



GOBIERNO  
DE ESPAÑA

MINISTERIO  
DE AGRICULTURA Y PESCA,  
ALIMENTACIÓN Y MEDIO AMBIENTE

**AEMet**  
Agencia Estatal de Meteorología

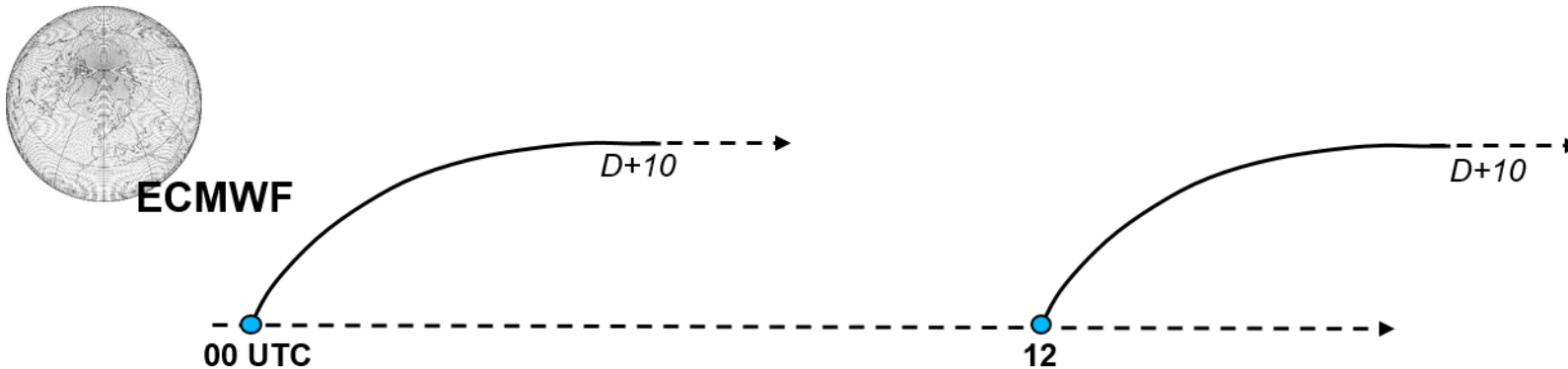
# Mejora de las predicciones con la asimilación de datos de aviones (AMDAR y Mode-S)

*Javier Calvo, Carlos Geijo, Joan Campins*  
Área de Modelización, AEMET

- Modelos Numéricos de Predicción de AEMET
- Impacto de los datos AMDAR en la asimilación
- Datos AMDAR de humedad
- Datos MODE-S
- Conclusiones

# ECMWF: Modelo global (escala sinóptica)

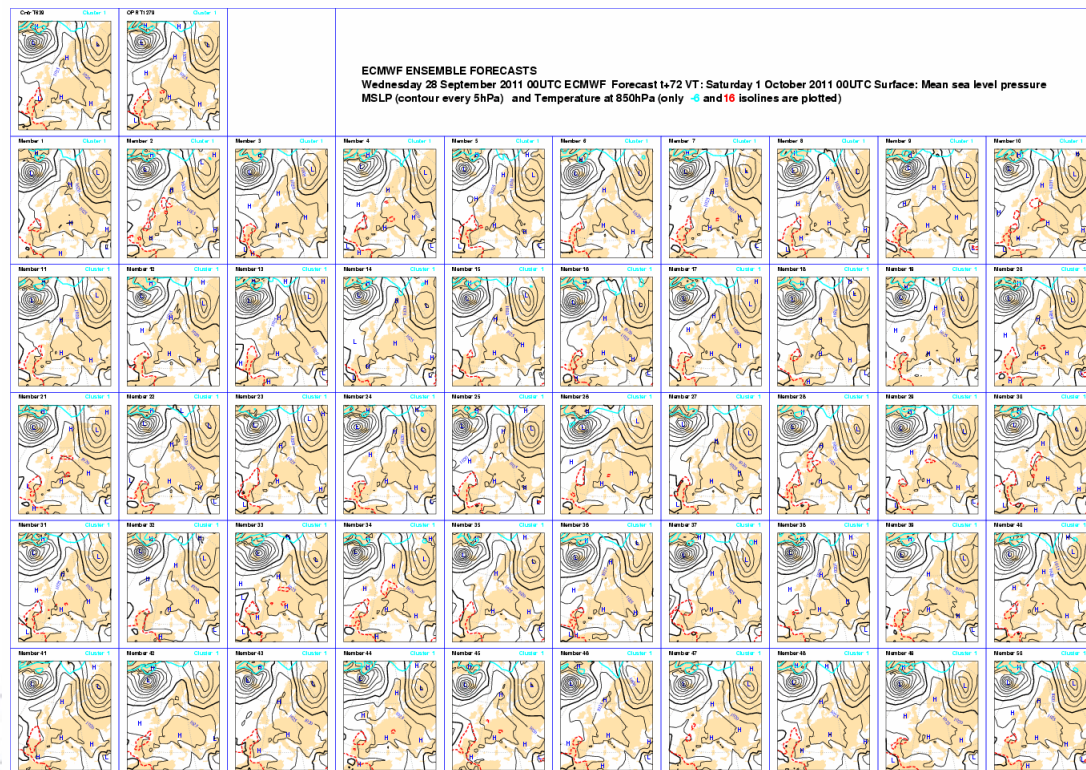
- HRES Determinista de alta resolución
  - T1279 16 km (9 km espacio de puntos de grid)
  - 4DVar análisis
    - Tiempo de espera obs.: 4 hr
    - Gran número de observaciones de satélite
  - D+10 con ciclos 00 y 12 UTC.



Available: + 6 hr

# ECMWF: Modelo global (escala sinóptica)

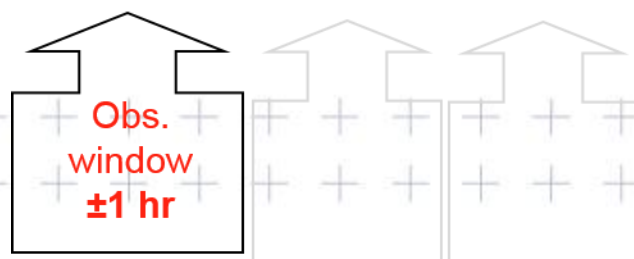
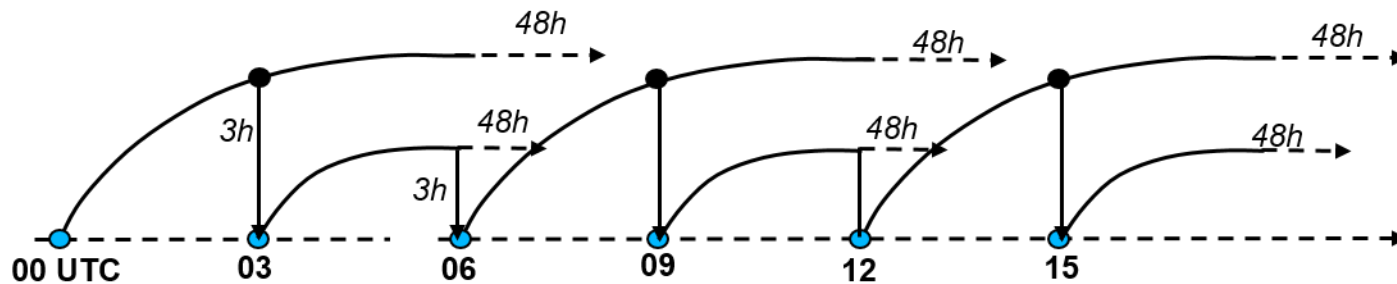
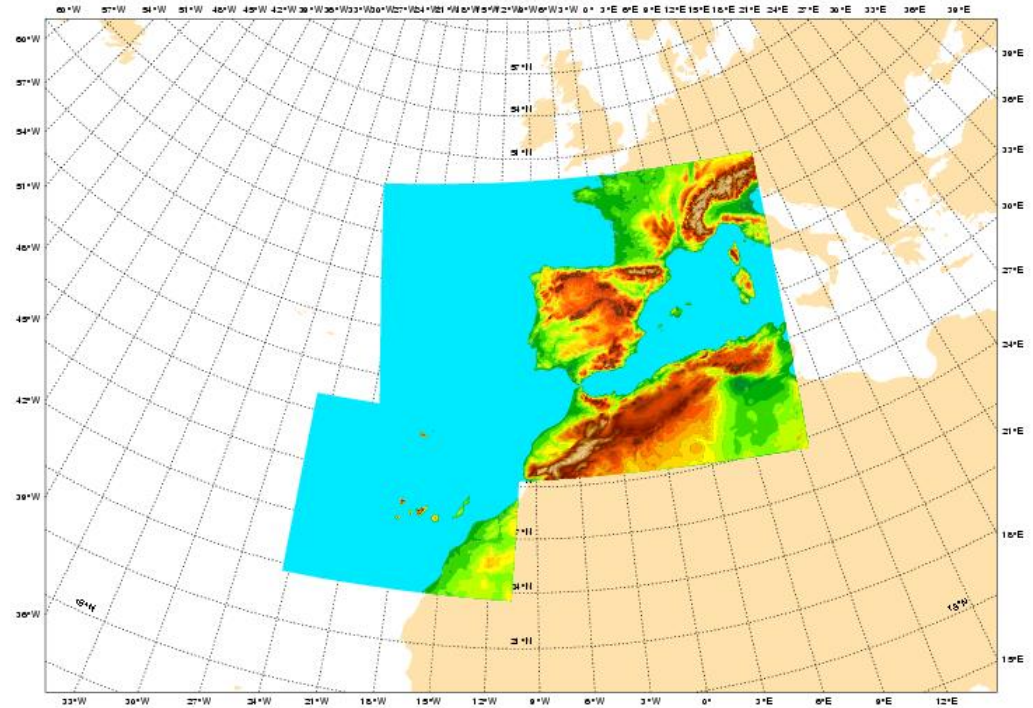
- EPS Sistema de Predicción por Conjuntos
  - T639 32 km D+10      51 miembros
  - Incertidumbre en las condiciones iniciales y en el propio modelo
  - Perturbaciones con el objetivo de estimar la **incertidumbre en el plazo medio D+2/3**





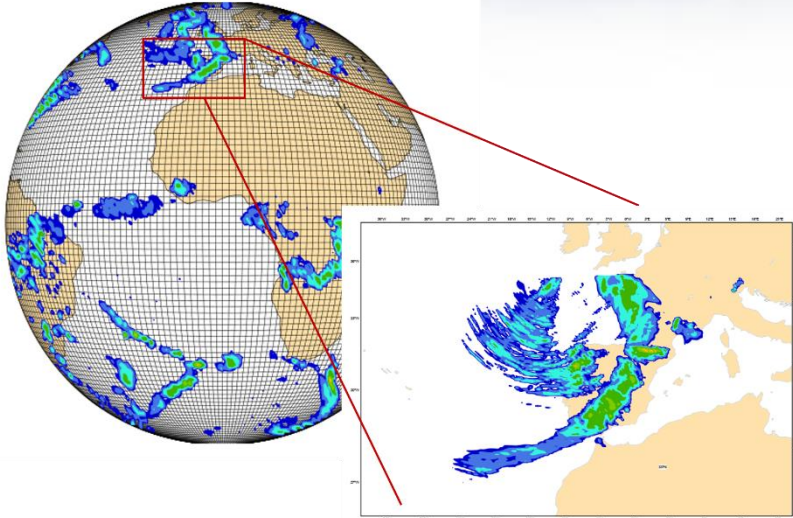
# HARMONIE-AROME en AEMET

- Non-Hydrostatic convection permitting (2.5 km): resolved convection
- Assimilation cycle every 3 hr
  - 1:10 cutoff time
- Forecast length:
  - H+48 with 15 min output for selected surface variables



Available: + 2:40 Peninsula, + 2:10 Canarias from the analysis time

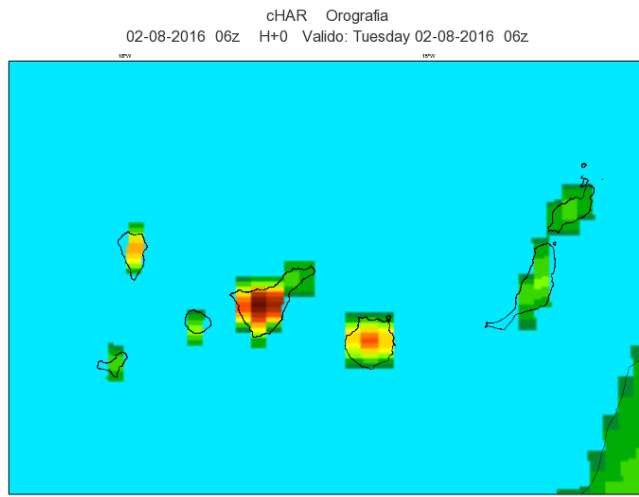
# Global vs Limited Area Models



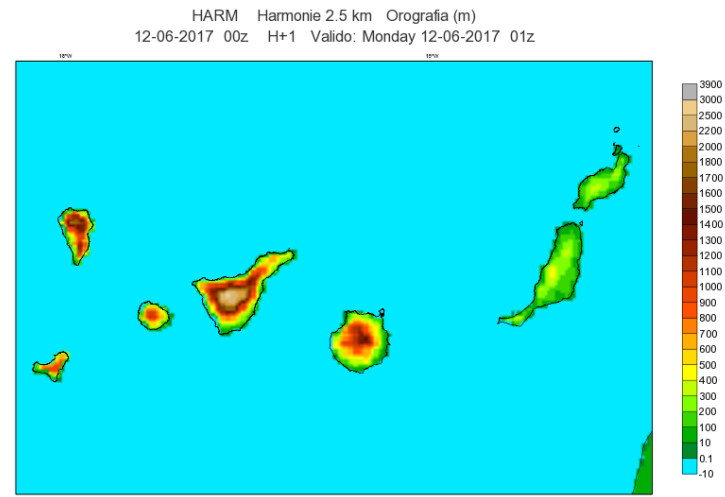
## Key aspects:

- Resolved convection
- Resolution
- Availability H+2/6

## ECMWF



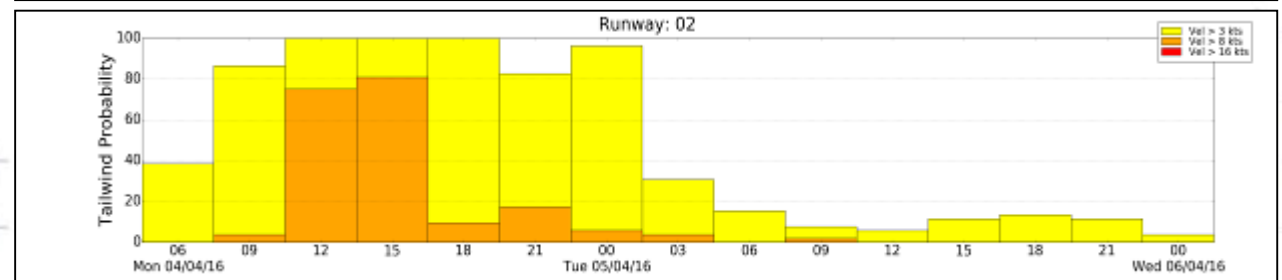
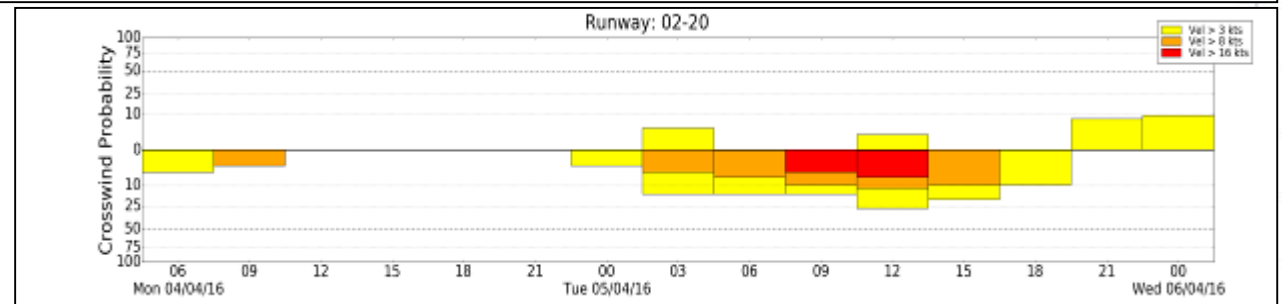
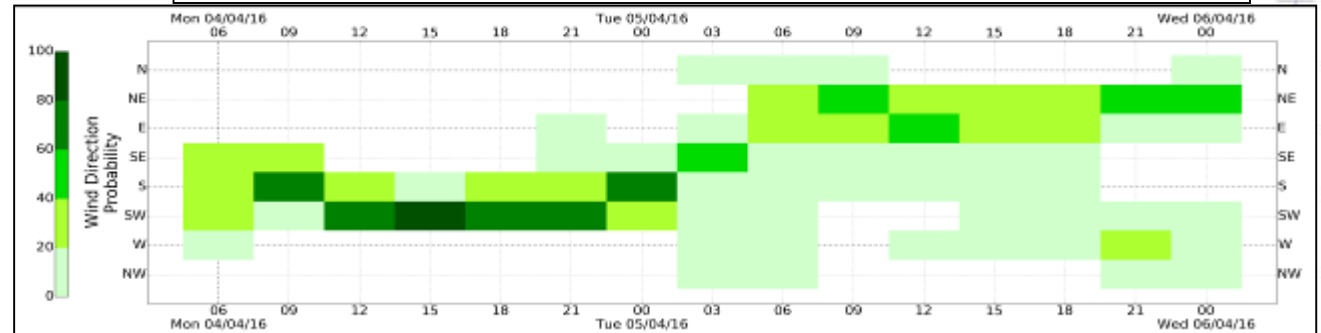
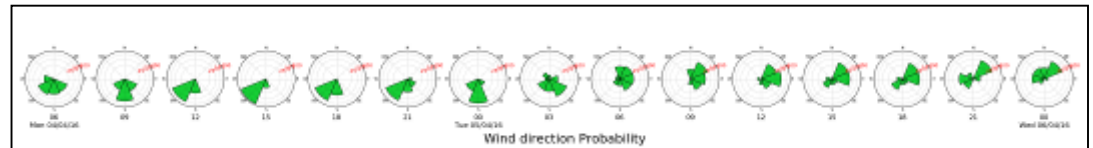
## HARMONIE



## $\gamma$ SREPS *AEROgrams*

Aeropuerto de Barcelona

- Predictability at convection scales is lower
- Ensemble approaches are mandatory
- Estimate uncertainty at short range

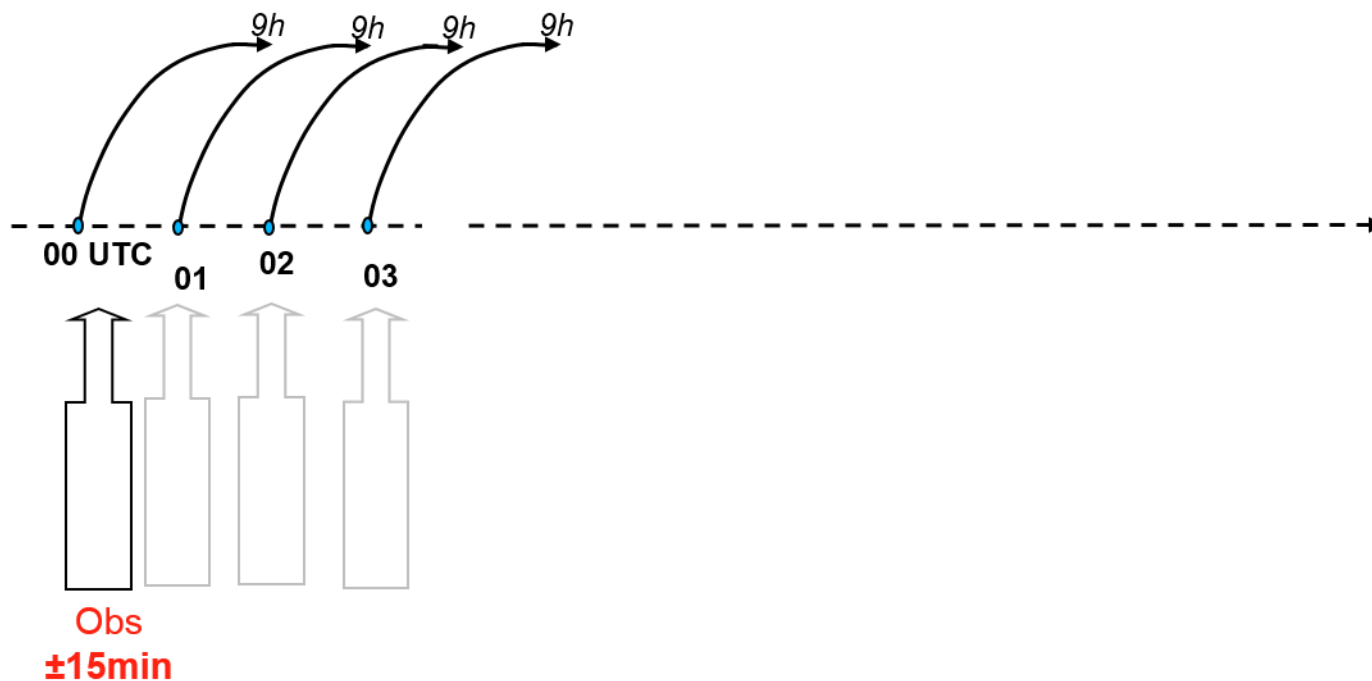


Thanks to Alfons Callado



# Nowcasting range suite (plans)

- ~15 min cutoff time (espera observaciones)
- Every hour, Forecast length: H+6/9 Available T+30 min



# Assimilation: Soundings

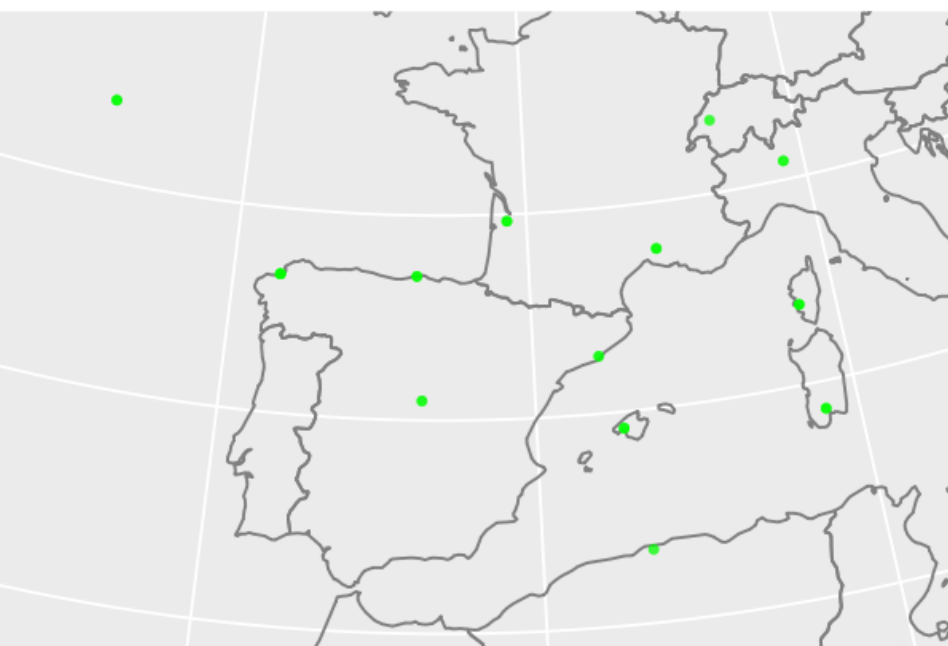
- Data with very good quality
  - Temperature, Wind, Humidity
  - But poor spatial and temporal resolution



00 UTC

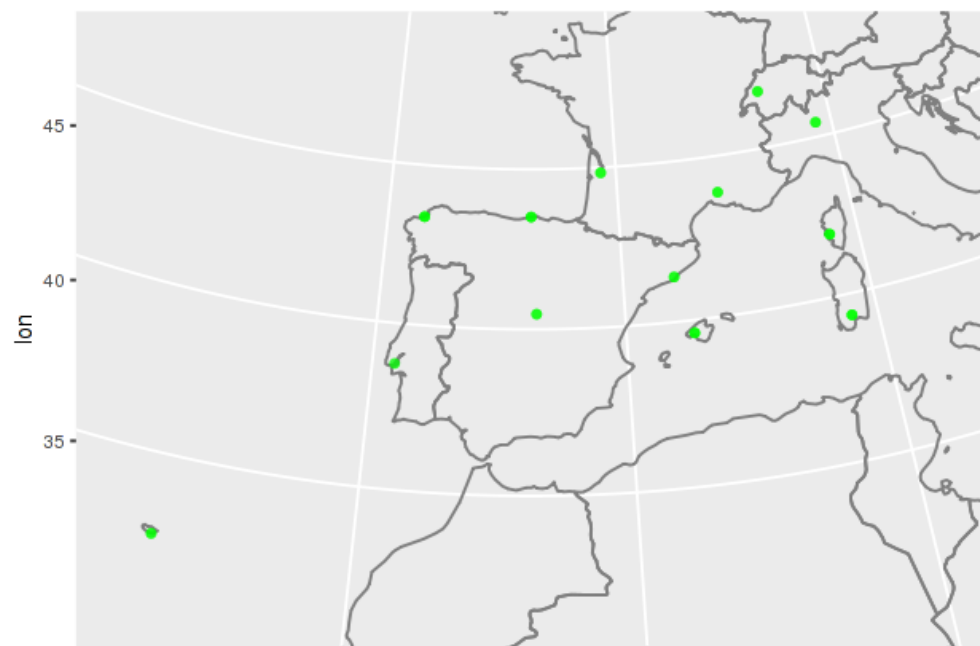
AIB: Observation Usage temp t 2018-04-29 00Z

0, 8500, 12500, 17500, 22500, 27500, 35000, 45000, 60000, 80000, 100000, 120000, 140000, 160000, 180000, 200000, 220000, 240000, 260000, 280000, 300000, 320000, 340000, 360000, 380000, 400000, 420000, 440000, 460000, 480000, 500000, 520000, 540000, 560000, 580000, 600000, 620000, 640000, 660000, 680000, 700000, 720000, 740000, 760000, 780000, 800000, 820000, 840000, 860000, 880000, 900000, 920000, 940000, 960000, 980000, 1000000



12 UTC

AIB: Observation Usage temp t 2018-04-29 12Z



# Assimilation Canary Islands: Soundings

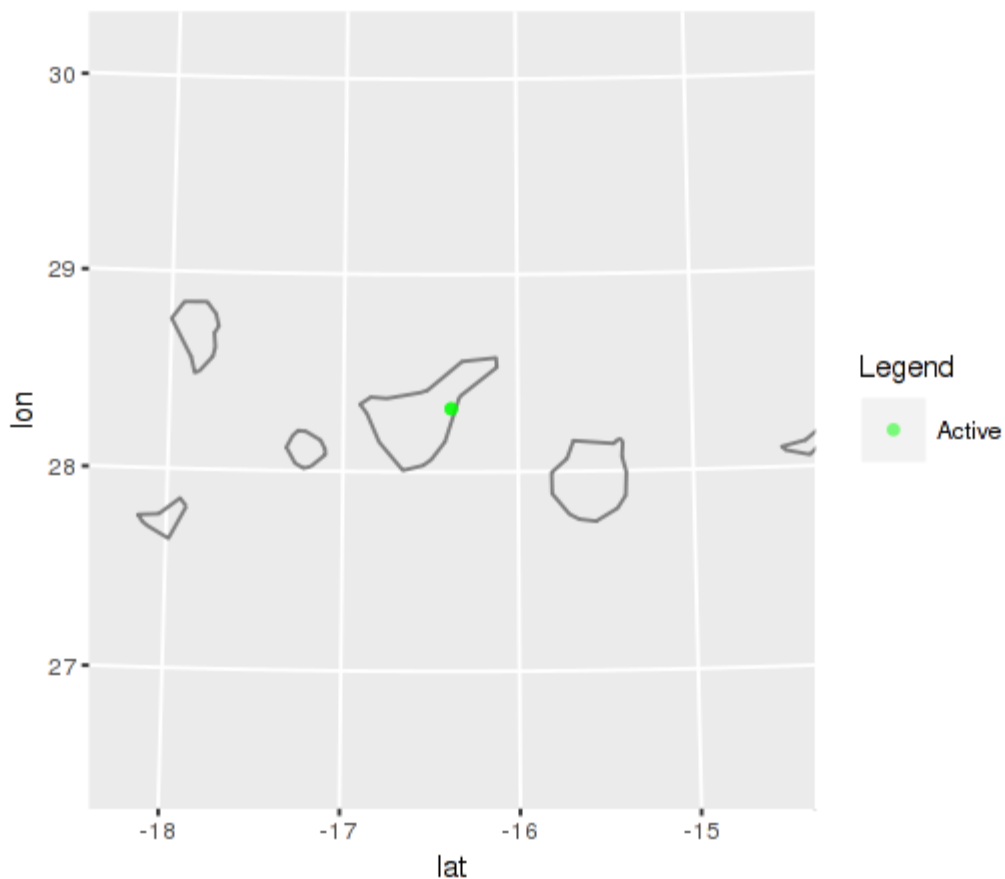
- Only 1 at 00 UTC and 2 at 12 UTC



00 UTC

AIC: Observation Usage temp t 2018-04-29 00Z

8500, 12500, 17500, 22500, 27500, 35000, 45000, 60000, 80000, 17500, 22500, 27500, 35000



12 UTC

Observation Usage temp t 2018-04-

8500, 12500, 17500, 22500, 27500, 35000, 45000, 60000, 80000, 17500, 22500, 27500, 35000



# AMDAR data



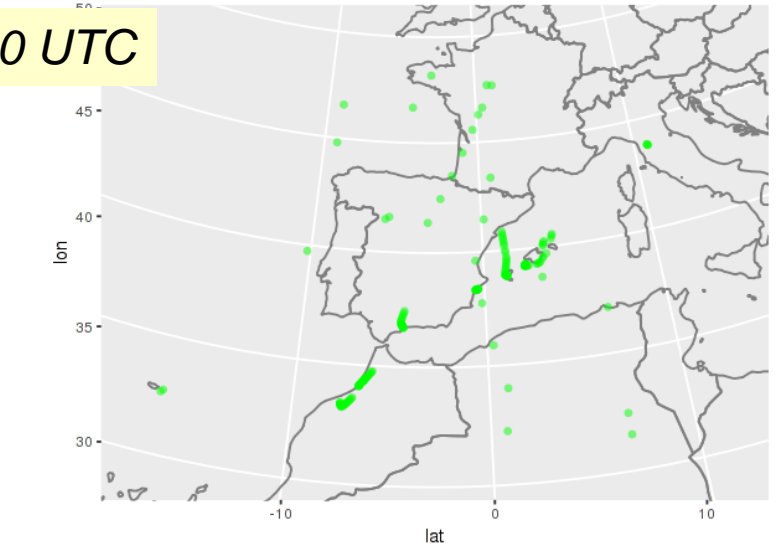
- Data with very good quality (similar to soundings) but quality control is very important
  - Temperature  $\leq 0.5$  K
  - Wind  $\leq 0.3$  m/s
  - Good spatial resolution over Europe
  - Most during the day
  - Timeliness: 90%  $\leq 50$  min
  - Much cheaper than soundings

# Asimilation Iberian domain: AMDAR



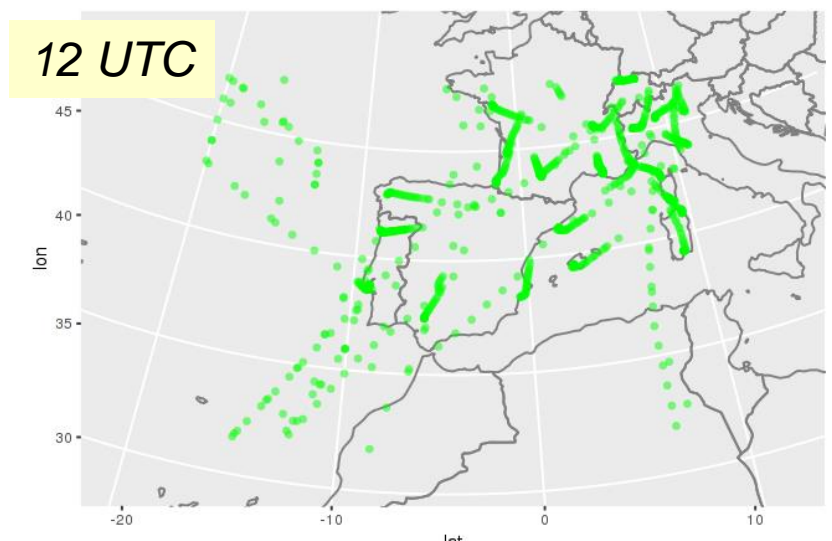
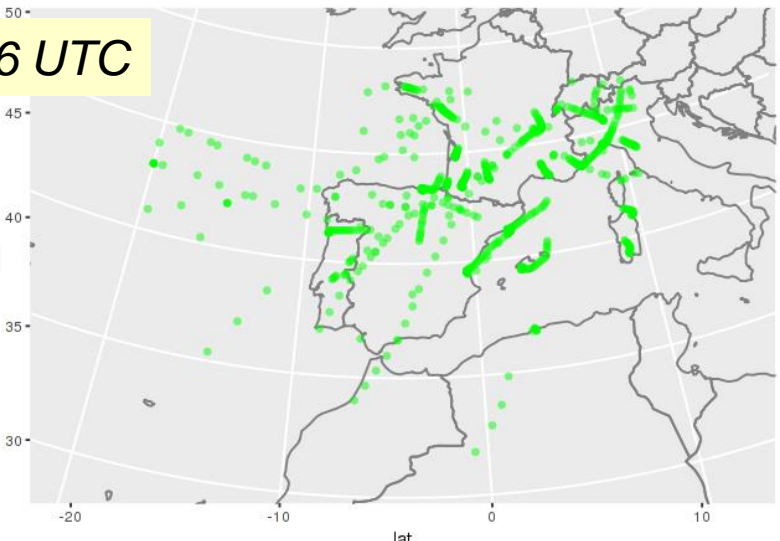
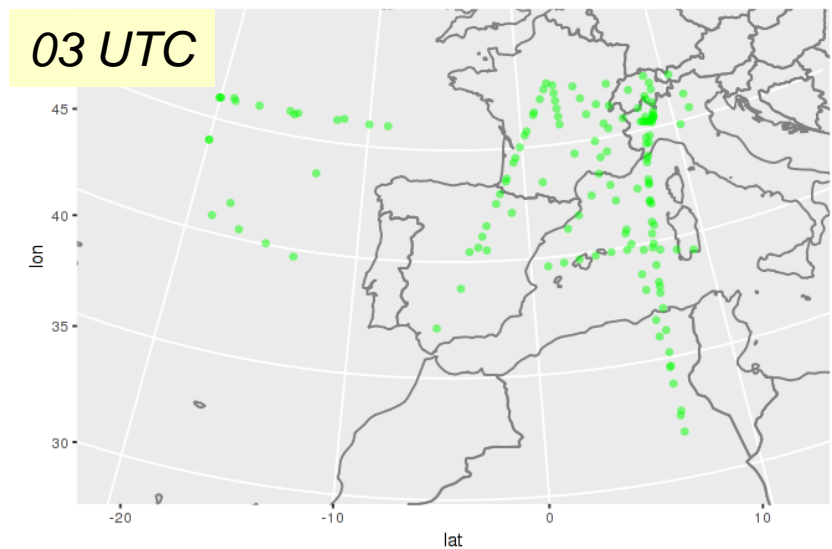
AIB: Observation Usage aircraft t 2018-05-29 00Z

levels: 17500, 22500, 27500, 35000, 45000, 60000, 80000, 92500, 100000



AIB: Observation Usage aircraft t 2018-05-29 03Z

levels: 17500, 22500, 27500, 35000, 45000, 60000, 80000, 92500, 100000



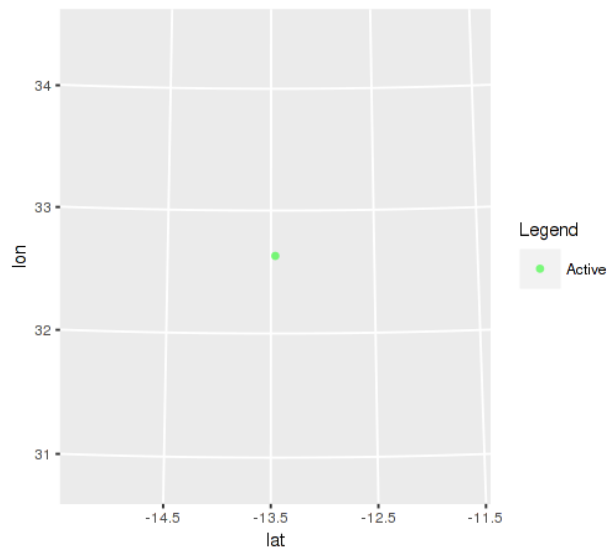
# Asimilacion Canarias: AMDAR



AIC: Observation Usage aircraft t 2018-04-29 00Z

levels: 17500, 22500, 27500, 35000, 45000, 60000, 80000, 92500, 100000

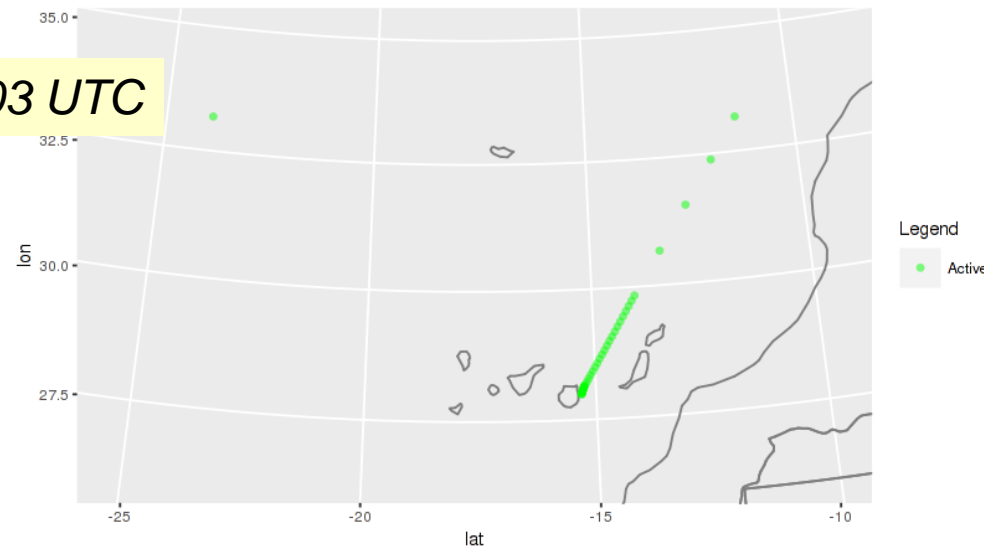
00 UTC



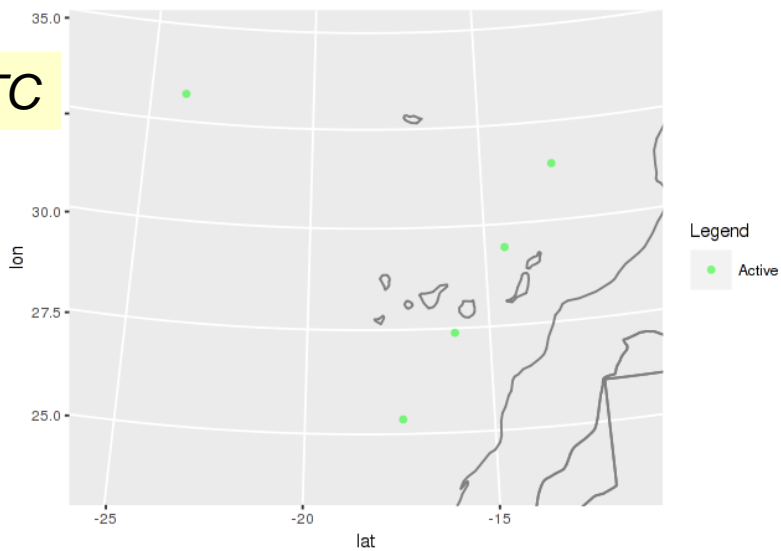
AIC: Observation Usage aircraft t 2018-04-

levels: 17500, 22500, 27500, 35000, 45000, 60000, 80000, 92500, 100000

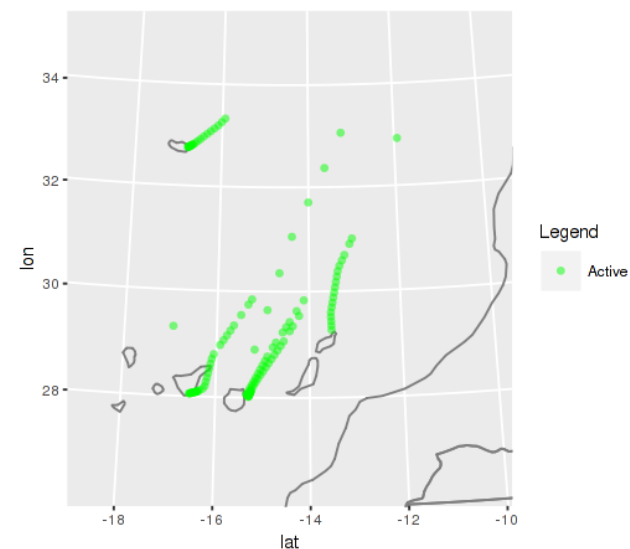
03 UTC



06 UTC

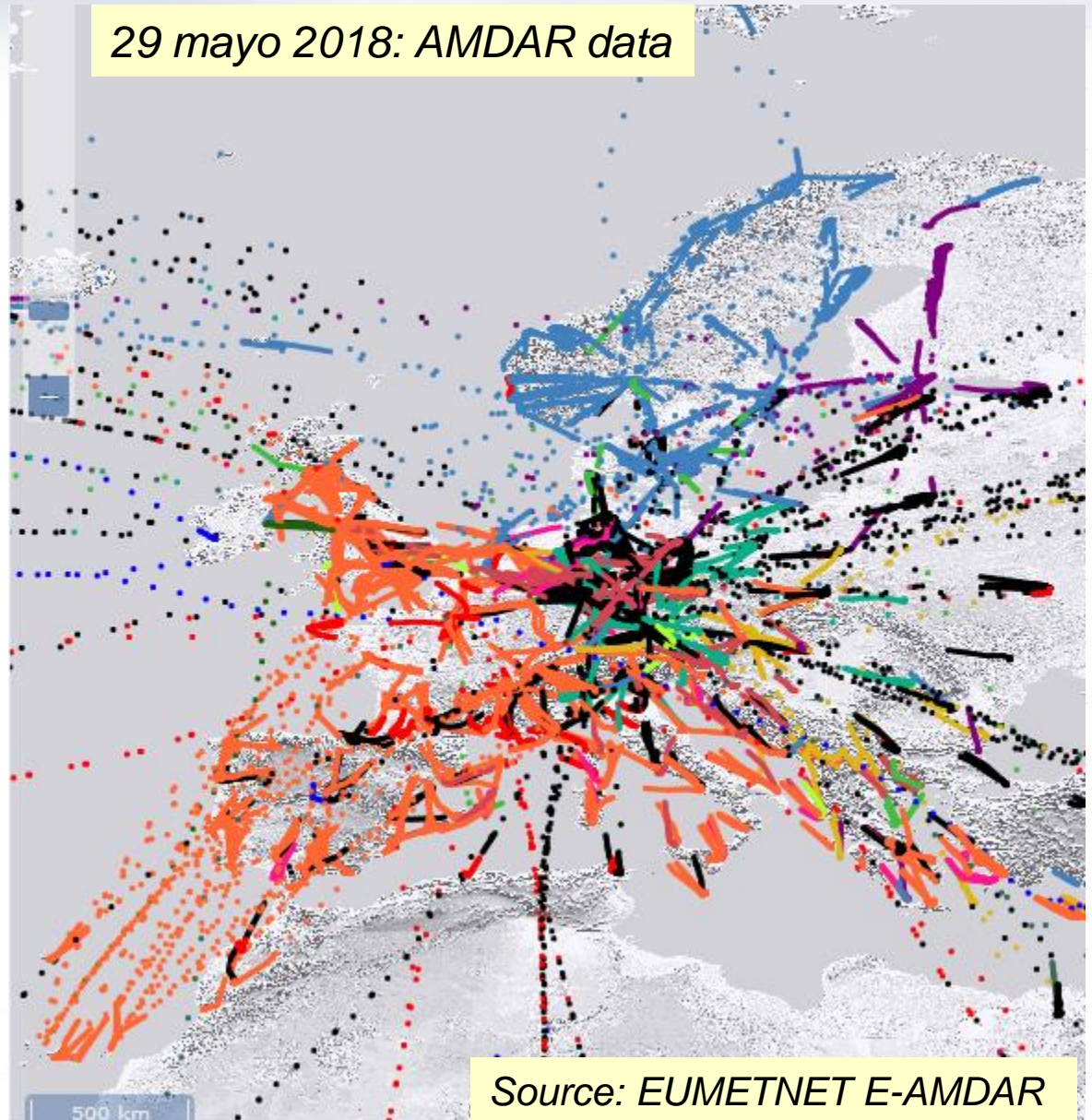


12 UTC



# AMDAR distribución para un día típico

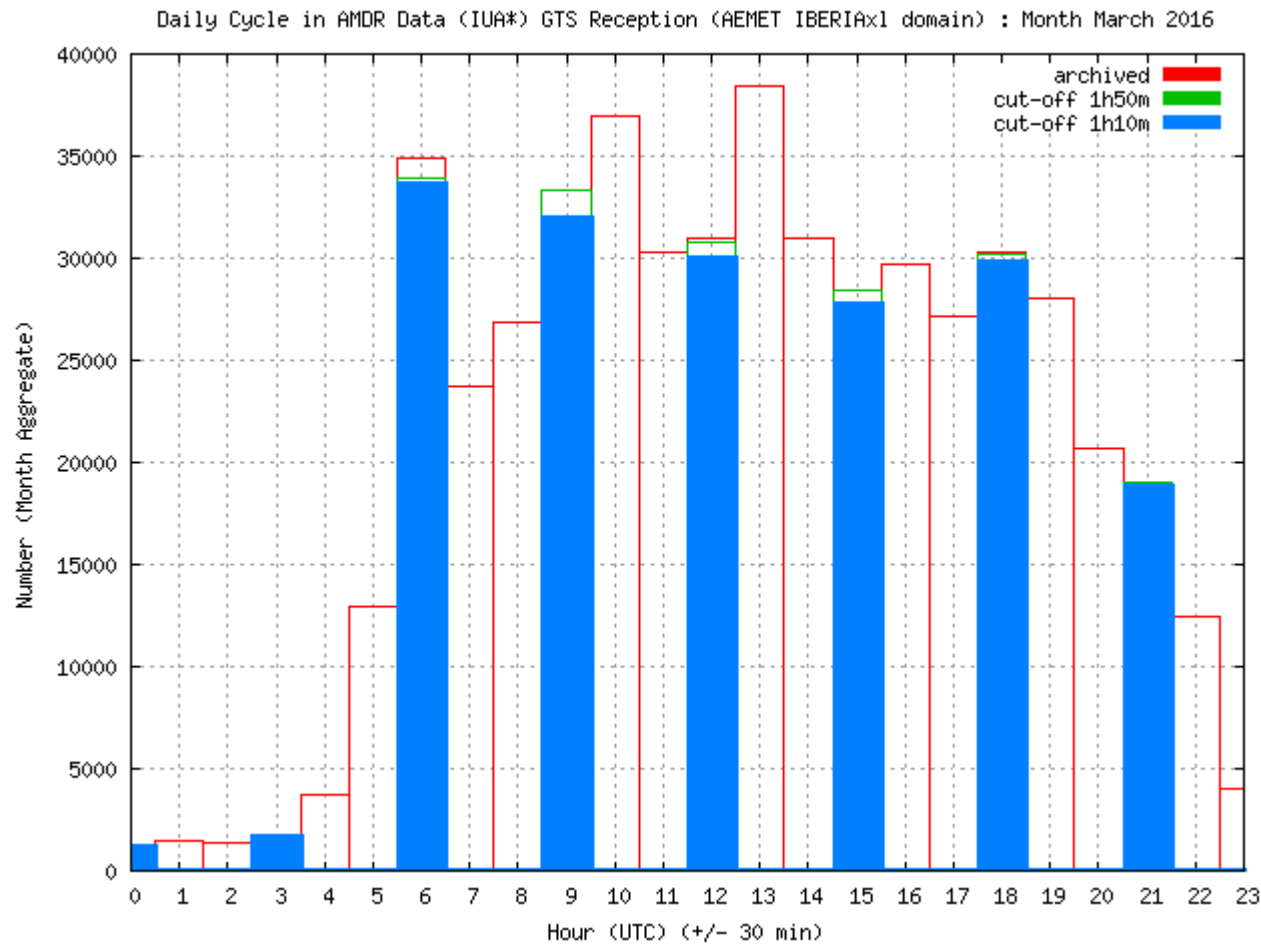
- Buena distribución pero podría mejorar sobre España y en especial sobre las Islas Canarias
- E-AMDAR:
  - Air France
  - Austrian Airways
  - Blue1
  - British Airways
  - EasyJet Airline
  - Finnair
  - KLM
  - Lufthansa Cargo
  - Lufthansa CityLine
  - Lufthansa Germanwings
  - Lufthansa Passage
  - Novair Scandinavia
  - Scandinavian Airlines
  - Thomas Cook



# Timeliness of AMDAR data during the day and depending on the cutoff-time

- Iberian domain

*E-AMDAR target: 90% of obs available T+50min*

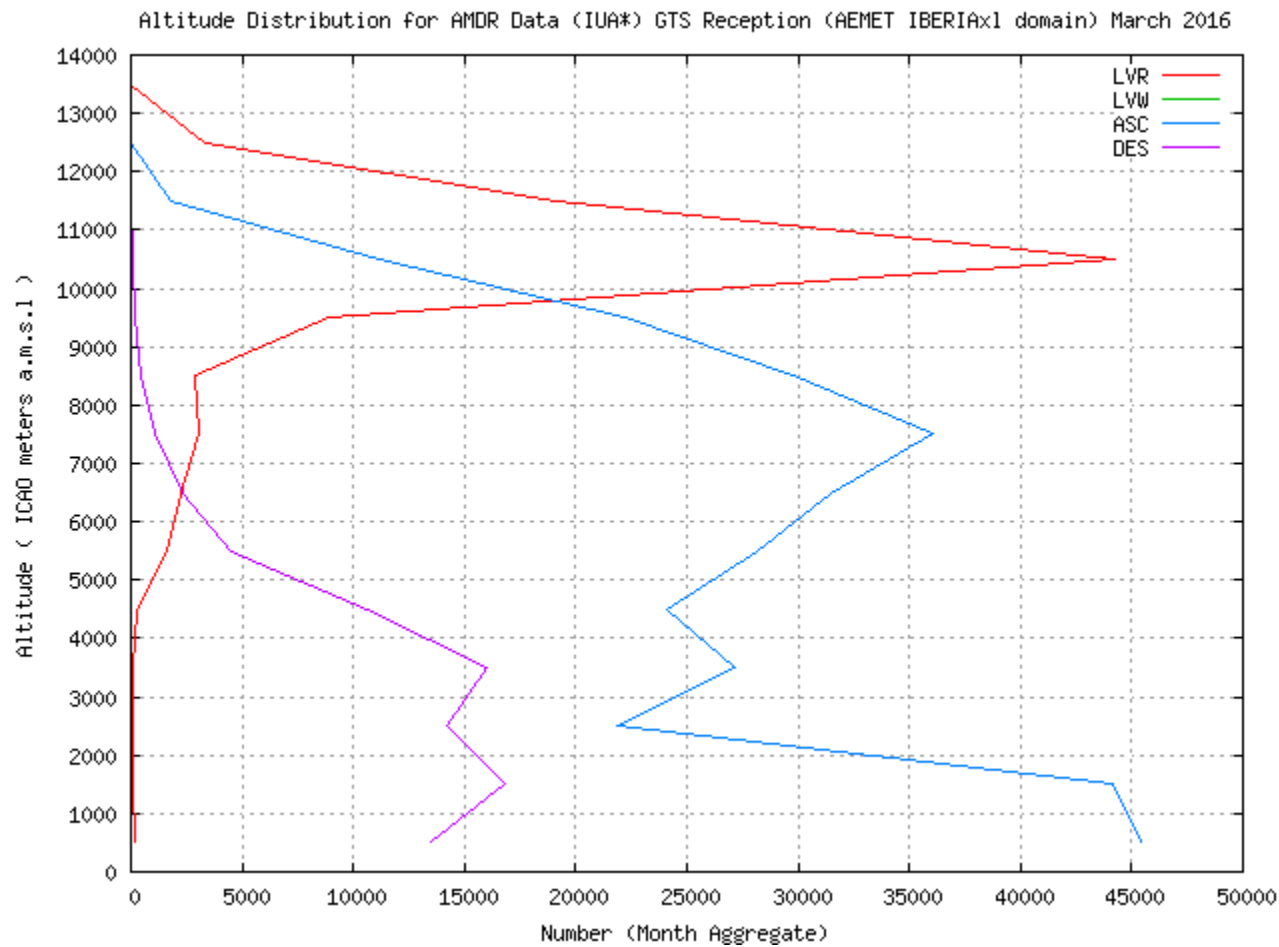


Thanks: Carlos Geijo



# Vertical distribution of AMDAR

- Iberian domain



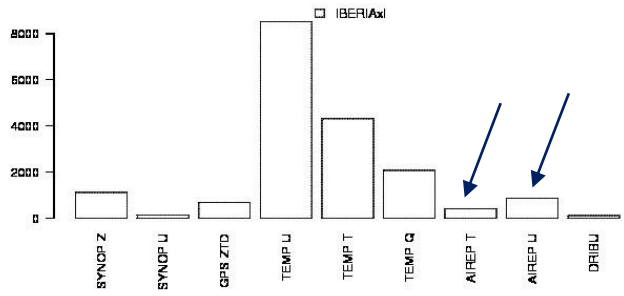
Thanks: Carlos Geijo

# Impact of different types of observations in the assimilation

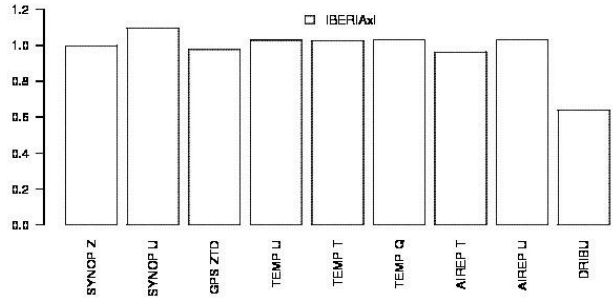
- Iberian Domain
- Big impact of AMDAR data specially when there are not sounding

00 UTC

Absolute Degree of Freedom for Signal (DFS)

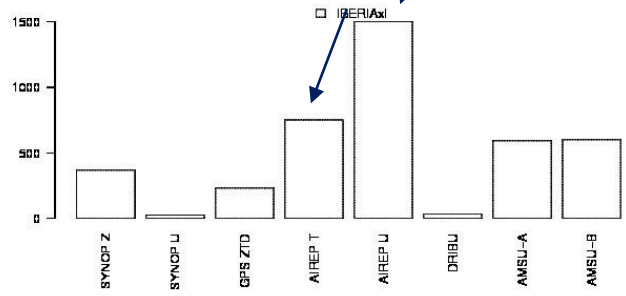


Relative Degree of Freedom for Signal (DFS/observations)

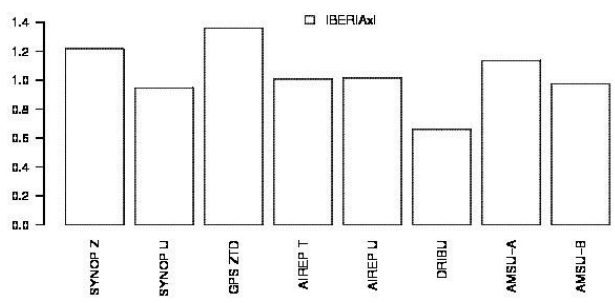


06 UTC

Absolute Degree of Freedom for Signal (DFS)

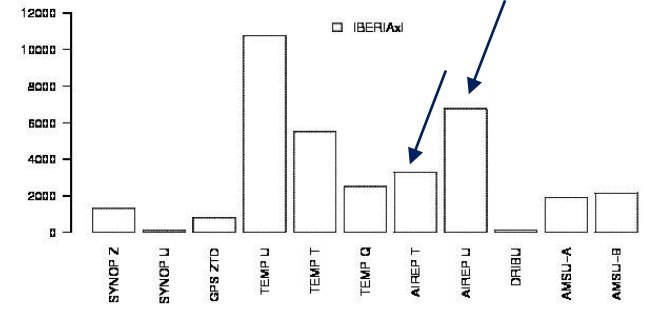


Relative Degree of Freedom for Signal (DFS/observations)

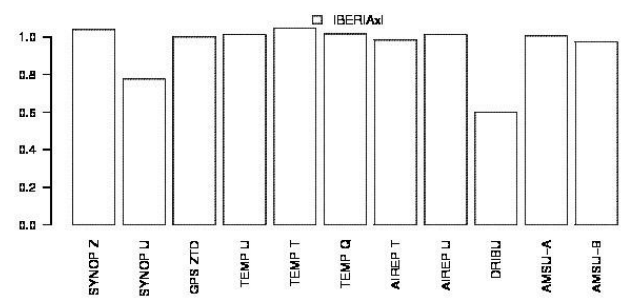


012 UTC

Absolute Degree of Freedom for Signal (DFS)



Relative Degree of Freedom for Signal (DFS/observations)



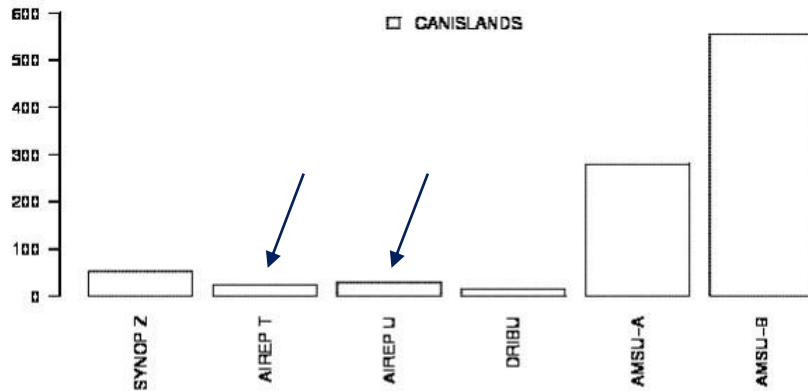
DFS: Degree of Freedom for Signal (Chapnik et al, 2006)

# Impact of different types of observations in the assimilation

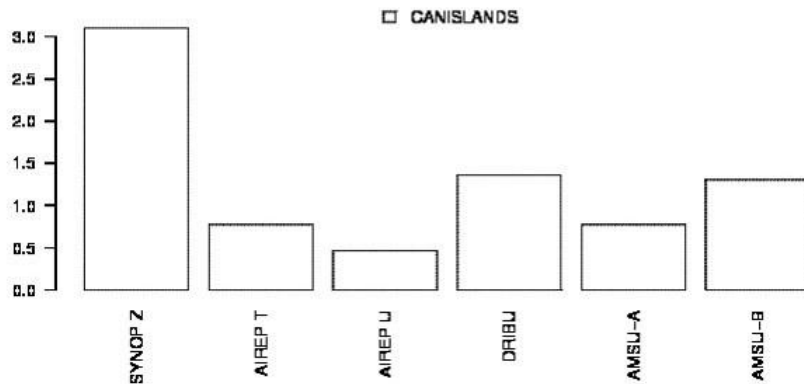
- Canary Islands domain
- Lower impact of AMDAR (less flights)

09 UTC

Absolute Degree of Freedom for Signal (DFS)

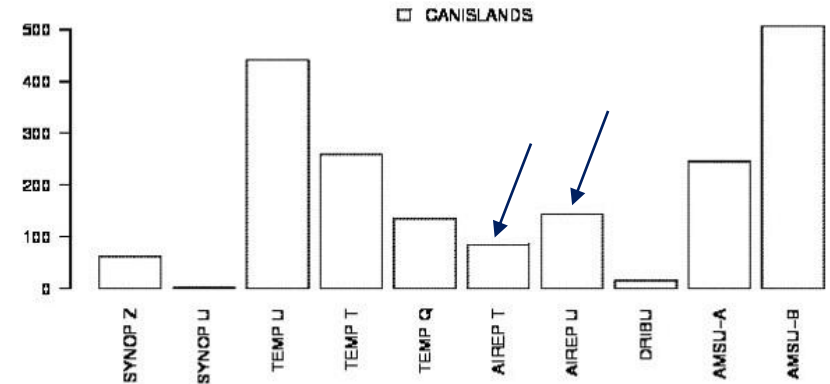


Relative Degree of Freedom for Signal (DFS/observations)

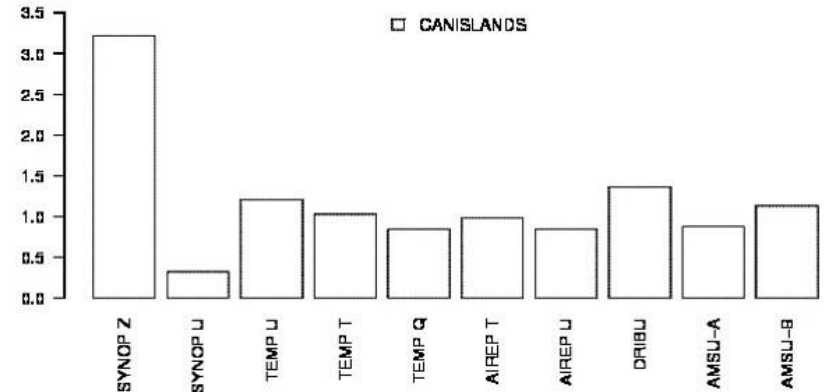


12 UTC

Absolute Degree of Freedom for Signal (DFS)



Relative Degree of Freedom for Signal (DFS/observations)

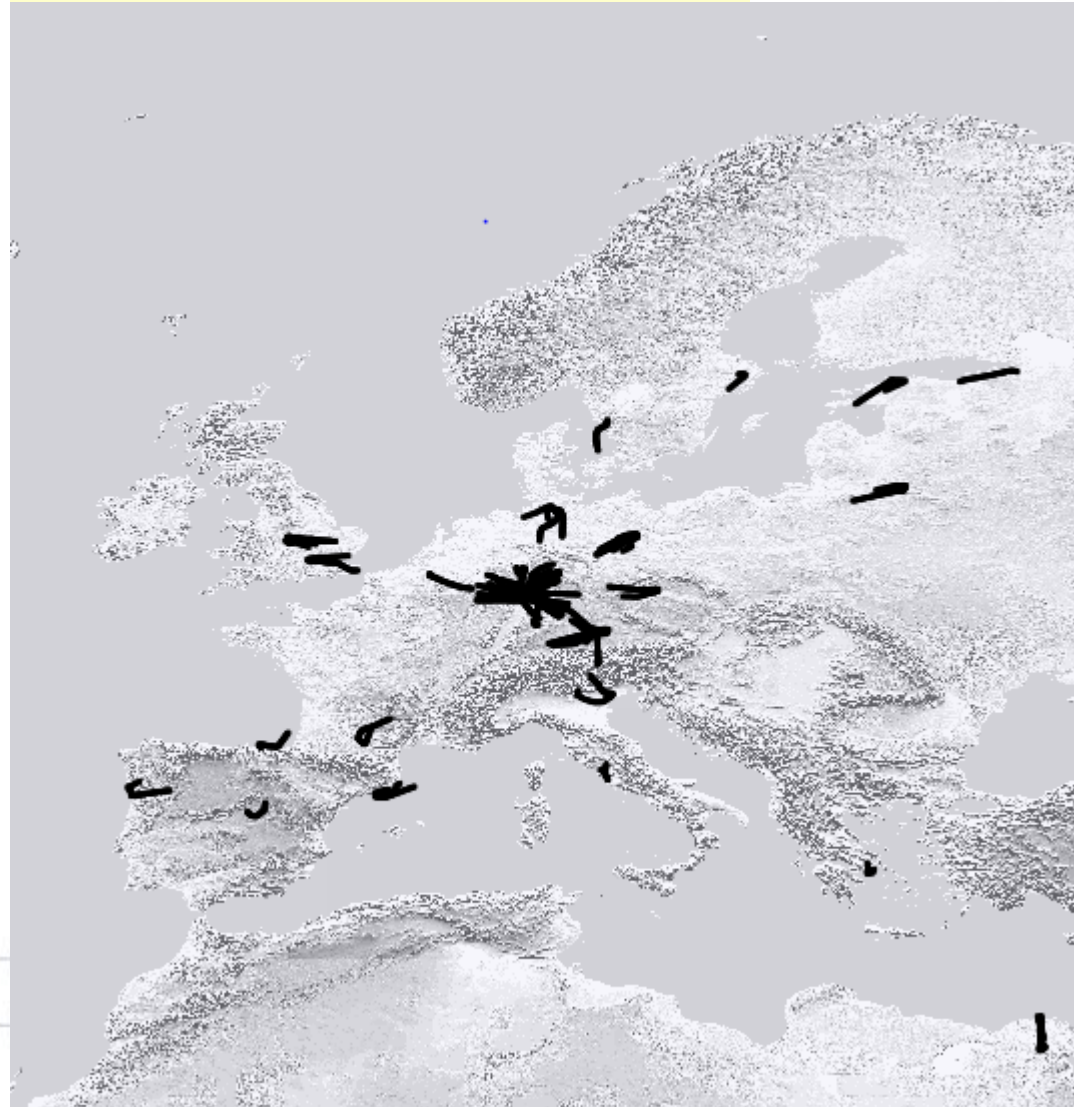


# AMDAR humidity

- Even better quality than soundings
- Good coverage over continental USA but
- Only 9 Lufthansa aircrafts in Europe
- Much more expensive than standard AMDAR and requires special installation in the airplanes
- Impact studies show positive impact on the forecast



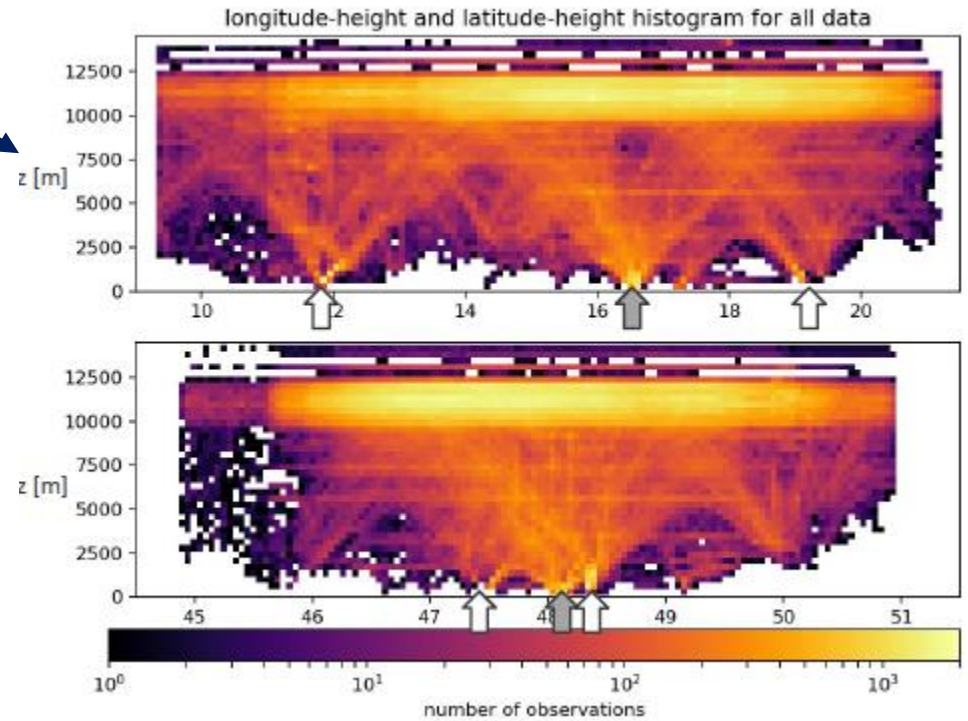
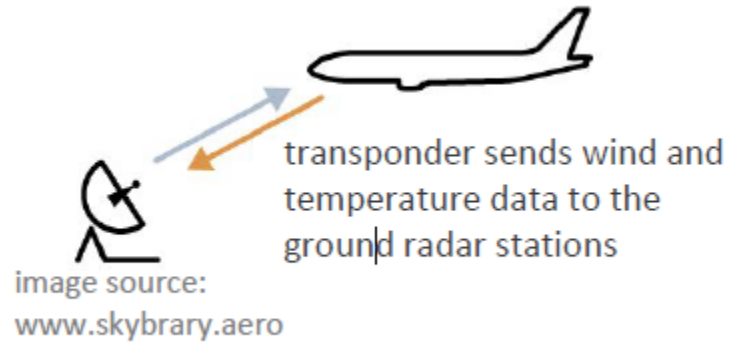
29 mayo 2018: AMDAR humidity



Source: EUMETNET E-AMDAR

# MODE-S data

- Secondary surveillance radar (SSR) receives temperature and wind data from aircraft
- Wind almost directly observed, temperature lower quality
- High resolution (~1km) thinning necessary
- Cruise level and vicinity of airports



Scheffknecht et al, 2018

- Preprocessing and quality control is very important
  - KNMI/ EMADDC currently funded by KNMI and SESAR but eventually may take part of EUMETNET E-ABO program
- Suitable for nowcasting

## Several impact studies assimilating Mode-S data on going:

- KNMI, UKMO, Meteo-France
- ZANG: [http://www.umr-cnrm.fr/aladin/IMG/pdf/phillip.scheffknecht\\_assimilation-mode-s-final.pdf](http://www.umr-cnrm.fr/aladin/IMG/pdf/phillip.scheffknecht_assimilation-mode-s-final.pdf)
- LACE: [http://www.umr-cnrm.fr/aladin/IMG/pdf/strajnar\\_modes\\_ehs.pdf](http://www.umr-cnrm.fr/aladin/IMG/pdf/strajnar_modes_ehs.pdf)
- Significant impact on the assimilation and short forecasting ranges (specially up to 12 hr).
- Despite lower quality, temperatura also improves the forecasts

# Conclusiones

- Los datos AMDAR tienen un impacto muy importante en la asimilación de datos
- Son mucho más baratos que los sondeos lo que permite optimizar las redes de observación
- La cobertura de datos podría mejorar bastante si las principales líneas aéreas que operan en España se suman al programa AMDAR.
- Los datos AMDAR de humedad tienen un impacto positivo en las predicciones pero de momento sólo programa piloto
  - Estudios financiados por EUMETNET para evaluar el impacto
- Resultados prometedores usando datos Mode-S
  - Impacto positivo tanto de los datos de viento como de temperatura
  - Mayor resolución de las observaciones y más baratas
  - Observaciones adecuadas para sistemas de nowcasting