GEMS: Global Earth system Monitoring using Space and in-situ data
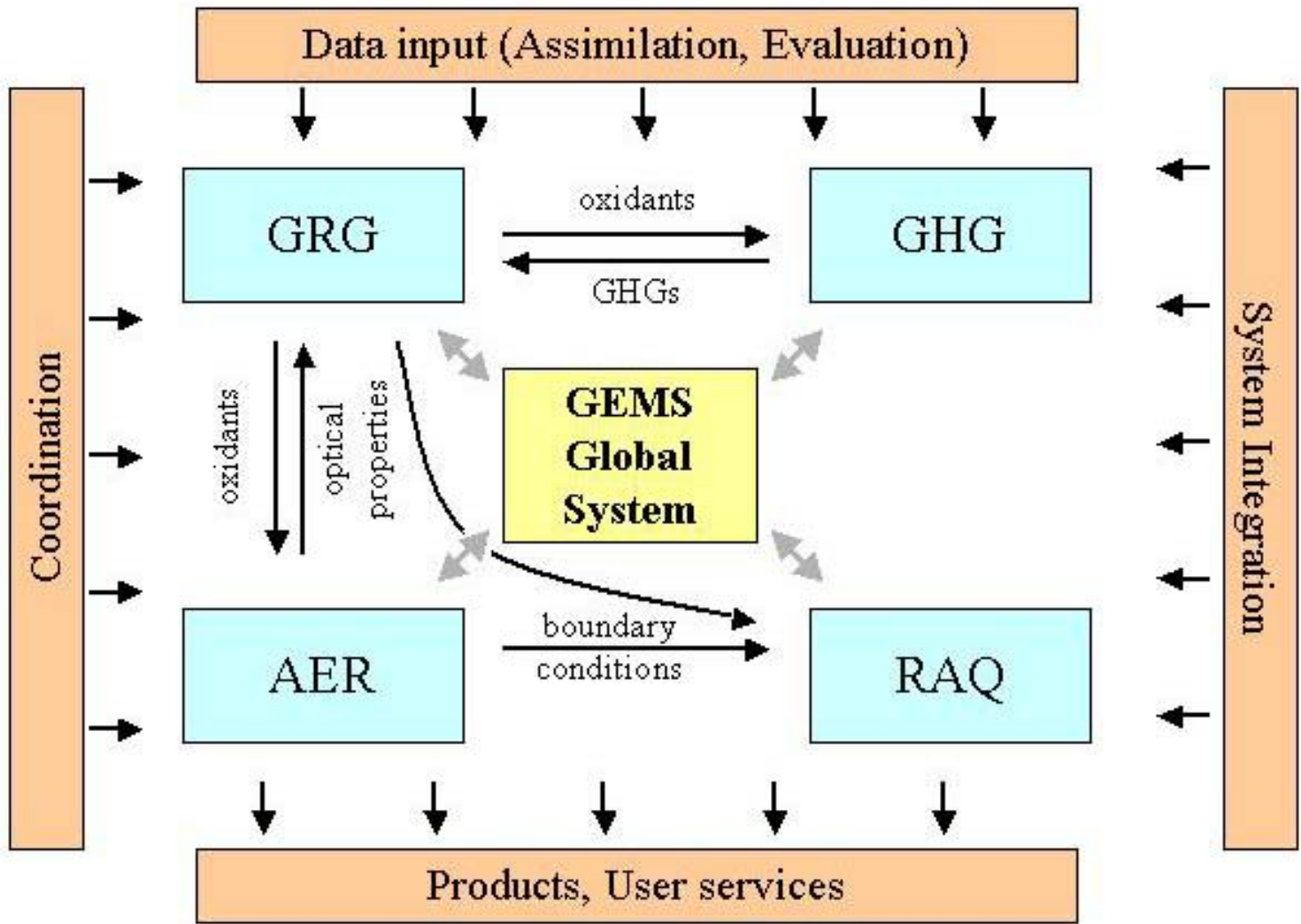
Links between the main elements of GEMS :

Greenhouse Gases (GHG), Global Reactive Gases (GRG), Global Aerosol (AER), Regional Air Quality (RAQ) & ECMWF global assimilation system.

GI

- **Greenhouse Gases**   A.Chedin (LMD-CNRS)

- **Reactive Gases**   G.Brasseur (MPI)

- **Aerosols**   O.Boucher (HC-MO)

- **Regional Air Quality**   V-H.Peuch (Meteo.Fr)

- **Validation**   H.Eskes (KNMI)

- **Production System**   A.Simmons, H.Boettger, J-N Thepaut, A Dethof, R Engelen, JJMorcrette (ECMWF)

- **Coordinator**   A.Hollingsworth (ECMWF)

GEMS   Research and Technical Goals

Build an <u>operational</u> thoroughly-validated assimilation system for atmospheric composition and dynamics, by 2008!

- **Delivering**
  - Daily global monitoring of atmospheric dynamics & composition
  - Improvements in daily regional air quality forecasts
  - Monthly / seasonal estimates of surface fluxes for CO_2 and other species
  - Extended reanalyses of composition & dynamics for validation, and in support of GCOS

- **Using**
  - Best available models, assimilation systems
  - Best available in-situ data
  - Best available satellite data and algorithms

- **Collaborating with MERSEA & GEOLAND to implement IGOS_P Themes on**
  - Carbon Cycle
  - Atmospheric Chemistry

Satellite observations assimilated by ECMWF operations, as of September 2003

- AQUA AIRS
- 3xAMSUA (NOAA-15/16/17) + AQUA AMSUA
- 3 SSMI (F-13/14/15)
- 2xHIRS (NOAA-16/17)
- 2xAMSU-B (NOAA-16/17)
- Radiances from 5xGEOS (Met-5/7 GOES-9/10/12)
- Winds from 4xGEOS (Met-5/7 GOES-10/12)and MODIS/TERRA
- SeaWinds from QuiKSCAT
- ERS-2 Altimeter / SAR (limited coverage)
- SBUV (NOAA 16)
- ENVISAT OZONE (MIPAS)

26 satellite data sources!

Environmental Concerns have triggered $25B for New satellite missions in 2001-2007

N.America	Europe / Collabs.	Asia /Collabs.
	JASON-1	
TERRA	ENVISAT	ADEOS-II
AQUA	MSG	GPM
SSMI/S	GOCE	COSMIC
AURA	CRYOSAT	
CALIPSO	METOP	
CLOUDSAT	ADM	
OCO		
HYDROS	SMOS	•Already launched
GIFTS		•To be launched

Main phases of GEMS work at ECMWF

|	
Month 1-12	Build and validate 3 separate assimilation systems for Greenhouse gases, Reactive gases, Aerosol; acquire data; build web-site
Month 13-24	Produce 3 different reanalyses for Greenhouse gases, Reactive gases, Aerosol; make them available for validation by all partners; feedback to data providers
Month 25-30	Merge the 3 assimilation systems into a unified system; upgrade the models and algorithms based on experiences of trial reanalyses
Month 31-42	Produce unified reanalyses for Greenhouse gases, Reactive gases, Aerosol; build operational system, with operational interfaces to partners
Month 43-48	Final pre-operational trials; documentation; scientific papers

GEMS AEROSOL Global Monitoring System

Leader: O. Boucher
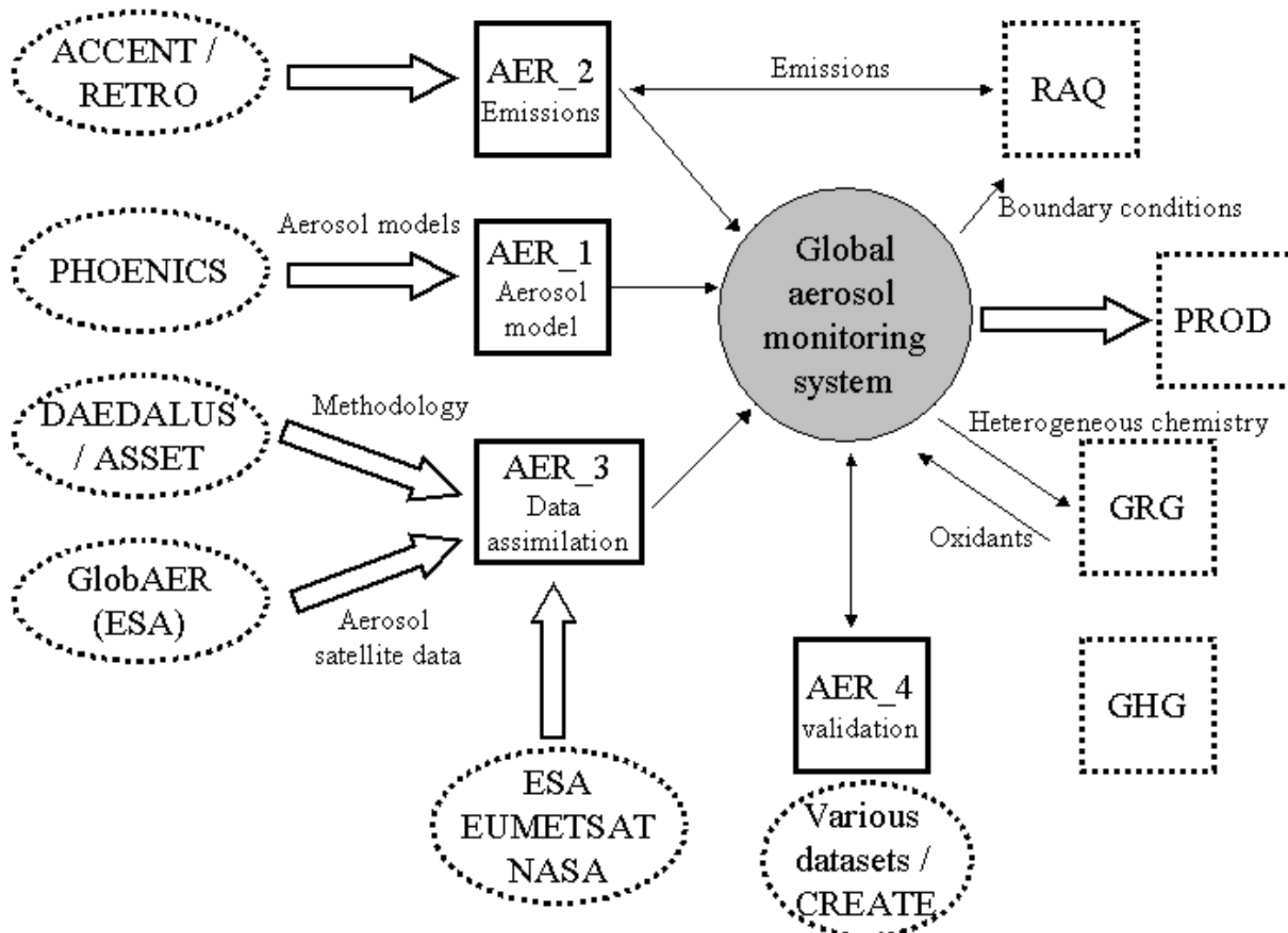
GEMS Aerosols

- **AER_1: Implementation of the direct physical aerosol model in the ECMWF model** *(O.Boucher, J. Feichter)*

  > *implementation of parameterisations for tropospheric aerosols*

  > *implementation of parameterisations for stratospheric aerosols*

  > *implementation of new emission inventories*

  > *implementation of aerosol optical properties*

  > *production of test simulations*

  HC-MO, MPI-M, CEA-LSCE, ECMWF, SA-UPMC

- **AER_2: Refinement of aerosol emission sources** *(M.Sofiev)*

  > *update and assimilation of the anthropogenic emission inventories of aerosol and its precursors*

  > *assimilation of information on wild fires*

  > *quantification of the wind-blown dust emission from desert areas*

  > *quantification of the wind-blown sea salt emission*

  > *sources of stratospheric aerosols*

  FMI, CEA-LSCE, MPI-M, SA-UPMC

GEMS Aerosols

- **AER_3: Aerosol data assimilation** *(J-J Morcrette)*

  > *adaptation of RT codes for SW and LW radiances in nadir geometry*

  > *preparation and harmonisation of aerosol satellite data sets*

  > *error covariance matrices*

  > *test of a 1D-Var system using aerosol products*

  > *test of a 1D-Var system using aerosol radiances*

  ECMWF, CEA-LSCE, HC-MO, SA-UPMC

- **AER_4: Evaluation of the model and analyses** *(C.O'Dowd, I. Chiapello)*

  > *assessment of diagnostics and skill scores*

  > *evaluation of aerosol radiative properties and associated radiative fluxes*

  > *evaluation of aerosol physico-chemical properties*

  > *analysis of model results with respect to air quality*

  NUIG, CNRS-LOA, CEA-LSCE, DWD, ECMWF, MPI-M, RMIB, SA-UPMC

Agency	Mission	Instrument	Parameters	Data volume
				per day of satellite
				life (Mb)
ESA	ENVISAT	MERIS	AerOpDepth @0.865	~250 max
			Angstrom coefficient	
			Radiances 7 WL	
ESA	ERS-2	ATSR	Radiances used in	TBD
	ENVISAT	AATSR	GLOBAER project	
EUMETSAT	MSG	SEVIRI	Radiances	low/moderate
	MSG	GERB	Radiation budget	low/moderate
NASA	TERRA	MODIS	AerOpDepth	~600
	AQUA		Type	
			Size distribution	
			Radiances	
NASA	AURA	HIRDLS	AerOptThickn 4 WL	low/moderate
NASA		SAGE-2	AerOptThickn 8 WL	low, available from
		SAGE-3	AerOptThickn 8 WL	Web

GEMS Aerosols: products @ end of contract

- **Analysis** of aerosol-related observations at ERA40 resolution (T_L159 L60 $[1.125 \text{ deg}]^2$) four times a day
- Total optical thickness at ~0.5 μm   OCEAN
- Angstrom coefficient (or τ at~ 0.865μm)   "
- Total optical thickness at ~0.5 μm   LAND

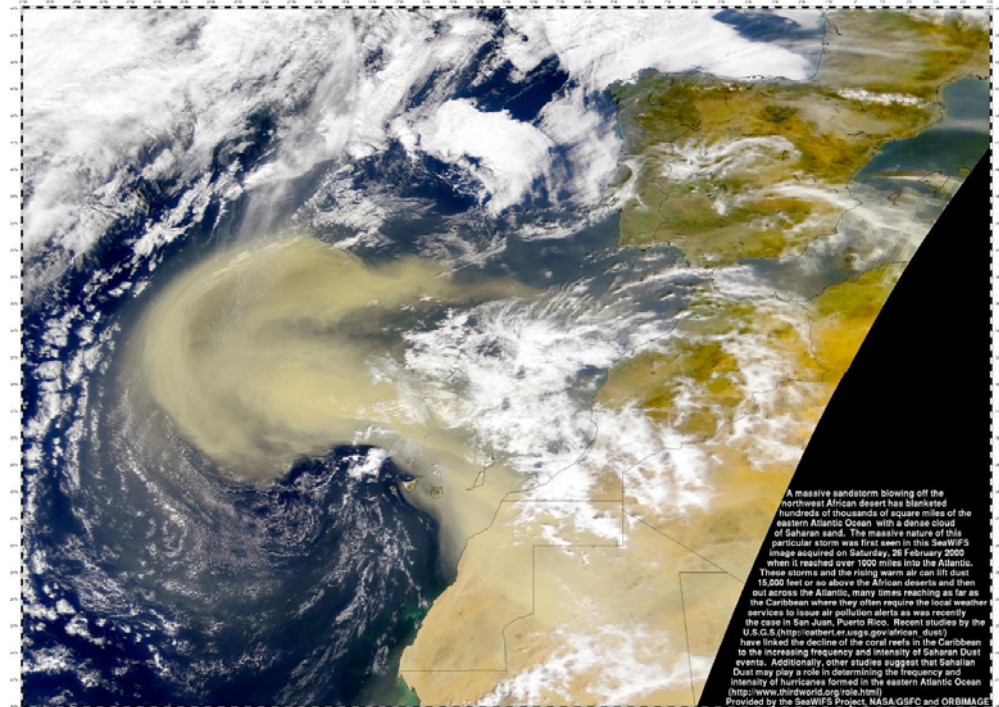- **From model 12-hour forecasts used in assimilation cycle**
  - .Up to 15 mixing ratio profiles of aerosols
    - sea salt   3 bins   **1st stage**
    - desert dust 3 bins
    - organic   **2nd stage**
    - black carbon, carbonaceous
    - sulfate
    - "stratospheric"
  - .Corresponding 2D-fields for sources and sinks

GEMS-AEROSOL: initial steps at ECMWF

JJMorcrette, A.Benedetti, S.Sourrar, A.Beljaars, P.Bechtold, A.Untch

- **Introduce aerosol prognostic variables in the Integrated Forecast System and assimilate global aerosol information**

- **Instruments:** MERIS, MODIS x 2, MISR, SEAWIFS, POLDER

- **R/T** **6S**

- **Modelling** **LMDZ**

- **Sources/Sinks** **LMD-Inca**

- **Data Assim. 1DVar**

- **Variables** τ**, radiances**

- **Validation AERONET**

A massive sandstorm blowing off the northwest African desert has blanketed hundreds of thousands of square miles of the eastern Atlantic Ocean with a dense cloud of Saharan sand. The massive nature of this particular storm was first seen in this SeaWiFS image acquired on Saturday, 26 February 2000 when it reached over 1000 miles into the Atlantic. These storms and the rising warm air can lift dust 15,000 feet or so above the African deserts and then out across the Atlantic, many times reaching as far as the Caribbean where they often require the local weather services to issue air pollution alerts as was recently the case in San Juan, Puerto Rico. Recent studies by the U.S.G.S (http://ealbert.er.usgs.gov/african_dust/) have linked the decline of the coral reefs in the Caribbean to the increasing frequency and intensity of Saharan Dust events. Additionally, other studies suggest that Sahalian Dust may play a role in determining the frequency and intensity of hurricanes formed in the eastern Atlantic Ocean (http://www.thirdworld.org/role.html)
Provided by the SeaWiFS Project, NASA/GSFC and ORBIMAGE

- Contract started 1 March 2005
- Official GEMS kick-off meeting: 4-6 July 2005, Hamburg
- GEMS/ECMWF Seminar 5-9 September 2005, Reading

END

thank you for your attention!

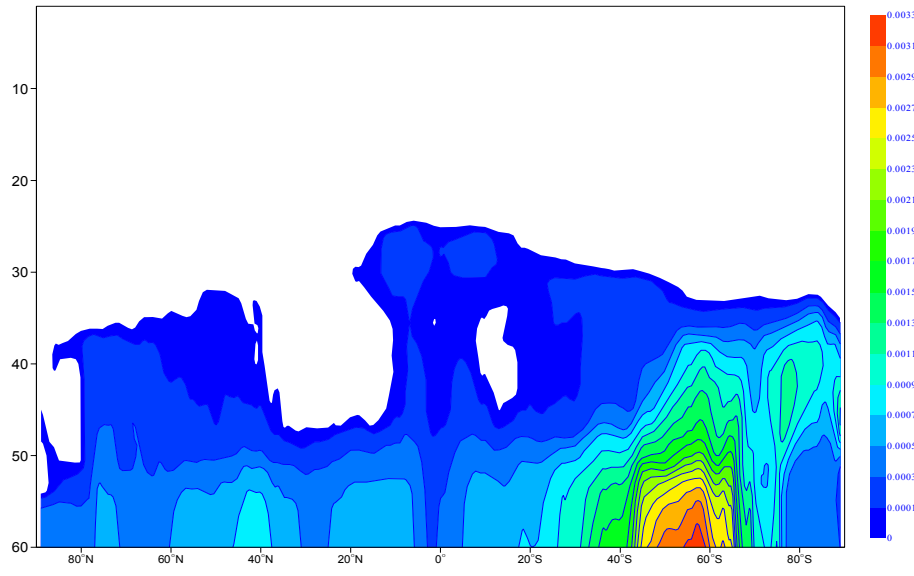Average of aermr01 20010501 1200 step 120 Expver en20 (180.0W-180.0E)

Table 2.7.3 Satellite Data on Aerosols to be used in GEMS

Agency	Mission	Instruments	Species	Data Volume per day of satellite life (MB/day)
ESA	ENVISAT	**MERIS**	Aerosol Optical Depth at 865 nm Aerosol Epsilon Factor Radiances	TBD (target ~250MB/day maximum)
ESA	ERS-2 ENVISAT	**ATSR AATSR**	Radiances used in GLOBAER project	TBD
EUMET	MSG	**SEVIRI**	Radiation budget Radiances for inversion	TBD low-moderate volume
	MSG	**GERB**	Radiation budget Radiances for inversion	TBD low-moderate volume
NASA	TERRA	**MODIS**	Aerosol optical depth / Type / Size Distribution Radiances	600