Cloud Study, Science Progress, and Activity

Jay Mace

Participants: Tristan L'Ecuyer, Matt Lebsock, Roger Marchand, Simone Tanelli, Steve Cooper

Objectives:

1. Initial work towards a suite of algorithms that can be applied to ACE remote sensors suite (passive and active)
2. Develop capacity for conducting studies that define instrument suite and characteristics that meet ACE science requirements as defined by STM

End-to-end Observing System Simulations

Tristan L'Ecuyer and Norm Wood
University of Wisconsin

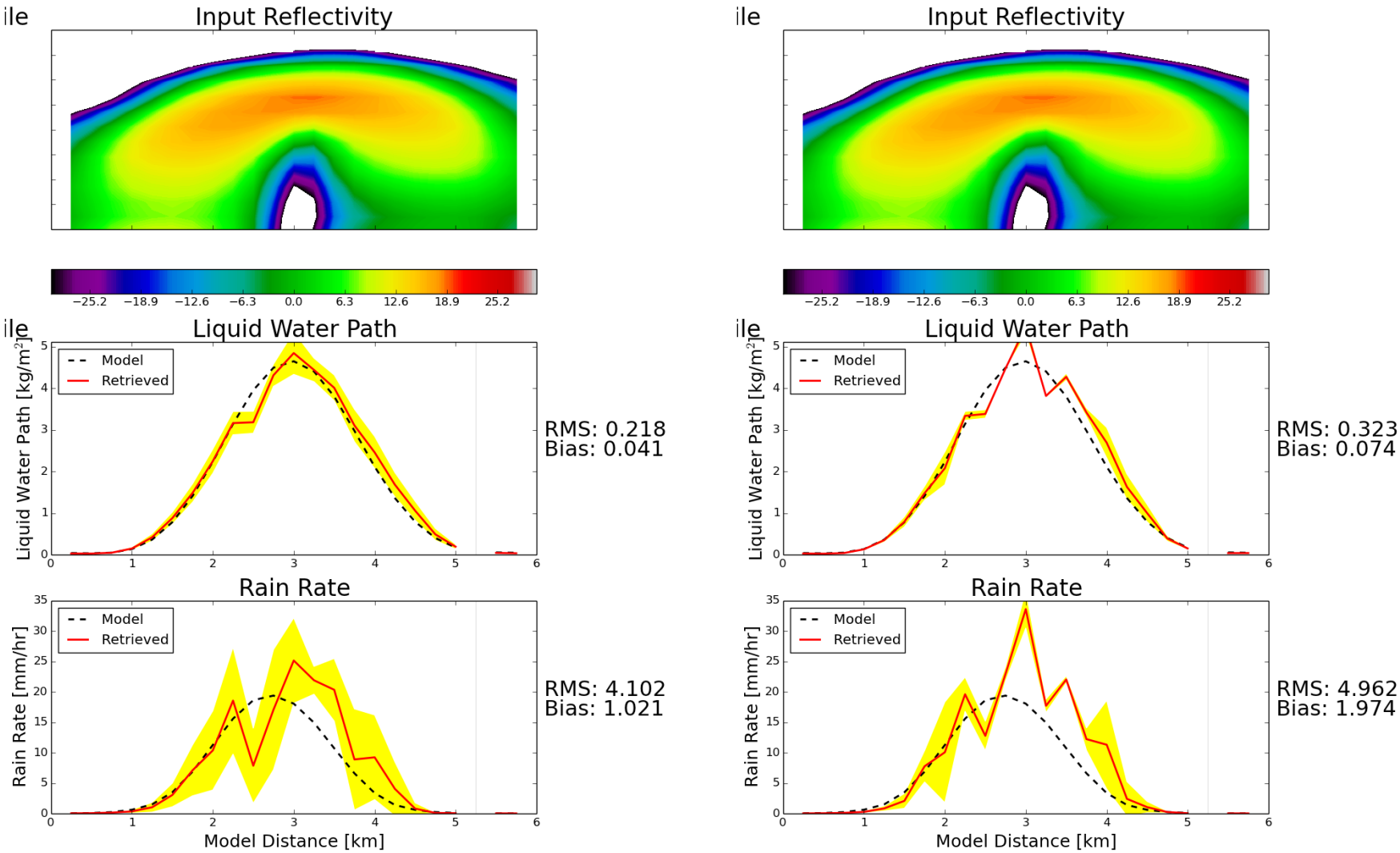
(work in progress…)

- Goal: To connect instrument requirements to science goals through synthetic retrievals.
- Apply multi-frequency & Doppler radar simulators to CRM simulations spanning a wide range of meteorological regimes.
- Develop Bayesian algorithms to quantify information content of radar observations assuming various instrument specifications.
- Connect uncertainties to anticipated accuracy required to satisfy science questions (e.g. quantify aerosol influences on precipitation formation in maritime congestus).

•Higher Latitude CRM Simulation Archive

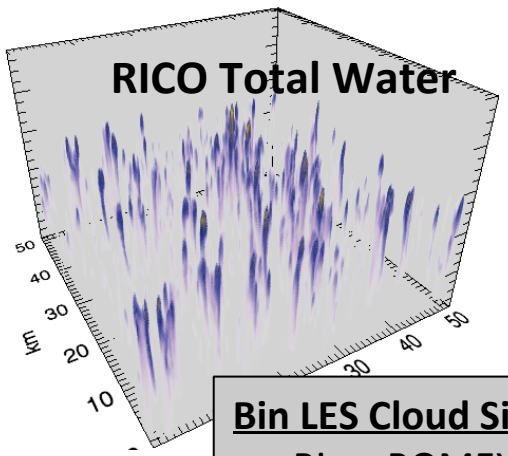
- Marine stratocumulus in Northeast Atlantic (varying CCN/GCCN)
- MCS
- Extra-tropical Cyclones
- High-latitude/shallow freezing level pre- and post-frontal rainfall
- Orographic, lake-effect, and synoptic snowfall

Connecting to Instrument Requirements



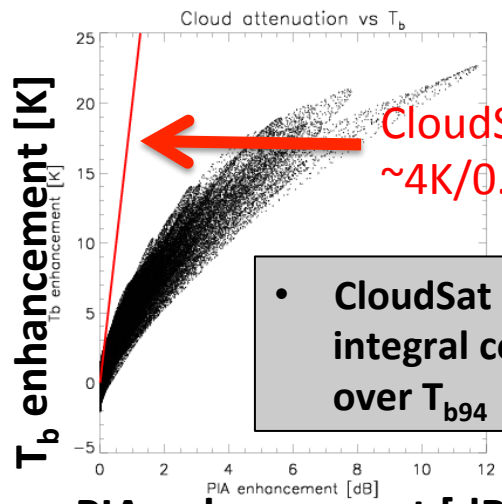
Warm Cloud Simulator Studies

Lebsock/Suzuki/Stephens: JPL



<u>Bin LES Cloud Simulations</u>:

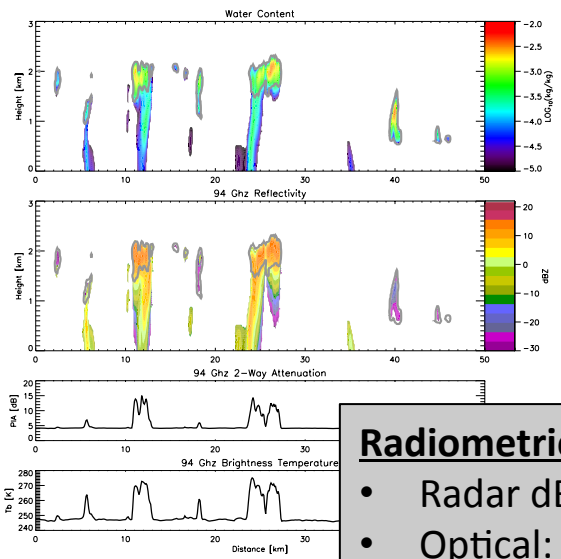
- Rico, BOMEX, DYCOMS



CloudSat noise ratio: ~4K/0.2dB

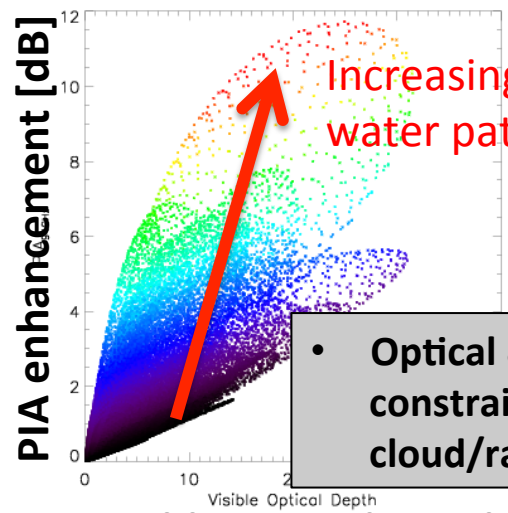
- **CloudSat SNR for 94 GHz integral constraint favors PIA over T_{b94}**

PIA enhancement [dB]



<u>Radiometric Simulators</u>:

- Radar dBZ, PIA, T_b
- Optical: $\tau_{visible}$



Increasing rain water path

- **Optical & W-band integral constraints allow separation of cloud/rain signals**

Visible Optical Depth

Retrieval of Boundary Layer Cloud Properties using 3D RT

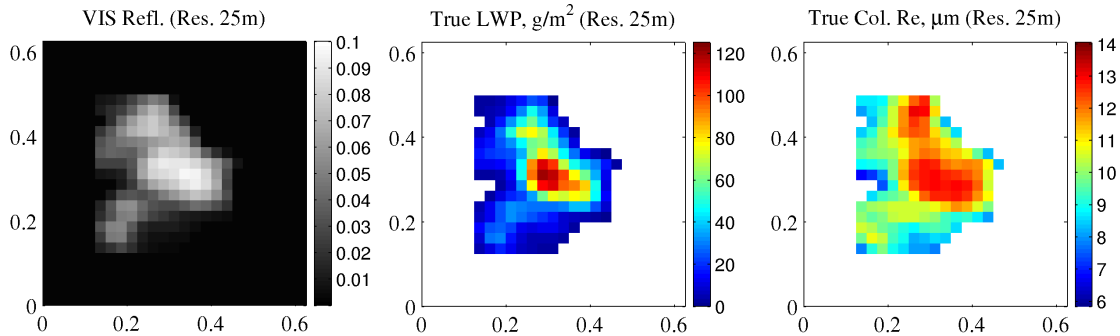
Roger Marchand, University of Washington

Current satellite retrievals of boundary layer cloud properties rely on 1D radiative transfer (RT), which leads to large errors in retrievals if applied to small cumulus clouds or "near" the edges of broken clouds.

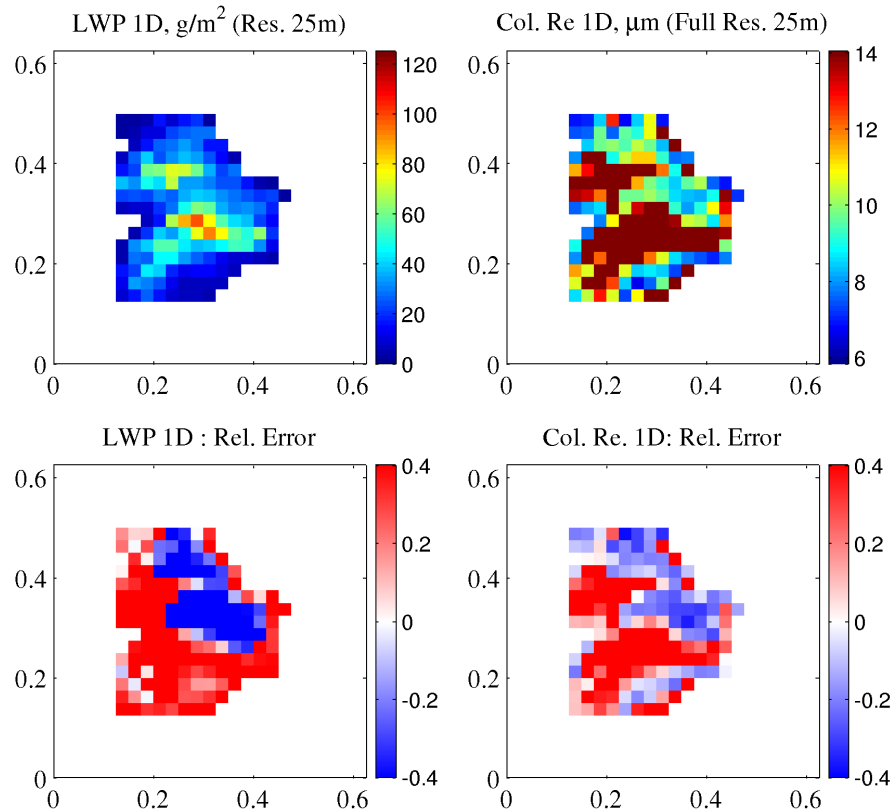
Can we obtain improved BL cloud properties using a combination of high-resolution imagery, 3D RT, and polarization?

Ultimately, I will use polarization/ cloudbow to constrain cloud-top Re, but here I thus far I have focused on 3D RT …

Example of Cumulus cloud from bin-LES



Traditional Retrieval based on 1D RT

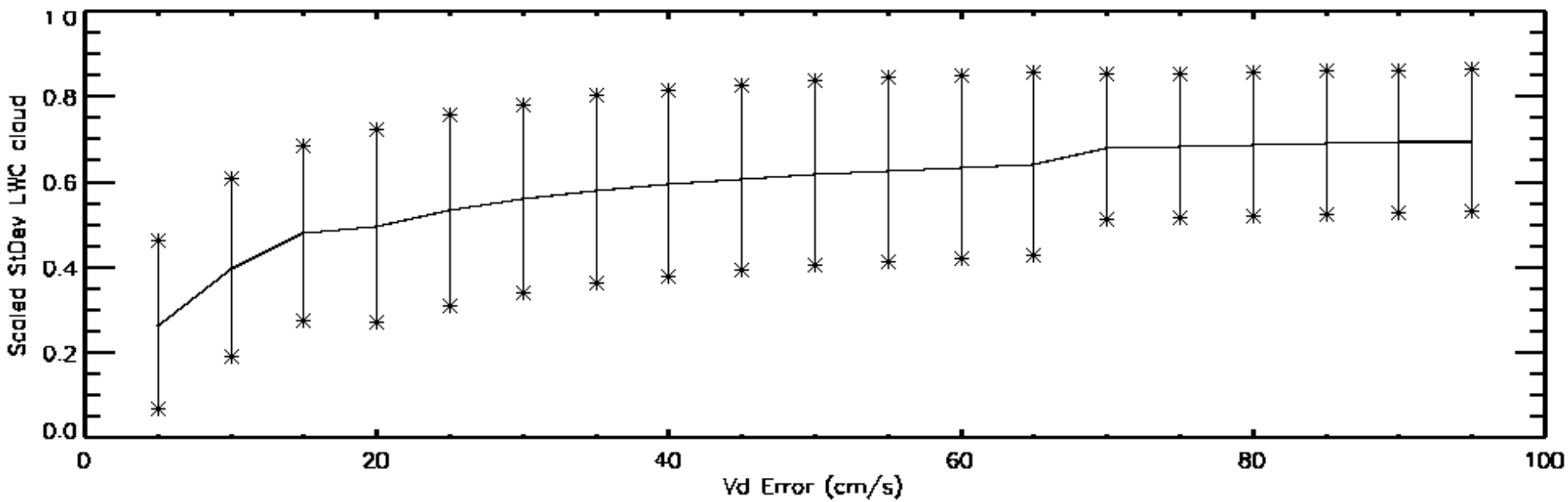


Work at Utah:

Developing initial algorithms to simultaneously retrieve vertical column of cloud, precipitation, vertical motion quantities with ACE-like data.

This application: Define what, in terms of measurement characteristics, are necessary to meet science goals for weakly precipitating warm marine clouds.

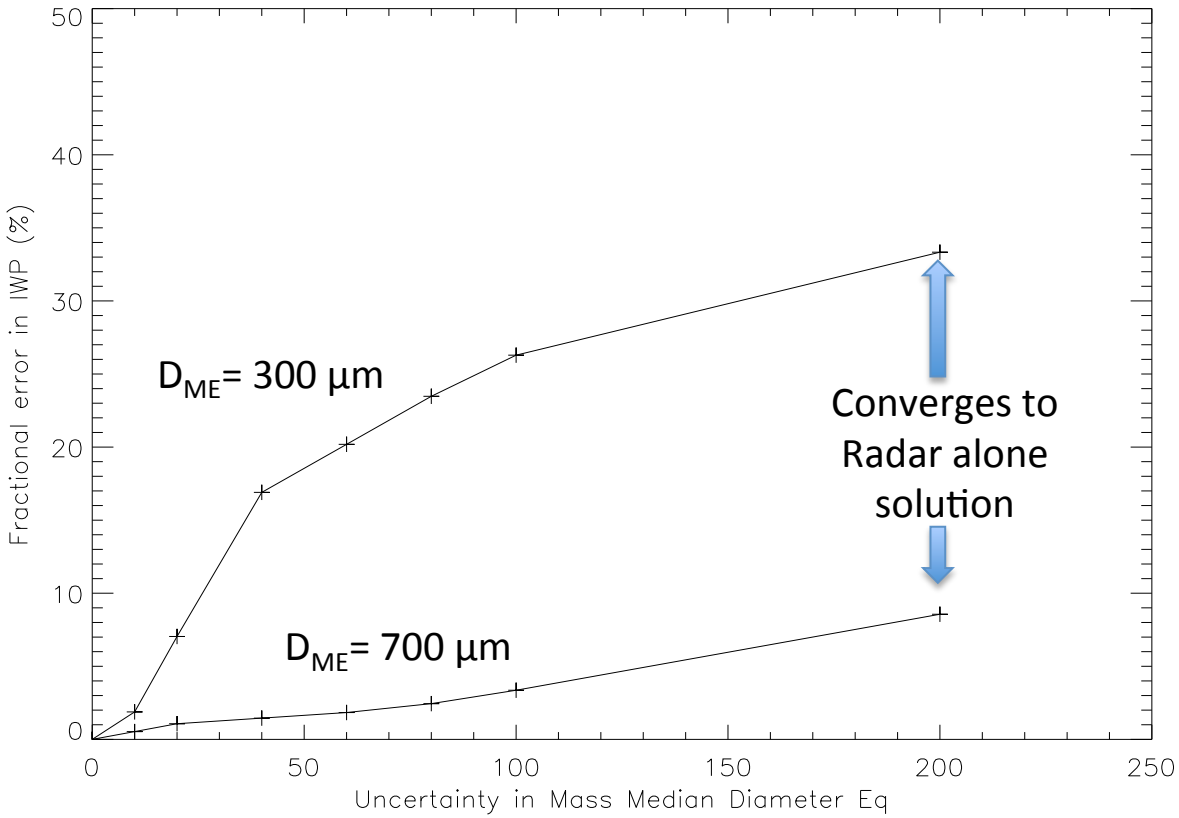
Plot shows how fractional error in cloud LWC increases as Doppler Velocity accuracy decreases for a shallow precipitating liquid cloud



Multi-sensor retrievals of ice cloud properties
Steve Cooper, Utah

Example, explore a combined radar and submm radiometry retrieval scheme exploiting complementary information for IWP, size distribution, and cloud height.

Figure below shows uncertainty in IWP for a combined radar- submm retrieval scheme as a function of uncertainty in the submm estimate of PSD. Error defined relative to base radar assumption of PSD with 500 µm D_{MME}.



ACE Radar Definition Experiment (RADEX)

Objective: characterize the suite of radar measurements (Multi Frequency Doppler) that, when combined with passive measurements, can meet the ACE cloud science goals.

- To accomplish this…
  1. Collect new remote sensing data sets that exceed present expected ACE radar payload characteristics with simultaneous in situ cloud and precipitation measurements for validation.

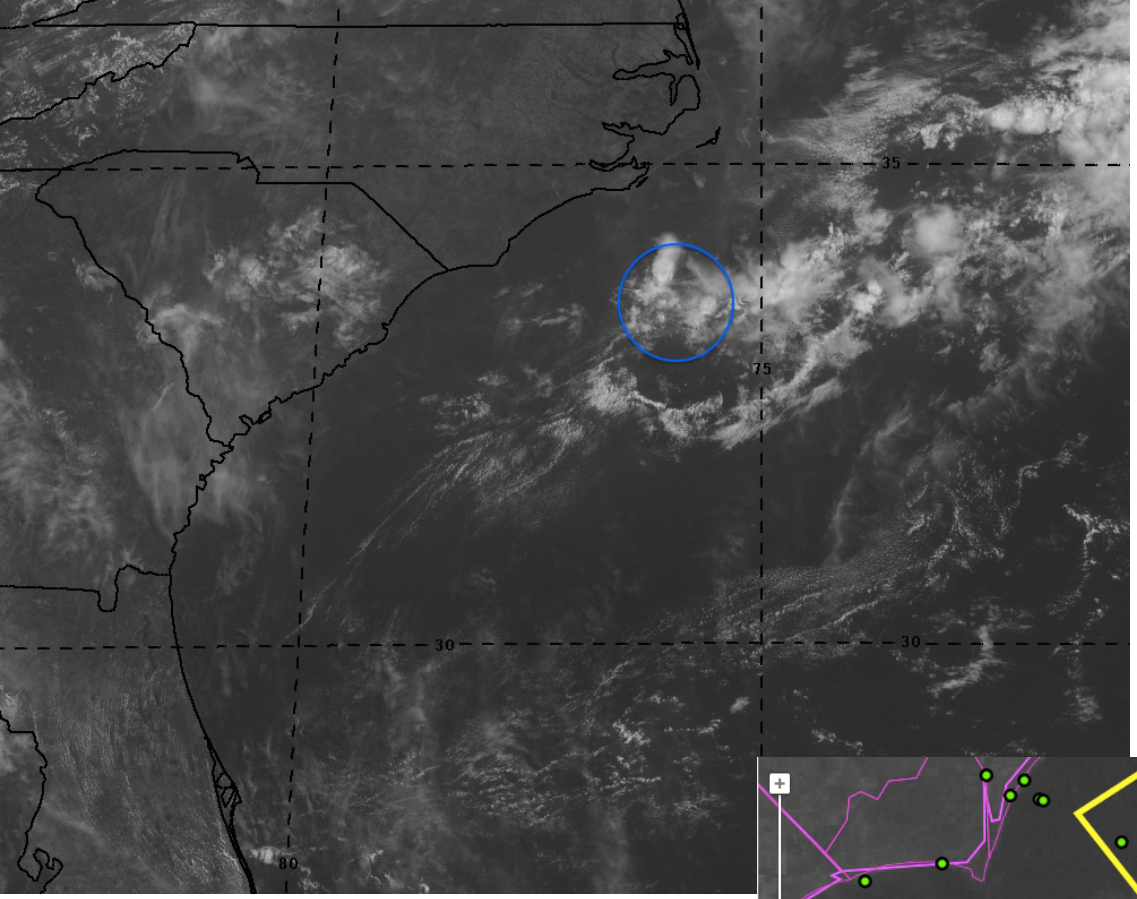
  2. Develop initial set of cloud and precipitation property retrieval algorithms that can be applied to and tested with ACE RADEX data.

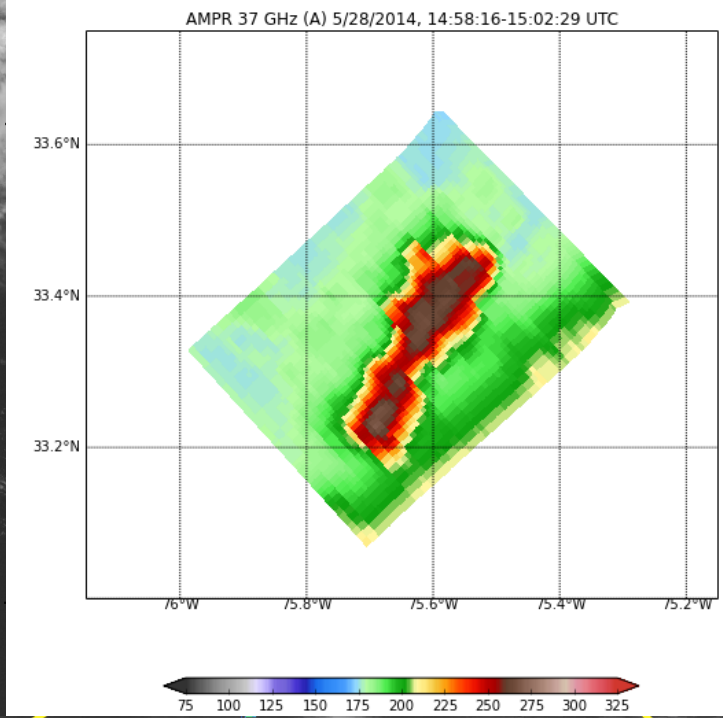
- Initial deployment is nearly complete – Collaborative with Integrated Precipitation and Hydrology Experiment (IPHEX) (GPM Validation, NOAA Hydrology)

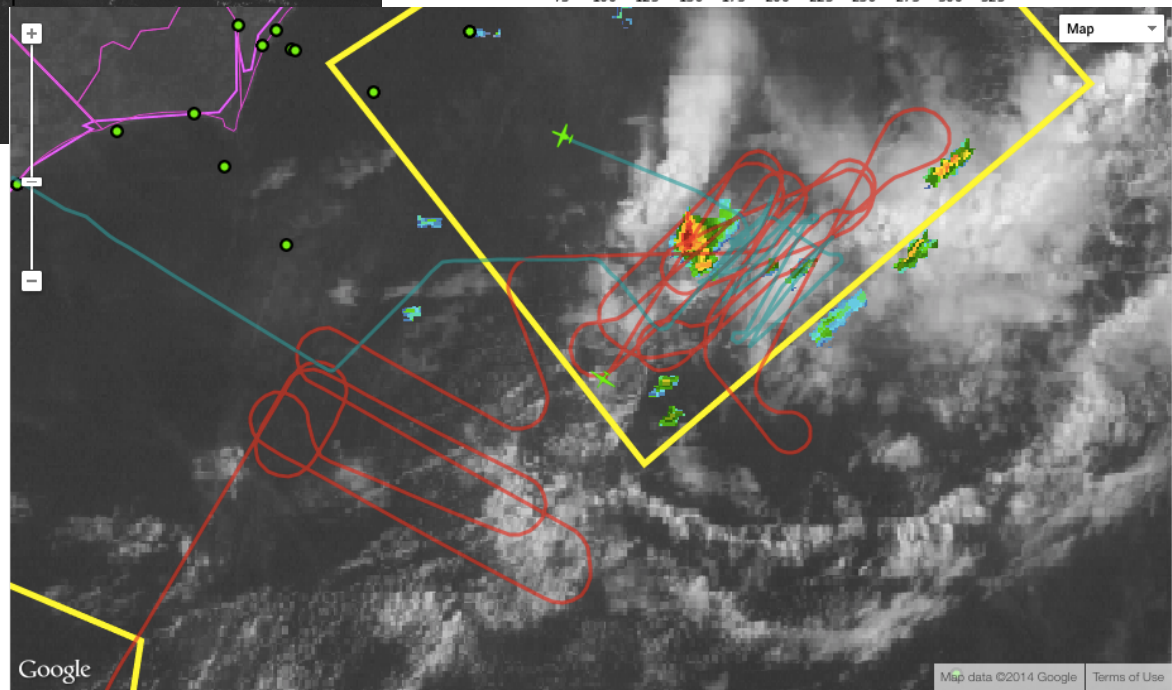
  - ER2 – 4 Doppler Radars (Heymsfied – W, Ka, Ku, X), AMPR (low frequency microwave), COSMIR (High frequency microwave)

  - Citation – Complete in situ payload

- Next Deployment – OLYMPEX in winter of 2015/6. Collaborative with GPM Val.





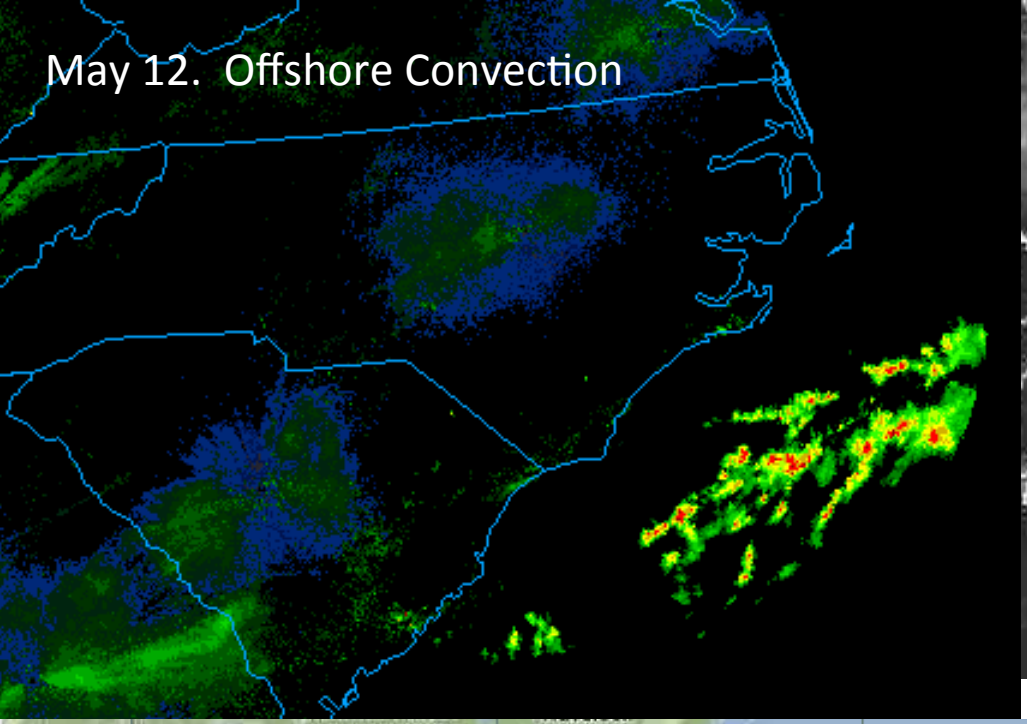


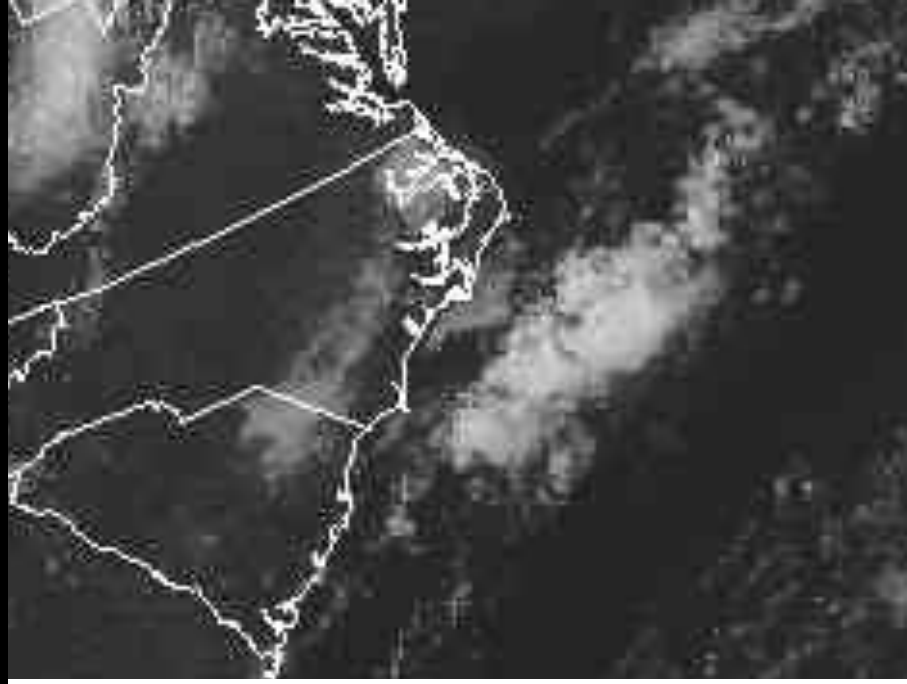
5/28: **Golden Day**.
Mixture of Shallow warm congestus with deeper convection. Both aircraft nicely coordinated.

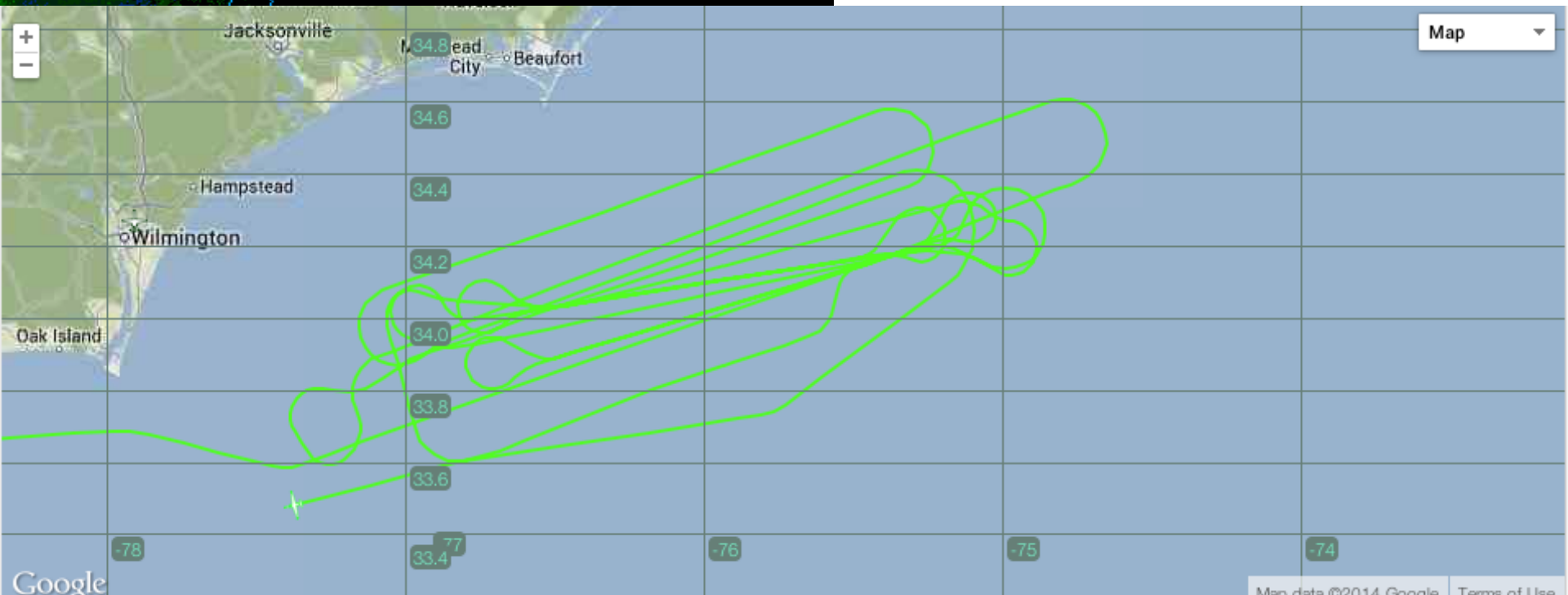
Cloud Studies Summary:

- Work ongoing to develop initial algorithms that could be applied to an ACE-like data set.
    - Focus is on trade studies using CRM output and high resolution ground-based (ARM) and airborne (TC4) data sets.
    - Initial deployment of ACE Radar Definition Experiment (RADEX) is nearing completion.
        - Collaboration with GPM Validation group has been very fruitful and we are looking forward to continued collaboration on data analysis and OLYMPEX deployment.

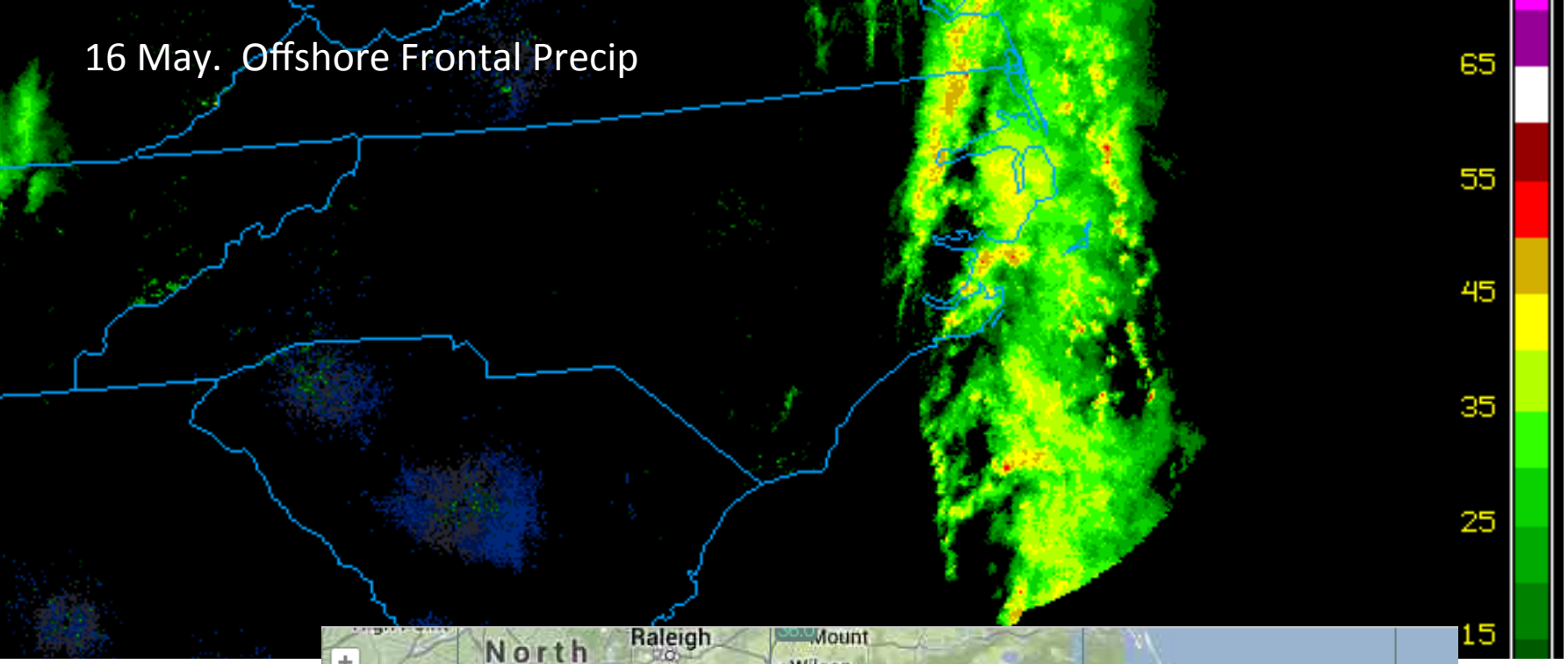
May 12. Offshore Convection

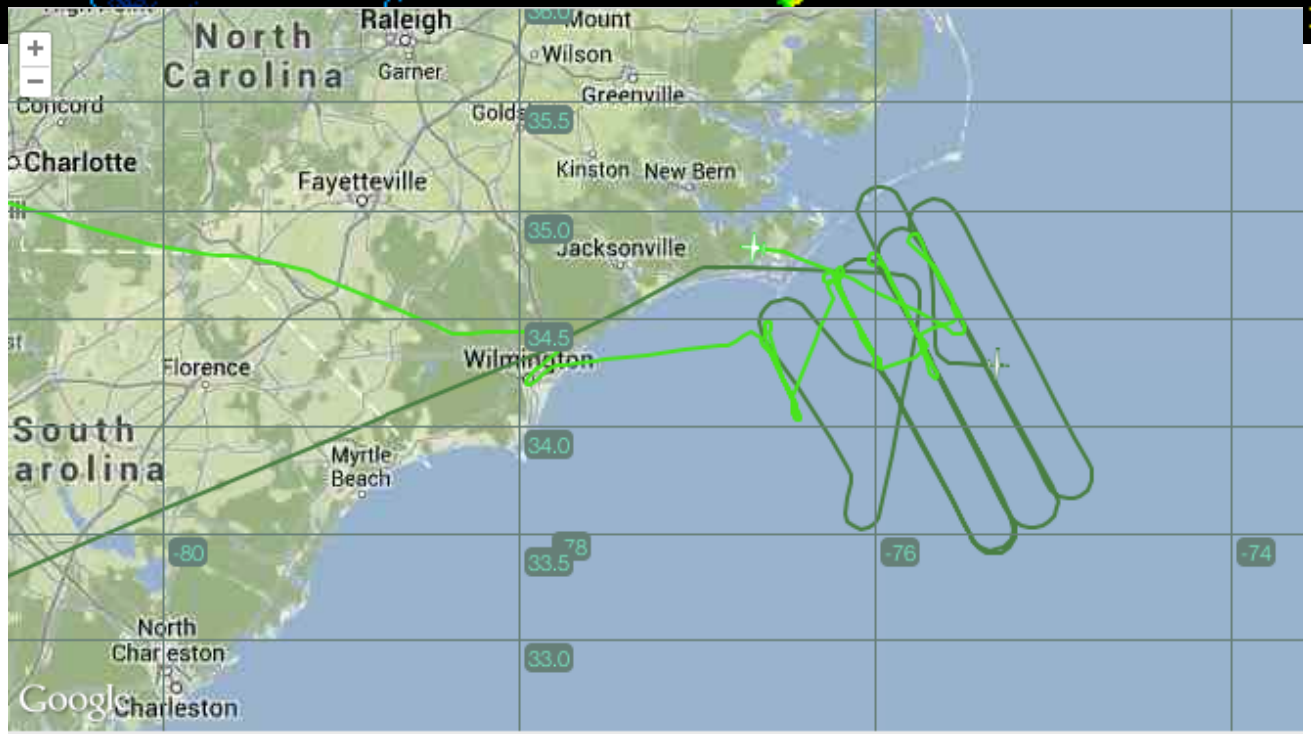




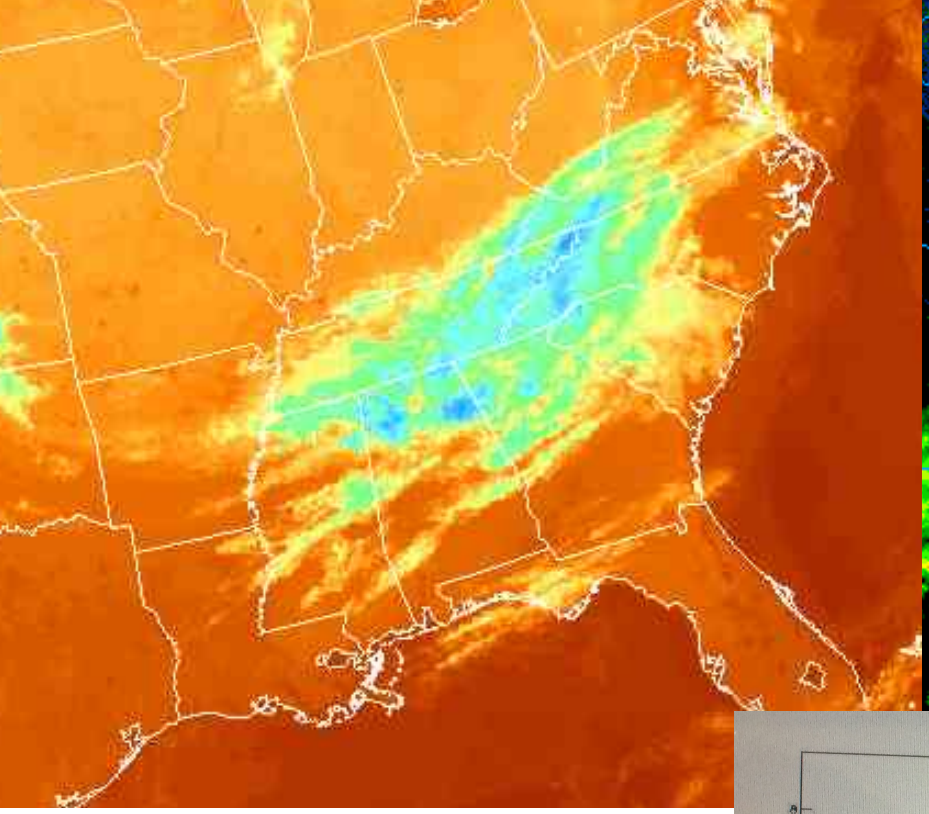


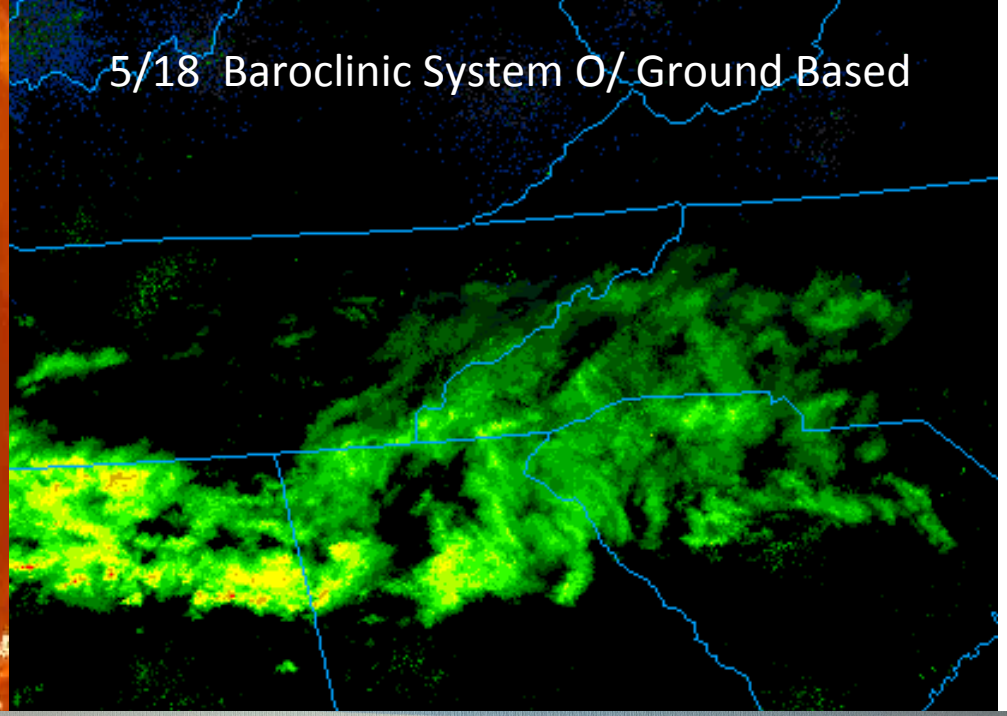
16 May. Offshore Frontal Precip

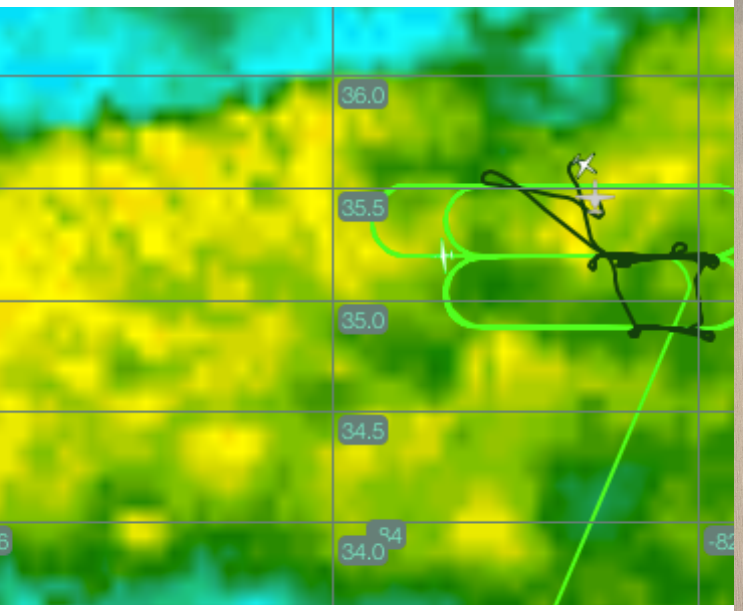


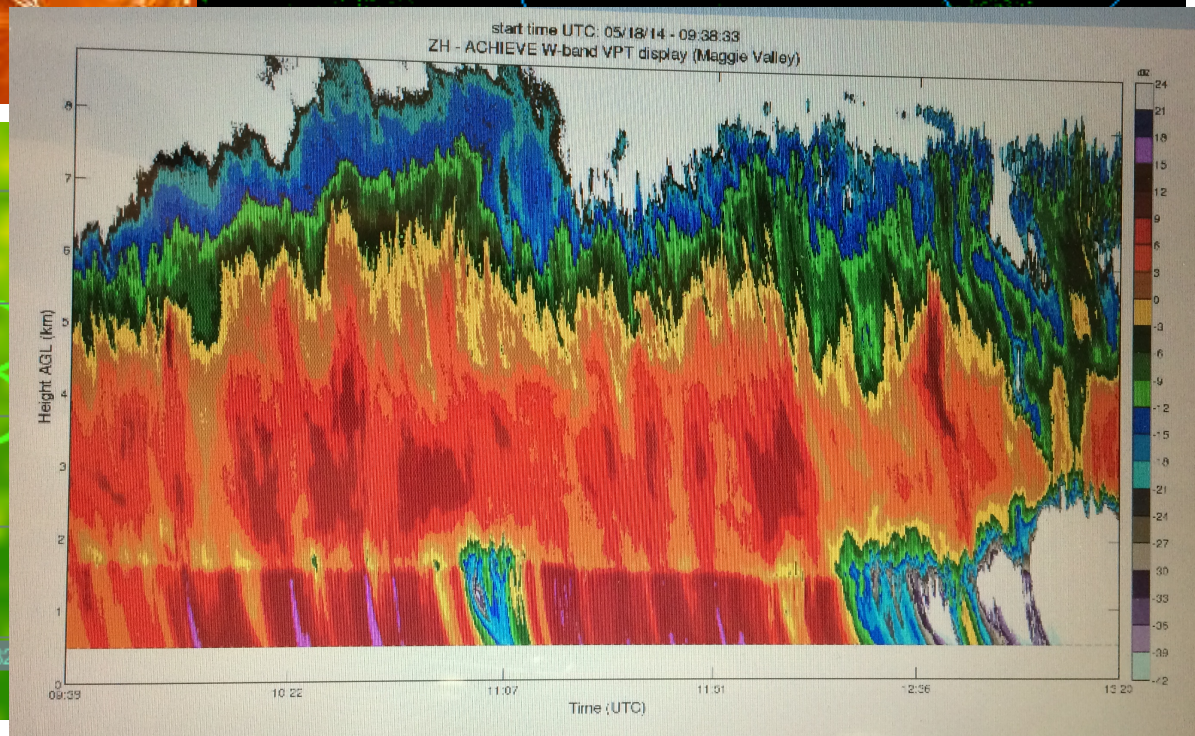


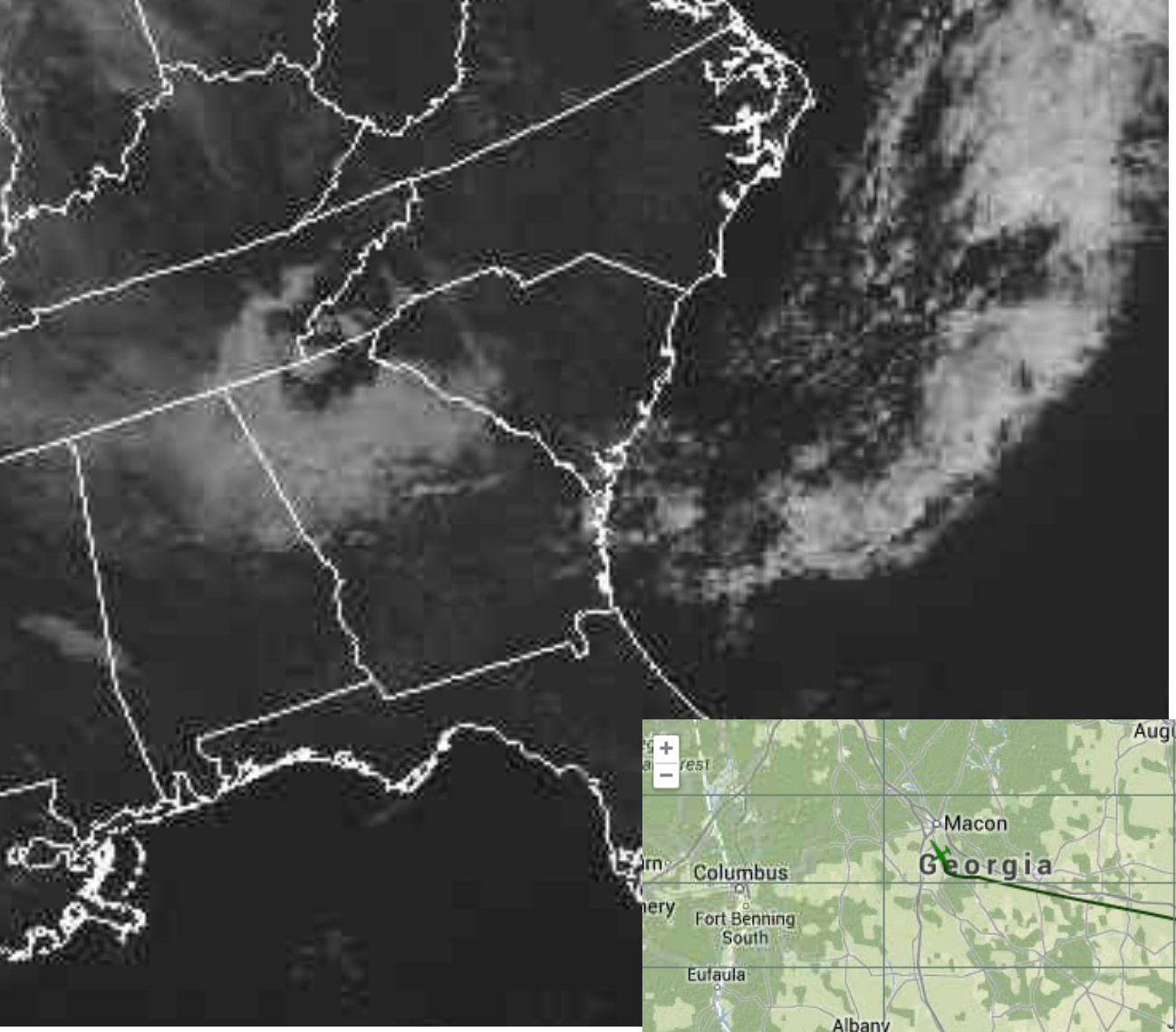
5/18 Baroclinic System O/ Ground Based



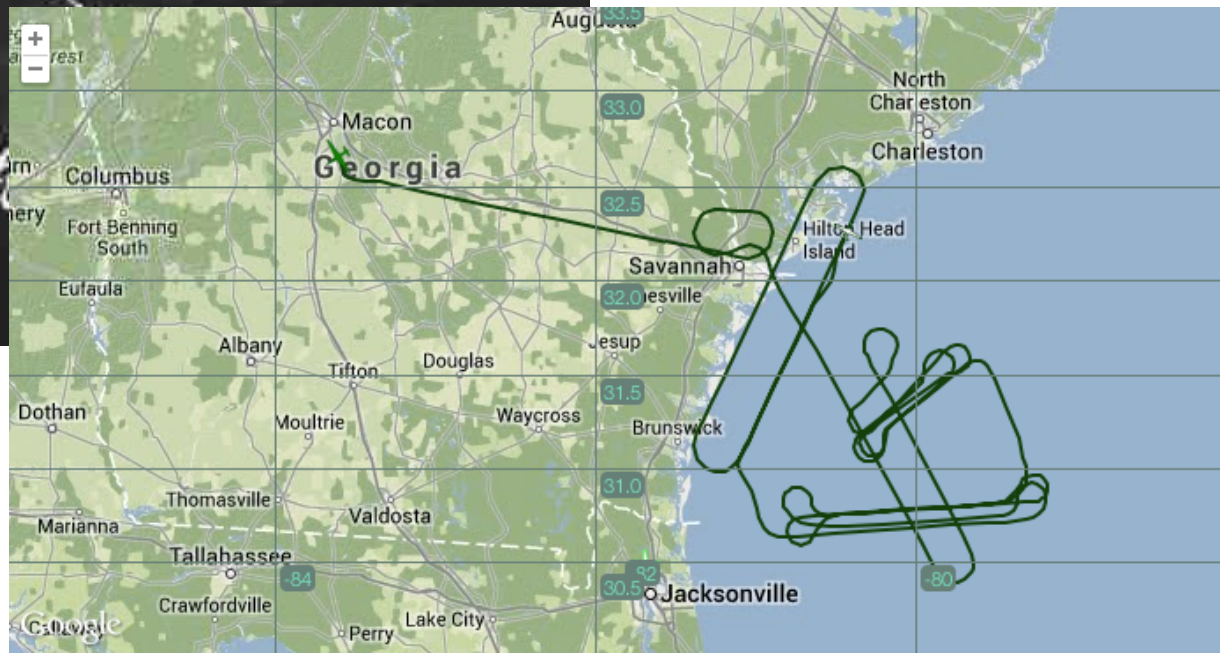


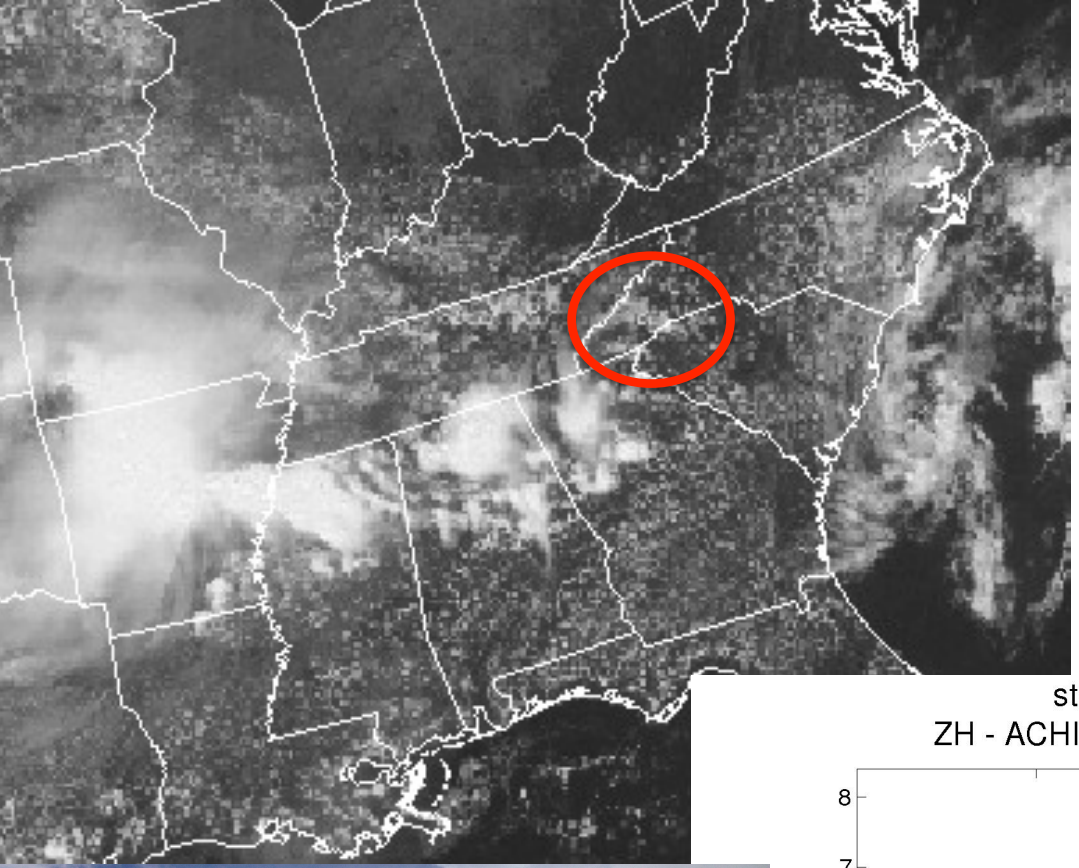




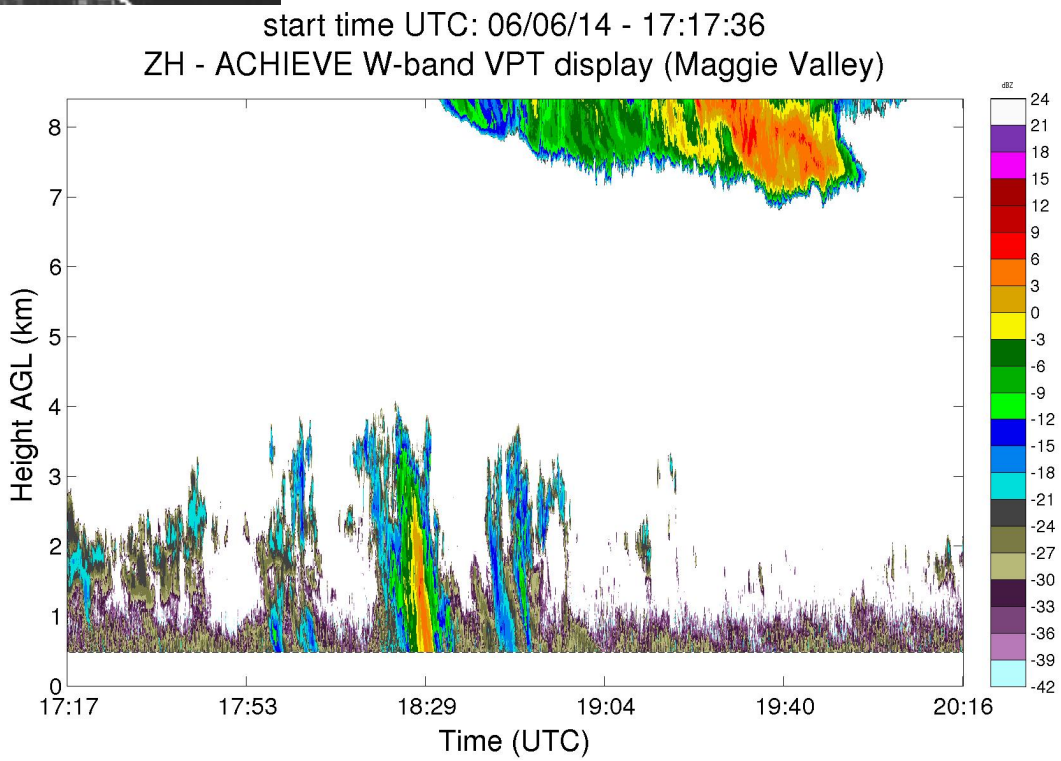


May 19. GPM overpass,
Warm Rain.
Coordinated sampling.
Very good case.





June 6. Congestus Sampling by Citation over ground-based Achieve site.



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