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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
NATIONAL METEOROLOGICAL CENTER

OFFICE NOTE 389

THE NATIONAL METEOROLOGICAL CENTER'S HISTORICAL 36- (30-) HOUR S1 SCORE RECORD

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INTRODUCTION

The S1 score record at the National Meteorological Center (NMC) dates back to 1947 when 30-hour mean sea level (MSL) verification started. Thirty-hour refers to the length of the forecast from the time of the latest surface analysis to the verification hour. During this early period, these analyses were at 0630Z (=UTC) and 1830Z, the synoptic hour closest to radiosonde observations taken at 0300Z and 1500Z; verification time was at 0030Z and 1230Z.

The score was designed by Teweles & Wobus (1954) to evaluate forecast ability of NMC meteorologists and identify difficult weather situations for future study. The S1 score is defined

$$S1 = 100. \frac{\sum |err|}{\sum |Grad|} \qquad (1)$$

where, err = error in the forecast gradient
Grad = observed or forecast gradient, whichever is greater

It is a single score, simple to calculate and use; it utilizes a very significant element, pressure gradient, of the prognosis. Normalization by the maxima of observed or forecast pressure gradient stabilizes the score since pressure gradient forecast errors are strongly influenced by seasonal differences in the strength of weather systems; in addition, it encourages true forecasting while penalizing hedging or over-conservativeness.

The verification area originally selected was 20-60 degrees north latitude and 50-160 degrees west longitude; shortly thereafter this was changed to 25-60 degrees north and 55-145 degrees west. The top portion of Figure I is a reproduction of the network from a figure in the Teweles & Wobus paper.

The average distance between stations or points used in the network is 350 miles; the range is 270-525 miles. Only one point, on the southern tip of James Bay, is used in computation for four different gradient directions; thirty six locations are used in only one computation and the rest of the 108 locations are used in two computations apiece.

Mean sea level pressure at network locations were read to the nearest millibar and S1 scores rounded off to the nearest whole number. A seasonal monthly adjustment, the difference between individual monthly means for a number of years and the overall mean value for the same period, was applied to the S1 score; adjustment was made to the nearest tenth. Seasonal adjustment has varied with changes to the averaging intervals used.

In 1964, the verification area was converted to a five-degree latitude by ten-degree longitude grid of 49 points, a subset of the 63 points within the 25-55 degree north and 65-145 degree west region. This network is shown in the middle portion of Figure I. In contrast with the older grid, there are twenty-six interior locations that are used in four gradient computations; nine and fourteen of the exterior points are used two and three times in computations respectively. Misreading of forecast and observed fields more adversely affects the 49-point set than the Teweles & Wobus set S1 scores.

The difference in MSL S1 scores computed on the two sets average about two and one-half points; higher scores were found using the 49-point network. Therefore, beginning in 1964, in addition to seasonal adjustment, a two and one-half point change in grid adjustment was deducted from the new network scores.

The Primitive Equation (PE) model was introduced in July 1966; the PE 36-hour S1 score is not adjusted seasonally, only for the change in grid. The 36-hour designation was adopted in the mid 1950s when radiosonde observation time was changed to 0000Z and 1200Z; it refers to the length of the forecast from coincident surface synoptic and radiosonde observation times to the verifying hours of 0000Z and 1200Z.

In January 1968, all MSL S1 scores were calculated to the nearest tenth of a point even though gridpoint pressures continued to be read to the nearest whole millibar. Finally, in January 1973, seasonal adjustments to manual forecast scores were eliminated.

The 500MB S1 score, in contrast with the MSL S1, was not computed directly from forecast gradients prior to 1978. Instead, it was estimated from monthly root-mean-square (RMS) geostrophic wind statistics averaged over NMC verification grid area 1 (see bottom of Figure I). The formula used is

$$S1 = 100. \frac{\text{RMS vecerr}}{\text{RMS wndspd}} - 4.5 \qquad (2)$$

where, vecerr = vector error of the geostrophic wind
wndspd = geostrophic wind speed analysis value

The subtractive constant was determined from comparison of parallel computations using actual gradients on the 49-point grid.

Beginning in October 1975, a completely automated program to compute MSL S1 scores was initiated (van Haaren 1978); gridpoint values are no longer restricted to whole numbers. On average, the difference between scores computed from whole numbers and actual values is less than one point; maxima are less than three S1 points and of either sign.

Shuman (1989) has described the progress of forecasting at NMC with respect to changes in forecast and analysis systems and computers. Here, the emphasis is on three periods: 1) pre-PE model, 2) the man-machine mix era (man plus PE), and 3) Spectral (SPEC or SPECTRAL) model period. All forecasts in the pre-PE model era are referred to as manual (MANUAL) or man (MAN). The following sections describe the data, estimates of skill, and application of the S1 in evaluation for all eras.

THE HISTORICAL S1 SCORE RECORD

A. THE DATA

Table I is the official NMC 36- (30-) hour MSL S1 score record from June 1947 thru December 1991. Average monthly, seasonal, and annual values are presented. Seasonal and annual averages are derived from weighted monthly values. The MANUAL period is from June 1947 thru February 1975 and the numerical model era from October 1975 thru December 1991. S1 score was computed on the Teweles & Wobus grid from 1947 thru 1963 and on the 49-point lat-lon grid thereafter.

Table II is the NMC 36-hour 500MB S1 score record from June 1954 thru December 1991; the format is the same as Table I. S1 scores from June 1954 thru December 1977 are estimated using equation 2. After December 1977, 49-point S1 scores are calculated from gradients using equation 1.

Table III is the barotropic (BARO) model 500MB forecast scores, January 1966 thru December 1991; the format is the same as Table I. During the period, January 1966 thru December 1975, S1 scores are computed, as the 500MB forecasts, using equation 2.

B. ANNUAL AVERAGE S1 SCORE

Figure II is the average annual 36- (30-) hour S1 score record thru 1991, at MSL starting from 1948 and at 500MB beginning with 1955; data are from Tables I and II. The beginning of official numerical model scores is delineated, starting with the PE model in in 1975 and SPECTRAL model in 1980. Despite all the vagaries in the S1 score record described in the Introduction, the long term trend is decreasing (improving) scores with the most significant changes occuring during major analysis and forecast system changes in the operational suite. The MSL record is distorted by the jump in values in 1974 after the adjustment for change in verification grids was eliminated.

C. S1 SCORES BY VERIFICATION PERIODS

The S1 score record, Tables I, II, and III, can be divided into several verification periods. These periods are:

1. June 1947	- June 1966	MAN (MSL)
June 1954	- June 1966	MAN (500MB)
2. July 1966	- February 1975	MAN, PE
3. October 1975	- July 1980	PE
4. August 1980	- December 1991	SPECTRAL

Note again that the official PE period begins in October 1975.

Section A of Table IV is a summary of monthly averages for these verification periods. This data is plotted in Figure III. December is plotted as the first month in order to display months by seasons. The MSL record is shown on the top half and 500MB on the lower half of the figure; a solid line is used for MAN and long dashed lines for model scores; BARO model averages are plotted as short dashed lines.

Manual MSL monthly averages are nearly the same for all months because of the seasonal adjustment used by Forecast Division (FD, currently the Meteorological Operations Division). During period 2, MANUAL scores are much better than PE values and, except for summer, follow the seasonal variation in model scores. During the official PE model era, period 3, averages are comparable to period 2 MANUAL averages; note that a fine-mesh version of the PE was introduced in January 1978 (see Table I 1978 scores). Monthly means during the SPECTRAL model period are very good; however, there is a larger seasonal variation with poorest scores during the summer season.

The trend in the monthly record at 500MB is similar to MSL with large improvement in forecast quality evident with the introduction of numerical products. BARO forecasts also benefit as analysis and forecast (first guess fields used by analyses) systems improve.

SKILL SCORES

A. NMC EMPIRICAL SKILL SCORE

During the 1960s, FD defined a near perfect MSL and 500MB S1 to be 30 and 20 respectively. These values were determined from a test devised to find a minimum calculable S1; the test involved an objective non-meteorological reading of data at grid points by two technicians. The S1 score calculated from the two sets of values, one set used as forecast and the other as observed data, was accepted as the minimum possible score; such low values of S1 were not observed in the verification records at that time.

As discussed in the Introduction, interior points of the 49 point grid affect the computation of gradients in four directions. A slight difference in gridpoint values between two readings will generate a large difference in score. For example, for 1991 data (not shown), the S1 score calculated from Limited Area Fine Mesh analysis used as forecast and Nested Grid Model analysis used as observed, had monthly average MSL values of from 12 to 17 points; maxima were in the lower 20s and minima slightly less than ten; at 500MB, monthly means were from three to six points lower.

Using FD's conception of perfection as well as the subjectively derived (FD) S1 values of 80 and 70 as useless forecasts at MSL and 500MB respectively, the S1 score can be transferred into an empirical skill score by

$$\text{EMPIRICAL SKILL} = 100. \frac{U - S1}{U - P} \qquad (3)$$

where, U = useless forecast
P = perfect forecast

In part i of section B, Table IV, NMC empirical skill scores for MSL and 500MB are presented. Seasonal data is given by verification periods and include BARO forecasts; average annual scores are also given. NMC empirical annual skill for SPEC forecasts at 500MB is nearing perfection during cool months; from Table II, S1 scores for individual months during the past four years have exceeded NMC's estimation of perfection.

The top half of Figure IV is a graph of seasonal NMC empirical skill, by verification periods, from data presented in Table IV. The magnitude of skill levels is rather high; note the skill level of BARO forecasts.

B. NMC SKILL SCORE

Using average monthly MAN S1 scores during the pre-model era, period 1 (see Table IV), a skill score can be defined

$$\text{NMC SKILL SCORE} = 100. \frac{S1 - S1man}{S1p - S1man} \qquad (4)$$

where, S1man = average MAN score
S1p = perfect forecast

Here, a perfect forecast has a S1 score of zero. This NMC skill score (NMC SKILL) is skill relative to historical MANUAL products. These scores are summarized in part ii of section B, Table IV; the format is the same as that used in part i for the NMC empirical skill score.

The lower half of Figure IV are graphs of seasonal NMC SKILL by verification periods. Both graphs are similar to the NMC empirical skill graphs in the top half of Figure IV since monthly MAN scores are nearly identical for each month. NMC SKILL values at MSL and 500MB are more than 40 points lower than NMC empirical skill scores; more important, however, is the removal of the arbitrary "perfect" and "useless" standards. Model skill relative to pre-model averages are better at 500MB than at MSL; SPECTRAL model skill at MSL is nearly double that of the PE model.

Figure V is a graph of the average annual, MSL and 500MB, NMC SKILL record. The increase in skill begins in the early 1960s when numerical products were first introduced (see Shuman), thru the early PE model years, and into the SPECTRAL model period.

NUMERICAL MODELS AND THE S1 SCORE

The Teweles & Wobus S1 score was designed to evaluate forecast ability. It was used to "handicap" meteorologists; the competitive atmosphere helped maintain skill levels of the better forecasters and raised the competence levels of the poorer or less experienced forecasters. The addition of numerical products introduced another element into the forecast environment. The original intent of the S1 score is altered somewhat; two examples are discussed below.

A. MAN-MACHINE MIX

When numerical forecasts were first introduced, forecasters considered them as competitors; the emphasis was on "beating" the machine. As numerical products improved, there was a shift to a man-machine mix concept, a cooperative effort to produce the best forecast.

The PE model was introduced in July 1966; from July 1966 thru February 1975, period 2, the man-machine era, MAN forecasts were the official NMC forecast. S1 and skill scores for this interval are found in Table IV, plotted in Figure III and IV, and discussed in the previous two sections. Both skill score graphs, Figure IV, clearly show the contribution by MAN described by Shuman; furthermore, Shuman also notes that, in 1971, the five point improvement in MSL S1 contributed by the forecaster translated into five years of progress in forecasting.

Better S1 scores can certainly be used as an indicator of improved forecast performance; however, in assessing the contribution by the forecaster to a machine product, the role of the forecaster in the man-machine scheme must be evaluated as to where that contribution was made. The best forecaster in this effort is one who makes the largest improvement when the model forecast is poorest and least or none when the model is best.

Table V summarizes individual forecaster versus PE S1 scores for the one year period from December 1972 thru November 1973. The five forecasters making the greatest number of forecasts are evaluated. In section A of Table V, total number of forecasts, average forecaster and PE scores, and differences (improvement) are given. There are four meteorologists within one-half S1 improvement points, 3.5 to 4.0, of each other. Since S1 is calculated using pressure readings to the nearest whole millibar, the one-half point difference in average improvement is not significant. Then, are the forecasters of comparable ability, all equally suited to their role in the man-machine mix? To answer this question the verification record must be further analyzed.

There are two 36-hour forecasts produced daily, one from each of the 00Z and 12Z analysis and forecast cycles. MAN forecast from the 00Z model guidance, verifying at 12Z, was exclusively the product of one individual; however, for the 12Z cycle, forecast verifying at 00Z, the prognosis is initiated by one forecaster, but completed by and credited to a second forecaster on a succeeding shift.

In order to assess individual forecaster ability it is necessary to differentiate between the two verifying times. In section B of Table V, evaluation is separated into forecasts verifying at 12Z (one forecaster) and 00Z (two forecasters). In addition, since meteorologists, unlike numerical models, rely on and build upon past forecast experience, data in section B are limited to forecast shift sets of four, five, and six consecutive days; forecasters are not as comfortable nor confident on irregular shifts of only one or two days. Long intervals of time between forecast shifts are also a disadvantage; for even longer periods, for example, Teweles & Wobus re-handicapped individuals starting at zero whenever they resumed forecasting after a lapse of six months.

For forecasts verifying at 12Z, there is a large range in improvement made; forecaster IV averages 4.4 points while the next highest is forecaster II with 3.0. This is quite different from the total for all cases in section A. In addition, forecaster IV's improvement is positive for all forecast sets, and the correlation between improvement and PE S1 score (CORCOF) is very large; this forecaster has very desirable qualities in the man-machine mix.

Forecaster V also has positive improvement for all sets, however, the range in improvement is small; there is no important correlation associated with improvement and quality of the PE forecast. The remaining three forecasters have good CORCOF although average improvement by forecaster III is rather small. The good CORCOF and appearance of negative set improvement indicate that forecasters I, II, and III continue to modify good (low S1 scores) model forecasts unnecessarily; this is either a lack in ability to recognize the quality of guidance or a failed attempt at maximizing improvement. For forecasts verifying at 00Z, forecaster characteristics are quite different. Overall, the two forecaster effort, lowers CORCOF and with the exception of forecaster IV, increases improvement; all but the best forecaster benefits. Forecaster V profits greatly, average improvement is large and CORCOF increases. Although there is a general increase in improvement by FD for forecasts verifying at 00Z, the desirable characteristic of concentrating improvement with poor numerical model guidance is not enhanced using more than one forecaster; successful prediction in the most difficult weather situations is definitely not in the purview of a great majority of of meteorologists or numerical models.

These results show that there are important differences between forecasters that are not readily apparent in the average improvement scores in section A of Table V. Here, it should be pointed out that forecaster V was the least experienced with only five or six years at NMC during this period; the remaining four forecasters had varied but considerable experience at NMC during pre-model years. The best forecasters in the early years are still the best suited for the man-machine era. That this distinction was not recognized nor sought is the fault of the designer of the evaluation system. The concluding sentence in Teweles & Wobus states, "There can be little excuse for a lack of effort to design reliable verification systems or for scheduling personnel without regard to the results of such systems when they are available."

B. ALTERNATIVE S1 SCORE

Teweles & Wobus used the greater of the forecast or observed gradient in the design of the S1 score (equation 1) to encourage bold forecasting and deter conservatism. A strategy for optimizing the S1 score by over predicting gradients was documented by Thompson & Carter (1972). The question raised in that paper, whether experienced forecasters "played the game" of minimizing the S1 score, is no longer relevant. However, for numerical models, systematic tendencies that contribute to the enhancement of gradients can lead to scores that are not consistent with forecast performance.

An S1 score can be defined using only the analyzed gradient (S1t) in the denominator of equation 1. In Table VI, S1t is compared with the conventional S1 score (S1x) for period 5, the interval between December 1988 and December 1991; S1x averages for the entire SPECTRAL era, period 4, are also included. For MSL and 500MB, section A is the average monthly score, section B is the average seasonal NMC SKILL, and section C, which includes BARO values, is a summary of the seasonal SPECTRAL record.

During 1991, at MSL, SPECTRAL model monthly average of the daily ratio, sum of forecast gradient to sum of analyzed gradient (not shown), was greatest during summer and spring, 1.05 to 1.10, and least during autumn and winter, 1.01 to 1.03. At 500MB, the monthly average ratio is near or slightly less than one in winter and autumn and near or slightly greater than one in spring and summer.

The top half of Figure VI is MSL and 500MB plots of monthly values from Table VI; the lower half of Figure VI is seasonal NMC SKILL for periods 4 and 5. At MSL, using S1t, there is a 27% reduction in skill during winter and autumn, 37% in spring, and 42% in summer. At 500MB, NMC SKILL using S1t values are about 9% smaller in winter and autumn and 14-17% less during spring and summer.

The SPECTRAL model tendency of consistently overforecasting MSL gradients contributes to an inflation of model skill levels. This characteristic is weaker at 500MB.

Difference in S1 score due to S1x and S1t type calculation are noticeable in the early years of the 500MB record. Recall that the denominator in equation 2 used the mean analyzed geostrophic wind value. In the bottom half of Figure III, note the difference between BARO period 2 and 3, and MAN period 2 (early PE) versus PE period 3. Figure IV skill score graphs also illustrate these differences. The subtractive constant used in equation 2 is not sufficient to totally compensate for the difference in calculation.

CONCLUDING REMARKS

The historical S1 score record traces the progress of weather prediction at NMC. Although the original intent was to evaluate MAN forecasts, it is still useful in the verification of numerical models.

The S1 is a simple score and only a minor adjustment to the choice of gradient used would make it better suited for numerical model evaluation. Also, for consistency with current operational models, it is necessary to modify the verification network to a finer mesh than the five degree latitude by ten degree longitude grid. Finally, it is also necessary to monitor a longer forecast period than 36 hours.

The above, of course, will be done in addition to maintaining the 49-point record.

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Teweles, S., and H. Wobus, 1954: Verification of prognostic charts. Bull. Amer. Met. Soc., 35, 455-463.

Thompson J. C., and G. M. Carter, 1972: On Some Characteristics of the S1 Score. J. Appl. Meteor., 11, 1384-1385.

van Haaren, R. J., 1978: Comparative Verification of the National Meteorological Center's (NMC) Operational Forecast Models. Preprints, Conference on Weather Forecasting and Analysis and Aviation Meteorology, October 16-19, 1978, Silver Spring, MD. (AMS).

I

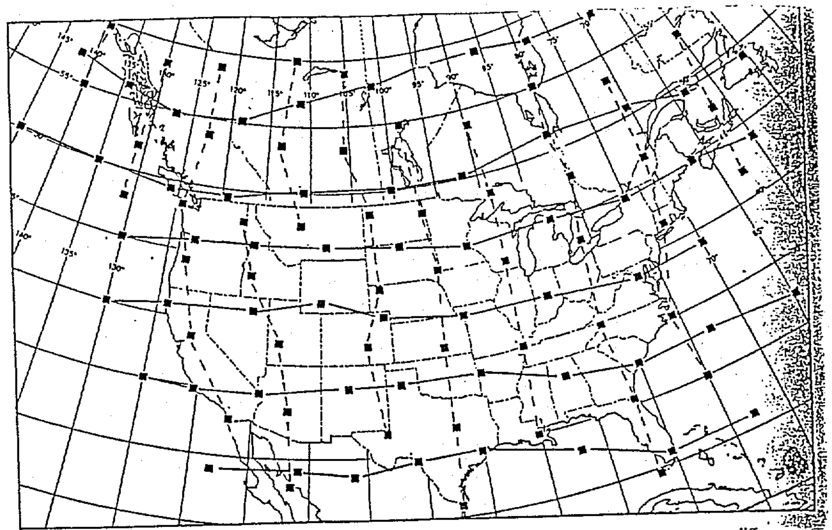
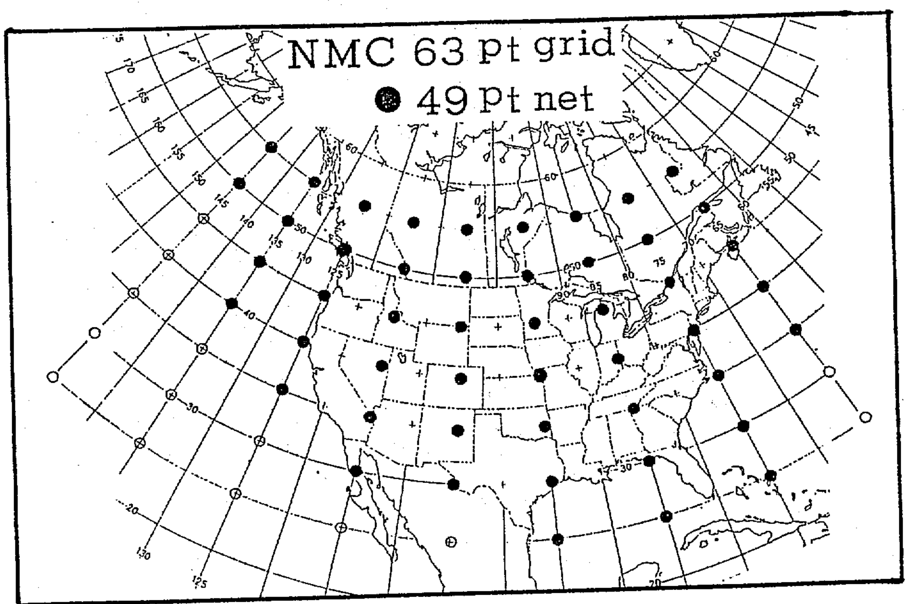
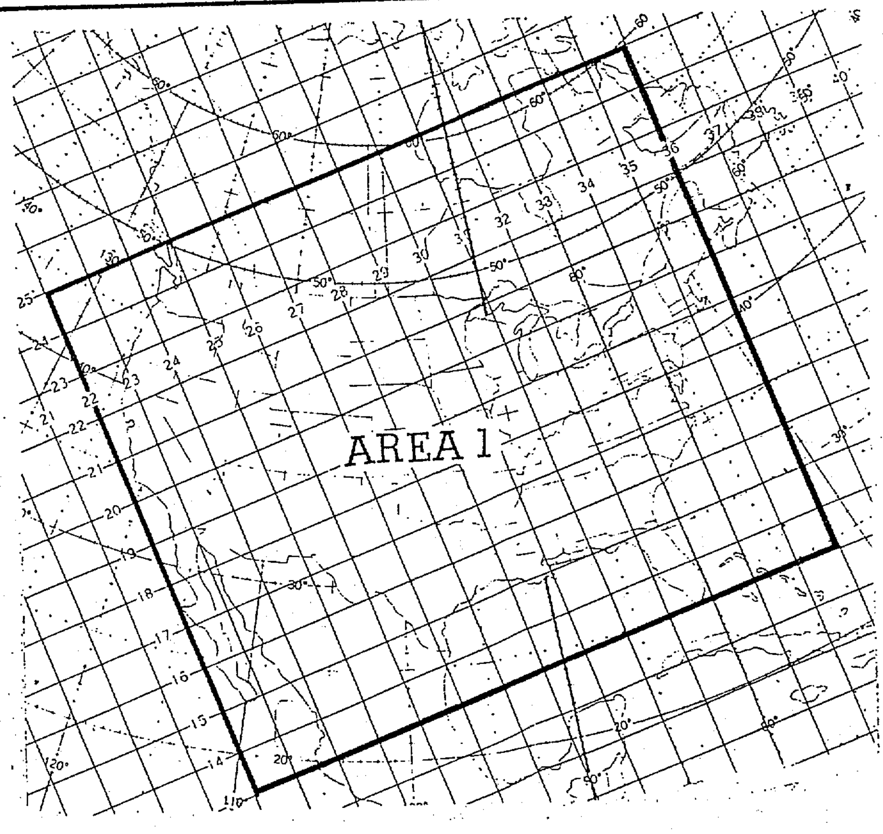
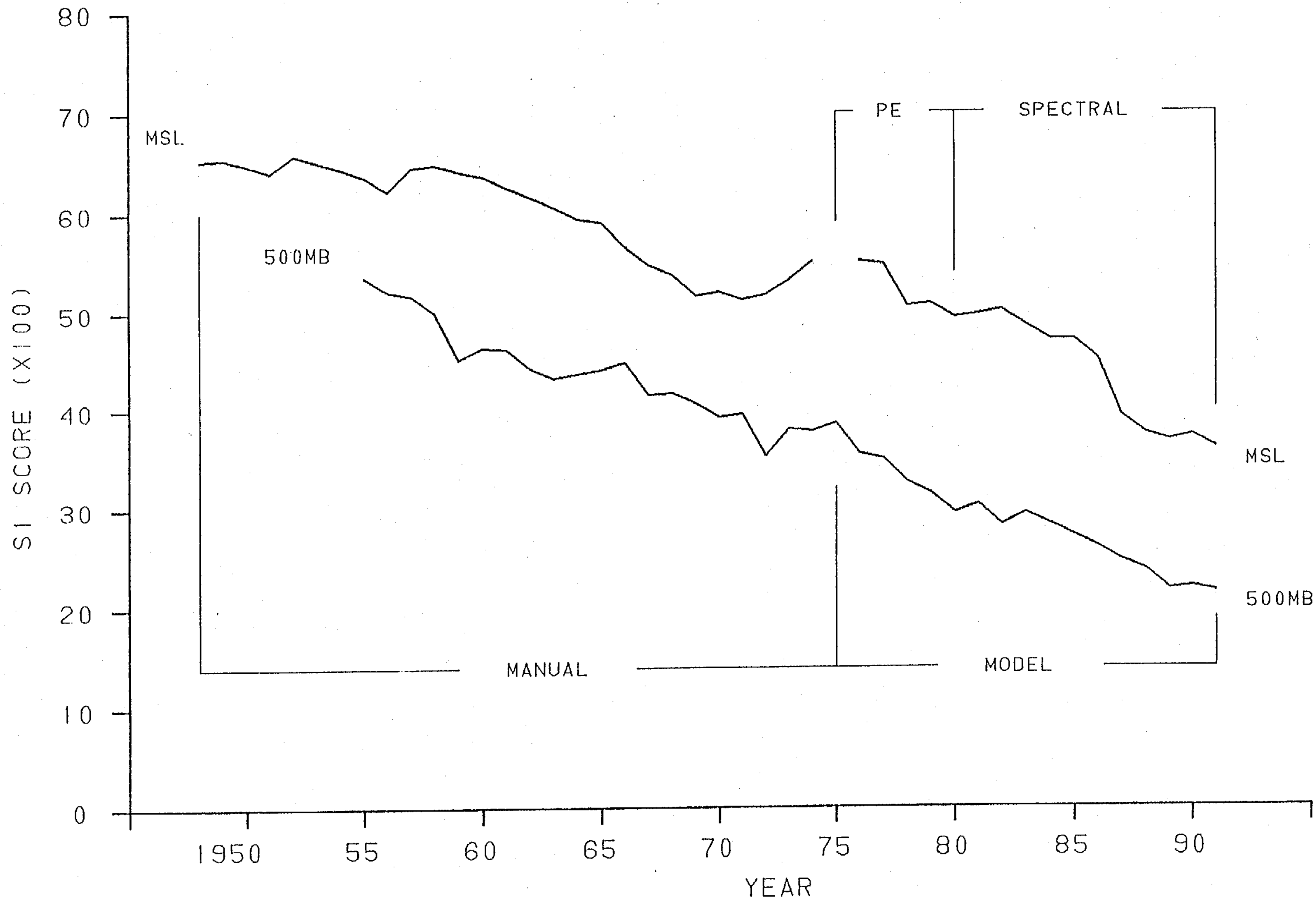


FIG. 1. The grid of points at which sea level pressures are read off for use in verification. Pressure differences are computed between points joined by a full or dashed line.

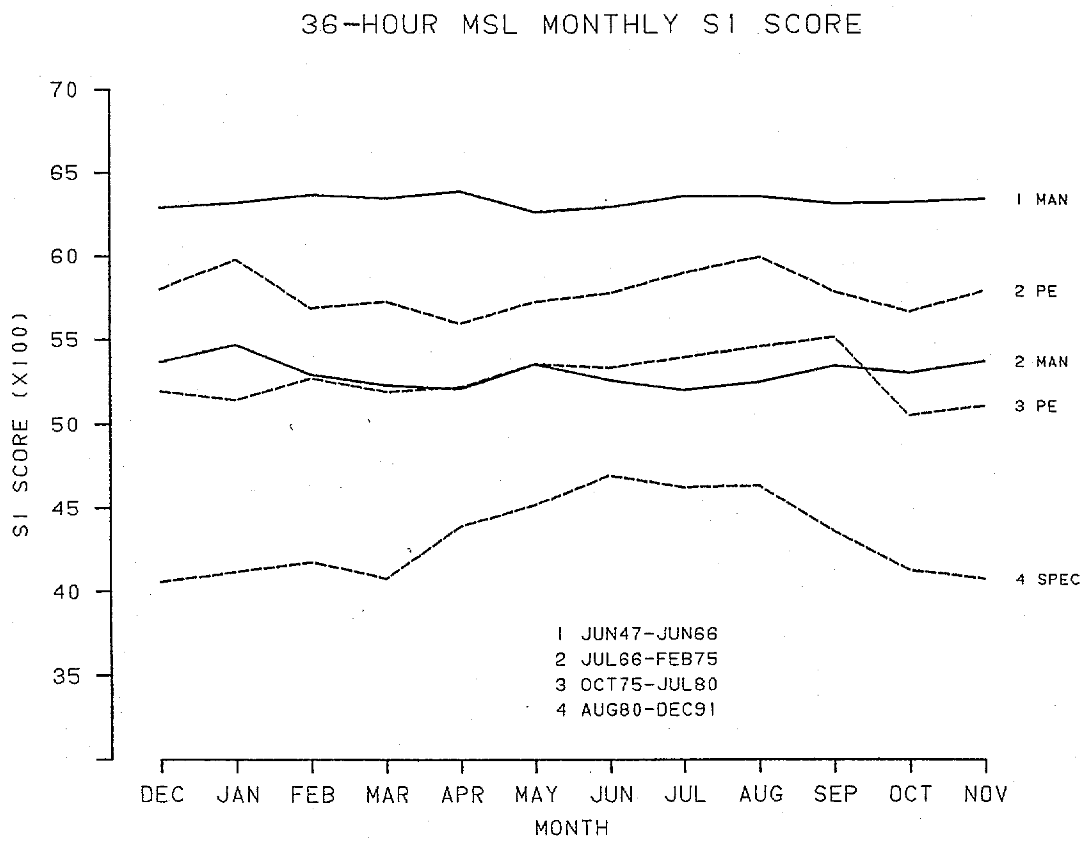


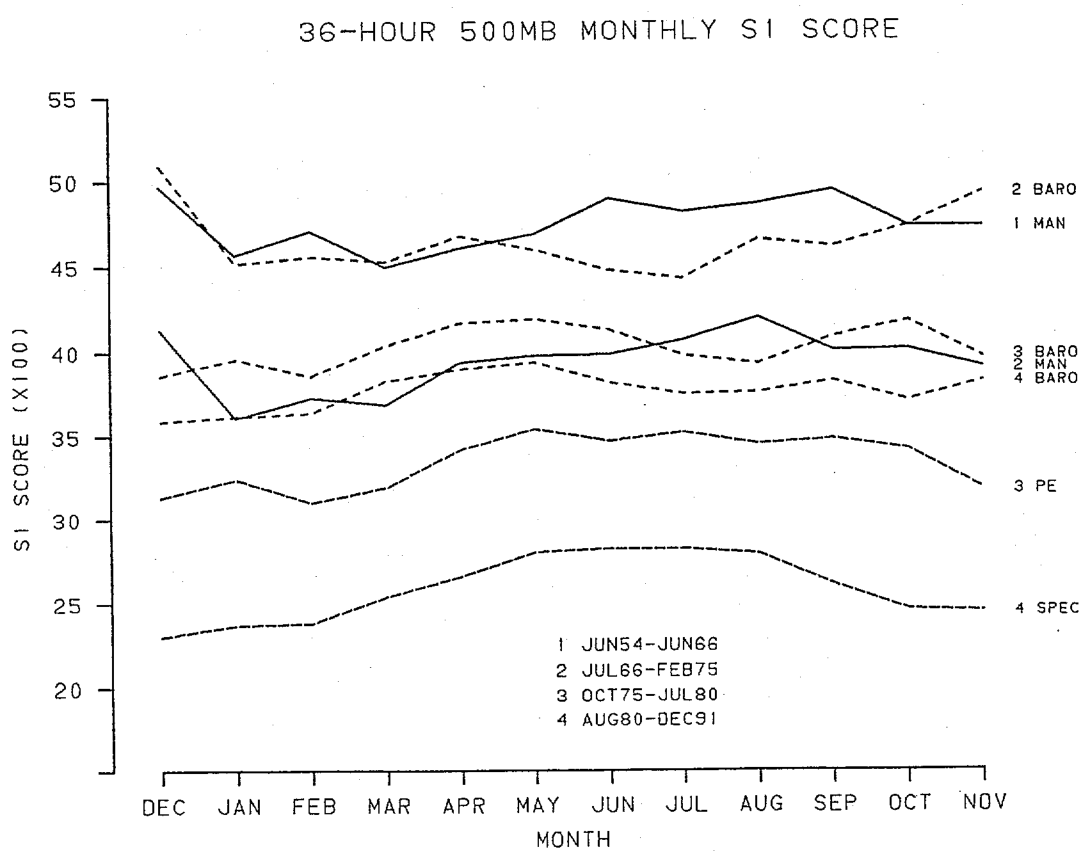


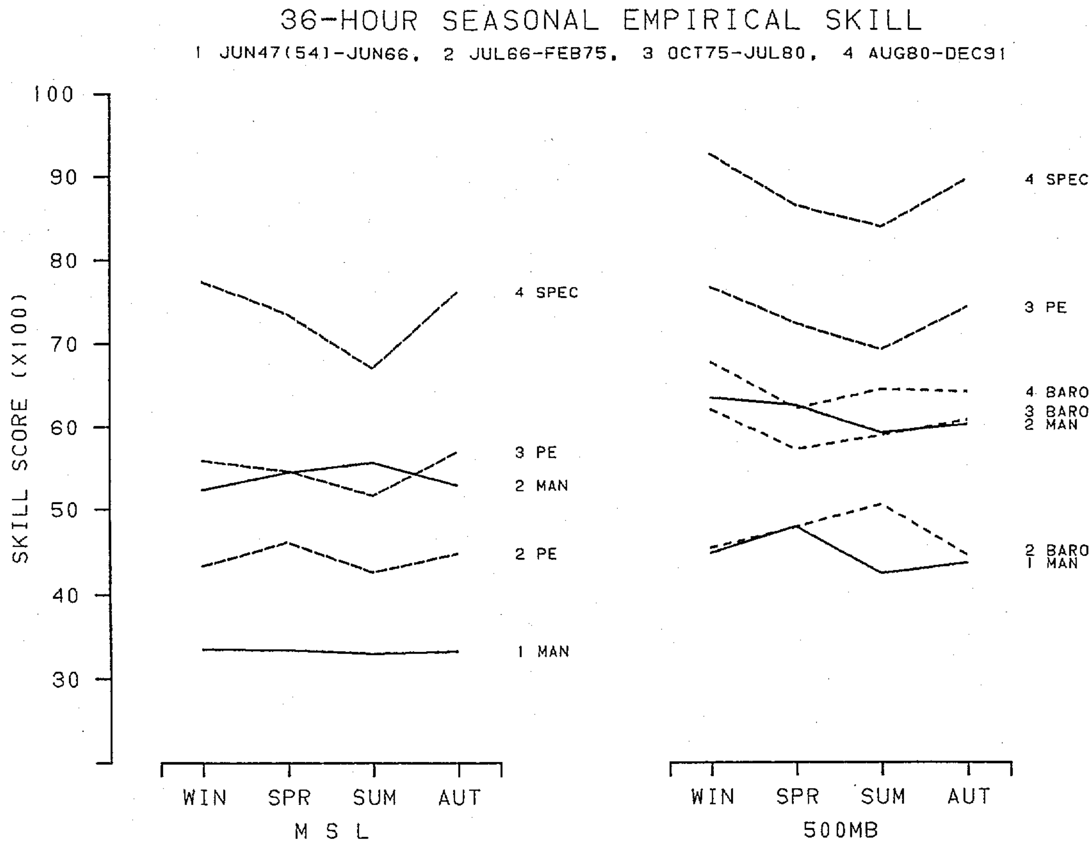
36-HOUR AVERAGE ANNUAL S1 SCORE

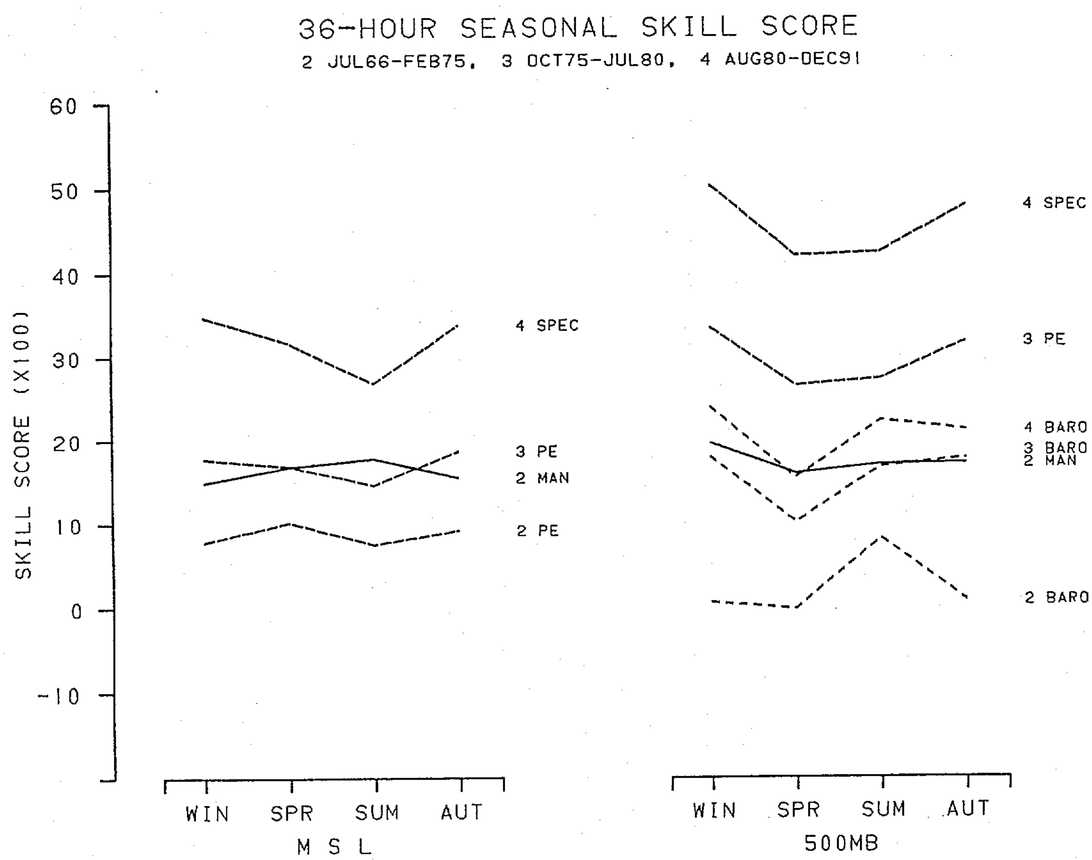


III


36-HOUR MSL MONTHLY S1 SCORE
S1 SCORE (X100)
70
65
60
55
50
45
40
35
1 MAN
2 PE
2 MAN
3 PE
4 SPEC
1 JUN47-JUN66
2 JUL66-FEB75
3 OCT75-JUL80
4 AUG80-DEC91
DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV
MONTH

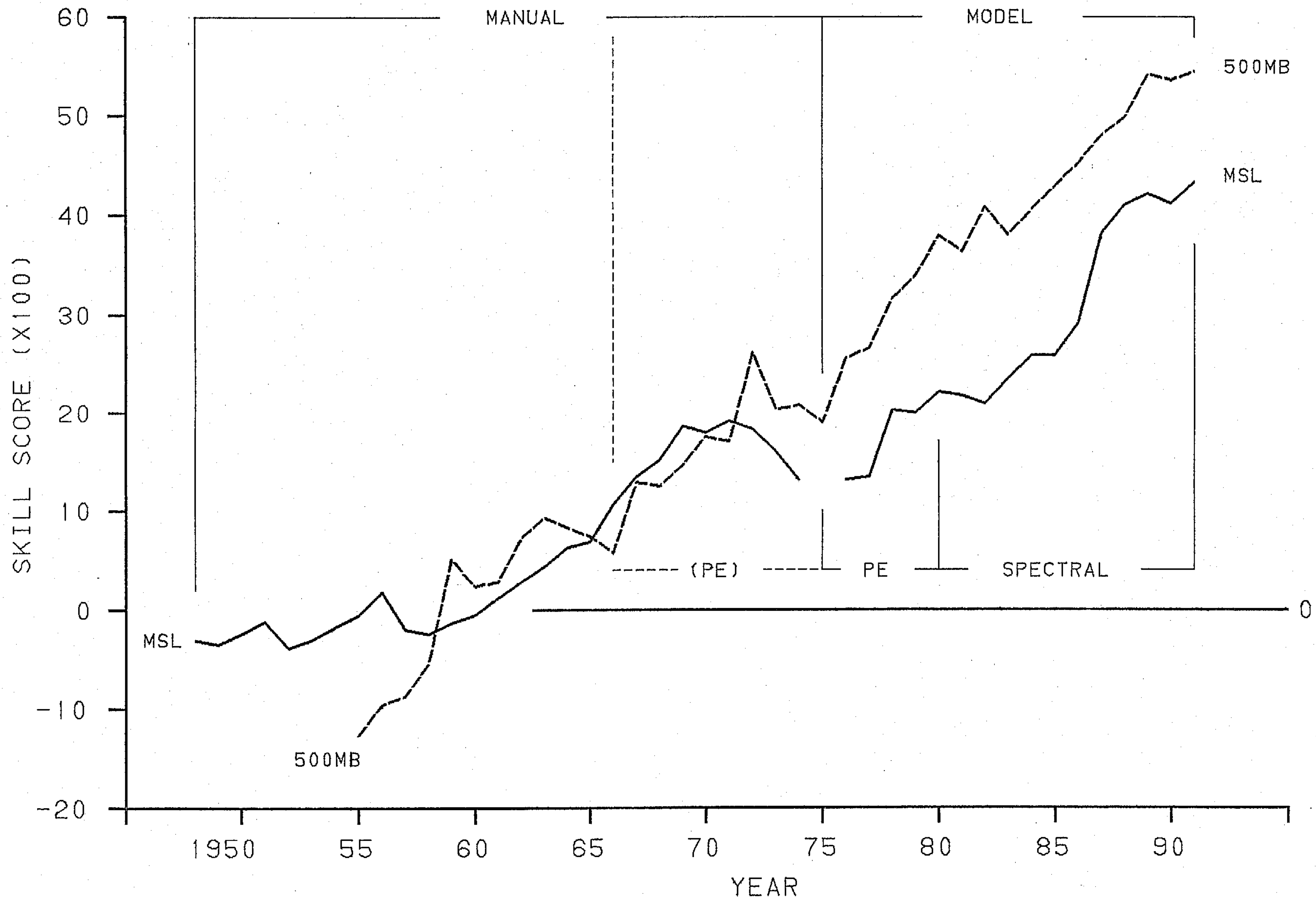

36-HOUR 500MB MONTHLY S1 SCORE
S1 SCORE (X100)
55
50
45
40
35
30
25
20
2 BARO
1 MAN
3 BARO
2 MAN
4 BARO
3 PE
4 SPEC
1 JUN54-JUN66
2 JUL66-FEB75
3 OCT75-JUL80
4 AUG80-DEC91
DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV
MONTH

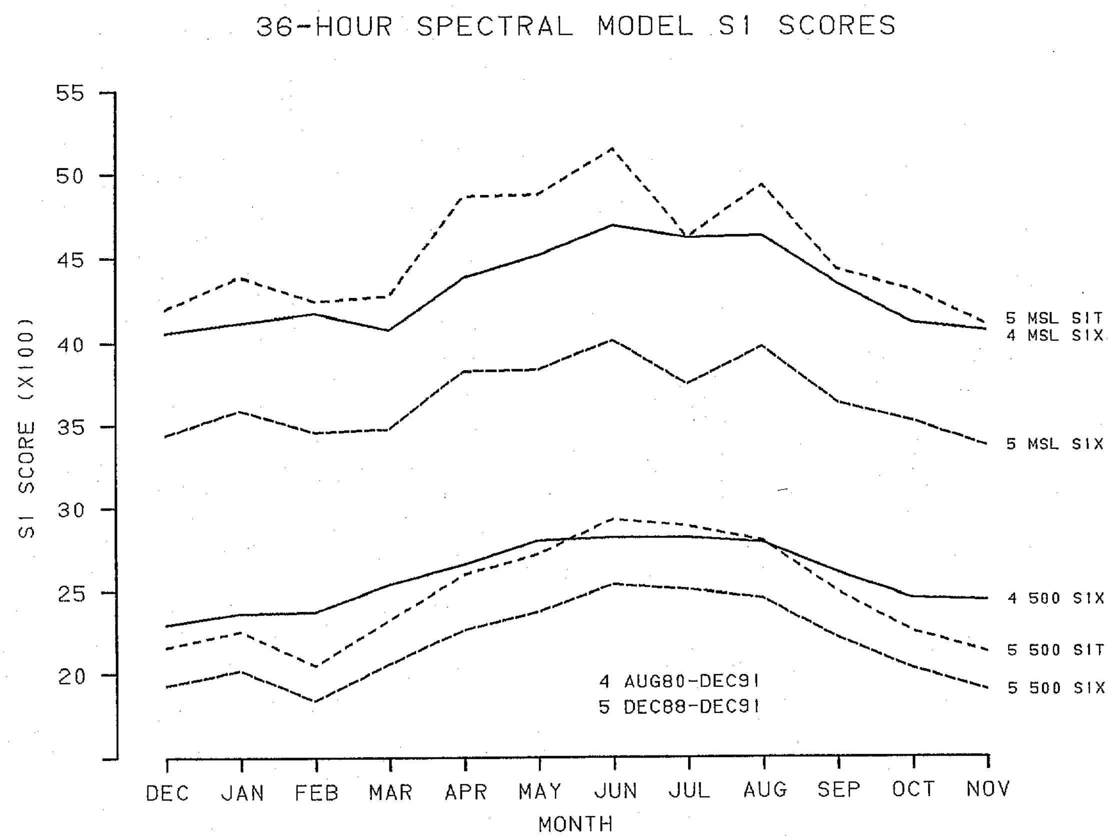

36-HOUR SEASONAL EMPIRICAL SKILL
1 JUN47(54)-JUN66, 2 JUL66-FEB75, 3 OCT75-JUL80, 4 AUG80-DEC91
SKILL SCORE (X100)
100
90
80
70
60
50
40
30
4 SPEC
3 PE
2 MAN
2 PE
1 MAN
4 SPEC
3 PE
4 BARO
3 BARO
2 MAN
2 BARO
1 MAN
WIN SPR SUM AUT
M S L
WIN SPR SUM AUT
500MB


36-HOUR SEASONAL SKILL SCORE
2 JUL66-FEB75, 3 OCT75-JUL80, 4 AUG80-DEC91
SKILL SCORE (X100)
60
50
40
30
20
10
0
-10
4 SPEC
3 PE
2 MAN
2 PE
4 SPEC
3 PE
4 BARO
3 BARO
2 MAN
2 BARO
WIN SPR SUM AUT
M S L
WIN SPR SUM AUT
500MB

36-HOUR AVERAGE ANNUAL SKILL SCORE

S1 SCORES THRU JUN66 AS STANDARD




36-HOUR SPECTRAL MODEL S1 SCORES
S1 SCORE (X100)
55
50
45
40
35
30
25
20
5 MSL S1T
4 MSL S1X
5 MSL S1X
4 500 S1X
5 500 S1T
5 500 S1X
4 AUG80-DEC91
5 DEC88-DEC91
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
MONTH

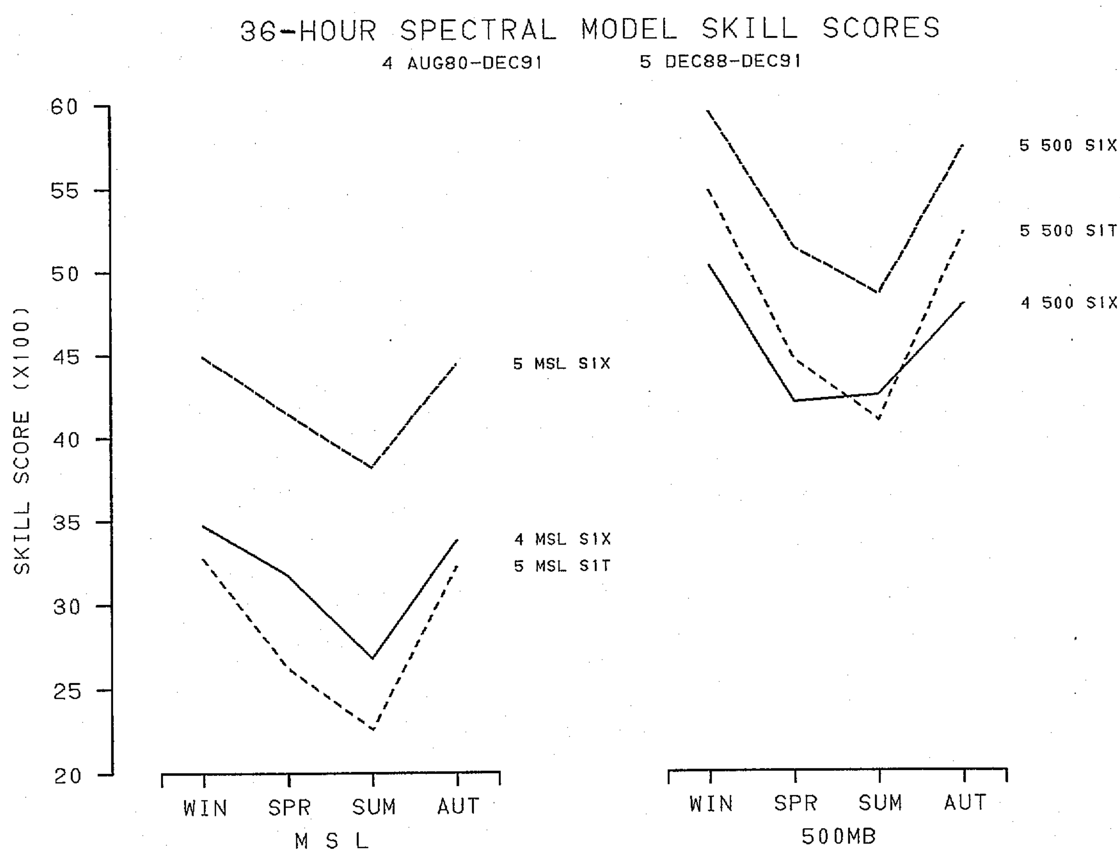

36-HOUR SPECTRAL MODEL SKILL SCORES
4 AUG80-DEC91
5 DEC88-DEC91
SKILL SCORE (X100)
60
55
50
45
40
35
30
25
20
5 MSL S1X
4 MSL S1X
5 MSL S1T
5 500 S1X
5 500 S1T
4 500 S1X
WIN
SPR
SUM
AUT
M S L
WIN
SPR
SUM
AUT
500MB

TABLE I: MSL 36-HOUR (30-HOUR MANUAL) S1 SCORES
JUNE 1947 - DECEMBER 1991

FORECASTS: MANUAL: June 1947 - February 1975
NUMERICAL MODEL: PE (October 1975 - July 1980)
SPECTRAL (August 1980 -)

VERIFICATION GRID: 1947-63 Teweles & Wobus network
1964-91 49-Point lat-lon network

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AVERAGE MONTHLY . . . .

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1947						61.1	63.8	66.1	64.3	66.5	66.6	67.3
1948	64.5	69.4	62.1	63.0	63.6	61.3	63.5	66.5	64.9	65.4	69.6	69.6
1949	66.3	67.2	64.1	66.3	67.7	64.6	64.3	67.1	67.3	63.0	62.9	65.9
1950	65.6	61.7	64.9	63.4	66.6	63.5	64.7	65.4	66.5	66.0	65.5	64.1
1951	63.8	64.0	62.8	63.2	63.2	62.4	63.6	65.0	64.8	69.2	63.4	63.9
1952	63.2	67.9	67.3	66.9	68.8	68.8	66.6	64.6	62.4	64.5	64.2	64.2
1953	67.0	65.5	65.2	64.3	66.4	66.9	65.7	65.7	64.4	65.3	64.9	61.4
1954	66.5	63.1	65.5	63.8	62.4	66.7	65.7	61.9	65.5	64.7	62.8	64.8
1955	68.6	65.6	66.0	65.5	61.7	61.0	65.6	62.8	61.7	61.8	63.5	60.9
1956	60.8	59.7	65.2	64.6	63.4	63.6	62.0	59.4	62.6	62.0	61.6	61.4
1957	63.8	67.9	62.8	63.3	60.7	67.6	68.0	64.1	64.5	61.4	65.3	66.1
1958	63.4	59.0	64.4	66.6	65.6	67.6	62.3	66.8	65.9	65.4	65.2	66.0
1959	61.1	66.2	65.1	65.7	62.9	65.4	64.0	65.8	59.6	65.4	65.7	63.2
1960	66.6	69.1	62.8	66.5	66.0	61.5	63.0	61.4	63.2	62.8	61.2	60.1
1961	61.5	61.1	64.7	65.0	60.9	61.1	62.2	63.7	63.0	63.7	62.4	61.9
1962	61.7	62.9	60.7	64.5	61.1	60.6	62.4	62.5	61.3	61.8	59.2	60.3
1963	62.7	62.8	63.6	60.3	59.1	60.6	61.1	59.8	62.5	57.9	60.8	56.5
1964	59.4	57.1	60.7	58.1	57.5	58.8	63.9	60.2	57.7	60.5	60.8	57.9
1965	58.7	62.0	61.6	61.6	57.0	57.6	56.9	59.7	58.6	56.0	60.3	58.8
1966	56.5	58.0	56.5	60.6	56.0	58.6	56.9	55.7	55.6	56.0	55.3	53.8
1967	56.5	55.0	55.6	52.6	55.0	54.6	54.9	51.7	57.2	53.5	57.4	53.9
1968	59.5	55.1	51.9	53.1	55.0	52.9	52.3	53.4	53.0	53.8	54.7	50.9
1969	51.4	47.7	52.2	52.1	54.3	54.5	48.0	49.6	50.4	51.9	54.1	52.2
1970	53.6	55.2	53.9	50.6	50.8	53.3	51.3	49.2	50.8	51.7	50.0	53.6
1971	49.8	50.2	47.9	51.0	53.2	53.6	47.4	51.2	50.2	52.5	52.7	54.8
1972	52.5	50.9	50.5	52.1	52.9	47.8	49.8	54.1	52.4	50.0	52.8	54.7
1973	53.0	52.6	52.7	53.0	52.0	51.7	52.2	54.8	53.9	54.2	54.1	54.1
1974	58.7	54.3	54.5	53.0	55.7	53.4	55.8	53.8	58.1	54.5	53.4	55.4
1975	57.4	55.8	----	----	----	----	----	----	----	56.0	55.3	56.1
1976	53.8	58.2	57.4	55.3	55.8	56.5	54.0	55.2	59.4	51.8	49.2	54.4
1977	56.3	54.3	53.2	54.4	56.5	57.3	57.0	58.3	56.9	50.3	52.6	51.1
1978	47.9	51.7	52.7	47.4	52.3	51.3	51.1	50.1	55.6	45.4	49.7	51.1
1979	49.5	48.8	49.3	54.4	52.6	51.1	53.3	54.6	48.9	49.6	49.0	47.3

TABLE I(continued): MSL 36-HOUR (30-HOUR MANUAL) S1 SCORES

AVERAGE MONTHLY . . . .

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1980	49.9	50.8	47.3	49.8	51.0	50.9	54.8	50.9	51.4	45.4	43.4	46.2
1981	47.1	46.3	47.9	47.2	51.4	55.9	54.3	55.0	50.3	45.5	46.5	47.6
1982	47.1	48.0	45.4	46.5	54.4	58.6	57.3	56.5	50.7	45.6	45.9	44.7
1983	43.9	46.0	42.8	50.9	50.3	51.9	52.8	54.3	46.6	46.0	46.8	49.6
1984	46.6	47.1	46.9	45.4	48.8	50.7	49.0	46.9	44.9	46.4	44.9	46.2
1985	43.1	45.4	45.8	48.6	50.6	50.9	51.2	47.6	44.9	43.2	49.5	42.9
1986	43.4	47.3	42.7	47.6	46.7	47.7	49.2	46.9	43.8	45.8	42.6	36.5
1987	38.2	40.0	36.1	42.2	40.0	41.5	42.2	41.4	42.5	37.0	34.0	35.6
1988	35.6	35.7	36.3	40.1	39.2	38.9	40.9	38.2	38.7	35.0	34.3	35.6
1989	36.3	32.9	35.3	40.3	38.8	41.1	39.3	39.7	35.9	33.7	34.2	32.7
1990	36.7	33.7	35.4	37.4	38.1	40.6	37.8	43.2	39.2	36.9	33.7	33.6
1991	34.8	37.1	33.7	37.1	38.4	39.0	35.5	36.5	34.2	35.4	33.6	35.8

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AVERAGE SEASONAL . . . .

YEAR	WINTER	SPRING	SUMMER	AUTUMN
1947			63.7	65.8
1948	67.0	62.9	63.8	66.6
1949	67.7	66.0	65.3	64.4
1950	64.5	65.0	64.5	66.0
1951	64.0	63.1	63.7	65.8
1952	64.9	67.7	66.6	63.7
1953	65.6	65.3	66.1	64.9
1954	63.7	63.9	64.7	64.3
1955	66.4	64.4	63.2	62.3
1956	60.5	64.4	61.6	62.1
1957	64.2	62.3	66.6	63.7
1958	63.0	65.5	65.5	65.5
1959	64.4	64.6	65.1	63.6
1960	66.2	65.1	62.0	62.4
1961	60.9	63.5	62.3	63.0
1962	62.1	62.1	61.8	60.8
1963	61.9	61.0	60.5	60.4
1964	57.7	58.8	61.0	59.7
1965	59.5	60.0	58.1	58.3
1966	57.8	57.7	57.0	55.6
1967	55.1	54.4	53.7	56.0
1968	56.2	53.3	52.9	53.8
1969	50.1	52.9	50.7	52.1

TABLE I(continued): MSL 36-HOUR (30-HOUR MANUAL) S1 SCORES

AVERAGE SEASONAL . . . .

YEAR	WINTER	SPRING	SUMMER	AUTUMN
1970	53.6	51.8	51.2	50.8
1971	51.2	50.7	50.7	51.8
1972	52.8	51.8	50.6	51.7
1973	53.5	52.6	52.9	54.1
1974	55.7	54.4	54.3	55.3
1975	56.2	----	----	----
1976	56.0	56.2	55.2	53.4
1977	55.0	54.7	57.5	53.2
1978	50.2	50.8	50.8	50.2
1979	49.8	52.1	53.0	49.2
1980	49.3	49.4	52.2	46.7
1981	46.5	48.9	55.1	47.4
1982	47.6	48.8	57.5	47.4
1983	44.8	48.0	53.0	46.5
1984	47.8	47.1	48.8	45.4
1985	44.9	48.3	49.9	45.8
1986	44.4	45.6	47.9	44.1
1987	38.2	39.4	41.7	37.8
1988	35.6	38.5	39.3	36.0
1989	35.0	38.1	40.0	34.6
1990	34.4	37.0	40.5	36.6
1991	35.1	36.4	37.0	34.4

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AVERAGE ANNUAL . . . .

YEAR	0	1	2	3	4	5	6	7	8	9
194-								----	65.3	65.5
195-	64.9	64.1	65.8	65.2	64.5	63.7	62.2	64.6	64.9	64.2
196-	63.7	62.6	61.6	60.6	59.4	59.0	56.6	54.8	53.8	51.6
197-	52.0	51.2	51.7	53.2	55.1	----	55.1	54.8	50.5	50.7
198-	49.3	49.6	50.1	48.5	47.0	47.0	45.0	39.2	37.4	36.7
199-	37.2	35.9								

TABLE II: 500MB 36-HOUR S1 SCORES
JUN54 - DEC77 Estimated from geostrophic wind errors
JAN78 - DEC91 Calculated from gradients

FORECASTS: MANUAL: June 1954 - September 1975
NUMERICAL MODEL: PE (October 1975 - July 1980)
SPECTRAL (August 1980 -)

VERIFICATION GRID: 1954-77 NMC verification Area 1
1978-91 49-Point lat-lon network

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AVERAGE MONTHLY . . . .

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1954						58.6	50.1	55.8	57.2	51.7	54.3	59.7
1955	54.1	52.1	49.6	55.3	53.7	51.7	54.3	54.4	54.6	52.6	56.2	54.0
1956	55.2	51.2	48.8	54.2	52.4	53.0	52.2	52.5	50.1	51.9	50.4	52.7
1957	45.6	53.1	52.1	47.4	52.9	55.0	49.3	51.5	51.9	55.2	52.5	53.9
1958	52.3	50.9	56.8	50.4	48.3	47.5	51.6	49.1	50.9	47.4	48.2	46.6
1959	40.2	45.9	40.6	46.9	44.2	45.7	47.9	48.7	45.2	42.7	42.1	51.8
1960	44.4	51.3	40.6	43.7	45.6	48.7	45.3	47.6	50.6	46.5	46.4	47.0
1961	40.8	46.6	42.6	45.5	43.9	43.4	47.8	48.8	50.0	51.0	47.1	47.4
1962	38.1	42.1	45.8	40.5	44.6	45.7	47.0	45.2	48.2	41.7	45.8	45.1
1963	37.3	43.0	39.0	40.8	43.3	47.4	45.3	46.3	45.8	42.7	44.0	43.4
1964	45.3	44.1	39.5	42.8	43.6	44.1	43.8	44.0	45.8	43.5	41.1	45.4
1965	44.6	41.1	41.8	43.9	45.2	51.9	43.9	40.4	43.7	41.8	40.5	49.7
1966	50.7	43.9	42.7	42.0	45.6	44.7	44.9	49.9	44.2	42.1	40.3	46.3
1967	41.5	39.4	34.8	41.9	40.9	39.3	41.2	42.0	47.8	45.6	38.8	44.2
1968	40.4	43.1	41.8	40.3	44.9	42.6	40.4	41.9	41.7	38.9	42.7	40.2
1969	38.5	38.3	42.1	40.1	40.3	41.3	41.0	42.9	38.5	42.4	39.2	42.1
1970	35.2	36.2	39.2	39.9	37.8	43.7	42.3	41.2	38.8	39.5	37.8	39.1
1971	30.7	41.2	36.2	44.3	42.4	40.6	40.7	38.3	39.3	41.1	37.9	41.3
1972	31.5	30.5	31.3	34.3	33.1	35.9	37.3	39.3	37.3	34.3	39.0	38.3
1973	36.5	33.2	38.4	37.5	37.6	38.1	40.3	44.6	39.3	36.9	34.4	37.7
1974	31.8	38.7	31.5	36.6	41.4	37.6	38.1	37.9	33.8	41.4	42.0	42.2
1975	38.5	35.4	37.3	36.9	42.6	42.1	38.0	41.9	38.7	38.7	36.5	35.1
1976	33.8	32.0	34.0	40.6	39.2	37.6	38.5	38.2	36.1	32.9	30.6	31.3
1977	35.1	34.0	35.0	31.7	35.3	38.5	36.7	33.7	36.5	37.6	33.5	31.6
1978	32.5	31.3	29.8	34.9	35.5	33.7	34.2	32.8	34.8	31.4	29.2	29.8
1979	32.3	27.8	32.1	31.5	32.8	32.4	34.9	33.2	31.7	30.2	29.0	28.8
1980	28.3	29.8	28.7	32.3	34.0	31.4	31.7	30.8	27.6	27.0	28.3	24.1
1981	27.0	28.4	32.4	27.8	32.6	32.2	32.8	33.6	32.2	26.8	29.8	27.8
1982	24.0	23.5	27.0	27.2	34.5	31.3	32.0	27.5	29.1	28.9	25.5	27.1
1983	28.2	29.6	30.7	30.8	29.5	32.1	31.1	28.3	27.1	29.1	31.0	25.6

TABLE II(continued): 500MB 36-HOUR S1 SCORES

AVERAGE MONTHLY . . . .

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1984	24.5	29.5	27.9	30.6	28.8	31.4	29.2	29.4	27.3	26.6	29.6	24.7
1985	25.4	25.1	27.7	25.7	30.7	31.8	28.1	29.4	28.5	25.3	24.9	22.7
1986	25.0	25.3	24.0	27.9	28.8	26.1	29.1	28.0	25.0	26.6	22.4	24.4
1987	24.9	26.1	25.6	27.7	25.9	24.3	25.7	25.0	23.4	21.6	23.6	22.7
1988	20.8	19.4	22.8	26.6	25.7	24.6	26.7	28.9	26.2	22.4	22.4	19.5
1989	20.6	17.8	20.3	21.4	22.8	26.1	24.4	25.8	23.8	21.2	18.4	18.4
1990	20.9	18.2	20.9	22.4	24.0	23.8	27.0	24.9	22.7	21.4	18.9	19.1
1991	19.0	19.3	20.5	24.4	24.7	26.3	24.0	23.1	20.2	18.3	19.7	20.2

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AVERAGE SEASONAL . . . .

YEAR	WINTER	SPRING	SUMMER	AUTUMN
1954			54.8	54.4
1955	55.4	52.8	53.5	54.4
1956	53.5	51.8	52.6	50.8
1957	50.4	50.8	51.9	53.2
1958	52.4	51.8	49.4	48.8
1959	44.2	43.9	47.5	43.3
1960	49.1	43.3	47.2	47.8
1961	44.7	44.0	46.7	49.4
1962	42.5	43.7	46.0	45.2
1963	41.8	41.0	46.3	44.2
1964	44.3	42.0	44.0	43.5
1965	43.8	43.6	45.3	42.0
1966	48.2	43.4	46.5	42.2
1967	42.5	39.2	40.8	44.1
1968	42.6	42.4	41.6	41.1
1969	39.0	40.8	41.7	40.1
1970	37.9	39.0	42.4	38.7
1971	36.9	40.9	39.9	39.5
1972	34.5	32.9	37.5	36.8
1973	36.1	37.8	41.0	36.9
1974	36.0	36.5	37.9	39.1
1975	38.8	39.0	40.7	38.0
1976	33.7	37.9	38.1	33.2
1977	33.4	34.0	36.3	35.9
1978	31.8	33.4	33.6	31.8
1979	30.0	32.1	33.5	30.3

TABLE II(continued): 500MB 36-HOUR S1 SCORES

AVERAGE SEASONAL . . . .

YEAR	WINTER	SPRING	SUMMER	AUTUMN
1980	28.9	31.7	31.3	27.6
1981	26.4	31.0	32.9	29.6
1982	25.2	29.6	30.3	27.8
1983	28.3	30.3	30.5	29.1
1984	26.5	29.1	30.0	27.8
1985	25.1	28.1	29.7	26.2
1986	24.3	26.9	27.8	24.7
1987	25.1	26.4	25.0	22.9
1988	21.0	25.0	26.8	23.7
1989	19.3	21.5	25.4	21.1
1990	19.2	22.4	25.2	21.0
1991	19.1	23.2	24.4	19.4

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AVERAGE ANNUAL . . . .

YEAR	0	1	2	3	4	5	6	7	8	9
195-					----	53.6	52.1	51.7	50.0	45.2
196-	46.4	46.2	44.2	43.2	43.6	44.1	44.8	41.5	41.6	40.6
197-	39.2	39.5	35.2	37.9	37.7	38.5	35.4	34.9	32.5	31.4
198-	29.5	30.3	28.2	29.4	28.3	27.1	26.1	24.7	23.8	21.8
199-	22.0	21.6								

TABLE III: 500MB 36-HOUR BAROTROPIC S1 SCORES
JAN66 - DEC75 Estimated from geostrophic wind errors
JAN76 - DEC91 Calculated from gradients

VERIFICATION GRID: 1966-75 NMC verification Area 1
1976-91 49-Point lat-lon network

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YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1966	56.9	49.1	46.7	46.5	51.2	50.5	48.9	54.2	46.2	51.8	49.9	59.6
1967	48.3	44.5	44.1	49.3	45.4	45.8	44.3	44.6	54.4	53.6	45.8	57.4
1968	48.3	49.6	51.6	47.7	48.2	46.2	40.1	43.7	50.6	49.0	52.9	49.2
1969	49.6	49.4	47.7	46.7	45.1	41.3	42.5	46.2	41.2	47.6	48.4	52.4
1970	46.1	46.9	45.6	48.8	44.9	49.5	44.4	46.2	44.8	43.2	49.8	46.4
1971	40.3	47.3	44.8	50.6	49.3	45.3	42.2	42.1	47.8	49.2	47.3	49.1
1972	41.1	40.6	40.1	43.3	43.6	42.8	46.1	46.0	39.2	41.1	49.2	46.9
1973	45.0	44.9	46.2	44.2	44.4	43.0	45.5	51.6	51.9	43.7	47.8	45.3
1974	39.3	47.3	42.5	44.1	47.5	44.6	44.3	44.6	40.1	47.4	53.3	51.9
1975	48.4	39.7	38.2	41.9	45.8	47.8	41.2	44.4	41.8	49.4	47.5	41.5
1976	37.6	36.7	37.8	42.1	42.8	44.8	42.4	42.0	43.8	32.9	33.9	36.1
1977	40.3	38.9	40.4	41.3	40.8	41.7	37.4	36.1	41.9	43.4	40.0	39.3
1978	39.4	39.8	38.4	44.3	42.7	40.8	39.9	38.6	38.3	40.2	39.1	37.0
1979	40.1	39.1	41.3	39.6	42.4	39.7	42.2	40.6	39.8	43.0	38.2	39.0
1980	40.6	38.8	44.2	41.4	40.7	39.3	36.9	37.9	38.6	35.3	38.8	35.8
1981	38.6	39.9	41.4	37.6	41.4	40.6	41.7	41.8	41.4	38.8	38.7	35.8
1982	36.5	35.6	38.9	40.0	43.5	38.6	40.1	37.4	39.5	39.6	38.3	39.0
1983	39.2	41.1	44.4	44.0	37.1	40.0	39.6	36.7	38.8	40.9	42.2	35.9
1984	35.0	40.0	38.6	42.5	39.4	38.8	37.0	38.4	38.5	36.2	44.0	35.8
1985	35.3	35.0	33.4	39.2	39.3	41.1	36.9	38.6	38.3	39.2	36.2	33.0
1986	36.7	36.5	39.3	38.7	36.1	36.3	36.3	36.5	36.0	36.5	35.6	38.2
1987	39.8	39.5	37.4	39.2	39.6	37.0	36.8	35.9	35.3	35.4	39.5	39.7
1988	34.8	33.4	35.5	40.0	44.8	35.6	36.2	36.0	38.8	33.8	39.7	36.6
1989	36.6	33.3	35.9	34.0	36.3	37.7	35.7	35.5	39.0	38.7	33.0	30.5
1990	35.5	36.4	35.6	34.2	39.6	36.5	37.7	36.4	37.1	36.5	39.0	34.7
1991	30.3	33.1	39.1	40.3	39.3	38.8	35.5	39.2	37.5	33.8	38.5	37.9

TABLE III(continued): 500MB 36-HOUR BAROTROPIC S1 SCORES

AVERAGE SEASONAL . . . .

YEAR	WINTER	SPRING	SUMMER	AUTUMN
1966		48.2	51.2	49.3
1967	51.0	46.2	44.9	51.3
1968	51.8	49.2	43.3	50.8
1969	49.4	46.5	43.4	45.8
1970	48.5	46.4	46.7	45.9
1971	44.6	48.2	43.2	48.1
1972	43.7	42.3	45.0	43.1
1973	45.6	44.9	46.7	47.8
1974	43.9	44.7	44.5	46.9
1975	46.9	42.0	44.4	46.3
1976	38.6	40.9	43.0	36.8
1977	38.4	40.8	38.4	41.8
1978	39.5	41.8	39.8	39.2
1979	38.7	41.1	40.8	40.4
1980	39.5	42.1	38.0	37.5
1981	38.0	40.2	41.4	39.6
1982	36.0	40.8	38.7	39.1
1983	39.7	41.8	38.8	40.6
1984	36.9	40.1	38.1	39.5
1985	35.4	37.3	38.8	37.9
1986	35.4	38.0	36.4	36.0
1987	39.2	38.7	36.6	36.7
1988	36.0	40.1	35.9	37.4
1989	35.6	35.4	36.3	36.9
1990	34.1	36.5	36.9	37.5
1991	32.7	39.6	37.8	36.6

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AVERAGE ANNUAL . . . .

YEAR	0	1	2	3	4	5	6	7	8	9
196-							51.0	48.1	48.1	46.5
197-	46.4	46.3	43.3	46.1	45.6	44.0	39.4	40.1	39.9	40.4
198-	39.0	39.8	38.9	40.0	38.7	37.1	36.9	37.9	37.1	35.5
199-	36.6	37.0								

TABLE IV: 36-HOUR (30-HOUR MANUAL) SCORES BY VERIFICATION PERIODS

PERIOD 1. JUN47 - JUN66 (MSL)
JUN54 - JUN66 (500MB)
2. JUL66 - FEB75
3. OCT75 - JUL80
4. AUG80 - DEC91

****

A. S1 SCORES

PERIOD	MEAN SEA LEVEL JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1 MAN	63.2	63.7	63.5	63.9	62.7	63.0	63.6	63.6	63.2	63.3	63.5	62.9
2 MAN	54.7	53.0	52.4	52.2	53.6	52.7	52.1	52.6	53.5	53.1	53.8	53.7
2 PE	59.8	56.9	57.3	56.0	57.3	57.8	59.0	60.0	57.9	56.7	58.0	58.0
3 PE	51.5	52.8	52.0	52.3	53.6	53.4	54.0	54.6	55.2	50.6	51.2	52.0
4 SPEC	41.2	41.8	40.8	43.9	45.2	47.0	46.3	46.4	43.6	41.3	40.8	40.6

PERIOD	500MB JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1 MAN	45.7	47.1	45.0	46.1	46.9	49.0	48.2	48.7	49.5	47.4	47.4	49.7
2 MAN	36.1	37.3	36.9	39.4	39.8	39.9	40.7	42.0	40.1	40.2	39.1	41.3
3 PE	32.4	31.0	31.9	34.2	35.4	34.7	35.2	34.5	34.8	34.2	31.8	31.3
4 SPEC	23.7	23.8	25.4	26.6	28.0	28.2	28.2	27.9	26.1	24.6	24.5	23.0
2 BARO	45.2	45.6	45.3	46.8	46.0	44.8	44.3	46.6	46.2	47.4	49.4	50.9
3 BARO	39.6	38.6	40.4	41.7	41.9	41.3	39.8	39.3	40.9	41.8	39.7	38.6
4 BARO	36.2	36.7	38.1	39.1	39.7	38.3	37.6	37.5	38.2	37.1	38.6	36.1

B. SKILL SCORES

(i). NMC EMPIRICAL SKILL SCORE

(a). SEASONAL

PERIOD	MSL WIN	SPR	SUM	AUT	500MB WIN	SPR	SUM	AUT
1 MAN	33.5	33.4	33.0	33.3	44.9	48.0	42.5	43.8
2 MAN	52.4	54.5	55.7	53.0	63.5	62.6	59.3	60.4
2 PE	43.4	46.2	42.7	44.9				
3 PE	55.9	54.7	51.7	57.0	76.8	72.4	69.3	74.4
4 SPEC	77.4	73.5	67.1	76.2	92.8	86.6	84.0	89.9
2 BARO					45.5	47.9	50.6	44.7
3 BARO					62.1	57.3	59.0	60.9
4 BARO					67.5	62.1	64.4	64.1

TABLE IV(continued): SCORES BY VERIFICATION PERIODS

(b). AVERAGE ANNUAL

YEAR	MSL 0	1	2	3	4	5	6	7	8	9
194-								----	29.5	28.9
195-	30.3	31.8	28.5	29.6	31.1	32.6	35.6	30.8	30.2	31.7
196-	32.7	34.8	36.9	38.8	41.2	41.9	46.8	50.4	52.4	56.9
197-	56.0	57.6	56.6	53.6	49.9	----	49.9	50.3	59.0	58.6
198-	61.4	60.8	59.9	63.0	66.0	66.1	70.0	81.6	85.2	86.6
199-	85.6	88.2								

YEAR	500MB 0	1	2	3	4	5	6	7	8	9
195-						32.9	35.9	36.6	40.0	49.7
196-	47.1	47.5	51.7	53.6	52.8	51.9	50.4	57.1	56.9	58.8
197-	61.5	61.1	69.6	64.2	64.5	63.0	69.2	70.1	75.0	77.2
198-	81.0	79.4	83.7	81.2	83.5	85.8	87.9	90.6	92.3	96.4
199-	95.9	96.7								

YEAR	BAROTROPIC 500MB 0	1	2	3	4	5	6	7	8	9
196-							38.0	43.7	43.9	47.0
197-	47.3	47.5	53.3	47.7	48.9	52.0	61.2	59.8	60.3	59.1
198-	62.0	60.4	62.1	60.1	62.7	65.7	66.2	64.2	65.8	68.9
199-	66.8	66.1								

(ii). NMC SKILL SCORE

(a). SEASONAL

PERIOD	MSL WIN	SPR	SUM	AUT	500MB WIN	SPR	SUM	AUT
2 MAN	14.9	16.8	17.8	15.5	19.6	15.9	17.0	17.2
2 PE	7.8	10.2	7.5	9.2				
3 PE	17.7	16.9	14.6	18.7	33.4	26.5	27.3	31.8
4 SPEC	34.7	31.7	26.8	33.8	50.3	42.0	42.4	47.9
2 BARO					.6	- .2	8.1	.8
3 BARO					17.9	10.1	16.7	17.8
4 BARO					23.6	15.3	22.3	21.0

TABLE IV(continued): SCORES BY VERIFICATION PERIODS

(b). AVERAGE ANNUAL

MSL

YEAR	0	1	2	3	4	5	6	7	8	9
194-								----	-3.0	-3.5
195-	-2.4	-1.2	-3.8	-3.0	-1.8	-0.6	1.8	-2.0	-2.4	-1.3
196-	-0.5	1.2	2.8	4.3	6.2	6.8	10.6	13.4	15.1	18.6
197-	17.9	19.1	18.3	16.0	13.1	----	13.1	13.4	20.2	19.9
198-	22.1	21.7	20.9	23.4	25.8	25.8	29.0	38.1	41.0	42.1
199-	41.2	43.3								

500MB

YEAR	0	1	2	3	4	5	6	7	8	9
195-						-12.7	-9.6	-8.7	-5.4	5.1
196-	2.4	2.8	7.2	9.3	8.3	7.4	5.7	12.9	12.5	14.6
197-	17.5	17.0	26.1	20.3	20.7	19.0	25.5	26.5	31.6	33.9
198-	37.9	36.3	40.8	38.0	40.5	42.9	45.2	48.0	49.8	54.2
199-	53.6	54.5								

BAROTROPIC 500MB

YEAR	0	1	2	3	4	5	6	7	8	9
196-							-7.3	-1.2	-1.2	2.0
197-	2.4	2.7	8.8	3.0	4.2	7.4	17.1	15.5	16.0	14.9
198-	17.8	16.2	18.0	15.8	18.6	21.9	22.3	20.2	21.9	25.2
199-	23.0	22.3								

TABLE V: NMC FORECASTER S1 VERSUS PE MODEL S1, DEC72 - NOV73
36- (30-) HOUR MSL FORECASTS, 49-POINT NETWORK

****

A. ALL CASES

FORECASTER	I	II	III	IV	V
# CASES	125	135	131	142	118
AVG S1f	53.8	52.0	54.7	52.9	53.8
AVG S1pe	57.8	55.6	56.7	56.4	57.5
DIF(PE - F)	4.0	3.6	1.9	3.5	3.9

****

B. BY FORECASTER SHIFT SETS (greater than four consecutive days)

i. V.T. 12Z ....

FORECASTER	I	II	III	IV	V
# SETS	10	11	11	11	11
CASES	53	62	62	61	60
AVG S1f	53.6	51.4	53.7	51.5	54.5
AVG S1pe	55.6	54.3	54.9	55.9	57.3
DIF(PE - F)					
MAX	8.2	6.6	7.2	9.2	5.6
MIN	-1.5	-3.4	-2.2	2.5	1.5
AVG	2.0	3.0	1.1	4.4	2.8
CORCOF DIF VS S1pe	.7149	.7133	.4175	.8032	.1041

ii. V.T. 00Z ....

FORECASTER	I	II	III	IV	V
# SETS	10	10	11	12	9
CASES	55	54	63	68	49
AVG S1f	54.8	51.8	55.3	55.5	52.6
AVG S1pe	60.5	56.3	57.8	56.5	57.3
DIF(PE - F)					
MAX	8.9	9.1	6.6	5.4	11.0
MIN	3.3	-0.3	0.1	-6.3	1.4
AVG	5.7	4.5	2.5	1.0	4.7
CORCOF DIF VS S1pe	.1264	.4114	.0884	.6536	.3621

TABLE VI: 36-HOUR SPECTRAL MODEL, 49-POINT GRID,
S1x (max gradient) AND S1t (true gradient) SCORES

VERIFICATION PERIODS: 4. AUG80 - DEC91
5. DEC88 - DEC91

****

A. AVERAGE MONTHLY S1 SCORES

MEAN SEA LEVEL..

PERIOD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
4 S1x	41.2	41.8	40.8	43.9	45.2	47.0	46.3	46.4	43.6	41.3	40.8	40.6
5 S1x	35.9	34.6	34.8	38.3	38.4	40.2	37.5	39.8	36.4	35.3	33.8	34.4
5 S1t	43.9	42.5	42.8	48.7	48.8	51.6	46.3	49.4	44.4	43.2	41.2	42.0

500MB...

PERIOD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
4 S1x	23.7	23.8	25.4	26.6	28.0	28.2	28.2	27.9	26.1	24.6	24.5	23.0
5 S1x	20.2	18.4	20.6	22.7	23.8	25.4	25.1	24.6	22.2	20.3	19.0	19.3
5 S1t	22.6	20.5	23.3	26.0	27.2	29.3	28.9	28.0	25.0	22.6	21.3	21.6

B. AVERAGE SEASONAL NMC SKILL SCORES

	MEAN SEA LEVEL...........				500MB....................			
PERIOD	WIN	SPR	SUM	AUT	WIN	SPR	SUM	AUT
4 S1x	34.7	31.7	26.8	33.8	50.3	42.0	42.4	47.9
5 S1x	44.9	41.4	38.2	44.4	59.5	51.4	48.5	57.4
5 S1t	32.7	26.2	22.6	32.2	54.8	44.6	40.9	52.3

C. SEASONAL NMC SKILL SCORE, 1980 - 1991

SPECTRAL MODEL MEAN SEA LEVEL.............................

SEASON	1980	81	82	83	84	85	86	87	88	89	90	91
WINTER		26.4	24.8	29.1	24.5	29.0	29.8	39.7	43.7	44.7	45.6	44.5
SPRING		22.9	22.9	24.3	25.7	23.7	28.0	37.8	39.2	39.9	41.7	42.5
SUMMER		13.2	9.4	16.4	22.9	21.3	24.4	34.2	38.0	36.9	36.1	41.7
AUTUMN	26.2	25.1	25.2	26.6	28.3	27.6	30.4	40.3	43.2	45.4	42.2	45.7

SPECTRAL MODEL 500MB......................................

SEASON	1980	81	82	83	84	85	86	87	88	89	90	91
WINTER		44.2	47.1	40.4	44.2	47.2	48.7	47.1	55.8	59.2	59.5	59.7
SPRING		32.7	35.8	34.0	36.8	39.0	41.6	42.6	45.6	53.3	51.3	49.6
SUMMER		32.4	37.8	37.3	38.3	38.9	42.9	48.6	45.0	47.7	48.1	49.7
AUTUMN	42.5	38.6	42.1	39.5	42.1	45.5	48.7	52.5	50.9	56.1	56.4	59.7

BAROTROPIC 500MB..

SEASON	1980	81	82	83	84	85	86	87	88	89	90	91
WINTER		19.7	24.2	16.3	22.2	25.5	25.4	17.4	24.2	25.1	28.1	31.3
SPRING		12.7	11.3	9.0	12.7	19.0	17.3	15.8	12.9	23.0	20.7	14.0
SUMMER		14.9	20.4	20.3	21.7	20.1	25.2	24.8	26.1	25.4	24.2	22.2
AUTUMN	21.9	17.6	18.6	15.4	17.7	21.1	25.0	23.6	22.3	23.3	21.9	24.0