SOME NOTES OF FORECASTING
JACKSONVILLE DISTRICT

- By -

Grady Norton
Weather Bureau Office
Jacksonville, Fla.

[Restored and transferred to electronic form by M. J. Bello (NOAA) in 2001 as part of the Coastal and Estuarine Data/Document Archeology and Rescue (CEDAR) for South Florida. Sponsored by the South Florida Ecosystem Restoration Prediction and Modeling Program. Original stored at the Library, Rosenstiel School of Marine and Atmospheric Science, University of Miami. Minor editorial changes were made.]

Some notes on Forecasting, Jacksonville District.
(North Carolina, South Carolina, Georgia and Florida)

(By Grady Norton, WBO, Jacksonville, Florida)

General weather and temperature forecasting in the South Atlantic States presents many problems not readily solved by the voluminous writings of recent years by meteorologists who have applied the frontal analysis system, isentropic analysis, and various theories and formulas of thermodynamics, etc., in an effort to answer the forecaster prayers for better interpretation and prognostic methods. After some years, we find it just as difficult to forecast a cold wave, a snow storm, a hurricane, or even local thundershowers as before the newer methods came into use. In fact, I believe the evidence is unmistakable that we are not doing as good a job all along the line. The problem has been confused by too much theoretical considerations. For this reason, the following is written in an effort to get back to earth and set down a few practical rules for forecasting in this district based on observed behavior of pressure patterns, with only descriptive reference to air masses, fronts, isentrophy, thermodynamics, etc.

In dealing with the Jacksonville District, it soon becomes apparent that the weather situations differ widely from north to south. There is no sharp line of demarcation, but generally we will be compelled to think of Florida in a separate category from Georgia and the Carolinas. Although considerable difference exist in various portions of Georgia and the Carolinas, north to south and west to east, we will not attempt to separate treatment as between these states. Florida will therefore be treated as one unit, while Georgia and the Carolinas will constitute another, for these purposes.

FLORIDA

FLORIDA weather must be divided into two classifications, viz, summer and winter. The months of April in spring and November in autumn will serve to divide the year roughly for this purpose, although some variation will occur from year to year. April is the dry month of spring in the average, while November is the dry month of autumn between the tropical rains of summer and the secondary rains of winter.

The summer rains, largely in the form of thundershowers, with occasional and infrequent tropical storms, begin with earnest in June, but may range from the middle of May to the middle of June. From this time until the latter part of October tropical conditions without any air mass temperature changes (except at very infrequent intervals) prevail over Florida.

During this summer period daily local or scattered thundershowers prevail with more or less regularity. Any given station in Florida will average a shower on half the days, but there is considerable irregularity in frequency and distribution of showers. It is only occasionally that these showers completely disappear from all portions of the state, but they will range from general and heavy to widely scattered and light, with noticeable periods extending over a week to a month, when they are fairly general or widely scattered.

From the stand point of the forecaster the main problem is to determine the period when showers thin out to the point where the areas covered will be too small and widely scattered to include them in the forecast. The problems of depth of moisture, convergence, conventional instability, insolation heating, divergence, subsidence, wind direction and force, and all related actions in a homogeneous air mass over a narrow strip of land extending nearly 500 miles southward into sub-tropical water, presents baffling situations of delicate balance. It may be recognized, therefore, that in Florida as elsewhere, 100% forecasting is impossible up to this time.

These few very generalized rules have been used with more or less success by the writer.

Atlantic High well developed as shown by Bermuda reading 1020-1025 mbs. or higher with western periphery near or over Florida.

This is a general daily shower type for Florida and can be depended on. This brings the isentropic moist tongue of tropical air over Florida in considerable depth around the center of the Atlantic high, far enough away so that subsidence is not present. If the Atlantic high protrudes well over the southeast, the moist tongue may be shoved westward to the central or west Gulf area and subsidence over Florida may be sufficient to thin the showers out, but even then showers will usually be indicated in sufficient numbers to warrant a shower forecast. If Atlantic high is weak or non-existent, showers become more doubtful.

The June Rains: After the dry weather of April and May (usual but not certain) farmers and fruit growers look hopefully for the beginning of the summer showers, which are popularly called "The June Rains". This is not a misnomer, for of all the summer months daily showers are more certain in June. A glance at the rainfall table in climatological data for June will show rainfall at a goodly number of stations practically every day. The exceptions are rare. As mentioned above, these rains may begin the latter part of May or be delayed to the 10th or 15th of June, but when they begin they will persist for some time with fewer interruptions than in other parts of summer. One feature of the June rains that should be kept in mind is they occur frequently at night as well as in the daytime. Later or in the summer by far the greater portion of showers occur in daytime - mostly in afternoon - with very few showers at night except when late afternoon showers extend s short time after sunset. The south wind of June is rainy.

TROPICAL PRESSURE WAVES

In recent years it has been shown that within the tropics there is a constant procession of pressure waves moving with the trade winds. For the most part these waves produce but small changes in pressure and they were not given much attention until recently. Dunn has shown (Bul. American Metl. Society, June 1940, also studies by New York University on same subject), that they are very significant in tropical weather. Under favorable conditions a falling wave will produce a hurricane, etc. Aside from their interest as hurricane breeders in perhaps 10% of cases, the katallobaric waves have associated with them such (if not most) of the general shower activity in the tropics. In their course westward, they frequently swing around the Atlantic high, turn northward and pass over Florida, or pass directly in from the Atlantic over or North of the Bahamas Islands. In so doing they bring an increase in shower activity and produce many of the general shower periods of summer. These waves of decreased pressure are attended by an increase in moisture, and a rise in, or complete destruction of, the subsidence inversion. In other words, the moist air extends to greeter heights and instability is increased. This, together with convective action, makes the ideal situation for showers. These are the moist tongues of the isotropic chart.

The rising, or anallobaric waves are more stable, the subsidence inversion level lowers, and the showers thin out after the rise moves in and establishes itself. However, the rising wave is by no means certain to stop the showers entirely. These, of course, are the so-called "dry tongues" on the isentropic chart. Some of the dry tongues move over the Atlantic from the northeast and east and may appear relatively dry and stable on the chart, but there is usually moisture and instability enough in them to produce scattered afternoon showers in Florida in mid-summer when daytime convection is strong over the land.

In this connection it should be pointed out that the "dry tongue", or anallobaric wave, or what you choose to call it, may increase convective activity at times. If the temperature is lowered aloft this is especially the case, since it steepness the lapse rate in the upper portion of then air, (there will be not moisture or temperature change at or near the surface.) This usually is the case as the rising wave moves in. Showers thin out later on after rise well established.

The periods in summer when showers thin to the vanishing point or disappear entirely are few, but they occasionally occur and may last a week or more. In most such cases it will be noted that a strong wave of falling pressure, perhaps a tropical storm, is passing westward far to the south of Florida or Northward in the Atlantic east of Florida. This draws drier air with a downward slope into the hurricane area and the showers disappear. In fact, there is nearly always a cessation of showers for a considerable distance around a hurricane in all directions, except possibly in the direction from which it is moving, and they usually do not extend very far out behind the storm.

Wind Velocity, is an important factor in shower development, or lack of it, and also the area of the state where they occur. For example, a wind of 15-20 mph at and near the surface from the east will overcome convective action until the western portion of the state in reached. If moisture and instability are not particularly favorable, such a wind may prevent shower formation in all sections, while the same moisture and instability would produce numerous convective showers if the lateral minds were, say, only 6-10 mph. The student should always take into account his wind velocity and direction in shower forecasting, as well as moisture and instability. A southwesterly wind will give little or no showers on the west coast, but will probably develop showers over interior points which will move to the east or northeast coast in late afternoon. Showers of the convective type tend to build up inland from the coast at a distance depending on wind direction and velocity.

Hurricane and tropical storms: It has already been indicated that waves of falling pressure with their deeper moisture and instability in the tropics, are shower producers, and that the more unstable waves may develop into tropical storms of various intensities. When a storm develops from a wave, or appears from the Atlantic already developed, the problem or forecasting is largely a matter of figuring storm movement and issuing warnings of dangerous winds. The copious rain they produce is an important, but secondary, consideration. Nearly all forecasters agree that each storm is a "law unto itself" and that the rain areas associated with them differ with each disturbance. In intense storms or increasing storms the heavy rain area hugs closely to the center. Around this heavy area are squalls that extend outward a distance and disappear.

The tropical storms of Florida may move over the state in any direction from east through south to west. Early and late season storms develop mostly over the western Caribbean Sea or Gulf of Mexico and move north and northeastward. The mid-season storms usually come from the east, but may curve up from the Caribbean or recurve to northeast after reaching the Gulf of Mexico. Except possibly in the case of young storms still in the development phase, they will be considerably weakened in crossing the Florida peninsula, but not dissipated. The more intense hurricanes will cross with winds reduced, but still of hurricane force. Small, but developing storms will cross with little loss of force. The point to remember, is that with few exceptions, tropical storms cross the peninsula intact. The loss in force by land friction, will be regained when open water is reached again. Some small weak disturbances, that have shown no indications of strong organization, may lose their identity in crossing the state, but this is rare.

Usually in a moving storm the rainfall extends a granter distance to the right of its path and this is especially so when it begins to curve northward. In most storms the heaviest rain will be in the right front quadrant. Rain dos not extend far out from the left of the center. A storm that ceases to move, will have rain all around it. Florida is affected by one or more of these storms annually on the average. The slower the movement, the heavier will be the rainfall because any given place visited will be in the rain area a longer period of time. A relatively weak disturbance may produce as much or more rain than a fully developed hurricane, especially if it moves slowly.

On the approach of a hurricane, the convective showers thin out or disappear for a day or more, then fitful squalls of wind and rain set in on the periphery of the hurricane circulation extending mostly from the center line toward the right. The squalls become more frequent and heavy as the storms approaches.

Disappearance of tropical showers in autumn

The convective showers begin their disappearance around the middle of September as a rule, usually with the advent of the first fresh polar continental air into Florida. High-pressure areas move off the continent and increase over the North Atlantic area as fall approaches, which gives a prevalence of northeast winds over Florida. These winds are relatively moist and unstable and bring rains, but they drive the old summer tropical air out. As October comes in there is a shift of the heavier rainfall to the eastern portion of the state, largely caused by the prevailing moist northeast winds impinging on the land. These rains ordinarily become lighter as the distance inland is increased and become very light or disappear before reaching the west coast, but the rain is often heavy on the east coast, especially the lower east coast.

In forecasting the east Florida rains in late September and October, of course the general descriptive matter above must be used judiciously. At times the moist tropical air has not been displaced southeastward, at other times tropical disturbances move northeastward from the Gulf, or weak disturbances remain in the Gulf with overflow of moist air aloft over Florida. In such cases, the rains will be general and prolonged. Usually, however, a forecast of rains over east and extreme south Florida is sufficient for early autumn "Northeasters". When the northeast winds change to some other direction, the rain will end. While on the subject, it might be stated that northeast winds having a wide sweep over the Atlantic from strong highs will give some rains, mostly light, along the Florida east coast at any season of the year. The condition is merely more productive of rain in early autumn.

Transition Period and end of rainy season comes with late October and November. The summer tropical rains are over and the winter disturbance do not move far enough south to produce rain. November is the driest month of the year, except in extreme Southeast Florida. December is the driest.

The Retrograde Wave Showers

In summer there is s rather peculiar type of thundershower not uncommon in north Florida. The situation will be more fully described under the discussion of summer weather in Georgia and the Carolinas because these states are more affected than Florida. Here it will be suffice to say that occasionally a weak bubble of low pressure lingers in the foehn area of South Carolina after the passage of a low pressure through off the north Atlantic coast, and is caught in the anticyclone circulation around a dome in the vicinity of Tennessee and the Ohio Valley, in the upper air. This circulation gives a northeast upper air wind over the Carolinas, which moves the weak surface bubble southwestward. The over-turning, due possibly to overrunning cooler air aloft, produces thundershowers which move southwestward over Georgia and north Florida. On at least two occasions such waves have moved further south than usual over north Florida and increased to hurricanes as they moved westward over the Gulf.

Some characteristics of these thundershowers are their formation at high levels above the surface, local or scattered, very severe electrical activity, frequently some hail which indicates severe turbulence, move from northeast, and are over as soon as the series pass - usually in one twelve hour period. They occur either day or night since they are not dependent on daytime convection.

Conclusions: The reader will be impressed by this time that the summer showers in Florida are not easy to forecast accurately, if they were not so impressed by the opening statements. The delicate balance maintained by the forces producing them often baffles correct interpretation. The most important factors are instability and convection. Of these two, convection over the heated lend surface in daytime, causes decided preponderance of showers in the daytime - (estimated). At night, convection weakens and disappears and during the latter part some subsidence occurs. Therefore, showers in afternoon and clear shy in early morning is the rule. For much of the average summer, the best forecast will be scattered or local afternoon thundershowers, with none at night and early forenoon.

But don't expect to verify with more then 80-85% accuracy, regardless of how you try to guess them.

Temperature changes summer

No air mass changes in temperature occur in Florida in summer. Temperatures are affected only by rainfall - or lack of it. As long as daily showers occur, no excessive heat is experienced, but when showers disappear temperatures rise with the cumulative effect of insolation. Then with the reappearance of showers the heat is modified. Beginning with June and extending to September, temperature changes may be ignored by the forecaster. Such changes as do occur are caused by rainfall, and since these are local, and since no air-mass change occurs, attempts to forecast are not justified ordinarily.

Florida winter

From late October to early December, especially in November, dry weather is the rule - the driest period of the year. The tropical rains of summer have been displaced by continental dry air, with frequent new importations from continental highs. During this period extreme care should be exercised in making rain forecast. Cold fronts frequently do not have any precipitation associated with them. The storms of the winter westerlies do not move far enough south in their tracks to give much rain in Florida.

This does not prevent sharp cold changes from reaching Florida in November, especially northern Florida. Therefore, forecasting in this period is largely a matter of being on the alert for the first damaging frosts.

Beginning with December and continuing roughly through March the extra-tropical winter disturbance may be expected to develop far enough south to make weather forecasting somewhat similar to that for frontal disturbances in other sections of the country. Wave disturbances that develop in the Gulf of Mexico or move east-northeastward from the Rio Grande country are the best rain producers. Ordinarily they give twice as much rain and with twice the frequency over northern Florida as in southern sections. Many winter disturbances give rain over north Florida without any in the south.

Frontal Rains: Warm Fronts:

The warm front in Florida during winter is not usually attended by much rain if the low center is to pass some distance north of the state. In such cases the warming is quite general simultaneously. This does not favor rain as a rule.

This is not true of wave disturbance from the Gulf moving northeastward. The warm fronts of such waves are preceded by general rains north and northeast of them, and as soon as the wave passes the rain ceases and the cold front, if not strong, will have none or only brief showers. The heaviest rainfall in winter is associated with the Gulf wave disturbance and is mostly of the warm front type. In most cases, the heavy rainfall will be north of the wave and its position when moving over the state will indicate the area where the heavy rainy will occur.

Cold Fronts: As already stated the cold fronts of Gulf waves, if well marked and oriented more north-south so that they pass over the state from west to east, may be attended by brief showers. Aside from the Gulf waves, with their warm front rains, the rainfall of winter disturbances is mostly cold front type; surface or aloft.

The best cold front, rain type is where the cold front extends well southward into the Gulf, followed by a high of sufficient strength to push it eastward over Florida still with a north-south orientation. If the front stalls over the Gulf and it's northern portion continues moving eastward, giving a more northeast-southwest orientation, then it may became stationary and wavy in the Gulf and over Florida, and one or more Gulf waves pass along it attended by rain.

However, if the cold front is fairly vigorous and is pushed on over Florida it will be preceded and attended by rain, mostly in the form of showers, followed immediately by clearing.

The movement of cold fronts and their behavior over the Gulf between Texas and Florida is a first class problem even when a reasonable number of ship reports are available from the Gulf. When ships reports are not available, the problem is practically impossible. To track, or extrapolate, the movements and changes of a cold front traversing nearly a thousand miles of tropical water, without reports, is a task that is almost impossible, especially in waves develop.

Cold fronts often undergo frontolysis without wave Formation over Florida and the Gulf. This happens in winter more frequently than might be expected. The front merely becomes weak, then diffused into a fairly broad zone, and finally disappears under subsidence and slow mixing and heating. At least, half the cold fronts, perhaps more, will behave in this manner. This will nearly always occur if the front is meeting an old modified polar air mass over Florida and the Gulf, and it even happens on occasions where tropical air prevails, although rain is more likely if the front is meeting tropical air. From this, the forecaster will see that cold fronts have to be carefully studied in each case. Don't jump to the conclusion that wave action will set up on the stalling front. Most of them will undergo frontolysis and disappear. Such dissipating fronts frequently have no rain associated with them. When the front extends due east-west it will very probably dissipate.

Cold Fronts Aloft - or pre-cold front rain and thunderstorms.

This type of rain should be looked for in winter and spring. It will occur more often than might be expected. The surface map should be carefully noted for any evidence of a cold front aloft or the development of a line of thundershowers well ahead of a cold front. If upper winds are available they should be studied for evidence of over-running or convergence at higher elevations. When the sold front aloft is present - (and it may be so weak that surface pressure tendencies are not much affected) - the rain will attend its passage, (some times attended bar thunderstorms or squalls) from 50 to 200 miles ahead of the surface front. In such cases, little or no rain will attend the surface front when it arrives, even though it is a fairly vigorous front. Clearing weather may follow the pre-frontal showers or cold front aloft, and the surface front have entirely clear weather on passage.

Cold waves, frost and freezing warnings

In the winter season it is the cold spells or sufficient severity to give frost and freezing that are of most concern. It is in winter that truck crops are grown and the ripened citrus fruits are exposed to damage from freezes. Cold waves as experienced in northern states are rare in Florida, Occasionally technical verifications may be experienced, but on most occasions the cold of damaging severity takes two days (or rather nights) to a cold wave minimum. Hence cold wave warnings are rarely needed and seldom used even if technical verification is expected; rather the minimum temperature expected is forecast.

It will be evident that the only way to go real cold weather into the Florida peninsula is to have a complete displacement of the normal maritime or tropical air. It will also be obvious that the only way to have polar air penetrate far into the peninsula is to have it flow off the continent and straight down over land. If cold air flows from the west over the Gulf it will be modified by the warm water. If it flows from the northeast or east, it also moves over warm Atlantic water. So, we must have an importation of polar continental air from the north or northwest, the only directions from which it can remain over land in its journey down the state and not be unduly modified by marine influences. But when cold air is drawn down over the peninsula it becomes very stable because it is colder than the air over the surrounding water, and it will be still remain in position undisturbed until a gradient flow or air from some marine region displaces it. Radiation in a thin surface layer of this polar air is terrific on a calm, clear night over Florida. This is usually the second night of the cold spell when the high center is over Florida or near enough to give calm conditions. The radiation effect will be disturbed or destroyed if the air is moving as much as 10 mph, during the night.

The question, then, is when will the polar air come from the right direction for penetration without modification, and how long will it stay? Will a calm night provide radiation before the cold air is displaced? If so, don't forecast warmer, but continue the cold warnings for another night. It will be colder in radiation pockets.

When a large number of winter maps are examined, it will soon appear that cold weather advancing from over the continent begins to slow in its advance into the southeast on many occasions, and the cold front slows to a stop. Much of this slowing and stopping occurs over southern Georgia and northern Florida. Unless the cold currents are strong and deep and flowing in a direction to come straight down the peninsula, the cold will not penetrate very far but will be shunted off to the northeast. Study the direction and depth of the cold air.

The ideal cold type is to have a <u>low</u> or a deep trough, pass over Florida with a deep cold current following from the northwest. However, the old idea that the passage of a deep low over the state is a necessary prerequisite to cold waves is not to be depended on. A deep cold current will bring the cold if it flows straight down off land over the state, regardless. Therefore, valuable clues are to be had from the upper air winds. These should be carefully studied in connection with all cold weather conditions.

A careful examination of the 12-hour and 3 hour pressure changes will frequently indicate the tendency to shunt off to northeast. If the greatest rises shift to northeast, while the rising tendency is weaker ever the Gulf States, it is good indication the cold will advance northeastward. The upper winds will usually confirm this by showing shallow northerly currents backing to westerly at higher elevations.

<u>The Texas High</u>: In the winter season, the high that moves off the plateau or plains across Texas and the Gulf States or Gulf should receive careful attention. The normal movement for such a high will bring the center from Texas to Florida in 24 hour. 0n the eastern side of this high as it advances, the stir will be pulled southward over Florida from the region of Tennessee, Alabama, and Georgia all day and part of the night. Then the latter part of the night the high center reaches Florida and the air becomes calm and, of course, clear. The northerly winds have brought air of dry continental type with low dew point into the state, and when it becomes calm, radiation gets in its work. Resultant temperatures over Florida will be considerable lower than were noted anywhere over the west Gulf states the previous morning in the high. Frost is likely to be heavy and extend over north and central portions of the state. Minimum temperature may be ten degrees lower in Florida than they were in Texas the previous morning. <u>The mistake that should not be made</u> is to be influenced by minimal over Texas, or to think because the <u>center</u> of the high will move near or over the Gulf in its journey to Florida that it will be modified on arrival. Rather note from whence the dry C.P. air is coming while the high is approaching, and decide what radiation can do to it during the calm hours after midnight.

<u>The high that is displaced southward</u>, lingers, and keeps polar air over the state under relatively calm night conditions, is another troublesome type. This happens when a high is depressed southward by a low with a considerable pressure fall advancing southeast or east over the northern states tending to run over the top of the high but not extending far enough southward to open a trough into the west Gulf. Under such conditions the high or a high ridge will be displaced southward over Florida extending Northeast-southeast or E-W, and will continue to have its polar air mass little disturbed. Radiation where relatively calm conditions prevail at night will continue. Greatest radiation will be under the center of the ridge (usually extending in a west-east direction). In Florida, care should be exercised, therefore in forecasting a rise in temperature under such condition. Usually minimal will not rise and frost conditions may continue until the ridge moves from the state. If the ridge is over southern Florida it will be colder there than in northern sections.

<u>Freezing in Central Florida</u>

In a study of cold wave types some years ago, Mr. W. J. Bennett concluded that freezing would not be experienced at Tampa the next morning unless temperatures as low as 32 degrees had reached the middle Gulf coast — at Mobile, Pensacola or, New Orleans. This is s very good rule for Tampa, but does not apply equally well to frost pockets in the interior east of Tampa. Even for Tampa the rule has exceptions, as we have observed on several occasions. Of course freezing will reach the middle Gulf coast many times in winter without similar temperatures reaching into central Florida 24 hours later, but failure of penetration will be evident from other factors.

It is reiterated as the writers experience that the best approach to cold penetration down the state lies in a careful survey of the strength, depth, and direction of flow of the cold winds. Are they deep and cold? And do they flow straight down over the state? If so, they will bring the cold. Then be on alert for a stayover for a second night with radiation. When the winds begin to come in from the <u>northeast</u> at the surface and/or moderate elevations above the surface, temperatures will begin to rise. This is usually the first indication or breaking of the cold. These winds come in off water and raise both temperature and humidity.

GEORGIA AND THE CAROLINAS

The weather in these states will be treated as a unit, although great variations in behavior of weather types are experienced. One of the principal causes of weather variations, aside from latitudinal considerations, is the topographic feature. The Appalachian Mountains on the west and northwest with elevations up to 6000 ft exert a very significant influence, but the warm water of the Atlantic and Gulf on the east and south is another great factor influencing the weather of the region. The topography of these states falls into three generally recognized zones, viz., The Mountains, the Piedmont, and the Coastal Plain. These divisions might be roughly defined by lines drawn through Greensboro, Charlotte, Greenville, and Atlanta; and another through Raleigh, Florence, and Southwest to Albany, Ga. Bordering the Atlantic and Florida will be the Coastal Plain, next, the Piedmont, and then the Mountains on the northwest. However, there are no sharp demarcation lines, or particular weather types associated with each, but rather certain graduations and contributory influences produced by each in weather disturbances passing over them.

The mountain barrier, while only 3000 to 6000 feet in elevation, is sufficient to slow the progress of fronts, which must pass over it. The weaker cold fronts, for example, with shallow cold air behind them may be stopped; those of moderate depth will be impeded to some extent until the cold air banks high enough to flow over. These results in a lag in getting the colder change over southern Georgia and east of the mountains in the Carolinas. Strong cold fronts will pass over without much, if any, slowing. Another pronounced temperature effect of these mountains is when warm, fronts move from the southwest or west and the warm air is raised to pass over, it will continue aloft and pass over a thin layer of cold air to the east and not change the surface temperature until the cold air is slowly scoured out, which may take some time. Occasionally in winter fairly deep low pressure systems will pass without completely removing this thin cold layer on the eastern side of the mountains. This will especially by noted if a secondary forms in the Piedmont or Coast Regions.

The mountains also have a certain amount of foehn effect on air flowing at gentle or moderate rates down the southeastern slope, especially if no precipitation is present. Although this foehn is very weak as compared to the eastern slope of the rockiest, it is a matter of sufficient importance to engage the attention of the forecaster. Its greatest effect is felt in the South Carolina Piedmont section. Mention has been made of the foehn low-pressure bubble, which forms in this area in summer, in discussing Florida weather. It was noted that it moves southward when a dome anticyclone circulation over Tennessee and the Ohio Valley is in a position to give northeast winds aloft over the Carolinas. In these cases it reaches best development when the air is initially too dry to produce showers and foehn heating has a chance to raise the temperature in the lower layers and the weak heat low has time to develop before showers and southwestward movement begins.

In winter, some writers have expressed the belief that the effect or these mountains in diverting the lower level winds, together with foehn action, are important factors in the development of South Atlantic Secondary lows. In winter, however the low-pressure areas developed in this area move northeastward out over the Atlantic, usually with increasing intensity. It is the writer's belief that the greatest factor in winter secondary development in this area is the warm Atlantic and the Gulf, which furnish heat and moisture so necessary for storm development. The effect of the Appalachian Mountains is a secondary, though significant feature.

The adiabatic temperature change by orographic lifting of the mountains and its effects in producing precipitation should be kept in mind. At the dry adiabatic rate, air forced to rise over this mountains (3,000 to 6,000 feet) would be cooled 18-36 degrees, if it started from sea level of the Gulf or Atlantic. At the saturation adiabatic, the cooling would amount to 11-22 degrees. From the Mississippi and Ohio valleys, which average only about 500 ft. Above sea level, the lifting is only slightly less. Of course there are some passes through the mountains at lower elevations and some air will pass through without so much cooling, but the forced ascent is a decided factor in producing precipitation. The heaviest annual rainfall in these states will be found in southwestern North Carolina and extreme northeastern Georgia where moist air from the Gulf and Atlantic is forced to rise over the Great Smokies.

It will be apparent that precipitation will be heavier, and will occur with greater frequency in these mountain areas. The forecaster should note the wind flow and keep in mind the orographic lifting. Rainfall will have to be forecast many times in the mountains when other sections will have little or none. At other times rain will begin in the mountain area much sooner than elsewhere.

These remarks on general features and topographic characteristics and influences, although but briefly outlined, should be constantly in the mind of the forecaster. Those preparing themselves to make forecasts for this area will profit by a thorough and careful study of the variations in the behavior of weather systems passing over them.

LOWS (WINTER)

Low pressure disturbances with idealized frontal patterns, which appear so easy when presented for illustrative purposes, as well as satisfactory computation of frontal movements, are rarely experienced in this area. Front and trough computations cannot be relied upon more than half the time in winter, and the rains associated with disturbances do not conform to idealized frontal patterns much better. Too many complicating factors are experienced. Old fronts may slow up, new fronts may form, or new secondary may form a completely new systems of fronts. The mountains may disturb the frontal continuity and the rain areas may be influenced by the orographic features, etc.

Therefore, the first rule of the forecaster has to do with divesting himself of many preconceived, or idealized, conceptions of frontal patterns, frontal movement, and the rainfall and temperature associated therewith. He must content himself with judicious and sparing use of these tools. There are times when they work well, and should be used, but more often the situations do not lend themselves to these prognostic methods.

The upper winds, if available, are more dependable for computing direction and speed of movement than frontal formulas, while the 12-hours, and to a lesser degree, the 3-hour pressure changes, come next in importance. The forecaster will find these charts very valuable and frequently the answer, when other methods give misleading results. Emphasis should be given these at all times and, if other methods do not confirm deductions therefrom, subsequent developments will soon convince the skeptical that the upper winds and the pressure changes are his best friends.

Southwest Lows: The disturbances from the southwest are the best and most certain rain producers. They may move notheastward over Tennessee and the Ohio Valley when there is a high over the south Atlantic area, or they my take a more easterly course and move across the Gulf States and up to the Atlantic coastal plains when pressure is high in the interior or when winds aloft are from the west. The disturbance moving northeastward with center west of the mountains may form a secondary with its own frontal system, just as if it was split into two sections by the mountains. The warmth and moisture of the Atlantic and the disturbance of warm air flow by the mountains are principal causes. The secondary increases, while the center west of the mountains fills. In either case, timing the beginning and ending of the rain is a problem. For most of the winter and spring season the best and surest indication is found in the 12-hour pressure change. A fall of 3 mbs. Or more on the Texas or Louisiana coast (8:30 a.m. map) with a receding high in the east will be followed by rain beginning in Georgia 24 hours and will cover most, or all, the area in 36 hours. If the fall is a secondary fall area with a primary area of fall to the northward over the plains or Mississippi Valley this rule is especially good, for it may be the first indication of southern secondary formation. This secondary pressure fall should be played for rains, unless, all other indications are against it. Occasionally a fall of foehn character has been pushed southward to this area. In this case, it has no rain with it and will probably fill up.

For speed and direction of movement look to the winds at levels of 5,000 to 8,000 feet, making some allowance for changes that may be expected in the next 24 hours, and for depth of the surface circulation. This type seldom lends itself to, frontal calculations. Warm front rain will have to be forecast many times when there is as yet no warm front on the map. Rain ends with passage of center of disturbance, except rains may linger in the mountains until the disturbance is well out of the way. If the southwest Low is well developed and moves northeastward without secondary formations, the temperature will rise evenly with the southerly winds flowing into it over the area. If a secondary forms, or if the Low takes a more easterly course, the temperature becomes a problem. In such cases temperatures rise until rains begin. Thereafter the rise will be confined to the coastal plain, while temperatures in the Piedmont and eastern mountain slope may fall in the rain to near the dewpoint and remain low throughout the passage of the disturbance. If dew points in the area are bellow freezing, precipitation may change to snow. Then when cold air from the northwest comes in behind the disturbance, a forecast of colder for the mountains and coastal plain will be necessary, while in the area that remained cold during the passage of the low, temperatures may rise slightly or not change until the temperature distribution is brought into normal relation. Thereafter temperature will fall more evenly if the advent of cold air continues.

The stalled cold front becomes wavy

Mention has already been made of the great number of cold fronts that slowdown and become stationary in this region, especially the southern portion. One reason frontal computations are so uncertain is that cold fronts advancing over the frontiers, especially from the northwest, begin to slow in their advances in the region of Tennessee, Mississippi, and Louisiana. Their continued movement will be regarded to an extent depending on the strength of the High over the South Atlantic area, compared with the strength of the advancing cold air mass. This will be discussed below. The fact is that a large percentage of cold fronts slow down and eventually stop and become wavy between the Appalachian Mountains and the Gulf and Atlantic coasts. This stalled front with its possibility of waves, presents one of the most difficult problems in forecasting. The formation of waves and the spread of the rain back north of them, and of course the failure of the cold air to advance until the waves get out of the way, causes many of the forecast failures in winter. Where will the front stop, and where will the waves form? Those are the hard questions.

The normal condition of a cold front from the northwest is to lag in its southern section while the northern swings on eastward. The southern lag is caused by the High holding over the southeast, the relative shallowness of the trough attending the front from a cyclone center moving eastward over the northern states, and other features such as the warm water of the Gulf, the Appalachian barrier, etc. A number of years of careful study has not given me the solution of the problems in all cases. It is believed, however, that the upper air winds and the pressure change charts are the best aids. If the High over the South Atlantic is fairly strong and stable, i. e., without appreciable pressure fall in 12 hours, and little or none in 3 hours, the front will stall. A careful study of the winds aloft may indicate where waves will form and where rain will spread, by their degree of over-running from the southwest.

If the high is giving way the southeast and the advancing high is vigorous, the frost will continue to advance without waves. In this connection, it will be noted that highs which move into the southeast from the west or southwest rarely become stationary and stable. These usually keep on moving eastward and out of the way. It is the high that comes down from the northwest or north and settle into the South Atlantic area that becomes the most stable and persistent barrier to fronts. The depth of its wind system in the upper air is an indication of its strength and stability. The pressure at Bermuda is another helpful index. If the pressure is 1025 abs. or higher and not falling appreciably there, or on the south Atlantic coast, you can be sure of and effective barrier to advancing fronts.

Where do the waves form? The answer is anywhere! Three places are favored. (1) The Gulf coast area (those forming east of the mouth of the Mississippi are the most troublesome because of proximity to the region and quick rain development.) (2) The southeastern slope of the Appalachians (usually the Piedmont Region of South Carolina and Georgia), and (3) Off the coast between Jacksonville and Hatteras.

The East Gulf wave is the most troublesome because it is not easy to find and when once formed it may spread rain over a good portion of the area in 12-18 hours. If it forms over the West Gulf it gives more time before rain begins. The spread of rain to north of the position of the old front depends on the strength of the wave. This may be indicated by the upper winds, if they are available, or by upper clouds when lower overcast is not present. In most such cases low clouds will be presented and not upper winds or high cloud information will be available. The forecaster then has to fall back on his surface pressure distribution and such 5,000 and 10,000 feet data as are available. Careful study will usually show some indications of when and where waves are forming or likely to form. Pressure falls do not appear until the wave is developing--often to late. The falls attends the wave and does not preceed it to any great extent.

The Piedmont waves are troublesome, but not so much so as the Gulf waves. In the first place they are easier to find, and usually rain will already be falling in the area and the forecaster merely has to continue it, and try to guess when it will stop. In the mean time temperature changes, or lack of them, will be difficult to forecast. The rain area will, of course, be mostly north and northeast to the wave, but showers may also occur in unstable air south of the wave and along the cold front, ending with the cold front passage. The change to colder is, of course, retarded until the wave passes.

At times the Piedmont wave is not developed by a good overrunning warm wind. It then assumes more of the form of a foehn wave. This may be expected when the high is weak or weakening slowly over the Atlantic and Florida. The colder air from the stalled northwestern high will flow into western Georgia, while the main portion swings over and comes down east of the mountains. This folds up the wave into occlusion usually in the Savannah River Valley. This is really the meeting of two sections of the cold front. The warm foehn air is easily shoved upward between the two cold fronts and passes off. The front meanwhile may straighten out off in the Atlantic or perhaps a portion of the wave near the coast did not occlude, in which case it reforms off shore and thereafter acts as an Atlantic wave. The rains which may have been present, will soon cease when the wave occludes. Drizzle may persist for a few hours after the occlusion, but it can be depended on to end shortly after occlusion is completed - or when the front gets off shore.

The South Atlantic Waves ordinarily do not give much precipitation, except possibly on the Carolina coast. When the cold front passes off the coast before a wave forms, the rain generally stays off shore, or only on the coast, and temperature falls normally - (or even faster) - over the area. The rule here is that once the front passes out into the Atlantic, it will not cause much trouble on land unless it extends into the Gulf where a Gulf wave may form later.

These waves move northeastward in winter, Unless there is positive indications that the wave will be caught by a high moving over on top and blocking it and later pushing it inland, northeastward movement can be depended on. This latter happens only on very rare occasions.

Another form of the South Atlantic wave, or front, will be formed at times when a high moves out over the Atlantic with center well to the north and tends to straddle over the warm Gulf Stream some distance off shore. As the main body of the high swings eastward or southeastward over the Atlantic, the warm front over the Gulf Stream area (more properly a pseudo warms front) is pushed back toward shore. At times this front joins in, or is drawn northward into, a low pressure system moving eastward over the lower Lake Region toward the middle and north Atlantic states. In such cases warm front rains advance rapidly northward. On most other occasions, however, this condition does not produce rainfall with any degree of certainty. Precipitation, if any, will be generally light scattered and flashy, and the chances of' forecasting it in the right place and at the right time are remote. This front is being returned by modified, and to some extent stabilized, polar air which is still relatively dry with some subsidence. On some occasions this pseudo warm front will advance northward with little disturbance of the general isobaric pattern and dissipate while the stable Atlantic high fills in under it.

Lows with cold fronts aloft or double cold fronts: Lows with such cold front patterns are rather frequent in winter and spring. The first front, either surface or aloft, is likely to be an m.p. front, while the second front will mark the advance of c.p. air. Precipitation associated with such systems is nearly always in connection with the first front and little or no rain attends the p.c. front, except in the mountains. The temperature fall is in a double wave, modifying the rapidity of the fall to cold wave proportions. Technical cold wave verification may fail in such cases. (See page 15 above)

Troughs with east-west isobars ahead of the front produce very little rain. The more north-south the orientation, the more convergence and rain. When isobars trend more east-west, little convergence occurs at the front, the wind merely shifts from west or west-southwest, to northwest. When winds flow from the west or west-southwest, there is a certain amount of down-slope movement, and since they will not be as moist as winds from the south to begin with, the slight foehn effect with descent will lower humidity. This does not favor much rain except in mountains.

While discussing troughs, it might be well to note that the summer troughs are rather treacherous also as shower procedures. The deeper the trough and the more east-west trend of the isobars in front, the more disappointing the rain is likely to be. The fresh winds of the deeper troughs seem to disturb convective processes and unless there is pronounced convergence little rainfall occurs. Here again the southwest and west winds have a slight down-slope foehn slope drying to add to weak convergence and disturbed convection.

HIGHS (WINTER)

Forecasting in connection with high pressure areas is generally relatively easy as compared to lows, troughs and waves. The typically clear, brisk, cold weather of highs is supposed to give the forecaster his breathing spells while he watches for the next story or rain area. So we should all like highs - at least those that behave. All we need to do is make accurate temperature and frost forecasts. The trouble, however, is that all highs are not as tractable as we would like them to be, far from it; Then let us devote some attention to those types of high pressures whose recalcitrant behavior makes them the black sheep in an otherwise unblemished flock.

The strong cP high which strings down from Alaska and Western Canada is a trouble maker. It seems to pivot in Western Canada while sending a stream of cold air south and southeast over the country, attended by very low temperature, which fans out somewhat as its forward isobars reach into the South. They look like cold waves with a vengeance, but very frequently it will be noted that winds aloft over the south are from west or even southwest, and the forward cold winds of the high are shallow. Then it will be noted that the southern elongation of the high begins to swing eastward, perhaps from the southern Plains or lower Mississippi Valley. When these conditions are noted, a rain or snow area develops over the South well up against the high, and its southern extension is swung rapidly eastward, with the rain following as rapidly. This is a case of over-running warm and relative moist air above the shallow surface cold. A shallow wave may develop but this does not always occur. The rains move rapidly eastward and the cold wedge ahead of it. What appeared to be a change to colder, finds temperature changed or rising its 18-24 hrs. over the southeast. When the rain area, or wave disturbance if it develops, reaches the Southeastern States, the parent high still over the northwest sends another rapidly moving impulse of cold air down the plains and Mississippi Valley behind the wave. This time the cold will come through if the strong westerly winds aloft do not persist, if they do persist, we have a repetition of the first movement and the process will continue until the cold high over the northwest finally comes through. The rapidly moving precipitation areas, and the rapidly fluctuating falls and rises in temperature, while a severe cold wave continues to threaten, causes many gray hairs for the forecaster.

The initial movement is the more frequently experience, viz, a rapid swing eastward of the first high impulse followed quickly by rain. Then another rapidly moving cold impulse which usually comes through with a cold wave. This movement is difficult to forecast properly, but when the process is repeated several times, it becomes one of the most disconcerting of all winter conditions.

<u>The Arctic High from Central Canada</u>

This is the Quick cold wave high that has a habit of catching forecasters mapping. Its a fast mover and plenty cold on arrival. The usual setting for such a high will be a strong Great Basin high which has persisted for some time and sent C.P. air under relative high pressure eastward and southeastward over the central and southern planes, the lower Mississippi Valley arid Gulf States to the south Atlantic.

A vigorous upper level cyclone will develop in the Lake Region and moderate surface lows will move southeastward into the lake Region and occlude. In the meantime the deep cyclonic circulation builds up and winds are strong from the north and northwest. Then the high appears over central Canada as the artic air is drown down from west of Hudson Bay, by way of Manitoba, showing a sharp rise in pressure and very low temperatures. It is usually preceded by a moderate fall in pressure. The basin high has begun to weaken. It is now time to wake up and move. The arctic front moves with the speed and direction of the gradient winds and will drive everything before it. It will frequently be noted that these winds are 40 to 60 m.p.h. from the north and northwest. A little plain multiplication by 24 hours will indicate where the arctic front (and the cold wave) will be tomorrow morning! It will show a 1000 to 2000 mile movement on many occasions, and that brings it into the Southeast. I have observed this front in Wisconsin and northern Iowa, and 24 hours later it was over northern Florida.

It should be remembered that this is <u>arctic air</u>, and therefore much colder than the polar air that may already have temperatures below normal. Its southward advance will be indicated, by some extent at least, by the <u>upper winds.</u> It will begin to swing eastward where the high level winds around the deep upper level cyclone become westerly. But the fact that this cyclone may be displaced eastward should be taken into account. This eastward displacement may change the winds to northerly as the system advances, and thus bring the cold father south.

<u>The high that stalls against the mountains in the south, but rolls over in the north and comes down east of the mountains.</u> There is a definite tendency for cold air to come down from the north and northeast, <u>east of the mountains</u> in connection with all highs that move into the middle Atlantic states from the west and north. The change to colder frequently extends southward and southwestward into Georgia. The extent of the southward journey being determined by the strength of the high and the resistance encountered. In winter the high that stalls against the mountains and rolls over, presents a double problem in forecasting temperature changes. The situation is frequently as follows: A cold, but rather shallow high advances to the mountains and middle Gulf states moving from the northwest. Here its progress is impeded or stalled, and the southern part saver the Gulf states does not make much more eastward progress. The main body of the high further north crosses over the mountains of West Virginia and Pennsylvania and the cold air begins moving southward east of the mountains. In the meantime temperatures have not changed, or may have actually risen in the foehn area, especially in South Carolina. Then the cold air sweeps down from the north and northeast bringing the colder change, perhaps to eastern and southern Georgia. Seldom will the cold change be of cold wave proportions, except at times in North Caroline, but considerably colder nevertheless.

It will seem that in these cases the forecast while have to delay a colder forecast while the cold air across the mountains to the north and returns down the eastern slope.

<u>High from Hudson Bay Region or Eastern Canada</u>.

These highs must be watched for the same tendency to send cold air down the Atlantic plain. Their normal movement is southeastward, but the cold air has a disconcerting habit of extending much farther south in the Atlantic plain area than might be expected. The forecaster should be alert to this characteristic, or he will not forecast colder for enough south. The "Northeaster" cold changes frequently reach southward to Savannah, Macon and Jacksonville, but <u>will not</u> reach further unless the temperature is much above normal in Florida when some cooling toward normal may occur.

When southward movements cease, the front frequently begins returning as a warm front. It will usually be extending from southeast to northwest through South Carolina and Georgia but sometimes may cross extreme North Florida into southern Alabama. Some rain may or may not attend the southward movement of the cold front, but quite frequently rains of the warm front, but quite frequently rains of the warm front type will appear and advance back northward ahead of it.

Highs from the west or southwest. Colder changes from these directions are usually moderate but may give freezing or lower. They generally move rapidly over the area without undue complications. If they follow a Gulf low or a south Atlantic secondary, the colder change may be complicated in North Carolina by cold air remaining east of the mountains as described above for South Atlantic secondaries.

The high that sends a vigorous tongue down the Atlantic plain is very persistent at times. This is most likely to occur in fall or early winter while the Atlantic is still warmer than it will be later in winter. It may have low pressure over the Atlantic as its counterpart, and remain in place for days, aided by the tendency for cold air to linger cast of the mountains until it is scoured out by south and southwest winds. In December it has been noted to persist for a week or ten days, when no well developed disturbance moved in from the west or southwest to disturb it. A flow of west or southwest winds aloft will not disturb it much since they are forced to rise over the mountains and pass over the thin cold layer. Cold drizzle, fog, and light rains will persist while such warm overflow continues without much temperature change. If there is no over-running winds, of course, fair weather prevails.

Summer Weather -- Georgia and Carolinas

In summer this area has few pronounced air mass changes but weak frontal systems are not uncommon and occasionally one of sufficient strength to change the prevailing tropical conditions will move through. The rainfall, therefore, is partly tropical and partly frontal showers, but there is less regularity of occurrence than in Florida. Southern Georgia shares with Florida in the prevalence of tropical shower conditions, but in the remainder of the area the purely tropical conditions decrease with distance from the tropics.

Much of the summer the Atlantic high pressure area with its variable strength and position is the most dominant factor. If it is well developed and in position to bring gentle winds from the southeast or south, the showers are more certain and general due to upslope movement. If the central ridge is farther south and southwesterly winds prevail, few showers occur except in the mountains and Georgia for elsewhere down-slope winds will not favor many showers. An ill-defined, flat, high pressure with little gradient and light wind movement is a good convective shower type. If a weak, indistinct from is present with gentle convergence, the conditions are very favorable for showers.

"Treacherous Troughs"

Mention has already been made that the stronger troughs are disappointing rain producers. I call them “treacherous troughs”. The lack of strong convergence at the front, the stronger gradient winds, foehn subsidence, and diversion, are some of the causes of scanty and scattered rainfall associated with them. Whatever the causes, many of these stronger low troughs in summer have less showers than most any other type of pressure distribution found in the area except possibly in mountains. The natural tendency of the forecaster is to expect general showers in a good trough, but when the condition has passed he will find that most of the cases will not give more than 25% - (and many times even less) - in the area covered by rainfall. Unless the high in the Atlantic is in the position to give a decided north-south orientation of isobars on the eastern side of the trough, caution should be exercised in forecasting showers.

Showers from the northeast.

The foehn developed low bubble that occasionally forms in the Piedmont area and moves southwestward by the upper winds has been mentioned above several times as a thundershower producer. It was stated that the South Carolina piedmont region was a favored area for such development, but this is not the only area east of the mountains where these developments are noted. They may be observed to originate over Maryland and Virginia, or even farther north. Namias has tried to show by isentropic analysis that the whole movement may attend a moist tongue circulating around the anticyclonic dome in the Ohio Valley, bringing moisture from the Lakes Region around and down the Atlantic Plain at the insentropic level. While such a transport of moisture may occur, it must be realized that more moisture is likely to be present initially in the Atlantic plain than in a tongue crossing the mountains and swinging south. In other words, there is usually sufficient moisture present. The returning winds aloft, being relatively cooler, steepen the lapse rate over the super-heated moist air in the surface layers east of the mountains and may add some moisture at higher levels. At any rate, this is a very good shower type, and they will progress from the northeast down the Atlantic plain, and then may continue west-southwest and westward over the Gulf States.

The forecaster should watch for the super - heated bubble anywhere from Maryland to Georgia. In summer it will usually show an 8: 30 a.m. isotherm of eighty degrees or higher. Then if the upper winds show the proper circulation, thundershowers will form and advance south and southwest. This movement will also result where a rise in pressure from the St. Lawrence Valley area develops southward over the north and middle Atlantic States. Clean-cut cases do not occur as often as complicated types of this condition. Like all other types, the forecaster will have to size up the individual situations according to the other features of the map. Many half-developed conditions will be noted. At times the upper winds give good movement, but at others will be light or indefinite.

These showers show decided evidence of thermal overturning and are not dependent entirely on convective action from surface heating in the daytime. They will occur at night as well as day. Another characteristic is that they cease with the restoration of thermal equilibrium. This occurs with the thunderstorm action, so that the showers do not continue for a long period of time, but rather they equalize the instability and end in a given locality, passing on southwestward. Usually one 12-hour period in a given locality will witness their beginning and ending. Severe turbulence and electrical activity are usually present. Some have hail. They are nearly always local in character and not of the line-squall type, but rather a numerous series of individual local storms.

South Carolina Showers:

In discussing summer showers in these states, attention is directed to a peculiarity frequently noted in South Carolina. It is a lack of showers for which no adequate explanation is available. It is frequently noted under the tropical showers type, i.e., when, most tropical air is flowing from the south or southwest, and showers are numerous in Georgia and a good portion of North Carolina, but none or very few are noted in South Carolina. A shower forecast will give good verification, except in South Carolina and perhaps the coastal area of North Carolina. This condition may have topography as its main cause, for such flow of air will be slightly down-slope as it tends to bend more toward the northeast. At any rate, the forecaster will soon learn to be more cautious in making showers forecasts under this set up for South Carolina than for other sections in summer. It should be pointed out, however, that this skipping of South Carolina does not always occur, and it cannot be set down as a rule to follow with assurance. It is merely a tendency with sufficient effect to cause many failures of showers forecasts.

SUMMER TEMPERATURE CHANGES

In common with all southern states, this area has very few air-mass temperature changes in summer that can be forecast-- In fact few changes, except those caused by showers. This does not mean that periods of heat followed by periods of moderate temperatures are not experienced. The heat builds up slowly under the cumulative effect of fohen action and/or insolation in the absence of showers. Then the heat wave is broken by the reappearance of showers. If showers break out generally on the same day, temperatures will be modified generally at the same time, but the more usual occurrence is for the heat to be broken over a period of several days by scattered thundershowers. It is well to note that temperatures are changed by the showers, regardless of the passage of fronts, and showers may attend fronts or otherwise. As a general rule, temperature forecasts will not be needed and this element may be left alone for the summer to be cared for by thundershowers verification rulers. Periods of unusually high temperature should be forecast as "continued warm" or "continued hot", until showers are expected. Then a forecast of continued warm except where modified by local showers" is a good one.

Prevailing Weather

All forecasters who have followed the weather for a number of years will be impressed with the tendency for given types of weather situations to persist. A drought or a rainy spell, for example. The development of certain types of disturbances, the chain-like movements of certain situations which persist for several weeks or even months and gives a prevailing type of weather, or a frequent recurrence of the same kind of change. This persistence of a given weather type should be constantly kept in mind. It is obviously true that "prevailing weather" has its limitations, else a type would perpetuate itself indefinitely. But when a given type is prevailing, it should be played to continue until there are real evidences of its breaking up; or changing to some other type. If drought conditions prevail, disturbances or fronts that ordinarily will produce rain, will pass with little or none. If wet weather prevails, it will be noted that rains will occur with the slightest provocation, etc. In the Southeastern States this tendency to persistence of "prevailing weather" if Judiciously used, can save the forecaster many losses. I doubt if there is any section east of the Rockies where this tendency can be played for more gains then over the Southern States in all seasons.

Tropical Disturbances.

These states are visited by tropical disturbances occasionally in summer and fall. It is only at rare intervals that storms of hurricanes force move inland from the Atlantic, but the North Carolina cape section is frequently affected by storms moving up from the south Atlantic. Most tropical storms recurve and start moving north and northeast in the vicinity of latitude 30. If the disturbance is over the Atlantic, the decided tendency is for the northeastward curvature to keep it offshore. However, at times due to the position of the Atlantic high, or to the movement of a fresh continental high into the Atlantic high, or to the movement of a fresh continental high into the Atlantic on top of a tropical storm, it does not recurve, but is driven in land. Many more will skirt the North Carolina Capes. A few will be driven on northwest into the mountains and broken up. Others will pass over these states, greatly weakened, after moving inland from the Gulf of Mexico, attended by heavy rainfall and strong winds to gale but not hurricane force.

For storms swinging up off the coast storm warnings may be needed, but unless the center is to move inland or very near the coast, hurricane warnings will not be necessary since the stronger winds will be near and east of the center. If the hurricane center moves inland we have hurricane winds on the coast near and to the right of the center, and they will extend inland for 50-75 miles before being reduced to gales. If a storm moves on northwest into the mountains it will be largely dissipated and slowed down or stalled. The orographic lifting, plus the stalling and slaw dissipation, causes torrential rainfall in the mountain region. These rains may be more destructive than the hurricane winds in coastal areas, and should be forecast as a special warning. If the center moves up off the coast or over the coastal plain, the rainfall will be confined near the center and to the right, and will not extend far to the left.

AUXILIARY CHARTS

The pressure change charts

There has been a tendency in recent years to assume that, with the entry of 3-hour pressure characteristics and changes on the A-charts, there was no real need for further pressure change charting. A little further consideration of the matter is bringing about some change of heart, and it is believed that we are realizing more and more that pressure changes in the recent past, (3 hours) while important, are not sufficient in themselves to bring out the full significance of the pressure change patterns. We continue to find in the 12 hours changes important forecasting aids not readily seen in the isallobaric pattern a 3-hourly changes. In fact, when dealing with tropical weather, we are finding that a 24-hour change chart is more significant than either of the shorter periods changes. Since we are still doing most of our forecasting on the basis the movement of pressure systems, we should look to any and all changes which may have possibilities of prognostics value.

The 12-hour chart: This is an oldest of the pressure change charts. It was found helpful when the Victorian concepts were in vogue, and like many other old Victorian virtues, it stands the test of time. Forecasters will do well to keep it close at hand and ponder its significance. Each forecaster will come to recognize certain changes as significant of coming weather in his district. They would not mean the same in another section of the country and the forecaster in another district might have a different interpretation al together. General rules can be given in some cases, and for these the reader is referred to those given by Bowie and Weightman in Supplement No.1, M.W.R. They are still good, along with the other empirical rules found therein. Showalter has mentioned the significance of the 12-hour change in relation to cyclonic troughs in the upper air (10,000 ft.) etc. (unpublished M.M.S.)

Reference has been made above of some significant 12-hour changes for the Jacksonville District. The fall of 3 mbs. or more on the west Gulf coast in winter on the 8:30 a.m. chart brings rain to Georgia in 24-hours if it is a fall that is developing in that area, as distinguished from a fall that has been pushed southward with a filling tendency over Texas. It may be the first indication of a southern secondary, etc. This is repented here because it is especially dependable. Over the South from Texas eastward the normal tendency under stable conditions is for the pressure to show slight 12-hour and 3-hour rises on the a.m. chart. Falls, even though small, anywhere in this area are significant for rain development. Due to rapid development and movement from the Gulf region, these falls may be the only intimation of development, or of instability conditions that will give quick rain. The rain area will move in the direction and with the approximate speed of the upper winds- (5,000 to 8,000 ft. usually)

The tendency of the inexperienced forecaster is to delay rain forecasters until more tangible evidence has developed. This rule is emphasized for this reason; if you wait for the actual formation of a disturbance, rain may cover much of the district without being forecast. Small falls are much more significant in the south than in more northern localities. These smaller falls may appear only on the 12-hour chart.

The moderate fall followed by a rise that moves eastward across south Texas into the Gulf and is lost so far as land stations are concerned. Remember that nine times out of ten they are not dead, --merely lost. Study the upper winds and figure how long it will take the fall to show up with the rain on the cast Gulf coast—and where.

The increasing storms from the Gulf region have sharply concentrated, pressure falls near the center or only a short distance ahead, both 12-hour or 3 hour.

If the fall extends far out ahead without a highly concentrated central front area, the low is not likely to increase much. It may elongate eastward and form a low gradually fills.

Wave formations on a stalled front do not show pressure falls of consequence until the wave is well into the formation process. After the wave forms, its strength and direction of movement will be indicated to some extend by the area of falling pressure and the amount of fall.

For lows moving eastward from the plains the extension of rain southward is often indicated by a secondary fall area somewhere southeast or south of the main fall. If the fall tapers of southward without a secondary area, it is good indication that little action will attend the southern portion of the low, and much of the district may not have rain. A secondary fall may indicate southern secondary formation. The first indication of occlusion and slow movements may be indicated by falls extending north to west of the low center in the Gulf States. A fall in decided nature north of a low will usually mean a movement toward the north of a low will begin to move and the direction it will follow after being stalled over the West Gulf States.

A good 12-hours rise over Texas and the Rio Grande Valley indicates a rapid movement of the low ahead of it, with rapid clearing and colder as soon as the center of disturbance passes. Until such is noted the movement will be much slower.

A moderate rise in the southeastern states ahead of a disturbance, means the Atlantic high is a strengthening and slow movement may be expected, or else the low will be shunted off northeastward. Care should be exercised in forecasting rain in such cases.

A fall moving southeastward, southeast of a low center, indicates that the low will continue southeastward movement with filling tendency. This helps to forecast action of disturbance coming from northwest of the district. For lows moving eastward or northeastward a fall southeast of the center would indicate an increase in intensity and rapid movement.

The 24-hour chart: During the summer in the tropics and up to the latitude 30, the pressure changes are small, and diurnal corrections are not available to bring the various observations into correct relation. The only satisfactory way we have found to trace pressure waves in this region is by means of comparison at 24 hours intervals. Such a change chart has been prepared at Jacksonville for a number of years during the hurricane season, and more recently for the entire year. On this chart the significant rise and fall areas can be located, whereas a shorter periods chart would result in the small changes being masked by diurnal changes and barometer errors. Then better barometer observations from the tropics are available and we have correction tables for diurnal variations, it may be found that shorter periods changes are better, but for the present there is not alternative to the 24 hour chart. The reader is again referred to the work of Dunn in the June of 1940 bulletin of the American Meteorological Society and also to studies at NYU on waves in the tropics.

Over the southern portion of the district, where summer weather is predominantly tropical, the weather moves up from the tropics. We must look to the tropics, therefore, for significant pressure changes, and this requires the 24 hour change chart. Since about all that is known of this changes and their significant in forecasting has already been published, they will not be elaborated on further here. Mr. R. Sanders of this station has also written an unpublished paper on these changes. They are discussed above under summer weather in Florida. The student should familiarize himself on the use on these changes by reading the available literature in the subject, and watching them on the current maps.

TEMPERATURE CHAGE AND DEPARTURE FROM NORMAL CHARTS

These charts are prepared twice daily for the 8:30 A.M. and P.M. observations during all except the summer months. There are useful aids in forecasting temperature changes during the fall, winter and spring when this element of the forecast is very important in the southeast. From these charts the forecaster can see at a glance the pattern of temperature changes and their movements over the country, together with their relation to normal.

The tendency of temperature is to remain near the normal. To bring about a considerable degree of departure requires forceful importation of an air mass, with temperatures colder or warmer than the normal. When these are lacking, temperatures tend to remain near the normal value. If temperatures are near normal they will not change much unless forced to do so. If they have been forced to wide temperatures, the tendency is to return toward normal just as soon as the force is relaxed. These are facts evident to all, but the forecaster will profit to keeping them in mind. The temperature chart is of great assistance in this. In forecasting the amount of temperature fall and the expected minima in a cold wave moving down from the northeast, for example: We may note that temperatures have been forced 30 degree below normal over the middle west. If the cold moves on without undue modification through the southeast, we would expect it to bring somewhat similar departures. The normal over Missouri might be 10°, and a -30° departure will give readings of -20°, but in North Carolina the normal will be around 40 and would expect minima of around 10° to 15°.

Of course, some allowance must be made for the fact that the further southward from the center of the continent, the smaller will be the changes, until in the Gulf of Florida the cold may taper off too much smaller departures. At least the forecaster will realize that the departure will seldom be larger as the wave comes south, and most of the time around the same of smaller. I have found these departures of great assistance in indicating expected minima for various portions of the district. In the stronger cold wave the maintenance of the departure relation is particularly dependable.

A colder change moving into an area where temperatures are already below normal would not be expected to cause the same degree of change that it would if temperatures were higher. Here again the normal departure relationship tends to be maintained. Conversely, warm air moving into an area where low departure prevails will result in much greater rises in that area, but if it moves into an area already above normal, little change will be expected.

While on the subject it should be remembered that normal values now in use were computed from urban observations. Since observations are now made mostly at suburban airports, there is need for up-to-day observation-hour normals based on reading from the new locations.

WINDS ALOF CHARTS

The winds aloft have been referred to so often in these notes, that it would seem unnecessary to add further comment. Next to the surface A-charts, I find more useful and usable forecast help in the winds aloft than any other. In preparing these charts the pressures at 5, 10 and 20 thousand feet elevation are entered from the radiosonde observations and isobars drawn. It will be noted, however, that carefully drawn wind-stream lines from the gradient level upward, so nearly conforms to isobars that a good pressure pattern is arrived at for all levels. Over-running, convergence, divergence, etc. can also been seen.

The stream lines show source regions of main currents follow them through. Surface disturbances are carried along as eddies by the upper circulation and fronts are moved along by the winds at the gradient levels behind them. Many and varied indeed are the uses of this charts.

To determine the direction and speed at which a disturbance will move in the South there is no method I know of more dependable than the upper winds. The question is, at which level is the significant carrying current found? A rule I have used with success does not employ any particular level, but rather the level at which we get above the surface cyclonic circulation. This will usually be found between 5,000 and 8,000 ft. Sometimes higher and very occasionally lower. Here we find the winds that will carry the whole disturbance along, passing right along over it in the upper level wave flow, note that the 10,000 ft map is generally too high. Where could front movements are concerned, the winds at the gradient level behind the front (and to some extent those ahead of it) will give very good results.

THE ISENTROPIC CHARTS

These charts are so far proven somewhat disappointing in this district. Especially so, since they were hailed with such enthusiasm when first brought into use. After several years we are still in doubt as to their real value in forecasting. This is specially the case in fall, winter and spring, when the isentropic tongues conform in general with the surface pressure patterns and add little, if any, additional information. The stream-flow patterns are usually determined as well or better from the upper air wind.

Our efforts to use isentropic analysis in forecasting have been disappointing in about the same degree as helpful, and no special rules of usage have been evolved.

In summer when movements are more sluggish and surface pressure is flat and indefinite, some help in forecasting showers is found in the isentropic charts and flow patterns. The show areas of greater moisture and the nearness to saturation. This may be shown to better advantage, however, by the individual charts of the Raysonde soundings. In this we have the temperature lapse rate as well as amount and depth of moisture, throughout the sounding, and not merely a few horizontal slices taken at some fixed levels which may or may not be significant. The most important aid in forecasting showers in the tropics obtained from the Roob Soundings is the height and degree of the inversion.