

Coupled Regional Climate Modeling Systems: Pros and Cons

Bodo Ahrens, Praveen K.
Pothapakula, Nora Leps, Naveed
Akhtar, Cristina Primo Ramos

Goethe University Frankfurt



Goal

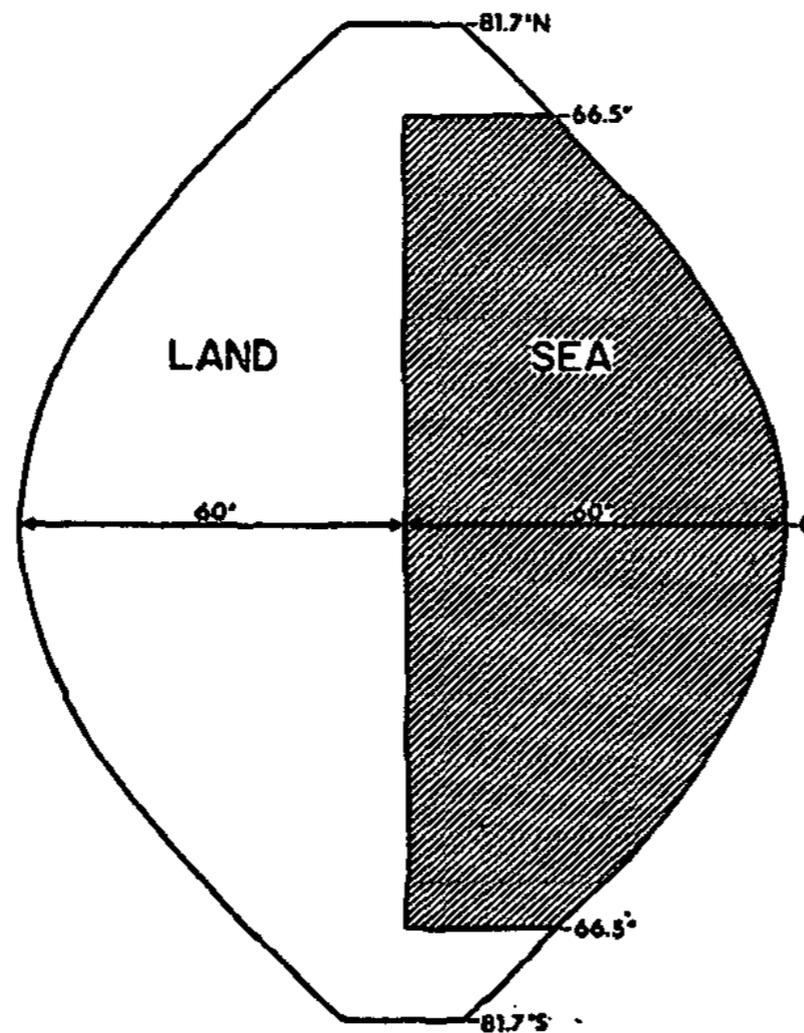
Discuss our(!) experience with a Regional Climate System Model, i.e. with coupled ocean



Global Climate System Models

Manabe & Bryan (1969):

“Empirical evidence indicates that the poleward heat transport by ocean currents is of the same order of magnitude as the poleward transport of energy in the atmosphere (Sverdrup, 1957).”

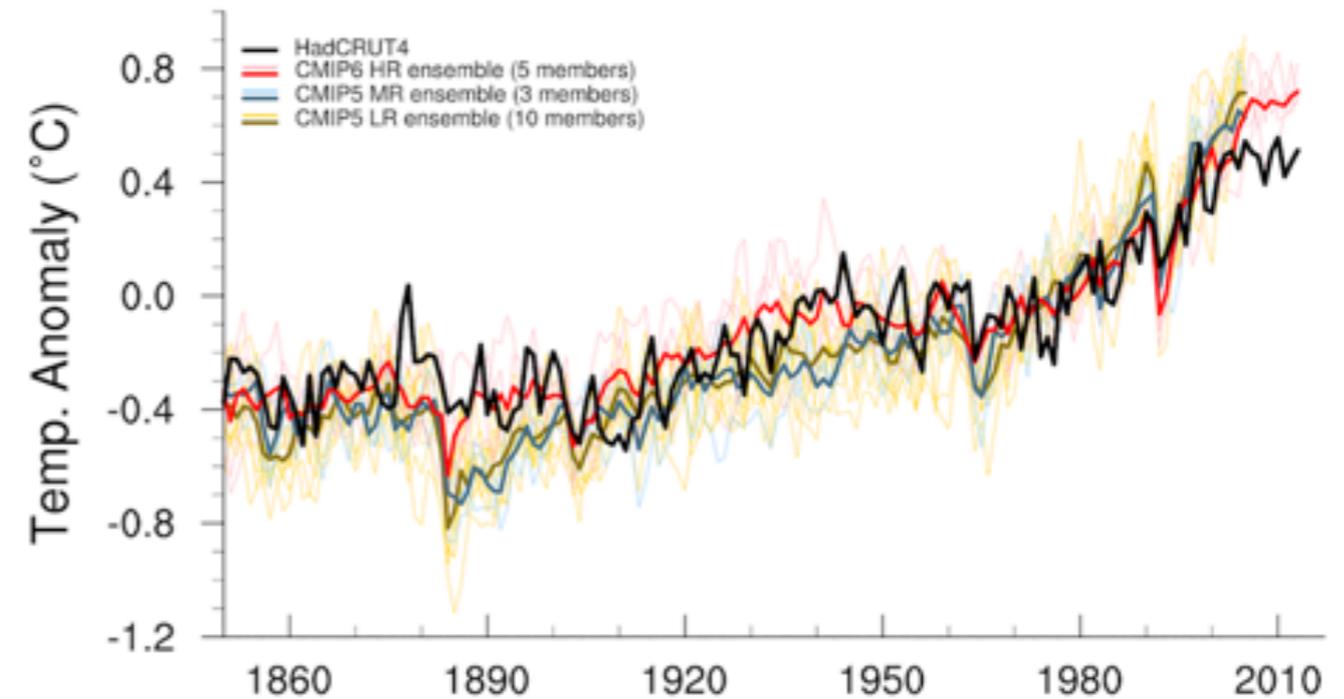


9 atm. & 5 oceanic layers

FIG. 1. Ocean-continent configuration of the model.

Global models today?

Global Mean Surface Temperature Anomalies
from 1961-1990 average



Example: MPI-ESM

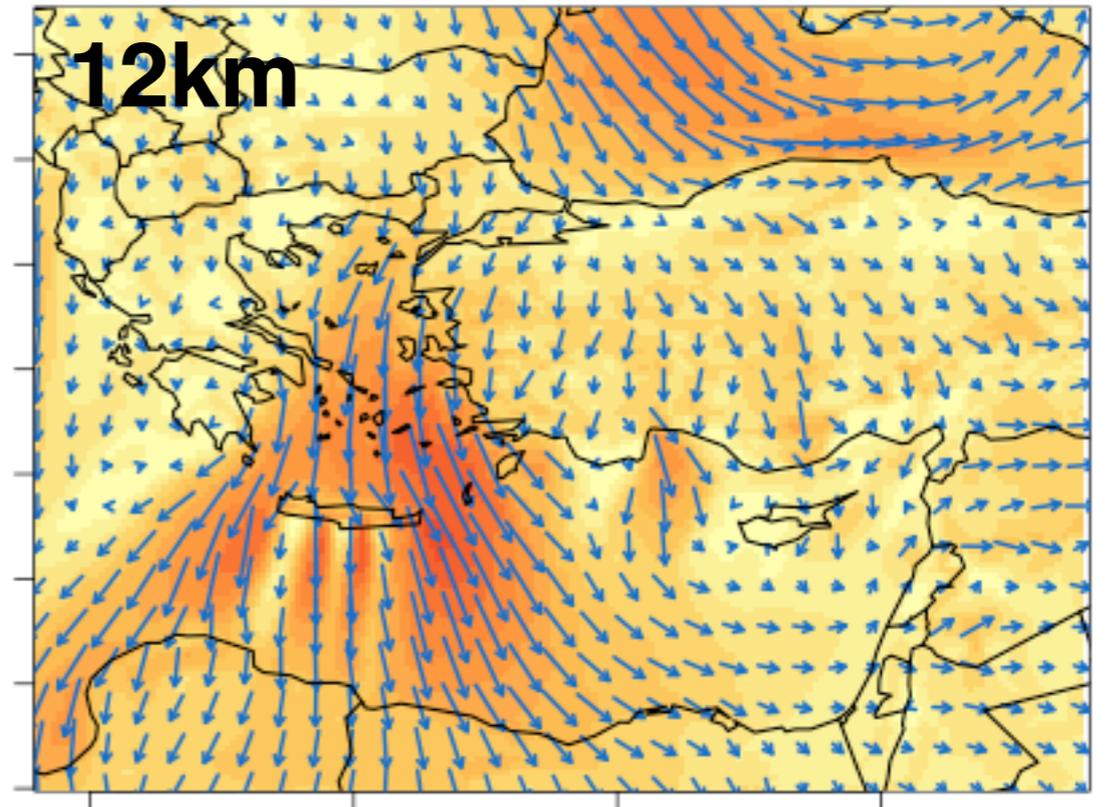
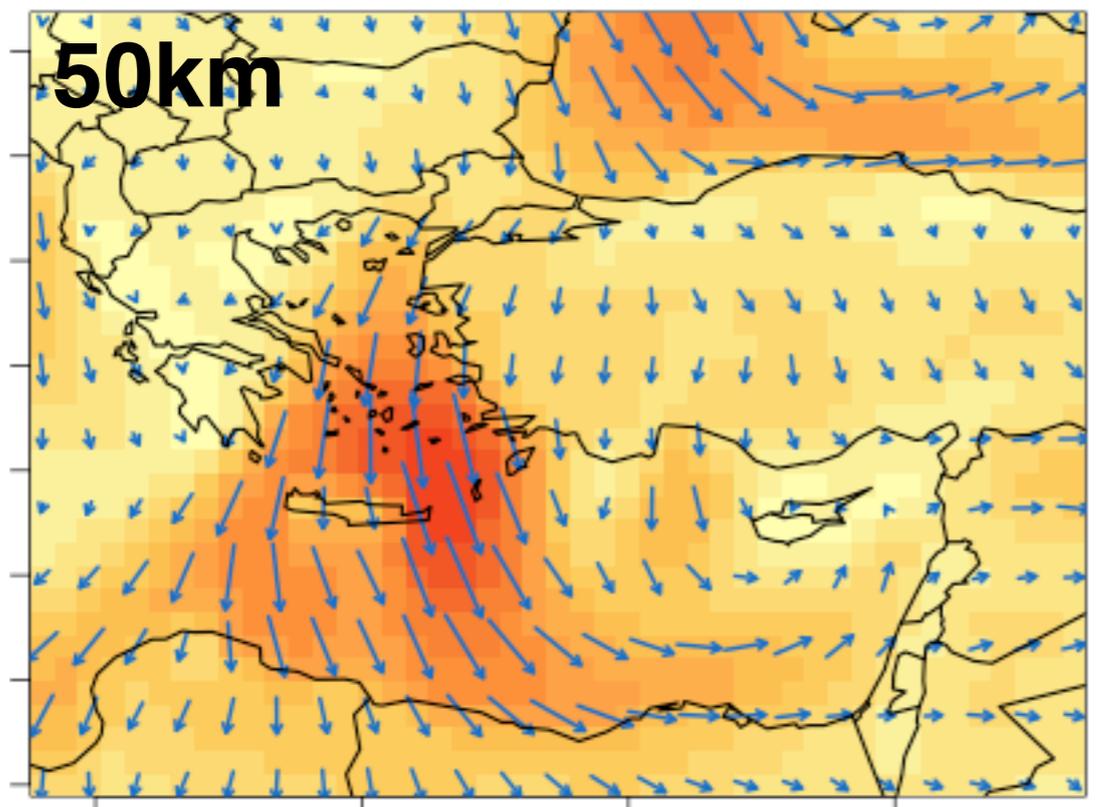
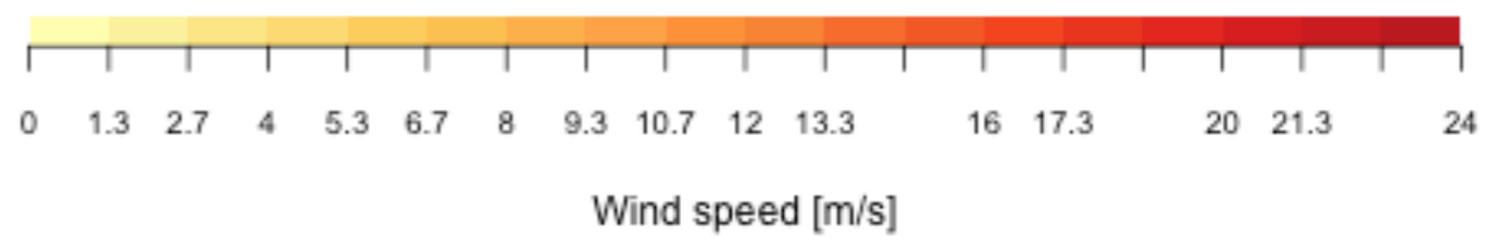
	Atmosphere		Ocean	
MPI-ESM1.2-LR	ECHAM6.3	T63 (1.9° x 1.9°) 47 vertical levels to 0.01 hPa	MPIOM1.63	GR1.5 (1.5° x 1.5°) 40 levels
MPI-ESM1.2-HR		T127 (1.0° x 1.0°) 95 vertical levels to 0.01 hPa		TP1.1 (0.4° x 0.4°) 40 levels
MPI-ESM1.2-XR*		T255 (0.5° x 0.5°) 95 vertical levels to 0.01 hPa		
ICON-ESM-LR	ICON-AES	Icosahedral 160 km 47 vertical levels to 0.01 hPa	ICON-OES	Icosahedral 40 km 40 levels

Smaller grid-spacings needed?

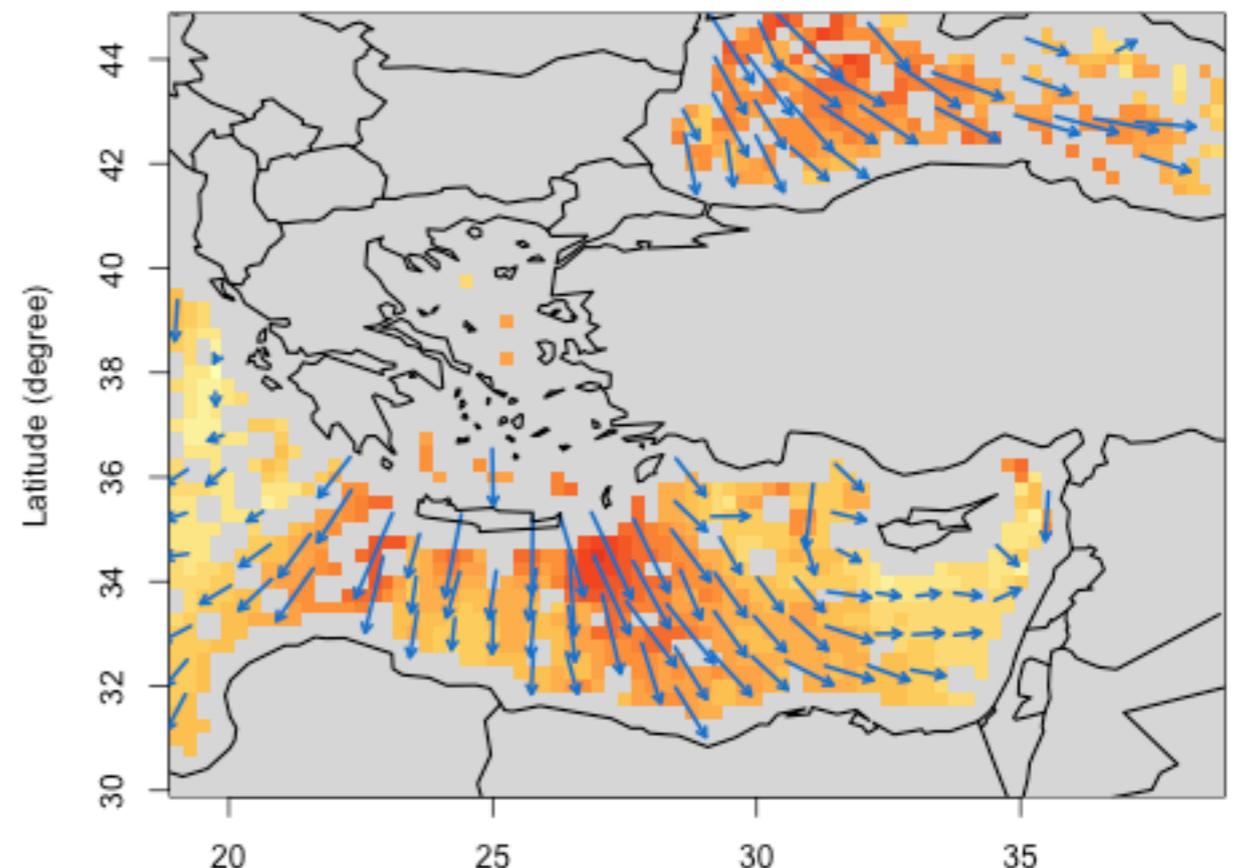
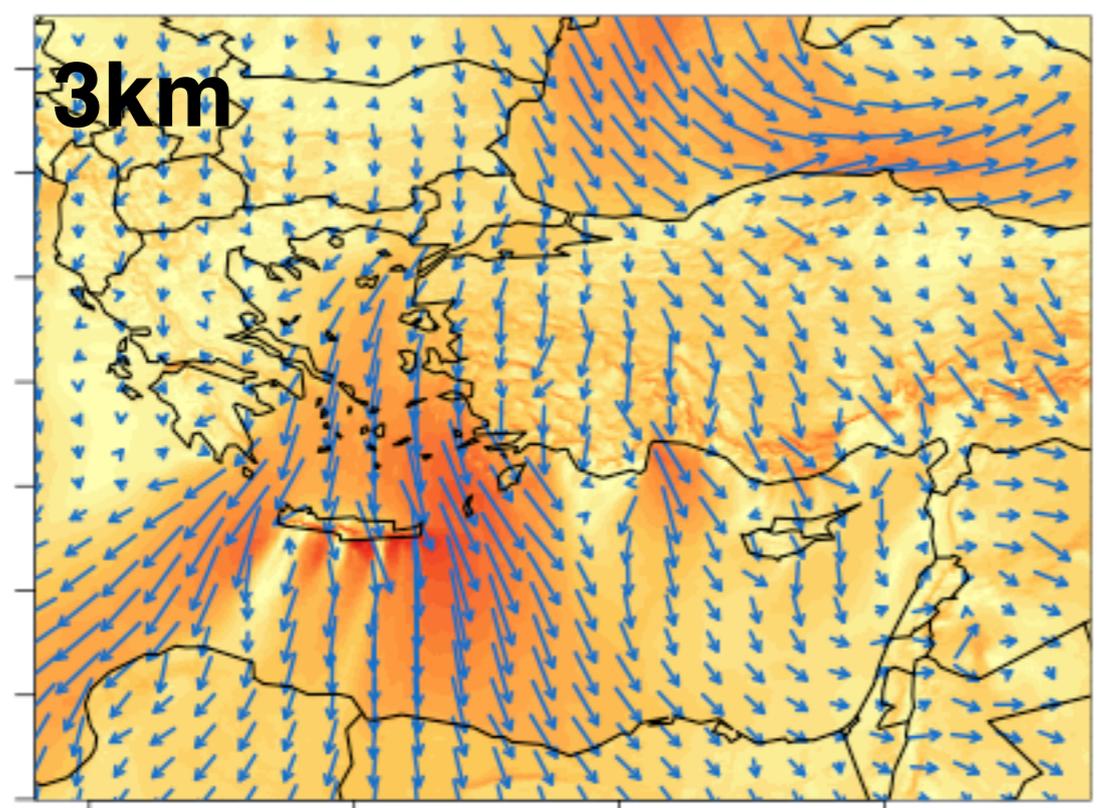
* The MPI-ESM1.2-XR is part of HighResMIP and will not perform the full DECK.



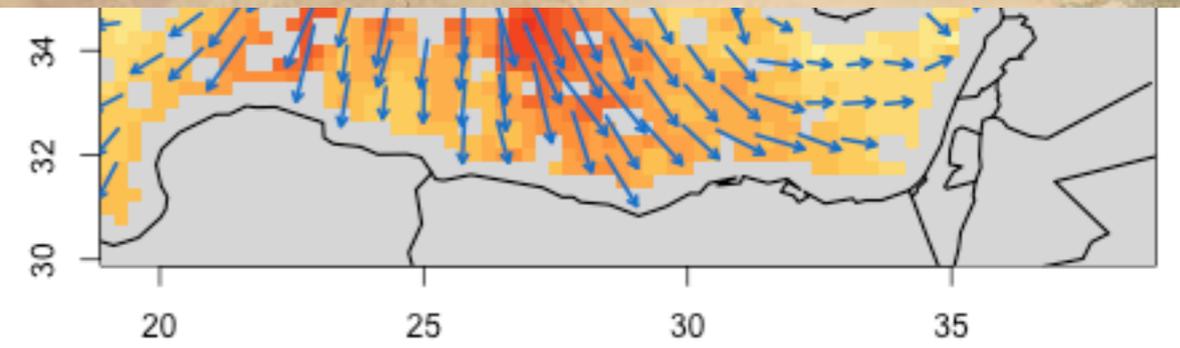
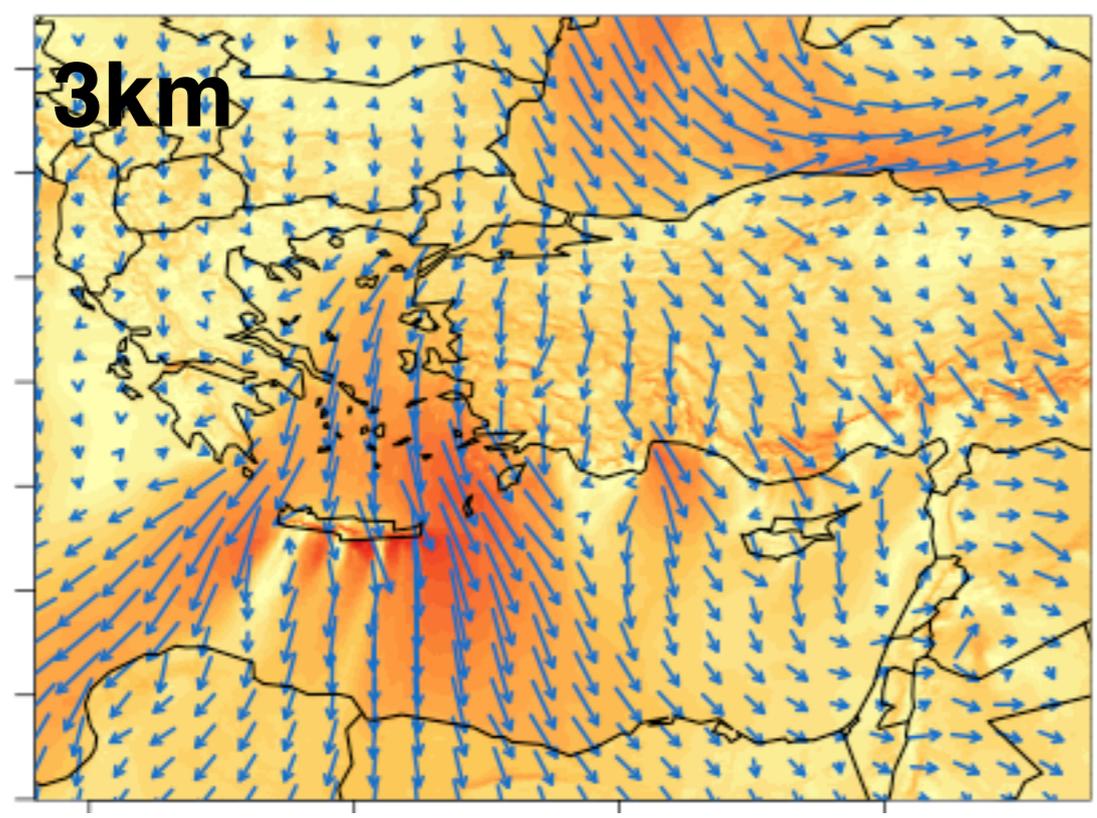
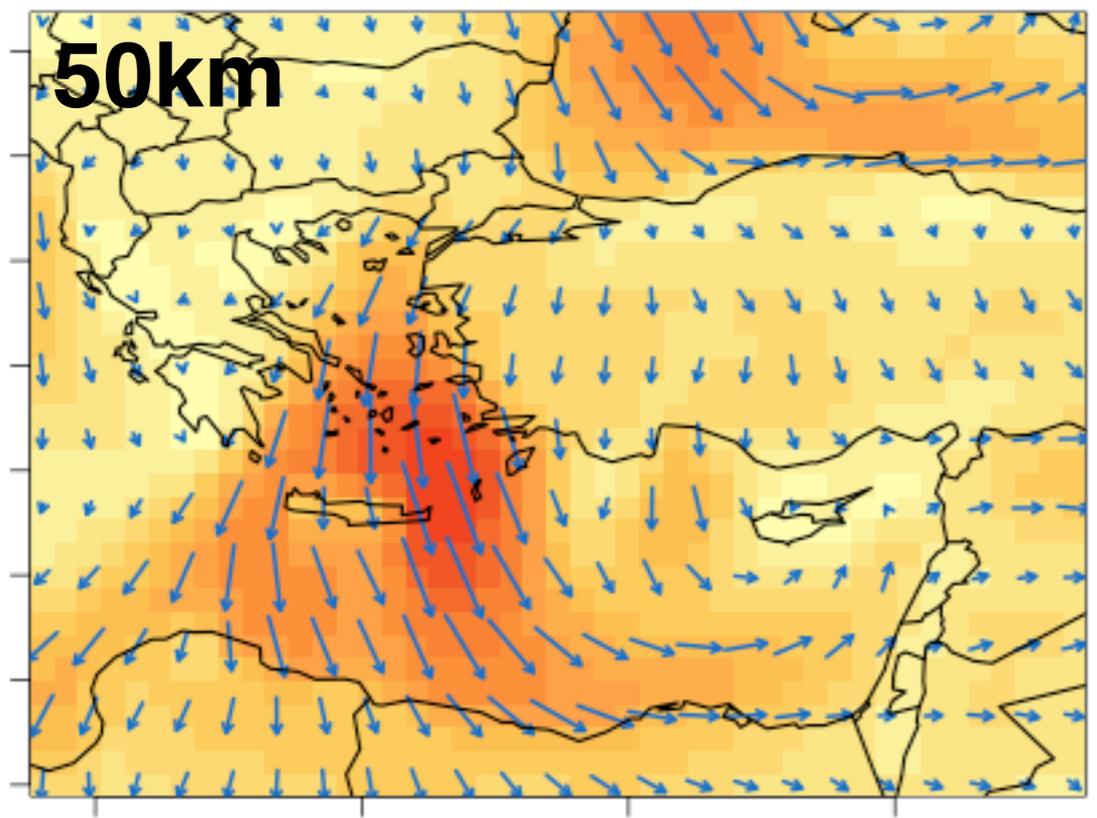
MedSea 19.6.00



QuikSCAT mean wind speed, 19.06.2000



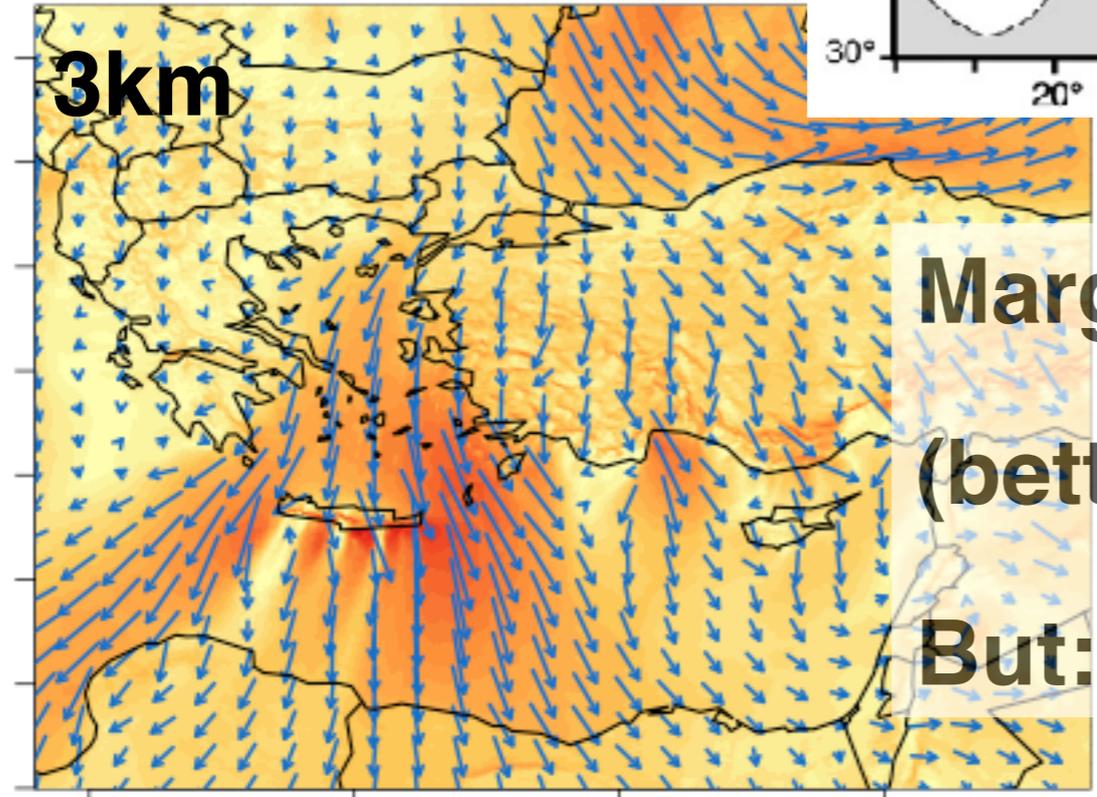
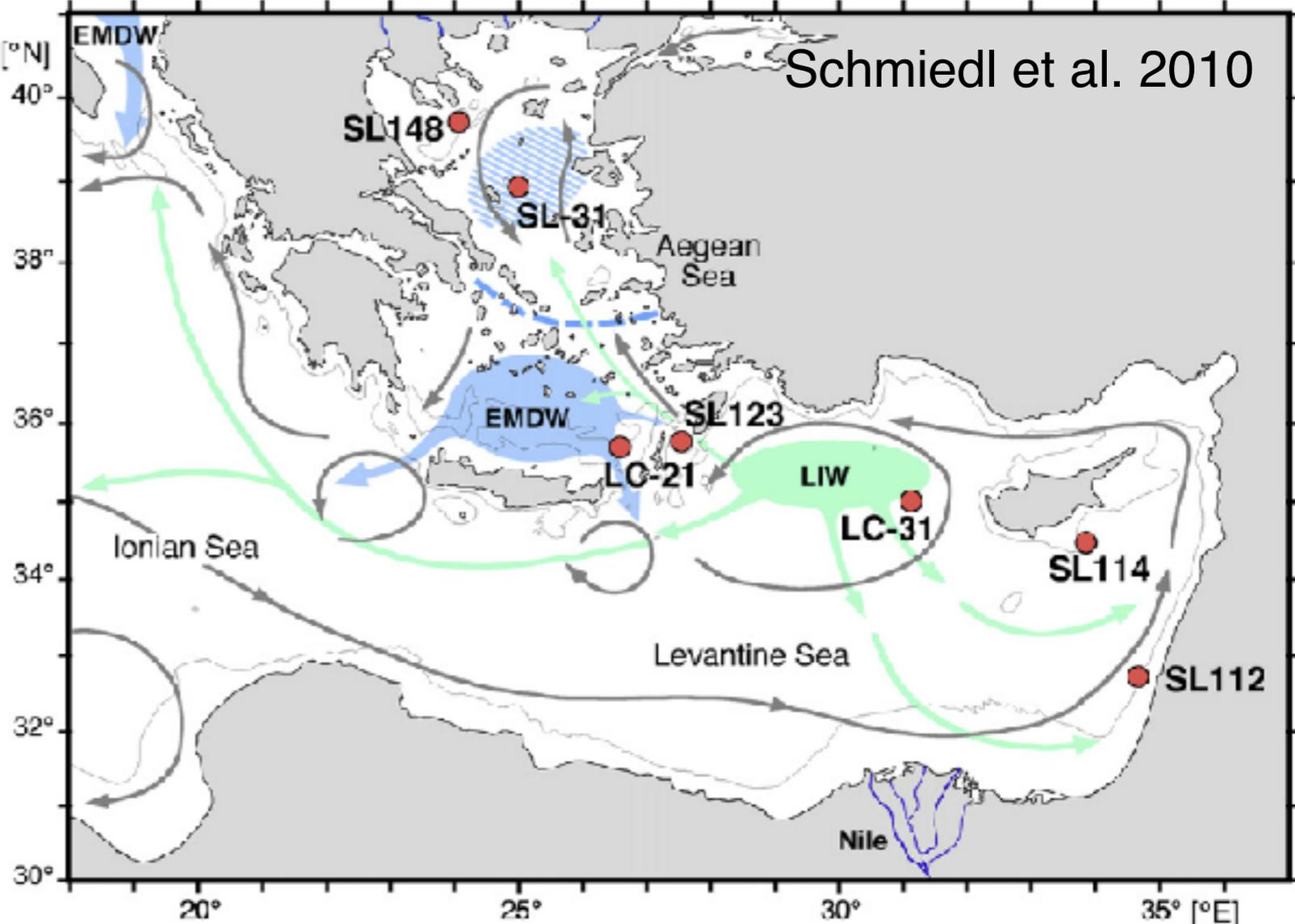
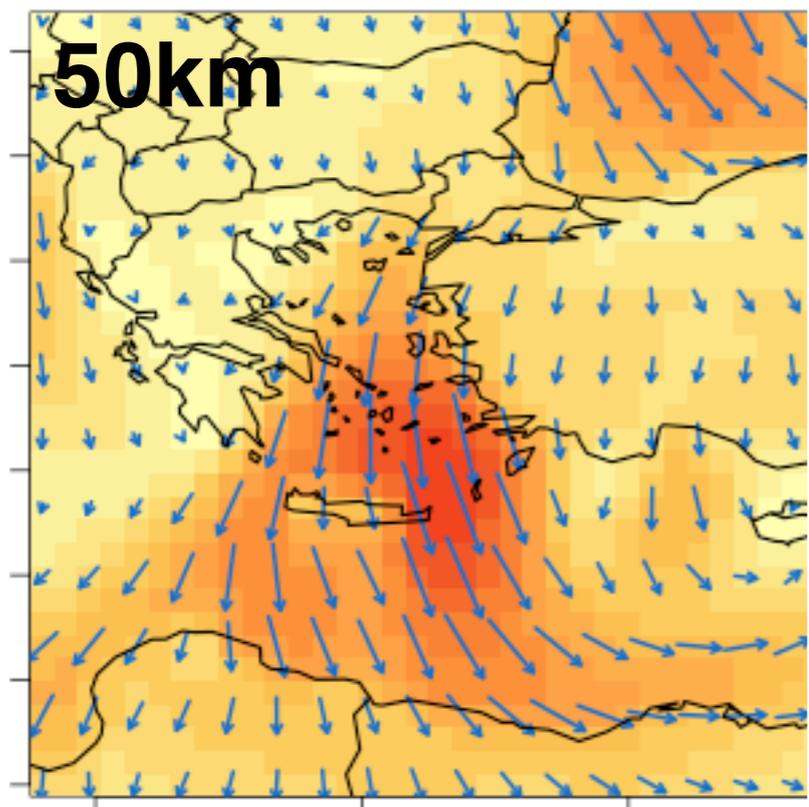
MedSea 19.6.00



MedSea 19.6.0C

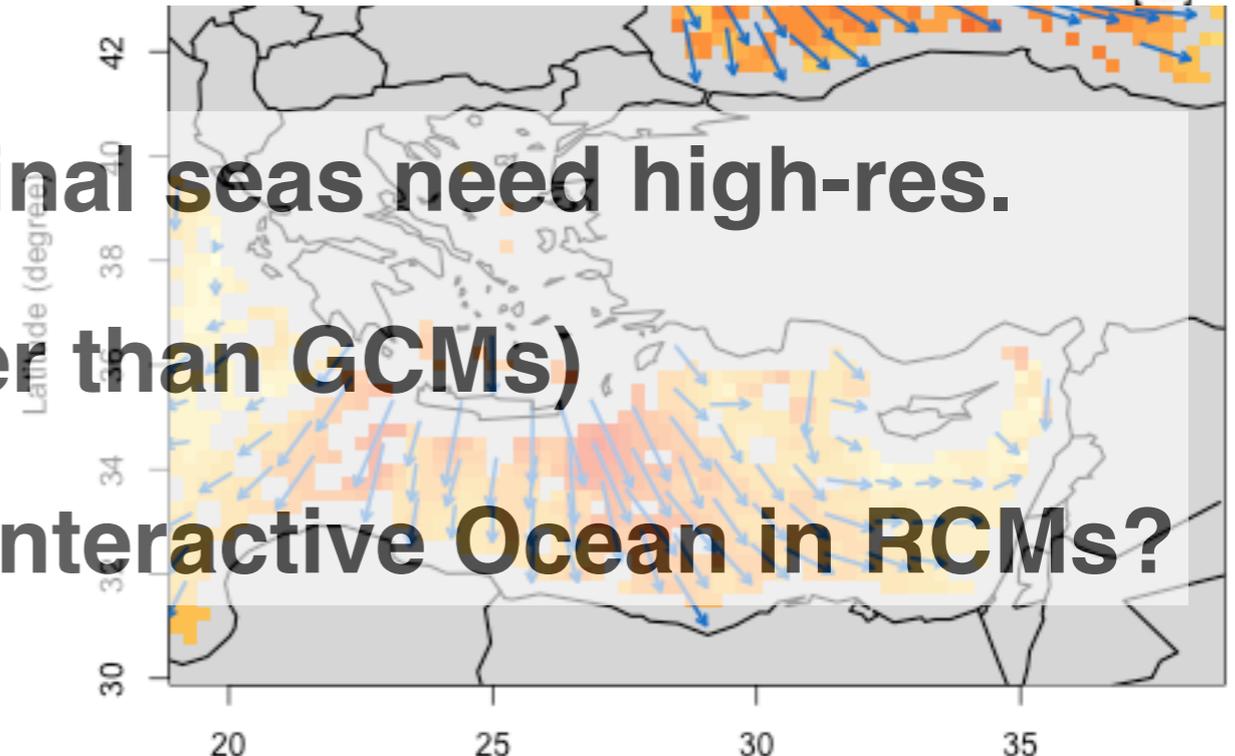


Schmiedl et al. 2010



**Marginal seas need high-res.
(better than GCMs)**

But: Interactive Ocean in RCMs?



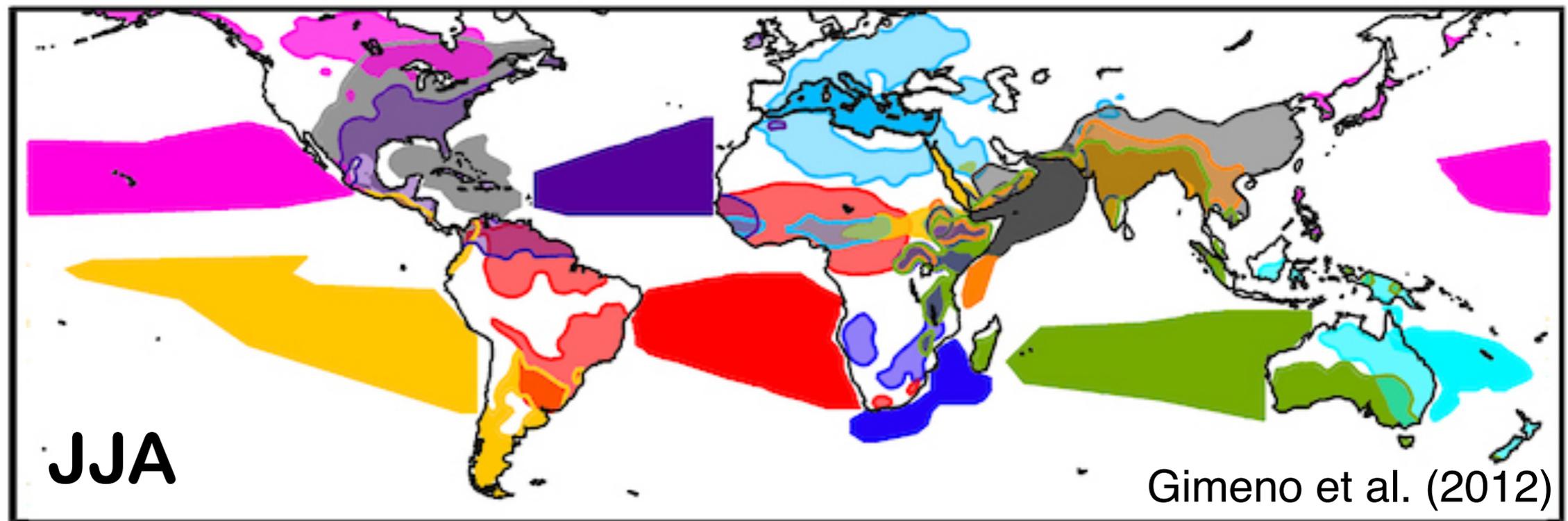
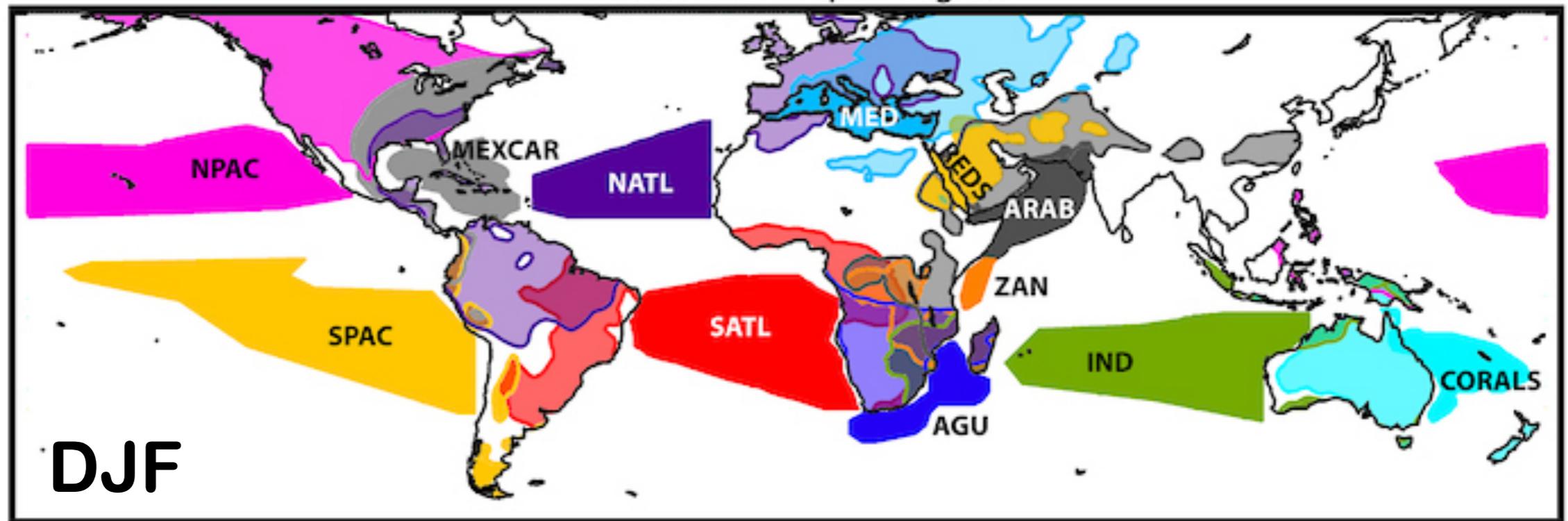
Regional Coupled Systems

Example: HWRF (operational since 2007)



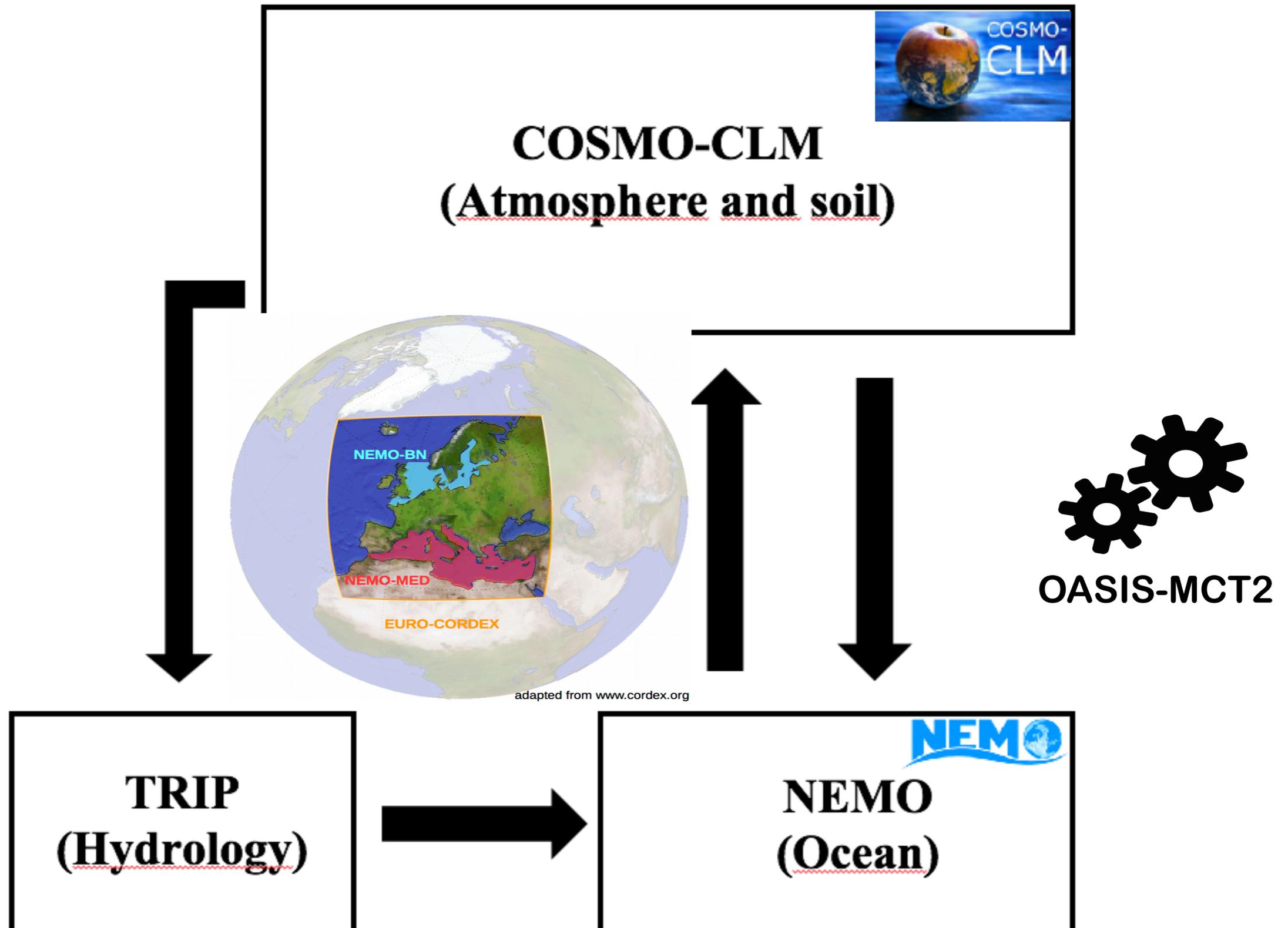
Ginis (2008)

Moisture source & receptor regions



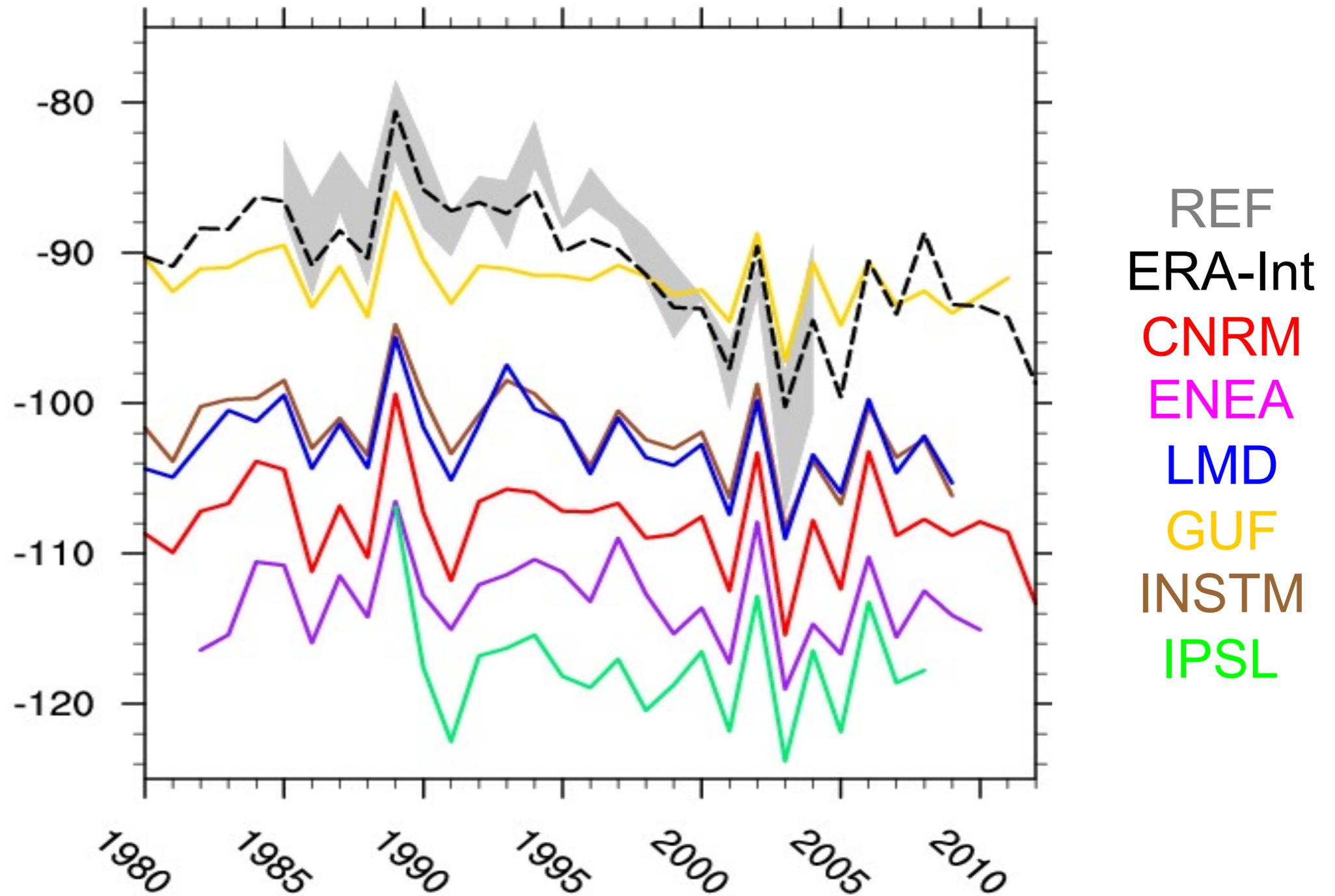
Gimeno et al. (2012)

RCSM COSMO-CLM/NEMO

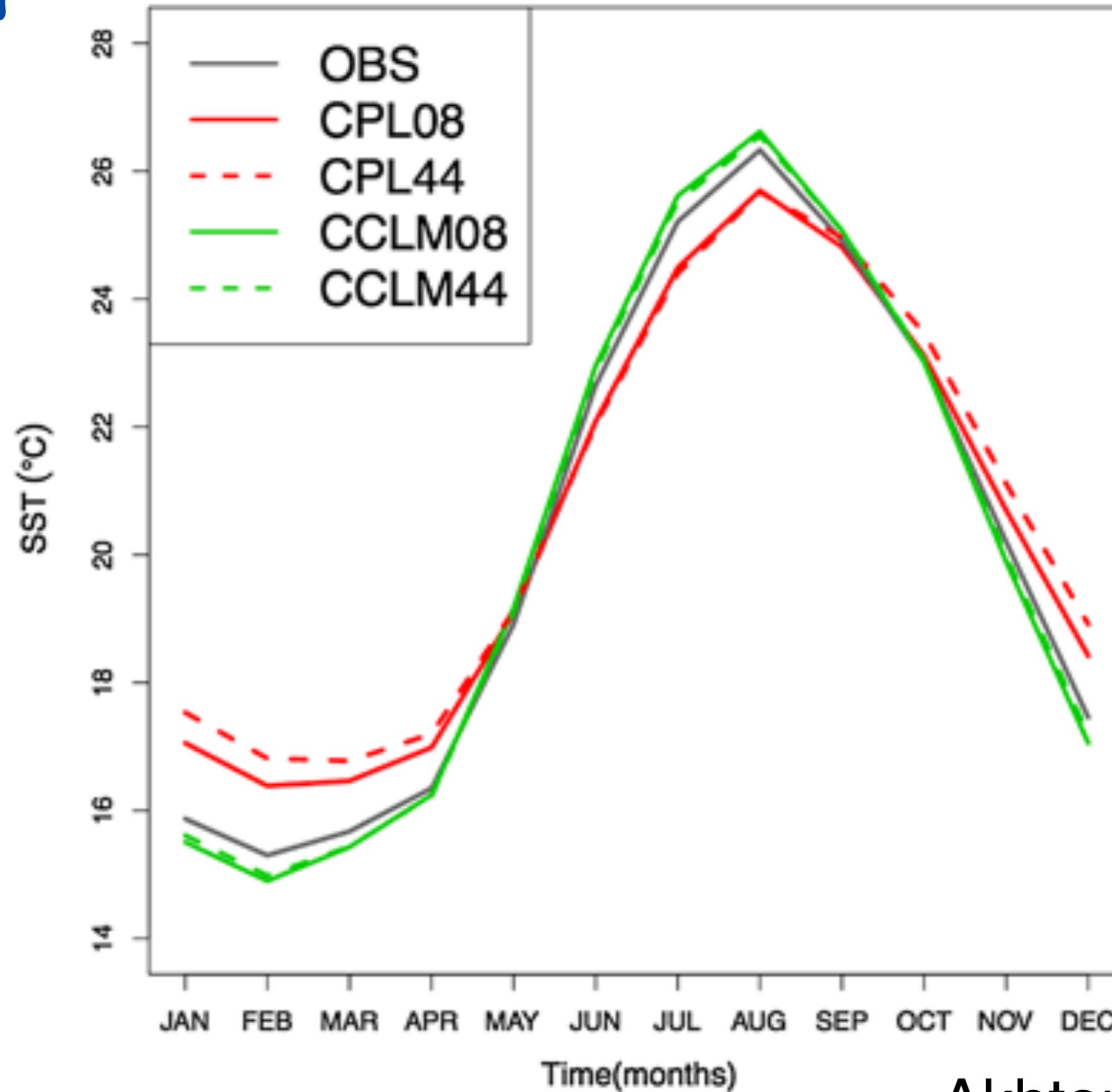


Evaporation over the Med.-Sea

in W/m²

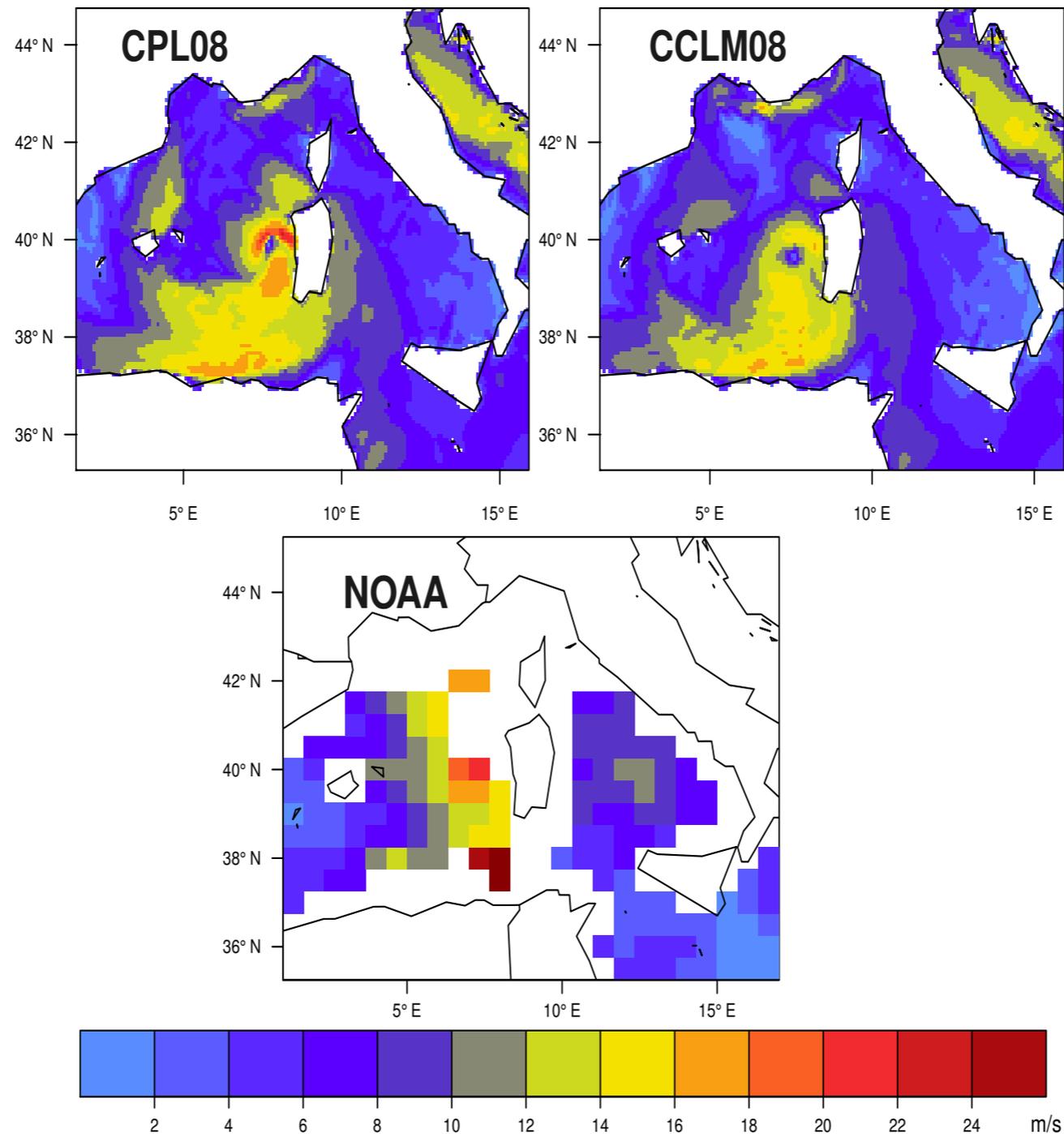


SST



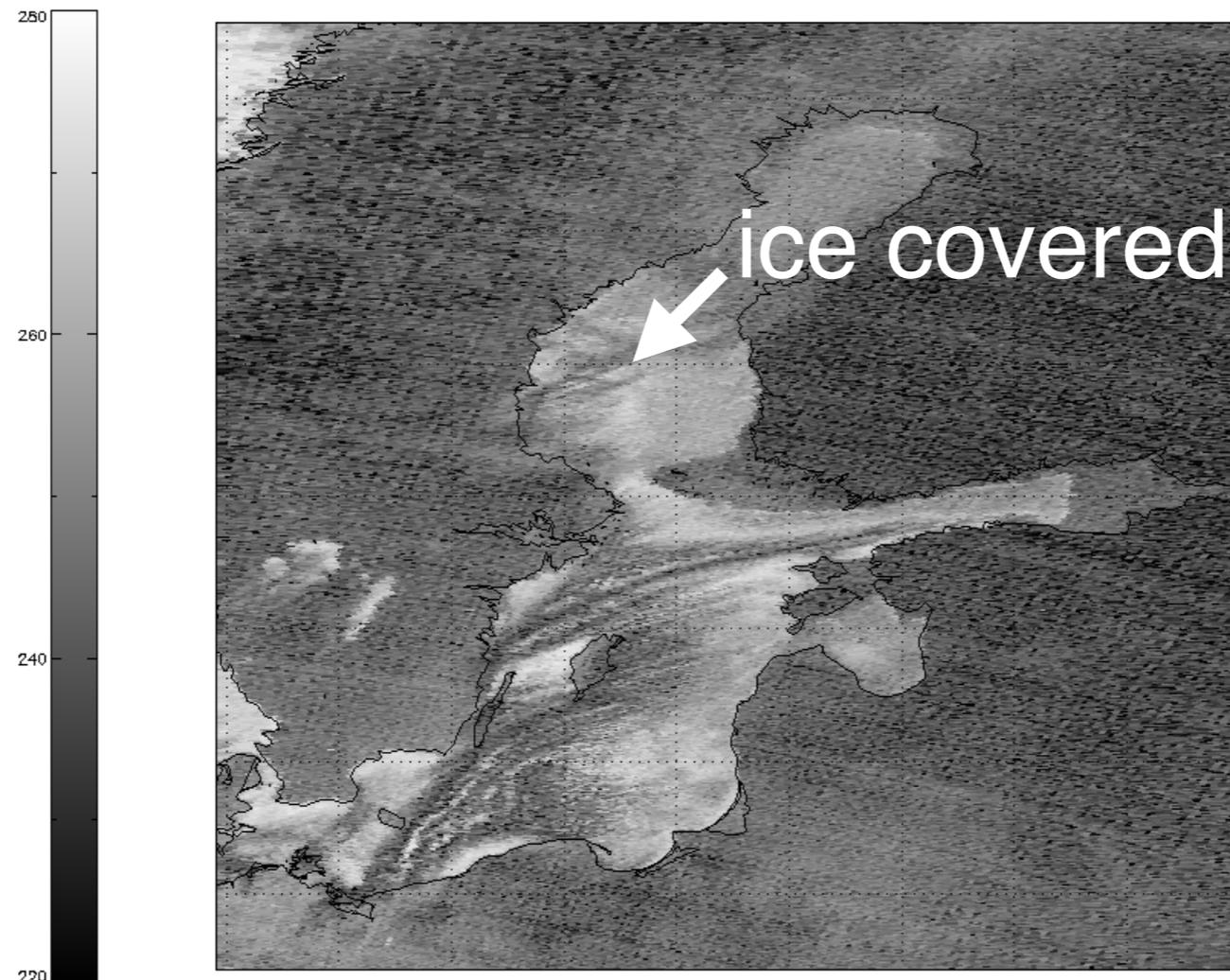
Near Sea Added Value: Medicanes

Medicane 10 Dec. 1996, 18:00; 10-m Wind



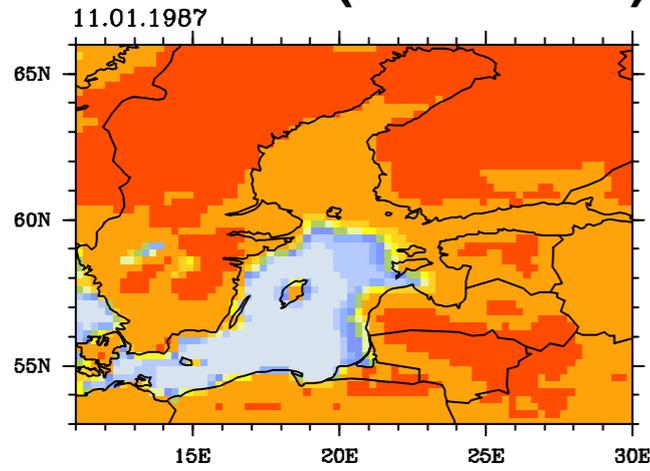
Near Sea Added Value:

Precipitation difference to E-Obs in mm/day
Infrared satellite image from NOAA-9
at 0210 UTC 11 January 1987

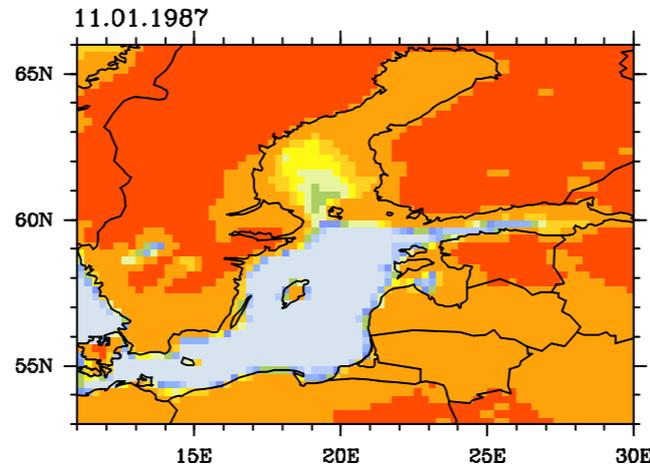


Near Sea Added Value: Convective Snowbands

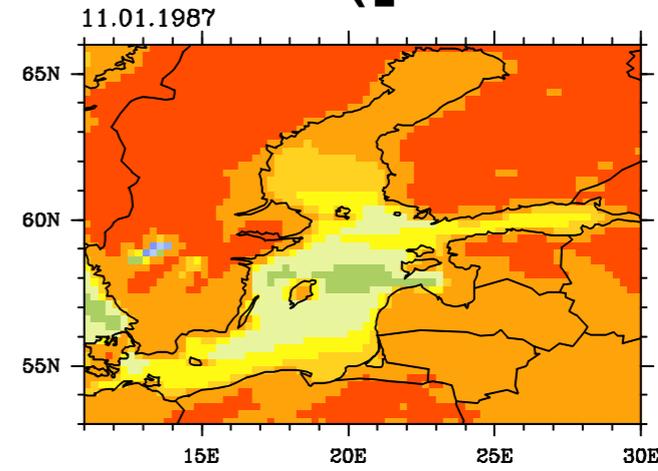
CCLM(ERA-I)



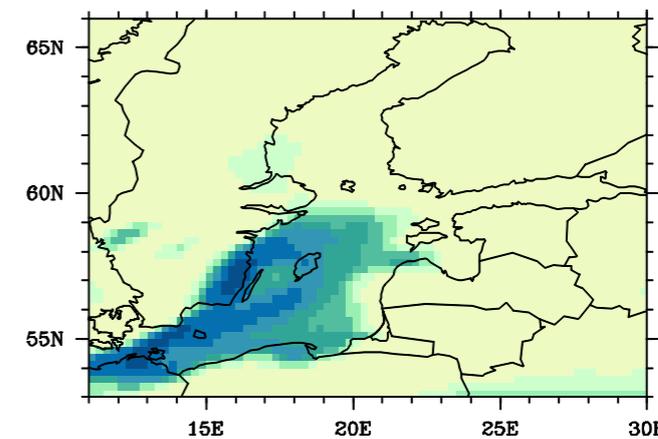
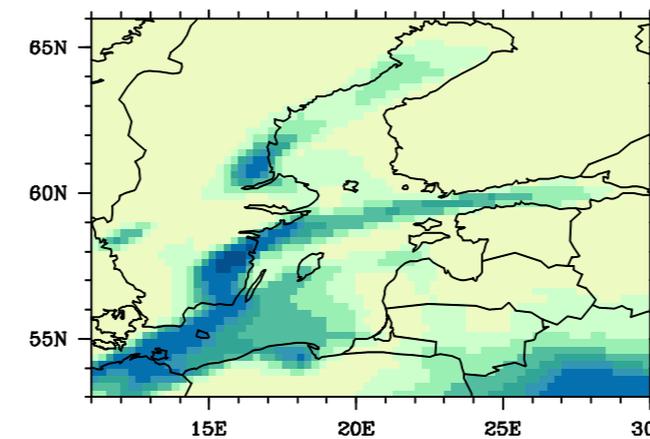
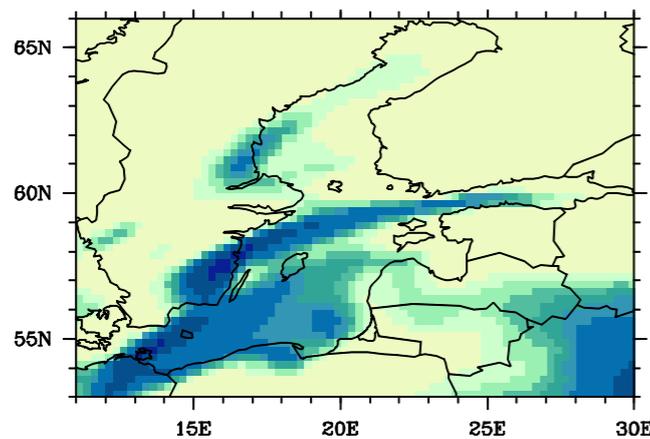
CCLM-NEMO



CCLM([ERA-I]month)



Latent heat flux
(W/m²)

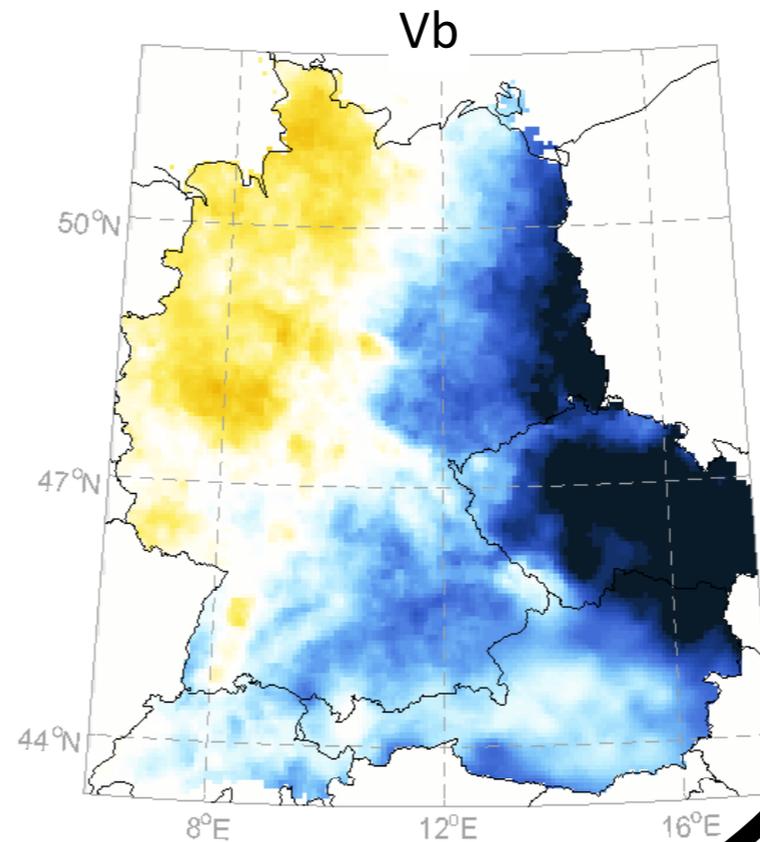
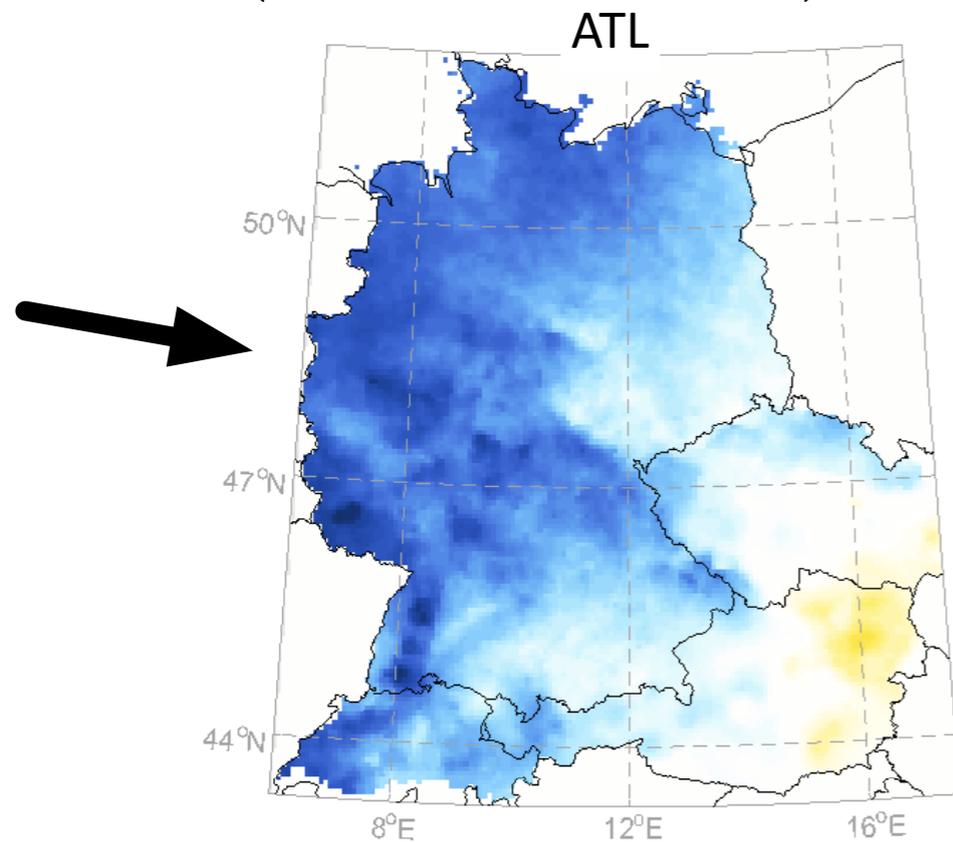
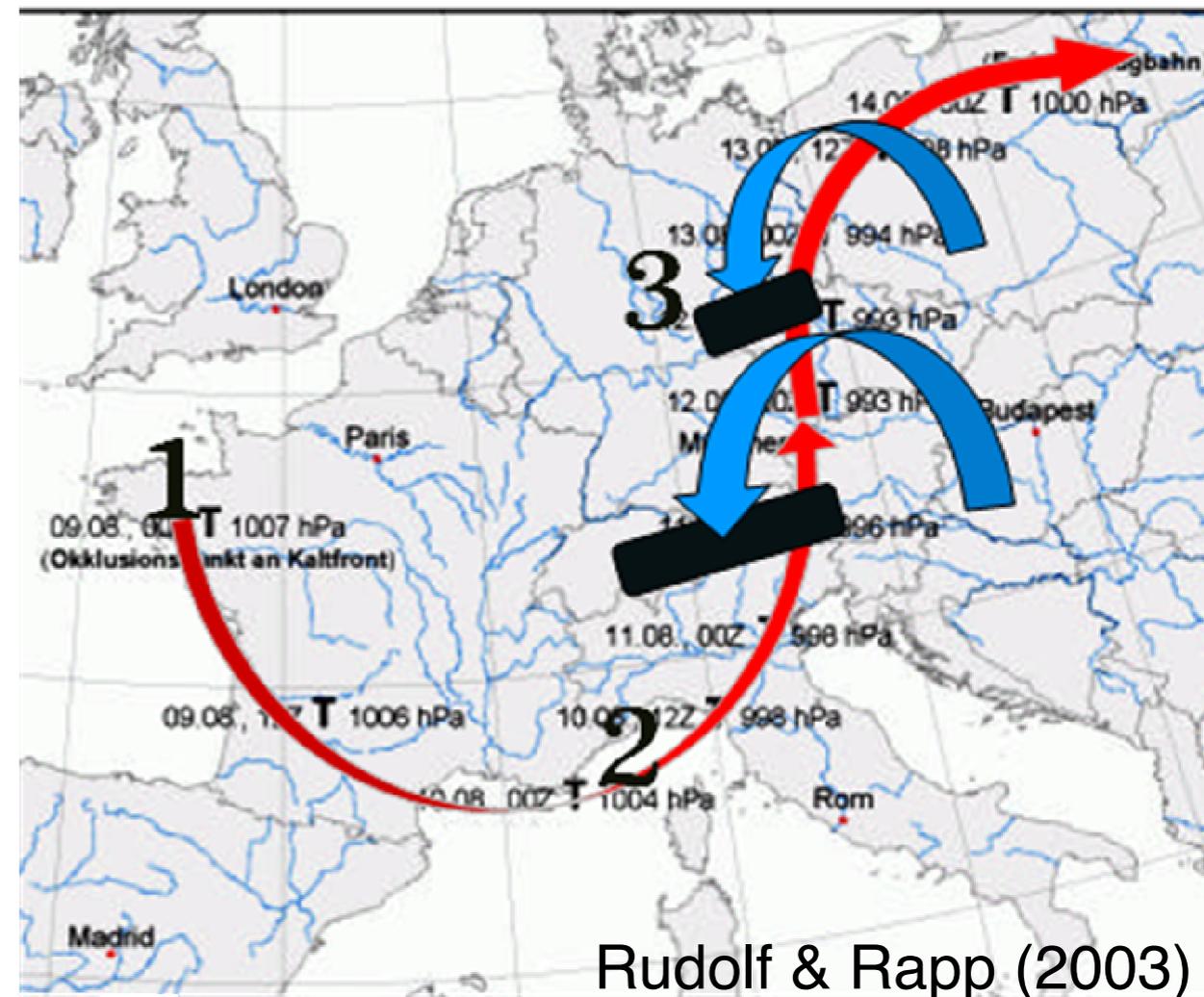


Precipitation
(mm/d)

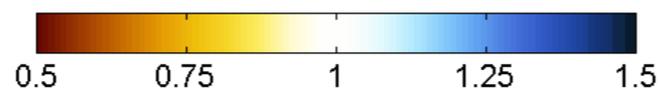
Pham et al. 2014, 2015

Vb-cyclones

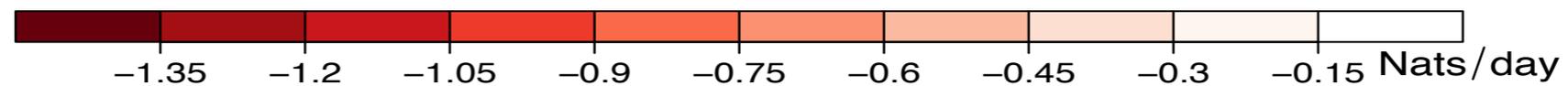
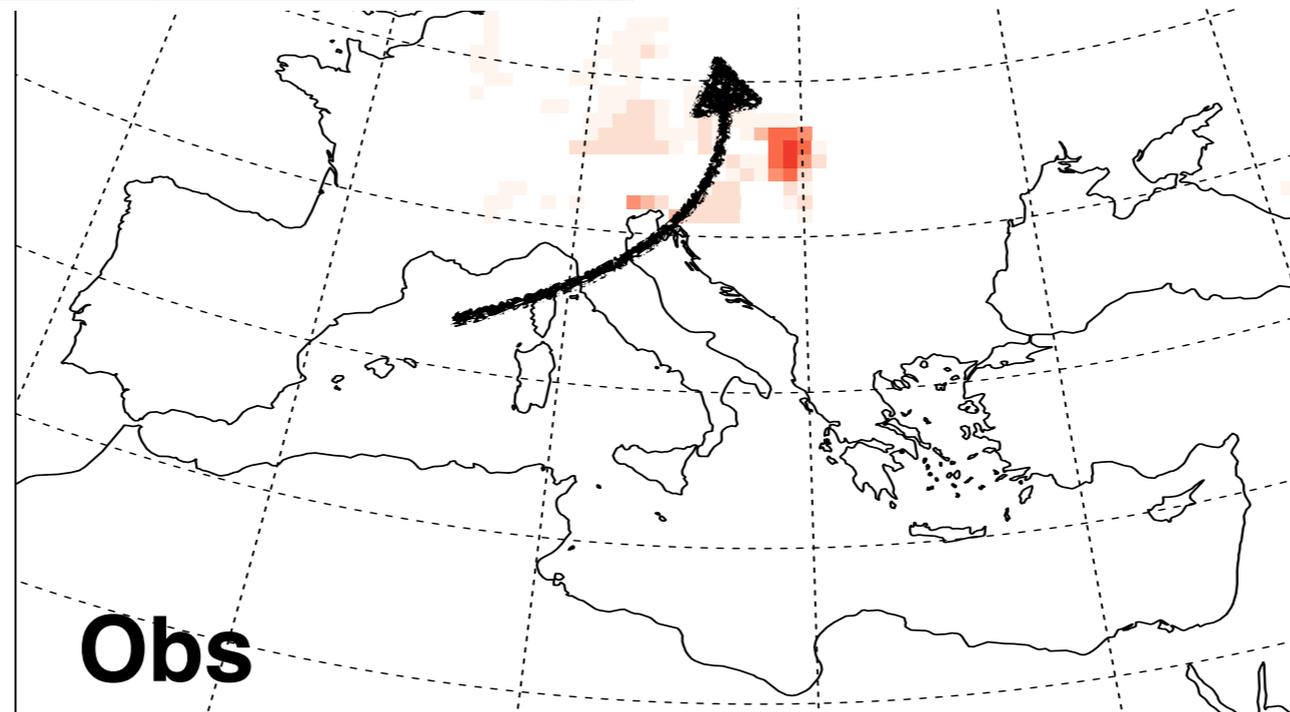
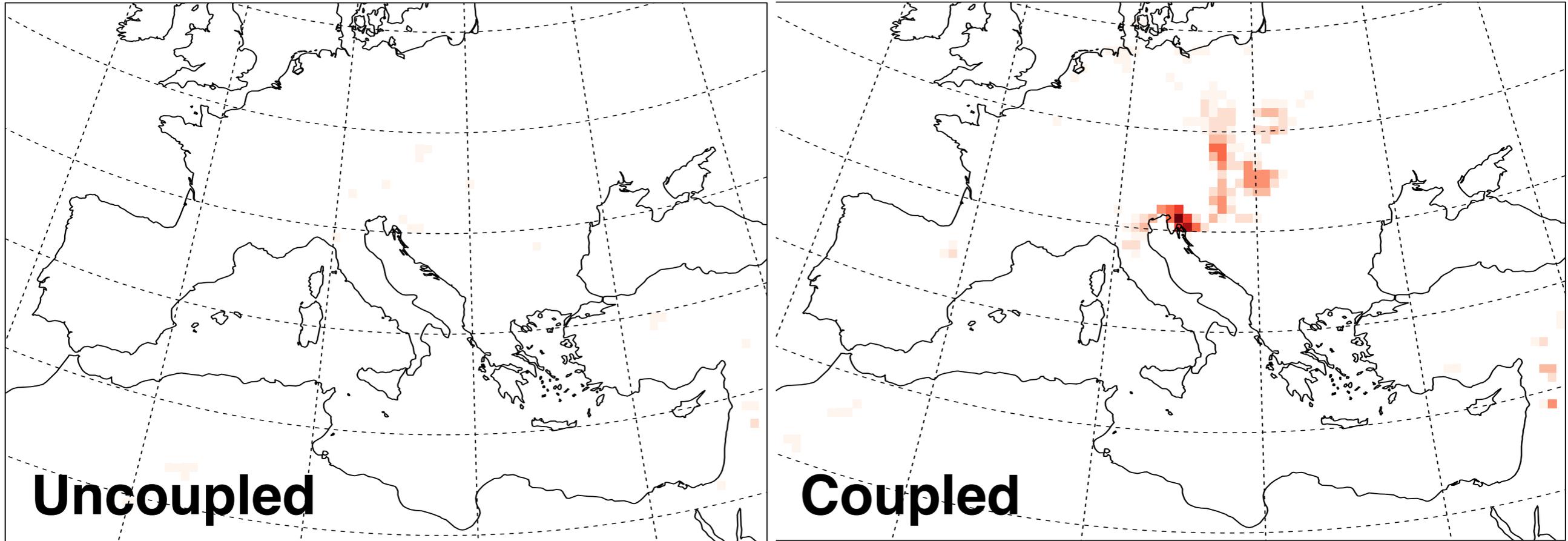
$$\frac{\overline{\text{Precip(ATL / Vb)}}}{\overline{\text{Precip(All Cyclones)}}$$



Hofstätter et al. (2016)

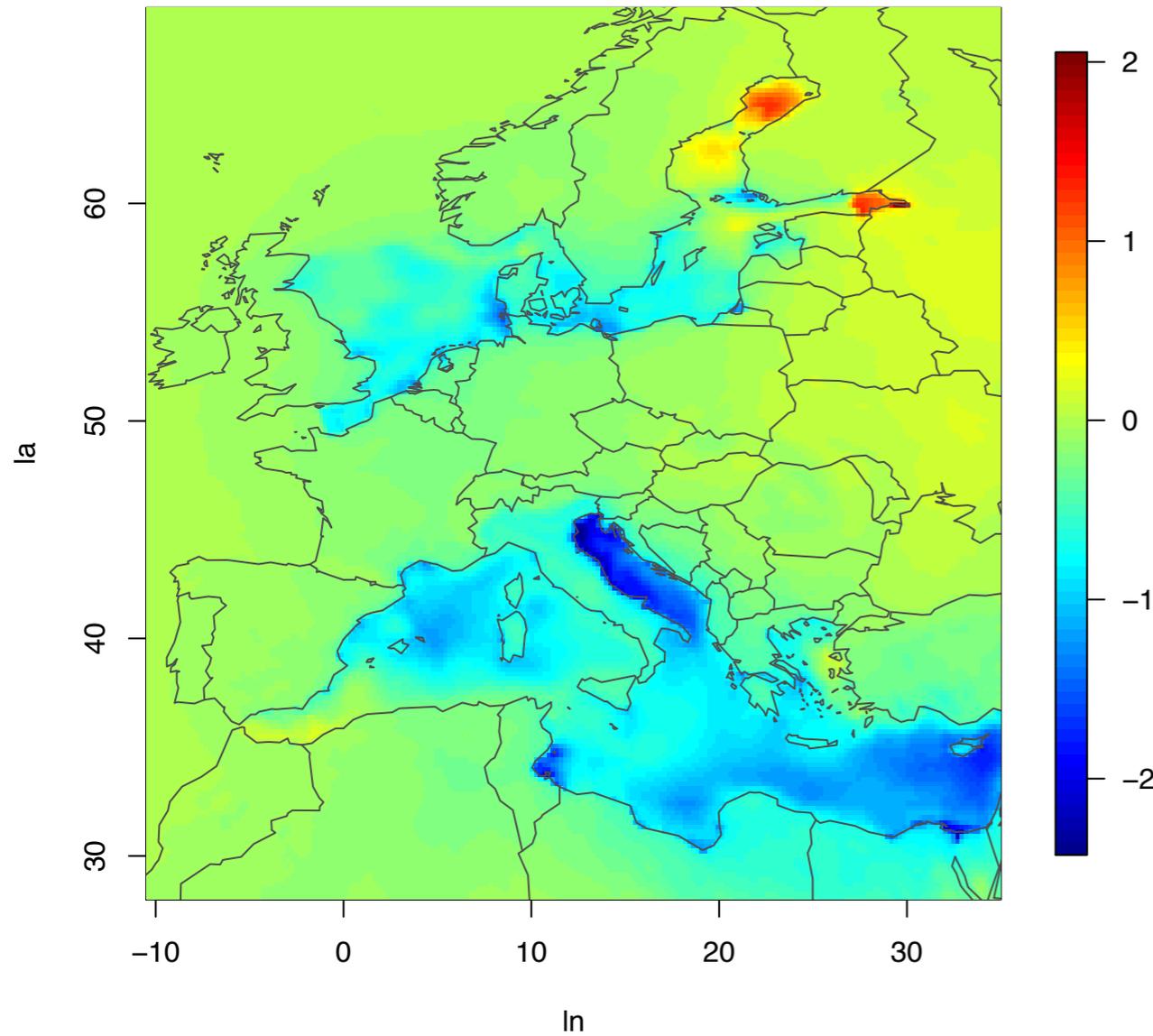


Inform. flow: SST(NWMed) -> Precip

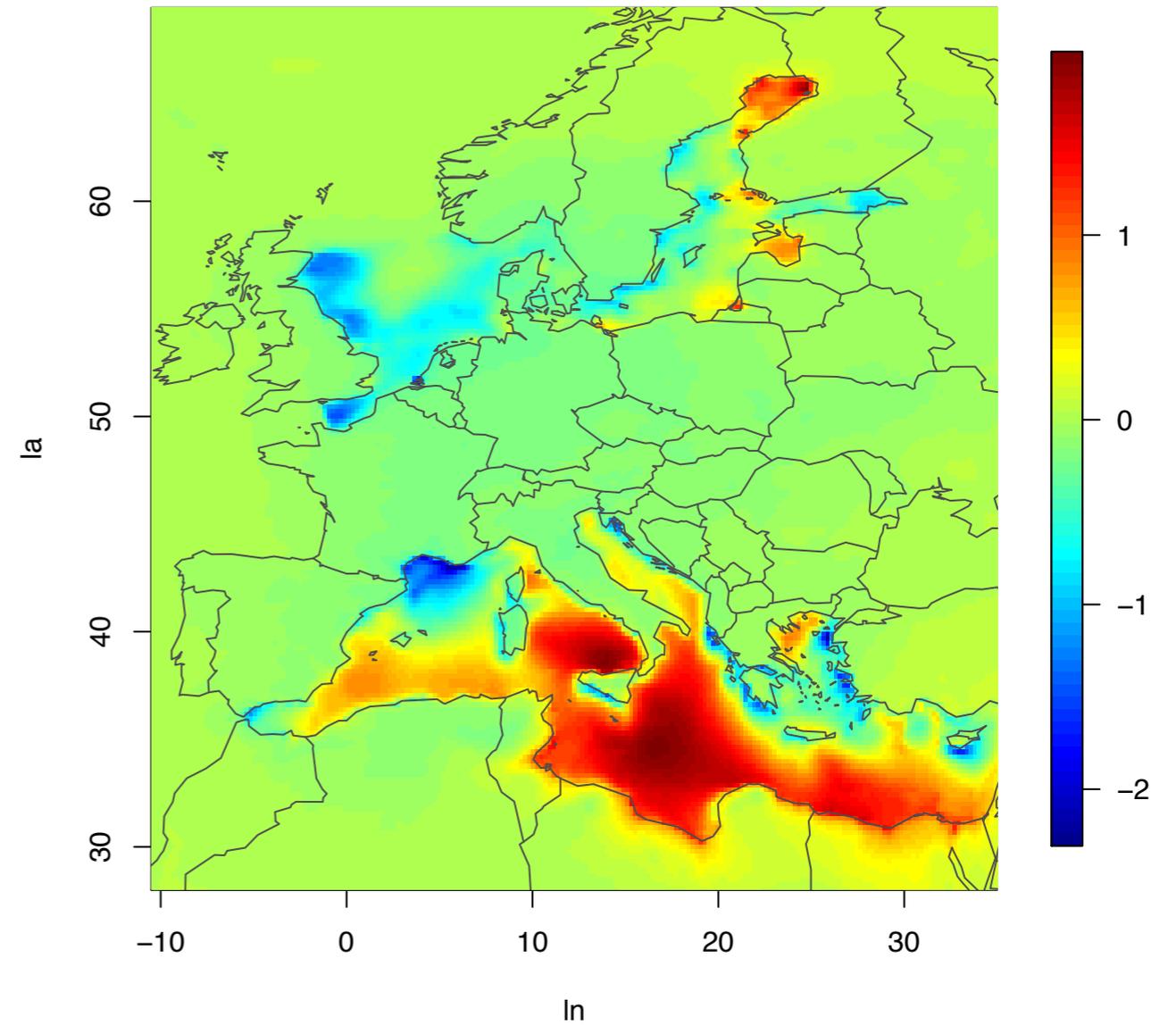


Centennial sim. in MPI-ESM nudged to NOAA/NCEP 20CR

T_{2M} diffs (Coupled–Uncoupled), DJF, mean 1901–2009

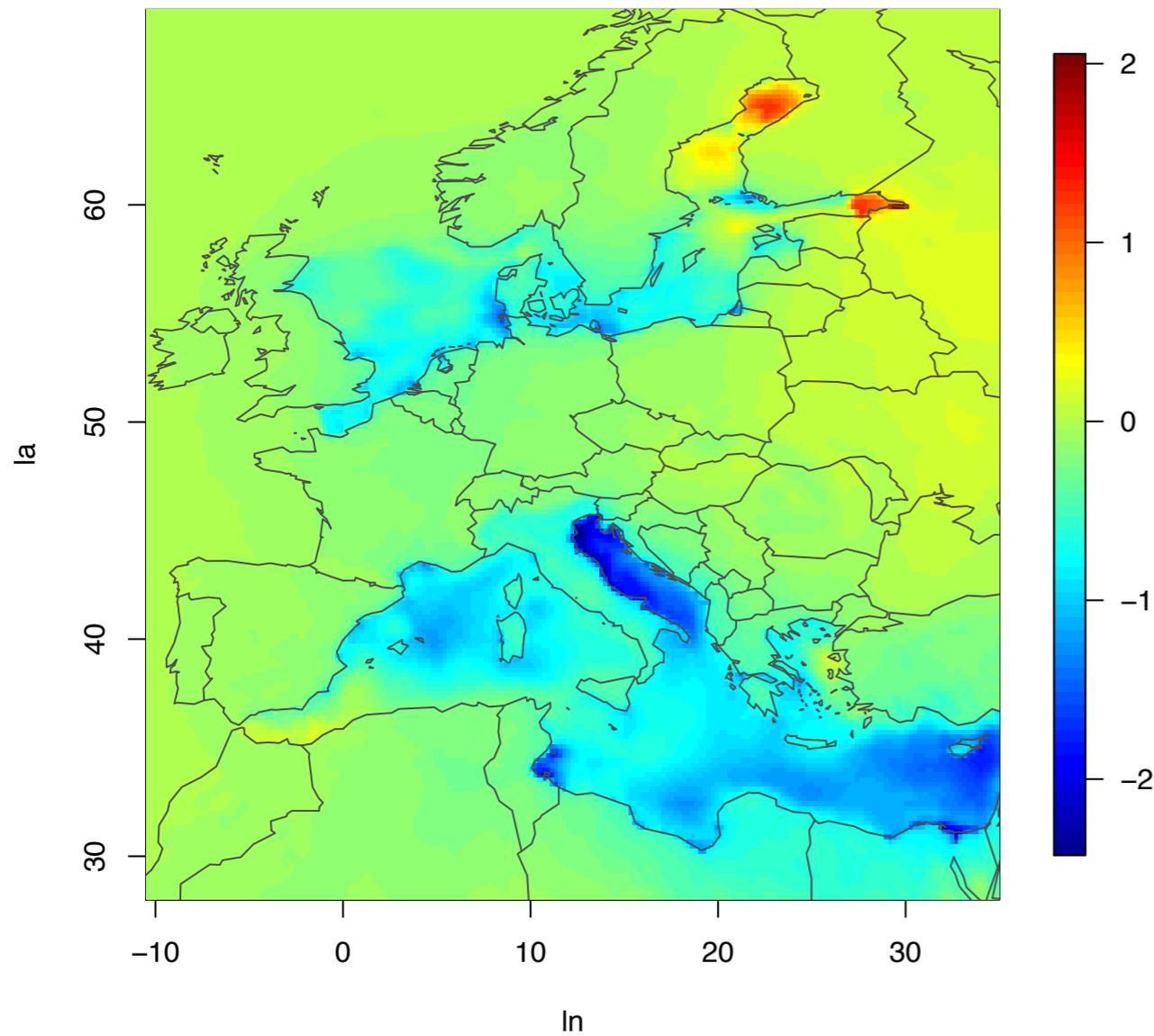


T_{2M} diffs (Coupled–Uncoupled), JJA, mean 1901–2009

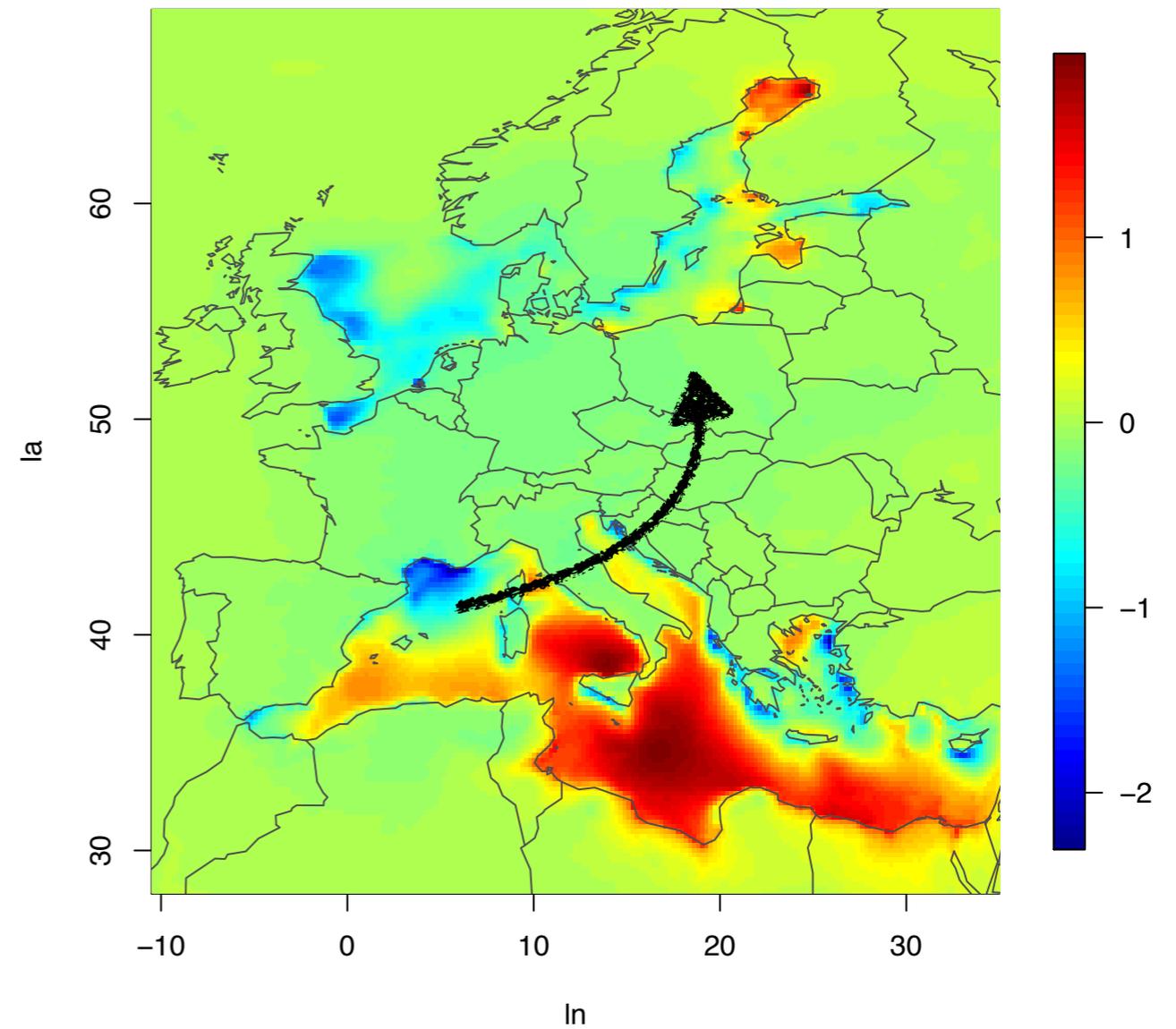


Centennial sim. in MPI-ESM nudged to NOAA/NCEP 20CR

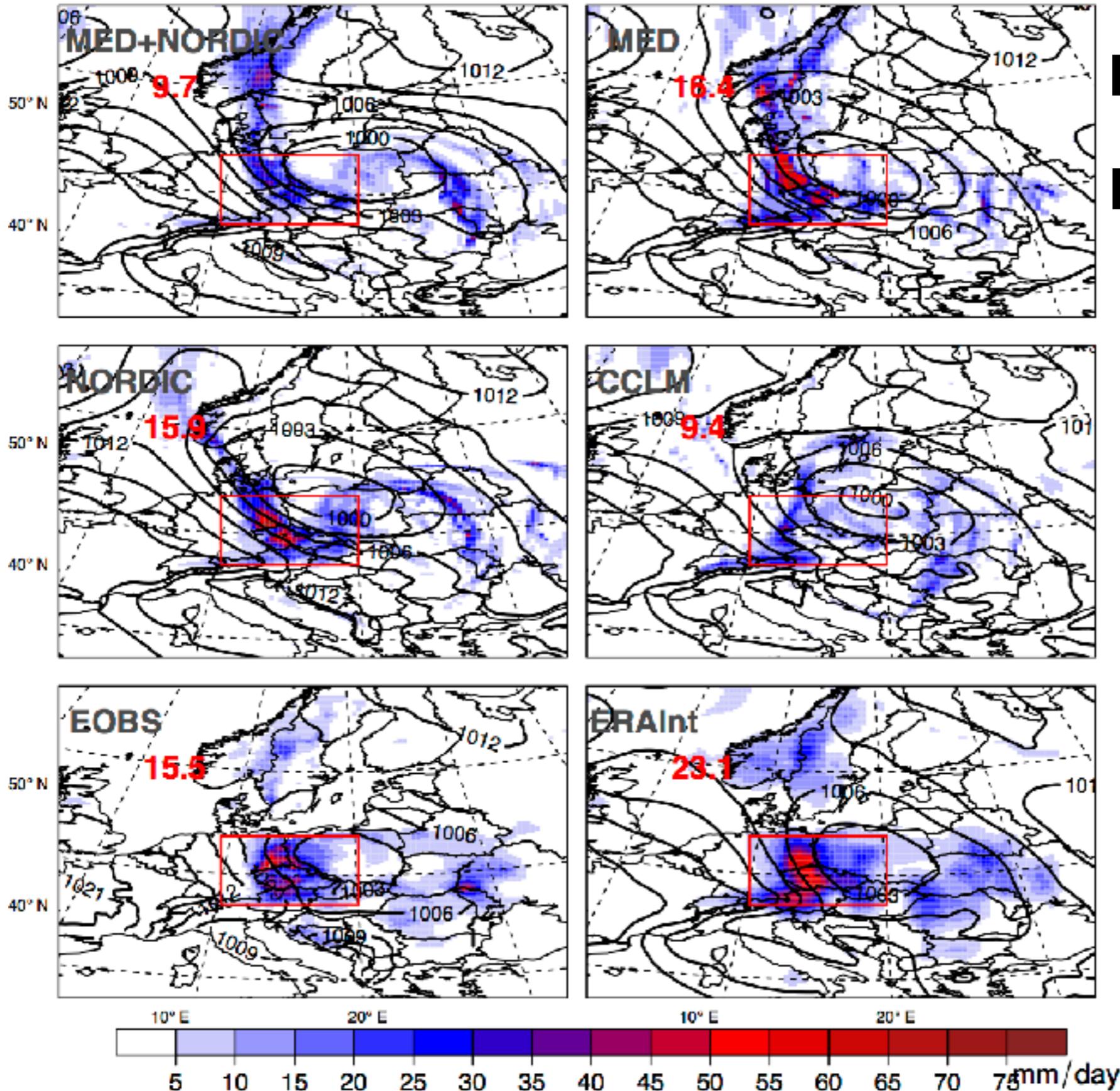
T_{2M} diffs (Coupled–Uncoupled), DJF, mean 1901–2009



T_{2M} diffs (Coupled–Uncoupled), JJA, mean 1901–2009

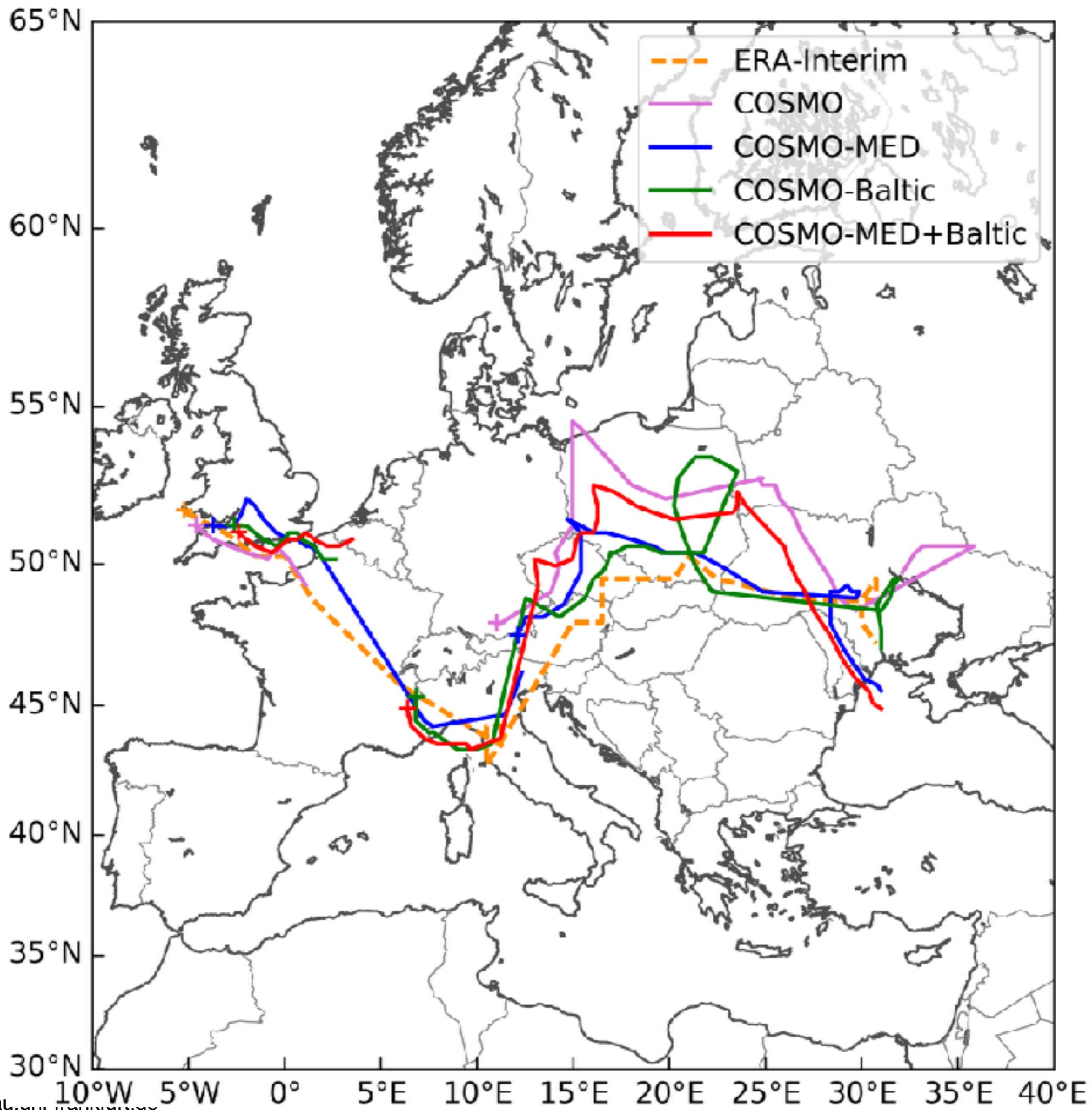


HPE 12-13 Aug 2002

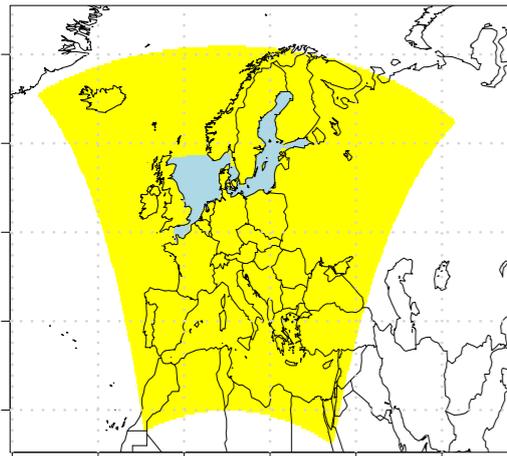


Dx = 0.22°

ERA1 driven



Ocean Ini.

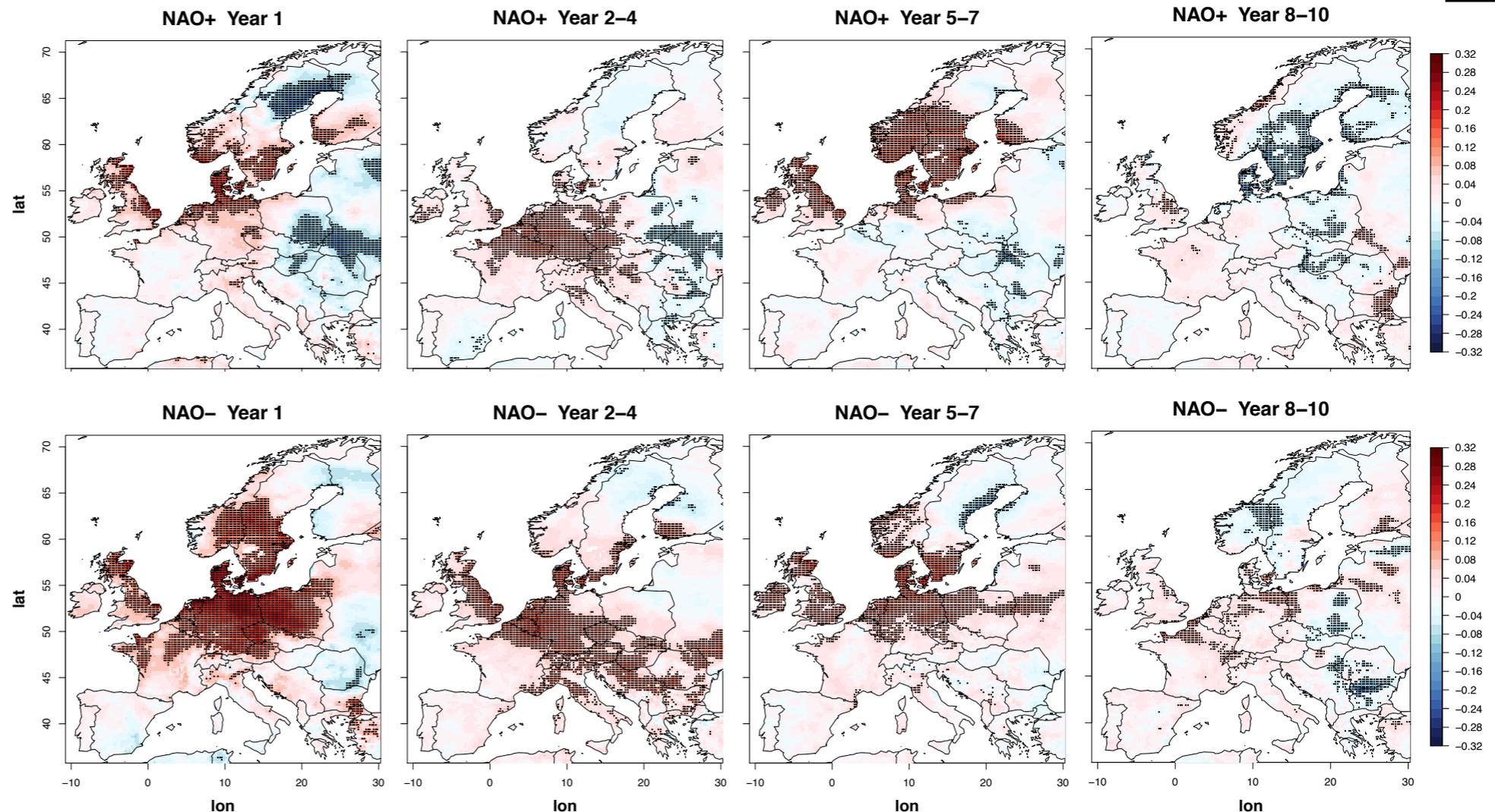


CCLM-NEMO

Ocean ini: NEMO simulation
with ERA-40 forcing

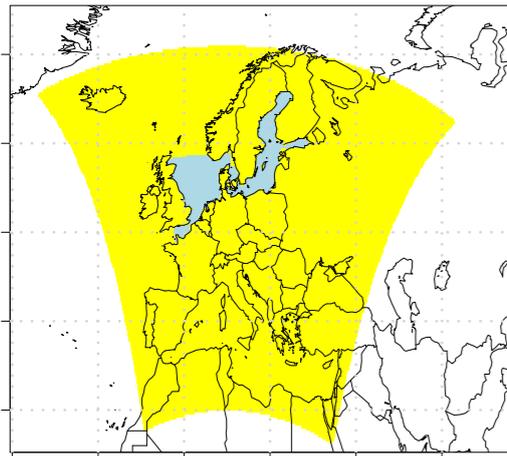
Nested in MPI-ESM hindcasts

MSESS
coupled vs
stand alone
in comparison
with obs.



Pham et al. Subm.

Ocean Ini.

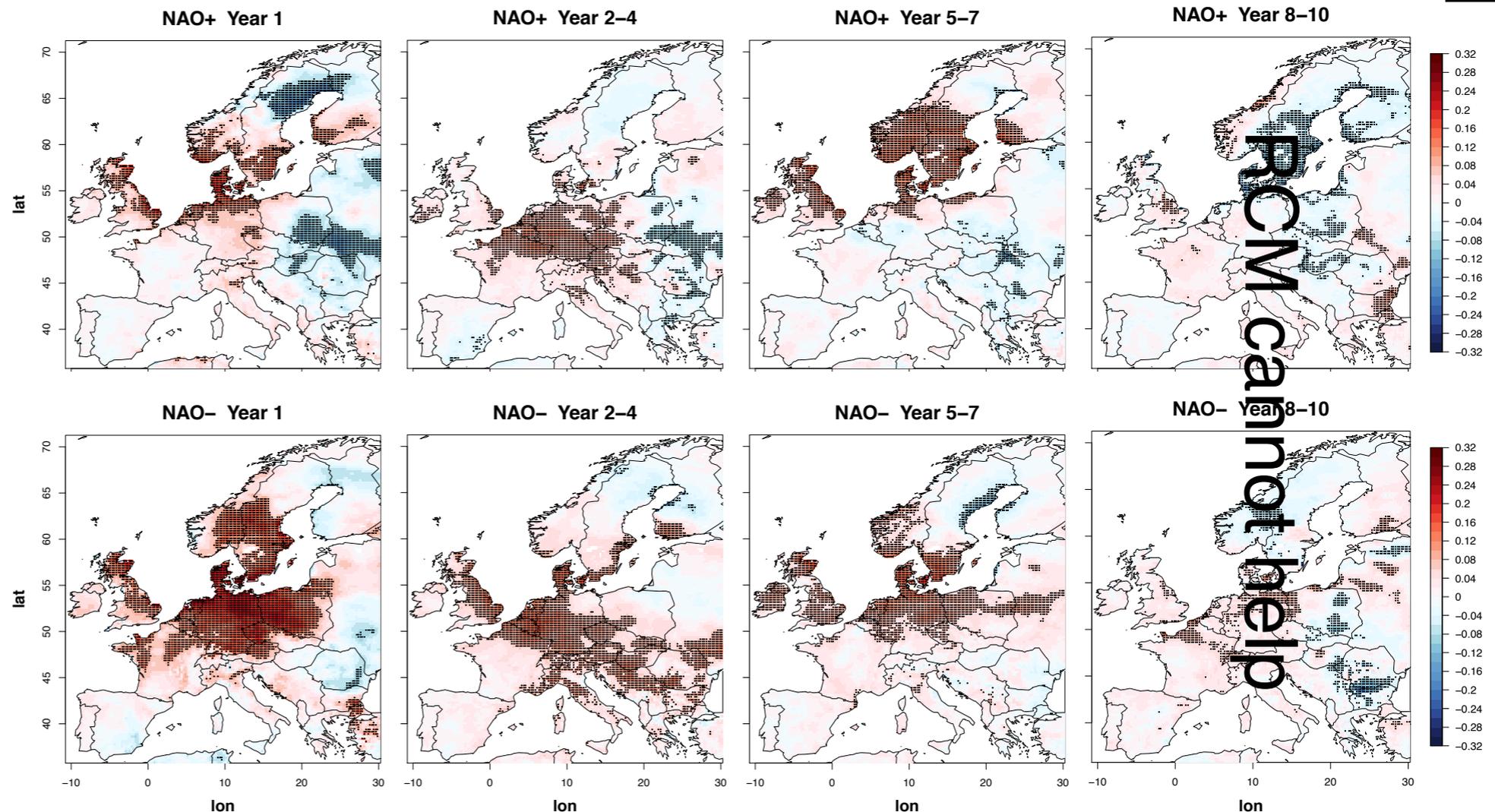


CCLM-NEMO

Ocean ini: NEMO simulation
with ERA-40 forcing

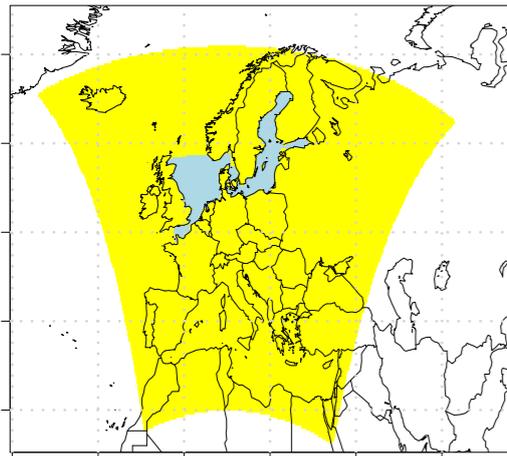
Nested in MPI-ESM hindcasts

MSESS
coupled vs
stand alone
in comparison
with obs.



Pham et al. Subm.

Ocean Ini.

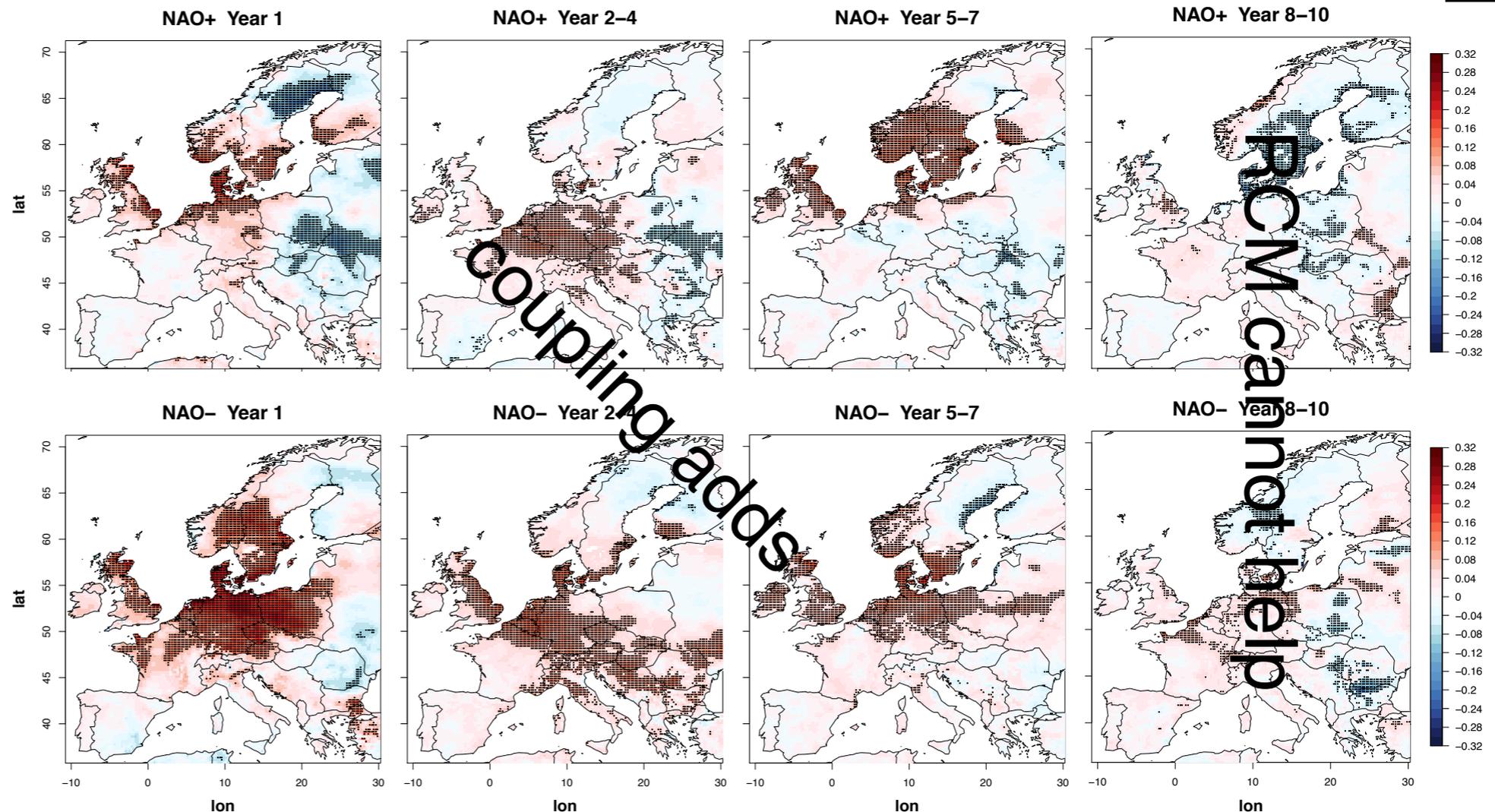


CCLM-NEMO

Ocean ini: NEMO simulation
with ERA-40 forcing

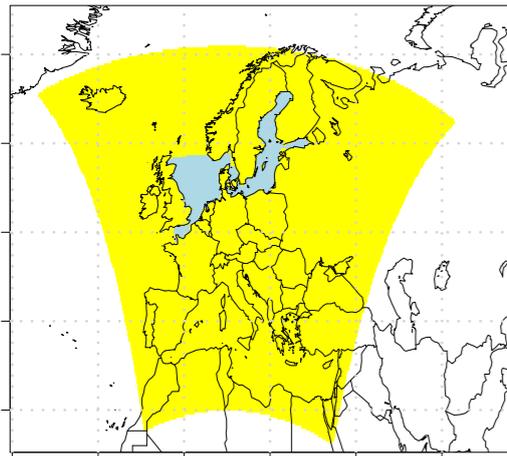
Nested in MPI-ESM hindcasts

MSESS
coupled vs
stand alone
in comparison
with obs.



Pham et al. Subm.

Ocean Ini.

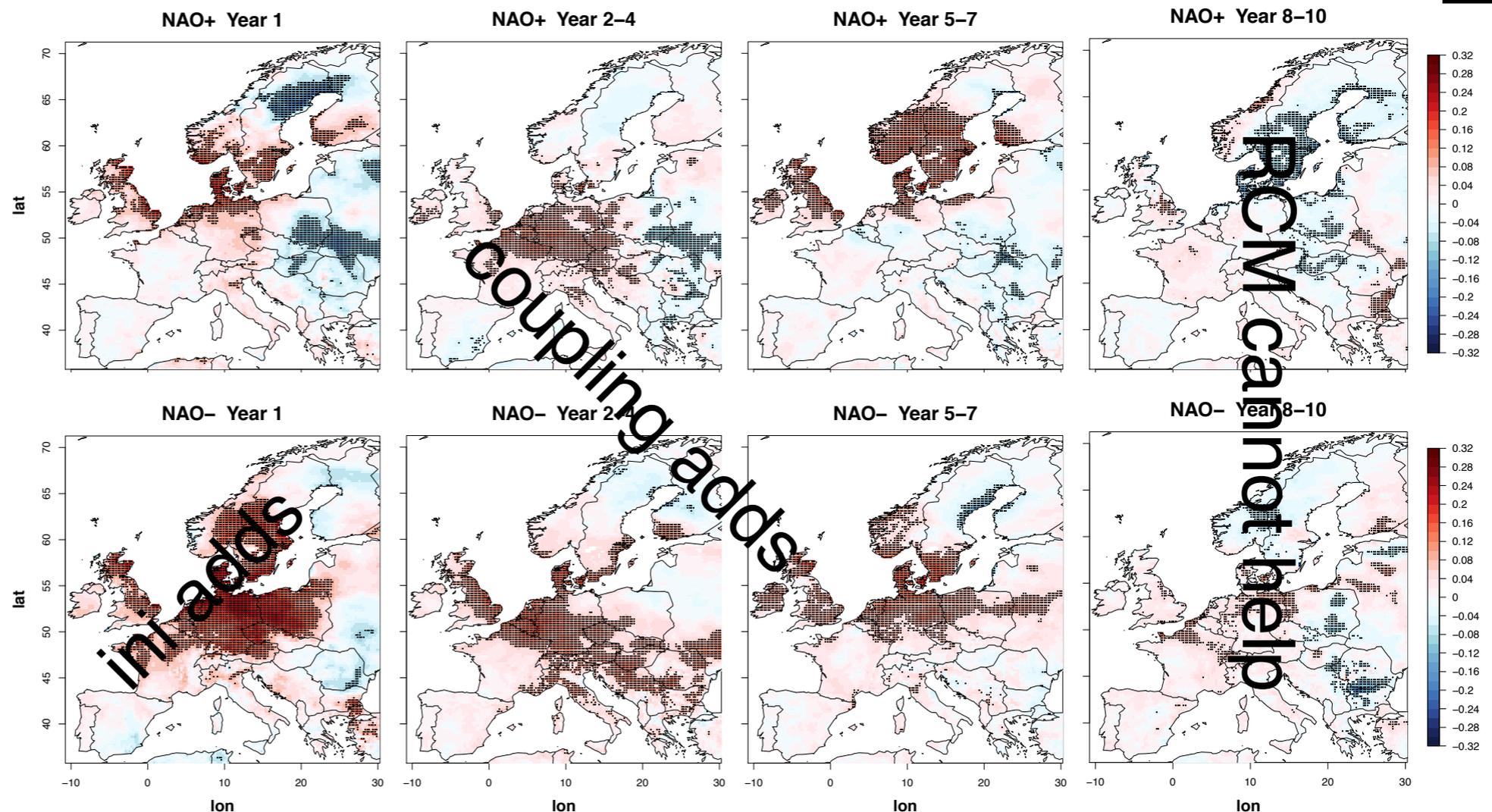


CCLM-NEMO

Ocean ini: NEMO simulation with ERA-40 forcing

Nested in MPI-ESM hindcasts

MSESS coupled vs stand alone in comparison with obs.

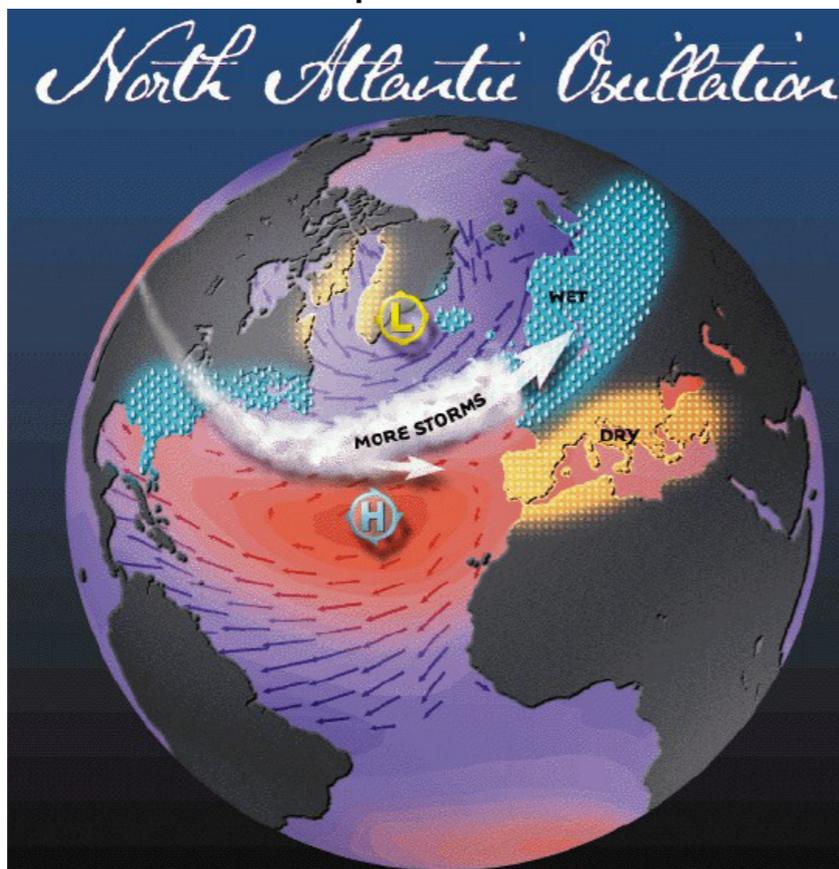


Pham et al. Subm.

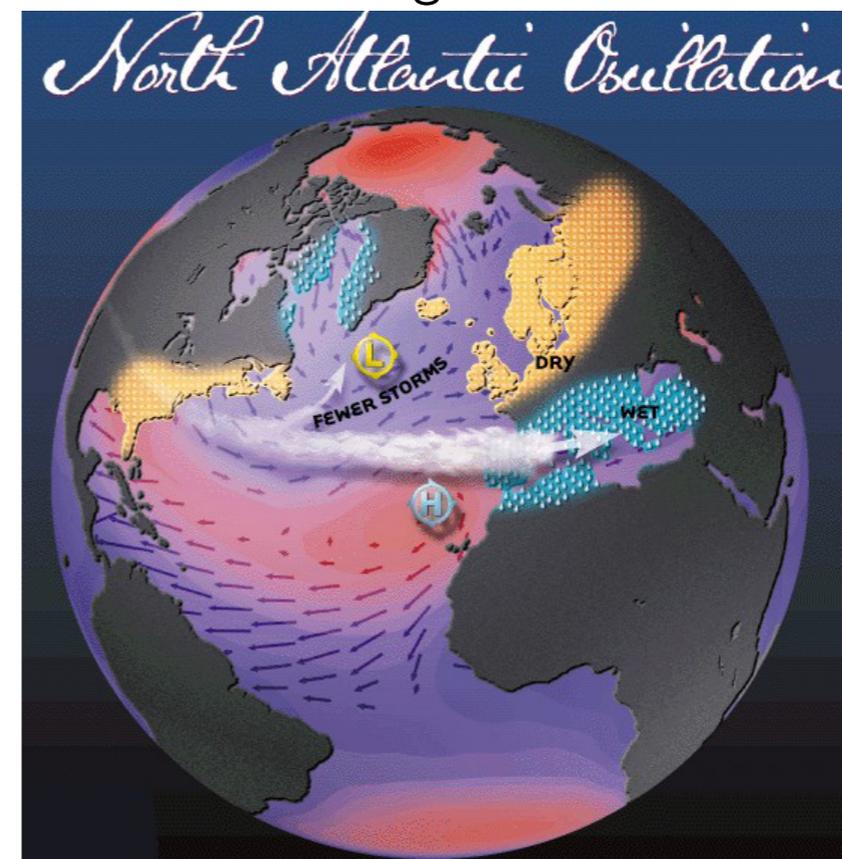
FROM cannot help

NAO±

positiv



negativ



Summary

RCSMs show

+ added value in climatologies of near-/sea extremes

(-> www.medcordex.eu)



+ potentially added value in climate projections,

- o but SST biases in present day simulations**

- o limited maturity (no 300y control sim. ...)**

- o limited added value “far” from coastlines (added value obscured?)**

...

Summary

RCSMs need

- o atmosphere & ocean LBCs

- o ocean adds to the atmosphere's LBC challenge
(like increasing domains)

- o ocean initialisation (spin-up procedure, ocean ana.)

- resources (nightmare for small research groups -
systems need to be more user-friendly and
flexible)

RCSMs are

- + perfect fit as testbeds for ESMs

Summary

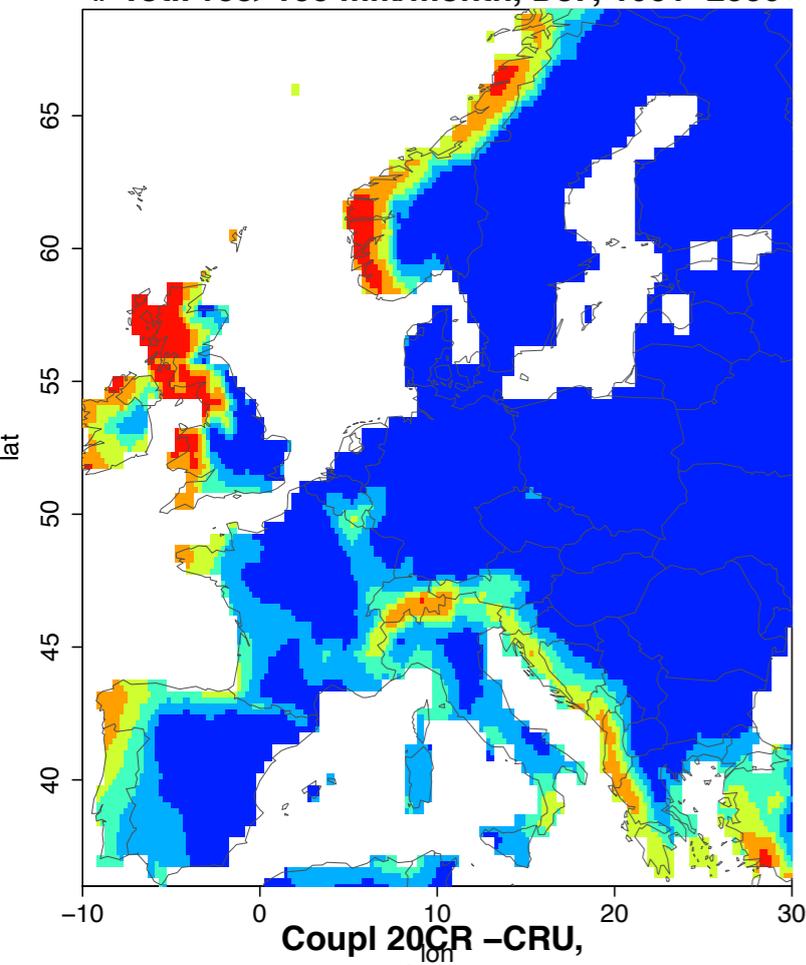
RCSMs add realism i.e. complexity!

“OK, so the computer has understood, but what about me?”

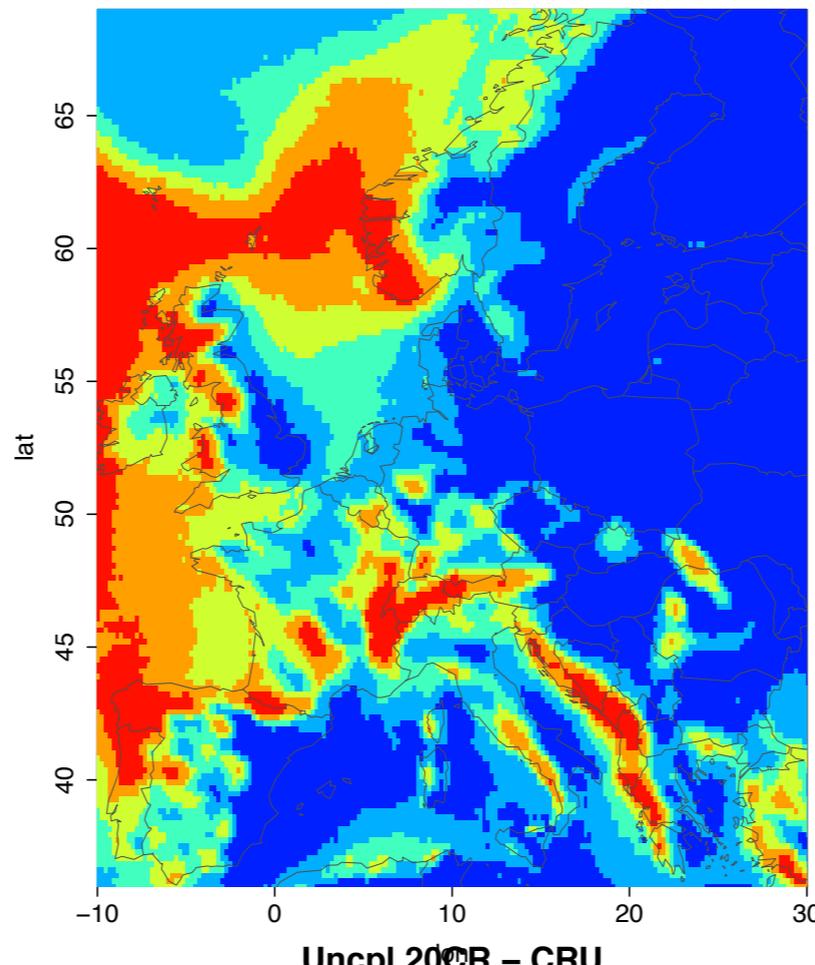
— Eugene Wigner

CRU,

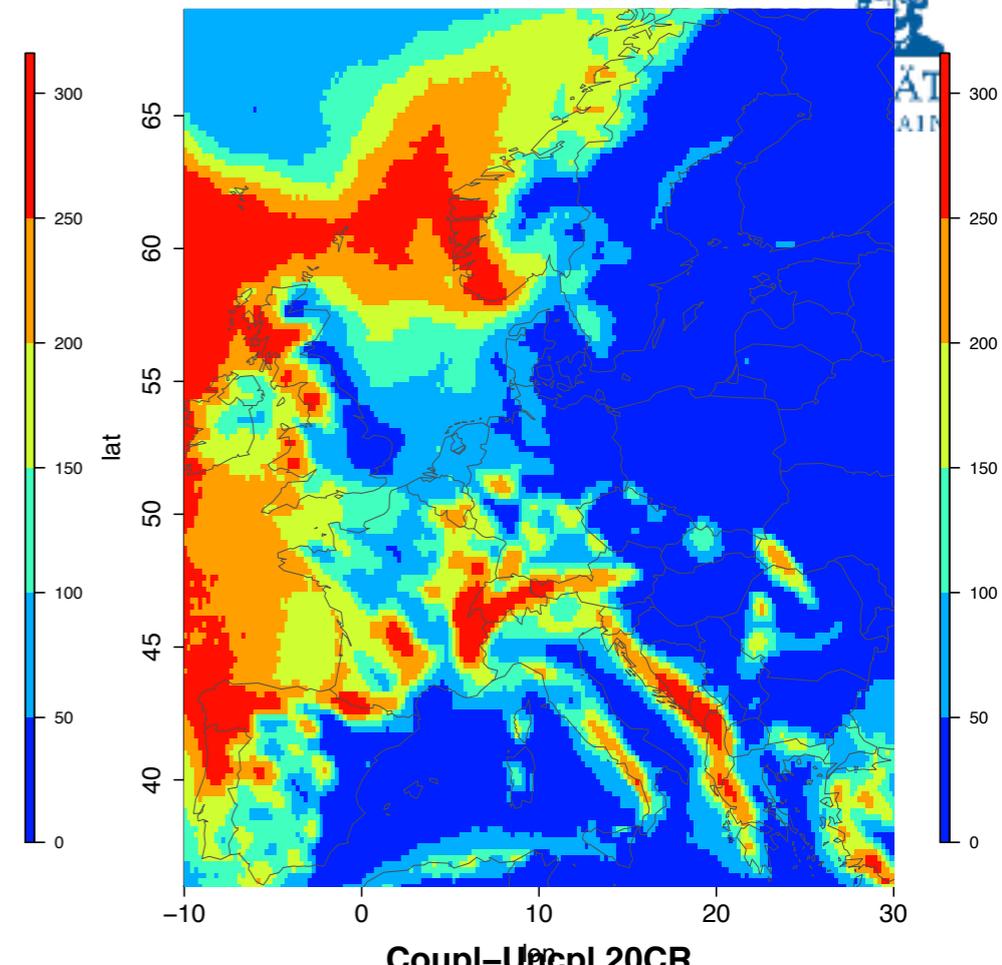
Tot.Prec>100 mm/month, DJF, 1901-2009



Uncpl 20CR



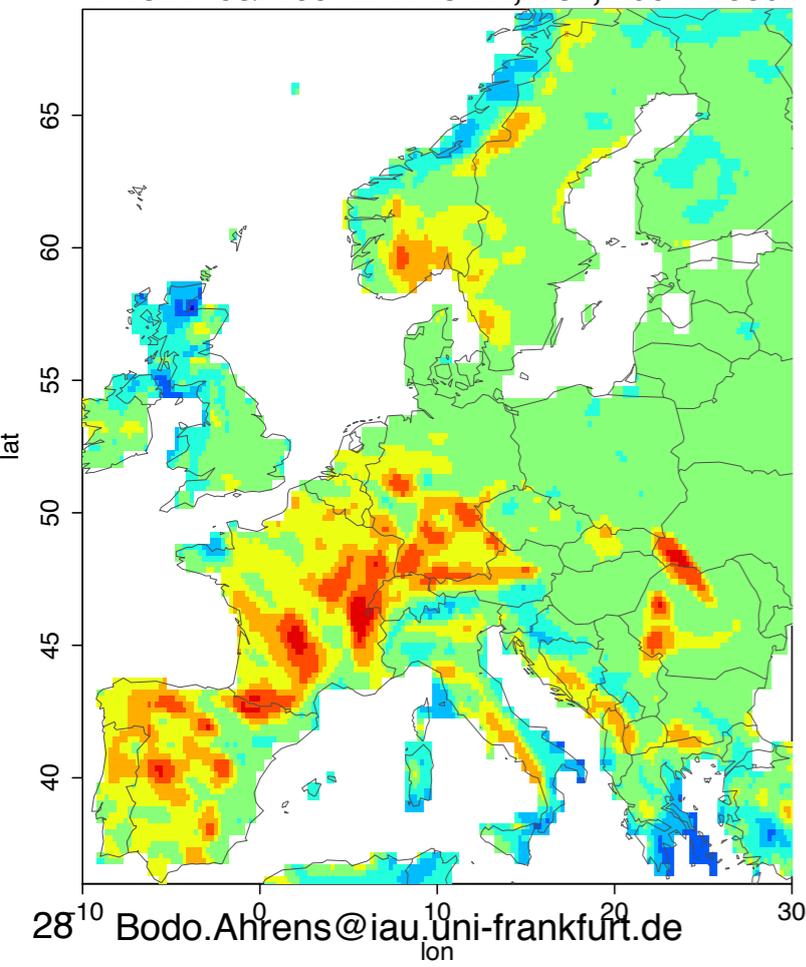
Coupled 20CR



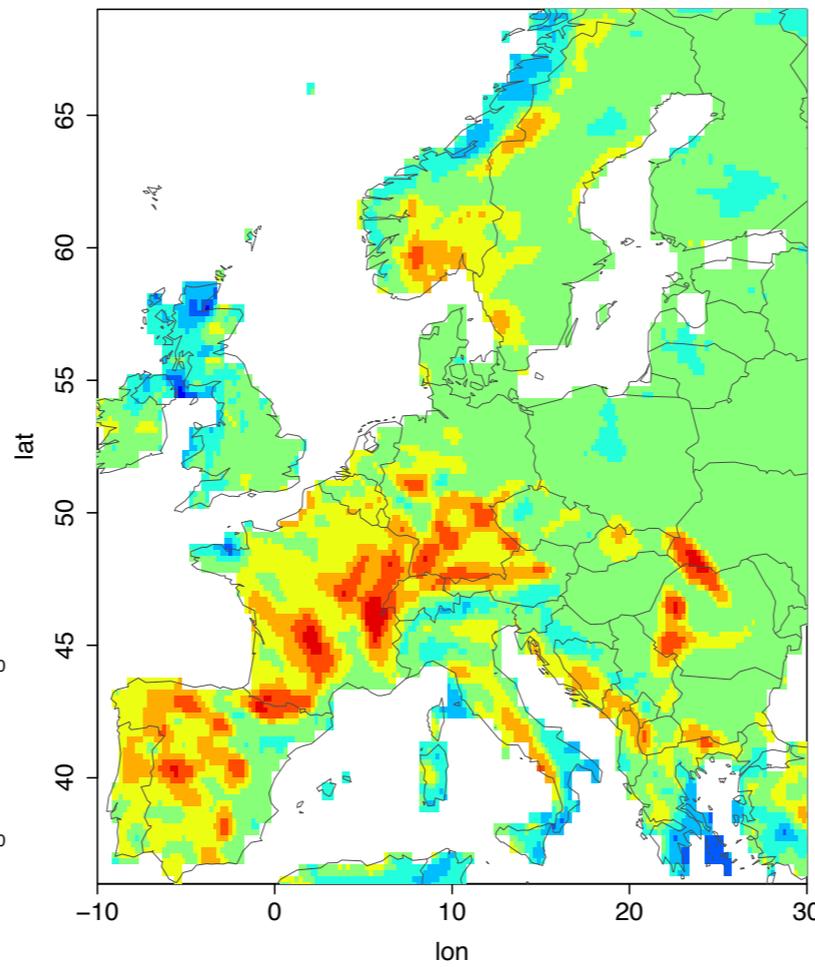
AT
AIR

Coupl 20CR - CRU,

Tot.Prec>100 mm/month, DJF, 1901-2009



Uncpl 20CR - CRU



Coupl - Uncpl 20CR

