Scatterometer Assimilation Experiments with HARMONIE

In the framework of IPMA/KNMI cooperation in scatterometry

Isabel Monteiro

Thanks to:

Gert-Jan Marseille, Ad Stoffelen, Jur Vogelzang

Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment

The EUMETSAT Network of Satellite Application Facilities

NWP SAF
Numerical Weather Prediction

what is done so far

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Outline

- Objectives
- Observing System Experiments (OSE) with mesoscale HARMONIE model
- Preliminary results
- Work to be done

Objectives and motivation

Many meteorological conditions over Portugal are generated in the Atlantic:

- Meteorological observations over the Atlantic are scarce.
  - NWP forecasts rely on accurate determination of the model initial state.
  - Observed winds are expected to contribute to a better model initial state.
  - Scatterometers provide regularly a large number of wind observations near the ocean surface.

Can scatterometer winds be used in DA for an improved estimate of the model initial state (namely for a domain over Iberia)?

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HARMONIE model

(Hirlam ALADIN Research on Meso-scale Operational NWP in Euromed)

Domain: IBERIAxxm_2.5

B Matrix, thanks to AEMET

- Non-Hydrostatic
- Cy40h1.1
- 800 (lon) X 648 (lat) grid
- 2.5 km grid size
- 65 vertical levels
- 3D-Var Assimilation
  - 8 times per day
  - 24-hour forecast
- ECMWF boundaries

All Experiments ran at ECMWF

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OSE

Experiment	Data Assimilated
Iberia_EXP0	Conventional
Iberia_EXP1	No observations
Iberia_EXP2	Conventional+ ASCAT-coastal (MetOp-A and MetOp-B) with data thinning (default setting in HARMONIE)
Iberia_EXP3 ??	Conventional + ASCAT-coastal + OSCAT-50/25
Iberia_EXP2a ??	Conventional + ASCAT-coastal (MetOp-A and MetOp-B) with no thinning

CONTROL

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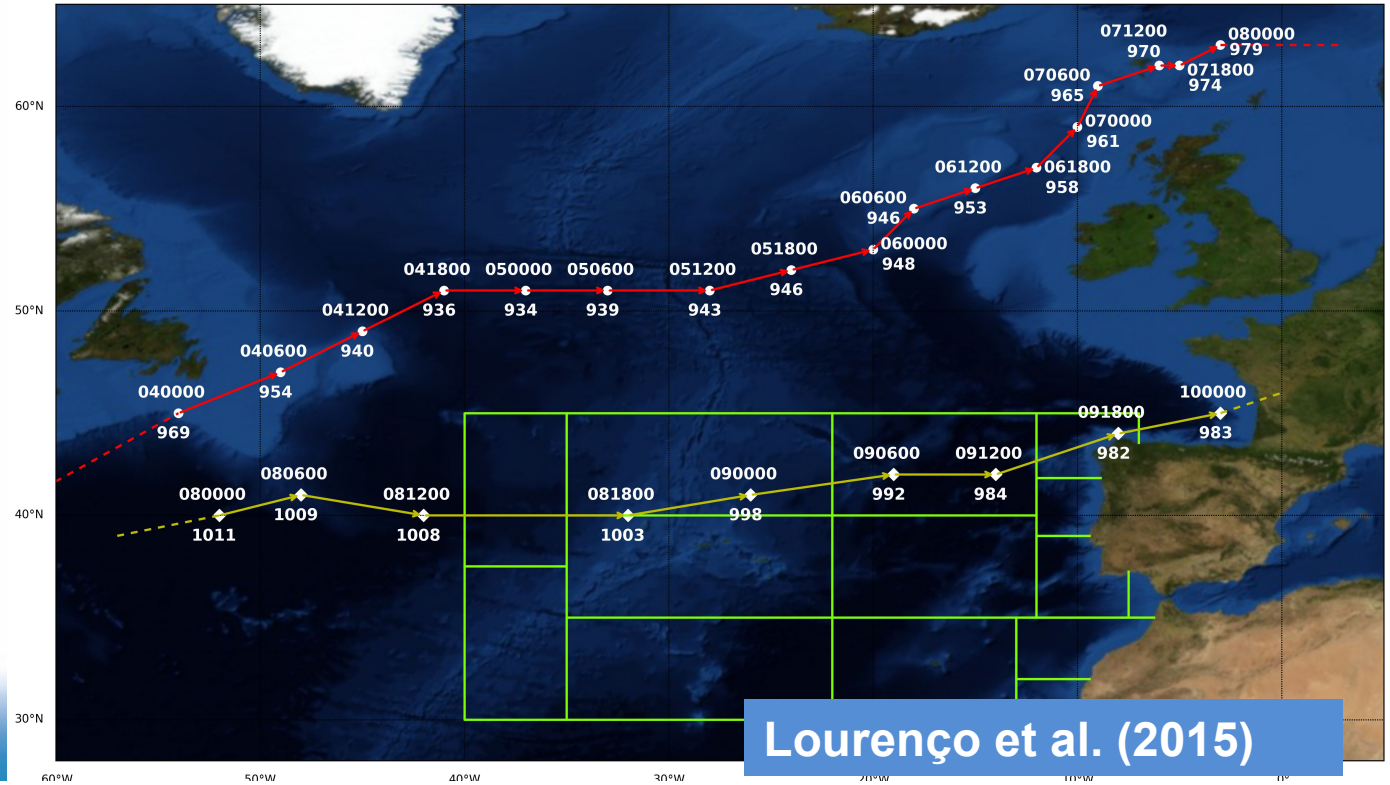
OSE

- 6 day period 06-02-2014 to 11-02-2014 which included the “Stephanie storm”
- High wind speeds at Iberia north coast
- 20 m wave heights registered at Estaca Bares Buoy
- Nice case: 4 scatterometers in orbit during this period



Lourenço et al. (2015)

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Data description - conventional

- Upper air observations:
  - radiosonde (TEMP)
  - aircraft reports (AIREP)
  - AMDAR, aircraft reports but according to WMO specifications
- Surface observations:
  - SYNOP
  - Drifting buoys
  - SHIPS

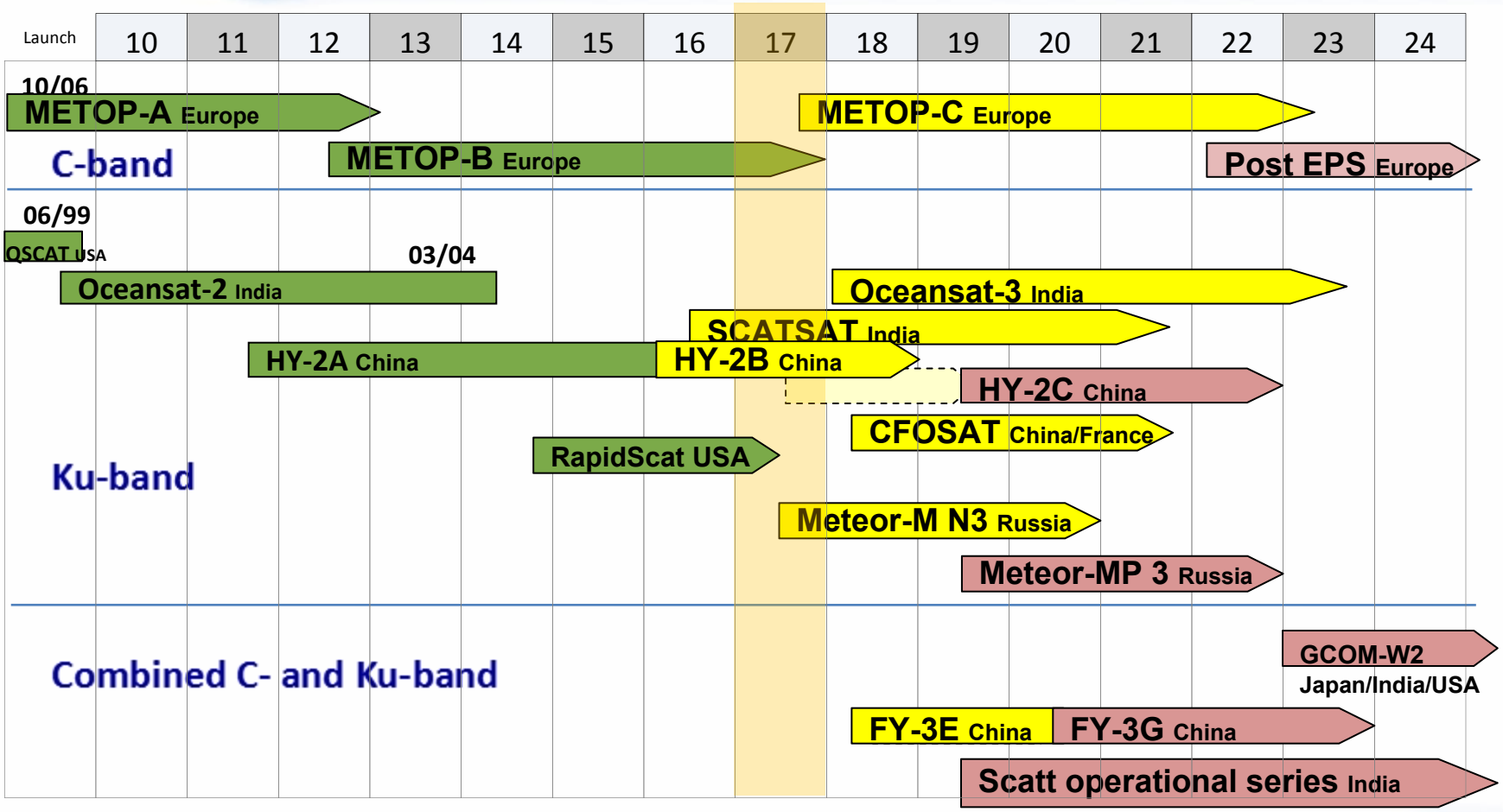
Data description-Scatterometres

Scatterometers are radar instruments, providing estimates of wind speed and direction near the sea surface.

- **ASCAT** - European C-band scatterometers onboard Metop-A and Metop-B satellites. Sun-syn orbit Local time (equator crossing) 09:30 UTC, 12.5 km sampling
- **OSCAT** - Indian Ku-band scatterometer on Oceansat-2 satellite Sun-syn 12:00 UTC, 50 km(use 25 km ??) sampling (use for verification only??)
- **HSCAT** (for verification purposes only) Sun-syn 06:00 UTC 25 km sampling

sampling ≠ resolution in the case of ASCAT-coastal product used in this study is about 28 km

Data description-Scatterometres



Source: WMO OSCAR database and direct interactions with agencies

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Committee on Earth Observation Satellites

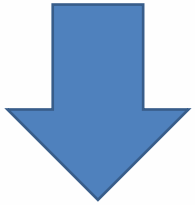
Data description-Scatterometres

- **Challenges to scatterometer DA (Marseille and Stoffelen, 2016):**
  - In 3D-Var, all observations within the assimilation window are used as if they were made at analysis time, not true for ASCAT and other scatterometres. In 3-hour cycling observations are used when measured within ±1.5 hours from analysis time
  - ASCAT estimates are not point observations but area averages and this is not taken into consideration in the observation operator H matrix (maybe a good approximation for a global hydrostatic model, but probably not the case for mesoscale models)

HARMONIE with a 2.5 km grid has a effective resolution of 15-20 km, higher than ASCAT 28 km effective resolution and much higher than Ku band scatterometers

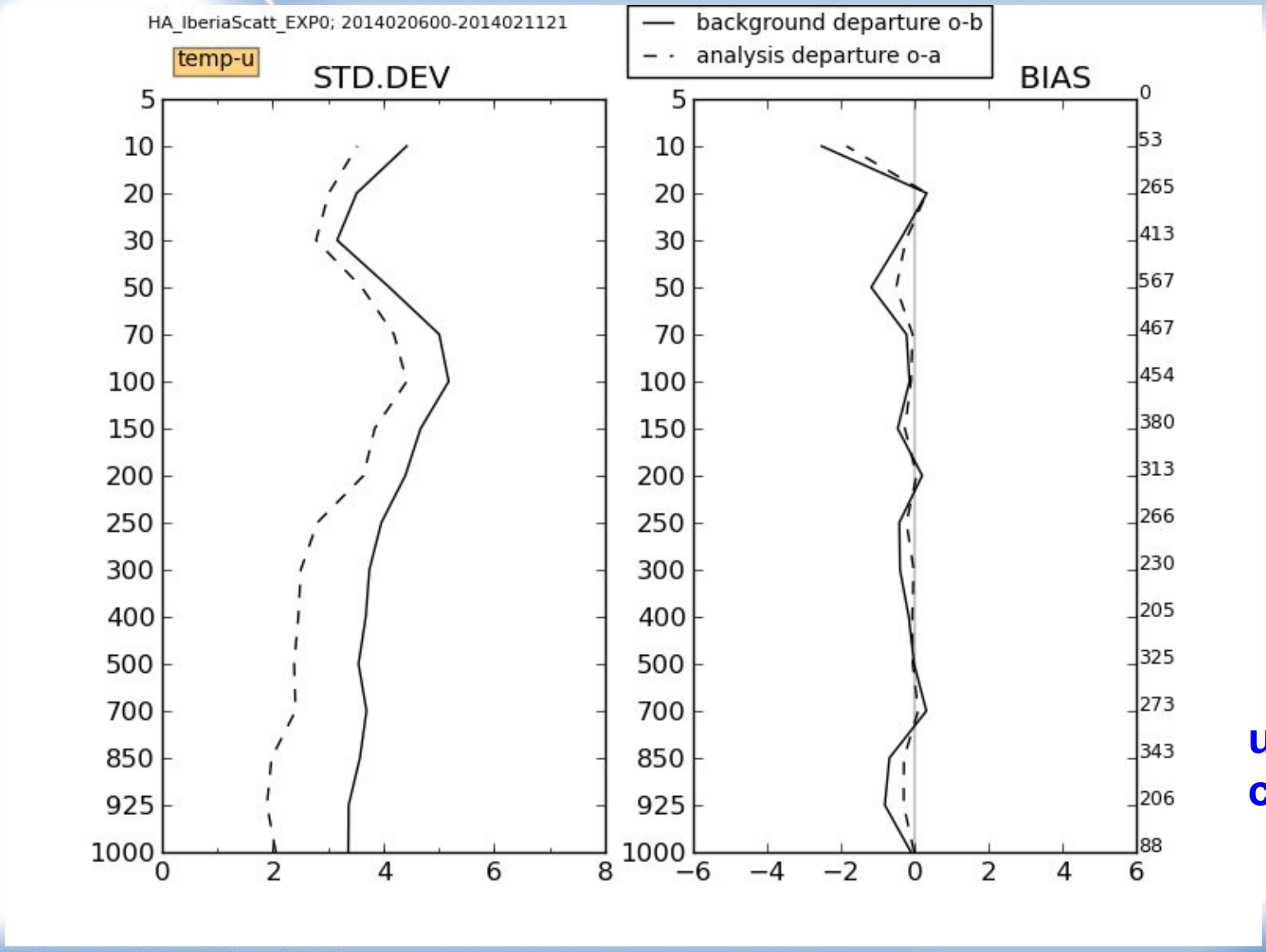
Preliminary Results

- A well-tuned DA system pulls the model state towards the true atmospheric state not only on observation locations, but also in non-observed regions.



- Do model simulations at analysis time (fc=0) compare best with observations?

Radiosondes (EXP0)



u component

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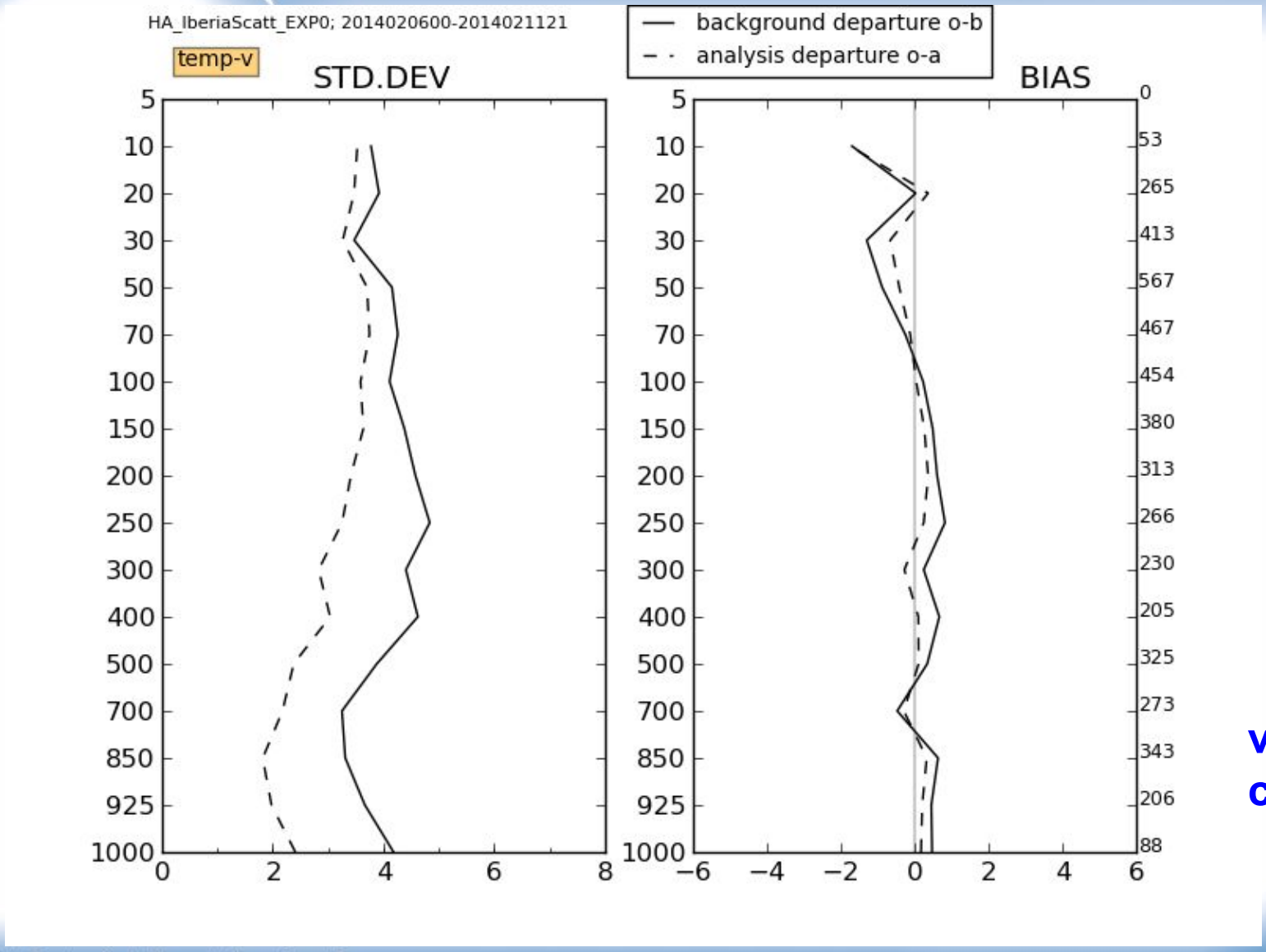
Radiosondes (EXP0)



v component

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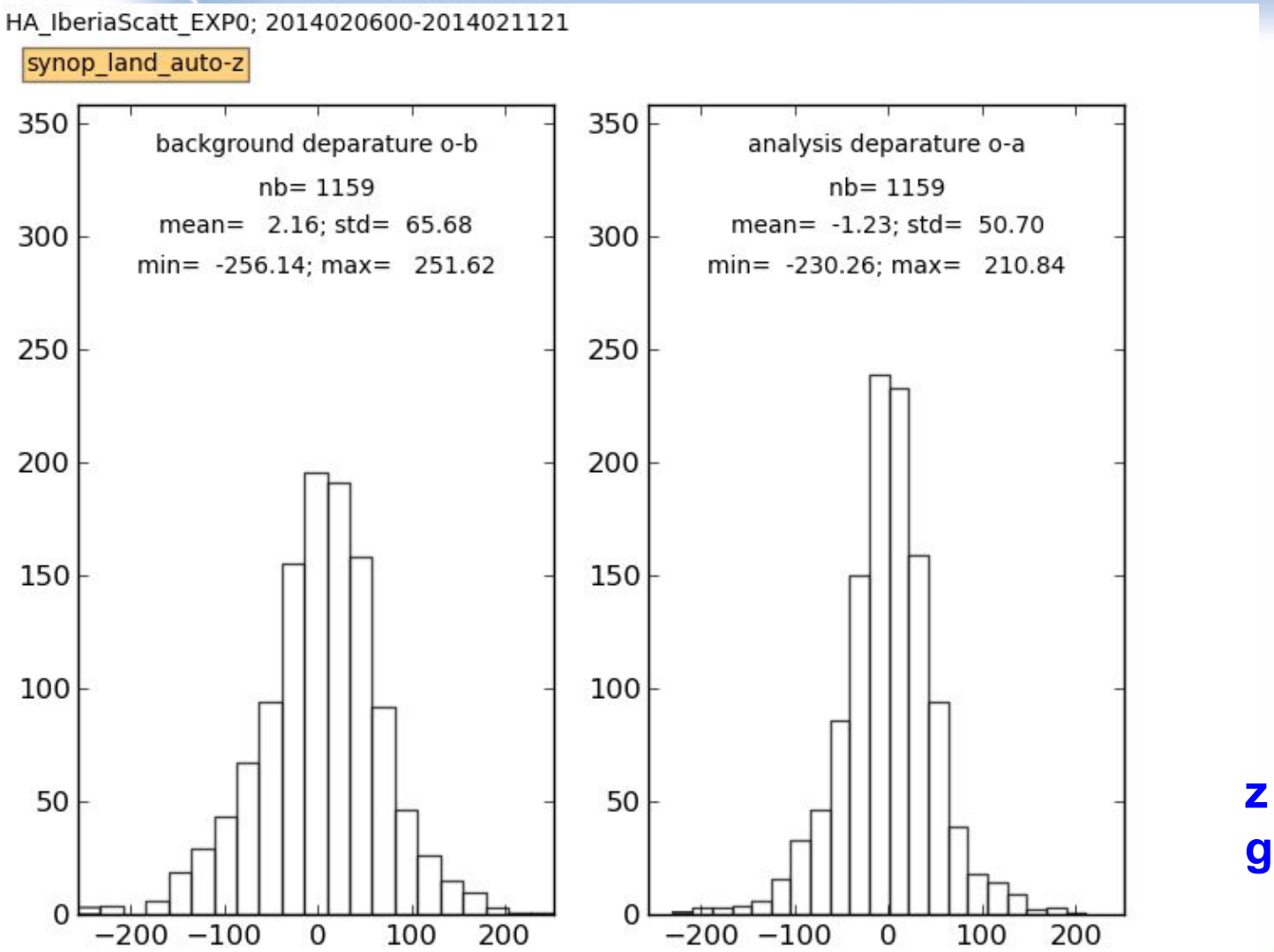
SYNOPs Land (EXP0)



z
geopot.

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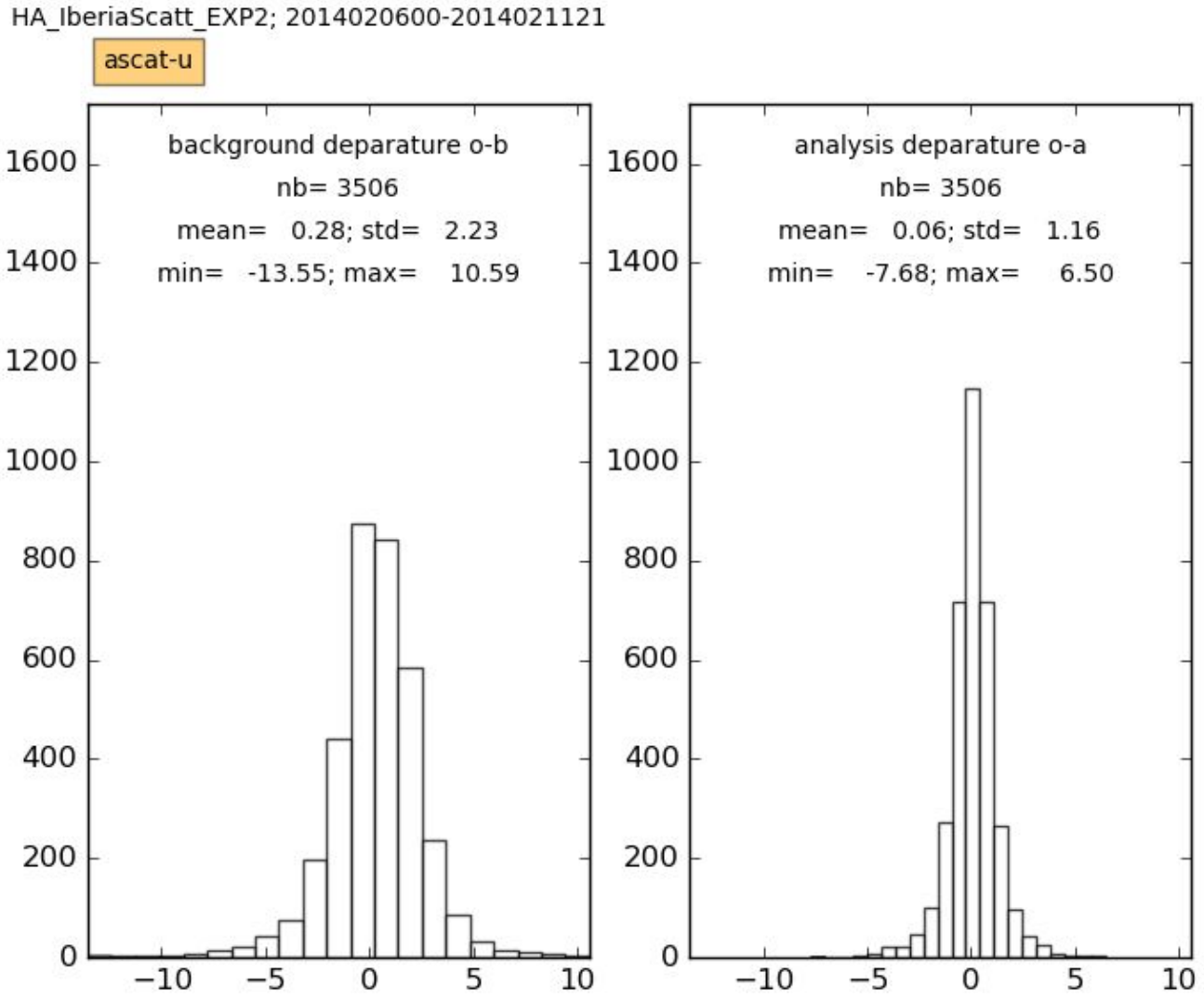
ASCAT (EXP2)



u component

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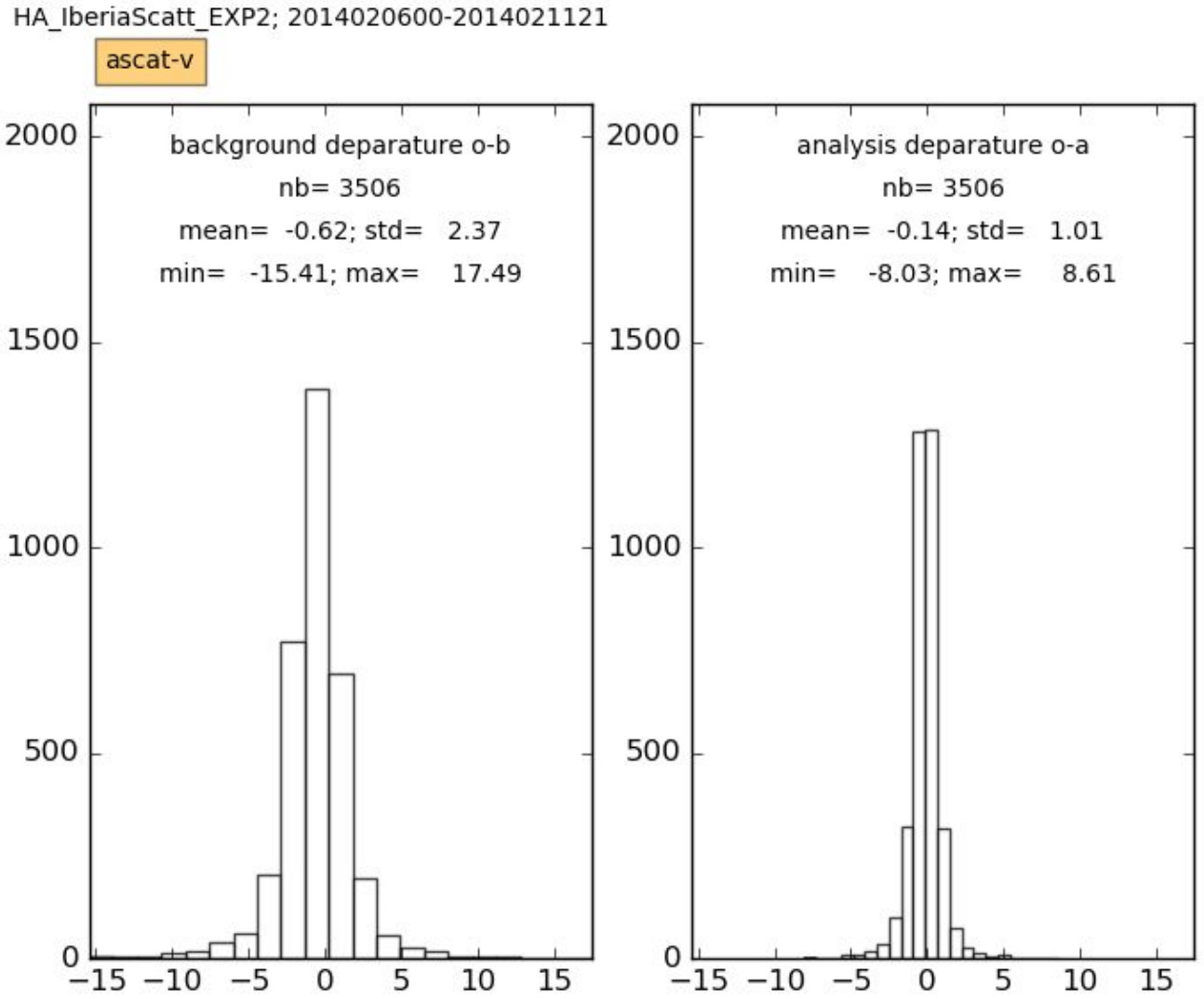
ASCAT (EXP2)



v component

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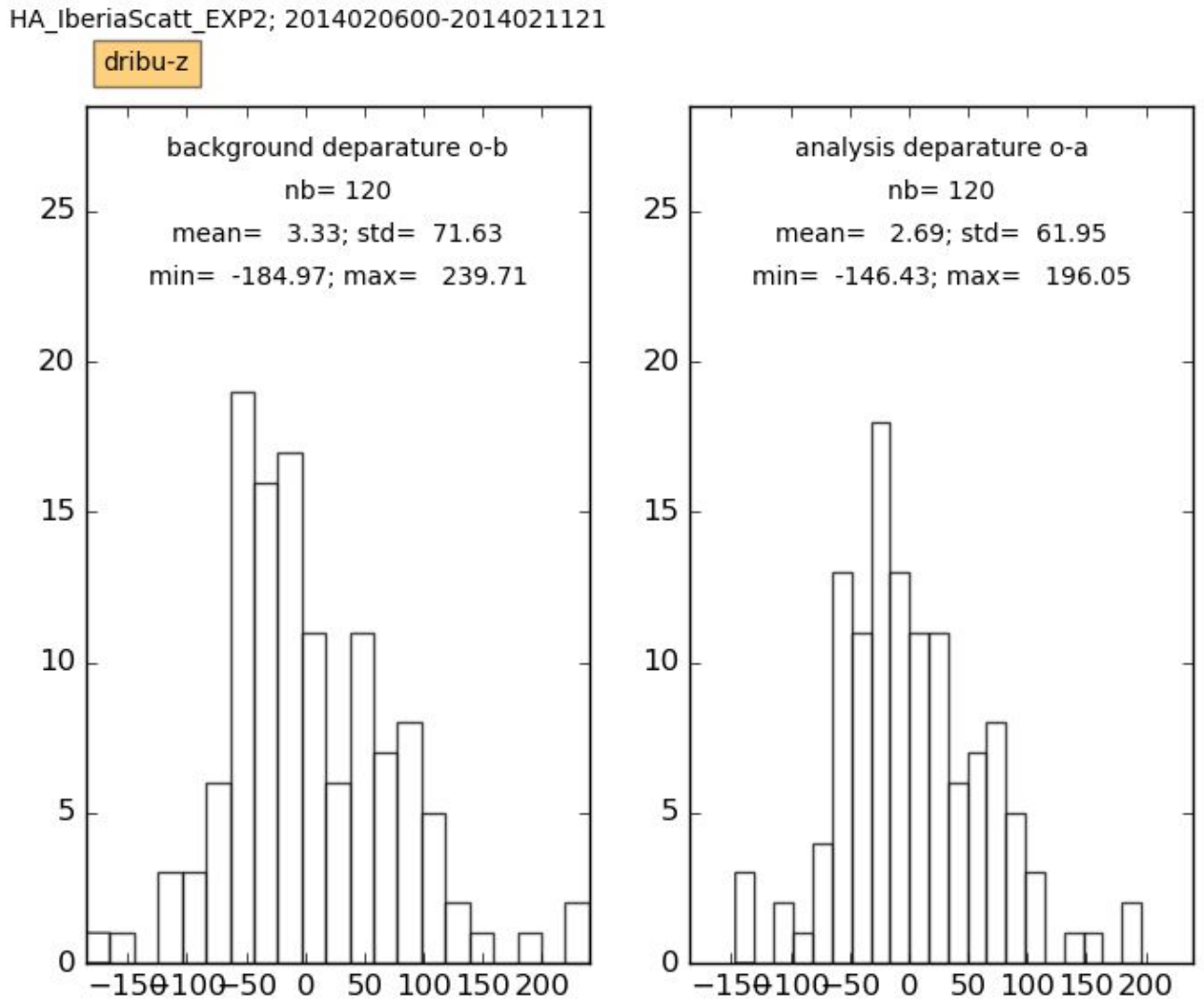
DriBuoys (EXP2)



z
geopot.

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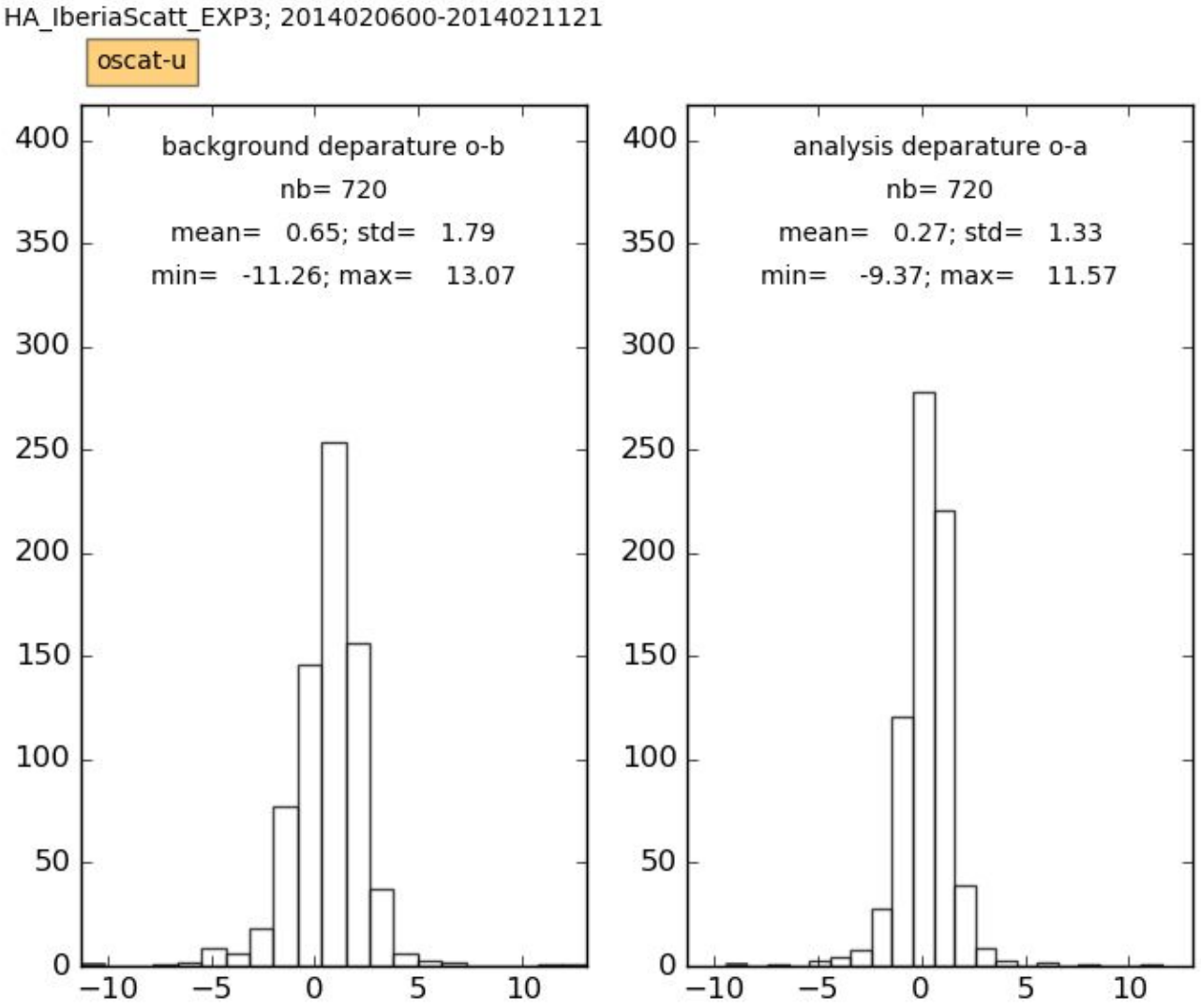
OSCAT (EXP3)



u component

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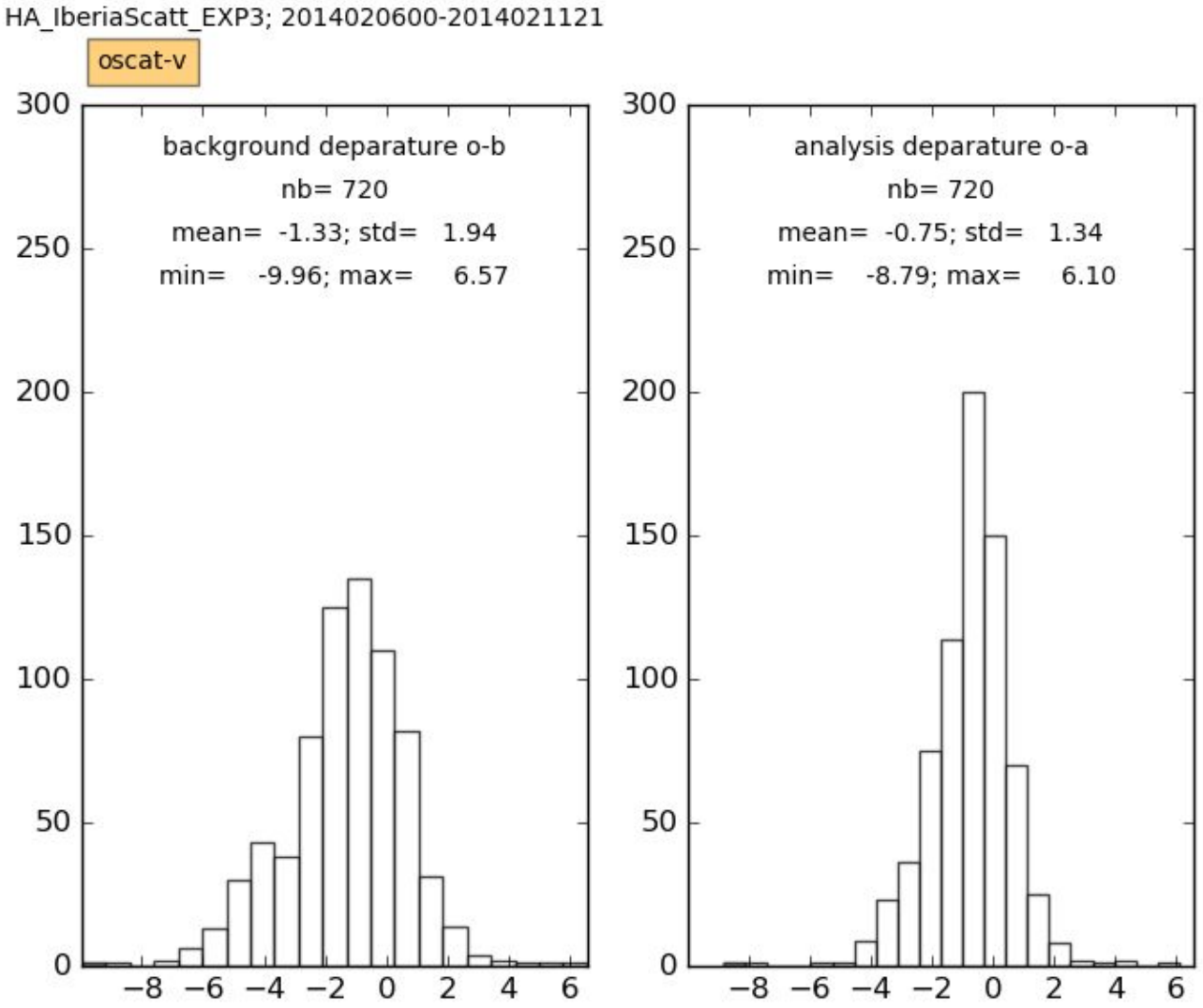
OSCAT (EXP3)



v component

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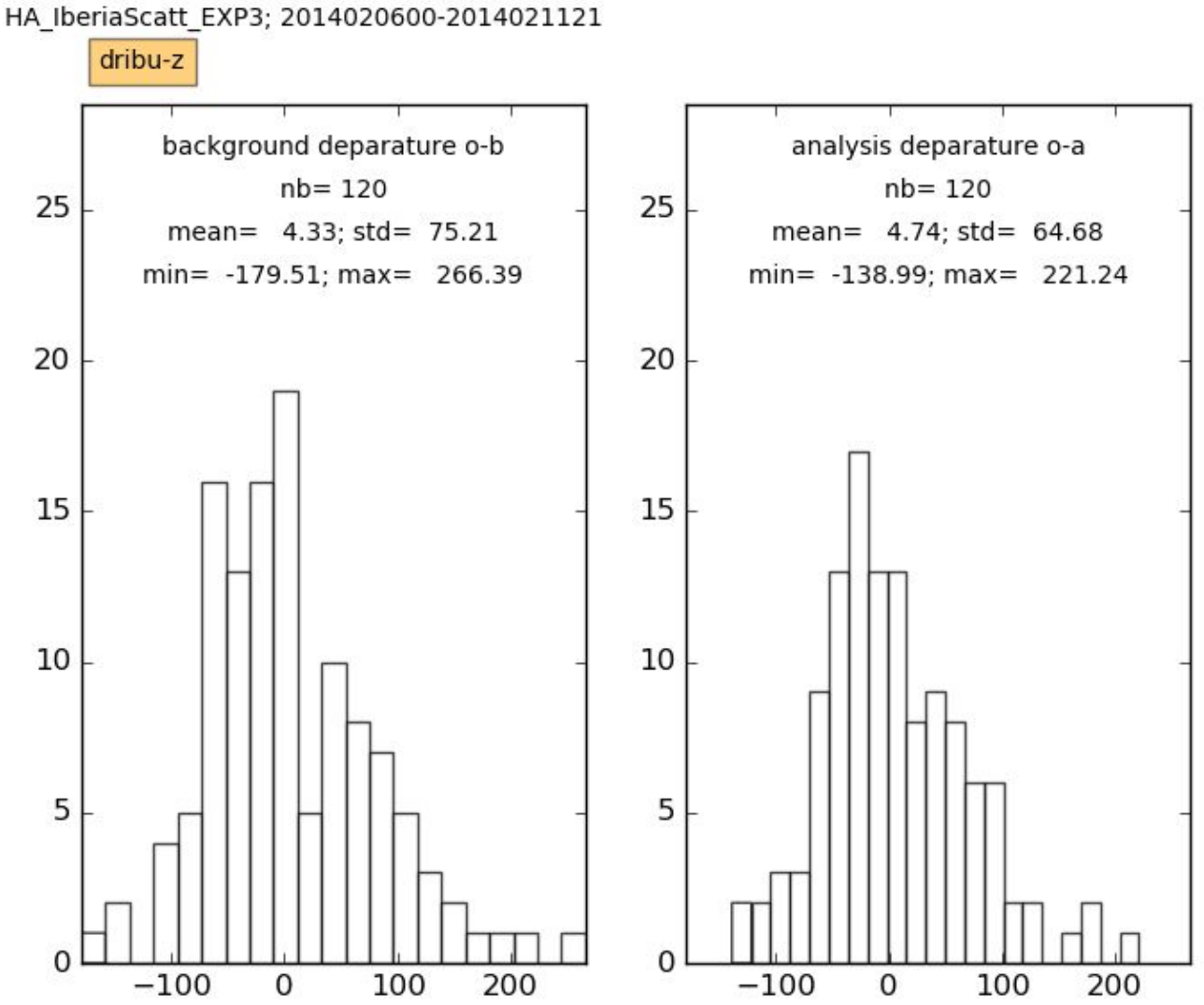
DriBuoys (EXP3)



z

geopot.

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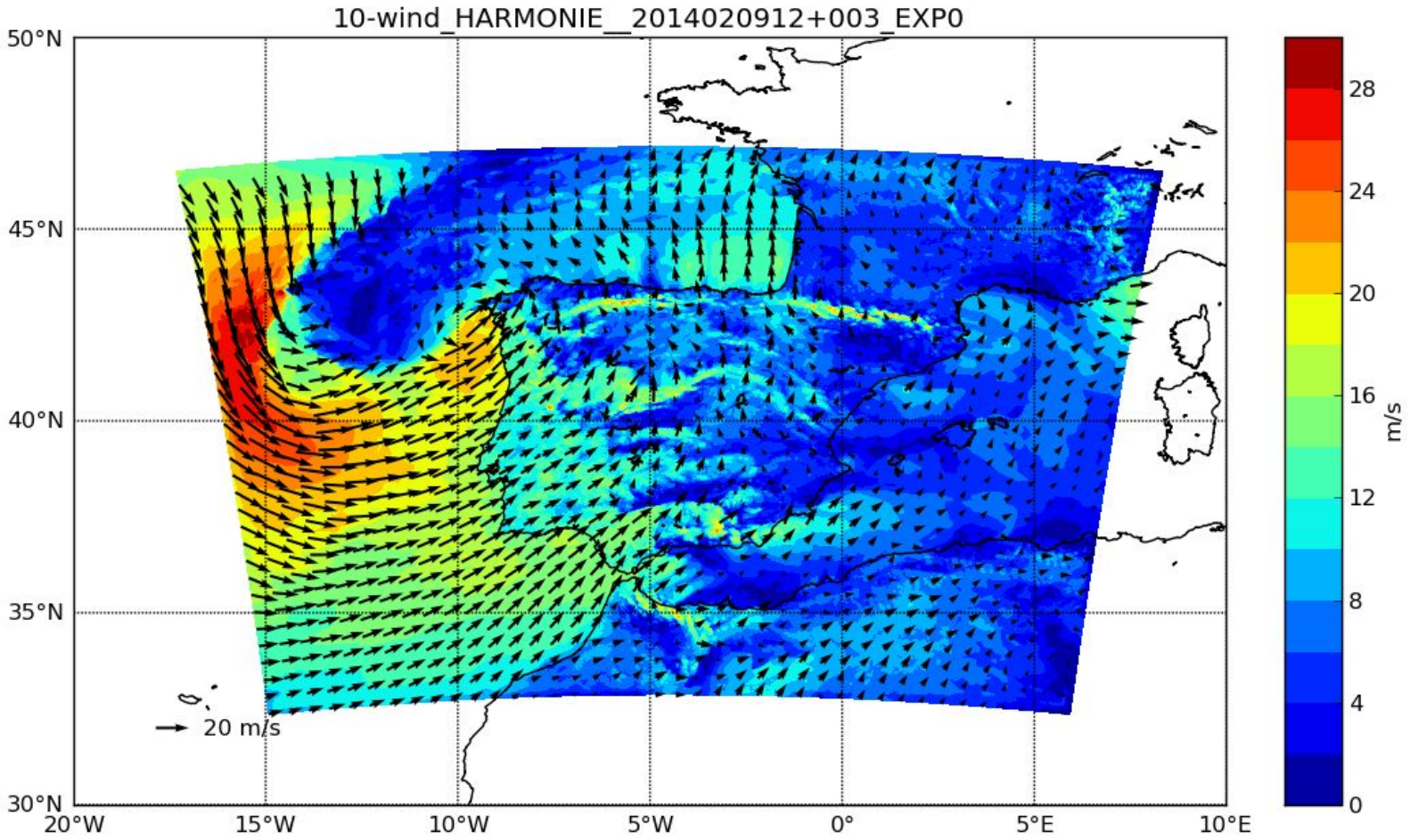
Preliminary Results

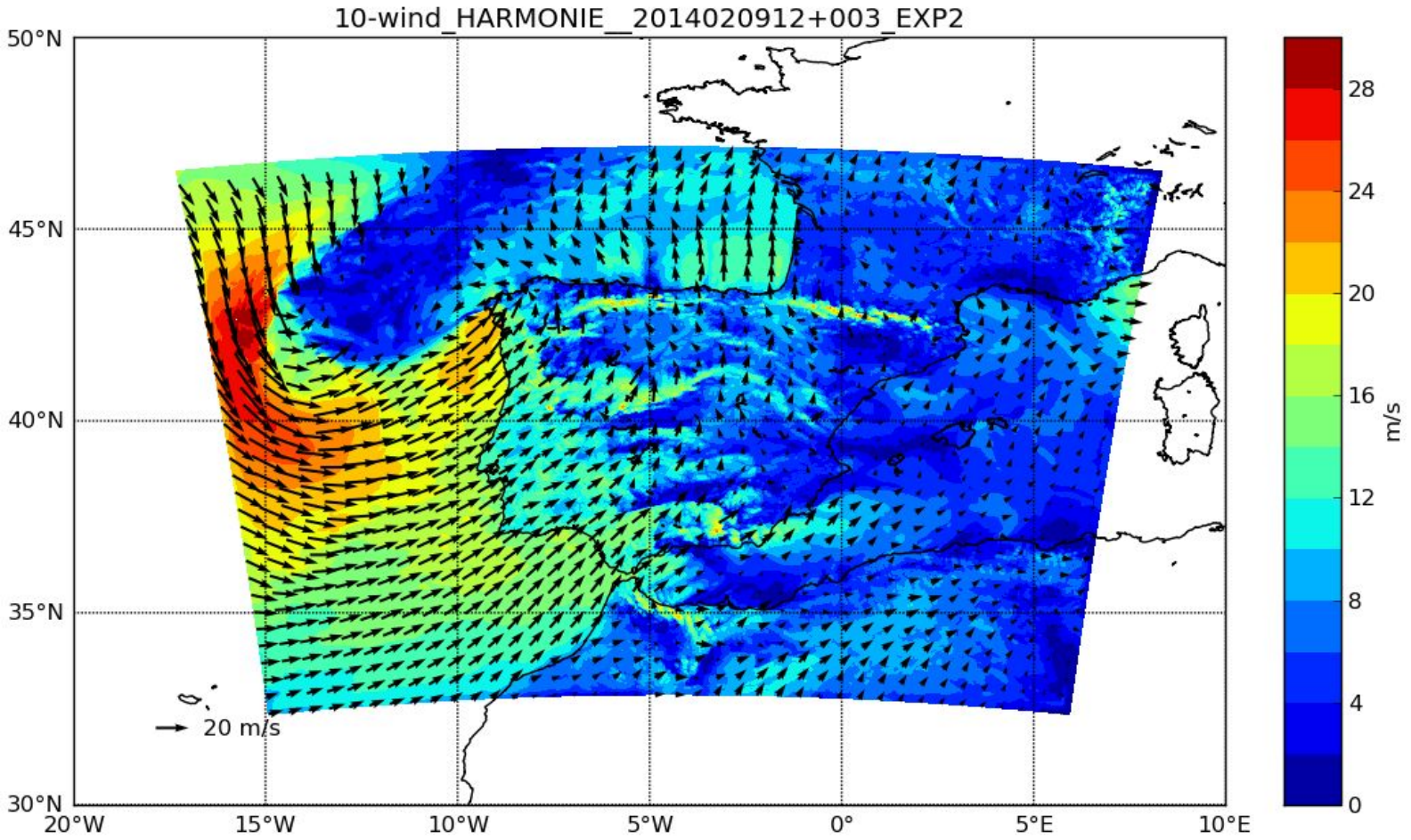
- **Do DA degradates the model ?**
  - statistics of data usage in the assimilation step (ccma files) show that both for stdev and bias (o-a) present smaller values than (o-b), as expected .
  - This is true for all observing systems
  - This is true for EXP0,EXP2 (and EXP3)

The system works, no deterioration

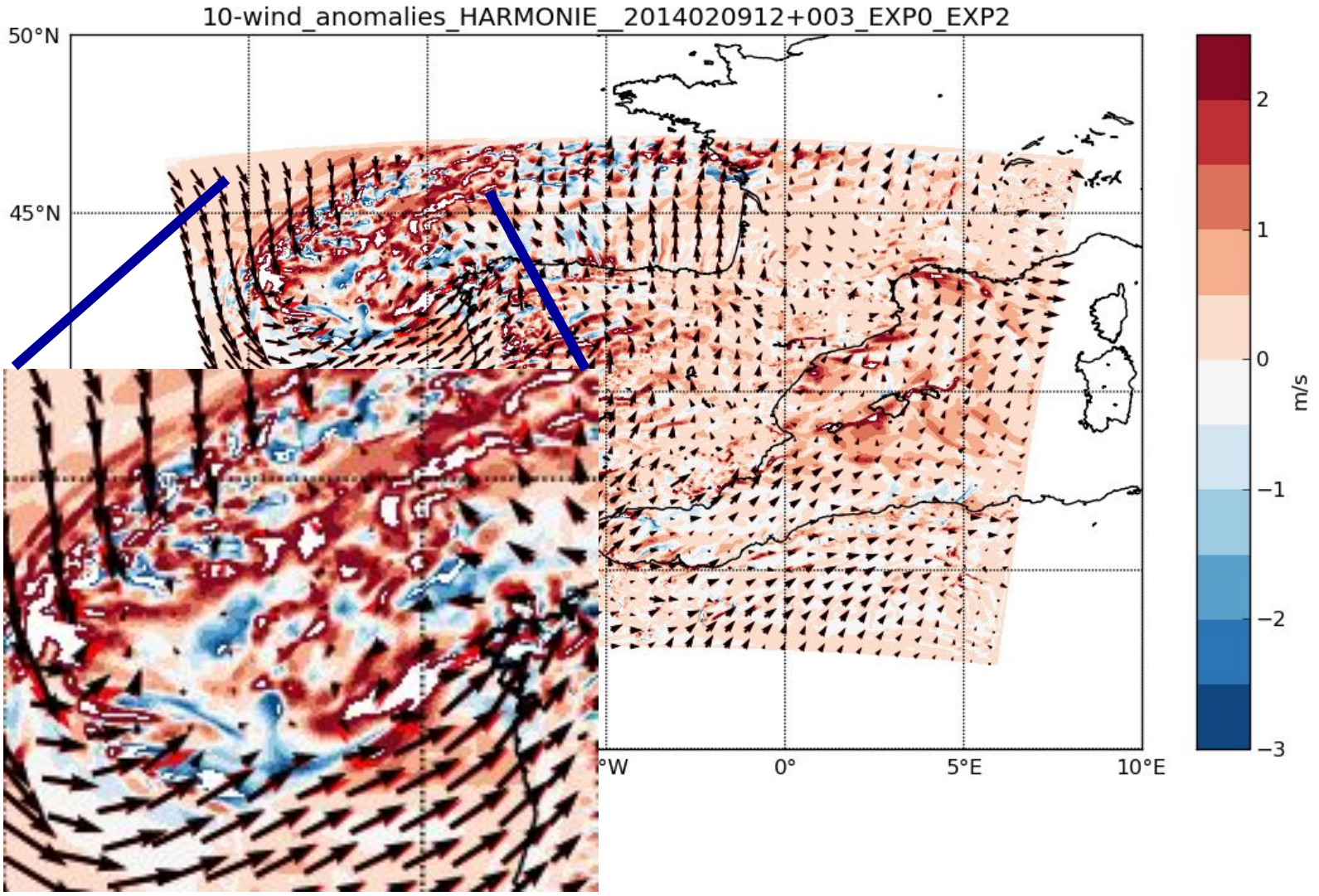
EXP0 - Control



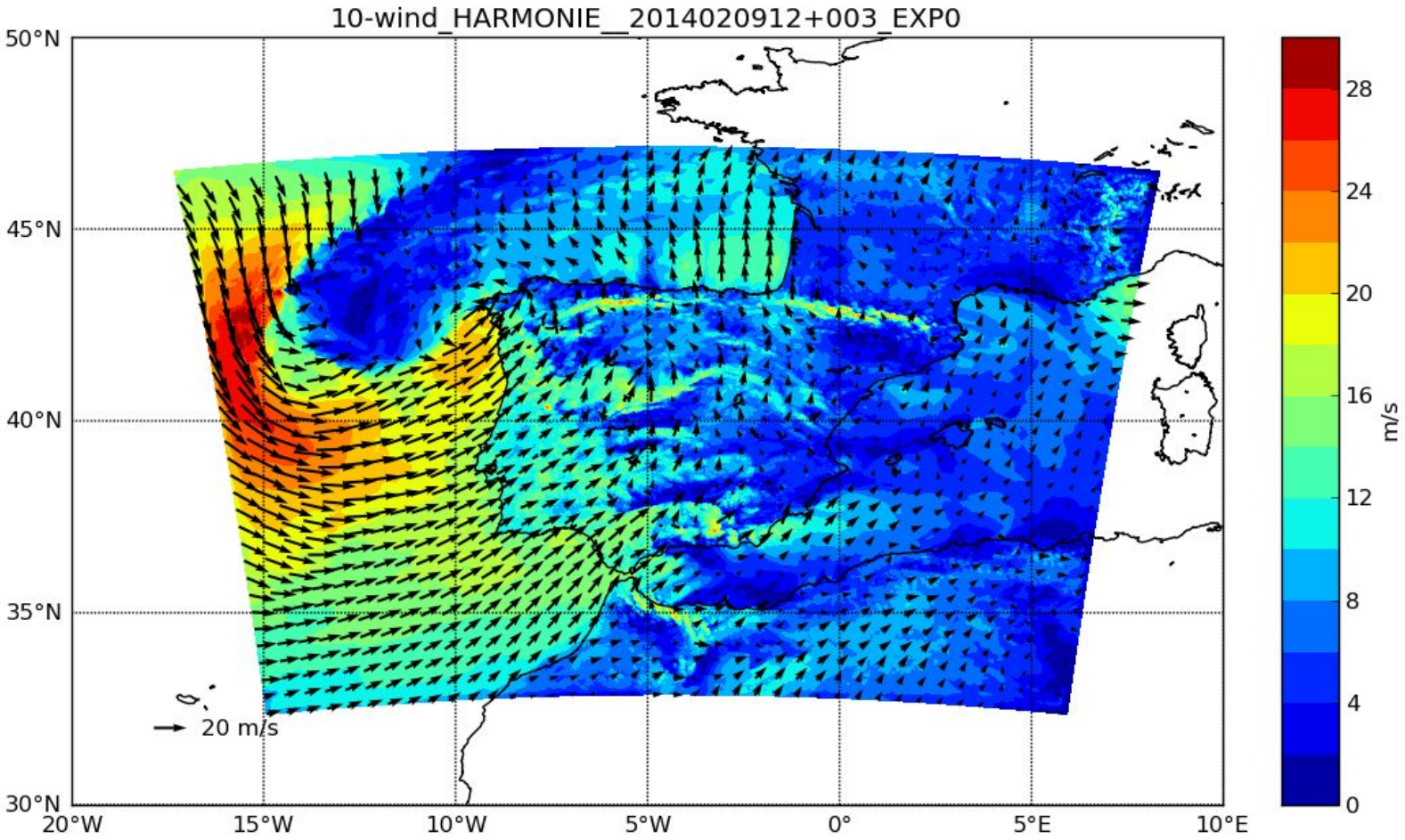
EXP2 - ASCAT-A/B



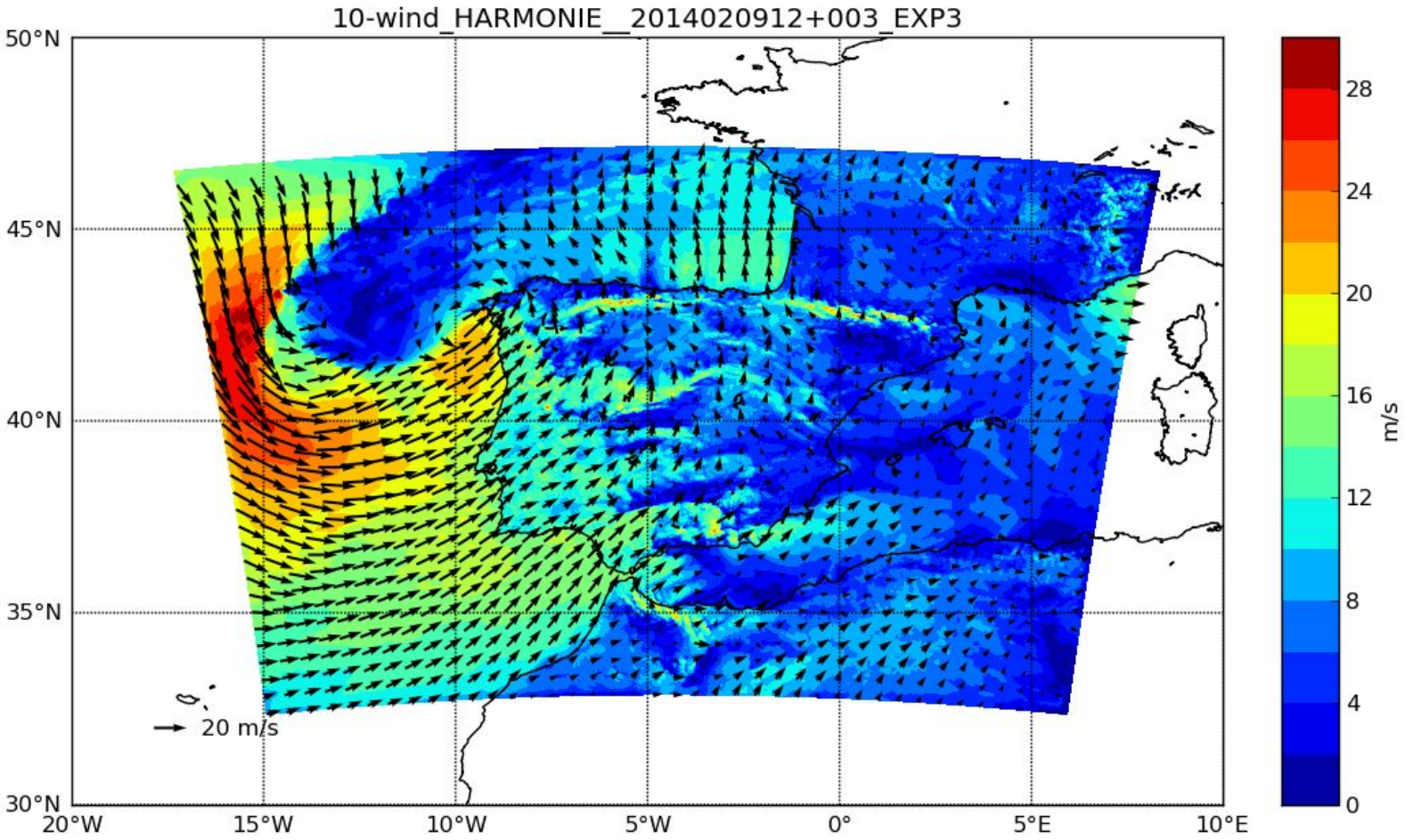
EXP0-EXP2


10-wind_anomalies_HARMONIE__2014020912+003_EXP0_EXP2
50°N
45°N
°W
0°
5°E
10°E
2
1
0
−1
−2
−3
m/s

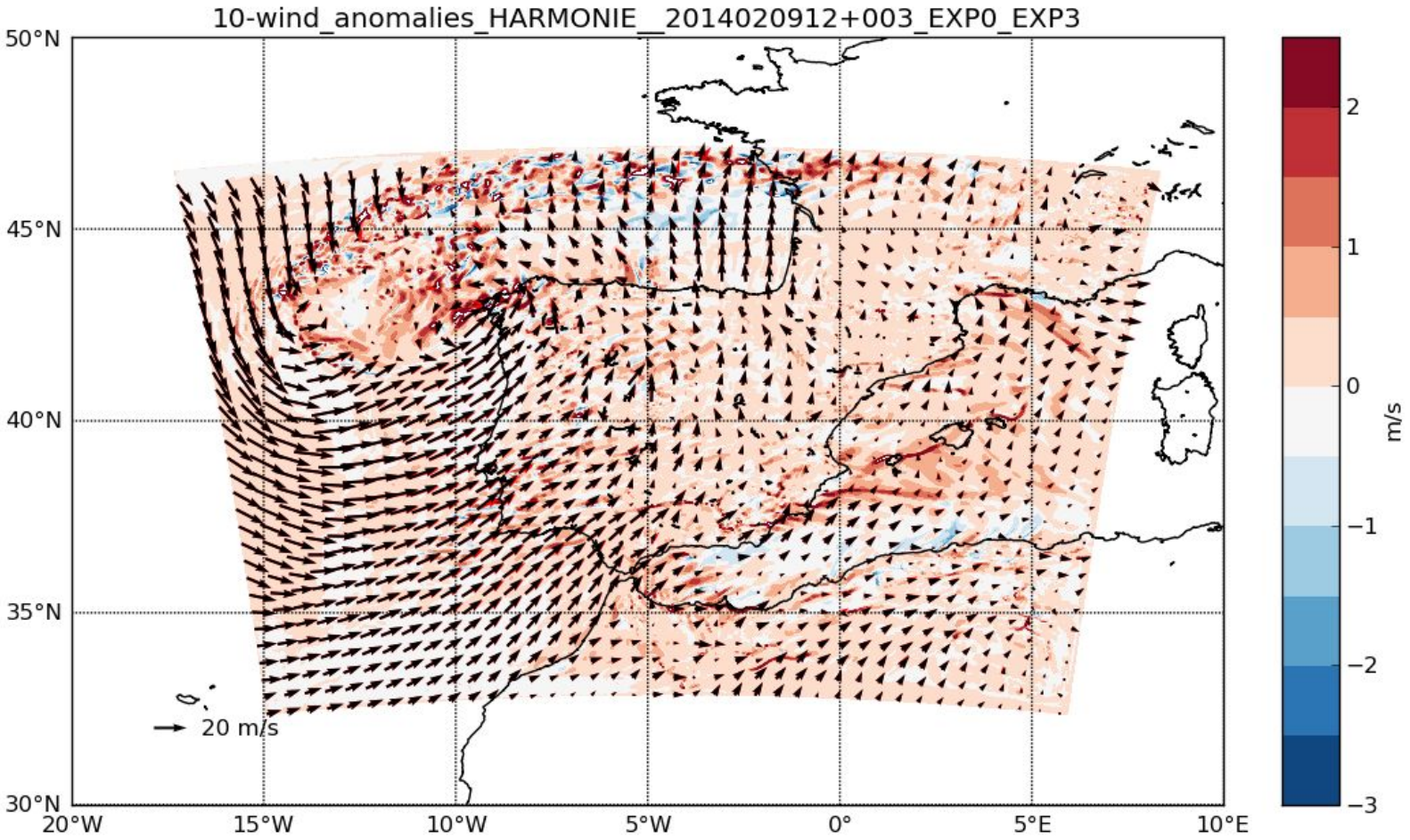
EXP0 - Control



EXP3 - ASCAT-A/B, OSCAT~50 km grid



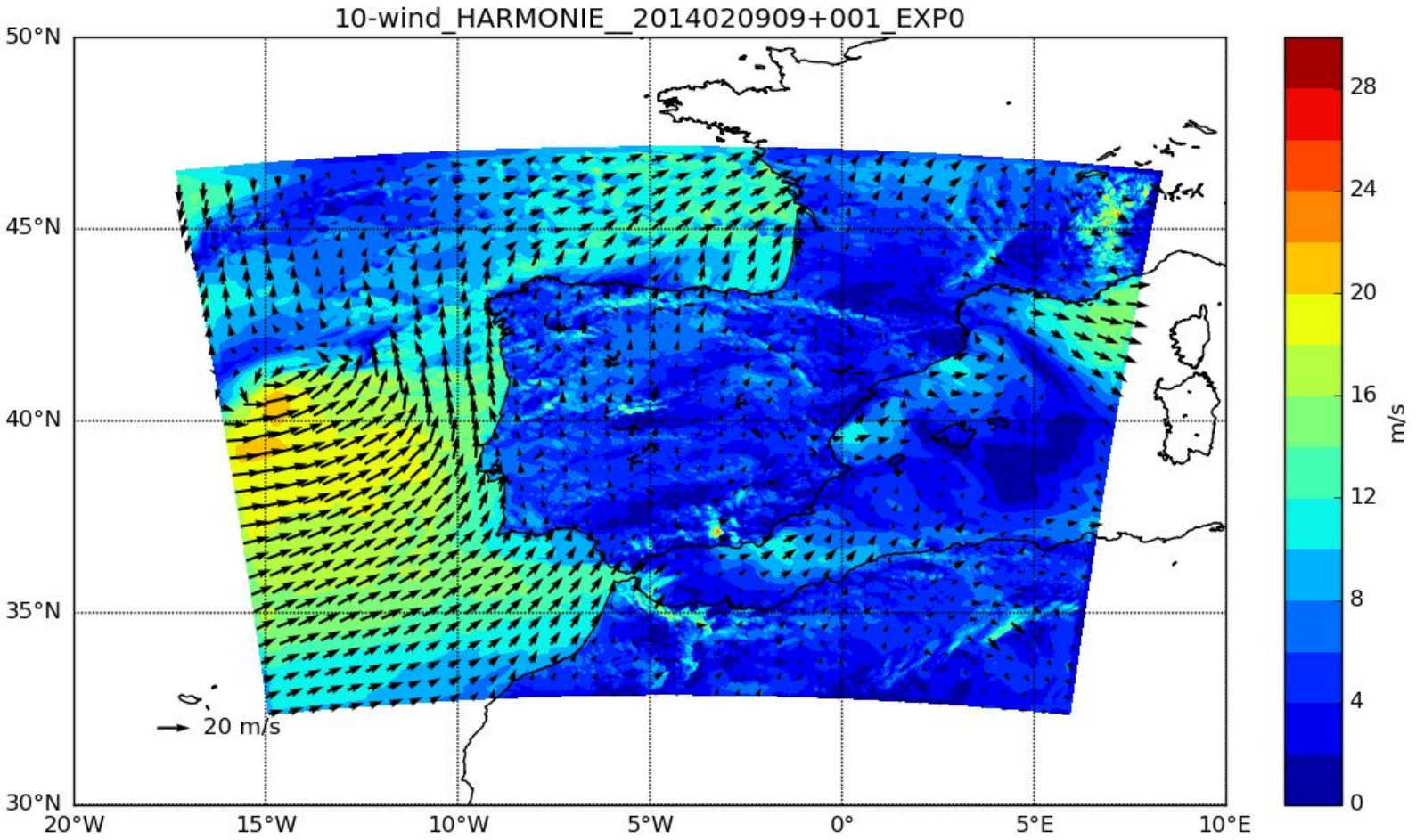
EXP0-EXP3


10-wind_anomalies_HARMONIE__2014020912+003_EXP0_EXP3
50°N
45°N
40°N
35°N
30°N
20°W
15°W
10°W
5°W
0°
5°E
10°E
20 m/s
2
1
0
−1
−2
−3
m/s

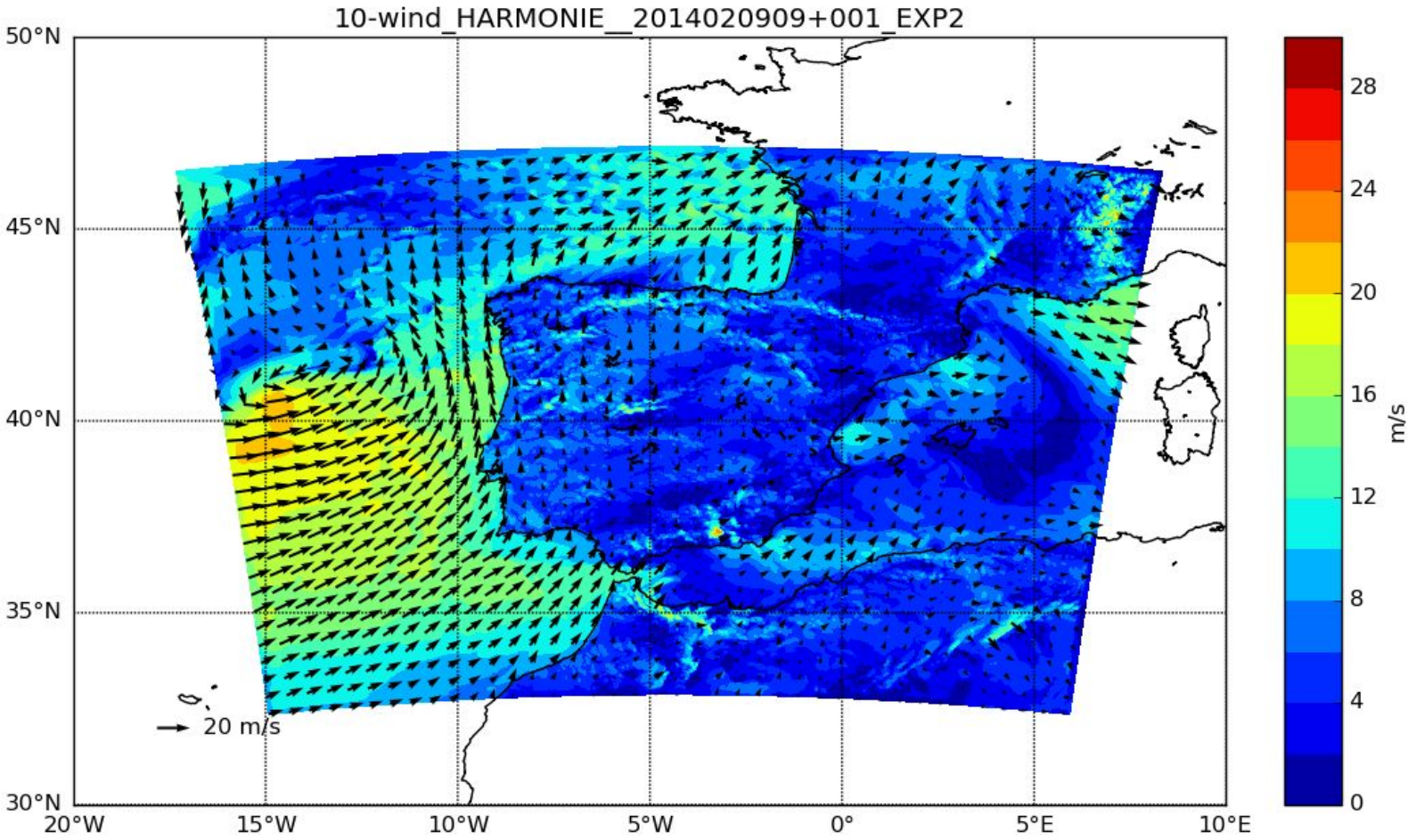
Verification

- Only analysis that used ASCAT DA will be used for comparison, i.e., 0900/2100 and/or 0000/1200
- Data to be used for verification purposes has to be considered carefully
  - Iberian (moored) coastal buoys
  - SYNOPs from coastal stations
  - Scatterometers not used in DA HSCAT / OSCAT(??)

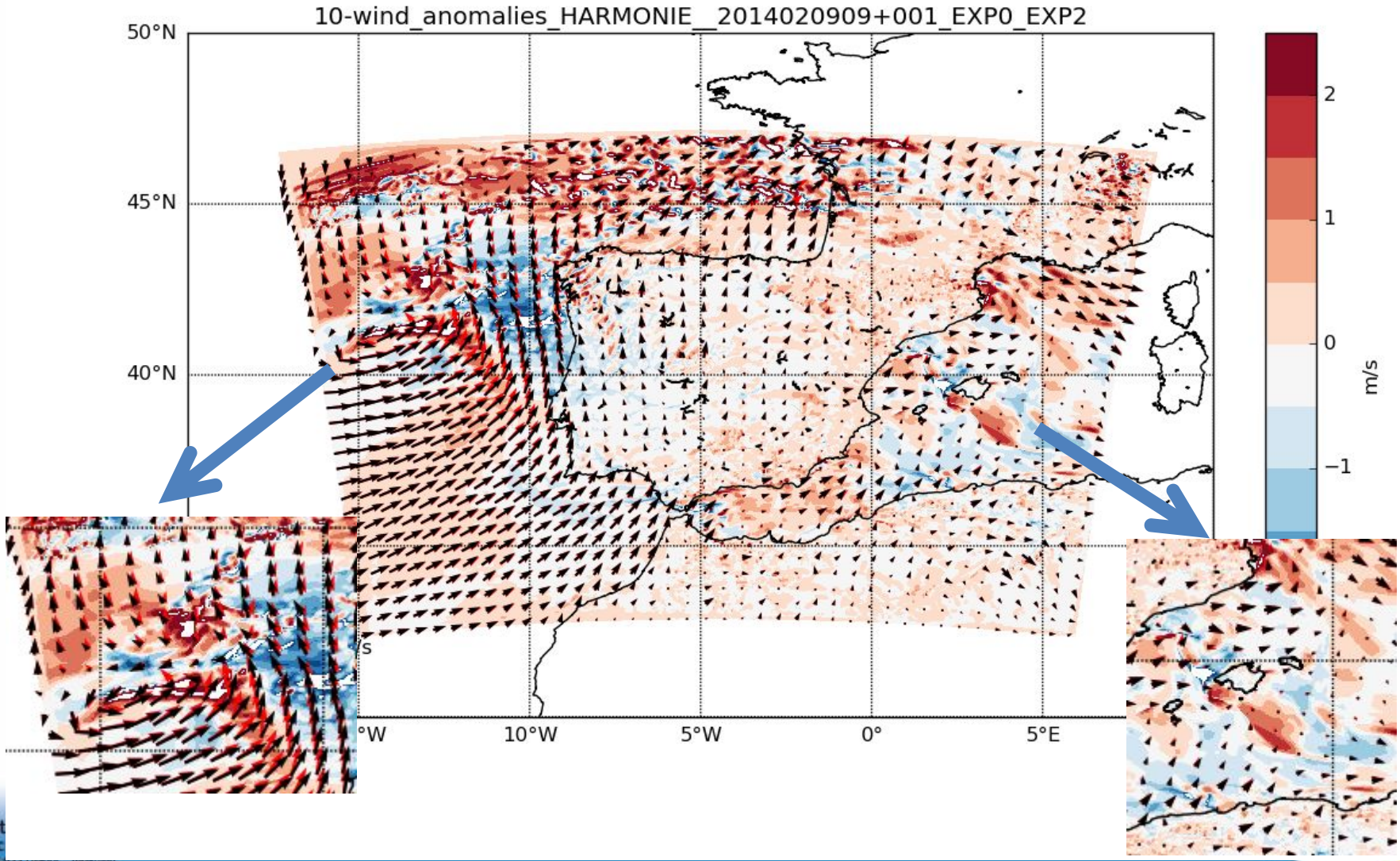
EXP0 - Control

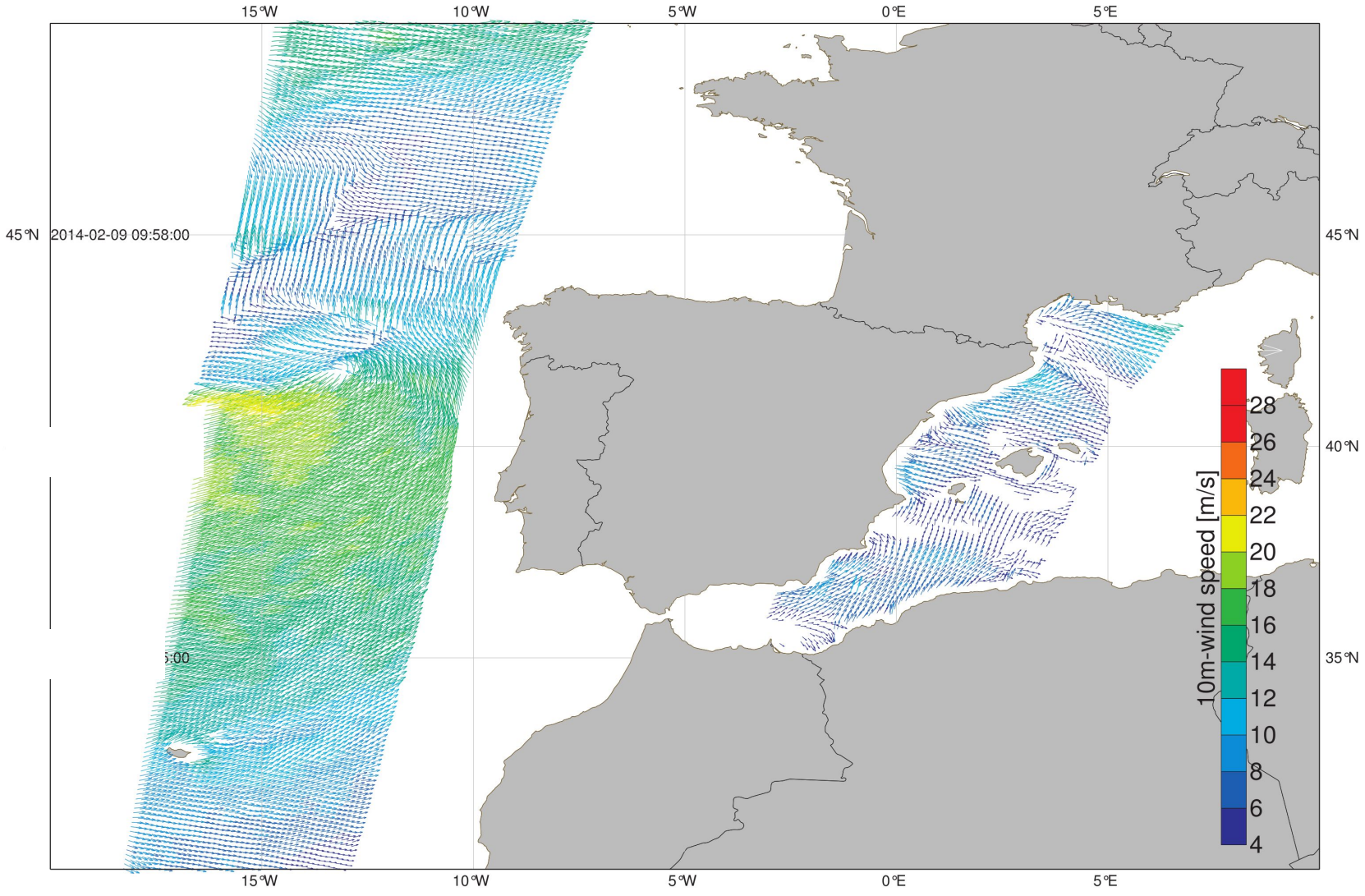


EXP2 - ASCAT-A/B



EXP0-EXP2


10-wind_anomalies_HARMONIE__2014020909+001_EXP0_EXP2
50°N
45°N
40°N
10°W
5°W
0°
5°E
2
1
0
−1
m/s



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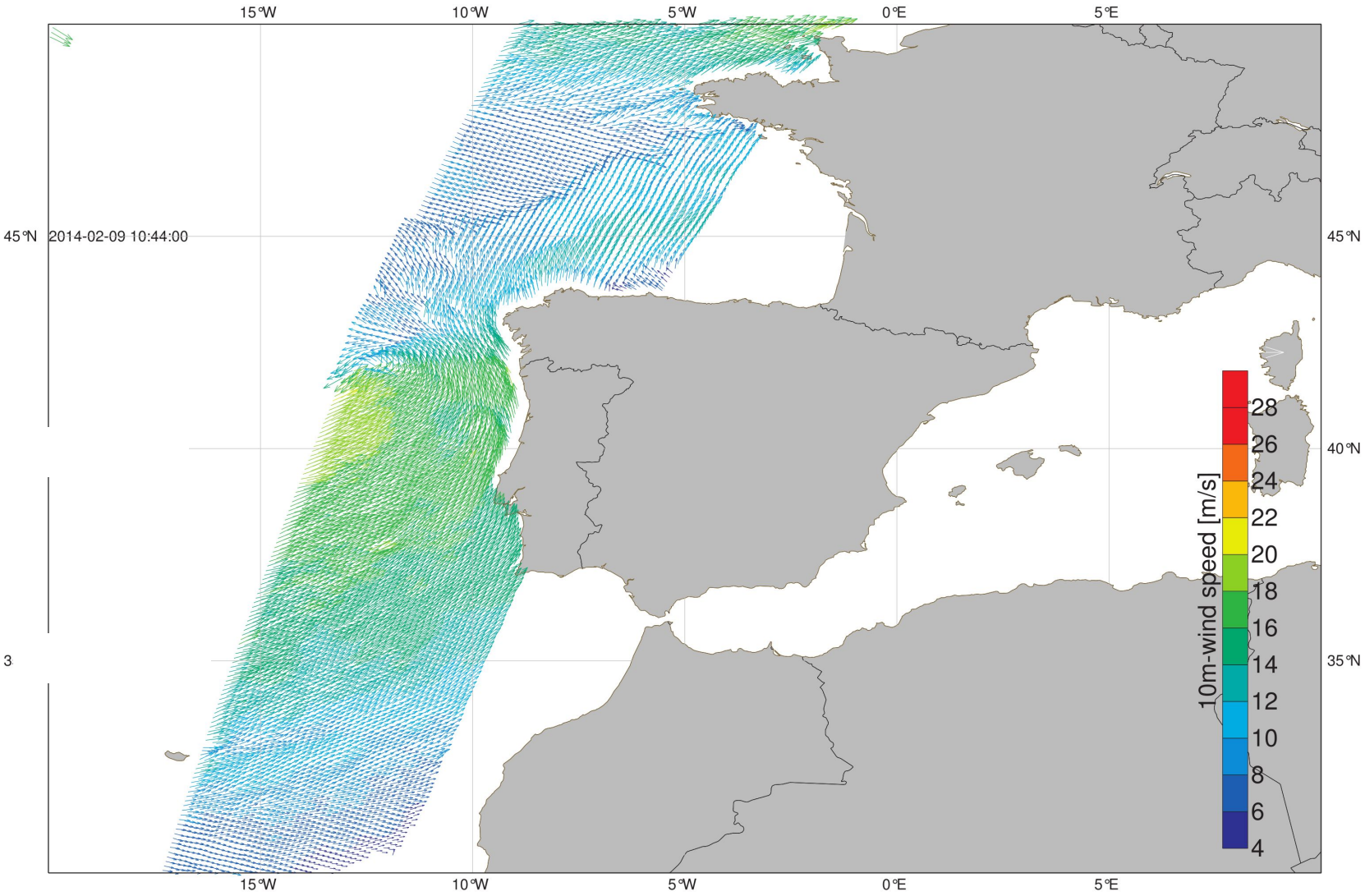

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Preliminary (first) conclusions

- Our DA system is well tunned

- ASCAT Data Assimilation has an impact on the model forecast.
- We still need to investigate if the forecast skill is improved (relatively to DA conventional observations)

Work to be done

- **The skill score** we are planning to use is from statistics of observations minus model forecasts **o-f** for
  - 10 m wind components
  - MSLP
- **Observations used for verification** purposes should come from an observation system not used in DA.
  - coastal stations not used in DA
  - IH (Portuguese Navy) and Puertos Del Estado buoys
  - Scatterometer not used in DA

  we need to have a number of observations large enough for significant statistics to be obtained

Thank you!

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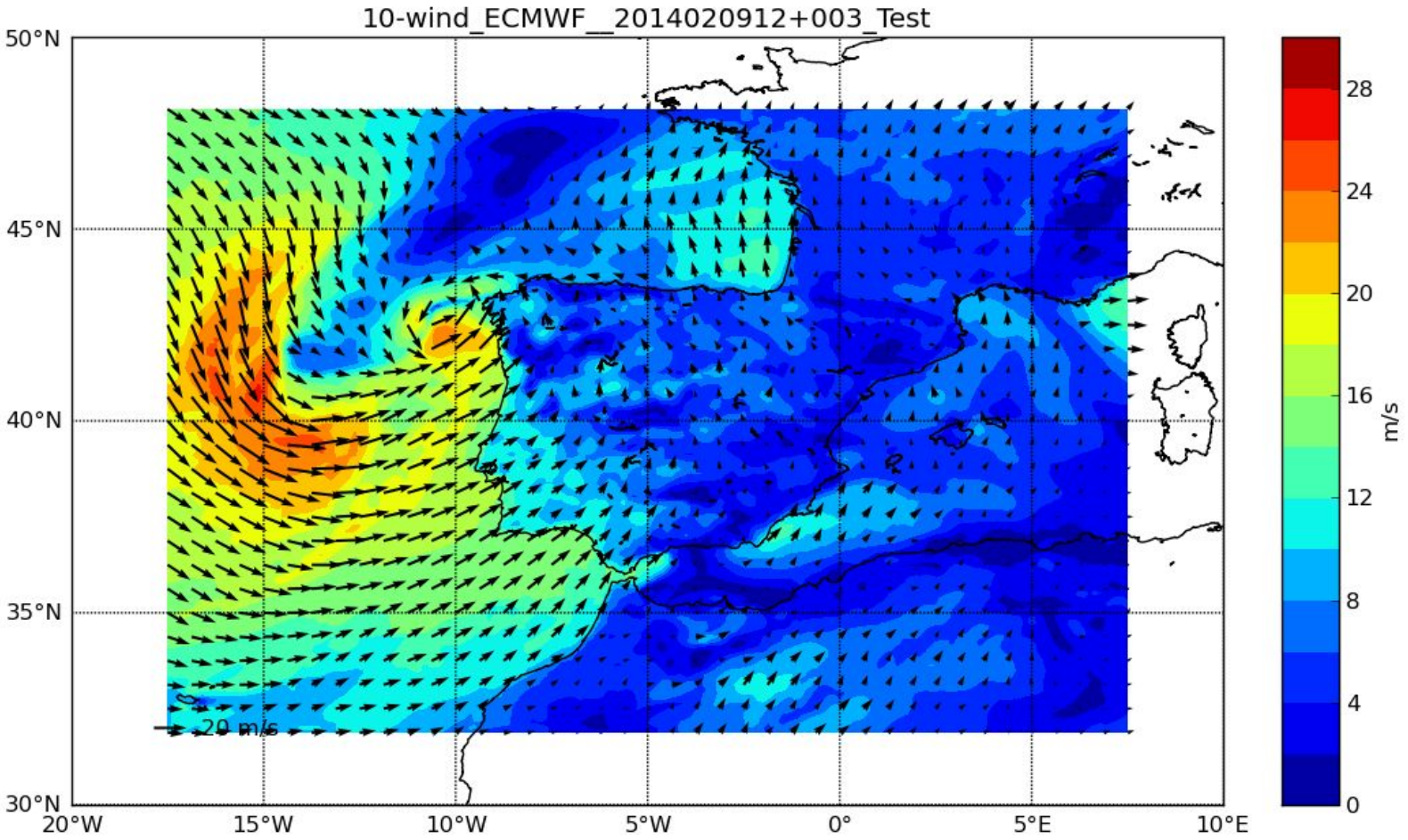
Backup slides


10-wind_ECMWF__2014020912+003_Test
50°N
45°N
40°N
35°N
30°N
20°W
15°W
10°W
5°W
0°
5°E
10°E
20 m/s
28
24
20
16
12
8
4
0
m/s

EXP2 - ASCAT-A/B