Polar Science Center
Applied Physics Laboratory
University of Washington

A Polar Specific 20-year Data Set of Cloud Fraction and Height Derived from Satellite Radiances

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Final Report, 2004

Note:
This is a final report to fulfill reporting requirements on NASA grant NASA NAG5-11800. Jennifer Francis, PI at Rutgers University is currently continuing work on this project under a no-cost extension. Work at the University Washington portion of the project is completed and reported here.

Major Accomplishments and Results:

- **Revised and extended TOVS Polar Pathfinder data set from 1979-2001**. The revised and extended data set has been delivered to NSIDC and is available from there.
- **Analyzed Arctic cloud variability** and conducted intercomparsions with other satellite-derived data sets and surface observations. Strong trends in cloud amount over the Arctic were found during spring and winter. Winter cloud amounts decreased by 5% per decade while spring cloud amounts increased by 5% per decade. Regionally spring cloud trends are even stronger. Over the Beaufort sea spring cloudiness has increased as much as 15% per decade. Changes in cloud amount appear to be associated with the changes in the atmospheric circulation. A paper (Schweiger, 2004) presenting these results has been published and is attached to this report.
- **Validated southern hemisphere ocean cloud retrievals** using ship observations and found excellent agreement of TOVS retrievals with surface observations.
- **Intercompared cloud height information** from AVHRR retrievals and surface-based cloud radar information.

Extension and reprocessing of TOVS Path-P data set:

The TOVS Polar Pathfinder data sets was reprocessed and extended. Reprocessing involved the correction of several processing errors and improvements in response to validation results. The data set was extended by additional 3-years from 1999 through 2001. The reprocessed data set was delivered to NSIDC in 2003 and has been available for distribution from there.

Analysis of Arctic Cloud Variability

Winter and spring changes in cloudiness are compared over the arctic seas (ocean areas north of 60×) from the TOVS (TIROS Operational Vertical Sounder) Polar Pathfinder retrievals and two separate datasets derived from the Advanced Very High Resolution Radiometer (AVHRR). All satellite products exhibit significant decreases in cloud fraction over the arctic seas during winter (December, January, February) on the order of 5%/decade. An equally striking increase in spring (March, April, May) cloudiness is evident from the TOVS Pathfinder (TPP) and the extended AVHRR Polar Pathfinder (APP-x) projects. Regionally these positive trends can be as large as 15%/decade. Surface observations from the Russian drifting meteorological stations are consistent with satellite- observed changes during the 1980s. Negative trends in spring cloud cloudiness reported by Comiso [2003] are in conflict with these findings. Spring changes in cloudiness are associated with changes in the atmospheric circulation. These dramatic, large-scale changes are expected to have substantial impacts on the surface energy balance. The paper reporting the results is [*Schweiger*, 2004] is attached

Analysis of Cloud Top Temperature

Figure 1 shows mean monthly cloud top temperatures from Path-P, AVHRR (CASPR algorithm) and from a combination of the ETL Cloud Radar/Lidar surface-based systems. Cloud top height from the Radar/Lidar source is converted to cloud top temperature using

SHEBA radiosonde measurements. There is a good agreement between the two satellite measurements. The surface retrievals from the Radar/Lidar systems are based on the interpretation of backscattered radiation. A large difference (over 10K) between satellite and surface-based measurements is notable. The likely explanation for this large difference is the presence of optically very thin high clouds over a deck of lower clouds. These optically very thin clouds are relatively transparent to the emitted radiation used in the satellite retrievals yielding much lower "effective" cloud top temperatures. The active Radar/Lidar systems on the other hand retrieve a physical boundary of the upper cloud which will be much higher. Interpretation of the backscatter also affects the highest reported level. Of course the potential mislabeling of clear vs. cloudy scenes also has an effect on the retrieval of cloud top temperature. The differences in the above retrieved cloud top temperatures point to the need of careful interpretation and application of these measurements. Future work will make use of profiles of cloud properties in combination with radiative transfer modeling to find the reason for these differences and how to best document and exploit this information in research applications.

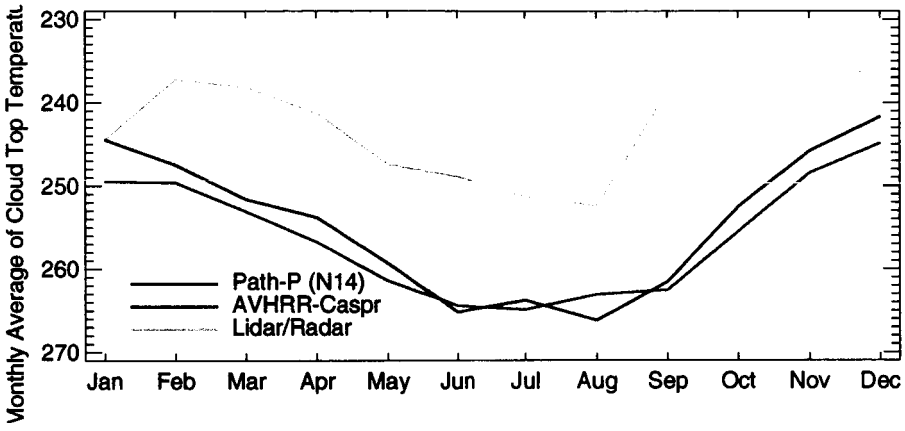

Figure 1. Monthly averaged cloud top temperature at the SHEBA site measured from the surface by a combination of Lidar/Radar systems, and from space using the AVHRR CASPR and TOVS Path-P algorithms.

Validation of Southern Hemisphere Cloud Retrievals

Meteorological Surface observations from research cruises by the German research ship Polar Stern include meteorological observations of cloud cover and surface temperatures. Data are predominantly from the Weddell Sea area. We obtained surface observations at daily resolution for the period of 1984-2001 and collocated them with Path-P TOVS retrievals using the closest grid cell. shows daily averaged total cloud amount from meteorological ship observations and Path-P retrievals. Following the procedure developed for the northern hemisphere data, cloud observations time series are smoothed using a 5-day running means. The results show a close correlation of surface observations with satellite retrievals and confirm that the Path-P retrieval algorithm is functioning properly over Antarctic waters. Further analysis of the cloud statistics and variability for the southern hemisphere is planned under separate funding.

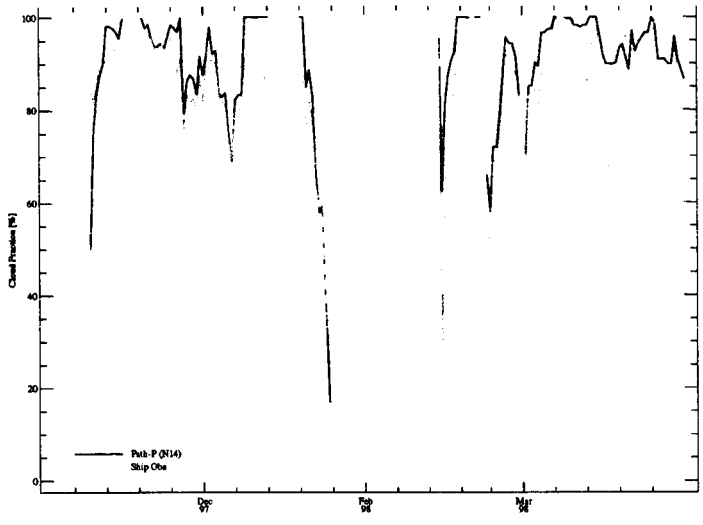

Figure 2 Daily averaged total cloud amount from TOVS Path-P and ship observations during a Polar Stern cruise in Summer of 1996.

References

Comiso, J.C., Warming trends in the Arctic from clear sky satellite observations, *Journal of Climate*, *16* (21), 3498-3510, 2003.

Schweiger, A., Seasonal Changes in Cloud Cover over the Arctic Seas from Satellite and Surface Observations, *Geophysical Research Letters*, *31*, L12207, doi:10.1029/2004GL020067, 2004.