Skin Surface Temperatures

First Look at analysis of COSMICS data

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Motivation

- Past work from arctic campaigns has focused on MW surface emission
- This analysis focuses on skin temperature retrievals to facilitate FIR retrievals of emissivity using TAFTS.
- Some MW retrievals are presented but this MW analysis is far from complete.

Three ways to estimate surface temperature

- (1) Onboard Heimann estimate of surface temperature
  - IR brightness temperature (8-14 µm)
  - High temporal resolution (1 or 64 Hz)
  - Must be calibrated to get surface temperature
- (2) ARIES IR Interferometer
  - T_B 500 to 3500 cm^{-1} at 1 cm^{-1}
  - Nadir and zenith and calibration measurements every X minutes
  - Simultaneous retrievals of surface temperature and emissivity
- MARSS: T_{eff} estimated from 183 GHz channels
  - Each MARSS footprint (nadir every 4 sec)
  - Only uses MARSS data to derive T_{eff}

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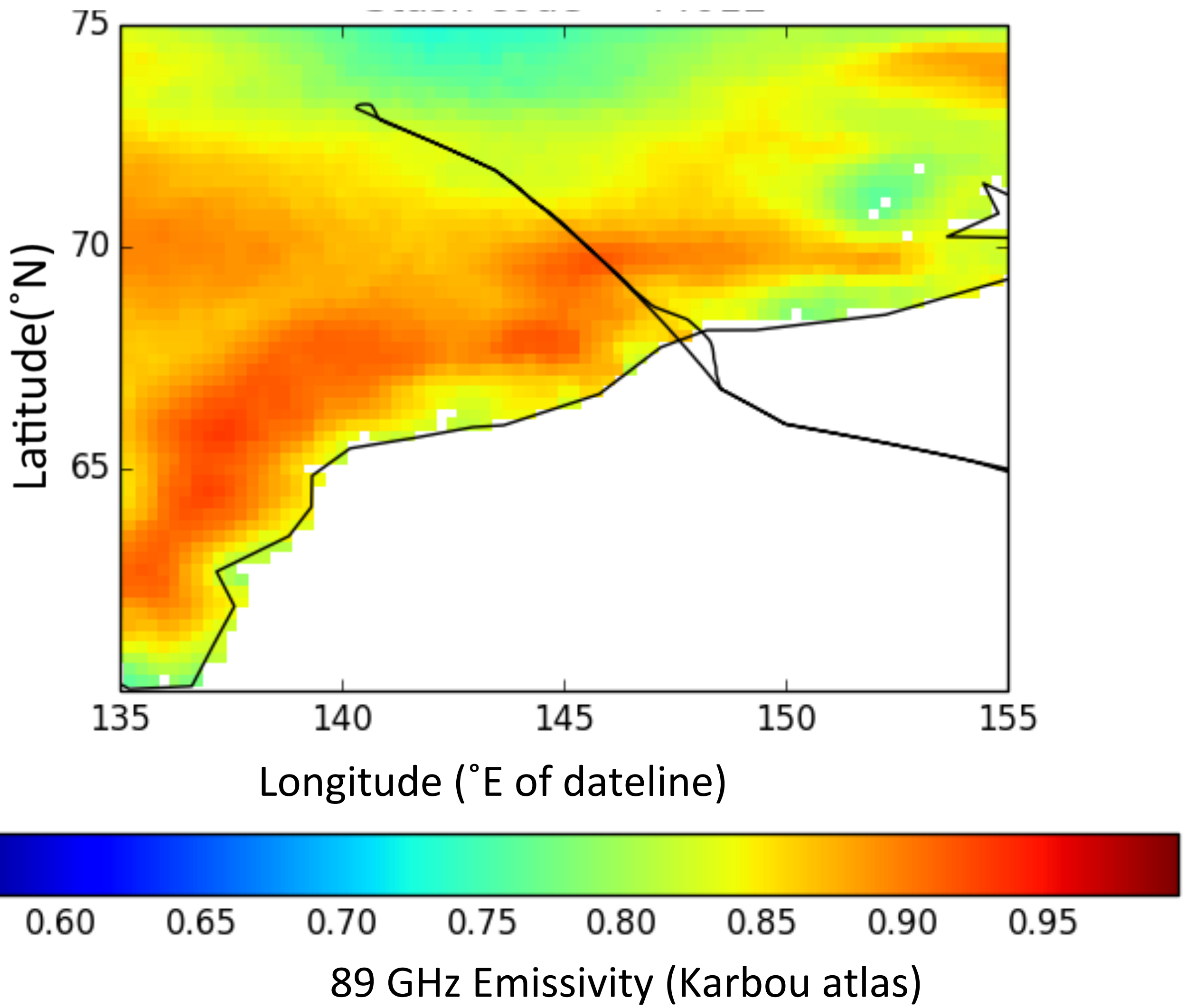
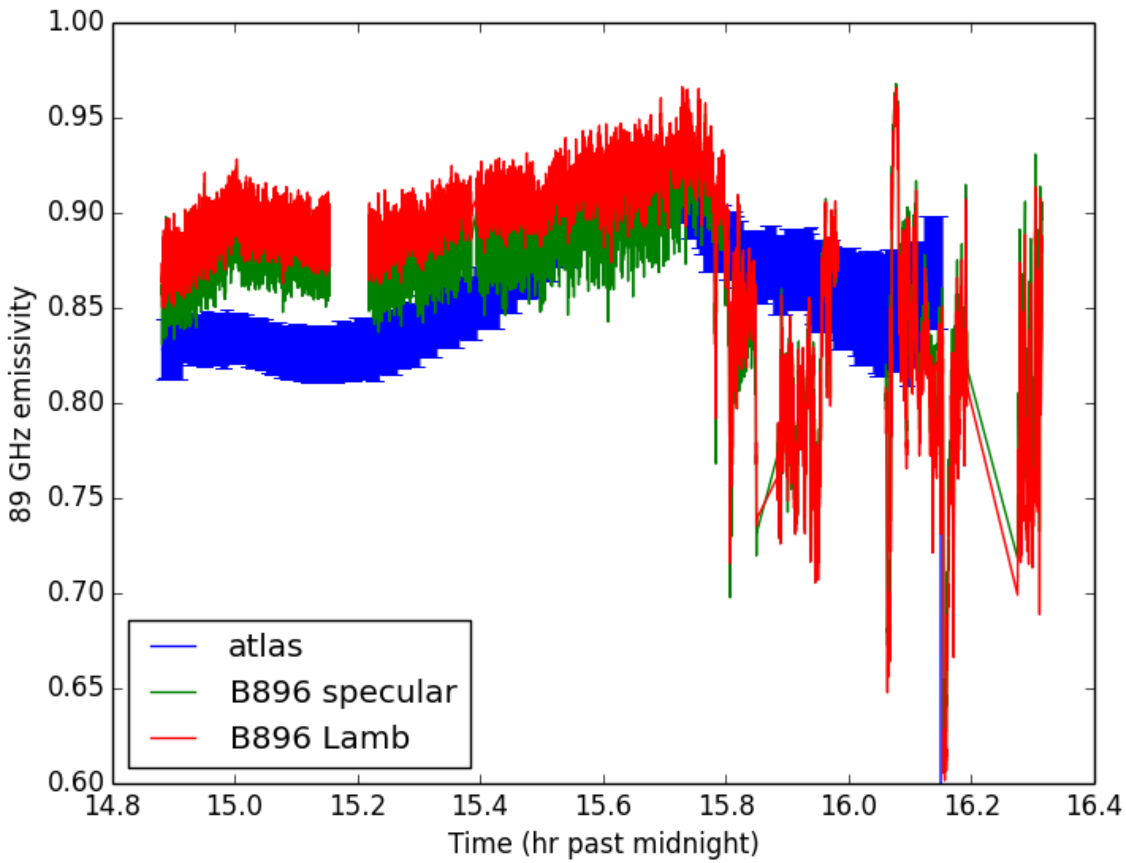
B896: First sortie over Greenland

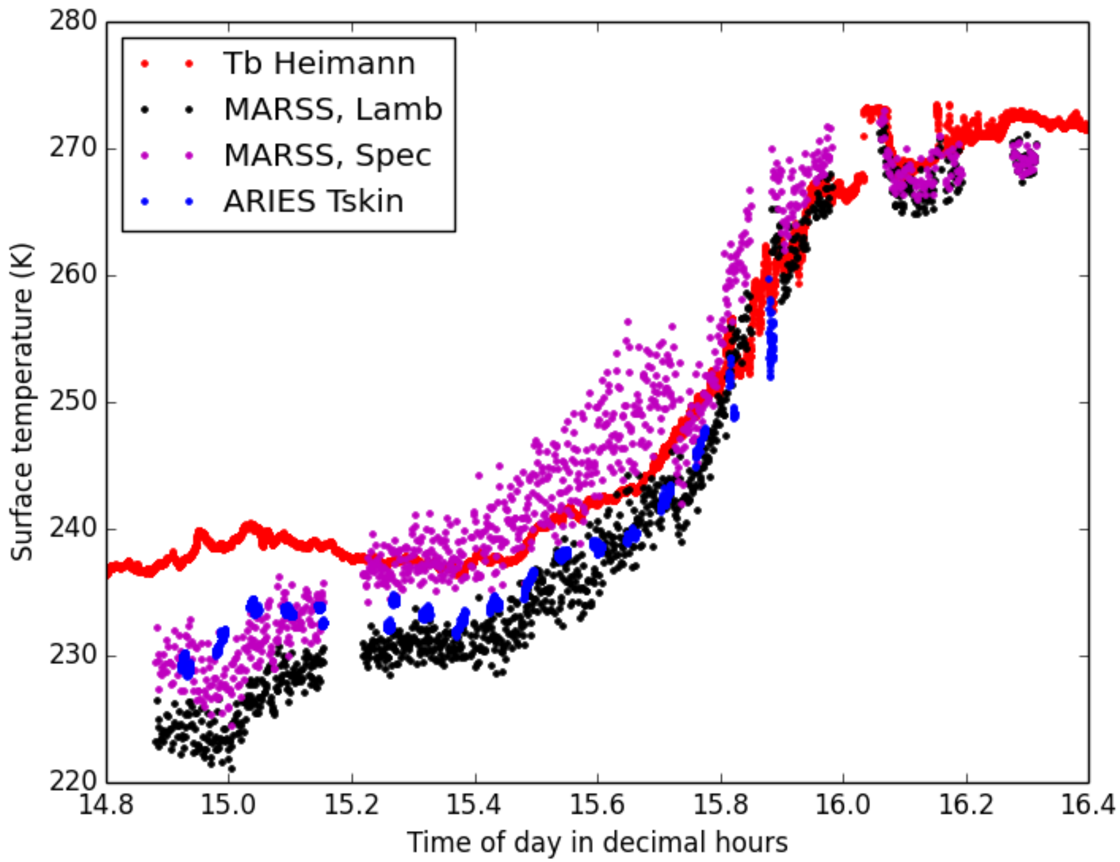


B896:Comparison of 89 GHz emissivity

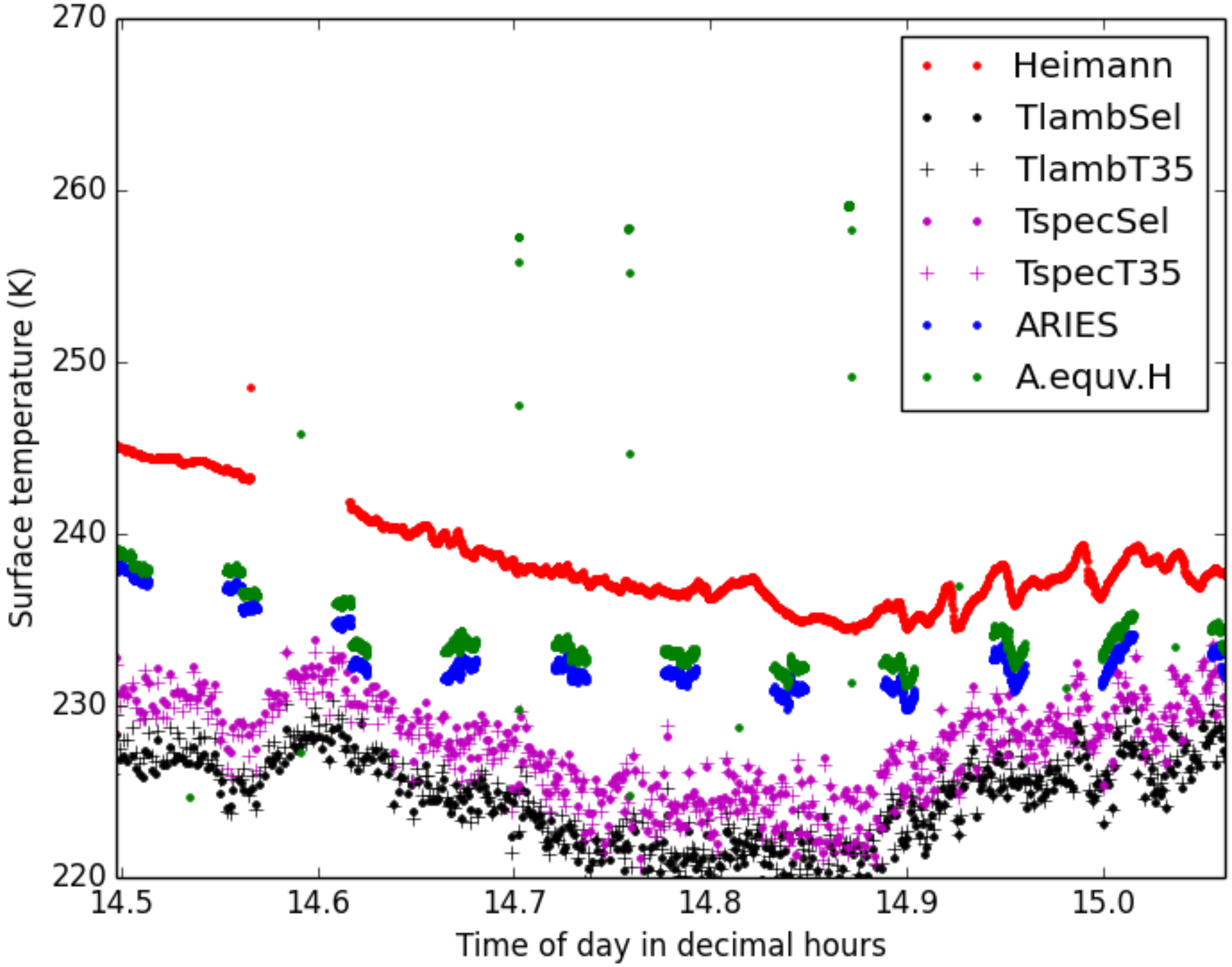


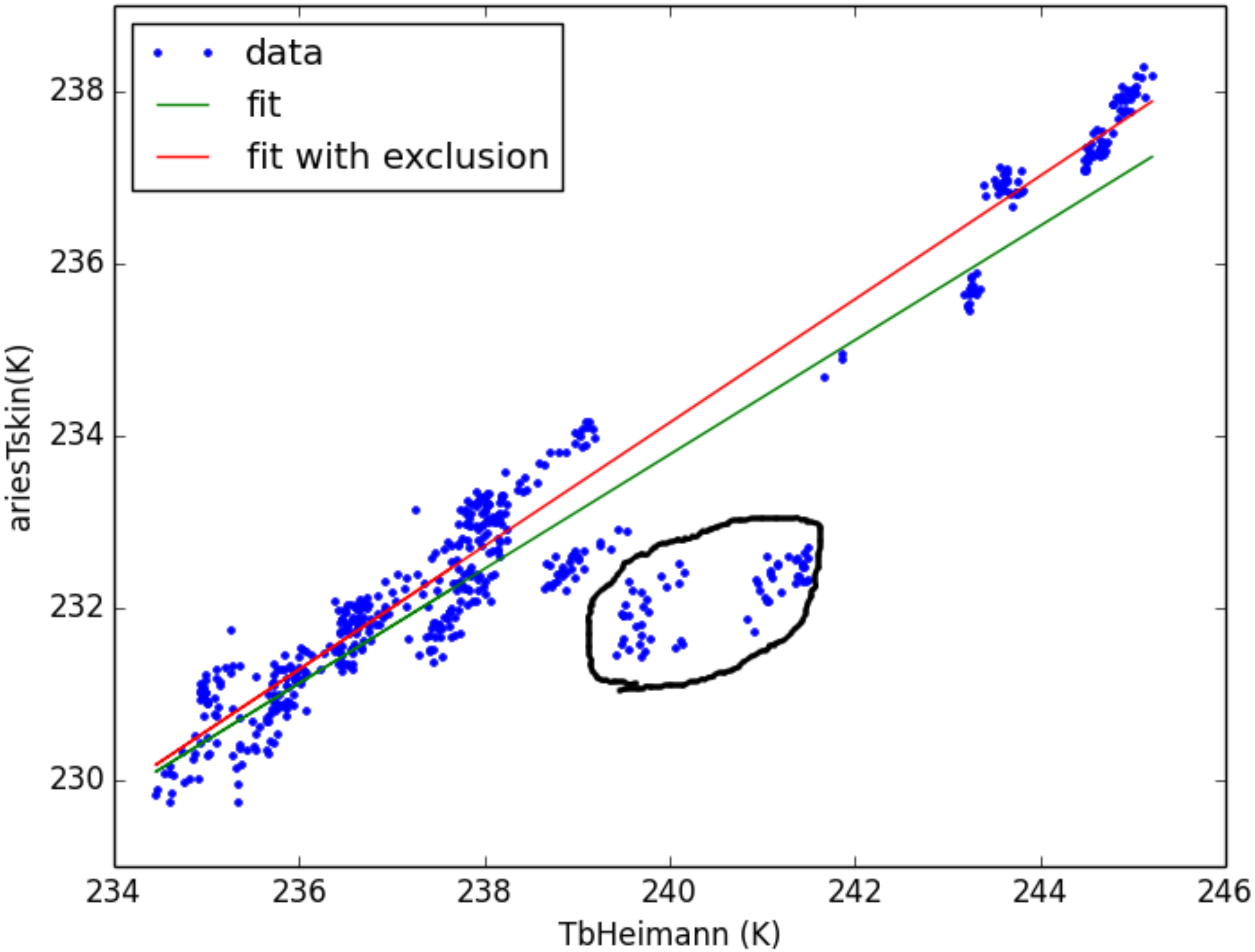
Karbou atlas in Blue

B896: comparison of surface temps



B898 Surface Temperatures

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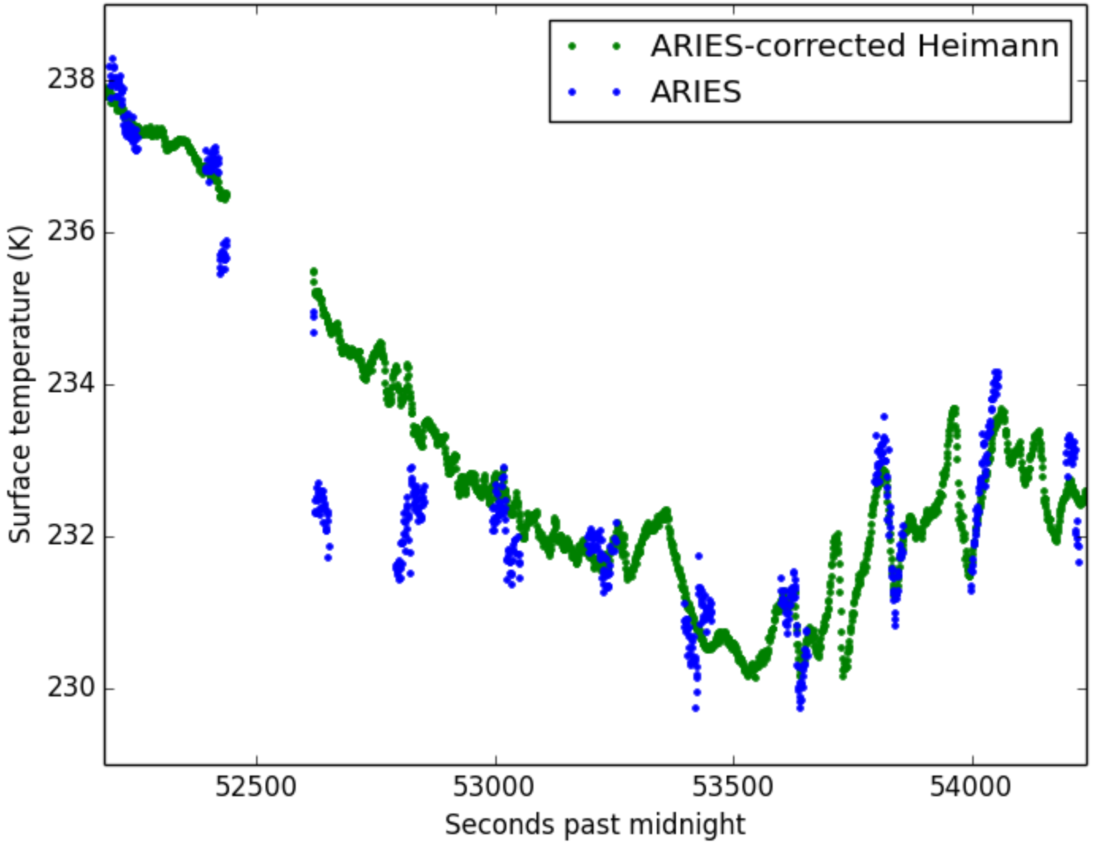

This surface temp used in retrievals of TAFTS emissvities to be presented at a later time.

Questions or comments

Determining emissivity and effective temperature

- Need
  - Measurements of T_{Bn} and T_{Bz} on 183 GHz sounding channels (183±1, 183±3 and 183±7 GHz).
  - Measurements of temperature and water vapor profile between the platform and surface.
- Assume linear emissivity gradient between 175 and 191 GHz
  - e(183±7) ≡ e(183±1) ≡ e(183±3) ≡ e(183 GHz)
- Use simple clear skies radiative transfer to extrapolate measurements at height to the surface (small effect in dry air)

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Selbach: 183 GHz effective temperature and emissivity

- Uses all three 183 GHz channels.
- Simple clear skies radiative transfer model

  $T_{Bn}=e_s T_{eff} exp(-\tau) - (1-e_s)T_d exp(-\tau) + T_a$

  $T_d=T_{Bz} exp(-\tau)+T_a$

  $T_a=(1-exp(-\tau))T_m$

  - e_s and T_{eff} -- surface emissivity and effective temperature.
  - T_{Bzi} and T_{Bni} – measured zenith and nadir viewing brightness temperatures in channel i.
  - T_m -- mean atmospheric temperature under the aircraft.
  - τ_i is the opacity in channel i. Determined with ARTS using dropsonde profiles.
- Differences between modelled and observed T_{Bn}'s on the three 183 GHz channels are analytically minimized in cost function.
  - Closed form solution: T_{eff} and e_s at 183 GHz

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Assumptions about reflection

- Up to this point all results presented use specular reflection assumption
- Recent literature (Mätzler, 2005; Mätzler and Rosenkranz, 2007) over snow covered surfaces
  - specularity not a good assumption for near-nadir viewing satellite instruments such as AMSU-A and AMSU-B.
  - Reflection more diffuse in character.
- MARSS scans between 0° and 50° incidence in the upward and downward directions.
  - Near-nadir views overlap with views of other radiometers ARIES and Heimann and the radar altimeter.
  - Diffuse surface scattering characteristic important for retrieving near-nadir emissivities.
- Now demonstrate effect of diffuse surface scattering.

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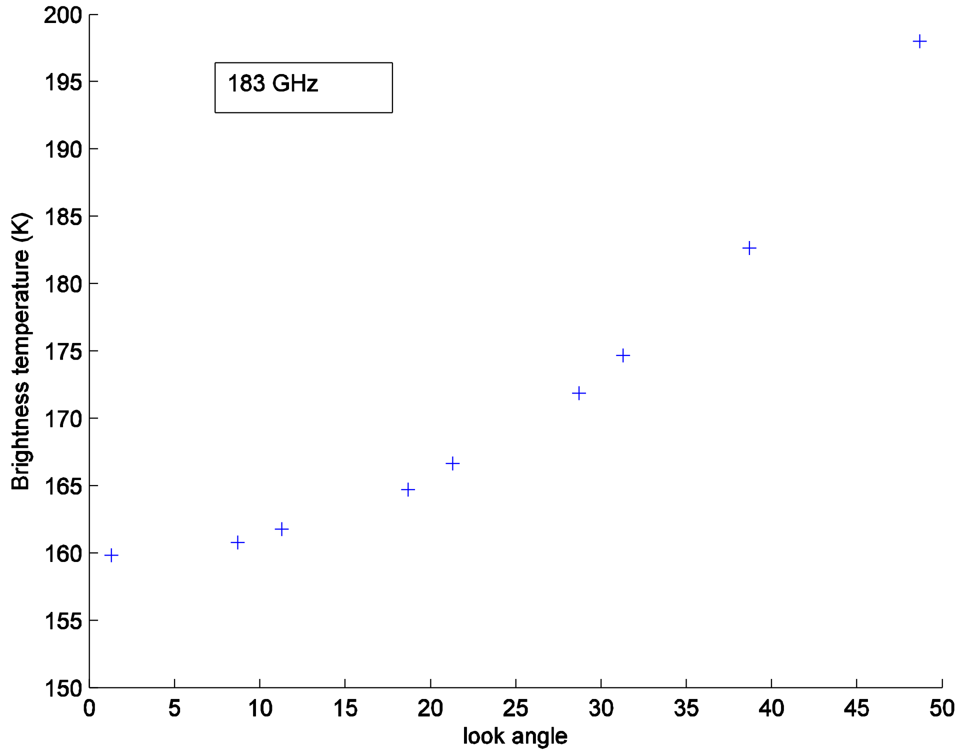
MARSS Tip Curve

- Optically thin channels have T_{bd} that increases with incidence angle.
- T_{MR} is the mean atmospheric temperature weighted by the absorption in each layer.
- T_{CMB} is the cosmic background radiation.
- At high optical depth, τ, $T_{bd}(\theta) = T_{MR}$



$$T_{bd}(\theta) = T_{MR}(1 - \exp(-\tau / \cos\theta)) + T_{CMB}\exp(-\tau / \cos\theta)$$

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Calculating surface scattering contribution with MARSS measurements.

$$T_d(\mu_0,\phi_0) = \frac{1}{4\pi\mu_0}\int_{2\pi} S(\mu_0,\phi_0,\mu,\phi)T_{bd}(\mu,\phi)d\Omega$$

- MARSS makes six angular measurements of T_{bd} at 1° to 49° wrt vertical in upward directions.
- Must estimate T_d (μ_0,ϕ_0) with the limited views provided by MARSS.
- There will be a contribution to T_d (μ_0,ϕ_0) from outside the scan.
  - Estimated by calculating above over theoretical 'Tip Curve' to estimate the proportion of integral outside of MARSS views.
  - $T_d(\mu_0,\phi_0)$ is then calculated for the MARSS measurements and corrected for partial coverage of sky.
  - These theoretical 'Tip Curves' are only valid for homogeneous, clear skies cases.

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Technote 35: 183 GHz effective temperature and emissivity

- Uses classical definition of emissivity ((2) below) (1)

$$T_{eff} = \frac{T_u(183 \pm 1GHz) - T_d(183 \pm 1GHz)}{e_s(183GHz)} + T_d(183 \pm 1GHz) \qquad (6)\ (1) \qquad (2)$$

$$e_s(183GHz) = \frac{T_u(183 \pm 7GHz) - T_d(183 \pm 7GHz)}{T_{eff} - T_d(183 \pm 7GHz)} \qquad (7)\ (2)$$

- (1) and (2) combine to form (3)

$$e_s(183) = \frac{T_u(183 \pm 7) - T_u(183 \pm 1) - T_d(183 \pm 7) + T_d(183 \pm 1)}{T_d(183 \pm 1) - T_d(183 \pm 7)}$$

- Solution of (3) used in (1) to find T_{eff}
- Only uses 183±1 and 183±7 GHz channels

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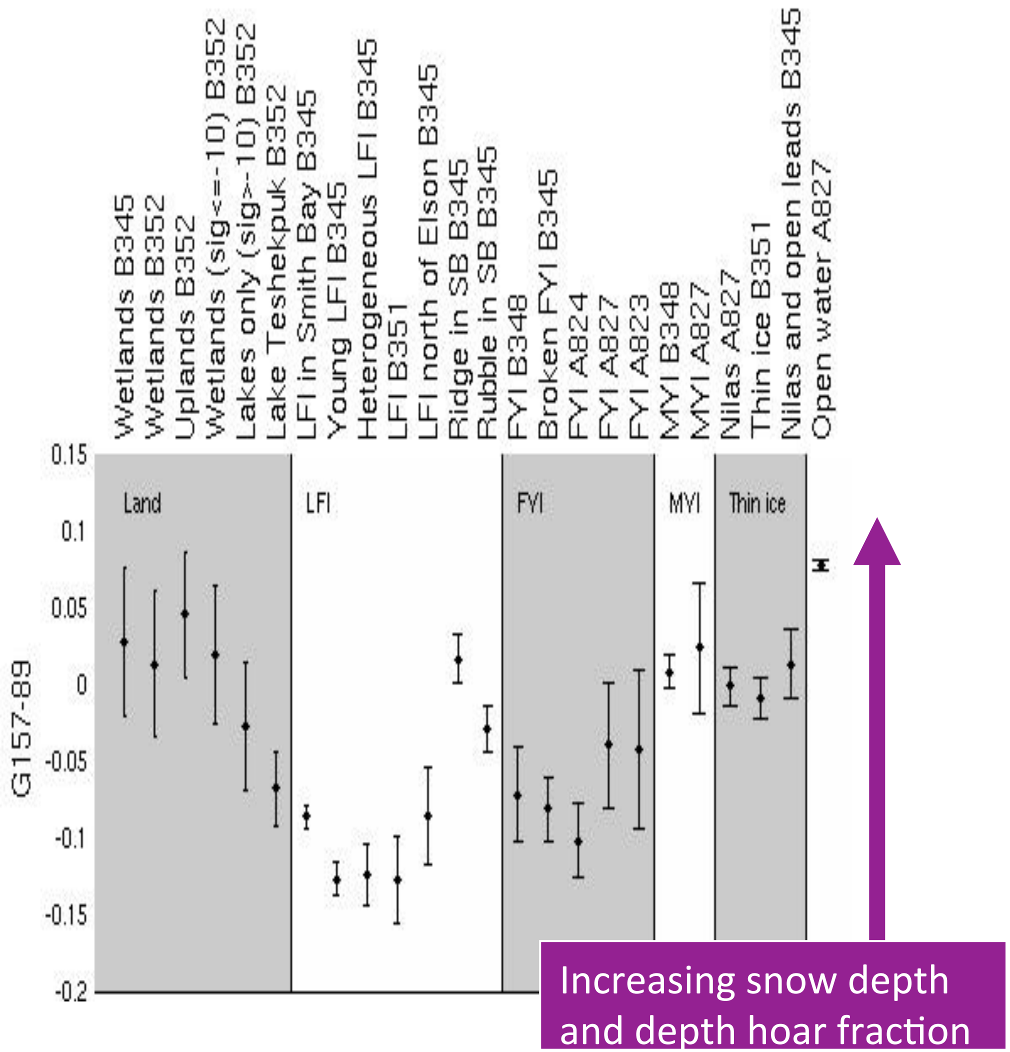
Sea ice mm-wave emissivities can be related to sea ice type

- Broad surface classes in alternating grey and white
- mm-wave Lambertian emis can be related to surface type (Harlow, 2010)
  - 157–89 GHz emis difference sensitive to snow depth and statigraphy.
  - 89 GHz radiation penetrates 10 – 20 cm in pack.
  - Penetration at 157 GHz shallower.
  - Insensitive to ice surface roughness and salinity
- Explore with MEMLS later



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