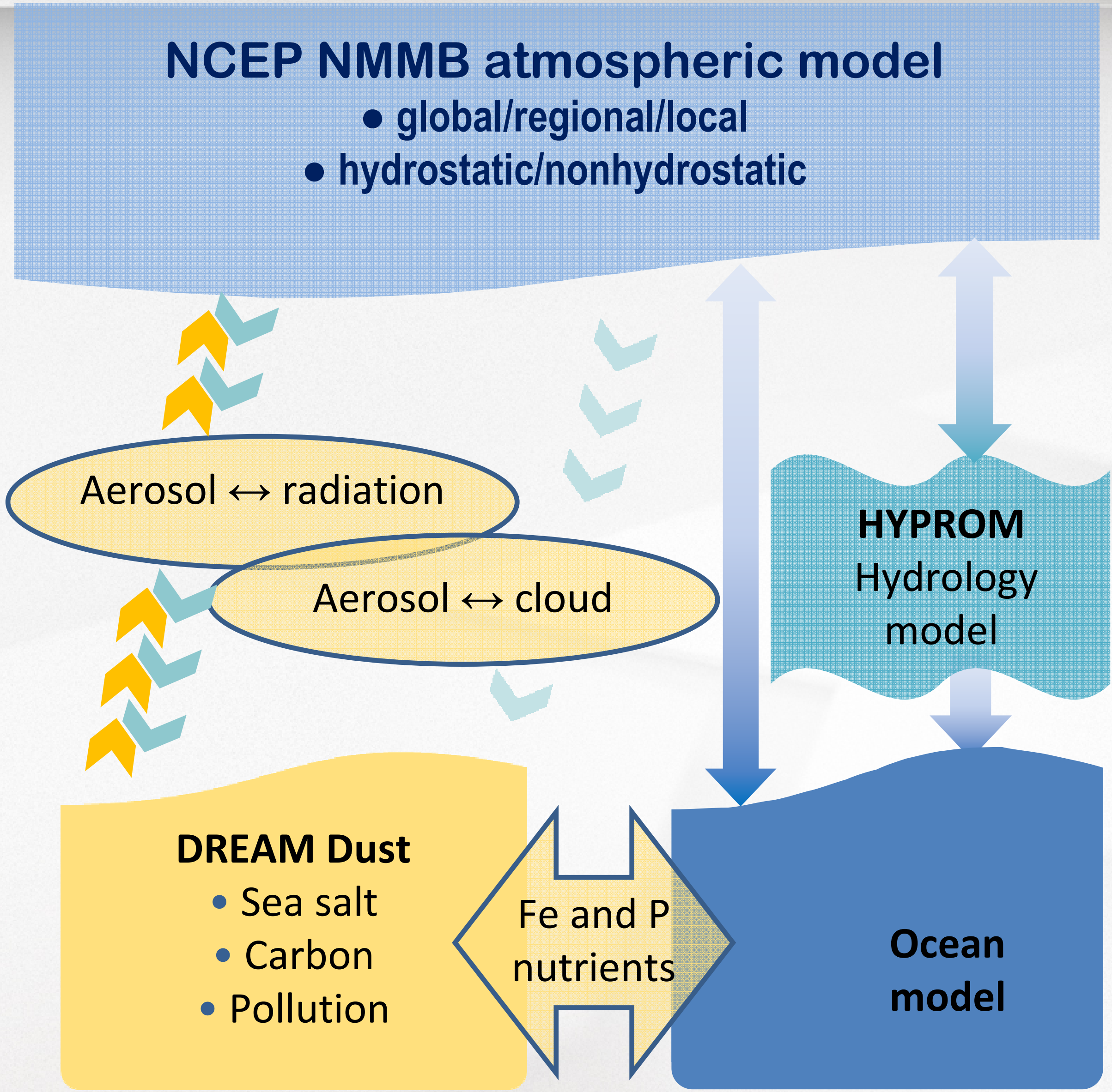
Integrated Earth Modeling System (**IEMS**) at RHMSS/SEEVCCC - Numerical models in use -

SEEVCCC Integrated Earth Modeling System



NMMB model characteristics

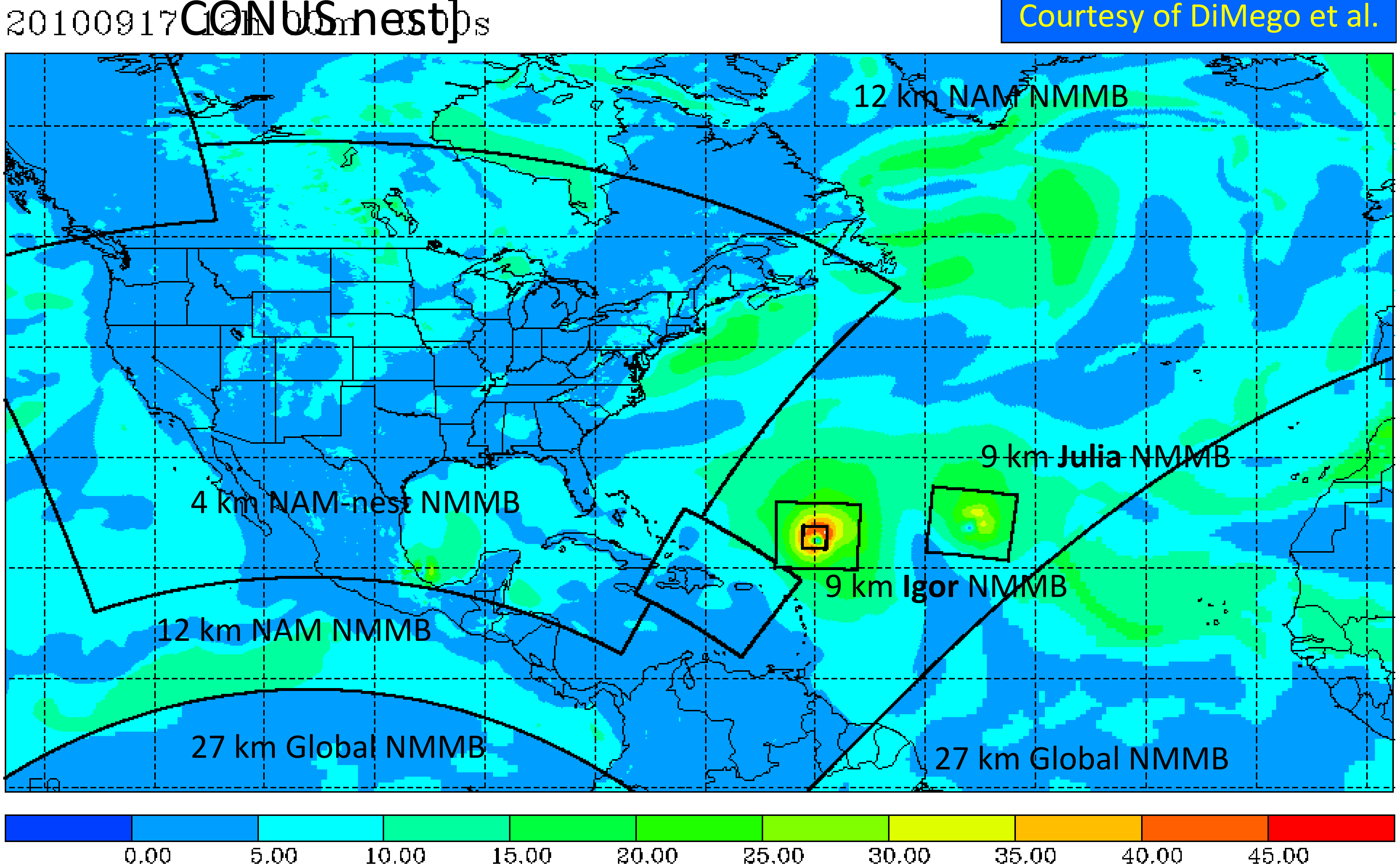
- Grid point model on Arakawa B grid
- Sigma vertical p-hybrid coordinate, Lorenz vertical grid
- Easily can be run as global or regional model
- Novel implementation of the nonhydrostatic
- Dynamical core with horizontal differencing that preserves many important properties of differential operators and conserves a variety of basic and derived quantities including, energy and enstrophy
- Two land surface packages: NOAH and LISS
- Two radiation schemes: RRTM and GFDL
- Two microphysics: Ferrier and Zhao
- Bets-Miller-Janjic convection
- Melloer-Yamada-Janjic turbulence and surface layer

For more information please check references:

(Janjic, 2005; Janjic and Black, 2007; Janjic et al., 2001, 2011,2013)

Hypothetical NMMB Simultaneous Run Global [with Igor & Julia] and NAM [with CONUS nest]

Courtesy of DiMego et al.

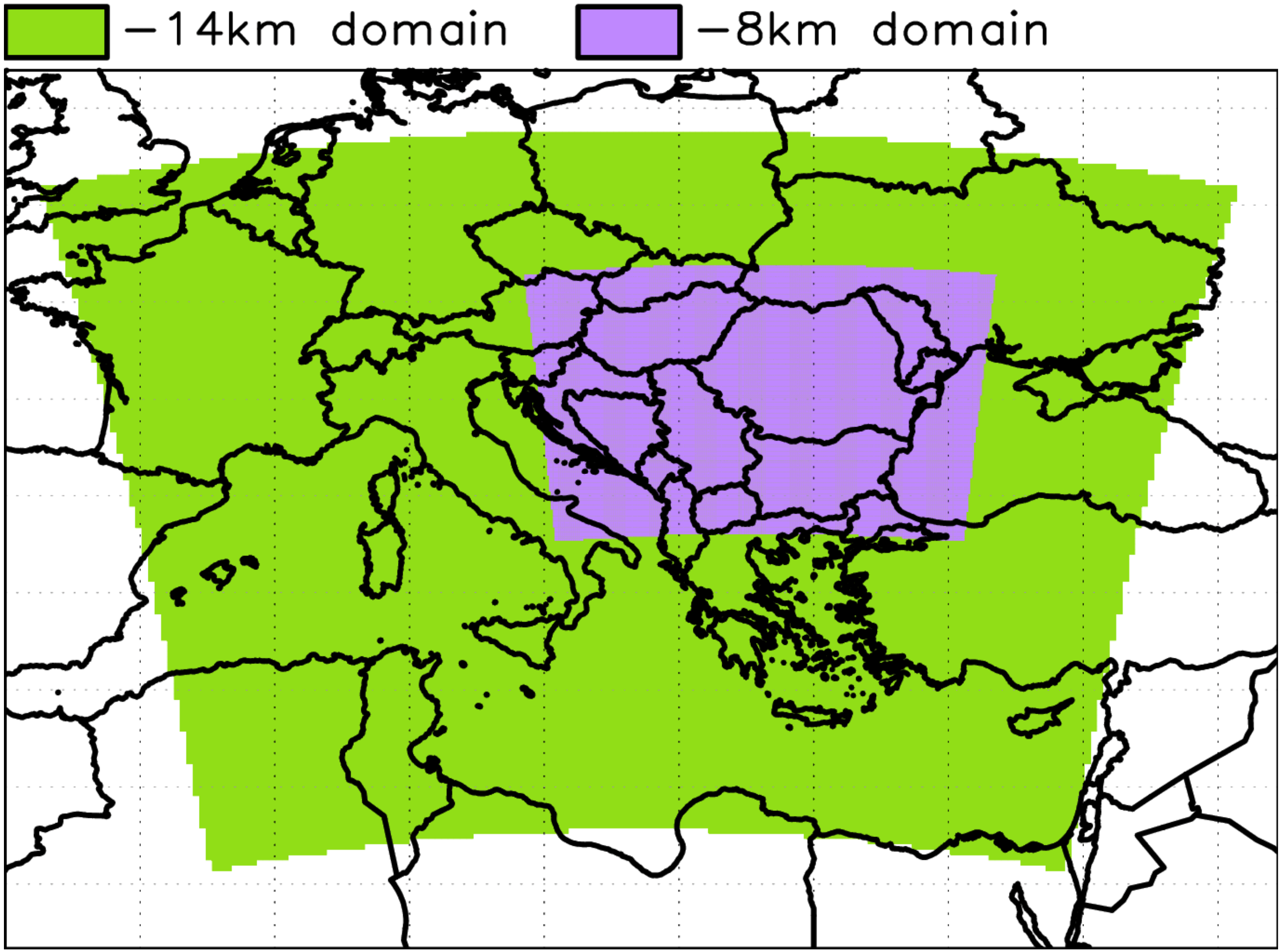


Introduction: downscaling set-up

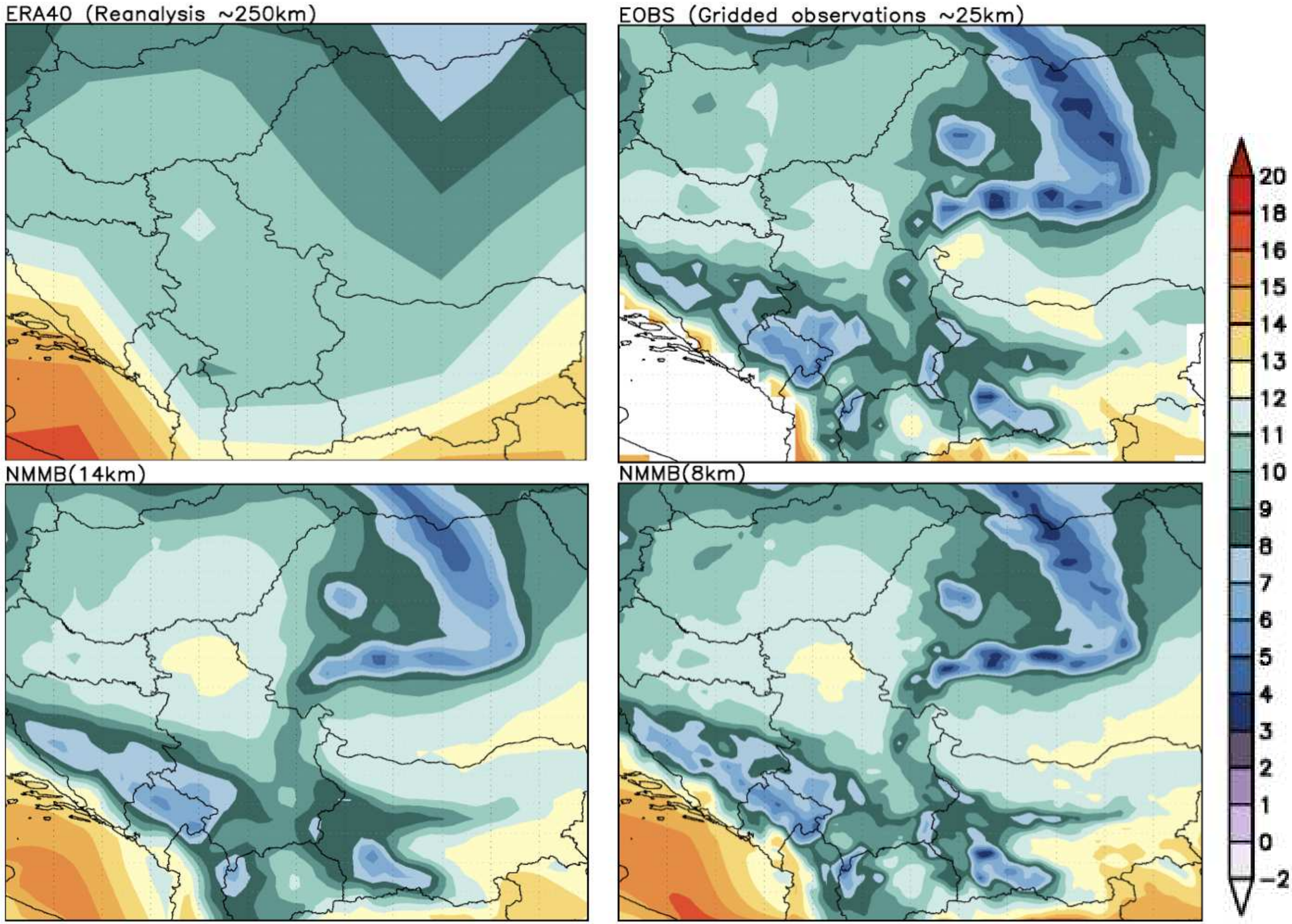
- **Regional model: NMMB (Nonhydrostatic Multiscale Model)**
  - **Horizontal resolution: 14km and 8km experiment**
- **Initial and lateral boundary data: ERA40 reanalysis**
  - **Horizontal resolution: 250km**
- **Downscaled period: 1971-2000**
- **Data used for verification**
  - **Observations from RHMSS station network**
  - **ERA40 surface fields, 250km resolution**
  - **EOBS, gridded climatology for EU, 25km resolution**
  - **CARPATCLIM, gridded climatology for Carpathian region, 10km resolution**

Introduction: downscaling set-up

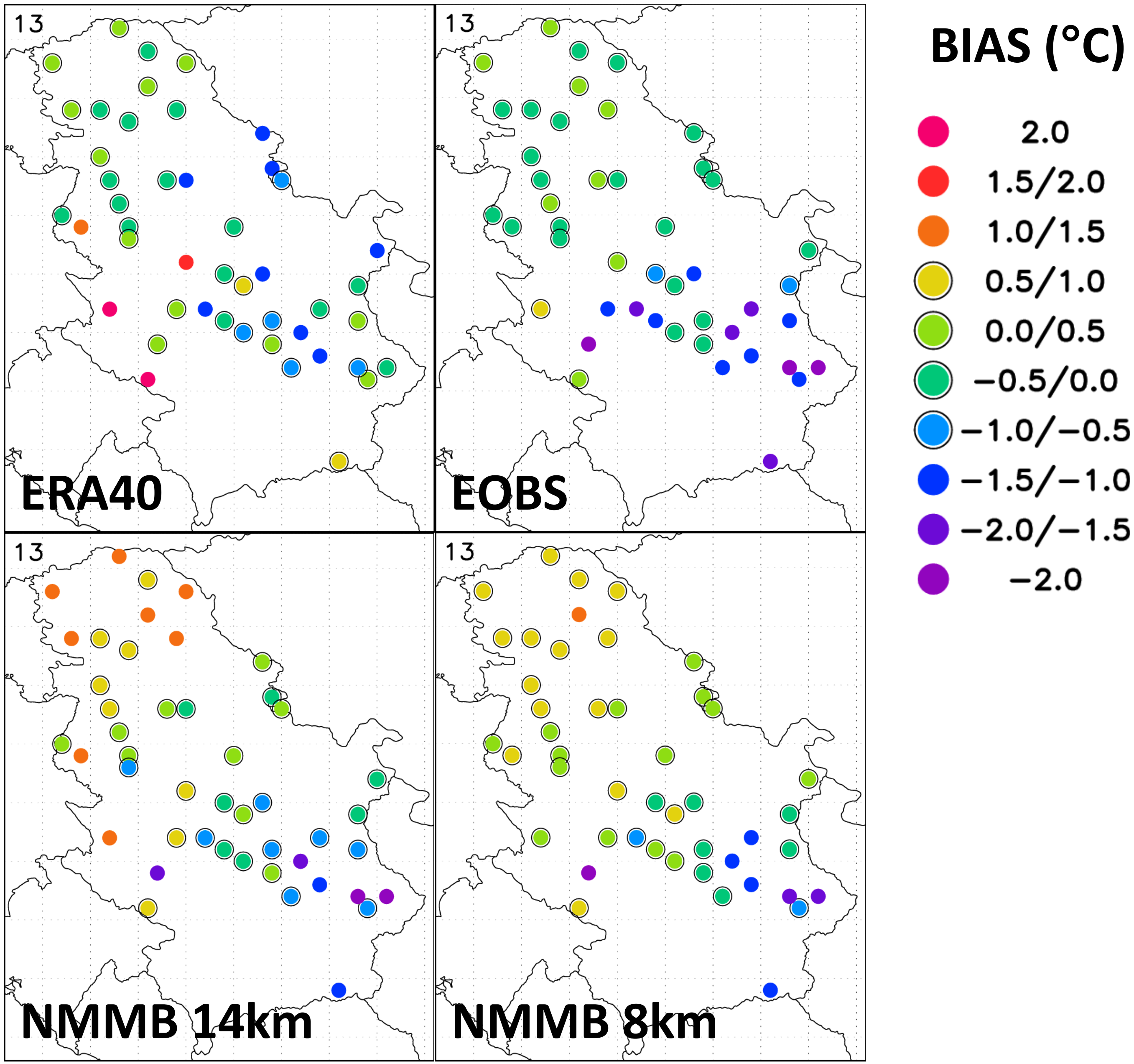
NMMB domains: green – low resolution
purple – high resolution



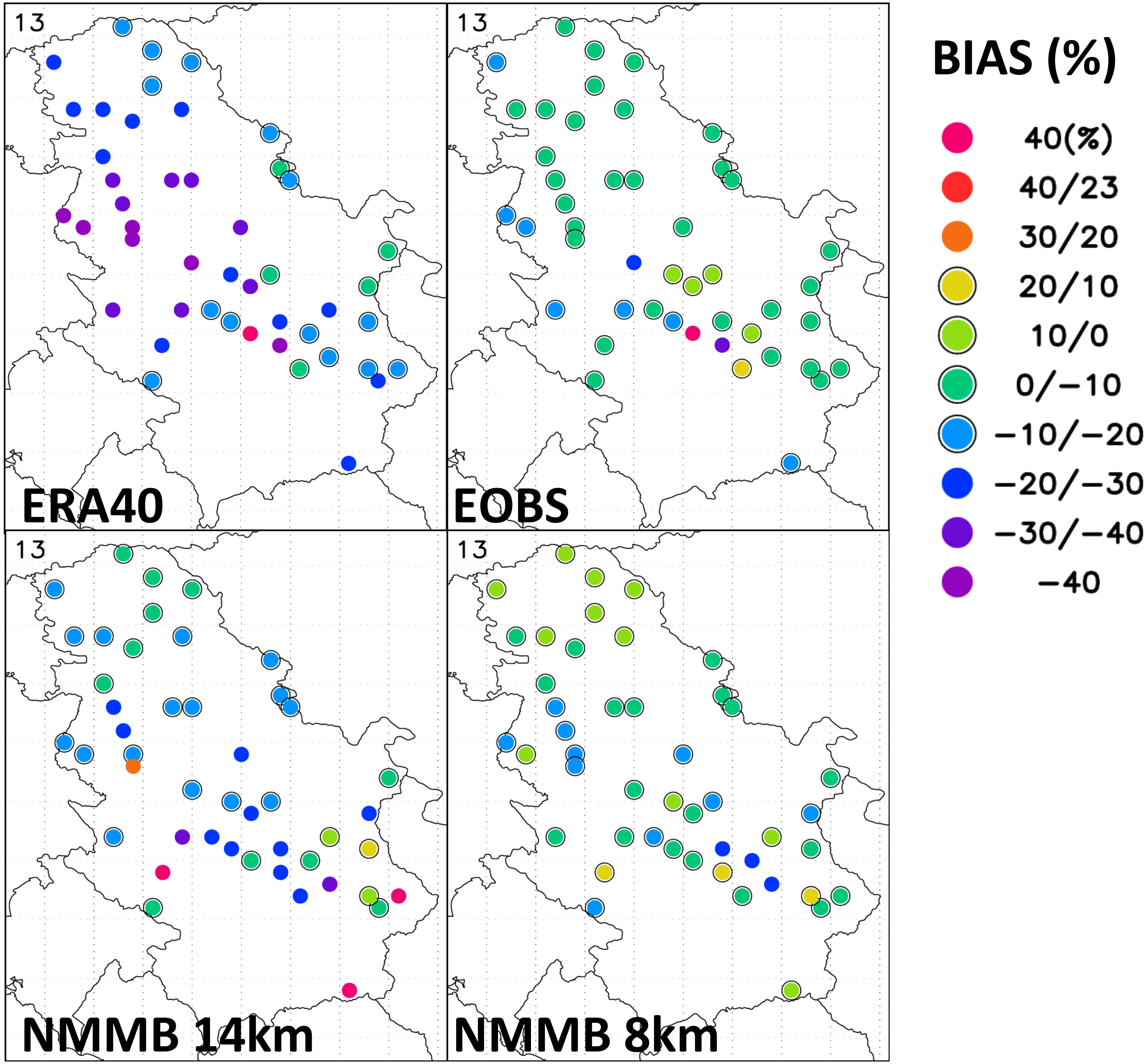
Mean annual temperature 1971-2000



Temperature annual mean bias (daily temperatures)

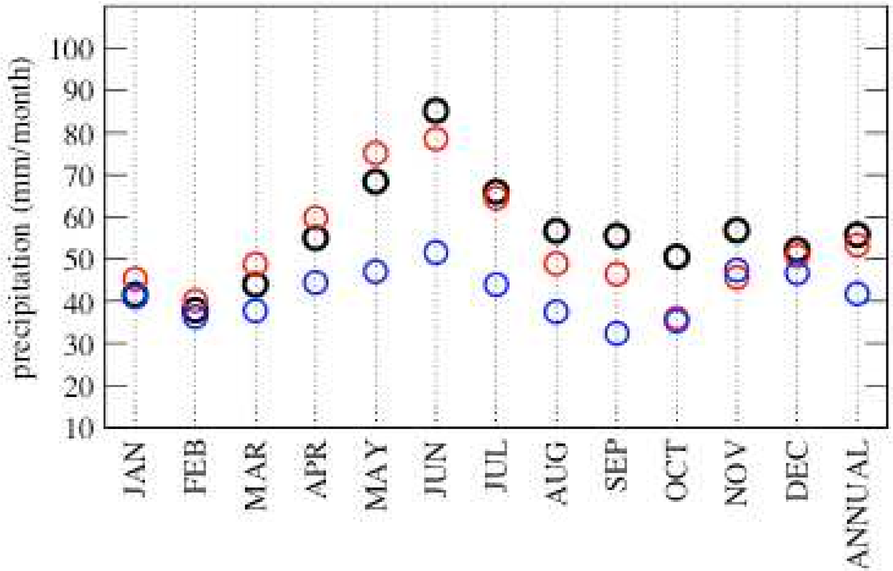


Precipitation annual mean bias (daily precipitation)



Precipitation annual cycle (daily precipitation)

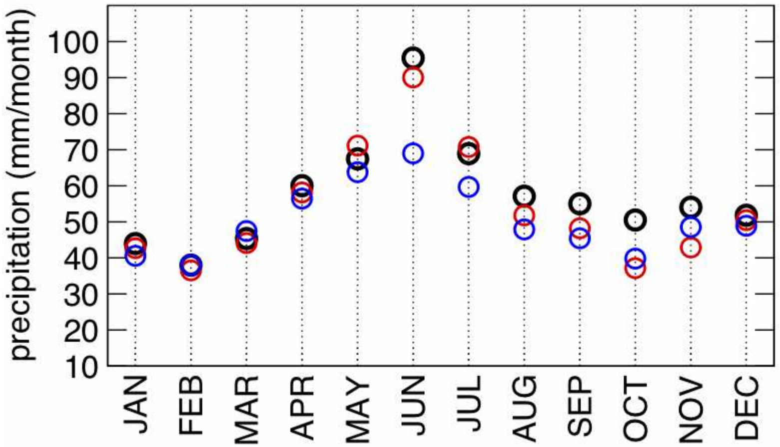
o ERA40; o NMMB8; o OBS



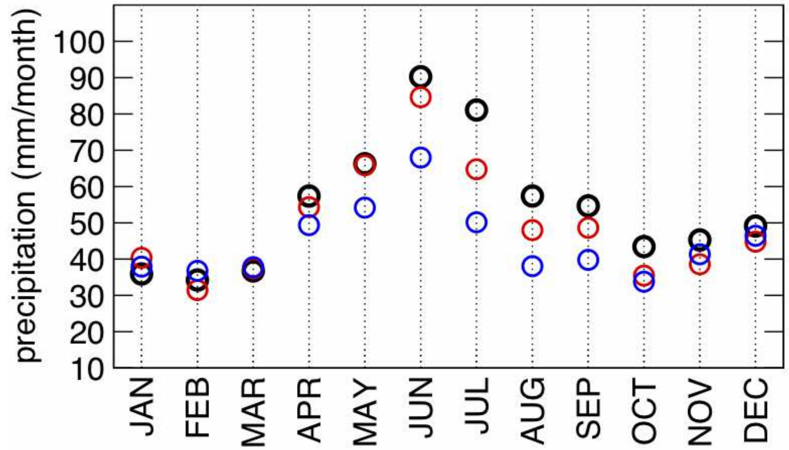
Selected stations:

o - Oservationas
o - NMMB-8
o - NMMB-14

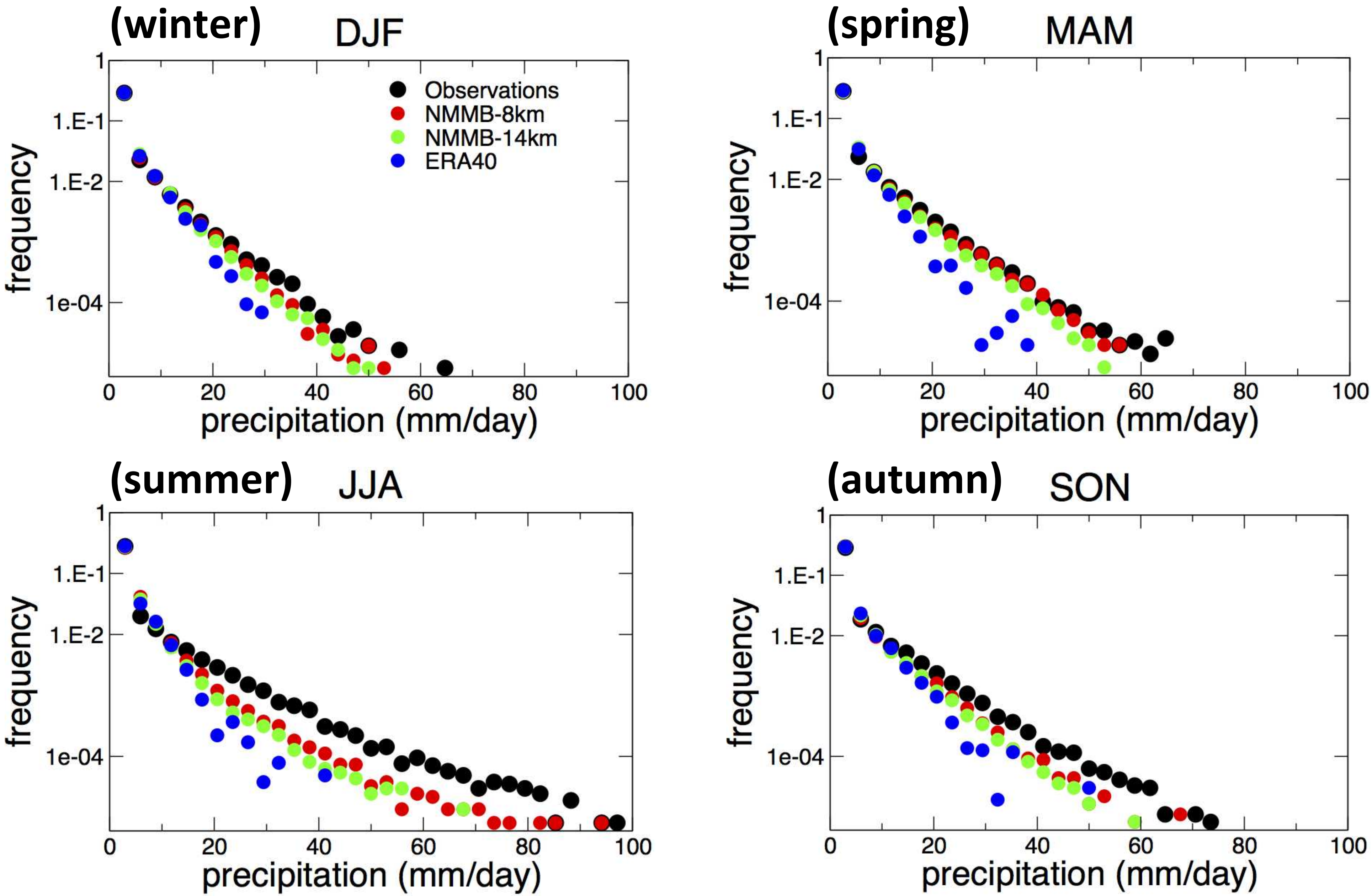
Beograd



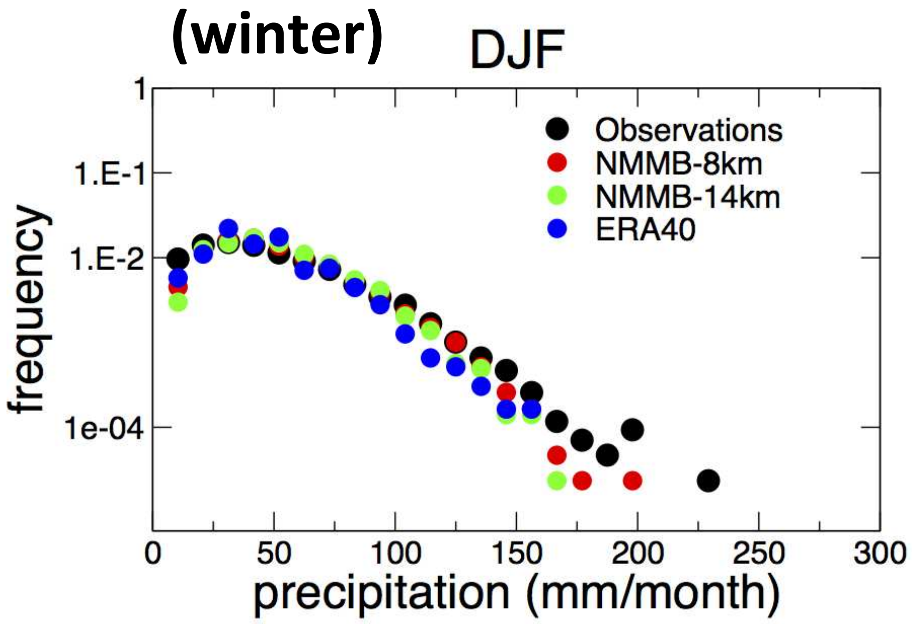
Vrsac

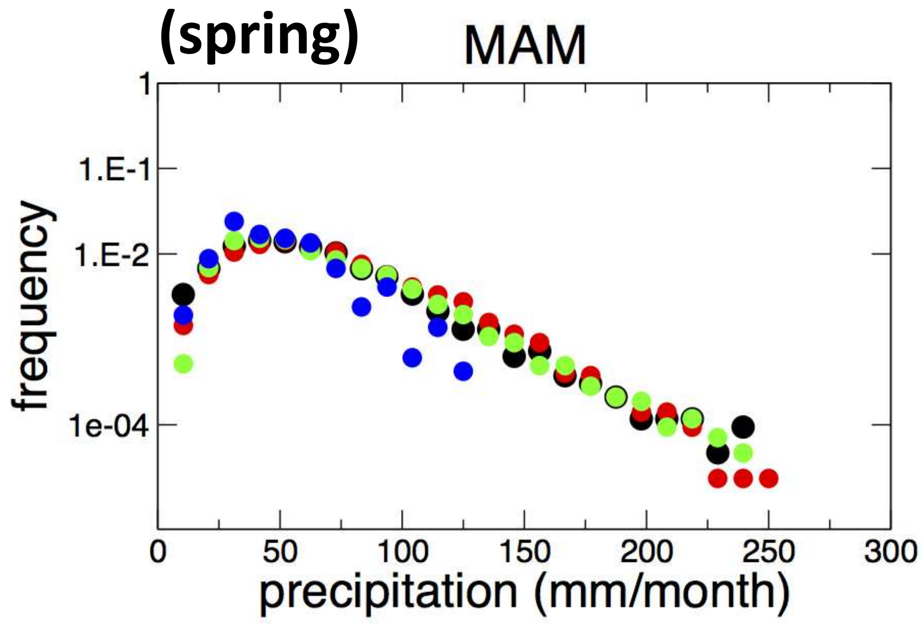


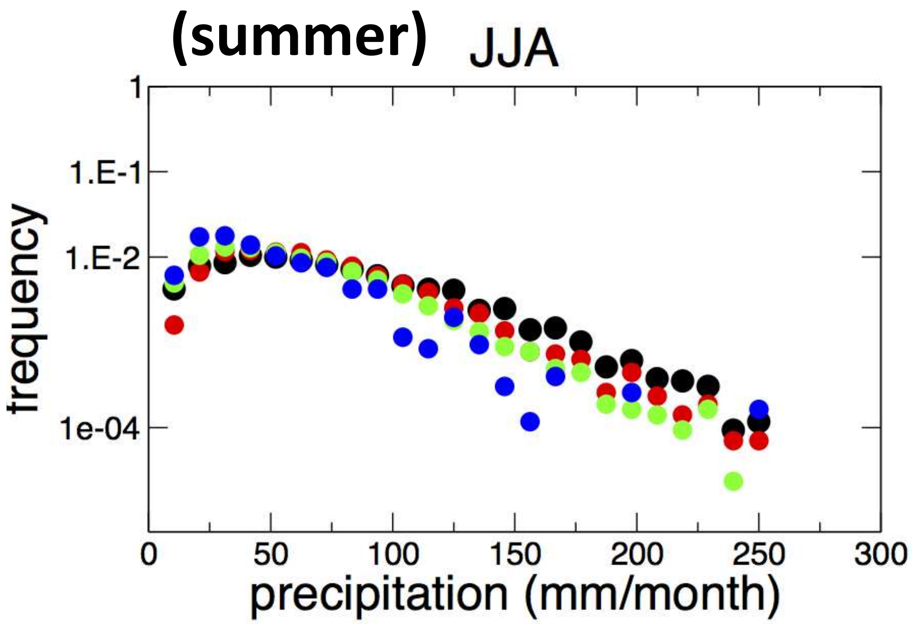
Daily precipitation - seasonal distributions

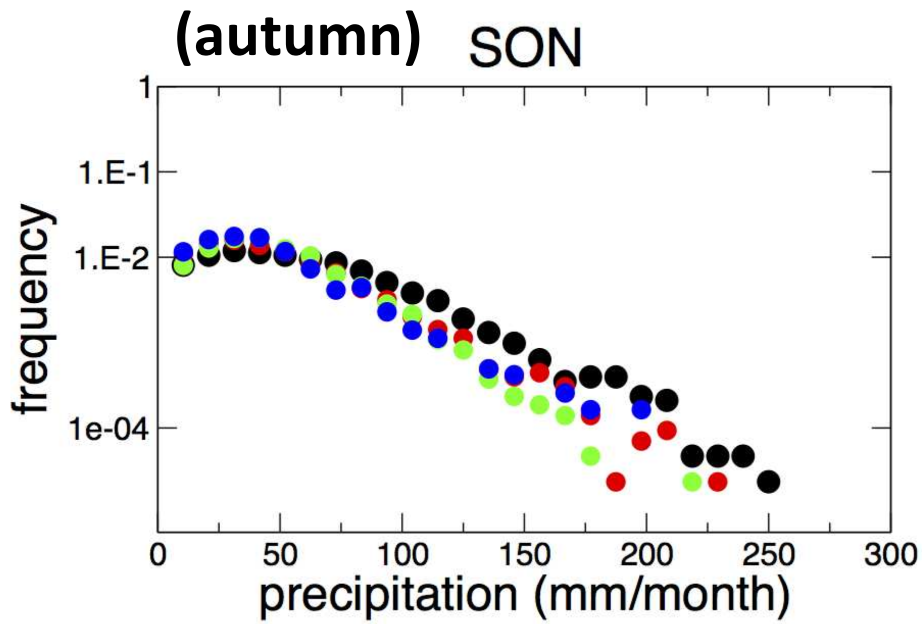


Monthly precipitation - seasonal distributions





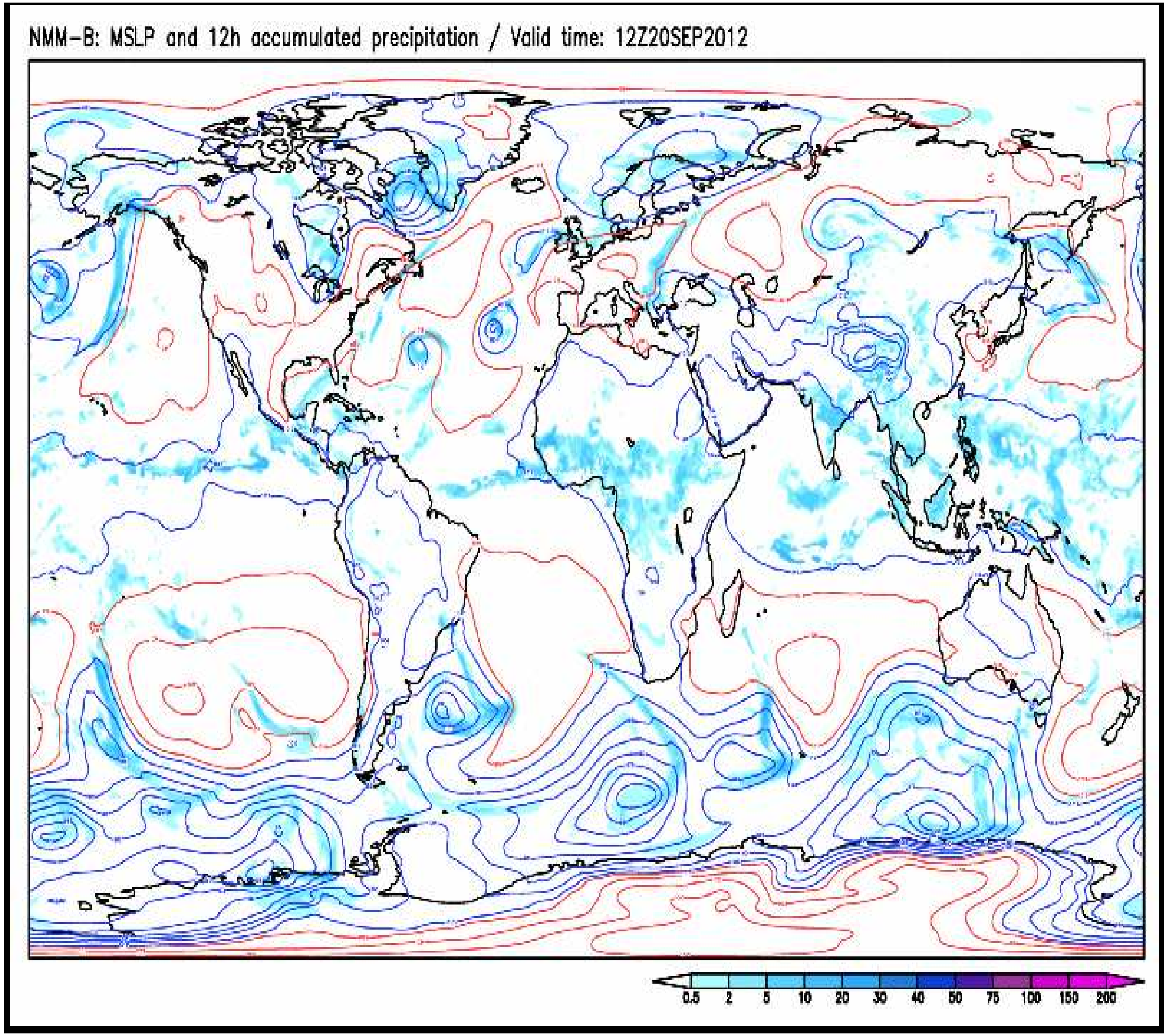




Non-hydrostatic Multiscale Model – NMMB (NCEP/Zavisa Janjic)
Global operational forecast at RHMSS/SEEVCCC

NMMB

- Global domain
- Horizontal res 0.48 x 0.36 deg
- Vertical res 64 levels
- 10 days forecast
- Initial conditions from GFS/ECMWF



Hydrology component of IEMS - HYPROM model -

• HYPROM model is developed to simulate overland watershed processes. It is designed to be easily applied to different watersheds and across a broad range of spatial scales, from local to regional and global. HYPROM can be useful tool for predicting short-term flood events, as well as for water balance assessments and climate studies (Nickovic et al., 2010).

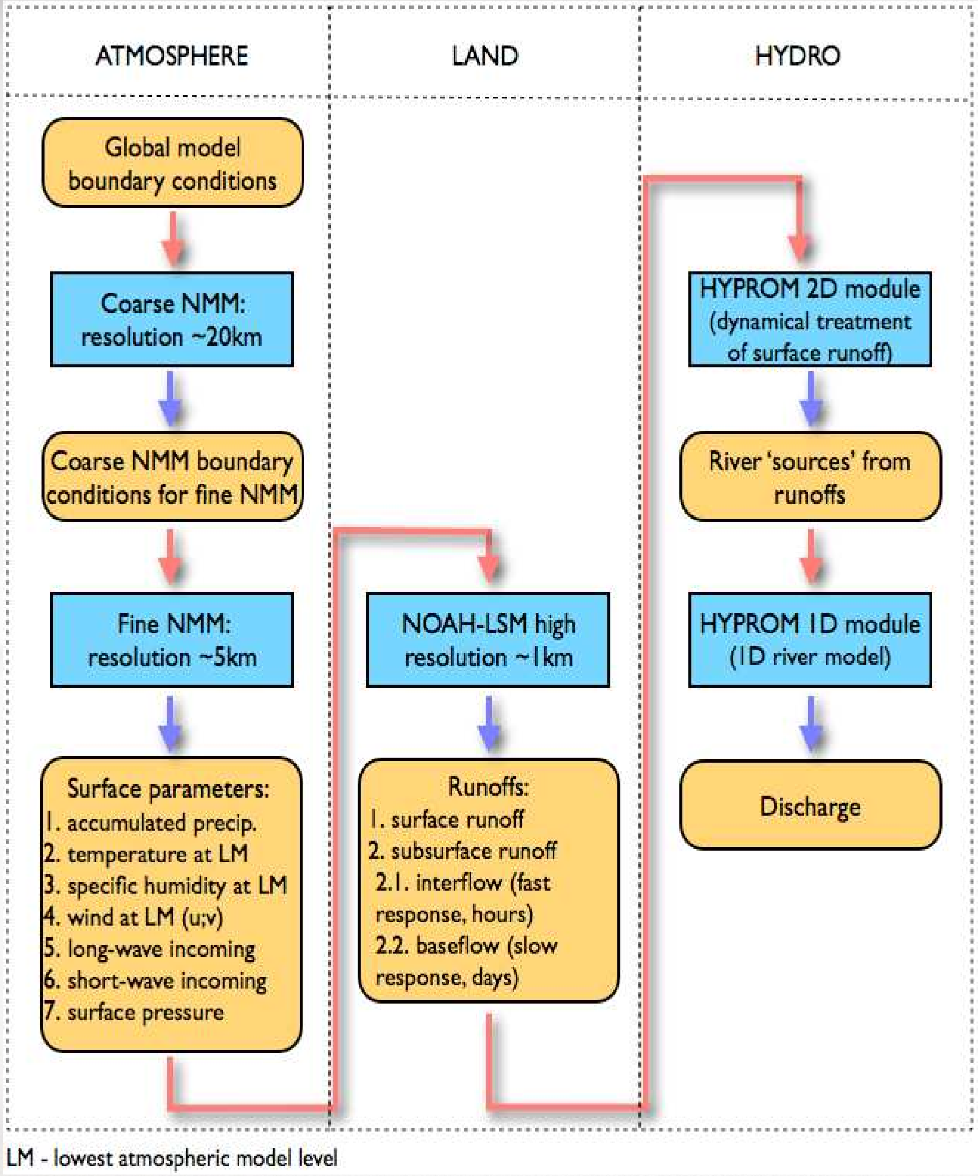
• HYPROM consists of two sub-models: two-dimensional representation of overland flow and one-dimensional river routing component that collects the excess water in a drainage basin. It uses real topography, river routing and soil texture data from USGS datasets.

• HYPROM model is driven with the advanced non-hydrostatic NCEP/NMM-E atmospheric model (Janjic et al., 2001; Janjic, 2003), which is widely used to produce operational weather forecasts. It simulates precipitation and calculate surface and base runoff from rainfall and snowmelt using the NMM-E land surface scheme.

HYdrology PROgnostic Model

HYPROM model:

- Dynamical treatment of overland flow
- Suitable for long term and flash floods simulations
- Applicable to small and large watersheds
- Computationally efficient



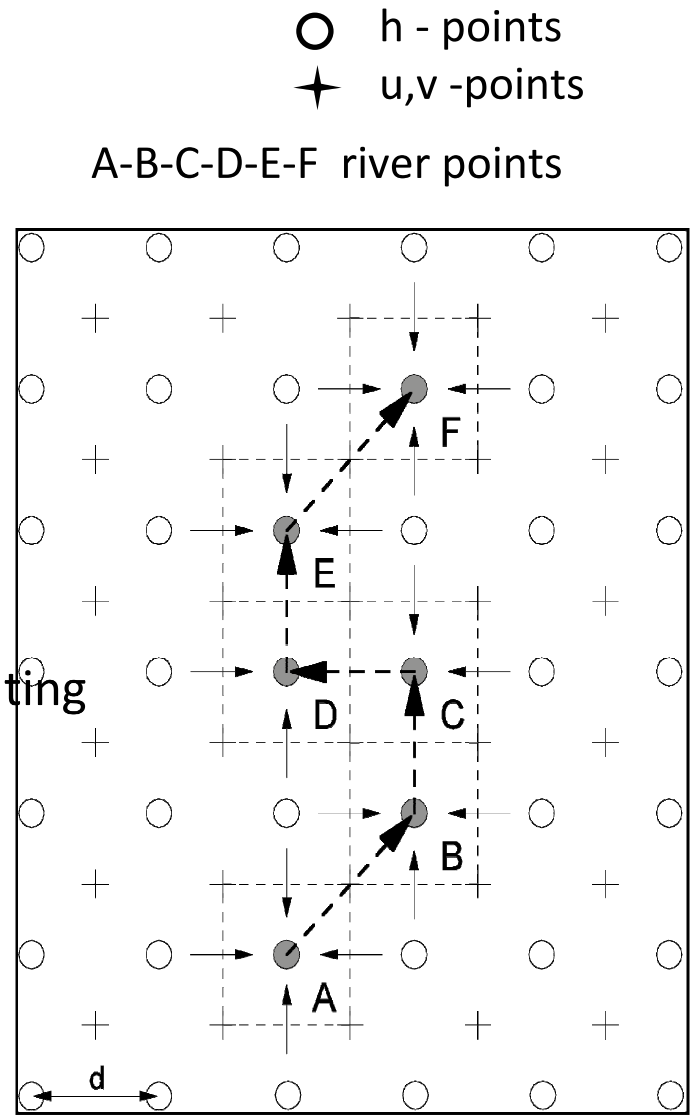
Governing equations

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+g\left[\frac{\partial h}{\partial x}+S_{fx}-S_{0x}\right]=0$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+g\left[\frac{\partial h}{\partial y}+S_{fy}-S_{0y}\right]=0$$

$$\frac{\partial h}{\partial t}+\frac{\partial (hu)}{\partial x}+\frac{\partial (hv)}{\partial y}+\dot{H}=0$$

$$\left.\begin{aligned}&\frac{\partial U}{\partial t}+U\delta_s\overline{U}^s+g\delta_s(R+h_s)+\frac{n^2|U|}{\overline{R^{4/3}}^s}U=0\\ &\frac{\partial R}{\partial t}+\delta_s\left(\overline{R}^sU\right)+\dot{R}=0\end{aligned}\right\}\text{One-D River routing}$$



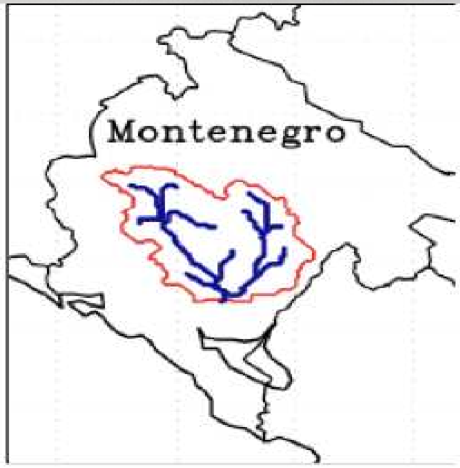
- dynamical treatment of overland flow (NO kinematic approximation!)
- numerically stable implicit time scheme for the friction term
- new numerical technique for preventing grid decoupling noise
- suitable for long term and flash flood simulations
- computationally efficient

Ničković S. et al, 2010: HYPROM hydrology surface-runoff prognostic model, *Water Resource Research*

Hydrology Prediction Model HYPROM   Case study: the Moraca river

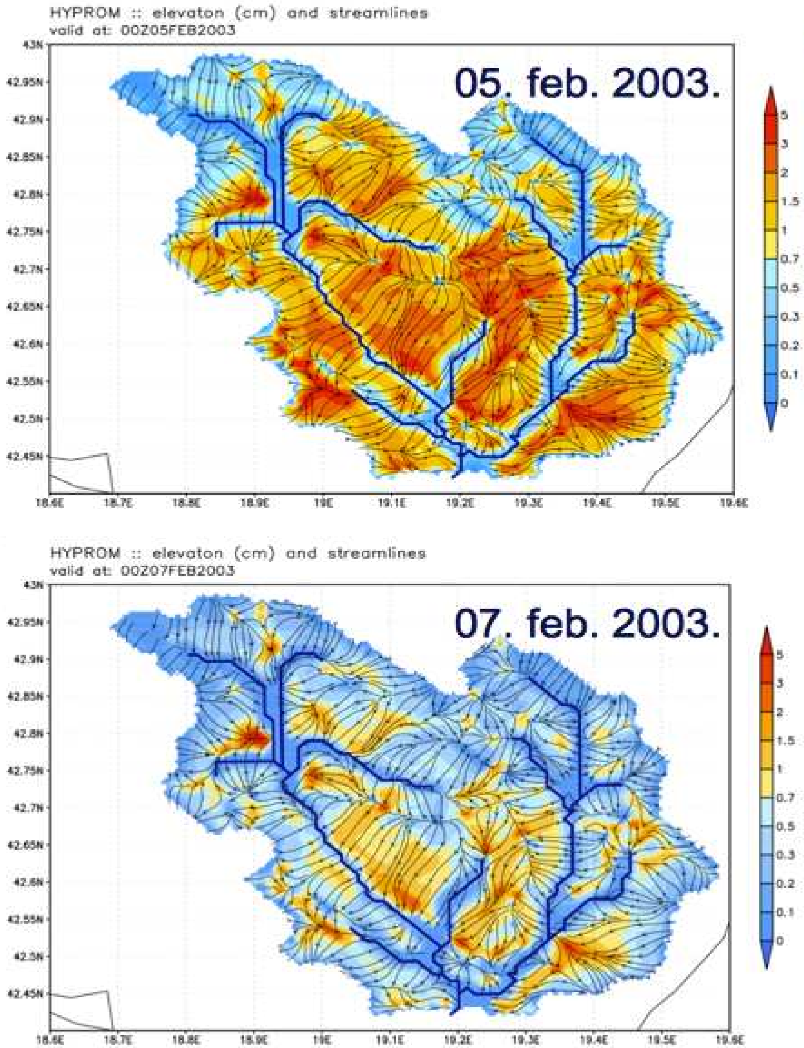
Moraca (Montenegro)

watershed: 3200 km^2

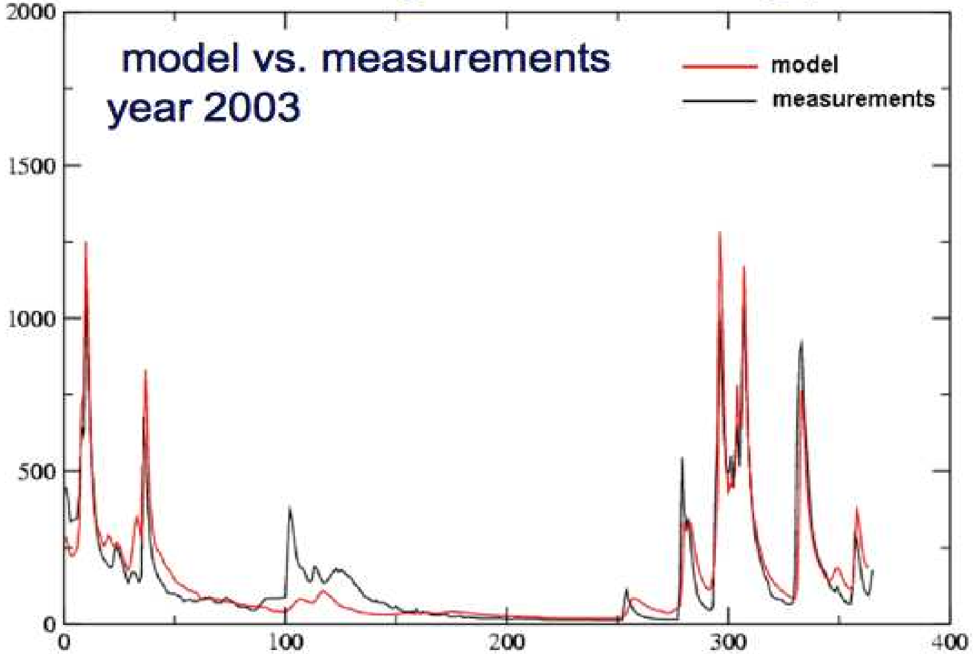


HYPROM - example of dynamical treatment of surface runoff after heavy rains

elevation (cm) and stream lines

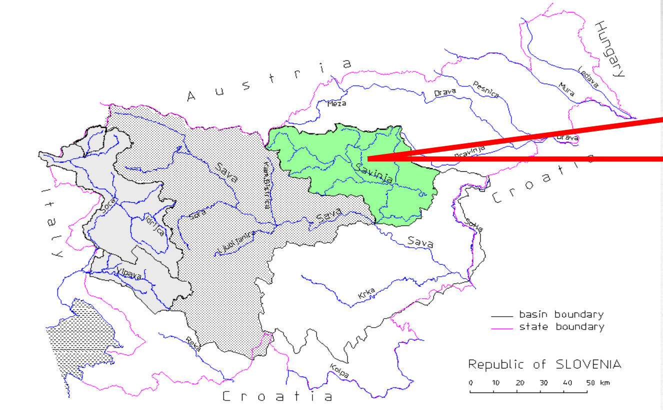


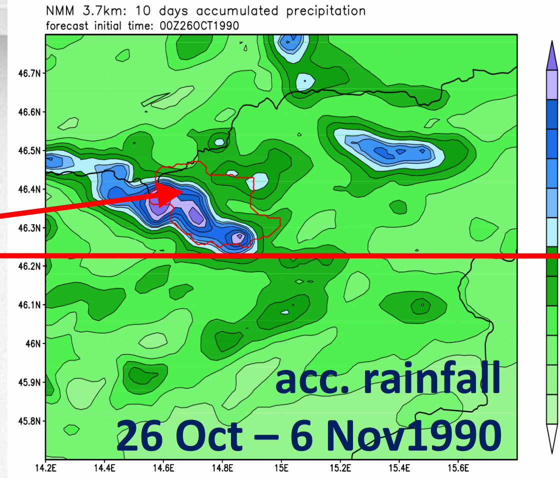
discharge (m^3/s) at **Podgorica** measuring point

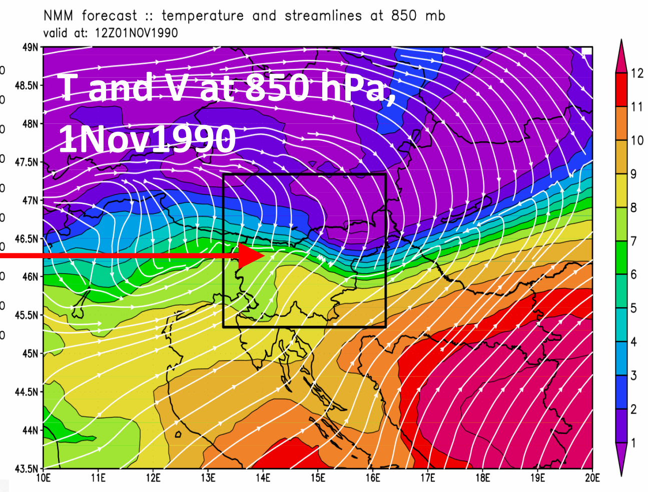


Case study: the Savinja river, flash flood event

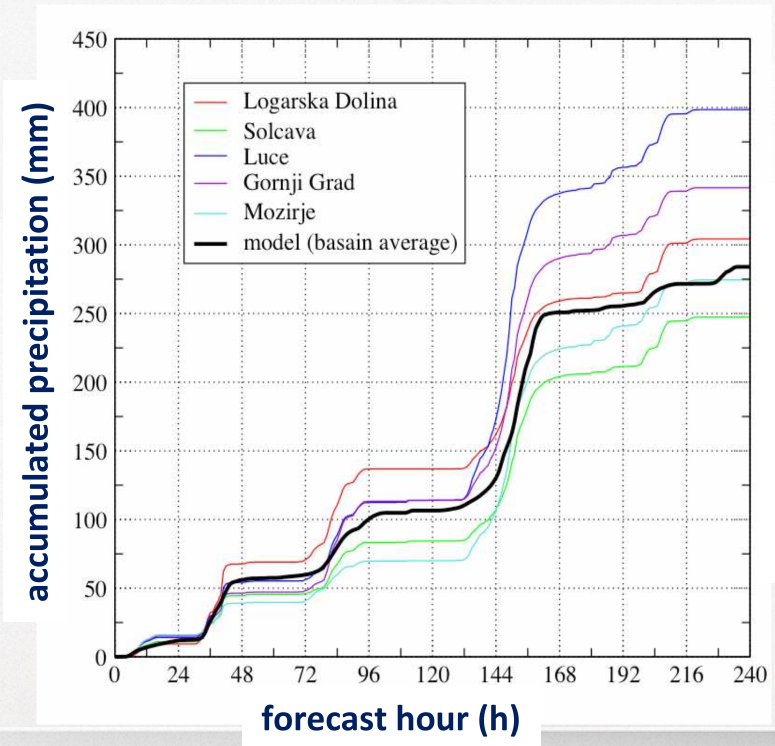
watershed: 1850 km²

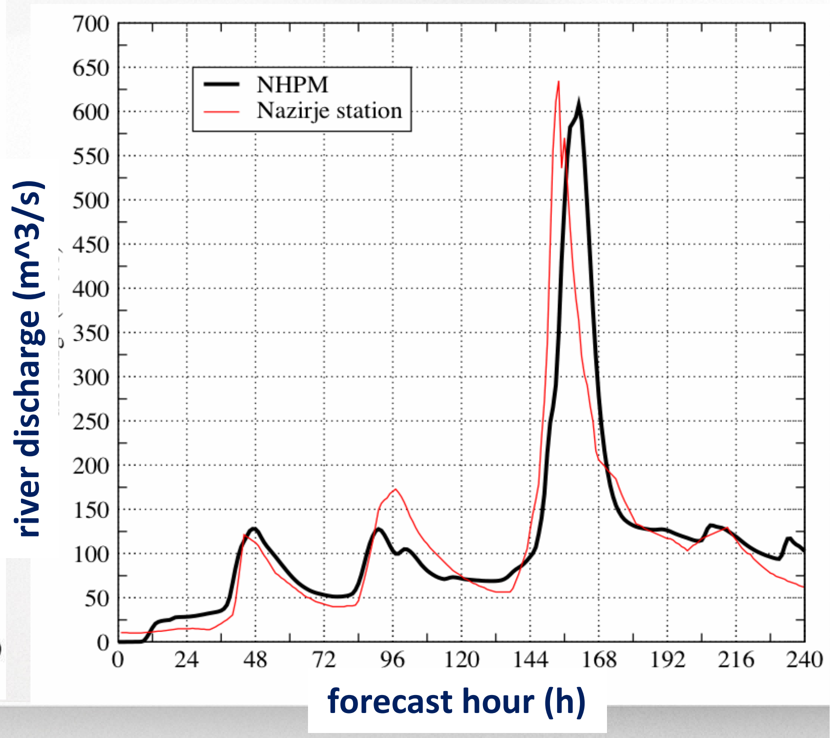






model .vs. observations





Aerosol component of IEMS
DREAM dust model

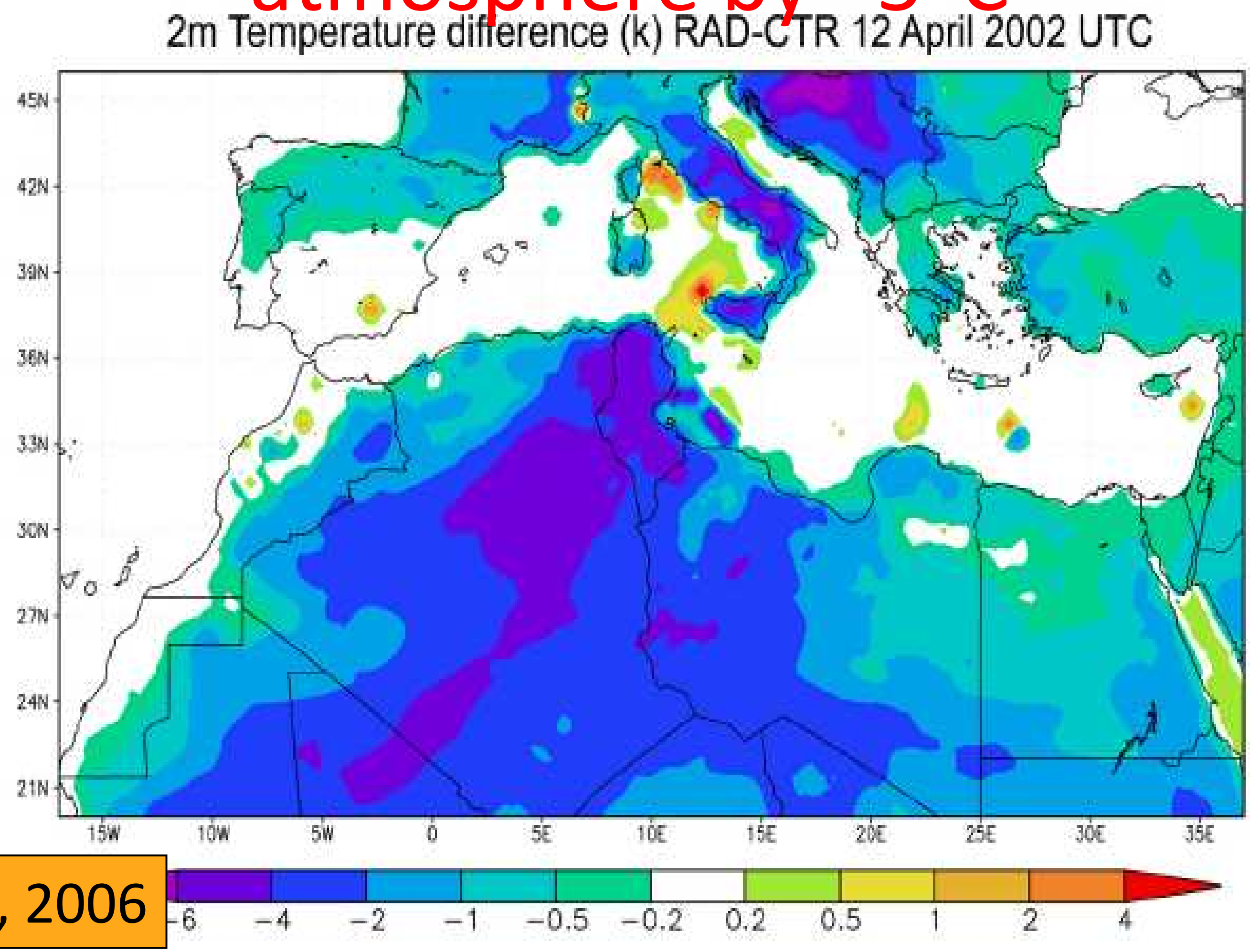
- DREAM model is developed as an add-on component of the atmospheric model and is designed to simulate and/or predict the atmospheric cycle of mineral dust aerosol. It solves the Euler-type partial differential nonlinear equation for dust mass continuity. Dust concentration is one of the governing prognostic equations in an atmospheric numerical prediction model (Janjic, 1990, 1994, and references thereinafter).

- DREAM simulates all major processes of the atmospheric dust cycle (Nickovic et al., 2001). During the model integration, calculation of the surface dust emission fluxes is made over the model cells declared as deserts. A viscous sub-layer parameterization regulates the amount of dust mass emission for a range of near-surface turbulent regimes. Once injected into the air, dust aerosol is driven by the atmospheric model variables: by turbulence in the early stage of the process when dust is lifted from the ground to the upper levels; by winds in the later phases of the process when dust travels away from the sources; and finally, by thermodynamic processes and rainfall of the atmospheric model and land cover features which provide wet and dry deposition of dust over the Earth surface.

Impacts of Sand and Dust

- Human Health (asthma, infections, meningitis in Africa, valley fever in the USA)
- Marine productivity
- Aviation
- Agriculture
- Ground transportation

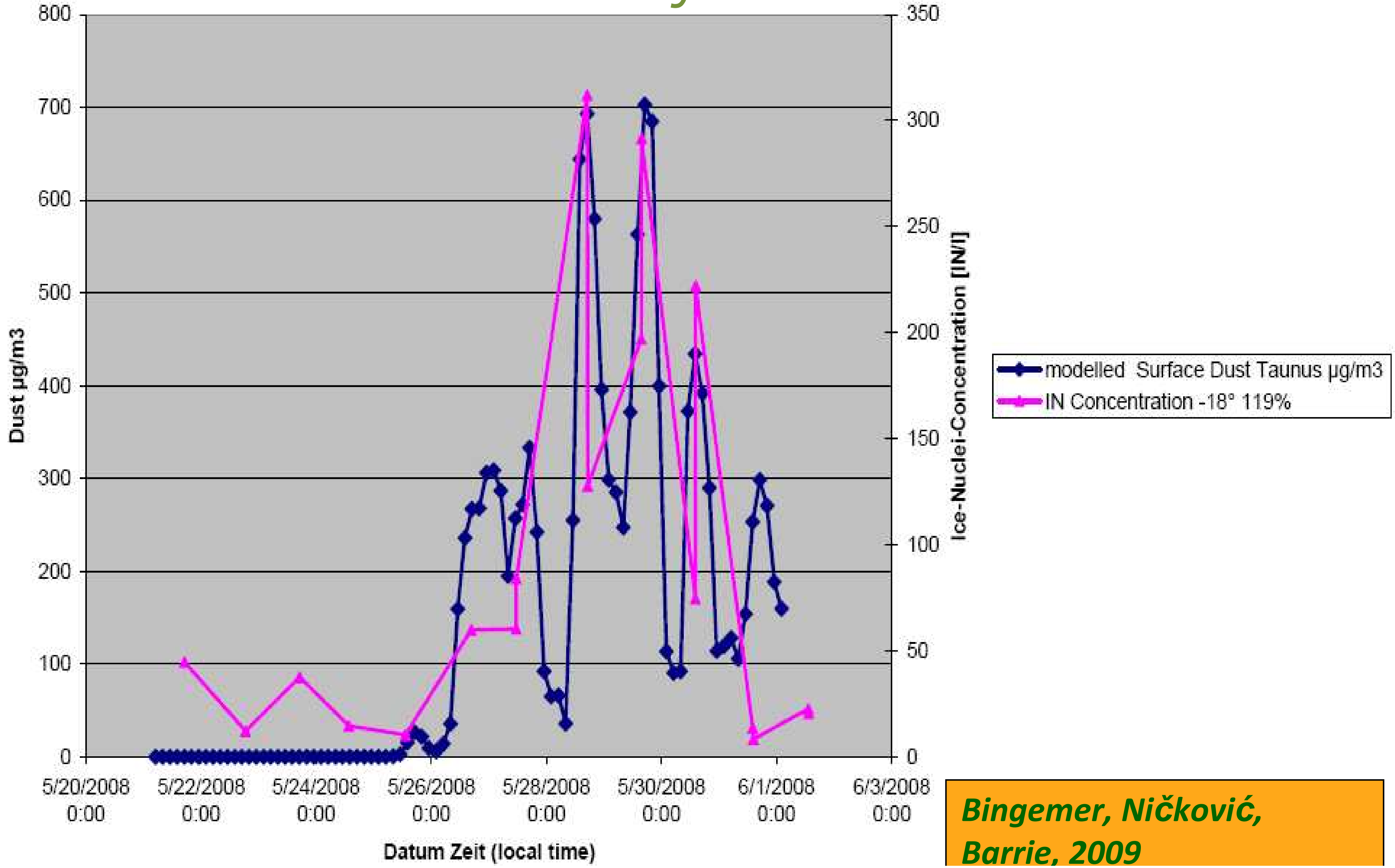
Impact on radiation: Cooling surface atmosphere by ~5°C



Perez et al, 2006

Figure 10. Vertical cross-sections between latitudes 30°N and 40°N along longitude 12°E of (a) the extinction coefficient at 550 nm from RAD and (b) the atmospheric temperature difference between RAD and CTR on the 12 April 2002 at 1200 UTC. (c) Horizontal distribution of 2m temperature difference over the whole domain.

Comparison of DREAM Model Aerosol Mass with Ice Nuclei Measurements at Kleinerfeldberg Frankfurt 20 May – 3 June 2008



Bingemer, Ničković, Barrie, 2009

Significance of mineral composition in desert soils

- Fe and P embedded in dust → ocean nutrients

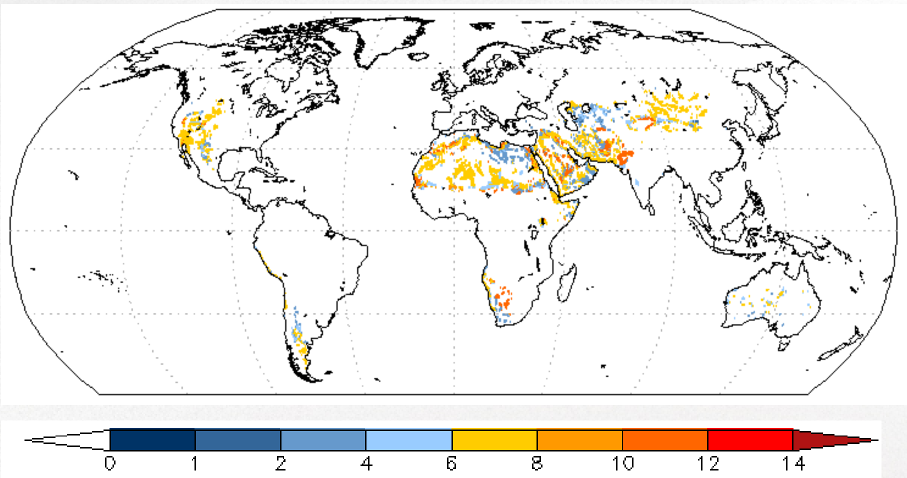
- Cloud ice nucleation sensitive to mineral composition

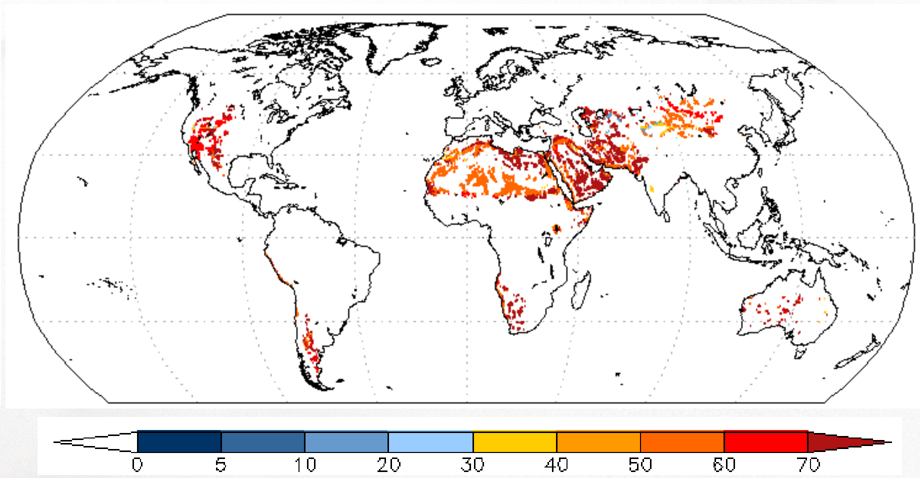
- Hypothesis: Fe as an enhancement factor in meningitis
  outbreaks (Thompson, 2008)

Minerals in erodible soils

• mineral composition of dust aerosols is important for:
  human health, ocean productivity, cloud ice nucleation, atmospheric radiation
• we develop 1km resolution global data set of mineral fractions in arid soils:
  silicates (quartz, feldspar, illite, kaolinite, smectite), carbonates (calcite), qypsum, iron oxides (hematite)
• work on implementation of mineral transport in atmospheric models
• mineral data set will be used as mask of mineral sources for uptake in atmospheric models with included transport on mineral particles

Example: quartz (mineral with largest percentage) content in erodible soils in silt and clay part





Phoenix (Arizona) Haboob, 5 July 2005

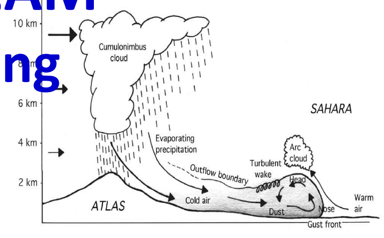
7:45 PM Phoenix as the dust storm neared

Dust modeling – NMME DREAM (operational model)

•Improved by assimilation of the dust analysis
•CCOR ~0.6 – quality forecast
•Among leading models by verification scores in WMO SDS-WAS project
•In high resolution case runs (<5km) for severe dust storms it shows potential for application in warning systems (work in progress).

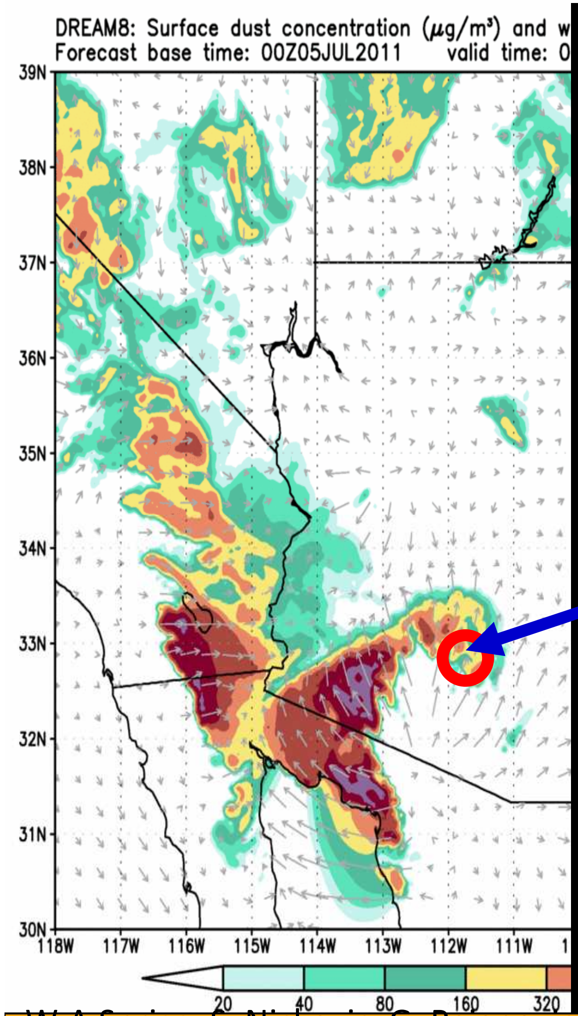
W.A.Sprigg, S. Ničković, G. Pejanović, J. Galgiani, A. Vuković

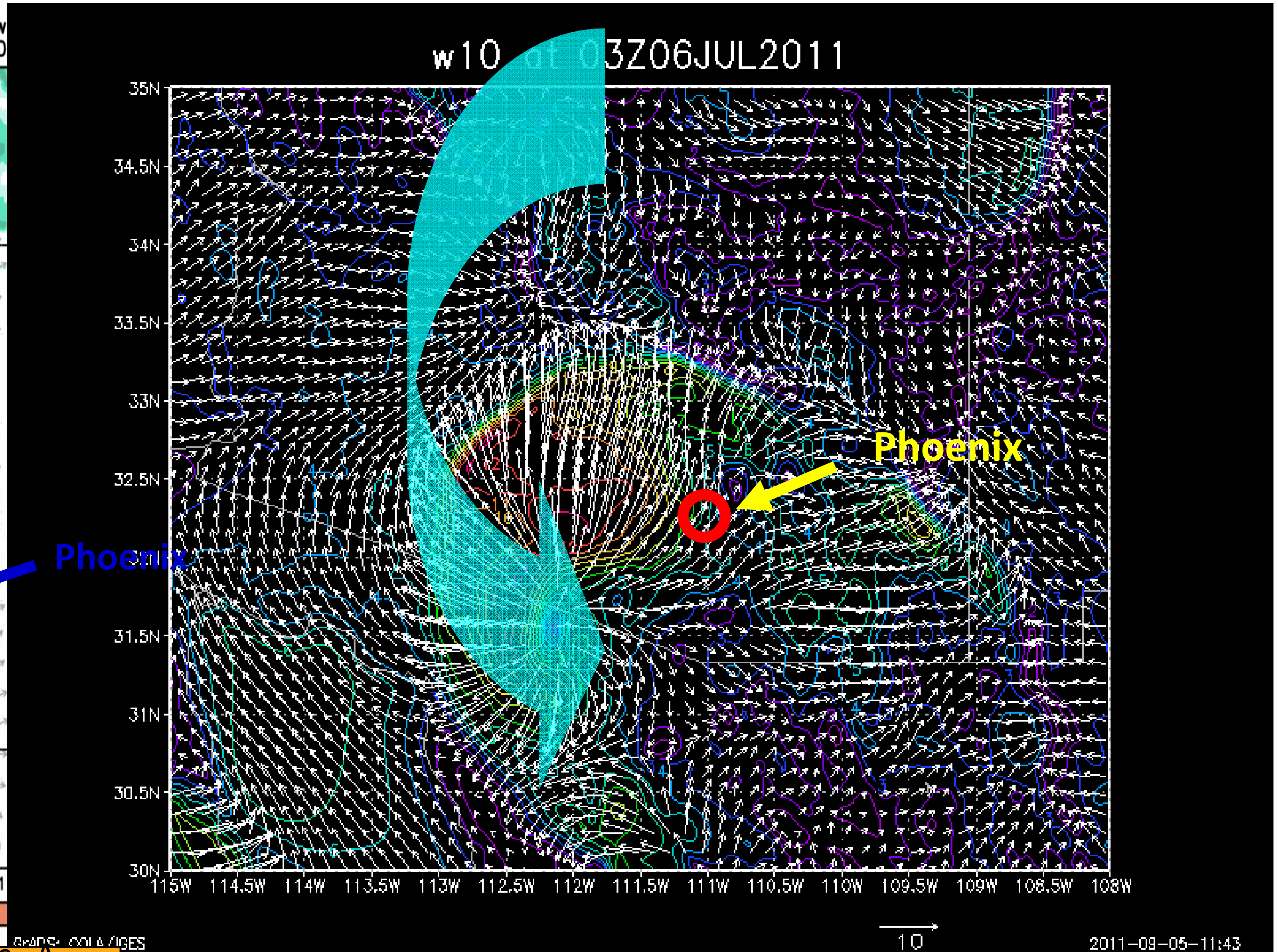
Successful simulation of the Phoenix Haboob: NMME-DREAM (collaboration: SEEVCCC and Chapman University dust modeling group)



from *Knippertz et al., JGR, 2007*

DUST SIMULATION: 3.5-km model





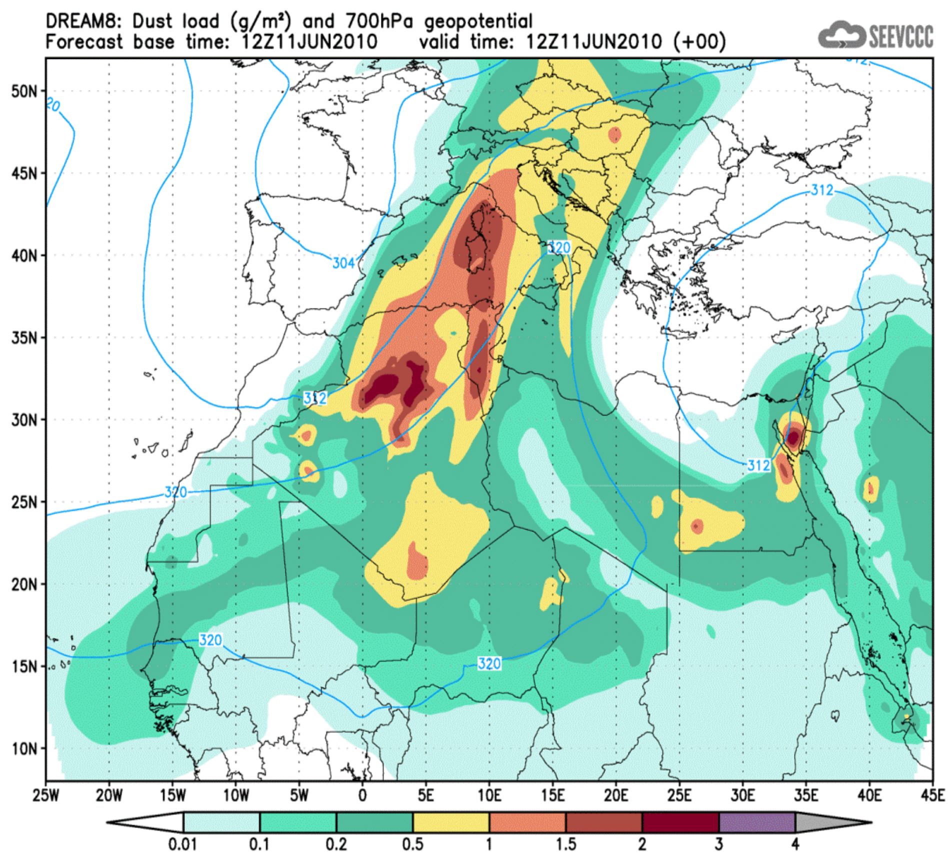
W.A.Sprigg, S. Nickovic, G. Pejanovic, A. Vukovic

Operational dust forecast: DREAM

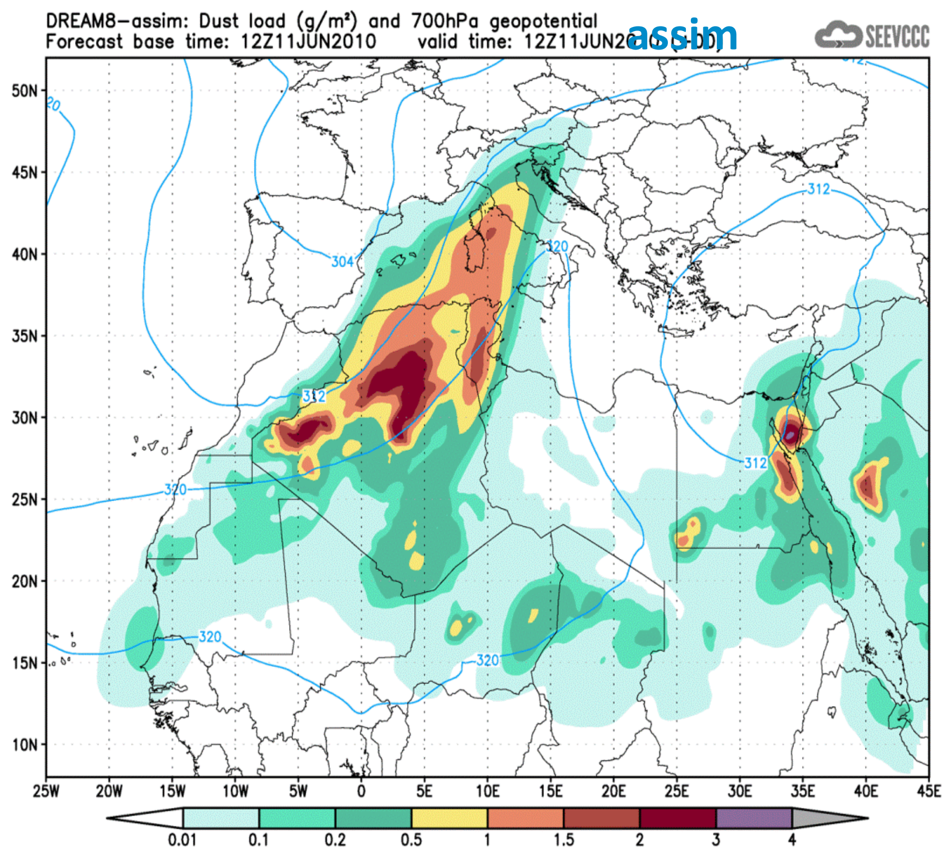
- **DREAM8**: **D**ust **R**egional **A**tmospheric **M**odel with 8 categories for particle sizes
  - **model runs:** 12UTC start ; +72h forecast
  - **model resolution:** 1/3 degrees (~35km)
  - **models:** DREAM8 and DREAM8-assim (assimilation using ECMWF dust aerosol analysis)

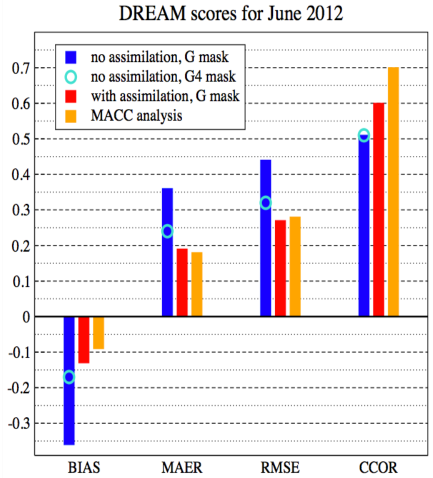
presented: model run from June 11th 2010 12UTC

DREAM8

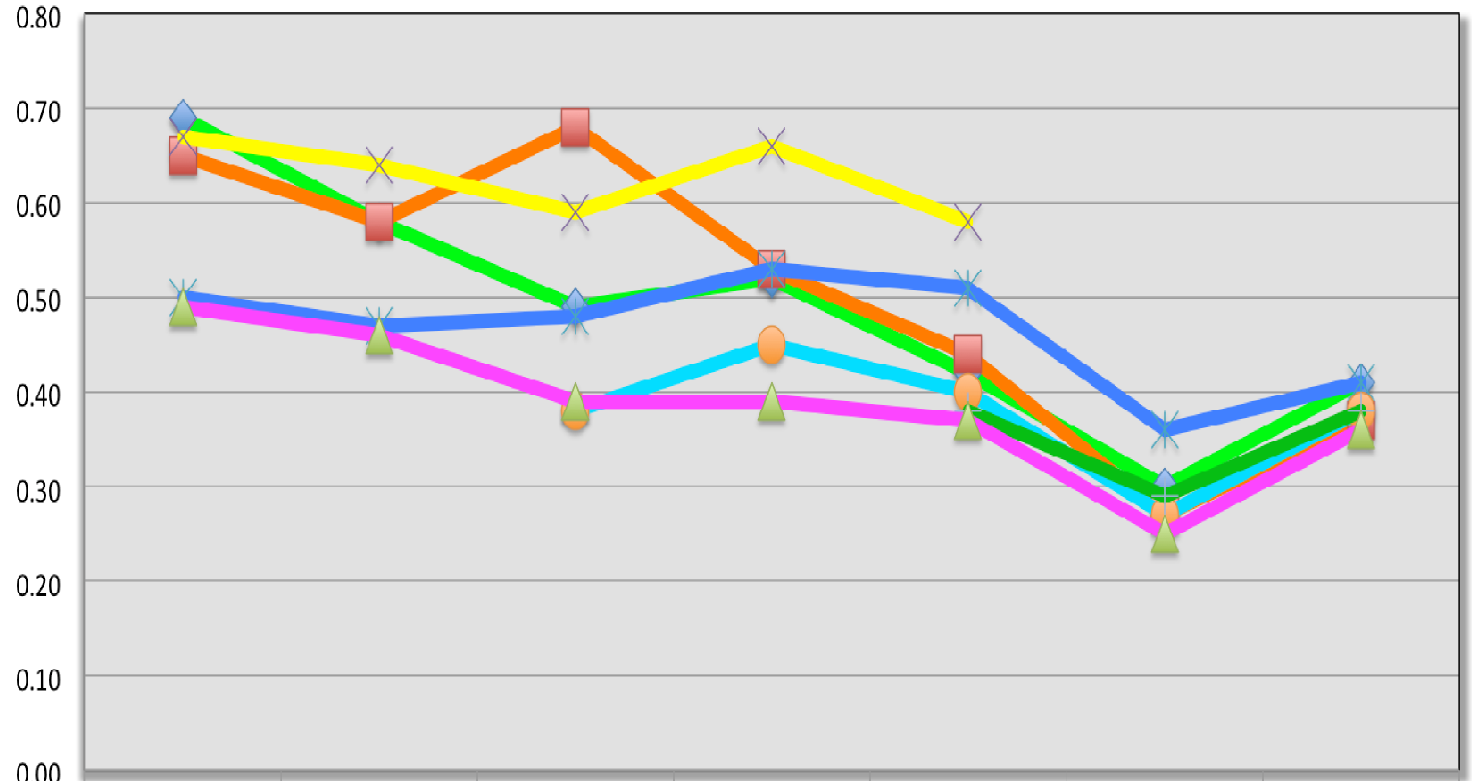


DREAM8 – assim





AOD 550 nm RMS error
WMO SDS-WAS Intercomparison



	Mar	Apr	May	Jun	Jul	Aug	Sep
BSC_DREAM8b (Barcelona)	0.69	0.58	0.49	0.52	0.42	0.3	0.41
MACC-ECMWF (Reading)	0.65	0.58	0.68	0.53	0.44	0.27	0.37
CHIMERE (Palaiseau)	0.67	0.64	0.59	0.66	0.58		
NMMB/BSC-Dust (Barcelona)	0.5	0.47	0.48	0.53	0.51	0.36	0.41
U.K. MetOffice (Exeter)			0.38	0.45	0.4	0.27	0.38
NASA GEOS-5					0.38	0.29	0.38
DREAM8-NMME-SEEVCCC (Belgrade)	0.49	0.46	0.39	0.39	0.37	0.25	0.36

Thank you