Observing Capabilities

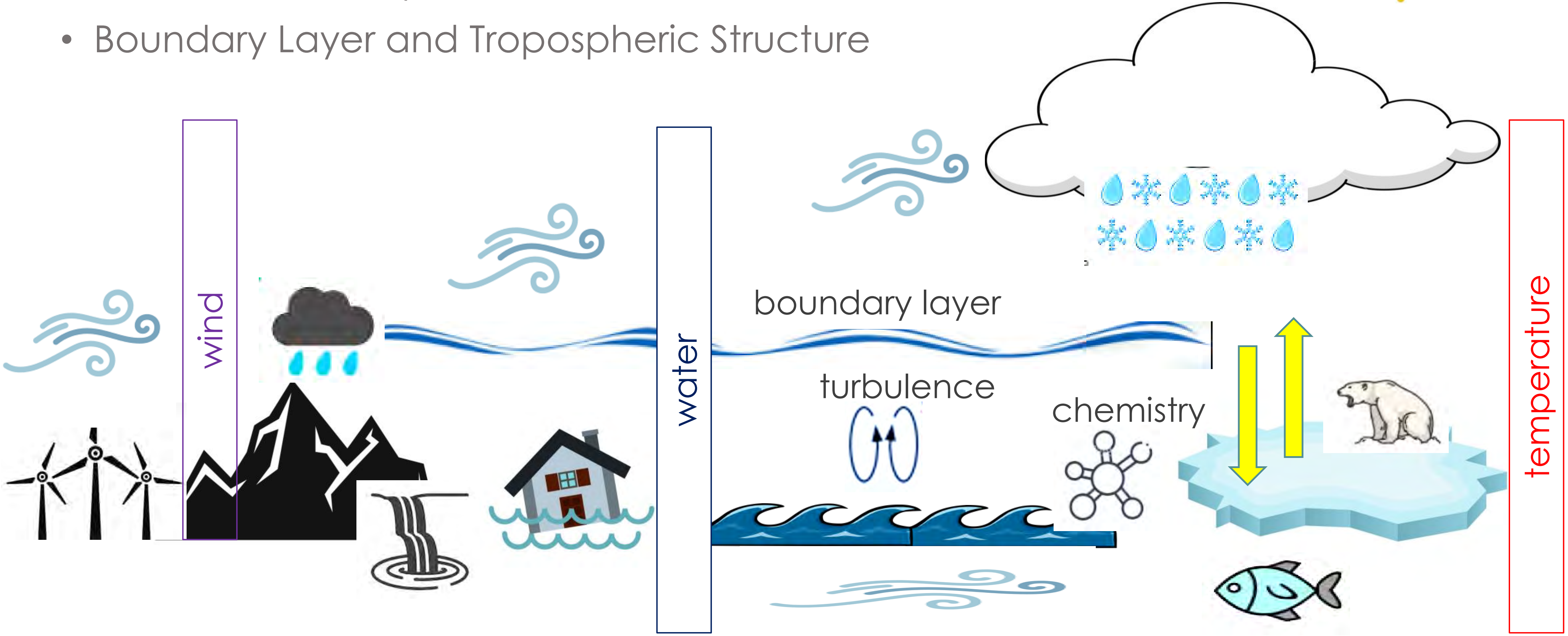
Presenter: Taneil Uttal

Subject Matter Experts: Paul Johnston, Allen White, Alex Voronovich, Chris Fairall, Gijs de Boer

NOAA Physical Sciences Laboratory Review
November 16-20, 2020

What PSL Measures

- Surface Energy Budget
- Clouds and Precipitation
- Boundary Layer and Tropospheric Structure



Observations of Essential Systems:

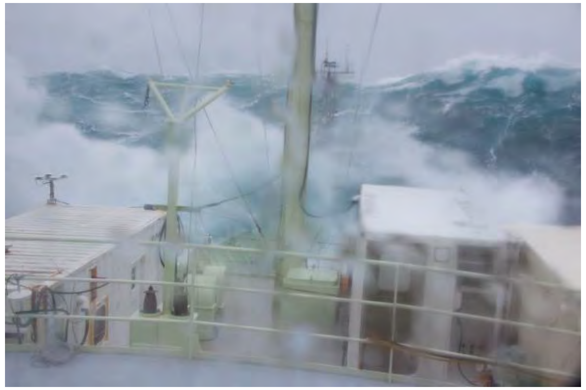
Air-Sea Interactions

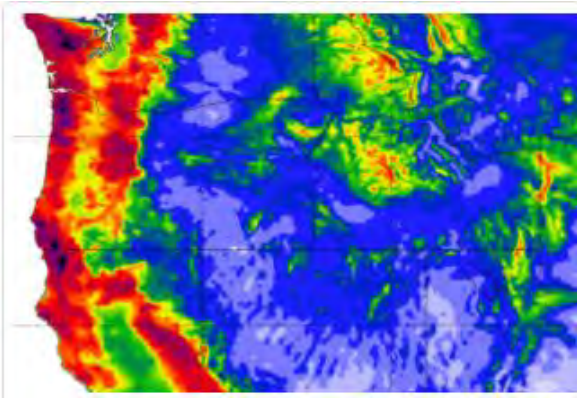
The Arctic System

The Hydrometeorological System

PBL and Tropospheric Structure

Relevant to





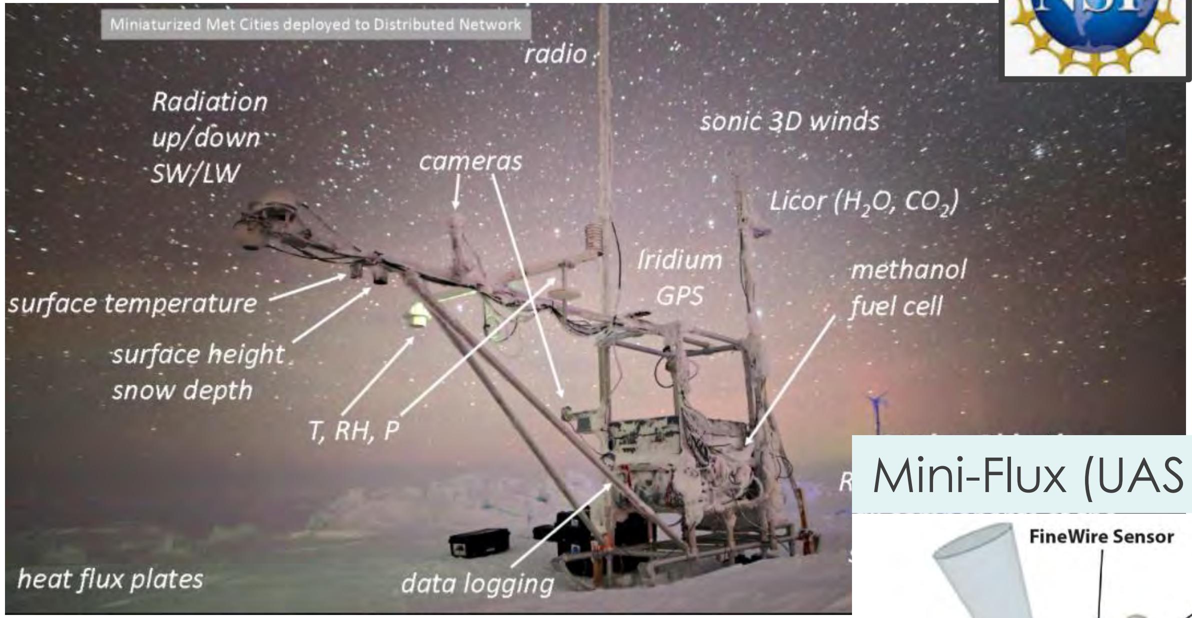
The PSL "Quiver" of Instruments (Remote and In Situ)

- Cloud radars (W-band, K_a band)
- Ocean Surface radar (WSRA, K_u band)
- Precipitation Profilers (pulsed, S band)
- Snow level radar (FM-CW, S band)
- Wind Profilers (449-MHz, 915-MHz)
- Microwave Radiometers
  - 90, 31, 24, 50 GHz
- Sodars
- Ceilometers
- IR Spectrometers
- Cameras
- Acoustic Doppler Current Profiler
- ROSR – Remote Ocean Surface Radiometer
- ASSIST – IR Spectrometer

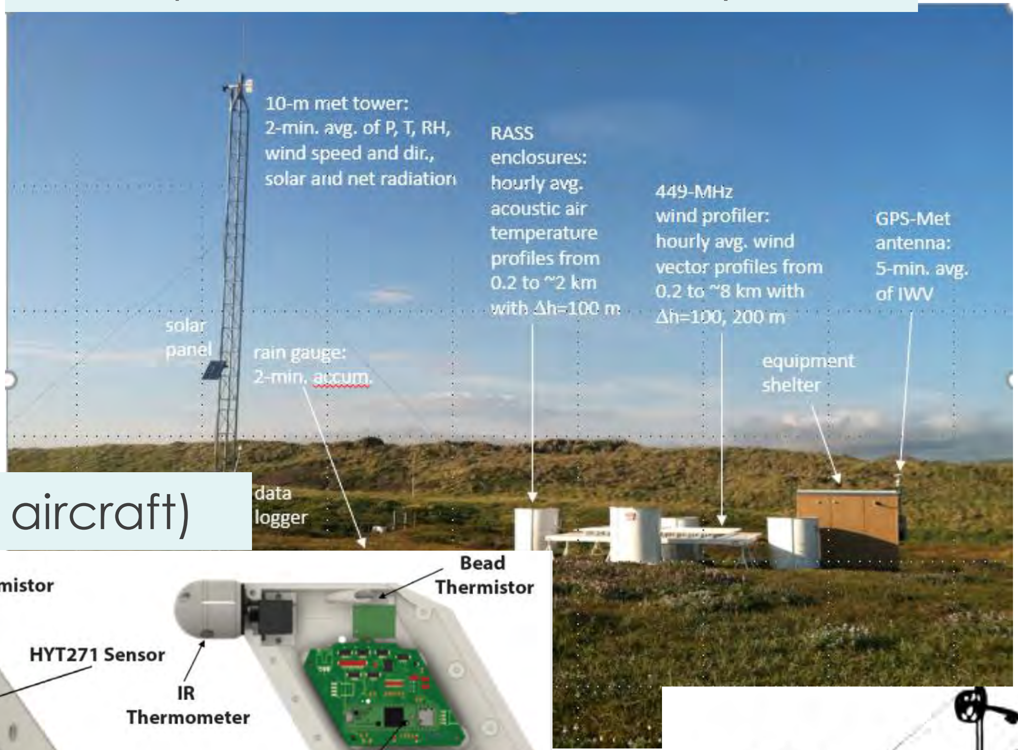
- Met sensors
  - Temperature sensors
  - Sonic anemometers
  - Rain gauges
  - Disdrometers
  - Barometers
  - Hygrometers
- Broadband Radiometers
  - SW global/diffuse/direct radiation
  - LW radiation
- Radiosonde Systems
- Soil Sensors
  - Moisture
  - Heat Flux Plates
  - Temperature
- Ocean
  - Sea Surface Temperature
  - Temperature
  - Salinity
- Navigation and Stability systems
- Gases (CO_2, O_3, CH_4, H_2O, C_2H_6S, CH_3OH, $C_2H_2O_2$)

PSL bundling suites of instruments into integrated systems

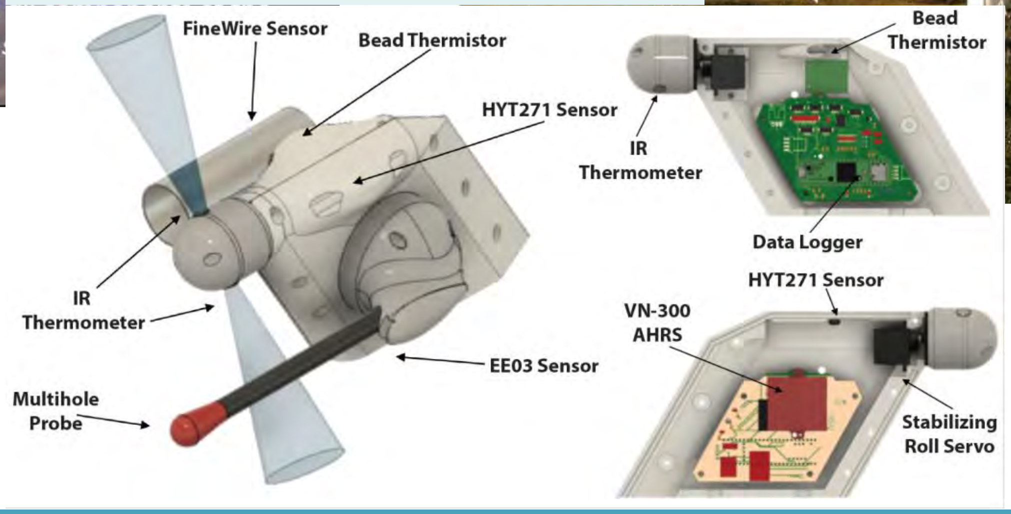
Atmospheric Surface Flux Station



Atmospheric River Observatory



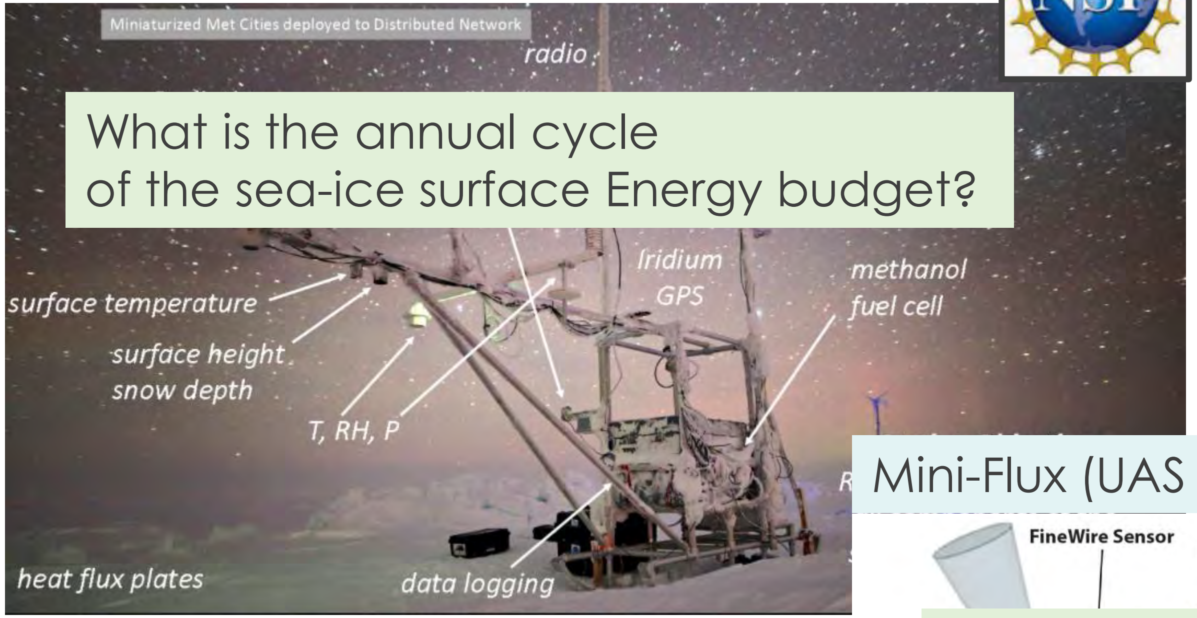
Mini-Flux (UAS and aircraft)



The whole is greater than the sum of its parts.
- Aristotle

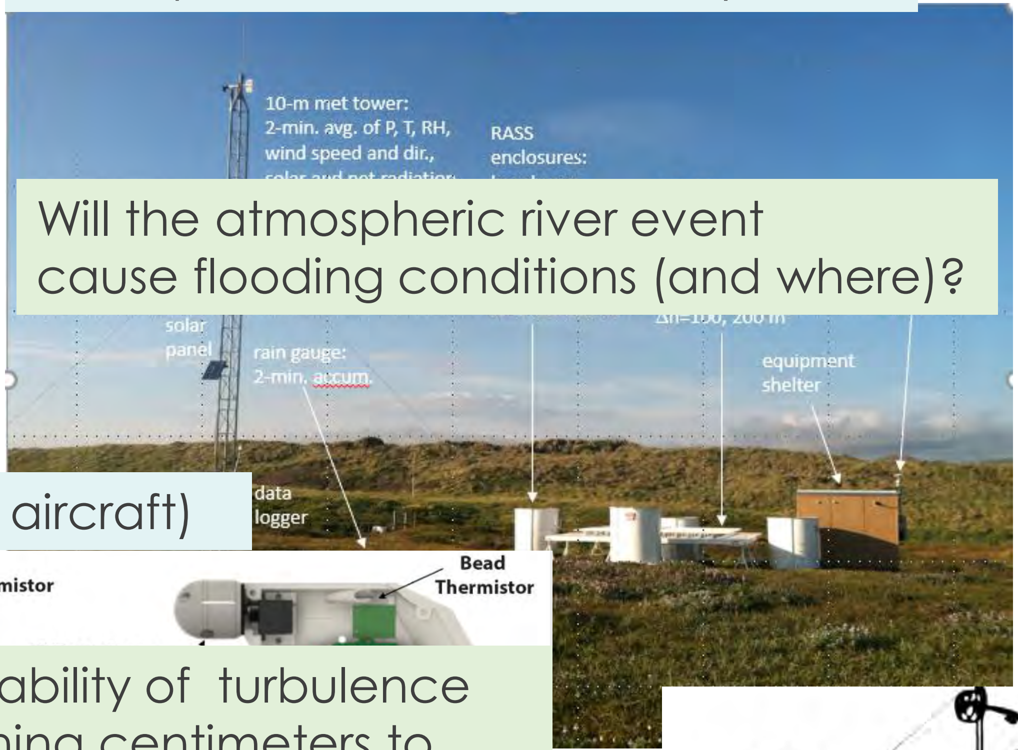
PSL bundling suites of instruments into integrated systems

Atmospheric Surface Flux Station



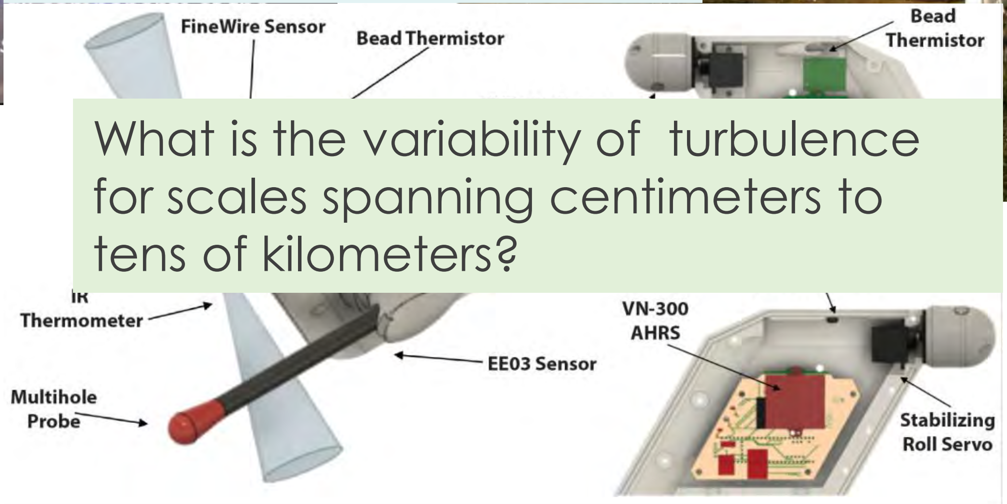
What is the annual cycle of the sea-ice surface Energy budget?

Atmospheric River Observatory



Will the atmospheric river event cause flooding conditions (and where)?

Mini-Flux (UAS and aircraft)



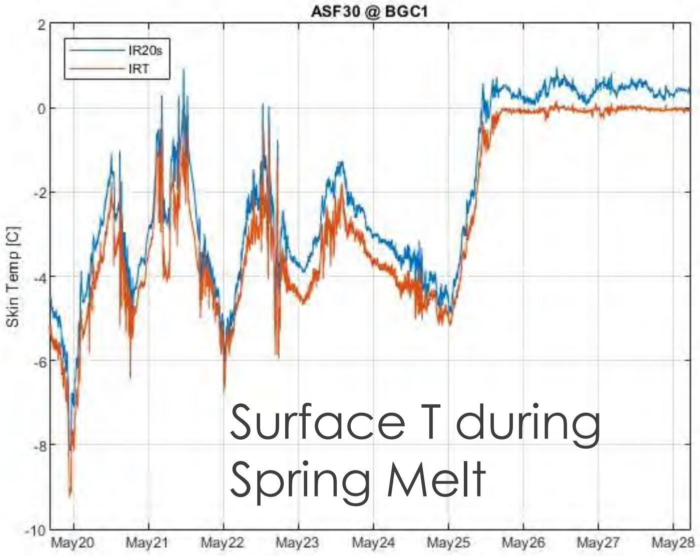
What is the variability of turbulence for scales spanning centimeters to tens of kilometers?

The whole is greater than the sum of its parts.
- Aristotle

CIRES IRISS INTEGRATED REMOTE & IN SITU SENSING

Types of data collected:

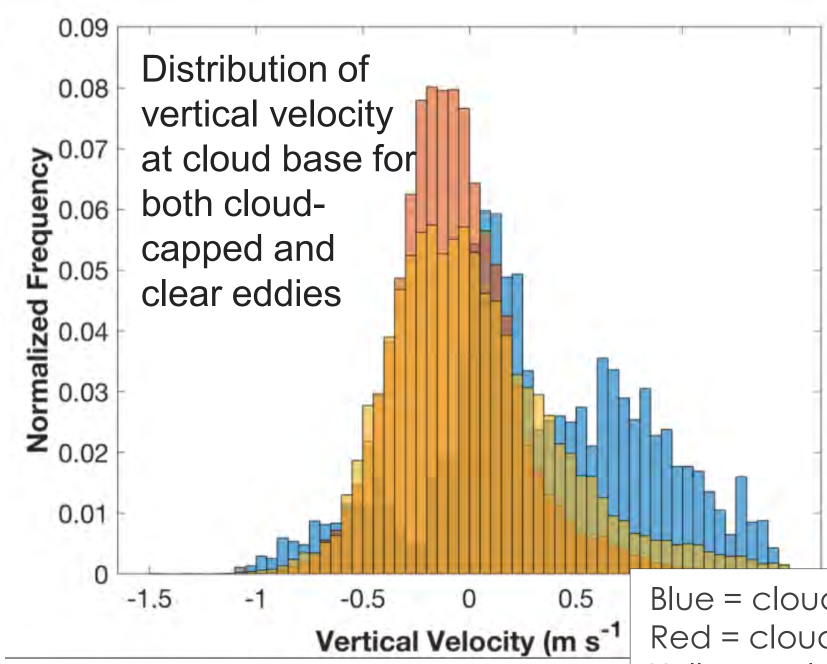
Automated Surface Flux Station



T, RH, P, u,v,w, SW(↑↓), LW (↑↓), Tsfc, GHF, H_2O, CO_2, gps, snow depth, images, turbulent fluxes

T, RH, P, IRT(↑↓), gps + multiple position and air speed variables, u,v,w, turbulent fluxes

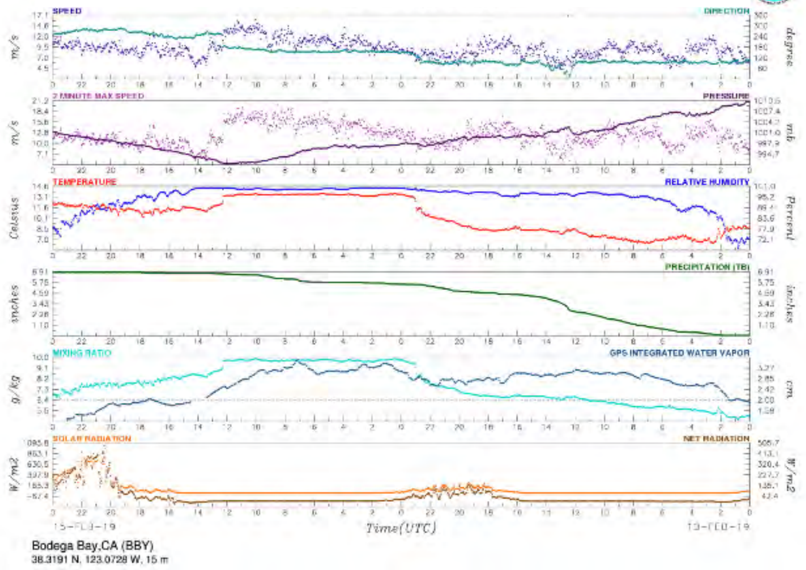
Mini-Flux



Blue = cloudy 0-500 m
Red = cloud free at 500 m
Yellow = cloud free < 200 m

Atmospheric River Observatory

PSL Meteorology and Physics



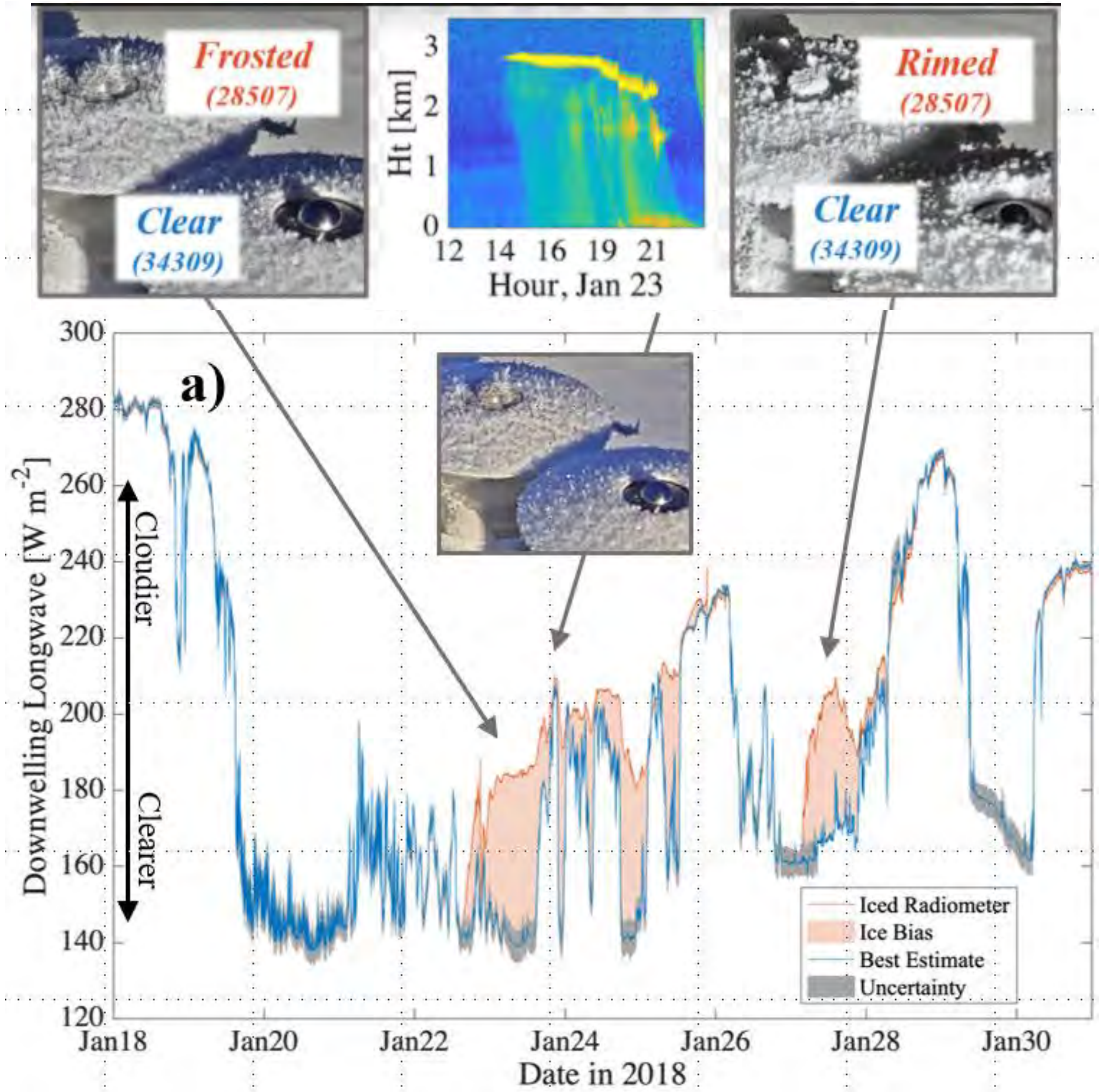
T(z),T, RH, P, r, u,v,w, SW(↓), LW (↓), IRT, RR, SW and LW flux, IWV (gps)

Observation Science: Advances in Measurement Strategies

Purpose: To evaluate existing ventilation and heating technologies developed to mitigate radiometer icing.

D-ICE

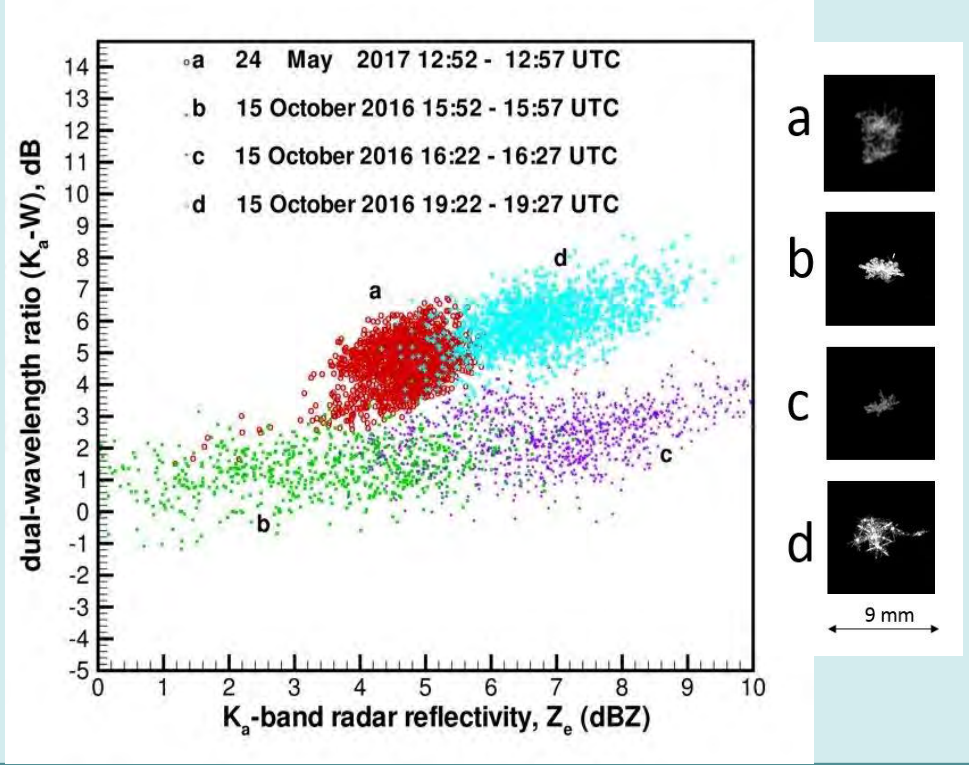
This activity was initiated during a Workshop of the Baseline Surface Radiation Network (BSRN) in the Cold Climate Issues Working Group and executed in coordination with GML



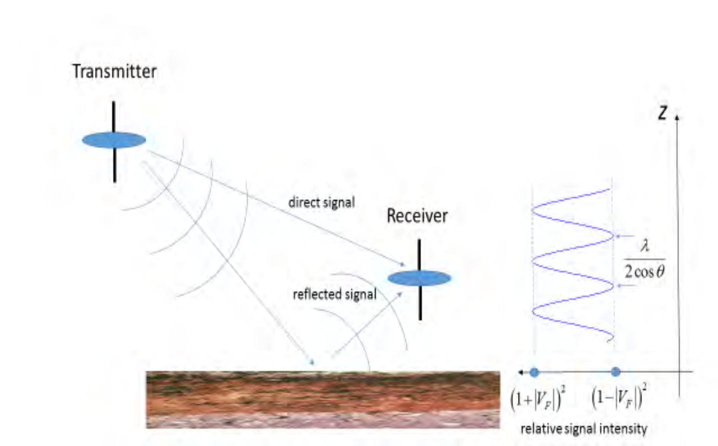
PSL Specializes in Retrievals

The science of 'modeling' measurements to obtain higher order geophysical variables

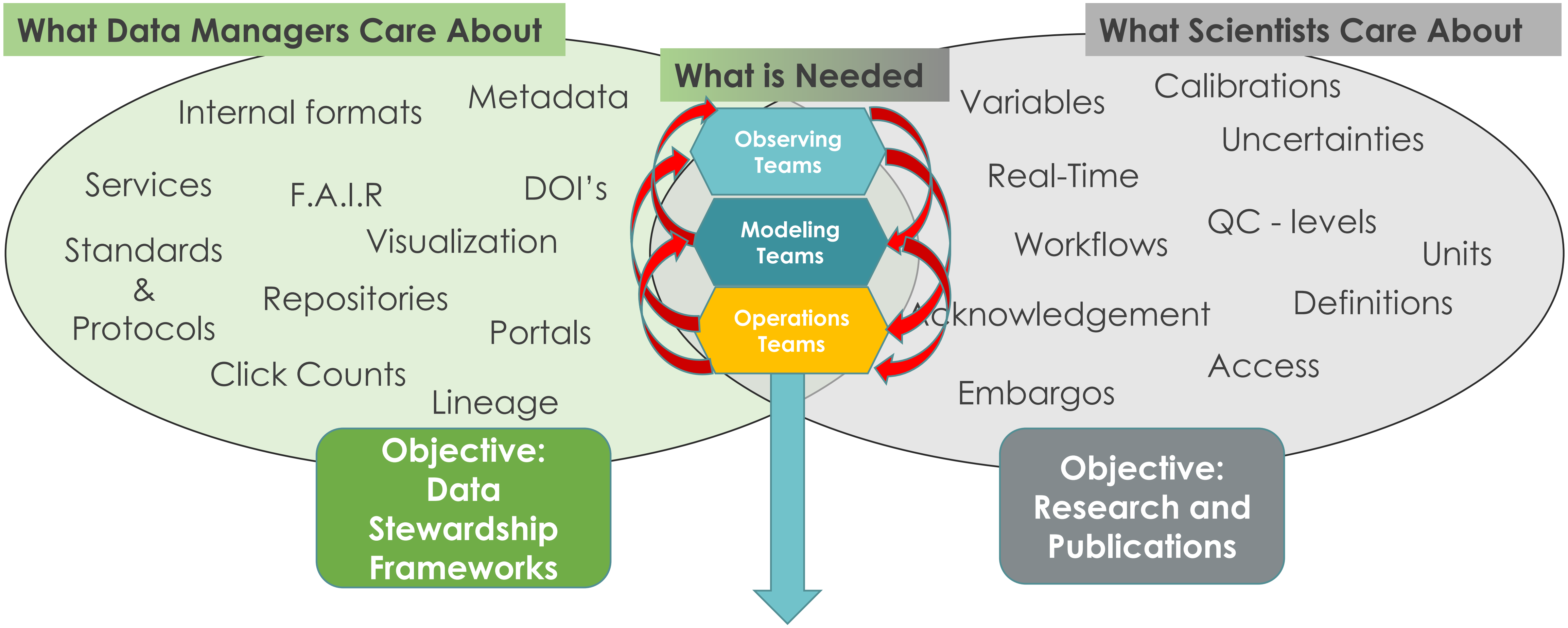
For Example: The use of vertically pointing dual-wavelength radar measurements to infer ice hydrometeor shape



For example: the use of angular- and frequency dependencies of the reflection coefficient to obtain soil moisture



Advancing Observing Data Stewardship



Promote an advanced level of data usability and interoperability to expedite research and predictive services

Publication and Developing Metadata for Observational Data Sets

Publishing in journals such as ESSD

Earth Syst. Sci. Data, 10, 1139–1164, 2018
https://doi.org/10.5194/essd-10-1139-2018

Open Access Earth System Science Data

Central-Pacific surface meteorology from the 2016 El Niño Rapid Response (ENRR) field campaign

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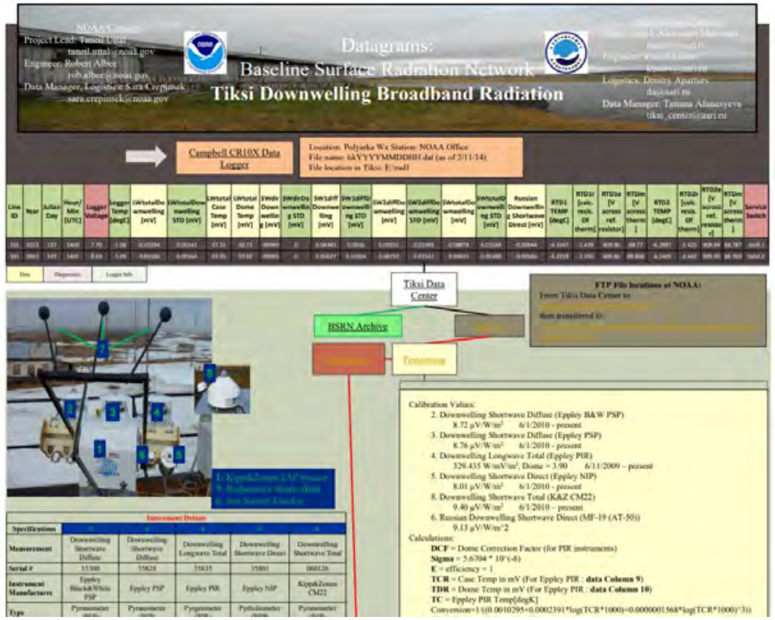
Revised: 23 April 2018 – Accepted: 30 May 2018 – Published: 20 June 2018

Abstract. During the early months of the 2015/2016 El Niño event, scientists led by the Earth System Research Laboratory's Physical Sciences Division conducted the National Oceanic and Atmospheric Administration's (NOAA's) El Niño Rapid Response (ENRR) field campaign. One component of ENRR involved in situ observa-

Data Set DOI assignments

Novel Metadata Methods - Datagrams



PSL Data Curatorship - https://psl.noaa.gov/data/index.html

Home » Data

Data and Imagery

PSL archives a wide range of data ranging from gridded climate datasets extending hundreds of years to real-time wind profiler data at a single location. The data or products derived from this data, organized by type, are available to scientists and the general public at the links below.

Resources

Help

The third party data appearing on this web site may be reformatted from their original form, but not altered as to the informational content contained therein. It is provided as a public service. Further, this data does not reflect an official view or position of NOAA.

Climate

- Gridded Climate Data
- Climate Model Simulations (FACTS)
- Reanalysis Datasets
- Atmospheric/Ocean Timeseries
- 20th Century Reanalysis Project

Cloud Profiling Radars

- North Slope of Alaska
- NOAA Observatory at Eureka, Canada
- Summit, Greenland Station
- Surface Heat Budget of the Arctic Ocean

Air-Sea & Air-Land Fluxes

- Arctic Observatories
- Research Cruises
- Working Group on Surface Fluxes

Wind Profiling Radars

- Tropical Wind Profiler Data
- Profiler Network Data & Images

Satellite

- Real-Time Satellite Imagery
- Archived Images and Data

Local Weather and Climate

- Boulder, CO Weather Information and Data

Observing Highlights – Air Sea Interactions

The sequel to the famous COARE Algorithm is the COAREG ALGORITHM

PSL and collaborators have pioneering direct observations of trace gas fluxes over the open ocean

$$F_x = \overline{w'x'} = \alpha_x k_x [X_w / \alpha_x - X_a]$$

w' turbulent vertical velocity fluctuation
x' turbulent concentration fluctuation
α_x solubility of gas x in seawater
k_x transfer velocity of gas x between seawater to air
X_w mean mass concentration of gas in water at reference depth
X_a mean mass concentration of gas in air at reference height

Flux=Measurement=Parameterization (COAREG)

Sonic anemometer>Motion>Coordinate>Distortion>w'
Fast gas analyzer>Dilution correct>crosstalk correct>x'

(Based on 30,000 hours of data)

Table 1. First open ocean measurement. All by PSL-Collaborator.

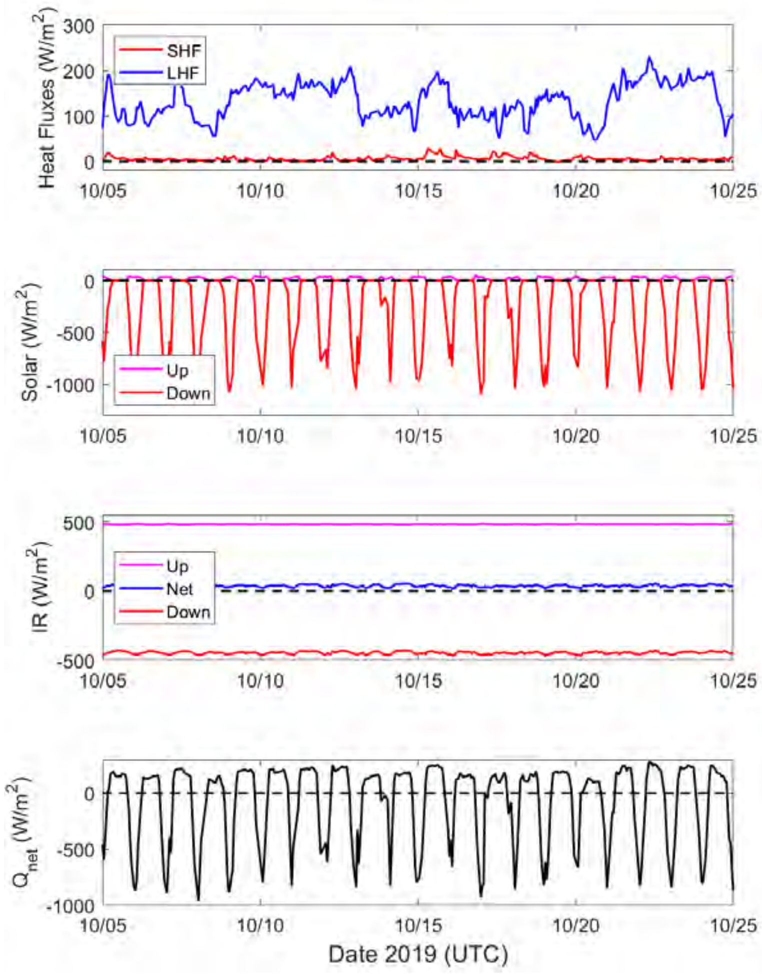
Year	Gas	Reference
1998	CO2	McGillis et al. 2001
2003	Dimethyl Sulfide	Huebert et al. 2004
2006	Ozone	Bariteau et al. 2010
2010	Methane	CALNEX
2011	CO	Blomquist et al. 2012
2012	Glyoxol	Coburn et al. 2014
2012	Methanol	Yang et al. 2013
2013	Acetone	Yang et al. 2013
2019	Several	MOSAIC

Observing Highlights – Air Sea Interactions

Near Real-Time Delivery

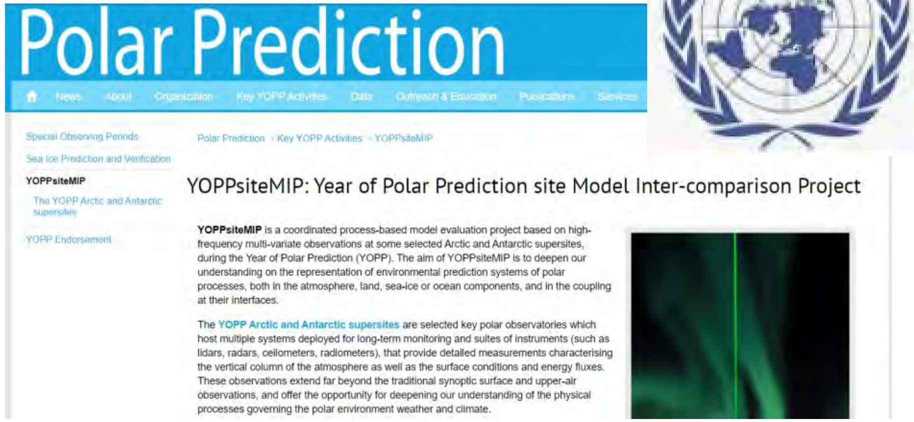
Direct Covariance Surface Stress and Buoyancy Fluxes, Radiative Fluxes, Bulk Momentum, Sensible and Latent Heat Fluxes, Net Heat Flux, Near Surface Currents, Ocean Current Profiles

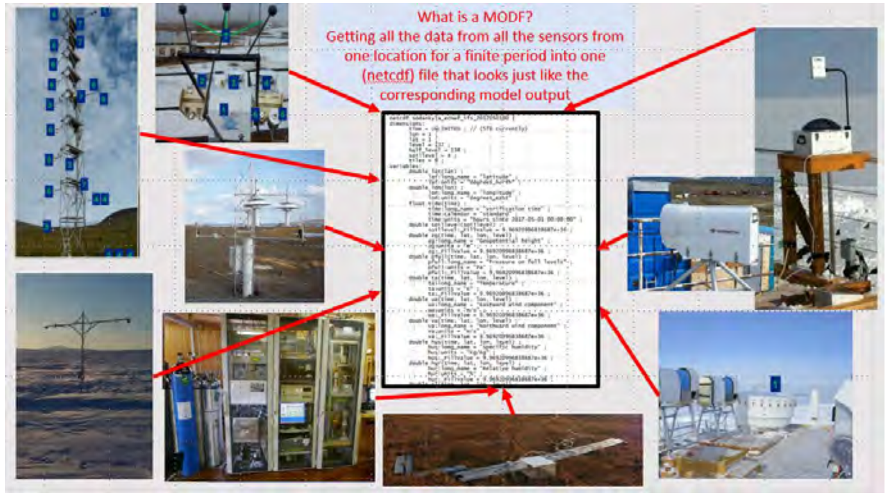
PSL Contributions to WHOI Buoy Development



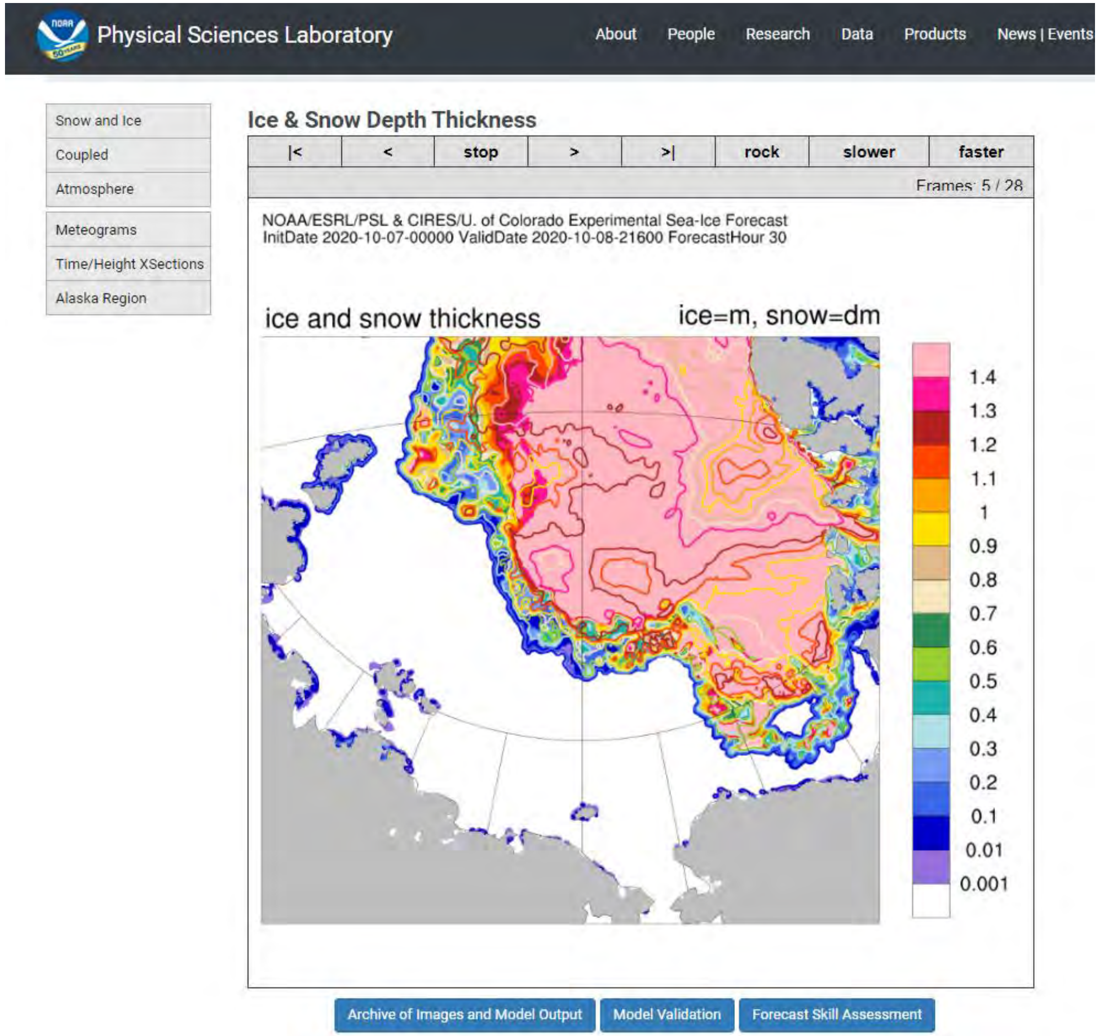
Observation Highlights – The Arctic System

YOPPsiteMIP

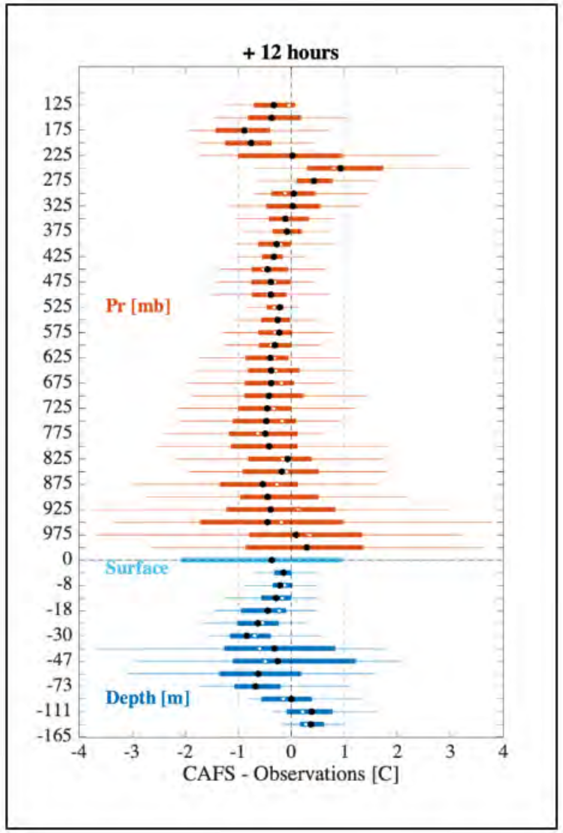


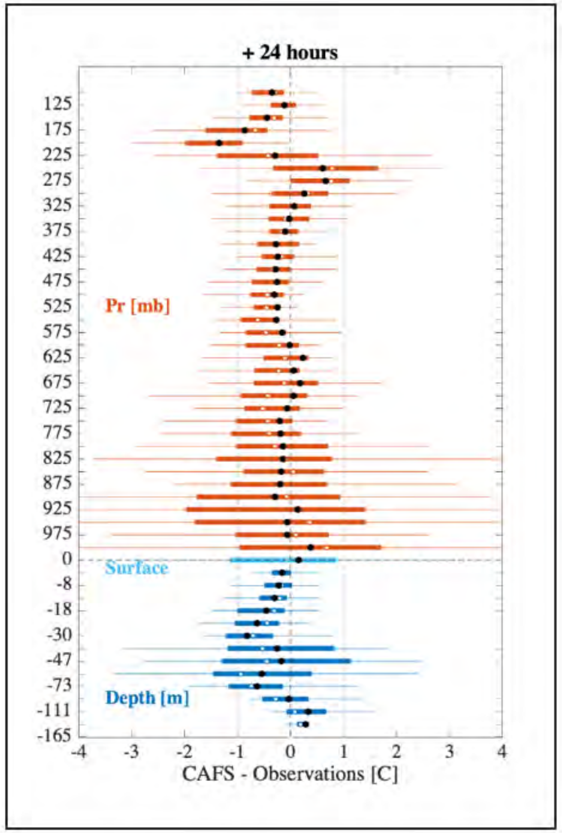


Observation Highlights – The Arctic System



Developing a sea-ice forecasting model based on observation based physics and verification

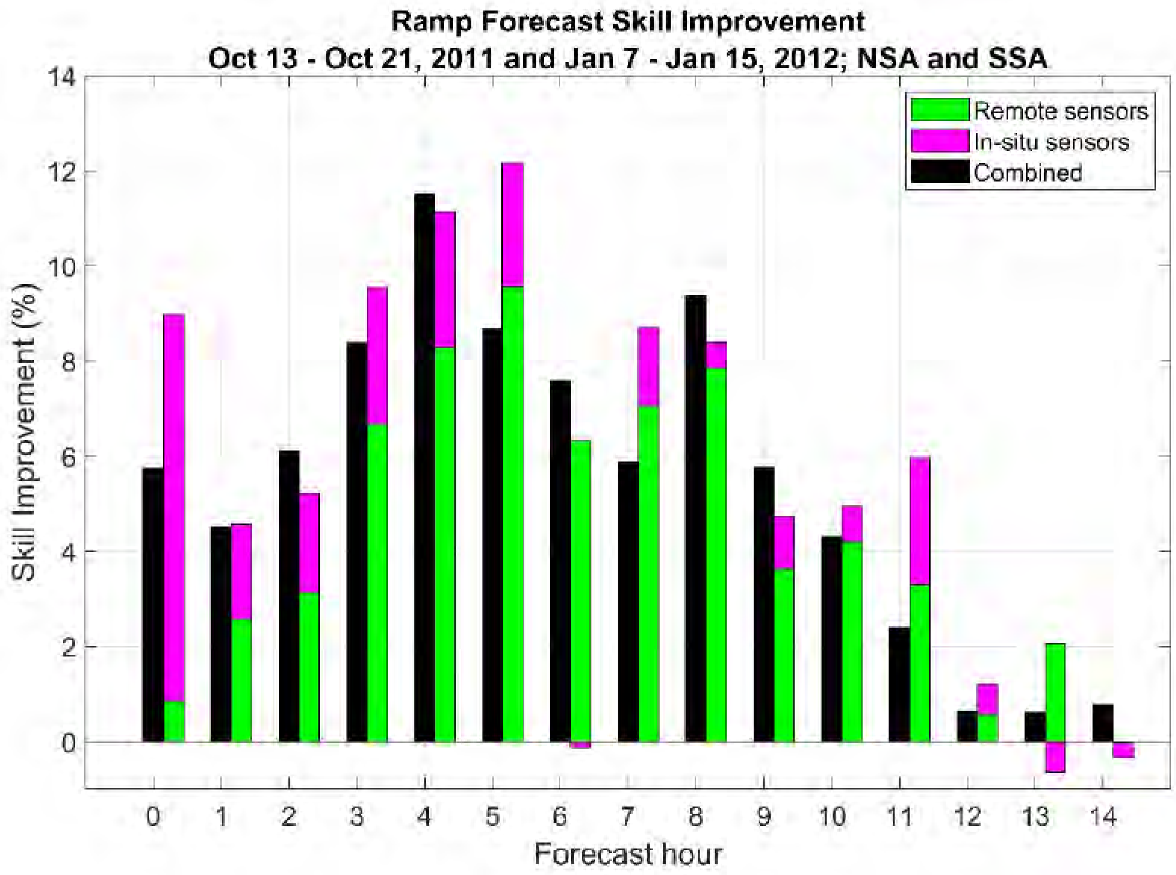




Observing Highlights – Wind Resources

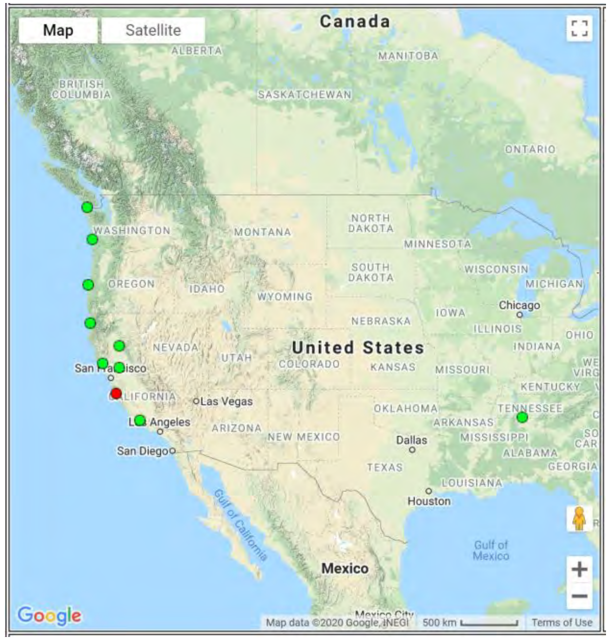
Reducing the Cost of Wind Energy by Improving the Forecasts

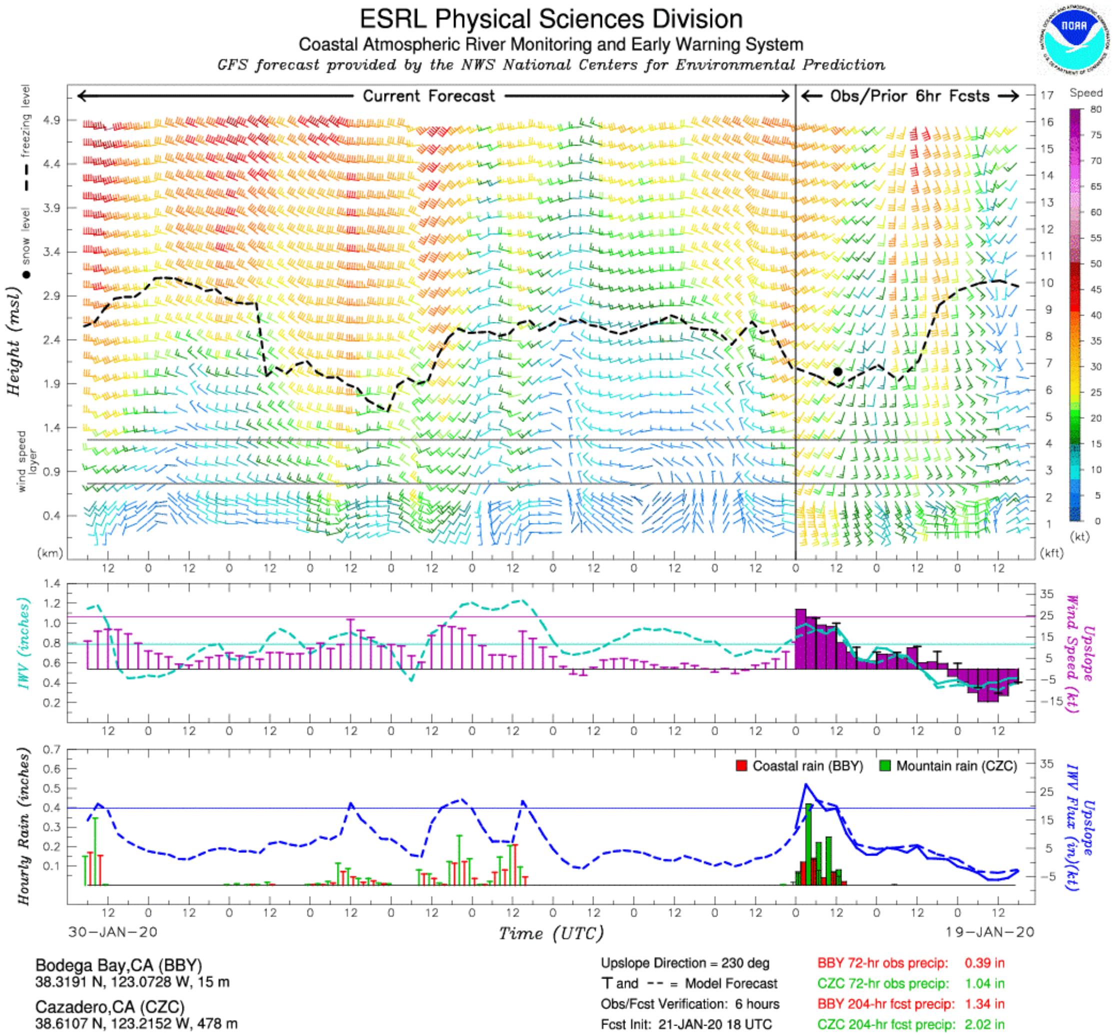
Measuring the impact of additional instrumentation on the skill of numerical weather prediction models at forecasting wind ramp events



Observing Highlight - Hydrometeorology

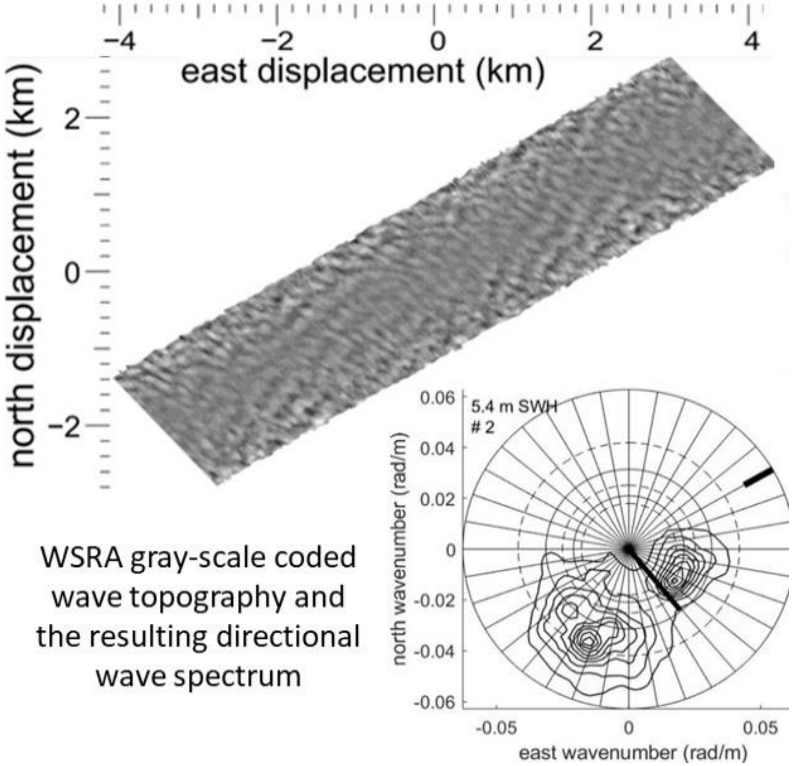
PSL's award-winning water vapor flux product: One of the most important parts of the water vapor flux tool is that it combines model output with real-time and past observations so that forecasters can judge how well models are portraying weather events.





Observations Supporting S2S and Extremes Science

PSL Wide Swath Radar Altimeter (WSRA) observing real-time mapping of hurricane ocean wave fields



WSRA gray-scale coded wave topography and the resulting directional wave spectrum

Hurricane Lorenzo 2019

Operations from the NOAA Hurricane Hunter

Observations Supporting Water Resource Management

PSL ARO Observing ASSETS

- S-PROF (pulsed S-band radar) - **5**; all in California and all owned by PSL.
- SLR (FMCW S-band radar) - 11; all in California. 10 owned by CA, **1** owned by PSL.
- 915-MHz wind profilers - **2**; both in California. Both owned by PSL.
- 449-MHz wind profilers - **9**; 4 in California owned by CA. 2 in OR, 1 in WA, 1 in CO, and 1 in AL (all owned by PSL).
- Disdrometers (impact) - **2**; both in California and both owned by PSL.
- Disdrometers (optical): **3**; all in California and all owned by PSL.
- Soil temp/moisture stations: 49; 45 in California all owned by CA, **4** in AZ owned by PSL.
- Tipping bucket rain gauges: **61**; 53 in California mostly owned by CA. 4 in AZ, 2 in OR, 1 in WA, and 1 in AL (**8** owned by PSL).
- Heated tipping bucket rain gauges: **9**; 7 in California mostly owned by PSL. 2 in CO owned by PSL.
- Surface Met (P, T, RH, WS, WD): **60**; 48 in California mostly owned by CA. 5 in OR, 3 in WA, 2 in CO, 1 in NV, 1 in AL (mostly owned by UNAVCO as part of the Plate Boundary Observatory).
- GPS Met (integrated water vapor): **61**; 48 in California owned by CA and UNAVCO. 5 in OR, 3 in WA, 2 in CO, 1 in NM, 1 in NV, and 1 in AL (mostly owned by UNAVCO as part of the Plate Boundary Observatory). GPS-Met data is processed to produce IWV by a contract between NWS and Earth Networks. Formerly this was done in Boulder by GSL with collaboration from Scripps.

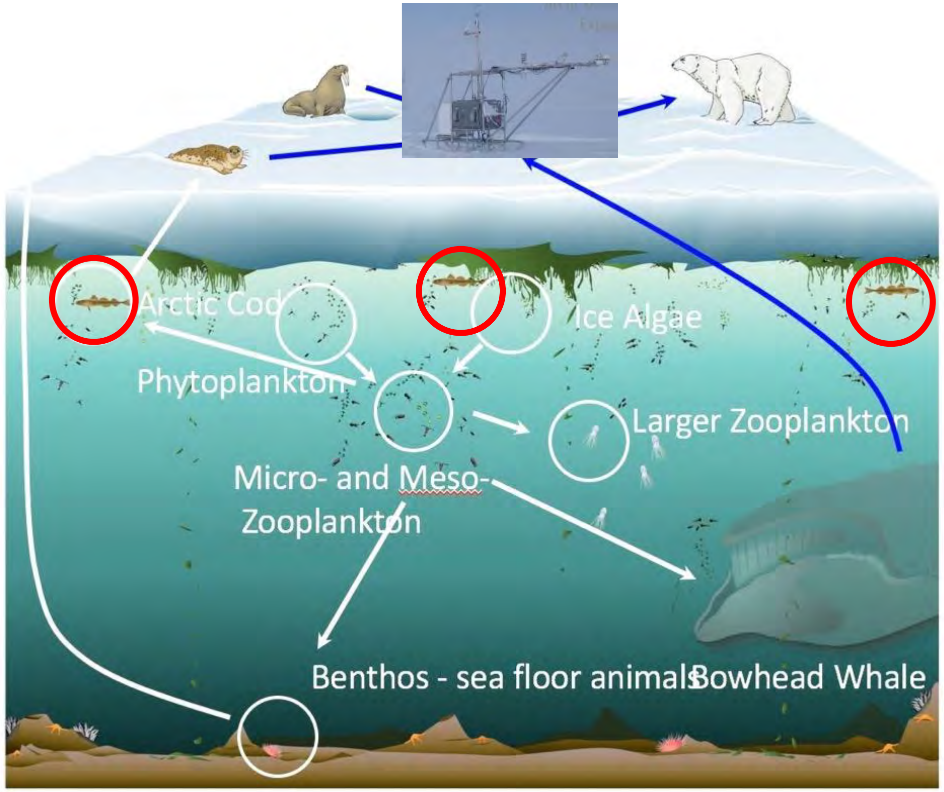
Heavy precipitation during 2–11 Feb 2017 resulted in excessive runoff into Lake Oroville, leading to the Oroville Dam incident

Observations Supporting Marine Resources Management Science

THE BLUE ECONOMY IN COLD PLACES

International Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean
Providing the environmental intelligence to support policy

MOSAiC International Arctic Drift Expedition → PSL →

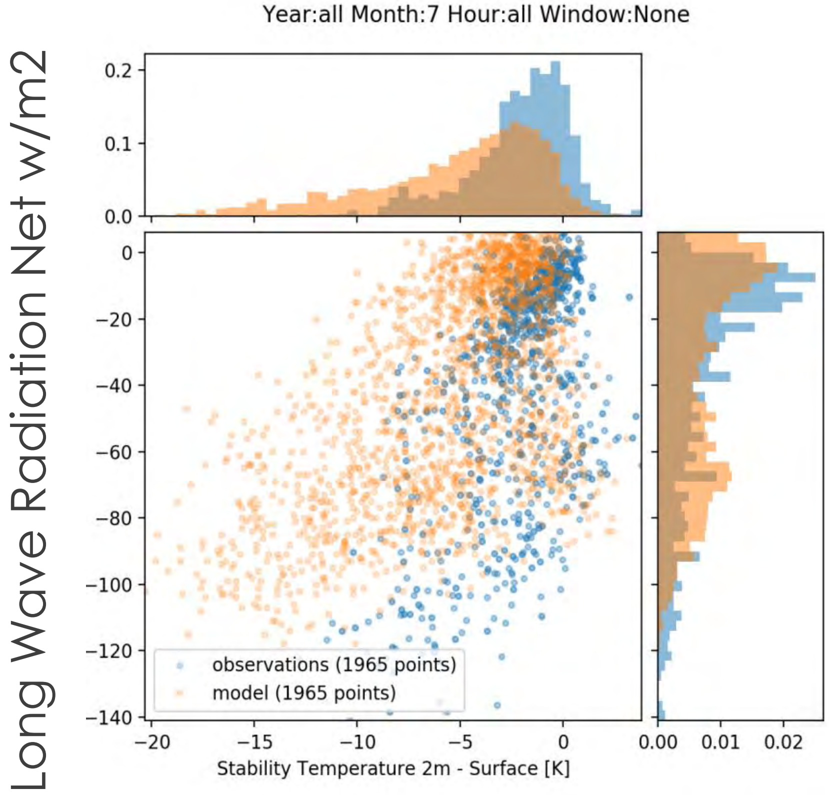


Operations in the Central Arctic Ocean

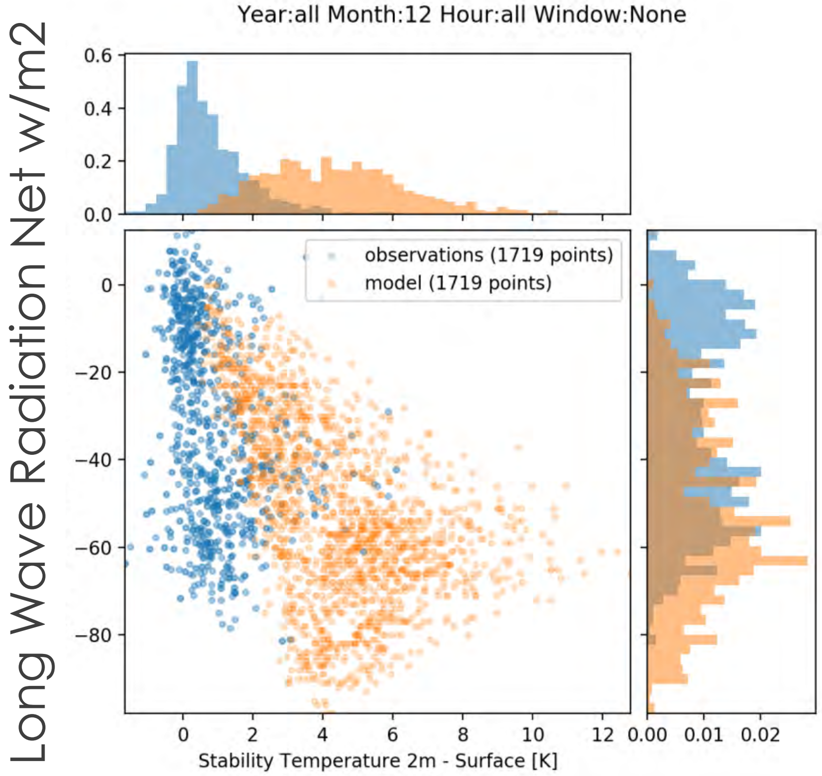
Looking Forward: Process Oriented Diagnostics

Seasonal Relationship between Scaled Sensible Heat Flux and Net Longwave Surface Radiation in BM3

Much less cloud cover in winter than observations and too much in summer (net longwave close to zero).



UFS Bench Mark Run 3 (July)



UFS Bench Mark Run 3 (December)

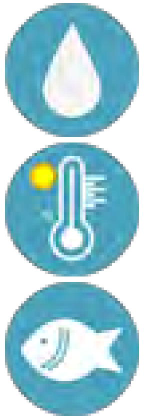
Looking Forward: A Bering Sea Observing System

Arctic Boundary as defined by the Arctic Research and Policy Act (ARPA)

All United States and foreign territory north of the Arctic Circle and all United States territory north and west of the boundary formed by the Porcupine, Yukon, and Kuskokwim Rivers; all contiguous seas, including the Arctic Ocean and the Beaufort, Bering and Chukchi Seas; and the Aleutian chain.[1]

The Bering Sea is a prime location for improved understanding of atmosphere-ocean-sea-ice processes that impact both marine ecosystems and weather forecasting for Alaska and the lower 48.

Summary: Observation-based process understanding



- Science questions drive the development of observing systems
- Observations need to answer the ‘why’ not just the ‘how’ to develop physics based understanding
- Understanding of complex, coupled processes requires measurements of the individual components of the coupled system
- Observations of sub-grid scale processes are necessary for proper representation in models
- Process level observations challenge models to get the right answers for the right reasons