15. THE ASSOCIATIONS BETWEEN CLIMATIC PARAMETERS AND A MODEL OF CHANGES OF CLIMATIC CONDITIONS IN THE HORNSUND REGION

There are a variety of correlations between multiannual monthly and annual mean values of particular parameters describing the state of climate in the Polish Polar Station region. A number of them were mentioned in the chapters discussing the specific climatic elements. Knowledge of associations between them allows a model of their behaviour under the influence of given forcing factors to be constructed.

The quantitative characteristics of the most important associations between particular climatic parameters together with an attempt at interpretation will be presented here. Interpretation of such associations is essential for several reasons. Some of them are causal – where physical change of one parameter causes change of another. The relationship between mean annual air temperature and mean annual water vapour pressure in the air may serve as an example. Some associations should be interpreted from the point of view of signal analysis, however – a change of value of one component signals the effect of some other, often unidentified process whose activity causes significant change in another climatic parameter. An example may be the association between annual air temperature and sunshine duration in which the true real controller of the association is atmospheric circulation affecting both air temperature and cloudiness. Cloudiness clearly controls both radiation and sunshine duration, as a result of which there are significant statistical relationships between sunshine duration and air temperature. Contrary to common opinion these relationships are often negative (see Chapter 7.4). Negative correlations between annual air temperature and annual frequency of calm weather are of similar character.

15.1. Associations between climatic parameters

In studies discussing interrelationships between climatic elements at different stations the factor yielding the strongest connections with the greatest number of parameters is usually frequency of occurrence of wind from a given direction. Analyses for Hornsund have shown that correlation of wind direction with the other elements is weak or absent in most cases, however. Statistically significant correlations are few.

Annual air temperature does not show strong association with wind frequency from particular directions, or with the frequency of variable winds. There is statistically significant correlation of annual temperature with frequency of calms ($r = -0.44$, $p < 0.016$). The nature of the atmospheric circulation is the reason for this association – calms occur during anticyclonal conditions in the Spitsbergen region. The increase of frequency of anticyclonal situations in the winter contributes to reduction of cloudiness which increases radiation losses and thus also decreases air temperature. Occurrence of high pressure conditions in the cold season also reduces possibilities for advection of warmer air that might increase the air temperature.

Similarly, there is a lack of association between the variability of annual atmospheric pressure and wind direction. The strongest positive association between atmospheric pressure and wind parameters is correlation with frequency of calms ($r = 0.36$). This does not exceed the threshold of statistical significance however ($p = 0.052$).

The only statistically significant relationship between wind direction and annual totals of precipitation at Hornsund occurs in the case of south-western winds (SWw).The correlation coefficient between these parameters reaches 0.47 ($p < 0.0095$). Variability of wind frequency from SW explains around 20% of the variability of total annual precipitation (RR_{annual}) over the analysed period. This interrelation is described by the equation:

$$RR_{annual} = 262.0(\pm 65.1) + 34.0(\pm 12.4) \cdot SWw_{annual} \qquad [15.1]$$

where RR_{annual} is annual total precipitation [mm], SWw_{annual} is percentage of winds from SW during a year.

The value of the regression coefficient shows that role of winds from this direction seems to be very important for total precipitation because a 1% change of annual wind frequency from SW changes the annual precipitation total by 34 mm on average, and with the same sign. Taking into account the standard error of estimate of the regression coefficient it changes precipitation totals in the range, 21.6 – 46.4 mm. Other wind directions do not contribute to changes of annual precipitation totals. The correlation coefficient between RR_{annual} and frequency of eastern winds, that is the most frequent wind direction at Hornsund during the year, is negative; the value of the regression coefficient is significantly smaller than accuracy of its estimation.

Association of RR_{annual} with frequency of SW winds seems to have casual characteristics. Inflow of air from the Greenland Sea and from the relatively near West Spitsbergen Current is connected with occurrence of SW winds. In the specific topoclimatic conditions of the northern shore of Hornsund, this air is forced to rise when flowing up the mountain slopes in the vicinity of the station. This contributes to occurrence of orographic precipitation or the orographic intensification of frontal precipitation. However, there is a lack of statistically significant associations between annual relative humidity of the air, water vapour pressure, general cloudiness and annual frequency of SW winds. The positive signs of the correlation coefficients in each case seem to confirm this hypothesis.

Wind velocity at Hornsund over the interannual course does not show association with the atmospheric pressure at the station, and neither do the monthly courses. It is also hard to detect association between wind velocity and precipitation totals. When such correlations occur (March, July; $r = \sim -0.4$) they are the most probably coincidence. Annual wind velocity shows a not very strong, significant positive relation ($r = 0.42$, $p = 0.022$) with annual cloudiness. Wind velocity does show relatively strong associations with general cloudiness in some months. Significant correlations between these quantities occur in April and May ($r = 0.69$ and $r = 0.42$, respectively) as well as in September and December ($r = \sim 0.45$). Clearly positive correlations prevail, but in July and August however correlation between these quantities changes sign to negative. The relationships between wind velocity and cloudiness at Hornsund may be interpreted as being forced by the circulation factor. The principal role should be attributed to concurrent increase of wind velocity and cloudiness that occurs with low-pressure systems. Concurrent increase of both quantities with increased frequency of low-pressure systems during a given period leads to the emergence of positive correlations between wind velocity and cloudiness. The activity of a local factor may be playing role here also – the orography contributes to increase of cloudiness when wind velocity increases.

Such weak correlation of variability of wind directions and velocity at Hornsund with the other climatic elements may be explained by the argument that wind parameters measured at the station do not record the real distribution of wind vectors in the lower troposphere but characterize only the directions and velocities of local ground wind, forced by the topography (morphology) of the surroundings. Directional distribution of wind frequency during a year and in particular months (see wind roses in Chapter 6) proves this. Wind measured at Hornsund is not representative of the region and does not show typical relations with processes of regional scale (even most general conformity of wind direction with air temperature for example).

Atmospheric pressure means changing strongly from month to month and from year to year at Hornsund display nearly autonomous behaviour. The monthly variability has nearly no stable relationships with the variability of the other climatic parameters. Annual atmospheric pressure correlates with annual air temperature at the level –0.25 ($p = 0.170$); in no month is a statistically significant relation between these quantities evident. The annual variability of atmospheric pressure shows a moderately strong relation with annual total of precipitation that is statistically significant ($r = -0.47$; $p = 0.008$). Most of the monthly associations of pressure with precipitation have negative signs, and in April and June these become significant (–0.42 and –0.60, respectively). In some months however (February, September, November and December) the sign of the association changes, proving its instability. Associations of monthly values of pressure with general cloudiness, water vapour pressure and relative humidity are similarly weak. In the case of cloudiness, vapour pressure and relative humidity negative associations definitely prevail. This shows that with decrease of pressure the value of a given element in a given month generally increases.

The accumulation of weak correlations over consecutive months, not significant but in majority of cases being of the same sign, is a reason that pressure shows a statistically significant relation of moderate strength with relative humidity ($r = -0.42$; $p = 0.024$) and stronger correlation with annual sunshine duration ($r = 0.59$, $p = 0.001$) over the annual cycles. In the case of sunshine duration, variability of annual pressure explains over 30% of its variability. The regression equation describing the correlation between these elements is:

$$SS_{annual} = -41862.4\ (\pm 11401.0) + 42.5(\pm 11.3) \cdot PP_{annual} \qquad [15.2]$$

where: SS_{annual} – annual sunshine duration in hours, PP_{annual} – annual atmospheric pressure [hPa]. Estimation of the parameters of equation [15.2] is statistically significant and the equation allows estimation of annual sunshine duration from annual values of atmospheric pressure, with a standard error ±129.5 hours. In face of the great variability of interannual sunshine duration at Hornsund (min – 760 hours, max – 1330 hours), such a value for the standard error of estimate appears to be acceptable.

The associations of pressure with precipitation, relative humidity, sunshine duration are actually regulated by cloudiness, with which pressure is related weakly ($r = -0.28$). Pressure shows very strong ($r = -0.76$) associations with the cyclonicity index of Niedźwiedź (1993, 1997b), which has a weaker relationship with cloudiness ($r = 0.48$). As a result the trends in pressure and cloudiness are similar to some degree, enough to create somewhat stronger correlations between pressure and those climatic elements which cloudiness actually regulates.

Annual air temperature shows statistically significant correlation with the annual total precipitation ($r = 0.46$, $p < 0.009$). Precipitation totals in the autumn (from September to November) show stronger association with monthly air temperature (r from 0.59 in November to 0.61 in September and October), and are quite strong also in January ($r = 0.60$). Generally, only in July and August is precipitation negatively correlated with monthly temperature. Annual precipitation total (RR_{annual}, mm) as a function of annual air temperature (Ta, °C) is described by the equation:

$$RR_{annual} = 569.6(\pm 50.4) + 31.6(\pm 11.3) \cdot Ta. \qquad [15.3]$$

This explains only around 18.5% of variation in annual precipitation totals ($R = 0.46$, $p < 0.01$), and its standard error of estimate is ~83 mm, which excludes any practical utility in the relationship[1]. From this relation however, on average increase of air temperature will increase precipitation totals at Hornsund. Annual temperature shows a considerably stronger relationship with cloudiness (see Chapter 7.1). Variability of annual temperature explains around 39% of annual cloudiness variability (N_{annual}). This relation is expressed as

$$N_{annual} = 6.37(\pm 0.13) + 0.13(\pm 0.03) \cdot Ta, \qquad [15.4]$$

where N_{annual} is annual general cloudiness (octas), Ta is annual air temperature. This relation is highly significant ($p < 0.0002$), and the standard error of estimate N_{annual} is relatively small (±0.22/8). Indeed, this relation is actually reversed (see Chapter 7.1); it is cloudiness associated with the direction of inflowing air masses that regulates air temperature. The strength of this relationship makes it possible to use it in model calculations in cases where the annual air temperature can be estimated.

Correlation between annual air temperature and the number of clear days ($N \leq 2$ octa) is very strong ($r = -0.77$).The regression equation however has no significant free term, which introduces a large error in estimation of the number of clear days. One may estimate however, that a one degree increase in annual air temperature reduces the number of clear days during a year by 6.2 days ($p < 0.0001$). Correlation of annual air temperature with number of cloudy days ($N \geq 7$ octa) is somewhat weaker. Increase of annual air temperature by one degree increases the number of cloudy days by 8.9 (±2.8). Taking into account the accuracy of the estimates, one may assume that increase of temperature replaces the number of clear days with a similar number of cloudy days.

Annual water vapour pressure (VP_{annual}, hPa) is almost an exact function of annual air temperature. Its approximation with linear equation gives:

$$VP_{annual} = 5.68\ (\pm 0.06) + 0.27\ (\pm 0.01) \cdot Ta. \qquad [15.5]$$

This equation explains ~94% of interannual variability of vapour pressure, with an error around 0.09 hPa ($R = 0.97$, $p < 0.0000$). At the same time, correlations between annual air temperature

[1] All estimates of annual totals of precipitation at Hornsund from relations with other climatic elements (water vapour pressure, cloudiness, etc.) are encumbered by the very big standard error of estimate, exceeding 80 mm. A similar situation occurs also in the case of correlating annual totals of precipitation with other predictors (SST on the N Atlantic, circulation indices, forms of circulation, etc.). It is the result of the very large share that random factors play in determining precipitation totals at Hornsund, or the activity of factors not identified as yet.

and relative humidity are very weak ($r \sim 0.26$). The reason is the lack of interannual variability in relative humidity – at the multiannual mean of 79%; the standard deviation is around 2 (1.98%). All observed annual humidity varied in the range of 76 to 83% and, except for a few cases, oscillated around 78–80% almost independently of the annual air temperature.

Annual air temperature is negatively correlated with annual insolation (SS_{annual}, hours), but this association is not statistically significant. Because the standard error of estimation of insolation as a function of air temperature is significantly greater than error of estimation with Equation 15.2 (144 hours), it will not be quoted. Analysis confirms the earlier conclusion (see Chapter 7.4), that the higher the annual temperature at Hornsund, the lower the annual insolation. As was explained earlier, atmospheric circulation and the changeability of cloudiness connected with it control both the variability of insolation and of air temperature.

The annual amplitude of temperature (AT_{annual}, deg) is strongly associated with annual air temperature at Hornsund. Variability of annual temperature explained 61% of its amplitude. This relationship takes the form:

$$AT_{annual} = 13.06\ (\pm 0.81) - 1.26\ (\pm 0.18) \cdot Ta \qquad [15.6]$$

and is highly significant ($p < 0.0001$). Error of estimate of AT_{annual} with it does not exceed 1.3 deg.

The lowest monthly temperature ($Tmin_{annual}$; °C) during a year (annual minimum in the sequence of monthly means) is also a function of annual temperature (T_{annual}). It may be estimated with the equation:

$$Tmin_{annual} = -7.92\ (\pm 0.78) + 1.41\ (\pm 0.17) \cdot T_{annual}, \qquad [15.7]$$

which explains 68% of the annual variability of $Tmin_{annual}$ ($R = 0.83$, $p < 0.0001$), with an error ±1.28°C (Fig. 15.1). The association of highest monthly temperature during a year ($Tmax_{annual}$, °C) with annual air temperature is considerably weaker, insignificantly exceeding the limit for statistical significance ($p < 0.037$). It takes the form:

$$Tmax_{annual} = 5.14\ (\pm 0.31) + 0.15\ (\pm 0.07) \cdot T_{annual}, \qquad [15.8]$$

and explains merely around 11% of $Tmax_{annual}$ variability. Attention should be drawn to the fact that the standard error of estimate of $Tmax_{annual}$ in Equation [15.8] is relatively small, only ±0.51°C. The cause of such a weak association is the very small interannual variability of the highest monthly temperature during the year. In the face of generally small variability of temperature in summer months, possible instability of Equation [15.8] does not play any major role in the construction of a model.

Equations [15.6] – [15.8] record characteristics of the Hornsund associations of annual minimum and maximum temperature with mean temperature, presenting them in measurable form. These equations confirm a fact already discussed and found earlier in studies by numerous researchers, that increasing warming occurs mainly as the distinct increase of temperature in the cold period. One result among others is the decrease of the annual amplitude of temperature. On Spitsbergen it magnifies the already distinct oceanic character of the climate.

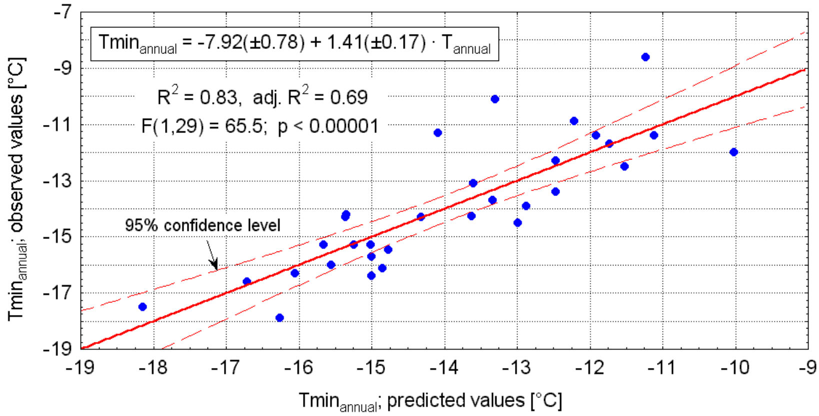

Fig. 15.1. Temperature of the coldest month [$Tmin_{annual}$] as a function of annual temperature [T_{annual}]; values estimated with Equation [15.7] in relation to observed values.

Annual cloudiness (N_{annual}) is strongly interrelated with annual totals of precipitation and annual insolation. In estimating parameters for the equation in which annual total precipitation is a function of annual cloudiness, the free term is not statistically significant and thus equation estimates annual total precipitation with an unacceptably large error (± 82 mm). Assuming nothing but the value of the regression coefficient (highly significant), one may approximately estimate that increase of cloudiness by one octa causes increase of annual total precipitation by around 71–77 mm. This value however makes sense for the present mean annual temperature, and with the assumption that the relationship is linear. Further increase of the air temperature in future should change this value because the effective relation is strongly non-linear. Annual insolation (SS_{annual}), as function of annual cloudiness may be estimated with a somewhat smaller error than as a function of atmospheric pressure (equation [15.2]). The relationship between insolation and general cloudiness is:

$$SS_{annual} = 3027.9\ (\pm 510.1) - 341.6\ (\pm 87.5) \cdot N_{annual} \qquad [15.9]$$

and explains ~34% of annual insolation variability (R = 0.60, F (1.27) = 15.2, p < 0.0006) with a standard error ±128 hours. The influence of changes of cloudiness during a year on the variability of insolation is obvious. The strength of correlation between these parameters, statistically relatively weak, is a result of variability of cloudiness over the complete year, whereas there is changeability of insolation only during a part of it. Changes of cloudiness during the polar night and short day affecting the mean annual value of N have no influence on variability of insolation because there is no insolation. Similarly, during the short day, insolation is very weakly connected with cloudiness.

The relationships presented above show that the principal climatic elements controlling other climatic parameters are air temperature and cloudiness, which are strongly interrelated. Direction and velocity of wind as well as atmospheric pressure change autonomously, not exerting greater influence on the variability of the other parameters.

15.2. A model to forecast climatic changes in the Hornsund region

For the construction of a model of climate changes at Hornsund predictors may be found to determine annual changes of air temperature, wind velocity, wind directions and cloudiness. A useful predictor for estimating annual air temperature may be the main factor influencing its variability, which is the changeability of heat resources introduced by Atlantic water in the West Spitsbergen Current, i.e. the $LF_{1\text{-}4}$ index of the preceding year (Chapters 3.3 and 9.5.4). Its direct and indirect control of the thermal conditions in the Hornsund region has been comprehensively discussed in preceding chapters and need not be repeated here. A model based on this predictor gives a very simplified view of reality but, however, allows rough but justifiable estimates of the directions and changes of individual climatic elements at the scale of annual mean values. It is worth remembering that the value of $LF_{1\text{-}4}$ obtained as early as the second half of May in a given year may allow one to estimate the character of the changes that will appear during the next year.

To simplify explanation of the model the sequence of the equations will be presented here, whether presented earlier in the text or not.

The annual air temperature (T_{annual}) at Hornsund in year k is calculated as a function of the $LF_{1\text{-}4}$ index in the preceding year (k-1):

$$T_{annual\,(k)} = 20.67\ (\pm 3.20) + 2.60\ (\pm 0.51) \cdot LF_{1\text{-}4\,(k-1)} \qquad [15.10]$$

The $LF_{1\text{-}4}$ index in year k-1, calculated from the ERSST v.2. data set (Smith and Reynolds, 2004)[2], explains around 46% of annual air temperature variability in the ensuing year (k) at Hornsund, with a standard error of estimate (SEE) of ±1.00°C (Chapters 3.3.1 and 9.5.4, Eqation [4] and Fig. 9.21).

Knowing the annual temperature (T_{annual}), one may estimate the annual amplitude of temperature (AT_{annual}) in year k:

$$AT_{annual} = 13.06\ (\pm 0.81) - 1.26\ (\pm 0.18) \cdot T_{annual} \qquad [15.11]$$

with a standard error of estimation of ±1.33°C, and next the temperature of the coldest month in year k ($Tmin_{annual}$):

$$Tmin_{annual} = -7.92\ (\pm 0.78) + 1.41\ (\pm 0.17) \cdot T_{annual} \qquad [15.12]$$

(SEE = ± 1.28°C) as well as the temperature of the warmest month in year k ($Tmax_{annual}$):

$$Tmax_{annual} = 5.14\ (\pm 0.31) + 0.15\ (\pm 0.07) \cdot T_{annual}, \qquad [15.13]$$

(SEE = ± 0.51°C).

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[2] The ERSST v.2. set ends in December 2009. At present NOAA NCDC gives global monthly SST with a spatial resolution 2x2° in the ERSST v. 3b set. Values of the $LF_{1\text{-}4}$ index calculated from this set also show highly statistically significant relations with the annual air temperature of the next year at Hornsund, but the level of explanation of annual air temperature variability is somewhat lower (adj. R^2 = 0.39), than with the data from the ERSST v.2 set.

Knowing the annual temperature T_{annual} in year k one may also estimate the general cloudiness of that year (N_{annual}; octas) with an accuracy of ±0.23 octas:

$$N_{annual} = 6.37\ (\pm 0.13) + 0.13\ (\pm 0.03) \cdot T_{annual} \qquad [15.14]$$

and next the annual insolation (SS_{annual}; hours) from annual cloudiness with SEE = ± 127.9 hours:

$$SS_{annual} = 3027.9\ (\pm 510.1) - 341.6\ (\pm 87.5) \cdot N_{annual}\ . \qquad [15.15]$$

From the $LF_{1\text{-}4}$ index in the preceding year (k-1) one may estimate mean temperatures of thermal seasons in a given year (k), (see Chapter 9).

Temperature of the winter T_W (December-April):

$$T_W = -31.27\ (\pm 5.94) + 3.35\ (\pm 0.91) \cdot LF_{1\text{-}4\ (k\text{-}1)} \qquad SEE = \pm\ 1.85°C. \qquad [15.16]$$

Temperature of the spring T_{Sp} (May-June):

$$T_{Sp} = -9.03\ (\pm 2.64) + 1.35\ (\pm 0.42) \cdot LF_{1\text{-}4\ (k\text{-}1)} \qquad SEE = \pm\ 0.82°C. \qquad [15.17]$$

Temperature of the summer T_{Su} (July-August):

$$T_{Su} = 0.67\ (\pm 0.01) \cdot LF_{1\text{-}4\ (k\text{-}1)} \qquad SEE = \pm\ 0.43°C. \qquad [15.18]$$

Temperature of the autumn T_{Au} (September-November):

$$T_{Au} = -20.49\ (\pm 4.84) + 2.80\ (\pm 0.76) \cdot LF_{1\text{-}4\ (k\text{-}1)} \qquad SEE = \pm\ 1.51°C. \qquad [15.19]$$

Similarly, knowing the $LF_{1\text{-}4}$ index in year (k-1) one may estimate mean annual wind velocity in year k (Vw_{annual}; $m \cdot s^{-1}$):

$$Vw_{annual} = 2.27\ (\pm 1.15) + 0.52\ (\pm 0.18) \cdot LF_{1\text{-}4\ (k\text{-}1)} \qquad [15.20]$$

with a standard error of estimation of ± 0.37 $m \cdot s^{-1}$.

The mean annual percentage of calms with ($Calm_{annual}$, %) may be estimated by

$$Calm_{annual}\ (\%) = 33.78\ (\pm 10.29) - 4.22\ (\pm 1.64)\ \ LF_{1\text{-}4\ (k\text{-}1)} \qquad [15.21]$$

with SEE = 2.63%. Deviation from mean annual precipitation (ΔRR_{annual}; 434.8 mm) may be roughly estimated by

$$\Delta RR_{annual} = -622.3\ (\pm 276.1) + 98.5\ (43.6) \cdot LF_{1\text{-}4\ (k\text{-}1)} \qquad [15.22]$$

(SEE = ± 86.1 mm). Estimation of annual total precipitation, as noted earlier, is hampered by very big errors, amounting to around 20% of the total.

The number of days with precipitation exceeding 10 mm ($DRR10_{annual}$) may be estimated in year k from the value of LF_{1-4} index in the preceding year (k-1) with a somewhat smaller error (± 3.4 days)

$$DRR10_{annual} = -19.3\ (\pm 10.9) + 4.6\ (\pm 1.7) \cdot LF_{1-4\ (k-1)} \qquad [15.23]$$

which shows that to some extent changes of total precipitation during a year will be associated with increase or decrease of individual precipitation intensities. Increase of the number of days with precipitation >10 mm per day estimated with Equation [10.23] will occur most often between September and December.

Mean thickness of the snow cover in June (SC_{June}; cm) is a value that is more accurate. It indirectly indicates the end of snow cover in f the Hornsund region in a given year

$$SC_{June} = 109.3\ (\pm 32.9) - 15.0\ (\pm 5.2) \cdot LF_{1-4\ (k-1)}\ . \qquad [15.24]$$

The accuracy of SC_{June} estimation is ± 10.2 cm. Mean annual water vapour pressure at Hornsund (VP_{annual}; hPa) may be also estimated from the value of $LF_{1-4\ (k-1)}$, with a mean standard error of estimation SSE of ± 0.26 hPa

$$VP_{annual} = 0.66\ (\pm 0.01) \cdot LF_{1-4\ (k-1)}\ . \qquad [15.25]$$

It is impossible to predict the behaviour of mean annual atmospheric pressure on the basis of changes of the LF_{1-4} index or other climatic elements at Hornsund. Generally, mean annual atmospheric pressure at Hornsund decreases together with increase of the amount of heat transported by oceanic circulation to the Arctic (with increase of LF_{1-4}). This relationship is weak however, unstable and statistically not significant. This element, despite its indirect relationships with some other climatic elements cannot be allowed for in the model. This does not means that variability of annual or winter (December-March, December-February, January-March) pressure in the Hornsund region is unpredictable. It is possible to predict atmospheric pressure few months in advance in this region (centred at 75°N, 15°E; Marsz and Styszyńska 2006). Seasonal values of some circulation indices of Niedźwiedź (1997b, 2001) are similarly predictable, however with less accuracy. These may be predicted from earlier distribution of SST anomaly on the Northern Atlantic. This is however a separate problem that will not be developed here.

The simplest computational format for the model is presented in Fig. 15.2. It exemplifies a structure that may be termed the "oceanic model" of climate change in Hornsund region, because oceanic processes are the only factor forcing changes of climatic elements in it. Other factors influencing short-term climate changes (e.g. atmospheric circulation) were completely omitted in the model. Introducing the LF_{1-4} index in the model gives as its output the parameters, and more precisely, ranges of most probable values of the climatic elements, being the responses of the system to change in the amount of heat transported with the water to the Atlantic Arctic. Because the equations which constitute the model are given here, all interested persons may write a short program to perform these calculations without any problem.

Although the model is incomplete and, one might say, unsophisticated, in action it simulates the observed behaviour year in, year out over the research period,1978–2009, quite well and describes the changes of climate recorded at the Hornsund station as well as their faster and faster evolution. The model does not contain as an inertial link, SST of seas surrounding Spitsbergen and sea ice cover on those seas. As was stressed earlier (Chapters 3.3.3 and 9.3), air temperature at Hornsund may be also estimated from changes of sea ice area on the Greenland Sea in the same year. Sea ice cover on the Greenland Sea in year k depends on SST on seas surrounding Spitsbergen. SST in year k is function of LF_{1-4} index changes in year (k-1), and also the DG_{3L} index in year (k-1).

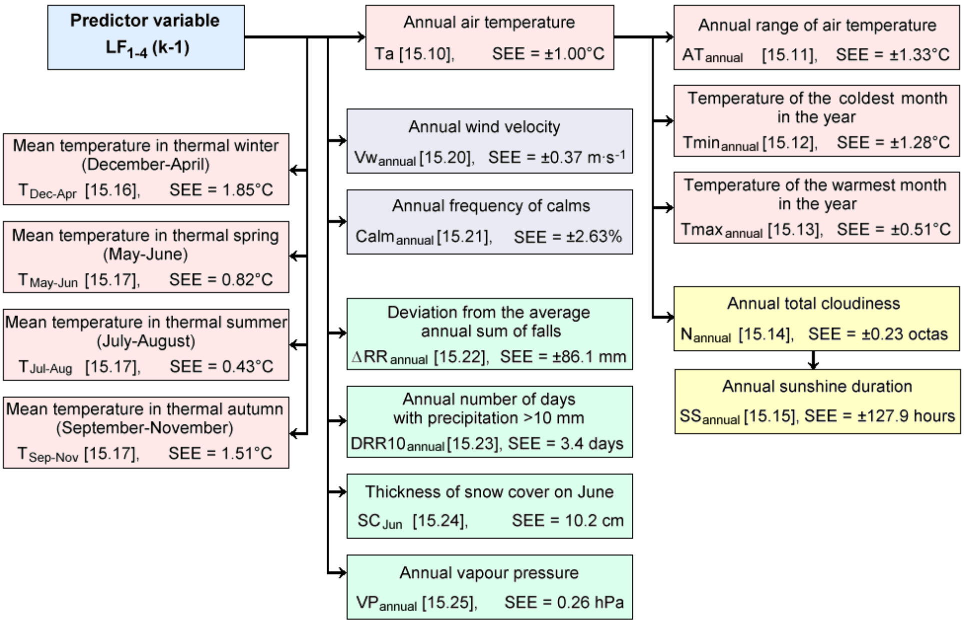

Fig. 15.2. The computational scheme of the "oceanic model" of climatic parameter changes at Hornsund occurring under the influence of changes of the amount of heat transported with the waters of the Norwegian and West Spitsbergen Currents in the preceding year ($LF_{1-4\ (k-1)}$ index; see text).

A separate problem, going far beyond the range of this work but interesting, are results of simulating the climatic conditions changes in the Hornsund region that might arise in the circumstances of slow and abrupt decrease of the heat resources transported with West Spitsbergen Current, using a model in which air temperature and a few other climatic elements are estimated with concurrent consideration of changes of heat amount transported with oceanic circulation to the Atlantic Arctic as well as changes of sea ice cover.