Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Verkeer en Waterstaat

High Resolution Mode-S observations

- Quality
- Impact on NWP
- Case Study

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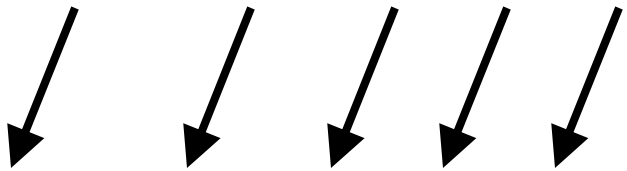
ASM 2010

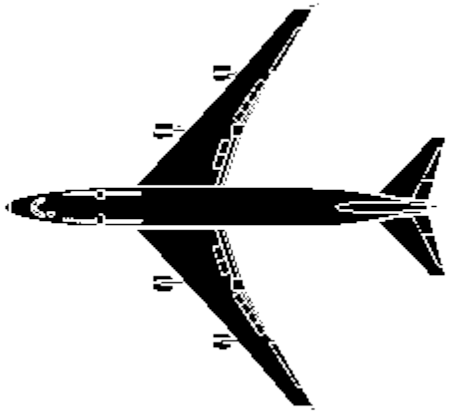
Aircraft measurements (Mode-S)

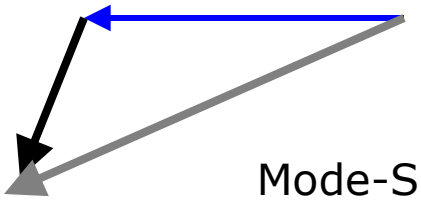
- Mode-Selective
- (almost) all aircraft measure
  - Height (pressure)
  - Temperature
  - Groundspeed
  - …..
- Aircraft broadcast this information to prevent collisions
- Air Traffic Control tracks all aircraft for surveillance
  - Every 4 seconds a full scan
- Idea: use ModeS data to improve first few hours of HIRLAM over Netherlands to improve forecasts of arrival times at Schiphol Airport

Atmospheric observations from Mode-S

Wind





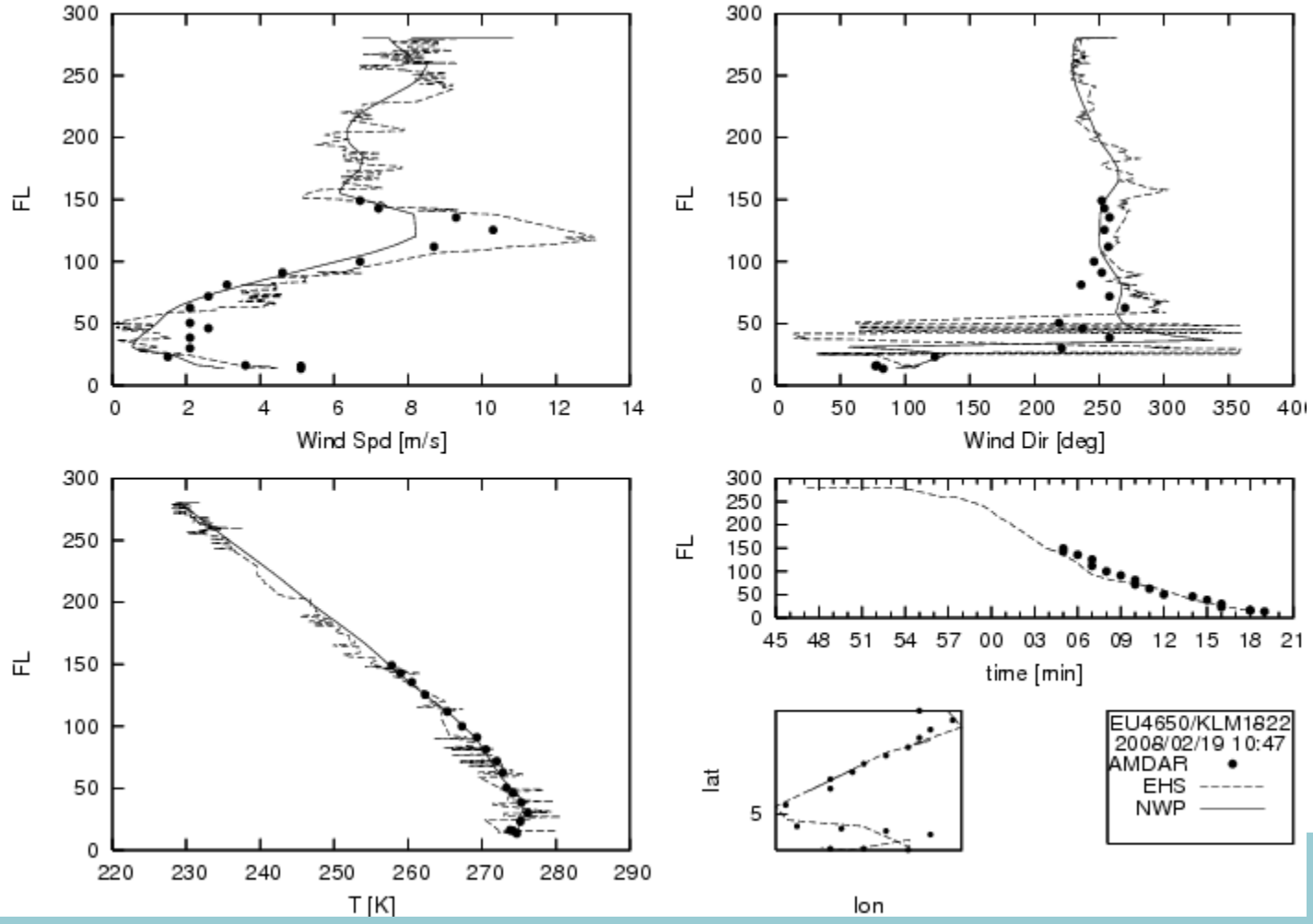


Mode-S message contains

- Groundspeed/path
- Heading of the aircraft
- True Airspeed
- Mach-number

$V_{true} \approx M\ T^{1/2}$

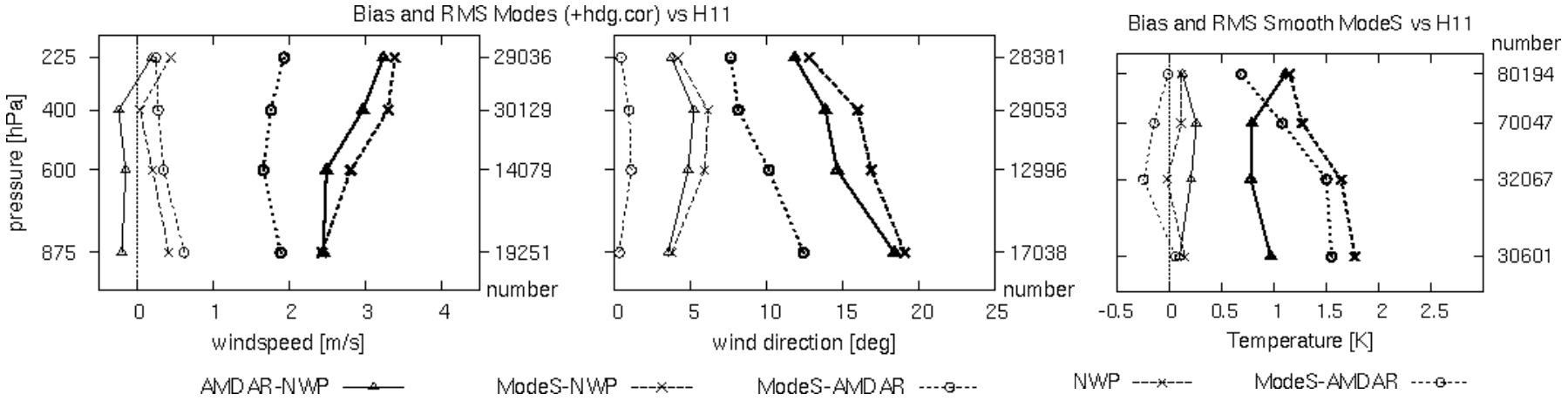
Example
Mode-S/AMDAR/Numerical Weather Prediction



Correction of observations

- Accuracy of observations 2 kt for wind speed and 0.04 for Mach number (temperature not very accurate)
- Smoothing over 60 seconds (15 observations) give good observations
- Heading correction possible with observations at runways, direction important because of high speed of airplanes
- Heading correction (plane dependent) and smoothing gives similar quality for wind compared to AMDAR and a little bit worse quality for temperature

Quality of Mode-S observations



✓ **Wind** observations are of good quality

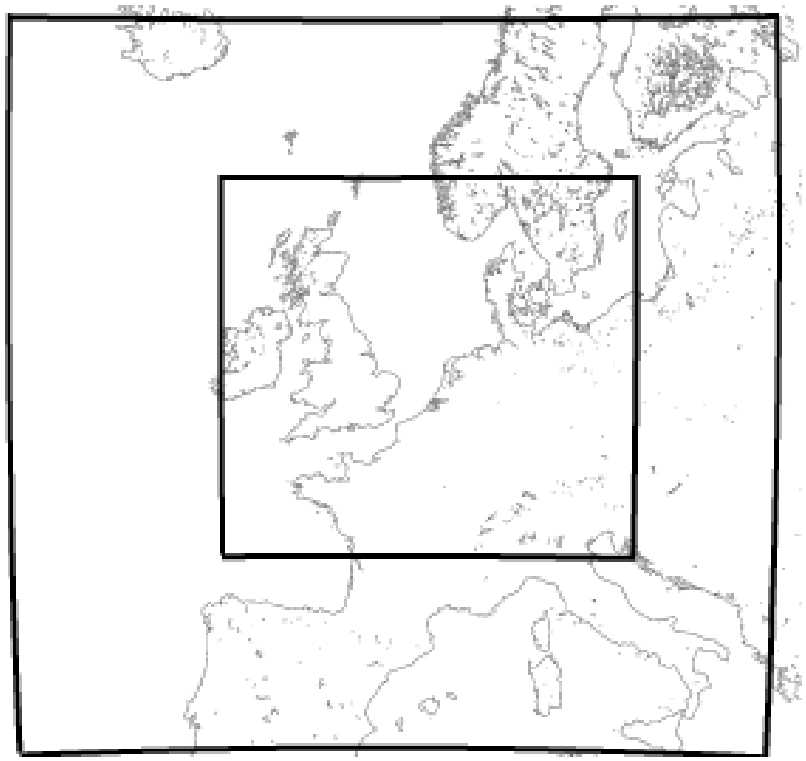
✘ **Temperature** observations not as good as AMDAR (is not a problem)

Quality ModeS wind observations comparable to AMDAR

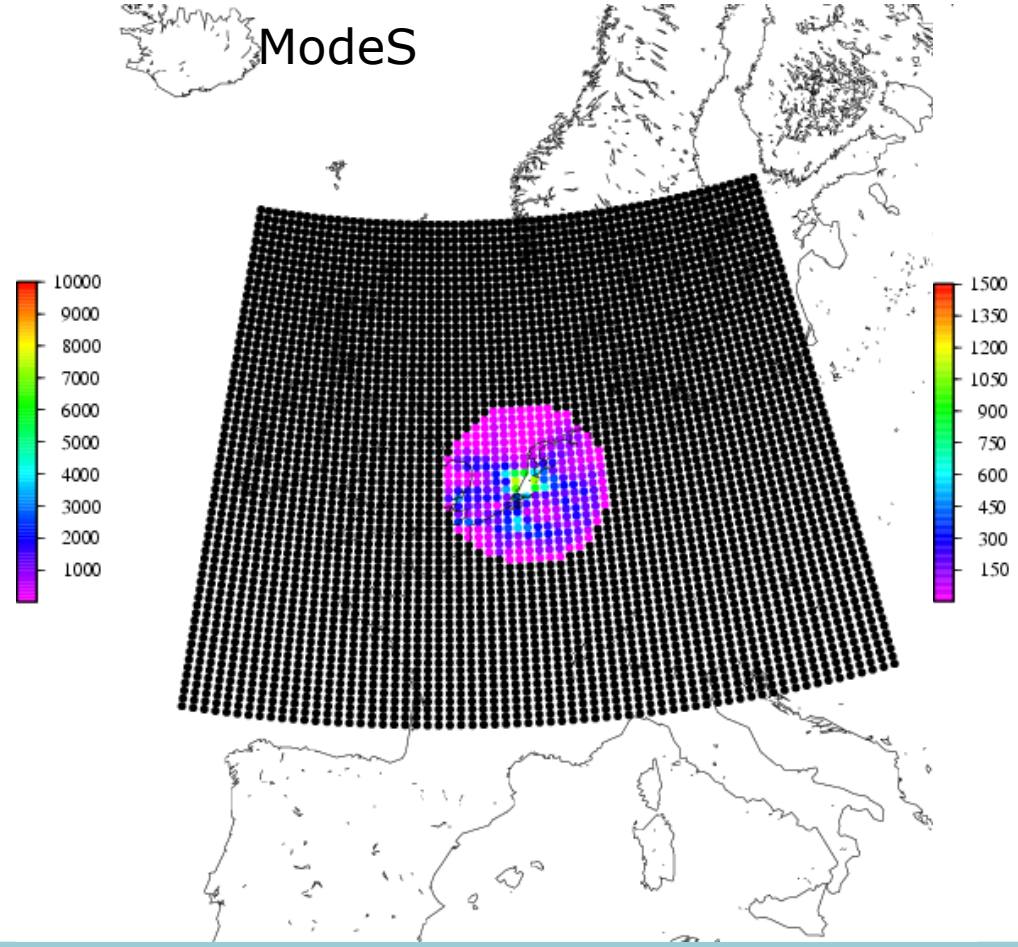
Assimilation in NWP

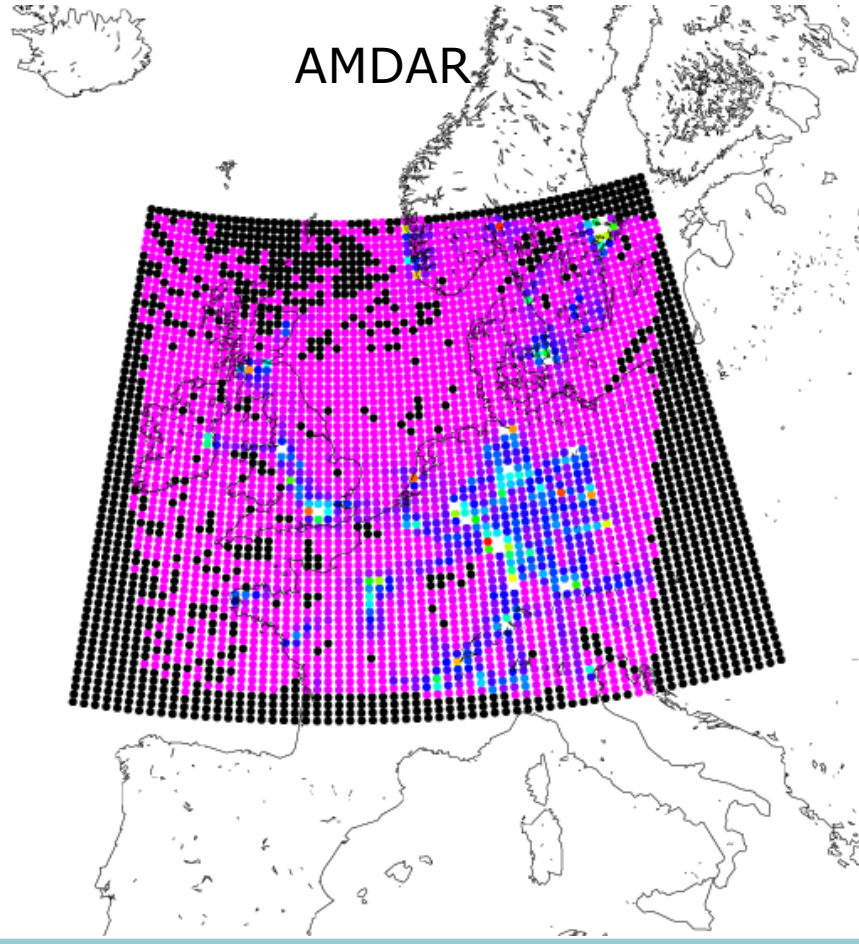
Assimilation (HIRLAM 7.0, RUC)

- Reference (large domain)
  - 3 hour cycle
  - SYNOP/TEMP/AMDAR
- Hourly run
  - FG is +001
  - adjusted "bg. error cov.scaling factor"
  - Hourly boundaries from ReRUN
  - Observations
    - Mode-S + SYNOP
    - …. + (fast!) AMDAR
- Aim: better 3D description of wind field for landing time forecasts
- Period: 2008/02/01 – 2008/03/10

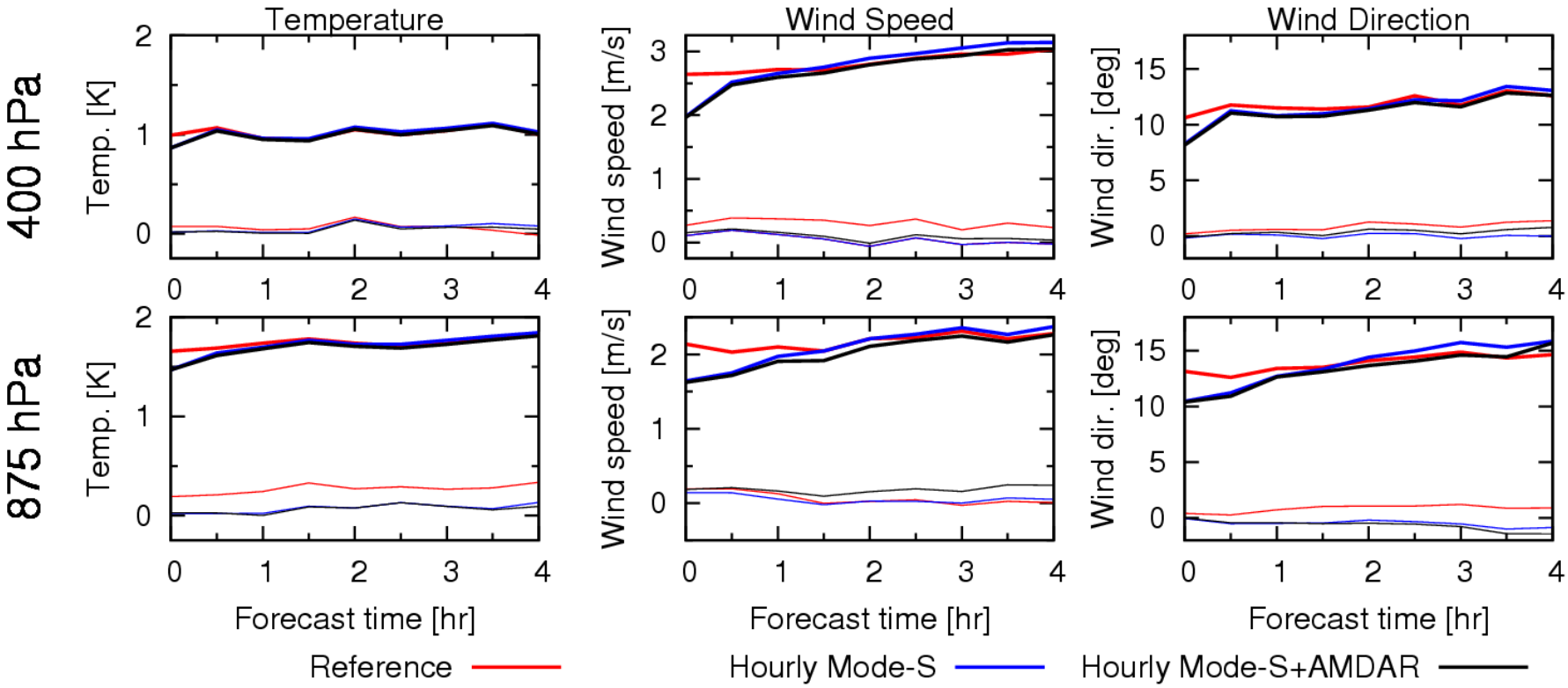


Number of observations between 01Feb-10Mar





Comparison with ModeS observations at 875hPa/400hPa



Bias reduction in temperature and wind direction
Assimilation of **ModeS** improves **RMS** in the first hours
Additionally **(fast)AMDAR** improves **RMS** up to +04

Case Study

Lightning 25/26 May 2009

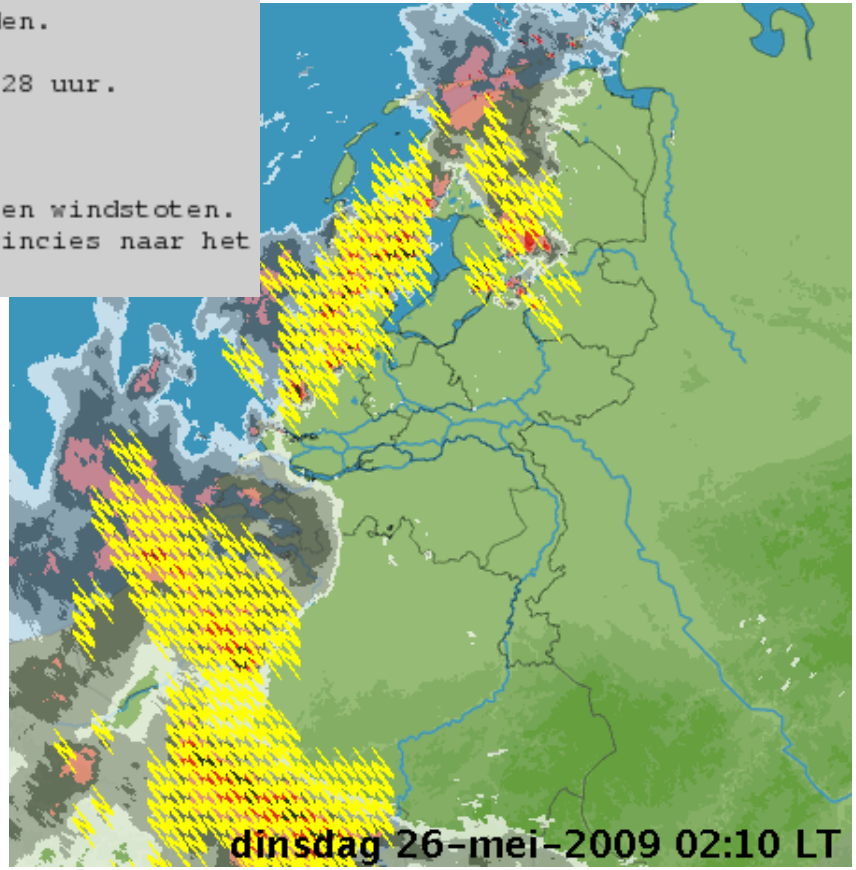
Waarschuwing voor verkeersbelemmerende weersomstandigheden.

Bericht opgesteld door het KNMI op maandag 25 mei om 20.28 uur.

VERKEERSOVERLAST DOOR ZWARE NEERSLAG

In Zeeland komen er zware buien voor, met onweer, hagel en windstoten. Deze buien trekken vanavond en vannacht over de kustprovincies naar het noorden.

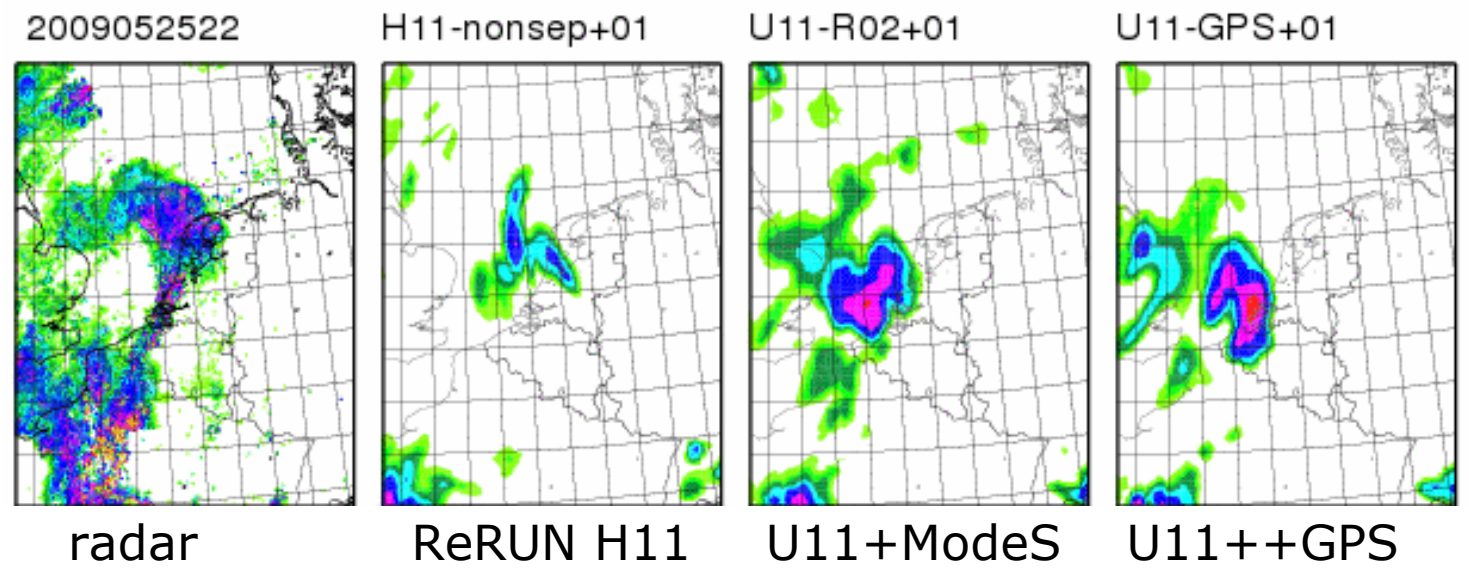
- Unexpected heavy thunderstorms
- Operational models gave no indication of strong convection over land
- Can the hourly run improve upon the operational runs?



ReRUNs of HiRLAM

H11	**U11-R02**	**U11+GPS**
Start analyses H11: 2009/05/25 00 UTC : "warming up" of 21 hour		
Each 3 hour	Each hour	
Start 1,5 hour later	Start 10 minutes later	
Non-seperable BgErrCov	Statistical balanced BgErrCov	
Radiosonde + Amdar + surface observations	*Available* standard observations + **ModeS**	*Available* standard observations + **ModeS + GPS**

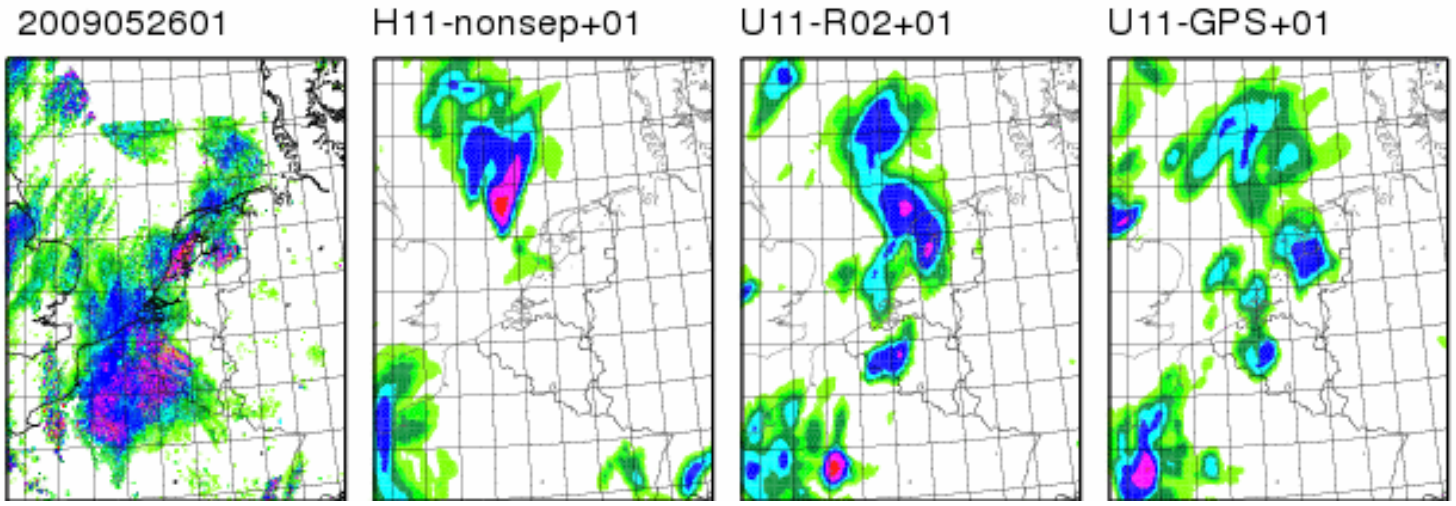
Hourly precipitation (1)



Start time: 2009/05/25 21 UTC

- **H11** dry Nederland
- **U11+ModeS** in Belgium heavy precipitation
- **U11+ModeS+GPS** weakens this convection

Hourly precipitation (2)



radar ReRUN H11 U11+ModeS U11++GPS

Start time: 2009/05/26 00UTC

- **U11+ModeS** en **U11+ModeS+GPS** both show a heavy convection over Belgium
- Convection Northern-France less extreme for **U11+ModeS+GPS**

Conclusions/Outlook

- Observations from ModeS
  - ModeS contains valuable wind information after calibration and correction (temperature is of less quality)
- Assimilation of ModeS
  - Hourly cycle assimilation of ModeS positive impact in first hours
  - Additional FAST-AMDAR generates a better forecast
- Positive impact on miss and false alarm of operational HIRLAM
- "Free" source of data, European exchange (with corrections)? High observation density!

Hourly Assimilation

- Routinely => operational?
- 6 hours forecast useful for the forecasters? Positive impact seen up to +12!

- Improvements in assimilation
  - Structure functions
    - Small structures?
    - Flow-dependent?
  - Other "fast" observations:
    - Radar winds
    - GPS
    - Mode-S data from Brussel (2010)

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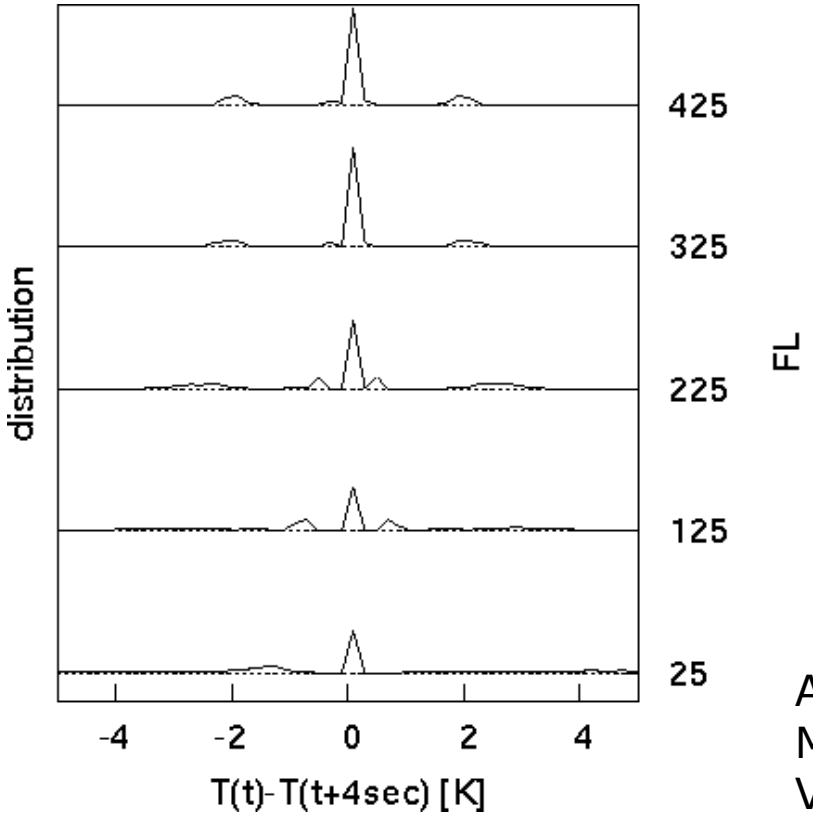
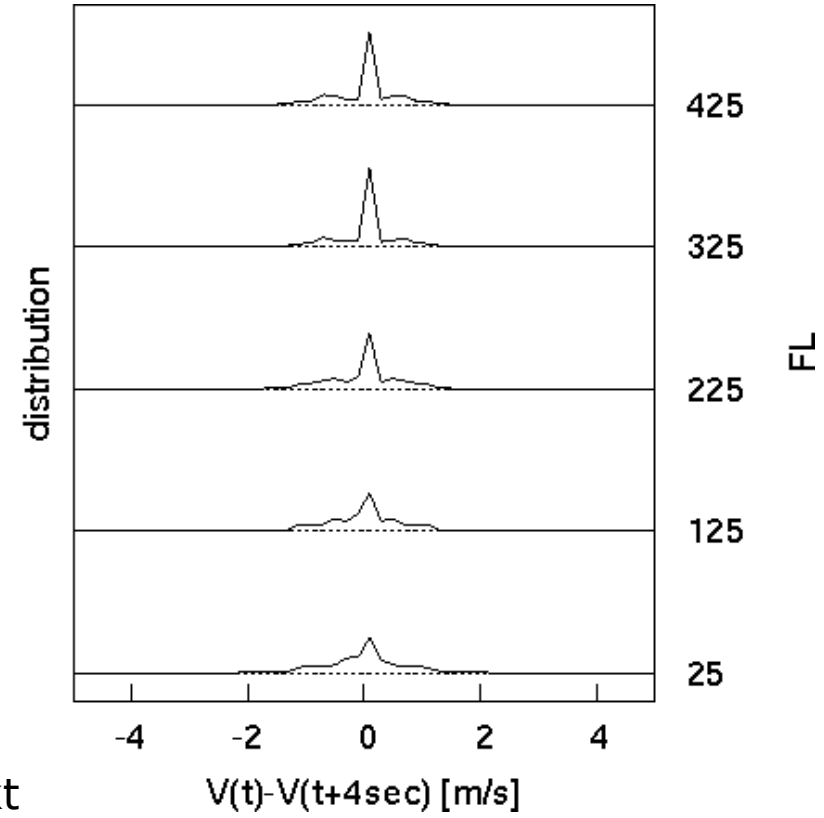
Thanks for your attention

ASM 2010

Consistency of observation (with next 4 sec)

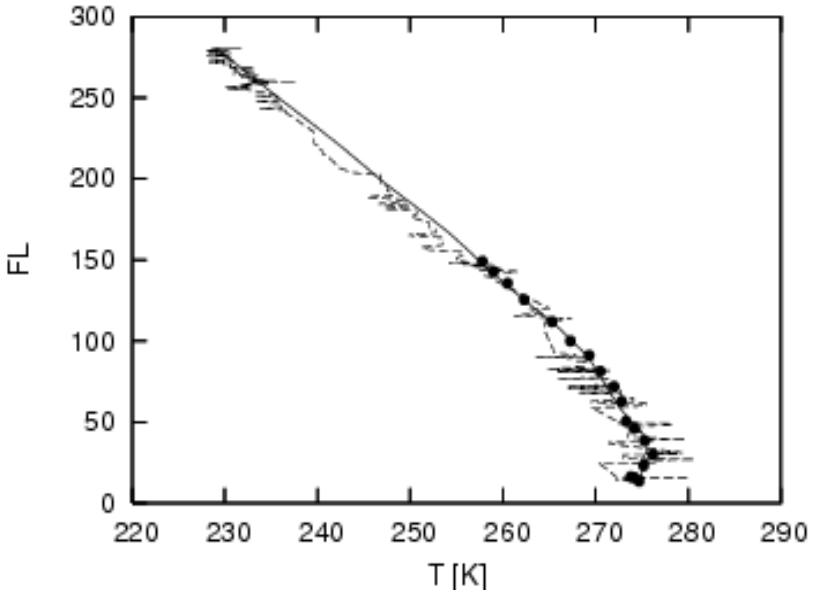


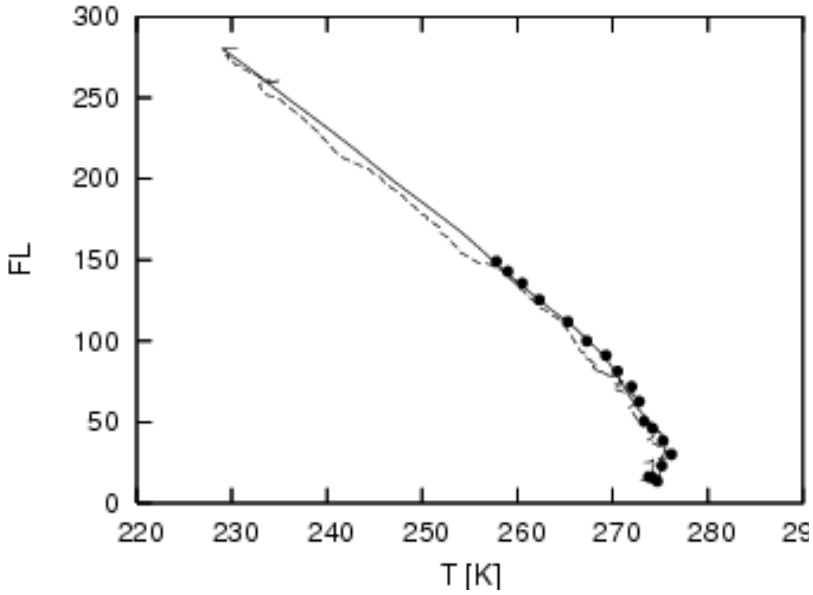
Accuracy
M in 0.04
V_{true} in 2 kt



Smoothing over 60 seconds (15 obs.)

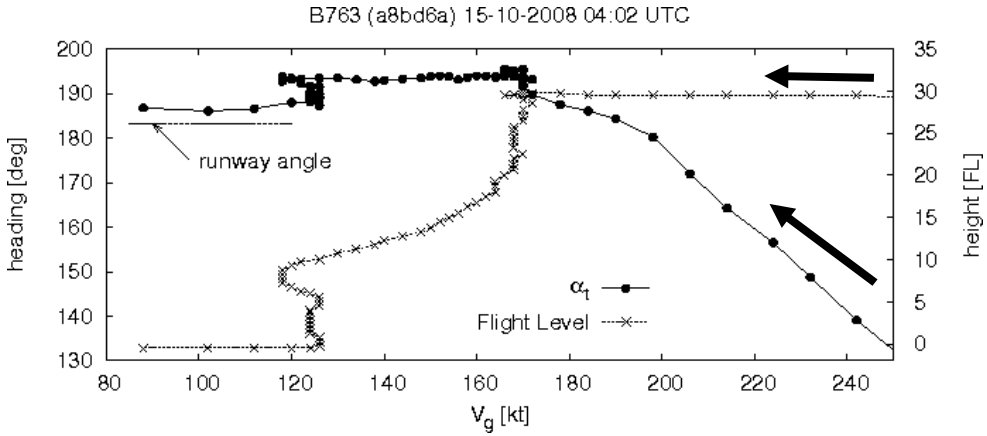
- Linear approximation of T and V_{true} over 60 sec.
- Reduction of noise in T and V_{true}

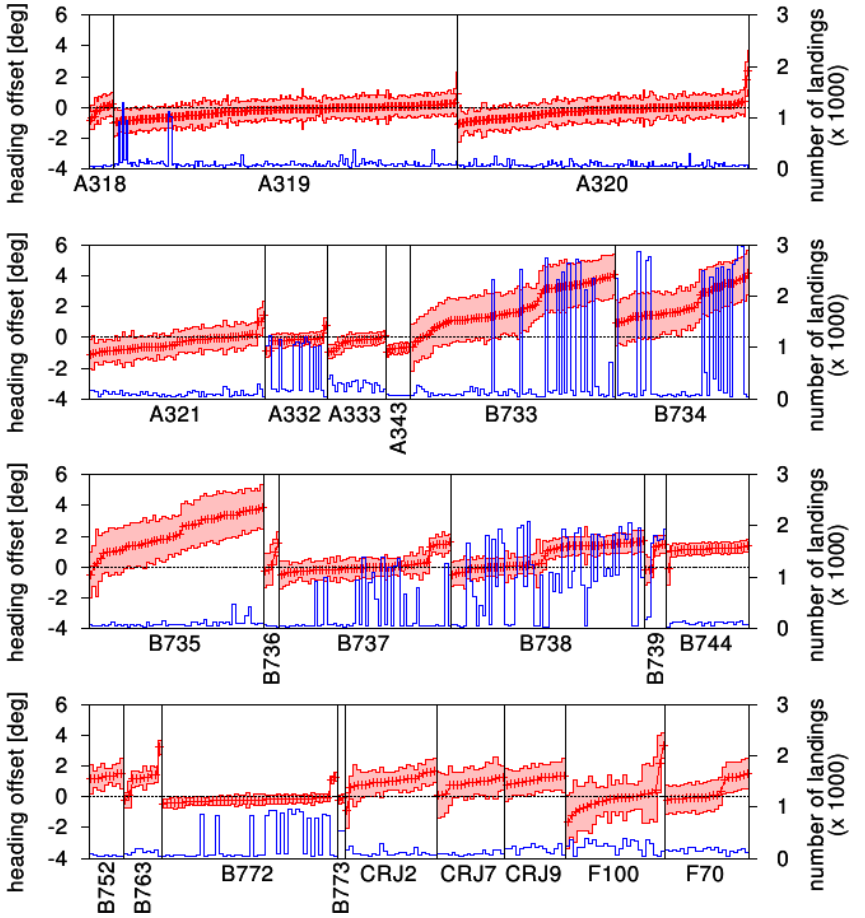




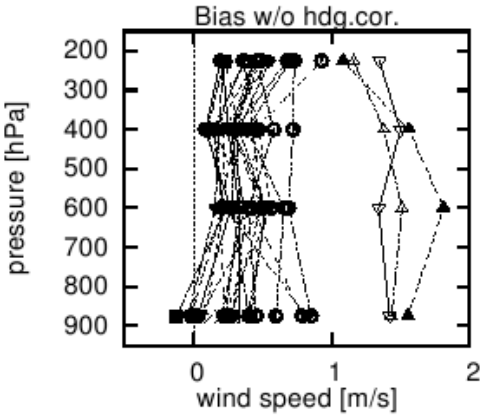
Wind observations improvements

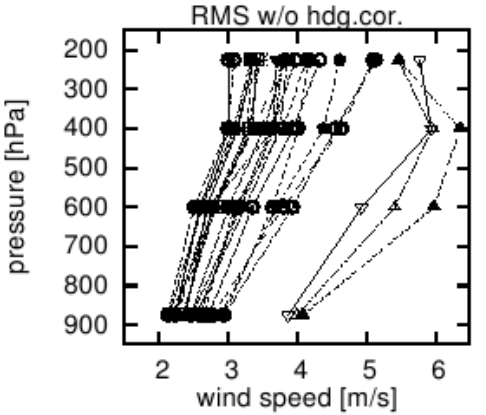
- "Heading" correction
  - "Magnetic" North versus "true"-North
    - Correction : 0 tot 1 degree
  - Landing calibration per aircraft
    - more than 10 landings
    - Correction: 1-2 degrees
    - Landing aircraft at Schiphol (1 yr)

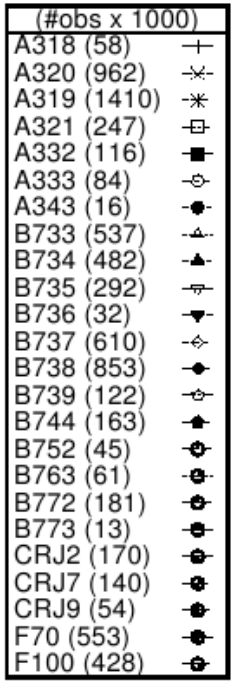




Applying “heading” calibration and smoothing

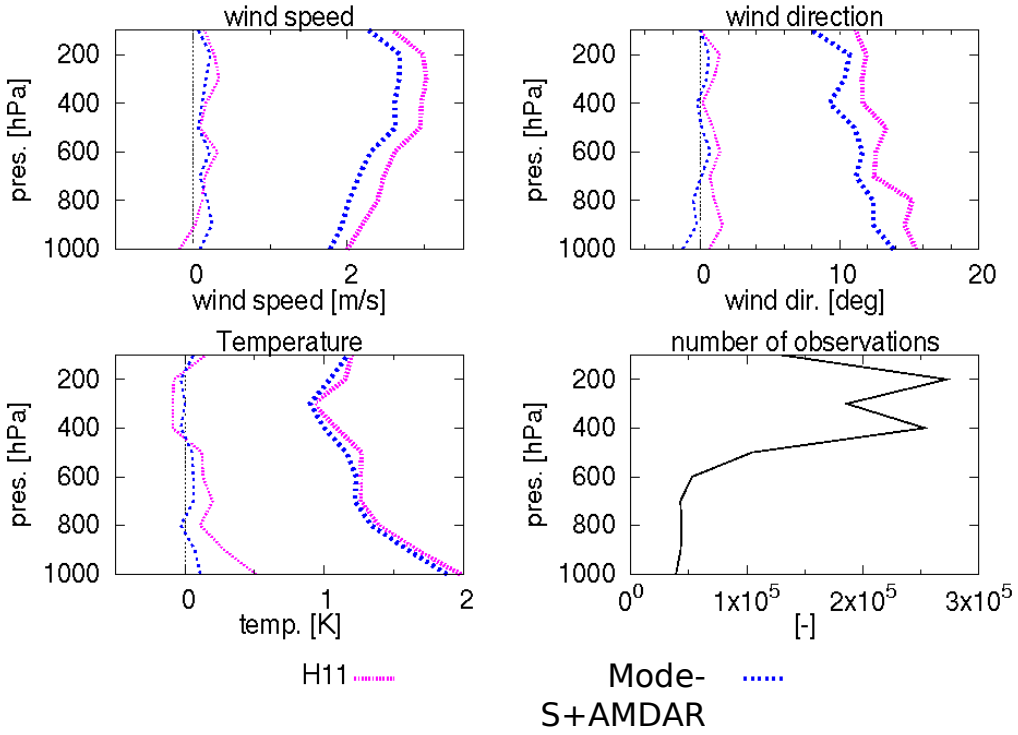






Comparison observations at appropriate time

- Hourly assimilation quicker available
- H11
  - **minimal** forecast time 2 hours
- U11 (for both runs)
  - **maximal** forecast time 2 hours



Temp: small positive impact
Wind: ModeS+AMDAR best run

Case study

Can the hourly run improve upon the operational runs?

Volkskrant 27/5/2009

75 duizend bliksems en toch geen alarm

15 000 000 Euro damage