The ARCHER automated TC center-fixing algorithm: Updates on real-time operations, accuracy and capabilities

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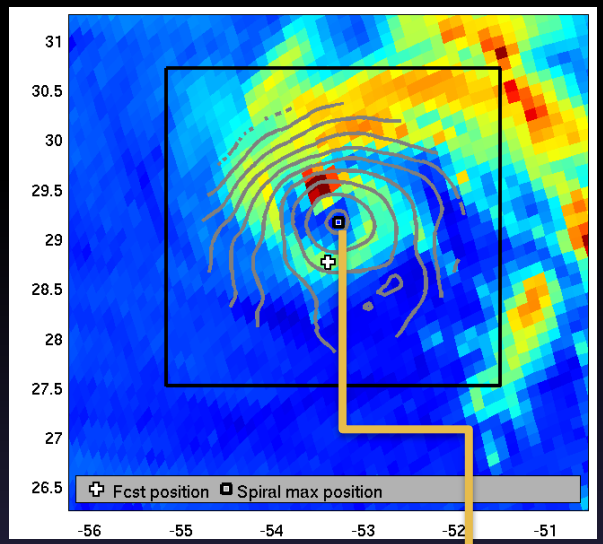
R&D supported by the Naval Research Lab and Office of Naval Research; Operational evaluation by the NOAA Joint Hurricane Testbed

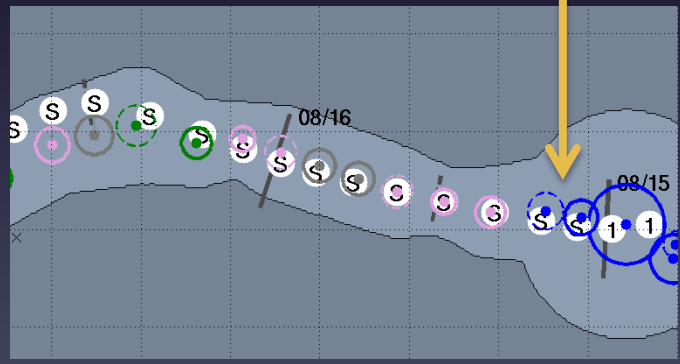
Background: The ARCHER algorithm

- Two main components:

1. **Image analysis**
   - Parallax adjustment
   - Determination of **center-fix**
   - Determination of **center-fix certainty** (confidence)
   - Additional metrics (**prob. of eye**, **eye size**, **coarse intensity estimate**)

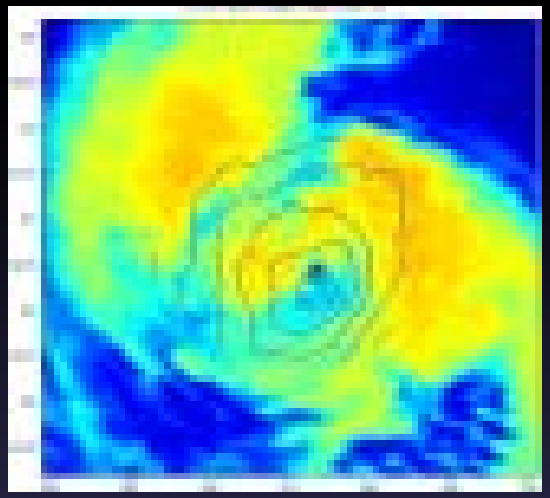
2. **Integration into storm track**
   - Adjust polar observations to a common timestep, in line with geostationary observations (0245, 0545, etc in NATL)
   - Selection of the best observation
   - Clean presentation of output



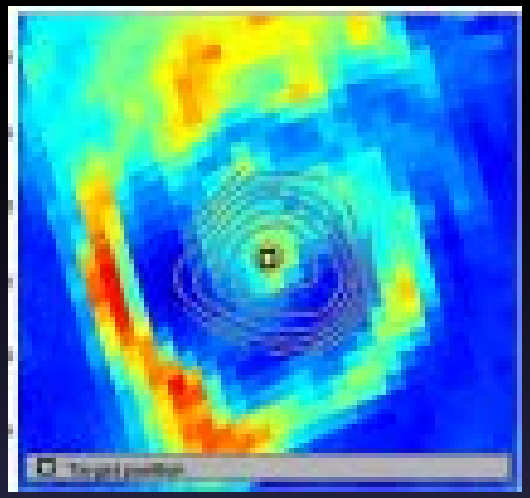


Real-time data sources

Processes imagery in real-time and near real-time from:

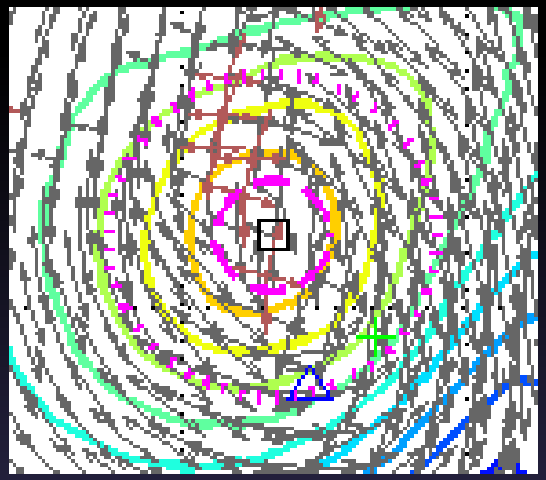


Geo imagers (Visible, IR, SWIR)



Microwave imagers (37, 85-92 GHz)

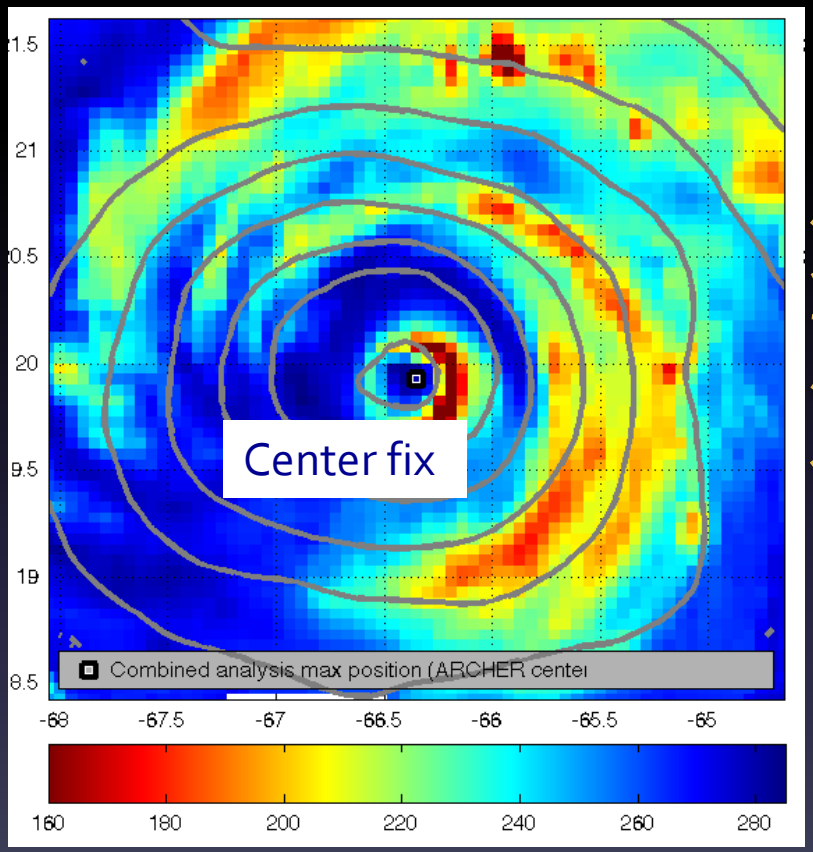
- SSMI, SSMIS, TMI, AMSR2, GMI, Windsat



Scatterometer

- ASCAT
- RapidSCAT (TBA)

Connections to other research/applications



85 GHz (H) Bright. Temp.

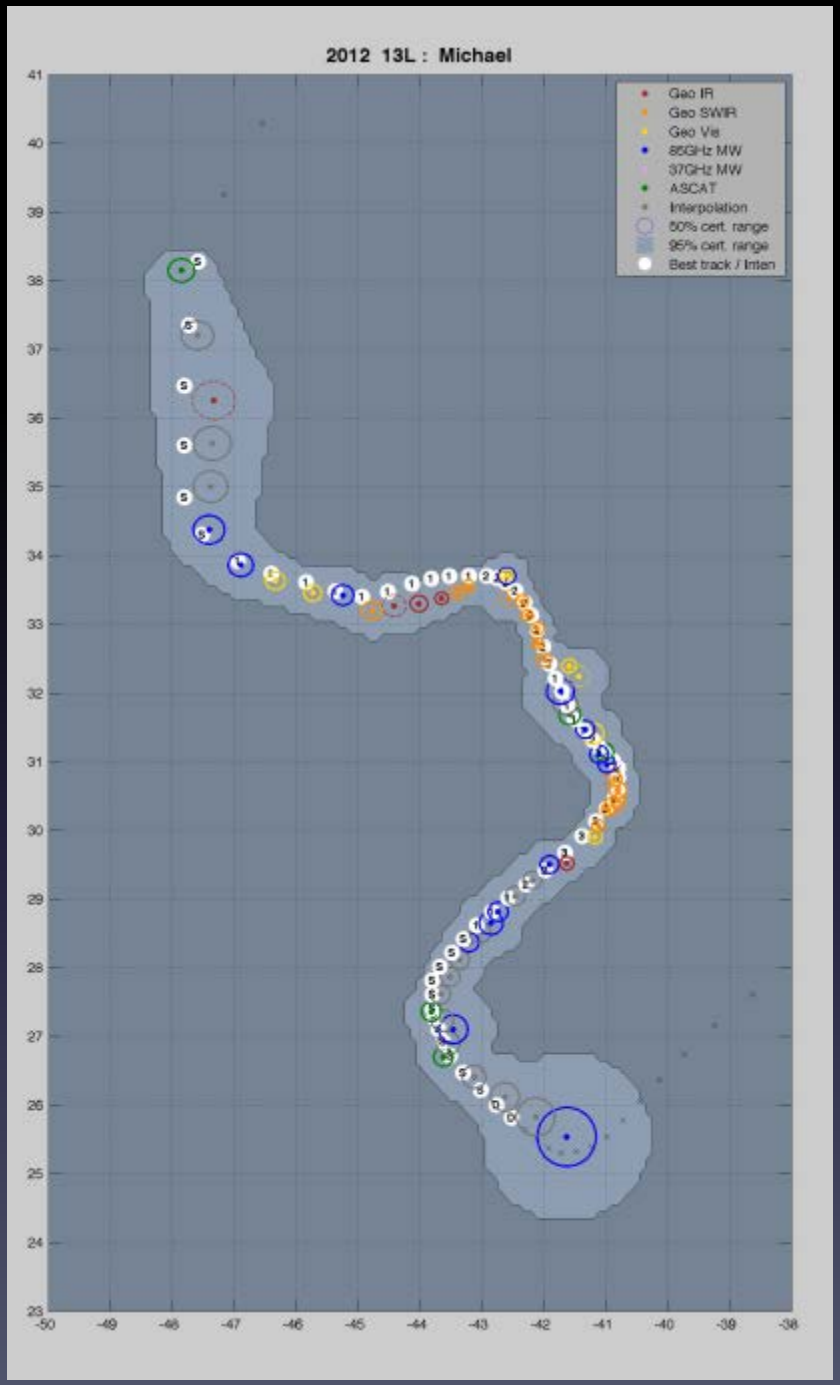
Rapid intensification (37 GHz – Jiang & Kieper, 85 GHz - Rozoff et al)

Automated Dvorak Technique (Velden et al)

Visualization (MIMIC - Wimmers & Velden)

TC structure (Cossuth et al)

Climatology (Knapp et al)

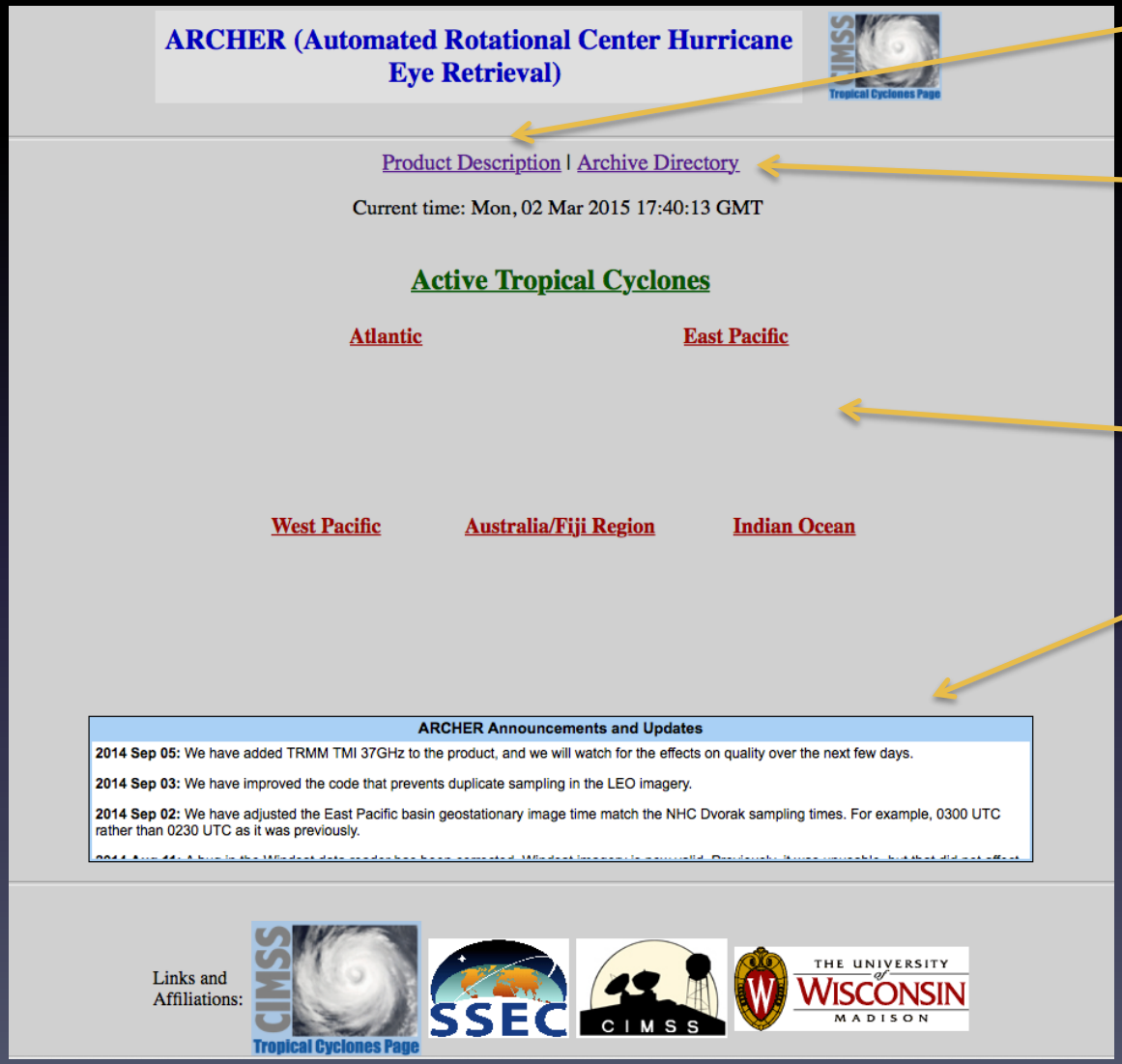


JHT Project

- R&D of ARCHER supported by NRL/ONR
- The two-year project with the Joint Hurricane Testbed includes:
  1. Implement an experimental version of ARCHER within JHT framework
  2. Evaluation and adaptations toward providing an operational, real-time algorithm
  3. Validation of the ARCHER scheme under simulated real-time conditions

Real-time product features

Main menu



ARCHER product description wiki

TC data/imagery archive

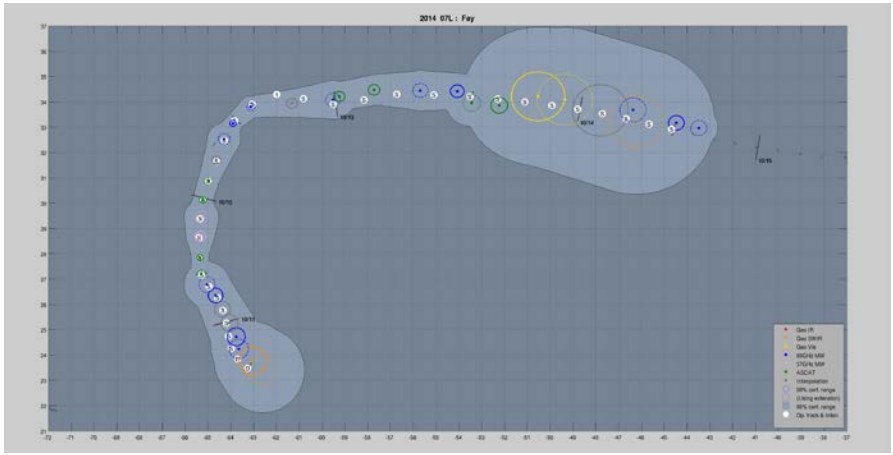
Active TCs

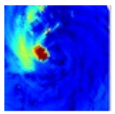
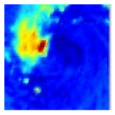
Announcements

Real-time product features

Track guidance page

Fay (2014)



Geo IR	85-92GHz	Date/Time (UTC)	Source	Sensor	Vmax(kts)	ARCHER Lat	Lon	Geo-ref Lat	Lon	50% cert. rad.	95% cert. rad.	Eye diam (deg)	% cert. of eve
		20141011 14:51:46	GMI	85-92GHz	60.0	28.07	-65.19	28.04	-65.18	0.28	0.79	0.50	29.7
		20141011 14:51:46	GMI	37GHz	60.0	27.92	-65.24	27.89	-65.24	0.23	0.66	0.25	***
		20141011 14:45:00	Geo	Vis	60.0	***	***	***	***	***	***	0.15	***
		20141011 14:45:00	Geo	NearIR	60.0	27.71	-66.40	27.71	-66.40	0.90	2.53	0.30	***
		20141011 14:45:00	Geo	IR	60.0	27.84	-66.18	27.84	-66.18	3.36	9.49	0.10	0.9
		20141011 14:39:00 *	**Metop-B**	**ASCAT**	**60.0**	**27.82**	**-65.36**	**27.84**	**-65.36**	**0.12**	**0.33**	***	***
		20141011 13:48:00 *	Metop-A	ASCAT	60.0	27.65	-65.36	27.90	-65.38	0.12	0.34	***	***
		20141011 11:45:00	Geo	Vis	59.6	***	***	***	***	***	***	0.05	***
		20141011 11:45:00	Geo	NearIR	59.6	26.53	-64.34	26.53	-64.34	3.36	9.49	0.50	***
		20141011 11:45:00	Geo	IR	59.6	***	***	***	***	***	***	0.35	***
		20141011 10:54:04	SSMIS-17	85-92GHz	58.2	27.31	-64.92	27.45	-64.98	0.36	1.02	0.75	8.9
		20141011 08:45:00	Geo	NearIR	54.6	25.84	-64.39	25.84	-64.39	0.83	2.36	0.10	***

Real-time product features

Text output

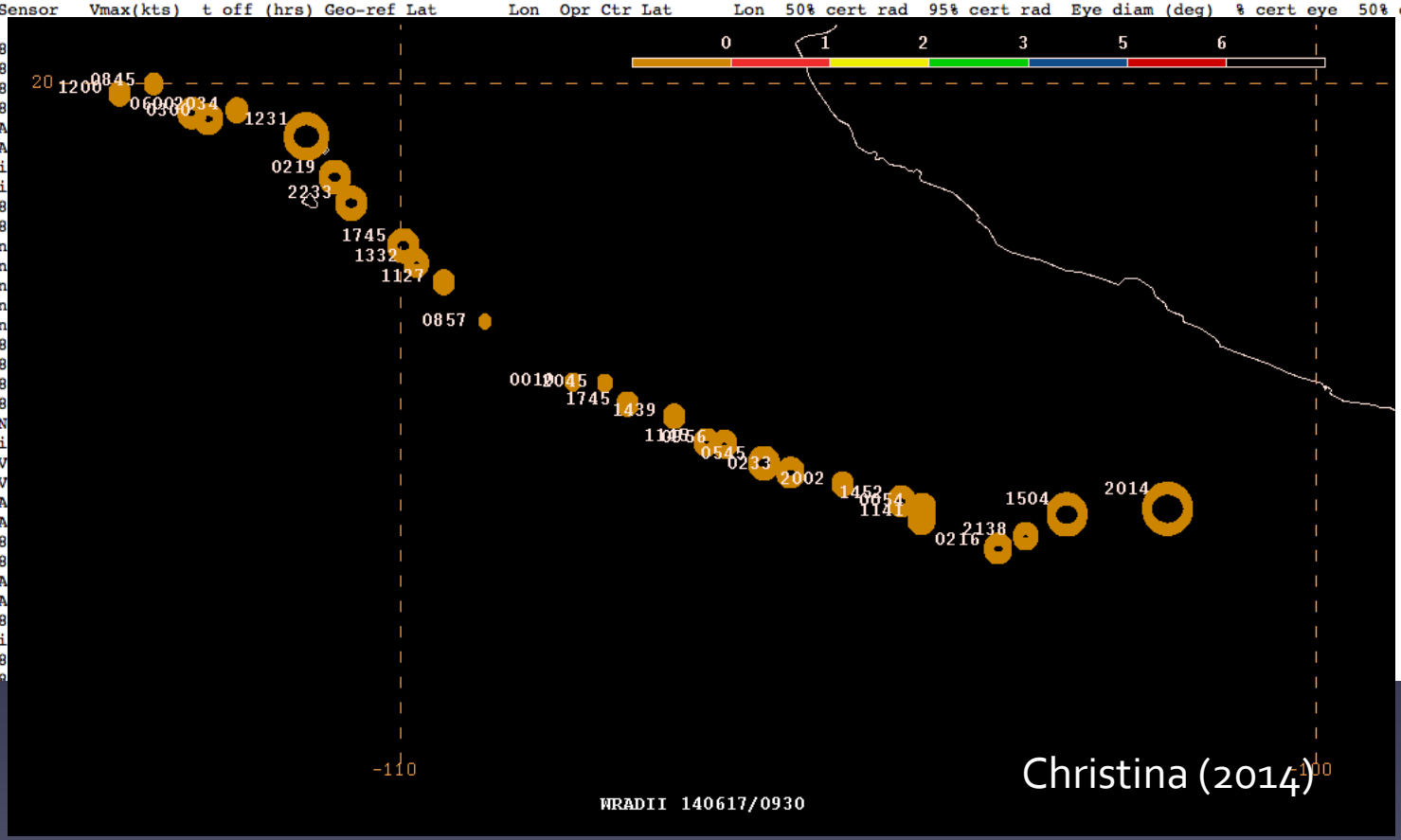
Date/Time_(UTC)	Source Sensor	Vmax(kts)	t_off (hrs)	Geo-ref Lat	Lon	Opr Ctr Lat	Lon	50% cert rad	95% cert rad	Eye diam (deg)	% cert eye	50% cert fxa
20141016 11:45:00	GMI 85-92GHz	30.0	-1.22	32.99	-30.28	31.99	-29.58	0.61	1.73	1.50	0.0	3.00
20141016 08:45:00	SSMIS-17 85-92GHz	30.3	-0.66	32.43	-31.26	31.93	-30.49	0.37	1.05	0.15	6.0	3.00
20141016 05:45:00	SSMI-15 85-92GHz	30.7	-0.53	32.23	-31.06	31.88	-31.42	0.38	1.08	0.15	10.1	3.00
20141016 02:45:00	SSMI-15 85-92GHz	31.3	2.47	32.20	-31.99	31.85	-32.35	0.41	1.17	***	***	3.00
20141015 23:45:00	Metop-A ASCAT	31.9	-0.05	32.32	-34.11	31.82	-33.28	0.51	1.44	***	***	3.00
20141015 20:45:00	Metop-A ASCAT	32.6	2.95	32.31	-35.05	31.81	-34.22	0.55	1.56	***	***	2.96
20141015 17:45:00	interp interp	33.4	0.00	32.41	-36.00	31.80	-35.17	0.46	1.31	***	***	2.74
20141015 14:45:00	interp interp	34.2	0.00	32.50	-36.95	31.80	-36.12	0.40	1.13	***	***	2.53
20141015 11:45:00	TMI 85-92GHz	35.1	-2.55	32.60	-37.90	31.80	-37.08	0.35	1.00	***	***	2.32
20141015 08:45:00	TMI 85-92GHz	36.1	0.45	32.64	-38.88	31.84	-38.05	0.32	0.91	1.50	0.0	2.12
20141015 05:45:00	n/a n/a	37.4	0.00	NaN	NaN	31.95	-39.04	NaN	NaN	***	***	1.93
20141015 02:45:00	n/a n/a	38.8	0.00	NaN	NaN	32.08	-40.02	NaN	NaN	***	***	1.75
20141014 23:45:00	n/a n/a	40.1	0.00	NaN	NaN	32.21	-40.98	NaN	NaN	***	***	1.57
20141014 20:45:00	n/a n/a	41.6	0.00	NaN	NaN	32.36	-41.91	NaN	NaN	***	***	1.40
20141014 17:45:00	n/a n/a	43.3	0.00	NaN	NaN	32.54	-42.81	NaN	NaN	***	***	1.23
20141014 14:45:00	TMI 85-92GHz	44.5	-1.36	32.33	-42.78	32.73	-43.73	0.55	1.54	0.10	1.0	1.07
20141014 11:45:00	TMI 85-92GHz	45.0	-1.63	32.97	-43.49	32.92	-44.68	0.30	0.84	***	***	0.93
20141014 08:45:00	TMI 85-92GHz	45.0	1.37	33.17	-44.47	33.12	-45.67	0.29	0.83	0.15	7.1	0.79
20141014 05:45:00	SSMIS-16 85-92GHz	45.0	2.18	33.68	-46.38	33.33	-46.67	0.48	1.35	***	***	0.66
20141014 02:45:00	Geo NearIR	45.0	3.00	33.24	-46.25	33.54	-47.71	1.02	2.89	***	***	0.55
20141013 23:45:00	interp interp	45.0	0.00	33.66	-47.80	33.71	-48.79	1.02	2.87	***	***	0.44
20141013 20:45:00	Geo Vis	46.5	-3.00	34.09	-49.35	33.86	-49.93	1.01	2.86	***	***	0.35
20141013 17:45:00	Geo Vis	48.9	0.00	34.22	-50.54	33.99	-51.11	0.97	2.73	***	***	0.27
20141013 14:45:00	Metop-B ASCAT	50.0	-0.80	33.86	-52.24	34.11	-52.30	0.31	0.87	***	***	0.20
20141013 11:45:00	Metop-B ASCAT	50.0	2.20	33.96	-53.45	34.21	-53.51	0.33	0.93	0.25	1.1	0.17
20141013 08:45:00	SSMIS-16 85-92GHz	52.8	-0.60	34.42	-54.08	34.27	-55.11	0.25	0.72	1.20	5.1	0.17
20141013 05:45:00	SSMIS-16 85-92GHz	55.0	2.40	34.45	-55.70	34.30	-56.72	0.28	0.80	***	***	0.17
20141013 02:45:00	Metop-B ASCAT	55.0	-1.15	34.48	-57.72	34.08	-58.16	0.21	0.60	***	***	0.17
20141012 23:45:00	Metop-A ASCAT	55.1	1.00	34.21	-59.24	33.90	-59.51	0.20	0.57	1.25	31.3	0.17
20141012 20:45:00	SSMIS-18 85-92GHz	60.6	2.11	34.07	-59.53	34.12	-60.82	0.27	0.77	1.35	6.5	0.17
20141012 17:45:00	interp interp	65.0	0.00	33.94	-61.32	34.30	-61.99	0.20	0.55	***	***	0.16
20141012 14:45:00	TMI 85-92GHz	62.2	-2.70	33.81	-63.12	33.90	-63.06	0.15	0.43	***	***	0.16
20141012 11:45:00	TMI 85-92GHz	60.0	0.30	33.15	-63.91	33.25	-63.85	0.12	0.33	0.45	100.0	0.17

Real-time product features

Text output

NMAP2 Display

Date/Time_(UTC)	Source Sensor	Vmax(kts)	t off (hrs) Geo-ref Lat	Lon	Opr Ctr Lat	Lon	50% cert rad	95% cert rad	Eye diam (deg)	% cert eye	50% cert fxa
20141016 11:45:00	GMI 8										3.00
20141016 08:45:00	SSMIS-17 8										3.00
20141016 05:45:00	SSMI-15 8										3.00
20141016 02:45:00	SSMI-15 8										3.00
20141015 23:45:00	Metop-A A										3.00
20141015 20:45:00	Metop-A A										2.96
20141015 17:45:00	interp i										2.74
20141015 14:45:00	interp i										2.53
20141015 11:45:00	TMI 8										2.32
20141015 08:45:00	TMI 8										2.12
20141015 05:45:00	n/a n										1.93
20141015 02:45:00	n/a n										1.75
20141014 23:45:00	n/a n										1.57
20141014 20:45:00	n/a n										1.40
20141014 17:45:00	n/a n										1.23
20141014 14:45:00	TMI 8										1.07
20141014 11:45:00	TMI 8										0.93
20141014 08:45:00	TMI 8										0.79
20141014 05:45:00	SSMIS-16 8										0.66
20141014 02:45:00	Geo N										0.55
20141013 23:45:00	interp i										0.44
20141013 20:45:00	Geo V										0.35
20141013 17:45:00	Geo V										0.27
20141013 14:45:00	Metop-B A										0.20
20141013 11:45:00	Metop-B A										0.17
20141013 08:45:00	SSMIS-16 8										0.17
20141013 05:45:00	SSMIS-16 8										0.17
20141013 02:45:00	Metop-B A										0.17
20141012 23:45:00	Metop-A A										0.17
20141012 20:45:00	SSMIS-18 8										0.17
20141012 17:45:00	interp i										0.16
20141012 14:45:00	TMI 8										0.16
20141012 11:45:00	TMI 8										0.17

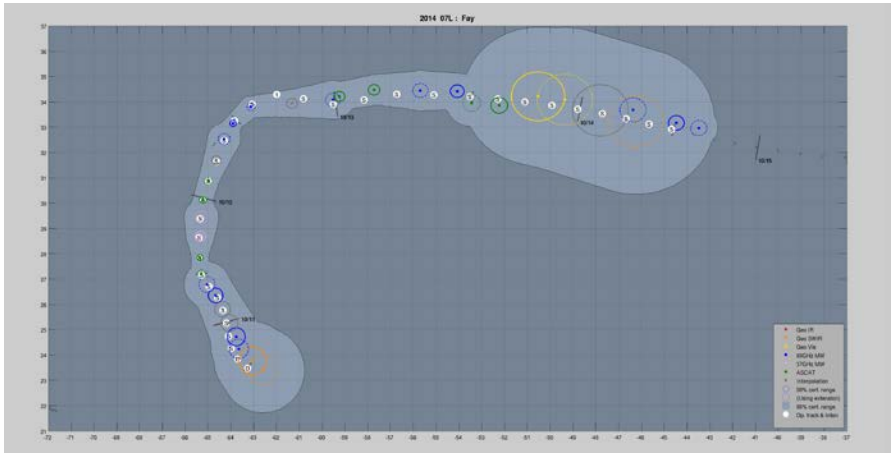


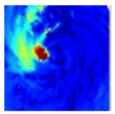
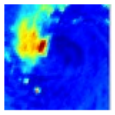
Christina (2014)

Real-time product features

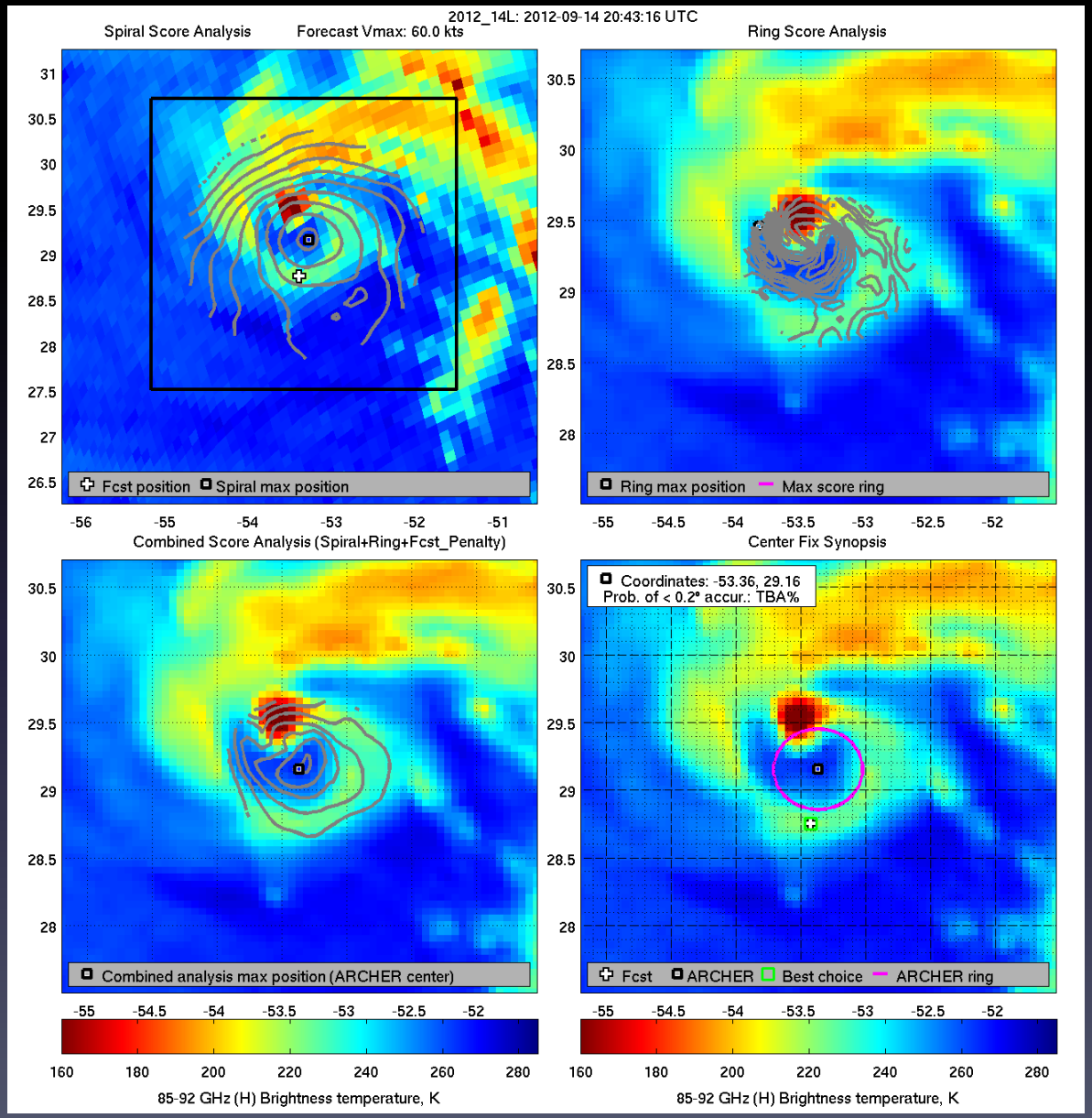
Track guidance page

Fay (2014)



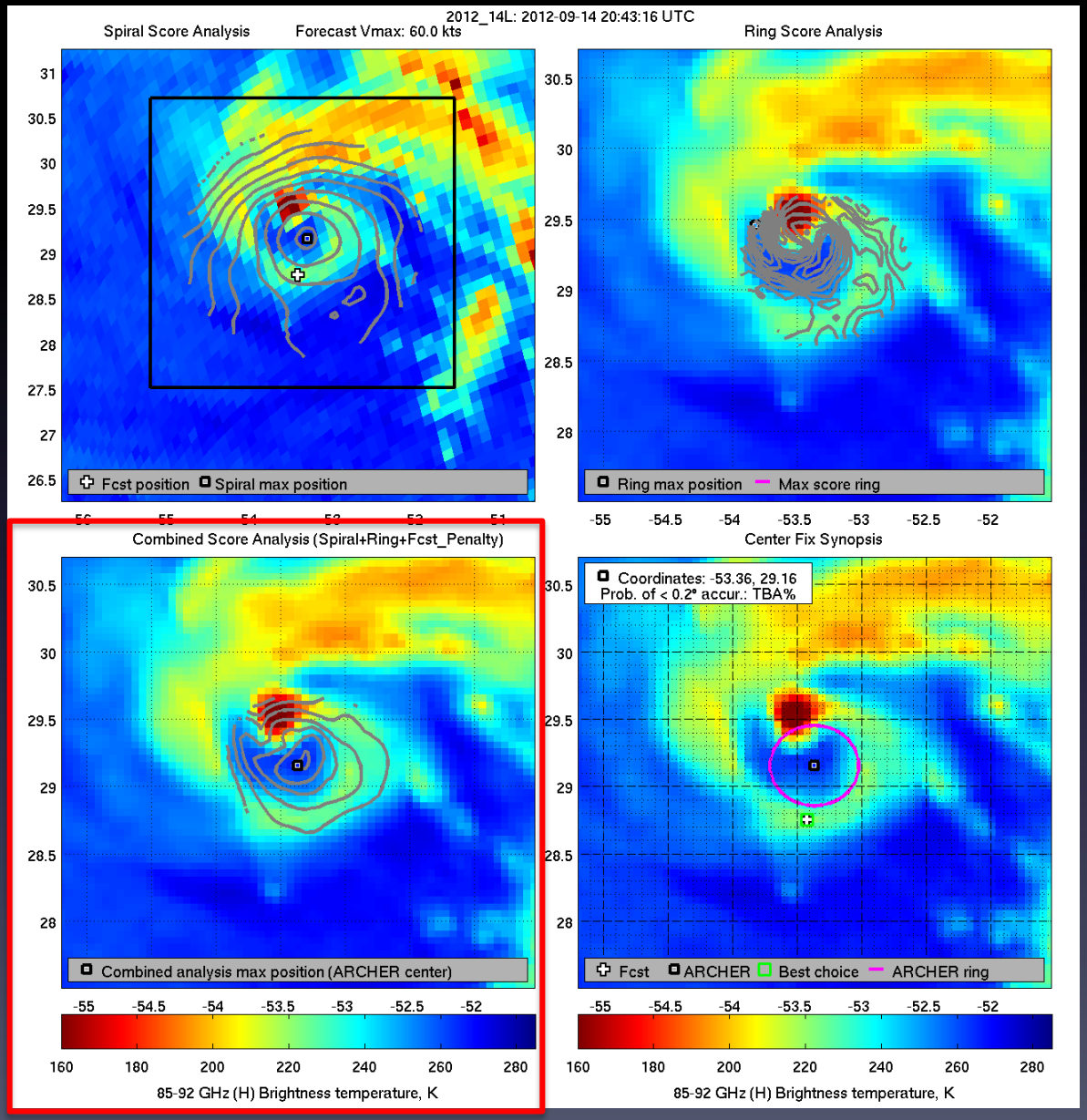
Geo IR	85-92GHz	Date/Time (UTC)	Source	Sensor	Vmax(kts)	ARCHER Lat	Lon	Geo-ref Lat	Lon	50% cert. rad.	95% cert. rad.	Eye diam (deg)	% cert. of eve
		20141011 14:51:46	GMI	85-92GHz	60.0	28.07	-65.19	28.04	-65.18	0.28	0.79	0.50	29.7
		20141011 14:51:46	GMI	37GHz	60.0	27.92	-65.24	27.89	-65.24	0.23	0.66	0.25	***
		20141011 14:45:00	Geo	Vis	60.0	***	***	***	***	***	***	0.15	***
		20141011 14:45:00	Geo	NearIR	60.0	27.71	-66.40	27.71	-66.40	0.90	2.53	0.30	***
		20141011 14:45:00	Geo	IR	60.0	27.84	-66.18	27.84	-66.18	3.36	9.49	0.10	0.9
		20141011 14:39:00 *	**Metop-B**	**ASCAT**	**60.0**	**27.82**	**-65.36**	**27.84**	**-65.36**	**0.12**	**0.33**	***	***
		20141011 13:48:00 *	Metop-A	ASCAT	60.0	27.65	-65.36	27.90	-65.38	0.12	0.34	***	***
		20141011 11:45:00	Geo	Vis	59.6	***	***	***	***	***	***	0.05	***
		20141011 11:45:00	Geo	NearIR	59.6	26.53	-64.34	26.53	-64.34	3.36	9.49	0.50	***
		20141011 11:45:00	Geo	IR	59.6	***	***	***	***	***	***	0.35	***
		20141011 10:54:04	SSMIS-17	85-92GHz	58.2	27.31	-64.92	27.45	-64.98	0.36	1.02	0.75	8.9
		20141011 08:45:00	Geo	NearIR	54.6	25.84	-64.39	25.84	-64.39	0.83	2.36	0.10	***

Real-time product features



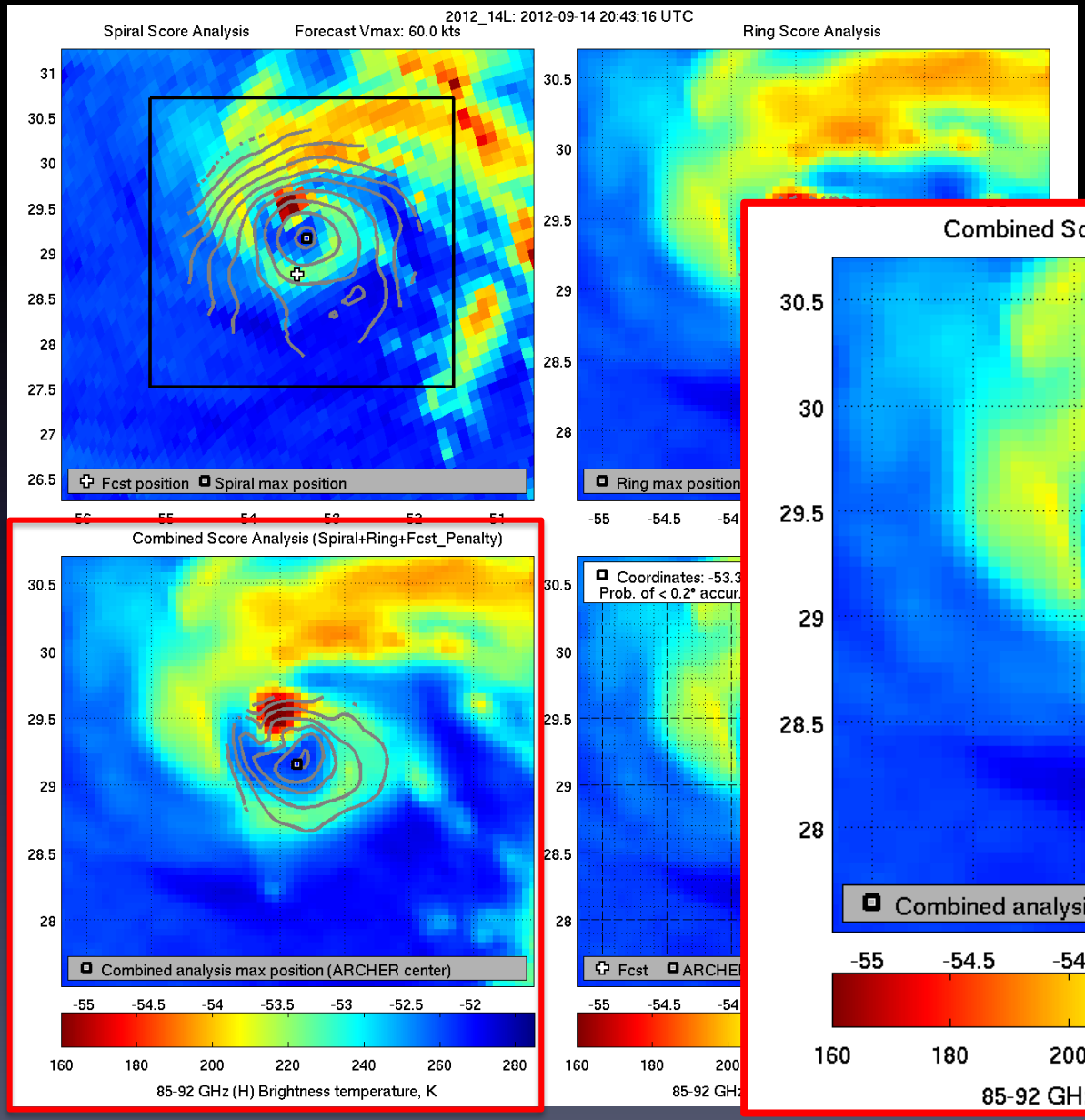
ARCHER image diagnostics

Real-time product features

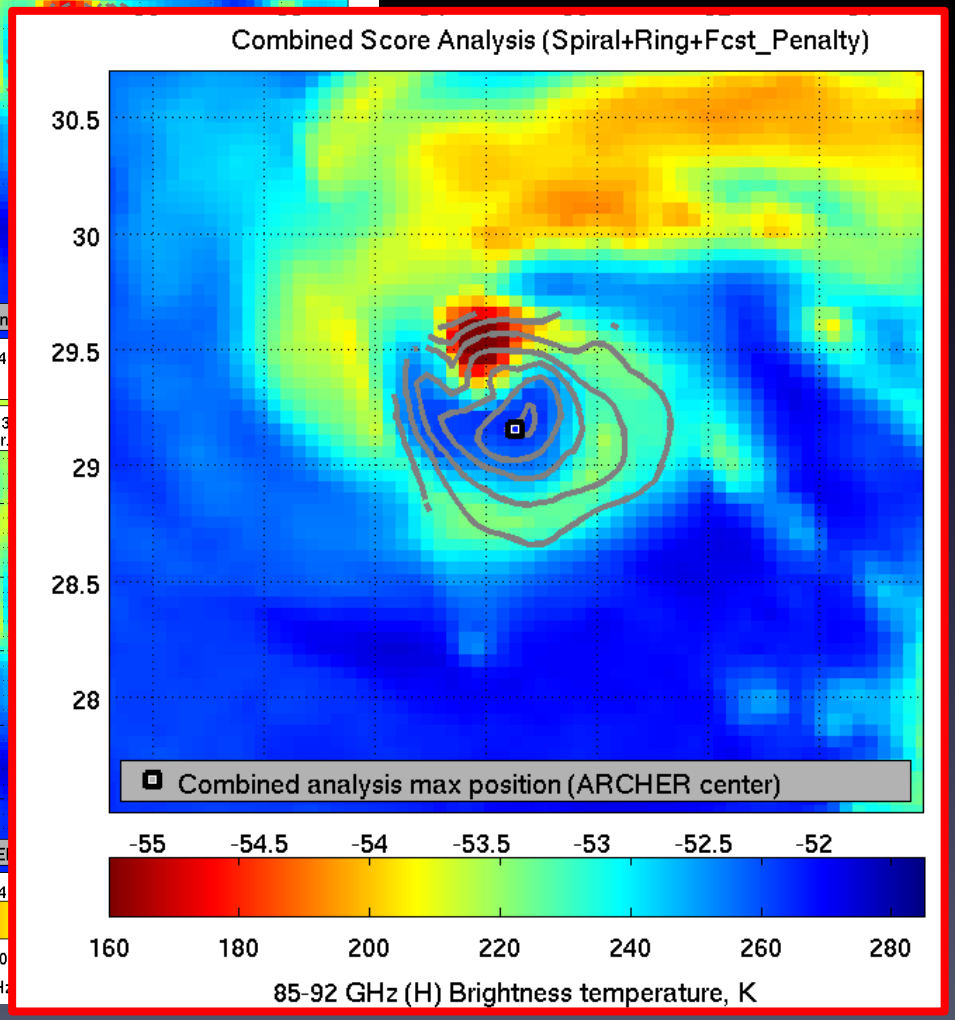


ARCHER image diagnostics

Real-time product features

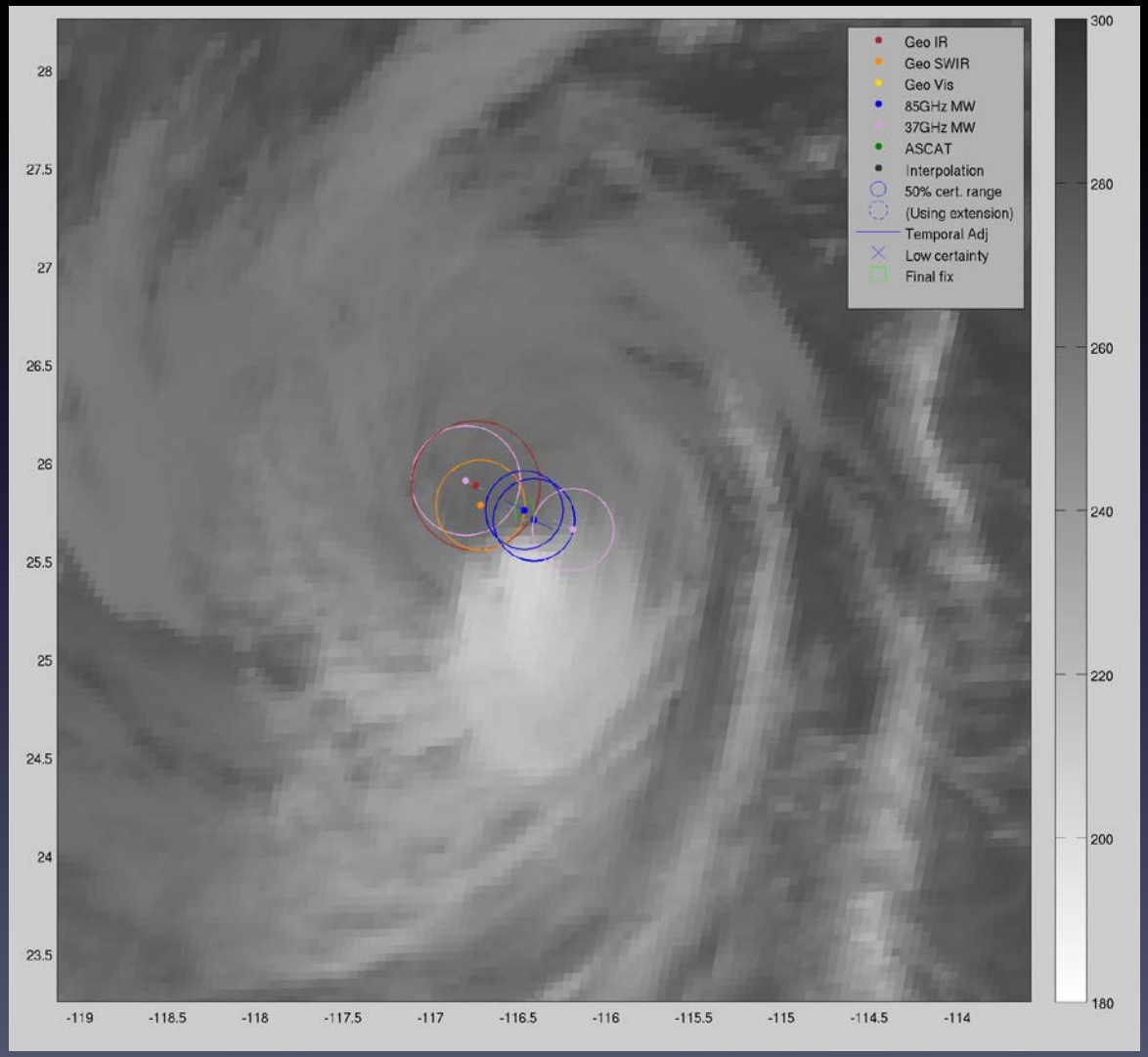


ARCHER image diagnostics



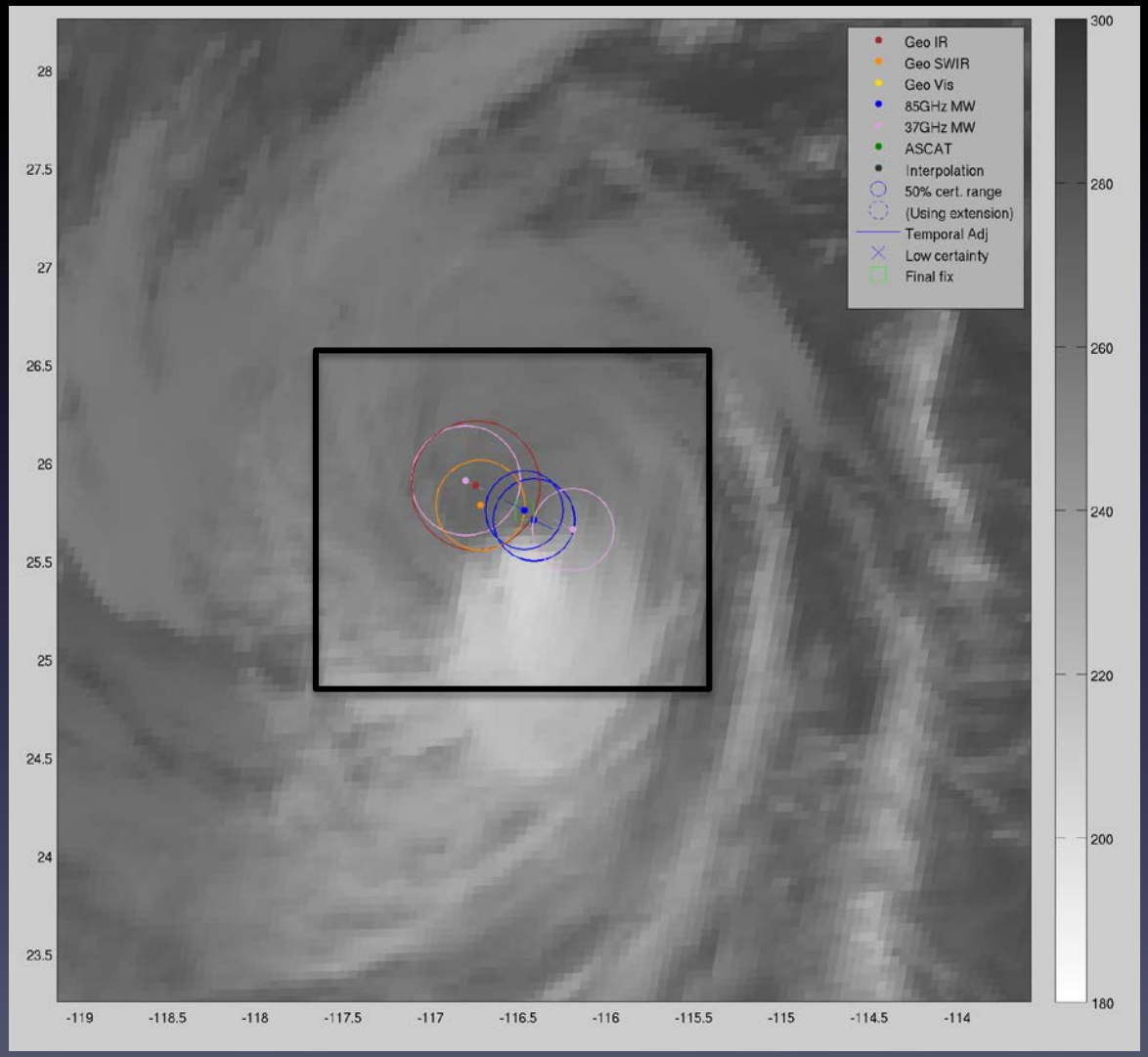
Real-time product features

ARCHER "best-center" selection diagnostic



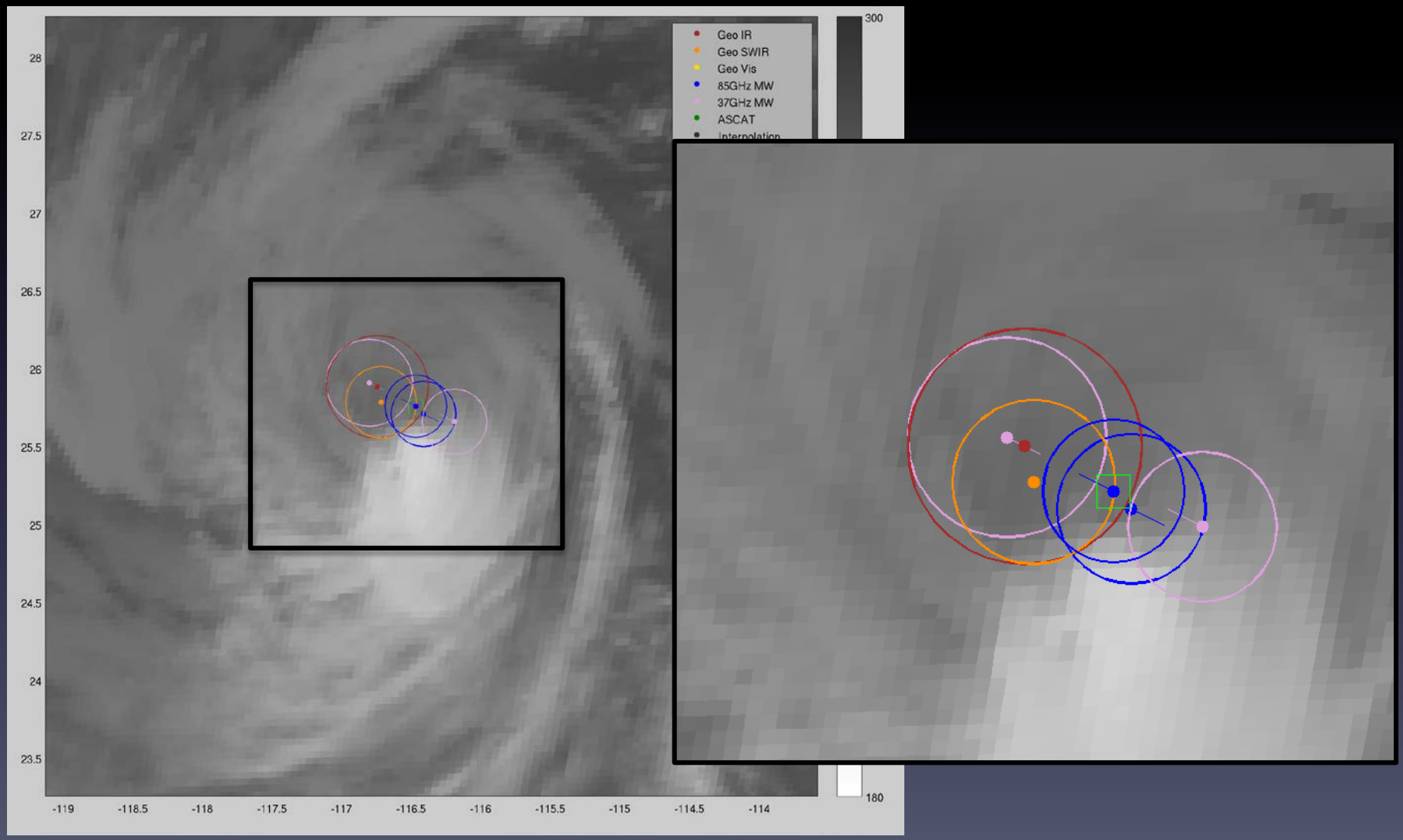
Real-time product features

ARCHER "best-center" selection diagnostic



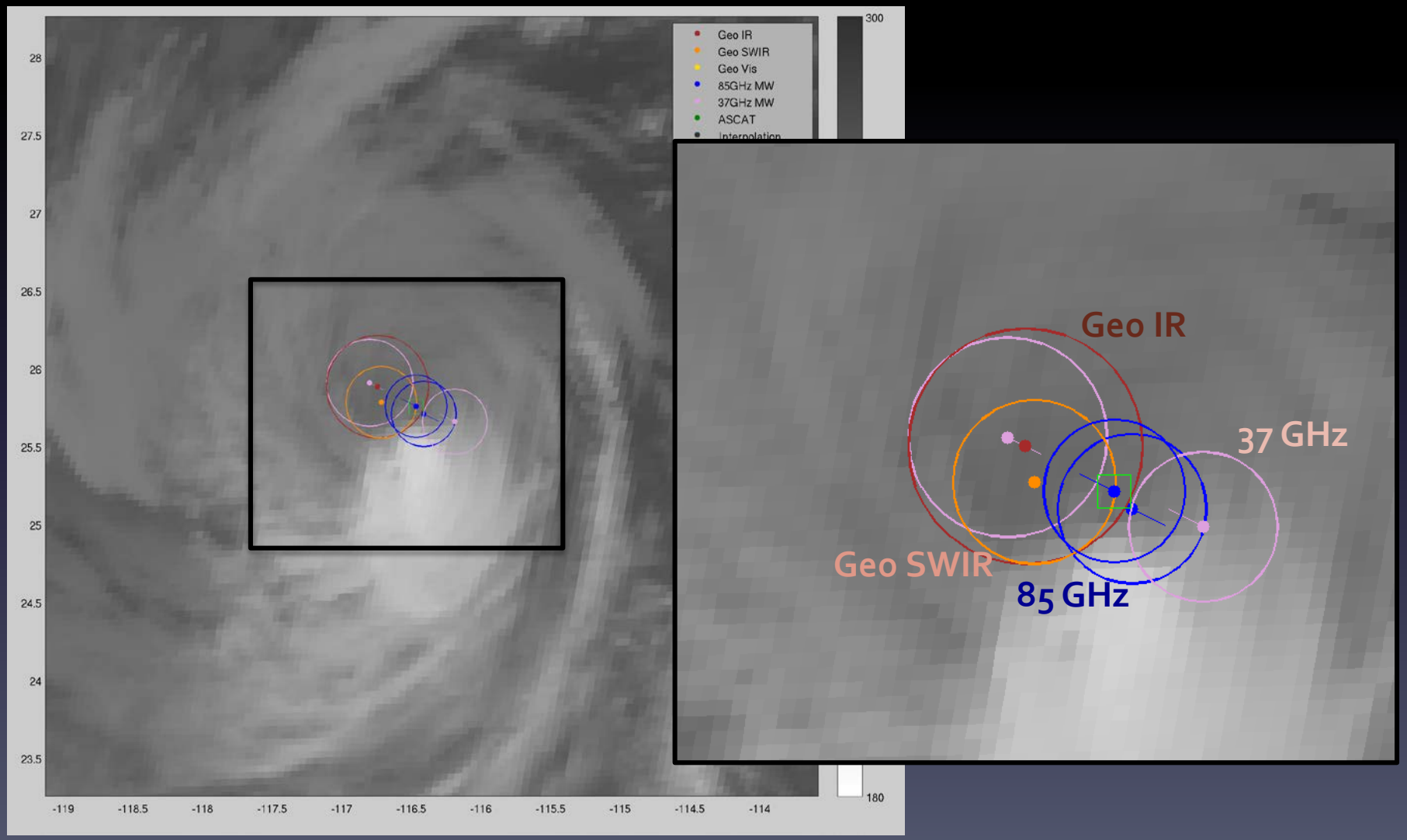
Real-time product features

ARCHER "best-center" selection diagnostic



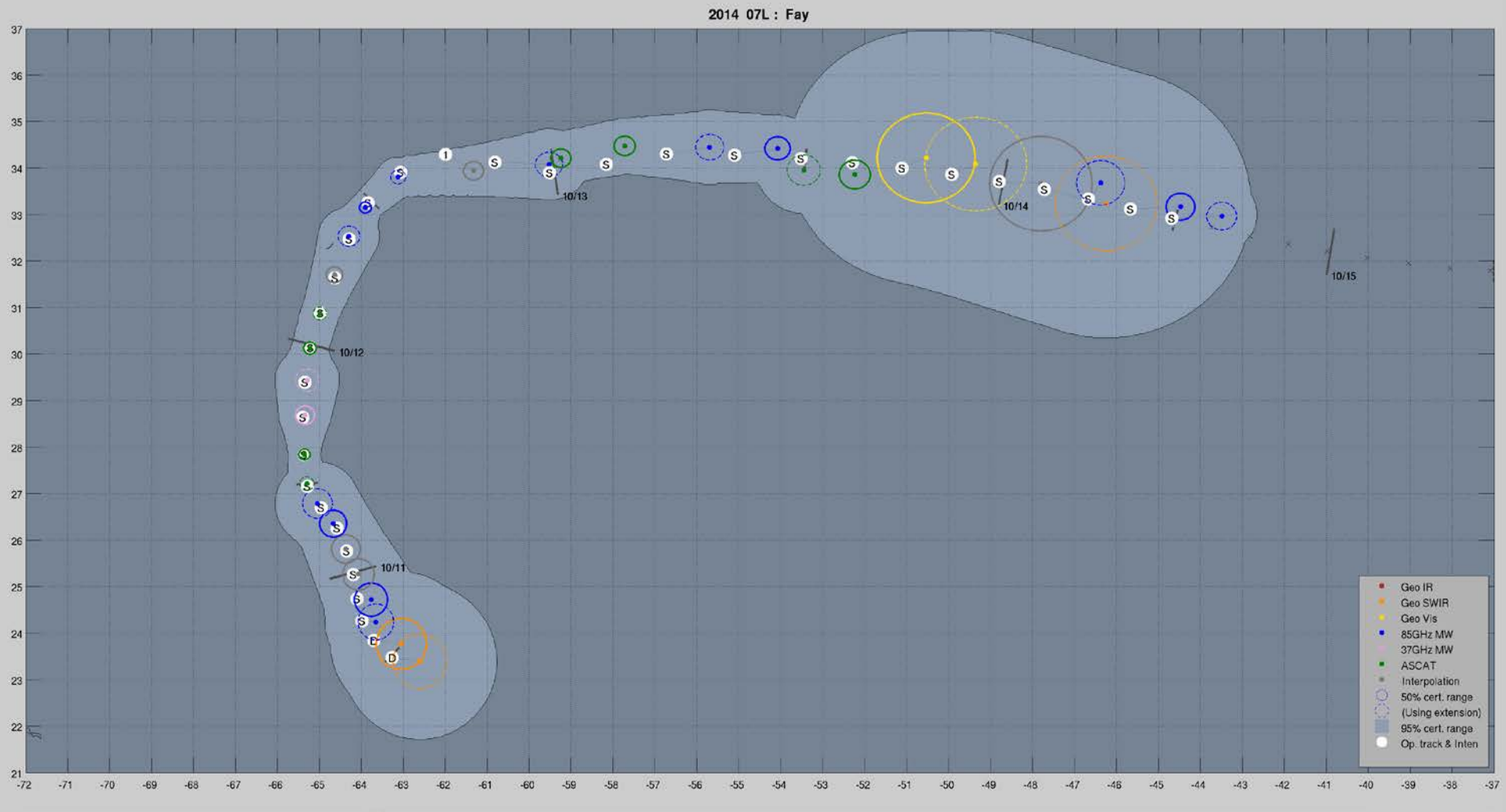
Real-time product features

ARCHER "best-center" selection diagnostic



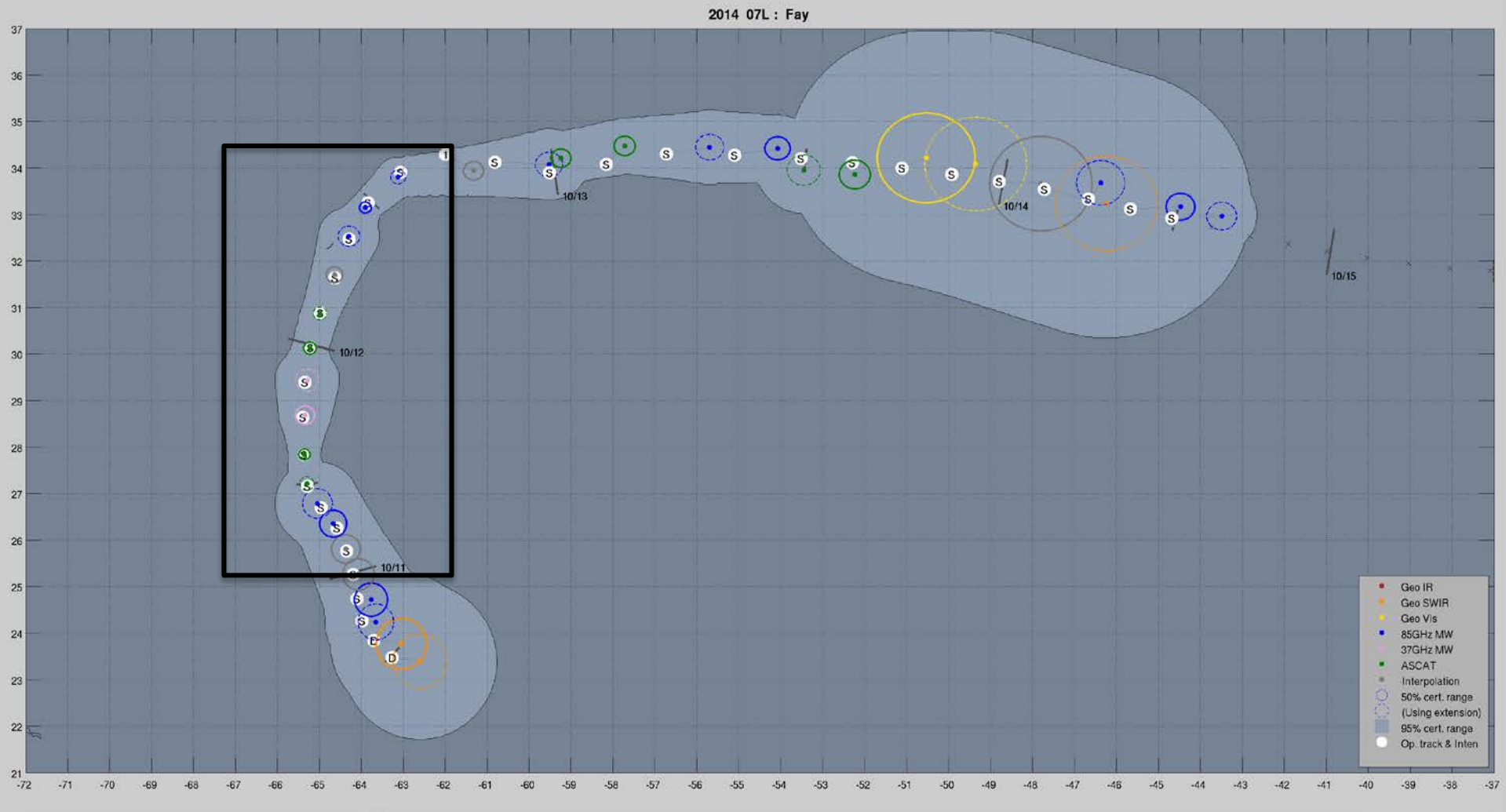
ARCHER: Performance

Fay (2014)

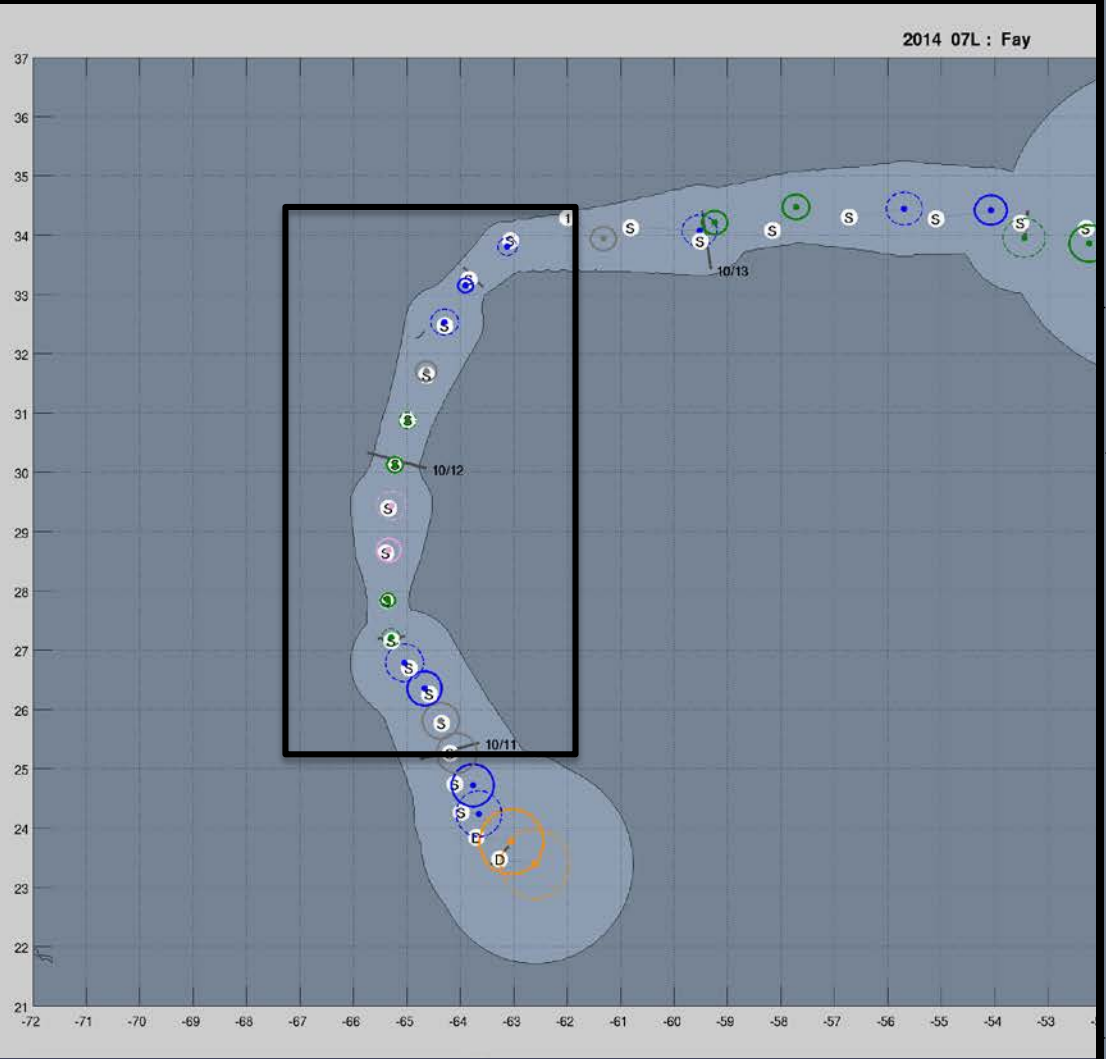


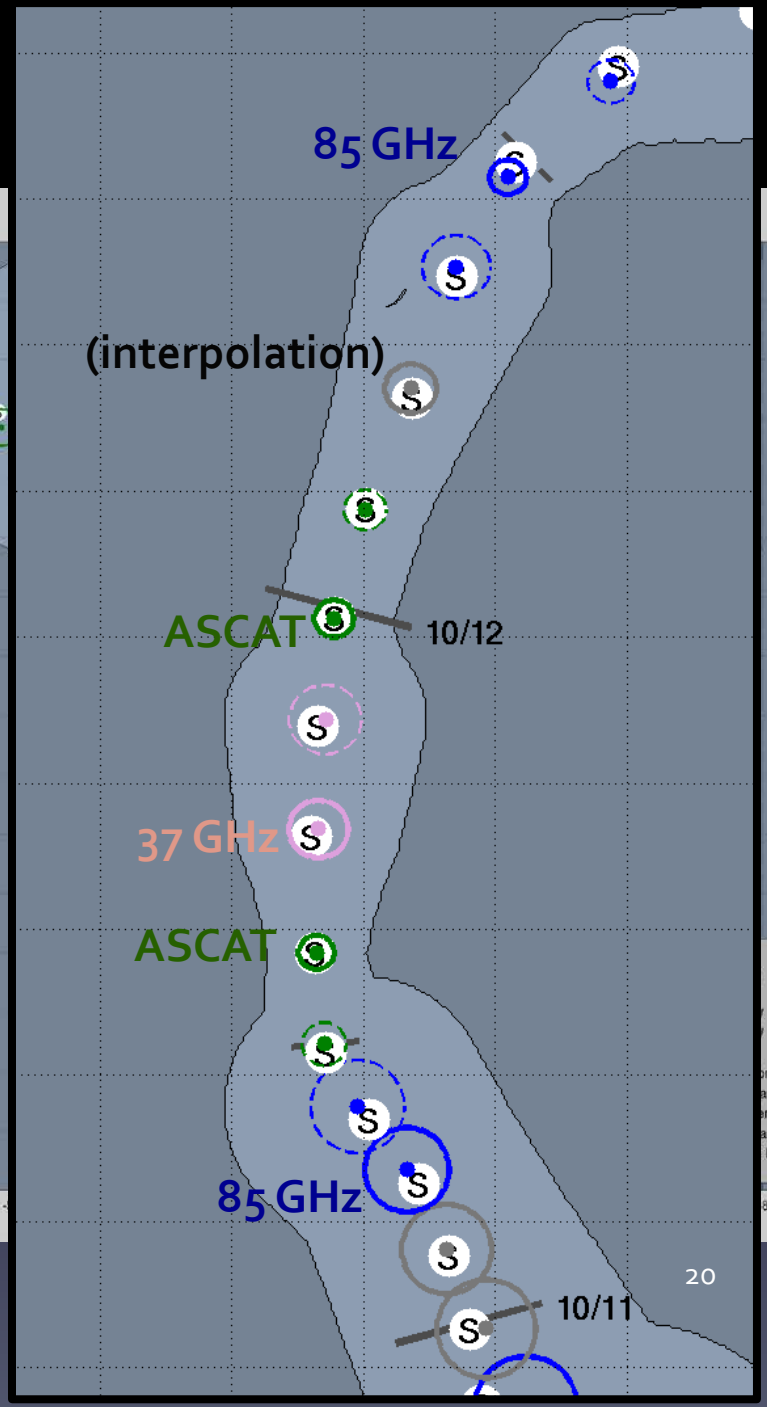
ARCHER: Performance

Fay (2014)



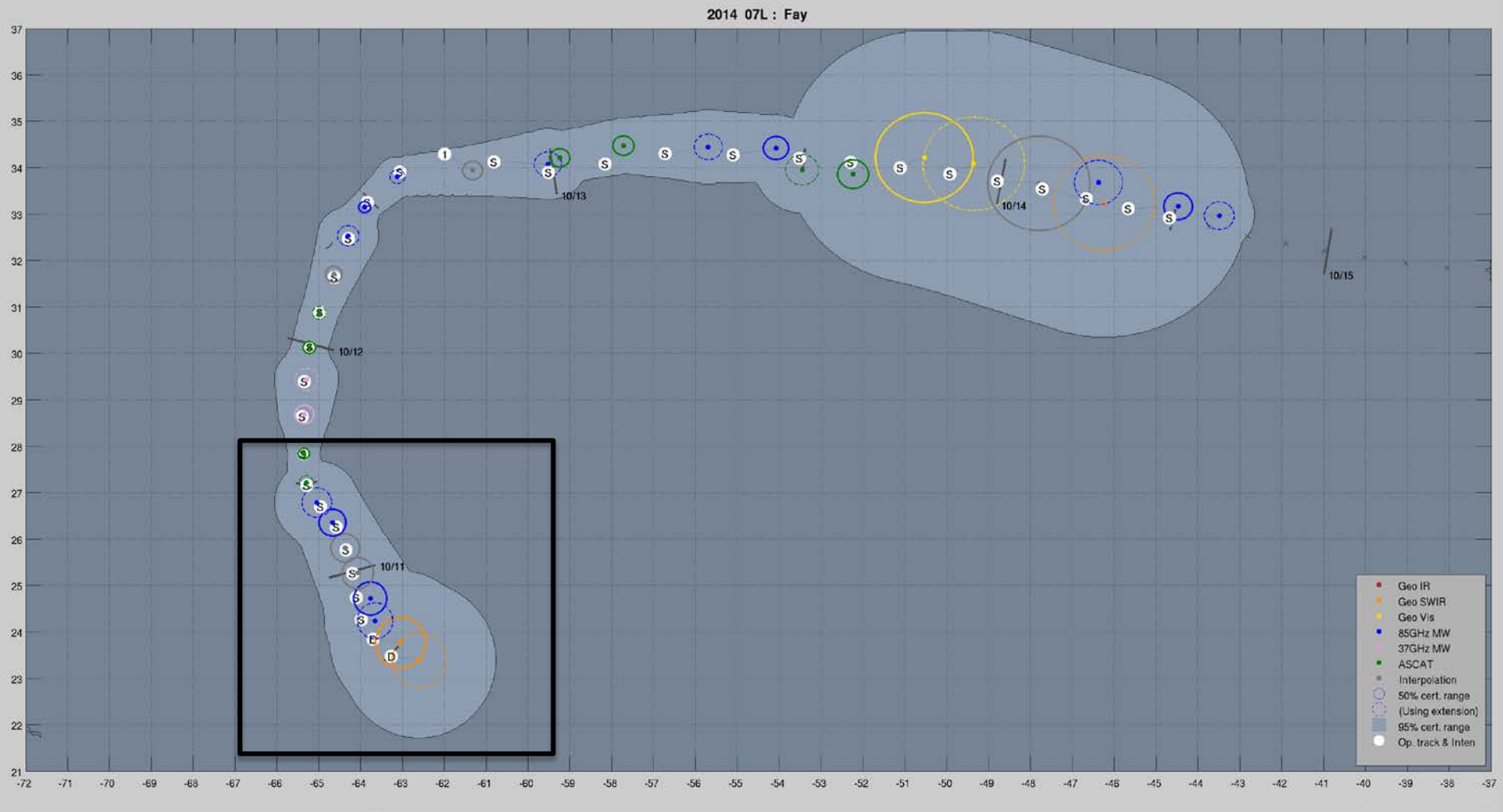
ARCHER: Performance





ARCHER: Performance

Fay (2014)



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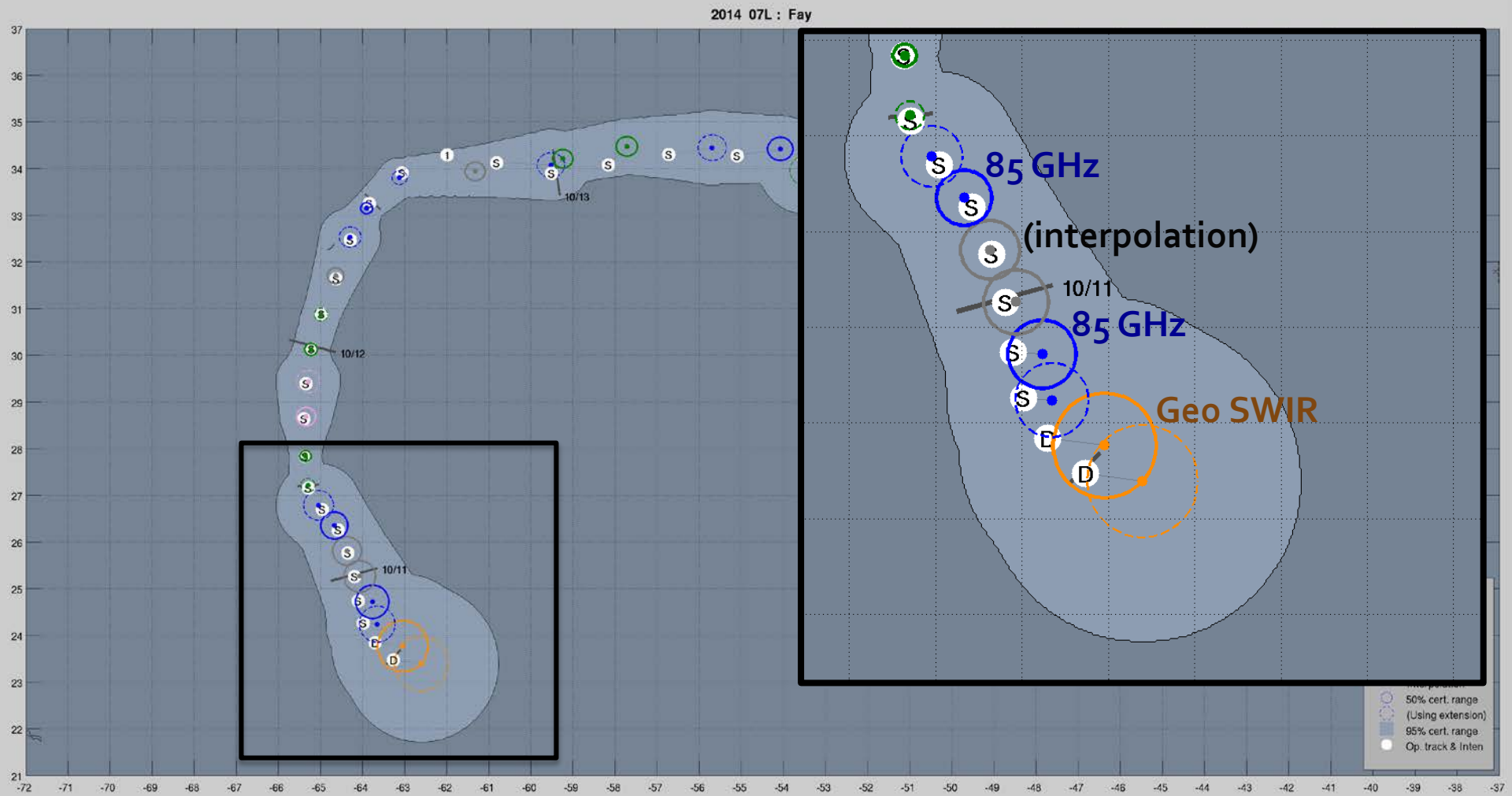
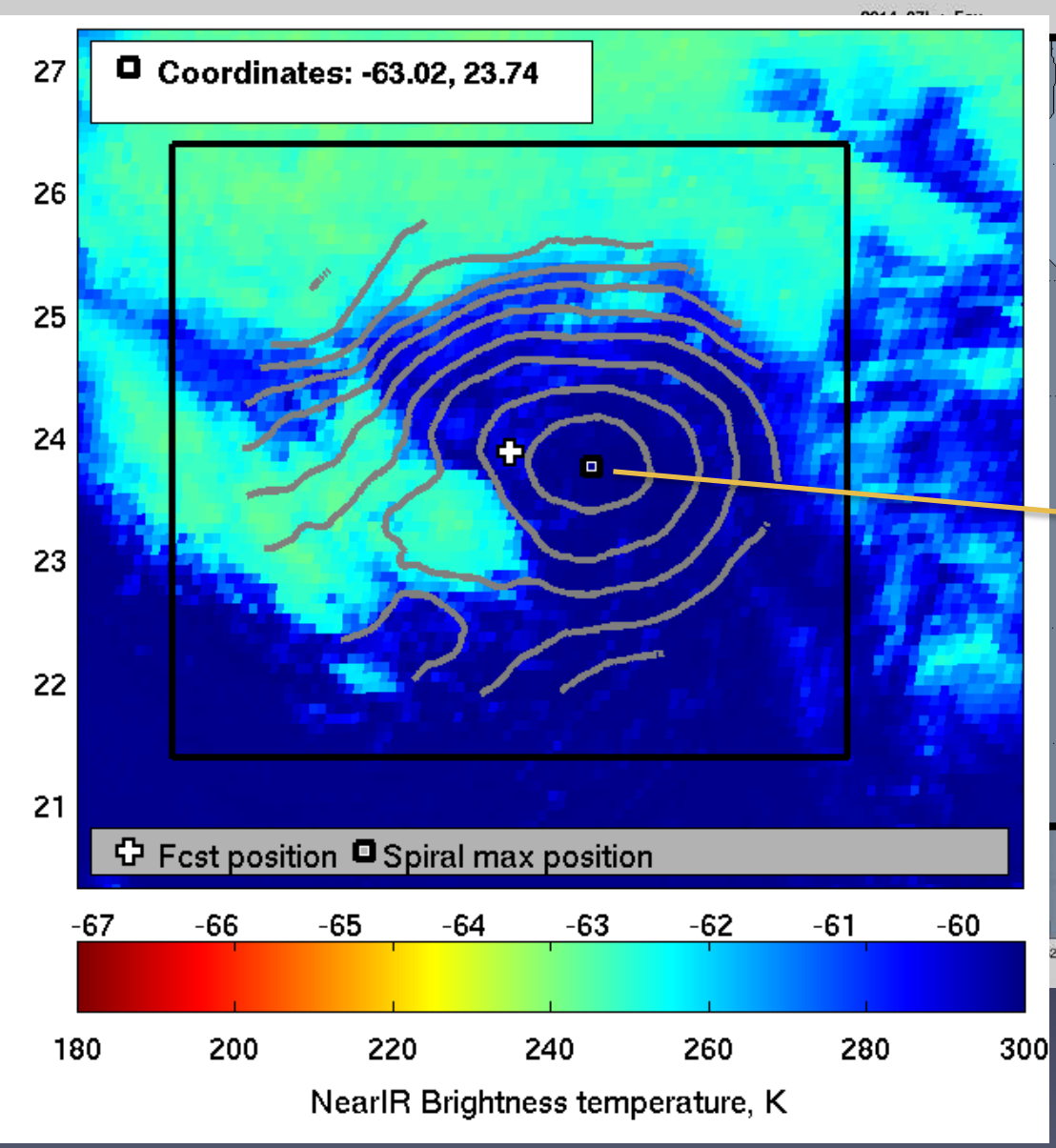
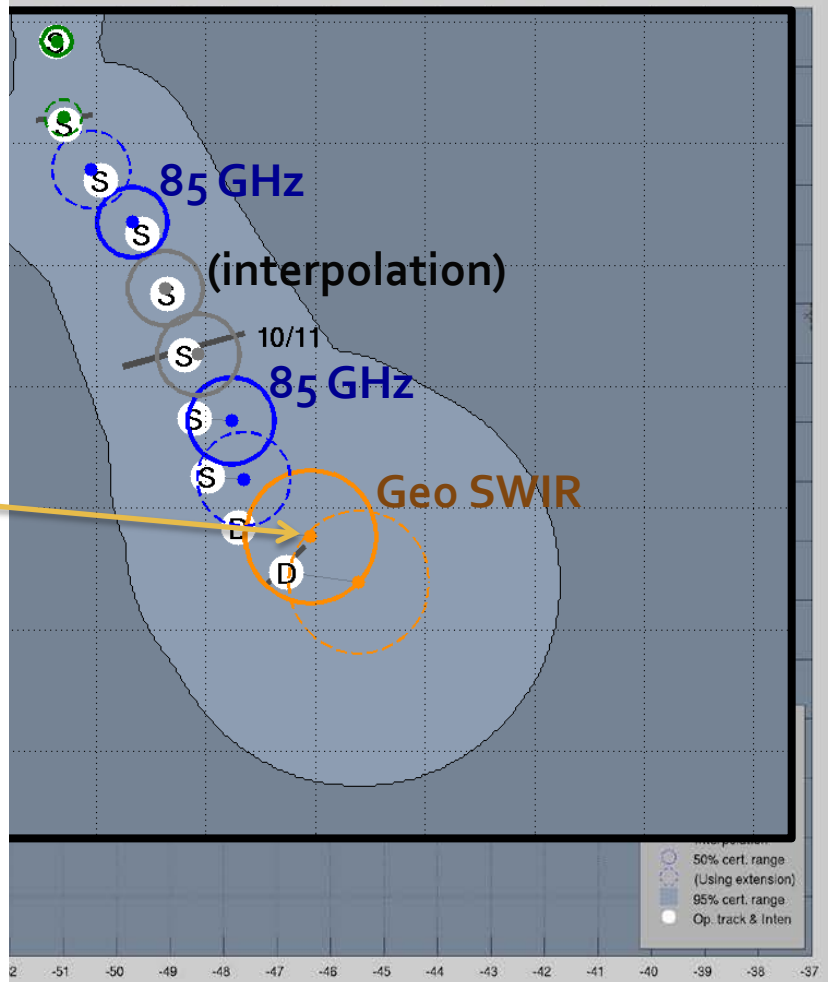


ARCHER: Performance

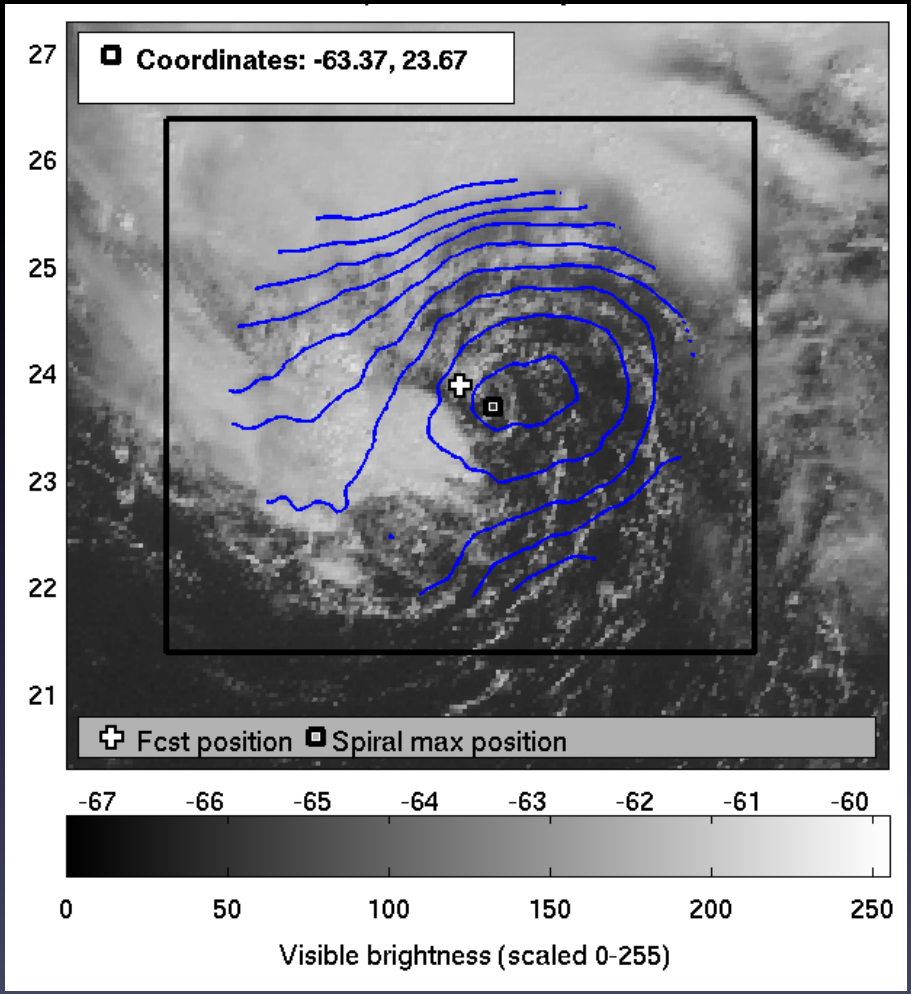
Fay (2014)



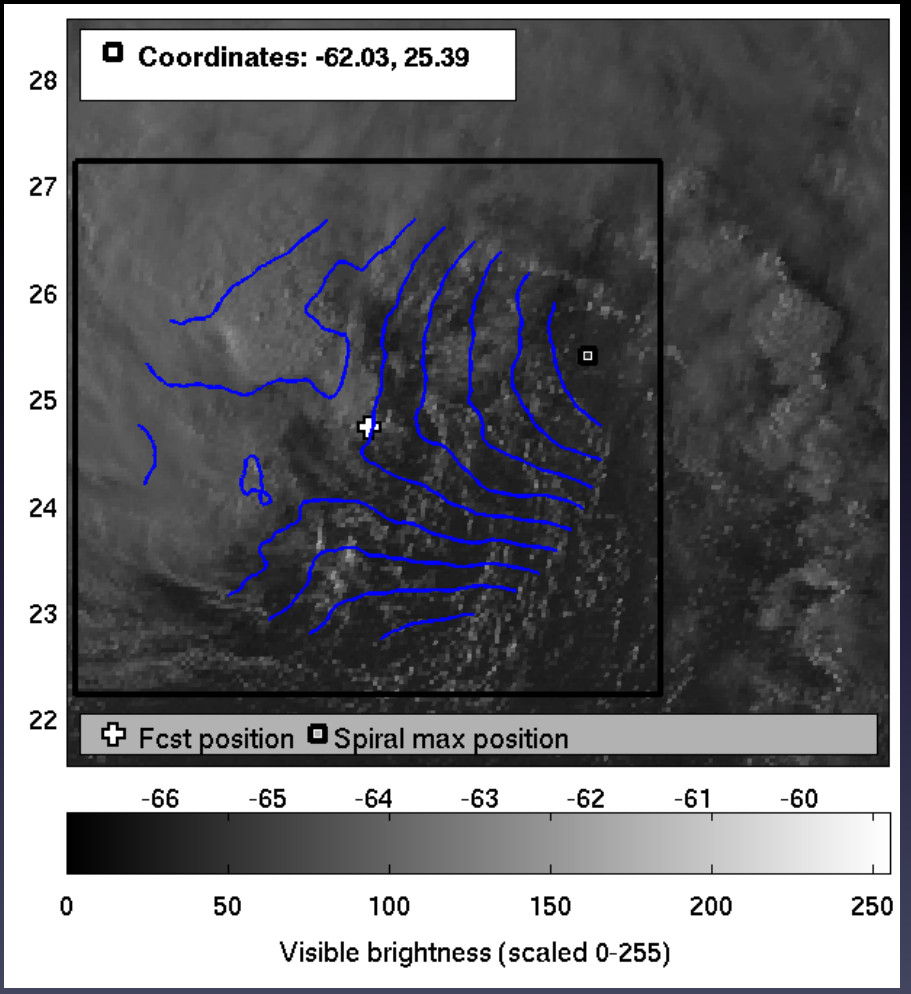


ARCHER: Performance – Visible imagery

GOOD: Fay (2014)



BAD: Bertha (2014)



Validation: Quantitative results

- What is the median ARCHER position error with respect to the best track? (2012 NATL)

	TD - TS	Cat 1	Cat 2-5
Real-time	38 km	29 km	18 km
Near real-time	32 km	24 km	17 km

Validation: Quantitative results

- How often does ARCHER outperform alternative center-fixing methods?

	TD - TS	Cat 1	Cat 2-5
SAB fix	31% / 40%	25% / 42%	21% / 26%
TAFB fix	37% / 43%	25% / 44%	26% / 21%

- We will be submitting these results for publication: ***Wimmers and Velden, "Advancements in objective multi-satellite tropical cyclone center-fixing"***

On the Horizon

- Validation for 2014 season
- Addition of RapidSCAT (definite), VIIRS DNB (if possible)
- Improvement of Visible channel center-fixing
- Improvement in the data ingestor for the first 6 hours of a TC
- Final decision to go operational with ARCHER at NHC/TAFB is expected from JHT management at the end of 2015