Disaster predictions with HPC

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EuroCC4SEE WORKSHOP IN BELGRADE
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Natural hazards

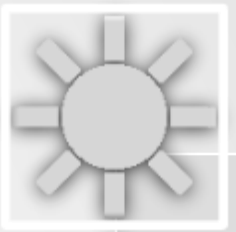
WMO classification

Geo hazards

- Earthquakes
- Tsunami
- Volcanoes
- Forest fires
- Slippery ground
- Epidemic air-borne diseases
- Avalanches, mud and landslides

Weather hazards

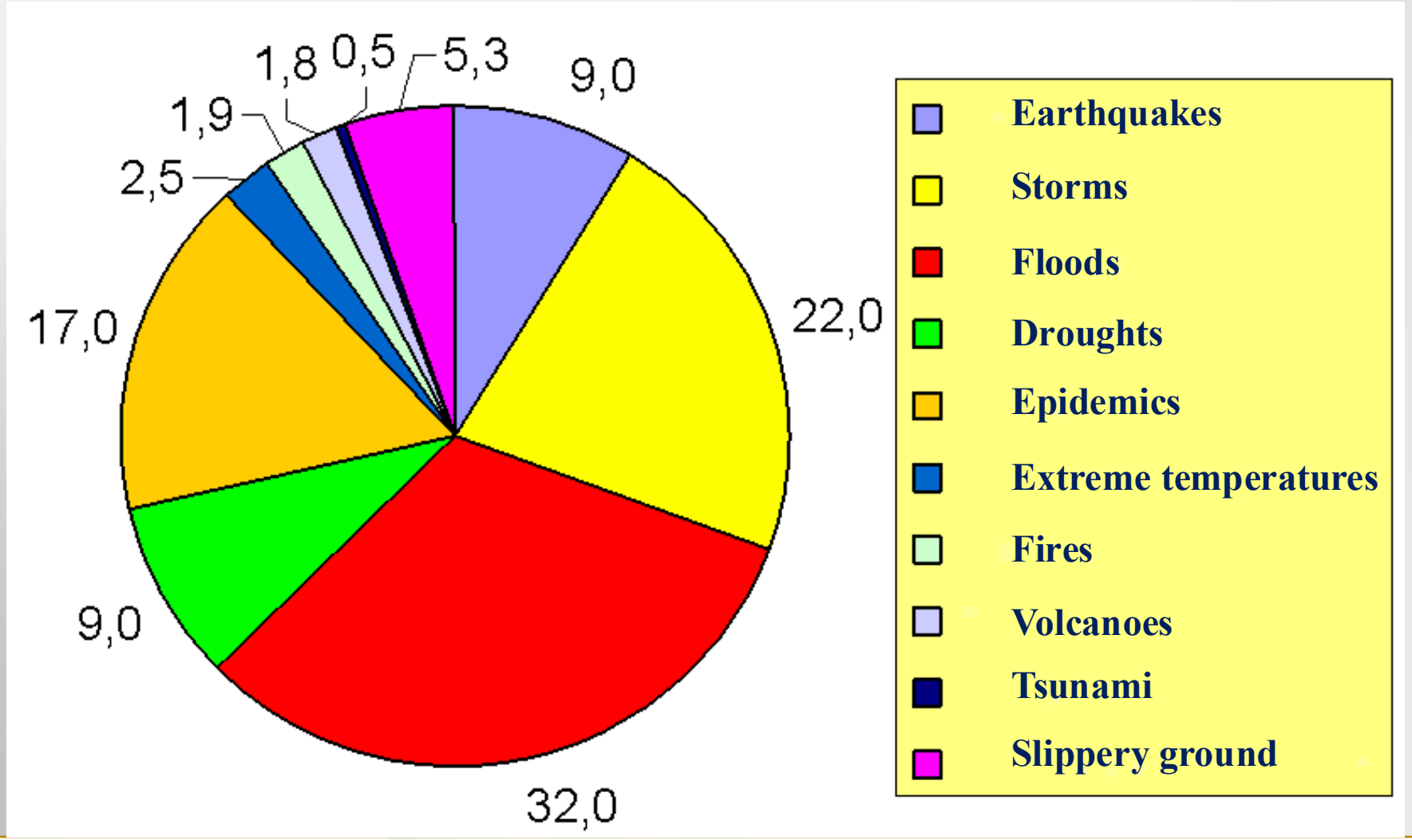
- Floods
- Tropical cyclones
- Storms, storm surges, ice storms
- Heavy rainfall
- Flash-floods
- Hail & lightning



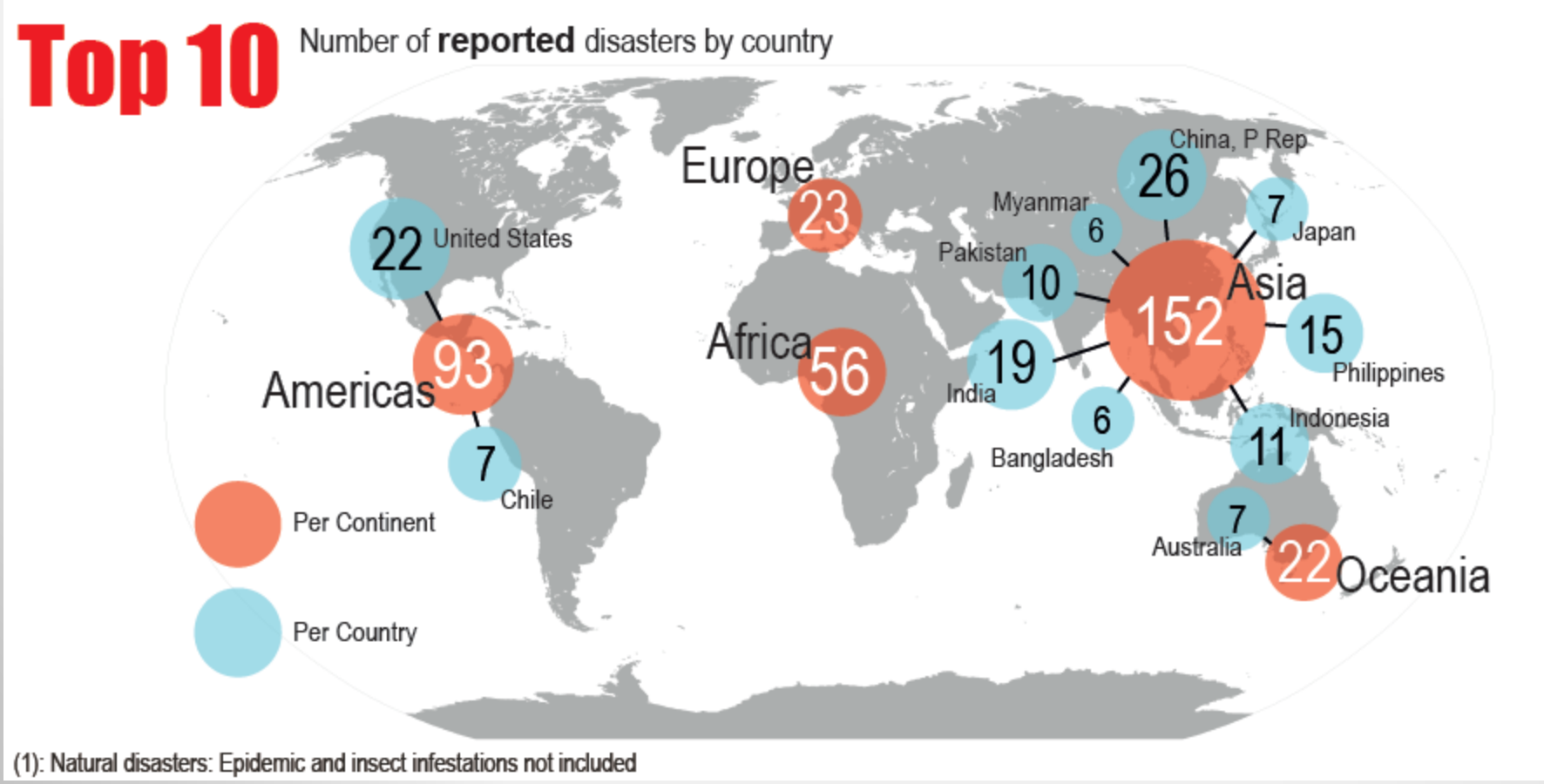
- Droughts
- Hot and cold spells
- Tornadoes

Natural hazards

WMO statistics



Natural hazards



Motivation

- **Global climate change has caused noticeable changes in the environment**

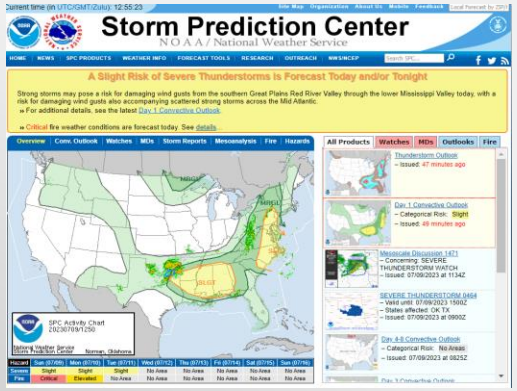
- One of the most visible and disruptive impacts is the occurrence of extreme weather events

Severe weather alert systems

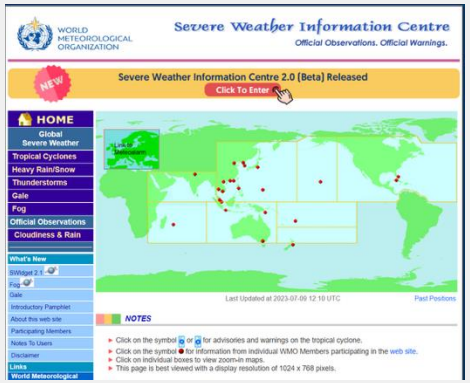
HPC.MK
EuroCC @North Macedonia

EURO4SEE

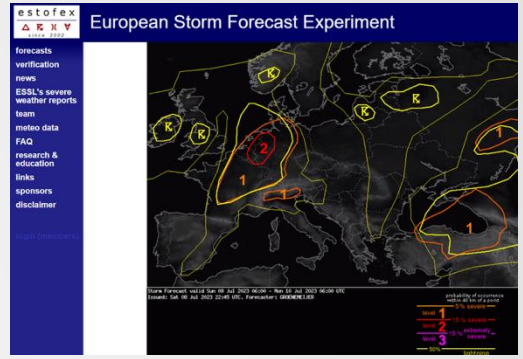
NOAA



WMO

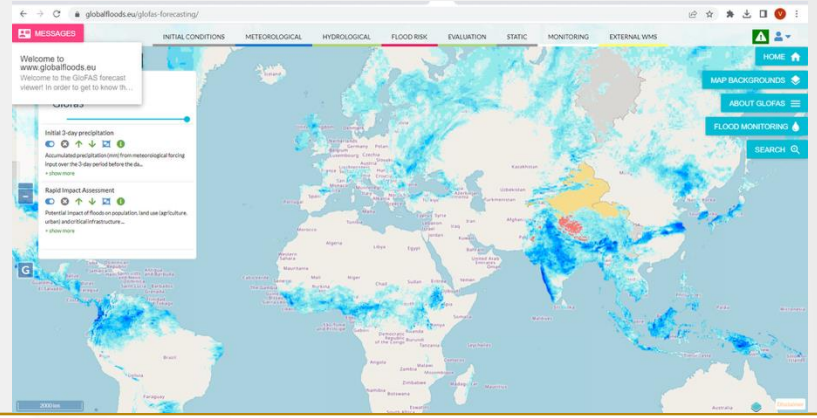


ESTOFEX



EU-METEOALARM

GLOFAS



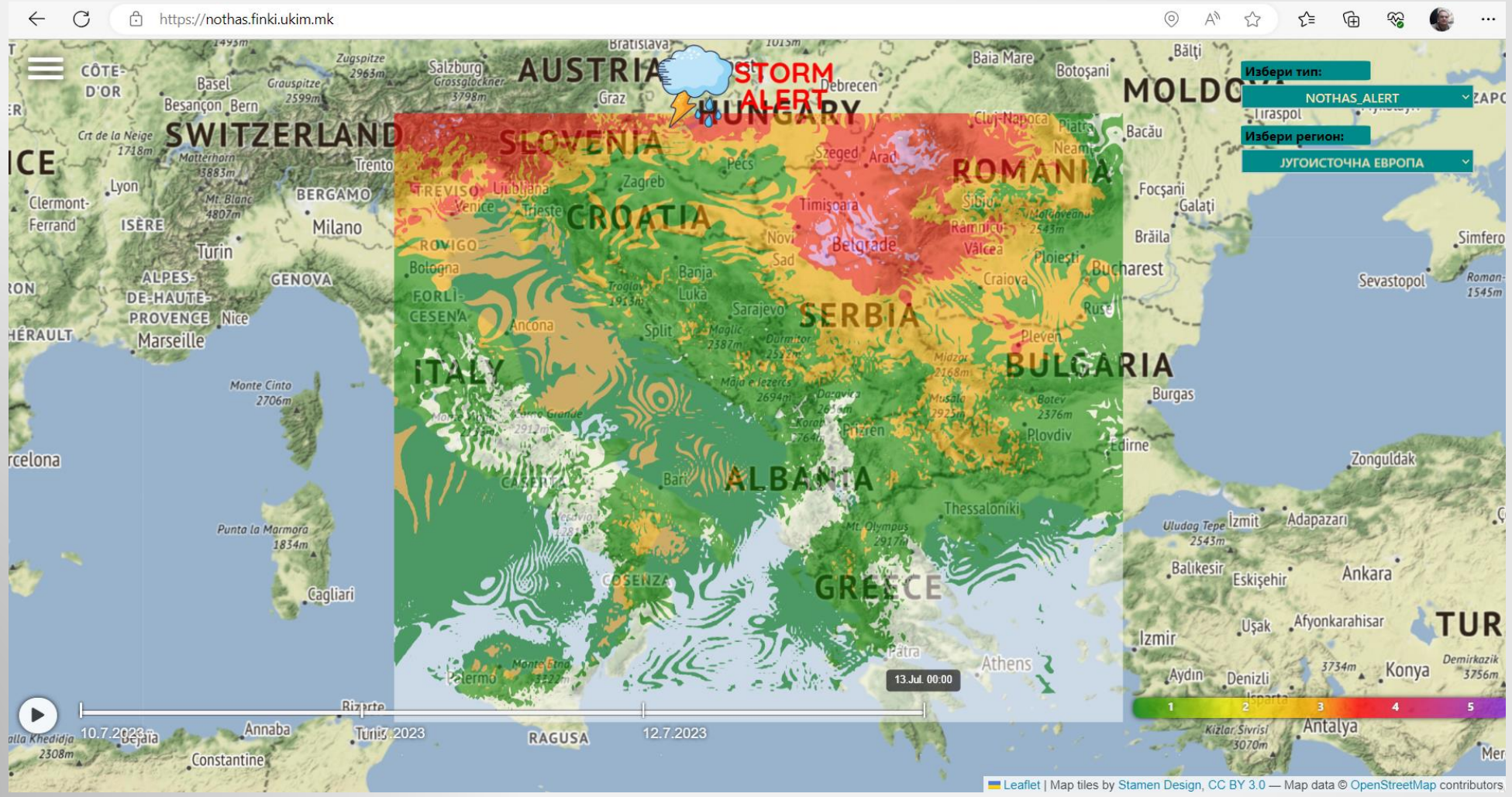
Center for Crisis Management

- The Crisis Management Center, was established to ensure constant consultations, coordination, timely response, efficiency and appropriate use of resources available in the event of a crisis, and to ensure timely, high-quality and realistic assessment of the threat to the security of the Republic of Macedonia from risks and dangers.
- Severe weather hazards present one of the most common hazard events in the past years
- Timely coordination, alerting and preparation for hazardous events is very important for the Crisis management process

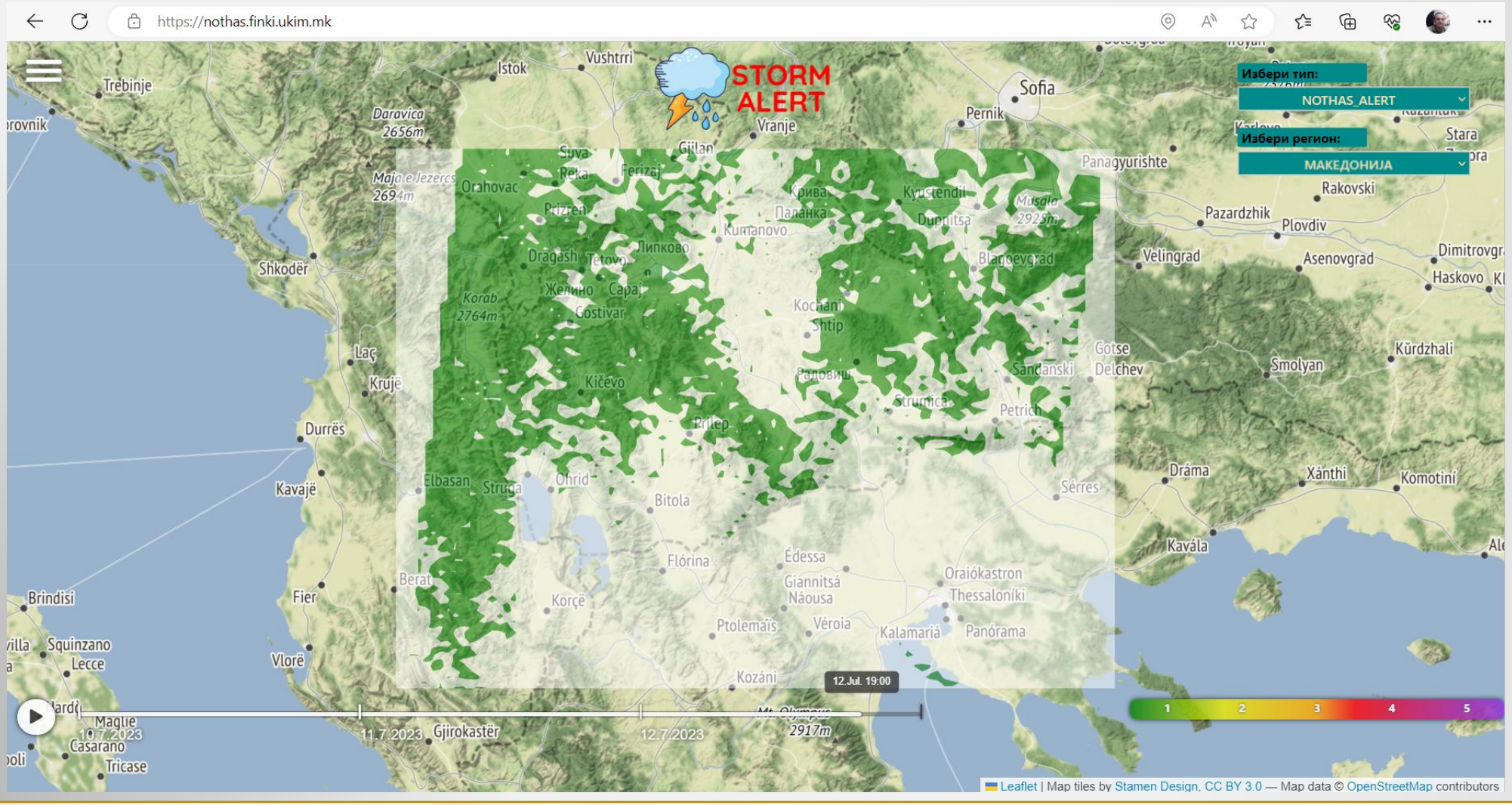
NOTHAS system

- Researchers from University in Skopje developed system for severe weather prediction model
- Based on several well-known Weather forecast open-source systems and tools
  - WRF-NMM
  - WRF-ARW
  - Postprocessing outputs
  - Generation of severe weather soring classification

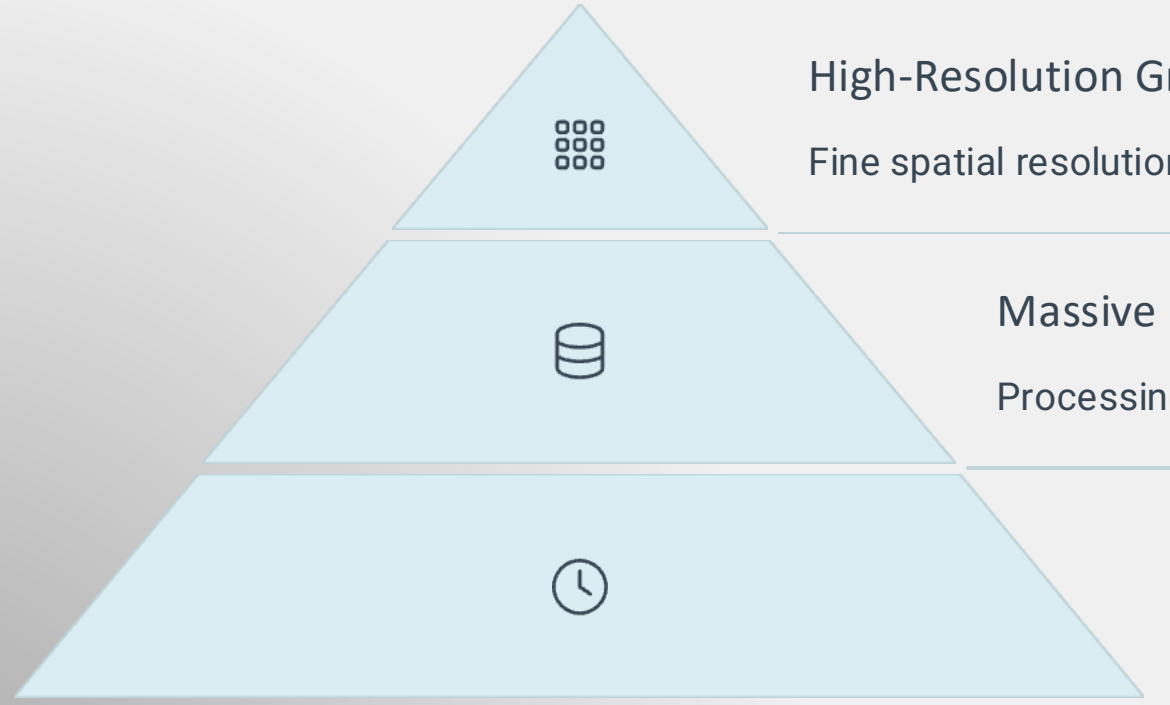
NOTHAS South East Europe



NOTHAS North Macedonia



Why WRF Needs HPC



High-Resolution Grids

Fine spatial resolution demands computational power

Massive Data Volume

Processing satellite imagery and observational data

Real-Time Constraints

Rapid completion for time-sensitive decisions

Why WRF Needs HPC

Optimization

Model verification

Ensemble forecasting

More complex models
WRF-CHEM

The list of model configurations and physical parameterizations

Model configuration	ARW v.4.4.2 (2022)	ARW triple nested run v.4.4.2 (2022)	NMM (v.4.3.3)	Ensemble 15 members
Physics	28, Thompson, Eidhammer (2014)	28, 28, 28	8, Thompson Graupel scheme (Thompson et al. 2008)	28, 8, 5 and 6 5, Ferrier scheme Ferrier, (1994) 6, WSM6 Hong and Lim, (2006)
PBL	1, Yonsei University YSU Hong (2010)	1, 1, 1	2, Mellor-Yamada-Janjic (Eta) TKE scheme	1, 2
Surface physics	2, Noah Land-Surface Model: Unified NCEP/NCAR/AFWA scheme	2, 2, 2	2	2
Cumulus convection	14, new scale and aerosol aware scheme (Shin and Hong, 2015; Han et al. 2017)	14, 14, 14	14	2, 14 2, Betts-Miller-Janjic scheme
Radiation **Short/Long**	1, RRTM Scheme Dudhia Scheme, Dudhia (1989) / Mlawer et al. (1997)	1, 1, 1 1, 1, 1	99, GFDL scheme: Geophysical Fluid Dyn. Lab. (GFDL) 99	1, 1
Hor. grid resolution	4-km	27 x 9 x 3 km	4-km	4-km
Vertical levels	44	44, 44, 44	50	44
Time step (s)	10	90, 30, 10	10	10
Initial data and LBC	NCEP FNL GDAS 0.25 deg			Slightly perturbed IC (Scaling) 6 members

A combined set of physical and environmental parameters

TOTAL ACC. RAIN

RADAR REFLECTIVITY

BRIGHT. TEMPERATURE

VORTICITY

CAPE

SWEAT

K-index

TOTALS

SRH

LI-index

HPC simulation for determination of the threshold values

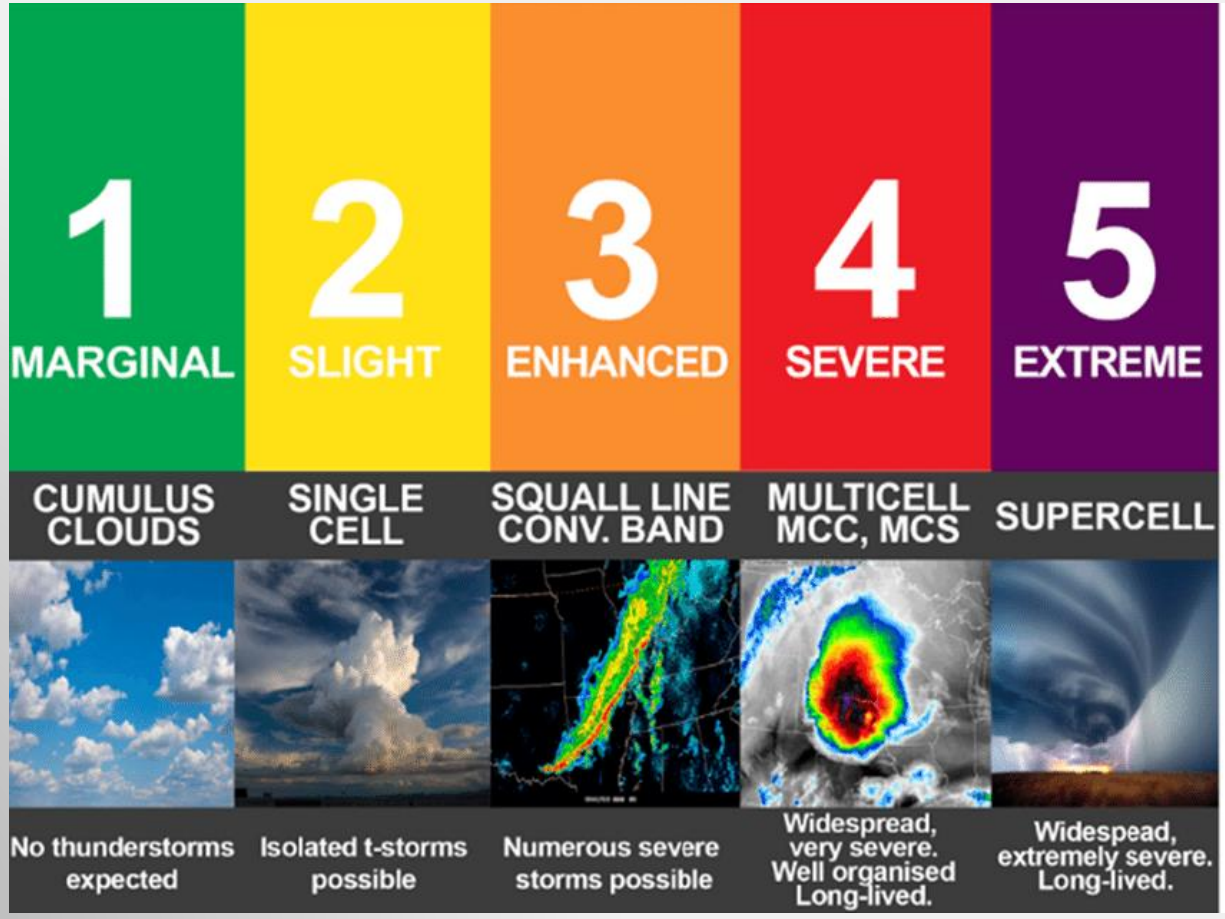
Parameters with thresholds and influence in NOTHAS

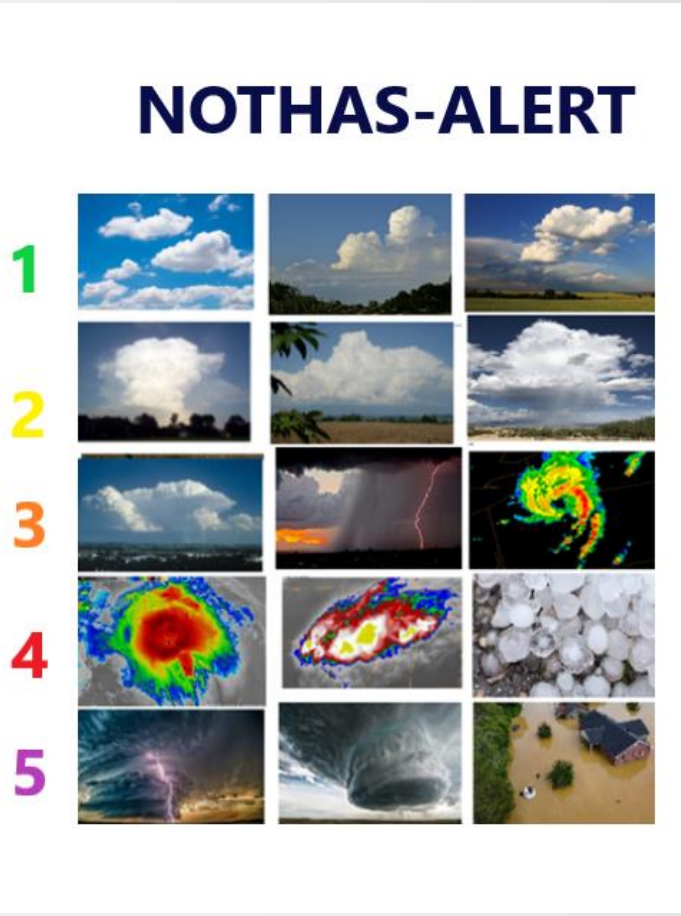
- Severe Weather Threat Index (SWEAT)
- Most Unstable Convective Available Potential Energy (MUCAPE) (J/kg)
- Gálvez-Davison Index (GDI)
- Storm Relative Helicity (SRH)
- Radar reflectivity (REFD) (dBZ)
- Brightness Temperature (BRTH)
- A total acc. hourly rain (mm)
- Wind gust over land (m/s) Saffir-Simpson Hurricane Wind Scale (m/s)
- K-Index

Different thresholds for different scale and location

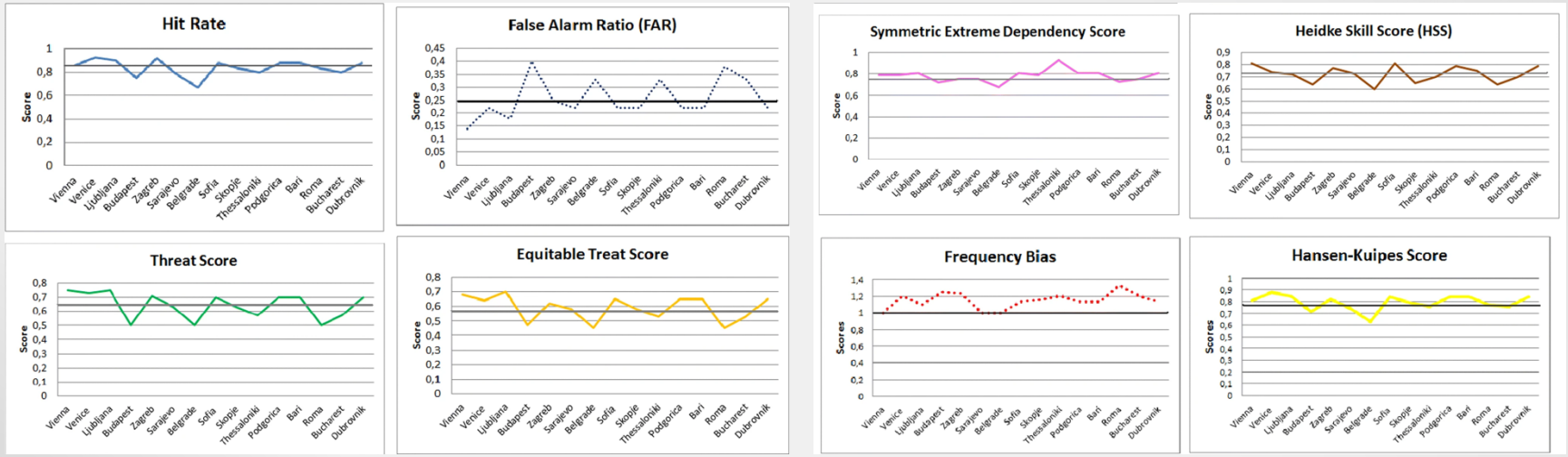
- Mid-latitude storm
- Tropical cyclone (Hurricane-Typhoon)
- Tropical storm

Severe convective weather alert

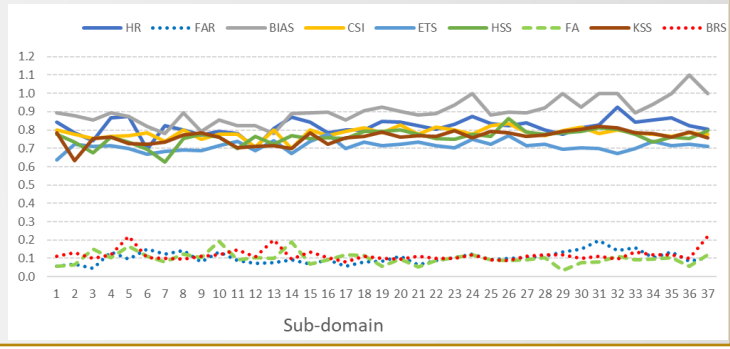




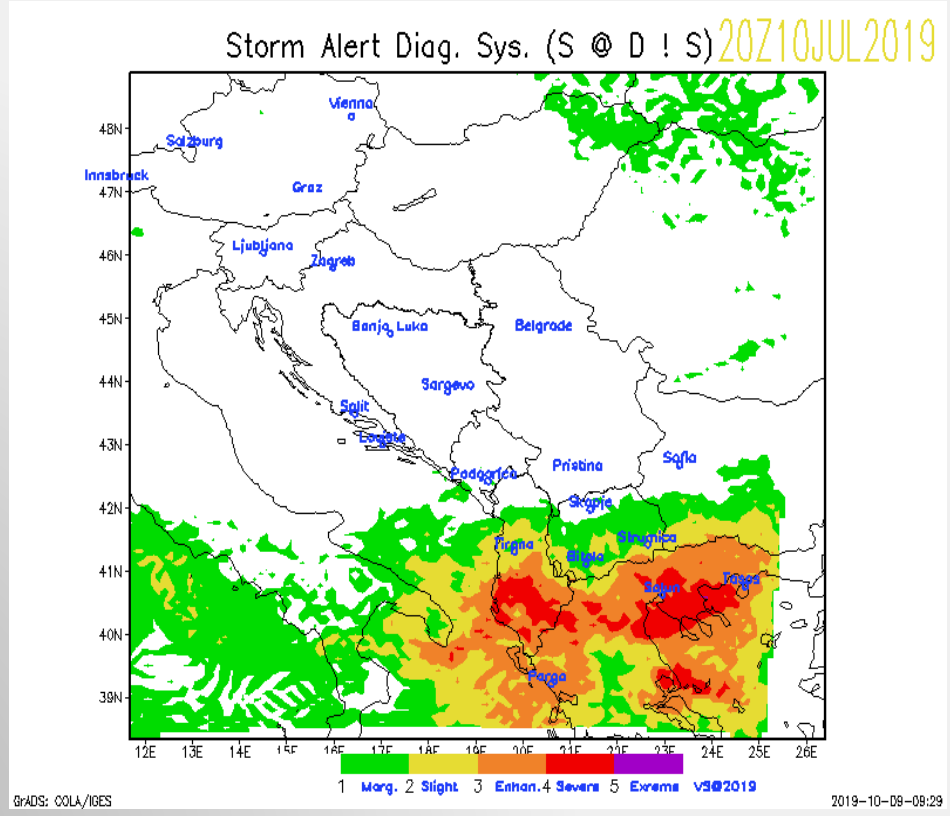
Verification Mid-latitude convective cases

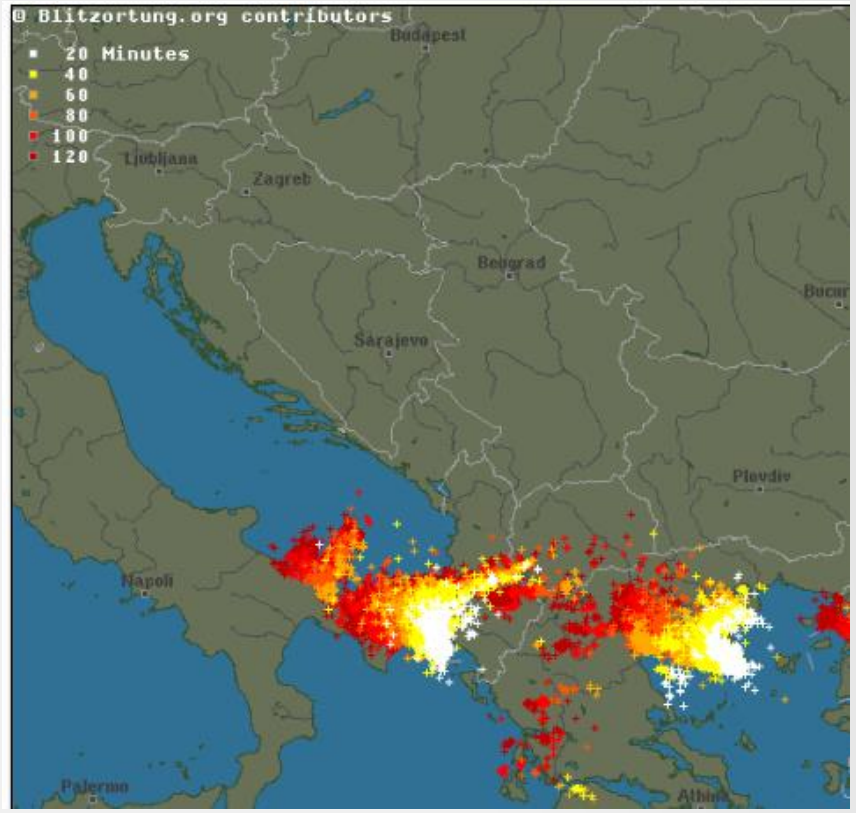


- Extensive set of experiments and verification has been performed from 2017-2023
- Verification Tropical convective cases

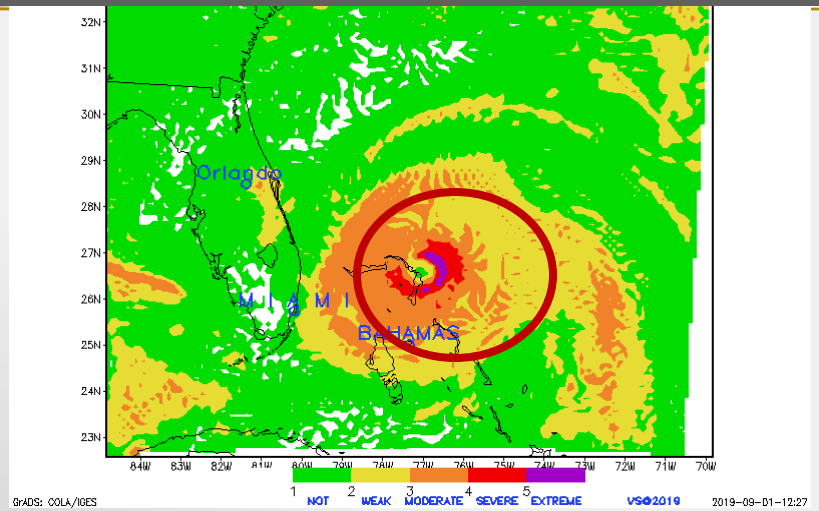


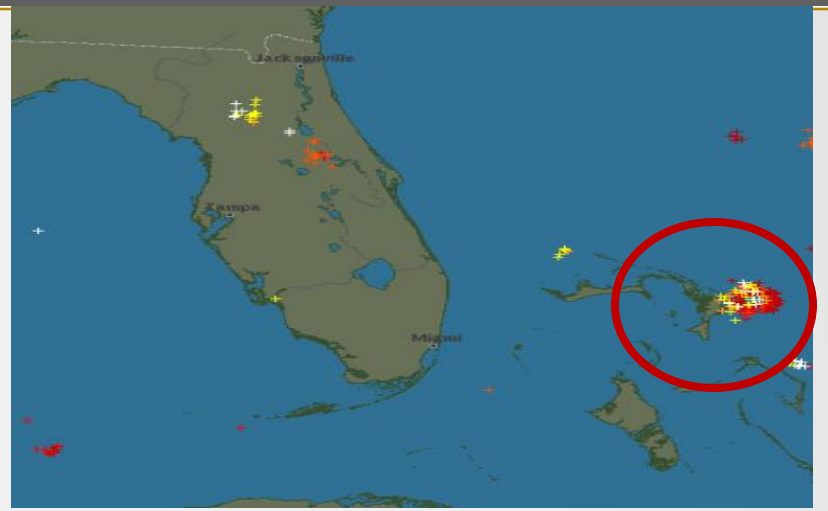
Supercell storm 10 July 2019 Halkidiki, Greece

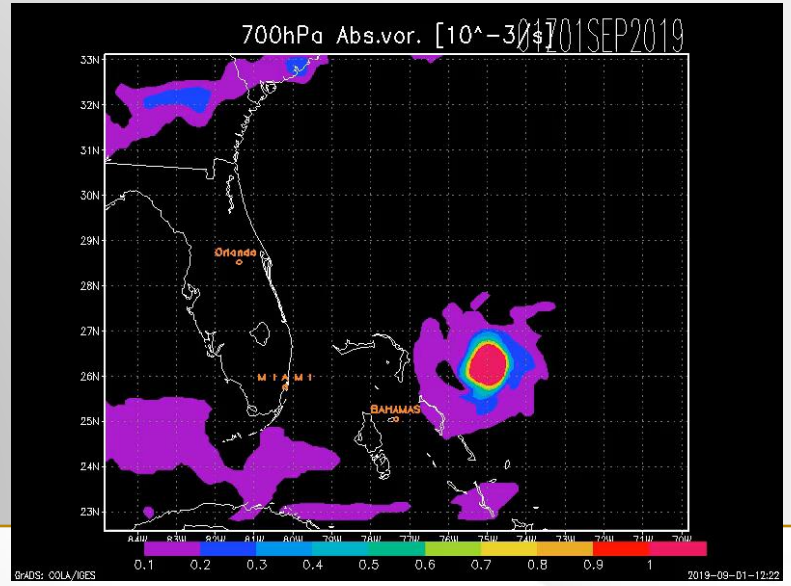


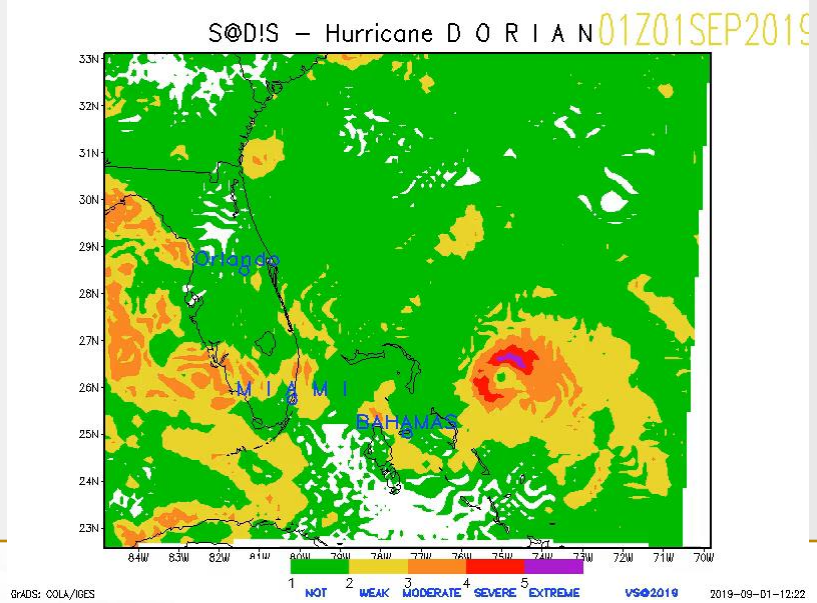


Hurricane “Dorian” 3 Sep 2019

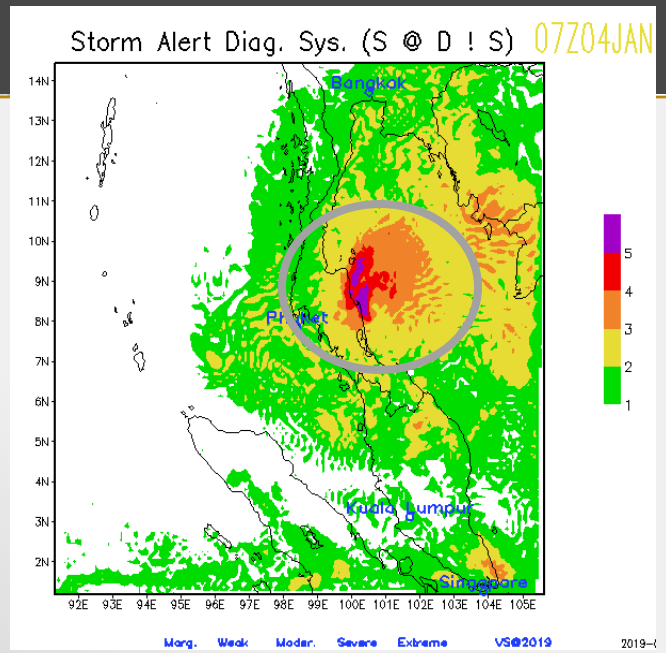


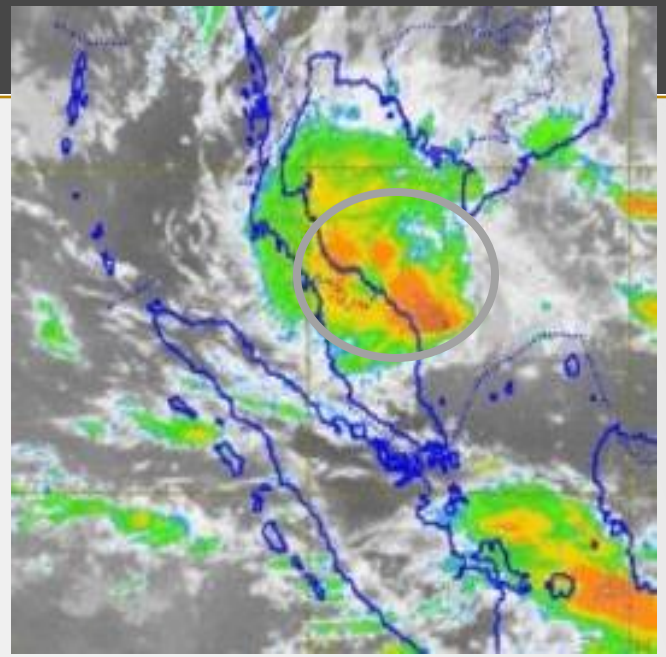


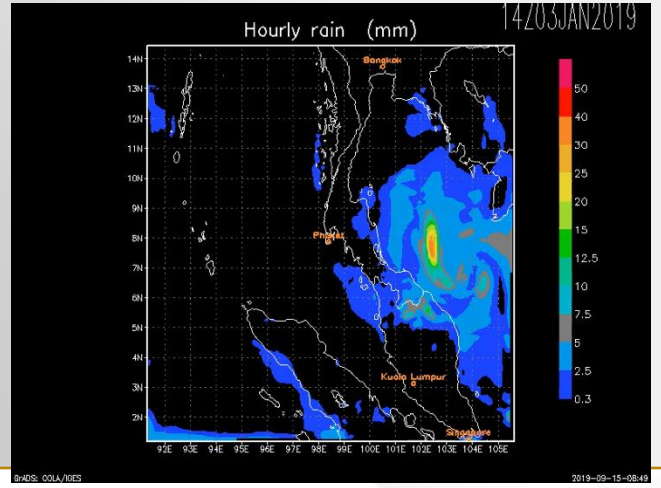


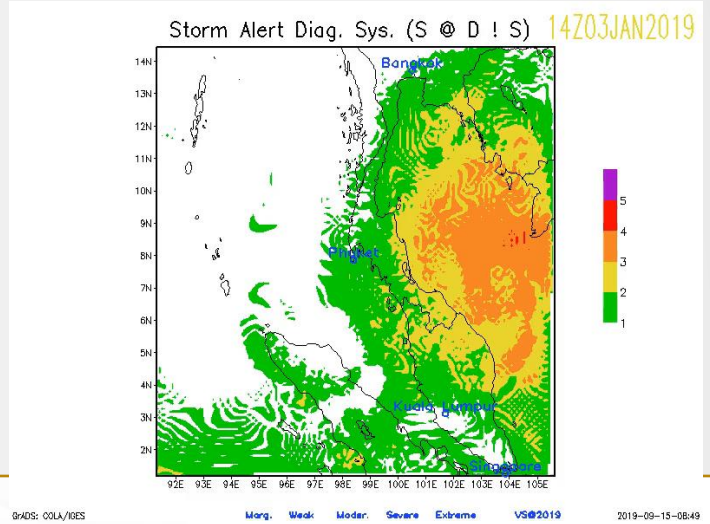


Tropical storm “Pabuk” 4 Jan. 2019









Thanks!

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