The Eastern Mediterranean Catastrophic Flash Floods: 11-12 December 2022 in Antalya, Türkiye

Meral Demirtaş
University of Samsun
Department of Meteorology, Samsun, Türkiye

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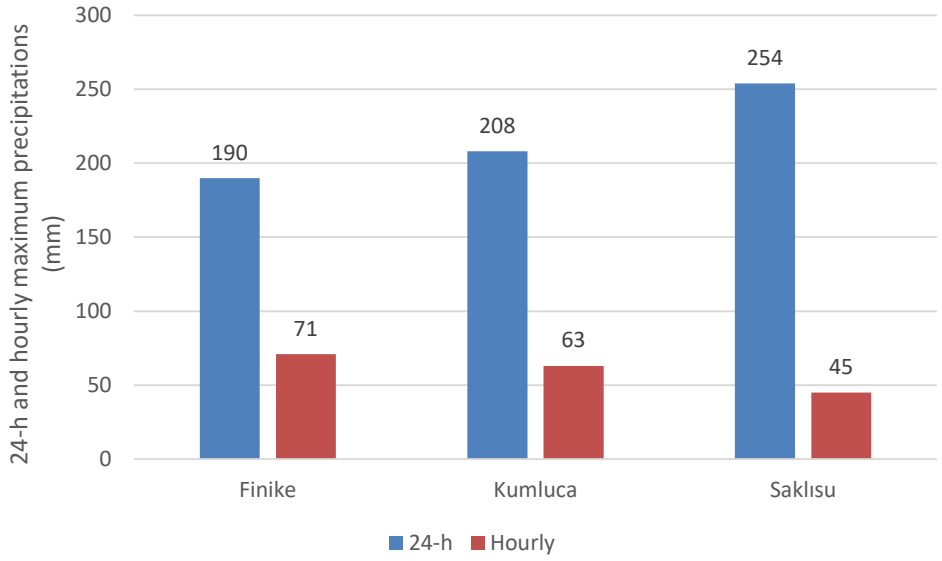
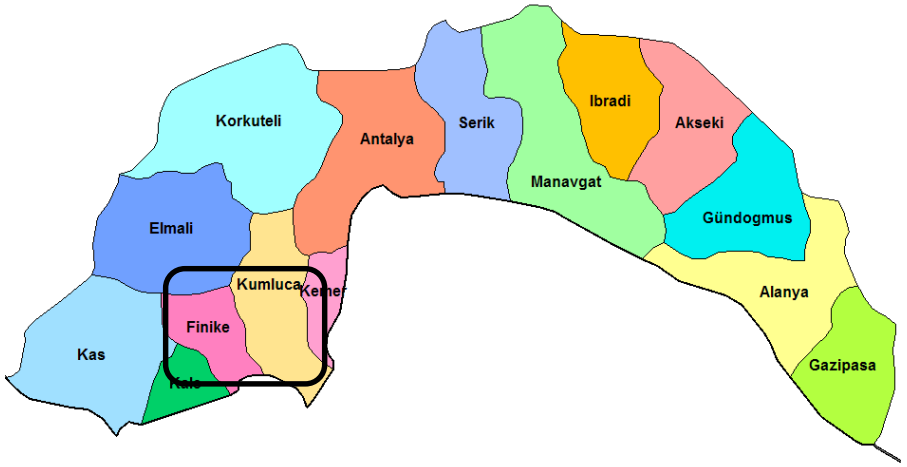
Introduction

- The Gulf of Antalya was affected by very heavy precipitation events on 11 - 12 December 2022, which resulted in 254 mm, 208 mm and 190 mm in 24h, and caused severe flash floods.
- Hourly maximum precipitation amounts were very large in some places; 71 mm, 63 mm and 45 mm.
- Quantitative precipitation forecasting of the phenomenon is explored using the Weather Research and Forecasting ARW core (WRF-ARW) with various physics options.
- Sensitivity experiments have been carried out to explore the mesoscale aspects of the precipitating structures and their dependence on orography, surface (sensible and latent heat) fluxes and sea-surface temperatures.

Observed precipitation amounts:
24h totals and hourly maximum amounts



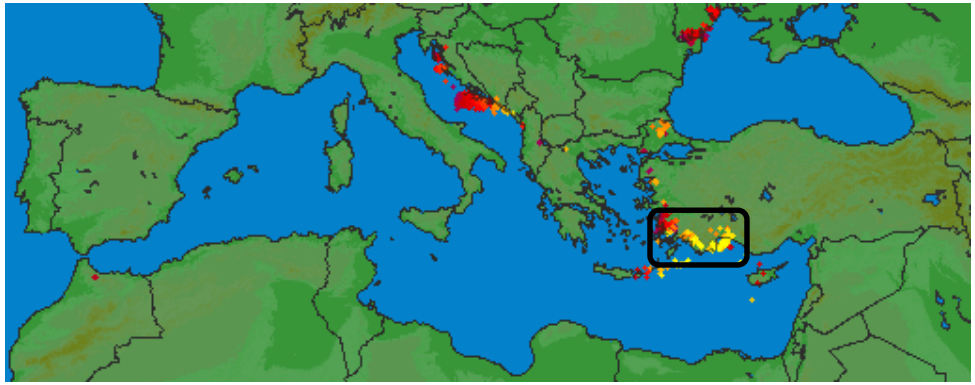


Hourly Heavy Precipitation Amounts (mm)

Date	Hour (UTC)	Saklısu	Kumluca	Finike
11 Dec	18	13,10	3,00	1,70
	19	45,70	0,60	0,8
	20	28,80	0,00	0,00
	21	18,00	0,00	0,00
	22	16,00	0,00	0,00
	23	40,50	38,00	27,70
12 Dec	0	19,80	63,20	19,30
	1	19,40	56,40	40,60
	2	6,70	10,80	71,30
	3	15,90	13,80	9,90

Lightning observations

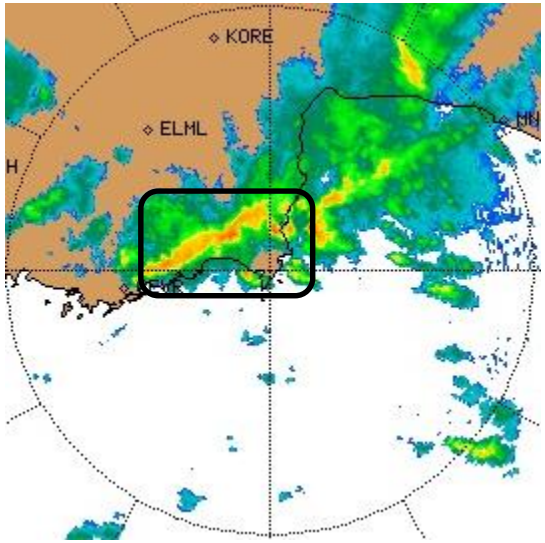
18 UTC
11 December 2022



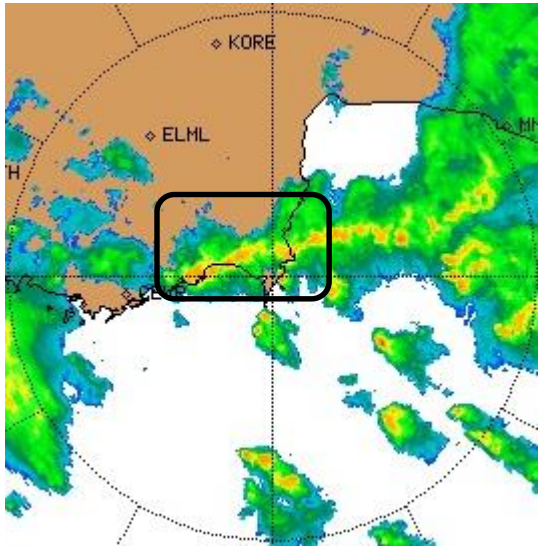
00 UTC
12 December 2022

LightningMaps.org CC BY-SA 4.0 / Lightning data by Blitzortung.org and contributors.
https://www.lightningmaps.org/blitzortung/europe/index.php?lang=en

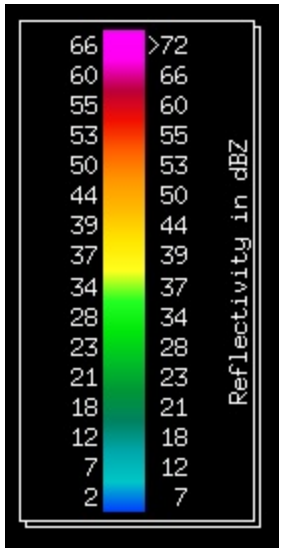
Antalya Radar Images



23 UTC 11 December 2022

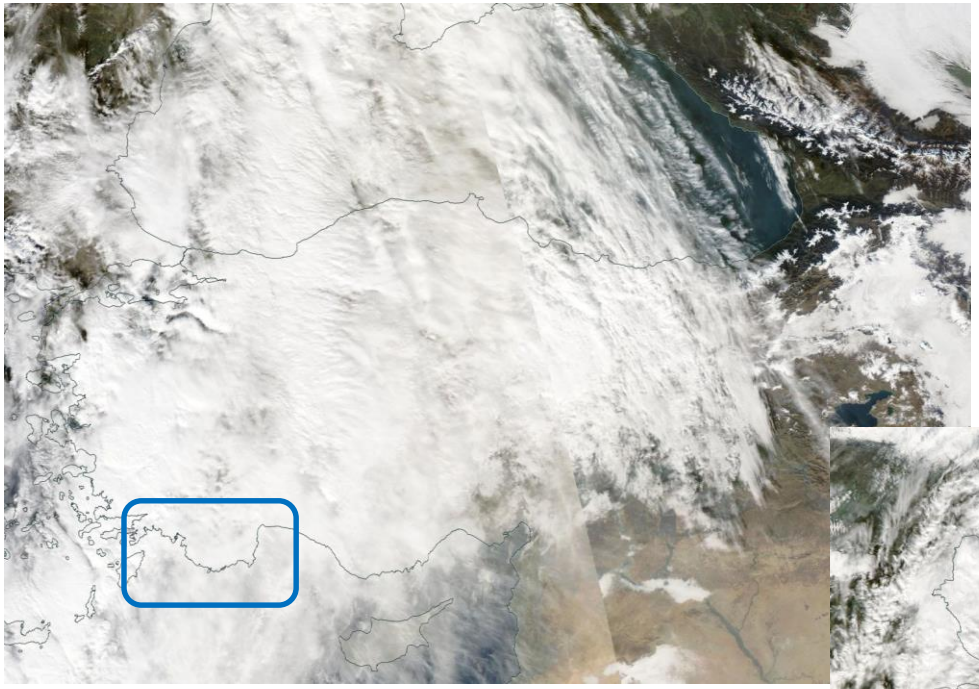


02 UTC 12 December 2022

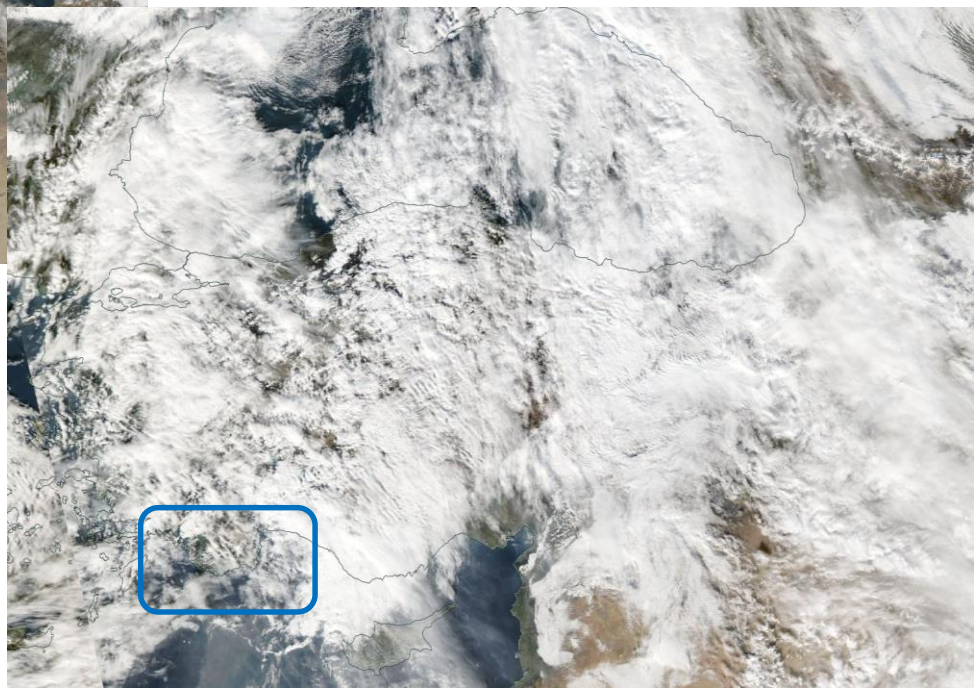


Satellite Images

11 December 2022

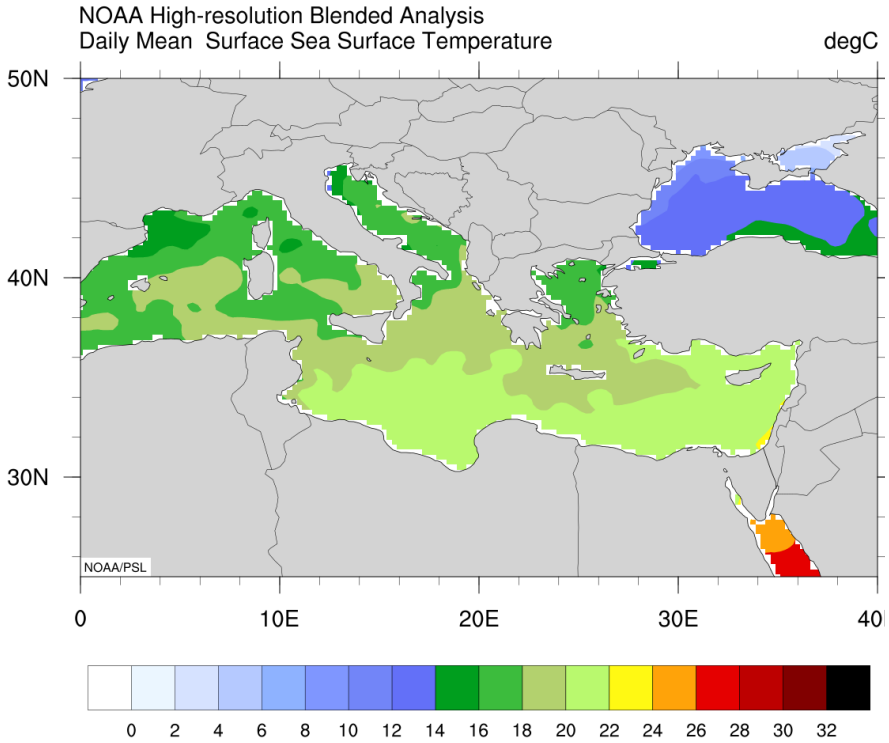


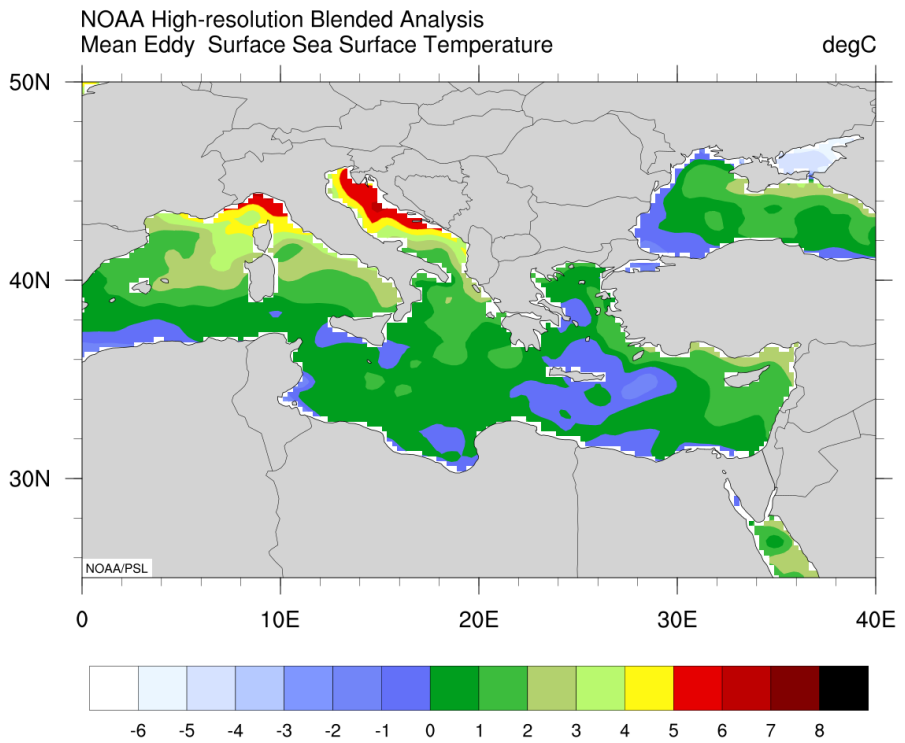
12 December 2022

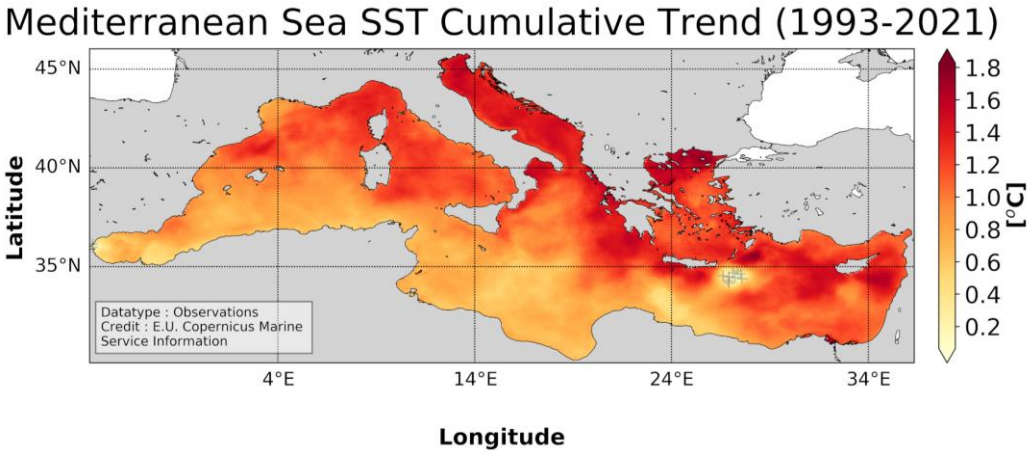


https://wvs.earthdata.nasa.gov

The Mediterranean Sea Surface Mean Temperatures and Anomalies



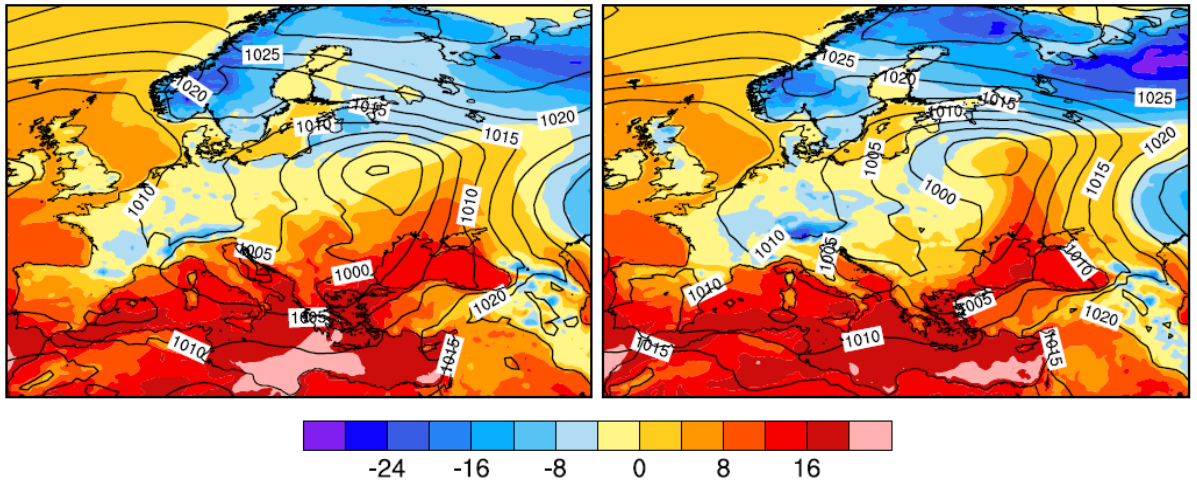




Analysis of synoptic-scale dynamical precursors

MSLP and 2 metre temperature

12 UTC
11 Dec. 2022



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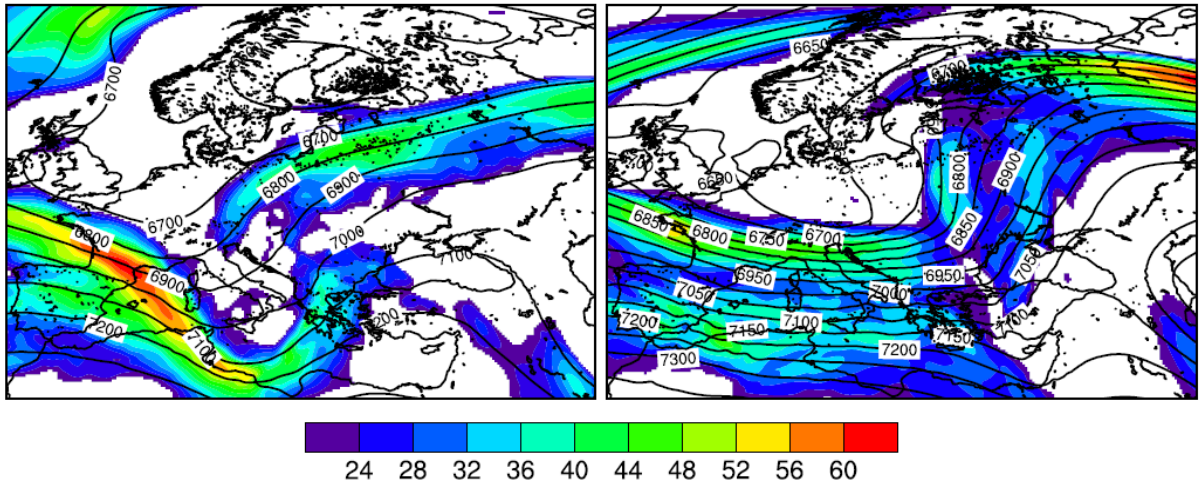
12 Dec. 2022

Geopotential height at 500 hPa and wind at 300 hPa

12 UTC
11 Dec. 2022



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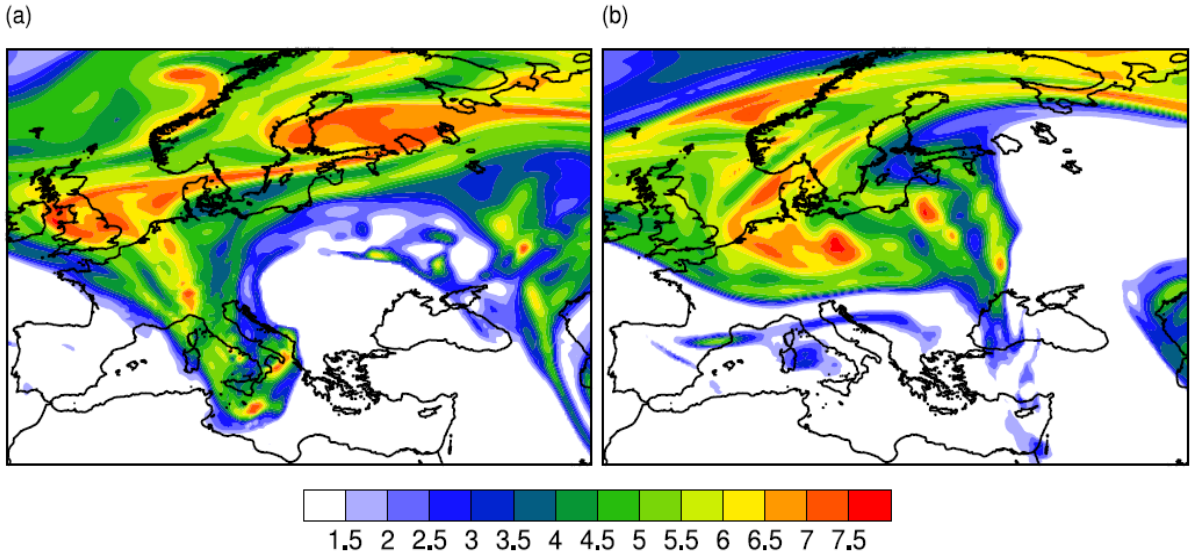
Analysis of synoptic-scale dynamical precursors

Potential vorticity at 330 K surface

12 UTC
11 Dec. 2022



00 UTC
12 Dec. 2022

Numerical Simulations with WRF-ARW

- Horizontal resolution: 3 km (dt = 18s)
- Vertical resolution: 57 levels
- Initial and boundary conditions: ECMWF ERA5

WRF-ARW Simulations

Physics section	Options used for the control run
Microphysics	Thompson
Cumulus parameterization	No
Longwave radiation	RRTMG
Shortwave radiation	RRTMG
Land surface model	Noah
Planetary boundary layer	YSU
Surface layer physics	Revised MM5

Simulations	Settings
Microphysics	WSMS6, WDMS4, Morrison
Surface fluxes	Switching off heat fluxes from the surface
Latent heating	Switching off latent heating in cloud processes
SST	SST anomalies removed
Topography	Smoothed topography

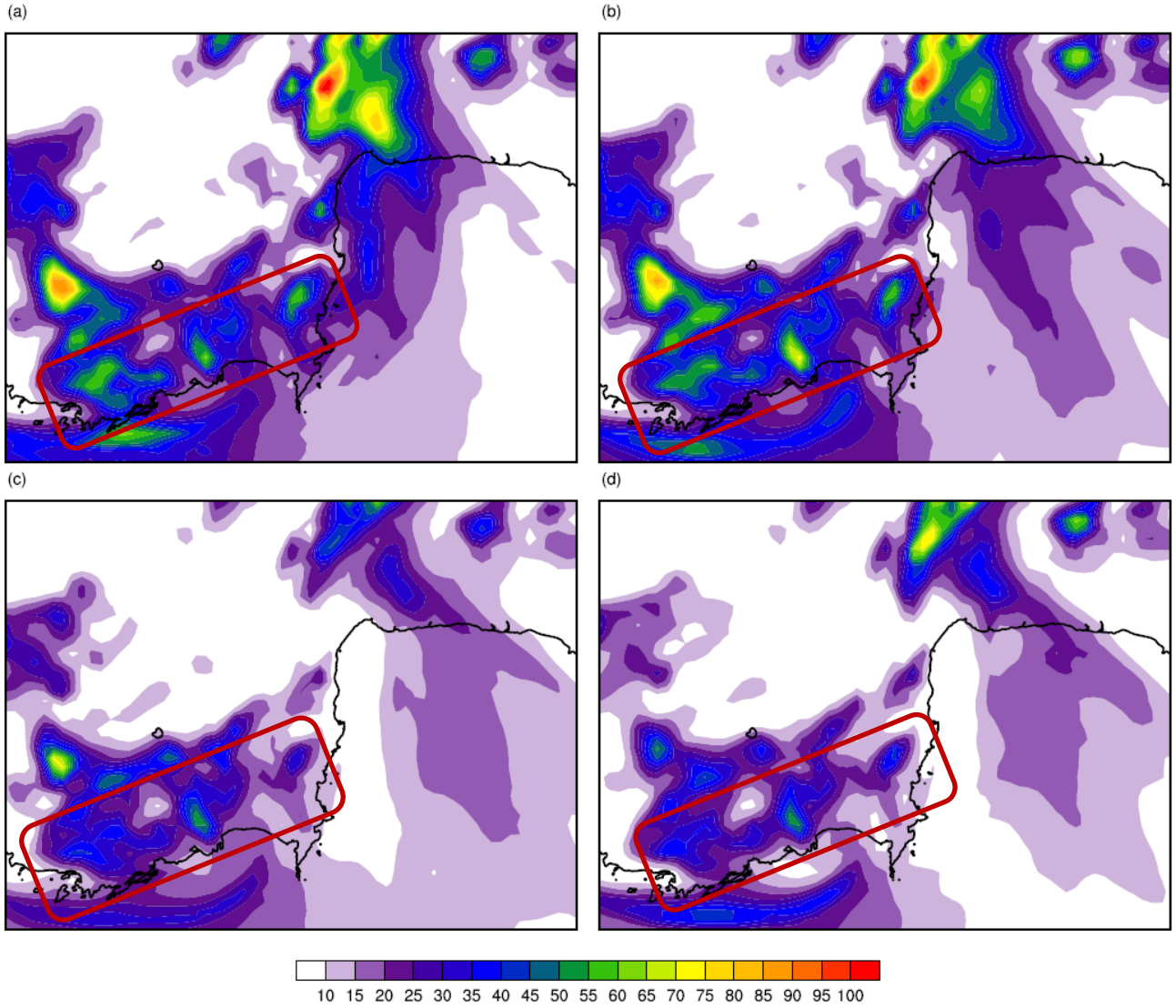
WRF-ARW Simulations at t+24: Microphysics

WSMS6

WDMS4

Thompson

Morrison



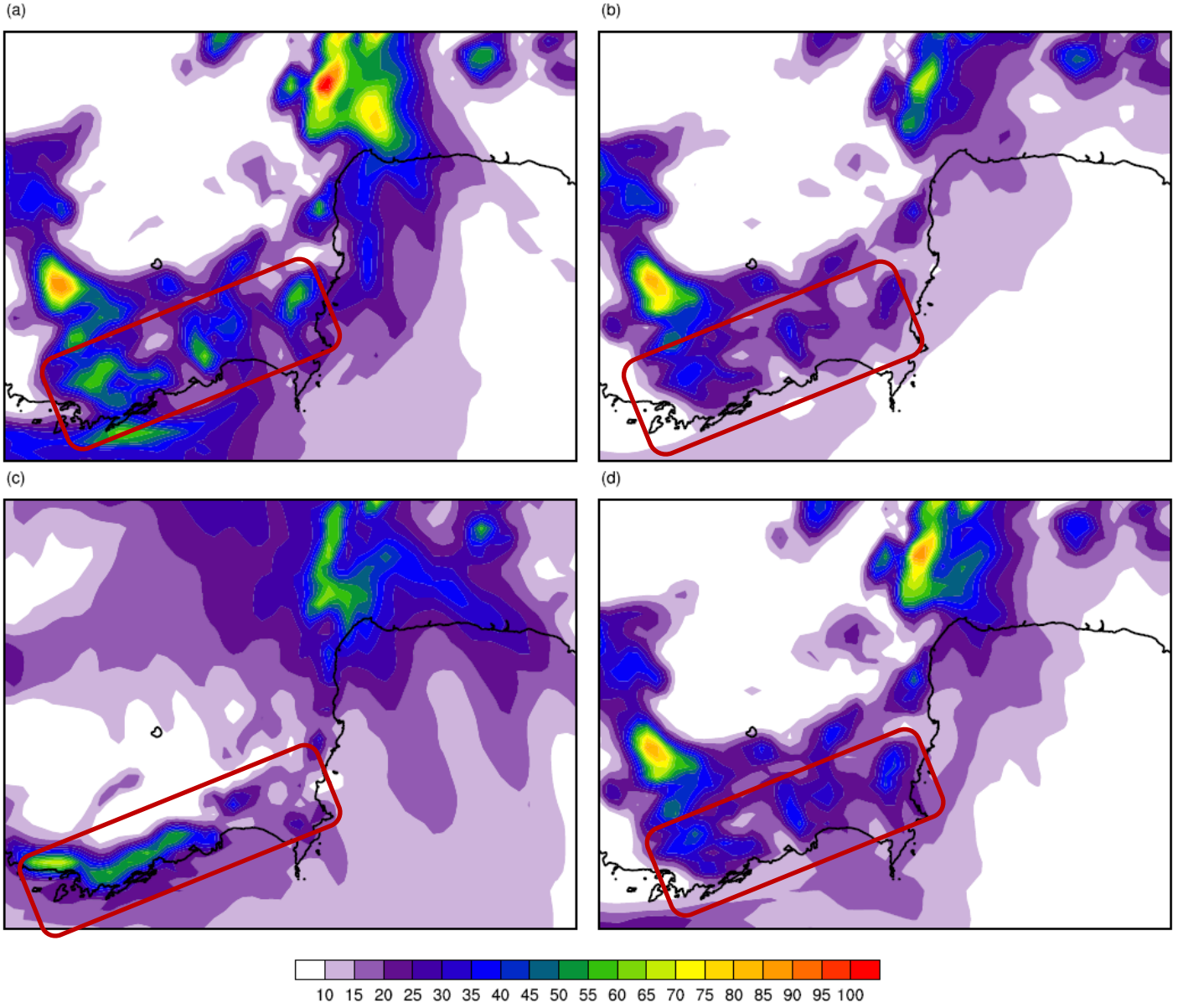
WRF-ARW Simulations at t+24: Sensitivity studies

WSMS6

SST-2K

Smoothed topography

No surface flux



Concluding remarks

- Analysis of numerical model products, based on diagnostics and comparison with conventional and remote-sensing observations, indicates that the remarkable amount of accumulated precipitation was strongly modulated by mesoscale effects induced on the synoptic-scale flow.
- There was a sustained co-alignment of an upper-tropospheric tongue of high potential vorticity over a pre-existing low-level baroclinic region.
- Numerical simulations with WRF-ARW highlighted the importance of using appropriate microphysics options. Results showed that WSMS6 and WDMS4 gave more promising precipitation estimates.
- Sensitivity experiments have been carried out to explore the mesoscale aspects of the precipitating structures and their dependence on topography, surface fluxes and sea surface temperatures. Smooth topography does not produce observed precipitation.
- The future work would employ 1-km run simulations to investigate whether it may provide precipitation forecasts that may be closer to observed amounts.

Thanks for attending...