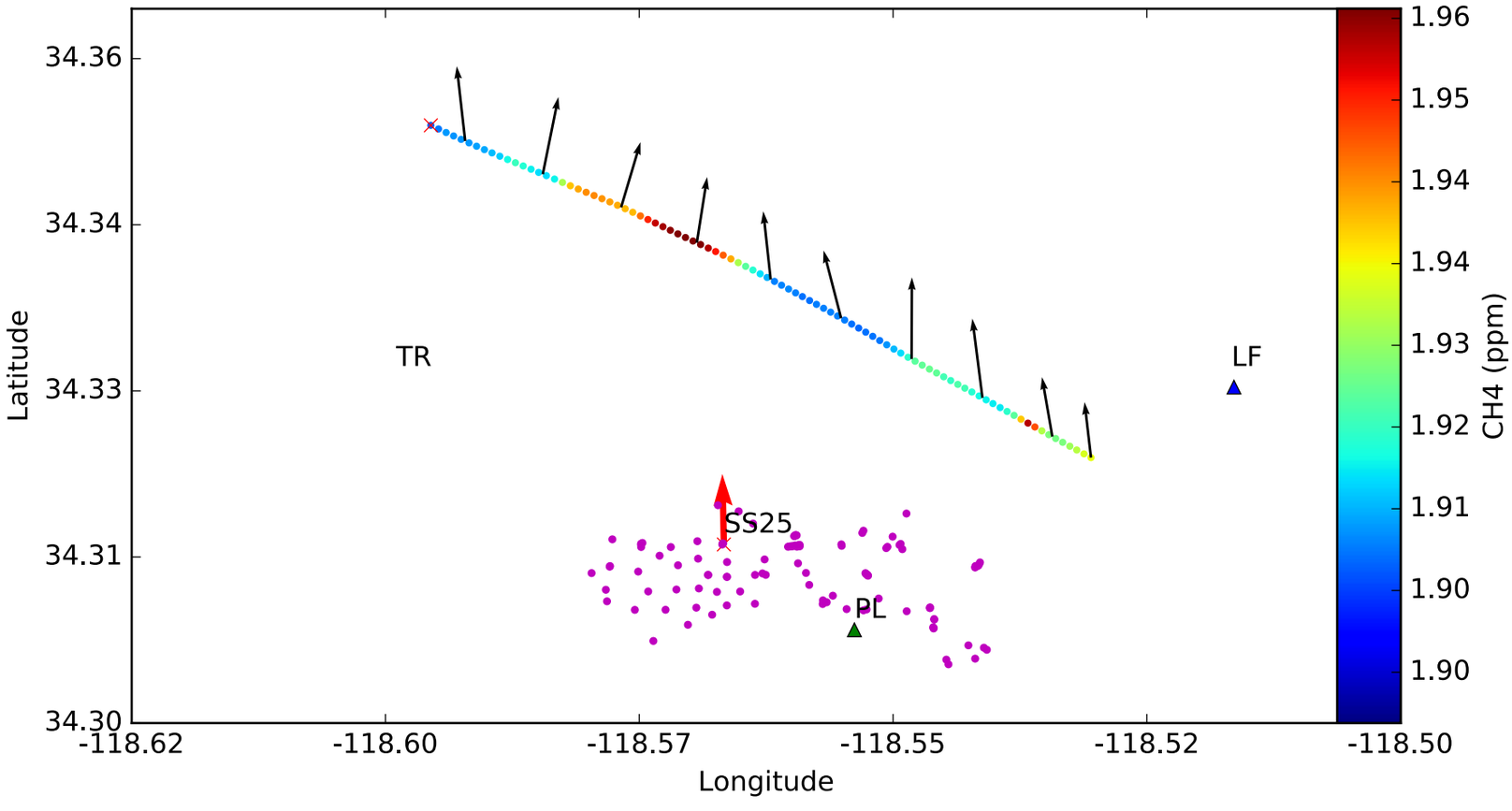

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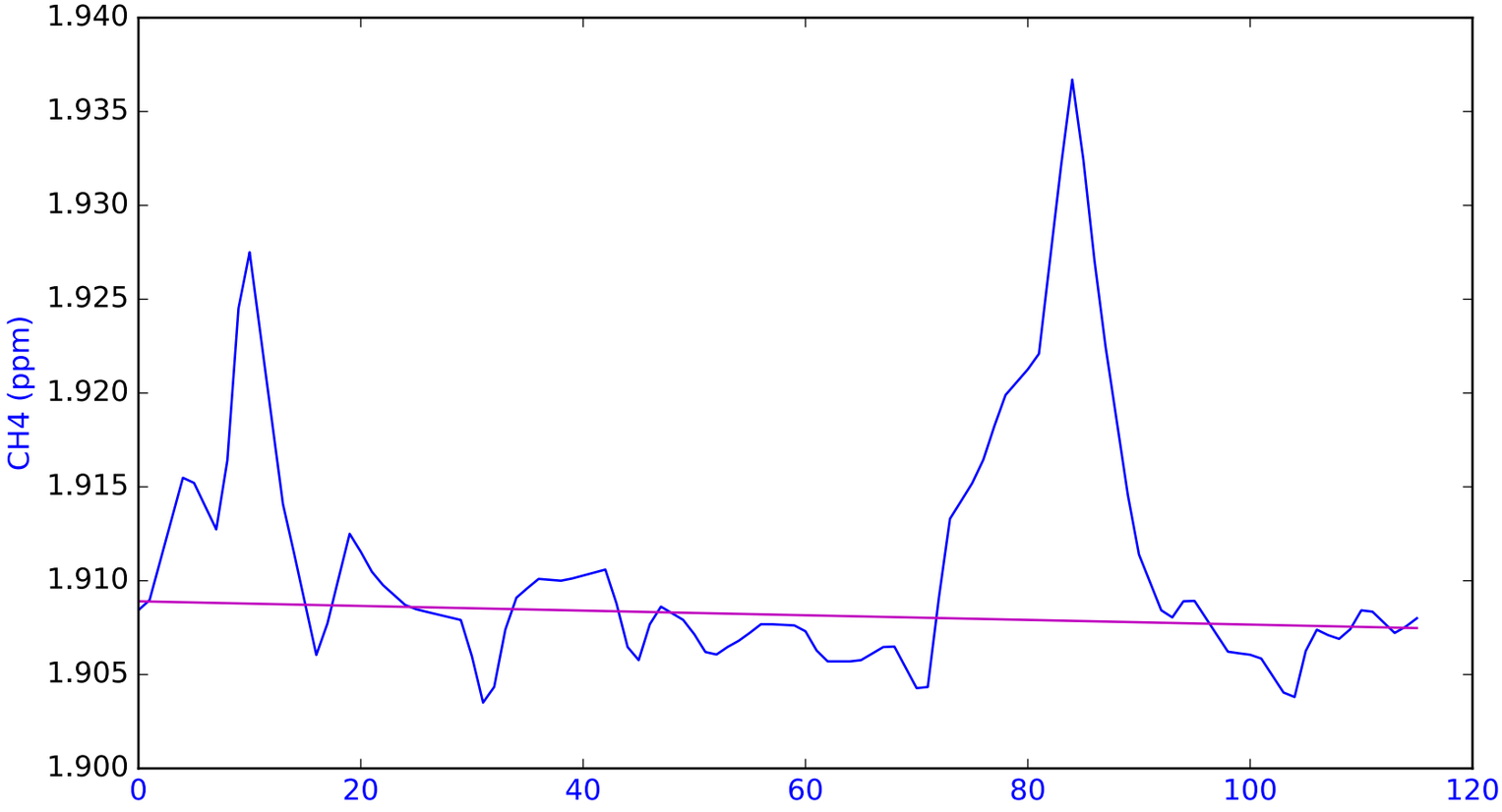

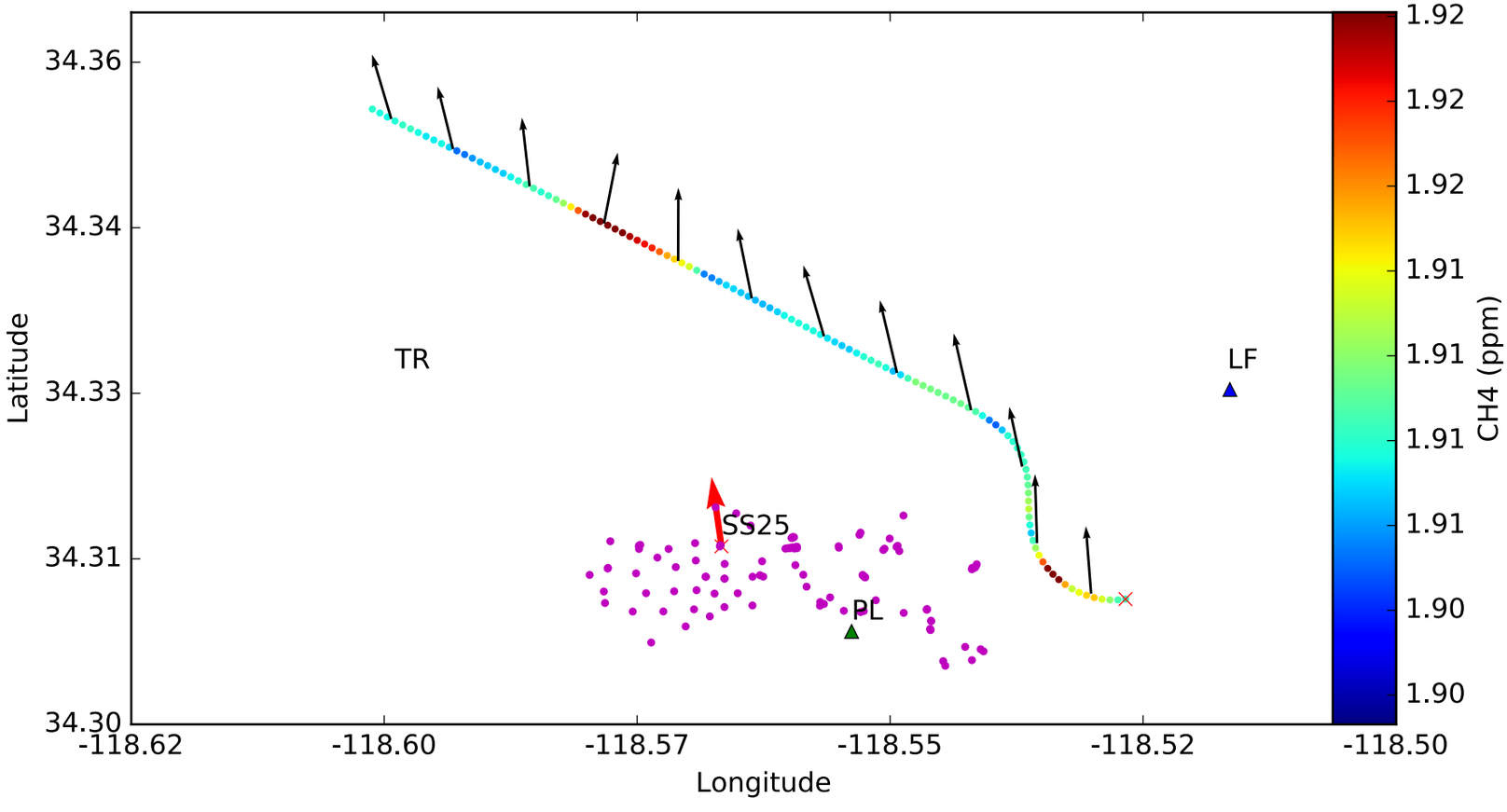

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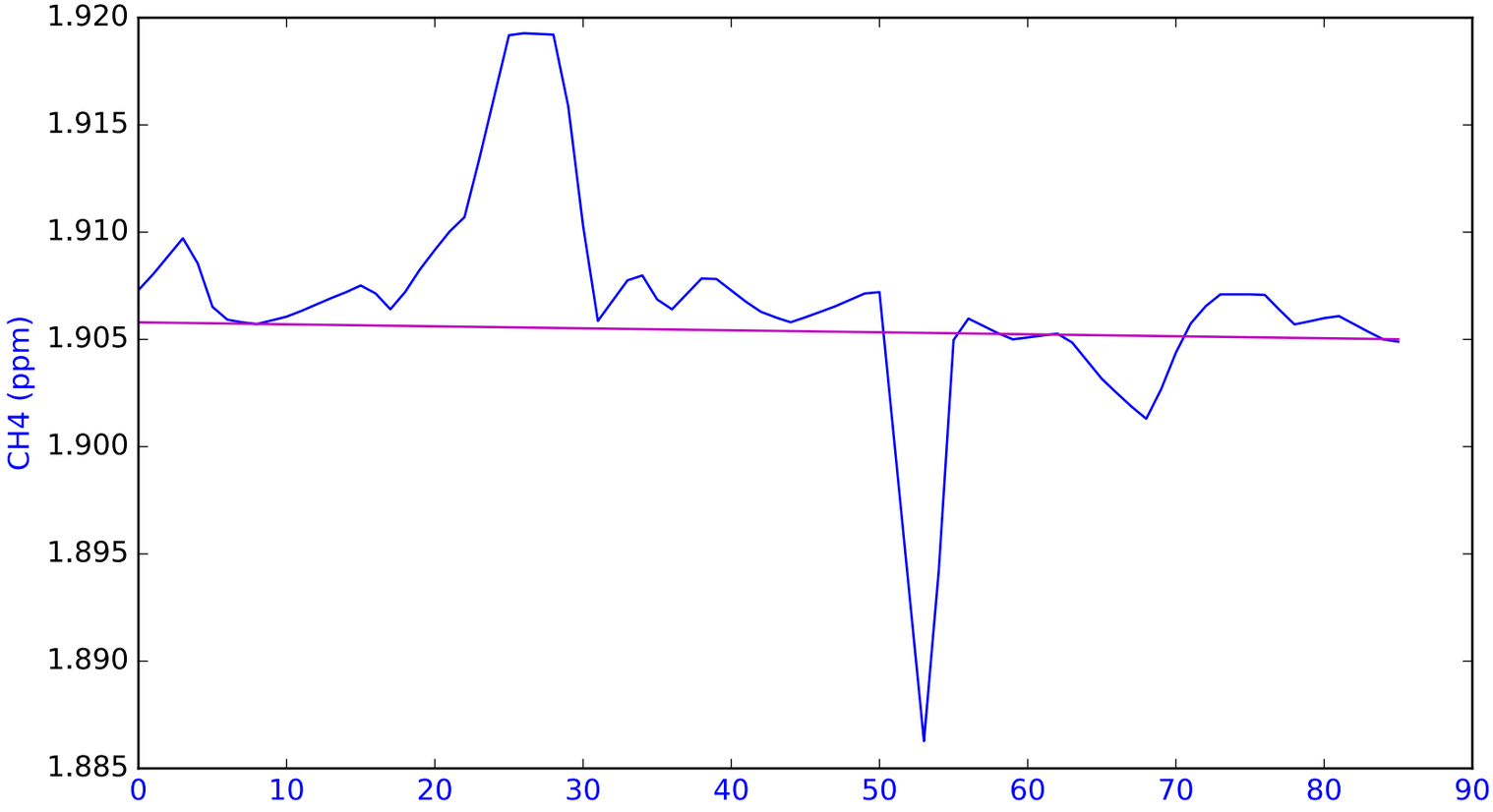

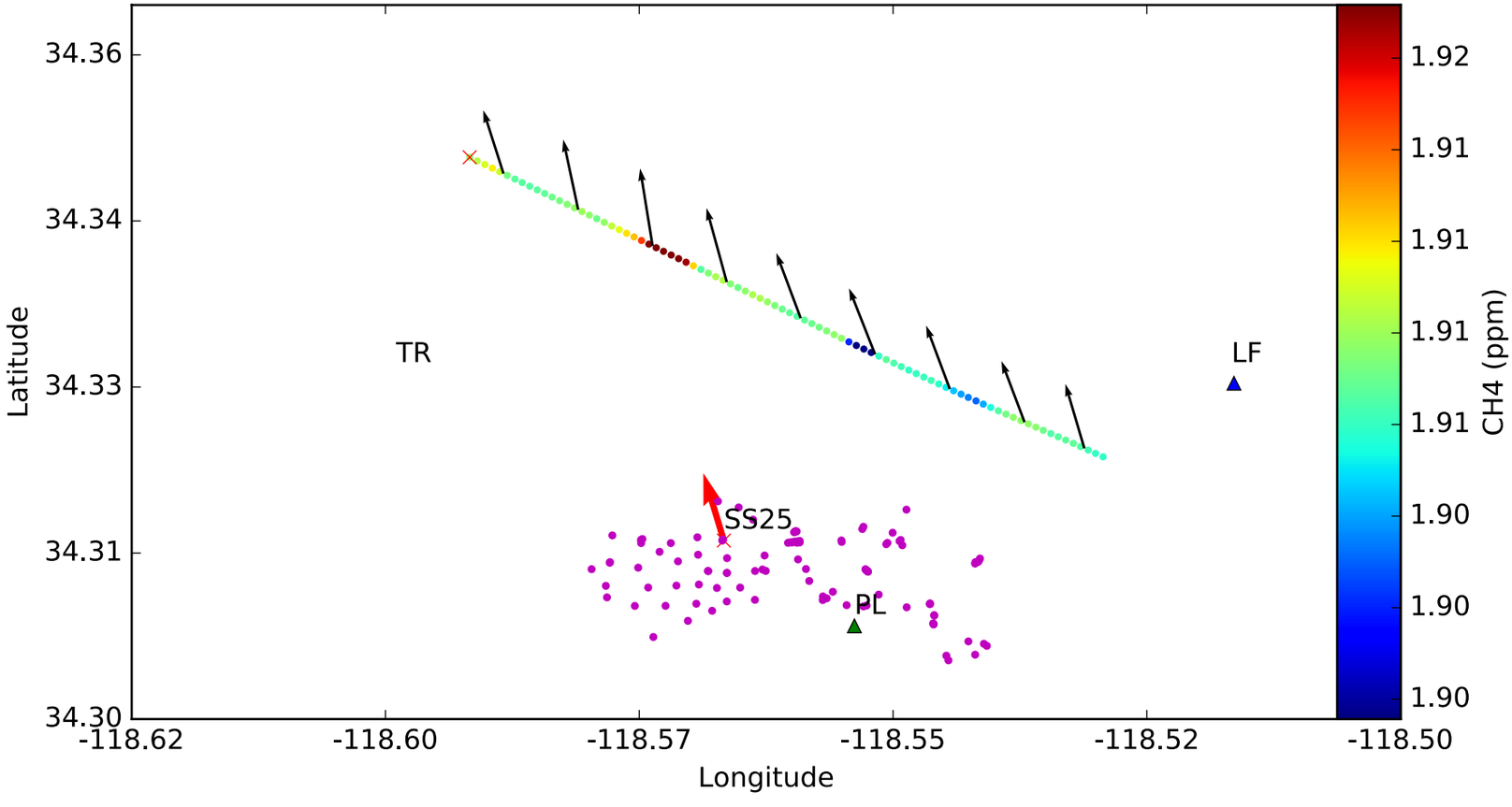

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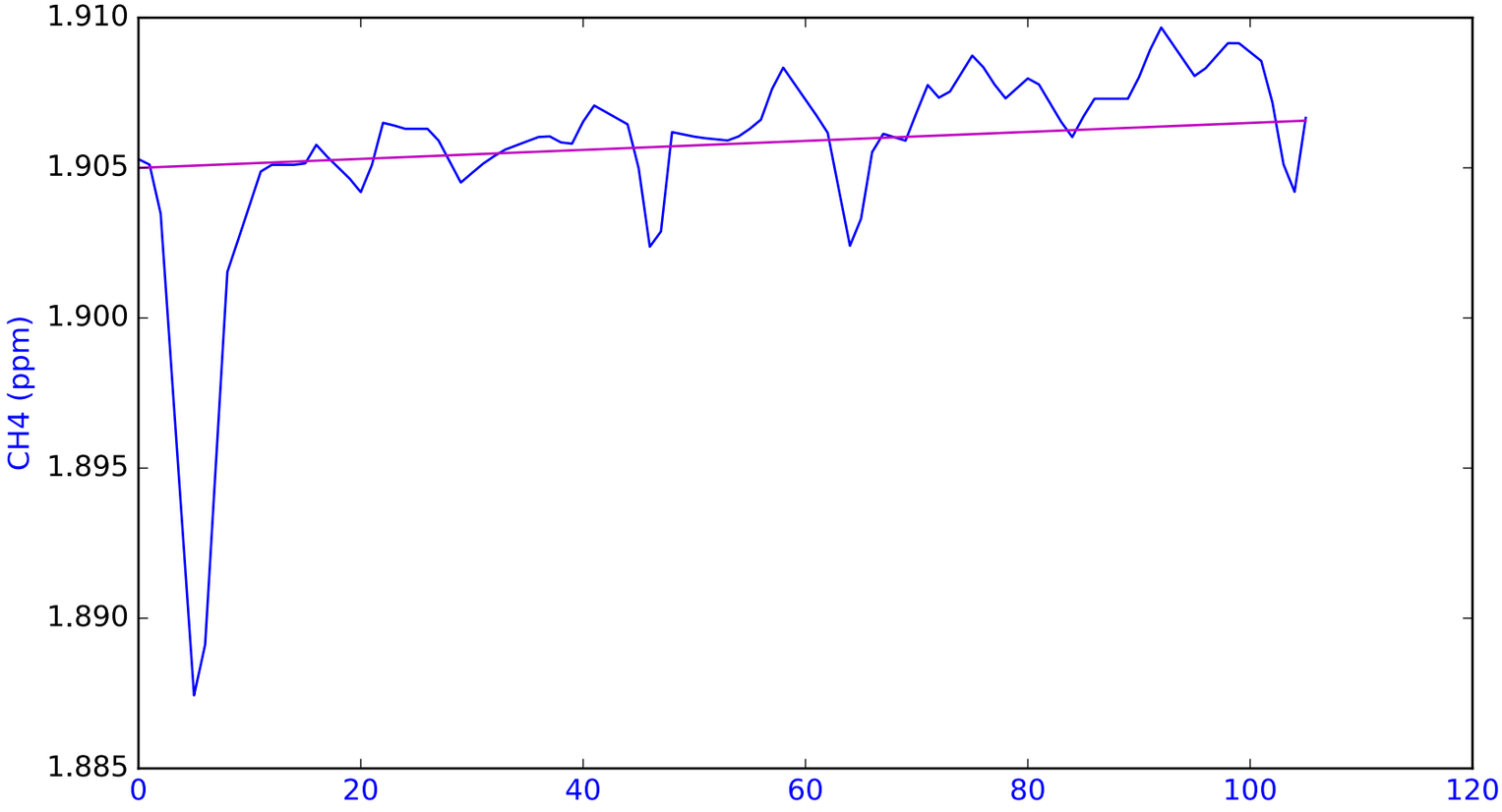

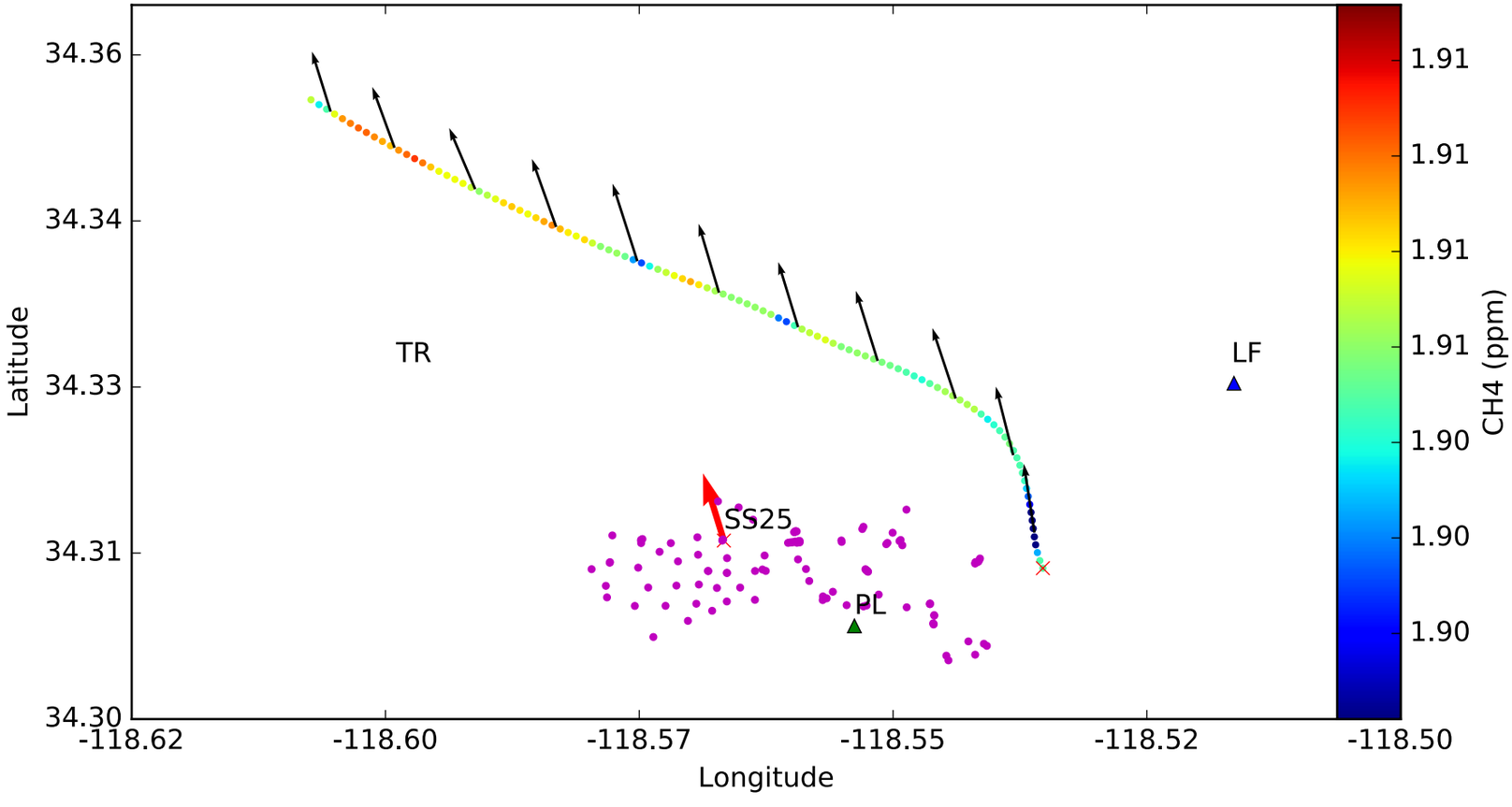

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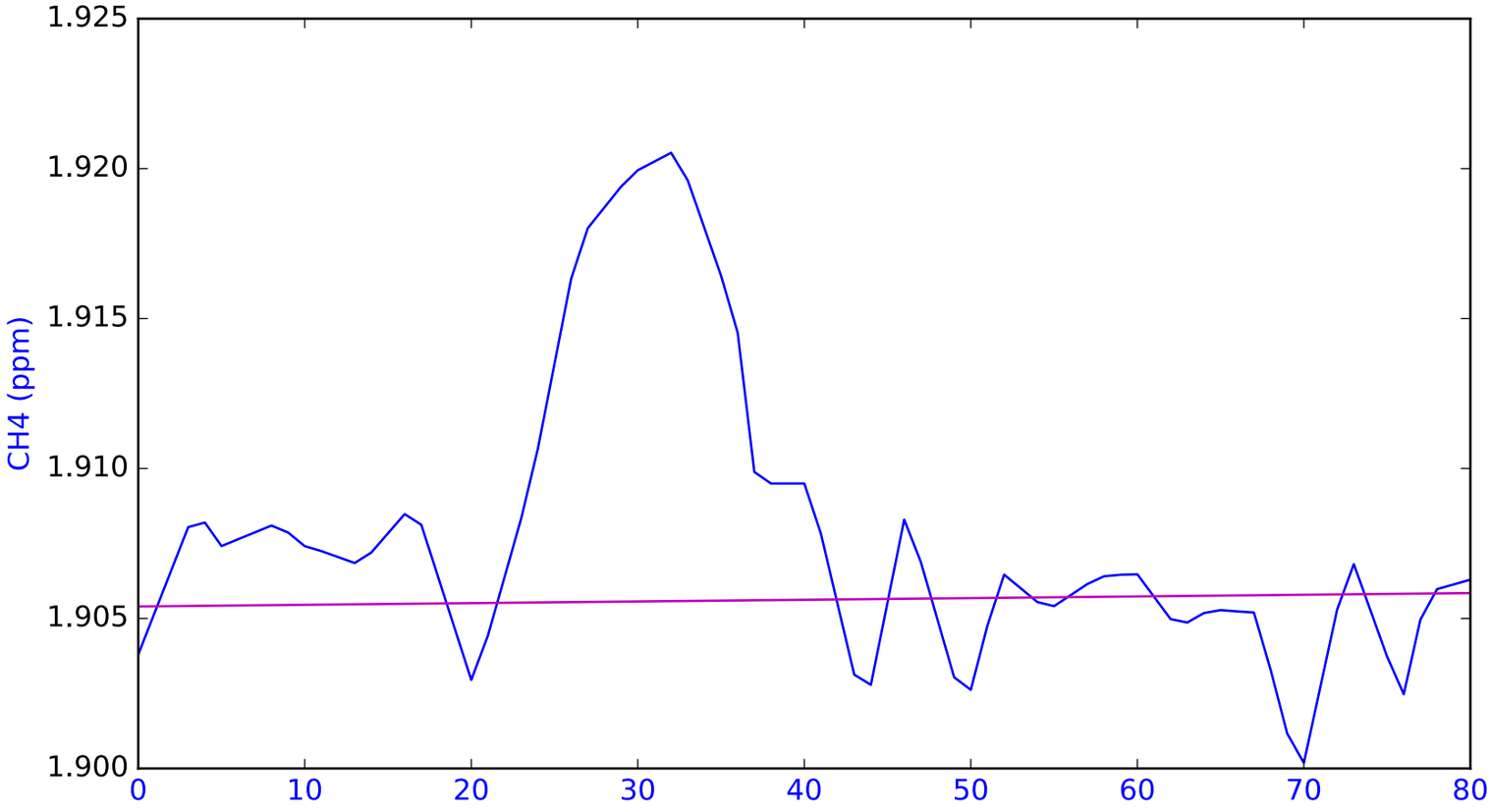

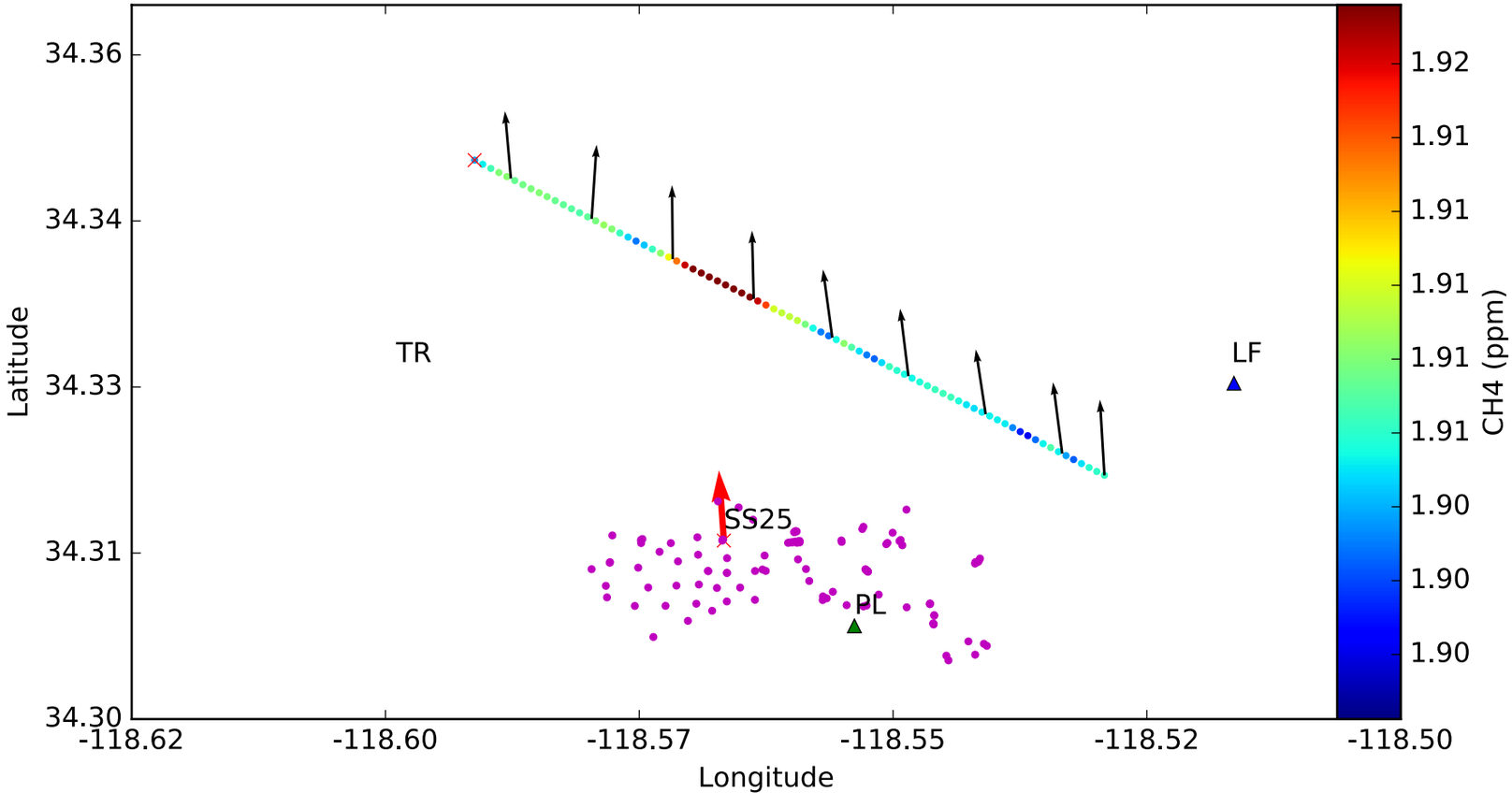

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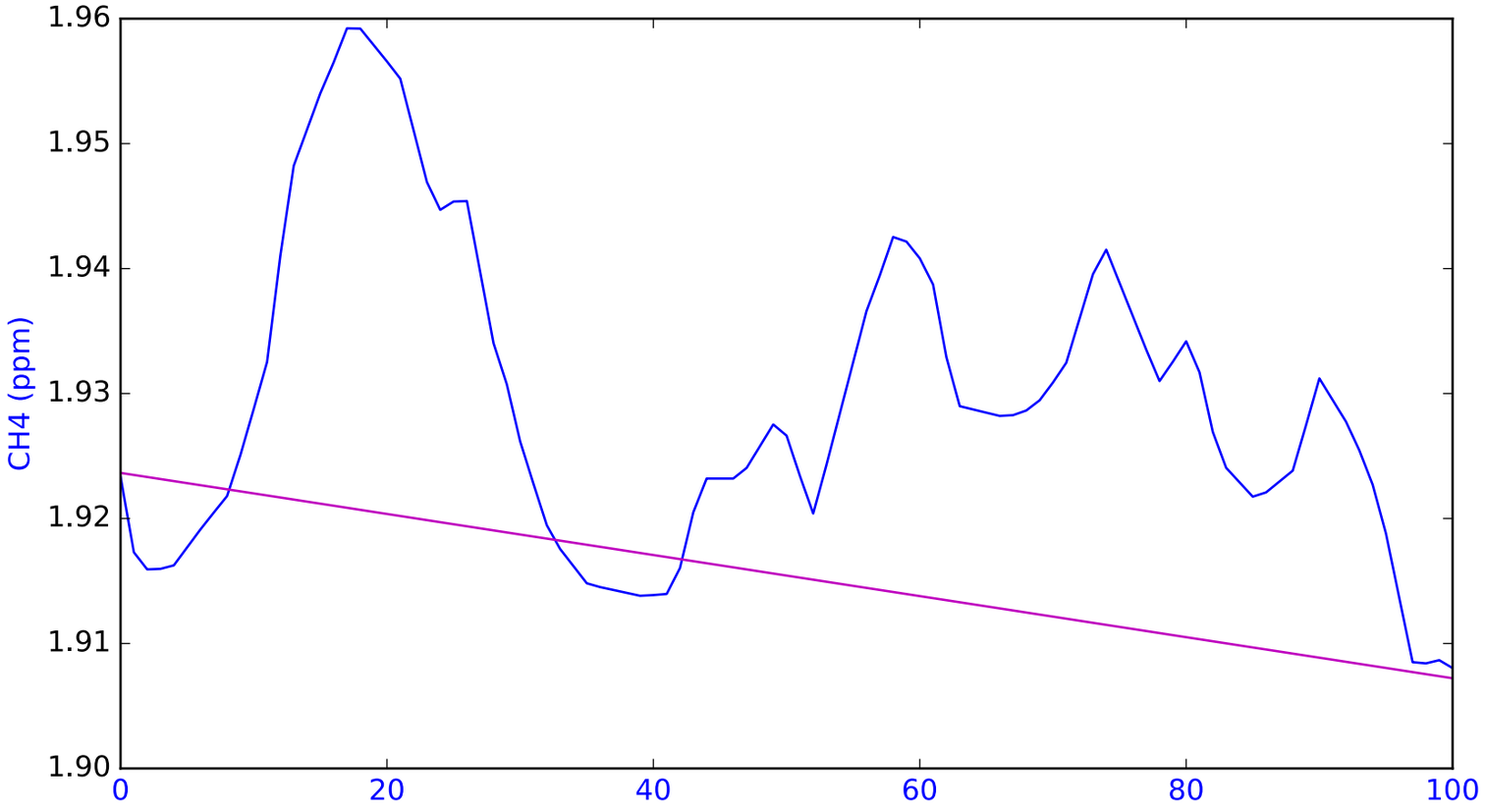

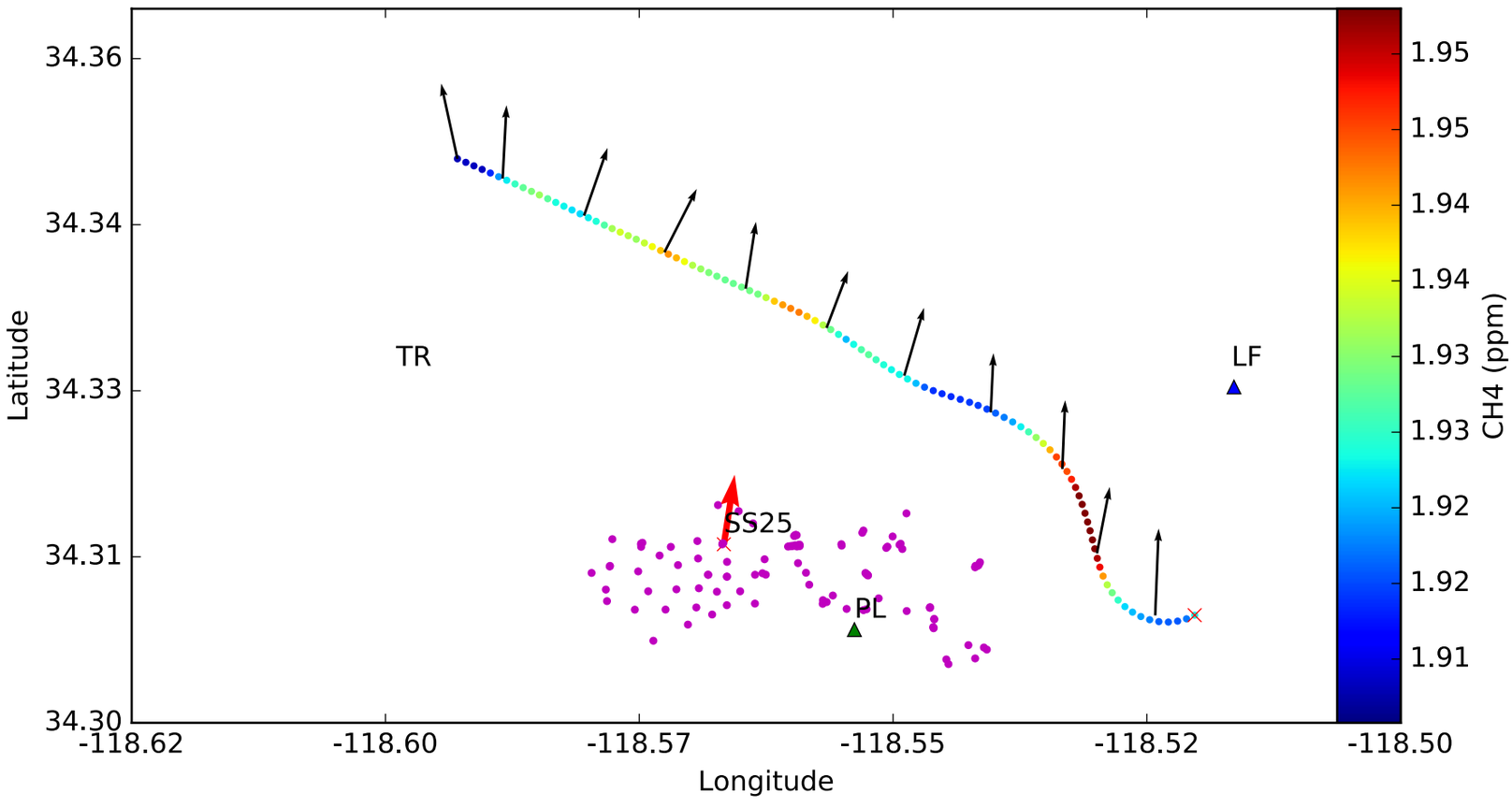

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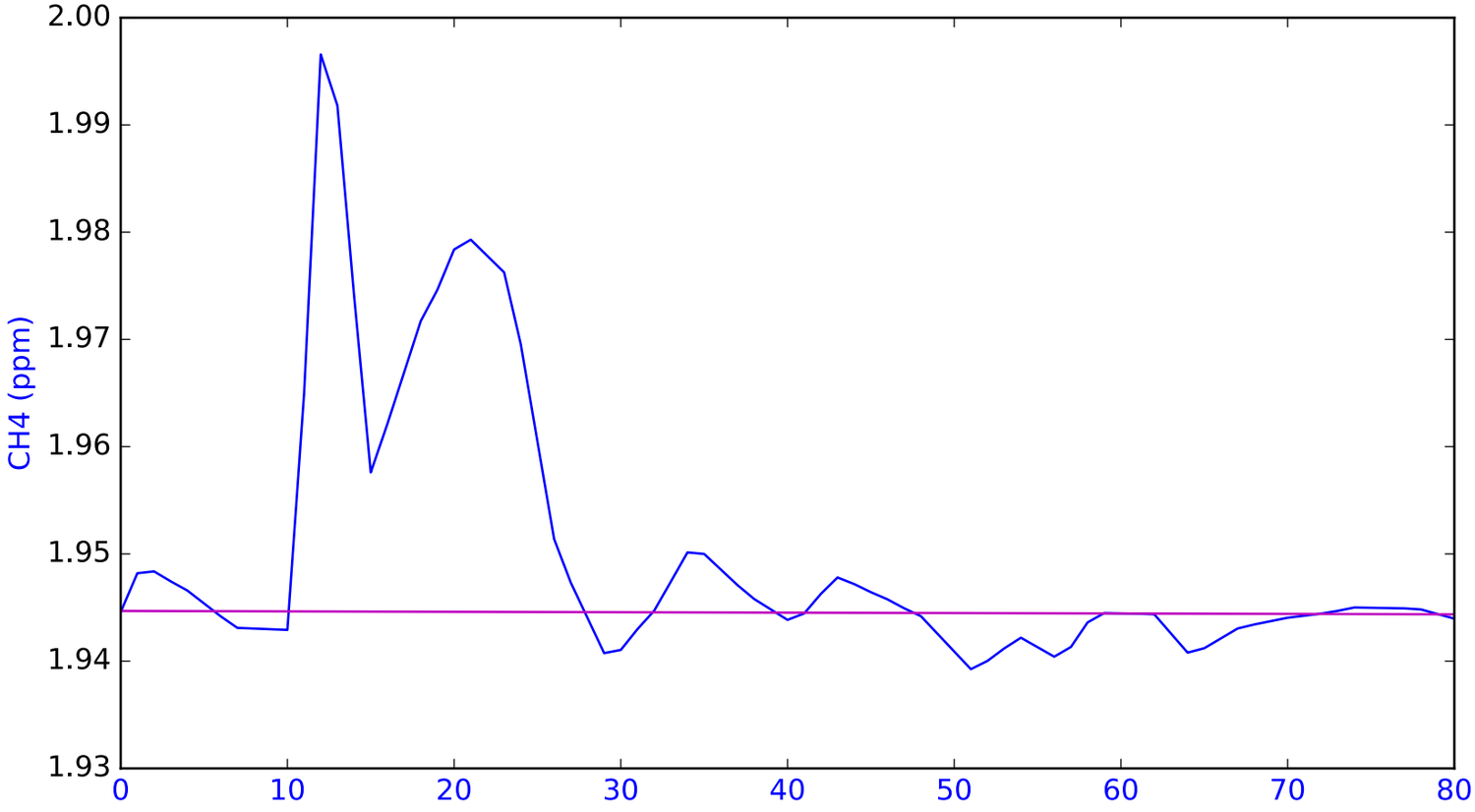

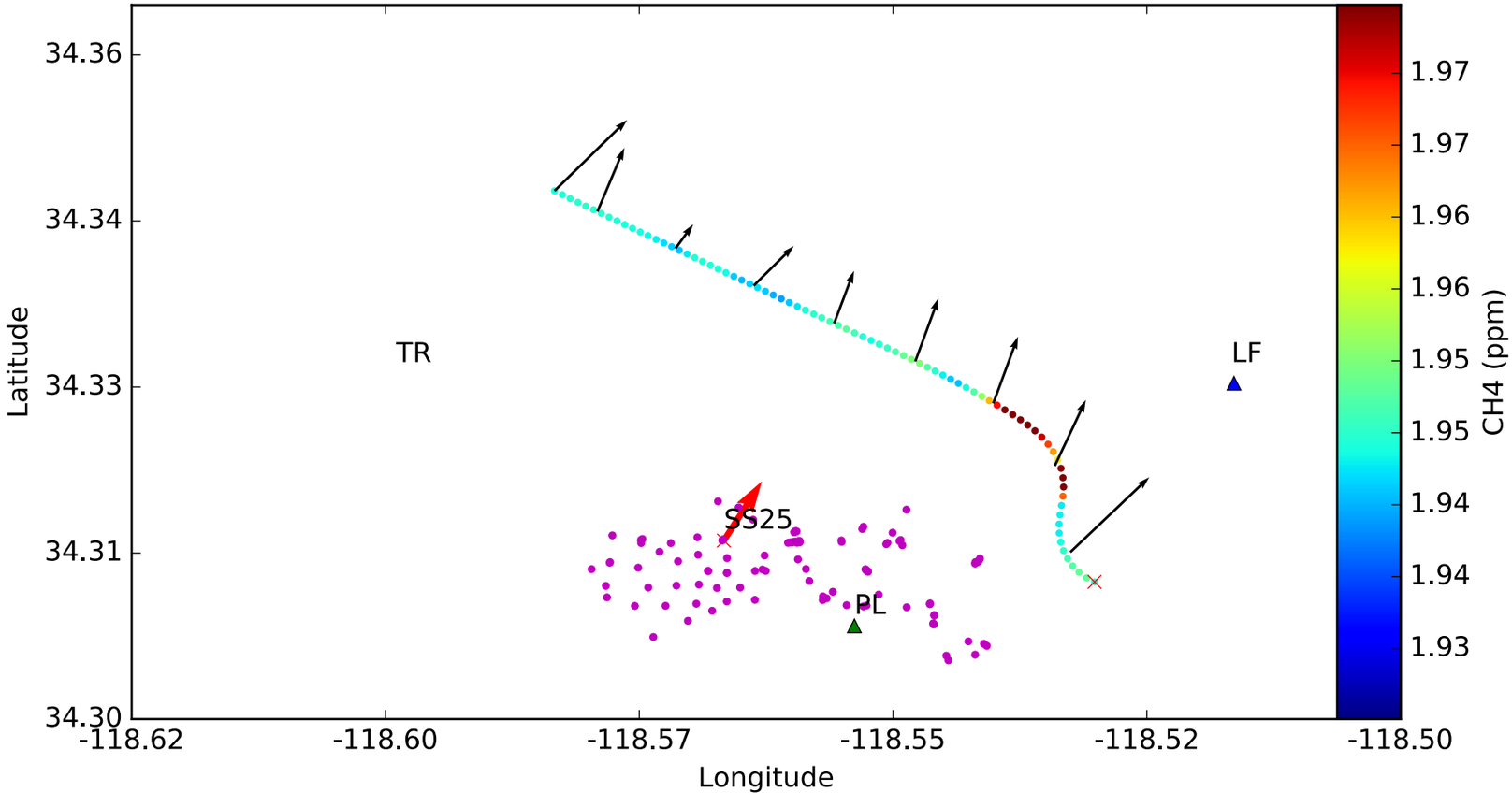

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