Precipitation Characteristics in Coastal Area of Alaska Revealed from Spaceborne Radars

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1. Introduction

The coastal area receives large amount of precipitation owing to the vicinity to the source of moisture. The TRMM (Tropical Rainfall Measuring Mission) PR (Precipitation Radar) observation have revealed the climatological rainfall characteristics in the tropics, and found that a remarkable amount of precipitation occurs in the tropical coastal region. This fact indicates that the concentrated precipitation plays an important role in the global water circulation between the ocean and the land (Ogino et al. 2017).
DPR (Dual-frequency Precipitation Radar) onboard GPM (Global Precipitation Measurement) core observatory were launched in March 2014. The DPR precipitation data cover mid-high latitudinal area where TRMM PR does not cover, because the GPM satellite has higher-angled orbit (about 65°instead of 35°). In this study, the coastal precipitation in mid-high latitude is investigated by using the newly obtained DPR dataset.
We mainly focused on the northwestern region of Northern American continent where the prevailing westerly wind brings moisture from the sea and produce precipitation on windward side of the coastal mountains. The mountains inhibit moisture to inland, so the region has large spatial gradients of precipitation properties. Because ground-based observations are sparse and biased due to the complicated orography and the inaccessibility of the place, satellite remote sensing data is useful to grasp precipitation characteristics in the southern coast of Alaska.

2. Data and Method

DPR measurements enabled us to obtain spatially detailed and uniform climatological precipitation dataset in regions with poor surface observation such as the southern coastal Alaska and the area above the ocean. DPR Level2 version 06A precipitation products from April 2014 to March 2019 were resampled to 0.1°×0.1° grid boxes. Then we calculated precipitation amount and frequency, which is defined by the ratio of number of precipitation-detected observation at a given location, in each gird box.
CPR (Cloud Profiling Radar) onboard CloudSat is more sensitive to precipitation due to its higher frequency and provide good estimates of light precipitation and snowfall especially in high latitude (Tang et al. 2017). CloudSat Level2 2C-PRECIP-COLUMN products from January 2007 to December 2015 were also resampled to 0.1°×0.1° grid boxes to obtain light rainfall and snowfall climatology.
We calculated mean precipitation amount and frequency per unit area as a function of the distance from the coastline, following to Ogino et al. (2016). The distance from the nearest coastline detected by using SRTM30 elevation data is determined in each 0.1°×0.1° grid.

3. Results and Discussion

3-1. Annual mean precipitation climatology

Figure shows the annual and seasonal mean precipitation frequency detected by DPR and CPR in the southern coast of Alaska as a function of the distance from the coastline. Annual mean DPR precipitation pattern showed that precipitation amount and frequency change sharply at the coastline. With distance from the coastline, DPR precipitation on the offshore grids decreased gradually in 0~300km seaside from the coast, besides that on the onshore grids decreased rapidly in 0~100km inland from the coast where high elevated coastal mountains exist. This fact indicates that the prevailing westerly moisture flow from

the Gulf of Alaska are inhibited by the coastal mountain and most of the moisture condense over the sea and low land near the coast.
CPR is more sensitive to the light precipitation and detected precipitation nearly 3 times more frequently than DPR in our study. CPR snowfall frequency had maximum value over coastal mountains where less precipitation is detected by DPR. Though the precipitation pattern of DPR roughly agree with previous climatological studies on Alaska, DPR precipitation in coastal highland is much less than precipitation estimated by them (Simpson et al. 2005). This may be mainly owing to the DPR poor detection of snowfall and the high ground clutter free bottom, but also the climate patterns estimated by using station data and climate models does not necessarily present the true precipitation because of sparse observation. Therefore, further studies are needed to obtain a reasonable description of precipitation in the area.

3-2. Seasonal climatology and precipitation mechanism
To reveal why so much precipitation occurs in offshore region, we compared precipitation rate at near surface with other atmospheric variables in some cases. Our case studies suggested that these precipitations occur when extratropical cyclones and fronts come and low-level moist air converges in windward side of the mountain.
We also compiled a seasonal climatology of the frequency of precipitation. In the offshore region, precipitation frequency was largest in autumn (SON), second largest in winter (DJF) and smaller in spring (MAM) and summer (JJA). The Gulf of Alaska, which is so called the “graveyard of Pacific storm”, has high storm track density, and especially, extratropical cyclones more frequently exist in the Gulf of Alaska in autumn and winter than in other seasons (Mesquita et al, 2009). Considering the case studies indicated the relation between the precipitations and storms, we can conclude that precipitation in offshore area is deeply related to the storm activities in the Gulf of Alaska.

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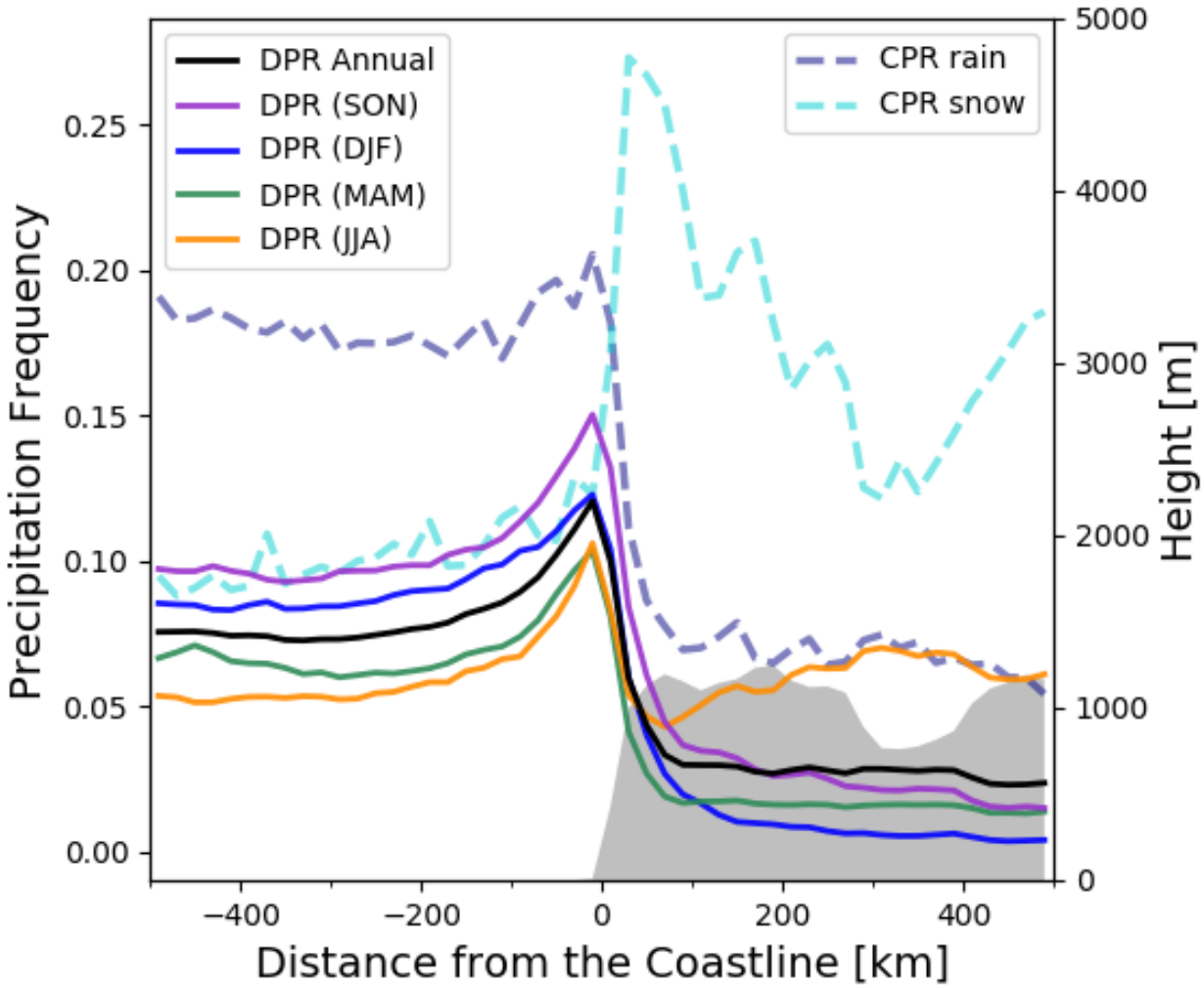
Figure. Relationship between annual (or seasonal) mean precipitation frequency and the distance from the coastline in Alaska (compiled all grids from 45° to 65°N, 125° to 155°W).

Keywords: spaceborne radar, coastal area, Alaska, orographic precipitation


DPR Annual
DPR (SON)
DPR (DJF)
DPR (MAM)
DPR (JJA)
CPR rain
CPR snow
Precipitation Frequency
Height [m]
Distance from the Coastline [km]
0.00
0.05
0.10
0.15
0.20
0.25
0
1000
2000
3000
4000
5000
−400
−200
0
200
400