Precipitation Climatology of Polar Regions

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Overview

Precipitation Climatology in Polar Regions

- A. Ice sheet
- B. Sea Ice

A. Ice Sheets

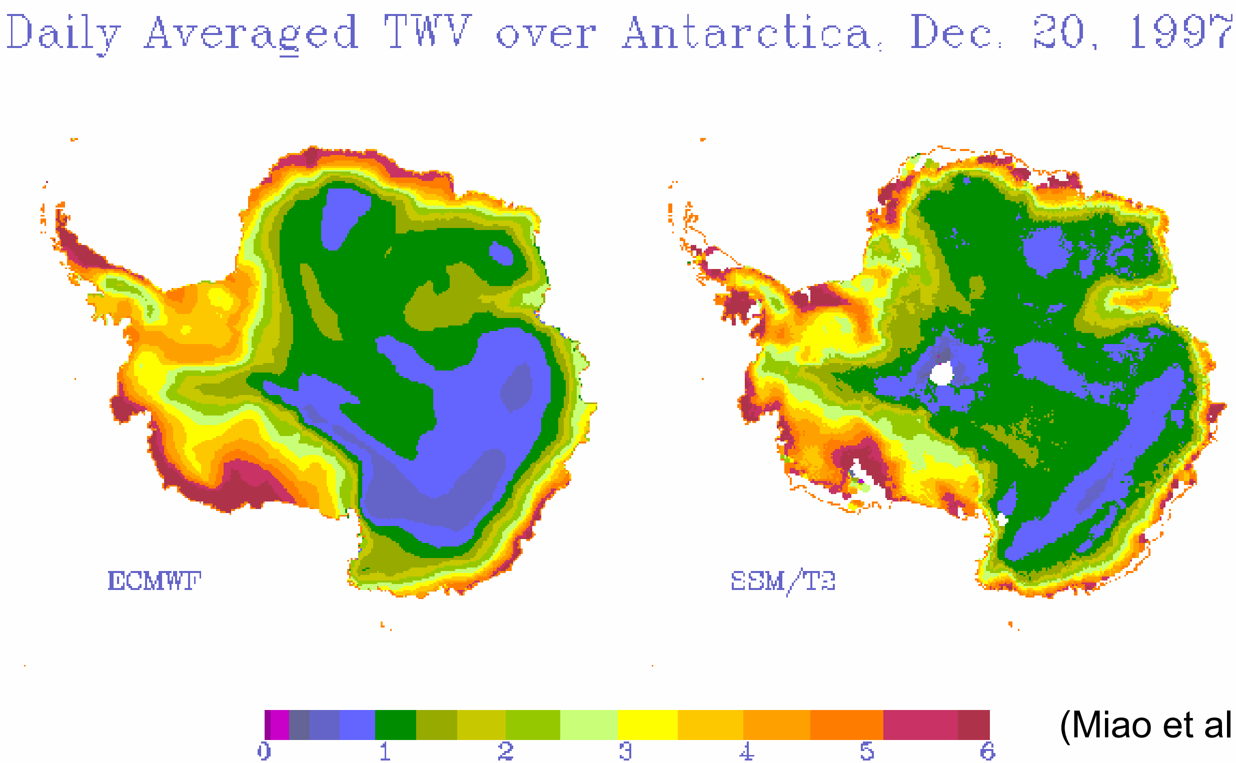
- Precipitation one of the largest uncertainties in the mass budget of ice sheets

- Change in height determined by
  - Precipitation P
  - Melting S
  - Displacement

- Determine daily maps of P from
  - atmospheric model and
  - daily water vapor from water vapor sounder AMSU-B
  - Procedure developed by Miao et al. (2001)

Total Water Vapour (TWV) from humidity sounders

- SSM/T2 and AMSU-B: 5 channels 183±1, ±3, ±7, 150, 89 GHz
- expressions ln (T1-T2)/(T2-T3) ~ TWV



(Miao et al., 2001)

A. Ice Sheets (cnt‘d)

- 3 ways to merge remote sensing and model data
  - Assimilation (NWP: IOMASA)
  - Nudging
  - Normalize model WV profiles of model with observed TWV
- Determine precipitation climatology and patterns of ice sheets
- Combine with
  - land ice models and
  - snow drift models
- Cross-check with thickness balance from CRYOSAT
- GLIMS (Global Land Ice Measurements from Space) contribution

B. Sea Ice

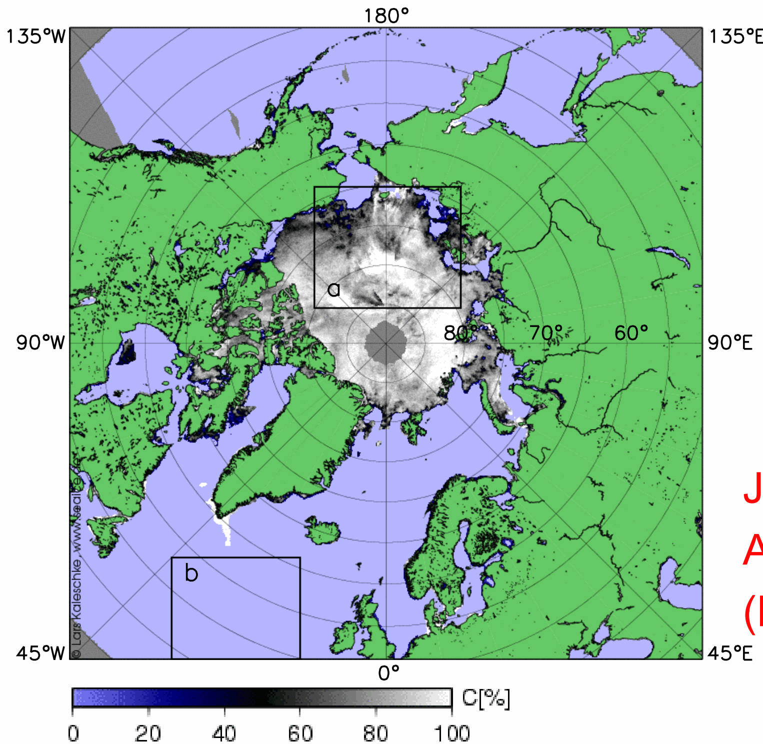
- Similarly: Develop precipitation climatology and distribution over sea ice

- Include also LWP from SSM/I and AMSR

- Method proposed by Miao et al. (2000) using

- *R*-factor $$R(f_1, f_2) = \ln \frac{T_v(f_1) - T_h(f_1)}{T_v(f_2) - T_h(f_2)}$$

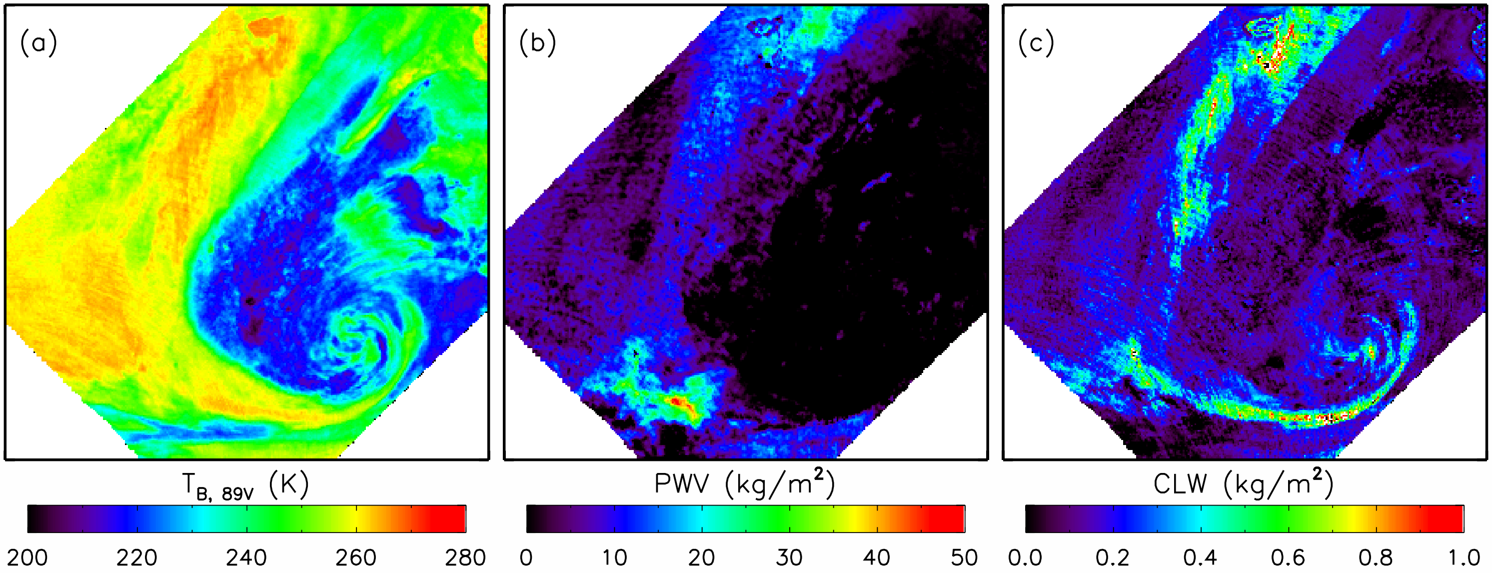
Regions of Interest



July 18, 2002,
ASI algorithm
(Kaleschke et al., 2001)

- *a*: Sea Ice
- *b*: Open Water

Applications: Sea Ice (region *a*)



- Cloud System of July 18, 2002
- CLW typical feature over meteorological front
- PWV low on rear side of low pressure system

B. Sea Ice (cont‘d)

- Validation of CLW difficult, Polarstern campaign with microwave radiometer?
- Assimilate precipitation into sea ice model
- Goal: Evaluate meteoric part of sea ice

Conclusions

- Combine atmospheric remote sensing data with atmospheric models
- Ice sheets:
  - Cross-validate ice thickness,
  - establish budget of components
- Sea ice:
  - Quantify meteoric part of sea ice

Retrieval Method: *R* factor

- Radiation received at sensor (Grody, 1986)

$$T_p(f) = T_s - T_s\left[1-\varepsilon_p(f)\right]\exp\left[-2\tau(f)\sec\vartheta\right]$$

with

$T_p(f)$	brightness temperature
p	polarization *h, v*
f	frequency
T_S	surface temperature
$\tau(f)$	nadir opacity
ϑ	zenith angle at surface

R factor

$$R(f_1, f_2) = \ln\frac{T_v(f_1) - T_h(f_1)}{T_v(f_2) - T_h(f_2)}$$

Retrieval Method: *R* factor (2)

- *R* factor $$R(f_1,f_2)=\ln\frac{T_v(f_1)-T_h(f_1)}{T_v(f_2)-T_h(f_2)}$$

$$=R_S(f_1,f_2)+\beta(f_1,f_2)\cdot\left[L+\alpha_{WL}(f_1,f_2)\cdot W\right]+R_d(f_1,f$$

with

$R_S(f_1,f_2)$	surface contribution
L	liquid water path
W	precipitable water path
$R_d(f_1,f_2)$	dry air contribution

$$\beta(f_2,f_1)=2\sec\theta\cdot\Delta\kappa_L$$

$$\alpha_{WL}(f_1,f_2)=\frac{\Delta\kappa_W(f_1,f_2)}{\Delta\kappa_L(f_1,f_2)}$$

$\Delta\kappa_L(f_1,f_2)$	liquid water mass absorption coefficient difference
$\Delta\kappa_W(f_1,f_2)$	water vapor mass absorption coefficient difference

Retrieval method: frequency combinations

Recall:

$$R = R_S + \beta\left(L + \alpha_{WL} W\right) + R_d$$

$$\beta(f_2, f_1) = 2\sec\theta \cdot \Delta\kappa_L$$

$$\alpha_{WL}\left(f_1, f_2\right) = \frac{\Delta\kappa_W\left(f_1, f_2\right)}{\Delta\kappa_L\left(f_1, f_2\right)}$$

Desired:

- α small: large CLW contribution
- β large: small surface contribution
- *Rs*: small surface contribution

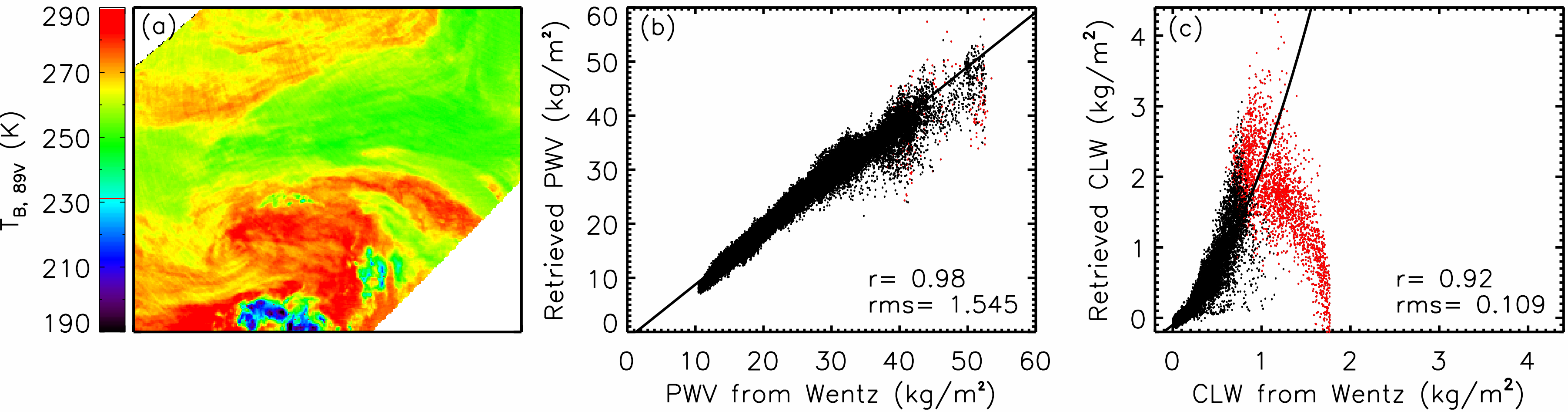
Select 2 frequency combinations: 2 eqs for 2 unkowns *L, W.*

SSM/I vs. AMSR characteristics

Frequency [GHz]		Resolution [km]	
SSM/I	AMSR(-E)	SSM/I	AMSR(-E)
-	6.9	-	71x41
-	10.7	-	46x25
19	18.7	69x43	25x15
22 V	23.8	50x50	23x14
37	36.5	37x29	14x8
85	89	15x13	6x4
-	50.3 V	-	12x6
-	52.8 V	-	12x6

All channels H + V polarisation if not indicated otherwise.
Channels near 50 GHz on AMSR only.

Applications: Open Ocean (region *b*)



- compare to results of Wentz of July 17, 2002
- exclude precipitating cases (*Tb* (36V) > 240K)
- PWV: correlation all data r = 0.98, below 35 kg/m2 stronger
- CLW: non-linear relation
- deviations potentially caused by scattering cloud ice

Conclusions

Retrieval of CLW and PWV over sea ice and open ocean

- appears feasible
- more knowledge about surface influence required
- concept of *R* factor may be noise sensitive, other approaches also considered