

# Dow we need a coupled modelling system when modelling extreme events?

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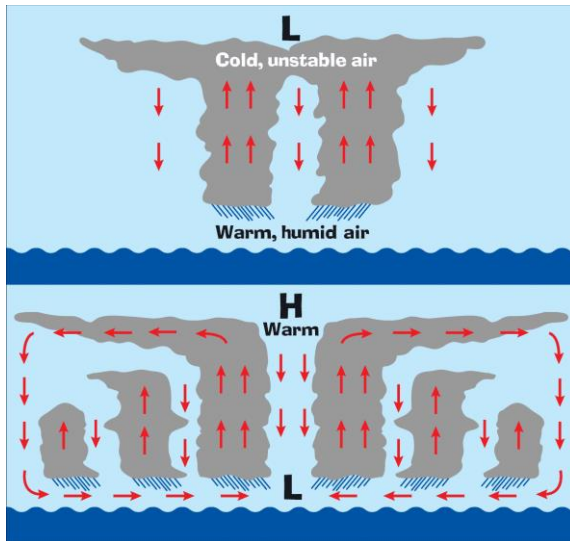
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Sweden



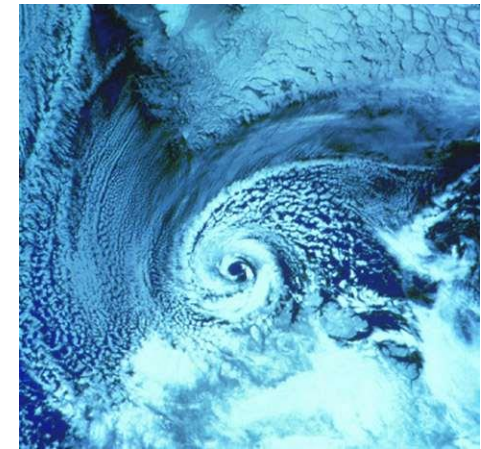
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# For most extreme events the interaction with the surface is a key element for the development

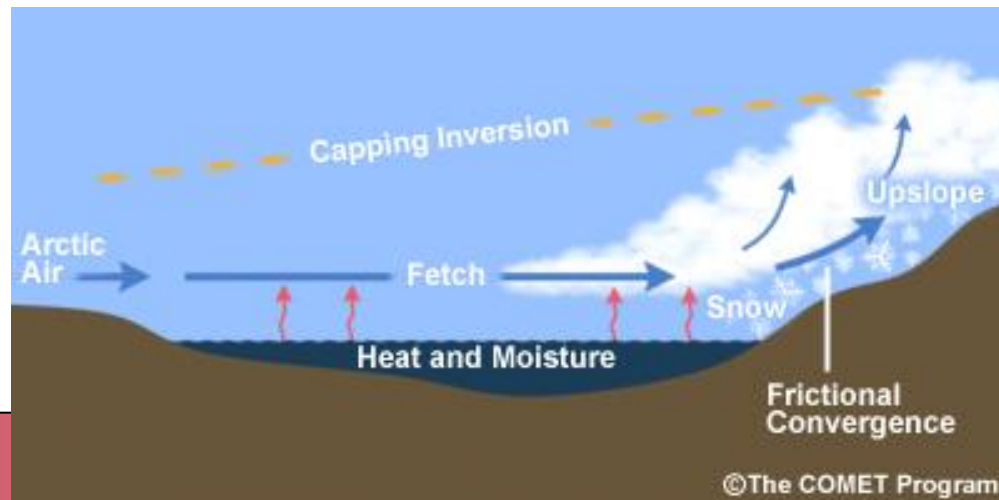
Classical examples:  
**Hurricanes**



**Polar lows - SST**



**Convective snowbands**



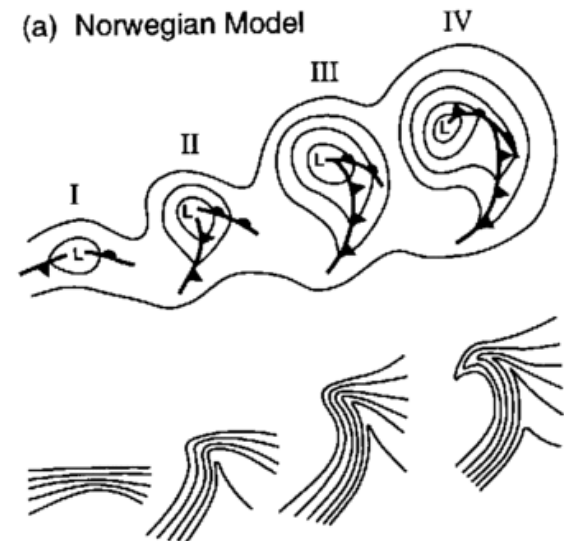
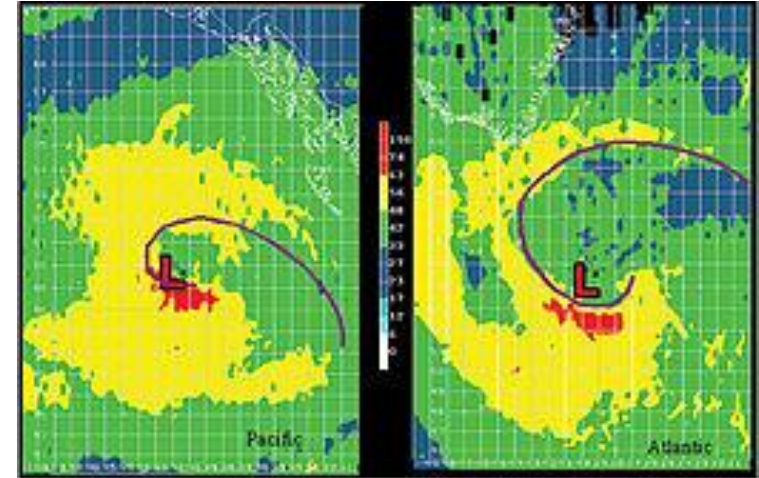


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# Development of deep extratropical cyclones

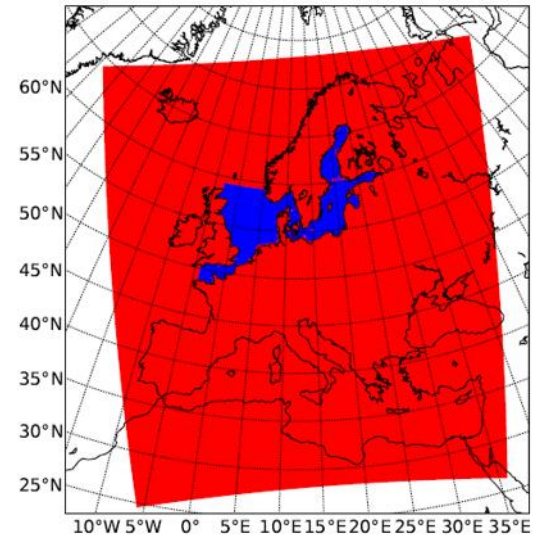
Question:

How important is the interaction between sea surface roughness (waves), sea surface temperature (ocean) and cyclone development?



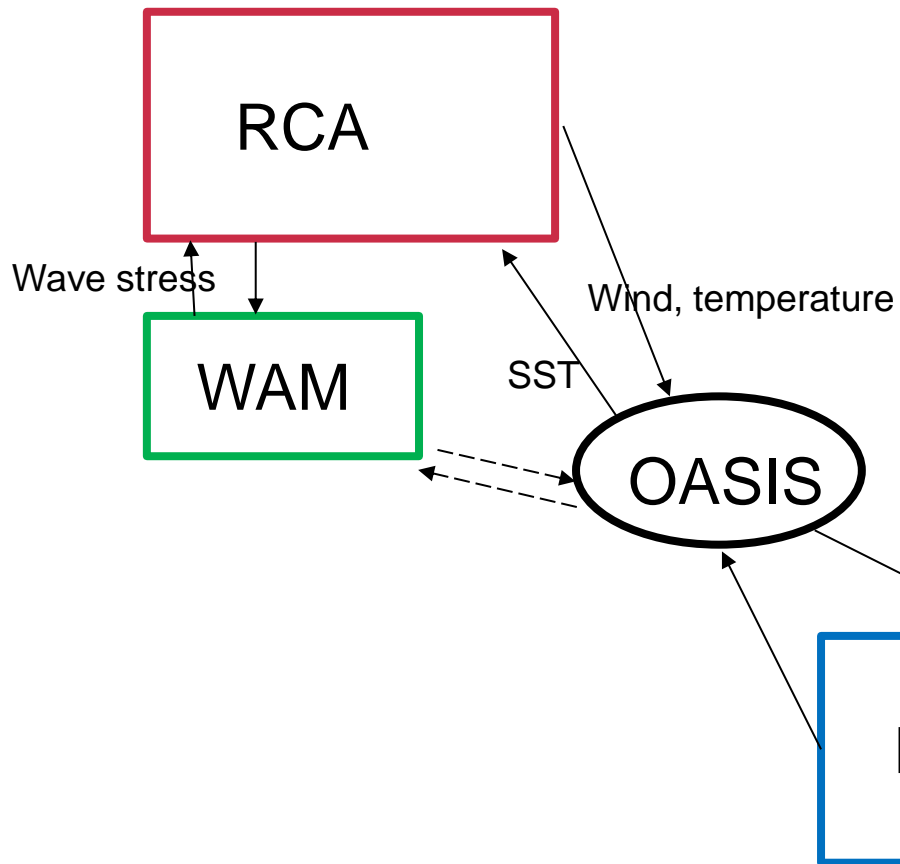
# RCA-WAM-NEMO, regional atmosphere climate-wave coupled model, developed to investigate the impact of waves on the atmosphere and ocean

- RCA, Rossby Centre regional climate model
  - 3D-model 22 km horizontal resolution
- WAM third generation wave model.
  - The sea state is described by a 2D wave energy spectrum by solving the spectral energy-balance equation:
$$F(f, \theta, \varphi, \lambda) = S_{in} + S_{nl} + S_d$$
- NEMO (Nucleus for European Modelling of the Ocean)
  - 3D-ocean model implemented for North Sea and Baltic Sea





# Model components



- \* Impact of surface waves on the atmosphere (roughness, mixing)
- \* Impact of ocean on atmosphere (SST)
- \* Impact of waves on the ocean
- \* Wave-current interaction
- \* Wave-radiation ...



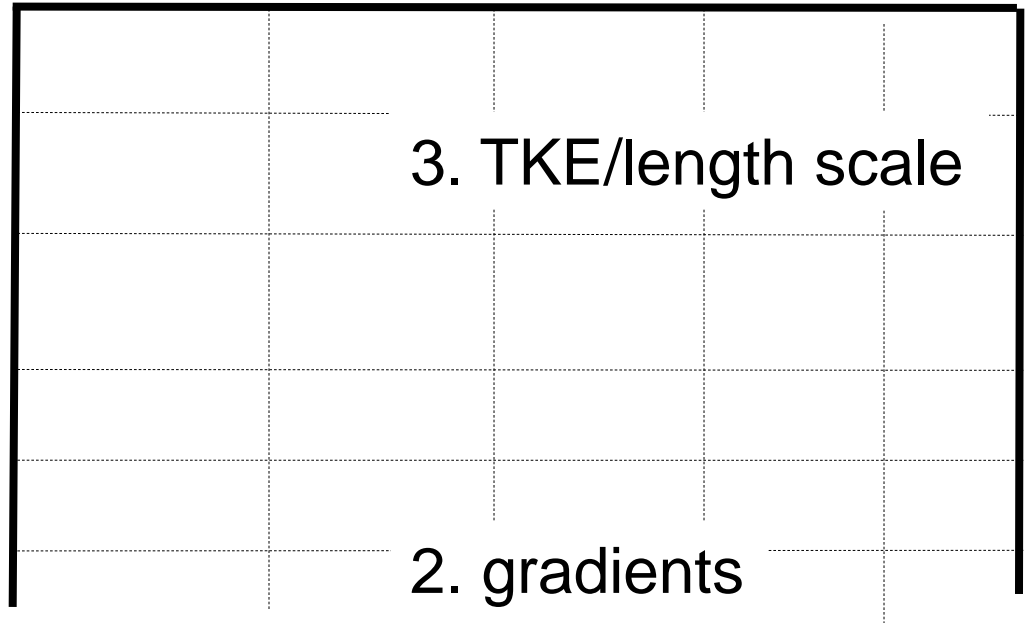
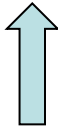
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# Coupled effect: atmosphere-waves

$U, V, u^*$



$H_s, c_p$



1.  $z_0$

WAM



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# Investigated cases

Focus: how important are surface waves and SST

**Fully coupled system: RCA-NEMO-WAM**

**Atmosphere-Ocean: RCA-NEMO**

**Atmosphere-wave: RCA-WAM**

**Observations: University of Reading**  
**Extreme wind catalogue**





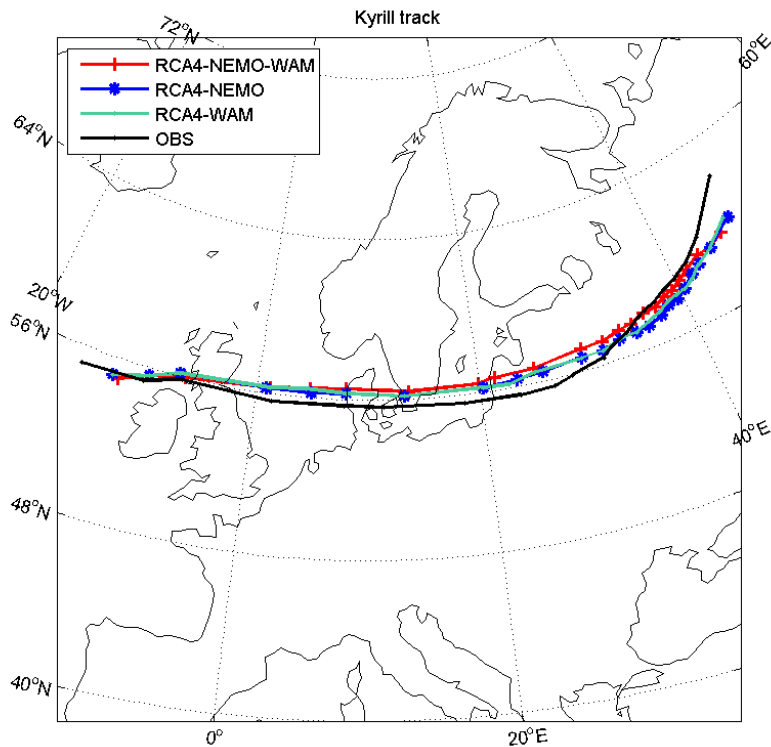
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# Investigated storms

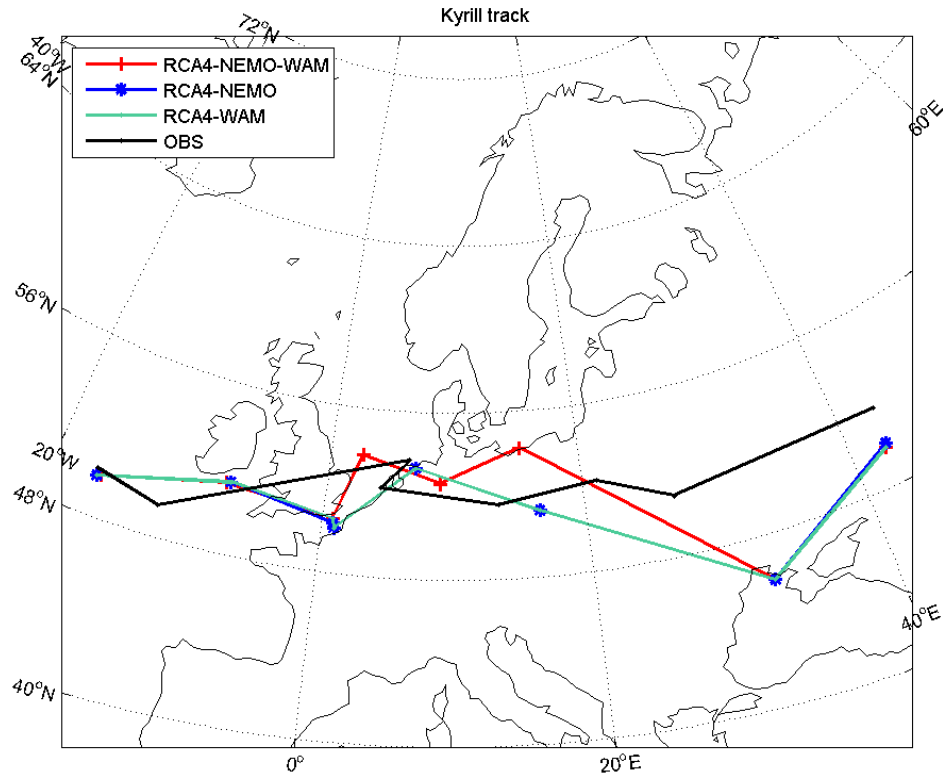
**Storm Kyrill** (*Lill-Per* in Sweden)  
January 18 to January 20 2007  
Caused severe damage in Germany



Minimum pressure



Wind max

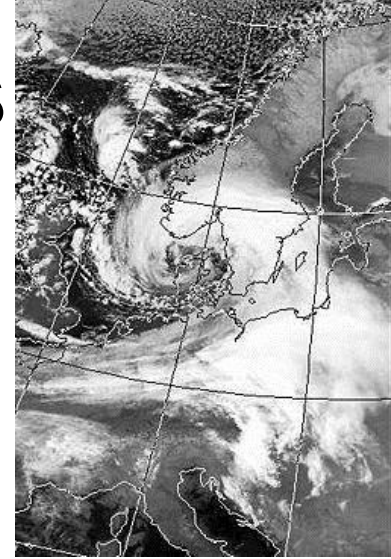






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# Investigated storms

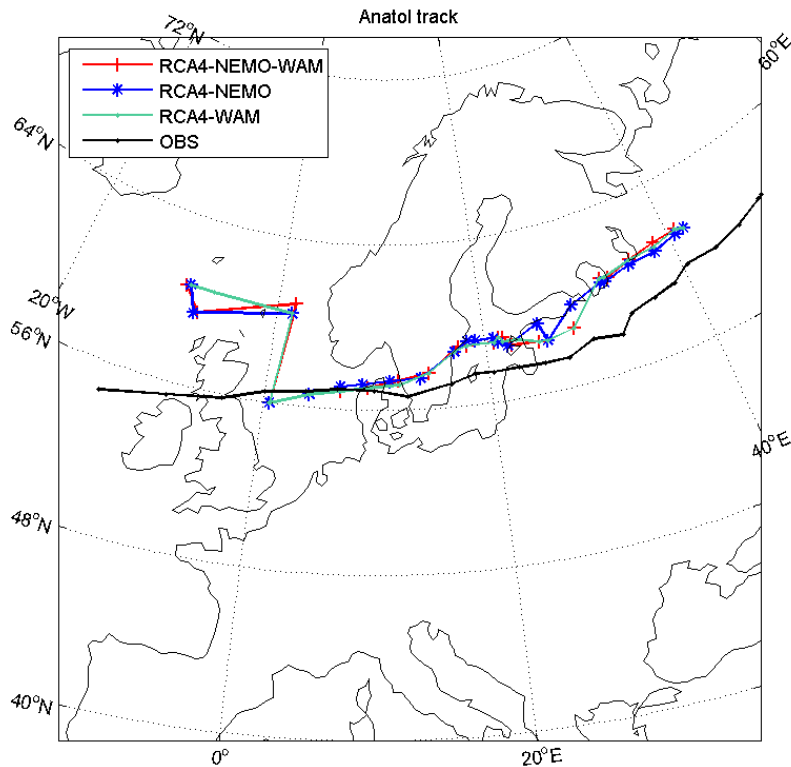


**Storm Anatol** (*Adam* in Denmark, *Carola* in Sweden)

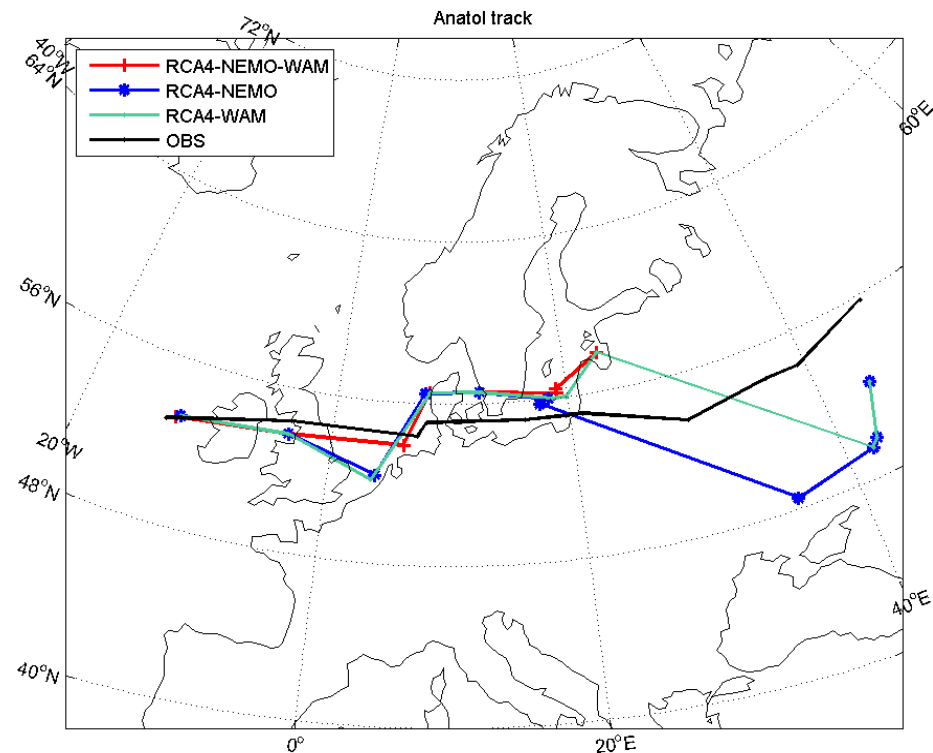
December 3 to December 5 1999

Caused 20 fatalities in Denmark

## Minimum pressure



## Wind max





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# Investigated storms

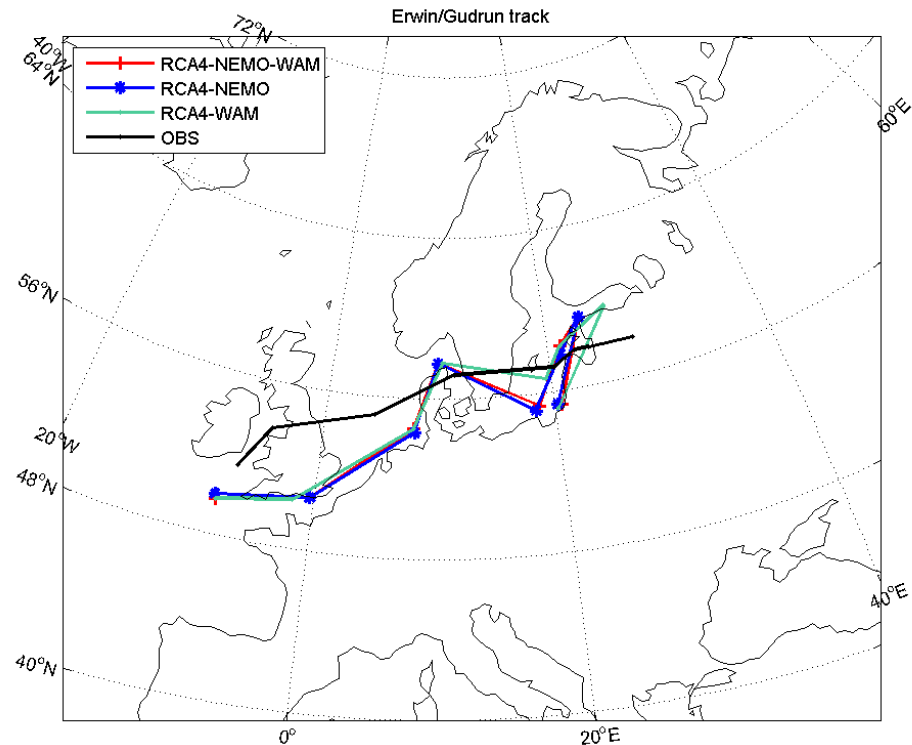
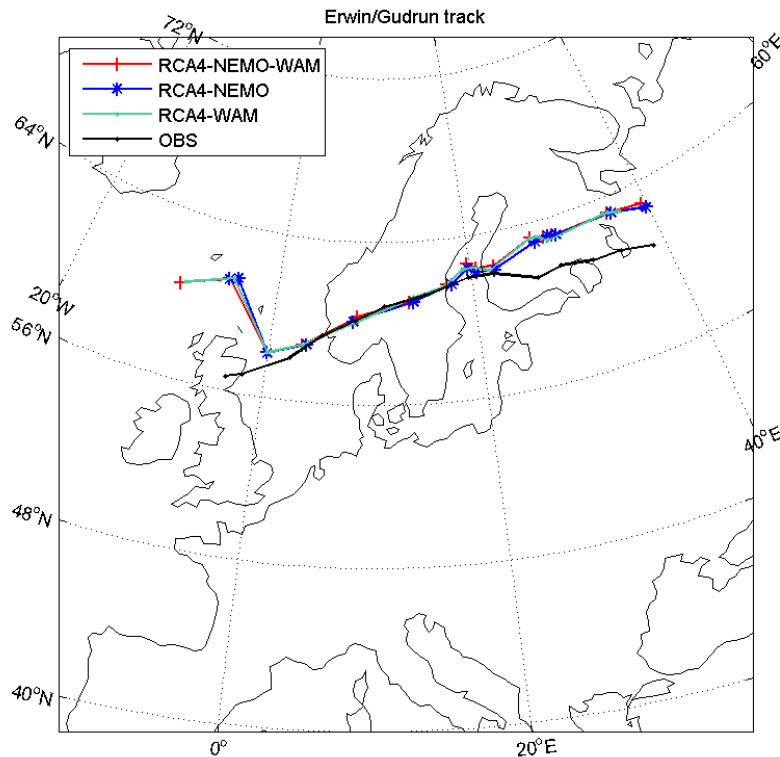
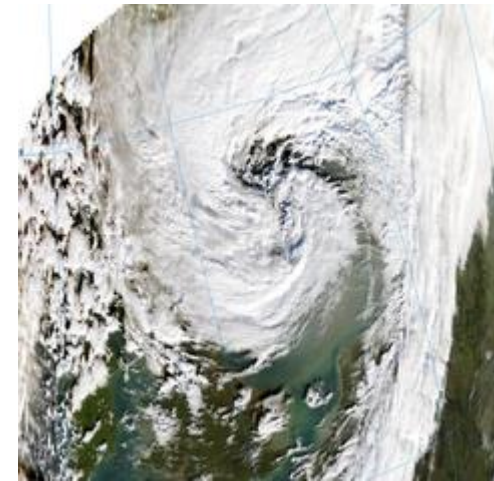
## Storm Erwin (Gudrun in Sweden)

January 8 to January 9 2005

more than 75,000,000 cubic metres of trees were  
destroyed

Minimum pressure

Wind max

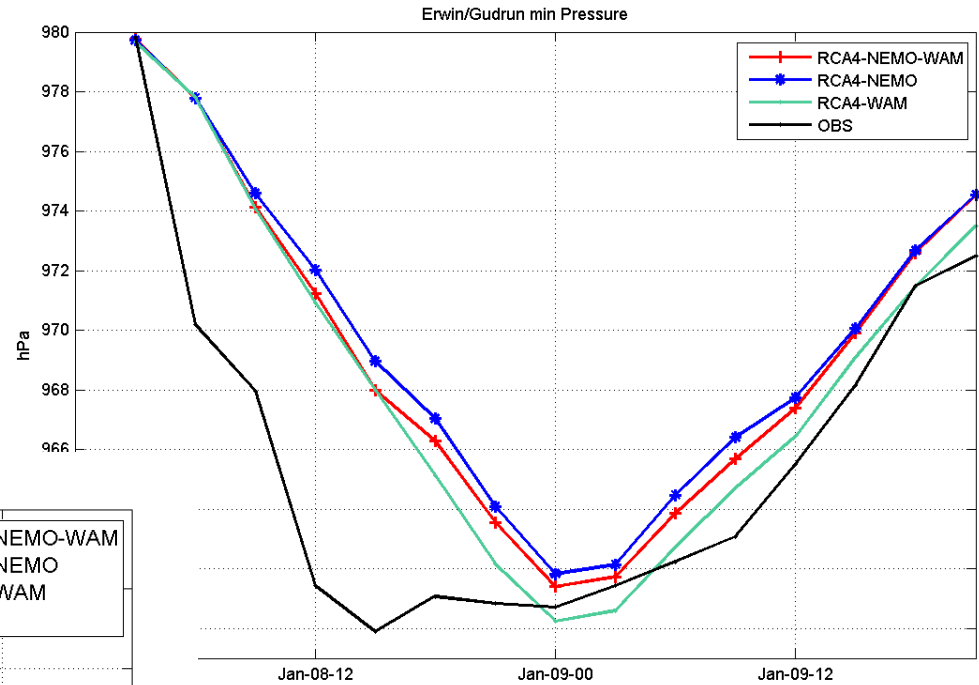
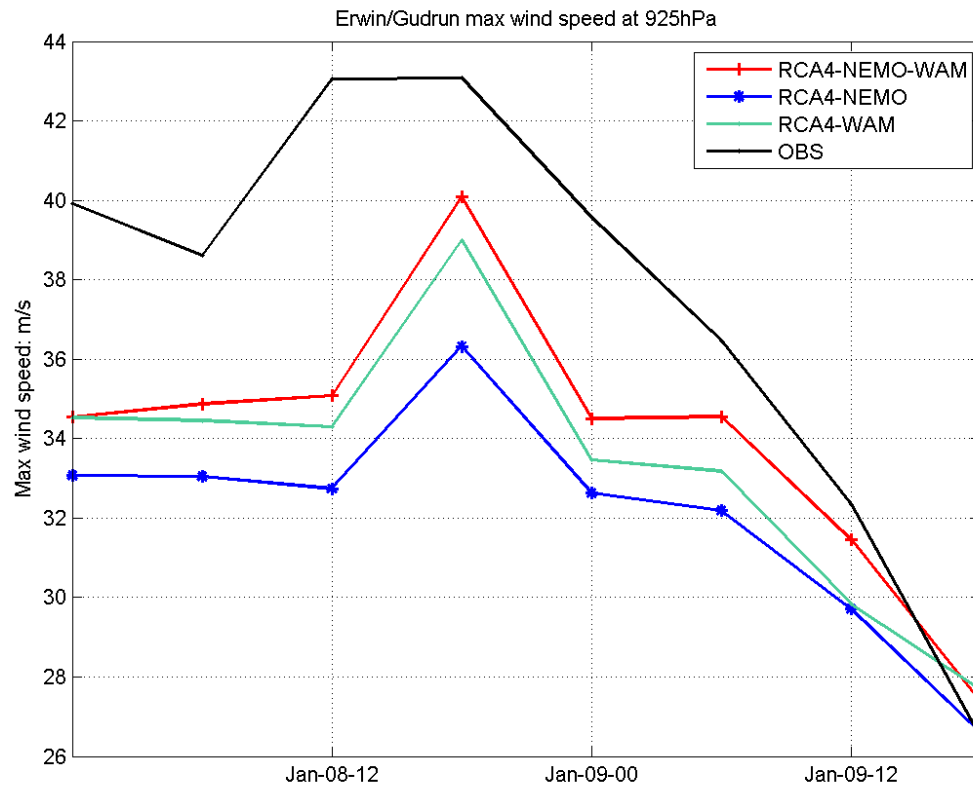




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# Erwin

## Maximum wind speed 925 hPa

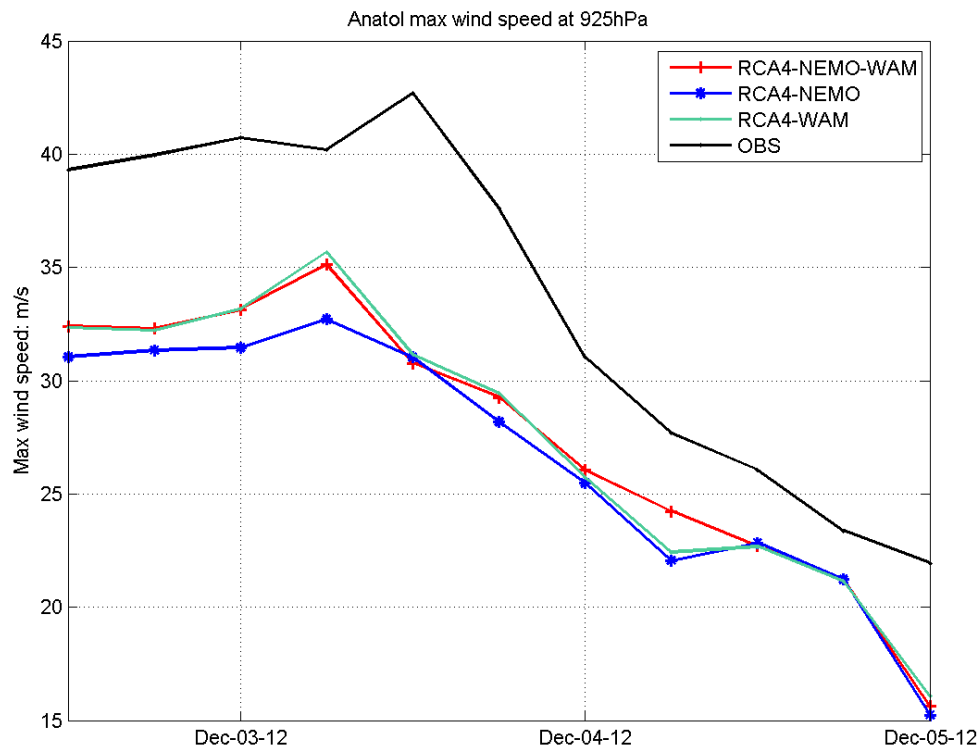


## Minimum pressure

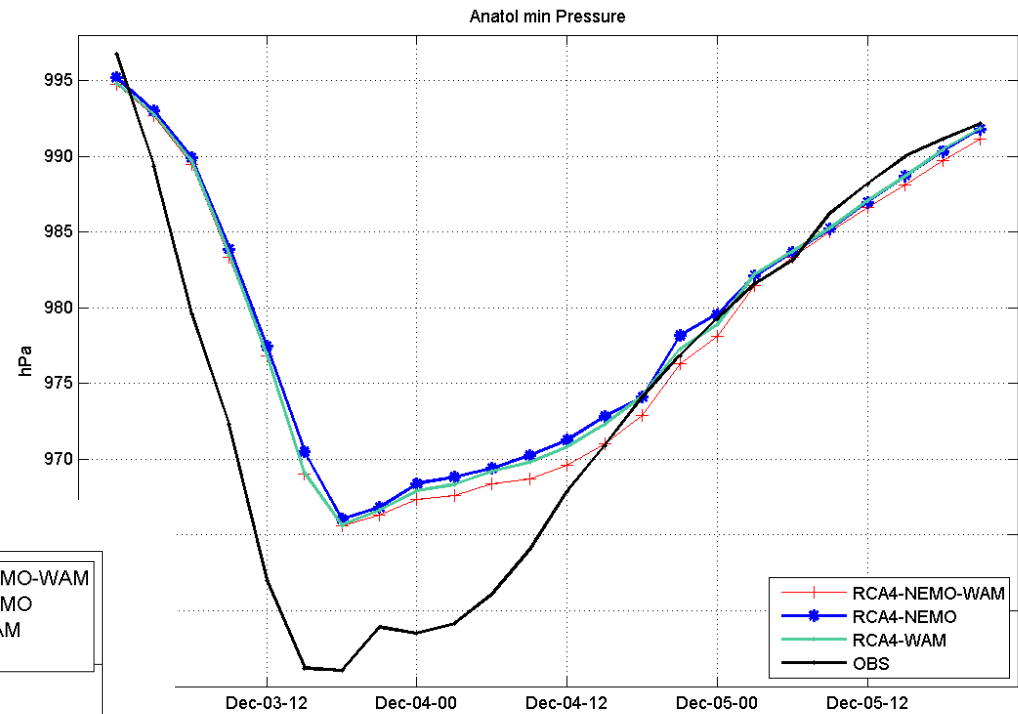


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## Maximum wind speed 925 hPa



# Anatol

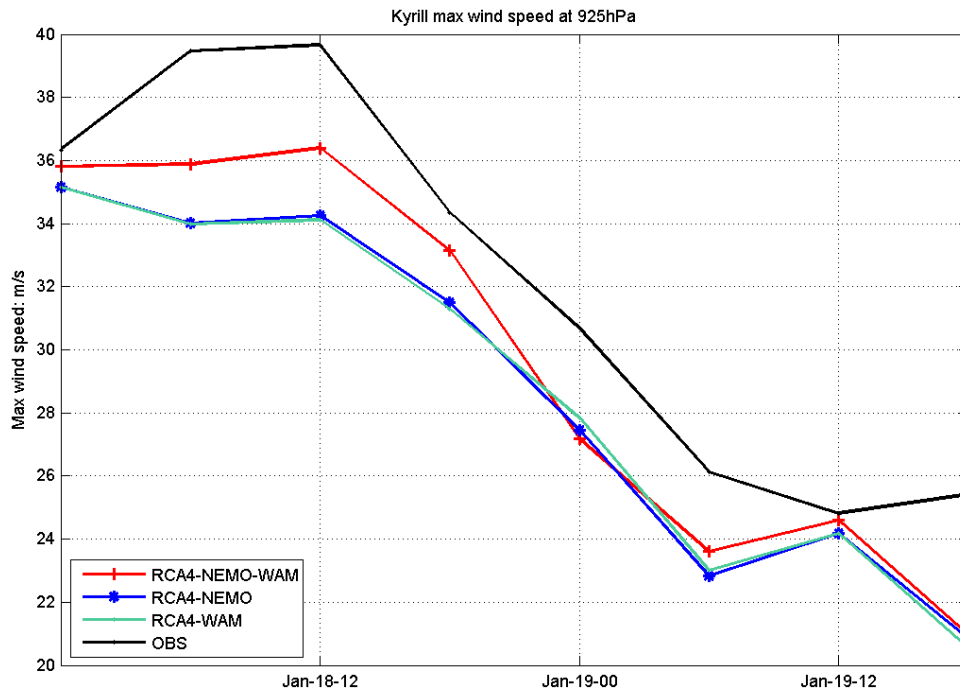


Minimum pressure

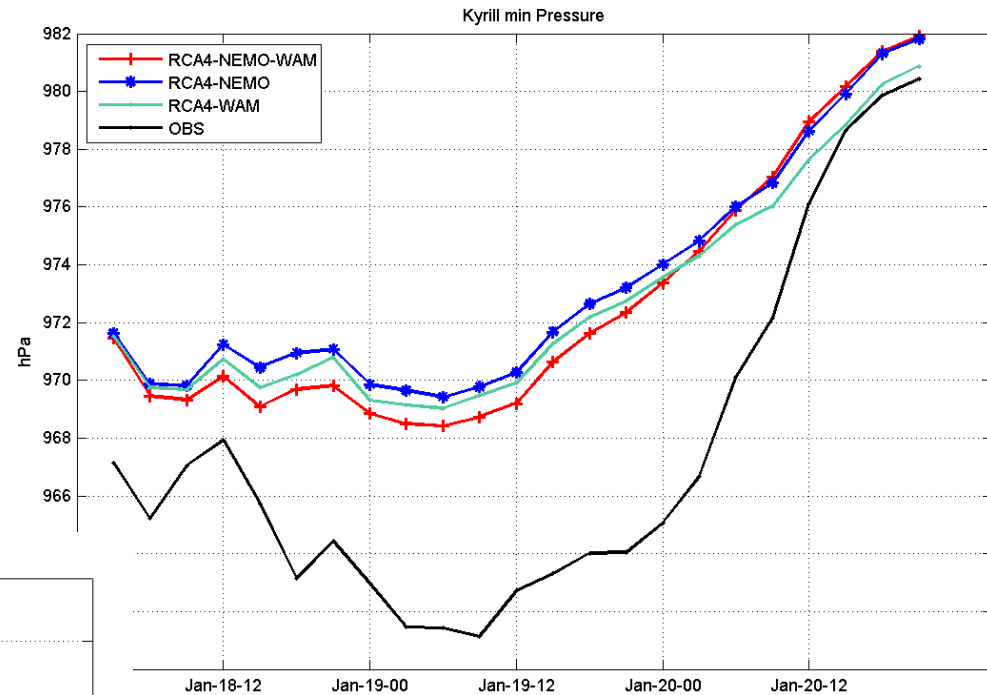


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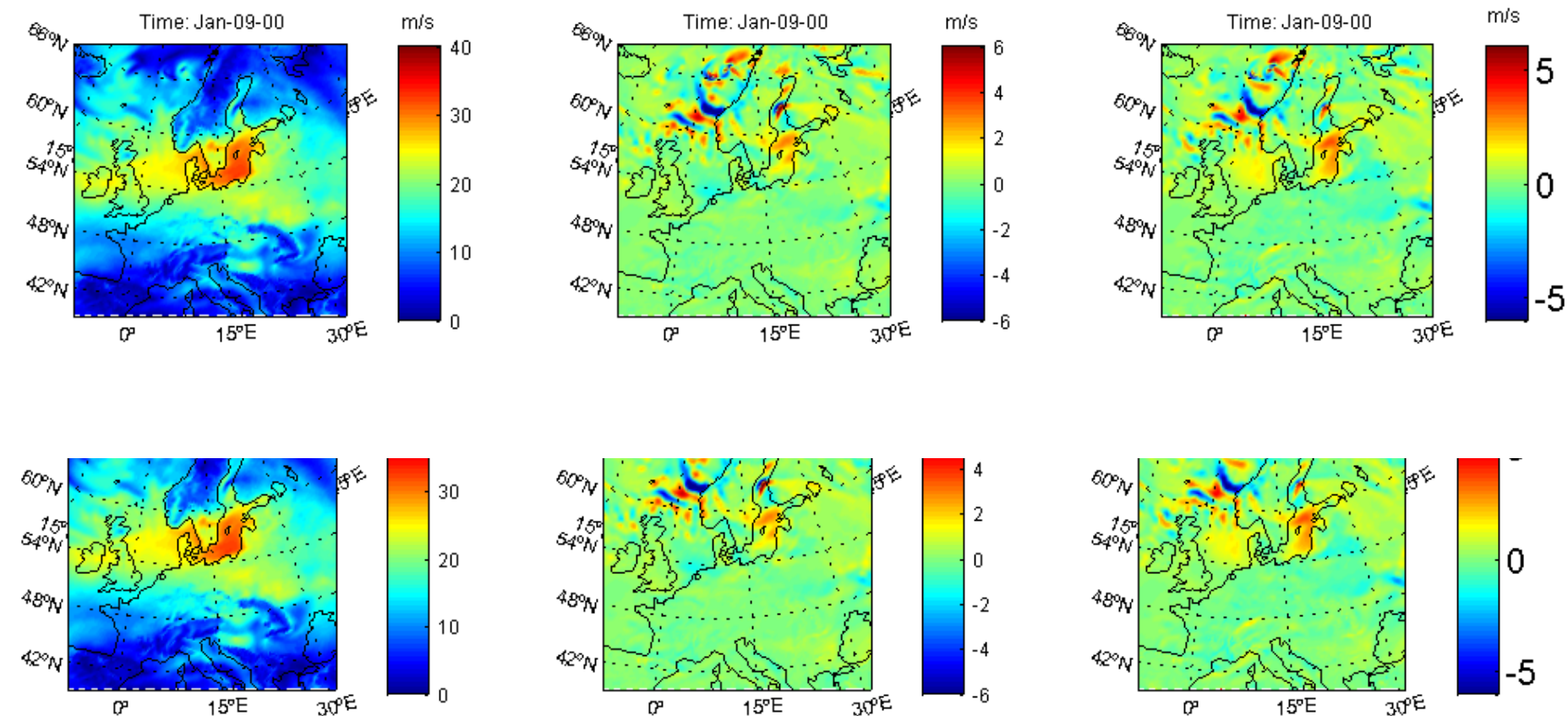
## Maximum wind speed 925 hPa



# Kyrill



Minimum pressure



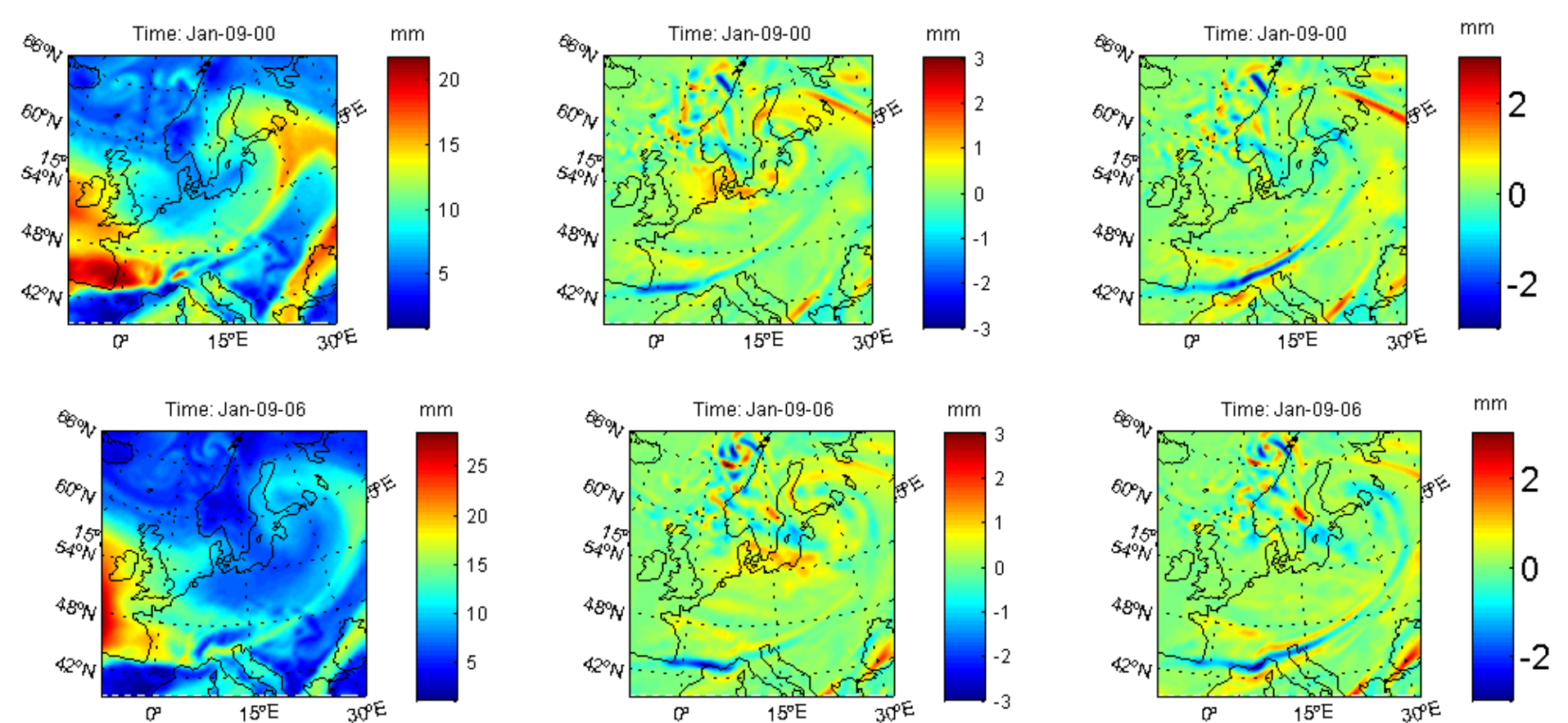
RCA-NEMO

RCA-WAM (Diff)

RCA-NEMO-WAM (Diff)

**Wind speed**





RCA-NEMO

RCA-WAM (Diff)

RCA-NEMO-WAM (Diff)

# Precipitation





# Conclusions

- Storm tracks only marginally affected
  - Systematically higher maximum winds and lower minimum pressure (along the track center) when we include waves
  - Higher winds in the vicinity of the track.
  - Secondary parameters influenced (precipitation).
- 
- Question: do include the waves correctly?
  - Missing: other interaction impacts of the coupling