# Re-analysis activities at SMHI

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# Components of the HIRLAM 4D-Var

•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 (option: linear grid)

•Multi-incremental minimization

•Possibilities to use spectral version och gridpoint version of non-linear HIRLAM for outer loops at full model resolution

•Normal mode initialization (TL and AD) or weak digital filter constraint

•Simple vertical diffusion (TL and AD, Buizza) or the simplified physics package from Meteo-France (TL and AD, Janiskova)

•Two options for analysis at nominal time: (1) TL propagation of increment, (2) Non-linear forecast

**Surface pressure increments for the Danish storm**



**4D-Var, spectral TL prop. of incr**
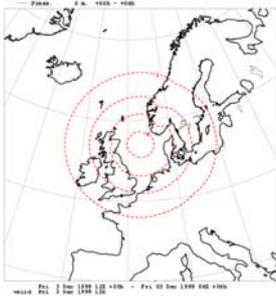


**3D-Var**



**4D-Var; gp model prop. of incr.**

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**The HIRLAM group (SMHI & FMI) has developed and applied methods for assimilation of Doppler radar winds**

- **both for VAD-winds**

- **and for radial winds**
    - **de-aliasing**
    - **anomalous propagation**
    - **super-obbing**
    - **forward model (2D or 3D winds)**

## BALTEX-BRIDGE
## Baltic regional reanalysis

- **High resolution reanalysis 1999-2000 focussing on the Baltic Sea runoff area**
  - **U Andrae (SMHI), C. Fortelius (FMI)**

- **0.2 º *0.2 º -  L31  3D-Var HIRVDA**
  - **TKE (Cuxart)**
  - **Rasch-Kristjanson + Kain-Fritsch condensation**

- **Coupled sea ice drift model 'BOBA'  and SMHI lake model**

- **http://hirlam.fmi.fi/Museo/bridge/index.html**

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## Timeseries comparing radar and BRIDGE precipitation
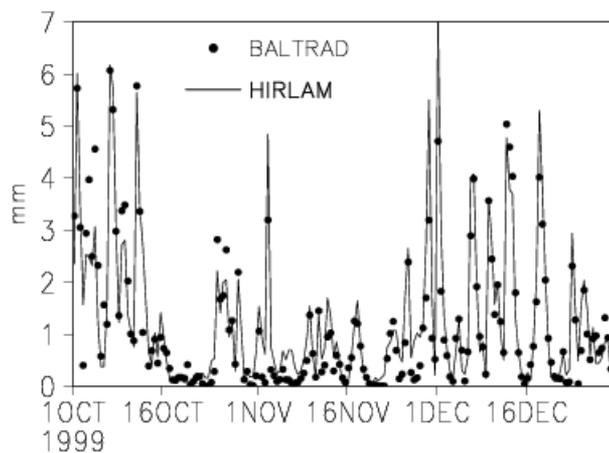
## Histogram comparing radar and BRIDGE precipitation



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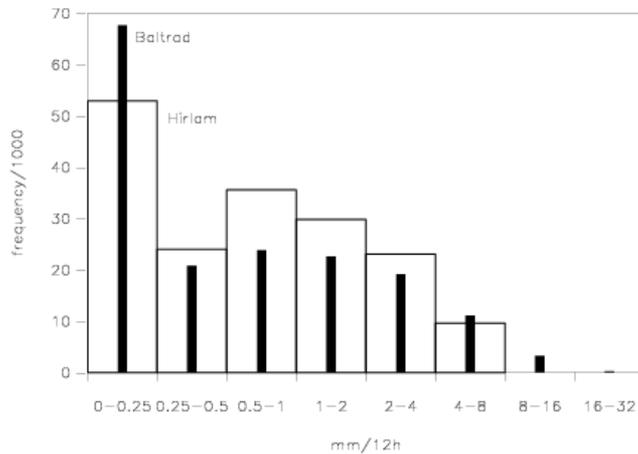
## DAMOCLES
### Developing Arctic Modeling and Observation Capabilities for Long-term Environment Studies

- **6th Framework Program**

- **'Integration and assimilation of observations with large-scale models'**

- **SMHI Rossby Centre jointly with MetNo**

- **HIRVDA, HIROMB (ocean model – currents, icedrift)**

**Potential SMHI contributions to EURRA**
**(in the 3D/4D HIRLAM/ALADIN configuration)**

- error covariance modelling for 4D-Var

- coupled ocean (current, ice, icedrift) model

- lake temperature and freezing model

- physics in the snow cover

- assimilation of Doppler radar winds

- assimilation of GPS humidity (total water  vapour column)

- SMHIs regional chemistry model MATCH

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# Operational MESAN
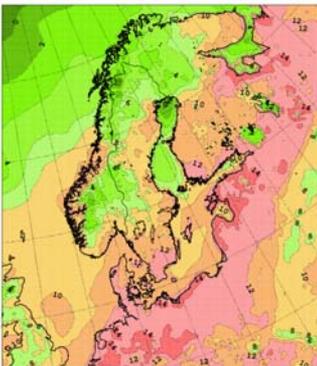


- **Resolution**
- 22 km, 11 km and 4 km

- **Method**
- optimal interpolation

- **Input**
- HIRLAM as first guess
- satellite and radar imagery
- synop, climate, metar and AWS
- physiographic fields

- **Status**
- operational since 1997
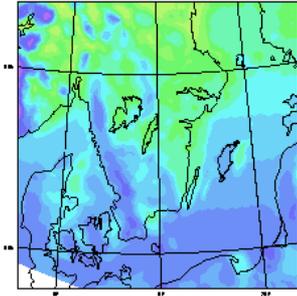- ongoing development

# Optimal interpolation in MESAN
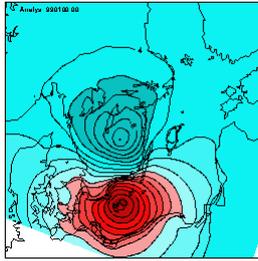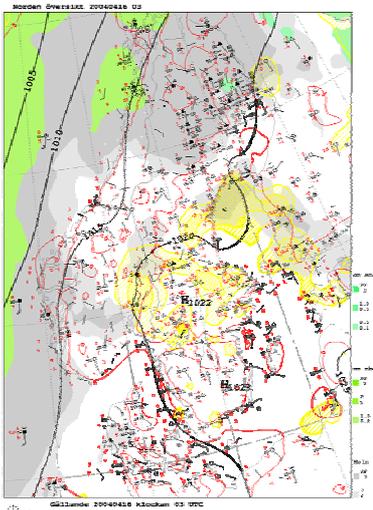


**Structure functions consider:**

- fraction of land/water

- roughness length

**First guess error reflecting precipitation climate**

**Ref: Tellus 2000, 52A, p 2-20**

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# Analysed parameters (22 km)



- pressure at msl
- 2 m temperature
- 2 m max- and min-temperature
- 2 m relative humidity
- 2 m wet bulb temperature
- visibility
- precipitation, 1, 3 ,12 and 24 h
- fresh snow, 1 and 3 h
- clouds: total, low, top, base
- 10 m wind and gust

# Applications of MESAN

**MESAN is directly used for:**

- guiding forecasters
- guiding road maintainers
- aviation products
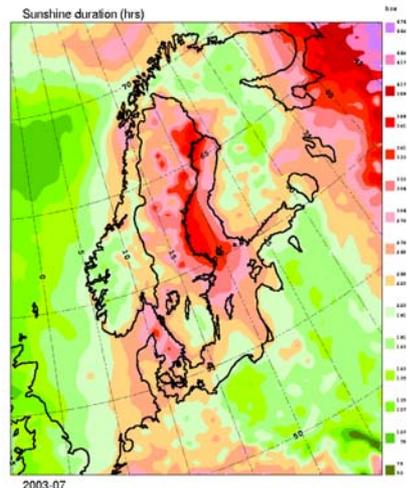- observation replacement

**MESAN provides input to:**

- radiation models
- atmospheric chemistry models
- fire risk models
- hydrological models

# STRÅNG

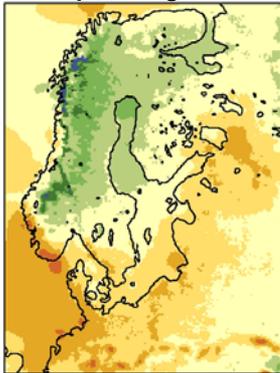## A mesoscale model for solar radiation

**Hourly, daily, monthly and yearly fields of:**

- Global radiation
- Direct radiation
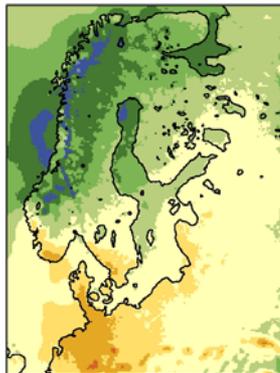- Sunshine duration
- PAR
- CIE-weighted UV-radiation



Sunshine duration (hrs)

2003-07

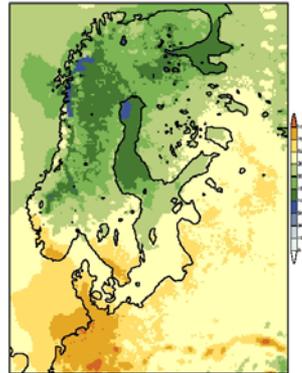# Wet+dry dep. over NW Europe annual mean 2002-2004

**Sulphur, mgS/m2**  **NOx-Nitrogen, N/m2**  **NHx-Nitrogen, N/m2**



**Based on:** - MATCH atm.chemistry 3-D modelling system (11x11 km)
- Atm. chemistry data assimilation (EMEP and national stations)
- MESAN meso-scale (11x11 km) meteorological 2-D re-analyses (3h)
- Detailed land-use information

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# MESAN used for a long time period

**Resolution:**
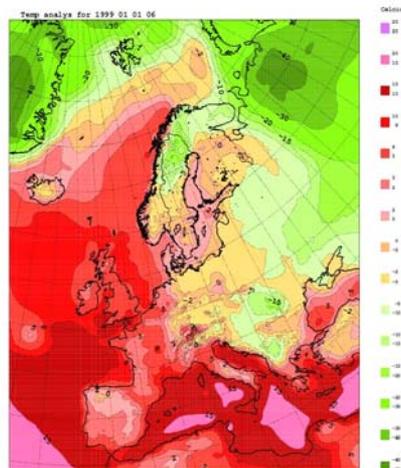- 11 km
- every 6 hour

**Analysed parameters:**
- 2 m temperature
- 12 and 24 h acc. precipitation
- 10 m u- and v-wind

**Time period:**
- 1990 – 2004

**Input data:**
- ERA-40 as first guess
- Observations from SMHI:s archive

# Preliminary comparison between ERA40 and ERAMESAN with Scandinavian Climate Data done in the NORDMET/NORDGRID-project

**ERA40**      Daily mean    **ERAMESAN**

## TEMPERATURE

| ERA40 | ERAMESAN |
|---|---|
| BIAS=0.16 | BIAS=0.16 |
| RMSE=1.23 | RMSE=0.52 |
| MAE=1.1 | MAE=0.73 |

## PRECIPITATION

| ERA40 | ERAMESAN |
|---|---|
| BIAS=-0.03 | BIAS=-0.17 |
| RMSE=3.15 | RMSE=1.75 |
| MAE=1.53 | MAE=0.98 |