Application of satellite OMI data and meteorological re-analysis information for the estimation of atmospheric transboundary fluxes of SO_2 in Siberia and Russian Far East within EANET region

Sergey A. Gromov (1,2)
Alisa Trifonova-Yakovleva (2,1)
Sergey S. Gromov (3,1)

(1) *Institute of Global Climate and Ecology, Roshydromet and RAS, Moscow, Russia*
(2) *Institute of Geography RAS, Moscow, Russia*
(3) *Max Planck Institute for Chemistry, Mainz, Germany*

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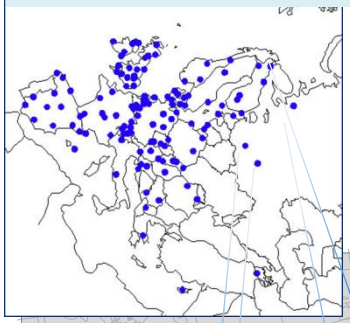
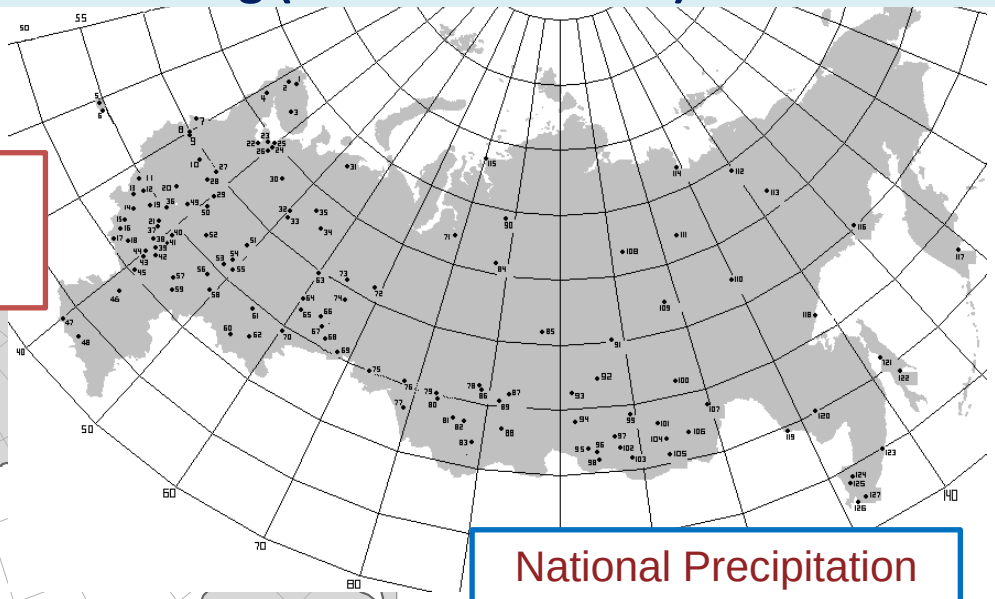
Problems of regional atmospheric pollution monitoring

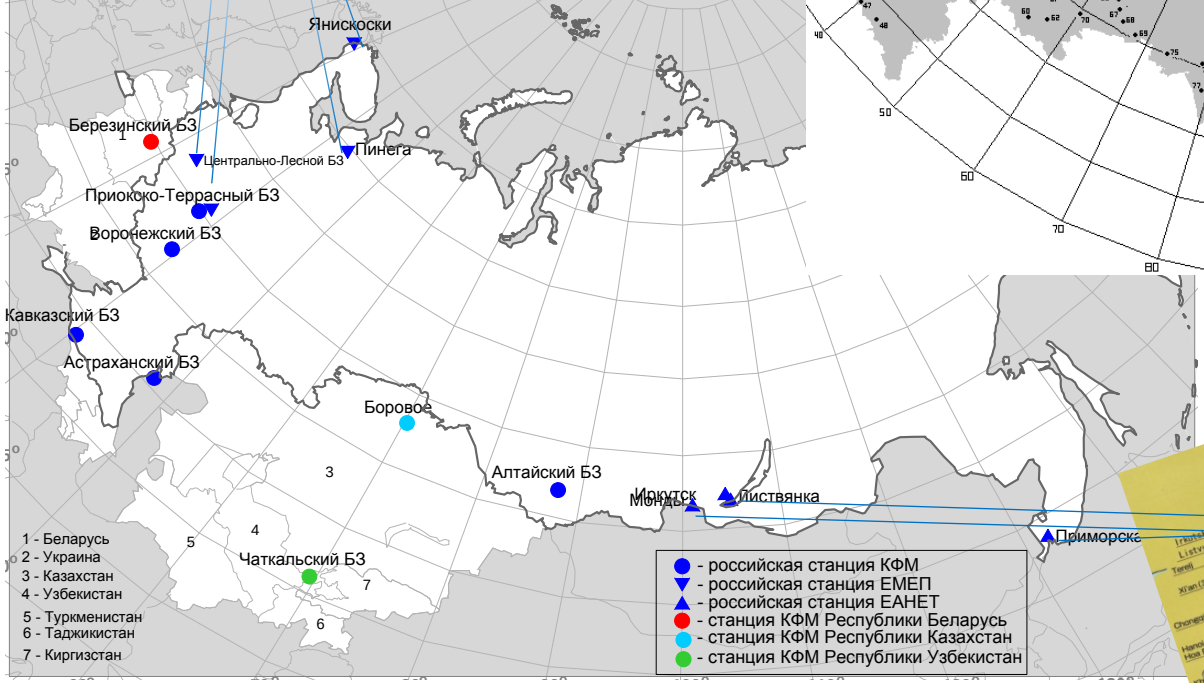
Networks of Integrated Background Monitoring (IBMon) and Transboundary atmospheric pollution monitoring (EMEP and EANET)

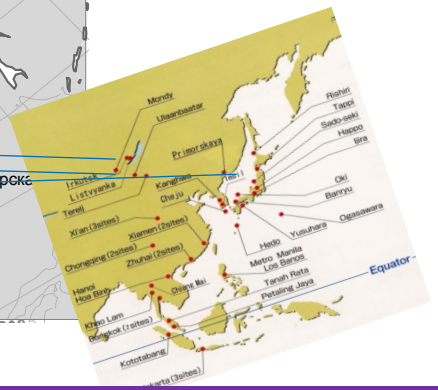


4 EMEP stations
5 IBMon stations
4 (3) EAHET stations



National Precipitation Chemistry network





EANET as the monitoring network

13 countries
28 laboratories

Air concentration monitoring

- Filter Pack (FP) - 43 sites
- Automatic (Auto) - 29 sites
- Passive sampler - 5 sites

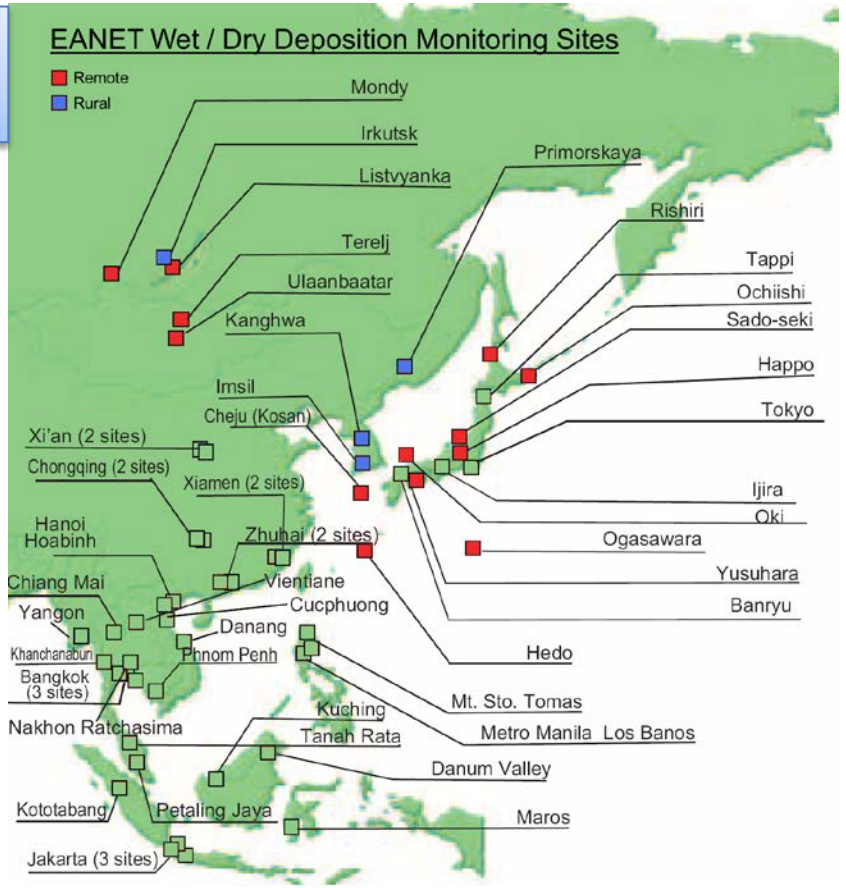
Site number for monitoring species in 2016

- SO2 (Auto + FP + PS) 48(50) sites :
- HNO3, NH3, HCl, PMC (FP) 38(41) sites
- NO, NOx/NOx* (Auto) 19(20) sites
- NO2 only (Auto + PS) 8 sites
- O3 (Auto) 23(25) sites
- PM10 (Auto) 23(24) sites
- PM2.5 (Auto) 20(21) sites

Ground base measurement in near surface layer

Continuous, unified protocols

Data and publications at *http://www.eanet.asia*



Remote (red) and rural (blue) EANET atmospheric monitoring stations (Total air concentration sites – 52)

EANET for environmental evaluation

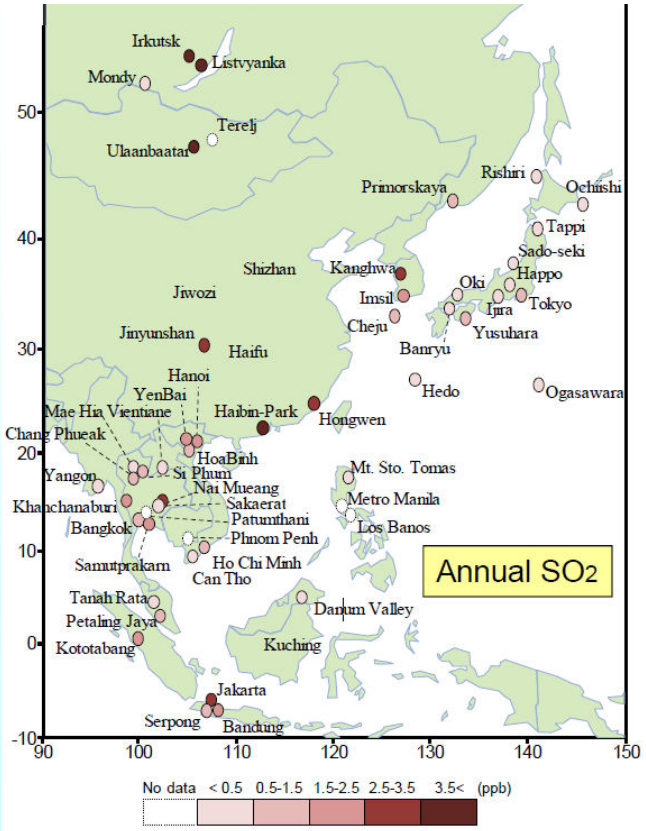
Routine data evaluations

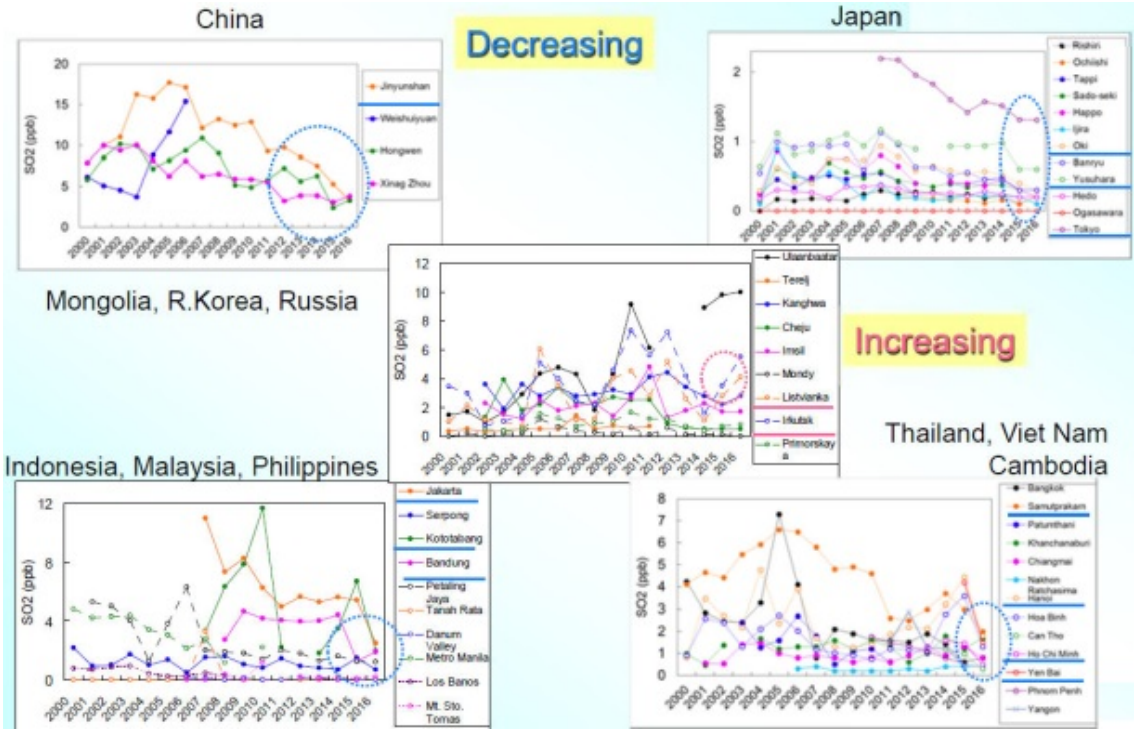
for 2001-2016

EANET Data Report (annually)

spatial

temporal





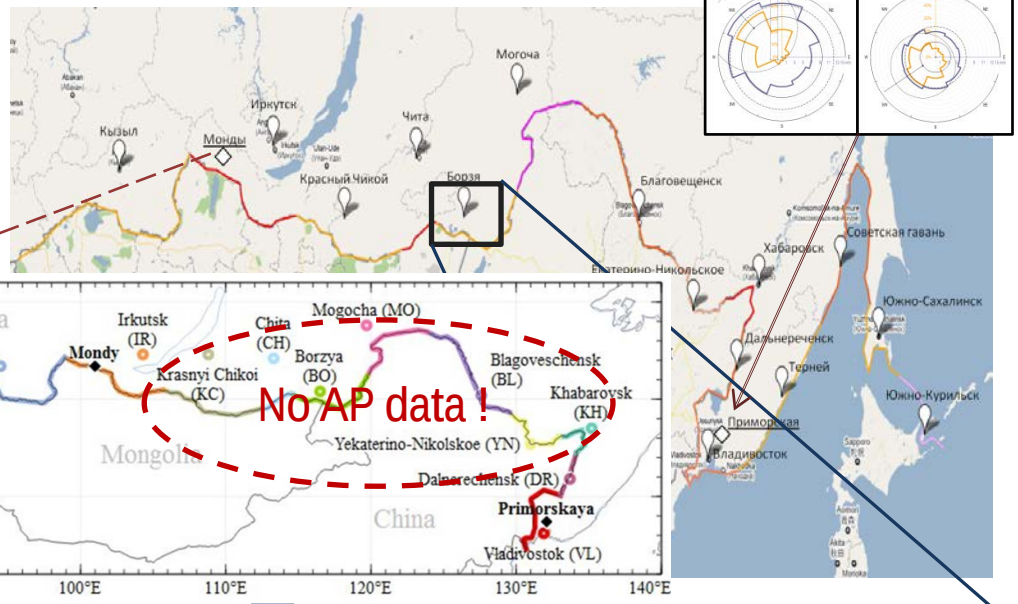
Transboundary flux evaluations

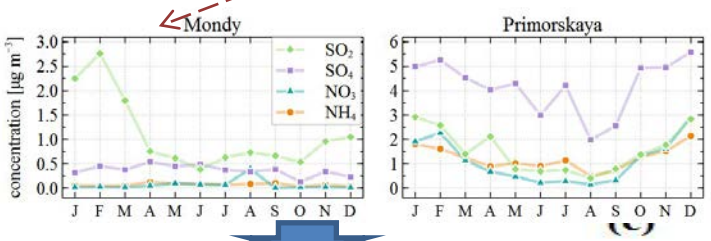
Using Climate wind data:

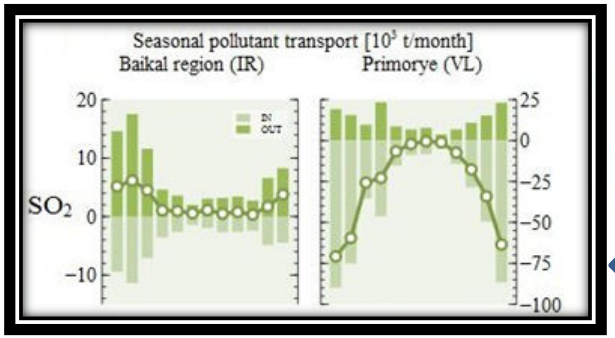
- Wind profile sounding for 10 years at meteo-points
- Probability of wind speed and directions (monthly)
- 0-3 km layer averages

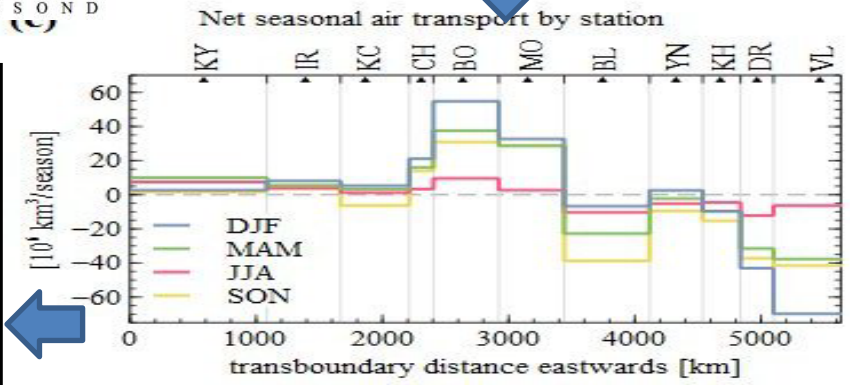
EANET air pollution (AP) data:

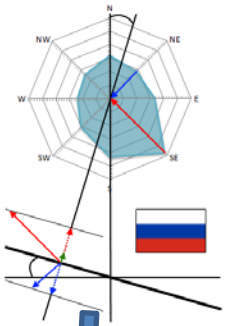
- Multiyear monthly averages











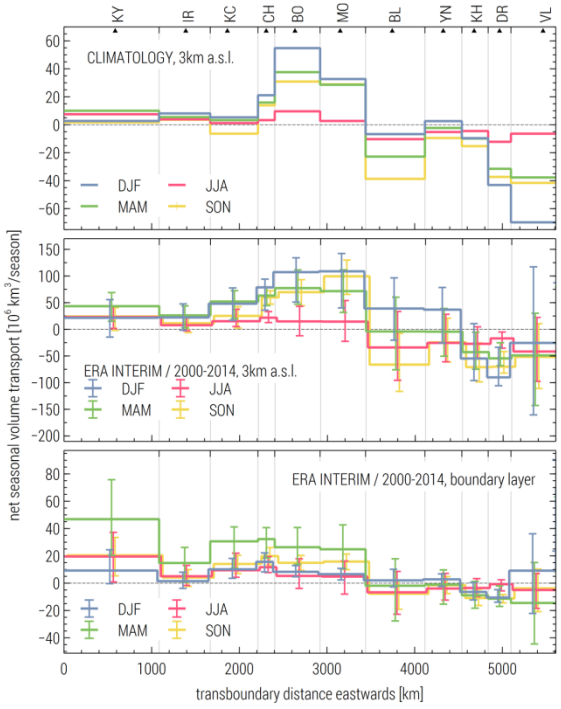
AQM Conf., 2012

Air mass transport across boundary

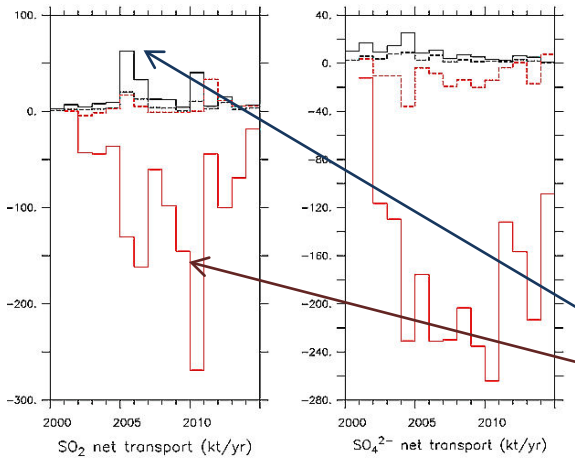
Improvement with meteo ERA INTERIM re-analysis (EIR)

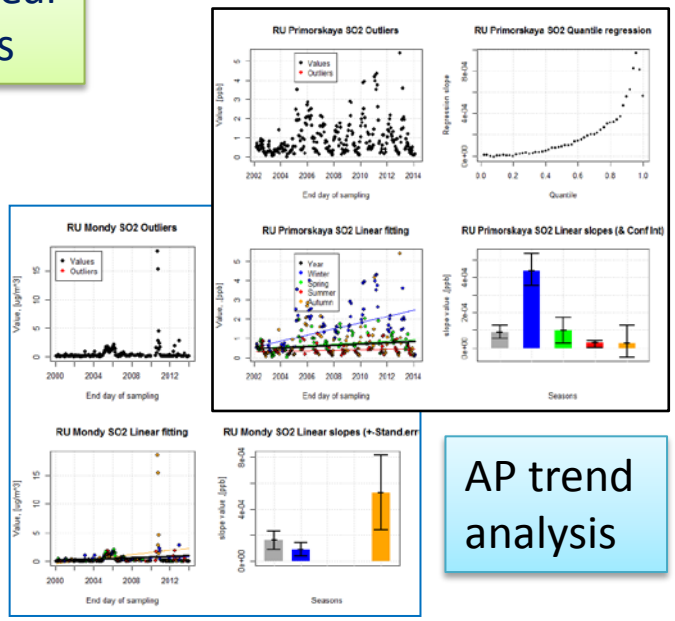
- Calculation of net air mass fluxes with EIR 6h terms for 2000-2014

Year-to-year variations



Annual SO2 fluxes by EIR application for 2000-2014 (0-3km vs BPL)





AP trend analysis

Irkutsk (Baikal area) in blue
Vladivostok (Far East) in red

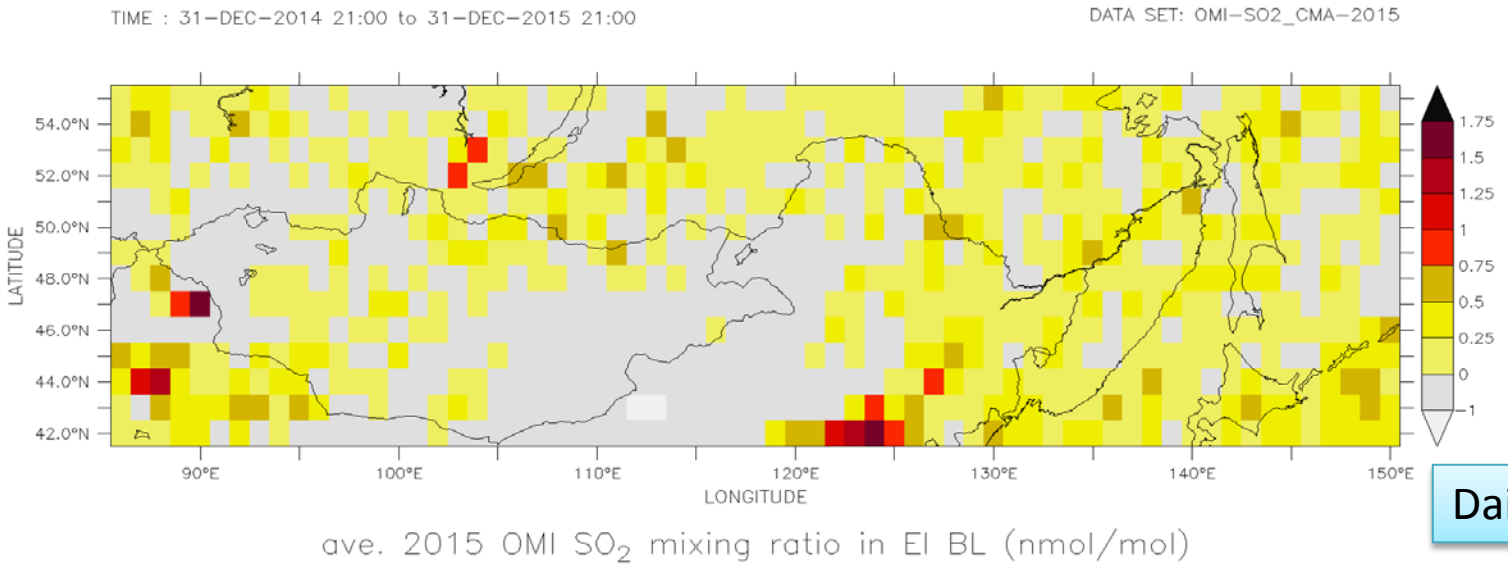
Satellite Data for EndUsers and Environmental Evaluations

Using the final product for EndUser:

- OMI instrument at Aura satellite at a sun-synchronous near polar orbit (ascending node is in daylight and crossing the equator at 1:45 PM approximately).
- Data on aerosol types (smoke, dust, and sulfates), on cloud, on tropospheric ozone
- Recalculation into OMI ***OMSO2G*** product with vertical CMA coordinates

Our data filtrations:

- Excluding some events (like volcano plumes)
- Found the maximum of SO2 content in semi-BPL (or lower layer: from 0 to 2-3 km)
- Calculations of SO_2 concentrations with CMA of BPL (using BPL meteo to recalculate from DU)

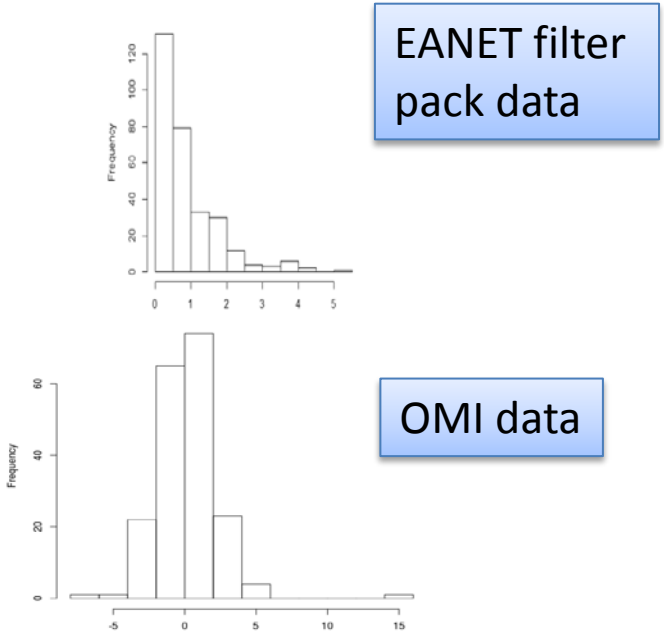


Daily picture

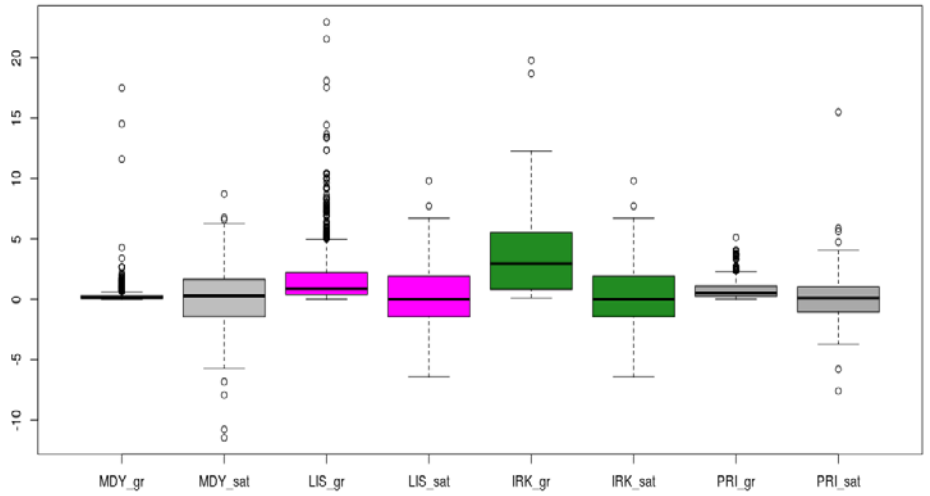
Comparison EANET and OMI data

- Based on averaged data (depends on ground base sampling periods)
- Relatively good agreement of single data pairs, but

  OMI results provide large noise / errors (but not shift)



Primorskaya, SO2, [ppb]

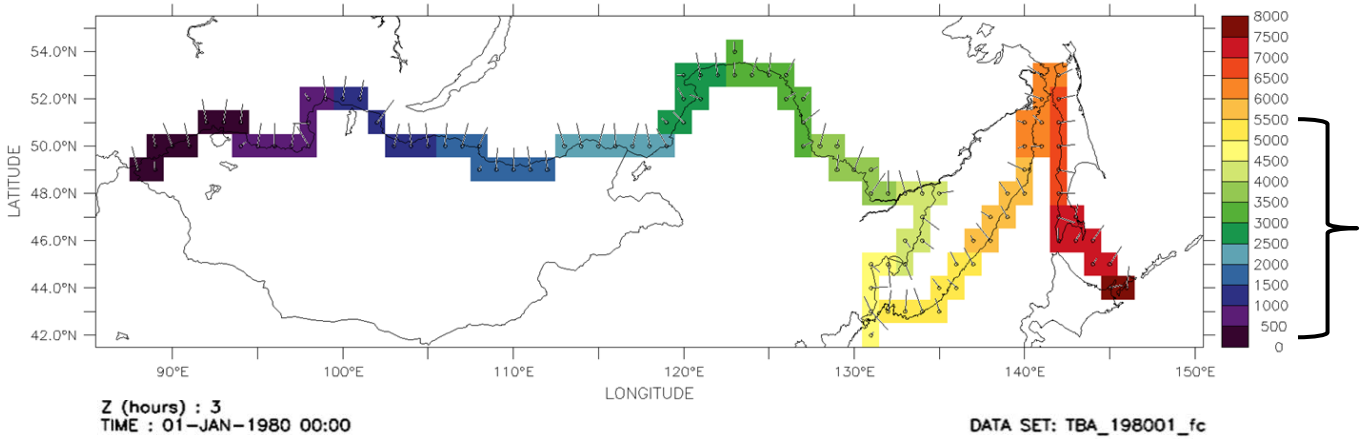


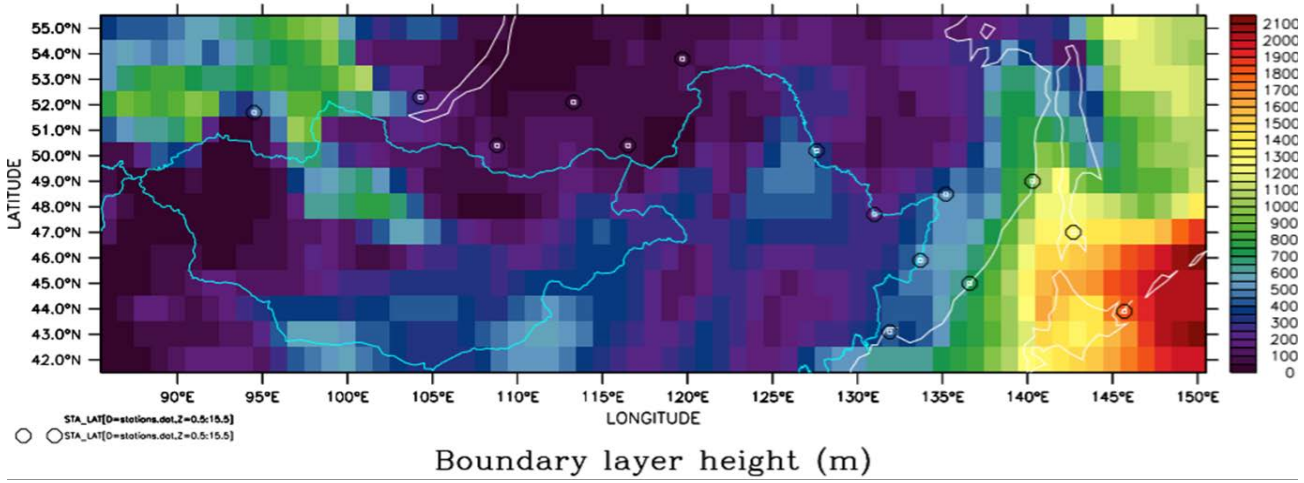
Pair plots of *Mondy* *Listvyanka* ***Irkutsk*** *Primorkaya*

Note: the local emission sources are affected in Irkutsk

Simplified “modeling” calculations

Quantifying the transboundary fluxes of SO_2 along Russian border in Asia with Mongolia and China For 2015





Arrows show air transport into Russia (negative).

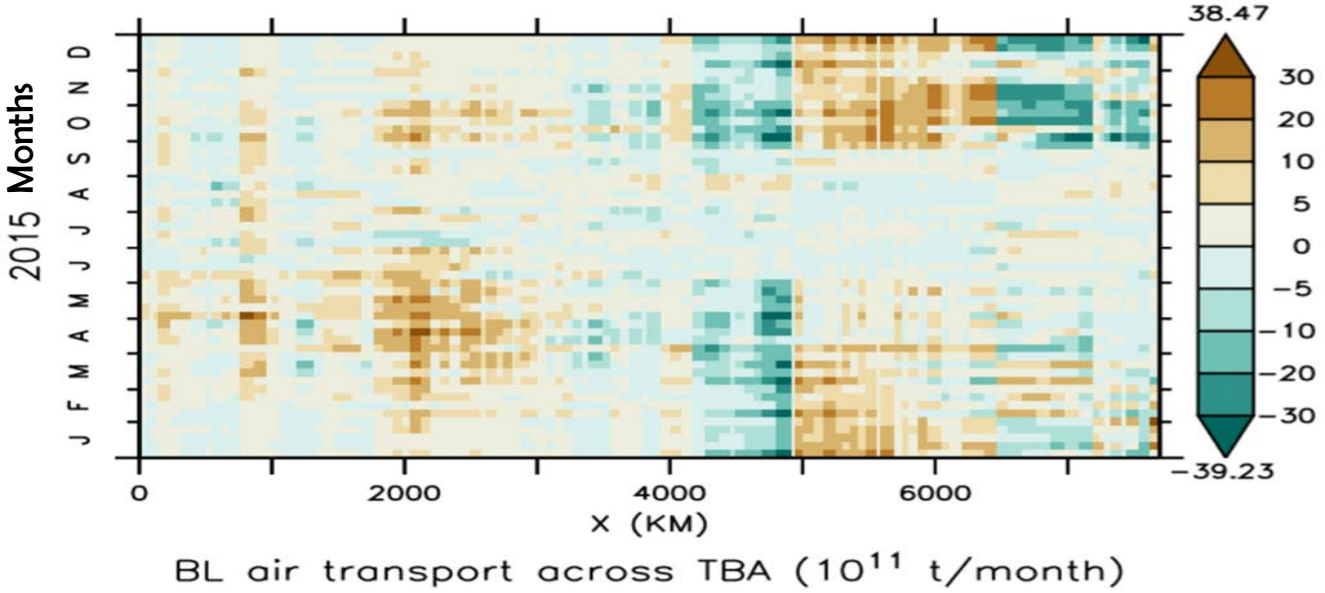
Length ~5600 km on continent

Sums and *Net* transfer might differs by orders of magnitude

ECMWF
reanalysis for 2015 (6 hr.):
T, P, U+V, etc. (анализ);

BPL height (calc)

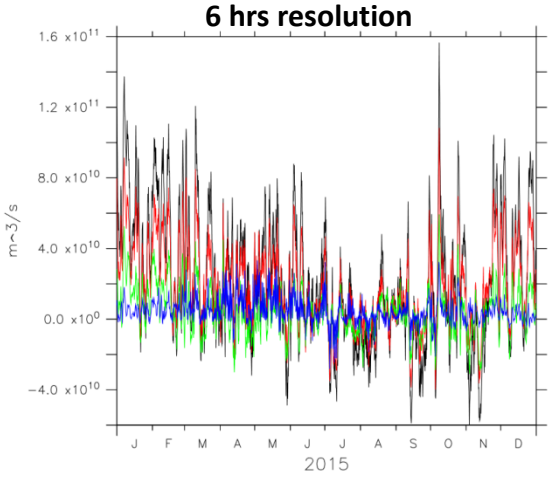
Air mass transport across the border



Distance cross-border exchange of air in BPL:

- From Russia (positive)

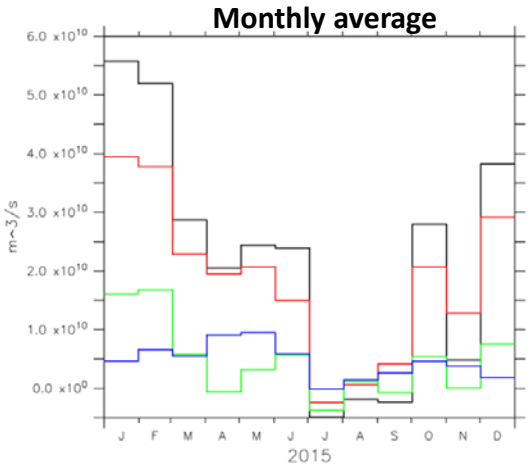
- Into Russia (negative)



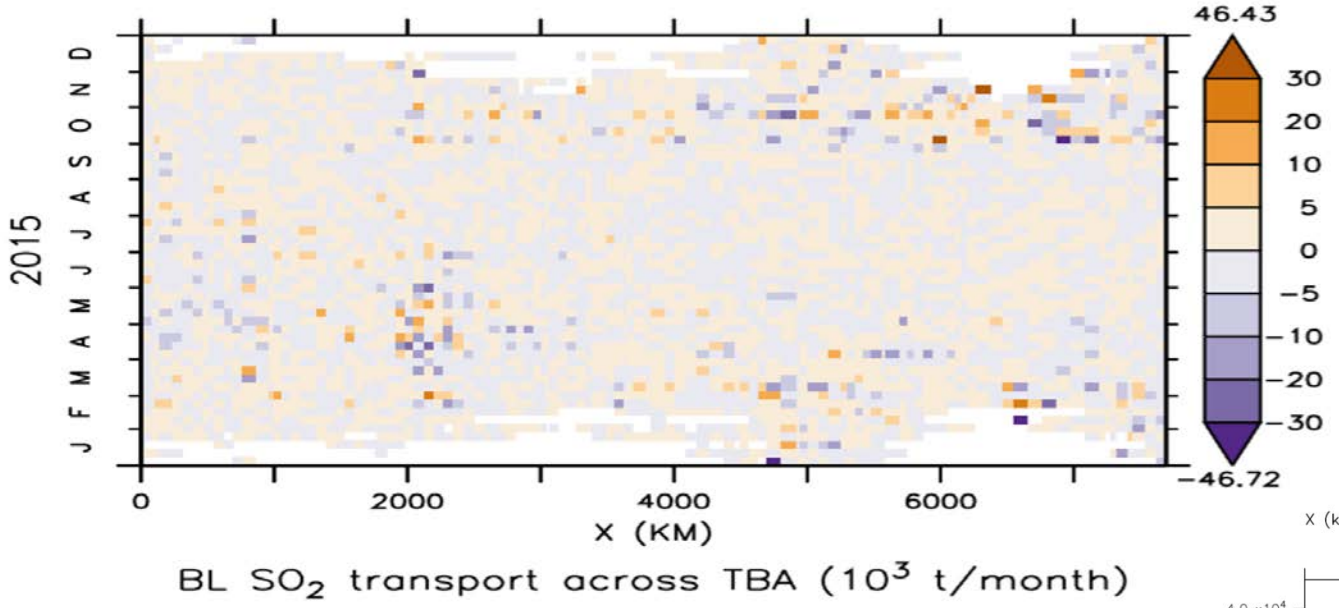
Transport dynamics in BPL and Troposphere (in м^3/s)

Free troposphere (dark)
Lower 3 км (0-3000m) (red)
Belowr 750 hPa (green)
Within BPL (blue)

)



SO_2 transport across the border



Distance cross-border exchange of SO_2 in BPL:

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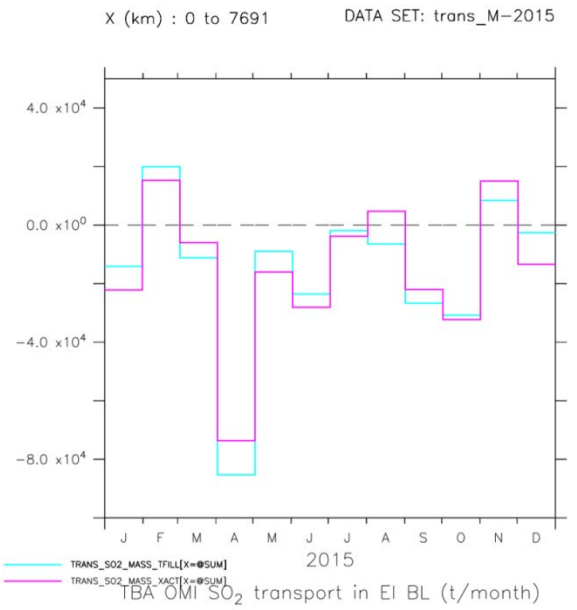

For 17% of total net air transfer are for the day hours with only correspondent satellite data is available (around noon or closer), 91% - of the remaining periods when using nearest upwind SO2 columns (e.g., night time, far from noon)

Total transport of SO2 per month

positive: outward Russia
negative : inward Russia
mag.: only noon terms
cyan: noon terms fill the entire day

Results and Uncertainties

- Estimated net transport of SO_2 was transported inwards Russia within the PBL not less than **(180-190)• 10^3 tons** in 2015.
- The largest import SO_2 flux in PBLinto Russia of about 80• 10^3 tons/month is diagnosed in April
- The general circulation pattern renders import of SO_2 into Russia prevailing throughout April-June and September-October, whilst smaller export fluxes (of up to 20• 10^3 tons/month) are reckoned for February and November
- SO_2 transport in January and December is poorly quantifiable due to less available OMI data (corresponding to <5% of total net air transport)
- This result is robust (within ±5• 10^3 tons per year, or ± 3%) when less certain data (e.g. at radiative cloud fraction > 0.2) from OMI PBL SO_2 product are included.
- The available satellite data covers well the periods of non-equilibrium air transport with elevated SO_2 burdens, which to a certain extent is intrinsic to the PBL diurnal dynamics.