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FINNISH METEOROLOGICAL INSTITUTE

Weather modelling at FMI - HIRLAM

Markku Kangas

FMI / Meteorological Research / Numerical Weather Models
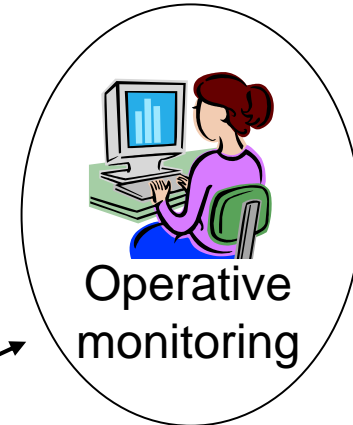
updated 22 April 2006, Laura Rontu

High Resolution Limited Area Model

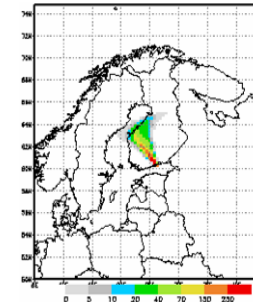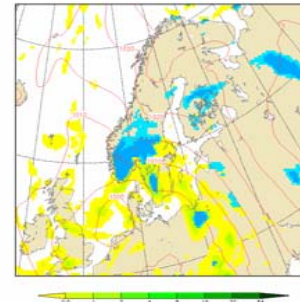**Hir lam**

Weather forecast modelling

Observations

Forecast

Operative monitoring

Expert involved production

Automated production
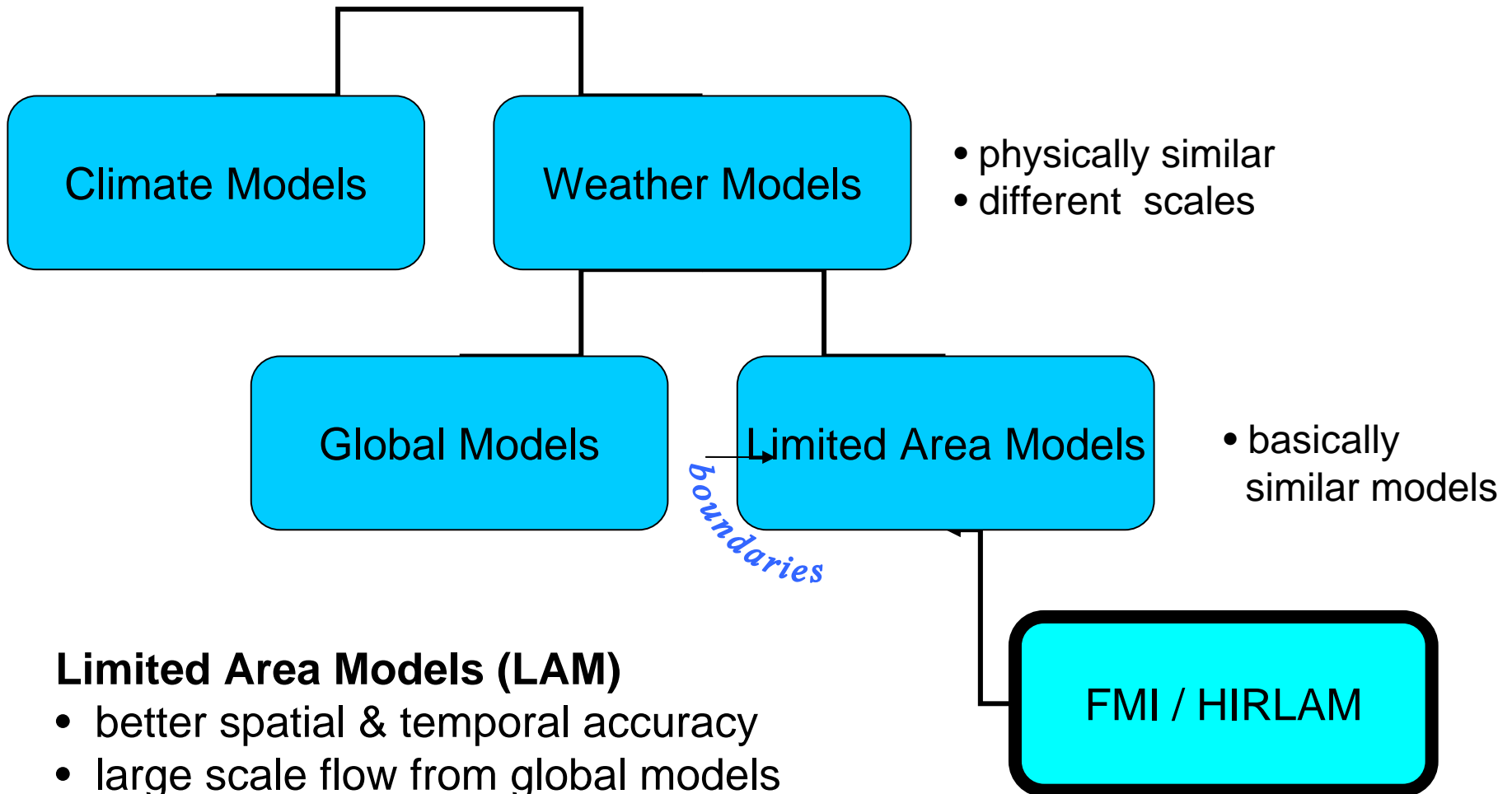
Atmospheric Models

Climate Models

Weather Models

- physically similar
- different scales

Global Models

Limited Area Models

boundaries

- basically
  similar models

FMI / HIRLAM

Limited Area Models (LAM)
- better spatial & temporal accuracy
- large scale flow from global models

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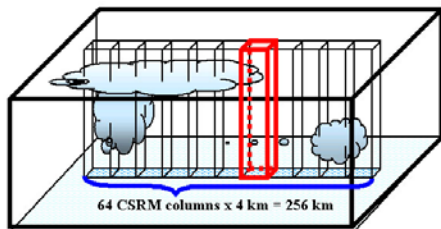
Numerical modeling

- **Atmospheric volume ➡ discrete points**

  - distance between points = resolution

- **Basic atmospheric equations**

  - continuity, temperature, moisture, momentum

- **Limited resolution (~10-20 km)**

  - parametrisation

    - clouds+convection, turbulence, radiation
   - land surface - atmosphere interaction

64 CSRM columns x 4 km = 256 km

T_{am} q_{am}
T_{forc} r_{afor}
w_{cfor} r_s, r_h T_{fora} q_{fora}
r_d T_{forsn} r_d r_{soilsc}

L91

L60

Pressure (hPa)

Level number

22.04.06   4
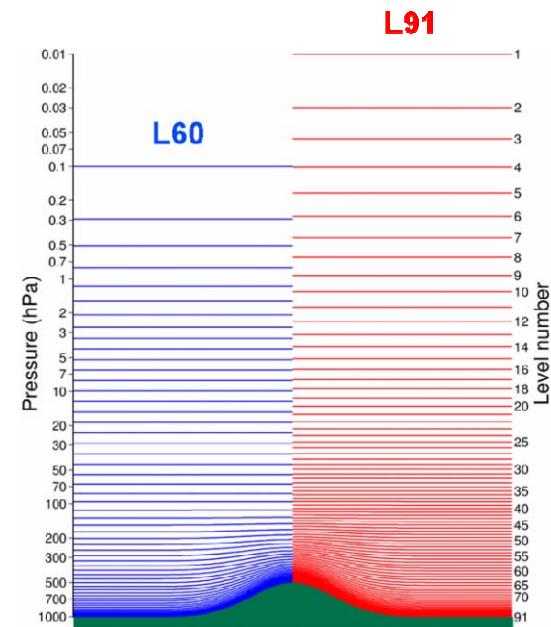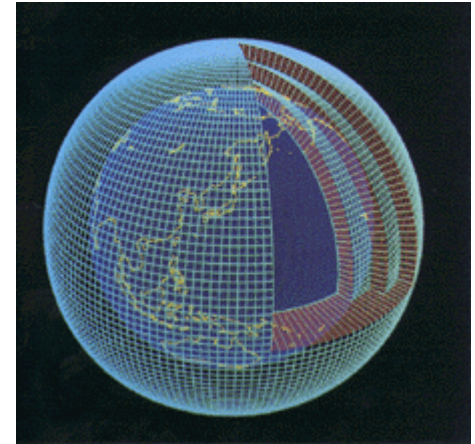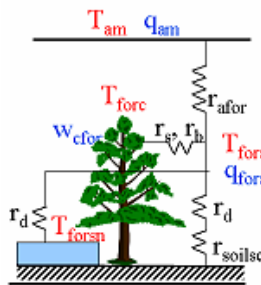
Dynamics: two approaches

- **Current : Hydrostatic models (dx > 8-10 km)**
  - hydrostatic equilibrium
  - pressure defined by mass, vertical movement by convergence

- **Upcoming : Non-hydrostatic models (dx < 2-3 km)**
  - no hydrostatic equilibrium
  - pressure defined by mass and movement (dynamic pressure)
  - additional equation for vertical acceleration

- **Kilometer-scale mesomodels**
  - hydrostatic ➡ non-hydrostatic
  - new parametrizations
  - new numerical solutions
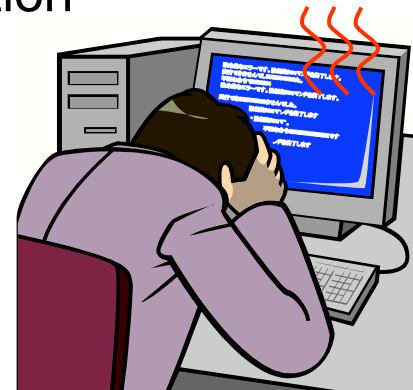
Numerical weather prediction system
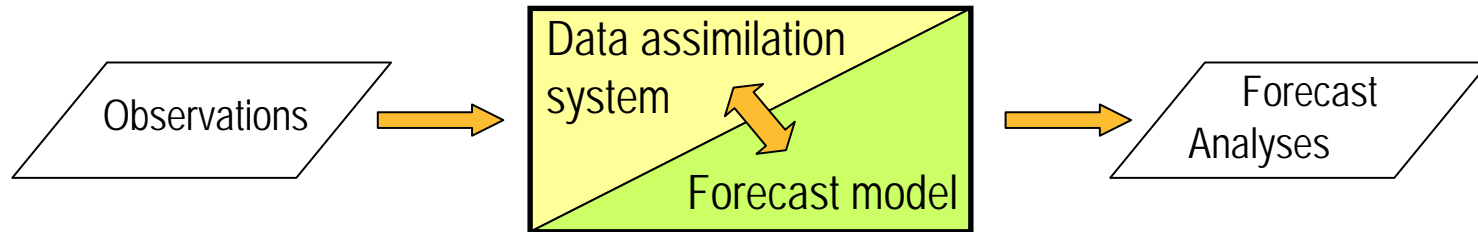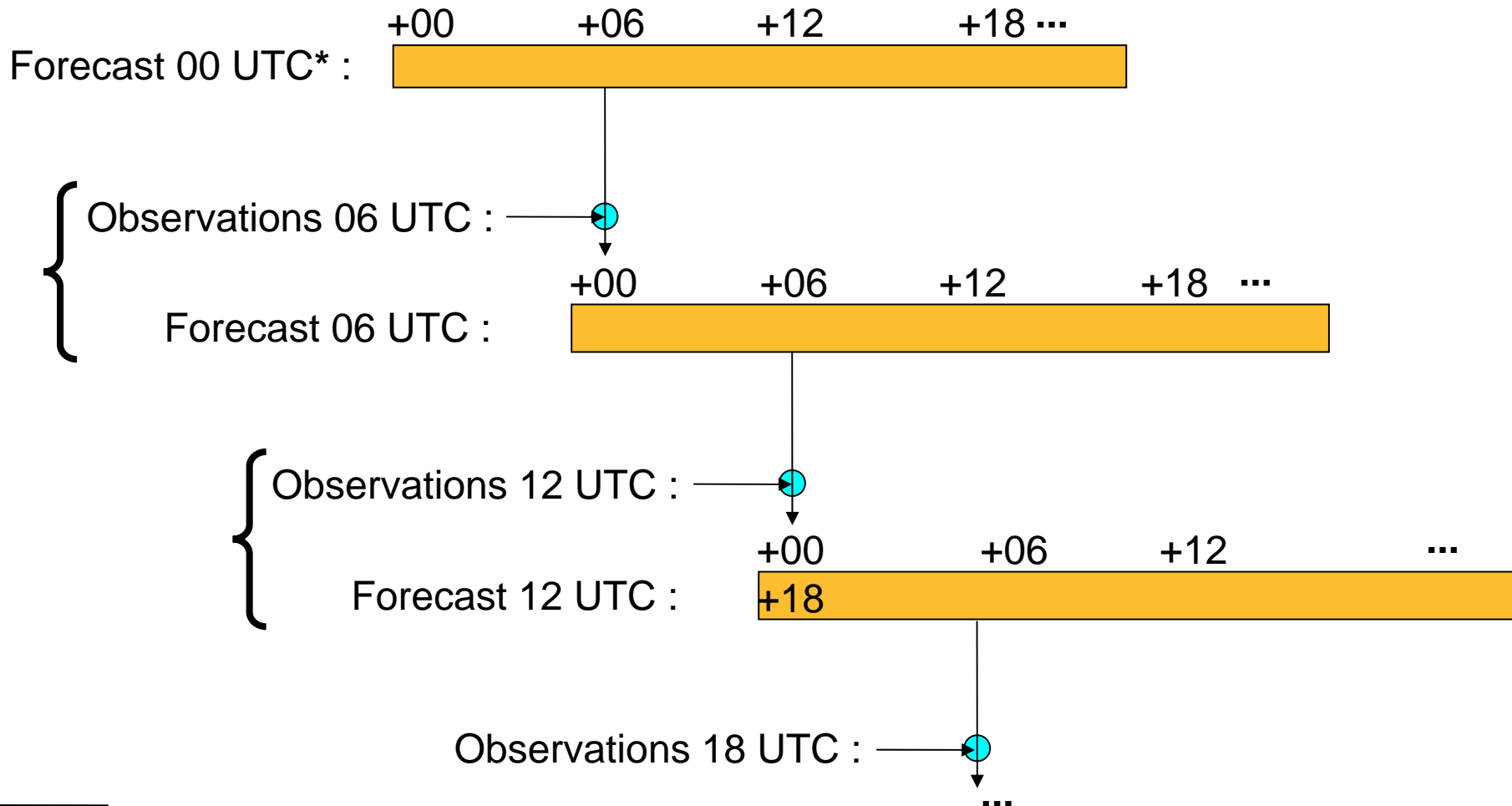

- **Data assimilation**
  - chaotic equations ➡ forecast <u>initial state important</u>
  - problem : observations inaccurate, sparse spatially and temporally
  - remedy : model gives a more complete state of the atmosphere
  - solution : combine observations with an earlier forecast to form the initial state of the forecast
    - optimization problem ➡ variational analysis
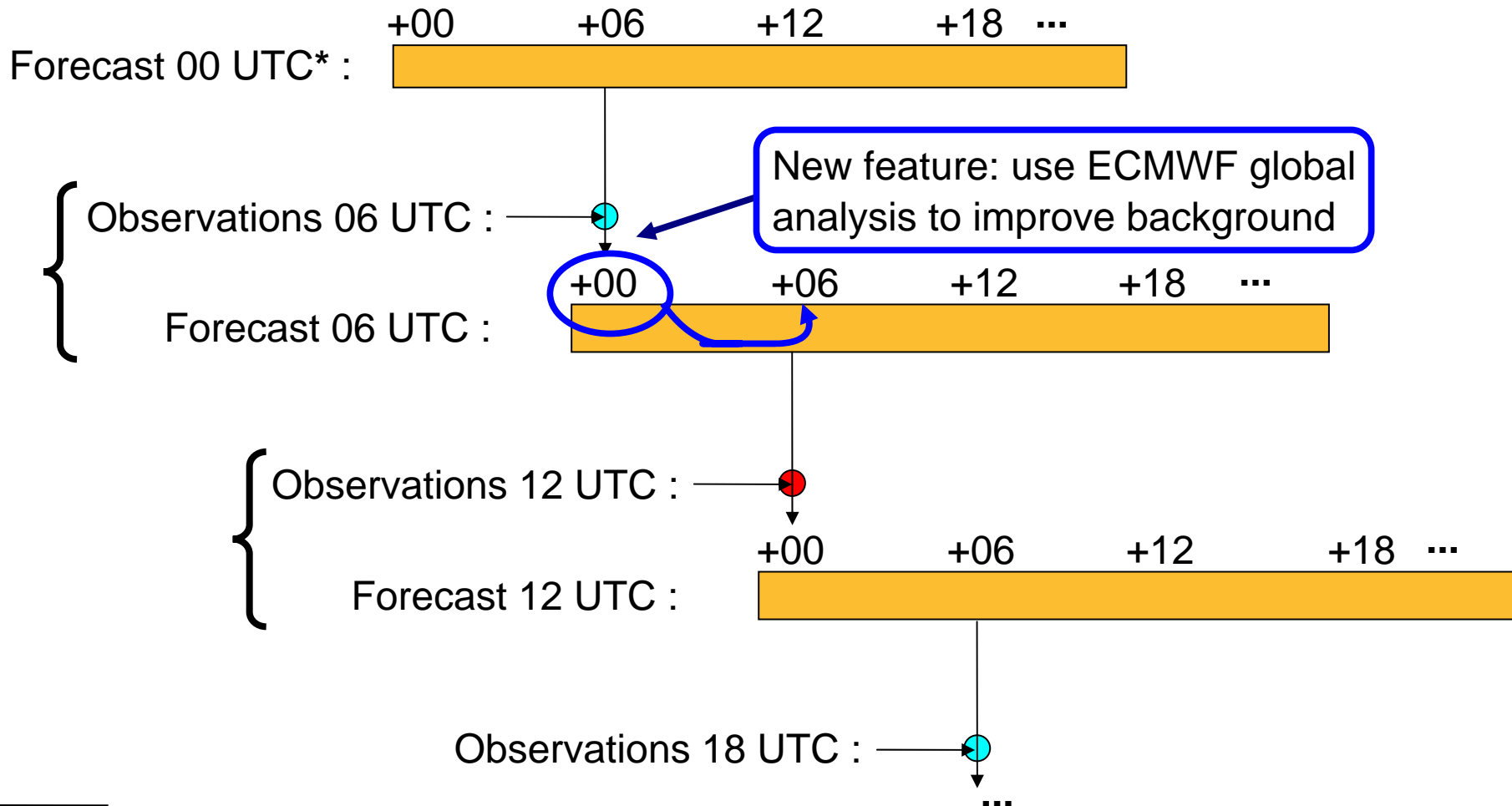   - 3DVAR, 4DVAR

Data assimilation (⬤) example : 6 hour cycle

	+00	+06	+12	+18 •••

Forecast 00 UTC* :

Observations 06 UTC :

	+00	+06	+12	+18 •••

Forecast 06 UTC :

Observations 12 UTC :

	+00	+06	+12	•••

Forecast 12 UTC : +18

Observations 18 UTC :

•••

*) UTC = **U**niversal **T**ime **C**oordinated (= GMT)

Data assimilation (⬤) example : 6 hour cycle

	+00	+06	+12	+18 •••

Forecast 00 UTC* :

Observations 06 UTC :

New feature: use ECMWF global analysis to improve background

	+00	+06	+12	+18 •••

Forecast 06 UTC :

Observations 12 UTC :

	+00	+06	+12	+18 •••

Forecast 12 UTC :

Observations 18 UTC :

•••

*) UTC = **U**niversal **T**ime **C**oordinated (= GMT)

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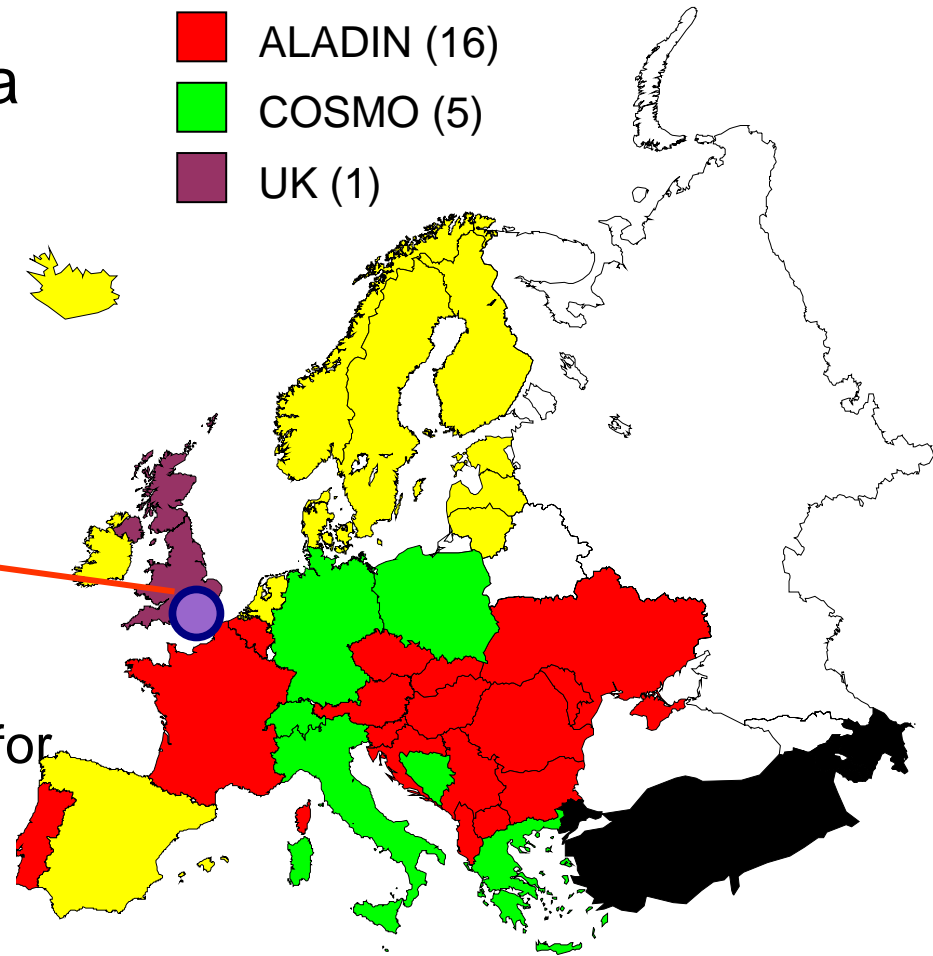
HIRLAM

- <u>H</u>igh <u>R</u>esolution <u>L</u>imited <u>A</u>rea <u>M</u>odel

- 8 countries (ca. 22 man-years)
  - development + operative use
  - FMI : reference runs (RCR)

- ECMWF
  - <u>E</u>uropean <u>C</u>entre for <u>M</u>edium-<u>R</u>ange <u>W</u>eather <u>F</u>orecasts
  - global forecast => boundaries for member LAMs

- Hirlam ver 1.0 y.1990
  - 2006 : Hirlam 7   Hirlam A

Europe's LAM consortia

- HIRLAM (8+3)
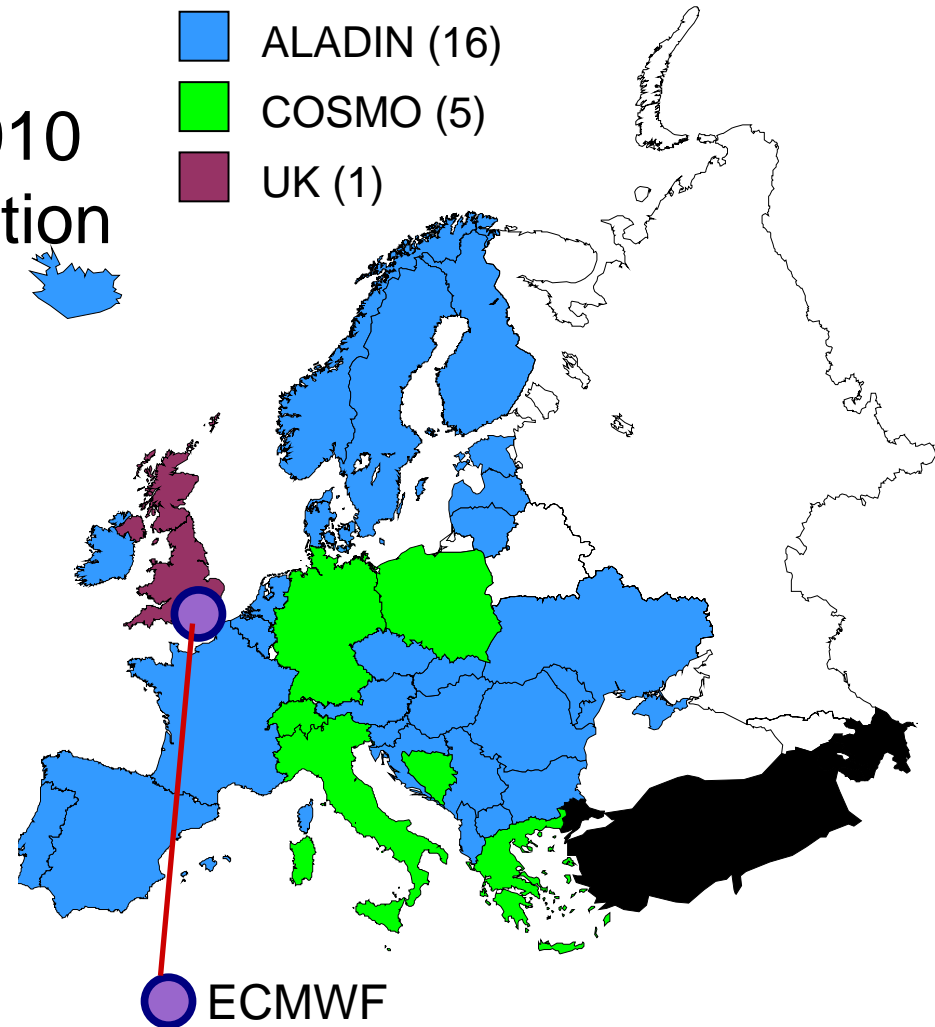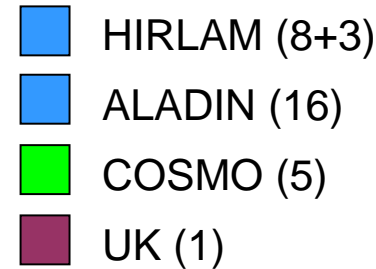- ALADIN (16)
- COSMO (5)
- UK (1)

HIRLAM-A

- NWP programme 2006-2010
- HIRLAM-ALADIN cooperation
- mesomodel development

- Scientific plan, yearly work plans

- HIRLAM Council, Advisory committee, All staff meetings

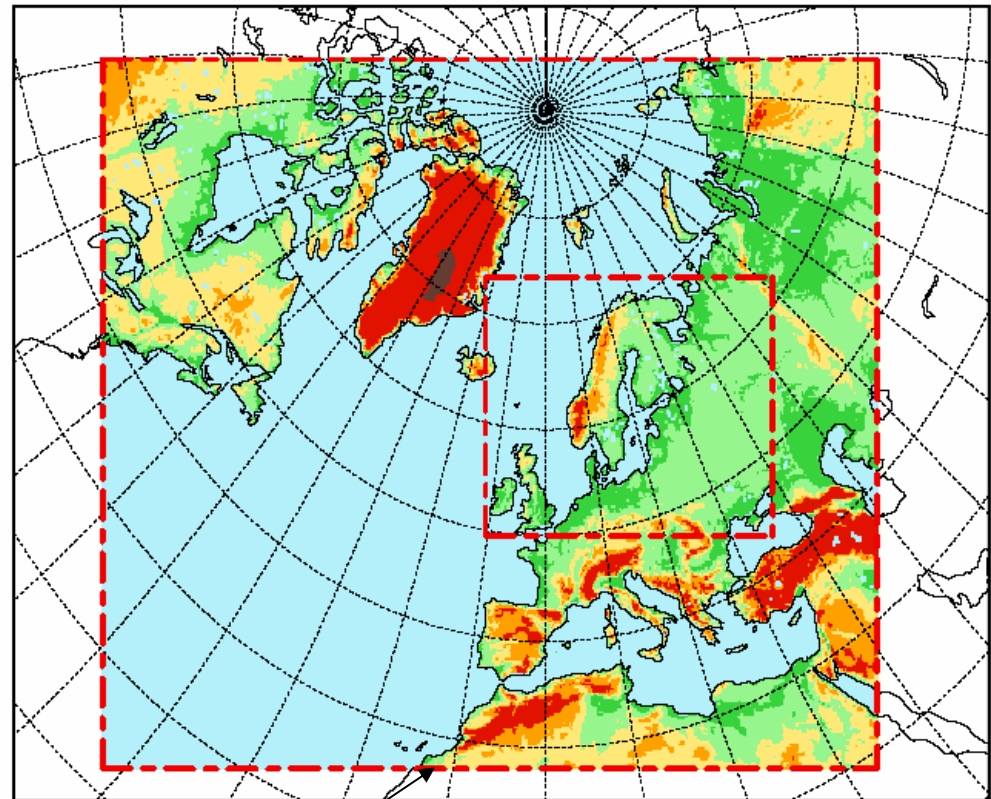- programme manager Jeannette Onvlee / KNMI (Netherlands)

HIRLAM (8+3)

ALADIN (16)

COSMO (5)

UK (1)

ECMWF

HIRLAM at FMI

- RCR = Hirlam <u>R</u>egular <u>C</u>ycle with the <u>R</u>eference system

  - dh = 0.2^o ~ 22 km

  - 40 levels in vertical (surface – 10 hPa)

  - dt = 7.5 min

- MBE = Hirlam <u>M</u>eso <u>BE</u>ta model

  - dh = 0.08^o ~ 9 km

  - 40 levels in vertical (surface – 10 hPa)

  - dt = 3 min

HIRLAM areas at FMI (dashed lines):
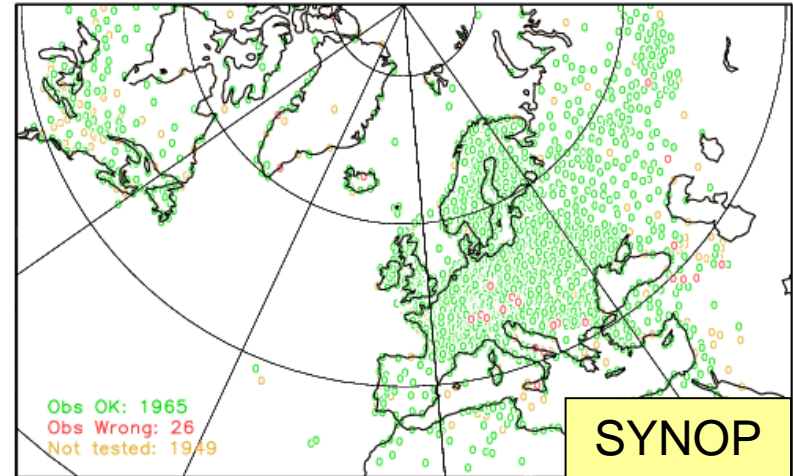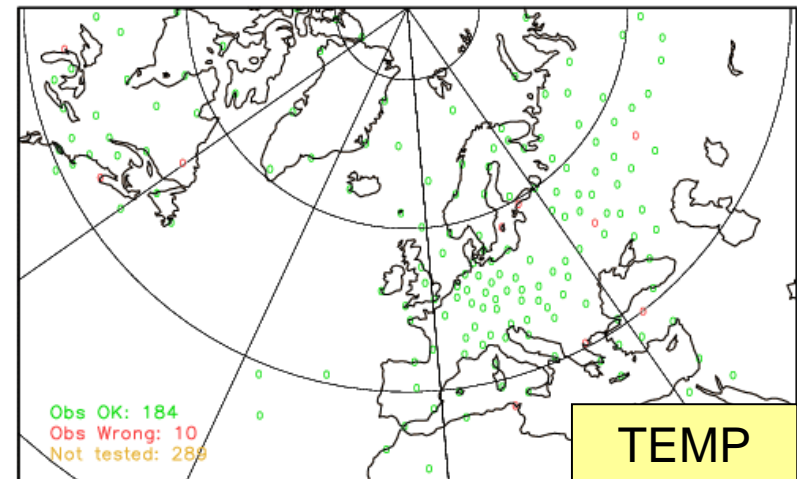Inner area MBE, outer area RCR

ECMWF boundaries

Operative system

FMRI
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MERENTUTKIMUSLAITOS

OBS : TEMP, PILOT, SYNOP, SHIP, AIREP, DRIBU, (ATOVS)

Baltic SST / ice data
2 kB/d

10 MB/d

European Centre for Medium-Range Weather Forecasts

archiving
14.5 GB/d , 13 MBt/s

boundaries
1.3 GB/d , 13 MBt/s

monitoring
reporting

Hirlam
HeXnet

Internet

IL / SGI Altix

- data assimilation
- forecast
- archiving (ECMWF + FMI)
- visualisation (internet)
- postprocessing

Observations

- **Surface observations**
  - SYNOP   : WMO network
  - SHIP   : ships
  - BUOY   : buoys (DRIBU)
  - AIREP
  - AMDAR   } : aircraft
  - ACARS

- Soundings (vertical distrib.)
  - TEMP   : radio soundings
  - [*ATOVS : satellite measurements (Advanced TIROS* Operational Vertical Sounder)*]

*)Television Infrared Observation Satellite Program

Obs   synop_z in exp V637 at 00Z08DEC2005

Obs OK: 1965
Obs Wrong: 26
Not tested: 1949

SYNOP

Obs   temp_T in exp V637 at 00Z08DEC2005

Obs OK: 184
Obs Wrong: 10
Not tested: 289

TEMP

Hirlam operational usage

- 54 h forecast : 00, 06, 12, 18 UTC

- 6 h forecast : 03, 09, 12, 15 UTC

    - first-guess field for longer forecasts from latest observations

- Visualisation and archiving

    - postprocessing, applications

    - fminwp.fmi.fi

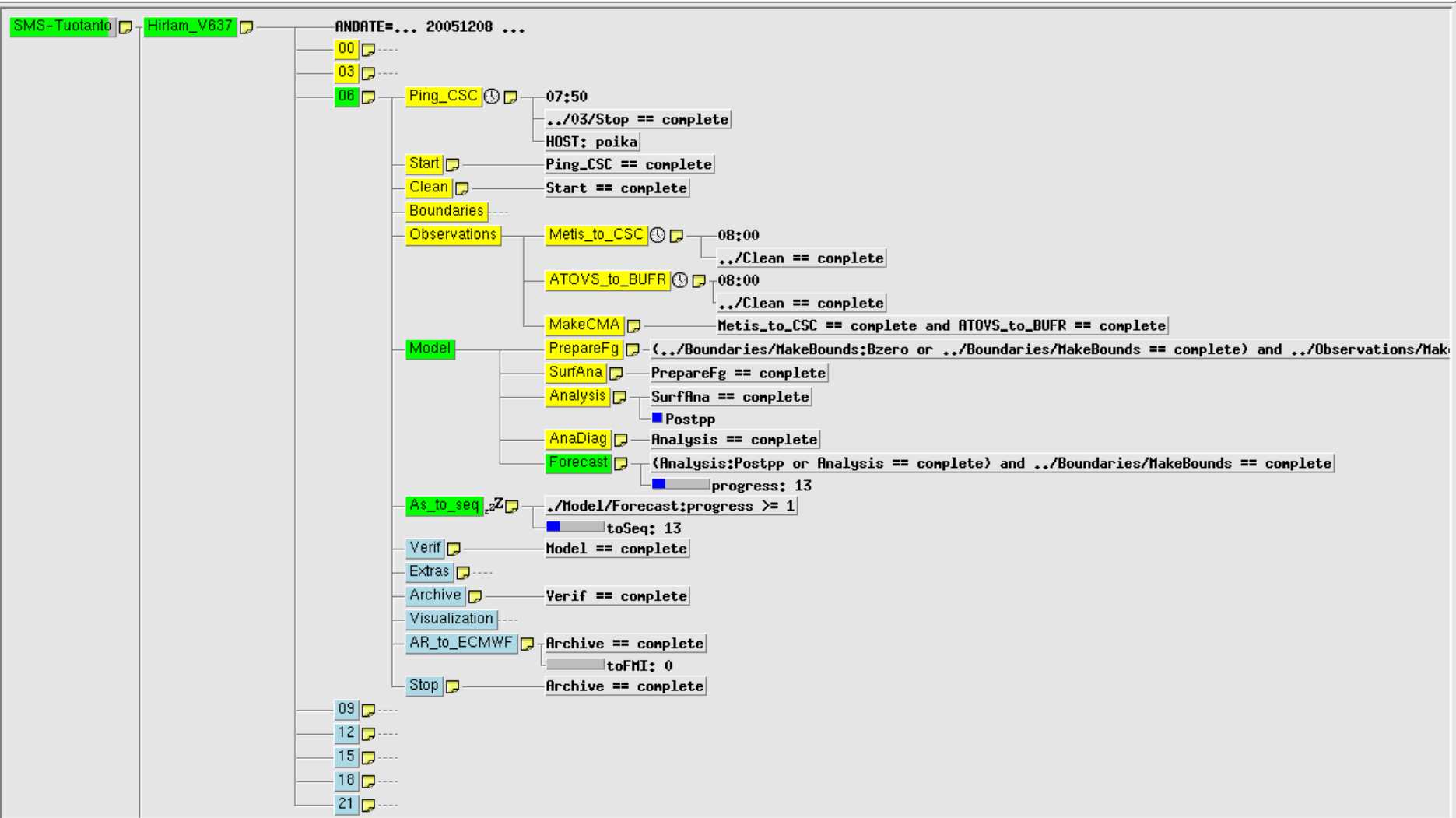Screenlevel temperature (C)
initial: 06Z08DEC2005 valid: 06Z10DEC2005

Links :   RCR   MBE

Helsinki–Vantaa

Operative system

SMS : **S**upervisor **M**onitor **S**cheduler
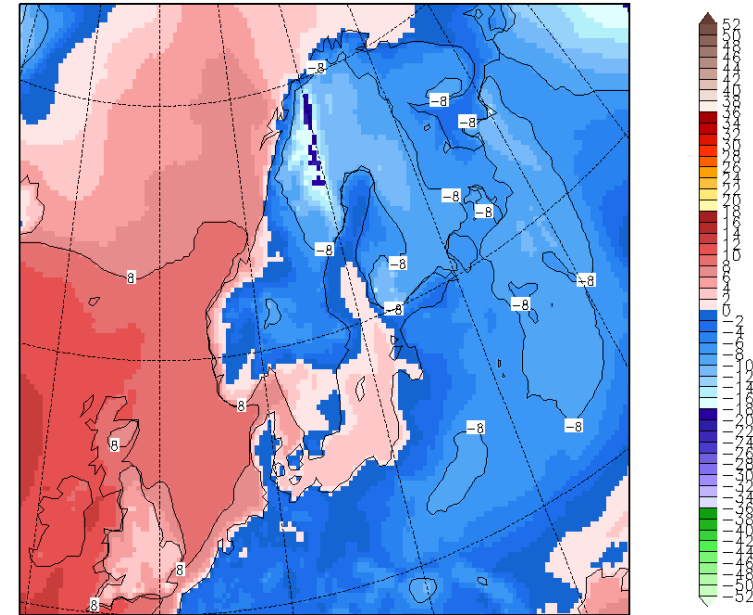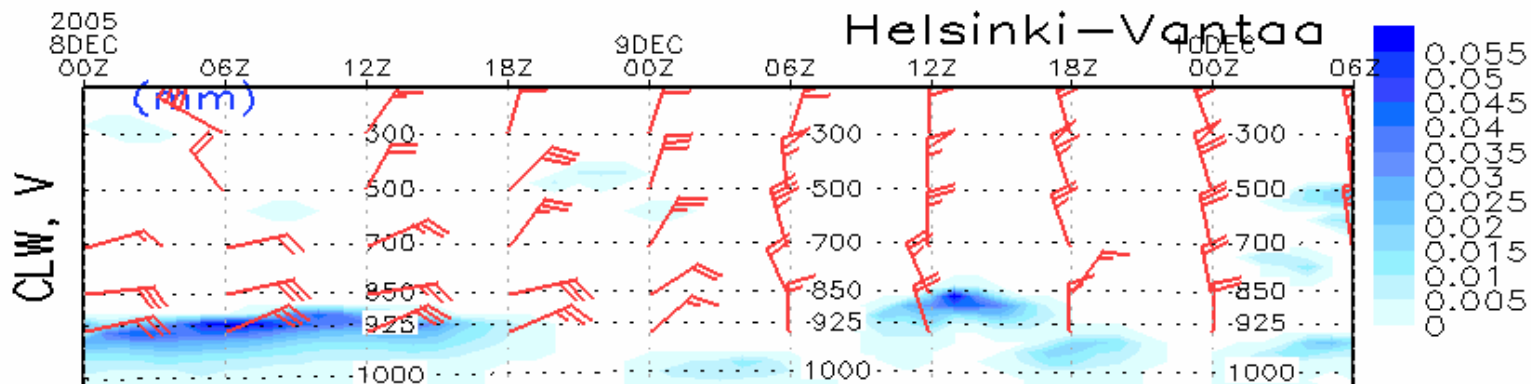
Computer system

- Silicon Graphics Altix-3700 BX2

  - Intel Itanium 2 -processors, 1.5 GHz, with 4MB internal cache

  - Total of 304 processors, 304 GT shared memory
    - 2 parts : 256 + 48 (jumbo + sambo)
    - HIRLAM : 42 processors in sambo

  - Novell Suse Linux

  - Intel compilers (C, Fortran)

  - LSF load management system

- Silicon Graphics Altix-350

  - 16 processors, 64 GT shared memory
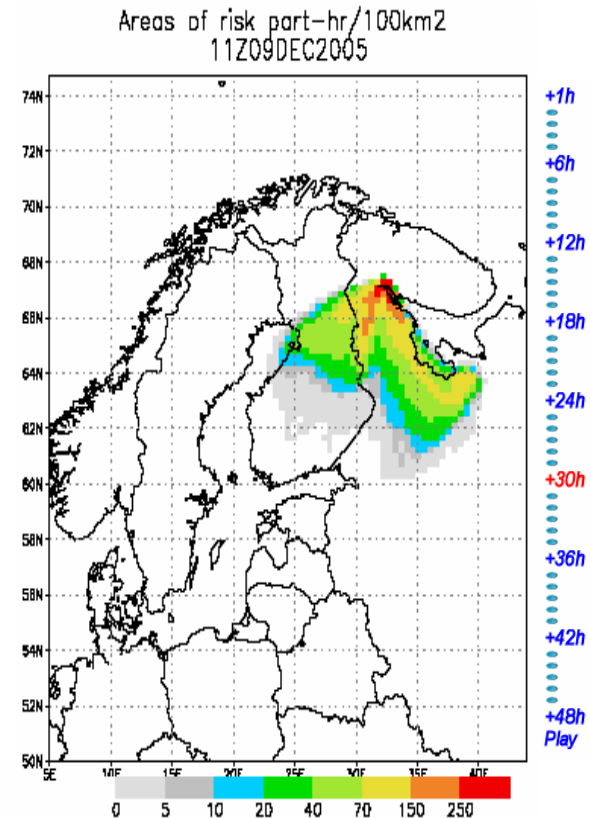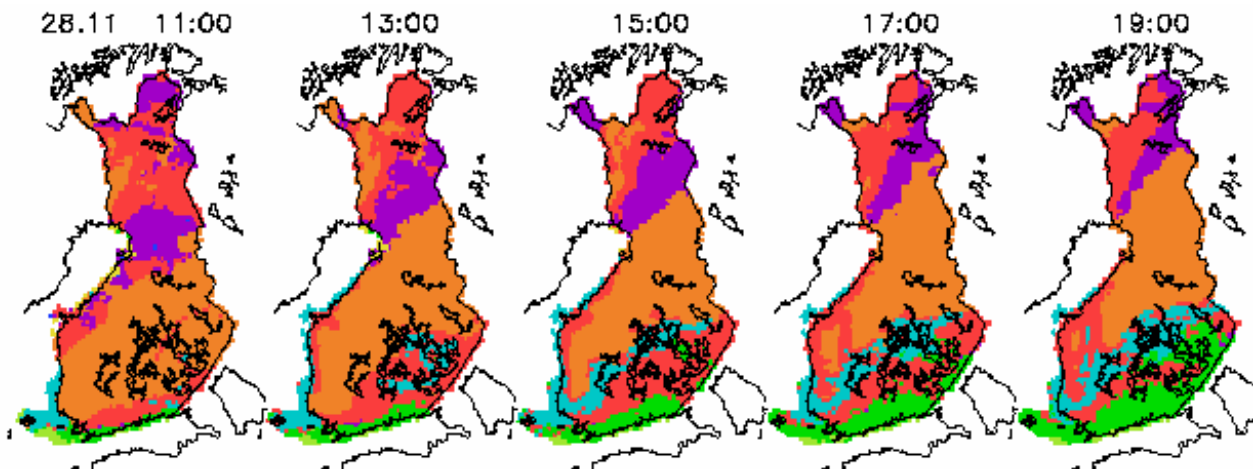
  - Red Hat Enterprise Linux

Computer resource development
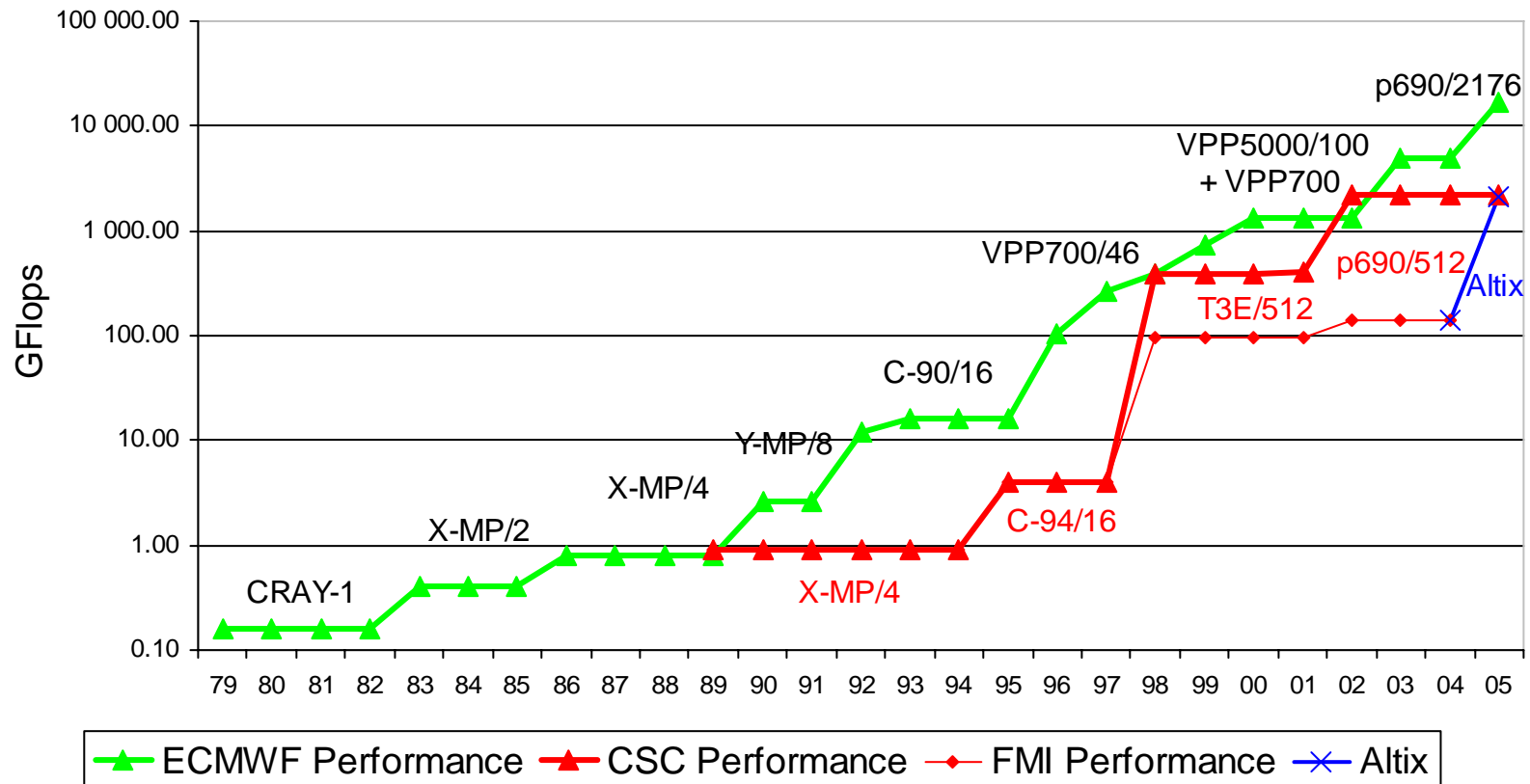
Hirlam applications

- **FMI public responsibilities**

  - environmental accidents

  - traffic condition warnings

- **SILAM :** long-range transport of chemicals and radioactive substances

- **Roadsurf :** road weather for traffic warnings

Areas of risk part-hr/100km2
11Z09DEC2005

28.11 11:00   13:00   15:00   17:00   19:00

Road condition

■ Dry snow	■ Wet snow
■ Icy	■ Wet
■ Partly icy	■ Damp
■ Frost	□ Dry

```
awk -F, '{for(i=2;i<=NF;i++){if($i==substr($1,length($1)-length($i),length($i))&&$i!=""){print "set -x";exit}}}'`
echo $trace,$VERBOSE|awk -F, '{for(i=2;i<=NF;i++){if($i==substr($1,length($1)-length($i),length($i))&&$i!=""){print "set -x";exit}}}'
++++ echo sh:,
++++ awk -F, '{for(i=2;i<=NF;i++){if($i==substr($1,length($1)-length($i),length($i))&&$i!=""){print "set -x";exit}}}'
+++ eval
# -----------------------------------------------------rcs stuff
# $Revision: 1.1 $, checked in by $Author: GCats $ at $Date: 1999/04/19 08:19:36 $
# $Log: Trace,v $
# Revision 1.1  1999/04/19 08:19:36  GCats
# Created from $HL_SCR, HIRLAM version 4.3.5, by Gerard Cats
#
set -k
++ set -k

$SMSBIN/smscomplete
+ /usr/people/sms/sms4.4.4/bin/smscomplete
SMS-> complete:/Hirlam_V637/06/Stop
date
+ date
Fri Dec  9 11:55:33 EET 2005
trap 0
+ trap 0
```

Kiitokset mielenkiinnosta !

Hir lam
High Resolution Limited Area Model

HIRLAM

FINNISH METEOROLOGICAL INSTITUTE

- Weather maps
- Baltic sea wind maps
- Meteograms
- Meteograms ABL
- Mast verification
- Statistical verification
- Monthly report
- Help and information

- Monitor window

Hirlam RCR

Meteograms

Western Finland
Espoo
Halli
Helsinki_meri
Helsinki-Vantaa
Hirlamsmossen
Hameenlinna
Kauhava
Kokkola
Maarianhamina
Niinisalo
Pori
Rauma
Rayskala
Tampere
Toholampi
Turku
Vasa
Eastern Finland
Joensuu
Jyvaskyla
Kuopio
Lahti
Lappeenranta
Mantyharju
Rantasalmi
Utti
Northern Finland
Ivalo
Kajaani
Kilpisjarvi
Kemi
Kittila
Kuhmo

Helsinki-Vantaa
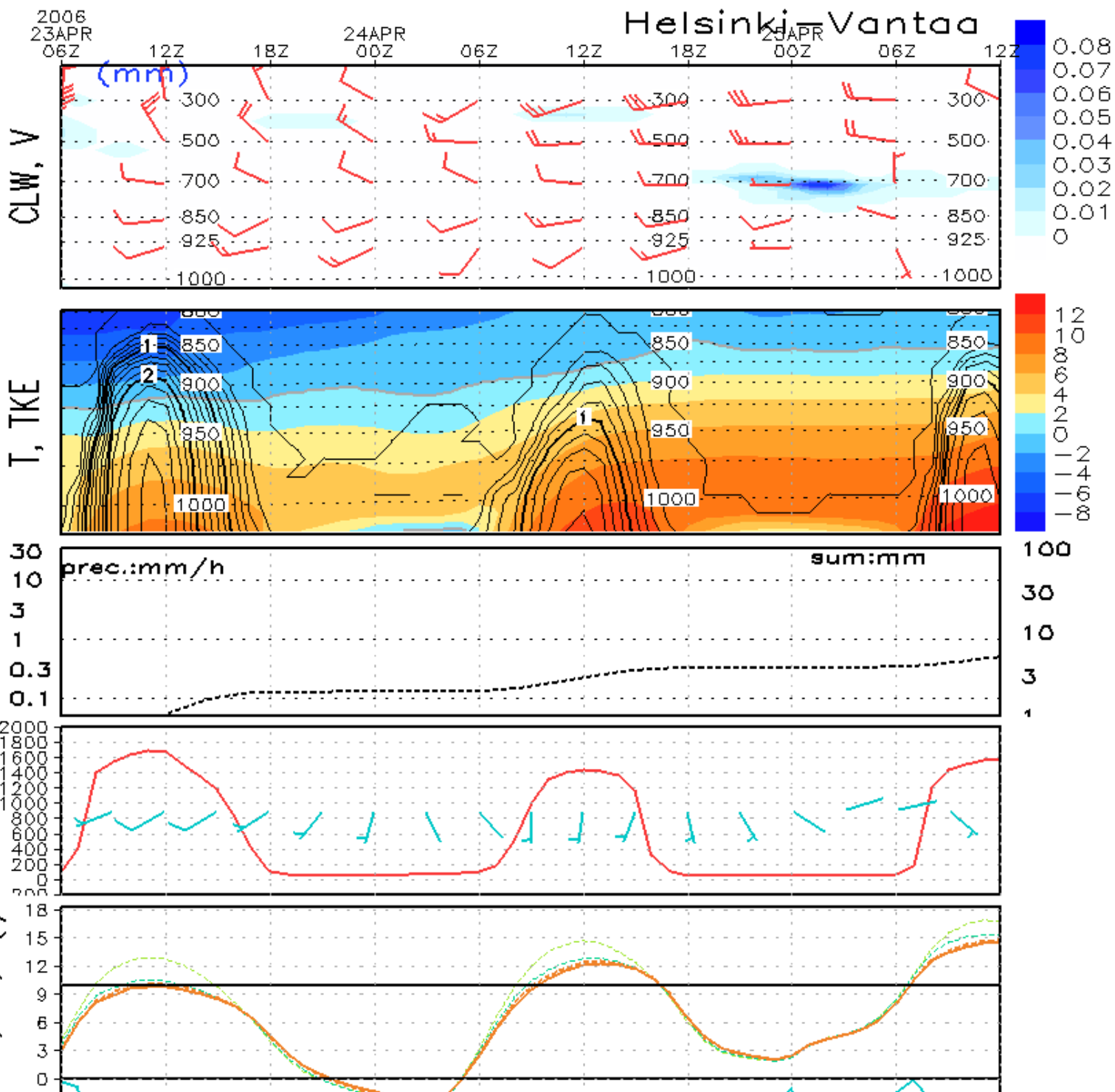
Kuusamo

Muonio

Oulu

Pudasjarvi

Rovaniemi

Salla

Sodankyla

Utsjoki

Other

Arlanda

Copenhagen

DeBilt

Dublin

Kaunas

Lulea

Madrid

Norrkoping

Oslo

Reykjavik

Riga

St.Petersburg

Tallinn

Toravere

Toulouse

Vilna

Updated
23.5.2005 by
MK
Comments to
Carl Fortelius
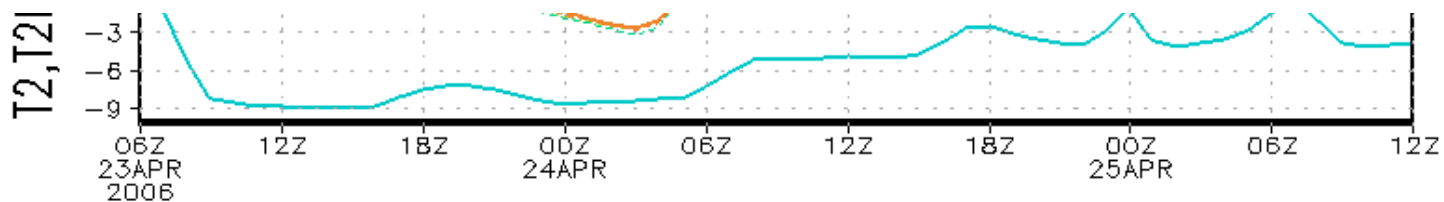
Selected grid-box: Lon=24.81 Lat=60.33 Elevation=51. m
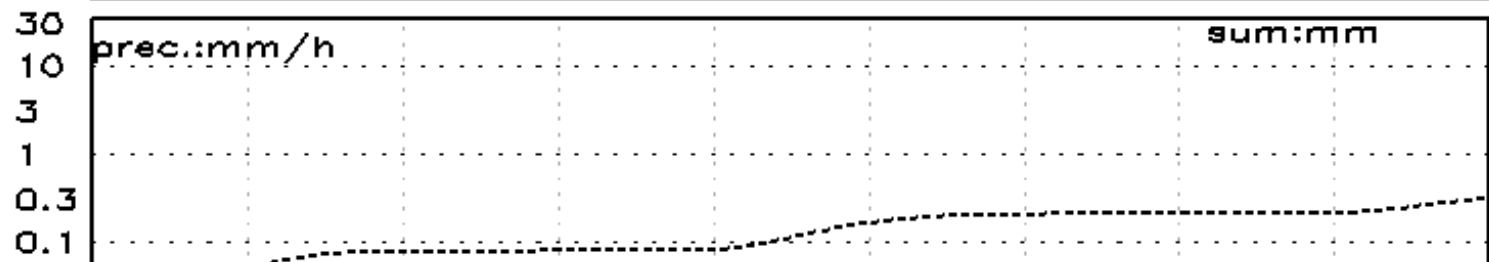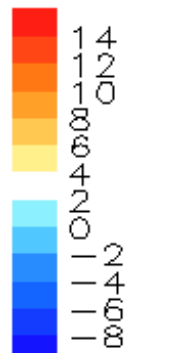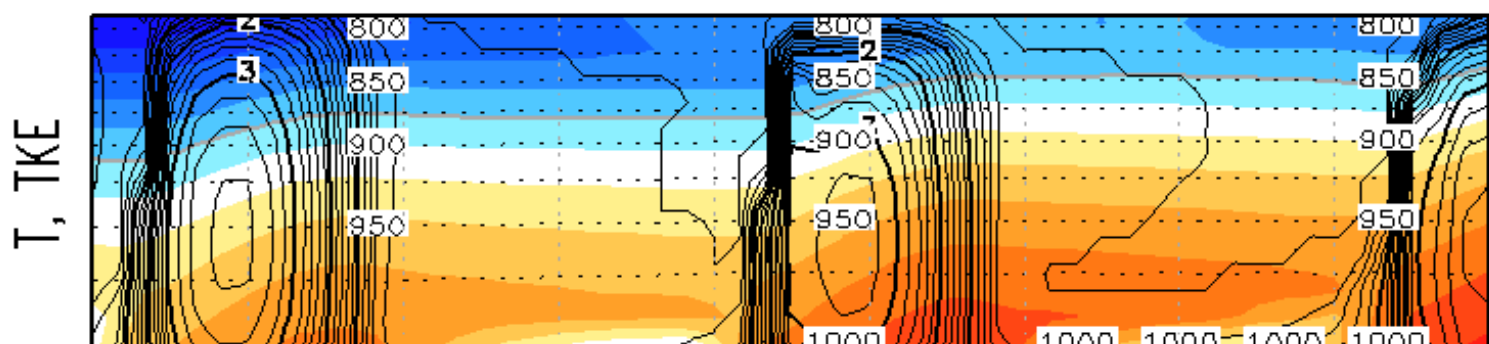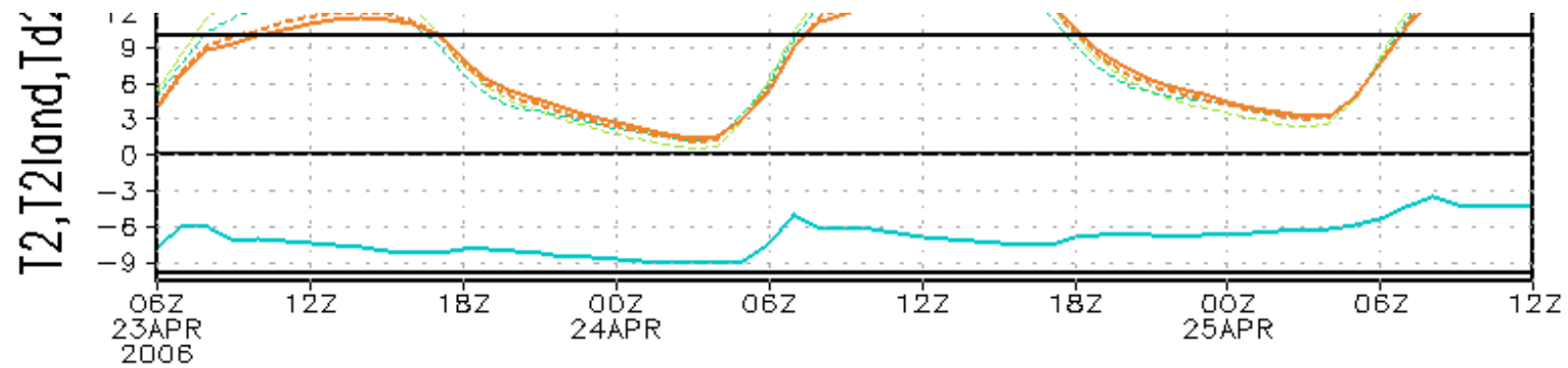Fractions: Land=1 Water=0 Ice=0 Bare land=0 Low veg=0.18 Forest=0.81

Hirlam RCR

Vilna
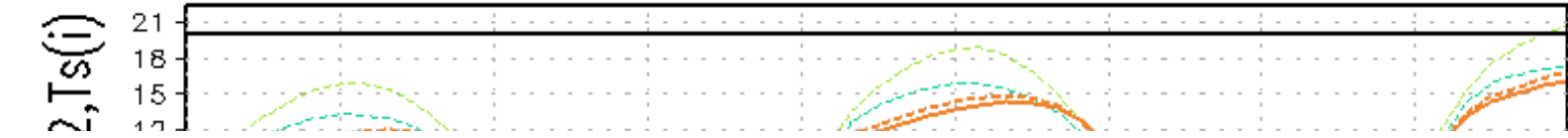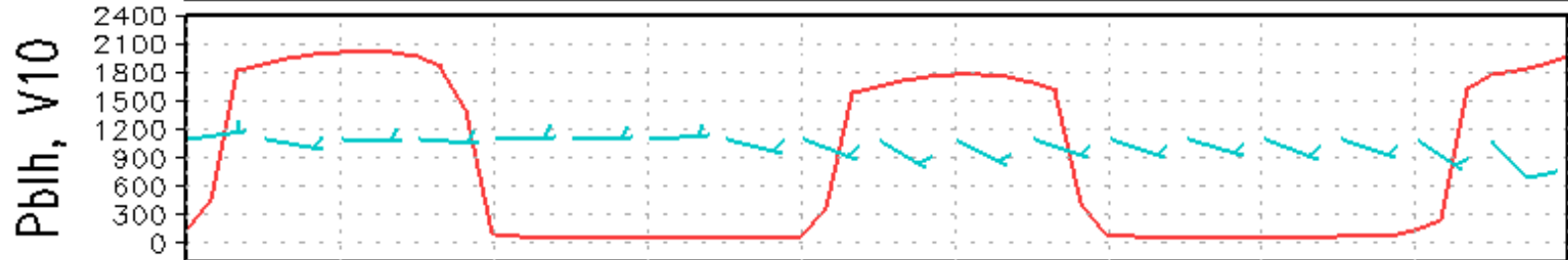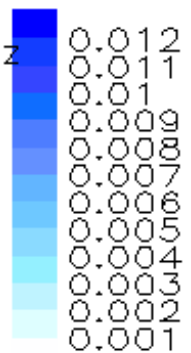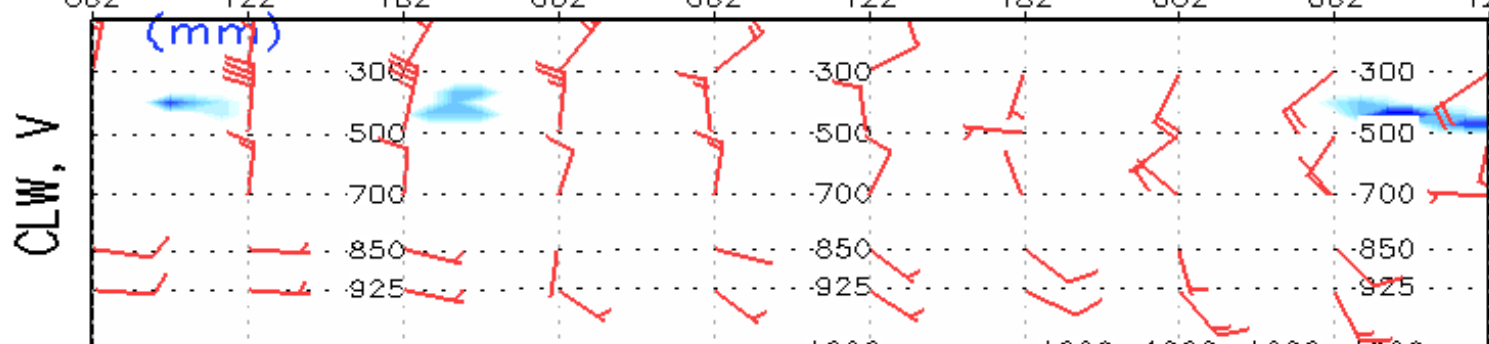
Selected grid-box: Lon=25.40 Lat=54.61 Elevation=176. m
Fractions: Land=1 Water=0 Ice=0 Bare land=0 Low veg=0.73 Forest=0.26