

**POSSIBLE CONTRIBUTIONS OF THE SOUTH-EAST EUROPE VIRTUAL CLIMATE
CHANGE CENTER TOWARDS A COORDINATED INTERNATIONAL EFFORT, UNDER
THE WORLD CLIMATE RESEARCH PROGRAMME (WCRP), TO IMPROVE THE NEXT
GENERATION REGIONAL CLIMATE CHANGE PROJECTIONS
– SOUTH-EAST EUROPE PERSPECTIVE –**

BELGRADE SEE CLIMATE CHANGE INITIATIVE

The Belgrade Initiative for enhancement of the South-East European Sub-regional cooperation in the field of climate change received full support of the Sixth Ministerial Conference "Environment for Europe" (entitled "Building Bridges to the Future") of the United Nations Economic Commission for Europe which was held in Belgrade, 10-12 October 2007 (Ref. #1: <http://www.unece.org/env/documents/2007/ece/ece.belgrade.conf.2007.8.e.pdf>).

The Belgrade Initiative is a result of the international cooperation effort amongst the countries of the South-East Europe (SEE), and dates back in 2006 when the 6th Informal Conference of South-Eastern Europe National Meteorological and Hydrological Services' (NMHSs) Directors discussed problems in their organizations and concluded that developing various centers of excellence within the sub-region might be of benefit for all NMHSs.

The action in pursuing the idea went simultaneously thereafter in two directions: the United Nations Economic Commission for Europe (UNECE, "environmental channel"); and the World Meteorological Organization (WMO) – through the official channels of the Regional Association VI (RA-VI, Europe).

As for the UNECE activities, under the Environment for Europe process, the countries of the UNECE region [covering Europe, North America (Canada and United States), Central and Western Asia] went through intensive negotiations when shaping the agenda for the Ministerial Conference, including during the preparations of the background documents. This process resulted in adoption of the so-called Belgrade Initiative on climate change in which the UNECE ministers of environment recognized that the countries of the SEE region are in a need to develop the Climate Change Framework Action Plan (CCFAP) to support implementation of the United Nations Framework Convention on Climate Change (UNFCCC), and in particular its Nairobi Work Programme related to impacts, vulnerability and adaptation to climate change. Ministers further concluded that the establishment of a South-East European sub-regional virtual climate change centre in Belgrade (SEE-VCCC hosted by the Republic Hydrometeorological Service of Serbia - RHMSS) would provide a means to develop and implement programmes and projects under the sub-regional CCFAP designed for interested countries of South-Eastern Europe, as well as to strengthen international partnerships that foster exchanges of experience and expertise in the fields of climate research and observation, education, public awareness-raising and capacity-building.

In parallel, the official communication with the WMO was initiated through the WMO RA-VI. The RA-VI Strategic Plan for the Enhancement of Meteorological and Hydrological Services in the

Region (Ref. #2: http://www.wmo.ch/pages/about/documents/sp_ra_vi.pdf) recognizes the need to support the establishment of specialized sub-Regional Centers where Members identify a need, identifying, inter alia, the South-East European Sub-regional Climate Change Centre in Serbia. This is a type of actions the Region is committed to implement, and represents the expected result related to the Enhanced capabilities for Members to provide more accurate climate predictions and assessments.

As a follow-up to the Belgrade Initiative, interested countries of the SEE sub-region in coordination of the SEE-VCCC, and the Regional Environmental Center (REC, <http://www.rec.org>), with the support of the Norwegian Ministry of Foreign Affairs, developed the SEE Climate Change Framework Action Plan for Adaptation (SEE/CCFAP-A) which was considered and adopted at the ministerial conference “Combating the climate change in SEE”, held in Sarajevo, 14 November, 2008.

The functions of the SEE-VCCC center are envisaged as two-fold: (i) it will contribute to the work of the Regional Climate Center to be designated by the WMO [RA-VI RCC] – the SEE-VCCC participates in drafting the Implementation plan under the Working Group on Climate-related Matters at present; and (ii) it will support the activities under the frame of the Nairobi Work Programme, including in the following areas: “methods and tools”, “data and observations”, and “climate modeling, scenarios and downscaling”. The Center will also participate in diverse programmes related to impacts of climate change to various economy sectors, including studies of the options for adaptation. The Center completed its work on SEE/CCFAP-A planning document recently.

ACTIVITIES OF THE SEE-VCCC IN BELGRADE

Completed

SINTA Project: SEE-VCCC (RHMSS) participated in the SINTA project (Simulations of climate change in the Mediterranean area; Ref. #3). The outcome of the project comprise several 21st Century time-slices of downscaled regional climate data covering Mediterranean area. The model database includes: 1961-1990 (present climate); 2001-2030 (A1B scenario); 2071-2100 (A1B and A2 scenarios). The production for the Mediterranean region was made using the interactively coupled atmosphere-ocean regional climate model (see attached slides for more information).

CCFAP-A Project: Interested countries from the SEE region participated in developing of Climate Change Framework Action Plan for Adaptation for South Eastern Europe for the period 2009-2015. Albania, Bosnia and Herzegovina, Former Yugoslav Republic of Macedonia, Montenegro, and Serbia in coordination of the SEE-VCCC and the REC developed a SEE/CCFAP-A document which sets out a framework for achieving key adaptation priorities that address the short term needs as well as long term objectives of the region in a cost effective manner. The plan aims at providing more successful climate change monitoring and forecasting, as well as assessment of climate change impacts on the human health, economic activities, availability of water and other natural resources, and the need for timely problem identification and adoption of measures and strategies to adapt to the changed climate conditions (see Ref. #4).

On-going

The SEE-VCCC (hosted by RHMSS) applied to become a member of the designated WMO Regional Association VI (Europe) Regional Climate Center (RA-VI RCC) with functions related to climate applications in the South Eastern Europe. For the time being the RA-VI RCC will be set up as a pilot network of several RCC Nodes in the domains of climate data, climate monitoring and long-

range forecasting, altogether forming the network core of the RA-VI RCC which will be officially designated later in 2009. Due to limited number of submissions with regard to climate applications, which did not cover the entire RA-VI region, this node is going to be covered by the nodes from the other three domains. The SEE-VCCC therefore actively participates in drafting the Implementation plan of the WMO RA-VI RCC in the above three domains.

Intended

In drafting the Implementation plan for the future RA-VI RCC network, the SEE-VCCC envisaged its sub-regional contribution to the following *mandatory*, as well as to *highly recommended* functions:

(RCC Nodes on Long Range Forecasting; Climate Monitoring; and Climate Data)

- Operational interpretation of GPCs products and assessment of GPCs forecast performance through monthly or quarterly bulletins analyzing and interpreting GPC products;
- Information and guidance on LRF methodologies and products (described in English and national languages of participating SEE countries);
- Providing the SEE sub-regional gridded model datasets for 1961-1990; providing gridded data sets on climate projections done using the interactively coupled atmosphere-ocean regional climate model (RHMSS/University of Belgrade) for 21st Century. These data sets contain already available data (A1B IPCC/SRES scenario for 2001-2030 and 2071-2100; A2 scenario for 2071-2100), and will contain other expected results from on-going and future activities.
- Creating and maintaining the archives of climate extremes and climate indices in the SEE region required for climate monitoring/climate watch activity.
- SEE-VCCC will coordinate the activities on implementation of the South East European Framework Action Plan for Adaptation (SEE/CCFAP-A) in its segment related to improvement of the climate data quality, database management and promotion of data exchange between the SEE participating countries [Ref. #4: <http://www.hidmet.gov.rs/CCFAP/CCFAP.pdf>];
- SEE-VCCC will contribute, in accordance with the recommendation from the Belgrade Initiative and SEE/CCFAP-A, in **training** and sharing of the best experience and practice in data management, climate modeling and interpretation of model outputs in the sub-region;
- SEE-VCCC will also coordinate and participate in sub-regional projects related to climate change impacts, vulnerability and adaptation assessments relevant for different sectors of economy (energy, water resources, health, agriculture, forestry, biodiversity, etc) [Ref. #4: Chapters 4 and 5 of SEE/CCFAP-A, <http://www.hidmet.gov.rs/CCFAP/CCFAP.pdf>];

LONG-TERM R&D ACTIVITIES

General

In pursuing the above ambitions the SEE-VCCC plans to engage to the extent possible the local, Southeast European expertise and knowledge. However, due to the fact that the sub-region still feels consequences of the recent history turmoil, vast number of excellent scientists from many SEE countries presently lives and works abroad. The SEE-VCCC intends to establish close

cooperation with broad international scientific community with special emphasis on the SEE scientific diaspora.

As a first step, the Center plans to contact the US National Centers for Environmental Prediction (NCEP) and to seek for possible cooperation in numerical modeling of the weather, climate and environment. In particular, through such potential cooperation the Center would try to benefit from the expertise of Prof. Zaviša Janjić, originally from the University of Belgrade, the author of several generations of NCEP's numerical weather and climate prediction models (Eta, WRF-NMM, and NMM-B models).

- The Center is particularly interested for the unified nonhydrostatic multiscale NMM-B model designed for a broad range of spatial (global to sub-regional and local) and temporal scales. This model is considered well suited for the mission of the Center, and the Center would like to adopt it and invest effort in its further development.

Modeling

SEE-VCCC will strive to contribute in defining the **R&D agenda** related to development of a multiscale, unified, computationally efficient atmospheric model that can be run on global and regional scales. Such model will serve as a driver to other environment modelling components (atmospheric composition, ocean, hydrology) and will be designed following the principles proven in regional climate studies. This agenda will also include problems related to, inter alia, interactive coupling of different environment systems:

- coupled NMM-B - ocean model;
- coupled NMM-B - Numerical Hydrology Prediction Model (NHPM); NHPM is consisting of two sub-models: 2-D river formation model and 1-D river routing model;
- Interactive NMM-B - DREAM aerosol transport model; with direct radiation effects included Interactive NMM-B - aerosol - cloud microphysics scheme; with indirect aerosol effects included;

R&D agenda will also include development of high-resolution climate change experiments for different IPCC SRES scenarios using both, dynamical (above coupled atmosphere-ocean-hydrological model) and statistical downscaling approaches.

Infrastructure

As for the required resources, both human and computational, the present situation is as follows;

- The Republic Hydrometeorological Service of Serbia, hosting the Center, recently purchased a High Performance Computer (HPC, initially consisting of 128 processors), and expandable data storage system (starting with initial capacity of 24 TB). This HPC and data storage system will be used for R&D and will also be available to other members of the SEE-VCCC virtual network.
- Simultaneously, the RHMSS has got new scientific positions, some of which are still vacant, in order to support the SEE-VCCC. In addition, the Center's network consists of various universities, ministries, non-governmental organizations and other interested bodies. Very close cooperation with the University of Belgrade, and scientific diaspora sets a scene for a promising cooperation.

The Center plans to organize a Conference in Belgrade (anticipated at the end of 2009, or at early 2010) dedicated to designing the R&D agenda in the field of global and regional climate change modeling.

ORGANIZATION

The SEE regional planning mechanism for adaptation to climate change, as presented in SEE/CCFAP-A, aims at identifying areas in which climate change actions are required and in which partnership and cooperation within and with SEE countries could be reinforced. It will provide a basis for further development of CCFAP-A, as well as detailed thematic/project-oriented action programmes, creating possibilities for improving partnerships at the national, sub-regional, bilateral and multilateral levels.

In the development and implementation of the SEE/CCFAP-A programmes, countries of SEE shall establish partnerships with relevant international and foreign organizations. A close relation should be promoted with the Secretariats of UNFCCC, WMO, GEF, as well as with UNDP, UNEP, EU and capacity building initiatives under relevant environmental agreements.

The virtual structure of the SEE-VCCC is an organizational model that uses to maximum possible extent the contemporary telecommunications and therefore requires no financial contribution for the work of the center. This network will rely on already established (e.g. bilateral like Italy-Serbia and other countries from SEE) and possible future partnerships (e.g. potentially NCEP-VCCC, and alike)

EXPECTED RESULTS

Involving, educating and training the critical number of young scientists from developing countries of SEE in improving skills in long-range weather forecasts, inter-annual and decadal predictions will result in enhanced capabilities of NMHSs of the sub-region to adequately participate in implementation of their commitments related to national adaptation programmes. The SEE-VCCC, as a network of participating NMHSs and other interested stakeholders in climate change will serve as a science-to-policy interface that shall support SEE economies in building resilience to consequences of climate extremes in SEE.

REFERENCES:

1. **Ministerial DECLARATION “Building Bridges to the Future”** by Ministers of the region of the United Nations Economic Commission for Europe (UNECE), Sixth Ministerial Conference “Environment for Europe” Belgrade, Serbia, 10-12 October 2007, (Document: ECE/BELGRADE.CONF/2007/8: <http://www.unece.org/env/documents/2007/ece/ece.belgrade.conf.2007.8.e.pdf>);
2. **The RA-VI Strategic Plan for the Enhancement of Meteorological and Hydrological Services in the Region, 2008-2011:** WMO Regional Association VI (Europe), http://www.wmo.ch/pages/about/documents/sp_ra_vi.pdf;
3. S.Gualdi, B.Rajkovic, V.Djurdjevic, S.Castellari, E.Scoccimarro, A.Navarra, M.Dacic, 2008: **SINTA Project:** Simulation of climate change in the Mediterranean area. Final Scientific Report. http://www.hidmet.gov.rs/SINTA-1/SINTA_Final_Science_Report_October_2008.pdf
4. **South East European Climate Change Framework Action Plan for Adaptation (SEE CCFAP-A), 2008:** SEE Sub-Regional Virtual Climate Change Centre (SEE-VCCC), <http://www.hidmet.gov.rs/CCFAP/CCFAP.pdf>

EBU-POM :: Coupled Regional Climate Model

Approach: two operational and well verified, atmosphere (EBU=Eta Belgrade University) and ocean (POM) models, are coupled in to one system.

Models exchange atmospheric surface fluxes and SST every physical time step in atmospheric model (between 3 and 6 min. depending on basic atmospheric time step.) without any flux correction.

Atmospheric component:

- ▶ Eta/NCEP model (**EBU=Eta Belgrade University**),
- ▶ Eta was operational model for NWP for many years in NCEP-USA,
- ▶ Primitive equation, grid point (Arakawa E-grid), hydrostatic,
- ▶ Eta vertical coordinate (quasi-horizontal coordinate),
- ▶ Horizontal advection scheme conserving all integral properties,
- ▶ NOAA/OSU-LSM surface scheme,
- ▶ Mellor-Yamada-Janjic 2.5 turbulence scheme,
- ▶ M-O theory for surface turbulent fluxes,
- ▶ Viscose sub layer over water (3 regimes),
- ▶ Goddard radiation scheme; with help of BSC-Earth Sciences group,
- ▶ Betts-Miller-Janjic convective scheme,
- ▶ ...

Atmospheric model setup:

- 0.25 horizontal resolution (~30 km) / 32 vertical levels
- 6h lateral boundary condition from INGV/CMMC, SX-G GCM integrations,
- Annual cycle of vegetation fraction,
- SST bottom boundary condition from SINTEX over uncoupled seas.

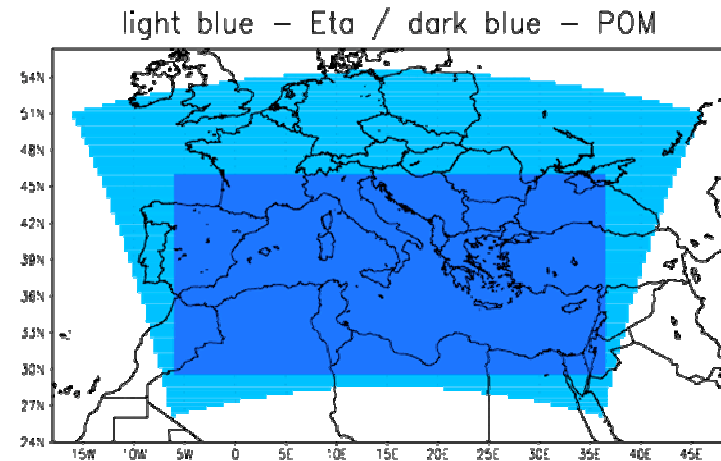
Ocean model setup:

- 0.2 horizontal resolution / 21 vertical levels (Mediterranean sea),
- Initial condition: MODB for 1961 / SINTEX for 2071.

Ocean component:

- ▶ POM - Princeton ocean model,
- ▶ Primitive equation, grid point (Arakawa C-grid), hydrostatic,
- ▶ Model has a free surface and a split time step,
- ▶ Sigma vertical coordinate,
- ▶ Mellor-Yamada 2.5 turbulence scheme,
- ▶ Complete thermodynamics,
- ▶ ...

model domain:



EBU-POM :: Coupled regional Climate Model

Several time-slices was covered:

1961-1990: 20C3M (present climate)

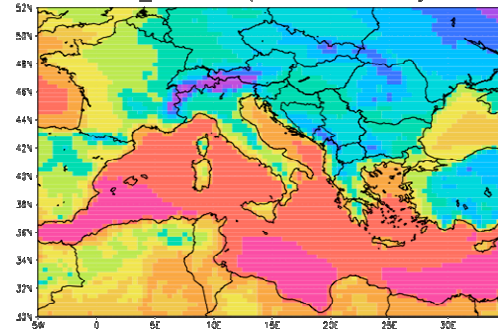
2001-2030: A1B

2071-2100: A1B, A2

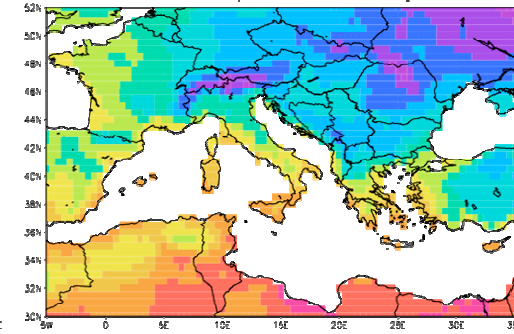
Output: 6h for atmosphere and 5-day averages for ocean

Present climate verification:

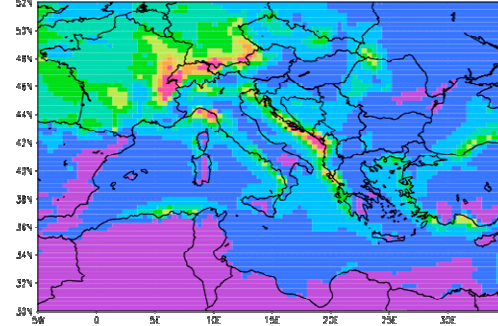
EBU_POM: temp 2m; season: djf



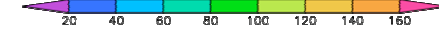
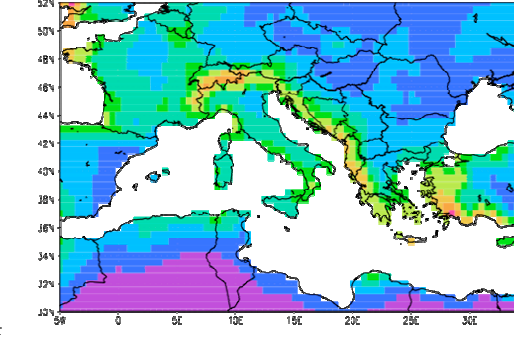
CRU: temp 2m; season: djf



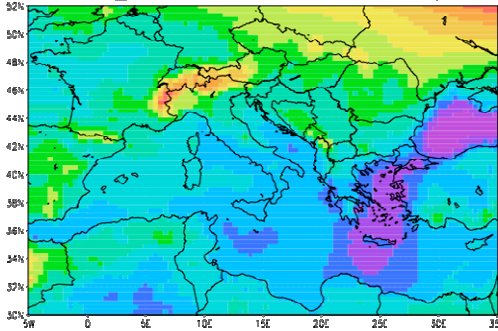
EBU_POM: precipitation; season: djf



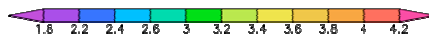
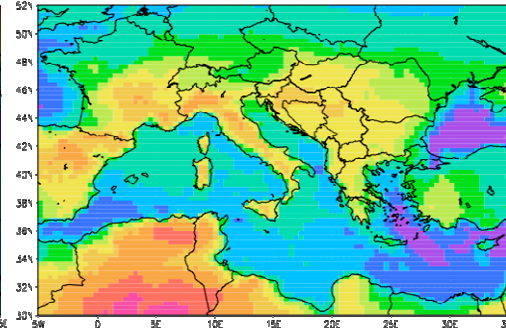
CRU: precipitation; season: djf



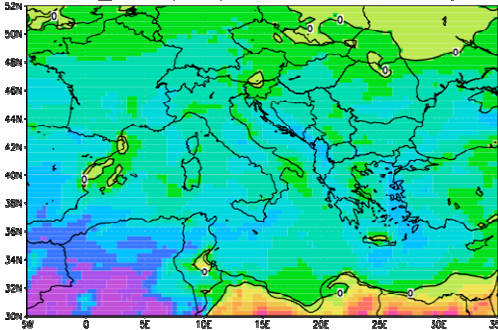
EBU_POM: temp 2m diff; season: djf



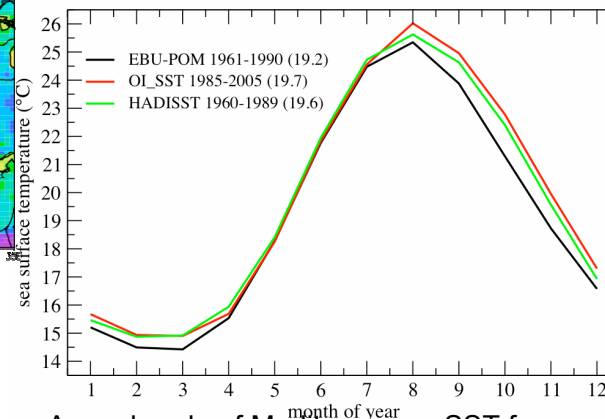
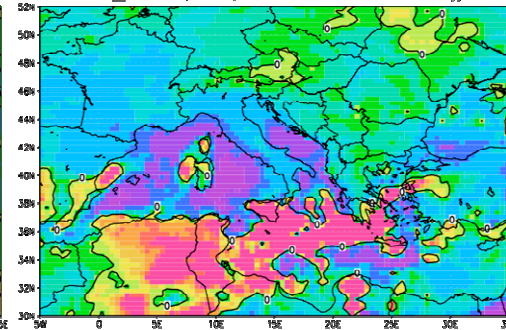
EBU_POM: temp 2m diff; season: jja



EBU_POM: precipitation diff; season: djf



EBU_POM: precipitation diff; season: jja



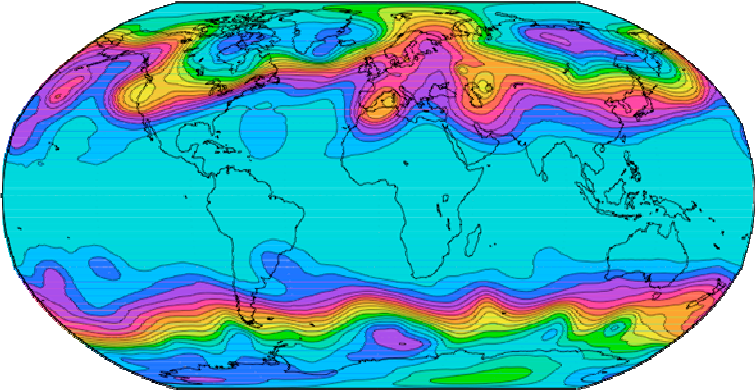
Annual cycle of Mediterranean SST from model (black) and two observation data set. Annual means for whole sea are in brackets.

Scores for seasonal 2m temperature. Model vs. CRU data.

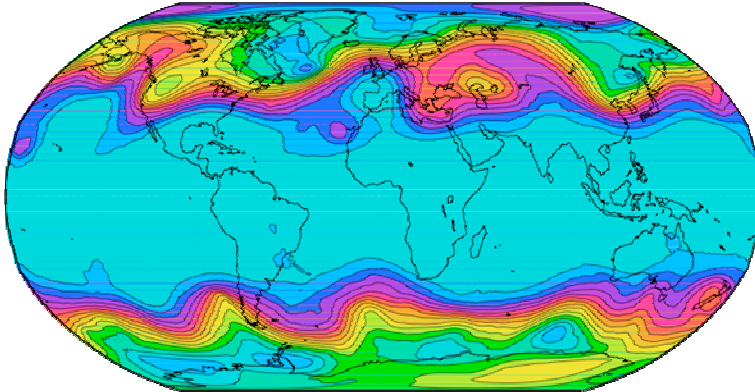
EP/CRU	bias	mae	rmse
DJF	-0,21	1,88	2,15
MAM	1,03	1,59	1,84
JJA	2,63	2,96	3,42
SON	-0,87	1,38	1,83
ANNUAL	0,64	1,63	1,87

Unified Model NMM-B - experimental run

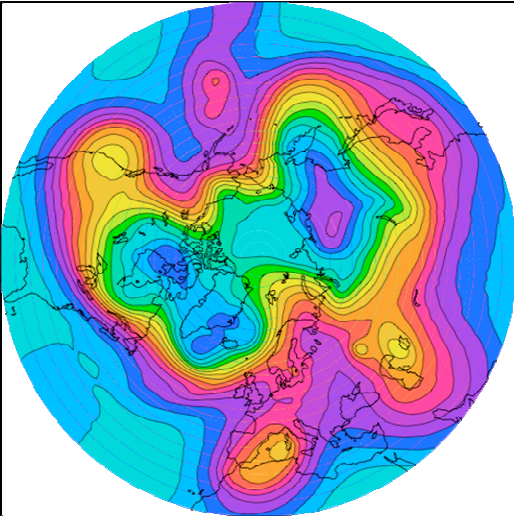
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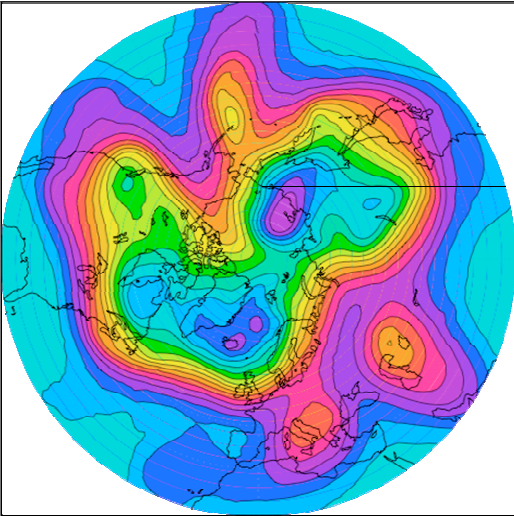
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