Advanced Microwave Precipitation Radiometer (AMPR) Observations during OLYMPEX/RADEX

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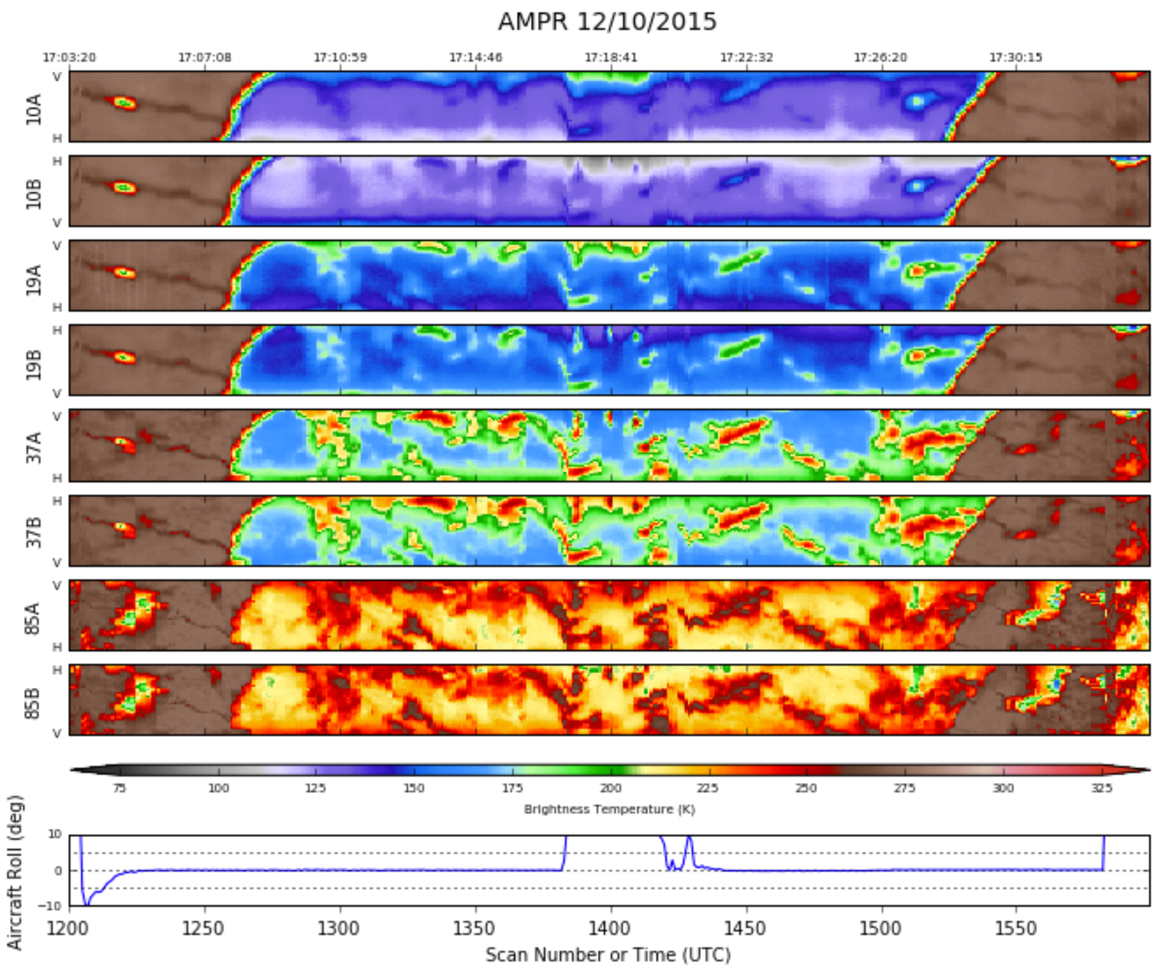

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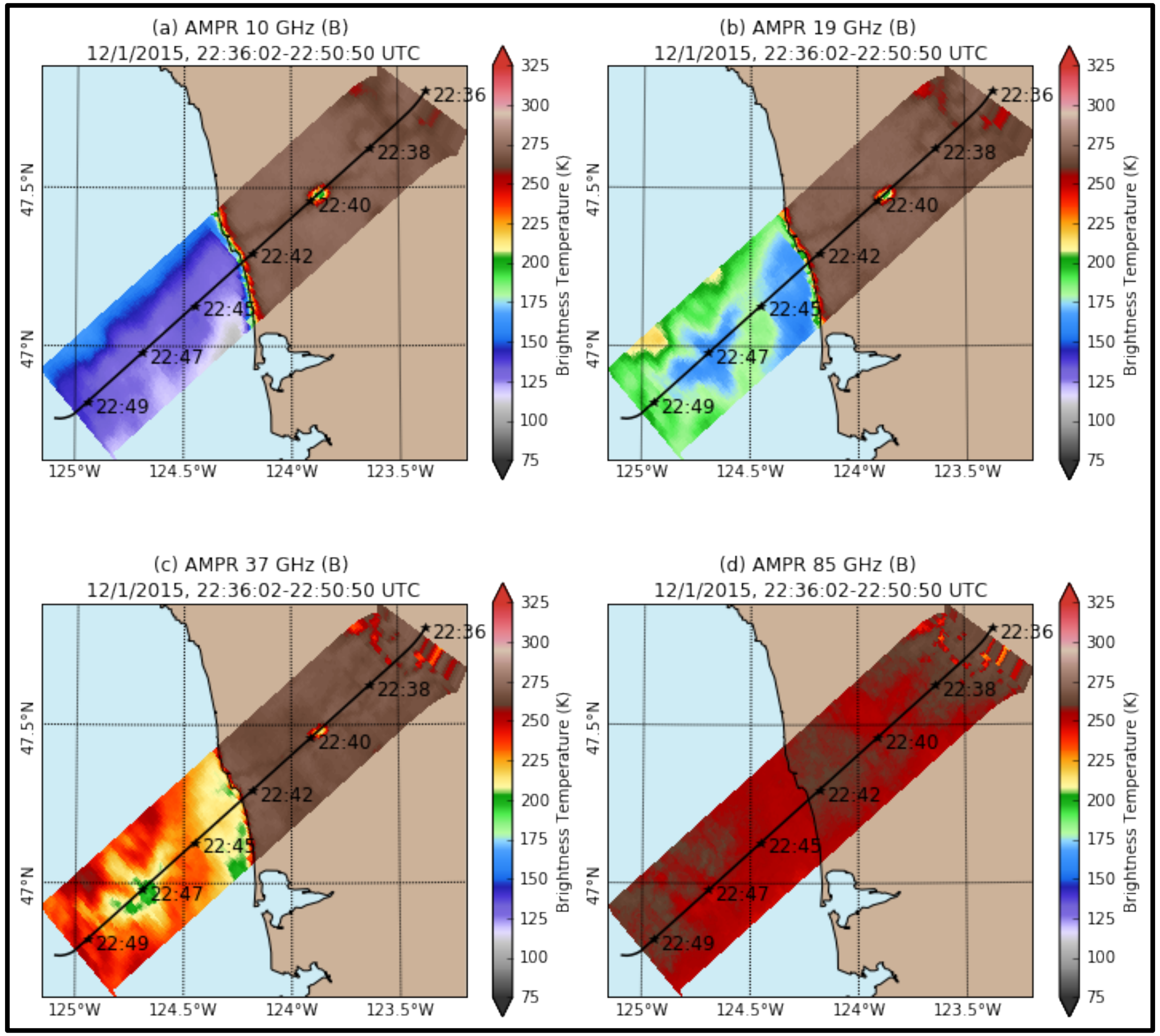
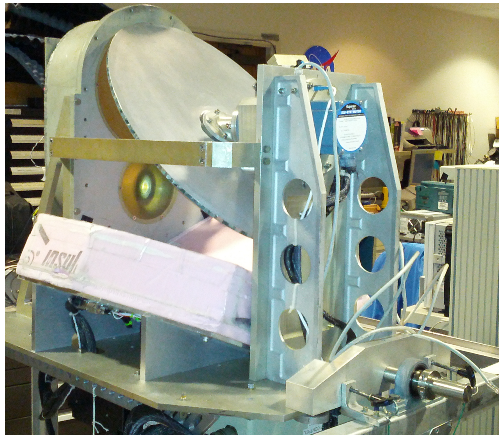
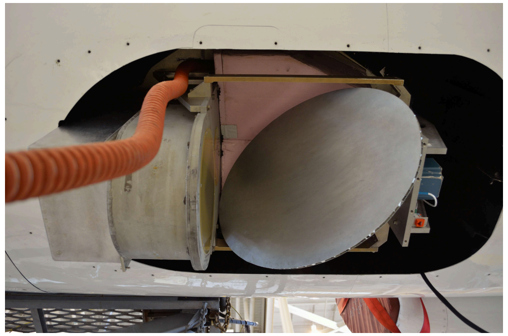


AMPR Instrument Summary

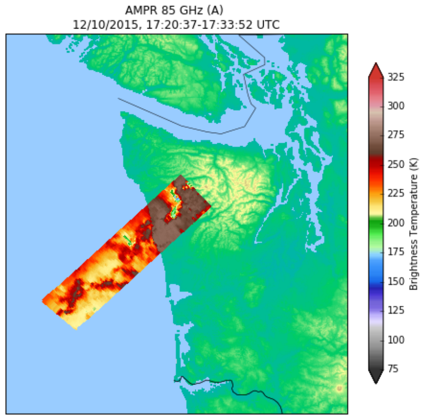
In the lab



In the plane



Over the storm



Instrument/Model name / PI:

AMPR (Advanced Microwave Precipitation Radiometer)

T. Lang, NASA MSFC

Data/Measurements/Retrievals:

- Passive microwave radiometer – Retrieve surface emission, cloud liquid water, precipitation rate, water vapor, ice scattering, and more
- Four frequencies - 10.7, 19.35, 37.1, 85.5 GHz, with 2 variable polarization channels apiece (Channel A: V -> H and Channel B: H -> V)
- Cross-track scanning, polarization state varies according to scan angle, H & V deconvolution possible

Previous deployments: IPHEx, MC3E, CAMEX 1-4, TCSP, TC4, KWAJEX, TRMM/LBA, TOGA-COARE, FIRE-III, TEFLUN-A

Notable publications:

Leppert II, K. D., and D. J. Cecil, 2015: Signatures of hydrometeor species from airborne passive microwave data for frequencies 10–183 GHz. *J. Appl. Meteor. Climatol.*, **54**, 1313–1334.

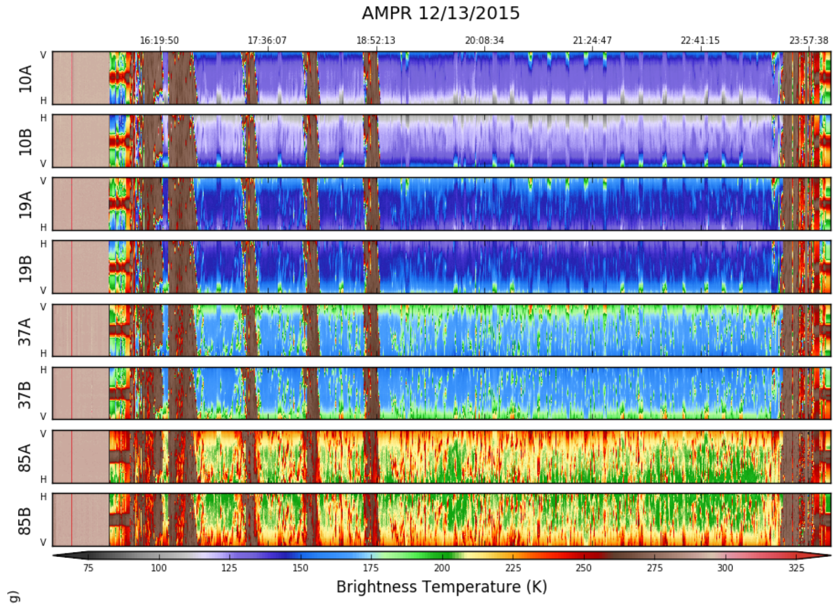
Hood, R. E., D. J. Cecil, F. J. LaFontaine, R. J. Blakeslee, D. M. Mach, G. M. Heymsfield, F. D. Marks Jr., E. J. Zipser, and M. Goodman, 2006: Classification of tropical oceanic precipitation using high-altitude aircraft microwave and electric field measurements. *J. Atmos. Sci.*, **63**, 218–233.

Spencer, R. W., R. E. Hood, F. J. Lafontaine, E. A. Smith, R. Platt, J. Galliano, V. L. Griffin, and E. Lobl, 1994: High-resolution imaging of rain systems with the advanced microwave precipitation radiometer. *J. Atmos. Oceanic Technol.*, **11**, 849–857.

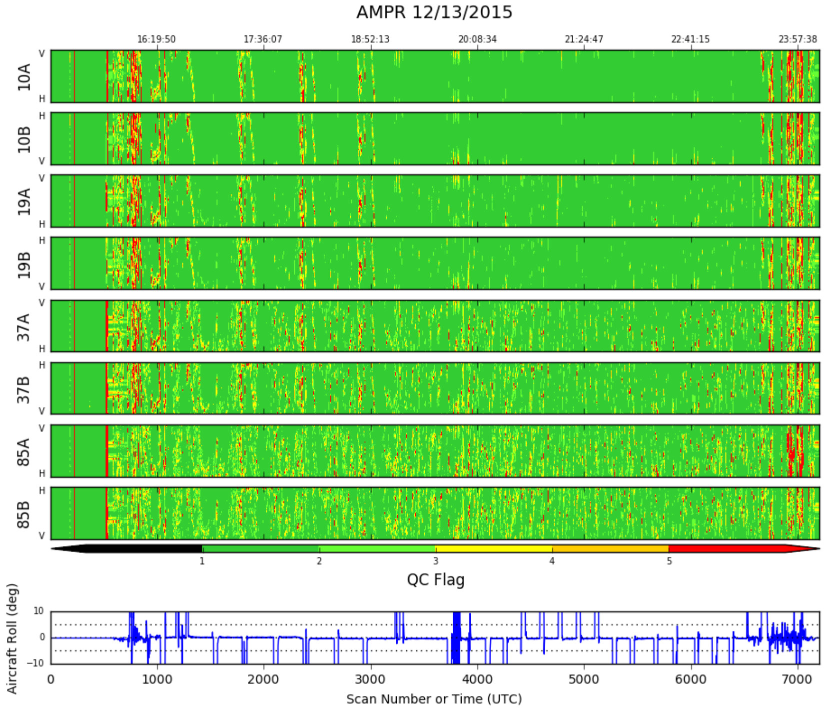
AMPR OLYMPEX Dataset Overview

- Geolocated Channel A and B mixed-pol TBs available in netCDF files from each day, wherever fine OLYMPEX data are found
- QC flags & land/water fraction available – Use as rough guide for data quality; see README
- Software to read/display/analyze here: https://github.com/nasa/PyAMPR
- 19 GHz unavailable 12/3-12/8
- 85 GHz (A) occasionally elevated noise floor masked open water signal (affected portions of 11/18, 12/4, 12/8)

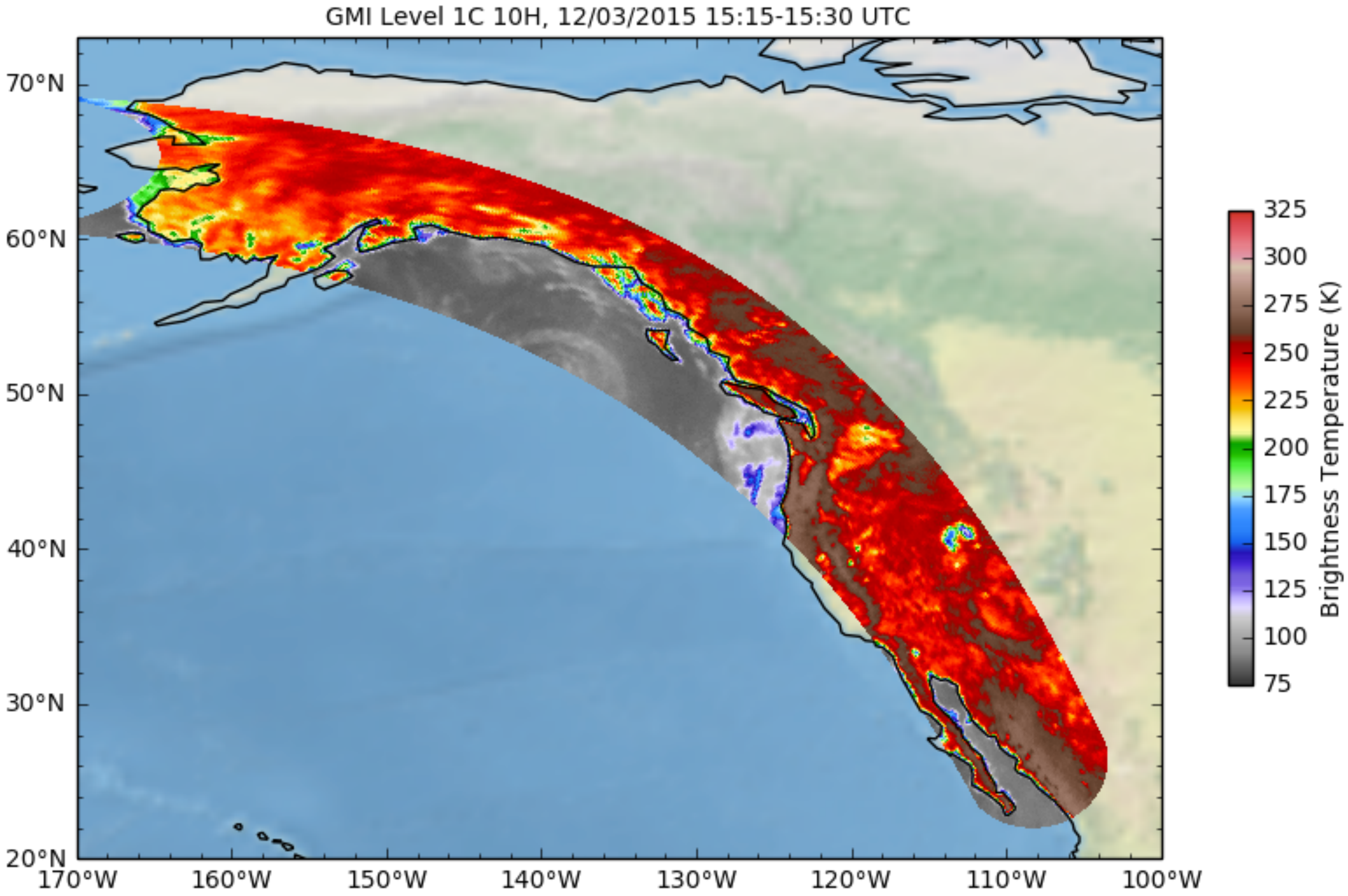
TBs



QC Flags



AMPR vs. GMI for 12/3 Underflight



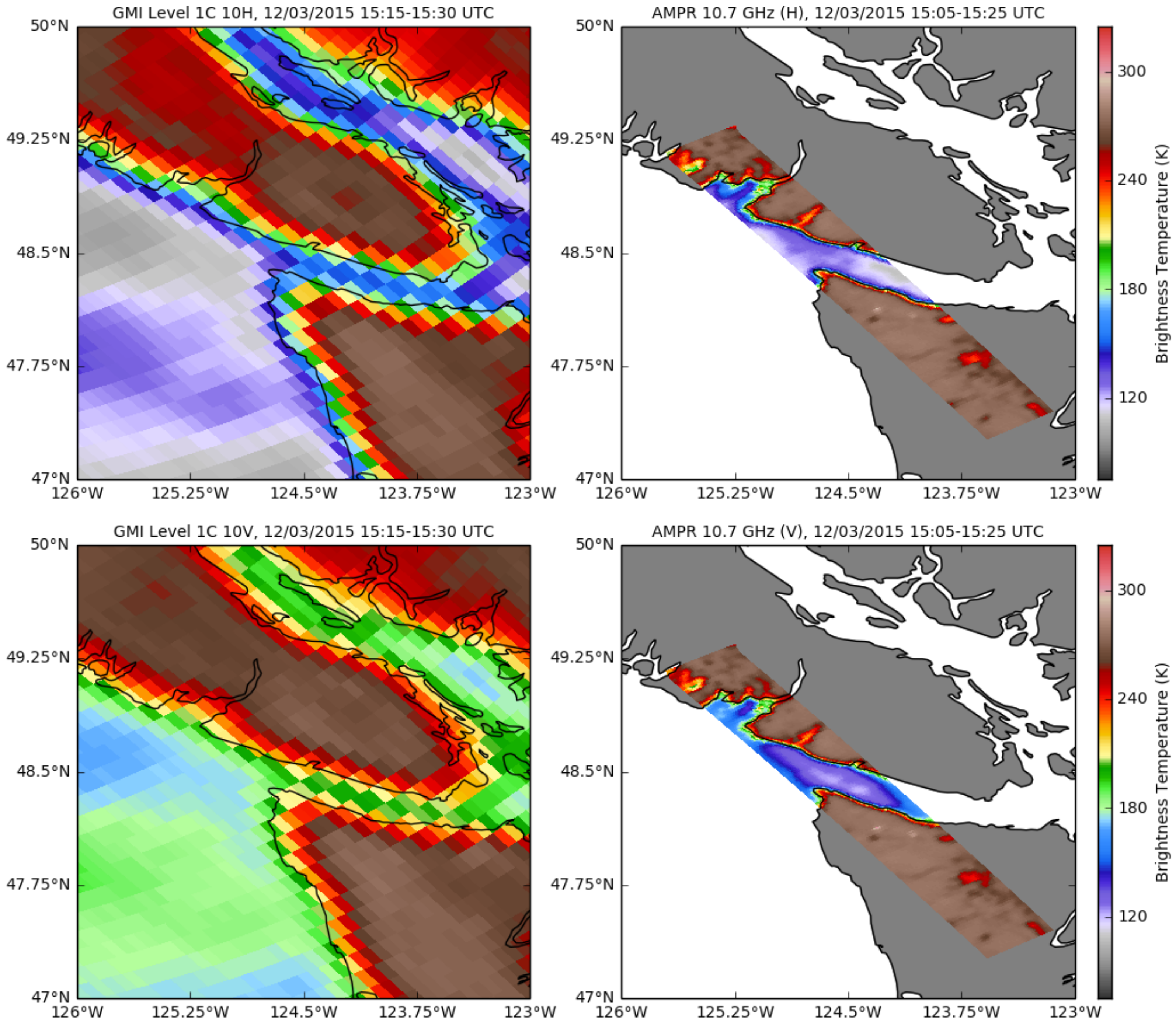
Note: These are polarization-deconvolved AMPR data!

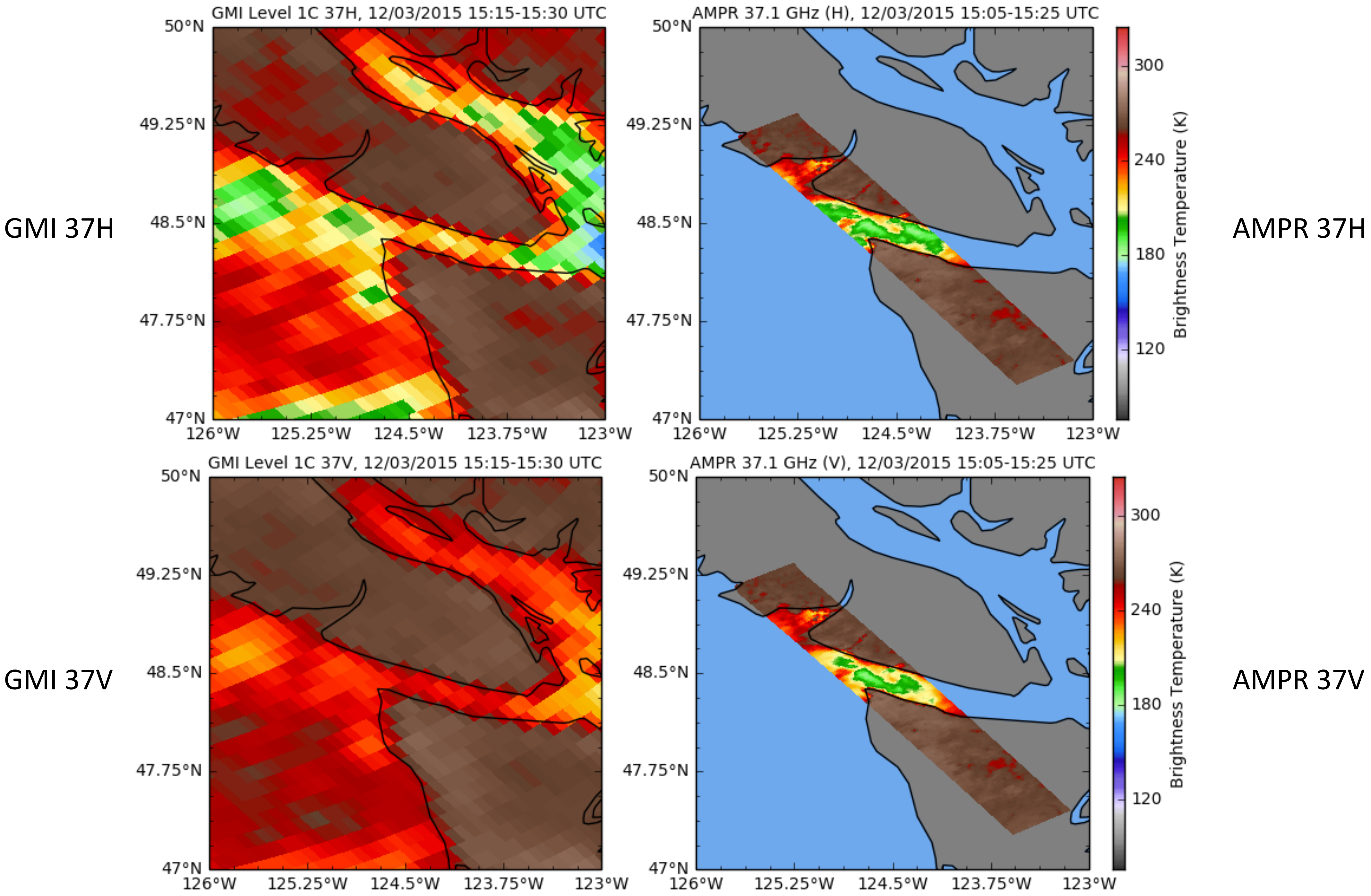
GMI 10H

AMPR 10H

GMI 10V

AMPR 10V



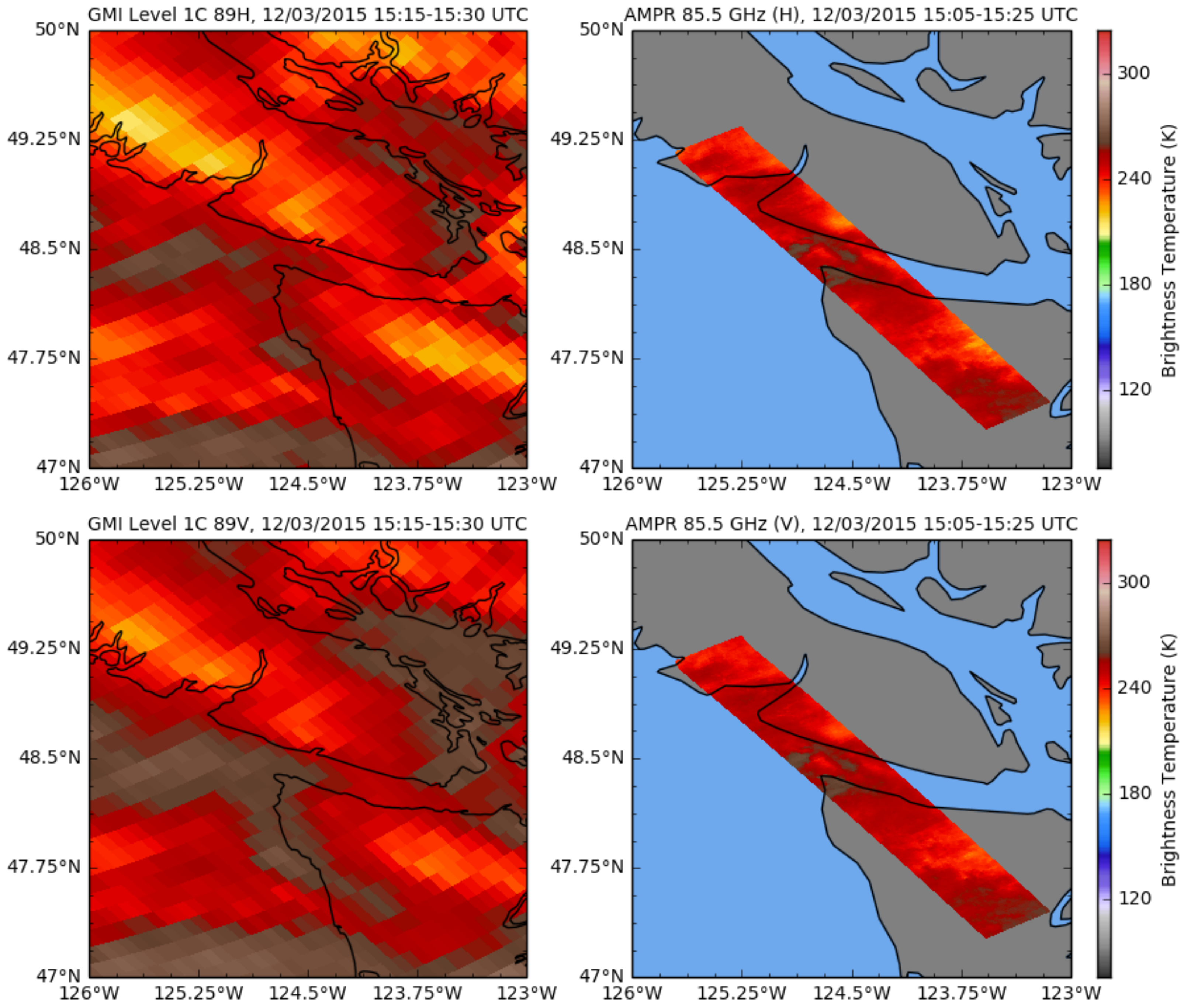

GMI Level 1C 37H, 12/03/2015 15:15-15:30 UTC
AMPR 37.1 GHz (H), 12/03/2015 15:05-15:25 UTC
GMI Level 1C 37V, 12/03/2015 15:15-15:30 UTC
AMPR 37.1 GHz (V), 12/03/2015 15:05-15:25 UTC
GMI 37H
AMPR 37H
GMI 37V
AMPR 37V
50°N
49.25°N
48.5°N
47.75°N
47°N
126°W
125.25°W
124.5°W
123.75°W
123°W
Brightness Temperature (K)
300
240
180
120

GMI 89H

AMPR 85H

GMI 89V

AMPR 85V



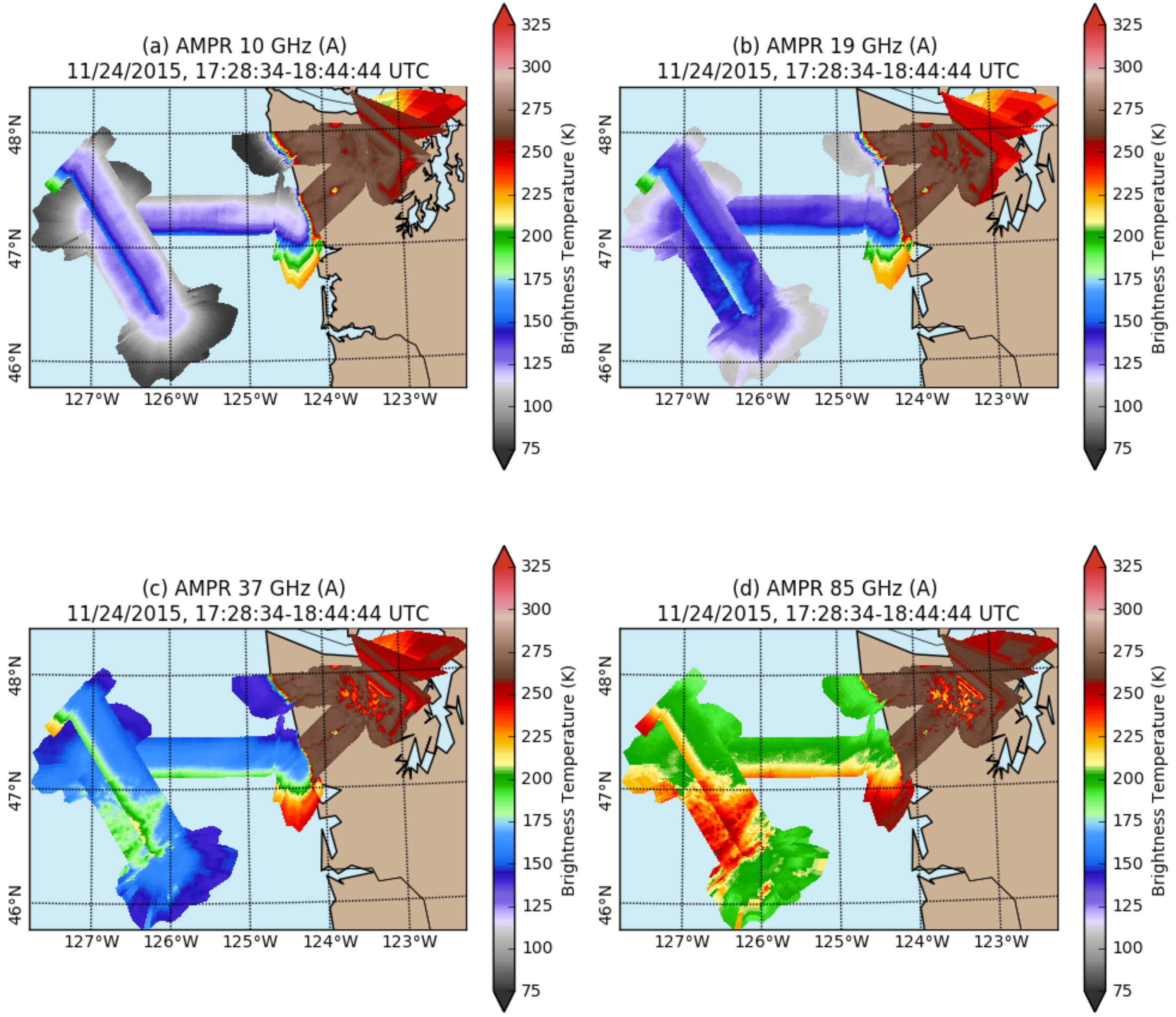
Major Takeaways from 12/3 Underflight

- AMPR resolves complex TB structure within Strait of Juan de Fuca, GMI affected by land/ocean FOV mixing

- Over land, away from coasts, there is broad agreement (taking into account resolution differences) – although AMPR senses apparent mountain snow fields at 10/37 GHz

- No AMPR 19 GHz this day – Gunn oscillator failure (was repaired later in project)

AMPR 11/24 Geophysical Retrievals



Multi-Linear Regression Model(s)

- Model for Columnar Water Vapor (V in mm):

$$V\,(mm) = a_0 + a_1{*}T_{B10v} + a_2{*}T_{B10h} + a_3{*}\ln(290-T_{B19v}) + a_4{*}\ln(290-T_{B19h}) + a_5{*}\ln(290-T_{B37v}) + a_6{*}\ln(290-T_{B37h}) \quad (1)$$

- Model for Columnar Cloud Liquid Water (L in mm):

$$L\,(mm) = a_0 + a_1{*}\ln(290-T_{B19v}) + a_2{*}\ln(290-T_{B19h}) + a_3{*}\ln(295-T_{B85v})+a_4{*}\ln(295-T_{B85h}) \quad (2)$$

- Model for Surface Wind Speed (WS in m/s):

$$WS\,(m/s) = a_0 + a_1{*}T_{B10v} + a_2{*}T_{B10h} + a_3{*}\ln(290-T_{B19v}) + a_4{*}\ln(290-T_{B19h}) + a_5{*}T^2_{B10v} + a_6{*}T^2_{B10h} + a_7{*}T_{B10v}{*}T_{B10h} + a_8{*}SST \quad (3)$$

Where, $T_{Bnv,h}$ = Measured T_B for n GHz v,h-polarization channels

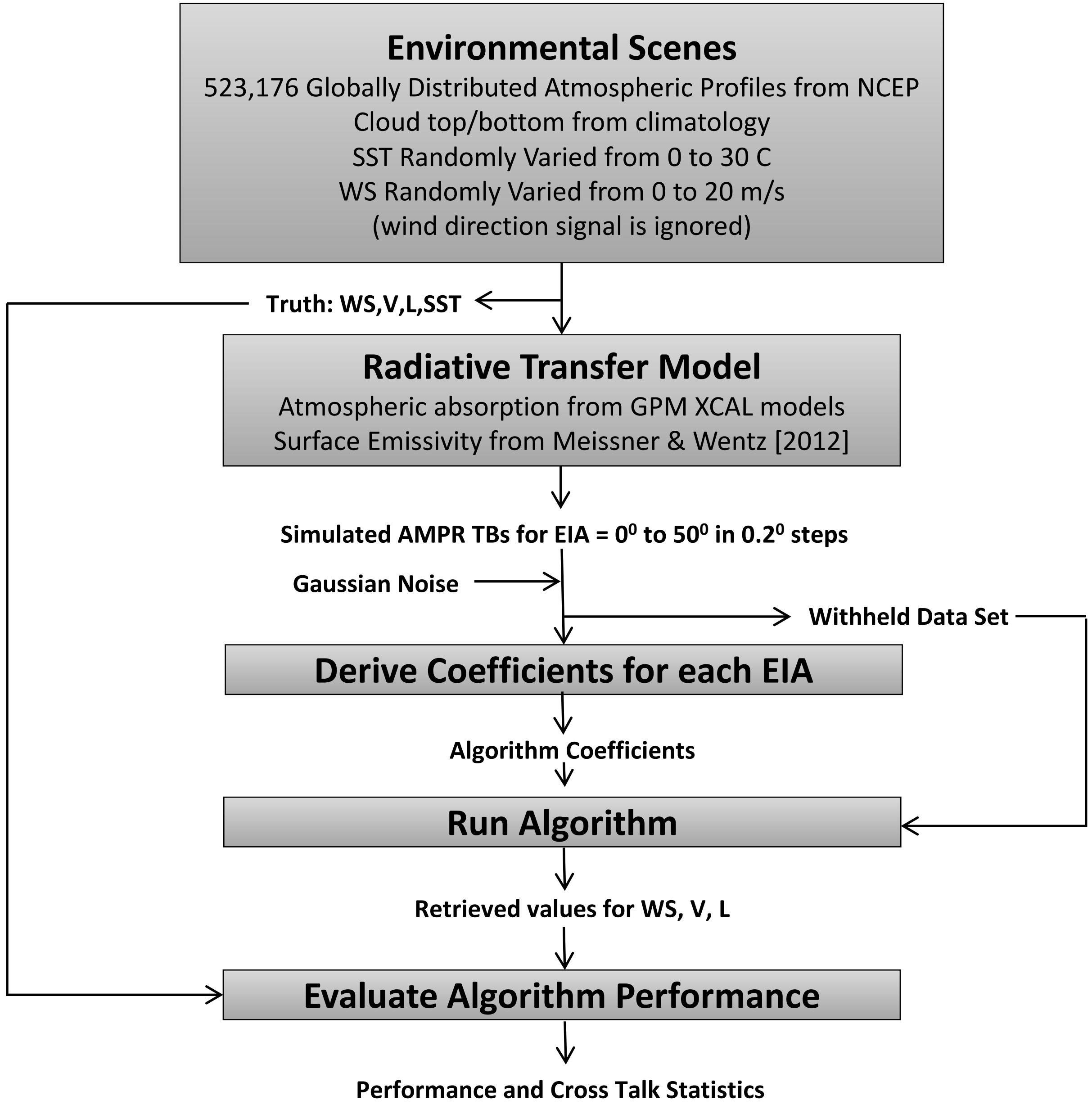
SST = Sea Surface Temperature in Kelvin (a priori value needed)

a_n coefficients are polynomial functions of the incidence angle*

The WS retrieval is further improved by generating ‘a’ coefficients for different range of wind speeds, e.g. WS<=3, WS>3<=7, WS>7<=12 & WS>12 .

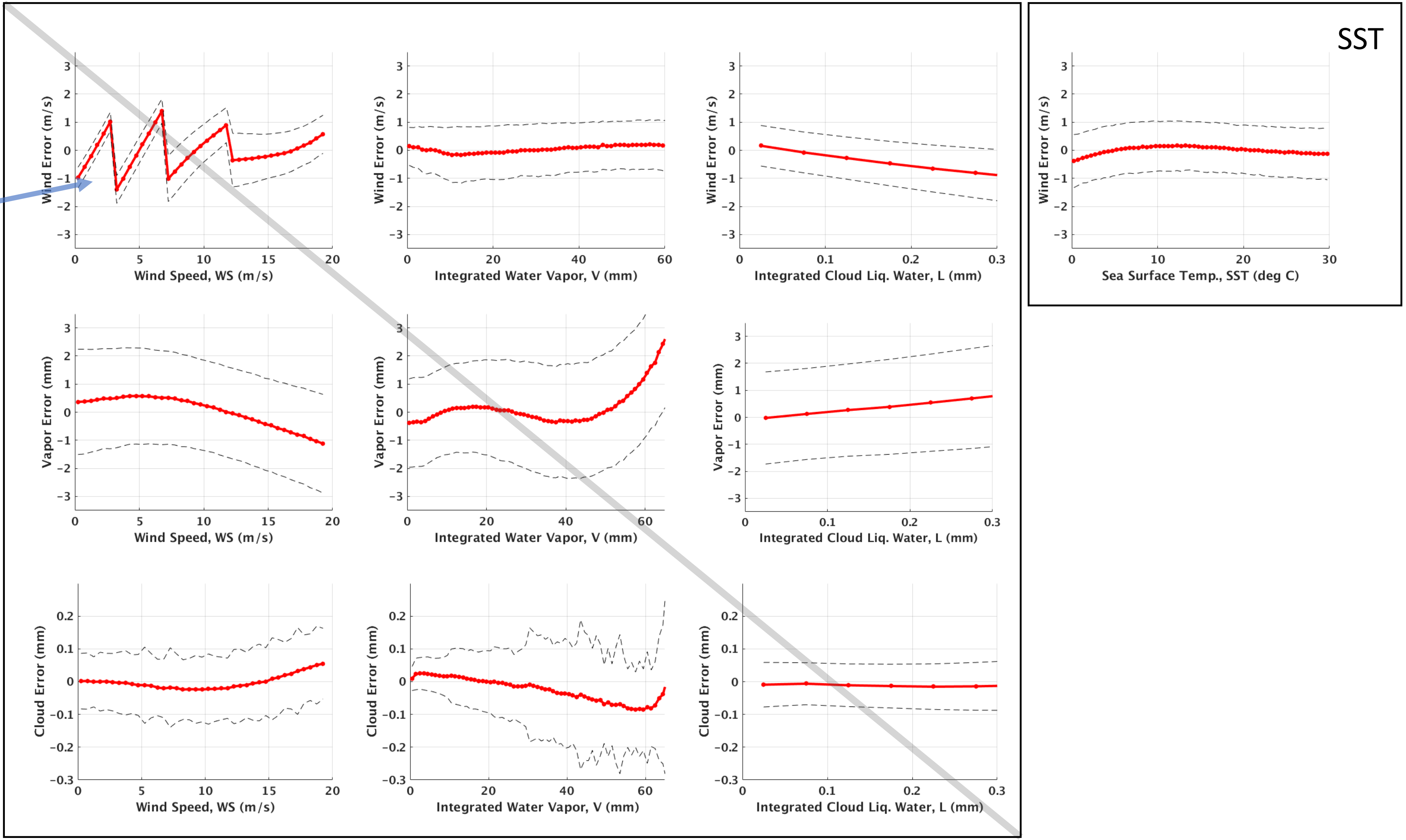
(*AMPR is a cross-track scanner and the observation incidence angle varies between 0^0 to 45^0)

Coefficient Derivation & Testing



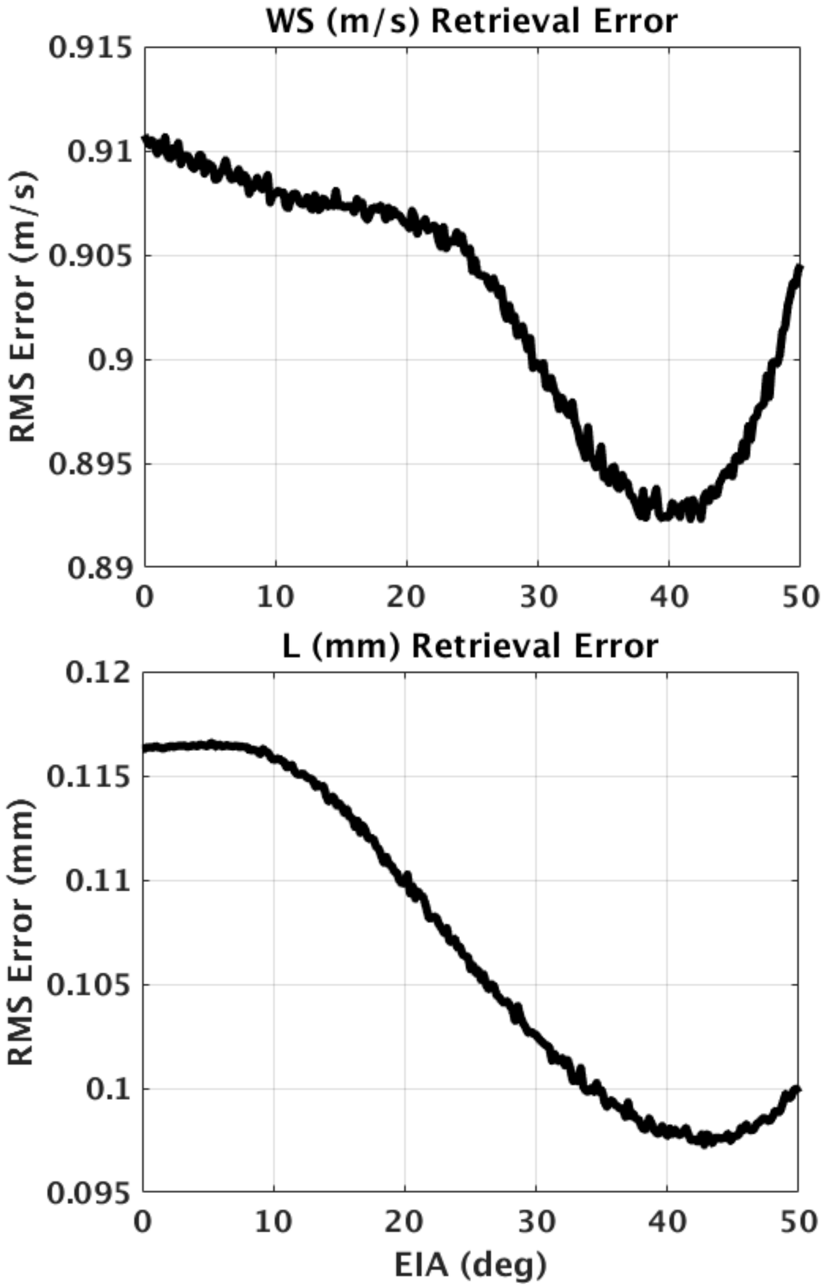
Retrieval and Cross-Talk Error

Multi-step wind retrieval to reduce low bias in weak winds



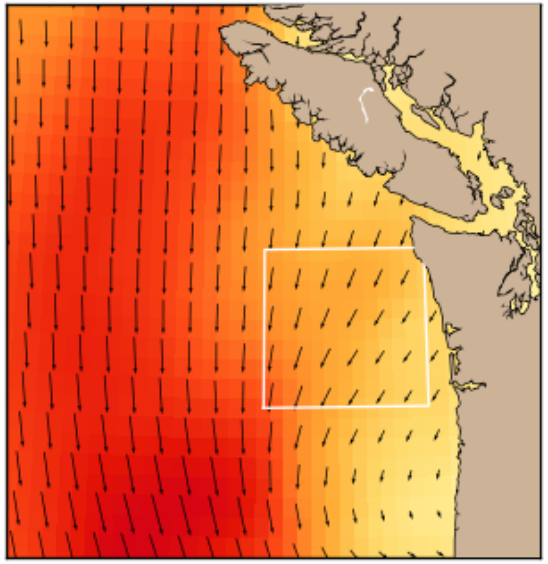
Errors are averaged over all Earth Incidence Angles (EIA) between 0 to 50 deg

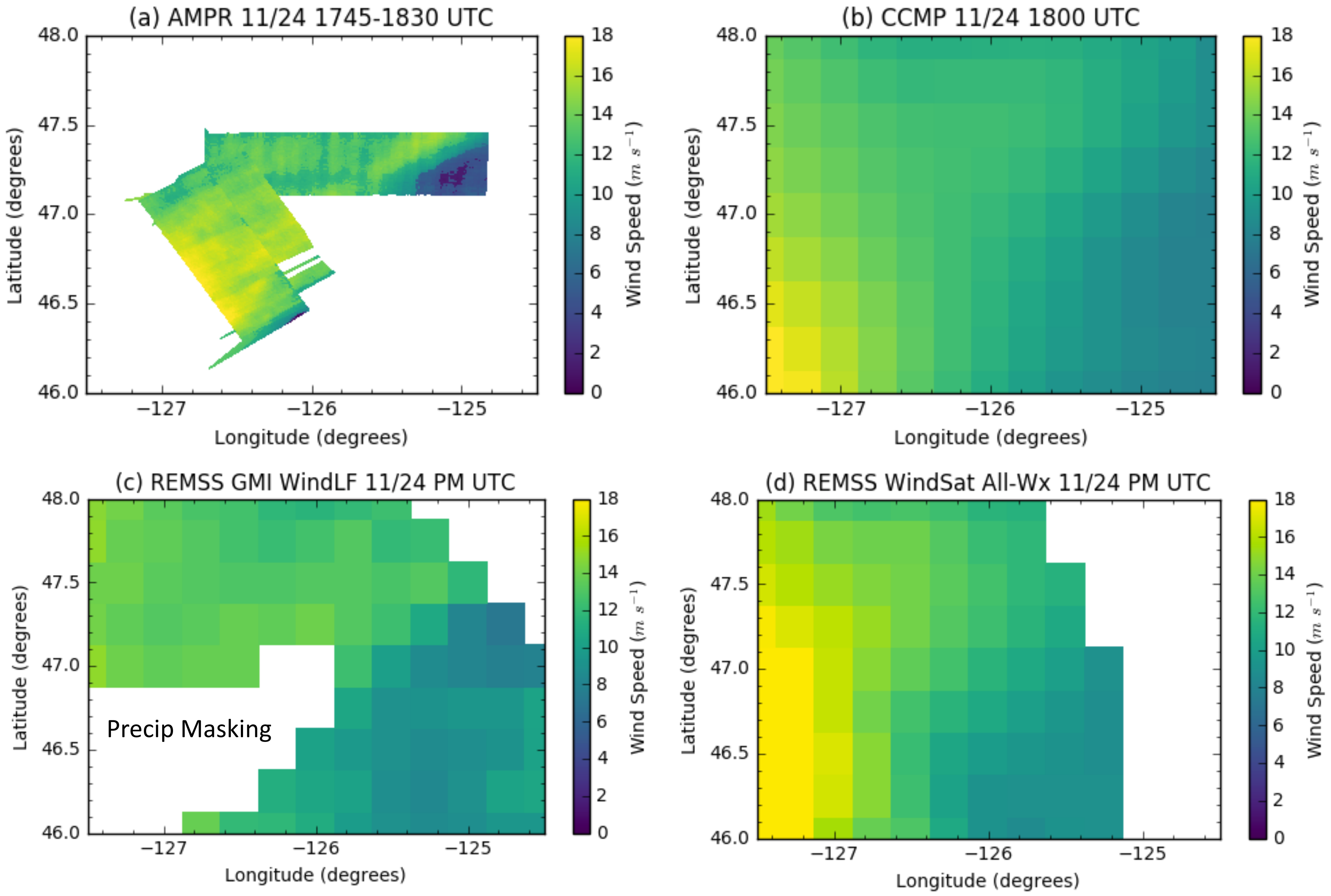
RMS Retrieval Error vs. Earth Incidence Angle (EIA)



EIA average RMS Retrieval Error	
WS (m/s)	0.9
V (mm)	1.85
L (mm)	0.11

AMPR vs. REMSS Wind Products

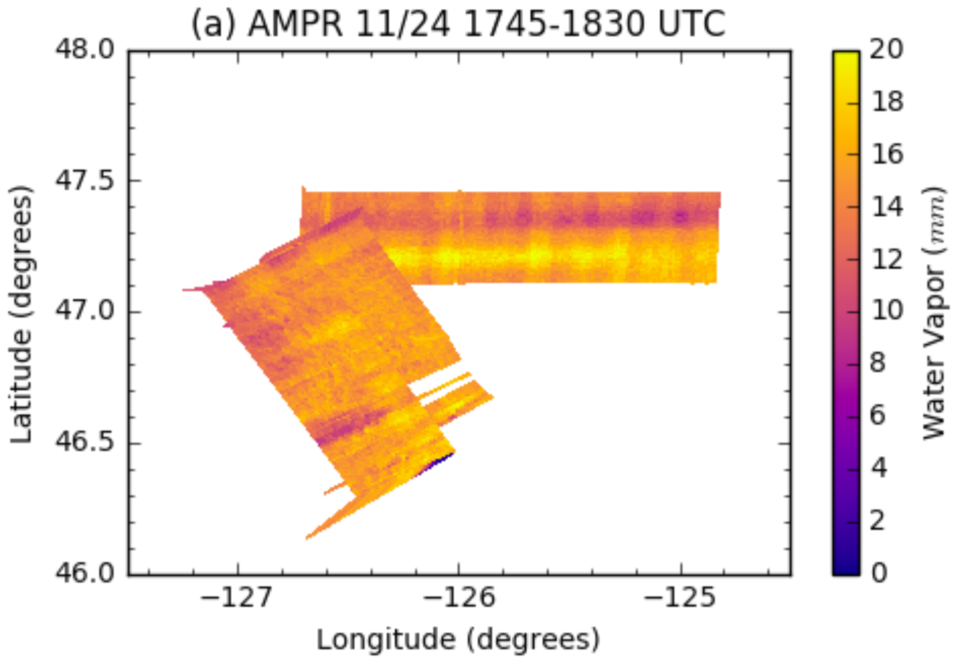


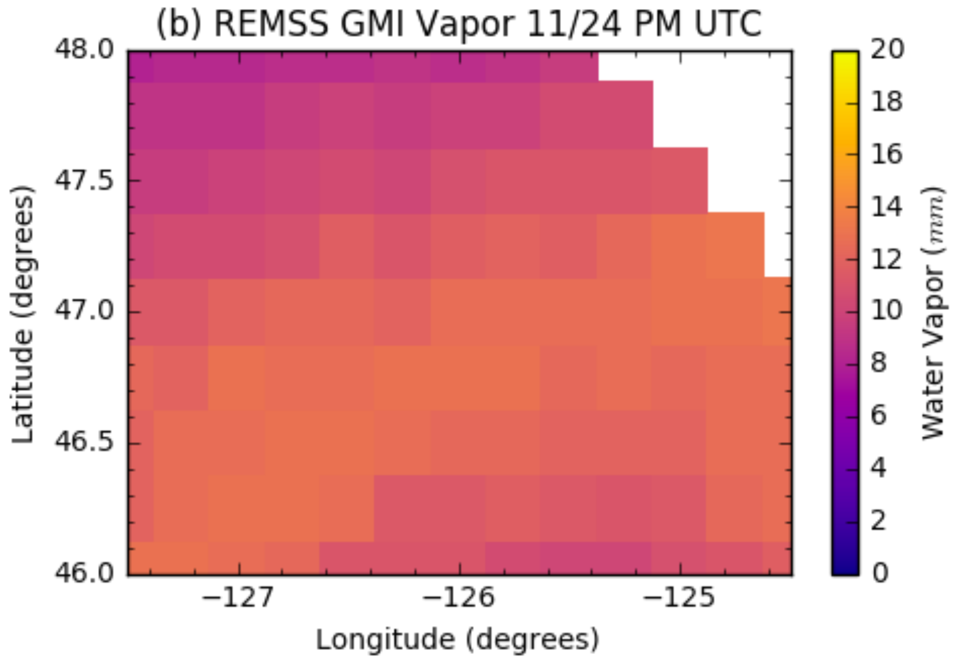


- Slantwise gradient captured by AMPR
- Range of domain wind speeds captured
- Possible precip influence at 19 GHz

Water Vapor

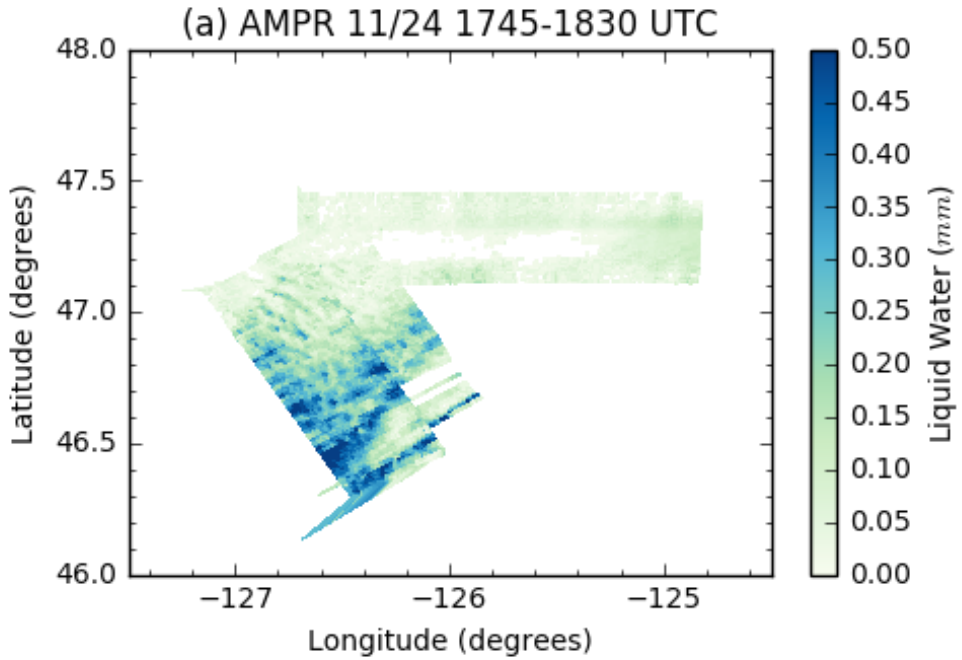
- AMPR High Bias?
- Scan Angle Dependence?
- Work to be done here

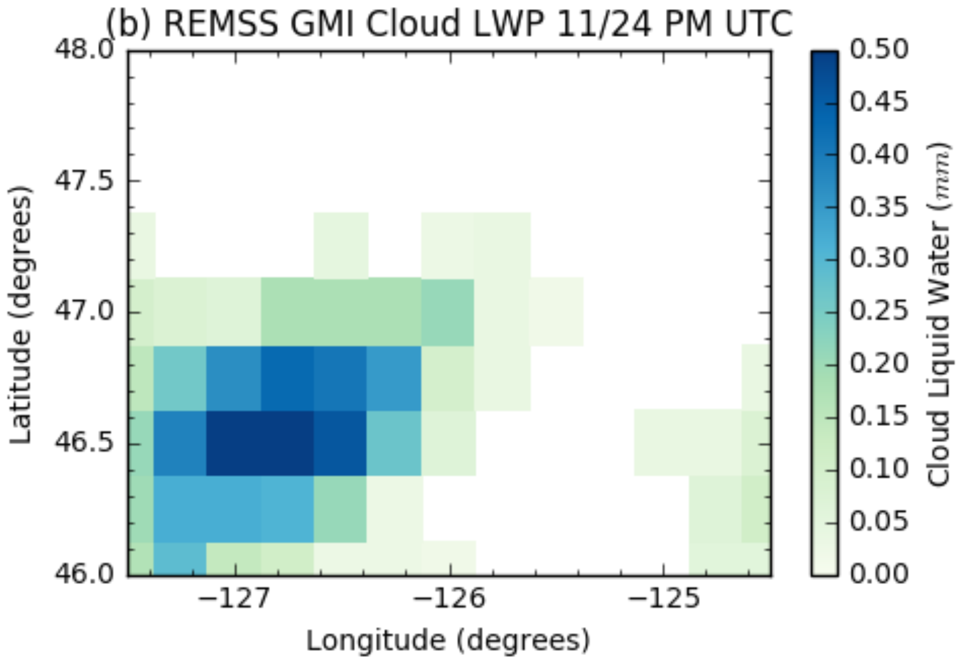




Cloud Water

- Range of values in domain captured
- Good location correspondence





Major Takeaways from 11/24 Geophysical Retrievals

- Empirical model for retrievals developed and applied to deconvolved H & V polarized observations
- Wind speed and cloud liquid water show promising results and demonstrate AMPR's potential resolution advantages
- Water vapor model requires more development to resolve observed biases

Ongoing and Future Work

- Currently upgrading AMPR data system (was delayed by OLYMPEX/ORACLES crush) – Will mitigate obsolescence risk and facilitate greater scanning agility

- Currently characterizing NEDT stability, pointing angle uncertainty, and receiver nonlinearity in lab – Will improve TB and geophysical retrievals

- Examining other IPHEx, OLYMPEX, and ORACLES cases – Need collaborators!

QUESTIONS?

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