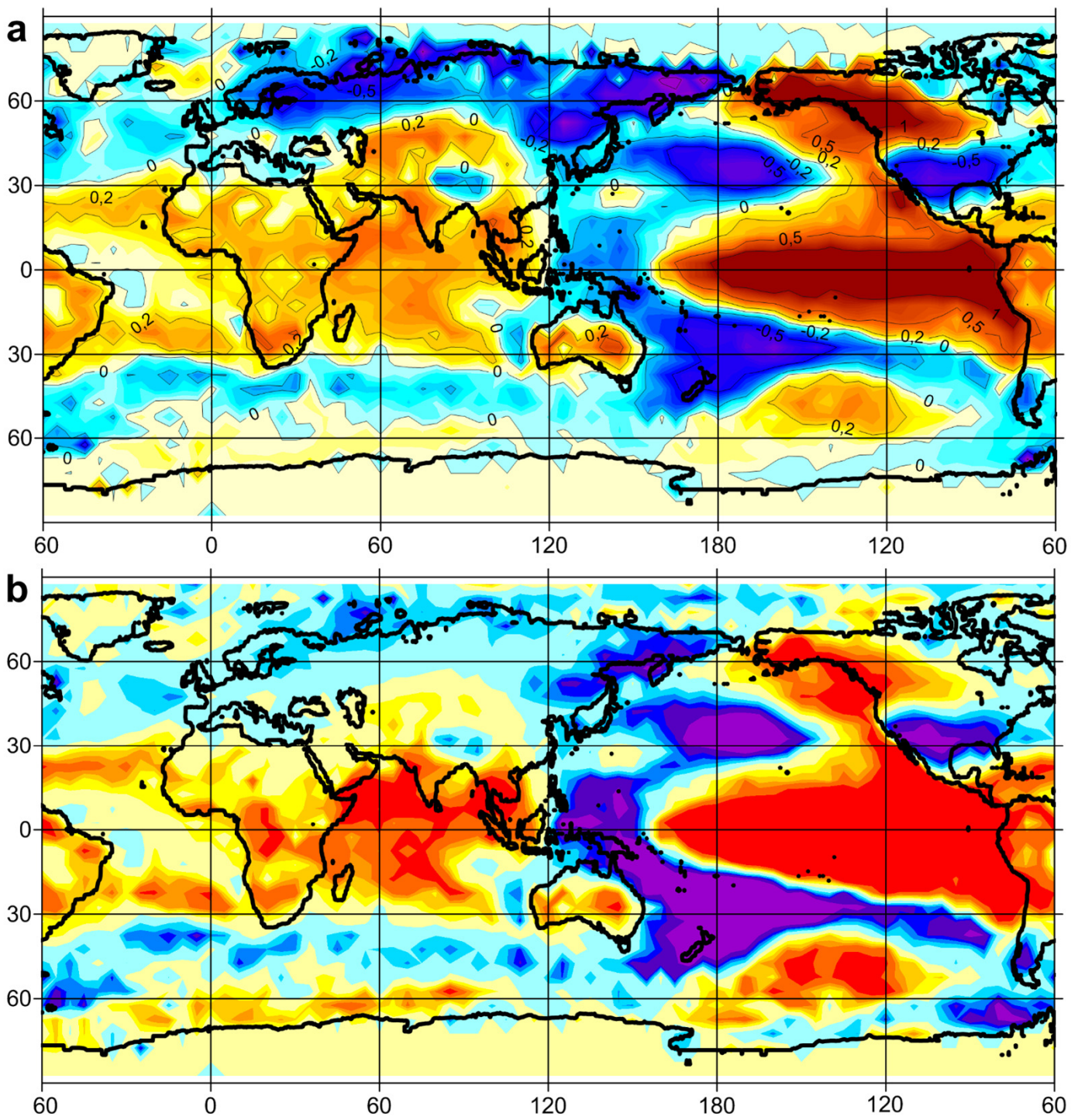
El Niño forecast based on the Global Atmospheric Oscillation (GAO)

Serykh Ilya Viktorovich,
Sonechkin Dmitry Mikhailovich

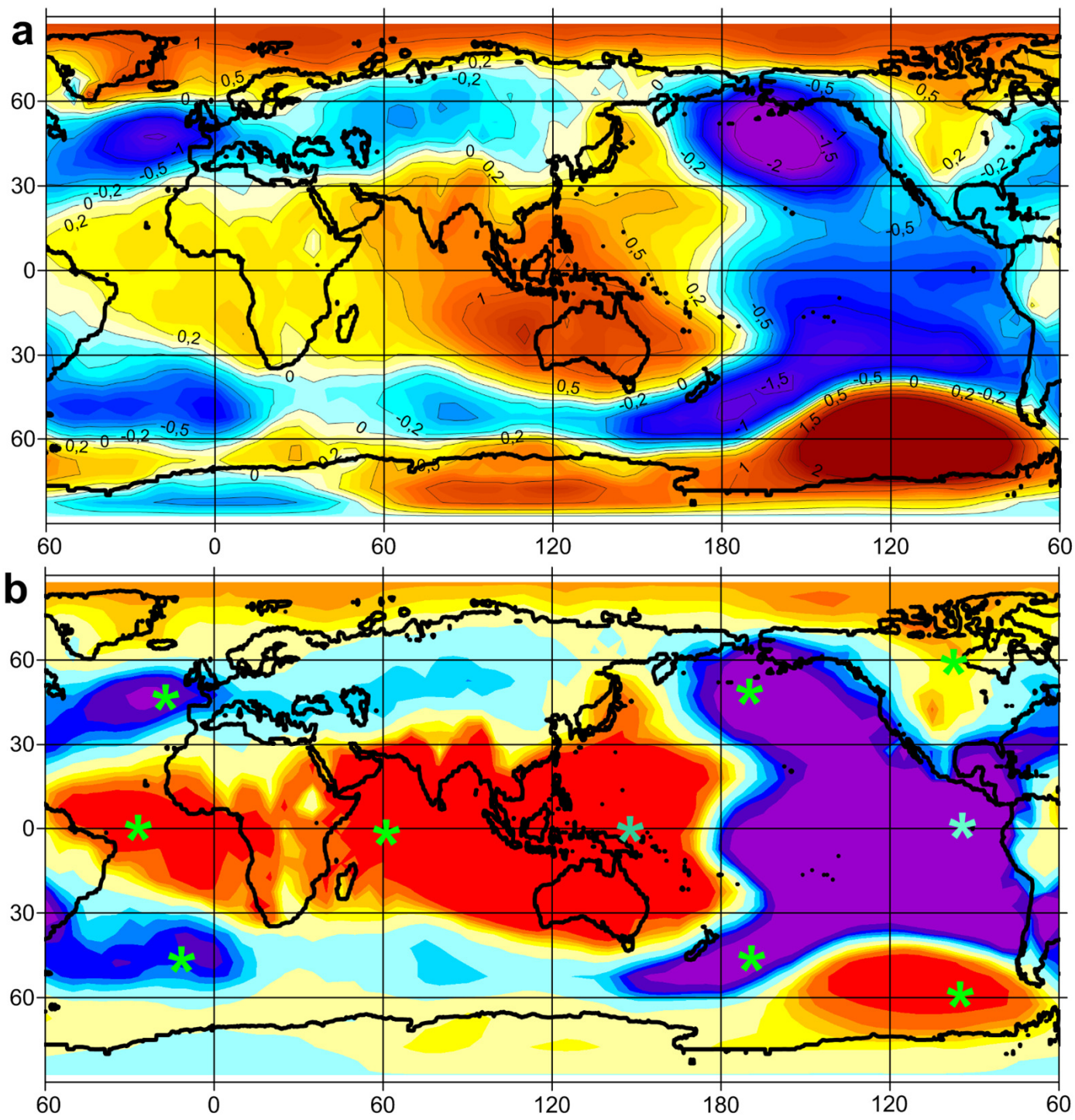
Shirshov Institute of Oceanology of the Russian Academy of Sciences
iserykh@ocean.ru



GAO of temperature

a) The global map of near-surface temperature (NST) anomalies showing the spatial structure of the Global Atmospheric Oscillation (GAO). NST anomalies were estimated from HadCRUT dataset covering the calendar years 1920-2017.

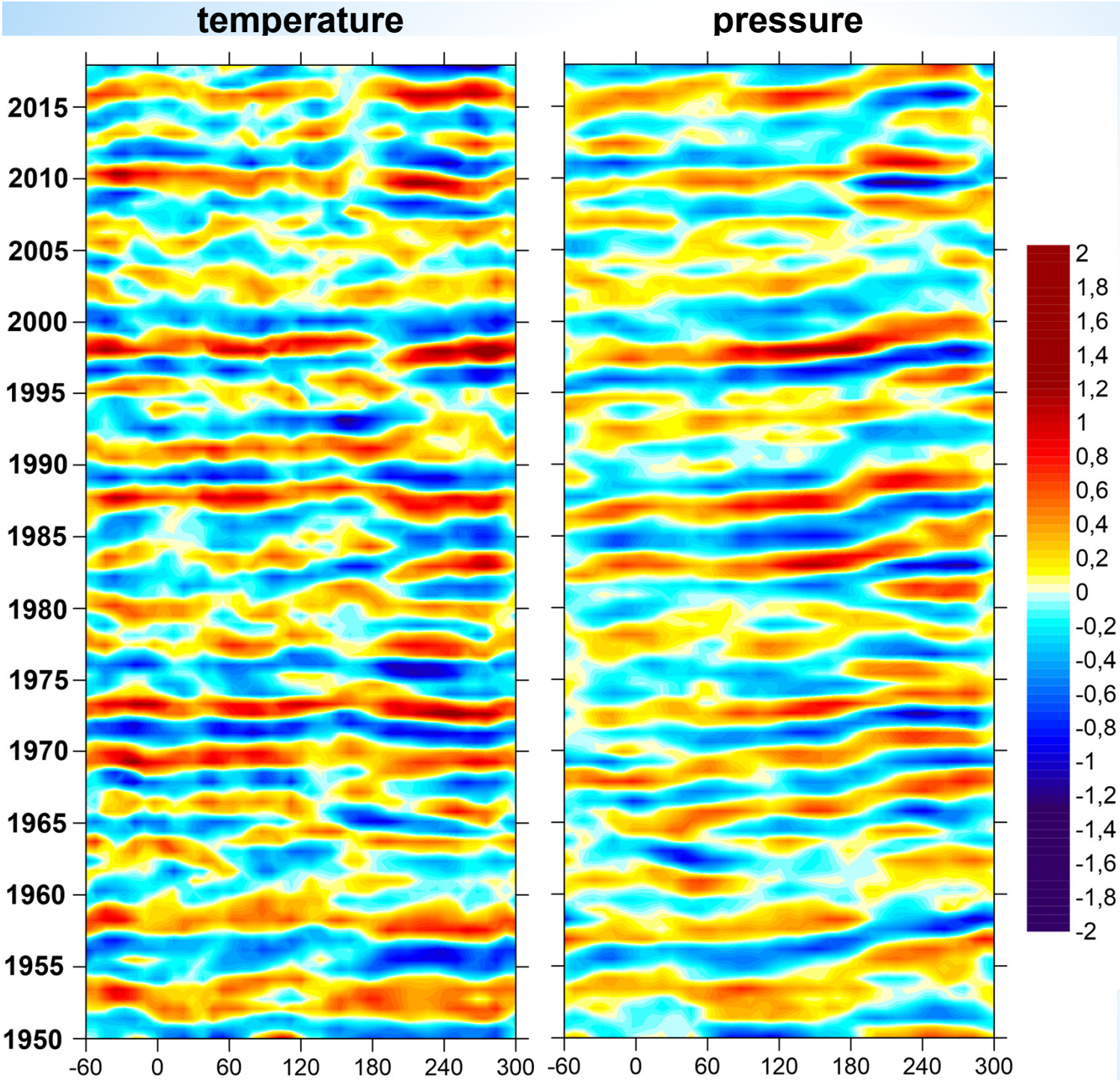
b) The global map of the *Student t*-test values corresponding to nonzero differences between the mean NST for El Niño and La Niña events observed during the 1920-2017 calendar years. Colors in the image correspond to degrees of probability of 99%, 95%, 90%, 80% and 60%.



GAO of pressure

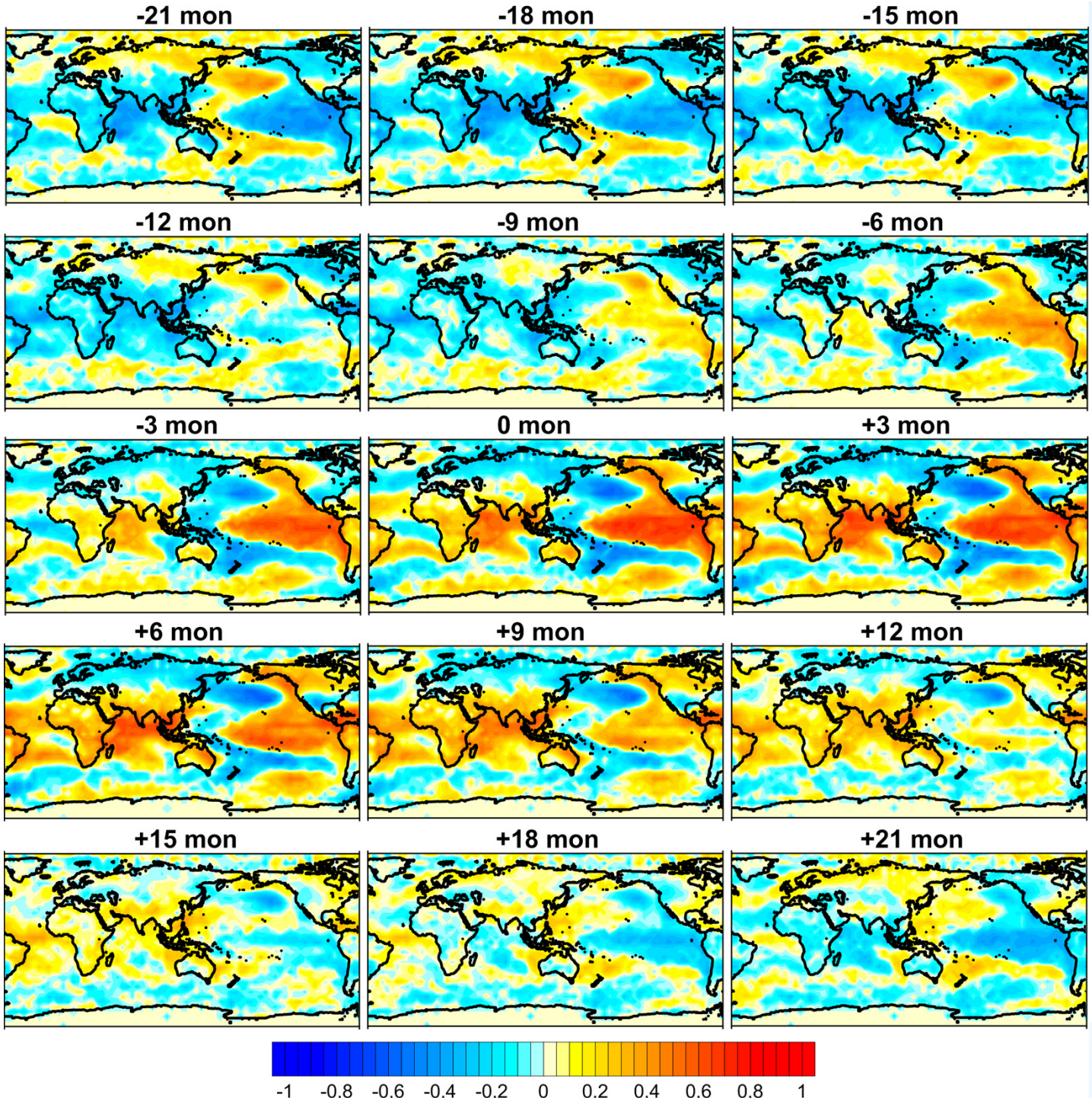
a) The global map of sea level pressure (SLP) anomalies showing the spatial structure of the Global Atmospheric Oscillation (GAO). SLP anomalies were estimated from HadSLP2 dataset covering the calendar years 1920-2017.

b) The global map of the *Student t*-test values corresponding to nonzero differences between the mean SLP for El Niño and La Niña events observed during the 1920-2017 calendar years. Colors in the image correspond to degrees of probability of 99%, 95%, 90%, 80% and 60%.



GAO dynamics

The spatio-temporal diagrams showing propagation of the inter-annual anomalies in the planetary tropical belt (30°N–30°S) of the air near-surface temperature (left) and the sea-level atmospheric pressure (right) from NCEP/NCAR reanalysis.
The X-axis represents longitudes from 60W to 300E, the Y-axis represents a period of 1950-2017.
Scale is in abstract values, because diagrams were centralized, normalized and filtered with band-pass filter for years 2 to 7.



GAO dynamics: temperature

The sequence of grid-point lag crosscorrelations fields with the lags from -21 to +21 months (given at intervals of 3 months) between GAO2 index and the near-surface temperature (NST) anomalies for 1880-2017 period demonstrating the temperature dynamics of GAO.

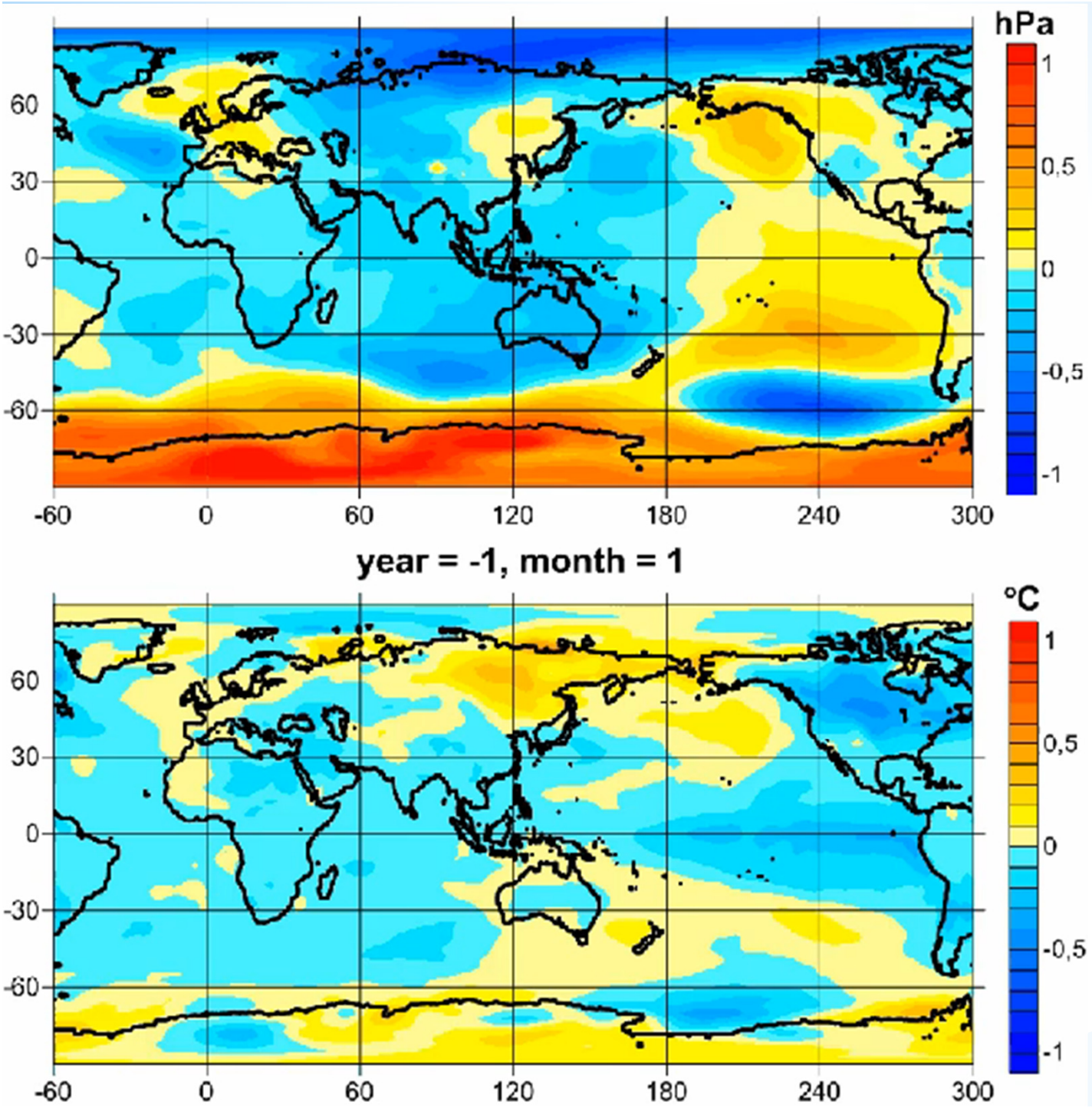
The El Niño leads NST anomalies at 21 months is defined as “−21 mon”, the zero-lag - as “0 mon”, and the El Niño lags NST anomalies at 21 months - as “+21 mon”.

GAO dynamics: pressure

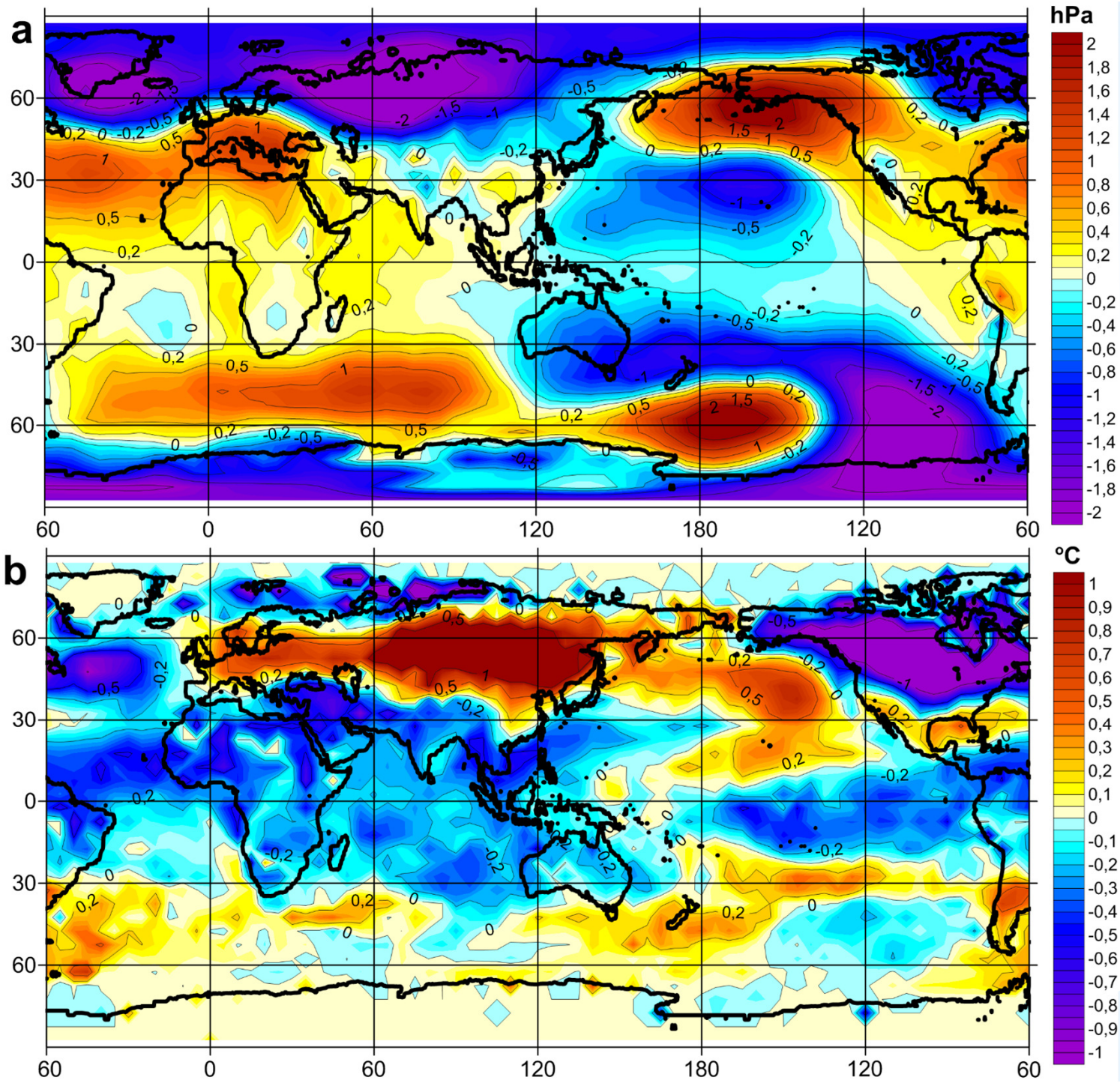
The sequence of grid-point lag cross correlations maps with the lags from -21 to +21 months (given at intervals of 3 months) between GAO2 index and the SLP-anomalies for 1880-2017 period, that show a sequence of the GAO development over 21 months before and after an El Niño events.

The El Niño leads SLP anomalies at 21 months is defined as “−21 mon”, the zero-lag - as “0 mon”, and the El Niño lags SLP anomalies at 21 months - as “+21 mon”.

GAO dynamics

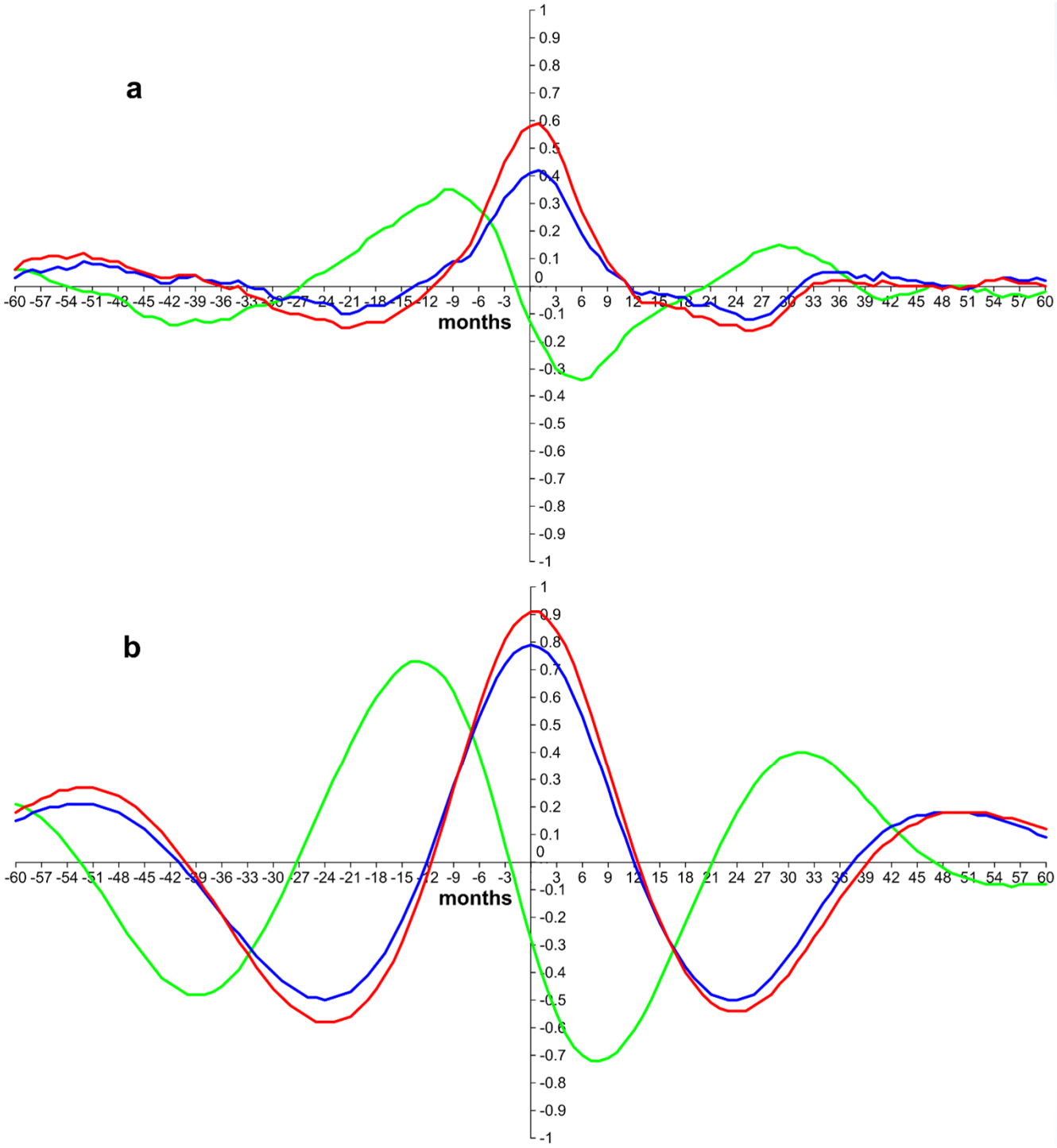


Fields of mean anomalies of sea level pressure and surface air temperature for various months before and during the 15 El Niño events from 1950-2018.



GAO predictor

The sea-level pressure (a) and near-surface temperature (b) maps of GAO for the moment of 12-14 months before an El Niño event when the spatial structure of GAO starts to transform itself into the opposite phase, i.e. the X-shaped structure becomes to be more similar to the elliptic-shaped structure, and the elliptic-shaped structure becomes to be similar to the X-shaped one.



GAO indexes

Cross-correlation of three Global Atmospheric Oscillation (GAO) indices (GAO1 – in red, GAO2 – in blue, GAO-predictor – in green) and the Extended Oceanic Niño index (EONI) estimated with observation-based datasets HadCRUT and HadSLP2 for the years 1920-2017 (a – time series without filtering, b – after band-pass filter for years 2 to 7).

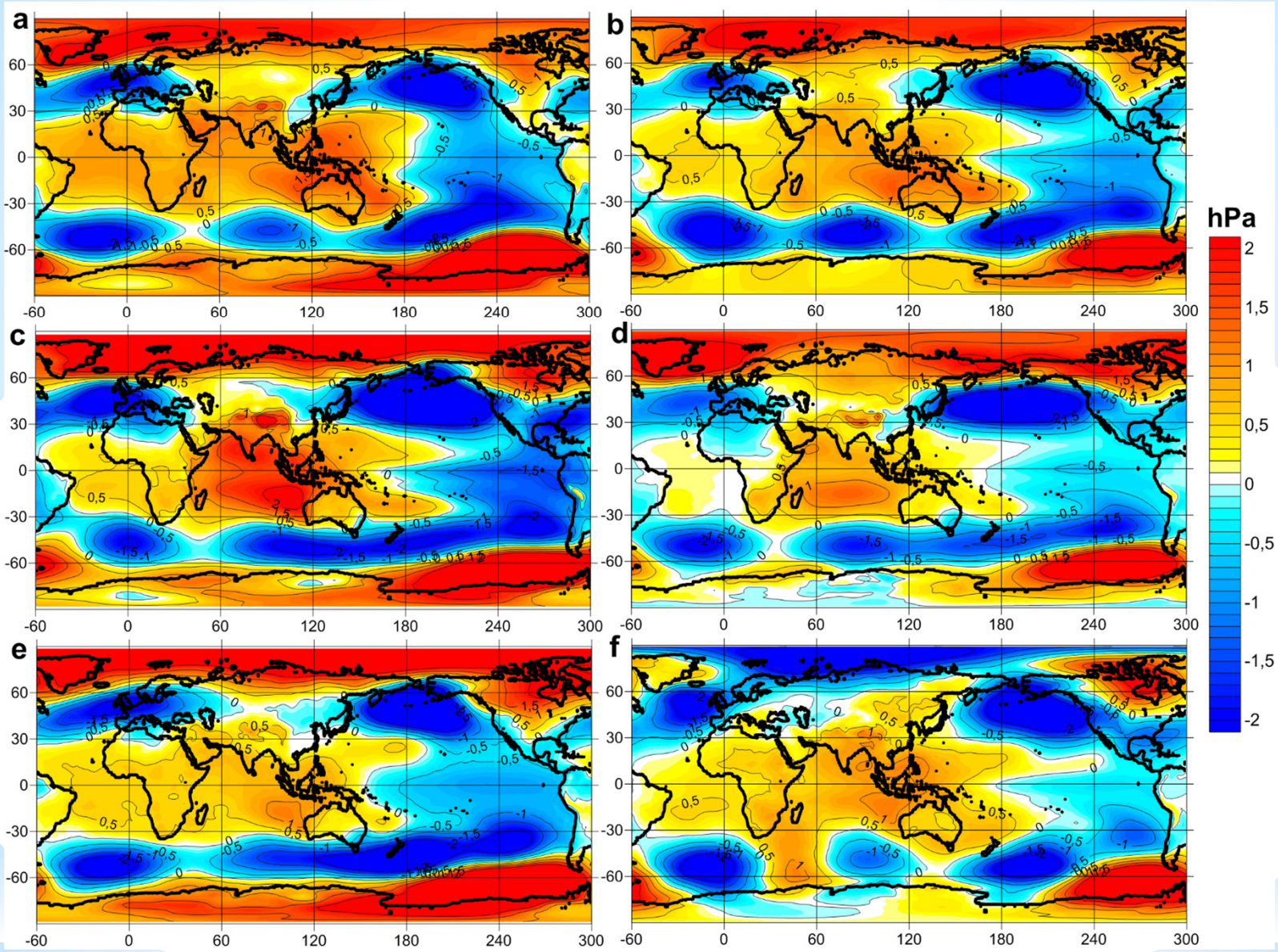
GAO extratropical

Graphs of the Oceanic Niño Index (ONI) (red) and the Extratropical Global Atmospheric Oscillation index (EGAO) (blue), filtered by a Butterworth bandpass filter from 2 to 7 years, centred, detrended and normalized by its standard deviations, for December 1950-2018 (upper). The cross-wavelet diagram of these indices without filtering and for all months of the year (bottom).

GAO predictor

Graphs of the Oceanic Niño Index (ONI) (red) and the index Predictor Global Atmospheric Oscillation (blue), filtered by a Butterworth bandpass filter from 2 to 7 years, centred, detrended and normalized by its standard deviations, for December 1950-2018 (upper). The cross-wavelet diagram of these indices without filtering and for all months of the year, with GAO Predictor index shifted forward by 12 months (bottom).

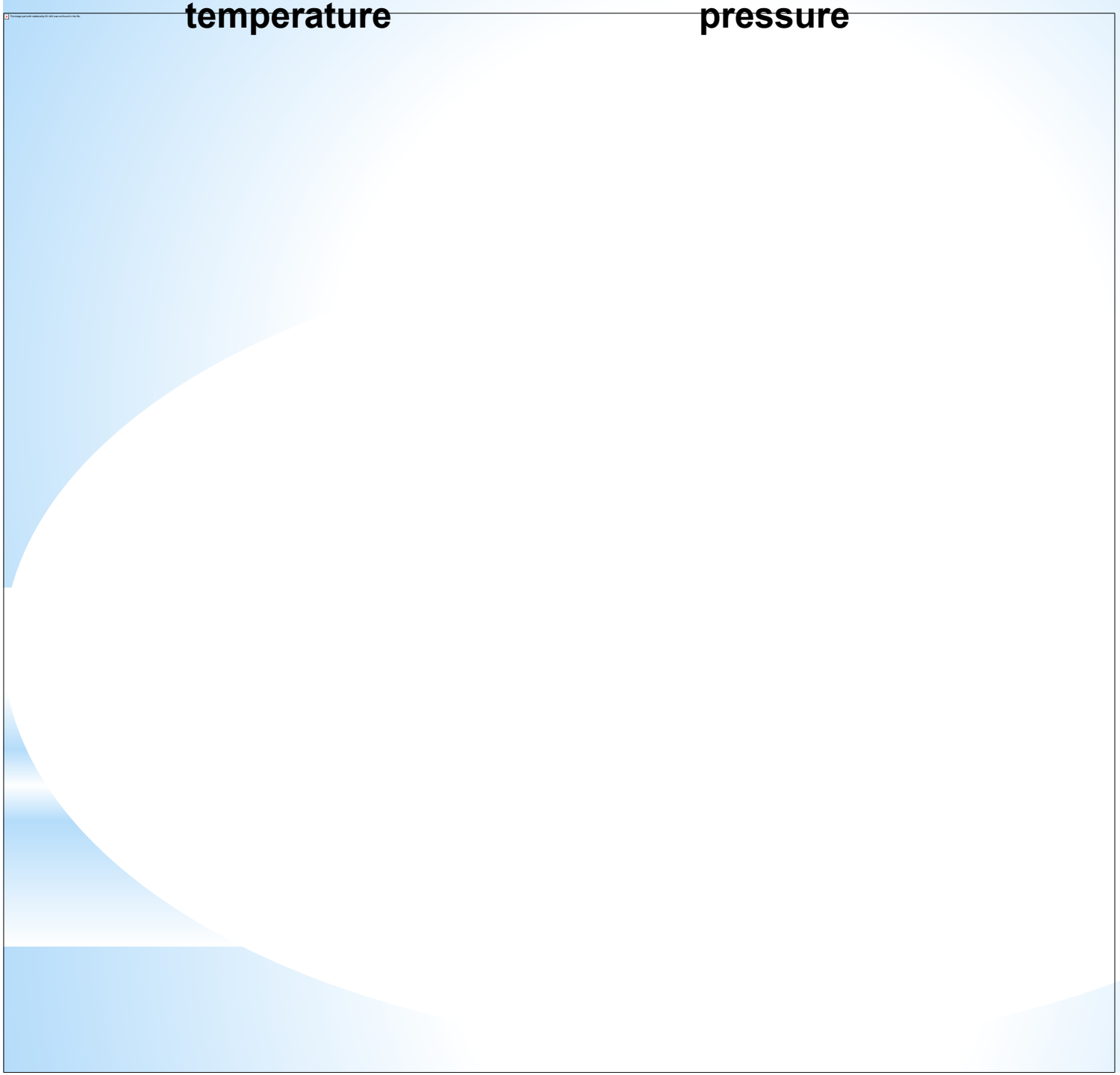
GAO in CMIP5 models



Sea-level pressure GAO maps estimated from 20thC_ReanV2c (a) and Historical experiment of CMIP5-models: ACCESS1-3 (b), CanESM2 (c), INM-CM4 (d), MPI-ESM-MR (e) и MRI-CGCM3 (f).

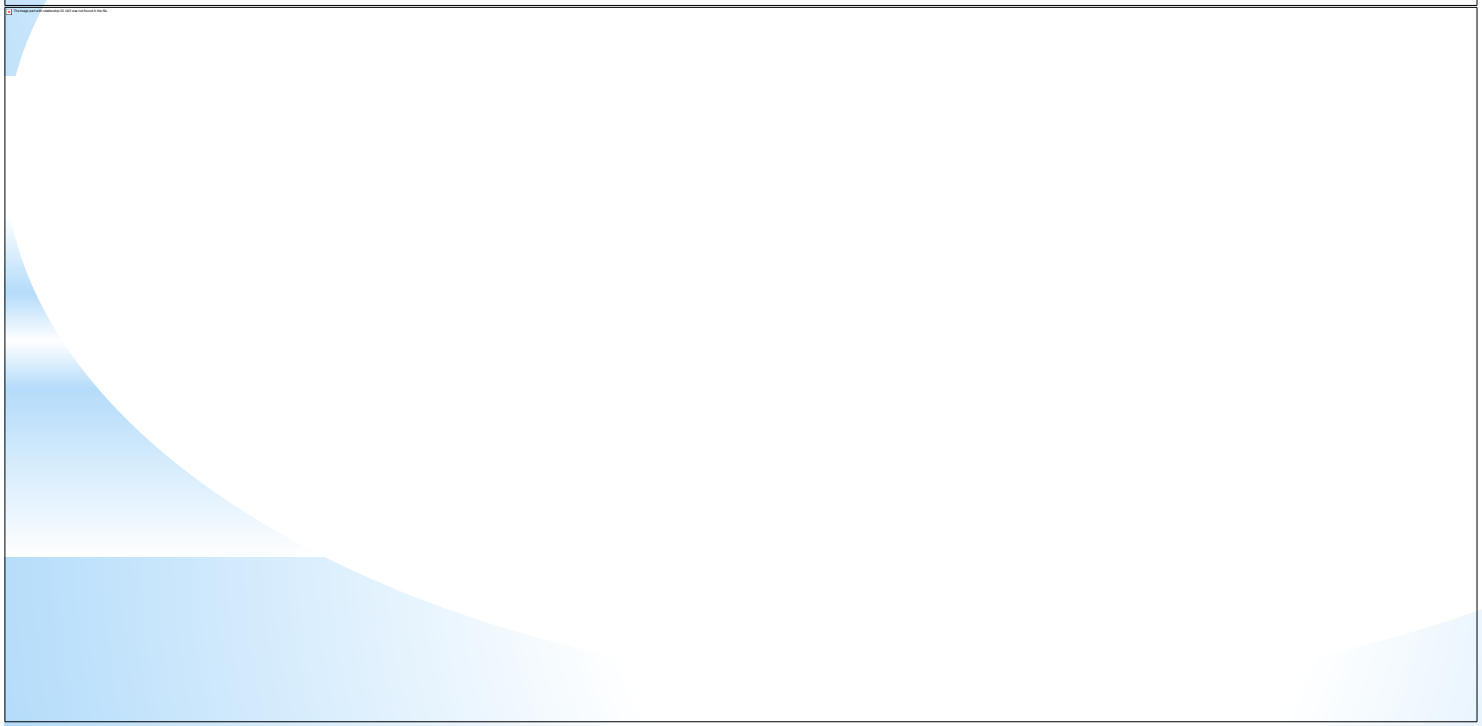
temperature

pressure



GAO in CMIP5 models

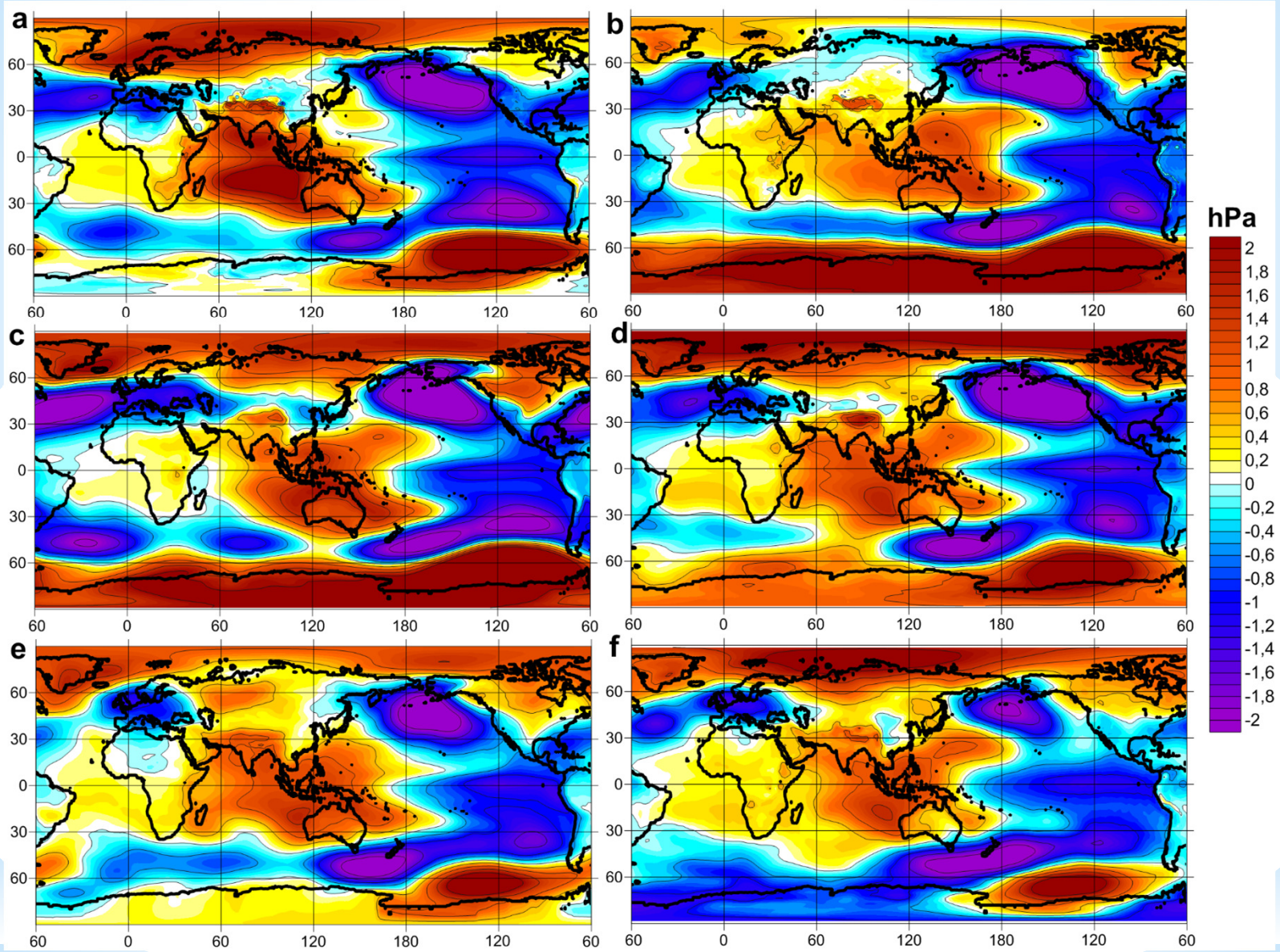
The spatio-temporal diagrams showing propagation of the inter-annual anomalies in the planetary tropical belt (30°N–30°S) of the air near-surface temperature (left) and the sea-level atmospheric pressure (right) from experiment Historical of CESM1-CAM5 model. The X-axis represents longitudes from 60W to 300E, the Y-axis represents a model period of 1938-2005. Scale is in abstract values, because diagrams were centralized, normalized and filtered with band-pass filter for years 2 to 7.



GAO in CMIP6 INM model

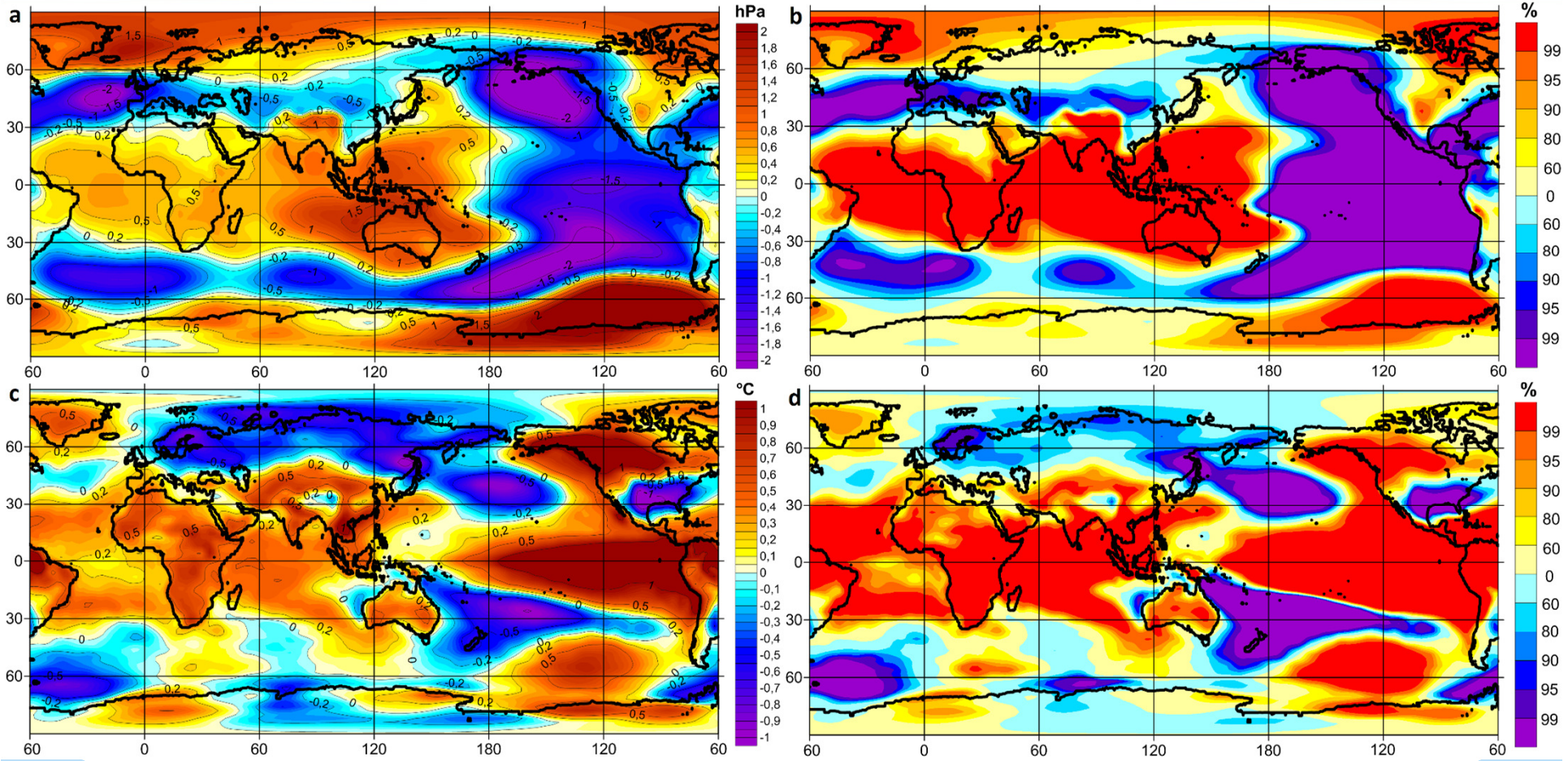
Sea-level pressure (upper) and near-surface air temperature (lower) anomalies estimated from Historical experiment of CMIP6 INM model for 1850-1999 time period using GAO1 index.

GAO in CMIP5 models



Sea-level pressure GAO maps estimated from CMIP5-models: CESM1-CAM5 (a), CMCC-CM (b), CNRM-CM5 (c), GFDL-CM3 (d), HadGEM2-ES (e), MPI-ESM-MR (f).

GAO from 20thC_ReanV2c



Sea-level pressure (a), near-surface air temperature (c) anomalies and corresponding *Student t-test* values (b, d) estimated from 20thC_ReanV2c for 1851-2014 period.

GAO from ERA-20C

Near-surface air temperature (a) and sea-level pressure (b) anomalies estimated from ERA-20C reanalysis for 1900-2010 time period using GAO2 index.

GAO from NCEP/NCAR

Near-surface air temperature (a) and sea-level pressure (b) anomalies estimated from NCEP/NCAR reanalysis for 1948-2017 time period using GAO2 index.

GAO from JRA-55

Near-surface air temperature (a) and sea-level pressure (b) anomalies estimated from JRA-55 reanalysis for 1958-2013 time period using GAO2 index.

GAO dynamics: temperature

Fields of mean anomalies of surface air temperature for various months before and during the 15 El Niño events from 1950–2018: a) September in the year preceding the year of El Niño's start; b) December in the year preceding the year of El Niño's start; c) March of the year of El Niño's start; d) June of the year of El Niño's start; e) September of the year of El Niño's start; f) December of the year of El Niño's start.

GAO dynamics: pressure

Fields of mean anomalies of sea level pressure for various months before and during the 15 El Niño events from 1950–2018: a) September in the year preceding the year of El Niño's start; b) December in the year preceding the year of El Niño's start; c) March of the year of El Niño's start; d) June of the year of El Niño's start; e) September of the year of El Niño's start; f) December of the year of El Niño's start.