

PACE-PAX research report 2024/09/23

**Compiled by Kirk Knobelspiesse, Ivona Cetinić, Brian Cairns, Michael Ondrusek,
2024/09/28, updated 2024/10/24**

Reviewed by Samuel LeBlanc

Coordinated observations with ER-2 and Twin Otter with clouds and aerosols over land, then PACE and EarthCARE underpasses over land. Latter has some clouds. Clouds styme coordination with Gliders and R/V Shearwater in Santa Barbara channel.

ER-2

Take off: 16:47

Landing: 23:00

Duration: 6.2 hrs

Pilot: Tim Williams, mobile: James Nelson

Twin Otter

Take off: 16:46

Landing: 20:49

Duration = 4.1 hrs

Manifest: Bryce Kujat (pilot), Jeff Martin (pilot), Michael Shook (QNC), Ed Winstead (QNC), Adam Ahern (QNC)

[See end for full Twin Otter report](#)

R/V Shearwater

Mission Scientist: Michael Ondrusek

Sailed out: 15:54 UTC

Back in port: 21:20 UTC

[See end for full R/V Shearwater report](#)

PACE

20:25, California/Nevada

EarthCARE

21:53, Utah/Arizona, orbit 1835

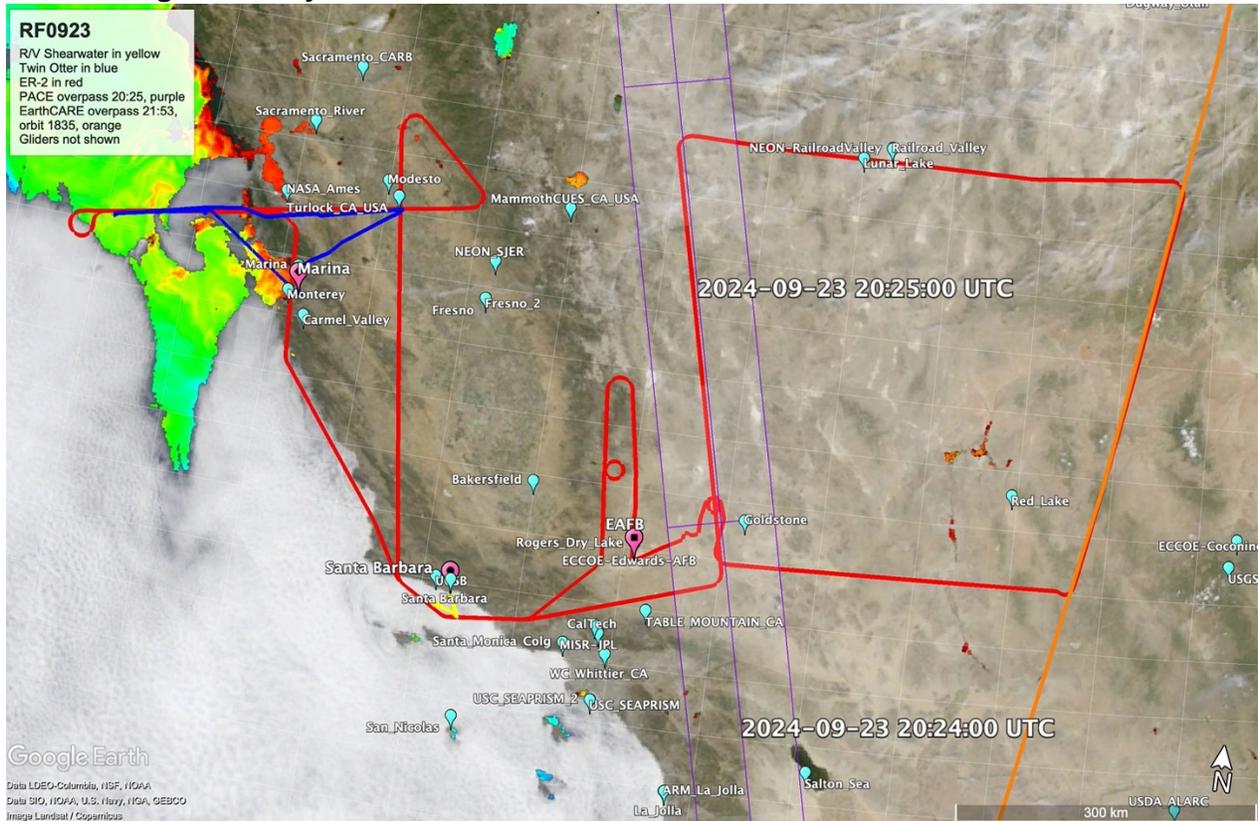
Gliders

Operational

HyperNAV

Operations concluded

Overall image summary



Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied, **red** to be confirmed

Time UTC	Platform	VTM(hrs)	
15:54	RS		Shearwater departs
16:46	TO		Twin Otter takeoff
16:46	RS		Arrives on station #32, departure 18:11. Cloudy for entire stay, ER-2 overpass (scored below)
16:47	ER2		ER-2 takeoff
17:39	ER2	4c(0.5)	ER-2 over Shearwater, but cloudy. Scored as bright/low polarization target
18:07	ER2	1d(0.5)	ER-2 over Monterey (AOD(500)=0.07), Marina Tower, and CEOBS site, cloud free. No Aeronet data at CEOBS,
18:20	ER2, TO	1e(1.5)	ER-2 overpass of Twin Otter spiraling through clouds
18:44	ER2, TO	1e(1.5)	ER-2 overpass of Twin Otter spiraling through clouds
18:51:30	ER2	1d(0.5)	ER-2 over NASA_Ames AERONET site, AOD(500)=0.07
19:00:17	ER2	1d(0.5)	ER-2 over Turlock AERONET site, AOD(500)=0.11
19:10	RS		Shearwater on station #33, departure 20:30
19:22	TO		Begin Twin Otter spiral down over Turlock.
19:23	ER2, TO	1d(1.5). 6d(1.5)	ER-2 over Turlock AERONET site, AOD(500)=0.11 plus spiraling Twin Otter
19:52	ER2, Glider	4c(0.5)	ER-2 over glider, but cloudy. Scored as bright/low polarization target
19:56	ER2, RS	4c(0.5)	ER-2 over Shearwater, but cloudy. Scored as bright/low polarization target

20:18	ER2	1d(1.0), 3b(1.0), 6d(0.5)	Begin PACE-OHS line, continues until 20:48. PACE overpass at 20:25. Cirrus over northern edge.
20:25	PACE		PACE Overpass
20:49	TO		Twin Otter lands
21:03:08	ER2	6d(0.5), 4a(0.5*0.5)	ER2 over Railroad Valley Aeronet, partial cirrus. No aeronet data, after 20.5UTC, AOD(500)=0.035.
21:20	RS		Shearwater returns
21:34	ER2	3d(1.0), 3e(1.0), 6d(1.0), 6f(1.0)	ER2 on EarthCARE line until 22:05. Some parts clear, some with thin cirrus, others with mid-level clouds
21:53	EarthCARE		EarthCARE overpass, orbit 1853
23:00	ER2		ER-2 lands

PACE-O: within swath of PACE's OCI instrument

PACE-OH: within swath of PACE's OCI and HARP2 instruments

PACE-OHS: within swath of PACE's OCI, SPExone and HARP2 instruments

TO: Twin Otter

RB: R/V Blissfully

RS: R/V Shearwater

Assessment:

- 4.1% of objectives observed. Successful coordination between ER-2 and TO, underpasses of PACE and EarthCARE. First ever measurements of aerosol under cloud. Attempts at observations over ship and glider stymied by clouds.
- Top remaining objective (score above 6.0): PACE aerosol in narrow swath over ocean (3a)

PACE-PAX progress tracking															
Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 9/23	Fractional success 9/24	Fractional success 9/25	Fractional success 9/26	Fractional success 9/27	Fractional success 9/29	Fractional success 9/30	Total success	Remaining score	
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.971	0.2	
	b	Ocean radiometric parameters	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.995	0.0	
	c	Aerosol parameters over the ocean	12	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.980	0.2	
	d	Aerosol parameters over land	12	8.0	6.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.000	0.0	
	e	Cloud parameters	12	8.0	3.0	5.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.873	1.5	
	f	Ocean surface parameters	1	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0	
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.354	6.5	
	b	Aerosol parameters over land (PACE)	10	8.0	2.0	13.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.535	4.7	
	c	Cloud parameters (PACE)	5	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.713	1.4	
	d	Aerosol parameters (EarthCARE)	8	4.0	1.0	3.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.855	1.1	
	e	Cloud parameters (EarthCARE)	8	4.0	1.0	15.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.465	4.3	
	a	Validate large reflectances	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.953	0.3	
4. Validate radiometric and polarimetric properties	b	Validate large reflectances with high polarization	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.632	2.2	
	c	Validate large reflectances with low polarization	6	2.0	1.5	3.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.970	0.2	
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.268	4.4	
	a	High aerosol loads over land	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.000	0.0	
	b	High aerosol loads over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.393	2.4	
	c	Multiple aerosol layers	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.000	0.0	
6. Focus on specific processes or phenomena	d	Aerosol under thin cirrus	2	2.0	3.5	82.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.826	0.3	
	e	Aerosol above liquid phase cloud	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.826	0.7	
	f	Broken clouds with complex structure	4	2.0	1.0	18.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.713	1.1	
	g	Dust aerosols over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.430	2.3	
	h	Aerosol and ocean parameters over turbid waters	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.790	0.4	
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.518	0.3	
	k	Smoke aerosols over ocean	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.713	0.3	
	total:			150	98	19.0	4.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	76.0%	
	total														
	ER-2 flight hours						2.8	0	0	0	0	0	0	0	2.8
TO flight hours						2.5	0	0	0	0	0	0	0	2.5	
Shearwater days						0	0	0	0	0	0	0	0	0	
PACE-PAX overall objectives satisfied:						80.1%									

Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

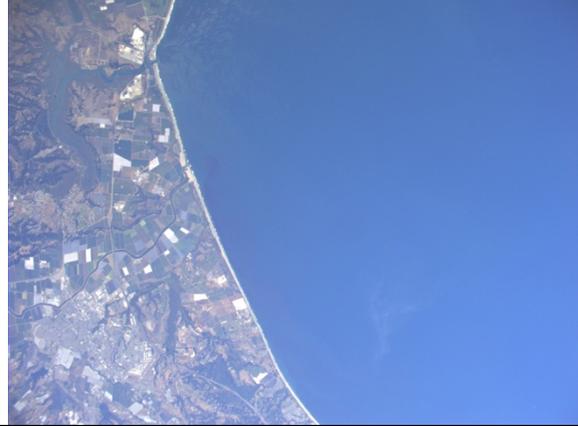
<https://www-air.larc.nasa.gov/missions/pacepax/index.html>

MVIS imagery

17:39 over R/V Shearwater



18:10 over CEOBS site



18:18 Over cloud spiraling Twin Otter



18:44 Over cloud spiraling Twin Otter



18:51:30 over NASA_Ames AERONET



19:00:17 over Turlock AERONET



19:23 over Turlock AERONET and Twin Otter. Very diffuse cirrus according to HSRL



19:52 ER-2 over gliders (too cloudy)



20:20 ER-2 during PACE overpass

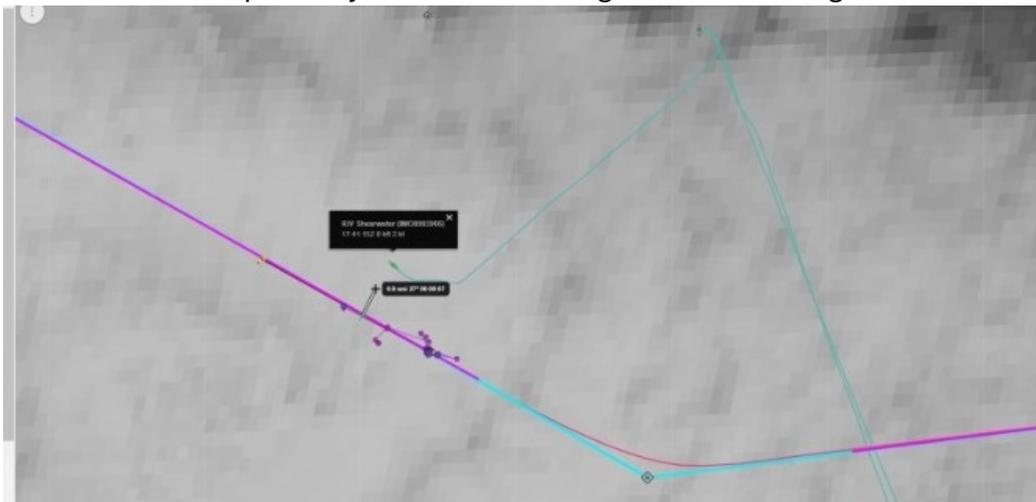


21:41 ER-2 on EarthCARE line

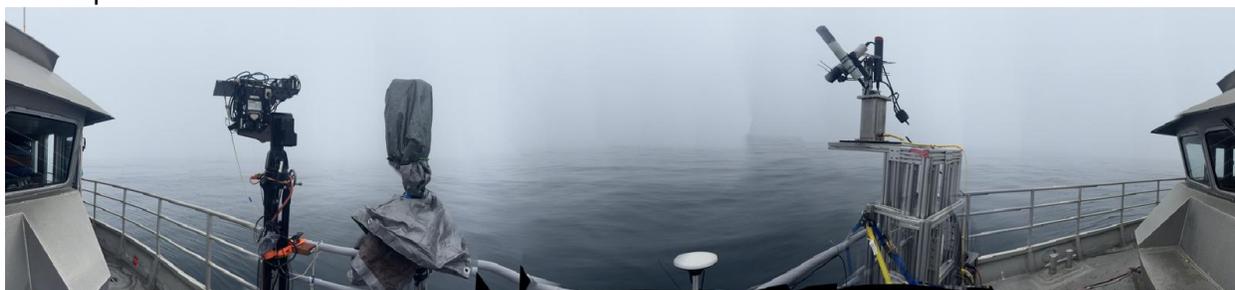


R/V Shearwater photos

Station #32 $34^{\circ} 17.646'$, $-119^{\circ} 51.478'$, arrival 16:46 UTC → departure 18:11 UTC
This station was in proximity of the UDelaware glider. ER-2 overflight at 17:38.



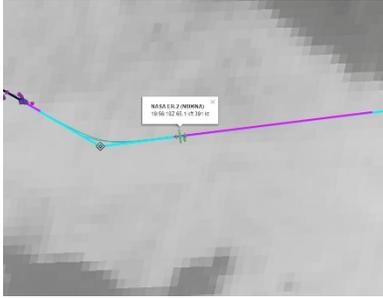
Arrival photo:



Departure photo (departure location - $34^{\circ} 18.455'$, $-119^{\circ} 52.238'$)



Station #33 $34^{\circ} 12.840'$, $-119^{\circ} 34.943'$, arrival 19:10 UTC → departure 20:30 UTC
ER-2 overflight at 19:56



Arrival photo:



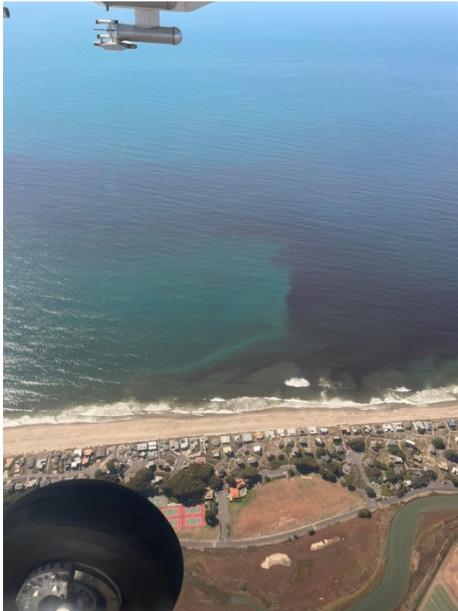
Departure photo: (34° 13.074', -119° 35.744')



Twin Otter photos



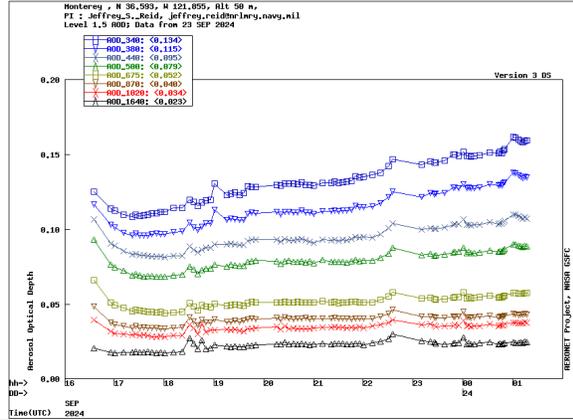
Very thin clouds near the ADIZ line at 17:21 UTC; photo by Michael Shook



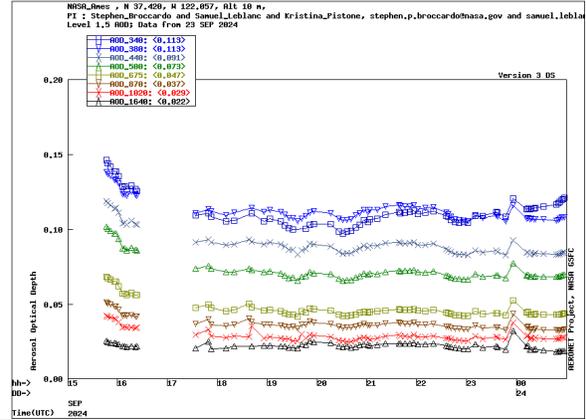
Potential harmful algae bloom near the CEOBS spiral; photo by Eddie Winstead

AERONET plots

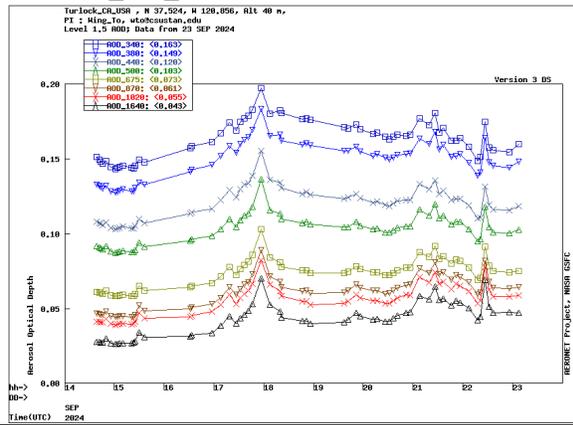
Monterey



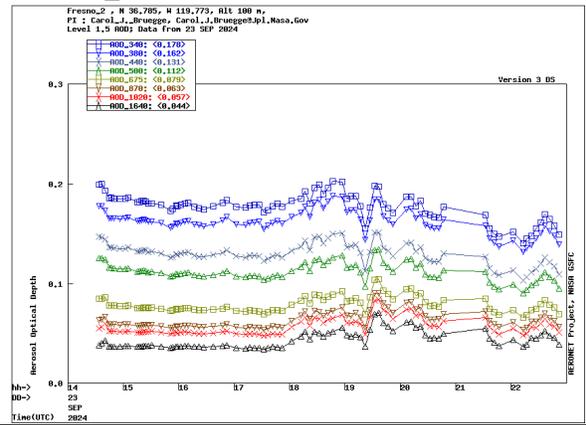
NASA_Ames



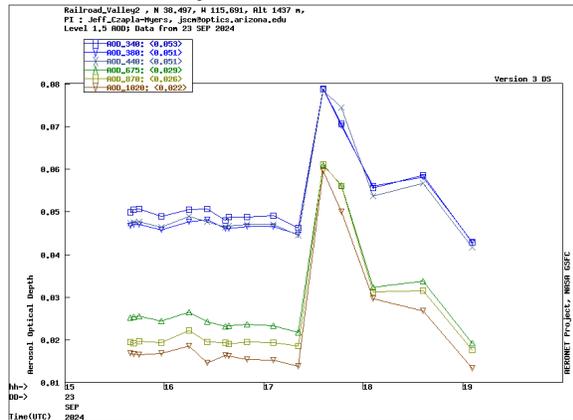
Turlock_CA_USA



Fresno_2



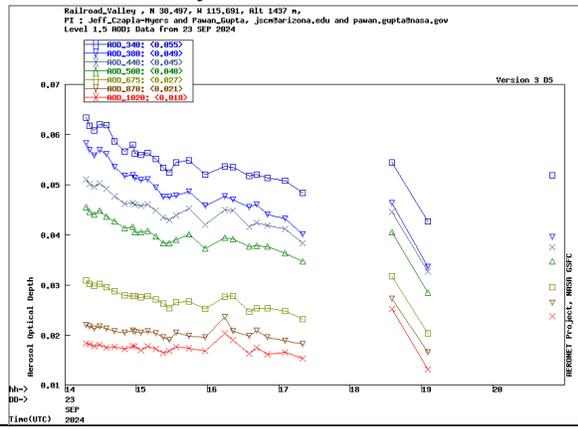
Railroad Valley 2



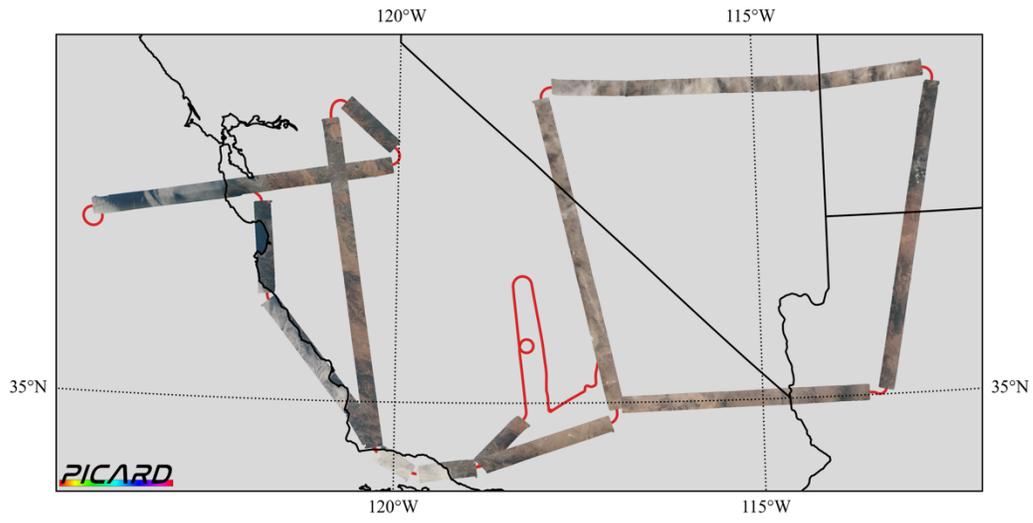
NRL_CEOBS_MBYCAUSA

Missing data?

Railroad Valley



PICARD quicklooks

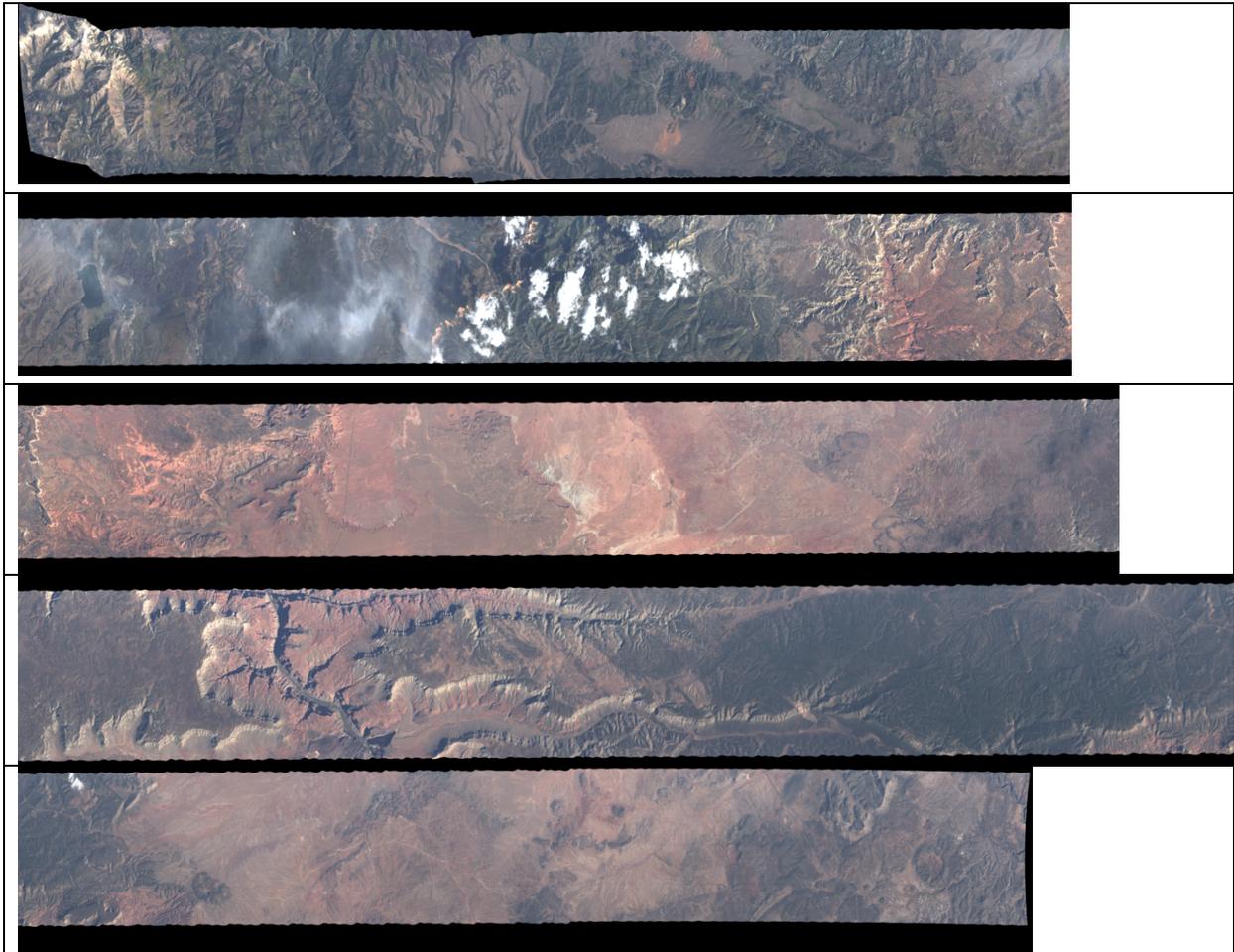


22:05:17 -> 22:29:36

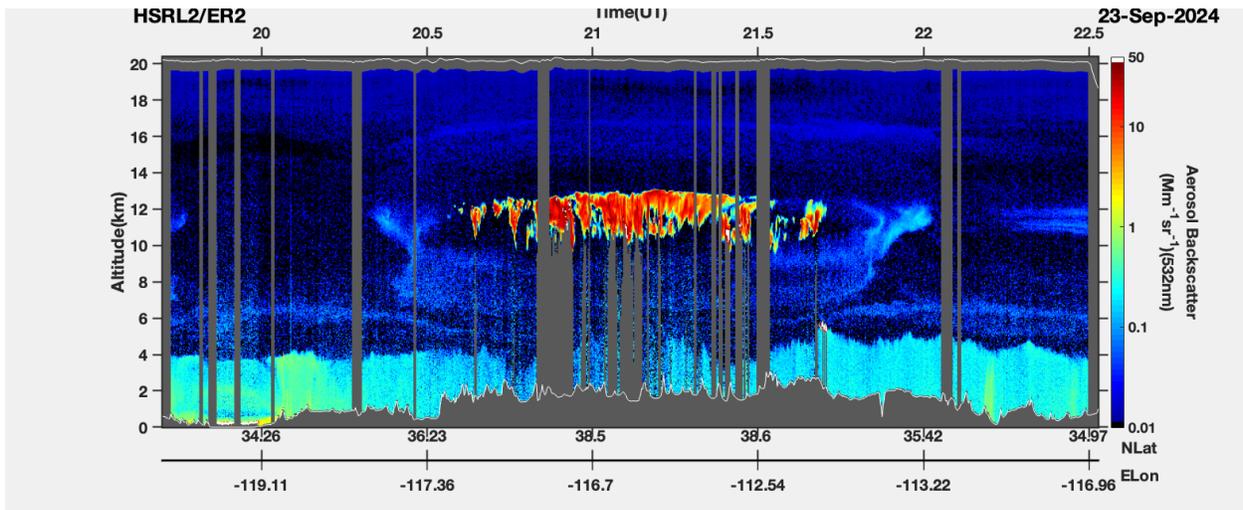
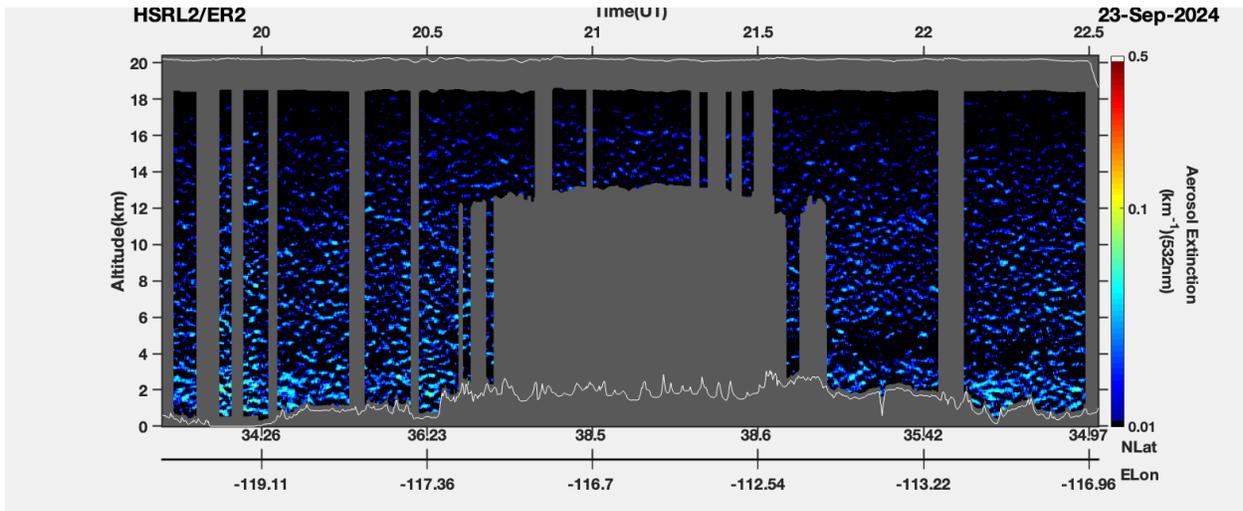


PRISM quicklooks

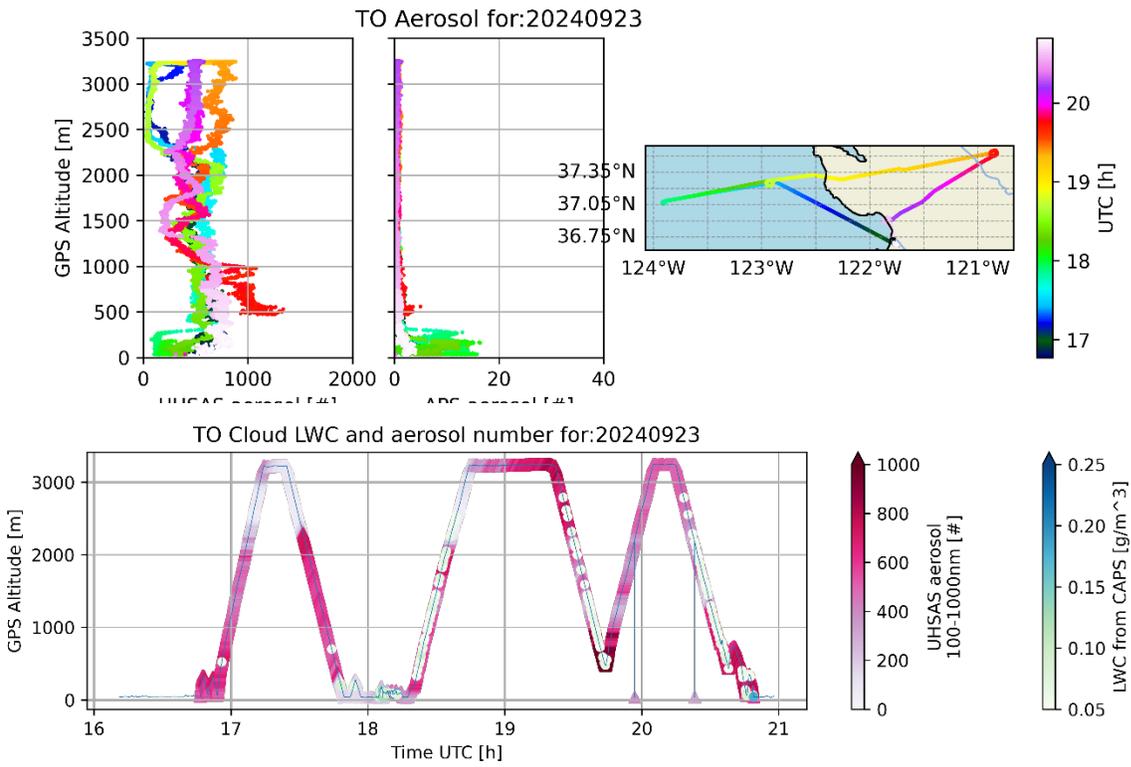
EarthCARE track, starting from north to south



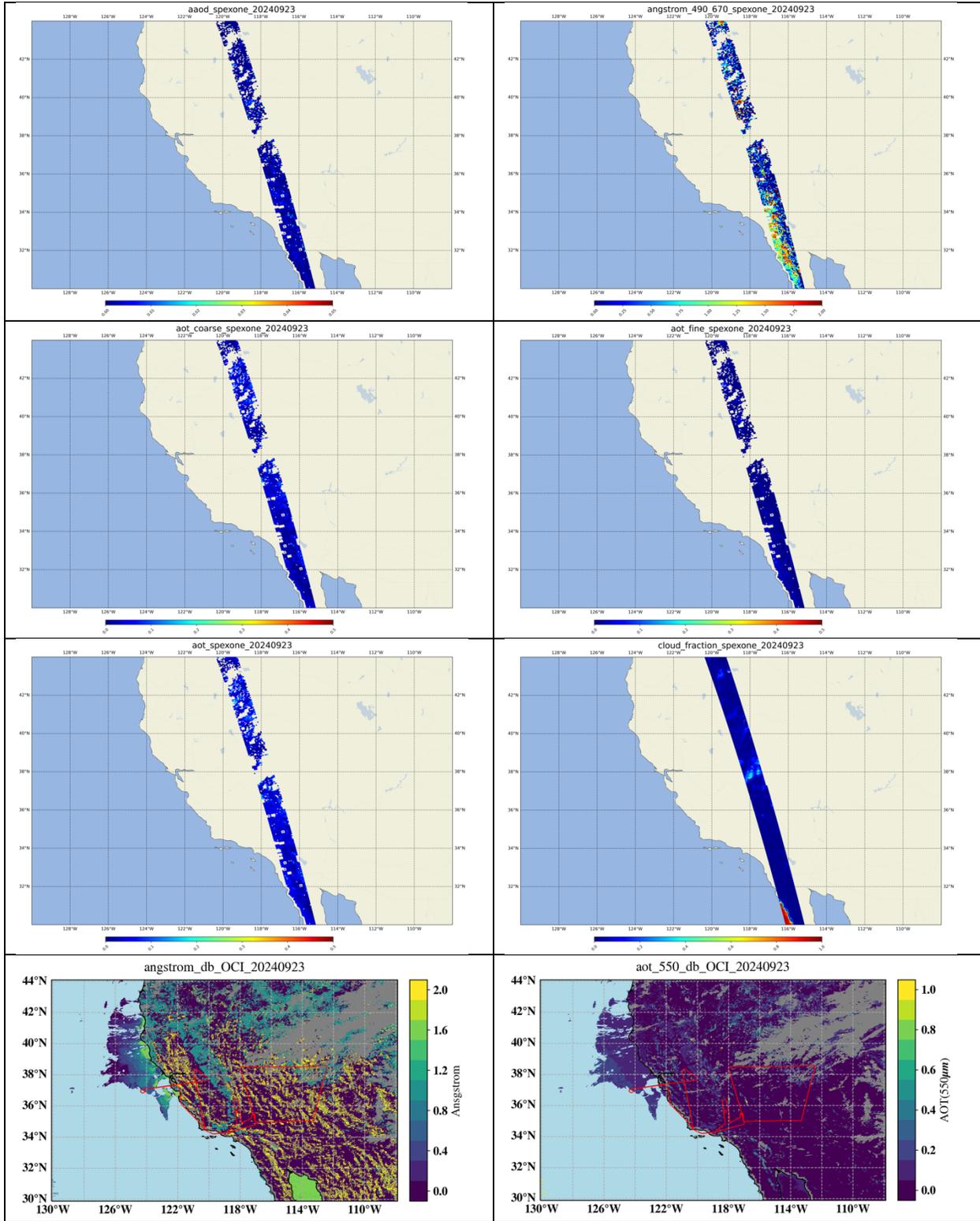
HSRL-2 Quicklooks

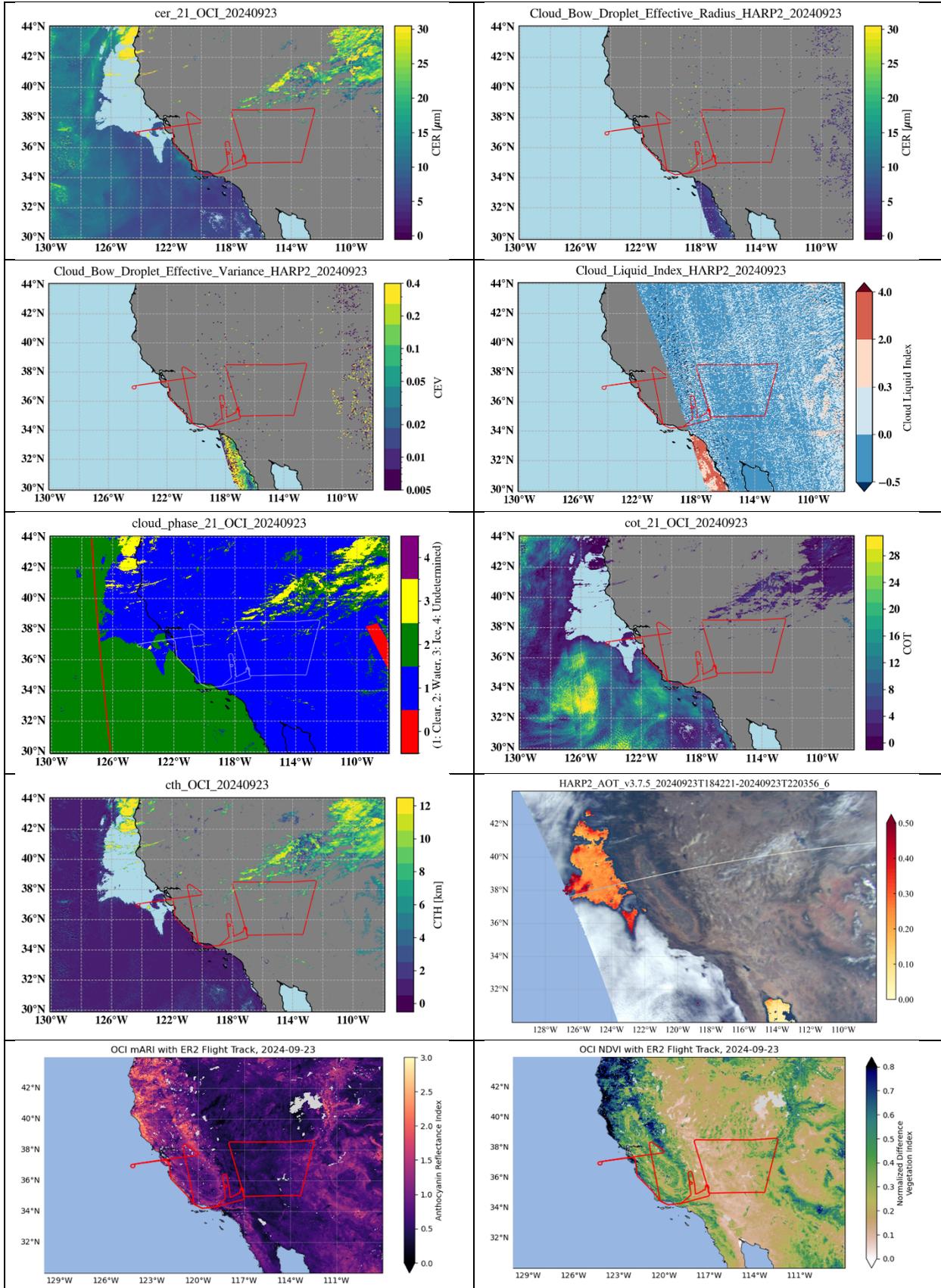


TO Quicklooks



PACE quicklooks





Twin Otter flight report

PACE-PAX Research Flight report 2024-09-23

Twin Otter Flight

Manifest:

Bryce Kujat (pilot)

Jeff Martin (pilot)

Michael Shook (QNC)

Adam Ahern (QNC)

Edward Winstead (QNC)

Note: This flight had coordination with the ER-2.

Take off: 09:46:35 (16:46:35 UTC) Marina Airport (OAR)

Landing: 13:49:05 (20:49:05 UTC) Marina Airport (OAR)

Duration = 4.1 hrs

Objectives: Low clouds and aerosol under cirrus. Planned cloud work includes porpoising west of the ADIZ line and a spiral up to 10kft near PIRAT underneath an ER-2 overpass at approximately 11:15 local (18:15 UTC). Then transit east to Turlock and spiral down underneath another ER-2 overpass at approximately 12:18 local (19:18 UTC). After that, ascend in-line to the CEOBS site and spiral down from 10kft to minimum altitude, with a PACE overpass at 13:25 local (20:25 UTC). If possible, perform low approaches at Marina prior to landing.

Summary: After taking off, we performed two low approaches at the Marina airport. Green scattering coefficient was $\sim 30 \text{Mm}^{-1}$ in the boundary layer and 15Mm^{-1} above it. Boundary layer height was estimated at 500 ft. As we climbed out, scattering coefficient dropped below 5Mm^{-1} by 17:07 UTC and eventually to $\sim 0 \text{Mm}^{-1}$ with $\sim 400 \text{ particles/cm}^3$ by 17:10 UTC before increasing to 4Mm^{-1} and $750 \text{ particles/cm}^3$ at 17:13 UTC. At 17:24 UTC we crossed the ADIZ line near PIRAT and began our in-line descent to 100 ft. Around 17:31 UTC, we encountered a layer at 7500 ft with $\sim 10 \text{Mm}^{-1}$ scattering coefficient and $f(\text{RH})$ near 1, with little to no absorption; pilots reported winds at that time were out of 90° (almost straight off the coast). By 17:36 UTC it was apparent that our descent rate was too slow to reach 100 ft at our planned turn point, and that we would be quite early to the PIRAT spiral, so we decided to extend our descent to the west. We encountered the clouds around 17:48 UTC, with tops at 740 ft and bases at 400 ft; below cloud, scattering

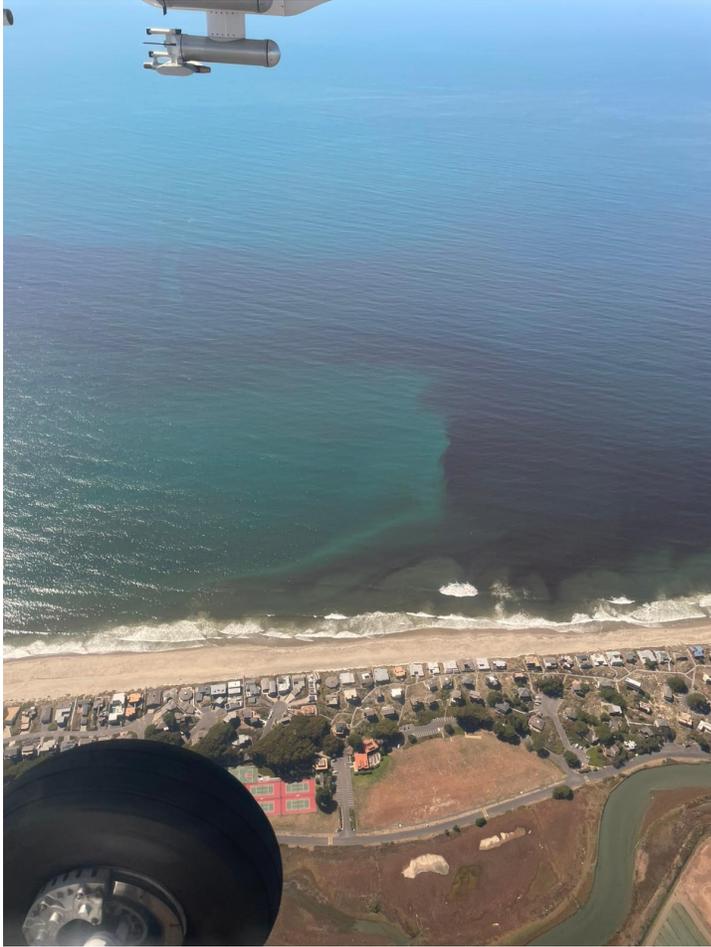
coefficient was $\sim 35\text{Mm}^{-1}$ with relatively high $f(\text{RH})$. We reached 100 ft, turned to the east, and began porpoising (profiling through the cloud, with ~ 10 seconds level and clear of cloud above and below). However, by 17:57 UTC we ran out of clouds, so we stayed at 100 ft to get the best aerosol sampling. At 18:04 UTC, we had to climb due to fog, with the top around 400 ft with a Liquid Water Content (LWC) around 0.24 g/m^3 . Because of the low visibility in the fog, we then began modified porpoising by flying in cloud tops for 1 minute and above cloud for 10 seconds. The cloud/fog was quite low and patchy, with tops around 200 ft and areas of no cloud. Scattering coefficient appeared lower in areas of no cloud, while it was $\sim 30\text{Mm}^{-1}$ above clouds.

At 18:18 UTC, we began our PIRAT spiral above cloud top, with $\sim 35\text{Mm}^{-1}$ scattering coefficient. Very sparse cirrus was visible to the east. The ER-2 passed overhead at 18:18 UTC, just as we were leaving the boundary layer. Scattering again dropped to zero around 7500 ft this time in the climb. The ER-2 passed over again at 18:44 UTC just as we were reaching 10kft. At this point, we were slightly behind for our next spiral time at Turlock, so we transited faster than our normal science sampling speed. We were vectored several times by ATC near the San Jose airport for traffic.

We began our Turlock spiral at 19:22 UTC just as the ER-2 flew over, with 10Mm^{-1} scattering coefficient. Again, there was very sparse cirrus in view around; diffuse radiation was estimated at 10% of total radiation from SPN. Turlock AERONET reported 0.12 AOD, and HSRL just saw very diffuse cirrus just at the overpass. By 19:39 UTC we had reached the boundary layer, where scattering coefficient was 18Mm^{-1} , and completed the spiral at 19:44 UTC. Not as much agricultural activity or dust was observed compared to the previous day. We then ascended in-line to the west to begin our CEOBS spiral at 20:15 UTC and ended at 20:39 UTC. As we transited back to Marina, the water below appeared to have a red tint, perhaps indicative of a harmful algal bloom. One low approach was performed at the Marina airport, where the scattering coefficient peaked to about 30Mm^{-1} .



Very thin clouds near the ADIZ line at 17:21 UTC; photo by Michael Shook



Potential harmful algae bloom near the CEOBS spiral; photo by Eddie Winstead

R/V Shearwater report

Date: 09/23/2024

Creator: Michael Ondrusek

Cruise ID: RF0923-RS

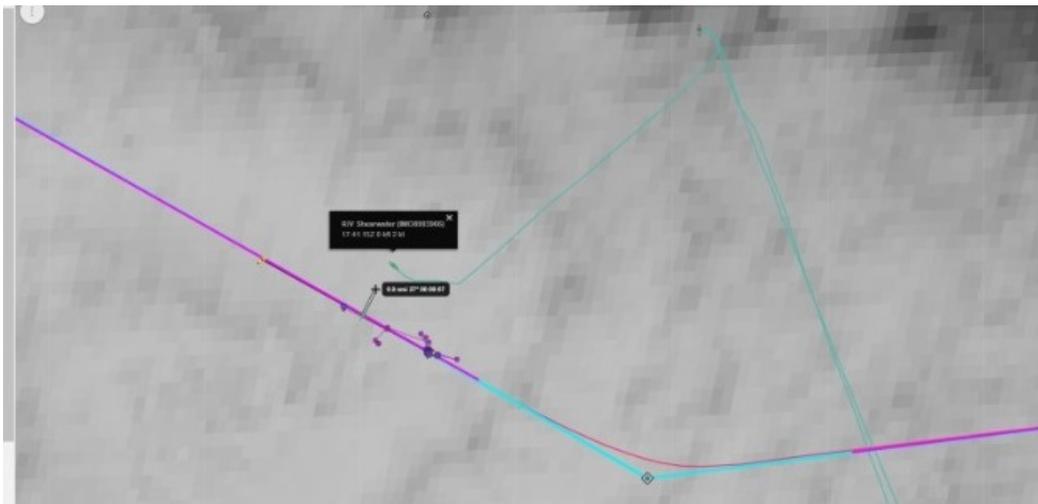
Sailed out: 15:54 UTC

Back in port: 21:20 UTC

Today, the ship occupied 2 stations along the ER-2 line, in cloudy covered Santa Barbara channel.

Station #32 $34^{\circ} 17.646'$, $-119^{\circ} 51.478'$, arrival 16:46 UTC → departure 18:11 UTC

This station was in proximity of the UDelaware glider. ER-2 overflight at 17:38.



Arrival photo:

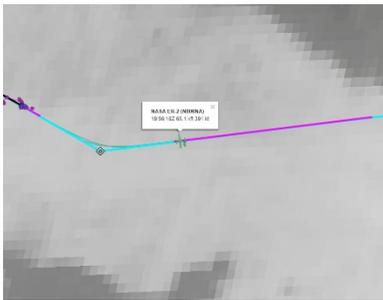


Departure photo (departure location - $34^{\circ} 18.455'$, $-119^{\circ} 52.238'$)



Station #33 $34^{\circ} 12.840'$, $-119^{\circ} 34.943'$, arrival 19:10 UTC → departure 20:30 UTC

ER-2 overflight at 19:56



Arrival photo:



Departure photo: ($34^{\circ} 13.074'$, $-119^{\circ} 35.744'$)



Tomorrow, RV Shearwater will

Ship plans through the next 3 days...

System Status...

All good

Group Status...

All great