Operation of Decision Support Systems for Nuclear Emergencies based on freely available meteorological data – New functionalities developed in the NERIS-TP project

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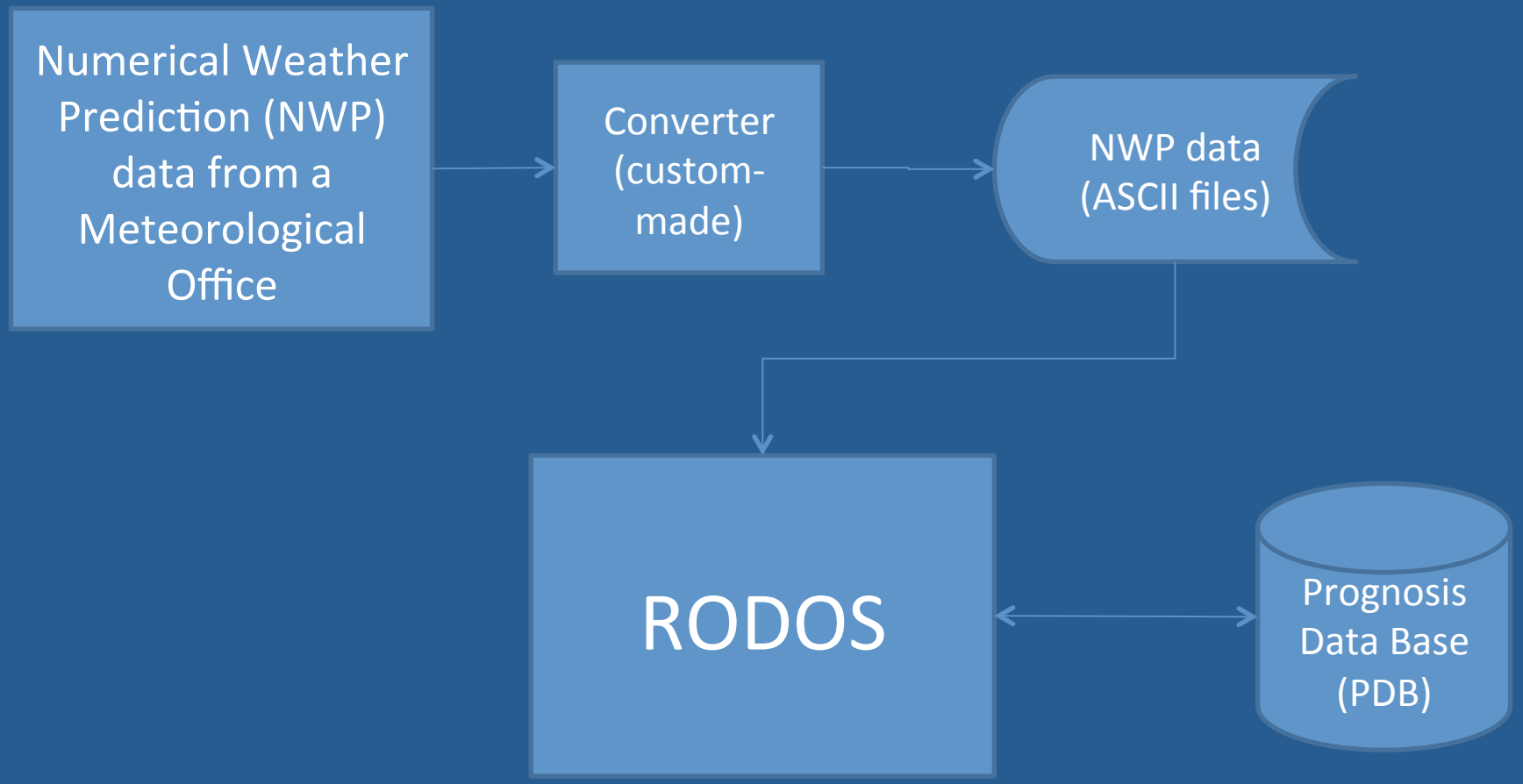
Facts:

- Decision Support Systems (DSS) for nuclear emergencies, such as RODOS, need weather prediction (prognostic meteorological) data to calculate prognoses of dispersion of radionuclides
- "Sources" of prognostic meteorological data: National Meteorological Offices
- DSSs also need measured meteorological data for now-casts (diagnosis) or to "correct" previously produced forecasts

Previous situation of RODOS



Rationale of new features introduced by NERIS-TP

- Independency of Meteorological Offices / Capability for “in-house” production of Numerical Weather Prediction data
- Higher spatial and temporal resolution than the NWP data of Meteorological Offices
- Capability for automatic operation of above functionalities, connected with RODOS DSS, and initiated by incoming emergency information message

How?

- Using the Weather Research and Forecasting (WRF) model
- Why WRF?
  - Freely-available to download and run
  - Uses as Initial and Boundary Conditions Global Prognostic Data, also freely available from NCEP (USA)
  - "Live", very large users' and developers' community

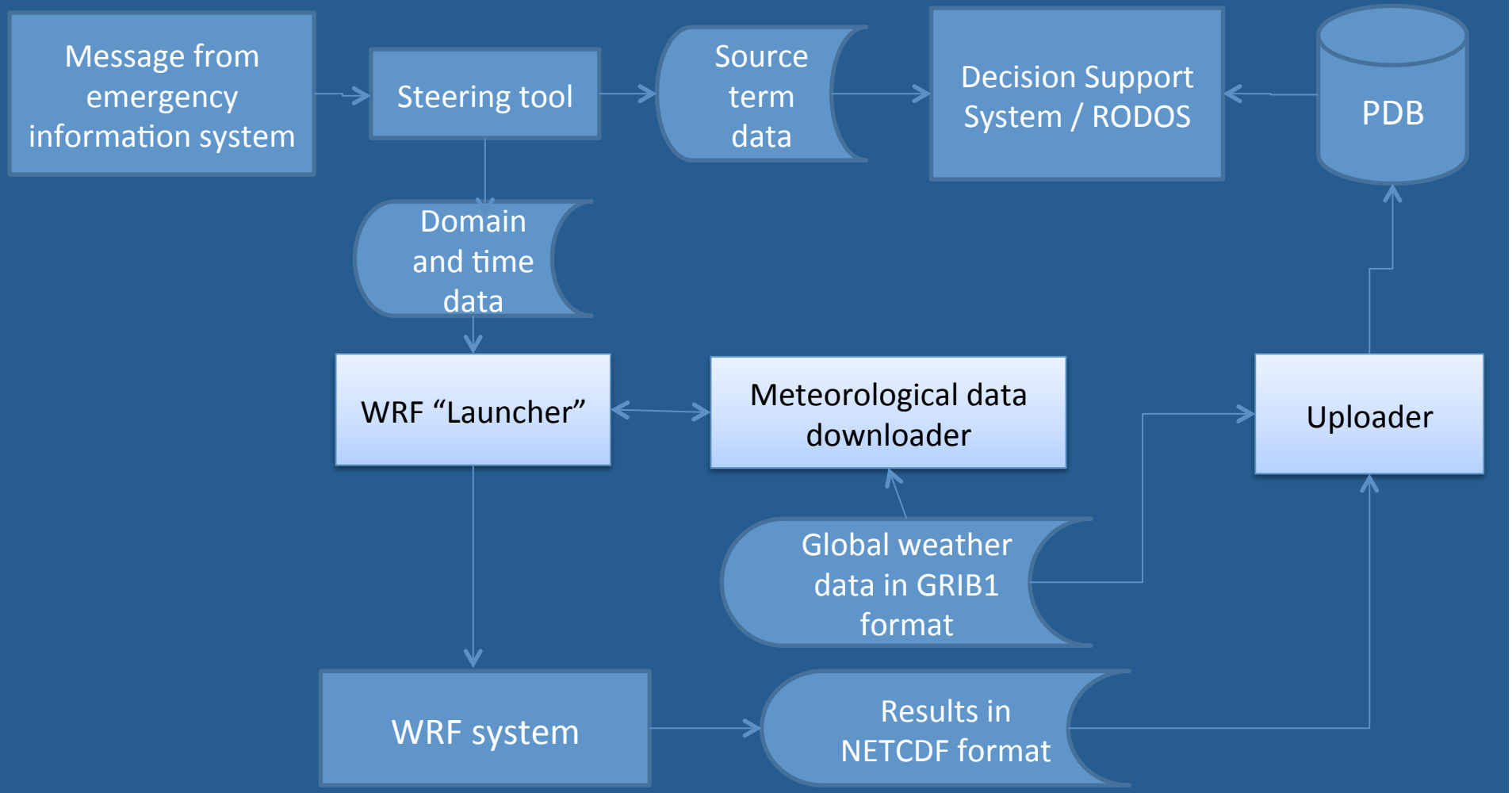
What is and how does WRF work?

- It is a regional to meso-scale prognostic meteorological model
- It "downscales" *from* global-scale coarse-resolution NWP data (e.g., 0.5 × 0.5 deg^2 and 6-hourly) to meso-scale (e.g., 1 × 1 km^2 and 1-hour)
- Nested computational domains

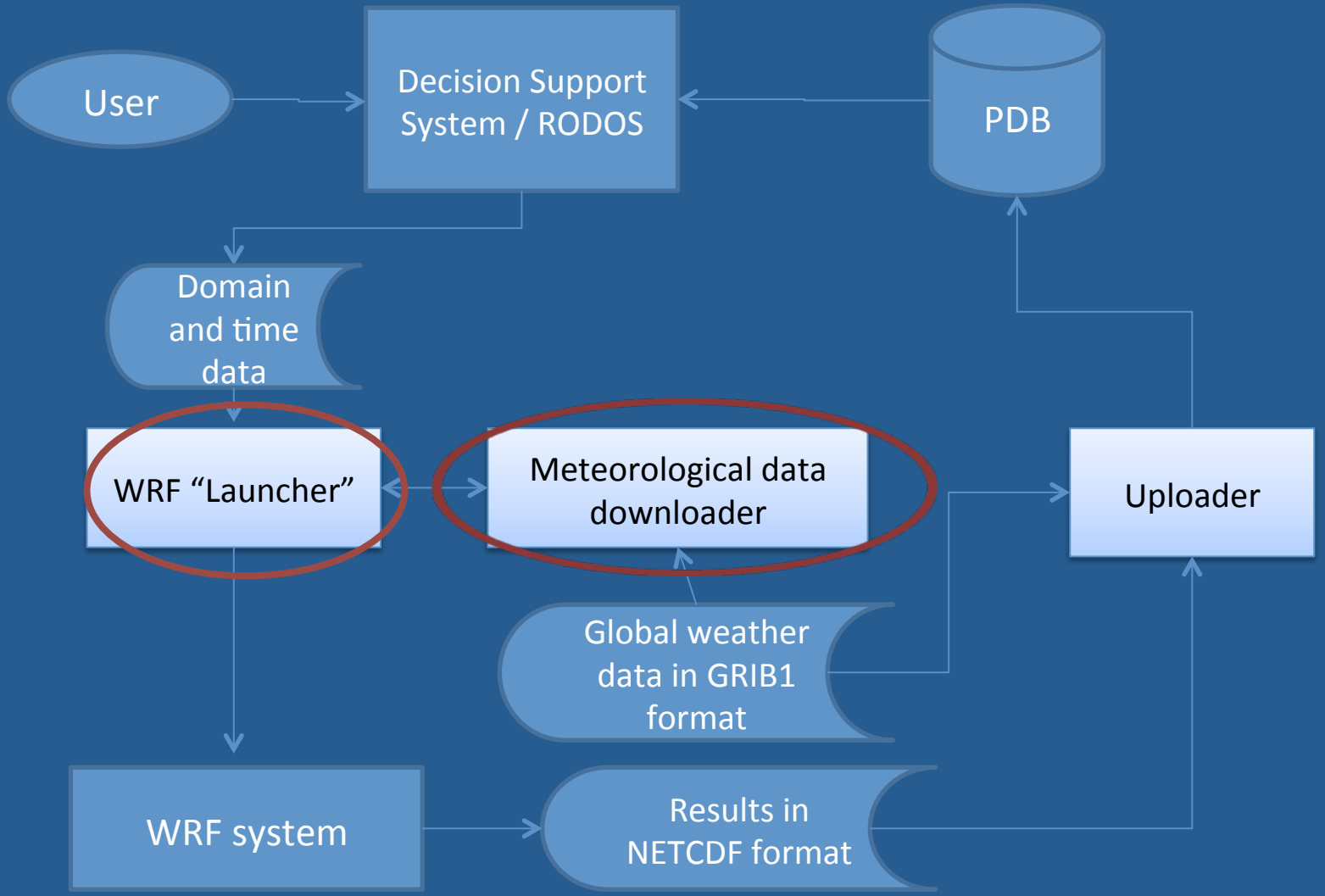
What did we succeed in NERIS-TP?

- Developed a series of software tools to combine the operation of WRF to DSS RODOS and to expand / make more flexible the availability of prognostic meteorological data
- How? – See next slide

Flow chart / 1st mode: automatic



Flow chart / 2nd mode: user



NOMADS Downloader – WRF Launcher

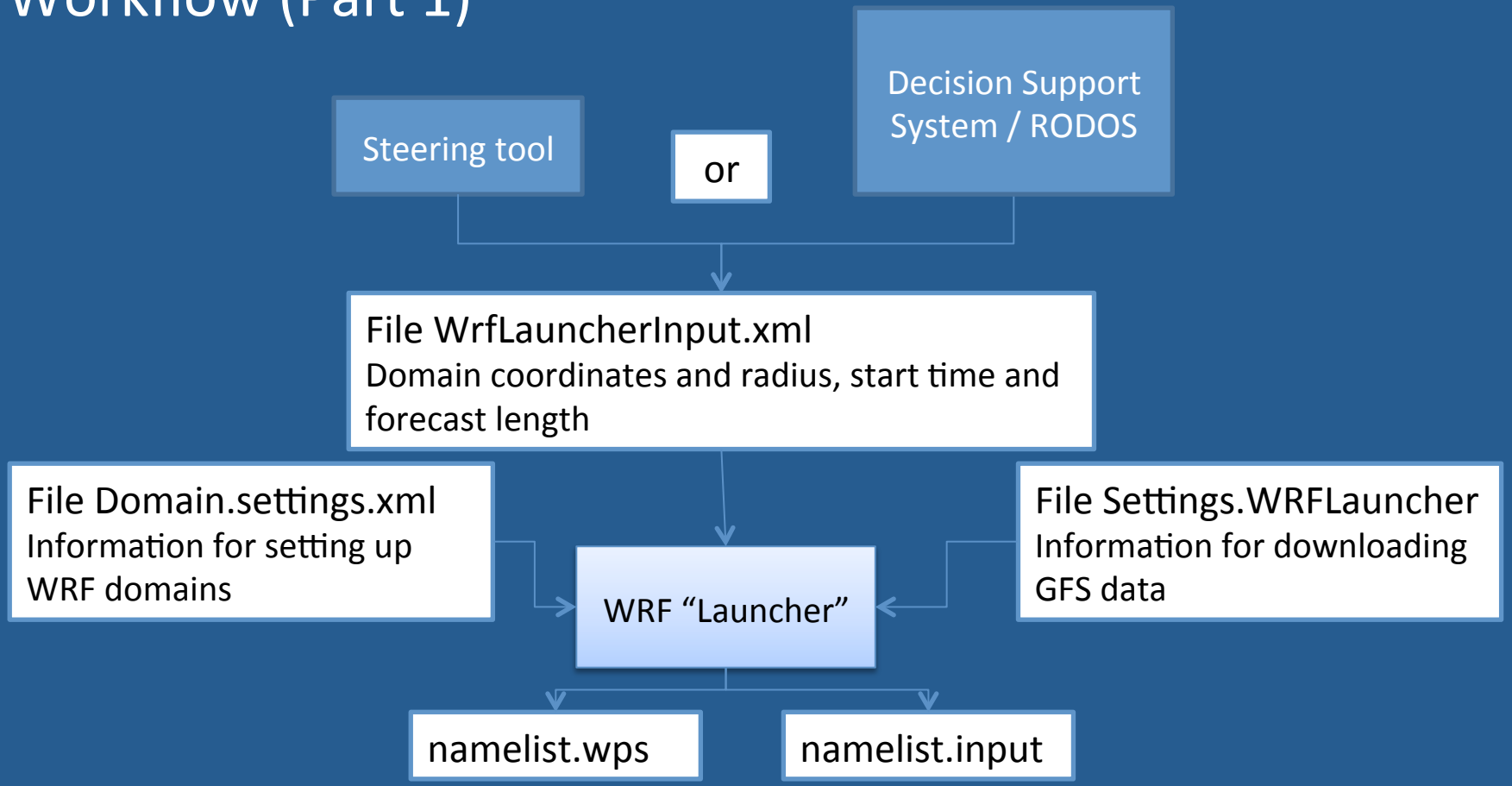
- Aim: provide the RODOS system with Numerical Weather Prediction data for an arbitrarily located computational domain
- This is accomplished by software tools that
  - Automatically download freely available global meteorological data from the Global Forecasting System (GFS) of NCEP, and
  - Operate the freely available Weather Research and Forecasting (WRF) modelling system

WRF Launcher (1)

- Software installed on Linux platform (as WRF) with Java
- Currently invoked manually by the user
- Next version: invoked within JRODOS
- Functions:
  - Set up the WRF run (prepare input files)
  - Determine dates and types of GFS data to be downloaded
  - Invoke the NOMADS Downloader to download the GFS data
  - Run WRF or pass directly the GFS data to the Uploader
  - WRF output is produced in NETCDF; in next versions output in GRIB will also be possible

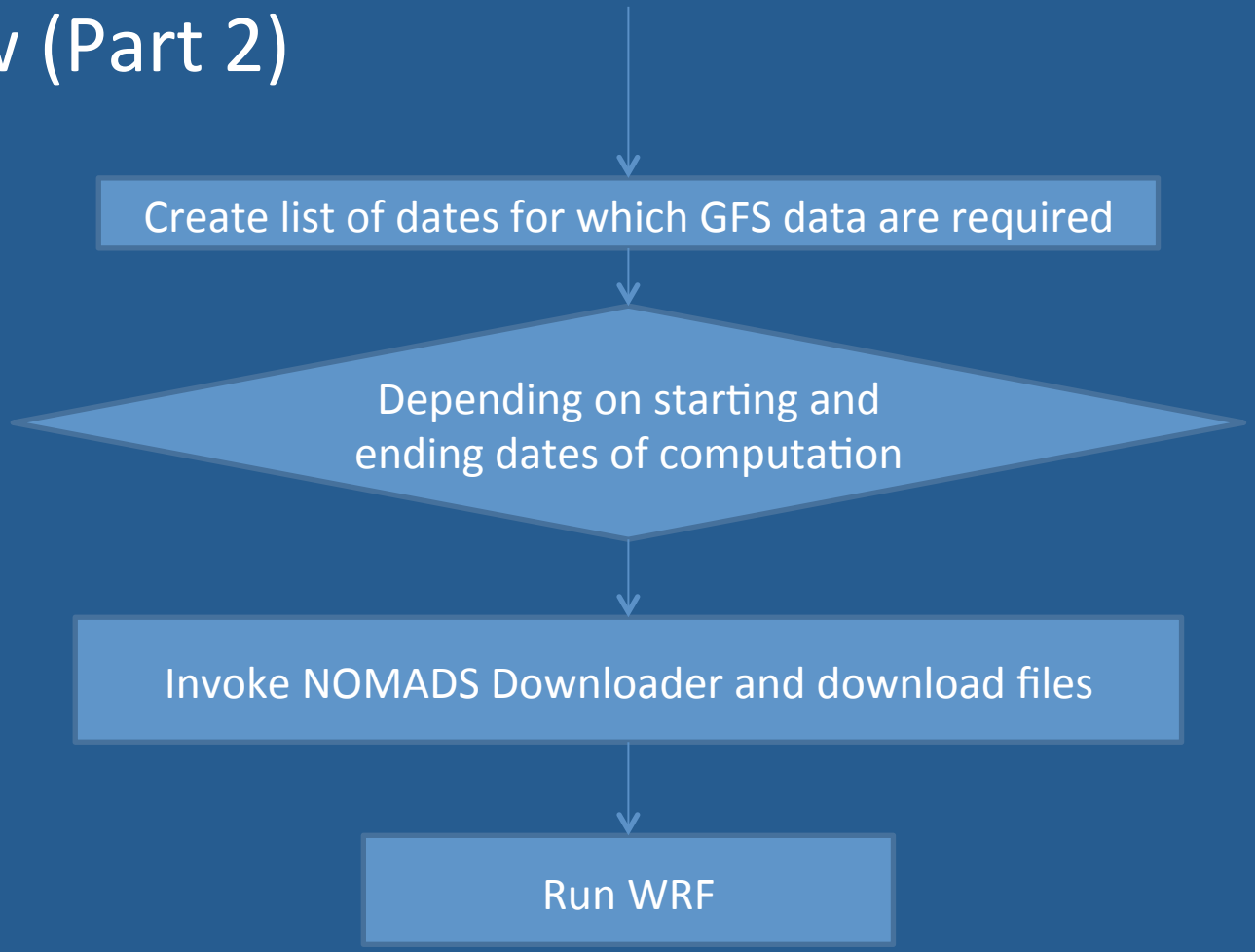
WRF Launcher (2)

Workflow (Part 1)



WRF Launcher (3)

Workflow (Part 2)



Global Weather Data (1)

- Calculated by the Global Forecasting System (GFS) of NCEP (National Centers for Environmental Protection – USA)
- Downloaded from the NOAA National Operational Model Archive & Distribution System (NOMADS) servers
- GRIB1 or GRIB2 (Gridded Binary Format of WMO) files
- Used for setting initial and boundary conditions of the WRF run

Global Weather Data (2)

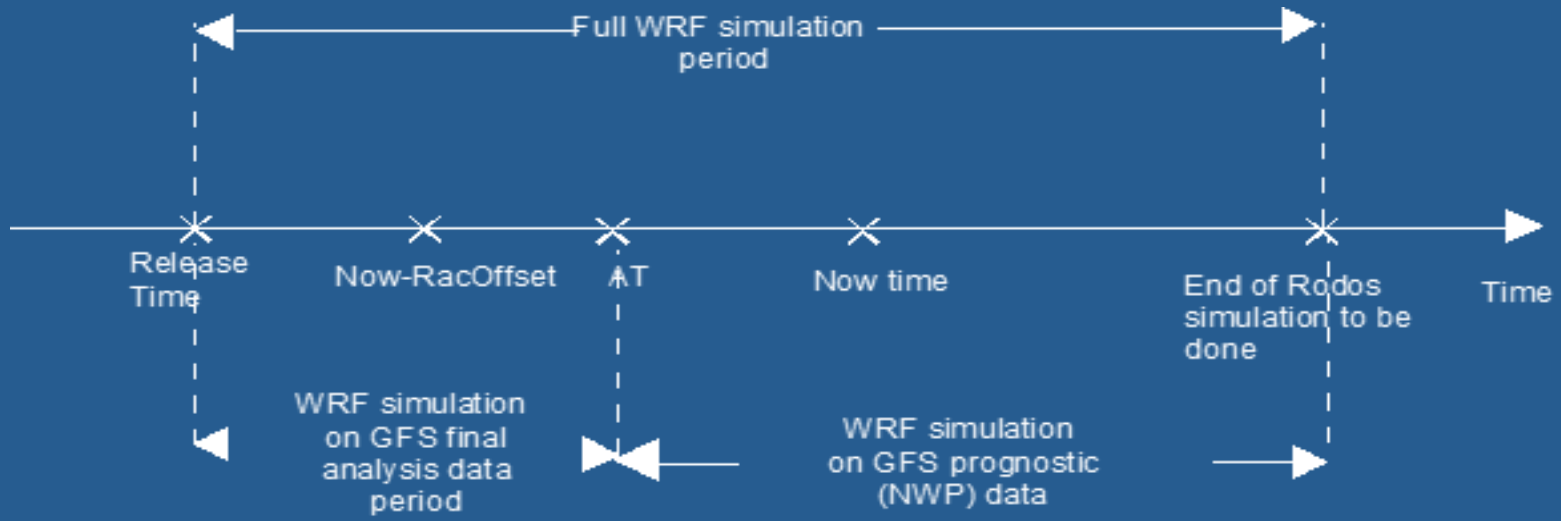
- 2 types of GFS data are used for WRF runs:
  - "Final analysis" data (3-d set of meteorological variables with which GFS model was initiated)
  - Numerical Weather Prediction (NWP) data
- For a date *yyyymmddhh* the GFS data set contains:
  - Final analysis data for *yyyymmddhh*
  - NWP data for *yyyymmddhh*+1 hour, +2 hours etc.

Global Weather Data (3)

- Final analysis data and NWP data are stored in different places
- Final analysis data are stored every 6-hours intervals
- NWP GFS data are freely available only for “recent” times
- Therefore a WRF run can be split in 2 parts

WRF run

- Simulation period of WRF can be split according to availability of NWP data:
  - "Older" period computation is based on final analysis data from GFS
  - "Newer" period computation is based on NWP data from GFS

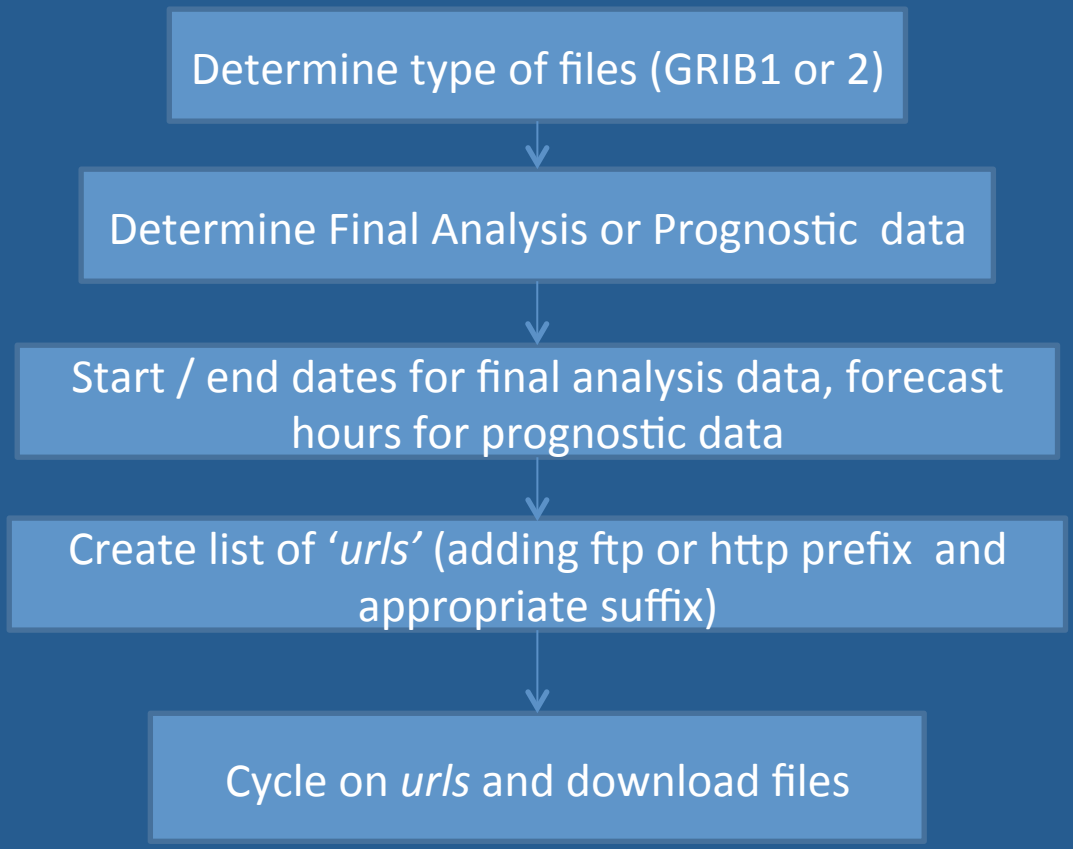


NOMADS Downloader (1)

- Software installed on Windows or Linux platform
- Purpose: download global weather data of GFS from the NOMADS servers
- Can download GRIB1 and GRIB2 files
- Invoked by user or by WRF Launcher
- Input information through command line and input file "`settings.NomadsDownloader`"
- If invoked by WRF Launcher then the command line is prepared as string by the latter

NOMADS Downloader (2)

- Workflow (simplified steps):



WRF Launcher and NOMADS Downloader

- Documentation:

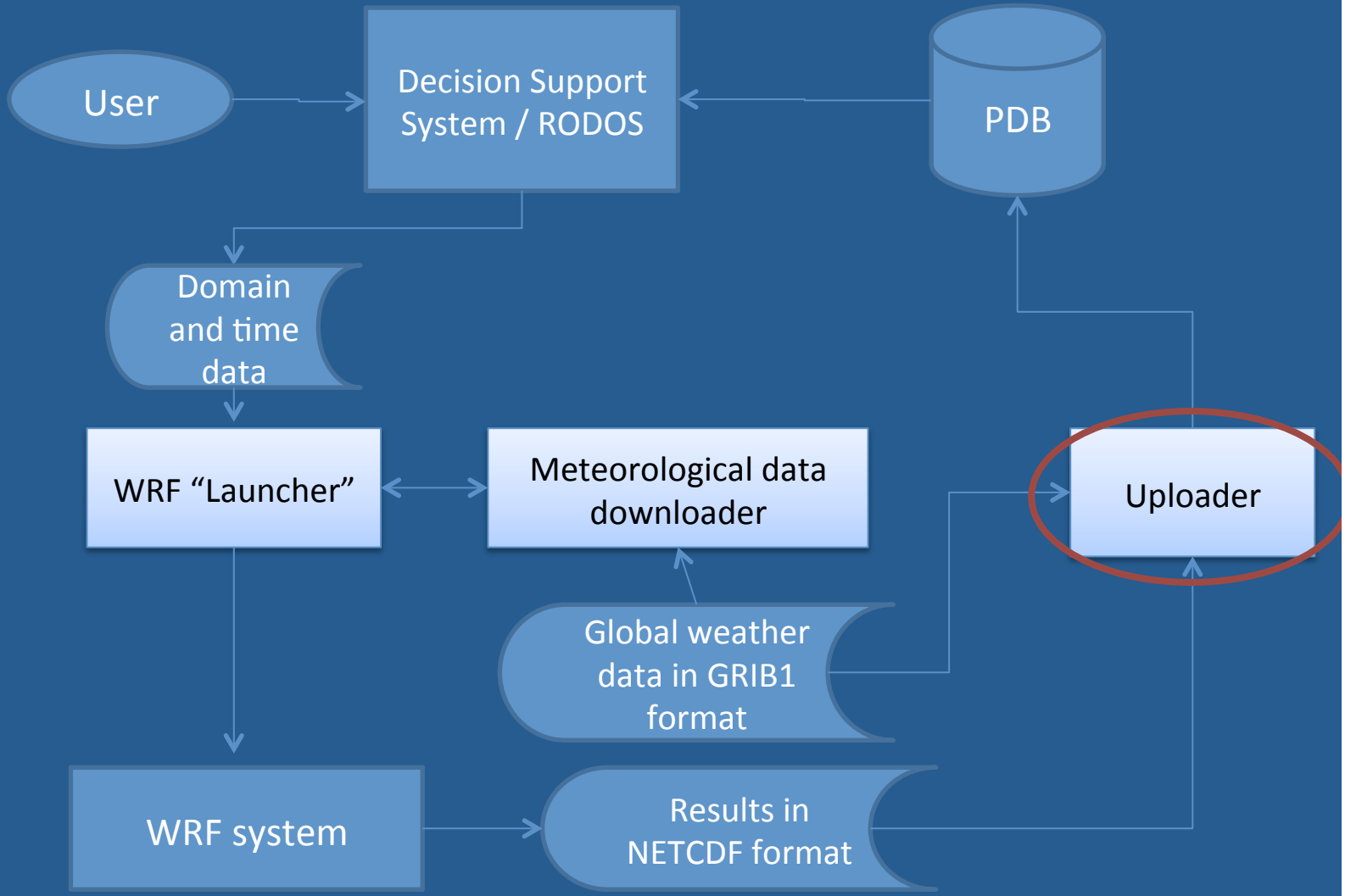
"Software tools and related documentation for the automatic downloading of global meteorological data and operation of the WRF meteorological modelling system"

Report NERIS-TP(WP4)-(13)-02

By

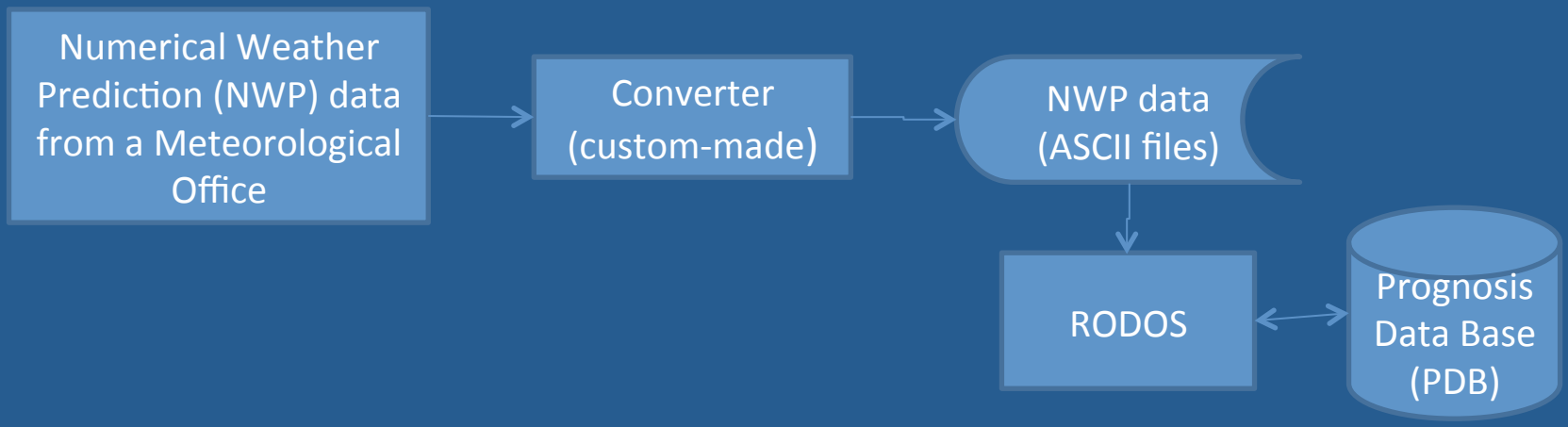
S. Didkivska, I. Ievdin, I. Kovalets and D. Trybushnyi

Flow chart / 2nd mode: user



Uploader of global and WRF weather data to RODOS (1)

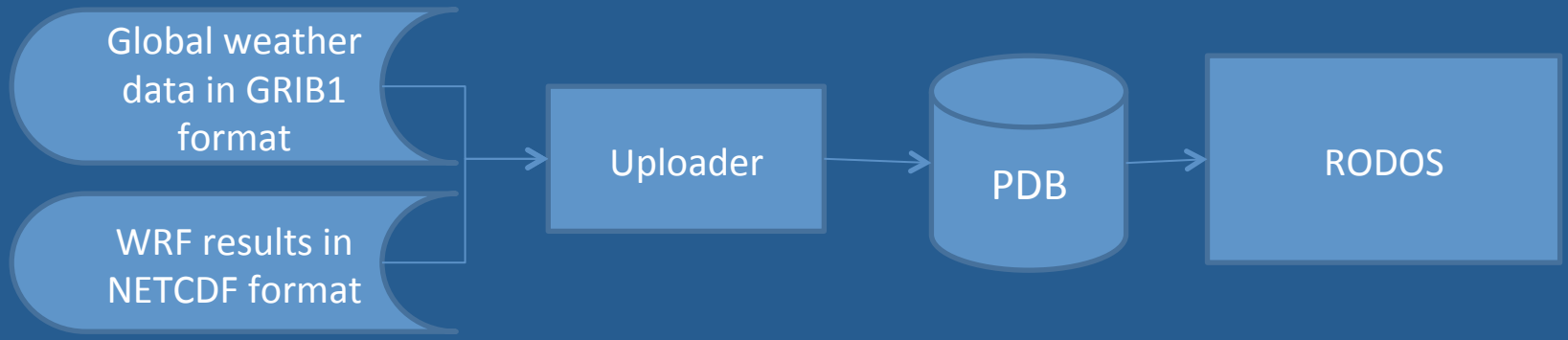
- Previous situation:



- Drawbacks:
  - Parsing of data files is done by RODOS – potential slowdown
  - Need to develop customized converter
  - Fixed computational domain

Uploader of global and WRF weather data to RODOS (2)

- New situation:



- Advantages:
  - Parsing is done by Uploader, externally of RODOS
  - No need for customized converter
  - Possibility to use data from several Weather Services
  - Possibility to use in-house calculated, hi-resolution weather data, by WRF
  - Possibility of world-wide application

Uploader of global and WRF weather data to RODOS (3)

- Java-based software tool with functionalities:
  - Job management (library *Quartz 1.6*)
  - GRIB1 file analyzer (library *jGrib*)
  - GIS (library *Geotools 2.3*)
  - Database access (library *Hibernate 3.6*)
- The uploader is installed on the machine where JRODOS Server is installed
- The uploader is activated independently from JRODOS Server, as soon as the Database Server (Postgres SQL) is installed in running

Uploader of global and WRF weather data to RODOS (4)

- Tasks executed by Uploader:
  - Monitor the folder where NETCDF or GRIB1 files appear
  - When new files appear, parse them, prepare data in form of classes mapped to PDB tables
  - Establish connection to PDB and load prepared classes

Uploader of global and WRF weather data to RODOS (5)

- Tables contained in PDB
  - **Provider**: information about NWP provider (name, prognosis duration, update period, sample analysis time, data interval …)
  - **Prognosis Set**: information about particular NWP data set (analysis time of prognosis, number of nodes in horizontal directions, …)
  - **Levels**: information about number of nodes in vertical direction of particular NWP set
  - **Prognosis data**: forecast times of a NWP set
  - **Single- and multi-level fields**: data for each forecast time of a NWP set

Uploader of global and WRF weather data to RODOS (6)

- NWP data in GRIB1 format [WMO94]
  - National Center for Environmental Prediction (NCEP) GFS model, data available at NOMADS servers
  - European Center for Medium Range Weather Forecasts (ECMWF)
  - Danish Meteorological Institute (DMI) Hirlam model
  - German Weather Service (DWD)
  - COSMO model
  - Etc.

Uploader of global and WRF weather data to RODOS (7)

- Configuration file needed, containing mapping between GRIB file variables and variables used in JRODOS Local-Scale-Model-Chain (LSMC)
- LSMC variables / single-level
  - Total precipitation in kg/m^2
  - Boundary layer height in m
  - Fraction of land [0 – 1], 1=land, 0=water
  - Roughness in m
- LSMC variables / multi-level
  - U and V components of wind field (m/s), or wind speed (m/s) and wind direction (degrees)
  - Temperature (K)
  - Geopotential height (gpm - geopotential meters) or (m^2/s^2)

Uploader of global and WRF weather data to RODOS (8)

- Possibilities of uploader related to WRF
  - WRF output -> NetCDF files
  - Uploader is able to process NetCDF files
  - WRF output -> WRF post-processor -> GRIB1 files

- Further details and file descriptions in document:

"Uploader of global and WRF weather data to the DSS in GRIB1 format - Technical Description and User Guide", Report **NERIS-TP(WP4)-(12)-01**, by *Y. Ievdin and I. Kovalets*

WRF to MATCH converter (1)

- MATCH (SHMI) is the long-range dispersion model in JRODOS
- MATCH is working with input meteorological data from DMI HIRLAM or from ECMWF models in GRIB format
- **New feature: MATCH to work with meteorological data from WRF (NETCDF format)**

WRF to MATCH converter (2)

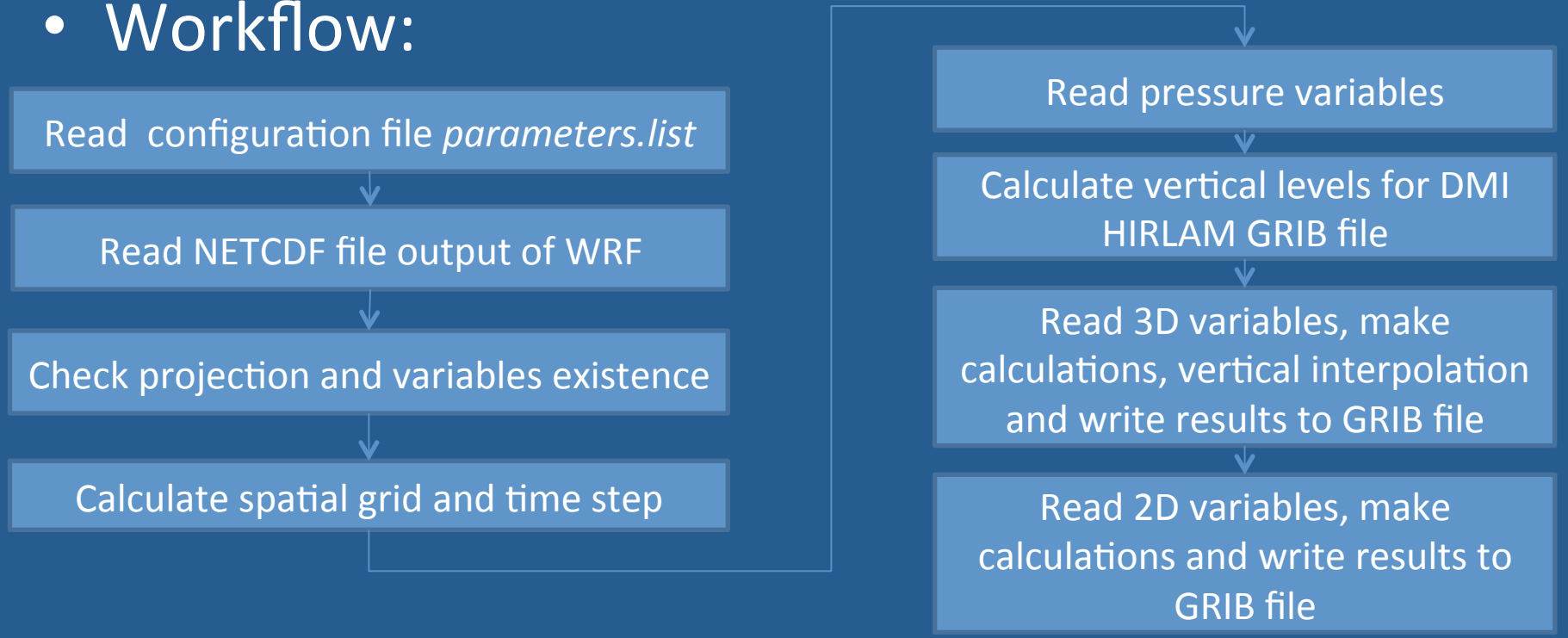
- Challenges between WRF and HIRLAM:
  - WRF output in NETCDF, HIRLAM output in GRIB
  - Different map projections
  - Different vertical layering
  - Correspondence between meteorological variables
- Program WRF2MATCH has been developed
  - Runs on NETCDF files
  - WRF run has to be performed in lat-lon grid

WRF to MATCH converter (3)

- WRF2MATCH converts WRF output to HIRLAM output
- Functions performed:
  - Set the appropriate values of map projection angles
  - Interpolate the output data of WRF on vertical levels of HIRLAM (linear in pressure)
  - Convert from the existing set of WRF output meteorological parameters to corresponding HIRLAM output parameters
  - Write above data into the of the WMO GRIB format

WRF to MATCH converter (4)

- WRF2MATCH program
  - Invoked manually by the user
- Workflow:



WRF to MATCH converter (5)

- Final remarks:
  - WRF for LSMC and WRF for MATCH: different runs of WRF on different domains
  - WRF producing results for LSMC and WRF producing results for MATCH are registered as providers of different types in DB of JRODOS

WRF to MATCH converter (6)

- Documentation:

"Software to convert WRF output to HIRLAM-GRIB format to enable running of MATCH. Technical Description and User Guide"

Report NERIS-TP(WP4)-(13)-01

By

S. Didkivska, Y. Ievdin, I. Kovalets

Thank you very much for your attention