| Title: SAVANT IOP CTEMPS DTS Dataset
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| 1.0 Data Set Description

The Stable Atmospheric Variability and Transport, or SAVANT field project
was held near Mahomet, Illinois and ran from 15 September 2018 to 15 November 2018. This project was executed by a team of researchers from the University of South Carolina and the University of Illinois.

Stable surface boundary layers (SBL) occur more than one-half the total time in mid-latitudes, yet our knowledge of the complexity of the near surface drainage and converging flows associated with stable conditions is very limited. Surface emissions produced in stable conditions are difficult to predict and display seemingly erratic high-concentration "clumps" which stay near the ground. These effects are seen in even shallow topographic conditions Some studies have measured converging background and drainage flows in mountain areas, however, few studies have examined this in less dramatic, but more common, topographic areas. In general, transport models and field sampling systems have not been adapted to converging flows. We propose a measurement campaign to address these open issues.

The goal of the proposed work is to quantify, through a field measurement
campaign, the effects of converging shallow cold air drainage and background flow on aerosols transport and dispersion to specifically answer the following questions:

(1) Under what conditions (i.e. cloud cover, threshold wind speed, and stability regime) do converging flows exist?

(2) What spatial scale of flows are generated by converging drainage and background flows, and do these flows follow the current theories of wind speed dependence?

(3) How is aerosol dispersion and transport influenced by turbulence forced oscillations generated in response to the collided flow?

(4) What are the effects of intermittent turbulence on drainage and converging flow spatial and temporal variability of aerosol transport?

Physical Location:

The Distributed Temperature Sensing (DTS) cable was deployed from the top of shallow gulley starting at [40.21028,-88.41221] and followed a straight-line along its upper length to [40.21143,-88.41097]. The cable then crossed the gulley three times beginning at [40.21148,-88.41076] and ending at [40.21154,-88.41045]. The cable followed a subsequent straight-line path along the lower length of the gulley to [40.21175,-88.40782].

GCMD Keywords:

Atmosphere/Atmospheric Temperature/Surface Temperature/Air Temperature: f634ab55-de40-4d0b-93bc-691bf5408ccb

Data Frequency:

Data was collected every second with a 0.127 meter resolution along the DTS fibre-optic cable.

Data Source:

The data is provided in .mat files created using MATLAB R2020b. More information on the software used and file type may be found at: https://www.mathworks.com/products/matlab.html

Web Address References:

SAVANT overview: https://www.eol.ucar.edu/field_projects/savant
SAVANT field catalogue: http://catalog.eol.ucar.edu/savant

| 2.0 Instrument Description

The CTEMPS Silixia* DTS system used in the field campaign employs Raman spectra scattering of light in an optical fiber to obtain a temperature, spatial, and temporal resolution of 0.01 degrees C, 12.5cm, and 1 second. The instrument operates around the principle that parts of a laser pulse sent along the length of the fiber-optic cable will be reflected towards the source. Most reflected energy will return at the same wavelength as the emitted pulse, some of that energy will be absorbed and re-emitted at shorter and longer wavelengths [3]. The frequency-shifted reflections comprise the Raman spectra, or backscatter: Stokes backscatter refers to the reflection with the longer-wavelength while anti-Stokes refers to the shorter-wavelengths [1]. The amplitude of the anti-Stokes linearly depends on temperature, measuring the Stokes/anti-Stokes thus measures the temperature everywhere along the fiber. The instrument has demonstrated success in high-resolution air-temperature sensing and continues to be applied in both atmospheric and marine applications [2].

* More information on the Silixia DTS system may be found at: https://silixa.com/technology/ultima-dts/.

| 3.0 Data Collection and Proccessing

The DTS fiber-optic cable was routed along the length of a down-sloping shallow gulley and suspended a foot above the ground using 6” diameter wooden dowels (“posts”) spaced approximately 15 meters apart. Wrapping the cable around the dowel once provided enough tension to keep the cable at a constant height along its length. A single-ended configuration was used [1], with a cold and warm calibration bath placed just before the region of interest and a lower cold calibration bath past the data range. A heat pack was placed on a post approximately halfway along the cable’s length as a reference point. The CTEMPS DTS instrument collected temperature data from both “upper” cold and warm calibration baths, date-time information, and the Stokes and anti-Stokes signal to output raw temperatures at set distances along the cable. A PT1000 sensor collected temperature data from the “lower” cold bath.

Although CTEMPS provides software for the calibration of raw data, complications during the field campaign meant data was unable to be collected up to the lower cold bath. Without three baths to reference, the software was unable to calibrate the temperatures along the wire. A program was thus developed to independently calibrate the raw temperature single only two baths as per a previously derived algorithm [1]. The attenuation (α) between the Stokes and anti-Stokes signals were derived using the backscatter and distance raw data; the shift in energy between a photon (γ) and dimensionless calibration parameter C were calculated using known temperatures at the upper baths. The calibrated temperature was thus calculated using the calibration parameters α, C, and γ. The root-mean square error over the length of the upper cold and warm baths, respectively, was determined at each time of measurement as quality assurance.

The 6” diameter dowels were found to have a significant impact on the temperature measurements, not only where the cable contacted the post itself, but a set distance before and after the center of each post. A second algorithm was developed to remove a user-determined range of data from around the post center relative to the respective spike in temperature at each post and apply a distance offset for the length of cable wrapped around the dowel. Distance is thus defined as distance down the cable excluding structurally-supporting loops around dowels.

| 4.0 Data Format

Files are provided with the following naming convention:
dts_(month).(day)_(start time of data).mat

Within each MATLAB file are 7 variables defined as follows:

alpha: Differential attenuation between the Stokes & anti-Stokes signals in the fiber (1/meters)

C: Calibration parameter (dimensionless)

calT: Calibrated temperature (Celsius)
-> 0.01 degrees C resolution

distance: Distance along cable, excluding posts (meters)
-> 12.7 cm resolution

datetime: UTC datetime as a serial date number.*
-> 1 second resolution

G: Representing γ, the shift in energy between a photon at the wavelength of the incident laser and the scattered Raman photon (Kelvin)

latlong: The coordinates of each measurement point: the first column contains latitude, the second column contains longitude. Spatial reference system WGS-84.

meancoldRMSE: The mean of root-mean square error at each time interval, based on the cold calibration bath.

meanwarmRmSE: The mean of root-mean square error at each time interval, based on the warm calibration bath.

RMSE_cold: Root-mean-square-error at each time interval as determined by the cold calibration bath.

RMSE_warm: Root-mean-square-error at each time interval as determined by the warm calibration bath.

The "alpha", "C", and "G" arrays represent parameters used in the calibration proceedure outlined in [1]. The calibration parameters, "RMSE_cold", and "RMSE_warm" array columns directly correlate to the columns in the "datetime" horizontal array. The "calT" array values are vertically correlated to the "datetime" array and horizontally correlated to the vertical "distance" and "longlat" arrays.

Each file was created using MATLAB R2020b and is accessible through the same program or MATLAB-compatible equivalent.

* More information on serial date number and datetime may be found at:
https://www.mathworks.com/help/finance/handling-and-converting-dates.html

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| 5.0 Data Remarks

The original field deployment of the CTEMPS DTS included two fiber-optic wires within a combined cable suspended along the length of the gulley. Wildlife intermittently chewed through the cables and necessitated splicing by the field team. Determining the efficacy of said splices was difficult in the field, one channel was deemed unusable and excluded from the dataset post-processing. The provided data is thus the output of only one channel and thus subject to any problems in the channel itself. However, there were no know issues in the wire besides the occasional need for splicing.

Non-intensive operation periods are not included, only IOPs where other instruments were deployed as a part of the SAVANT field campaign are included in this dataset. Gaps in distance and associated rows of calibrated temperature may be accounted for as ranges of data impacted by post temperature peaks.

| 6.0 References

[1] Hausner, M. B., Suárez, F., Glander, K. E., Van de Giesen, N., Selker, J. S., & Tyler, S. W. (2011). Calibrating single-ended fiber-optic Raman spectra distributed temperature sensing data. Sensors (Basel, Switzerland), 11(11), 10859–10879. DOI: 10.3390/s111110859.

[2] Thomas, C. K., Kennedy, A. M., Selker, J. S., Moretti, A., Schroth, M. H., Smoot, A. R., Tufillaro, N. B., & Zeeman, M. J. (2011). A New Tool to Study the Two-Dimensional Structure of Atmospheric Surface-Layer Flow. Boundary-Layer Meterology, 142, 177-192. DOI: 10.1007/s10546-011-9672-7.

[3] Selker, J., van de Giesen, N., Westhoff, M., Luxemburg, W., & Parlange, M. B. (2006), Fiber optics opens window on stream dynamics, Geophysical Research Letters, 33(24), L24401. DOI: 10.1029/2006GL027979.