Determination of Water Vapor for Stratospheric Observatory for Infrared Astronomy Aircraft (SOFIA)

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Earth’s Atmosphere, Altitude, and Water Vapor Existence:
Earth’s atmosphere reaches over 600 km (=2 million ft) from the surface of the Earth. Only the lower atmospheric layer, Troposphere, contains the most of water vapor. This is the reason why SOFIA is flying above the Troposphere.

Tool – weather balloon atmospheric global model:
A weather balloon is used to measure the atmospheric parameter of pressure, temperature, humidity, and wind speed in the atmosphere. In order to obtain wind data, it is tracked by radar or navigation system, such as satellite based Global Positioning System (GPS).

The role of Water Vapor absorption in IR Astronomy
Water vapor = greenhouse gas, absorbs IR energy and re-emits the energy in all direction. Strong absorbance by water vapor occurs at wavelengths around 2900, 1950, and 1450 (nm), with other absorption all in the infrared spectrum. *Important* small percentage of water vapor in the atmosphere can still have a large influence on infrared spectrum. The effect of water vapor absorption is important because infrared astronomy is detecting infrared radiation emission.

Our mission:
Is to accurately predict the water vapor loading in the atmosphere which may further designate trajectory of SOFIA in order to have the best results in infrared astronomy observation.

Method:
- The current atmospheric model used for this project is the Global atmosphere model (Goddard Earth Observing System Model, Version 5(GEOS-5)) from NASA Goddard Space Flight Center to determine the water loading.
- This is the comparison of two data sources: GEOS-5 (High Resolution as 0.5° latitude, 0.66° longitude) vs. Actual Sounding Data (@ U. of Wyoming as 2° latitude, 2° longitude)

Formuлаe to Calculate Water Vapor Loading

\[
\text{Water Vapor Loading} = \frac{5}{980.616} \times (W_i + W_e) \times (P_i - P_e)
\]

Where
- \(980.616\) = acceleration of gravity (cm/s^2)
- \(W\) = mixing ratio in grams per kilogram
- \(P\) = pressure (millibar)
- \(i\) = index ranging from the surface to the current level

Conclusion:
- SOFIA may need to fly higher in order to reduce water vapor loading under 20µm.
- There is always a difference between model and actual data.
- Data from the model will be used to determine the amount of water vapor loading from the aircraft flight level to the top of the model (75km).
- When the project is completed, it will provide an alternative atmospheric profile along the trajectory with the water vapor loading highlights.

Results & Discussion
Most of the upper air data provided in the United States are taken by the weather balloons. However, there isn’t a lot data from the ocean. Once the flying region of SOFIA expands globally, water vapor loading in the atmosphere may become a concern because of the lack of measurements of atmospheric parameters needed to calculate water vapor loading. With more satellites being added to the space constellation and many to provide data on the earths atmosphere, it won’t be long until satellites will be an additional source of atmospheric data.

Acknowledgements
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Resources


About SOFIA: The world largest airborne observatory that will complement the Hubble, Spitzer, Herschel and James Webb space telescopes and major Earth based telescopes. It will provide better image quality and vastly increased observational sensitivity, a joint program by NASA and DLR (German Aerospace Center). It is based out of NASA Dryden Palmdale Facility and will be flying globally.

Christopher’s contribution: list the atmospheric parameter and show the path of the flight.

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