Properties of Fair Weather Cumuli at the ACRF Darwin Site

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Outline

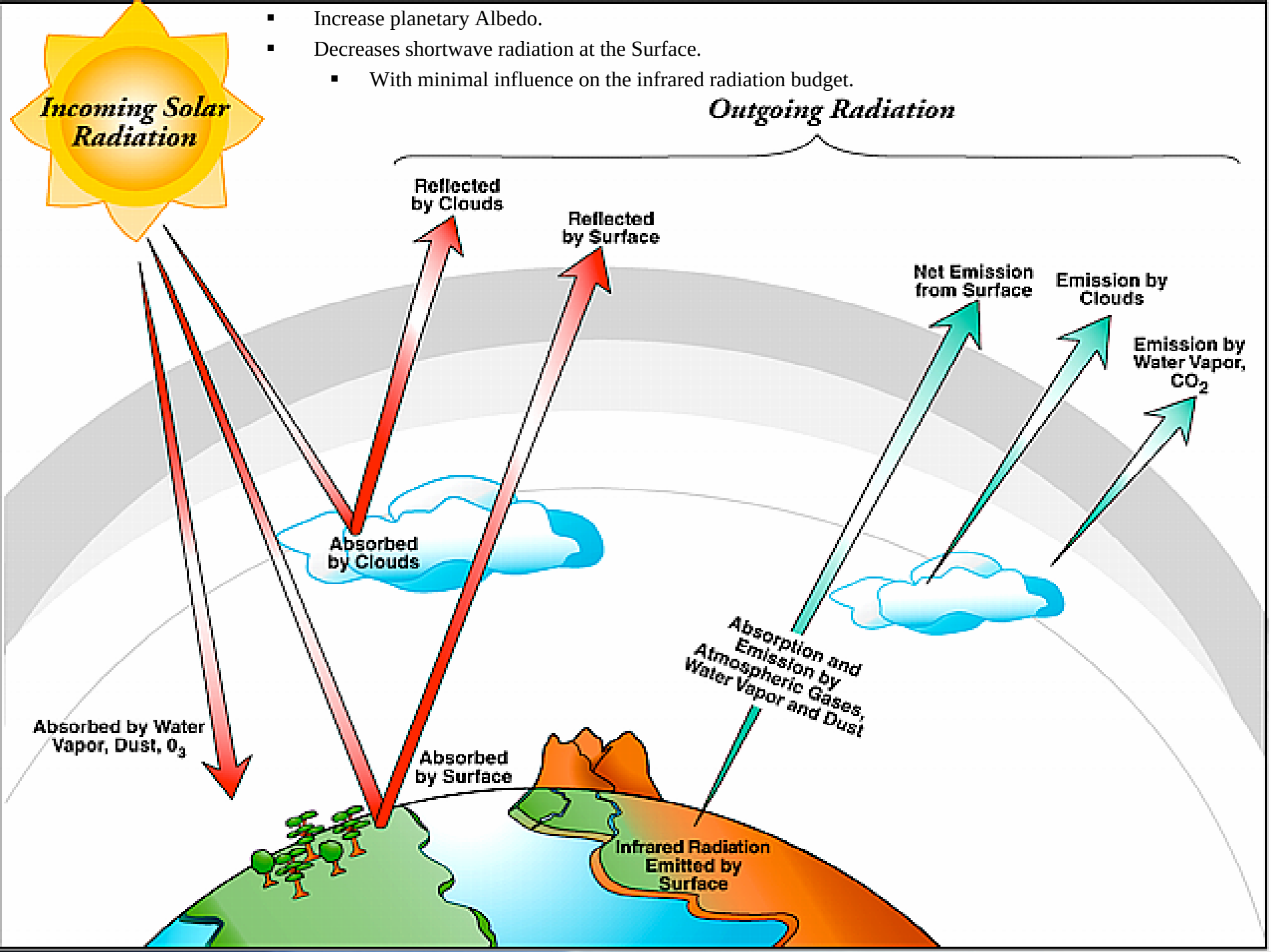
- Define Fair Weather Cumuli (FWC)
- Implication for climate
- Previous work
- Analysis of data from Darwin
- Conclusions

Fair Weather Cumuli

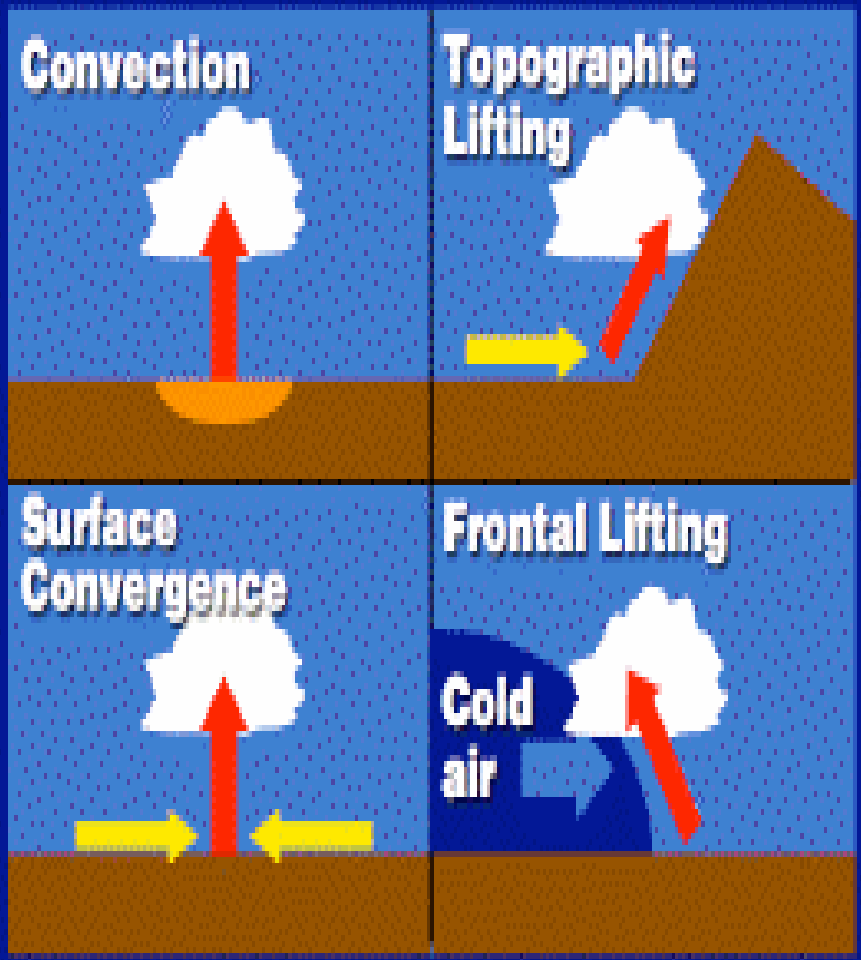
- Small clouds primarily with flat bottoms and round tops formed by:
  - Moisture
  - Lifting Mechanism
  - Instability

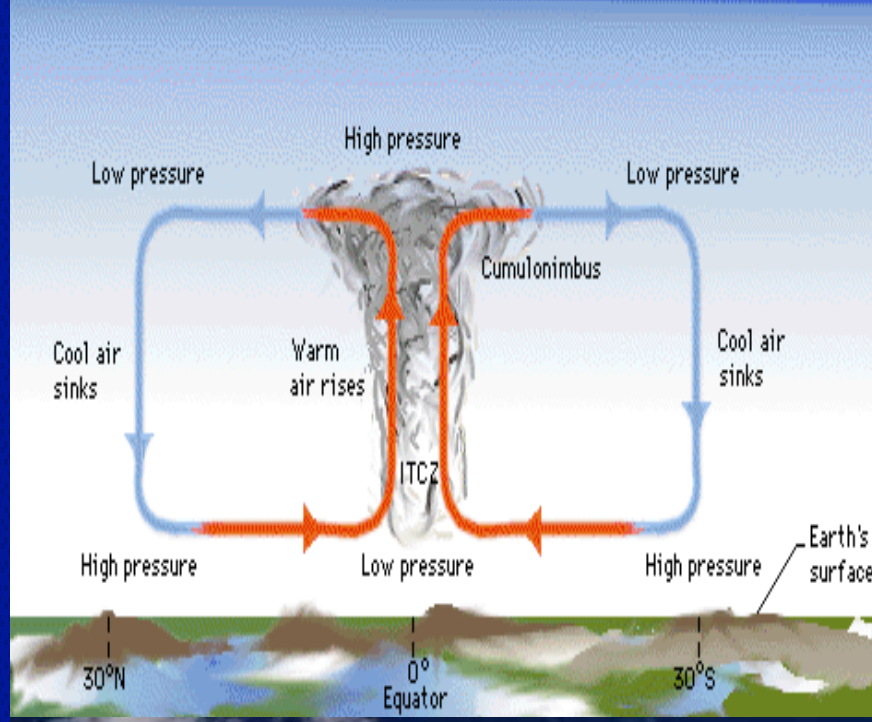
- Life span of individual clouds are 5 to 40 minutes.
- Life span of cloud fields are on the order of hours.

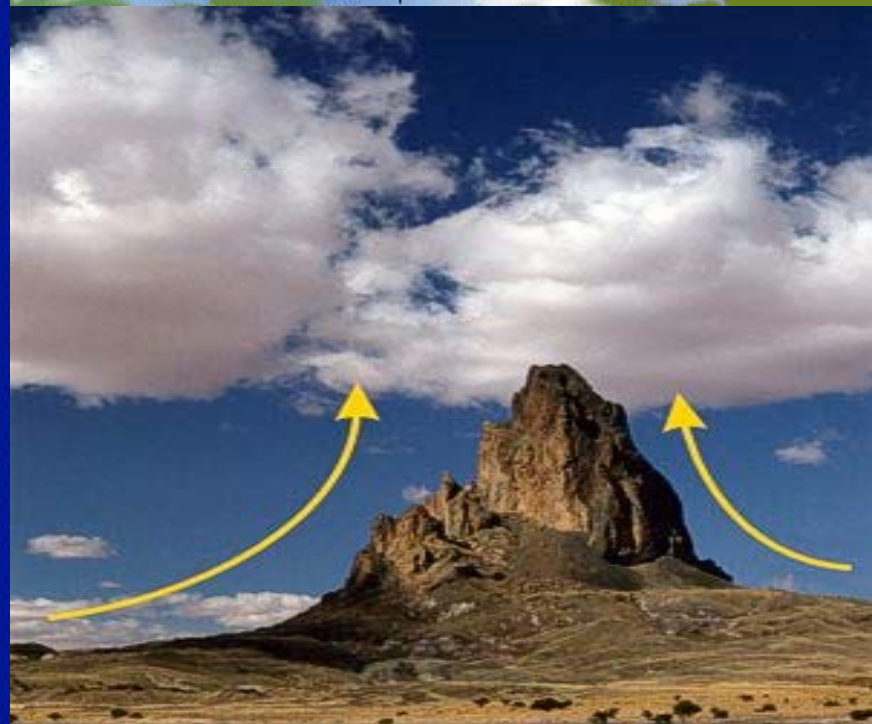
- Increase planetary Albedo.
- Decreases shortwave radiation at the Surface.
  - With minimal influence on the infrared radiation budget.



Lifting Mechanisms







Links to Global Change

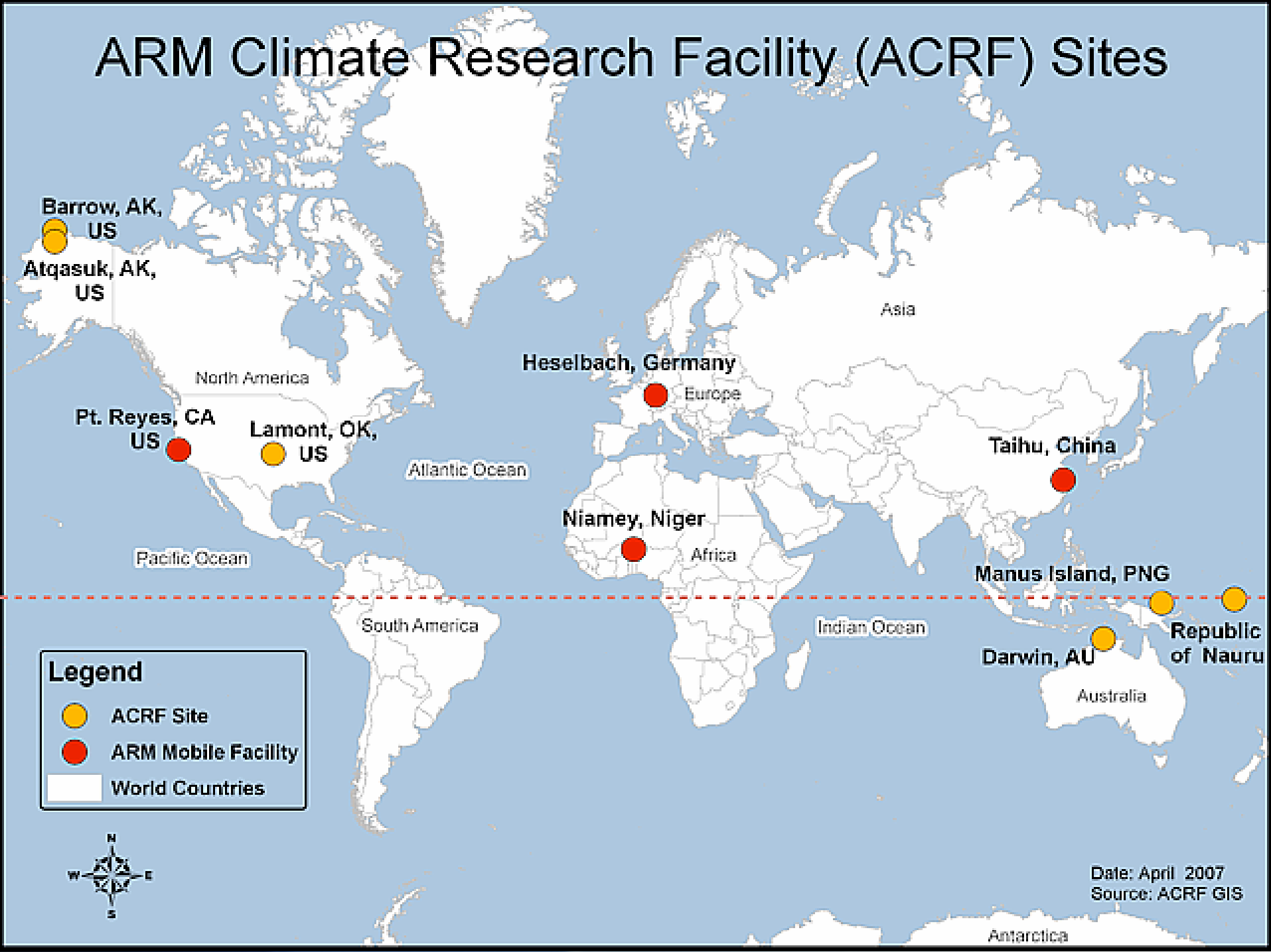
- Uncertainties in global change predictions can be associated with misrepresentations of clouds in climate models.
  - Since shallow cumulus clouds are smaller than a grid scale, they must be parameterized.

Previous Work

- Berg and Kassianov (2007). Used data from ACRF SGP Sites (Central Oklahoma).
- Study included data from the summer (May-August) of 2000-2004.
- Average Cloud Base Height (CBH), Cloud Top Height (CTH), Cloud Thickness (CTK), and Cloud Fraction (CF) were computed over each hour interval.

Purpose of This Study

- To Increase understanding of behavior and development of FWC in tropical regions.
- To Increase the Accuracy of the climate models.


ARM Climate Research Facility (ACRF) Sites
Barrow, AK, US
Atqasuk, AK, US
North America
Pt. Reyes, CA US
Lamont, OK, US
Pacific Ocean
Atlantic Ocean
Heselbach, Germany
Europe
Asia
Taihu, China
Niamey, Niger
Africa
Manus Island, PNG
Republic of Nauru
Indian Ocean
Darwin, AU
Australia
South America
Antarctica
Legend
ACRF Site
ARM Mobile Facility
World Countries
N
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E
S
Date: April 2007
Source: ACRF GIS

Required Instruments

- Actively Remotely Sensed Clouds Locations, Value-Added Product (ARSCL VAP)
- Surface Meteorological Instrument (SMET)
- Balloon-borne Sounding (Sonde)
- Total Sky Imager (TSI)

ARSCL VAP

(Active Remotely Sensed Clouds Locations, Value-Added Product)

- Used to provide the best estimate of:
  - Cloud Base Height
  - Cloud Thickness
  - Cloud Top Height

ARSCL Instruments

Microwave Radiometer (MWR)

Can be used to verify clouds.

Measurements of column-integrated amounts of water vapor and liquid water.

Millimeter-Wave Cloud Radar (MWCR)

Measure Cloud base and top.

Vaisala Ceilometer (VCEIL)

Measure cloud-base height at up to three levels. Maximum vertical range of 25,000 ft.

Micropulse Lidar (MPL)

Determines the altitude of clouds overhead.

Surface Meteorological Instrument (SMET)

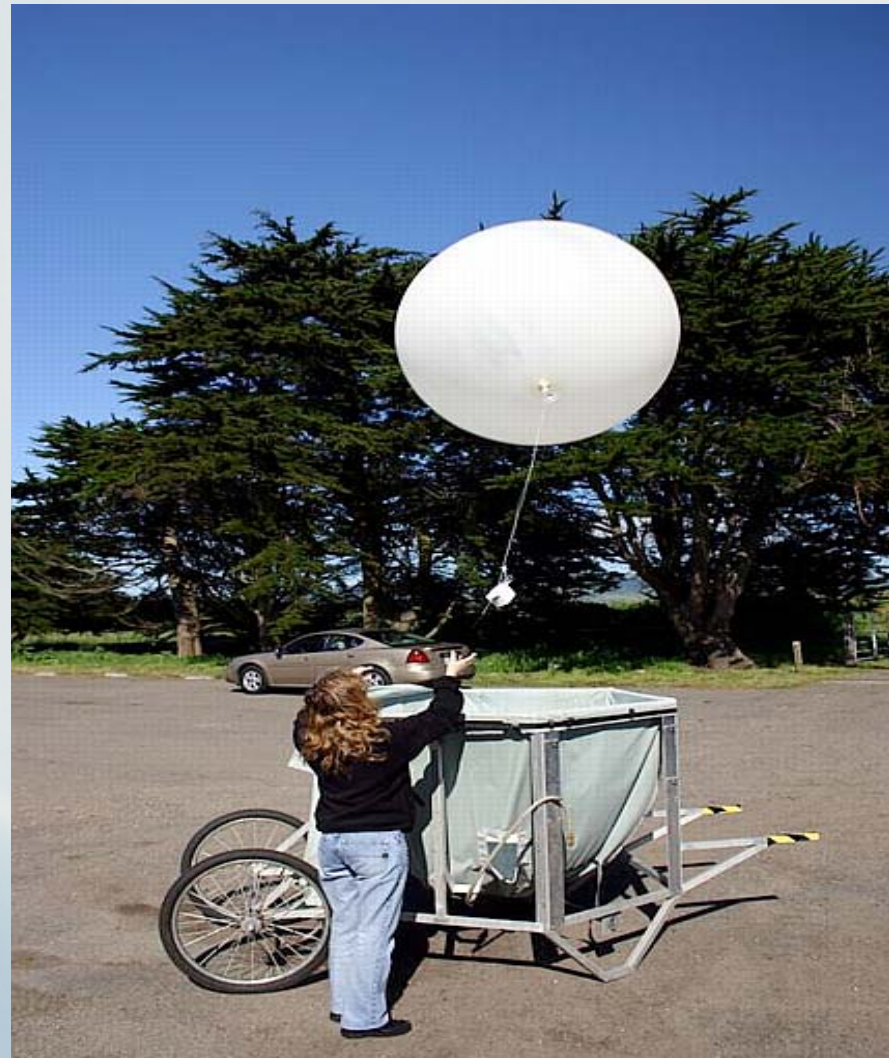
One minute statistics of:

- Surface Wind speed
- Wind direction
- Air Temperature
- Relative humidity
- Barometric Pressure
- Rain-rate

Balloon-borne Sounding (Sonde)

Provides information on:

- Thermodynamic state of the atmosphere.
- Vertical wind speed and Direction.



Total Sky Imager (TSI)

Provides

- Time series of Hemispheric sky images during daylight hours.

- Visual record of sky condition


ARM


Shoal Bay
N
Darwin
Intl. Airport
Darwin
ARCS Site
Darwin
Howard
Springs
1
Cox
Peninsula
Manus Island, PNG
Republic
of Nauru
Darwin, AU
Australia

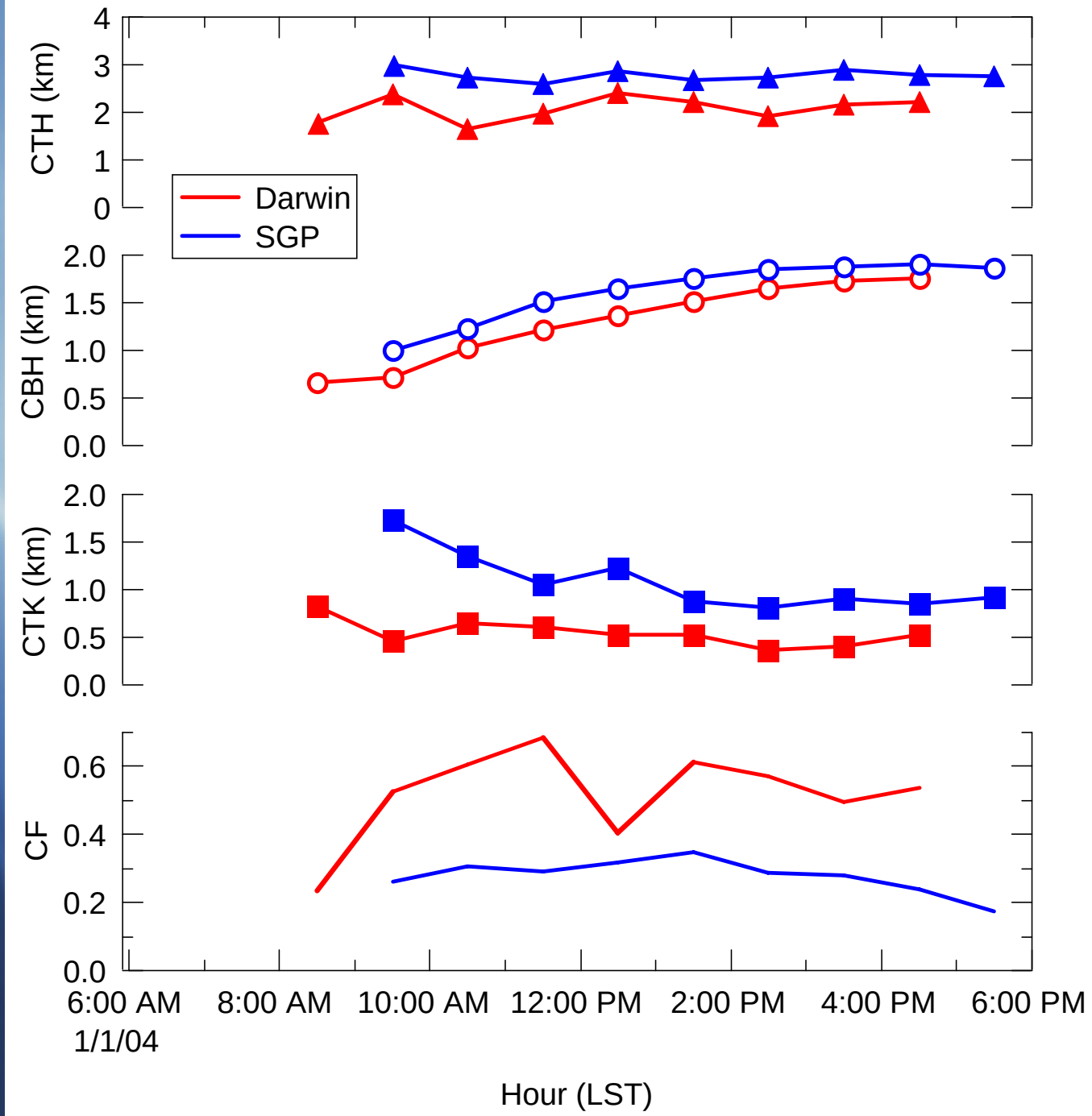
Darwin

Features

- Analyzed Days:
  - With no precipitation or convective activity.
  - Cloud Fraction less than 80%
- Derived hourly averages of:
  - Cloud Base Height
  - Cloud Top Height
  - Cloud Thickness
  - Cloud Fraction

Darwin 2006-2007

- 27 days with clear skies
- There were 29 days of shallow cumulus clouds.
- Approximately 88% of the year had precipitation


CTH (km)
CBH (km)
CTK (km)
CF
Darwin
SGP
0
1
2
3
4
0.0
0.5
1.0
1.5
2.0
0.2
0.4
0.6
6:00 AM
1/1/04
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
Hour (LST)

Properties

- Approximately 1700m is the maximum hourly averaged thickness of FWC at the SGP site from 2000-2004

- Approximately 800m is the maximum hourly averaged thickness at Darwin from 2006-2007.
  - Clouds with thickness exceeding 800m produced precipitation.

- Though the maximum hourly averaged thickness at Darwin is less than half of that of SGP; Cloud fraction percentages at Darwin are much higher than the SGP sites.

- With the CF percentage higher it indicates that the clouds at Darwin may have a larger impact on reflecting incoming solar radiation.

Conclusion

- Darwin compared to SGP has similarities, with very significant differences.
  - Shallow cumulus at SGP sites can become thicker without precipitation or thunderstorms.
  - Shallow cumulus at Darwin exceeding 800m are likely to develop into a precipitating or storm producing cloud.

Further Research

- A Multiple year research for Darwin, Nauru, and Manus to find a thickness threshold for precipitating clouds.

- Research the facilities:
  - During the monsoon season (November-February).
  - During the remainder of the year.
  - During occurrences with light precipitation.

- "Courtesy: U.S. Department of Energy's Atmospheric Radiation Measurement Program."
- Heidorn, Keith C. "Cumulus Humilis: a Fair Weather Cloudscape." Weather Phenomenon and Elements. 1 Nov. 2005. <http://www.islandnet.com/~see/weather/elements/cuhum.htm>.
- <http://www.srh.weather.gov/jetstream/mesoscale/ingredient.htm> .
- "Lifting Mechanisms." Cloud Formation. UCLA Department of Atmospheric Science. <http://www.atmos.ucla.edu/as3/scrns/clouddev/Note11.html>.
- "National Aeronautics and Space Administration." NASA. <www.nasa.gov/pdf/135641main_clouds_trifold21.pdf>.

Thanks

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