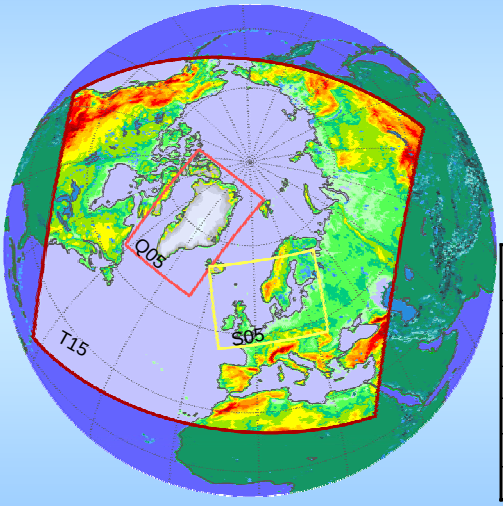
DMI-HIRLAM and EURRA

- Introduction of DMI-HIRLAM
- DMI's participation in EURRA
- Suggestions

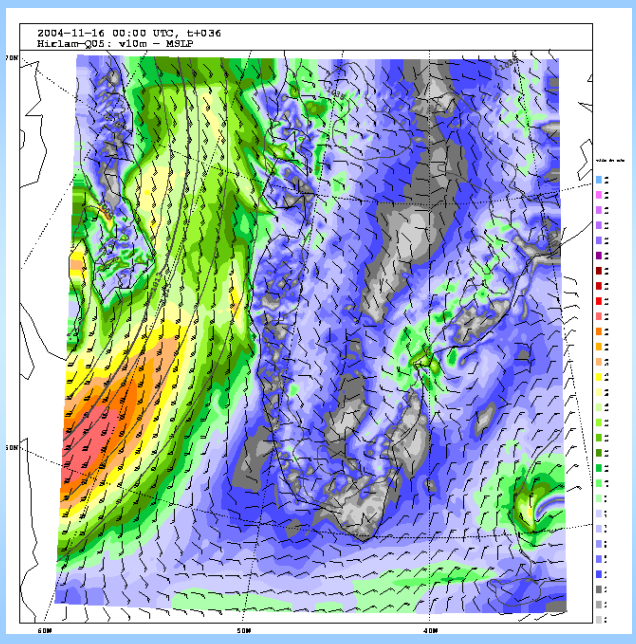
Operational domains of DMI-HIRLAM



	T15	S05	Q05
mlon	610	496	550
mlat	568	372	378
vertical levels	40	40	40
horizontal res. (deg)	0,15°	0,05°	0,05°
time step	360s	120s	120s
host model	ECMWF	T15	T15

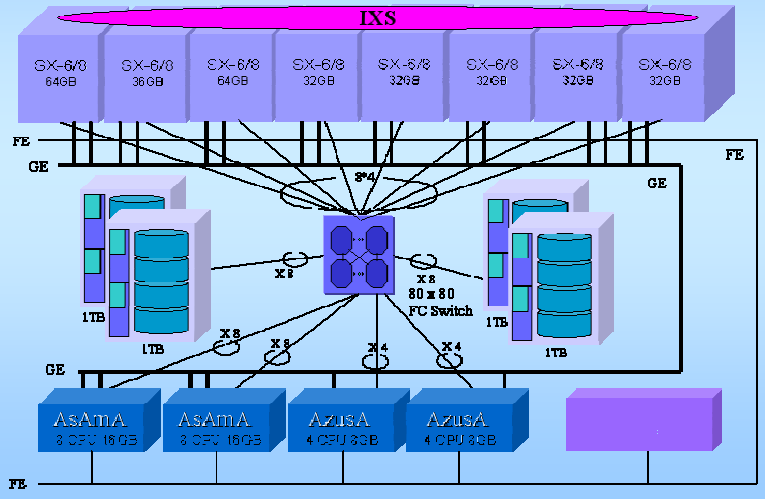
DMI-HIRLAM, Main features

- Hydrostatic, primitive equation, grid-point model on hybrid-pressure coordinate, rotated grid
- Main forecast production at 0.15 degree, with two internally nested high resolution models covering Denmark and Greenland
- 6-hourly re-assimilation cycling with late arriving ECMWF analysis blended in (since 2000)
- 3DVAR-FGAT analysis (since 2000), assimilating conventional data + NOAA 15/16 AMSU-A, QuikScat Seawinds, Meteosat 8 AMV wind. A separate surface analysis module using tiled structure (ISBA)
- A parallel 4DVAR monitoring suite soon to start (2005)
- A nested nonhydrostatic system based on ALADIN dynamic core+HIRLAM physics at 2.5 km resolution has been running in parallel since earlier this year.



Super-computer Facility at DMI

DMI Phase2 Configuration
SX-6/64M8, 320GB



HIRLAM Analysis System

$$J' = \mathrm{B}^{-1}\delta\mathrm{x} + \mathrm{M}^T\mathrm{H}^T\mathrm{R}^{-1}\mathrm{H}\mathrm{M}\delta\mathrm{x} + \mathrm{M}^T\mathrm{H}^T\mathrm{R}^{-1}\{H[M(\mathrm{x})] - \mathrm{y}\}$$

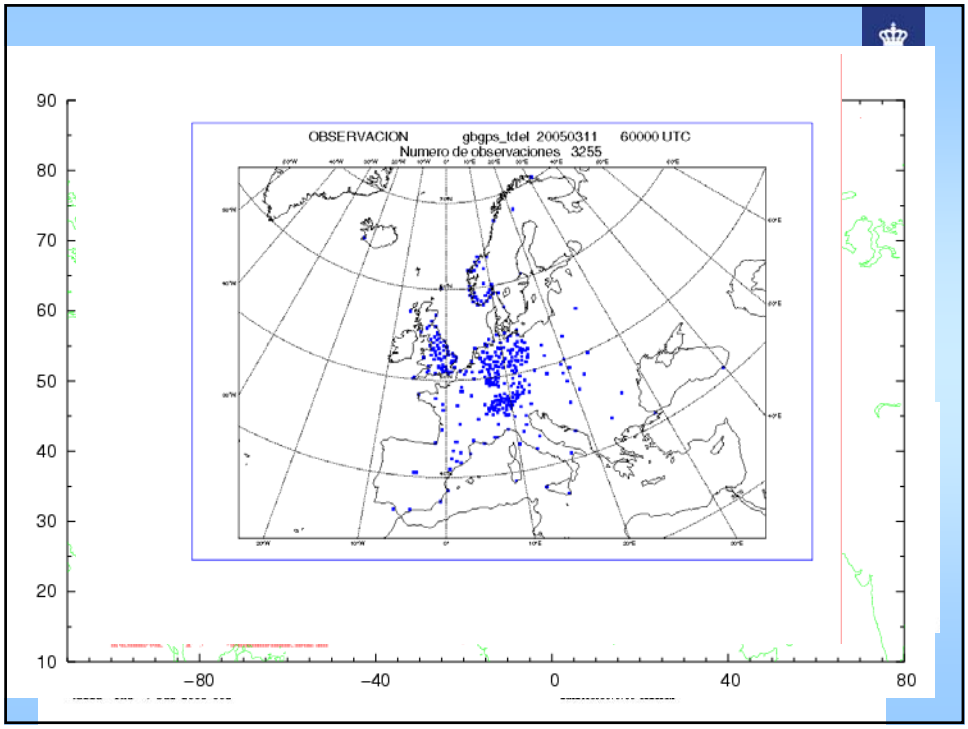
Main Characteritics

- Incremental formulation with spectral HIRLAM for control vector including Ps,U,V,T,Q
- Background error statistics derived with NMC method
- Observation operator for conventional data + NOAA 15/16 AMSU-A (RTTOV 7/8), QuikScat Seawinds, SATOB(Meteosat 8 AMV wind), SSMI BT, Radar SuperObs/VAD/winds, ground-based GPS wet-delay/slant delay
- Moisture analysis following ECMWF (E. Holm approach under test)
- Operational 3D-VAR implementation uses First Guess at Appropriate Time (FGAT) option

Development started in 1995

First 3DVAR operational implementation in Sept. 2000 at DMI, replacing the analysis scheme based on Optimal Interpolation

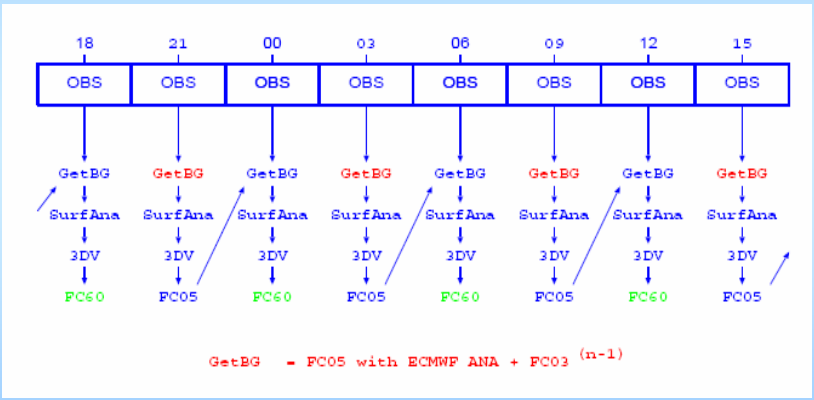
HIRLAM 4D-VAR to be in parallel run in late 2005 and targeted to be operational in 2006



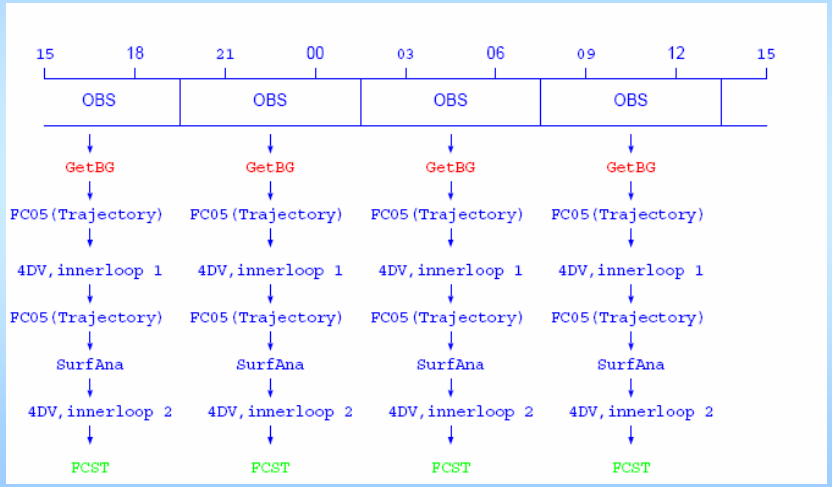
HIRLAM 4DVAR, main characteristics

- Multi-incremental multi-outerloop 4DVAR minimization using grid-point HIRLAM to derive nonlinear trajectory
- TL and AD models are based on the spectral HIRLAM with either (a) Eulerian semi-implicit scheme or (b) Two time level semi-implicit semi-Lagrangian scheme with SETTLS
- Linear physics mainly based on Meteo-France Simplified Physics
- Nominal 4DVAR analysis at synoptic time through TLM projection
- Normal mode initialization (TL and AD) or weak digital filter constraint
- Parallel suite with 4DVAR planned to start in late 2005 (DMI)

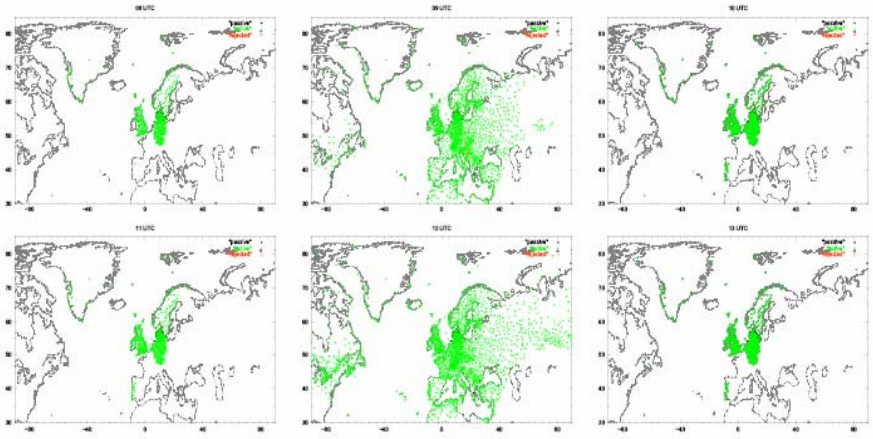
3D-VAR Cycling: analysis centered at the observation window; sensitivity to assimilation interval (3h/6h)



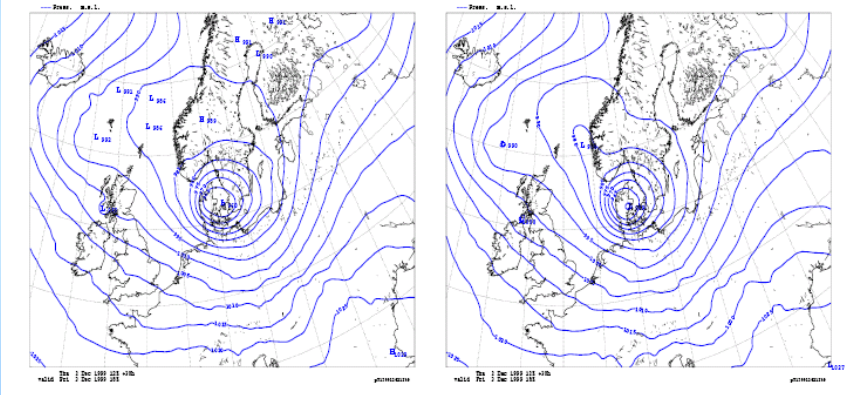
4D-VAR Cycling: Flexible analysis window



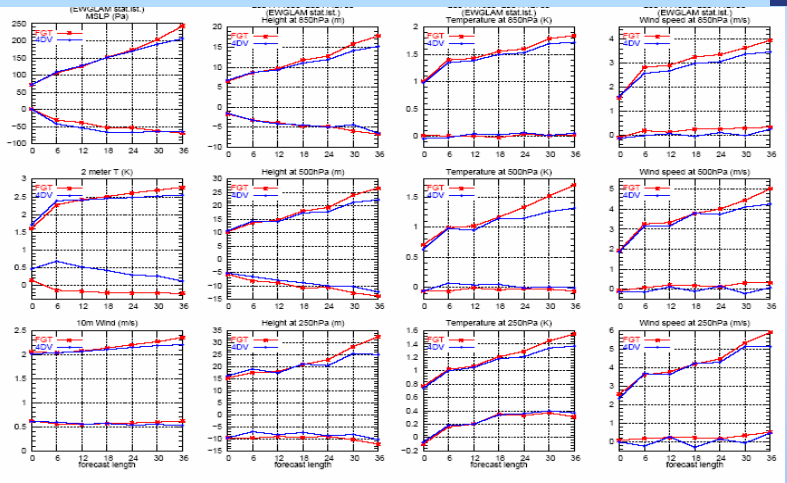
Land SYNOP data usage: 4D-Var



4D-VAR improves model skill in fast moving systems – Danish storm in Dec 3 1999



Validation of HIRLAM-4DVAR



Blending scheme in model coupling

- Why: size of LAM domain limits representation of large scale features; global model can do better due to better use of observation data
- Implicit blending: (global) large scale analysis used as weak constraint in nested model analysis
- Explicit blending: Incremental Raymond Filtering applied to host and nested analysis at the start of forecast (re-analysis scenario)

$$\mathbf{X}_{ini} = \mathbf{X}_{sfa} + \overline{\mathbf{Y}_{ana}}^{RF} - \overline{\mathbf{X}_{ana}}^{RF} + \overline{\mathbf{X}_{ana}}^{DFI} - \overline{\mathbf{X}_{sfa}}^{DFI}$$

- For real time application in which global analysis is not available, similar method of blending can be applied to host and nested first guesses to obtain a modified background

Production focus in EURRA project

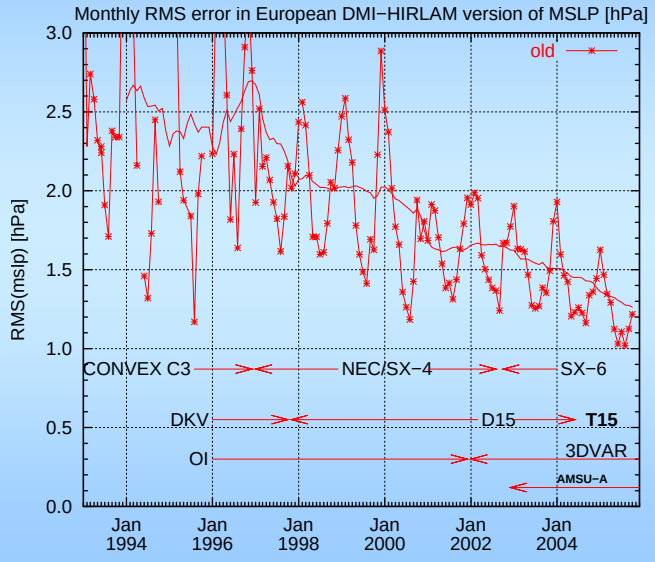
- A high quality, high resolution, consistent re-analysis data set
- Emphasis on near surface properties (T2m, V10m, Rh2m) and precipitation
- Good spin-up property desirable due to production focus on analysis itself + short range forecast
- EURRA is also a good platform for study of a range of scientific issues
  - Data impact study
  - Observation platform study
  - Examination of assimilation technology (method, resolution…)
  - Study of nesting technique (global/regional, internal nesting)
  - Verification technique at high resolution evaluation

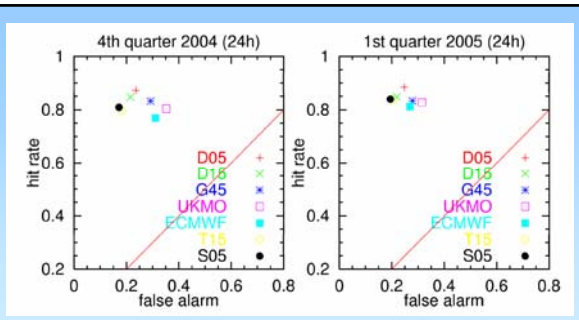
DMI, an ideal EURRA production partner

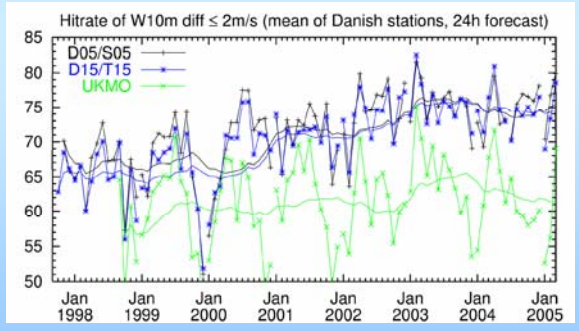
DMI is well-geared to be a EURRA production partner:

- A good LAM system
  - Very high quality forecasts for near surface parameters (T2m, V10m) and precipitation at high resolution
  - Long history of high resolution forecast from 15 km down to 5 km;
  - One of the pioneers in regional 3D-VAR
  - Ideal system for re-analysis production
    - Optional 4DVAR. 4D-VAR is targeted to be operational in near future, which provides well balanced, high temporal frequency analyses
    - A well-behaved moisture spin-up
- Good computation facility
- Experienced staff on regional re-analysis
  - Main development partner of HIRLAM VAR system
  - Participation of earlier projects such as BALTEX/NEWBALTEX
  - Expertise on model inter-comparison, energy and water budget study

Progress of DMI-HIRLAM's skill in MSLP 24 hr forecasts



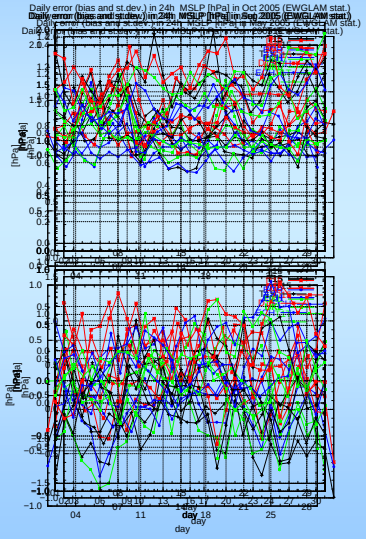




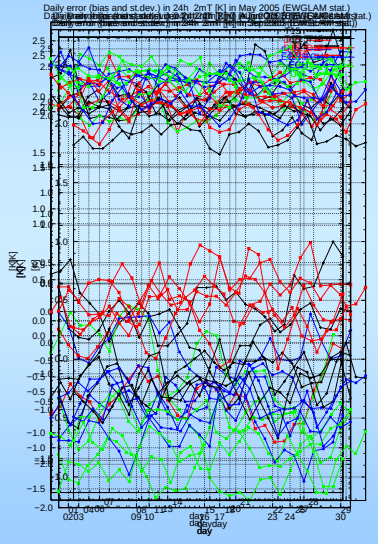
DMI-HIRLAM

Hit rate of W10m forecast

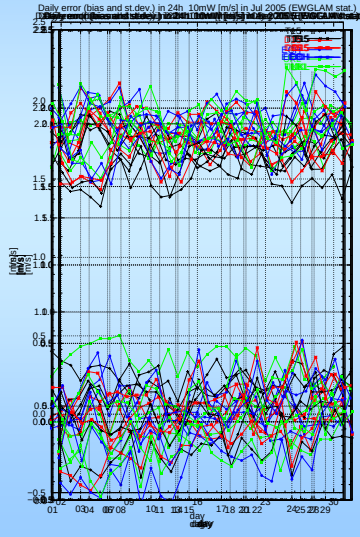
LAM's disadvantage in large scale…



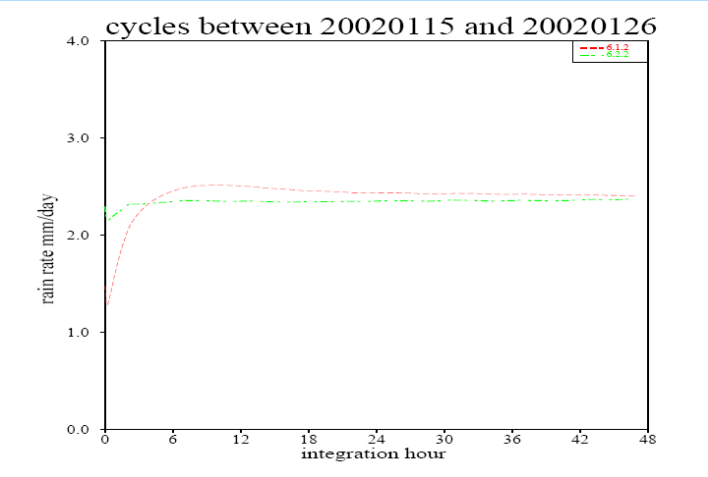
LAM's advantages in near surface features (1)…



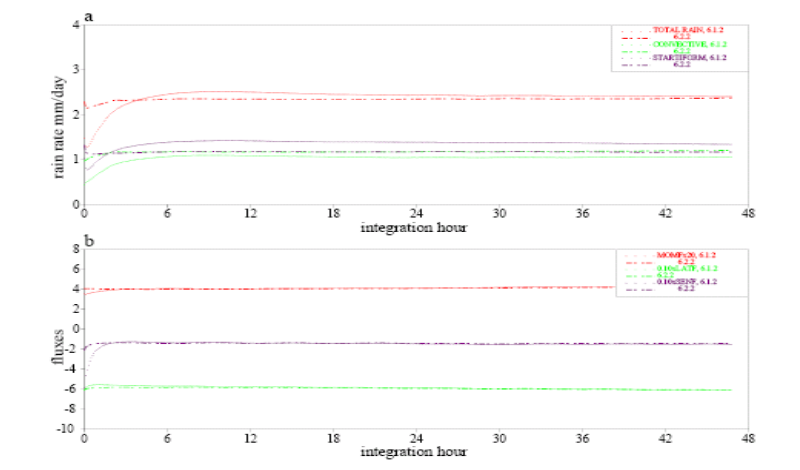
LAM's advantages in near surface features… (2)



A well-tamed moisture spin-up in DMI-HIRLAM due to incremental DFI



Full DFI vs Incremental DFI



DMI's participation to EURRA (1) : (As production partner)

Data assimilation with HIRLAM:

- Downscaling forecast using interpolated ERA-40
- EURRA re-analysis with 4D-VAR at 30/10/2 km with HIRLAM and HIRLAM/ALADIN
- Contribution of local physiology/observation data when applicable
- Possibly a joint effort by several HIRLAM partners to carry out re-analysis
- Possibly a partner in an EURRA production chain together with global analysis and other regional analyses producers.

DMI's participation to EURRA (2): (As research partner)

- Study of LAM assimilation/model coupling technique; study of methodology in re-analysis; study of optimal assimilation configuration in km scale re-analysis/forecast
- Efforts toward improved moisture analysis. Investigation of possibilities for assimilation of precipitation (radar data)
- Impact study of observation network (e.g., conventional data-only/thinned upper air network etc. for a multi-year period compared to control run).
- Validation study/verification technique. Studies of the homogeneity of the final product.
- Climate studies of the final product, including application models such as advanced hydrological models, wave and surge models.
- Budget study, Physical process study

Proposal on EURRA

- Phased approach
  - Trial/demonstration stage ; Start with downscaling forecast using ERA-40
  - Gradually increased resolution in LAM data assimilation at 30, 10, 2 km
- Emphasis on coupling of global and regional models
- Focus on high quality surface parameters (T2m,V10m) and Precipitation
- Use of advanced upper air data assimilation (4D-VAR) and increased focus on surface analysis