Air Force Research Laboratory

Comparison of CIMSS DCOMP and TWST cloud optical depth retrievals

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Outline

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Acronyms

- ACHA
  - AWG [Algorithm Working Group] Cloud Height Algorithm [ATBD]
- AERONET (Aerosol Robotic Network)
- AHI (Advanced Himawari Imager)
  - Himawari-8 (platform) launched October 2014
- BOM (Australia Bureau of Meteorology)
- CIMSS (Cooperative Institute for Meteorological Satellite Studies)
  - Established through MOU with University of Wisconsin – Madison, NOAA, and NASA (1980)
  - Himawari cloud products based on CIMSS algorithms -- not an official JAXA product
- COD (cloud optical depth)
- DCOMP (Daytime Cloud Optical and Microphysical Properties)
  - Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document (ATBD) for DCOMP
- DOE ARM (Department of Energy Atmospheric Radiation Measurements)
- DSTG (Defence Science and Technology Group, Australia)
- JAXA (Japan Aerospace Exploration Agency, formerly NASDA)
- RAAF (Royal Australian Air Force)
- TWST (Three-Waveband Spectrally agile Technique)

Field site

- RAAF Woomera Range Complex
- Major Australian military and civilian aerospace facility 450 km NW of Adelaide
- Areal extent: 122 km^2
- "Golden Day" (25 June 2016)

Image: Wikipedia

Image: Goway Travel

TWST

- Portable ground-based sensor measuring COD built by Aerodyne
  - Data acquisition: 1 Hz
  - FOV = 0.5°
  - Employs absorption in O_2 A-band to resolve COD ambiguity
  - Validated[1] against AERONET cloud-mode instrument at DOE ARM site, Lamont, OK

[1]E. Niple, et al, Application of oxygen A-band equivalent width to disambiguate downwelling radiance for cloud optical depth measurement, Atmos. Meas. Tech., 9, 4167-4179 (2016).

Himawari-8/9 (AHI) specs

Wvl (μm)	Spatial Resol'n (km)	Wvl (μm)	Spatial Resol'n (km)
0.47	1	6.9	2
0.51	1	7.3	2
0.64	0.5	8.6	2
0.86	1	9.6	2
1.6	2	10.4	2
2.3	2	11.2	2
3.9	2	12.4	2
6.2	2	13.3	2

Full disk scan every 10 minutes

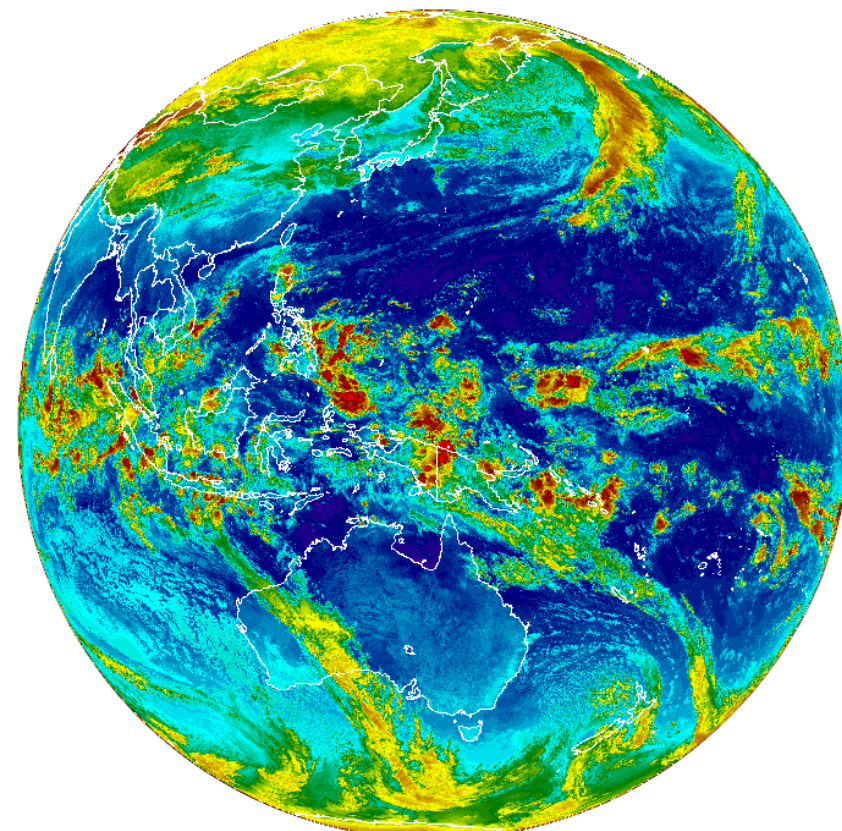HIMAWARI-8 RAINBOW IR CH. 4 - NOV 16 16 19:00 UTC

Image: NOAA

Definitions and typical values

- Cloud particle size (CPS): synonymous with cloud effective radius
- Cloud effective radius (r_e): ratio of the third to the second moment of a droplet size distribution
- Cloud optical depth (τ_c) 640 nm: vertical optical thickness between the top and bottom of an atmospheric column (almost λ independent in the VIS)
- Cloud water path: measure of total mass of water in a cloud column (either liquid or ice)

DCOMP typical values

r_e	10 µm
τ_c	12
τ_r (above)	0.03
τ_{aer} (above)	0.05
$\tau_{r,0}$ (background)	0.044
$\tau_{aer,0}$ (background)	0.1
surface albedo	0.08

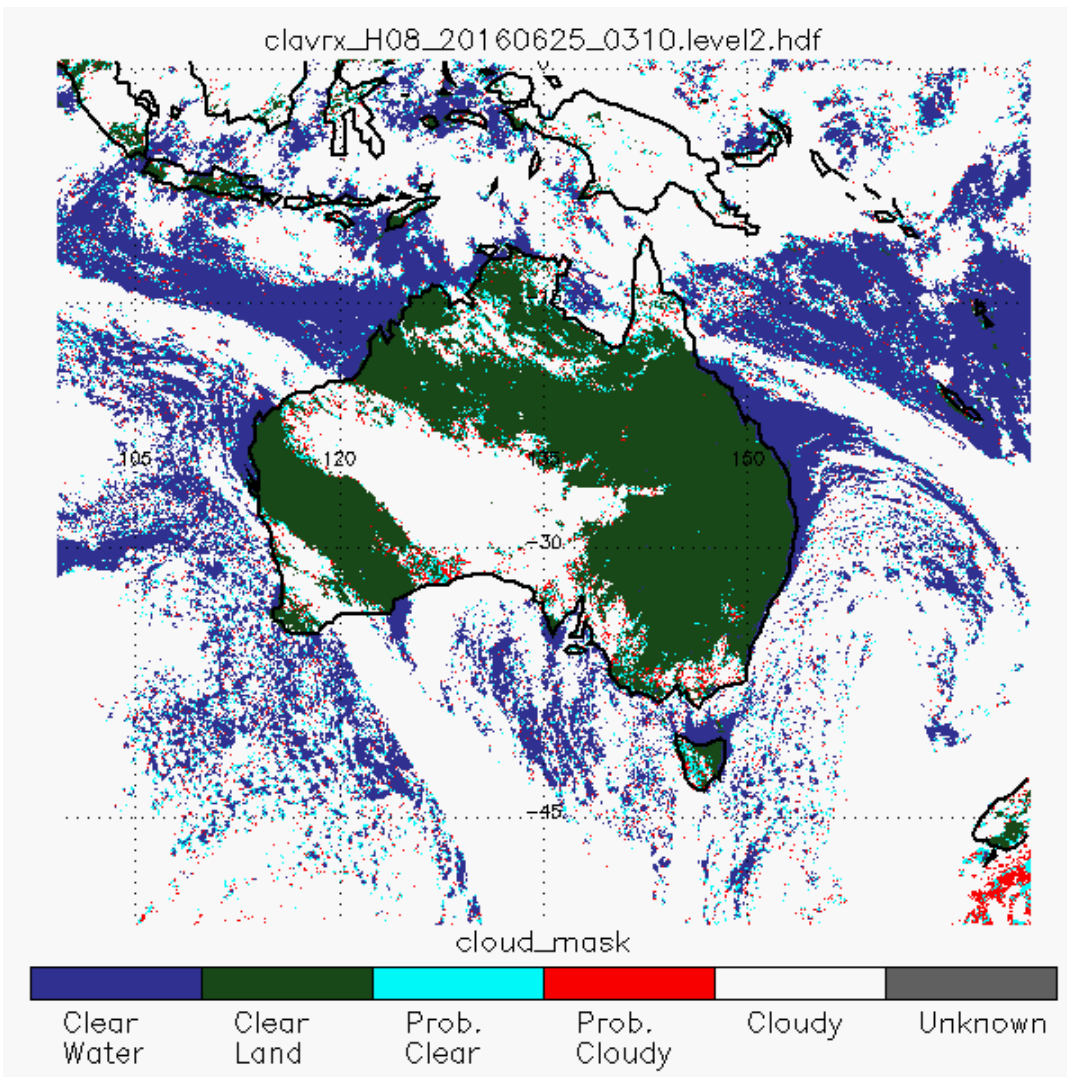# A serendipitous series of events

- BOM delivered processed Himawari images to DSTG
    - No lat/lon file in metadata
    - BOM uses CIMSS algorithms to process Himawari data
- Asked CIMSS colleagues to reprocess golden day data as a personal favor based on long history of interfacing with them (20 years)
    - CIMSS graciously reprocessed original data within two days including the lat/lon file in metadata

Methodology

clavrx_H08_20160625_0310.level2.hdf

cloud_mask

| Clear Water | Clear Land | Prob. Clear | Prob. Cloudy | Cloudy | Unknown |

- Locate closest Himawari pixel to TWST lat/lon based on where statements
  - Geodetic distance = 0.760571 km
- Find TWST acquisition time closest to Himawari scan line time
  - UTC 3.27195

- Cloud type = supercooled
- Cloud phase = supercooled liquid H_2O
- Cloud albedo$_{640\ nm}$ = 0.547244
- Cloud height base (ACHA) = 1.58361 km
- Cloud height top (ACHA) = 2.66701 km
- Cloud temperature (ACHA) = 269.864 K
- Cloud layer = surface to 642 hPa
- Cloud water path = 89.638 g/m^2
- Low cloud fraction = 1.
- r_e = 11.3504 um
- τ_c = 13.6678 (Himawari) τ_c = 13.763849 (TWST)

Caveat and observation

- Always a scaling problem with point source and satellite data (e.g., spatial resolution and assumption of "horizontal homogeneity")
- Very good agreement between TWST and Himawari COD (within 1%)
- Cannot make overarching generalizations with a sample population of one point

Acknowledgments

- Steve Wanzong and Andy Heidinger (reprocessing Himawari data)
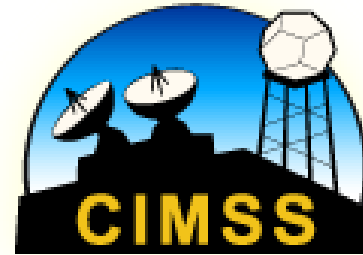
- Vlad Perejogin

Australian Government

Department of Defence

Defence Science and Technology Group