Republic Hydrometeorological Service of Serbia
(established 1888, WMO member since 1947)

http://seecop.meteo.co.me/

South-East European Consortium for Operational weather Prediction (SEECOP)

Bojan Cvetkovic
Republic Hydrometeorological Service of Serbia (RHMSS), Belgrade, Serbia
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Workshop on Regional NWP and EUMETSAT Next-Generation Satellite Programme, January 2020, EUMETSAT HQ, Darmstadt

South East Europe Consortium for Operational Weather Prediction SEECOP

- 2006:
  - RHMSS initiated establishment of South East European Virtual Climate Change Center (SEEVCCC);
  - supported by UNECE (The United Nations Economic Commission for Europe) and MET services in the region;
- 2010:
  - SEEVCCC has been formally established and hosted by RHMSS (collaboration to combat climate change and its impacts)
  - Expert Workshop “SEE Research Framework in Regional Climate Modeling”, 2011, Belgrade
- 2015:
  - Logical extension of this efforts resulted in establishing the SEECOP Consortium (collaboration in short-range numerical weather prediction)

South East Europe Consortium for Operational Weather Prediction (SEECOP)

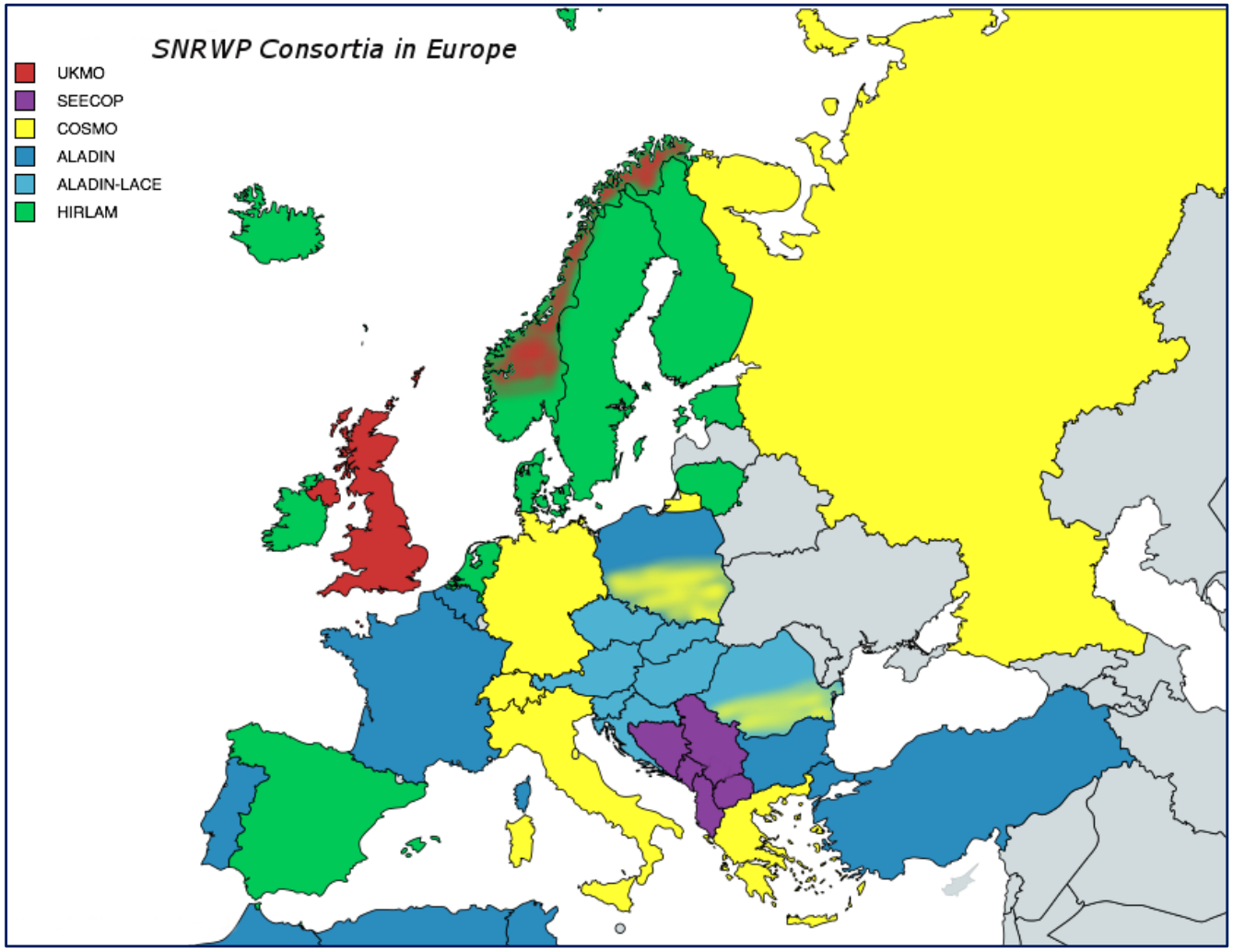
- **Established 2015 as a result of the RHMSS initiative**
- **Consortium model - NCEP/NMMB prognostic model**

- **SEECOP member countries**
  - Serbia
  - Montenegro
  - Federation of Bosnia and Herzegovina (both entities)
  - Republic of North Macedonia
  - Albania
  - Ukraine
  - Belarus (pending approval)

- **Open policy for joining SEECOP**

  Cyprus, Greece, Turkey and Moldova showed interst to join

- Other European consortia of the same kind:
  - UKMO, COSMO, ALADIN, HIRLAM

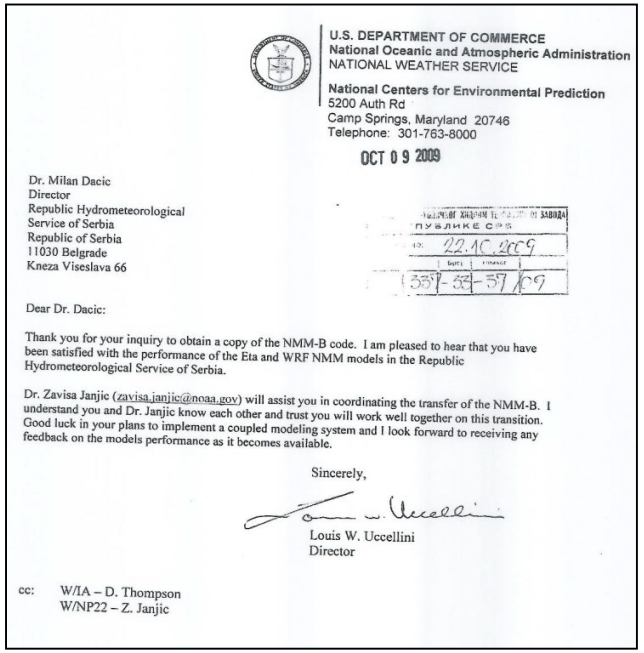


SEECOP agreement objectives

- Using NMMB model to:
  - Improve accuracy of NWP and warning services related to severe weather phenomena;
  - Further improve environmental forecasts in general, including hydrological, oceanographic, aerosol forecasts etc. driven by NMMB;
  - Perform research and development focussed on operational forecasts;
  - Share available expertise, data, modelling and technical resources between Members;
  - Reduce overlapping in NWP between Members;
  - Organize trainings for different areas related to NWP;
  - Enhance in general the operability in NWP in the region.

The SEECOP model: NCEP/NMMB

- Its distant cousins: models in 70ties and 80ties of the Belgrade NWP group
- NMMB is developed by Prof. Zavisa Janjic
- Operational regional model at NCEP
- Agreement between NCEP and RHMSS on collaboration – NMMB implementation and developments
- Global and regional NMMB at RHMSS from Jan 2012
- Most of SEECOP members already use or test NMMB



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE

National Centers for Environmental Prediction
5200 Auth Rd
Camp Springs, Maryland 20746
Telephone: 301-763-8000

OCT 0 9 2009

Dr. Milan Dacic
Director
Republic Hydrometeorological
Service of Serbia
Republic of Serbia
11030 Belgrade
Kneza Viseslava 66

Dear Dr. Dacic:

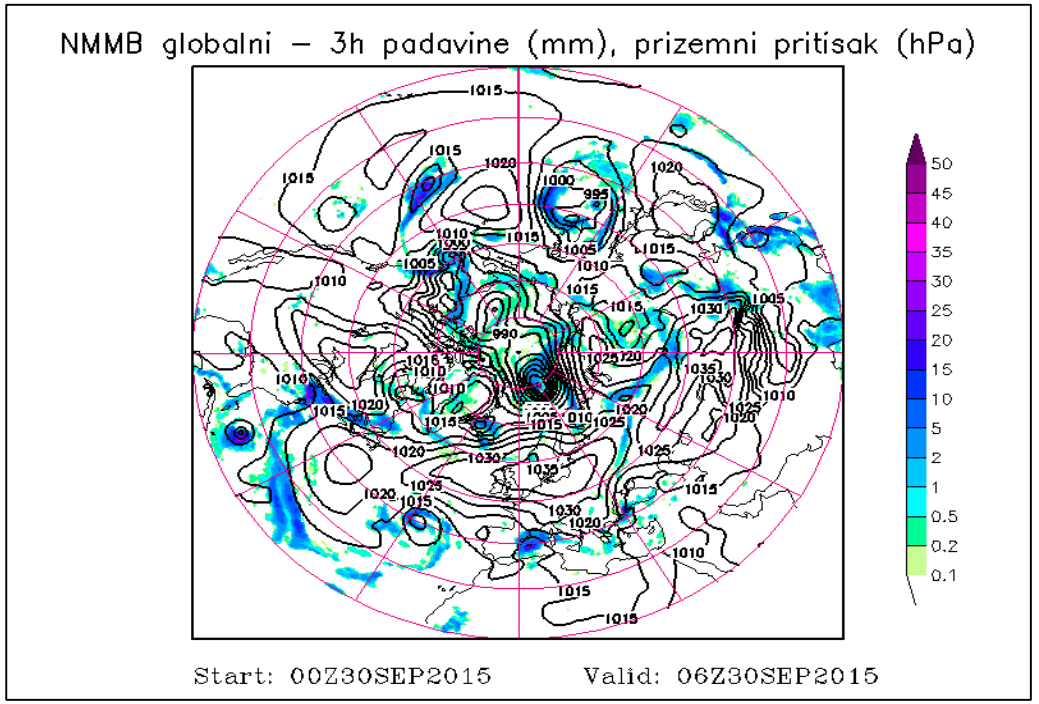
Thank you for your inquiry to obtain a copy of the NMM-B code. I am pleased to hear that you have been satisfied with the performance of the Eta and WRF NMM models in the Republic Hydrometeorological Service of Serbia.

Dr. Zavisa Janjic (zavisa.janjic@noaa.gov) will assist you in coordinating the transfer of the NMM-B. I understand you and Dr. Janjic know each other and trust you will work well together on this transition. Good luck in your plans to implement a coupled modeling system and I look forward to receiving any feedback on the models performance as it becomes available.

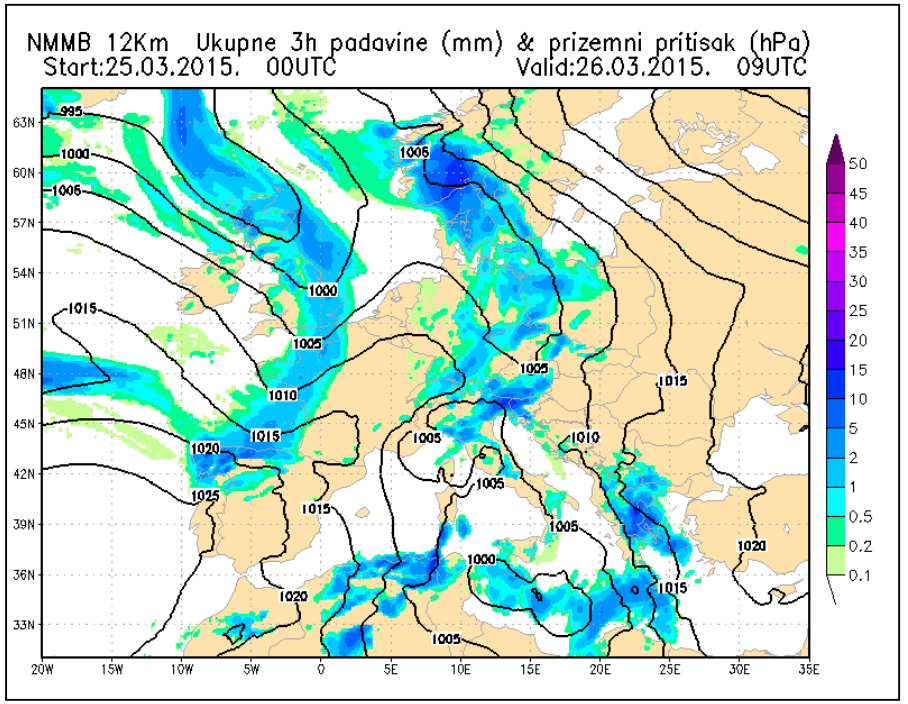
Sincerely,

Louis W. Uccellini
Director

cc: W/IA – D. Thompson
W/NP22 – Z. Janjic



GLOBAL NMMB



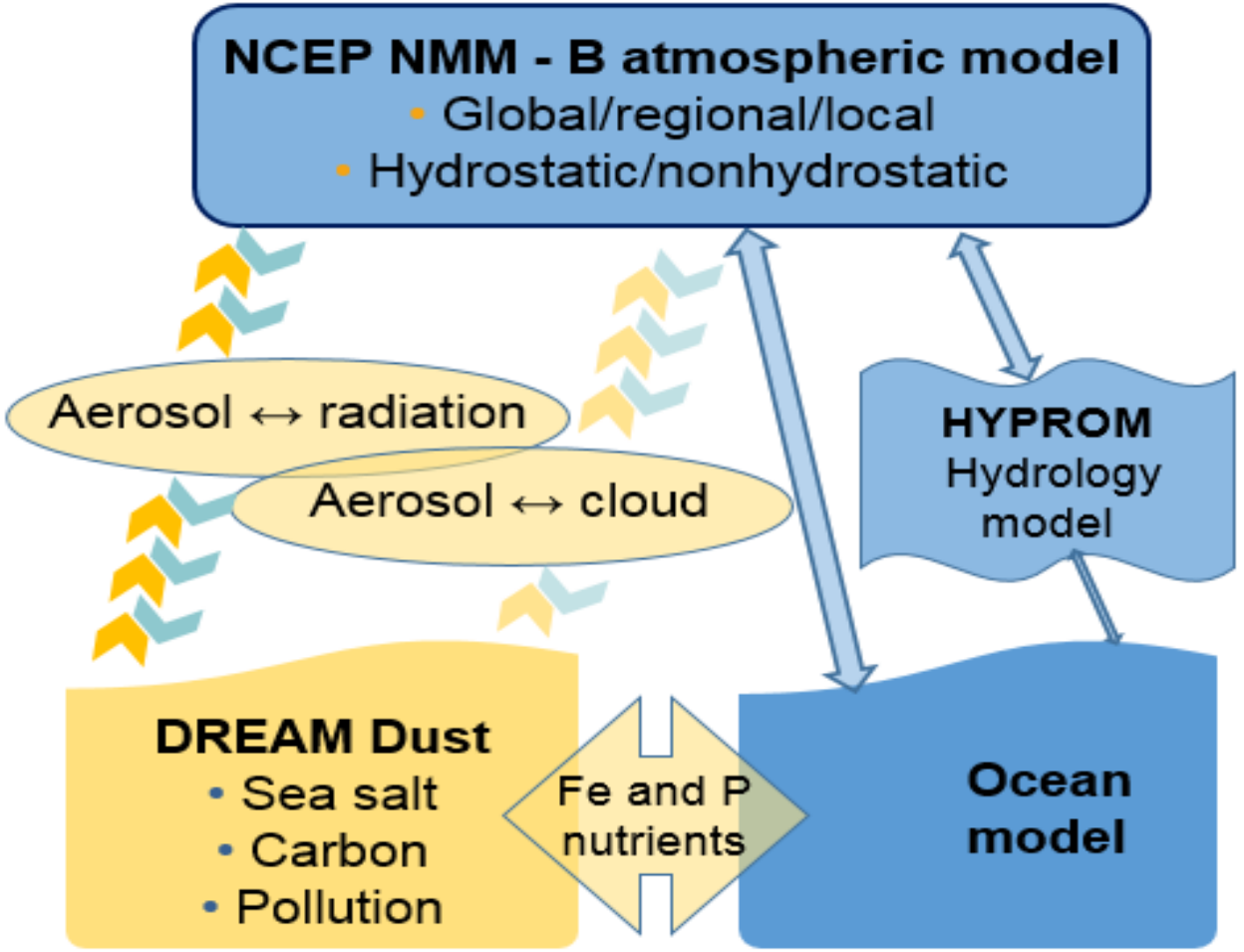
REGIONAL NMMB

List of models in use (operationally and research) at RHMSS and other SEECOP member countries

- Model: WRF (ARW Core) - East Mediterranean basin in 3 nested domains (with 2-way feedback) at 18km, 6km and 2km horizontal resolution and 60 vertical (eta) levels. Forecast period = 120 hours, initialized for 00 and 12UTC from GFS (3hr data ingestion interval). Model compiled using the Intel C/Fortran compiler suite.
- WRF-NMM: 4 km - once a day, for the next 96 h, pgi compiler. NMMB model 6 km, ifort, fort the next 96 h.
- Eta DREAM - operational, first version h.r about 30 km , Mediterranean+N.Afrika 120h forecast WAM, 1.0 Mediterranean , h.r 0.25 degree East Mediterranean , h.r. 0.125 degree Adriatic h.r. 0.0625 degree 144h forecast WRF NMM the latest version v4.1.1 from Mediterranean to 1/2 Montenegro from 12km to 0.5km h.r resolution 144 to 120 h forecast pgi, gfortran , intel research: Eta_Slop, workstation_all, NMM-E HIres, WRF-ARW, WRF-NMM, NMMB in process to building.
- NMME_v3.9.1 - running daily on a computer in our premises, however we have external help for any programming issues including maintenance of the system and solving any kind of problems connected to the model
- WRF-ARW - model with three nested domains for the Eastern Meriterranean, the Cyprus FIR and focusing on Cyprus at 2km (18km,6km,2km.) We use the gnu compilers and NCL for post processing
- NMMB Global - Global, resolution 30km, 10 days forecast, initial conditions GFS NCEP, start at 00UTC NMMB12 – Regional (Mediterranean, Europe and East Atlantic), resoultion 12km, 5 days forecast, boundary conditions from NMMB global, start at 00 and 12 UTC NMMB4
- NMMB nested in NMMB12 km - regional (Balkan region), resolution 4km, 3 days forecast, start at 00 and 12 UTC
- NMMBEC NMMB - BC from IFS ECMWF (9km) operational on CRAY, regional (Mediterranean, Europe and East Atlantic), horizontal resolution is about 4 km, 3 days forecast, start 00 UTC ECNMM WRF-NMM v3.5.1 with BC from IFS ECMWF, regional (Balkan region), horizontal resolution is about 4 km, 3 days forecast , boundary conditions DWD and GFS, start 00 UTC
- ETA - regional (Mediterranean, Europe and East Atlantic), 26 km resolution, 5 days forecast, DWD boundary conditions, start 00 and 12 UTC
- NMME-DREAM8 - Dust Regional Atmospheric Model with 8 categories for dust particle sizes (DREAM8) embedded in NCEP Nonhydrostatic Mesoscale Model on E-grid (NCEP/NMME), operational version resolution 25 km, fully dynamic dust transport model, start 00 UTC, assimilation of ECMWF dust analysis, 3 days forecast, region (East Atlantic, Europe, Africa, and Middle east)
- NMME-DREAM8 - regional model, for testing purposes, horizontal resolution from 15 to 3.5 km
- NMME-DREAM-ICELAND - regional operational model for high latitude dust sources and transport, resolution 7.5 km, 3 days forecast
- GLOBAL NMMB-DREAM - resolution 25 km, will be operational soon

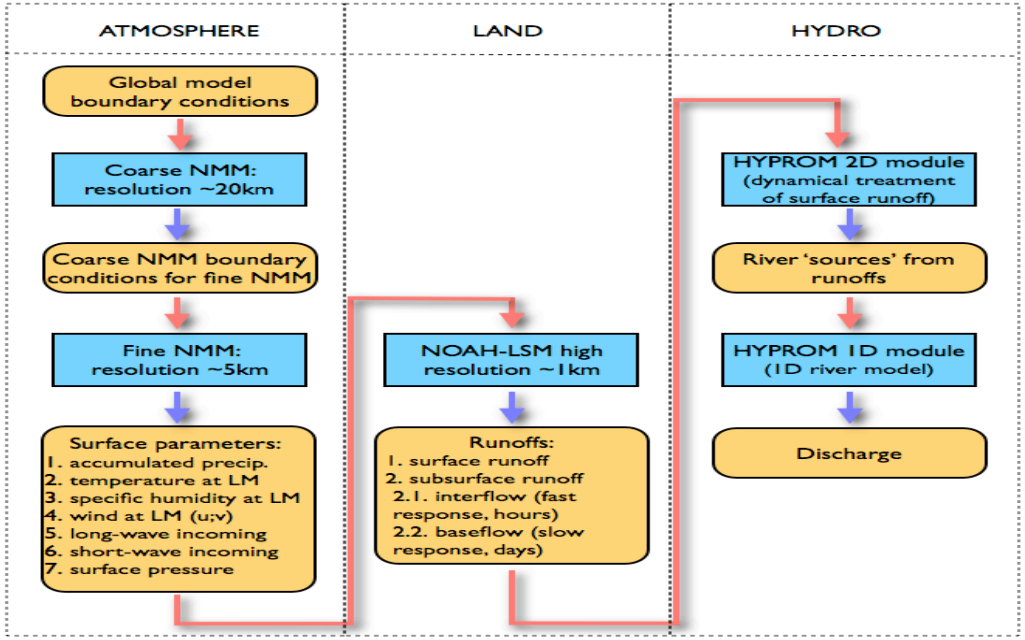
Development of the Earth Modeling System

RCC Highly recommended functions (example):
RHMSS/SEEVCCC
Earth Modeling System



Components:

Atmosphere
Land
Aerosol
Hydrology
Ocean



LM - lowest atmospheric model level

Two examples of using satellite data in aerosol transport modelling (assimilation and verification)

- Assimilation - MSG/SEVIRI dust aerosol optical depth
- Verification - MSG/SEVIRI Ice Water Path used to verify heterogeneous ice nucleation due to mineral

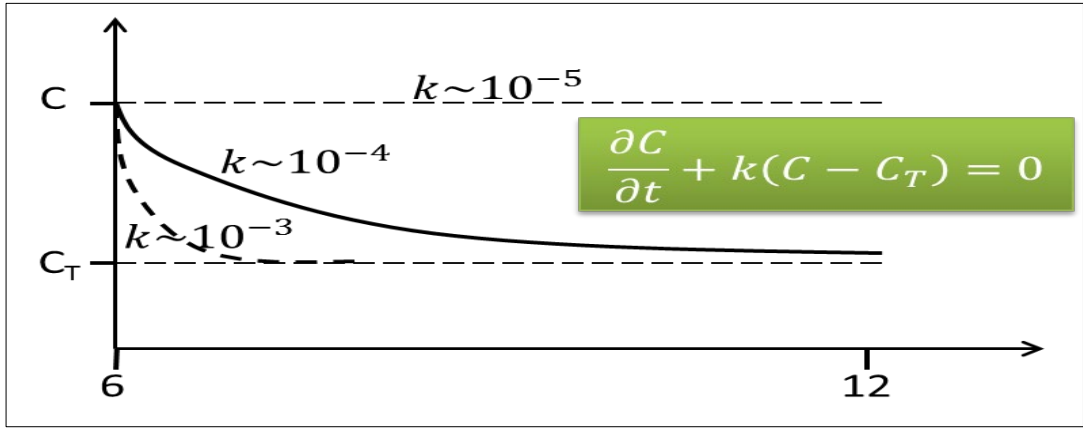
MSG satellite dust assimilation in NMME-DREAM model

Coupled Numerical Weather Prediction (NMME or NMMB) model with DUST model (DREAM)

MSG satellite dust assimilation:

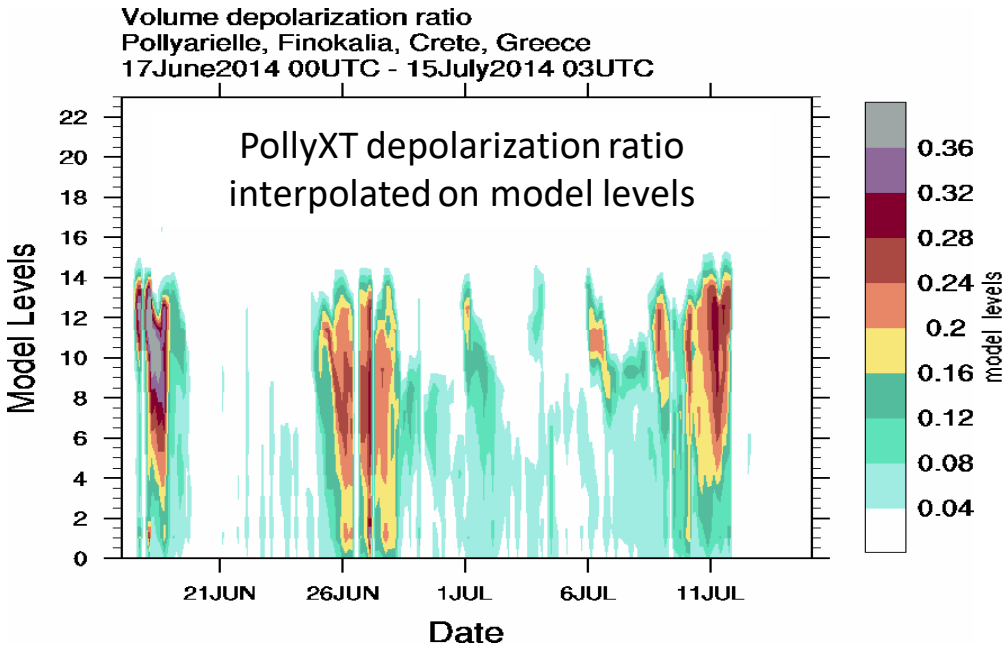
- The result of collaboration between RHMSS, National Observatory of Athens and UK Metoffice
- MSG-SEVIRI dust optical depth available every 15’
- Newtonian Relaxation method applied (Pejanovic et al.,2010)

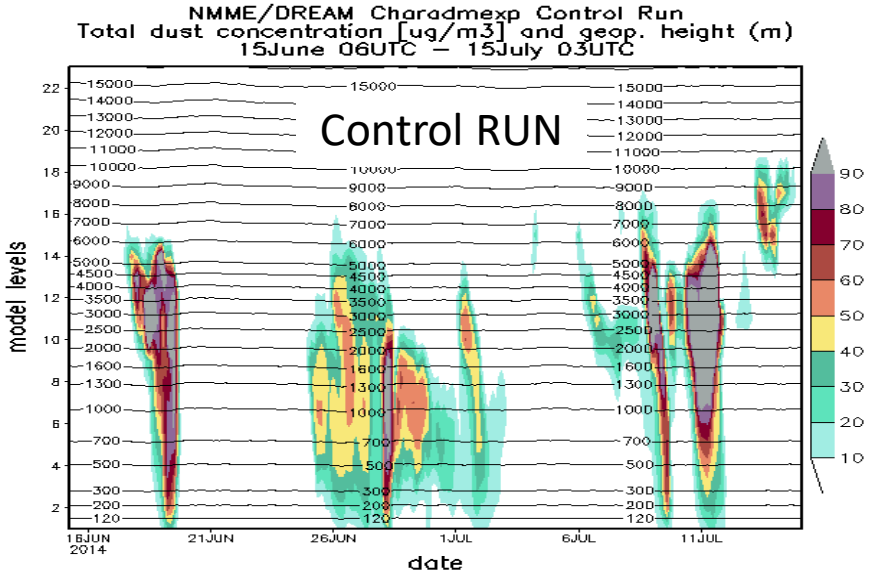
Assimilation - MSG/SEVIRI dust aerosol optical depth

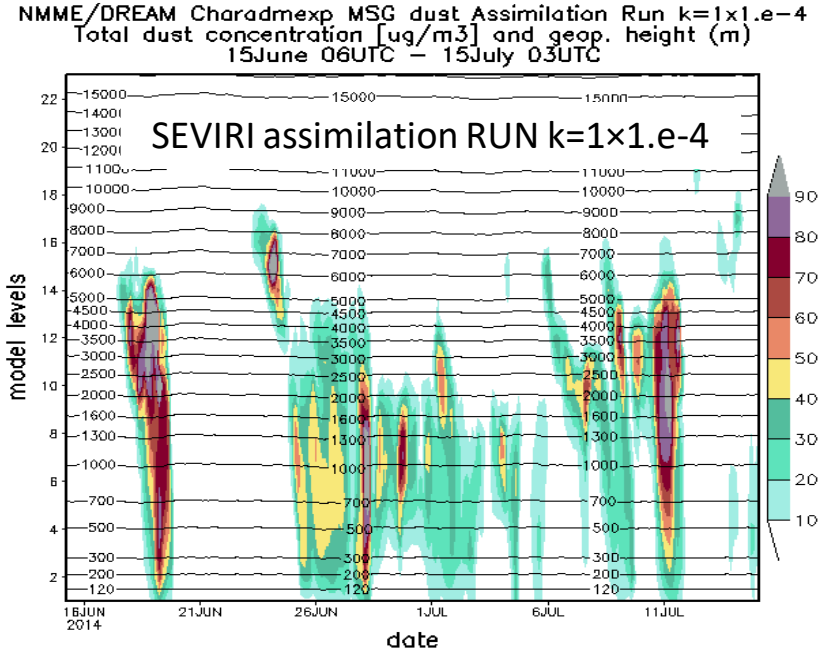


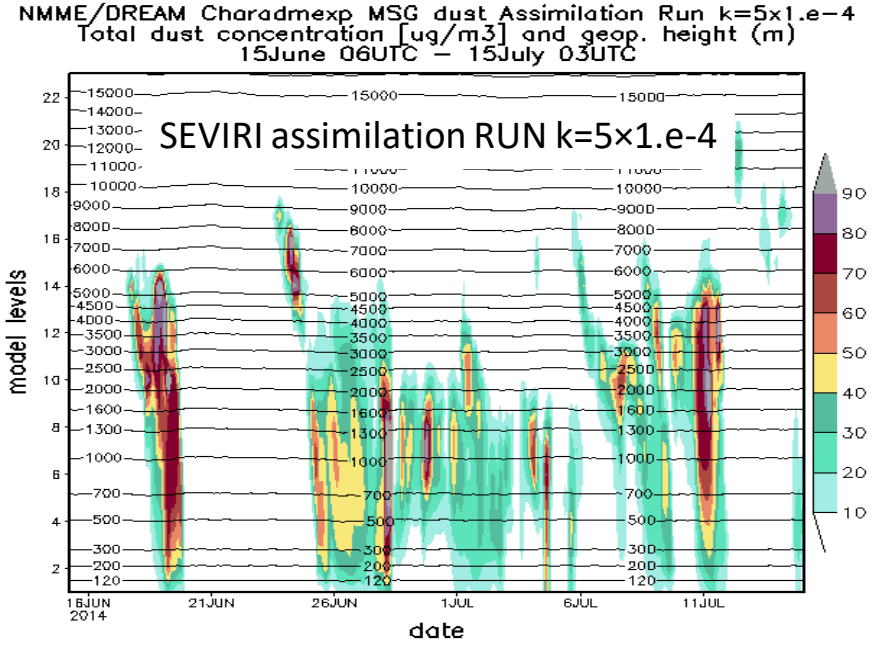
Nickovic, Solomos, Pejanovic, Pradhan, Marenco, Amiridis, Brooks, Marinou, Petkovic, Cvetkovic

MSG dust assimilation in NMME-DREAM (first results - Vertical profiles) verified by LIDAR



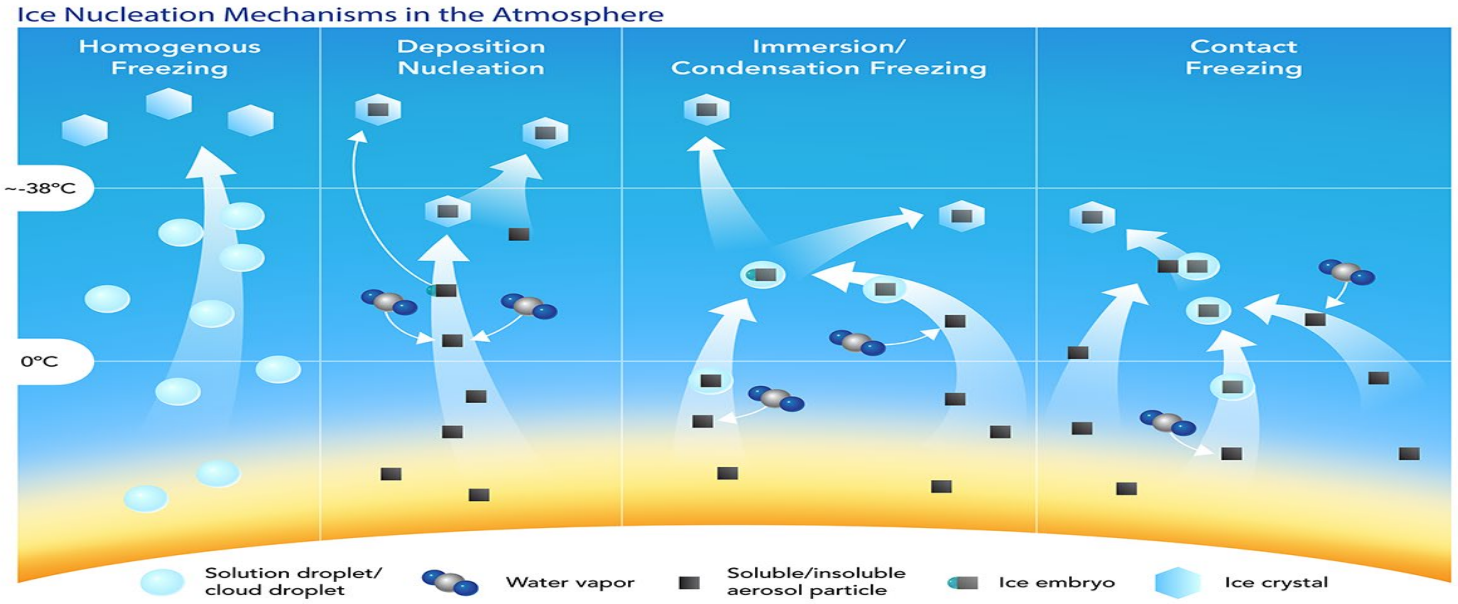


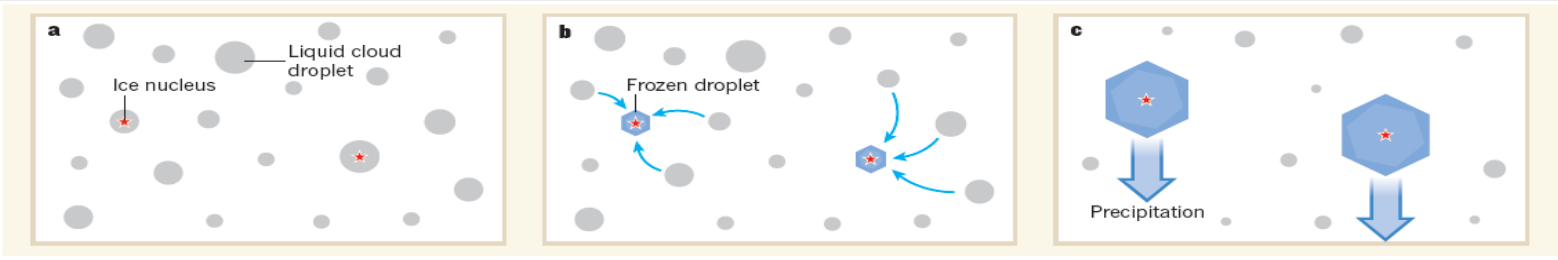




Heterogeneous cold clouds formation

- Mineral dust particles act as efficient heterogeneous ice nuclei in the tropospheric cold and mixed-phase clouds
- Dust particles lifted to the cold cloud layer effectively glaciate supercooled cloud water



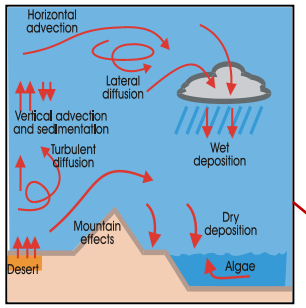


Koop and Mahowald, Nature, 2013

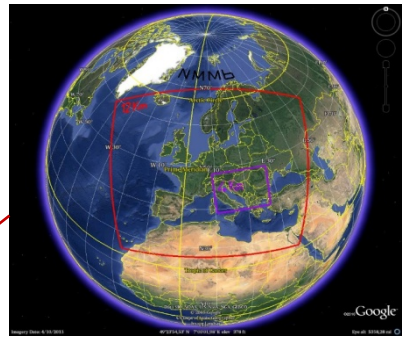
Ice formation and precipitation

- **Mineral dust – key aerosol for cloud ice nucleation and cold cloud formation**
- **RHMSS/SEEVCCC develops a prognostic system by integrating NMM and DREAM to improve cloud and rainfall predictions**
- **Daily dust and ice nucleation predictions at RHMSS/SEEVCCC**
- **DREAM participates in WMO dust model Intercomparison project**

‘Cooking’ cold clouds: our recipe



DREAM model



NMM model

Dust C

T, RH

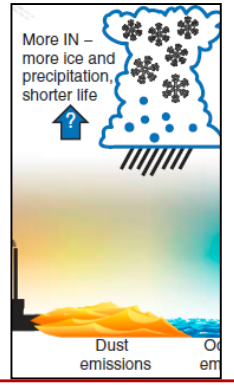
DeMott (2015) [-35°C <T<-5°C]

$$n_{IN} = C(n_{dust})^{(\alpha(273.16-T)+\beta)} \exp^{(\gamma(273.16-T)+\delta)}$$

Steinke et al (2015) [-55°C <T<-35°C]

$$n_{IN} = S_{dust} 1.88 \cdot 10^5 e^{-pT+q(RH_{ice}-100\%)}$$

n_{IN}

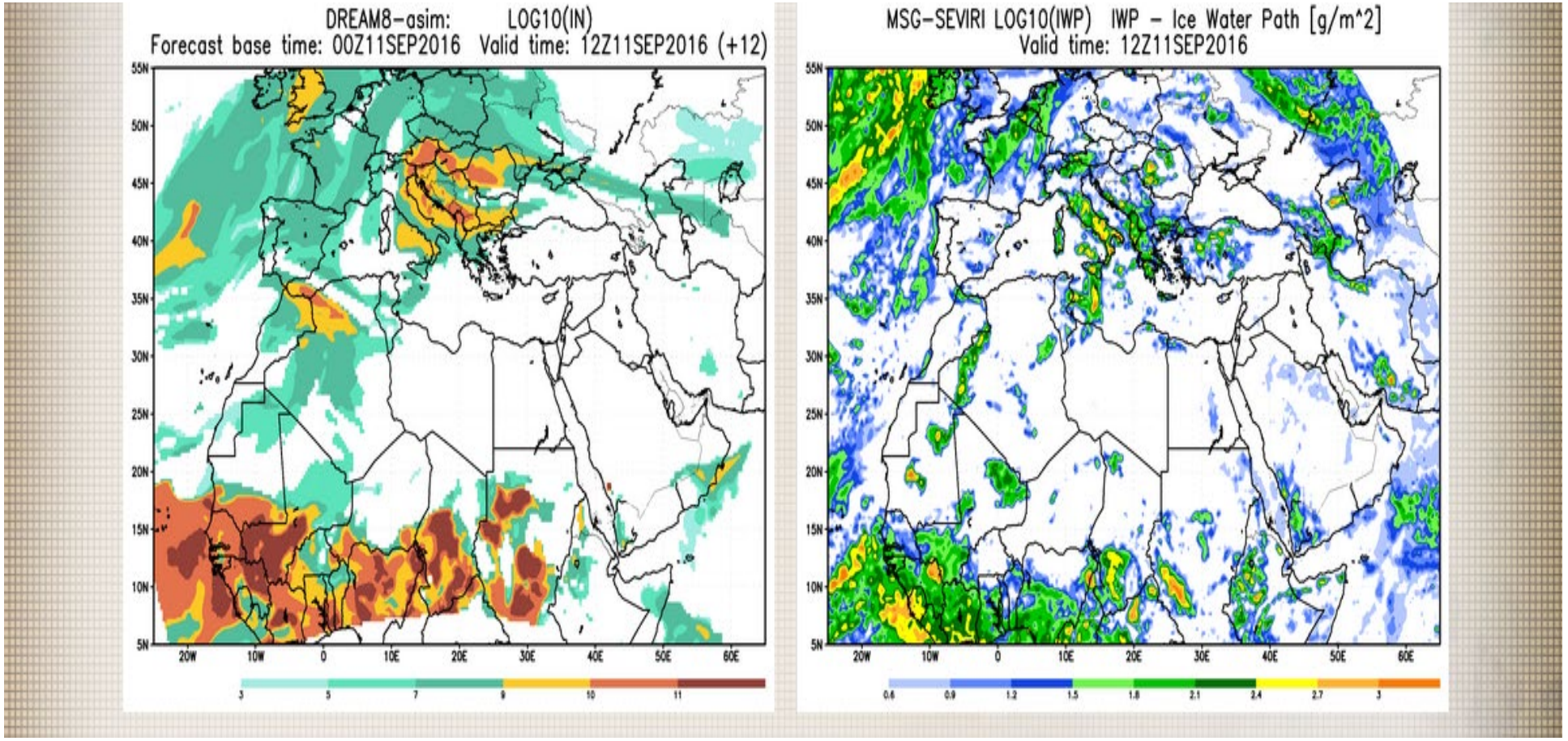


NMMB Thompson dust-friendly cold cloud micrphysics

Nickovic et al, 2016, Atmos. Chem. Phys., 16, 11367–11378

Verification - MSG/SEVIRI Ice Water Path used to
verify heterogeneous ice nucleation due to mineral dust

Daily IN maps
http://www.seevccc.rs/?p=8



NWP groups interested to use daily #IN forecasts will soon have it available through the WMO SDS-WAS (dust) project

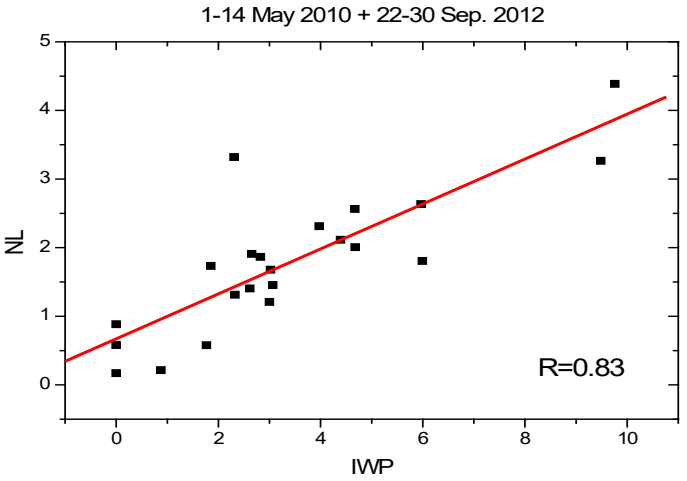
[Nickovic et al., 2001, Pejanovic et al, 2009; Vukovic et al, 2014, Nickovic et al., 2016]

Model well reproduced timing, duration and position of #IN

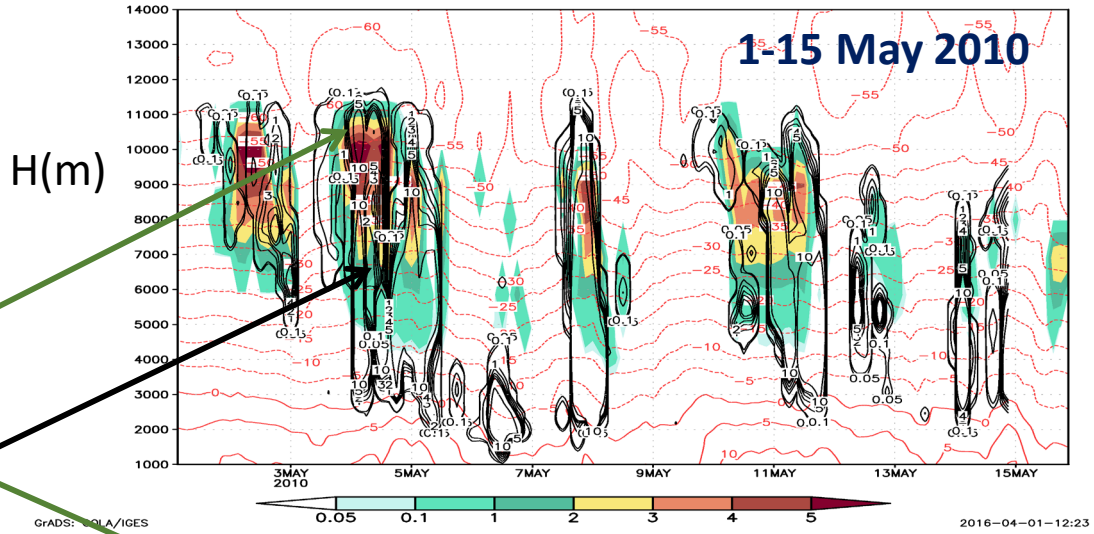
Vertical distribution
Data for model validation:
Lidar and cloud radar
CNR-IMAA Atmospheric Observatory CIAO, Potenza, Italy

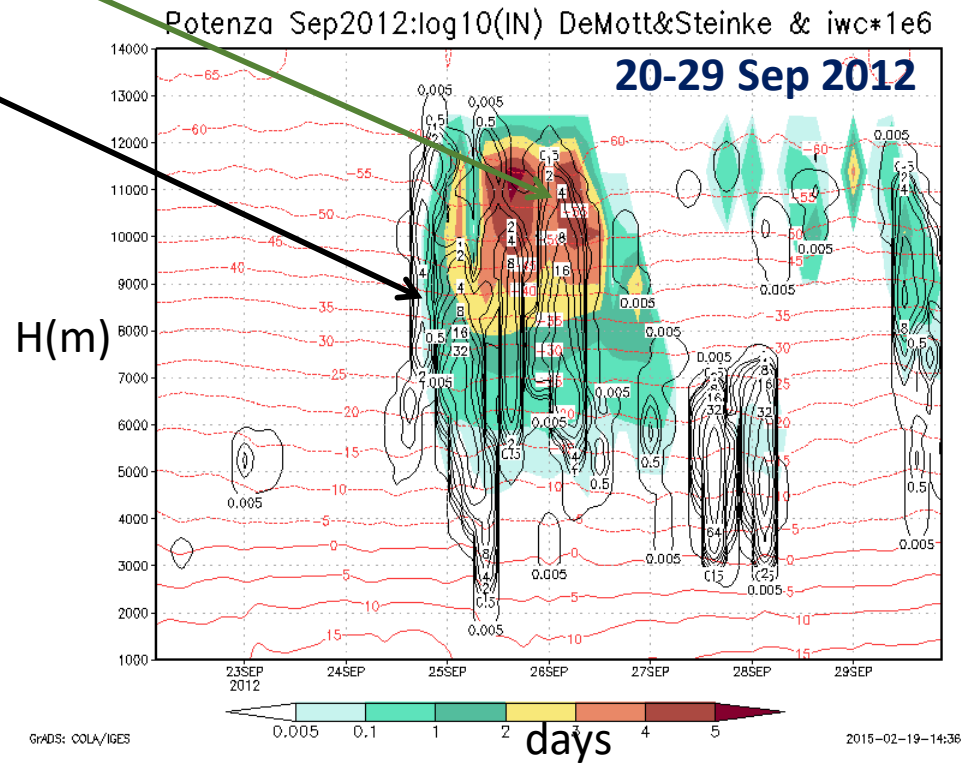
- **Model #IN (shaded)**

- **MIRA55 Ice Cloud Water (black contours)**

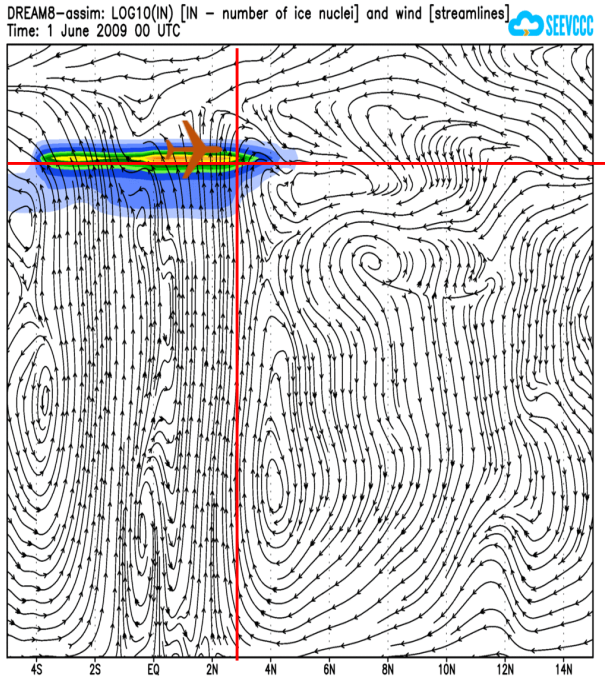


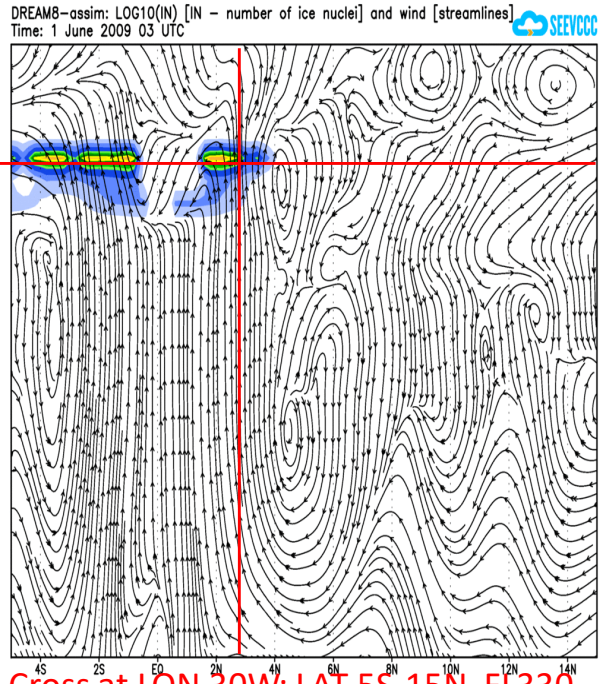
Daily averaged vertical loads
Potenza , May 2010 & Sep 2012



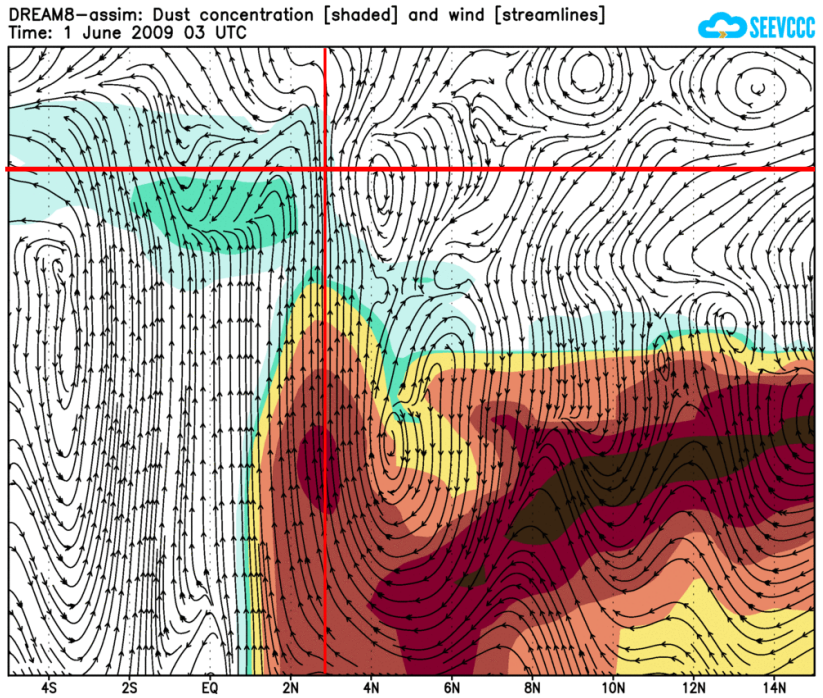


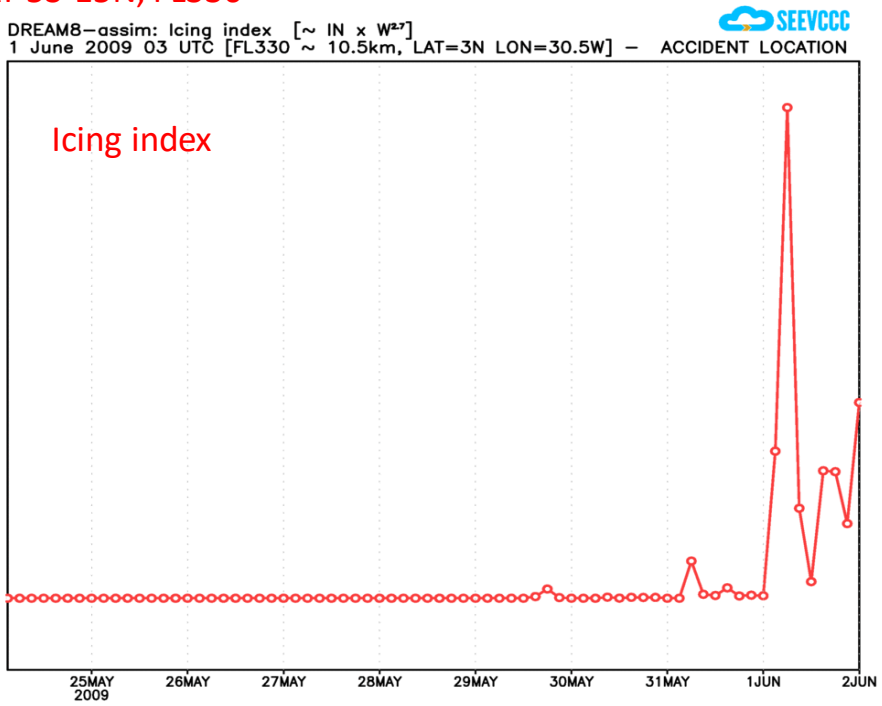
Possible use of developed product - air safety
indicator of icing





Cross at LON 30W; LAT 5S-15N, FL330





AIR FRANCE AF477

AIR CRASH HYPOTHESYS
INTENSE ICE NUCLEATION DUE TO SUDDEN UPDRAFT OF DUST PARTICLES INTO SUPERCOOLED CLOUD LAYER

1st June 2009
Airbus A330-203 operated by Air France
flight AF 447 Rio de Janeiro - Paris

CONCLUSION:

The constant development and increasing need for high resolution atmospheric, hydrology and aerosol modelling implies both the higher spatial and temporal resolution of satellite products, such as:

- **Land cover**
- **NDVI and EVI index**
- **Soil texture**
- **Clay/silt fraction**
- **Soil mineralogy**
- **Soil wetness**
- **Albedo**
- **Cloud properties (cloud phase, vertical structure …)**
- **AOD**
- **Aerosol vertical profiles**

Thank you kindly for your attention!

South-East European Consortium for Operational weather Prediction

SEECOP

http://seecop.meteo.co.me/