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Measure Radiative Flux Divergence in the Dark![†]

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[†]Warren's suggested title, not mine -- but I like it!

General Thoughts

- Measuring radiative heating rate (HR) profiles in cloudy atmospheres is not easy or trivial
  - Calibration of the uplooking/downlooking sensors
  - Aircraft pitch-and-roll introduces artifacts in measured fluxes
  - Temporal evolution / advection of the clouds when trying to measure the fluxes at different levels with a single aircraft
  - 3-d variability in the cloud field (i.e., what's really in the radiometer's field-of-view?)
  - How representative are the in-situ HR profiles, and can these obs really be compared well to calculations?
- It is possible to reduce these uncertainties to make the observations 'easier' to interpret…

Motivation (1)

- The broadband heating rate profiles (BBHRP) efforts in ARM are critical for the success of the program
- We routinely calculate HR profiles from remote sensing observations, but the only “validation” currently available are comparisons against surface and TOA flux observations
  - Getting the surface and TOA fluxes correct does not necessarily mean the HR profile is correct
- Need accurate observations of the HR profile, or at least of fluxes at different levels of the the atmosphere, for validation
- Computing the Arctic radiative HR profile is very complicated due to the frequency of mixed-phase clouds, multiple cloud layers, strong inversion(s), etc.

Motivation (2)

- Variability in clouds require *A LOT* of in-situ radiative flux measurements for validation (need statistics)
  - The uncertainty in the distribution of clouds (cloud fraction, etc) will likely have a larger impact on the accuracy of the computed HR profile than the microphysical retrieval algorithm employed to get the cloud propertes
- Requires frequent and routine observations
  - The new AVP provides us such an opportunity
- Ideally, these observations should be made in an environment where the clouds are as plane-parallel as possible
  - The Arctic is such a place; clouds there are primarily stratiform in nature
- Radiance observations are complementary to flux observations, and can be used together to investigate 3-d homogeneity

Motivation (3)

- Radiative flux divergence has two components: shortwave and longwave
- Shortwave fluxes, measured by pyranometers, are very sensitive to aircraft pitch and roll and uplooking instrument needs to be stabilized
- Longwave fluxes, measured by pyrgeometers, are relatively insensitive to pitch and roll (less than ~5º)
- Radiative surface energy budget of the Arctic is dominated by the longwave for most of the year (other than mid-summer)
- Arctic clouds are usually semi-transparent in the infrared, which allows measured longwave fluxes to be sensitive to water path, particle size, and cloud temperature

ARM's Aerial Vehicle Program (AVP)

- ARM recently refocused its Unmanned Aerial Vehicle program (UAV) to create the AVP
- AVP will be a 3-pronged program to:
  - Provide routine observations of clouds, aerosols, and radiative properties
  - Participate in IOPs
  - Foster an instrument incubator program, especially miniature in-situ and remote sensing instruments
- AVP will use both piloted and unpiloted aircraft
- AVP will be open to all investigators through the peer-reviewed process (like any of the ARM CRFs)

The Experiment

- Measure upwelling and downwelling longwave fluxes and radiances from routine aircraft observations over the NSA site
  - Excellent use of AVP flights
  - Less difficult / expensive because stabilized platform is not needed for aircraft
  - The simultaneous radiance obs (e.g. from IRTs) provide another way to validate the cloud properties used in the BBHRP calculations and are less influenced by 3-d variations in cloud field
  - Arctic clouds are quite often semi-transparent in the IR, and thus getting the longwave HR profile correct will be a strong constraint on the shortwave HR profile