Global-Regional Scales Interactions for Atmospheric Chemical Transport Modeling

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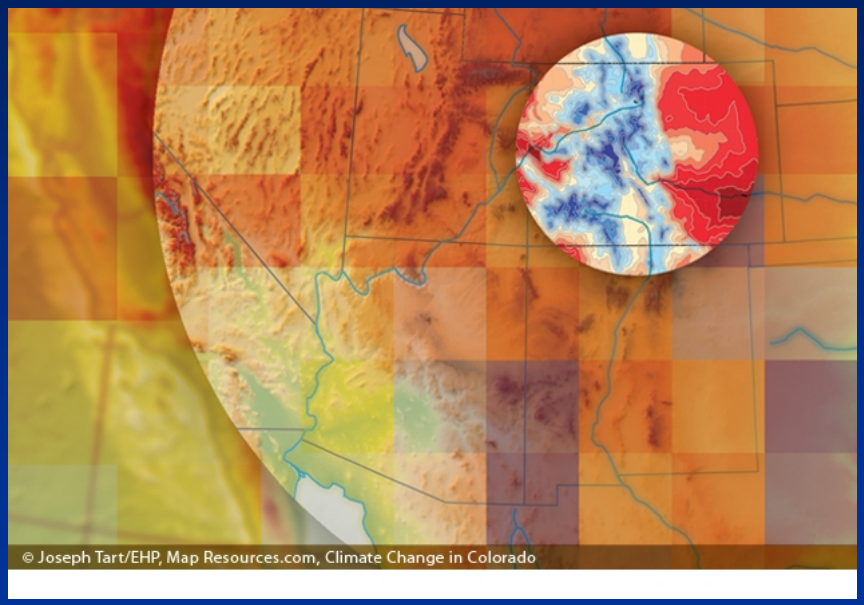
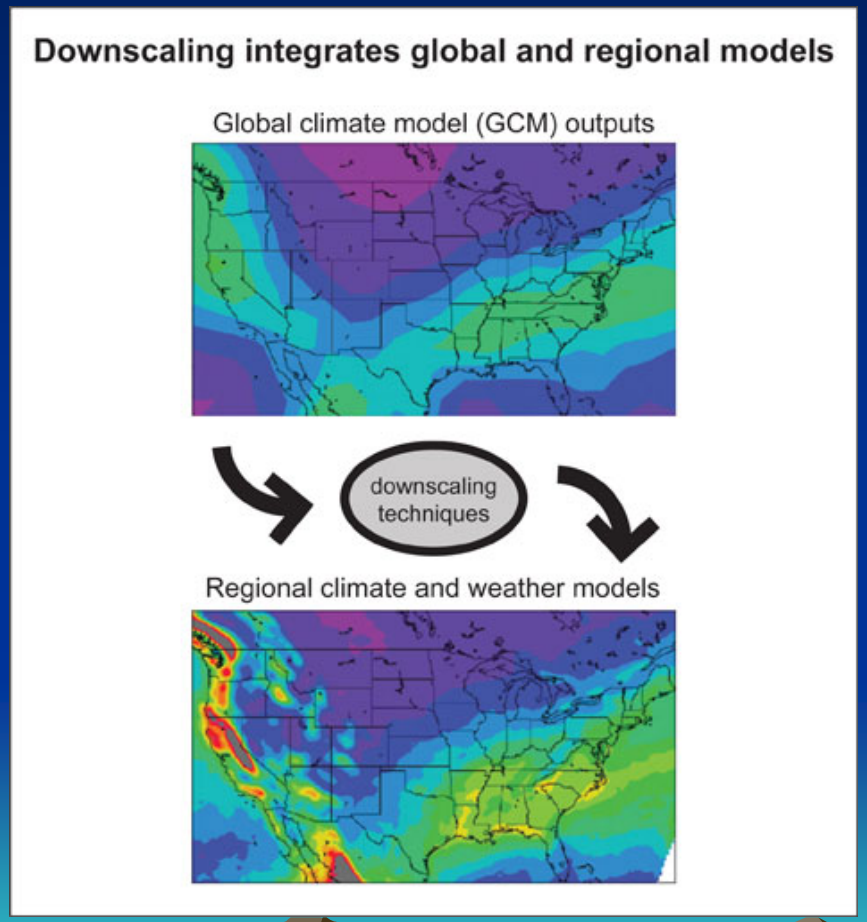
Motivation



Time scale for regional modeling – several days
Time scale for global – modeling – years and decades

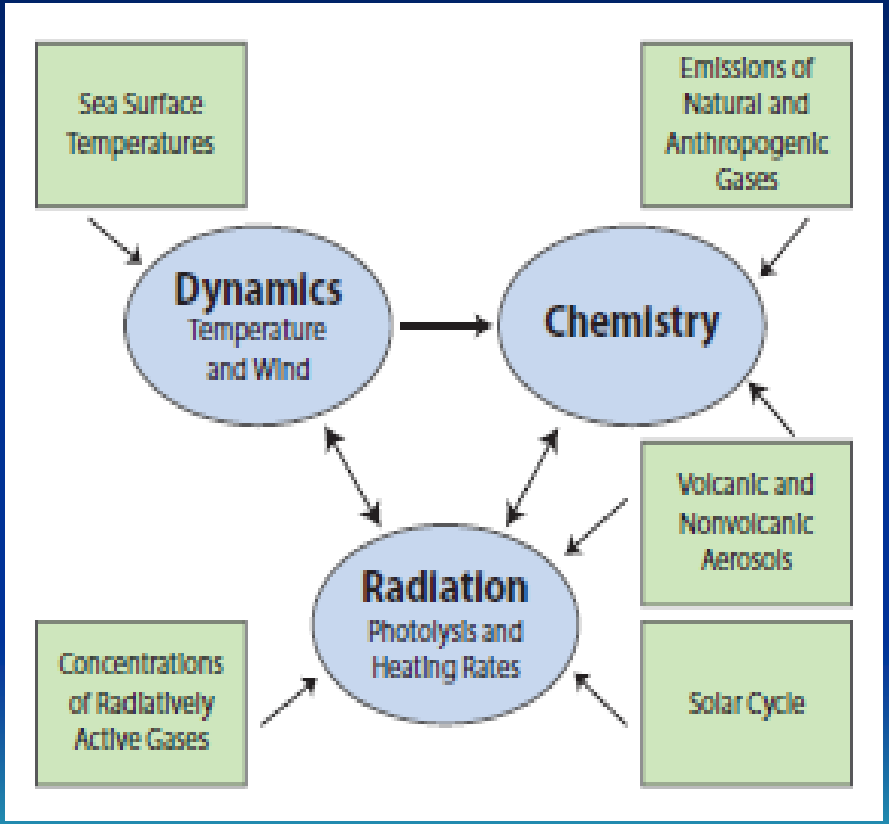
- Regional air quality models provide forecast for atmospheric chemistry change at the local and regional level.
- Global air composition change projections are developed using global-scale models that generate average concentration changes that can be expected to occur over decades and far into the past and future. These global models are unable to represent granular atmospheric features such as local pollution sources. Yet these smaller details can have a big impact on local air quality, which is one reason the effects of chemistry change are expected to vary depending on geographic location.
- Intermediate scale-continental, for example, the scale of Eurasia requires taking into account the influence of both regional and global processes

DownScaling



- Two-way interaction
- Global models of the chemical composition of the lower and middle atmosphere are used to set initial and boundary conditions for air quality model
- Regional models are used to Refine the initial and boundary conditions for global models

Chemistry-Climate Model (CCM)



- Online interaction between radiation, dynamics and chemistry
- Physics and chemistry feedbacks are taking into account

Problems That We Address with CCM

- Long-term ozone and temperature variability
- Direct and indirect effects of solar fluxes variability
- Sea surface temperature and sea ice coverage impact on the atmospheric composition

From CCM to Chemistry-Transport Model (CTM)

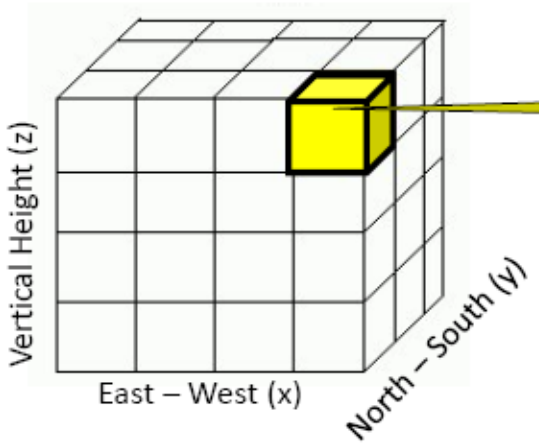
Radiosondes-+	1970 – present	NCEP
PIBAL winds	1970 ; present	NCEP
Wind profiles	1992/5/14 ; present	UCAR
ConvenEonal, ASDAR and MDCRS aircraft rep.	1970 ; present	NCEP
Dropsondes	1970 ; present	NCEP
PAOB	1978 – 2010/8	NCEP
GMS, METEOSAT, cloud drift IR & visible winds	1977 ; present	NCEP
GOES cloud drift winds	1997 ; present	NCEP
EOS/Terra/MODIS winds	2002/7/01 ; present	NCEP
EOS/Aqua/MODIS winds	2003/9/01 ; present	NCEP
Surface ship and buoy observaEons	1977 ; present	NCEP
Surface land observaEons	1970 ; present	NCEP
SSM/I V6 wind speed	1987/7 ; present	RSS
SSM/I rain rate	1987/7 ; present	GSFC
TMI rain rate	1997/12 ; present	GSFC
QuikSCAT surface winds	1999/7 – 2009/9	JPL
ERS;1 surface winds	1991/8/5 – 1996/5/21	CERSAT
ERS;2 surface winds	1996/3/19 – 2001/1/17	CERSAT
SBUV ozone (V8 retrievals)	1978/10 ; present	GSFC

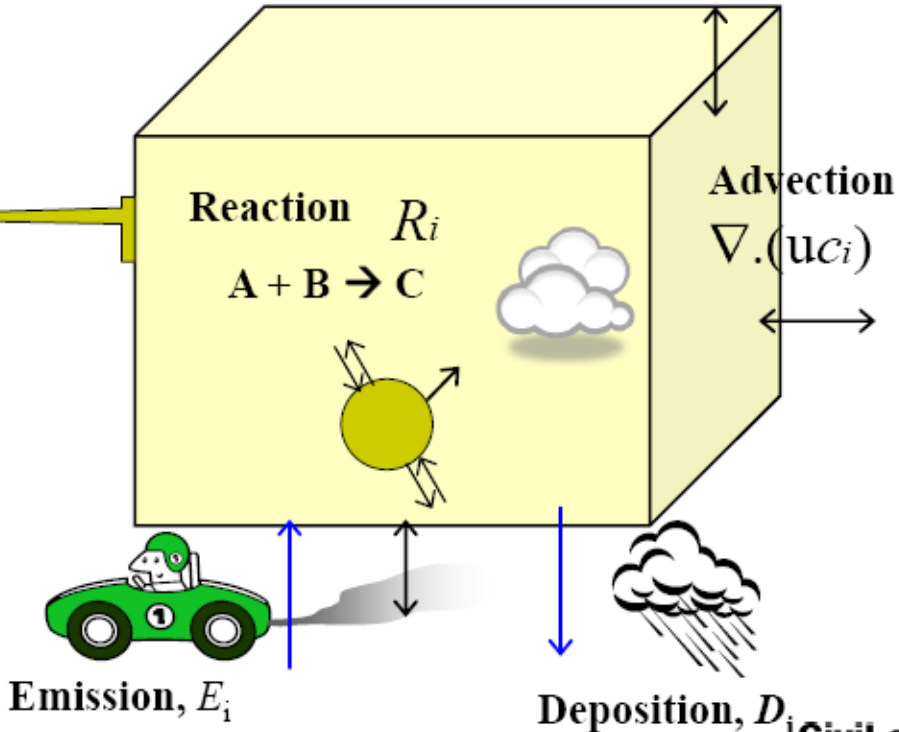
- The same chemical scheme ;
- Meteorological fields are not calculated but specified from th Modern-Era Retrospective Analysis for Research and Applications (MERRA) reanalysis or ERA-Interim reanalysis data
- The model has 5x4 horizontal resolution in longitude by latitude and 31 vertical sigma levels from the surface up to approximately 60 km.
- The distribution of the oxygen, hydrogen, nitrogen, chlorine, bromine and carbon gases are calculated with the manner described in].
- Polar stratospheric clouds formation and evolution is take into account

Chemistry-Transport Model (CTM)

- Divide atmosphere into 3D grid of locations
- Each grid box has a mass balance ("continuity" equation)
- Use rate of change (dc_i/dt) to step forward in time

Grid Set-up:





Models

- 3-D Chemistry-Transport Global Model (CTM) **RSHU**
- 74 gases, 174 chemical reactions, 51 processes of photolysis, 29 heterogeneous reactions (**oxygen, nitrogen, hydrogen, chlorine, bromine, carbon and sulfur families**), 39 altitude levels (14 in the troposphere) (0—90 km), 5x4 horizontal resolution (88 S—88 N), polar stratospheric clouds formation and evolution

  Smyshlyaev S.P. , V.L.Dvortsov, M.A.Geller, V.Yudin, *J.Geophys.Res.*, 103, 28373-28387, 1998.

- 3-D Regional Chemistry-Transport Model **(CTM) with 0.5x0.5 horizontal resolution over Eurasia only**

  V.Ya. Galin, S.P. Smyshlyaev, E.M. Volodin, "Combined Chemistry-Climate Model of the Atmosphere", Izv., Atmos. Ocean. Phys. 43, 3-17, 2007

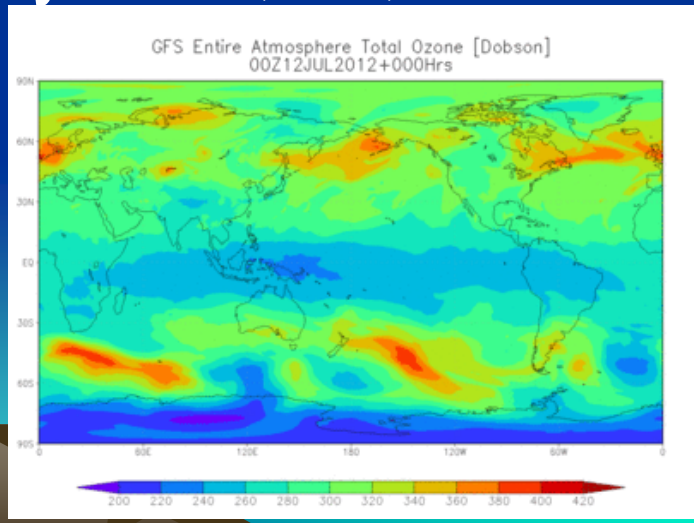
GFS data

- The horizontal resolution ~25 km → ~13 km
- Top layer centered around 10.0 hPa → 0.27hPa
- NCEP's global forecasts provide forecast out to

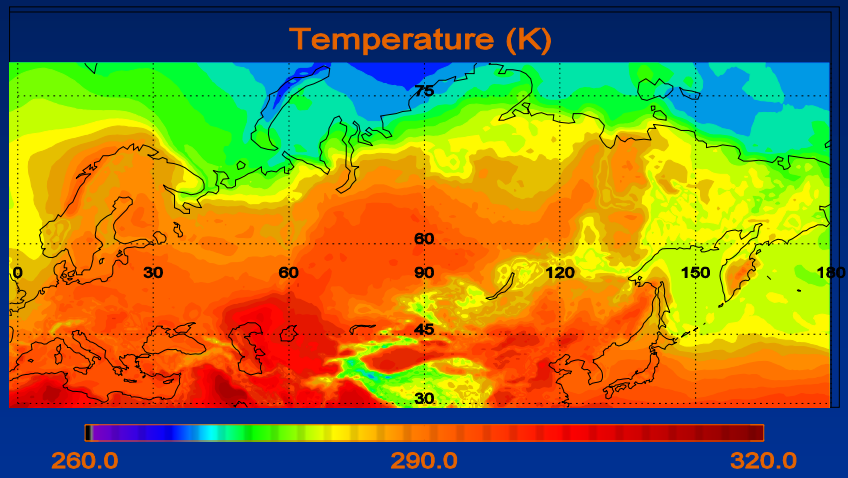
  8 days → 16 days

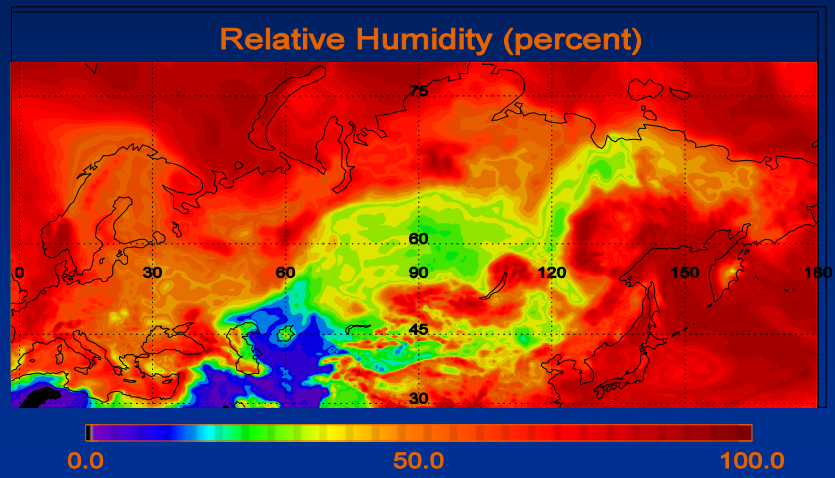
- GFS data are made four times daily at 00, 06, 12 and 18 UTC

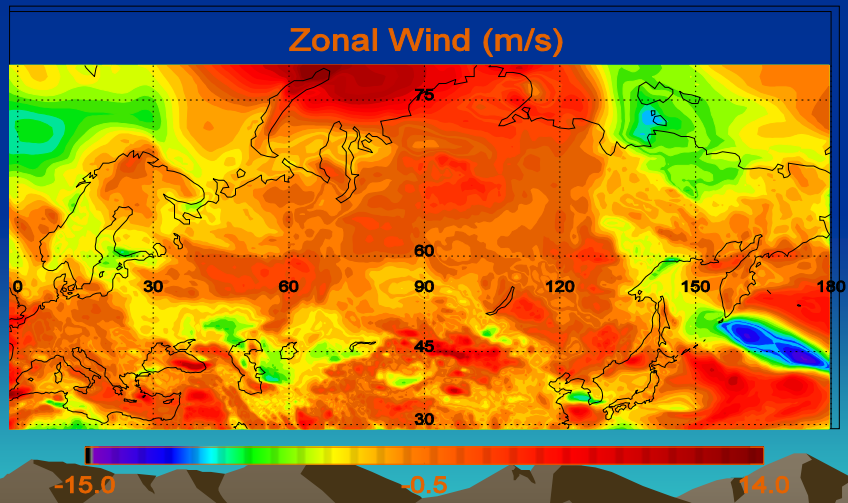
- CCM provide forecast for 72 hours

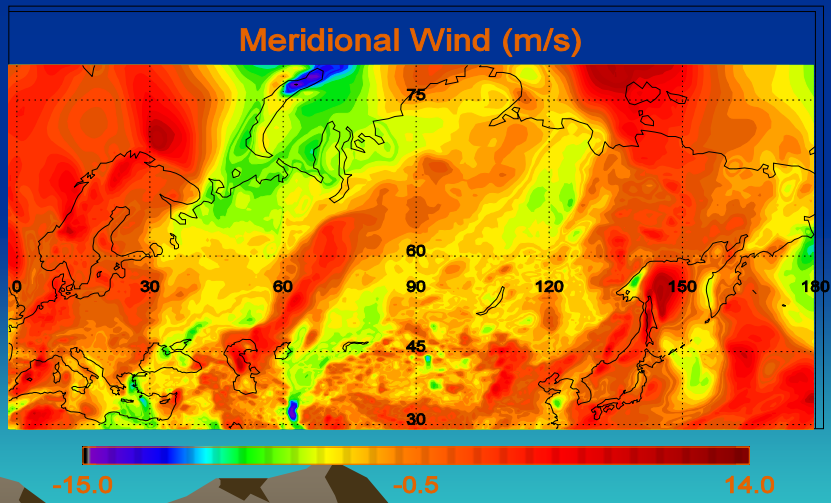


Meteorological Analysis
July 6, 2019 r. (GFS analysis)

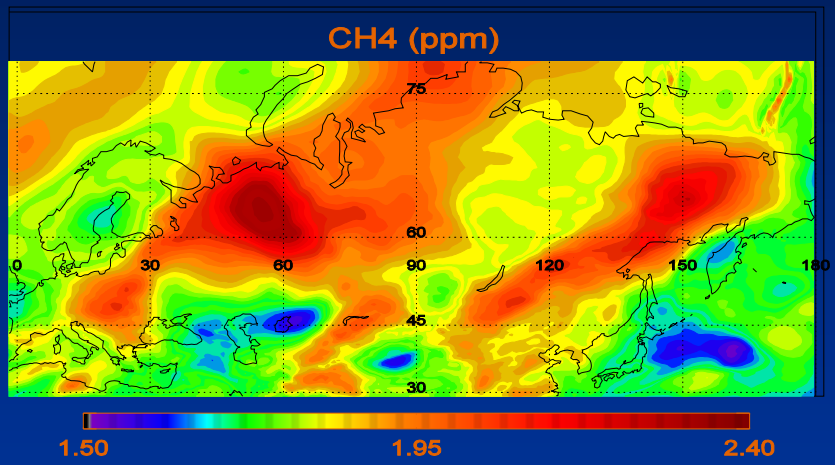


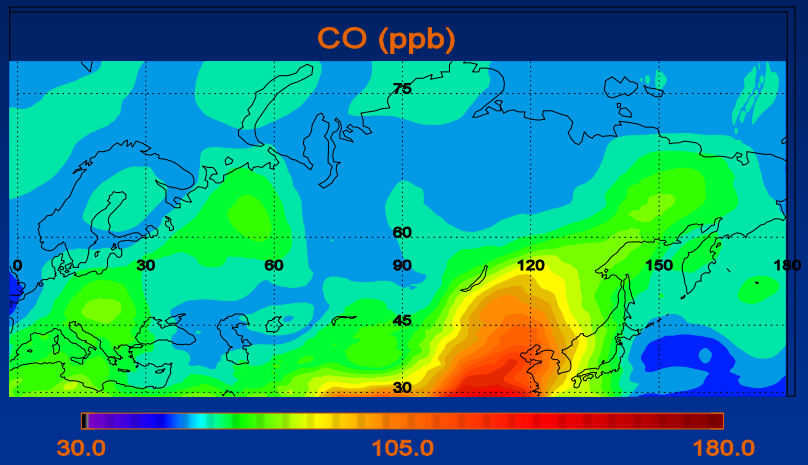


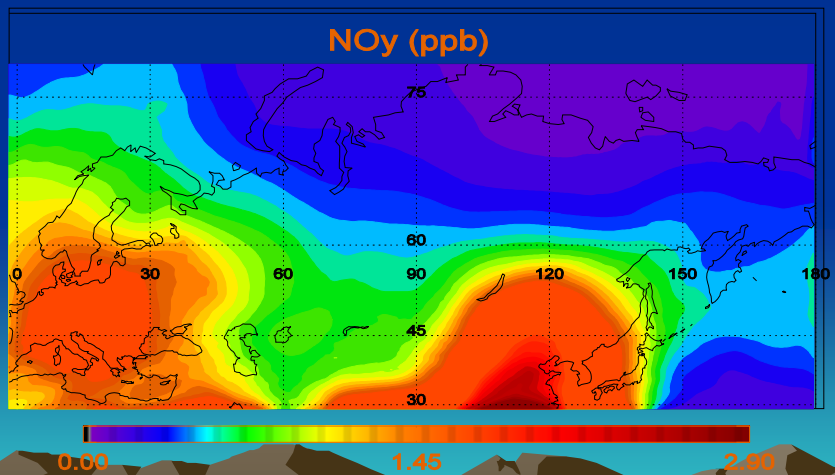


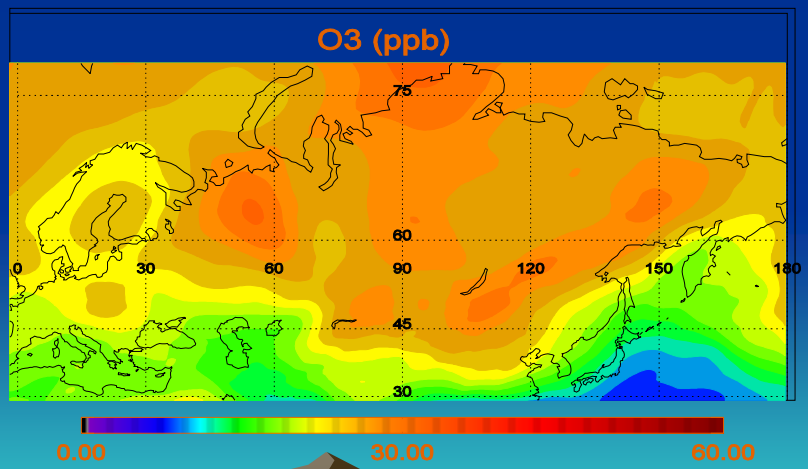


Eurasia Gas Composition
July 6, 2019 г. (RSHU model)

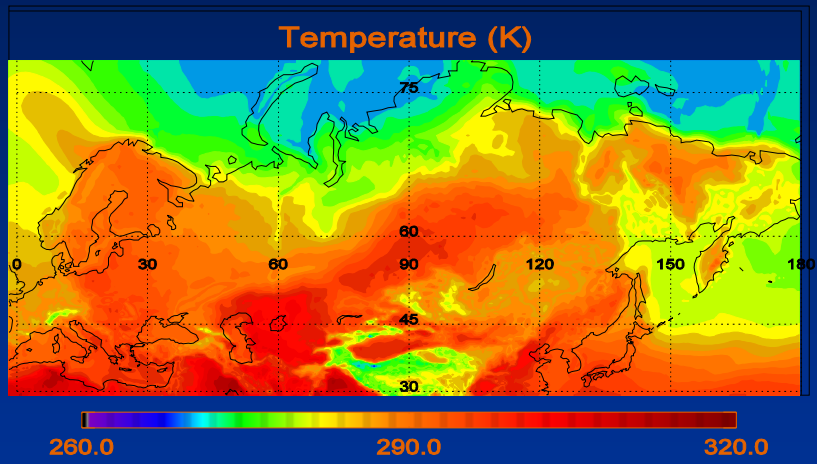


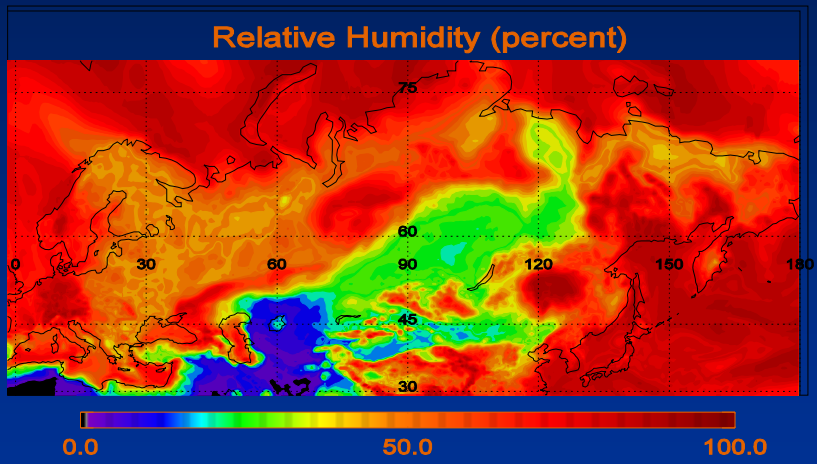


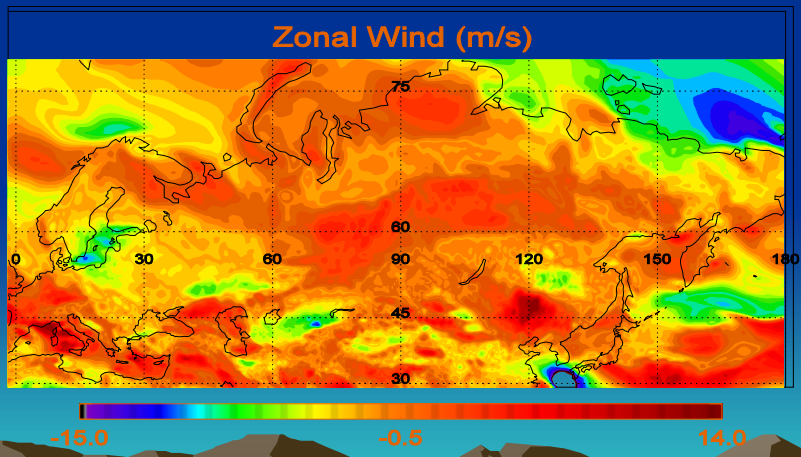


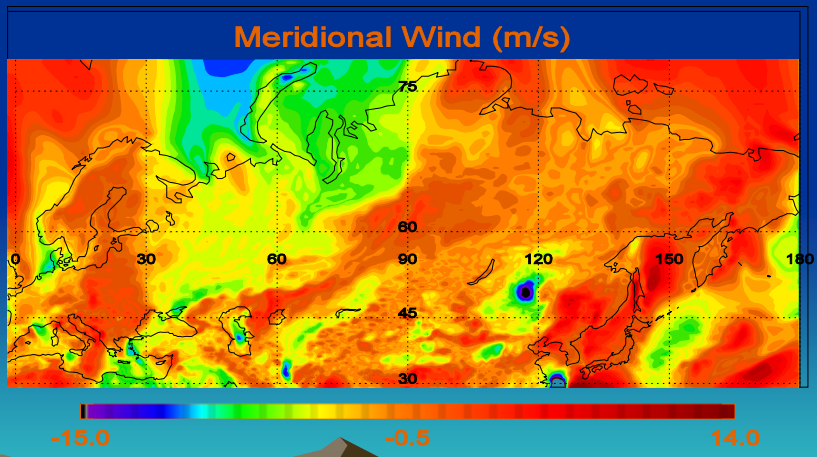


Meteorological Forecast
July 8, 2019 г. (GFS forecast)

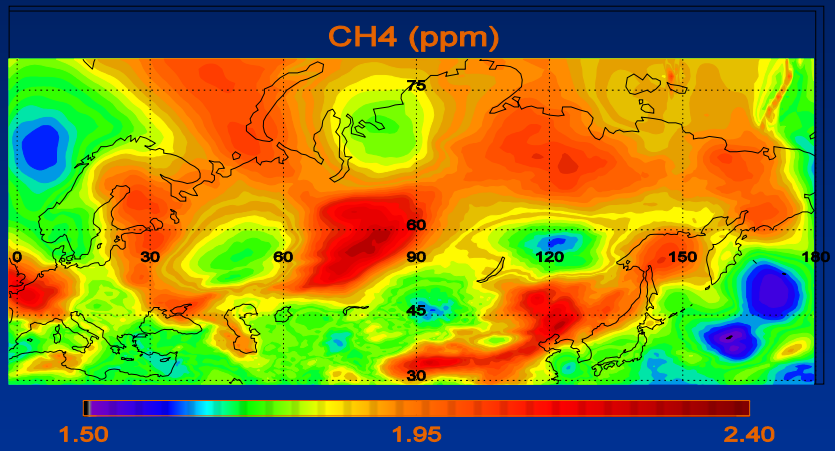


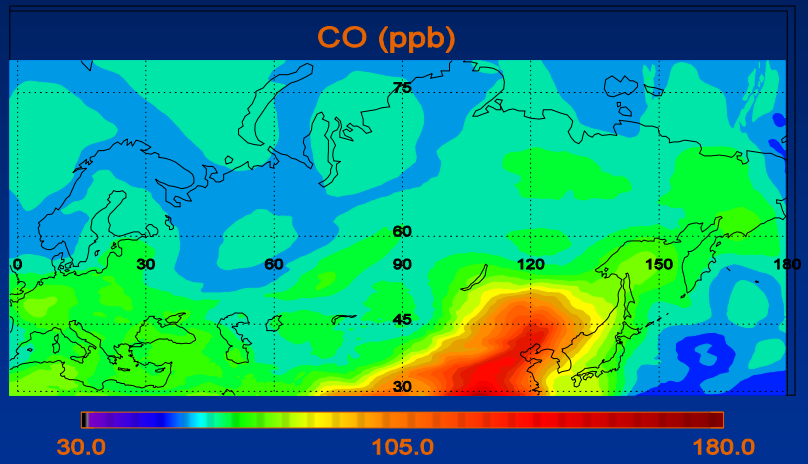


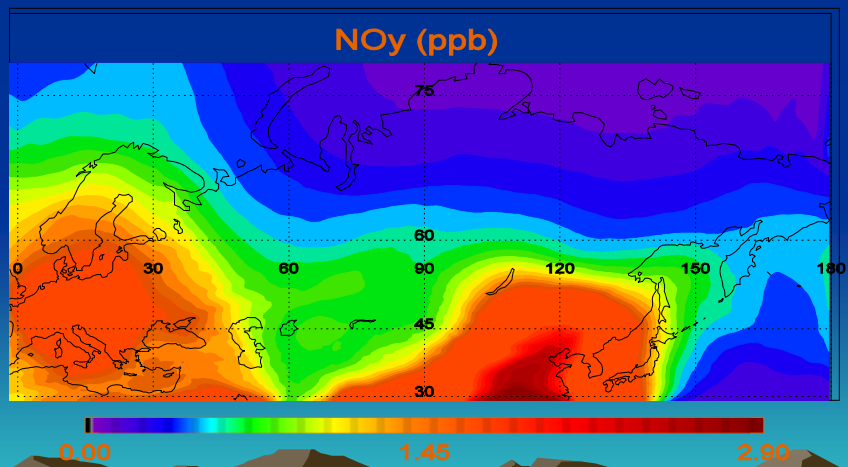


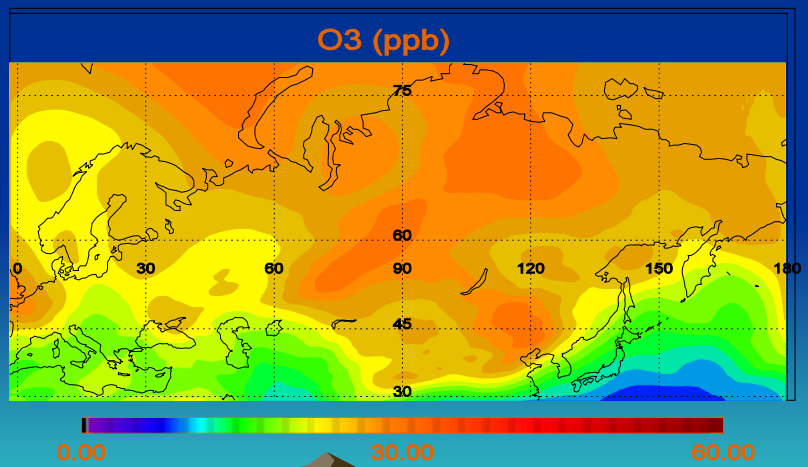


Chemical Forecast
July 9, 2019 r. (RSHU forecast)









Conclusions

1. Interaction between global and regional processes are very important both for long-term global changes and regional atmospheric composition variability
2. Coupled Global and Regional ChemistryTransport Models are very suitable for global and regional chemistry composition change assessments
3. Chemistry-transport models driven by re-analysis data are useful to study observed short-term gas composition variability
4. Both chemical and dynamical processes may be responsible for the observed air quality variability over Eurasia

Thanks for Your Attention!