IOMASA WP 1.2: Development of algorithms for retrieval of atmospheric parameters

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1. Total water vapor from AMSU-B
2. Surface emissivity at temperature sounding frequencies
3. Cloud liquid water

TWV retrieval from AMSU-B

Basics: RTE

- Starting point: Brightness temperature measured by satellite for not too opaque atmosphere

$$T_b(\theta) = m_p T_s - (T_0 - T_C)(1 - \epsilon_s)\mathrm{e}^{-2\tau_0 \sec\theta}$$

θ – incident angle (off-nadir),
m_p $(= 1 + \ldots)$ – contains effect of deviation from isothermal atmosphere and difference between surface and air temperature,
T_0 – atmosphere temperature at ground level,
T_C – cosmic background,
τ_0 – nadir opacity of atmosphere

- Assume linear relation between opacity and total water vapor (TWV, a.k.a. column water vapor, total precipitable water), W:

$$\tau_0 = \kappa_v W$$

where κ – mass absorption coefficient of water vapor.

Algorithm

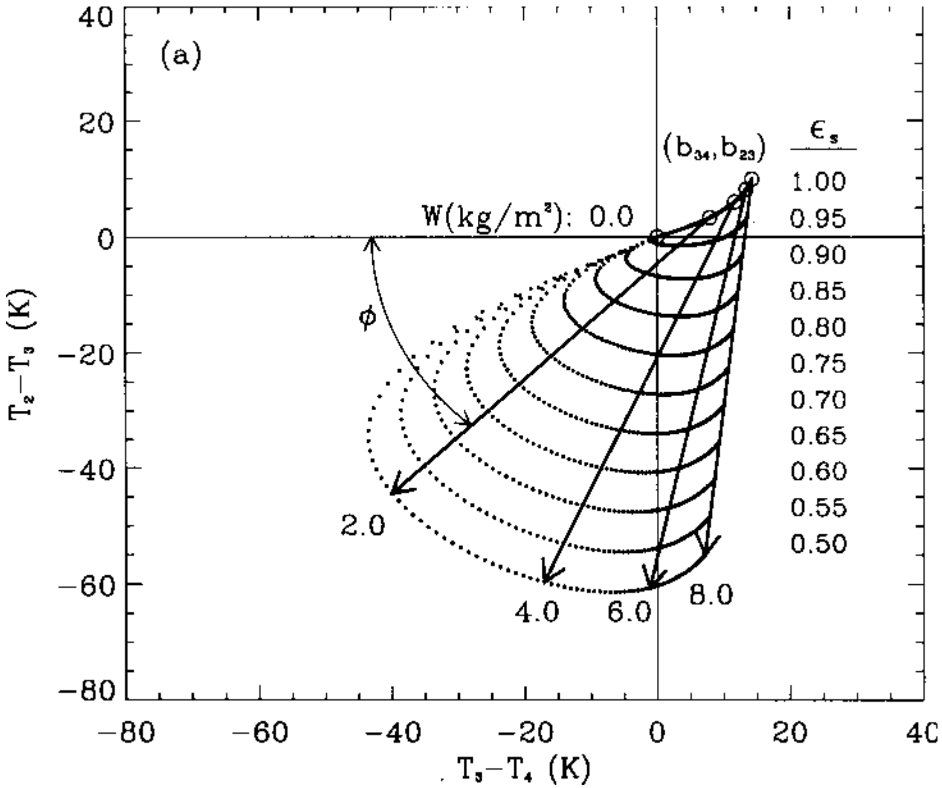
- Measure T_b at 3 different frequencies i, j, k at which ground emissivity ϵ_s is similar but water vapor absorption different; $\kappa_i < \kappa_j < \kappa_k$
- Then the following relation can be derived

$$\ln \eta_c = \ln \left(\frac{T_{b,i} - T_{b,j} - b_{ij}}{T_{b,j} - T_{b,k} - b_{jk}} \right) = c_0 + c_1 W \sec \theta$$

where the “bias” (b_{jk}, b_{ij})

$$b_{ij} \approx \int_0^H \left[\mathrm{e}^{\tau_i(z,H) \sec \theta} - \mathrm{e}^{\tau_j(z,H) \sec \theta} \right] \frac{\mathrm{d}T(z)}{\mathrm{d}z} \, \mathrm{d}z$$

contains the influence of the atmospheric temperature and water vapor profiles

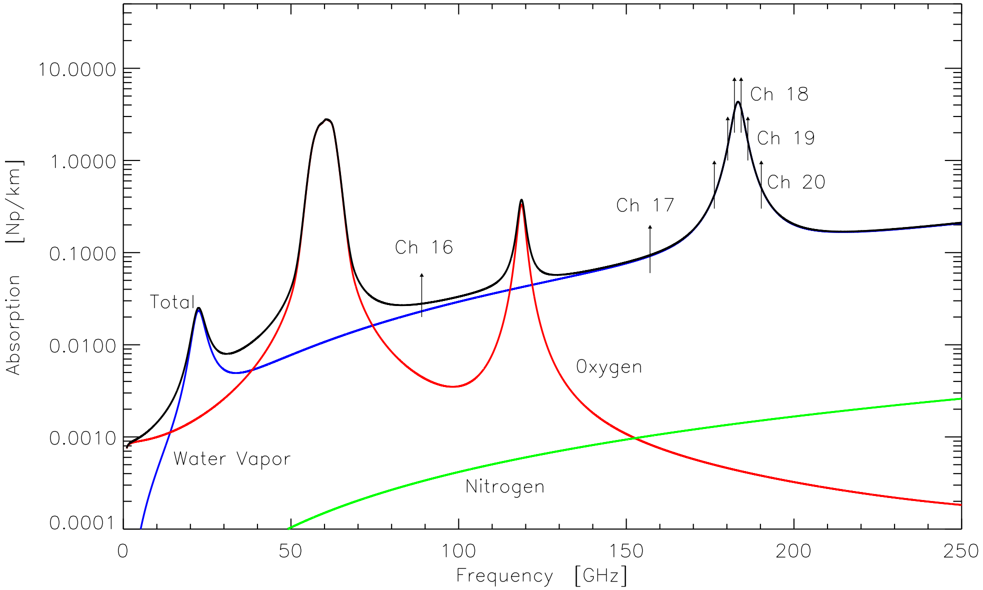


$$\tan\varphi = \eta_c = \frac{T_{b,i} - T_{b,j} - b_{ij}}{T_{b,j} - T_{b,k} - b_{jk}}$$

$$\ln(\tan\varphi) = c_0 + c_1 W \sec\theta$$

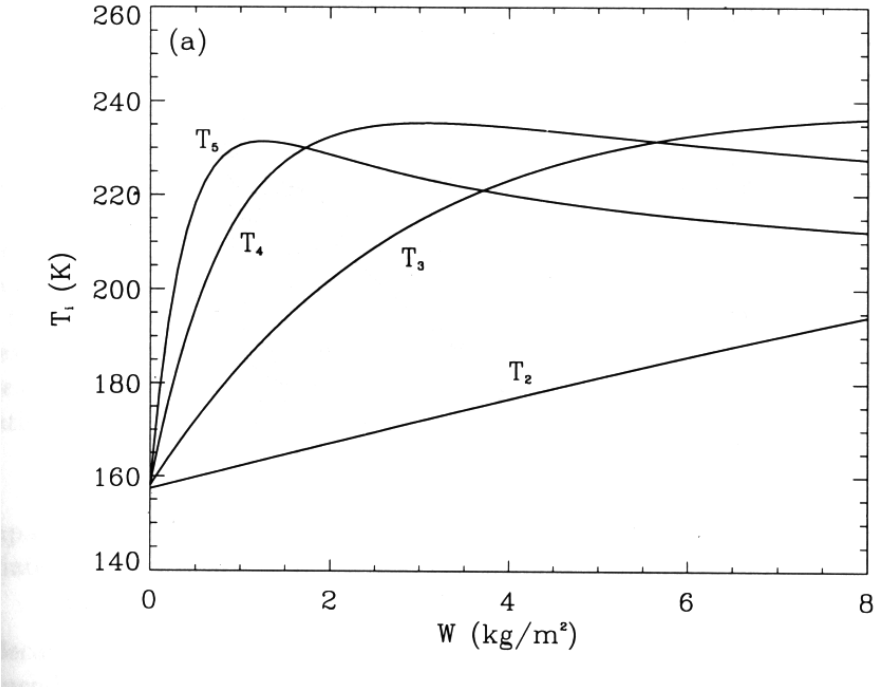
Note: (b_{jk}, b_{ij}) slightly dependent on T and W profile
$\Rightarrow$ find some kind of average $(\overline{b_{jk}}, \overline{b_{ij}})$ (focal point, see below)

AMSU-B



AMSU-B channels (sorted such that such that $\kappa_2 < \kappa_3 < \kappa_4 < \kappa_5$)

our no.	1	2	3	4	5
Freq. [GHz]	89.0	150.0	182.31±7	182.31±3	182.31±1
AMSU channel	16	17	20	19	18



- low TWV (<1.5 kg/m^2) $\rightarrow T_5 > T_4 > T_3 \rightarrow$ use channels 3, 4, 5 (182 GHz channels)
- higher $TWV \rightarrow T_5 \leq T_4 \rightarrow$ use channels 2, 3, 4; problem: $\epsilon_{s,2}$ different from the others $\Rightarrow$ less accuracy
- too high TWV (> 6 kg/m^2) $\rightarrow T_4 \leq T_3 \rightarrow$ no retrieval (yet)

Algorithm Development for AMSU-B

Algorithm development algorithm

1. - Use radiosonde (RS) profiles, integrate TWV from them
   - Simulate AMSU-B brightness temperatures T_1, T_2, T_3, T_4, T_5 for a range of ground emissivities ϵ_s for each RS profile
2. Linear fit of ΔT_{ij} vs. ΔT_{jk} for each RS profile (many different emissivities)
3. Find focal point $(\overline{b_{jk}}, \overline{b_{ij}})$ as point of least square distance from all fitted lines
4. Linear fit of $TWV \sec\theta$ vs. $\ln \eta_c = \ln\left(\frac{\Delta T_{ij}-\overline{b_{ij}}}{\Delta T_{jk}-\overline{b_{jk}}}\right)$ yields:

$$\boxed{TWV \sec\theta = C_0 + C_1 \ln \eta_c}$$

Note:

- Use only RS profiles with $TWV < 1.5$ (kg/m^2) for algorithm with $(i, j, k) = (3, 4, 5)$
- Use only RS profiles with $1.5 < TWV < 6$ for algorithm with $(i, j, k) = (2, 3, 4)$

Current Status

- Reading and integration routines for RS profiles (global TEMP, and Polarstern)
- Almost finished reimplementing algorithm development algorithm, using ARTS (instead of MWMOD)
  - Modular, customizable
  - Developed and maintained “next door” (IUP)
  - Rosenkranz absorption model (continuum and lines) for H_2O, O_2, N_2 (all other standard models can be used as well)

Ongoing Work, Ideas

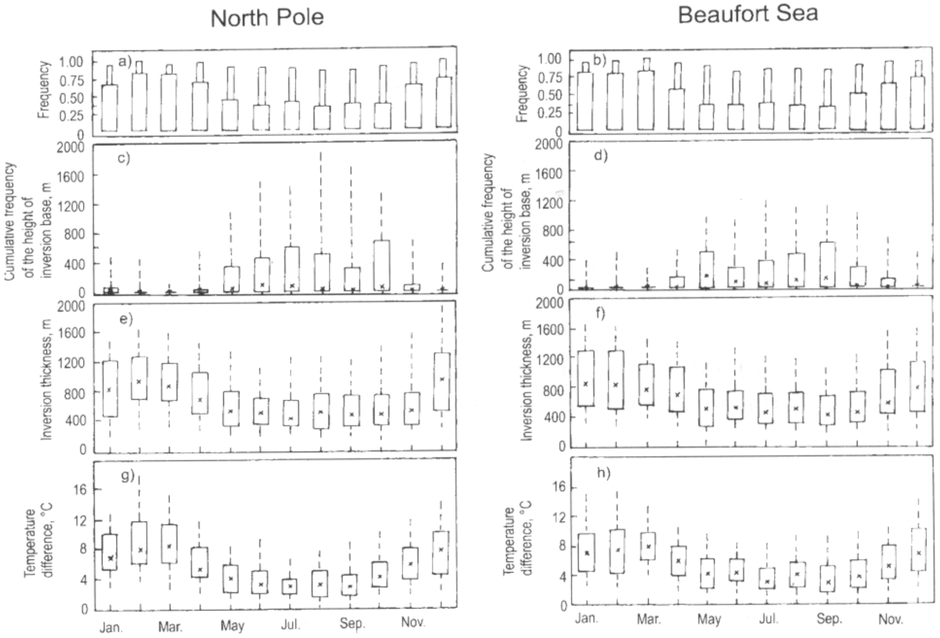
- bias depends on $\frac{\mathrm{d}T(z)}{\mathrm{d}z}$ and $W(z)$

$\Rightarrow$ separate algorithms for seasons: summer and winter (and spring/autumn?)

$\Rightarrow$ separate algorithms for regions:

- Canadian Arctic
- European Arctic
- Siberia/Central Arctic

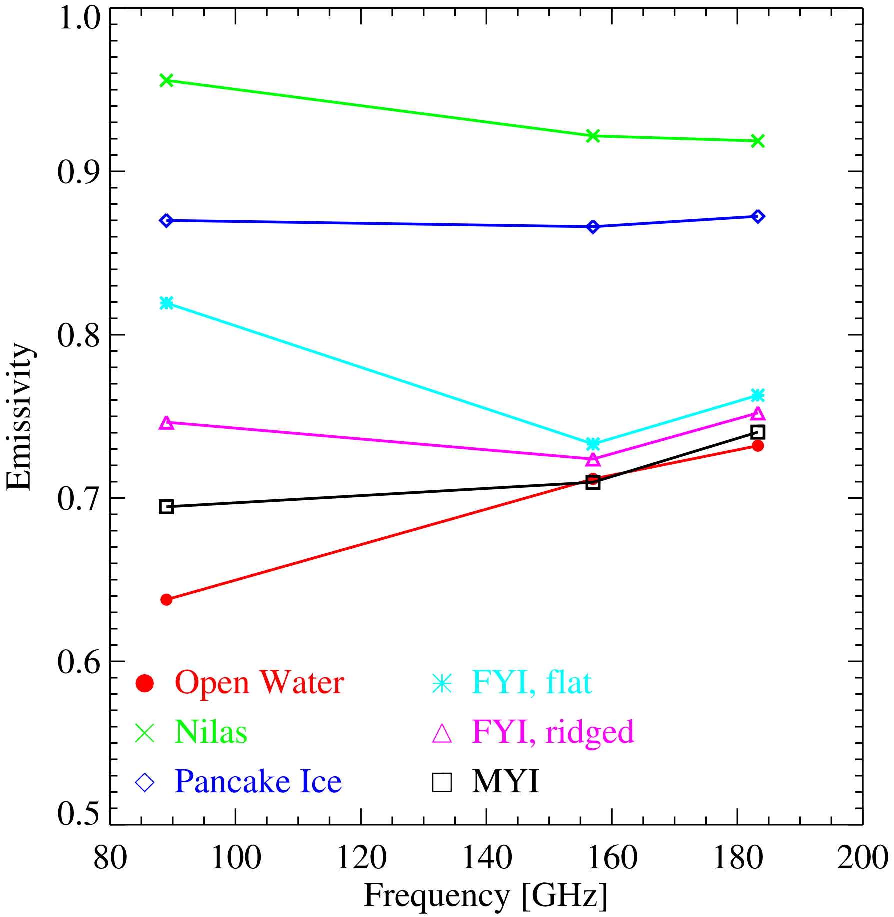
$\Rightarrow$ Weather influence: avoid rain, snow (synop data?)



Related Work

PhD thesis by Nathalie Selbach: SEPOR-POLEX measurements with airborne radiometer (channels similar to AMSU-B); dropsonde TWV measurements; ϵ_s measurements:

- possible to improve algorithm with knowledge about emissivity ratio $\epsilon_s(182)/\epsilon_s(150)$ – from where?



2. Surface emissivity at temperature sounding frequencies

- PhD student (Nizy Mathew) working on that, since past summer.