New Russian long-range prediction system

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SL-AV global atmosphere model

SL-AV: **S**emi-**L**agrangian, based on **A**bsolute **V**orticity equation

- **Finite-difference semi-implicit semi-Lagrangian** dynamical core of own development. Vorticity-divergence formulation, unstaggered grid (Z grid), 4th order finite differences, variable resolution in latitude, possibility to use **reduced lat-lon grid** (Tolstykh et.al., Geosci.Mod.Dev., 2017).
- Many parameterisation algorithms from ALADIN/ALARO (except for radiation and land surface)
- The model can run at 9072 cores with 63 % efficiency (at 13608 cores with 52 % efficiency).

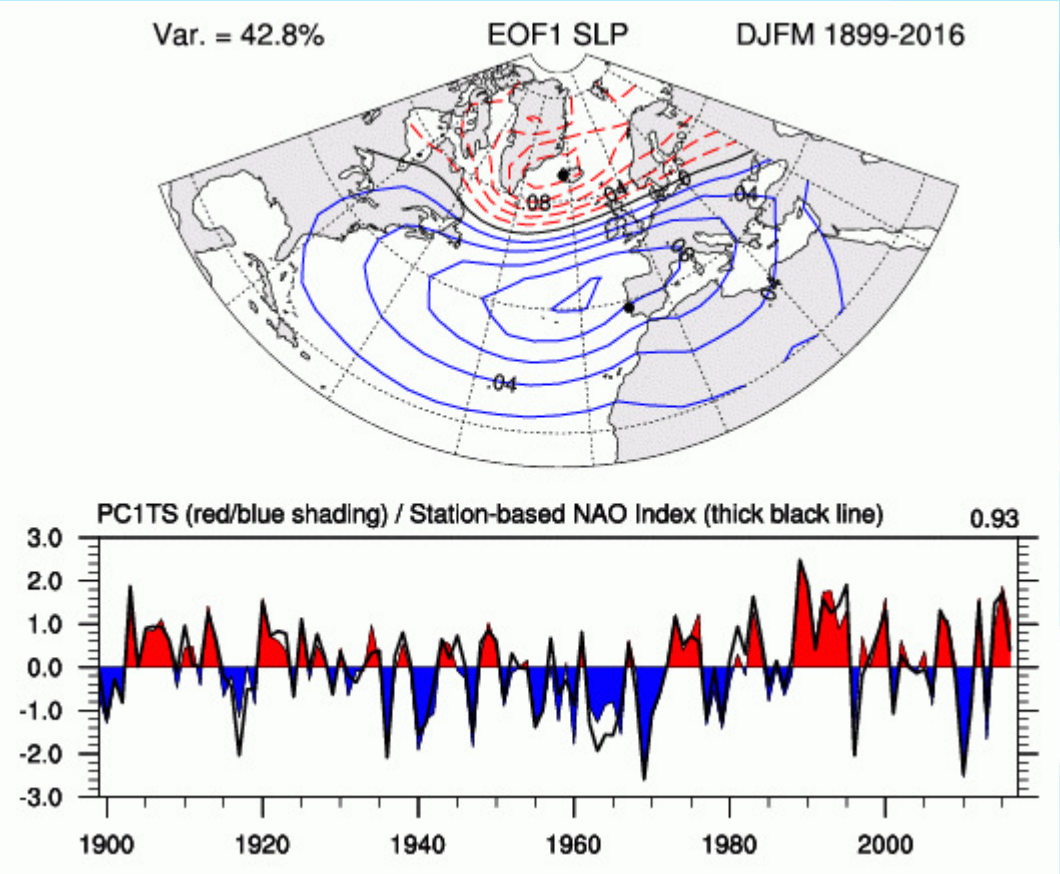
SL-AV is currently applied for:

- Medium-range operational forecast at Hydrometcenter of Russia;
- Subseasonal and seasonal forecasts at Hydrometcentre (with the old version), also S2S;
- Short-range prediction in Novosibirsk

Sources of subseasonal predictability (Vitart, 2012)

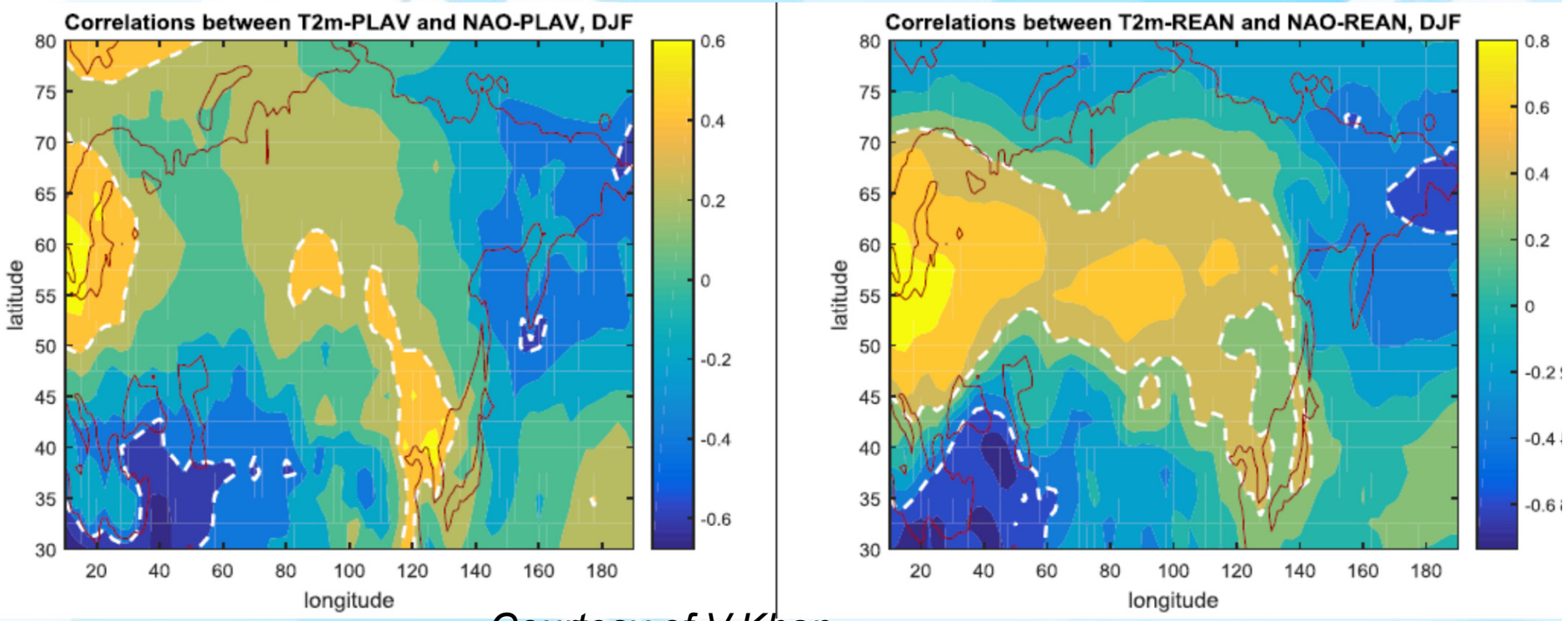
- Sea surface temperature
- Land conditions (surface temperature, snow cover, vegetation characteristics, albedo,…)
- Sea ice
- Madden-Julian oscillation (MJO)
- El-Nino-Southern oscillation (ENSO)
- North-Atlantic oscillation (NAO)
- Stratospheric variability (sudden stratosphere warmings, quasi-biennial oscillation, …)

North-Atlantic Oscillation index



Winter index is relatively predictable by the models !

Correlations of winter NAO index and T2m: old SL-AV model (left) and NCEP/NCAR2 reanalysis (right)



Courtesy of V.Khan

Making NAO forecast better would provide practically useful winter T2m seasonal forecast over significant part of N.Eurasia

Sources of NAO predictability (A.Scaife et al 2014)

- **El-Nino-Southern Oscillation (ENSO)**

- **Atlantic Ocean**

- **Kara sea-ice**

- **Quasi Biennial Oscillation**

Old and new long-range prediction system at Hydrometcentre of Russia

SL-AV 2008

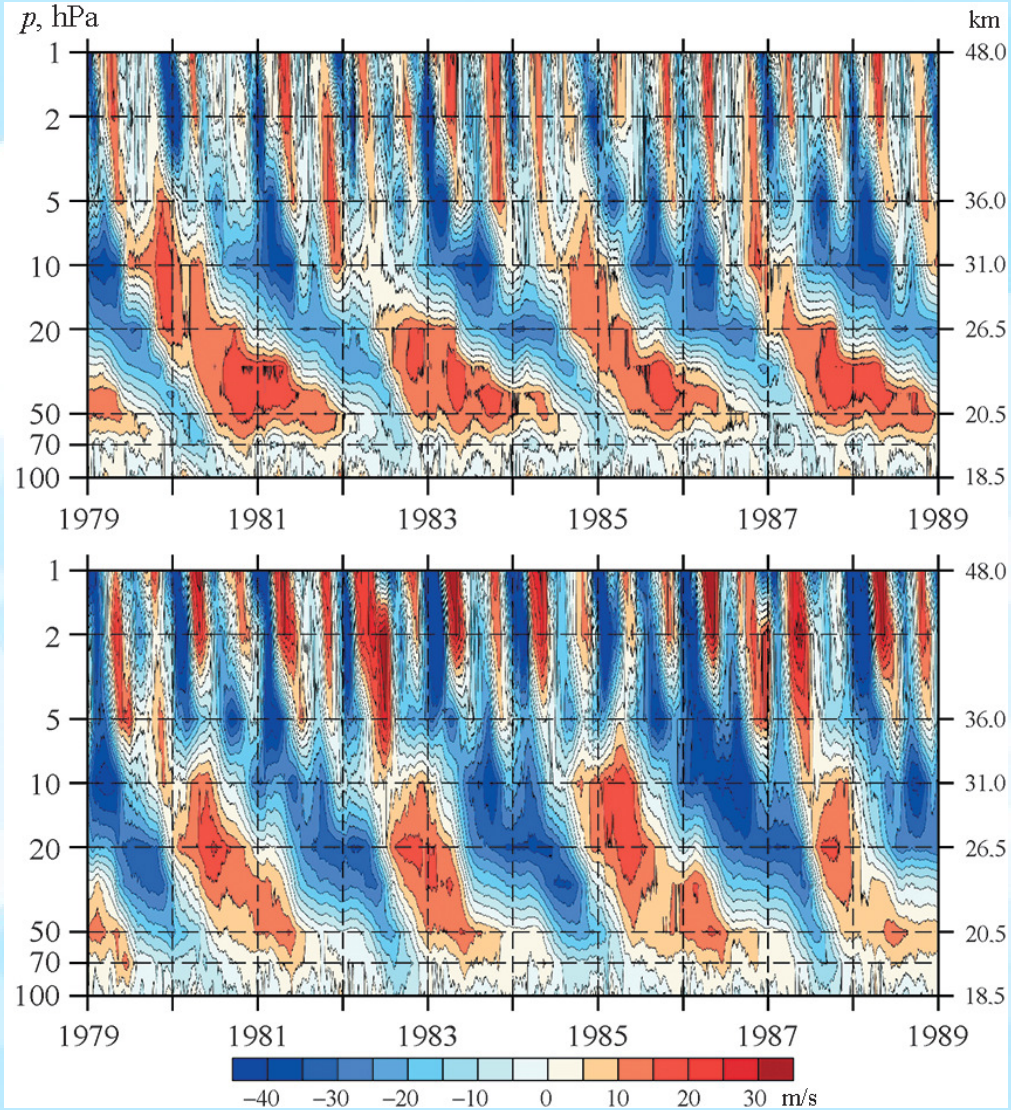
- Resolution 1,4x1,125° lon-lat, 28 levels
- Uppermost level at 5 hPa
- 1.5-3 km resolution in the stratosphere
- SW and LW radiation: Ritter, Geleyn 1992 (1+1 band)
- Boundary layer – improved version of Geleyn 1982
- ISBA surface scheme
- 4 months forecast in 40 min at 8 cores of Cray XC40

SL-AV 2015

- Resolution 0,9x0,72° lon-lat, 96 levels
- Uppermost level at 0,04 hPa
- 500-700 m resolution in the stratosphere
- SW radiation: CLIRAD SW, LW radiation: RRTMG LW (11 + 16 spectral bands)
- Boundary layer: Bastak-Duran et al JAS 2014
- Marime stratoculumus, sea-ice T
- INM RAS mulilayer soil scheme
- 4 months forecast in 40 min at 480 cores of Cray XC40

Quasi-biennial oscillation in SLAV

(V.Shashkin et al Russ Met. And Hydr. 2019)



SL-AV – top,
ERA I - bottom

NAO index ACC comparison for old and new SL-AV model (1991-2010)

	November	December	January	February	DJF
Lead time	0 month	1 month	2 months	3 months	1 month
SL-AV old	0.46	-0.08	0.14	0.29	0.17
SL-AV new	0.78	-0.09	0.29	0.34	0.29

Some technology features

Old version:

- initial data uncertainty - breeding
- Model uncertainty – perturbation of parameterisation parameters (2 so far)

New version:

- Initial data uncertainty – LETKF centered to operational objective analysis
- Model uncertainty – as currently (but 4-6 parameters) + equivalent of SKEB

Coupled model components

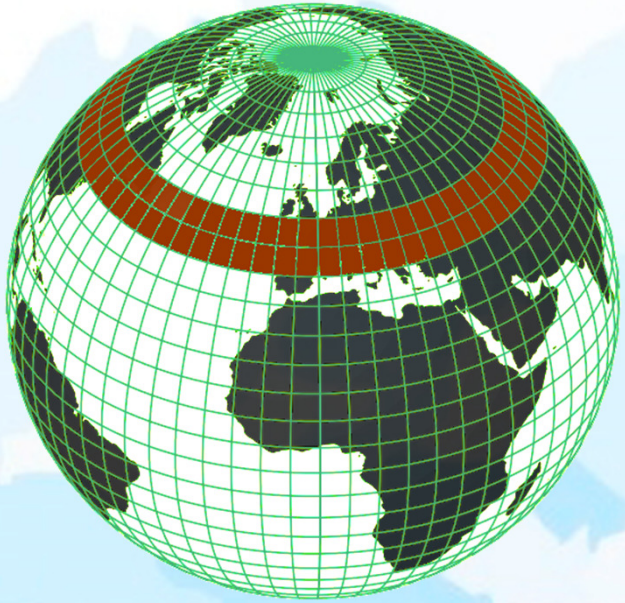
SLAV atmosphere model

0.9°x0.72° (400x250), **85** levels.

Δt = 1440 s.

Lat-Lon, 1D MPI decomposition.

* includes multilayer soil model.

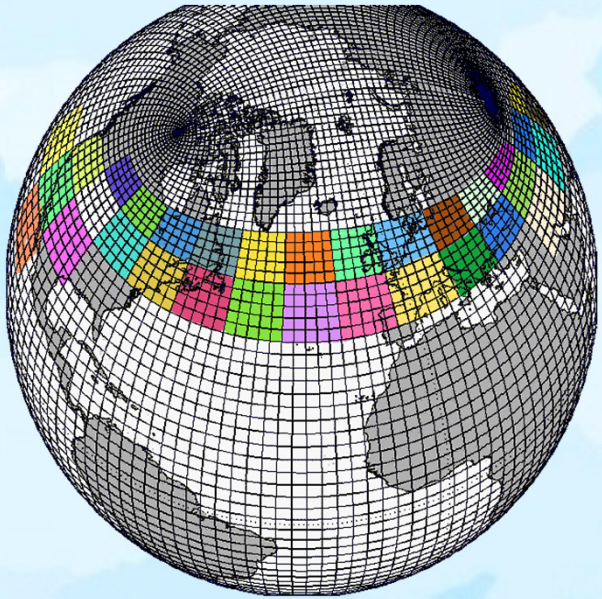


INMIO World ocean model

0.5°x0.5° (720x360), 49 levels.

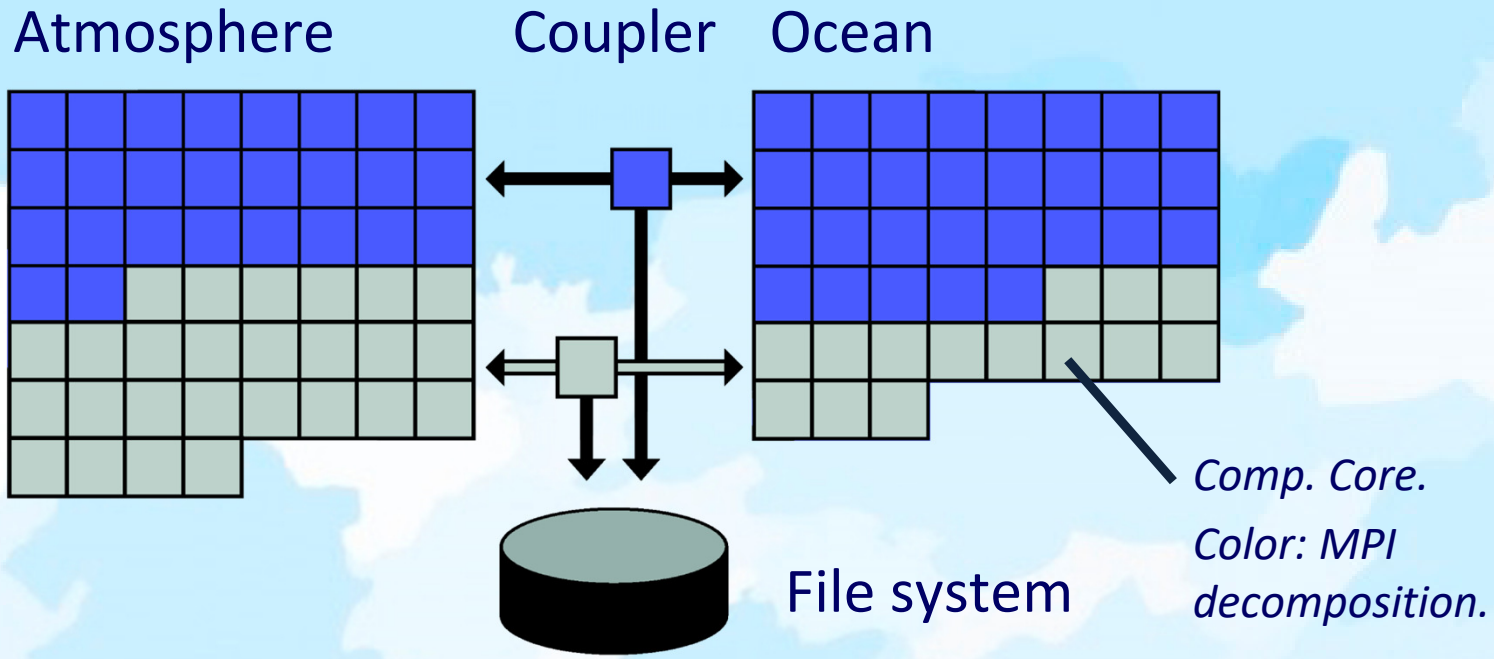
Δt = 600 s.

Tri-polar grid, 2D MPI decomposition.



Tolstykh et al, GMD, 2017;
Ibrayev et al, Izv AOP, 2012;
Fadeev et al, RJNAMM, 2016.

Coupled model structure



Coupler: synchronize the components, transfer (with interpolation) data between them, works with file system.

Data flow: 9 fields from atm to ocean every 2 hour,

3 fields from ocean to atm every 4 hour.

Efficiency: 2 years/day on 258 cores (ATM 125, OCN 132, CPL 1).

Conclusions

- New version of the SL-AV model reproduces main atmosphere characteristics
- A work is needed to improve stochastic mechanisms in the model to increase dispersion of model ensemble. So far, we use perturbations of model parameterizations parameters and plan to implement an equivalent of SKEB

- It is supposed to switch the operational subseasonal and seasonal forecasts to the new version once the technology is ready.

Thank you for attention!

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