P3.12 CHARACTERIZATION OF HIGH LATITUDE NEAR-SURFACE OPTICAL TURBULENCE - PHASE I

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ABSTRACT

Is there a latitudinal dependency in the timing of the diurnal stability transitions? The Stability Transition Forecast Model has worked successfully in mid-latitude desert sites under the ideal weather scenarios of clear skies, low winds and low humidity. The seasonal influence on the depth of the local temperature inversion(s) holds a major impact on the stability transition timing. What if the mid-latitude model algorithms were recalculated using data from an equivalent high latitude desert site? How would they differ? These are some of the many questions we hope to answer from the ongoing field study being conducted in Barrow Alaska. Near-surface, 24 hrs, 7 days/week atmospheric optical turbulence measurements are scheduled for acquisition between 2004 Oct and 2005 Sep. The University Partnering for Operational Support [UPOS] joins the efforts of the University of Alaska-Fairbanks and the Army Research Laboratory. This presentation briefly explains the foundational study, the field test plan and the current findings of this 12-month study.

1. Introduction – Foundational Study.

In 1995, the Army Research Laboratory published a mid-latitude model for forecasting the Stability Transition [ST] over a southwestern USA desert environment (1995, Vaucher et al). The ST occurs at least twice a day for any environment that experiences near-surface unstable daytime and stable nighttime atmospheric conditions. The first ST generally follows sunrise and the second precedes sunset. Since the atmosphere is neither unstable nor stable during this time period, this transition has also been called a "Neutral Event". Prior to the model, the operational guidance for forecasting ST was an intermittently successful linear calculation based on local sunrise and sunset times. Using 16 months of atmospheric optical turbulence data at a single location, a quasi-sinusoidal pattern surfaced within the observed annual ST timing. A Fourier Waveform Analysis was performed resulting in the current Forecasting ST Model. Initial model validation showed that the best results occurred when skies were clear, ground moisture was low and winds were low. These conditions were labeled "Ideal Cases" or just "Ideal". All other cases were called, "Non-Ideal".

In 2001, the ST Forecast Model was brought to an alternate mid-latitude, southwestern USA, desert location. During this model validation, the Ideal cases again proved highly successful. Other results included empirically identifying three ST patterns: a Single, Extended and Multiple ST. The Single ST occurred during the Ideal cases and had a duration ranging from less than a minute to several minutes. Extended and Multiple ST occurred during Non-Ideal cases. The maximum duration was over 20 minutes. Though it is still not proven, the Extended ST appeared to be primarily associated with moist desert soil. The Multiple STs were generally associated with morning (or evening) clouds that would occult the solar disc, thus interrupting the rate of surface heating/cooling. Cirrus clouds were particularly influential in the Multiple ST scenarios. Thus, the ST definition was no longer limited to just a transition between day/night unstable and stable conditions, but included intermittent and temporary 'neutral' atmospheric conditions. The ST Forecast Model's goal, to determine the time of the final day-to-night and night-to-day transitions, remained. While the current data analysis includes information for these other NE types, the consistency of the Single NE seasonal algorithm begs the question of latitudinal dependency. Understanding how the ST event comes about is a key factor in answering the dependency question. In the next section, we will briefly highlight two possible explanations for the cause of a ST.

2. Stability Transition

Traditional thinking explains the mid-latitude desert ST as follows: Under clear skies, nighttime radiative cooling generates a surface temperature inversion. The depth of this inversion tends to be a function of the cooling time and general surface air mass temperature. When the sun rises under clear skies, the ground warms and begins to convectively heat the air mass above it. The temperature inversion subsequently decays until the once stable surface air mass becomes unstable. A pictorial summary of this cycle is found in *Meteorology for Scientists and Engineers* (Stull, 2000).

An alternate perspective is that the surface neutral conditions result from the mixing down from a temperature-contrasted air mass. This concept would fit nicely in the arctic environment where the snow surfaces provide little surface heat for convection, yet stability transitions are still observed.

With the 12-month Optical Turbulence Study in Barrow Alaska, we hope to quantitatively define near-surface arctic ST patterns and offer possible explanations for these patterns. The next section describes the ongoing field test for executing this investigation.

3. UPOS: Optical Turbulence Study Field Test

The University Partnering for Operational Support [UPOS] joins the Army Research Laboratory [ARL] with the University of Alaska Fairbanks [UAF] on the *Characterization of Optical Turbulence in the High Latitude Atmosphere* (a.k.a. *UPOS: Optical Turbulence Study*) Project. Our primary sensor is a Reciprocal-Path ScinTech BLS-900 Scintillometer System. The BLS-900 sensor emits a light pulse in the near-infrared part of the spectrum (880 nm). The light traverses an approximately 900m near-surface horizontal path, and is then detected by a receiver at the far end of the path. After processing the received signal, the optical turbulence over the entire path is quantified in the form of an index-of-refraction structure-function, C_n^2. To ensure high data confidence, an identical BLS-900 system simultaneously acquired data along side the initial path, but views the same path in the opposite direction. A single computer receives the data from this reciprocal path sensor system. See Figure 1.

The selected horizontal path is located in Barrow Alaska, with endpoints that include the Atmospheric Radiation Measurement Project's Skydeck (attached to 'the Great White' trailer) and the Air Force Dewline Microwave Tower. See Figure 2.

Additional standard meteorological parameters will be simultaneously collected. The data acquisition is scheduled for 12 months at 24 hr/day, 7 days/week. Sampling will be reduced to 1-minute averages.

4. Latitudinal Dependency?

At the time of this writing, the sensors were installed and being checked. Our hope is to include some of our preliminary finding in the 2005 January presentation.

One question we hope to answer is whether there is a latitudinal dependency in the ST timing. Previous mid-latitude desert-sites studies discovered that under Ideal conditions, the minimum monthly-averaged time between sunrise and the ST occurred in the equinox months: March and September. The maximum monthly-averaged time between sunrise and ST fell in the solstice months of June and December. See Figure 3. The cyclical pattern for the evening ST was not as well behaved.

One explanation for these minimum and maximum sunrise-to-ST patterns starts by considering a 24 hr perspective. During the equinox, there is an even amount of heating/cooling within the 24 hr cycle. Thus, the surface temperature inversion developed overnight would be of a minimal depth. The solstice period is characterized by a skewed 24-hr heating / cooling pattern. Therefore, these conditions might suggest the potential for a deeper surface inversion at sunrise. With a deeper inversion, the time taken for the surface heating to 'decay' the inversion and create an unstable environment would be longer than the equinox scenario (which starts with a shallower surface inversion).

Converting the seasonal explanation into a modeling algorithm, ST would be a function of solar heating (which is latitudinally dependent) and the local surface temperature inversion depth.

5. Summary

The UPOS joins ARL and UAF in the *Characterization of Optical Turbulence in the High Latitude Atmosphere* Project. This project is aimed at determining whether a latitudinal dependency exists in forecasting atmospheric optical Neutral Events (a.k.a. stability transitions). Mid-latitude near-surface horizontal atmospheric optical turbulence measurements have been analyzed resulting in an empirically derived ST Forecast Model. Under Ideal cases, this model has been successfully validated. A strong seasonal dependency is evident in this mid-latitude model. By re-creating the mid-latitude atmospheric optical turbulence field test in Barrow Alaska, the authors intend to quantitatively define the near-surface optical turbulence pattern over high latitude 'land', and determine if a latitudinal dependency exists in the seasonal variations of this daily pattern. At the time of this writing the sensors for this field test were installed on the ARM and Air Force sites in Barrow, Alaska. Twelve months of 24 hr/7 days per week acquisition was scheduled to begin in October 2004.

REFERENCES

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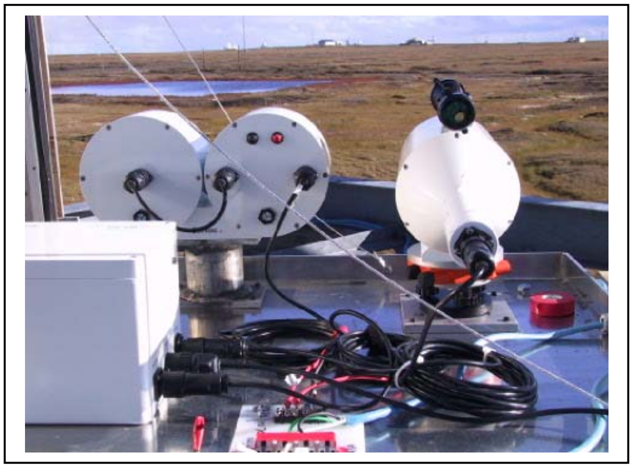

Figure 1. Reciprocal Path BLS-900 Scintillometers mounted at the ARM site in Barrow, Alaska.

Figure 2. View along horizontal path from Barrow Alaska Dewline Towers to ARM ‘Skydeck’ building on the distant horizon.

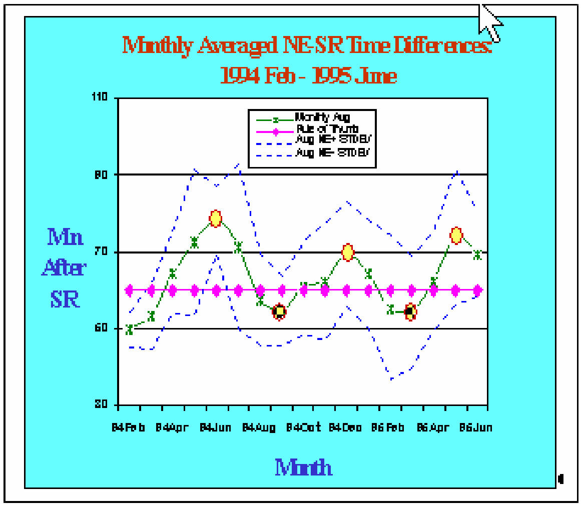

Figure 3. Monthly-averaged Neutral-Event-to-Sunrise time differences over a 16-month period at a mid-latitude, southwestern-USA, desert site. Maximum minutes after sunrise [SR] occurred in June and Dec, and are indicated by yellow-filled circles. Minimum minutes after SR occurred in March and September. Checkered circles highlight the minima.

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