



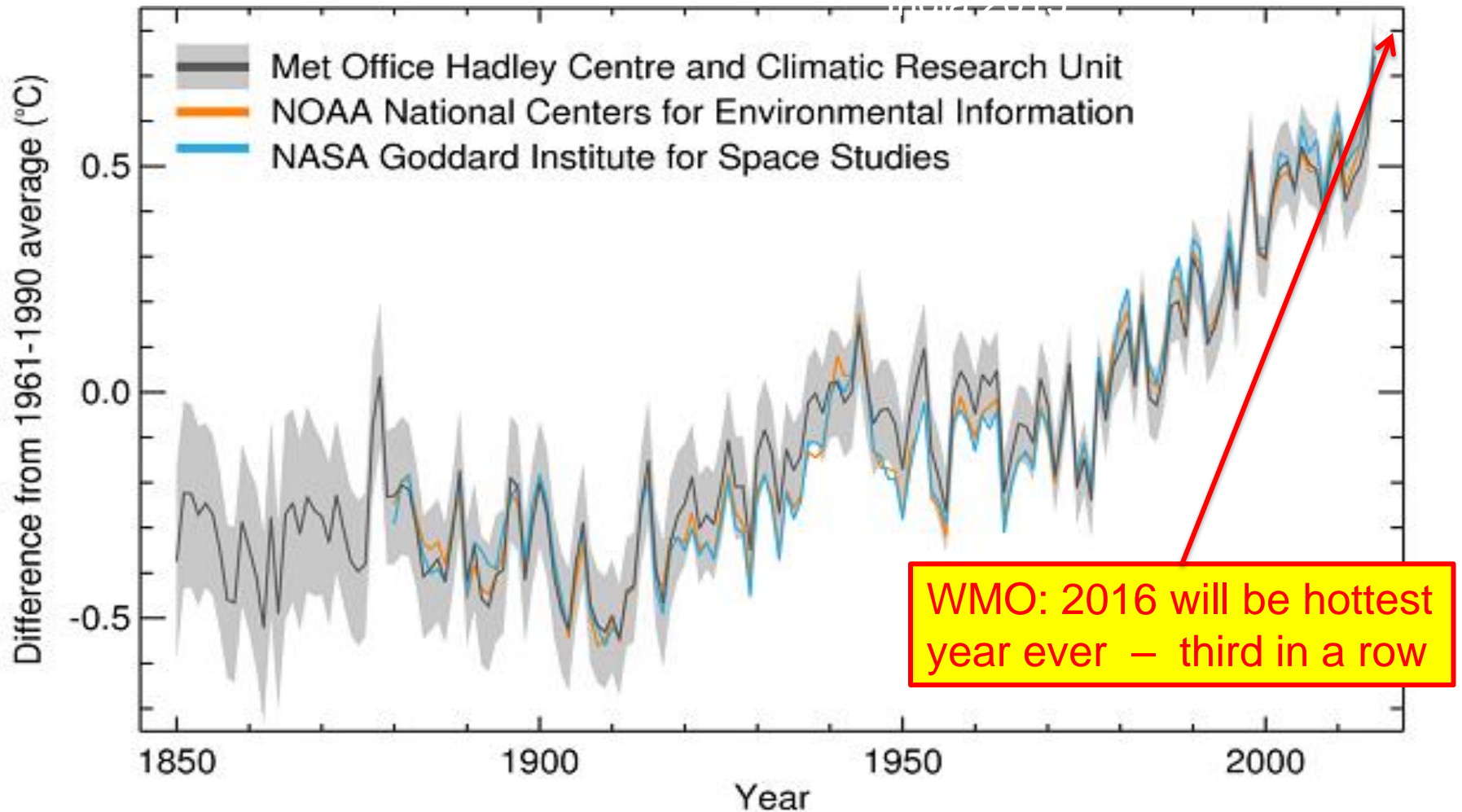
Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Infrastructuur en Milieu

Developments in meteorology from the NMS perspective

*Gerard van der Steenhoven
Director General KNMI &
University of Twente*

NVBM annual meeting,
Amersfoort, 25 November 2016

Global average temperature



Drought in California 2014

Lake Oroville,
19 August 2014:
40 m below normal



Forest fires in Indonesia 2015



Two worldwide UN agreements in 2015



→ Paris 2015: limit ΔT_{global} to 1.5 - 2 °C

→ Marakesh 2016:
ratification COP21



Innovation in meteorology

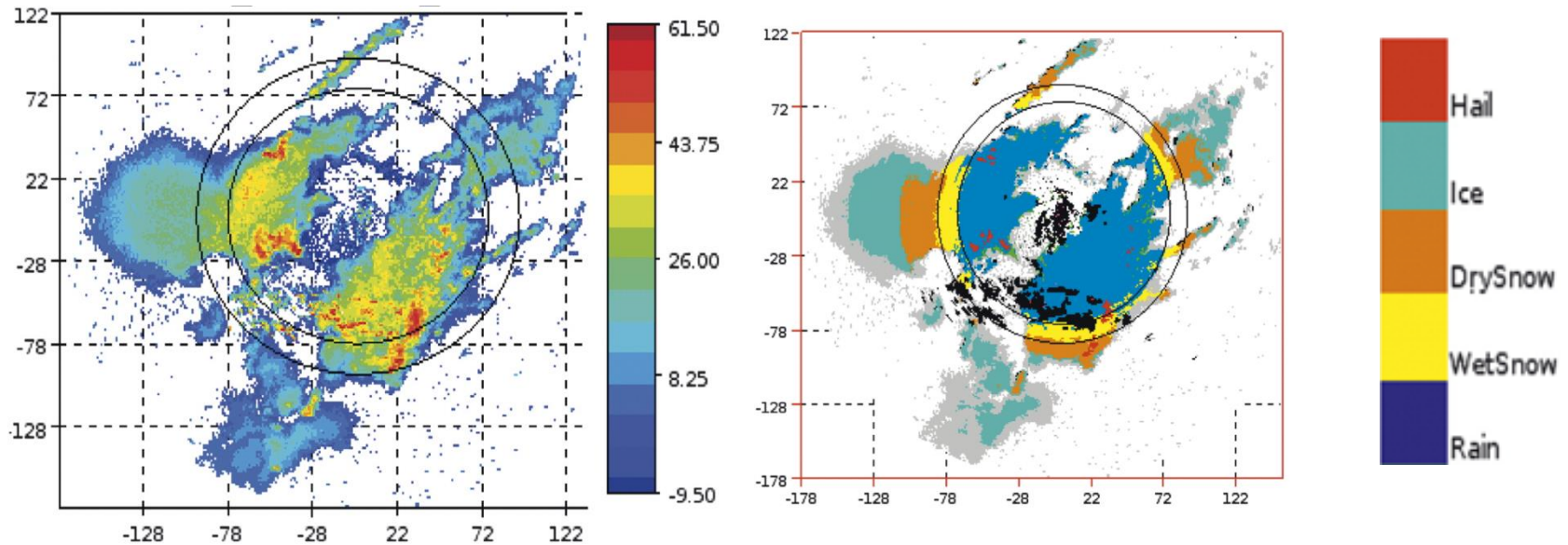
- Mission National Meteorological Services:
 - inform, advice and warn society in case of atmospheric hazards
- Climate change: high-impact weather
 - Coincidences with other natural hazards



- Required innovations:
 - Instrumentation, crowd sourcing, etc.
 - Weather models: increase forecast horizon
 - Impact-based warnings & advices
 - (Multi-Hazard) Early Warning Centre
 - Novel types of collaboration

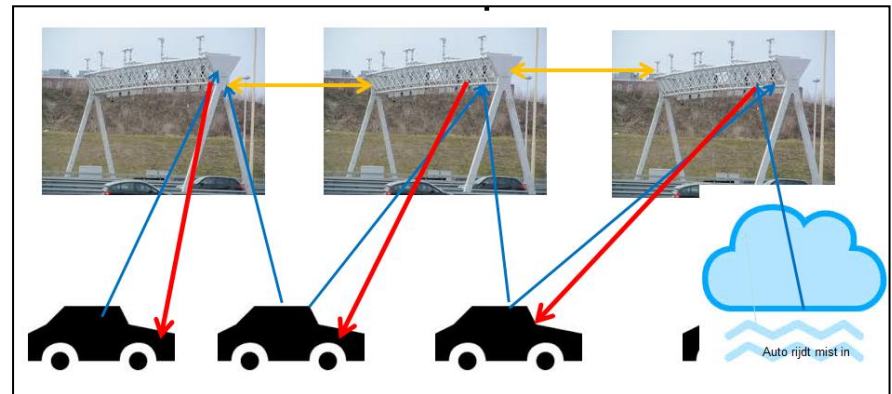
1. Innovations in instrumentation - I

- New dual polarization radars: precipitation type



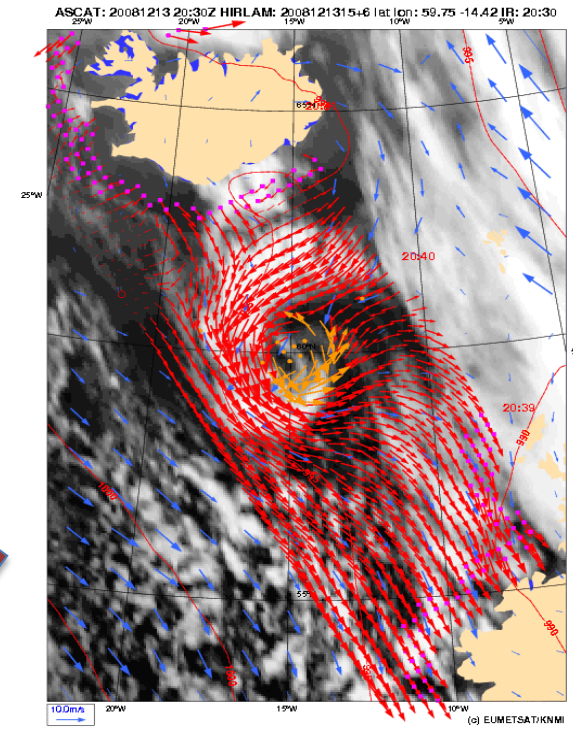
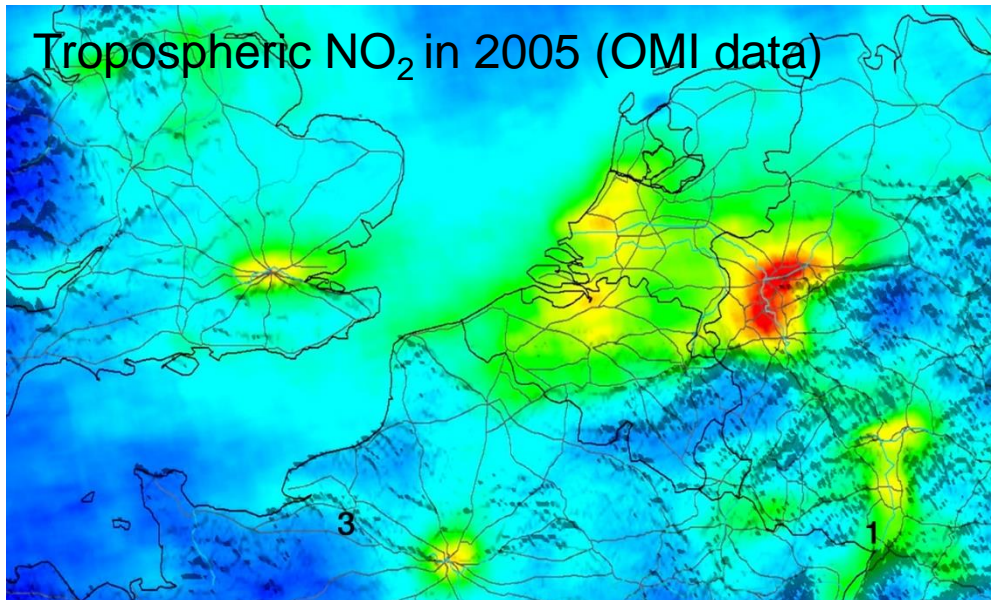
- Internet of things:

- S-car-Go → →
- WoW



Ad 1. New satellite data

- New European satellites:
 - EUMETSAT: MTG and EPS-SG series
 - ESA/Copernicus: Sentinel series
- Wind at zee (ASCAT satelliet)
- Airquality (OMI, Tropomi)



2. Innovation in numerical weather models

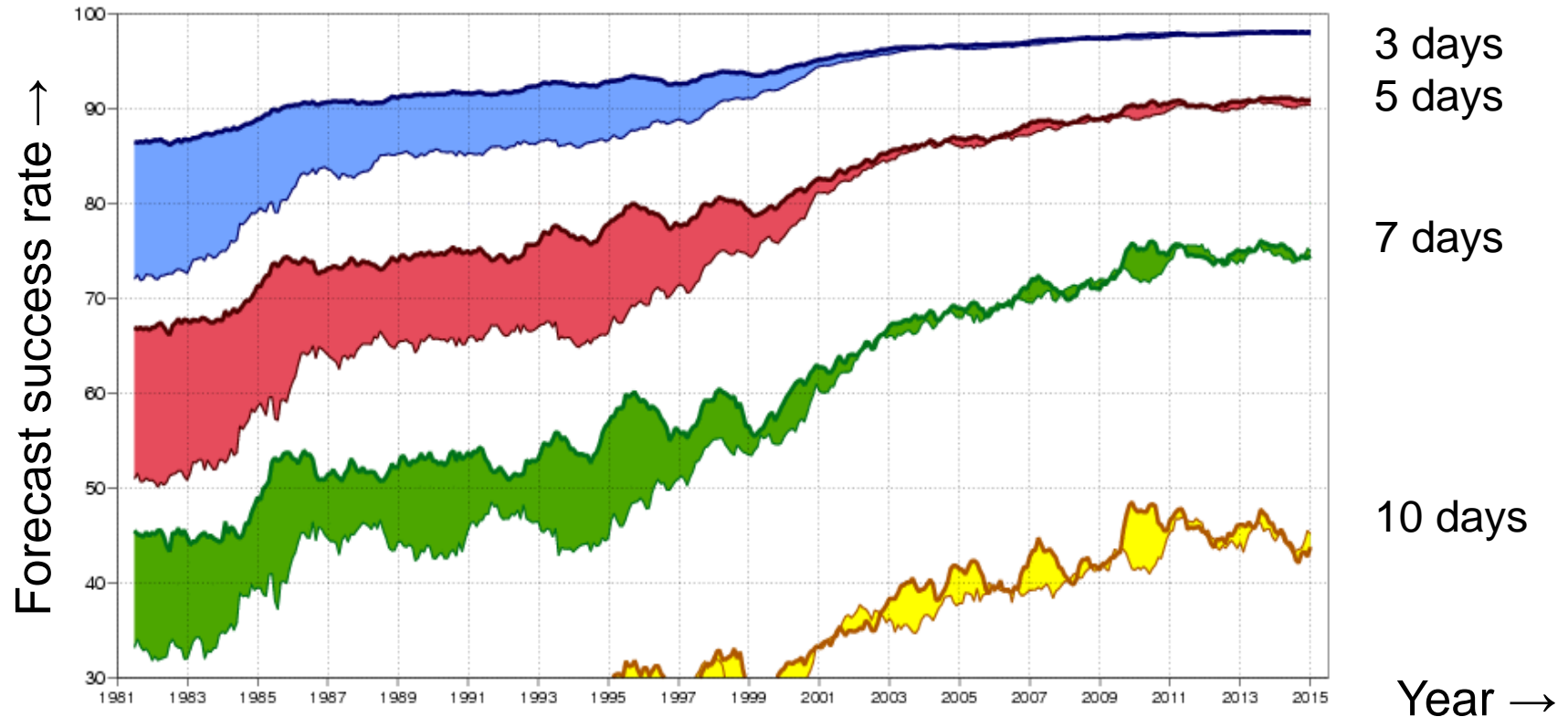
- ECMWF strategy wrt forecast horizons:
 - High-impact weather: *two weeks*
 - Regime changes: *four weeks*
 - Seasonal anomalies: *one year*
- Requirements:
 - More data: satellites, aircraft, I-of-T, etc
 - New concepts: scalability, cloud param.
 - Powerfull HPC – new KNMI purchase:
 - 385 Tflops/s (factor 6 faster)
 - 0,48 kW/Tflop (factor 5 more efficient)
 - 20 member ensemble for LAM



Ad 2. Massive assimilation satellite data

- Silent revolution in meteorology

Improvement of ECMWF global weather forecasts 1981 - 2015



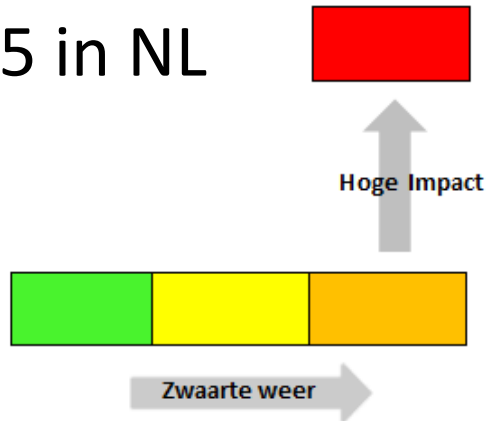
Ad 2. High-resolution cloud modelling

- Pier Siebesma et al: sub-km modeling @ QPU cluster

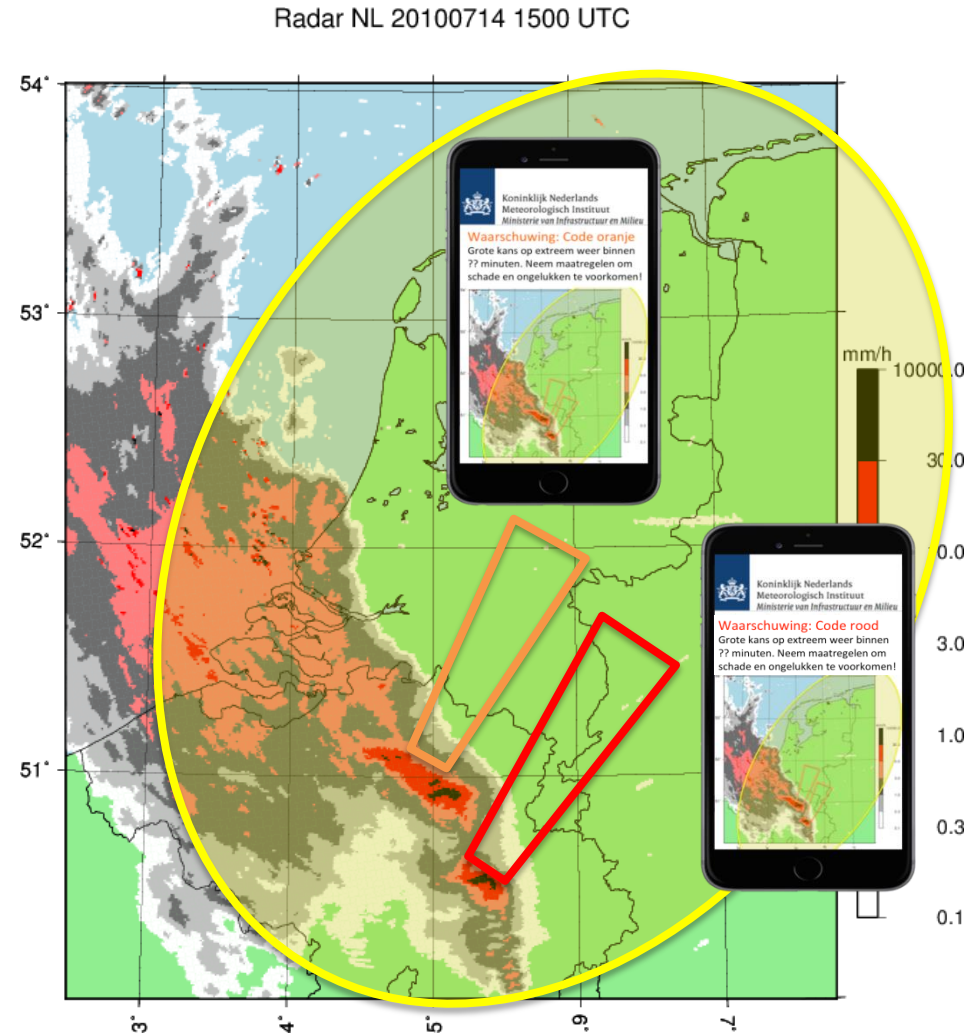
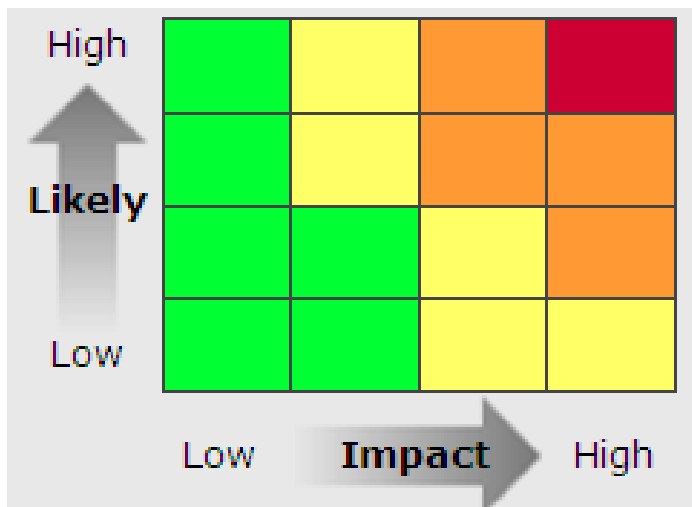


3. Impact-based warnings and alerts

- Oct '15 in NL



- UK MetOffice system



4. Early Warning Centre

- Considerations:
 - Requested by COP21 agreement
 - More extreme weather events
 - Push back forecast horizon
 - Society: custom-made advice
 - Impact-based warnings
 - Multiple geophysical hazards:
 - High-impact weather
 - Dutch Caribbean
 - Earthquakes (Groningen)
 - Vulcano's & explosions
 - Space weather

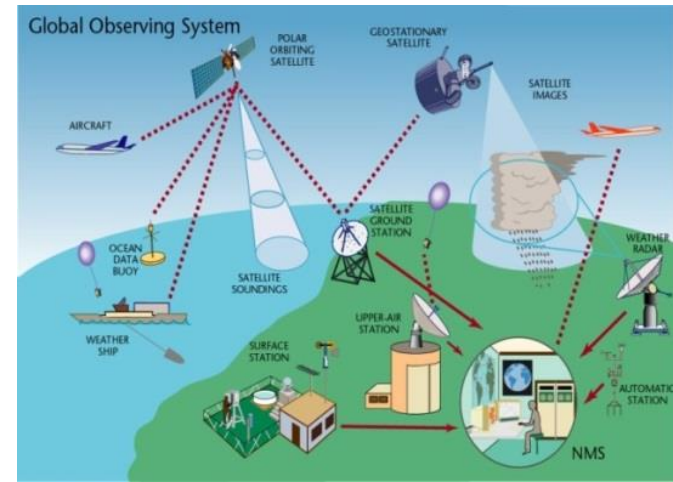


EWC@KNMI – the plan:

- Develop concept: '17
- Start operations: '18
- Gradual development

[illegible]

-
- A long row of Cray ECMPF supercomputing nodes in a data center. Each node has a large monitor displaying various scientific plots and charts, including contour maps and line graphs. The nodes are arranged in a long line, and the monitors are illuminated by overhead lights. The Cray logo and ECMPF text are visible on the top of the nodes.



Climate change as innovation driver

- Mitigation: reduce CO₂ emissions
 - Adaptation: modify infrastructure
 - Societal: change public attitude
- } → innovation

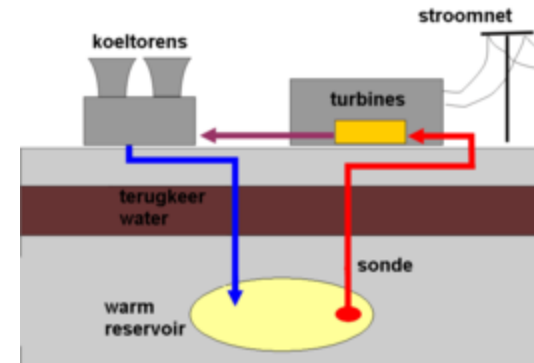
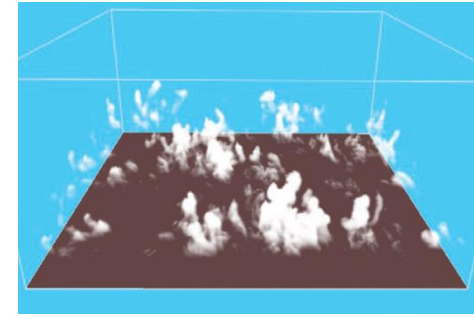


Energy transition & monitoring

- Energy transition:

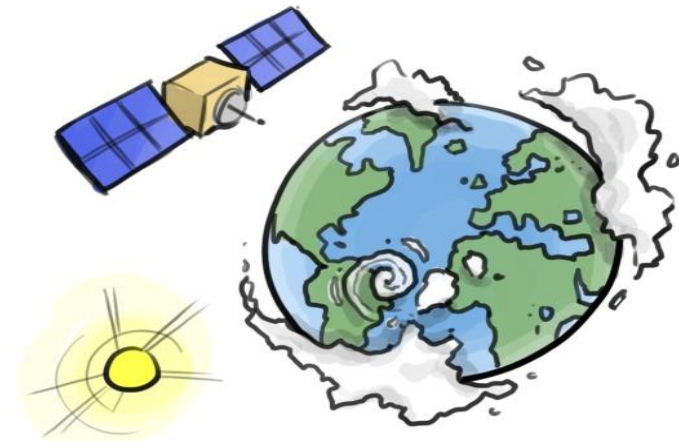
- Wind at sea → wind @ 300 m, new satellites
- Solar power → cloud resolving weather models
- Geothermal energy
- CO₂ capture and storage

} Seismology



- Climate monitoring:

- Trend monitoring (climate series)
- Emission sources (Tropomi satellite)
- Impact analyses (on infrastructure)



Societal change

- Raising climate change awareness
- Impact-based (climate) warnings
- Social science: measure & study response



Outlook

→ COP22 @ Marakesh



Developments in meteorology from the NMHS perspective:

- Climate change as a driver of innovations:
 - Extreme weather → Early Warning Centre
 - Energy transition → wind, solar, geothermal
 - Societal change → climate awareness