



POLAR SATELLITE DATA FOR HYDROLOGIC APPLICATIONS IN ALASKA

11/19/19

Filling The Observation Gaps

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OUTLINE

- Observation deficiencies in Alaska
- Polar Satellites & Sensors
- Direct Broadcast
- Product Examples

GEOGRAPHIC INFORMATION NETWORK OF ALASKA (GINA)

- GINA's Near Real-time system became operational in Oct 2015.
 - Polar satellite products for NWS Advanced Weather Interactive Processing System (AWIPS)
 - GIS polar products (GeoTIFF):
 - Alaska Sea Ice Program (ASIP).
 - Alaska Fire Service (AFS)
 - Raw data feeds:
 - Alaska Volcano Observatory (AVO)
 - Other partners
- GINA provides access and support to state of the art products developed by partners (CIMSS, CIRA, SPOrT, GMU, CCNY, etc).



GINA is part of the UAF Geophysical Institute (GI) located on the Fairbanks campus. This photo shows the Akasofu (left) and the Elvey (right) buildings where offices for the GI and the International Arctic Research Center (IARC) are located.

ALASKA ABOUNDS IN SHORT-FUSED NATURAL HAZARDS

Often involving water (or the lack of it) in some form or another



Sea Ice Movement



Avalanches



Volcanic Ash



River Ice Jam Flooding



Forest Fires



Coastal Storm Floods

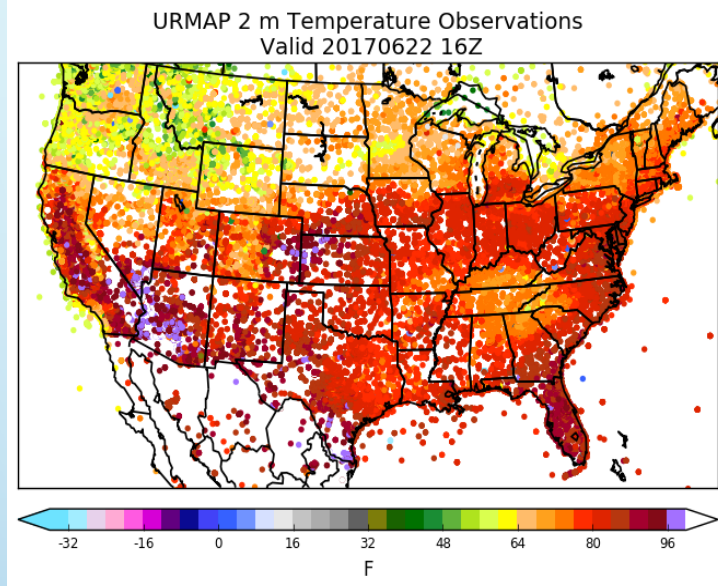
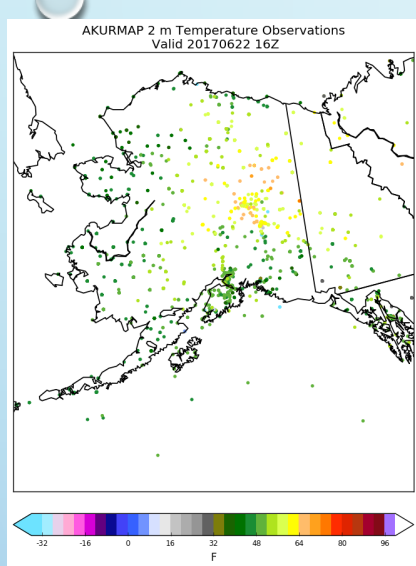


Smoke & Air Quality

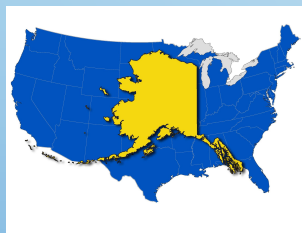


Heavy Precipitation

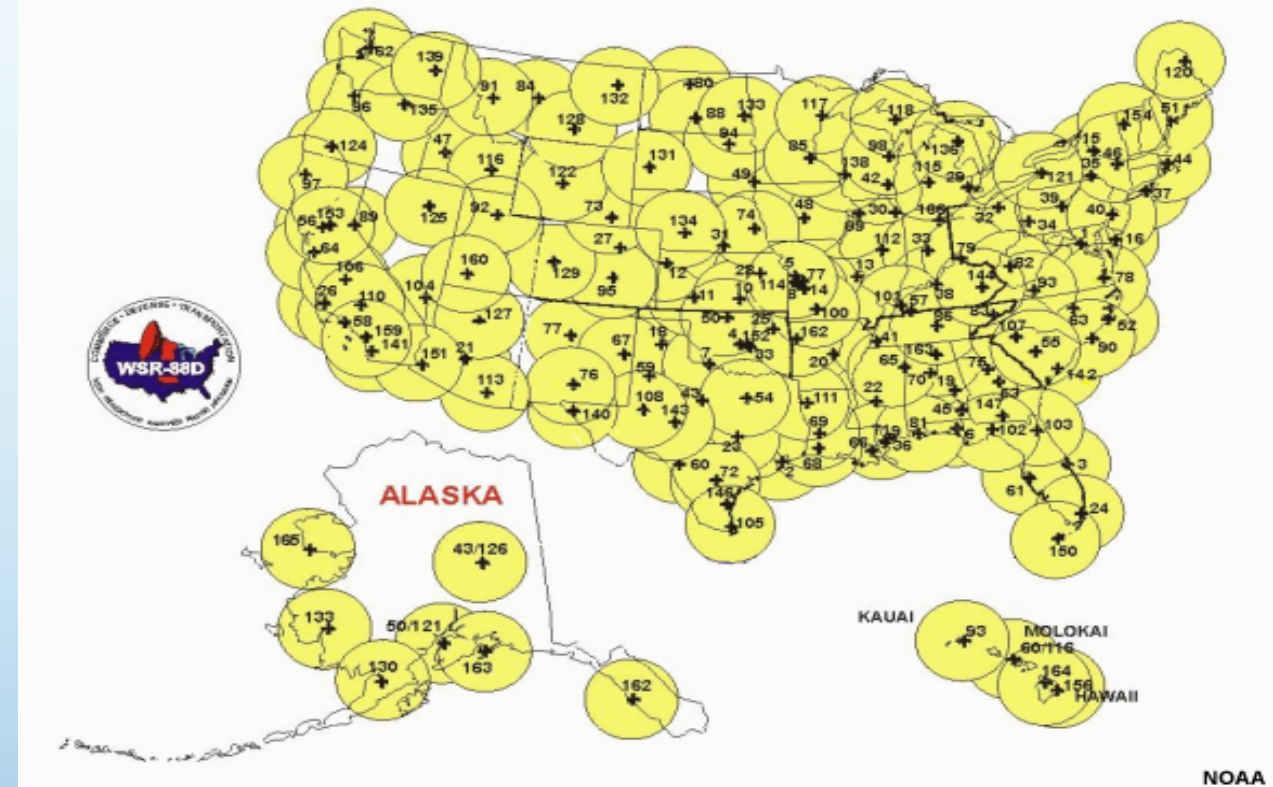
ALASKA: "THE GREAT LAND" – FEW OBSERVATIONS



Surface temperature observation density - Alaska vs CONUS



Locations of WSR-88D Radars with the idealized 230-km Coverage Areas

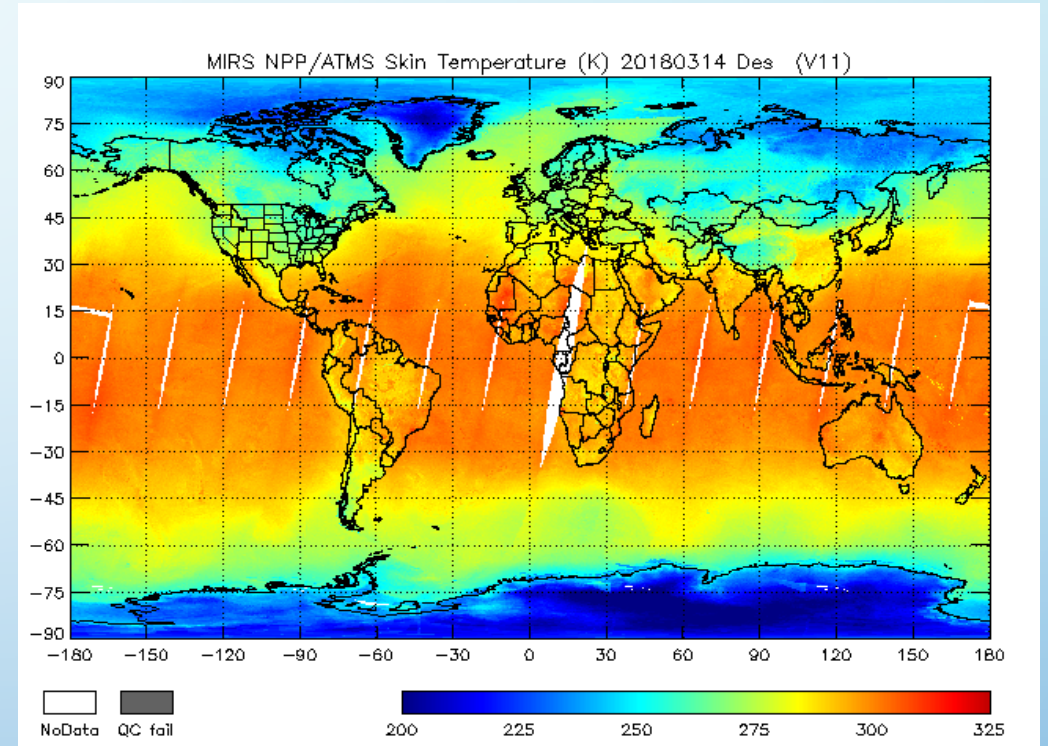


Radar coverage - Alaska vs CONUS

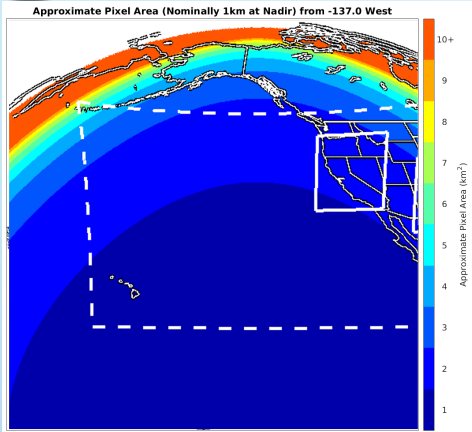
Satellite data helps to fill the void, but quick access is critical!

POLAR AND GEOSTATIONARY SATELLITE ORBITS

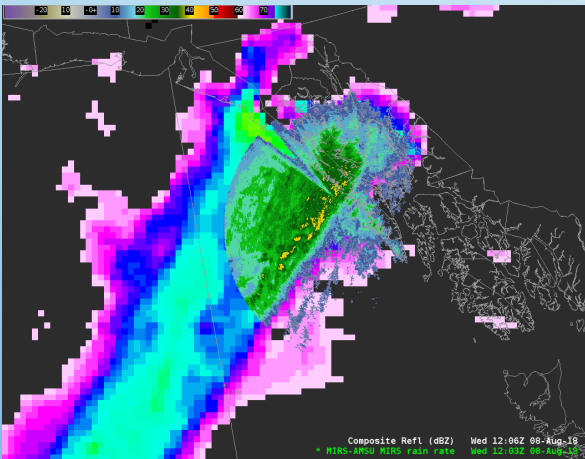
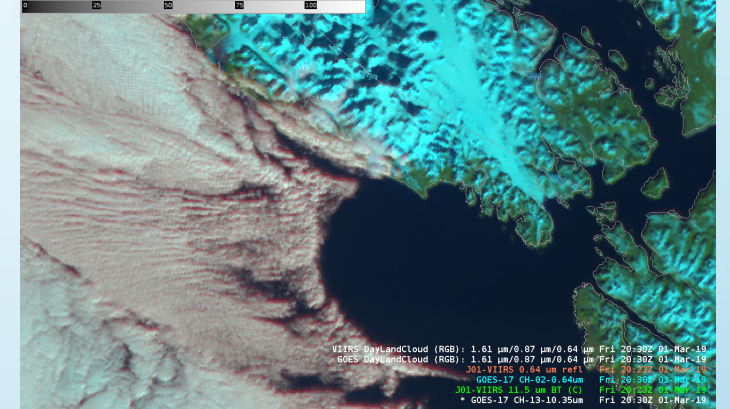
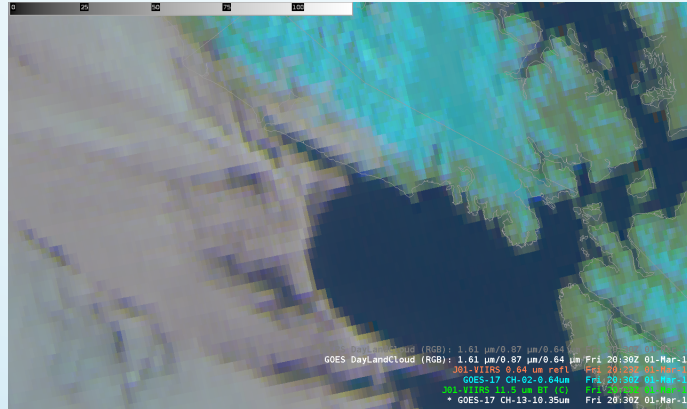
- Geostationary – follows the earth’s rotation at a point above the equator (GEO):
 - fixed position relative to the earth.
 - High image frequency (10 min to 30 secs).
 - Altitude \approx 35500 km (22000 mi).
- Polar – passes over polar regions from north to south in “low earth orbit” (LEO).
 - “Sun-Synchronous” - passes over a region at the same time of day
 - Scans entire earth twice per day (ascending & descending)
 - Much higher resolution than GEO.
 - Altitude \approx 1360 km (850 mi)



POLAR SATELLITE ADVANTAGES IN ALASKA

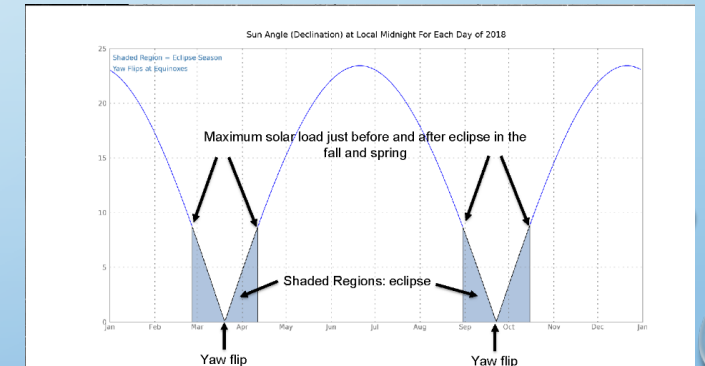


GOES resolution decreases exponentially across Alaska. GOES parallax & limb-cooling increases.



Microwave sensors only on Polar satellites. Rain Rates help fill gaps in radar & surface observations.

GOES-17 Loop Heat Pipe Malfunction: Polar satellite data mitigates GOES data loss during eclipse outages.



MULTIPLE POLAR SATELLITE/SENSOR SOURCES



- **NOAA-20, SNPP**

- VIIRS
- ATMS
- CRIS
- OMPS

- **AQUA, TERRA**

- MODIS

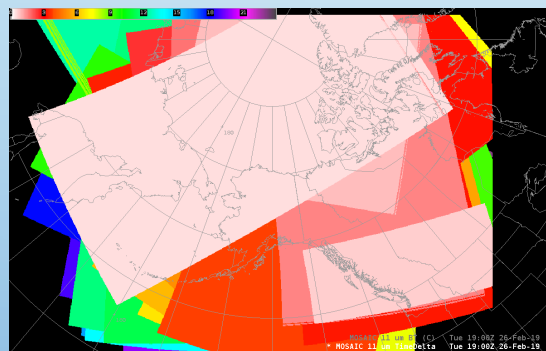
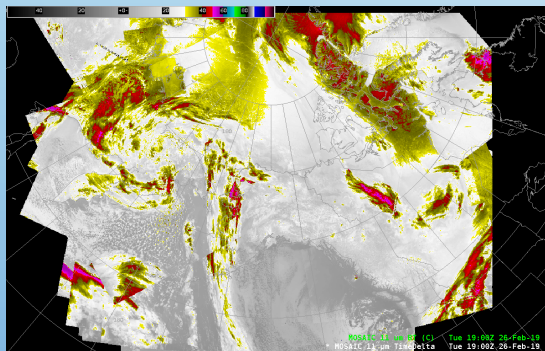
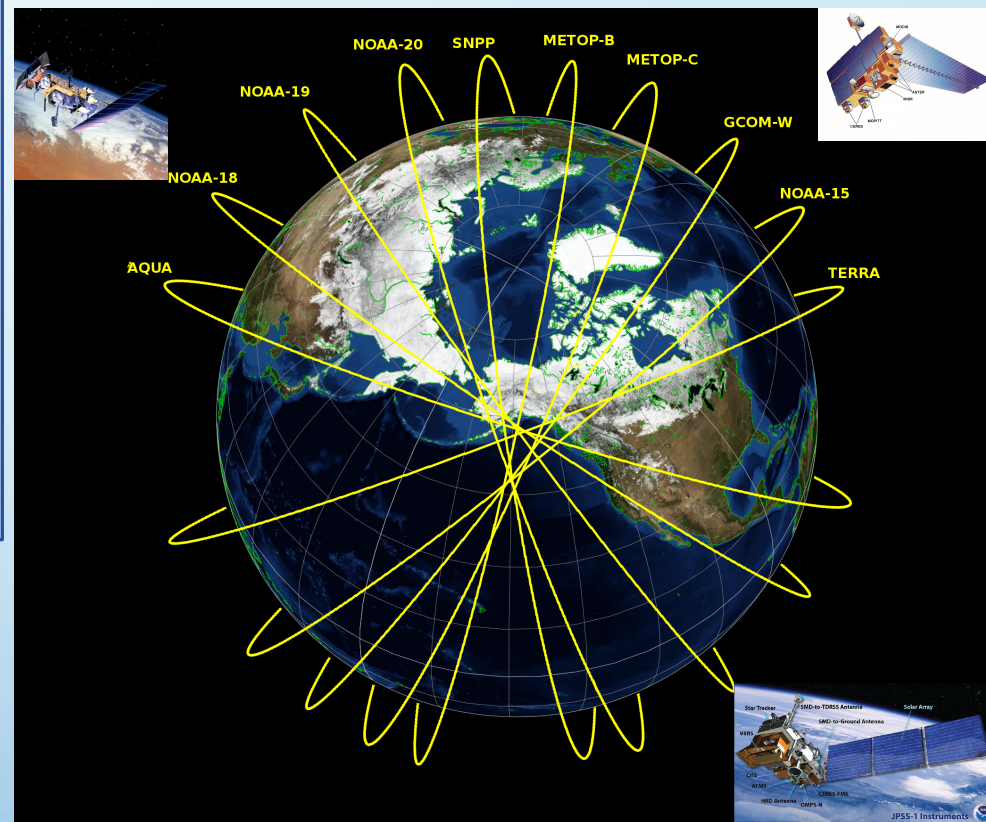
- **METOP-B, METOP-C, NOAA-19, NOAA-18, NOAA-15**

- AVHRR
- AMSU-A/MHS

- **GCOM-W**

- AMSR2 (near future)

GINA's Direct Broadcast Satellite Sources



Regional Mosaic Composite (11 um & Time Delta)

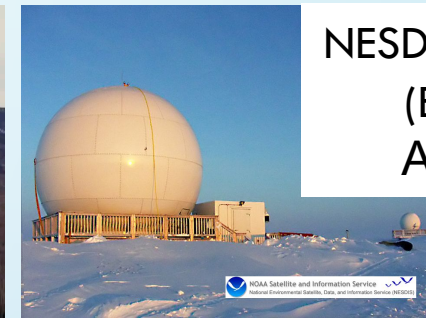
MULTIPLE SATELLITE DOWNLINK RESOURCES



UAF/GINA Sandy Dog
Gilmore Creek



NESDIS FCDAS GILMORE CREEK



NESDIS Utqiaġvik
(Barrow)
Antenna



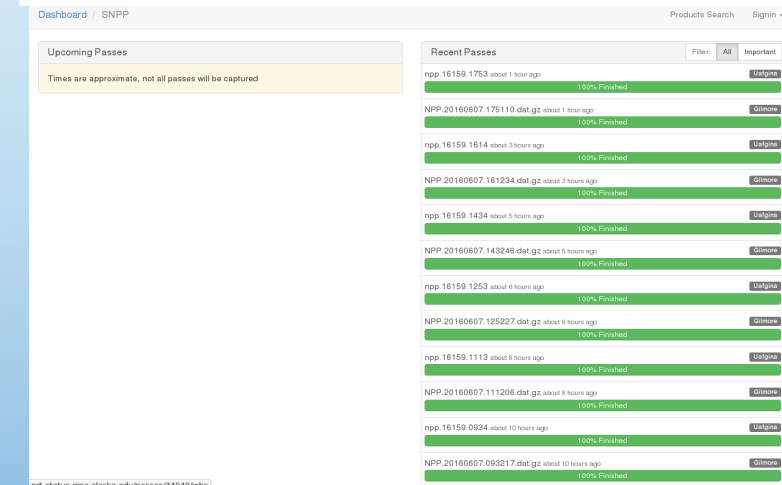
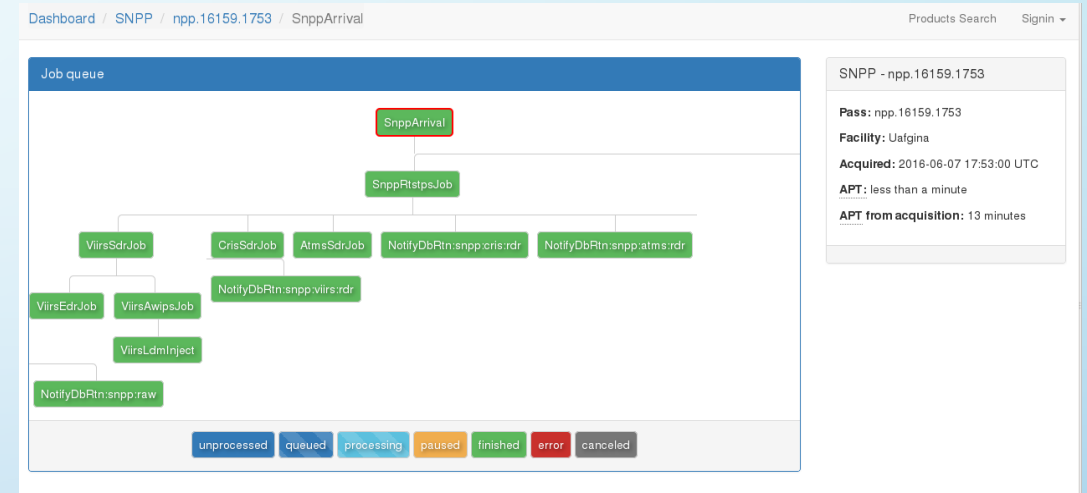
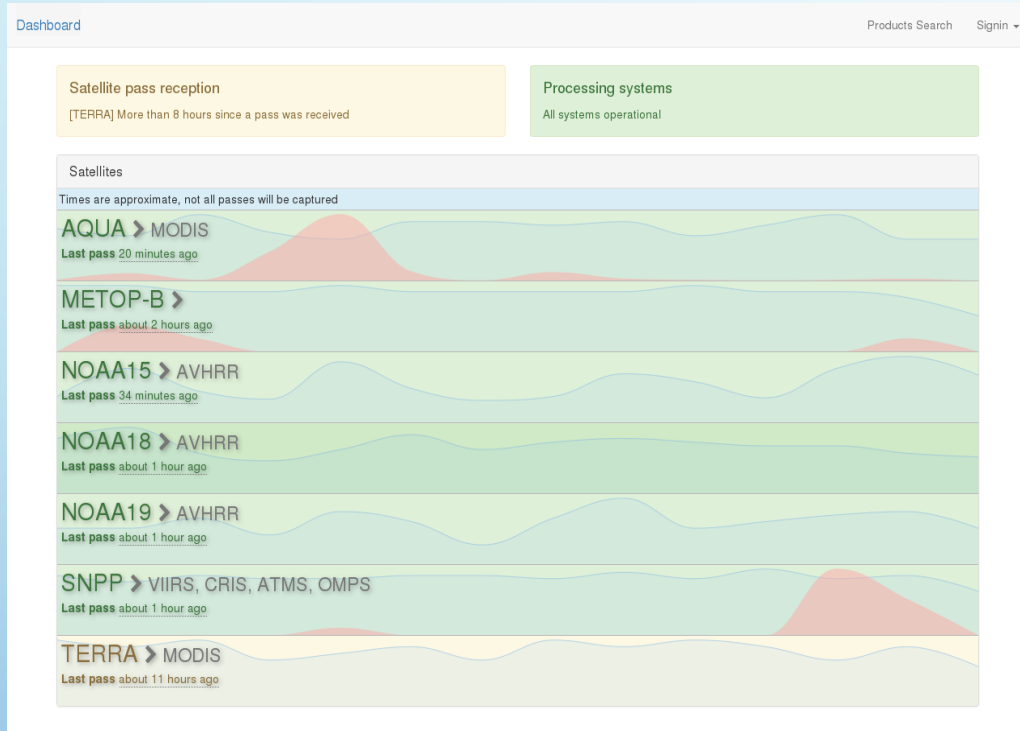
UAF/GINA
Big Dog
(X-band)
UAF Campus

- Multiple sites and antenna resources available to GINA
- Near Real Time (NRT) processing system
- CIMSS CSPP / Polar2grid software
- Connectivity to NWS office via LDM
- **Products delivered to users within 15-30 min (global downlink 1-2 hrs ... faster for NOAA-20)**

Avg Pass Reception	Passes / Week
Gilmore	442
Barrow	194
UAF	156

GINA'S NRT SYSTEM: PRODUCTION MONITORING

Online at: <http://nrt-ops.gina.alaska.edu>

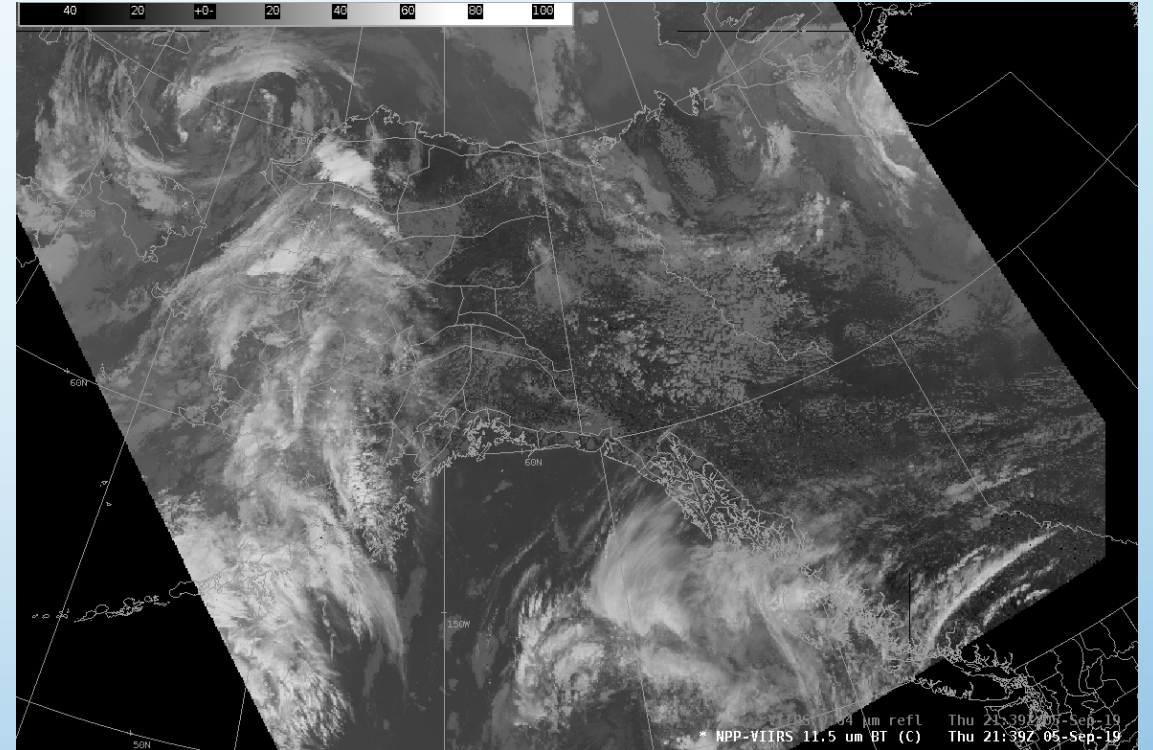
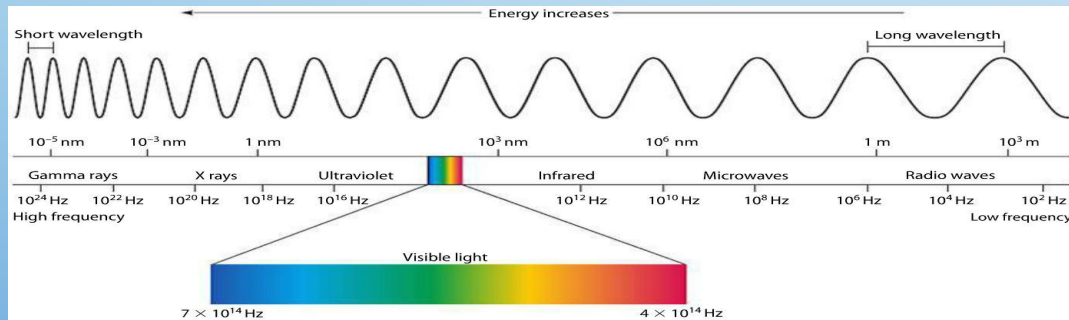


GINA Avg Production	Files / Week	Daily Volume
SCMI Full-Res Tiles	285,500	45.9 GB
Regionalsat (1 km)	9700	5.9 GB

SATELLITE VISIBLE & INFRARED SENSOR BANDS

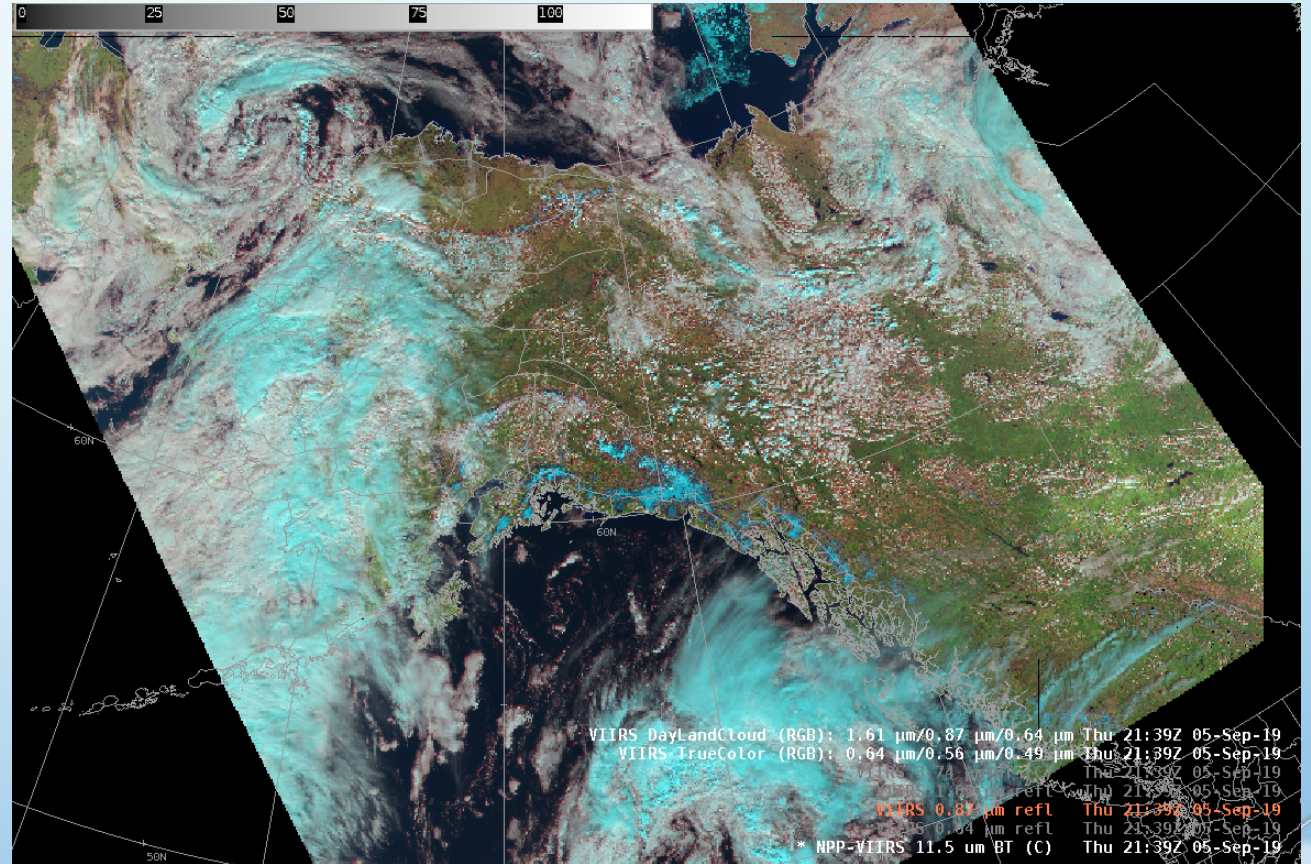
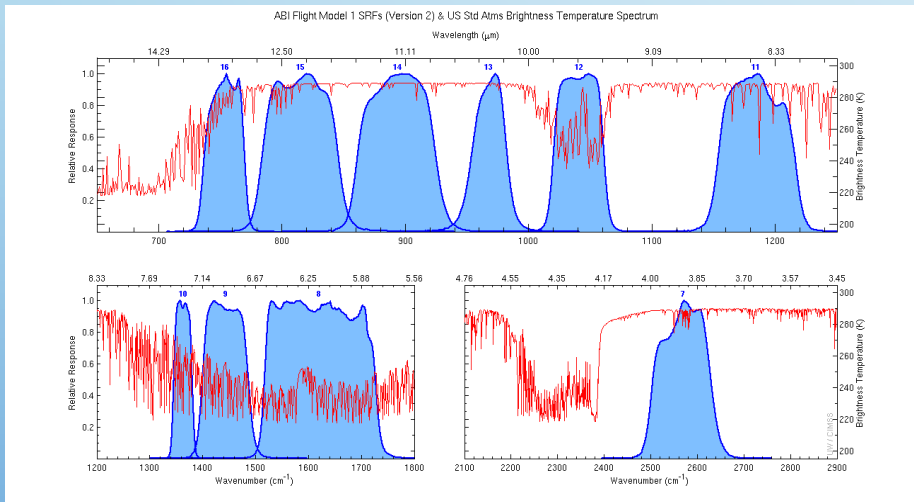
Common satellite bands for weather:

- Visible & near IR - reflected energy (0.4 μ m-2.3 μ m)
 - VIIRS (15 channels)
 - MODIS (20 channels)
- Infrared - emitted energy (3.5 μ m – 14.0 μ m)
 - VIIRS (7 channels)
 - MODIS (15 channels)



MULTISPECTRAL SATELLITE PRODUCTS

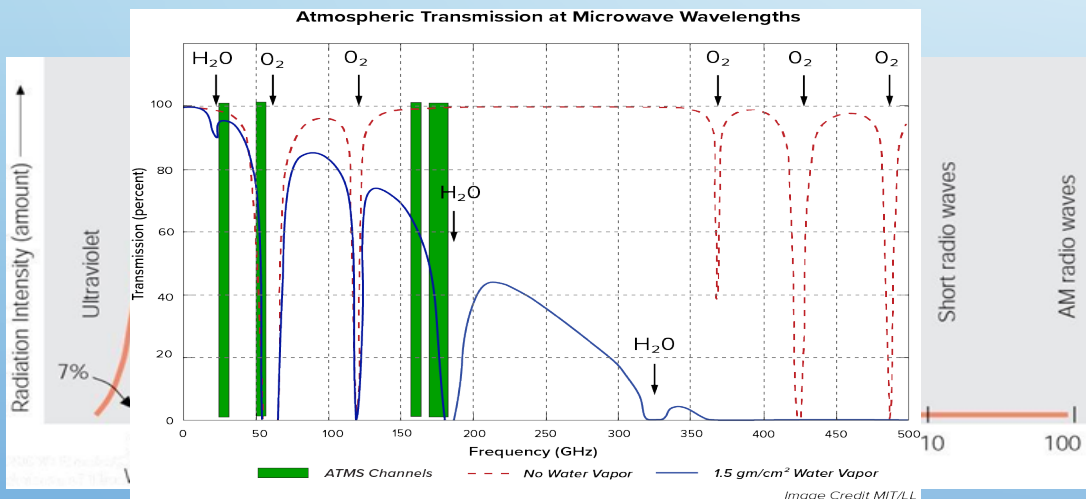
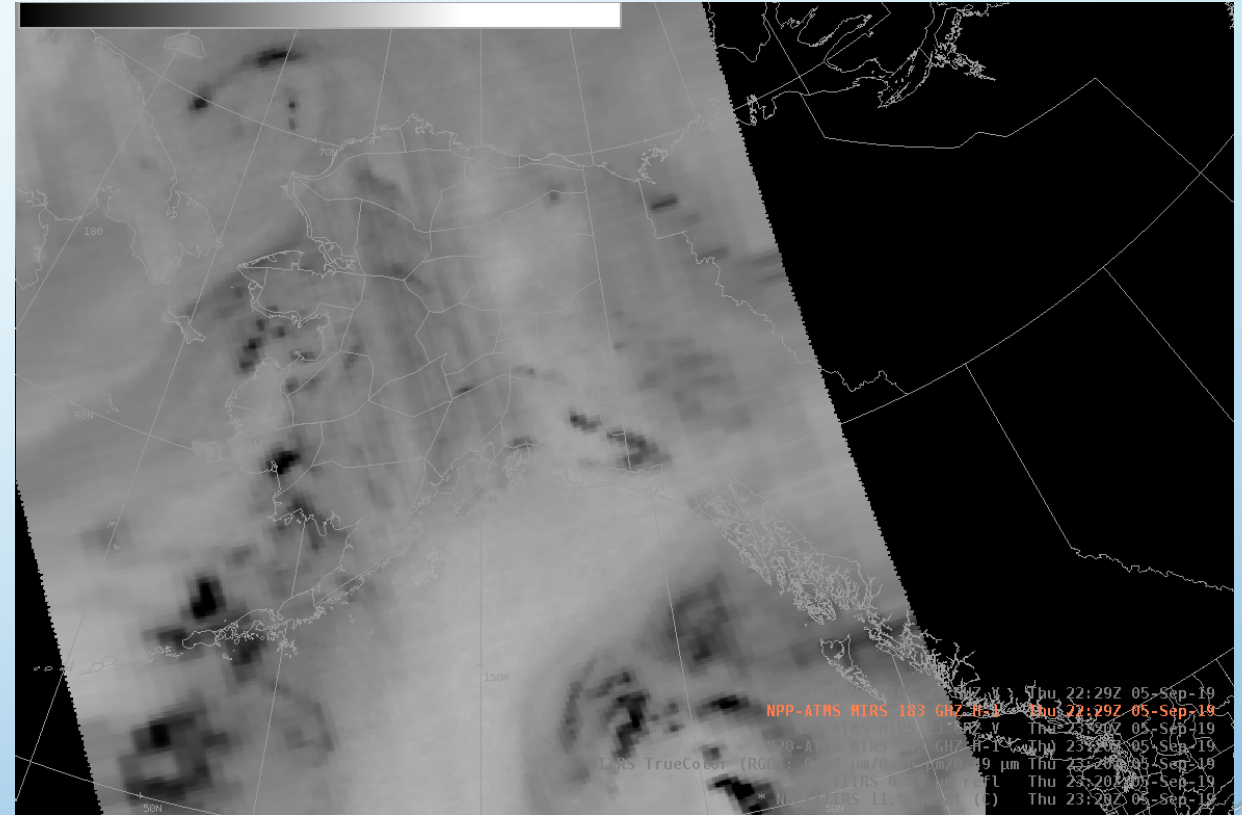
- Multiple bands combined into multi-spectral products (RGB, etc)
- Exploits absorption/reflection characteristics
- Clouds obscure conditions below



DayLandCloud (RGB) 2039Z Sep 2019
 TrueColor (RGB) 2039Z Sep 2019
 BT (C) 2039Z Sep 2019

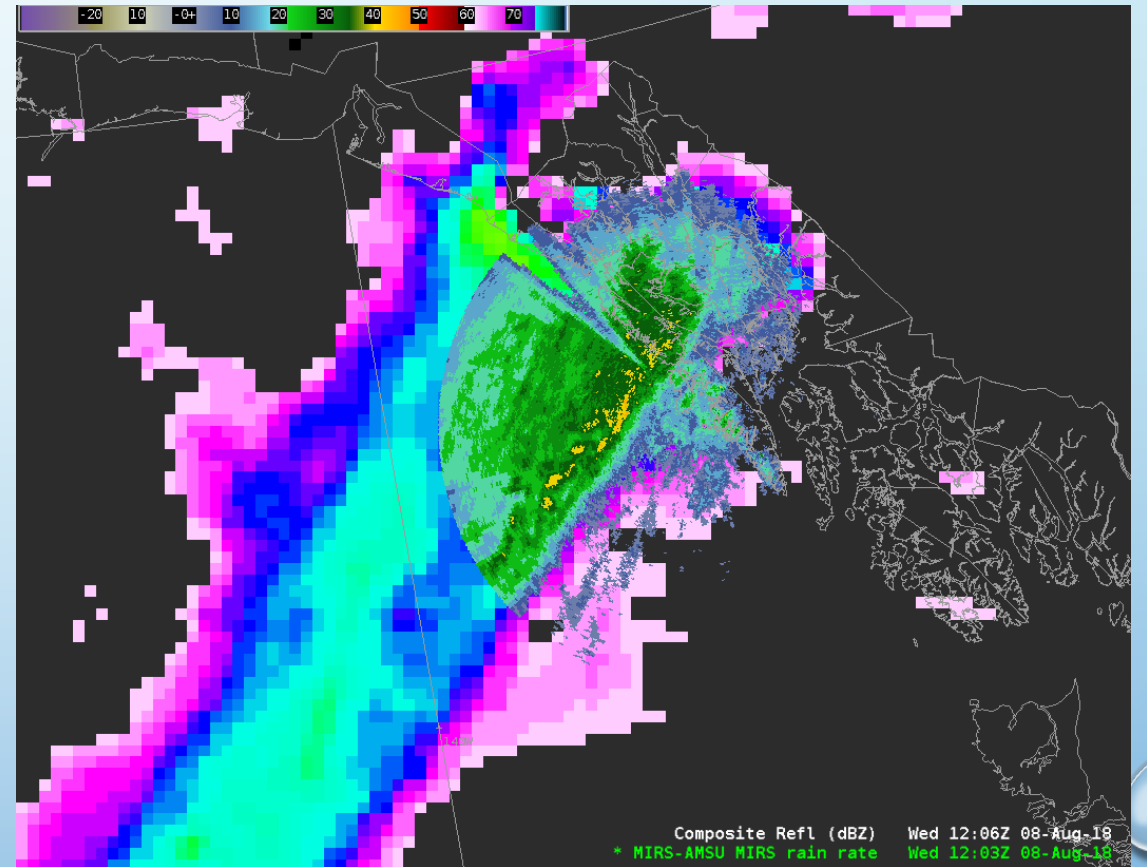
SATELLITE MICROWAVE SENSORS

- Many polar satellites have microwave sensors:
- Longer wavelengths less affected by clouds
- Very low emitted energy requires larger field of view (FOV) and low earth orbit (LEO)
- Products based on emissivity differences – land surfaces and atmospheric moisture



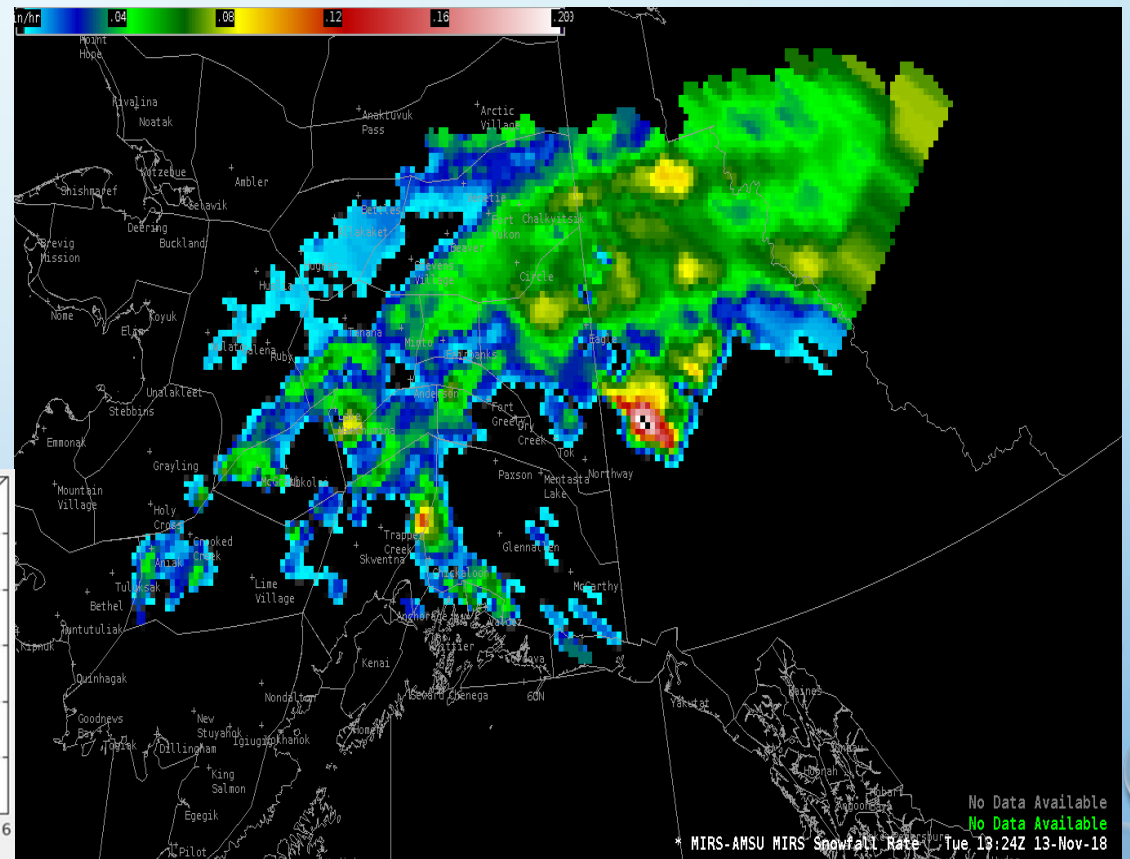
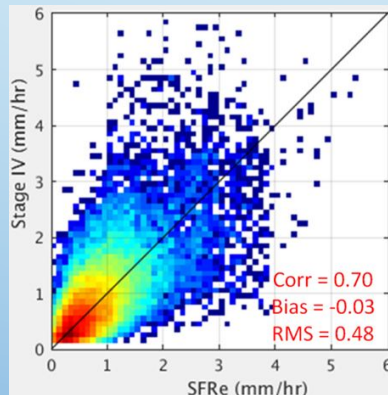
MIRS “MICROWAVE” RAIN RATES

- Microwave Integrated Retrieval System (MIRS)
- Instantaneous rainfall estimate
- Upper level clouds obscure precipitation pattern (Visible & IR imagery)
- Microwave rain rates estimate precipitation below clouds
- Radar highly detailed but has range limits and terrain blockage issues
- Rain rates more coarse than radar but provide larger “synoptic” scale view of precipitation
- No estimate over surface snow or ice



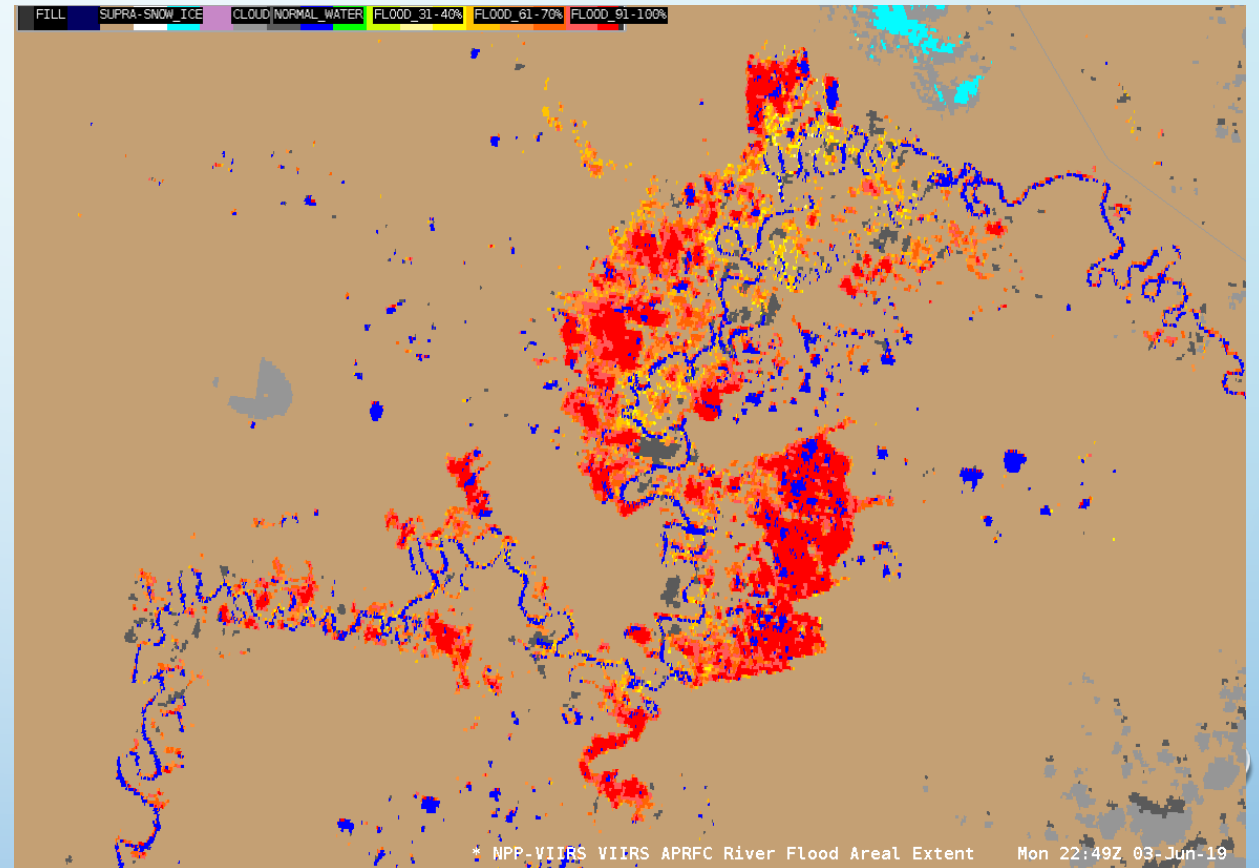
MIRS "MICROWAVE" SNOWFALL RATES

- Instantaneous snowfall estimate
- Maximum 2" per hour
- Valid with surface temps down to around 7 deg F.
- Continually enhanced by observations
- Land only – being tested over water

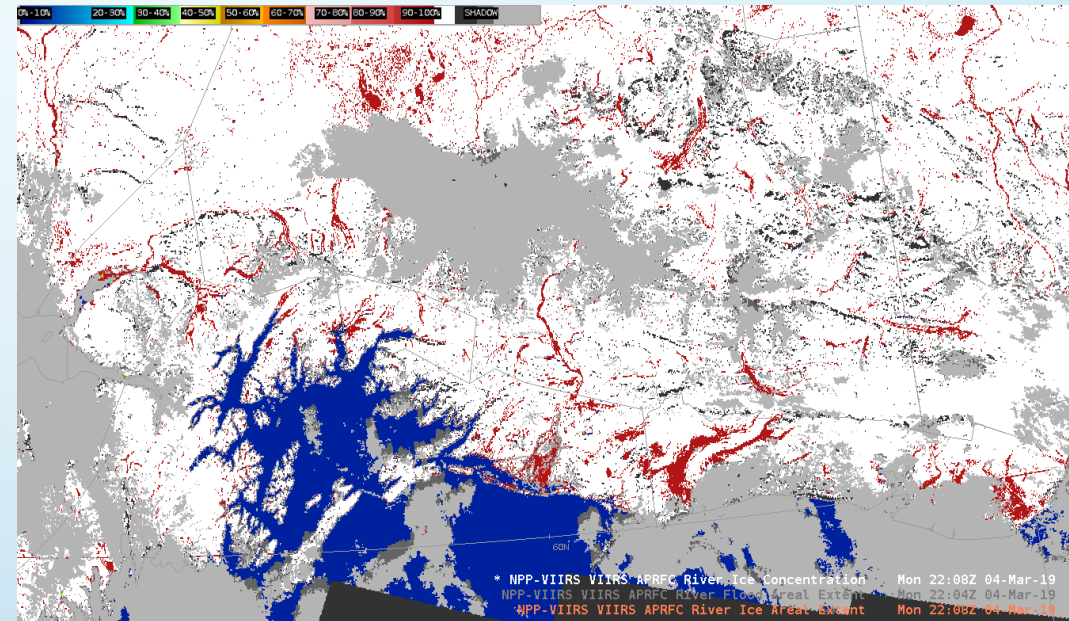
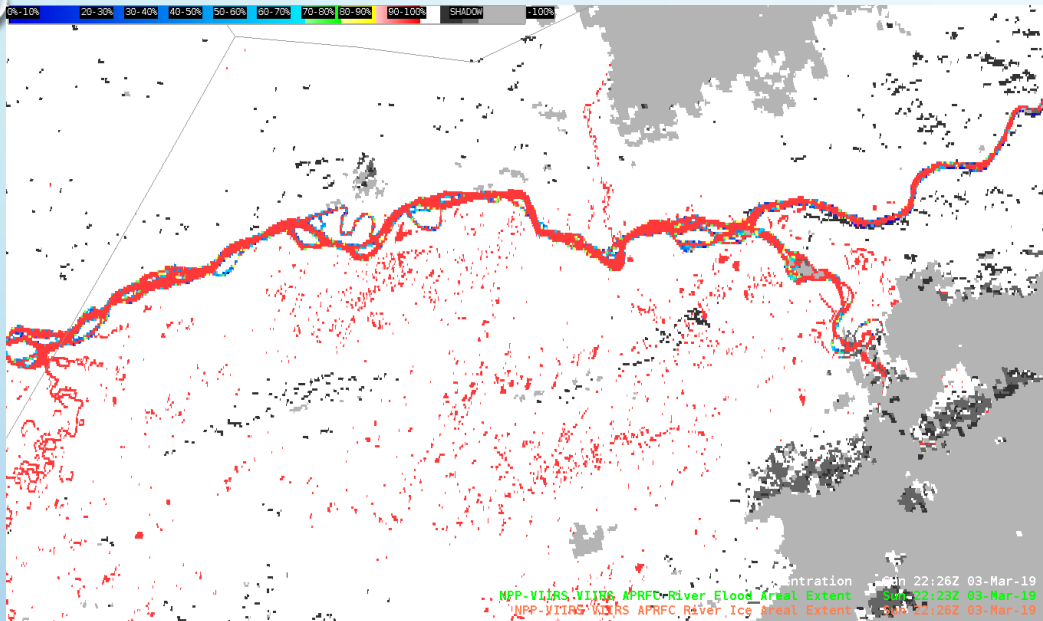


RIVER FLOOD AREAL EXTENT

- Percentage of above normal water covered land.
- Very high resolution (375m - VIIRS)
- Extremely useful for river ice jam floods from Break-up
- Daytime only
- Obscured by clouds



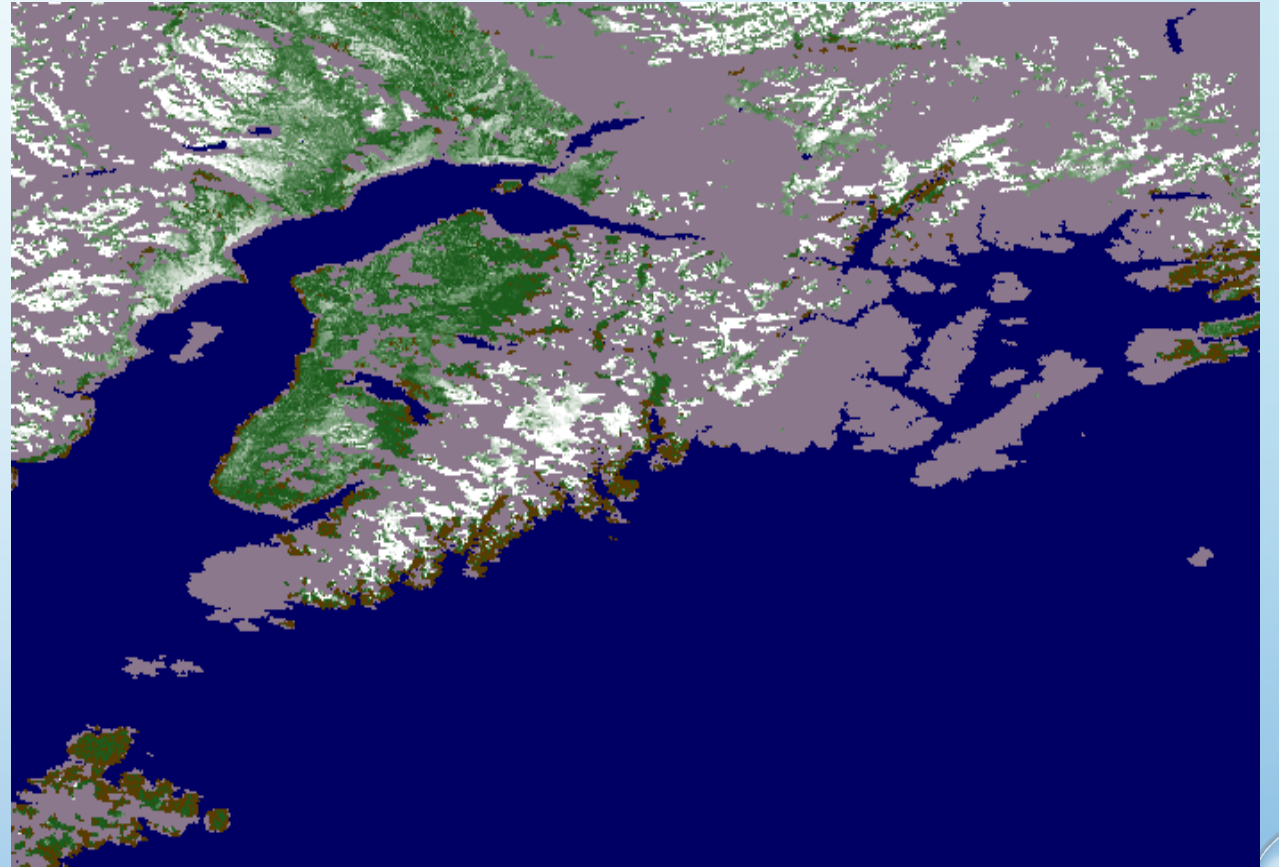
RIVER ICE CONCENTRATION



- Percentage of Ice in normally water covered areas
- Very high resolution (375m – VIIRS)
- Daytime only
- Obscured by clouds

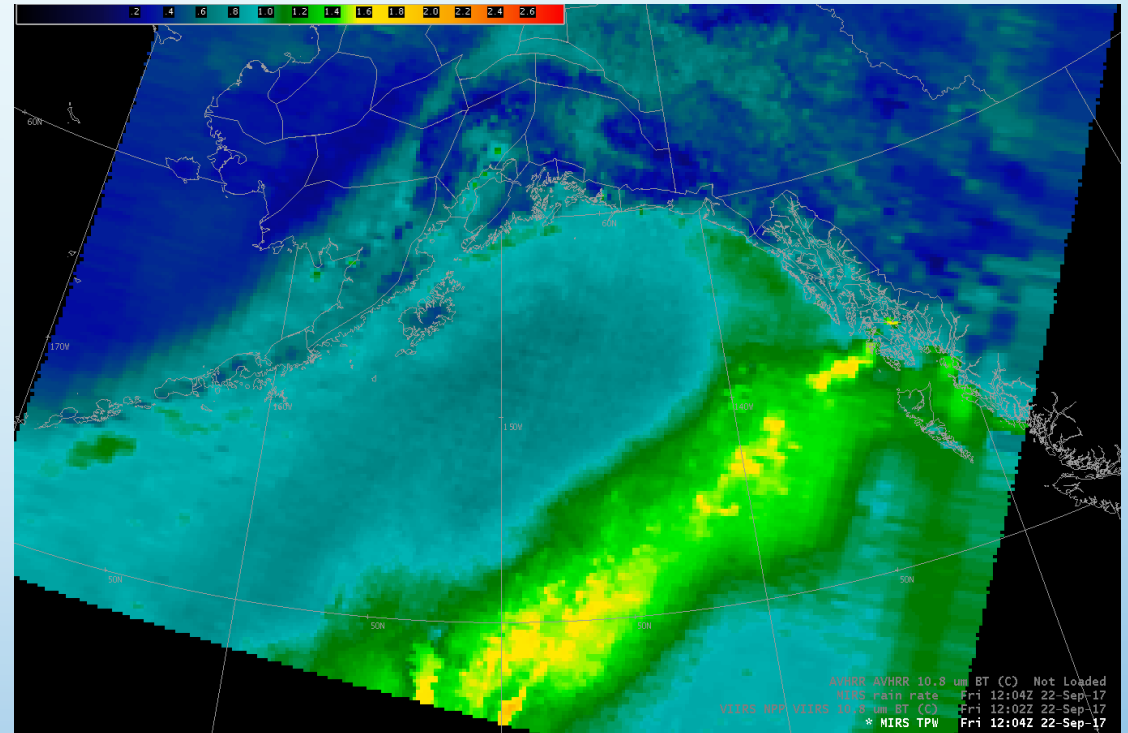
SURFACE SNOWPACK ESTIMATES

- DayLandCloud RGB (1.61um, .86um, .64um)
 - Daytime only
 - High resolution
 - Subjective (Not quantitative)
- MIRS Snow Water Equivalent (SWE)
 - Quantitative estimates
 - Coarse resolution
 - Day or night
 - Minimally affected by clouds (microwave)
 - Less reliable in melting snow
- VIIRS Snow Fraction
 - High resolution
 - Daytime only
 - No snow depth information
 - Obscured by clouds

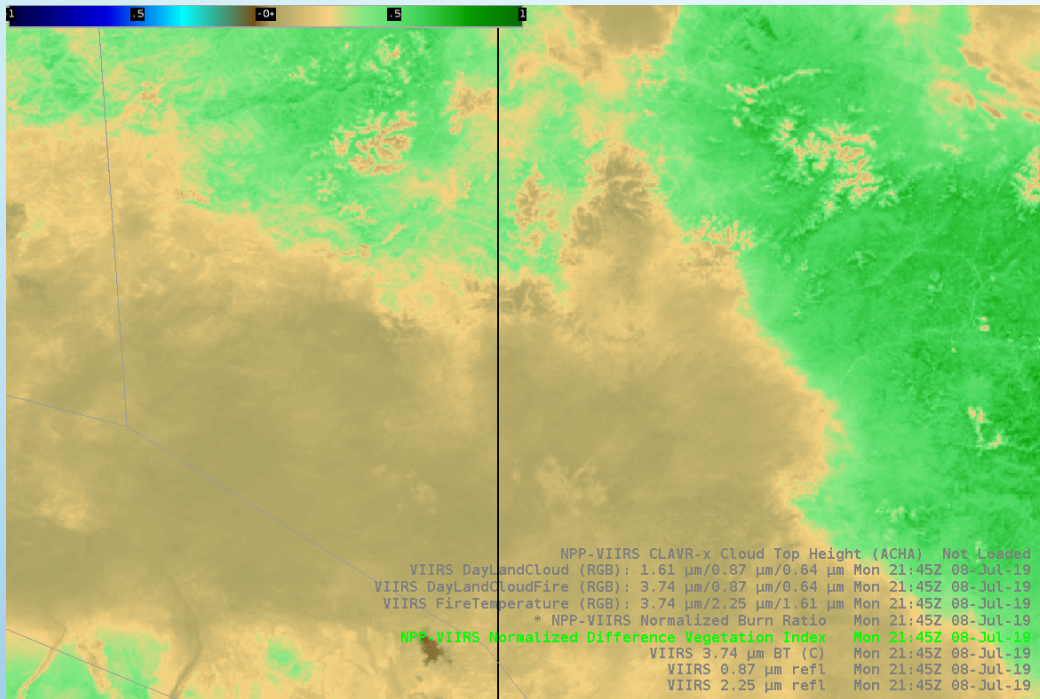


MIRS TOTAL PRECIPITABLE WATER (TPW)

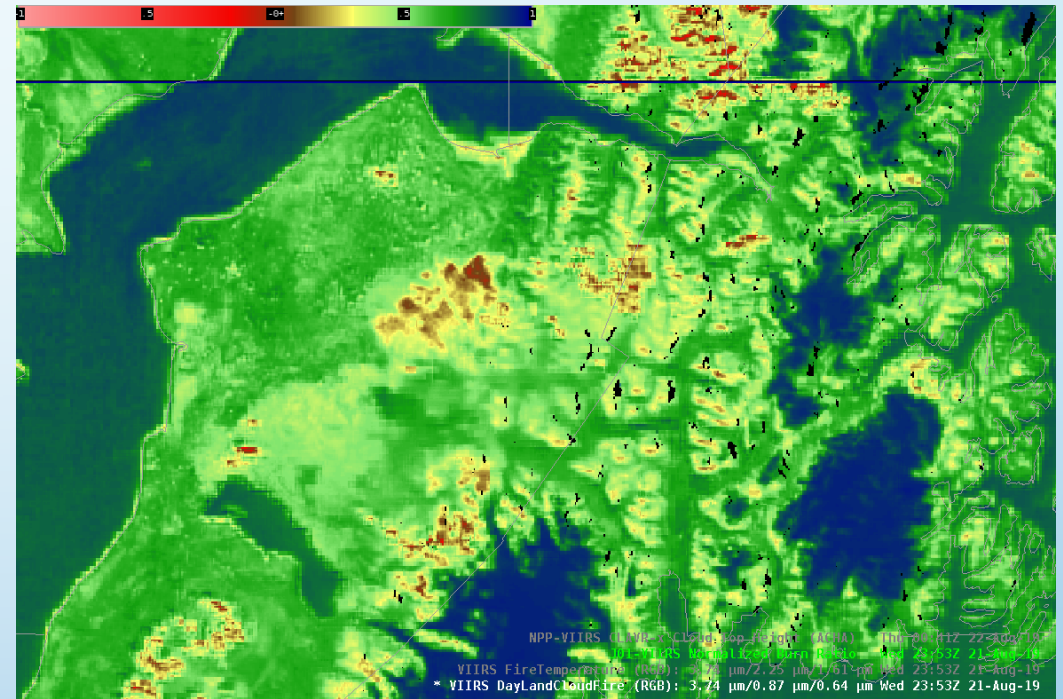
- Estimates total moisture in vertical column of atmosphere
- Rainfall “potential”
- Minimally impacted by clouds
- Less reliable in heavy rain
- Helps to identify Atmospheric Rivers (AR)



VEGETATION INDICES



Normalized Difference Vegetation Index (NDVI)

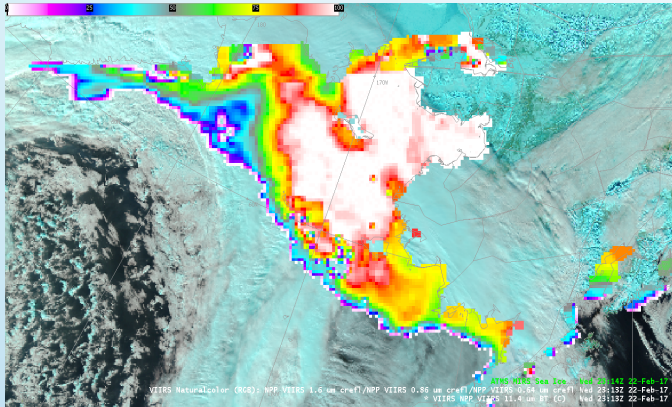


Normalized Burn Ratio (NBR)

- High Resolution (750 m)
- Daytime Only
- Obscured by clouds

SEA ICE ANALYSIS & FORECASTING

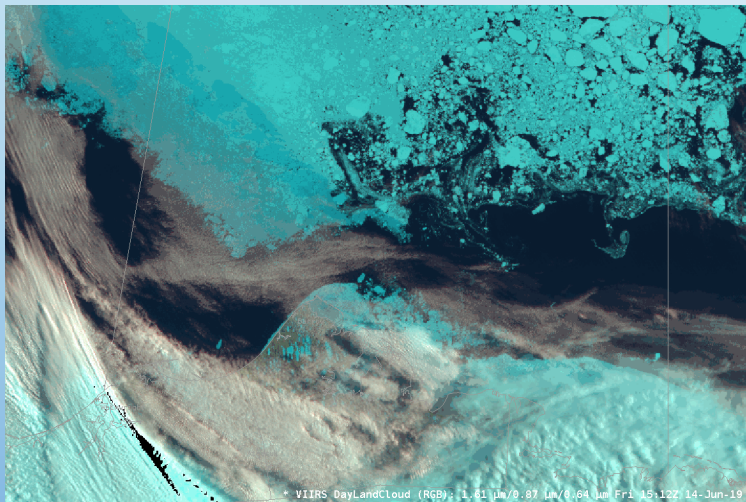
MIRS Sea Ice Concentration



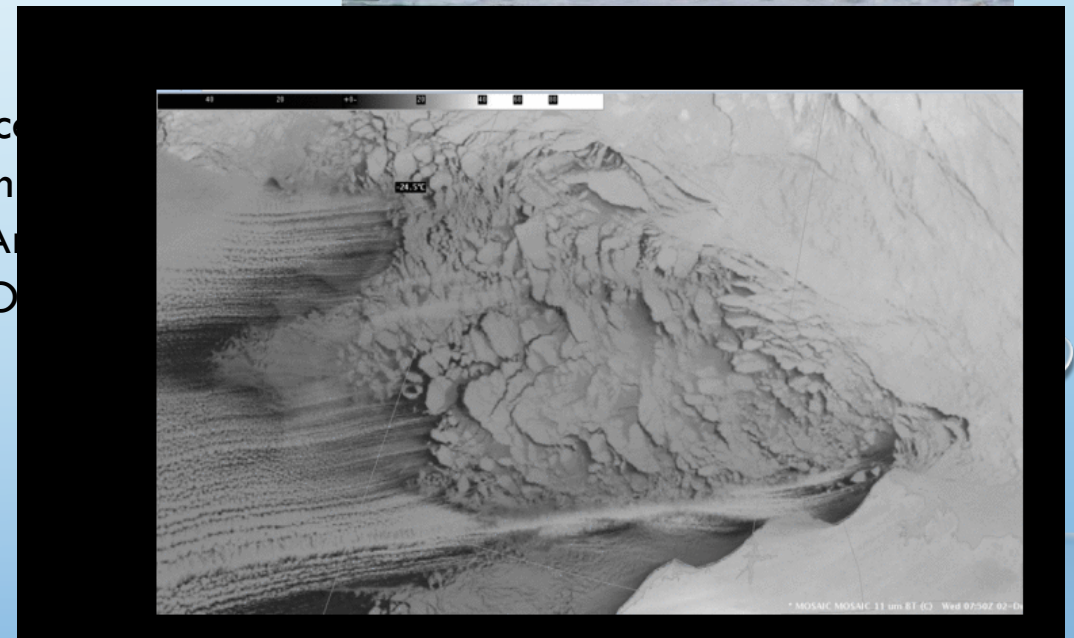
Ice rescue in the Bering Sea



VIIRS ice drift in Arctic Ocean



Ice in Arctic Ocean



SUMMARY

LEO = Polar-Orbiting Satellites GEO = Geostationary Satellites

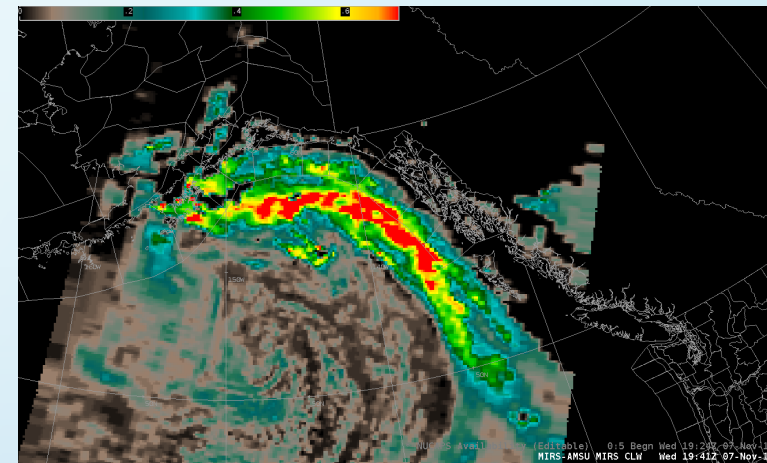
- GINA's Direct Broadcast system provides a number of satellite products in Near Real-time (15-30 min) that help to assess water characteristics in Alaska.
- Polar satellites provide significant resolution advantages over Alaska and the arctic (GEO resolution degrades exponentially in northern latitudes).
- Multiple LEO satellites provides frequent coverage in northern latitudes.
- Multiple passes can be composited into mosaics.
- Microwave data helps fill gaps in surface-based observations. (Precipitation, ocean winds, satellite soundings)

The image features a light blue gradient background with several realistic water droplets of various sizes scattered in the corners. The droplets have highlights and shadows, giving them a three-dimensional appearance. The word "QUESTIONS?" is centered in the middle of the page in a bold, black, sans-serif font.

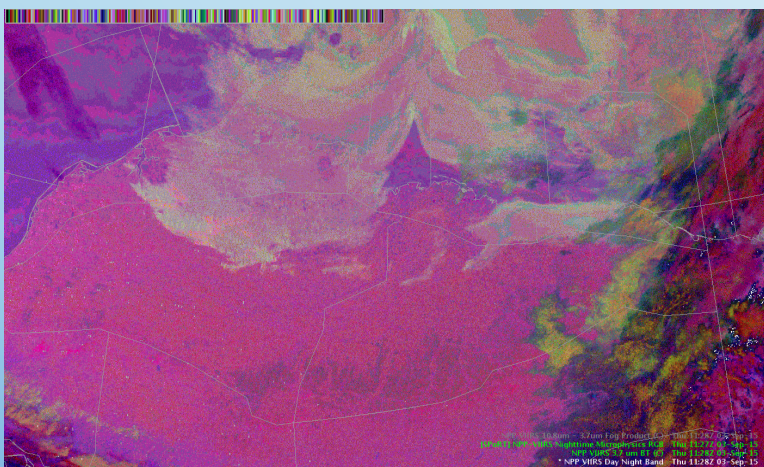
QUESTIONS?

MISCELLANEOUS CLOUD WATER SATELLITE PRODUCTS

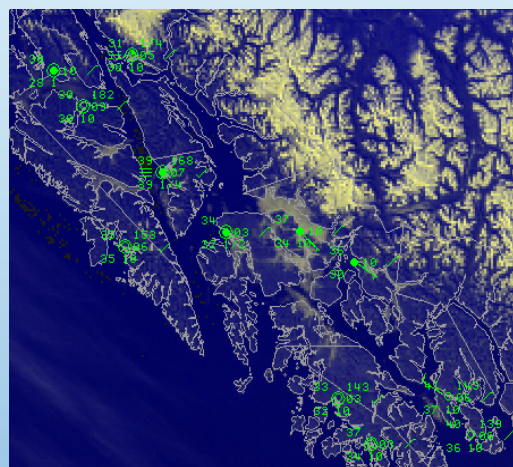
**Other Miscellaneous Satellite Products
Created from GINA's Direct Broadcast System**



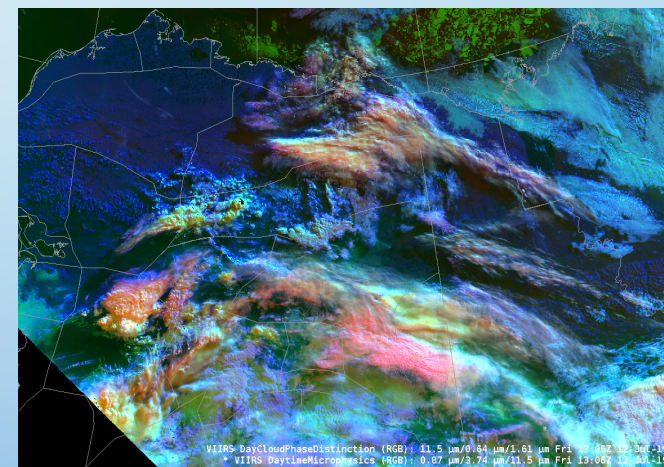
MIRS Cloud Liquid Water (icing)



Nighttime Microphysics RGB (fog)



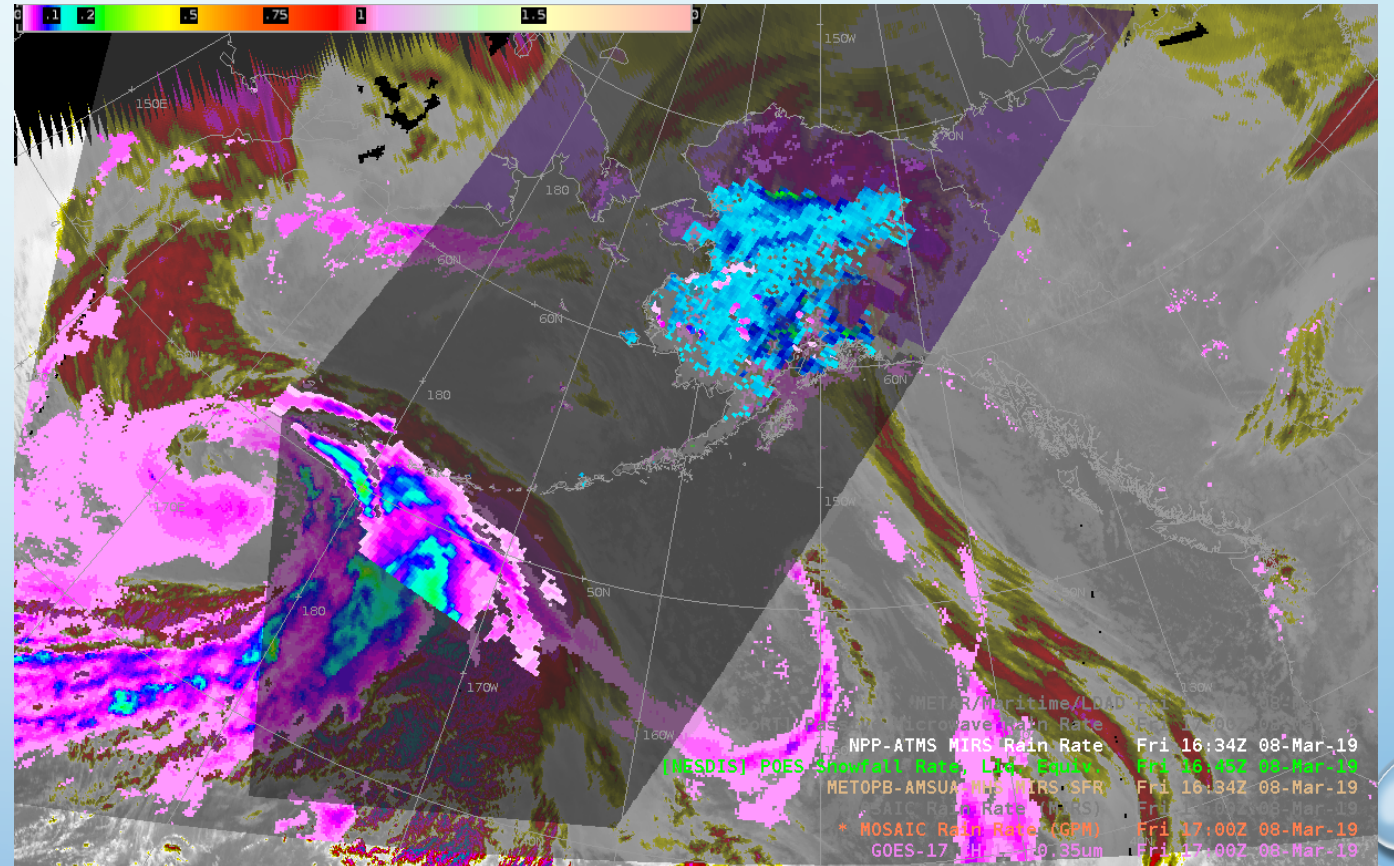
DNB (fog)



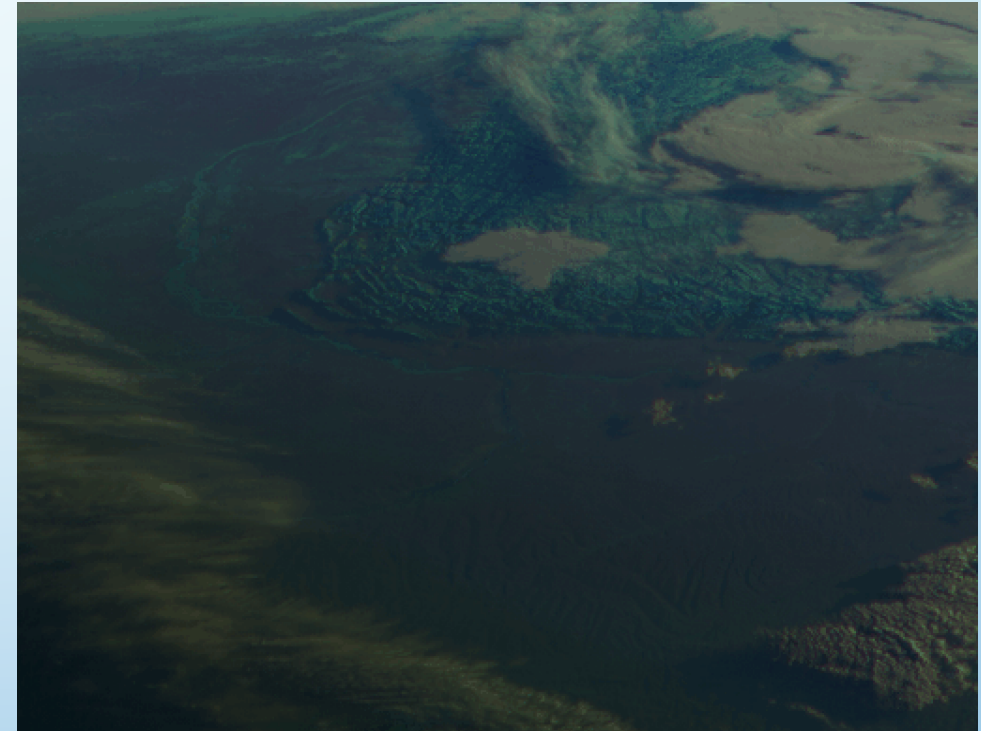
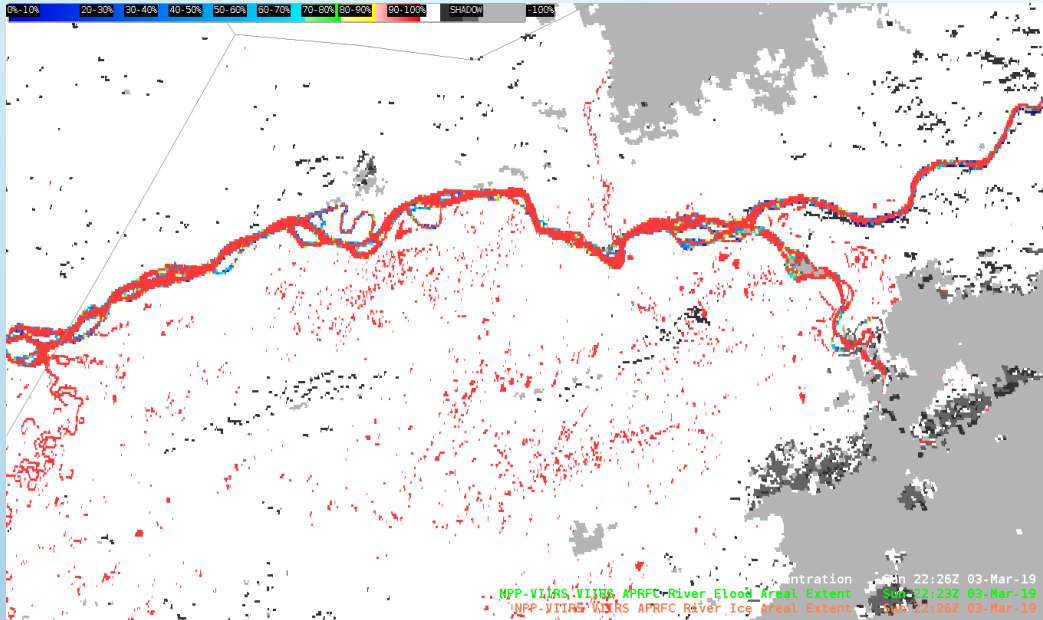
CloudPhaseDistinction RGB (icing/convection)

MICROWAVE RAIN RATE ESTIMATES

- System movement & trend (GEO)
- Precipitation distribution & type (LEO)
- Region-wide precipitation pattern (LEO-Mosaic)



RIVER ICE CONCENTRATION



Lena River Ice breakup – Russia
17 May 2018

GINA Partners:

- NWS River Forecast Center (APRFC)
- State of Alaska
- City and Village Emergency Managers
- JPSS River Ice and Flood Initiative