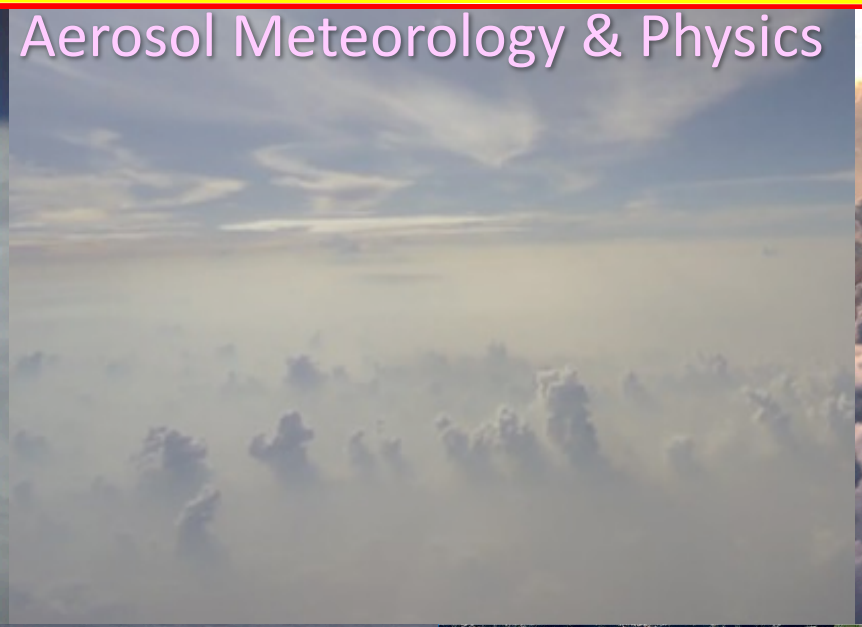
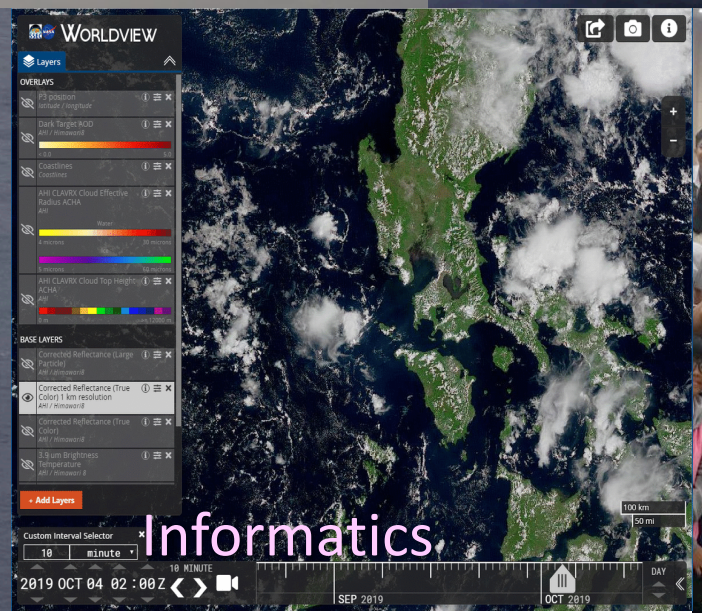
Overview of the Camp2Ex Field Campaign and NRT use of Himawari AHI Geosynchronous Imager Data

Robert Holz, Ralph Kuehn, Willem Marais, Greg Quinn, Ryan Boller, Matthew Cechini, Robert Levy, Steve Platnick, Kerry Meyer, Gala Wind, Jeffery Reid, Hal Maring, Jemma Teresa Narisma

CAMP²Ex In Pictures





Types of measurements

NASA P-3B

- **Aerosol / gas in-situ microphysics**
  - Black carbon-SP2
  - Cloud condensation nuclei (3 nm, 10 nm, 10 nm non vol)
  - Composition (POM, SO_4, NO_y, NH_4, Cl)
  - Light scattering (TSI 3λ, dry & 80%)
  - Size distribution (FIMS, LAS, PCASP)
  - Tracer gases (CO_2, CO, SO_2, NO, NO_y)
- **Cloud cover/properties**
  - Up and down all sky camera
  - Cloud in-situ microphysics
  - Droplet/ice particle size
- **Aerosol, Cloud & Precip remote sensing**
  - 18-27-94 GHz radar-APR3
  - Cloud cameras (MW &LW)
  - HSRL 3β+2α Lidar
  - Microwave radiometer-AMPR
  - RSP Polarimeter
  - SWIR hyperspectral

Radiative Balance

- Hyperspectral up/down VNIR (SSFR)
- Solar & IR up/down flux (BBR)
- Solar direct/diffuse (VPN)

State variables (temperature, wind, humidity):

- In-situ & dropsonde
- 50 hz 5 hole and 20 hz q
- Sea surface temperature (Kt 19 and IR camera)

SPEC Lear Jet 35

Aerosol Size (PCASP)

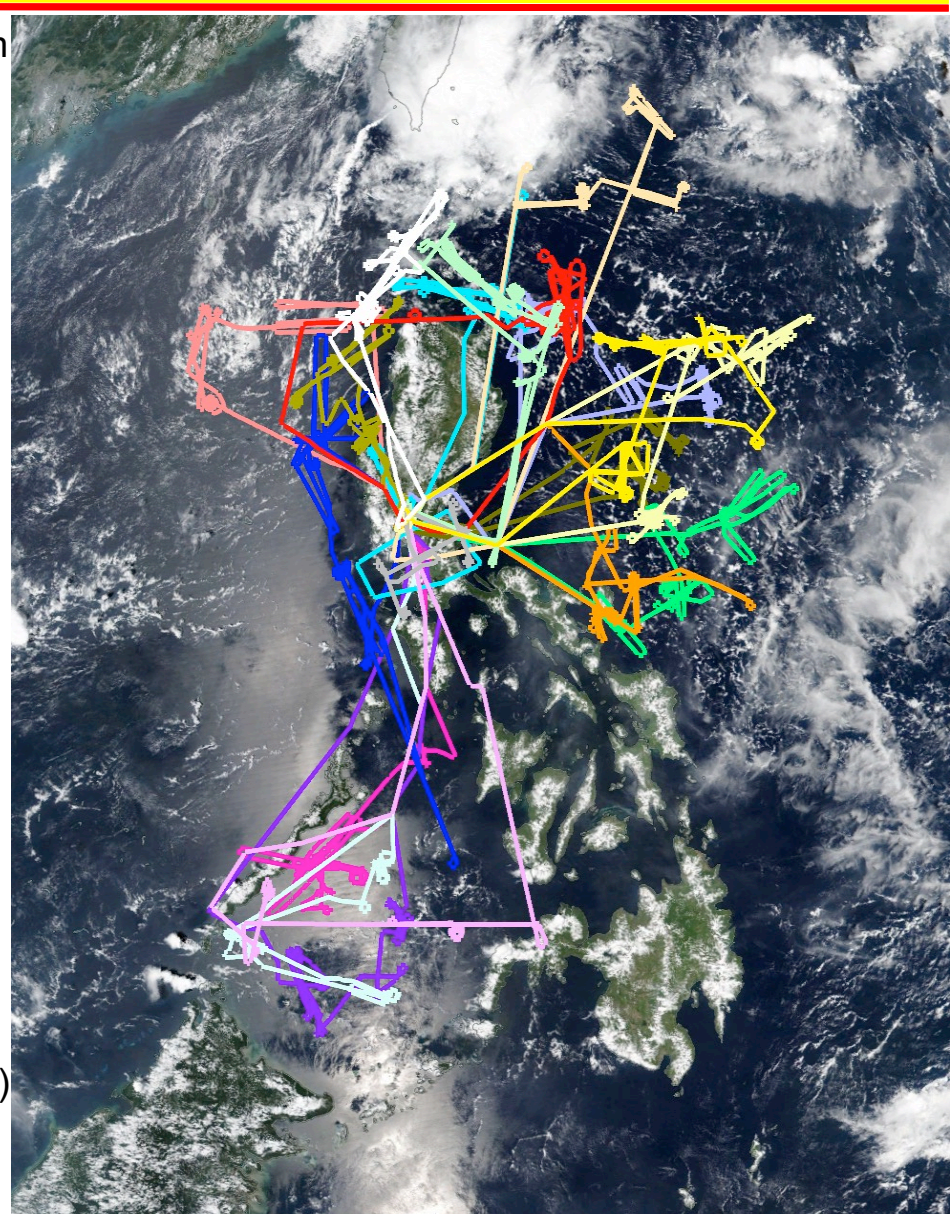
Cloud in-situ microphysics

droplet/ice particle size

precipitation

P3 and Spec Lear Flights

- Research flights: 19 from 25 Aug to 5 Oct, 2019; 147 research flight hours, flights ranging form 4.5 to 9.5 hrs (Avg 7.75 hrs).
- R/V Sally Ride P3 3 (Sep 9, 22, 24); Lear 35 5 (Sep 10, 13, 15, 22)
- Sampling conditions:
  - P3+Lear 4 tight formation flights, 4 regional
  - Outflow boundary/cold pools (3); Convergence lines (3)
  - High aerosol loading: smoke (3); Asia pollution(1.5); Clark (18) Manila (2); Batangus(1)
  - Pristine conditions (3);
  - Sunrise radiation/Aeolus flights (2)
  - Preliminary AOD (532 nm) ~1; PBL flt avg ranges c_m to ~80 $\mu g\ m^{-3}$; CCN to 60-2500 cm^{-3}. f(80%) ~1.2-2.2;
  - 201 dropsondes; 307 cloud water samples
- Satellite Sensors (direct underpass+proximity)
  - JMA-JAXA: AHI continuous 10 min+ 2.5 rapid scan limited domain.
  - Polar Proxies: Terra MODIS (14+4): Aqua MODIS (15+2); SNPP (15+1); NOAA20 (16+2)
  - “Specialty” MISR (5+2); GPM(5+1); Cloudsat-CALPSO (1)
  - Hi Res: ASTER(1+3); Landsat 8 (1+2); Worldview (2 & 2 others)
  - JAXA GCOM-C SGLI(9+4); GCOM–W AMSR2(11+3); GOSAT 1& 2 TANSO(4+1; 5+5); ESA: Aeolus(2); Sentinel2A(4+1); Sentinel 2B(1+2); Sentinel 3A OLCI(9+2) SLSTR (3+1); Sentinel-5P(14+2)
  - Scatterometer: MetOp-A(8+4); MetOp-B(7+7); MetOp-C(7+4); ScatSat-1(4+1); SMAP (1+3)
  - Sentinel-1 SAR: 4 regional cases



Example science highlights-by discipline

- Clouds and precipitation
  - Characterized convergence zone lines in clean and polluted conditions.
  - Sampled outflow boundaries in in cleaner and heavy smoke
  - Tight coordination between P3 remote sensors and Lear 35 microphysics for quasi steady state convergence line.
- Composition
  - Sampled a major Borneo peat fire event on multiple occasions.
  - Characterized a variety of aerosol sources from clean marine, Martiem continent, Asia, Manila, etc…
  - First cloud water samples in SE Asia, and first in Altocu ever
- Radiation
  - Two sunrise radiation flights to observe cooling versus heating crossover for diurnal work.
  - Impact of sub pixel clouds on radiation budget.
- Remote Sensing
  - Significant coordination with multiscale environmental and commercial satellites including aerosol, cloud and precipitation products.
  - Emphasis on next gen science (high resolution, new sensors)
  - AMPR was operated multiple times in a nadir-staring mode that - when coupled with APR-3 - will enable unique, ultra-high-resolution combined active/passive retrievals of cloud microphysical properties

NRT AHI Products For CAMP2X

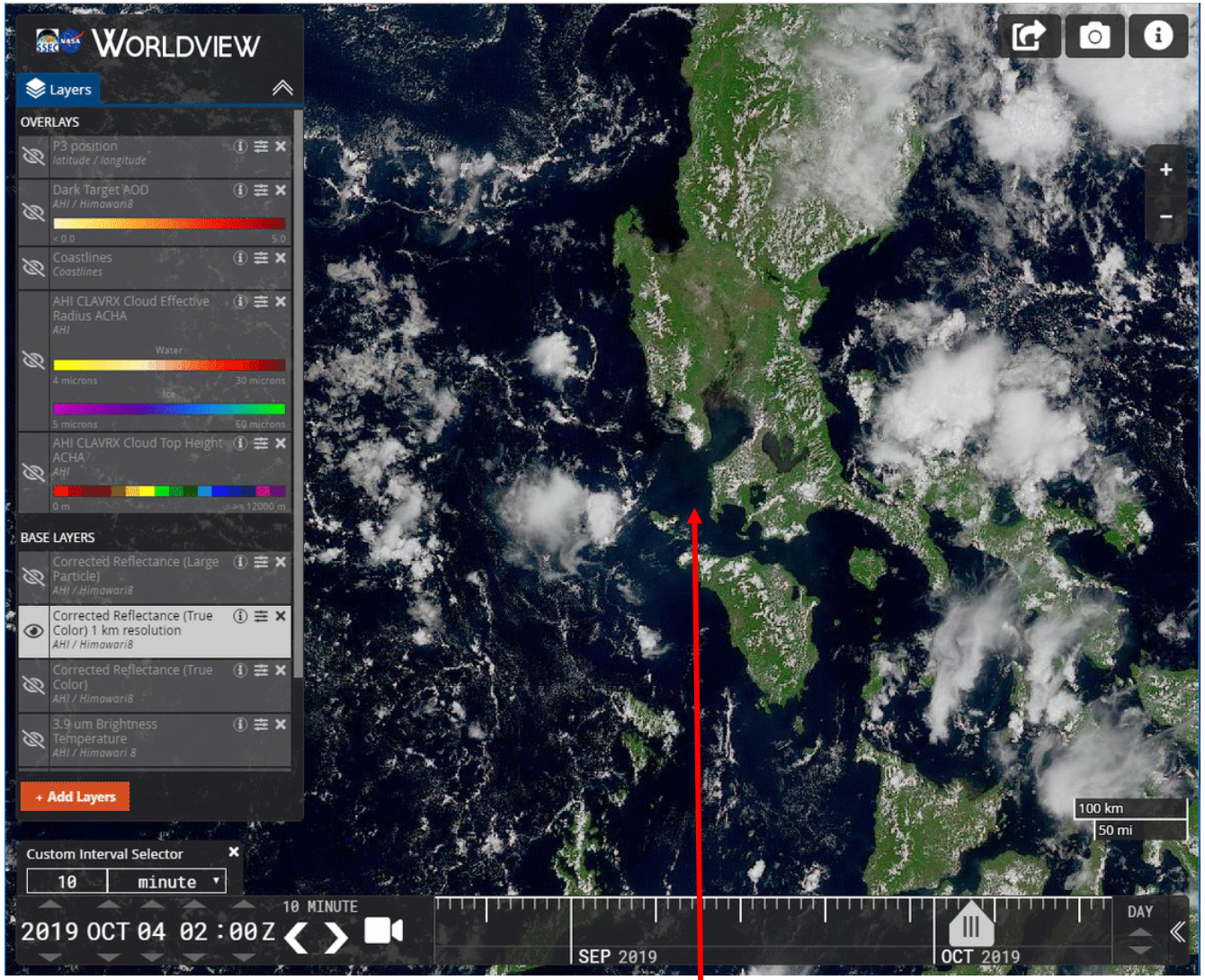
Imagery	Products	Tracks/Boundaries	Model Data
Corrected Reflectance (True Color) 2km	NASA Cloud Optical Properties (Cloud Phase separated) Optical Thickness and Effective Radius	P3 Aircraft Position Lear Aircraft Position	NAVGEM 850 and 200 mb winds
Corrected Reflectance (True Color) 1km resolution	NASA AHI Dark target AOD (MEASURES)	Sally Ride Region	
Corrected Reflectance Large Particle 2km	AHI CLAVRX ACHA IR Cloud Properties	ICOA Regions	
	AHI CLAVRX Cloud Top Height (ACHA IR)	Sally Ride Ship Position	
	AHI CLAVRX DCOMP (VIS) Cloud Effective Radius and Optical Thickness separated by phase		
	AHI CLAVRX Cloud Phase		

NRT AWS Cloud Processing

- Challenges in supporting NRT AHI products at Clark Philippines
  - Uncertainty in internet bandwidth to the Philippines
  - L1b AHI data feed is complex
  - Power and compute infrastructure at Clark was limited
- Solutions
  - The NASA Worldview interface was modified to support high temporal resolution imagery (Geo-Stationary) with the help of the worldview development team (Ryan and Matt)
  - We (SSEC) installed our own instance of worldview on local servers at SSEC (geoworldview.ssec.wisc.edu) and deployed a local instance in the hanger (Clark Philippines) to support the experiment
  - Using a combination of the SSEC and Japanese data feeds of NRT AHI L1b data we processed L1 Imagery, L2 products and custom layers using an AWS cloud instance in Tokyo
  - The layers (imagery) was then pushed to the local servers at Clark with the goal very low latency (<20 min) imagery available to the science team in the hanger viewable on worldview

Geo-Worldview: https://geoworldview.ssec.wisc.edu
Geostationary adaptation of NASA Worldview

- CAMP²Ex operations required the same functionality as NASA Worldview but with AHI temporal sampling.
- SSEC collaborated with NASA GSFC to modify the worldview application to support 10 minute time resolution.
- The SSEC “geoworldview” instance provided GEO and LEO imagery and L2 products customized for CAMP²Ex.
- The site was hosted using a local server at the CAMP²Ex hanger to reduce bandwidth and improve latency
- Geoworldview was the primary tool for directing CAMP²Ex flight operations and is an invaluable resource for post mission analysis.

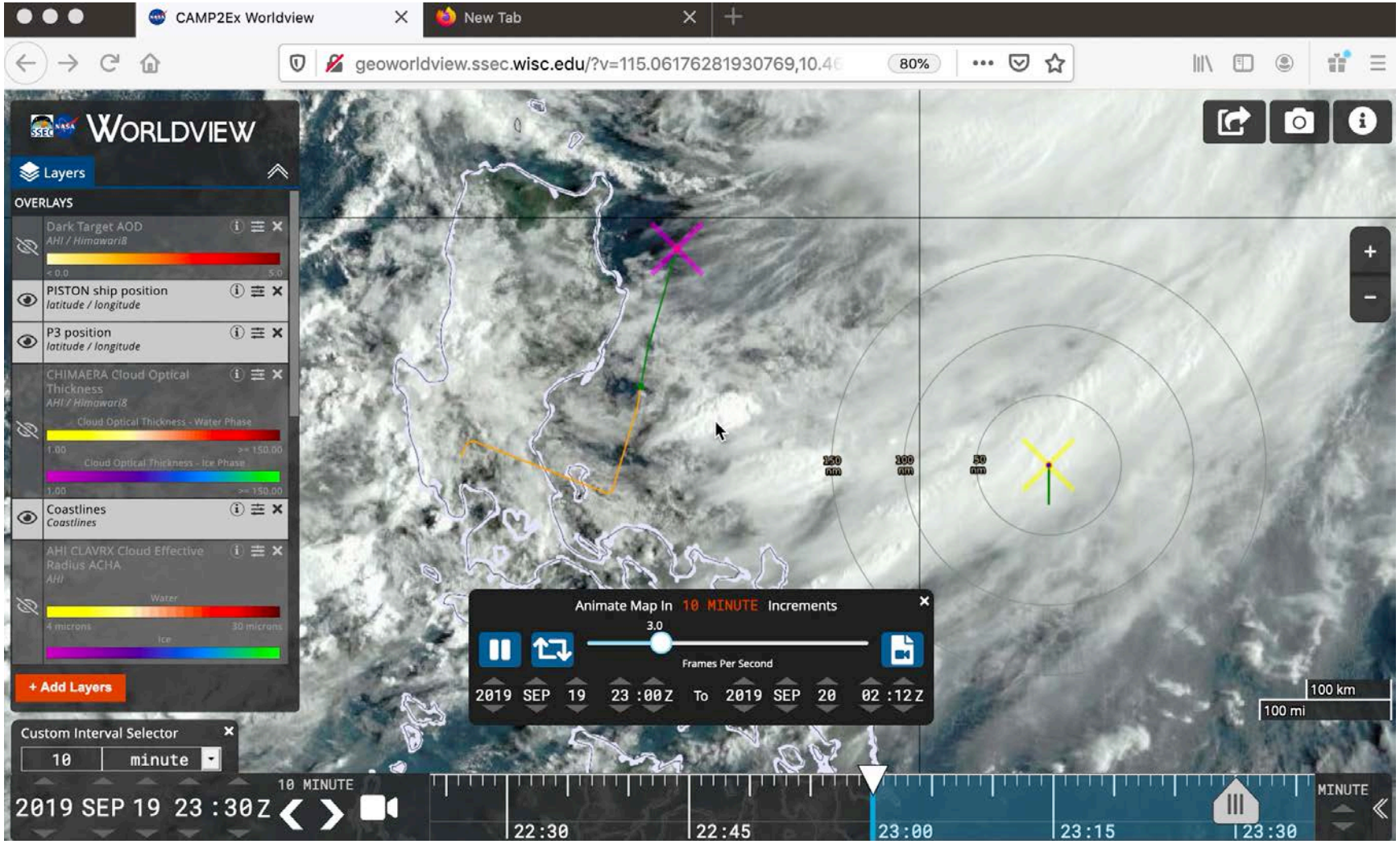


Variable time increment

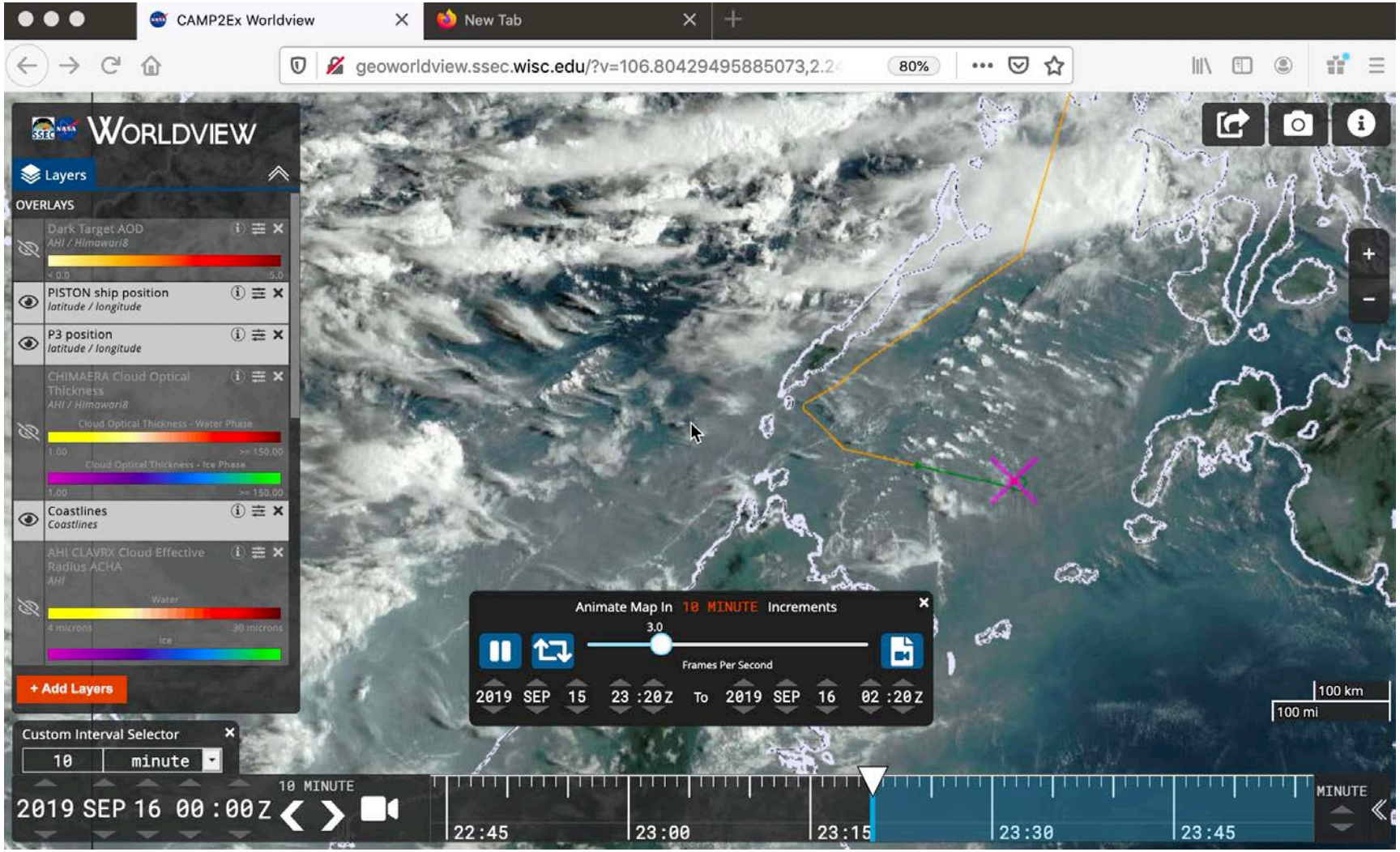
Manila Plume

Time bar from days to seconds

September 20th Flight



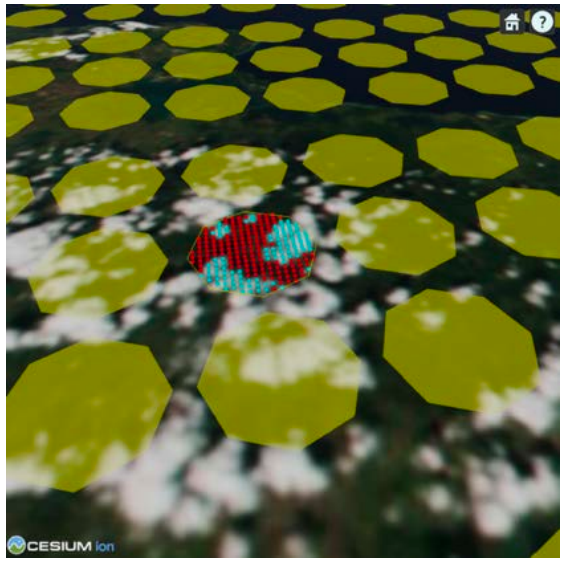
September 16th[th] Flight



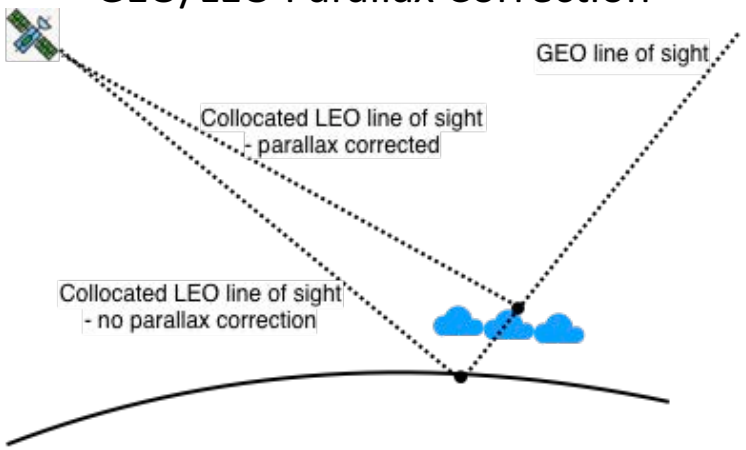
GEO/LEO Collocation and Merged Products

- A Beta version of the VIIRS/MODIS cloud continuity products (CLARVx and Optical Properties) where processed on 10-minute AHI observations
- Dark Target (MEASURS) processed in NRT on AHI at 10-minute data
- Leveraging the processing and collocation tools developed at SSEC the AHI and VIIRS retrievals are collocated and saved in a NETCDF4 match file

Physical Collocation

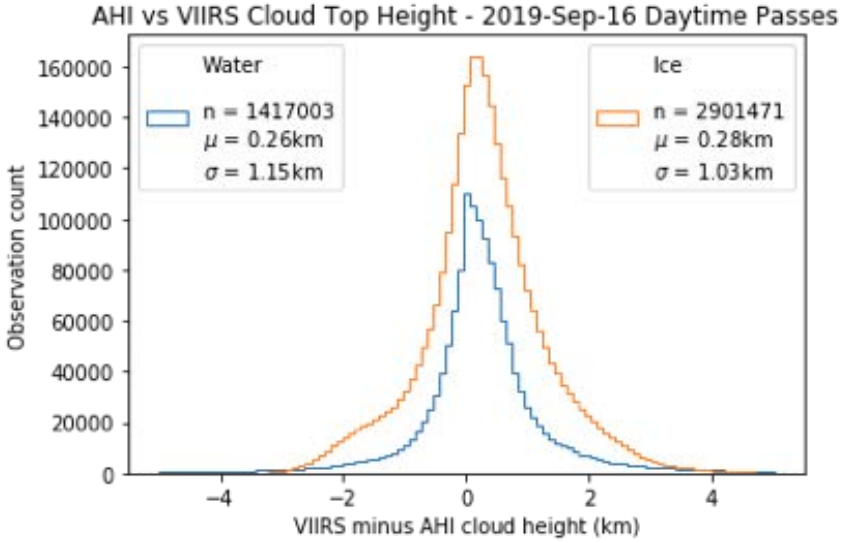


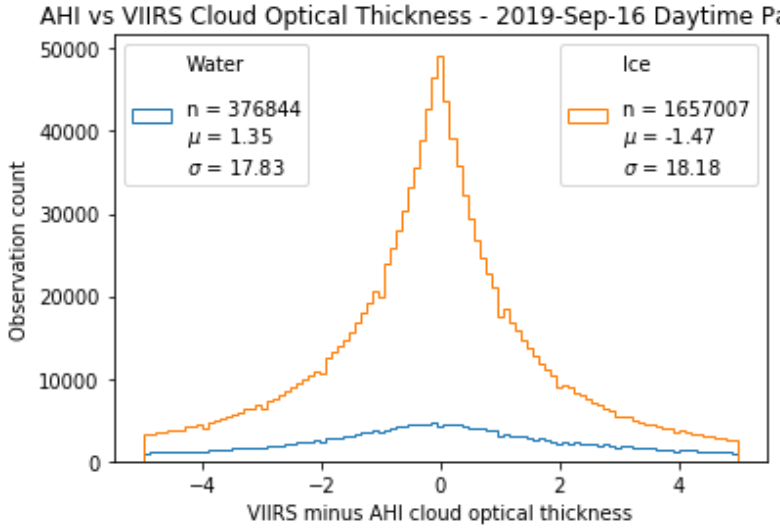
GEO/LEO Parallax Correction

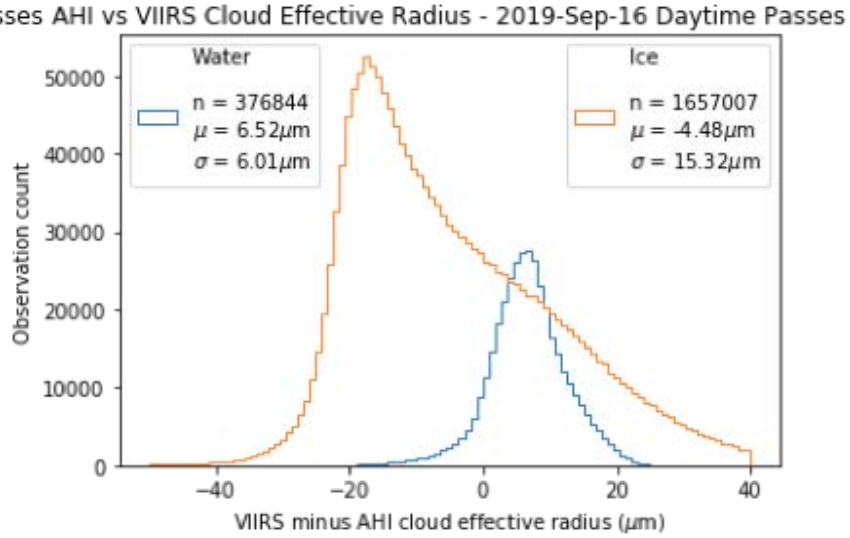


Collocated Aircraft/AHI/VIIRS Match Files

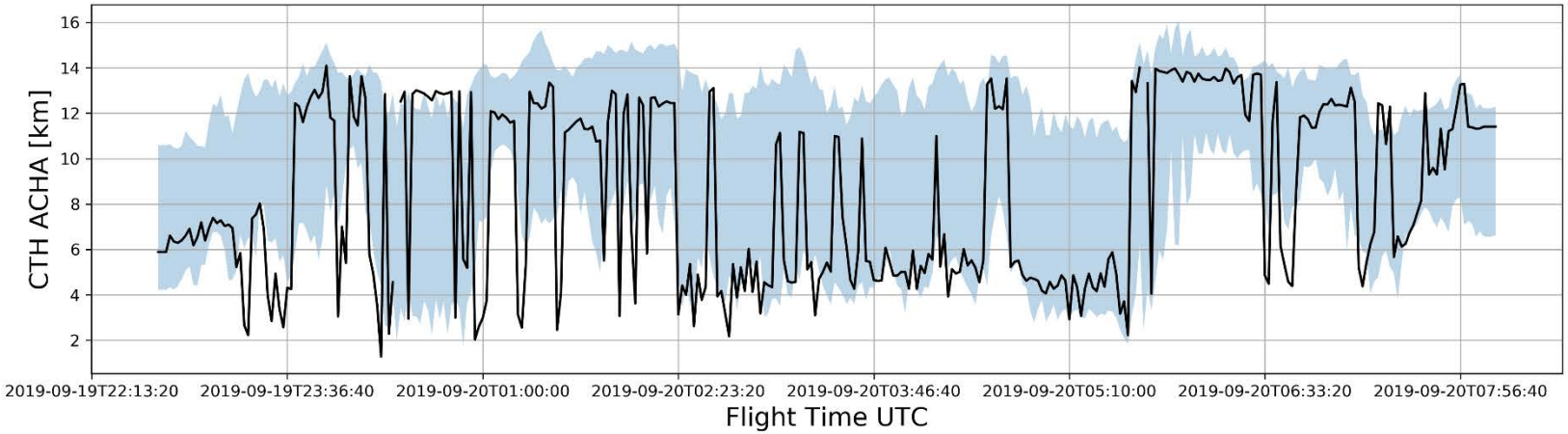
Collocated and Parallax Corrected VIIRS vs AHI Cloud Optical Properties (Beta)



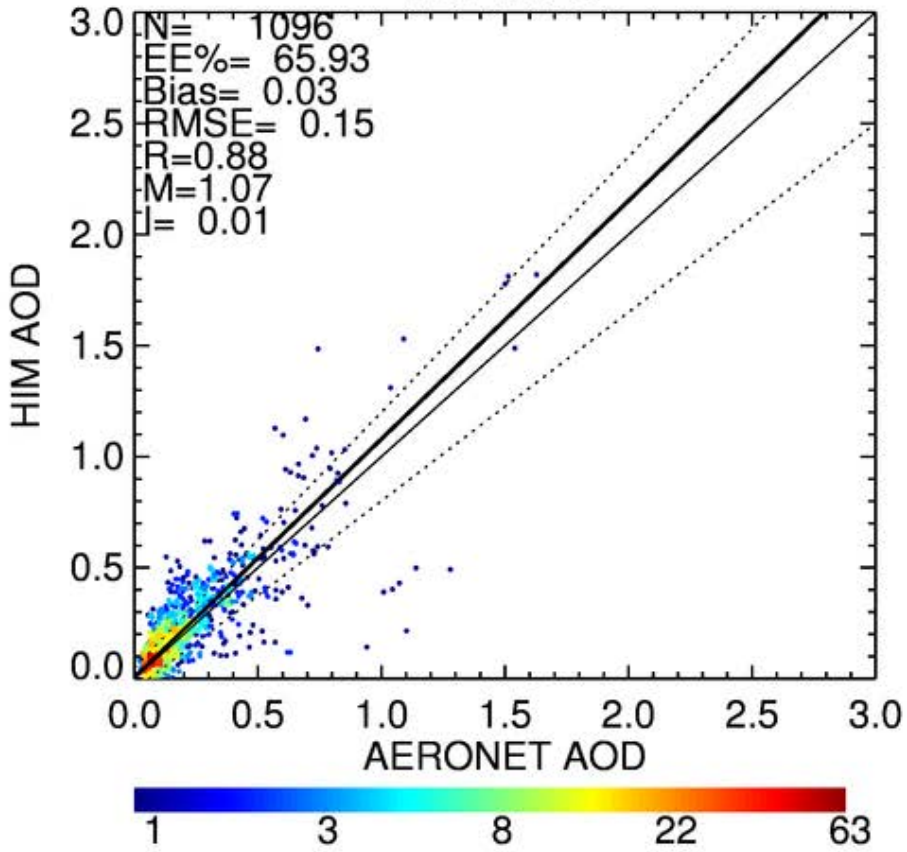


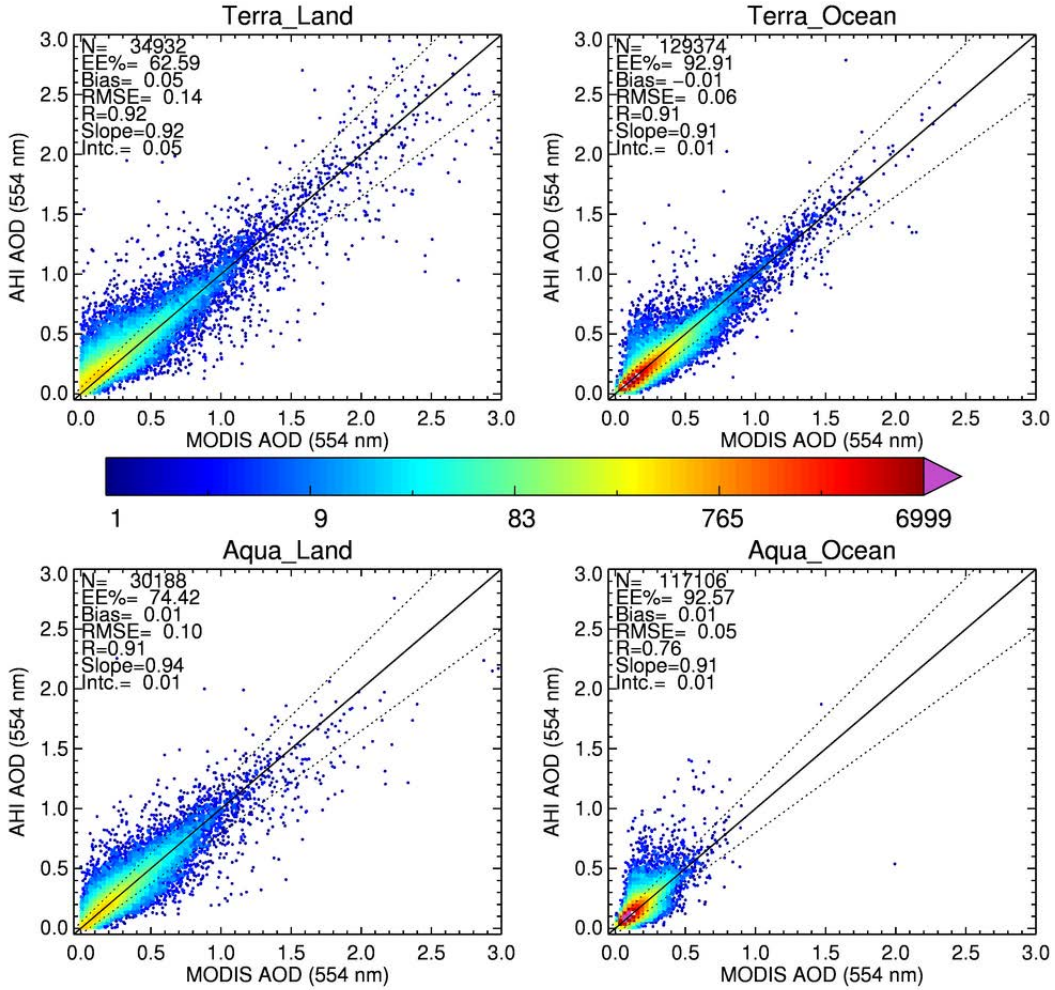


Aircraft Match Temporal variability of the CLAVRx Cloud Top Height



DT AOD Evaluation during CAMPEx





Summery

- Near Real Time AHI observations proved critical for CAMP^{2}EX flight planning, inflight support, and post flight analysis
- With the help of the Worldview team (Ryan Boller and Matt Cechin) a custom version of worldview capable of displaying high temporal resolution geostationary observation was used to visualize the AHI imagery and products.
- Leveraging the AWS cloud for processing and a low latency feed provided by JMA, 20-minute imagery and 25-30 min latency for CLAVERx and aerosol the Dark Target Aerosol product was available in the hanger at Clark
- Using SSEC collocation and compute capabilities post mission merged GEO/LEO cloud and aerosol products are being generated matched to the aircraft flight tracks.
- The aircraft remote sensing and in situ observations combined with the next generation geo-stationary observations provides a unique data set for algorithm development and understanding the information content provided by the high time resolution data provided by next generation geo-stationary observations