Introduction to numerical weather forecast

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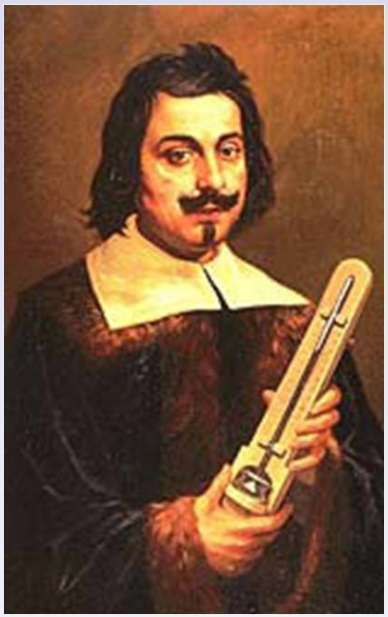
Observation

Historic weather forecast through observations

- Development of weather lore (Bauernregeln)
- „100-jähriger Kalender“
  - Weather record of a salesment over a period of 7 years
  - Selection of the title for better sellings

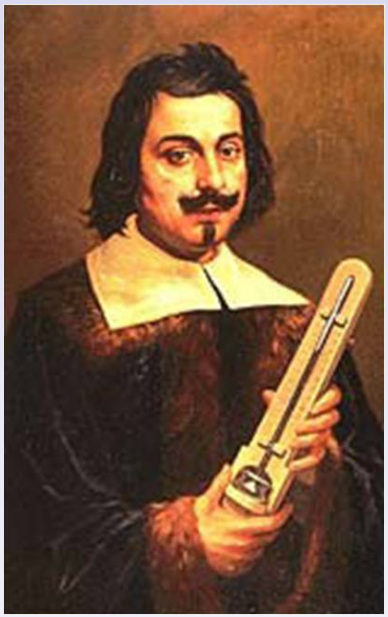
Measuring instruments

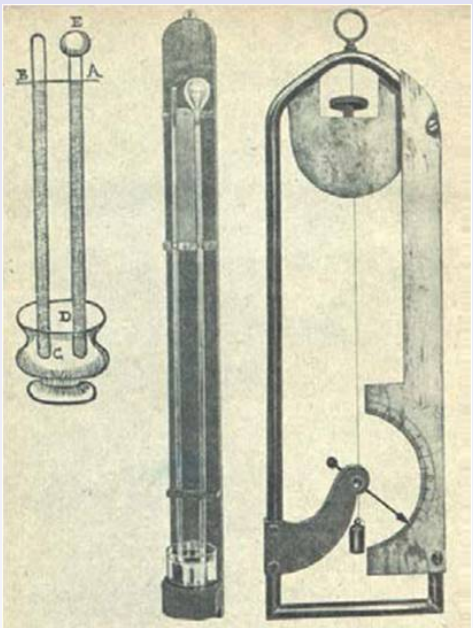


Development of the thermometer and barometers by Torricelli in 1643

[4]

Measuring instruments





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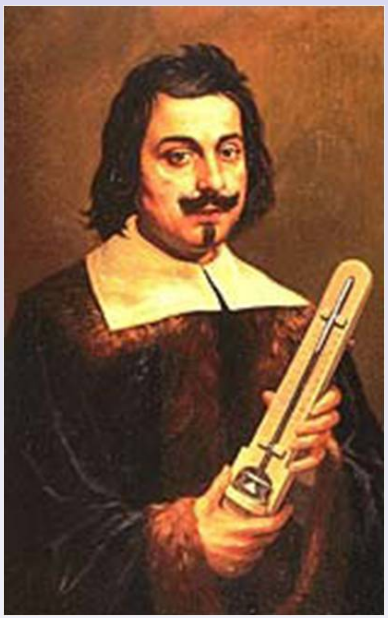

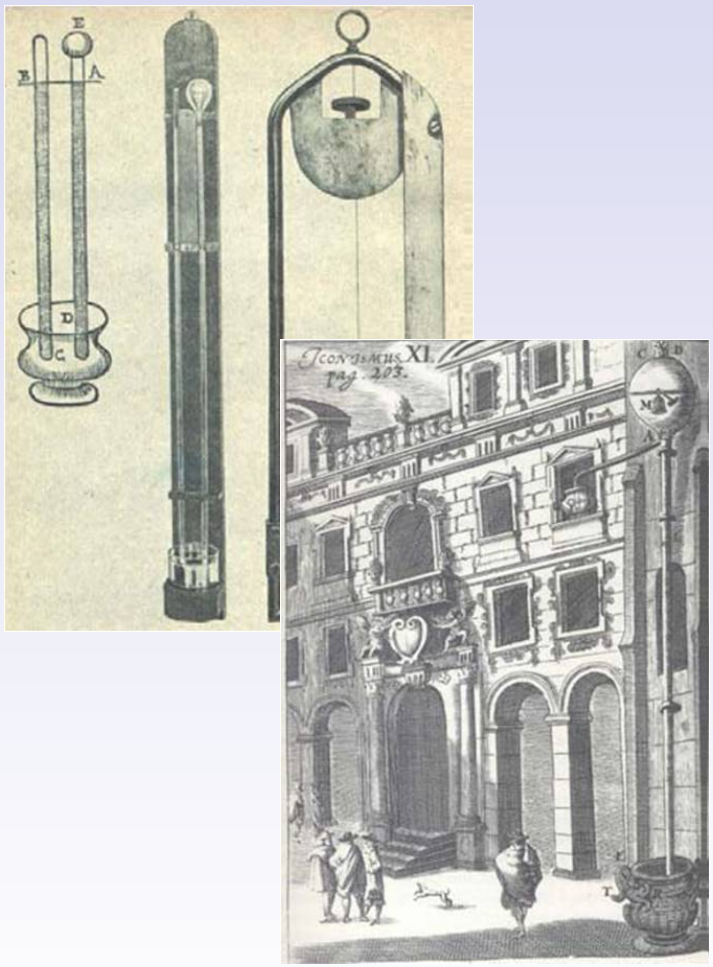

Development of the thermometer and barometers by Torricelli in 1643

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Development

- around 1650: Establishment of the first meteo. network
- 1780: Foundation of the „Societas Meteorologica Palatina“ by elector Karl Theodor of Mannheim
- around 1840: Telegraphy allows faster data transfer of meteorological data

[4]

Development

- Nov. 1854: Storm destroys the majority of the osmanian-france fleet during the Krim crisis
  - Analysis of observation data showed that the fleet could have been saved if the information had been forwarded
- 1913: Approach of spatial-temporal rasterization of the atmosphere by V. Bjerknes

Development

- 1921: Numerical forecast by L. F. Richardson
  - Access to detailed 3D-dataset from the International Meteorological Organization in 1910
  - Manual calculation of the physical equations
- 1950: First successful numerical forecast from Charney, Fjörtoft and von Neumann

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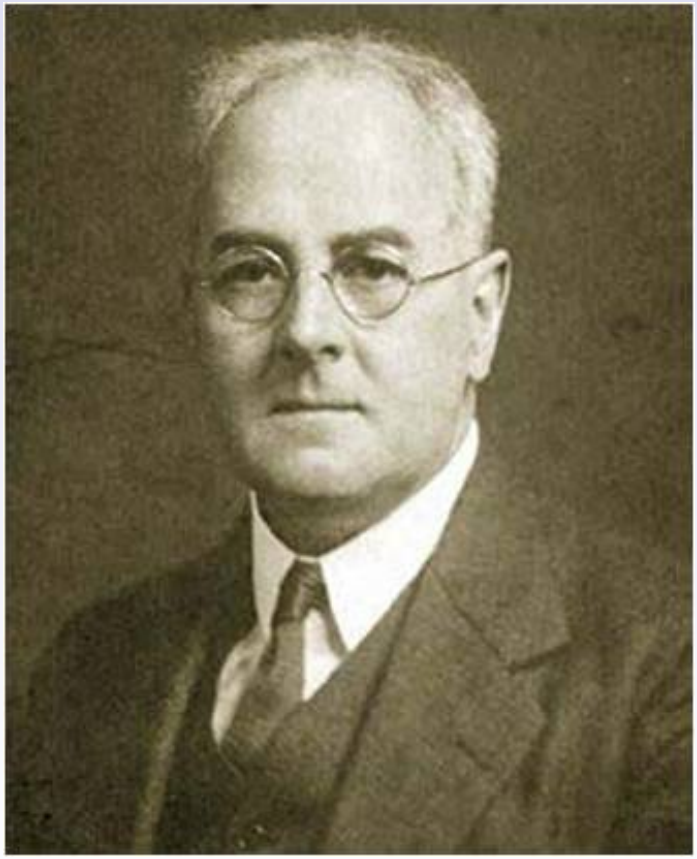

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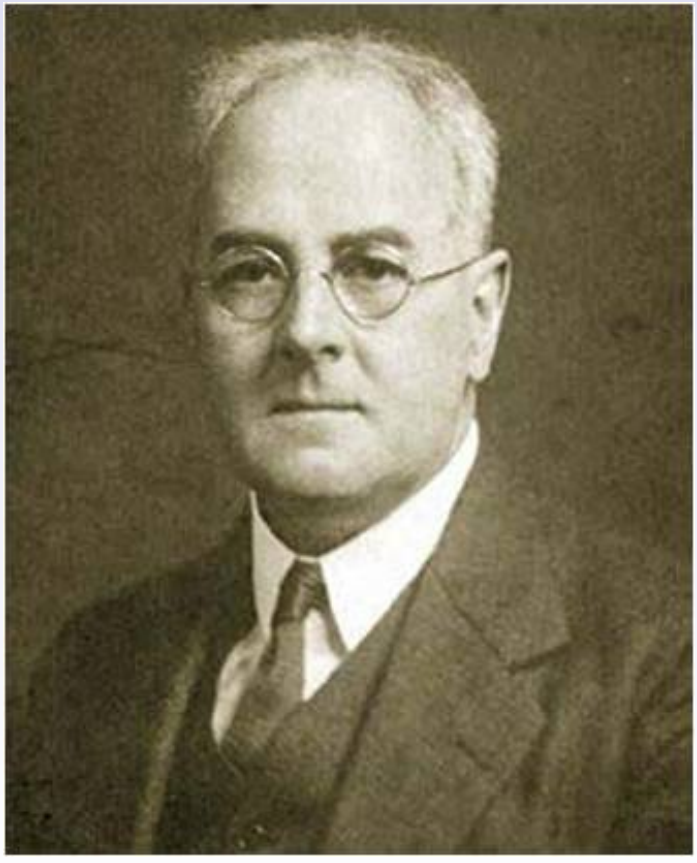
  $\Rightarrow$ Confirmation of Richardsons results



[4]

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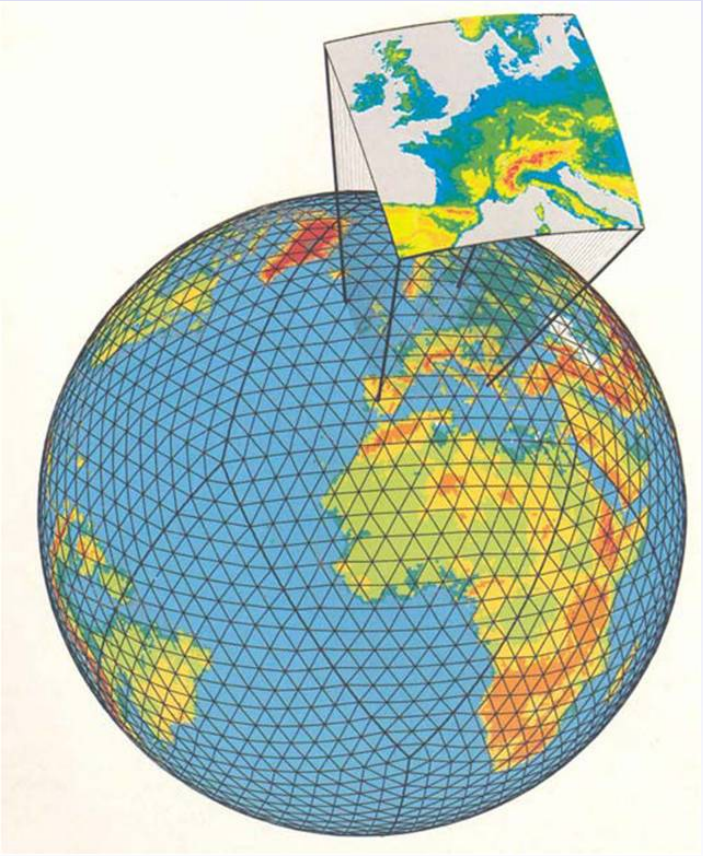
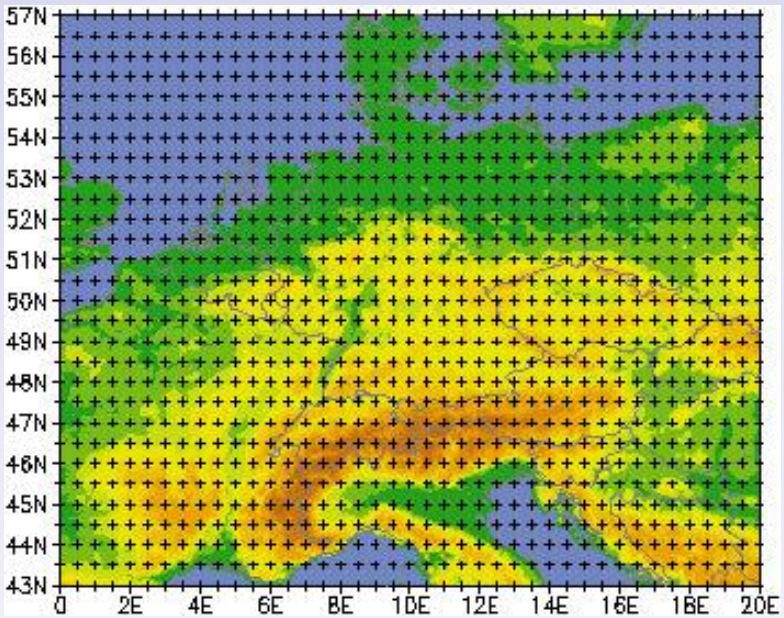
Numerical grid

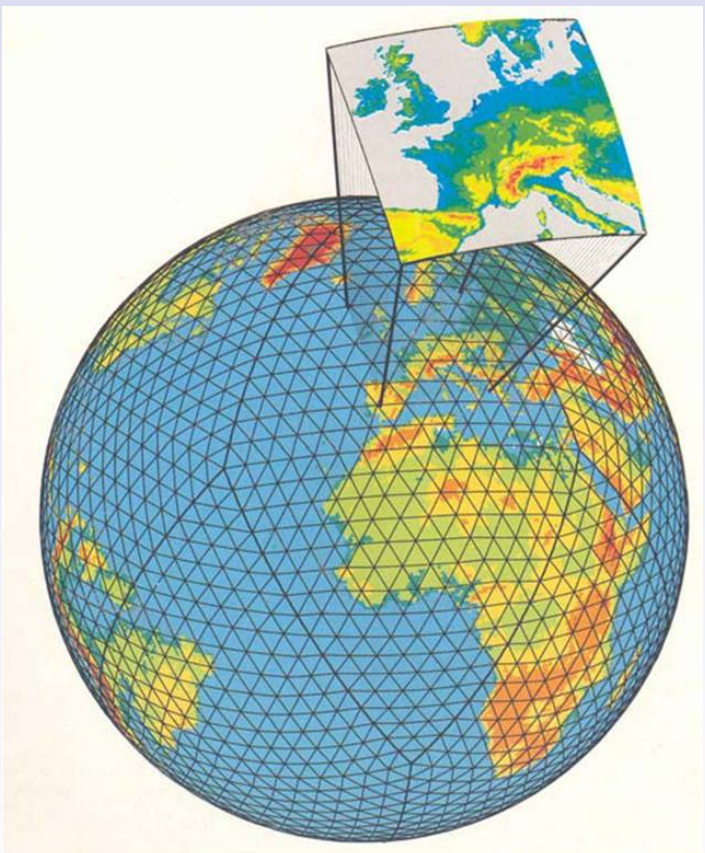
Separation of the forecast region by a three-dimensional numerical grid

[7], [1]



Numerical grid

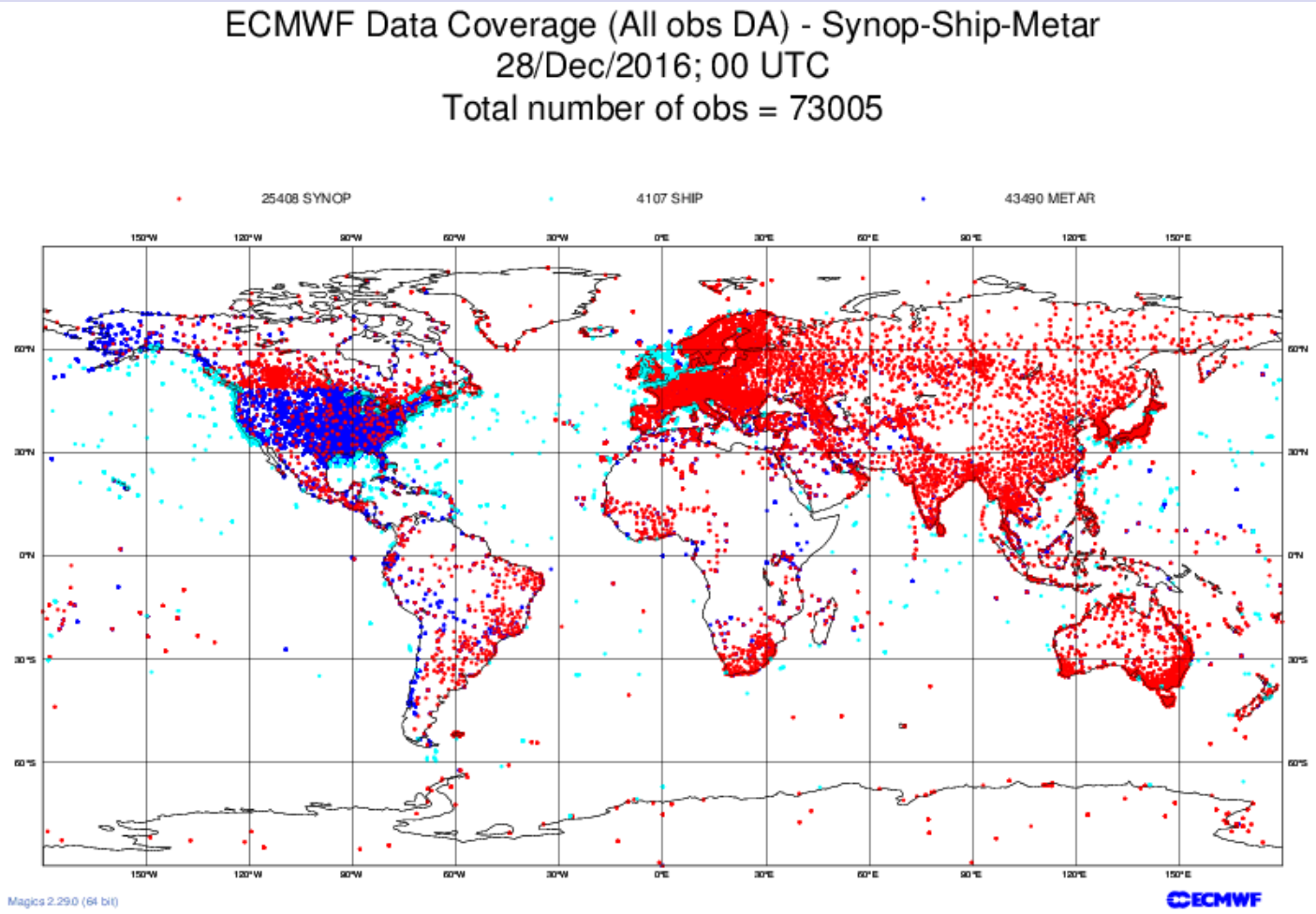




Separation of the forecast region by a three-dimensional numerical grid

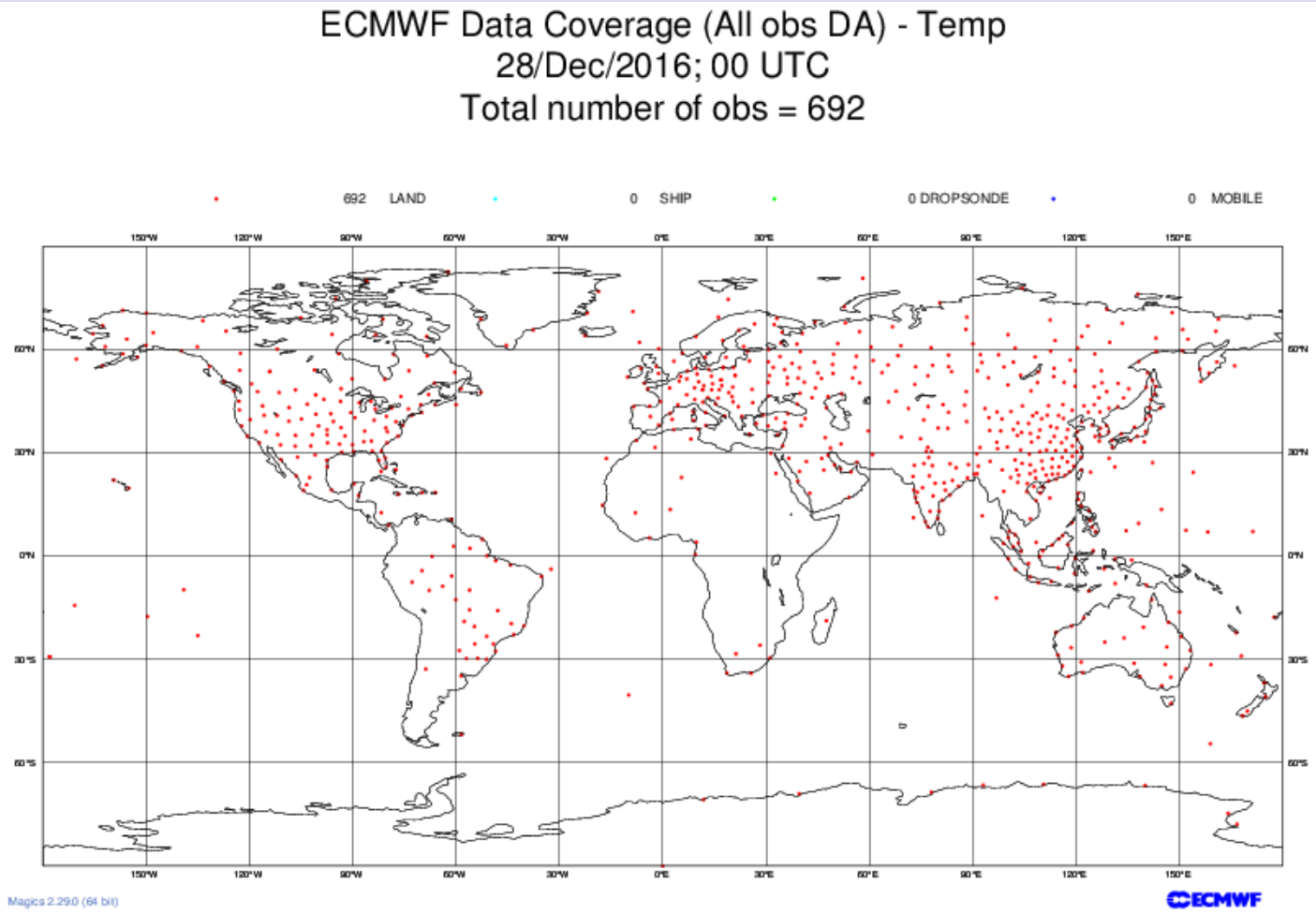
[7], [1]

Input data


ECMWF Data Coverage (All obs DA) - Synop-Ship-Metar
28/Dec/2016; 00 UTC
Total number of obs = 73005
25408 SYNOP
4107 SHIP
43490 METAR
Magics 2.29.0 (64 bit)
ECMWF

[2]

Input data

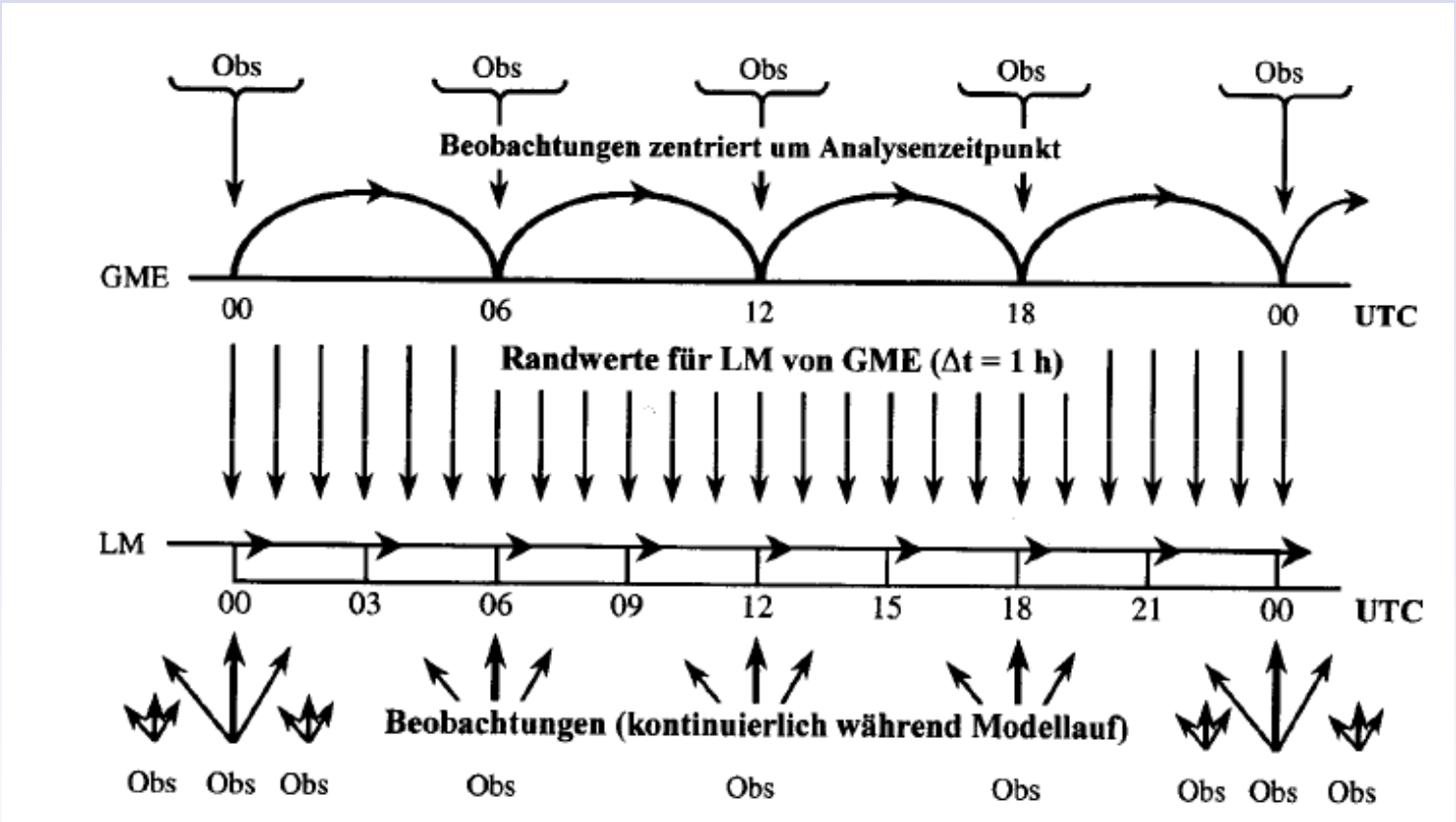

ECMWF Data Coverage (All obs DA) - Temp
28/Dec/2016; 00 UTC
Total number of obs = 692
692 LAND
0 SHIP
0 DROPSONDE
0 MOBILE
Magics 2.29.0 (64 bit)
ECMWF

[2]

Starting conditions

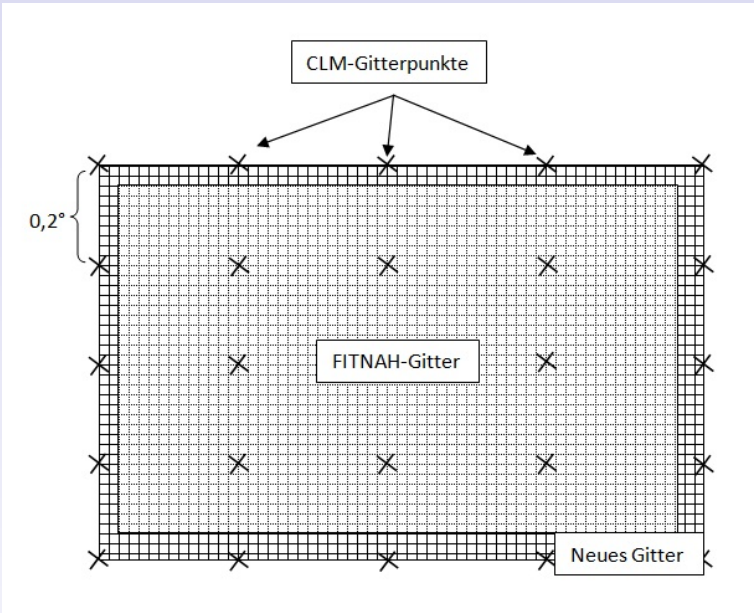
- Land use: e.g. city, water, field, forest
- Ground-near wind profile: logarithmic function
- Large-scale wind speed: different direction
- Meteorological data for the starting point from models greater grid resolution
  - Temperature
  - Pressure
  - Wind direction and speed
  - Humidity

Usage of starting conditions



[1]

Local models



Nesting of models for local forecast with various starting values [5]

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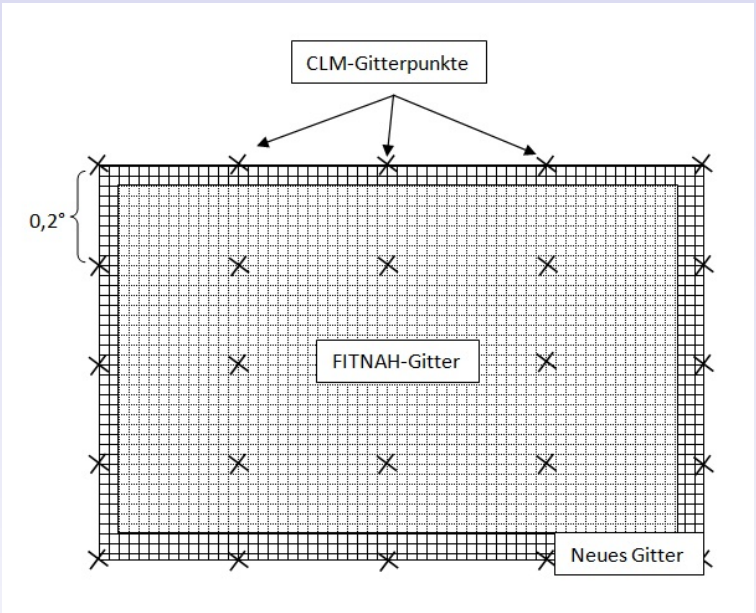

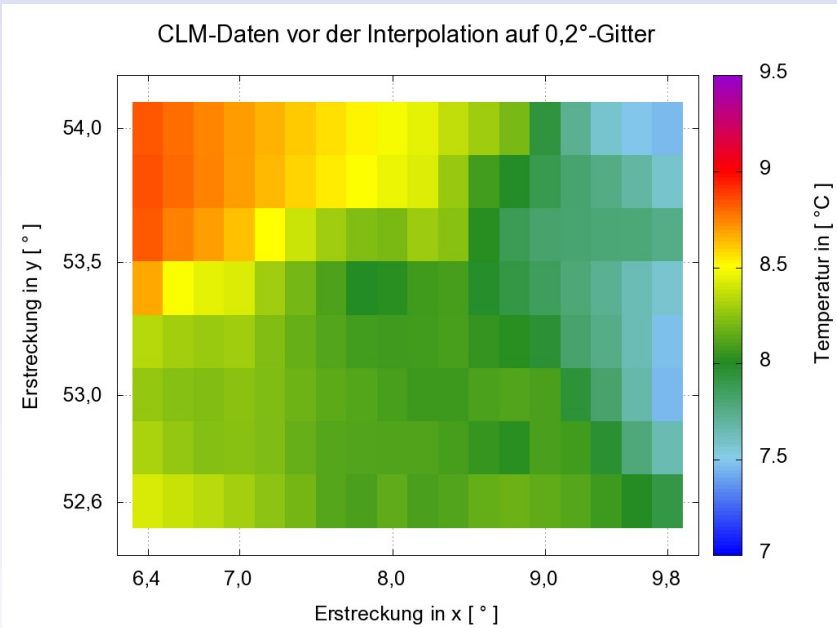

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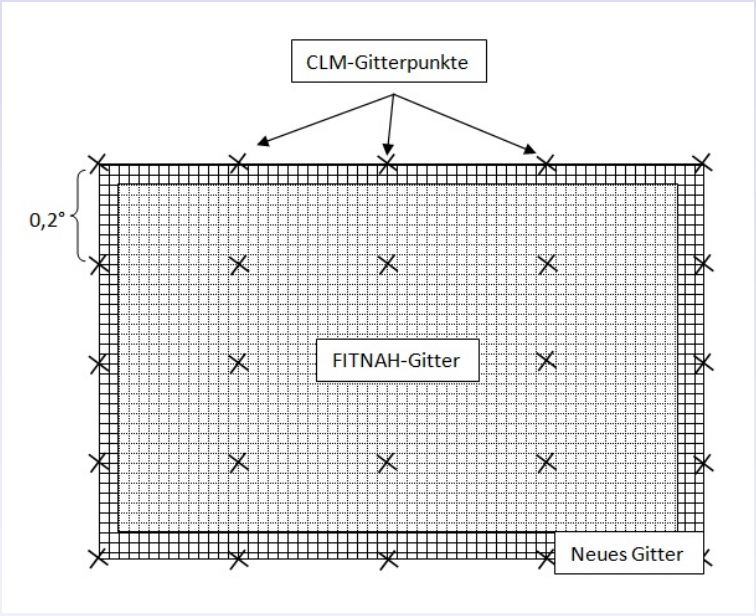

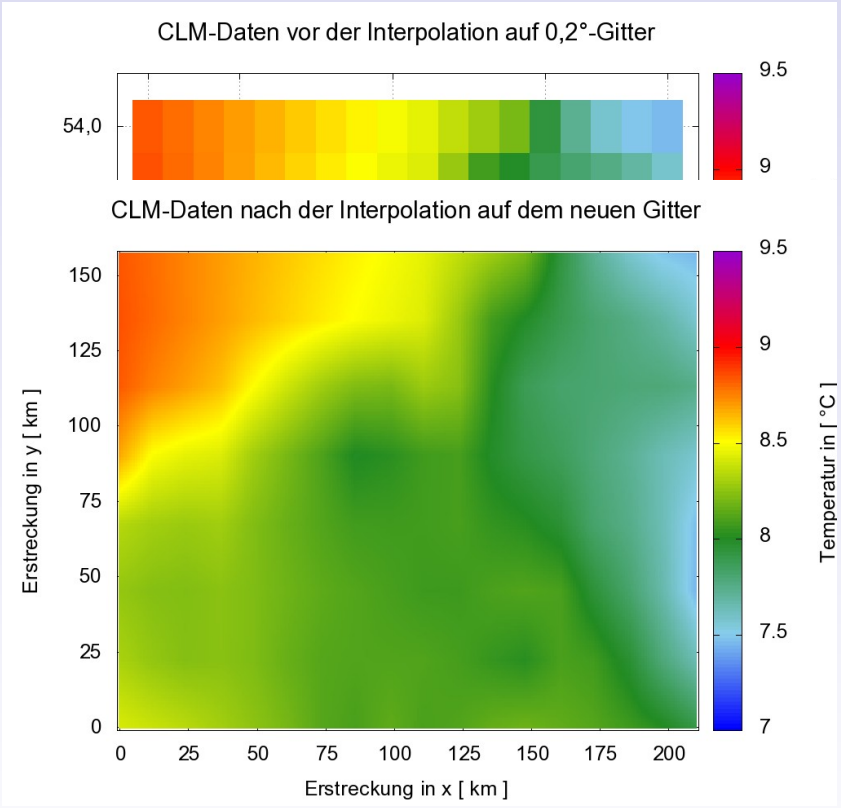

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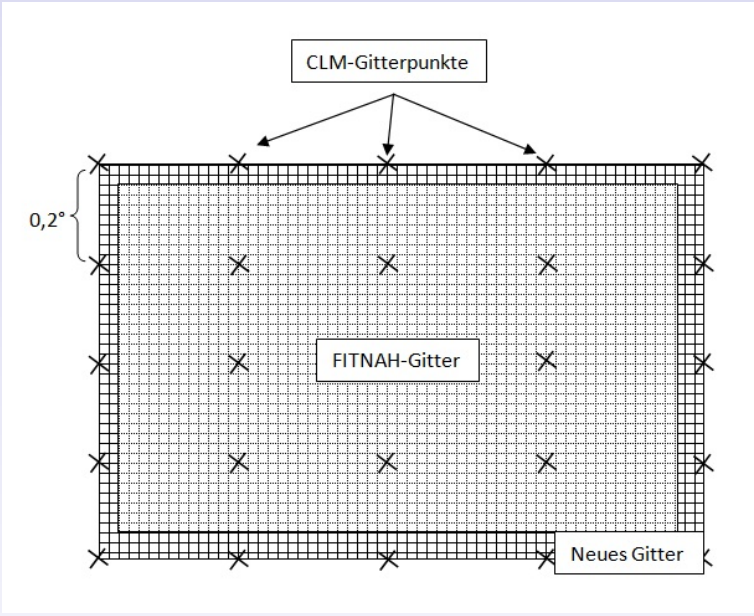

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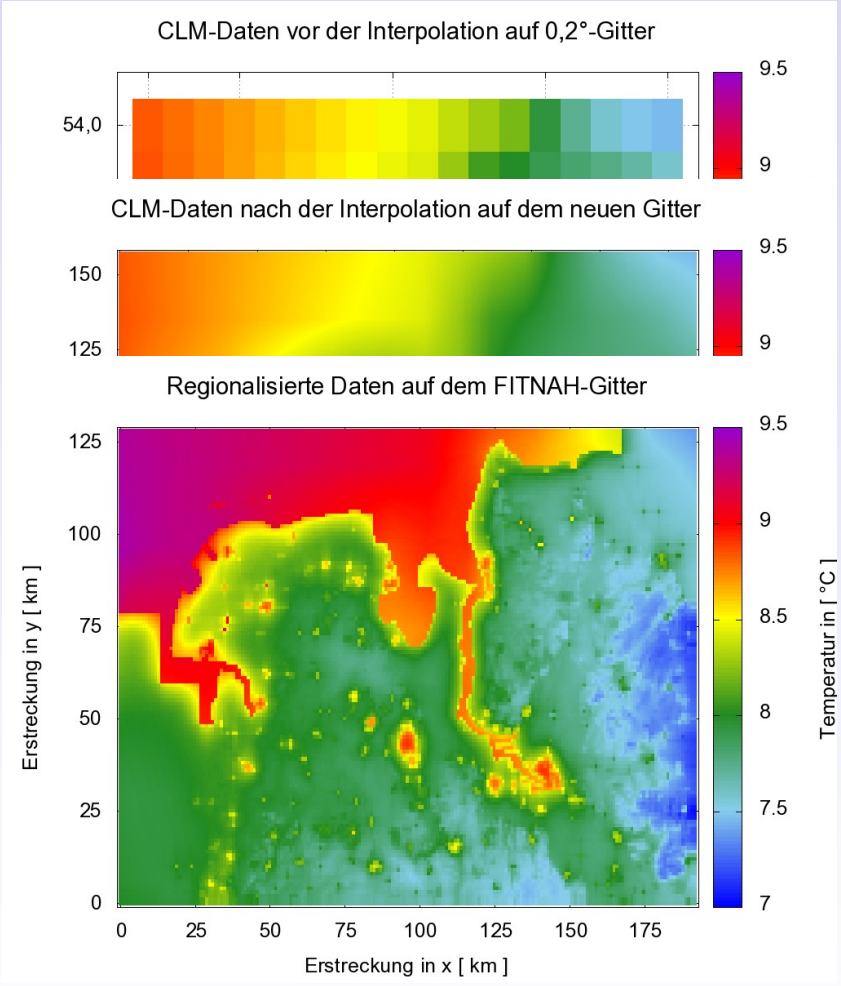

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  - Warnings, Forecasts, Analysis of ground measurements
  - Special data or complete datasets for a fee
  - Global (ICON) and local model (COSMO) [1]
- National Oceanic and Atmospheric Administration (NOAA)
  - govermental, freely available
  - GFS: Global Forecast System (NOAA), z.B. 0.5°x 0.5°[6]
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  - based in Reading, UK, but supported by 34 states
  - Weather forecasts, season forecasts, ensemble forecasts
  - IFS: Integrated Forecast System, every 12 h; forecasts up to 10 days [2]
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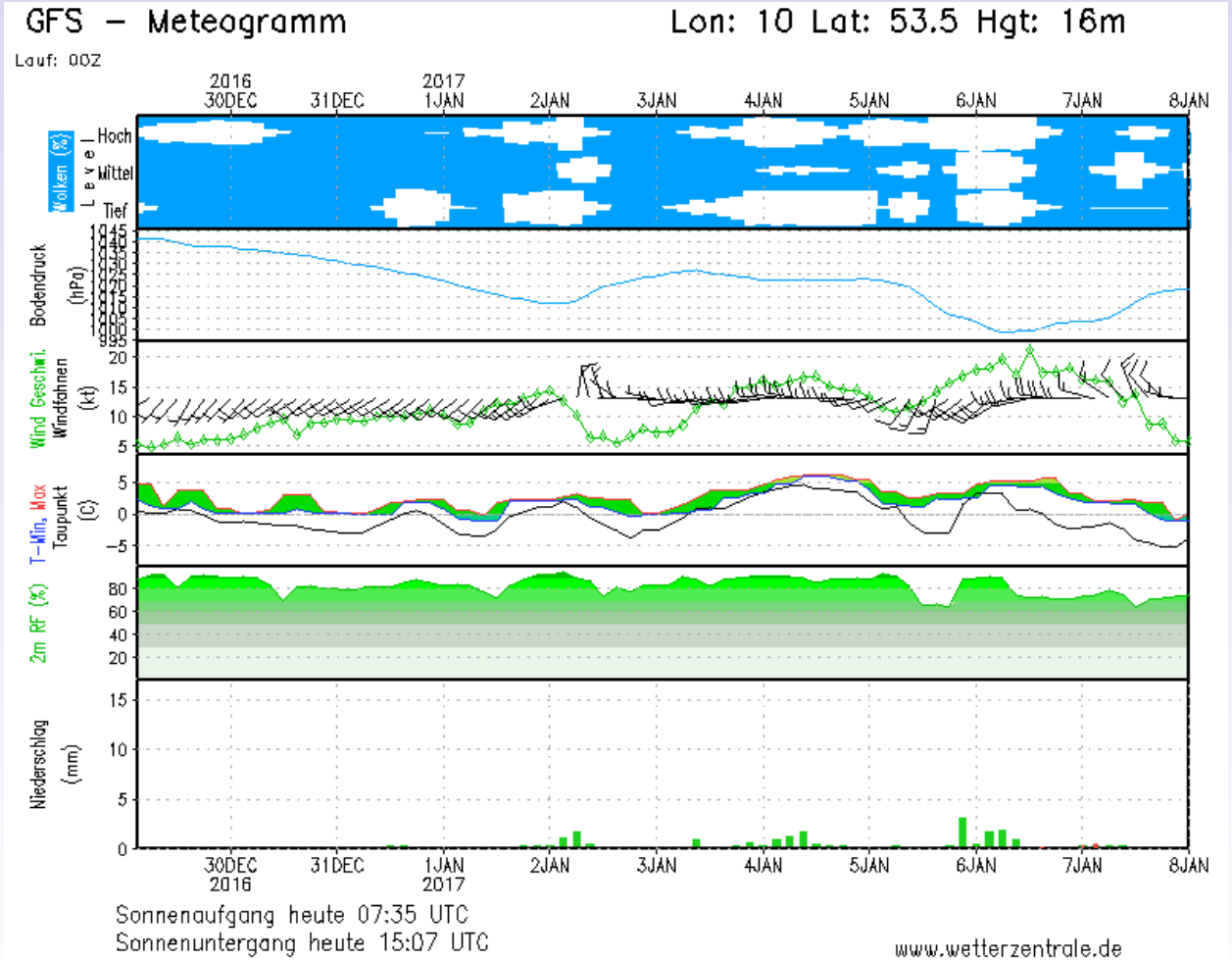
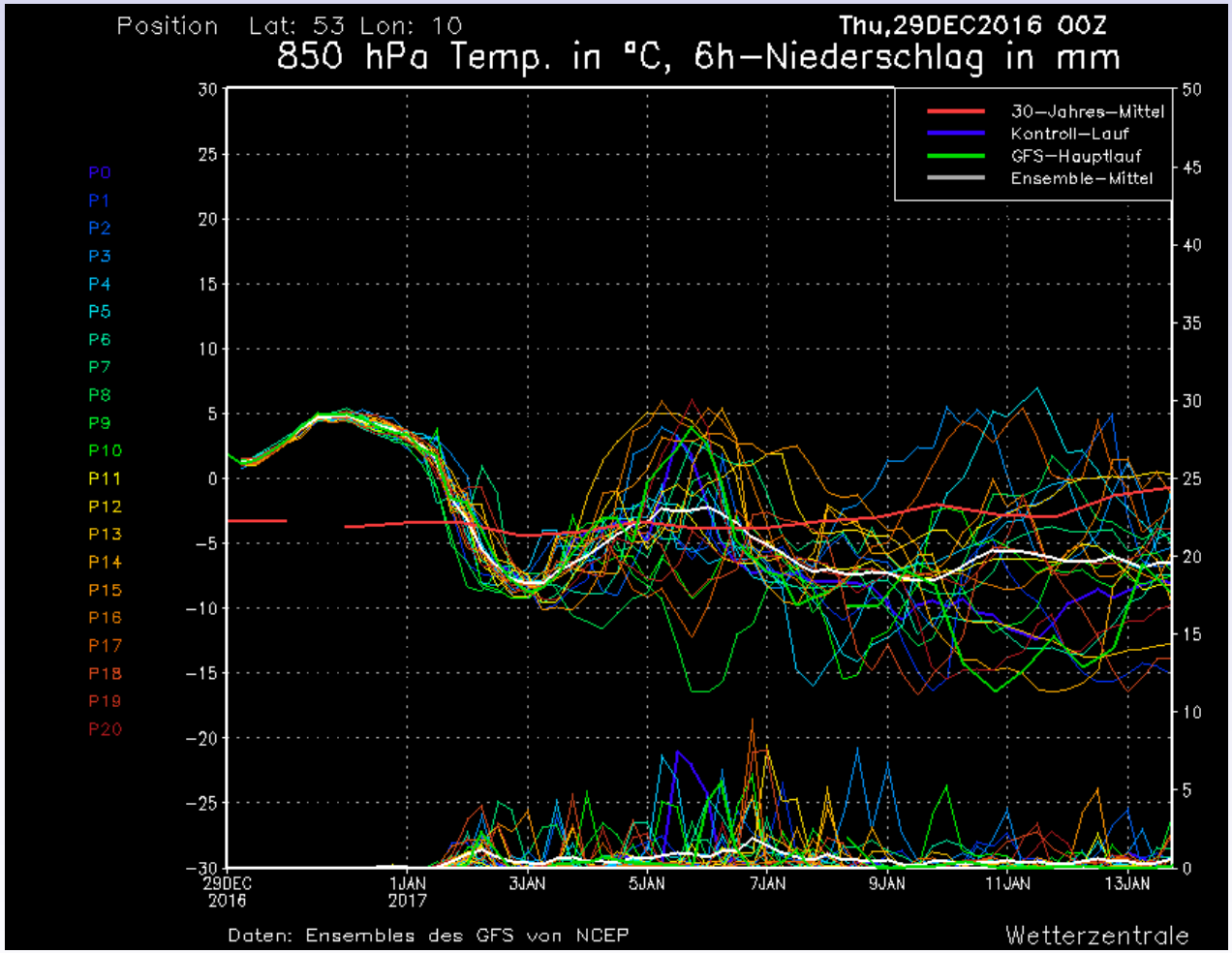
Meteogramm



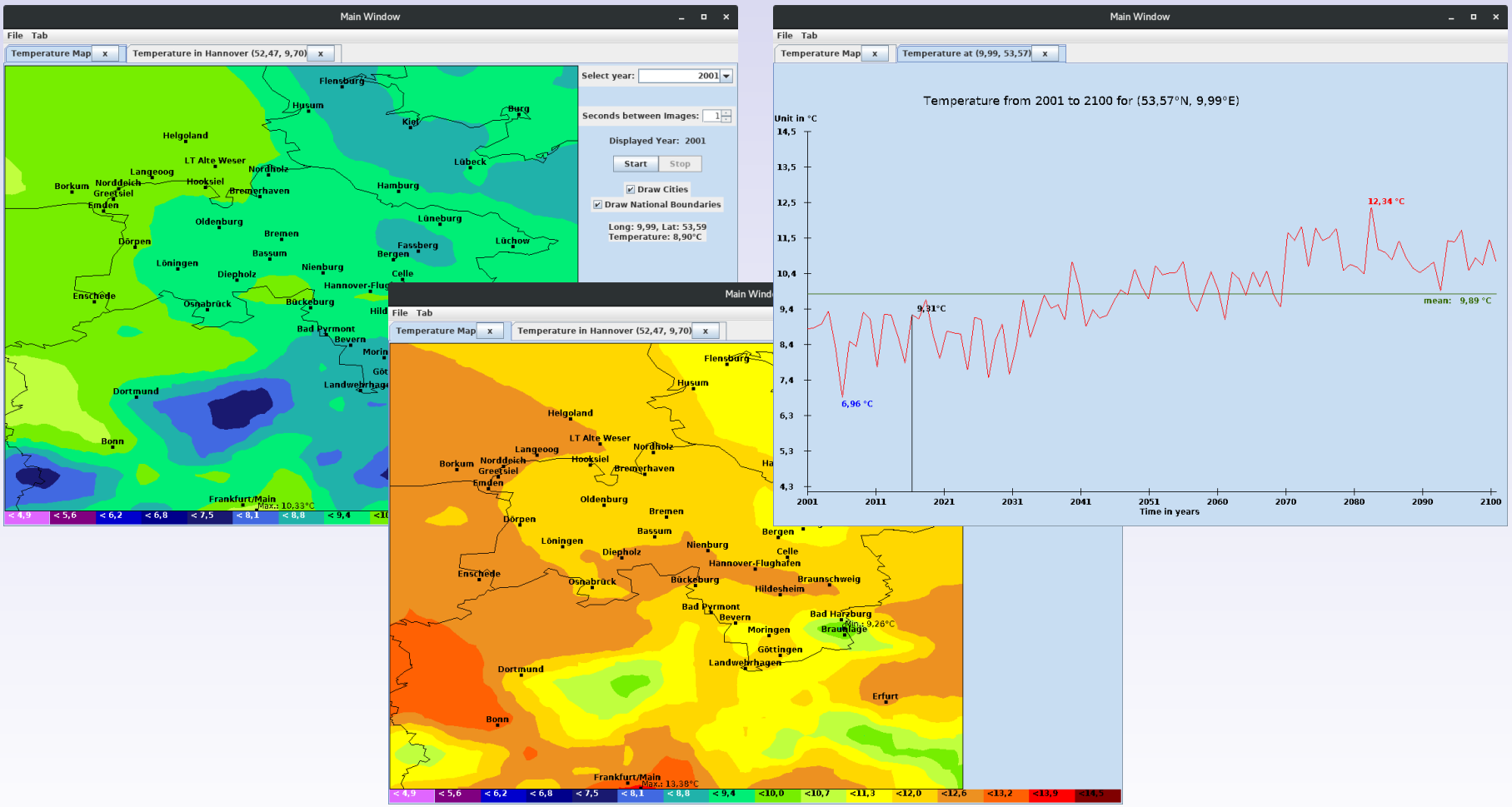
[7]

Medium-range ensemble-forecasts



[7]

Demo: Temperature visualization



Inhalt

- At first weather forecast as rules and observation...
- ... and through technical developments on basis of physical equations
- Weather forecast more detailed with better hardware - but still no absolute accuracy
- Observation by humans still important
- Weather data / weather forecast as a service

Questions? Feedback?

DWD.
German Weather Service (Deutscher Wetterdienst).
www.dwd.de, 09 2016.

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Inhalt

- Die erste Gleichung ist die Erhaltungsgleichung für den Impuls, die Navier-Stokes-Gleichung.

$$\frac{\partial u_i}{\partial t} + u_k \frac{\partial u_i}{\partial x_k} = -\varepsilon_{ijk} f_j u_k - \frac{\partial \Phi}{\partial x_i} - \frac{1}{\rho}\frac{\partial p}{\partial x_i} + \frac{\mu}{\rho}\frac{\partial^2 u_i}{\partial x_k^2} \qquad (1)$$

- Als Bilanzgleichung für die potentielle Temperatur dient der Erste Hauptsatz der Thermodynamik.

$$\frac{\partial \Theta}{\partial t} + u_k \frac{\partial \Theta}{\partial x_k} = P_\Theta \qquad (2)$$

- Als weitere Gleichung dient die Bilanzgleichung für die spezifische Feuchte.

$$\frac{\partial s}{\partial t} + u_k \frac{\partial s}{\partial x_k} = P_s \tag{3}$$

- Die Kontinuitätsgleichung dient als Bilanzgleichung für die Masse.

$$\frac{\partial \rho}{\partial t} + u_k \frac{\partial \rho}{\partial x_k} = -\rho \frac{\partial u_k}{\partial x_k} \tag{4}$$

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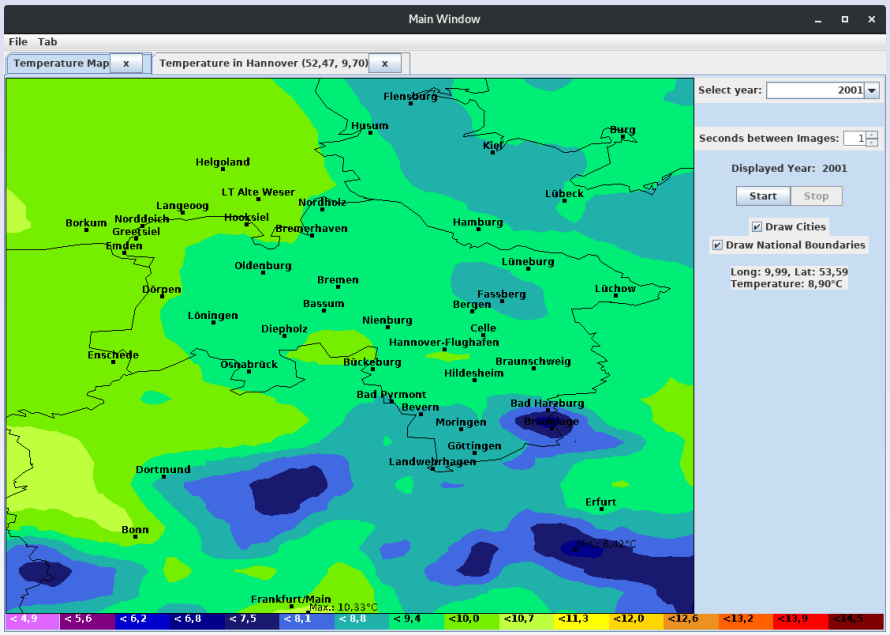
Temperature visualization



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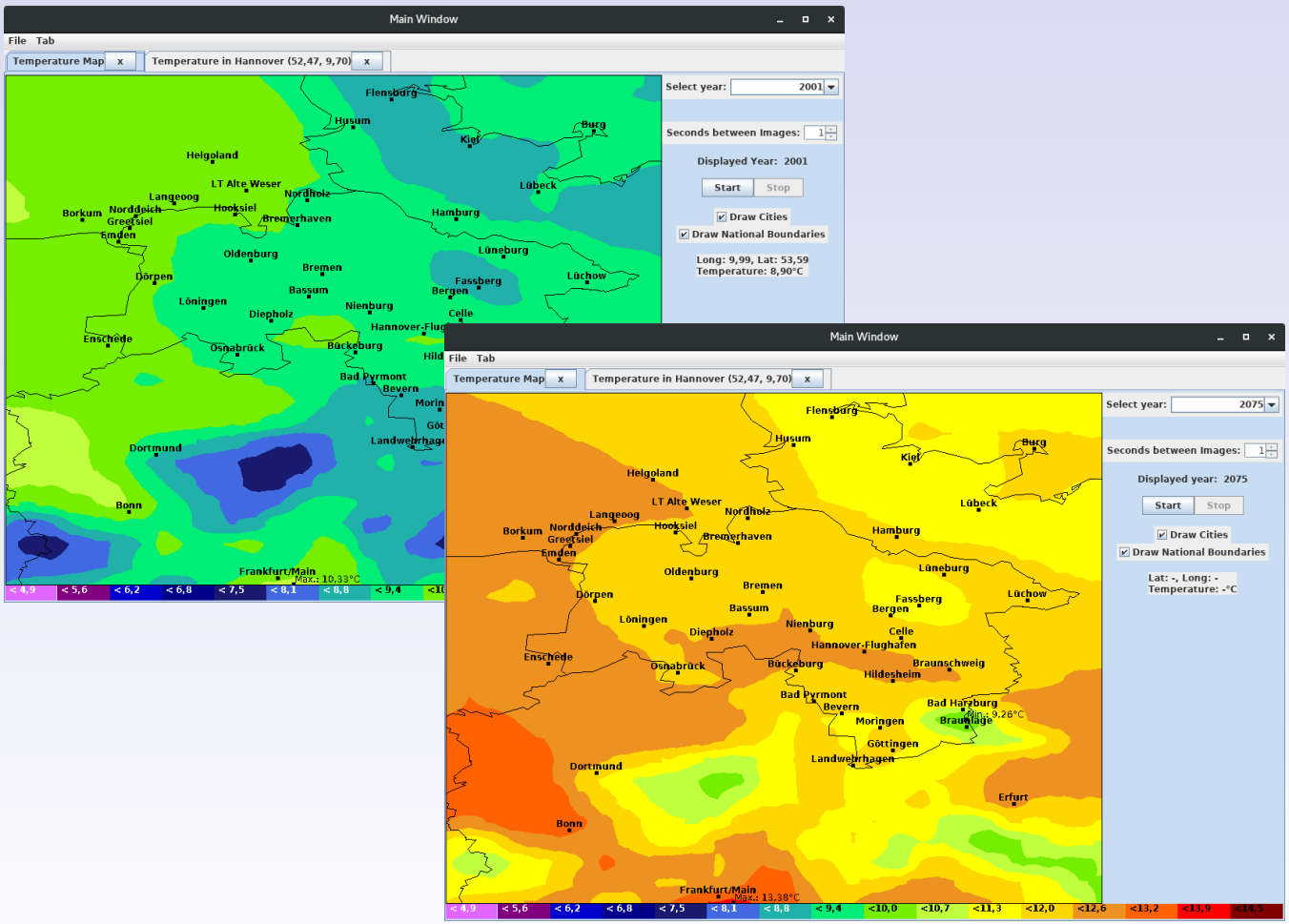

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