

European regional climate simulation performed with **ALADIN-Climate**

work performed at Météo-France and
collaborations

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Météo-France / CNRM / GMGEC

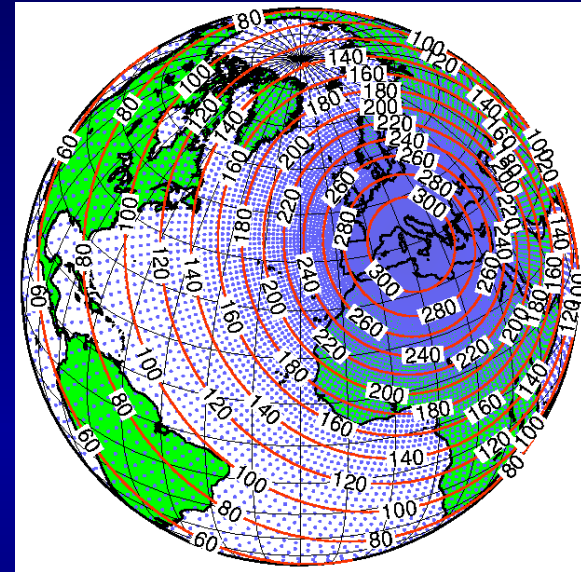
Motivations

ARPEGE-Climate, stretched

- Regional climate change scenario
- Study of regional physical processes
- No boundary problem/inconsistency
- 50 km over Europe

No dynamical downscaling of ERA40

Too expensive to go to better resolution



ALADIN

- LAM: forecast system (Meteo-France)
- developed by a large community (1991)
- low cost way of increasing resolution

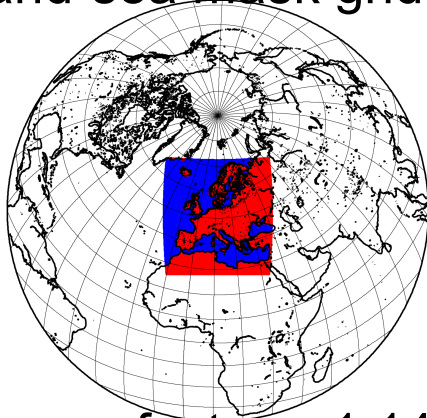
no climate version

ALADIN-Climate

- ALADIN dynamics (cy15)
- Climate physics (version 4)

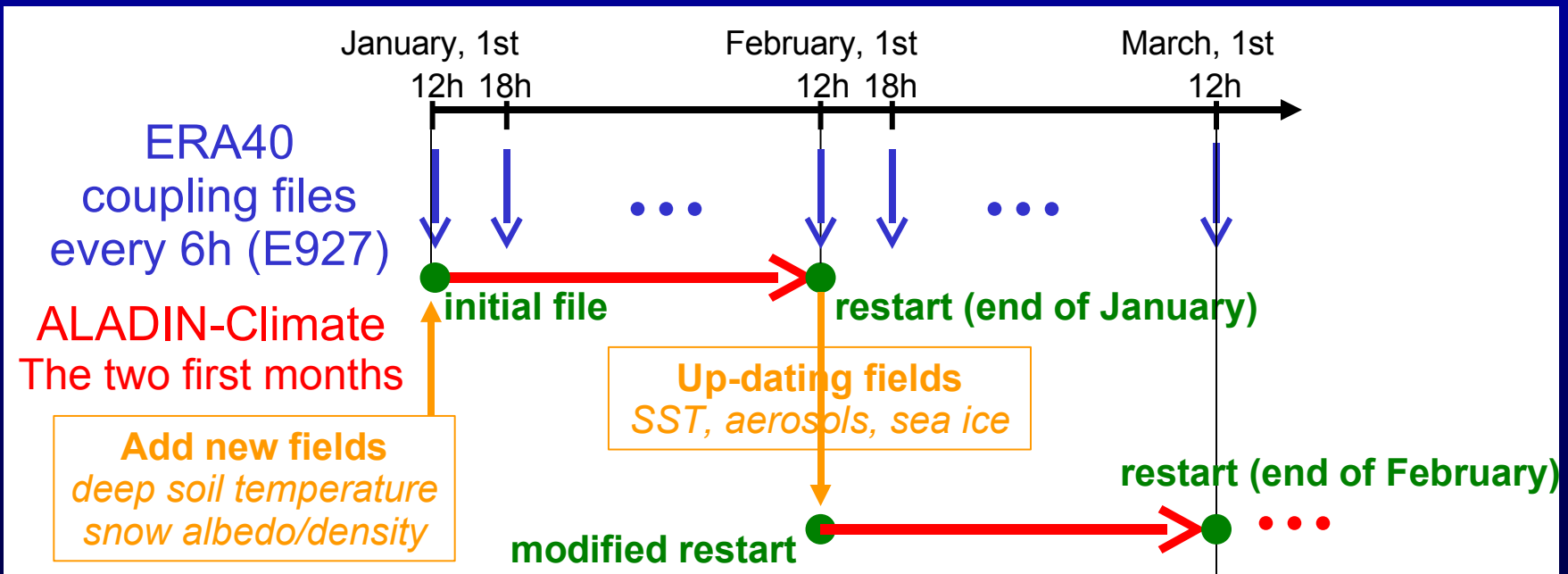
ALADIN-Climate : grid ENS50

land-sea mask gridC



map factor < 1.14

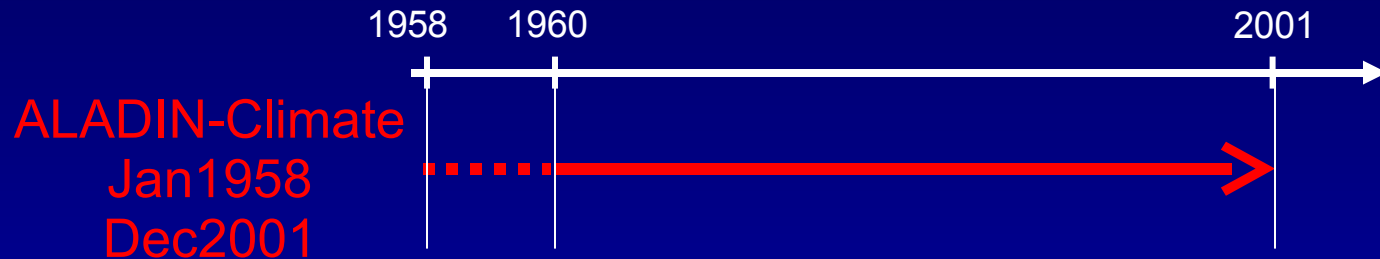
- ENSEMBLES Project: Europe at 50 km
- 128 x 120 grid points
- 31 vertical levels (hybrid coordinate)
- Time step = 1350s = 22.5min
- CPU : 4000s/month



Climate Physics : version 4

- **Radiation scheme:** FMR15 (*Morcrette, 1990* / from ECMWF / cy15)
 - Water vapour + Ozone + 4 GHG (CO₂, CH₄, N₂O, CFC)
 - Aerosols: monthly clim (*Tegen*: Land/Sea/Desert/Black Carbon/Sulfate)
 - Without indirect effect
- **Convective scheme:** *Bougeault, 1985* (ARPEGE, cy18)
- **Cloud/precipitation/vertical diffusion:** *Ricard and Royer, 1993*
 - diagnostic TKE (Mellor/Yamada 2.0)
 - Shallow convection
 - Statistical approach using Bougeault fixed pdf functions (stratiform clouds and precipitation)
- **Soil scheme:** ISBA (*Noilhan and Planton, 1989*) / *prescribed vegetation map*
 - 4-layer soil temperature
 - 2-layer soil hydrology (including soil freezing)
 - 1-layer snow scheme (variable albedo and density - *Douville, 2000*)
- **G.W. Drag:** mountain blocking and lift effect + *new Geleyn's formulation*

ALADIN-Climate: ERA40@50km run



Simulation

- 42-year simulation + 2-year spin-up
- LBC: ERA40 (1.125° x 1.125°, 6h)
- Bottom boundary: ARPEGE-Climate driven by ERA40
 - » Counteract a heavy soil moisture depletion (eastern half of the domain)
 - » The soil water balance remains closed $\langle P+E+R \rangle = 0$
 - » The high-frequency (1-15 days) of soil moisture is let free
 - » The low-frequency is consistent with ERA40 forcing

Stretched ARPEGE-Climate driven by ERA40

ARPEGE-Climate:

- Global, spectral, stretched
- 50 km over Europe

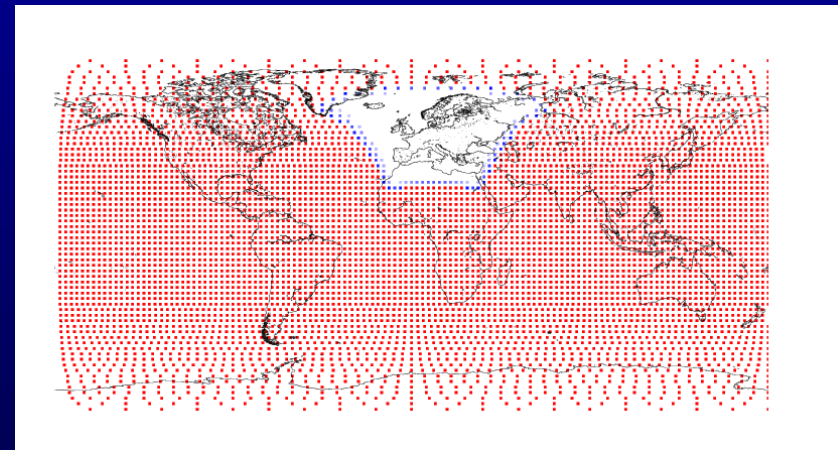
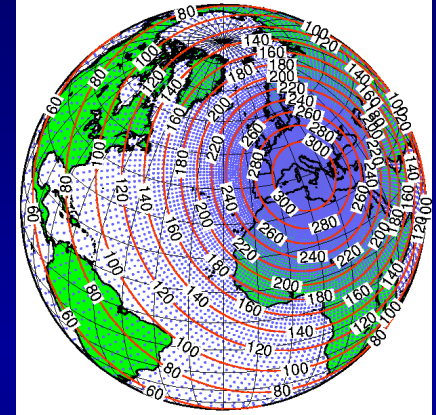
Spectral Nudging:

- ERA40 data, every 6h
- Only for scales larger than T63 (120km over Europe)
- Smaller scales are free

Grid-point Nudging + Free Window:

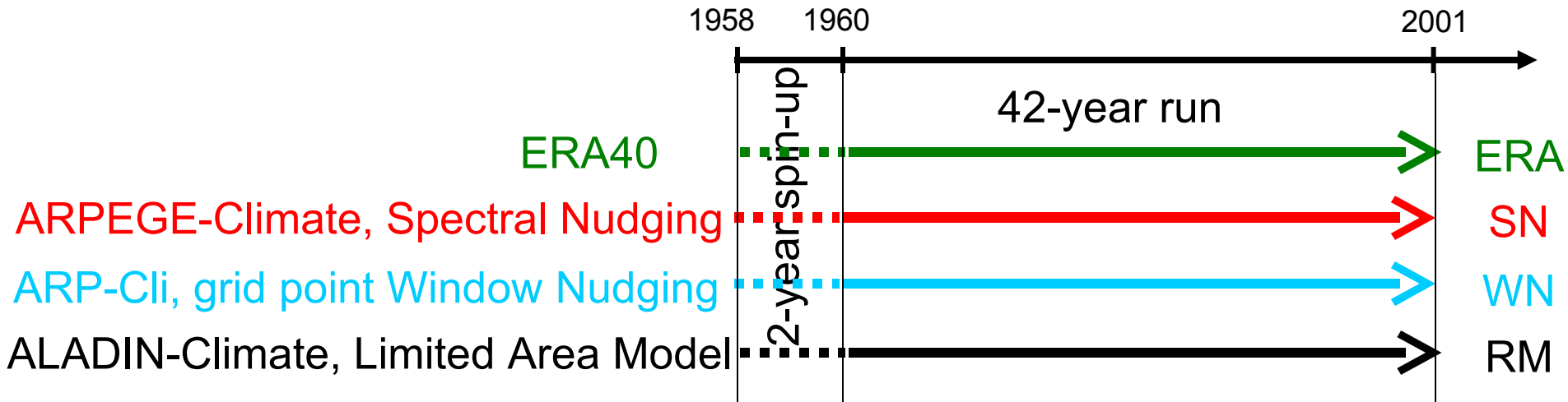
- ERA40 data, every 6h
- Everywhere except for the LAM domain
- Equivalent to a LAM with a very big relaxation zone

ARPEGE-Climate grid



Relaxation zone

Comparison of nudging methods

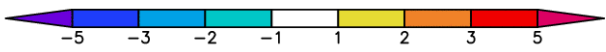
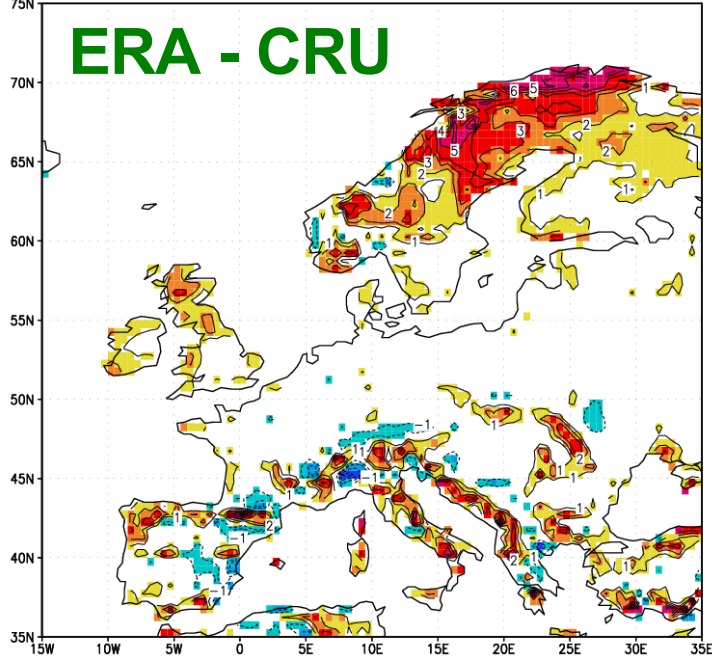


Analysis

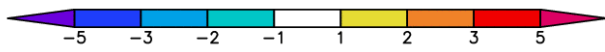
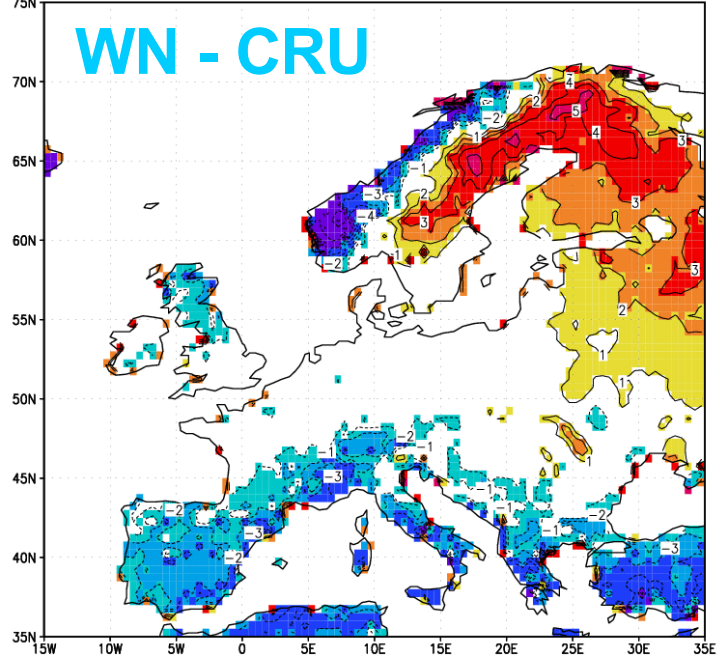
- Comparison to CRU data (land gridded observed data from stations, $0.5^{\circ} \times 0.5^{\circ}$, temperature, precipitation)
- 1960-2001 seasonal average : mean climate validation
- 1960-2001 monthly mean : chronology validation

WINTER T2M (42y, °C)

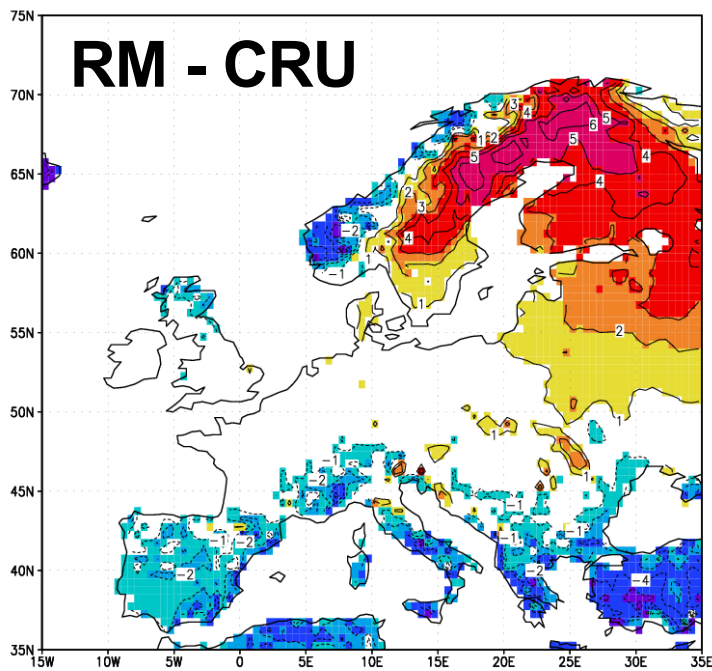
ERA - CRU



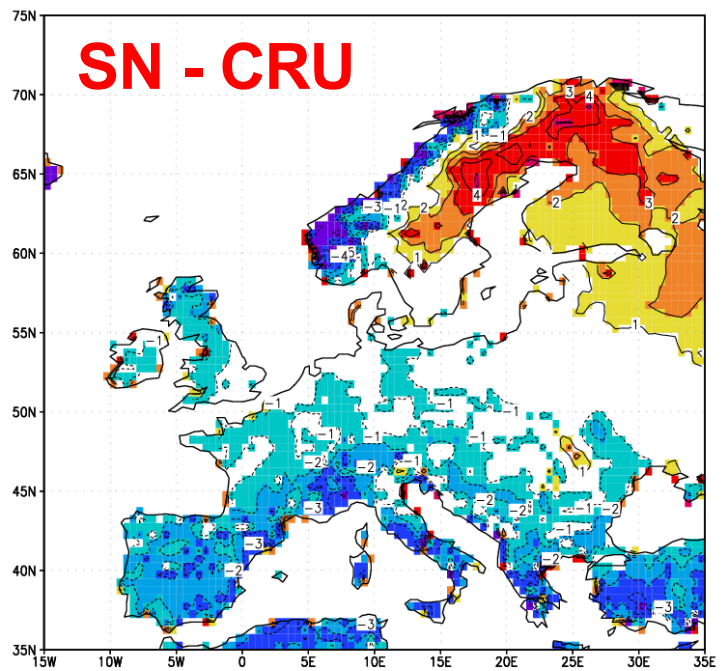
WN - CRU



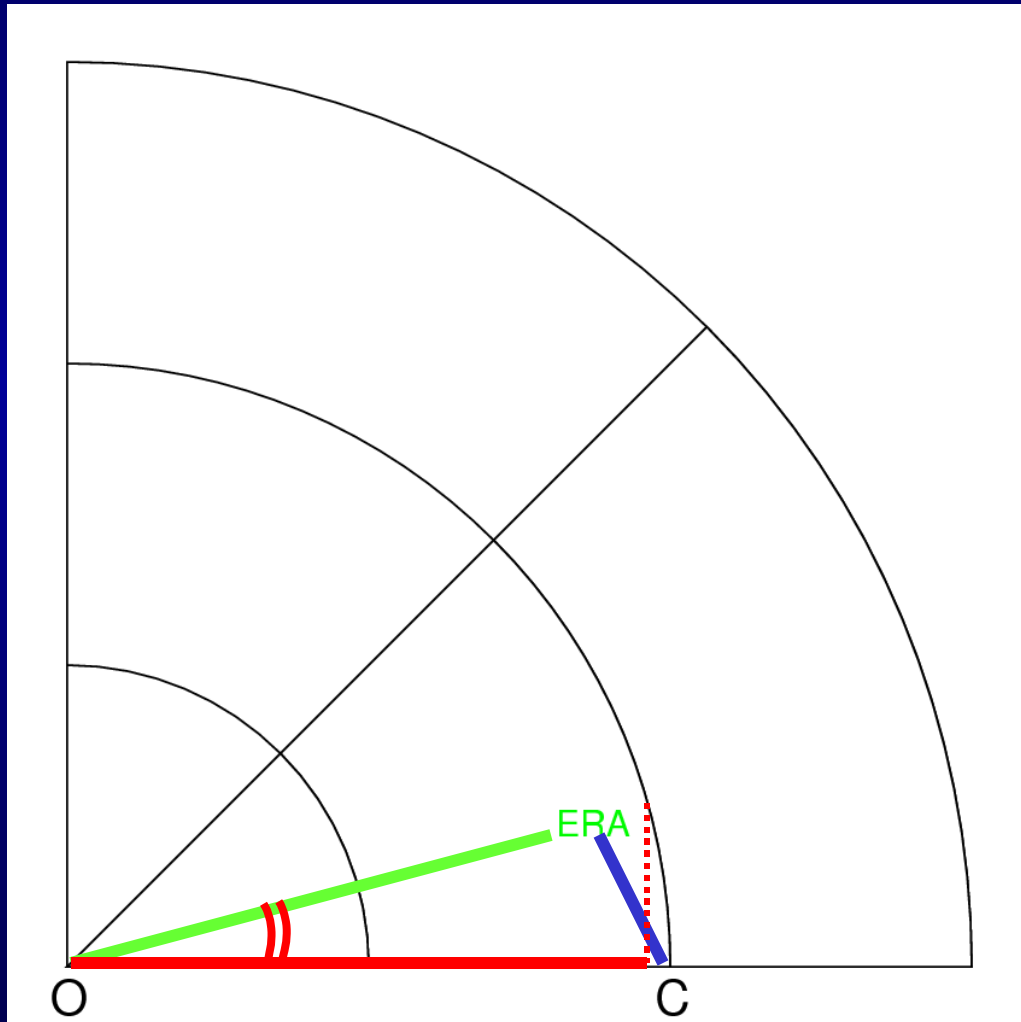
RM - CRU



SN - CRU



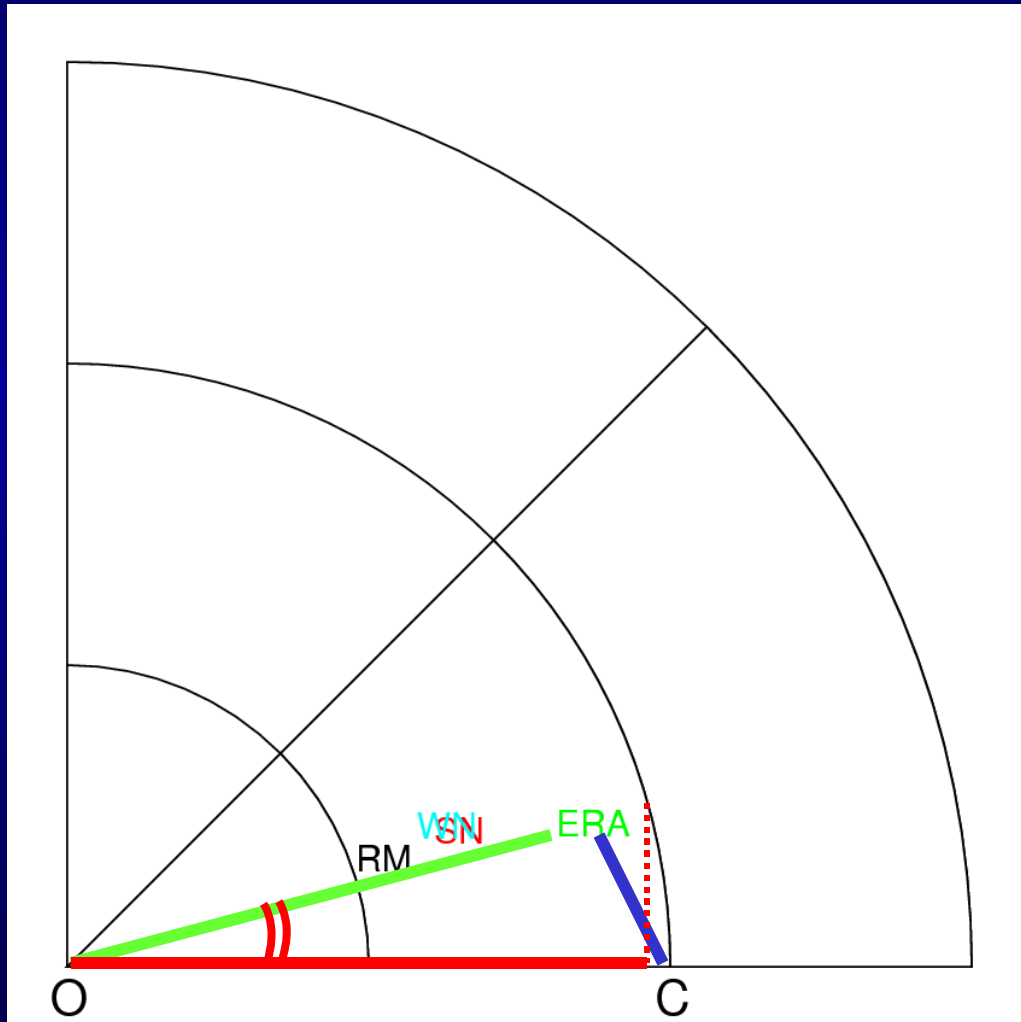
Winter, t2m



Taylor diagram

- RMS difference (bias)
- pattern spatial correlation
- ratio of spatial variance

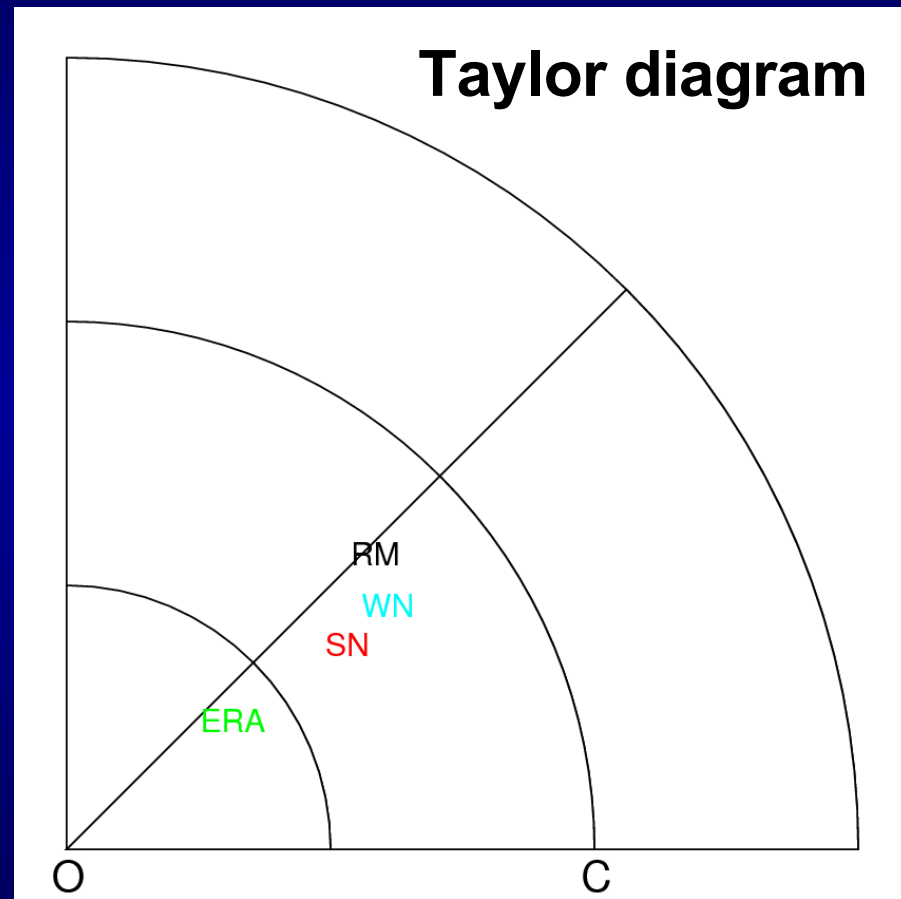
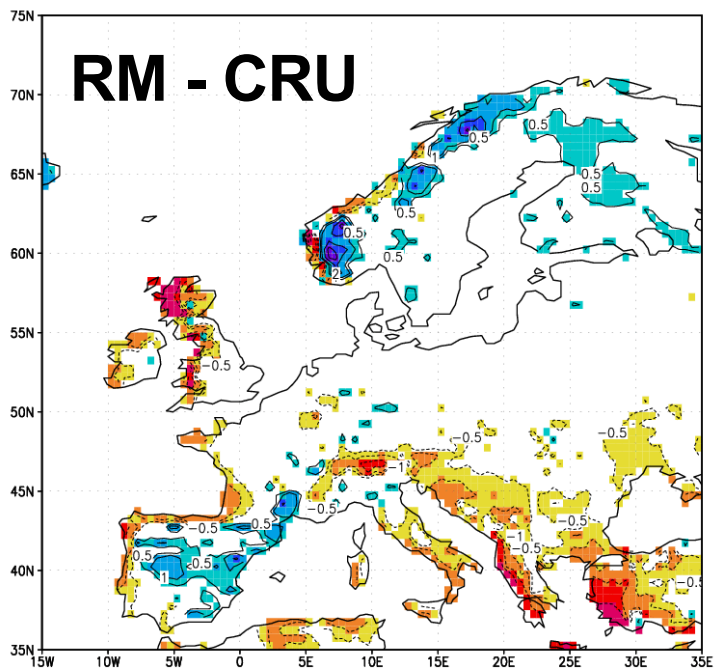
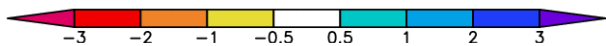
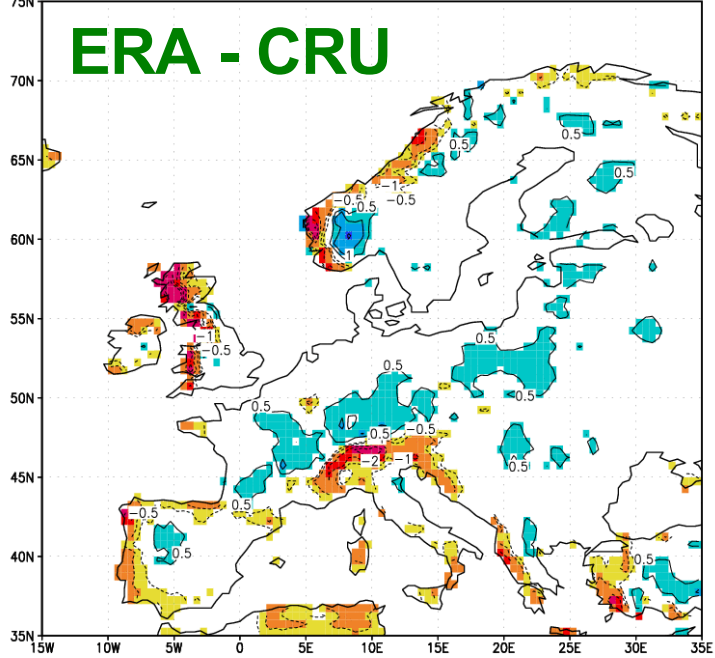
Winter, t2m



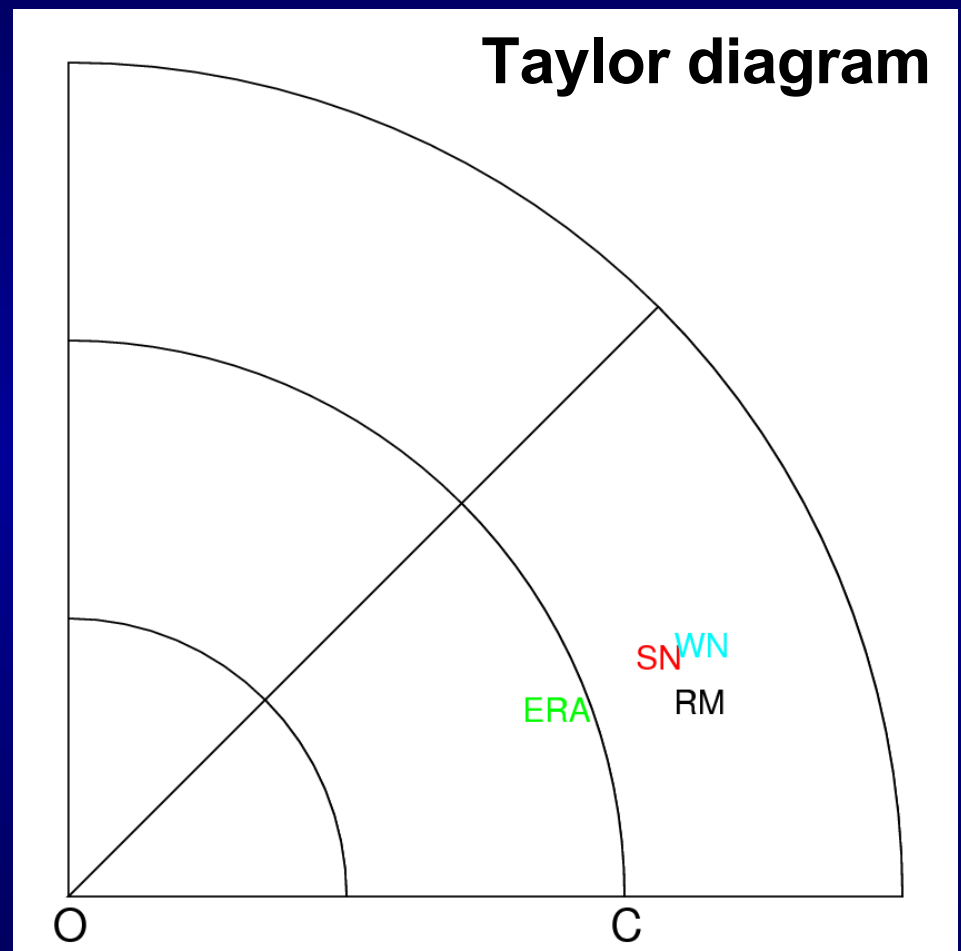
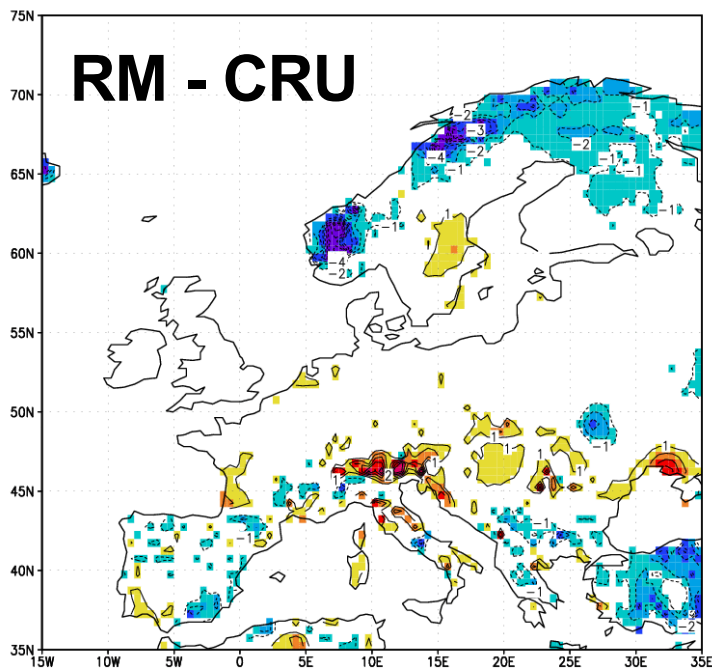
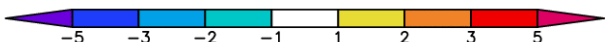
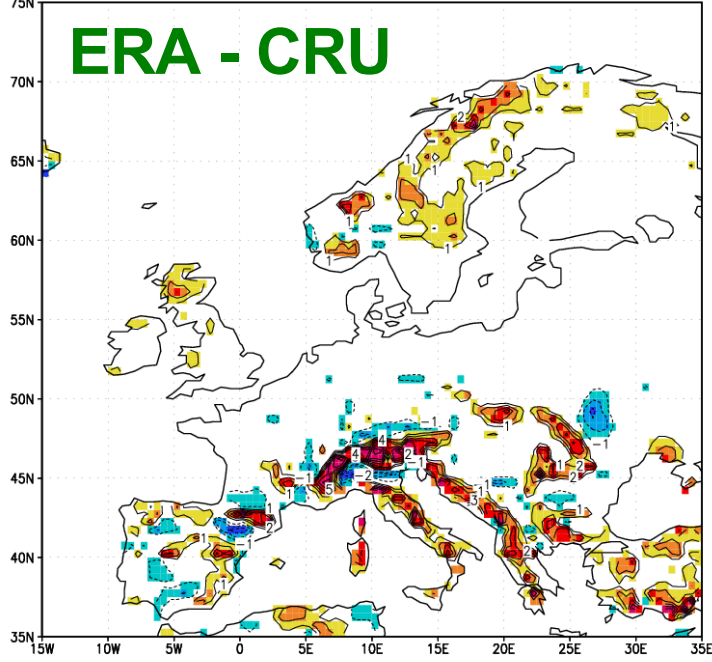
Taylor diagram

- RMS difference (bias)
- pattern spatial correlation
- ratio of spatial variance

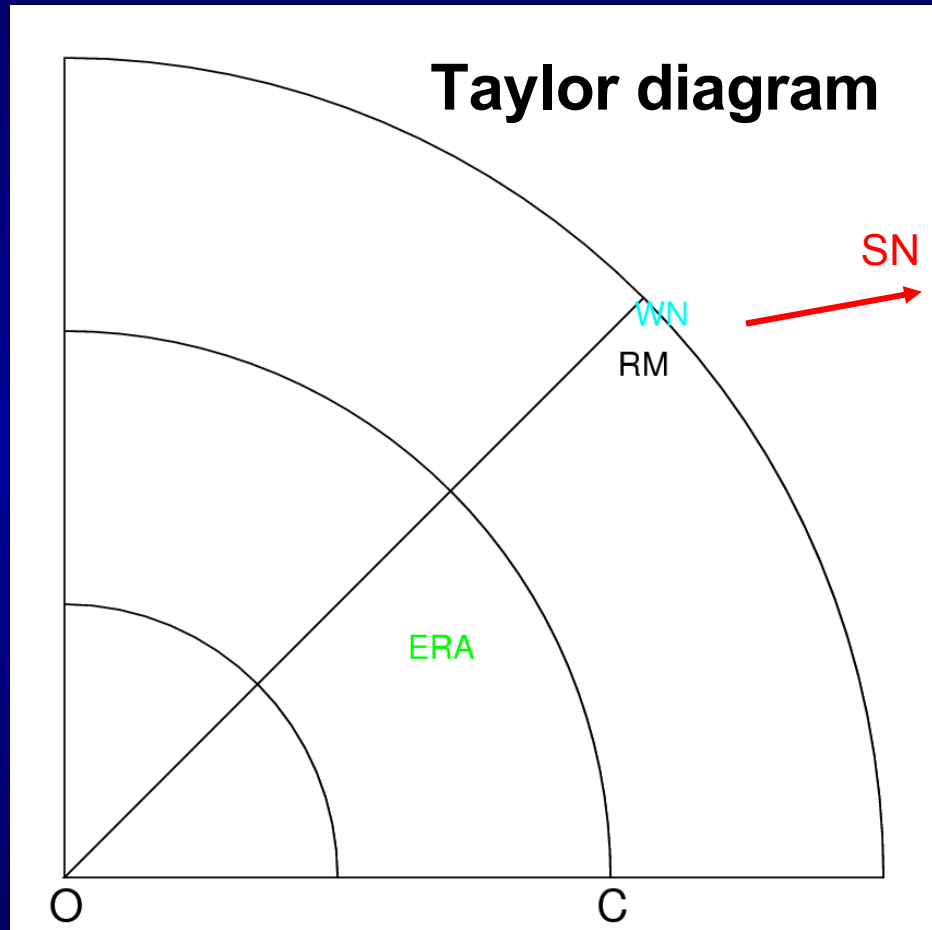
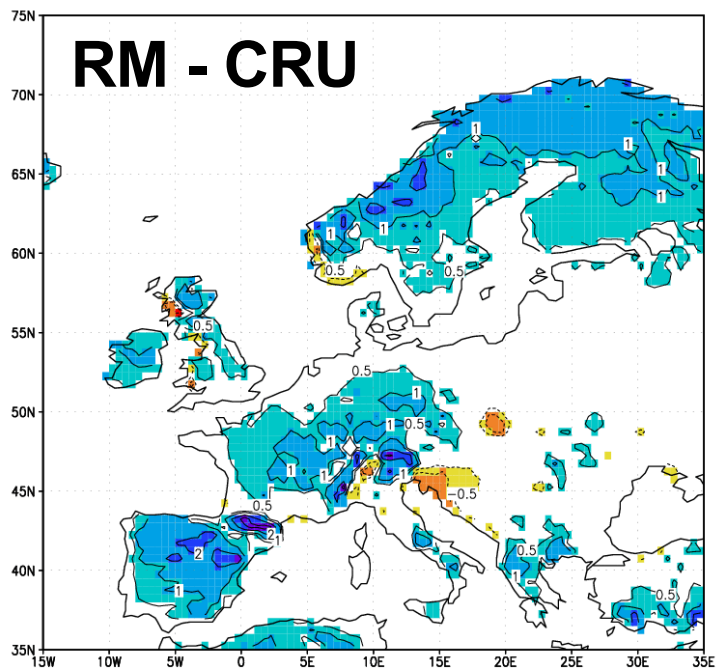
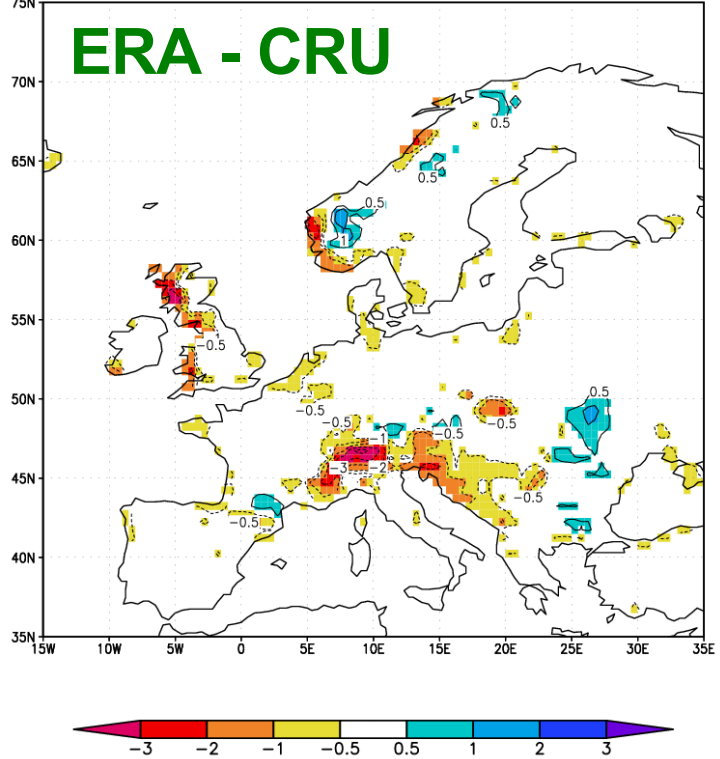
WINTER PREC (42y, mm/d)



SUMMER T2M (42y, °C)



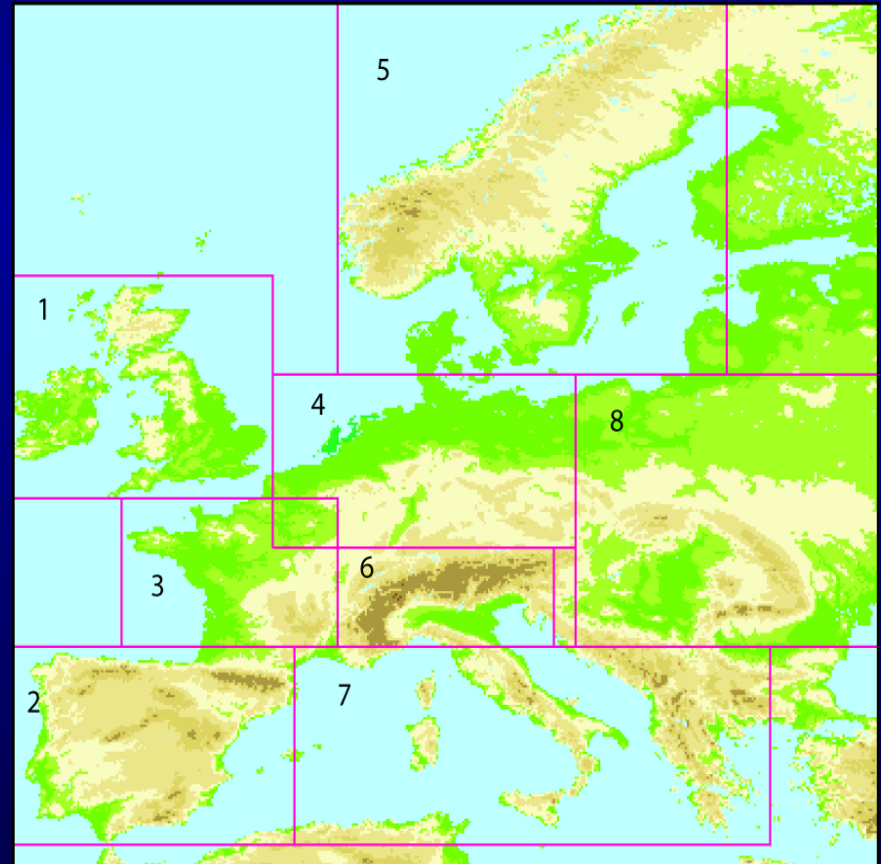
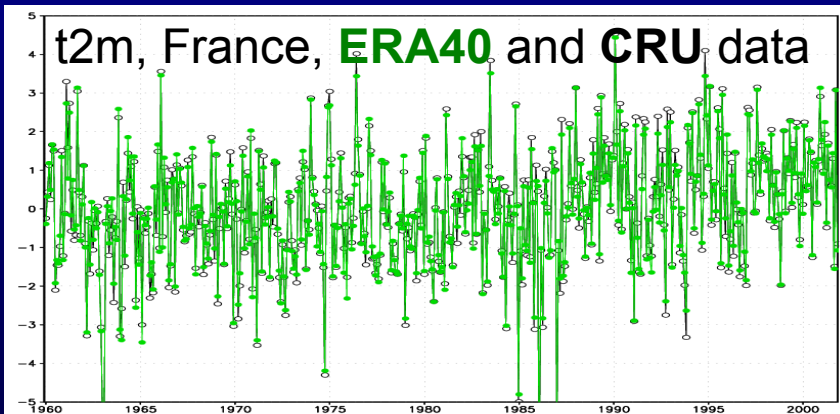
SUMMER PREC (42y, mm/d)



Monthly time chronology

Adapted Taylor diagram for chronology validation over boxes

- Comparison to CRU data (0.5°x0.5°, temperature, precipitation) over « Rockel » boxes : **France** [3]
- We remove the mean seasonal cycle of each dataset (data without bias)
- RMS difference, time correlation and ratio of time variance



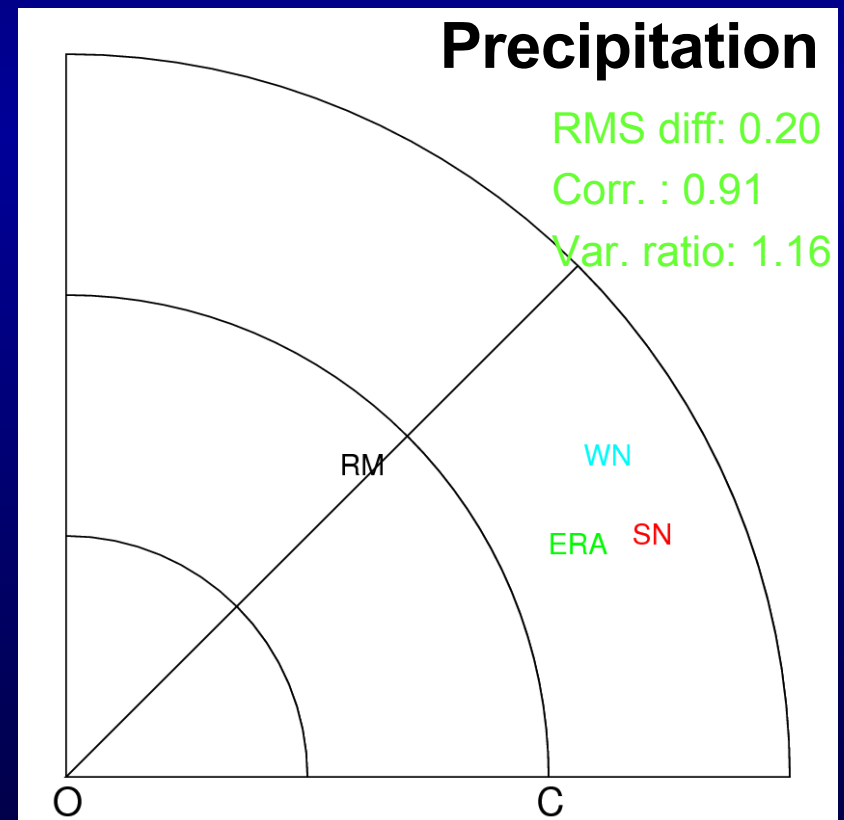
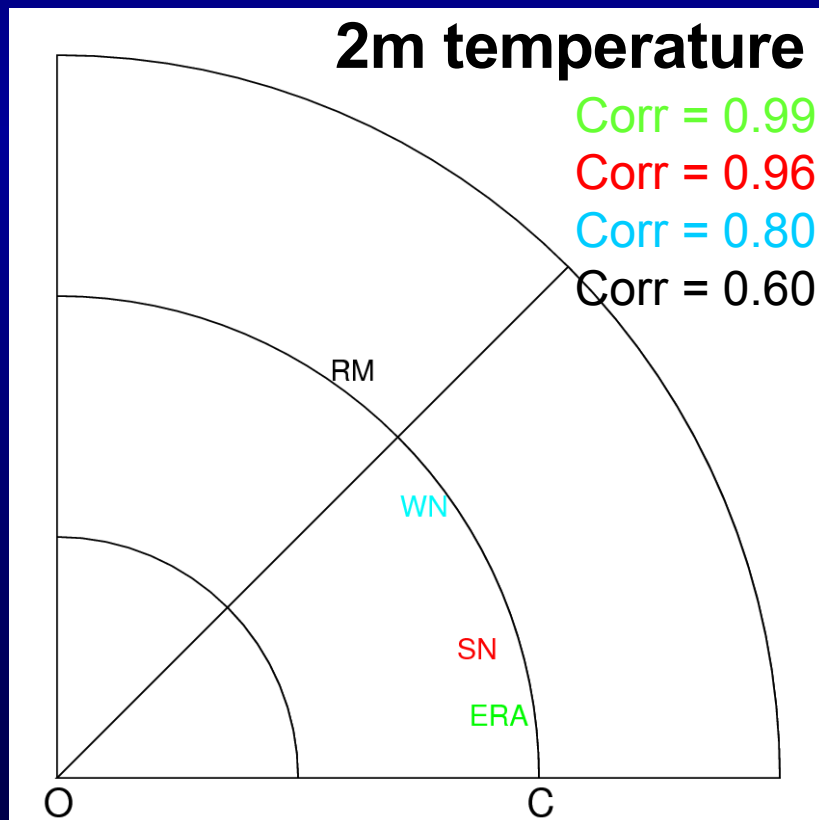
Monthly chronology : France box

The chronology is better when the nudging is stronger

SN : ERA40 forcing everywhere

WN : ERA40 forcing over a huge relaxation zone

RM : ERA40 forcing over a small relaxation zone



Conclusions

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- *ALADIN-Climate, Toulouse, Climate Physics Version 4*
 - Simulation ERA40@50km : completed (1958-2001)
 - Mean climate compares with CRU
 - Bias : too rainy summer in the West, too warm winter in Scandinavia, too cold winter in Mediterranean
- *Testing different driving methods*
 - Limited Area Model, Spectral nudging, Grid point nudging with free window
 - Mean Seasonal Bias : the LAM is as good as the other even with less constraints to ERA40
 - Time chronology : ERA40 chronology is very good only for temperature
 - Time chronology : the spectral nudging is the best method, the LAM is the worst

Working plan / Collaborations

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- *ENSEMBLES European Project (FP6)*
 - **February 2006:** ALADIN-Climate at 50 km forced by ERA40, 44y
 - **October 2006:** ALADIN-Climate at 25 km forced by ERA40, 44y
 - **October 2007:** ALADIN-Climate at 25 km forced by ARPEGE-Climate, 1950-2050, IPCC scenario
 - **Assessing uncertainties in regional climate change :**
forcings, resolutions, LAMs, physics, scenarios
- *Collaborations around ALADIN-Climate*
 - **Bulgaria:** V. Spiridonov
 - **Czech Rep:** A. Farda, Th. Halenka
 - **Hungaria:** H. Toth, A. Horanyi
 - Impact of domain size, physics, resolution
 - Beginning of the European CECILIA Project in 1 month