Changes in the frequency of airflow types over Finland - a preliminary study

Kirsti Jylhä
Finnish Meteorological Institute

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1. Introduction

Atmospheric circulation is a key factor in determining both the day-to-day weather variations and the prevailing weather conditions of a region. This preliminary work examines the current and projected future frequencies of different atmospheric circulation types in Finland, using both observations and model simulations.

2. Method

The quantity to be considered is the ratio between the vorticity and magnitude of geostrophic wind, referred here also to as the circulation degree. Geostrophic wind fields were calculated from grid-point sea-level pressure values using three sets of monthly data: NCEP/NCAR reanalysis data[(1)] and two greenhouse gas experiments, one computed by the general circulation model HADCM3[(2)] and the other by the model ECHAM4/OPYC3[(3)]. In the calculations, analysis capabilities provided by GrADS[(4)] were utilised.

In order to smooth out small-scale features area averages of the wind components and vorticity were taken over Finland, or strictly speaking, between latitudes of 60-70°N and longitudes of 15-35°E. As shown by Fig. 1, a ratio close to zero corresponds to a directional flow type in Finland, whereas strongly cyclonic (anticyclonic) situations result in large positive (negative) values of the ratio.

3. Present-day circulation

A comparison of the present-day[(5)] circulation degrees in Figs. 2-4, derived from the three sets of monthly data, indicates important similarities:
- Nearly directional types dominate throughout the year, but:
- Cyclonic cases are at their most frequent in summer.
- There is no obvious dependence between the circulation degree and the wind direction (Fig. 4).

Some deviations may also be found:
- In winter, the modelled portion of cyclonic and anticyclonic types is larger than that based on observations.
- Westerly winds dominate more strongly on the basis of the observations than in the model runs.

4. Projected flow types

In order to assess changes in airflow types from present to future, the simulated circulation degrees during the reference period 1961-1990 were compared with projections for the 30-year future period 2070-2099. The following remarks may be made on the basis of Figs. 5-6:
- No large changes in monthly patterns are projected.

- A slight increase (decrease) in the frequency of wintertime cyclonic (anticyclonic) cases is suggested by ECHAM4; in summer the trend is much weaker.
- A slight increase in the frequency of directional flow patterns is suggested by HadCM3.
- The relation between the circulation degree and the wind direction remains weak, but in the ECHAM4 simulations westerly winds dominate more clearly during 2070-2099 than in 1961-1990 (not shown).

5. Discussion

On the basis of this very preliminary work, only minor changes in the frequency of airflow types could be found. Aspects to be considered in a further study include, among other things:
- Dependence of the value of the circulation degree on the
  - temporal resolution: daily vs. monthly weather patterns
  - spatial resolution: size of the area considered
- Correspondence in Finland between the values of the circulation degree and a subjective classification of weather types (e.g., Lamb weather types)
- Uncertainty and noise in the projections: use of several model experiments
- Changes in cumulative frequency distributions of the circulation degree.

Figure captions

Fig. 1. Examples of monthly-mean sea-level pressure patterns (hPa), as provided by the model ECHAM4/OPYC3 (top), the NCEP/NCAR Reanalysis Project (center) and the model HADCM3 (bottom), in a highly anticyclonic, a directional and a highly cyclonic situation, respectively. Corresponding monthly mean geostrophic wind vectors are also shown. The circulation degree is about –20·10e-6 m-1, 0, and 20·10e-3 m-1, respectively.

Fig. 2. Current seasonal variation of the monthly circulation degree in Finland: observations and simulations.

Fig. 3. Present-day frequency distribution of the monthly circulation degree in winter and summer: observations and simulations.

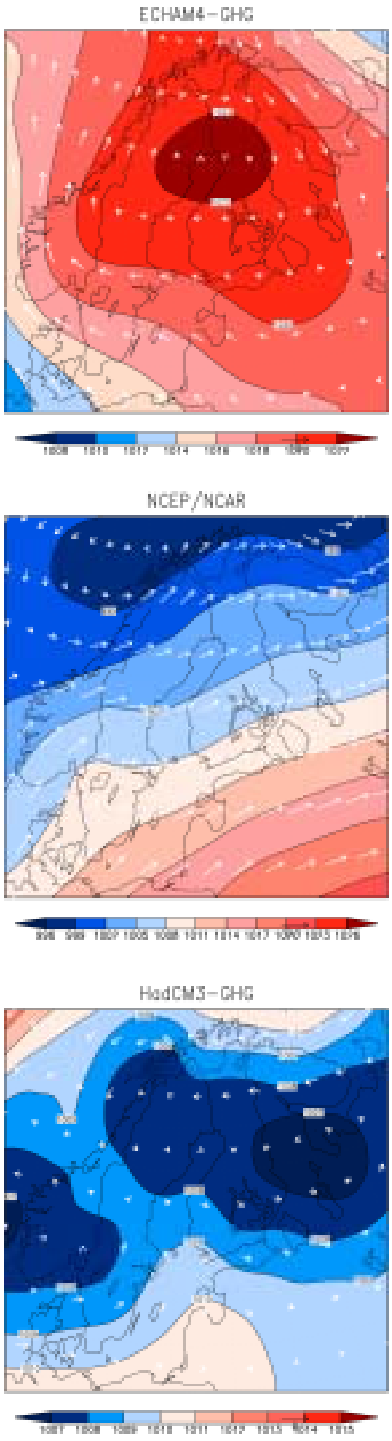
Fig. 4. The relation between the monthly circulation degree and mean geostrophic wind direction.

Fig. 5. Simulated seasonal variation of the monthly circulation degree in Finland in 1961-1990 and 2070-2099.

Fig. 6. Same as Fig. 3, but for simulations in 1961-1990 and 2070-2099.

Footnotes

(1) The NCEP/NCAR Reanalysis Project; grid size 2.5ºx2.5º
(2) Hadley Centre for Climate Prediction and Research, UK; grid size 2.5ºx3.75º; historic CO2 & IS95a.
(3) Max-Planck-Institut für Meteorologie, Germany; grid size 2.8º x 2.8º; historic CO2 & IS92a.
(2-3) Distributed by the IPCC Data Distribution Centre
(4) The Grid Analysis and Display System
(5) Due to a NCEP/NCAR reanalysis problem in mean sea-level pressure for 1948-1967, the 30-year period 1971-2000 is considered for the NCEP/NCAR data.



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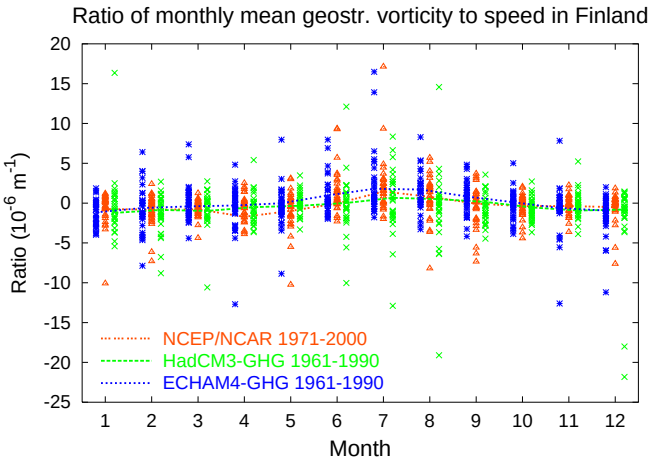


Fig. 2. Current seasonal variation of the monthly circulation degree in Finland: observations and simulations.

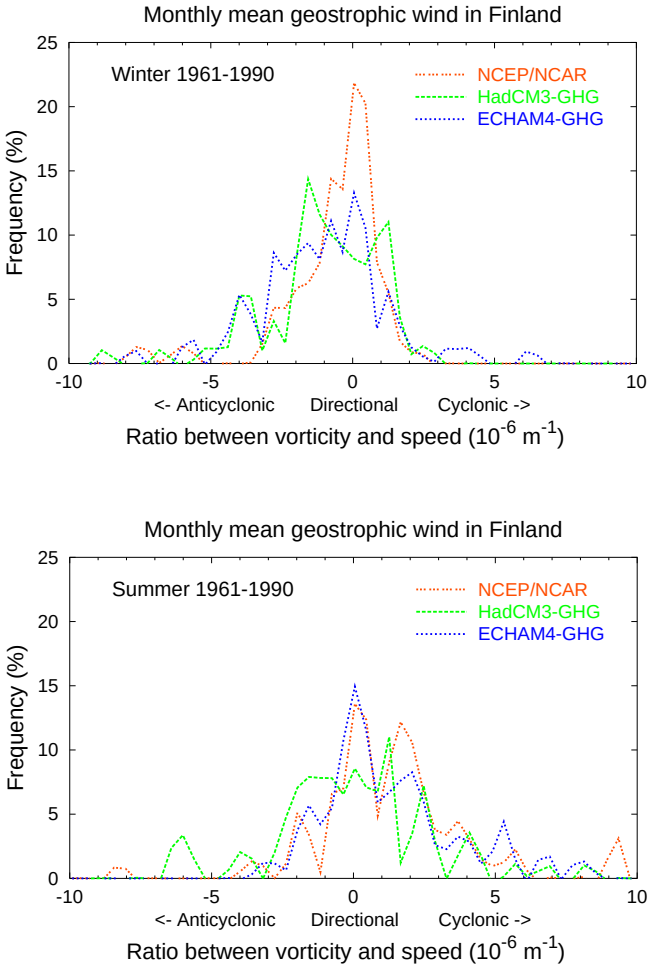


Fig. 3. Present-day frequency distribution of the monthly circulation degree in winter and summer: observations and simulations.

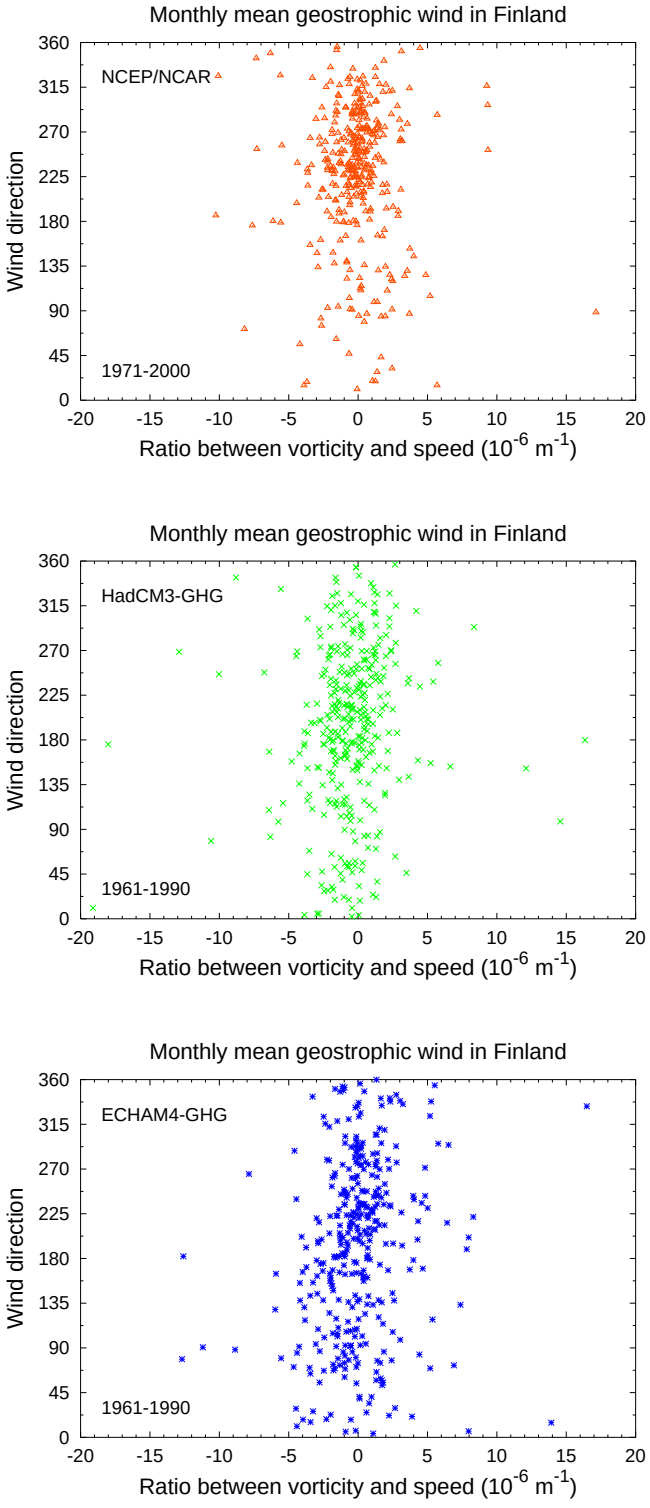


Fig. 4. The relation between the monthly circulation degree and mean geostrophic wind direction.

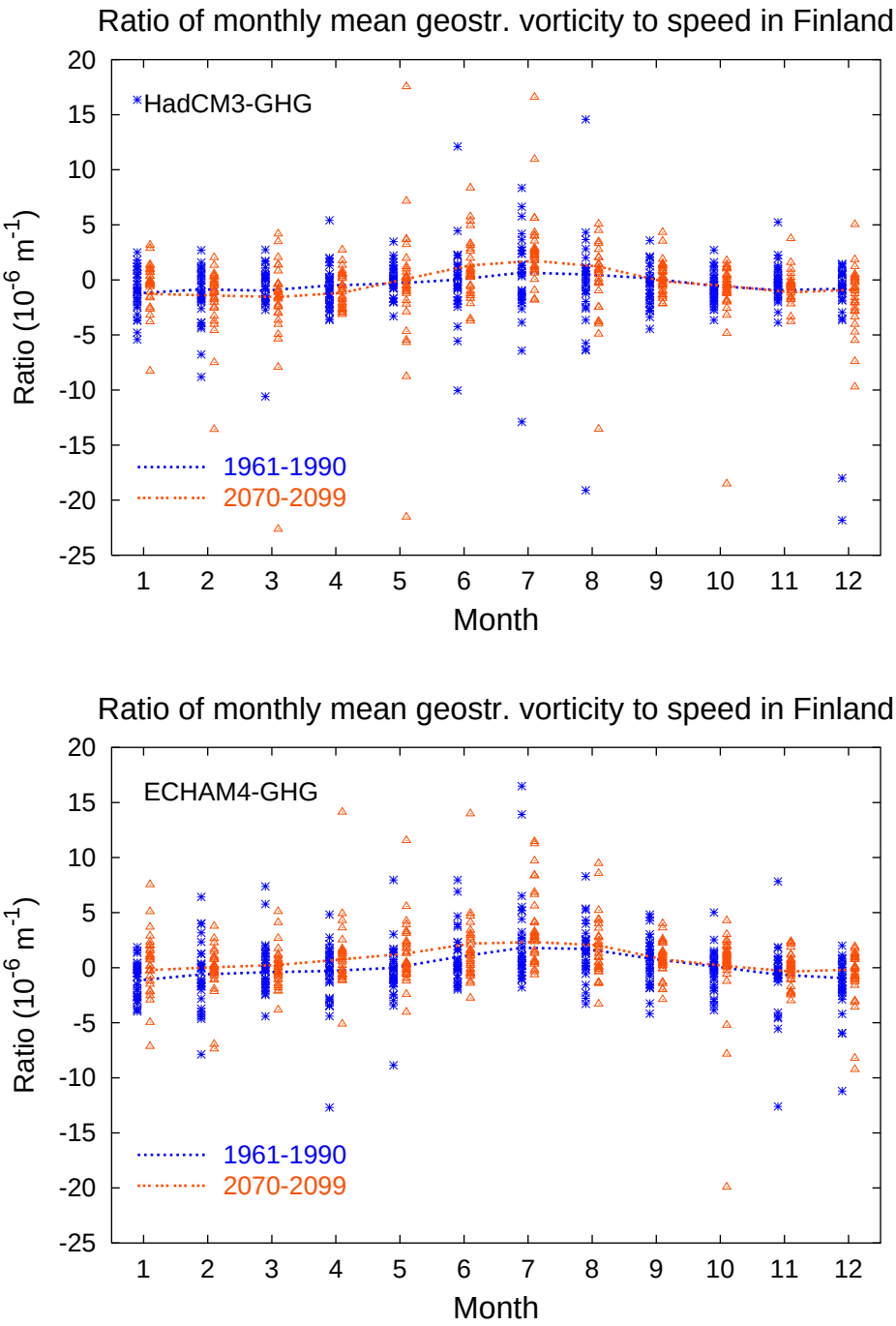
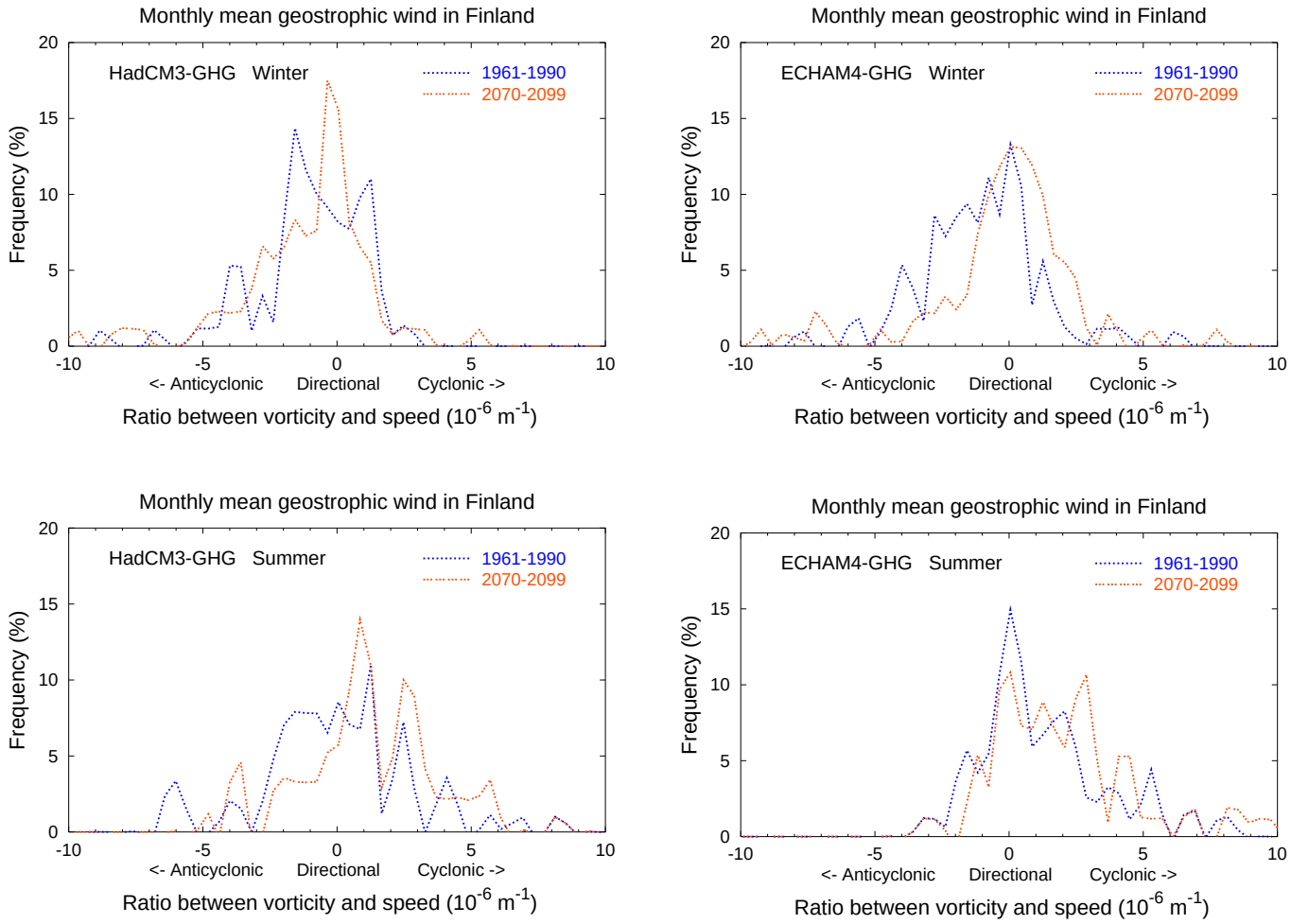


Fig. 5. Simulated seasonal variation of the monthly circulation degree in Finland in 1961-1990 and 2070-2099.



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