WRF/Chem: Updates and Developments (V3 and beyond)

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+ Rainer Schmitz (University of Chile)

+ Saulo Freitas, Karla Longo (CPTEC, BRAZIL)

+ Christine Wiedinmyer, Xue-Xi and others from NCAR

+ many more national and international collaborators

WRF/Chem web site - http://wrf-model.org/WG11

WRF/chem – What's new

- Released together with regular WRF
  - Tarfile now available from WRF WEB site
  - Only one version is supported by wrfchemhelp (V3)
  - User forum is available (http://forum.wrfforum.com)
- The first WRF/Chem tutorial will be held this July in conjunction with the regular WRF tutorial
  - Two days, basic WRF knowledge is expected
  - Documentation is being worked on. Since there is a significant number of developers from all over the world, this is a slow process
  - First documentation success: smoke/wildfire emissions and global emissions program documented for online WEB application (thanks to collaboration with Saulo Freitas and Karla Longo from CPTEC, and the Arctic Region Supercomputing Center in Alaska)

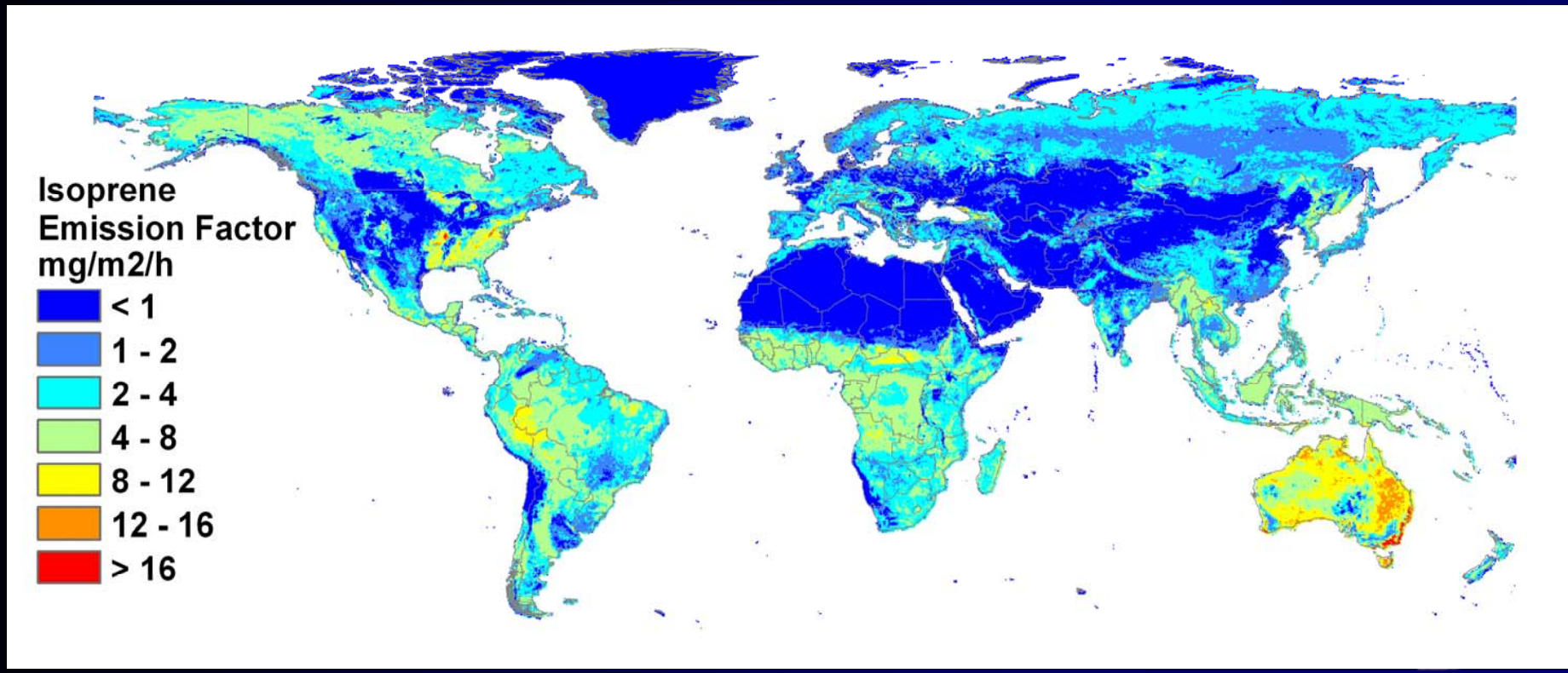
New in biogenic emissions

- **Implementation of the *M*odel of *E*missions of *G*ases and *A*erosols from *N*ature MEGAN in WRFV3/Chem (Courtesy of Christine Wiedinmyer and Alex Gunther from NCAR, also Serena Chung, and Jerome Fast)**

- **Update from BEIS 3.11 to BEIS 3.13**

MEGAN: Model of Emissions of Gases and Aerosols from Nature

- Global biogenic emissions model
  - 1 km^2 spatial resolution
  - Predicts emissions of > 50 VOC



Gas-phase mechanisms, Improvements for KPP:

- New and improved equation files:
  - RACM-MIM
  - RACM-ESRL
  - CB4
  - NMHC9 (for global applications, from MPI Mainz)
- KPP2.2 may be used (currently available from a user from CALTECH)
- KPP2.1 has fixes for some additional compilers (Thanks to John Michalakes as well as Anton Kulchitsky)
- KPP mechanisms can now also be used with wildfire emissions and GOCART (however, this is not yet allowed in V3)
- Documentation exists describing how to implement new equation files and how to run and compile KPP within WRF/Chem

New available Aerosols modules

1. PM total mass advection, transport, emissions and deposition only
2. GOCART - very simple approach with only few species. In V3 GOCART options still have a highly experimental status.

Also improvements on the other available modules (modal approach (MADE/SORGAM) and sectional approach (MOSAIC))

GOCART Dust, Sea-salt, and DMS emissions

- Dust module:
  - Global – Calculated as a function of erosion factor, surface porosity, and surface wind speed (Ginoux et al. 2001)
  - Total 5 size bins 0.1 – 10 μm
- Sea-salt module:
  - Calculated as a function of surface wind speed (Gong et al., 2003)
  - 4 size bins 0.1 – 10 μm (1 submicron, 3 super micron)
- DMS emissions module: dependent on wind speed, sea-surface temps and DMS reference fields
- Dust and sea-salt parameterizations also are implemented for CBMZ/MOSAIC

Work in progress to make these parameterizations available for other aerosol modules

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Aerosol direct/indirect effect

- PNNL has done a substantial amount of work to generalize the aerosol/radiation interaction
- Optical driver was created (Mie calculation separate from photolysis routine can now be used in much more general fashion)
- MADE/SORGAM can now also be used to study the direct effect
- The indirect effect was improved further and is moved from “experimental” to “regular” status
- Indirect effect also works for MADE/SORGAM, but is not officially released

Photolysis Packages – all coupled to aerosols and hydrometeors

In addition to Madronich Photolysis and Fast-j photolysis scheme

- Madronich F-TUV code also available, in V3 release, but not well tested

More New Stuff

(1) Improved non-resolved convective transport

- Wet scavenging included for aerosols
- SO2 to SO4 oxidation included for all GOCART options

(2) 1-way, 2-way nesting and coupling to other modeling systems (MOZART, RAQMS, CHASER, MATCH) has now been tested more thoroughly

(3) Global emissions data sets are available

- from CPTEC program: RETRO/EDGAR for gas-phase, GOCART for aerosols
- Radi Ajjaji from UAE has created a global emissions data base and is willing to provide the same (see also poster)

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A model within a model : Fire Plumerise (Collaboration with Saulo Freitas from CPTEC in Brazil)

Initialized with GOES-ABBA and MODIS

1-D Plume model

$$\frac{\partial w}{\partial t} + w\frac{\partial w}{\partial z} = \gamma g B - \frac{2\alpha}{R} w^2 \quad \begin{cases} \gamma = \dfrac{1}{1+0.5} & \textit{Simpson\&Wiggert, 1968} \\ \gamma = \dfrac{1}{1-2\mu} & \textit{Siebesma et al, subm. JAS} \end{cases}$$

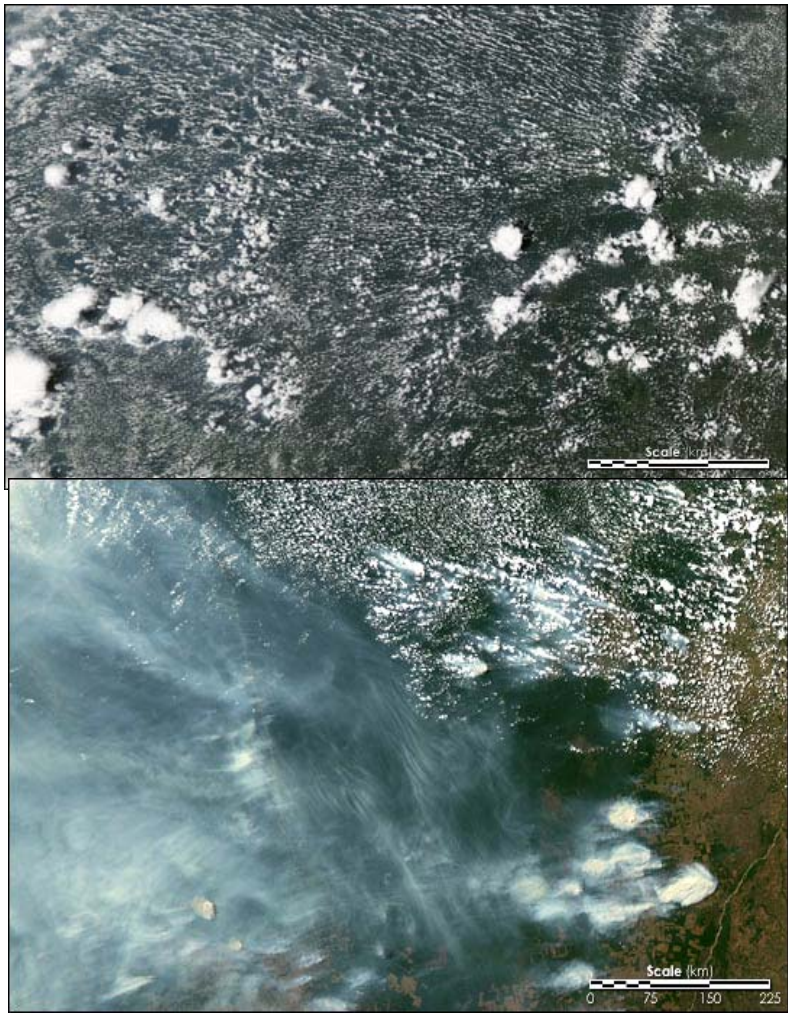
$$\frac{\partial T}{\partial t} + w\frac{\partial T}{\partial z} = -w\frac{g}{c_p} - \frac{2\alpha}{R}|w|(T - T_e) + \left(\frac{\partial T}{\partial t}\right)_{microphysics}$$

$$\frac{\partial r_v}{\partial t} + w\frac{\partial r_v}{\partial z} = -\frac{2\alpha}{R}|w|(r_v - r_{ve}) + \left(\frac{\partial r_v}{\partial t}\right)_{microphysics}$$

$$\frac{\partial r_c}{\partial t} + w\frac{\partial r_c}{\partial z} = -\frac{2\alpha}{R}|w| r_c + \left(\frac{\partial r_c}{\partial t}\right)_{microphysics}$$

$$\frac{\partial r_{ice,rain}}{\partial t} + w\frac{\partial r_{ice,rain}}{\partial z} = -\frac{2\alpha}{R}|w| r_{ice,rain} + \left(\frac{\partial r_{ice,rain}}{\partial t}\right)_{microphysics} + \text{sedim}$$

$$\left(\frac{\partial \xi}{\partial t}\right)_{microphysics} \quad (\xi = T, r_v, r_c, r_{rain}, r_{ice}), \quad \text{sedim} \begin{cases} \textit{bulk microphysics:} \\ \textit{Kessler, 1969} \\ \textit{Ogura \& Takahashi,1971} \\ \textit{Berry,1967} \end{cases}$$

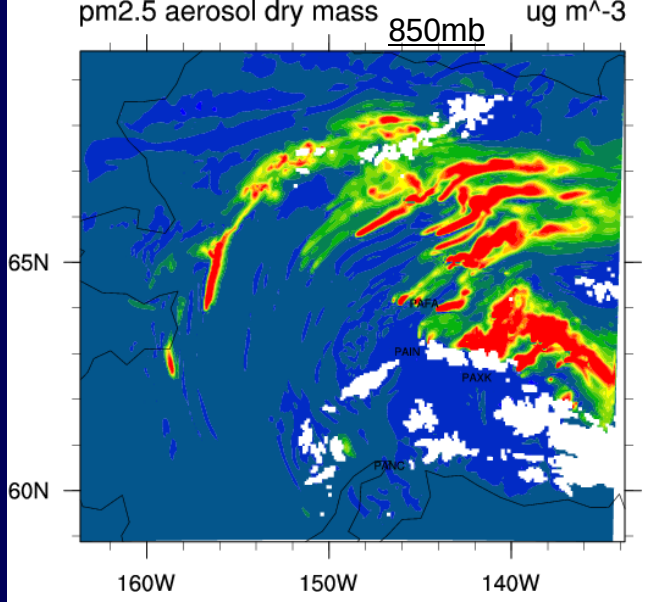


Wildfires initialized with:

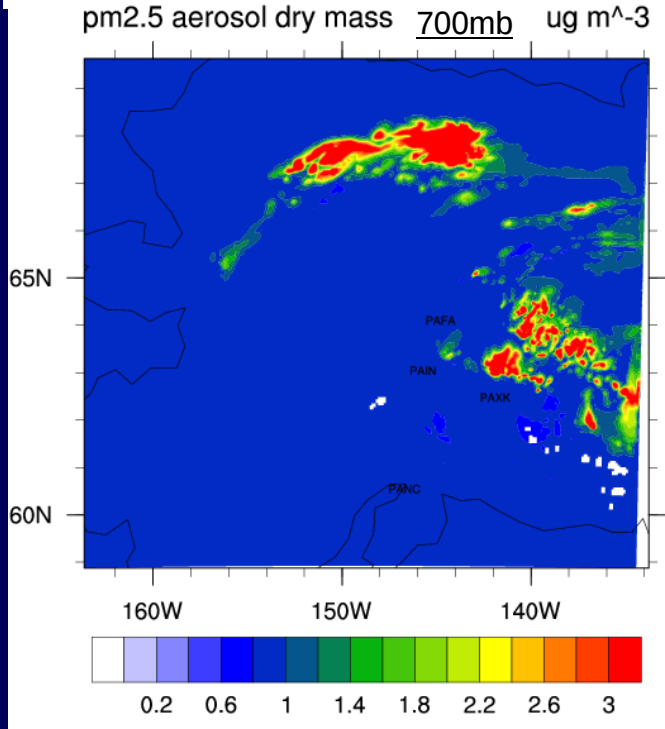
- Remote sensing satellite information (real-time or historic)
  - MODIS
  - WFABBA (Wildfire Automated Biomass Burning Algorithm)
- Alaska Interagency Coordination Center (AICC), using various sources of ground and aerial surveys, also remote sensing (MOD14)

Model calculates injection heights online

Currently runs in real-time in Alaska and will also run in real-time at ESRL



The July 2004 fires



Future line-up for WRF/Chem, with various groups working on these issues

To Infinity and Beyond

- Testing of global WRF/Chem
- More aerosol modules
- Chemical data assimilation
  - 4dvar work in collaboration with Greg Carmichael using WRF-var
  - Will create adjoint of WRF/Chem
  - 3dvar work at ESRL using GSI
- More choices for “interactive” parameterizations
  - CAMS radiation package
  - Various microphysics packages
  - GD/G3 convection parameterization

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WRF/Chem Aerosol related work

- Graham Feingold and Hailong Wang (ESRL/CSD): Implementation of TelAviv sectional microphysics
- Graham Feingold and Hailong Wang (ESRL/CSD): Implementation of double moment bulk microphysics scheme (Feingold et al. 1998)
  - A successful LES simulation of strato-cu on a large domain already exists
- Gordon McFiggans (U of Manchester, UK), implementing their multicomponent aerosol approach
- Source oriented approach from UC Davis (Mike Kleeman) may also be in the works
- Laura Fowler and others from CSU, implementing some of the RAMS microphysics routines into WRF