Introduction into Enviro-HIRLAM SSRPs: *PART 2*

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Online Young Scientist School

Multi-Scales and -Processes Integrated Modelling, Observations and Assessment for Environmental Applications

MEGAPOLIS-2021

15 Nov – 3 Dec 2021

Zoom-Meetings
on Enviro-HIRLAM SSRPs

Starting at 16:00 pm of Helsinki time/ Finland

Tue, 16 Nov – intro in Enviro-HIRLAM model/ 1h

Thu, 18 Nov – intro in SSRPs Part-1/ 1h

Tue, 23 Nov – intro in SSRPs Part-2/ 1h

Thu, 25 Nov – zoom for questions /1+h

Wed, 1 Dec – zoom for questions /1+h

& Finals

Fri, 3 Dec – Presentations/ Defences of SSRP by Groups/Teams

& Awarding The MEGAPOLIS-2021 YSSchool Certificates

SSRPs - Your Progress
List-To-Do (until 23rd Nov)

- **Install software/ tools** for visualization and analysis of Enviro-HIRAM model output (see slides above) & **help** each-other in case problems will appear with installations/visualizations
- **Download** from google-folder (**example of Enviro-HIRLAM model output** files) **& learn & practice** on how to convert between formats, visualize and interpret/analyze various meteo. & aerosol related parameters
- **Initiate discussions** in your groups on SSRPs, based on model output, which questions/problems/tasks might be of interests, which parameters will be of interest to analyze, etc.
- **Think** about your **possible expected outcomes** in your group SSRP
- **Think outline/content** of your group **future presentation** on SSRP (& you may prepare a few slides if you want to share your ideas with the other groups)

Our Plans for 23rd Nov 2021

(1) **Suggest** list of questions and tasks to be answered in each SSRP (programme minimum vs. maximum)

(2) **Demonstrate** setup and run of Enviro-HIRLAM model at CSC's HPC/ Finland

(3) **Provide** access to already simulated Enviro-HIRLAM model outputs for mentioned 4 SSRPs (with focus on Case Studies)

(4) **Outline** List-to-Do until next zoom-meeting (25th Nov 2021)

* **Teachers** – demo setup & run of the Enviro-HIRLAM model for selected geographical domains and episodes

* **Students** – will start to realize jointly SSRP in own groups (*downloading modeling results, post-processing, starting visualization & analysis of these, analysis/description of meteorological situation for selected case study/episode, drafting presentation*)

Possible topics of interest to explore …

Small–Scale Research Projects (Case Studies/ Episodes)

===Enviro-HIRLAM-1===

Aerosol effects on regional scale for North-West Russia and Northern Europe

Case study/ episode - Aug 2010

Runs (15 km) and REF/CTRL & DAE & IDAE

Possible topics of interest to explore:

- **How aerosols might influence the temperature regime on synoptic scale?**
- **How aerosols might influence the moisture regime of the atmospheric boundary layer over the land and water areas?**
- **How aerosols might influence the radiative fluxes at the surface?**
- **How simulated meteorology might influence the deposition patterns (* by which processes)?**
- **Your suggestions?**

Small–Scale Research Projects (Case Studies/ Episodes)

===Enviro-HIRLAM-2 ===

Effects of model resolution on meteorology & pollution dispersion over Kola Peninsula

Case study/ episode - Jul 2017

Downscaling runs (5-1.5 km) – REF/CTRL

Possible topics of interest to explore:

- **How horizontal resolution might influence the formation and development of the heat-moisture-momentum meteorology related fields in the atmospheric boundary layer (ABL) and free troposphere?**
- **How resolution might influence the concentration of aerosol patterns within ABL on a diurnal cycle?**
- **How resolution might influence the structure of deposition and sedimentation fields of aerosols?**
- **How resolution might influence the formation and development of wind characteristics over the land and water surfaces (* by which turbulent related processes)?**
- **Your suggestions?**

Small–Scale Research Projects (Case Studies/ Episodes)

===Enviro-HIRLAM-3===

Effects of model urbanization on meteorology over the Paris metropolitan area

Case study/ episode - July 2009

Downscaling runs (15-5-2.5 km) - REF/CTRL

& urbanization at 2.5 km (with AHF+BEP)

Possible topics of interest to explore:

- **How horizontal resolution might influence the heat-moisture-momentum regimes on regional-subregional-urban scales?**
- **How model urbanization might influence the formation and development of meteorological fields over the urban vs. rural areas?**
- **How changes in anthropogenic heat flux might influence the meteorological patterns?**
- **What are the differences in ABL structure over urbanized vs. rural areas (*by which processes)?**
- **Your suggestions?**

Small–Scale Research Projects (Case Studies/ Episodes)

===Enviro-HIRLAM-4===

Aerosol-meteorology interactions in Siberian Arctic

Case study/ episode - July 2019

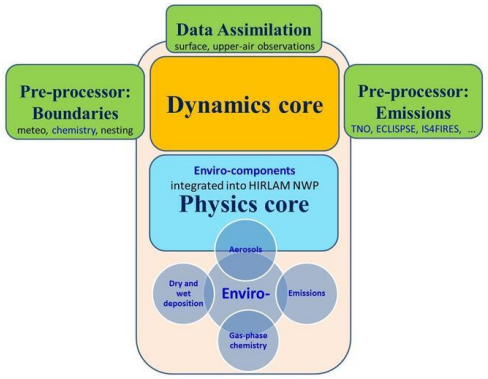
Downscaling runs (5-2 km) - REF/CTRL & DAE & IDAE

Possible topics of interest to explore:

- **How resolution might influence the meteorological patterns on meso- and fine scales?**
- **How aerosols might influence the heat-moisture regimes of the atmospheric boundary layer?**
- **How aerosols might influence the radiative fluxes at the surface?**
- **How aerosols through meteorology might influence the deposition patterns (* by which processes/ feedbacks)?**
- **Your suggestions?**

Enviro-HIRLAM Modelling System

Preparatory Steps



- **Setup of the model at computer/ HPC**
- **Defining the model domain (& numerical setup at computer)**

- **Extraction of ICs/BCs for meteorology, aerosols and gases and pre-processing + observational data/ BUFR**
- **Preparing & pre-processing emission inventories**
- **Test runs for 1 UTC cycle & 1 full day cycle**
- **Job submission**

Baklanov et al. (2017) Enviro-HIRLAM online integrated meteorology–chemistry modelling system: strategy, methodology, developments and applications
https://gmd.copernicus.org/articles/10/2971/2017/
https://www2.helsinki.fi/en/researchgroups/multi-scale-modelling/enviro-hirlam

Model Domain Definition

```
  Y02)              # (dowscaling for Yamal Peninsula & oil+gas pipelines regio
  NLON=460          # number of grid points along longitude
  NLAT=460          # number of grid points along latitude
  NLEV=40           # number of model vertical levels
  SOUTH=-28.757     # south boundary in rotated system of coordinates (deg)
  NORTH=-19.577     # north boundary in rotated system of coordinates
  WEST=-9.025       # west boundary in rotated system of coordinates
  EAST=0.155        # east boundary in rotated system of coordinates
  POLAT=0.0         # coordinates of South pole - latitude (deg)
  POLON=80.0        # coordinates of South pole - longitude
  NPBPTS=4          # number of passive boundary points
  NBNDRY=12         # width of boundary zone (=NPBPTS+GPHALO)
  GPHALO=8          # number of halo-zone points
  NDTIME=60         # dynamics time step (s)
  HDFSET=9000       # old, regular, 9000: climate data set projection
  HIRES=0.0125      # resolution of climate datasets (as per available: 0.0125, 0.025)
  DMINPROC=256      # total number of processors (=DMINTASKS*DMINODES)
  DMINODES=2        # total number of nodes
  DMINTASKS=128     # total number of mpi tasks per node
  DMINPROCX=16      # number of mpi sub-domains along longitude (DMINPROCX*DMINPROCY)<=DMINPROC
  DMINPROCY=16      # number of mpi subdomains along latitude
  DMINPROCX4D=16    # number of mpi subdomains along longitude for 4DVAR (DMINPROCX4D=DMINPROCX)
  DMINPROCY4D=16    # number of mpi subdomains along latitude for 4DVAR  (DMINPROCY4D=DMINPROCY)
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  DMIRENODES=2         #
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  DMIRENPROCY=16       #
  DMINPROCXVARAN=16    #
  DMINPROCYVARAN=16    #
  DMINODESVARAN=2      #
  DMICLOCK1=03:50:00  # 03:59:00  wallclock time for model run
  DMICLOCK2=02:50:00  # 02:50:00  wallclock time for 4DVAR / data assimilation
  DMICLOCK3=01:30:00  # 01:35:00  wallclock time for postprocessing
  DMIBND=Y05          # name to dir/path with boundary conditions for meteo+chem and emissions
export DMINPROC DMINODES DMINTASKS DMINPROCX DMINPROCY DMIBND DMINPROCX4D DMINPROCY4D DMINPROCXVARAN
DMINPROCYVARAN DMINODESVARAN DMICLOCK1 DMICLOCK2 DMICLOCK3 DMINPROCXVARAN DMINPROCYVARAN DMINODESVARAN
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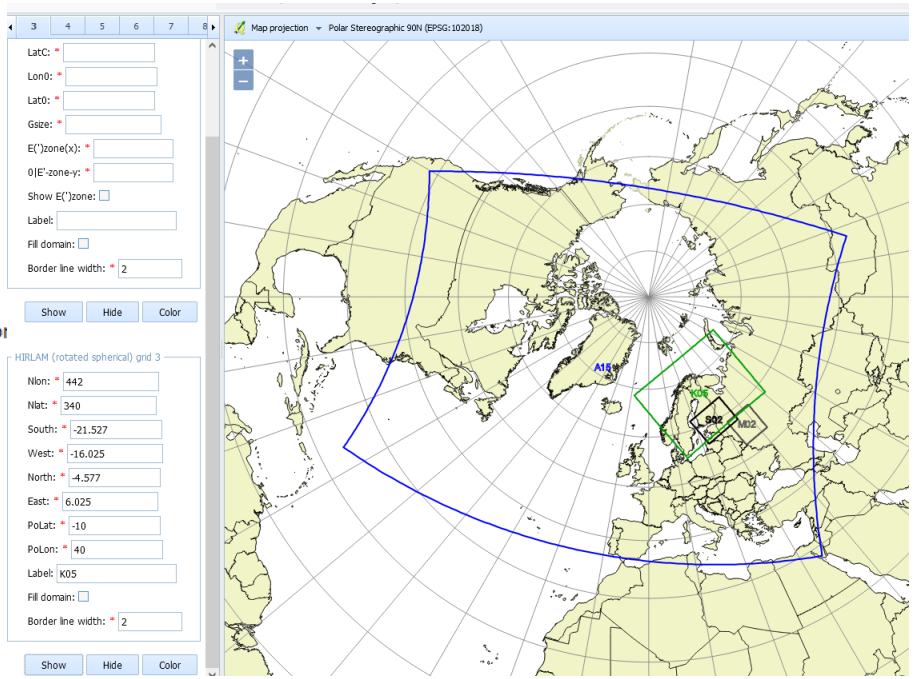
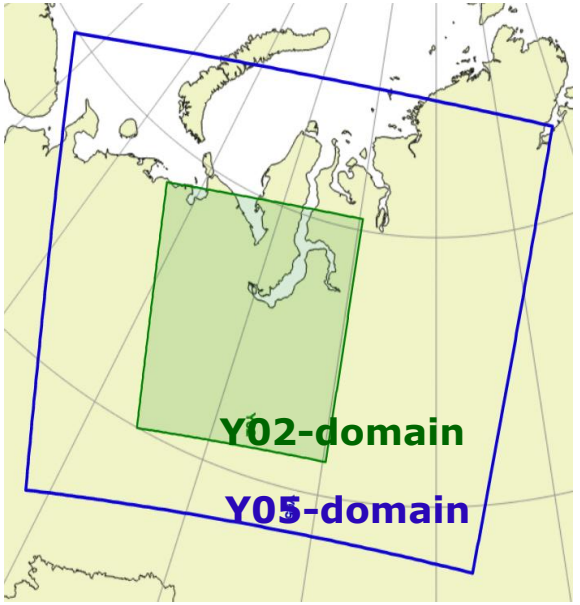
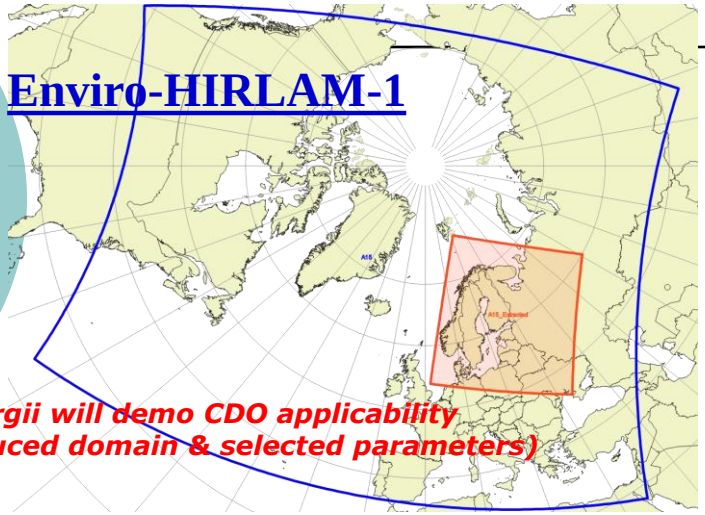




https://www.hirlam.org/nwptools/domain.html (registration is required)

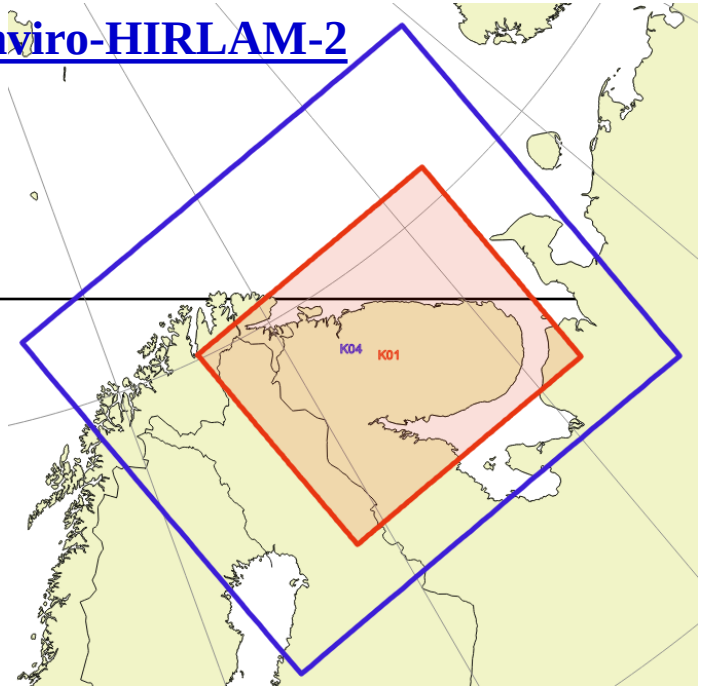
SSRPs
Model Domains

Enviro-HIRLAM-1

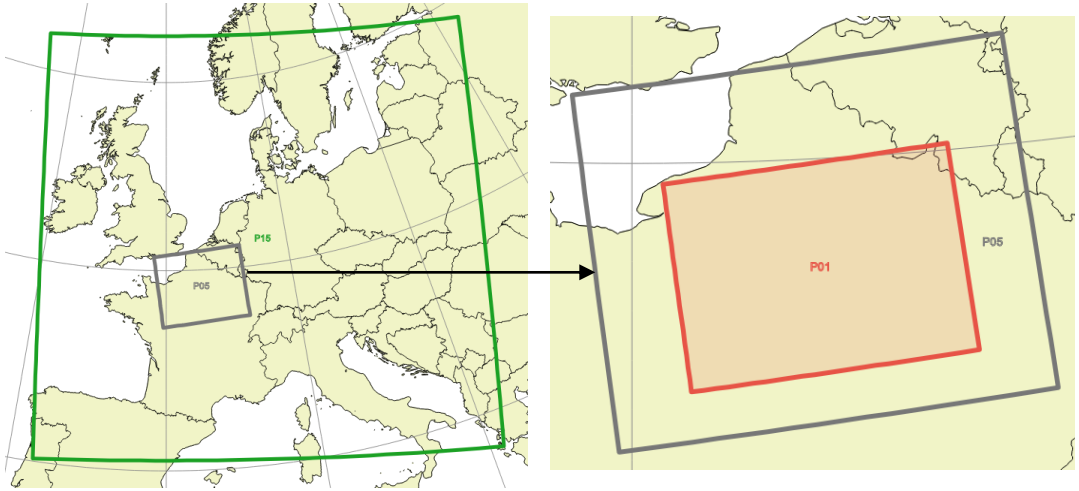


(!) Georgii will demo CDO applicability
(to reduced domain & selected parameters)

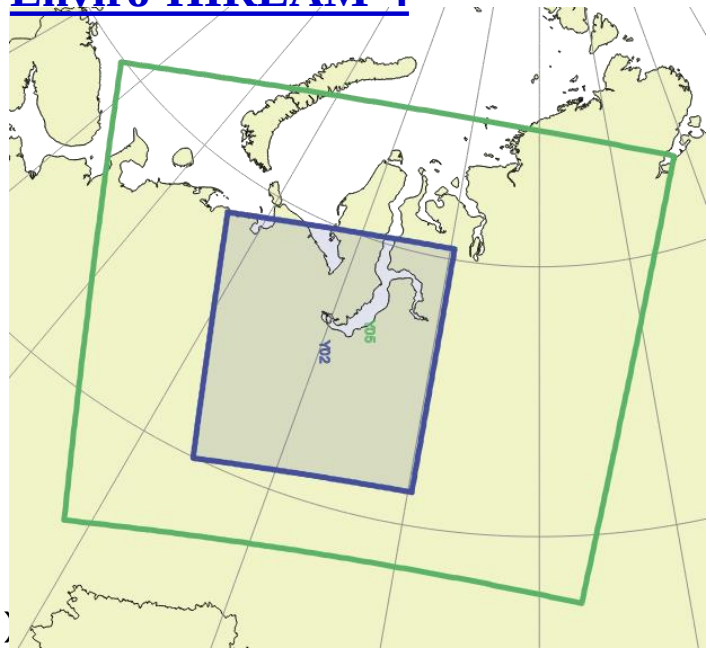
Enviro-HIRLAM-2



Enviro-HIRLAM-3



Enviro-HIRLAM-4



https://www.hirlam.org/nwptools/domain.html (registration is required)

ICs/BCs Meteorology Related

ERA-5 is produced using coupled ECMWF Integrated Forecast System (IFS) and Nucleus for European Modelling of the Ocean (NEMO) models, which were run with assimilation of observation data.

ERA-5 Meteorology / Reanalysis

(u, v, t, q, logP) daily at 06 & 18 UTC cycles (for 00, 03, 06, 09, 12 h forecast length)

& soil temperature at 1st level/ surface [K], sea ice area fraction [0 - 1], land-sea mask [0 - 1], sea surface temperature [K]

(!) extracted from ECMWF's MARS archives for selected geographical domain

Submission example

ICs/BCs Aerosols & Gases Related

CAMS (Copernicus Atmospheric Monitoring Service) - aerosols and gases 3D fields - daily at every 3 h interval at 00, 03, 06, 09, 12, 15, 18, and 21 UTCs

Aerosols Mixing ratio [kg/kg]:

- Dust aerosol 0.03 - 0.55 um
- Dust aerosol 0.55 - 0.9 um
- Dust aerosol 0.9 - 20 um
- Hydrophilic & hydrophobic organic matter aerosol
- Hydrophilic & hydrophobic black carbon aerosol
- Sulphate aerosol

Submission example

Gases mixing ratio [kg/kg]:

Ozone, Sulphur dioxide, Nitrogen dioxide, Nitrogen monoxide, Hydrogen peroxide [H2O2], Hydroxyl radical [OH], Nitrate radical [NO3], Hydroperoxy radical [HO2], Dimethyl sulfide [DMS]

Observations / BUFR data

BUFR –

Binary Universal Form for Representation of meteorological data

daily every 3 h interval (at 00, 03, 06, 09, 12, 15, 18, 21 UTCs)

incl.

- **SYNOP – surface synoptic observations (LAND & SEA) (pressure, temperatures, precipitations, visibility, clouds, winds, etc.)**
- **DRIBU – sea surface temperature**
- **TEMP - upper air soundings (pressure, temperature, wind)**

Extracted from ECMWF archives

Submission example

Emission Inventories

Preparing / pre-processing needed emission inventories

- **Anthropogenic (ECLIPSE v5)**
- **Forest fires (IS4FIRES, GFAS)**
- **Ocean emissions (EDGAR)**
- **Ship emissions (IIASA, IPCC/RCP)**
- **others**

Test Runs & Job Submission

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Hirlam start DTG=2019070200 DTGEND=2019073112 LL=06

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COMPLETE

Research & Development through Collaboration with Partners

(2017-…) Enviro-HIRLAM on CSC – "*Enviro-HIRLAM seamless modelling of meteorology-chemistry-aerosols interactions and feedbacks on multi-scales*"

(2018-2020) Enviro-PEEX on ECMWF - "*PEEX-MP research and development for online coupled integrated meteorology-chemistry-aerosols feedbacks & interactions in weather, climate & atmospheric composition multi-scale modelling*" https://www.atm.helsinki.fi/peex/index.php/enviro-peex-2018-2020

- **(2021-2023) Enviro-PEEX(Plus) on ECMWF (Plus)** - "*Research and development for integrated meteorology – atmospheric composition multi-scales and – processes modelling for the PEEX domain for weather, air quality and climate applications*" https://www.atm.helsinki.fi/peex/index.php/enviro-peex_plus

- **(2020-2022) PEEX-MP-Europa3** – "*PEEX Modelling Platform research and development through HPC-Europa3 Transnational Access Programme*" (individual grants)
  https://www.atm.helsinki.fi/peex/index.php/peex-mp-europa3

✓ Project: *High-Resolution Integrated Urban Environmental Modeling*

✓ Project: *Online Integrated Atmospheric Modelling: the Python Way*

✓ Project: *Integrated Modelling for Assessment of Potential Pollution Regional Atmospheric Transport as Result of Accidental Wildfires*

✓ Project: *Integrated Modelling and Analysis of Influence of Land Cover Changes on Regional Weather Conditions/ Patterns*

Enviro-HIRLAM Running / DEMO

Demo at CSC's HPC MAHTI

source - https://research.csc.fi/-/mahti

Currently ongoing run for the Enviro-HIRLAM-Y02 (with DAE) at CSC's HPC MAHTI

Submission example

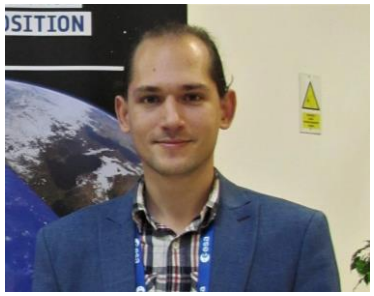
tail -f /scratch/project_number/wrk/username/hl_home/Y02/hirlam.log

squeue -u username

Enviro-HIRLAM Running / DEMO

Demo at CSC's HPC PUHTI

source - https://research.csc.fi/-/puhti



Regional Atmospheric Transport due to Accidental Wildfires in the Chernobyl Zone

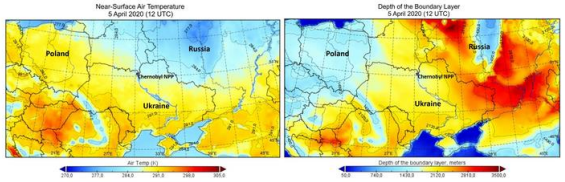


Figure 1: Modelled (a) near-surface air temperature and (b) depth of the atmospheric boundary layer on 5th of April 2020 (12 UTC) at the beginning of the wildfire episode (reference run; without including aerosol effects)

The project "Integrated Modelling for Assessment of Potential Pollution Regional Atmospheric Transport as Result of Accidental Wildfires" (IMA-WFires) has started its computations at the CSC (https://www.csc.fi/en) actively using the super-computing infrastructure and resources. It is implemented within the frameworks of the HPC individual grant of the HPC-Europa3 Transnational Access Programme.

The IMA-WFires study aims to analyze the regional influence of wildfire emissions occurred in the exclusion zone (abandon area) of the Chernobyl nuclear power plant (Ukraine) and to identify the affected territories in case of active fires near and within radioactive polluted spots and in a close proximity to the plant.

PEEX BLOG

The PEEX Blog brings you news and activity overviews from our international community at PEEX and UArctic Boreal-Hub Network.

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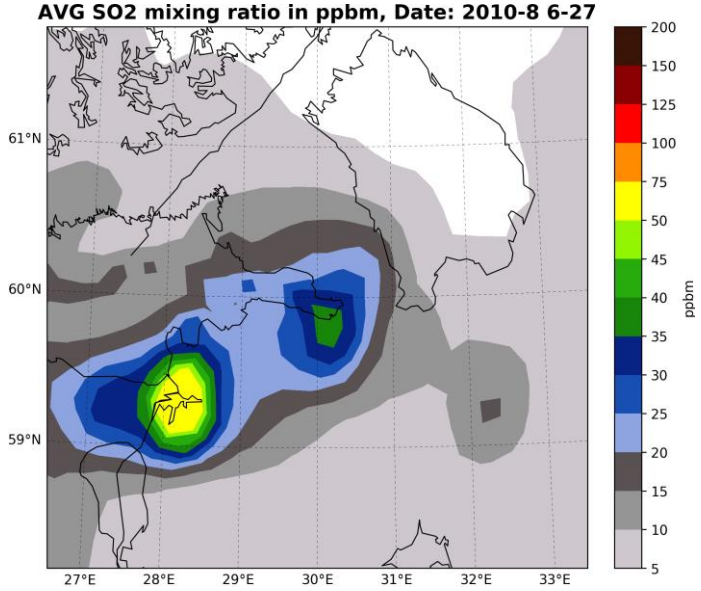
Submission example

https://peexhq.home.blog/2021/09/24/regional-atmospheric-transport/
https://www.atm.helsinki.fi/peex/index.php/peex-mp-europa3
https://www.atm.helsinki.fi/peex/index.php/enviro-peex_plus

Enviro-HIRLAM Running / DEMO

Demo at ECMWF's HPC CCA/ CRAY-XC40

https://www.ecmwf.int/en/computing/our-facilities/supercomputer



Submission example

Averaged (6-27 Aug 2010) SO2 concentration at the 1st model level

https://www.atm.helsinki.fi/peex/index.php/enviro-peex_plus
https://www.atm.helsinki.fi/peex/index.php/enviro-peex-2018-2020

Model Output - REMINDER

fc20190702_06+003 **fcyyyymmdd_hh+lll**
history file: modelled parameters (meteo+aerosols) at model levels
fc20190702_06+003md **fcyyyymmdd_hh+lllmd**
diagnostics file: modelled meteo.parameters at & on surface
fc20190702_06+003ve **fcyyyymmdd_hh+lllve**
verification file: modelled meteo.parameters

The model writes its primary output to history file (**fcyyyymmdd_hh+lll**) - complete snapshot of the model state described by NWP model for a particular time.
In addition, model output including post-processing/diagnostic fields is written to file (**fcyyyymmdd_hh+lllmd**)
&
pressure and single level parameters for field verification and observation verification (**fcyyyymmdd_hh+lllve**)
&
wet, dry deposition and sedimentation for aerosol components
EHIR_SEDEPO_2019070206+006.nc (**EHIR_SEDEPO_yyyymmddhh+lll.nc**)

Access/ Download Data

In case of problems to download the files –

contact Roman Nuterman

https://sid.erda.dk/cgi-sid/ls.py?share_id=pxUUBw1w3J

Enviro_HIRLAM_1
Enviro_HIRLAM_2
Enviro_HIRLAM_3
Enviro_HIRLAM_4

Comment: for Enviro_HIRLAM_3 – 00 UTC with 000, …, 024 h FL

Analysis

Model is run daily at 00, 06, 12, 18 UTCs

with forecast lengths +000 +003 +006

Remember(!) in UTC (Coordinated Universal Time)

Programme MINIMUM:

analysis of 3 meteo. related variables

What you can visualize & analyze:

- **Fields of individual meteorological and aerosol variables (see list in Annexes 1-2)**
- **Fields of diurnal cycle of selected meteo./aerosols variables**
- **Field of differences between REF/CTRL vs DAE vs IDAE model output**
- **Vertical and horizontal cross-sections of selected meteo./aerosols variables**
- **Animations (sequence of the atmosphere state snapshots)**
- **Time-series of modelled vs. observed meteorological variables**

SSRPs Communication

REMEMBER

- You are realising **small-scale research project**, SSRP as the **team**

- Remember to **collaborate between teams/groups** involved into other Enviro-HIRLAM SSRPs

- You may **follow suggestions** on possible topics of interest to explore (slides 6-9) **or select your own** topic of interest

- You can **ask questions** during scheduled **zoom-meeting/ consulting**

List-To-Do before the next zoom-meet on 25th November 2021, Thursday

- **Download the simulated model output for your own SSRP**
- **Select your case study/episode & describe meteorological situation**

  Meteorological archives: https://www.wetterzentrale.de

  Vertical sounding http://weather.uwyo.edu/upperair/sounding.html
- **Start visualization and analysis of your downloaded data**
- **Draft presentation before next meet on 25 Nov – max 5 min – your research plan *(outline: title of your SSRP, team/co-authors, formulate main aim & objectives, describe methodology, list planed tasks with focus on which meteo/aerosol variables will be analyzed and which approaches (from slide 24) will be taken, expected results, acknowledgements, references)***

- ***REMEMBER: each person should contribute, discuss in your group and share/distribute responsibilities and contributions for each member in your group SSRP***

Science Education: Small-Scale Research Projects (SSRPs) to be continued

See you in the next zoom-meetings
25 November & 1 December 2021
Thursday & Wednesday
16 pm of Helsinki time

://www.helsinki.fi/en/inar-institute-for-atmospheric-and-earth-system-research

Thank you!

https://www.atm.helsinki.fi/peex