Assimilation of GNSS observations in NWP models

Maciej Kryza, Marta Stanek

Department of Climatology and Atmosphere Protection
Wrocław University

TOMOlab, Wrocław, 08.12.2014

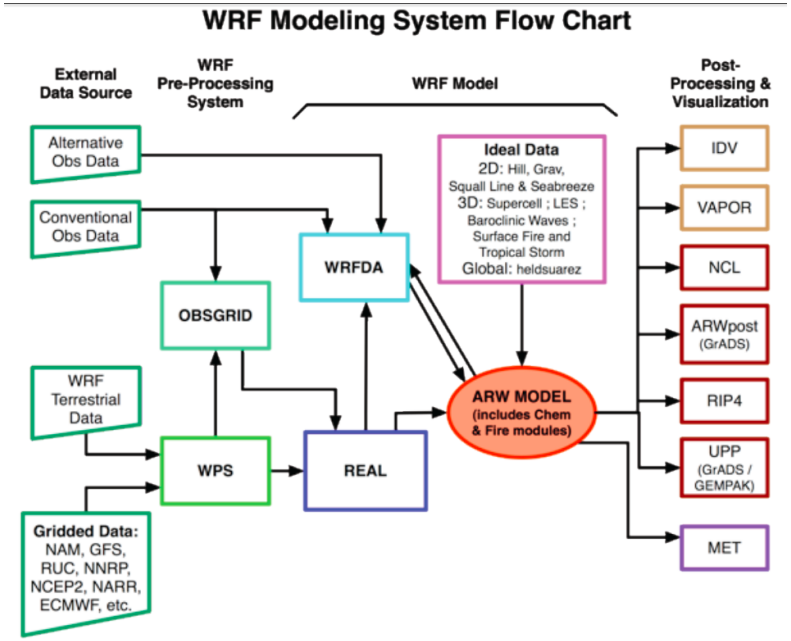
Outline

The WRF model

The WRF model

- The Weather Research and Forecasting model
- Mesoscale meteorological model
- Various applications: weather forecasting, dynamical downscaling
- Very large number of configuration options: nesting, radiation, boundary layer, microphysics, convection...

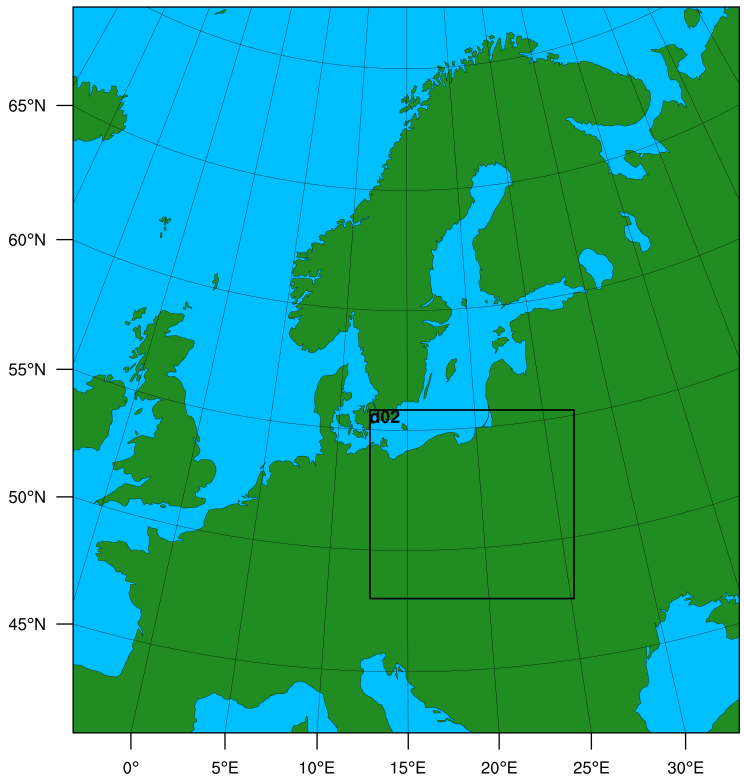
The WRF model scheme



- The WPS preprocessing system (WPS)
- WRF-DA
- ARW Solver
- Postprocessing and visualisation

The main code is maintained by Mesoscale and Microscale Meteorology Division of NCAR

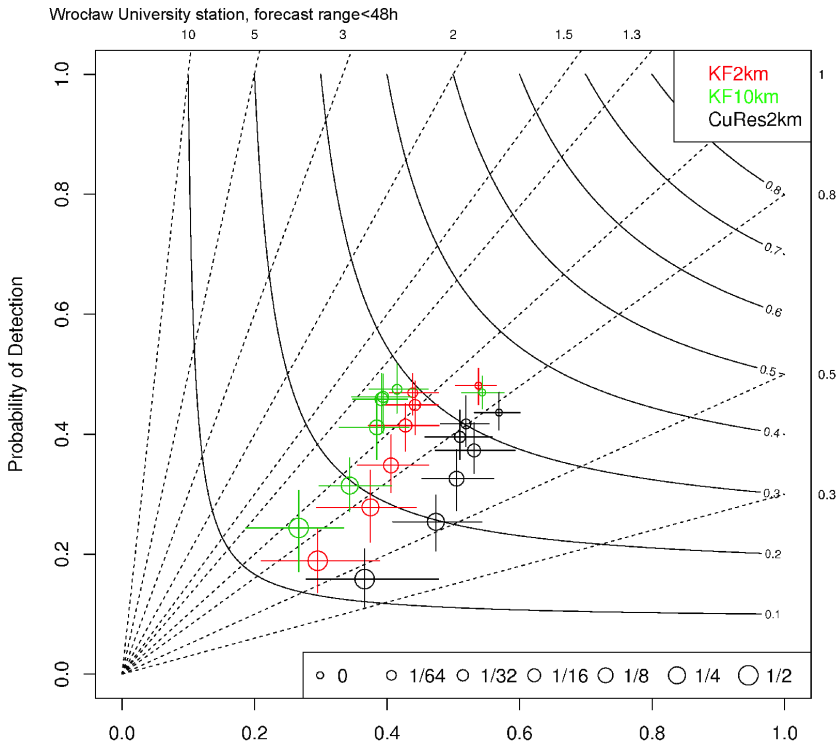
Model configuration at Wroc Uni

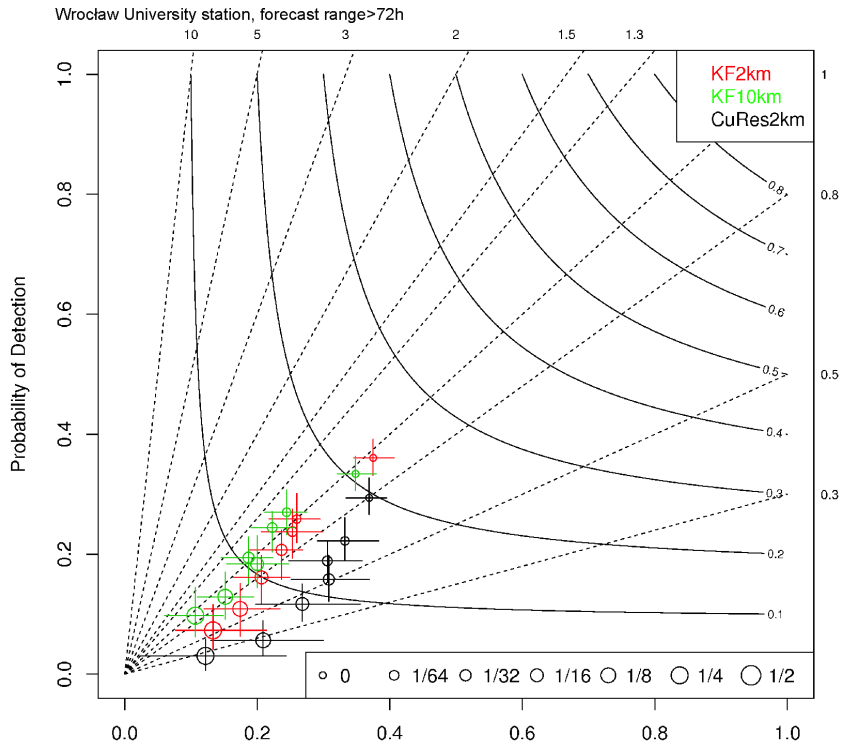


Model configuration:

- Two nested domains: 12 and 4km
- Initial and boundary conditions: GFS
- Convection explicitly resolved for d02
- Convection parameterized for d01
- Other options consisted between the domains
- Forecast updated every 6h

Rainfall for test period - Wrocław Uni





WRF DA

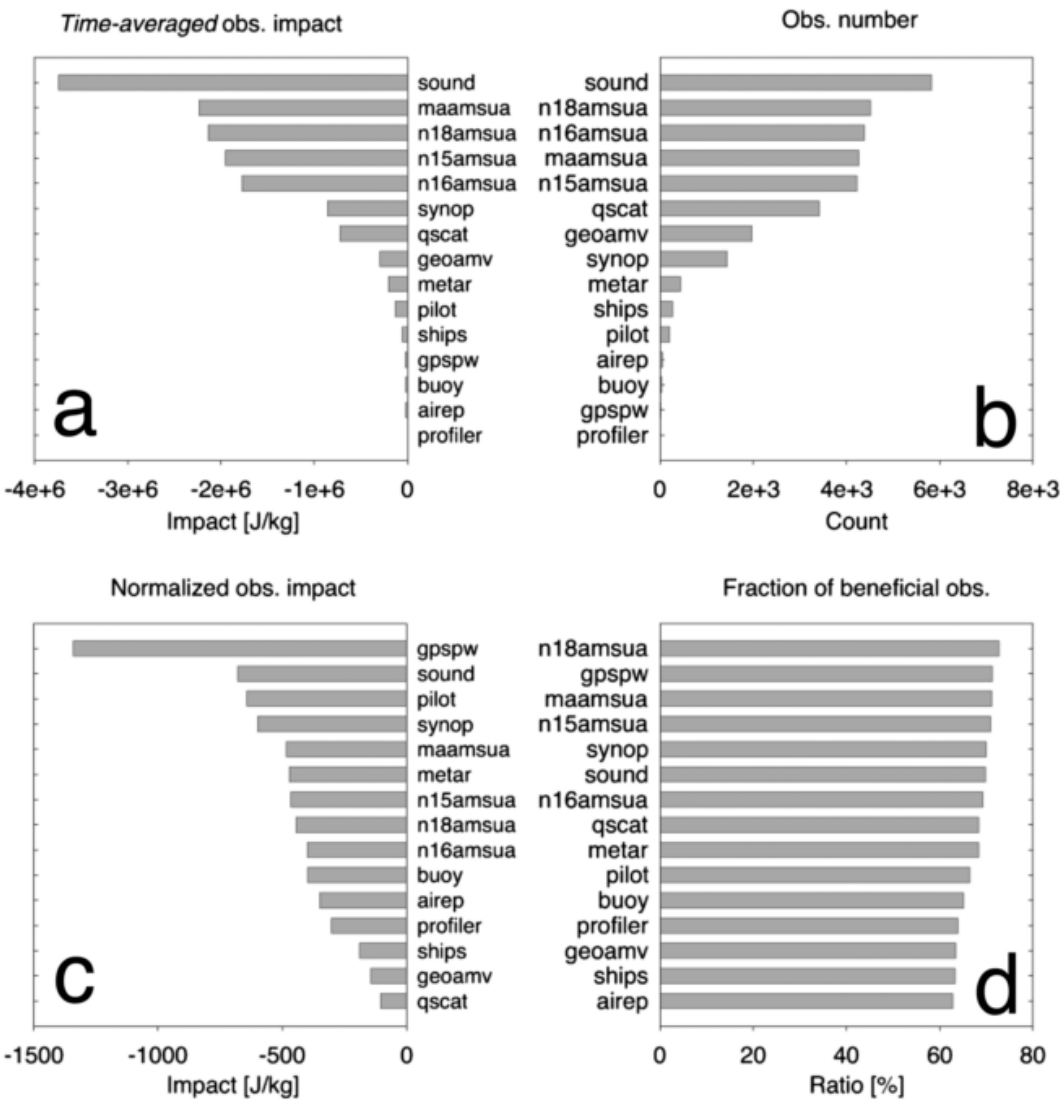
WRF DA

- Key reference: Barker et al. 2012, Bull. Amer. Meteor. Soc. 93
- Optional
- Used to:
  - ingest observations into the interpolated analyses created by WPS
  - update WRF model's initial conditions when the WRF model is run in cycling mode
- Techniques:
  - 3D-Var
  - 4D-Var
  - Ensamble Da
  - Hybrid Variational/Ensemble

- In-situ
  - Surface (SYNOP, METAR, SHIP, BUOY)
  - Upper air (TEMP, PIBAL, AIREP, ACARS, TAMDAR)
- Remotely sensed retrievals
  - Atmospheric Motion Vectors (geo/polar)
  - SATEM thickness
  - Ground-based GPS Total Precipitable Water/Zenith Total Delay
  - SSM/I oceanic surface wind speed and TPW
  - Scatterometer oceanic surface winds
  - Wind Profiler
  - Radar radial velocities and reflectivities
  - Satellite temperature/humidity/thickness profiles
  - GPS refractivity (e.g. COSMIC)
- Radiative Transfer (RTTOV or CRTM)
  - HIRS from NOAA-16, NOAA-17, NOAA-18, NOAA-19, METOP-2
  - AMSU-A from NOAA-15, NOAA-16, NOAA-18, NOAA-19, EOS-Aqua, METOP-2
  - AMSU-B from NOAA-15, NOAA-16, NOAA-17
  - MHS from NOAA-18, NOAA-19, METOP-2
  - AIRS from EOS-Aqua
  - SSMIS from DMSP-16

WRF DA examples - GNSS assimilation

WRF DA examples - PWAT



Jung et al. 2013:

- Typhoon season 2008 West North Pacific
- Forecast system: WRF and WRF DA
- Aim: effect of observations on forecast, adjoint-derived method
- The largest impact from radiance - large number of data
- The greatest observation impact per observation number: GPSPW

WRF DA examples - ZTD

Schwitalla et al. 2011:

- WRF and WRF DA forecasts for France
- Convection permitting resolution (3.6 km)
- GPS ZTD data assimilation from France, Germany (very dense network) and Italy (320 observations in total)

WRF DA examples - ZTD

Precipitation threshold (mm)	FAR			POD			ETS			FBIAS		
	CTL	FZD	NZD	CTL	FZD	NZD	CTL	FZD	NZD	CTL	FZD	NZD
0.5	0.16	0.15	0.13	0.86	0.87	0.88	0.26	0.32	0.36	1.02	1.00	1.02
1.0	0.20	0.18	0.16	0.83	0.82	0.83	0.25	0.28	0.32	1.03	1.00	1.00
5.0	0.45	0.41	0.38	0.63	0.59	0.63	0.13	0.16	0.21	1.14	1.00	1.00
10.0	0.68	0.63	0.63	0.44	0.42	0.43	0.08	0.10	0.12	1.36	1.13	1.16
25.0	0.95	0.95	0.91	0.13	0.10	0.19	0.02	0.02	0.02	2.35	1.81	1.87

- CTL - no DA, FZD - surface and ZTD, NZD - surface only
- Improvements for Equitable Threat Score (ETS) and Frequency Bias (FBIAS)
- Very short period: 20-21 July 2007

Summary

- WRF and WRF DA systems
- Wide range of data can be assimilated
- Recent papers conclude that GNSS products have large and positive effect on WRF forecasts
- Lack of long-term studies

Thank you!