The combined role of satellites and aircraft in assessing aerosol indirect radiative forcing

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The indirect radiative forcing:

• Increases in the number concentrations of cloud droplets by increases in aerosol particles increases the geometrical surface area of the cloud. In turn, scattering of solar radiation by the clouds back to space increases.
• The development of warm precipitation in the cloud can also be affected, potentially increasing the cloud lifetime of clouds and further enhancing the reflected radiation.

Here:

• Use data from 2003 Canadian SOLAS program to discuss the complementary aspects of these two observation platforms in trying to assess the indirect effect of aerosols on climate
• Some results from the Canadian GCM related to satellite estimates
What can satellites see and not see (or not see so well)?

Cloud albedo increase from carbonaceous aerosol


(A) Flight 1
(B) Flight 2
(C) LWC
(D) Extinction
What can satellites see and not see (or not see so well)?

Figure 2

Mass Concentration ($\mu$g m$^{-3}$)

Diameter (nm)

dN/dlogD (cm$^{-3}$)

Time (UT)

Altitude (m-MSL); Cloud droplet number cn. (cm$^{-3}$)

Vertical gust speed (m s$^{-1}$)

Altitude

CDNC (FSSP-100)

Vertical gust speed

Cloud marker Flight 1

Cloud marker Flight 2

Sulfate Flight 1

Organics Flight 1

Sulfate Flight 2

Organics Flight 2
What can satellites see and not see (or not see so well)?
What do satellites and GCMs see?

Large spatial scales.

Aircraft allow probing on a fine scale.

How do we combine the two to maximise our knowledge gain? We must establish a larger database comparing satellite and airborne profiles through clouds.

The aircraft measurements tell us what processes are affecting the clouds. The satellites tell us first about the result; second …

GCMs also look at large scales and is a natural partner with satellites.
Evaluation of clouds, aerosols and radiation in CanAM4 using satellite-based observations

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The A-Train

A-Train is a multi-satellite observing platform in near-polar orbit
⇒ 1:30 PM ascending equatorial crossing time
⇒ Footprint overlap MODIS, CERES, CALIPSO and CloudSat
Matching MODIS and CERES instruments on Terra
⇒ 10:30 AM descending equatorial crossing time
⇒ MISR instrument on Terra only
CFMIP Observational Simulator Package (COSP)

- The ISCCP simulator has spawned others
- Effort to group simulators under COSP
  - ISCCP ⇒ $C(p_{top}, \tau), p_{top}, \alpha_{clld}$
  - CALIPSO ⇒ $C(z), SR(z), CFAD(SR)$
  - CloudSat ⇒ $C(z), RR(z), CFAD(RR)$
  - PARASOL ⇒ $R(\theta_\circ, \phi_\circ)$
  - MODIS ⇒ $C, r_{eff}, \tau, p_{top}, \text{histograms}$
  - MISR ⇒ $C(z_{top}, \tau_{top}), z_{top}$
  - Others (RRTOV, TRMM, CERES, etc)

⇒ Output for CMIP5 and AMIP experiments

- Created obs. dataset at same time as simulators
  - CALIPSO product (GOCCP) Chepfer, 2010
  - Same thresholds and vertical grid
Aerosol optical thickness evaluation (Y. Peng)

- Aerosol optical thickness at 550 nm
- Diagnosed in CanAM4, consistent with rad. trans.
CALIPSO total cloud fraction (2007-2008)

CANAM4 (aae) CALIPSO tot cld frac (annual)

GOCCCP CALIPSO tot cld frac (annual)
Constraining the indirect effect in CanAM4/CanCM4

<table>
<thead>
<tr>
<th>Exp</th>
<th>Parameterization</th>
<th>RFP (W/m²)</th>
<th>Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>CER03</td>
<td>$N_c = 174(\text{SO}_4 + 0.27\text{SS})^{0.67}$</td>
<td>-2.8</td>
<td>N/Y</td>
</tr>
<tr>
<td>CER08</td>
<td>$N_c = 114.82\text{SO}_4^{0.48}$</td>
<td>-2.9</td>
<td>N/Y</td>
</tr>
<tr>
<td>CER16</td>
<td>$N_c = 66\text{SO}_4^{0.3}$, no 2$^{nd}$</td>
<td>-1.0</td>
<td>Y/Y</td>
</tr>
</tbody>
</table>

![Graph showing Low cloud effective radius vs Latitude](image-url)

Canadian Centre for Climate Modelling and Analysis
Centre canadien de la modélisation et de l'analyse climatique