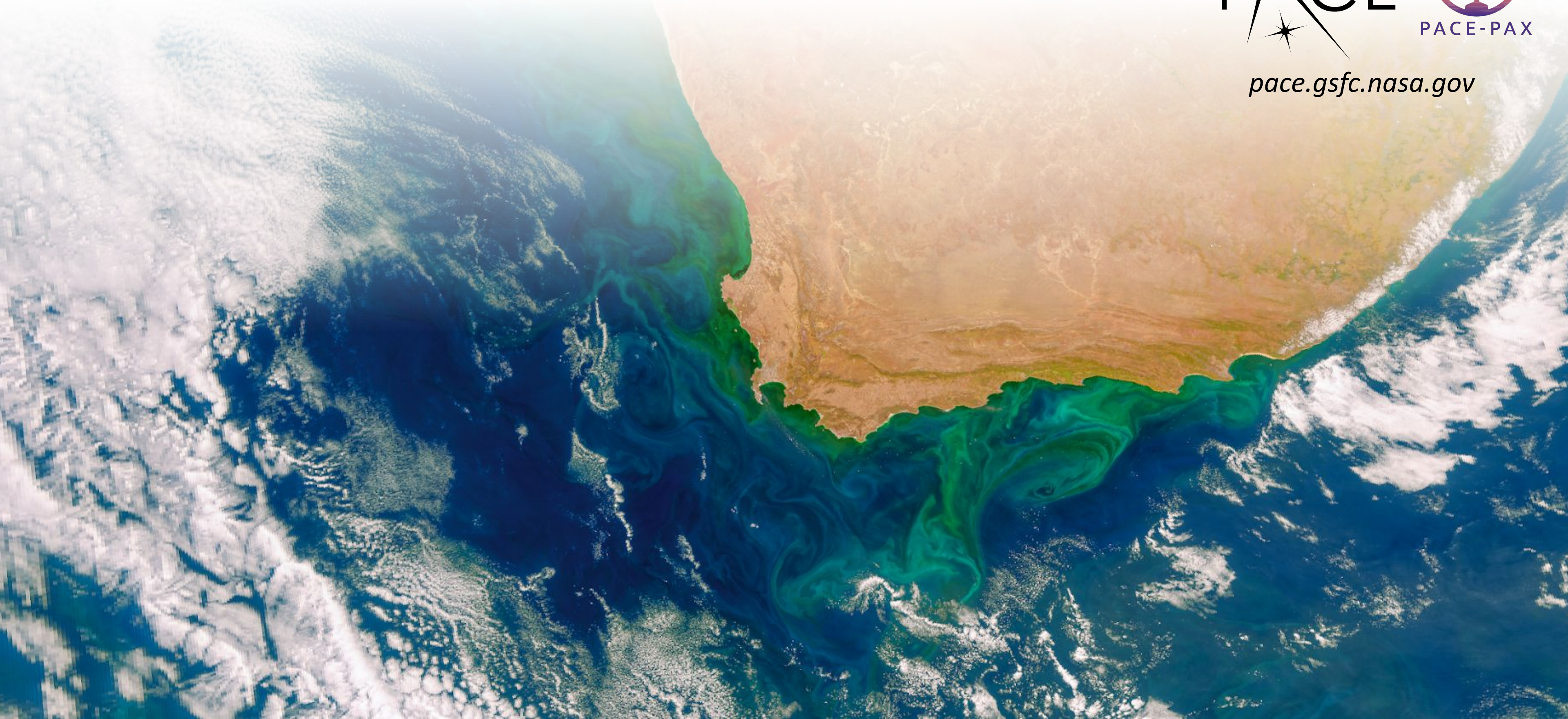
AERONET observations as a valuable component of the PACE Postlaunch Airborne eXperiment (PACE-PAX)

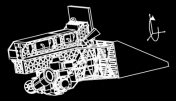
Andrew Sayer on behalf of the PACE-PAX team and PACE project
(leads: Kirk Knobelspiesse, Brian Cairns, Ivona Cetinić, P. Jeremy Werdell)

PACE

PACE-PAX

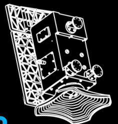
pace.gsfc.nasa.gov





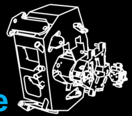
OCI

340-890 nm in 2.5 nm steps
7 discrete SWIR, 940-2260 nm
1-2 day coverage ±20° tilt, 1km



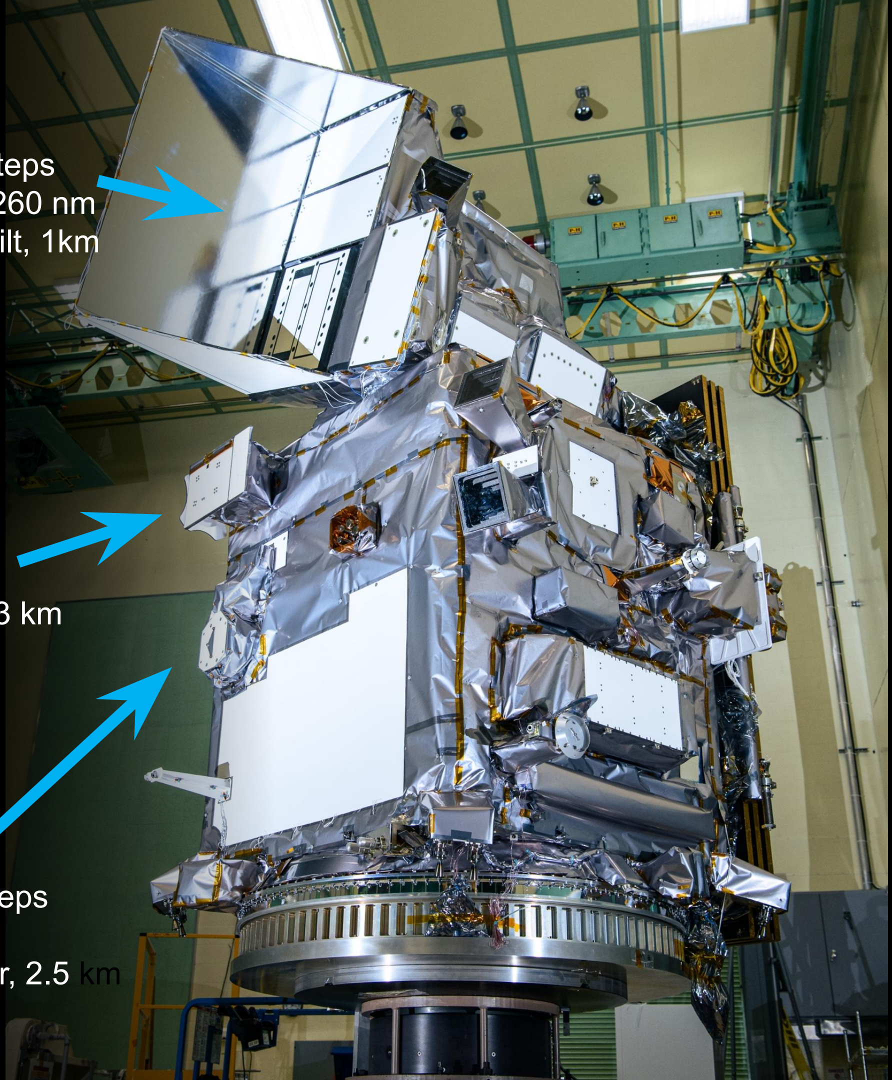
HARP2

440, 550, 670, 870 nm
10-60 viewing angles
wide swath polarimeter, 3 km



SPEXone

380-770 nm in 2-4 nm steps
5 viewing angles
narrow swath polarimeter, 2.5 km



NASA Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission

PACE will extend key systematic ocean color, aerosol, & cloud climate data records, reveal the diversity of organisms fueling marine food webs, and introduce new methods to observe aerosols and clouds, the largest source of climate uncertainty.

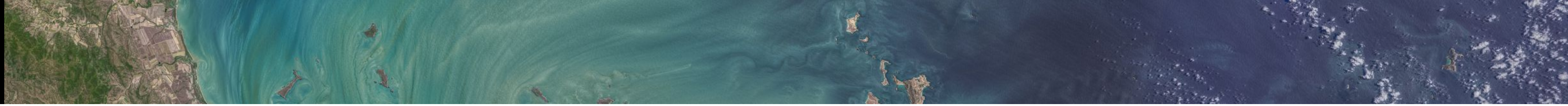
Characteristics:

- February 8th launch, April 11th initial data release
- 676.5 km, polar, ascending orbit, 98°
- Sun synchronous, 13:00 Equatorial crossing
- Global (land and ocean) data
- Data to OB.DAAC (oceancolor.gsfc.nasa.gov)

PACE has many data products

… some are currently available, others coming soon, being tested, or potential future development

PACE-PAX



PACE validation plan

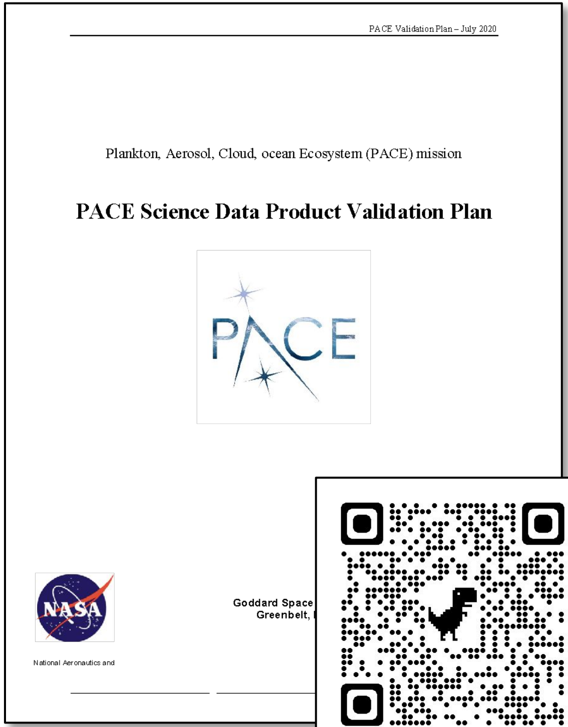
Our mission requirements include validation

“post-launch field validation work is required to evaluate the PACE science data products … within 12 months of commissioning. The PACE validation programs (provided by HQ PACE Science) shall include the following for the mission duration:

a) Shipboard and aircraft campaigns as required …

*b) Autonomous instrument systems that collect continuous records of any of the individual data products…”**

The PACE Science Data Product Validation Plan describes activities to meet these requirements


PACE Validation Plan – July 2020

Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission

PACE Science Data Product Validation Plan

PACE

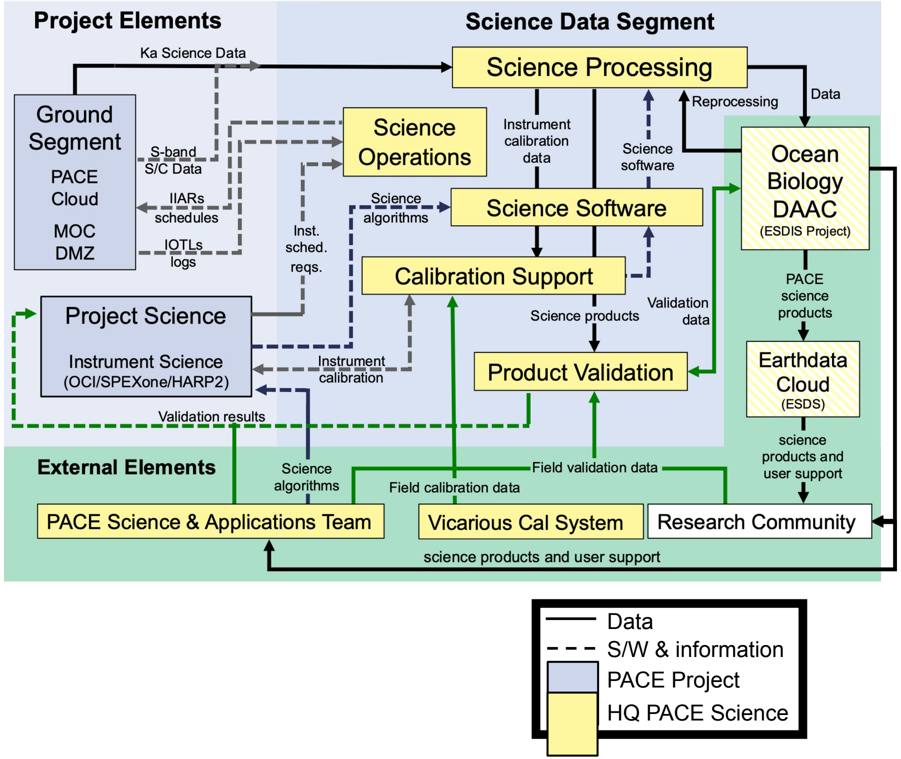
Goddard Space
Greenbelt,

National Aeronautics and

pace.oceansciences.org/documents.htm

*from PACE Program Level Requirements Agreement (PLRA) and Mission Requirements Document (MRD)

PACE validation plan



- NASA Ocean Ecology Lab field support group
- PACE Validation Science Team (PVST)
- Existing community activities
  - Instrument networks e.g. AERONET, ARM, Cloudnet
  - Ongoing field activities
- OEL hosted archive and analysis system (SeaBASS)
- **PACE Postlaunch Airborne eXperiment**

Related: System Vicarious Calibration

Autonomous regular measurement of ocean water leaving radiance for OCI vicarious calibration. Two systems:

- HyperNAV – Lagrangian profiling buoys (Crete + TBD)
- MarONet – fixed mooring based on MOBY (W. Australia)
- MOBY refresh – fixed mooring (Hawaii)


PACE-PAX
3-27 September 2024


256


NOAA

PACE Postlaunch Airborne EXperiment

Goddard Earth Sciences

NPS

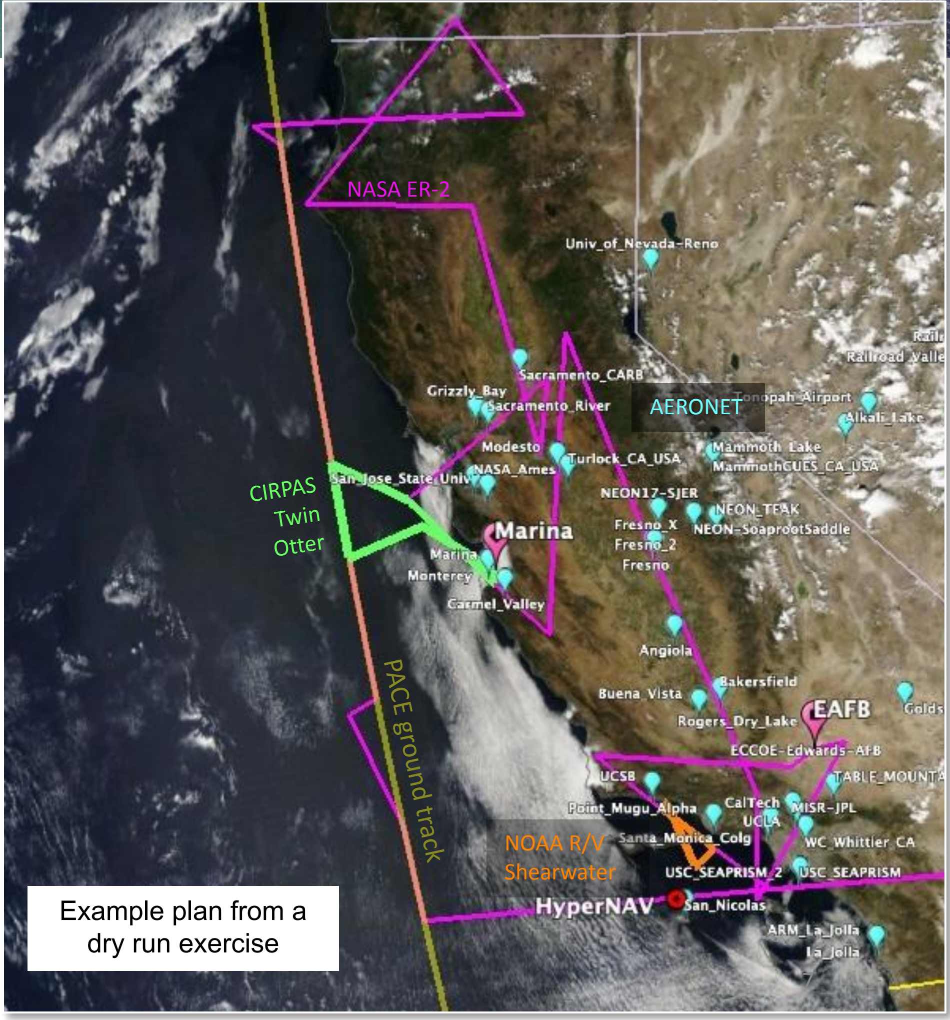
SRON Netherlands Institute for Space Research

JPL Jet Propulsion Laboratory California Institute of Technology

NOAA

UMBC

NASA Langley Research Center



Example plan from a dry run exercise

How we designed PACE-PAX

Validation objectives	
Validate new retrieval properties	*Needed so products can mature from "provisional" to "standard" status*
Validate in a narrow swath	*Enables validation of narrow swath PACE/SPEXone and EarthCARE*
Validate radiometric and polarimetric properties	*Traceability for satellite and airborne instrument characterization*
Focus on specific processes or phenomena	*Target uncommon special cases*

Start with several top-level objectives

How we designed PACE-PAX

Validation objectives	Measurement objectives	Importance, w
Validate new retrieval properties	Land surface parameters	8
	Ocean radiometric parameters	10
	Aerosol parameters over the ocean	12
	Aerosol parameters over land	12
	Cloud parameters	12
	Ocean surface parameters	1
Validate in a narrow swath	Aerosol parameters over the ocean (PACE)	10
	Aerosol parameters over land (PACE)	10
	Cloud parameters (PACE)	5
	Aerosol parameters (EarthCARE)	8
	Cloud parameters (EarthCARE)	8
Validate radiometric and polarimetric properties	Validate large reflectances	6
	Validate large reflectances with high polarization	6
	Validate large reflectances with low polarization	6
	Overfly vicarious calibration sites	6
Focus on specific processes or phenomena	High aerosol loads over land	4
	High aerosol loads over ocean	4
	Multiple aerosol layers	1
	Aerosol under thin cirrus	2
	Aerosol above liquid phase cloud	4
	Broken clouds with complex structure	4
	Dust aerosols over ocean	4
	Aerosol and ocean parameters over turbid waters	2
	Aerosol and ocean parameters over biologically productive waters	4
	Smoke aerosols over ocean	1
		150

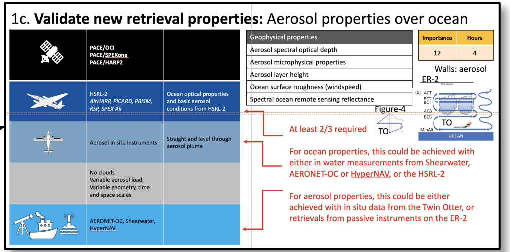
Flow to specific measurement objectives

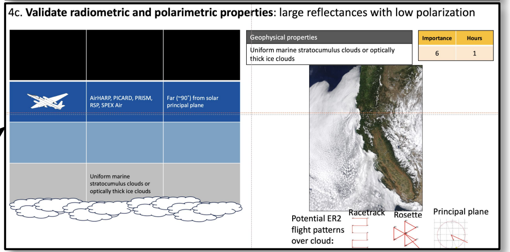
Prioritize with ‘importance’ metric

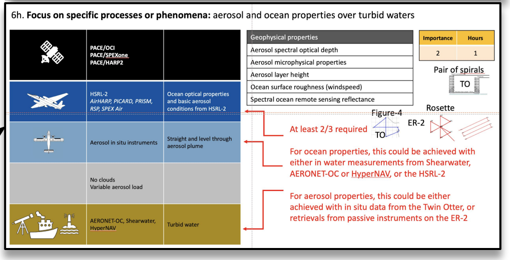
Validation Traceability Matrix

Identify needed measurements

Validation objectives	Measurement objectives	Importance, w
Validate new retrieval properties	Land surface parameters	8
	Ocean radiometric parameters	10
	Aerosol parameters over the ocean	12
	Aerosol parameters over land	12
	Cloud parameters	12
	Ocean surface parameters	1
Validate in a narrow swath	Aerosol parameters over the ocean (PACE)	10
	Aerosol parameters over land (PACE)	10
	Cloud parameters (PACE)	5
	Aerosol parameters (EarthCARE)	8
	Cloud parameters (EarthCARE)	8
Validate radiometric and polarimetric properties	Validate large reflectances	6
	Validate large reflectances with high polarization	6
	Validate large reflectances with low polarization	6
	Overfly vicarious calibration sites	6
Focus on specific processes or phenomena	High aerosol loads over land	4
	High aerosol loads over ocean	4
	Multiple aerosol layers	1
	Aerosol under thin cirrus	2
	Aerosol above liquid phase cloud	4
	Broken clouds with complex structure	4
	Dust aerosols over ocean	4
	Aerosol and ocean parameters over turbid waters	2
	Aerosol and ocean parameters over biologically productive waters	4
	Smoke aerosols over ocean	1
		150







How we designed PACE-PAX

Importance weights provide for a way to assess multiple options, make flight planning decisions and assess overall success

Overall 1st dry run progress tracking

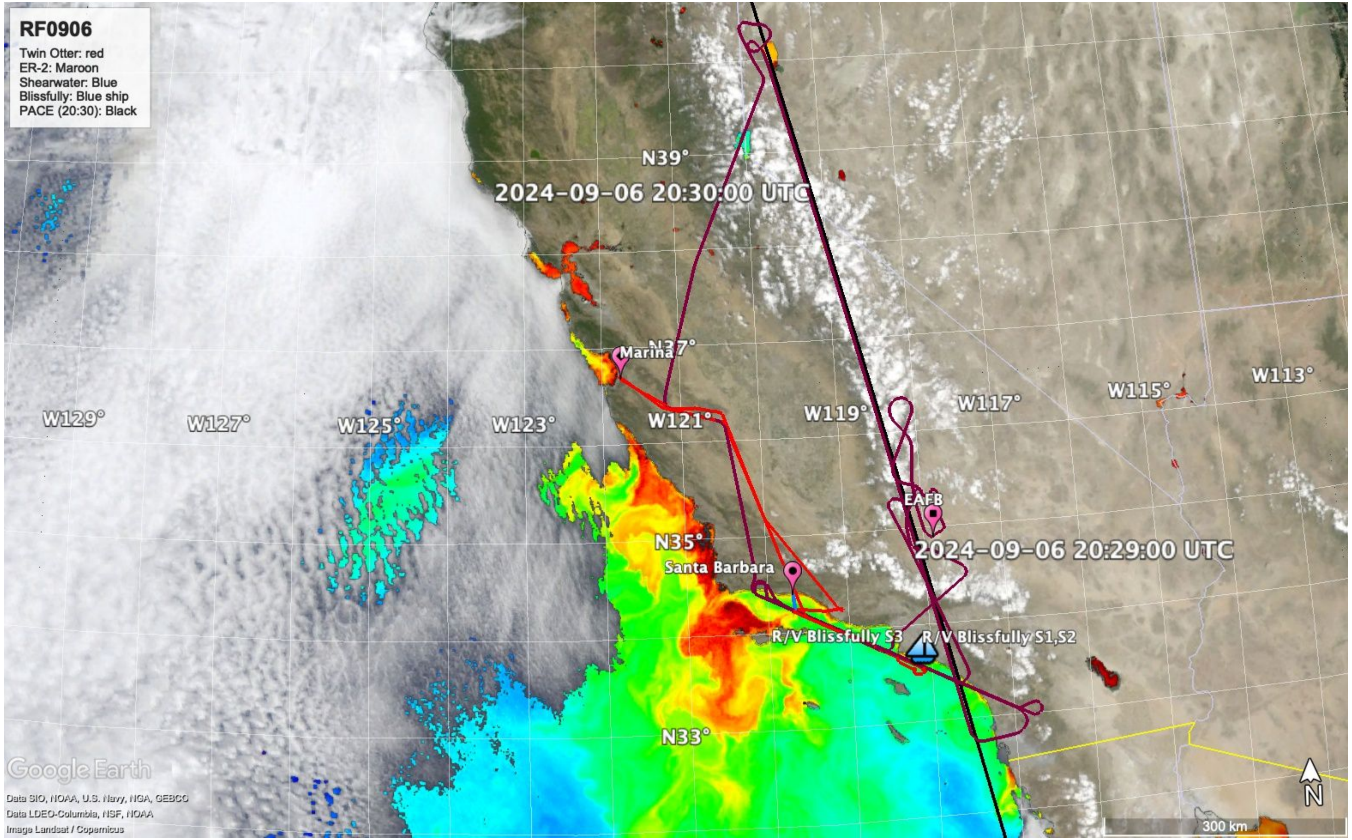
Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 3/7	Fractional success 3/8	Fractional success 3/9	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	1.0	1.0	0.0%	63.2%	0.0%	63.2%	2.9
	b	Ocean radiometric parameters	10	4.0	5.0	0.0%	46.5%	24.9%	71.3%	2.9
	c	Aerosol parameters over the ocean	12	4.0	6.5	0.0%	58.3%	22.0%	80.3%	2.4
	d	Aerosol parameters over land	12	4.0	4.0	0.0%	58.3%	4.9%	63.2%	4.4
	e	Cloud parameters	12	4.0	1.0	0.0%	0.0%	17.1%	17.1%	9.9
	f	Ocean surface parameters	1	4.0	0.5	0.0%	11.8%	0.0%	11.8%	0.9
3. Validate in a narrow swath	a	Aerosol parameters over the ocean	10	4.0	1.0	0.0%	0.0%	22.1%	22.1%	7.8
	b	Aerosol parameters over land	10	4.0	0.5	0.0%	0.0%	11.8%	11.8%	8.8
	c	Cloud parameters	5	1.0	1.0	0.0%	0.0%	52.8%	52.8%	2.4
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	1.0	1.0	0.0%	63.2%	0.0%	63.2%	2.2
	b	Validate large reflectances with high polarization	6	1.0	0.0	0.0%	0.0%	0.0%	0.0%	6.0
	c	Validate large reflectances with low polarization	6	1.0	1.0	0.0%	0.0%	52.8%	52.8%	2.8
	d	Overfly vicarious calibration sites	6	2.0	1.0	0.0%	39.3%	0.0%	39.3%	3.6
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	1.0	0.0	0.0%	0.0%	0.0%	0.0%	4.0
	b	High aerosol loads over ocean	4	1.0	0.0	0.0%	0.0%	0.0%	0.0%	4.0
	c	Multiple aerosol layers	1	1.0	0.0	0.0%	0.0%	0.0%	0.0%	1.0
	d	Aerosol under thin cirrus	2	1.0	0.0	0.0%	0.0%	0.0%	0.0%	2.0
	e	Aerosol above liquid phase cloud	4	1.0	0.0	0.0%	0.0%	0.0%	0.0%	4.0
	f	Broken clouds with complex structure	4	1.0	0.0	0.0%	0.0%	0.0%	0.0%	4.0
	g	Dust aerosols over ocean	4	1.0	3.0	0.0%	0.0%	95.0%	95.0%	0.2
	h	Aerosol and ocean parameters over turbid waters	2	1.0	0.0	0.0%	0.0%	0.0%	0.0%	2.0
	i	Aerosol and ocean parameters over biologically productive waters	4	1.0	4.0	0.0%	95.0%	3.1%	98.2%	0.1
	k	Smoke aerosols over ocean	1	1.0	0.0	0.0%	0.0%	0.0%	0.0%	1.0
		total:	134	45	30.5	0.0%	25.2%	15.6%	40.8%	

PACE-PAX instrumentation

Instrument	Platform	Role	Lead PI	Institution
AirHARP	ER-2	PACE/HARP2 polarimetry proxy	J. Vanderlei Martins	UMBC
PICARD	ER-2	PACE/OCI spectrometer proxy	J. Jacobson / K. Meyer	NASA ARC/GSFC
PRISM	ER-2	PACE/OCI spectrometer proxy	David R. Thompson	JPL
SPEX Airborne	ER-2	PACE/SPEXone polarimetry proxy	B. van Diedenhoven	SRON
HSRL-2	ER-2	Aerosol/cloud/ocean Lidar	T. Shingler / J. Hair	NASA LaRC
RSP	ER-2	Multi-angle polarimeter ref.	B. Cairns / K. Sinclair	NASA GISS
Facility instruments	Twin Otter	Aerosol/cloud in situ instruments	Anthony Bucholtz	NPS
LARGE	Twin Otter	Aerosol/cloud in situ instruments	Luke Ziemba	NASA LaRC
LI-Nephelometer	Twin Otter	Aerosol phase functions	Adam Ahern	NOAA
ISARA	Twin Otter	In situ data synergy activity	Snorre Stamnes	NASA LaRC
Ocean instruments*	RV Shearwater	Day cruises, instrumentation TBD	Mike Ondrusek	NOAA
HyperNAV*	Ocean floats	Radiometric calibration ocean floats	Andrew Barnard	OSU
AERONET, AERONET-OC*	Surface	Aerosol prop., water leaving radiance	P. Gupta / E. Lind	NASA GSFC

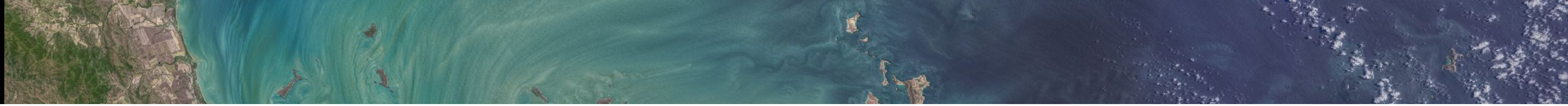
*externally supported activities

September 6 flight



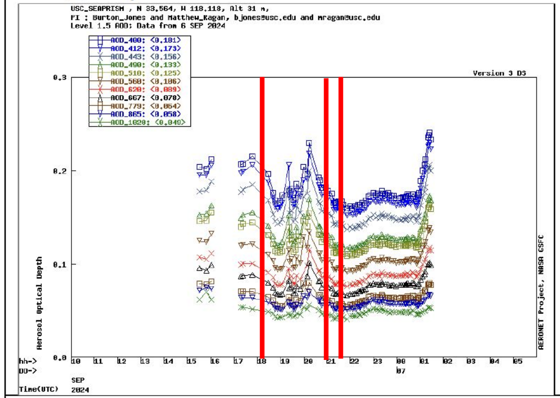
Twin Otter
ER-2
RV Shearwater
RV Blissfully
PACE

Background: RGB and PACE OCI Chlorophyll

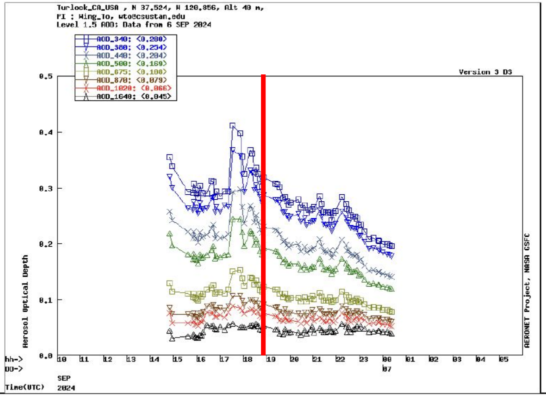


September 6 flight

Usc_seaprism

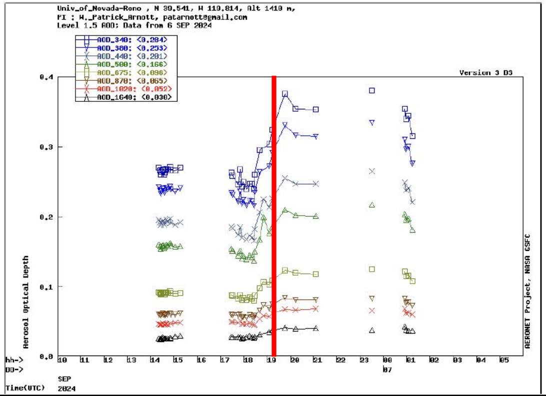


Turlock

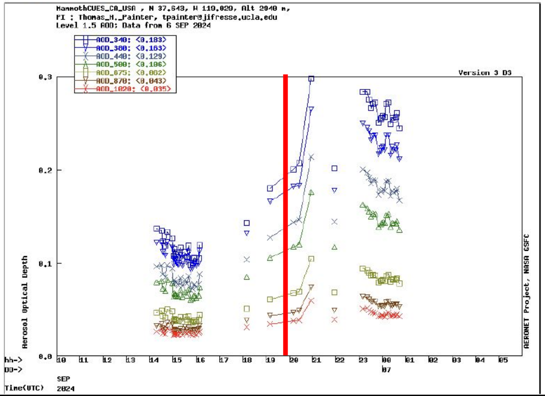


20:56:00 ER2+TO+RB+USC_SeaPRISM

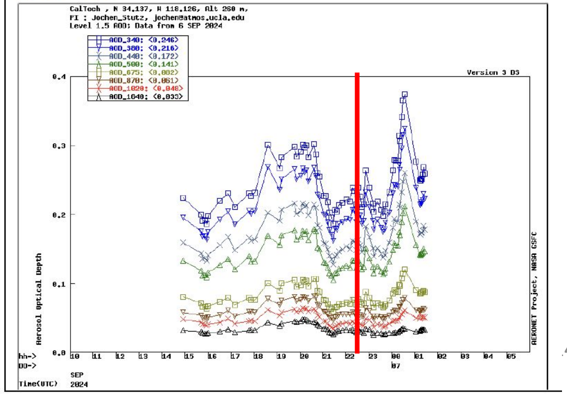
U. Nevada Reno



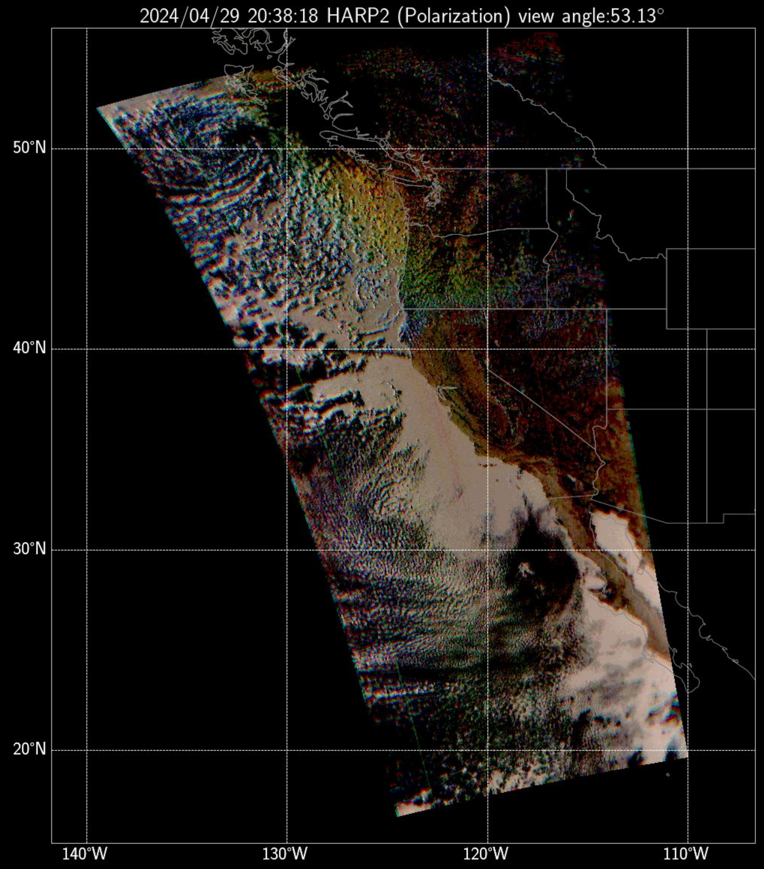
Mammoth CUES



CalTech



- Data product validation is crucial to PACE
- Validation activities are varied, many different teams contribute
- PACE-PAX is a dedicated PACE validation field campaign, happening now in California
- All data available at Langley DAAC end of March 2025



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