

European Regional Re- analysis (EURRA)

Expression of Interest
 from the
 Finnish Meteorological
 Institute

Reading, 22-23 Nov. 2005

MINISTRY OF TRANSPORT AND COMMUNICATIONS

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FMI STAFF & BUDGET

- **552 man-years:** women 41% , men 59%
- 265 in services ; **230 in Research** ; Others: 60 my
- 55% with University degrees, 15% PhD
- Budget 41 M€ 65% government,
35% from commercial/research contracts
- **40-50% of R&D activities externally funded:**
EC, ESA, EUMETSAT, Finnish Academy,
Tekes (Technology Development Centre)
- **Responsibilities for many ministries:** Transport, Defense,
Environment, Agriculture, Internal Affairs, Foreign Affairs

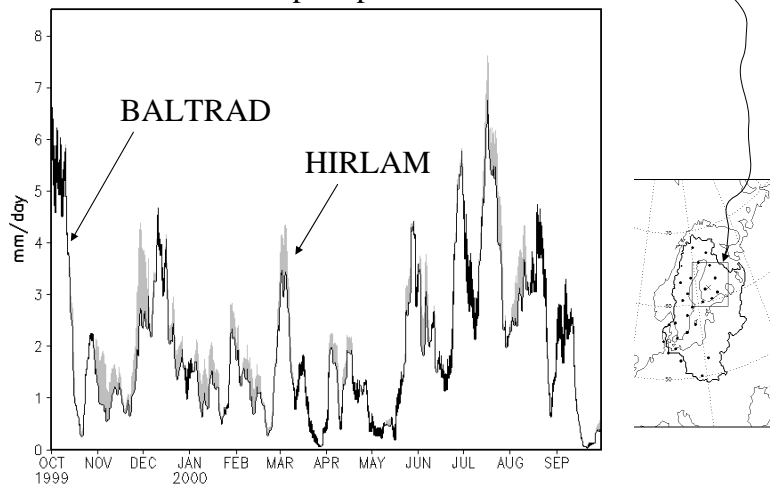
FMI experience in D/A systems (1/2)

- **Operational NWP since 1970**
- **HIRLAM Lead Centre for Reference System Runs (RCR)**
 - **Installation and operation (22 km, 40 levels)**
 - **V.6.3 + Baltic SST/Ice obs + Climatol. Lake obs**
 - **Monitoring of system and outputs:** obs coverage, D/A feedback, obs and field verification, on line verification (towers), forecasters' evaluation
 - **Distribution: archive @ECMWF**
 - **Unified developing environment (RCR-parallel)**
 - **Reporting**
- **Nested high-resolution version (9 km, 40 levels)**
- **New SGI Supercomputer**

FMI experience in D/A systems (2/2)

- **BALTEX Regional Re-analysis: “Climatic energy and water cycles by data assimilation”**
 - FMI, SMHI, DMI, ECMWF special project
 - HIRLAM + interactive SST/Sea ice models+ lake model
 - Oct. 1999...Sept. 2000
 - Described in: *Fortelius, Andrae, Forsblom, 2002: The BALTEX regional reanalysis project, Boreal Env. Res., 7, 193-201*

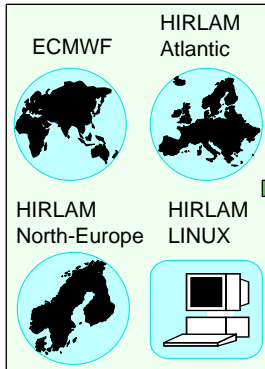
Areal precipitation



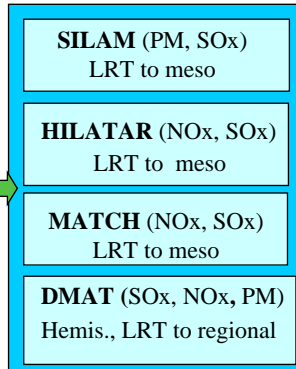
Forecast: 6-12 hrs
7-day running averages

FMI Modelling system

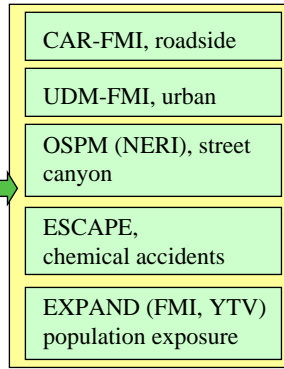
Weather prediction models



Dispersion models - long-range, regional



Dispersion and effects models – urban, local



Process models

MONO32 (U. Helsinki, Stadia), BUOYANT (micro): aerosol processes

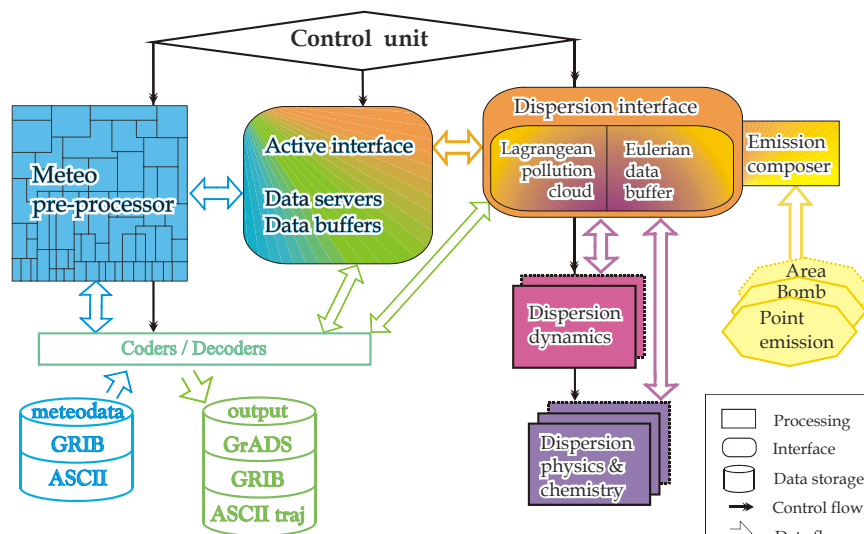
FMI regional dispersion modelling

- **Four models available:** two (SILAM and MATCH) are operationally available for various projects (e.g., GEMS RAQ).
- **Species**
 - SILAM: SO_x, size-resolved primary PM, radioactivity, natural allergens, probability outputs
 - MATCH: SO_x, NO_x, NH_x, O₃, radioactivity
- **EMEP emission data** for Europe, with interface to SILAM and MATCH models (standard EMEP resolution and time coverage)
- **Finnish national inventory:** 1 km resolution, 5 PM size classes, gases, 2000-2002.
- **RETRO Database** (global fields of concentrations of main pollutants)
- **Time variation emission coefficients** (GENEMIS, 1990 reference year)
- Technicalities: ECMWF IDs obtained, there is an in-house experience with MARS.

Features of SILAM v.3.5

- **Model**
 - 3D Lagrangian random-walk (refined advection)
 - 4D-VAR data assimilation & inverse problem (research only)
 - Capable of forward & adjoint simulations
 - Environment for operational automatic runs (updated)
 - Manual runs directly or via Graphical User Interface
- **Input**
 - Multiple point / area / nuclear-bomb emission sources
 - HIRLAM or ECMWF
- **Species**
 - Up to 496 nuclides with decay chains
 - Pollen grains
 - Inert aerosol (size resolved)
 - SO_x
 - Passive tracer

Meso-to-regional modelling system SILAM

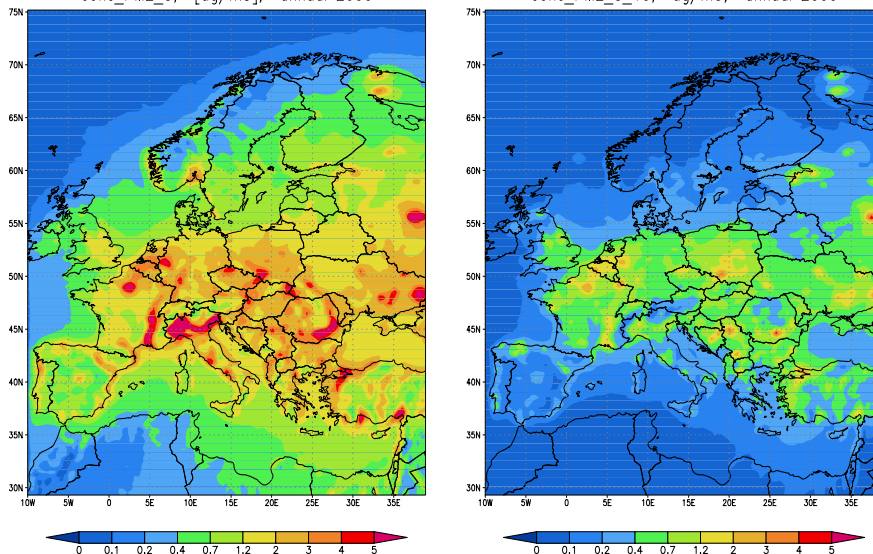


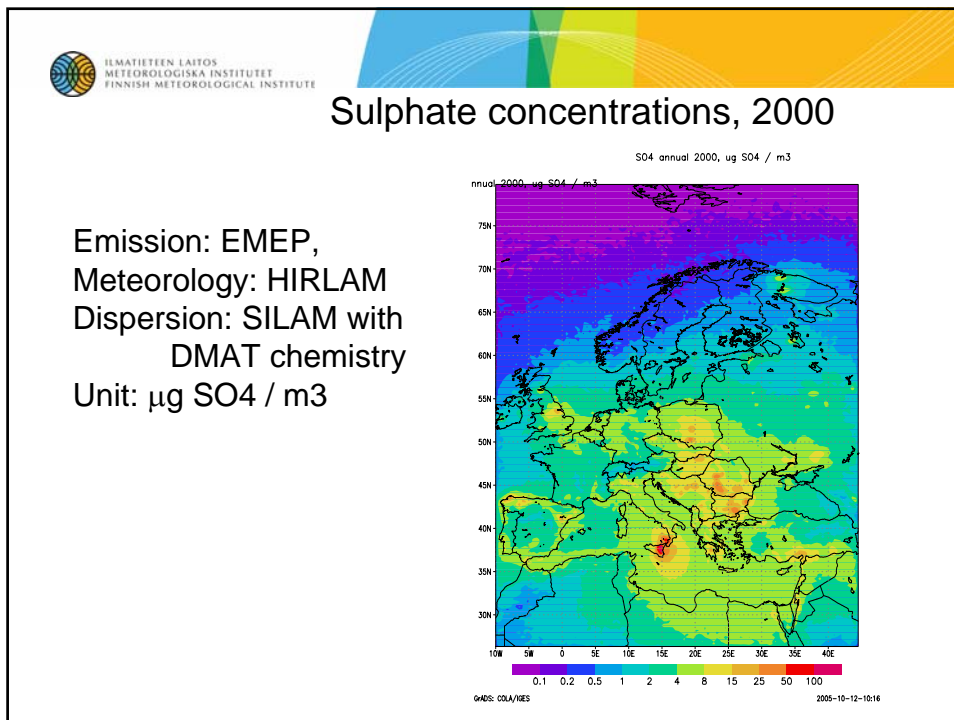
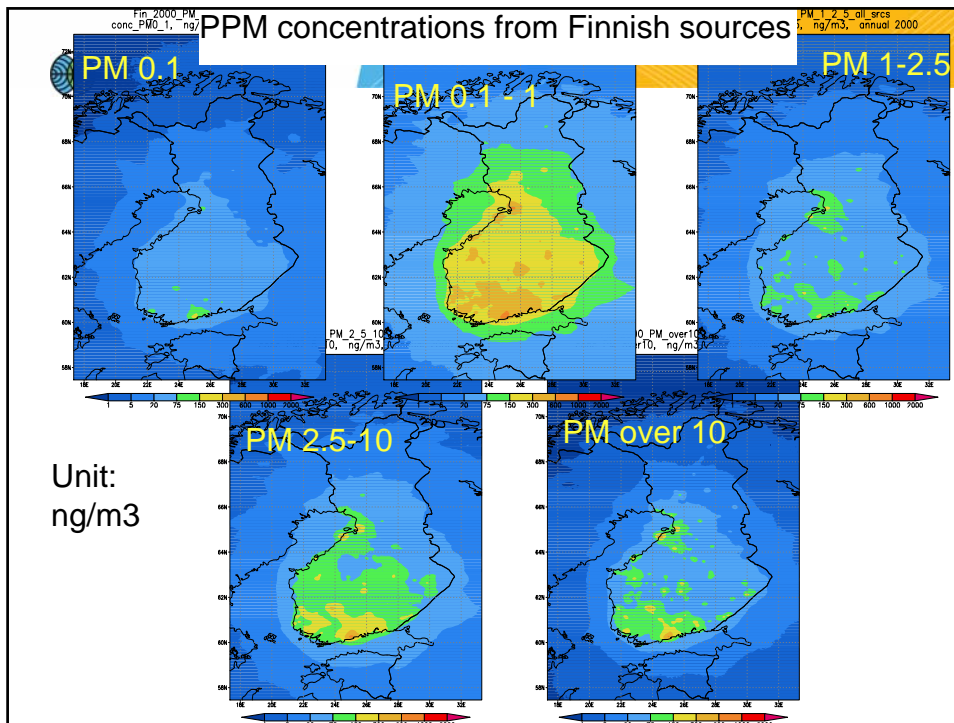
Some Applications

- **FMI: National Reference Centre of EEA for Air Quality (AirBase)**
- **FMI maintains national EMEP, HELCOM,.. air chemistry monitoring networks**
- **Re-analysis of PM from European and Finnish sources (on-going)**
 - **SILAM-model** with HIRLAM, ERA-40 as inputs
 - Period: 2000-2002
 - Spatial resolution: 20km (Europe), 5km (Finland)
 - Temporal resolution: 1 day / 1 hour for obs. campaigns (both)
 - Species: primary PM (BC, OC, non-combustion anthrop. dust), SO_x, sea salt.
- **Wind-blown dust over the Northern Hemisphere**
 - **DMAT-model** with as inputs post-processed NCAR re-analysis
 - Period: 1967-1988
 - Resolution: 150km, daily
 - Species: sand elevated during dust storms

European PPM concentrations, 2000

PM 2.5 model: SILAM, unit: $\mu\text{g}/\text{m}^3$ PM 2.5-10
EMEP_2000_att10_all_srcs_2001 conc_PM2_5, [$\mu\text{g}/\text{m}^3$], annual 2000
EMEP_2000_PM2_5_10_all_srcs conc_PM2_5_10, $\mu\text{g}/\text{m}^3$, annual 2000

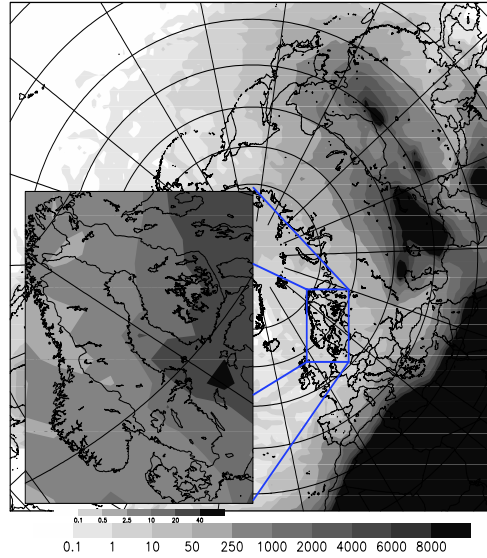
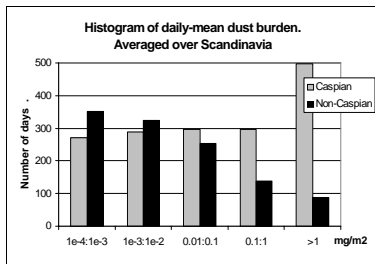




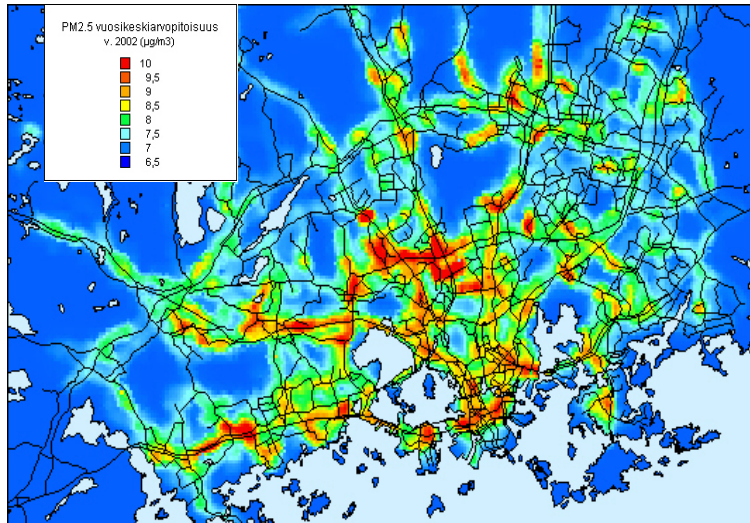
Wind-blown dust computations

Mean dust column burden (right),
mg/m², mean 1967-88 (N.B.:
different scale for the enlarged area)

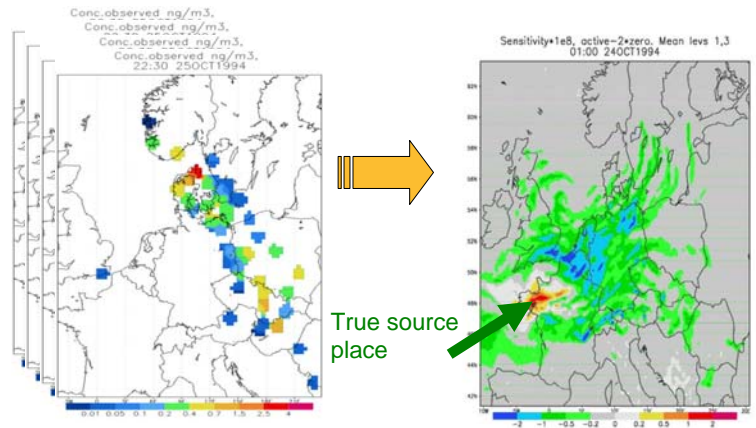
Episode statistics for Caspian /
non-Caspian dust storms (below)



PM_{2.5} -yearly average concentrations- all emissions 2002

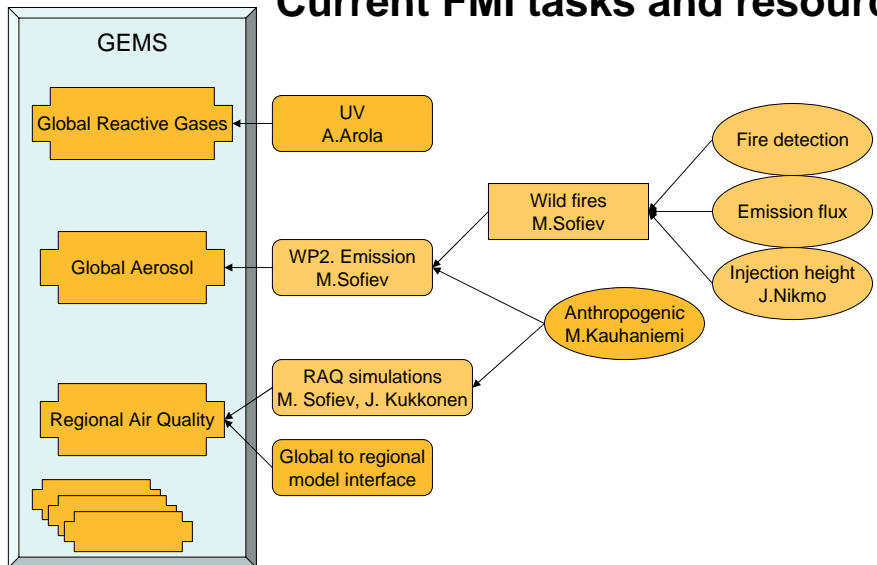


Inverse problem solution with SILAM using 4DVAR

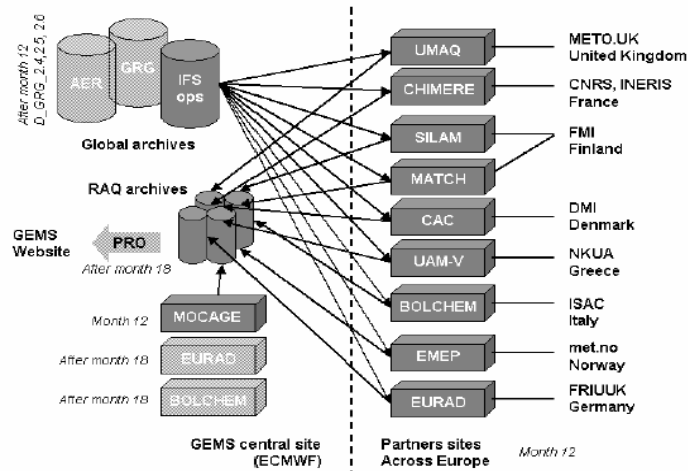


European Tracer Experiment ETEX-1:
 Left panel: observations [ng m^{-3}] ; Right: probability density for source location [m^{-2}]

Current FMI tasks and resources



GEMS: Regional Air Quality subproject



Stratospheric Chemical Data Assimilation

- Data from atmospheric chemistry satellites are restricted by the orbit of the satellite, are not always continuous and data quality vary from one measurement to another.
=> harmonisation of datasets using assimilation of data into chemical-transport models.
- **3D chemical-transport model FIN-ROSE used for D/A**
FIN-ROSE model is dynamically **forced by ECMWF** meteorological data in order to ensure correct dynamics.
- **Satellite data** (O₃) from GOMOS instrument (Envisat) and from OSIRIS instrument (Odin).
- The chemical assimilation method is so-called sequential assimilation (**Kalman filter**). The model and assimilation scheme known as FASP (Finnish Assimilation System of Profiles).
- Radiative transfer development
- Inverse modelling

RE-analysis of the TROpospheric chemical composition over the past 40 years

- **RETRO aims at establishing global fields of concentrations of key pollutants**, and analysing their trend and variability.
- Based on:
 - Several sophisticated global chemistry transport models
 - A variety of data sets (**ERA-40**) from ground based, air and space borne measurements.
 - Consider key pollutant species (O₃, CO, NO_x, HNO₃, SO₂, VOC), key compounds in tropospheric oxidation (O₃, OH, H₂O₂, CO, CH₄), and key compounds for radiative forcing (CO₂, CH₄, O₃, sulphate, black carbon, organic carbon, dust, sea salt, H₂O, CFCs).
- **FMI produces stratospheric boundary conditions for O₃ for tropospheric chemistry-transport models (1957-2002)**
- Estimates surface UV changes over the last 40 years.

CANDIDOZ: Chemical and Dynamical Influences on Decadal Ozone Change

- **FMI Coordination (2002-2005)**
- **Objectives:**

To establish scientific basis for the detection of the earliest signs of O₃ recovery from Montreal protocol and its amendments.
- Approach relies on **comprehensive global data analysis** and global modelling involving most recent long-term data sets of meteorological analysis.
- Based on **long-term O₃ and meteorological data sets** available (from [ECMWF](#) and [NCEP](#)).
- Meteorological data allow to determine the dynamical changes and trends and assess their role in re-distribution of stratospheric ozone in recent decades.

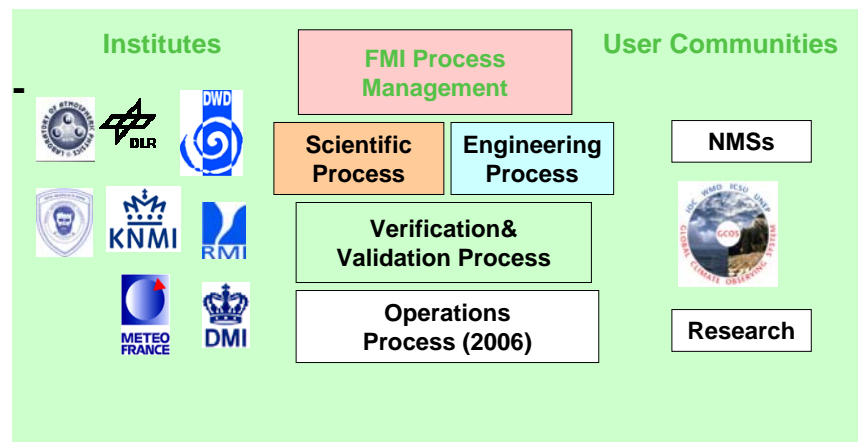


ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

EUMETSAT Satellite Application Facility on Ozone Monitoring and UV

- O3-SAF development **led by FMI** since 1997 => AC-SAF (2006)
- To design a facility to process satellite-acquired data on O3, other trace gases, aerosols and UV radiation.
- SAF specifies and **designs algorithms** to be used in the EUMETSAT Central Facilities for processing total O3 data produced by the MSG instrumentation.
- When operational, the SAF **will produce near-real-time products** derived primarily from EPS-data (until then from current satellite systems such as ERS-2 GOME + NOAA/TOVS).
- Available data: UV fields, total O3, O3 profiles and total amounts of chemically important gases such as NO2, chlorine dioxide (OCIO), and bromine oxide (BrO) as well as stratospheric aerosols.
- Data to be archived for later access by researchers. Data products distributed to users.

EUMETSAT Satellite Application Facility on Ozone Monitoring



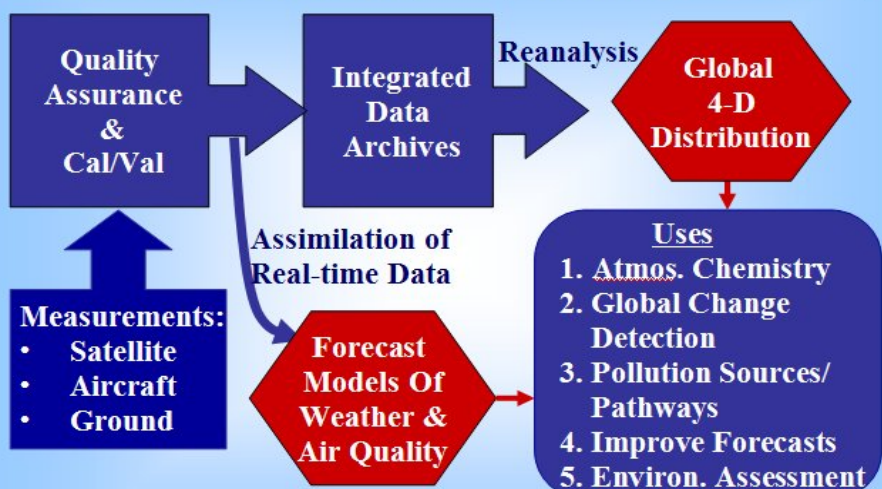
Other Satellite data activities

- **FMI Satellite Data Centre (ESA): data analysis for research needs:**
 - ESA ENVISAT environmental satellite GOMOS O3 data: 2002-2008
 - Odin satellite OSIRIS O3 data: 2001-2006.
- **Activities extended in 2004 also towards data reception, archiving and user services:**
 - NASA EOS/Aura satellite **OMI** O3 and UV-data: 2004 - 2007, reception and processing
 - NASA EOS/Terra and Aqua satellites **MODIS** data 2003-2007, reception and processing
 - UV-data (2006 – 2020), processing, archiving and user services
 - European UV database (EUVDB)
- **Other SAF involvements:** Climate Monitoring, Land Surface Analysis, Operational Hydrology and Water Management.
- **PROMOTE (PROtocol MO尼Toring for the GMES Service Element: Atmosphere):** ESA Service Consolidation actions of the Earthwatch GMES Services Element (GSE)
- **WMO IGACO-O3 Secretariat** (Integrated Global Atmospheric Chemistry Observations) at **FMI**

The IGACO System Components

The Data Stream

Products & Uses



1. Reprocessing of the ERA-40 Observations

- FMI responsible of the operational running of the HIRLAM reference system.
- => Reprocessing ERA-40 observations and re-analyses with the HIRLAM data-assimilation system.
- => Regional scale re-analyses of atmospheric fields to be subsequently used for evaluating pollutant concentrations in the troposphere (& stratosphere).

2. Re-analyses of Atmospheric Pollutant Concentrations

- Coordinate/contribute to the modelling of pollutant concentrations in the troposphere using regional scale dispersion and chemistry models.
- Multi-model ensemble approach involving models used at various NMS's.
- FMI to use regional models SILAM and MATCH, and hemispheric model DMAT.
- Evaluation of European high-resol. concentrations of S- and N-compounds, O₃ and PM.
- Strong expertise on aerosol processes and relations with fine PM concentrations.
- PM modelling including both anthropogenic and natural emissions + evolution of size spectrum and chemical composition (coordination of global aerosol emissions in GEMS).

3. Evaluation of Tropospheric Trace Gas Columns

- FMI hosts EUMETSAT SAF on Ozone-UV Monitoring (=>Atmospheric Chemistry) to produce a set of near real-time and offline products and validation services.