The role of boundary layer clouds in the global energy and water cycle: An integrated assessment using satellite observations

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Outline

• Low clouds/light rain: What do we know? Why do we care?

• Creating a combined MODIS/AMSR dataset

• Regional studies

• Project timeline
Annual mean liquid water path from CMIP3 models

Lauer and Hamilton
Annual mean liquid water path from CMIP5 models

Lauer and Hamilton
• Balance of latent heat release, shortwave, and longwave radiative heating/cooling play dominant role in maintenance of these clouds

• Cloud albedo strongly affected via cloud-break-up/reorganization of cloud structures.

• Aerosols modify precipitation efficiency and albedo via changes in cloud droplet number concentration

• A-train observations can provide baseline for understanding these processes
Basic physical relations

\[ LWP = f \cdot \rho_L \cdot \tau_{VIS} \cdot r_{eff} \]

\[ N = C \cdot \tau_{VIS}^3 \cdot LWP^{-5/2} \]

- LWP from VIS/NIR: Factor f depends on stratification of cloud (e.g. f=5/9 for adiabatic, f=2/3 for vertically uniform)

- N for an adiabatic cloud related to optical depth and LWP. C depends weakly on temperature and width of droplet spectrum
Basic physical relations

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- MW: Very direct measurement. Mass absorption coefficient depends slightly on temperature, \( \sigma_r \) depends on rain water content too.
Basic physical relations

Bennartz et al. (2010)
Basic physical relations

\[ \tau_{MW} = \sigma_L \cdot LWP + \sigma_R \cdot RWP \]

\[ RWP = -\frac{aH_R}{2b} + \sqrt{\left(\frac{aH_R}{2b}\right)^2 + \frac{H_R}{b} \left(\tau_{MW} - \sigma_L \cdot LWP\right)} \]

Bennartz et al. (2010)
Basic physical relations

Three input variables \((T_{\text{VIS}} \ r_{\text{eff}} \ T_{\text{MW}})\) \\
\rightarrow \\
Three output variables \((N, \text{LWP}, \text{RWP})\)
Basic physical relations

Three input variables \( (T_{\text{VIS}} \; r_{\text{eff}} \; T_{\text{MW}}) \)

\[ \rightarrow \]

Three output variables \( (N,LWP,RWP) \)

Auxiliary data, assumptions:

- Cloud top height
- Cloud top temperature
- Drizzle/rain particle size distribution
- Width of cloud droplet spectrum
Basic physical relations

- Direct physical relationship between MW/VNIR optical properties and cloud physical properties.
- Errors and uncertainties due to input and auxiliary parameters can be specified and dependencies can be explicitly spelled out.
- Validity of assumptions can be assessed from observations.
- No unknown unknowns (though a lot of known unknowns).
Bennartz et al. (2010), Bennartz (2007), Rausch et al. (2010)
Cloud droplet number concentration
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(Bennartz et al. GRL, 2011)
Cloud droplet number concentration

(Bennartz, Fan, Rausch, Leung, Heidinger, GRL, 2011)
Plans for NEWS

• Ongoing/This meeting: Coordinate with other PIs.

• Ongoing: Case study selection; acquire datasets (MODIS C6)

• Uncertainty/error analysis; case studies

• Fall 2014: Peer reviewed publication.

• Fall 2014 Make dataset available to community.