# Relating GMI Brightness Temperatures to Hydrometeor Types

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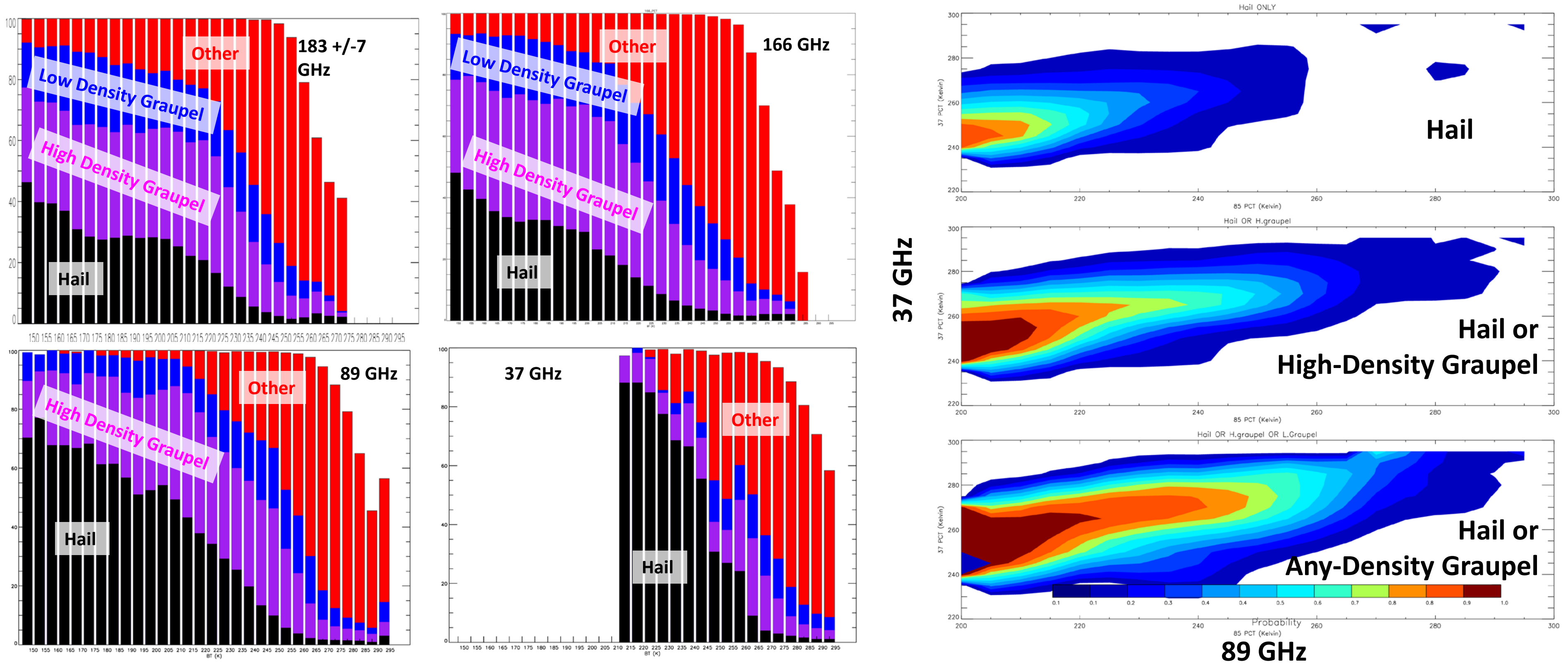
## Overview

The main goal of this project is to assess and understand how passive microwave brightness temperature values relate to particular hydrometeor types:

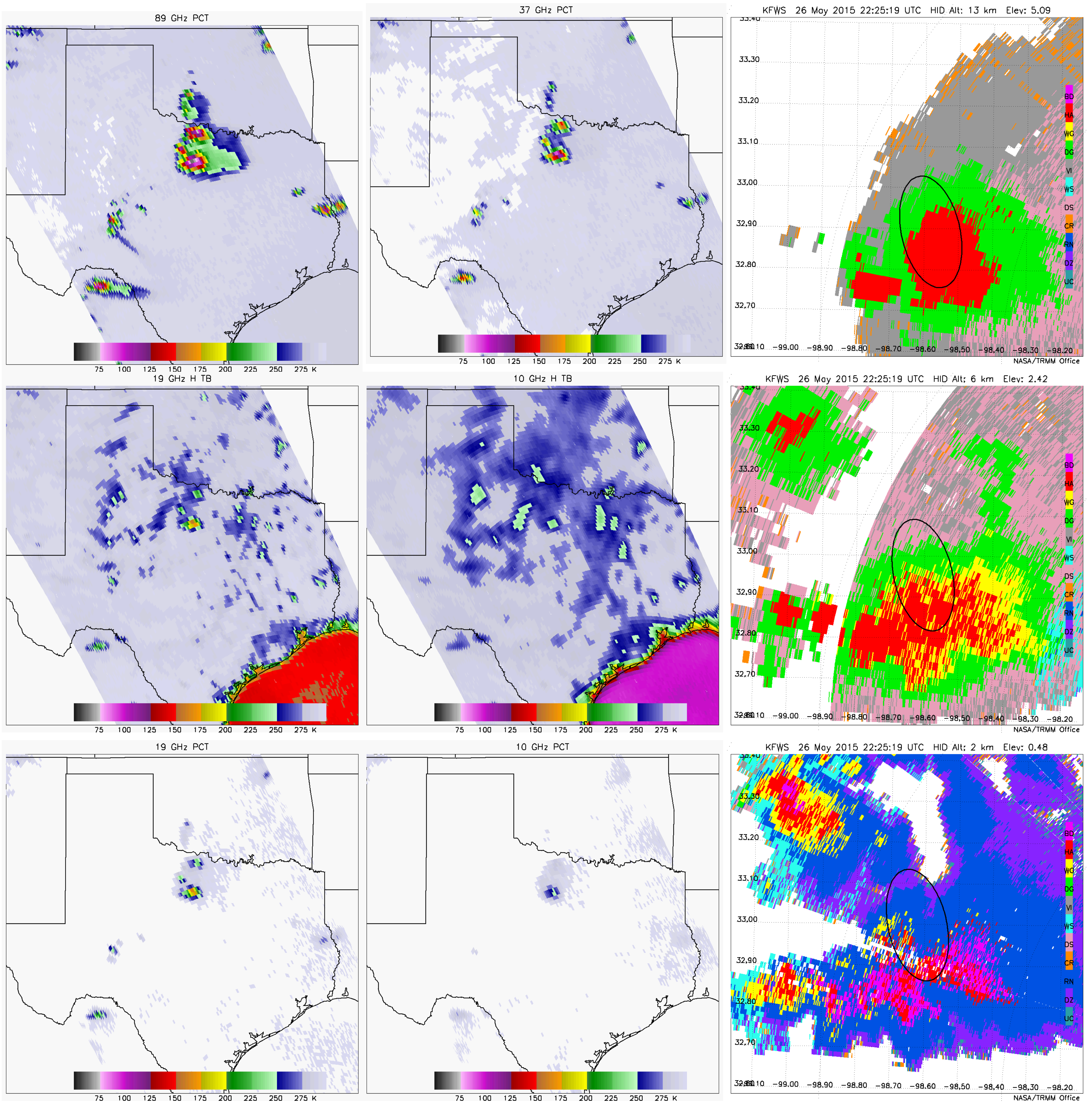
**Given a certain brightness temperature from GMI, what is the probability the vertical column includes:**



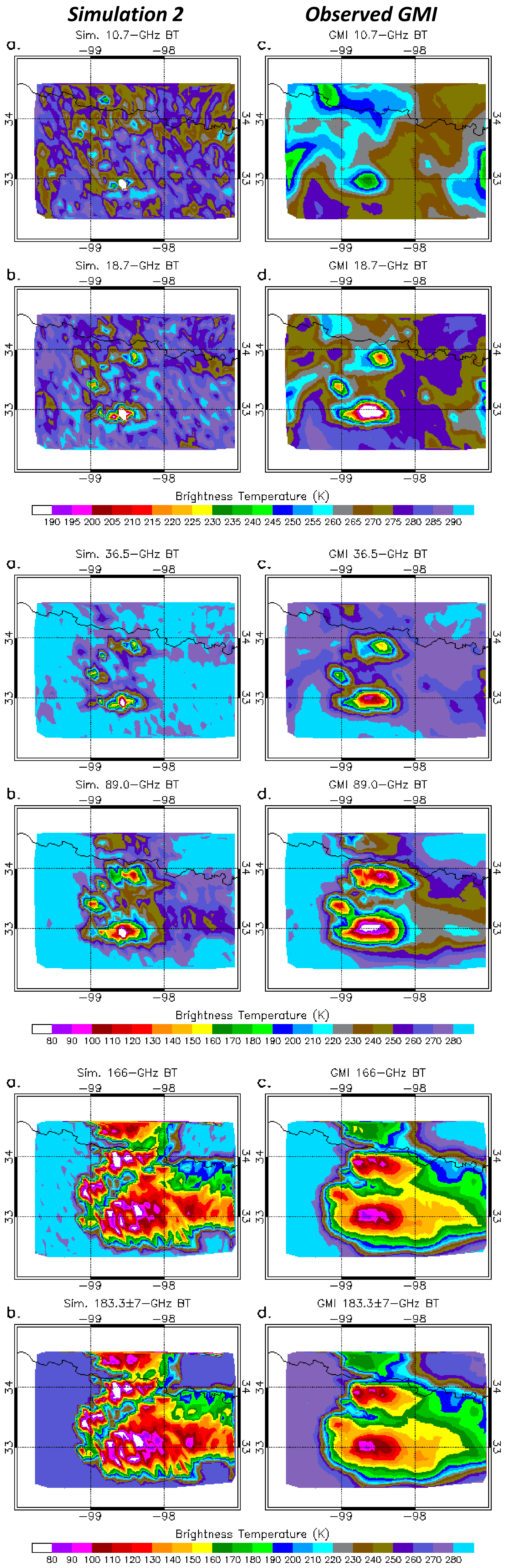
Recent efforts (in this poster) focus on:

1) How well can we simulate the measured brightness temperatures from real cases, using ground-based radar and assumed DSD as inputs?
2) What are the best coefficients to use for Polarization Corrected Temperatures (PCT), in order to more effectively extend empirical analysis of precipitation signatures over land to low-frequency channels (10 and 19 GHz)?

We are using a **26 May 2015 GPM case near Forth Worth, TX** for examples. It had noteworthy ice scattering signatures in all GMI channels, and reports of large hail at the surface.



## ARTS Atmospheric Radiative Transfer Simulator (ARTS) applied to ground-radar-based reflectivities and hydrometeor types



From KFWS Ft. Worth WSR-88D dual-polarized radar data, we derive hydrometeor type following Dolan et al. (2009). We construct a normalized gamma distribution for the Drop Size Distribution (DSD), and use assumed shape parameter and median diameter values. *The assumed shape parameter and median diameter are subject to sensitivity tests (ongoing work, not shown here)*.

The DSD is constrained to be consistent with the measured radar reflectivity.

We simulate GMI brightness temperatures using ARTS together with the constructed DSD, hydrometeor characteristics, and GMI viewing geometry through the grid of radar-based retrievals.

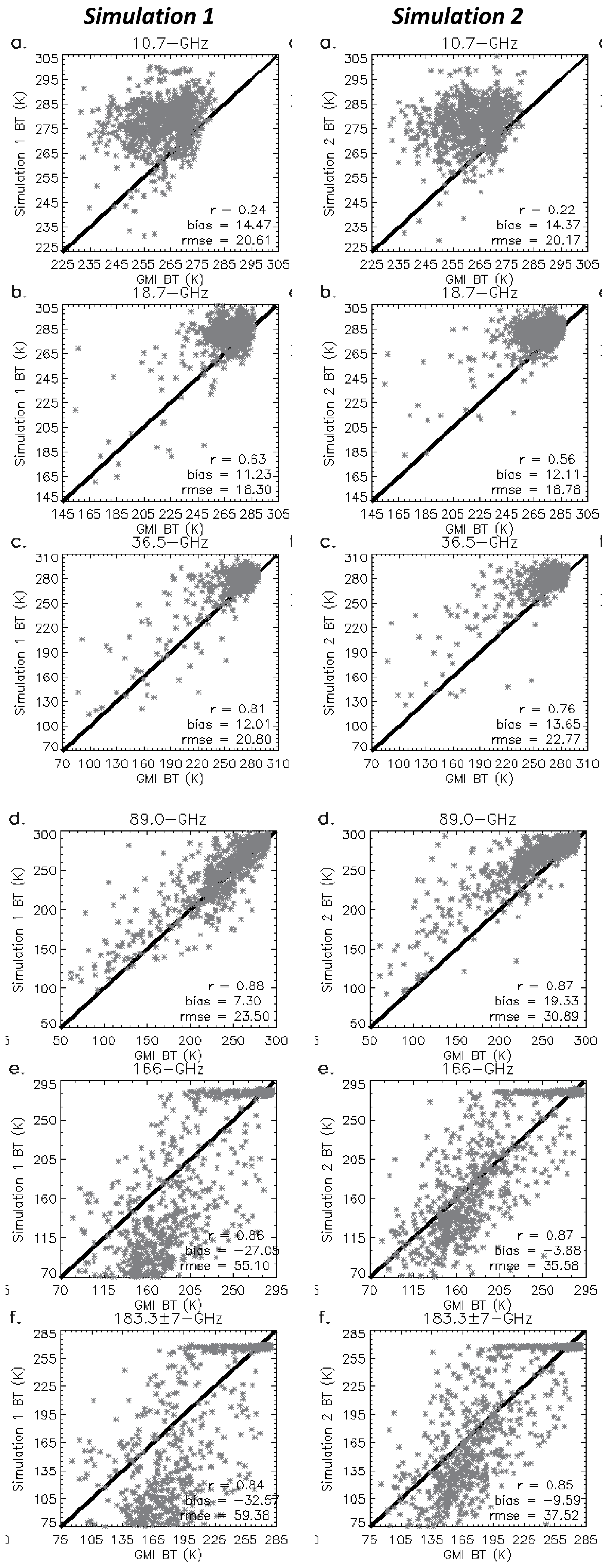
Initial conclusions from the comparison of simulated-versus-observed brightness temperatures (TBs) are that:

1) In low frequencies, the differences are dominated by improper treatment of the land surface, which is not (yet) a focus of this study.
2) Convective cores have simulated TBs that are too low, but also too restricted spatially in the 10-89 GHz channels (i.e., the convective core looks too strong, but too isolated).
3) In the high frequencies (166 & 183 GHz), the forward anvils have too much simulated scattering (simulated TBs too low), but have "holes" in the convective cores where the simulated TBs are anomalously warm. These holes point out that the high frequencies are better suited to detecting graupel than hail.

We suspected that those problems could be partly due to assigning each radar grid box as entirely hail, or entirely graupel, entirely crystals, etc., without allowing a mixture of hydrometeor types within a sample volume.

In the hydrometeor classification algorithm, a score is assigned to each possible hydrometeor type based on how well that type fits the polarimetric measurements. In our control simulation (Simulation 1) and most applications, the single hydrometeor type with the highest score for a given grid box is used.

In Simulation 2, we treat those scores as representing the relative contribution to total radar reflectivity from each hydrometeor type. For example, if a bin has Zh = 50 dBZ (1 x $10^5$ mm$^6$/m$^3$) with scores of 6 from hail, 4 from high-density graupel, and 0 from everything else, we treat that bin as having 6 x $10^4$ mm$^6$/m$^3$ (48 dBZ) from hail and 4 x $10^4$ mm$^6$/m$^3$ (46 dBZ) from high-density graupel.



Using mixed hydrometeor types in Simulation 2 (right column) improves the simulation of the high-frequency channels (166 & 183 GHz). There is still too much scattering in the forward anvil and not enough scattering in the convective core, but to a lesser degree than in the control Simulation 1.

The mixed hydrometeor types in Simulation 2 add to a high bias for the 19-89 GHz frequencies. Systematic changes are not obvious for the 10.7 GHz channel.

# Polarization Corrected Temperature (PCT) Coefficients

The purpose of the Polarization Corrected Temperature (PCT) work here is to enable more straightforward assessment of the impact of hydrometeors on GMI measurements, without worrying about variability in the underlying surface.

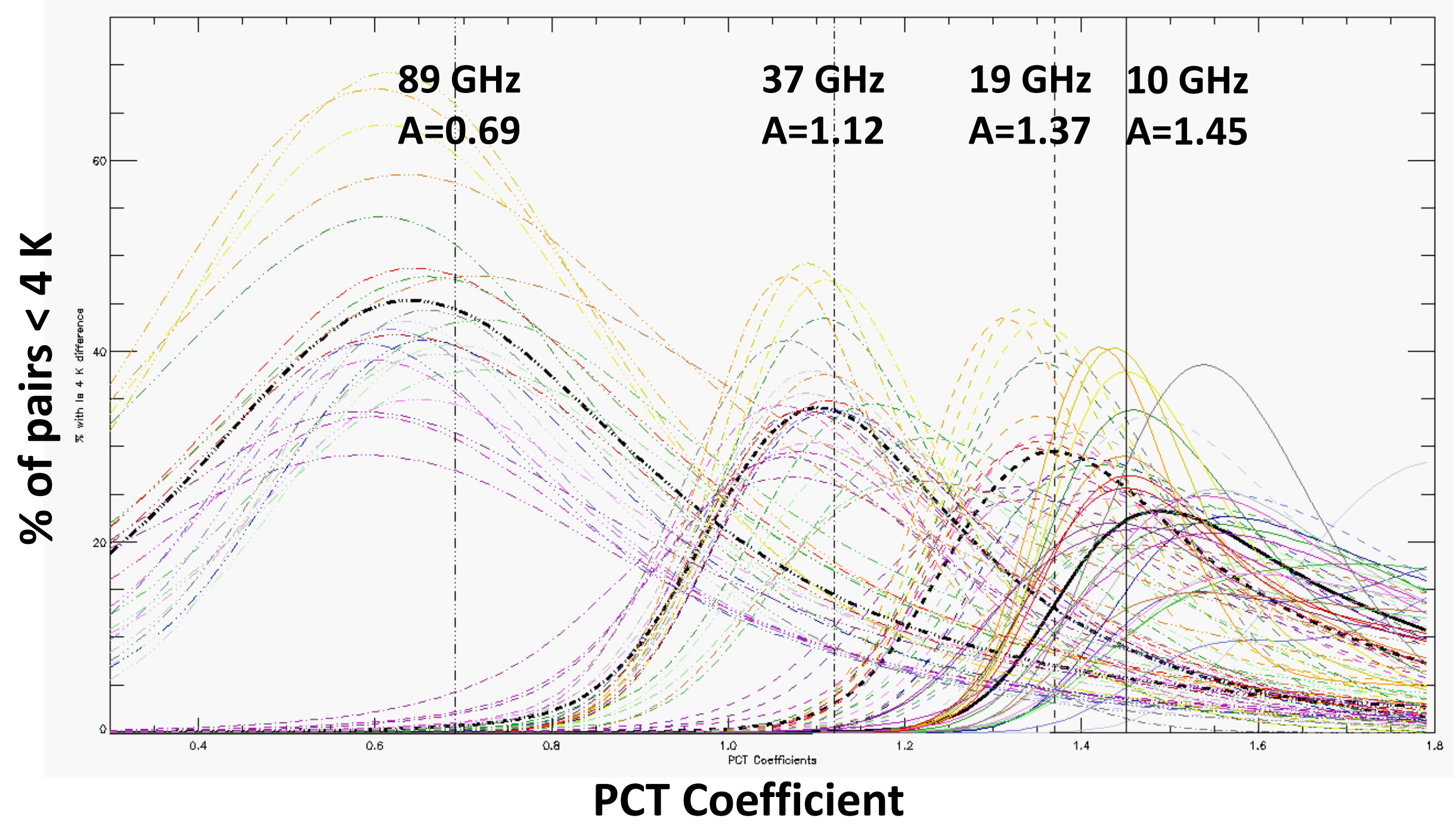
**PCTxx = (Axx+1) * $TB_H$xx – Axx*$TB_V$xx**
PCT85 = 1.82 * $TB_V$85 – 0.82 * $TB_H$85 (Spencer et al. 1989)
PCT37 – 2.2- * $TB_V$37 – 1.20 * $TB_H$37 (Toracinta et al. 2002)

Key considerations:

- Want PCT values to be the same for adjacent land and water surfaces, so that PCT depressions can be interpreted as precipitation signatures.
- ➢ -- coastlines should not be obvious in the PCT field
- Want PCT coefficients that work reasonably well for all latitudes and all seasons
- Good PCT coefficients have already been developed and widely used for 85/89 and 37 GHz, so emphasis is on lower frequencies (10 and 19 GHz)

Approach:

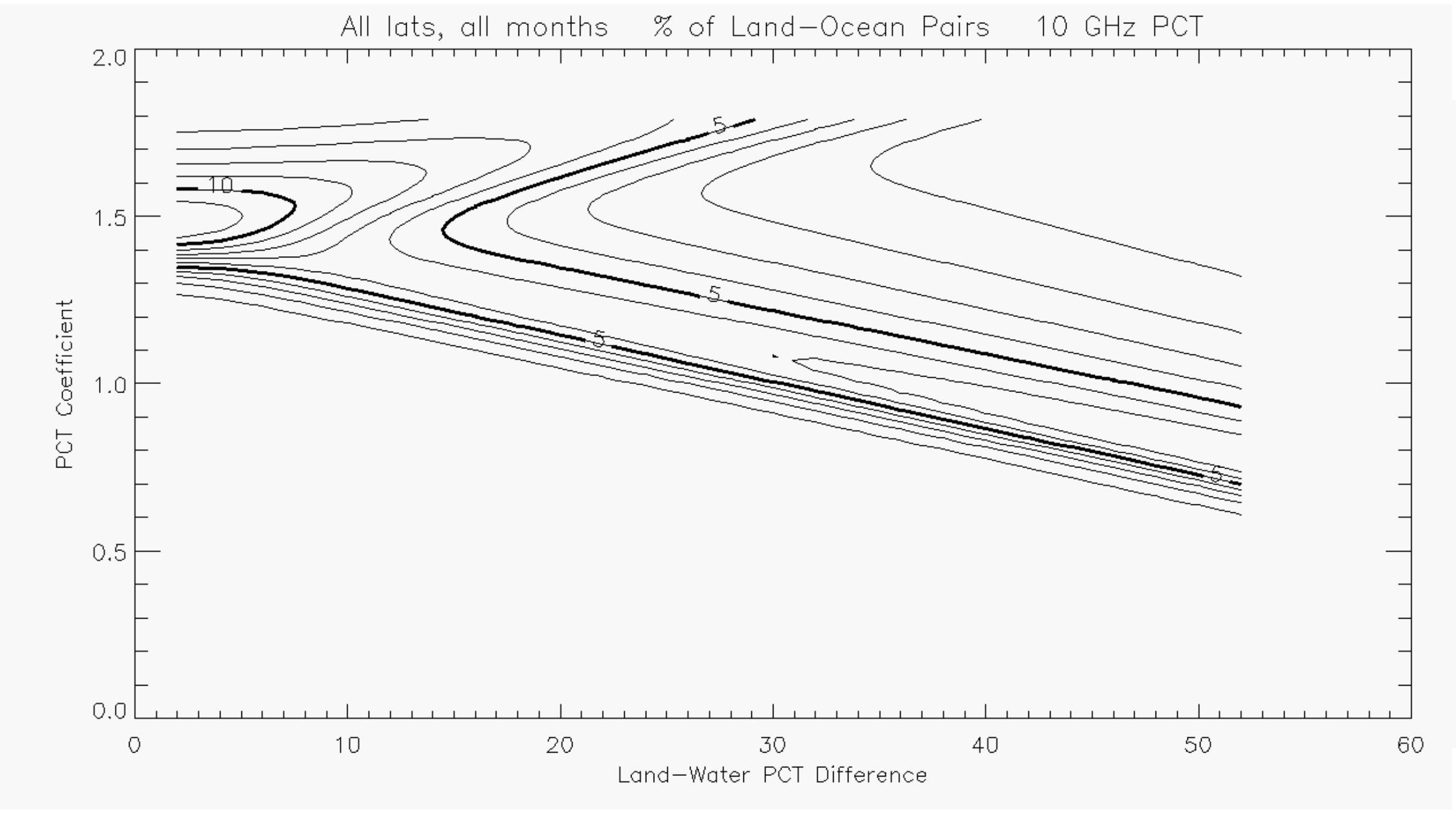
- For each 5° bin of latitude in a GMI orbit, identify all precipitation-free land and ocean GMI pixels (using standard GPROF output)
- Loop through a range of potential PCT coefficients, and compute the land-ocean PCT difference for every possible combination of land and ocean pixels
- Construct 2-d histogram of land-ocean PCT differences for each coefficient value
- Accumulate the 2-d histograms over a large set of orbits (every other orbit, April 2014 – March 2017)
- ➢ 23 billion land-ocean pairs; ~1 billion for 5° latitude bin
- Separate histograms by month and by latitude
- Determine which PCT coefficients most consistently give precip-free land-ocean PCT differences near zero.



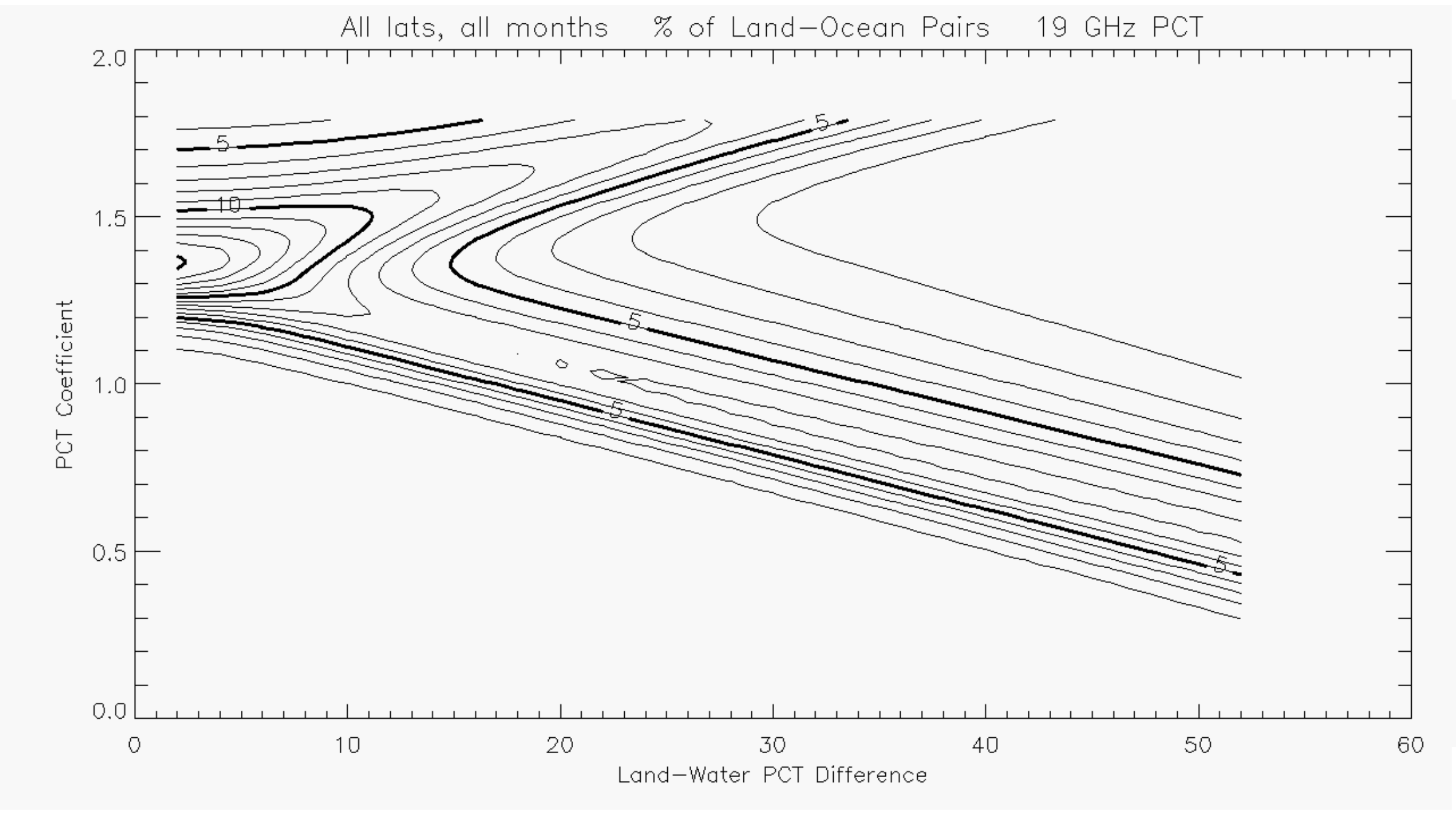
***Percentage of land-ocean pairings with < 4 K PCT difference, as a function of PCT coefficient.***
**Black lines:** Totals for all months and all latitudes
**Colors:** Individual 5° latitude bins, to convey variability
**Vertical Lines:** PCT Coefficients that give the most latitude/month combinations with < 2 K PCT difference for at least 15% of land-ocean pairings (i.e., which coefficient works well in the most latitudes and months?)

## 2-D histograms of Land-Ocean PCT differences, accumulated over all latitudes and all months

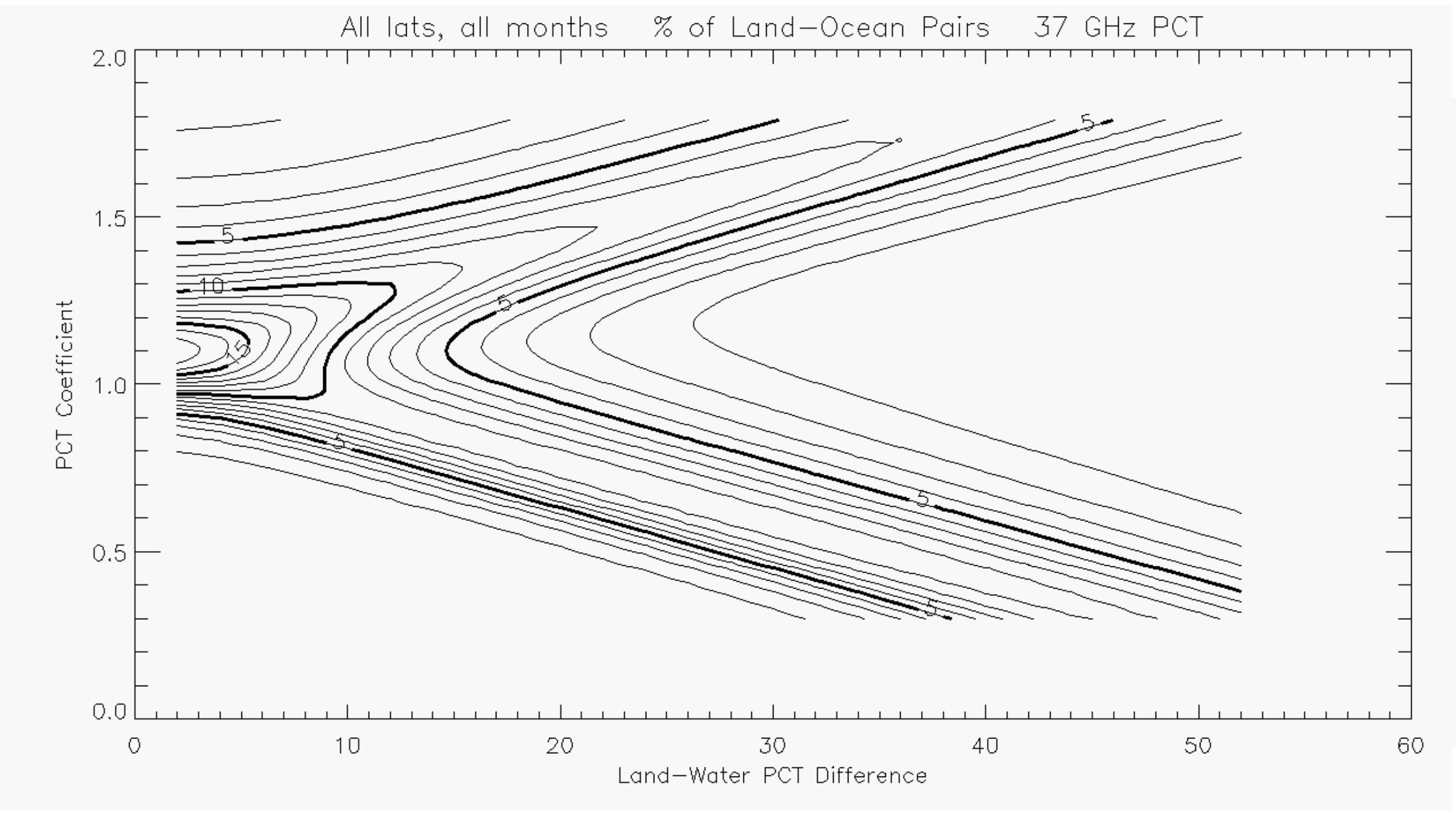
**10 GHz**



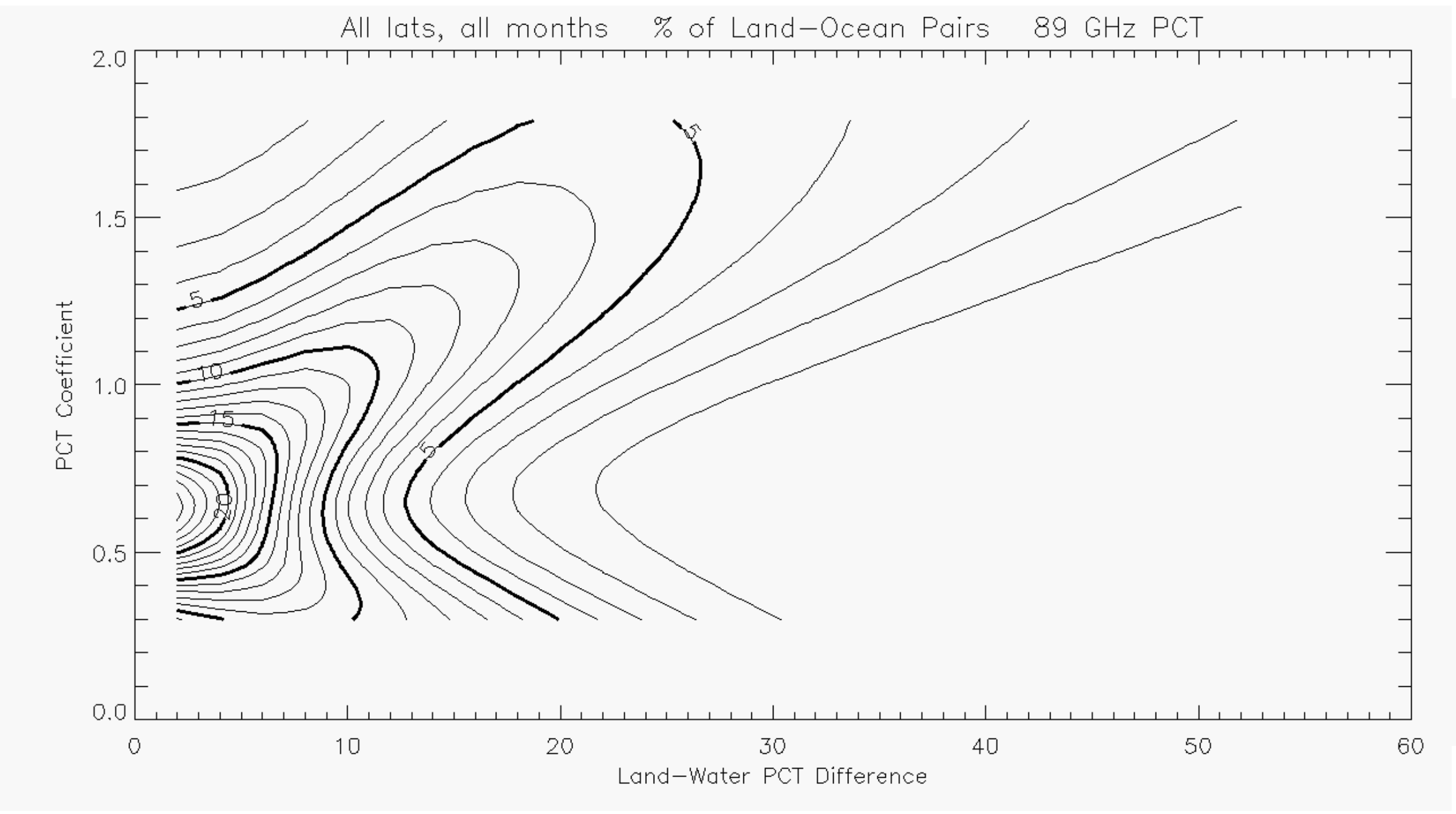
**19 GHz**



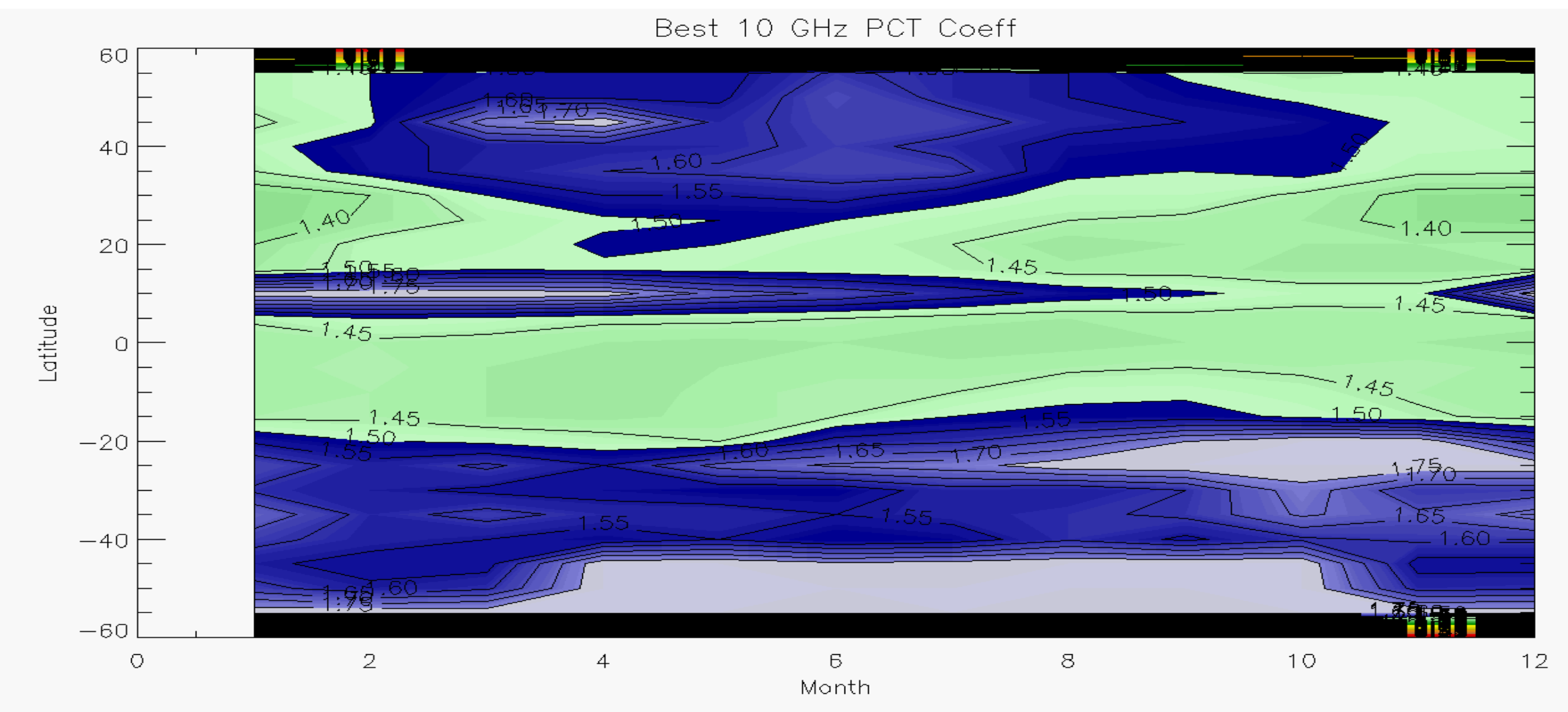
**37 GHz**

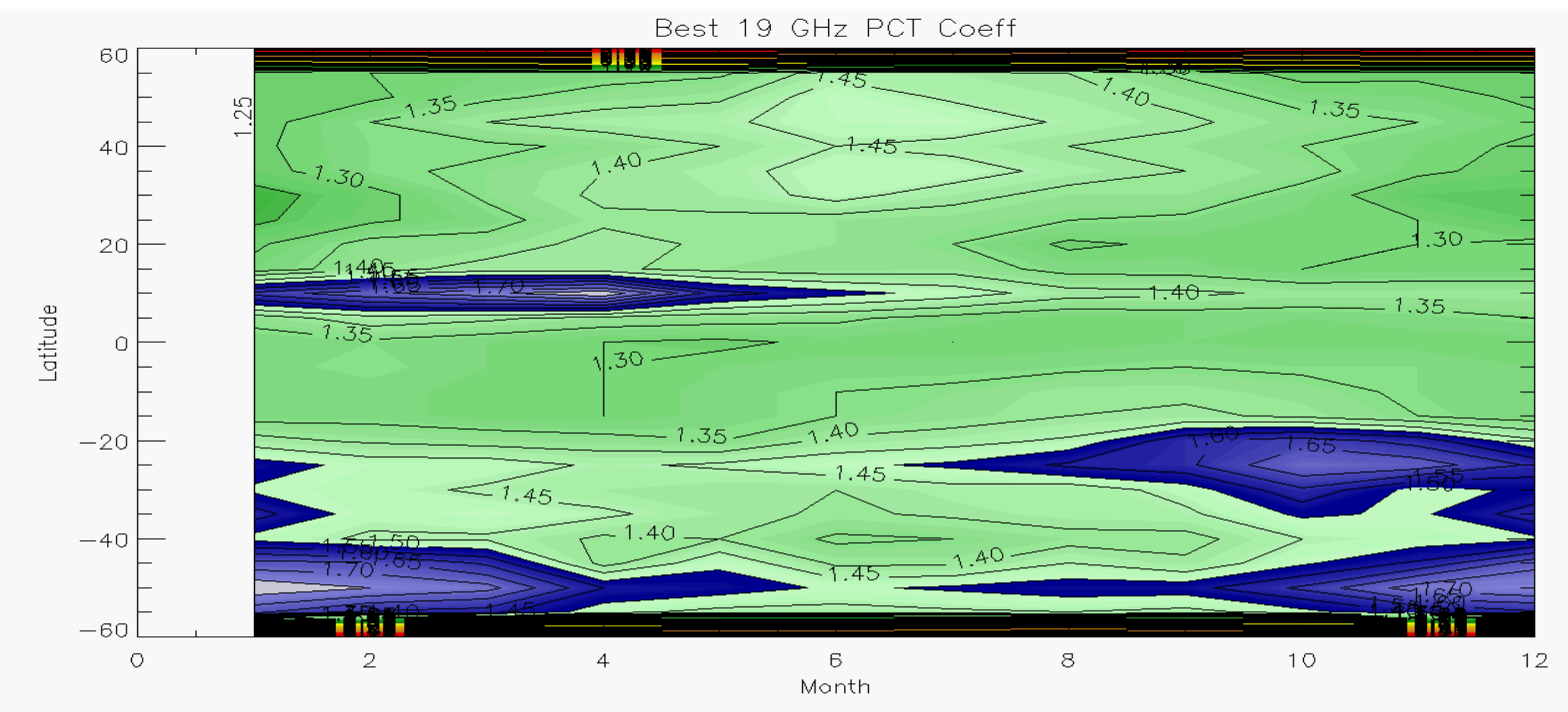


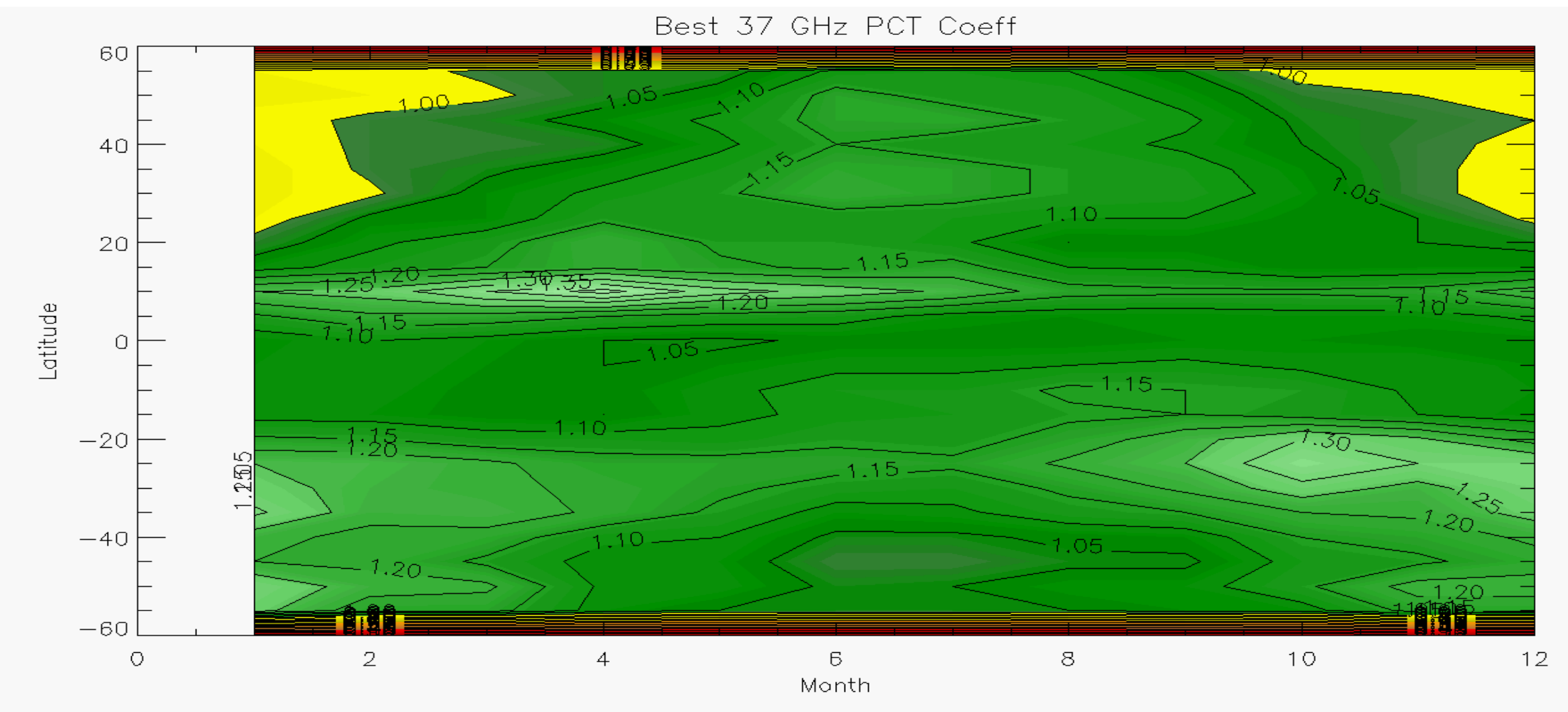
**89 GHz**

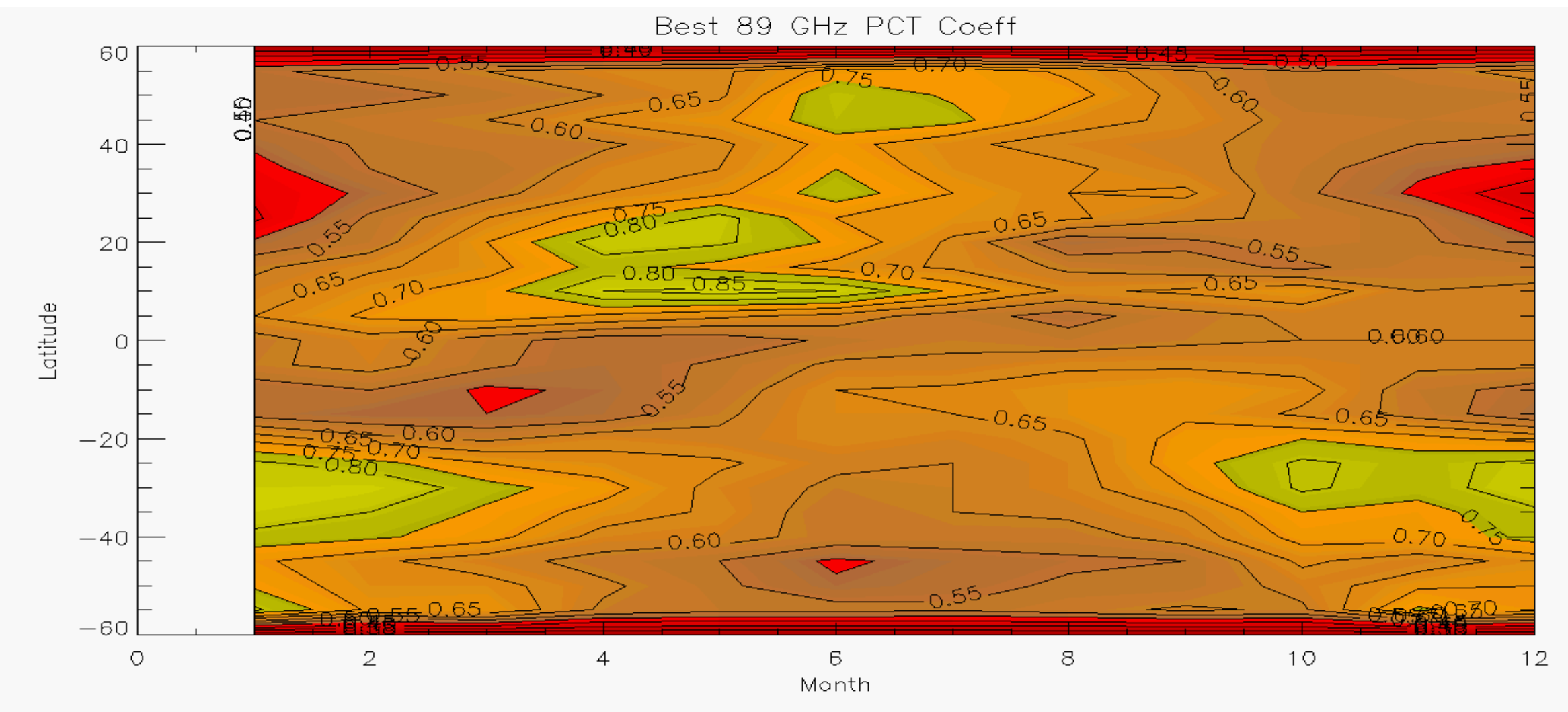


## PCT Coefficient that best minimizes the Land-Ocean differences, as a function of latitude and month



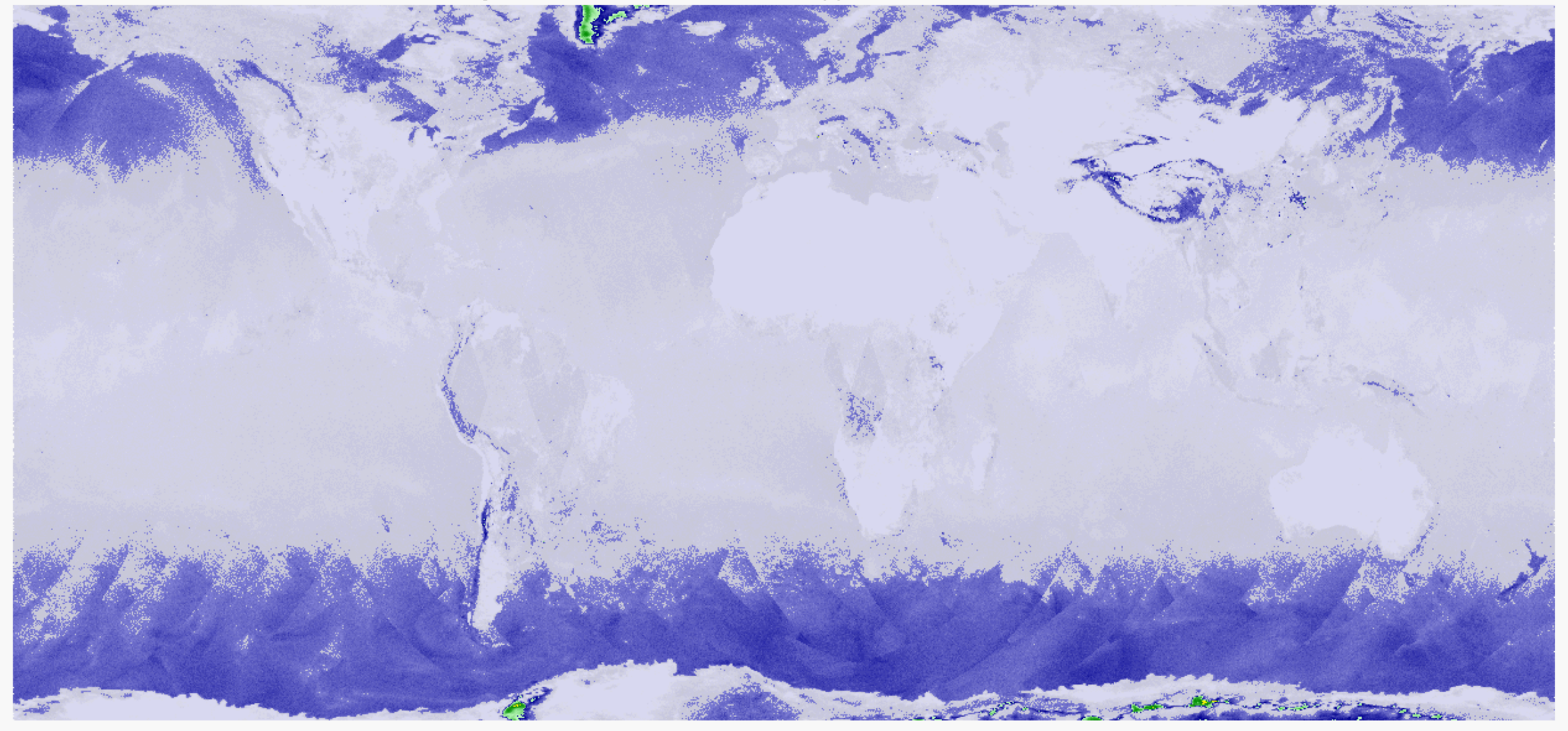




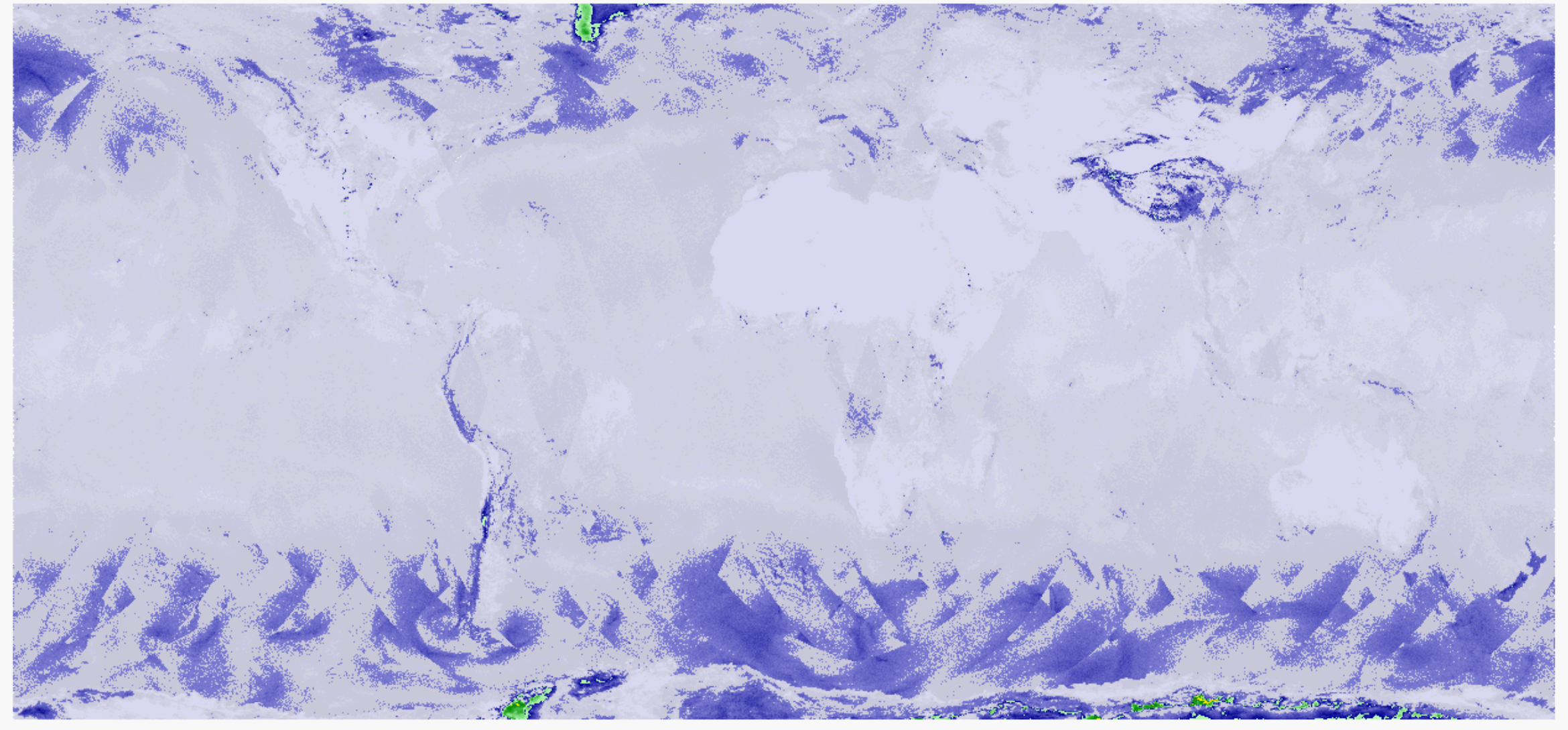


## Selected PCT coefficient applied to three days of GMI orbits, 26-28 May 2015. Want the PCT to eliminate land-ocean differences.

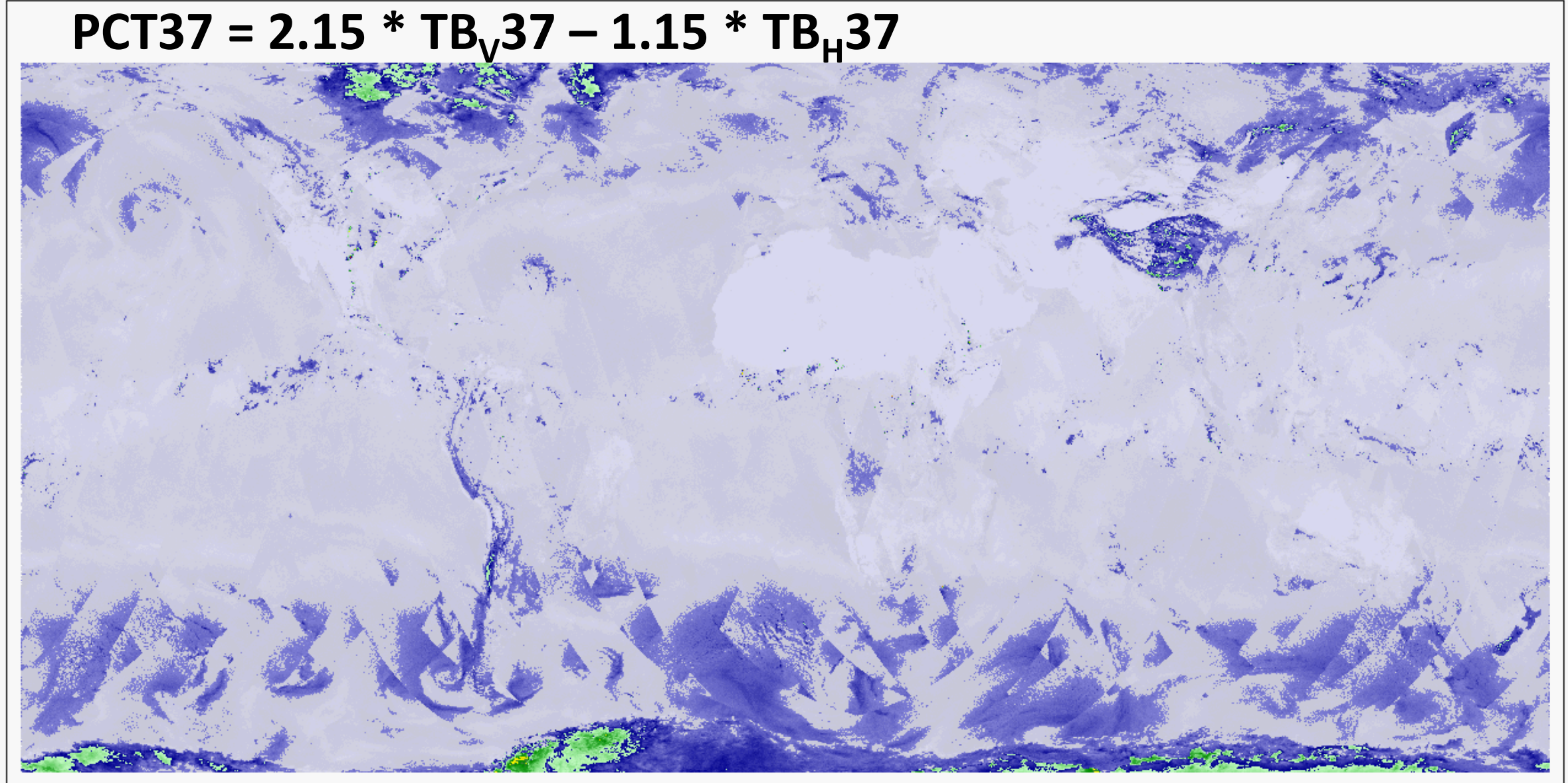
**PCT10 = 2.50 * $TB_V$10 – 1.50 * $TB_H$10**



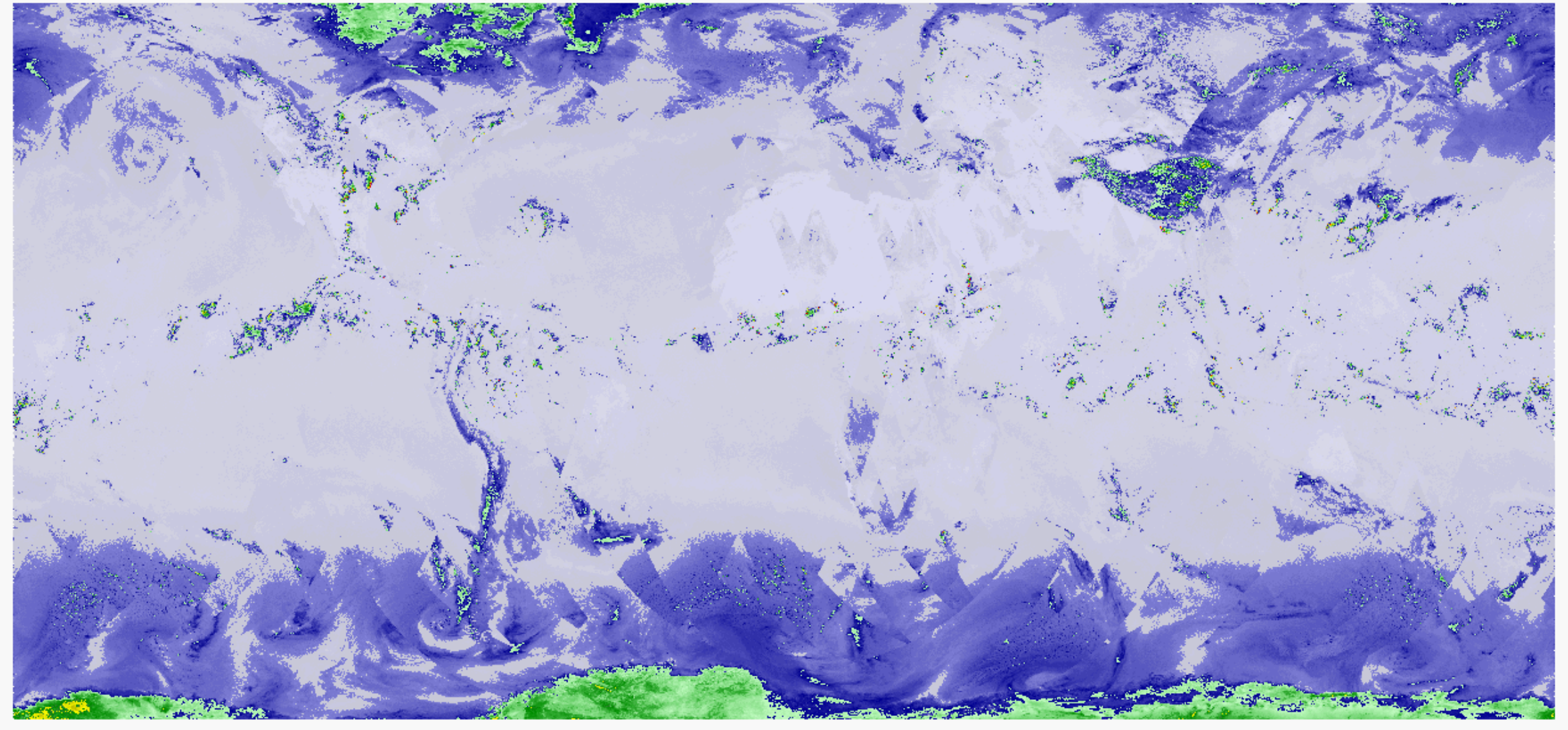
**PCT19 = 2.40 * $TB_V$19 – 1.40 * $TB_H$19**



**PCT37 = 2.15 * $TB_V$37 – 1.15 * $TB_H$37**



**PCT89 = 1.70 * $TB_V$89 – 0.70 * $TB_H$89**



**Conclusions from the Polarization Corrected Temperature analysis:**

- For each frequency, there is no single coefficient value that is clearly best - a range of values will work. Some values work better for particular locations than others. A user could choose which works best for a particular topic.
- Performance of the "best" coefficient values increases with increasing frequency… the best 10 GHz PCT does not perform as well as even a bad choice of 89 GHz PCT coefficients.
- Higher coefficient values generally work better at mid-high latitudes, without substantially compromising the effectiveness at low latitudes.
- ***It is probably better to choose the higher values that work at mid-latitudes, than the lower values that give the best global "scores".***
- Manuscript in preparation that will suggest a particular set of coefficients to use for each frequency
- May repeat the analysis with 166 GHz included