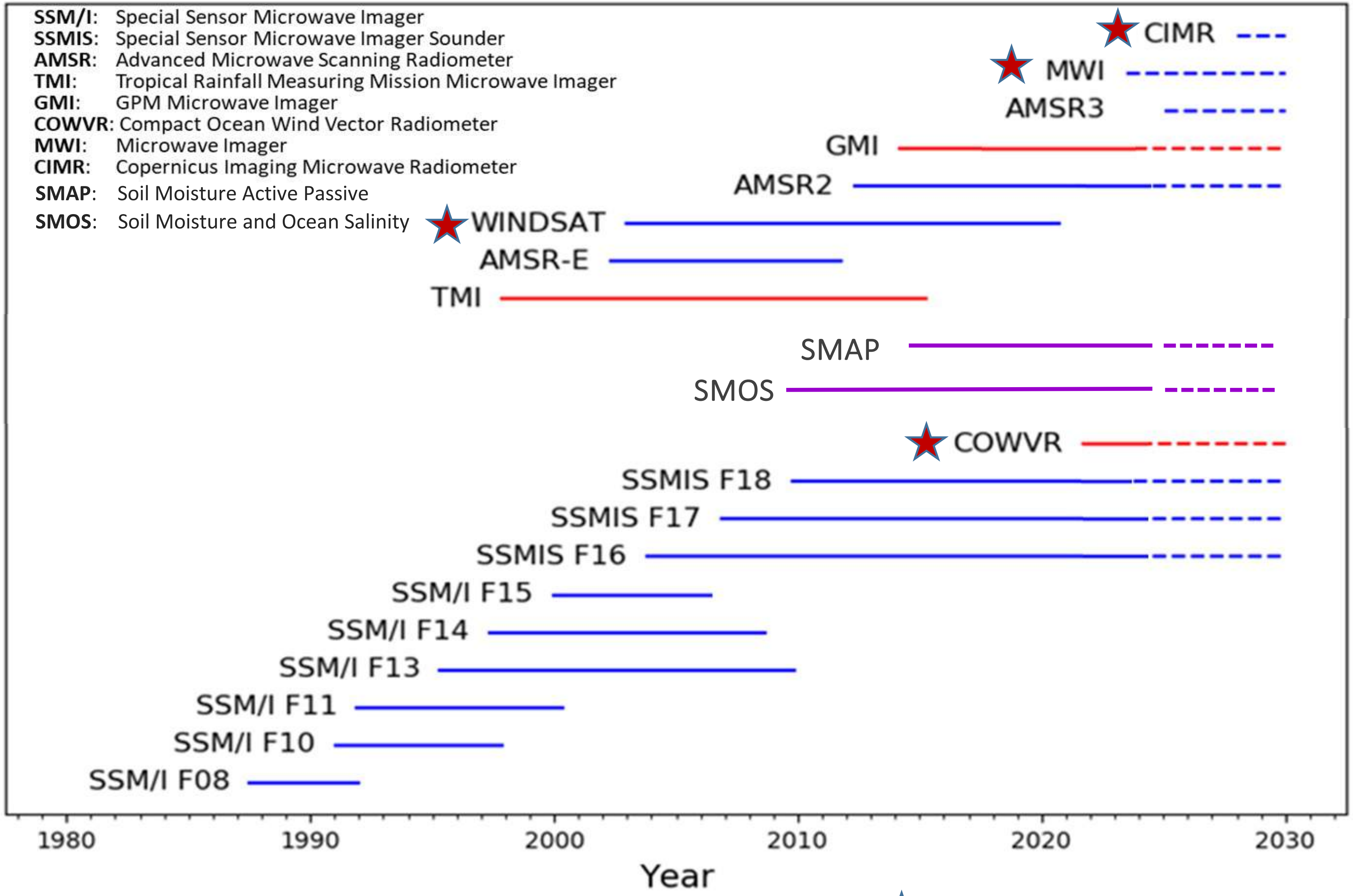
MW Radiometer Missions with Wind Retrieval Capability



L-band only

Non-sun-synchronous

★ Fully Polarimetric (wind vector)

MW Channel Utilization in Surface Wind Retrievals

Primary Channels and Source of Emission							
Band (GHz)	**1.4** **L-band only**	**6-7**	**10**	**18-19**	**22-23**	**34-37**	**85-91**
Sensors	**SMAP, SMOS**	**AMSR, WSAT** **SFMR**	**TMI, GMI, MWI, AMSR, WSAT**	**ALL (incl. COWVR)**	**ALL (+COWVR)**	**ALL (+COWVR)**	**TMI, GMI, MWI SSMIS, AMSR**
SST							
Wind	**No rain impact/ Sensitivity to high winds**						
Water Vapor							
Rain/Cloud							
Ice/Scatter.							

Surface → **Atmosphere**

RADIOMETERS WINDS: PROS/CONS

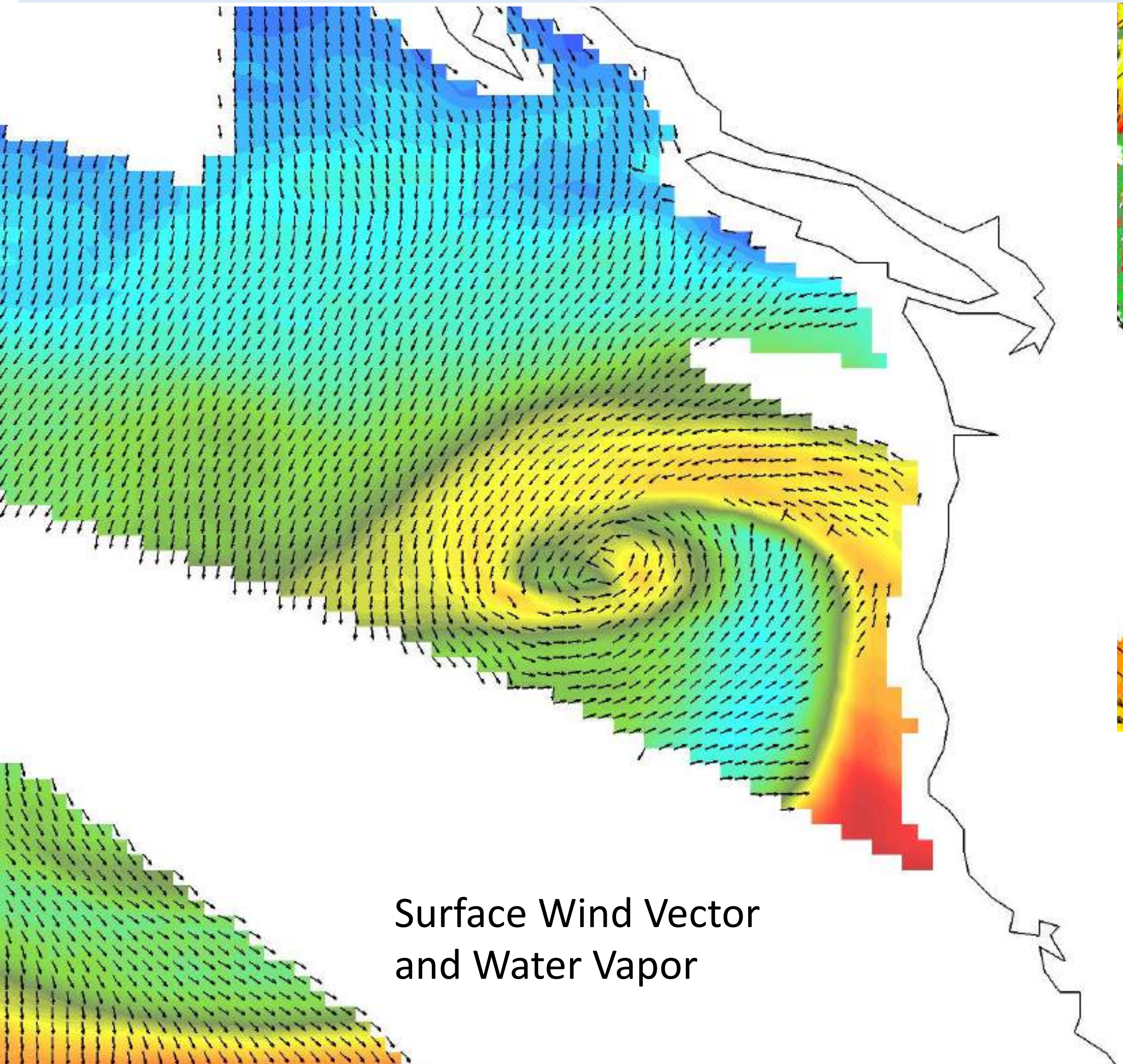
Advantages

- Long legacy (continuous, since 1988), overlapping and cross-calibrated sensors
- Allowing Climate Data Records
- Diurnal sampling: variety of fixed orbit times + non-sun-synchronous (TMI, GMI, COWVR)
- Simultaneous observations of several environmental parameters:
  wind, rain, water vapor, SST, cloud
- Capability of wind vector retrievals with polarimetric channels
- L-band very sensitive to high winds and insensitive to rain (winds in TCs)
- Potential for downscaling to lower cost small satellites (i.e. COWVR)
- Fully polarimetric + fore/aft observing mitigates wind direction ambiguities in retrievals

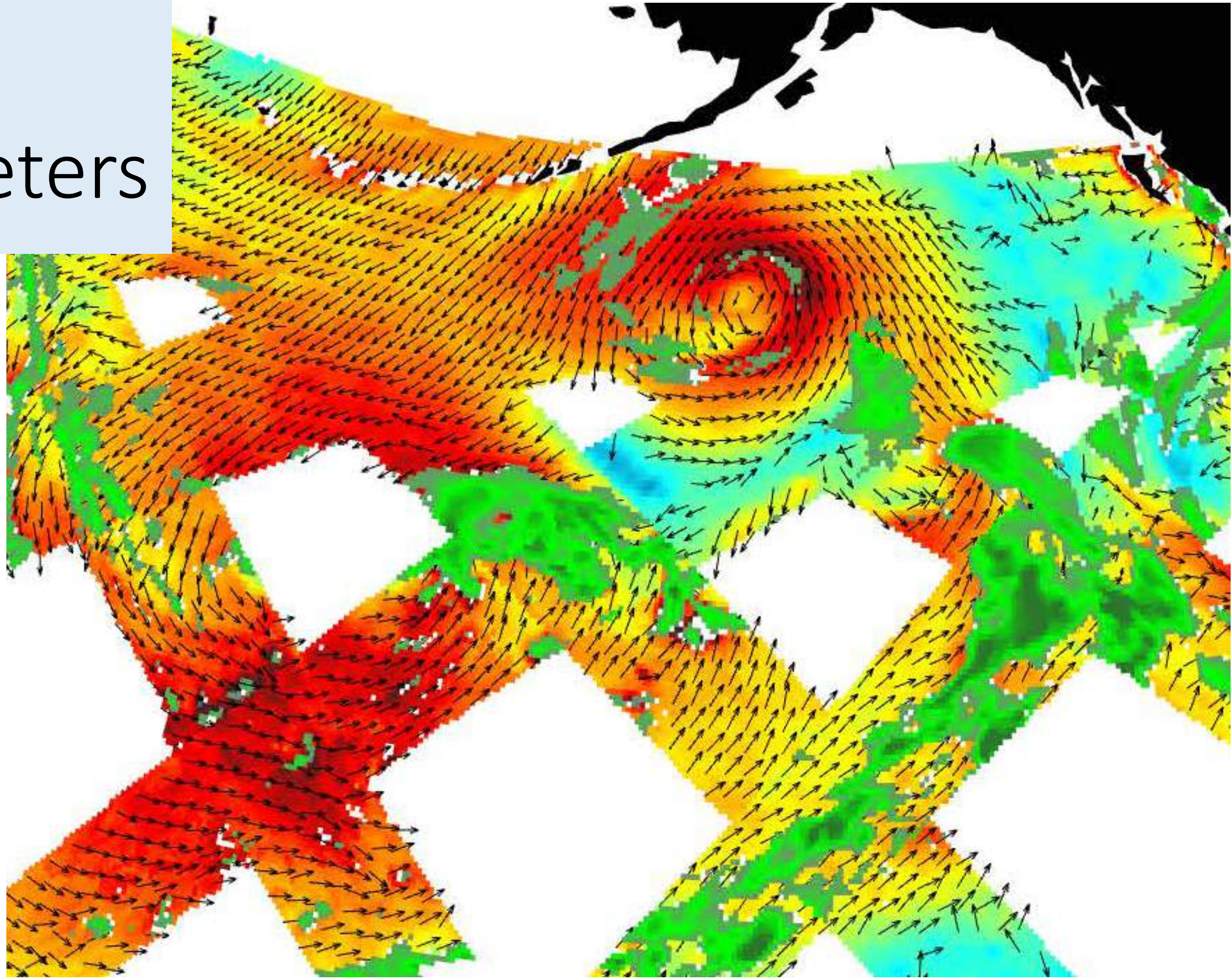
Disadvantages

- Lower resolution (25-50 km) than scatterometers
- Rain impact on wind retrievals (can be mitigated with 6 GHz channel)
- Radio Frequency Interference (RFI) is a growing problem (requiring more agile sensors)
- Most of climate record is scalar winds (fully polarimetric generally not required for most MW missions i.e. precip)

Radiometer capabilities: Wind vector and other parameters



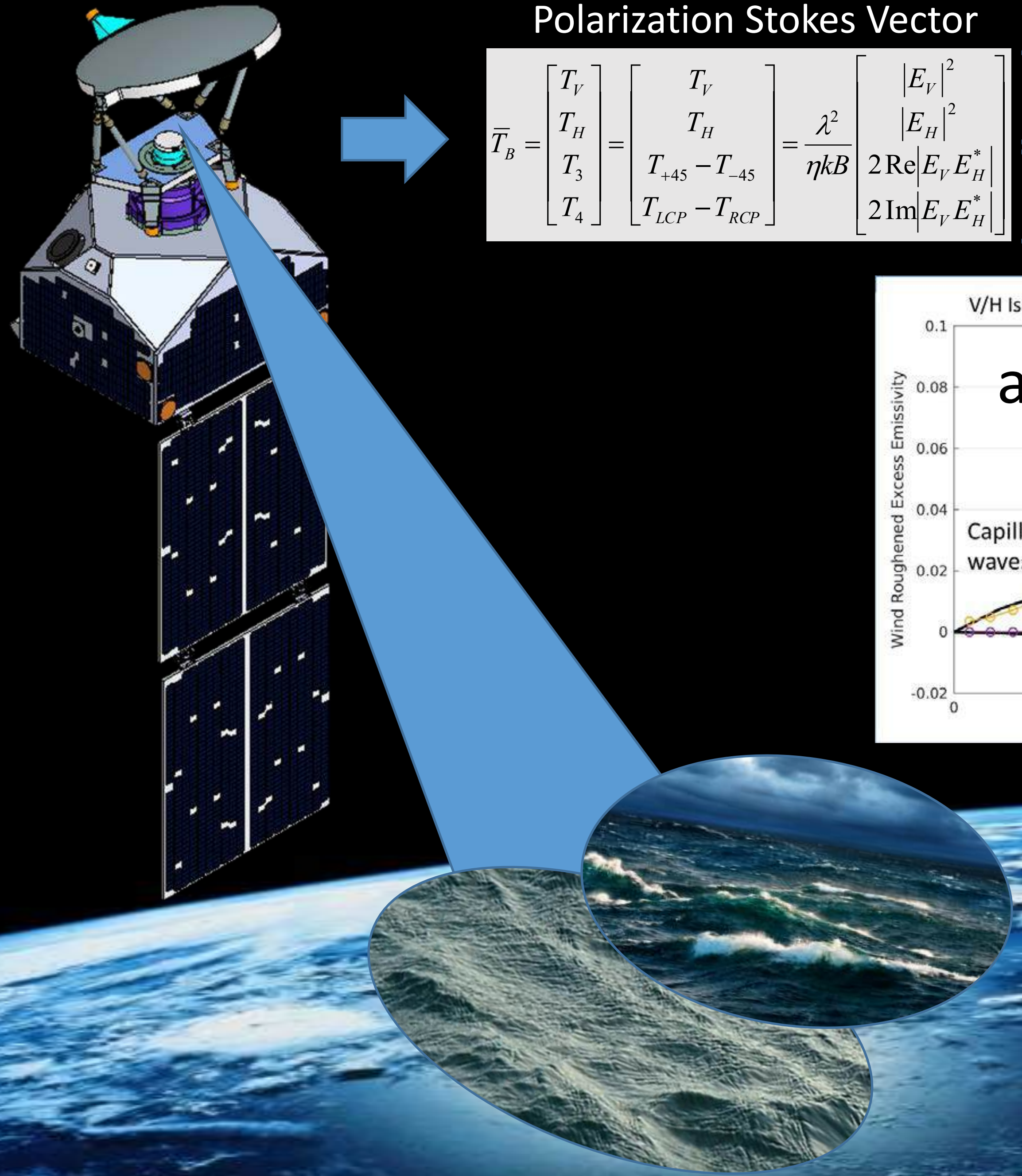
Surface Wind Vector and Water Vapor



Surface Wind Vector and Rain

Microwave Radiometers have added benefit of co-located observations of water vapor, clouds, rain, SST

Backup



Polarization Stokes Vector

$$\overline{T}_B = \begin{bmatrix} T_V \\ T_H \\ T_3 \\ T_4 \end{bmatrix} = \begin{bmatrix} T_V \\ T_H \\ T_{+45} - T_{-45} \\ T_{LCP} - T_{RCP} \end{bmatrix} = \frac{\lambda^2}{\eta k B} \begin{bmatrix} \left|E_V\right|^2 \\ \left|E_H\right|^2 \\ 2\,\mathrm{Re}\left|E_V E_H^*\right| \\ 2\,\mathrm{Im}\left|E_V E_H^*\right| \end{bmatrix}$$

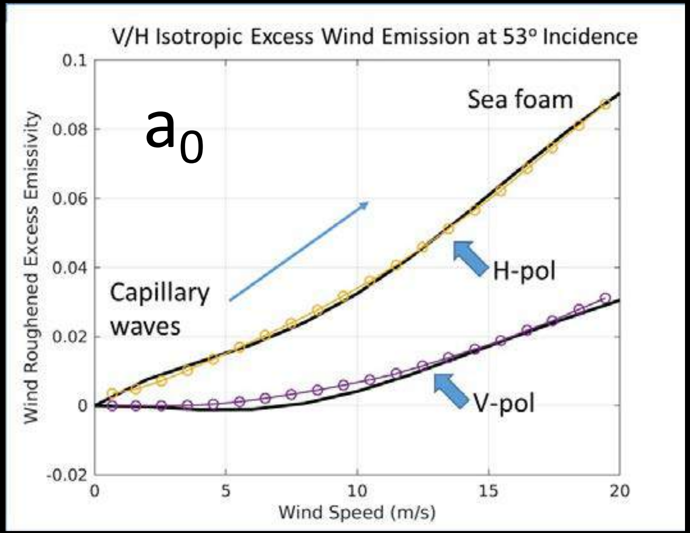
Ocean Emissivity Model Function

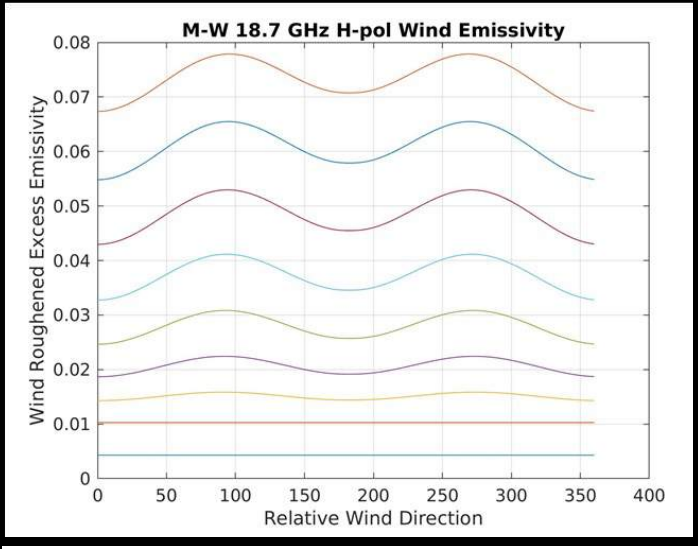
$$\varepsilon_{V/H} = a_0 + a_1 \cos\varphi_{rel} + a_2 \cos 2\varphi_{rel}$$

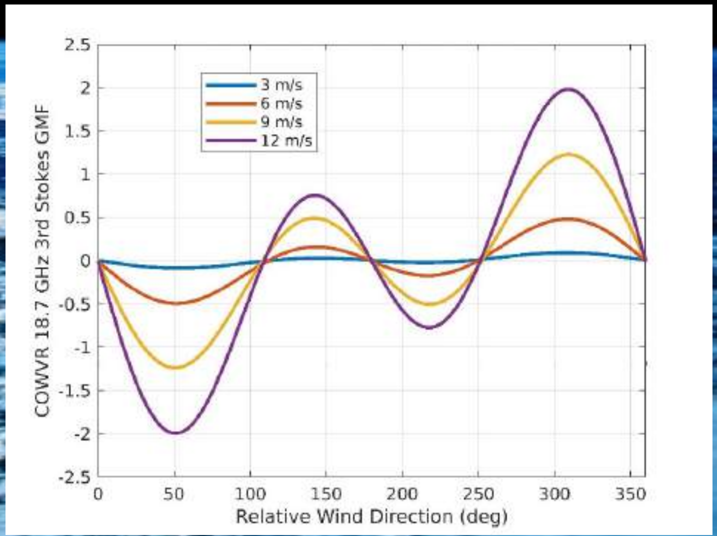
Dual-pol radiometer

$$\varepsilon_{3/4} = b_1 \sin\varphi_{rel} + b_2 \sin 2\varphi_{rel}$$

Fully polarimetric





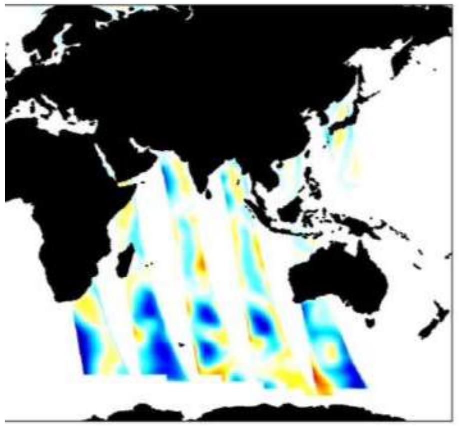


2-Look Passive Microwave Radiometry

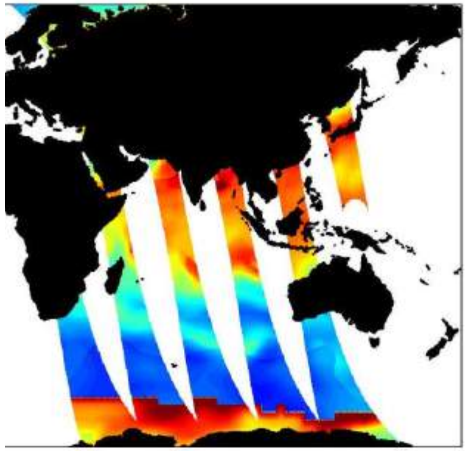
- V/H-pol channels have orthogonal wind direction signal from 3rd/4th, but the small signal at the ocean surface is swamped by the atmospheric contribution
- Taking the fore/aft difference largely cancels out atmosphere, similar to 3rd and 4th stokes channels

$$T_3 = \varepsilon_3 \left(SST - T_{Downwelling}\right) e^{-\tau}$$

3rd Stokes Top-of-Atmosphere



V-pol Fore-Aft Top-of-Atmosphere



from simulation

$$T_{V\_Fore} - T_{V\_Aft} = \left(\varepsilon_{\phi\_Fore} - \varepsilon_{\phi\_Aft}\right)\left(SST - T_{Downwelling}\right) e^{-\tau}$$