Impact of Aerosols on the Evolution of a Medicane in November 2011

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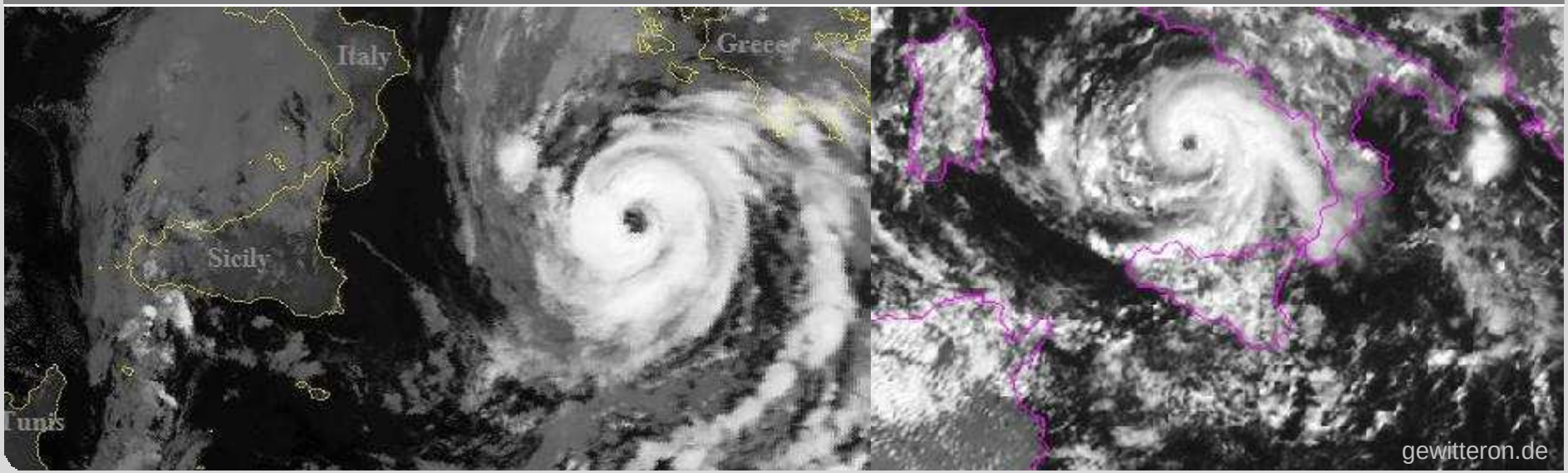

What is a Medicane? (MEDIterranean HurriCANE)

- Tropical like cyclone
- Driven by latent heat release of warm and humid airmass
  → warm core
- Common development: transformation of an extratropical cyclone to a cyclone with tropical features

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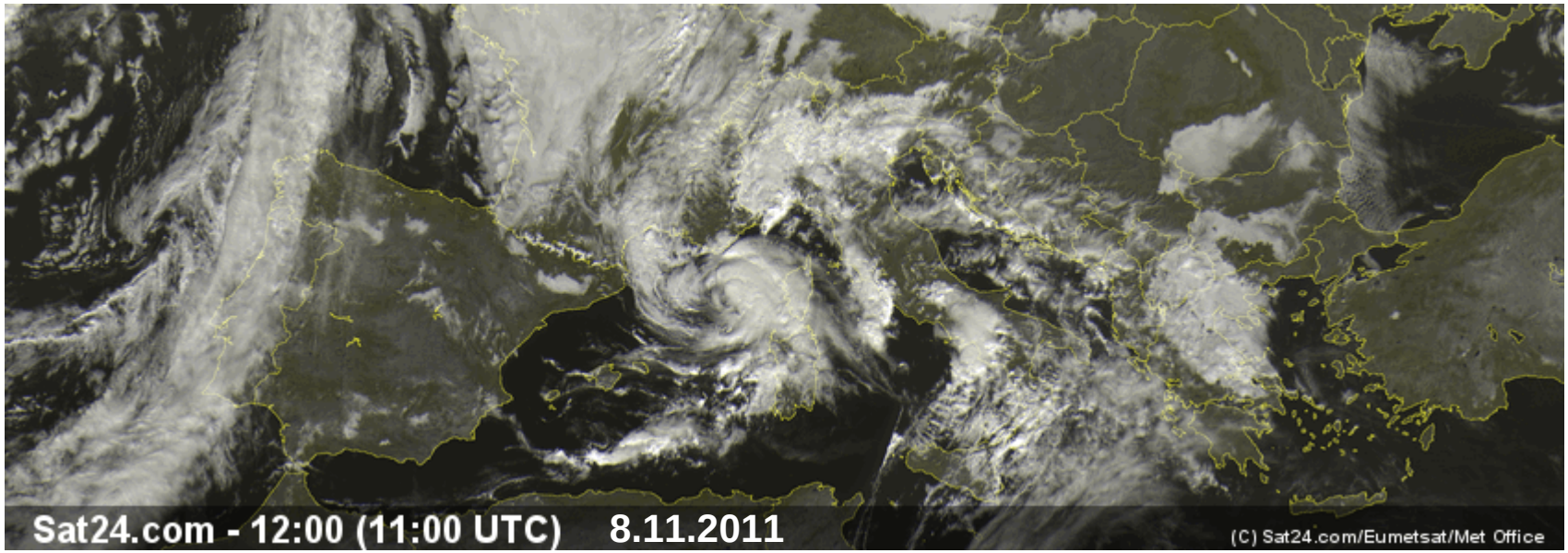
Depression “Rolf”

- Surface low “Rolf” on November 5 at lee of the Pyrenees
- Moves towards Balearic Islands, turns towards Sardinia (November 7)
- Northwards direction to French coast (November 8)

- Classified as Medicane on November 7, 18 UTC



Consequences of „Rolf“

- In coastal regions in France windspeed of 150 km/h
- Heavy precipitation from Marseille to Nice
- High surf breaks in France and Italy
- Flooding

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Aerosols in the Mediterranean Sea

- Aerosols have an impact on cloud formation and precipitation by altering the energy budget and water cycles

- Mixture of aerosol composition over Mediterranean Sea

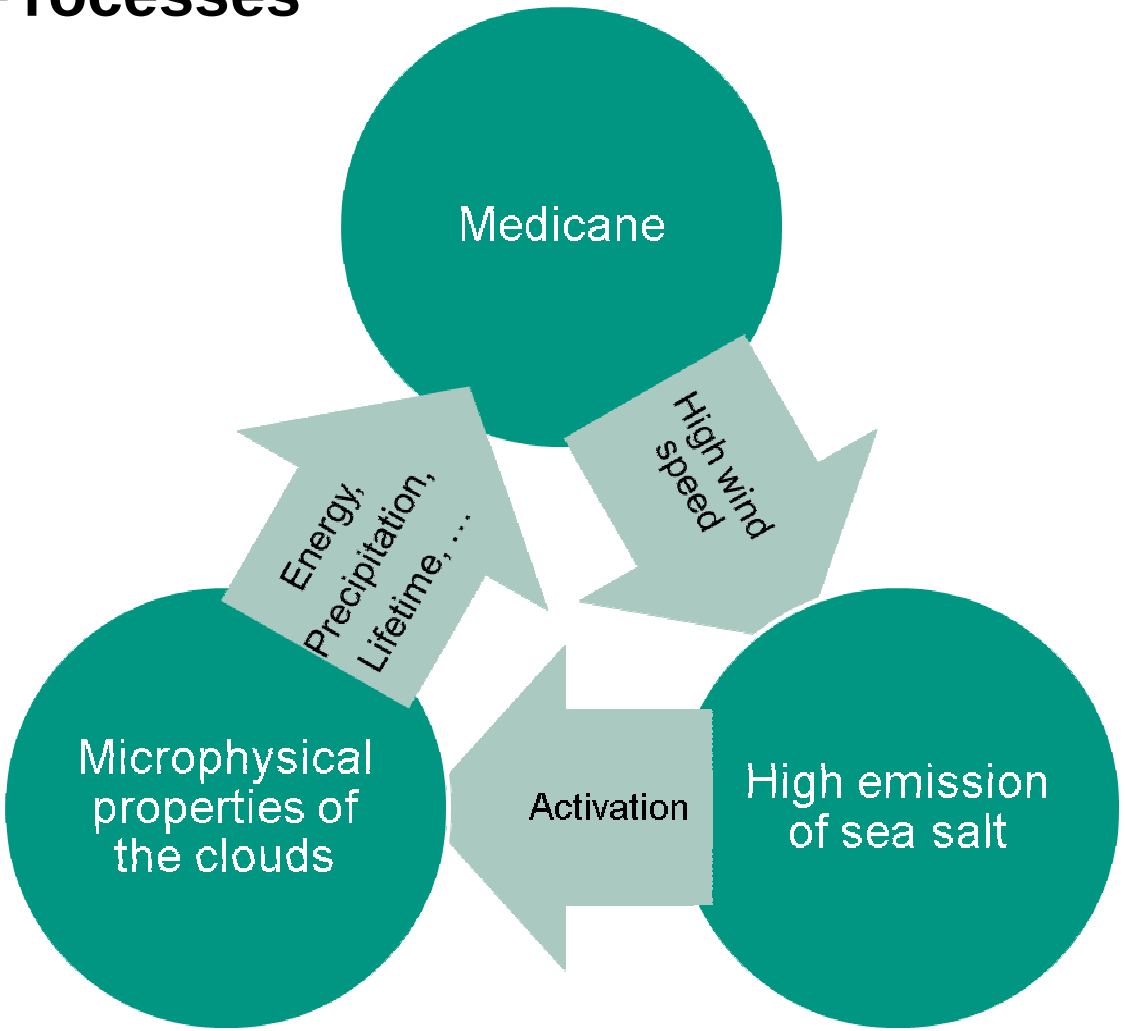
→ First simulations regarding sea salt

Sea Salt Aerosol

- Sea salt has the highest mass production rate of all natural aerosols

- It is emitted directly out of the sea by bursting of air bubbles and tearing directly off the wave crest
  - Depends on wind speed and sea surface temperature
  - Particle size distribution depends on wind speed

Feedback Processes



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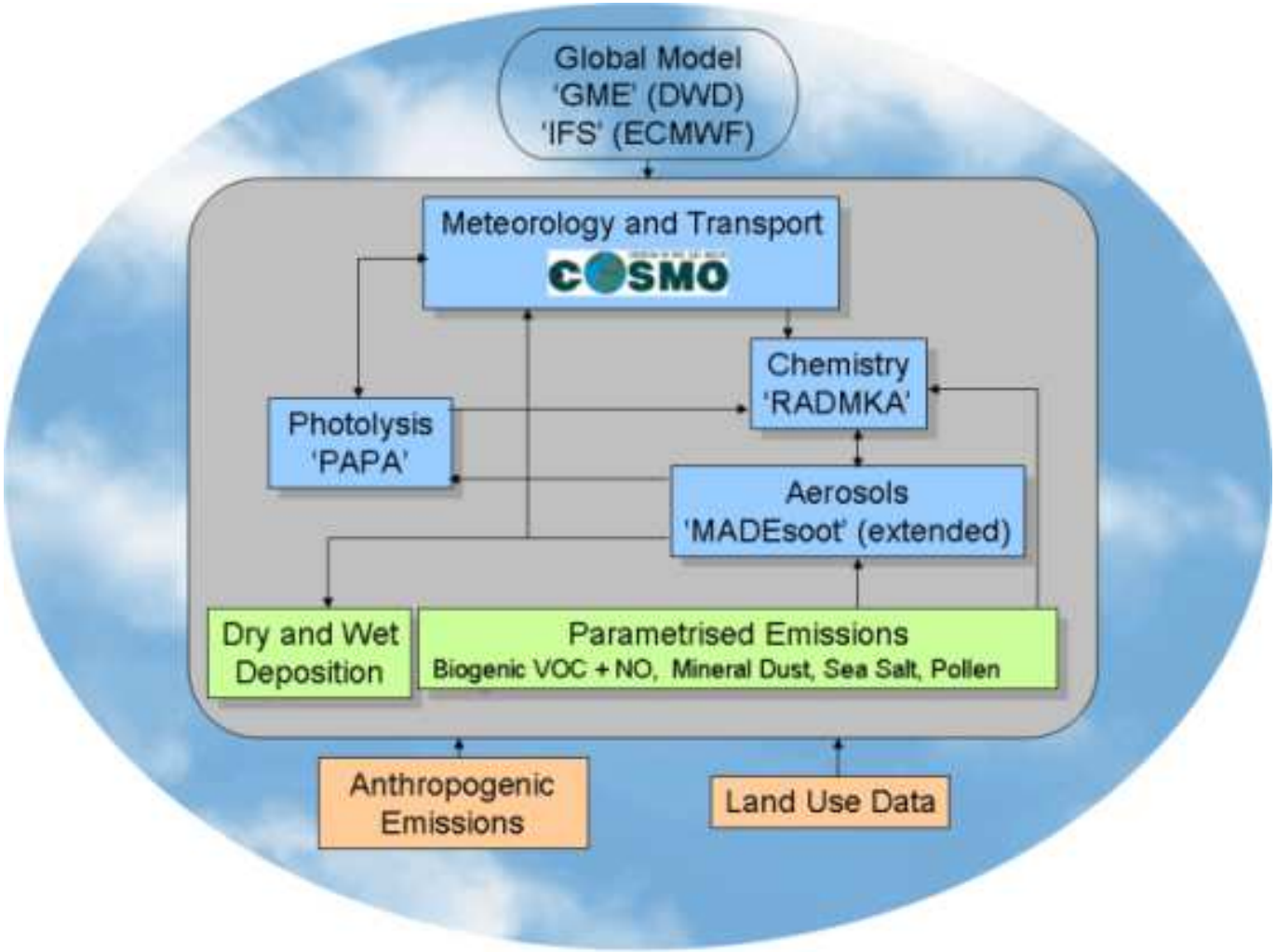
Model System:
COSMO-ART (Aerosols and Reactive Trace gases)



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Coupling of Aerosols and Cloud Microphysics

- **Sea salt size distribution** by three overlapping modes
  (d=0.2, 2, 12 μm, Lundgren et al., 2012)

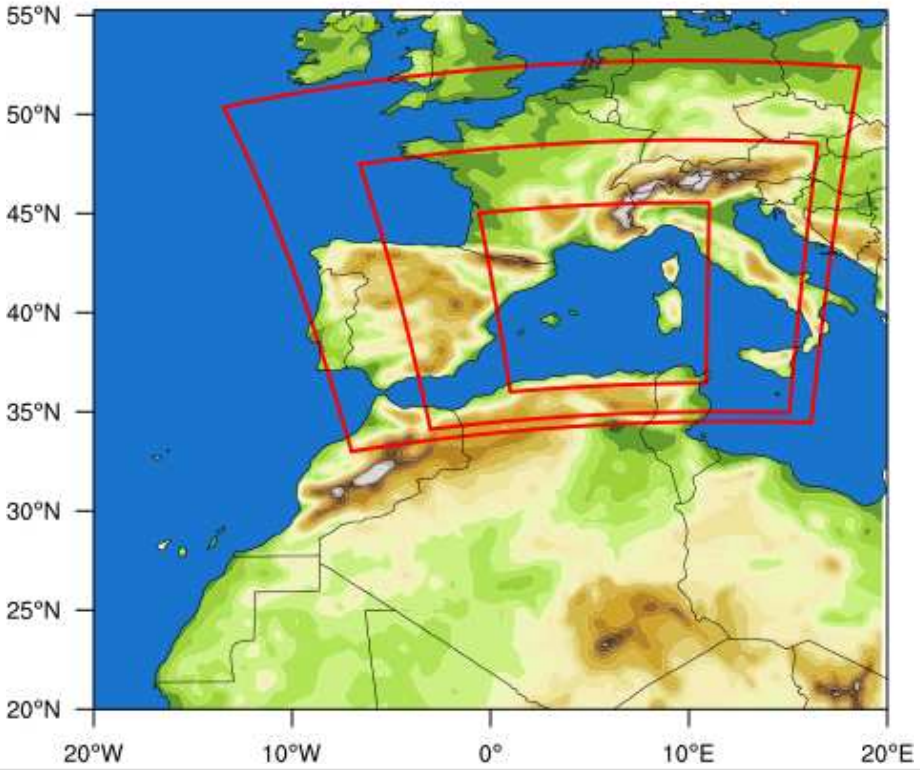
- **Two moment cloud microphysics, six hydrometeor classes**
  (Seifert and Beheng, 2006)
  → e.g. prognostic cloud droplet number and mass concentration

- **Aerosol activation**
  (Bangert et al., 2011)
  → competition of aerosol particles for water vapor during cloud formation

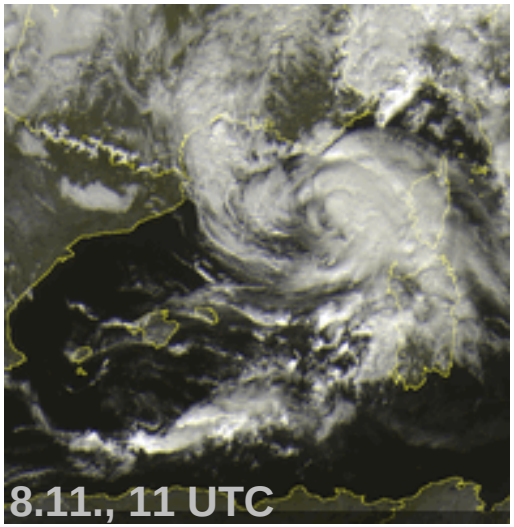
Model Setup

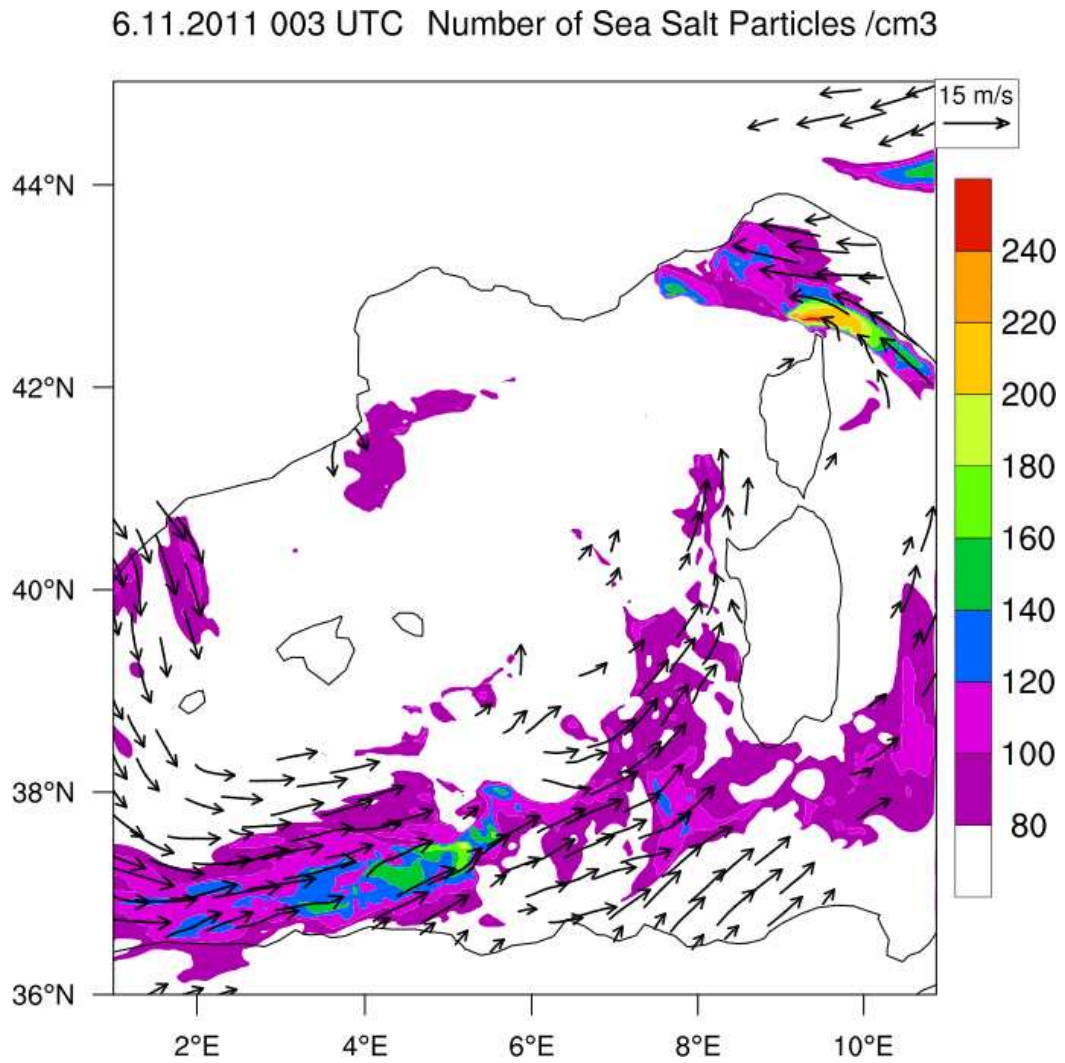
- Initial and boundary conditions: GME
- Triple nesting, highest resolution: 2.8 km, 50 layers, $\Delta t = 25$ s
- Simulation period November 5 to November 9, 2011
- Aerosol background concentration: 400 particles cm^{-3} (Sulfate)
- No direct feedback on radiation

- Scenarios:
  - no sea salt
  - with sea salt

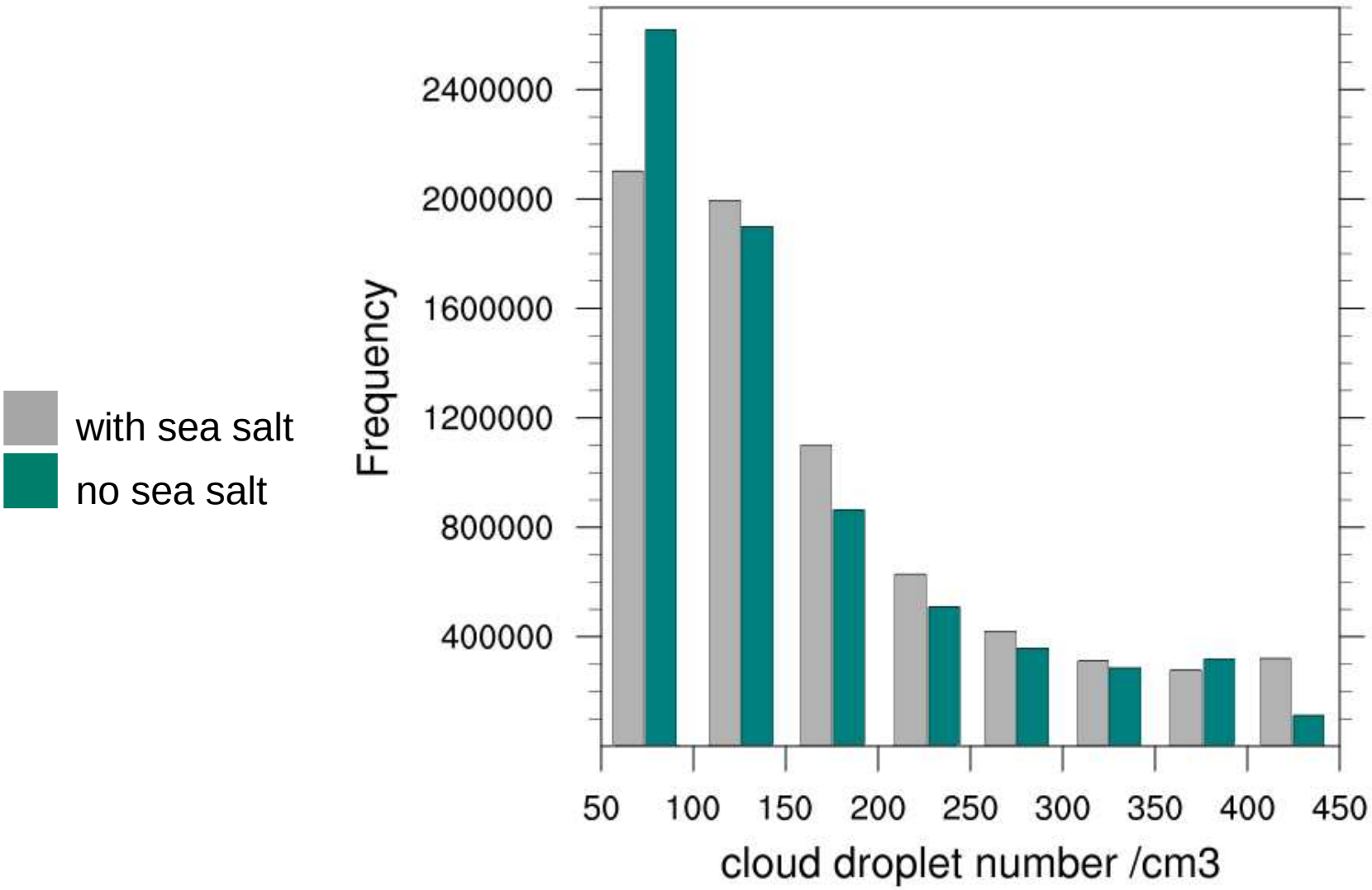


Number Concentration of Sea Salt Particles

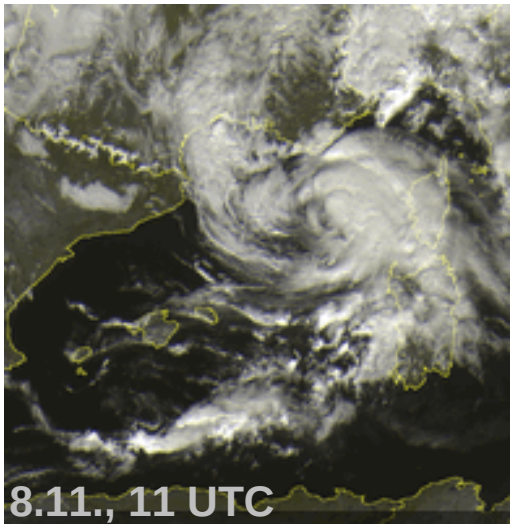


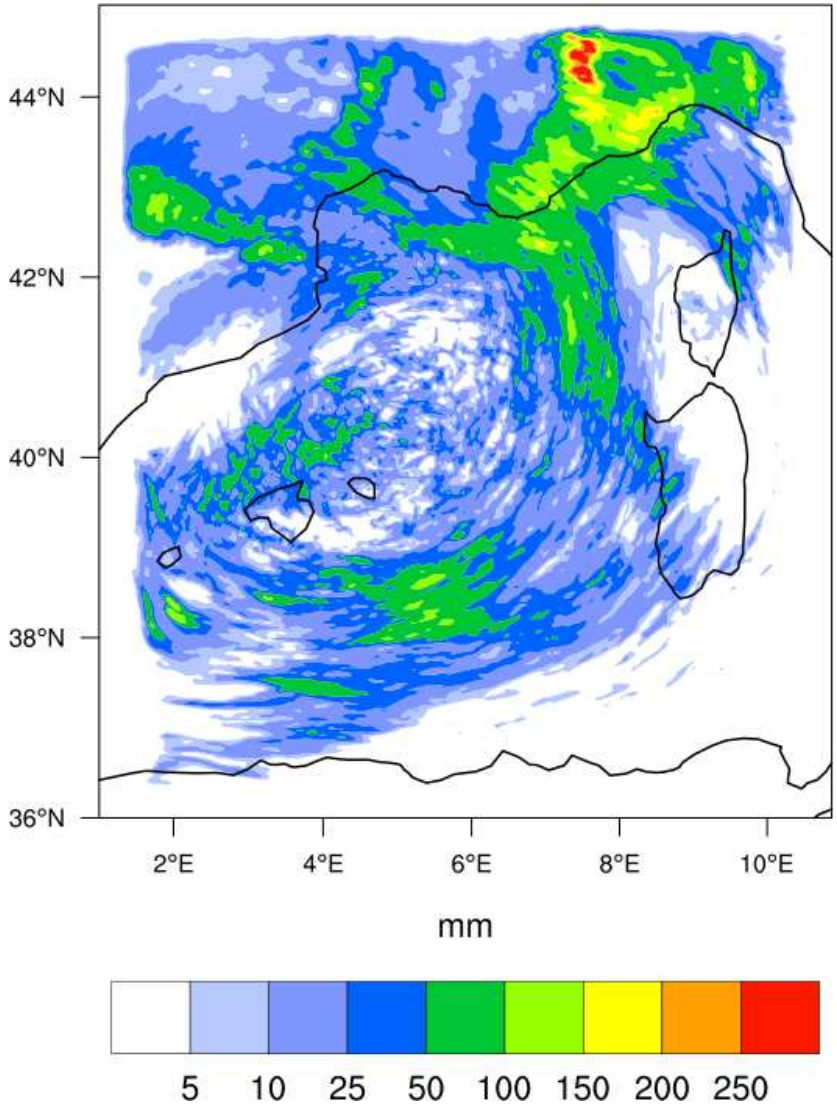


Cloud Droplet Number



Accumulated Precipitation (6. – 9.11.2011)





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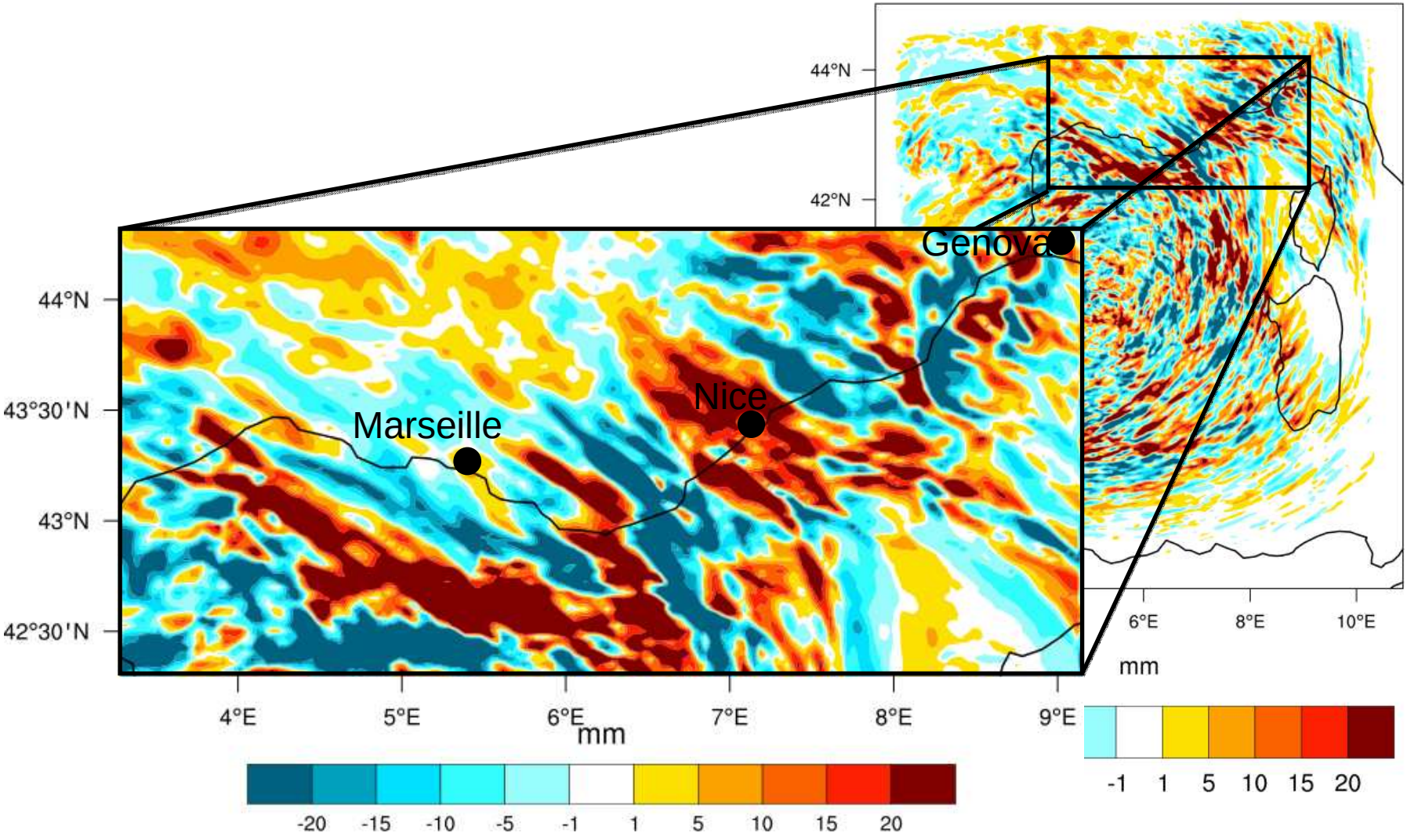
Difference in Accumulated Precipitation (6. – 9.11.)



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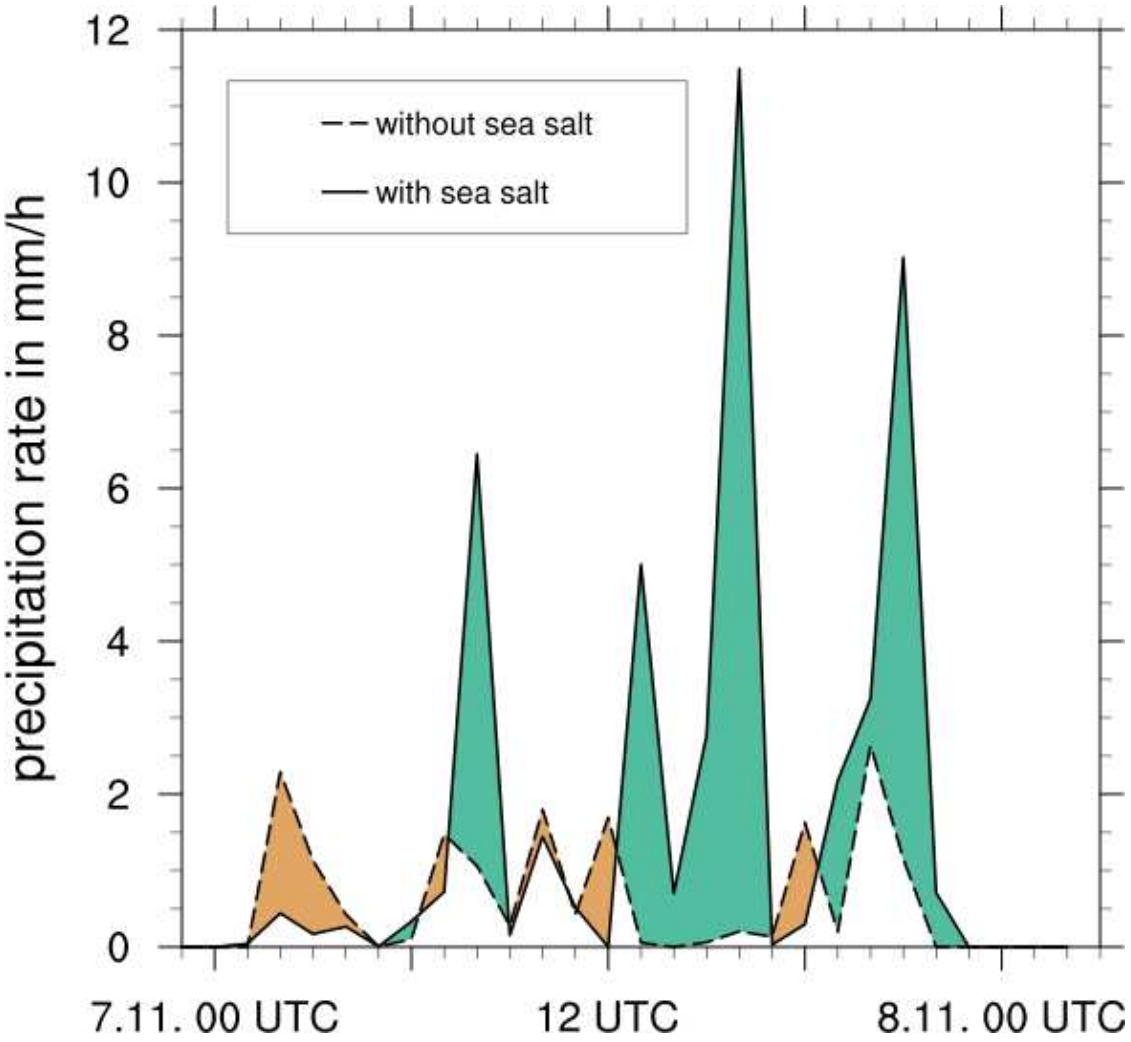
Precipitation Rate in Nice



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Summary

- Impact of sea salt on clouds during a medicane was studied by simulations with COSMO-ART
- Sea salt particles caused an increase of cloud droplet number
- Locally strong influences of sea salt on precipitation were found (systematic effects?)

Sea Salt Parameterization

- emission flux depending on horizontal wind speed in 10 m height and water surface temperature (Mårtensson et al., 2003)

$$\frac{dF_0}{d\log D_p} = \phi(T_w, D_p) 3.84 \times 10^{-6} U_{10}^{3.41}$$

Φ : Aerosol number flux depends on sea surface temperature and particle diameter

U10: wind speed in 10 m height

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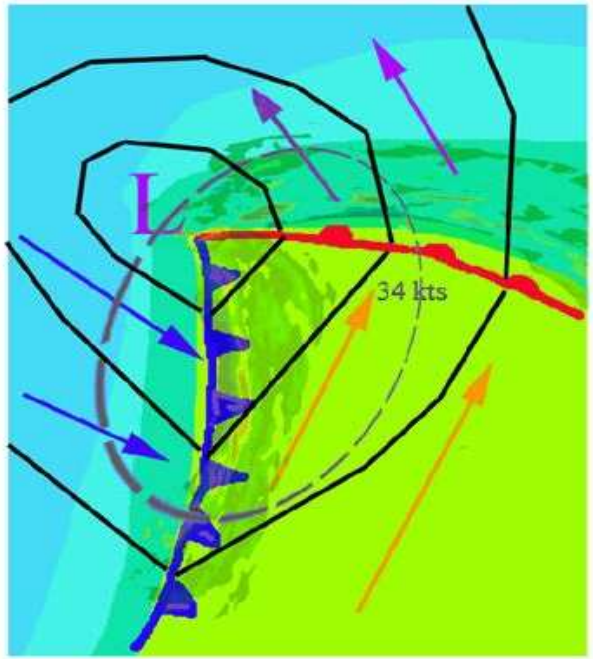
What is a Medicane? (MEDIterranean HurriCANE)

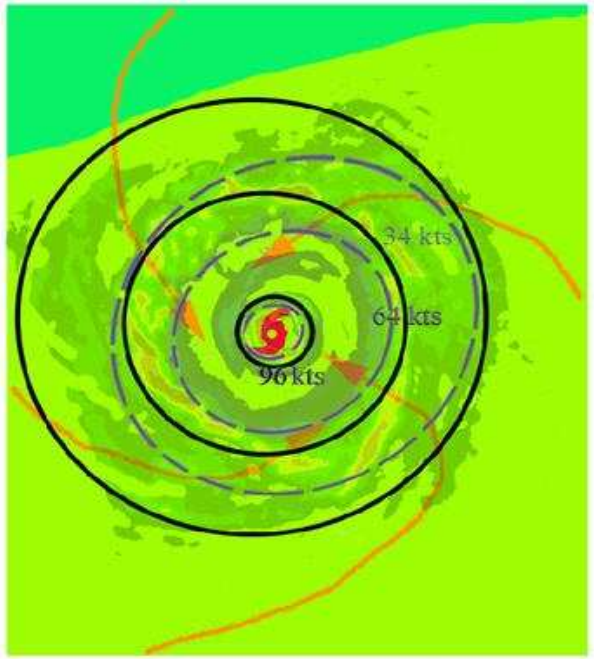
- **Extratropical** cyclone



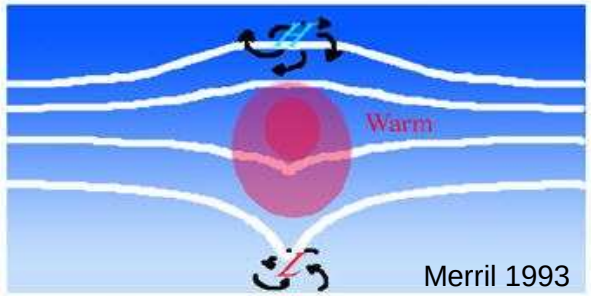
Pushed by different airmass

cold core

- **Tropical** cyclone



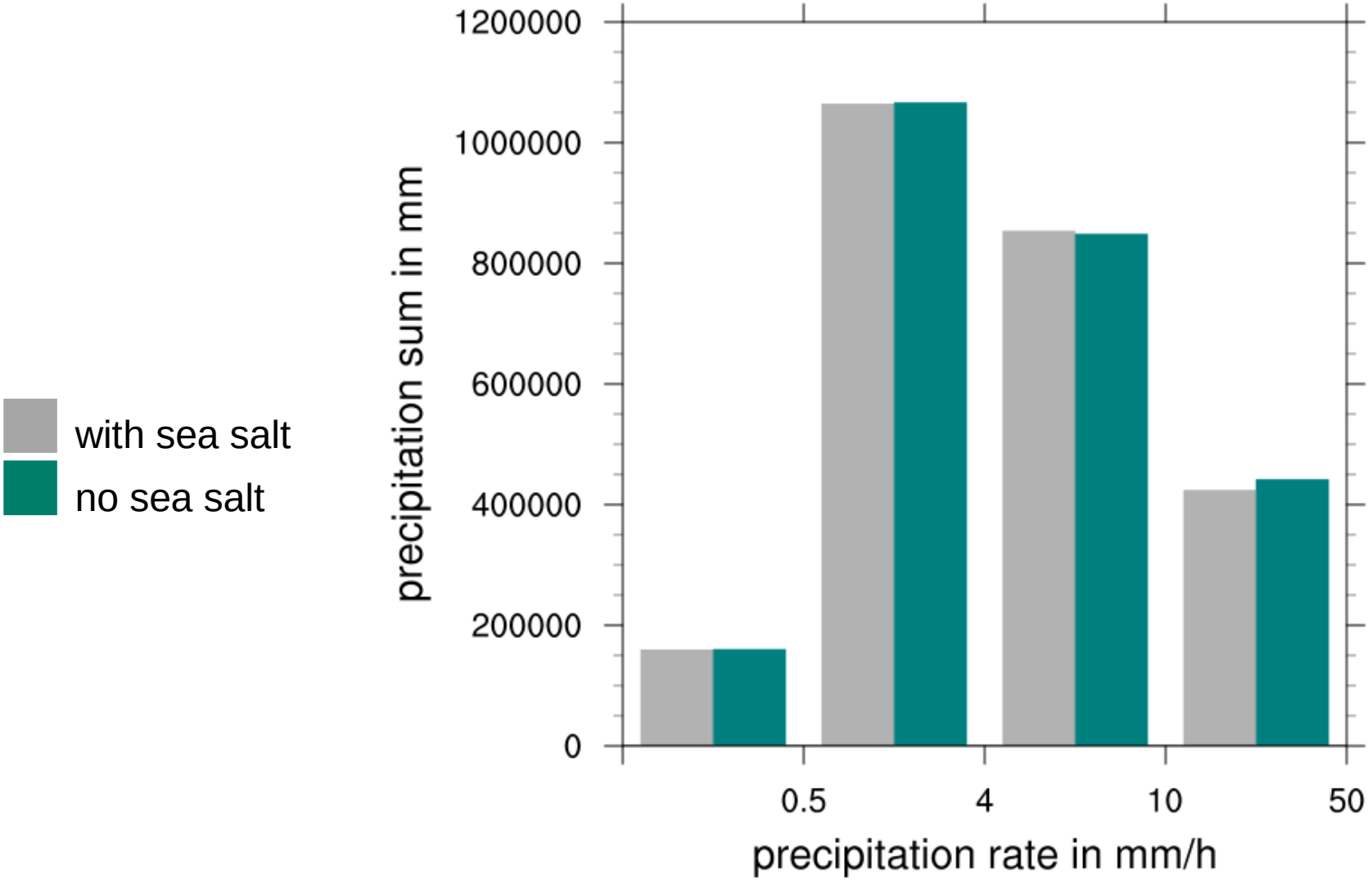
Latent heat release of warm and humid airmass



warm core

Merril 1993

Distribution of Precipitation (6. – 9.11.)



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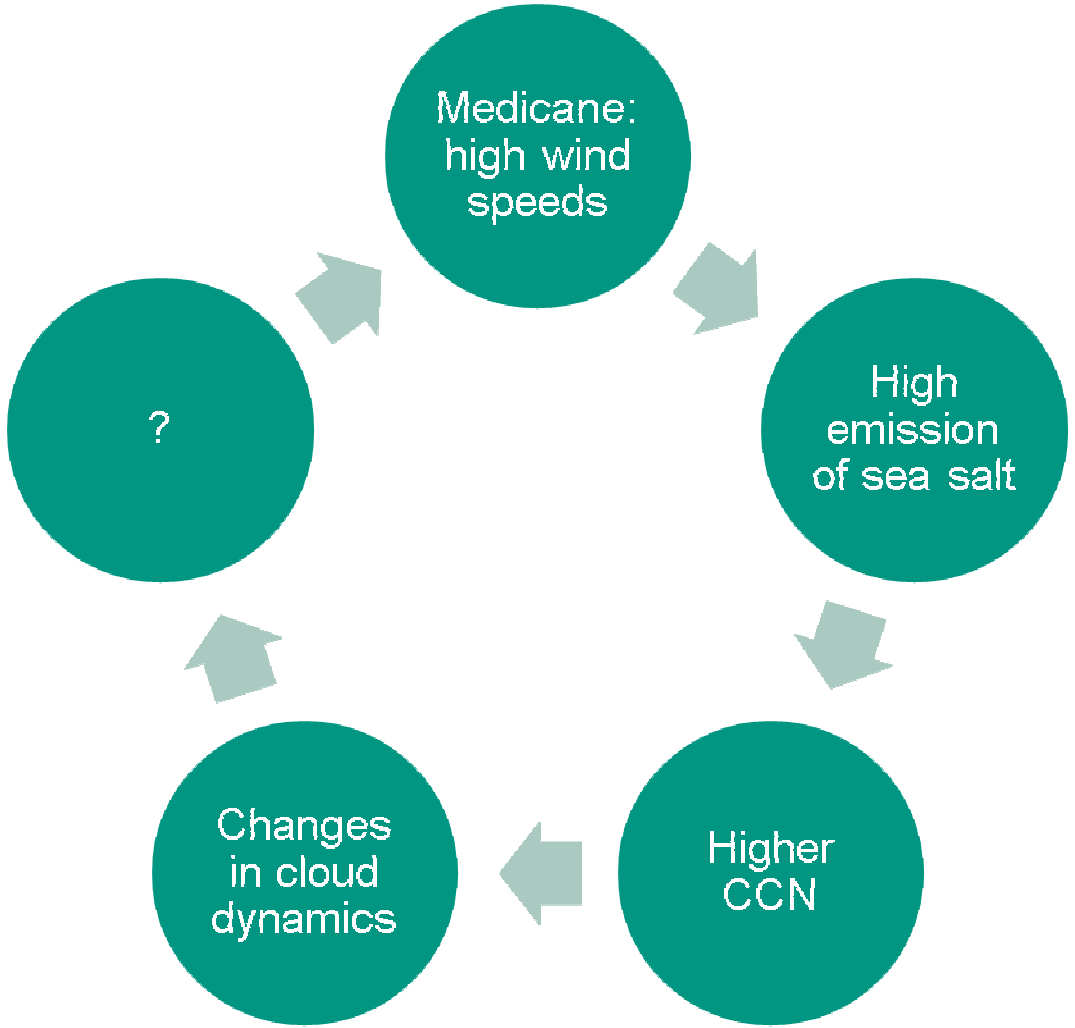
Why aerosols?

- Aerosols scatter and absorb (solar and terrestrial) radiation
- Aerosols acting as CCN
  - impact on cloud droplet number and particle sizes
  - impact on precipitation, cloud height, cloud lifetime, amount of precipitation

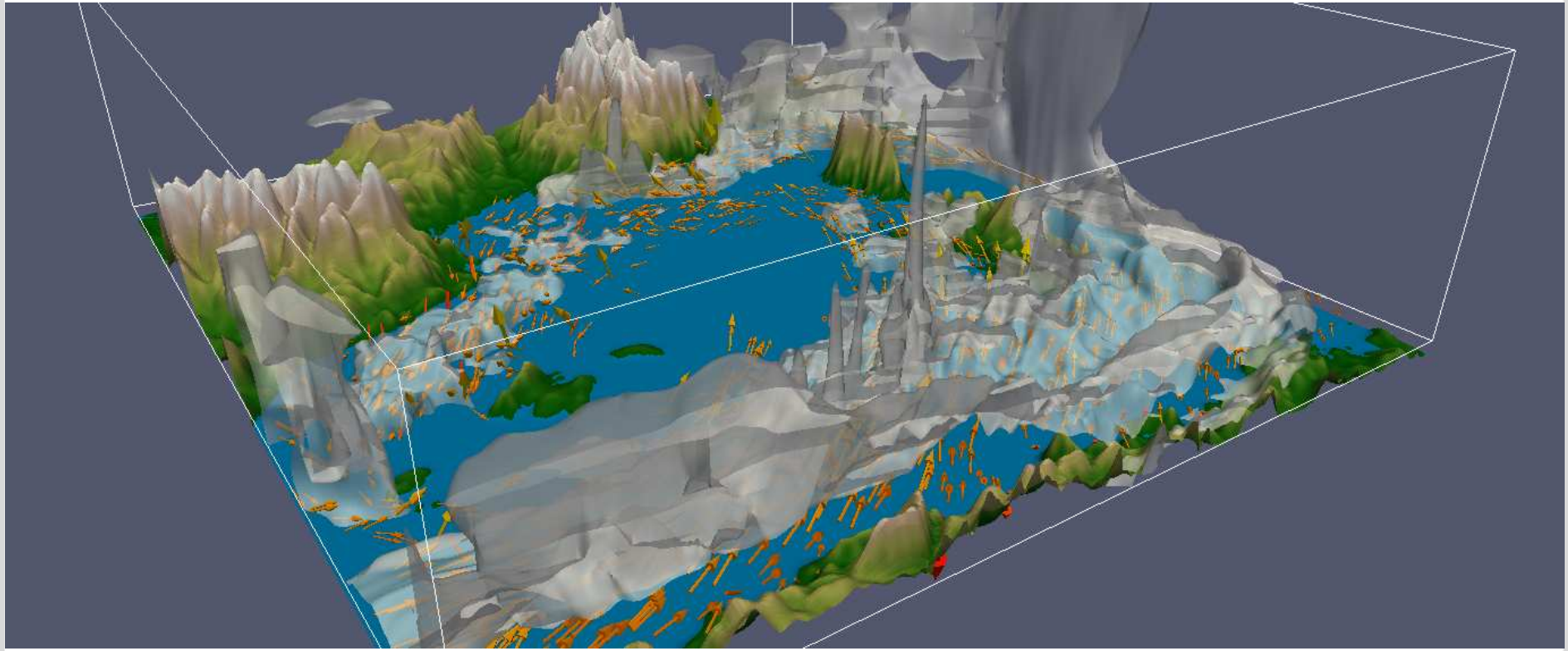
Aerosols	Direct effect	Indirect effects
Sea salt		X
Dust		
Anthropogenic aerosol		


Medicane: high wind speeds
High emission of sea salt
Higher CCN
Changes in cloud dynamics
?

Parameterization of sea salt in COSMO-ART

- Size distribution by three overlapping modes (d=0.2, 2, 12 μm, tri modal lognormal distribution, O'Dowd et al., 1997)
- Loss: sedimentation, deposition and washout
- Production: emission flux depending on horizontal wind speed in 10 m height and water surface temperature (Mårtensson et al., 2003)

Sea Salt Mass Concentration



Sea salt mass concentration iso surface on 25 µg/m^3

Outlook

- Distinguish between statistical uncertainties and systematical effects
- Add direct radiative feedback
- Include further aerosols:
  - Mineral dust
  - Anthropogenic aerosols