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Sea Atmosphere Interaction and Climate Laboratory **(SAIL)**

The North Atlantic Atmospheric Rivers in high-resolution atmospheric WRF hindcast (1979+)

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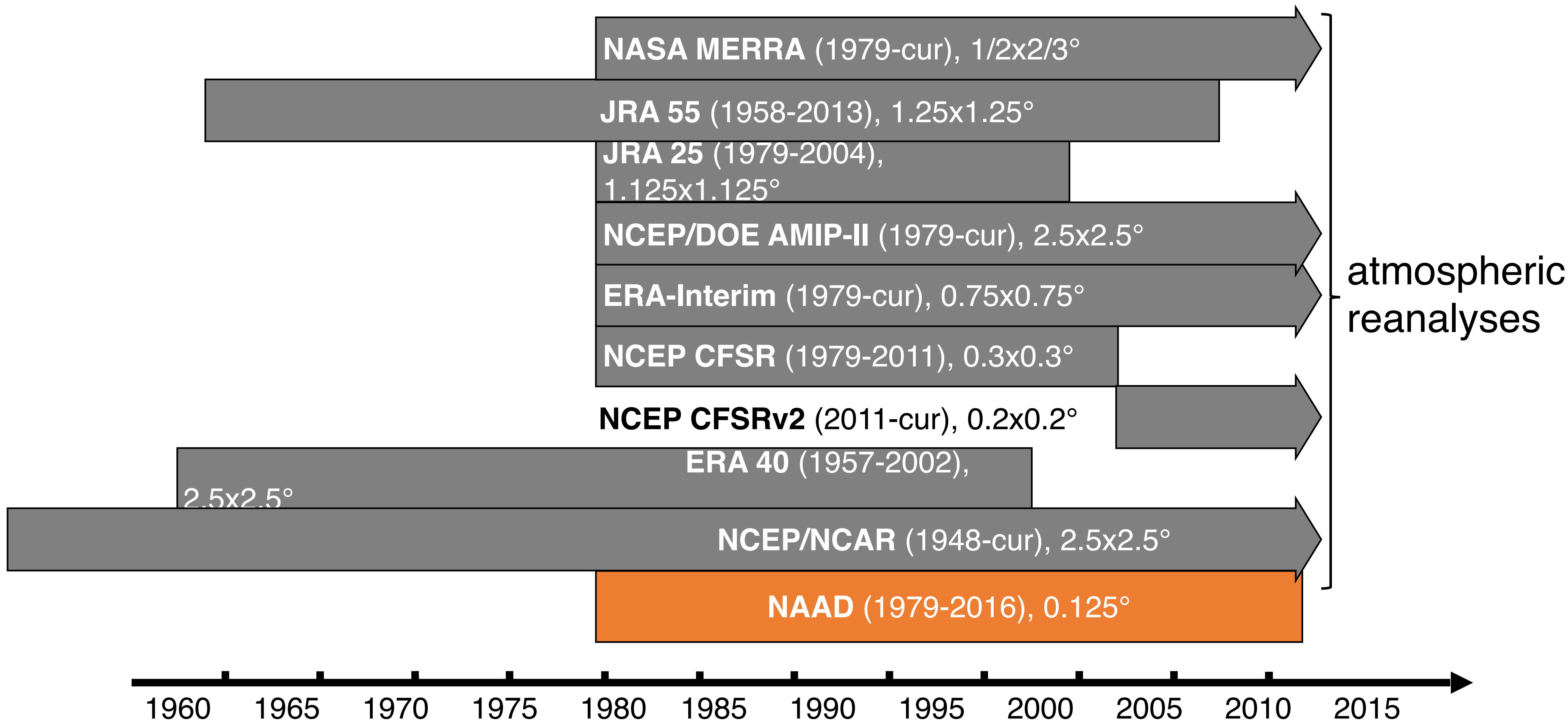
International **A**tmospheric **R**ivers **C**onference 2018, La Jolla, CA

Motivation

Knowing that increasing resolution in atmospheric models often leads to different representation of processes …

Does this affects atmospheric rivers, qualitatively and quantitatively?

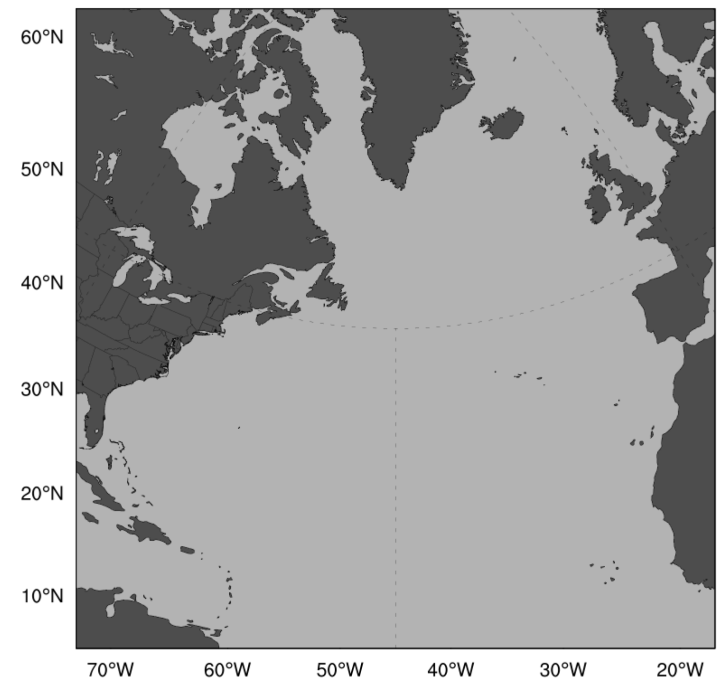


- Non-hydrostaric model formulation - vertical wind component impact
- Potentially better vertical transports and convection
- Hi-resolution parametrizations

WRF Configuration

GENERAL CONFIGURATION	LoRes	HiRes
WRF version	**WRF-ARW 3.8.1** (non-hydrostatic)	
Horizontal resolution	0.7° (77 km)	**1/8° (14 km)**
Vertical levels	**50 (from 10 m to 50 hPa)**	
RK time step	360 s	30 s
Forcing	**ERA-Interim (N128) + NUDGING + [2]**	
PARAMETRISATIONS	**LoRes**	**HiRes**
Microphysics scheme	WSM3	WSM6
Radiative transfer	RRTMG (+ features [3])	
Surface layer scheme	new MM5 (with COARE3 for Ch, Cq) + [1]	
PBL	YSU	
Cumulus physics	new Kain-Fritsch + features [3]	

Computational domain



Additional features for long-term simulations:

(1) calculating skin temp based on Zeng and Beljaars (2005)
(2) sst update every 6hr (ERA-Interim)
(3) CAM aerosol climatology, ozone account and sub-grid cloud effect to the optical depth account in RRTMG scheme

Design of experiment 1979 - ongoing

WRF ARW **v3.8.1** - Weather Research and Forecasting Model

INPUT:
ERA-Interim, 1979-2016, 0.7x0.7°, every 6hr

WRF-ARW v3.8.1:

Configuration:
Sensitivity tests, validation, data assimilation tests

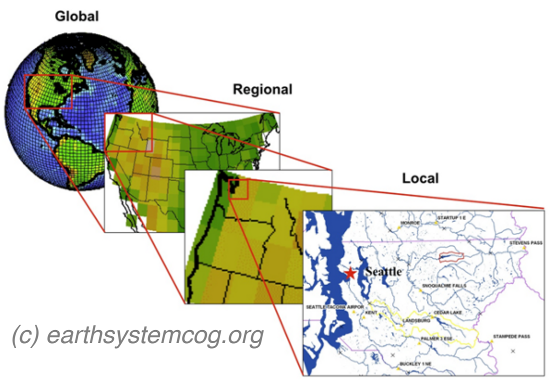
Run:
Low and high resolution experiments

OUTPUT:
NAADv4, 1979-2016,
1) 14 km, every 3hr
2) 77 km, every 3hr

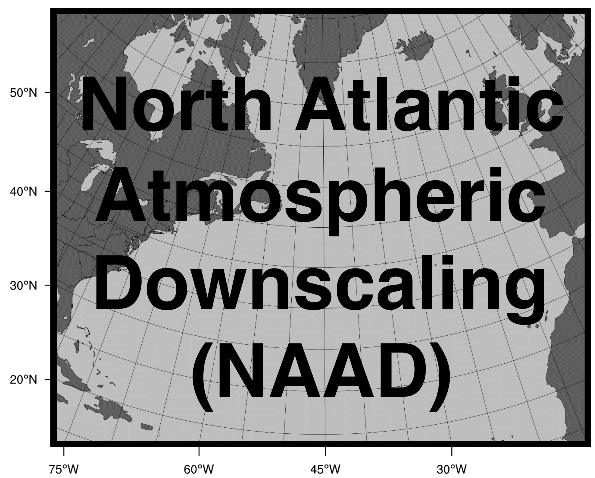
Analytics:

Mesoscale impact:
the climatic impact of increasing resolution using near-surface variables: wind, temperature, turbulent fluxes etc

Extreme climatology:
Building the dataset of mesoscale processes (40-400 km)



(c) earthsystemcog.org



Nearest future: *incorporate to high-resolution*

WAVEWATCH III:
spectral wave model

NEMO:
Ocean dynamics and thermodynamics model

Spectral nudging for U, V, SLP and T2M

WRF uses a **spectral (interior) nudging** relaxation technique to solve the problem of distortion of large scale dynamics. The idea is to add an extra source into the dynamic core of the model which will keep longwave fluctuations close to boundary conditions (reanalysis). Small-scale dynamics are left unchanged. Nudging applies to a given wavenumber (m, n) and longer, with strength of K_{mn} and from the model's upper level downward to a given level.

NAAD nudging settings	
wavelength	**1100 km**
strength	
height	**PBL**

$$\frac{dQ}{dt} = L(Q) - \sum_{|n|\leq N} \sum_{|m|\leq M} K_{mn}(Q_{mn} - Q_{omn})e^{ik_m x}e^{ik_n y}$$

$$k_m = \frac{2\pi m}{D_x};\ k_n = \frac{2\pi n}{D_y}$$

[Miguez-Macho et al., 2004]

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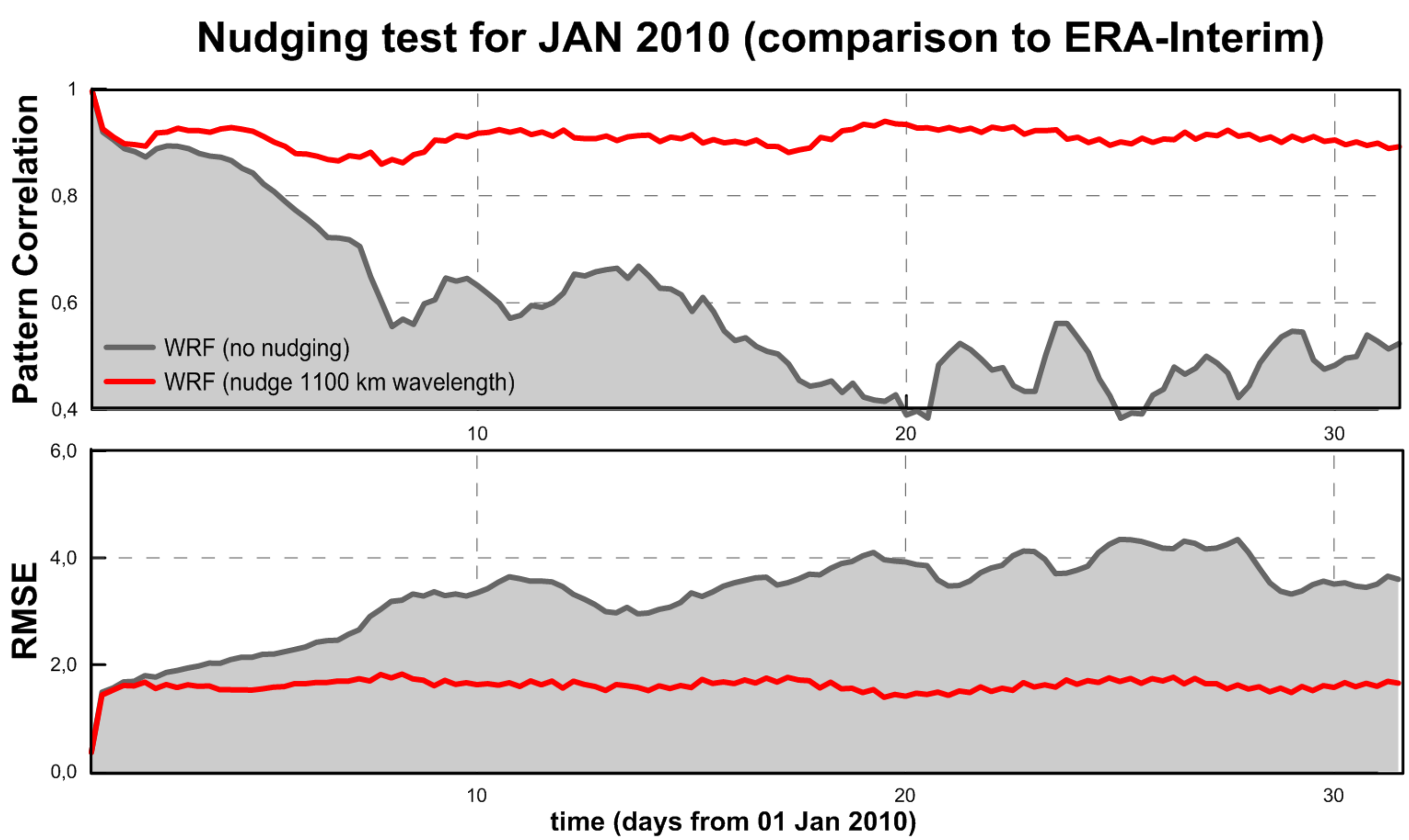

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strength	
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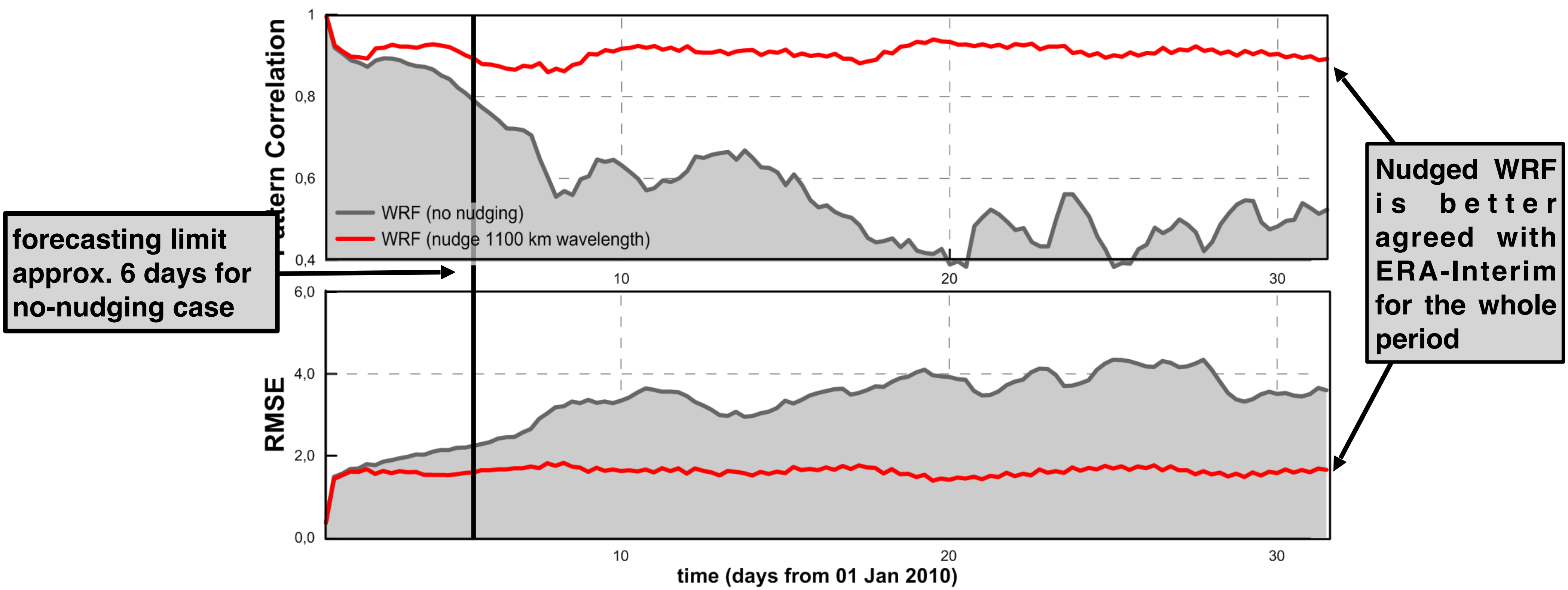
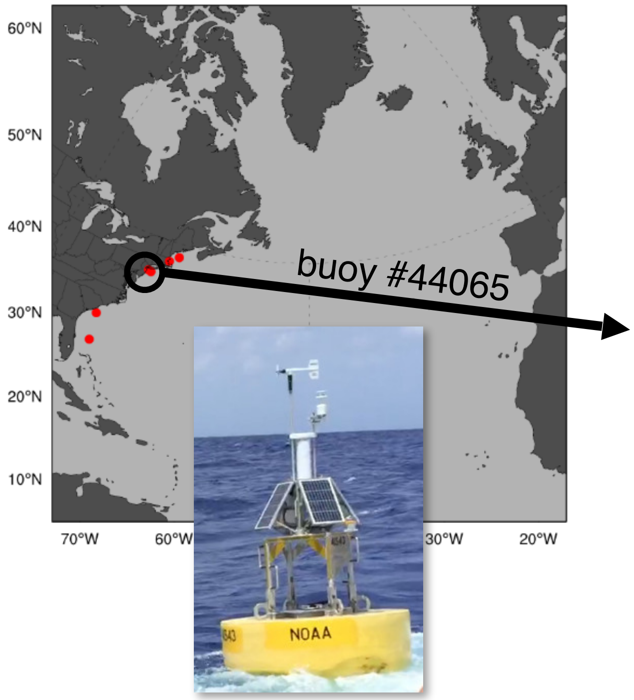
Nudging test for JAN 2010 (comparison to ERA-Interim)

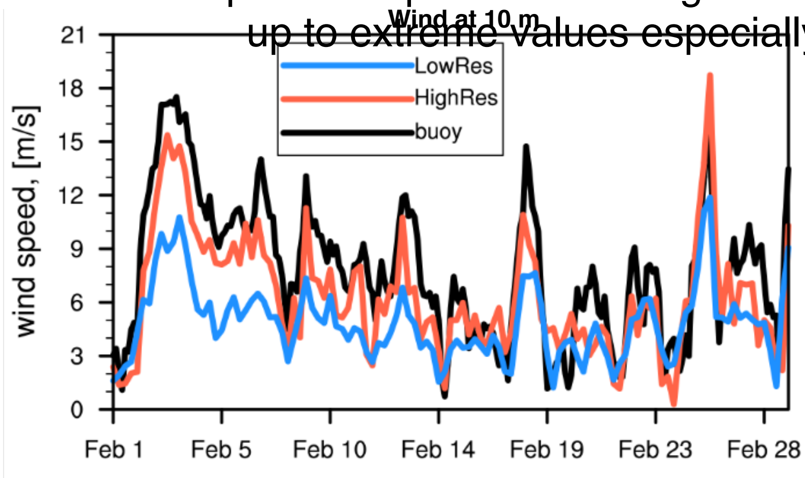


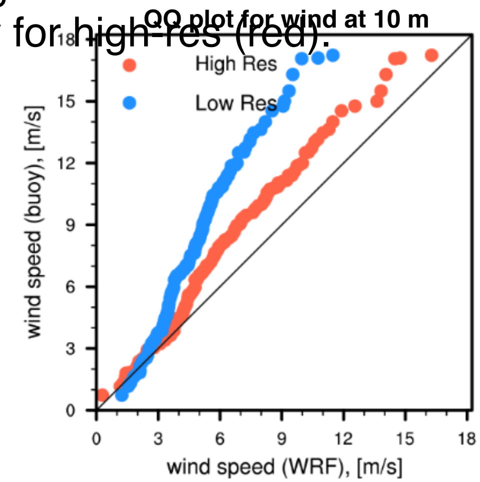
Validation - wind



Validation **against NDBC** (National Data Buoy Center) buoys

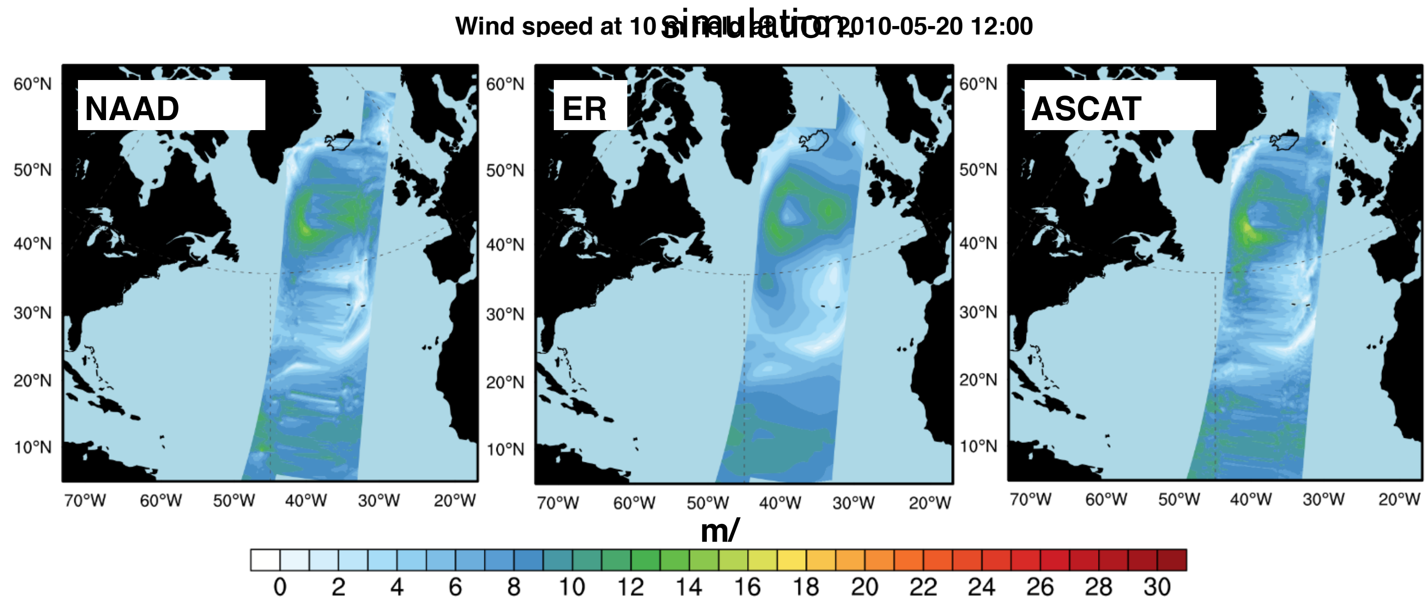
Grid-to-point comparison shows good agreement with observations up to extreme values especially for high-res (red).





Validation **against ASCAT/METOP-A** satellite data (12.5 km)

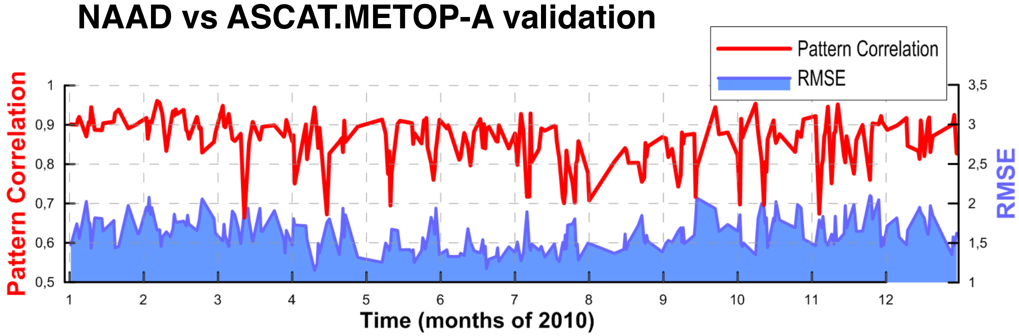
Wind speed at 10 m shows good agreement with observations for high-resolution simulation.



Validation

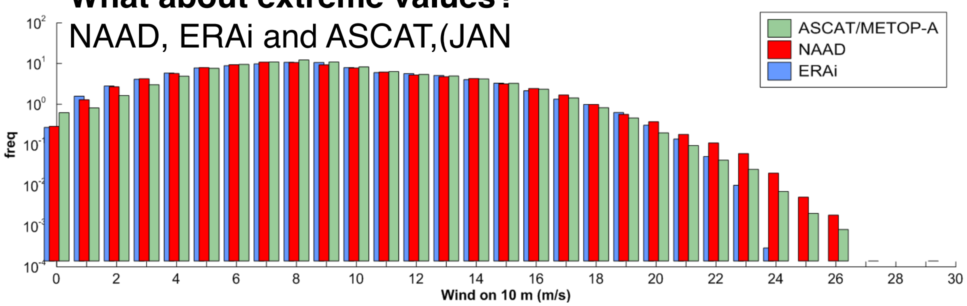
Validation against **ASCAT/METOP-A** satellite data (12.5 km) **Wind speed**

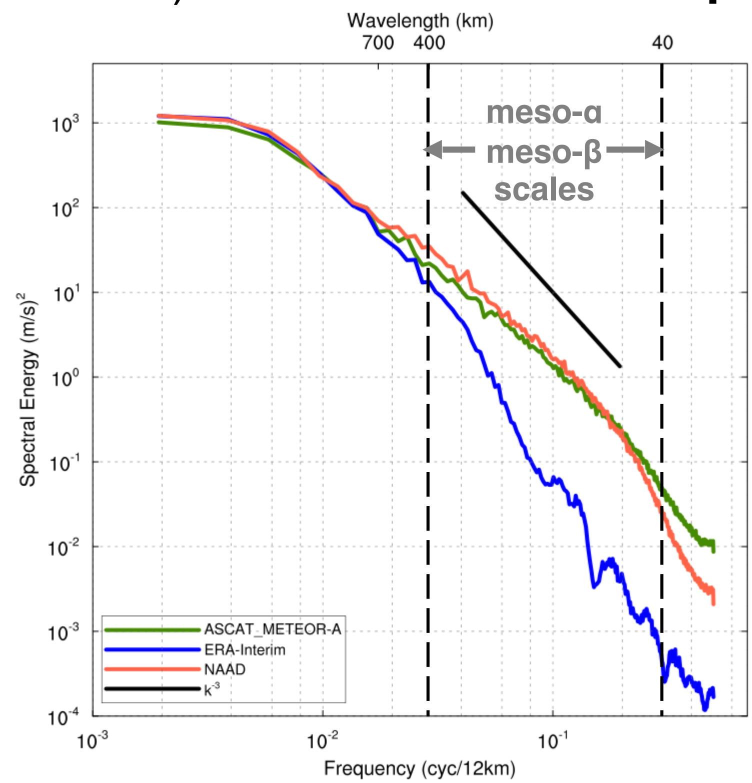
NAAD vs ASCAT.METOP-A validation



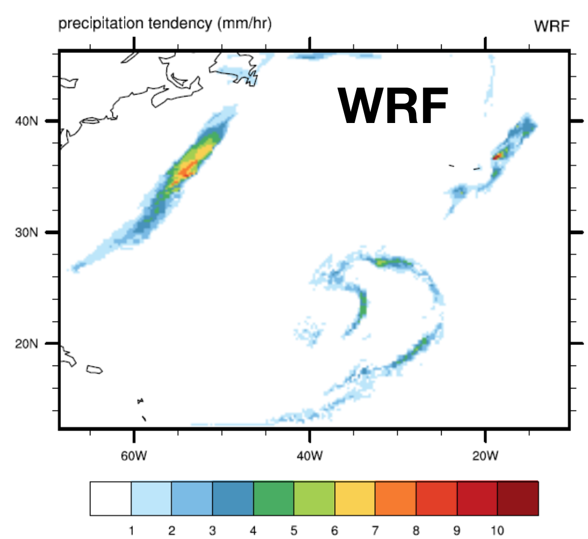
What about extreme values?

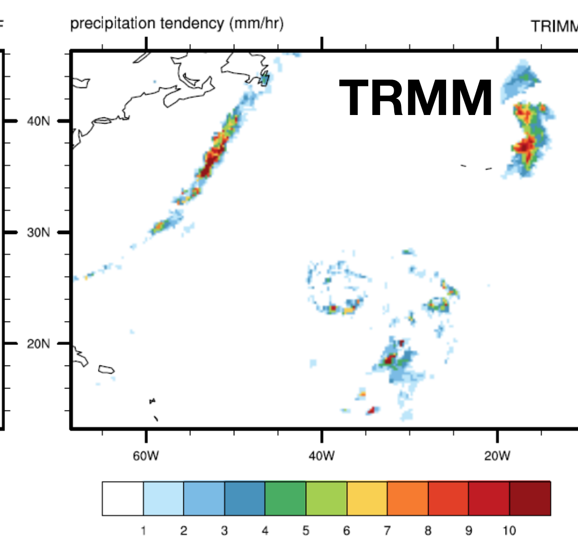
NAAD, ERAi and ASCAT,(JAN





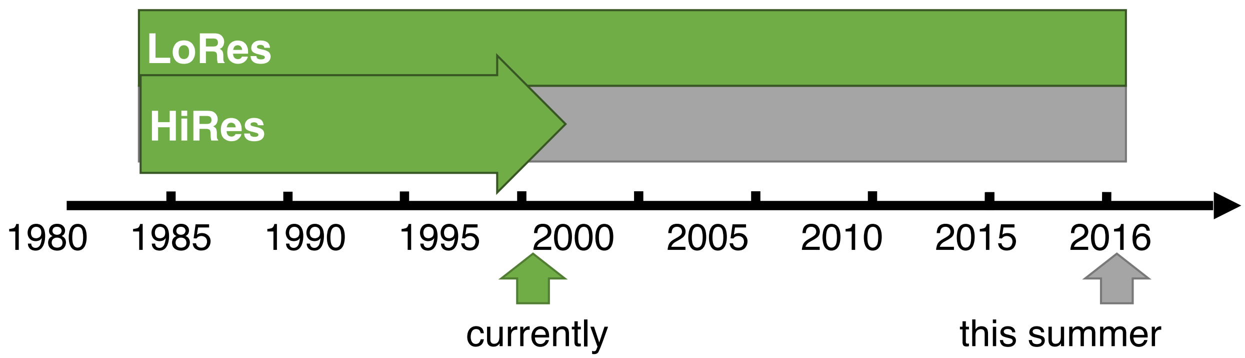
Precipitation
TRMM
(Tropical Rainfall Measurement Mission)





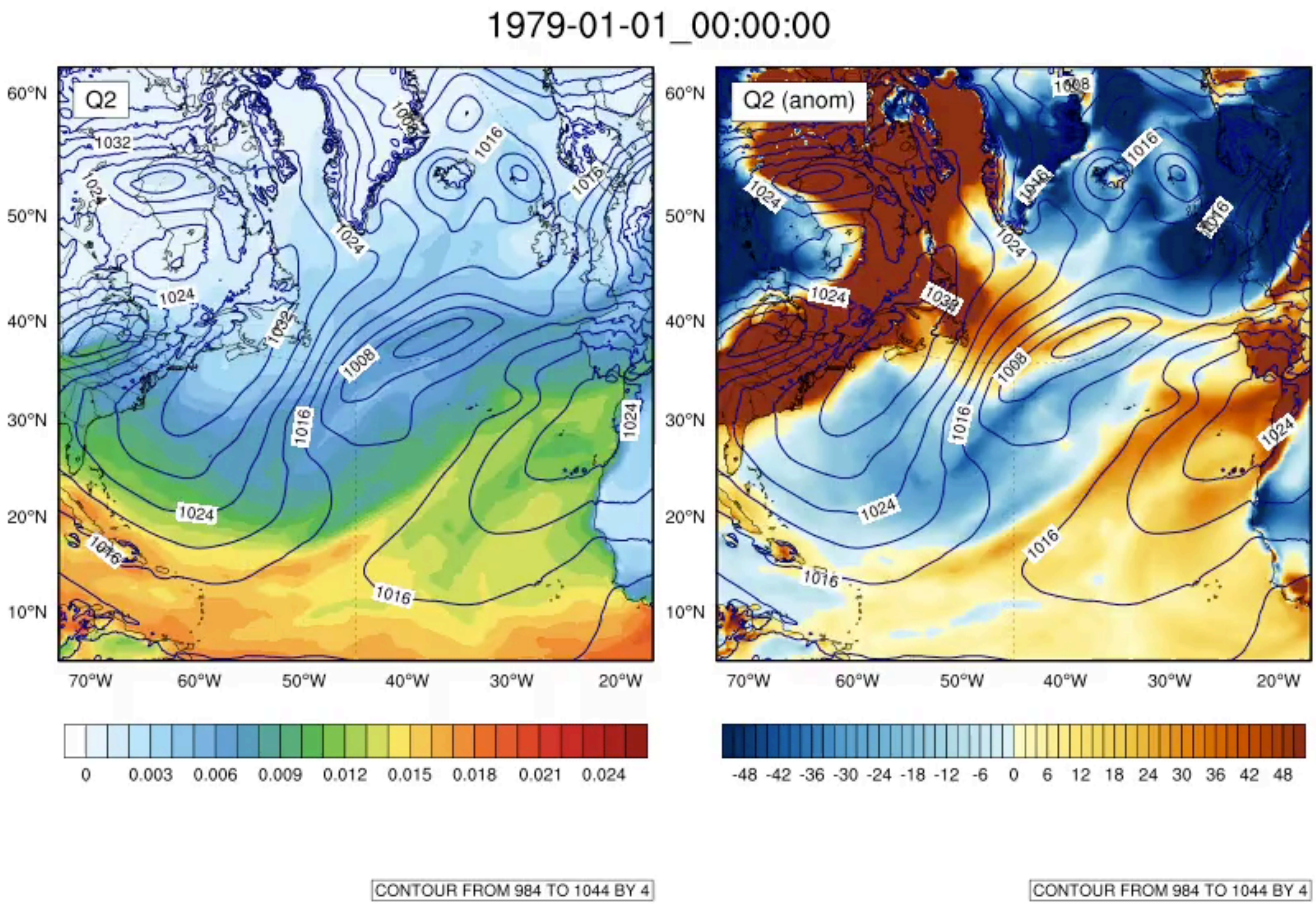
Progress

Currently High Resolution hindcast is not yet finished, but will be this summer!



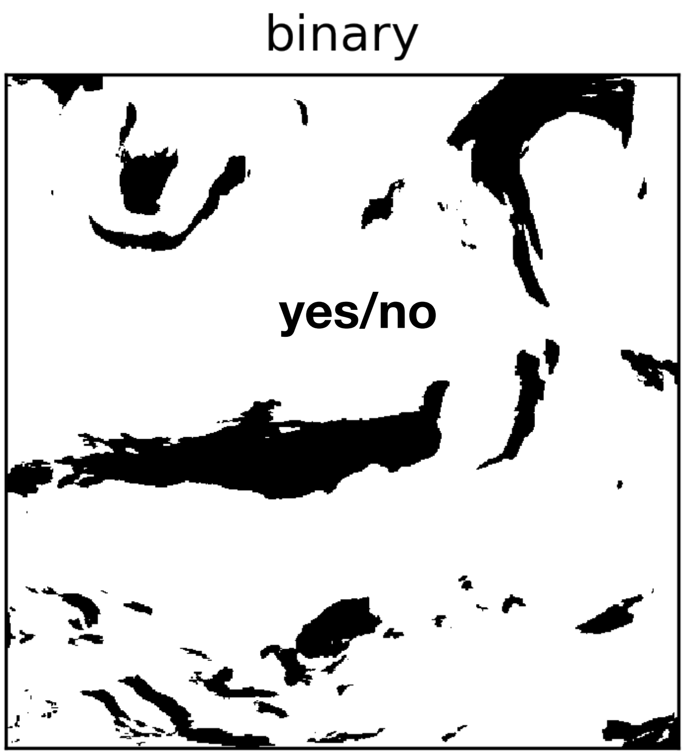
All analysis of ARs relates to the 1979 - 1997 period

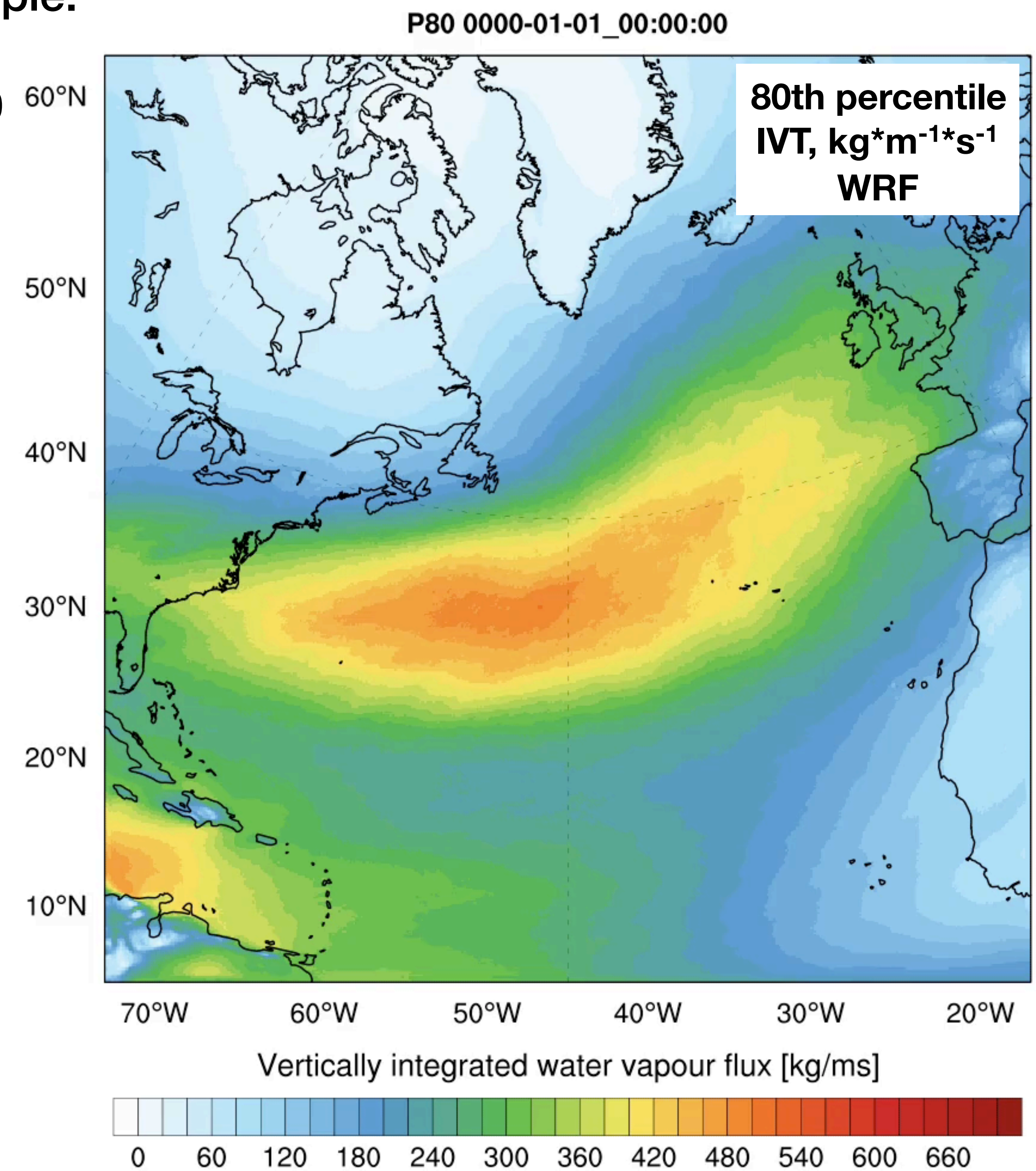
2 meter relative humidity - WRF hindcast



ARs detection, running percentile, 20 days window

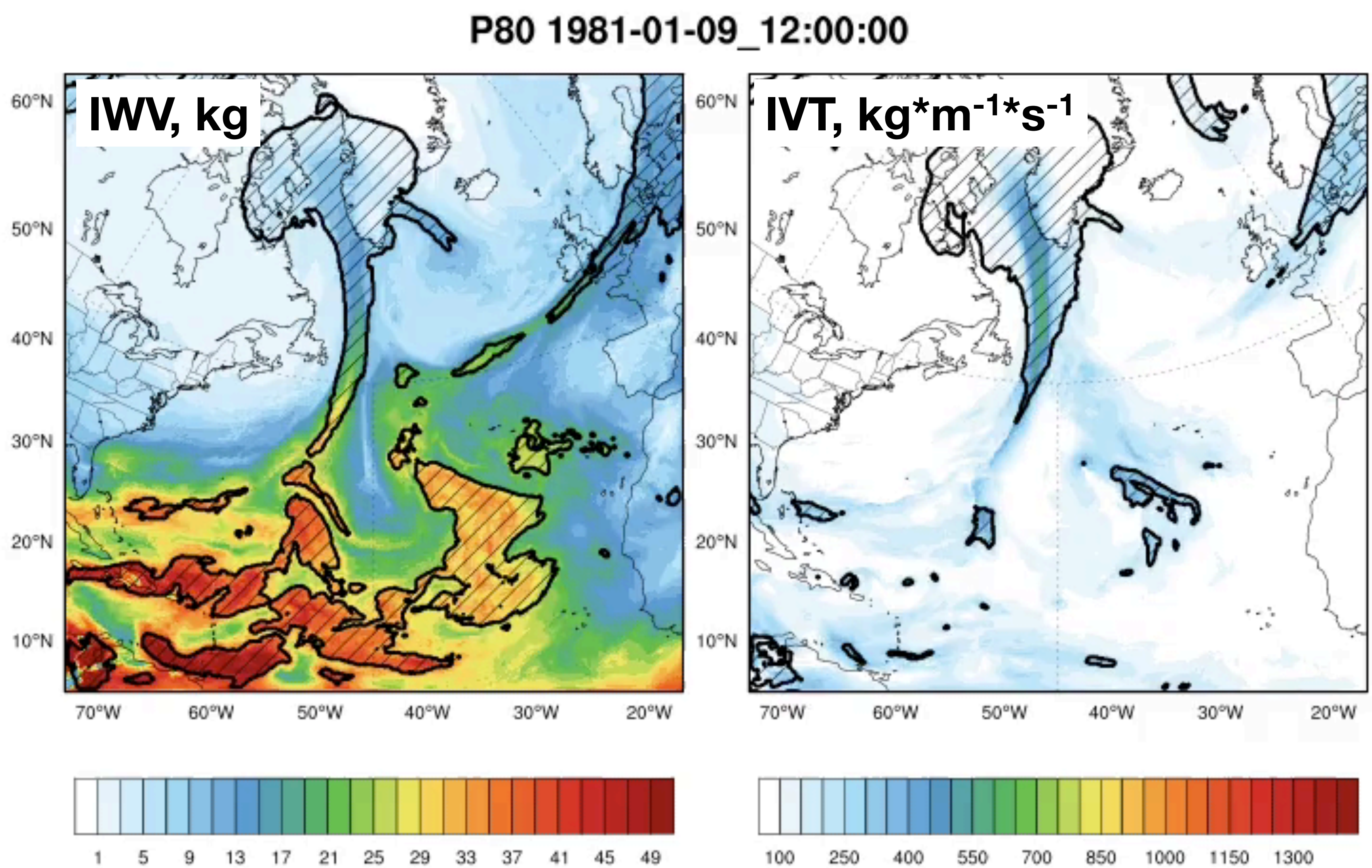
For the 03:00 20th of January we subsample:
11 - 30 January 1979 - 1997
20 days * 3h output * 19 years = 1140





ARs detection, running percentile, 20 days window

WRF hindcast



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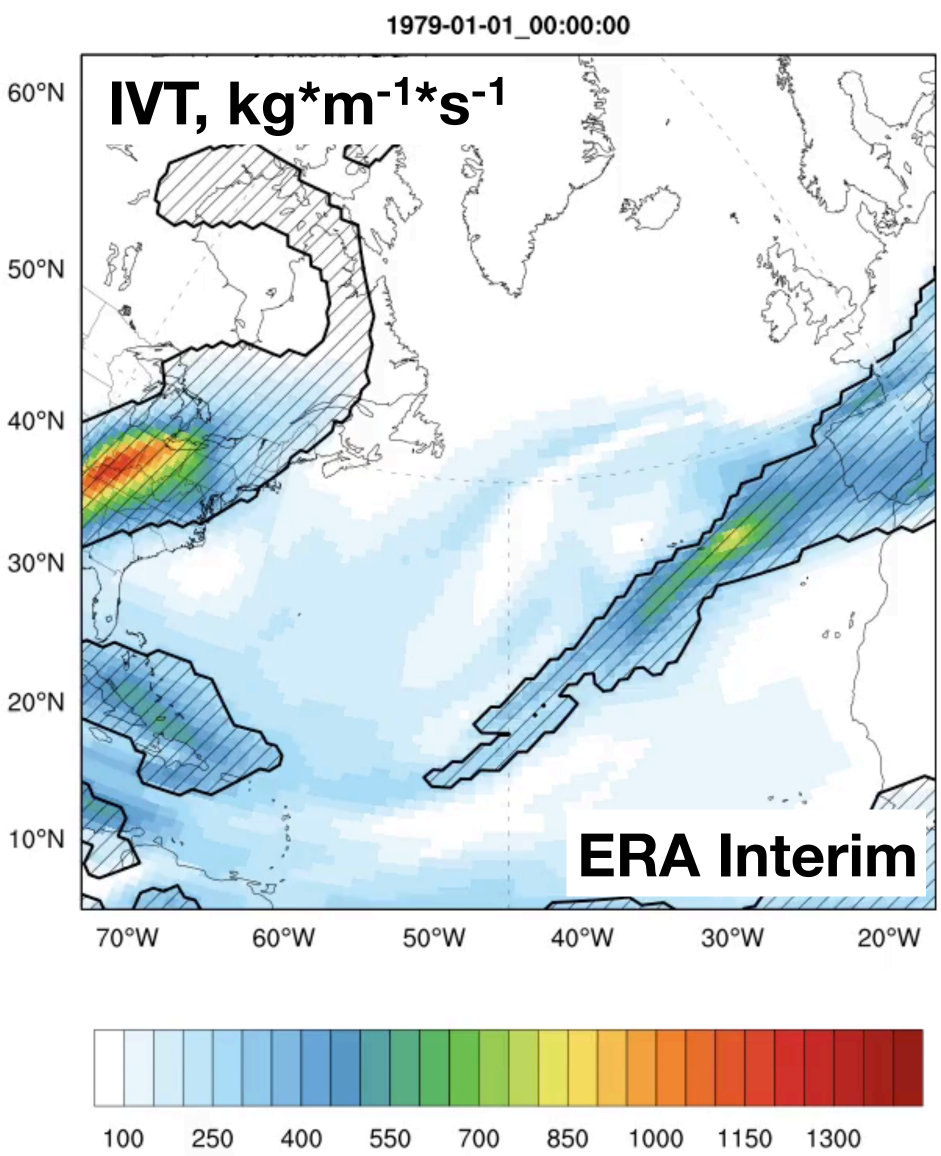
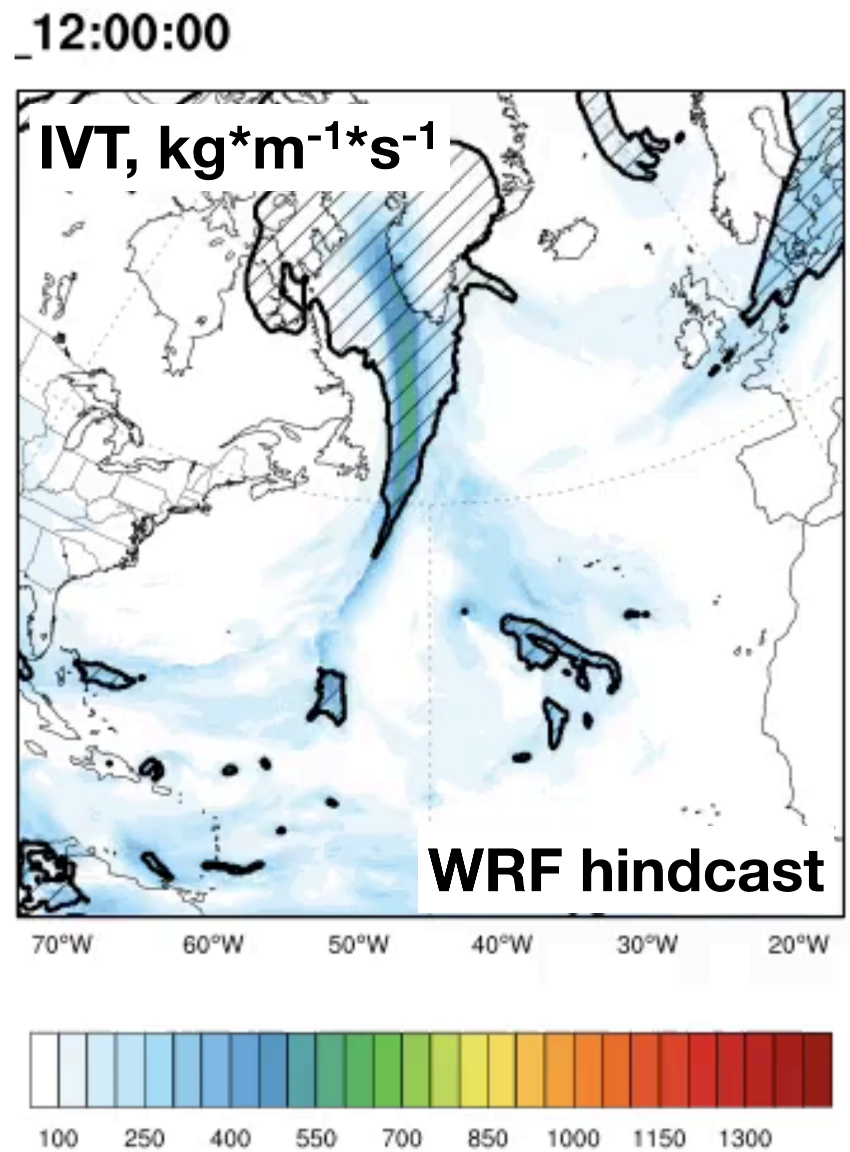
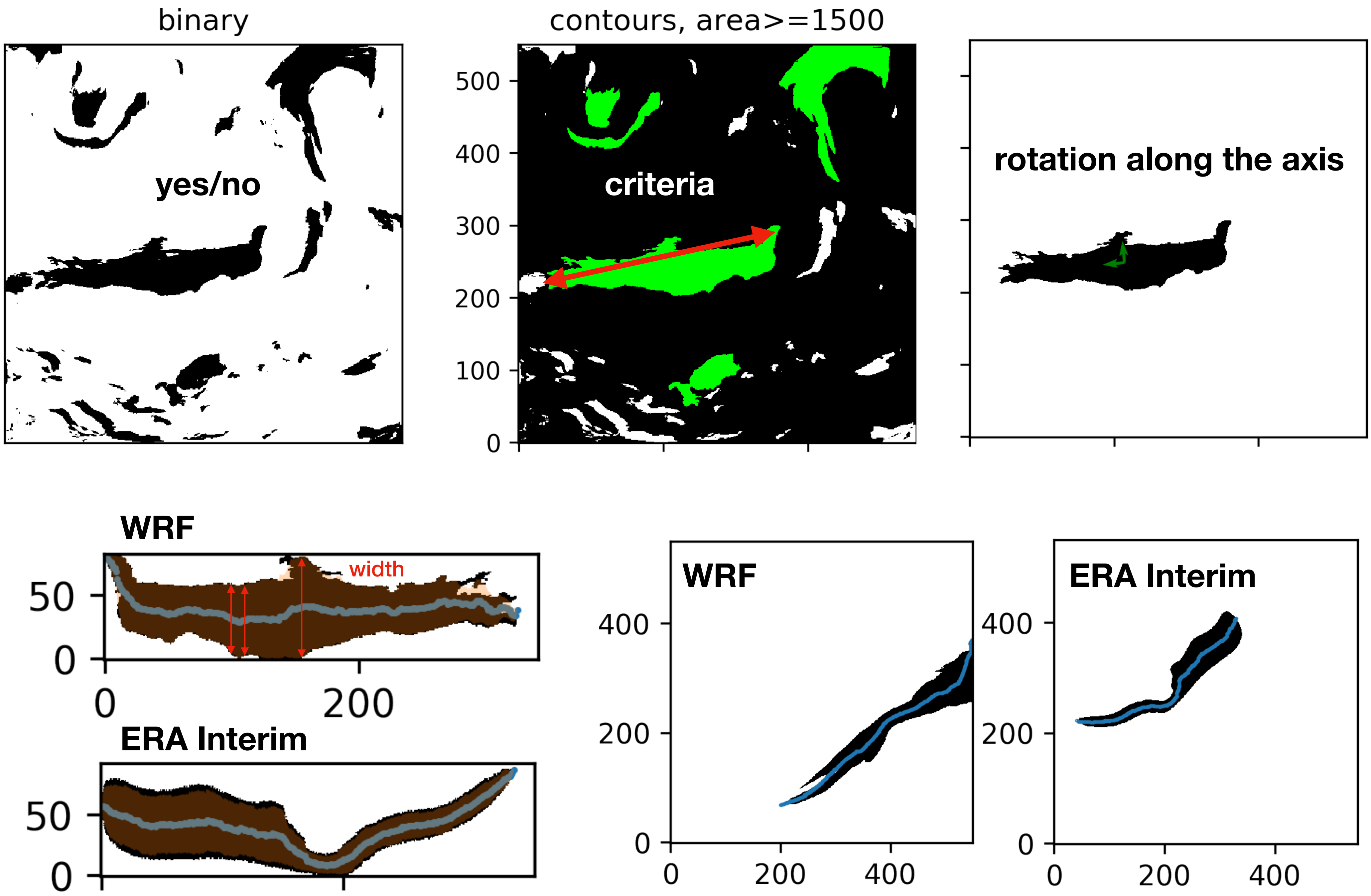
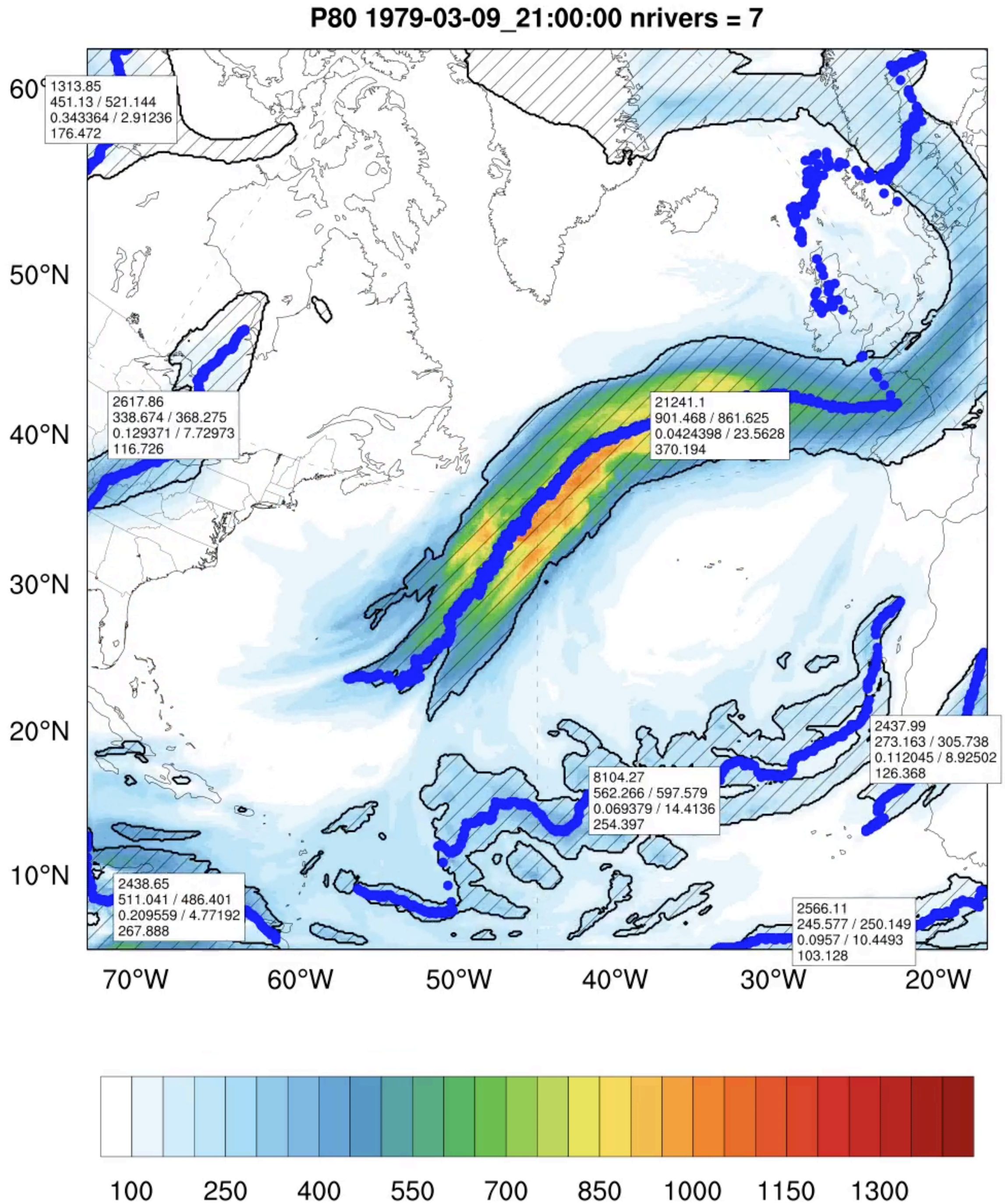




ARs identification, WRF hindcast snapshot



Progress

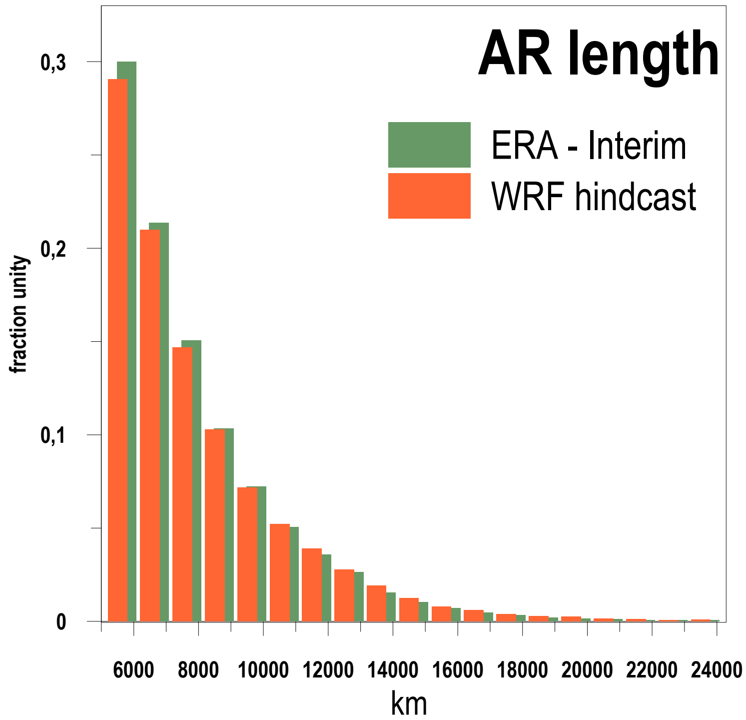


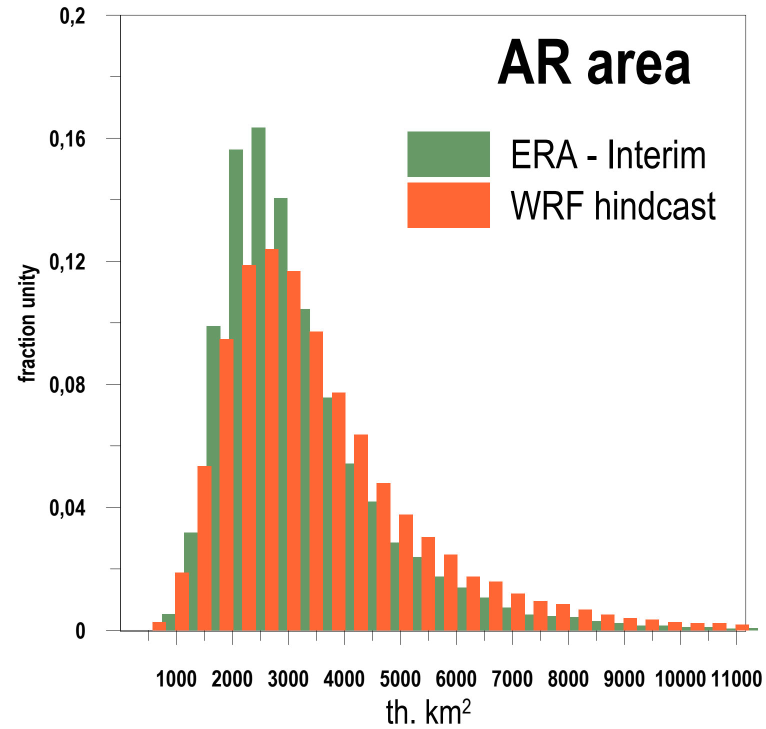
Set of criteria:

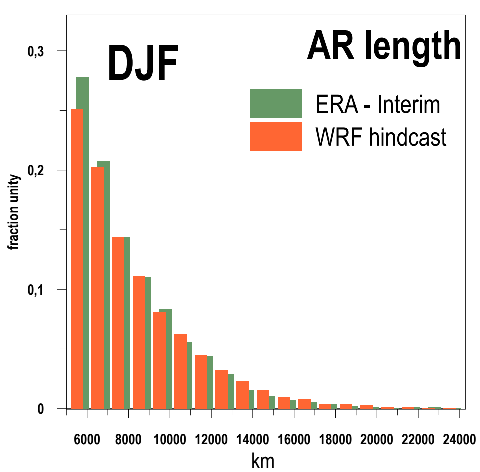
- > 5000 km length
- > 5 aspect ratio (length/width)
- > 25 average latitude
- > 100 $km*m^{-1*}s^{-1}$

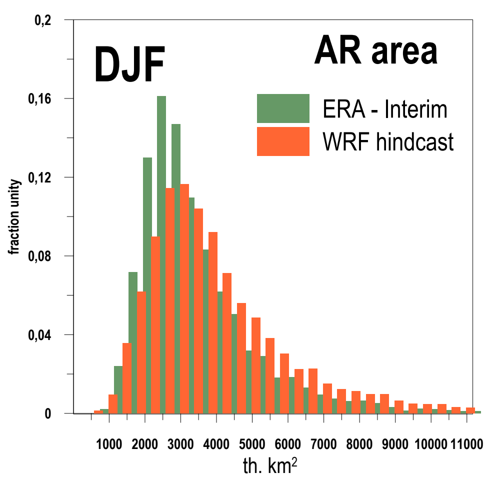
AR lifecycle characteristics

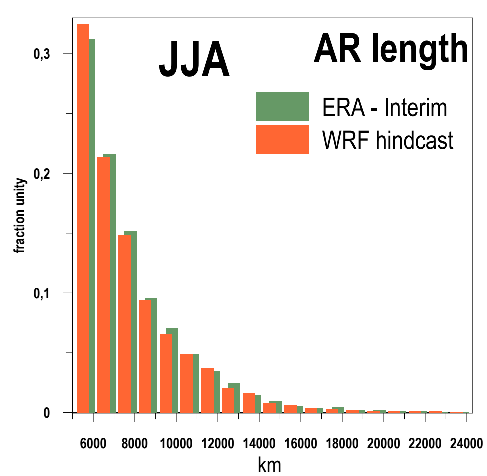
Annual

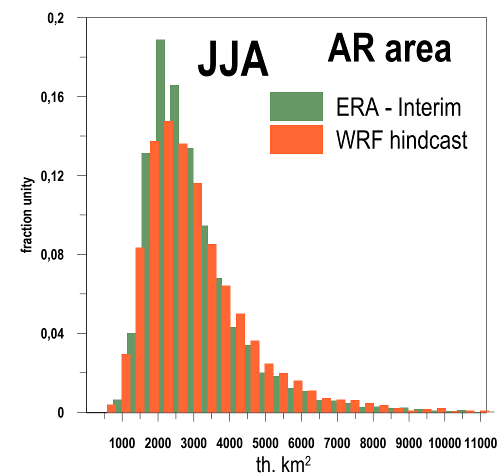












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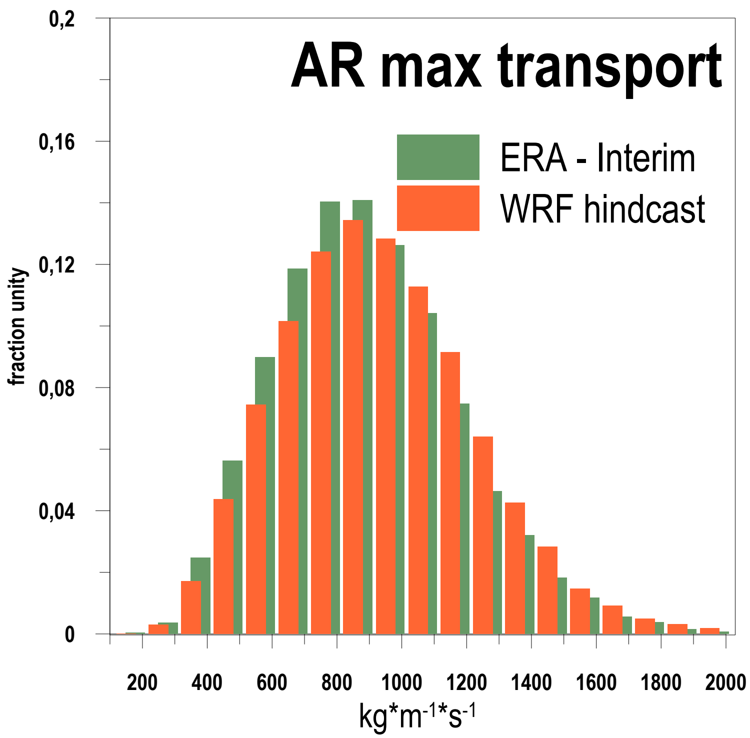
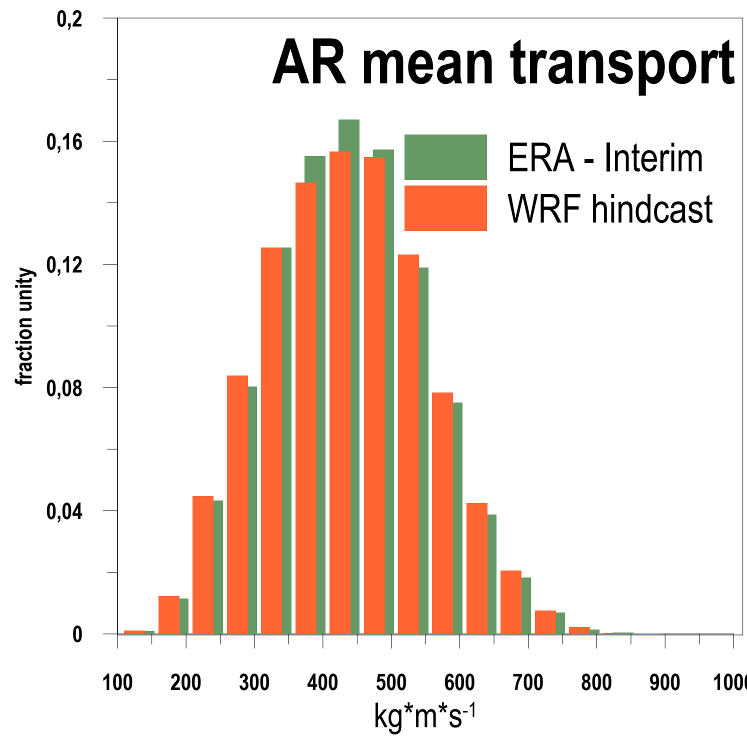
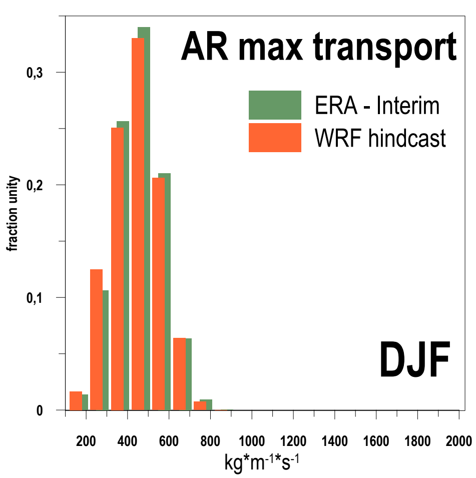
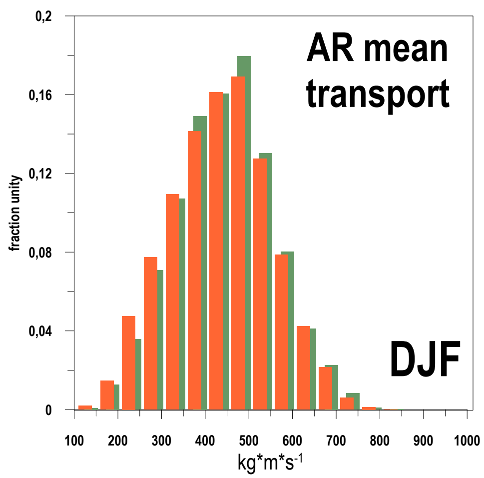
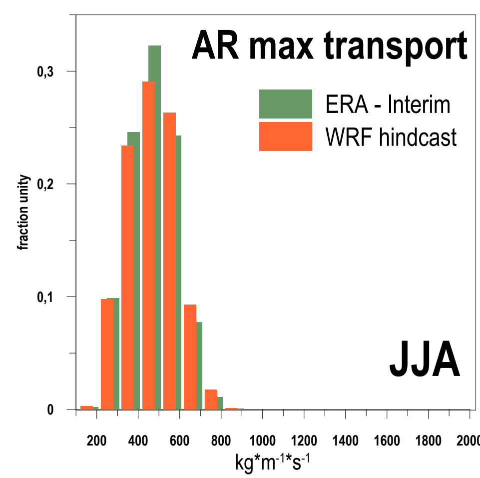
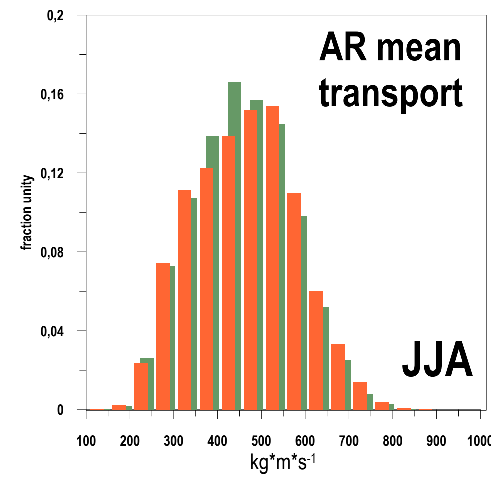






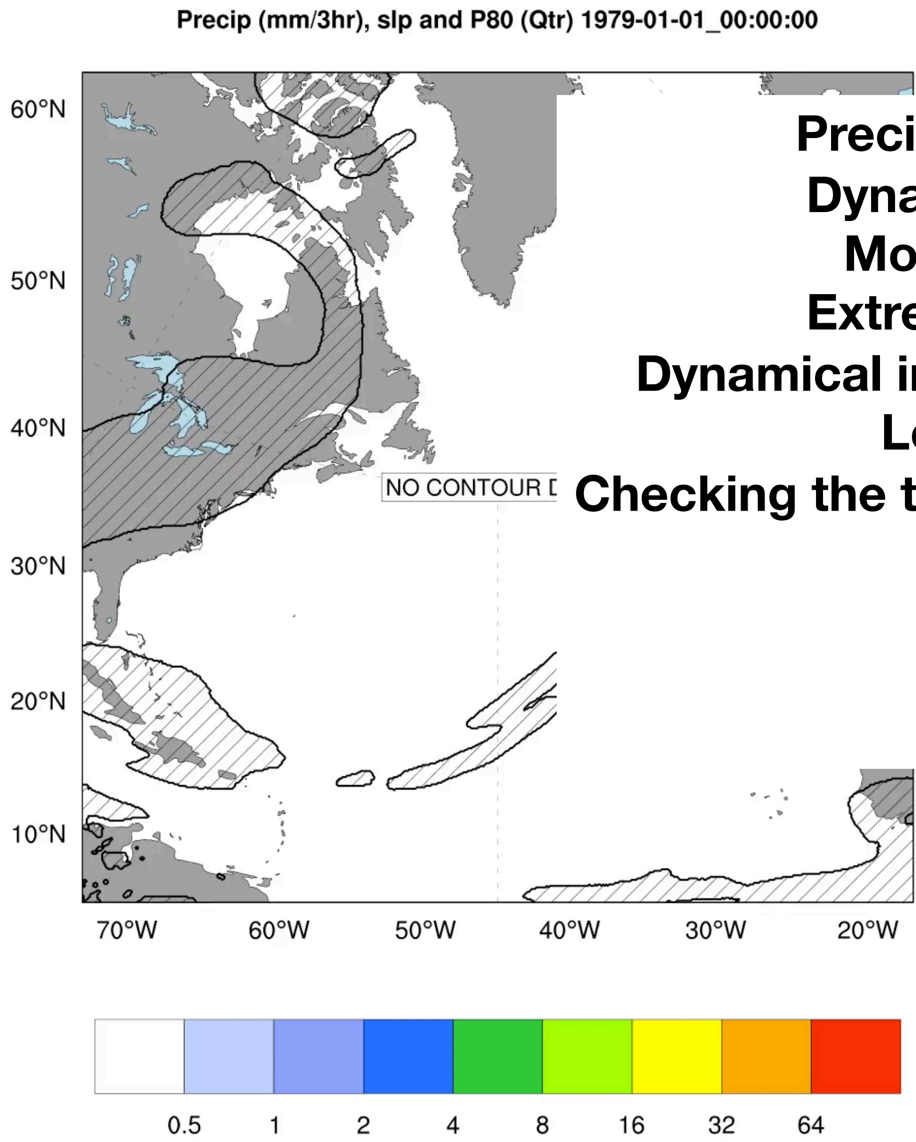




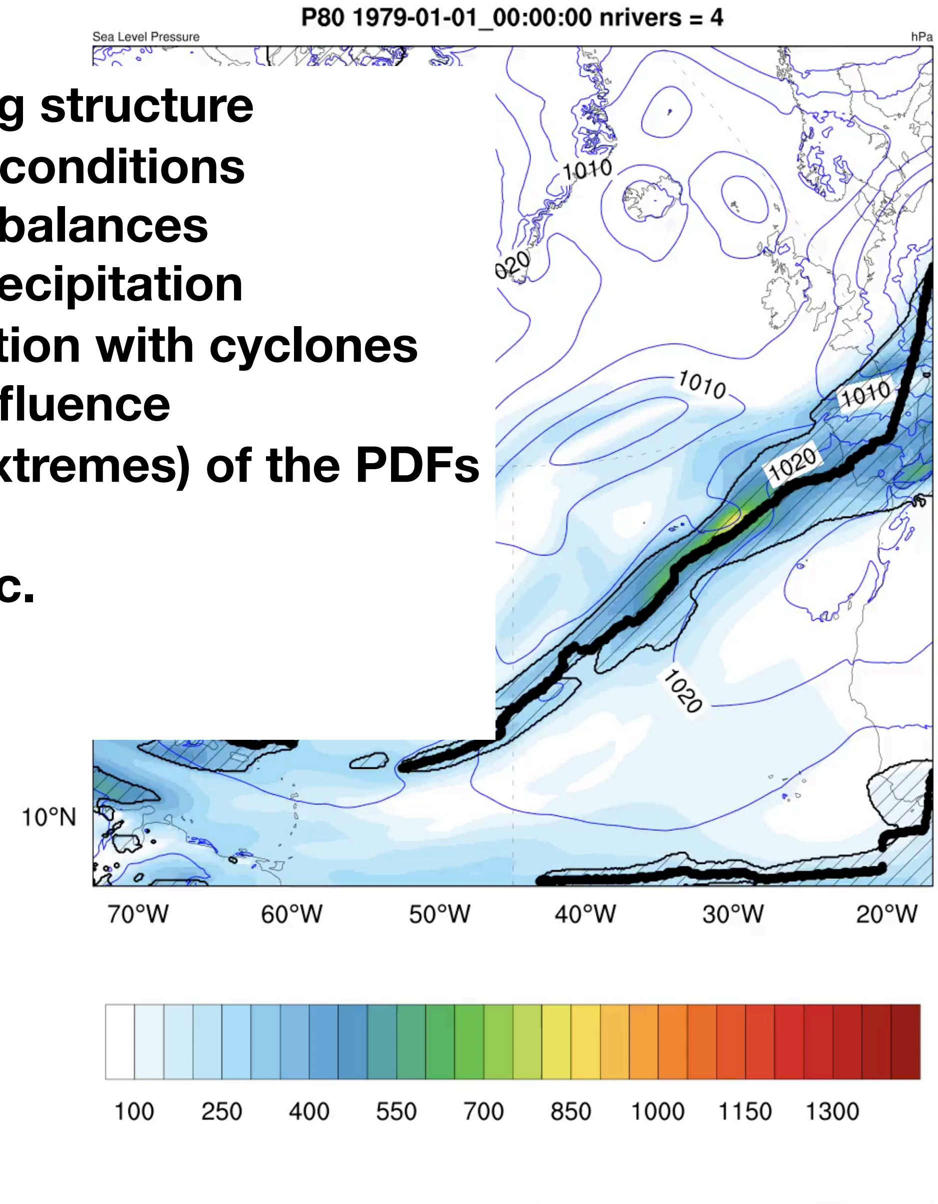


Further research

Precipitation



Synoptic conditions



Precipitating structure
Dynamical conditions
Moisture balances
Extreme precipitation
Dynamical interaction with cyclones
Local influence
Checking the tails (extremes) of the PDFs

etc.

Conclusions

- We present the North Atlantic Atmospheric Downscaling (NAAD) dataset, 14 km spatial and 3 hourly temporal resolution for period of 1979 - ongoing (1997 currently)

- Validation with observational dataset shows good representation of windspeed extremes and small scale precipitation patters

- Procedure of Atmospheric Rivers identification, based on running percentiles and bounding areas detection

- Intercomparison with forcing dataset (ERA Interim) shows general agreement in characteristics of ARs with heavier tails in WRF hindcast (extremes!)

- WRF hindcast adaptation to various regions

- Allows for comprehensive analysis of general atmospheric circulation (e.g. cyclone tracking)

- Advantage of resolving mesoscales

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