Science_Flight_20151208

December 9, 2015

In this report, we'll review the science flight of the ER-2 starting on 12/08/2015. This was a ~6.5-h flight that sampled stratiform precipitation from an atmospheric river, and also underflew I think a Suomi NPP overpass offshore. First, let's import all the needed modules and ingest and process the raw data.

```
In [1]: from __future__ import print_function
        import numpy as np
        import matplotlib.pyplot as plt
        import datetime as dt
        import os
        import glob
        import pyart
        import rawpyampr
        import pyampr
        import dualpol
        from copy import deepcopy
        from IPython.display import Image
        from awot.graph.common import create_basemap
        from awot.graph.flight_level import FlightLevel
        from pyart_tools import (
            plot_list_of_fields, list_nexrad_files, read_nexrad_aws)
        %matplotlib inline
```

```
In [2]: import warnings
        warnings.filterwarnings('ignore')
        def delete_file(fname):
            try:
                os.remove(fname)
            except:
                pass
```

```
In [3]: datadir = './'
        files = glob.glob(datadir + '*.dat')
        print(files)
        fname = os.path.basename(files[0])[:-4]
```

```
['./AMPR-20151208-150815.dat', './AMPR-20151208-180756.dat', './AMPR-20151208-223611.dat']
```

```
In [4]: payload = rawpyampr.ampr_payload.AMPR_Payload(files)
        l1file = fname + '_L1.nc'
        l2file = fname + '_L2.nc'
        delete_file(l1file)
        payload.writeLevel1B(l1file)
        L1B = rawpyampr.ampr_level1b.AMPR_QC(l1file)
        delete_file(l2file)
        L1B.writeLevel2B(l2file)
```

```
All of file: ./AMPR-20151208-150815.dat Read Successfully
End of data stream reached
All of file: ./AMPR-20151208-180756.dat Read Successfully
End of data stream reached
All of file: ./AMPR-20151208-223611.dat Read Successfully
End of data stream reached
Interpreting Navigation Records as: IWG1
 No navigation file found
Navigating pixels using internal recording of nav data.
Number points to converge: 4
Writing to output file:  AMPR-20151208-150815_L1.nc
Found Navigation Data!
Writing to output file: AMPR-20151208-150815_L2.nc
File containing water fraction not on path
```

Now we are ready to read in and display the L2 geolocated brightness temperatures.

```
In [5]: data = pyampr.AmprTb(l2file)
        data.plot_ampr_channels()

********************
read_ampr_tb_level2b(): Reading AMPR-20151208-150815_L2.nc
Assuming OLYMPEX data structure.
Change to proper project if incorrect, otherwise errors will occur.
Currently available field projects: OLYMPEX, IPHEX, MC3E, TC4, TCSP, JAX90, COARE,
CAMEX1, CAMEX2, CAMEX3, CAMEX4, TRMMLBA, KWAJEX, TEFLUNA, FIRE3ACE, CAPE
Default: project = 'OLYMPEX'
Found Navigation Data!
(5563,)
********************


********************
plot_ampr_channels():
Available scans = 1 to 5563
Available times = 15:08:20 - 00:43:48
********************
```

AMPR 12/8/2015
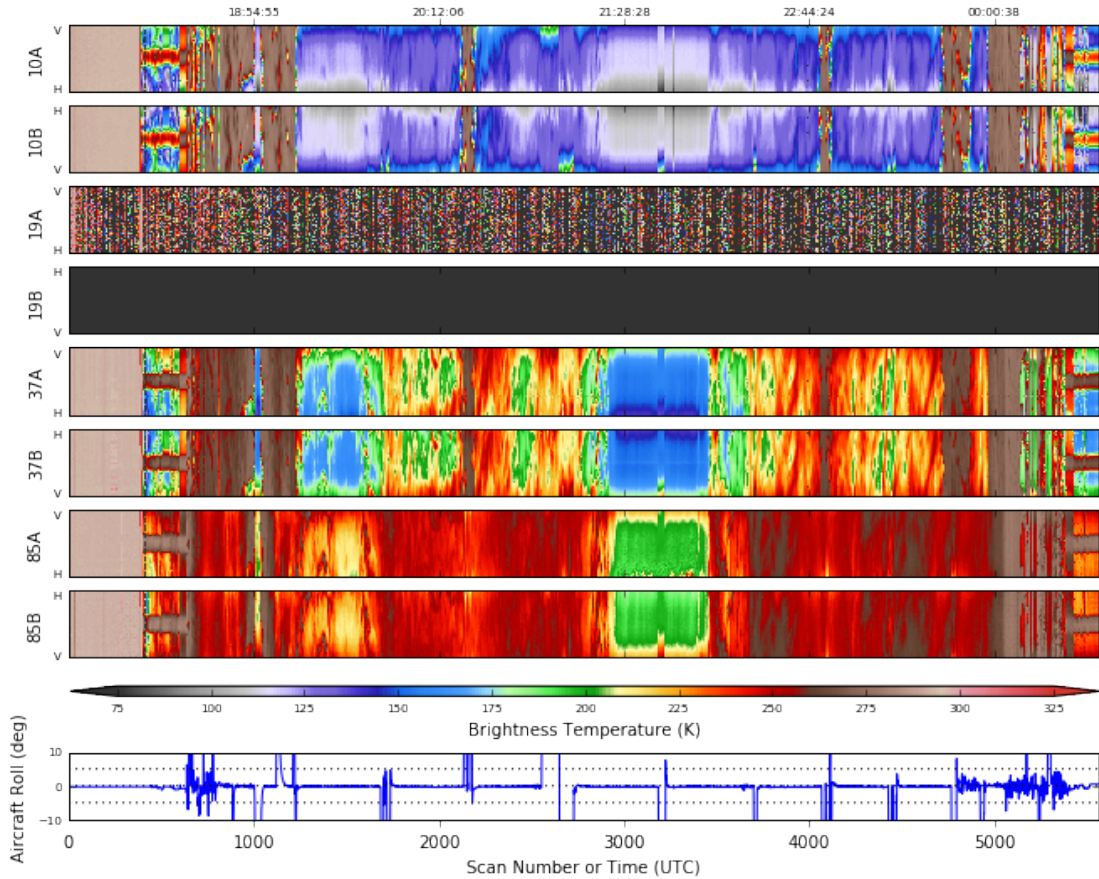
As can be seen, we did not have the **19 GHz** channels again during this flight. The other channels behaved well. However, there were some suspicious higher TBs on the right edge of the **85 GHz (A)** channel when the aircraft was flying over relatively clear ocean (~2130 UTC). We are not sure if this is due to a few clouds that were near the scan edge, or elevated noise floor issues. However, there was no obvious speckling in the center of the swath like in previous incidents, so if it was a noise floor issue it was very mild. The early part of the chart consists of engineering test data, which is why the functioning channels look so uniform before the flight.

The instrument will be pulled the morning of 12/9 to attempt a 19-GHz repair. For now, we will focus on the science. The ER-2, after gaining altitude, performed long overflights of widespread stratiform precipitation. Let's examine one of the overflights that occurred close to the OLYMPEX domain.

In [9]: data.plot_ampr_channels(scanrange=[2150, 2600])

```
********************
plot_ampr_channels():
Available scans = 1 to 5563
Available times = 15:08:20 - 00:43:48
********************
```

3

AMPR 12/8/2015
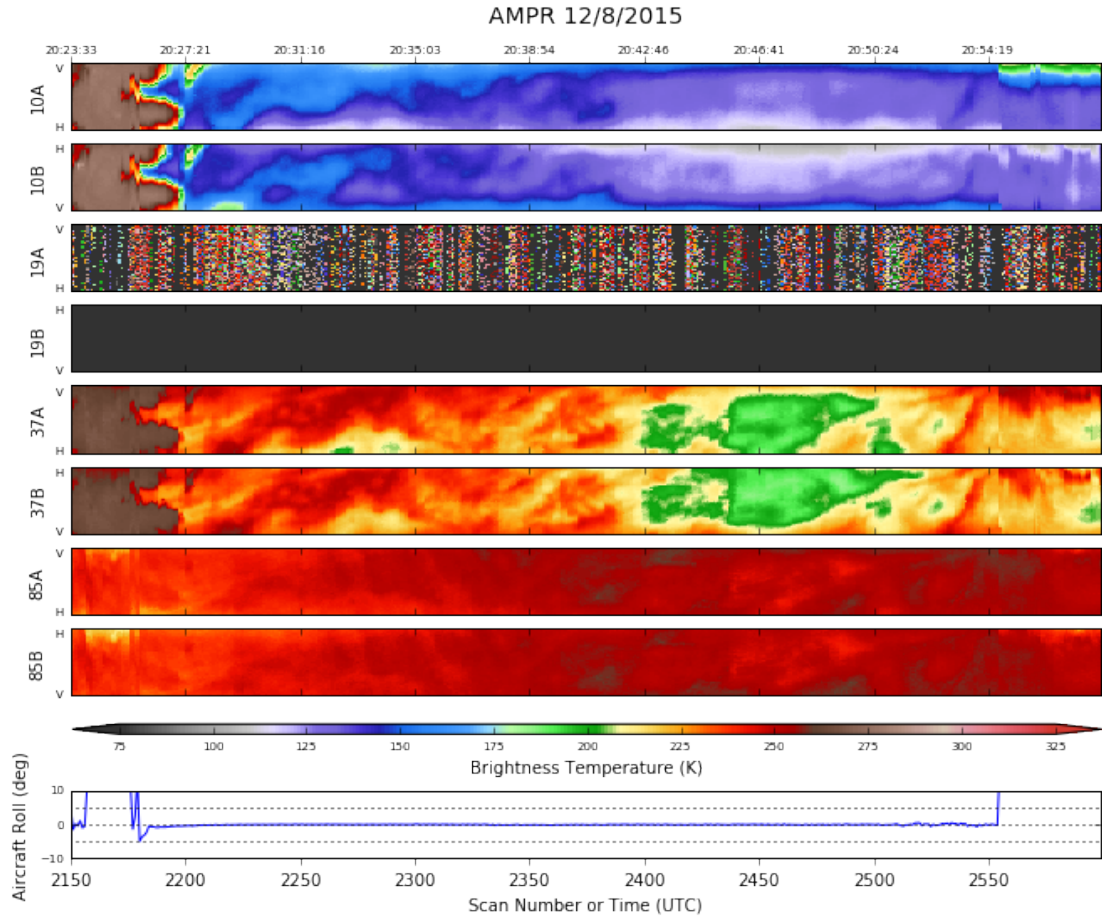
This is becoming a pretty classic stratiform pattern. There is substantial emission signal at all functioning channels, although between scans 2400 and 2500 there precipitation appears to be reduced. Let's try looking at the deconvolved H and V polarizations with the same plot.

```
In [10]: data.plot_ampr_channels(scanrange=[2150, 2600], show_pol=True)

********************
plot_ampr_channels():
Missing some pol channels, trying calc_polarization() before plot

********************
calc_polarization():
Calculating for 10 GHz channel
Calculating for 19 GHz channel
Calculating for 37 GHz channel
Calculating for 85 GHz channel
0.38486599922180176 seconds to calculate H & V
If successful, following attributes are now available:
TB10H TB10V TB19H TB19V TB37H TB37V TB85H TB85V
********************
```

4

```
Available scans = 1 to 5563
Available times = 15:08:20 - 00:43:48
*******************
```


AMPR 12/8/2015
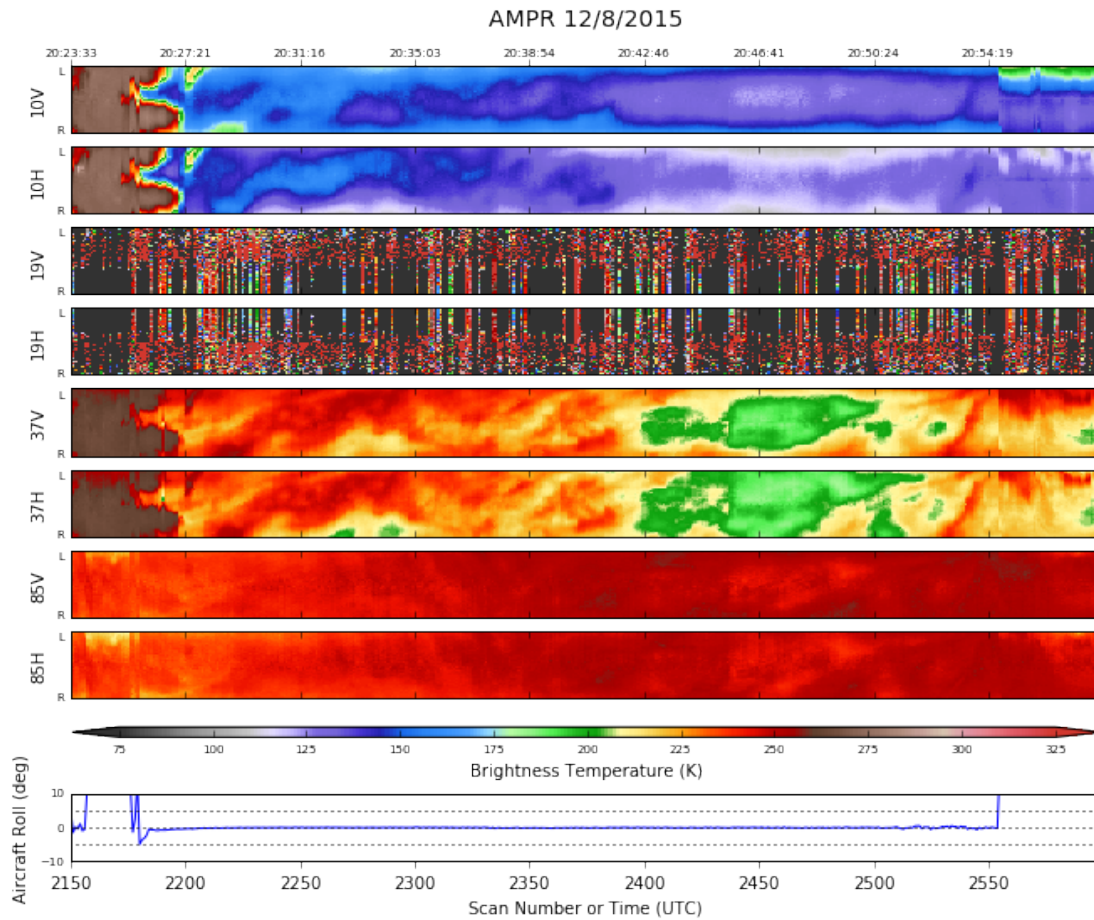
85 GHz looks nearly the same whether it's H or V. Just lots and lots of stratiform precip! We start to see differences at 37 GHz, although keep in mind the HIWRAP signal in 37B could mess up the deconvolution when the precip is reduced, since that hasn't been removed yet. We also haven't finalized instrument calibration so that also could affect the deconvolution. At 10 GHz we start to see some of the ocean signal seep thru the precipitation (especially scans 2400-2500 when precip is lighter), with high V (low H) values off nadir.

Let's look at the geolocated data during this time. Since we're missing the 19 GHz channel, let's overplot NEXRAD data in its place.

```
In [14]: # Let's grab NEXRAD data for this case
         radlist = list_nexrad_files(2015, month='12', day='08', station='KLGX')
         # print(radlist)
         radar = read_nexrad_aws('KLGX20151208_203822_V06.gz')
```

https://noaa-nexrad-level2.s3.amazonaws.com/2015/12/08/KLGX/KLGX20151208_203822_V06.gz

```
In [15]:  # Do some quick QC on the NEXRAD data
          zc = deepcopy(radar.fields['REF']['data'])
          radar.add_field_like('REF', 'ZC', zc, replace_existing=True)
          retrieve = dualpol.DualPolRetrieval(
              radar, dz='ZC', dr='ZDR', dp='PHI', rh='RHO', use_temp=False,
              dsd_flag=False, fhc_flag=False, precip_flag=False,
              liquid_ice_flag=False, kdp_window=5, verbose=False,
              ice_flag=False, qc_flag=True, gs=250.0,
              thresh_sdp=20.0, speckle=3,
              thresh_dr=np.array(dualpol.DEFAULT_DR_THRESH)+1.0)
```

```
1.1871120929718018 seconds to run csu_kdp
No sounding provided
```

```
In [29]:  # Import the ER-2 nav into AWOT (https://github.com/nguy/AWOT)
          # This simplifies plotting the track with time stamps
          flight = pyampr.read_aircraft_nav_into_awot(data)
          tst = '20:26:10'
          ted = '20:55:00'
          start = '2015-12-08 ' + tst
          end = '2015-12-08 ' + ted
          offs = (-0.05, -0.12)
```

```
In [30]:  display = data.plot_ampr_track_4panel(
              chan='b', timerange=[tst, ted], maneuver=False, return_flag=True,
              meridians=1, parallels=0.5, resolution='i',
              show_grid=True, latrange=[45, 47])  # , lonrange=[-124.99, -124])
          display.ax2.set_title('(b) AMPR 19 GHz (B) \nKLGX 2038 UTC 0.5 deg')

          # Play some tricks to overplot NEXRAD on the same basemap using Py-ART
          dr = pyart.graph.RadarMapDisplay(radar)
          rdata = dr._get_data('ZC', 1, None, True, None)
          x, y = dr._get_x_y('ZC', 1, True, True)
          _x0, _y0 = display.basemap(dr.loc[1], dr.loc[0])
          pm = display.basemap.pcolormesh(
              _x0 + x * 1000., _y0 + y * 1000.,
              rdata, vmin=0, vmax=75, cmap='pyart_NWSRef', ax=display.ax2)
          cax = display.fig.add_axes([0.52, 0.54, 0.35, 0.01])
          plt.colorbar(pm, label='Reflectivity (dBZ)', cax=cax, orientation='horizontal')

          # And plot flight times too
          f2 = FlightLevel(flight, basemap=display.basemap)
          for ax in [display.ax1, display.ax2, display.ax3, display.ax4]:
              f2.plot_trackmap(min_altitude=50., lw=2.5, start_time=start,
                               end_time=end, ax=ax)
              f2.time_stamps(start_time=start, end_time=end,
                             labelspacing=60, ax=ax, label_offset=offs)
          # plt.savefig('combo_ampr_nexrad.png')
```
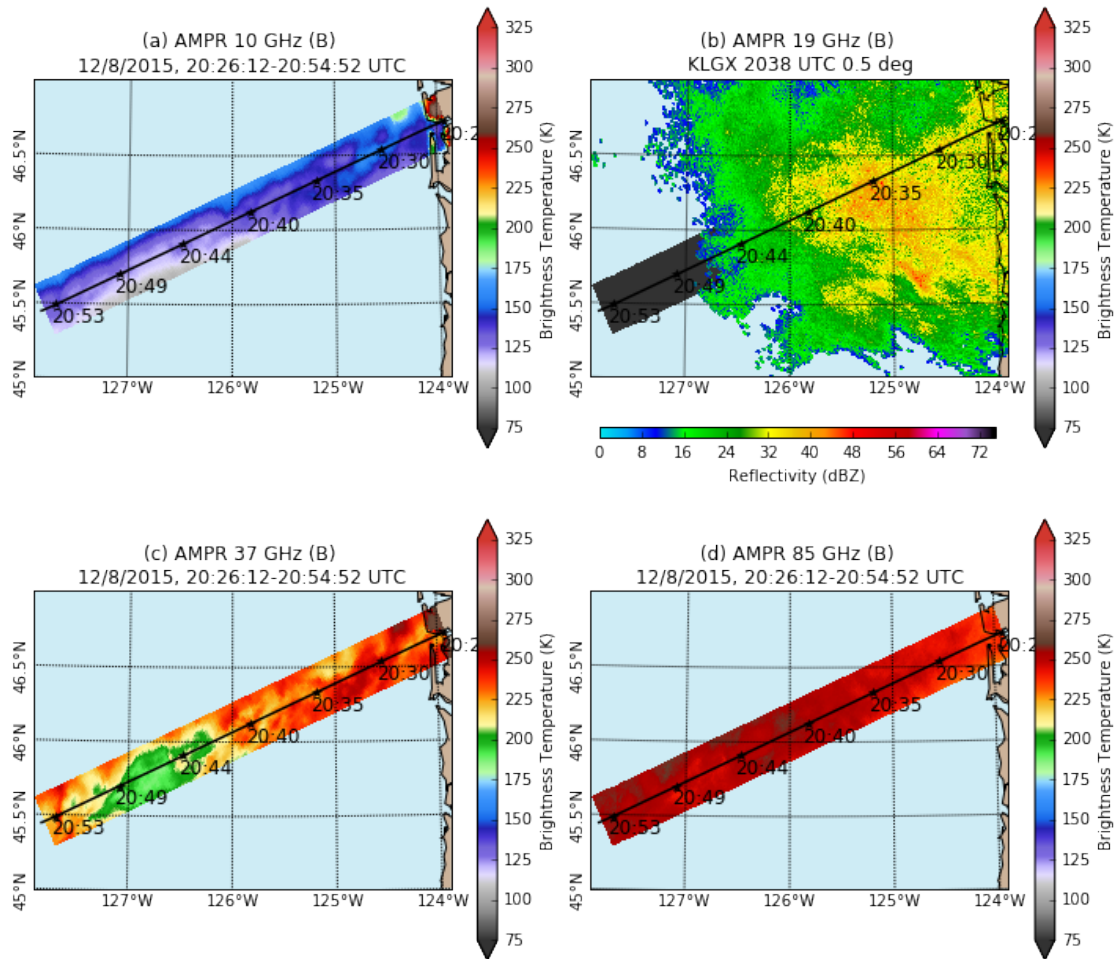
This was a really long run to the west of the Olympic Peninsula. The radar indicates widespread stratiform precipitation off the coast. By the end of the run the aircraft is getting beyond radar range, but do note that the western edge of the echo is where we start to see much less emission at 10 and 37 GHz. Now let's look at the run the ER-2 did to support the satellite overpass.
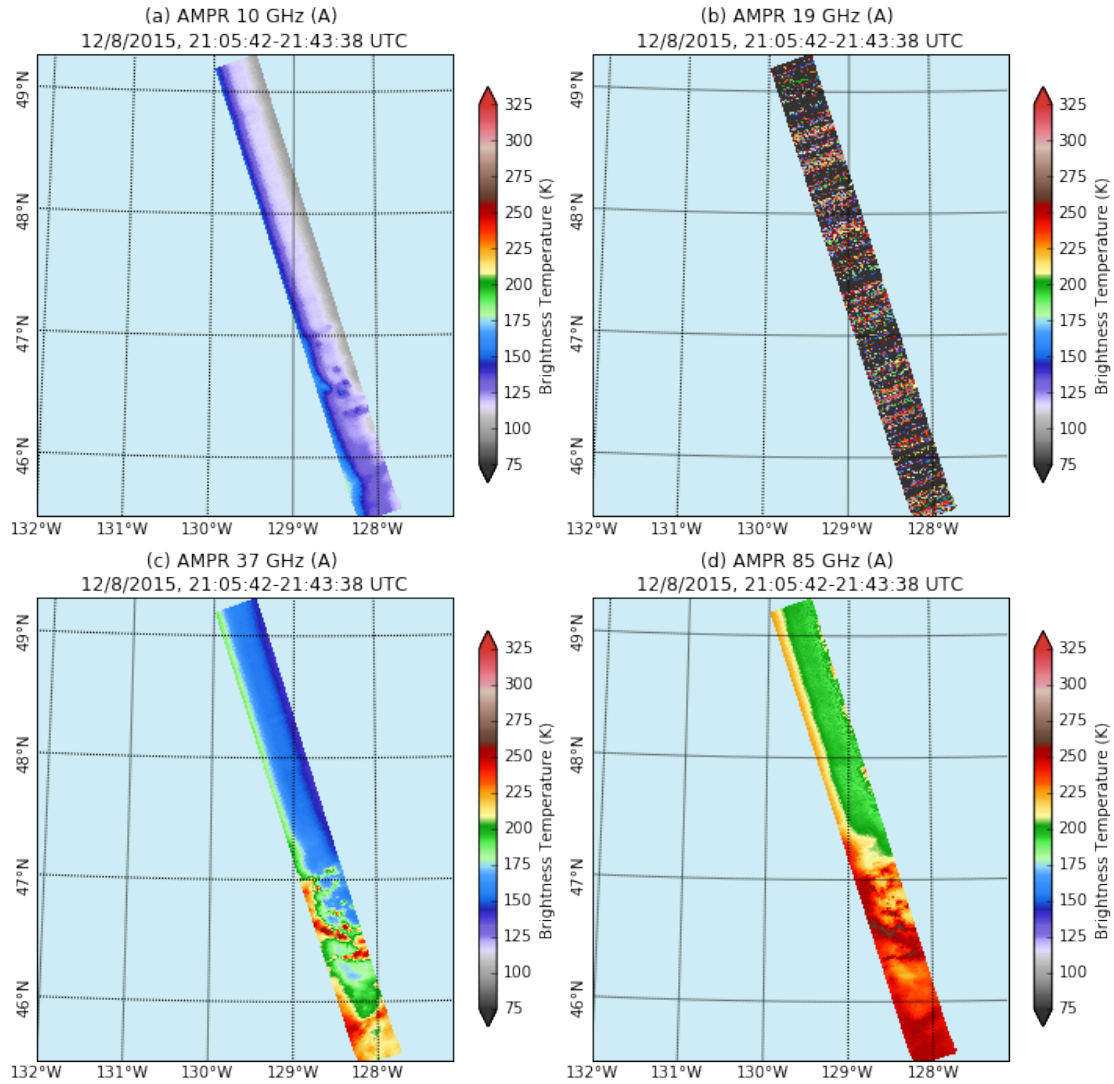
```
In [26]: data.plot_ampr_channels(scanrange=[2700, 3200])

*******************
plot_ampr_channels():
Available scans = 1 to 5563
Available times = 15:08:20 - 00:43:48
*******************
```

AMPR 12/8/2015
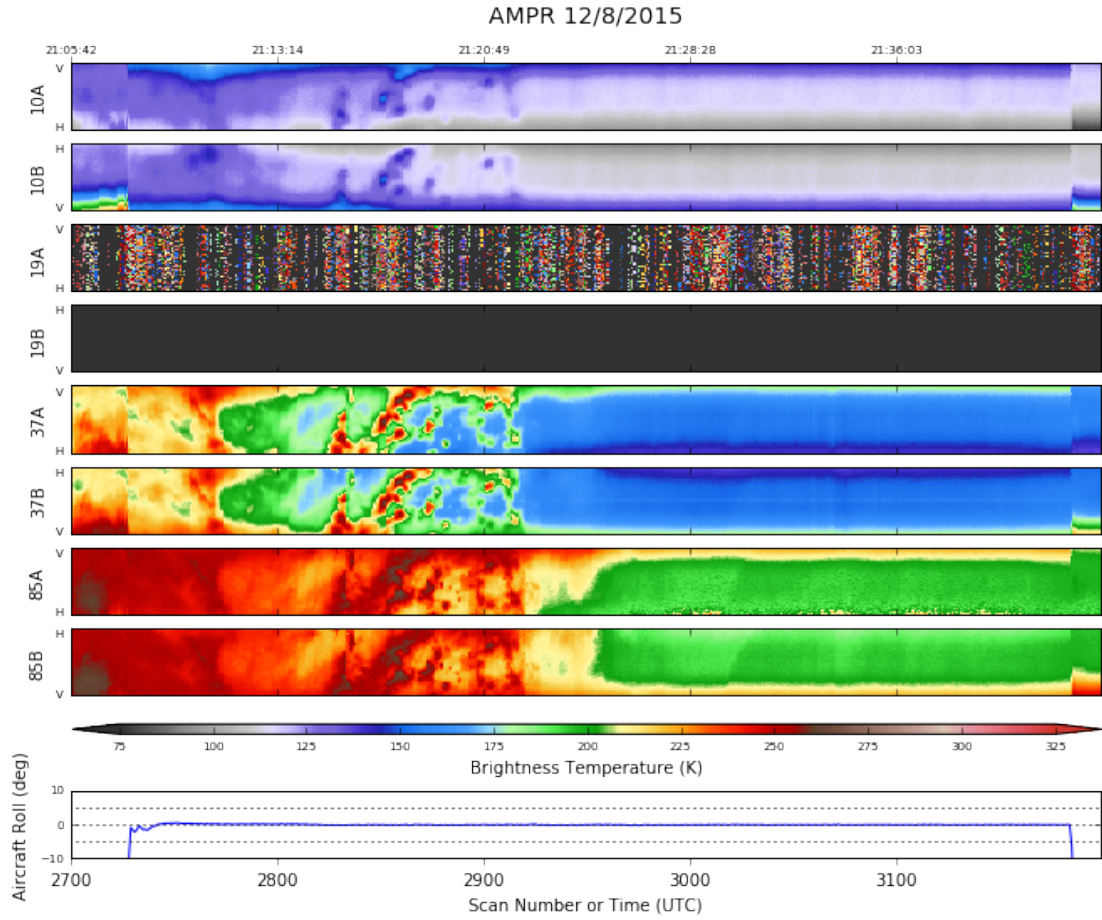
This is a really nice example of a transition from mostly stratiform precip, to what appears to be embedded convection, and then finally open ocean (at least from the perspective of these microwave frequencies, there was still some clouds). The convection is distinctive even at 10 GHz. Over the "clear" water note the near-nadir" reflected signal from HIWRAP at 37 GHz (B). Let's look at the geolocated data during this SE-NW run. We are beyond radar range so we'll skip adding that.

```
In [37]: data.plot_ampr_track_4panel(scanrange=[2700, 3200], lonrange=[-132, -127],
                                      maneuver=False, meridians=1, parallels=1)
```

(a) AMPR 10 GHz (A)
12/8/2015, 21:05:42-21:43:38 UTC

(b) AMPR 19 GHz (A)
12/8/2015, 21:05:42-21:43:38 UTC

(c) AMPR 37 GHz (A)
12/8/2015, 21:05:42-21:43:38 UTC

(d) AMPR 85 GHz (A)
12/8/2015, 21:05:42-21:43:38 UTC

In order to check out what the clouds were doing during these far-offshore runs, let's look at an MTS screenshot from around **2230 UTC**, on the way back from the satellite underflight. Note that the AMPR swath is from the realtime data, which is coarser resolution than the full-rate data we've been looking at.

In [2]: Image('mts_screenshot.png')

Out[2]:
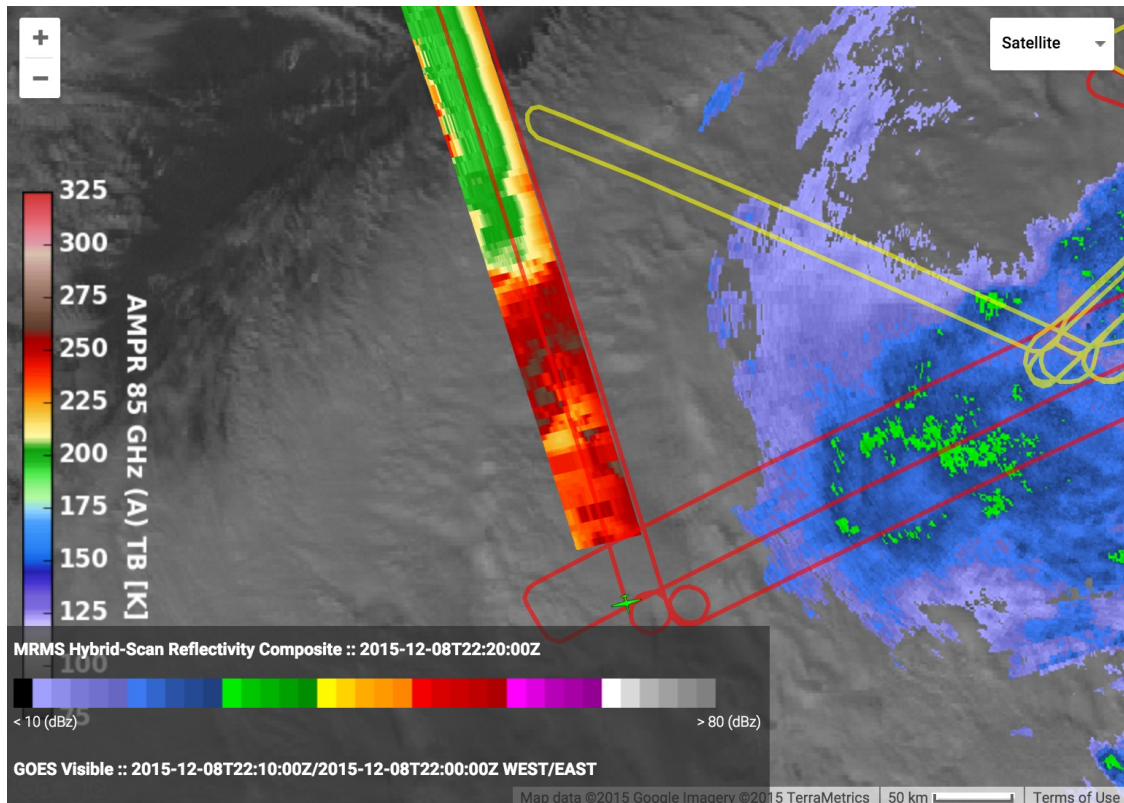
Note how the transition from the ocean view at 85 GHz occurs south of the edge of the cloud deck. However, there are some scattered clouds to the NW, so that is why we are not entirely sure the right edge of the 85A swath isn't seeing meteorological signal even beyond the main cloud deck.

The 19-GHz repair is scheduled for Wednesday, 12/9. We hope to bring back both channels A and B in time for Thursday's planned flight.

In [ ]: