Recommendations for a Global Fire Assimilation System (GFAS) in GMES

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Outline

- **Introduction**
- **Review of Available Data**
- **Recommendation: Global Fire Assimilation System (GFAS)**
- **Recent Developments in GEMS**
- **Summary**

INTRODUCTION

Significance for Land Monitoring

- **Wildfires are an important sink mechanism for the terrestrial carbon pools in the global carbon cycle.**
  - **wildfire emissions, typical global values: 1.5 – 4 Gt C / year**
  - **fossil fuel emissions of Europe + North America: 3 Gt C / year**

- **Wildfire behaviour characterises land cover types with repeated fire events.**
  - **typical fire repeat period**
  - **typical fire intensity**
  - **typical fire seasonality**
  - **…**

- **Wildfires can change the land cover type irreversibly**
  - **tropical deforestation**
  - **…**

Atmosphere: Biomass Burning (BB) Emissions ...

AIR QUALITY:

- **… can dominate local and regional air quality with poisonous smoke**
- **… can elevate background of atmospheric pollutant after long range transport** [Stohl et al. 2001, Forster et al. 2001, Andreae et al. 2001]

POLLUTION CONTROL:

- **… significantly contributes to global budgets of several gases**
  - **Kyoto, CLRTAP, …**

WEATHER: (absorbing aerosols)

- **… influences the radiative energy budget** [Konzelmann et al., JGR 1996]
- **… provides cloud condensation nuclei** [Andreae et al., Science 2004]
- **Heat release accelerates deep convection.** [Damoah et al., ACP 2006]

REMOTE SENSING:

- **… affects essential a priori information for remote sensing (AOD, profiles)**

CHALLENGE:

- **… are highly variable on all time scales from hours to decades**

Biomass Burning in GMES

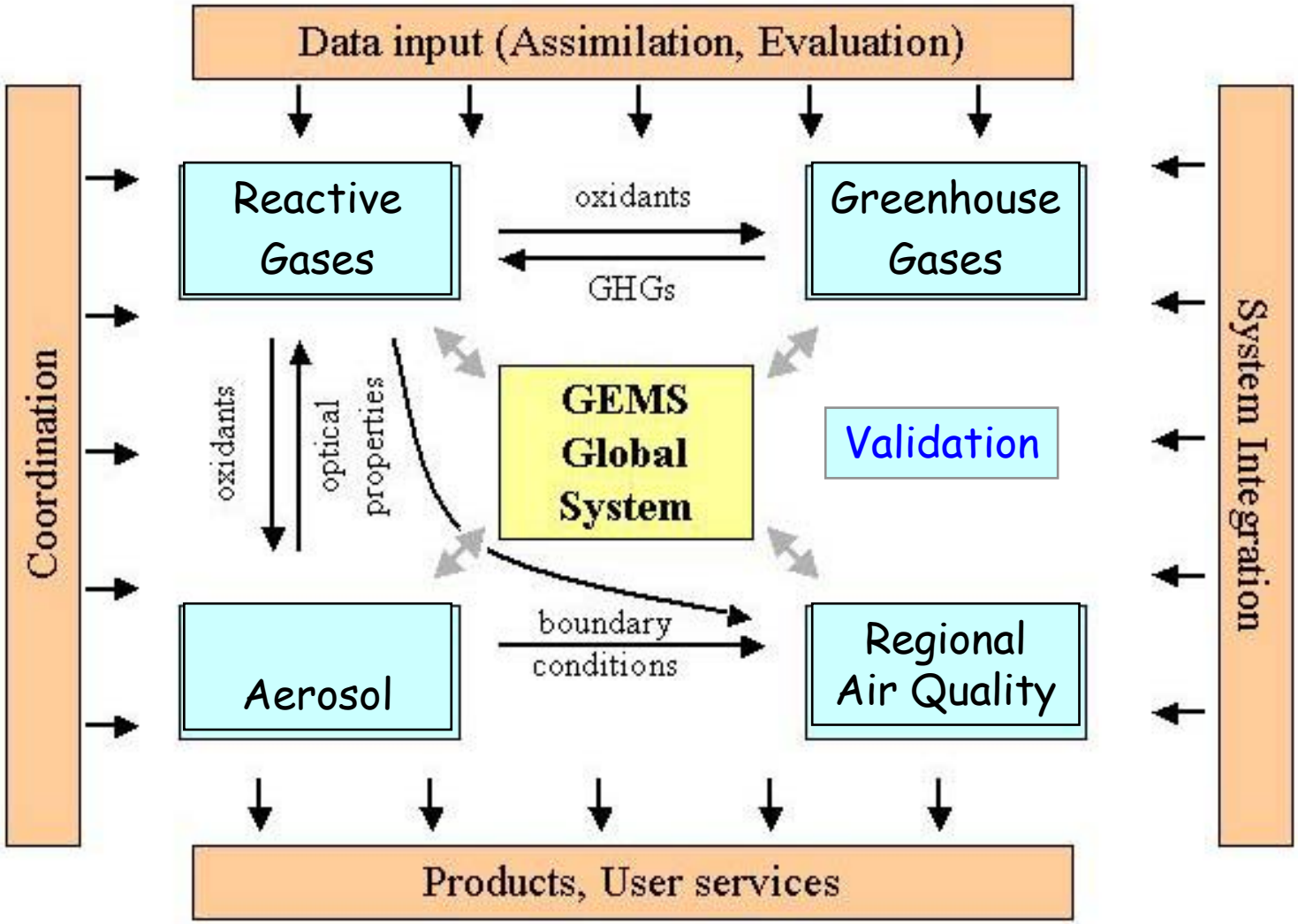
- **GMES is an initiative by EU and ESA. It aims at designing and establishing a European capacity for the provision and use of operational services for Global Monitoring of Environment and Security.**
- **The integrated project (IP) GEMS develops the atmosphere monitoring system for GMES.**
- **The integrated project (IP) GEOLAND develops the land monitoring system for GMES.**
- **Biomass Burning (BB) is a major interface between both the atmosphere and land monitoring systems.**

Global Earth-system Monitoring using Space and in-situ data – GEMS

- **Creation of an operational system for greenhouse, reactive gases, and aerosols in the troposphere and in the stratosphere on the regional and on the global scale by 2009.**
- **Production of near-real-time and retrospective analyses of global monitoring, and medium and short range forecasts of atmospheric chemistry and dynamics.**
- **Information relevant to the Kyoto and Montreal protocols, to the UN Convention on Long-Range Trans-boundary Air Pollution.**
- **Regional Air Quality Forecasts for Europe.**

Organisation of the GEMS Project

GEMS is organised in 6 projects



Scientific recommendations
Land-Atmosphere: Biomass estimates

Land Carbon component of GEOLAND

Objectives

- Improve the current carbon accounting systems

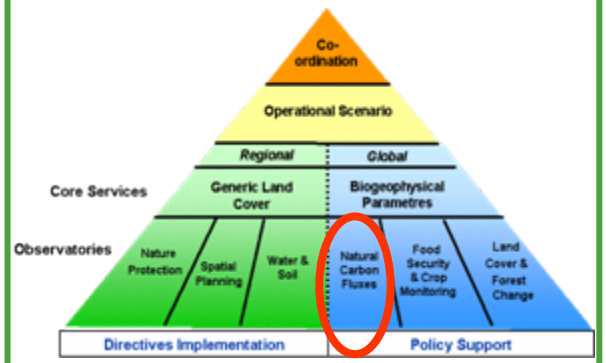
(i.e. National forest inventories with a sampling time of about 10 years)

- Address all temporal scales (hour to decade)

- Global/continental maps on a regular grid:
  - ➢ account for all vegetation types (not only forests)
  - ➢ use all the available data (EO/in situ)

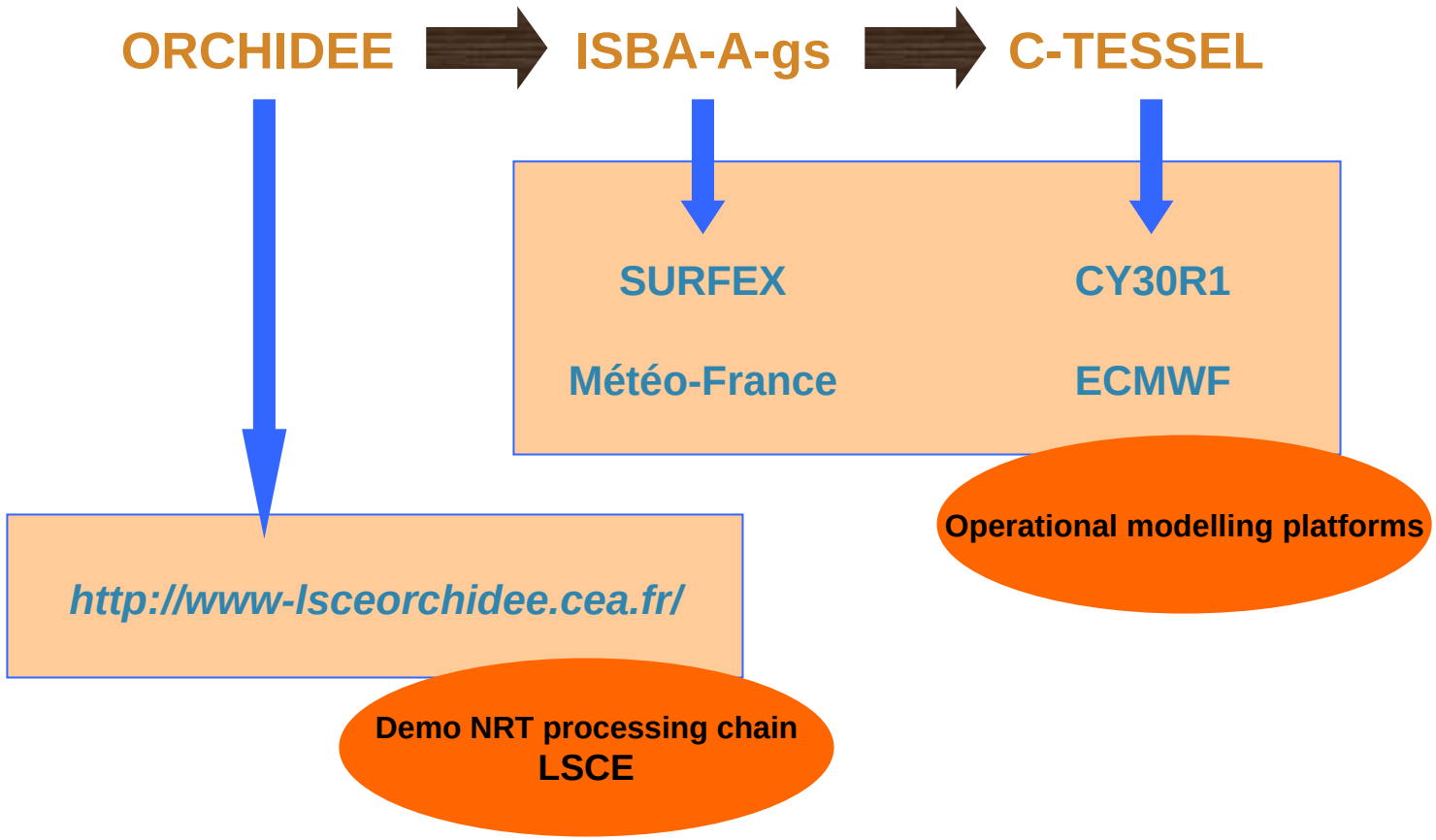
- Assess the uncertainties

geoland (2004-2006):
a FP6 contribution to GMES



Scientific recommendations
Land-Atmosphere: Biomass estimates

Modelling: „greening“ of operational weather forecast models



Motivation for this Presentation

- **Monitoring and forecasting of the atmospheric composition requires input of**
  - **fire emission of various atmospheric trace constituents**
    - aerosols, CO, CO2, NOx, HCHO, …
  - **fire emission injection heights**

- **Monitoring of terrestrial carbon fluxes requires input of**
  - **pyro-changes of terrestrial carbon stocks**

- **Fire Monitoring is required**
  - **globally**
  - **near-real time**
  - **retrospectively**

GEMS/GEOLAND BB PRODUCT REQUIREMENTS

	GEMS	GEOLAND
PRODUCTS	amounts of trace gases (CO2, CH4, CO, O3, NO2, SO2,…) and aerosols emitted	
		amount of biomass burnt
		type of vegetation burnt
	date, time, and location of fire	date and location of fire
	injection height profiles	
COVERAGE	spatial:	global, consistent
	temporal: > 8 years	> 10 years, consistently
RESOLUTION	spatial:	≈ 25 km
	temporal: 1-6 hours	1 day
AVAILABILITY	near-real time	
	retrospectively	

[Kaiser et al. 2006]

REVIEW OF AVAILABLE DATA

Observation System: Current Fire Products

NAME	REFERENCE	SENSOR(S)	COVERAGE		RESOLUTION		AVAILABILITY	STATUS
			spatial	temporal	spatial	temporal		
Active Fire Products (no quantitative information)								
MODIS active fire	http://modis-fire.umd.edu/products.asp Justice et al. [2002]	Aqua/Terra-MODIS	global	2001 – present	1 km	1 day	NRT	operational
World Fire Atlas (WFA-algo1)	http://dup.esrin.esa.int/ionia/wfa	ERS2-ATSR2, Envisat-AATSR	global	1995 - present	1 km	1 day	NRT	operational
Active Fire Monitoring (FIR)	http://www.eumetsat.int/idcplg?IdcService =SS_GET_PAGE&nodeId=522	Meteosat-SEVIRI	Africa & Europe		3 km	15 min	NRT	operational
IGBP-GFP	http://www-tem.jrc.it/ Dwyer et al. [2000]	NOAA-AVHRR	global	1992-1993	1 km	1 day	retrospectively	finished
TRMM	http://earthobservatory.nasa.gov/ Observatory/Datasets/fires.trmm.html Giglio et al. [2000]	TRMM-VIRS	40°N - 40°S	1988-2002	2 km / 0.5° (sensor/ product)	1 month	retrospectively	finished
Active Fire Products with quantitative information								
WF_ABBA, Dozier method	http://cimss.ssec.wisc.edu/goes/burn/ detection.html Prins et al. [2001, 2004]	GOES-E/W	N/S-America	1995-present	4 km	30 min	NRT	operational
WF_ABBA, Dozier method	Prins et al. [2001, 2004]	several GEO satellites	global		4 km	30 min	NRT	in planning
MODIS FRP	http://modis-fire.umd.edu/products.asp Justice et al. [2002]	MODIS	global	2001-present	1 km	1 day	NRT	operational
SEVIRI FRP	http://www.eumetsat.int/idcplg?IdcService =SS_GET_PAGE&nodeId=522	Meteosat-SEVIRI	Africa & Europe		3 km	15 min	NRT	under development
global FRP from GEOs	M. Wooster, private comm..	several GEO satellites	global		4 km	30 min	NRT	in planning
Burnt Area Products								
GBA1982-1999	http://www-tem.jrc.it/ Carmona-Moreno et al.[2005]	NOAA-AVHRR	global	1982-1999	8 km	1 week	retrospectively	finished
GBA2000	http://www-tem.jrc.it/fire/gba2000 Tansey et al.[2004a, 2004b]	SPOT-VGT	global	Nov1999-Dec2000	1 km	1 month	retrospectively	finished
GLOBSCAR	http://dup.esrin.esa.int/ionia/projects/ summaryp24.asp Simon *et al.* [2004]	ERS2-ATSR2	global	2000	1 km	1 month	retrospectively	existing
MODIS Fire Affected Area	http://modis-fire.umd.edu/products.asp#8	Aquaa/Terra-MODIS	global	2001-present	500 m	1 day	retrospectively	under development
Global Daily Burnt Area (GDBAv1)	GDBA partnership: Leicester Univ.(UK), Louvain-La-Neuve Univ.(B), Tropical Res. Inst.(P), JRC (EC)	SPOT-VGT	global	2000-2005	1 km	1 day	retrospectively	under development
Burnt Area for GEOLAND (BAG)	http://www-gvm.jrc.it/tem/ Restricted access (GEOLAND)	SPOT-VGT	Africa & Eurasia	1998-2003	1 km	10 days	retrospectively	under development
VGT4Africa	http://www-gvm.jrc.it/tem/	SPOT-VGT	global	2005-present	1 km	1 day	NRT	under development
GLOBCARBON	http://dup.esrin.esa.it/projects/ summaryp43.asp	ERS2-ATSR2, Envisat-AATSR, Envisat-MERIS, SPOT-VGT	global	1998-2007	8 km	1 month	retrospectively	under development

[Kaiser et al. 2006]

Issues with Available Products

- **No single EO product satisfies all technical GMES requirements.**

- **It is non-trivial to assess the quality of existing EO products:**

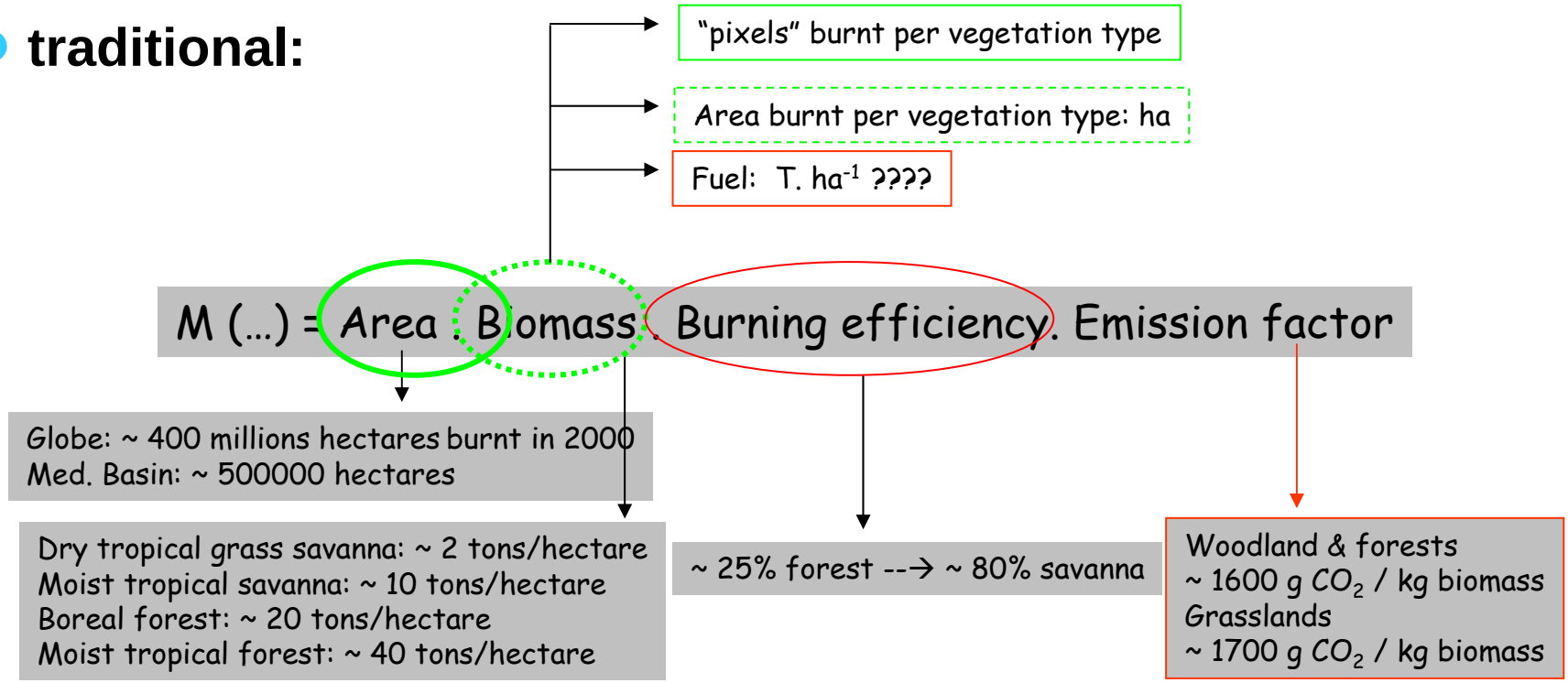
  - **complementary (GEO – LEO, hot spots – burnt areas)** [e.g. C. Michel et al., JGR 2005]
  - **consistency** [Boschetti et al. 2004]
  - **spatial resolution**

Relevant Pros and Cons

- **geostationary observation**
  - **operational real time availability**
  - **good temporal resolution**
  - **quantitative products: WF_ABBA, SEVIRI-FRE**
  - **no global coverage**
  - **no burnt area inventories and long time series**
- **fire radiative power products**
  - **eliminate sources of uncertainty in emission modelling**
  - **not well established, i.e. validated**
  - **no burnt area estimation**

OBSERVATIONS: Calculating Emission Amounts

- **traditional:**

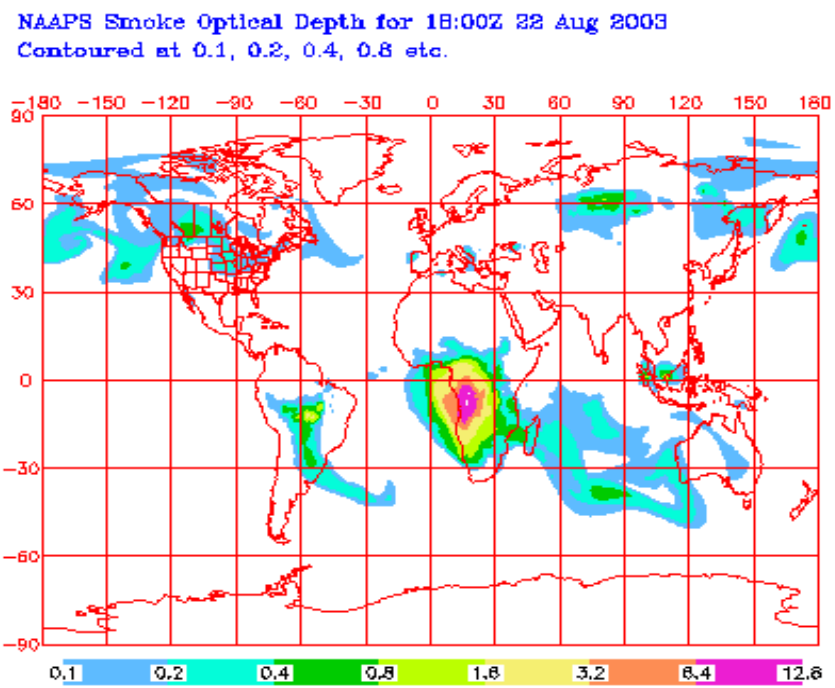


- **Fire Radiative Power (FRP):**
  - **M(X) = FRP * time * scaling factor * emission factor(X)**

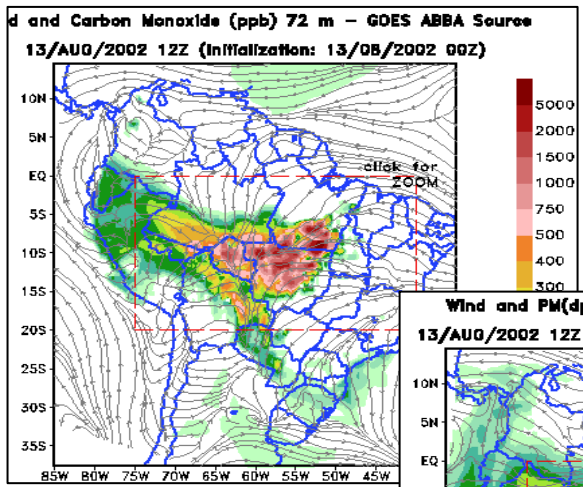
Current NRT Fire Emission Monitoring Systems

- **NRL/NAAPS aerosol model in the FLAMBE project**
  - **Additionally assimilates the MODIS active fire product**
  - **Delivers global aerosol emissions**

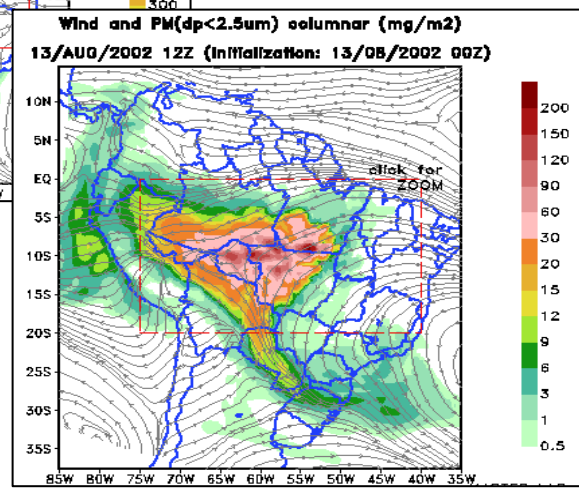
- **RAMS model at INPE/CPTEC**
  - Assimilation of WF_ABBA product from GEOS satellites
  - Delivers CO and aerosol emissions over the Americas



NAAPS Smoke Optical Depth
22 August 2003 at 18:00 UTC



RAMS
CO Product



RAMS
PM2.5 Product

Adapted from E. Prins

Conclusions on Available Systems

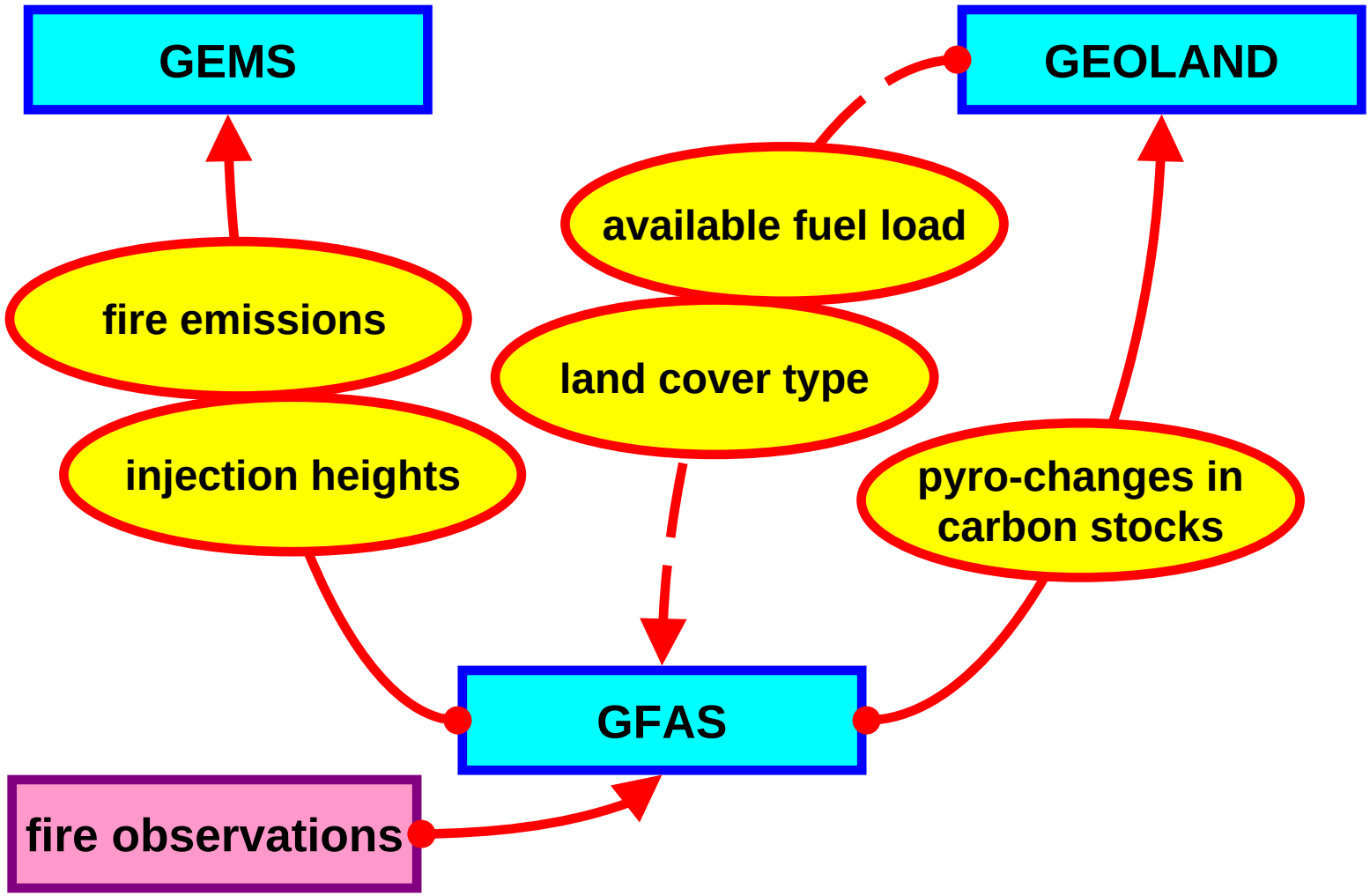
- **Two existing monitoring systems for aerosols / carbon monoxide**
  - **prove the feasibility of atmospheric composition monitoring based on fire EO data and a meteorological model**
  - **highlight the importance of quantitative geostationary fire products**

RECOMMENDATION:
Global Fire Assimilation System (GFAS)

Benefits of Near-real-Time fire information for GEMS & GEOLAND

- **GEMS largely neglects the variability of fire emissions.**
- **Biosphere carbon monitoring in GEOLAND-2 suffers from inaccuracy of the existing fire products.**
- **A future service, GFAS, could use complementary satellite fire observations, plus a fire model, to provide**
  - **Emissions**
  - **Profiles of emission injection heights**
  - **Pyro-change in biomass**
  - **burnt area**
- **GEMS would benefit through more realistic and timely fire emission information.**
- **GEOLAND would benefit through estimates of change in carbon stocks.**
- **GFAS would benefit from fuel estimates provided by GEOLAND-2 as experience develops.**

HALO-GFAS serves GEMS and GEOLAND.



Additional GFAS Benefits

- **single, consistent, operational fire processing for all GMES systems**
  - **global and regional**
- **GEOLAND will benefit from improved land cover characterisation and land cover change detection, i.e. burnt areas.**
- **Numerical Weather Prediction will benefit from fire heat release product for driving the convection.**
- **A multi-parameter inversion of the observed fire plumes will yield**
  - **improved fire emission fluxes (GEMS)**
  - **information on the fire properties**
  - **improvement of the fire model to be used by, e.g., climate models**

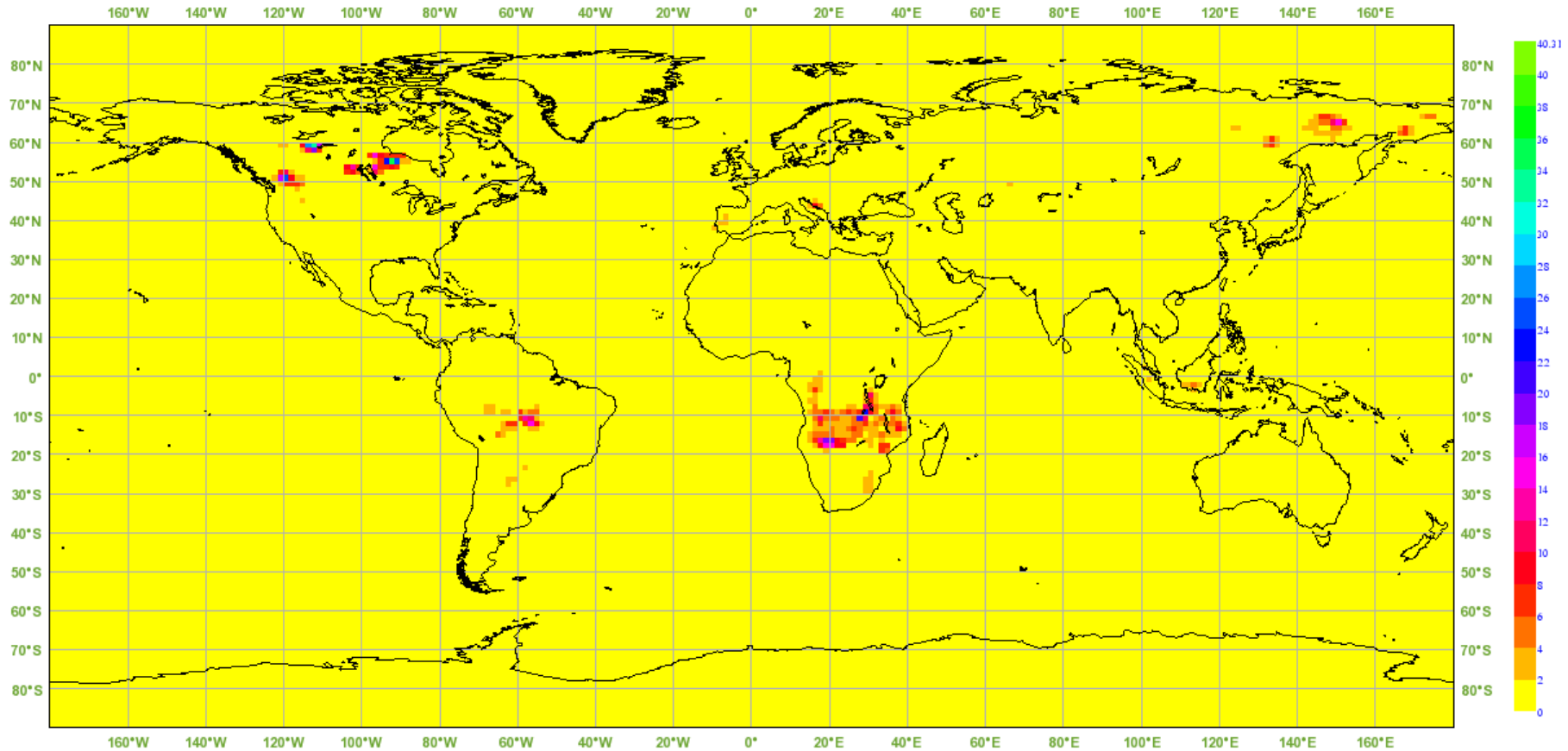
- **Collaboration of space agencies, satellite retrieval experts, biosphere & atmosphere modellers, and other users**

RECENT DEVELOPMENTS IN GEMS

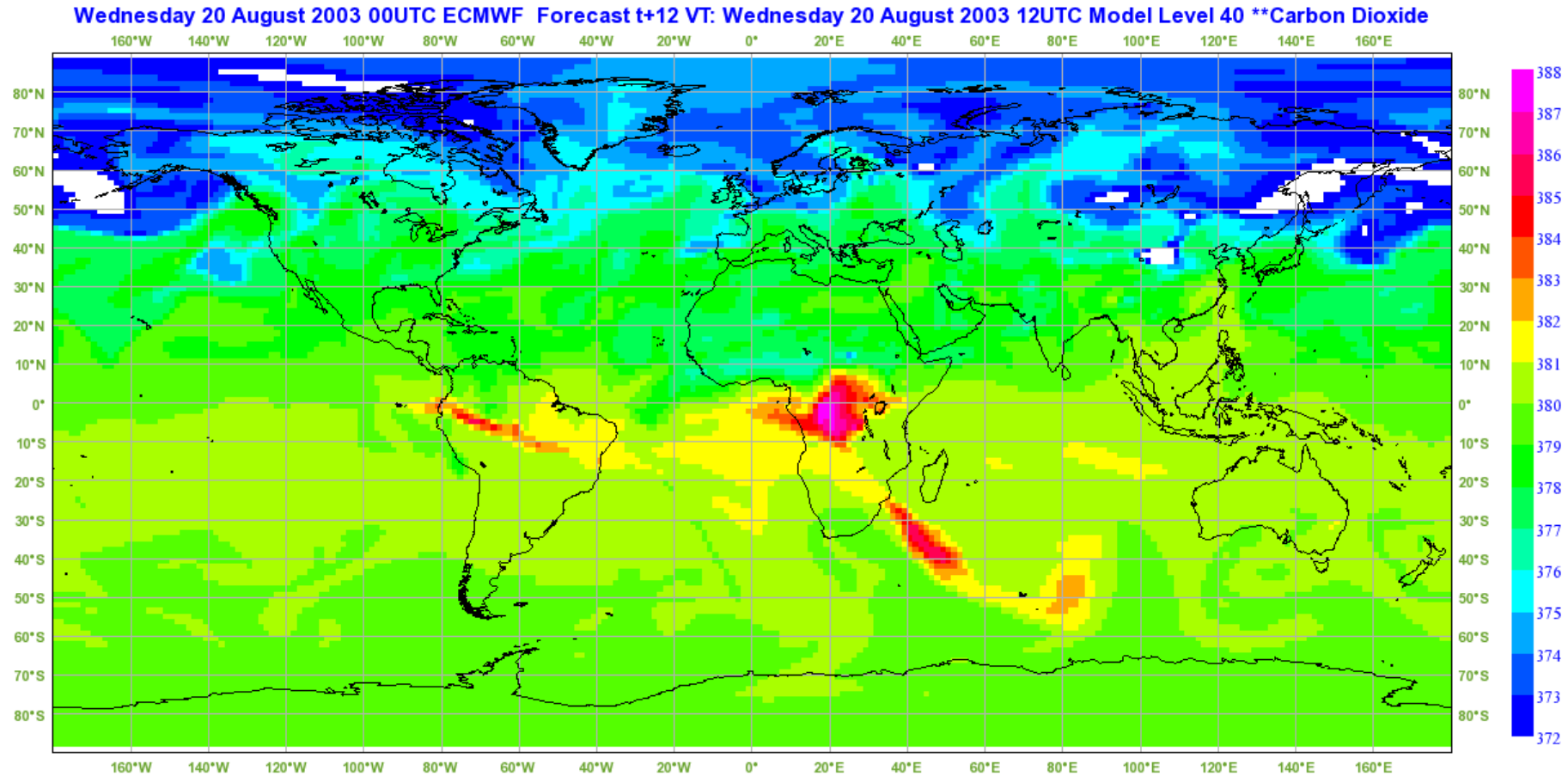
Preliminary Approach for Global Reanalyses

- **use fire emission inventory GFEDv2** [van der Werf et al., ACP 2006]
  - **CO2**
  - **aerosols**
- **thus combining**
  - **MODIS hot spot observations**
  - **biomass from CASA vegetation model driven by EO**
  - **modelling of atmospheric CO2 and aerosols**
- **shortcomings**
  - **not near-real time**
  - **time resolution of 8 days**

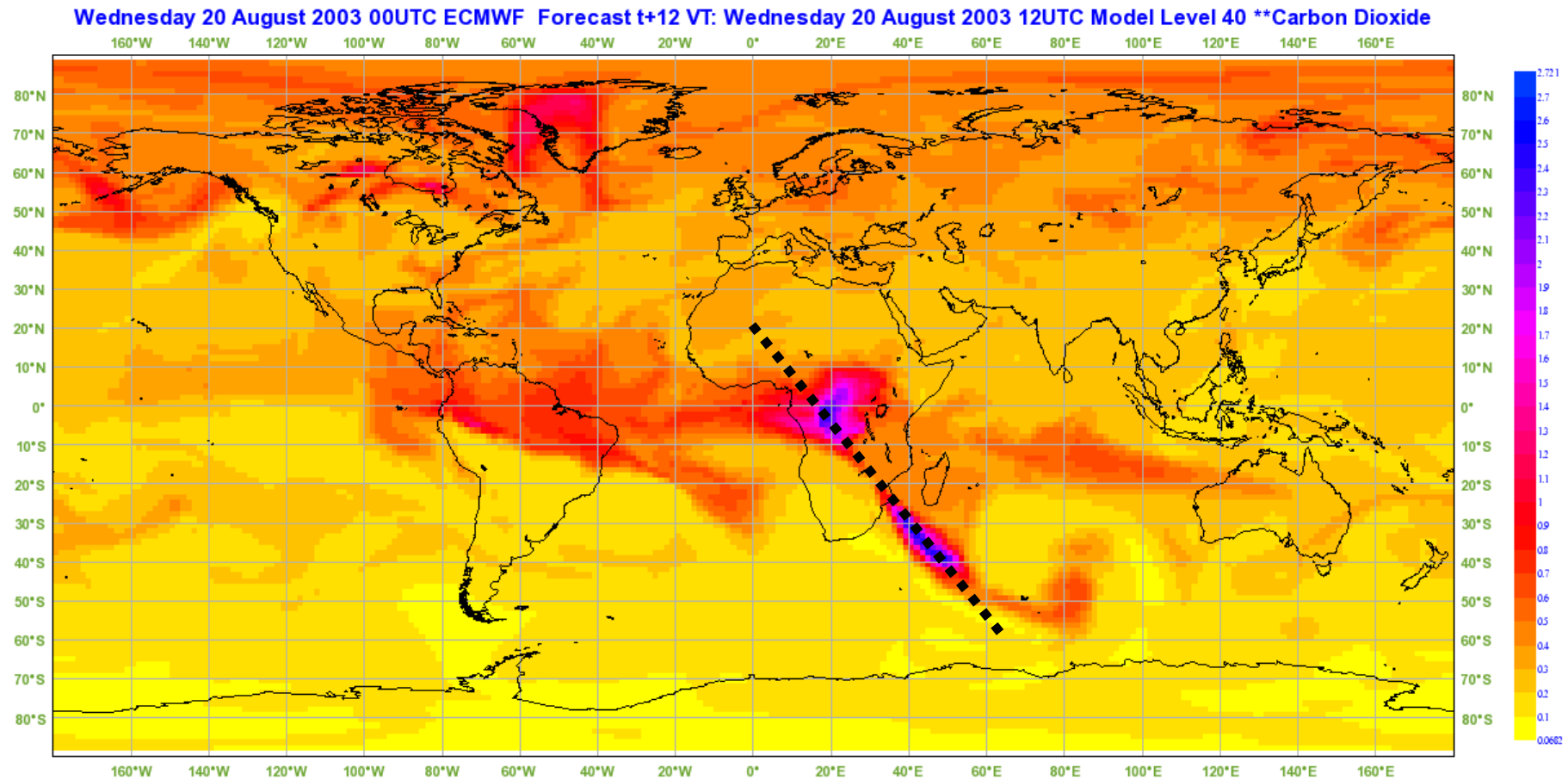
CO2 Fire Emission on 20 Aug 2003 12UTC [g/m2/month / 24] (GFEDv3-8d)



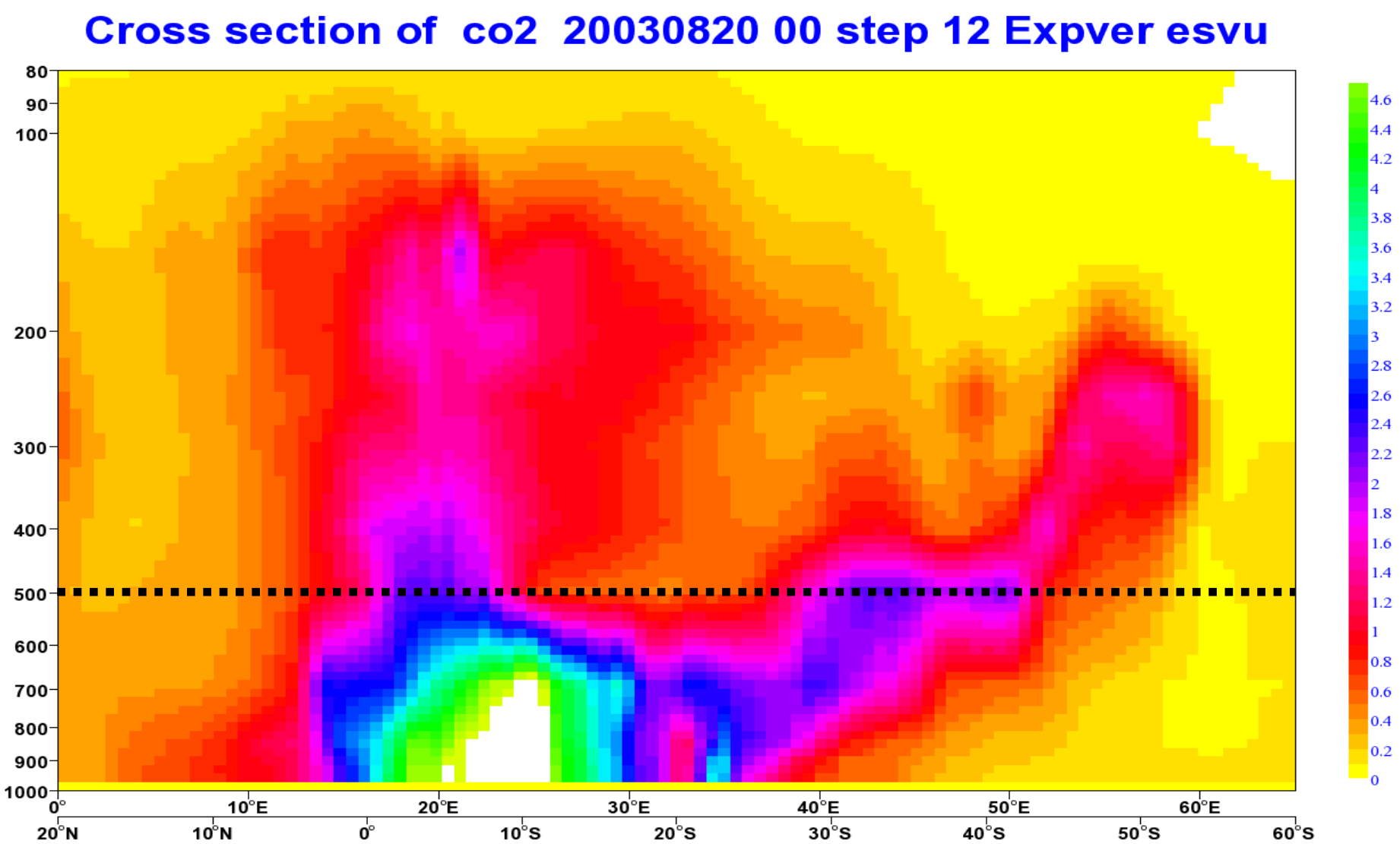
CO2 Model Field with Fires @ 500hPa [ppm]

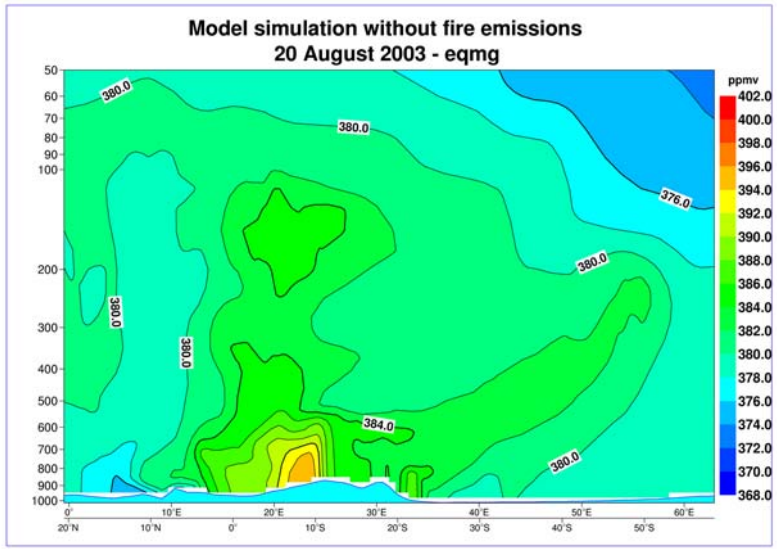


Excess CO2 due to Fires I [ppm]



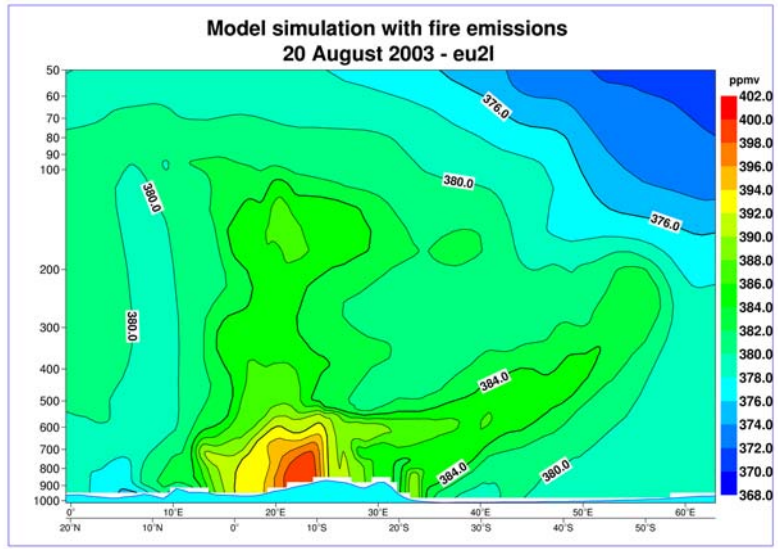
Excess CO2 due to Fires II [ppm]





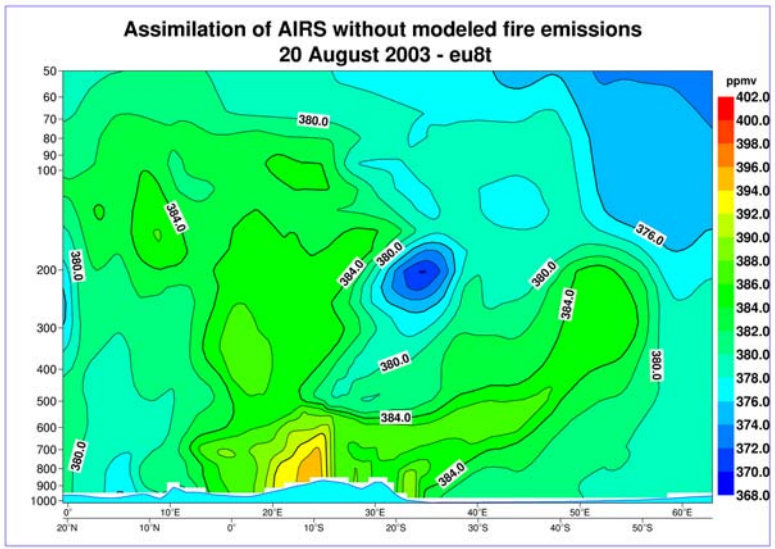
No

AIRS

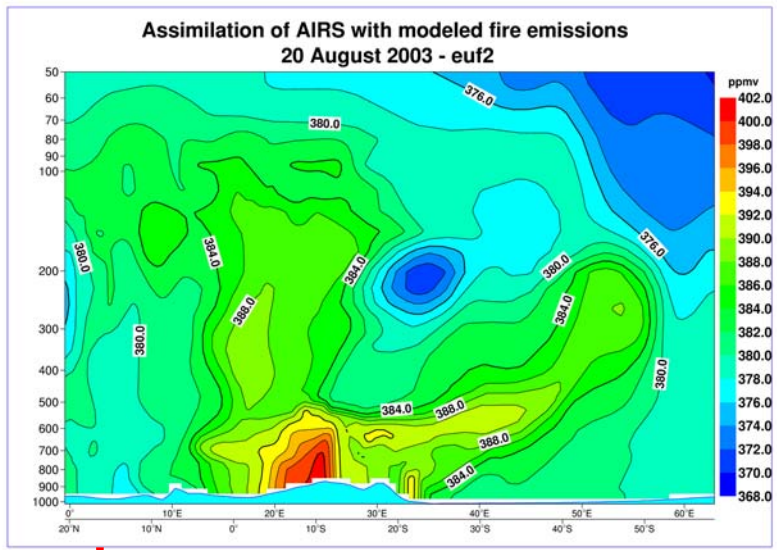


No fire emissions

With fire emissions

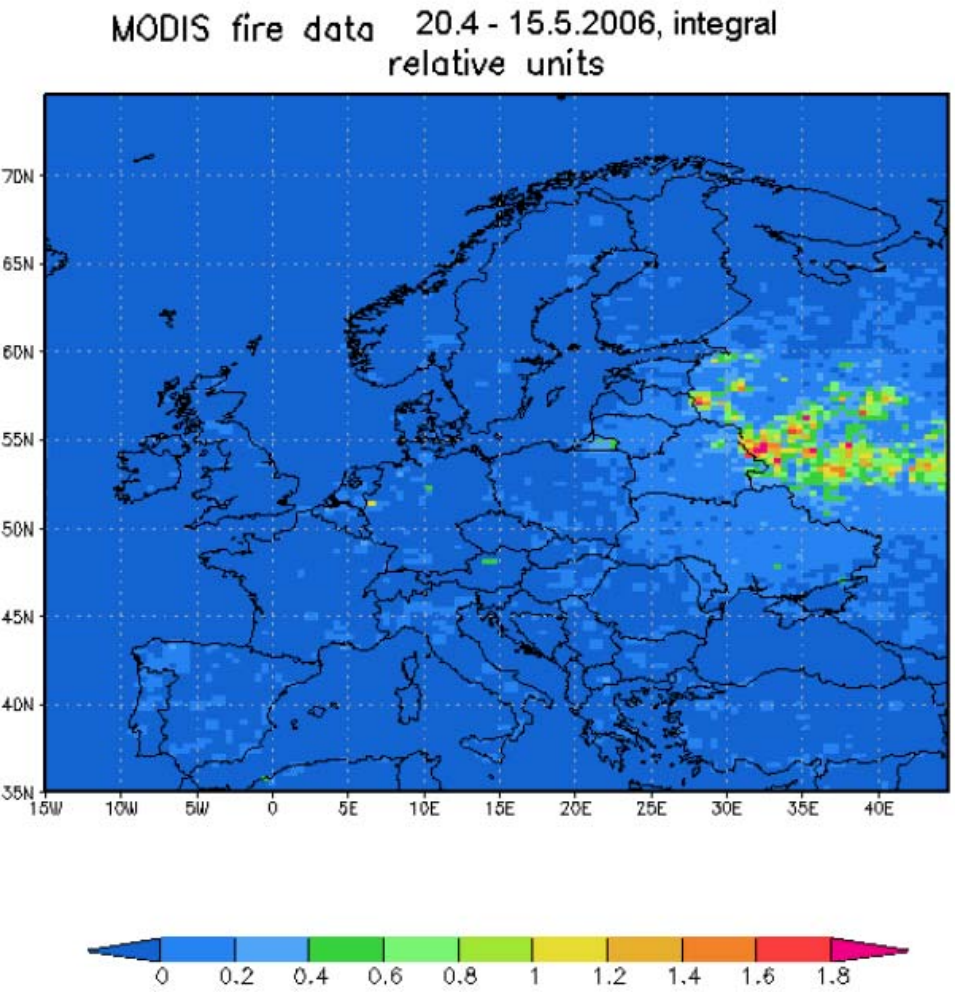


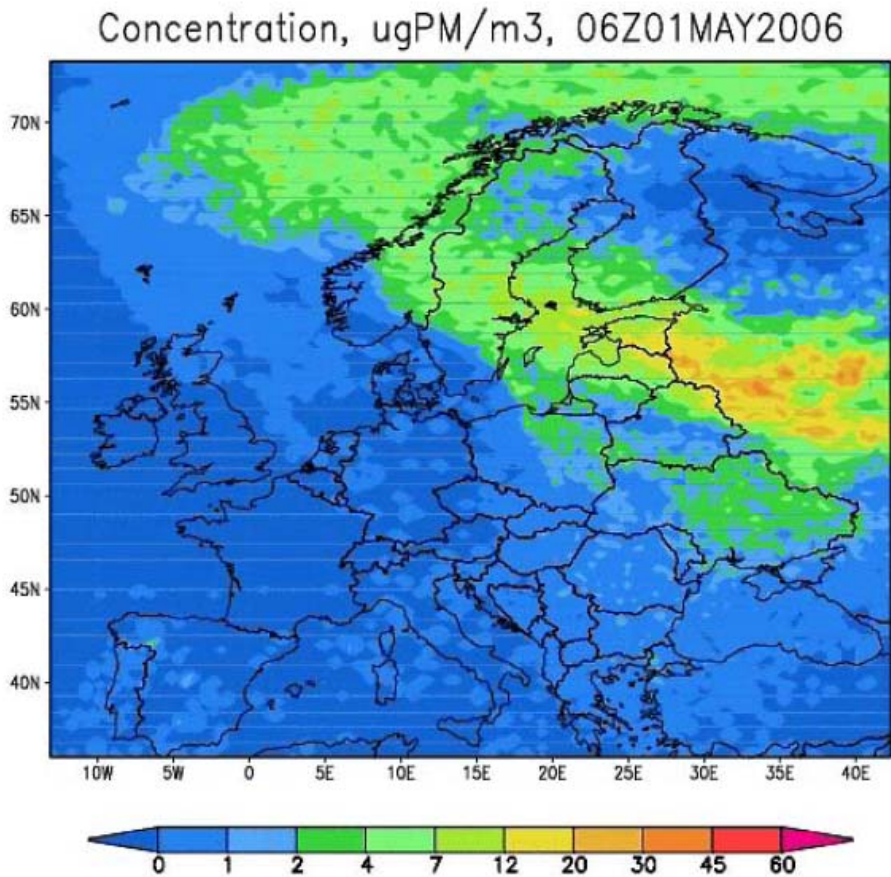
AIRS



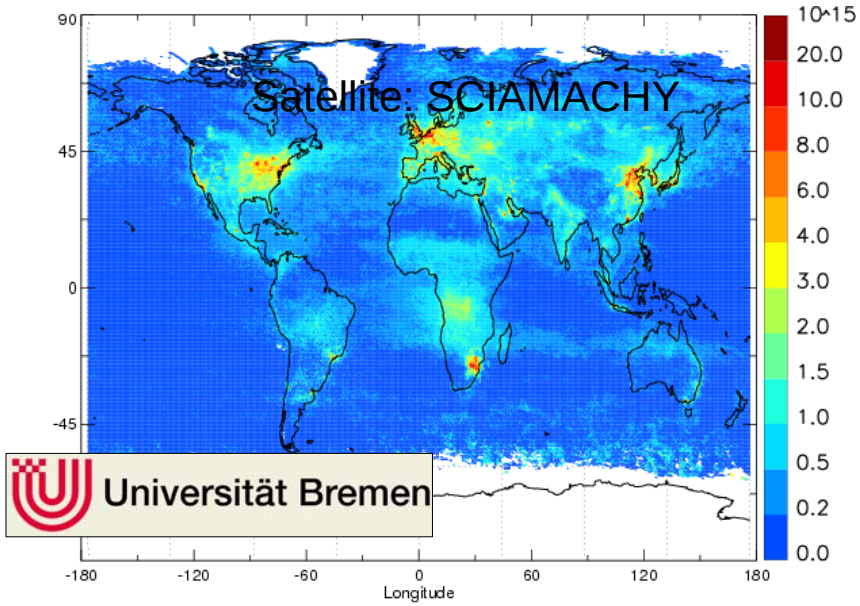
very preliminary!

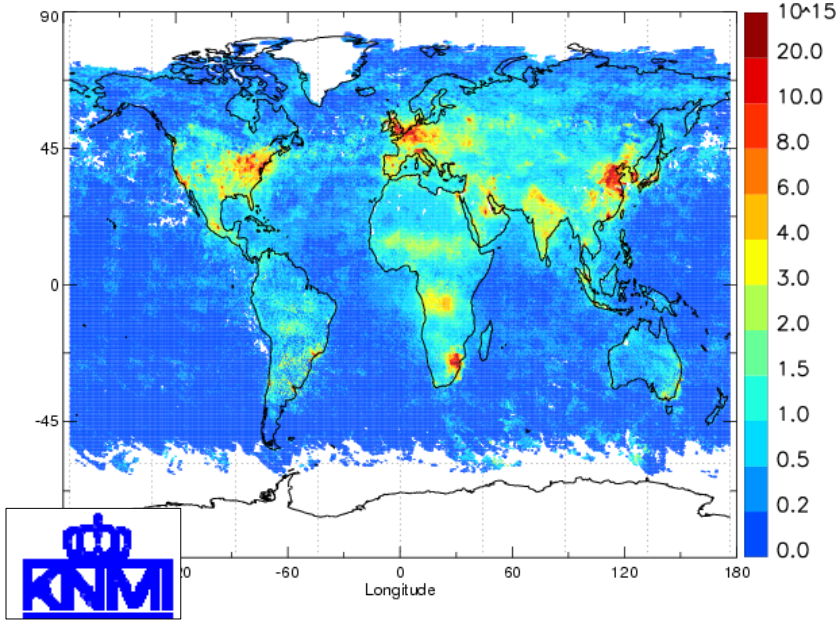
Regional PM2.5 Emission by Fire Modelled in NRT from MODIS FRP (M. Sofiev, FMI)

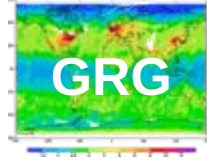




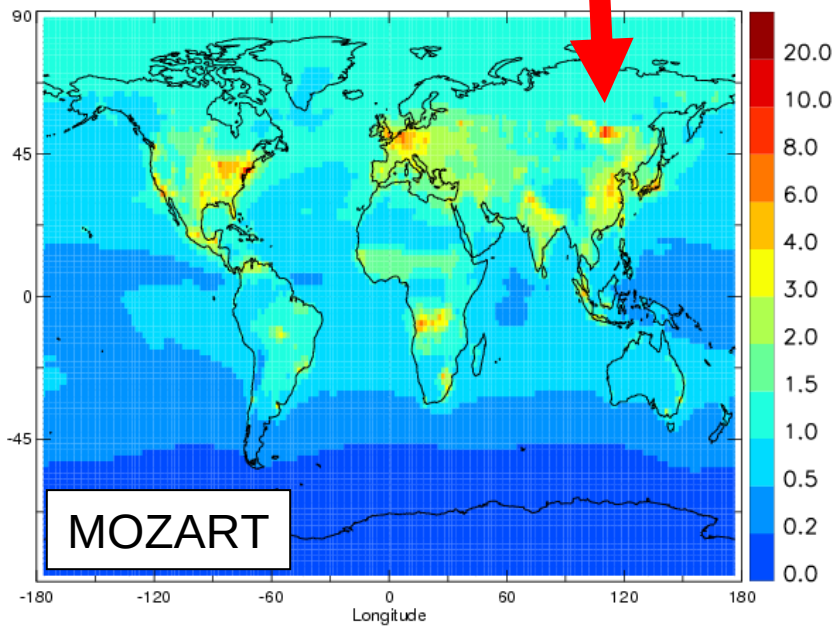
Model evaluation: Tropospheric NO_2 column







Model: MOZART
with ECMWF meteorology



Model agrees reasonably well with satellites.

But fire emission in Siberia not observed!?

SUMMARY

SUMMARY

- **GEOLAND and GEMS need global Biomass Burning modelling in near-real time and consistent multi-year time series.**
- **No single suitable EO product or monitoring service is available.**

- **We propose to develop a Global Fire Assimilation System (GFAS) to serve the GMES requirements. It should combine:**
  - **fire EO products**
  - **meteorological conditions**
  - **land cover: ecosystem, biomass incl. all carbon stocks**
  - **numerical model of fire activity**

- **A global fire radiative energy product from geostationary satellite observations would provide an important and unique input to such a GFAS.**

- **The recommended GFAS is widely supported in the European science community.**
- **GFAS needs funding and a host.**

MORE INFORMATION

- www.ecmwf.int/research/EU_projects/HALO
- www.ecmwf.int/research/EU_projects/GEMS
- www.gmes-geoland.info
- j.kaiser@ecmwf.int

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