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Precipitation Characteristics with Mid-latitude Frontal Systems

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I. INTRODUCTION

The GPM mission is designed to better quantify precipitation characteristics at middle and high latitudes. During the cold season, precipitation is often associated with frontal cyclones. Using radar observations, precipitation is commonly categorized as bands/clusters according to its location relative to fronts and cyclones. This study initiates an investigation to characterize the precipitation bands/clusters along the storm track in the Northern Pacific.

We use GPM IMERG and model reanalysis (MERRA2) data to identify different types of precipitation bands. Precipitation Feature (PF) data based on Ku PR reflectivity is applied to describe the precipitation characteristics.

Type	*Subtype*	*Definition*	*References*
Cold-frontal band	**Wide (WCFR)**	A band parallel to and in the vicinity of the cold front	HH1982; Locatelli et al. 1994; Han et al. 2009
	Narrow (NCFR)	A band (~ 10 km wide) with high reflectivities collocated with the surface cold front	HH1982; Braun et al. 1997; Han et al. 2009
Warm-frontal band	–	A band in the vicinity of the warm front	HH1982; Han et al. 2007
Warm-sector band	–	A band in the warm sector	Nozumi and Arakawa 1968; HH1982
Occlusion band	–	A band close to a low and associated with weak temperature gradients	HH1982; SK1990
Post-frontal precp.	–	A group of open- or closed-cellular convective cells, or organized precip. behind the cold front	Monteverdi 1976; Reed 1979; HH1982; Reed and Blier 1986; Braun and Monteverdi 1991; Stevens et al. 2005

Table 1: Precipitation bands/clusters (HH is Houze and Hobbs; SK is Shapiro and Keyser)

Total 351 orbits in Northern Pacific during January 2016						
	Cold F (NCFR+WCFR)	Warm F	Warm F+Warm sector	Occlusion	Post F	Coastal (N. America)
# of orbits	26	14	7	8	many	3

Table 2: Ku PR orbits with sufficient coverage

II. COLD FRONTAL

IMERG and MERRA data show cyclones and frontal precipitation bands in the Northern Pacific. The Ku radar swaths captured the intense cold frontal bands. Histograms of reflectivity and mass spectrum mean diameter (Dm, melted) of PFs are shown. The cold frontal bands extended into the upper troposphere and produce up to 50 dBZ intensities.

Fig. 1: Orbit 10466

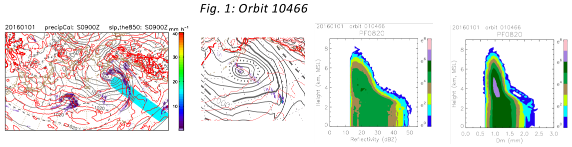
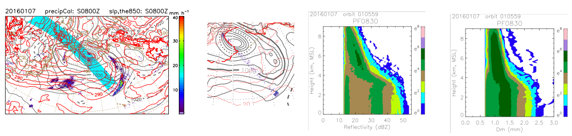
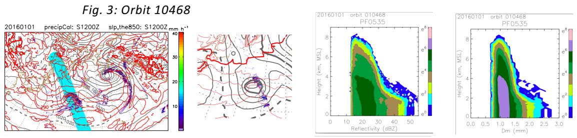


Fig. 2: Orbit 10559

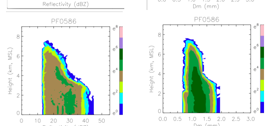


III. WARM FRONTAL / WARM SECTOR

Fig. 3: Orbit 10468



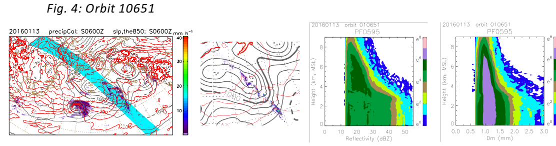
The GMI imager scanned a developing cyclone in the central Pacific. Ku PR captured segments of the warm frontal/warm sector bands.



III. WARM FRONTAL / WARM SECTOR (continued)

The GMI imager scanned a relatively weak cyclone in the central Pacific. The Ku PR captured a strong warm sector precipitation feature (PF). This PF has the largest Dm among all precipitation events in the Northern Pacific in January 2016.

Fig. 4: Orbit 10651



IV. OCCLUDED

GPM overpasses of occluded cyclones at higher latitudes, where precipitation is shallower and precipitation particles appear smaller.

Fig. 5: Orbit 10477

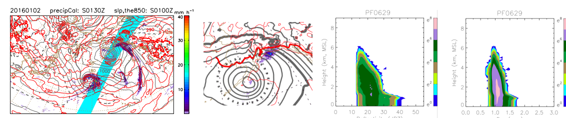
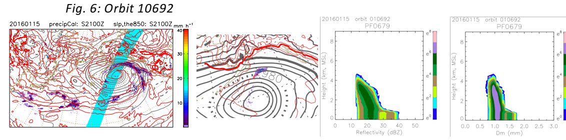


Fig. 6: Orbit 10692

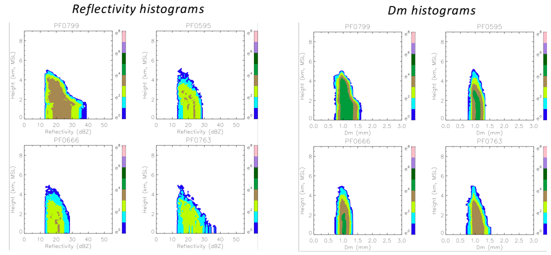


V. POST-FRONTAL

Post frontal precipitation cells/clusters produced in the cold sector of cyclones are commonly observed by GPM sensors.

Fig. 7: Four largest post frontal PFs in orbit 10466 (see Fig. 1 for the synoptic view)

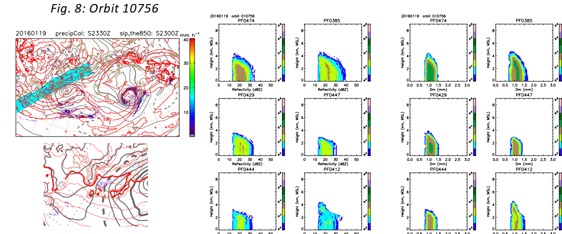
Reflectivity histograms *Dm histograms*



V. POST-FRONTAL (continued)

Post frontal precipitation clusters produced by cold air outbreaks in the Sea of Japan.

Fig. 8: Orbit 10756



VI. WESTERN AND EASTERN PACIFIC

GPM overpasses of an intense developing cyclone and an occluded cyclone on Jan 17th. A cold frontal band was captured by Ku PR in the western Pacific. In the eastern Pacific, an Atmospheric River in the warm sector of an occluded cyclone transported a large amount of moisture to the California coast. The precipitation appears to be more intense within the developing cyclone in the western Pacific.

Fig. 9: Orbit 10716

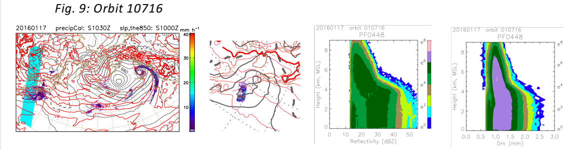
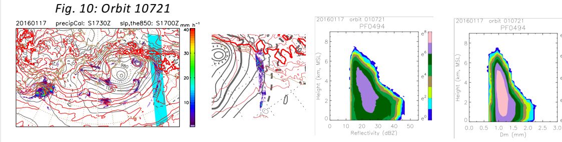


Fig. 10: Orbit 10721



VII. SUMMARY

Observations from the GPM core satellite were analyzed to characterize frontal precipitation bands/clusters in the Northern Pacific. 351 orbits in January 2016 were selected. During the study, we manually selected cases that are representative of different types of precipitation bands/clusters, including cold frontal bands, warm frontal bands, warm sector bands/clusters, occlusion bands, and post-frontal bands/clusters. Frontal bands and warm sector bands appear to have higher vertical extent. Occlusion and post-frontal bands/clusters appear to have shallower vertical extent. The features appear to be consistent with their dynamic causes. The mode of particle sizes (Dm) in most cases is within 1.0 – 1.5 mm.

The preliminary results demonstrate that precipitation sampled by the GPM satellite over the open oceans can be classified into different categories of bands/clusters in a way relatively similar to their coastal/land counter parts documented in the early literature. This study begins a comprehensive study of precipitation characteristics and hydrometeor properties associated with different types of precipitation bands/clusters. Future analysis will incorporate more objective measures derived from reanalysis data to describe the relationship between the precipitation bands/clusters and their dynamic and thermodynamic environment.