

# Science\_Flight\_20151123

November 23, 2015

In this report, we'll review the science flight of the ER-2 starting on 11/23/2015. This was a ~8-h flight that overflowed a frontal system that impacted the coast of the Olympic Peninsula. First let's import all the needed modules and ingest and process the raw data.

```
In [1]: from IPython.display import display
        from IPython.display import HTML
        # Example: di.display_html('<h3>%s:</h3>' % str, raw=True)
        import IPython.core.display as di

        # This line will hide code by default when the notebook is exported as HTML
        di.display_html('<script>jQuery(function() +
            ' {if (jQuery("body.notebook_app").length == 0)' +
            ' { jQuery(".input_area").toggle(); ' +
            ' jQuery(".prompt").toggle();}});</script>', raw=True)

        # This line will add a button to toggle visibility of code blocks,
        # for use with the HTML export version
        di.display_html('<button onclick="jQuery(\'.input_area\').toggle(); ' +
            'jQuery(\'.prompt\').toggle();">Toggle code</button>', raw=True)
```

```
In [25]: 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
         from awot.graph.common import create_basemap
         from awot.graph.flight_level import FlightLevel
         from pyart_tools import plot_list_of_fields
         %matplotlib inline
```

```
In [3]: import warnings
        warnings.filterwarnings('ignore')
        def delete_file(fname):
            try:
                os.remove(fname)
            except:
                pass
```

```
In [4]: datadir = './'
        files = glob.glob(datadir + '*.dat')
```

```

print(files)
fname = os.path.basename(files[0])[:-4]

['./AMPR-20151123-134810.dat', './AMPR-20151123-181704.dat']

```

```

In [5]: 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-20151123-134810.dat Read Successfully
End of data stream reached
All of file: ./AMPR-20151123-181704.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-20151123-134810_L1.nc
Found Navigation Data!
Writing to output file: AMPR-20151123-134810_L2.nc
File containing water fraction not on path

```

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

```

In [6]: data = pyampr.AmprTb(l2file)
        data.plot_ampr_channels()

```

```

*****
read_ampr.tb_level2b(): Reading AMPR-20151123-134810_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!
(6790,)
*****

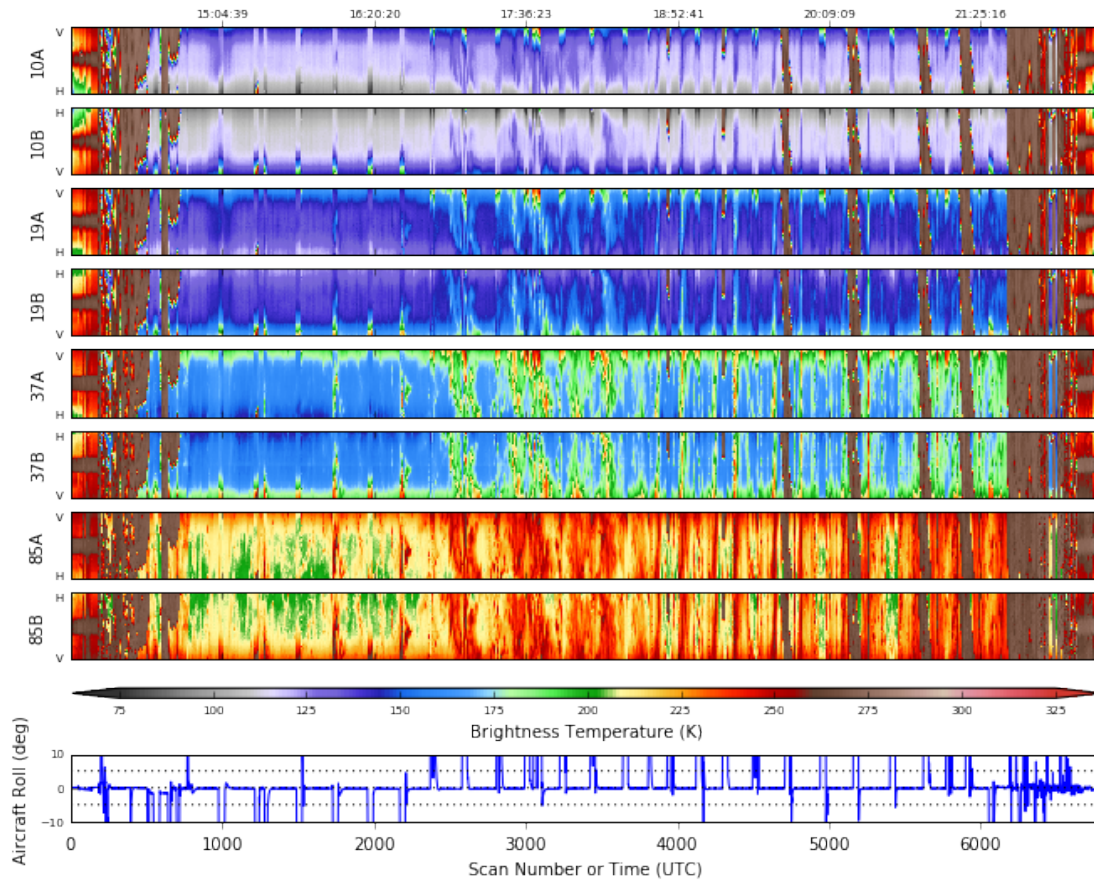
```

```

*****
plot_ampr_channels():
Available scans = 1 to 6790
Available times = 13:48:15 - 22:25:30
*****

```

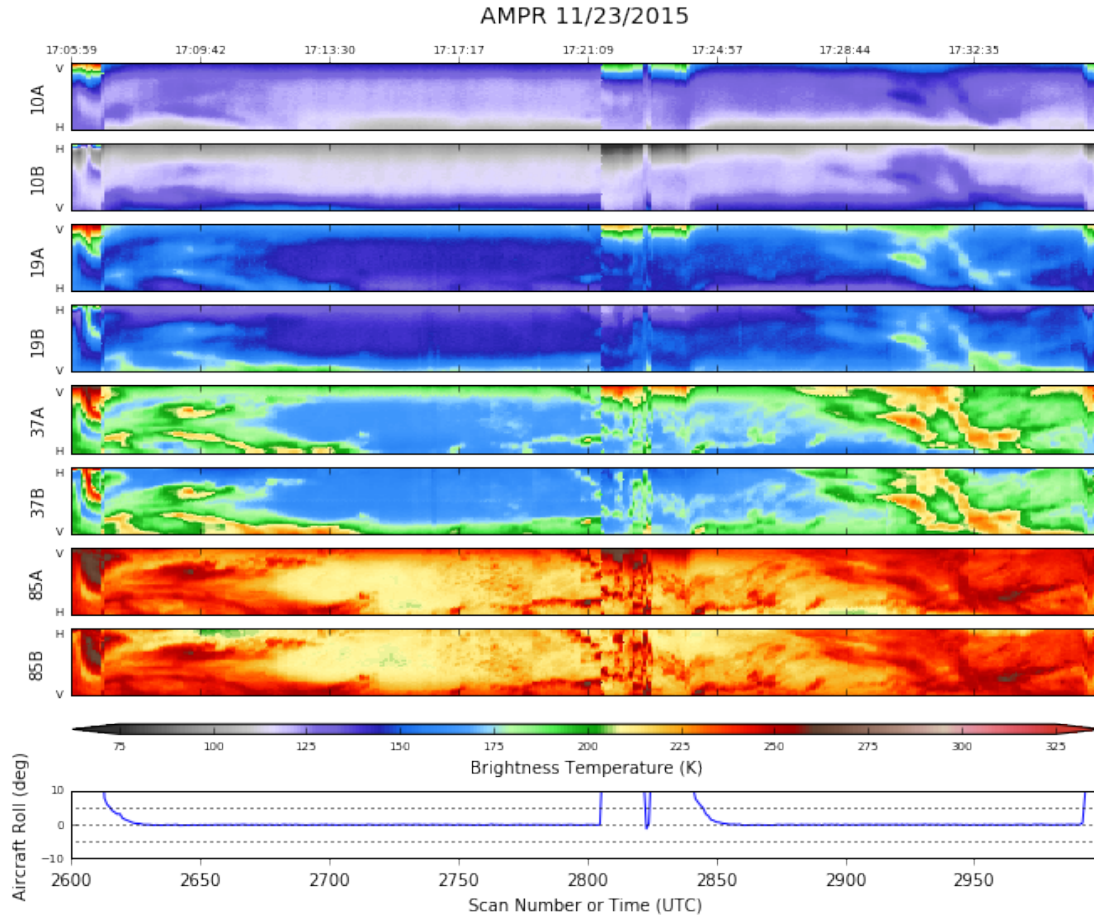
AMPR 11/23/2015



Overall, this looks really good. All channels behaved well, including the 85 GHz (A) channel that has some issues last flight. Thus, we can just focus on the science. The ER-2 performed several orbits over the frontal system, in concert with both the DC-8 and the Citation. Let's look at a particular orbit that occurred during the early portion of the flight, when the front was well offshore.

```
In [7]: data.plot_ampr_channels(scanrange=[2600, 3000])
```

```
*****
plot_ampr_channels():
Available scans = 1 to 6790
Available times = 13:48:15 - 22:25:30
*****
```



```
In [8]: # 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)
```

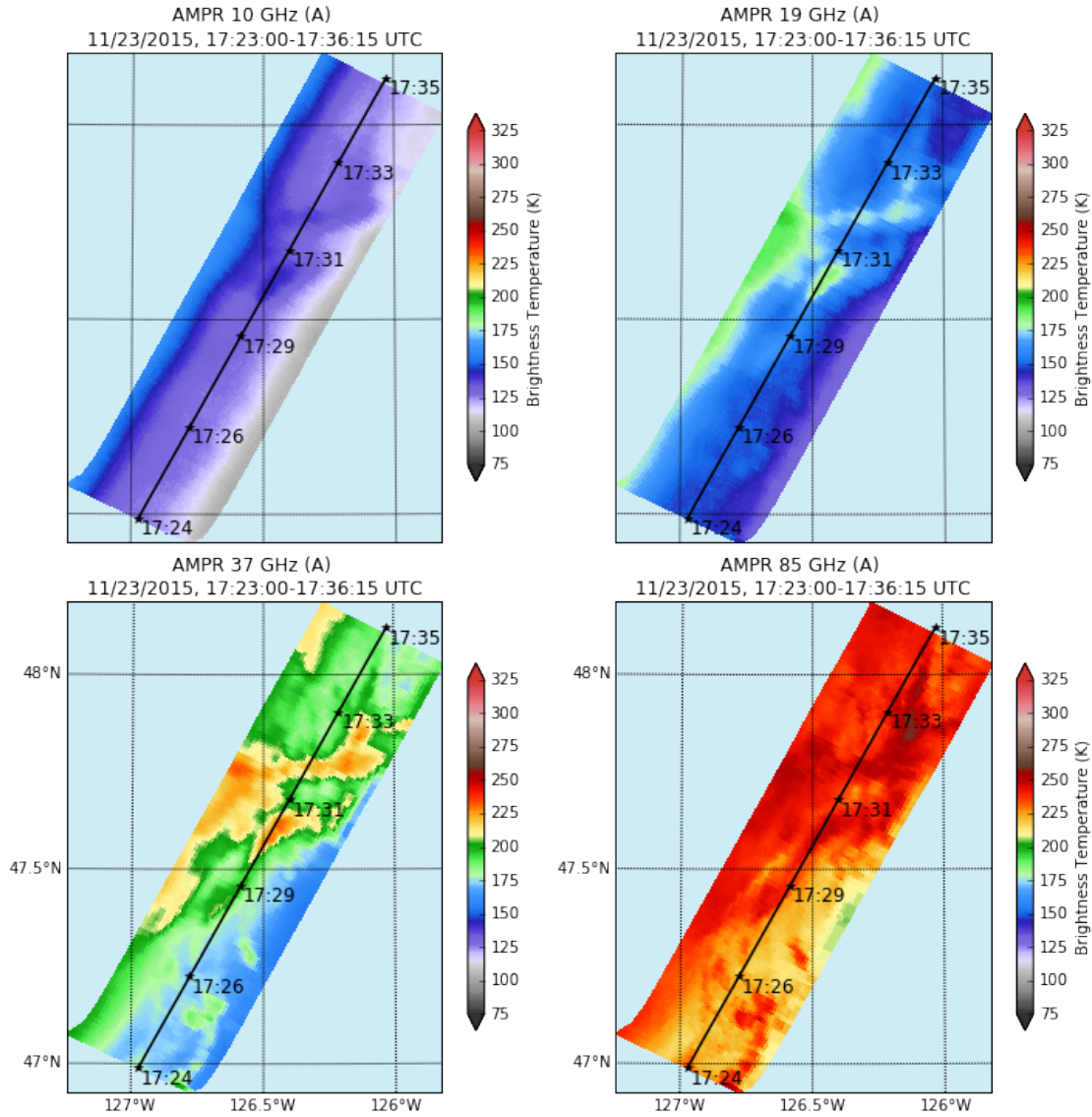
And now let's inspect select track plots from portions of this orbit.

```
In [15]: fig, [[ax1, ax2], [ax3, ax4]] = plt.subplots(2, 2, figsize=(10, 10))
stuff = data.plot_ampr_track(
    '10a', scanrange=[2825, 3000], ax=ax1, grid_labels=False,
    maneuver=False, meridians=0.5, parallels=0.5,
    colorbar_label=True, fig=fig, return_flag=True, resolution='1')
f2 = FlightLevel(flight, basemap=stuff[2])
start = '2015-11-23 17:24:30'
end = '2015-11-23 17:36:00'
f2.plot_trackmap(min_altitude=50., lw=2.5, start_time=start,
    end_time=end, ax=stuff[1])
f2.time_stamps(start_time=start, end_time=end,
    labelspacing=30, ax=stuff[1], label_offset=(0.01, -0.04))
data.plot_ampr_track(
    '19a', scanrange=[2825, 3000],
    maneuver=False, meridians=0.5, parallels=0.5,
```

```

    ax=ax2, fig=fig, grid_labels=False, basemap=stuff[2])
f2.plot_trackmap(min_altitude=50., lw=2.5, start_time=start,
                 end_time=end, ax=ax2)
f2.time_stamps(start_time=start, end_time=end,
               labelspacing=30, ax=ax2, label_offset=(0.01, -0.04))
data.plot_ampr_track(
    '37a', scanrange=[2825, 3000],
    maneuver=False, meridians=0.5, parallels=0.5,
    ax=ax3, fig=fig, colorbar_label=False, basemap=stuff[2])
f2.plot_trackmap(min_altitude=50., lw=2.5, start_time=start,
                 end_time=end, ax=ax3)
f2.time_stamps(start_time=start, end_time=end,
               labelspacing=30, ax=ax3, label_offset=(0.01, -0.04))
data.plot_ampr_track(
    '85a', scanrange=[2825, 3000],
    maneuver=False, meridians=0.5, parallels=0.5,
    ax=ax4, fig=fig, grid_labels=True, basemap=stuff[2])
f2.plot_trackmap(min_altitude=50., lw=2.5, start_time=start,
                 end_time=end, ax=ax4)
f2.time_stamps(start_time=start, end_time=end,
               labelspacing=30, ax=ax4, label_offset=(0.01, -0.04))
plt.tight_layout()

```

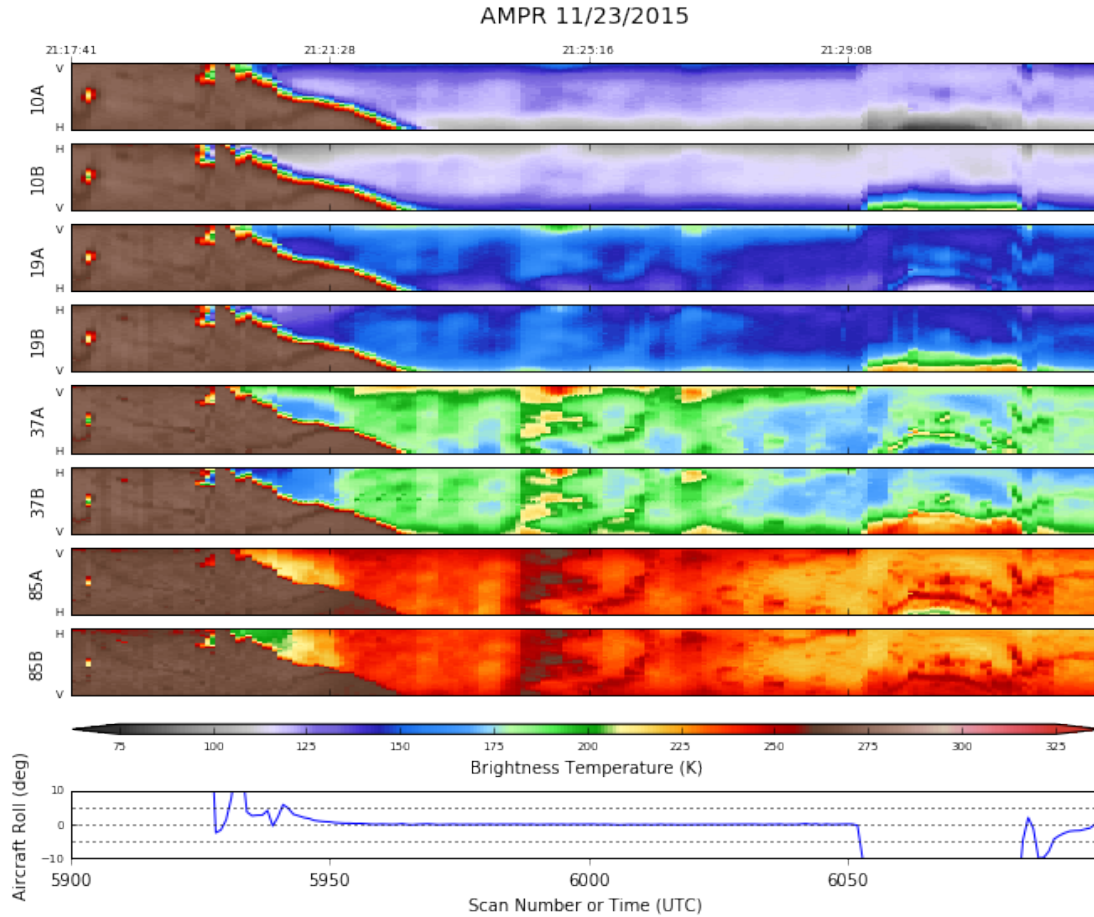


The 85 GHz channel saw a lot of emission from this system, with 37 GHz also responding to the widespread stratiform echo. The heaviest raining cores (overflow around 1730 UTC) had signals down to 10 GHz, and should provide an excellent opportunity for multi-instrument retrievals due to the nadir bullseye at that time.

Now let's inspect a later time period, when the frontal system was moving onshore near NPOL. Again, both DC-8 and Citation supported this portion of the flight.

```
In [17]: data.plot_ampr_channels(scanrange=[5900, 6100])
```

```
*****
plot_ampr_channels():
Available scans = 1 to 6790
Available times = 13:48:15 - 22:25:30
*****
```



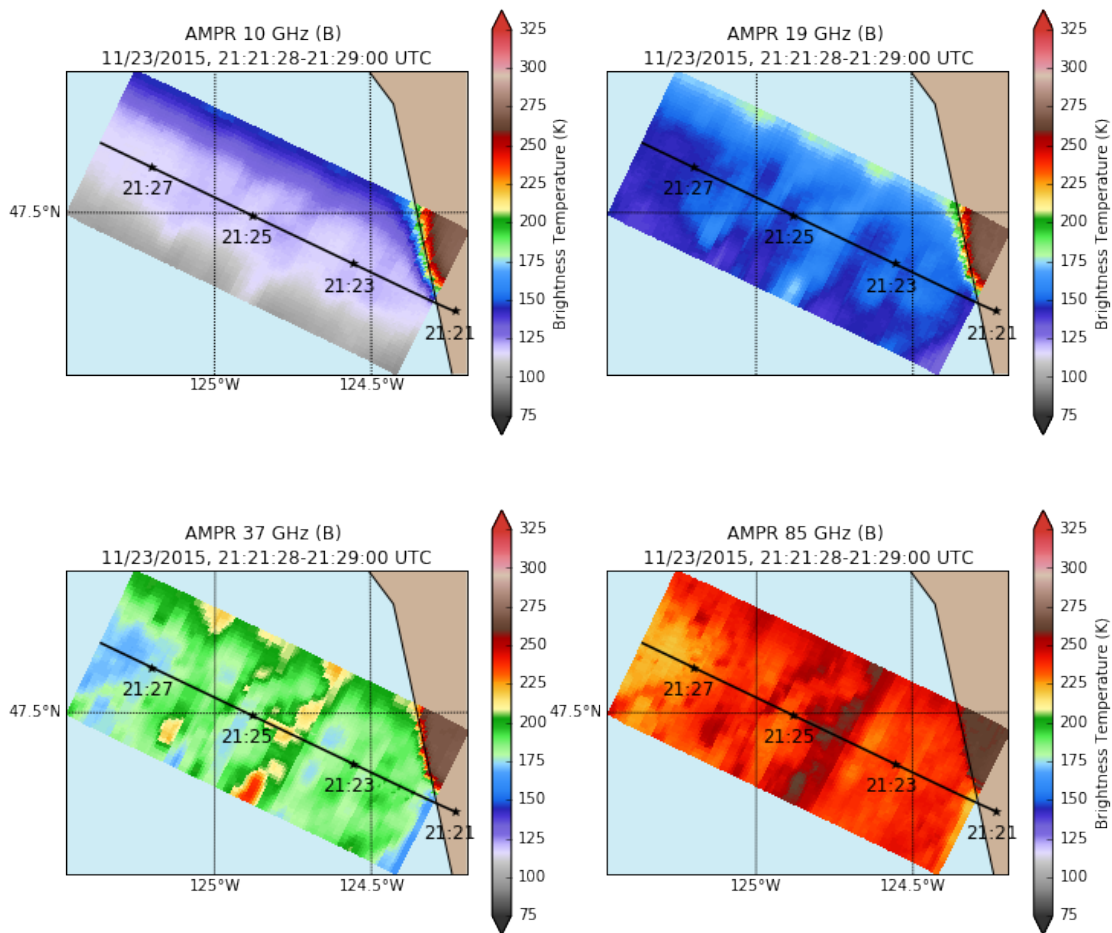
Let's again look at track plots during a portion of this outbound leg. This was a great setup, when the Citation was well position to support the ER-2 and DC-8 with stacked in situ legs. For a change of pace, let's examine the B channels.

```
In [27]: fig, [[ax1, ax2], [ax3, ax4]] = plt.subplots(2, 2, figsize=(10, 10))
stuff = data.plot_ampr_track(
    '10b', scanrange=[5950, 6050], ax=ax1, grid_labels=True,
    maneuver=False, meridians=0.5, parallels=0.5,
    colorbar_label=True, fig=fig, return_flag=True, resolution='1')
f2 = FlightLevel(flight, basemap=stuff[2])
start = '2015-11-23 21:21:00'
end = '2015-11-23 21:29:00'
f2.plot_trackmap(min_altitude=50., lw=2.5, start_time=start,
    end_time=end, ax=stuff[1])
f2.time_stamps(start_time=start, end_time=end,
    labelspacing=30, ax=stuff[1], label_offset=(-0.1, -0.06))
data.plot_ampr_track(
    '19b', scanrange=[5950, 6050],
    maneuver=False, meridians=0.5, parallels=0.5,
    ax=ax2, fig=fig, grid_labels=False, basemap=stuff[2])
f2.plot_trackmap(min_altitude=50., lw=2.5, start_time=start,
```

```

        end_time=end, ax=ax2)
f2.time_stamps(start_time=start, end_time=end,
               labelspacing=30, ax=ax2, label_offset=(-0.1, -0.06))
data.plot_ampr_track(
    '37b', scanrange=[5950, 6050],
    maneuver=False, meridians=0.5, parallels=0.5,
    ax=ax3, fig=fig, colorbar_label=False, basemap=stuff[2])
f2.plot_trackmap(min_altitude=50., lw=2.5, start_time=start,
                end_time=end, ax=ax3)
f2.time_stamps(start_time=start, end_time=end,
               labelspacing=30, ax=ax3, label_offset=(-0.1, -0.06))
data.plot_ampr_track(
    '85b', scanrange=[5950, 6050],
    maneuver=False, meridians=0.5, parallels=0.5,
    ax=ax4, fig=fig, grid_labels=True, basemap=stuff[2])
f2.plot_trackmap(min_altitude=50., lw=2.5, start_time=start,
                end_time=end, ax=ax4)
f2.time_stamps(start_time=start, end_time=end,
               labelspacing=30, ax=ax4, label_offset=(-0.1, -0.06))
plt.tight_layout()

```



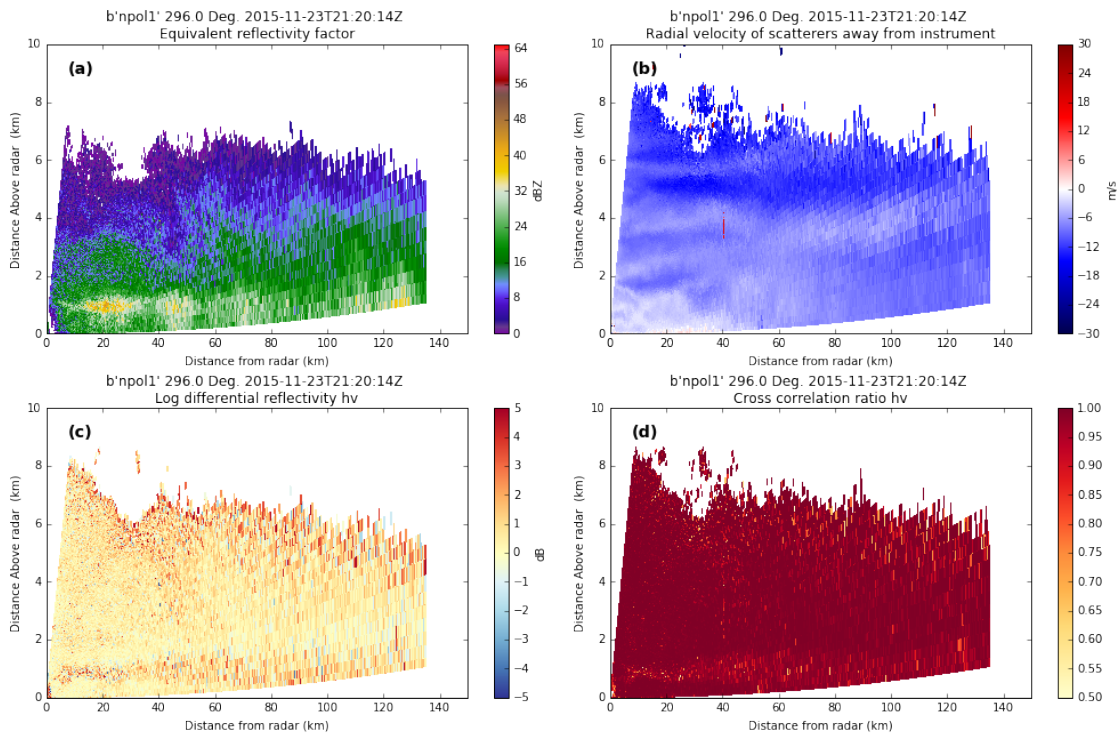


The line of precip appears very abruptly just before 21:25 UTC in both the 37 GHz and 85 GHz channels. Let's look at NPOL RHIs along this radial at that time to get a sense of why this might be the case.

```
In [24]: # print(list_nexrad_files(year='2015', month='11', day='18', station='KLGX'))
import ftplib
import tempfile
ftp = ftplib.FTP('trmm-fc.gsfc.nasa.gov')
ftp.login("anonymous", "timothy.j.lang@nasa.gov")
ftp.cwd("Wallops_PRF/NPOL/Olympex/8bit_rhi_a")
fname = 'np1151123212013.RAWTNBA'
localfile = tempfile.NamedTemporaryFile()
ftp.retrbinary("RETR "+fname, open(localfile.name, 'wb').write)
rhia = pyart.io.read(localfile.name)
localfile.close()
print([key for key in rhia.fields.keys()])
```

['cross\_correlation\_ratio', 'reflectivity', 'total\_power', 'differential\_reflectivity', 'velocity', 'diff

```
In [26]: xlim = [0, 150]
ylim = [0, 10]
display = plot_list_of_fields(
    rhia, -11, fields=[
        'reflectivity', 'velocity', 'differential_reflectivity',
        'cross_correlation_ratio'],
    vmin=[0, -30, -5, 0.5], vmax=[65, 30, 5, 1],
    units=['dBZ', 'm/s', 'dB', ''],
    cmap=['pyart_Carbone42', 'seismic', 'RdYlBu_r', 'YlOrRd'],
    return_flag=True, rhi=True, columns=2, xlim=xlim, ylim=ylim)
```



The overall structure is stratiform with local enhancements in the bright band (esp. noticeable in the polarimetric variables ZDR and RHOHV - c & d, respectively). These enhancements appear to be associated with increased reflectivity near the surface (i.e., rain rate) as well as enhanced thermal emission signatures at 37 and 85 GHz in AMPR, although there are also indications of enhancements at 19 and 10 GHz.

To sum up, this was a solid dataset from AMPR, looking at mostly stratiform rainfall associated with a maritime cold front. Data quality look excellent, and the ER-2 was coordinated well with the DC-8 and Citation. Thus, there should be a lot of good opportunities for cross-comparison between different instruments.

In [ ]: