

Science_Flight_20151205

December 5, 2015

In this report, we'll review the science flight of the ER-2 starting on 12/05/2015. This was a ~4-h flight that sampled warm frontal stratiform precipitation, both inland and 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 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-20151205-111216.dat', './AMPR-20151205-134450.dat', './AMPR-20151205-194833.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)
```

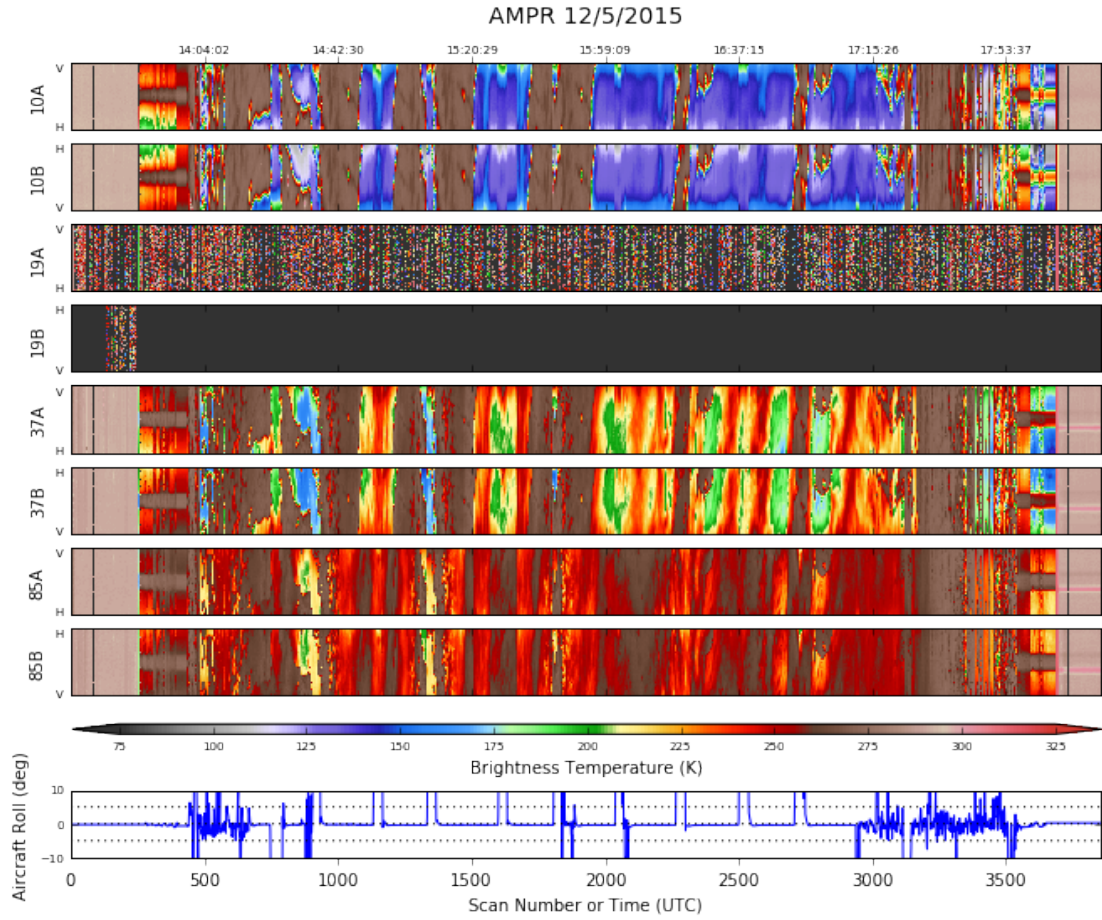
```
All of file: ./AMPR-20151205-111216.dat Read Successfully
End of data stream reached
All of file: ./AMPR-20151205-134450.dat Read Successfully
End of data stream reached
All of file: ./AMPR-20151205-194833.dat Read Successfully
End of data stream reached
Interpreting Navigation Records as: IWG1
  No navigation file found
Navigating pixels using internal recording of nav data.
Number points to converge: 4
Writing to output file:  AMPR-20151205-111216_L1.nc
Found Navigation Data!
Writing to output file: AMPR-20151205-111216_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-20151205-111216_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!
(3854,)
*****
```

```
*****
plot_ampr_channels():
Available scans = 1 to 3854
Available times = 11:12:22 - 20:01:01
*****
```

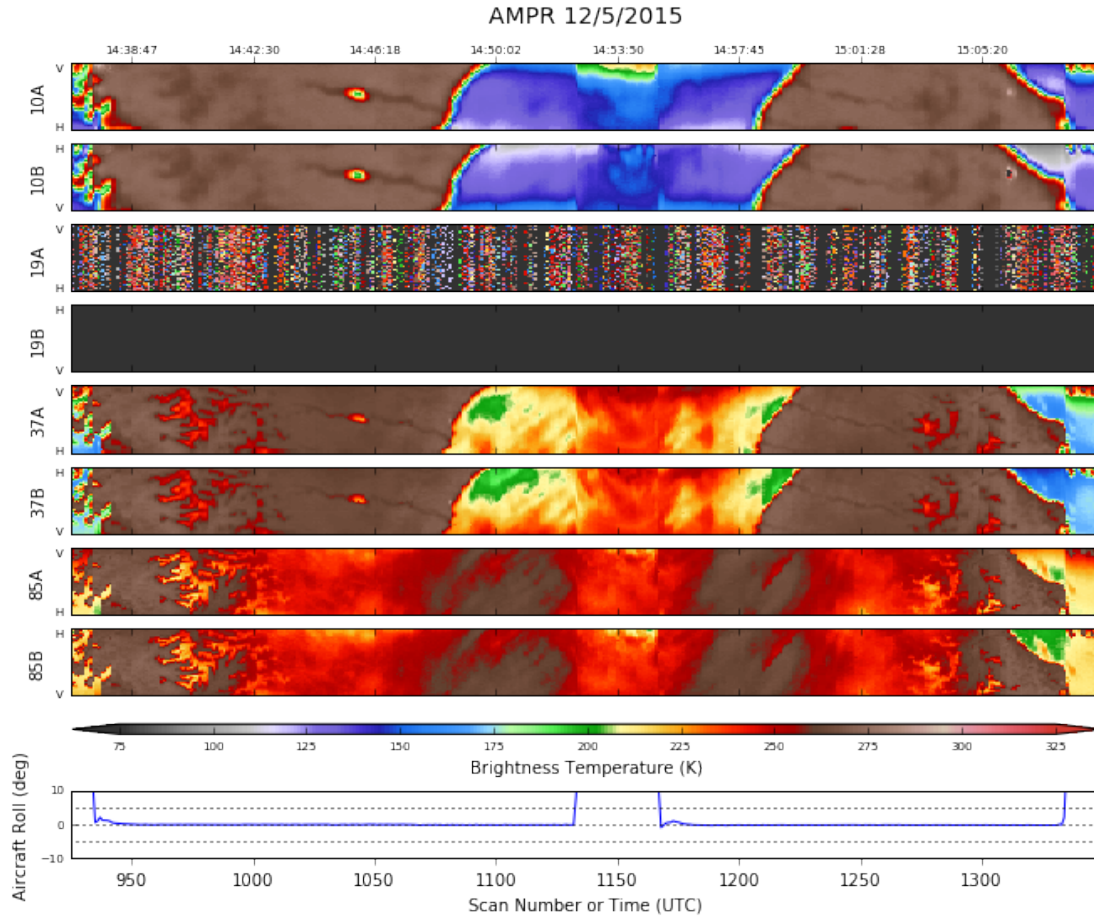


As can be seen, we did not have the 19 GHz channels again during this flight. The other channels behaved well. The early and latter parts of the chart consist of engineering test data, which is why the functioning channels look so uniform before and after the flight. We pulled the instrument after this flight to check it out during the next couple days, since there will be no flights Sunday and Monday.

For now, we will focus on the science. The ER-2, after gaining altitude, performed coordinated overflights of widespread pre-frontal stratiform precipitation. Let's examine one of these overpasses.

```
In [23]: data.plot_ampr_channels(scanrange=[925, 1350])
```

```
*****
plot_ampr_channels():
Available scans = 1 to 3854
Available times = 11:12:22 - 20:01:01
*****
```



This is a very similar pattern to the last couple stratiform cases. There is substantial emission signal at 85 GHz, which does not show up as well in 10 or 37 GHz, at least over the land. 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 [9]: # Let's grab NEXRAD data for this case
        radlist = list_nexrad_files(2015, month='12', day='05', station='KLGX')
        # print(radlist)
        radar = read_nexrad_aws('KLGX20151205_144155_V06.gz')
```

https://noaa-nexrad-level2.s3.amazonaws.com/2015/12/05/KLGX/KLGX20151205_144155_V06.gz

```
In [10]: # 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)
```

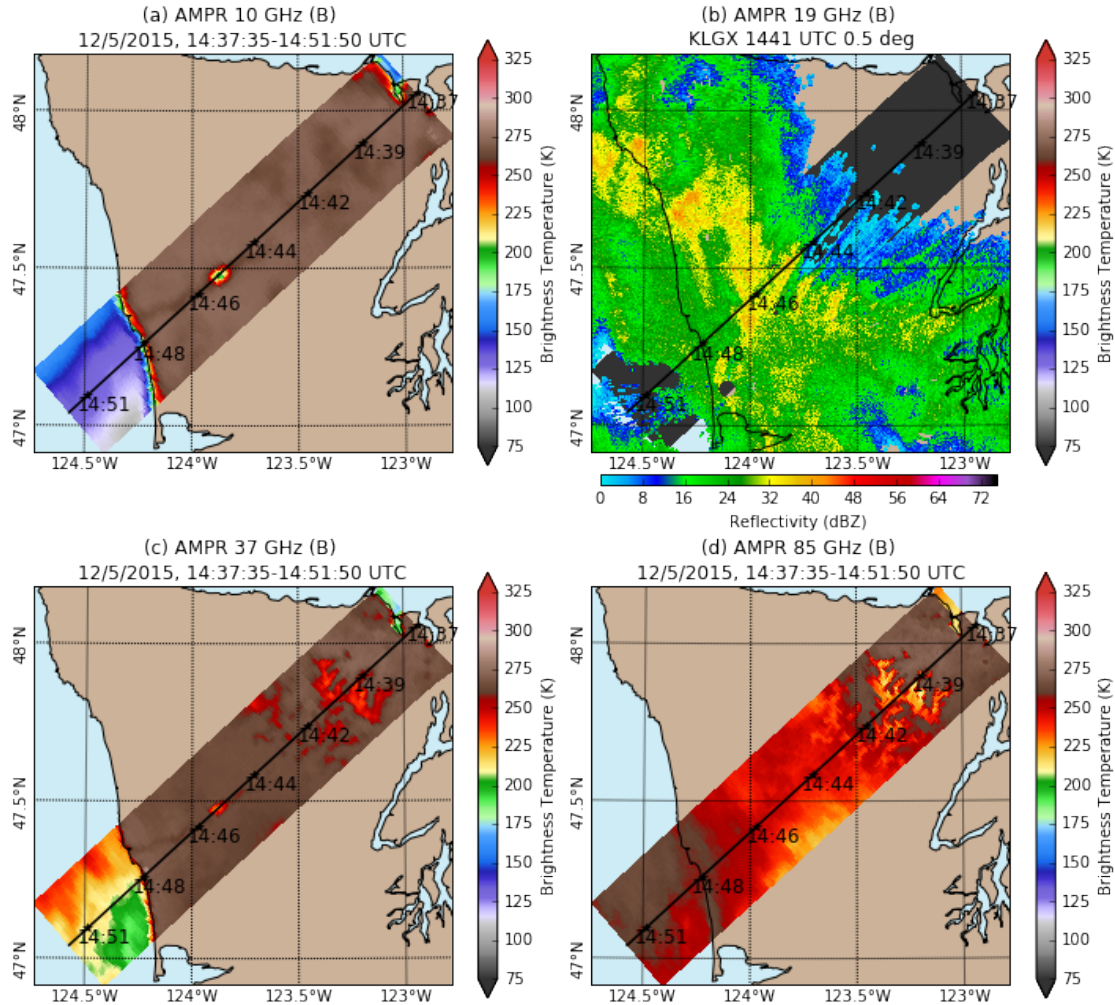
1.070343017578125 seconds to run csu_kdp
No sounding provided

```
In [12]: # 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 = '14:37:30'
ted = '14:52:00'
start = '2015-12-05 ' + tst
end = '2015-12-05 ' + ted
offs = (-0.05, -0.05)

In [17]: display = data.plot_ampr_track_4panel(
    chan='b', timerange=[tst, ted], maneuver=False, return_flag=True,
    meridians=0.5, parallels=0.5, resolution='h',
    show_grid=True) # , latrange=[47, 47.5], lonrange=[-124.99, -124])
display.ax2.set_title('(b) AMPR 19 GHz (B) \nKLGX 1441 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, 0.53, 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,
                  labelspace=30, ax=ax, label_offset=offs)
plt.savefig('combo_ampr_nexrad.png')
```

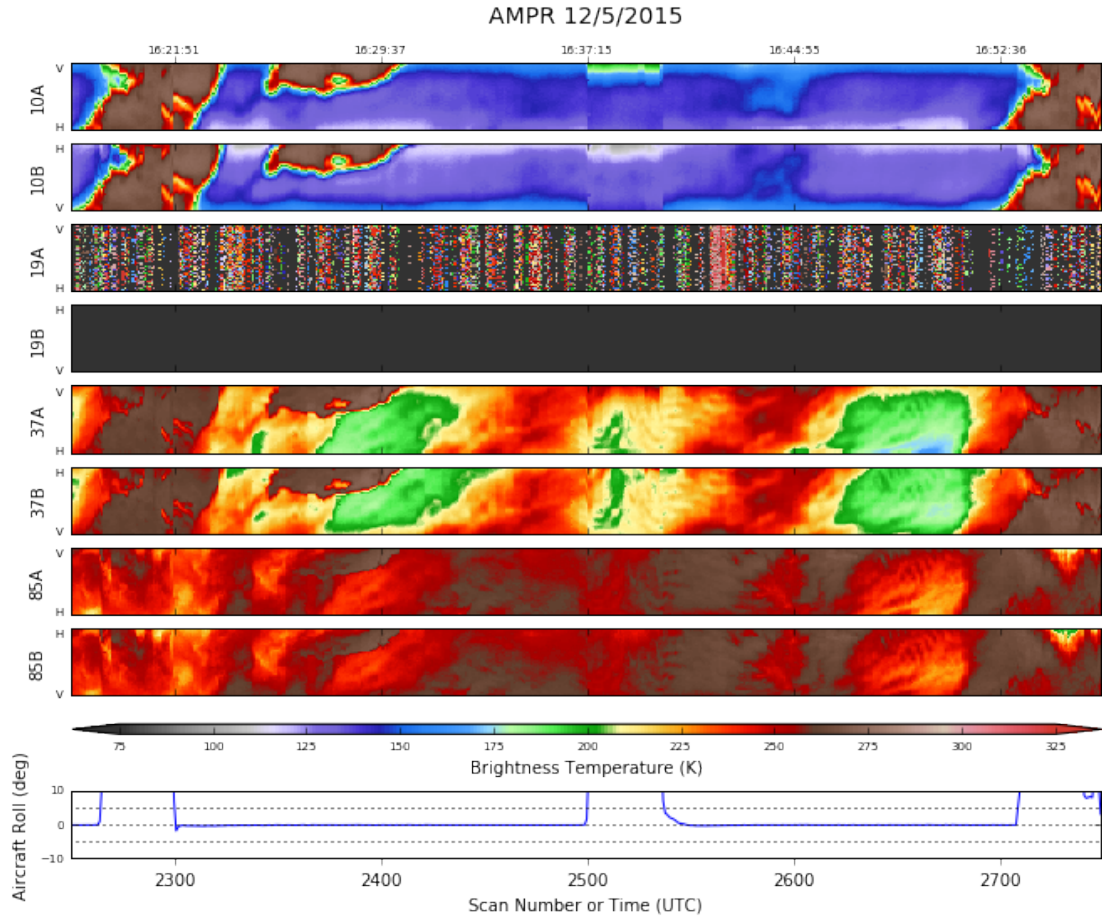


The radar indicates widespread stratiform precipitation, but is blocked to the NE over the Olympics. AMPR suggests some interesting emission signatures from precipitation at 85 GHz, which appears to mix in with signal from the snow-covered peaks of the eastern Olympics. Interestingly, 10 GHz is almost featureless except for Lake Quinault.

Later in the flight, the ER-2 did some overpasses of precipitation offshore. AMPR got some good observations from this period as well.

```
In [29]: data.plot_ampr_channels(scanrange=[2250, 2750])
```

```
*****
plot_ampr_channels():
Available scans = 1 to 3854
Available times = 11:12:22 - 20:01:01
*****
```



At this point the ER-2 was doing north-south racetracks of the NW tip of the Olympic Peninsula. Let's take another look at AMPR geolocated with the NEXRAD data. Let's try something different - let's merge the A and B channels and deconvolve the pure H and pure V scenes. This is a little risky without thoroughly checking the calibrations first, but let's see what happens anyway.

```
In [39]: data.calc_polarization()

*****
calc_polarization():
Calculating for 10 GHz channel
Calculating for 19 GHz channel
Calculating for 37 GHz channel
Calculating for 85 GHz channel
0.2792658805847168 seconds to calculate H & V
If successful, following attributes are now available:
TB10H TB10V TB19H TB19V TB37H TB37V TB85H TB85V
*****

In [36]: # print(radlist)
         radar2 = read_nexrad_aws('KLGX20151205_162330_V06.gz')
         zc = deepcopy(radar2.fields['REF']['data'])
```

```

radar2.add_field_like('REF', 'ZC', zc, replace_existing=True)
retrieve = dualpol.DualPolRetrieval(
    radar2, 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)

```

https://noaa-nexrad-level2.s3.amazonaws.com/2015/12/05/KLGX/KLGX20151205.162330_V06.gz
 1.643484115600586 seconds to run csu_kdp
 No sounding provided

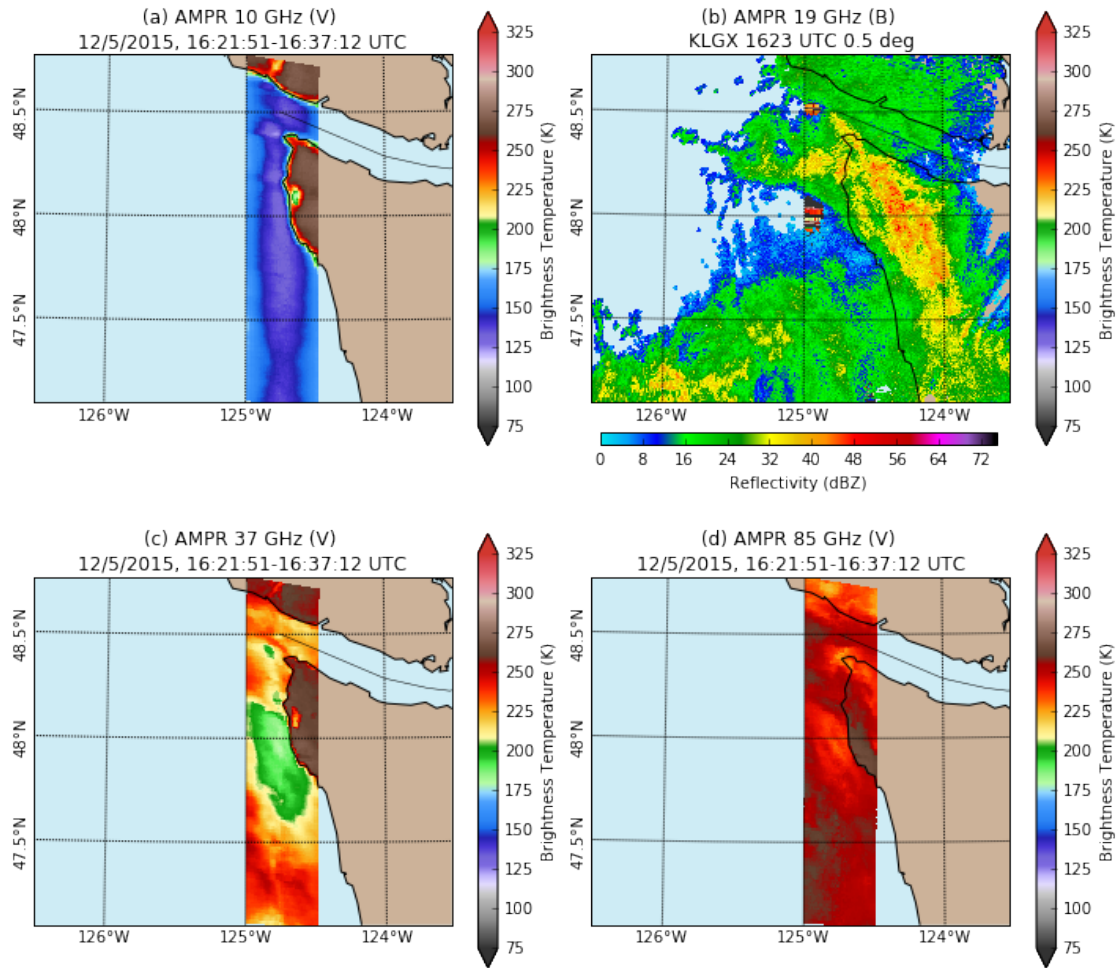
```

In [41]: display = data.plot_ampr_track_4panel(
    chan='v', maneuver=False, return_flag=True,
    meridians=1, parallels=0.5, resolution='i',
    show_grid=True, scanrange=[2300, 2500], lonrange=[-126.5, -123.5])
display.ax2.set_title('(b) AMPR 19 GHz (B) \nKLGX 1623 UTC 0.5 deg')

# Play some tricks to overplot NEXRAD on the same basemap using Py-ART
dr = pyart.graph.RadarMapDisplay(radar2)
rdata = dr._get_data('ZC', 0, None, True, None)
x, y = dr._get_x_y('ZC', 0, 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')

```

Out[41]: <matplotlib.colorbar.Colorbar at 0x123bc3b00>

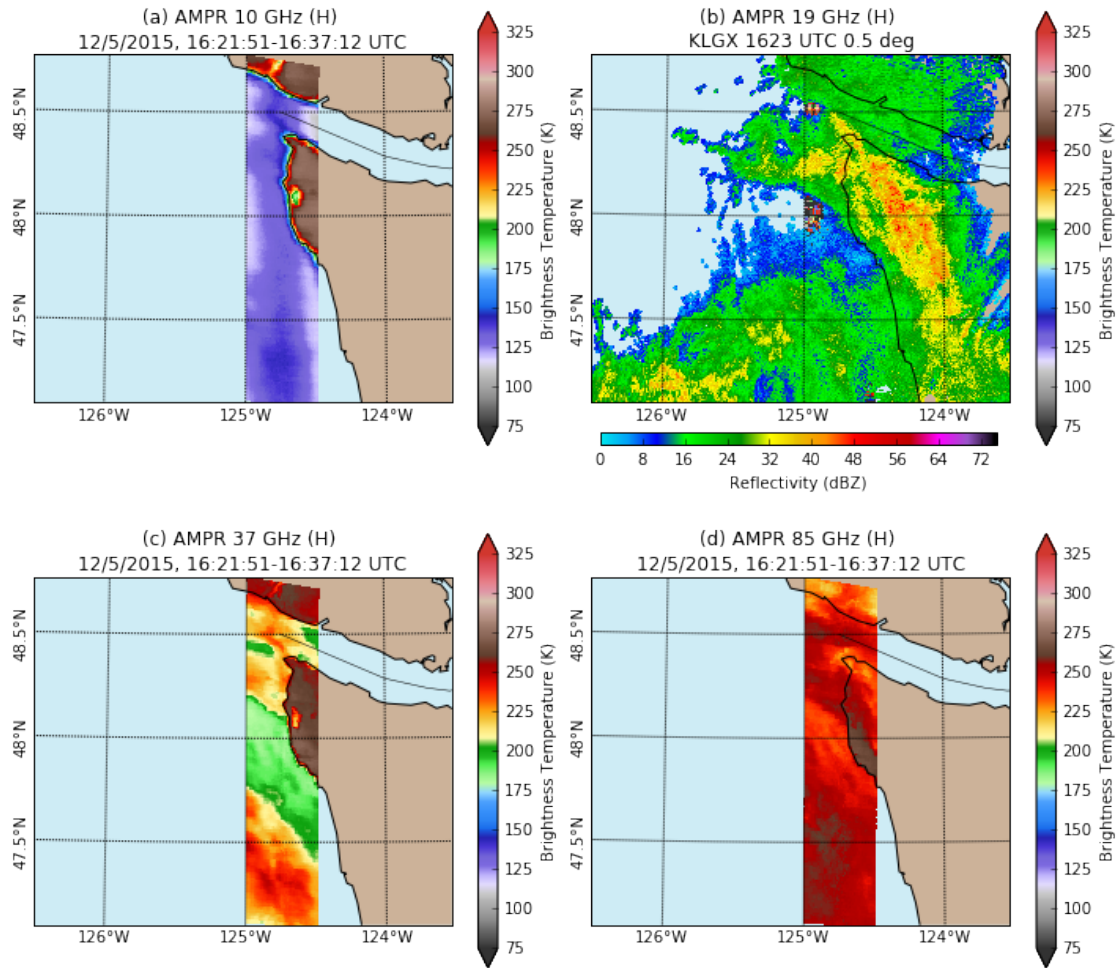


That was for the V scenes. And now the corresponding look for the H scenes:

```
In [44]: display = data.plot_ampr_track_4panel(
    chan='h', maneuver=False, return_flag=True,
    meridians=1, parallels=0.5, resolution='i',
    show_grid=True, scanrange=[2300, 2500], lonrange=[-126.5, -123.5])
display.ax2.set_title('(b) AMPR 19 GHz (H) \nKLGX 1623 UTC 0.5 deg')

# Play some tricks to overplot NEXRAD on the same basemap using Py-ART
dr = pyart.graph.RadarMapDisplay(radar2)
rdata = dr._get_data('ZC', 0, None, True, None)
x, y = dr._get_x_y('ZC', 0, 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')
```

Out[44]: <matplotlib.colorbar.Colorbar at 0x15b07ba20>



Some interesting differences between the pure V and pure H scenes. The most distinctive differences occur at 37 GHz. In particular, the 37 GHz (H) scene corresponds very nicely to the KLGX reflectivity pattern over water. Similarly, the 10 GHz (H) shows some emission from the enhanced reflectivity tongue over the mouth of the Strait of Juan de Fuca.

In []: